. cleared

Subject: cleared
From: Scott Smullen <[redacted]@noaa.gov>
Date: Thu, 22 Sep 2005 11:23:08 -0400
To: Kent Laborde <[redacted]@noaa.gov>
CC: "Jordan St.John" <[redacted]@noaa.gov>

kent - this is cleared, with the caveat that we tell richard to be very careful with how he frames the global warming signal aspect. sensitivities there, as you know. thanks ss

----

with has asked to talk to someone about sea surface temperatures in the Gulf of Mexico and whether temps have risen in the past few years. He understands that the hurricane intensity is attributed to the multi-decadal cycle, but wants to know independent of that discussion whether the Gulf is warmer than in past years/decades.

Our best spokesperson on this is Richard Reynolds at National Climatic Data Center. He is the oceanographer there and expert on oceanic temperatures and trends. He has experience talking with media.

According to Richard, the Gulf is warmer. This is attributed to cyclical warming patterns, but there is also a global warming signal involved. The warming signal shows steady progression, which shows averaged over a decade, the rise in Gulf water temp is less than 1 degree Celsius. However, there is a trend of month-by-month temp increase over the years.

deadline is tomorrow afternoon.

Subject: Re: GFDI
From: "Jana Goldman" [redacted]@noaa.gov>
Date: Mon, 13 Jun 2005 13:05:14 -0400
To: Kent Laborde <[redacted]@noaa.gov>

thanx for this --
jana

Kent Laborde wrote:

> CEQ and OSTP have given the green light for the interview with Ram. They had me call to find out more specifics. She will be asking the following:
> *what research are you doing with climate change
> *what research has been encouraged or discouraged by the administration
> *what interaction has he had with the administration
> *does he have free reign to conduct the research her wants to do
>
> I told that he feels comfortable to comment only on science and does not want to loose his scientific objectivity by addressing policy/potitical questions. She said since he is not a policy maker, she wouldn't ask policy questions.
>
> Michele wants me to monitor the call and report back to her when it's done. I will set up the interview for later today or early tomorrow, depending on her and Ram's schedules.
>
> Points for these questions: It's all covered in the strategic plan, which guides all federally funded scientific research on climate change. The SP coordinates the efforts to maximize the benefits and outcomes of the research -- eliminates redundancies and fills in gaps in research.
>
> While research is "guided" in this way by the administration, the individual scientists have a great deal of input into the specifics of the reseach they conduct and they had a voice in directing the research goals set out in the SP.
>
> Finally, no scientist has completely free regin. In this case, the research is focused on providing decision support tools and eliminating uncertainties in climate science. Whether in academia or corporate settings, science is conducted in a coordinated and constructive manner.

--
Jana Goldman
Public Affairs Officer
NOAA Research

1315 East West Highway
SSMC3 #11460
Silver Spring, MD 20910

[redacted] fax

[redacted]@noaa.gov

RE Fwd Fwd Roger Pielke Sr. resigns from CCSP Temperature Trend Study
From: Kent Laborde [[redacted]@noaa.gov]
Sent: Friday, August 19, 2005 11:12 AM
To: St. Martin, Michele M.
Cc: Barnett, Megan H.
Subject: Re: [Fwd: Fwd: Roger Pielke Sr. resigns from CCSP Temperature
Trend Study]

Will do.

St. Martin, Michele M. wrote:

>Ok, thanks. Give me a wrap up of the interview and how you think it
>went and when the story is expected so I can give Dana and others a
>heads up -thanks.
>
>-----Original Message-----
>From: Kent Laborde [mailto:[redacted]@noaa.gov]
>Sent: Friday, August 19, 2005 11:08 AM
>To: St. Martin, Michele M.
>Cc: Barnett, Megan H.
>Subject: Re: [Fwd: Fwd: Roger Pielke Sr. resigns from CCSP Temperature
>Trend Study]
>
>I didn't know about the resignation either. I guess everyone expected
>it to come, but no one expected it to be so public.
>
>As far as Revkin's angle, I think that he's looking to exonerate
>himself since it was his article that was the "last straw." He wants,
>as he points out in the email I forwarded to you, to know if he was
>justified in talking to the scientists about the three papers published
>in Science.
>
>Mahoney will be the interview subject. This won't be a contentious
>article. It will be mostly about the process, rather than content of
>studies.
>
>St. Martin, Michele M. wrote:
>
>
>
>>Kent- when did we know the scientist was going to resign? The first I
>>heard about it was yesterday in the news?? Did I miss the heads up? As
>>far as the story goes..what is Revkin's angle..? The same as the
>>past...? Who is going on the record? Thanks.
>>
>>-----Original Message-----
>>From: Barnett, Megan H.
>>Sent: Friday, August 19, 2005 10:58 AM
>>To: '[redacted]@noaa.gov'; St. Martin, Michele M.
>>Subject: Re: [Fwd: Fwd: Roger Pielke Sr. resigns from CCSP Temperature
>>Trend Study]
>>
>>Hi Kent - thanks for the heads up about Revkin. I'm CCing Michele St.
>>Martin - CEQ Comm. Director - because she's back from vacation.
>>
>>
>>
>>
>>-----Original Message-----
>>From: Kent Laborde <[redacted]@noaa.gov>
>>To: Barnett, Megan H. <[redacted]@ceq.eop.gov>
>>Sent: Fri Aug 19 10:49:25 2005
>>Subject: [Fwd: Fwd: Roger Pielke Sr. resigns from CCSP Temperature

>>Trend Study]
>>
>>Meg,
>>I got this email from Andy Revkin regarding the coverage we had on
>>CCSP
>>
>>
>
>
>
>>last week. Aparently the only dissenting voice on the panel of
>>scientists resigned and did so very publicly. His reason was that by
>>talking with media about the three papers that were published somehow
>>corrupted overall CCSP process for producing the Synthesis and
>>Assessment 1.1. He feels that by going so public about it, the panel
>>has illustrated that it has a predetermined outcome, and that oposing
>>views would not be considered. CCSP participants should hold a level
>>of
>>
>>
>
>
>
>>confidentiality.
>>
>>Our response is that we have an open and transparent process at every
>>level of leadership and stage of development. Scientists who did
>>discuss this were only addressing findings that were published in the
>>Science articles. These were peer-reviewed, vetted public documents.
>>No
>>
>>
>
>
>
>>one discussed the final outcome of S&A 1.1.
>>
>>Please let me know if you have any questions. We are planning on
>>talking to Revkin today at 2 p.m.
>>
>>Kent Laborde
>>[redacted]
>>
>>
>>
>>
>>
>
>
>

Subject: RE: on lehrer request... kent laborde will
From: [redacted]Fuqua[redacted]
Date: Wed, 19 Oct 2005 08:22:17 -0400
To: Kent.Laborde[redacted]

how did NewsHour go? please send me a report so I can share. thanks.

-----Original Message-----
From: Kent Laborde <[redacted]@noaa.gov> [mailto:Kent Laborde <[redacted]@noaa.gov>]

Sent: Tuesday, October 18, 2005 3:46 PM
To: [redacted]Fuqua[redacted]
Subject: Re: on lehrer request... kent laborde will

This was done several months ago. We will follow the new proceedures. Chirs is extremely even tempered and academic. He wouldn't raise his voice or get into an argument. We will report. Thanks for clearing.

[redacted]Fuqua[redacted] wrote:

> kent,
> Landsea can go on, even if together. please make sure Chris is on
> message and that it is a friendly discussion. I don't want our people
> in a precarious position or subject to an ugly scene. I'm not
> completely comfortable with this, but feel its better than him not
> going on. I need a report on how it goes. Thanks.
>
> Also, the interview you reference was done without our knowledge and I
> trust that won't happen again. thanks.
>
> -----Original Message-----
> *From:* Kent Laborde [mailto:Kent Laborde
>]
> *Sent:* Tuesday, October 18, 2005 3:32 PM
> *To:* [redacted]Fuqua[redacted]
> *Subject:* Re: on lehrer request... kent laborde will
>

Subject: RE: [Fwd: media request for tonight with Knutson]
From: [redacted]Fuqua[redacted]
Date: Wed, 19 Oct 2005 11:04:36 -0400
To: Kent.Laborde[redacted]

what is Knutson's position on global warming vs. decadal cycles? is he consistant with Bell and Landsea?

-----Original Message-----
From: Kent Laborde <[redacted]@noaa.gov> [mailto:Kent Laborde <[redacted]@noaa.gov>]

Sent: Wednesday, October 19, 2005 10:50 AM
To: CHUCK FUQUA [redacted]
Subject: [Fwd: media request for tonight with Knutson]

Chuck, Here's a request for tonight. Please see below.

From: Jana Goldman
Date: Wed, 19 Oct 2005 09:50:47 -0400
To: "Jordan St.John" , Scott Smullen
Cc: Kent Laborde
Subject: media request for tonight with Knutson

Media outlet:
CNBC - On the Money
Journalist name & number and/or email:
Stephanie -- [redacted] (it sounds like she's a booker)
Interview topic:
Hurricanes and global warming
Deadline:
Show is tonight - 7-8 p.m. -- this also is tentative.
NOAA expert and title:
Tom Knutson, hurricane modeler at Geophysical Fluid Dynamics Laboratory, Princeton, N.J.
Proposed questions:
is global warming contributing to number/intensity of hurricanes?
Specific answers:
Knutson is the co-author of a December 2004 paper that indicated IF carbon dioxide continues to rise at its current rate that hurricane intensity can rise about 5 percent over the next 80 years. This has nothing to do with the NUMBER of storms.
Background or relevancy, if needed:
Knutson has been on this show before

Subject: RE: [Fwd: media request for tonight with Knutson]
From: [redacted]Fuqua[redacted]
Date: Wed, 19 Oct 2005 11:15:00 -0400
To: Kent.Laborde[redacted]

call me.

[redacted]

-----Original Message-----
From: Kent Laborde <[redacted]@noaa.gov> [mailto:Kent Laborde <[redacted]@noaa.gov>]
Sent: Wednesday, October 19, 2005 11:14 AM
To: [redacted]Fuqua[redacted]
Subject: Re: [Fwd: media request for tonight with Knutson]

Bell is unavailable because of other commitments and Landsea is busy at the hurricane center with Wilma.

[redacted]Fuqua[redacted] wrote:

> why can't we have one of the other guys on then?
>
> -----Original Message-----
> *From:* Kent Laborde [mailto:Kent Laborde
>]
> *Sent:* Wednesday, October 19, 2005 11:11 AM
> *To:* [redacted]Fuqua[redacted]
> *Subject:* Re: [Fwd: media request for tonight with Knutson]
>
> He is consistant, but a bit of a different animal. He isn't on the
> meteorological side. He's purely a numerical modeler. He takes
> existing
> data from observation and projects forward. His take is that even
> with
> worse case projections of green house gas concentrations, there
> will be
> a very small increase in hurricane intensity that won't be realized
> until almost 100 years from now.
>
> [redacted]Fuqua[redacted] wrote:
>
> > what is Knutson's position on global warming vs. decadal cycles? is
> > he consistant with Bell and Landsea?
> >
> > -----Original Message-----
> > *From:* Kent Laborde [mailto:Kent Laborde
> >]
> > *Sent:* Wednesday, October 19, 2005 10:50 AM

Subject: RE: [Fwd: media request for tonight with Knutson]
From: [redacted]Fuqua[redacted]
Date: Wed, 19 Oct 2005 11:13:00 -0400
To: Kent.Laborde[redacted]

why can't we have one of the other guys on then?

-----Original Message-----
From: Kent Laborde <[redacted]@noaa.gov> [mailto:Kent Laborde <[redacted]@noaa.gov>]
Sent: Wednesday, October 19, 2005 11:11 AM
To: [redacted]Fuqua[redacted]
Subject: Re: [Fwd: media request for tonight with Knutson]

He is consistant, but a bit of a different animal. He isn't on the meteorological side. He's purely a numerical modeler. He takes existing data from observation and projects forward. His take is that even with worse case projections of green house gas concentrations, there will be a very small increase in hurricane intensity that won't be realized until almost 100 years from now.

[redacted]Fuqua[redacted] wrote:

> what is Knutson's position on global warming vs. decadal cycles? is
> he consistant with Bell and Landsea?
>
> -----Original Message-----
> *From:* Kent Laborde [mailto:Kent Laborde
>]
> *Sent:* Wednesday, October 19, 2005 10:50 AM
> *To:* CHUCK FUQUA
> *Subject:* [Fwd: media request for tonight with Knutson]
>
> Chuck, Here's a request for tonight. Please see below.
> --
> *From:* Jana Goldman
> *Date:* Wed, 19 Oct 2005 09:50:47 -0400
> *To:* "Jordan St.John" , Scott Smullen
> *Cc:* Kent Laborde
> *Subject:* media request for tonight with Knutson
>
> Media outlet:
> CNBC - On the Money
> Journalist name & number and/or email:
> Stephanie -- [redacted] (it sounds like she's a booker)
> Interview topic:
> Hurricanes and global warming
> Deadline:
> Show is tonight - 7-8 p,m, -- this also is tentative.

From: Levinson, Katie
To: "[redacted]Fuqua[redacted]"; St. Martin, Michele M.;
CC: Barnett, Megan H.; Martin, Catherine;
Subject: Re: [Fwd: media request for tonight with Knutson]
Date: Wednesday, October 19, 2005 12:13:46 PM
Attachments:

Yes. Focus should be on this hurricane not academic debate in my opinion

-----Original Message-----
From: [redacted]Fuqua[redacted] <[redacted]Fuqua[redacted]>
To: Levinson, Katie <[redacted]@who.eop.gov>; [redacted]Fuqua[redacted] <[redacted]Fuqua[redacted]>; St. Martin, Michele M. <[redacted]@ceq.eop.gov>
CC: Barnett, Megan H. <[redacted]@ceq.eop.gov>; Martin, Catherine <[redacted]@who.eop.gov>
Sent: Wed Oct 19 12:12:39 2005
Subject: RE: [Fwd: media request for tonight with Knutson]

that would be my preference. I think its understandable that our resources are tracking the impending hurricane. If you all are okay with that, I'll take that tact during the hurricane.

-----Original Message-----
From: "Levinson, Katie" <[redacted]@who.eop.gov> [mailto:"Levinson, Katie" <[redacted]@who.eop.gov>]
Sent: Wednesday, October 19, 2005 12:05 PM
To: <[redacted]Fuqua[redacted]>; "St. Martin, Michele M." <[redacted]@ceq.eop.gov>
Cc: "Barnett, Megan H." <[redacted]@ceq.eop.gov>; "Martin, Catherine" <[redacted]@who.eop.gov>
Subject: Re: [Fwd: media request for tonight with Knutson]

Do we really want to be having this debate on a day when a Cat 5 is about to hit? Seems to me we would want our guys out talking about prepartions for the storm....

-----Original Message-----
From: [redacted]Fuqua [redacted]
To: Levinson, Katie ; St. Martin, Michele M.
CC: Barnett, Megan H.
Sent: Wed Oct 19 12:01:50 2005
Subject: FW: [Fwd: media request for tonight with Knutson]

Katie/Michele,
below is a request by CNBC to have someone on to discuss if global warming is contributing. NOAA suggests Tom Knutson, hurricane modeler. My understanding is that Knutson has been approved by CEQ for interviews on this topic in the past. He is a modeler and comes from a bit of a different angle, but is apparently consistant with Dr. Bell and Chris Landsea who represent the position that we are in a decadal cycle and that warming is not the cause of increased hurricane activity. Bell and Landsea are not available for this and I've pressed NOAA to make sure he's consistant with the views represented, and am assured he is.

Let me know if you're okay with this. thanks.
-Chuck
-----Original Message-----
From: Kent Laborde [mailto:Kent Laborde]
Sent: Wednesday, October 19, 2005 11:41 AM
To: [redacted]Fuqua [redacted]
Subject: Re: [Fwd: media request for tonight with Knutson]

Tom Knutson is a modeler. As such, he will only be able to talk about projections for the future, and will tell them that if pressed to comment on what is happening now.

For the future, his computations indicate that in 80 years, we will see a 5% increase in intensity over what we have now. There is no increase in frequency of storms, only intensity of storms.

> > >
> > > -----Original Message-----
> > > *From:* Kent Laborde [mailto:Kent Laborde
> > >]
> > > *Sent:* Wednesday, October 19, 2005 10:50 AM
> > > *To:* CHUCK FUQUA
> > > *Subject:* [Fwd: media request for tonight with Knutson]

> > >
> > > Chuck, Here's a request for tonight. Please see below.
> > >
> >
> --
>
> >
> > > *From:* Jana Goldman
> > > *Date:* Wed, 19 Oct 2005 09:50:47 -0400
> > > *To:* "Jordan St.John" , Scott Smullen
> > > *Cc:* Kent Laborde
> > > *Subject:* media request for tonight with Knutson
> > >
> > > Media outlet:
> > > CNBC - On the Money
> > > Journalist name & number and/or email:
> > > Stephanie -- [redacted] (it sounds like she's a booker)
> > > Interview topic:
> > > Hurricanes and global warming
> > > Deadline:
> > > Show is tonight - 7-8 p,m, -- this also is tentative.
> > > NOAA expert and title:
> > > Tom Knutson, hurricane modeler at Geophysical Fluid Dynamics
> > > Laboratory,
> > > Princeton, N.J.
> > > Proposed questions:
> > > is global warming contributing to number/intensity of hurricanes?
> > > Specific answers:
> > > Knutson is the co-author of a December 2004 paper that
> indicated IF
> > > carbon dioxide continues to rise at its current rate that
> hurricane
> > > intensity can rise about 5 percent over the next 80 years.
> This has
> > > nothing to do with the NUMBER of storms.
> > > Background or relevancy, if needed:
> > > Knutson has been on this show before
> > >
> >
>

Chuck Fuqua/HCHB/Osnet

From: "St. Martin, Michele M." <[redacted]@ceq.eop.gov>
Sent: Monday, September 19, 2005 4:44 PM
To: "Perino, Dana M." <[redacted]@who.eop.gov>; "Levinson, Katie" <[redacted]@who.eop.gov>; <[redacted]Fuqua[redacted]
Cc: [redacted]Trinh[redacted]; "Martin, Catherine" <[redacted]@who.eop.gov>
Subject: RE: clearance #5, g.warming not causing intense hurricanes, bell for today show 9-19

We should be out there with our statement that says no connection..it is accurate and 90% of scientists agree.

From: Perino, Dana M.
Sent: Monday, September 19, 2005 4:42 PM
To: Levinson, Katie; '[redacted]Fuqua[redacted]
Cc: '[redacted]Trinh[redacted]; St. Martin, Michele M.; Martin, Catherine
Subject: RE: clearance #5, g.warming not causing intense hurricanes, bell for today show 9-19

Problem is we need people to be pushing back on his statements – especially when the facts are on our side. If you don't want a fed gov scientist on, can NOAA suggest a surrogate? Chris landsea of noaa was asked by dateline if there was a link and he said no.

Also, Michele – pls call me about the gw story from Friday (left vm this a.m.)

From: Levinson, Katie
Sent: Monday, September 19, 2005 4:40 PM
To: [redacted]Fuqua[redacted]
Cc: [redacted]Trinh[redacted] St. Martin, Michele M.; Perino, Dana M.; Martin, Catherine
Subject: RE: clearance #5, g.warming not causing intense hurricanes, bell for today show 9-19

Not sure this is a good idea. Gets into Al Gore statement/politics of global warming.

> -----Original Message-----
> **From:** [redacted]Fuqua[redacted] [mailto:[redacted]Fuqua[redacted]
> **Sent:** Monday, September 19, 2005 4:40 PM
> **To:** Levinson, Katie
> **Cc:** [redacted]Trinh[redacted] St. Martin, Michele M.
> **Subject:** FW: clearance #5, g.warming not causing intense hurricanes, bell for today show 9-19
>
> Katie,
> please see below request to have Dr. Bell on the Today Show to discuss if there is a link between hurricanes and global warming. the warming of the waters contributes to the intesity of hurricanes, but they are warmer because we are in a cycle of every 20-30 years that produces such warmer water. Dr. Bell would discuss that line of reasoning.
>
> Are you okay with this?
>
> Thanks.
> -Chuck
>
> -----Original Message-----
> **From:** Catherine Trinh/HCHB/Osnet
> **Sent:** Monday, September 19, 2005 4:18 PM
> **To:** Chuck Fuqua/HCHB/Osnet
> **Subject:** Fw: clearance #5, g.warming not causing intense hurricanes, bell for today show 9-19
>
> ---------------------------

Sent from my BlackBerry Wireless Handheld

----- Original Message -----
From: Scott Smullen [[redacted]@noaa.gov]
Sent: 09/19/2005 03:58 PM
To: [redacted]trinh[redacted]
Cc: "Jordan St.John"
Subject: clearance #5, g.warming not causing intense hurricanes, bell for today show 9-19

Jay Blackman from the NBC Today Show (tel: [redacted]) would like to conduct a taped interview with Dr. Gerry Bell, CPC scientist and lead on the NOAA Atlantic Hurricane Outlook, on Tuesday, September 20 in the morning, discussing if there is a linkage between hurricanes and global warming. Dr. Bell would state:

* Global climate change does not mean greenhouse warming.

From: "Eileen Imada" [redacted]@WBUR.BU.EDU>
Organization: The WBUR Group
To: [redacted]@giss.nasa.gov
Date: Thu, 08 Dec 2005 15:02:15 -0500
Subject: NPR Interview Request
Priority: normal
X-mailer: Pegasus Mail for Windows (v4.11)

Dear Ms. Nolan:

I am writing on behalf of NPR's "On Point" produced out of WBUR Boston's NPR news station.

I am putting together a show for Monday, December 12 for the 10 am hour ET about global warming on the heels of the United Nations Climate Change Conference being held in Montreal. I would love to have James Hansen join us for the hour. Ideally, we would like to do the show on Monday as close to the end of the conference as possible, but we could possible schedule the show for Tuesday morning if he is unavailable on Monday.

Please email me or call at the main newsline [redacted]

Best,

Eileen Imada
"On Point" WBUR-FM
[redacted] (direct)
[redacted] (main)

Affidavit of Leslie Nolan McCarthy

I, Leslie Nolan McCarthy, affirm the following:

I am Assistant Chief for Outreach at NASA's Goddard Institute for Space Studies (GISS). As a career civil servant, I have worked at NASA for about 13 years, the last 10 years of which I have spent at the Goddard Institute for Space Studies.

I am submitting this affidavit in my personal capacity at the request of the Committee on Oversight and Government Reform.

In November 2005, Dwayne Brown joined Erica Hupp and George Deutsch as a public affairs officer for NASA's Science Mission Directorate at Headquarters. Mr. Brown is a career civil servant. Mr. Deutsch was a political appointee.

On November 29, 2005, I received a call from Dwayne Brown. He wanted to better understand my role with respect to Dr. Jim Hansen, the Director of NASA GISS, and other GISS scientists. According to my notes, Mr. Brown said that there were "heavy politics" at NASA Headquarters and that the "only emphasis is to not make President look bad." He also said that he had "never seen this as bad."

On December 8, 2005, I received voicemail and email messages in which NPR requested to interview Dr. Hansen on "global warming on the heels of the United Nations Climate Change Conference being held in Montreal.". HQ Public Affairs Office (PAO) was notified of this request. Mr. Deutsch commented to me that "NPR was the most liberal media outlet," witnessed by Dr. Larry Travis, the Deputy Chief of GISS, who entered my office at the tail-end of my conversation with Mr. Deutsch. In an email to Dr. Colleen Hartman, Deutsch typed "we just had this interview request sent to us, and the details are below. We discussed it with the 9th Floor, and it was decided that we'd like you to handle this interview." In an email minutes later to Drs. Hartman and Mary Cleave (then Associate Administrator and Deputy Associate Administrator for the Science Mission Directorate at NASA HQ), Mr. Deutsch comments "Are (sic) main concern is hitting our messages and not getting dragged down into any discussions we shouldn't get into." I received an email at 11:51 am on December 9 from Mssrs. Deutsch and Brown, saying "Senior management has asked us not to use Jim Hansen for this interview." At 12:07 pm, Deutsch and Brown left me a voicemail in which they said that they did not want Dr. Hansen to do the NPR interview.

On December 12, 2005, Dwayne Brown left me another voicemail message. According to my notes, Mr. Brown said that NASA Headquarters said "no NPR interview." Mr. Brown also stated: "If Hansen does interview, there will be dire consequences." Mr. Brown said that "NPR turned down Colleen Hartman" and that "they may try to get Hansen." An email dated 1:46 pm on the 12th from Mr. Deutsch stated "The NPR people have apparently turned their noses up at the guests we have offered them, and Headquarters does not want Dr. Hansen doing this interview tomorrow."

That afternoon, I participated in a 6-way telephone conference call with Dwayne Brown, George Deutsch, along with Mark Hess, Ed Campion, and Don Savage, all of the NASA Goddard Space Flight Center (GSFC). Among the subjects of the call were the NPR climate change that would include an interview with Dr. Hansen, as well as an update on GISS' plans to post new temperature data for the newly ended meteorological year. Mr. Brown and Mr. Deutsch explained that they had offered Drs. Cleave and Hartman as guests to NPR, but that NPR "kept pressing for Hansen." Mr. Brown and Mr. Deutsch reported that the 9th Floor said: "Do not do interview." Don Savage (a career employee and deputy head of public affairs at GSFC responded that we "always referred reporters to those scientists with expertise in their field" and that nothing is "solved by muzzling scientists." Mr. Deutsch commented "Hansen can't say anything good about government", and that "We cannot have this any more." On the subject of the posting of the GISS temperature data, we reminded Mssrs. Deutsch and Brown that the NASA story related to last year's meteorological year-end data posting was the most heavily downloaded news story at the Goddard Space Flight Center of 2005, and it likely would be a big story again in 2006, given the number of hurricanes and other climate/weather activity.

On December 14, 2005, Dwayne Brown told me that he had talked to Mary Cleave (the head of the Science Mission Directorate) and Colleen Hartman. My notes read: "9th Floor resolute to getting this crap ended."

On December 15, 2005, I received a telephone call from Mr. Brown, telling me there was a "shitstorm on this," referring to HQ reaction to an early morning ABC news program story which referenced GISS temperature data. Mssrs. Brown and Deutsch, via a "PAO Point Paper" to undisclosed recipients dated December 15, stated "In past discussions with GISS PAO Leslie Nolan-McCarthy, she has sent Headquarters mixed signals as to if/when this data would be released. Headquarters was unaware Hansen would be releasing this data when he did." This was completely contradictory to the details on this data posting which were given to Deutsch and Brown by me in the six way teleconference just three days earlier.

That afternoon, I received direction from NASA HQ to remove this temperature data from the GISS website. Later that evening, I was phoned by Mr. Dean Acosta, then-Deputy Associate Administrator for Public Affairs at NASA HQ, and Mr. David Mould, Associate Administrator for Public Affairs at NASA HQ. Mr. Acosta expressed displeasure that they were caught off-guard by the ABC story. He was angry, stating that HQ was tired of Hansen running his own independent operation and directed me, from this night on, to monitor Dr. Hansen's schedule and apprise him of all potential items "well in advance." My notes from that conversation read that Acosta asserted that the Administrator was giving Drs. Hartman and Cleave direction here—coming from the top—and that representations were made that specific rules and expectations of conduct and procedures would be spelled out by Dr. Cleave to Dr. Hansen. Mr. Brown joined the call at some point, and said that he had "just spoken with Dr. Cleave" and that there were "2 rules of engagement starting immediately." These involved the approval of all GISS web content, including refereed science journal articles, and that all requests for media interviews for GISS scientists must go first to Drs. Cleave and Hartman for "right of first refusal," and then appropriated out to Dr. Hansen and other GISS scientists if need-be.

On December 16, 2005, Mr. Hess, Chief of Public Affairs for NASA's Goddard Space Flight Center, told me that he had received a telephone call from Mr. Acosta, in which Mr. Acosta told him about his conversation with me the previous evening, and detailing the new policies and procedures.

On December 20, 2005, Mr. Hess emailed Mssrs. Mould and Acosta asking for written clarification of the new policies and procedures that would apply to Dr. Hansen and others at GISS. No reply of any type was received.

On January 3, 2006, Dwayne Brown told me that "political sensitivities are at a high level right now." On January 9, 2006, I spoke with Mr. Deutsch. According to my notes, he said that "Hansen is extremely disrespectful of government – this belief is shared by management."

On January 30, 2006, I received a call from Ms. Hupp, requesting a list of all Dr. Hansen's press interviews, press releases, and web data postings for the December 2005-January 2006 time period.

On February 8, 2006, I learned that Mr. Deutsch had left NASA HQ the day before. On February 9, 2006, Dwayne Brown called to tell me that Mary Cleave and Colleen Hartman still "have right of 1st refusal on interviews."

Leslie Nolan McCarthy

Leslie Nolan McCarthy

03-19-2007

Date

SUBSCRIBED AND SWORN TO before me this 19th day of March, 2007, by Leslie Nolan McCarthy.

Cheryl Badstuebner

NOTARY PUBLIC

My Commission Expires: 1/17/10

CHERYL BADSTUEBNER
Notary Public, State of New York
No. 01BA6139684
Qualified in Nassau County
Commission Expires Jan. 17, 20 10

Subject: NPR Interview Request
Date: Thu, 8 Dec 2005 16:49:37 -0500
X-MS-Has-Attach:
X-MS-TNEF-Correlator:
Thread-Topic: NPR Interview Request
thread-index: AcX8Pvo76hGQ2koqQs2Urrb3uDxDcQAACf9QAABgC/A=
From: "Deutsch, George \(HQ-NB000\)" <[redacted]@nasa.gov>
To: "Hartman, Colleen \(HQ-DF000\)" <[redacted]@nasa.gov>,
"Brown, Dwayne C. \(HQ-NB030\)" <[redacted]@nasa.gov>,
"Hupp, Erica \(HQ-NB000\)" <[redacted]@nasa.gov>
Cc: <[redacted]@giss.nasa.gov>
X-OriginalArrivalTime: 08 Dec 2005 21:49:38.0728 (UTC) FILETIME=[49919A80:01C5FC41]
X-MIME-Autoconverted: from quoted-printable to 8bit by server2.giss.nasa.gov id
jB8LpRsV12611818

Hey, Colleen. We just had this interview request sent to us, and the details are below. We discussed it with the 9th Floor, and it was decided that we'd like you to handle this interview. Please let us know what you think and if you would be willing to do it. We can discuss the details on the phone or in person. Thank you.

George Deutsch
SMD Public Affairs
[redacted]

Original Message:

From: Eileen Imada Eimada@WBUR.BU.EDU
Date: Thu, 08 Dec 2005 15:02:15 -0500
To: [redacted]@giss.nasa.gov
Subject: NPR Interview Request

Dear Ms. Nolan:

I am writing on behalf of NPR's "On Point" produced out of WBUR, Boston's NPR news station.

I am putting together a show for Monday, December 12 for the 10 am hour ET about global warming on the heels of the United Nations Climate Change Conference being held in Montreal. I would love to have James Hansen join us for the hour. Ideally, we would like to do the show on Monday as close to the end of the conference as possible, but we could possible schedule the show for Tuesday morning if he is unavailable on Monday.

Please email me or call at the main newsline [redacted]

Best,

Subject: FW: NPR Interview Request
Date: Thu, 8 Dec 2005 17:07:49 -0500
X-MS-Has-Attach:
X-MS-TNEF-Correlator:
Thread-Topic: NPR Interview Request
thread-index:
AcX8Pvo76hGQ2koqQs2Urrb3uDxDcQAACf9QAABgC/AAAGWWUQAAC9SQAAA+EWAAAB
From: "Deutsch, George \(HQ-NB000\)" <[redacted]@nasa.gov>
To: <[redacted]@giss.nasa.gov>
X-OriginalArrivalTime: 08 Dec 2005 22:07:50.0058 (UTC) FILETIME=[D40D58A0:01C5FC43]
X-MIME-Autoconverted: from quoted-printable to 8bit by server2.giss.nasa.gov id jB8M9TsS12630511

It looks like Mary or Colleen will be doing it. I spoke with Dean about how best to broach this topic with Jim, and he said to simply say "you boss would like to handle this interview." So, there you go. Stay tuned for more, Leslie. Thanks!

-----Original Message-----
From: Deutsch, George (HQ-NB000)
Sent: Thursday, December 08, 2005 5:05 PM
To: Deutsch, George (HQ-NB000)
Subject: FW: NPR Interview Request

Subject: RE: NPR Interview Request

Thanks for the quick reply. Oh, we can certainly have Mary do it if you/she would prefer that. We just thought it would be best to run it by you first. But either of you would be a great candidate for this. What are your thoughts?

Are main concern is hitting our messages and not getting dragged down into any discussions we shouldn't get into. But we can discuss these details and have some prep time beforehand. Please let us know which of you two ladies would like to tackle this one, and we'll speak with the NPR folks and discuss the logistics and get back to you.

Thank you.

George

-----Original Message-----
From: Hartman, Colleen (HQ-DF000)
Sent: Thursday, December 08, 2005 4:56 PM
To: Deutsch, George (HQ-NB000)
Subject: Re: NPR Interview Request

Did you discuss having Mary do it? Thanks George!

On 12/8/05 4:49 PM, "Deutsch, George (HQ-NB000)"

Subject: NPR Request
Date: Fri, 9 Dec 2005 11:51:38 -0500
X-MS-Has-Attach:
X-MS-TNEF-Correlator:
Thread-Topic: NPR Request
thread-index: AcX84NJep38NKCbcStujqlkL++jQLQ==
From: "Deutsch, George \(HQ-NB000\)" <[redacted]@nasa.gov>
To: <[redacted]@giss.nasa.gov>,
"Brown, Dwayne C. \(HQ-NB030\)" <[redacted]@nasa.gov>,
"Deutsch, George \(HQ-NB000\)" <[redacted]@nasa.gov>
X-OriginalArrivalTime: 09 Dec 2005 16:51:39.0217 (UTC) FILETIME=[D2F67C10:01C5FCE0]

Hey Leslie. I don't know if you're working from home today or what, but I just wanted to shoot you an email and give you an update (repeating the same stuff I just left you in a voicemail) about what direction we will be heading in on this NPR request. You need to be in the loop.

Senior management has asked us not to use Jim Hansen for this interview. His SMD bosses, Colleen and Mary, have expressed interest in doing it. So, if any NPR folks contact you/Jim about this, please let them know someone else will be available for their interview and let them know. I will be coordinating this request and all correspondence relating to it need go through me specifically (or Dwayne Brown if not me). Mary and Colleen have not yet decided who will take the helm on this one.

I spoke with NPR today briefly and they said they really wanted Jim but they'll take who we can give them, and since they hadn't heard back from us they pushed the interview date back to later in the week (no firm date was given to me, so it could be as early as Tuesday or as late as Friday). I will find out more details when they call me back this afternoon.

Anyway, so that's where we are. Thank you for your help with this, and let's be sure to stay coordinated with each other on this one until we get this request knocked out. Please call me or Dwayne as soon as you can and we can discuss it further. Thanks again.

George
[redacted]

Dwayne
[redacted]

Subject: URGENT: NPR INTERVIEW
Date: Mon, 12 Dec 2005 13:46:53 -0500
X-MS-Has-Attach:
X-MS-TNEF-Correlator:
Thread-Topic: URGENT: NPR INTERVIEW
thread-index: AcX/TGuoW5vJ8EfhT/WHEu877b59sw==
From: "Deutsch, George \(HQ-NB000\)" <[redacted]@nasa.gov>
To: <[redacted]@giss.nasa.gov>
Cc: "Brown, Dwayne C. \(HQ-NB030\)" <[redacted]@nasa.gov>,
"Deutsch, George \(HQ-NB000\)" <[redacted]@nasa.gov>
X-OriginalArrivalTime: 12 Dec 2005 18:46:54.0705 (UTC) FILETIME=[6C277610:01C5FF4C]

Leslie, Please call me ([redacted]) or Dwayne ([redacted]) as soon as you read this email. The NPR people have apparently turned their noses up at the guests we have offered them, and Headquarters does not want Dr. Hansen doing this interview tomorrow. Call immediately and we'll discuss. Thank you.

George

predecisional — NOT cleared by NOAA

Subject: For Review: NOAA testimony (Karl) for July 20th hearing on Introduction to Climate Change
From: <Noel.Turner[redacted]
Date: Wed, 12 Jul 2006 21:53:51 -0400
To: Jennifer.Sprague[redacted],Ahsha.Tribble[redacted], Glenn.E.Tallia[redacted],Julie.Hite[redacted],Erin.Olson[redacted], Matthew.Borgia[redacted],Alyssa.Denzer[redacted],Eric.Webster[redacted], Jason.Robertson[redacted]
CC: Thomas.R.Karl[redacted],brown[redacted]

Hello All,
Attached for NOAA review and clearance is testimony (9 pages plus figures) for a July 20th (i.e. next Thursday) hearing before the House Government Reform Committee (this is the second of two taskers for climate-related hearings). Dr. Tom Karl, Director of the National Climatic Data Center (NESDIS) will testify on behalf of NOAA.

Due to the extreme late notice of this hearing, it is necessary to ask both for expedited NOAA review, and to conduct NOAA review simultaneously with DOC review.

Please provide your comments/clearance on this testimony to me by 10AM, this Friday, July 13th, in order to allow for sufficient time for OMB review prior to the hearing. Please note that if you would like to ensure your comments are incorporated into this document prior to DOC review, please let me know by 9am tomorrow morning, and I can hold the testimony until 3PM (meaning I would need to receive your comments by 3PM). If I do not hear from anyone requesting I hold the testimony, I will transmit the testimony to DOC at 10AM on Thursday, for simultaneous review.

For those of you who saw earlier drafts from Tom, please send your comments through on this most recent draft.

NOAA Budget -- FYI, there is no budget-related content here.

Please let me know if you have any questions regarding this testimony. Thank you very much for your review and assistance -- your efforts are greatly appreciated given the unusually tight deadlines,
Noel

Climate Change (general) testimony for July 20 OLA to NOAA.doc **Content-Type:** application
Content-Encoding: base64

WRITTEN STATEMENT BY
DR. THOMAS R. KARL
DIRECTOR, NATIONAL CLIMATIC DATA CENTER
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)
U.S. DEPARTMENT OF COMMERCE

FOR AN OVERSIGHT HEARING:
INTRODUCTION TO CLIMATE CHANGE

BEFORE THE
COMMITTEE ON GOVERNMENT REFORM
U.S. HOUSE OF REPRESENTATIVES

JULY 20, 2006

Mr. Chairman and Members of the Committee: As Director of the National Climatic Data Center, which is part of the National Environmental Satellite, Data, and Information Service (NESDIS) within the National Oceanic and Atmospheric Administration (NOAA), and as Program Manger for one of five different NOAA Climate Goal Programs (Climate Observations and Analysis), I am pleased to have the opportunity to testify before you today. The National Climatic Data Center is the world's largest archive of weather and climate data, which includes data critical to understanding climate variability and change, and also acts as the Nation's Scorekeeper regarding the trends and anomalies of weather and climate.

I was the co-convening lead author of the Intergovernmental Panel on Climate Change (IPCC) 2001 report (and had been lead author for the first and second IPCC assessments), which contained a number of statements regarding human influences on climate and potential climate change. Presently, I am one of the review editors for the fourth IPCC assessment, scheduled to be released in 2007. Since the 2001 report, there has been considerable additional research in this area, building upon the science underpinning influence of humans on global climate change.

I begin my testimony by briefly reviewing the IPCC process from a participating scientist's perspective. I will provide an overview of our basic understanding of the atmosphere in terms of: the role that greenhouse gases play in the atmosphere; evidence for how greenhouse gases are already influencing the climate in both general and in specific ways; and why it is very likely (>95 percent probability) that humans are largely responsible for many of the observed changes in climate over the past several decades.

The IPCC Process from a Participating and Reviewing Scientist's Perspective

The primary intent of the IPCC periodic assessments is to provide government policy-makers with the latest and most comprehensive scientific information possible about human influences on our global climate, in a language that has meaning and relevance to governmental policy-makers. The IPCC assessments have, however, provided much more. From purely a scientific perspective, participation in the IPCC process is extremely desirable, as it provides the means for the world's scientists to discuss leading-edge issues with rigorous worldwide scientific review. The IPCC process ensures that the scientists who participate walk away from the process with a fuller appreciation of where important pay-offs in new research and observing systems are most likely to emerge. This has important impacts on our nation's climate change programs including both the United States Global Change Research Program and the Climate Change Science Program.

Atmospheric Composition and Greenhouse Gases

The atmosphere is made up of a number of gases, most notably nitrogen at 78 percent and oxygen at about 20 percent. However, the remainder of the atmosphere is composed of a number of very important gases that include important greenhouse gases such as water vapor at about 2 percent and carbon dioxide at about 0.04 percent. These last two gases, plus a number of other greenhouse gases that exist in even smaller quantities (e.g., ozone, methane, nitrous oxides) absorb some of the heat energy (infrared radiation) given off by the Earth's surface that otherwise would be transmitted back to space. The various atmospheric gases contribute to the greenhouse effect, the impact of which in clear skies is ~60 percent from water vapor, ~26 percent from carbon dioxide, ~8 percent from ozone, and the rest from trace gases including methane and nitrous oxide. The presence of these greenhouse gases are critical to regulating the Earth's average temperature at about 60°F, as without these gases the Earth's average temperature would be approximately 5°F – too cold to support life as we know it.

Then, if greenhouse gases are critical to life, why is there concern about greenhouse gases increasing? On average, the energy from the sun received at the top of the Earth's atmosphere amounts to 175 petawatts (PW; 175 quadrillion watts or 175×10^{15} watts), of which ~31 percent is reflected by clouds and from the surface. The rest of the energy (120 PW) is absorbed by the atmosphere, land, or ocean, and ultimately emitted back to space as infrared radiation. The main way in which humans alter global climate is by interfering with the natural flows of energy through changes in atmospheric composition, not by actually generating heat in energy usage. On a global scale, even a 1 percent change in the energy flows, which is the order of the estimated change to date, dominates all other direct influences humans have on climate.

Global changes in atmospheric composition occur from anthropogenic emissions of greenhouse gases, such as carbon dioxide that results from burning fossil fuels and methane and nitrous oxide from multiple human activities. Because these gases have long (decades to centuries) atmospheric lifetimes, the result is an accumulation of these gases in the atmosphere, and a buildup in concentrations that are clearly shown both by instrumental observations of air samples (dating back to 1958) and in bubbles of air trapped in ice cores (prior to 1958) (Figure 1). Moreover, these gases are well distributed in the atmosphere across the globe, simplifying a global monitoring strategy. Carbon dioxide has increased 31 percent since pre-industrial times, from 280 parts per million by volume (ppmv) to more than 370 ppmv today, and half of the increase has been since 1965 (Figure 2).

Emissions into the atmosphere from fuel burning further result in gases that are oxidized to become highly reflective micrometer-sized aerosols, such as sulfate, and strongly absorbing aerosols, such as black carbon or soot. Aerosols are rapidly removed (usually within two weeks or less) from the atmosphere through the natural hydrological cycle and dry deposition as they travel away from their source. Nonetheless, atmospheric concentrations can substantially exceed background conditions in large areas around and downwind of the emission sources. Depending on their reflectivity and absorption properties, geometry and size distribution, lifetimes in the atmosphere, and interactions with clouds and moisture, these particulates can lead to either net cooling, as for sulfate aerosols, or net heating, as for black carbon. Importantly, sulfate aerosols affect climate directly by reflecting solar radiation and indirectly by changing the reflective properties of clouds and their lifetimes. There is some episodic evidence from naturally occurring aerosols attributed to volcanic eruptions to suggest that these aerosols can impact global precipitation, but only for a few years after explosive eruptions. There is also some evidence to suggest that anthropogenic aerosols can influence regional precipitation patterns, but it is difficult to generalize and quantify this result. Understanding the precise impact of aerosols has been hampered by our inability to measure them directly, as well as by their spatial heterogeneity and rapid changes in time. Large-scale measurements of aerosol patterns have been inferred through satellites, emission data, special field experiments, and other indirect measurements such as sun photometers.

Human activities also have a large-scale impact on the land surface. Changes in land use through urbanization and agricultural practices, although not global, are often most pronounced where people live, work, and grow food, and are part of the human impact on climate. Large-scale deforestation and desertification in Amazonia and the Sahel, respectively, are two instances where evidence suggests there is likely to be human influence on regional climate. In general, city climates differ from those in surrounding rural green areas, because of the "concrete jungle" and its effects on heat retention, runoff, and pollution, resulting in urban heat islands[1].

There is no doubt that the composition of the atmosphere is changing because of human activities, and today greenhouse gases are the largest human influence on global climate.

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[1] The global impact of these urban heat islands has been extensively analyzed and assessed to ensure measurements of global temperature are not biased by local urban heat islands.

How do we know the global air temperature is increasing?

There has now been a comprehensive analysis of the changes of temperatures near the surface and throughout much of the atmosphere in the recent Climate Change Science Program (CCSP) Synthesis and Assessment Report 1.1. This report addressed the nagging issue of differences in the rate of warming between measurements derived near the surface and those taken from the atmosphere. The surface air temperatures are derived from several different analyses teams using various combinations of ocean ships and buoys, land observations from weather reporting stations, and satellite data. Atmospheric data sets have been derived using satellites, weather balloons, and a combination of the two.

Considering all the latest satellite, balloon and surface records, the CCSP report concluded there is no significant discrepancy between the rates of temperature change over the past several decades at the surface compared to changes higher in the atmosphere. The report does, however, acknowledge there are still uncertainties in the tropics, and this is primarily related to data from weather balloons. There is uncertainty as to whether scientists have been able to adequately adjust for known biases and errors in the data, especially in the tropics where many developing nations struggle to routinely launch weather balloons and process these measurements.

Globally, data indicate the rates of temperature change have been similar throughout the atmosphere since 1979 when satellite data were first available, and the rates of temperature change have been slightly greater in the atmosphere compared to the surface air temperature since 1958 (the time at which weather balloons had adequate spatial coverage for global calculations). The global surface temperature time series, shown in Figure 2, indicates warming on even longer time scales, with acceleration since 1976.

Instrumental measurements are not our only evidence for increasing global temperatures. The observed increased melting of glaciers can be used to estimate the rate of temperature increase since the late 19^{th} Century. Estimates of the near-surface temperature based on glacial melting are very similar to estimates based on instrumental data. There has been a 15-20 percent reduction in Arctic sea ice since the 1970s, a 10 percent decrease in snow cover since the 1970s, and shortened periods of lake and river ice cover (about 2 weeks shorter since the 19^{th} century). Also, ocean heat content has significantly increased over the past several decades.

Why do we think humans are influencing the Earth's climate?

The scientific community has been actively working on detection and attribution of climate change as related to human activities since the 1980s. One set of tools often used to examine these issues are mathematical computer models of the climate. Not only are these models the primary tools for predicting future climate, they are also very important in helping us to understand the causes of past climate variability and change. The models used are global in extent and are fully coupled, mathematical, computer-based models of the physics, chemistry, and biology of the atmosphere, land surface, oceans, and cryosphere (ice covered portions of the planet), and their interactions with each other and with the sun and other influences (such as volcanic eruptions). Outstanding issues in modeling include specifying forcing mechanisms (e.g., the causes of climate variability and change) within the climate system; properly dealing with complex feedback processes that affect carbon, energy, and water sources, sinks and transports; and improving simulations of regional weather, especially extreme events. Today's inadequate or incomplete measurements of the various forcing mechanisms, with the exception of well-mixed greenhouse gases, add uncertainty when trying to simulate past and present climate. Confidence in our ability to predict future climate depends on our ability to use climate models to attribute past and present climate change to specific causes. The climate models simulate the workings of the climate, such as the winds, clouds and precipitation, and the air temperature. Climate scientists have used these models to examine how the observed changes in climate forcing mechanisms, including increasing greenhouse gases, changes in the sun's output, volcanic activity, and sulfate aerosols, have affected the climate over the 20th century.

Recent greenhouse gas emission trends in the United States are upward, as are global emissions trends, with increases between 0.5 and 1 percent per year over the past few decades. Concentrations of both reflective and nonreflective aerosols are also estimated to be increasing. Because radiative forcings[2] from greenhouse gases dominate over the net cooling forcings from aerosols, the popular term for the human influence on global climate is "global warming," although it really means global heating, of which the observed global temperature increase is only one consequence. Already the global temperature has exceeded the bounds of natural variability. This has been the case since about 1980. By raising the air temperature, the capacity of the atmosphere to hold more water vapor is increased, which defines the upper bounds of the amount of precipitation that can occur during short term (~daily or less) extreme precipitation events.

As an example of how models are used to detect human influence on the climate system Figure 3 shows that without including all the observed forcing mechanisms the models cannot replicate the observed global temperature changes. There are many other aspects of the climate system that have been tested for human influences. Today, there is convincing evidence from a variety of model and data climate attribution studies pointing to human influences on climate. These include regional analyses of changes in temperature, the paleoclimatic[3] temperature record, three dimensional analysis of

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[2] Radiative forcing is the change in the net vertical irradiance (expressed in Watts per square meter: Wm^{-2}) at the tropopause due to an internal change or a change in the external forcing of the climate system, such as, for example, a change in the concentration of carbon dioxide or the output of the Sun.

[3] Climate during periods prior to the development of measuring instruments, including historic and geologic time, for which only proxy climate records are available. A proxy climate indicator is a local record that is interpreted, using physical and biophysical principles, to represent some combination of climate-related variations back in time. Climate-related data derived in this way are referred to as proxy data. Examples of proxies are: tree ring records, characteristics of corals, and various data derived from ice cores.

atmospheric temperature change, changes of free atmospheric temperature, changes in sea ice extent and other components of the cryosphere, changes in ocean heat content, and new studies on extreme weather and climate events. Thus, there is considerable confidence that the observed warming, especially the period since 1970s is mostly attributable to increases in greenhouse gases.

Changes in Extremes in the United States

The U.S. Climate Change Science Program Synthesis and Assessment Report 3.3 will specifically address the issue of changes in extreme events, focusing on North America. This assessment plans on comprehensively assessing a wide range of climate-related extreme events and promises to help clarify what we know and do not yet understand about these important events, as related to climate change. Here, three types of climate extremes are discussed as they are likely to be influenced by rising global temperatures. This includes changes the frequency and intensity of heavy and extreme precipitation events, droughts, and [redacted]

Increasing air temperature leads to increased water vapor in the atmosphere. Surface moisture, if available (as it always is over the oceans), effectively acts as the "air conditioner" of the surface – as heat used for evaporation moistens the air rather than warming it. Therefore, another consequence of global heating of the lower troposphere is accelerated land-surface drying and more atmospheric water vapor (the dominant greenhouse gas). Satellite measurements now confirm a significant increase in atmospheric water vapor, consistent with theoretical expectations given the rate of observed atmospheric warming during the past several decades. Accelerated drying, without an increase in precipitation, increases the incidence and severity of droughts, whereas additional atmospheric water vapor increases the risk of heavy precipitation events. Increases in global temperature also increase sea surface temperatures, one of several important factors affecting the [redacted] intensity and frequency.

NOAA's National Climatic Data Center calculates a Climate Extremes Index (CEI) over the United States that includes extremes related to all of these indicators including temperature, precipitation, drought and [redacted] Although no index can claim to adequately capture all of the important changes in extremes, the changes and variations of the CEI as reflected in Figure 4 is illustrative of the varying decadal variability of climate extremes. Currently, the CEI is at record levels during the past decade or so, but not higher than previous decades, and so is a clear indication of a general increase in the aggregate set of extremes included in the CEI.

Changes in Heavy and Extreme Precipitation
Basic theory, climate model simulations, and empirical evidence (Figure 5) confirm that warmer climates, owing to increased water vapor, lead to more intense precipitation events even when the total precipitation remains constant, and with prospects for even stronger events when precipitation amounts increase. Figure 6 depicts the aggregate

land-surface world-wide changes in heavy precipitation events over the last half of the 20th century with an associated geographic depiction of where changes in heavy precipitation have occurred, with most areas showing increases. World-wide, an increase of a few percent in heavy precipitation events is evident since the middle of the 20th century, particularly in the middle and high latitudes. By the end of the 21st Century a 10-20 percent increase in the precipitation rate for 1-day extreme precipitation events (20 year return periods) is in the middle range of a variety of climate models, when forced with a rather conservative change in atmospheric greenhouse gases. Carbon dioxide does not exceed 550 ppmv[4].

The practical implications of addressing these changes are seen in NOAA's recent update of the Ohio River Basin's 100-year 24-hour precipitation return period. Over the past several decades increases in precipitation rates for the 1 in 100 year extreme daily precipitation amount was observed in many areas of the eastern United States over the past several decades. These data are used to help set engineering design standard related to excessive rainfall.

Changes in Drought Severity and Frequency

Drought is a recurring feature of the climate system. In other words, we have had major droughts in the past, and expect to have major droughts in the future. At any given time, at least part of the U.S. is in drought, with percentages ranging from 5-80 percent of the total land area. U.S. droughts show pronounced multi-year to multi-decadal variability, but no convincing evidence for systematic long-term trends toward more or fewer events. Drought calculations have been made showing that over the U.S, the increase in temperatures that may have lead to increased evaporation have been compensated by a general increase in precipitation over the past few decades. In general, there are no clear patterns of precipitation increase emerging from climate model simulations as global temperatures increase, so the increase in precipitation over the past few decades may not persist and could reverse. Such a reversal, added to the continuing increase in temperatures (January through June of 2006 have been the warmest temperatures in U.S. records dating back to 1895) could lead to greater drought severity and frequency, especially during periods of dry weather due to increases in evaporation.

For the continental U.S., the most extensive U.S. drought in the modern observational record occurred from 1933 to 1938. In July 1934, 80 percent of the U.S. was gripped by moderate or greater drought (Figure 7), and 63 percent was experiencing severe to extreme drought. During 1953-1957, severe drought covered up to 50 percent of the country. Paleoclimatic data (e.g. tree ring measurements) have been used to reconstruct drought patterns for the period prior to the modern instrumental record. These reconstructions show that during most of the past two millennia the climate of the western U.S. has been more arid than at present. The recent intense Western drought from 1999 to 2004 that strongly affected the Colorado River basin was exceeded in severity as recently as the 19th century. Within the past millennium there have been

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[4] Such a scenario is built on the storyline of relatively low population growth and with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies.

severe droughts in both the western U.S. and Midwest that have lasted for multiple decades.

Long-term warming trends have led to changes in the timing of snow melt and stream flows, especially in the West. This is resulting in earlier peak stream flows and diminished summer-time flows.

Changes in Hurricane Intensity and Frequency

Tropical storms, particularly hurricanes, are an important issue of concern for the United States. The unprecedented hurricane season of 2005, and especially the havoc created by Katrina, raised public awareness of the dangers of hurricanes to new heights. Hurricanes respond to a number of environmental factors including ocean temperatures, atmospheric stability, El Niño, and other factors. One important question is whether hurricane activity has changed over the last 100 years. Since 1995, Atlantic hurricane activity has significantly increased, with more hurricanes, and more intense hurricanes, compared to the two previous decades (Figure 8). However, earlier periods, such as the 1945 to 1970 period were nearly as active.

An important consideration in hurricane intensity is a trend toward warmer ocean temperatures, particularly in the tropical Atlantic and Gulf of Mexico, indicating that global warming is playing some role in the increased activity. Another factor is a slow cycle of natural fluctuations in atmospheric conditions and ocean temperatures in the North Atlantic referred to as the Atlantic Multi-decadal Oscillation (AMO). This AMO is currently in a warm ocean temperature phase.

What does the future hold for hurricane activity? In the near term, it is expected that favorable conditions for hurricanes will persist for the next decade or so based on previous active periods. For the longer term, climate models simulate about 1/2 Category increase in the intensity of strong hurricanes late in the 21st Century, if tropical sea surface rise nearly 2°C warmer than at present. The models also simulate about a 20 percent increase in near-storm rainfall rates under those conditions. However, it is unclear if the total number of hurricanes will change in future years.

New analyses of precipitation rates for different strengths of landfalling Atlantic tropical cyclones (both hurricanes and tropical storms) over the southeastern United States have recently been completed. These analyses show that daily precipitation amounts increase with tropical cyclone strength, while hourly precipitation does not. This means that the more intense hurricanes have longer periods with heavy rainfall. The implications are relevant for local planning, if indeed tropical cyclone strength increases in the future.

Conclusion

Modern climate change is dominated by human influences, which are now large enough to exceed the bounds of natural variability. The main source of global climate change is human-induced changes in atmospheric composition. These perturbations primarily result from emissions associated with energy use, but on local and regional scales, urbanization and land use changes are also important. Although there has been progress in monitoring and understanding climate change, there remain many scientific, technical, and institutional impediments to precisely planning for, adapting to, and mitigating the effects of climate change. There is still considerable uncertainty about the rates of change that can be expected, however, it is clear that these changes will be increasingly manifested in important and tangible ways, such as changes in extremes of temperature and precipitation, decreases in seasonal and perennial snow and ice extent, sea level rise, and now there is accumulating evidence to suggest that there will be increases in [redacted]tensity and related heavy and extreme precipitation. Anthropogenic climate change is now likely to continue for many centuries. In many respects we are venturing into the unknown territory with changes in climate, and its associated effects could be quite disruptive. The rate of human-induced climate change is projected to be much faster than most natural processes prevailing over the past 10,000 years

Thank you again, Mr. Chairman for allowing me the opportunity to help inform the Committee about climate change.

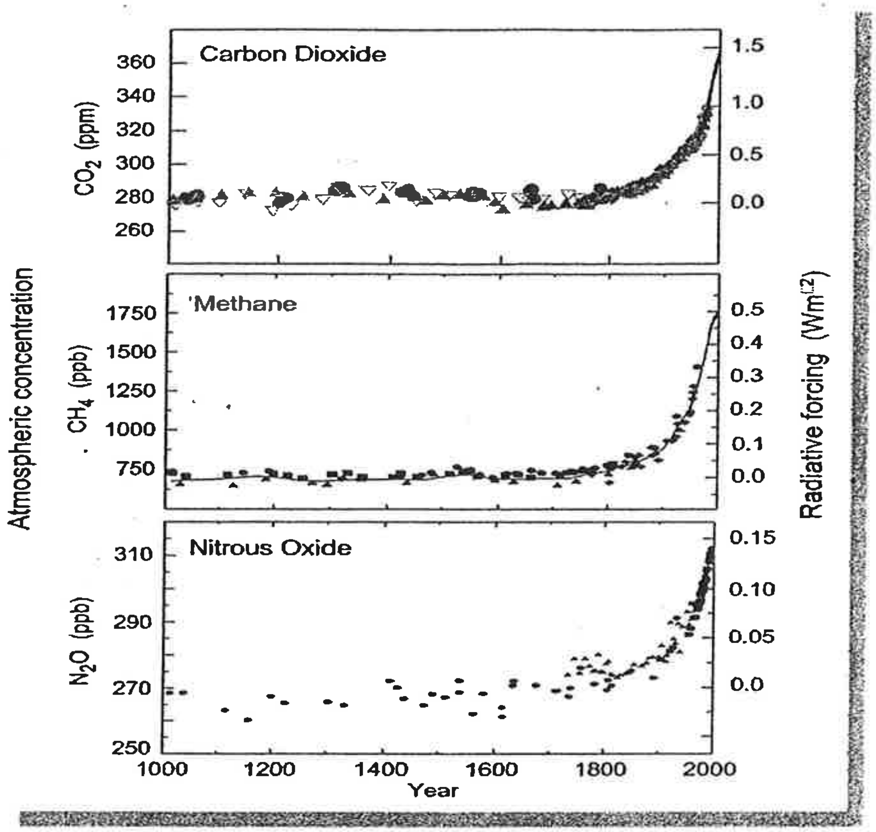

Figure 1: Changes in atmospheric concentration of carbon dioxide, methane, and nitrous oxide since 1000 A.D. (from IPCC, 2001).

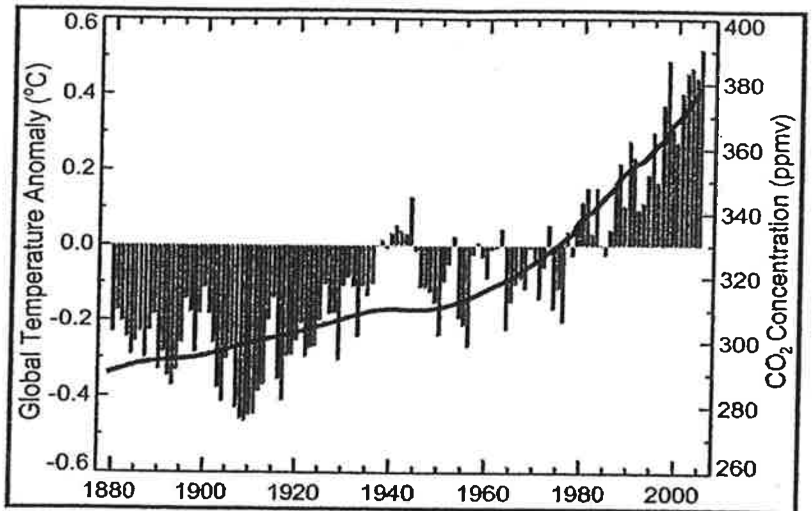

Figure 2: Globally averaged surface air temperature and carbon dioxide concentration (parts per million by volume) since 1880 (Updated from Karl and Trenberth, 2002).

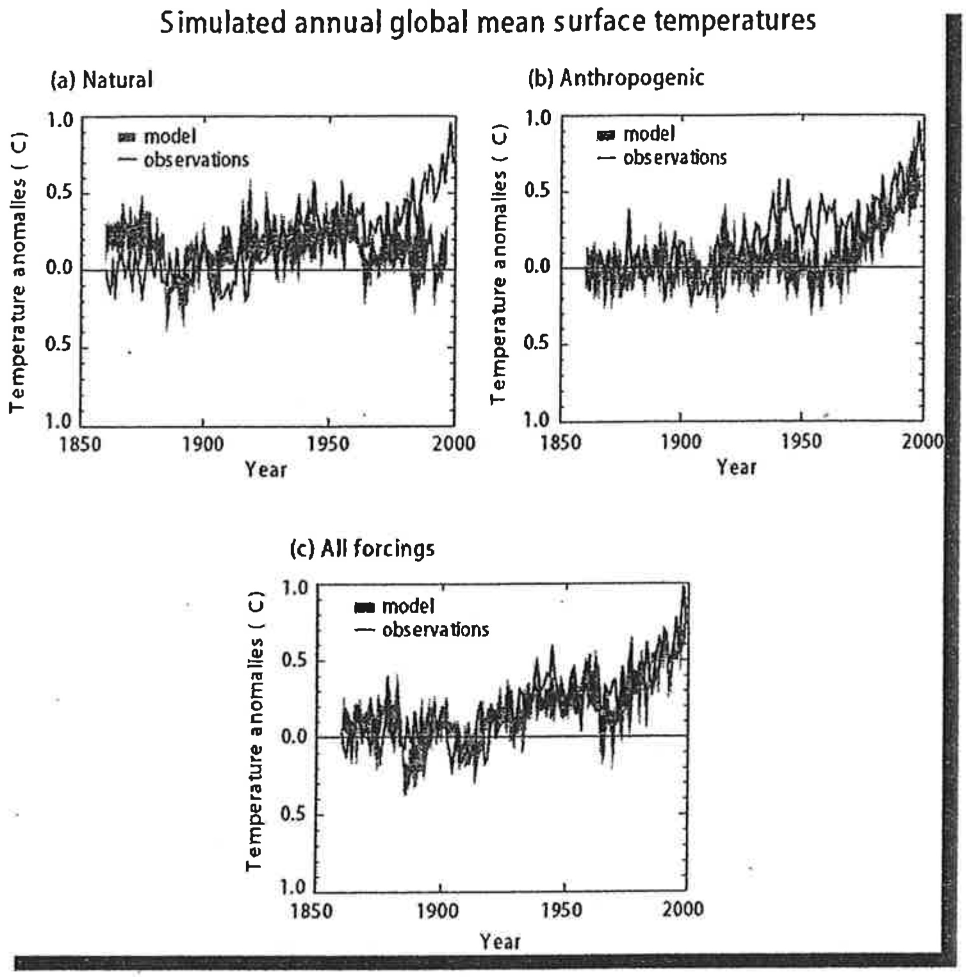

Figure 3: Climate model simulations of the global air temperature for the period 1860-2000. Figure 3a includes only natural forcing mechanisms such as volcanic eruptions and solar variability; 3b includes only anthropogenic greenhouse gas increases; and 3c includes both natural and anthropogenic forcing mechanisms (from IPCC 2001).

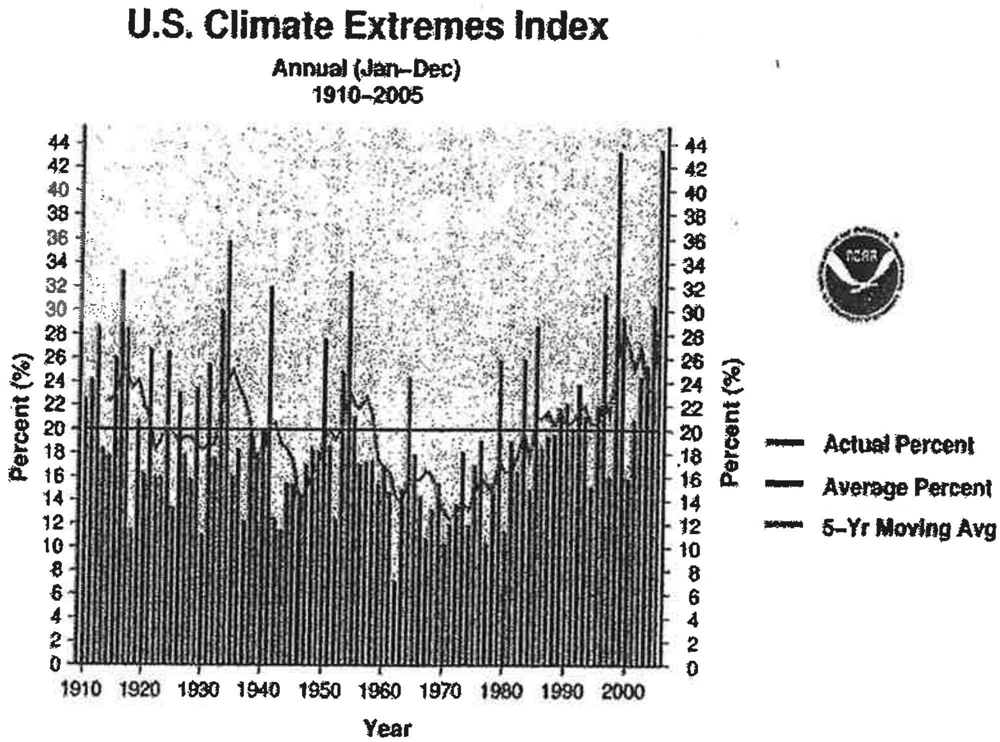

Figure 4: The U.S. Climate Extremes Index (CEI) is the average of the percent of U.S. land area experiencing extremes in temperatures, drought, precipitation, and tropical storms. More detailed information on the CEI is available at http://www.ncdc.noaa.gov/oa/climate/research/cei/cei.html.

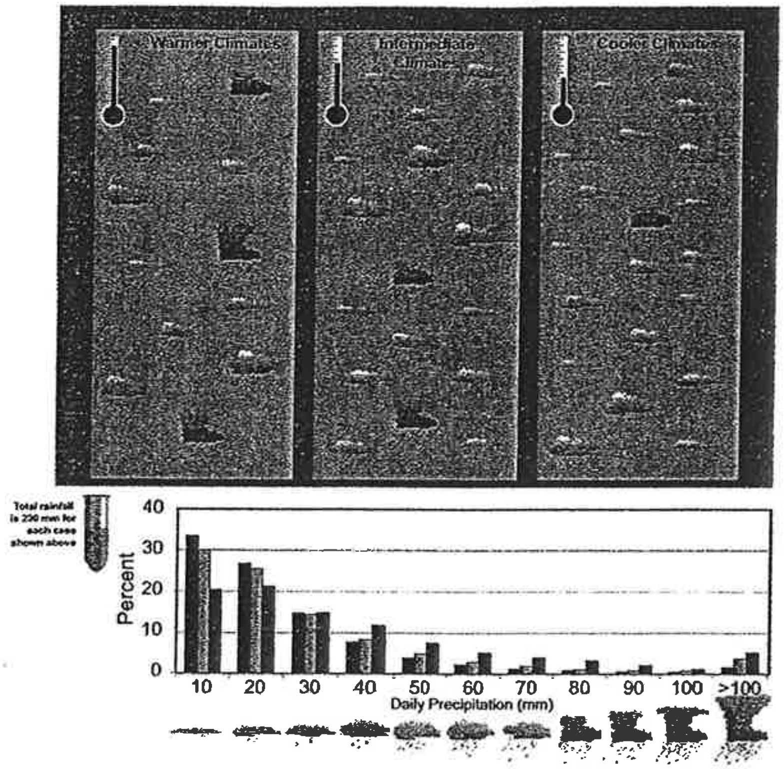

Figure 5: The diagram shows that warmer climates (red) have a higher percentage of total rainfall coming from heavy and very heavy events. All stations have the same seasonal mean precipitation amount of 230 (±5) mm. For cool climates (blue), there are more daily precipitation events than in warmer climates (Adapted from Karl and Trenberth, 2002).

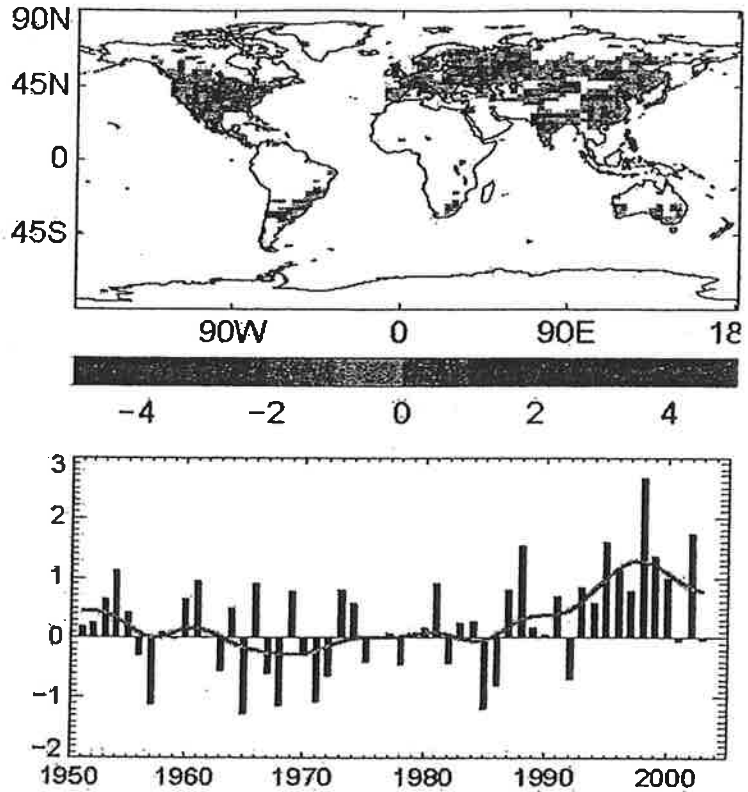

Figure 6: Changes in the contribution of heavy precipitation events to the annual total amount. Globally there has been a change of nearly two percent since the mid-20th century (from Alexander, L.V., et al., 2006: Global observed changes in daily climate extremes of temperature and precipitation. *J. Geophys. Res.*, D05109, doi:10.1029/2005JD006290).

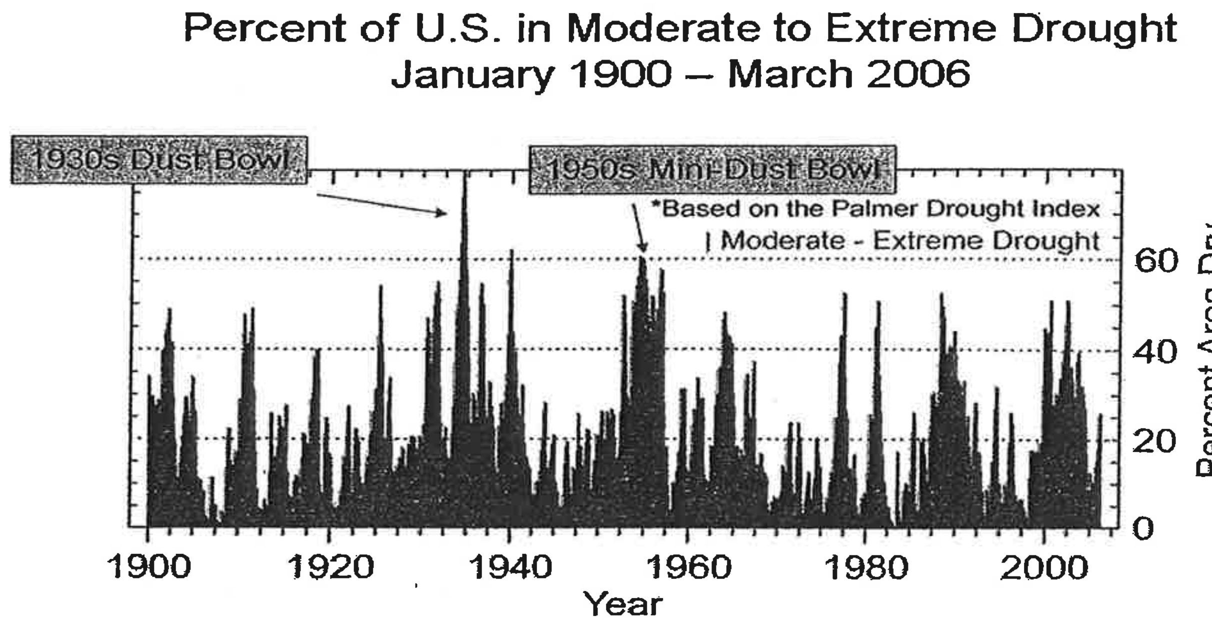

Figure 7: The percentage of the contiguous U.S. land area in moderate to severe drought (NOAA, National Climatic Data Center).

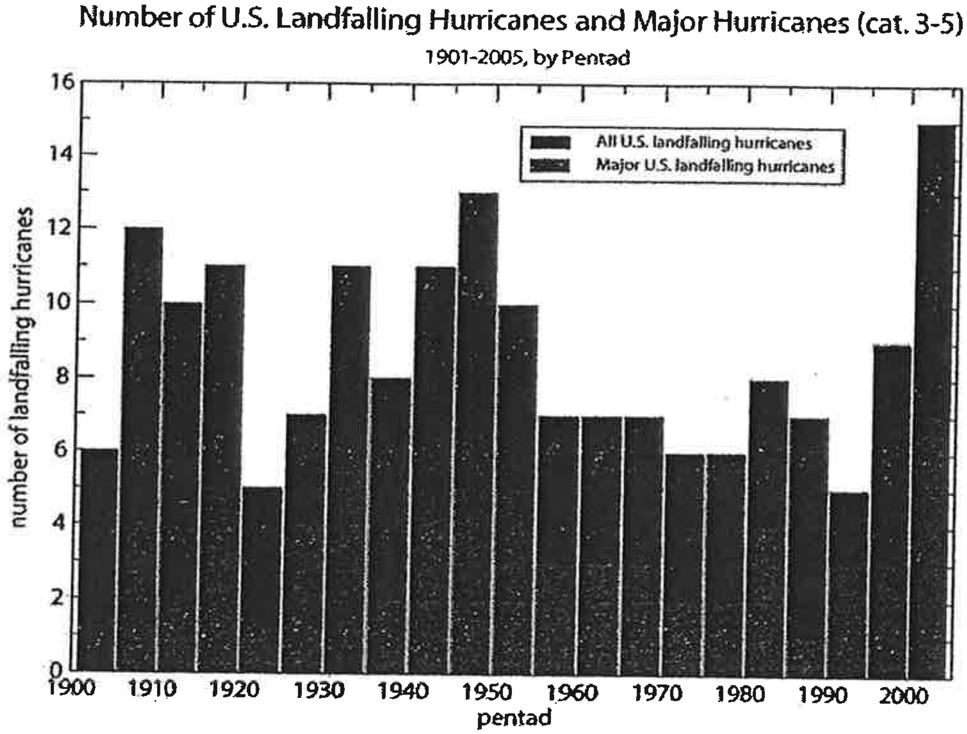

Figure 8: The number of hurricanes making landfall in the U.S., summed by five year periods (e.g. 1901-1905, 1906-1910, etc.). The red bar is the number of major hurricanes (category 3-5) and blue bar is the total number of all hurricanes per five year period (pentad). (NOAA, National Climatic Data Center)

Kelly Brown/HCHB/Osnet
07/14/2006 04:37 PM

To [redacted]Holly_Fitter[redacted]omb.eop.gov

cc Lewis_D._McCulloch[redacted], Noel.Turner[redacted], Michael Levitt/HCHB/Osnet@osnet, Leah Harrelson/HCHB/Osnet@osnet, Chris Scheve/HCHB/Osnet@osnet, Pete Dalmut/HCHB/Osnet@osnet

bcc

Subject For OMB Review -- DOC/NOAA Testimony for July 20th Hearing on "Introduction to Climate Change" Before the House Committee on Government Reform

7/18 See various emails & CEQ edits, p10

7/ 5:30pm 2) CEQ more edits 4, 7 pso Bob Rainey → look also for email

Attached, for you review, is draft DOC-cleared NOAA/DOC testimony (9 pages plus figures) for a Thursday July 20th hearing before the House Government Reform Committee. This is the second of two testimonies to be presented by Dr. Karl, Director of the National Climatic Data Center, for climate-related hearings.

M 6 Climate Change Testimony for July 20 to OMB 430 pm 7-14-06.doc

Please note that the discussion of hurricane intensity (pages 9-10) reflects the ongoing debate among NOAA scientists. Please let us know if there are any questions regarding this section, or anything else in the testimony. I will be out of the office on Monday, July 17th, and back in the office on July 18th. In my absence on Monday, please contact Pete Dalmut (pdalmut@doc.gov; 202-482-3084) with any questions. Thank you.

The Committee has requested testimony no later than 10am Tuesday, July 18th. We understand this deadline is unrealistic. Please let us know if it would be possible to begin receiving OMB/interagency comments by 4:00 PM Tuesday, July 18th, allowing us time to address any comments. Thank you.

Please let me know if you have any questions regarding this request. Thank you for your review and assistance.

Kelly Brown
Office of the Assistant General Counsel
for Legislation and Regulation
U.S. Department of Commerce
Phone: [redacted]
Fax: [redacted]
Internet: [redacted]Brown[redacted]

WRITTEN STATEMENT BY
DR. THOMAS R. KARL
DIRECTOR, NATIONAL CLIMATIC DATA CENTER
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)
U.S. DEPARTMENT OF COMMERCE

FOR AN OVERSIGHT HEARING: INTRODUCTION TO CLIMATE CHANGE

BEFORE THE COMMITTEE ON GOVERNMENT REFORM U.S. HOUSE OF REPRESENTATIVES

JULY 20, 2006

5th 7/18 Bob Rainey (CEQ) These comments come from "high up" the chair of CEQ

Mr. Chairman and Members of the Committee: As Director of the National Climatic Data Center, which is part of the National Environmental Satellite, Data, and Information Service (NESDIS) within the National Oceanic and Atmospheric Administration (NOAA), and as Program Manger for one of five different NOAA Climate Goal Programs (Climate Observations and Analysis), I am pleased to have the opportunity to testify before you today. The National Climatic Data Center is the world's largest archive of weather and climate data, which includes data critical to understanding climate variability and change, and also acts as the Nation's Scorekeeper regarding the trends and anomalies of weather and climate.

The U.S. Climate Change Science Program integrates federal research on global climate change, as sponsored by thirteen federal agencies.[1] Since CCSP was created in 2002, the program has successfully integrated a wide range of research, climate science priorities and budgets of the thirteen CCSP agencies. With an approximately $2 billion annual expenditure, CCSP has taken on the most challenging questions in climate science and is developing products to convey the most advanced state of knowledge to be used by federal, state and local decision makers, resource managers, the science community, the media, and the general public. Over the next two years CCSP will be completing a series of 21 Synthesis and Assessment Reports, the first of which was just released a few months ago. The collection of these Synthesis and Assessment Report will address many of the issues pertinent to this testimony.

CEQ - wants beefed up - talk about what a great program this is.

(use some old climate testimony)

I will provide an overview of our basic understanding of the atmosphere in terms of: the role that greenhouse gases play in the atmosphere; evidence for how greenhouse gases

explaining what doing what spending how great it is

3-4 sentences

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[1] The CCSP participating agencies include the Departments of Agriculture, Commerce, Defense, Energy, Health and Human Services, the Interior, State, and Transportation, the National Science Foundation, the Environmental Protection Agency (EPA), the National Aeronautics and Space Administration (NASA), U.S. Agency for International Development, and the Smithsonian Institution. Additional CCSP liaisons reside in the Office of Science and Technology Policy, the Council on Environmental Quality, the National Economic Council and the Office of Management and Budget.

Also - tie back all the parts of CCSP

are already influencing the climate in both general and in specific ways; a short tutorial on the use of global climate models; how we know global temperatures are increasing; and why we think it is very likely (>95 percent probability) that humans are largely responsible for many of the observed general and specific changes in climate over the past several decades.

Atmospheric Composition and Greenhouse Gases

The natural "greenhouse" effect is real, and is an essential component of the planet's climate process. A small percentage (roughly 2 percent) of the atmosphere is, and long has been, composed of greenhouse gases (water vapor, carbon dioxide, ozone and methane). These gases effectively prevent part of the heat radiated by the Earth's surface from otherwise escaping to space. The response of the global system to this trapped heat is a climate that is warmer than it would be otherwise without the presence of these gases. In the absence of these greenhouse gases the temperature on Earth would be too cold to support life as we know it today. Of all the greenhouse gases, water vapor is by far the most dominant, but other the gases are more effective at trapping heat energy from certain portions of the electromagnetic spectrum whereas water vapor is semi-transparent to heat escaping from the Earth's surface.

In addition to the natural greenhouse effect outlined above, there is a change underway in the greenhouse radiation balance. Some greenhouse gases are increasing in the atmosphere because of human activities and increasingly trapping more heat. Direct atmospheric measurements made over the past 50 years have documented the steady growth in the atmospheric abundance of carbon dioxide. In addition to these direct real-time measurements, ice cores have revealed the atmospheric carbon dioxide concentrations of the distant past. Measurements using air bubbles trapped within layers of accumulating snow show that atmospheric carbon dioxide has increased by nearly 35 percent over the Industrial Era (since 1750), compared to the relatively constant abundance of carbon dioxide over at least the preceding 750 years of the past millennium (Figure 1). The predominant cause of this increase in carbon dioxide is the combustion of fossil fuels and the burning of forests. Further, methane abundance has doubled over the Industrial Era, but the increase of methane has slowed over the recent decade for reasons not clearly understood. Other heat-trapping gases are also increasing as a result of human activities. We are unable to state with certainty the exact rate at which these gases will continue to increase because of uncertainties in future emissions, as well as uncertainties regarding how these emissions will be taken up by the atmosphere, land, and oceans. We are certain, however, that once in the atmosphere these greenhouse gases have a relatively long life-time, on the order of decades to centuries. This means they become well mixed throughout the globe.

The increase in heat-trapping greenhouse gases is projected to be amplified by feedback effects, such as changes in water vapor, snow cover, and sea ice. As atmospheric concentrations of carbon dioxide and other greenhouse gases increase, the resulting increase in surface temperature leads to less sea ice and snow cover helping to raise temperatures even further. As snow cover and sea ice decrease, more of the Sun's energy

is absorbed by the planet, instead of being reflected back to space by the snow cover and sea ice. Present evidence also suggests that as greenhouse gases lead to temperature increases, evaporation increases leading to more atmospheric water vapor. Additional water vapor (which, as mentioned above, is a dominant greenhouse gas) acts as a very important feedback to further increase temperature. Our present understanding suggests that these feedback effects account for about 60 percent of the warming. The magnitude of these feedback effects, and others such as changes in clouds, remains a significant source of uncertainty related to our understanding of the impact of increasing greenhouse gases. For example, increases in evaporation and water vapor affect global climate in other ways besides increasing temperature such as increasing rainfall and snowfall rates, and accelerating drying during droughts. The increase in greenhouse gas concentrations in the atmosphere implies a positive radiative forcing, i.e., a tendency to warm the climate system.

Particles (or aerosols) in the atmosphere resulting from human activities can also affect climate. Aerosols vary considerably by region. Some aerosol types act in a sense opposite to the greenhouse gases and cause a negative forcing or cooling of the climate system (e.g., sulfate aerosol). Other aerosols act in the same way as greenhouse gases, and warm the climate (e.g., soot). In contrast to the long-lived nature of carbon dioxide (centuries), aerosols are short-lived and removed from the lower atmosphere within a few days. Therefore, human-generated aerosols exert a long-term forcing on climate only because their emissions continue each day of the year. Aerosol effects on climate can be manifested directly by their ability to reflect and trap heat, but they can also have an indirect effect by changing the lifetime of clouds and changing the clouds reflectivity to sunshine. The magnitude of the negative forcing of the indirect effect of aerosols is highly uncertain, but may be larger than the direct effect of aerosols.

Emissions of greenhouse gases and aerosols continue to alter the atmosphere in ways that are expected to affect the climate. There are also natural factors which exert a forcing on climate, e.g., changes in the Sun's energy output and short-lived (a few years) aerosols in the stratosphere following episodic and explosive volcanic eruptions. The decadal time-scale forcing estimates of the greenhouse gases are larger than all the other forcings over the past several decades and continue to grow disproportionately larger.

Human activities also have a large-scale impact on the land surface. Changes in land use through urbanization and agricultural practices, although not global, are often most pronounced where people live, work, and grow food, and are part of the human impact on climate. Large-scale deforestation and desertification in Amazonia and the Sahel, respectively, are two instances where evidence suggests there is likely to be human influence on regional climate. In general, city climates differ from those in surrounding rural green areas, because of the "concrete jungle" and its effects on heat retention, runoff, and pollution, resulting in urban heat islands.[2]

[2] The global impact of these urban heat islands has been extensively analyzed and assessed to ensure measurements of global temperature are not biased by local urban heat islands.

There is no doubt that the composition of the atmosphere is changing because of human activities, and today greenhouse gases are the largest human influence on global climate.

What exactly is a climate model and why is it useful?

Many of the laws governing climate change and the processes involved can be quantified and linked by mathematical equations. Figure 2 shows schematically the kinds of processes that can be included in climate models. Among these are many earth system components such as atmospheric chemistry, ocean circulation, sea-ice, land-surface hydrology, biogeochemistry, atmospheric circulation, etc. The physics of many of the processes governing climate change are well understood, and may be described by mathematical equations. Linking these equations creates mathematical models of climate that may be run on computers or super-computers. Coupled climate models can include mathematical equations describing physical, chemical, and biogeochemical processes.

In fact, coupled climate models are the preferred way to approach climate modeling. This is because if we put all our understanding into a single model, it would be too complex to run on any existing computer systems. The decisions for how to build any given climate model includes trade-offs between the complexity of the model and number of Earth system components included, the horizontal and spatial resolution within the model, and the number of years of simulations the model can produce per day of computer time. Consequently, there is a hierarchy of model complexity, often based on the degree to which approximations are required for each model or component processes omitted.

Approximations in climate models represent aspects of the models that require parameter choices and "tuning." This "tuning" is referred to as model parameterization. As a simple example, imagine a single cumulus cloud and how it has to be represented in a global climate model. The cloud may only encompass only a few hundred meters in the vertical and horizontal extent, which is much finer resolution than can be run on today's coupled atmosphere and ocean climate models. This then means that in order to incorporate such clouds into the climate model, some approximations have to be made regarding the statistical properties of such clouds within say an area 100 or 1000 times larger than the cloud itself – because this area is the level of resolution the model can accept. A similar approach is also required in today's state-of-the-science weather forecasting models.

An important difference between weather forecasting models and climate models is that weather models are initialized with a specific set of observations representing today's weather to precisely predict the weather "x" days or hours into the future. The initial starting conditions of the climate models, however, are not nearly as important. Climate models are used to simulate many years of "weather" into the future with the intent of understanding the difference in the collection of weather events at some point in the future, compared to some other time in the past (often the climate of the last 30 years or so). This comparison enables scientists to study the output of climate model simulations to understand the effect of various modifications of those aspects of the climate system that might cause the climate to change. A key challenge in climate modeling is to isolate and identify cause and effect – which requires knowledge about the

changes and variations of the external forcings controlling climate, and a comprehensive understanding of climate feedbacks (such as a change in the earth's reflectivity because of a change sea ice or cloud amount) and natural climate variability.

Model simulations of climate over specified periods can be verified and validated against the observational record. Models that prove to describe climate variability and change well can be used as a tool to increase our understanding of the climate system. Once evaluated and validated, climate models can then be used for predictive purposes. Given specific forcing scenarios, climate models can provide viable projections of future climate. In fact, climate models have become the primary means to predict climate, although prediction is ultimately likely to be achieved through a variety of means, including the observed rate of global climate change.

How do we know the global air temperature is increasing?

There has now been a comprehensive analysis of the changes of temperatures near the surface and throughout much of the atmosphere in the recent Climate Change Science Program (CCSP) Synthesis and Assessment Report 1.1. This report addressed the nagging issue of differences in the rate of warming between measurements derived near the surface and those taken from the atmosphere. The surface air temperatures are derived from several different analyses teams using various combinations of ocean ships and buoys, land observations from weather reporting stations, and satellite data. Atmospheric data sets have been derived using satellites, weather balloons, and a combination of the two.

Considering all the latest satellite, balloon and surface records, the CCSP report concluded there is no significant discrepancy between the rates of global temperature change over the past several decades at the surface compared to changes higher in the atmosphere. The report does, however, acknowledge there are still uncertainties in the tropics, and this is primarily related to data from weather balloons. There is uncertainty as to whether scientists have been able to adequately adjust for known biases and errors in the data, especially in the tropics where many developing nations struggle to routinely launch weather balloons and process these measurements.

Globally, data indicate the rates of temperature change have been similar throughout the atmosphere since 1979 when satellite data were first available, and the rates of temperature change have been slightly greater in the atmosphere compared to the surface air temperature since 1958 (the time at which weather balloons had adequate spatial coverage for global calculations). The global surface temperature time series, shown in Figure 3, indicates warming on even longer time scales, with acceleration since 1976.

Instrumental measurements are not our only evidence for increasing global temperatures. The observed increased melting of glaciers can be used to estimate the rate of temperature increase since the late 19th Century. Estimates of the near-surface temperature based on glacial melting are very similar to estimates based on instrumental data. There has been a 15-20 percent reduction in Arctic sea ice since the 1970s, a 10 percent decrease in snow cover since the 1970s, and shortened periods of lake and river ice cover (about 2 weeks shorter since the 19th century). Also, ocean heat content has significantly increased over the past several decades.

Why do we think humans are influencing the Earth's climate?

The scientific community has been actively working on detection and attribution of climate change as related to human activities since the 1980s. As described above, one set of tools often used to examine these issues are mathematical computer models of the climate. Outstanding issues in modeling include specifying forcing mechanisms (e.g., the causes of climate variability and change) within the climate system; properly dealing with complex feedback processes that affect carbon, energy, and water sources, sinks and transports; and improving simulations of regional weather, especially extreme events. Today's inadequate or incomplete measurements of the various forcing mechanisms, with the exception of well-mixed greenhouse gases, add uncertainty when trying to simulate past and present climate. Confidence in our ability to predict future climate depends on our ability to use climate models to attribute past and present climate change to specific causes.

Recent carbon dioxide emission trends in the United States are upward, as are global emissions trends, with increases between 0.5 and 1 percent per year over the past few decades. Concentrations of both reflective and nonreflective aerosols are also estimated to be increasing. Radiative forcings[3] from greenhouse gases dominate over the net cooling forcings from aerosols and the global temperature has exceeded the bounds of natural variability. This has been the case since about 1980. By raising the air temperature, the capacity of the atmosphere to hold more water vapor is increased, which defines the upper bounds of the amount of precipitation that can occur during short term (~daily or less) extreme precipitation events.

As an example of how models are used to detect human influence on the climate system Figure 4 shows that without including all the observed forcing mechanisms the models cannot replicate the observed global temperature changes. There are many other aspects of the climate system besides global surface temperatures that have been tested for human influences. Today, there is convincing evidence from a variety of model and data climate attribution studies pointing to human influences on climate. These include regional analyses of changes in temperature, the paleoclimatic[4] temperature record, three

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[3] Radiative forcing is the change in the net vertical irradiance (expressed in Watts per square meter: Wm^{-2}) at the tropopause due to an internal change or a change in the external forcing of the climate system, such as, for example, a change in the concentration of carbon dioxide or the output of the Sun.

[4] Climate during periods prior to the development of measuring instruments, including historic and geologic time, for which only proxy climate records are available. A proxy climate indicator is a local record that is interpreted, using physical and biophysical principles, to represent some combination of climate-related variations back in time. Climate-related data derived in this way are referred to as proxy

dimensional analysis of atmospheric temperature change, changes of free atmospheric temperature, changes in sea ice extent and other components of the cryosphere, changes in ocean heat content, and new studies on extreme weather and climate events. Thus, there is considerable confidence that the observed warming, especially the period since 1970s is ~~mostly attributable to~~ Influenced by increases in greenhouse gases.] Bob Rainey (he may back off this – if this not right.) he'd like to talk to Karl about that

Changes in Extremes in the United States

The U.S. Climate Change Science Program Synthesis and Assessment Report 3.3 will specifically address the issue of changes in extreme events, focusing on North America. This assessment plans on comprehensively assessing a wide range of climate-related extreme events and promises to help clarify what we know and do not yet understand about these important events, as related to climate change. Here, three types of climate extremes are discussed as they are likely to be influenced by rising global temperatures. This includes changes the frequency and intensity of heavy and extreme precipitation events, droughts, and hurricanes.

Increasing air temperature leads to increased water vapor in the atmosphere. Surface moisture, if available (as it always is over the oceans), effectively acts as the "air conditioner" of the surface – as heat used for evaporation moistens the air rather than warming it. Therefore, another consequence of global heating of the lower troposphere is accelerated land-surface drying and more atmospheric water vapor (the dominant greenhouse gas). Satellite measurements now confirm a significant increase in atmospheric water vapor, consistent with theoretical expectations given the rate of observed atmospheric warming during the past several decades. Accelerated drying, without an increase in precipitation, increases the incidence and severity of droughts, whereas additional atmospheric water vapor increases the risk of heavy precipitation events. Increases in global temperature also increase sea surface temperatures, one of several important factors affecting the hurricane intensity.

NOAA's National Climatic Data Center calculates a Climate Extremes Index (CEI) over the United States that includes extremes related to all of these indicators including temperature, precipitation, drought and hurricanes. Although no index can claim to adequately capture all of the important changes in extremes, the changes and variations of the CEI as reflected in Figure 5 is illustrative of the varying decadal variability of climate extremes. Currently, the CEI is at record levels during the past decade or so, but not much higher than in previous decades, and so there is no clear indication of a general increase in the aggregate set of extremes included in the CEI when viewed across much of the 20th Century.

Changes in Heavy and Extreme Precipitation

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data. Examples of proxies are: tree ring records, characteristics of corals, and various data derived from ice cores.

Basic theory, climate model simulations, and empirical evidence (Figure 6) confirm that warmer climates, owing to increased water vapor, lead to more intense precipitation events even when the total precipitation remains constant, and with prospects for even stronger events when precipitation amounts increase. Figure 7 depicts the aggregate land-surface world-wide changes in heavy precipitation events over the last half of the 20th century with an associated geographic depiction of where changes in heavy precipitation have occurred, with most areas showing increases. World-wide, an increase of a few percent in heavy precipitation events is evident since the middle of the 20th century, particularly in the middle and high latitudes. By the end of the 21st Century a 10-20 percent increase in the precipitation rate for 1-day extreme precipitation events (20 year return periods) is in the middle range of a variety of climate models, when forced with a rather conservative change in atmospheric greenhouse gases. Carbon dioxide does not exceed 550 ppmv[5].

The practical implications of addressing these changes are seen in NOAA's recent update of the Ohio River Basin's 100-year 24-hour precipitation return period. Over the past several decades increases in precipitation rates for the 1 in 100 year extreme daily precipitation amount was observed in many areas of the eastern United States over the past several decades. These data are used to help set engineering design standard related to excessive rainfall.

Changes in Drought Severity and Frequency

Drought is a recurring feature of the climate system. In other words, we have had major droughts in the past, and expect to have major droughts in the future. At any given time, at least part of the U.S. is in drought, with percentages ranging from 5-80 percent of the total land area. U.S. droughts show pronounced multi-year to multi-decadal variability, but no convincing evidence for systematic long-term trends toward more or fewer events. Drought calculations have been made showing that over the U.S, the increase in temperatures that may have lead to increased evaporation have been compensated by a general increase in precipitation over the past few decades. In general, there are no clear patterns of precipitation increase emerging from climate model simulations as global temperatures increase, so the increase in precipitation over the past few decades may not persist and could reverse. Such a reversal, added to the continuing increase in temperatures (January through June of 2006 have been the warmest temperatures in U.S. records dating back to 1895) could lead to greater drought severity and frequency, especially during periods of dry weather due to increases in evaporation.

For the continental U.S., the most extensive U.S. drought in the modern observational record occurred from 1933 to 1938. In July 1934, 80 percent of the U.S. was gripped by moderate or greater drought (Figure 8), and 63 percent was experiencing severe to extreme drought. During 1953-1957, severe drought covered up to 50 percent of the country. Paleoclimatic data (e.g. tree ring measurements) have been used to reconstruct drought patterns for the period prior to the modern instrumental record. These

[5] Such a scenario is built on the storyline of relatively low population growth and with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies.

reconstructions show that during most of the past two millennia the climate of the western U.S. has been more arid than at present. The recent intense Western drought from 1999 to 2004 that strongly affected the Colorado River basin was exceeded in severity as recently as the 19th century. Within the past millennium there have been severe droughts in both the western U.S. and Midwest that have lasted for multiple decades.

Long-term warming trends have led to changes in the timing of snow melt and stream flows, especially in the West. This is resulting in earlier peak stream flows and diminished summer-time flows.

Changes in Hurricane Intensity and Frequency
Tropical storms and particularly hurricanes, are an important issue of concern for the United States. The unprecedented hurricane season of 2005, and especially the havoc created by Katrina, raised public awareness of the dangers of hurricanes to new heights. Hurricanes respond to a number of environmental factors including ocean temperatures, atmospheric stability, El Niño, and other factors. One important question is whether hurricane activity has changed over the last 100 years. Since 1995, Atlantic hurricane activity has significantly increased, with more hurricanes, and more intense hurricanes, compared to the two previous decades (Figure 9). However, earlier periods, such as the 1945 to 1970 period were nearly as active.

An important consideration in hurricane intensity is a trend toward warmer sea surface temperatures, particularly in the tropical Atlantic and Gulf of Mexico, indicating climate change may play some role in the increased hurricane intensity. Another factor is a slow cycle of natural fluctuations in atmospheric conditions and ocean temperatures in the North Atlantic referred to as the Atlantic Multi-decadal Oscillation (AMO). This AMO is currently in a warm ocean temperature phase.

What does the future hold for hurricane activity? In the near term, it is expected that favorable conditions for Atlantic hurricanes will persist for the next decade or so based on previous active periods. For the longer term, climate models simulate about a ½ Category increase (approximately 6 percent increase in wind speed) in the intensity of strong hurricanes late in the 21st Century, with a tropical sea surface temperature increase of nearly 2°C higher than at present. The models also simulate about a 20 percent increase in near-storm rainfall rates under those conditions. However, it is unclear if the total number of hurricanes will change in future years.

New analyses of precipitation rates for different strengths of landfalling Atlantic tropical cyclones (both hurricanes and tropical storms) over the southeastern United States have recently been completed. These analyses show that daily precipitation amounts increase with tropical cyclone strength, while hourly precipitation does not. This means that the more intense hurricanes have longer periods with heavy rainfall. The implications are relevant for local planning, if indeed tropical cyclone strength increases in the future.

Overall, the issue of hurricanes and climate change is an ongoing debate. The scientific community has varying viewpoints on the magnitude of influence of global climate change on hurricanes and how long the current active period will last. NOAA recognizes the debate and continues to study hurricane development, intensity, activity, and modeling.

Conclusion

The state of the science continues to indicate that modern climate change is dominated by human influences, specifically human-induced changes in atmospheric composition. These perturbations primarily result from emissions associated with energy use, but on local and regional scales, urbanization and land use changes are also important. While there is still considerable uncertainty about the rates of change that can be expected, it is clear these changes will be increasingly manifested in important and tangible ways, such as changes in extremes of temperature and precipitation, decreases in seasonal and perennial snow and ice extent, sea level rise, and now there is accumulating evidence to suggest that there will be increases in hurricane intensity and related heavy and extreme precipitation. Furthermore, while there has been progress in monitoring and understanding climate change, there remain many scientific, technical, and institutional impediments to precisely planning for, adapting to, and mitigating the effects of climate change. ~~In many respects we are venturing into the unknown territory with changes in climate, and its associated effects.~~

Thank you again, Mr. Chairman for allowing me the opportunity to help inform the Committee about climate change.

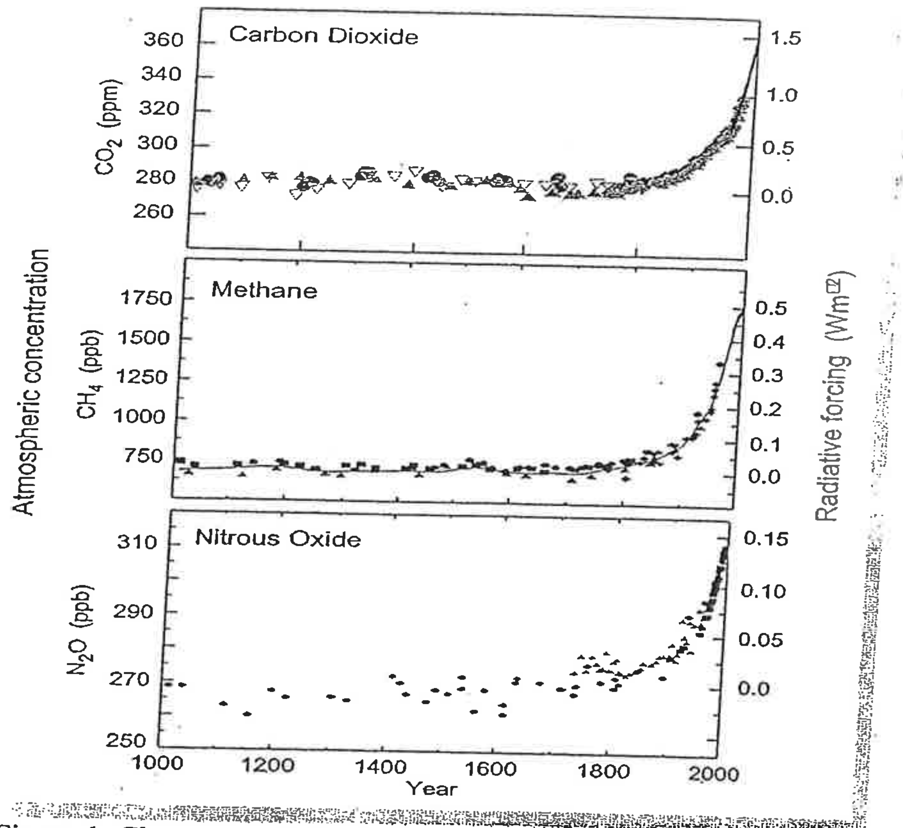

Figure 1: Changes in atmospheric concentration of carbon dioxide, methane, and nitrous oxide since 1000 A.D. (from IPCC, 2001).

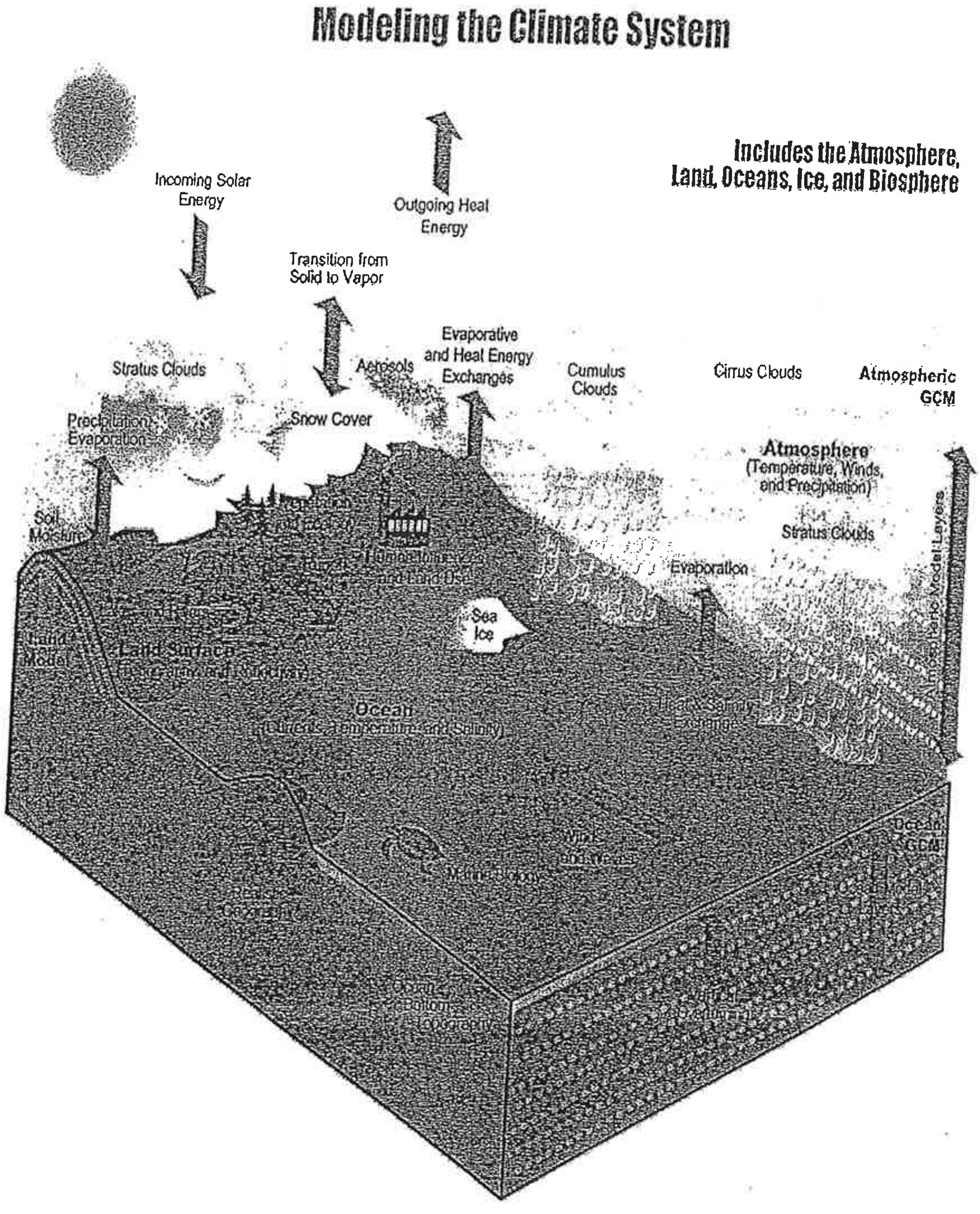

Figure 2. Components of the climate system and the interactions among them, including the human component. All these components have to be modeled as a coupled system that includes the oceans, atmosphere, land, cryosphere, and biosphere.

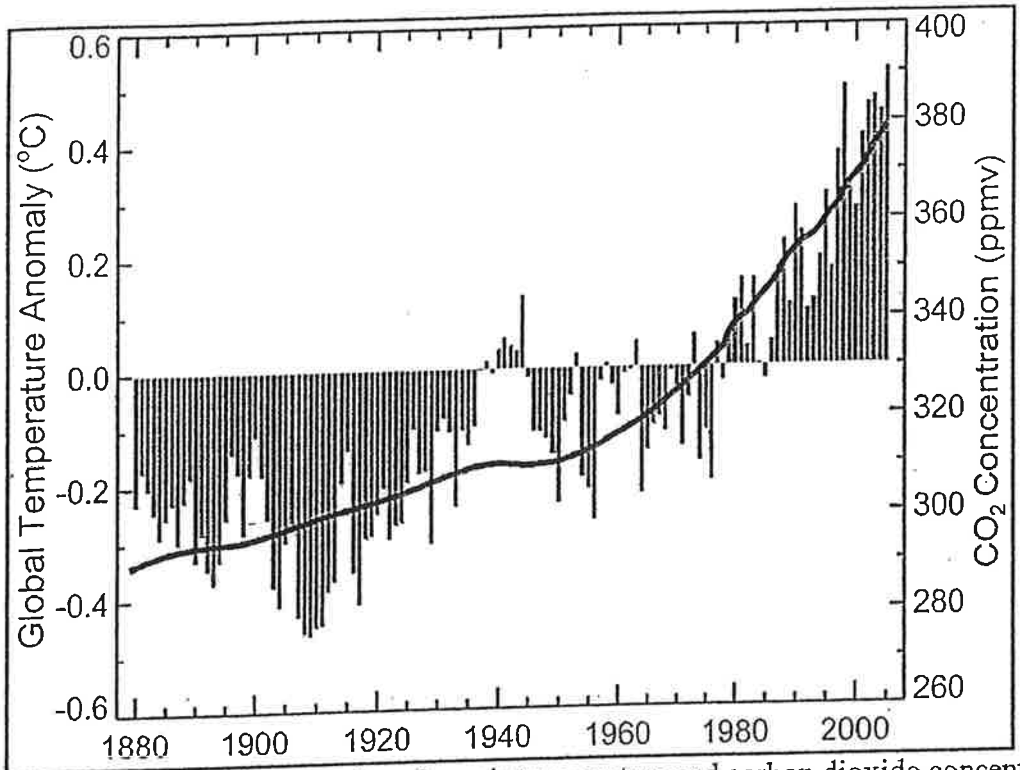

Figure 3: Globally averaged surface air temperature and carbon dioxide concentration (parts per million by volume) since 1880 (Updated from Karl and Trenberth, 2002).

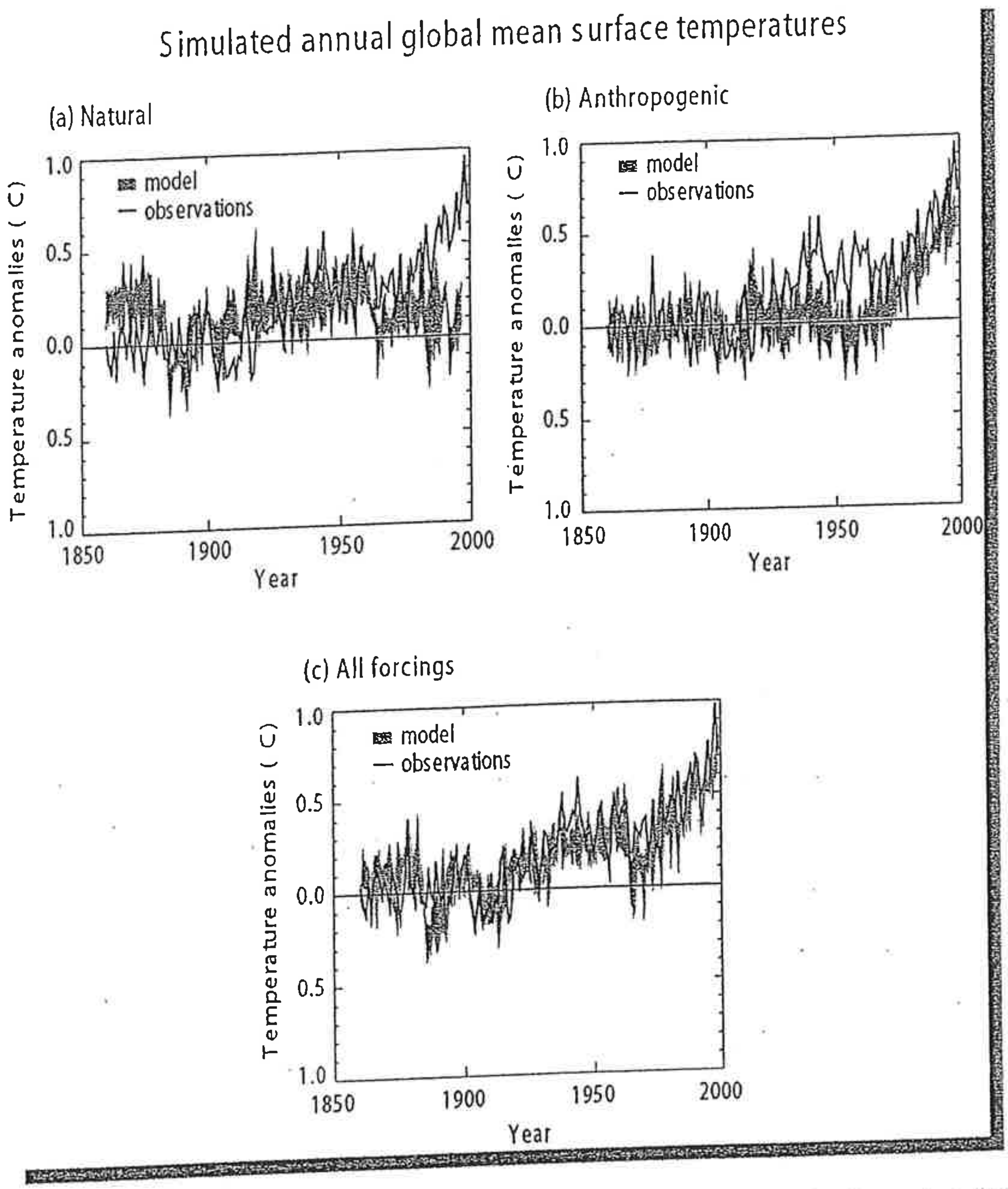

Figure 4: Climate model simulations of the global air temperature for the period 1860-2000. Figure 3a includes only natural forcing mechanisms such as volcanic eruptions and solar variability; 3b includes only anthropogenic greenhouse gas increases; and 3c includes both natural and anthropogenic forcing mechanisms (from IPCC 2001).

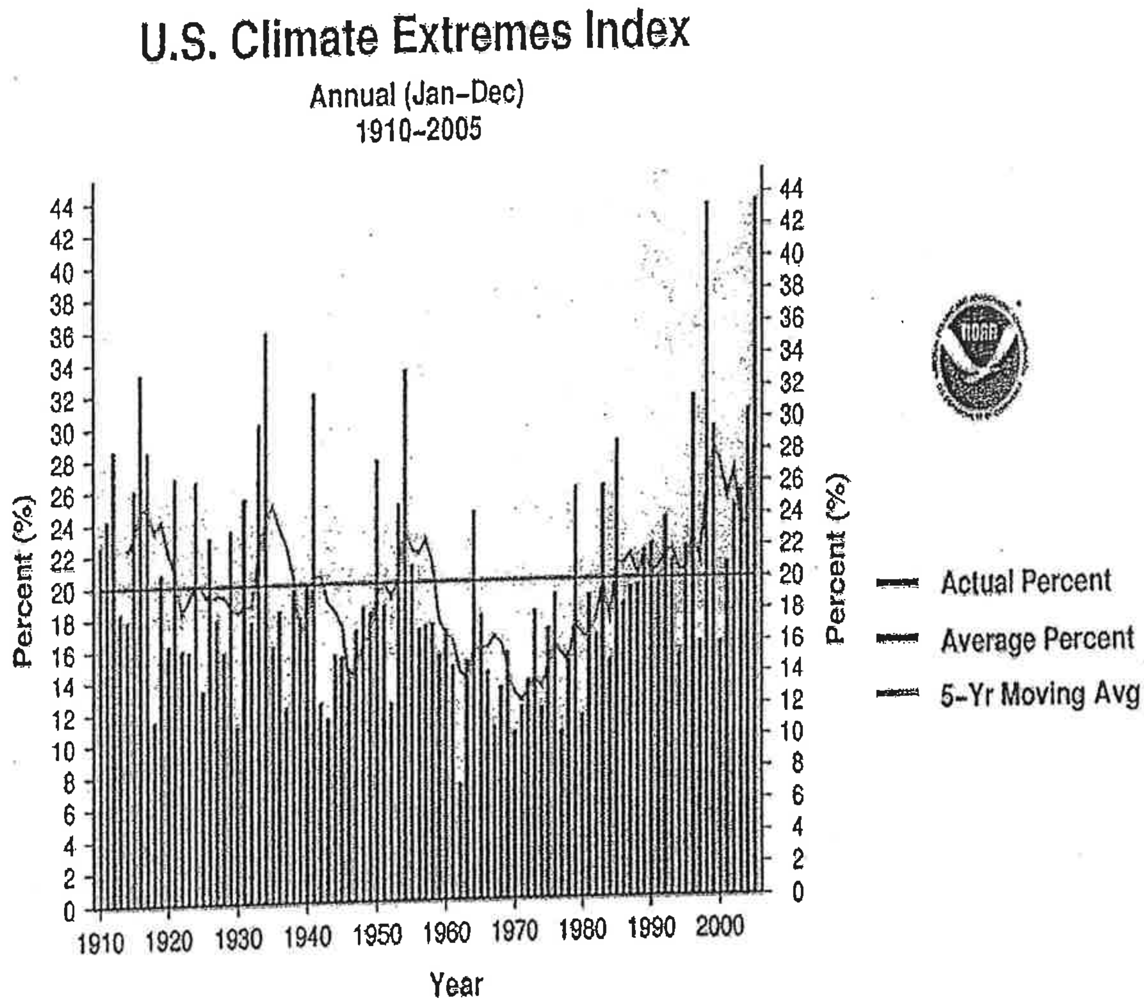

Figure 5: The U.S. Climate Extremes Index (CEI) is the average of the percent of U.S. land area experiencing extremes in temperatures, drought, precipitation, and tropical storms. More detailed information on the CEI is available at http://www.ncdc.noaa.gov/oa/climate/research/cei/cei.html.

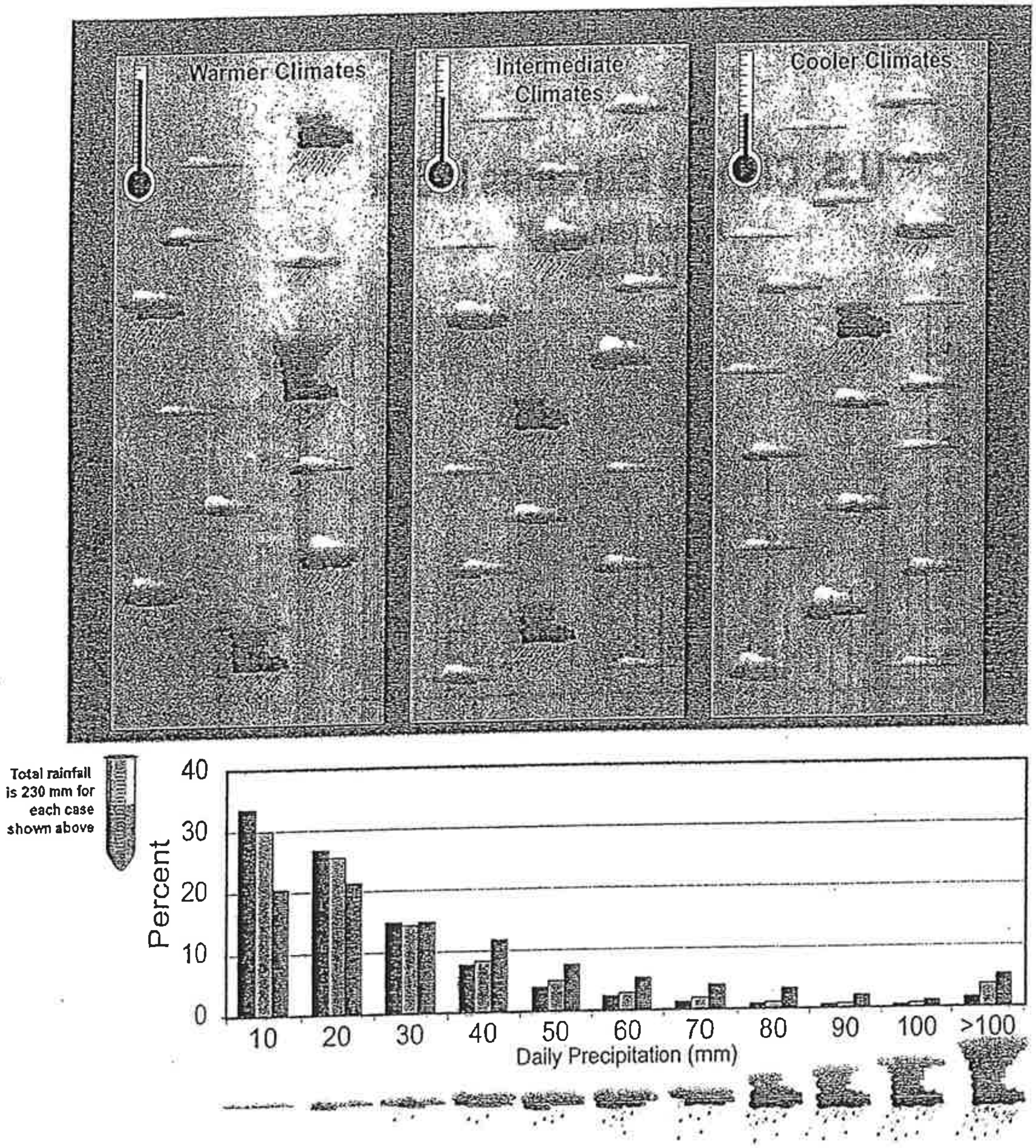

Figure 6: The diagram shows that warmer climates (red) have a higher percentage of total rainfall coming from heavy and very heavy events. The data are based on a worldwide distribution of observing stations, but each have the same seasonal mean precipitation amount of 230 (±5) mm. For cool climates (blue), there are more daily precipitation events than in warmer climates (Adapted from Karl and Trenberth, 2002). The various cloud and rain symbols reflect the various daily precipitation rates and have been categorized in the top panel of this figure to reflect the approximate proportion of the various precipitation rates for cool, moderate, and warm climates across the globe.

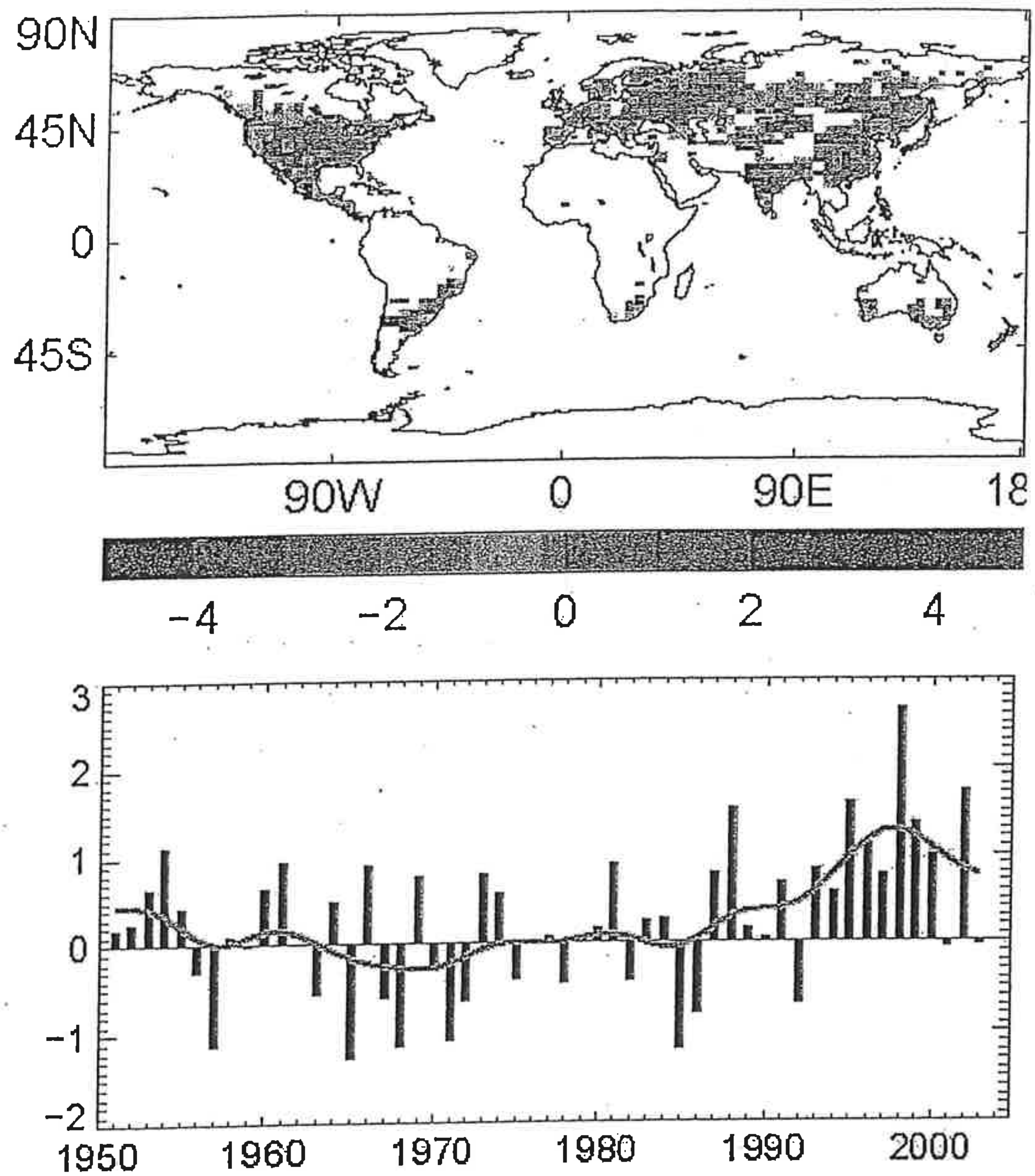

Figure 7: Changes in the contribution of heavy precipitation events to the annual total amount. Globally there has been a change of nearly two percent since the mid-20th century (from Alexander et al., 2006: Global observed changes in daily climate extremes of temperature and precipitation. *J. Geophys. Res.*, D05109, doi:10.1029/2005JD006290).

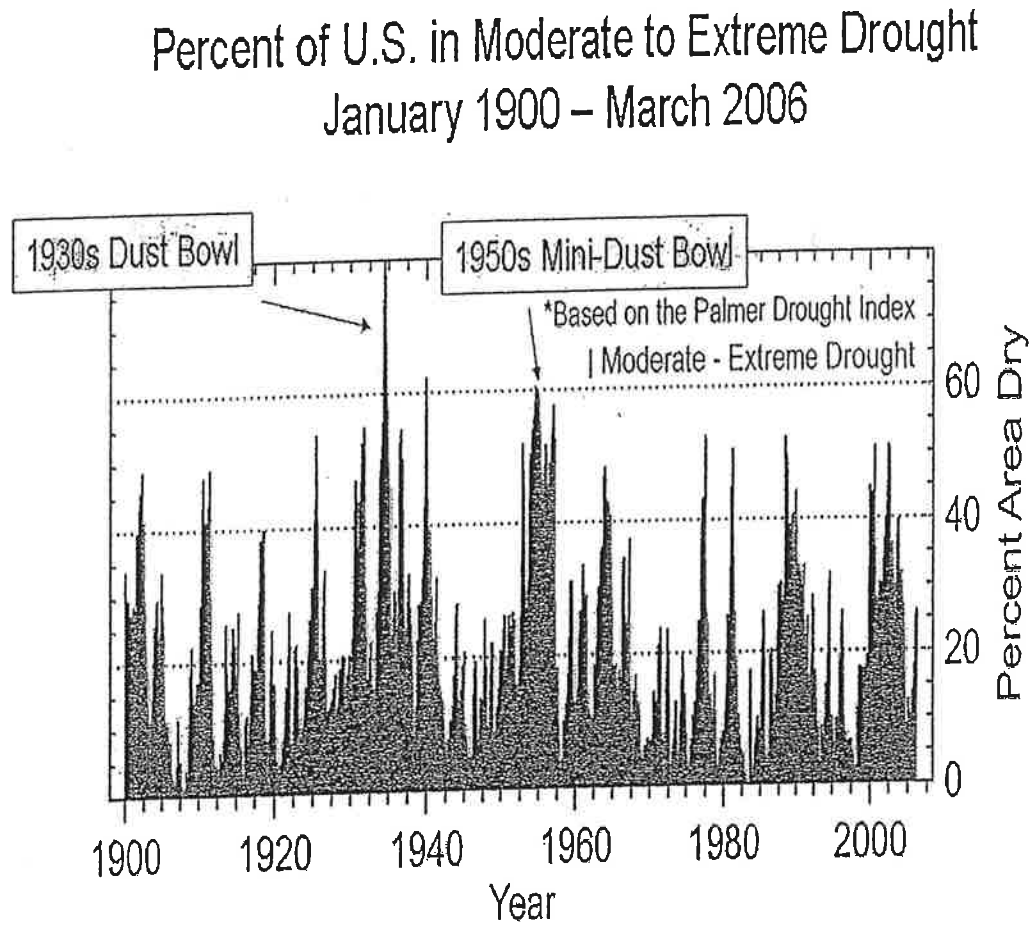

Figure 8: The percentage of the contiguous U.S. land area in moderate to severe drought (NOAA, National Climatic Data Center).

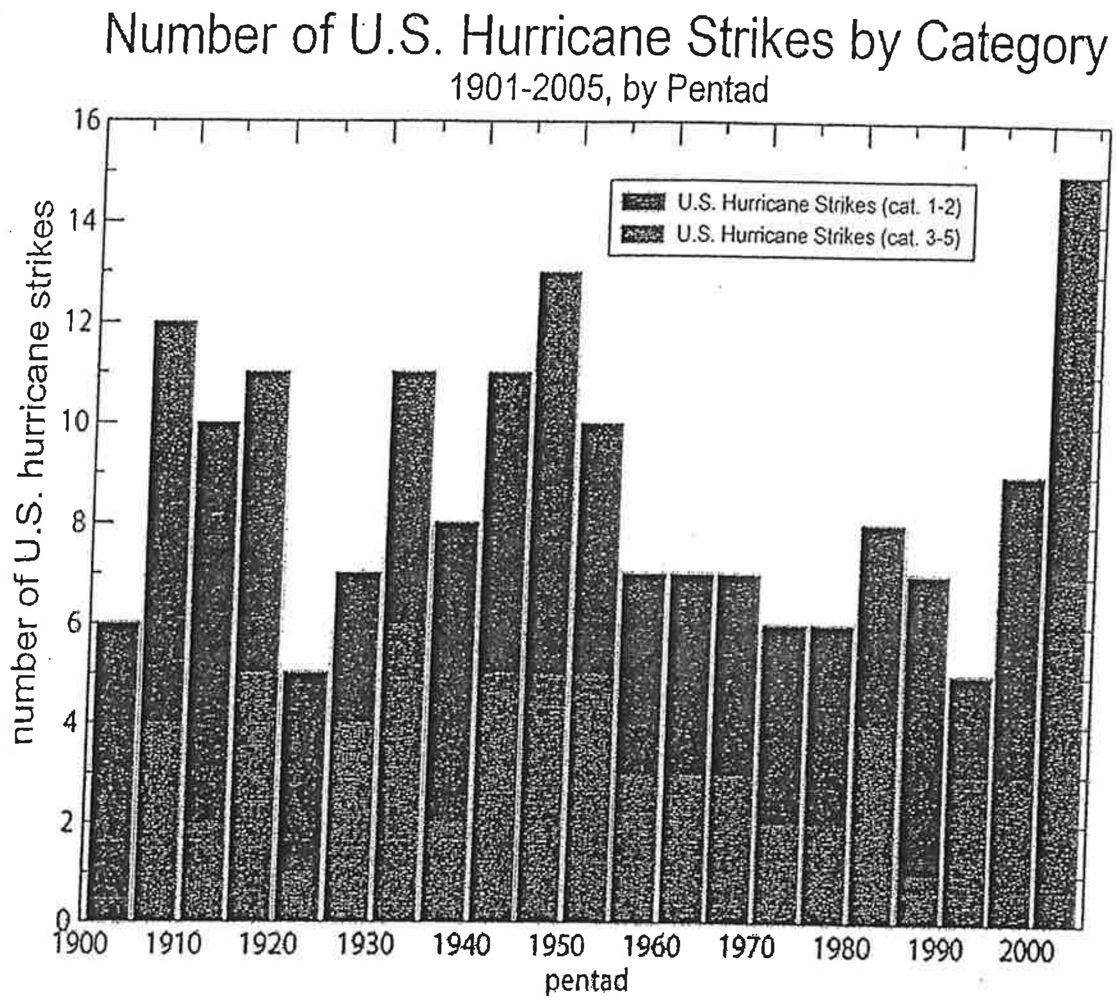

Figure 9: The number of hurricanes striking the U.S. summed by five year periods (e.g. 1901-1905, 1906-1910, etc.). The red bar is the number of major hurricanes (category 3-5) and blue bar is the number of weaker category 1 and 2 hurricanes per five year period (pentad). (NOAA, National Climatic Data Center)

More OMB Comments
7/20/06 HRG

Kelly Brown/HCHB/Osnet
07/18/2006 02:37 PM

To Noel.Turner[redacted]
cc
bcc
Subject Fw: LRM EHF511 - - Two pieces of COMMERCE Oversight Testimony on Climate Change

Hi Noel,

These comments are in addtion to the two CEQ edits we just discussed for the Conclusion paragraph on page 10 (replacing "dominated" with "affected", and deleting the last sentence).

Please let me know the NOAA responses to these comments. Thanks very much. -Kelly

Kelly Brown
Office of the Assistant General Counsel
for Legislation and Regulation
U.S. Department of Commerce
Phone: [redacted]
Fax: [redacted]
Internet: [redacted]

----- Forwarded by Kelly Brown/HCHB/Osnet on 07/18/2006 02:35 PM -----

"Fitter, E. Holly"
[redacted]@omb[redacted]
07/18/2006 02:31 PM

To "Kelly Brown"[redacted]doc.gov>
cc
Subject FW: LRM EHF511 - - Two pieces of COMMERCE Oversight Testimony on Climate Change

Preliminary thoughts from omb. Many requests for citations of statements made.

From: Gray, Jason
Sent: Tuesday, July 18, 2006 11:36 AM
To: Fitter, E. Holly
Subject: RE: LRM EHF511 - - Two pieces of COMMERCE Oversight Testimony on Climate Change

<<M 6 Climate Change Testimony for July 20 to OMB 430 pm 7-14-06_EBR.doc>>

M 6 Climate Change Testimony for July 20 to OMB 430 pm 7-14-06_EBR.doc

WRITTEN STATEMENT BY
DR. THOMAS R. KARL
DIRECTOR, NATIONAL CLIMATIC DATA CENTER
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)
U.S. DEPARTMENT OF COMMERCE

FOR AN OVERSIGHT HEARING:
INTRODUCTION TO CLIMATE CHANGE

BEFORE THE
COMMITTEE ON GOVERNMENT REFORM
U.S. HOUSE OF REPRESENTATIVES

JULY 20, 2006

Mr. Chairman and Members of the Committee: As Director of the National Climatic Data Center, which is part of the National Environmental Satellite, Data, and Information Service (NESDIS) within the National Oceanic and Atmospheric Administration (NOAA), and as Program Manger for one of five different NOAA Climate Goal Programs (Climate Observations and Analysis), I am pleased to have the opportunity to testify before you today. The National Climatic Data Center is the world's largest archive of weather and climate data, which includes data critical to understanding climate variability and change, and also acts as the Nation's Scorekeeper regarding the trends and anomalies of weather and climate.

The U.S. Climate Change Science Program integrates federal research on global climate change, as sponsored by thirteen federal agencies.[1] Since CCSP was created in 2002, the program has successfully integrated a wide range of research, climate science priorities and budgets of the thirteen CCSP agencies. ~~With an approximately $2 billion annual expenditure,~~ CCSP has taken on the most challenging questions in climate science and is developing products to convey the most advanced state of knowledge to be used by federal, state and local decision makers, resource managers, the science community, the media, and the general public. Over the next two years CCSP will be completing a series of 21 Synthesis and Assessment Reports, the first of which was just released a few months ago. The collection of these Synthesis and Assessment Report will address many of the issues pertinent to this testimony.

I will provide an overview of our basic understanding of the atmosphere in terms of: the role that greenhouse gases play in the atmosphere; evidence for how greenhouse gases

[1] The CCSP participating agencies include the Departments of Agriculture, Commerce, Defense, Energy, Health and Human Services, the Interior, State, and Transportation, the National Science Foundation, the Environmental Protection Agency (EPA), the National Aeronautics and Space Administration (NASA), U.S. Agency for International Development, and the Smithsonian Institution. Additional CCSP liaisons reside in the Office of Science and Technology Policy, the Council on Environmental Quality, the National Economic Council and the Office of Management and Budget.

are already influencing the climate in both general and in specific ways; a short tutorial on the use of global climate models and; how we know global temperatures are increasing.; ~~and why we think it is very likely (>95 percent probability) that humans are largely responsible for many of the observed general and specific changes in climate over the past several decades.~~

Comment [A1]: Who is we? Where did this come from?

APR 7/18 Jason Gray OMB → HFAFER

Atmospheric Composition and Greenhouse Gases

The natural "greenhouse" effect is real, and is an essential component of the planet's climate process. A small percentage (roughly 2 percent) of the atmosphere is, and long has been, composed of greenhouse gases (water vapor, carbon dioxide, ozone and methane). These gases effectively prevent part of the heat radiated by the Earth's surface from otherwise escaping to space. The response of the global system to this trapped heat is a climate that is warmer than it would be otherwise without the presence of these gases. In the absence of these greenhouse gases the temperature on Earth would be too cold to support life as we know it today. Of all the greenhouse gases, water vapor is by far the most dominant, but other the gases are more effective at trapping heat energy from certain portions of the electromagnetic spectrum whereas water vapor is semi-transparent to heat escaping from the Earth's surface.

haven't seen this before - what's source? is it his personal opinion; -vs- Admin's position? OMB is open to revising (vs- deletion)

In addition to the natural greenhouse effect outlined above, there is a change underway in the greenhouse radiation balance. Some greenhouse gases are increasing in the atmosphere because of human activities and increasingly trapping more heat. Direct atmospheric measurements made over the past 50 years have documented the steady growth in the atmospheric abundance of carbon dioxide. In addition to these direct real-time measurements, ice cores have revealed the atmospheric carbon dioxide concentrations of the distant past. Measurements using air bubbles trapped within layers of accumulating snow show that atmospheric carbon dioxide has increased by nearly 35 percent over the Industrial Era (since 1750), compared to the relatively constant abundance of carbon dioxide over at least the preceding 750 years of the past millennium (Figure 1). The predominant cause of this increase in carbon dioxide is the combustion of fossil fuels and the burning of forests. Further, methane abundance has doubled over the Industrial Era, but the increase of methane has slowed over the recent decade for reasons not clearly understood. Other heat-trapping gases are also increasing as a result of human activities. We are unable to state with certainty the exact rate at which these gases will continue to increase because of uncertainties in future emissions, as well as uncertainties regarding how these emissions will be taken up by the atmosphere, land, and oceans. We are certain, however, that once in the atmosphere these greenhouse gases have a relatively long life-time, on the order of decades to centuries. This means they become well mixed throughout the globe.

The increase in heat-trapping greenhouse gases is projected to be amplified by feedback effects, such as changes in water vapor, snow cover, and sea ice. As atmospheric concentrations of carbon dioxide and other greenhouse gases increase, the resulting increase in surface temperature leads to less sea ice and snow cover helping to raise temperatures even further. As snow cover and sea ice decrease, more of the Sun's energy

is absorbed by the planet, instead of being reflected back to space by the snow cover and sea ice. Present evidence also suggests that as greenhouse gases lead to temperature increases, evaporation increases leading to more atmospheric water vapor. Additional water vapor (which, as mentioned above, is ~~a~~ the dominant greenhouse gas) acts as a very important feedback to further increase temperature. Our present understanding suggests that these feedback effects account for about 60 percent of the warming. The magnitude of these feedback effects, and others such as changes in clouds, remains a significant source of uncertainty related to our understanding of the impact of increasing greenhouse gases. For example, increases in evaporation and water vapor affect global climate in other ways besides increasing temperature such as increasing rainfall and snowfall rates, and accelerating drying during droughts. The increase in greenhouse gas concentrations in the atmosphere implies a positive radiative forcing, i.e., a tendency to warm the climate system.

Particles (or aerosols) in the atmosphere resulting from human activities can also affect climate. Aerosols vary considerably by region. Some aerosol types act in a sense opposite to the greenhouse gases and cause a negative forcing or cooling of the climate system (e.g., sulfate aerosol). Other aerosols act in the same way as greenhouse gases, and warm the climate (e.g., soot). In contrast to the long-lived nature of carbon dioxide (centuries), aerosols are short-lived and removed from the lower atmosphere within a few days. Therefore, human-generated aerosols exert a long-term forcing on climate only because their emissions continue each day of the year. Aerosol effects on climate can be manifested directly by their ability to reflect and trap heat, but they can also have an indirect effect by changing the lifetime of clouds and changing the clouds reflectivity to sunshine. The magnitude of the negative forcing of the indirect effect of aerosols is highly uncertain, but may be larger than the direct effect of aerosols.

Comment [A2]: It may be helpful to expand upon how these aerosols cool the climate system.

Emissions of greenhouse gases and aerosols continue to alter the atmosphere in ways that are expected to affect the climate. There are also natural factors which exert a forcing on climate, e.g., changes in the Sun's energy output and short-lived (a few years) aerosols in the stratosphere following episodic and explosive volcanic eruptions. The decadal time-scale forcing estimates of the greenhouse gases are larger than all the other forcings over the past several decades and continue to grow disproportionately larger.

Human activities also have a large-scale impact on the land surface. Changes in land use through urbanization and agricultural practices, although not global, are often most pronounced where people live, work, and grow food, and are part of the human impact on climate. Large-scale deforestation and desertification in Amazonia and the Sahel, respectively, are two instances where evidence suggests there is likely to be human influence on regional climate. In general, city climates differ from those in surrounding rural green areas, because of the "concrete jungle" and its effects on heat retention, runoff, and pollution, resulting in urban heat islands.[2]

Comment [A3]: Should provide the citation that supports this statement.

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[2] The global impact of these urban heat islands has been extensively analyzed and assessed to ensure measurements of global temperature are not biased by local urban heat islands.

There is no doubt that the composition of the atmosphere is changing because of human activities, and today greenhouse gases are the largest human influence on global climate.

What exactly is a climate model and why is it useful?

Many of the laws governing climate change and the processes involved can be quantified and linked by mathematical equations. Figure 2 shows schematically the kinds of processes that can be included in climate models. Among these are many earth system components such as atmospheric chemistry, ocean circulation, sea-ice, land-surface hydrology, biogeochemistry, atmospheric circulation, etc. The physics of many of the processes governing climate change are well understood, and may be described by mathematical equations. Linking these equations creates mathematical models of climate that may be run on computers or super-computers. Coupled climate models can include mathematical equations describing physical, chemical, and biogeochemical processes.

In fact, coupled climate models are the preferred way to approach climate modeling. This is because if we put all our understanding into a single model, it would be too complex to run on any existing computer systems. The decisions for how to build any given climate model includes trade-offs between the complexity of the model and number of Earth system components included, the horizontal and spatial resolution within the model, and the number of years of simulations the model can produce per day of computer time. Consequently, there is a hierarchy of model complexity, often based on the degree to which approximations are required for each model or component processes omitted.

Approximations in climate models represent aspects of the models that require parameter choices and "tuning." This "tuning" is referred to as model parameterization. As a simple example, imagine a single cumulus cloud and how it has to be represented in a global climate model. The cloud may only encompass only a few hundred meters in the vertical and horizontal extent, which is much finer resolution than can be run on today's coupled atmosphere and ocean climate models. This then means that in order to incorporate such clouds into the climate model, some approximations have to be made regarding the statistical properties of such clouds within say an area 100 or 1000 times larger than the cloud itself – because this area is the level of resolution the model can accept. A similar approach is also required in today's state-of-the-science weather forecasting models.

An important difference between weather forecasting models and climate models is that weather models are initialized with a specific set of observations representing today's weather to precisely predict the weather "x" days or hours into the future. The initial starting conditions of the climate models, however, are not nearly as important. Climate models are used to simulate many years of "weather" into the future with the intent of understanding the difference in the collection of weather events at some point in the future, compared to some other time in the past (often the climate of the last 30 years or so). This comparison enables scientists to study the output of climate model simulations to understand the effect of various modifications of those aspects of the climate system that might cause the climate to change. A key challenge in climate modeling is to isolate and identify cause and effect – which requires knowledge about the

changes and variations of the external forcings controlling climate, and a comprehensive understanding of climate feedbacks (such as a change in the earth's reflectivity because of a change sea ice or cloud amount) and natural climate variability.

Model simulations of climate over specified periods can be verified and validated against the observational record. Models that prove to describe climate variability and change well can be used as a tool to increase our understanding of the climate system. Once evaluated and validated, climate models can then be used for predictive purposes. Given specific forcing scenarios, climate models can provide viable projections of future climate. In fact, climate models have become the primary means to predict climate, although prediction is ultimately likely to be achieved through a variety of means, including the observed rate of global climate change.

How do we know the global air temperature is increasing?

There has now been a comprehensive analysis of the changes of temperatures near the surface and throughout much of the atmosphere in the ~~recent~~ April 2006 Climate Change Science Program (CCSP) Synthesis and Assessment Report 1.1. This report addressed the nagging issue of differences in the rate of warming between measurements derived near the surface and those taken from the atmosphere. The surface air temperatures are derived from several different analyses teams using various combinations of ocean ships and buoys, land observations from weather reporting stations, and satellite data. Atmospheric data sets have been derived using satellites, weather balloons, and a combination of the two.

Considering all the latest satellite, balloon and surface records, the CCSP report concluded there is no significant discrepancy between the rates of global temperature change over the past several decades at the surface compared to changes higher in the atmosphere. The report does, however, acknowledge there are still uncertainties in the tropics, and this is primarily related to data from weather balloons. There is uncertainty as to whether scientists have been able to adequately adjust for known biases and errors in the data, especially in the tropics where many developing nations struggle to routinely launch weather balloons and process these measurements.

Globally, data indicate the rates of temperature change have been similar throughout the atmosphere since 1979 when satellite data were first available, and the rates of temperature change have been slightly greater in the atmosphere compared to the surface air temperature since 1958 (the time at which weather balloons had adequate spatial coverage for global calculations). The global surface temperature time series, shown in Figure 3, indicates warming on even longer time scales, with acceleration since 1976.

Instrumental measurements are not our only evidence for increasing global temperatures. The observed increased melting of glaciers can be used to estimate the rate of temperature increase since the late 19^{th} Century. Estimates of the near-surface temperature based on glacial melting are very similar to estimates based on instrumental data. There has been a 15-20 percent reduction in Arctic sea ice since the 1970s, a 10 percent decrease in snow cover since the 1970s, and shortened periods of lake and river ice cover (about 2 weeks shorter since the 19th century). Also, ocean heat content has significantly increased over the past several decades.

Why do we think humans are influencing the Earth's climate?

The scientific community has been actively working on detection and attribution of climate change as related to human activities since the 1980s. As described above, one set of tools often used to examine these issues are mathematical computer models of the climate. Outstanding issues in modeling include specifying forcing mechanisms (e.g., the causes of climate variability and change) within the climate system; properly dealing with complex feedback processes that affect carbon, energy, and water sources, sinks and transports; and improving simulations of regional weather, especially extreme events. Today's inadequate or incomplete measurements of the various forcing mechanisms, with the exception of well-mixed greenhouse gases, add uncertainty when trying to simulate past and present climate. Confidence in our ability to predict future climate depends on our ability to use climate models to attribute past and present climate change to specific causes.

Recent carbon dioxide emission trends in the United States are upward, as are global emissions trends, with increases between 0.5 and 1 percent per year over the past few decades. Concentrations of both reflective and nonreflective aerosols are also estimated to be increasing. Radiative forcings[3] from greenhouse gases dominate over the net cooling forcings from aerosols and the global temperature has exceeded the bounds of natural variability. This has been the case since about 1980. By raising the air temperature, the capacity of the atmosphere to hold more water vapor is increased, which defines the upper bounds of the amount of precipitation that can occur during short term (~daily or less) extreme precipitation events.

Comment [A4]: Citations?

As an example of how models are used to detect human influence on the climate system Figure 4 shows that without including all the observed forcing mechanisms the models cannot replicate the observed global temperature changes. There are many other aspects of the climate system besides global surface temperatures that have been tested for human influences. Today, there is convincing evidence from a variety of model and data climate attribution studies pointing to human influences on climate. These include regional analyses of changes in temperature, the paleoclimatic[4] temperature record, three

Comment [A5]: Insufficient evidence here that it is "convincing".

[3] Radiative forcing is the change in the net vertical irradiance (expressed in Watts per square meter: Wm^{-2}) at the tropopause due to an internal change or a change in the external forcing of the climate system, such as, for example, a change in the concentration of carbon dioxide or the output of the Sun.

[4] Climate during periods prior to the development of measuring instruments, including historic and geologic time, for which only proxy climate records are available. A proxy climate indicator is a local record that is interpreted, using physical and biophysical principles, to represent some combination of climate-related variations back in time. Climate-related data derived in this way are referred to as proxy

dimensional analysis of atmospheric temperature change, changes of free atmospheric temperature, changes in sea ice extent and other components of the cryosphere, changes in ocean heat content, and new studies on extreme weather and climate events. Thus, there is considerable confidence that the observed warming, especially the period since 1970s is mostly attributable to increases in greenhouse gases.

Comment [A6]: Should provide citations for the specific studies referenced

Changes in Extremes in the United States

The U.S. Climate Change Science Program Synthesis and Assessment Report 3.3 will specifically address the issue of changes in extreme events, focusing on North America. This assessment plans on comprehensively assessing a wide range of climate-related extreme events and promises to help clarify what we know and do not yet understand about these important events, as related to climate change. Here, three types of climate extremes are discussed as they are likely to be influenced by rising global temperatures. This includes changes the frequency and intensity of heavy and extreme precipitation events, droughts, and hurricanes.

Increasing air temperature leads to increased water vapor in the atmosphere. Surface moisture, if available (as it always is over the oceans), effectively acts as the "air conditioner" of the surface – as heat used for evaporation moistens the air rather than warming it. Therefore, another consequence of global heating of the lower troposphere is accelerated land-surface drying and more atmospheric water vapor (the dominant greenhouse gas). Satellite measurements now confirm a significant increase in atmospheric water vapor, consistent with theoretical expectations given the rate of observed atmospheric warming during the past several decades. Accelerated drying, without an increase in precipitation, increases the incidence and severity of droughts, whereas additional atmospheric water vapor increases the risk of heavy precipitation events. Increases in global temperature also increase sea surface temperatures, one of several important factors affecting the hurricane intensity.

NOAA's National Climatic Data Center calculates a Climate Extremes Index (CEI) over the United States that includes extremes related to all of these indicators including temperature, precipitation, drought and hurricanes. Although no index can claim to adequately capture all of the important changes in extremes, the changes and variations of the CEI as reflected in Figure 5 is illustrative of the varying decadal variability of climate extremes. Currently, the CEI is at record levels during the past decade or so, but not much higher than in previous decades, and so there is no clear indication of a general increase in the aggregate set of extremes included in the CEI when viewed across much of the 20th Century.

Changes in Heavy and Extreme Precipitation

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data. Examples of proxies are: tree ring records, characteristics of corals, and various data derived from ice cores.

Basic theory, climate model simulations, and empirical evidence (Figure 6) confirm that warmer climates, owing to increased water vapor, lead to more intense precipitation events even when the total precipitation remains constant, and with prospects for even stronger events when precipitation amounts increase. Figure 7 depicts the aggregate land-surface world-wide changes in heavy precipitation events over the last half of the 20th century with an associated geographic depiction of where changes in heavy precipitation have occurred, with most areas showing increases. World-wide, an increase of a few percent in heavy precipitation events is evident since the middle of the 20th century, particularly in the middle and high latitudes. By the end of the 21st Century a 10-20 percent increase in the precipitation rate for 1-day extreme precipitation events (20 year return periods) is in the middle range of a variety of climate models, when forced with a rather conservative change in atmospheric greenhouse gases: Carbon dioxide does not exceed 550 ppmv[5].

The practical implications of addressing these changes are seen in NOAA's recent update of the Ohio River Basin's 100-year 24-hour precipitation return period. Over the past several decades increases in precipitation rates for the 1 in 100 year extreme daily precipitation amount was observed in many areas of the eastern United States over the past several decades. These data are used to help set engineering design standard related to excessive rainfall.

Changes in Drought Severity and Frequency

Drought is a recurring feature of the climate system. In other words, we have had major droughts in the past, and expect to have major droughts in the future. At any given time, at least part of the U.S. is in drought, with percentages ranging from 5-80 percent of the total land area. U.S. droughts show pronounced multi-year to multi-decadal variability, but no convincing evidence for systematic long-term trends toward more or fewer events. Drought calculations have been made showing that over the U.S, the increase in temperatures that may have lead to increased evaporation have been compensated by a general increase in precipitation over the past few decades. In general, there are no clear patterns of precipitation increase emerging from climate model simulations as global temperatures increase, so the increase in precipitation over the past few decades may not persist and could reverse. Such a reversal, added to the continuing increase in temperatures (January through June of 2006 have been the warmest temperatures in U.S. records dating back to 1895) could lead to greater drought severity and frequency, especially during periods of dry weather due to increases in evaporation.

For the continental U.S., the most extensive U.S. drought in the modern observational record occurred from 1933 to 1938. In July 1934, 80 percent of the U.S. was gripped by moderate or greater drought (Figure 8), and 63 percent was experiencing severe to extreme drought. During 1953-1957, severe drought covered up to 50 percent of the country. Paleoclimatic data (e.g. tree ring measurements) have been used to reconstruct drought patterns for the period prior to the modern instrumental record. These

[5] Such a scenario is built on the storyline of relatively low population growth and with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies.

reconstructions show that during most of the past two millennia the climate of the western U.S. has been more arid than at present. The recent intense Western drought from 1999 to 2004 that strongly affected the Colorado River basin was exceeded in severity as recently as the 19th century. Within the past millennium there have been severe droughts in both the western U.S. and Midwest that have lasted for multiple decades.

Long-term warming trends have led to changes in the timing of snow melt and stream flows, especially in the West. This is resulting in earlier peak stream flows and diminished summer-time flows.

Changes in Hurricane Intensity and Frequency

Tropical storms and particularly hurricanes, are an important issue of concern for the United States. The unprecedented hurricane season of 2005, and especially the havoc created by Katrina, raised public awareness of the dangers of hurricanes to new heights. Hurricanes respond to a number of environmental factors including ocean temperatures, atmospheric stability, El Niño, and other factors. One important question is whether hurricane activity has changed over the last 100 years. Since 1995, Atlantic hurricane activity has significantly increased, with more hurricanes, and more intense hurricanes, compared to the two previous decades (Figure 9). However, earlier periods, such as the 1945 to 1970 period were nearly as active.

Comment [A7]: Figure 9 doesn't explicitly support this statement as it presents only the number of hurricanes striking the U.S.

An important consideration in hurricane intensity is a trend toward warmer sea surface temperatures, particularly in the tropical Atlantic and Gulf of Mexico, indicating climate change may play some role in the increased hurricane intensity. Another factor is a slow cycle of natural fluctuations in atmospheric conditions and ocean temperatures in the North Atlantic referred to as the Atlantic Multi-decadal Oscillation (AMO). This AMO is currently in a warm ocean temperature phase.

What does the future hold for hurricane activity? In the near term, it is expected that favorable conditions for Atlantic hurricanes will persist for the next decade or so based on previous active periods. For the longer term, climate models simulate about a ½ Category increase (approximately 6 percent increase in wind speed) in the intensity of strong hurricanes late in the 21st Century, with a tropical sea surface temperature increase of nearly 2°C higher than at present. The models also simulate about a 20 percent increase in near-storm rainfall rates under those conditions. However, it is unclear if the total number of hurricanes will change in future years.

New analyses of precipitation rates for different strengths of landfalling Atlantic tropical cyclones (both hurricanes and tropical storms) over the southeastern United States have recently been completed. These analyses show that daily precipitation amounts increase with tropical cyclone strength, while hourly precipitation does not. This means that the more intense hurricanes have longer periods with heavy rainfall. The implications are relevant for local planning, if indeed tropical cyclone strength increases in the future.

Comment [A8]: Citations?

Overall, the issue of hurricanes and climate change is an ongoing debate. The scientific community has varying viewpoints on the magnitude of influence of global climate change on hurricanes and how long the current active period will last. NOAA recognizes the debate and continues to study hurricane development, intensity, activity, and modeling.

Conclusion

The state of the science continues to indicate that modern climate change is dominated by human influences, specifically human-induced changes in atmospheric composition. These perturbations primarily result from emissions associated with energy use, but on local and regional scales, urbanization and land use changes are also important. While there is still considerable uncertainty about the rates of change that can be expected, it is clear these changes will be increasingly manifested in important and tangible ways, such as changes in extremes of temperature and precipitation, decreases in seasonal and perennial snow and ice extent, sea level rise, and now there is accumulating evidence to suggest that there will be increases in hurricane intensity and related heavy and extreme precipitation. Furthermore, while there has been progress in monitoring and understanding climate change, there remain many scientific, technical, and institutional impediments to precisely planning for, adapting to, and mitigating the effects of climate change. In many respects we are venturing into the unknown territory with changes in climate, and its associated effects.

Comment [A9]: The testimony does not seem to adequately demonstrate/support this statement.

Thank you again, Mr. Chairman for allowing me the opportunity to help inform the Committee about climate change.

Modeling the Climate System

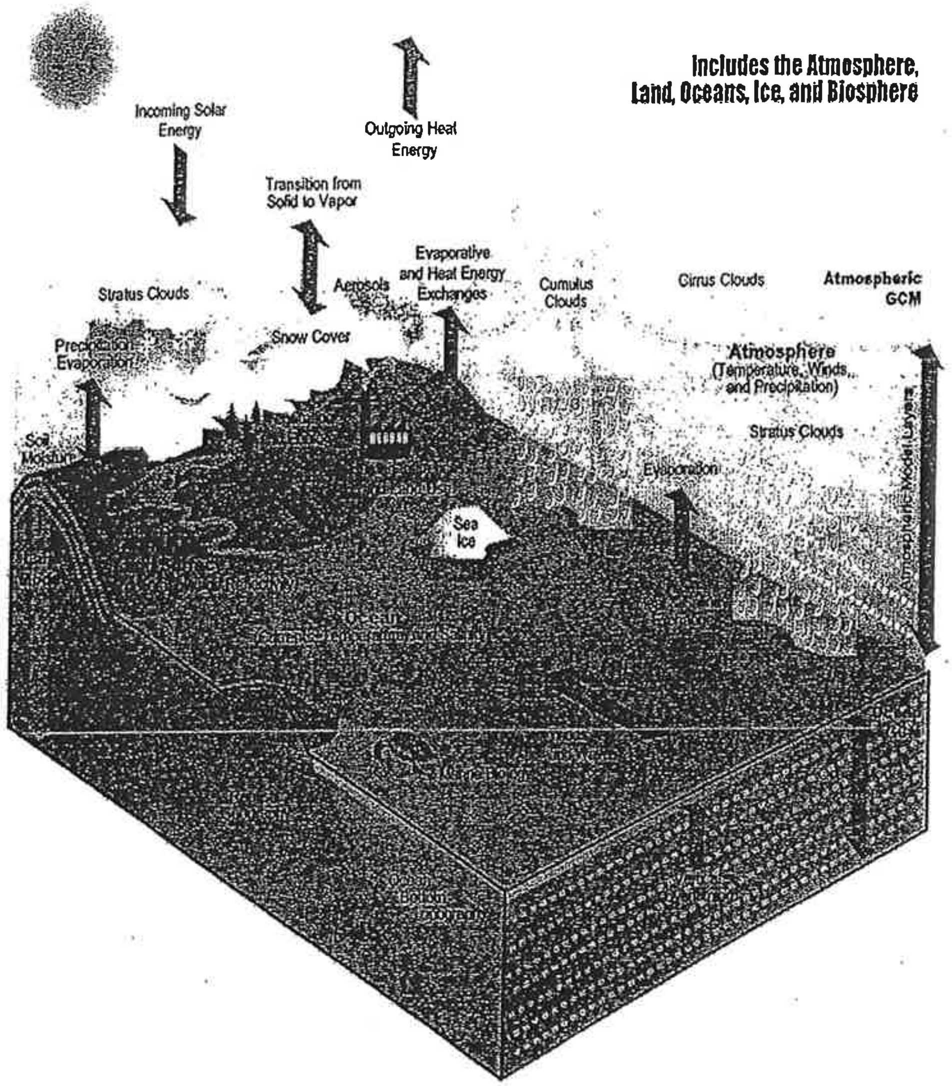

Figure 2. Components of the climate system and the interactions among them, including the human component. All these components have to be modeled as a coupled system that includes the oceans, atmosphere, land, cryosphere, and biosphere.

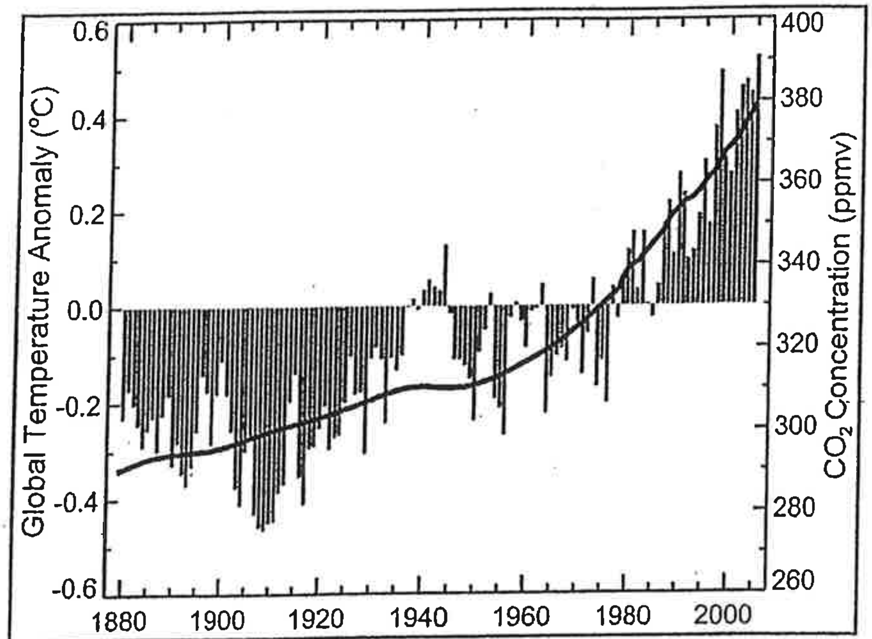

Figure 3: Globally averaged surface air temperature and carbon dioxide concentration (parts per million by volume) since 1880 (Updated from Karl and Trenberth, 2002).

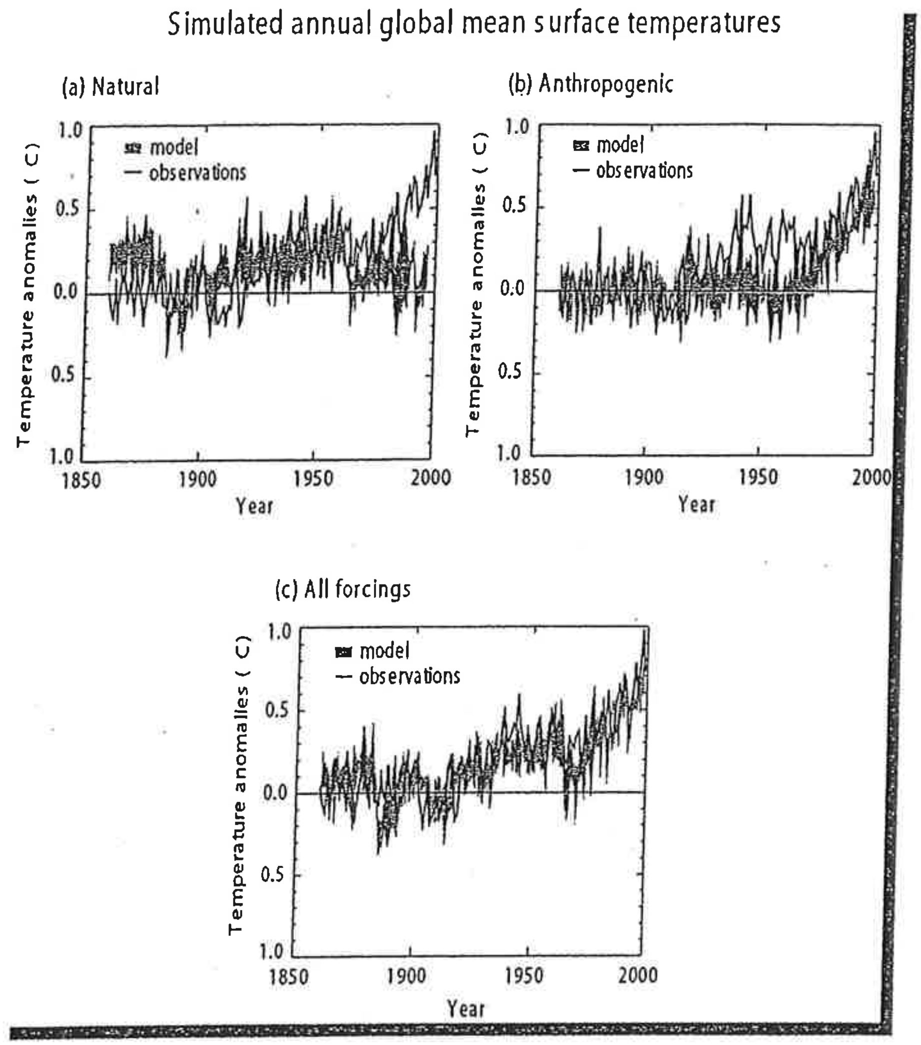

Figure 4: Climate model simulations of the global air temperature for the period 1860-2000. Figure 4~~3~~a includes only natural forcing mechanisms such as volcanic eruptions and solar variability; 4~~3~~b includes only anthropogenic greenhouse gas increases; and 4~~3~~c includes both natural and anthropogenic forcing mechanisms (from IPCC 2001).

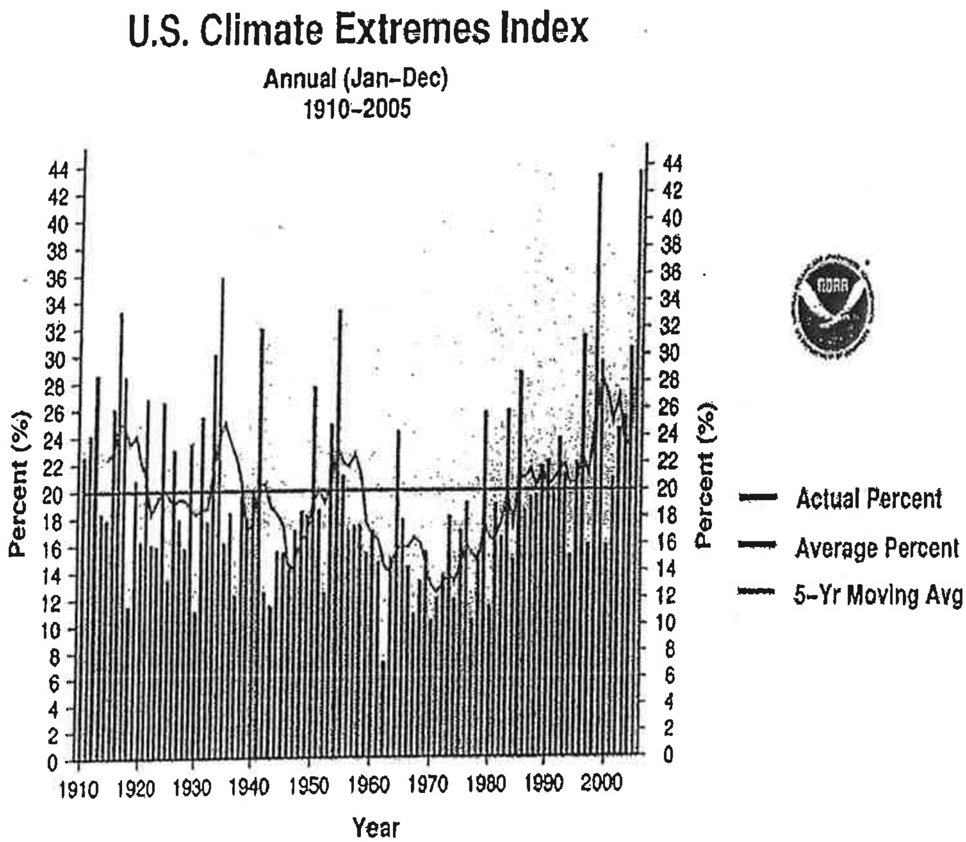

Figure 5: The U.S. Climate Extremes Index (CEI) is the average of the percent of U.S. land area experiencing extremes in temperatures, drought, precipitation, and tropical storms. More detailed information on the CEI is available at http://www.ncdc.noaa.gov/oa/climate/research/cei/cei.html.

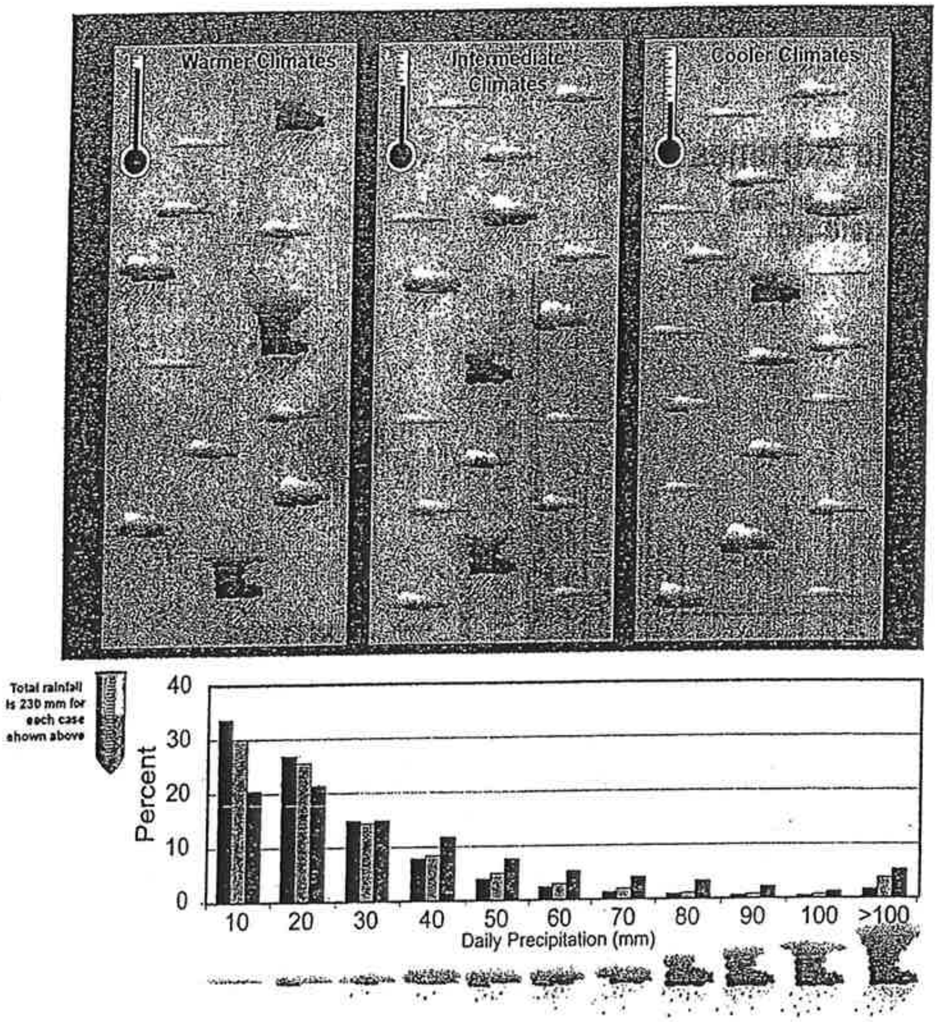

Figure 6: The diagram shows that warmer climates (red) have a higher percentage of total rainfall coming from heavy and very heavy events. The data are based on a worldwide distribution of observing stations, but each have the same seasonal mean precipitation amount of 230 (±5) mm. For cool climates (blue), there are more daily precipitation events than in warmer climates (Adapted from Karl and Trenberth, 2002). The various cloud and rain symbols reflect the various daily precipitation rates and have been categorized in the top panel of this figure to reflect the approximate proportion of the various precipitation rates for cool, moderate, and warm climates across the globe.

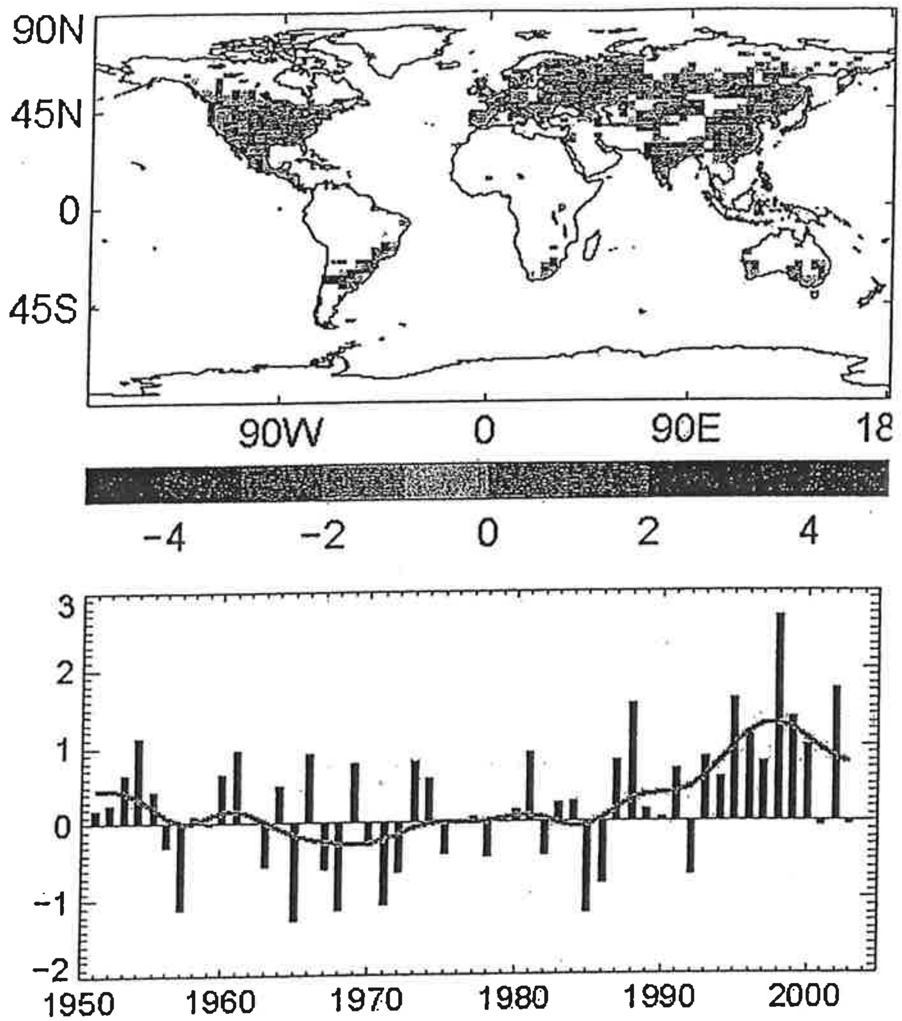

Figure 7: Changes in the contribution of heavy precipitation events to the annual total amount. Globally there has been a change of nearly two percent since the mid-20th century (from Alexander et al., 2006: Global observed changes in daily climate extremes of temperature and precipitation. *J. Geophys. Res.*, D05109, doi:10.1029/2005JD006290).

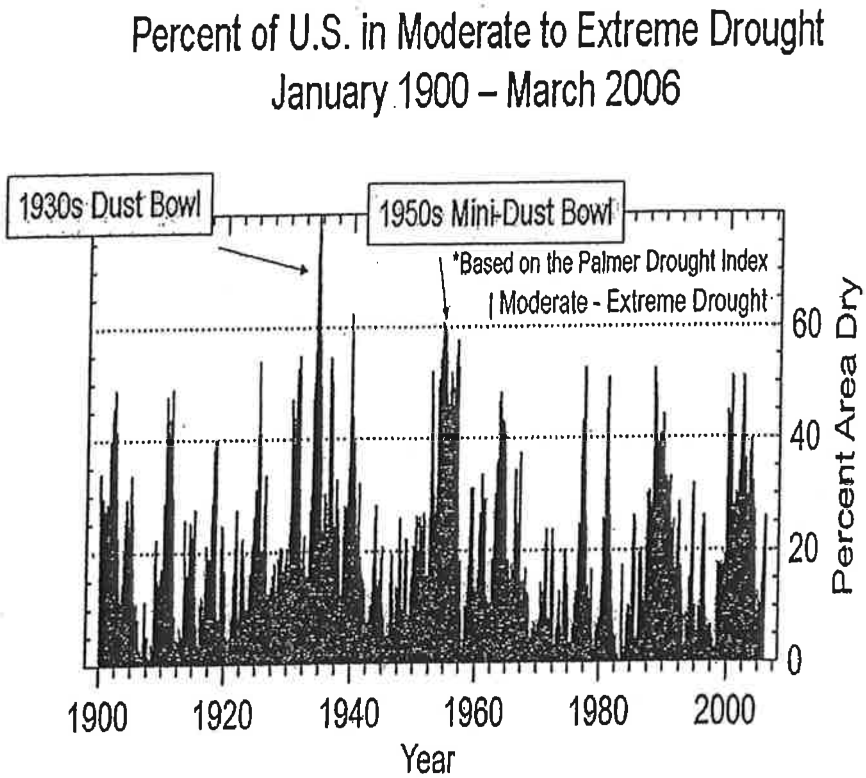

Figure 8: The percentage of the contiguous U.S. land area in moderate to severe drought (NOAA, National Climatic Data Center).

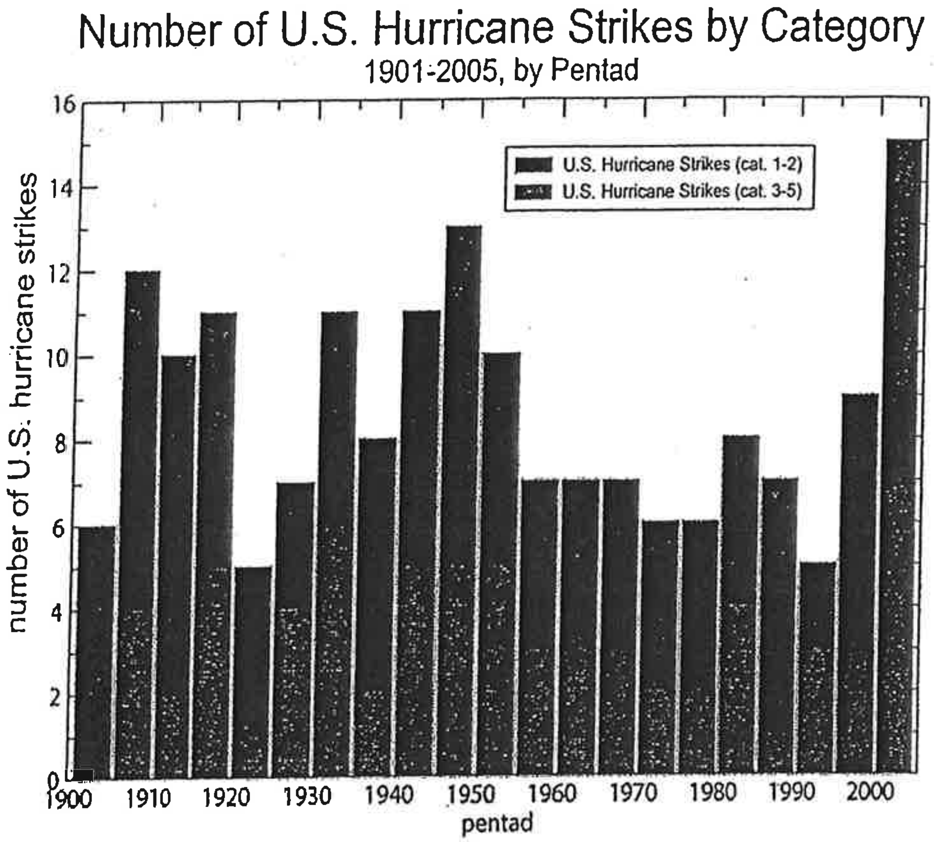

Figure 9: The number of hurricanes striking the U.S. summed by five year periods (e.g. 1901-1905, 1906-1910, etc.). The red bar is the number of major hurricanes (category 3-5) and blue bar is the number of weaker category 1 and 2 hurricanes per five year period (pentad). (NOAA, National Climatic Data Center)

7/20 Hrg - Copy (OMB on Overview

"Fitter, E. Holly" <[redacted]Holly_Fitter[redacted]omb[redacted]

07/17/2006 01:31 PM

To "Kelly Brown" <[redacted]@doc.gov>, "Pete Dalmut" <[redacted]@doc.gov>

cc "Gray, Jason" <[redacted]@omb.eop.gov>, "Rainey, Robert H." [redacted]@ceq.eop.gov>

bcc

Subject OMB Commerce Branch comments on LRM EHF511 - - Two pieces of COMMERCE Oversight Testimony on Climate Change

<u>DOC</u>: Please advise of any problems with these (I see Lewis has already sent directly to you). Please know that you will be receiving additional comments from OMB and others later today and tomorrow morning.

<u>Jason Gray/Bob Rainey</u>: Please provide your comments later today on Hockey stick - you can piggy back on this markup if it makes sense, otherwise, just provide your comments. Thanks.

The goal is to get all of the comments on hockey stick to DOC tonight and all the comments on the 7/20 hearing to commerce tomorrow morning.

From: McCulloch, Lewis D.
Sent: Monday, July 17, 2006 1:26 PM
To: Fitter, E. Holly
Cc: Lyon, Randolph M.;[redacted]Brown[redacted];[redacted]Dalmut[redacted]
Subject: RE: LRM EHF511 - - Two pieces of COMMERCE Oversight Testimony on Climate Change

Holly,

Here are Commerce Branch comments on the two pieces of climate change testimony. These comments are focused on clarifying the testimony and do not impact the scientific judgment expressed within. Please let me know if you have any questions.

Thanks,
Lewis

<<M 6 Climate Change Testimony for July 20 to OMB 430 pm 7-14-06-OMCcomments.doc>> <<Hockey Stick testimony for July 19 DOC_OMBcomments.doc>>

M 6 Climate Change Testimony for July 20 to OMB 430 pm 7-14-06-OMCcomments.doc

Hockey Stick testimony for July 19 DOC_OMBcomments.doc

WRITTEN STATEMENT BY
DR. THOMAS R. KARL
DIRECTOR, NATIONAL CLIMATIC DATA CENTER
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)
U.S. DEPARTMENT OF COMMERCE

FOR AN OVERSIGHT HEARING:
INTRODUCTION TO CLIMATE CHANGE

BEFORE THE
COMMITTEE ON GOVERNMENT REFORM
U.S. HOUSE OF REPRESENTATIVES

JULY 20, 2006

Mr. Chairman and Members of the Committee: As Director of the National Climatic Data Center, which is part of the National Environmental Satellite, Data, and Information Service (NESDIS) within the National Oceanic and Atmospheric Administration (NOAA), and as Program Manger for one of five different NOAA Climate Goal Programs (Climate Observations and Analysis), I am pleased to have the opportunity to testify before you today. The National Climatic Data Center is the world's largest archive of weather and climate data, which includes data critical to understanding climate variability and change, and also acts as the Nation's Scorekeeper regarding the trends and anomalies of weather and climate.

The U.S. Climate Change Science Program integrates federal research on global climate change, as sponsored by thirteen federal agencies.[1] Since CCSP was created in 2002, the program has successfully integrated a wide range of research, climate science priorities and budgets of the thirteen CCSP agencies. With an approximately $2 billion annual expenditure, CCSP has taken on the most challenging questions in climate science and is developing products to convey the most advanced state of knowledge to be used by federal, state and local decision makers, resource managers, the science community, the media, and the general public. Over the next two years CCSP will be completing a series of 21 Synthesis and Assessment Reports, the first of which was just released a few months ago. The collection of these Synthesis and Assessment Report will address many of the issues pertinent to this testimony.

I will provide an overview of our basic understanding of the atmosphere in terms of: the role that greenhouse gases play in the atmosphere; evidence for how greenhouse gases

[1] The CCSP participating agencies include the Departments of Agriculture, Commerce, Defense, Energy, Health and Human Services, the Interior, State, and Transportation, the National Science Foundation, the Environmental Protection Agency (EPA), the National Aeronautics and Space Administration (NASA), U.S. Agency for International Development, and the Smithsonian Institution. Additional CCSP liaisons reside in the Office of Science and Technology Policy, the Council on Environmental Quality, the National Economic Council and the Office of Management and Budget.

are already influencing the climate in both general and in specific ways; an introduction ~~short tutorial~~ to ~~on~~ the use of global climate models; how we know global temperatures are increasing; and why we think it is very likely (>95 percent probability) that humans are largely responsible for many of the observed general and specific changes in climate over the past several decades.

Comment [rl1]: Could be useful to include footnotes with citations throughout, since this is largely scientific testimony. Would help show the depth of the analysis and conclusions presented.

Atmospheric Composition and Greenhouse Gases

The natural "greenhouse" effect is real, and is an essential component of the planet's climate process. A small percentage (roughly 2 percent) of the atmosphere is, and long has been, composed of greenhouse gases (water vapor, carbon dioxide, ozone and methane). These gases effectively prevent part of the heat radiated by the Earth's surface from otherwise escaping to space. The response of the global system to this trapped heat is a climate that is warmer than it would be otherwise without the presence of these gases. In the absence of these greenhouse gases the temperature on Earth would be too cold to support life as we know it today. Of all the greenhouse gases, water vapor is by far the most dominant, but other ~~the~~ gases are more effective at trapping heat energy from certain portions of the electromagnetic spectrum whereas water vapor is semi-transparent to heat escaping from the Earth's surface.

Comment [m2]: See comment on Pg. 3. These two statements seem to be at odds with each other...

In addition to the natural greenhouse effect outlined above, there is a change underway in the greenhouse radiation balance. Some greenhouse gases are increasing in the atmosphere because of human activities and increasingly trapping more heat. Direct atmospheric measurements made over the past 50 years have documented the steady growth in the atmospheric abundance of carbon dioxide. In addition to these direct real-time measurements, ice cores have revealed the atmospheric carbon dioxide concentrations of the distant past. Measurements using air bubbles trapped within layers of accumulating snow show that atmospheric carbon dioxide has increased by nearly 35 percent over the Industrial Era (since 1750), compared to the relatively constant abundance of carbon dioxide over at least the preceding 750 years of the past millennium (Figure 1). The predominant cause of this increase in carbon dioxide is the combustion of fossil fuels and the burning of forests. Further, methane abundance has doubled over the Industrial Era, but the increase of methane has slowed over the recent decade for reasons not clearly understood. Other heat-trapping gases are also increasing as a result of human activities. We are unable to state with certainty the exact rate at which these gases will continue to increase because of uncertainties in future emissions, as well as uncertainties regarding how these emissions will be taken up by the atmosphere, land, and oceans. We are certain, however, that once in the atmosphere these greenhouse gases have a relatively long life-time, on the order of decades to centuries. This means they become well mixed throughout the globe.

The increase in heat-trapping greenhouse gases is projected to be amplified by feedback effects, such as changes in water vapor, snow cover, and sea ice. As atmospheric concentrations of carbon dioxide and other greenhouse gases increase, the resulting increase in surface temperature leads to less sea ice and snow cover helping to raise temperatures even further. As snow cover and sea ice decrease, more of the Sun's energy

is absorbed by the planet, instead of being reflected back to space by the snow cover and sea ice. Present evidence also suggests that as greenhouse gases lead to temperature increases, evaporation increases leading to more atmospheric water vapor. Additional water vapor (which, as mentioned above, is a dominant greenhouse gas) acts as a very important feedback to further increase temperature. Our present understanding suggests that these feedback effects account for about 60 percent of the warming. The magnitude of these feedback effects, and others such as changes in clouds, remains a significant source of uncertainty related to our understanding of the impact of increasing greenhouse gases. For example, increases in evaporation and water vapor affect global climate in other ways besides increasing temperature such as increasing rainfall and snowfall rates, and accelerating drying during droughts. The increase in greenhouse gas concentrations in the atmosphere implies a positive radiative forcing, i.e., a tendency to warm the climate system.

Comment [m3]: See comment on Pg. 2. These statements seem to be at odds with each other...

Particles (or aerosols) in the atmosphere resulting from human activities can also affect climate. Aerosols vary considerably by region. Some aerosol types act in a sense opposite to the greenhouse gases and cause a negative forcing or cooling of the climate system (e.g., sulfate aerosol). Other aerosols act in the same way as greenhouse gases, and warm the climate (e.g., soot). In contrast to the long-lived nature of carbon dioxide (centuries), aerosols are short-lived and removed from the lower atmosphere within a few days. Therefore, human-generated aerosols exert a long-term forcing on climate only because their emissions continue each day of the year. Aerosol effects on climate can be manifested directly by their ability to reflect and trap heat, but they can also have an indirect effect by changing the lifetime of clouds and changing the clouds reflectivity to sunshine. The magnitude of the negative forcing of the indirect effect of aerosols is highly uncertain, but may be larger than the direct effect of aerosols.

Emissions of greenhouse gases and aerosols continue to alter the atmosphere in ways that are expected to affect the climate. There are also natural factors which exert a forcing on climate, e.g., changes in the Sun's energy output and short-lived (a few years) aerosols in the stratosphere following episodic and explosive volcanic eruptions. The decadal time-scale forcing estimates of the greenhouse gases are larger than all the other forcings over the past several decades and continue to grow disproportionately larger.

Comment [m4]: A little more explanation is needed here.

Comment [m5]: A little more explanation is needed here.

Human activities also have a large-scale impact on the land surface. Changes in land use through urbanization and agricultural practices, although not global, are often most pronounced where people live, work, and grow food, and are part of the human impact on climate. Large-scale deforestation and desertification in Amazonia and the Sahel, respectively, are two instances where evidence suggests there is likely to be human influence on regional climate. In general, city climates differ from those in surrounding rural green areas, because of the "concrete jungle" and its effects on heat retention, runoff, and pollution, resulting in urban heat islands.[2]

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[2] The global impact of these urban heat islands has been extensively analyzed and assessed to ensure measurements of global temperature are not biased by local urban heat islands.

There is no doubt that the composition of the atmosphere is changing because of human activities, and today greenhouse gases are the largest human influence on global climate.

What exactly is a climate model and why is it useful?

Many of the laws governing climate change and the processes involved can be quantified and linked by mathematical equations. Figure 2 shows schematically the kinds of processes that can be included in climate models. Among these are many earth system components such as atmospheric chemistry, ocean circulation, sea-ice, land-surface hydrology, biogeochemistry, atmospheric circulation, etc. The physics of many, though not all (OK?), of the processes governing climate change are well understood, and may be described by mathematical equations. Linking these equations creates mathematical models of climate that may be run on computers or super-computers. Coupled climate models can include mathematical equations describing physical, chemical, and biogeochemical processes.

Comment [m6]: Please provide a definition of this term.

In fact, coupled climate models are the preferred way to approach climate modeling. This is because if we put all our understanding into a single model, it would be too complex to run on any existing computer systems. The decisions for how to build any given climate model includes trade-offs between the complexity of the model and number of Earth system components included, the horizontal and spatial resolution within the model, and the number of years of simulations the model can produce per day of computer time. Consequently, there is a hierarchy of model complexity, often based on the degree to which approximations are required for each model or component processes omitted.

Approximations in climate models represent aspects of the models that require parameter choices and "tuning." This "tuning" is referred to as model parameterization. As a simple example, imagine a single cumulus cloud and how it has to be represented in a global climate model. The cloud may only encompass only a few hundred meters in the vertical and horizontal extent, which is much finer resolution than can be run on today's coupled atmosphere and ocean climate models. This then means that in order to incorporate such clouds into the climate model, some approximations have to be made regarding the statistical properties of such clouds within say an area 100 or 1000 times larger than the cloud itself – because this area is the level of resolution the model can accept. A similar approach is also required in today's state-of-the-science weather forecasting models.

An important difference between weather forecasting models and climate models is that weather models are initialized with a specific set of observations representing today's weather to precisely predict the weather "x" days or hours into the future. The initial starting conditions of the climate models, however, are not nearly as important. Climate models are used to simulate many years of "weather" into the future with the intent of understanding the difference in the collection of weather events at some point in the future, compared to some other time in the past (often the climate of the last 30 years or so). This comparison enables scientists to study the output of climate model simulations to understand the effect of various modifications of those aspects of the climate system that might cause the climate to change. A key challenge in climate modeling is to isolate and identify cause and effect – which requires knowledge about the

changes and variations of the external forcings controlling climate, and a comprehensive understanding of climate feedbacks (such as a change in the earth's reflectivity because of a change sea ice or cloud amount) and natural climate variability.

Model simulations of climate over specified periods can be verified and validated against the observational record. Models that prove to describe climate variability and change well can be used as a tool to increase our understanding of the climate system. Once evaluated and validated, climate models can then be used for predictive purposes. Given specific forcing scenarios, climate models can provide viable projections of future climate. In fact, climate models have become the primary means to predict climate, although prediction is ultimately likely to be achieved through a variety of means, including the observed rate of global climate change.

How do we know the global air temperature is increasing?

There has now been a comprehensive analysis of the changes of temperatures near the surface and throughout much of the atmosphere in the recent Climate Change Science Program (CCSP) Synthesis and Assessment Report 1.1. This report addressed the nagging issue of differences in the rate of warming between measurements derived near the surface and those taken from the atmosphere. The surface air temperatures are derived from several different analyses teams using various combinations of ocean ships and buoys, land observations from weather reporting stations, and satellite data. Atmospheric data sets have been derived using satellites, weather balloons, and a combination of the two.

Considering all the latest satellite, balloon and surface records, the CCSP report concluded there is no significant discrepancy between the rates of global temperature change over the past several decades at the surface compared to changes higher in the atmosphere. The report does, however, acknowledge there are still uncertainties in the tropics, and this is primarily related to data from weather balloons. There is uncertainty as to whether scientists have been able to adequately adjust for known biases and errors in the data, especially in the tropics where many developing nations struggle to routinely launch weather balloons and process these measurements.

Globally, data indicate the rates of temperature change have been similar throughout the atmosphere since 1979 when satellite data were first available, and the rates of temperature change have been slightly greater in the atmosphere compared to the surface air temperature since 1958 (the time at which weather balloons had adequate spatial coverage for global calculations). The global surface temperature time series, shown in Figure 3, indicates warming on even longer time scales, with acceleration since 1976.

Instrumental temperature measurements are not our only evidence for increasing global temperatures. The observed increased melting of glaciers can be used to estimate the rate of temperature increase since the late 19th Century. Estimates of the near-surface temperature based on glacial melting are very similar to estimates based on instrumental temperature data. There has been a 15-20 percent reduction in Arctic sea ice since the 1970s, a 10 percent decrease in snow cover since the 1970s, and shortened periods of lake and river ice cover (about 2 weeks shorter since the 19th century). Also, ocean heat content has significantly increased over the past several decades.

Why do we think humans are influencing the Earth's climate?

The scientific community has been actively working on detection and attribution of climate change as related to human activities since the 1980s. As described above, one set of tools often used to examine these issues are mathematical computer models of the climate. Outstanding issues in modeling include specifying forcing mechanisms (e.g., the causes of climate variability and change) within the climate system; properly dealing with complex feedback processes that affect carbon, energy, and water sources, sinks and transports; and improving simulations of regional weather, especially extreme events. Today's inadequate or incomplete measurements of the various forcing mechanisms, with the exception of well-mixed greenhouse gases, add uncertainty when trying to simulate past and present climate. Confidence in our ability to predict future climate depends on our ability to use climate models to attribute past and present climate change to specific causes.

Recent carbon dioxide emission trends in the United States are upward, as are global emissions trends, with increases between 0.5 and 1 percent per year over the past few decades. Concentrations of both reflective and nonreflective aerosols are also estimated to be increasing. Radiative forcings[3] from greenhouse gases dominate over the net cooling forcings from aerosols and the global temperature has exceeded the bounds of natural variability. This has been the case since about 1980. By raising the air temperature, the capacity of the atmosphere to hold more water vapor is increased, which defines the upper bounds of the amount of precipitation that can occur during short term (~daily or less) extreme precipitation events.

Comment [m7]: Why is it relevant to point this out here? The rest of the testimony focuses on global issues.

Comment [m8]: Please provide definition for "tropopause" in the footnote. Also, this footnote contains too much jargon.

Comment [m9]: What qualifying term should go after temperature? Change? Level?

Comment [m10]: This sentence does not seem to fit with this paragraph?

As an example of how models are used to detect human influence on the climate system Figure 4 shows that without including all the observed forcing mechanisms the models cannot replicate the observed global temperature changes. There are many other aspects of the climate system besides global surface temperatures that have been tested for human influences. Today, there is convincing evidence from a variety of model and data climate attribution studies pointing to human influences on climate. These include regional analyses of changes in temperature, the paleoclimatic[4] temperature record, three

[3] Radiative forcing is the change in the net vertical irradiance (expressed in Watts per square meter: Wm^{-2}) at the tropopause due to an internal change or a change in the external forcing of the climate system, such as, for example, a change in the concentration of carbon dioxide or the output of the Sun.

[4] Climate during periods prior to the development of measuring instruments, including historic and geologic time, for which only proxy climate records are available. A proxy climate indicator is a local record that is interpreted, using physical and biophysical principles, to represent some combination of climate-related variations back in time. Climate-related data derived in this way are referred to as proxy

dimensional analysis of atmospheric temperature change, changes of free atmospheric temperature, changes in sea ice extent and other components of the cryosphere, changes in ocean heat content, and new studies on extreme weather and climate events. Thus, there is considerable confidence that the observed warming, especially the period since 1970s is mostly attributable to increases in greenhouse gases.

Comment [m11]: What does this mean? Atmospheric analysis were done at a regional scale?

Changes in Extremes in the United States

The U.S. Climate Change Science Program Synthesis and Assessment Report 3.3 will specifically address the issue of changes in extreme events, focusing on North America. This assessment plans on comprehensively assessing a wide range of climate-related extreme events and promises to help clarify what we know and do not yet understand about these important events, as related to climate change. Here, three types of climate extremes are discussed as they are likely to be influenced by rising global temperatures. This includes changes the frequency and intensity of heavy and extreme precipitation events, droughts, and hurricanes.

Increasing air temperature leads to increased water vapor in the atmosphere. Surface moisture, if available (as it always is over the oceans), effectively acts as the "air conditioner" of the surface – as heat used for evaporation moistens the air rather than warming it. Therefore, another consequence of global heating of the lower troposphere is accelerated land-surface drying and more atmospheric water vapor (the dominant greenhouse gas). Satellite measurements now confirm a significant increase in atmospheric water vapor, consistent with theoretical expectations given the rate of observed atmospheric warming during the past several decades. Accelerated drying, without an increase in precipitation, increases the incidence and severity of droughts, whereas additional atmospheric water vapor increases the risk of heavy precipitation events. Increases in global temperature also increase sea surface temperatures, one of several important factors affecting the hurricane intensity.

NOAA's National Climatic Data Center calculates a Climate Extremes Index (CEI) over the United States that includes extremes related to all of these indicators including temperature, precipitation, drought and hurricanes. Although no index can claim to adequately capture all of the important changes in extremes, the changes and variations of the CEI as reflected in Figure 5 is illustrative of the varying decadal variability of climate extremes. Currently, the CEI is at record levels during the past decade or so, but not much higher than in previous decades, and so there is no clear indication of a general increase in the aggregate set of extremes included in the CEI when viewed across much of the 20th Century.

Changes in Heavy and Extreme Precipitation

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data. Examples of proxies are: tree ring records, characteristics of corals, and various data derived from ice cores.

Basic theory, climate model simulations, and empirical evidence (Figure 6) confirm that warmer climates, owing to increased water vapor, lead to more intense precipitation events even when the total precipitation remains constant, and with prospects for even stronger events when precipitation amounts increase. Figure 7 depicts the aggregate land-surface world-wide changes in heavy precipitation events over the last half of the 20th century with an associated geographic depiction of where changes in heavy precipitation have occurred, with most areas showing increases. World-wide, an increase of a few percent in heavy precipitation events is evident since the middle of the 20th century, particularly in the middle and high latitudes. By the end of the 21st Century a 10-20 percent increase in the precipitation rate for 1-day extreme precipitation events (20 year return periods) is in the middle range of a variety of climate models, when forced with a rather conservative change in atmospheric greenhouse gases. Carbon dioxide does not exceed 550 ppmv[5].

Comment [m12]: This section is unclear and needs to be revised for a non-technical audience.

The practical implications of addressing these changes are seen in NOAA's recent update of the Ohio River Basin's 100-year 24-hour precipitation return period. Over the past several decades increases in precipitation rates for the 1 in 100 year extreme daily precipitation amount was observed in many areas of the eastern United States over the past several decades. These data are used to help set engineering design standard related to excessive rainfall.

Comment [m13]: Suggest providing a numerical example to make this clearer.

Changes in Drought Severity and Frequency

Drought is a recurring feature of the climate system. In other words, we have had major droughts in the past, and expect to have major droughts in the future. At any given time, at least part of the U.S. is in drought, with percentages ranging from 5-80 percent of the total land area. U.S. droughts show pronounced multi-year to multi-decadal variability, but no convincing evidence for systematic long-term trends toward more or fewer events. Drought calculations have been made showing that over the U.S, the increase in temperatures that may have lead to increased evaporation hasve been compensated by a general increase in precipitation over the past few decades. In general, there are no clear patterns of precipitation increase emerging from climate model simulations as global temperatures increase, so the increase in precipitation over the past few decades may not persist and could reverse. Such a reversal, added to the continuing increase in temperatures (January through June of 2006 have been the warmest temperatures in U.S. records dating back to 1895) could lead to greater drought severity and frequency, especially during periods of dry weather due to increases in evaporation.

Comment [m14]: Non-sequiter? Is this an important observation? If so, probably should be put into context (with other info on the past decade, etc.) rather than just dropped in here.

For the continental U.S., the most extensive U.S. drought in the modern observational record occurred from 1933 to 1938. In July 1934, 80 percent of the U.S. was gripped by moderate or greater drought (Figure 8), and 63 percent was experiencing severe to extreme drought. During 1953-1957, severe drought covered up to 50 percent of the country. Paleoclimatic data (e.g. tree ring measurements) have been used to reconstruct drought patterns for the period prior to the modern instrumental record. These

[5] Such a scenario is built on the storyline of relatively low population growth and with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies.

reconstructions show that during most of the past two millennia the climate of the western U.S. has been more arid than at present. The recent intense Western drought from 1999 to 2004 that strongly affected the Colorado River basin was exceeded in severity as recently as the 19th century. Within the past millennium there have been severe droughts in both the western U.S. and Midwest that have lasted for multiple decades.

Long-term warming trends have led to changes in the timing of snow melt and stream flows, especially in the West. This is resulting in earlier peak stream flows and diminished summer-time flows.

Changes in Hurricane Intensity and Frequency

Tropical storms and particularly hurricanes, are an important issue of concern for the United States. The unprecedented hurricane season of 2005, and especially the havoc created by Katrina, raised public awareness of the dangers of hurricanes to new heights. Hurricanes respond to a number of environmental factors including ocean temperatures, atmospheric stability, El Niño, and other factors. One important question is whether hurricane activity has changed over the last 100 years. Since 1995, Atlantic hurricane activity has significantly increased, with more hurricanes, and more intense hurricanes, compared to the two previous decades (Figure 9). However, earlier periods, such as the 1945 to 1970 period were nearly as active.

Comment [m15]: Stong?

An important consideration in hurricane intensity is a trend toward warmer sea surface temperatures, particularly in the tropical Atlantic and Gulf of Mexico, indicating climate change may play some role in the increased hurricane intensity. Another factor is a slow cycle of natural fluctuations in atmospheric conditions and ocean temperatures in the North Atlantic referred to as the Atlantic Multi-decadal Oscillation (AMO). This AMO is currently in a warm ocean temperature phase.

What does the future hold for hurricane activity? In the near term, it is expected that favorable conditions for Atlantic hurricanes will persist for the next decade or so based on previous active periods. For the longer term, climate models simulate about a ½ Category increase (approximately 6 percent increase in wind speed) in the intensity of strong hurricanes late in the 21st Century, with a tropical sea surface temperature increase of nearly 2°C higher than at present. The models also simulate about a 20 percent increase in near-storm rainfall rates under those conditions. However, it is unclear if the total number of hurricanes will change in future years.

Comment [m16]: There is lots of jargon in this paragraph. Please simplify.

New analyses of precipitation rates for different strengths of landfalling Atlantic tropical cyclones (both hurricanes and tropical storms) over the southeastern United States have recently been completed. These analyses show that daily precipitation amounts increase with tropical cyclone strength, while hourly precipitation does not. This means that the more intense hurricanes have longer periods with heavy rainfall. The implications are relevant for local planning, if indeed tropical cyclone strength increases in the future.

Overall, the issue of hurricanes and climate change is an ongoing debate. The scientific community has varying viewpoints on the magnitude of influence of global climate change on hurricanes and how long the current active period will last. NOAA recognizes the debate and continues to study hurricane development, intensity, activity, and modeling.

Comment [m17]: What about adding citations here and elsewhere in this testimony?

Conclusion

The state of the science continues to indicate that modern climate change is dominated by human influences, specifically human-induced changes in atmospheric composition. These perturbations primarily result from emissions associated with energy use, but on local and regional scales, urbanization and land use changes are also important. While there is still considerable uncertainty about the rates of change that can be expected, it is clear these changes will be increasingly manifested in important and tangible ways, such as changes in extremes of temperature and precipitation, decreases in seasonal and perennial snow and ice extent, sea level rise, and now there is accumulating evidence to suggest that there will be increases in hurricane intensity and related heavy and extreme precipitation. Furthermore, while there has been progress in monitoring and understanding climate change, there remain many scientific, technical, and institutional impediments to precisely planning for, adapting to, and mitigating the effects of climate change. In many respects we are venturing into the unknown territory with changes in climate, and its associated effects.

Thank you again, Mr. Chairman for allowing me the opportunity to help inform the Committee about climate change.

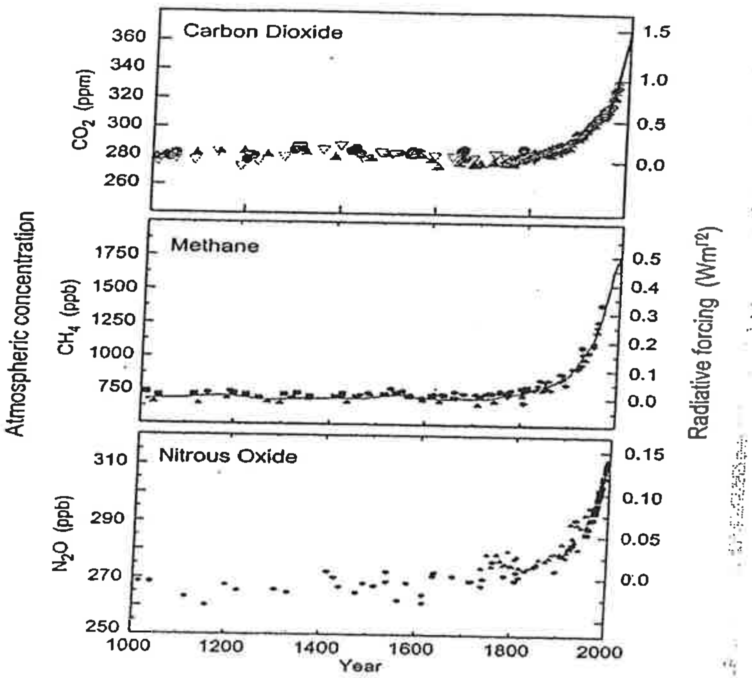

Figure 1: Changes in atmospheric concentration of carbon dioxide, methane, and nitrous oxide since 1000 A.D. (from IPCC, 2001).

Comment [m18]: Should these graphs be scaled to start at zero for ppm/ppd (Y axis)? At a minimum, the Y axis should show a break between these levels and zero.

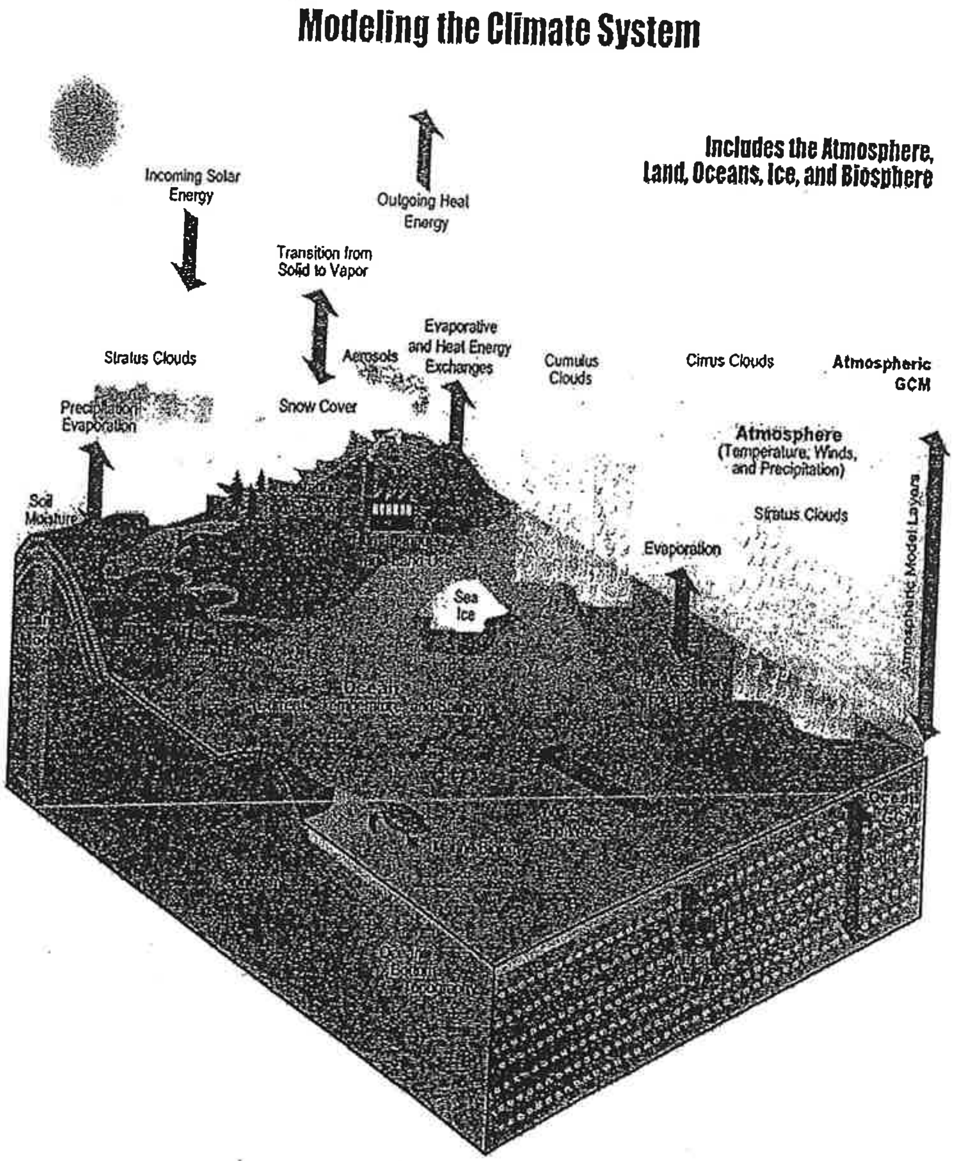

Figure 2. Components of the climate system and the interactions among them, including the human component. All these components have to be modeled as a coupled system that includes the oceans, atmosphere, land, cryosphere, and biosphere.

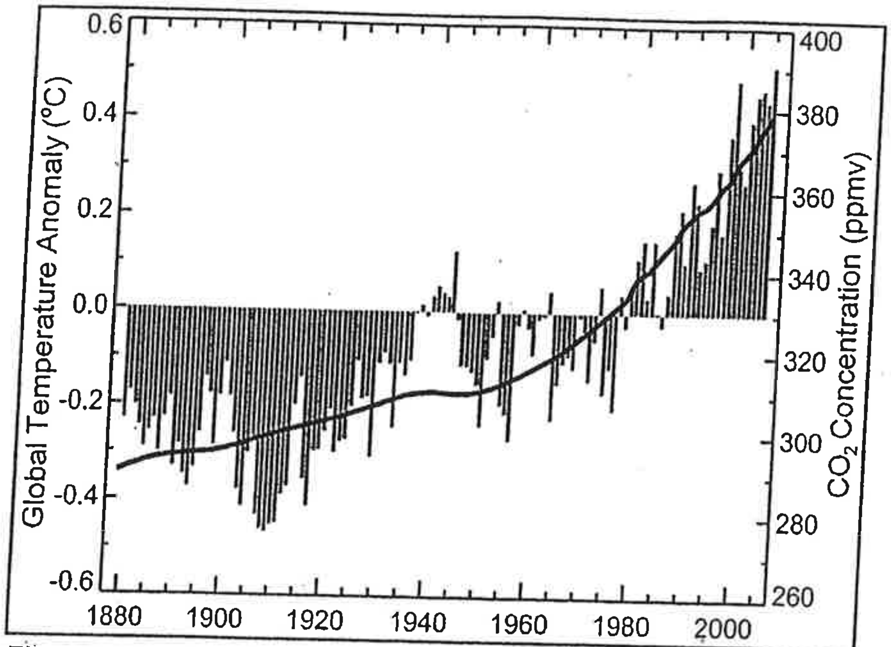

Figure 3: Globally averaged surface air temperature and carbon dioxide concentration (parts per million by volume) since 1880 (Updated from Karl and Trenberth, 2002).

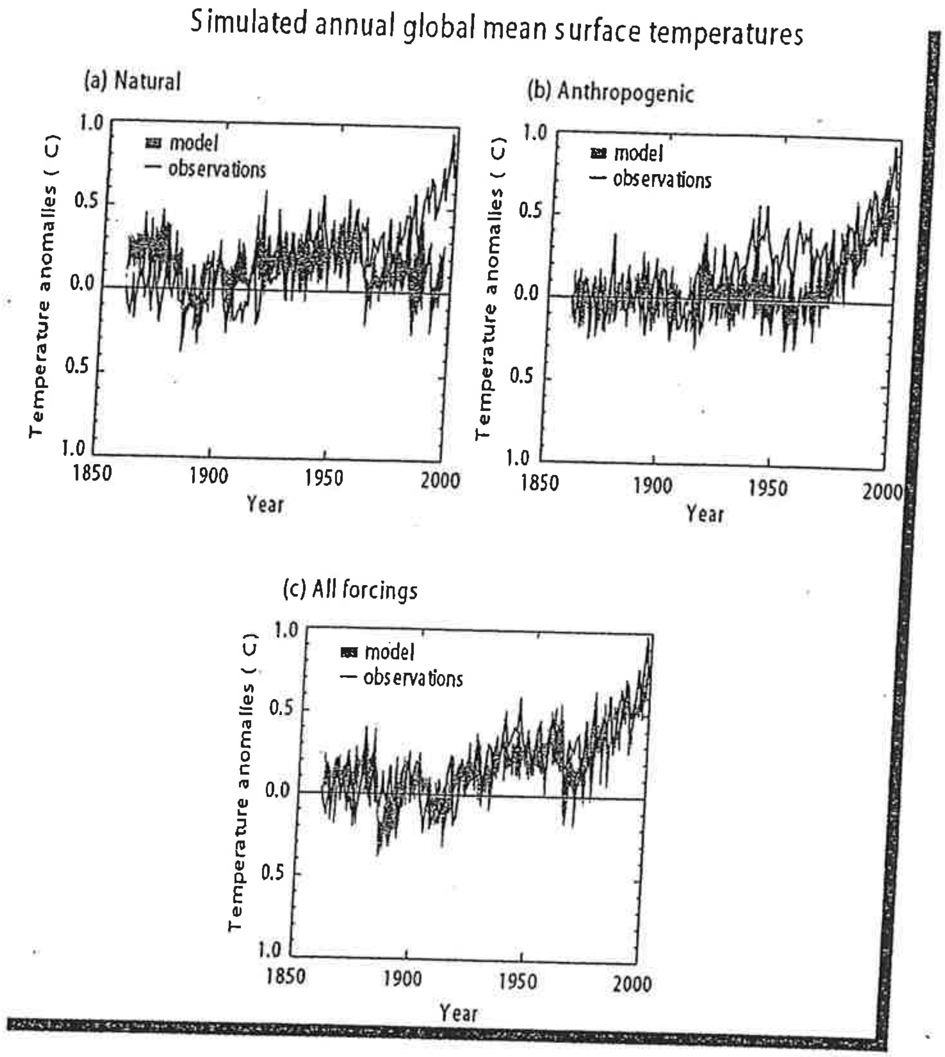

Figure 4: Climate model simulations of the global air temperature for the period 1860-2000. Figure 3a includes only natural forcing mechanisms such as volcanic eruptions and solar variability; 3b includes only anthropogenic greenhouse gas increases; and 3c includes both natural and anthropogenic forcing mechanisms (from IPCC 2001).

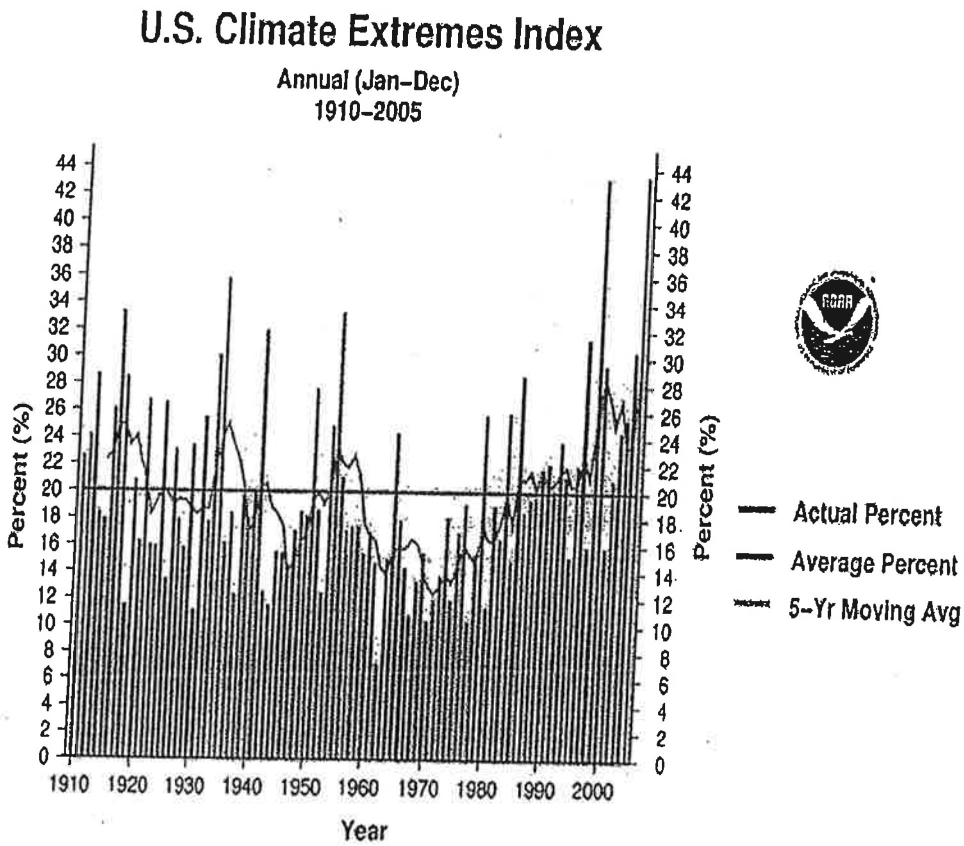

Figure 5: The U.S. Climate Extremes Index (CEI) is the average of the percent of U.S. land area experiencing extremes in temperatures, drought, precipitation, and tropical storms. More detailed information on the CEI is available at http://www.ncdc.noaa.gov/oa/climate/research/cei/cei.html.

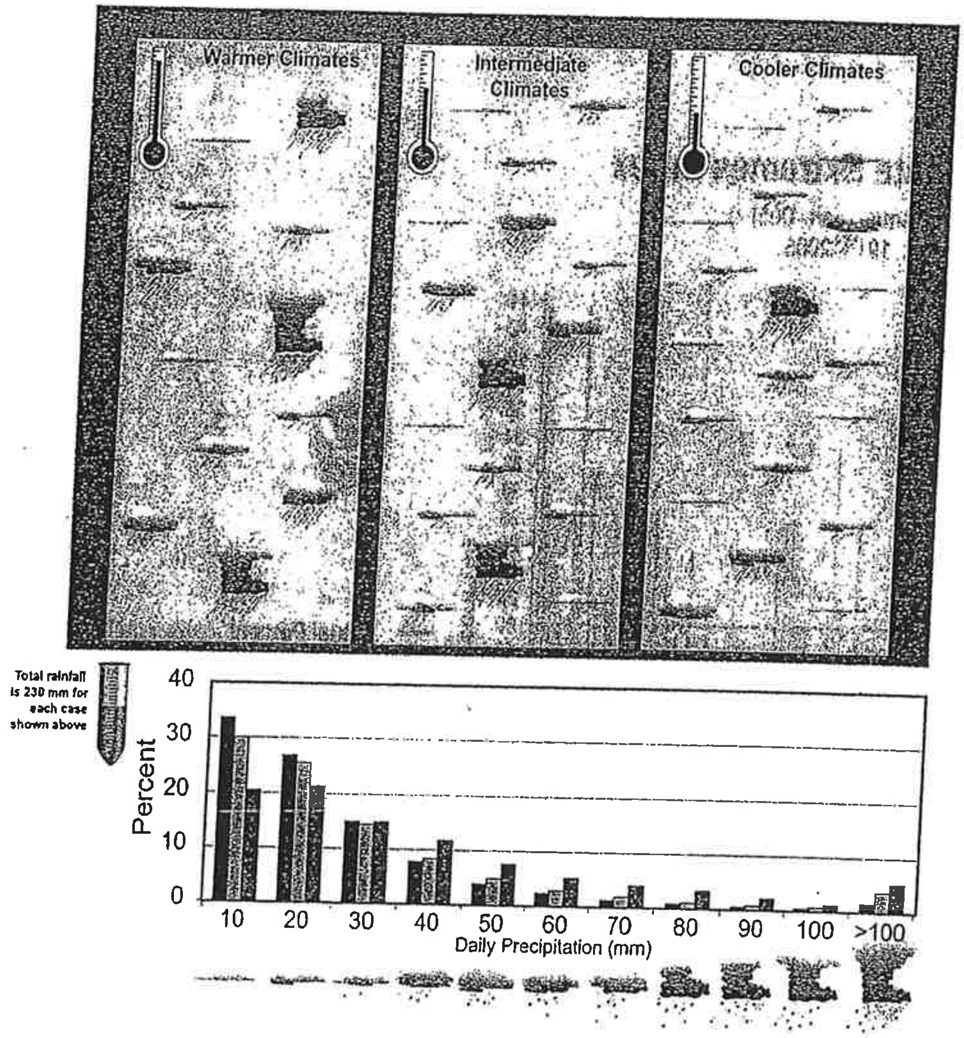

Figure 6: The diagram shows that warmer climates (red) have a higher percentage of total rainfall coming from heavy and very heavy events. The data are based on a worldwide distribution of observing stations, but each have the same seasonal mean precipitation amount of 230 (±5) mm. For cool climates (blue), there are more daily precipitation events than in warmer climates (Adapted from Karl and Trenberth, 2002). The various cloud and rain symbols reflect the various daily precipitation rates and have been categorized in the top panel of this figure to reflect the approximate proportion of the various precipitation rates for cool, moderate, and warm climates across the globe.

Comment [m19]: Is this based on a simulation (based on an assumption of constant mean precipitation) or based on observations in different regions?

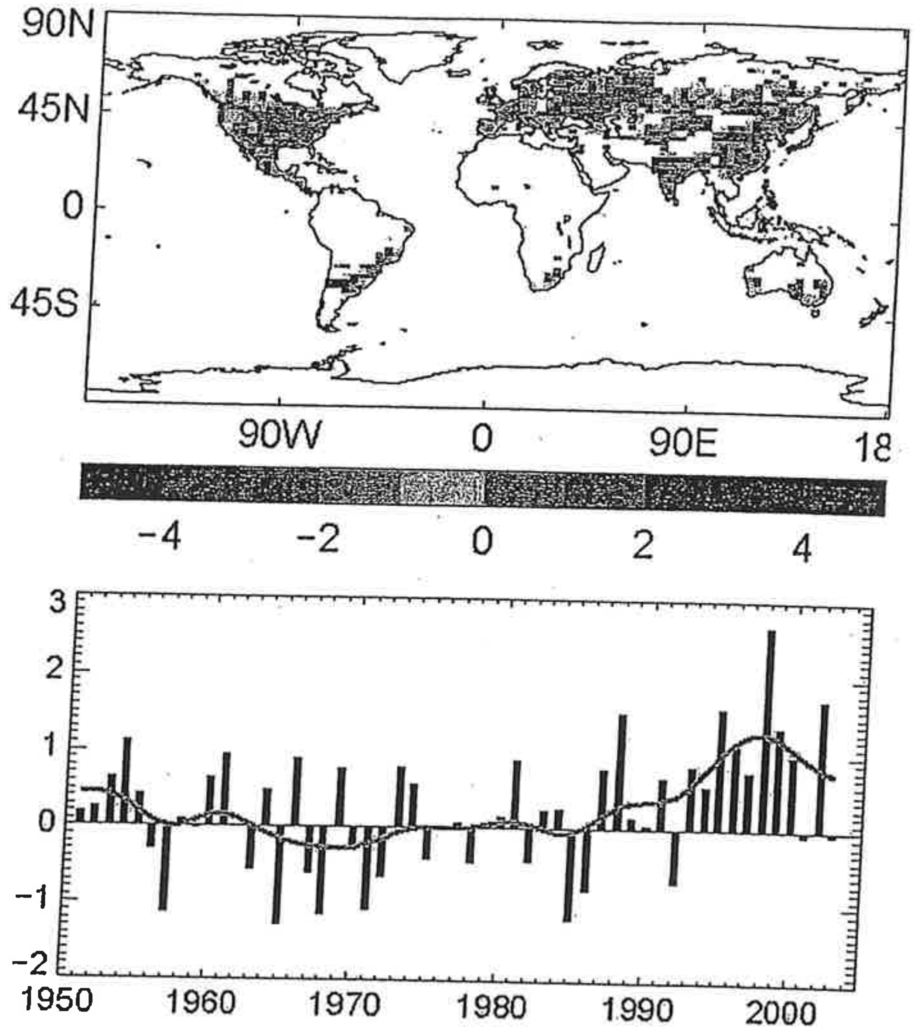

Figure 7: Changes in the contribution of heavy precipitation events to the annual total amount. Globally there has been a change of nearly two percent since the mid-20th century (from Alexander et al., 2006: Global observed changes in daily climate extremes of temperature and precipitation. *J. Geophys. Res.*, D05109, doi:10.1029/2005JD006290).

Comment [m20]: What does the orange line represent on this graph?

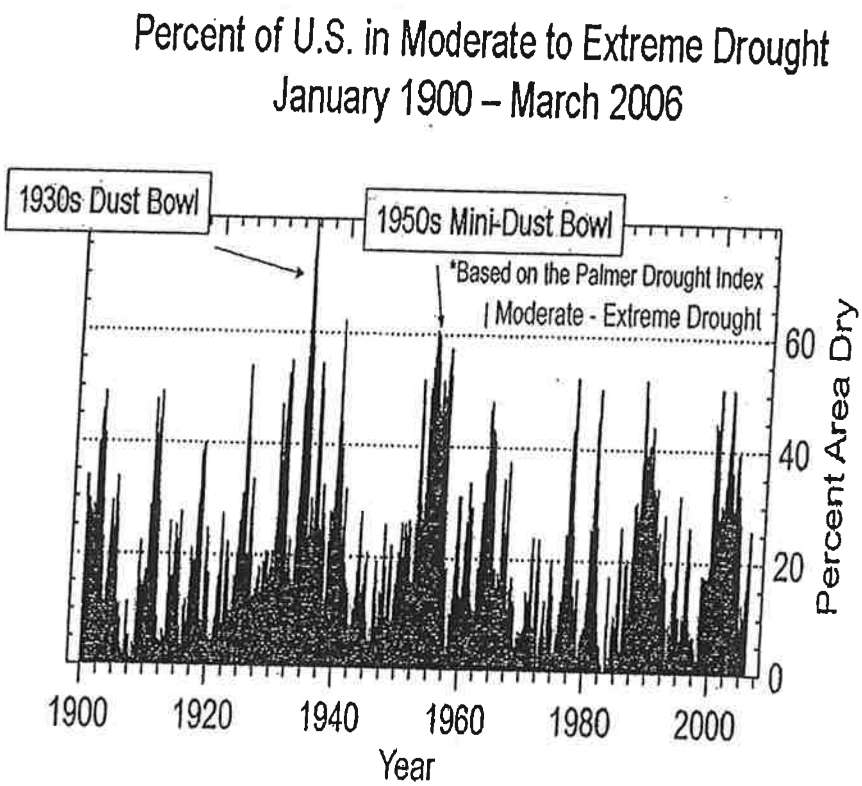

Figure 8: The percentage of the contiguous U.S. land area in moderate to severe drought (NOAA, National Climatic Data Center).

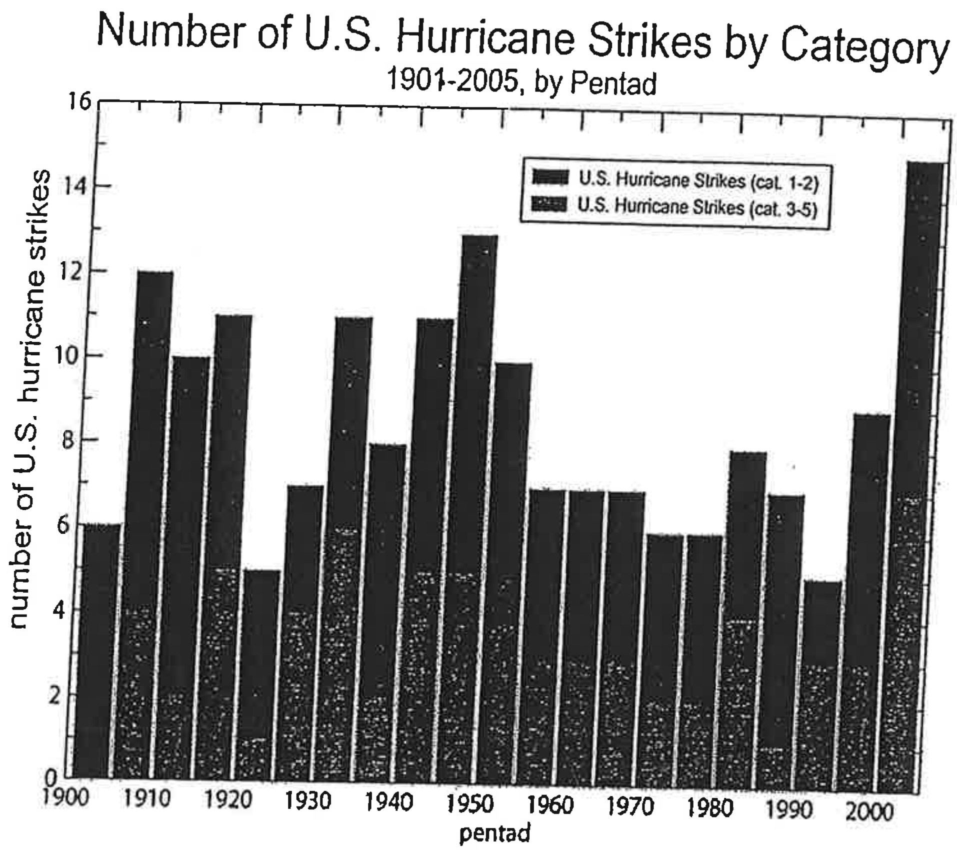

Figure 9: The number of hurricanes striking the U.S. summed by five year periods (e.g. 1901-1905, 1906-1910, etc.). The red bar is the number of major hurricanes (category 3-5) and blue bar is the number of weaker category 1 and 2 hurricanes per five year period (pentad). (NOAA, National Climatic Data Center)

Subject: Re: Updates to July 20th testimony
From: Jennifer Sprague <[redacted]@noaa.gov>
Date: Fri, 14 Jul 2006 11:22:58 -0400
To: Noel.Turner[redacted]

NOT cleared by NOAA

Noel,

See the attached changes.
Jen

Noel.Turner[redacted] wrote:

> Jen, Ahsha and Glenn,
> Attached is an updated version of the July 20th testimony. Eric asked that the IPCC stuff up front be cut (and inserted into the July 19th testimony instead). Eric recommended to Tom that he used some of the language from his 2001 testimony, which discusses greenhouse gases in more simpler terms (as this is truly a 101 hearing). In addition, Eric asked Tom to include a section explaining what exactly climate models are.
>
> This draft also includes a few nits from Tom and from OAR.
>
> These changes are shown in the attached using the tracked changes function. Please review these changes and let me know if you have any comments asap tomorrow.
>
> Many thanks,
> Noel

not all edits in attached from Sprague

--
Jennifer M. Sprague
Policy Advisor
Office of the Under Secretary of Commerce
for Oceans and Atmosphere
National Oceanic & Atmospheric Administration (NOAA) Phone: [redacted]
Fax: [redacted]

POLICY Climate Change (general) testimony for July 20.doc **Content-Type:** application/mswo
Content-Encoding: base64

WRITTEN STATEMENT BY
DR. THOMAS R. KARL
DIRECTOR, NATIONAL CLIMATIC DATA CENTER
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)
U.S. DEPARTMENT OF COMMERCE

FOR AN OVERSIGHT HEARING:
INTRODUCTION TO CLIMATE CHANGE

BEFORE THE
COMMITTEE ON GOVERNMENT REFORM
U.S. HOUSE OF REPRESENTATIVES

JULY 20, 2006

Mr. Chairman and Members of the Committee: As Director of the National Climatic Data Center, which is part of the National Environmental Satellite, Data, and Information Service (NESDIS) within the National Oceanic and Atmospheric Administration (NOAA), and as Program Manger for one of five different NOAA Climate Goal Programs (Climate Observations and Analysis), I am pleased to have the opportunity to testify before you today. The National Climatic Data Center is the world's largest archive of weather and climate data, which includes data critical to understanding climate variability and change, and also acts as the Nation's Scorekeeper regarding the trends and anomalies of weather and climate.

I was the co-convening lead author of the Intergovernmental Panel on Climate Change (IPCC) 2001 report (and had been lead author for the first and second IPCC assessments), which contained a number of statements regarding human influences on climate and potential climate change. Presently, I am one of the review editors for the fourth IPCC assessment, scheduled to be released in 2007. Since the 2001 report, there has been considerable additional research in this area, building upon the science underpinning the influence of humans on global climate change.

Deleted: I begin my testimony by briefly reviewing the IPCC process from a participating scientist's perspective. I will provide an overview of our basic understanding of the atmosphere in terms of: the role that greenhouse gases play in the atmosphere; evidence for how greenhouse gases are already influencing the climate in both general and in specific ways; and why it is very likely (>95 percent probability) that humans are largely responsible for many of the observed changes in climate over the past several decades. ¶

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The IPCC Process from a Participating and Reviewing Scientist's Perspective¶

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The primary intent of the IPCC periodic assessments is to provide government policy-makers with the latest and most comprehensive scientific information possible about human influences on our global climate, in a language that has meaning and relevance to governmental policy-makers. The IPCC assessments have, however, provided much more. From purely a scientific perspective, participation in the IPCC process is extremely desirable, as it provides the means for the world's scientists to discuss leading-edge issues with rigorous worldwide scientific review. The IPCC process ensures that the scientists who participate walk away from the process with a fuller appreciation of where important pay-offs in new research and observing systems are most likely to emerge. This has important impacts on our nation's climate change programs including both the United States Global Change Research Program and the Climate Change Science Program. ¶

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Atmospheric Composition and Greenhouse Gases

The natural "greenhouse" effect is real, and is an essential component of the planet's climate process. A small percentage (roughly 2%) of the atmosphere is, and long has been, composed of greenhouse gases (water vapor, carbon dioxide, ozone and methane). These effectively prevent part of the heat radiated by the Earth's surface from otherwise escaping to space. The global system responds to this trapped heat with a climate that is warmer, on the average, than it would be otherwise without the presence of these gases. In the absence of these greenhouse gases the temperature would be too cold to support life as we know it today. Of all the greenhouse gases, water vapor is by far the most dominant, but other gases are more effective at trapping heat energy from certain portions of the electromagnetic spectrum where water vapor is semi-transparent to heat escaping from the Earth's surface.

In addition to the natural greenhouse effect above, there is a change underway in the greenhouse radiation balance. Some greenhouse gases are increasing in the atmosphere because of human activities and increasingly trapping more heat. Direct atmospheric measurements made over the past 50 years have documented the steady growth in the atmospheric abundance of carbon dioxide. In addition to these direct real-time measurements, ice cores have revealed the atmospheric carbon dioxide concentrations of the distant past. Measurements using air bubbles trapped within layers of accumulating snow show that atmospheric carbon dioxide has increased by nearly 35% over the Industrial Era (since 1750), compared to the relatively constant abundance that it had over at least the preceding 750 years of the past millennium. The predominant cause of this increase in carbon dioxide is the combustion of fossil fuels and the burning of forests. Further, methane abundance has doubled over the Industrial Era, but its increase has slowed over the recent decade for reasons not clearly understood. Other heat-trapping gases are also increasing as a result of human activities. We are unable to state with certainty the exact rate at which these gases will continue to increase because of uncertainties in future emissions as well as how these emissions will be taken up by the atmosphere, land, and oceans. We are certain, however, that once in the atmosphere these greenhouse gases have a relatively long life-time, in the order of decades to centuries. This means they become well mixed throughout the globe.

The increase in heat-trapping greenhouse gases are projected to be amplified by feedback effects, such as changes in water vapor, snow cover, and sea ice. As atmospheric concentrations of carbon dioxide and other greenhouse gases increase, the resulting increase in surface temperature leads to less sea ice and snow cover helping to raise temperatures even further. As snow and sea ice decrease, more of the Sun's energy is absorbed by the planet instead of being reflected back to space by the underlying snow and sea ice cover. Present evidence also suggests that as greenhouse gases increase, evaporation increases leading to more atmospheric water vapor. Additional water vapor acts as a very important feedback to further increase temperature. Our present understanding suggests that these feedback effects account for about 60% of the warming. The magnitude of these feedback effects and others, such as changes in clouds, remain a significant source of uncertainty related to our understanding of the impact of increasing greenhouse gases. Increases in evaporation and water vapor affect global climate in other ways besides increasing temperature such as increasing rainfall and snowfall rates, and accelerating drying during droughts.

Comment [DMS1]: Already obvious from previous paragraphs. No need to [illegible]

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The increase in greenhouse gas concentrations in the atmosphere implies a positive radiative forcing, i.e., a tendency to warm the climate system.

Particles (or aerosols) in the atmosphere resulting from human activities can also affect climate. Aerosols vary considerably by region. Some aerosol types act in a sense opposite to the greenhouse gases and cause a negative forcing or cooling of the climate system (e.g., sulfate aerosol), while others act in the same sense and warm the climate (e.g., soot). In contrast to the long-lived nature of carbon dioxide (centuries), aerosols are short-lived and removed from the lower atmosphere relatively quickly (within a few days). Therefore, human generated aerosols exert a long-term forcing on climate only because their emissions continue each day of the year. Aerosol effects on climate can be manifested directly by their ability to reflect and trap heat, but they can also have an indirect effect by changing the lifetime of clouds and changing their reflectivity to sunshine. The magnitude of the negative forcing of the indirect effect of aerosols is highly uncertain, but may be larger than the direct effect of aerosols.

Emissions of greenhouse gases and aerosols continue to alter the atmosphere in ways that are expected to affect the climate. There are also natural factors which exert a forcing on climate, e.g., changes in the Sun's energy output and short-lived (a few years) aerosols in the stratosphere following episodic and explosive volcanic eruptions. The decadal time-scale forcing estimates in the case of the greenhouse gases are larger than all the other forcings over the past several decades and continue to grow disproportionately larger.

Human activities also have a large-scale impact on the land surface. Changes in land use through urbanization and agricultural practices, although not global, are often most pronounced where people live, work, and grow food, and are part of the human impact on climate. Large-scale deforestation and desertification in Amazonia and the Sahel, respectively, are two instances where evidence suggests there is likely to be human influence on regional climate. In general, city climates differ from those in surrounding rural green areas, because of the "concrete jungle" and its effects on heat retention, runoff, and pollution, resulting in urban heat islands[1].

There is no doubt that the composition of the atmosphere is changing because of human activities, and today greenhouse gases are the largest human influence on global climate.

What exactly is a climate model and why is it useful?

Many of the laws governing climate change and the processes involved can be quantified and linked by mathematical equations. Figure 3 shows schematically the kinds of processes that can be include in climate models. This includes many earth system components such as atmospheric chemistry, ocean circulation, sea-ice, land-surface hydrology, biogeochemistry, atmospheric circulation, etc. The physics of many of the processes governing climate change are well understood, and may be described by mathematical equations. Linking these equations creates mathematical models of climate that may be run on computers or super-computers. Coupled climate models can include physics, chemistry, and biogeochemistry.

In fact however, if we put all our understanding into a single model it would be too complex to run on any existing computer systems. Therefore, all models have trade-offs between the

[1] The global impact of these urban heat islands has been extensively analyzed and assessed to ensure measurements of global temperature are not biased by local urban heat islands.

Comment [DMS2]: Already obvious. No need to restate.

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Deleted: The atmosphere is made up of a number of gases, most notably nitrogen at 78 percent and oxygen at about 20 percent. However, the remainder of the atmosphere is composed of a number of very important gases that include important greenhouse gases such as water vapor at about 2 percent and carbon dioxide at about 0.04 percent. These last two gases, plus a number of other greenhouse gases that exist in even smaller quantities (e.g., ozone, methane, nitrous oxides) absorb some of the heat energy (infrared radiation) given off by the Earth's surface that otherwise would be transmitted back to space. The various atmospheric gases contribute to the greenhouse effect, the impact of which in clear skies is ~60 percent from water vapor, ~26 percent from carbon dioxide, ~8 percent from ozone, and the rest from trace gases including methane and nitrous oxide. The presence of these greenhouse gases are critical to regulating the Earth's average temperature at about 60°F, as without these gases the Earth's average temperature would be approximately 5°F – too cold to support life as we know it. ¶
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Then, if greenhouse gases are critical to life, why is there concern about greenhouse gases increasing? On average, the energy from the sun received at the top of the Earth's atmosphere amounts to 175 petawatts (PW; 175 quadrillion watts or 175×10^{15} watts), of which ~31 percent is reflected by clouds and from the surface. The rest of the energy (120 PW) is absorbed by the atmosphere, land, or ocean, and ultimately emitted back to space as infrared radiation. The main way in which humans alter global climate is by interfering with the natural flows of energy through changes in atmospheric composition, not by actually generating heat in energy usage. On a global scale, even a 1 percent change in the energy flows, which is the order of the estimated change to date, dominates all other direct influences humans have on climate. ¶
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Global changes in atmospheric composition occur from anthropogenic emissions of greenhouse gases, such as carbon dioxide that results from burning fossil fuels and methane and nitrous oxide from multiple human activities. Because these gases have long (decades to centuries) atmospheric lifetimes, the result is an accumulation of these gases in the atmosphere, and a buildup in concentrations that are clearly shown both by instrumental observations ... [1]

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complexity and number of earth system components included, the horizontal and spatial resolution within the model, and the number of years of simulations the model can produce over a specific set of computational hours. This leads to a hierarchy of model complexity, often based on the degree to which approximations are required in each model or component processes omitted.

Approximations in climate models represent those aspects of the models that require parameter choices and "tuning". This is referred to as model parameterization. As a simple example, imagine a single puffy popcorn-like cumulus cloud and how it has to be represented in a global climate model. The cloud may only encompass only a few hundred meters in the vertical and horizontal extent, but today's coupled atmosphere and ocean climate models cannot be run on such high resolution. This then means to incorporate such clouds into the climate model some approximations have to be made regarding the statistical properties of such clouds within say an area 100 or 1000 times larger than the cloud itself. A similar approach is also required in today's state-of-the-science weather models.

An important difference between weather models and climate models is that weather models are initialized with a specific set of observations representing today's weather to precisely predict the weather "x" days or hours into the future. The initial starting conditions of the climate models however, are not nearly as important. Climate models are used to simulate many years of "weather" into the future with the intent of understanding the difference in the collection of weather events at some point in the future, compared to some other time in the past (often the climate of the last 30 years or so). This enables scientists to study the output of climate model simulations to understand the effect of various modifications of those aspects of the climate system that might cause the climate to change or vary. A key challenge is to isolate (if possible) the contribution specific mechanisms make to climate change and to identify cause and effect. This requires knowledge about the changes and variations of the external forcings controlling the climate, and a comprehensive understanding of the climate feedbacks (such as a change in the earth's reflectivity because of a change sea ice or cloud amount) and natural climate variability.

Model simulations of climate over specified periods can be verified and validated against the observational record. Models that can describe the nature of climate change, variations, and steady state climate conditions serve not only as a measure of our understanding, but as a tool to increase this understanding. Once evaluated, they can then be used for predictive purposes. Given specific forcing scenarios, models can provide viable climate-response scenarios. They are the primary means we have to predict climate, although ultimately prediction is likely to be achieved through a variety of means, including the observed rate of global climate change.

How do we know the global air temperature is increasing?

There has now been a comprehensive analysis of the changes of temperatures near the surface and throughout much of the atmosphere in the recent Climate Change Science Program (CCSP) Synthesis and Assessment Report 1.1. This report addressed the nagging issue of differences in the rate of warming between measurements derived near the surface and those taken from the atmosphere. The surface air temperatures are derived from several different analyses teams using various combinations of ocean ships and buoys, land observations from weather reporting stations, and satellite data. Atmospheric data sets have been derived using satellites, weather balloons, and a combination of the two.

Considering all the latest satellite, balloon and surface records, the CCSP report concluded there is no significant discrepancy between the rates of global temperature change over the past several decades at the surface compared to changes higher in the atmosphere. The report does, however, acknowledge there are still uncertainties in the tropics, and this is primarily related to data from weather balloons. There is uncertainty as to whether scientists have been able to adequately adjust for known biases and errors in the data, especially in the tropics where many developing nations struggle to routinely launch weather balloons and process these measurements.

Globally, data indicate the rates of temperature change have been similar throughout the atmosphere since 1979 when satellite data were first available, and the rates of temperature change have been slightly greater in the atmosphere compared to the surface air temperature since 1958 (the time at which weather balloons had adequate spatial coverage for global calculations). The global surface temperature time series, shown in Figure 2, indicates warming on even longer time scales, with acceleration since 1976.

Instrumental measurements are not our only evidence for increasing global temperatures. The observed increased melting of glaciers can be used to estimate the rate of temperature increase since the late 19th Century. Estimates of the near-surface temperature based on glacial melting are very similar to estimates based on instrumental data. There has been a 15-20 percent reduction in Arctic sea ice since the 1970s, a 10 percent decrease in snow cover since the 1970s, and shortened periods of lake and river ice cover (about 2 weeks shorter since the 19th century). Also, ocean heat content has significantly increased over the past several decades.

Why do we think humans are influencing the Earth's climate?

The scientific community has been actively working on detection and attribution of climate change as related to human activities since the 1980s. One set of tools often used to examine these issues are mathematical computer models of the climate. Not only are these models the primary tools for predicting future climate, they are also very important in helping us to understand the causes of past climate variability and change. The models used are global in extent and are fully coupled, mathematical, computer-based models of the physics, chemistry, and biology of the atmosphere, land surface, oceans, and cryosphere (ice covered portions of the planet), and their interactions with each other and with the sun and other influences (such as volcanic eruptions). Outstanding issues in modeling include specifying forcing mechanisms (e.g., the causes of climate variability and change) within the climate system; properly dealing with complex feedback processes that affect carbon, energy, and water sources, sinks and transports; and improving simulations of regional weather, especially extreme events. Today's inadequate or incomplete measurements of the various forcing mechanisms, with the exception of well-mixed greenhouse gases, add uncertainty when trying to simulate past and present climate. Confidence in our ability to predict future climate depends on our ability to use climate models to attribute past and present climate change to specific causes. The climate models simulate the workings of the climate, such as the winds, clouds and precipitation, and the air temperature. Climate scientists have used these models to examine how the observed changes in climate forcing mechanisms, including increasing greenhouse gases, changes in land use and land cover, changes in the sun's output, volcanic activity, and sulfate aerosols, have affected the climate over the 20th century.

Recent carbon dioxide emission trends in the United States are upward, as are global emissions trends, with increases between 0.5 and 1 percent per year over the past few decades. Concentrations of both reflective and nonreflective aerosols are also estimated to be increasing. Radiative forcings[2] from greenhouse gases dominate over the net cooling forcings from aerosols and at this point the global temperature has exceeded the bounds of natural variability. This has been the case since about 1980. By raising the air temperature, the capacity of the atmosphere to hold more water vapor is increased, which defines the upper bounds of the amount of precipitation that can occur during short term (~daily or less) extreme precipitation events.

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As an example of how models are used to detect human influence on the climate system Figure 4 shows that without including all the observed forcing mechanisms the models cannot replicate the observed global temperature changes. There are many other aspects of the climate system besides global surface temperatures that have been tested for human influences. Today, there is convincing evidence from a variety of model and data climate attribution studies pointing to human influences on climate. These include regional analyses of changes in temperature, the paleoclimatic[3] temperature record, three dimensional analysis of atmospheric temperature change, changes of free atmospheric temperature, changes in sea ice extent and other components of the cryosphere, changes in ocean heat content, and new studies on extreme weather and climate events. Thus, there is considerable confidence that the observed warming, especially the period since 1970s is mostly attributable to increases in greenhouse gases.

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[2] Radiative forcing is the change in the net vertical irradiance (expressed in Watts per square meter: Wm^{-2}) at the tropopause due to an internal change or a change in the external forcing of the climate system, such as, for example, a change in the concentration of carbon dioxide or the output of the Sun.

[3] Climate during periods prior to the development of measuring instruments, including historic and geologic time, for which only proxy climate records are available. A proxy climate indicator is a local record that is interpreted, using physical and biophysical principles, to represent some combination of climate-related variations back in time. Climate-related data derived in this way are referred to as proxy data. Examples of proxies are: tree ring records, characteristics of corals, and various data derived from ice cores.

Changes in Extremes in the United States

The U.S. Climate Change Science Program Synthesis and Assessment Report 3.3 will specifically address the issue of changes in extreme events, focusing on North America. This assessment plans on comprehensively assessing a wide range of climate-related extreme events and promises to help clarify what we know and do not yet understand about these important events, as related to climate change. Here, three types of climate extremes are discussed as they are likely to be influenced by rising global temperatures. This includes changes the frequency and intensity of heavy and extreme precipitation events, droughts, and hurricanes.

Increasing air temperature leads to increased water vapor in the atmosphere. Surface moisture, if available (as it always is over the oceans), effectively acts as the "air conditioner" of the surface – as heat used for evaporation moistens the air rather than warming it. Therefore, another consequence of global heating of the lower troposphere is accelerated land-surface drying and more atmospheric water vapor (the dominant greenhouse gas). Satellite measurements now confirm a significant increase in atmospheric water vapor, consistent with theoretical expectations given the rate of observed atmospheric warming during the past several decades. Accelerated drying, without an increase in precipitation, increases the incidence and severity of droughts, whereas additional atmospheric water vapor increases the risk of heavy precipitation events. Increases in global temperature also increase sea surface temperatures, one of several important factors affecting the hurricane intensity.

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NOAA's National Climatic Data Center calculates a Climate Extremes Index (CEI) over the United States that includes extremes related to all of these indicators including temperature, precipitation, drought and hurricanes. Although no index can claim to adequately capture all of the important changes in extremes, the changes and variations of the CEI as reflected in Figure 5 is illustrative of the varying decadal variability of climate extremes. Currently, the CEI is at record levels during the past decade or so, but not much higher than in previous decades, and so there is no clear indication of a general increase in the aggregate set of extremes included in the CEI when viewed across much of the 20th Century.

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Changes in Heavy and Extreme Precipitation

Basic theory, climate model simulations, and empirical evidence (Figure 6) confirm that warmer climates, owing to increased water vapor, lead to more intense precipitation events even when the total precipitation remains constant, and with prospects for even stronger events when precipitation amounts increase. Figure 7 depicts the aggregate land-surface world-wide changes in heavy precipitation events over the last half of the 20th century with an associated geographic depiction of where changes in heavy precipitation have occurred, with most areas showing increases. World-wide, an increase of a few percent in heavy precipitation events is evident since the middle of the 20th century, particularly in the middle and high latitudes. By the end of the 21st Century a 10-20 percent increase in the precipitation rate for 1-day extreme precipitation events (20 year return periods) is in the middle range of a variety of climate models, when forced

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with a rather conservative change in atmospheric greenhouse gases. Carbon dioxide does not exceed 550 ppmv[4].

The practical implications of addressing these changes are seen in NOAA's recent update of the Ohio River Basin's 100-year 24-hour precipitation return period. Over the past several decades increases in precipitation rates for the 1 in 100 year extreme daily precipitation amount was observed in many areas of the eastern United States over the past several decades. These data are used to help set engineering design standard related to excessive rainfall.

Changes in Drought Severity and Frequency

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Drought is a recurring feature of the climate system. In other words, we have had major droughts in the past, and expect to have major droughts in the future. At any given time, at least part of the U.S. is in drought, with percentages ranging from 5-80 percent of the total land area. U.S. droughts show pronounced multi-year to multi-decadal variability, but no convincing evidence for systematic long-term trends toward more or fewer events. Drought calculations have been made showing that over the U.S, the increase in temperatures that may have lead to increased evaporation have been compensated by a general increase in precipitation over the past few decades. In general, there are no clear patterns of precipitation increase emerging from climate model simulations as global temperatures increase, so the increase in precipitation over the past few decades may not persist and could reverse. Such a reversal, added to the continuing increase in temperatures (January through June of 2006 have been the warmest temperatures in U.S. records dating back to 1895) could lead to greater drought severity and frequency, especially during periods of dry weather due to increases in evaporation.

For the continental U.S., the most extensive U.S. drought in the modern observational record occurred from 1933 to 1938. In July 1934, 80 percent of the U.S. was gripped by moderate or greater drought (Figure 8), and 63 percent was experiencing severe to extreme drought. During 1953-1957, severe drought covered up to 50 percent of the country. Paleoclimatic data (e.g. tree ring measurements) have been used to reconstruct drought patterns for the period prior to the modern instrumental record. These reconstructions show that during most of the past two millennia the climate of the western U.S. has been more arid than at present. The recent intense Western drought from 1999 to 2004 that strongly affected the Colorado River basin was exceeded in severity as recently as the 19th century. Within the past millennium there have been severe droughts in both the western U.S. and Midwest that have lasted for multiple decades.

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Long-term warming trends have led to changes in the timing of snow melt and stream flows, especially in the West. This is resulting in earlier peak stream flows and diminished summer-time flows.

[4] Such a scenario is built on the storyline of relatively low population growth and with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies.

Changes in Hurricane Intensity and Frequency

Tropical storms and particularly hurricanes, are an important issue of concern for the United States. The unprecedented hurricane season of 2005, and especially the havoc created by Katrina, raised public awareness of the dangers of hurricanes to new heights. Hurricanes respond to a number of environmental factors including ocean temperatures, atmospheric stability, El Niño, and other factors. One important question is whether hurricane activity has changed over the last 100 years. Since 1995, Atlantic hurricane activity has significantly increased, with more hurricanes, and more intense hurricanes, compared to the two previous decades (Figure 9). However, earlier periods, such as the 1945 to 1970 period were nearly as active.

An important consideration in hurricane intensity is a trend toward warmer sea surface temperatures, particularly in the tropical Atlantic and Gulf of Mexico, indicating that climate change could be playing some role in the increased activity. Another factor is a slow cycle of natural fluctuations in atmospheric conditions and ocean temperatures in the North Atlantic referred to as the Atlantic Multi-decadal Oscillation (AMO). This AMO is currently in a warm ocean temperature phase.

What does the future hold for hurricane activity? In the near term, it is expected that favorable conditions for Atlantic hurricanes will persist for the next decade or so based on previous active periods. For the longer term, climate models simulate about [illegible]% increase in the intensity of strong hurricanes late in the 21st Century, with a tropical sea surface temperature increase of nearly 2°C higher than at present. The models also simulate about a 20 percent increase in near-storm rainfall rates under those conditions. However, it is unclear if the total number of hurricanes will change in future years.

New analyses of precipitation rates for different strengths of landfalling Atlantic tropical cyclones (both hurricanes and tropical storms) over the southeastern United States have recently been completed. These analyses show that daily precipitation amounts increase with tropical cyclone strength, while hourly precipitation does not. This means that the more intense hurricanes have longer periods with heavy rainfall. The implications are relevant for local planning, if indeed tropical cyclone strength increases in the future.

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Conclusion

The state of the science continues to indicate that modern climate change is dominated by human influences, specifically, human-induced changes in atmospheric composition. These perturbations primarily result from emissions associated with energy use, but on local and regional scales, urbanization and land use changes are also important. While there is still considerable uncertainty about the rates of change that can be expected, it is clear these changes will be increasingly manifested in important and tangible ways, such as changes in extremes of temperature and precipitation, decreases in seasonal and perennial snow and ice extent, sea level rise, and now there is accumulating evidence to suggest that there will be increases in hurricane intensity and related heavy and extreme precipitation. Furthermore, while there has been progress in monitoring and understanding climate change, there remain many scientific, technical, and institutional impediments to precisely planning for, adapting to, and mitigating the effects of climate change. In many respects we are venturing into the unknown territory with changes in climate, and its associated effects.

Over the next two years the Climate Change Science Program will be completing a series of 21 Synthesis and Assessment Reports, the first of which has just be released a few months ago. The collection of these Synthesis and Assessment Report will address many of the issues pertinent to this testimony. NOAA and the CCSP Agencies would be please to brief this Committee on those reports as they become available.

Thank you again, Mr. Chairman for allowing me the opportunity to help inform the Committee about climate change.

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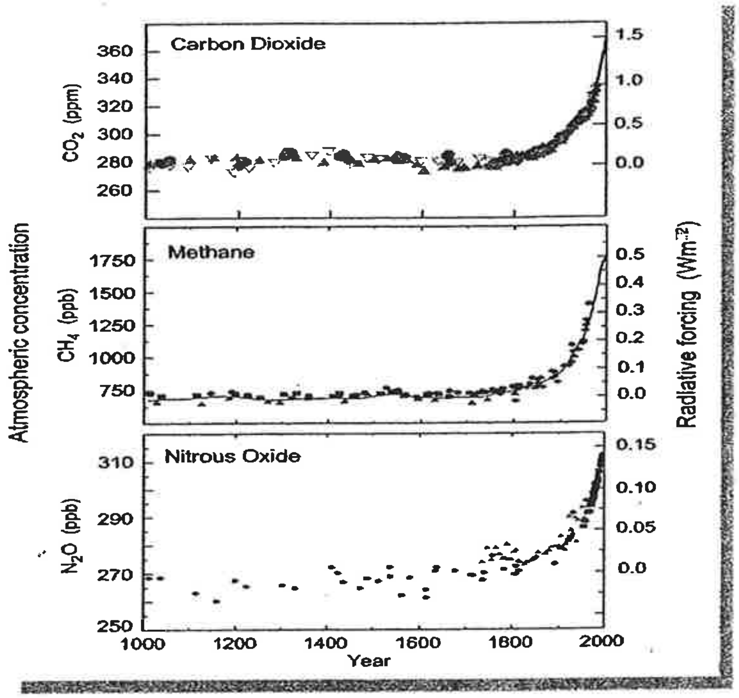

Figure 1: Changes in atmospheric concentration of carbon dioxide, methane, and nitrous oxide since 1000 A.D. (from IPCC, 2001).

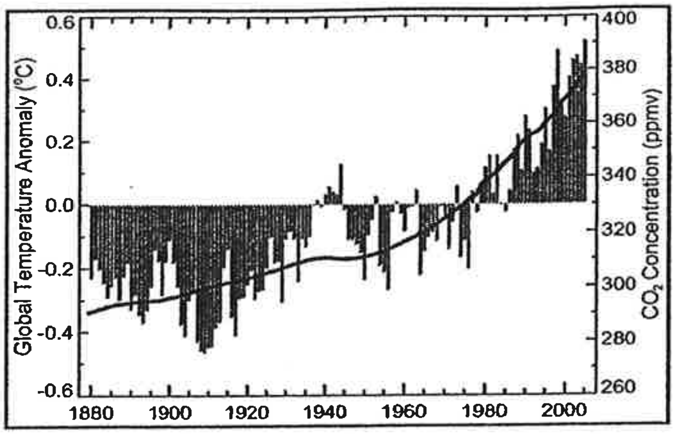

Figure 2: Globally averaged surface air temperature and carbon dioxide concentration (parts per million by volume) since 1880 (Updated from Karl and Trenberth, 2002).

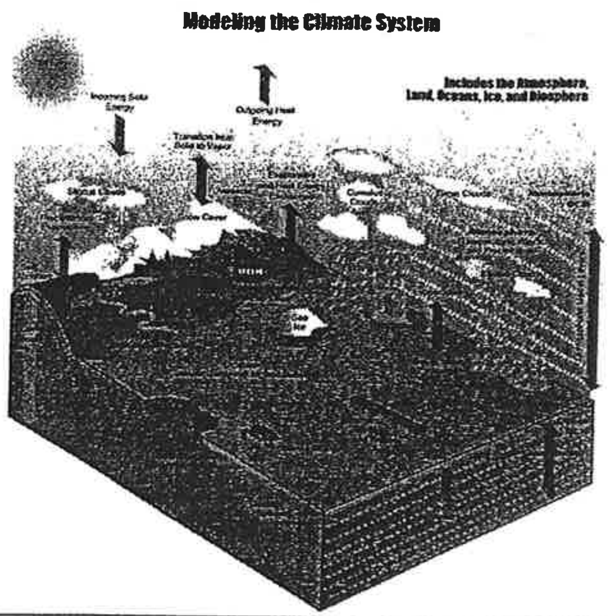

Figure 3 Components of the climate system and the interactions among them, including the human component. All these components have to be modeled as a coupled system that includes the oceans, atmosphere, land, cryosphere, and biosphere.

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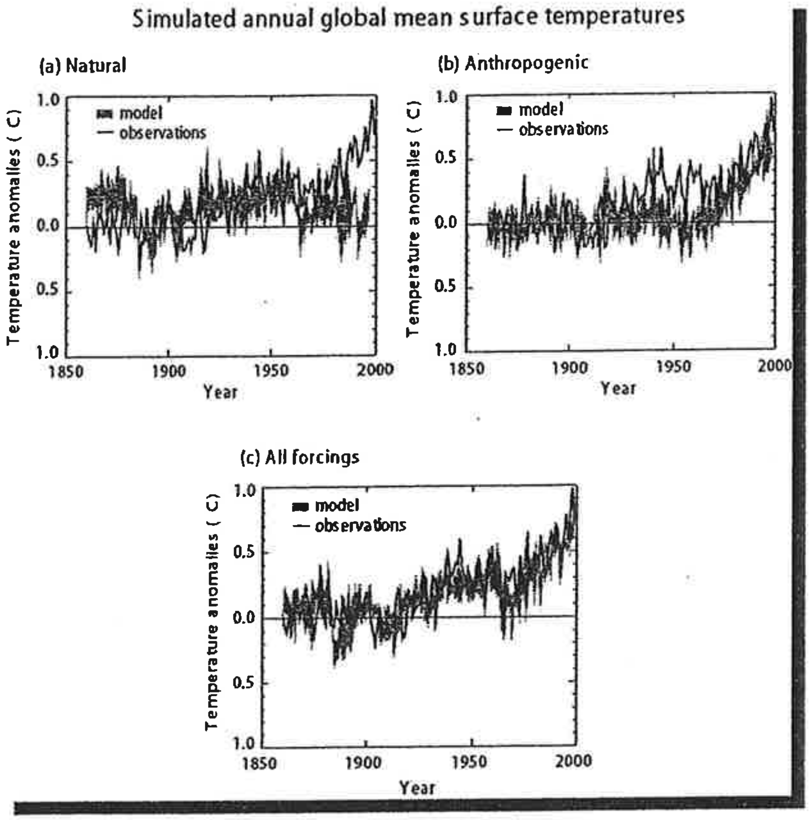

Figure 4: Climate model simulations of the global air temperature for the period 1860-2000. Figure 3a includes only natural forcing mechanisms such as volcanic eruptions and solar variability; 3b includes only anthropogenic greenhouse gas increases; and 3c includes both natural and anthropogenic forcing mechanisms (from IPCC 2001).

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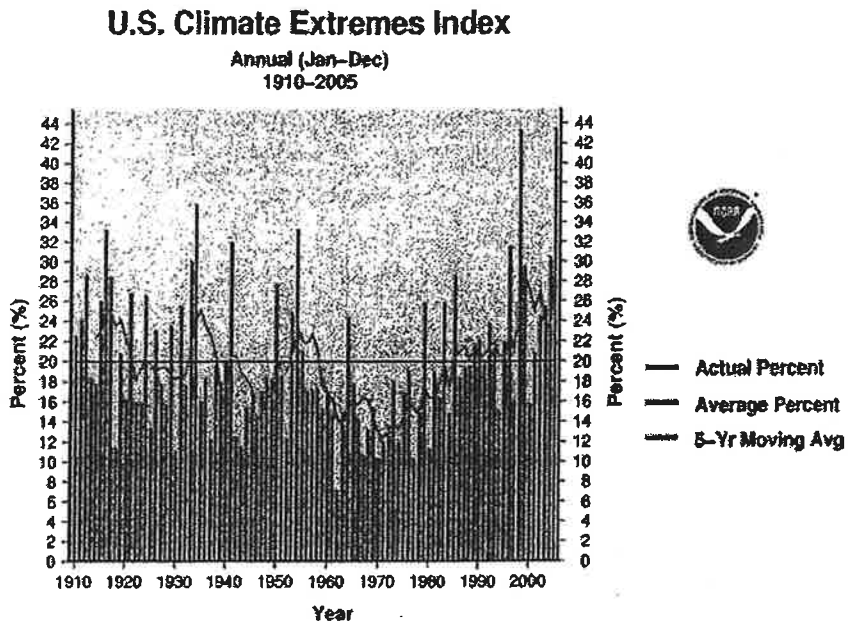

Figure 5: The U.S. Climate Extremes Index (CEI) is the average of the percent of U.S. land area experiencing extremes in temperatures, drought, precipitation, and tropical storms. More detailed information on the CEI is available at http://www.ncdc.noaa.gov/oa/climate/research/cei/cei.html.

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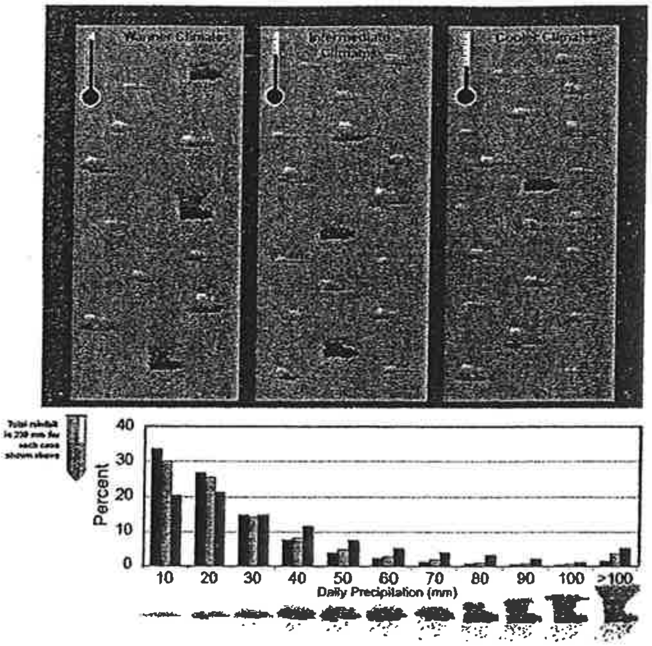

Figure 6: The diagram shows that warmer climates (red) have a higher percentage of total rainfall coming from heavy and very heavy events. The data are based on a worldwide distribution of observing stations, but each have the same seasonal mean precipitation amount of 230 (±5) mm. For cool climates (blue), there are more daily precipitation events than in warmer climates (Adapted from Karl and Trenberth, 2002). The various cloud and rain symbols reflect the various daily precipitation rates and have been categorized in the top panel of this figure to reflect the approximate proportion of the various precipitation rates for cool, moderate, and warm climates across the globe.

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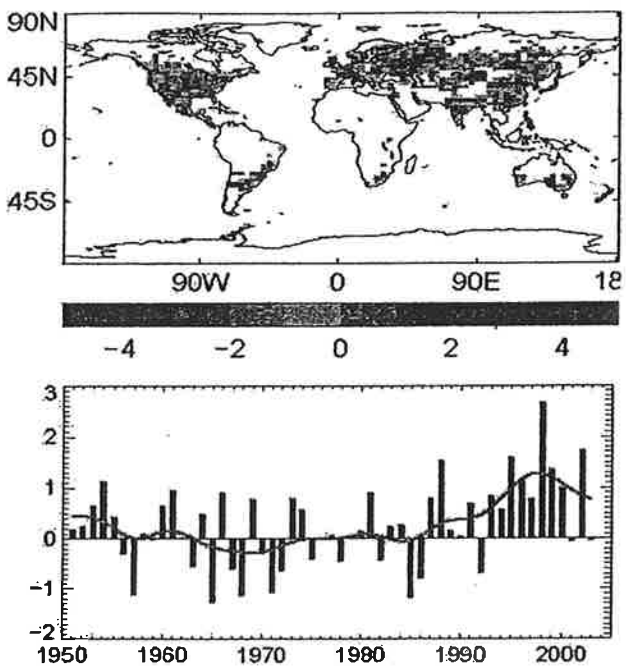

Figure 7: Changes in the contribution of heavy precipitation events to the annual total amount. Globally there has been a change of nearly two percent since the mid-20th century (from Alexander, L.V., et al., 2006: Global observed changes in daily climate extremes of temperature and precipitation. *J. Geophys. Res.*, D05109, doi:10.1029/2005JD006290).

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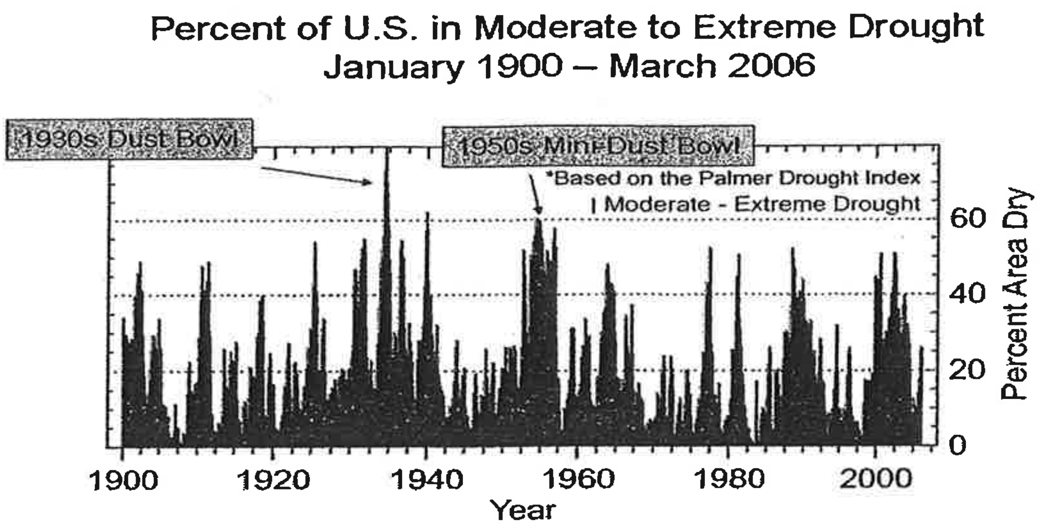

Figure 8: The percentage of the contiguous U.S. land area in moderate to severe drought (NOAA, National Climatic Data Center).

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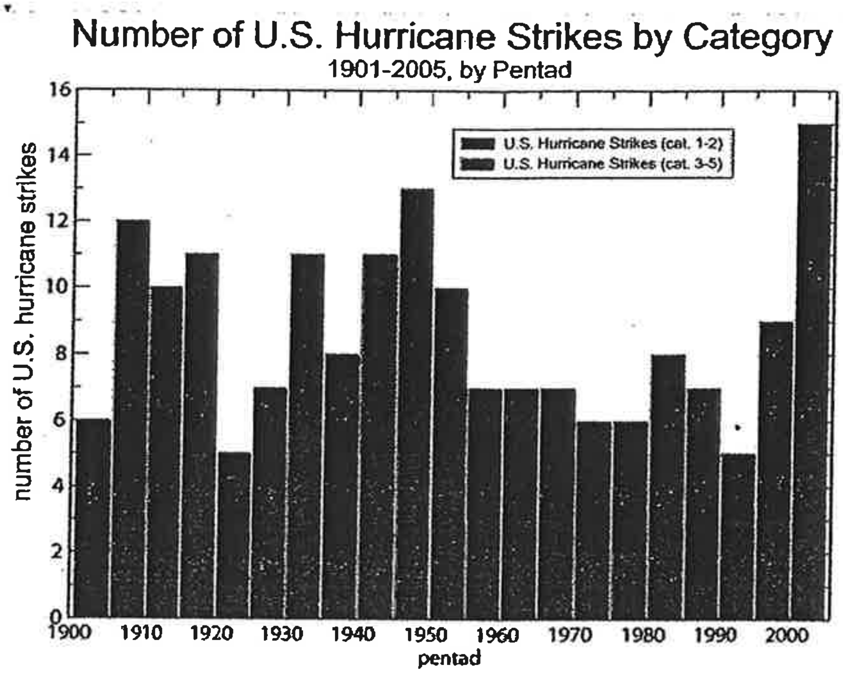

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Figure 9: The number of hurricanes striking the U.S. summed by five year periods (e.g. 1901-1905, 1906-1910, etc.). The red bar is the number of major hurricanes (category 3-5) and blue bar is the number of category is the total number of all hurricanes per five year period (pentad). (NOAA, National Climatic Data Center)

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The atmosphere is made up of a number of gases, most notably nitrogen at 78 percent and oxygen at about 20 percent. However, the remainder of the atmosphere is composed of a number of very important gases that include important greenhouse gases such as water vapor at about 2 percent and carbon dioxide at about 0.04 percent. These last two gases, plus a number of other greenhouse gases that exist in even smaller quantities (e.g., ozone, methane, nitrous oxides) absorb some of the heat energy (infrared radiation) given off by the Earth's surface that otherwise would be transmitted back to space. The various atmospheric gases contribute to the greenhouse effect, the impact of which in clear skies is ~60 percent from water vapor, ~26 percent from carbon dioxide, ~8 percent from ozone, and the rest from trace gases including methane and nitrous oxide. The presence of these greenhouse gases are critical to regulating the Earth's average temperature at about 60°F, as without these gases the Earth's average temperature would be approximately 5°F – too cold to support life as we know it.

Then, if greenhouse gases are critical to life, why is there concern about greenhouse gases increasing? On average, the energy from the sun received at the top of the Earth's atmosphere amounts to 175 petawatts (PW; 175 quadrillion watts or 175×10^{15} watts), of which ~31 percent is reflected by clouds and from the surface. The rest of the energy (120 PW) is absorbed by the atmosphere, land, or ocean, and ultimately emitted back to space as infrared radiation. The main way in which humans alter global climate is by interfering with the natural flows of energy through changes in atmospheric composition, not by actually generating heat in energy usage. On a global scale, even a 1 percent change in the energy flows, which is the order of the estimated change to date, dominates all other direct influences humans have on climate.

Global changes in atmospheric composition occur from anthropogenic emissions of greenhouse gases, such as carbon dioxide that results from burning fossil fuels and methane and nitrous oxide from multiple human activities. Because these gases have long (decades to centuries) atmospheric lifetimes, the result is an accumulation of these gases in the atmosphere, and a buildup in concentrations that are clearly shown both by instrumental observations of air samples (dating back to 1958) and in bubbles of air trapped in ice cores (prior to 1958) (Figure 1). Moreover, these gases are well distributed in the atmosphere across the globe, simplifying a global monitoring strategy. Carbon dioxide has increased 31 percent since pre-industrial times, from 280 parts per million by volume (ppmv) to more than 370 ppmv today, and half of the increase has been since 1965 (Figure 2).

Emissions into the atmosphere from fuel burning further result in gases that are oxidized to become highly reflective micrometer-sized aerosols, such as sulfate, and strongly absorbing aerosols, such as black carbon or soot. Aerosols are rapidly removed (usually within two weeks or less) from the atmosphere through the natural hydrological cycle and dry deposition as they travel away from their source. Nonetheless, atmospheric concentrations can substantially exceed background conditions in large areas around and downwind of the emission sources. Depending on their reflectivity and absorption properties, geometry and size distribution, lifetimes in the atmosphere, and interactions with clouds and moisture, these particulates can lead to either net cooling, as for sulfate aerosols, or net heating, as for black carbon. Importantly, sulfate aerosols affect climate directly by reflecting solar radiation and indirectly by changing the reflective properties of clouds and their lifetimes. There is some episodic evidence from naturally occurring aerosols attributed to volcanic eruptions to suggest that these aerosols can impact global precipitation, but only for a few years after explosive eruptions. There is also some evidence to suggest that anthropogenic aerosols can influence regional precipitation patterns, but it is difficult to generalize and quantify this result. Understanding the precise impact of aerosols has been hampered by our inability to measure them directly, as well as by their spatial heterogeneity and rapid changes in time. Large-scale measurements of aerosol patterns have been inferred through satellites, emission data, special field experiments, and other indirect measurements such as sun photometers.

~~PREDECISIONAL~~

Subject: Re: testimony
From: Ahsha Tribble <[redacted]@noaa.gov>
Date: Fri, 14 Jul 2006 13:11:57 -0400
To: "Noel.Turner" <[redacted]@noaa.gov>
CC: Eric Webster <[redacted]@noaa.gov>

not cleared by NOAA

Comments on the hurricane section and conclusion. note additional comments in attachment not from Ahsha Note, the hurricane section is nearly verbatim from the Hurricane Fact Sheet (approved by NEP/NEC, stalled at the department) - albeit we can defend the statements. I added a sentence about the ongoing debate and research.

Let me know if you want to still want to back down a bit on the language. I do want to make some statements resulting from NOAA research, but still recognize the debate. Let the other participants take sides.

Ahsha

Noel.Turner wrote:

> Thanks for letting me know. I understand the crunch.
>
> Ahsha Tribble wrote:
>
>> I just spoke with Eric. The hurricanes section needs some edits. I got a request from CEQ just now and I am working on that. I will get back to you shortly. Sorry...
>> --
>> ***
>> Ahsha N. Tribble, Ph.D.
>> Technical Chief of Staff
>> Office of Assistant Secretary of Commerce
>> For Oceans and Atmosphere
>> HCHB/Room 5804
>> 14th & Constitution Ave, NW
>> Washington, DC 20230
>> [redacted](DOC)
>> [redacted](Fax)
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Ahsha N. Tribble, Ph.D.
Technical Chief of Staff
Office of Assistant Secretary of Commerce
For Oceans and Atmosphere
HCHB/Room 5804

WRITTEN STATEMENT BY
DR. THOMAS R. KARL
DIRECTOR, NATIONAL CLIMATIC DATA CENTER
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)
U.S. DEPARTMENT OF COMMERCE

FOR AN OVERSIGHT HEARING:
INTRODUCTION TO CLIMATE CHANGE

BEFORE THE
COMMITTEE ON GOVERNMENT REFORM
U.S. HOUSE OF REPRESENTATIVES

JULY 20, 2006

Mr. Chairman and Members of the Committee: As Director of the National Climatic Data Center, which is part of the National Environmental Satellite, Data, and Information Service (NESDIS) within the National Oceanic and Atmospheric Administration (NOAA), and as Program Manger for one of five different NOAA Climate Goal Programs (Climate Observations and Analysis), I am pleased to have the opportunity to testify before you today. The National Climatic Data Center is the world's largest archive of weather and climate data, which includes data critical to understanding climate variability and change, and also acts as the Nation's Scorekeeper regarding the trends and anomalies of weather and climate.

I was one of two Co-ordinating Lead Authors for Chapter 3 of the Intergovernmental Panel on Climate Change (IPCC) 2001 report (and had been lead author for the first and second IPCC assessments), which contained a number of statements regarding human influences on climate and potential climate change. Presently, I am one of the review editors for the fourth IPCC assessment, scheduled to be released in 2007. Since the 2001 report, there has been considerable additional research in this area, building upon the science underpinning the influence of humans on global climate change.

Atmospheric Composition and Greenhouse Gases

The natural "greenhouse" effect is real, and is an essential component of the planet's climate process. A small percentage (roughly 2%) of the atmosphere is, and long has been, composed of greenhouse gases (water vapor, carbon dioxide, ozone and methane). These effectively prevent part of the heat radiated by the Earth's surface from otherwise escaping to space. The global system responds to this trapped heat with a climate that is warmer, on the average, than it would be otherwise without the presence of these gases. In the absence of these greenhouse gases the temperature would be too cold to support life as we know it today. Of all the greenhouse gases, water vapor is by far the most dominant, but other gases are more effective at trapping heat energy from certain portions

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Deleted: I begin my testimony by briefly reviewing the IPCC process from a participating scientist's perspective. I will provide an overview of our basic understanding of the atmosphere in terms of: the role that greenhouse gases play in the atmosphere; evidence for how greenhouse gases are already influencing the climate in both general and in specific ways; and why it is very likely (>95 percent probability) that humans are largely responsible for many of the observed changes in climate over the past several decades. ¶
¶
¶
The IPCC Process from a Participating and Reviewing Scientist's Perspective¶
¶
The primary intent of the IPCC periodic assessments is to provide government policy-makers with the latest and most comprehensive scientific information possible about human influences on our global climate, in a language that has meaning and relevance to governmental policy-makers. The IPCC assessments have, however, provided much more. From purely a scientific perspective, participation in the IPCC process is extremely desirable, as it provides the means for the world's scientists to discuss leading-edge issues with rigorous worldwide scientific review. The IPCC process ensures that the scientists who participate walk away from the process with a fuller appreciation of where important pay-offs in new research and observing systems are most likely to emerge. This has important impacts on our nation's climate change programs including both the United States Global Change Research Program and the Climate Change Science Program. ¶
¶

of the electromagnetic spectrum where water vapor is semi-transparent to heat escaping from the Earth's surface.

In addition to the natural greenhouse effect above, there is a change underway in the greenhouse radiation balance. Some greenhouse gases are increasing in the atmosphere because of human activities and increasingly trapping more heat. Direct atmospheric measurements made over the past 50 years have documented the steady growth in the atmospheric abundance of carbon dioxide. In addition to these direct real-time measurements, ice cores have revealed the atmospheric carbon dioxide concentrations of the distant past. Measurements using air bubbles trapped within layers of accumulating snow show that atmospheric carbon dioxide has increased by nearly 35% over the Industrial Era (since 1750), compared to the relatively constant abundance that it had over at least the preceding 750 years of the past millennium. The predominant cause of this increase in carbon dioxide is the combustion of fossil fuels and the burning of forests. Further, methane abundance has doubled over the Industrial Era, but its increase has slowed over the recent decade for reasons not clearly understood. Other heat-trapping gases are also increasing as a result of human activities. We are unable to state with certainty the exact rate at which these gases will continue to increase because of uncertainties in future emissions as well as how these emissions will be taken up by the atmosphere, land, and oceans. We are certain, however, that once in the atmosphere these greenhouse gases have a relatively long life-time, in the order of decades to centuries. This means they become well mixed throughout the globe.

The increase in heat-trapping greenhouse gases due to human activities are projected to be amplified by feedback effects, such as changes in water vapor, snow cover, and sea ice. As atmospheric concentrations of carbon dioxide and other greenhouse gases increase, the resulting increase in surface temperature leads to less sea ice and snow cover helping to raise temperatures even further. As snow and sea ice decrease, more of the Sun's energy is absorbed by the planet instead of being reflected back to space by the underlying snow and sea ice cover. Present evidence also suggests that as greenhouse gases increase, evaporation increases leading to more atmospheric water vapor. Additional water vapor acts as a very important feedback to further increase temperature. Our present understanding suggests that these feedback effects account for about 60% of the warming. The magnitude of these feedback effects and others, such as changes in clouds, remain a significant source of uncertainty related to our understanding of the impact of increasing greenhouse gases. Increases in evaporation and water vapor affect global climate in other ways besides increasing temperature such as increasing rainfall and snowfall rates, and accelerating drying during droughts.

The increase in greenhouse gas concentrations in the atmosphere implies a positive radiative forcing, i.e., a tendency to warm the climate system.

Particles (or aerosols) in the atmosphere resulting from human activities can also affect climate. Aerosols vary considerably by region. Some aerosol types act in a sense opposite to the greenhouse gases and cause a negative forcing or cooling of the climate system (e.g., sulfate aerosol), while others act in the same sense and warm the climate (e.g., soot). In contrast to the long-lived nature of carbon dioxide (centuries), aerosols are short-lived and removed from the lower atmosphere relatively quickly (within a few days). Therefore, human generated aerosols exert a long-term forcing on climate only because their emissions continue each day of the year. Aerosol effects on climate can be manifested directly by their ability to reflect and trap heat, but they can also have an indirect effect by changing the lifetime of clouds and changing their reflectivity to sunshine. The magnitude of the negative forcing of the indirect effect of aerosols is highly uncertain, but may be larger than the direct effect of aerosols.

Emissions of greenhouse gases and aerosols due to human activities continue to alter the atmosphere in ways that are expected to affect the climate. There are also natural factors which exert a forcing on climate, e.g., changes in the Sun's energy output and short-lived (a few years) aerosols in the stratosphere following episodic and explosive volcanic eruptions. The decadal time-scale forcing estimates in the case of the greenhouse gases are larger than all the other forcings over the past several decades and continue to grow disproportionately larger.

Human activities also have a large-scale impact on the land surface. Changes in land use through urbanization and agricultural practices, although not global, are often most pronounced where people live, work, and grow food, and are part of the human impact on climate. Large-scale deforestation and desertification in Amazonia and the Sahel, respectively, are two instances where evidence suggests there is likely to be human influence on regional climate. In general, city climates differ from those in surrounding rural green areas, because of the "concrete jungle" and its effects on heat retention, runoff, and pollution, resulting in urban heat islands[1].

There is no doubt that the composition of the atmosphere is changing because of human activities, and today greenhouse gases are the largest human influence on global climate.

What exactly is a climate model and why is it useful?

Many of the laws governing climate change and the processes involved can be quantified and linked by mathematical equations. Figure 3 shows schematically the kinds of processes that can be include in climate models. This includes many earth system components such as atmospheric chemistry, ocean circulation, sea-ice, land-surface hydrology, biogeochemistry, atmospheric circulation, etc. The physics of many of the processes governing climate change are well understood, and may be described by mathematical equations. Linking these equations creates mathematical models of climate that may be run on computers or super-computers. Coupled climate models can include physics, chemistry, and biogeochemistry.

[1] The global impact of these urban heat islands has been extensively analyzed and assessed to ensure measurements of global temperature are not biased by local urban heat islands.

Deleted: The atmosphere is made up of a number of gases, most notably nitrogen at 78 percent and oxygen at about 20 percent. However, the remainder of the atmosphere is composed of a number of very important gases that include important greenhouse gases such as water vapor at about 2 percent and carbon dioxide at about 0.04 percent. These last two gases, plus a number of other greenhouse gases that exist in even smaller quantities (e.g., ozone, methane, nitrous oxides) absorb some of the heat energy (infrared radiation) given off by the Earth's surface that otherwise would be transmitted back to space. The various atmospheric gases contribute to the greenhouse effect, the impact of which in clear skies is ~60 percent from water vapor, ~26 percent from carbon dioxide, ~8 percent from ozone, and the rest from trace gases including methane and nitrous oxide. The presence of these greenhouse gases are critical to regulating the Earth's average temperature at about 60°F, as without these gases the Earth's average temperature would be approximately 5°F – too cold to support life as we know it. ¶

¶

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¶

Global changes in atmospheric composition occur from anthropogenic emissions of greenhouse gases, such as carbon dioxide that results from burning fossil fuels and methane and nitrous oxide from multiple human activities. Because these gases have long (decades to centuries) atmospheric lifetimes, the result is an accumulation of these gases in the atmosphere, and a buildup in concentrations that are clearly shown both by instrumental observations of air samples (dating back to 1958) and in bubbles of air trapped in ice cores (prior to 1958) (Figure 1). Moreover, these gases are well distributed in the ... [1]

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In fact however, if we put all our understanding into a single model it would be too complex to run on any existing computer systems. Therefore, all models have trade-offs between the complexity and number of earth system components included, the horizontal and spatial resolution within the model, and the number of years of simulations the model can produce over a specific set of computational hours. This leads to a hierarchy of model complexity, often based on the degree to which approximations are required in each model or component processes omitted.

Approximations in climate models represent those aspects of the models that require parameter choices and "tuning". This is referred to as model parameterization. As a simple example, imagine a single puffy popcorn-like cumulus cloud and how it has to be represented in a global climate model. The cloud may only encompass only a few hundred meters in the vertical and horizontal extent, but today's coupled atmosphere and ocean climate models cannot be run on such high resolution. This then means to incorporate such clouds into the climate model some approximations have to be made regarding the statistical properties of such clouds within say an area 100 or 1000 times larger than the cloud itself. A similar approach is also required in today's state-of-the-science weather models.

An important difference between weather models and climate models is that weather models are initialized with a specific set of observations representing today's weather to precisely predict the weather "x" days or hours into the future. The initial starting conditions of the climate models however, are not nearly as important. Climate models are used to simulate many years of "weather" into the future with the intent of understanding the difference in the collection of weather events at some point in the future, compared to some other time in the past (often the climate of the last 30 years or so). This enables scientists to study the output of climate model simulations to understand the effect of various modifications of those aspects of the climate system that might cause the climate to change or vary. A key challenge is to isolate (if possible) the contribution specific mechanisms make to climate change and to identify cause and effect. This requires knowledge about the changes and variations of the external forcings controlling the climate, and a comprehensive understanding of the climate feedbacks (such as a change in the earth's reflectivity because of a change sea ice or cloud amount) and natural climate variability.

Model simulations of climate over specified periods can be verified and validated against the observational record. Models that can describe the nature of climate change, variations, and steady state climate conditions serve not only as a measure of our understanding, but as a tool to increase this understanding. Once evaluated, they can then be used for predictive purposes. Given specific forcing scenarios, models can provide viable climate-response scenarios. They are the primary means we have to predict climate, although ultimately prediction is likely to be achieved through a variety of means, including the observed rate of global climate change.

How do we know the global air temperature is increasing?

There has now been a comprehensive analysis of the changes of temperatures near the surface and throughout much of the atmosphere in the recent Climate Change Science

Program (CCSP) Synthesis and Assessment Report 1.1. This report addressed the nagging issue of differences in the rate of warming between measurements derived near the surface and those taken from the atmosphere. The surface air temperatures are derived from several different analyses teams using various combinations of ocean ships and buoys, land observations from weather reporting stations, and satellite data. Atmospheric data sets have been derived using satellites, weather balloons, and a combination of the two.

Considering all the latest satellite, balloon and surface records, the CCSP report concluded there is no significant discrepancy between the rates of global temperature change over the past several decades at the surface compared to changes higher in the atmosphere. The report does, however, acknowledge there are still uncertainties in the tropics, and this is primarily related to data from weather balloons. There is uncertainty as to whether scientists have been able to adequately adjust for known biases and errors in the data, especially in the tropics where many developing nations struggle to routinely launch weather balloons and process these measurements.

Globally, data indicate the rates of temperature change have been similar throughout the atmosphere since 1979 when satellite data were first available, and the rates of temperature change have been slightly greater in the atmosphere compared to the surface air temperature since 1958 (the time at which weather balloons had adequate spatial coverage for global calculations). The global surface temperature time series, shown in Figure 2, indicates warming on even longer time scales, with acceleration since 1976.

Instrumental measurements are not our only evidence for increasing global temperatures. The observed increased melting of glaciers can be used to estimate the rate of temperature increase since the late 19th Century. Estimates of the near-surface temperature based on glacial melting are very similar to estimates based on instrumental data. There has been a 15-20 percent reduction in Arctic sea ice since the 1970s, a 10 percent decrease in snow cover since the 1970s, and shortened periods of lake and river ice cover (about 2 weeks shorter since the 19th century). Also, ocean heat content has significantly increased over the past several decades.

Why do we think humans are influencing the Earth's climate?

The scientific community has been actively working on detection and attribution of climate change as related to human activities since the 1980s. One set of tools often used to examine these issues are mathematical computer models of the climate. Not only are these models the primary tools for predicting future climate, they are also very important in helping us to understand the causes of past climate variability and change. The models used are global in extent and are fully coupled, mathematical, computer-based models of the physics, chemistry, and biology of the atmosphere, land surface, oceans, and cryosphere (ice covered portions of the planet), and their interactions with each other and with the sun and other influences (such as volcanic eruptions). Outstanding issues in modeling include specifying forcing mechanisms (e.g., the causes of climate variability and change) within the climate system; properly dealing with complex feedback processes that affect carbon, energy, and water sources, sinks and transports; and improving simulations of regional weather, especially extreme events. Today's inadequate or incomplete measurements of the various forcing mechanisms, with the exception of well-mixed greenhouse gases, add uncertainty when trying to simulate past and present climate. Confidence in our ability to predict future climate depends on our ability to use climate models to attribute past and present climate change to specific causes. The climate models simulate the workings of the climate, such as the winds, clouds and precipitation, and the air temperature. Climate scientists have used these models to examine how the observed changes in climate forcing mechanisms, including increasing greenhouse gases, changes in land use and land cover, changes in the sun's output, volcanic activity, and sulfate aerosols, have affected the climate over the 20th century.

Recent carbon dioxide emission trends in the United States are upward, as are global emissions trends, with increases between 0.5 and 1 percent per year over the past few decades. Concentrations of both reflective and nonreflective aerosols are also estimated to be increasing. Because radiative forcings[2] from greenhouse gases dominate over the net cooling forcings from aerosols, the popular term for the human influence on global climate is "global warming," although it really means global heating, of which the observed global temperature increase is only one consequence. Already the global temperature has exceeded the bounds of natural variability. This has been the case since about 1980. By raising the air temperature, the capacity of the atmosphere to hold more water vapor is increased, which defines the upper bounds of the amount of precipitation that can occur during short term (~daily or less) extreme precipitation events.

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As an example of how models are used to detect human influence on the climate system Figure 4 shows that without including all the observed forcing mechanisms the models cannot replicate the observed global temperature changes. There are many other aspects of the climate system besides global surface temperatures that have been tested for human influences. Today, there is convincing evidence from a variety of model and data climate attribution studies pointing to human influences on climate. These include regional analyses of changes in temperature, the paleoclimatic[3] temperature record, three dimensional analysis of atmospheric temperature change, changes of free atmospheric temperature, changes in sea ice extent and other components of the cryosphere, changes

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[2] Radiative forcing is the change in the net vertical irradiance (expressed in Watts per square meter: Wm^{-2}) at the tropopause due to an internal change or a change in the external forcing of the climate system, such as, for example, a change in the concentration of carbon dioxide or the output of the Sun.

[3] Climate during periods prior to the development of measuring instruments, including historic and geologic time, for which only proxy climate records are available. A proxy climate indicator is a local record that is interpreted, using physical and biophysical principles, to represent some combination of climate-related variations back in time. Climate-related data derived in this way are referred to as proxy data. Examples of proxies are: tree ring records, characteristics of corals, and various data derived from ice cores.

in ocean heat content, and new studies on extreme weather and climate events. Thus, there is considerable confidence that the observed warming, especially the period since 1970s is mostly attributable to increases in greenhouse gases.

Changes in Extremes in the United States

The U.S. Climate Change Science Program Synthesis and Assessment Report 3.3 will specifically address the issue of changes in extreme events, focusing on North America. This assessment plans on comprehensively assessing a wide range of climate-related extreme events and promises to help clarify what we know and do not yet understand about these important events, as related to climate change. Here, three types of climate extremes are discussed as they are likely to be influenced by rising global temperatures. This includes changes the frequency and intensity of heavy and extreme precipitation events, droughts, and hurricanes.

Increasing air temperature leads to increased water vapor in the atmosphere. Surface moisture, if available (as it always is over the oceans), effectively acts as the "air conditioner" of the surface – as heat used for evaporation moistens the air rather than warming it. Therefore, another consequence of global heating of the lower troposphere is accelerated land-surface drying and more atmospheric water vapor (the dominant greenhouse gas). Satellite measurements now confirm a significant increase in atmospheric water vapor, consistent with theoretical expectations given the rate of observed atmospheric warming during the past several decades. Accelerated drying, without an increase in precipitation, increases the incidence and severity of droughts, whereas additional atmospheric water vapor increases the risk of heavy precipitation events. Increases in global temperature also increase sea surface temperatures, one of several important factors affecting the hurricane intensity.

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NOAA's National Climatic Data Center calculates a Climate Extremes Index (CEI) over the United States that includes extremes related to all of these indicators including temperature, precipitation, drought and hurricanes. Although no index can claim to adequately capture all of the important changes in extremes, the changes and variations of the CEI as reflected in Figure 5 is illustrative of the varying decadal variability of climate extremes. Currently, the CEI is at record levels during the past decade or so, but not much higher than in previous decades, and so there is no clear indication of a general increase in the aggregate set of extremes included in the CEI when viewed across much of the 20th Century.

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Changes in Heavy and Extreme Precipitation

Basic theory, climate model simulations, and empirical evidence (Figure 6) confirm that warmer climates, owing to increased water vapor, lead to more intense precipitation events even when the total precipitation remains constant, and with prospects for even stronger events when precipitation amounts increase. Figure 7 depicts the aggregate land-surface world-wide changes in heavy precipitation events over the last half of the 20th century with an associated geographic depiction of where changes in heavy precipitation have occurred, with most areas showing increases. World-wide, an increase

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of a few percent in heavy precipitation events is evident since the middle of the 20th century, particularly in the middle and high latitudes. By the end of the 21st Century a 10-20 percent increase in the precipitation rate for 1-day extreme precipitation events (20 year return periods) is in the middle range of a variety of climate models, when forced with a rather conservative change in atmospheric greenhouse gases. Carbon dioxide does not exceed 550 ppmv[4].

The practical implications of addressing these changes are seen in NOAA's recent update of the Ohio River Basin's 100-year 24-hour precipitation return period. Over the past several decades increases in precipitation rates for the 1 in 100 year extreme daily precipitation amount was observed in many areas of the eastern United States over the past several decades. These data are used to help set engineering design standard related to excessive rainfall.

Changes in Drought Severity and Frequency

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Drought is a recurring feature of the climate system. In other words, we have had major droughts in the past, and expect to have major droughts in the future. At any given time, at least part of the U.S. is in drought, with percentages ranging from 5-80 percent of the total land area. U.S. droughts show pronounced multi-year to multi-decadal variability, but no convincing evidence for systematic long-term trends toward more or fewer events. Drought calculations have been made showing that over the U.S, the increase in temperatures that may have lead to increased evaporation have been compensated by a general increase in precipitation over the past few decades. In general, there are no clear patterns of precipitation increase emerging from climate model simulations as global temperatures increase, so the increase in precipitation over the past few decades may not persist and could reverse. Such a reversal, added to the continuing increase in temperatures (January through June of 2006 have been the warmest temperatures in U.S. records dating back to 1895) could lead to greater drought severity and frequency, especially during periods of dry weather due to increases in evaporation.

For the continental U.S., the most extensive U.S. drought in the modern observational record occurred from 1933 to 1938. In July 1934, 80 percent of the U.S. was gripped by moderate or greater drought (Figure 8), and 63 percent was experiencing severe to extreme drought. During 1953-1957, severe drought covered up to 50 percent of the country. Paleoclimatic data (e.g. tree ring measurements) have been used to reconstruct drought patterns for the period prior to the modern instrumental record. These reconstructions show that during most of the past two millennia the climate of the western U.S. has been more arid than at present. The recent intense Western drought from 1999 to 2004 that strongly affected the Colorado River basin was exceeded in severity as recently as the 19th century. Within the past millennium there have been severe droughts in both the western U.S. and Midwest that have lasted for multiple decades.

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[4] Such a scenario is built on the storyline of relatively low population growth and with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies.

Long-term warming trends have led to changes in the timing of snow melt and stream flows, especially in the West. This is resulting in earlier peak stream flows and diminished summer-time flows.

Changes in Hurricane Intensity and Frequency

Tropical storms and particularly hurricanes, are an important issue of concern for the United States. The unprecedented hurricane season of 2005, and especially the havoc created by Katrina, raised public awareness of the dangers of hurricanes to new heights. Hurricanes respond to a number of environmental factors including ocean temperatures, atmospheric stability, El Niño, and other factors. One important question is whether hurricane activity has changed over the last 100 years. Since 1995, Atlantic hurricane activity has significantly increased, with more hurricanes, and more intense hurricanes, compared to the two previous decades (Figure 9). However, earlier periods, such as the 1945 to 1970 period were nearly as active.

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An important consideration in hurricane intensity is a trend toward warmer ocean temperatures, particularly in the tropical Atlantic and Gulf of Mexico, indicating that global warming may play some role in the increased hurricane intensity. Another factor is a slow cycle of natural fluctuations in atmospheric conditions and ocean temperatures in the North Atlantic referred to as the Atlantic Multi-decadal Oscillation (AMO). This AMO is currently in a warm ocean temperature phase.

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What does the future hold for hurricane activity? In the near term, it is expected that favorable conditions for Atlantic hurricanes will persist for the next decade or so based on previous active periods. For the longer term, climate models simulate about 1/2 Category increase (approximately six percent increase in wind speed, and approximately 15 percent decrease in central pressure) in the intensity of strong hurricanes late in the 21st Century, with a tropical sea surface temperature increase of nearly 2°C higher than at present. The models also simulate about a 20 percent increase in near-storm rainfall rates under those conditions. However, it is unclear if the total number of hurricanes will change in future years.

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New analyses of precipitation rates for different strengths of landfalling Atlantic tropical cyclones (both hurricanes and tropical storms) over the southeastern United States have recently been completed. These analyses show that daily precipitation amounts increase with tropical cyclone strength, while hourly precipitation does not. This means that the more intense hurricanes have longer periods with heavy rainfall. The implications are relevant for local planning, if indeed tropical cyclone strength increases in the future.

Overall, the scientific community has varying viewpoints on the magnitude of influence of global warming on hurricanes and how long the current active period will last. NOAA recognizes the debate and continues to study hurricane development, intensity, activity, and modeling.

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Conclusion

Modern climate change is dominated by human influences, which are now large enough to exceed the bounds of natural variability. The main source of global climate change is human-induced changes in atmospheric composition. These perturbations primarily result from emissions associated with energy use, but on local and regional scales, urbanization and land use changes are also important. Although there has been progress in monitoring and understanding climate change, there remain many scientific, technical, and institutional impediments to precisely planning for, adapting to, and mitigating the effects of climate change. There is still considerable uncertainty about the rates of change that can be expected, however, it is clear that these changes will be increasingly manifested in important and tangible ways, such as changes in extremes of temperature and precipitation, decreases in seasonal and perennial snow and ice extent, sea level rise, and now there is accumulating evidence to suggest that there will be increases in hurricane intensity and related heavy and extreme precipitation. Anthropogenic climate change is now likely to continue for many centuries. In many respects we are venturing into the unknown territory with changes in climate, and its associated effects could be quite disruptive. The rate of human-induced climate change is projected to be much faster than most natural processes prevailing over the past 10,000 years

Over the next two years the Climate Change Science Program will be completing a series of 21 Synthesis and Assessment Reports, the first of which has just be released a few months ago. The collection of these Synthesis and Assessment Report will address many of the issues pertinent to this testimony. NOAA and the CCSP Agencies would be pleased to brief this Committee on those reports as they become available.

Thank you again, Mr. Chairman for allowing me the opportunity to help inform the Committee about climate change.

Subject: Re: Oral Testimony --- Tom
From: Eric.Webster[redacted]
Date: Thu, 20 Jul 2006 00:32:00 -0400
To: Thomas.R.Karl[redacted]
CC: Jason Robertson <[redacted]@noaa.gov>, Noel Turner <[redacted]@noaa.gov>, Ahsha Tribble <[redacted]@noaa.gov>, Thomas R Karl <[redacted]@noaa.gov>

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Tom: I made significant modifications to simplify and clarify many of
the points. I used parts of the written and my own words. Please read
through it in the morning to ensure I didn't change any important
points. Also, see the 1st paragraph on CCSP report 1.1 to ensure I
characterized it correctly.

Please make sure you are comfortable with all my edits -- it is late
so I hope I didn't many any mistakes.  We can review in the morning
but there won't be a lot of time.

Thanks,
Eric
```

Climate change oral july 20 -tk.doc	**Content-Type:** application/octet-stream **Content-Encoding:** base64

the steady growth of carbon dioxide in the atmosphere (SEE SLIDE 1). This growth is predominantly caused by the increase in the combustion of fossil fuels. Once this greenhouse gas enters the atmosphere it stays for a long time -- from decades to centuries.

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While SLIDE 1 shows a strong positive correlation between increases in carbon dioxide and global temperature, a specific cause and effect relationship cannot be assumed. Climate scientists must use other tools to link climate change to human influences. This is where climate models enter into the picture.

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So, what exactly is a climate model and why is it useful? SLIDE 2 shows schematically the kinds of processes that can be included in climate models. Among these are many earth system components such as atmospheric chemistry, ocean circulation, and land-surface hydrology. Many of the scientific laws governing climate change and the processes involved can be quantified and linked by mathematical equations. Linking these equations creates mathematical models of climate that may be run on computers or super-computers. Given the magnitude of data (and understanding) of all these physical and chemical processes, it is

Deleted: SLIDE 2 shows schematically the kinds of processes that can be included in climate models. Among these are many earth system components such as atmospheric chemistry, ocean circulation, sea-ice, land-surface hydrology, biogeochemistry, and atmospheric circulation.

Deleted: The physics and chemistry of many, though not all, of the processes governing climate change are well understood, and may be described by mathematical equations.

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scientific community has been actively working on detection and attribution of climate change as related to human activities since the 1980s.

Research has shown there are many other aspects of the climate system besides global surface temperatures that have been influenced by human activity, such as regional changes in temperature, changes in ocean heat content, and extreme weather and climate events. There is considerable confidence that the observed warming, especially since the 1970s, is mostly attributable to changes in atmospheric composition due to human influences.

In conclusion, the state of the science continues to indicate that modern climate change is affected by human influences, primarily human-induced changes in atmospheric composition. While there is still considerable uncertainty about the rates of change that can be expected, it is clear these changes will be increasingly manifested in important and tangible ways. Recent evidence suggests there will be changes in extremes of temperature and precipitation, decreases in seasonal and perennial snow and ice extent, sea level rise, and increases in hurricane intensity and related heavy and extreme precipitation. Furthermore, while there has been progress in monitoring and understanding the causes of climate change, there remain

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The U.S. Climate Change Science Program is addressing the scientific dimensions of these challenges through research, observations, decision support, and communication. This federal government program, which encompasses the efforts of 13 federal agencies, helps prioritize and integrate federal research on global climate change. The program's vision, as guided by its 2003 Strategic Plan, is to improve the nation's ability to manage the risks and opportunities of climate change and related environmental systems.

Within the next two years the program will produce a series of synthesis and assessment reports that describe the state-of-the-science on a range of key issues. The first report released this past May addressed the debate about differences in detected temperature increases by satellites and surface observations. The issue had led some to cast doubt about the magnitude of global warming. Subsequent reports will provide further important contributions to the nation's discussions of climate change.

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Deleted: rate of temperature increased observed both by satellites and surface based observations. This Synthesis and Assessment was released this past May and has already made a valuable contribution to the national dialogue.

Thank you again, Mr. Chairman for the opportunity to testify about this important topic.

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Subject: FW: Fwd: Re: Talking point on global warming
From: "Jones, Tom (Commerce)" <[redacted]@commerce.senate.gov>
Date: Tue, 6 Sep 2005 13:50:47 -0400
To: "Noel Turner (E-mail)" <[redacted]@noaa.gov>

[redacted]

-----Original Message-----
From: Jones, Tom (Commerce)
Sent: Saturday, September 03, 2005 1:04 PM
To: 'Scott.Carter[redacted]
Cc: 'Jennifer.Sprague[redacted]
Subject: Re: Fwd: Re: Talking point on global warming

Cool. Thanks guys. We're going to work on smacking the shit out of this issue.

At the hearing on the 14th we're going to ask max mayfield about it. I'd love to have an answer from him that doesn't contain any long words or flavor of equivication. Something like, "mr chairman, the individuals who are implying that katrina has something to do with global warming are just plain wrong. They don't understand the science and they're shamelessly trying to make political hay out of a national tragedy."

Thanks
Tom

Sent from Tom Jones' BlackBerry

-----Original Message-----
From: Scott.Carter[redacted] <[redacted]@noaa.gov>
To: Jones, Tom (Commerce) <[redacted]@commerce.senate.gov>
CC: Jennifer.Sprague[redacted]
Sent: Sat Sep 03 12:56:00 2005
Subject: Fwd: Re: Talking point on global warming

Tom,

See the email from Jen. Let .e know if need anything else at this tiem. Jen is in Wyoming and is having troible with email.

Thanks

Scott

-----Original Message-----

From: Jennifer Sprague <[redacted]
Subj: Re: Talking point on global warming
Date: Sat Sep 3, 2005 11:24 am
Size: 2K
To: Scott.Carter[redacted]

PREDECISIONAL NOT FOR REDISTRUBUTION

Hey Tom,
I am out of town for the next few days in Wyoming and don't have full access to all of my statistics and info. Having said that, I have placed a call to Carter and he will help me get some of the materials if you need "scrubbed" talking points now.

Below are some rough talking points. While I believe we have already sent you the cleared QFRs from the June 29 hearing with Max Mayfield (Carter will you resend to Tom and I?) I think we need to have a strong response. The media has done a very good job of getting out there and "convincing" many people that Hurricane Katrina is a result of global warming....we need to be prepared with a response. I spoke with NOAA public affairs yesterday and plan to speak to CEQ when I return. There is a sensitivity to be mindful of as we don't need to politicize this issue at a time when people have lost their loved ones and property....but we need to be prepared with an answer...and the truth.

We are in a multi decadal period of increased hurricane activity.. Similiar to the 30s and 40s. (will get the scientific prognosis for you when I return (Carter is this something we could task Mayfield or Rappaport?)

Max Mayfield, Director of the National Hurricane Center, Dr. William Gray, well-respected hurricane researcher and Chris Landsea, also well-respected NOAA scientist who left the IPCC due to inside pressure to conform his views , have all stated the lack of any correlation or rather stong evidence between global warming and our current increase in hurricanes. (I have the articles and statements at my office and can get the info to you on Wednesday morning)

Thomas Knutson, the GFDL researcher whose recent study on global warming and hurricanes, and who gave a Hill briefing at a June AMS sponsored event, has been quoted in recent news articles,(I believe a little out of context.) His research shows that when increased sea surface temperatures are placed intothe models it shows a 1 percent increase in the intensity of hurricanes over 80 years (I have his report at my office and can give you a better read on Wednesday. I also want to take a closer look at the news articles related to Knutson. I believe they are taking his report way out of context, but want to be sure.)

I hope this helps and is at least a good starting point. I apologize I don't have everything on me to give you a better response, but will jam on this further on Wednesday.

I have my TREO on me and my contact # [redacted].

Have a good weekend!
Jen
-----Original Message-----

From: "Jones, Tom (Commerce)" <[redacted]@commerce.senate.gov>
Subj: Talking point on global warming
Date: Fri Sep 2, 2005 5:13 pm
Size: 187 bytes
To: Jennifer.Sprague[redacted]

Jen

Need this!

This was the headline today in USA Today "USA--Katrina reignites global warming debate"

Thanks

Tom

Sent from Tom Jones' BlackBerry

Scott A. Carter
NOAA Legislative Affairs

Subject: testimony info
From: "Noel.Turner" <[redacted]@noaa.gov>
Date: Tue, 06 Sep 2005 15:26:19 -0400
To: John Sokich <[redacted]@noaa.gov>

Hi John,

Talked to Tom Jones a bit today, and have additional insight into what he is looking for. With respect to the climate change issue, he is looking for something quotable. I believe his exact words were something "pithy, short, and quotable." While I don't think the verbage is quite right, he is looking for something along the lines of "Mr chairman, the individuals who are implying that Katrina has something to do with global warming are just plain wrong. They don't understand the science and they're shamelessly trying to make political hay out of a national tragedy." I would not say that, verbatim, would be appropriate for either the VADM or Max, as it just doesn't sound like something they'd say -- but if we can get something close and quotable, that would probably be good. I know he's been talking to Sprague about this as well.

Also, did you/Potts have a talk with Gallagher about where we are with the Supplemental, and whether we will be able to discuss needs for improved forecasts?? If so, we would not want to include dollar amounts, only talk about what we need money for. Apparently Tom will be fighting to get us some money and he doesn't want us putting out a lower number than what he has planned. I told him I didn't think numbers would survive anyway, and I didn't know if that section would make it in at all.

I ran him through what we are drafting based on what Eric requested, and he seems fine with it all. I think he number one priority with this hearing is making FEMA look bad. Number two could be killing the climate change and hurricanes issue. Number three could be fighting for money in a supplemental.

Let me know if you have questions about any of this.
Thanks,
Noel

--
Noel Turner
Legislative Affairs Specialist
Office of Legislative Affairs
National Oceanic and Atmospheric Administration
[redacted]

Subject: testimony and Q&As
From: "Noel.Turner" <[redacted]@noaa.gov>
Date: Wed, 21 Sep 2005 08:57:50 -0400
To: John Sokich <[redacted]@noaa.gov>

[redacted]

Hi John,
I've attached the latest and greatest here. We'll need to pow-wow with Carter and Sprague late this morning on exactly what members are trying to get out of this hearing, and what types of questions we will be asked. I think this one will be an odd one to prep for, because I would expect some people to be right on top of the issues, and others to be relatively ignorant about what we do...
Talk to you soon,
N

--
Noel Turner
Legislative Affairs Specialist
Office of Legislative Affairs
National Oceanic and Atmospheric Administration
[redacted]@noaa.gov
[redacted]

Hurricane Q&A MASTER NOAA - FINAL.doc — **Content-Type:** application/msword **Content-Encoding:** base64

NOAA FINAL Senate Katrina Testimony 9.14.05.doc — **Content-Type:** application/msword **Content-Encoding:** base64

9) <u>QUESTION</u>: SOME ORGANIZATIONS, POLITICIANS AND POLITICAL PUNDITS ARE MAKING A CONNECTION BETWEEN HURRICANE KATRINA, AND INCREASED HURRICANE ACTIVITY GENERALLY, AND GLOBAL WARMING. IN YOUR OPINION, WAS HURRICANE KATRINA A RESULT OF GLOBAL WARMING?

<u>ANSWER</u>: Those who would link Hurricane Katrina to global warming just don't understand the science. Quite simply, it's not logical to link one hurricane to global warming. There is always natural variability in our planet's climate and we are in a period of heightened hurricane activity, similar to the period we experienced during the 1940s through the 1960s.

In my view, thousands of people have lost their homes, their possessions and in some cases their lives and this is not the time for anyone to make or promote unproven statements connecting Hurricane Katrina to global warming. .

10) <u>QUESTION</u>: I APPRECIATE YOUR RESPONSE IN REGARD TO HURRICANE KATRINA AND GLOBAL WARMING, BUT IT SEEMS WE HAVE ENTERED A PERIOD OF INCREASED HURRICANE ACTIVITY. CAN YOU EXPLAIN THIS?

<u>ANSWER</u>: In my opinion, as a 35 year civil servant involved in hurricane prediction, the increased hurricane activity is due to natural cycles of hurricane activity driven by the Atlantic Ocean along with the atmosphere above it. These natural cycles are far greater than any human influences that may be related to hurricanes.

From the studies I am aware of on climate change, including hurricane modeling and theoretical studies, the studies suggest no major changes in where hurricanes form or occur. Preliminary analyses suggest that, approximately a century from now, either no change or a small change may occur globally in the NUMBER of hurricanes. On a regional level, there may be areas that have either minor increases or minor decreases in frequency (on the order of ± 10%). While the PEAK and AVERAGE INTENSITY of tropical cyclones may increase by about 5% in wind speeds and storm total RAINFALL may also increase on the order of about 5% more precipitation, these are hypothesized changes that may occur by around 2080, **IF AND WHEN** a doubling in the amount of carbon dioxide in the atmosphere may be observed. Changes seen today are likely to be on the order of a 1% alteration in frequency, intensity and rainfall in hurricanes - not even measurable by today's observational techniques.

The fact is the number of tropical cyclones is not increasing over the globe as a whole and in fact has decreased in some ocean basins such as the eastern North Pacific. History shows a multi-decadal period of increased Atlantic hurricane activity from the 1940s to the late 1960s, fewer than average major hurricanes for about the next 25 years, and now an increased number since 1995. If the cycle persists, we may very well be in a period of increased hurricane activity for the next 10 to 20 years or more. I would think that no one could plausibly take any one year (or one hurricane) and attempt to link that to climate change.

11) <u>QUESTION</u>: MR. MAYFIELD, I AM SURE YOU ARE FAMILIAR WITH KERRY EMMANUAL'S STUDY IN A RECENT ARTICLE IN THE JOURNAL NATURE; DOESN'T THAT INDICATE THAT GLOBAL WARMING IS ALREADY IMPACTING HURRICANE ACTIVITY?

<u>ANSWER</u>: The recently published paper by Prof. Emanuel in Nature did suggest an "unprecedented" increase in Atlantic hurricane activity in the last ten years, which he then linked to warming of Atlantic Ocean temperatures. However, because of the methodology of the study and limitations of the dataset, it is instead likely that the recent hurricane activity is quite similar to that observed during 1940s to the late 1960s and is not unprecedented in nature **in my opinion.**

In my opinion, Prof. Emmanuel's study does not properly present the data as described. It utilizes a wind correction scheme for the Atlantic that is not warranted and further investigation of U.S. hurricanes and sea surface temperatures shows no tendency for increasing destructiveness over the last 100 years. A National Hurricane Center meteorologist is currently writing a paper to respond to the Emanuel study.

However, more study is needed to better understand the complex interaction between these storms and the tropical atmosphere/ocean as well as to extend our knowledge of hurricane climate variations back in time as much as possible with both historical reconstructions and longer term geological studies.

12) QUESTION: MR. MAYFIELD, THERE IS YET ANOTHER STUDY THAT WAS PUBLISHED JUST LAST WEEK IN THE JOURNAL SCIENCE BY PROFESSOR PETER WEBSTER, WHICH SUGGESTS MORE HURRICANES ARE REACHING STRONGER INTENSITIES. WHAT IS YOUR COMMENT TO THIS RECENT STUDY?

ANSWER: This study indicates that globally there has been no change in either numbers or duration of hurricanes. However, it did suggest that a higher proportion of these storms were reaching Category 4 and 5 intensities. It is of note that the study found no significant increase in percentage of Category 4 and 5 hurricanes in the Atlantic, where hurricanes are by far the best monitored. The increases were only seen where hurricanes were observed by satellite imagery alone and there are critical questions regarding the data consistency over the 30 year period. Again, this study brings up important questions, but is by no means convincing evidence that anthropogenic global warming is impacting hurricanes.

[redacted]

Subject: Attached is the MOST RECENT set of Q&As
From: Jennifer Sprague <Jennifer.Sprague[redacted]
Date: Thu, 06 Oct 2005 14:57:57 -0500
To: Scott.Carter[redacted], Eric.Webster[redacted], Noel.Turner[redacted], carrie.selberg[redacted] Garner R Yates <[redacted]@noaa.gov>, John.Sokich[redacted], Joanne Swanson <[redacted]@noaa.gov>, Chris.Scheve[redacted]harrelson[redacted]

Folks,

Eric Webster will be making additional changes to the Master list of QAs. IF you MUST make any changes, send any/all changes to Eric Webster.

Thank you. See you in the morning at the 8:00 a.m. pre-brief in HCHB Room #5215

Jen

MASTER House Science Q&A DRAFT - 10.06.05.doc	**Content-Type:**	application/msword
	Content-Encoding:	base64

FROM A TROPICAL DEPRESSION TO A TROPICAL STORM AND ON AUGUST 25, KATRINA INTENSIFIED TO A HURRICANE A MERE 3 HOURS PRIOR TO LANDFALL. DID THE NATIONAL HURRICANE CENTER PROVIDE SUFFICIENT NOTIFICATION TO THE RESIDENTS OF SOUTH FLORIDA IN REGARD TO KATRINA'S INTENSIFICATION AND POSSIBLE IMPACTS?

Answer: The National Hurricane Center issued a Tropical Storm Warning and Hurricane Watch at 11:00 a.m. EDT August 24 for the southeast coast of Florida from Vero Beach to Florida City (at the same time Katrina strengthened from a tropical depression to a tropical storm) approximately 31 hours prior landfall in FL as a Category 1. A Hurricane Warning was issued at 11:00 p.m. EDT August 24 for the southeast coast of Florida from Vero Beach to Florida City, about 19 hours prior to landfall as a Category 1.

All forecasts indicated that Katrina would come ashore in Florida as a strong Tropical Storm or a Category 1 hurricane and due to its slow forward speed; Katrina was expected to produce a significant amount of heavy rainfall with total rainfall accumulations of 6 to 12 inches with isolated maximum amounts of 15 to 20 inches possible. Hurricane Katrina made landfall as a Category 1 hurricane at 6:30 p.m. EDT, Thursday, August 25 and produced rainfall amounts near 16 inches in some places of south Florida.

Question: **SOME ORGANIZATIONS, POLITICIANS AND POLITICAL PUNDITS ARE MAKING A CONNECTION BETWEEN HURRICANE KATRINA, AND INCREASED HURRICANE ACTIVITY GENERALLY, AND GLOBAL WARMING. IN YOUR OPINION, WAS HURRICANE KATRINA A RESULT OF GLOBAL WARMING?**

Answer: I am not a global warming expert, I am a hurricane specialist; however, those who would link Hurricane Katrina to global warming just don't understand the science. Quite simply, it's not logical to link one hurricane to global warming. There is always natural variability in our planet's climate and we are in a period of heightened hurricane activity, similar to the period we experienced during the 1940s through the 1960s and we can expect this activity to last another 10 – 20 years.

Question: **I APPRECIATE YOUR RESPONSE IN REGARD TO HURRICANE KATRINA AND GLOBAL WARMING, BUT IT SEEMS WE HAVE ENTERED A PERIOD OF INCREASED HURRICANE ACTIVITY. CAN YOU EXPLAIN THIS?**

Answer: Again, I am not a global warming expert, I am a hurricane specialist, however, in my opinion, the increased hurricane activity can be explained completely by natural cycles of hurricane activity driven by the Atlantic Ocean along with the atmosphere above it. These natural cycles are far greater than any human influences that may be related to hurricanes and one need not invoke global warming to explain the observed hurricane activity.

From the studies I am aware of on climate change, including hurricane modeling and theoretical studies, the studies suggest no major changes in where hurricanes form or occur. Preliminary analyses suggest that, approximately a century from now, either no change or a small change may occur globally in the NUMBER of hurricanes. On a regional level, there may be areas that have either minor increases or minor decreases in frequency (on the order of ± 10%). While the PEAK and AVERAGE INTENSITY of tropical cyclones may increase by about 5% in wind speeds and storm total RAINFALL may also increase on the order of about 5% more precipitation, these are hypothesized changes that may occur by around 2080, **IF AND WHEN** a doubling in the amount of carbon dioxide in the atmosphere may be observed. Changes seen today are likely to be on the order of a 1% alteration in frequency, intensity and rainfall in hurricanes - not even measurable by today's observational techniques.

The fact is the number of tropical cyclones is not increasing over the globe as a whole and in fact has decreased in some ocean basins such as the eastern North Pacific. History shows a multi-decadal period of increased Atlantic hurricane activity from the 1940s to the late 1960s, fewer than average major hurricanes for about the next 25 years, and now an increased number since 1995. If the cycle persists, we may very well be in a period of increased hurricane activity for the next 10 to 20 years or more. I would think that no one could plausibly take any one year (or one hurricane) and attempt to link that to climate change.

Question: MR. MAYFIELD, I AM SURE YOU ARE FAMILIAR WITH KERRY EMMANUEL'S STUDY IN A RECENT ARTICLE IN THE JOURNAL NATURE; DOESN'T THAT INDICATE THAT GLOBAL WARMING IS ALREADY IMPACTING HURRICANE ACTIVITY?

Answer: The recently published paper by Prof. Emanuel in Nature did suggest an "unprecedented" increase in Atlantic hurricane activity in the last ten years, which he then linked to warming of Atlantic Ocean temperatures. However, because of the methodology of the study and limitations of the dataset, it is instead likely that the recent hurricane activity is quite similar to that observed during 1940s to the late 1960s and is not unprecedented in nature **in my opinion.**

In my opinion, Prof. Emmanuel's study does not properly present the data as described. It utilizes a wind correction scheme for the Atlantic that is not warranted and further investigation of U.S. hurricanes and sea surface temperatures shows no tendency for increasing destructiveness over the last 100 years. A National Hurricane Center meteorologist is currently writing a paper to respond to the Emanuel study.

However, more study is needed to better understand the complex interaction between these storms and the tropical atmosphere/ocean as well as to extend our knowledge of hurricane climate variations back in time as much as possible with both historical reconstructions and longer term geological studies.

Question: MR. MAYFIELD, THERE IS YET ANOTHER STUDY THAT WAS PUBLISHED JUST LAST WEEK IN THE JOURNAL SCIENCE BY PROFESSOR PETER WEBSTER AND CO-AUTHORED BY JUDITH CURRY, WHICH SUGGESTS MORE HURRICANES ARE REACHING STRONGER INTENSITIES. WHAT IS YOUR COMMENT TO THIS RECENT STUDY?

Answer: That study indicates that globally there has been no change in either numbers or duration of hurricanes. However, it did suggest that a higher proportion of these storms were reaching Category 4 and 5 intensities. It is of note that the study found no significant increase in percentage of Category 4 and 5 hurricanes in the Atlantic, where hurricanes are by far the best monitored. The increases were only seen where hurricanes were observed by satellite imagery alone and there are critical questions regarding the data consistency over the 30 year period. Again, this study brings up important questions, but is by no means convincing evidence that anthropogenic global warming is impacting hurricanes.

Question: YOU TESTIFIED IN THIS HEARING AND AT THE JUNE 29, 2005 HEARING THAT INTENSITY PREDICTION IS ONE OF THE GREATEST CHALLENGES FACING HURRICANE PREDICTION, WHAT TOOLS, BOTH COMPUTATIONAL AND OBSERVATIONAL, ARE NECESSARY TO INCREASE THE EFFECTIVENESS OF HURRICANE INTENSITY PREDICTIONS? YOU HAVE TESTIFIED TODAY THAT PREDICTION REGARDING INTENSITY IS TIED TO THE ACTUAL HURRICANE TRACK FORECAST, PLEASE EXPLAIN WHY THIS IS SO AND WHAT TOOLS, BOTH COMPUTATIONAL AND OBSERVATIONAL, ARE NECESSARY TO INCREASE THE ACCURACY OF HURRICANE TRACK AND INTENSITY FORECASTING?

Answer: NOAA funding is focused on continued model improvements, including gathering data and preparing those data for use by computer models. While track forecasts for large and strong hurricanes have been better lately, weaker storms, such as Ophelia can pose forecasting challenges. We still have much to do to improve our track forecasts as well as our intensity predictions. While we did well forecasting the intensity of Hurricanes Katrina and Rita at landfall along the central Gulf Coast, they both intensified faster than we predicted. Katrina went from tropical storm strength to a Category 2 hurricane in just 9 hours. That was quick and not predicted by us or by any of the forecast models. We have much work to do to understand why, how and when such rapid deepening can occur.

Question: HOW IMPORTANT ARE SATELLITES IN FORECASTING TROPICAL SYSTEMS?

Answer: We use NOAA satellite information in our models when we predict intensity and forecast track. NOAA research efforts are focused on using satellite data to provide improved measurements of the ocean, including wave height and sea surface temperature. The next generation NPOESS and GOES-R satellite systems hold great promise for