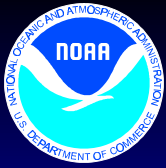


1999 NWS Field Assessment of GOES Sounder Products

Overview & Case Studies

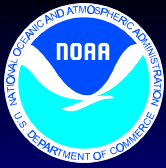
***NWS Office of Meteorology
August 2000***



GOES Sounder Assessment Overview



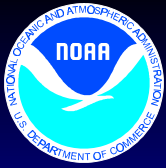
- **Purpose:** Assess the operational value of GOES Sounder Products to the NWS Forecast and Warning Program
- **Conducted:** July 19 - August 30, 1999



GOES Sounder Assessment Overview (cont.)



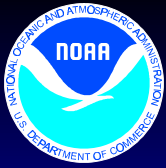
- **Products Assessed:**
 - **Moisture: Total Precipitable Water (TPW)**
 - **Stability:**
 - **Lifted Index (LI)**
 - **Convective Available Potential Energy (CAPE)**
 - **Convective Inhibition (CINH)**
 - **Vertical Temperature/Moisture Soundings**
 - **Miscellaneous (limited evaluation, results not presented here):**
 - **Skin Temperature**
 - **Cloud Top Pressure**



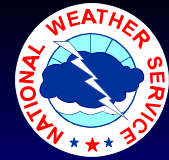
GOES Sounder Assessment Overview (cont.)



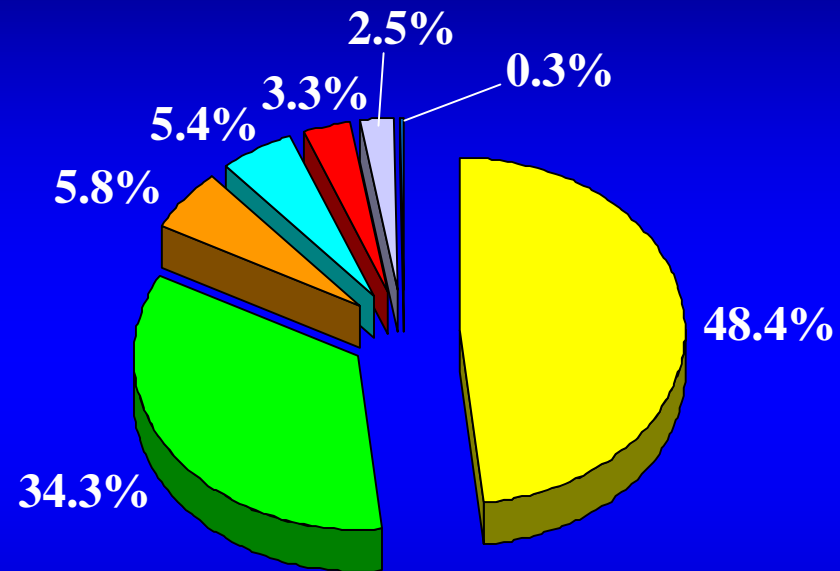
- **Total responses received:**
 - **Web-based - 635 from 37 Forecast Offices, NCEP's Marine Prediction Center and NESDIS Satellite Analysis Branch**
 - **Written - 1 each from Storm Prediction, Aviation Weather and Hydrometeorological Prediction Centers**

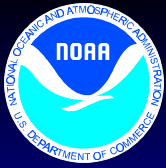


GOES Sounder Assessment Web-Based Responses



- **Weather Situations Evaluated (635 total)**
 - Tornado Warning (2)
 - Flash Flood Wtch/Wrng (16)
 - Svr Tstm Wtch/Wrng (21)
 - Other (34)
 - Monsoon (37)
 - Convection Expected (218)
 - No Significant Wx (307)
- **328 Active Weather Cases**

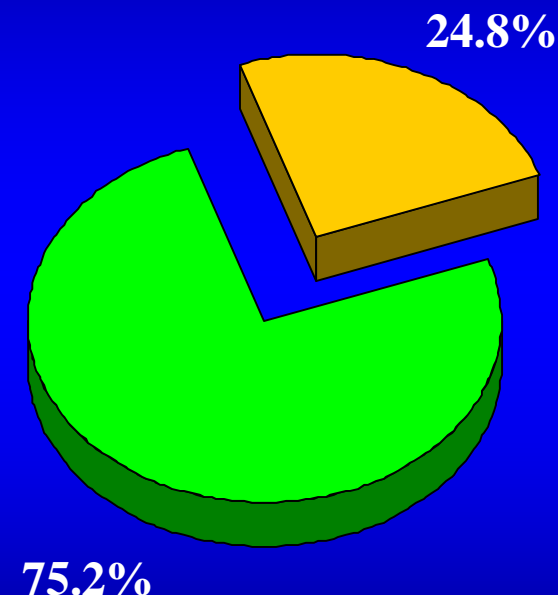




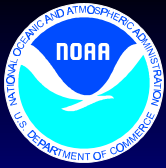
GOES Sounder Assessment Use in Convective Situations



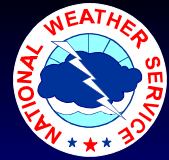
- Did the GOES Sounder Products increase your confidence convection would/ would not develop? (250 valid wx cases)
 - Yes (188)
 - No (62)



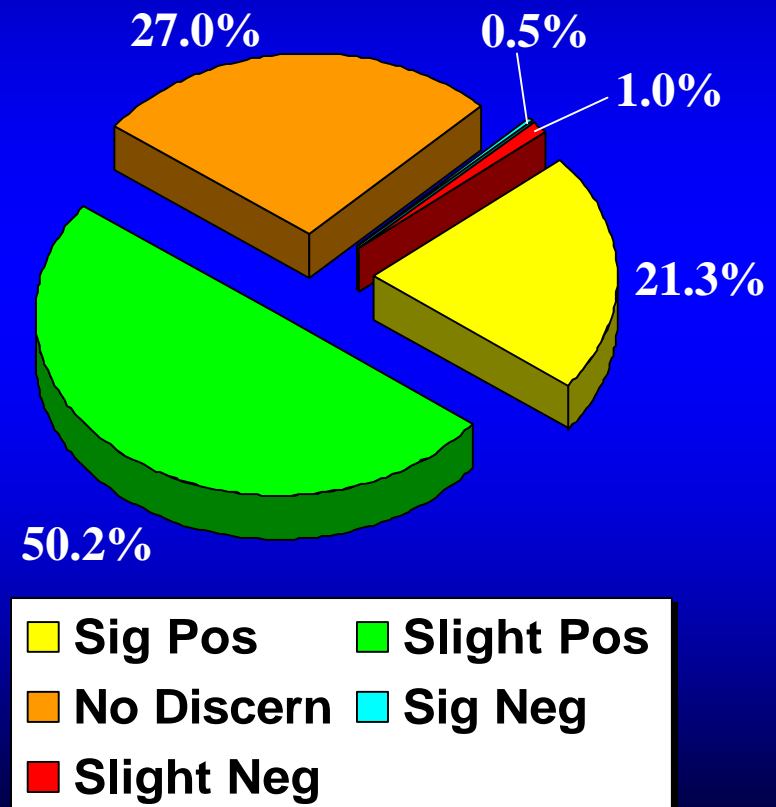
■ Yes ■ No

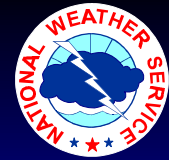
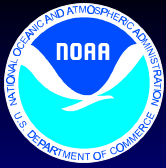


GOES Sounder Assessment Use of Moisture Product



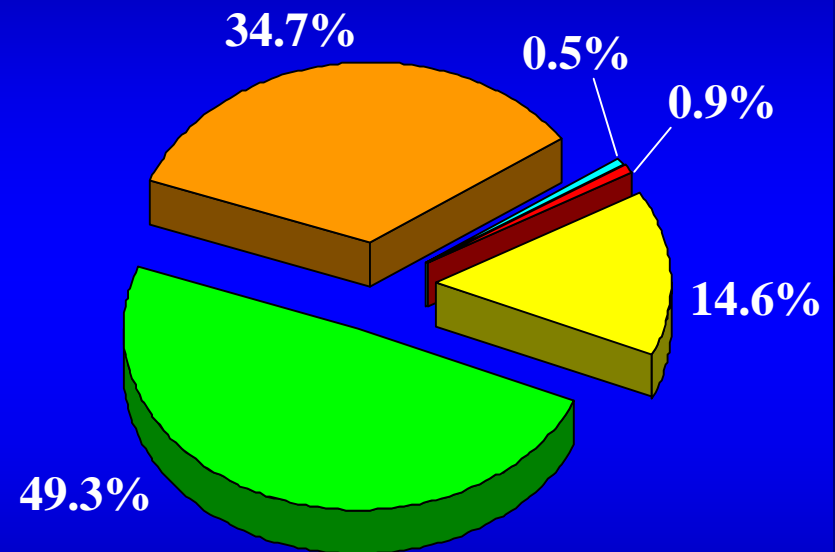
- Rate the usefulness of the Total Precipitable Water product to your precipitation program. (207 valid wx cases)
 - Significant Positive Impact (44)
 - Slight Positive Impact (104)
 - No Discernible Impact (56)
 - Slight Negative Impact (2)
 - Significant Negative Impact (1)

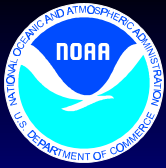




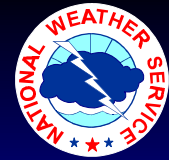
GOES Sounder Assessment Use of Moisture Product (cont.)

- Rate the usefulness of the Total Precipitable Water product for the location & timing of thunderstorm activity. (213 valid wx cases)
 - Significant Positive Impact (31)
 - Slight Positive Impact (105)
 - No Discernible Impact (74)
 - Slight Negative Impact (2)
 - Significant Negative Impact (1)

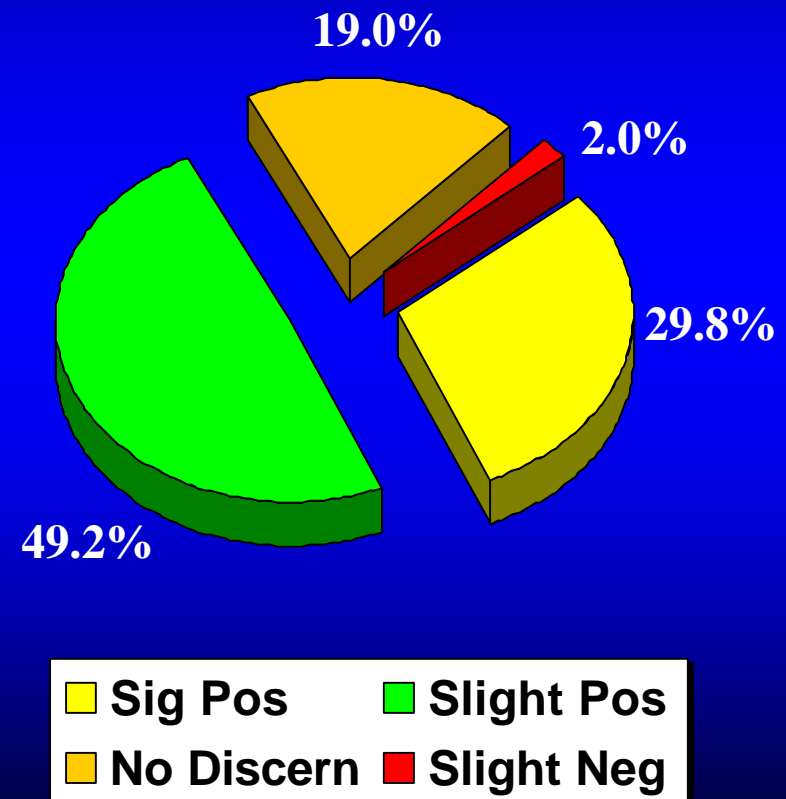


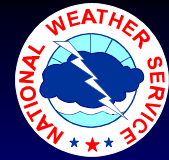
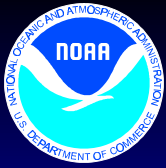


GOES Sounder Assessment Use of Stability Products



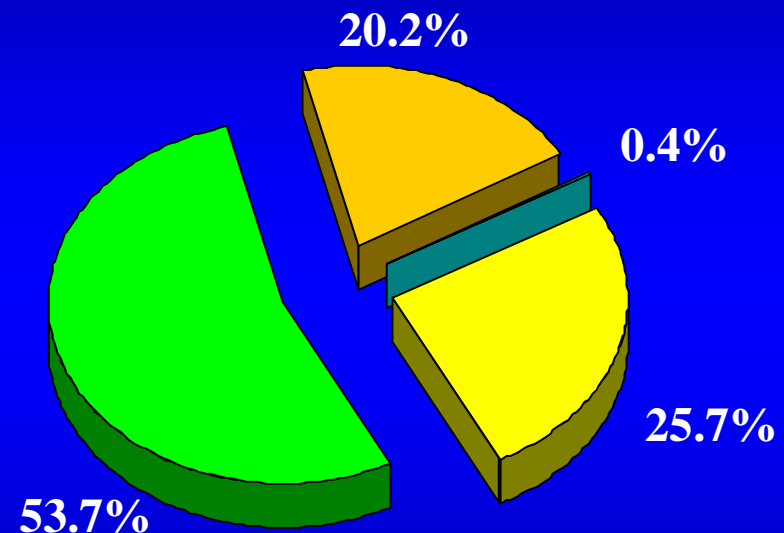
- Rate the usefulness of the stability products (i.e., LI, CAPE & CINH) for the location and timing of thunderstorm activity. (248 valid wx cases)
 - Significant Positive Impact (74)
 - Slight Positive Impact (122)
 - No Discernible Impact (47)
 - Slight Negative Impact (5)

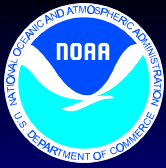




GOES Sounder Assessment Use of Products in General

- How much of an impact did the GOES Sounding Products make relative to available hourly model (ETA/RUC) data to your programs & services? (218 valid wx cases)
 - Significant Positive Impact (56)
 - Slight Positive Impact (117)
 - No Discernible Impact (44)
 - Slight Negative Impact (1)

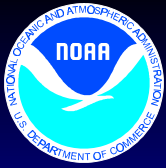




GOES Sounder Assessment Case Studies



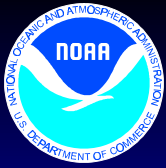
- The 6-week assessment indicated the GOES sounder data heightened NWS forecasters' awareness to potential watch/warning scenarios & often led to the issuance of improved forecast products.
- The 3 case studies which follow provide a sample of the more widely used GOES sounder products:
 - Lifted Index (LI)
 - Convective Available Potential Energy (CAPE)
 - Total Precipitable Water (TPW)
 - Convective Inhibition (CINH)



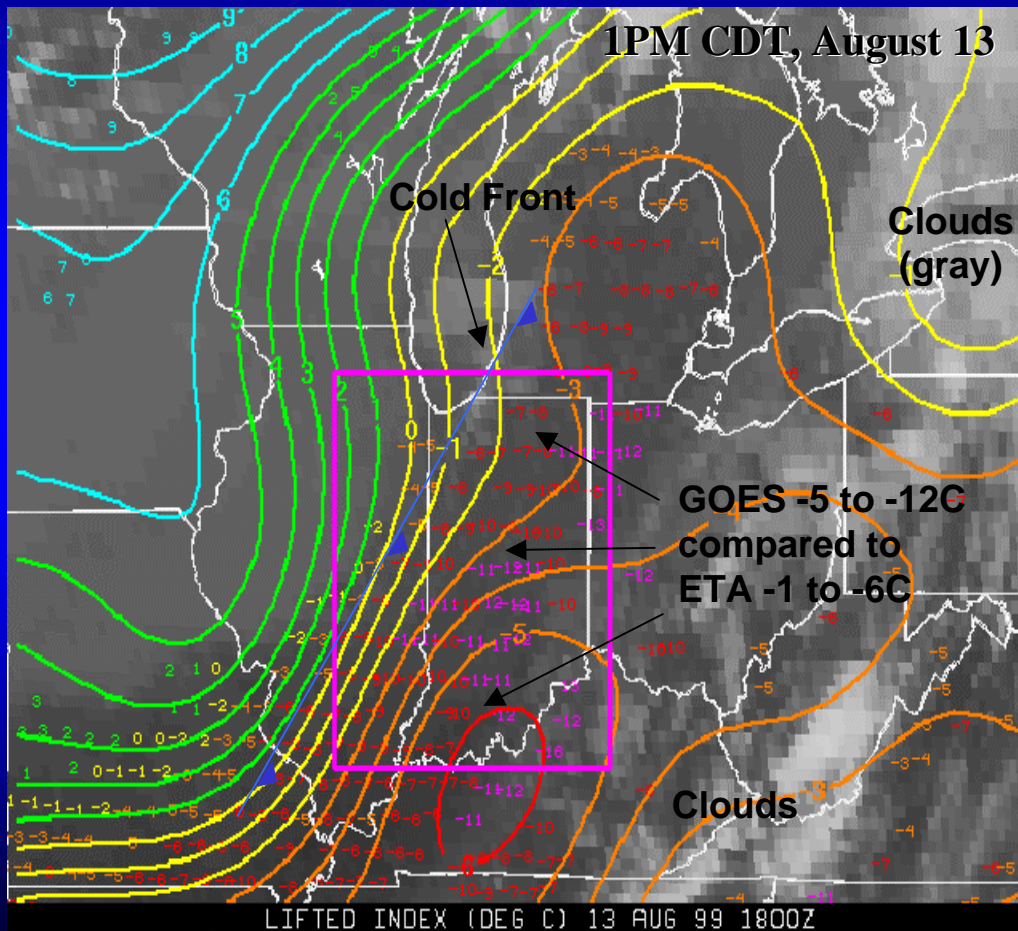
GOES Sounder Assessment Mid-West Precipitation



- **NWS Forecast Office North Webster, IN (IWX)**
- **Afternoon/evening on August 13, 1999**
- **“(The GOES Sounder) confirmed instability in areas ahead of the front that had breaks in the clouds. ...this led to a forecast of scattered afternoon thunderstorms... (which) began firing around 13/18Z... Few exceeded severe limits but heavy rain did occur.”**
- **“The GOES products gave us confidence that the models were under-estimating the instability and the afternoon precipitation... (they) were very useful.”**



GOES Sounder Assessment Mid-West Precipitation (cont.)

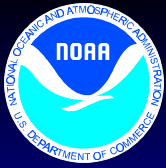


**GOES-8 Lifted Index (LI) (numeric values) compared to
ETA model LI (contours), plotted in degrees Celsius (C)**

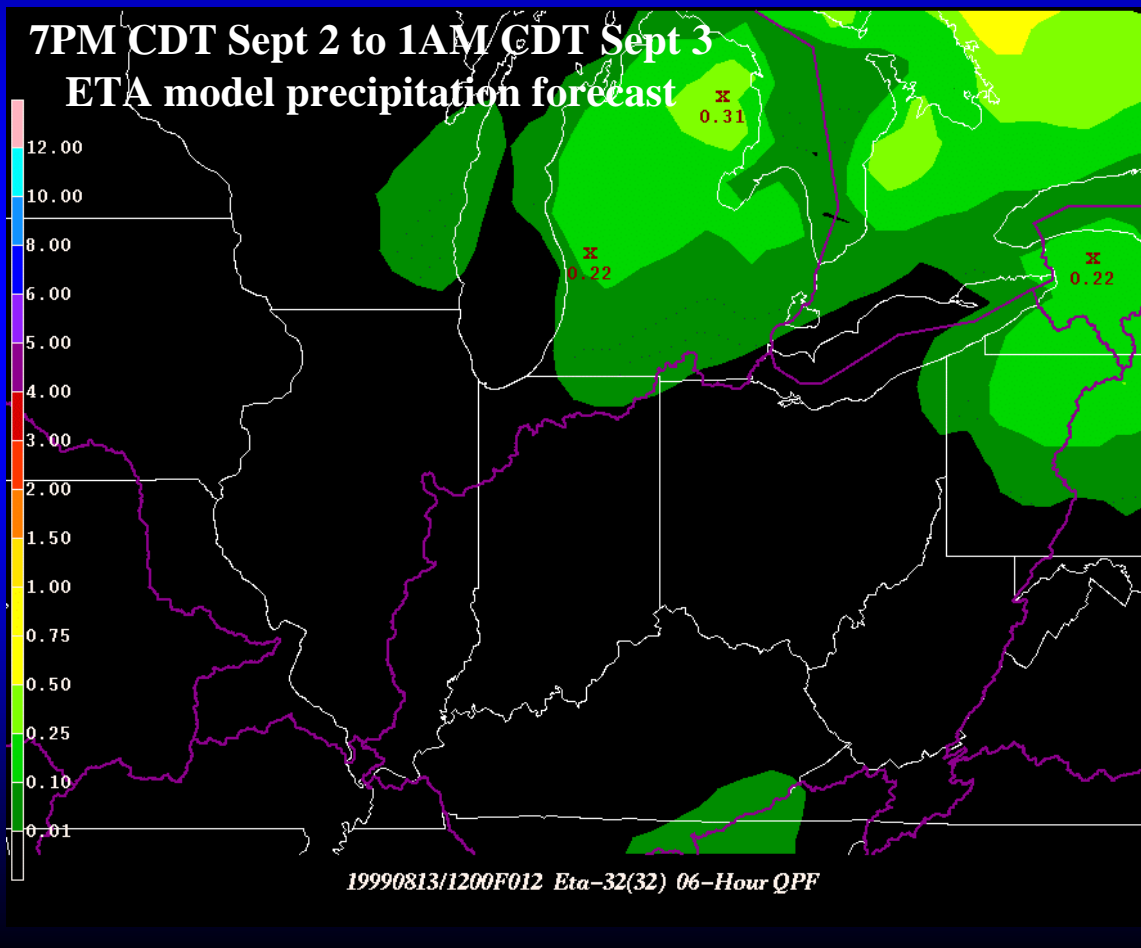
At 1pm, a cold front (in blue) is sweeping east across Indiana. The infrared GOES Sounder generates its suite of products in the clear air ahead of the front.

The first GOES Sounder product presented is the Lifted Index (LI). The LI gives forecasters a critical measure of atmospheric instability. The more negative the LI value the higher the instability.

Note the significant difference in the area bounded by the magenta rectangle. The observed GOES LI's are much lower than the forecast ETA LI's (common color scale used for both).



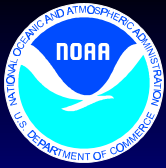
GOES Sounder Assessment Mid-West Precipitation (cont.)



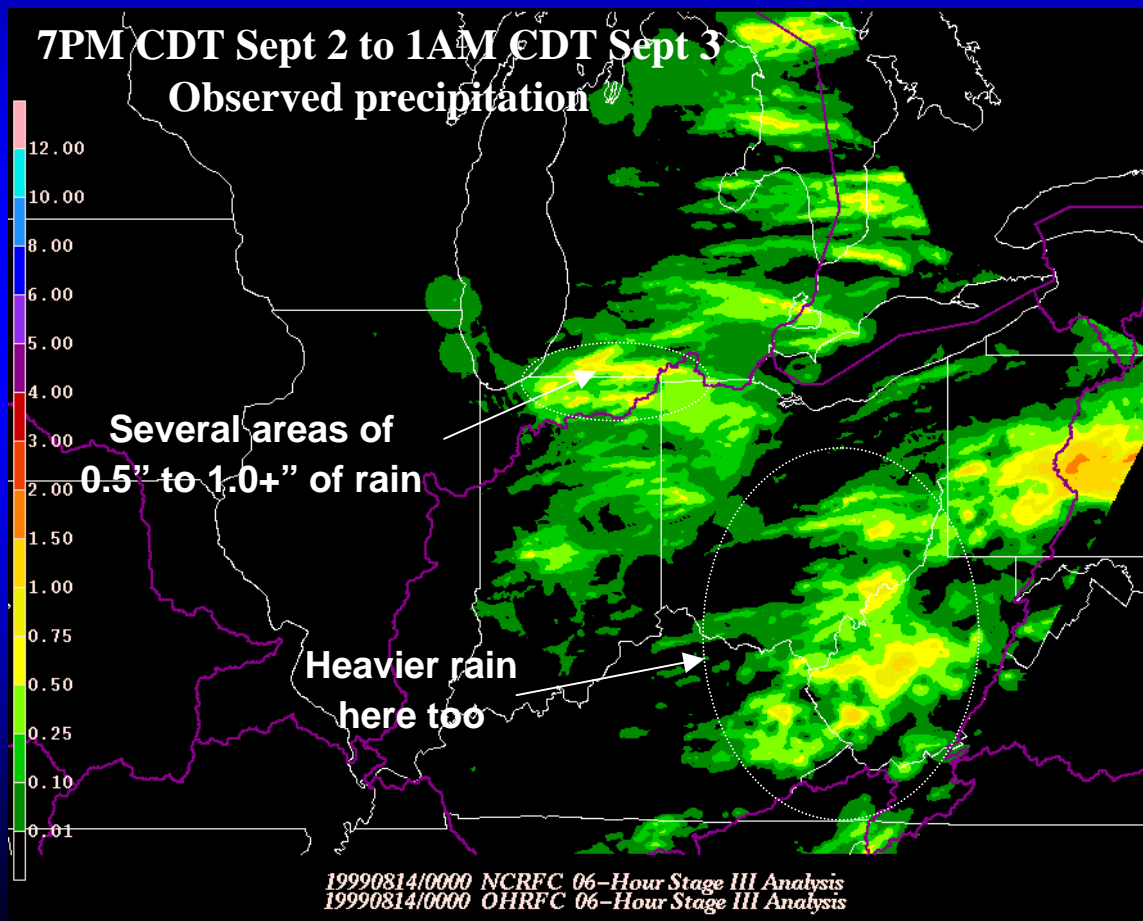
Here is the 6-hour ETA model precipitation forecast for 1-7pm on August 13, 1999.

Note the extensive area where no precipitation is forecast, particularly in Indiana, Ohio, Kentucky, and West Virginia.

The ETA forecasts 0.01" to 0.10" (dark green) in extreme northern Indiana, southern Michigan, and eastern Ohio.



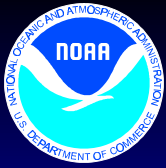
GOES Sounder Assessment Mid-West Precipitation (cont.)



Here is the observed 6-hour precipitation (from rain gauges and WSR-88D radars) for the same period.

Note the locally heavy rains in North Webster's (IWX) forecast area (roughly the northern 1/3 of Indiana, extreme southern Michigan, and northwestern Ohio)

Eastern portions of Ohio & Kentucky and the western half of West Virginia also received a great deal more rain than forecast by the ETA model.

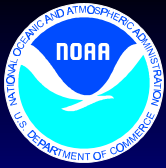


GOES Sounder Assessment

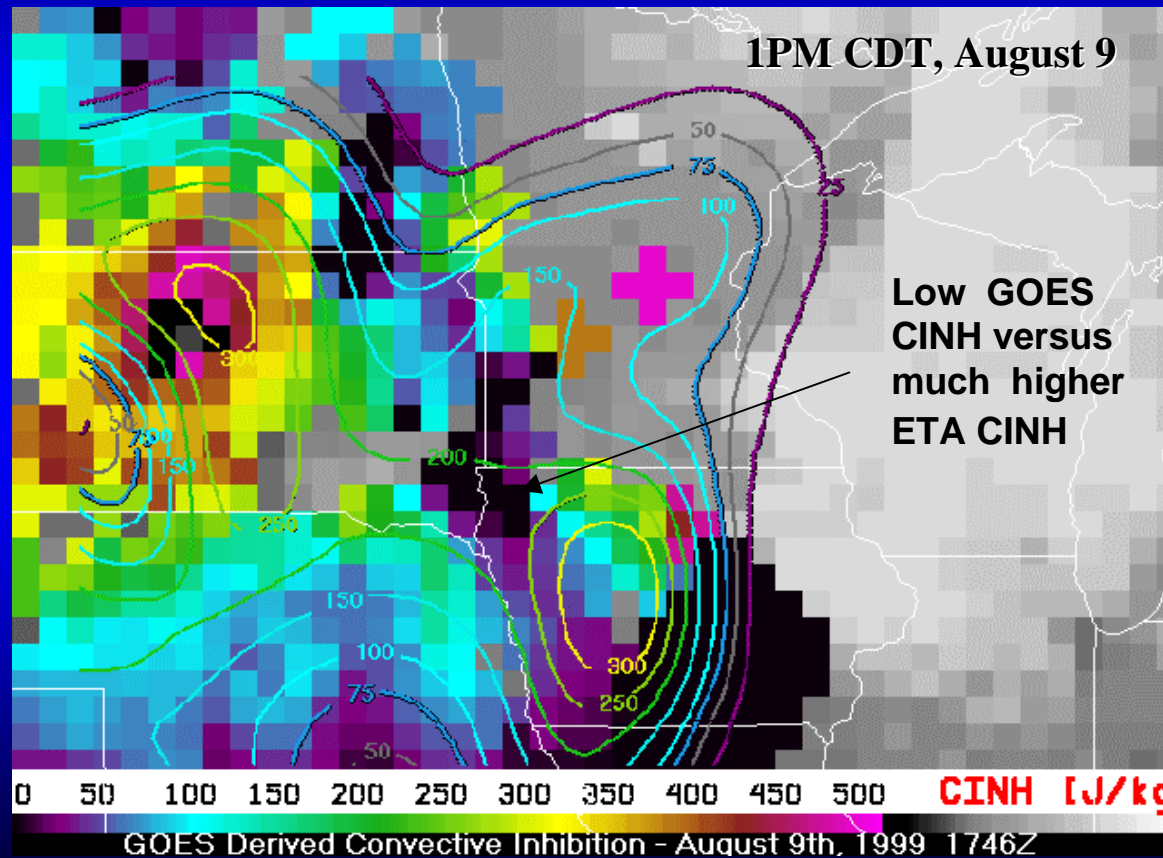
Minnesota (MN)/Iowa (IA) Tornadoes



- **NWS Forecast Offices Minneapolis, MN (MPX) and Des Moines, IA (DMX)**
- **Late evening on August 9, 1999**
- **MPX - “The (hourly) Sounder Derived Product Imagery (DPI) helped a lot anticipating convective development over southern MN this evening. I...saw a definite decreasing trend in the CINH (Convective Inhibition) from 19-21Z... Impressive CAPE values (3500-4500J/KG) and LI's -10 to -12...”**
- **DMX - “...the GOES data was a better guide than LAPS (model) data.”**



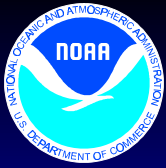
GOES Sounder Assessment MN/IA Tornadoes (cont.)



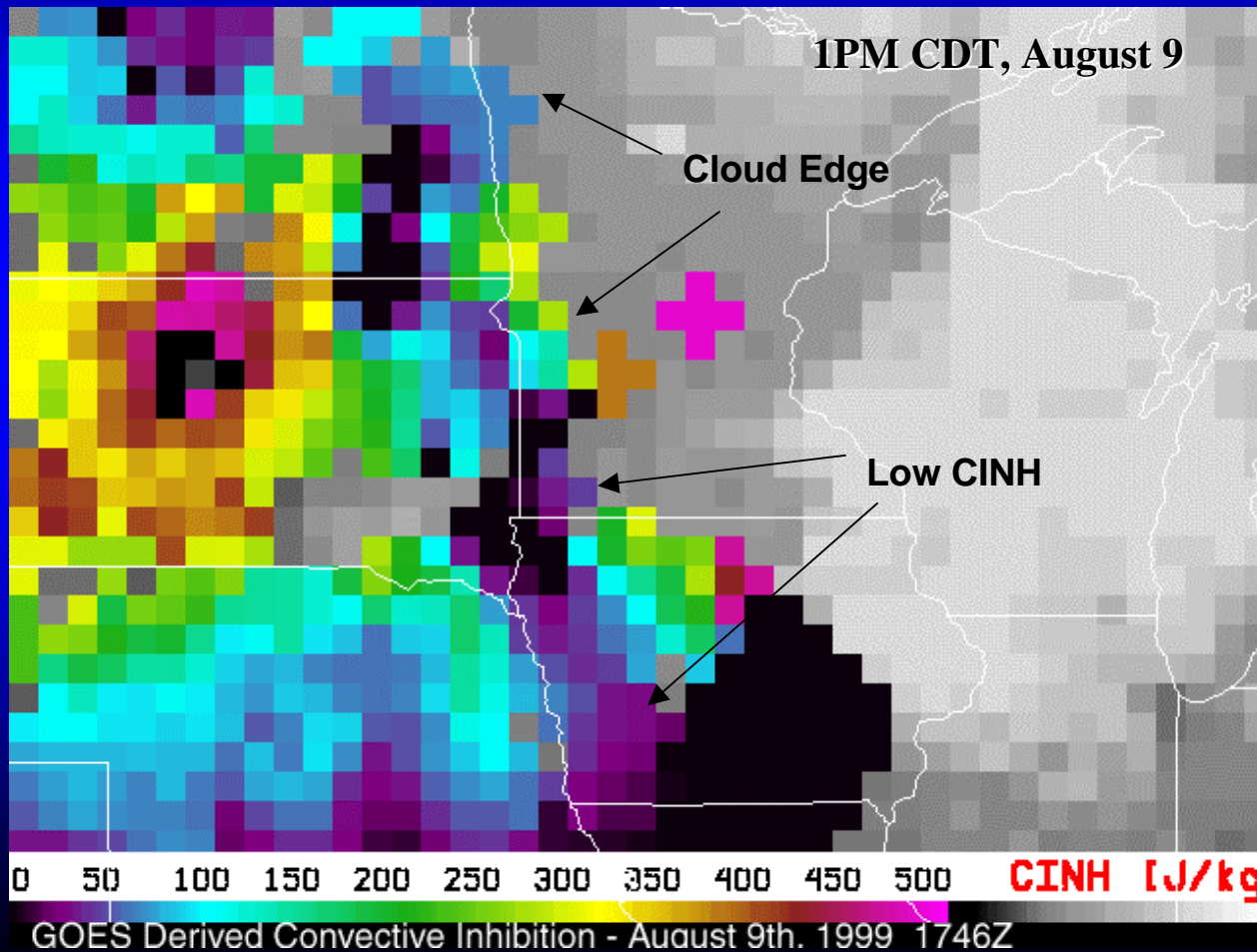
CINH, another (in)stability product, is a measure of the “capping” inversion or warmer air aloft that tends to inhibit the release of buoyant energy. Lower CINH values mean less of a “cap” and increase the likelihood of showers & thunderstorms.

Note the low (~0) **observed** GOES CINH and the higher ETA **forecast** value (150-200) over southwestern MN & northwestern IA.

Comparison of GOES-8 Sounder Convective Inhibition (CINH) (colorized images) to ETA CINH (contours), plotted in joules/kg

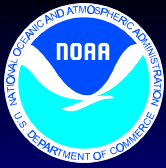


GOES Sounder Assessment MN/IA Tornadoes (cont.)

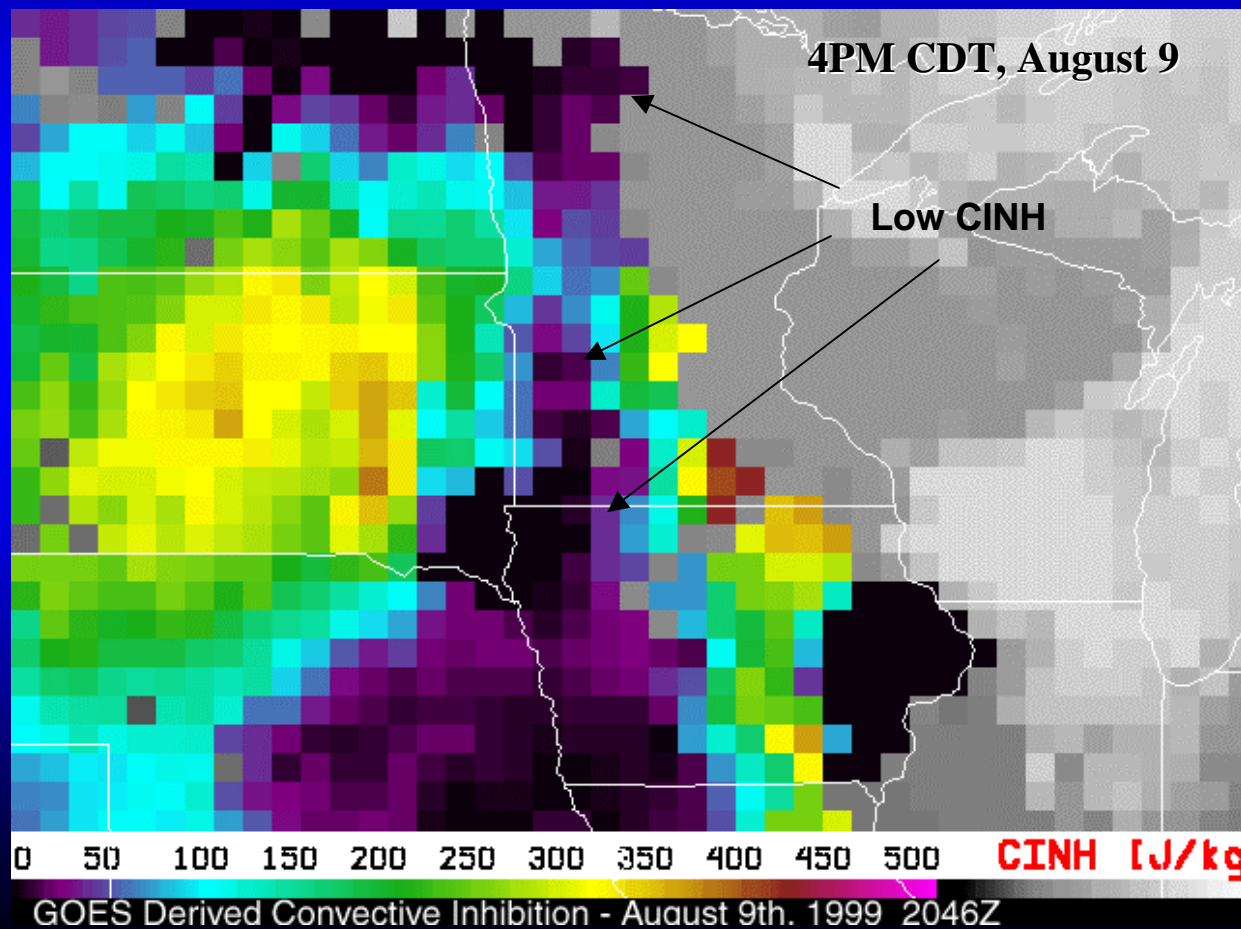


This is the same view of the GOES CINH without the ETA CINH superimposed.

The GOES CINH is colorized to make viewing of gradients & axes and changes to them easier to follow.

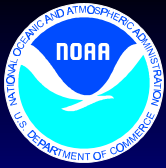


GOES Sounder Assessment MN/IA Tornadoes (cont.)

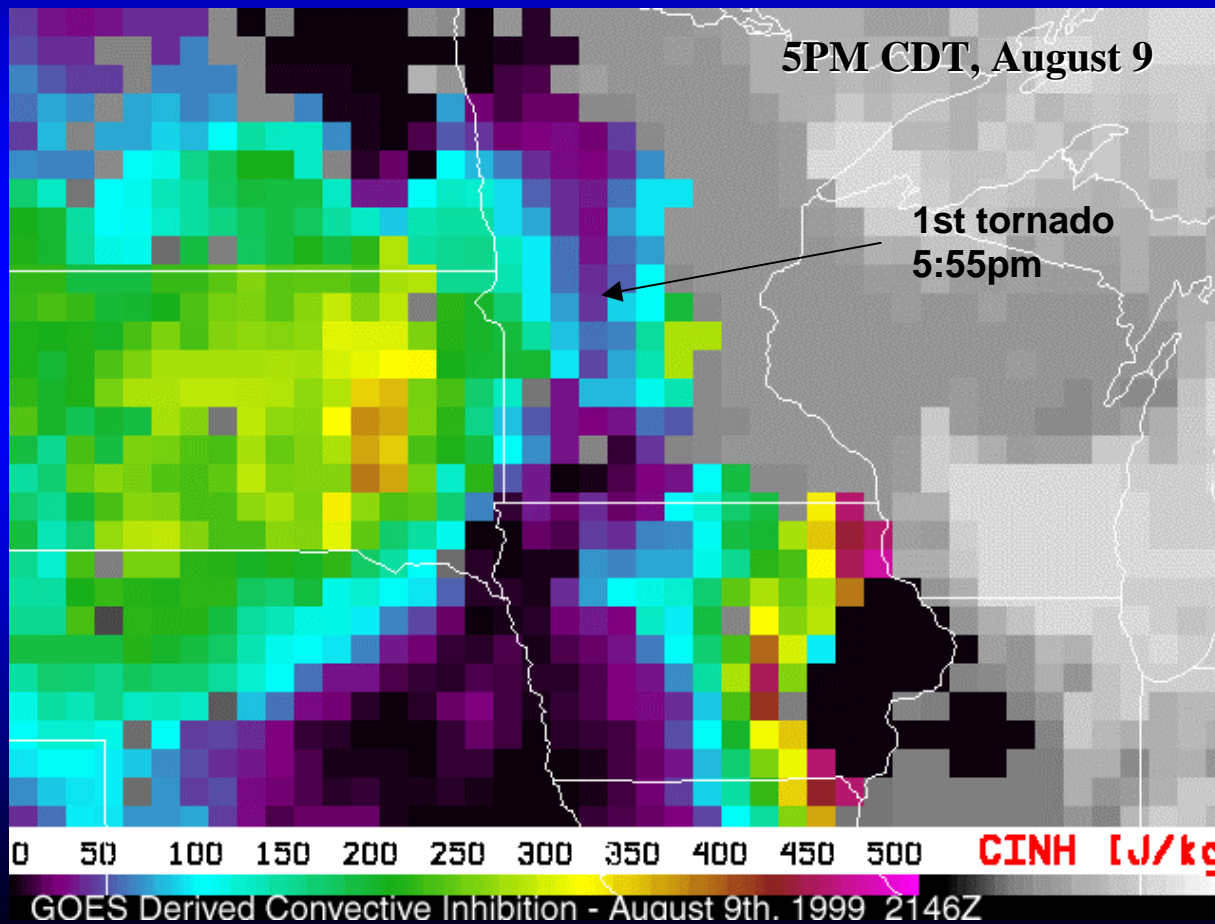


During the next three hours lower CINH, signifying a less “capped” atmosphere, continues moving east.

At 4pm, very low CINH values are evident in southwestern Minnesota and the western half of Iowa.



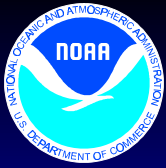
GOES Sounder Assessment MN/IA Tornadoes (cont.)



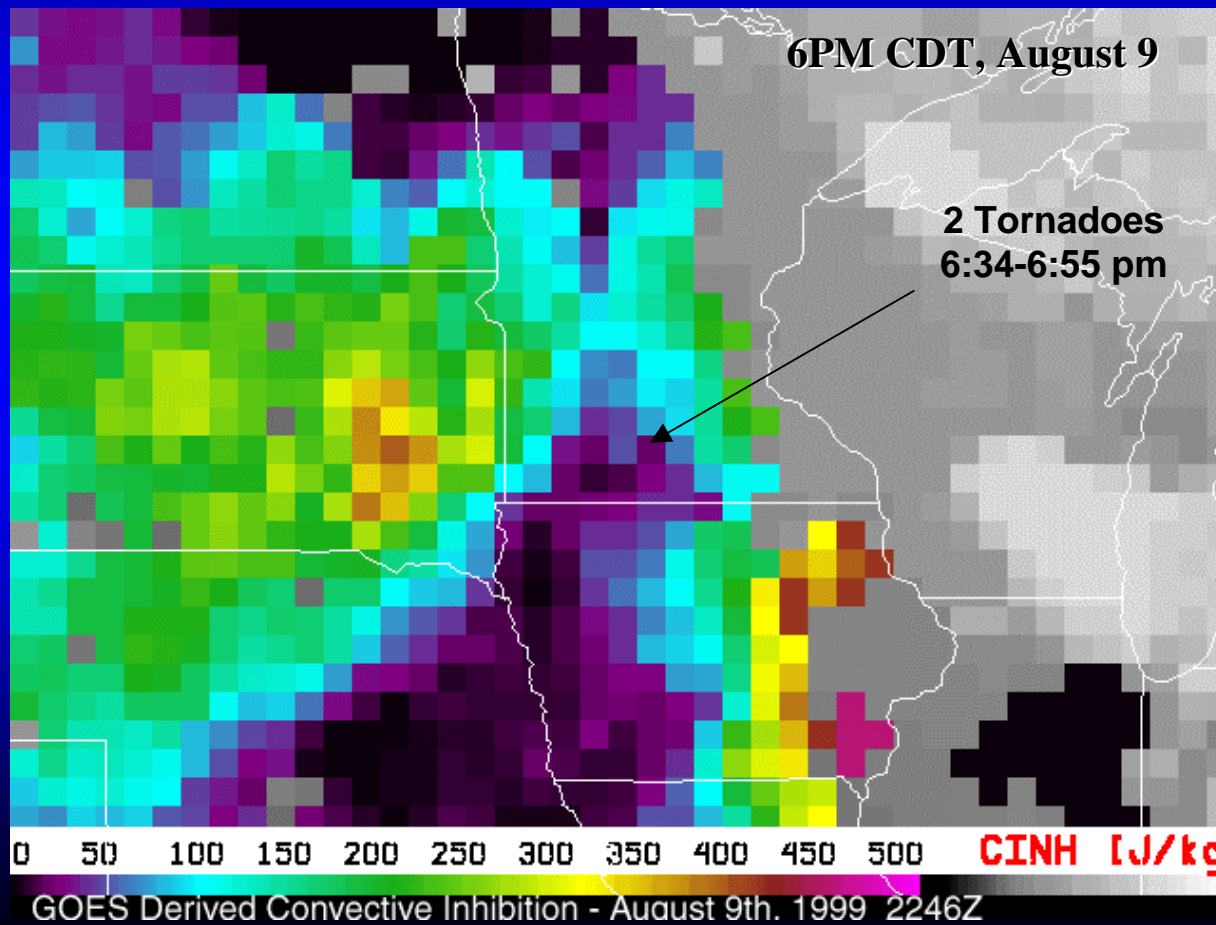
By 5pm, the lower CINH area shows signs of a split in Minnesota.

An axis of low CINH shows up about 1/3 of the way (west-to-east) across Minnesota. Eastward movement of lower CINH is evident along the MN-IA border.

An F-1 tornado strikes Belgrade, MN at 5:55pm (along axis of low CINH).

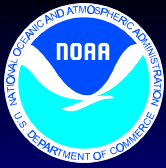


GOES Sounder Assessment MN/IA Tornadoes (cont.)

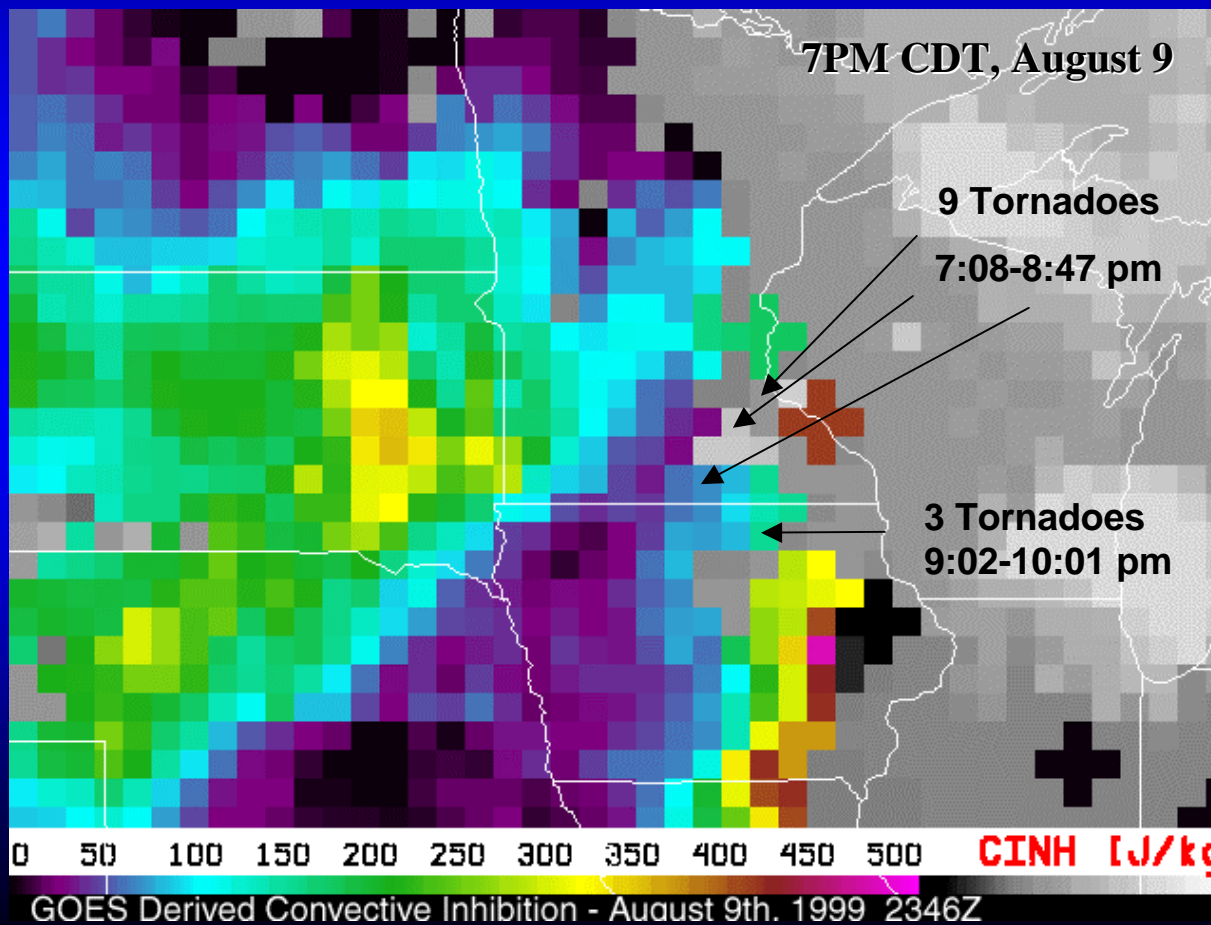


The lower CINH area has clearly split by 6pm. South central Minnesota now becomes the focus for convection. Lower CINH spreading slowly eastward in Iowa.

2 F-1 tornadoes strike south central Minnesota just north of Mankato - one tornado is on the ground for 18 minutes.



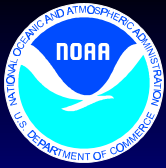
GOES Sounder Assessment MN/IA Tornadoes (cont.)



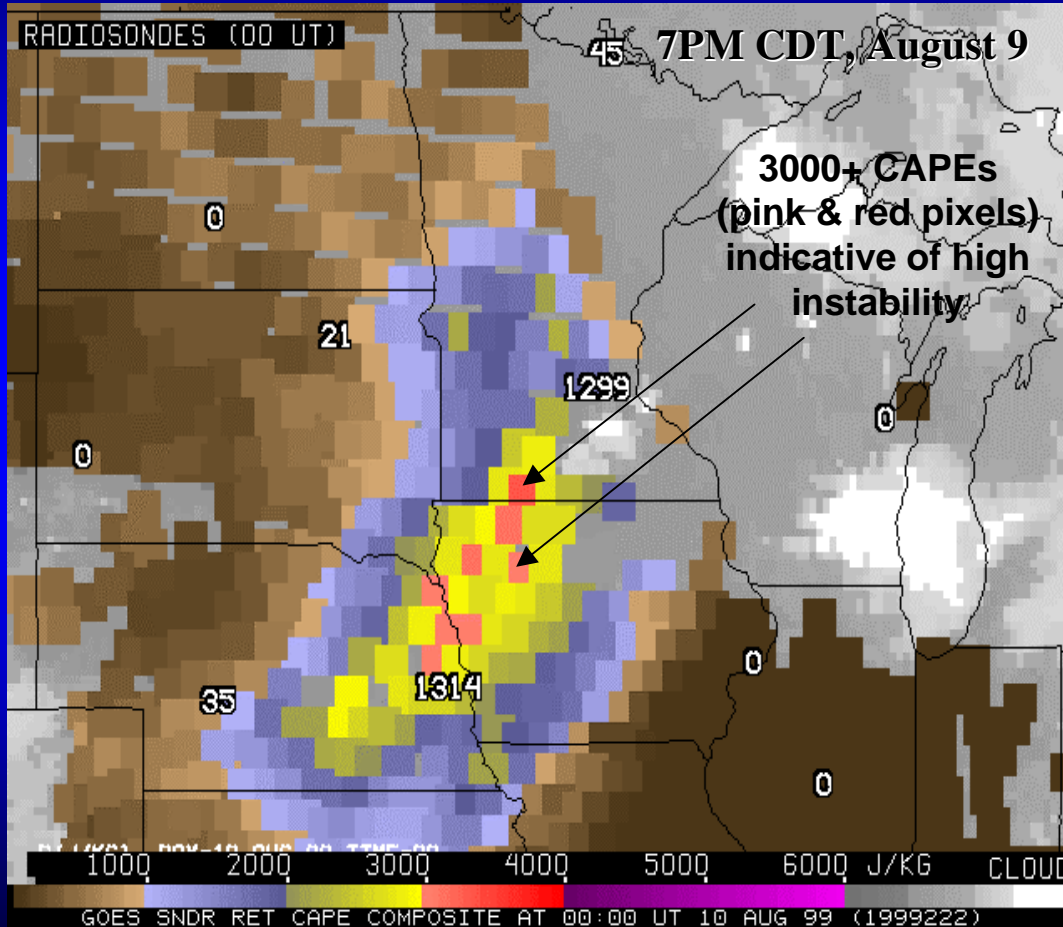
By 7pm, clouds (white & gray pixels) from the earlier tornadoes are visible in SE Minnesota.

9 more F-0 tornadoes strike southern Minnesota in a little over 1.5 hours.

Follow-on CINH images are contaminated by cloud debris over north central Iowa where 3 (2 F-2 & 1 F-0) tornadoes touch down shortly thereafter.



GOES Sounder Assessment MN/IA Tornadoes (cont.)

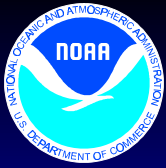


Here's another widely used GOES Sounder instability product.

The Convective Available Potential Energy (CAPE) depicts atmospheric buoyancy. Generally, the higher the CAPE, the greater the potential for convection, thunderstorms, and severe weather.

CAPEs determined from upper air (radiosonde) measurements are superimposed on the image for comparison. Note the much higher spatial resolution of the GOES data.

GOES-8 Sounder Convective Available Potential Energy (CAPE) values (colorized), plotted in joules/kg



GOES Sounder Assessment MN/IA Tornadoes (cont.)



Summary: Both MSX and DMX credit the GOES Sounder data with helping them focus in on this tornado outbreak. The verification statistics (below) for the event, compared to the national averages and the NWS long-range goals bear this out:

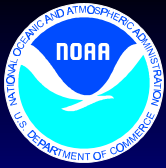
F-0, F-1 & F-2 Tornadoes

	MSX/DMX	Nat'l*	2005 Goal**
Number	15	136	--
POD	0.73	0.58	0.80
FAR	0.31	0.73	0.40
LT (min)	13.8	8.3	15.0

*7/19/99-8/30/99

** all tornadoes

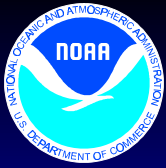
Note: The False Alarm Rate exceeds the 2005 goal while the Probability Of Detection and Lead-Time nearly hit the long-range goal.



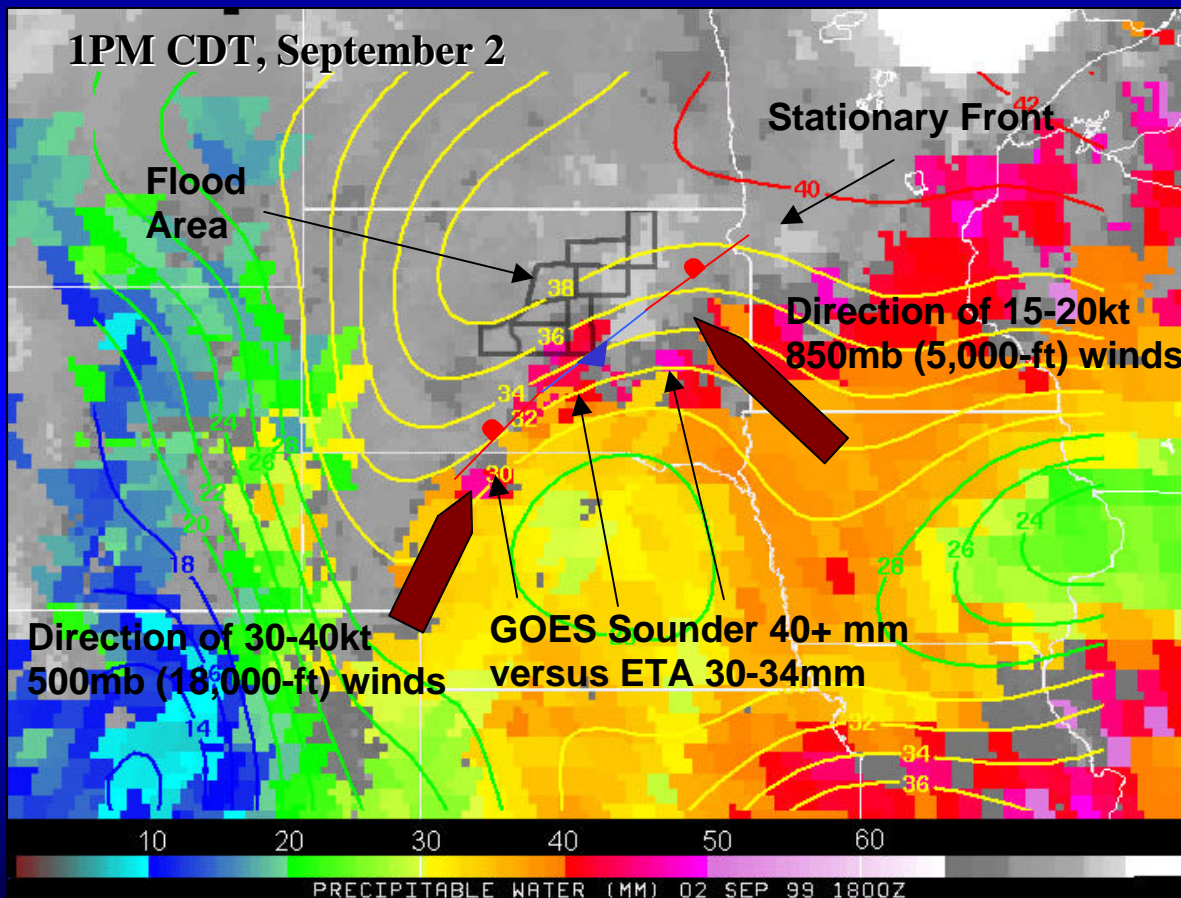
GOES Sounder Assessment South Dakota (SD) Flash Floods



- **NWS Forecast Office Aberdeen, SD**
- **Overnight hours on September 2-3, 1999**
- **Hourly GOES Sounder Data used by the Aberdeen, SD Forecast Office:**
 - “. . . strongly contributed (to) the forecaster’s situational awareness”.
 - “. . . significantly contributed to (the) issuance of timely and accurate warnings”.
 - Was a “. . .very useful analysis and forecast tool during this event”.



GOES Sounder Assessment SD Flash Floods (cont.)

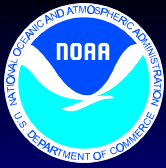


Eight SD counties north and west of a stationary front were inundated by flooding rains.

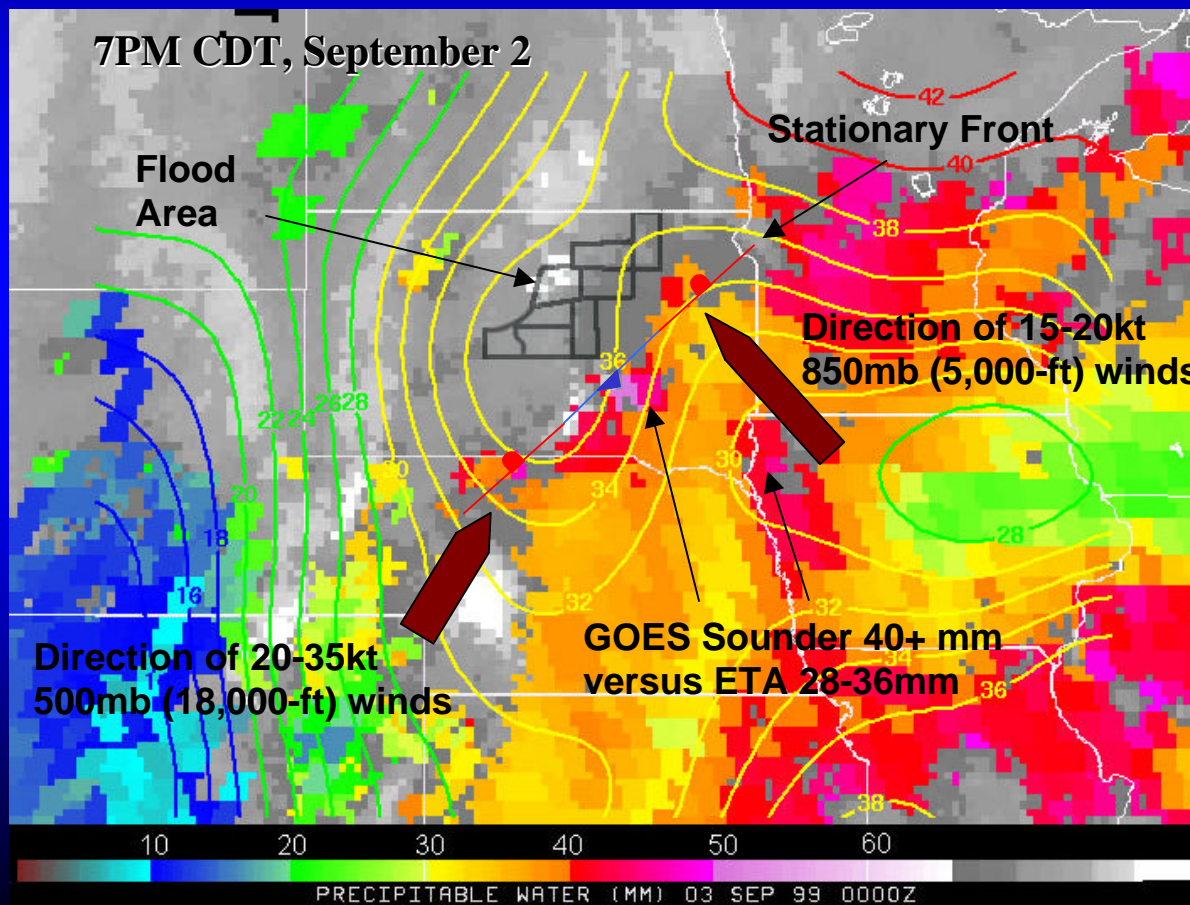
The GOES Sounder indicated much greater amounts of TPW (liquid content) streaming into the threatened area than the ETA model.

Clouds, depicted in gray and white, preclude generation of products from the current sounder.

GOES Sounder Total Precipitable Water (colorized images) & ETA PW (contours) PW, plotted here in mm, is a measure of the liquid content of atmosphere



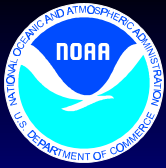
GOES Sounder Assessment SD Flash Floods (cont.)



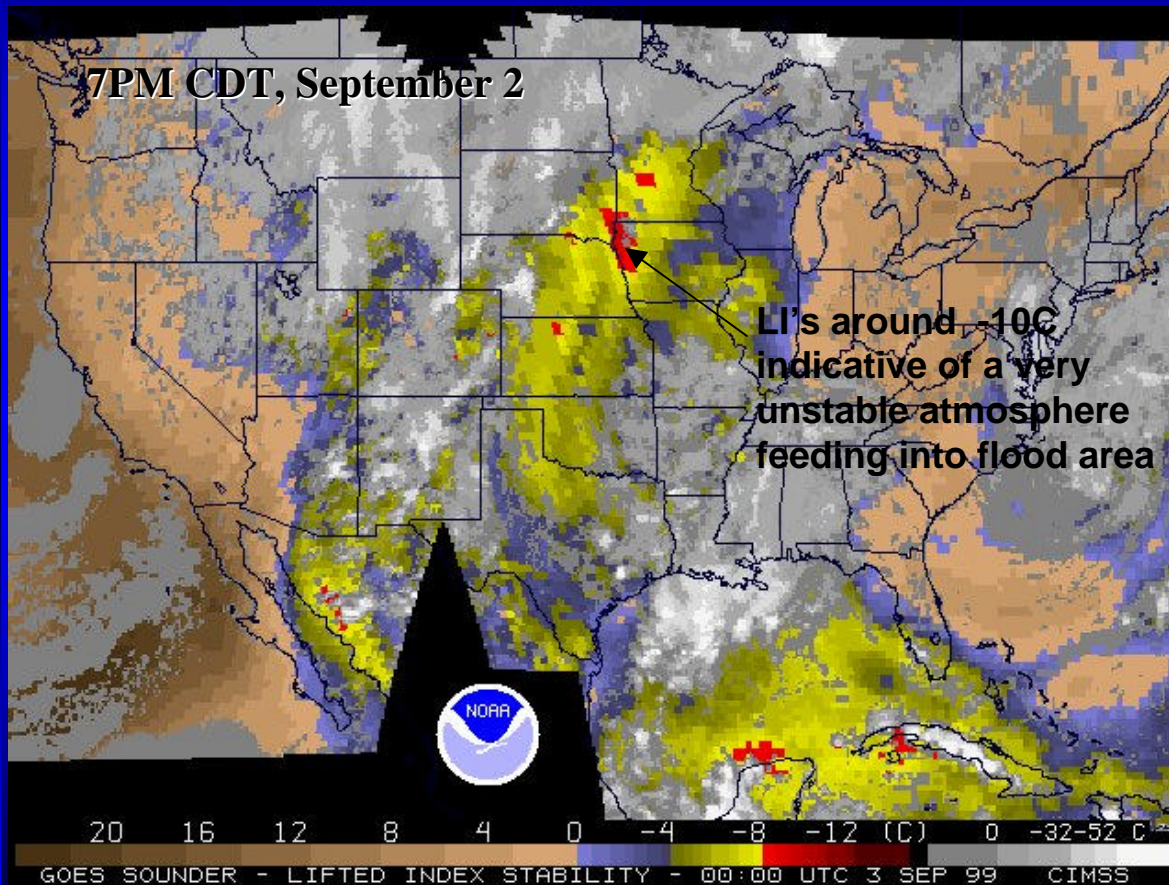
The weather pattern remains nearly the same at 7pm.

A lobe of much higher TPW streaming northward from Iowa into the flood area is evident. The GOES Sounder indicated 40+ mm versus 28-30 mm forecast by the ETA in this area.

Much of the heaviest rain is now occurring.



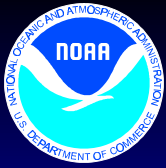
GOES Sounder Assessment SD Flash Floods (cont.)



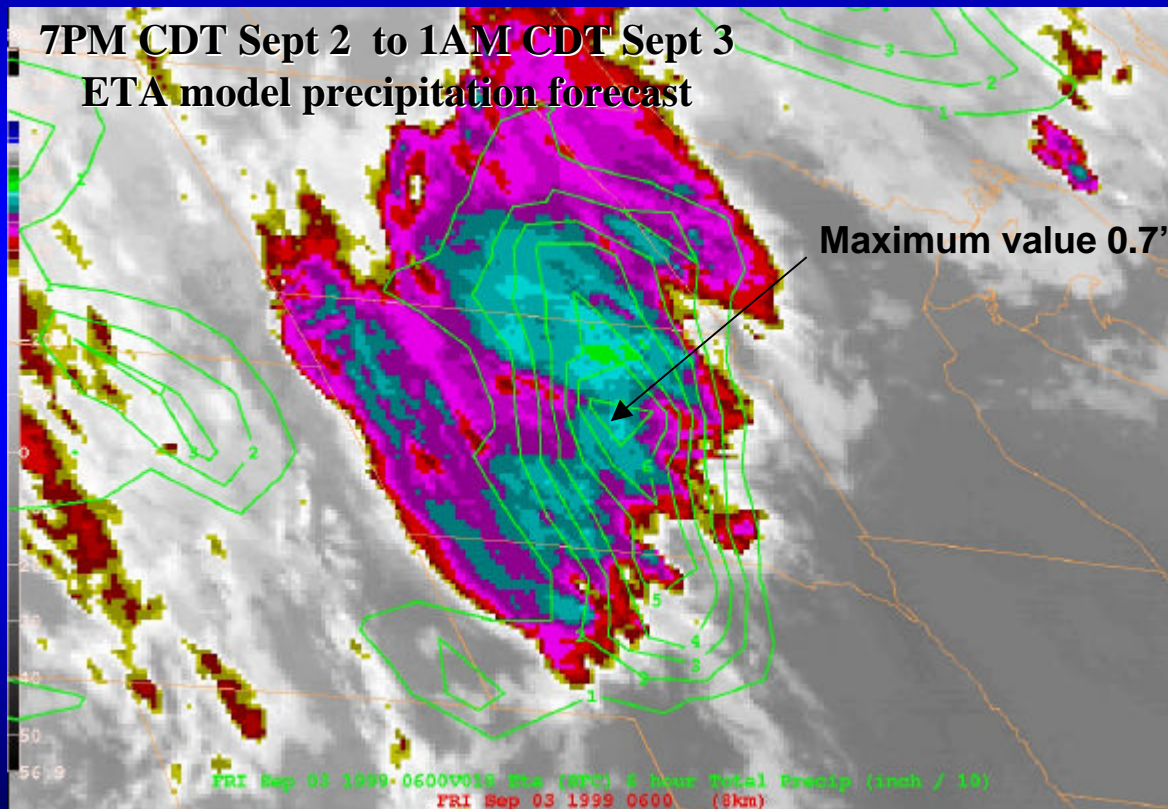
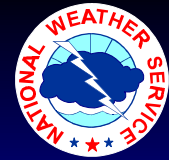
**GOES-8 and GOES-10 Composite Lifted Index (LI),
plotted in degrees Celsius (C)**

Here's the GOES Lifted Index (LI) product again. Recall the LI is a measure of atmospheric instability. The more negative the LI value the higher the instability.

NWSFO Aberdeen indicated the ETA forecast minimum LI's were -5C to -6C (in the red area) compared to a GOES Sounder LI of -10C. The more unstable GOES data meant more rapid destabilization was occurring resulting in deeper convection and more rain.



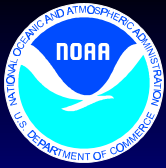
GOES Sounder Assessment SD Flash Floods (cont.)



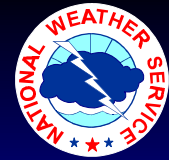
GOES infrared image (from the imager) overlaid with the 6-hour ETA forecast precipitation ending at 1AM CDT, September 3

According to NWSFO Aberdeen (ABR), the heaviest rain fell between about 7pm, September 2nd and 1am, September 3rd.

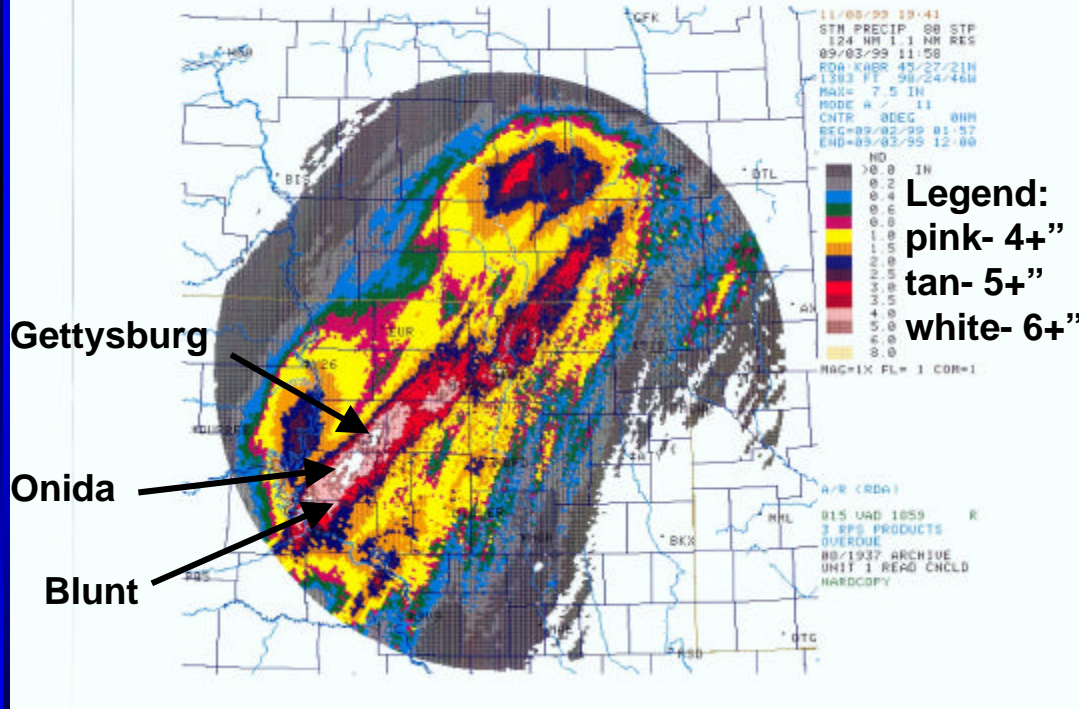
The GOES infrared satellite image on the left has the ETA 6-hour precipitation forecast superimposed on it. ABR indicated the ETA location of the axis of maximum forecast precipitation was “reasonably close”, but observed precipitation was several times (as much as 10 times) greater.



GOES Sounder Assessment SD Flash Floods (cont.)



**WSR-88D Estimated Rainfall from
9PM CDT September 1 to 7AM CDT September 3**



Gettysburg
Onida
Blunt

Severe flooding occurred in Onida and Blunt, just south of Gettysburg (GTY)

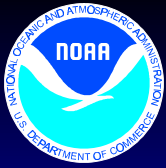
Summary

Aberdeen: “Continuous comparison of GOES Sounder TPW..., radar precipitation estimates, and area precipitation reports significantly increased (the) forecaster’s ability to warn the public of the impacts of the heavy rainfall”. Here are the verification numbers for this event (all exceed 2005 goals):

Flash Floods

	Event	Nat'l *	2005 Goal
Number	8	310	--
POD	1.00	0.73	0.90
LT (min)	72.1	30.7	65.0

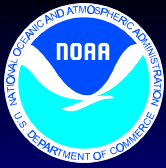
* 7/19/99 - 9/3/99



GOES Sounder Assessment Summary

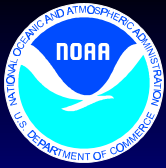


- **GOES Sounder Products:**
 - Heightened the forecasters' situational awareness to potential watch/warnings scenarios.
 - Led to the issuance of improved forecast products in over 79% of all active weather situations.
 - Are especially valuable for:
 - locating maximum instability & atmospheric moisture axes prior to convective development
 - observing temporal changes in stability & moisture, and
 - judging the validity of numerical model forecasts
 - Scheduled for AWIPS during 2001-2002



GOES Sounder Assessment Summary (cont.)

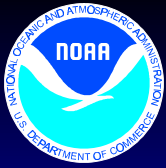
- **Infrared sounders (on both GOES & POES) cannot “see” through clouds/precipitation. This was noted in a number of assessments.**
- **A microwave sounder would be more of an all-weather instrument. However, such a sounder will likely not be flown operationally on a geostationary satellite before 2025.**
- **So where do we go from here? See next viewgraph for the answer...**



GOES Sounder Assessment Summary (cont.)



- **The Advanced Baseline Sounder (~2012), although still IR, would offer substantial improvements over the current GOES Sounder:**
 - **increased temperature/humidity accuracy**
 - **far more vertical water vapor detail**
 - **increased low-level temperature/humidity sensitivity**
 - **increased number of soundings**
 - **more soundings closer to cloud edges & in smaller gaps between clouds**



GOES Sounder Assessment Case Studies -- Acknowledgements



- **Dozens of people - too many to list here - made a significant contribution to the development of the case studies in this presentation. Specific offices with substantial involvement include:**
 - **NWSFOs Minneapolis, MN & Aberdeen, SD**
 - **NCEP HPC**
 - **NESDIS ORA/FPDT**
 - **NESDIS OSD**
 - **CIMSS**
 - **COMET**