NOAA GOES-8/9

ASSESSMENT PLAN

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ACRONYMS

AFOS	Automation of Field Operations and Services (NWS)
AM	Area Manager (NWS)
ARAD	Atmospheric Research and Applications Division (NESDIS)
ASOS	Automated Surface Observing System
AWC	Aviation Weather Center (NWS)
AWIPS	Advanced Weather Interactive Processing System
CIMSS	Cooperative Institute for Meteorological Satellite Studies
CIRA	Cooperative Institute for Research in the Atmosphere
COMET	Cooperative Program for Operational Meteorology, Education, and Training (UCAR)
CONUS	continental United States
DPI	derived product images
EMC	Environmental Modeling Center (NWS)
ESD/IPC	Environmental Satellite Distribution/Interactive Processing Center
FPDT	Forecast Products Development Team
FSL	Forecast Systems Laboratory (OAR)
GIMPAP	GOES I-M Product Assurance Plan
GINI	GOES ingest NOAAPORT interface
GOES	Geostationary Operational Environmental Satellite
GSFC	Goddard Space Flight Center (NASA)
GSIWG	GOES Special Issues Working Group
GSS	GOES Sectorizer System
GVAR	GOES variable (GOES I-M retransmitted processed data format)
HPC	Hydrometeorological Prediction Center (NWS)
IFFA	Interactive Flash Flood Analysis (NESDIS)
IPB	Interactive Processing Branch (NESDIS)
IPD	Information Processing Division (NESDIS)
ISPAN	Information Stream Project for AWIPS/NOAAPORT
LES	Lake-Effect Snow Study
McIDAS	Man-Computer Interactive Data Access System
MIC	meteorologist in charge (NWS)
MIDAS	Multidiscipline Interactive Display and Analysis System
N-AWIPS	national centers AWIPS
NASA	National Aeronautics and Space Administration
NESDIS	National Environmental Satellite, Data, and Information Service
NCEP	National Centers for Environmental Prediction (NWS)
NOAA	National Oceanic and Atmospheric Administration
NOHRSC	National Operational Hydrologic Remote Sensing Center (NWS)
NWS	National Weather Service
OAR	Office of Atmospheric Research (NOAA)
OH	Office of Hydrology (NWS)
OM	Office of Meteorology (NWS)
ORA	Office of Research and Applications (NESDIS)

OSDPD	Office of Satellite Data Processing and Distribution (NESDIS)
OSO	Office of Satellite Operations (NESDIS)
OWSO	Olympic Weather Support Office (NWS)
POP	Product Oversight Panels (NESDIS)
PRC	NESDIS GOES-Tap Contractor
RAMMB	Regional and Mesoscale Meteorology Branch (NESDIS)
RAMSDIS	Regional and Mesoscale Meteorology Branch Advanced Meteorological Satellite Demonstration and Interpretation System
RISC	reduced instructions set computer
RSO	rapid scan operation
RUC	rapid update cycle
SAB	Synoptic Analysis Branch (NESDIS)
SAO	Systems Acquisition Office (NOAA)
SCP	ASOS satellite cloud product
SDAB	Systems Design and Applications Branch (NESDIS)
SFDF	Satellite Field Distribution Facility
SMS	synchronous meteorological satellite
SOCC	Satellite Operations Control Center (NESDIS)
SOO	Science and Operations Officer (NWS)
SPC	Storm Prediction Center (NWS)
SPE	satellite precipitation estimate
SPSRB	Satellite Products/Services Review Board (NESDIS)
SSD	Satellite Services Division (NESDIS)
SWIS	Satellite Weather Information System
TPC	Tropical Prediction Center (NWS)
VAS	VISSR atmospheric sounder
VDUC	VAS Data Utilization Center

EXECUTIVE SUMMARY

The first Geostationary Operational Environmental Satellite (GOES-1) of the National Oceanic and Atmospheric Administration (NOAA) was launched into orbit 35,800 km above the Earth's surface on October 16, 1975. Each of the GOES satellites up through and including GOES-7 was spin stabilized, spinning at about 100 rpm about its vertical axis, which is oriented parallel to the Earth's axis. West to east scan lines were produced as the spin of the spacecraft viewed the Earth through the instrument's scan mirror. North to south scanning was done by stepping the scan mirror between Earth views, taking a full disk image in 18 minutes. The primary sensor on the early GOES satellites was the Visible Infrared Spin Scan Radiometer (VISSR). Starting with GOES-4 in September 1980, the satellites were modified to carry the new VISSR atmospheric sounder (VAS). The VAS is a visible and infrared radiometer that provides image (VISSR mode) and dwell sounding (VAS mode) by repeatedly scanning the same Earth swath in 12 infrared spectral bands. The dwell time demands of the sounding mode did not permit sumultaneous imaging and sounding with VAS. In its imaging mode, GOES-7 could be programmed to include data from one to three atmospheric sounder channels to accompany its routinely available visible and 11μm infrared data.

GOES-8/9, the first in a series of advanced GOES satellites, are tri-axis stabilized, with nearly continuous views of the Earth and simultaneous imaging and sounding operations. The multichannel instruments sweep east to west and west to east simultaneously along a north to south path by means of a two-axis mirror scan system, requiring 26 minutes for a full disk image. The GOES-8/9 imager is a multichannel instrument designed to sense radiant and solar reflected energy from one visible channel and four infrared channels. The GOES sounder is a 19-channel discrete filter radiometer covering the spectral range from the visible channel wavelengths out to 15μm.

GOES-8/9 are superior to its predecessors in the following ways:

1. enhanced imager and sounder capabilities, more data channels, increased data resolution, improved signal-to- noise ratio, and improved Earth location accuracy;

2. simultaneous operation of the imager and sounder, not time shared as were earlier versions of similar instrumentation, with more flexible area coverage by the imager and sounder (e.g., can control both the north-south and east-west boundaries).

This assessment plan:

1. outlines the methods and procedures by which operational and research units within the National Weather Service(NWS) and the National Environmental Satellite, Data, and Information Service (NESDIS) will determine the utility and quality of the GOES-8/9 satellite products and services as they come on line and

2. defines the responsibilities of NWS and NESDIS offices during the assessment process.

The major goals of this assessment are to:

1. assure the quality and meteorological utility of GOES-8/9 "day-one" products,

2. determine any necessary modifications to the GOES-8/9 "day-one" products,

3. provide input to modifications for GOES-I/M and next-generation GOES systems requirements,

4. provide input to GOES training requirements, and

5. provide input for the effective use of GOES-8/9 data on the Advanced Weather Interactive Processing System.

The utility of GOES data for numerical weather prediction has been and will continue to be evaluated by a series of model impact studies conducted by the National Centers for Environmental Prediction. Initially these studies will concentrate on radiances from the sounder and the influence of high-density moisture drift and cloud-drift winds. Studies concerning the detection of severe convective storms and hurricanes will be undertaken using multispectral imagery and sounding data from GOES-8/9.

Also, a study utilizing GOES-8/9 imagery in locating and forecasting snow squalls downwind from the Great Lakes is ongoing at several NWS Eastern and Central Region forecast offices.

New or enhanced satellite products under development include: quantitative precipitation estimates, derived indicators of convective stability in the prethunderstorm environment, deep-layer wind measurements in the tropical environment, and ozone measurements. Deep-layer precipitable water and other low-, mid- and upper-level moisture fields will also be assessed. Furthermore, a new image product, which is related to the difference between infrared channel 2 (3.9μm) and channel 4 (10.7μm), will be assessed for its ability to detect low clouds and fog.

This plan outlines the assessment strategy, methods and participants, as well as the procedures for reporting results and making recommendations. Assessment results from field offices, national centers, and research facilities will be reported in real time electronically and at annual assessment meetings. These results will be folded into an annual assessment report.

1.0 Introduction

The National Oceanic and Atmospheric Administration's (NOAA) Geostationary Operational Environmental Satellite (GOES) program has provided continuous imaging operations since the launch of the Synchronous Meteorological Satellite in May 1974. The first satellite in the next series of NOAA geostationary satellites is GOES-8, which was successfully launched April 13, 1994. This launch was followed by the successful launch of GOES-9 on May 23, 1995.

GOES-8 began day-to-day operations on June 1, 1995, and GOES-9 on January 11, 1996. GOES-8, at its location over the equator and 75°W, affords a view of most of North America, the Gulf of Mexico, the Caribbean Sea, and the western Atlantic Ocean; while GOES-9, over the equator and 135°W, covers most of western North America as well as the central and eastern Pacific Ocean. Figure 1 provides a summary of differences between GOES-7 and GOES-8/9.

While GOES-7 is a spin-stabilized spacecraft and operationally scans from the North Pole southward, GOES-8/9 operates on a three-axis-stabilized platform. This platform allows for east-west as well as north-south defined sector boundaries and, thereby, a more timely sensing of severe convective storm areas and/or hurricanes. GOES-8/9 provides improved resolution and signal-to-noise ratio than did its predecessors. This improvement translates into sharper and better defined products. GOES-8/9 features more data channels, which have the potential for several new derived products. However, the three-axis operating mode of GOES-8/9 also necessitates increased spacecraft commanding, resulting in longer periods of data loss during eclipse seasons, a different schedule of satellite maneuvers, and different calibration procedures, which may cause disruptions to the data flow required for monitoring severe weather events.

The strategy of postlaunch product validation is articulated in the "GOES I-M Product Assurance Plan (GIMPAP)" (NOAA/NESDIS, December 1994). The NESDIS Product Oversight Panels (POP) provide the venue for feedback on product quality, enhancements, and new product developments. The POPs, which are attended by NOAA representatives, determine whether individual GOES-8/9 products under their oversight are ready to be implemented operationally. NESDIS will declare GOES-8/9 products operational with the approval of the Satellite Products/Services Review Board (SPSRB) and with the concurrence of the appropriate POP chairs. The GOES Council, comprised of the Assistant Administrators of NWS and NESDIS and the Director of SAO, is a forum for senior NOAA management to review the NOAA/GOES program and allocate resources. The GOES evaluation outlined in this plan is in concurrence with this process.

IMPROVED GOES CAPABILITIES

GOES-7	GOES-8/9
• EARTH LOCATION ACCURACY - 10 KM	• EARTH LOCATION ACCURACY - 2-4 KM
• IR RESOLUTION - 7 KM	• IR RESOLUTION - 4 KM IMPROVED TRACKING & DETECTION OF SEVERE STORMS/FLASH FLOODS
• SOUNDER RESOLUTION - 14 KM EXPERIMENTAL CAPABILITY	• SOUNDER RESOLUTION - 8 KM FULL-TIME OPERATION 7 MORE CHANNELS
• IMAGERS OR SOUNDINGS	• SIMULTANEOUS IMAGING/SOUNDING
• LIMITED "SMALL PICTURE" REPETITIVE VIEWING	• CAN TAKE "SMALL PICTURE" VIEW OF A SEVERE STORM EVERY MINUTE

Figure 1
5

The purpose of this assessment plan is to: (a) outline the process and methods by which the National Environmental Satellite, Data, and Information Service's (NESDIS) and the National Weather Service's (NWS) operational and research units will determine the GOES-8/9 product validity and quality as the GOES products become operational and (b) delineate the responsibilities between NWS and NESDIS in this assessment process. In addition, the plan describes the process by which ongoing evaluation outcomes will be used to help define requirements for "day-two" products, for follow-on GOES series satellites, for training, and for effective utilization of GOES-8/9 digital data combined with other data on the Advanced Weather Interactive Processing System (AWIPS).

The development and implementation of this plan has been a joint effort among the NESDIS Offices of Satellite Data Processing and Distribution (OSDPD) and Research and Applications (ORA) and the NWS Office of Meteorology (OM) and evaluation focal points at NWS national and regional centers. GOES software implementation is the responsibility of the Satellite Services Division (SSD) and the Information Processing Division within OSDPD; the Atmospheric Research and Applications Division (ARAD) conducts the necessary product research in ORA.

The initial suite of products from GOES-8/9 is referred to in this plan as "day-one" products (appendix A). As a result of the operational use and evaluation of "day-one" products, improved or new products, called "day-two" products, will be developed.

In general, GOES-8/9 "day-one" image products for NWS field distribution replicate existing GOES-7 products and introduce new ones (e.g., the 3.9μm 4km data). Evaluation of these products as outlined in this plan should be relatively straight-forward. On the other hand, the advent of a truly operational sounder on GOES-8/9 and a new roster of "day-two" products from the sounder/imager, along with their frequency and timeliness, make them candidates for a more involved evaluation prior to and during operational implementation.

NESDIS is to provide operational GOES products to the forecast offices and national centers of the NWS and other users. Operating and maintaining product systems, monitoring and improving product delivery, and maintaining product quality remain functions of NESDIS in the GOES I-M era. As outlined in this plan, NESDIS and the NWS will work together to schedule dates for the actual implementation of individual product streams once each product is deemed operational.

The new generation of products available from GOES-8/9 has required the NWS to re-evaluate its training needs. The lack of formal instruction in satellite meteorology by the vast majority of NWS operational meteorologists will be remedied in large

partby a series of computer-based learning modules and by a series of formal courses presented by NESDIS and NWS.

The GIMPAP outlines resources, instrument-performance capabilities, data-production standards, and sensor and product evolution, making it essentially an instrument validation effort. The GOES-8/9 assessment plan is a road map that guides the product-evaluation process. This assessment plan states the GOES-8/9 assessment goals and objectives and outlines the evaluation process, including feedback of results. These assessment results assist in defining requirements for future products, training, follow-on GOES system architecture, and AWIPS/NOAAPORT. This plan will also benefit the actual process for reporting results and making recommendations. Schedules are also provided. Although there is overlap between the GIMPAP and the assessment plan, the GIMPAP focus is on science, while the plan focuses on product value (e.g., accuracy, timeliness, impact, and reliability).

Evaluation strategies, logistics, and methodologies are only **outlined** in this plan. Details of the processes will be developed and documented by the NESDIS POPs and the participating NWS forecast offices and national centers.

2.0 GOES-8/9 Assessment Goals

The goals of the GOES assessment are as follows:

A. assure GOES-8/9 "day-one" product quality and assess the meteorological utility of GOES data and products at national centers and local forecast offices;

B. determine necessary modifications to "day-one" products and refine definitions of the operational "day-two" products;

C. provide input to GOES-8/9 satellite and processing system, changes to future GOES-I/M systems, and requirements for next-generation GOES;.

D. provide technical and procedural guidance to the GOES training program; and

E. provide input to requirements for effectively utilizing GOES digital data on AWIPS/NOAAPORT.

3.0 GOES-8/9 Assessment Objectives

The GOES assessment objectives are as follows (goals A through E are defined in section 2.0):

A. Objectives to accomplish goal A:

- evaluate GOES-8/9 navigation, calibration, and remapping systems performance;

- evaluate the validity and quality of the GOES-8/9 image products on GOES-Tap, Multidiscipline Interactive Display and Analysis System (MIDAS), Regional and Mesoscale Meteorology Branch Advanced Meteorological Satellite Demonstration and Interpretation System (RAMSDIS), Micro Satellite Weather Information System (MicroSWIS), Information Stream Project for AWIPS/NOAAPORT (ISPAN), and AWIPS/NOAAPORT;

- evaluate the validity and quality of GOES-8/9 sounder products including temperature and moisture retrievals within operational numerical models, as well as digital product images (DPI) such as precipitable water and convective stability images;

- evaluate the winds products, which include cloud drift, water vapor, and thermal-gradient winds (both automated and manual procedures require evaluation);

- evaluate the GOES-8/9 high and middle cloud data (from both the imager and sounder) in support of Automated Surface Observing System; and

- evaluate the interactive image analyses including the quantitative satellite precipitation estimates (SPE), interactive flash flood analysis, cloud-top heights, moisture bogus, tropical-storm analysis, other synoptic analyses, and volcano-alert support.

B. Objectives to accomplish goal B:

- develop, implement, and evaluate new "day-two" products based on the improved GOES-8/9 imager and sounder performance capabilities.

C. Objectives to accomplish goal C:

- provide input to the NESDIS budget for satellite system enhancements; and

- complete the NWS science-requirements document.

D. Objectives to accomplish goal D:

- review of evaluation results by the OM Training and Professional Development Program and appropriate

NESDIS units will determine GOES training requirements and will lead to the necessary changes and enhancements to NWS training modules; further development of CD-ROM and interactive video training modules will continue.

E. Objectives to accomplish goal E:

- based on evaluation results, OM will review and recommend modifications to AWIPS/NOAAPORT requirements for effective utilization of GOES data on AWIPS and N-AWIPS.

4.0 Evaluation of GOES-8/9 Products

NESDIS and NWS operational and research units are currently evaluating GOES-8/9 products. This evaluation is an ongoing process and is summarized in table 1. Updated information will be available through the annual NWS assessment reports.

In NWS, GOES evaluation will be done at selected field sites: the Environmental Modeling Center (EMC), the Hydrometeorological Prediction Center (HPC), the Aviation Weather Center (AWC), the Storm Prediction Center (SPC), the Tropical Prediction Center (TPC), and the National Operational Hydrologic Remote Sensing Center (NOHRSC). AWC, SPC, TPC, and NOHRSC will participate in the assessment, but this participation will not interfere with normal operations. Although the SPC will not be formally involved in GOES-8/9 assessment initially, its assessment participation is expected as it becomes an operational unit. NWS field sites and focal points formally involved in the evaluation are listed in appendix B. Results will be reported monthly to Andy Noel (W/OM22).

The Alaska and Pacific Regions obtain their GOES-9 data via direct readout. This in-house data collection and processing capability gives these Regions a unique opportunity to assess product generation from an end-to-end perspective.

Also, EMC is proposing an additional series of numerical weather-prediction experiments to NESDIS to further evaluate the impact of GOES-8/9 data. Although EMC is defining the scientific scope of these experiments, results will be reported monthly to Jim Heil (W/OM22).

In NESDIS, quality assurance of the "day-one" product stream from GOES-8/9 is the function of the POPs within ORA and OSDPD. The GOES evaluation focal points for the NWS national and regional headquarters, national centers, and NESDIS are given in appendix C.

The following sections outline the evaluation methodology for

each of the objectives listed in section 3.0.

4.1 Navigation, Registration, and Calibration

As an obvious prerequisite to operational production of GOES-8/9 products, satellite navigation and calibration systems must be functioning properly. NESDIS's Office of Satellite Operations and ORA personnel will verify the efficacy of these two critical subsystems through their ability to produce imager (and sounder) data streams that are within performance specifications. Calibration and navigation performance summaries are routinely included in NESDIS weekly reports. These findings will be provided to the NWS offices participating in the assessment. Given nominal navigation, registration, and calibration, the quality of individual GOES products and services can be determined.

All assessment participants are requested to include in their reports any problems with navigation, registration, or calibration (e.g., image-to-image misregistration, misgridded images, and image striping). Scheduling discrepancies such as missing images should also be noted. Except in emergencies (e.g., watch or warning situations), which should be reported in real time, these findings are to be included in the participants' regular assessment reports.

4.2 Imager Products

Operational "day-one" imager products include all images available to NWS forecast offices and national centers as well as the NESDIS Synoptic Analysis Branch (SAB). The national centers have the capability to ingest GOES digital data in real time. The Pacific and Alaska Regions are developing direct readout capabilities. This capability will provide additional significant assessment opportunities (e.g., local generation of the fog product and potential benefits of an expanded imager footprint).

Additionally, selected NWS operational offices have received a RAMSDIS PC (see appendix B). These sites receive real-time, digital GOES-8/9 imagery from NESDIS via a MIDAS/ Internet connection. These images and this service are not considered operational and cannot be assumed to meet the timeliness and availability requirements imposed on operational systems delivering satellite images. However, this imagery can add very useful information to the assessment process and a preview of the GOES-AWIPS assessments.

The NWS's Aviation Weather Center (AWC) and Tropical Prediction Center (TPC) are receiving GOES-8/9 imager products by direct readout of the new GOES-8/9 GOES variable (GVAR) data stream through each center's McIDAS computer system network. In

addition, the NESDIS site at NCEP is providing images to both TPC and AWC indirectly via T1 circuits connecting them to the new national centers AWIPS (N-AWIPS) networks at the centers.

GOES-8/9 McIDAS operations at NCEP are conducted by NESDIS SSD and its operations and maintenance contractor. The contractor performs as network manager and McIDAS operator for GOES-8/9.

4.2.1 Evaluation by NESDIS

Since the beginning of GOES-8/9 operations, the GOES-Tap facsimile distribution system continued to be the primary conduit of images to NWS field sites. Currently, a new GOES-Tap production system, the GOES Sectorizer System, is fully operational and distributing GOES-8 and GOES-9 imagery.

Before becoming operational, NESDIS SSD and ARAD evaluated the new GOES-8 GOES-Tap imagery. ARAD provided the 10- to 8-bit data conversion tables for imagery and, in concert with the NWS, evaluated the appropriateness of these tables. Of particular interest was the quality and information contained in the GOES-8/9 3.9μm channel (channel 2). The pictorial display of the difference between channels 2 and 4 became *the first identified "day-two" product, the low cloud/fog product*. Methods are being considered to provide this product to GOES-Tap users in the near future.

Unlike previous GOES systems, the new GVAR (retransmitted GOES data format) gridding and navigation functions and tuning are performed in real time at the NESDIS Satellite Operations Control Center (SOCC). PRC, which operates and maintains the NESDIS GOES-Tap program on a continuous basis, will receive reports of anomalies from NWS field sites. PRC will relay these reports to SOCC in accordance with existing NESDIS GOES-Tap procedures. SOCC operators at the continuously staffed product monitor are operationally responsible for correcting navigation, registration, gridding, or calibration errors. Feedback from the NWS field sites via OM and SSD to PRC will provide additional confirmation of such observed anomalies. NESDIS SOCC, with a RAMSDIS workstation in house, has closed the loop with other evaluators and can directly monitor its reported data anomalies.

4.2.2 Evaluation by NWS

4.2.2.1 Logistics

In March 1995, a series of evaluations was begun at NWS RAMSDIS/Pathfinder field sites and at the national centers. Selected operational NWS sites formally involved in the evaluation are listed in appendix B.

The GOES-8/9 product suite for the evaluation will depend on the

specific location of the participants. The NESDIS Environmental Satellite Distribution/Interactive Processing Center will distribute the following GOES-8/9 products over the specific GOES-Tap circuits to the Satellite Field Distribution Facilities:

- real-time visible imagery with geopolitical boundaries;
- a suite of real-time infrared imagery with geopolitical boundaries; and
- real-time water vapor imagery with geopolitical boundaries.

4.2.2.2 Evaluation by NWS Field Offices

All participating NWS field offices (AWIPS, RAMSDIS, Pathfinder, and GOES-Tap sites) are requested to evaluate and report their findings on GOES-8/9-based products and services [e.g., SPE, ASOS satellite cloud product (SCP), and the fog product]. Narrative reports will be sent through regional headquarters to OM summarizing their evaluations. There is no prescribed format for these reports, only that they be descriptive and timely. Observed navigation and calibration problems are to be included in the summaries. At a minimum, these reports will be submitted monthly, but they may be sent as frequently as weekly should the situation warrant. Any problems deemed serious will be reported in real time in accordance with established GOES-Tap operational procedures.

4.2.2.2.1 Evaluation at RAMSDIS and Pathfinder Sites

Selected operational NWS sites (appendix B) will evaluate the meteorological utility of GOES-8/9 data. Forecasters at RAMSDIS and Pathfinder sites will evaluate GOES digital data to assess its utility for specific forecast problems. In the Lake Effect Snow Study, for example, forecasters will develop more extensive qualitative use of the imagery to detect the development of cloud bands and quantitative uses for estimating snowfall rates. This evaluation will include not only meteorological issues, but also system implications involved with the collection and dissemination of various satellite products, for example optimal temporal resolution. Another aspect of this evaluation involves the methodology for comparing snow squall detection on satellite imagery with information collected from the Doppler weather surveillance radar sites near and along the Great Lakes. The goal of this evaluation is to determine the extent to which quantitative snowfall information can be derived from both observing systems and the resultant impact on the local forecast.

NWS AWIPS, RAMSDIS and Pathfinder sites will have the ability to call for and evaluate GOES-8/9 rapid scan operations (RSO) 7.5-minute data. Sites are encouraged to report on the increased

temporal resolution data and its utility to mesoscale meteorological operations and services.

Assessment findings based on RAMSDIS or Pathfinder data shall be reported monthly via the RAMSDIS bulletin board to Jim Gurka (W/OM21), while assessment results from AWIPS sites shall be sent to Glenn Rutledge (W/OM22).

4.2.2.2.2 Evaluation at GOES-Tap Sites

NWS GOES-Tap sites will evaluate the meteorological utility, timeliness, and accuracy of the analog GOES-8/9 data disseminated on the SWIS, MicroSWIS, or other display devices. Assessments should include the ability of the analog data to discern significant meteorological features ranging from the synoptic scale down to and including the meso/microscale (e.g., vorticity/circulation centers, dry air intrusions, over-shooting thunderstorm tops, gust fronts, etc.).

GOES-Tap sites are also encouraged to report other assessment aspects (e.g., suggestions for image enhancement, schedule conflicts, product selection, and product timeliness). Assessments pertaining to GOES-Tap imagery will be routinely sent to the appropriate regional satellite focal point who will forward them monthly to Andy Noel (W/OM22).

4.2.2.2.3 Evaluation of Selected Products at NWS Field Sites

Reports on SPEs, SCPs, and the fog product should include the following, if possible:

SPE - event date, time, and location; general meteorological conditions; usefulness to operations; timeliness (how long did it take SAB to start generating SPEs); accuracy (i.e., is ground-truth available for comparison, is the product accurate, or is it over- or under-estimated).

SCP - timeliness (compare receipt time to image/sounder dwell time); accuracy (is it representative of cloud conditions above 12,000 feet AGL). How is this data being utilized locally? Is there any utility to aviation forecasting (e.g., determining the cloud conditions above 12,000 feet)? Is there any utility to public products? Is the SCP routinely being integrated into the hourly weather roundup? In the event of an hourly weather roundup problem, please provide event date and time and general meteorological conditions that may lead to the discrepancy.

Assessments pertaining to the aforementioned products will be routinely sent to the appropriate regional satellite focal point who will in turn forward them monthly to Andy Noel (W/OM22).

4.2.2.2.4 Evaluation of 1996 Summer Olympics Weather Support

The Olympic Weather Support Office (OWSO) provided superb mesoscale forecasting and warning support to the July/August 1996 Games in Atlanta, Georgia. A collection of new technology and applications, including high-resolution routine and RSO satellite imagery, contributed significantly to the Office's success.

An evaluation of OWSO's meteorological tools will likely help to provide insight into the forecasting and warning operations of a "modernized" NWS office. An assessment of the utility of GOES-8 imagery/operations will be a portion of the total evaluation.

4.2.2.3 Evaluation by the NWS Office of Meteorology

NWS OM is evaluating the GOES-8 imagery on the RAMSDIS and N-AWIPS units located in the OM media room. This informal evaluation centers on navigation and calibration. A log book will be kept routinely highlighting image quality. These findings will be reported at the GOES Special Issues Working Group (GSIWG). OM will also be providing quality control for GOES-Tap imagery. In addition to the imagery, OM will continue to evaluate the timeliness of the Automated Surface Observing System (ASOS) satellite cloud product from the GOES-8/9 sounders. When appropriate, OM will evaluate a similar cloud product derived from the imager.

4.2.2.4 Evaluation by NCEP

The NCEP centers indicated below will continue to assess GOES-8/9 imagery. Under the recently completed NCEP reorganization, the responsibilities for aviation weather support and severe storm forecasting guidance formerly collocated at Kansas City, Missouri, have been separated. The AWC will remain at Kansas City while the SPC will relocate to Norman, Oklahoma. An overview of the AWC's assessment activities follows. When the assessment role of the SPC becomes more clearly focused, a section will be included in this plan to indicate its participation. All ongoing and future assessment results will be reported to Jim Heil (W/OM22).

4.2.2.4.1 Evaluation by EMC

EMC has already conducted preliminary model impact studies with the GOES three-layer precipitable water, temperature soundings and cloud track, and water vapor winds. These assessments revealed some problems and inadequacies that will require considerable additional investigation. EMC has submitted a proposal to NESDIS that extends the GOES product assessments already completed. This proposal outlines the steps that will lead to a more thorough assessment of GOES-8/9 winds and radiances and that will lead to the development of other GOES

products such as advanced Earth-surface products (e.g., high resolution precipitation retrievals and ocean currents through feature tracking). Appendix D details this proposal.

4.2.2.4.2 Evaluation by AWC

GOES-8/9 digital data are directly received at AWC via an antenna on the Federal Office Building. Evaluation of products began in December 1994.

The AWC Support Branch set up ingest and gridding programs so that the data are displayed through a menu of multiple loops. Any number of the loops may be used for the GOES-8 data at the discretion of the meteorologist at each VAS Data Utilization Center (VDUC) terminal. The AWC Support Branch works with the operational forecasters to develop improved products to provide optimal support for operations. This is a continuing effort.

The AWC forecasters will routinely use an enhanced version of the low cloud/fog product. At night, this imagery already has become a required data set for forecast operations. During the day, differences between channels 2 and 4 will be normalized with visible channel 1. The resulting data will then be sectorized into areas where the infrared (IR) temperatures are between 0°C and -15°C. These images will be examined to determine if clouds comprised of supercooled water droplets can be identified from those made up of ice crystals. More experimentation concerning the validity of this derived icing product will be done as data are collected during the colder winter months.

A technique for identifying volcanic ash clouds, currently used successfully with polar orbiter imagery over Alaska, is also being investigated by AWC. The differences between infrared channel 4 and channel 5, masking out the preciptable water signatures, are being utilized in this experiment. Volcanic eruptions within satellite view are needed to test the accuracy of this algorithm.

AWC will work in conjunction with EMC in evaluating the specialized products that are produced for them. AWC plans to rely on the evaluation of soundings provided by NESDIS. Particular attention will be paid to the moisture distribution from the split window in order to compare the low-level and mid-level moisture fields.

The derived sounder products, such as precipitable water and convective stability indices, will also be available to AWC via T1 circuits from MIDAS for ingest in VDUC. Once in VDUC, these data may be evaluated by selecting and displaying them in special loops. This process will begin as the products become available from NESDIS.

AWC plans to further use the sounder to derive multi-spectral imagery products, possibly fields of lifted index and precipitable water over large areas and point locations, for use in the observation and forecasting of severe convective activity. The question to be answered is what does this new information add to the analysis and the resulting forecasts.

Severe weather test cases including individual GOES-8/9 data fields, e.g., low-level moisture (derived from channels 4 and 5) or mid-tropospheric moisture (channel 3) will be compared to the same control cases without GOES-8/9 moisture information. The results will be evaluated to determine what improvements in the forecasts can be attributed to the GOES-8/9 data. A similar set of tests using a composite precipitable water product (derived from channels 3, 4, and 5) hopefully will yield encouraging results.

4.2.2.4.3 Evaluation by TPC

The TPC has qualitatively evaluated GOES-8/9 imagery over the tropics by comparing/contrasting it with GOES-7 imagery for weather features of interest. These features include tropical cyclones, upper-level troughs and cut-off lows, fronts, upper-level dry slots, and jet stream cloud and turbulence boundaries.

Results indicate that the GOES-8/9 water vapor imagery is generally superior to that from GOES-7. The new imagery provides clearer and better resolution of the features listed above which are of interest to TPC aviation and marine forecasts. The GOES-8/9 infrared imagery provides clearer representations of mesoscale cloud features and turbulence boundaries used to forecast significant meteorological information (SIGMET) to aviation and aviation weather over the Gulf of Mexico and Caribbean Sea. Relative to GOES-7, the GOES-8/9 visible imagery appears to provide better position estimates of tropical cyclones. However, it was not possible to make a quantitative comparison, because the area of overlap (with comparable viewing angles) was over the eastern Pacific where aircraft reconnaissance data were not available for ground truth. In addition, no suitable tropical cyclone cases were available for a direct comparison because the eastern Pacific was very inactive during 1995.

With GOES-7 now in a standby mode, the qualitative comparisons can no longer continue. Because of TPC’s large area of responsibility, computer capabilities are not sufficient to routinely ingest the new imagery at its highest resolution. As these capabilities become available in the future, the evaluation of the new GOES-8/9 data will evolve.

4.2.2.5 Evaluation by AWIPS Sites

The AWIPS Network Control Facility (NCF) has been transmitting GOES-8 data via the AWIPS Satellite Broadcast Network/NOAAPORT since spring 1995. Initially the data were received only at Pathfinder sites. The NCF began distribution of GOES-8 and GOES-9 data during spring 1996 in preparation for the initial deployment of AWIPS beginning in August 1996.

For the AWIPS operational test and evaluation, satellite data will be assessed with respect to the AWIPS requirements stated in appendices F and K of the AWIPS requirements document. Evaluation will be made based on data quality, availability, increased number of data channels, more frequent receipt, and perceived advantage/disadvantage of integrating satellite data with numerical model output.

AWIPS sites will have the ability to call for and evaluate GOES-8/9 RSO 7.5-minute data. Sites are encouraged to report on the increased temporal resolution of the data and its utility to mesoscale meteorological analysis and forecasting.

4.2.2.6 Evaluation by OH/NOHRSC

When satellite snow-mapping products are to be integrated with other geospatial data sets, it is critical for the navigation and registration of GOES-8/9 products to be as accurately and precisely defined as possible. It is especially important for meso-resolution data sets. A registration error of one pixel can result in a 4 kilometer misalignment with other data sets. For example, GOES-GVAR data sets are used by the NWS Office of Hydrology / National Operational Hydrologic Remote Sensing Center (OH/NOHRSC) to identify the areal extent of snow cover. These data are integrated with digital elevation models to yield spatially interpolated estimates of snow-water equivalents. For accurate estimates of snow-water equivalents, it is critical that the two data sets be properly aligned.

An accurate and consistent way of assessing GOES data navigation and registration is through comparison with reference data. A commonly employed method is to overlay the GOES data with vector coastlines. This method is prone to subjectivity since analysis may not always agree on how raster and vector data agree. The level of subjectiveness increases with (1) the coarseness of the raster data and (2) the precision of the vector data. The method has appeal since both data sets can be viewed simultaneously.

The level of subjectiveness can be decreased by comparing navigated and registered GOES data with a controlled reference image of the same resolution. An objective assessment can be made by comparing the two images. The disadvantage of this method is that two raster images cannot be viewed simultaneously

in an effective manner (Note: They can be viewed simultaneously as separate 8-bit overlays on displays supporting at least 16-bits, but the procedure is cumbersome at best). This disadvantage can be overcome by vectorizing the controlled reference image. The reference image need only define major water bodies. The vectorized reference image can be displayed over the navigated and registered satellite data serving as (1) a more objective assessment tool and (2) serve as a convenient template to which an image can be shifted up-down, left-right to match the reference image.

4.2.2.6.1 Snow-Mapping Products

The NOHRSC method of assessing GOES-8/9 navigation is to register new images against a control-registered full resolution snow- and ice-free, cloud-free, and cloud-shadow-free visible CONUS image for daytime assessment and full resolution cloud-free 3.9μm and/or 11μm infrared image for nighttime assessment.

The most critical step is building the CONUS control image for each satellite. This step will require mosaicing many registered GOES-8/9 images to avoid snow, ice, clouds, and cloud shadows. A series of landmarks with known latitude and longitude will be selected to test navigation/registration for each mosaic input image. The final registered CONUS mosaic for GOES-8 and GOES-9 must have precise and consistent image navigation and registration using the existing GOES landmark data base.

To create the most effective assessment, software will be required to either automate the registration or interactively enable operational users to check the registration with minimal impact upon the station operations. The software will also be capable of generating the results in a format that will allow real time, daily, weekly, monthly, or quarterly reports to be generated.

As discussed above, there are two elements of subjectivity in image-to-image registration, (1) the individual doing the registration and (2) the landmarks chosen to do each registration. GVAR uses absolute navigation for the individual pixels in a scene and, therefore, we will endeavor to do more automated registration by statistically determining the best line/element shift using multiple landmarks for each scene. The CONUS control image will be used to select landmarks with large differences in albedo with surrounding terrain (coastlines, lakes, and reservoirs). These landmarks will be used to register all visible imagery. The registration software will then determine if each landmark on an image is obscured by clouds/cloud-shadows by searching for patterns that meet the criteria for each landmark in the scene. After selecting the landmarks usable for registration, the software will compare the location of each landmark in the image with the landmark on the

control image to determine if the image requires a line/element shift to fit the CONUS control image. After determining the amount of shift required to match each landmark on the control image, the optimum shift will be computed for the entire image. A report will be generated for each image containing statistics required to match each landmark. Monthly reports will be submitted to the OM Satellite Program Leader (W/OM22).

4.3 Sounder Products

Data from the GOES-8/9 sounders began flowing into the NESDIS product systems in December 1994. For the first time, NESDIS was able to create hourly operational products from sounder data without interruption by the imager.

4.3.1 Evaluation of Soundings by NESDIS

The NESDIS Forecast Products Development Team (FPDT) initiates sounding production, maintains data bases of sounding error statistics and works with NESDIS's operations and maintenance contractor to ensure rigorous functionality testing of new soundings software and associated IBM RISC6000 network hardware at NCEP.

In concert with FPDT, NOAA's Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin at Madison began the evaluation of sounding quality and radiosonde match statistics in September 1994. In addition, the sounding data bases and associated match statistics are routinely copied to files for NCEP inspection and evaluation.

4.3.2 Evaluation of Soundings by NWS

EMC has completed an early impact study using a limited set of GOES soundings. EMC has submitted proposals to NESDIS for the development and evaluation of sounder temperatures in radiance form and a precipitable water product. Impact studies will be conducted. Maximal use of sounder radiance data will occur when the ASOS cloud product is being produced from the imager rather than from the sounder as it is currently. The three-layer precipitable water product from the sounder is currently being evaluated for operational use. Early tests showed a small positive impact, primarily due to the observation of cloud-free areas where the model was cloudy in the initial condition. There was no distinct positive impact on forecasts of heavy precipitation areas from the GOES layer precipitable water data.

In conjunction with their tropical cyclone support, the TPC will evaluate sounder profile data. Calculations of derived atmospheric parameters over oceans, such as static stability, will be made. These calculations will require data at least four times a day from over both the Atlantic and Pacific Oceans.

These data will be included in the TPC N-AWIPS data base.

NWS Western and Central Regions also wish to evaluate the sounder retrievals to determine if the frequent profiles will improve their forecasts. The Western Region has a particular interest in sounder profiles over the Pacific so that its forecasters have an improved analysis of the weather upstream. Included in the evaluation is a measurement of how the atmosphere is changing in advance of weather systems and how these changes will impact forecast office products.

4.3.3 Evaluation of ASOS Sounder Product by NESDIS

NESDIS is generating CONUS ASOS SCPs using GOES-8/9 sounder data In concert with the NWS, NESDIS's FPDT and CIMSS assess and continue to improve the SCP's meteorological accuracy while the Interactive Processing Branch (IPB) ensures timely SCP generation and delivery to NWS communications systems. An imager-based product which extends coverage to Hawaii and Puerto Rico is being evaluated as well.

4.3.4 Evaluation of ASOS SCP by NWS

Since the early 1990's, the Technology and Forecast Systems Core of OM has led the development, evaluation, and operational implementation effort of the ASOS SCP, which is designed to provide cloud information above the 12,000-foot ceiling of the ASOS sensor. During 1996, OM established the first detailed end-to-end statistical analyses of the NESDIS generation and the NWS receipt of the SCP. This study resulted in a substantial increase (from 60 percent in February 1996 to 90+ percent today) in the timely delivery of SCPs to the NWS field offices. Due to resource limitations, OM has scaled back some of this centralized monitoring function and has encouraged field sites to increase their participation concerning a number of SCP issues (e.g., evaluating the meteorological accuracy of the data, identifying additional SCP reports for commissioned ASOS sites, etc.). OM collects these findings and relays them to NESDIS operations personnel and products oversight panels for action. Details of the NWS field evaluations of the sounder-based ASOS SCP are given in section 4.2.2.2.3.

4.3.5 Evaluation of Derived Product Images by NESDIS

DPIs of lifted index and precipitable water will be created and evaluated by FPDT and CIMSS. These products will initially be used at AWC, HPC, and NESDIS's Synoptic Analysis Branch (SAB). When production is stable, these products will be transmitted to AWC for further evaluation beginning in spring 1996. DPIs will be compared to radiosonde-observation-based parameters for quality control. These accuracy statistics will be collected and evaluated by CIMSS and AWC.

4.3.6 Evaluation of Derived Product Images by NWS

NCEP development units will continue research on optimizing the use of GOES data in mesoscale, synoptic, and global-scale models. These data include, but are not limited to, derived products such as total precipitable water. Collaborations with CIMSS to work with these data are also planned.

Once NESDIS has completed its evaluation of the DPIs, they will be available in NESDIS's MIDAS for access through AWC's satellite file server. Through the VDUC menu system, the AWC VDUC work station will have access to these data. Once available, AWC will use the derived products in real-time forecast situations to evaluate the quality and timeliness of the data. This function will evolve as the products become available and their usefulness determined operationally.

The TPC and Western and Central Regions wish to evaluate the role of DPIs in improving the forecast process. Currently the Western Region is receiving DPIs from CIMSS and distributing them for evaluation to each of its 24 forecast offices. The Central Region plans to make the same evaluation at a later date. The TPC is concerned with DPIs over ocean areas, a data source that was not previously available. These data can be found on the CIMSS GOES homepage.

4.4 Wind Products

Historically, assigning heights to satellite-derived wind products has been the most difficult part of determining satellite winds. Cloud motion vectors represent the wind at cloud-top altitudes, while moisture drift vectors are more representative of deeper mid-tropospheric layers.

4.4.1 Evaluation of Cloud Motion and Water Vapor Winds

4.4.1.1 Evaluation by NESDIS

NESDIS's FPDT and CIMSS have responsibility for the initial evaluation of winds-product accuracies (cloud motion and water vapor) and the examination of wind fields, error statistics and, GOES-7 winds comparisons. Some statistics have been forwarded to NCEP for evaluation.

The NESDIS operations and maintenance contractor is responsible for testing the winds software and associated reduced instruction set computer (RISC) hardware. The NESDIS IPB verifies the operational readiness of winds production jobs in concert with NESDIS SAB and the Products Systems Branch. Winds products have been compared twice daily to radiosonde observation matches and to NCEP model guess statistics. Weekly summaries of the resultant error statistics will be compiled by the NESDIS IPB.

4.4.1.2 Evaluation by NWS

The NCEP EMC and NESDIS will cooperate on the evaluation of high density GOES wind data for hurricane cases from August-September 1995. Work on this evaluation began in early April 1996 and continues. These activities are described in a proposal for GOES-8/9 product development that EMC has submitted to NESDIS (appendix D).

4.4.2 Evaluation of Gradient Winds

4.4.2.1 Evaluation by NESDIS

Wind vectors derived from GOES-8 soundings gradients have been evaluated by FPDT and the CIMSS. Accuracy statistics associated with these fields have been saved and made available to NCEP. The product quality must equal or exceed that of the similar GOES-7 product. Gradient wind accuracies have been determined and compiled in the same manner as cloud drift wind accuracies using radiosonde observation and guess-match statistics.

4.4.3 Evaluation of High Density Combined Winds

The TPC is receiving from CIMSS a combination of high density cloud motion and water vapor winds, winds from visible imagery, and sounder winds. NESDIS processes the high density cloud motion and water vapor winds and sends the data to CIMSS where they are merged with wind data derived from the visible imagery and the sounder. This combined product is then made available to the TPC for its evaluation and use in tropical cyclone analysis and prediction.

4.5 Interactive Image Analyses

The following "day-one," interactive GOES-8/9 products will be evaluated:

- Cloud Motion and Water Vapor Vectors
- Precipitation Estimates (Interactive Flash Flood Analysis)
- Cloud Top Heights
- Moisture Bogus/Replacement Moisture Product
- Tropical Storm Analyses
- Other Synoptic Analyses (fronts, jets, etc.)
- Volcano Alert Support
- Derived Product Images (PW, LI and SST).

Higher resolution infrared images will likely improve the accuracy of these operational analyses over those produced from GOES-7 and METEOSAT imagery.

4.5.1 Evaluation of Interactive Image Analyses by NESDIS

NESDIS IPB and SAB are responsible for "day-one" interactive image analysis. Intercomparisons of the precipitation estimates performed by IPB and SAB validate the utility of GOES-8/9 imagery for this task. Similarly, other cloud and moisture analyses are compared to GOES-7 data.

Since the relative quality of the analyses provided by SAB to NCEP is largely related to both image quality and timeliness, the same guidelines for assessing GOES-8/9 image quality at the national centers apply to the evaluation of these interactive products. Assessment of most analyses remains a qualitative one with GOES-8/9 data. However, accuracies of precipitation estimates and cloud-top heights are prescribed in the "day-one" products list and must be attained before the products are deemed operational. As the situation arises, volcanic alert support will be made with any other available satellite imagery.

4.5.2 Evaluation of Interactive Image Analyses by NWS

4.5.2.1 Evaluation by NCEP

4.5.2.1.1 Evaluation by HPC

HPC forecasters will use the GOES 8/9 imagery in the preparation of HPC forecast products and compare the clarity, reliability, and quality of these data with previously available imagery. The evaluation will be subjective and will reflect the utility of these data in the preparation of HPC forecast products. A written summary of HPC findings will be provided monthly. Any errors will be called to the attention of NESDIS. NCEP expects that inclusion of GOES-8/9 moisture imagery products may strongly influence the forecast of heavy precipitation; so these types of events may be the most eligible candidates for case studies.

Model impact studies are dependent on the findings of the aforementioned activities. Every indication is that the GOES-8/9 products will be an improvement over GOES-7, and the statistical analysis is also expected to reflect this. Once the statistical comparisons are completed, specific case study candidates will be used for the model impact studies.

4.5.2.1.2 Evaluation by AWC

Operational use of GOES-8/9 imagery and derived products at AWC routinely include interactive use of GOES-8 data along with and including surface observation, radiosonde observation, model, wind profiler, radar and, pilot report data. This approach has been employed with GOES-7 data and continues with GOES-8 data.

4.5.2.1.3 Evaluation by TPC

As mentioned in section 4.2.2.6, the eastern Pacific area was very inactive during 1995, so there was little opportunity to make a direct comparison of the Dvorak classification technique using GOES-8 and GOES-7 imagery. However, GOES-8 was routinely used for Dvorak classifications for storms in the Atlantic basin, and GOES-9 will be used in the eastern Pacific beginning with the 1996 season. The classifications using the new GOES data will be compared in a statistical sense with the previous classifications using GOES-7. In the Atlantic basin, aircraft observations will be used for ground truth. In this way, any differences in the average errors of the Dvorak classifications with the new GOES data versus those using GOES-7 can be determined.

One intercomparison test of the Woodley-Griffth rainfall algorithm was performed during the 1995 hurricane season. For a brief period of time, a tropical disturbance was located in the eastern Pacific where GOES-7 and GOES-8 had comparable viewing angles. Although this disturbance was not a tropical cyclone, results showed that the rainfall algorithm produced nearly identical results using input from the two systems. Because GOES-7 is no longer available, no further intercomparisons are planned. In future applications, the rainfall algorithm with GOES-8/9 input will be evaluated using any available surface rainfall measurements and could be used as a benchmark for evaluating new rainfall algorithms for tropical regions.

5.0 Feedback into Requirements

5.1 Feedback into Requirements for Future Systems and Products

The GOES evaluation reports produced by the various NWS and NESDIS units described above will include recommendations for improvements to products and systems. These recommendations will translate into short, medium, and long-term formal requirements for both products and systems changes.

In NWS, OM’s Technology and Forecast Systems Core will develop a formal NWS GOES science requirements document. In NESDIS, the Cooperative Institute for Research in the Atmosphere (CIRA) and CIMSS are the primary sources of future requirements and products.

5.1.1 "Day-One" Product Modifications

Evaluation results will include recommendations for the modification or elimination of GOES-8/9 "day-one" products and requirements for "day-two" products. Development of "day-two" products, as well as changes to "day-one" products, will be accomplished according to accepted practices in NESDIS under the POP/SPSRB structure. NWS participation in the POPs is critical

to these actions.

The primary focus of new product development in NESDIS is in ARAD, through the two Cooperative Institutes. Activities in this area at both CIRA and CIMSS are documented in the GIMPAP.

5.1.2 System Modifications

Requirements for the medium range time period initially have been identified to include global and national imaging without conflict and an improved sounder if possible.

For the longer range, major systems development will govern requirements, the review process, and the involvement of the Systems Acquisitions Office (SAO) and the National Aeronautics and Space Administration (NASA). For this time frame, an NWS GOES science document has been drafted. Results from this assessment will be incorporated into this document as appropriate.

5.2 Feedback into Requirements for GOES Training

As of March 1995, over 90 percent of operational NWS meteorologists had never received any formal satellite remote-sensing education from the NWS or universities. However, extensive workshops, office visits, and NWS Training Center lectures on GOES imagery interpretation were conducted by NESDIS ARAD from 1975 through 1996. Additionally, NESDIS books, Technical Memorandums, and Satellite Applications Information Notes have been widely distributed throughout NWS field forecast offices and national centers. Most of these workshops and documents focused on the use of analog satellite imagery available via the GOES-Tap system.

Since March 1995, NWS OM and the Cooperative Program for Operational Meteorology, Education, and Training (COMET) have led an aggressive, pro-active program to educate operational meteorologists on the utilization of digital GOES-8/9 satellite data. The satellite education program consists of classroom residence courses at COMET, a series of computer-based learning (CBL) modules and a homepage on satellite meteorology, which is part of the COMET WorldWide Web site. As of December 1996, 92 NWS Science and Operations Officers and Satellite Focal Points had successfully completed either one of the four "Satellite Meteorology Courses" or the Satellite Symposium in March 1995, which was conducted at COMET. The graduates of these courses have, in turn, begun to educate the staff at their forecast offices by using material found on the Satellite Meteorology Homepage. Furthermore, an estimated 200 forecasters have completed the first in a series of CBLs on the utilization of meteorological satellite data, called Satellite Meteorology: Remote Sensing Using the New GOES Imager.

Initial results from the GOES-8/9 assessment have already provided valuable information on NWS satellite meteorology education needs and have led to modifications in the satellite meteorology residence course and plans for future CBL modules.

5.3 Feedback into Requirements for AWIPS

The GOES evaluation reports produced by the various NWS and NESDIS units described above and from the independent assessment will include recommendations for improvements to products. The Technology and Forecast Systems Core in NWS's OM will translate these recommendations into medium- and long-term formal requirements for AWIPS, as appropriate.

6.0 Reporting GOES-8/9 Product and Services Assessment Results

The assessment function is the starting point for a systematic process to modify the existing GOES instruments and ground-processing technologies as well as proposing new designs for future instruments. The NWS Satellite Program Leader is responsible for collecting and merging all NWS GOES assessment results and findings and presenting this information to NWS, NESDIS, and SAO managers. There are many existing forums for communicating assessment results. They are:

1. NWS Office of Meteorology Annual GOES Assessment Meeting
2. NWS Office of Meteorology Monthly Program Review
3. NWS Transition Management Meeting
4. NOAA GOES Council
5. NESDIS Product Oversight Panels
6. NESDIS Satellite Product/Services Review Board
7. NESDIS Satellite Configuration Control Board
8. NOAA GOES Special Issues Working Group
9. AWIPS Integrated Operations/Services Committee
10. Director's Advisory Committee on Forecast Operations

The groups described above normally produce standard annual meeting schedules. These meeting schedules allow for an orderly process to present GOES assessment results. For example, the SPSRB will provide a yearly schedule and specifically what months the soundings POP will be on the agenda. NWS GOES sounding assessment results can then be collected and presented at the appropriate SPSRB meeting.

These groups are designed to facilitate the process of translating GOES assessment results into new NWS science requirements, which, in turn, lead to new GOES instruments. The NWS Satellite Program Leader will prepare and present GOES assessment results obtained from the national centers and the local forecast offices via the regional offices at the appropriate meeting.

The POPs in NESDIS (see appendix E) provide the venue for feedback on product quality, enhancements and new product development. The POPs, which include representation from the NWS, determine that individual GOES-8/9 products under their oversight are ready to be implemented operationally. NESDIS will declare GOES-8/9 products operational with the approval of the SPSRB and with the concurrence of the appropriate POP chairs.

Recently, the GSIWG was formed to coordinate technical and operational information on satellite issues. The GSIWG will provide a forum to assess the performance of the GOES spacecrafts and products and data delivery systems. The GSIWG meets monthly and is co-chaired by managers from NWS and NESDIS.

The NWS Satellite Program in the Technology/Forecast Systems Core will fund, organize, and host an annual GOES assessment meeting. The purpose of these meetings is to document GOES-8/9 assessment results from NWS regions and national centers for the calendar year. NESDIS and NASA representatives will be invited to attend and to make presentations if appropriate. The meetings, based on current assessment results and findings, will also outline GOES assessment objectives for the upcoming year. An annual GOES assessment report will be produced by the Technology/Forecast Systems Core following each meeting. An intermediate meeting may be scheduled depending on the NWS budget situation.

Quality assurance of the "day-one" product stream from GOES-8/9 is the joint responsibility of NESDIS's ORA and OSDPD. These two offices will provide reports on evaluation results to the POP chairpersons, the SPSRB, and the GSIWG.

Monthly evaluation reports from NWS field offices and national centers will be forwarded to the NWS satellite assessment focal points in OM. Significant findings or problems, however, will be reported as soon as possible to the OM Satellite Program Leader. These focal points will ensure the programmatic and scientific integrity and accuracy of the reports and will be responsible for forwarding them to the NESDIS GOES Product Manager for inclusion in reports to the appropriate NOAA managers. The NWS Satellite Program Leader and NESDIS GOES Program Manager will also organize and conduct yearly assessment meetings with approriate field participation. Quarterly and yearly assessment reports will be prepared and delivered to NWS and NESDIS senior managers.

NWS participation in the POPs ensures that its interests, as a user of the new GOES-8/9 imagery and sounding products, will be represented prior to NESDIS decisions to implement GOES-8/9 products.

Evaluation results will be presented by NESDIS and NWS to the Transition Management Meetings, GOES Council, NESDIS's SPSRB, the GSIWG, NWS Coordination Meetings, and other forums as identified.

Table 1

GOES Assessment Activities Matrix									
Satellite Products/Services									
Assessors (National Centers)	Imagery	RSO	SPE	ASOS/ SCP	Winds	T/M Profiles	DPI	Fog	Sfc Prod
NCEP/EMC					X	Radiance			X
NCEP/HPC	M		X						
NCEP/AWC	X			X			X	X	
NCEP/SPC	X	TBD	TBD			TBD	TBD		
NCEP/TPC	X		Man?		X	X			
SR/SMG									
OH/NOHRSC	X								X

M - Moisture Channel Imagery
Man - Manually Produced
TBD - To Be Determined

GOES Assessment Activities Matrix									
Satellite Products/Services									
Assessors (Field Offices)	Imagery	RSO	SPE	ASOS/ SCP	Winds	DPI	Fog	Sfc Prod	LES
ER RAMSDIS									
Binghamton	X		X						X
Buffalo	X		X						X
Cincinnati	X		X				X		
Cleveland	X		X			X	X		X
New York	X						X		
Raleigh	X								
State College	X								X
ER Pathfinder									
Boston	X	X							
Pittsburgh	X	X							X
ER Analog									
Burlington				X					
Philadelphia			X				X		
Wakefield			X						

GOES Assessment Activities Matrix										
Satellite Products/Services										
Assessors (Field Offices)	Imagery	RSO	SPE	ASOS/ SCP	Winds	T/M Profiles	DPI	Fog	Sfc Prod	LES
WR RAMSDIS										
Billings	V,I,M	X			X		X	X		
Boise	V,I,M	X			X		X	X		
Elko	V,I,M	X			X		X	X		
Eureka	V,I,M	X			X	X	X	X		
Flagstaff	V,I,M	X			X		X	X		
Fresno	V,I,M	X			X		X	X		
Glasgow	V,I,M	X			X	X	X	X		
Great Falls	V,I,M	X			X		X	X		
Las Vegas	V,I,M	X			X	X	X	X		
Medford	V,I,M	X			X		X	X		
Missoula	V,I,M	X			X		X	X		
Monterey	V,I,M	X			X	X	X	X		
Oxnard	V,I,M	X			X	X	X	X		
Pendleton	V,I,M	X			X	X	X	X		
Phoenix	V,I,M	X		X	X	X	X	X		
Pocatello	V,I,M	X			X		X	X		

V - Visible Imagery
I - Infrared Imagery
M - Moisture Channel Imagery

GOES Assessment Activities Matrix										
	Satellite Products/Services									
Assessors (Field Offices)	Imagery	RSO	SPE	ASOS/ SCP	Winds	T/M Profiles	DPI	Fog	Sfc Prod	LES
WR RAMSDIS Continued										
Portland	V,I,M	X			X		X	X		
Reno	V,I,M	X			X		X	X		
Sacramento	V,I,M	X	X		X		X	X		
Salt Lake City	V,I,M	X			X	X	X	X		
San Diego	V,I,M	X			X	X	X	X		
Seattle	V,I,M	X			X	X	X	X		
Spokane	V,I,M	X			X		X	X		
Tucson	V,I,M	X			X	X	X	X		

V - Visible Imagery
I - Infrared Imagery
M - Moisture Channel Imagery

GOES Assessment Activities Matrix								
Satellite Products/Services								
Assessors (Field Offices)	Imagery	RSO	SPE	ASOS/ SCP	DPI	Fog	Sfc Prod	LES
CR Digital								
Chicago	V							
Detroit	V,I							
Sioux Falls				X				
CR Analog								
LaCrosse					X	X		

V - Visible Imagery
I - Infrared Imagery

GOES Assessment Activities Matrix									
Satellite Products/Services									
Assessors (Field Offices)	Imagery	RSO	SPE	ASOS	Winds	DPI	Fog	Sfc Prod	LES
Alaska Region									
Anchorage		X			X		X		
Fairbanks		X			X		X		
Juneau		X			X		X		

GOES Assessment Activities Matrix									
Satellite Products/Services									
Assessors (Field Offices)	Imagery	RSO	SPE	ASOS	Winds	DPI	Fog	Sfc Prod	LES
Pacific Region									
Offices ***(TBD)***	X		X	X					

GOES Assessment Activities Matrix											
	Satellite Products/Services										
Assessors (Field Offices)	Imagery	RSO	SPE	ASOS /SCP	Winds	T/M Profiles	DPI	Fog	Sfc Prod	AWIPS	LES
SR Digital											
Houston											
Melbourne (McIDAS)											
Tallahassee	V						X				
Tulsa											
SR Analog											
Abilene											
Albuquerque											
Amarillo											
Apalachicola											
Athens											
Atlanta											
Austin											
Baton Rouge											
Birmingham	V,I,M						X				

V - Visible Imagery
I - Infrared imagery
M - Moisture Channel Imagery

GOES Assessment Activities Matrix											
Satellite Products/Services											
Assessors (Field Offices)	Imagery	RSO	SPE	ASOS /SCP	Winds	T/M Profiles	DPI	Fog	Sfc Prod	AWIPS	LES
SR Analog Continued											
Brownsville											
Chattanooga											
Columbus											
Corpus Christi											
Daytona Beach											
Del Rio											
El Paso											
Ft. Smith											
Ft. Worth											
Huntsville											
Jackson											
Jacksonville											
Knoxville											
Lake Charles											
Little Rock											

GOES Assessment Activities Matrix											
Satellite Products/Services											
Assessors (Field Offices)	Imagery	RSO	SPE	ASOS /SCP	Winds	T/M Profiles	DPI	Fog	Sfc Prod	AWIPS	LES
SR Analog Continued											
Lubbock											
Macon											
Memphis											
Meridian											
Miami											
Midland /Odessa											
Mobile											
Montgomery											
Nashville											
New Orleans							X				
Oklahoma City											
Pensacola											
Roswell											
San Angelo											
San Antonio	I			X				X			

I - Infrared Imagery

GOES Assessment Activities Matrix											
Satellite Products/Services											
Assessors (Field Offices)	Imagery	RSO	SPE	ASOS /SCP	Winds	T/M Profiles	DPI	Fog	Sfc Prod	AWIPS	LES
SR Analog Continued											
Savannah											
Shreveport											
Tampa Bay											
Vicksburg											
Victoria											
Waco											
West Palm Beach											
Wichita Falls											

Appendix A - Suite of GOES-8/9 “Day-One Products

GOES I-M DAY ONE PRODUCTS

PRODUCTS	ACCURACY	HORIZONTAL RESOLUTION	VERTICAL RESOLUTION	AREAL COVERAGE	FREQUENCY	DATA GRID SIZE	NESDIS FOCAL POINTS	NWS FOCAL POINTS
Cloud Parameters								
Cloud Heights (Cloud Top Temp)	±50 mb	10 km	N/A	CONUS E/W FD E/W	1/hr	50 km	Lynch	Noel
Cloud Amount (ASOS Satellite Cloud Product)	category	50 km	category	CONUS E/W	1/hr	N/A	Matson, Gray	Noel
Enhanced Data Sets (Imagery)								
GOES Projection								
(GOES-Tap facsimile)		VIS 1 km IR 4/8 km	N/A	Hemis. CONUS Regional	2/hr	N/A	Paquette	Noel
(WEFAX)		VIS 16 km IR 16 km	N/A	FD E/W	8/day	N/A	Patterson, Paquette	Noel
AWIPS Remapped								
Lambert Conformal		VIS 1 km IR 4/8 km	N/A	CONUS E/W	2,4,8/hr	N/A	Vizbulis	Rutledge
Polar Projection		VIS 2 km IR 8/16 km	N/A	Alaska	2,4,4/hr 2,2,2/hr	N/A	Vizbulis	Rutledge
Mercator Projection		VIS 1 km IR 4/8 km	N/A	Hawaii Puerto Rico	2,4,4/hr 2,4,4/hr	N/A	Vizbulis	Rutledge
Polar Stereographic		(VIS&14km IR) 8 km	N/A	N. wrn. hemi. Super natl.	2/hr 2/hr	N/A	Vizbulis	Rutledge
Atmospheric Parameters								
Sounding retrievals								
Vertical Temperature Profiles (°K)	±2.5°K	50 km	40 levels 1000-0.1 mb	CONUS E/W; Adj. oceans	1/hr 8/day	50 km	Matson, Gray	Lord
Layer Mean Virtual Temperatures (°K)		50 km	14 layers 1000-10 mb	CONUS E/W Adj. oceans	1/hr 8/day	50 km	Matson, Gray	Lord
Vertical Moisture Profiles (Specific Humidity)	±30%	50 km	15 levels 1000-300 mb 3 layers 1000-300 mb	CONUS E/W Adj. oceans CONUS E/W	1/hr 8/day 4/day	50 km 50 km	Matson, Gray	Lord

PRODUCTS	ACCURACY	HORIZONTAL RESOLUTION	VERTICAL RESOLUTION	AREAL COVERAGE	FREQUENCY	DATA GRID SIZE	NESDIS FOCAL POINTS	NWS FOCAL POINTS
Layer Precipitable Water (mm)		50 km	3 levels 1000-300 mb	CONUS E/W Adj. oceans	1/hr 8/day	50 km	Matson, Gray	Lord
Total Precipitable Water (mm)	±10%	50 km	N/A	CONUS E/W	1/hr	50 km	Matson, Gray	Lord
Channel Brightness Temps (°K)		50 km	3 km	CONUS E/W Adj. oceans	1/hr 8/day	50 km	Matson, Gray	Lord
Lifted Index	±2°K	50 km	N/A	CONUS E/W	1/hr	50 km	Matson, Gray	Lord
Geopotential Heights (m)		50 km	14 layers sfc-10 mb	CONUS E/W Adj. oceans	1/hr 8/day	50 km	Matson, Gray	Lord
Thermal Wind Profiles (Gradient Winds) (m/s)	±7m/s	50 km	5 levels sfc-10 mb	CONUS E/W Adj. oceans	1/hr 8/day	50 km	Matson, Gray	Lord
Total Precipitable Water (mm) (AWIPS Remapped)	±10%	4 km	N/A	CONUS E/W	1/hr	N/A	Vizbulis, Gray	Lord
Lifted Index (AWIPS Remapped)	±2°K	4 km	N/A	CONUS E/W	1/hr	N/A	Vizbulis, Gray	Lord
Moisture Analysis (Interactive)		N/A	6 levels	40N-40S; E/W (over water)	4/day	2.5° lat	Lynch	Lord
Precipitation Estimates (Scofield, Interactive)	±30%	N/A	N/A	CONUS E/W Hawaii Puerto Rico	Event driven, 1/1-3hr	N/A	Lynch	Noel
Precipitation Histograms	N/A	N/A	N/A	40N-40S; E/W	8/day	2.5° lat	Hughes	Noel
Archive Products								
GVAR Bulk Data	N/A	1,4,8 km	N/A	FD	All data	N/A	Matson, Money	None Required
Synoptic Imagery	N/A	4,8 km	N/A		8/day	N/A	Matson, Money	None Required
Sounder	N/A	8 km	N/A	CONUS E/W Adj. oceans	1/hr	N/A	Matson, Money	None Required

PRODUCTS	ACCURACY	HORIZONTAL RESOLUTION	VERTICAL RESOLUTION	AREAL COVERAGE	FREQUENCY	DATA GRID SIZE	NESDIS FOCAL POINTS	NWS FOCAL POINTS
VIS/IR Sectors for Calibration	N/A	1/4/8 km	N/A	As required	12/day		Tarpley, Hughes	None Required
Calibration Data; Long Term Thermal; VIS Normalization	N/A	1/4/8 km	N/A	As required	1/month		Weinreb	None Required
Winds								
Cloud Drift (Picture Triplet)	low level 2-7 m/s/±30°/±50 mb			50N-50S E/W	4/day		Hughes	Lord
Cloud Drift (McIDAS/VDUC)	high & mid level 5-10 m/s/±30°/±50 mb			50N-50S E/W	4/day		Matson, Gray	Lord
Moisture Drift (McIDAS/VDUC)	high level 5-10 m/s/±30°/±50 mb			50N-50S E/W	4/day		Matson, Gray	Lord
Deep Layer Mean	5 m/s	60 km	1 layer	Atlantic/ E. Pacific (Trop. cyclone regions)	4/day		Matson, Gray	Lord

Appendix B

NWS Field Site Evaluation Participants

Eastern Region

Site	Focal Point	Telephone #
NWSO State College	Rich Grumm (SOO)	(814) 237-1159
WSFO New York	Jeff Tongue (SOO)	(516) 924-0141
WSFO Boston	Jim Lee (SOO)	(508) 823-2242
WSO Cincinnati	John Di Stefano (SOO)	(513) 383-0623
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WSFO Cleveland	Robert LaPlante (SOO)	(216) 265-2372
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Southern Region

SRH Ft. Worth	Bernard Meisner (SSD)	(817) 334-2671
NWSO Tallahassee	Irv Watson (SOO)	(904) 576-1811
NWSFO Tulsa (AWIPS)	Steve Amburn (SOO)	(918) 581-7748
NWSO Houston	Steve Allen (SOO)	(713) 337-5192
NWSFO Birmingham	Tom Bradshaw	(205) 664-7829
NWSFO New Orleans	Robert Ricks	(504) 649-0429

Central Region

WSFO Milwaukee/Sullivan	John Eise (SOO)	(414) 297-2343
WSFO Cheyenne	Peter Manousos (SOO)	(307) 772-2468
WSFO Chicago	Ken Labas (SOO)	(815) 834-0673

WSO Kansas City (AWIPS)	Peter Browning (SOO)	(816) 374-6552
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Western Region

WSFO Salt Lake City	Larry Dunn (SOO)	(801) 524-6945
WSFO Seattle	Brad Colman (SOO)	(206) 526-6085
WSO Sacramento	Scott Cunningham (SOO)	(916) 551-1418
WSFO Phoenix	Doug Green (SOO)	(602) 379-4607
WSFO Boise	Rusty Billingsly (SOO)	(208) 334-9860

Alaska Region

WSFO Anchorage	Carven Scott (SOO)	(907) 271-3073
WSFO Juneau	Carl Dierking (SOO)	(907) 586-7497
WSFO Fairbanks	Kraig Gilkey (SOO)	(907) 456-0380

Pacific Region

WSFO Honolulu	Pete Donaldson	(808) 973-5285

Appendix C

NWS and NESDIS Evaluation Focal Points

Office	Point(s) of Contact	Office	Telephone #
NESDIS			
GOES Product Manager	Jamison Hawkins	E/OSD	(301) 763-4715
Chief, SSD	Benjamin Watkins	E/SP2	(301) 763-8051
GOES-Tap Manager	John Paquette	E/SP2	(301) 763-8051
Chief, IPB	Michael Matson	E/SP22	(301) 763-8241
Chief, SAB	James Lynch	E/SP23	(301) 763-8444
Chief, IPD	Robert Mairs	E/SP1	(301) 457-5165
Chief, ARAD	Fran Holt	E/RA21	(301) 763-8251
NESDIS Central Facility	Shift Supervisor		(301) 763-8222
IPD	Gene Legg Sam Patterson	E/SP13	(301) 457-5195
Chief, Regional Mesoscale Meteor. Branch	Jim Purdom	E/RA25	(303) 498-1124
Chief, SDAB	Paul Menzel	E/RA24	(608) 264-5325
Chief, FPDT	Donald Gray	E/RA23	(301) 457-5188
NWS			
WSH	Richard Przywarty Greg Mandt Jim Gurka Ron Gird Jim Heil Carl Weiss Andy Noel	W/OM1 W/OM2 W/OM21 W/OM22 W/OM22 W/OM22 W/OM22	(301) 713-1706 (301) 713-1858 (301) 713-1970 (301) 713-1867 (301) 713-1867 (301) 713-0462 (301) 713-1867
ER	Bud Dorr Gary Carter	W/ER1 W/ER3	(516) 244-0121 (516) 244-0131

SR	Mac McLaughlin	W/SR1	(817) 334-2659
	Judson Ladd	W/SR1x2	(817) 334-2652
	Dan Smith	W/SR3	(817) 334-2671
CR	Mike Looney	W/CR1	(816) 426-3239
	Richard Livingston	W/CR3	(816) 426-5672
WR	Bob Richey	W/WR1	(801) 524-4000
	Andy Edman	W/WR3	(801) 524-5131
	Kevin Schrab	W/WR3x3	(801) 524-5131
AR	Gary Hufford	W/AR1x3	(907) 271-3886
PR	Ed Young	W/PR1	(808) 532-6412
	Ben Hablutzel	WSFO/HNL	(808) 973-5273
WSFO SFO (SFDF)	Ernest Daghir	W/SFO	(415) 876-9122
NCEP	Steve Lord	W/NP2x1	(301) 763-8005
	Art Wick	W/NP14	(301) 763-8648
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AWC (SFDF)	Fred Mosher	W/NP6	(816) 426-3367
SPC	Bob Johns	W/NP72	(405) 579-0705
TPC	Jerry Jarrell	W/NP8	(305) 536-5547
(SFDF)	Jiann-Gwo Jiing	W/NP8	(305) 229-4443
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OH	Tom Carroll	W/OH23	(612) 725-3039
OSO	Joan Slade	W/OSO12	(301) 713-0386
	Dick Thigpen	W/OSO21	(301) 713-0864

Appendix D

Proposal for Accelerated Assessment and Application of GOES-8/9 Satellite Data for Numerical Weather Prediction

A Solicited Proposal from the National Centers for Environmental Prediction, Environmental Modeling Center to the National Environmental Satellite Data and Information Service

Principal Investigator: Stephen J. Lord, Deputy Director
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Co-Principal Investigators at NCEP/EMC:
Regional Modeling: Geoffrey DiMego
Eric Rogers
Ying Lin

Global Modeling: Mark Iredell
Wan-shu Wu

Ocean Modeling: D. B. Rao
Larry Breaker

I. Summary

The National Centers for Environmental Prediction/Environmental Modeling Center (NCEP/EMC) requests $305K in National Environmental Satellite, Data, and Information Service (NESDIS) funds over 2 years for partial support of activities to develop optimal data assimilation methods for NESDIS GOES-8/9 sounder products and to assess the quality and impact of these GOES-8/9 products on NCEP forecasts. Future developmental products, especially new wind and precipitation products, will also be evaluated. This funding will assist timely development of optimal methods for data assimilation of geostationary satellite products, in particular radiances from the sounder and new wind products derived from the sounder. It will also help to provide EMC support for NESDIS/Wisconsin's effort to use the NCEP Eta model in its product assessment activities. This proposal is closely linked in methodology and scope to its companion for accelerated development of polar-orbiter (TOVS and DMSP) sounding products. In sum, a vast improvement in interactions between NCEP and NESDIS should result from both of these proposed efforts.

II. Introduction

Recent results of forecast sensitivity experiments with Geostationary Operational Environmental Satellite (GOES) wind and thermodynamic observations have indicated some small positive impact from the four-layer precipitable water product in the NCEP Eta model; no impact on the large scale from operational cloud and water vapor drift wind data; and some negative impact from temperature soundings that appeared due to errors in instrument calibrations. Much work needs to be done to ensure the appropriate ongoing evaluation and optimal use of current and future GOES products in operational NCEP models. This proposal provides a 2-year development plan and funding for (1) accelerated development of optimal methods for data assimilation for GOES sounder products by the NCEP Environmental Modeling Center and (2) further evaluation of GOES-8/9 operational and developmental products including precipitable water and winds. These development and evaluation activities are consistent with the NCEP commitment to GOES assessment as described in the draft NOAA GOES-8/9 Assessment Plan (October 12, 1995). The activities proposed herein are also consistent with the results of the recent joint NWS/NESDIS Review of NESDIS Products and Services, which noted that improved wind products from NESDIS are a high priority and that efforts should be made to accelerate the optimal usage of satellite radiances from both NOAA and non-NOAA platforms.

Work supported by this proposal will lay the foundation for out-year studies that are beyond the scope of this proposal. While this proposal concentrates on bringing recent data impact studies to a more mature stage of understanding and, hopefully, operational implementation, there are larger issues that must be addressed as part of a longer-term developmental effort. These issues are outlined below.

The recent, rapidly evolving improvements to data assimilation systems and forecast models have meant that satellite-derived precipitation, Earth-surface and cloud products must be used to help initialize these models. Both the NCEP regional (Eta) and global data assimilation systems and forecast models have sophisticated land-surface physics packages that require accurate specification of the Earth-surface initial conditions: snow cover, surface wetness, green vegetation fraction and albedo over land, and sea-surface temperature over the oceans. Forecast models with increasingly higher horizontal resolution and sophisticated parameterizations are increasingly sensitive to Earth-surface initial conditions. For example, some recent forecast "busts" in the regional Eta model have been attributed directly to improper specification in the initial snow field. The Eta model now forecasts cloud water and requires initialization of this field; the global model will have a similar scheme in the near future. A new scheme to assimilate

precipitation observations is currently being tested.

NCEP/EMC and NESDIS will need to continue to cooperate closely on these issues. EMC will be exploring optimal, more sophisticated methods for assimilating cloud water and precipitation and Earth-surface products. Optimal methods for assimilating radiance data for channels that measure cloud water and precipitation will need to be developed. What is the relative value of assimilating radiances versus retrieved products in this context? Work done under this proposal will pave the way for investigating these problems more fully in the future.

III. Development of Improved Data Assimilation for GOES-8/9 Sounder Products

In October 1995, NCEP implemented the direct use of TOVS radiances as a more effective use of satellite temperature measurements from polar-orbiting platforms. This implementation led to the largest improvement in forecast skill of any change in data assimilation over the last decade and indicates that GOES sounder products must be assimilated as radiances to have maximal impact on forecasts. The direct use of radiances requires instrument-specific radiative transfer ("forward") models and their adjoints but involves a very straightforward implementation once these codes are available. The direct assimilation of GOES radiances can take advantage of the basic developmental work already accomplished by EMC with the TOVS radiances. Preliminary efforts in this area have already begun, and NESDIS/Wisconsin has contributed to this effort. Funding from this proposal will accelerate testing of the forward models in the data assimilation system and will provide support for a complete evaluation of GOES 8/9 radiance data with the NCEP regional and global numerical weather prediction systems. This evaluation will include measuring the impact of hourly radiances compared to that of lower time resolution.

Resources required: 14.0 person months ($100K) over 2 years.

IV. Evaluation of the GOES-8/9 Precipitable Water Product

The current GOES-8 precipitable water (PW) product was evaluated in an 80 km version of the operational Eta Data Assimilation System over a one month period in June 1995. Impact results were slightly positive and of the same magnitude as an earlier data sensitivity test conducted for the polar-orbiter SSM/I PW product. Detailed evaluation showed that the main effect of the GOES PW data was to dry out the model atmosphere where the model produced too much cloud and precipitation. Little impact was noted in heavy precipitation areas, where the GOES sounder cannot provide data. Since this test, GOES-9 has been launched and deployed to cover the western sector and GOES-8 has been deployed to the eastern sector of the United States. GOES-9 products have

not been evaluated for operational use. Therefore, the GOES-9 PW will be evaluated in a short test in conjunction with the GOES-8 product so that product quality and impact can be reassessed. If results are satisfactory, viz., no negative impact and data receipts are regular, the PW product from both GOES-8/9 will be implemented operationally into the NCEP regional and global models.

Resources required: 2.0 person months ($15K) in the first year.

V. GOES-8/9 Wind Products (Cloud Drift and Water Vapor Drift Winds)

EMC conducted a data impact for GOES-8 winds in summer 1995. The test was performed with a low resolution (T62) global model over a period of 28 days in May-June 1995. The results showed little sensitivity of the synoptic-scale wind forecasts at the jet level (250 mb) to the GOES-8 data and the GOES-7 data. Other diagnostics, such as matches of forecast data fields to observations (including the GOES winds) confirmed this lack of impact. Some of the possible explanations for this lack of positive forecast impact are:

1. the data quality is insufficient;

2. the data quantity is insufficient, either horizontally, vertically, or both; and

3. there may be insufficiencies in one of the following: the model resolution, use of the data in the assimilation, or assessment statistics.

A great deal of further investigation is required to determine which, if any, of these explanations pertains. In the meantime, GOES-8/9 winds must be assessed for data quality by comparisons with the model background. Some further assessment of wind quality may be done by comparing rawinsonde fits to the model background with those of the GOES winds. This comparison may be done in data rich areas, where the model background is likely to be more accurate, and isolated oceanic rawinsondes, where the model background error is likely to be larger. These comparisons will calibrate the accuracy of the model background for comparison with the GOES winds, which should give more information about the data quality.

Further assessment of the GOES-8/9 winds will occur with data impact tests using a high resolution global forecast model over portions of the August-September 1995 period. Research data sets from the Cooperative Institute for Meteorological Satellite Studies (CIMSS) with high density winds from hurricane cases will be used to investigate hurricane track forecast sensitivity. These data sets have already been used to produce positive impact

for hurricane forecasts with the Geophysical Fluid Dynamics Laboratory model (no data assimilation was used) so that a similar impact in the global model would be very encouraging. These experiments will allow a specific evaluation of the data impact, rather than global statistics as used previously. These data impact tests will investigate the entire suite of GOES-8/9 wind products, except the gradient winds that are redundant when GOES radiances are assimilated. It is anticipated that these tests will provide a more complete evaluation of satellite-derived wind products for data assimilation that will benefit both the National Weather Service and NESDIS.

Resources required: 16.0 person months ($115K) over 2 years.

VI. Preliminary Investigation of Advanced GOES/8-9 Earth Surface Products

Tests of precipitation assimilation over land in the NCEP Eta Data Assimilation System (EDAS) have shown a positive impact, both in the current optimal interpolation analysis scheme and in the new three-dimensional variational scheme. NESDIS has recently developed a very promising, real time, hourly high resolution precipitation retrieval from GOES. The assimilation of this product in the EDAS, or a combination of this product and the NESDIS Interactive Flash Flood Analysis product in the eastern Pacific (for West Coast storms) and in the Gulf of Mexico and Mexico (for southern states), holds great promise for improving Eta precipitation forecasts in key coastal areas. Therefore, some effort toward the assimilation of GOES precipitation estimates, in conjunction with assimilation of SSM/I and NOAA/AMSU precipitation estimates, should be made under this proposal.

Ocean-surface currents are urgently needed in support of the ongoing East Coast Ocean Forecast System (ECOFS). Surface currents off the United States east and west coasts can be estimated using feature tracking techniques from GOES-8/9 imagery. Ground truth support from drifting buoys (on the West Coast) is being put into place, and the opportunity for a combined development and validation effort is now here. The end result will be a new operational surface current product that will be used for assimilation into the ECOFS and for model validation. EMC has developed the software for such a product; the main task will be to port the system to NESDIS platforms and begin a program of evaluation and quality assurance.

Resources required: 6.0 person months ($45K) over 2 years.

VII. Enhanced Cooperation Between NCEP/EMC and CIMSS

EMC and CIMSS will cooperate more closely in the assessment of GOES-8/9 products, in the development of improved data

assimilation methods and in the evaluation of development products. This cooperation will take the form, but not be limited to, the following activities:

1. use of the NCEP Eta model at Wisconsin for data-impact studies;

2. testing of developmental products such as winds derived from GOES sounder channels; and

3. applied research and development on topics such as improved data-weighting schemes for GOES wind products.

Resources required: 4.0 person months ($30K) over 2 years.

VIII. Chronological Milestones

NESDIS funding of $60 K is currently being used to begin some of the activities under this proposal. The following milestones assume that the remainder of the funding will arrive on June 1, 1996. Since these activities are currently not completely funded, the milestones would have to be revised if this assumption is not valid.

1. June 1996 - Evaluate GOES-8/9 PW product and implement operationally.

2. July 1996 - Evaluate impact of GOES-8 wind products on hurricane forecasts with NCEP models.

3. December 1996 - Develop and test radiative transfer forward models and associated codes for GOES-8/9 sounder radiances.

4. March 1997 - Port NCEP/EMC current feature tracking code to NESDIS platforms and test product with drifting buoys that have been deployed in the eastern Pacific Ocean.

5. May 1997 - Run data impact tests for high time-resolution GOES-8/9 radiances with new data assimilation system, including tests that describe the impact of hourly radiances compared to that of lower time resolution.

6. September 1997 - Evaluate quality and forecast impact of GOES-8/9 sounder-based winds and improve data assimilation techniques for NESDIS wind products in general.

7. FY 96-97 - Provide support for port of Eta model to CIMSS and/or support for CIMSS in running data-impact tests with Eta model at NCEP.

Appendix E

NESDIS Product Oversight Panels (POP)

POP	Co-Chair	Office	Telephone
Calibration	Stan Brown	OSDPD	(301) 457-5247
	C. R. N. Rao	ORA	(301) 763-8136
Earth Radiation Budget	Chris Duda	OSDPD	(301) 457-5195
	Herb Jacobowitz	ORA	(301) 763-8053
Imagery, Cloud, & Aerosol	Chris Duda	OSDPD	(301) 457-5195
	Larry Stowe	ORA	(301) 763-8053
Navigation	Emily Harrod	OSDPD	(301) 457-5245
	James Hudson	OSO	(301) 457-5130
Ocean Color	John Sapper	OSDPD	(301) 457-5195
	Chris Brown	ORA	(301) 763-8251
Ocean Products	John Sapper	OSDPD	(301) 457-5195
	William Pichel	ORA	(301) 763-8231
Ozone	Dudley Bowman	OSDPD	(301) 457-5195
	Walt Planet	ORA	(301) 763-8136
Precipitation	Richard Borneman	OSDPD	(301) 763-8444
	Rod Scofield	ORA	(301) 763-8251
Services	Dane Clark	OSDPD	(301) 763-8051
	James Heil	OM	(301) 713-1867
Soundings	Ellen Brown	OSDPD	(301) 457-5195
	Tom Kleespies	ORA	(301) 763-8136
Surface Products	Bruce Ramsay	OSDPD	(301) 763-8142
	Dan Tarpley	ORA	(301) 763-8042
Winds	Ricky Irving	OSDPD	(301) 763-8142
	Don Gray	ORA	(301) 457-5188