Sandy Supplemental Grant Recipient Final Report

Network of Direct Broadcast Antenna Systems to Provide Real-Time Infrared and Microwave Sounder Data to NOAA for Numerical Weather Prediction

Award Number: NA13NES4830007

The National Oceanic and Atmospheric Administration
National Environmental Satellite Data and Information Service
Center for SaTellite Applications and Research (STAR)

For the Period
1 September 2013 – 30 June 2015

On behalf of
The Cooperative Institute for Meteorological Satellite Studies (CIMSS)
Space Science and Engineering Center (SSEC)
at the University of Wisconsin-Madison
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Sandy Supplemental Grant Recipient Quarterly Progress Report
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I. Introduction

Cooperative Institute Description

The Cooperative Institute for Meteorological Satellite Studies (CIMSS) is a collaborative relationship between the National Oceanic and Atmospheric Administration (NOAA) and the University of Wisconsin-Madison (UW-Madison). This partnership has and continues to provide outstanding benefits to the atmospheric science community and to the nation through improved use of remote sensing measurements for weather forecasting, climate analysis and monitoring environmental conditions. Under the auspices of CIMSS, scientists from NOAA/NESDIS and the UW-Madison Space Science and Engineering Center (SSEC) have a formal basis for ongoing collaborative research efforts. CIMSS scientists work closely with the NOAA/NESDIS Advanced Satellite Product Branch (ASPB) stationed at the UW-Madison campus. This collaboration includes a scientist from the National Climate Data Center (NCDC), who joined the NOAA NESDIS employees stationed at CIMSS.

CIMSS conducts a broad array of research and education activities, many of which are projects funded through this Cooperative Agreement with NOAA. This Cooperative Agreement identifies four CIMSS themes:

1. Satellite Meteorology Research and Applications, to support weather analysis and forecasting through participation in NESDIS product assurance and risk reduction programs and the associated transitioning of research progress into NOAA operations,
2. Satellite Sensors and Techniques, to conduct instrument trade studies and sensor performance analysis supporting NOAA's future satellite needs as well as assisting in the long term calibration and validation of remote sensing data and derived products,
3. Environmental Models and Data Assimilation, to work with the Joint Center for Satellite Data Assimilation (JCSDA) on improving satellite data assimilation techniques in operational weather forecast models, and
4. Outreach and Education, to engage the workforce of the future in understanding and using environmental satellite observations for the benefit of an informed society.

CI Management and Organizational Structure

CIMSS resides as an integral part of the Space Science and Engineering Center (SSEC). CIMSS is led by its Director, Dr. Steven Ackerman, who is also a faculty member within the UW-Madison Department of Atmospheric and Oceanic Sciences. Executive Director Wayne Feltz provides day-to-day oversight of the CIMSS staff, science programs, and facilities. The education and outreach activities at CIMSS are coordinated by Senior Outreach Specialist Margaret Mooney. The individual science projects are led by University Principal Investigators (PIs) in conjunction with a strong and diverse support staff who provide additional expertise to

the research programs. CIMSS is advised by a Board of Directors and a Science Advisory Council.

The CIMSS administrative home is within the Space Science and Engineering Center (SSEC), a research and development center within the UW–Madison's Office of the Vice Chancellor of Research. The independent CIMSS 5-year review panel for administration wrote that they were "…impressed by the people, systems and processes in place." The SSEC mission focuses on geophysical research and technology to enhance understanding of the Earth, other planets in the Solar System, and the cosmos. To conduct its science mission on the UW-Madison campus, SSEC has developed a strong administrative and programmatic infrastructure. This infrastructure serves all SSEC/CIMSS staff.

The CIMSS mission includes three goals:

- Foster collaborative research among NOAA, NASA, and the University in those aspects of atmospheric and earth system science that exploit the use of satellite technology;
- Serve as a center at which scientists and engineers working on problems of mutual interest can focus on satellite-related research in atmospheric and earth system science;
- Stimulate the training of scientists and engineers in the disciplines involved in atmospheric and earth sciences.

Executive Summary of CI Banner Research Activities

CIMSS is a collaboration between NOAA and UW–Madison that has increased the effectiveness of research and the quality of education in the environmental sciences. In a *Space Policy* article in 1986, William Bishop, former acting Director of NESDIS, noted, "Remote sensing from space can only thrive as a series of partnerships." He used CIMSS as a positive working example of the government-academia partnership, noting "The Institute pioneered the computation of wind speeds at cloud heights by tracking cloud features from image to image. These are now a stable product provided from the satellites to the global models at the National Meteorological Center." CIMSS continues to be a leader in the measurement of winds from satellite observations and leads the way in many other research endeavors as outlined above. There is great value to NOAA and UW-Madison in this long-term collaboration known as CIMSS.

II. Funded Project

Award Number: NA13NES4830007

Project Title: Network of Direct Broadcast Antenna Systems to Provide Real-Time Infrared and Microwave Sounder Data to NOAA for Numerical Weather Prediction

PI: Liam Gumley
PM: Kathy Strabala

NOAA Sponsor: Mitch Goldberg, NOAA/NESDIS

NOAA Collaborator: Timothy J. Schmit, NOAA/NESDIS/STAR

NOAA Sponsoring Organization: NOAA NESDIS

Reporting Period: 1 September 2013 – 30 June 2015

Description of Task I Activities
Primarily activity involves quarter reporting.

NOAA Strategic Goal(s)
NOAA Mission Goals

1. Climate Adaptation and Mitigation: An informed society anticipating and responding to climate and its impacts
2. Weather-Ready Nation: Society is prepared for and responds to weather-related events

NOAA Strategic Plan-Mission Goals

1. Serve society's needs for weather and water
2. Understand climate variability and change to enhance society's ability to plan and respond
3. Provide critical support for the NOAA mission

Research Progress
The Space Science and Engineering Center at the University of Wisconsin-Madison proposes to operate a network of direct broadcast satellite data reception stations to acquire and process infrared and microwave sounder data from polar orbiting meteorological satellites and deliver the resulting products to NOAA with low latency for assimilation in NCEP numerical weather prediction models.

I) Improvements in Direct Broadcast Ingest and Processing

1 September 2013 – 31 December 2013 Milestone Progress

1. A new ingest and processing server was procured and installed (lightning.ssec.wisc.edu).
2. New data notifications for NOAA 15/16/18/19, Metop-A/B, SNPP, and Aqua data are now being sent automatically from the SSEC antenna system to the ingest system.
3. New data files are being ingested starting within 5 seconds of a notification being received.

1 January 2014 – 31 December 2014 Milestone Progress

4. Beginning 7 May 2014, BUFR files from CrIS and ATMS are being routinely generated from passes received at SSEC and NWS-Honolulu. This uses the NOAA Unique CrIS ATMS Product System (NUCAPS) and NOAA Product Reformatter (NPR) software from Tom King, which converts the level 1 files to netCDF, then to BUFR files in a format that NCEP expects. BUFR files of AMSU-A, AMSU-B, HIRS, MHS from the NOAA satellites are also available.
5. The software processing stack to be deployed at the antenna sites is now running operationally in test mode at SSEC. It is processing up to Level 1B for SNPP, NOAA 15/18/19, Metop A/B, Aqua, and FY-3B.

6. ATMS and CrIS Level 0 data are now ingested from antennas at SSEC, OSU, GSFC, and HCC (Honolulu) and processed to Level 1B and BUFR. The products are delivered to the SSEC FTP site for ingest by NOAA.
7. SSEC implemented a stand-alone data readiness notification system for the antenna acquisition servers the works identically for all satellites and data types (previously each satellite and sensor used a different method). This greatly simplifies the ingest mechanism for bringing the data back to SSEC.
8. Mark Werner has taken over from Will Robus at SSEC in the role of antenna installation logistics.
9. Metop A and Metop B data are now processed routinely at SSEC to provide IASI, AMSU, MHS, and HIRS files in BUFR format.
10. Ingest and processing of CrIS and ATMS data from the NOAA antenna in Honolulu is now operational.
11. A new server for monitoring the external DB network servers was installed and configured at SSEC.
12. SSEC supplied Global Imaging with the information they needed to start sending CrIS, ATMS, IASI, AMSU, MHS, and HIRS data from the new antenna in Monterey. Data is now being sent to SSEC routinely from Monterey and processed to Level 1B and BUFR.
13. SSEC initiated a discussion with Dennis Keyser at NCEP about ingest of the BUFR product files.
14. The DB network processing system continues to create real-time Level 1B products with an average latency of 15 minutes, relative to the start of each DB overpass.
15. Contacted NOAA Monterey to check if SNPP data latency can be reduced.
16. Requested AIRS BUFR converter software from NESDIS.
17. Created real-time data latency plots for all sites in the network.
18. Added Aqua AIRS to the DBRTN processing chain at SSEC.
19. Worked with U-Hawaii on preparing for antenna equipment rack relocation at HCC.
20. Following request to NOAA, latency for data arriving from Monterey antenna has improved dramatically.
21. HCC site was visited to check on logistics for antenna rack relocation.
22. Monitoring system for data ingest was redesigned and improved.
23. AIRS L1B was added to the processing system. Now working BUFR format issues with NCEP.

1 January 2015 – 30 June 2015 Milestone Progress

24. Ingest of SNPP sounder data from GINA at UAF is now operational.
25. Ingest of Aqua AIRS and AMSU data NRL Monterey is now operational
26. The equipment rack at HCC in Honolulu was moved to a new location with much better cooling and it quality. SSEC organized all the logistics for new electrical and network connections; server cleaning, and rack shutdown/move/powerup. The system is now running again in the new location.
27. Team continued to work on resolving BUFR format issues with NCEP, which uses non-standard internally developed BUFR tables. As of April 2015, all issues had been resolved and CrIS, ATMS, HIRS, AMSU, MHS, and AIRS products were being delivered to NCEP and decoded into the internal BUFR tank files for evaluation. Remaining issues with IASI BUFR formatting are being worked.
28. DBRTN team developed and tested a Docker container for distributing and running the AAPP and OPS-LRS processing stack.
29. DBRTN began ingest of SNPP sounder data from CCNY.
30. Met with EUMETSAT to discuss details of how DBRTN data will be delivered to EARS for retransmission. The data will be pushed to EUMETSAT in standard AAPP BUFR formats.
31. SSEC team identified issues in the NOAA and Aqua data Level 0 data ingested from NWS in Monterey and worked with Global Imaging to test a solution. These issues are now resolved.
32. SSEC team added automated monitoring tools to all ingest and compute servers used at DB sites to monitor uptime, disk space, and processing problems.
33. SSEC team installed and tested the DB processing system on the compute server destined for installation in Puerto Rico.

34. SSEC enhanced the DB processing stack to include NUCAPS retrieval processing, VIIRS ocean color processing, and AVHRR image processing.
35. The NESDIS BUFR conversion software was installed and tested at SSEC by NESDIS staff.
36. SSEC staff installed the NESDIS BUFR conversion software in the DB processing stream for ATMS.
37. SSEC, NESDIS, and NCEP staff worked in close coordination to resolve a time offset in the DB vs. global ATMS BUFR files. A leap second update at the start of the DB processing chain was identified as the culprit and was resolved.
38. SSEC staff installed the IASI 616-channel BUFR conversion software supporting variable length granules in DB processing stream.
39. SSEC staff will continue to work with NESDIS and NCEP staff to ensure that DB BUFR files are identical in format to the global BUFR files already ingested by NCEP.

II) NOAA/Atlantic Oceanographic and Meteorological Laboratory (AOML), Miami FL Direct Broadcast Antenna Installation

NOAA/Atlantic Oceanographic and Meteorological Laboratory
4301 Rickenbacker Causeway
Miami, FL 33149

Latitude: 25.734 N
Longitude: 80.162 W
Elevation in Feet: 4 m
Elevation Mask: TBD (depending on installation site)

1 September 2013 – 31 December 2013 Milestone Progress

1. A telecon with the SSEC and AOML principals was held to discuss site preparation details. Will Robus is the POS at SSEC for the AOML antenna installation.
2. A purchase order for the AOML antenna system has been issued to Orbital Systems.

1 January 2014 – 31 December 2014 Milestone Progress

3. AOML, SSEC, and Orbital went over the antenna installation design in detail and resolved several issues related to cable routing and rack location.
4. A contractor was selected for the electrical work at AOML Miami.
5. After reviewing the only proposal for the rooftop work at Miami, the proposal was rejected because of insufficient proposal detail and excessive cost. An alternative contractor has been identified and a dialog between SSEC, the contractor, and Transystems (the engineering contractor) has begun, with the aim of having an acceptable proposal submitted to SSEC in July.
6. Processing server for Miami was received at SSEC and shipped to Orbital Systems in Dallas. The server was integrated in the Miami rack by Orbital and operating system was installed and tested. LDM software was installed and tested.
7. Baseline Level 1 and Level 2 software stack was installed and tested on the processing server for Miami.
8. Complete Level 1 and Level 2 software stack for processing server is in system integration and testing stage.
9. SSEC now had a contract in place with a cement contractor for the rooftop work at AOML (Certified Contracting Group) in July 2014. The contractor made a visit to the AOML installation site.
10. SSEC worked with AOML to go over IT security requirements and the deployment plan for the two servers to be installed at AOML in the Orbital rack.

11. Responsibility for AOML installation logistics at SSEC was transitioned from Will Robus to Mark Werner.
12. Mark Werner worked multiple issues with Miami roofing contractor (Certified Construction) and electrical contractor (Stryker Electric), including cable run lengths, electrical specifications, crane scheduling, and installation logistics during August.
13. Rooftop work at AOML began on Aug. 25 with concrete poured on Sept. 5.
14. SSEC has worked out all IT security concerns with the IT director at AOML. The EOS-FES server will be able to get TLE files from Orbital. SSEC is able to ssh to the processing box, and then ssh to the FES. The processing box will be able to send data out via HTTP. Worked on getting all the IP address information from AOML in September 2014.
15. Infrastructure for remote data notification and ingest was redesigned.
16. Rooftop construction at AOML Miami was completed by Certified Contracting in the first week of September.
17. Electrical work at AOML Miami was completed by Stryker Electric in the second week of September.
18. The 2.4-meter antenna, pedestal, radome, and equipment rack was installed at AOML Miami by Orbital Systems on September 15-17.
19. The processing computer was installed at AOML Miami by SSEC on September 15-
20. Multiple networking issues at AOML Miami were solved by collaborative efforts involving AOML, SSEC, and Orbital Systems.
21. AOML Miami antenna is routinely acquiring data from Suomi NPP, NOAA-15/18/19, Metop-A/B, Terra, Aqua, and GCOM-W1.
22. Resolved several outstanding network issues at AOML.
23. Switched to secure HTTP sever configuration at AOML.
24. Created real-time data latency plots for all sites in the network.
25. Data notifications from Miami were received successfully at SSEC.
26. AOML applications workshop is set for February 9-13. Worked with AOML to set up location logistics.
27. Firewall issues at AOML were resolved and real-time system monitoring for DBPS and EOS-FES is now running.
28. Monitoring software tools were installed at AOML.
29. Worked on planning syllabus for AOML applications workshop in Feb 2015.

1 January 2015 – 30 June 2015 Milestone Progress

30. DBRTN is now ingesting data from SNPP, Metop, NOAA, and Aqua sounders from the new antenna at AOML Miami
31. DBRTN team presented a workshop on SNPP satellite data and applications at AOML Miami, and it was attended by AOML, NWS, and NOAA Fisheries staff.
32. DBRTN is now ingesting data from SNPP, Metop, NOAA, and Aqua sounders from the new antenna at AOML Miami

III) UPR-Mayaguez, Puerto Rico Direct Broadcast Antenna Installation

UPR-Mayaguez, Puerto Rico

Latitude: 18.201 N
Longitude 67.143 W
Elevation: 12 m
Elevation Mask: TBD

1 September 2013 – 31 December 2013 Milestone Progress

1. Funding focus was on the AOML antenna installation.

1 January 2015 – 30 June 2015 Milestone Progress

2. Site visit to Puerto Rico was conducted the week of June 16. Liam Gumley, Will Robus, Jordan Gerth, and Mitch Goldberg were in attendance. Sites visited included the NWS Forecast Office in San Juan and the University of Puerto Rico - Mayaguez. Potential antenna sites were scouted at both locations, however the UPR-Mayaguez emerged as the preferred site because (a) a suitable rooftop site already exists (housing a non-operational Radarsat antenna), and (b) sufficient Internet bandwidth is available from UPR to SSEC (for sending sounder raw data). A dialog with the antenna vendor about an installation at UPR has commenced. The next step is to obtain engineering drawings from UPR showing the roof mounting hardware for the old Radarsat antenna.
3. Procurement and installation logistics for Puerto Rico antenna installation are in development.
4. Contacted UPR to start planning for antenna installation logistics.
5. Started NEPA approval process for Puerto Rico (PR) antenna installation.
6. Official agreement letter between SSEC and UPR was drafted and sent to UPR for signatures.
7. Ordered DBPS processing server for PR.
8. DBPS server for Puerto Rico (PR) was installed and tested.
9. PR antenna system bid process was closed. One bid was received.
10. Working to find electrical and construction contractors for PR.
11. Working on completing NEPA study for PR.
12. UPR antenna purchase order was prepared and sent out.
13. Continued working with UPR on SSEC/UPS agreement and NEPA documentation.

1 January 2015 – 30 June 2015 Milestone Progress

14. Engineering contractor visited UPR-Mayaguez to sort details of installation for new antenna. “The trip was successful and we were able to accomplish our goals. Rafael was very helpful and accommodating throughout the process. We were also able to meet with a potential contractor as well as our local engineering contact. We measured up the existing platform, roof, etc… The platform structural members are in decent shape but the platform itself will need some modifications for the new installation as we anticipated. We are now working on the plans for the improvements.”
15. Antenna equipment rack and data processing server have been integrated and tested at Orbital Systems.
16. Antenna system has been packed for shipment to PR.
17. Contractor proposal has been has been accepted for local installation work in Mayaguez PR.
18. Fabrication of the adapter plate for the new antenna mount is coordinated with UW-Physical Sciences Laboratory.
19. Installation has been coordinated for mid October.
20. Weekly status telecons are being held with all the parties involved.
21. All funding has been committed/invoiced for project completion