Title of Grant / Cooperative Agreement:	International MODIS/AIRS Processing Package(IMAPP) maintenance and development of real-time applications and operational usage of Terra and Aqua
Type of Report:	Summary of Research
Name of Principal Investigator:	Hung-Lung Allen Huang
Period Covered by Report:	2/14/11 - 2/13/14
Name and Address of recipient's institution:	The Board of Regents of the University of Wisconsin Systems
NASA Grant / Cooperative Agreement Number:	NNX11AH63G

Reference 14 CFR § 1260.28 Patent Rights *(abbreviated below)*
The Recipient shall include a list of any Subject Inventions required to be disclosed during the preceding year in the performance report, technical report, or renewal proposal. A complete list (or a negative statement) for the entire award period shall be included in the summary of research.

Subject inventions include any new process, machine, manufacture, or composition of matter, including software, and improvements to, or new applications of, existing processes, machines, manufactures, and compositions of matter, including software.

Have any Subject Inventions / New Technology Items resulted from work performed under this Grant / Cooperative Agreement?	No ⦿	Yes ◯
If yes a complete listing should be provided here: Details can be provided in the body of the Summary of Research report.		

Reference 14 CFR § 1260.27 Equipment and Other Property (abbreviated below)
A Final Inventory Report of Federally Owned Property, including equipment where title was taken by the Government, will be submitted by the Recipient no later than 60 days after the expiration date of the grant. Negative responses for Final Inventory Reports are required.

Is there any Federally Owned Property, either Government Furnished or Grantee Acquired, in the custody of the Recipient?	No ⦿	Yes ◯
If yes please attach a complete listing including information as set forth at § 1260.134(f)(1).		

Attach the Summary of Research text behind this cover sheet.

Reference 14 CFR § 1260.22 Technical publications and reports (December 2003)
Reports shall be in the English language, informal in nature, and ordinarily not exceed three pages (not counting bibliographies, abstracts, and lists of other media).

A Summary of Research (or Educational Activity Report in the case of Education Grants) is due within 90 days after the expiration date of the grant, regardless of whether or not support is continued under another grant. This report shall be a comprehensive summary of significant accomplishments during the duration of the grant.

Hpcn**Report for NASA Award NNX11AH63G**
Reporting Period: 6/14/2013 to 6/13/2014

International MODIS/AIRS Processing Package (IMAPP) Maintenance and Development of Real-time Applications and Operational Usage of Terra and Aqua Direct Broadcast Products

Principal Investigator:
Hung-Lung Allen Huang

Co-Investigators:
Liam Gumley and Kathleen Strabala

Program Manager:
Kathleen Strabala

Cooperative Institute for Meteorological Satellite Studies
Space Science and Engineering Center
University of Wisconsin-Madison
1225 W. Dayton St.
Madison WI 53706
Ph: 608 263 5283
E-mail: allenh@ssec.wisc.edu

April 2014

Final Report for NASA Award NNX11AH63G
Reporting Period: 4/14/2011 to 4/13/2014

International MODIS/AIRS Processing Package (IMAPP) Maintenance and Development of Real-time Applications and Operational Usage of Terra and Aqua Direct Broadcast Products

Introduction

NASA's Earth Observing spacecraft, Terra and Aqua, continue to support global environmental applications. The high quality of the instrument data and products as well as the availability of unencrypted direct downlink, means local users can acquire and use the data from their own antenna in real time. The International MODIS/AIRS Processing Package (IMAPP) is a collection of software which allows any ground station capable of receiving Terra or Aqua direct broadcast data to process the raw data from Level 0 (raw instrument packets) to Level 1B (calibrated and geolocated radiances), and to a selection of Level 2 products (geophysical products). Supported instruments include MODIS, AIRS, AMSU, HSB, and AMSR-E. This provides Direct Broadcast (DB) users the capability to support their own local environmental applications.

During this reporting period, the number of IMAPP registrants continued to grow, now including more than 1700 users from 75 different countries. In addition to four new software packages that were released this last year in support of MODIS and AIRS instruments, several other activities related to Aqua and Terra direct broadcast were also sponsored. The first IMAPP (and CSPP) direct broadcast software users' group meeting was held in Madison, Wisconsin in May, and brought together scientists, technicians, vendors, software engineers and end users in an exchange of information and ideas on how direct broadcast Aqua and Terra data can better serve local communities. More than 50 attendees participated including representatives from EUMETSAT, METEOFrance, UK Met Office and CONABIO in Mexico. UW Madison personnel also sponsored a booth at the 2013 NOAA Satellite Conference for Direct Readout in which IMAPP software and output products were displayed and promoted. IMAPP software and products were also used as part of a training workshop held for operational National Weather Service Forecasters in Honolulu and graduate students in the School of Ocean and Earth Sciences and Technology at the University of Hawaii, Monoa. The training provided experience in using Aqua and Terra data for both environmental forecasting and and research.

Highlights in the Reporting Period

The highlights demonstrate significant accomplishments gained by the IMAPP project during the reporting period.

1. January 30, 2014   (MODIS Aerosol Air Quality Forecast Software Version 1.1)
Update to the release of the MODIS Aerosol IDEA-I air quality forecast tool that uses a trajectory model to forecast the movement of aerosols over a 48 hour period. Updates include the improvement in efficiency of the trajectory model and new PHP software that can display the output set of forecast images in a Web Browser animation. This version can also use either Collect 5 or Collect 6 MODIS aerosol and cloud products as input.

2. October 18, 2013   (MODIS L1B GeoTIFF Reprojection Software Version 1.1)
First IMAPP software release that enables users to create reprojected MODIS L1B GeoTIFF files as well as 24 bit True Color GeoTIFF files. This python based software allows the users to choose from a selection of geographic projections, and to define their own grid locations and dimensions.

3. September 24, 2013   (AIRS, CrIS and IASI Dual Regression Retrieval Software Version 1.2)
Update to the software package that uses input Aqua AIRS, Suomi NPP CrIS or MetOP IASI radiances and retrieves vertical profiles of temperature, moisture, ozone as well as cloud and surface properties at single field-of-view resolution. This update includes new instrument coefficient files, as well as a bug fix for surface emissivity over the oceans.

4. August 20-23, 2013   (Hawaii Polar Orbiter Workshop)
Training workshop in support of X/L Band antenna installed at University of Hawaii-Manoa Campus. The workshop was intended to support the National Weather Service in Honolulu, as well as Remote Sensing Science Graduate Students.

5. May 21-23, 2013   (CSPP/IMAPP Users' Group Meeting)
The University of Wisconsin-Madison hosted the first direct broadcast software package users' group meeting as a means of exchanging information relevant to processing and applications of downlinked Aqua, Terra and Suomi-NPP data and products.

5. April 8-12, 2013   (NOAA 2013 Satellite Conference for Direct Readout)
The University of Wisconsin-Madison sponsored an exhibit booth at the NOAA 2013 Satellite Conference for Direct Readout. IMAPP data products and applications were showcased to the user community.

6. April 29, 2013   (AIRS, CrIS and IASI Dual Regression Retrieval Software Version 1.1)
Update to the software package that uses input Aqua AIRS, Suomi NPP CrIS or MetOP IASI radiances and retrieves vertical profiles of temperature, moisture, ozone as well as cloud and surface properties at single field-of-view resolution. The dual regression technique was developed at the University of Wisconsin-Madison.

A.1   General Activities

The IMAPP project continues to promote the global use of EOS Aqua and Terra Satellite direct broadcast data for local applications. The main efforts this reporting period involved working directly with the user community, including hosting an IMAPP users' conference as well as teaching a direct broadcast application workshop in support of a new antenna deployed in Hawaii.

a) Support for a large global user base

The global use of IMAPP software continues to increase. The UW continues to support the DB user community with software and real time distribution of data and products generated from our own local direct broadcast antennae. The IMAPP download page has now had over 1700 registrants from around the world, representing 75 different countries, which is more than 38% of the world total.   Table 1 displays a list of countries with at least one registered IMAPP user.

Table 1: List of countries of registrants from the International MODIS/AIRS Processing Package (IMAPP) (75 total) download page.

Italy	Mexico
Argentina	Hungary
Brazil	Belgium
Kazakhstan	Norway
Ukraine	Venezuela
Indonesia	Sri Lanka
China	France
Denmark	Russia
South Africa	Vietnam
Taiwan	Mongolia
Japan	Turkey
Morocco	South Korea
Iran	United Arab Emirates
Singapore	Lithuania
India	United States
Germany	Thailand
United Kingdom	Romania
Australia	Malaysia
Czech Republic	Algeria
Canada	Reunion
Spain	Austria
Chile	Finland
Pakistan	Nigeria
Nepal	New Zealand
Portugal	Guatemala
Poland	Uruguay
Saudi Arabia	Israel

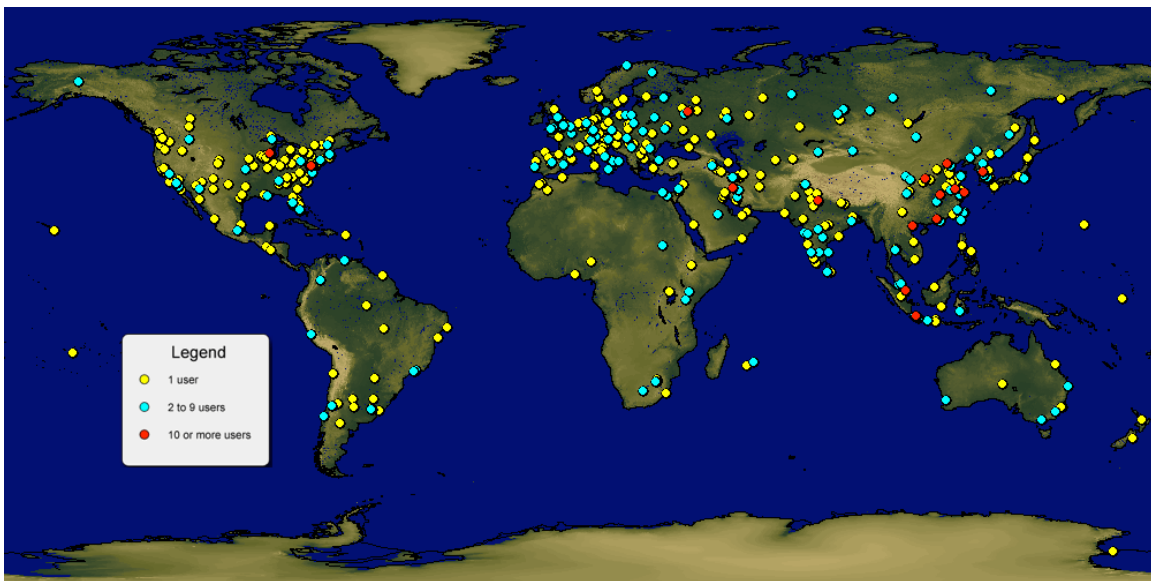| El Salvador	Azerbaijan
Colômbia	Cuba
Serbia	Kuwait
Kenya	Syria
Oman	Dominican Republic
Sweden	Belarus
Uzbekistan	Iceland
Philippines	Switzerland
Sudan	Slovenia
Peru	Uganda
Suriname	Ethiopia
Laos	

Figure 1. Graphical display of the IMAPP user community. This map includes all users who registered since the launch of the new IMAPP web page in 2007.

UW hosted the first IMAPP Users' Group Meeting (co-sponsored with the Community Satellite Processing Package (CSPP)) in May 2013, in Madison Wisconsin. The purpose of the meeting was to bring together the worldwide community of CSPP and IMAPP users to discuss issues relevant to reception, processing, and applications of data acquired by direct broadcast from Suomi NPP, Terra, and Aqua. Topics that were discussed included:

- Local usage and applications of CSPP and IMAPP products from VIIRS, CrIS, ATMS, MODIS, AIRS, and AMSU
- CSPP and IMAPP software technical topics, including related software packages
- Status of current and future polar environmental satellite missions and sensors
- Providing feedback and guidance to the CSPP and IMAPP development teams on current products and future priorities
- Interactive session on satellite data analysis applications (e.g., Python)

More then 50 people attended the meeting, including representatives from 10 countries. Delegates from operational weather forecast offices in the United States, Norway, Sweden, Germany, and the United Kingdom attended, as well as research to operations institutes like METEOFrance and CONABIO in Mexico, vendors such as SeaSpace and Orbital Systems, and federal personnel from NASA and NOAA all participated. The meeting included user presentations and poster sessions, and culminated in group discussions that led to the creation of a list of priorities for changes and additions to the IMAPP products suite. This list included the request to disseminate information to the user community through the IMAPP online Forum, as well as a request to improve the way the IMAPP MODIS infrared destriping software is executed. The final meeting agenda is listed below. All presentations are available through the website at:

http://www.ssec.wisc.edu/meetings/cspp/ .

CSPP/IMAPP USERS GROUP MEETING AGENDA

May 21-23, 2013
Pyle Center, 702 Langdon Street, Madison, WI 53706, USA

Hosted by CIMSS/SSEC, University of Wisconsin-Madison
Liam.Gumley@ssec.wisc.edu (+1 608 265 5358)
Kathy.Strabala@ssec.wisc.edu (+1 608 263 8572)
Maria.Vasys@ssec.wisc.edu (+1 608 263 7435)

Tuesday, 21 May 2013		
08:00 - 09:00	Registration	Pyle Auditorium
09:00 - 09:15	Welcome and Logistics	Liam Gumley and Kathy Strabala
09:15 - 10:00	Keynote: Suomi NPP and the Joint Polar Satellite System	Mitch Goldberg NOAA
10:00 - 10:30	Processing and Use of Direct Broadcast Data at the Met Office	Nigel Atkinson Met Office
10:30 - 11:00	Break	Lee Lounge
11:00 -	Suomi NPP Local Data Processing and Use at	Pascale Roquet

11:30	MeteoFrance/CMS	MeteoFrance
11:30 - 12:00	An Overview of MODIS and Suomi NPP VIIRS Satellite Data Processing in Western Australia (Movie)	Jackie Marsden Landgate
12:00 - 01:30	Lunch	AT&T Lounge
13:00 - 13:30	Weather Briefing	Jordan Gerth CIMSS/SSEC
13:30 - 14:00	PPS: A Direct Readout Package for the Retrieval of Cloud Properties from AVHRR and VIIRS	Adam Dybbroe SMHI
14:00 - 14:30	EARS-ATMS, EARS-CrIS, and EARS-VIIRS: Three New Regional Services for Suomi NPP	Anders Soerensen EUMETSAT
14:30 - 15:00	Using VIIRS Direct Readout Capabilities for the Improvement of Mexico's Wild Fire Alert System	Juan Manuel Escamilla CONABIO
15:00 - 15:30	Pytroll, A Python Weather Satellite Processing Framework: The VIIRS and MODIS Use Cases	Martin Raspaud SMHI
15:30 - 16:00	Break	Lee Lounge
16:00 - 16:30	The Use of CSPP and IMAPP at Deutscher Wetterdienst	Katja Hungershoefer DWD
16:30 - 17:00	Implementation of IMAPP/IDEA-I Over the Po Valley Region of Northern Italy for Air Quality Monitoring and Forecasting	Barbara Arvani EURAC
17:00 - 19:00	Poster Presentations and Reception	Alumni Lounge
Wednesday, 22 May 2013		
08:00 - 09:00	Registration	Pyle Auditorium
09:00 - 09:15	Weather Briefing	
09:15 - 09:40	Keynote: Transitioning NASA Earth Science to Address Real World Weather Related Issues	Tsengdar Lee NASA
09:40 - 10:00	EOS Terra and Aqua Status	Angie Kelly NASA
10:00 - 10:30	The Global Impact of 14 years of IMAPP Support for Terra and Aqua Direct Broadcast	Kathy Strabala CIMSS/SSEC
10:30 -	Break	Lee Lounge

11:00		
11:00 - 11:30	CSPP and IMAPP RealTime Processing in Alaska	Scott MacFarlane GINA
11:30 - 12:00	A Direct Broadcast Demonstration of CSPP and IMAPP at McMurdo Station, Antarctica	Matthew Lazzara CIMSS/SSEC
12:00 - 13:30	Lunch	AT&T Lounge
13:30 - 14:00	CSPP at 1.5 years: Achievements and Future Plans	Liam Gumley CIMSS/SSEC
14:00 - 14:30	CSPP VIIRS SDR Performance Enhancements	Scott Mindock CIMSS/SSEC
14:30 - 15:00	The CSPP VIIRS EDR Package	Geoff Cureton CIMSS/SSEC
15:00 - 15:30	CrIS and ATMS SDR Processing in CSPP	Graeme Martin CIMSS/SSEC
15:30 - 16:00	Break	Lee Lounge
16:00 - 16:30	A Fresh Look at Hyperspectral Sounders: How 3-D Quantitative Information About the Atmosphere Can Enhance Real-Time Applications and Decision Making	Nadia Smith CIMSS/SSEC
16:30 - 17:00	IDEA-I: A Globally Configurable Software Package in Support of Air Quality Forecasts, Stratospheric Intrusions of Ozone, and High Aerosol Concentrations	James Davies CIMSS/SSEC
Thursday, 23 May 2013		
08:00 - 09:00	Registration	Pyle Auditorium
09:00 - 09:15	Weather Briefing	
09:15 - 10:00	Discussion	
10:00 - 10:30	CLAVR-X in CSPP	Andrew Heidinger NOAA
10:30 - 11:00	Break	Lee Lounge
11:00 - 11:30	Status of Operational Suomi NPP Algorithms	Bonnie Reed NOAA
11:30 -	Supporting Direct Broadcast Systems Using TeraScan	Kota Prasad

12:00	Software from SeaSpace	SeaSpace Corp.
12:00 - 13:30	Lunch	Alumni Lounge
13:30 - 13:50	Applications of IMAPP at Eastern China Normal University, Shanghai China	Yan'an Liu ECNU
13:50 - 14:10	Supporting Alaska Region National Weather Service Volcanic Ash Advisory Center and Weather Forecast Offices with IMAPP Processing	Justin Sieglaff CIMSS/SSEC
14:10 - 14:30	Improvements to the IMAPP Direct Broadcast Regional Assimilation System (DBCRAS)	Robert Aune NOAA
14:30 - 14:50	Analyzing VIIRS, CrIS, and ATMS Data with Hydra2	Thomas Rink CIMSS/SSEC
14:50 - 15:10	Visualization and Analysis of IMAPP and CSPP Products in McIDAS-V	David Santek CIMSS/SSEC
15:10 - 15:30	Wrap-up Discussion	
15:30 - 16:00	Break	
16:00 - 17:00	SSEC Building Tour	AOSS Building
17:00 - 18:00	Cookout on the Roof	AOSS Building

b) Direct Broadcast Applications Workshop

A Direct Broadcast Applications workshop featuring IMAPP MODIS products was taught by UW personnel in Honolulu, Hawaii in August 20-23, 2013. Attendees included National Weather Service Forecasters from the Honolulu Office, Remote Sensing Graduate Students from the University of Hawaii-Manoa Campus, and forecasters from the Joint Typhoon Warning Center (JTWC). A total of 20+ students attended the workshop. NOAA sponsored the procurement and installation of an X/L-Band antenna in Honolulu in support of forecasters in the NWS Pacific Region. MODIS data and products acquired by the antenna are now being created and distributed to the operational forecasters for display in the Advanced Weather Interactive Processing System (AWIPS)-I and/or II.

The course consisted of morning lectures describing the direct broadcast data and products, general principles of remote sensing, product science algorithms, and demonstrations of product applications. Afternoon workshop sessions consisted of hands-on labs where students could investigate the data and products in detail. The final day consisted of student presentations on a topic of their choosing using case study data including Hurricane Flossie, clear skies in around the Hawaiian Islands for land/ocean surface studies and a severe weather hail/flooding case from March, 2012. The lectures,

labs, data and visualization software, HYDRA-II was provided to the students, and staged at the workshop website, http://cimss.ssec.wisc.edu/dbs/Hawaii2013/.

The workshop agenda is listed below, followed by Figure 2, showing the students working in the lab.

2013 Hawaii Polar Orbiter Workshop: Satellite Direct Broadcast for Real-Time Environmental Applications

Location: University of Hawaii – Manoa Campus

Date: 20-23 August 2013

Workshop Agenda

Day One   MODIS and VIIRS sensors
20 August 2013   Liam Gumley

AM Lecture Session: Introduction to Suomi-NPP (SNPP), Aqua and Terra Satellites
  • Properties of VIIRS and MODIS sensors
  • Bowtie effects and data aggregation
  • SDR and Level 1B products and formats
  • Software for visualization SDRs and Level 1B files
  • Overview of DB system at HCC
  • Overview of Software for SDR and L1B file generation
  • CSPP and MODISL1B

PM Lab Session
  • Exploring MODIS and VIIRS L1B data in Hydra
      ○   Learning Hydra
      ○   Exploring SNPP SDR and MODIS L1B using data from HCC antenna

Day Two   MODIS and VIIRS Products and Applications
21 August 2013   Kathleen Strabala

AM Lecture Session: MODIS Level 2 and VIIRS EDR algorithms and products
  • MODIS and VIIRS Atmosphere Products
  • MODIS and VIIRS Land Products
  • MODIS and VIIRS Ocean Products
  • MODIS and VIIRS applications including identification of severe weather signatures and atmospheric turbulence.

PM Lab Session
  • Exploring MODIS and VIIRS products and their applications including the use of sun glint patterns and cloud top severe weather signatures.

10

<u>Day Three</u>   MODIS and VIIRS Products and Applications continued
22 August 2013   Kathleen Strabala

1 hour AM Lecture Session: MODIS Level 2 and VIIRS EDR algorithms and products

2 Hour AM Lab Session
- Exploring hot spot detection techniques using MODIS and VIIRS and exploring the detection capabilities of the Day/Night Band under four lunar illumination regimes.

PM Lab Session
- Students in groups of three will choose a topic to investigate. They will explore the VIIRS and MODIS data from a case study or from the HCC antenna data from the last month, and present the results of their investigation to the class on Friday. NetCDF3 AWIPS-I compatible files are available for the case studies. More details to come.

<u>Day Four</u>   Participant Presentations
23 August 2013

AM Student 15 minute presentations

Figure 2. Students investigating direct broadcast data and products as part of a lab during the Hawaii direct broadcast applications workshop, held in Honolulu, August 2013.

c) Participation in the NOAA Satellite Direct Readout Conference

The IMAPP project helped to sponsor a booth for displaying and demonstrating MODIS and AIRS data, products and applications at the 2013 NOAA Satellite Direct Readout Meeting held at College Park, Maryland, April 8-12. The booth is an effective way of meeting satellite data users who might not normally attend specific conference talks. That was especially true of the 2013 meeting, which was held as part of the general 2013 NOAA Satellite Conference. Figure 3 is a picture of UW personnel talking to a visitor at the UW direct broadcast exhibit.

Figure 3. UW personnel talking to a visitor at the UW-Madison Direct Readout Activities Booth, exhibited during the 2013 NOAA Satellite Conference.

Kathleen Strabala also gave an oral presentation about the IMAPP project, entitled "The Global Impact of 10+ Years of IMAPP Software in Support of Aqua and Terra".

A.2   MODIS Activities

a) Support of the US National Weather Service Forecasters

Use of the IMAPP MODIS products generated from our DB antenna data and distributed to the National Weather Service (NWS) field offices continues to increase. The total number of Forecast Offices that are supported has now reached 61, including the 4 US regional offices of Bohemia, New York (East Region Headquarters), Kansas City, Missouri (Central Region Headquarters), Fort Worth, Texas (Southern Region Headquarters) and Salt Lake City, Utah (Western Region Headquarters).   Figure 4 shows the current distribution of supported forecast offices, and the office name (regional offices are not included in this number). The gap in the Southeastern United States are offices that are supported by the NASA Short-term Prediction Research and Transition Center (SPoRT); the MODIS Level 1B data they supply to users are from SSEC antennae and include some IMAPP products. Hawaii offices are now included, since SSEC is now maintaining the software to support the NWS forecasters in Honolulu as well.
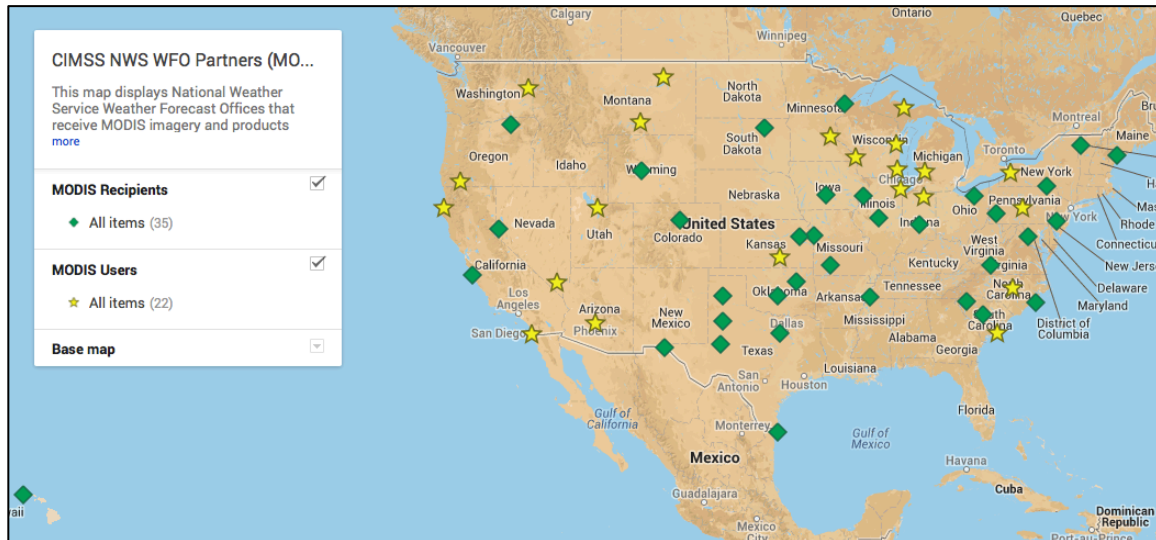
Figure 4. Graphical distribution of NWS offices that receive MODIS IMAPP products distributed by the UW from DB data acquired and processed in real time at SSEC, or by the antenna supported by IMAPP software running in Honolulu.

We continue to ensure that these products are useful as decision making tools for the NWS by tracking the number of times the MODIS products are mentioned as a decision making tool in the forecaster Area Forecast Discussions (AFDs). The total number since we began supplying the data now stands at more than 465; an addition of more than 100 in the last year.

In the example below, the MODIS 11-4 micron brightness temperature difference is used to determine the location of local fog formation in the ridge and river valleys across Pennsylvania. The high MODIS spectral and spatial resolution means that the instrument can provide information for forecasters that cannot be gathered through any other means, since the GOES satellite spatial resolution is too large, and the surface observation network is sparse. Figure 5 shows the scene that the forecaster was viewing in AWIPS-I, overlaid with the concurrent surface observation station plot.

AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE
STATE COLLEGE PA
556 AM EDT WED OCT 9 2013
….
.NEAR TERM /UNTIL 6 PM THIS EVENING/…CIRRUS SHIELD ASSOC WITH UPPER LOW OVR NORTH CAROLINA WILL CONTINUE TO AFFECT MAINLY THE SE HALF OF PA EARLY THIS AM. MEANWHILE ...CLEAR SKIES AND A CALM WIND HAVE ALLOWED VALLEY FOG TO FORM ACROSS NORTHERN PA...AS SEEN IN MODIS 11-3.7UM IMAGERY. FROST ADVISORY WILL CONTINUE THRU 8 AM FOR THE N TIER COUNTIES ...WHERE GROWING SEASON STILL GOING. OBS SHOW SOME OF THE COLDER VALLEYS UP THERE HAVE DROPPED TO THE L/M30S AS OF 09Z.
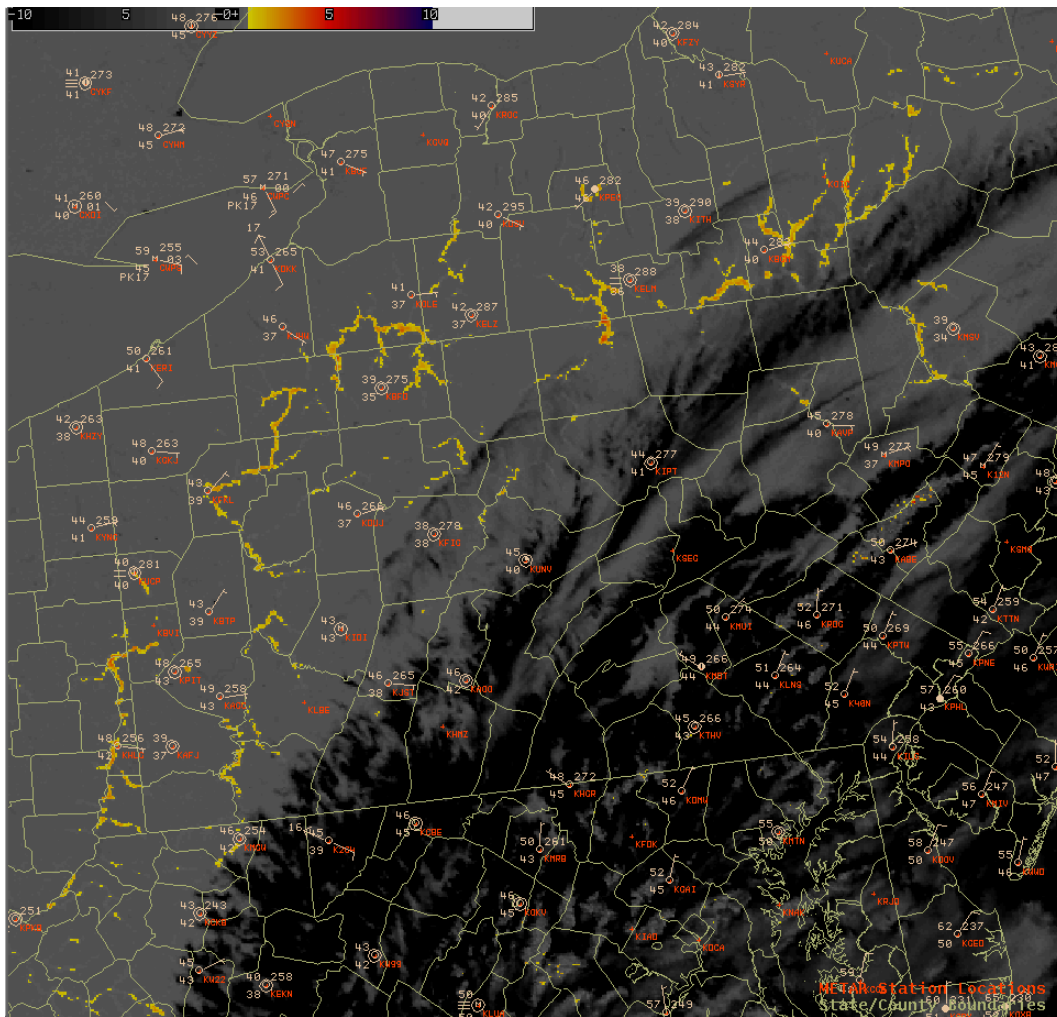
 Figure 5. Screen capture from AWIPS of the MODIS 11 minus 3.7 micron brightness temperature difference from 0703 UTC, 9 October 2013, which can help to identify areas of low cloud and fog. This example was used by the operational NWS forecaster in State College, Pennsylvania to help determine the extent of the fog and stratus development at night.

The next example (Figure 6) shows how a forecaster in Chicago, Illinois used the high resolution MODIS true color imagery that is created using the IMAPP DB in Google Earth package to determine the location and extend of ice coverage on Lake Michigan. This is an important piece of information for making marine forecasts (eg., wave activity) as well as lake effect snow forecasts.

AREA FORECAST DISCUSSION
 NATIONAL WEATHER SERVICE CHICAGO/ROMEOVILLE IL
 240 AM CST SAT FEB 8 2014

 .DISCUSSION...

856 PM CST

FOR OUR ILLINOIS/INDIANA NEARSHORE WATERS...BEAUTIFUL MODIS
POLAR ORBITER SATELLITE IMAGERY FROM THE LAST TWO SUNNY DAYS
INDICATES MUCH OF THE INDIANA WATERS ARE SOLIDLY ICE-COVERED
...WHILE THICKER ICE HAD PUSHED EAST OFF THE ILLINOIS SHORE WITH
THE STRONGER WEST WINDS OF THE LAST SEVERAL DAYS. HOWEVER
...WEB CAMS SUGGEST THAT OUR SINGLE DIGIT TEMPS HAVE ALLOWED
AT LEAST SOME ICE TO CONTINUE TO DEVELOP ALONG THE ILLINOIS
SHORE AND THUS WILL OMIT WAVE HEIGHTS IN THE NEARSHORE
FORECAST AS LIKELY LITTLE WAVE DEVELOPMENT GIVEN LARGE
AMOUNT OF ICE.

….

RATZER
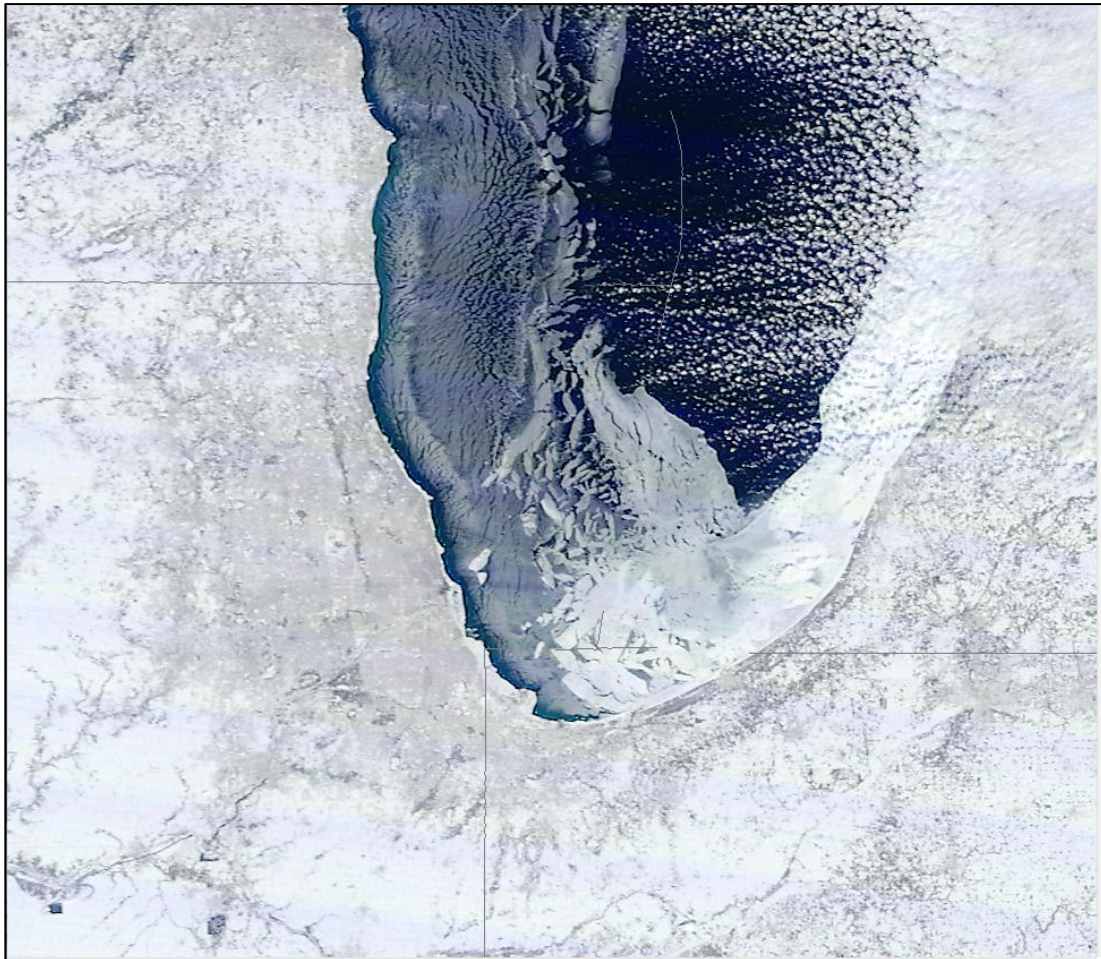
Figure 6. MODIS true color image of Chicago and the southern portion of Lake
Michigan as shown from the MODIS Today website (http://ge.ssec.wisc.edu/modis-
today/. The observations were acquired from the Terra overpass, 7 February 2014, 18:09
UTC.

Finally, the utility of the MODIS data and products is best indicated by the anticipation of the Aqua and Terra overpasses by the NWS forecasters. The following example shows how the forecasters in Marquette, Michigan are lamenting the fact that there has not been a good clear view over Lake Superior for a few days. They are hoping to use it to determine the chances for lake effect snows over their forecast region.

AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE MARQUETTE MI
358 PM EST SUN JAN 12 2014
 …

 BEHIND THE COLD FRONT...AND WEAK SECONDARY BOUNDARY LES WILL BEGIN TO DEVELOP OVER THE W. ALREADY HAVE REPORTS OF SNOW BEHIND THE LOW OVER S SASKATCHEWAN. ADDING LAKE SUPERIOR TO THE MIX WILL ONLY INCREASE THE POTENTIAL FOR SNOW ACROSS THE KEWEENAW PENINSULA. DID NOT CHANGE POPS MUCH FOR MONDAY. LES WILL BE DIFFICULT TO FIGURE OVER GOGEBIC COUNTY...AS IT WILL DEPEND ON HOW MUCH HAS BEEN ABLE TO SET UP OVER SW LAKE SUPERIOR. HAVE NOT HAD A GOOD VIEW /MODIS IMG/ SINCE THE 8TH OF JANUARY. WHILE TEMPS HAVE BEEN COLD...WINDS HAVE BEEN STRONG ENOUGH TO RESULT IN SOME BREAKING OF QUICK FORMING ICE. EXPECT ENOUGH BREAKS W OF IWD TO KEEP SLIGHT CHANCE LES GOING THROUGH THE DAYTIME HOURS. THE NEAR-SFC WINDS MAY BECOME A BIT TOO WESTERLY OR OUT OF THE W-SW FROM MID AFTERNOON ON TO KEEP MUCH GOING. OTHERWISE...WITH RATIOS NEARING 17:1...COULD HAVE 1 TO NEAR 2IN OF SNOW ACROSS THE KEWEENAW PENINSULA.

b) MODIS Polar2Grid Reprojection and Reformatting Tool

The first version of a stand alone MODIS reprojection tool was created and released in October 2013. The main goal of this Polar2Grid package was to provide a portable tool that could create high quality reprojections of MODIS data and products, and reformat them for display in AWIPS-I and AWIPS-II in support of National Weather Service forecasters. This process became critical with the installation of the new antenna and processing system in Hawaii. The software that is being used at the UW in support of the NWS in the Contiguous US is McIDAS-X based, which is licensed software; to use the same processing flow would cost yearly support fees.

The Python based Polar2Grid software was installed in Honolulu in July 2013, and has been creating and delivering AWIPS NetCDF files for display in the Honolulu forecast office since that time. In addition, the entire suite of IMAPP products has also been installed, with the data and products being staged for use by local School of Ocean and Earth Sciences and Technology, University of Hawaii – Manoa graduate students. An example of the high quality, high resolution MODIS data as displayed in AWIPS-I is shown in Figure 7.
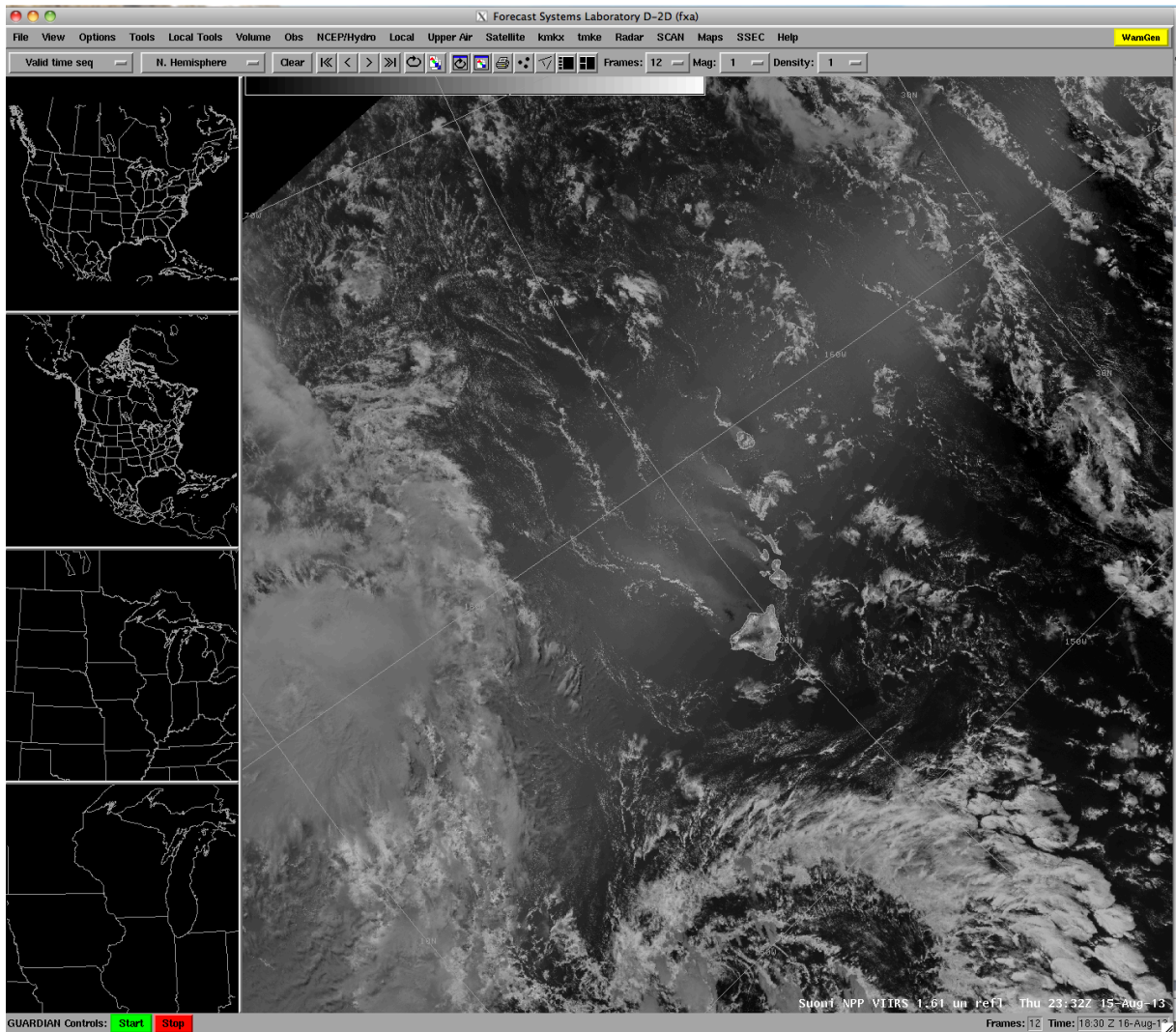
Figure 7. MODIS direct broadcast image, received at the X/L Band antenna in Honolulu, displayed in AWIPS-I. The data is reformatted and reprojected using the IMAPP Polar2Grid software. This example 1.6 micron data was observed at 23:32 UTC, 15 August 2013.

The Polar2Grid software also allows users the capability to create GeoTIFF files, including true color images, for use in GIS systems. Execution options include the capability to define the center point, domain, and resolution of the output image file.

c) **Update to the Globally Configurable Air Quality Forecasting Tool**

An update to the Air Quality Forecast and Monitoring tool, Infusing Satellite Data into air quality Environmental Applications – International (IDEA-I) was released in January 2014. This package uses the IMAPP MODIS Terra and Aqua Aerosol Optical Depth (AOD) products (part of MOD04) to define regions of high aerosol loading. Any pixel in the daily passes where the AOD is observed to be greater than 0.4, a trajectory is initialized and a 48 hour trajectory forecast is created showing the progression of those

aerosols in the horizontal and vertical directions over the user domain. The domain is configurable in that the user defines the center point and the extent of the area covered.

A number of updates were made to the original software package, including:

- The trajectory model performance has been dramatically improved. The execution speed depends on the number of trajectories that are initialized. The performance should be 2-3x faster than for a similar number of trajectories processed in version 1.0.
- Both Aqua and Terra data can be used (previous release supported Terra only).
- A new main run script, IDEA-I.bash, has been added.
- Many changes have been made to the configuration file, including the capability to point to different sources of GFS ancillary data for archived data processing.
- The PHP software, that provides for the display of the output image files in a web browser, now allows the user to display more than one product per website.
- MODIS Collect 5 and/or Collect 6 MOD04 and MOD06CT files can be used as input.

Figure 8 shows output from an installation of the software from a user in Budapest Hungary. This case shows dust aerosols over the Mediterranean Sea moving away from Hungary.
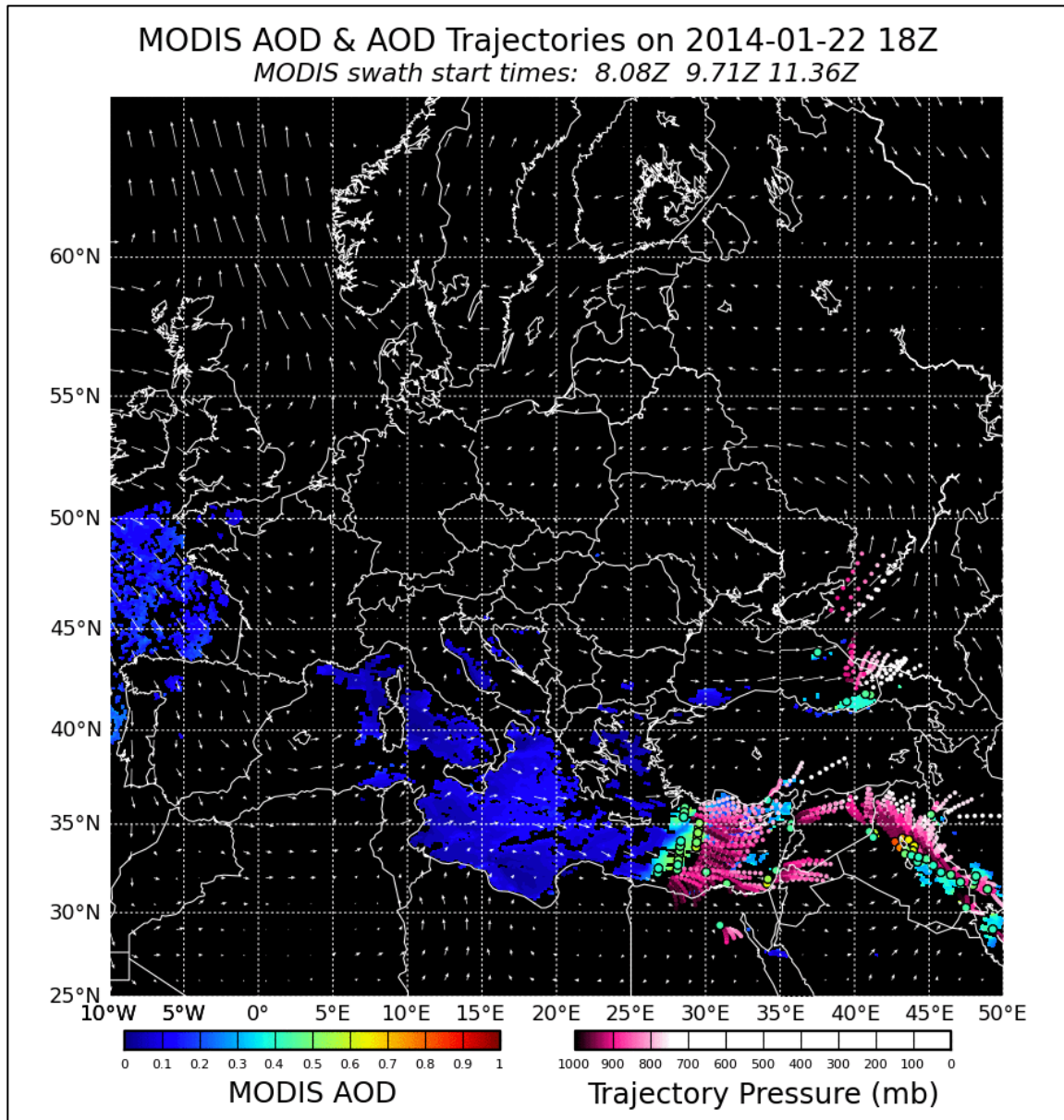
Figure 8. IDEA-I output image file showing the vertical and horizontal trajectory forecast of aerosols over Europe and North Africa. This scene was provided by a user who installed the latest update (v1.1) of the IMAPP IDEA-I aerosol package. The Terra data was captured and processed by Aniko Kern in Budapest, Hungary, on 22 January 2013.

d) Preparation for the release of a new IMAPP MODIS Level 2 Collect 6 package

A new version of the IMAPP MODIS Level 2 atmosphere products package is being prepared for release prior to the end of the award date. This version will include all Collect 6 MODIS Atmosphere Level 2 Swath Based algorithms, and produce files that are identical in format to those archived at NASA LAADS. Previous releases of the Level 2 software required some rewriting of the NASA input/output modules to produce smaller output files and easier installations. Users have requested that we produce files

that include all output parameters, be in HDFEOS format, and include all of the metadata fields as well. The new software will now be used exactly as it is in operations; execution takes place using wrapped python scripts. The products will now produce files that are as close to identical as can be; they can never be exactly the same because the ancillary files that are used in real-time are different from the ones used in operations (GFS NWP forecast files as opposed to GDAS NWP analysis files which are not available until at least 6 hours after real-time).

e) Preparation for the release of an IMAPP Web Mapping Services Software Package

UW personnel are also preparing a stand alone package that will allow users to display their MODIS GeoTIFF data and products in a web browser using a Web Mapping Service in the form of a Virtual Machine. Images created using the Polar2Grid software can be readily displayed using this wms at high resolution in Google Earth mapping. This will allow users an easy way to share their data with their user community.

A.3 AIRS Activities

a) Updates to the AIRS Dual Regression Retrieval Software Package

Two updates to the Hyperspectral University of Wisconsin-Madison retrieval software package were released in the last year. The hyperspectral retrieval algorithm is based on the concept of 'Dual Regression' (DR) that is a statistical eigenvector regression method.

The changes included fixing a bug that resulted in unrealistic emissivity values retrieved over ocean surfaces, new coefficient files, and new eigenvectors separated between land and ocean.

Elisabeth Weisz and Nadia Smith are working with National Weather Service forecasters in defining forecaster needs that can be met using these retrievals. Since the dual-regression retrieval software will create the same HDF5 retrievals from three hyperspectral instruments on 4 satellites (AIRS (Aqua), CrIS (S-NPP) and IASI (MetOP-A and B), this has the potential to provide detailed atmospheric information at relatively high temporal resolution, especially at high latitudes. Products such as Cloud Top Temperature, Lifted Index, Total Water Vapor, and the difference fields from one pass to another are currently being tested for delivery to Alaska forecasters to assess their utility. An example of how combining these multi-satellite retrieval products might be useful even in the Continguous US, is provided in Figure 9, which shows the progression of cloud top temperature observations over the Central US on 20 May 2013, as observed using 4 hyperspectral sensors. It is especially worthwhile to note the strong cloud top cooling that takes place in 30 minutes between the CrIS and AIRS retrievals indicating very strong updrafts. An EF-5 tornado struck Moore Oklahoma about 25 minutes after the AIRS observations were made.
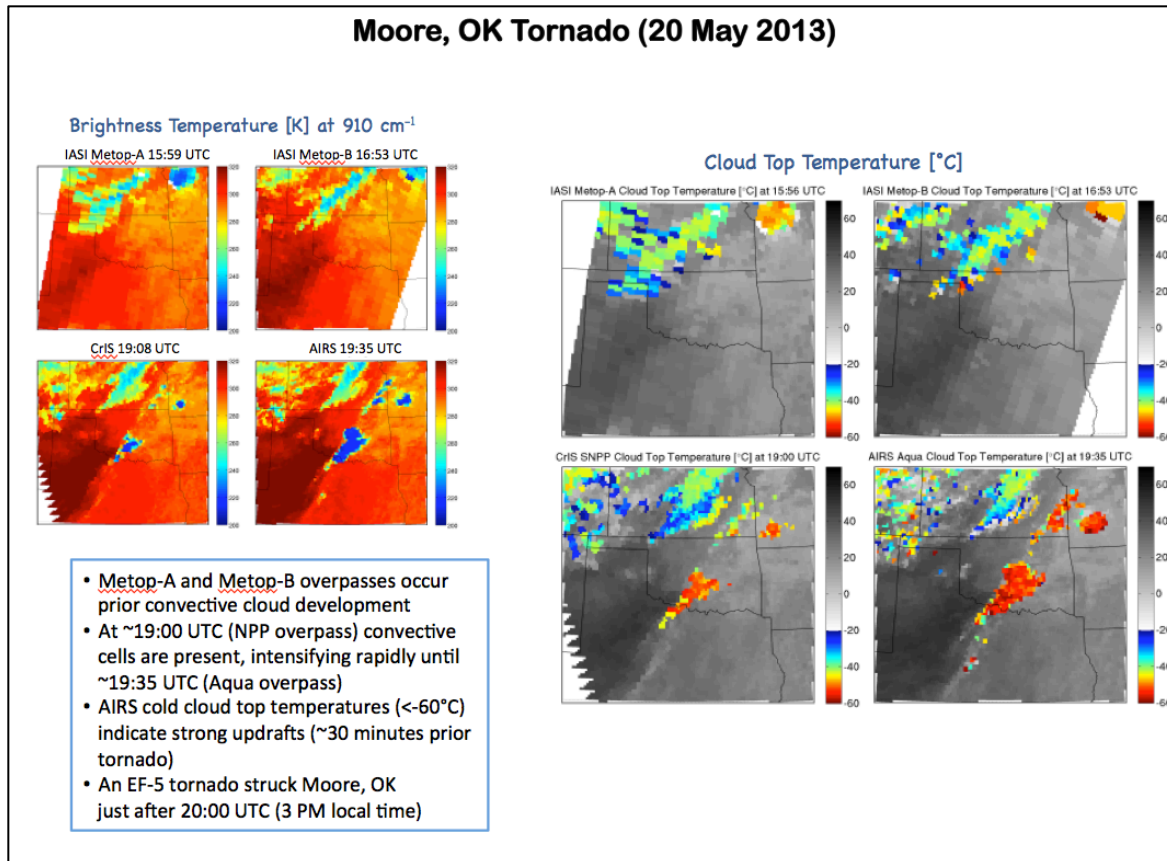
Figure 9. Dual Regression Hyperspectral Sounder Brightness Temperatures at 910 cm^{-1} (Upper Left), and Cloud Top Temperature retrievals (Right) from 4 instruments on 20 May 2013. The images show the potential utility of the retrievals in providing lead time warning of strong to severe storms.

b) Stratospheric Ozone Intrusion Software Package

Working with Brad Pierce, of NOAA STAR, the UW IMAPP team is preparing a software package that will allow users to identify regions of strastospheric ozone intrusions into the troposphere, and forecast the movement of these regions in 3 dimensions. The software will be released prior to the end of the award date. The goal is to help governments and decision makers know if these intrusions will reach the surface, where it can be harmful to people. The software package uses the UW Dual Regression retrievals to identify cases that could be stratospheric intrusions, based on ozone, temperature and water vapor retrievals. Forward trajectories are then run to see whether they are likely to impact the surface over the next 48 hours. This package, called Infusing satellite Data into Environmental Applications – International (IDEA-I) Ozone, has been tested on a case study Stratospheric Intrusion (SI) event that occurred on 6 June 2012. In this case, the State of Wyoming needed to prove that the elevated ozone readings for June 6th were caused by an intrusion of stratospheric air rather than pollution, otherwise they would be in violation of the Clean Air Act.

The Clean Air Act requires that states and tribes attain the National Ambient Air Quality Standard (NAAQS) for ozone, currently defined as a 3-year average of the 4th highest daily 8-hour average ozone greater than 75 ppb. If the NAAQS is violated, EPA may designate areas as failing to meet the ozone levels standard, necessitating the development of plans for improvement in air quality. However, heightened ozone levels caused by exceptional events (usually from natural sources) can be excluded if explained by appropriate documentation.

Analysis using back trajectories of the Wyoming event showed that the source of the ozone went back to a very persistent cyclone circulating around the Aleutians. These high amplitude troughs that are often observed over California in the springtime come off of the Pacific. Then, because of the high topography, the ozone that comes in with these troughs will often affect the western mountain states. Gathering data from the days of this event provided evidence that the IDEA-I forecasts would have provided early warning of the potential for SI to affect the surface. Using the evidence gathered by Pierce and others studying occurrences of raised ozone levels, the State of Wyoming Department of Environmental Quality/Air Quality Division has filed a report documenting why exceeding the EPA standards in Thunder Basin was an "exceptional event," and that in this case, the elevated ozone level was the result of a natural occurrence and not pollution. Figure 10 is one of the IDEA-I Ozone trajectory forecast panels showing ozone intrusions occurring over Wyoming on 6 July 2012 (pink trajectories). This single pane was one in a sequence of forecast images showing the movement of ozone over a 48 hour time period. This case study was presented in more detail in a report published in the UW SSEC Newsletter at this link:

https://www.ssec.wisc.edu/media/fromorbit/october2013/page2.html
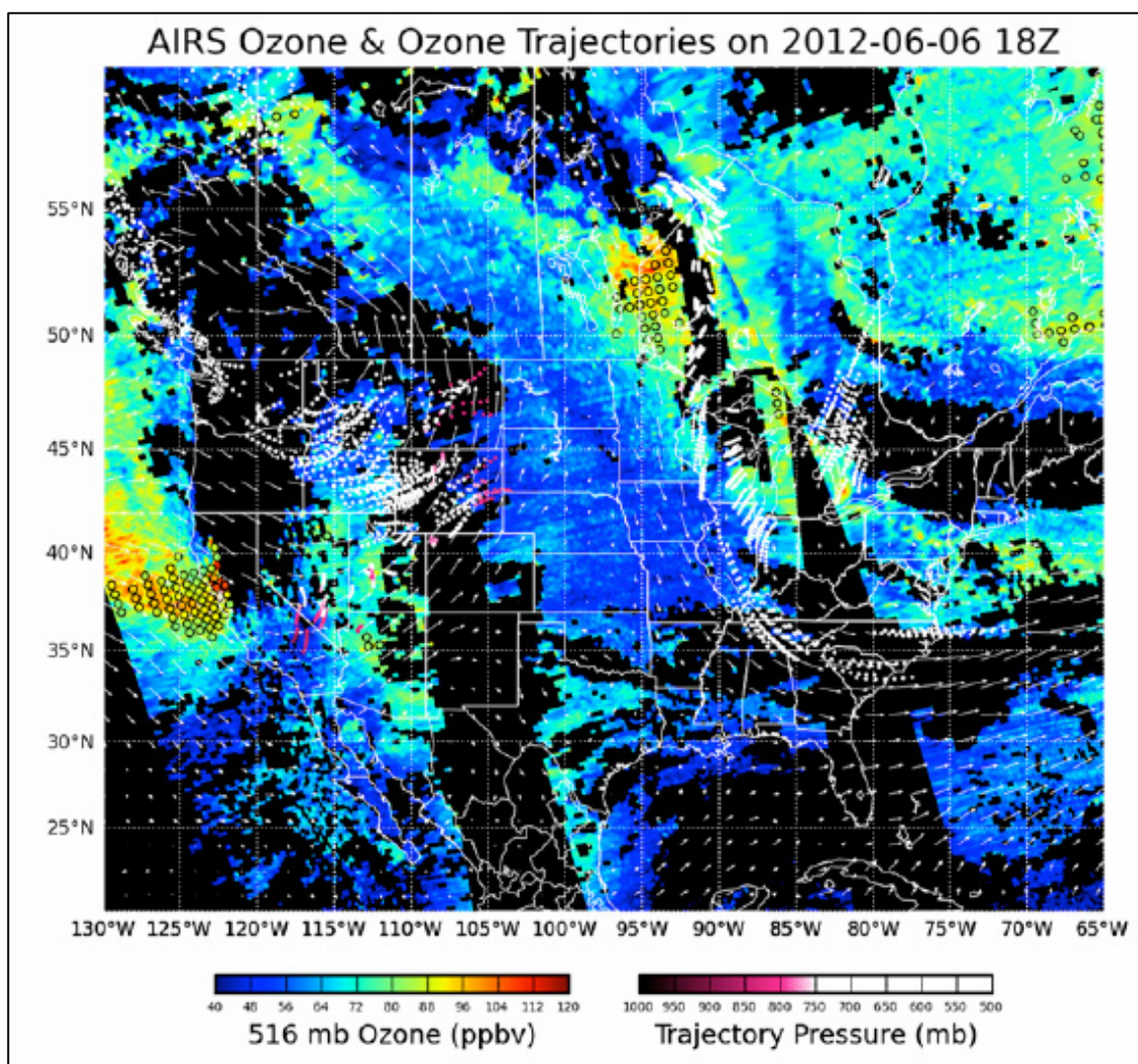
Figure 10. IDEA-I SI forecast (red and white trajectories over Wyoming, Idaho, and Montana) valid at 18Z (11am MST) on 06 June 2012 initialized with AIRS ozone observations from 04 June 2012. The IDEA-I SI trajectories are initialized in regions of high ozone (open circles) off the coast of California and show the downward transport (red indicates high trajectory pressures near the surface) of the high ozone air over Northeastern Wyoming and Montana. The initial AIRS ozone retrieval at 516mb (mid troposphere) is also shown along with 500mb winds from the NOAA Global Forecasting System (GFS) which are used to predict the trajectory movement.

c) Investigations using GPU technology

Bormin Huang continues to investigate the use of low-cost Graphics Processing Unit (GPU)-based High-Performance Computing (HPC) technology to reduce the latency for the creation of critical IMAPP products in data assimilation and weather forecasting. During this reporting period, a GPU-based multi-input radiative transfer model (RTM) for IASI/AIRS/CrIS was further developed. It concurrently computes 40 radiance spectra to take advantage of GPU's massive parallelism capability. To compute one day's

amount of 1,296,000 IASI spectra, the original forward model (with –O2 optimization) will take ~10 days on a 3.0 GHz CPU core; the single-input GPU-RTM will take ~ 10 minutes (with 1455x speedup), whereas the multi-input GPU-RTM will take ~ 5 minutes (with 3024x speedup). This example is displayed graphically in Figure 11.
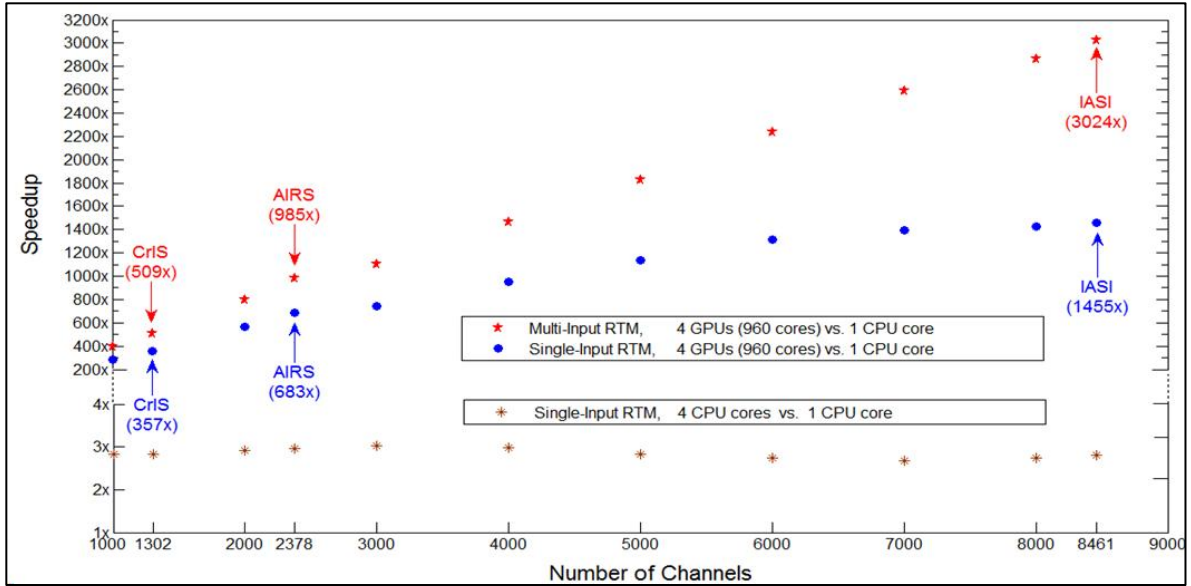

Figure 11. Example of using GPU technology to improve the processing speed of a hyperspectral instrument forward model.

A.4 AMSR-E Activities

The AMSR-E instrument began operating again, however, it is rotating at 2 RPM which is far below the normal 40 RPM, and is not intended for producing data products. On 4 October 2011, the AMSR-E instrument on board the Aqua satellite stopped producing data due to a problem with the rotation of its antenna. No further data collection is expected. It is operating now only in order to do calibrations in relation to AMSR2.

B.1   Real-time Data Customers

UW SSEC continued to provide real-time Terra and Aqua products to a number of customers in the US. The reliability and timeliness of products from the SSEC reception and processing system enabled these customers to make use of EOS products in near real-time. A list of current real-time data customers is shown below:

US National Weather Service
Central, Western, Eastern, Southern and Pacific Regions (AWIPS)

Naval Research Laboratory Monterey

NASA/MSFC Short-term Prediction Research and Transition Center
http://weather.msfc.nasa.gov/sport/

NOAA CoastWatch Great Lakes Node
http://coastwatch.glerl.noaa.gov/modis/region_map.html

Bonneville Power Administration (BPA), part of the Department of Energy (DOE)
http://www.bpa.gov/corporate/

WisconsinView
http://www.wisconsinview.org/

UMBC US Air Quality Blog
http://alg.umbc.edu/usaq/

Canadian Ice Service
http://ice-glaces.ec.gc.ca/

Real-Time Images for PDAs
http://www.ssec.wisc.edu/data/paw/

MODIS Today website
http://ge.ssec.wisc.edu/modis-today/

United States Forest Service
http://activefiremaps.fs.fed.us/imagery.php

Space Science and Engineering Center Web Mapping Services
http://imapp.ssec.wisc.edu:8001/

Louisiana State University
http://www.esl.lsu.edu/

C.1 Outreach

a) Workshops

A direct broadcast workshop was held for Pacific Region NWS forecasters and University of Hawaii – Manoa graduate students in August 2013, entitled "2013 Hawaii Polar Orbiter Workshop: Satellite Direct Broadcast for Real-Time Environmental Applications". Please see Section A.1.b for a detailed description of the course.

Conference/Invited Presentations and Lectures

Smith, W. L., E. Weisz, N. Smith, H. Revercomb, S. Kireev, J. Li, D. Santek, Exploratory Science – Weather and Climate Satellite Applications, Presentation at the NOAA Virtual Science Week, 21 March 2013.

Smith, W. L., E. Weisz, N. Smith, H. Revercomb, Forecasting Hurricane Intensity and

Severe Convective Storms Satellite Sounding Pairs, presented at the NOAA 2013 Satellite Conference, 8-12 April 2013, College Park, MD.

Strabala, K.I., L.E. Gumley, H.-L. Huang: The Global Impact of 14 years of IMAPP Support for Terra and Aqua Direct Broadcast, presented at the NOAA 2013 Satellite Conference, 8-12 April 2013, College Park, MD.

Smith, N., E. Weisz, W. L. Smith, A Fresh Look at Hyperspectral Sounders: How 3-D Quantitative Information About the Atmosphere Can Enhance Real-Time Applications and Decision Making, presented at the CSPP/IMAPP Users' Group Meeting, 21-23 May 2013, Madison, WI.

Strabala, K.I., L.E. Gumley, H.-L. Huang: The Global Impact of 14 years of IMAPP Support for Terra and Aqua Direct Broadcast, presented at the CSPP/IMAPP Users' Group Meeting, 21-23 May 2013, Madison, WI.

Weisz, E., W. L. Smith, N. Smith, JPSS PG Hyperspectral Sounder Retrieval Applications. JPSS Science Seminar (presented remotely from CIMSS, Madison, WI), 22 July 2013, Lanham, MD.

Smith, N., E. Weisz, and W.L. Smith Sr., Nowcasting applications with polar-orbiting sounders: a multi-instrument approach. Workshop on NWC applications using MTG-IRS, 25–26 July 2013, EUMETSAT HQ, Darmstadt, Germany.

Davies, J.E., K.I. Strabala, N. Smith, E. Weisz, R. Cintineo, E. Schiffer, R.B. Pierce, H.-L. Huang, IDEA-I: A Globally Configurable Software Package in Support of Air Quality Forecasts; High Aerosol Concentrations and Stratospheric Intrusions of Ozone, poster presented at the 2013 Joint EUMETSAT/AMS Conference, 16-20 September 2013, Vienna, Austria.

Weisz, E., W. L. Smith, N. Smith, Quantitative Information Retrieved from Hyperspectral Sounders fro Real-Time Applications, presented at the 2013 Joint EUMETSAT/AMS Conference, 16-20 September 2013, Vienna, Austria.

Smith, N., E. Weisz, W. L. Smith, Correlation between atmospheric composition and vertical structure as measured by three generations of hyperspectral sounders in space, presented at the 2013 Joint EUMETSAT/AMS Conference, 16-20 September 2013, Vienna, Austria.

Smith, N., H. M. de Klerk, E. Weisz, W. L. Smith, A multi-instrument analysis of atmospheric composition in fire driven ecosystems, presented at the 2013 Joint EUMETSAT/AMS Conference, 16-20 September 2013, Vienna, Austria.

Smith, W. L., E. Weisz, N. Smith, Comparison of Aircraft and Satellite Ultraspectral Atmospheric Stability Retrievals Antecedent to the Moore, OK tornado, presented at the 2013 Joint EUMETSAT/AMS Conference, 16-20 September 2013, Vienna, Austria.

Smith, W. L., E. Weisz, A. Larar, H. Revercomb, D. Zhou, X. Liu, M. Yesalusky, N.

Smith, Satellite Ultraspectral Soundings: validation using airborne and ground-based measurements, presented at the 2013 Joint EUMETSAT/AMS Conference, 16-20 September 2013, Vienna, Austria.

Weisz, E., W. L. Smith, N. Smith, Quantitative Information Retrieved from Hyperspectral Sounders for Real-Time Applications, presented at the 2013 Joint EUMETSAT/AMS Conference, 16-20 September 2013, Vienna, Austria.

Weisz, E., N. Smith, P. Menzel, B. Baum, W. L. Smith, Global Cloud trends derived from a decade of polar-orbiting hyper-spectral sounder measurements, presented at the 2013 Joint EUMETSAT/AMS Conference, 16-20 September 2013, Vienna, Austria.

Weisz, E., N. Smith, W. L. Smith, P. Menzel, B. Baum, N. Bearson, Cloud Property Retrievals from Hyperspectral Sounder Measurements, CIMSS Science Symposium, 25 November 2013, Madison, Wisconsin, U.S.A.

Smith, N., E. Weisz, Information from hyperspectral data for nowcasting applications, presented at the SAWS–EUMETSAT 3rd Satellite Application Course, 2-6 December 2013, Pretoria, South Africa.

Weisz, E., N. Smith, W. L. Smith, Hyperspectral Sounder Retrievals and Applications, presented at the 5-year CIMSS Review, 16 December2013, Madison, Wisconsin, U.S.A.

Cintineo, R., K.I. Strabala, L. E. Gumley, A. Huang, J. E. Davies, E. Borbas, E. Weisz, and B. Pierce, IMAPP MODIS Level 2 Software: Supporting the Aqua and Terra Operational Community, poster presentation at the 94th AMS Annual Meeting, 2-6 February 2014, Atlanta, Georgia.

Weisz, E., W. L. Smith, N. Smith, W. Straka, R. Garcia, D. Hoese, Encouraging the Use of Hyperspectral Sounder Products in Forecasting Applications, 94th AMS Annual Meeting, 2-6 February 2014, Atlanta, Georgia.

Weisz, E., W. L. Smith, N. Smith, J. Feltz, S. Bachmeyer, J. Gerth, New Perspectives on Using Multi-Instrument Hyperspectral Sounder Information in the Analysis of Severe Local Storms, 94th AMS Annual Meeting, 2-6 February 2014, Atlanta, Georgia.

Weisz, E., W. L. Smith, N. Smith, Using Real-Time Retrievals from Multiple Hyperspectral Sounders in the Analysis of Superstorm Sandy, 94th AMS Annual Meeting, 2-6 February 2014, Atlanta, Georgia.

Peer Reviewed Publications

Weisz, E., W. L. Smith, and Nadia Smith (2013), Advances in simultaneous atmospheric profile and cloud parameter regression based retrieval from high-spectral resolution radiance measurements. *Journal of Geophysical Research -Atmospheres, 118, 6433-6443*.

Hobson, M., E. Weisz, New Retrieval Technique Yields More Useful Satellite Data. SSEC news article available at http://www.ssec.wisc.edu/news/articles/3649. posted 20 June 2013.

Other IMAPP Related Publications

Barnes, B.B.; Chuanmin Hu, "A Hybrid Cloud Detection Algorithm to Improve MODIS Sea Surface Temperature Data Quality and Coverage Over the Eastern Gulf of Mexico," Geoscience and Remote Sensing, IEEE Transactions on , vol.51, no.6, pp.3273,3285, June 2013. doi: 10.1109/TGRS.2012.2223217

Bryksin V, Kozlov A. Development of technology for publishing very large spatial data volumes using open source systems. (English). Vestnik IKBFU [serial online]. April 2013;(4):140-147. Available from: Academic Search Premier, Ipswich, MA. Accessed February 10, 2014.

Carmen Recondo, Juan José Peón, Eva Zapico, and Enrique Pendás . "Empirical models for estimating daily surface water vapour pressure, air temperature, and humidity using MODIS and spatiotemporal variables. Applications to peninsular Spain."International Journal of Remote Sensing, Vol. 34, Iss. 22, 2013. doi: 10.1080/01431161.2013.828185

Case, J.L.; LaFontaine, F.J.; Bell, J.R.; Jedlovec, G.J.; Kumar, S.V.; Peters-Lidard, C.D., "A Real-Time MODIS Vegetation Product for Land Surface and Numerical Weather Prediction Models," Geoscience and Remote Sensing, IEEE Transactions on , vol.52, no.3, pp.1772,1786, March 2014. doi: 10.1109/TGRS.2013.2255059

Quanjun He, "Night-time cloud detection for FY-3A/VIRR using multispectral thresholds," International Journal of Remote Sensing, Vol. 34, Iss. 8, 2013. doi: 10.1080/01431161.2012.755275

Rolando Herrero ; Vinay K. Ingle. "Analytical and comparative analysis of lossy ultraspectral image compression", Proc. SPIE 8743, Algorithms and Technologies for Multispectral, Hyperspectral, and Ultraspectral Imagery XIX, 87430V (May 18, 2013); doi:10.1117/12.2017629.

M. Hirtl, S. Mantovani, B.C. Krüger, G. Triebnig, C. Flandorfer, M. Bottoni, M. Cavicchi, "Improvement of air quality forecasts with satellite and ground based particulate matter observations." Atmospheric Environment, Volume 84, February 2014, Pages 20-27, ISSN 1352-2310, http://dx.doi.org/10.1016/j.atmosenv.2013.11.027. (http://www.sciencedirect.com/science/article/pii/S135223101300856X)

Wang Xin, Deng Xiaobo, Zhang Shenglan. "Retrieving Atmospheric Precipitable Water Vapor Using Artificial Neural Network Approach". TELKOMNIKA Indonesian Journal of Electrical Engineering, vol. 11, no. 12, ", number 12, 7174-7181, 2013. doi: 10.11591/telkomnika.v11i12.3749

Liu Yang, CaiBo, Ban Xianxiu. "Research progress of retrieving atmosphere humidity profiles from AIRSdata." Advances in Earth Science, 28(8), 890-896, 2013.

Masters Degrees based upon IMAPP products at East China Normal University:
Xiaoyun Zhuang : Localization of temperature profile retrieval (IMAPP Dual Regression).
Yunzhu Chen : Data fusion of aerosol optical depth. (IMAPP MOD04 products).
Cong Zhou : Research on CO2 (IMAPP Dual Regression Retrievals).
Yuanyuan Chen : PM 10 forecast (IMAPP IDEA-I products).

PHD Thesis:

Agnes Lim: Assimilation of AIRS Radiances for Short Term Regional Forecasts using Community Models.