Summary of Research Report for NASA Award NNX14AK06G
Reporting Period: 6/06/2014 to 11/04/2017

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

January 2018

1.0 Accomplishments During the Reporting Period

Direct downlink of NASA's Earth Observing spacecraft Terra and Aqua instruments provides the international environmental monitoring community high quality data for near-real-time decision making. Direct broadcast science software provided through the International MODIS/AIRS Processing Package (IMAPP) allows users with X-Band reception the capability to process the raw data from Level 0 (raw instrument packets) to Level 1B (calibrated and geolocated radiances), and to create a selection of Level 2 products (geophysical products) including direct applications. Supported instruments include MODIS, AIRS, AMSU, and AMSR-E. This provides Direct Broadcast (DB) users the capability to support their own local environmental applications.

The IMAPP user community grew during the reporting period by more than 800 registrants; the total number of registrants since the launch of the IMAPP distribution website in 2007 (http://cimss.ssec.wisc.edu/imapp) is now more than 2500, representing all continents and more than 95 different countries. The geographic distribution of IMAPP users is displayed in Figure 1.
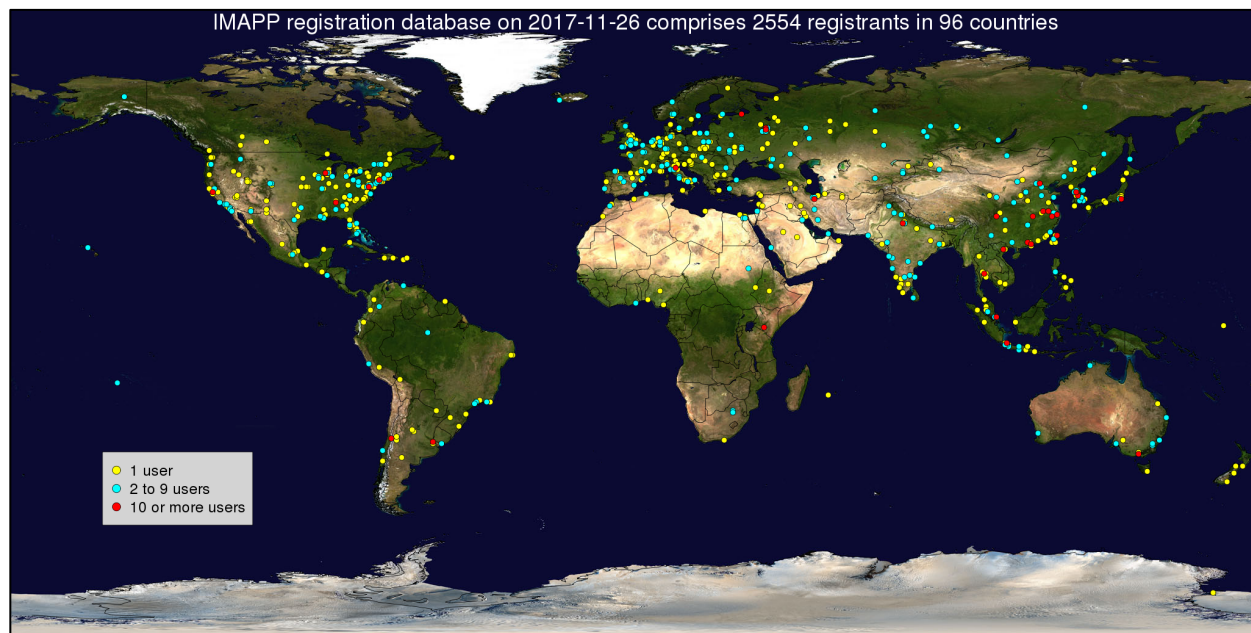

Figure 1. Global distribution of IMAPP registrants to date (> 2500).

1.1 Software Releases

The following IMAPP software packages were released during the reporting period:

November 03, 2017 (IMAPP Virtual Appliance Version 3.0 Release)
Updated release of a stand-alone processing system for Terra and Aqua direct broadcast data. This release includes updates to the MODIS L1B software, updates to the Ocean Level 2 processing software and the addition of Aqua AIRS Level 1B and Level 2 Jet Propulsion Lab retrievals. The software is supported on Windows, Mac OS X and Linux Operating Systems.

October 30, 2017   ([MODIS Level 2 Version 3.1.1 Software Patch](#))
A Patch to the IMAPP MODIS Level 2 Software that improves Terra retrievals after the Terra Safe-Hold event that occurred in February 2016.

July 17, 2017 ([AIRS/AMSU/HSB Processing Package for Direct Broadcast v6.0](#))
New package for the creation of AIRS/AMSU/HSB Level 1 and Level 2 retrievals from direct broadcast data. Software is provided by the NASA Jet Propusion Lab (JPL).

April 27, 2017   ([MODIS/VIIRS Polar2Grid Reprojection Software Version 2.1](#))
Update to the software that enables users to easily create high quality reprojected Polar Orbiter Satellite imagery, including MODIS and VIIRS GeoTIFFs, AWIPS NetCDF files as well as 24 bit True Color and False Color imagery in a selection of projections or grids for entire swaths of data or covering a user defined region. This version includes updates that allow overlays of coastlines, political boundaries and latitude/longitude grids as well as adding color maps to Polar2Grid GeoTIFF output files.

December 2, 2016   ([MODIS/VIIRS Aerosol Air Quality Forecast Software Version 1.2](#))
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 addition of support for the Suomi NPP VIIRS instrument AOD retrievals.

November 7, 2016   ([MODIS Infrared Band Destriping Version 1.3 Release](#))
Update to the coefficient files and main run script that are part of the software package to remove artificial striping in the infrared data due to noise and mirror side differences. The main change is an updated Terra MODIS coefficient file that is effective for the time period after the February 2016 safe hold event.

July 15, 2016   ([MODIS Aerosol Visibility and Fog/Low Stratus Aviation Weather Hazard Forecast Software Version 1.0](#))
First release of software that identifies potential aviation hazards due to Aerosols and Fog/Low Stratus. This package consists of two algorithms, both developed in preparation for the United States GOES-R Advanced Baseline Imager (ABI) instrument launch, and ported for use with MODIS. Inputs include MODIS Level 1B and Level 2 products and Global Forecast System (GFS) Numerical Weather Prediction (NWP) grib2 files. Outputs consist of one HDF4 data file, as well as output product imagery showing regions of reduced visibility due to aerosols, and probabilities of Instrument Flight Rules (MVFR,IFR,LIFR) on a map.

March 11, 2016   ([MODIS GeoTIFF Web Mapping Service (WMS) Display Package Version 2.0](#))
Updated release of the software package that provides users with the capability to display and share GeoTIFF products through a web browser in a Google Maps interface. It is designed specifically for display of MODIS and VIIRS default GeoTIFF files created by the [Polar2Grid](#) reprojection software package. It is distributed in the form of a virtual machine (VM). Updates include improved VM speed and efficiency, expanded number of supported imagery products, more display sharing options and more map overlay options.

February 22, 2016   ([Aqua and Terra HYDRA2 Multispectral Data Analysis Toolkit Version 2.0](#))
New release of the HYDRA2 visualization and analysis toolkit for interrogating NASA EOS Aqua and Terra and JPSS S-NPP instrument data. This toolkit was developed to assist research and development of remote sensing applications as well as education and

training of remote sensing scientists. This update includes improvements in toolkit functionality and usability.

October 12, 2015   (MODIS Polar2Grid Reprojection Software Version 2.0)

Update to the software that enables users to create reprojected MODIS L1B GeoTIFF, AWIPS NetCDF files as well as 24 bit True Color and False Color imagery in a selection of projections or grids for entire swaths of data or covering a user defined region. This version includes updates that allow the creation of output KMZ, Binary and HDF5 data formats as well.

September 3, 2015   (MODIS Aviation Weather Forecast Software Version 1.1)

Update to the software that identifies potential aviation hazards from overshooting convective thunderstorm tops. The software uses input MODIS Level 1B 1km files to produce an output HDF4 file that contains the locations of the overshooting tops as well as images that display the areal coverage of the potential hazards that surround them. This update includes improved python image creation scripts and improvements to the ancillary data identification and download.

April 24, 2015   (IMAPP Virtual Appliance Version 2.0 Release)

Updated release of a stand-alone processing system for MODIS direct broadcast data. This release includes updates to the MODIS L1B and Level 2 processing packages as well as an update to a 64 bit Lubuntu Virtual Machine. The software is supported on Windows, Mac OS X and Linux Operating Systems.

March 16, 2015   (MODIS Level 2 Product Software Update Version 3.1)

Update to the IMAPP MODIS Level 2 software package that includes support for the MODIS atmosphere products. This update includes the addition of the MOD06OD optical properties Collect 6 NASA baselined software that generates the Cloud Effective Radius and Cloud Optical Thickness products

August 28, 2014   (MODIS L1B GeoTIFF Reprojection Software Version 1.2)

Update to the software (Polar2Grid) that enables users to create reprojected MODIS L1B, GeoTIFF files as well as 24 bit True Color GeoTIFF files, in a selection of projections or grids to use for the remapping, for entire swaths of data or covering a user defined region. This software also creates reprojections in a format required for display in the US National Weather Service AWIPS visualization system.

August 8, 2014   (MODIS Level 2 Product Software Update Version 3.0)

Update to the IMAPP MODIS Level 2 product generation package that includes the MODIS atmosphere products. This update includes major changes including the inclusion of NASA baselined Collect 6 atmosphere software, which will create products identical in format (including metadata) as the official archived HDF4 product files.

1.2 IMAPP Users' Group Meetings

The community of IMAPP users gathered for the 2nd and 3rd IMAPP Users' Group Meetings; one was hosted at the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) in Darmstadt Germany, 14-16 April 2015. The other was hosted at the University of Wisconsin-Madison Fluno Center on 27-29 June 2017.   More than 60 direct broadcast users from more than 20 global organizations attended each meeting, presented their

applications and provided guidance on IMAPP products, uses and priorities. Workshop websites containing all meeting materials are available at:

> http://www.ssec.wisc.edu/meetings/cspp/2015/index.html
> http://www.ssec.wisc.edu/meetings/cspp/2017/index.html

1.3 Outreach - Direct Broadcast Applications Workshops

IMAPP outreach focused on teaching direct broadcast applications workshops. The goal of the workshops is to make local users aware of the myriad of data and products that are available from direct broadcast, to present some example applications of local interest and foster the next generation of remote sensing scientists.

The workshops follow a pattern of morning lectures, and afternoon hands on labs to apply the lessons learned during the morning sessions. Local data is used. The last workshop day consists of students choosing a topic of interest to investigate with their local data, and presenting their research results.

The Direct Broadcast workshop materials used are freely distributed, including the lectures, labs and software from the website:
> http://cimss.ssec.wisc.edu/dbs/

Three workshops were hosted during the reporting period:

a). A workshop was taught by University of Wisconsin personnel in Miami, Florida in February 2015, entitled "Satellite Direct Broadcast in Support of Real-Time Environmental Applications". The workshop featured IMAPP MODIS direct broadcast products, including applications to forecasting and monitoring of tropical weather, cyclones and U.S. fisheries. Attendees included National Weather Service Forecasters from the Miami office, National Hurricane Center (NHC) forecasters, researchers from the NOAA Hurricane Research Division (HRD), and US Fisheries personnel.

The antenna located at NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML) now acquires, processes and distributes data in near-real-time to support a number of users, including the NHC.

b). A second Direct Broadcast Applications Workshop was taught in support of an antenna installed at the University of Puerto Rico at Mayagüez, 26-29 April 2016. The attendees included professors and graduate students in the fields of environmental research and applications.

c). The third Direct Broadcast Applications Workshop was taught in support of an antenna installed at the University of Hampton in Virginia, 6-9 June 2017. The course was taught in cooperation with Dr. William Smith, Sr., who is a distinguished professor at the University. About 20 students attended the workshop, including NASA Langly scientists Kris Bedka and

Sarah Bedka. Figure 3 shows students using HYDRA2 during one of the afternoon labs to investigate features in a locally acquired MODIS data set.

Figure 3. Students using HYDRA2 to investigate a MODIS scene as part of the 2017 Hampton University Direct Broadcast Applications workshop.

1.4 - An example of one Direct IMAPP Application

The goal of the IMAPP project is to facilitate the near-real-time use of NASA data. Through user interactions, it is known that IMAPP supports a wide variety of global environmental decisions makers. Here is one example from the United States.

1.4.1 Supporting Air Quality Environmental Decision Makers

A software package in support of air quality forecasters, called Infusing satellite Data into Environmental air quality Applications – International (IDEA-I) Ozone, was released that allows users to identify stratospheric ozone intrusions and forecast the 48-hour movement of the airmass in three dimensions. The software uses the single Field-of-View (FOV) University of Wisconsin Dual Regression retrievals of AIRS, CrIS and IASI ozone, temperature, and water vapor as input to identify the stratospheric instrustions. Trajectories are initialized in regions of high ozone concentrations above 500 hPa; those regions are then projected forward using the US Numerical Weather Prediction (NWP) Global Forecast System (GFS) model forecast wind fields in 3 dimensions. The trajectories are color coded based on their elevation so that locations can be identified where the ozone will impact humans at the surface. The shade of pink becomes progressively darker as the trajectory nears the surface.

The software is globally configurable; a simple configuration file edit allows users to set the boundaries of their domain. There are options to use either AIRS, CrIS or IASI products, to set the download of required ancillary data, or process and use either their own Direct Broadcast acquired data, or archived products from a NASA near-real time or LAADS server.

This software is extremely useful for Western high elevation states, where air quality monitors need to validate the source of elevated pollution levels. If the levels are really high, the states can be fined unless they can prove the source of the pollution is from a natural event. One such case occurred on 6 June 2012.

Raised levels of ozone in the troposphere are usually caused by anthropogenic sources such as smog or related polluting factors, but on occasion an SI event – a downward transport of stratospheric air that pushes its way very deeply into the troposphere – can increase ozone content to dangerous levels. Surface monitors in Wyoming showed that the concentration of ozone in the air reached nearly 100 parts per billion (ppb), with 8 hour averages registering above the 75 ppb public health standard established by the Environmental Protection Agency (EPA).

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. IMAPP IDEA-I was a tool that the team started with to determine the possible source of the elevated ozone levels were due to stratospheric ozone intrusion (exception event). Using the evidence gathered 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.

This investigation was published in 2017: Kaldunski, B., Pierce, B., & Holloway, T. (2017). When Stratospheric Ozone Hits Ground-level Regulation: Exceptional Events in Wyoming. Bulletin of the American Meteorological Society, 98(5), 889-892.

The IDEA-I product is used daily during the winter months to monitor the risk of stratospheric intrusions in the higher elevations of the Western United States.

1.5 Accomplishments versus Proposed Goals for Reporting Period

The main task for IMAPP since its inception has been to port the MODIS Atmosphere Science Team software for stand alone execution by the direct broadcast user community. The most recent science software (Collection 6.1) has been ported but was never released through IMAPP, because the Collect 6.1 Level 1B software is not yet available for direct broadcast users (the direct broadcast MODIS Level 1B software is ported and released by the NASA Ocean Biology Processing Group). After conversations with the MODIS Science Team, it was determined that it was not advisable to distribute the Atmosphere Group Collection 6.1 software before the 6.1 Level 1B was available, because the science results applied to the Collect 6.0

Level 1B data would not produce valid retrievals. The two need to be used together. Perhaps future funding will allow us to release this software.

2.0 Dissemination of Results

All IMAPP software is freely distributed via the IMAPP website:

http://cimss.ssec.wisc.edu/imapp/.

In addition, all IMAPP data and products created in real-time from Aqua and Terra data acquired from the two University of Wisconsin antennas, is merged and staged on anonymous ftp sites:

ftp://ftp.ssec.wisc.edu/pub/eosdb/aqua/
ftp://ftp.ssec.wisc.edu/pub/eosdb/terra/

MODIS and AIRS data is also available via Man-computer Interactive Data Access System (McIDAS) servers which allow easy delivery of subsetted data.
Finally, IMAPP products are created and distributed to 61 different US National Weather Service Forecast (NWS) forecast offices. The data is reprojected and reformatted for display in the US NWS AWIPS-II visualization and analysis toolkit using the IMAPP Polar2Grid software. The MODIS data has been mentioned as a decision making tool in forecaster Area Forecast Discussions more than 400 times since we began distributing the products to local offices in 2006.

UW SSEC continued to provide real-time Terra and Aqua products to a number of other 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:

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

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-Earth UW SSEC Web Mapping Interface
http://realearth.ssec.wisc.edu/

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

United States Forest Service
https://fsapps.nwcg.gov/gisdata.php

IMAPP MODIS/VIIRS Web Mapping Service
http://imapp.ssec.wisc.edu:8001/

College of Earth, Ocean, and Environment, University of Delaware University
http://muenchow.cms.udel.edu/html/remotesensing.html

Peer Reviewed Publications:

Jang, Hyun-Sung, et al. "Improved AIRS Temperature and Moisture Soundings with Local A Priori Information for the 1DVAR Method." *Journal of Atmospheric and Oceanic Technology* 34.5 (2017): 1083-1095.

Greenwald, Thomas J., et al. "Real-Time Simulation of the GOES-R ABI for User Readiness and Product Evaluation." *Bulletin of the American Meteorological Society* 2015 (2015).

Kaldunski, B., Pierce, B., & Holloway, T. (2017). When Stratospheric Ozone Hits Ground-level Regulation: Exceptional Events in Wyoming. Bulletin of the American Meteorological Society, 98(5), 889-892.

Rink, T., Menzel, W. P., Gumley, L., & Strabala, K. (2015). HYDRA2-A Multispectral Data Analysis Toolkit for sensors on Suomi NPP and other current satellite platforms. *Bulletin of the American Meteorological Society*, (2015).

Smith, N., W. L. Smith Sr., E. Weisz & H. E. Revercomb (2015), AIRS, IASI, and CrIS Retrieval Records at Climate Scales: An Investigation into the Propagation of Systematic Uncertainty. *J. Appl. Meteor. Climatol.*, 54, 1465–1481.

Weisz, Elisabeth, Nadia Smith, and William L. Smith. "The use of hyperspectral sounding information to monitor atmospheric tendencies leading to severe local storms." *Earth and Space Science* (2015).

Global IMAPP User Publications

Mhawish, A., Kumar, M., Mishra, A. K., Srivastava, P. K., & Banerjee, T. (2018). Remote sensing of aerosols from space: retrieval of properties and applications. In *Remote Sensing of Aerosols, Clouds, and Precipitation* (pp. 45-83).

Bognár, Péter, et al. "Yield estimation and forecasting for winter wheat in Hungary using time series of MODIS data." International Journal of Remote Sensing 38.11 (2017): 3394-3414.

Dumitrache, R. C., Iriza, A., Maco, B. A., Barbu, C. D., Hirtl, M., Mantovani, S., & Diamandi, A. (2016). Study on the influence of ground and satellite observations on the

numerical air-quality for PM10 over Romanian territory. Atmospheric Environment, 143, 278-289.

Hirtl, Marcus, et al. "Improvement of air quality forecasts with satellite and ground based particulate matter observations." Atmospheric Environment 84 (2014): 20-27.

Liu, Yi, et al. "Software to facilitate remote sensing data access for disease early warning systems." *Environmental Modelling & Software* 74 (2015): 247-257.

Murphy, Kevin J., et al. "LANCE, NASA's Land, Atmosphere Near Real-Time Capability for EOS." *Time-Sensitive Remote Sensing*. Springer New York, 2015. 113-127.

Recondo, Carmen, Juan Carlos Fernández-Iglesias, and Juanjo Peón. "Distribución de productos MODIS por parte de la Universidad de Oviedo." Teledetección: Humedales y Espacios Protegidos. XVI Congreso de la Asociación Española de Teledetección, pp. 199-202. Sevilla 21-23 Octubre 2015.

Arlene M. Fiore, R. Bradley Pierce, Russel R. Dickerson, and Meiyun Lin. "Detecting and Attributing Episodic High Background Ozone Events". Air & Waste Management Association Magazine for Environmental Managers, Februrary 2014, pp. 22-28.

Brian N. Duncan, Ana I. Prados, Lok N. Lamsal, Yang Liu, David G. Streets, Pawan Gupta, Ernest Hilsenrath, Ralph A. Kahn, J. Eric Nielsen, Andreas J. Beyersdorf, Sharon P. Burton, Arlene M. Fiore, Jack Fishman, Daven K. Henze, Chris A. Hostetler, Nickolay A. Krotkov, Pius Lee, Meiyun Lin, Steven Pawson, Gabriele Pfister, Kenneth E. Pickering, R. Bradley Pierce, Yasuko Yoshida, Luke D. Ziemba. "Satellite data of atmospheric pollution for U.S. air quality applications: Examples of applications, summary of data end-user resources, answers to FAQs, and common mistakes to avoid." Atmospheric Environment, Vol. 94, September 2014, pp. 647-662. doi: 10.1016/j.atmosenv.2014.05.061.

Juan José Peón, Carmen Recondo, and Javier F. Calleja, "Improvements in the estimation of daily minimum air temperature in peninsular Spain using MODIS land surface temperature." International Journal of Remote Sensing, Vol. 35, Iss. 13, 2014. doi: 10.1080/01431161.2014.935831.

Kern Aniko, Bognar Peter, Pasztor Szilard, Timar Gabor, Lichtenberger Janos, Ferencz Csaba, Steinbach Peter, Ferencz Orsolya. "Kozvetlen vetelu MODIS adatok alkalmazasai Magyarorszag tersegere." Remote Sensing Technologies & GIS, June 2014, No. 1, pp. 5-13.

Yang Lei, Feng Xiaohu, LV Ke, and Shang Jian. "Automated Landmark Matching of FY-2 Visible Imagery with Its Applications to the On-Orbit Image Navigation Performance Analysis and Improvements." Chinese Journal of Electronics, Vol. 23, No. 3, July 2014, pp. 649-654.

Science Conference Presentations

Strabala, K., Davies, J. & Cintineo, R. (2017). NASA International MODIS/AIRS Processing Package (IMAPP): Current Status and Future Plans. Where do we go from here? Oral presentation. 21st International TOVS Study Conference (ITSC-21), 29 November – 5 December 2017, Darmstadt, Germany.

Strabala, K. Davies, J. & Cintineo, R. (2017). IMAPP: Where do we go from here? Oral Presentation at the CSPP/IMAPP Users' Group Meeting, Madison, Wisconsin, 27-29 July 2017.

Kern, A. (2017). Estimation and forecast of winter wheat yield in Hungary using Direct Broadcast MODIS data. Oral Presentation at the CSPP/IMAPP Users' Group Meeting, Madison, Wisconsin, 27-29 July 2017.

Liu, Y. (2017). Performance and application of IMAPP/CSPP in East China. Oral Presentation at the CSPP/IMAPP Users' Group Meeting, Madison, Wisconsin, 27-29 July 2017.

Lapeta, B. (2017). The use of Direct Broadcast Processing System in Poland. Oral Presentation at the CSPP/IMAPP Users' Group Meeting, Madison, Wisconsin, 27-29 July 2017.

Strabala, K., Gumley, L., Huang, A. & Menzel, W.P. (2017). Meteorological Satellite Training Workshops – From Theory to Application. Oral Presentation at the 97th AMS Annual Meeting, Seattle, Washington, 22-26 January 2017.

Davies, J., Strabala, K., Smith, N., Weisz, E., Peirce, B., Barnet, C., Gambacorta, A. & Huang, A. (2016). IDEA-I: A Globally Configurable IMAPP Air Quality Forecast Software Package using Suomi-NPP, Terra and Aqua Aerosol and Trace Gas Retrievals. Keynote oral presentation at the 2016 EUMETSAT Satellite Conference, Darmstadt, Germany, 26-30 September 2016.

Davies, J., Strabala, K., Pierce, B. & Cintineo, R. (2016). International MODIS and AIRS Processing Package (IMAPP) Implementation of Infusion of Satellite Data into Environmental Applications-International (IDEA-I) for Air Quality Forecasts using Suomi-NPP, Terra and Aqua Aerosol Retrievals. Poster presentation at the AGU Fall Meeting, 12-16 December 2017, San Francisco, California.

Cintineo, R. Rebecca C., Strabala, K., Gumley, L., Huang, H.-L., Davies, J., Borbas, E., Weisz, E. & Pierce, B. (2015). IMAPP: Supporting the Aqua and Terra Operational Community". Poster Presentation at the CSPP/IMAPP Users' Group Meeting, EUMETSAT, Darmstadt, Germany, 14-16 April 2015.

Hoese, D. (2015). Polar2Grid Version 2.0. Oral Presentation at the CSPP/IMAPP Users' Group Meeting, EUMETSAT, Darmstadt, Germany, 14-16 April 2015.

Kern, A. (2015). Monitoring Vegetation Activity in Hungary using Direct Broadcast MODIS data. Oral Presentation at the CSPP/IMAPP Users' Group Meeting, EUMETSAT, Darmstadt, Germany, 14-16 April 2015.

Smith, N., B. Zavodsky et al., Novel Applications of Temperature Soundings in High Latitude Regions-Aviation in Alaska (poster), 20th International TOVS Study Conference (ITSC-20), 28 October - 3 November 2015, Lake Geneva, Wisconsin, USA.

Smith, W. L., E. Weisz, N. Smith, The Retrievals of Atmospheric Profiles from Satellite Radiances for NWP Data Assimilation, 20th International TOVS Study Conference (ITSC-20), 28 October - 3 November 2015, Lake Geneva, Wisconsin, USA.

Strabala, K., Gumley, L., Huang, H.-L., Cintineo, R., Hoese, D., Davies, J. & Pierce, B. (2016). Aqua and Terra Polar Orbiter Direct Broadcast Data in Support of Operational Environmental Forecasters. Oral Presentation at the AMS Annual Meeting, New Orleans, Louisiana, 13 January 2016.

Strabala, K., Gumley, L., & Huang, H.-L. (2015). IMAPP: Supporting Aqua and Terra Direct Broadcast Users for 15 Years. Oral Presentation at the CSPP/IMAPP Users' Group Meeting, EUMETSAT, Darmstadt, Germany, 14-16 April 2015.

Strabala, K., Gumley, L., & Huang, H.-L. (2015). IMAPP: Supporting Aqua and Terra Direct Broadcast Users for 15 Years. Oral Presentation at the Internationa TOVS Study Conference, Lake Geneva, Wisconsin, 28 October 2015.

Weisz, E., N. Smith, W. L. Smith, Satellite-based Hyperspectral Sounder Retrievals in Real-time Weather Applications, 2015 AGU Fall Meeting, 14-18 December, San Francisco, California, USA.

Weisz, E., W. L. Smith, N. Smith, Assessing Hyperspectral Retrieval Algorithms and their Products for Use in Direct Broadcast Applications, 20th International TOVS Study Conference (ITSC-20), 28 October - 3 November 2015, Lake Geneva, Wisconsin, USA.

Cintineo, R. J. Davies, B. Pierce, E. Weisz, N. Smith, and K. Strabala: IDEA-I Air Quality Forecast Software Package: Aerosol, Ozone, and Carbon Monoxide Detection and Trajectories, poster presented at the 19th International TOVS Study Conference, 26 March 2014 – 1 April 2014, Jeju Island, South Korea.

Smith, J., E. Weisz, and W. L. Smith: An Overview of the UW Hyperspectral Retrieval System for AIRS, IASI and CrIS, presented at the 19th International TOVS Study Conference, 26 March 2014 – 1 April 2014, Jeju Island, South Korea.

Strabala, K., L. Gumley, A. Huang, R. Cintineo: International MODIS/AIRS Processing Package (IMAPP): Proof that Polar Orbiter Data is Useful to Operational Weather Forecasters, presented at the 19th International TOVS Study Conference, 26 March 2014 – 1 April 2014, Jeju Island, South Korea.

Barabara Arvani, R. Bradley Pierce, Sergio Teggi, Grazia Ghermandi, Luca Lombroso: Study of Saharan dust outbreak episode over the Po valley (northern Italy) using IDEA-international air quality forecast product, presented at 1st International Conference on Atmospheric Dust, 1-6 June 2014, Castellaneta Marina, Italy.

Cintineo, R., K.I. Strabala, L.E. Gumley, A. Huang, E. Borbas, E. Weisz, and B. Pierce, IMAPP: Supporting the Aqua and Terra Operational Community, poster presented at the 95th AMS Annual Meeting, 4-8 January 2015, Phoenix, Arizona.