International MODIS/AIRS Processing Package (IMAPP)

Where do we go from here?

Kathleen Strabala, James Davies, Rebecca Cintineo
Space Science and Engineering Center (SSEC)
University of Wisconsin - Madison
and a cast of thousands ….

Colleagues

Brad Pierce, Elisabeth Weisz, Eva Borbas, Robert Aune, William Straka, Scott Mindock, Ray Garcia, Graeme Martin, Nadia Smith, Rebecca Cintineo, Dave Hoese, Eva Schiffer, Katja Hungershöfer, Jeff Key, Jordan Gerth, Scott Bachmeieir, Mike Pavolonis, Crystal Schaaf, Yanmin Shuai, Peter Albert, Kris Bedka, Nigel Atkinson, Denis Denis Margetic, Tom Heinrichs, Dayne Broderson, Peter (Kung-Hwa) Wang, Aniko Kern, Christelle Ponsard, Philip Frost, Riris Adriyanto, Wei Gao, Jerrold Robaidek, Rosie Spangler, Paul Menzel, Tom Rink, Maria Vasys, Jerrold Robaidek, Rosie Spangler, Janean Hill, Douglas Ratcliff, Kevin Hallock, Nick Bearson, Richard Frey, Chris Moeller, Steve Ackerman, Dave Santek, Russ Dengel, William Smith, Scott Nolin, John LaLande, Bill Bellon

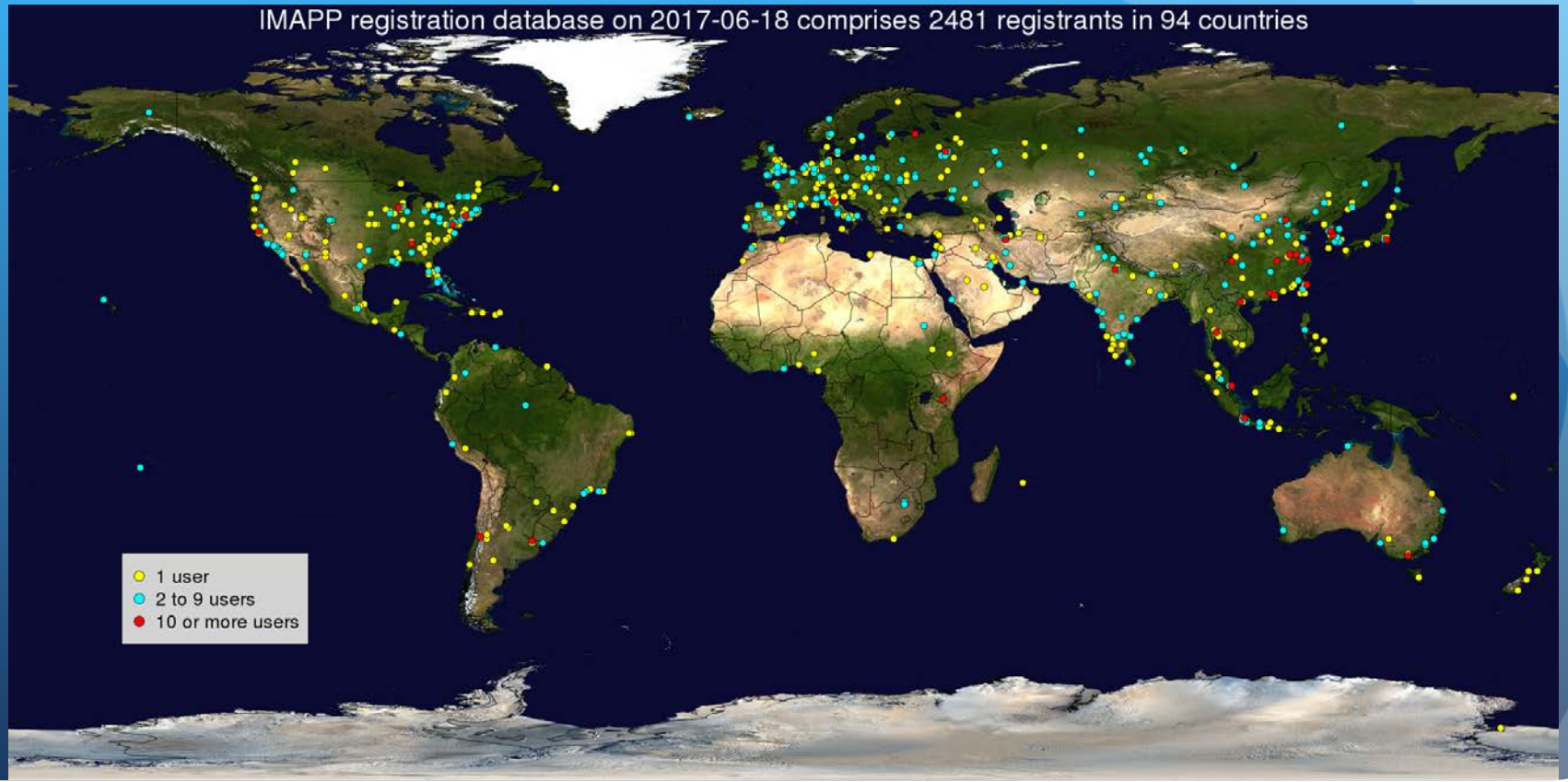
Collaborations

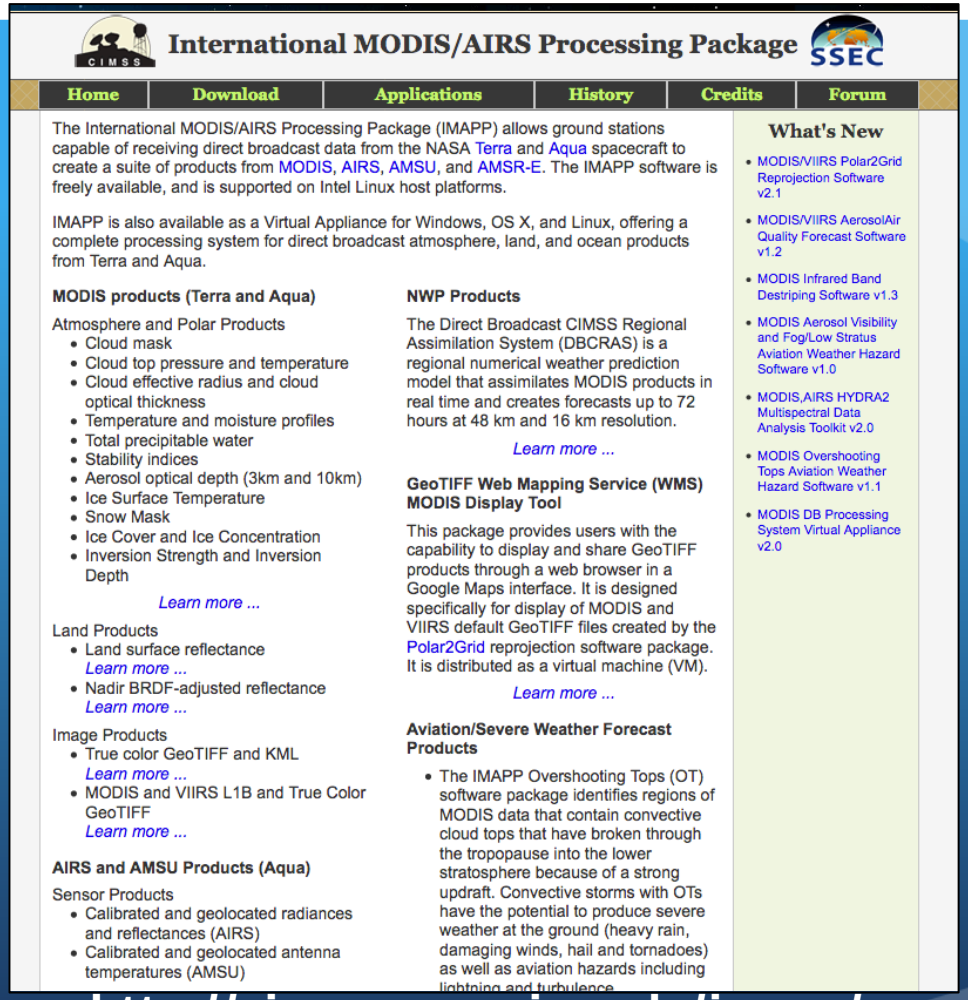
- UW SSEC
- NOAA/STAR
- Boston University
- NASA Goddard Space Flight Center
- Instituted für Weltraumwissenschaften, Freie Universität, Berlin, Germany
- German Weather Service (DWD)
- NASA Langley
- NASA SPoRT
- Met Office
- NWS
- Taiwan Central Weather Bureau, Taipei
- Australian Bureau of Meteorology
- Eötvös Loránd University, Budapest, Hungary
- East China Normal University, Shanghai, China
- GINA Alaska
- EUMETSAT
- BMKG, Indonesian Agency for Meteorology, Climatology and Geophysics
- CSIR South Africa
- INPE/CPTEC Brazil
- Jet Propulsion Lab (JPL)

What is IMAPP?

- The International MODIS/AIRS Processing Package is a collection of software systems for processing data from NASA Aqua and Terra satellites.
- The primary goal of IMAPP is to facilitate and promote the use of Level 1 and Level 2 products for environmental applications.
- Funding is supplied by NASA.

IMAPP Registrants





International MODIS/AIRS Processing Package

Home | Download | Applications | History | Credits | Forum

The International MODIS/AIRS Processing Package (IMAPP) allows ground stations capable of receiving direct broadcast data from the NASA Terra and Aqua spacecraft to create a suite of products from MODIS, AIRS, AMSU, and AMSR-E. The IMAPP software is freely available, and is supported on Intel Linux host platforms.

IMAPP is also available as a Virtual Appliance for Windows, OS X, and Linux, offering a complete processing system for direct broadcast atmosphere, land, and ocean products from Terra and Aqua.

MODIS products (Terra and Aqua)

Atmosphere and Polar Products

- Cloud mask
- Cloud top pressure and temperature
- Cloud effective radius and cloud optical thickness
- Temperature and moisture profiles
- Total precipitable water
- Stability indices
- Aerosol optical depth (3km and 10km)
- Ice Surface Temperature
- Snow Mask
- Ice Cover and Ice Concentration
- Inversion Strength and Inversion Depth

Learn more ...

Land Products

- Land surface reflectance
  Learn more ...
- Nadir BRDF-adjusted reflectance
  Learn more ...

Image Products

- True color GeoTIFF and KML
  Learn more ...
- MODIS and VIIRS L1B and True Color GeoTIFF
  Learn more ...

AIRS and AMSU Products (Aqua)

Sensor Products

- Calibrated and geolocated radiances and reflectances (AIRS)
- Calibrated and geolocated antenna temperatures (AMSU)

NWP Products

The Direct Broadcast CIMSS Regional Assimilation System (DBCRAS) is a regional numerical weather prediction model that assimilates MODIS products in real time and creates forecasts up to 72 hours at 48 km and 16 km resolution.

Learn more ...

GeoTIFF Web Mapping Service (WMS) MODIS Display Tool

This package 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 as a virtual machine (VM).

Learn more ...

Aviation/Severe Weather Forecast Products

- The IMAPP Overshooting Tops (OT) software package identifies regions of MODIS data that contain convective cloud tops that have broken through the tropopause into the lower stratosphere because of a strong updraft. Convective storms with OTs have the potential to produce severe weather at the ground (heavy rain, damaging winds, hail and tornadoes) as well as aviation hazards including lightning and turbulence

What's New

- MODIS/VIIRS Polar2Grid Reprojection Software v2.1
- MODIS/VIIRS AerosolAir Quality Forecast Software v1.2
- MODIS Infrared Band Destriping Software v1.3
- MODIS Aerosol Visibility and Fog/Low Stratus Aviation Weather Hazard Software v1.0
- MODIS,AIRS HYDRA2 Multispectral Data Analysis Toolkit v2.0
- MODIS Overshooting Tops Aviation Weather Hazard Software v1.1
- MODIS DB Processing System Virtual Appliance v2.0

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

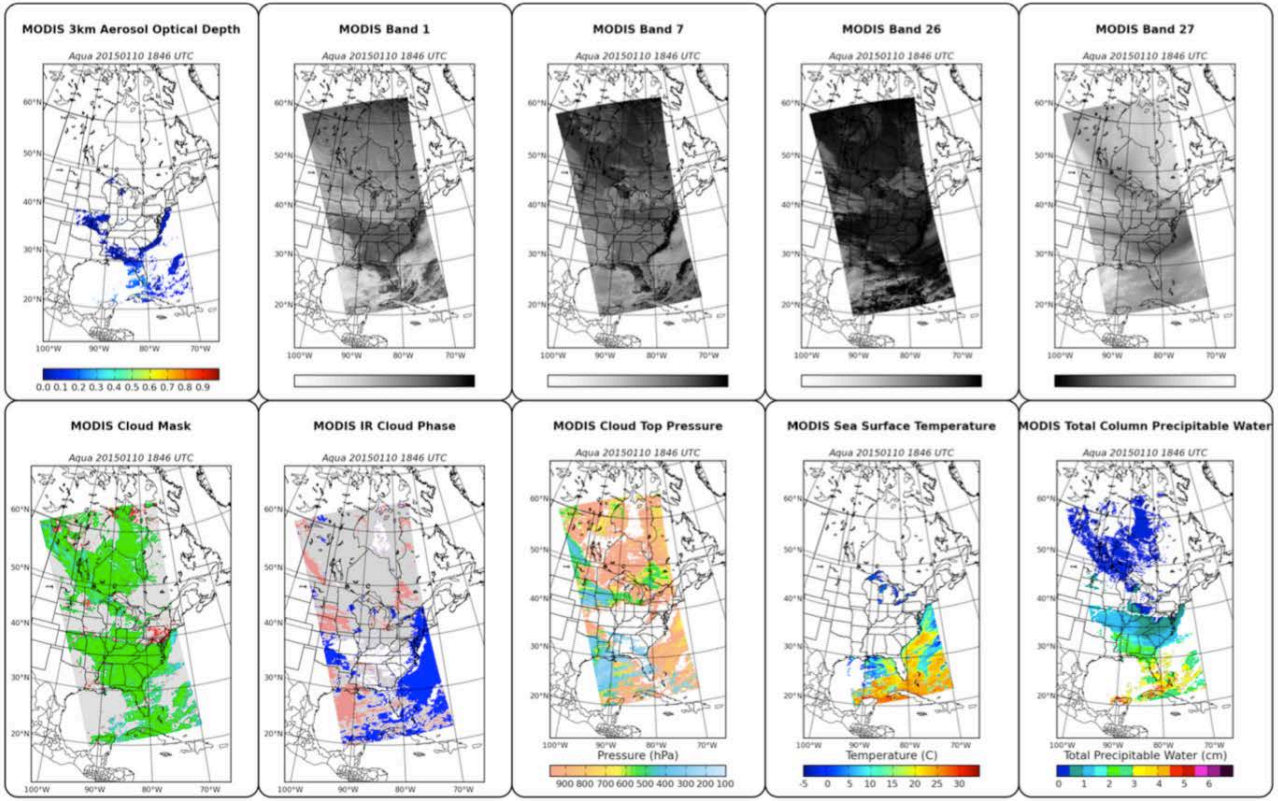
Suite of Products

MODIS Products (Terra and Aqua)

- **Atmosphere Group Collect 6 – MODIS Science Team Software**
  - Cloud mask (MOD35)
  - Cloud top pressure and temperature (MOD06CT)
  - Cloud effective radius and cloud optical thickness (MOD06OD)
  - Temperature and moisture profiles (MOD07)
  - Total precipitable water (MOD07)
  - Stability indices (MOD07)
  - Aerosol optical depth (3km and 10km) (MOD04)
  - Bright Target Aerosol Optical Depth (Deep Blue) (MOD04)

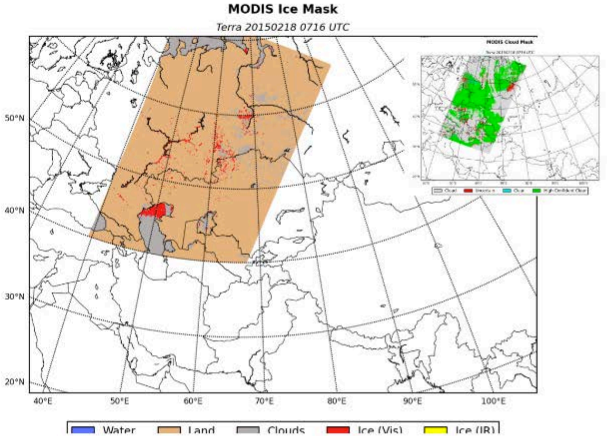
- **Polar Products from Jeff Key (NOAA Cryosphere Scientist)**
  - Ice Surface Temperature
  - Snow Mask
  - Ice Cover and Ice Concentration
  - Inversion Strength and Inversion Depth

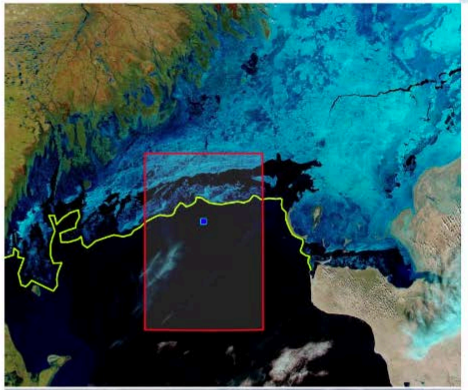
IMAPP MODIS Level 2 Products



MODIS Polar Product Use in Russia

IMAPP Polar products below 60N





Using MODIS images and data for sea-ice monitoring for navigation and oil extraction safety

Suite of Products

MODIS Land Products (Terra and Aqua)

- MODIS Surface Reflectance (MOD09)
- Nadir Bidirectional Reflectance Distribution Function (BRDF) MCD43 - Working with Crystal Schaaf

MODIS Image Products

- Polar2Grid reprojection software – David Hoese Poster
- True Color Reprojection for Display in Google Earth (DB Google Earth) – Full Resolution

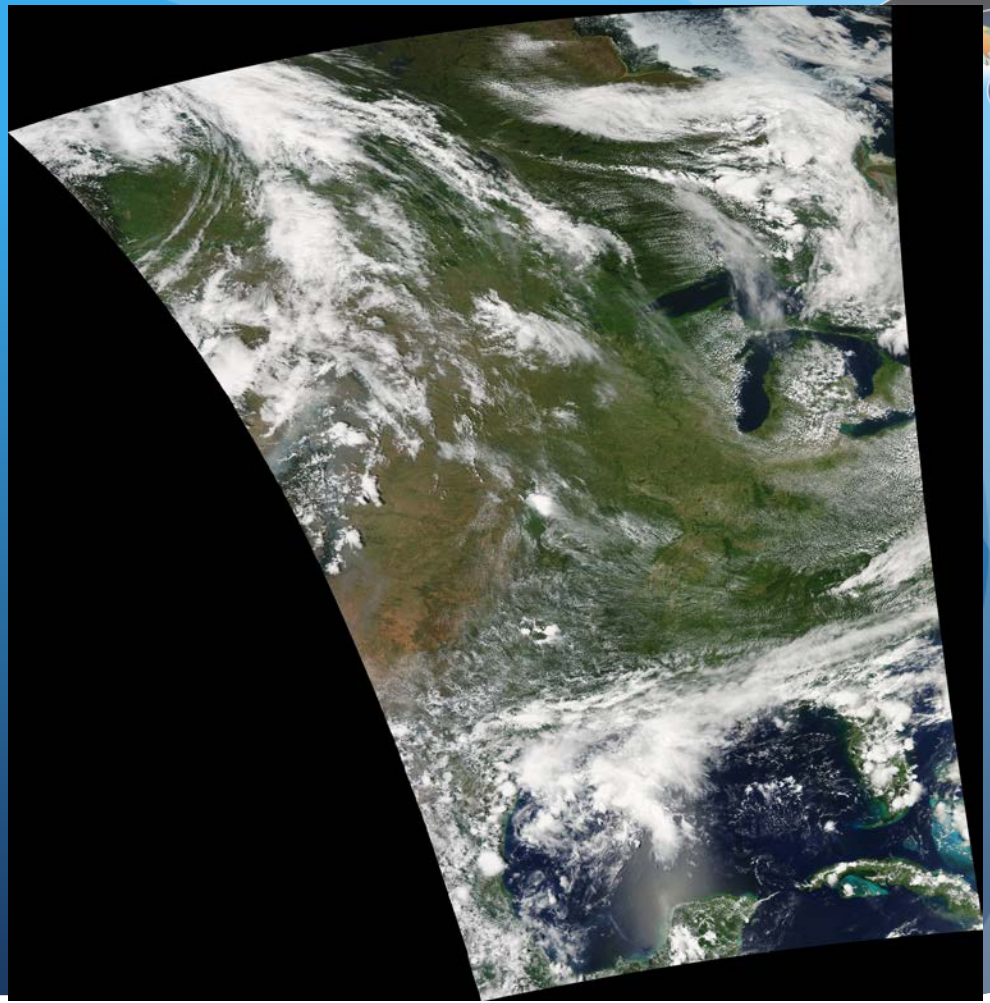
AIRS and AMSU Products (Aqua) from NASA Jet Propulsion Lab (JPL)

- Calibrated and geolocated radiances (AIRS)
- Calibrated and geolocated antenna temperatures (AMSU)

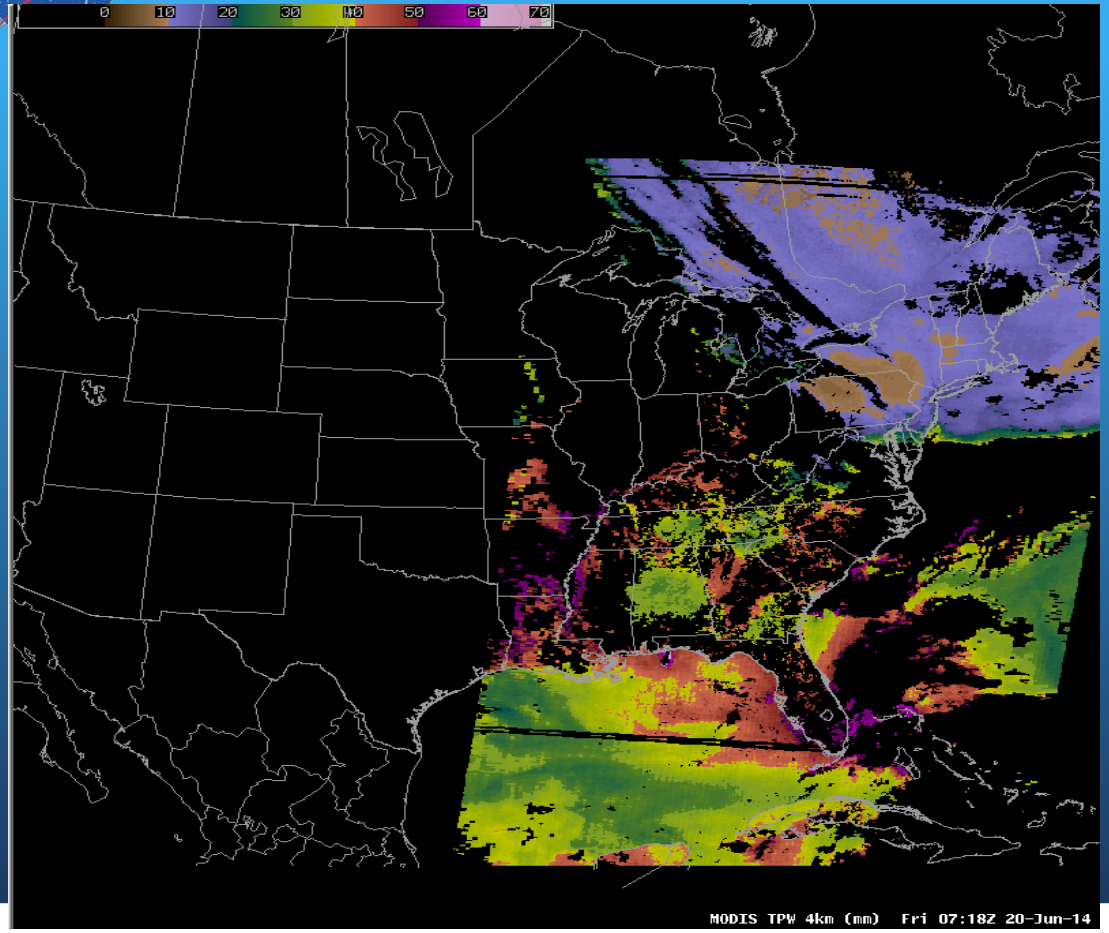
Polar2Grid

Easy to use interface to create high quality polar orbiter satellite data reprojections

polar2grid.sh modis crefl –f <dir>



AWIPS Forecasting POPs

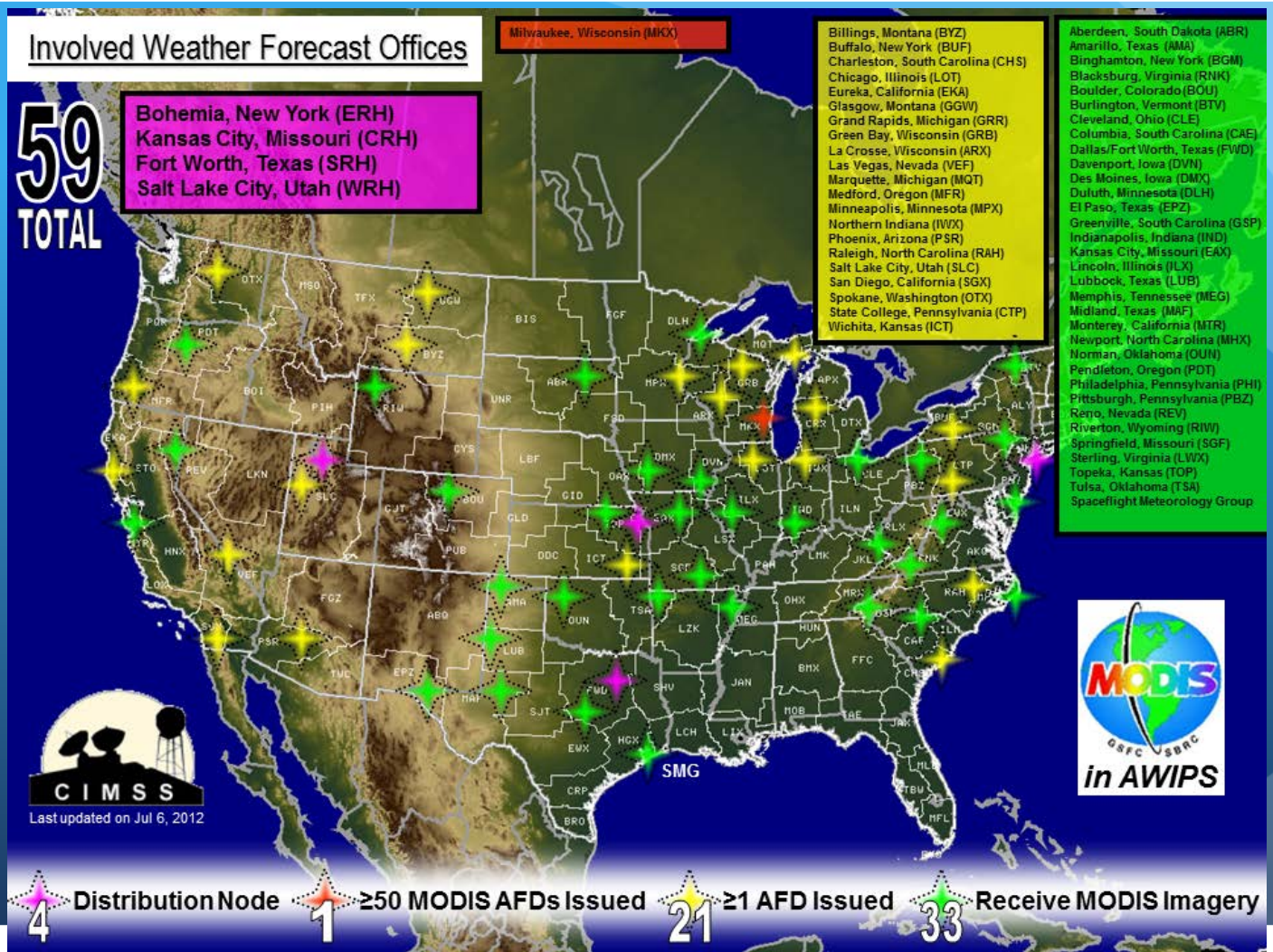


AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE
BROWNSVILLE TX
359 AM CDT FRI JUN 20 2014

FOR THE FORECAST BASED IT AROUND A SCENARIO WHERE THE GULF TROUGHINESS IS NOT QUITE AS PRONOUNCED...BUT THE DEEP 30 KNOT EASTERLY WINDS IN THE 850/700MB LAYER DO NOT GET QUITE AS CARRIED AWAY EITHER. THE WAVES IN QUESTION ARE CLEARLY PRETTY PRONOUNCED ON SATELLITE IMAGERY BUT NOT ASSOCIATED WITH MUCH PRECIP AT THE MOMENT AND ***AMSU/SSMI AND MODIS TOTAL PRECIPITABLE WATER IMAGERY APPEAR TO SUGGEST THERE IS NOT AS MUCH AVAILABLE MOISTURE AS THE ECMWF INITIALIZED.*** EVEN IF THE SYNOPTIC ECMWF SOLUTION WERE TO VERIFY THE 40 AND 50 PCT POPS PRESENTED BY ECX MOS APPEAR FAR TOO HIGH AND THUNDER WOULD BE DIFFICULT/IMPOSSIBLE IN A ZONE WITH LAPSE RATES AS POOR AS SHOULD BE IN PLACE. SO PAINTED LOW GRADE POPS/SHOWERS STARTING IN THE MORNING ALONG THE COAST WORKING INLAND THROUGH THE DAY AND INTO THE MORE FAVORED SEABREEZE ZONES BY AFTERNOON WEDNESDAY AND THURSDAY AND HUGGED BACK TOWARDS A DRIER SOLUTION ON FRIDAY.

Area Forecast Discussion
National Weather Service Milwaukee/Sullivan WI
949 AM CDT Thu Jun 1 2017

.MARINE…Light and variable winds over the nearshore waters will be turning onshore in the next 1-3 hours as lake breeze develops. Light pressure gradient due to nearby high pressure will result in wind speeds remaining mostly less than 10 knots. *Latest MODIS imagery shows Lake Michigan surface temperatures have warmed into the upper 40s to lower 50s in the near shore waters as well as to mid-lake. Average Lake Michigan surface water temperature running close to the long-term average for June 1st.*


Involved Weather Forecast Offices
59 TOTAL
Bohemia, New York (ERH)
Kansas City, Missouri (CRH)
Fort Worth, Texas (SRH)
Salt Lake City, Utah (WRH)
Milwaukee, Wisconsin (MKX)
Billings, Montana (BYZ)
Buffalo, New York (BUF)
Charleston, South Carolina (CHS)
Chicago, Illinois (LOT)
Eureka, California (EKA)
Glasgow, Montana (GGW)
Grand Rapids, Michigan (GRR)
Green Bay, Wisconsin (GRB)
La Crosse, Wisconsin (ARX)
Las Vegas, Nevada (VEF)
Marquette, Michigan (MQT)
Medford, Oregon (MFR)
Minneapolis, Minnesota (MPX)
Northern Indiana (IWX)
Phoenix, Arizona (PSR)
Raleigh, North Carolina (RAH)
Salt Lake City, Utah (SLC)
San Diego, California (SGX)
Spokane, Washington (OTX)
State College, Pennsylvania (CTP)
Wichita, Kansas (ICT)
Aberdeen, South Dakota (ABR)
Amarillo, Texas (AMA)
Binghamton, New York (BGM)
Blacksburg, Virginia (RNK)
Boulder, Colorado (BOU)
Burlington, Vermont (BTV)
Cleveland, Ohio (CLE)
Columbia, South Carolina (CAE)
Dallas/Fort Worth, Texas (FWD)
Davenport, Iowa (DVN)
Des Moines, Iowa (DMX)
Duluth, Minnesota (DLH)
El Paso, Texas (EPZ)
Greenville, South Carolina (GSP)
Indianapolis, Indiana (IND)
Kansas City, Missouri (EAX)
Lincoln, Illinois (ILX)
Lubbock, Texas (LUB)
Memphis, Tennessee (MEG)
Midland, Texas (MAF)
Monterey, California (MTR)
Newport, North Carolina (MHX)
Norman, Oklahoma (OUN)
Pendleton, Oregon (PDT)
Philadelphia, Pennsylvania (PHI)
Pittsburgh, Pennsylvania (PBZ)
Reno, Nevada (REV)
Riverton, Wyoming (RIW)
Springfield, Missouri (SGF)
Sterling, Virginia (LWX)
Topeka, Kansas (TOP)
Tulsa, Oklahoma (TSA)
Spaceflight Meteorology Group
SMG
CIMSS
Last updated on Jul 6, 2012
MODIS
GSFC SBRC
in AWIPS
4 Distribution Node
1 ≥50 MODIS AFDs Issued
21 ≥1 AFD Issued
33 Receive MODIS Imagery

Suite of Products

AIRS and AMSU Products (Aqua)

- 3x3 AIRS FOV retrievals – JPL (Collect 5)
- UW Dual Regression single FOV retrievals (AIRS, CrIS, IASI)
- Collocated AIRS/MODIS FOVs
- AIRS/AMSU HDF4 to BUFR Converter with UK Met Office (Meeting request from John Le Marshall at BOM)

AMSR-E Products

- Calibrated and Geolocated Antenna Temperatures
- Rain Rate
- Soil Moisture
- Snow Water Equivalent

Suite of Products

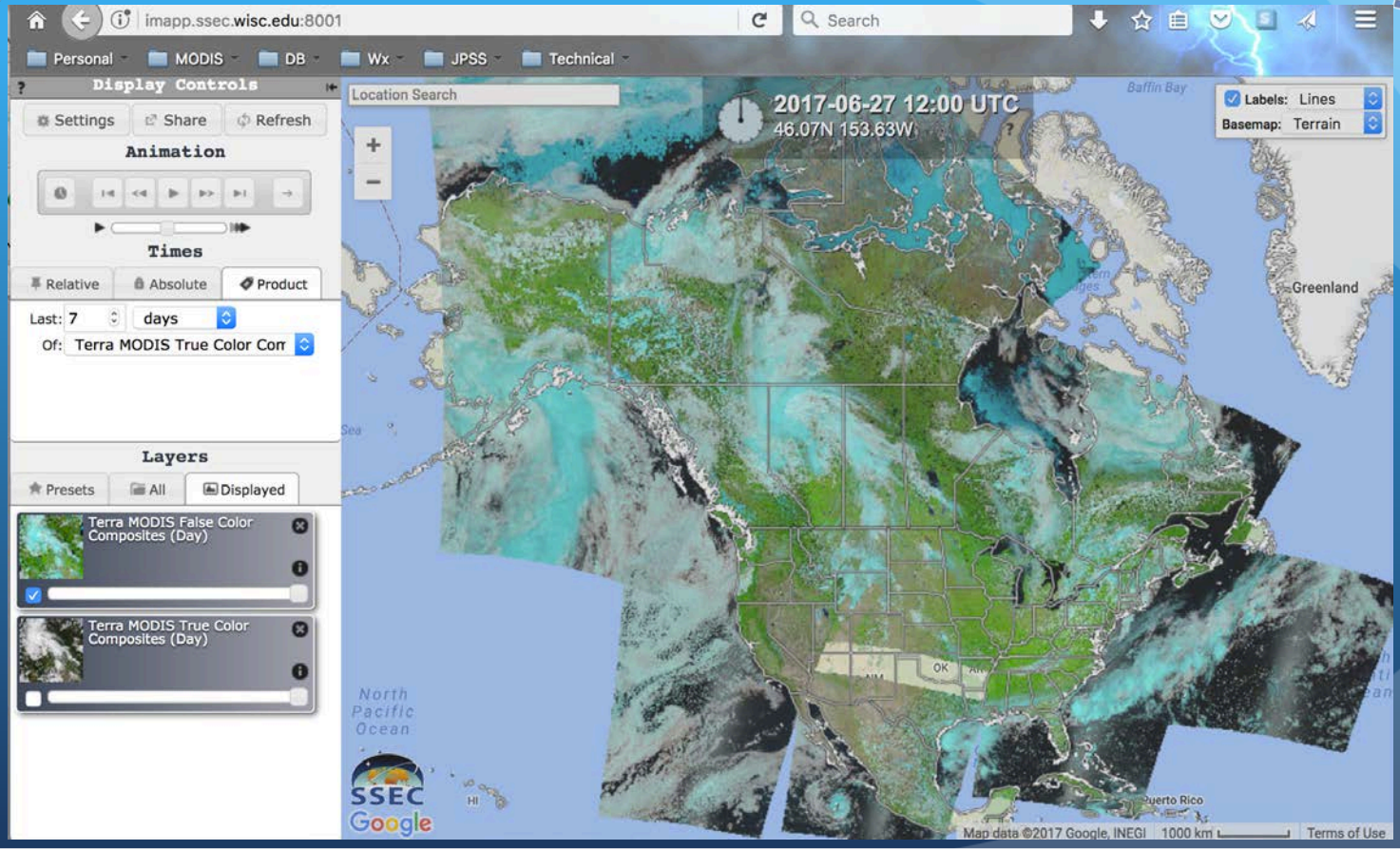
HYDRA2 Multispectral Data Analysis Toolkit – Paul Menzel Talk on Thursday

Web Mapping Service (WMS) for display of local GeoTIFFs created by Polar2Grid

Numerical Weather Prediction (NWP) Model DBCRAS

- Direct Broadcast CIMSS Regional Assimilation system (DBCRAS).
- Globally configurable NWP at 48 km resolution
- Nested grid at 16 km.
- 72 hour forecast of gridded meteorological fields.
- Assimilates MODIS Cloud (MOD06) and Moisture (MOD07) Retrievals to improve initial conditions in the model.
- Output includes forecast IR and Water Vapor Satellite Imagery.
- Used in several sites around the world including ISRO India.

IMAPP wms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Terra MODIS True Color Composites (Day)
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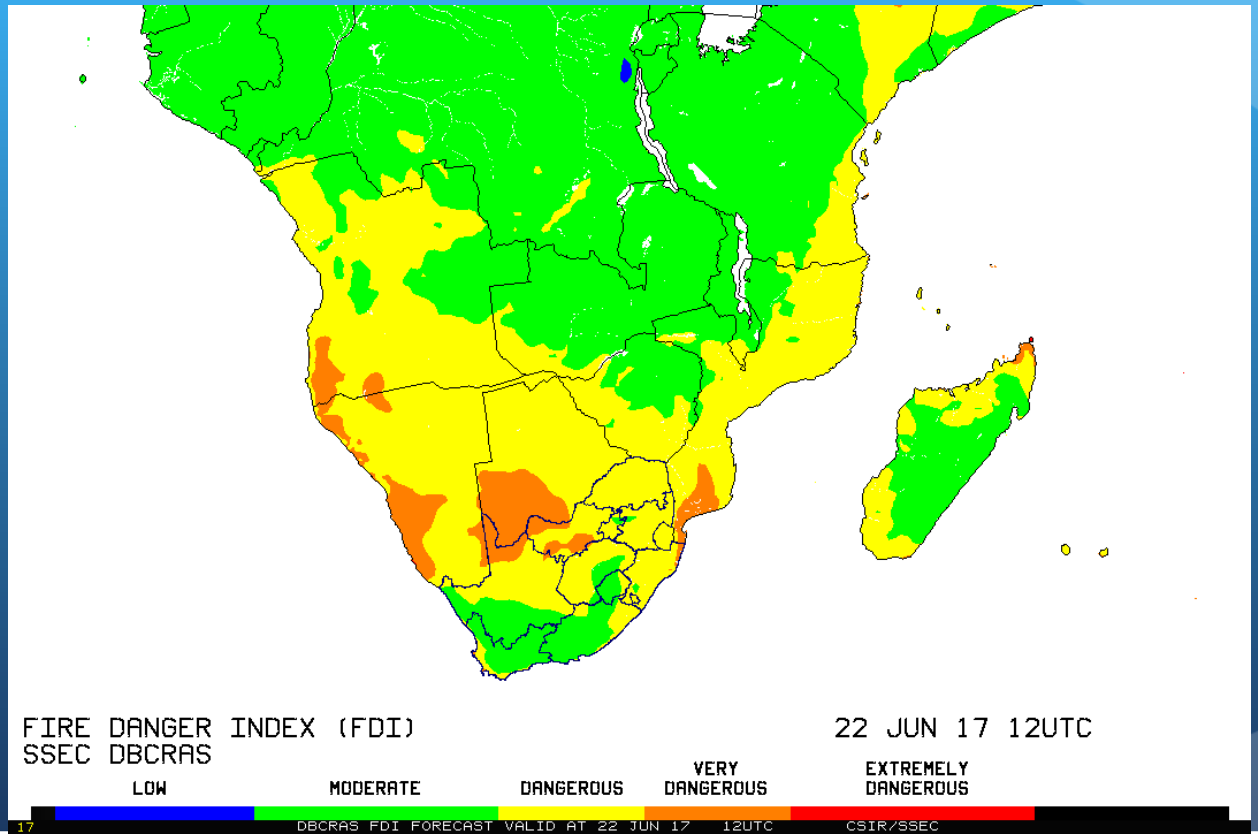
2017-06-27 12:00 UTC
46.07N 153.63W
Labels: Lines
Basemap: Terrain
Baffin Bay
Greenland
North Pacific Ocean
SSEC
Google
Map data ©2017 Google, INEGI
1000 km
Terms of Use

DBCRAS South Africa Domain



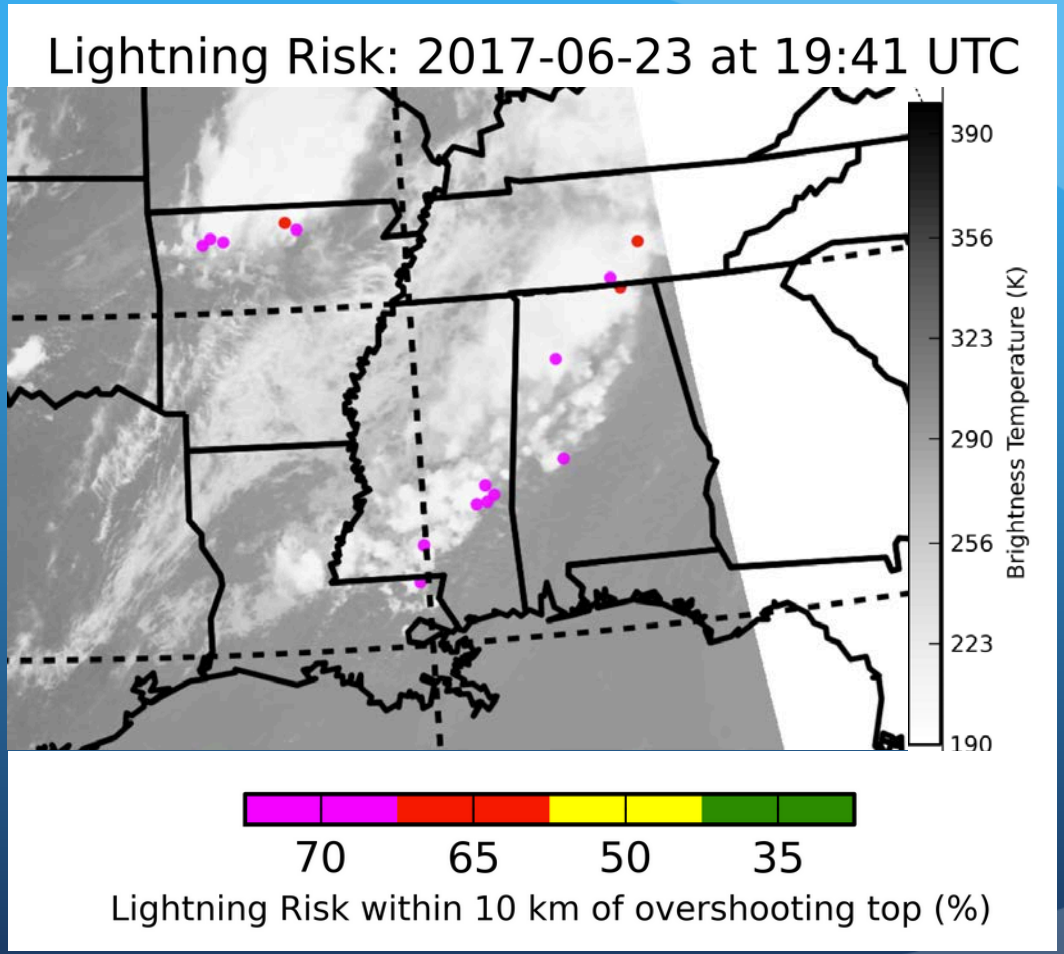
Suite of Products

Overshooting Tops Aviation Hazard Software

- Identifies potentially dangerous convection that protrudes into the stratosphere.
- Using NASA Scientist Dr. Kris Bedka algorithm applied to IR bands.
- Creates output product images that include areal coverage of danger of lightning and turbulence.

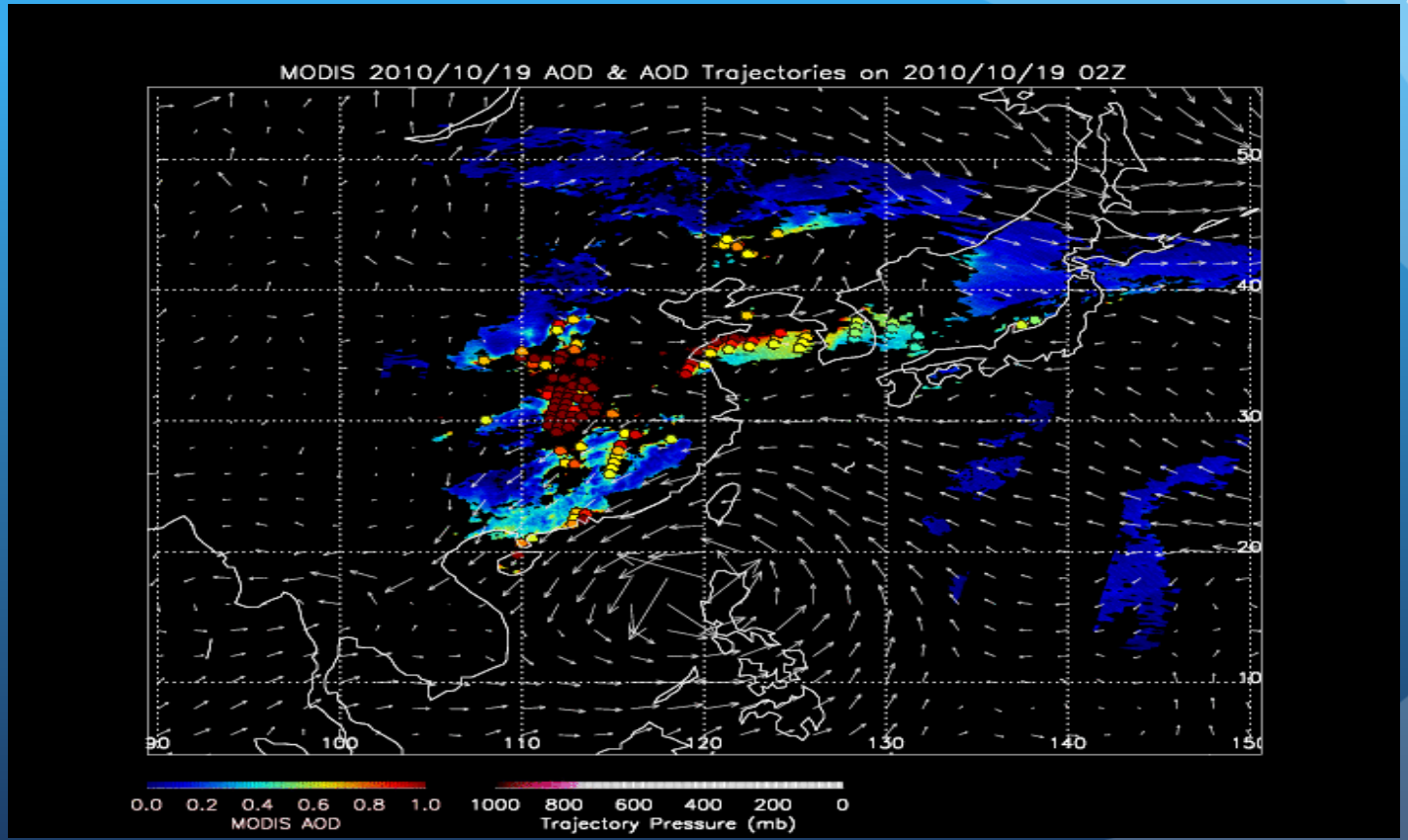
Infusing satellite Data into Environmental Applications – International (IDEA-I)

- Globally configurable package for Air Quality Forecasters
- MODIS Aerosol Pollution forecast trajectories, using MOD04 products with web interface and control of animations.
- AIRS Stratospheric Ozone intrusions trajectories, using AIRS upper tropospheric ozone retrievals with web interface and control of animations.



IMAPP Overshooting Top Lightning Risk Image Product

IDEA-I Trajectory 48 hour forecast



IDEA-I Infusing satellite Data into Environmental Applications — International

CIMSS

http://cimss.ssec.wisc.edu/idea-i/USozone/

MODIS

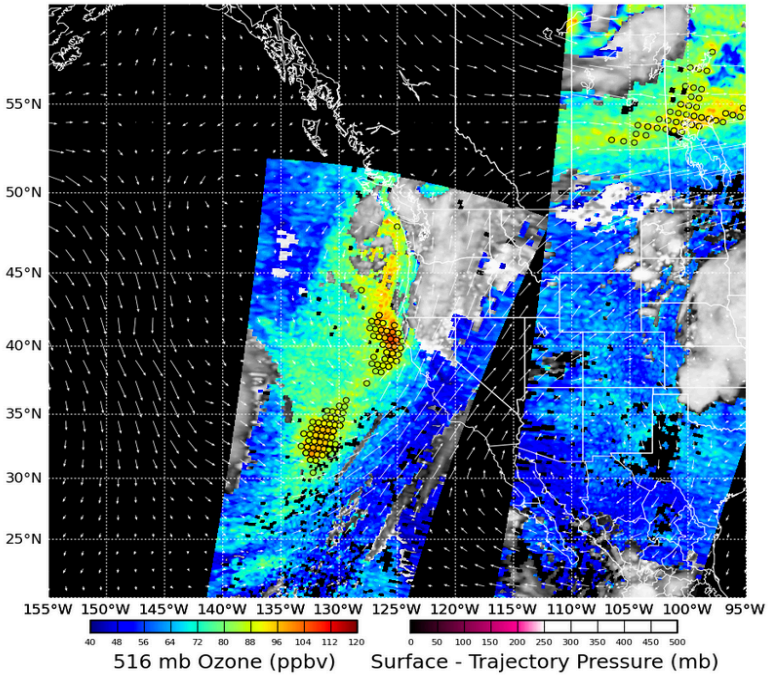
SSEC

Ozone Forward Trajectory Forecast

Sensor: AIRS CrIS IASI » **Node:** Ascend Descend » **Date:** 18-Jun-2016

AIRS Ozone & Ozone Trajectories on 2016-06-18 09Z

AIRS swath start times: 848Z 1029Z

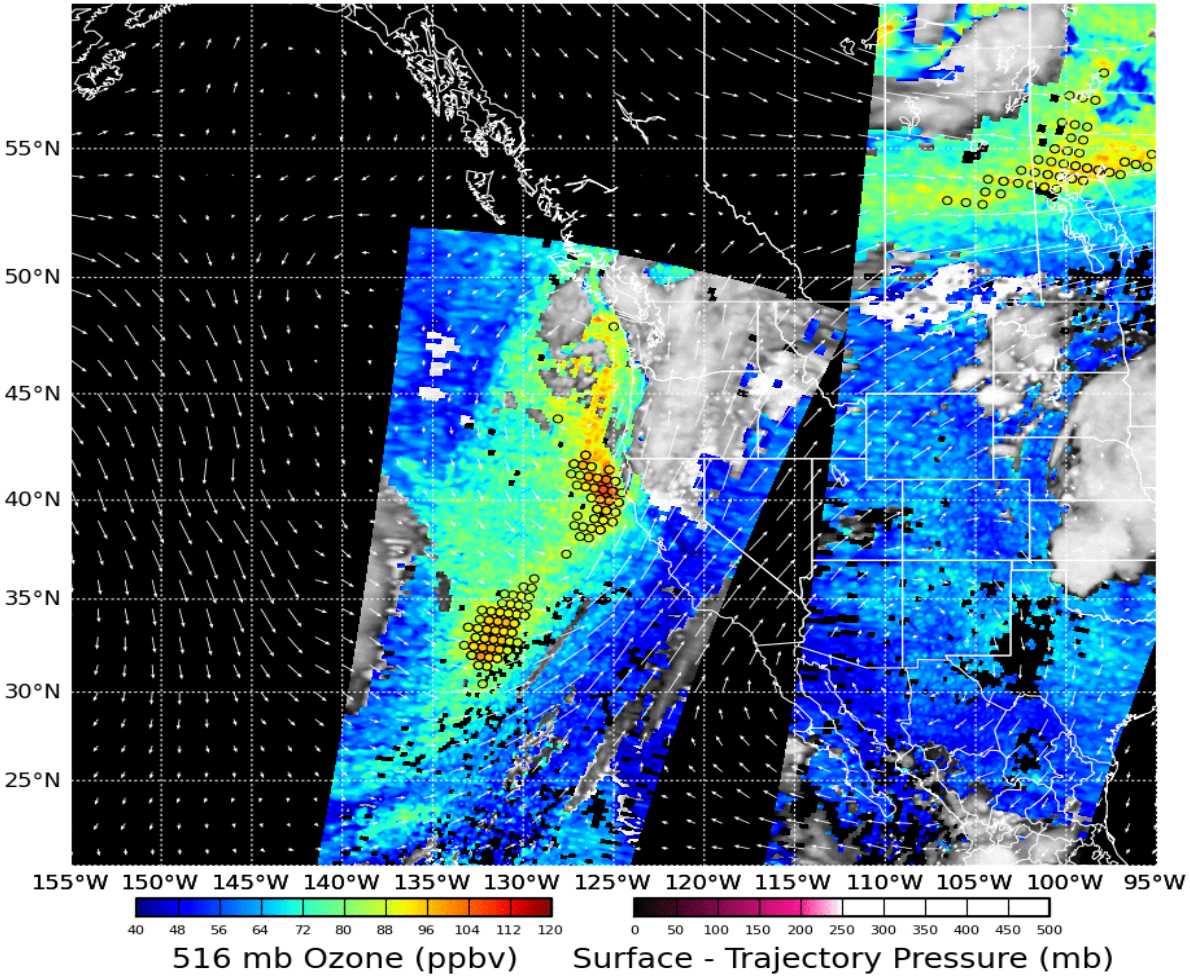


516 mb Ozone (ppbv) Surface - Trajectory Pressure (mb)

Animate

AIRS Ozone & Ozone Trajectories on 2016-06-18 09Z

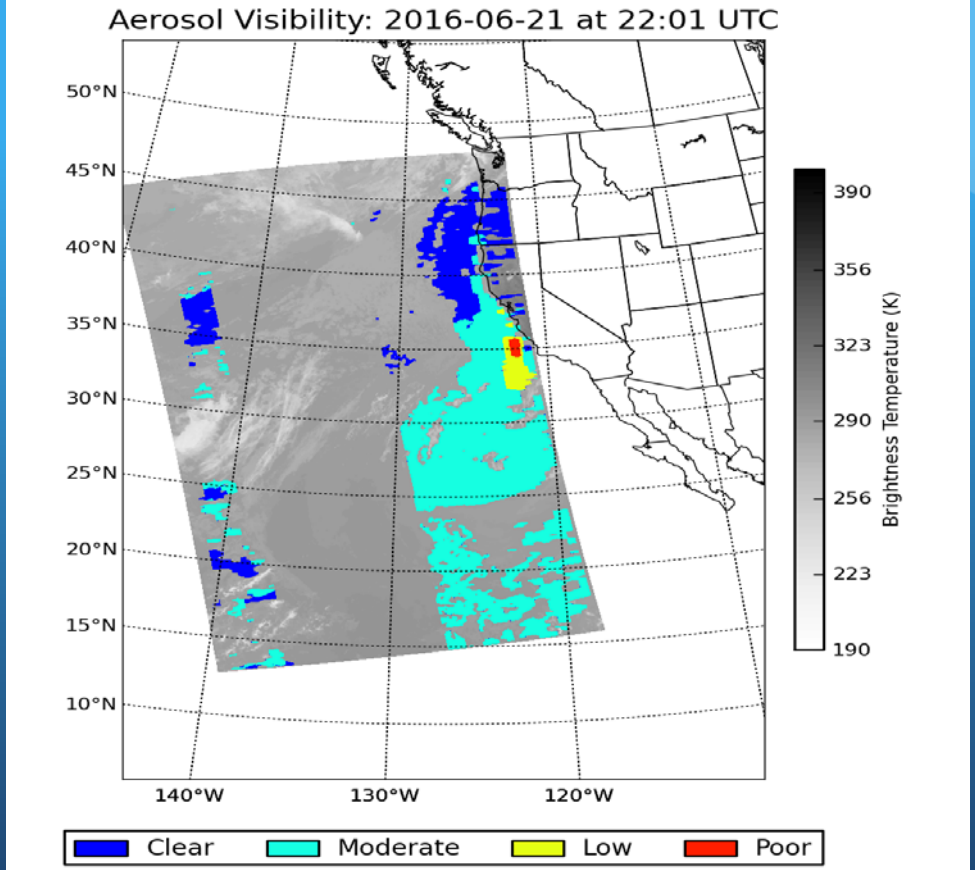
AIRS swath start times: 848Z 1029Z



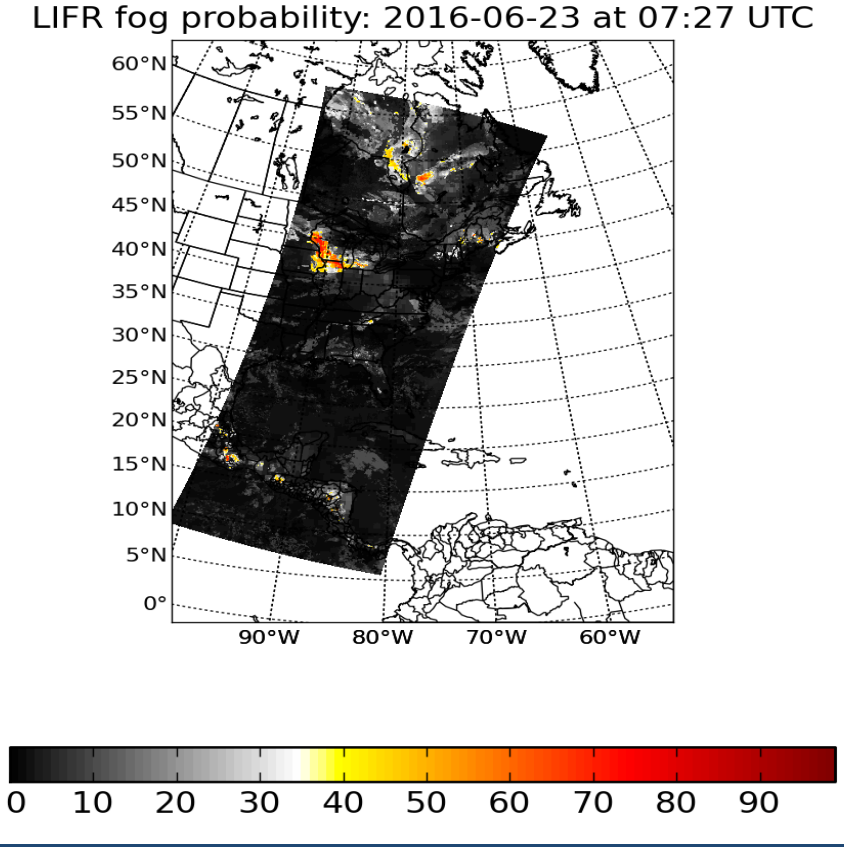
Suite of Products

Visibility Products – Aviation Applications

- Aerosol Visibility Product – Brad Pierce – NOAA/STAR
- Fog/Low Status Product
  - Aviation Visibillty output products – Software provided by Michael Pavolonis –NOAA/STAR



Brunner, J., R. B. Pierce, and A. Lenzen, “Development and validation of satellite-based estimates of surface visibility”, Atmos. Meas. Tech., 9, 409–422, 2016.



MODIS Fog and Low Stratus Product

Suite of Products

IMAPP Virtual Appliance

- A complete free Aqua and Terra DB processing system (Level 0 to Level 2 products plus quicklooks) in the form of a Virtual Appliance which can be installed and run on:
  - Microsoft Windows (7, Vista, XP)
  - Linux
  - Apple OS X
- Uses most of the freely available software that is available from IMAPP, SeaDAS and NASA DRL
- Easy to install and run full-featured processing system Level 0 – Level 2 plus browse images

IMAPP Training Workshops

Global Direct Broadcast Application Workshops

- Promote the local use of satellite data
  - Lectures and hands-on labs determined by student interest/needs
  - Lectures, labs, data and software freely distributed
    http://cimss.ssec.wisc.edu/dbs
- How can the data inform decision making?
  - Remote sensing complemented by local knowledge
- Encourages international collaborations both between NASA/global science community as well as and community to community
- Teach the principles of remote sensing to foster the next generation of scientists

Timeline of DB Training Courses

2004 – Nanjing, China
2004 – Perth, Australia
2005 – Taipei, Taiwan
2005 – Beijing, China
2006 – Andenes, Norway
2006 – Pretoria, South Africa
2007 - Cachoeira Paulista, Brazil as part of **GEOSS**
2009 – Stellenbosch University, South Africa
IGARSS Short Course 4: MODIS direct broadcast data for enhanced forecasting and real-time environmental decision making
2011 - June – Shanghai, China
2011 - September – Indonesia
WMO Region V Training workshop on satellite applications for meteorology and climatology
2013 - September – Honolulu, Hawaii
Hawaii VIIRS / MODIS Direct Broadcast Applications Workshop
2015 - February – Miami, Florida
AOML Miami VIIRS / MODIS Direct Broadcast Applications Workshop
2016 - April – Mayaguez, Puerto Rico
Mayaguez Direct Broadcast Applications Workshop – NOAA CREST
2016 - October – **Korea as part of the 7th Asia/Oceania Meteorological Satellite Users' Conference (AOMSUC-7)**
2016 - November – University of Moscow, Russia
2017 - June – Hampton University, Virginia, USA

Hampton University Direct Broadcast Applications Workshop 6-9 June 2017

Hampton University Satellite Direct Broadcast Workshop: Polar Orbiter Satellites in Support of Real-Time Environmental Applications

Location: Hampton University, Virginia
Date: 6-9 June 2017

Workshop Agenda

<u>Day One</u> Polar Orbiter Imager Sensors - including MODIS and VIIRS
6 June 2017 Kathy Strabala and Jessica Braun

9:00 AM – 12:00 PM Lecture: Introduction to Polar-Orbiting Satellites and Sensors

- Properties of Polar-Orbiting Satellite sensors
- Bowtie effects and data aggregation
- SDR and Level 1B products and formats
- Software for visualization of SDRs and Level 1B files
- Overview of Direct Broadcast system at Hampton University
- Overview of Software for SDR and L1B file generation
- CSPP – Community Satellite Processing Package

Noon – 1:00 PM Group Lunch and Loading of Lab Data onto Laptops

1:00 PM – 5:00 PM Lab Session: Exploring MODIS and VIIRS L1B data in Hydra

- Learning Hydra
- Exploring S-NPP SDR and MODIS L1B using direct broadcast data
- Exploring VIIRS Day/Night Band Capabilities.

Funding

- 3 year cycle ended 6 June 2017
- Cost extension provided through November, 2017
- New NASA ROSES amendment includes real time algorithms for Aqua, Terra and S-NPP

IMAPP Short Term Updates

- IMAPP MODIS Level 2 Atmosphere Products
  - Update algorithms to NASA Collect 6.1
- New DBVM Version 3.0
- New AIRS/AMSU Version 6 L1 and Version 5 L2 from JPL
- New Version of the IMAPP wms
  - See Sam Batzli talk on RealEarth (Thursday)

What do we see in the future?

- Addition of support for S-NPP (and JPSS-1)
  - Kris Bedka Overshooting Tops for VIIRS?
- BRDF product update with Crystal Schaaf (Boston University)
- Improve latency of processing
- Focus on Applications software
  - Aniko's winter wheat yield and forecast algorithm?
  - Replace DBCRAS NWP model with WRF
  - Update to IDEA-I using high spatial resolution trajectory model
- More Direct Broadcast Workshops!
  - Leads to numerous long-lasting collaborations

Questions?

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