

Polar Orbiting Weather Satellite Proving Ground: Facilitating Broad and Optimal Use of Global Direct Broadcast Data

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University of Wisconsin-Madison, USA



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NOAA: Tim Schmit, Brad Pierce, Bob Aune, Jeff Key,
Andy Heidinger, & many more

UW-Madison: Jordan, Gerth, William Straka, Wayne
Feltz & many more

Sec.6 Preparing the user communities II
**Seventh Annual Symposium on Future Operational
Environmental Satellite Systems**

2011 AMS Annual Meeting
Seattle, Washington
Wednesday, 26 January, 2011



Polar Orbiting Weather Satellite Proving Ground (PG): Facilitating Broad and Optimal Use of Global Direct Broadcast Data

Outlines/Objectives:

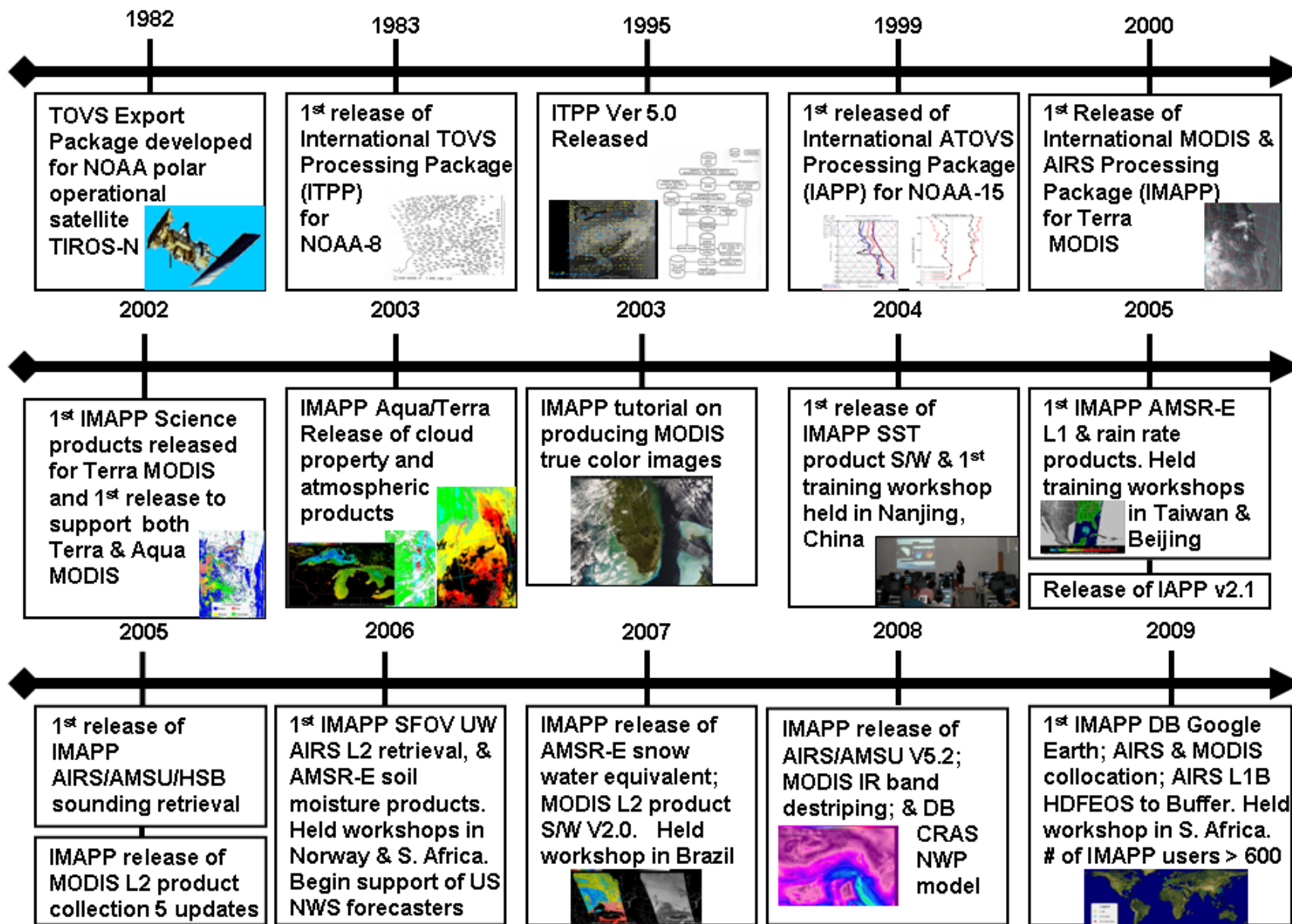
In close partnership with NOAA, NASA, and EUMETSAT through Joint Polar Orbiting Satellite System (JPSS), the Space Science and Engineering Center (SSEC) of University of Wisconsin-Madison is embarking upon **demonstrating the operational uses of both research and operational weather satellite data to support operational users such as NOAA's National Weather Service and other federal agencies.**

Our companion paper covers the likely examples of global impact of polar orbiting weather satellite data and their various uses and applications from developed and developing countries.

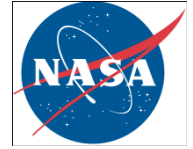
This talk, however, will mainly **focus on the proving ground activities dedicated to facilitate and demonstrate the use of direct broadcast data collected from the current NASA Terra and Aqua, and NOAA.**

Special attention will be paid to the **seamless interface with NWS field offices** and other emerging government offices

History of UW-CIMSS Polar Orbiting Satellite Direct Broadcast Processing Packages



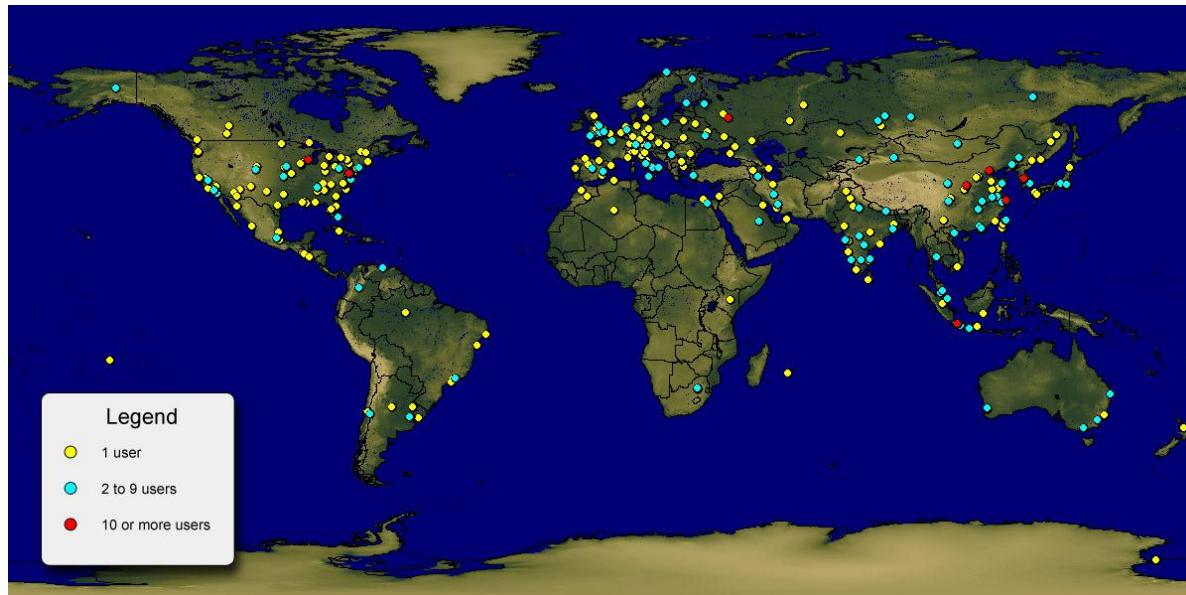
NASA funded International MODIS/AIRS Processing Package (IMAPP)



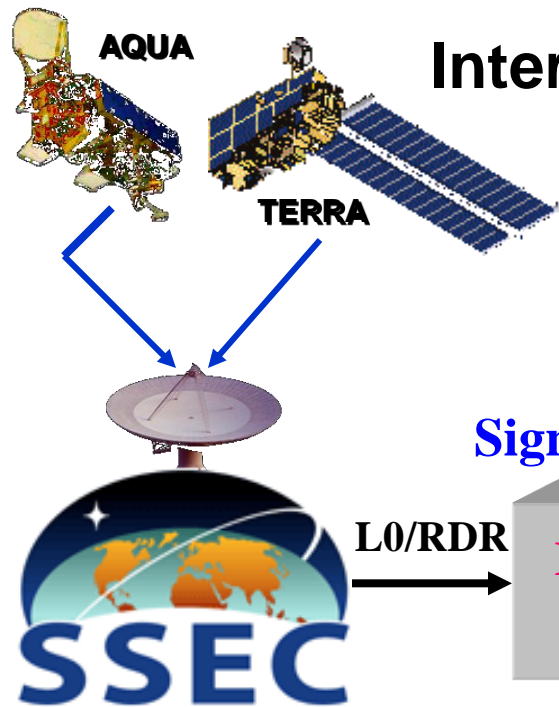
Purpose: To allow DB users capability of producing local Aqua and Terra products from direct broadcast data

- Software packages derived from the operational EOS processing
- Modified to be compatible with direct broadcast data.

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



Global IMAPP users

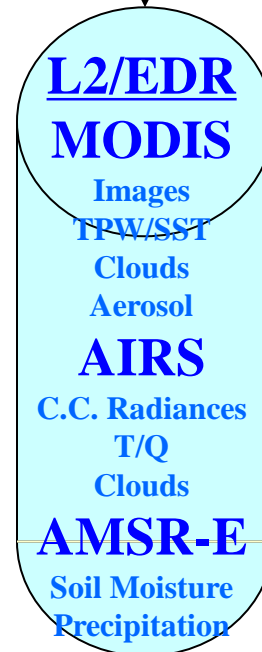
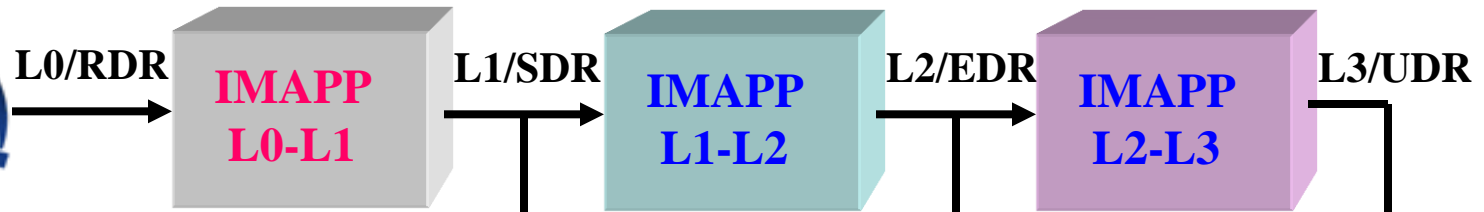


International MODIS/AIRS Processing Package

Schematic of NASA EOS End-to-End Processing

1. Understanding of instrument design principals
2. Analysis of measurement characteristics
3. Development of processing algorithms

Signal to Data Data to Products Products to Information

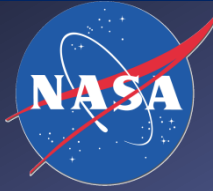


Schematic of NASA EOS End-to-End Processing

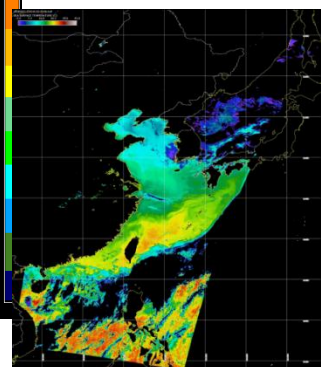
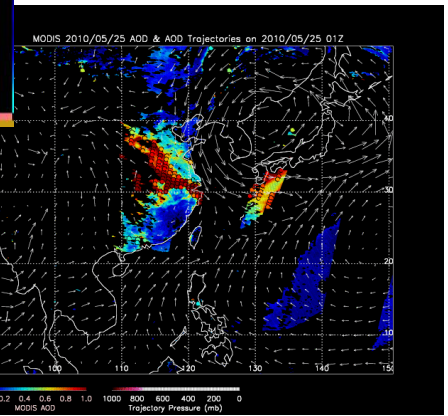
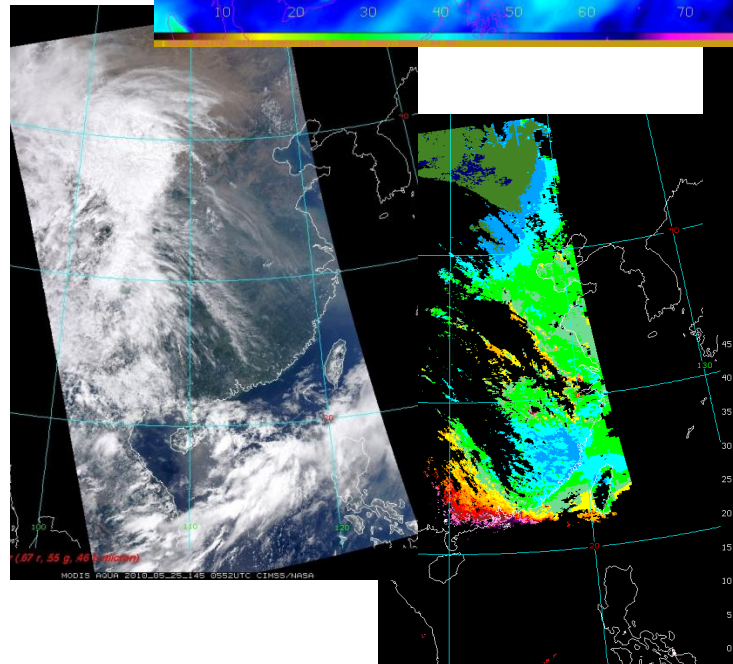
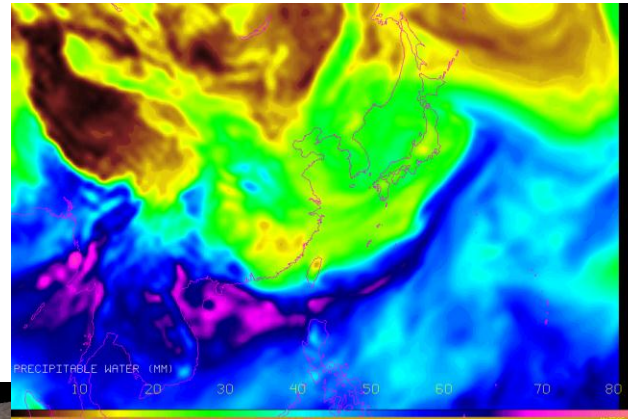
4. Use of processing S/W System
5. Linkage to meteorological & environmental modeling & applications



IMAPP Sites (54 countries with 639 users)

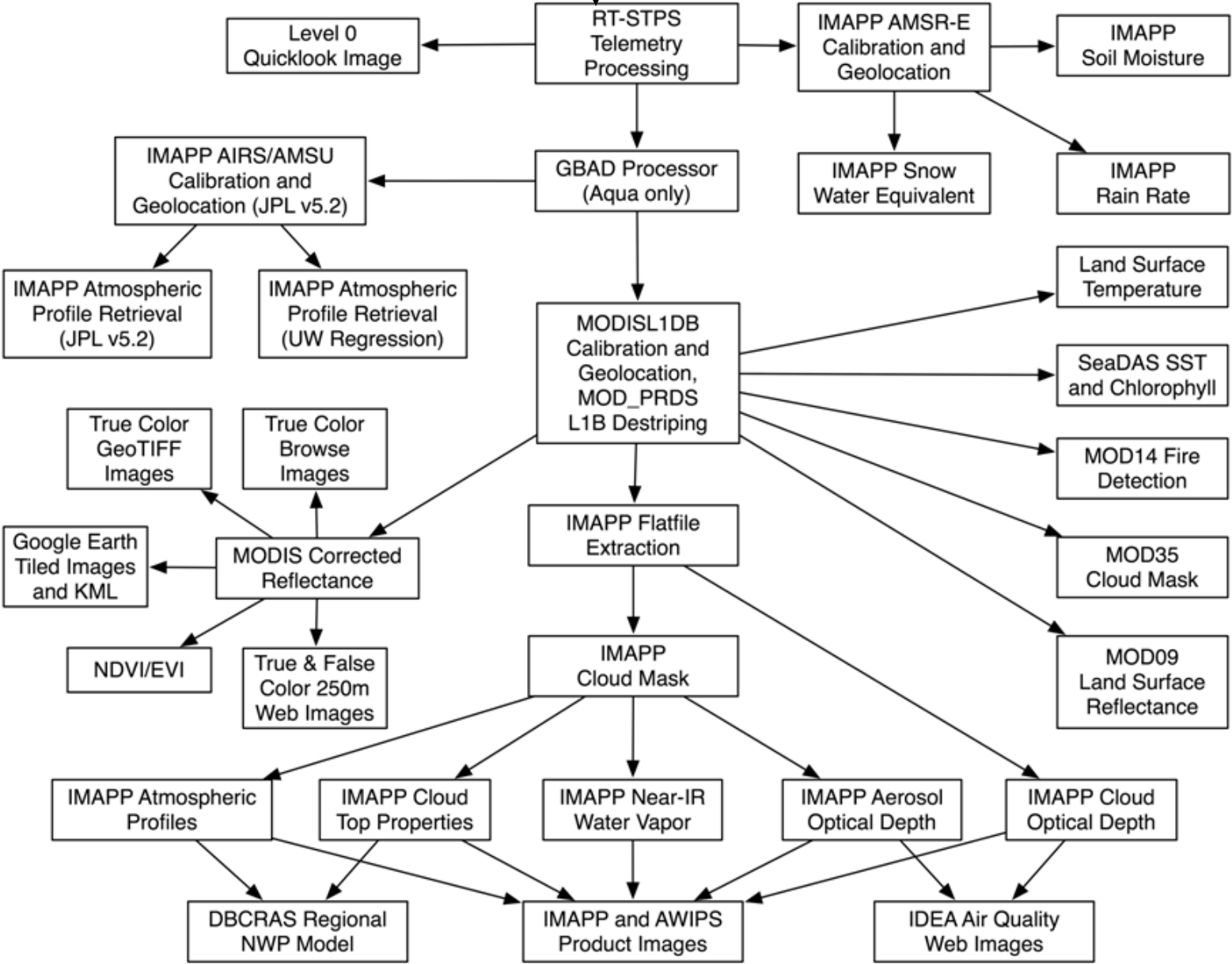


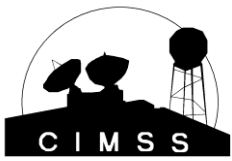
A Direct Broadcast Processing & Application System (DBPAS)



EOS-FES

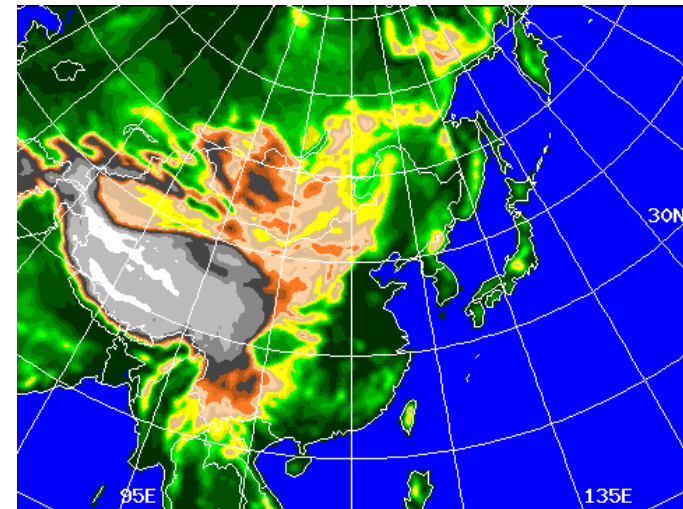
E-T-E DBPAS Flow Diagram





Direct Broadcast CRAS Configuration Re-locatable anywhere on the globe

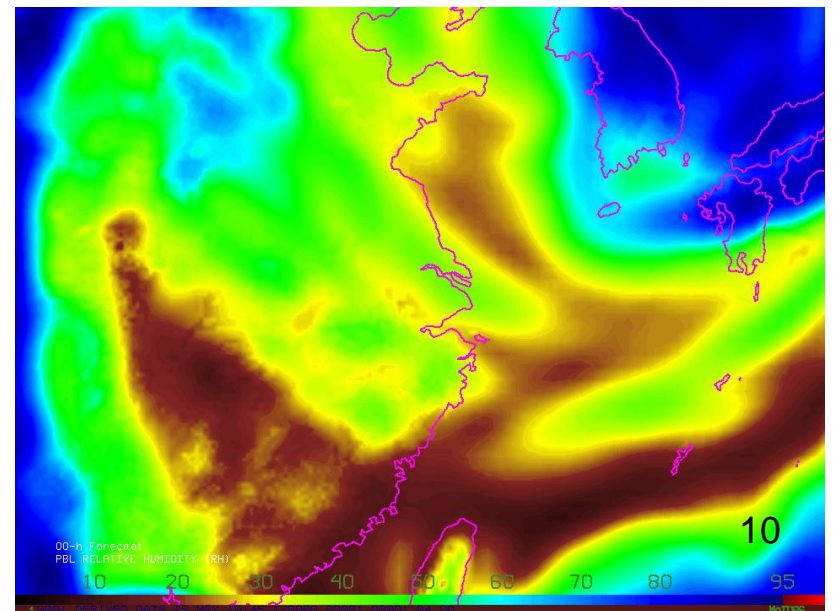
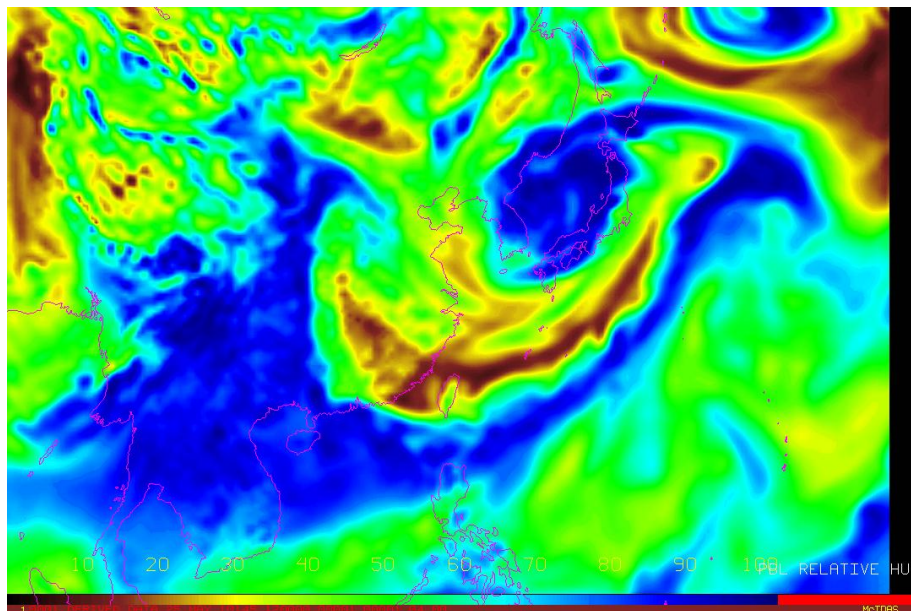
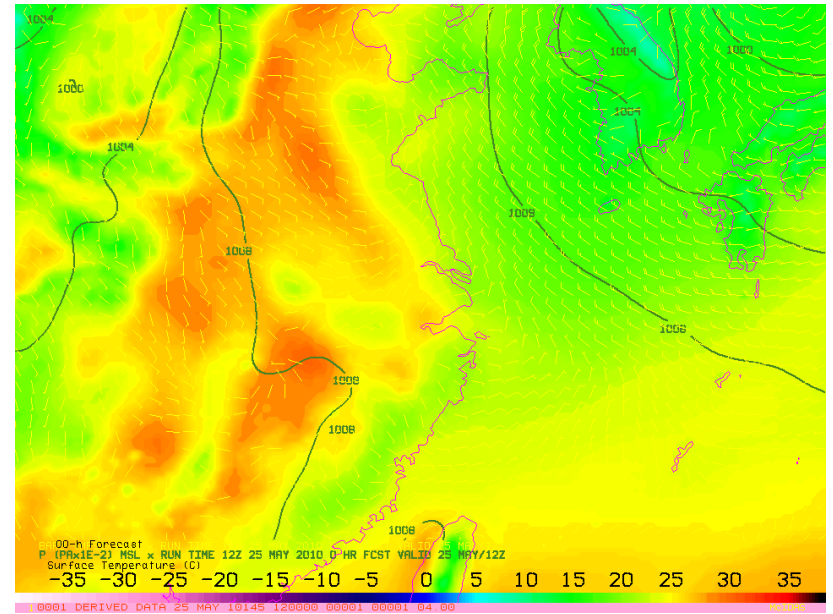
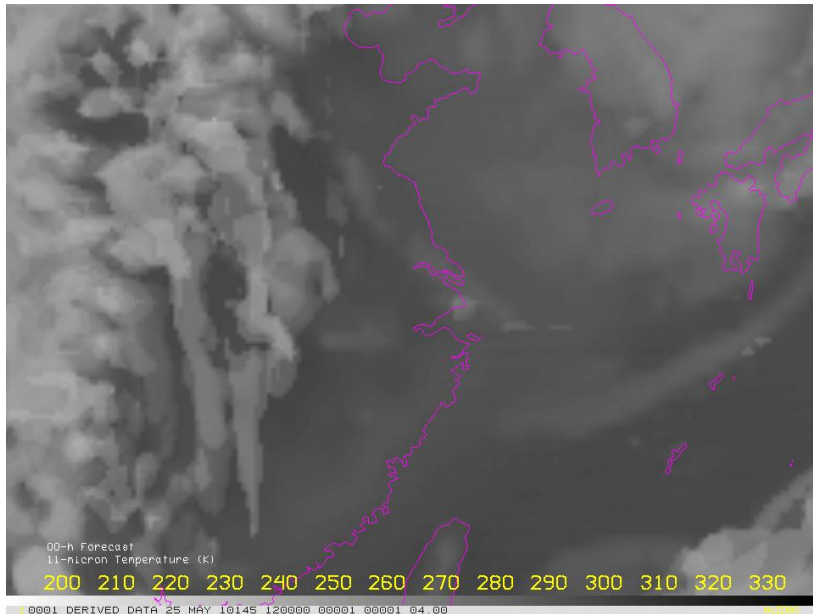
Resolution:	48 km
Sigma levels:	38
Grid Size	201x151
Time-step:	240 seconds
Forecast length:	72 hours
Initialization:	12-hr spin-up with 5-7 MODIS inserts
Output:	3 hourly, grib2 format
Initial times (UTC):	00/12 UTC
Start times (UTC):	00:25/12:25 UTC
Initial conditions:	1/2 degree GFS, 6 hr Forecast
Boundaries:	6 hourly, one degree GFS Forecasts
Inputs:	Surface, RAOBs MODIS: Total precipitable water, cloud-top pressure
Verification:	RAOBs, Surface, MODIS



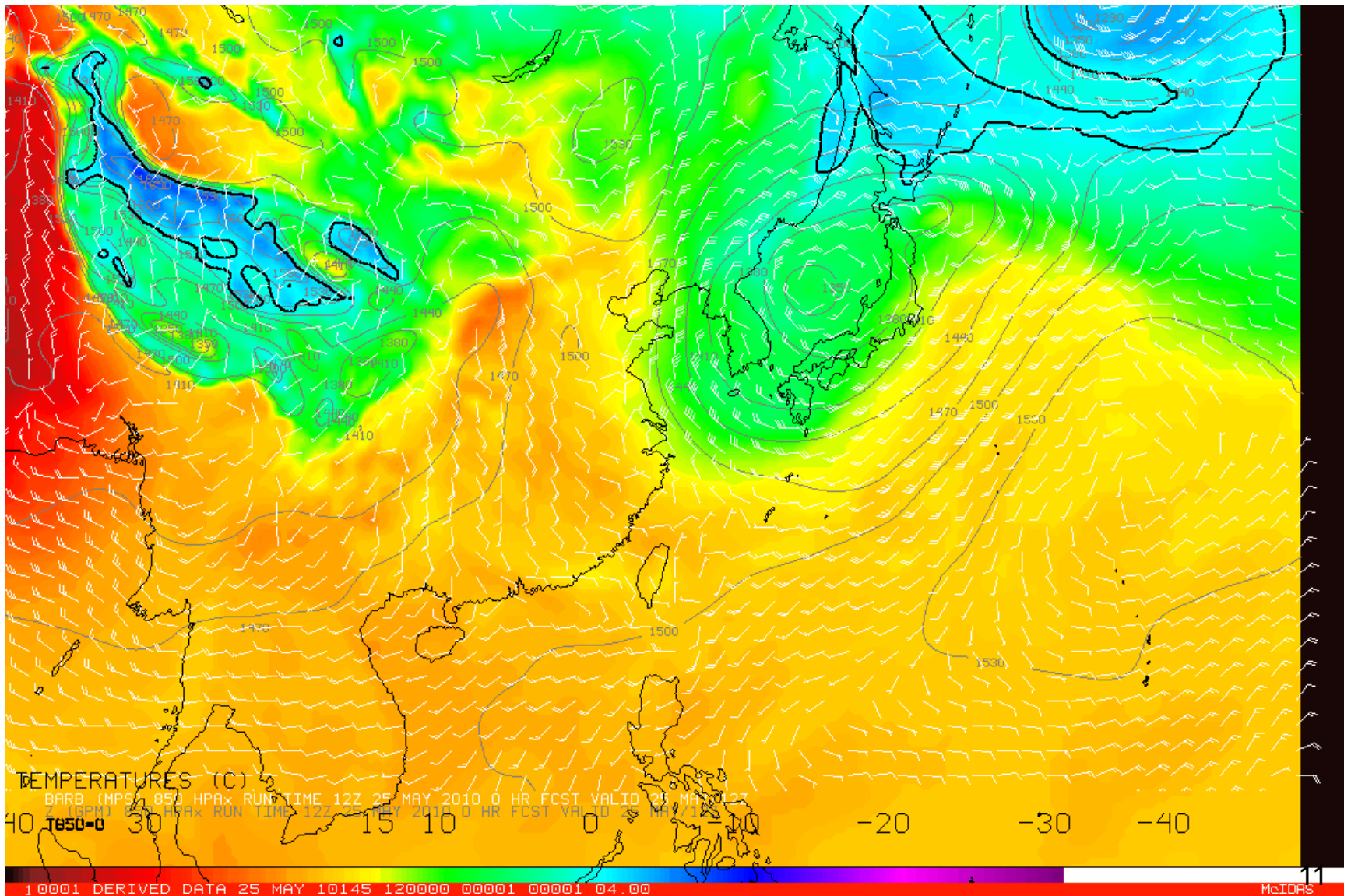
Example DBCRAS Domain

Note: Multiple high-resolution nests can be placed anywhere in the 48 km grid.

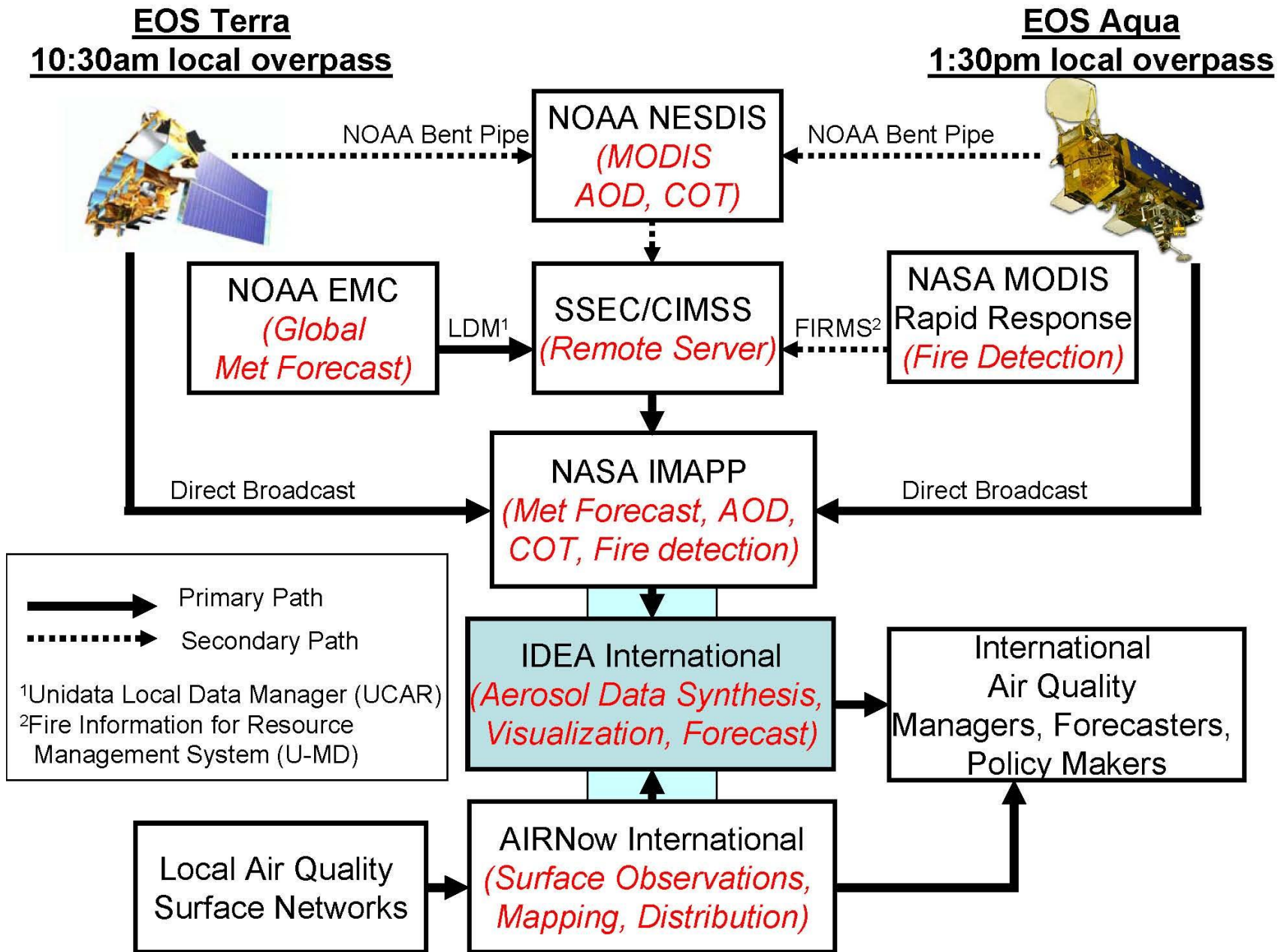
ECNU DBPAS: Data Assimilation & Forecast System



ECNU DBPAS: Data Assimilation & Forecast System

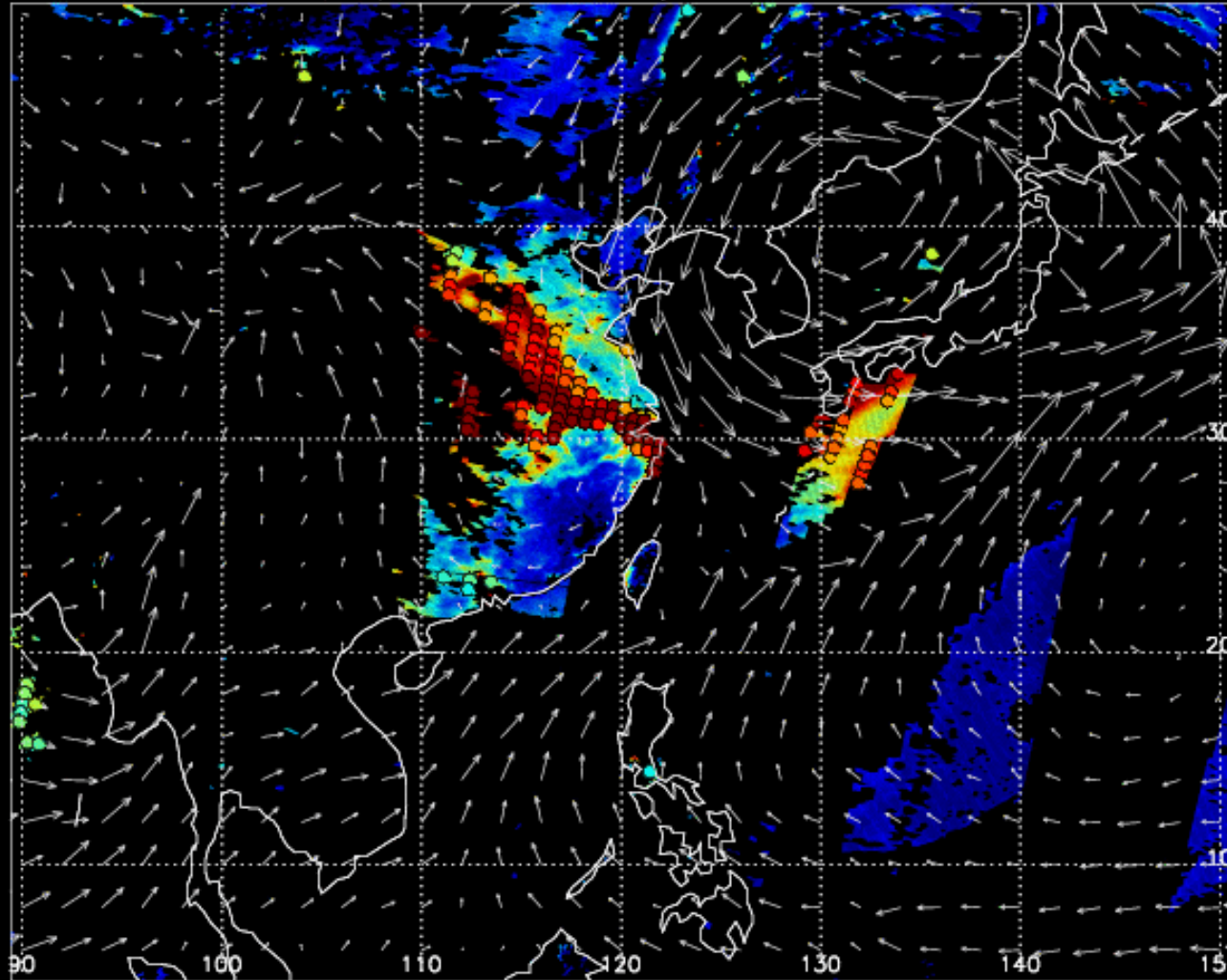


Schematic illustration of how IDEA-I will be used to link MODIS satellite data and trajectory forecasting capabilities to AIRNow-I



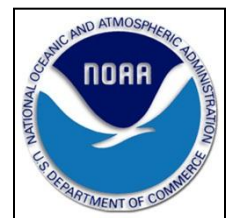
ECNU DBPAS: Air Quality Forecast System

MODIS 2010/05/25 AOD & AOD Trajectories on 2010/05/25 01Z



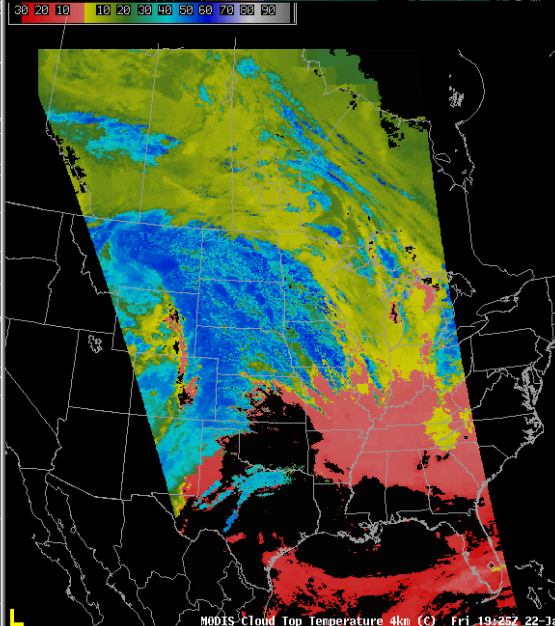
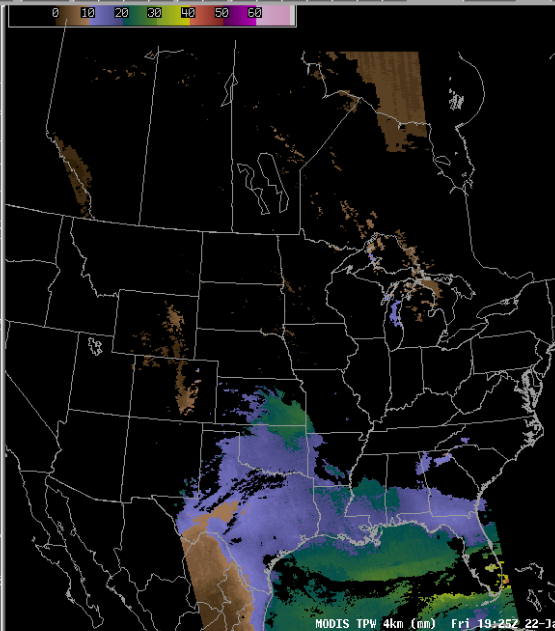
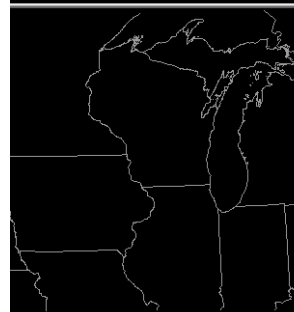
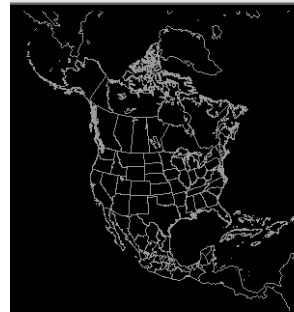
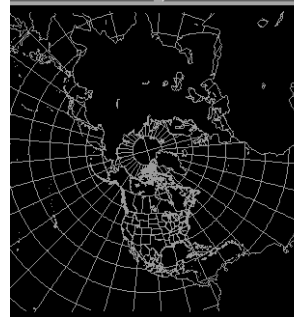
IMAPP Support of US National Weather Service Forecasters – Proving Ground

- University of Wisconsin began providing Direct Broadcast MODIS products NWS in June 2006
- **1km Reflectances and Brightness Temperatures**
 - Bands 1 (.68 μm), Band 26 (1.38 μm), Band 7 (2.1 μm)
 - Band 20 (3.7 μm), Band 27 (6.7 μm), Band 31 (11 μm)
- **Products**
 - 1 km
 - Sea Surface Temperature, NDVI (DB version).



Valid time seq CONUS

Clear [Navigation icons] Frames: 12 Mag:



MODIS Products

- 1km Resolution - East
- 4km Resolution - East
- 1km Resolution - West
- 4km Resolution - West
- 1km Resolution - East/West
- 4km Resolution - East/West
- Marine - 1km Resolution
- 250m Resolution - Wisconsin
- MODIS GOES Fog Comparison
- MODIS Orbit Itinerary Viewer

CRAS Prediction

- Eastern CONUS
- Western CONUS
- Combination CONUS
- Alaska

GOES Sounder Extras

- Eastern CONUS
- Western CONUS
- Combination CONUS

Convective Initiation

- GOES-12 Sector

AVHRR Products

- 1km Resolution - CONUS
- 1km Resolution - Alaska

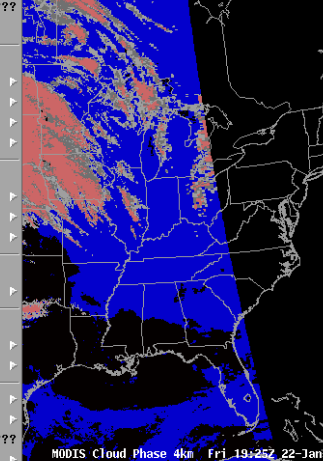
AIRS DPI

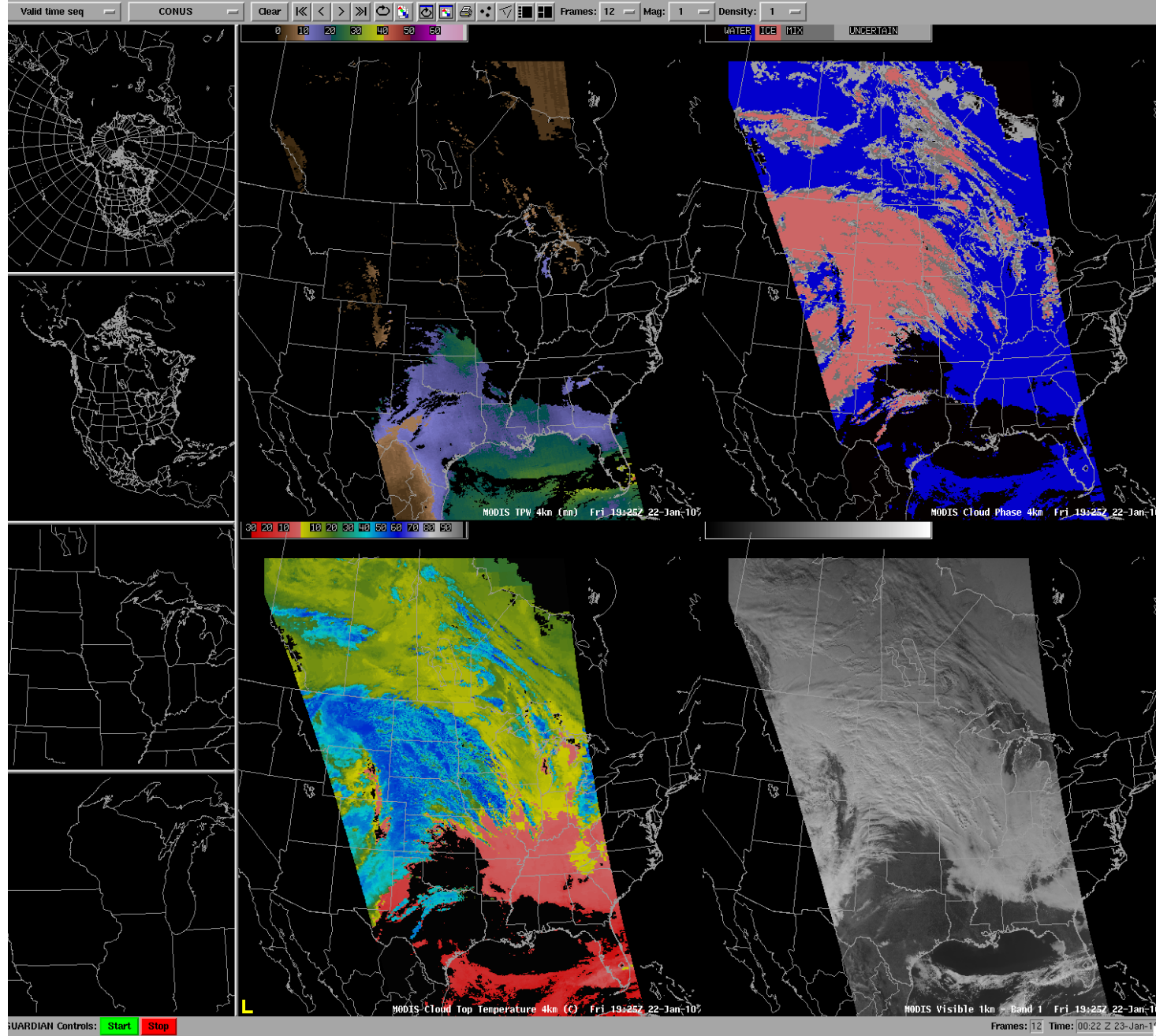
- High Density Winds
- MIMIC Total Precipitable Water (mm)
- Upper Air Plots

MADIS Experimental GOES Winds

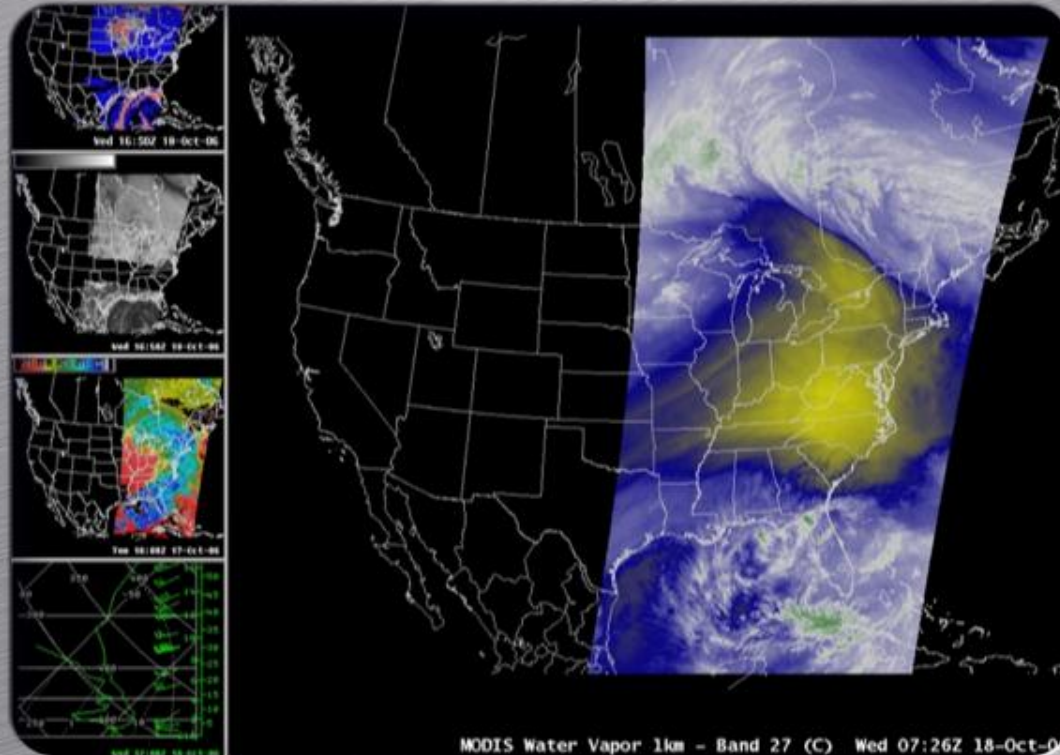
- GOES 1h High Density Winds

MODIS TPW 4km (mm)	??.????
MODIS Cloud Phase 4km	??.????
MODIS Cloud Top Temperature 4km (C)	??.????
MODIS Lifted Index 4km (C)	??.????
MODIS Total Totals 4km (C)	??.????
MODIS K Index 4km (C)	??.????





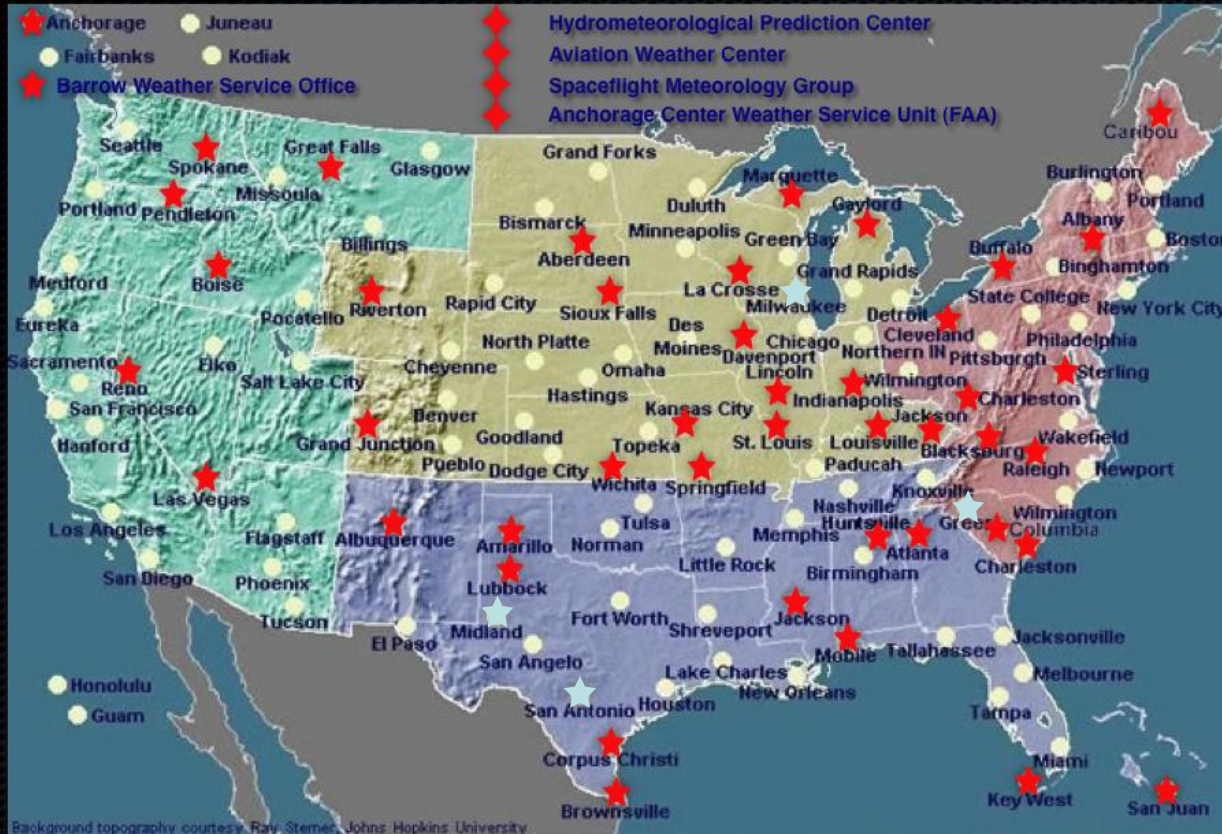
MODIS Products in AWIPS



National Weather Service • Integrated Sensor Training Professional Development Series
Virtual Institute for Satellite Integration Training

Virtual Institute for Satellite Integration Training
(VISIT) lesson - offered since October 2006

MODIS Products in AWIPS

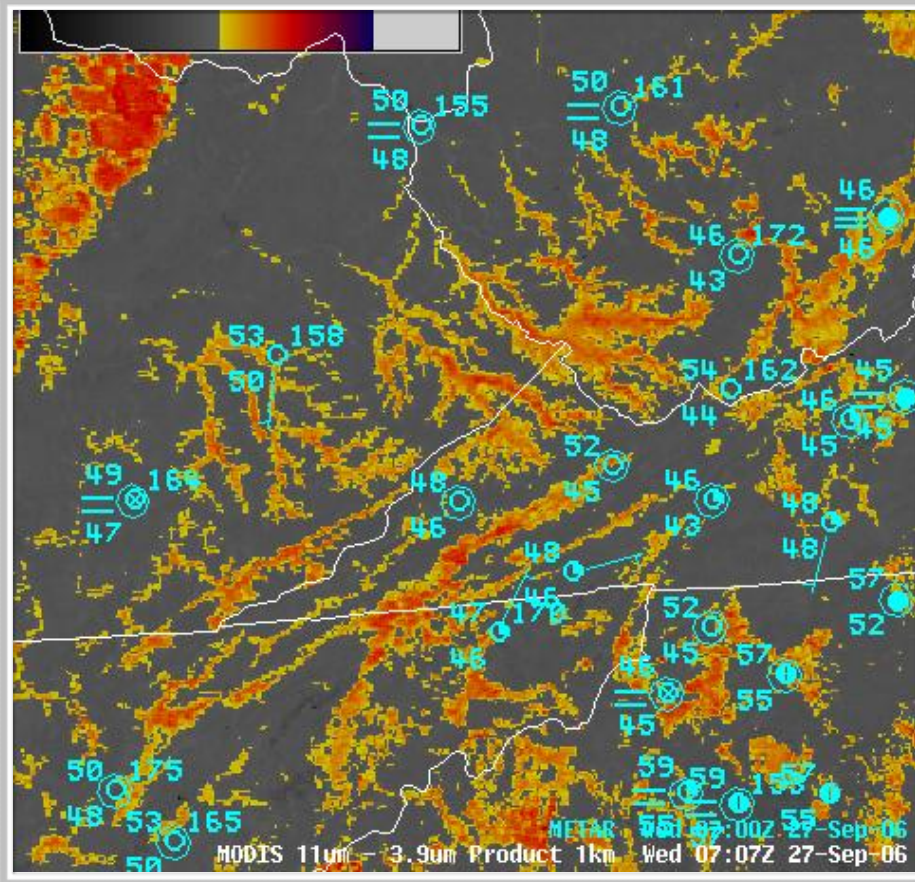


“MODIS Products in AWIPS” VISIT Lesson Participation

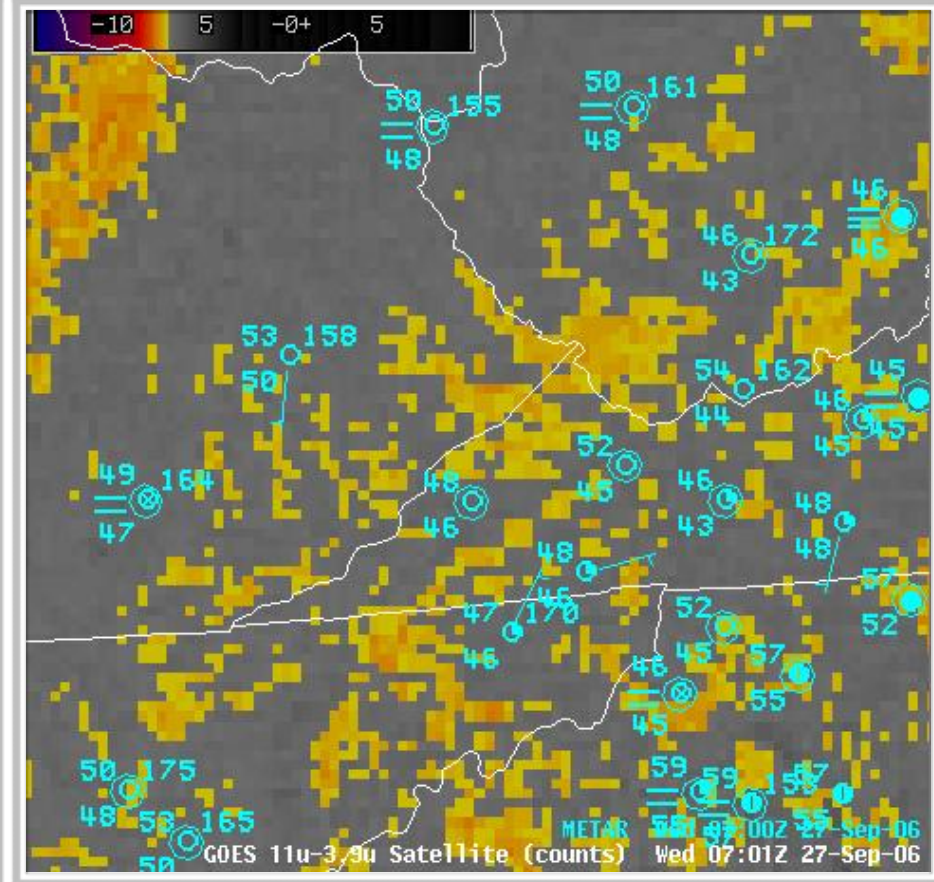
53 NWS forecast offices participating

MODIS Imagery in AWIPS

Fog/stratus product ($11.0\mu\text{m} - 3.7\mu\text{m}$)

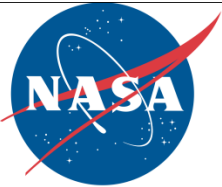


1-km MODIS

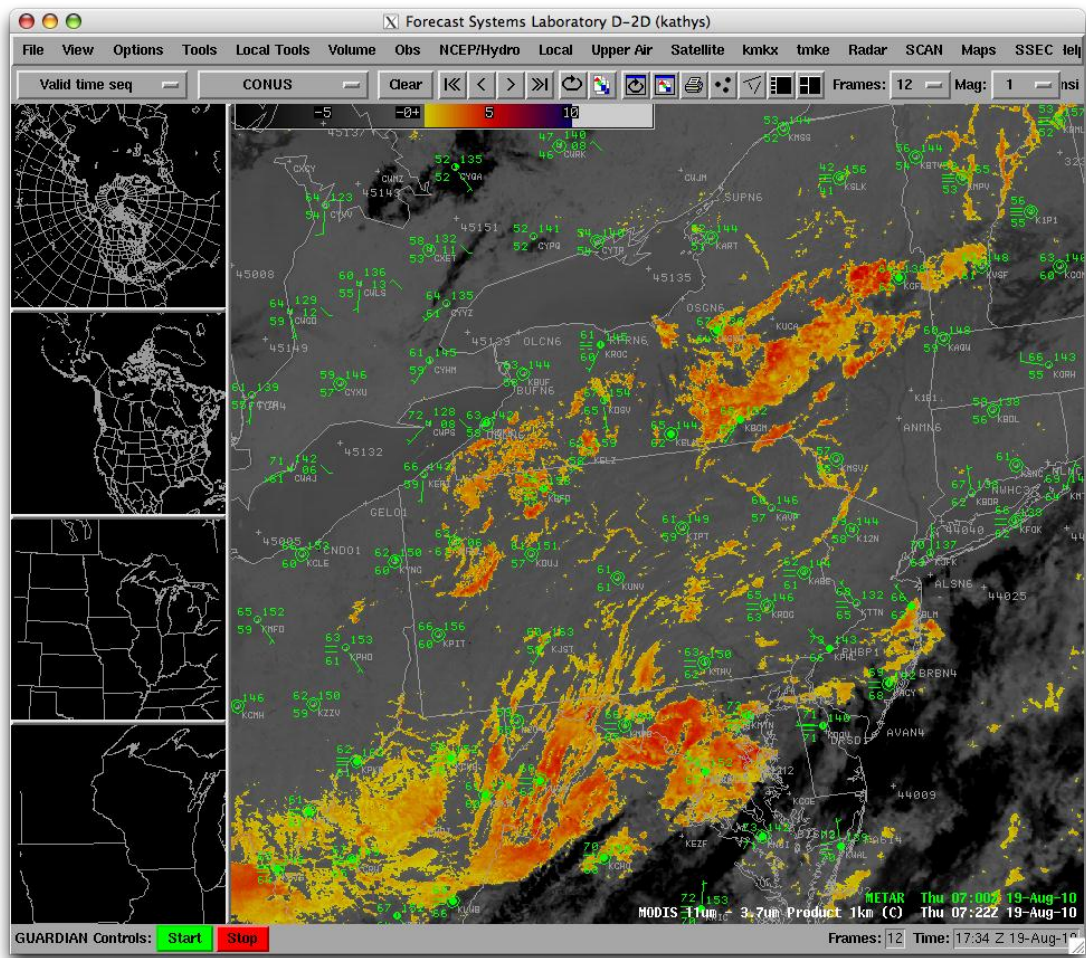


4-km GOES

Improved fog/stratus detection capability



Recent AFD using MOC



AREA FORECAST DISCUSSION
 NATIONAL WEATHER SERVICE
 STATE COLLEGE PA
 522 AM EDT THU AUG 19 2010.

SYNOPSIS...A WEAK FRONT COLD FRONT WILL PUSH THROUGH PENNSYLVANIA LATE TONIGHT AND FRIDAY. HIGH PRESSURE WILL BUILD OVER THE STATE LATE FRIDAY AND SATURDAY. COLD FRONTS ARE LIKELY TO AFFECT THE AREA LATE SUNDAY AND AGAIN AROUND NEXT WEDNESDAY.

NEAR TERM /UNTIL 6 PM THIS EVENING/...**EARLY MORNING MODIS 11-3.78UM IMAGERY SHOWING PATCHY VALLEY FOG ACROSS CENTRAL PA...**WHILE FOG A BIT MORE WIDESPREAD ACROSS THE S TIER...WHERE RAIN FELL YESTERDAY. **LATEST 3KM HRRR AND LAMPGUIDANCE BOTH SUGGEST FOG WILL BURN OFF IN MOST LOCATIONS BY13-14Z.**





MODIS true color
250 m resolution image
From 31 January 2010 as
displayed in the MKE
Forecast office “Top News
of the Day” page.

The image was acquired,
processed and distributed
by the University of
Wisconsin-Madison Space
Science and Engineering
Center (SSEC).



Lake Michigan Ice Now Visible - Updated 1/31/10

Below is a high resolution [MODIS](#) satellite image taken around 1250 pm CST Sunday afternoon (1/31/10). It revealed an extensive ice field roughly from Milwaukee south to the Indiana shore. The light colored ice field stands out against the darker color of the surrounding water.

The image shows a satellite view of Lake Michigan with a large, light-colored ice field drifting eastward. Labels in red text point to 'Milwaukee' at the top, 'Chicago' at the bottom, and 'Lake Ice Drifting East' in the center. Other labels include 'Clouds' and 'Lake Geneva'. The surrounding land is shown in shades of brown and green.

High Resolution MODIS Visible Image
January 31, 2010

**National Weather Service Weather Forecast Office
Milwaukee/Sullivan, WI**

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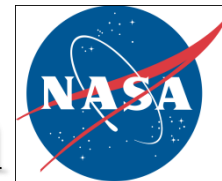
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MKE Area Forecast Discussion



3:50 AM 15 February 2010

MARINE

LATEST VSBL **MODIS** HI RES IMAGERY SHOWING VERY LITTLE SIGNIFICANT ICE IN THE NEARSHORE..HOWEVER HAZY...BROWNISH COLORING MAY BE TENDRILS OF ICE/SNOW WITH TRAPPED ALGAE EXTENDING OUTWARD FROM SHORE. NEVER THE LESS...WL AGAIN KNOCK DOWN ICE COVER ANALYZED BY GLCFS TO 10 TO 40 PERCENT OVER NEARSHORE AREA.



MODIS image from UW DB antenna
19:32 UTC 14 December 2010





Local forecast by "City, St" or Zip Code

City, St

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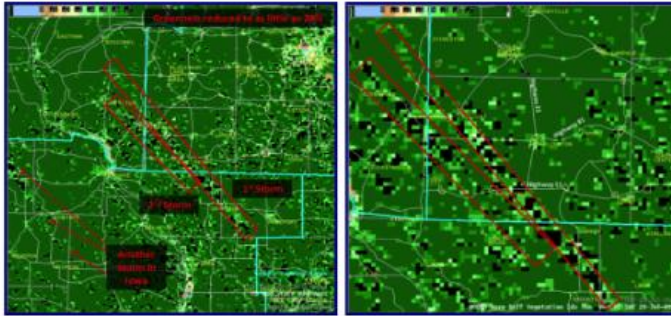
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Hail Scars Visible On Satellite Imagery

On Friday July 24, 2009, multiple significant hail storms moved southeastward across northeast Iowa, southwest Wisconsin, and northwest Illinois. These hail storms produced extremely large hail, and copious amounts of hail, which led to some concentrated swaths of damage to vegetation. In some areas, most of the crops were severely damaged or destroyed. For a complete write-up on the situation, [click here](#).

With a relatively clear day today, some of the scarring is visible on satellite images. First, the MODIS Vegetation Index which is a 1km resolution product designed to pick up on areas of greenness in the vegetation:

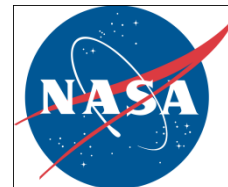
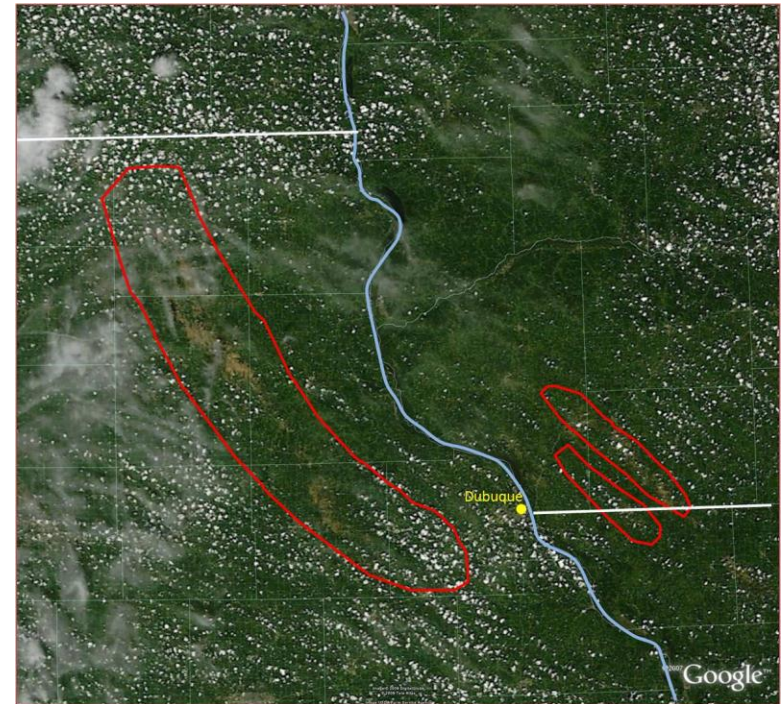


A minimum of about 28% greenness is evident just south-southeast of Belmont, which is not surprising given that is where some of the worst crop damage was observed. Corn stalks were completely stripped and sheared off to a height of less than 2 feet. These damaged areas of vegetation now absorb more radiation from the sun, thereby allowing the surface to heat faster. This phenomenon is evident in the MODIS 250m resolution satellite image from below. Cumulus clouds fired in greater abundance on the Wisconsin hail swaths, which makes them less distinguishable than the Iowa hail swath.

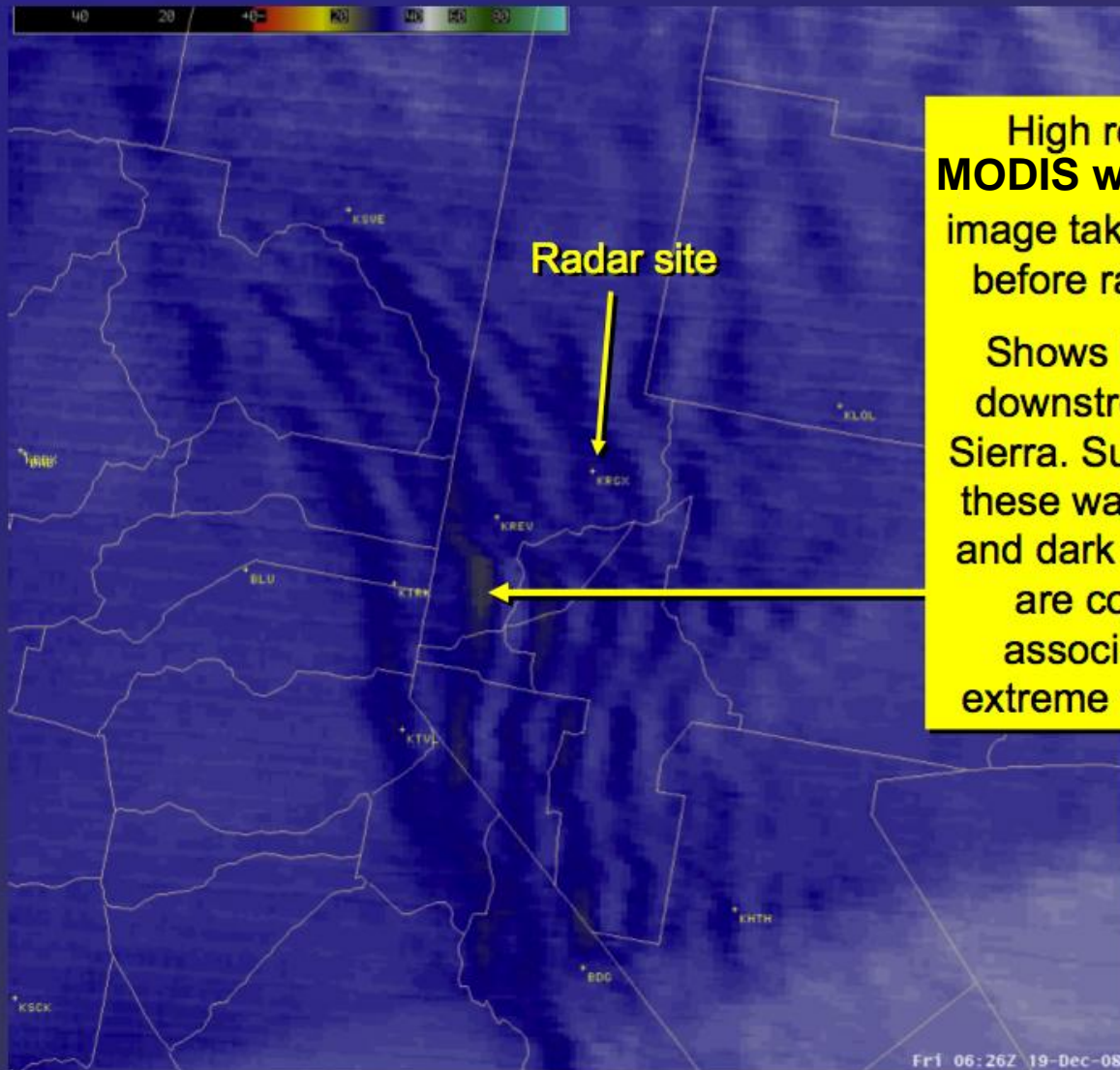


The below image is from a few days later, a little earlier in the day so fewer cumulus clouds. The hail scars are more clearly visible over southwest Wisconsin as well as in northeast Iowa.

MODIS NDVI product used to determine extent of hail damage July 2008



Lee Waves



High resolution
MODIS water vapor
image taken ~4 hours
before radar failed.

Shows lee waves
downstream of the
Sierra. Subsidence in
these waves (yellow
and dark blue areas)
are commonly
associated with
extreme wind gusts.

(credit: NWS forecast office, Reno NV)

Photos

Photos taken by NWS Reno electronics team, on first visit to radar after dome failure (19 Dec.).

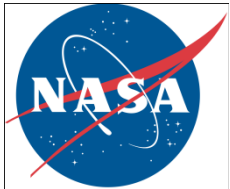


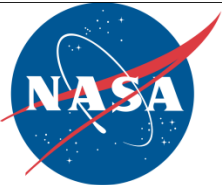
(credit: NWS forecast office, Reno NV)

MODIS Products in AWIPS

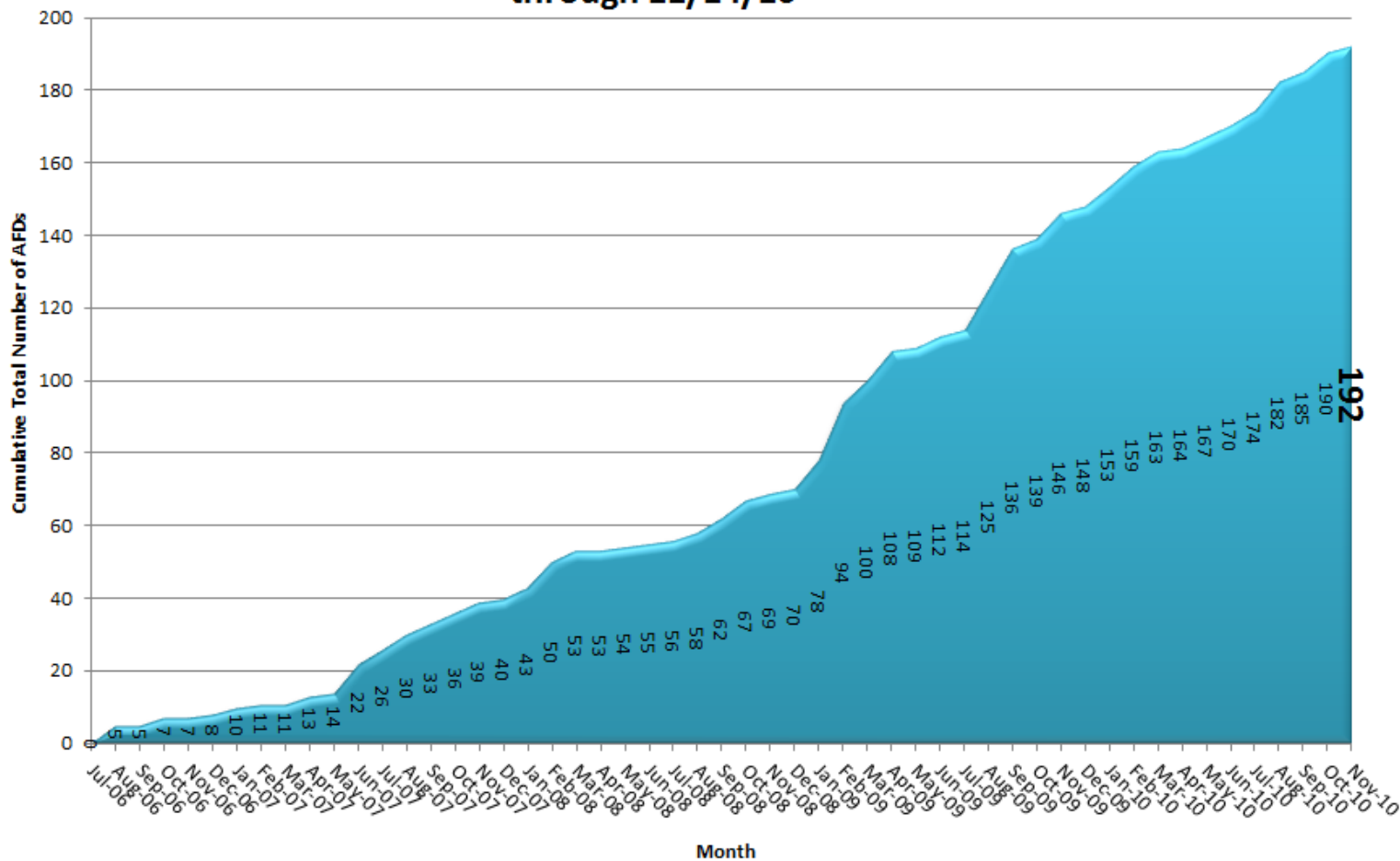
AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE RENO NV
337 AM PST TUE NOV 4 2008

ANOTHER BIG STORY WITH THIS LOW HAS BEEN THE WINDS WITH MANY LOCATIONS REMAINING QUITE WINDY OVERNIGHT AS THE COLD FRONT PASSED. **HIGH RES MODIS WATER VAPOR IMAGERY SHOWS GOOD MOUNTAIN WAVE ACTIVITY ALONG THE SIERRA AS THE SUPPRESSED TROPOPAUSE MOVED THROUGH OVERNIGHT. THIS UPPER FEATURE LIKELY HELPED TO DUCT STRONGER WINDS ALOFT DOWN TO THE SURFACE IN THE STABLE PRE-FRONTAL ENVIRONMENT SOUTH OF THE RENO AND TAHOE AREAS.**





MODIS in Area Forecast Discussions at NWS Forecast Offices through 11/14/10



Disaster Monitoring - Gulf Oil Spill



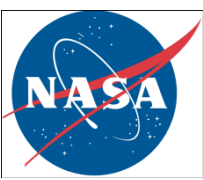
NASA Feature Article

Data Acquired and Processed at the University of Wisconsin-Madison from MODIS Direct Broadcast.

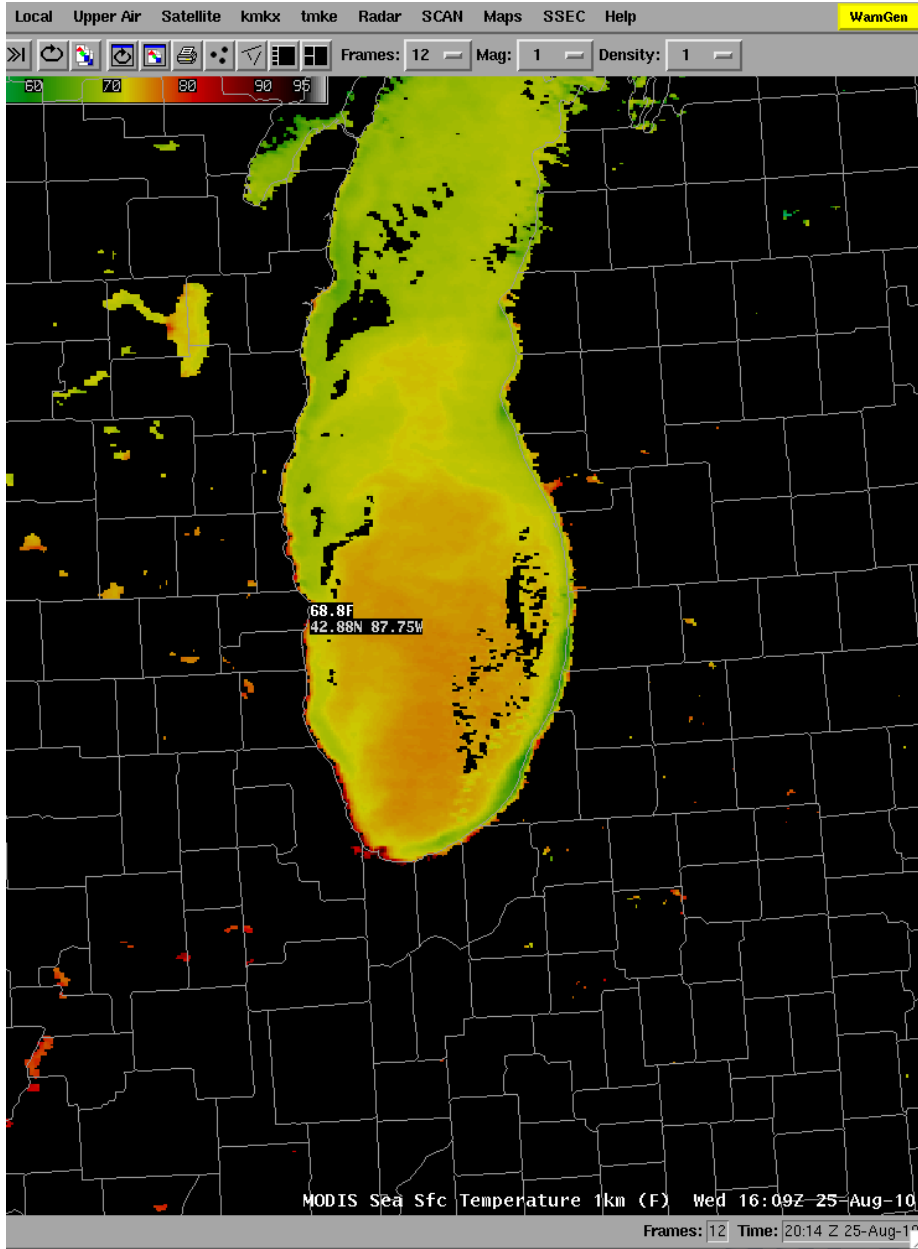


The screenshot shows a web browser window displaying a NASA article. The browser's address bar shows the URL: <http://www.nasa.gov/topics/earth/features/oil-creep.html>. The page features a navigation menu with links for HOME, NEWS, MISSIONS, MULTIMEDIA, ABOUT NASA, and CONNECT. Below the navigation is a search bar and a breadcrumb trail: NASA Home > News & Features > News Topics > Looking at Earth > Features. The main content area is titled 'News' and contains an article titled 'NASA Satellite Imagery Keeping Eye on the Gulf Oil Spill' dated 04.30.10. The article includes two satellite images: a wide-view natural-color image of the Gulf of Mexico coastline with a white outline indicating the oil slick, and a closer view of the slick showing its complex, interlocking shape. A scale bar of 100 km is visible in the first image, and a 25 km scale bar is in the second. The article text describes the MODIS image from the Terra satellite, noting the appearance of the oil slick as dull gray interlocking comma shapes and the enhancement of visibility by sun glint. It credits NASA/Earth Observatory/Jesse Allen and the University of Wisconsin's Space Science and Engineering Center MODIS Direct Broadcast system. A 'Larger Image' link is provided at the bottom of the article.

<http://www.nasa.gov/topics/earth/features/oil-creep.html>



Recent AFD using MOI



AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE
MILWAUKEE/SULLIVAN WI
228 PM CDT WED AUG 25 2010.

SHORT TERM...TONIGHT THROUGH
FRIDAY...FORECAST CONFIDENCE
HIGH.

...

**TONIGHT...WILL HAVE A CLEAR COOL
NIGHT...WITH UPPER 40S
INLAND...AND N-NE GRADIENT WINDS
OFF THE UPPER 60 LAKE WATER
TEMPERATURES INDICATED BY THE
MODIS SEA SFC TEMPERATURE
IMAGERY HOLDING LAKESHORE
TEMPS UP. LOWER DEW POINTS
ADVECTING IN OFF-SET BY WARM
GROUND TO KEEP
TEMPERATURE/DEW POINT SPREADS
SUFFICIENT TO LIMIT ANY FOG TO
RIVER VALLEYS AND LAKES.**



National Weather Service Weather Forecast Office
Milwaukee/Sullivan, WI

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 "City, ST" or Zip Code
 City, St Go

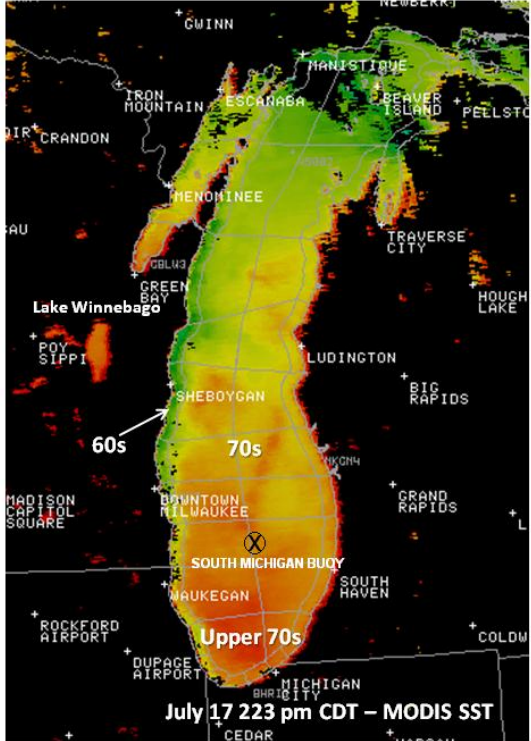
XML RSS Feeds
 Current Hazards
 Watches/Warnings
 Outlooks
 Submit Report
 Current Conditions
 Observations

Unseasonably Warm Lake Michigan Cooling Off!

The prolonged period of unseasonably warm temperatures during July and August across southern Wisconsin and surrounding regions pushed the Lake Michigan sea surface temperature to 80 degrees several times during the month of August at the [south Lake Michigan buoy](#) located 43 miles east-southeast of Milwaukee. The buoy reached 80 °F on August 1st, August 10th, and August 12th.

.....

The sea surface temperature image below taken by the [Moderate Resolution Imaging Spectroradiometer \(MODIS\)](#) equipment on a polar orbiting satellite in mid-July show the sea surface temperature had warmed into the middle to upper 70s across the southern mid-lake waters.



July 17 223 pm CDT – MODIS SST

The following graphics are a monthly breakdown of the average daily surface temperature observed this year versus the average daily surface temperature for the period between 1981 and 2009.

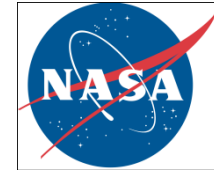


MODIS 1 km resolution image from 17 July 2010 showing unusually warm Sea Surface Temperatures over Lake Michigan in July. This image was created using AWIPS and Appeared in the MKE Forecast office "Top News of the Day" page.

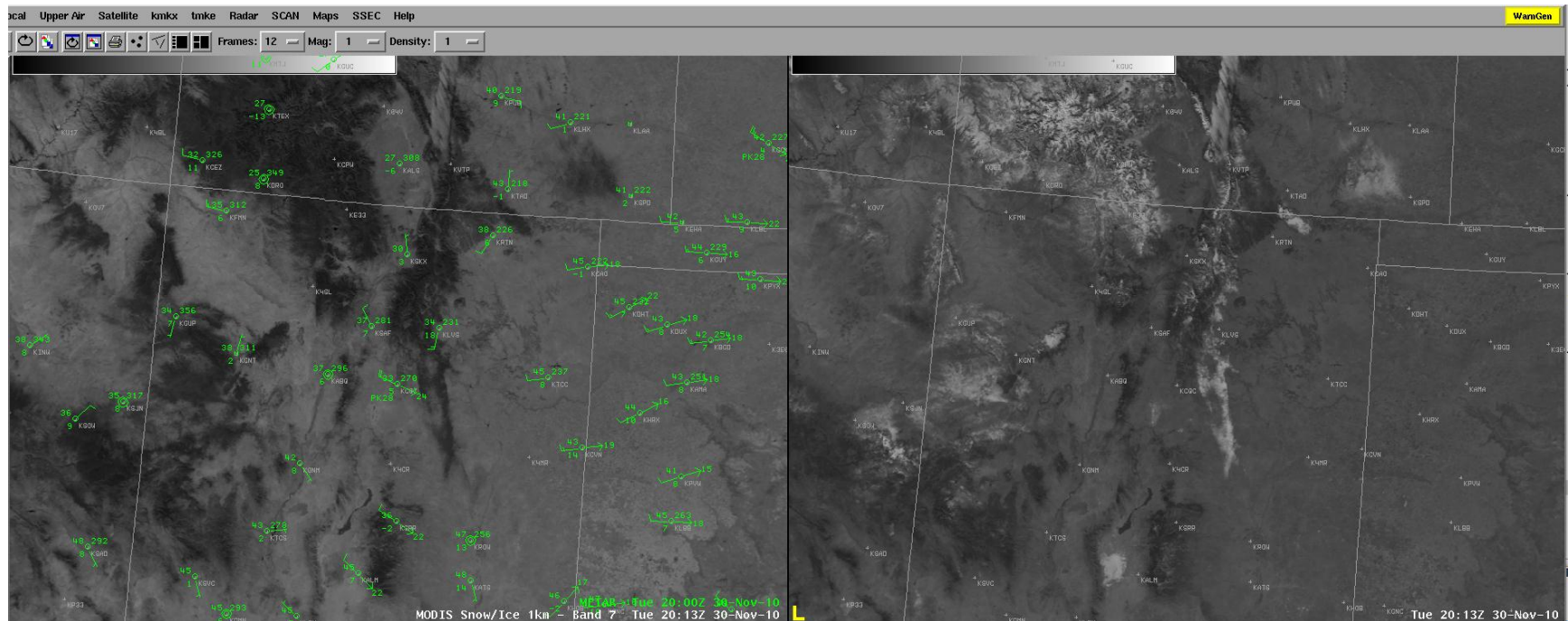
The image was acquired, processed and distributed by the University of Wisconsin-Madison Space Science and Engineering Center (SSEC).

Support for Fire Wx Forecasts

AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE ALBUQUERQUE NM
300 AM MST WED DEC 1 2010



.FIRE WEATHER...ONLY MINOR CHANGES TO OVERALL FORECAST THROUGH THE WEEKEND. A 1016MB LEE TROUGH OVER THE PLAINS HAS ALLOWED WESTERLY DOWNSLOPE WINDS TO DOMINATE THE AREA...THUS TEMPS ARE MUCH WARMER AND WINDS SLIGHTLY BREEZIER. AN ISOLATED AREA OF MARGINAL CRITICAL FIRE WX CONDITIONS WILL DEVELOP BTWN CLINES CORNERS...VAUGHN...SANTA ROSA...AND LAS VEGAS BY LATE THIS MORNING HOWEVER NO FIRE WX HIGHLIGHTS WILL BE ISSUED. **MELTING SNOWPACK EVIDENT ON THE 2013Z MODIS 1KM VISIBLE IMAGERY TUESDAY IN NEARLY THE EXACT SAME AREA WILL MITIGATE SURFACE FUEL DRYNESS.** MIN RH VALUES WILL RANGE FROM 20-25 PCT ALONG THE COLORADO BORDER TO 10-15 PCT ACROSS THE SOUTH. VENT RATES TODAY WILL BE POOR MOST AREAS EXCEPT ALONG THE EAST SLOPES WHERE FAIR VALUES ARE EXPECTED.



U.S. Air Quality

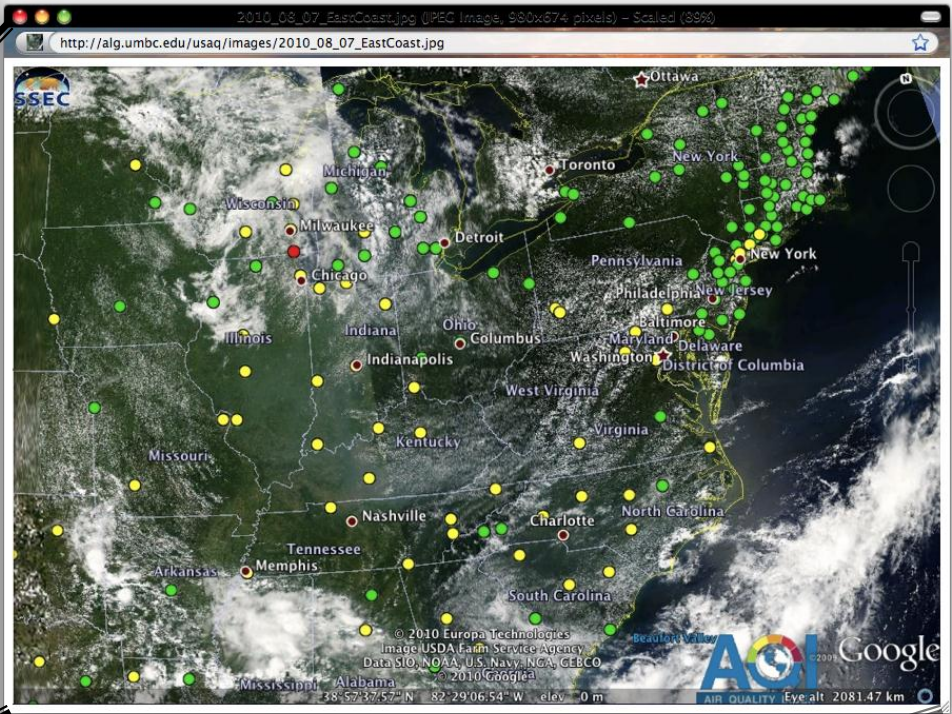
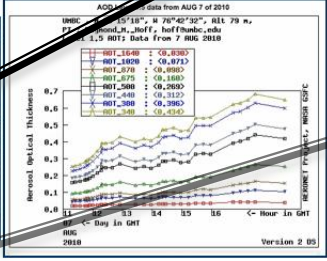
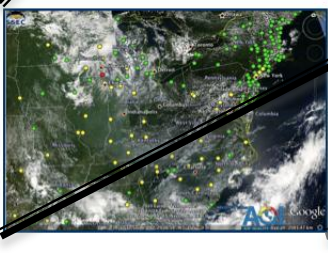
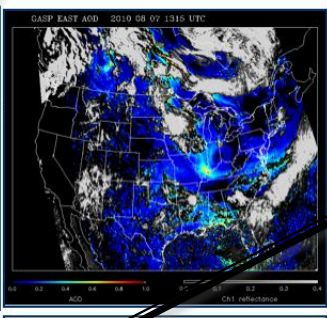
The Smog Blog

« Code Orange PM2.5 and High AOD from Smoke in Northwest; | Main | Smoke reaches the East Coast of the US »

August 7, 2010

SMOKE BLANKETS MUCH OF NORTH AMERICA

A broad band of smoke continues to pour down from Canadian wildfires and from fires in Oregon and Washington. The path of the smoke through the western Great Lakes region reaches down to Kentucky and then turns eastward pouring out into the Atlantic over the mid-Atlantic states. The smoke is largely aloft although moderate PM air quality readings are seen over the same region. The first panel (upper left) shows the Hazard Mapping System's identification of the boundaries of the smoke. The second panel (upper right) shows the GASP AOD loop for this morning and afternoon. The third panel shows the composite of the afternoon AQUA MODIS overpass and the AIRNOW AQI readings which are mostly in the yellow (hazardous for sensitive groups) levels. The bright red reading at Kenosha WI was a PM AQI of 154 which was not seen in the AIRNOW Tech plots, so some care needs to be taken on this isolated reading. On the lower right, the optical depth continues to rise over the day at UMBC.



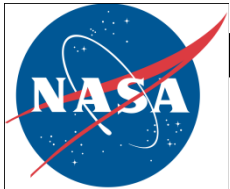
MODIS Today images are regularly used to support US Air Quality forecasters as part of the UMBC/NASA Smog Blog: <http://alg.umbc.edu/usaq/>

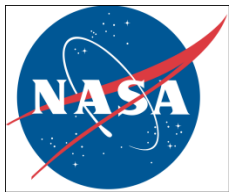
How do we know MODIS data is useful to forecasters?

- Forecaster surveys
 - >70 percent responded that MODIS data is useful
- MODIS data used as a forecast decision making tool in AFD's
- MODIS data has been designated as

critical” for inclusion in AWIPS II

UW responsible for writing AWIPS II MODIS plug-in





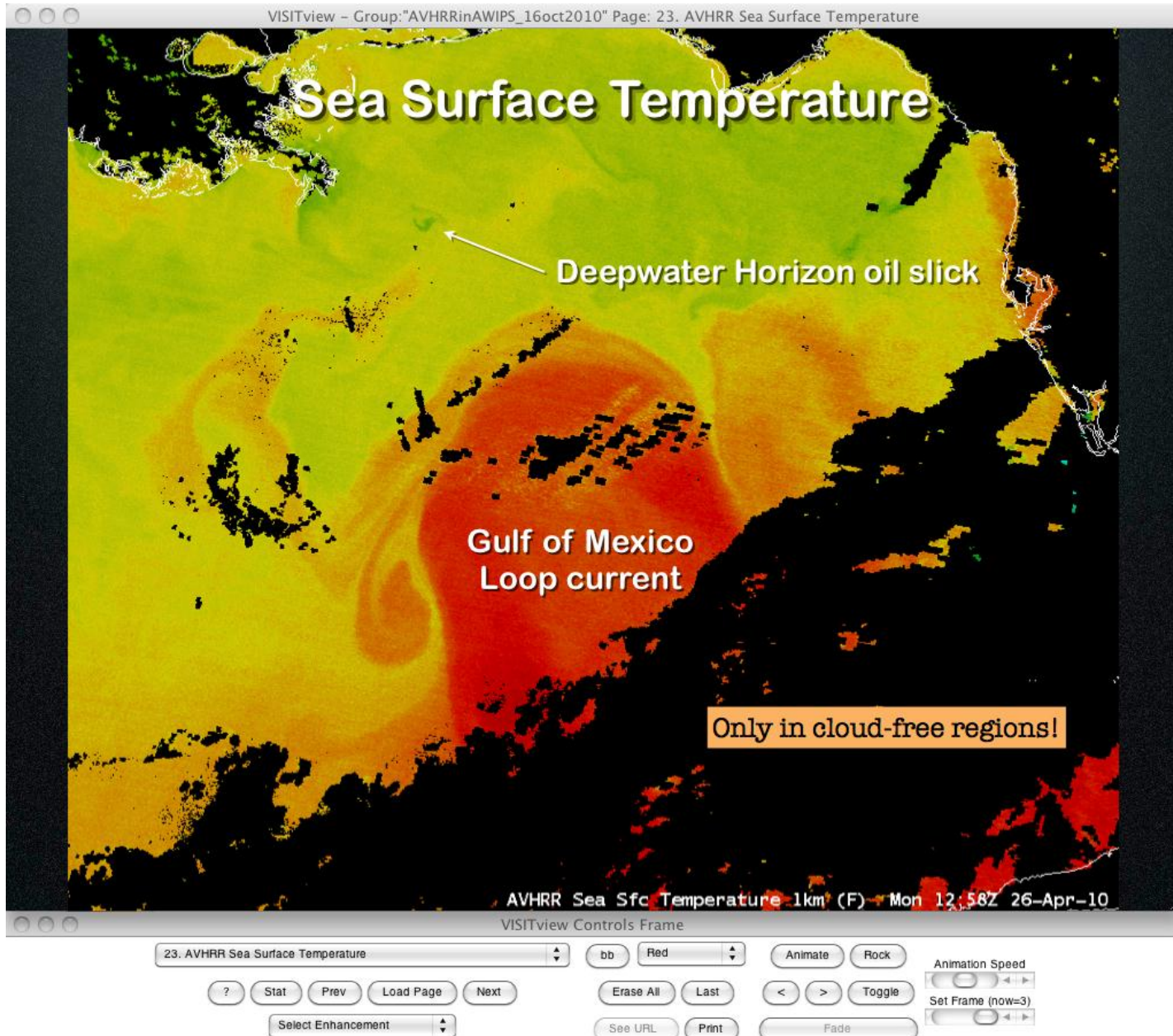
Keys to Success



- Directly talk to NWS personnel to understand how the data may help
 - UW visited all 3 Wisconsin Forecast Offices
- Jordan Gerth figured out a way to deliver the products to NWS using the LDM
 - Bandwidth and security a constraint
- MODIS can provide something that is new or improved from what forecasters are used to
- Training - VISIT “MODIS in AWIPS”
module



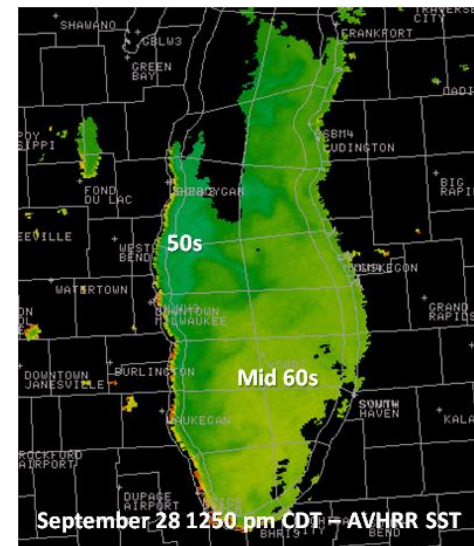
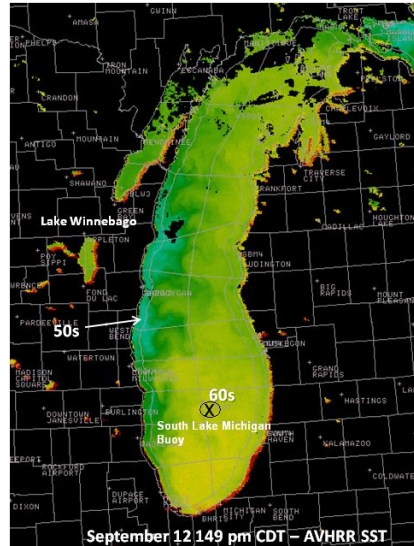
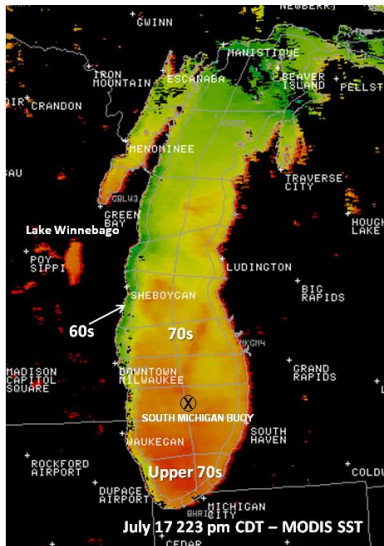
Training forecasters



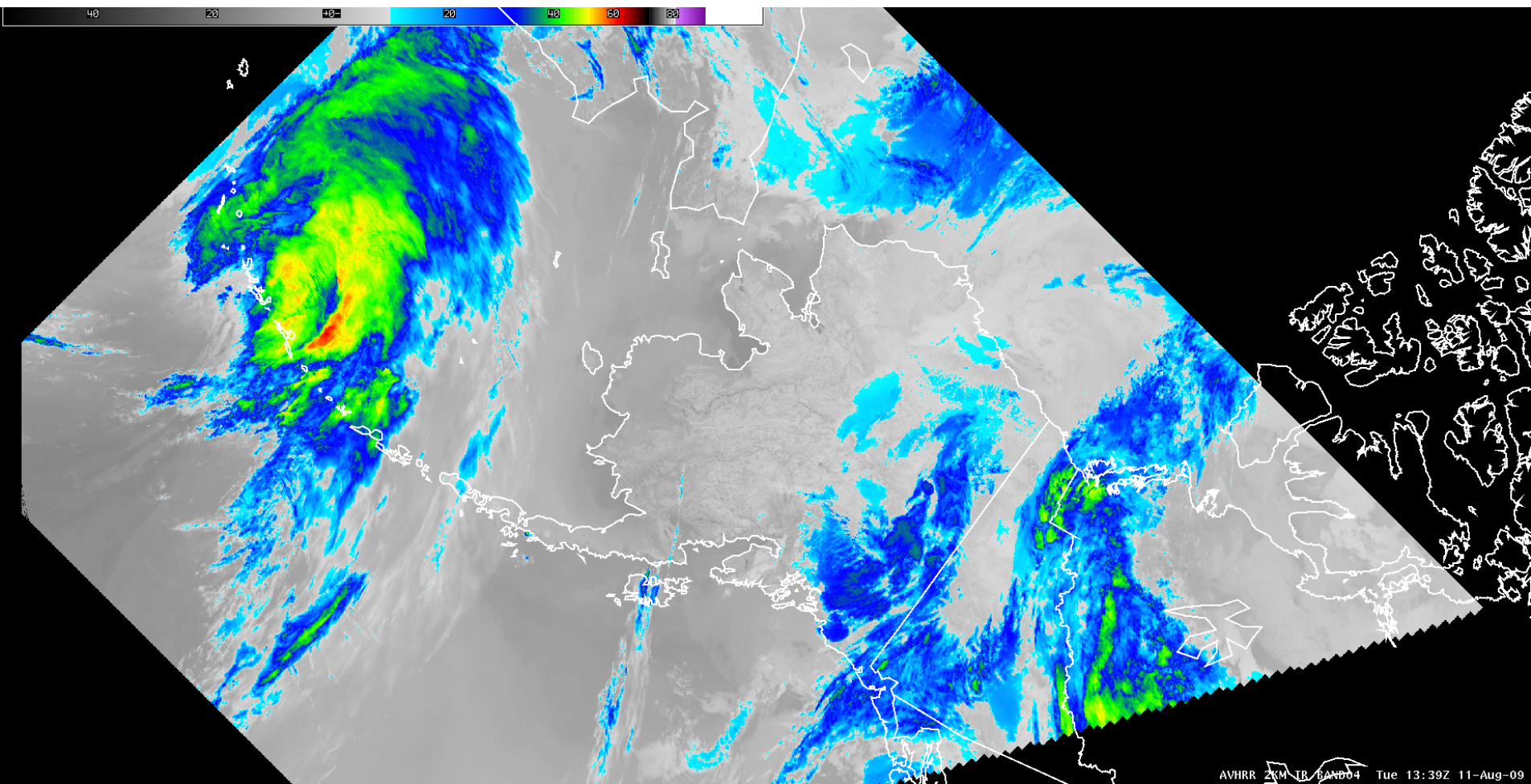
MODIS and AVHRR in AWIPS

http://www.crh.noaa.gov/news/display_cmsstory.php?wfo=mkx&storyid=57591&source=0

“Lake Michigan sea surface temperatures have remained fairly steady the past two weeks due to the persistent seasonal temperatures and a lack of a significant push of cold air across the lake. Below is the AVHRR image taken on September 28th showing sea surface temperatures holding in the 50s over the nearshore waters of Lake Michigan, with middle 60s in the open waters of the southern end of the lake.... ”



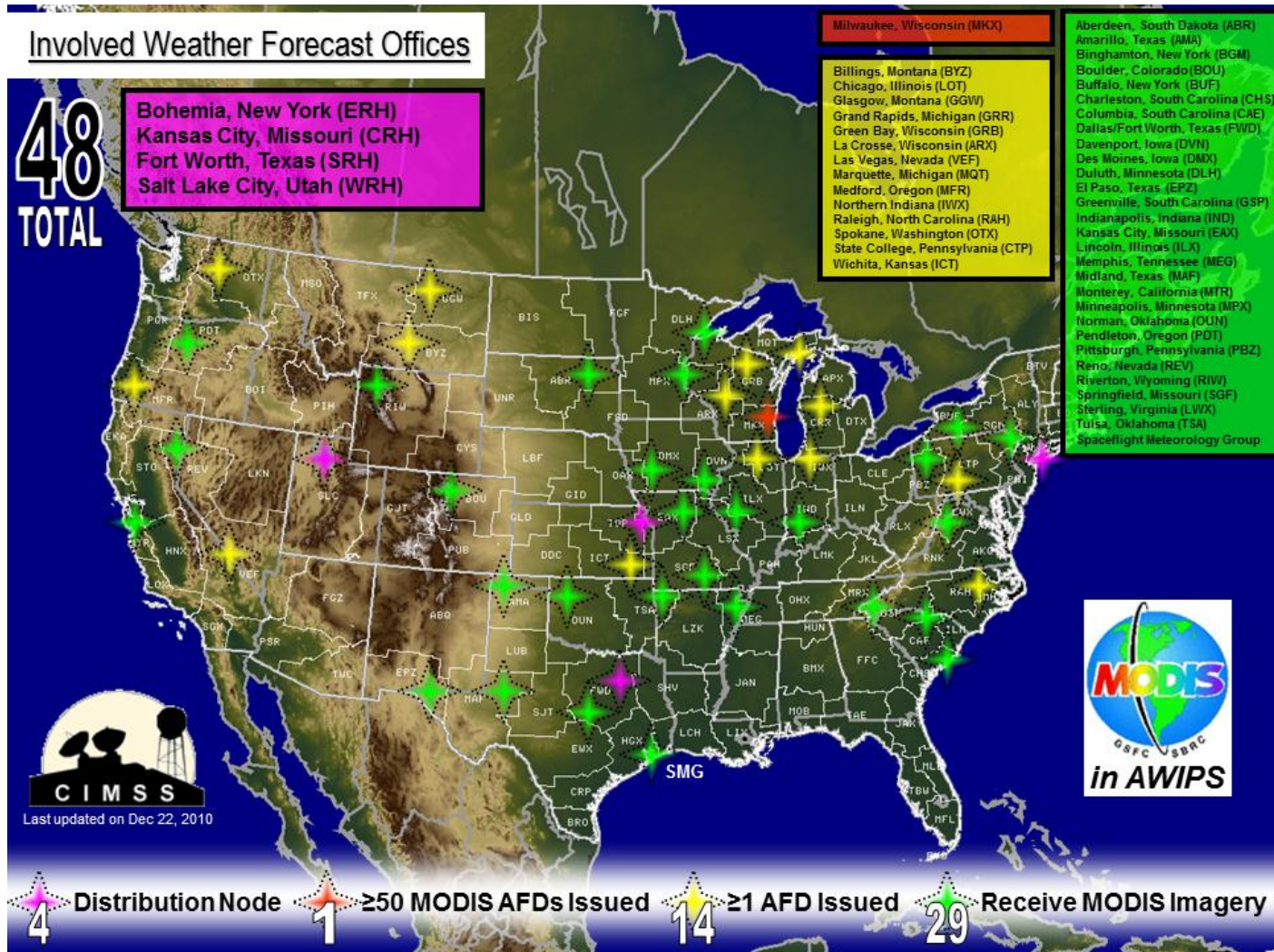
AVHRR in AWIPS



Example of other products:

http://cimss.ssec.wisc.edu/goes/blog/wp-content/uploads/2009/08/090811_avhrr_ir_type_anim.gif

SSEC UW Direct Broadcast MODIS and AVHRR Data used by the National Weather Service (NWS)



MODIS and AVHRR products have been mentioned in Area Forecast Discussions 192 times

SSEC UW-Madison Direct Broadcast Users

1. US National Weather Service (NWS):

- Central,
- Western,
- Eastern and
- Southern Regions

2. NWS Space Flight Meteorology Group <http://www.srh.noaa.gov/smg>

3. Naval Research Laboratory Monterey

http://www.nrlmry.navy.mil/nexsat_pages/nexsat_home.html

4. NASA/MSFC Short-term Prediction Research and Transition Center

<http://weather.msfc.nasa.gov/sport/>

5. NOAA CoastWatch Great Lakes Node

http://coastwatch.glerl.noaa.gov/modis/region_map.html

6. WisconsinView <http://www.wisconsinview.org/>

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

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

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

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

11. Weather Underground <http://www.wunderground.com/blog/Rainman32>

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

**Polar Orbiting Weather Satellite Proving Ground (PG):
Facilitating Broad and Optimal Use of Global Direct Broadcast Data
SUMMARY**

Leveraging GOES-R PG partnership, NOAA, & NASA support, SSEC/UW is committed to fully support NOAA PG Activities to:

- Maintain existing DB Processing Packages (i.e. IMAPP) for MODIS and AIRS and to develop new capabilities/applications and software packages for NPP/JPSS (IPOP), & METOP (L1-L2 PP) systems.
- Upgrade DB real-time processing system efficiency, functions, and effort in enhancing Numerical Weather Prediction (DBCRA) and air quality model (IDEA-I) and other applications to directly assimilate real time products (i.e. clouds, water vapor, and aerosol) to optimize broad use of DB products.
- Provide DB users a turn-key, end-to-end, real-time data acquisition, processing and distribution system
- Support NOAA NNWS offices & Real-Time DB users in the efficient and broad use of the current and future polar orbiting satellite data/information.
- Offer DB users training workshops in processing algorithms, S/W package operations and real-time applications