

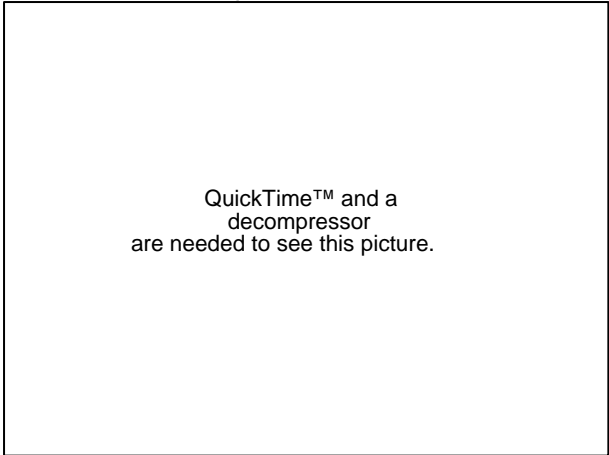
IMAPP: Software to Transform EOS Direct Broadcast Data into Science Products



Kathleen Strabala, Liam Gumley,
Allen Huang, Elisabeth Weisz, Jun
Huang

Overview of Wisconsin DB Activities

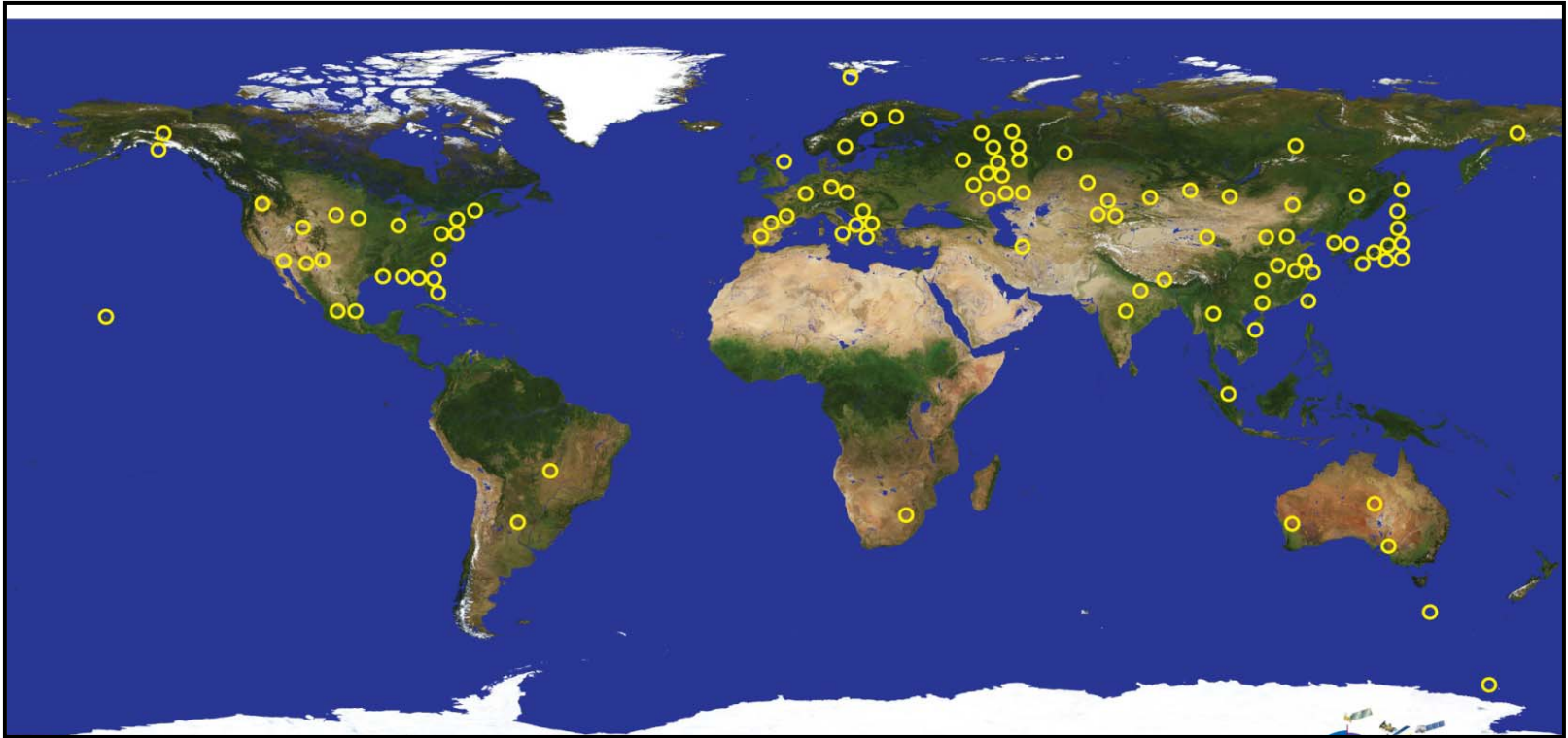
- *Real time data processing and distribution - (NWS)*
 - Real time direct broadcast web pages
 - Support of environmental monitoring and weather forecasting where quality and timeliness of data are vital
- *Software development and distribution - (IMAPP)*
 - IMAPP allows other users the ability to support their own real time data and processing systems
 - Testbed for MODIS/AIRS products
 - Support of our own research (total control of system from end to end)
 - AIRS data for ABI simulations
 - MODIS/AIRS combined products
 - MOD07 TPW / near-infrared validations
- *Remote sensing workshops*
 - Global outreach
 - Now that we have data and products, what do we do with them?



QuickTime™ and a
decompressor
are needed to see this picture.

EOS Direct Broadcast Ground Stations

~ 125 Sites (40 in China alone)



NASA funded International MODIS/AIRS Processing Package (IMAPP)

Builds upon our previous experience with

- ITPP (International TOVS Processing Package) since 1985
- IAPP (International ATOVS Processing Package) since 1998

Purpose: To allow DB users capability of producing EOS products

IMAPP is derived from the operational EOS processing software developed at NASA GSFC and JPL, and has been modified to be compatible with direct broadcast data. The main differences between IMAPP and the operational software are:

- portability,
- wherever possible, the reliance on toolkits has been eliminated,
- the IMAPP processing environment is greatly simplified,
- overpasses of arbitrary size may be processed.

New IMAPP web page and download interface:

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

Current IMAPP Status

MODIS products

- cloud mask (MOD35), cloud properties (MOD06CT) - height, temperature, emissivity, phase
- atmospheric profiles (MOD07) T, q, tpw, total ozone, stability
- aerosol optical depth (MOD04)
- sea surface temperatures (Jim Davies not MOD28)
- near-infrared water vapor (Peter Albert, Ralf Bennartz not MOD05)

MODIS utilities

- creating true color images tutorial
- Visualization software (McIDAS binaries for automatic quick look product creation)

AIRS products

- AIRS/AMSU/HSB Level 1 and Level 2 (with JPL - 3x3 pixels)
- AIRS Level 2 profiles (UW - single pixel clear sky only)

AMSR-E products – RSS LIB software

- Rain rate, rain type
- Soil Moisture
- Snow Water Equivalence

IMAPP MODIS Level 2 v2.0 Released

(So far, 36 different countries have obtained MODIS L2 v2.0)

Improvements:

- Collect 5 algorithm updates
- Repackaged to run as a series of executables called from one script - (SeaDAS like)
- Ancillary data automatically identified and fetched from IMAPP ftp site
- Ancillary data archive covers entire lifetime of Aqua and Terra
- IDL no longer required for HDF file generation (Thanks to DRL for conversion routines)
- Imaging software based on McIDAS produces quick look product images automatically
- Removes confusion over dependencies between previous versions of Level 2 releases

Global Examples

IMAPP MODIS L2 Downloads

Italy

Argentina

Brazil

Kazakhstan

Ukraine

Indonesia

China

Denmark

South Africa

Taiwan

Japan

Morocco

Iran

Singapore

India

Germany

United Kingdom

Australia

Mexico

Hungary

Belgium

Norway

Venezuela

Sri Lanka

France

Russia

Vietnam

Mongolia

Turkey

South Korea

United Arab Emirates

Lithuania

United States

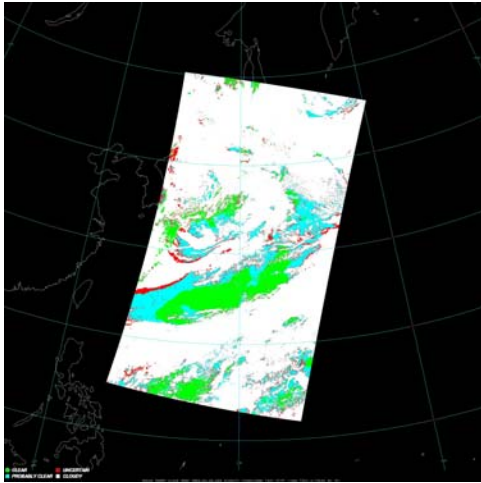
Thailand

Romania

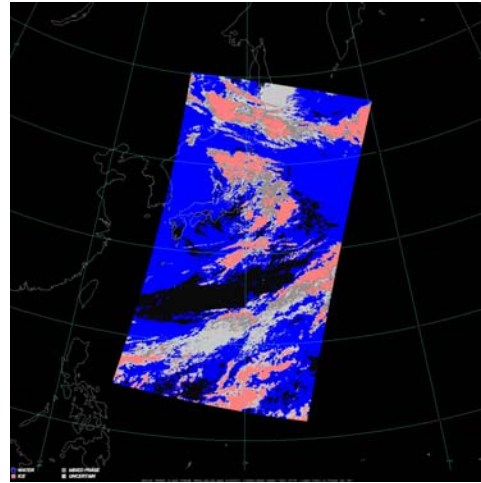
Malaysia

MODIS Level-2 Processing

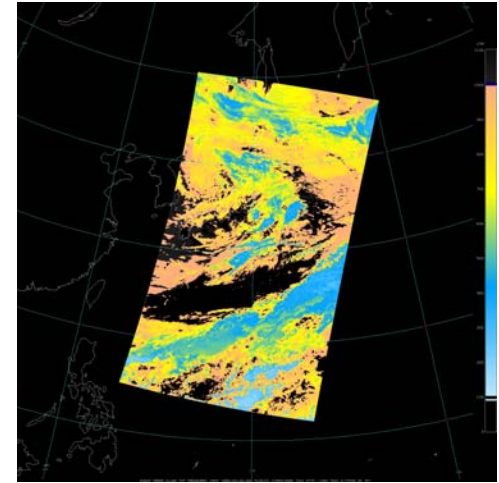
Example from Tokyo University



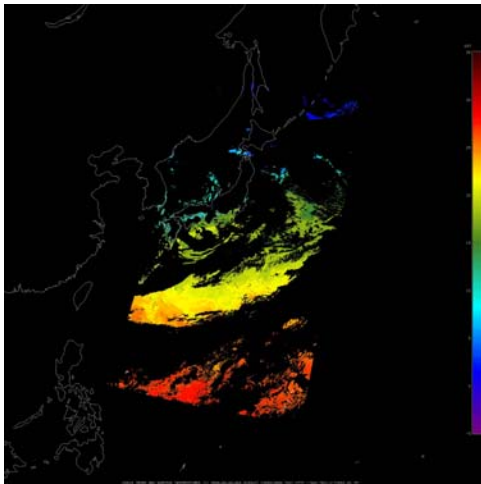
Cloud Mask



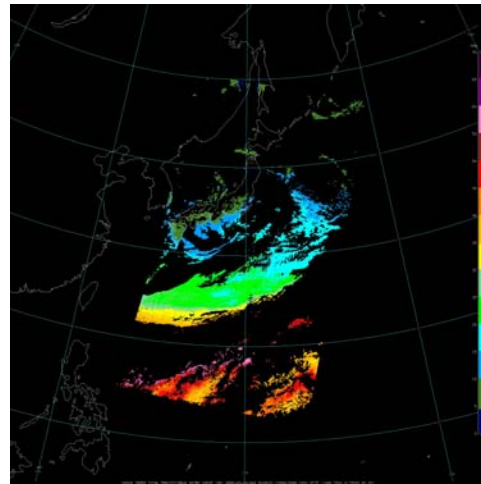
Cloud Phase



Cloud Top
Pressure

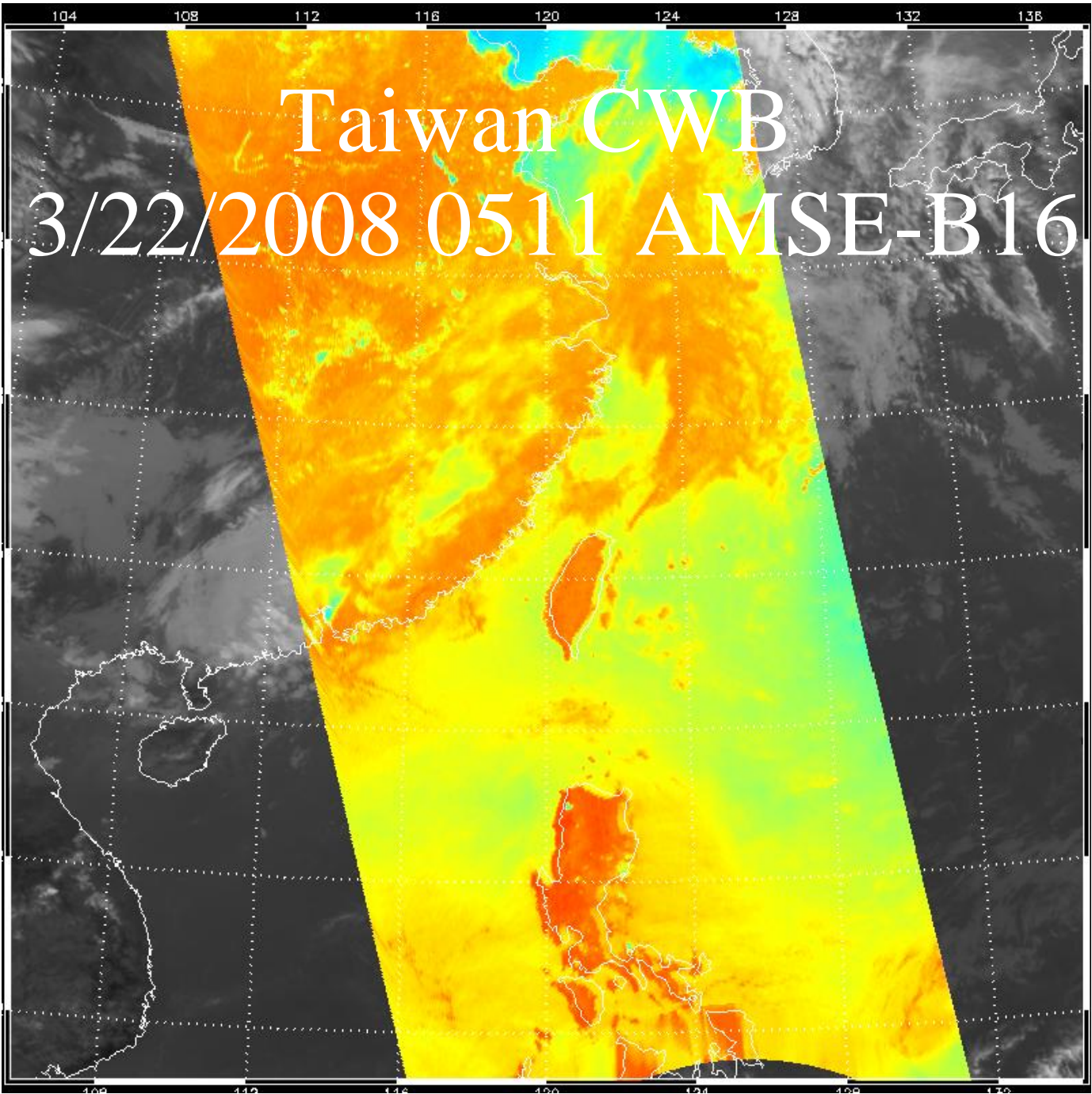


SST



Water Vapor

Terra
28 February 2008




IMAPP Products Used for Forecasting at the Poles

http://stratus.ssec.wisc.edu/cgi-bin/db_main?site=mcmurdo

Getting Started Apple Personal MODIS DB Wx Technical

NESDIS/STAR/ASPT Home Products Projects Scenes Links CIMSS

Real-Time MODIS Products from McMurdo



McMurdo Home
Tromsø Home
Sodankylä Home
Fairbanks Home
Barrow Home
Real-Time Home

Atmosphere Products:

MODIS winds
Cloud mask
Cloud pressure
Cloud phase
TPW
Inversions:
Strength
Depth

Surface Products:

Surface Temperature
Surface Albedo
Snow Index
Vegetation Index

Image Products:

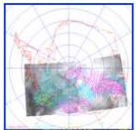

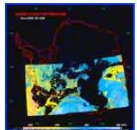
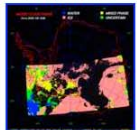
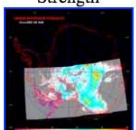
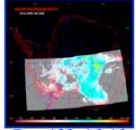
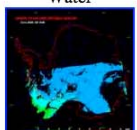
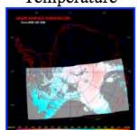
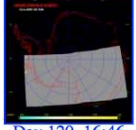
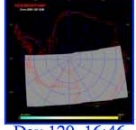
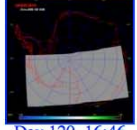
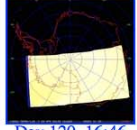
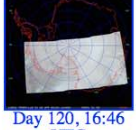
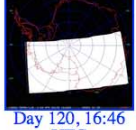
RGB Day
RGB Night
True Color

Misc:

Data Access
Credits
Cautions
Processing times
Model winds:
Surface
400 hPa

A number of MODIS products are generated on-site at McMurdo, Antarctica, using data from the National Science Foundation's direct broadcast system. Here are the most recent images for each product. **Click on the product links at left for more images of a specific product.** The purpose of this direct broadcast real-time system is two-fold: (1) to generate polar wind and other information more quickly than is done with our current system, so that numerical weather prediction centers can assimilate more polar data in their model runs, and (2) to provide an additional source of information, primarily winds, for weather forecasters in Antarctica.

TERRA:

Winds  Day 120, 16:46 UTC	Cloud Mask  Day 120, 16:46 UTC	Cloud Pressure  Day 120, 16:46 UTC	Cloud Phase  Day 120, 16:46 UTC
Inversion Strength  Day 120, 16:46 UTC	Inversion Depth  Day 120, 16:46 UTC	Precipitable Water  Day 120, 16:46 UTC	Surface Temperature  Day 120, 16:46 UTC
Surface Albedo  Day 120, 16:46 UTC	Snow Index  Day 120, 16:46 UTC	Vegetation Index  Day 120, 16:46 UTC	RGB Day  Day 120, 16:46 UTC
RGB Night  Day 120, 16:46 UTC	True Color  Day 120, 16:46 UTC		


Find: Wang Next Previous Highlight all Match case Done

http://stratus.ssec.wisc.edu/cgi-bin/db_main?site=tromso

Getting Started Apple Personal MODIS DB Wx Technical

NESDIS/STAR/ASPT Home Products Projects Scenes Links CIMSS

Real-Time MODIS Products from Tromsø, Norway



Tromsø Home
McMurdo Home
Sodankylä Home
Fairbanks Home
Barrow Home
Real-Time Home

Atmosphere Products:

MODIS winds
Cloud mask
Cloud pressure
Cloud phase
TPW
Inversions:
Strength
Depth

Surface Products:

Surface Temperature
Surface Albedo
Snow Index
Vegetation Index

Image Products:

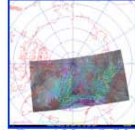
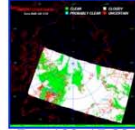
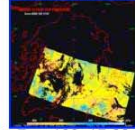
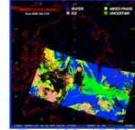
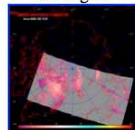
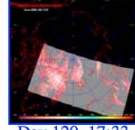
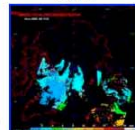
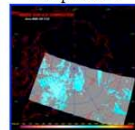
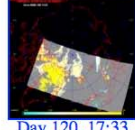
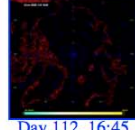
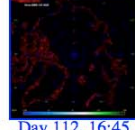
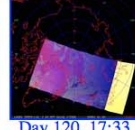
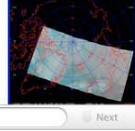
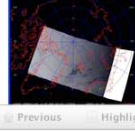
RGB Day
RGB Night
True Color

Misc:

Data Access
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Cautions
Processing times
Model winds:
Surface
400 hPa

A number of MODIS products are generated on-site at Tromsø, Norway, using data from the Integrated Program Office's direct broadcast system. That system is operated by Ksat. Here are the most recent images for each product. **Click on the product links at left for more images of a specific product.** The purpose of this direct broadcast real-time system is two-fold: (1) to generate polar wind and other information more quickly than is done with our current system, so that numerical weather prediction centers can assimilate more polar data in their model runs, and (2) to provide an additional source of information, primarily winds, for local weather forecasters. NOTE: Because of Aqua playback scheduling, only Terra data are used for these products.

TERRA:

Winds  Day 120, 15:56 UTC	Cloud Mask  Day 120, 17:33 UTC	Cloud Pressure  Day 120, 17:33 UTC	Cloud Phase  Day 120, 17:33 UTC
Inversion Strength  Day 120, 17:33 UTC	Inversion Depth  Day 120, 17:33 UTC	Precipitable Water  Day 120, 17:33 UTC	Surface Temperature  Day 120, 17:33 UTC
Surface Albedo  Day 120, 17:33 UTC	Snow Index  Day 112, 16:45 UTC	Vegetation Index  Day 112, 16:45 UTC	RGB Day  Day 120, 17:33 UTC
RGB Night  Day 120, 17:33 UTC	True Color  Day 120, 17:33 UTC		

Find: Next Previous Highlight all Done

Vendor Distributions

- SeaSpace Corporation
- Kongsburg Satellite Services

Description:

MODIS Cloud Top Temperature Product (1KM)

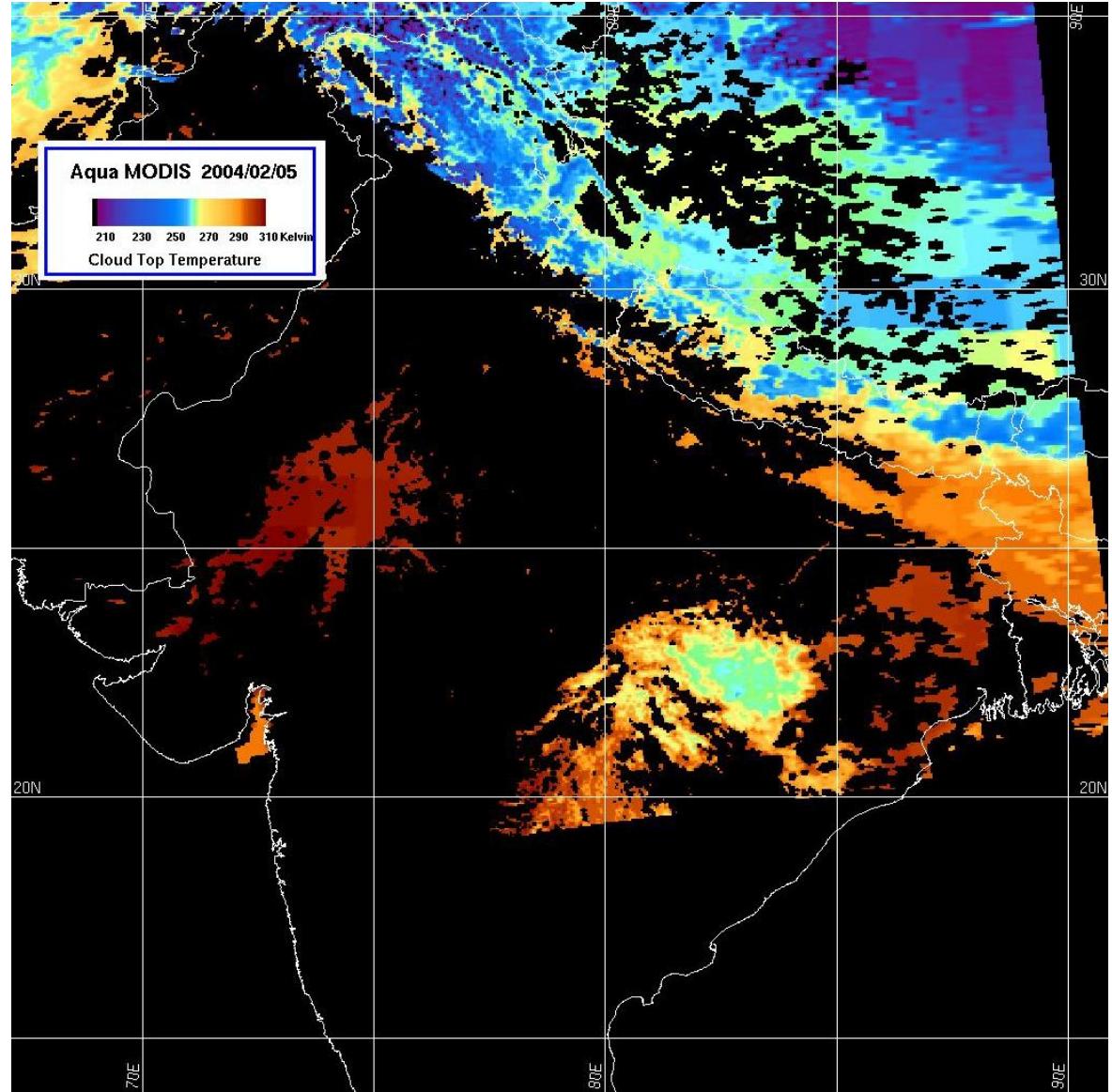
MOD06 Cloud Top product

Cloud Top Temperature

Aqua/MODIS 1000m calibrated data as inputs to the MOD06 algorithm – Automated supervised classification scheme

Estimates cloud top temperatures

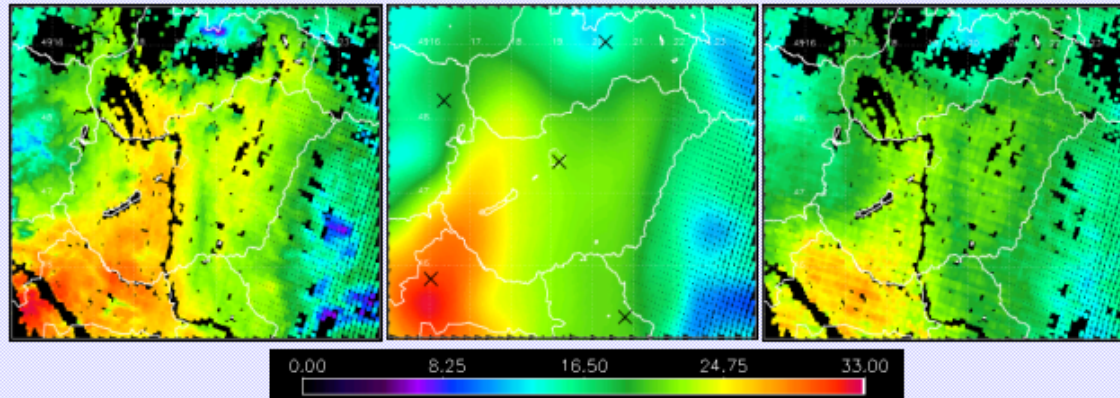
**SeaSpace Example:
5 February 2005**



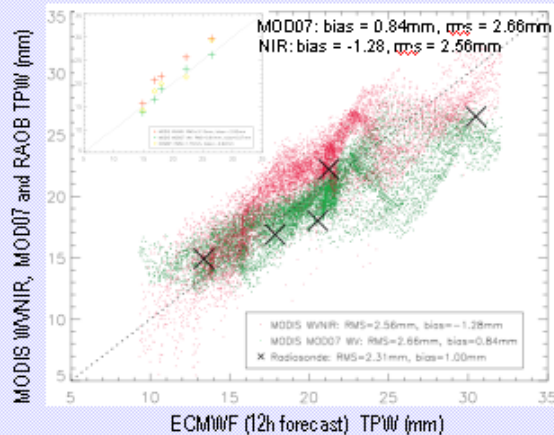
Estimation of vertically integrated water vapor in Hungary using MODIS imagery

Aniko Kern, Judit Bartholy, Eva E. Borbas, Zoltan Barcza, Rita Pongracz, Csaba Ferencz, 2008: *Advances in Space Research*, **41**, 1933-1945.

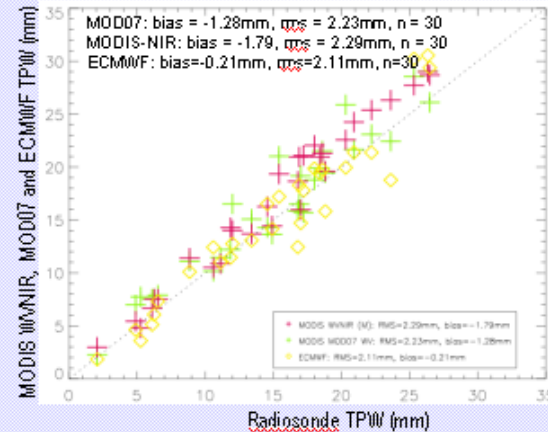
Comparison of IR and NIR TPW over the Carpathian Basin



Comparison of the MODIS Near-IR (left), ECMWF forecast (middle) and MOD07 (right) derived TPW for Terra satellite on Sept 8 2005 at 9:55 UTC (Radiosonde stations are indicated by X on the middle image). The MODIS data were received at the MODIS DB station in Budapest, Hungary.



Comparison of TPW from MOD07 (red), Near-IR WVN (green), and radiosonde (black crosses) with the ECMWF 00+12 h forecast for September 8, 2005, 9:55 UTC



Comparison of TPW from MOD07 (green+), Near-IR WVN (red+), and ECMWF (yellow o) with the radiosondes for 20 Terra clear sky overpasses between March 2005 and Jun 2006.

Local Applications

Supporting US National Weather
Service

Can Research Satellites be used in Operations?

What makes satellite data useful?

- High quality
- Timeliness (DB makes this possible)
- Reliability
- Provides something new or better
- AWIPS compatibility

MODIS 1km Imagery and 5km Products in AWIPS

Band 20 - ($3.7\mu\text{m}$) -
Shortwave IR

Band 26 - ($1.3\mu\text{m}$) - Cirrus
detection

Band 27 - ($6.7\mu\text{m}$) - Water
vapor

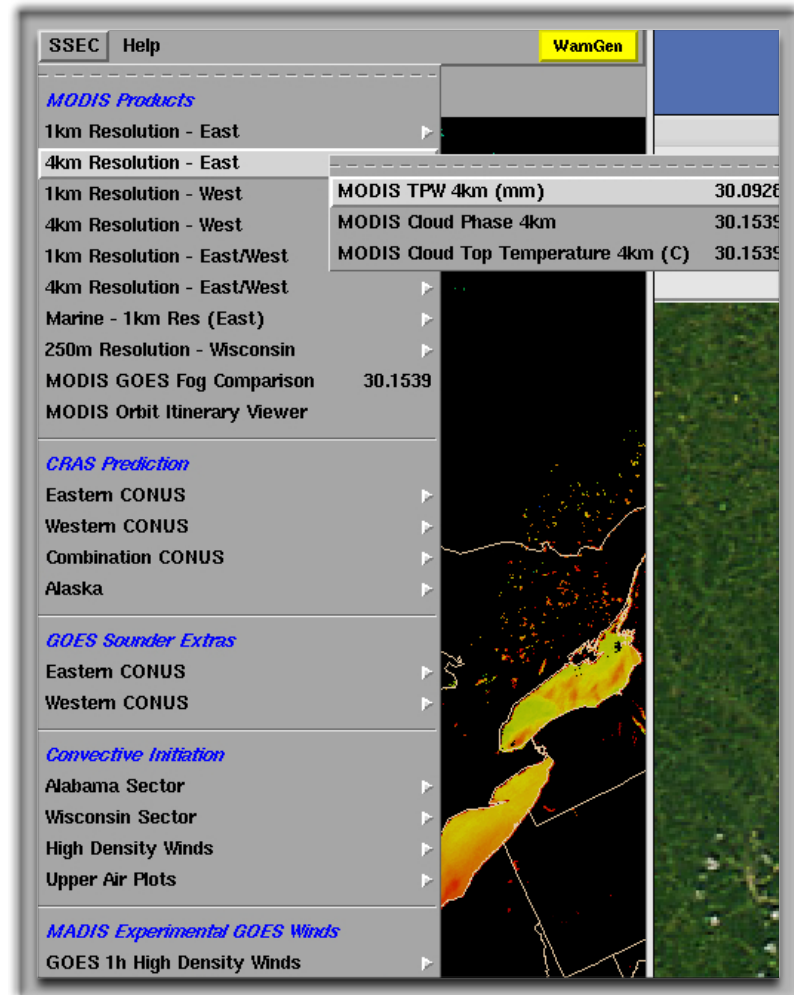
Band 31 - ($11.0\mu\text{m}$) - IR
window

$11\mu\text{m} - 3.7\mu\text{m}$ - Fog/stratus
product

IMAPP products:

Total precipitable water
(TPW)

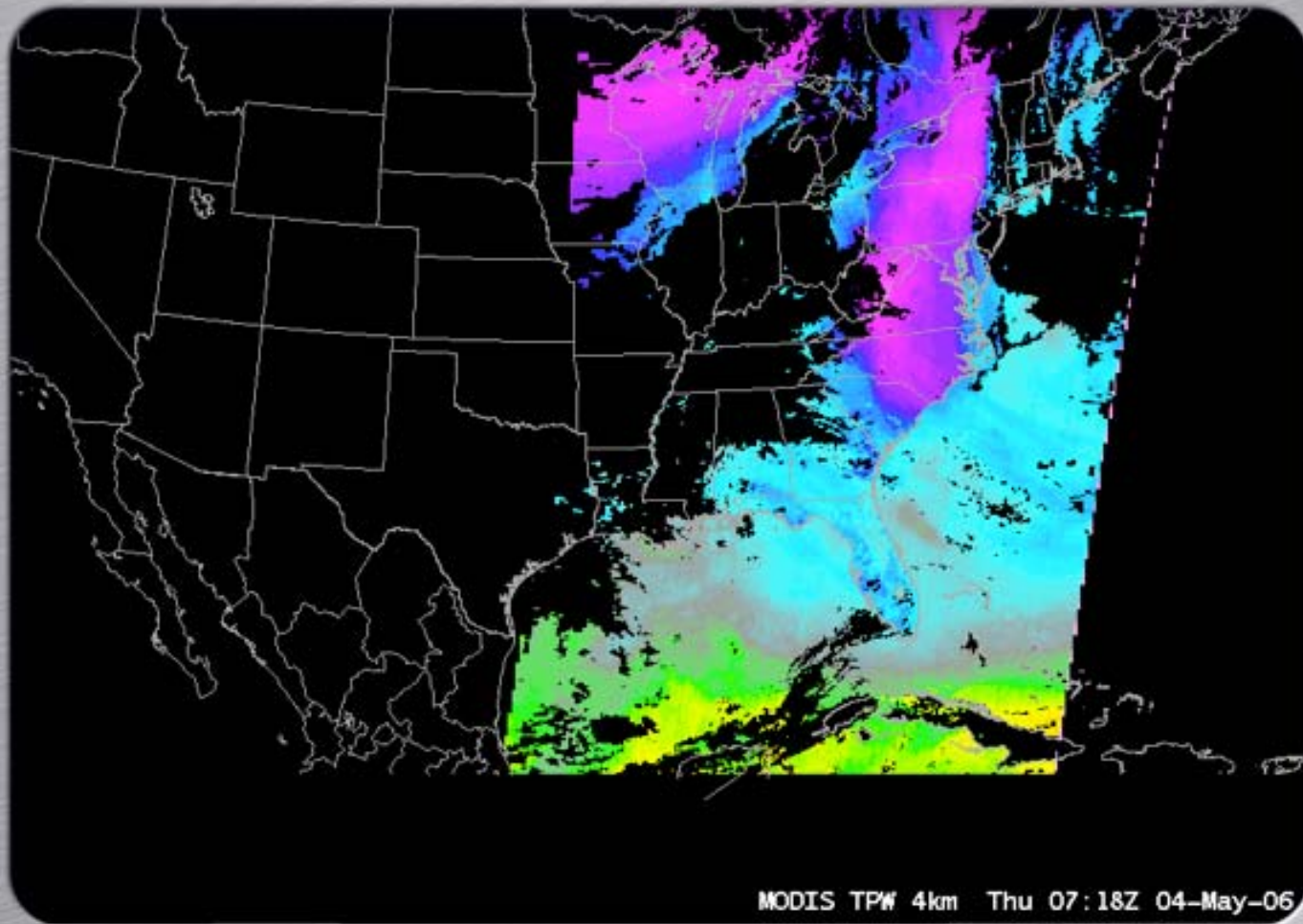
Cloud phase



Support of US National Weather Service Forecasters

- Routine feed of UW direct broadcast products to Central Region Forecast Office began 30 June 2006
 - 16 offices currently receiving MODIS data
 - Spaceflight Meteorology Group (Space Shuttle Weather Forecasting), Johnson Space Flight Center
- Marshall Space Flight Center (MSFC) also providing products to NWS using UW DB data to the Southern Region.
 - Different delivery system

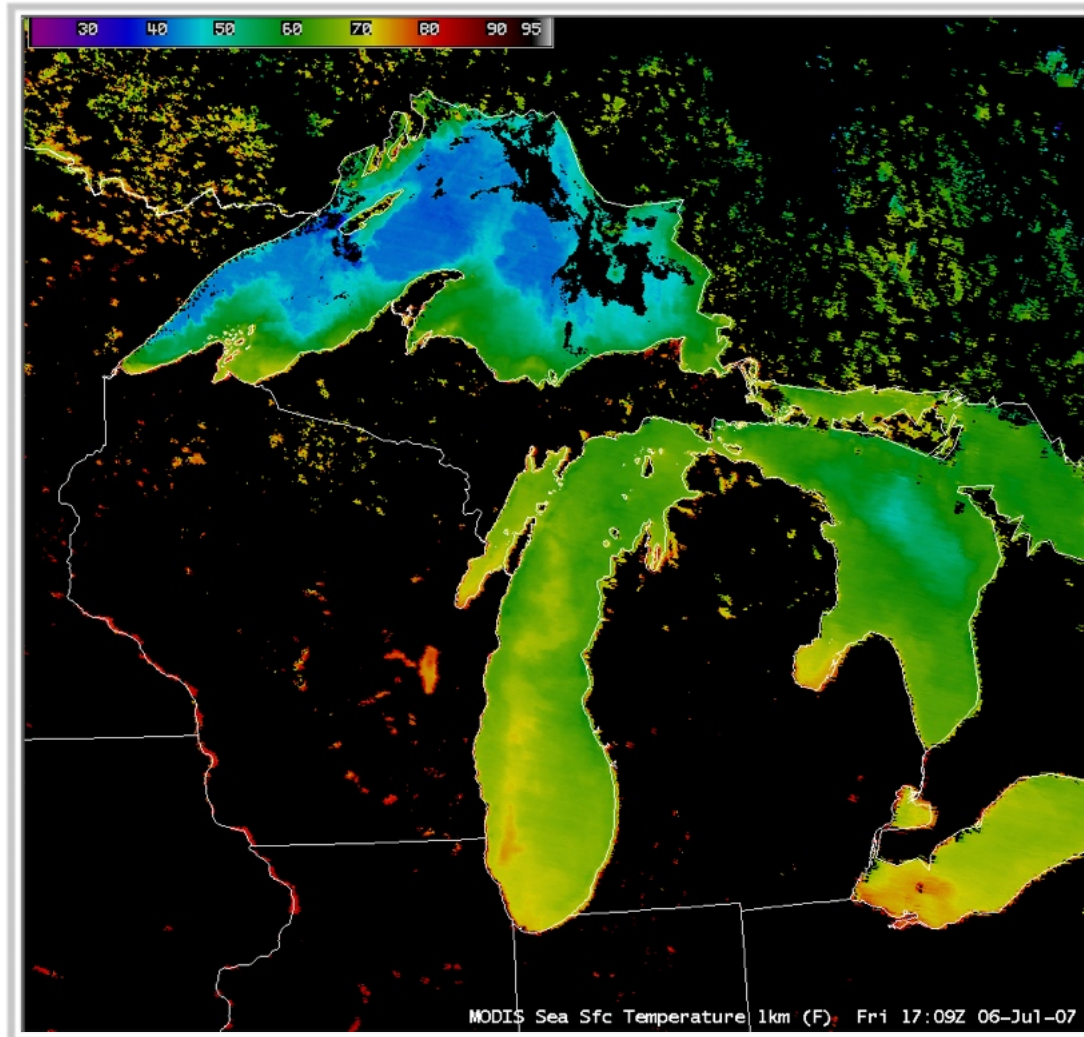
MODIS Imagery in AWIPS



Total Precipitable Water

MODIS Imagery in AWIPS

Sea surface temperature



Validation

How do we know if the products are useful to
NWS forecasters?

- MODIS used in Area Forecast Discussions as a tool in decision making
 - Mentioned by forecast offices 42 times
- Online surveys taken by forecasters
 - Results
 - 20 forecasters from KMKE, KRIW, KARX and KDVN
 - 75 % of forecasters rate DB MODIS AWIPS products as either very useful or useful
 - Only 10 % rated products as not useful
 - Most used products are Visible, SST, Fog Product and Water Vapor

000

FXUS63 KMKX 311948

AFDMKX

AREA FORECAST DISCUSSION

NATIONAL WEATHER SERVICE MILWAUKEE/SULLIVAN WI

248 PM CDT FRI AUG 31 2007

.SHORT TERM...

ANY REMAINING AFTERNOON CU WILL BE QUICK TO DISSIPATE. MAIN FORECAST PROBLEM WILL BE ON GROUND FOG POTENTIAL. **MODIS PRECIPITABLE WATER INDICATING AROUND 0.90 INCHES UP FROM AROUND 0.53 INCHES YESTERDAY EVENING. SINCE MUCH OF THIS INCREASE IS IN THE MID LEVELS...EXPECT RADIATION CONDITIONS TO BE A BIT LESS FAVORABLE FOR FOG TONIGHT. HOWEVER DEW POINTS ARE A BIT HIGHER...AND WITH CLEAR SKIES AND LIGHT WINDS STILL THINK FOG WILL FORM MAINLY IN THE RIVER VALLEYS AND LOW AREAS. GFS MOS MIN TEMPS SEEM A BIT TOO COOL AGAIN TONIGHT.**

SURFACE HIGH TO DOMINATE SO MESOSCALE EFFECTS WILL DOMINATE. MODIS WATER TEMPS SHOW LAKE TEMPERATURES RATHER UNIFORMLY IN THE UPPER 60S. WITH LIGHT EAST FLOW...TEMPS SHOULD BE SLOWER TO FALL NEAR THE LAKE THIS EVENING UNTIL LAND BREEZE SETS IN AFTER MIDNIGHT.

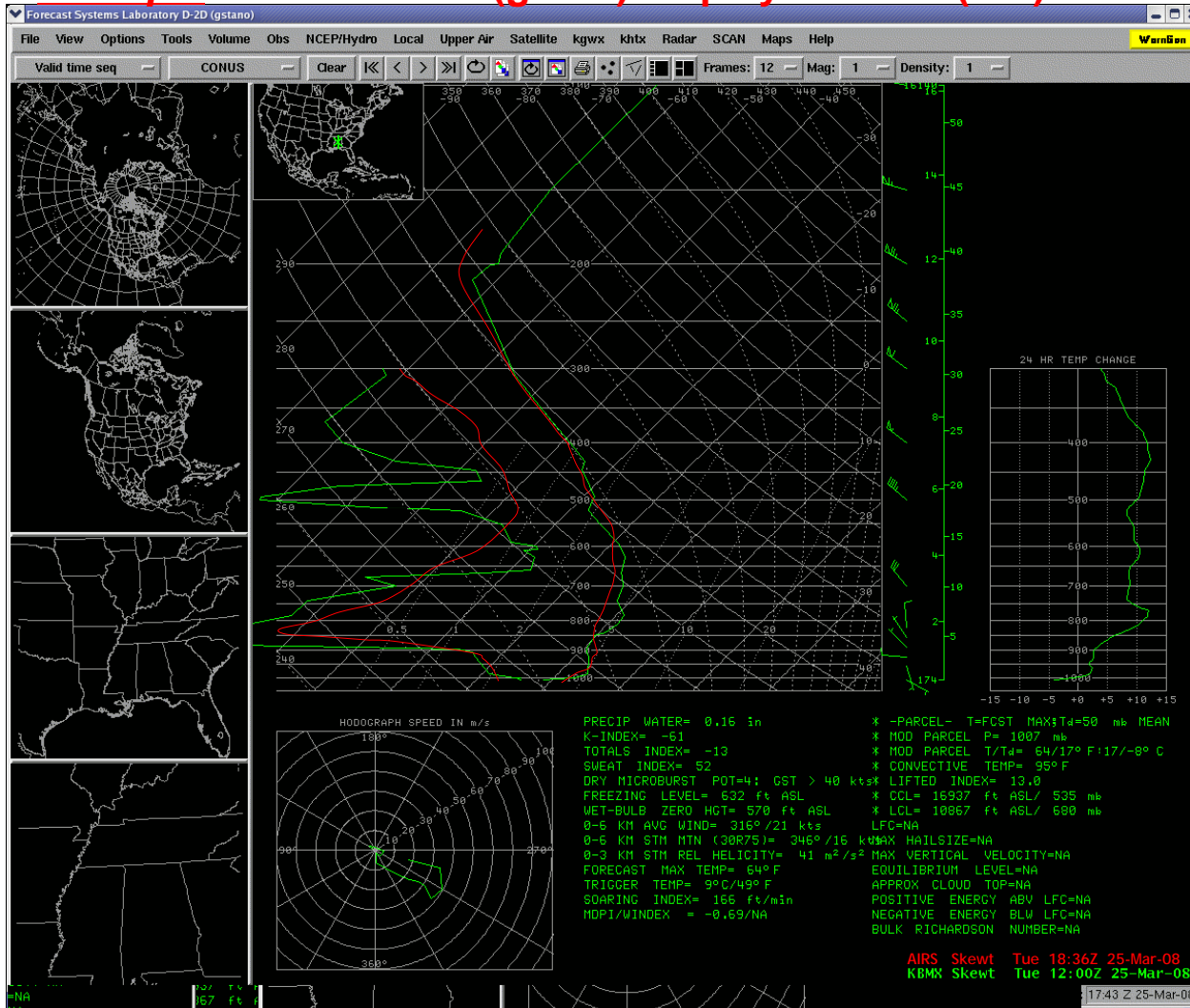


L2 Temperature and Moisture Profile Product

Brad Zavodsky, Gary Jedlovec



Example AWIPS RAOB (green) display w/ AIRS (red) overlain

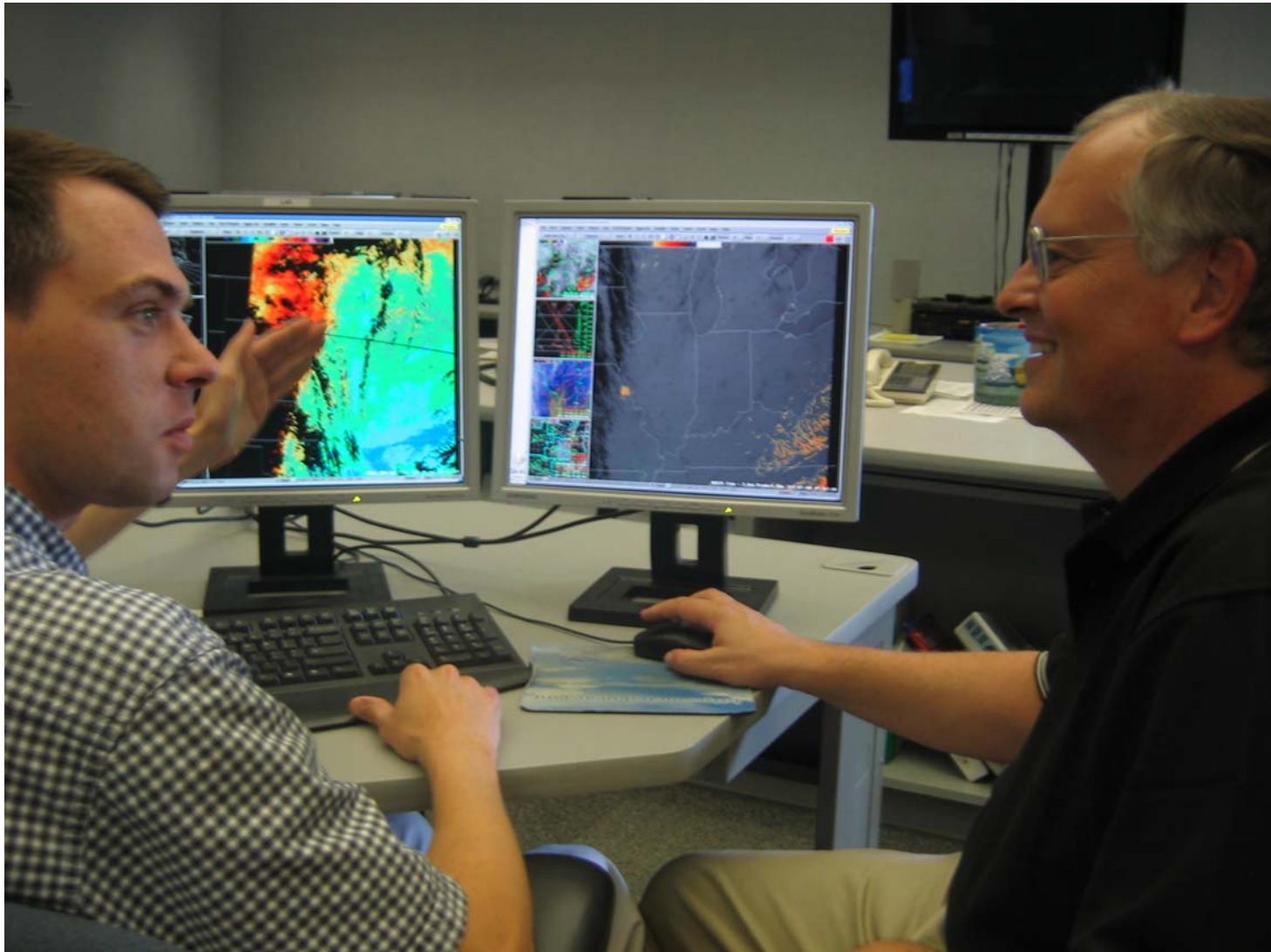


- Profiles configured for view in native NWS display system (AWIPS)
- Forecasters can click on each sounding location to display sounding info and overlay with other data
- Familiar soundings (forecast, radiosonde) are used to train forecasters to use AIRS soundings



Sullivan Wisconsin

Weather Service Field Office July 2006



Forecasters discussing MODIS Fog and TPW products as displayed in AWIPS

Workshops

Remote Sensing Workshops

(See posters B01 and B02)

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 CPTEC/INPE GEOSS Americas Workshop)

- **Teach Principles of Environmental Remote Sensing**
 - building on the work of Paul Menzel
- **Promote use of Aqua and Terra Data and Products**
 - Lectures On Topics Determined by Student Interest
 - Labs (Practical hands on use – learn strengths and weaknesses of algorithms)
- **Get young scientists excited**
- **Foster collaborations and international relations**



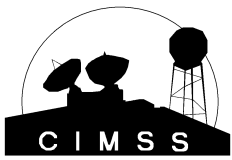
Brazil 2007

Future IMAPP Releases

Aqua and Terra expected lifetimes Terra 2014, Aqua 2015

Current funding through 2010

- AIRS Level 2 5.2
- MODIS Collect 6 algorithm updates?
- MODIS destriping algorithm
 - Reduces detector-to-detector non-physical variation (striping) in IR data
- AMSR-E L1A, L2A updates (RSS no longer supports the L1B software distributed through IMAPP)
- Cloud Optical Thickness, Cloud Effective Radius (MOD06OD)
- MODIS/AIRS Collocation Software
- MODIS/AIRS combined retrievals
- DB CRAS - NWP model
 - Domain centered on DB station - 48 km and 20 km nested grid
 - Assimilates IMAPP MOD07 and MOD06CT products
 - Produces standard NWP gridded fields as well as forecast satellite IR and WV imagery (currently used by US NWS)



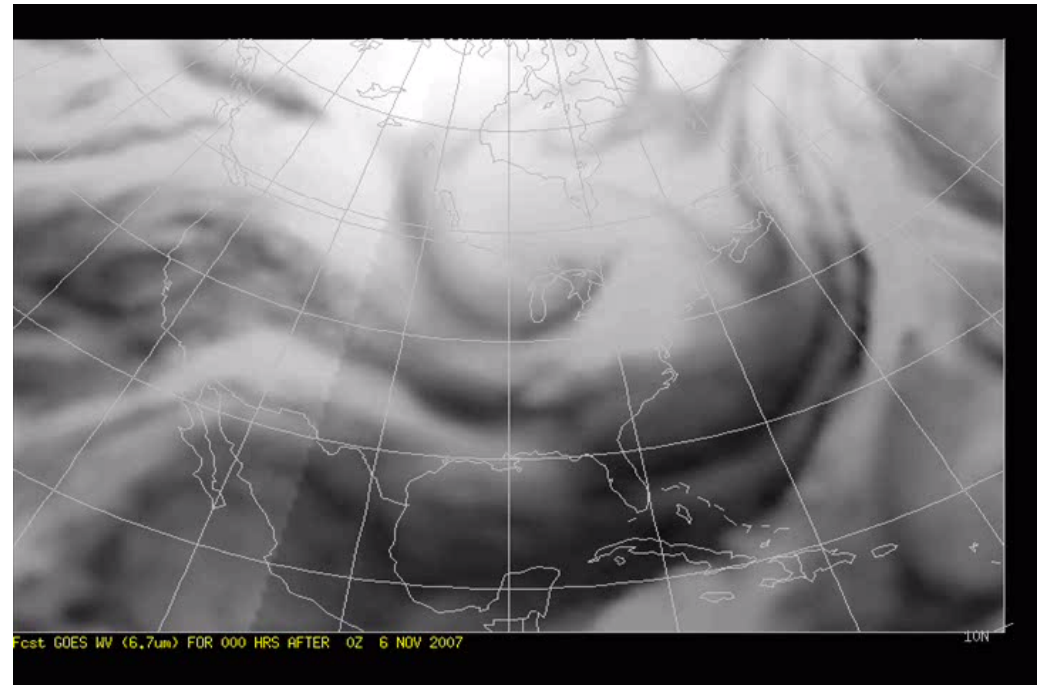
CIMSS Regional Assimilation System for MODIS Direct Broadcast Sites (DBCRAAS)



To test the feasibility of assimilating retrieved products from MODIS, CIMSS configured a version of CRAS to use data from its own MODIS Direct Broadcast antenna, processed locally using IMAPP software.

DBCRAAS domain using MODIS direct broadcast products from the antenna at the Space Science and Engineering Center, University of Wisconsin, Madison.

TERRA Orbital Tracks



12-hour loop of simulated 6.7 micron water vapor image from a DBCRAAS spin-up forecast. The impact MODIS direct broadcast products can be seen as the Aqua and Terra satellites pass over the SSEC direct broadcast site.



DB CRAS - Summary

- CIMSS/NOAA have configured a version of CIMSS Regional Assimilation System (CRAS) that is relocatable anywhere on the globe, runs on a basic Linux platform, and is “MODIS retrieval ready”.

- CIMSS/NOAA successfully demonstrated that moisture information from MODIS can improve DBCRAS forecasts of clouds for

- China,
- North America (Wisconsin),
- the North Pole,
- Antarctica, and the
- North Sea region.

- DB CRAS will be available for distribution to MODIS DB users in June, 2008 through IMAPP.