THE GLOBAL IMPACT OF MODIS DIRECT BROADCAST ATMOSPHERE PRODUCTS

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MODIS/VIIRS Science Team Meeting, 28 January 2010

What is Direct Broadcast?

- Direct Broadcast is the real-time transmission of earth observation data from the spacecraft to the ground (via X-band on Terra and Aqua)
- On Terra, only MODIS is broadcast
- On Aqua, all data is broadcast
- Data are free and clear with no encryption

- All you need is an antenna and receiver!
- "Terra and Aqua are a great gift to the world" *(Vladimir Gershenzon, ScanEx)*

Why is this important?

- X-band ground stations that we know of
  - No one knows for sure how many there are

How can DB data be useful?

- Freely distributed software packages
  - Calibration, navigation
  - Ocean, atmosphere, land products (from NASA versions)
  - Visualization tools
- These allow support of local:
  - Environmental Monitoring and Forecasting
    - Timeliness of data is vital
  - Research
  - Teaching
    - Remote Sensing Schools – eg. Paul Menzel
    - Direct Broadcast Workshops
      - Such as IGARSS short course SC4: MODIS direct broadcast data for enhanced forecasting and real-time environmental decision making

Free Direct Broadcast Software Packages

- MODISL1DB – MODIS Calibration/geolocation
  - Distributed by MODIS Ocean Biology Group
  - http://oceancolor.gsfc.nasa.gov/seadas/modisl1db/
- SeaDAS
  - MODIS Ocean Products
  - http://oceancolor.gsfc.nasa.gov/seadas/
- International MODIS/AIRS Processing Package (IMAPP) – More to come
- Direct Readout Lab
  - Surface Reflectance (MOD09), Corrected Reflectance, simple NDVI/EVI, Land Surface Temperature, Fire Product (MOD14)
  - http://directreadout.sci.gsfc.nasa.gov/
- Visualization (examples)
  - HDFLook: http://www-loa.univ-lille1.fr/Hdflook/
  - Hydra: http://www.ssec.wisc.edu/hydra/

NASA funded International MODIS/AIRS Processing Package (IMAPP)

Freely distributed and 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 – Level 2 (Collection 5)

- Cloud mask (MOD35),
- Cloud top properties (MOD06CT) – height, temperature, emissivity, phase
- Cloud optical properties (MOD06OD) – cloud effective radius, cloud optical thickness
- Atmospheric profiles (MOD07) T, q, tpw, total ozone, stability
- Aerosol optical depth (MOD04)
- Near-infrared water vapor

MODIS utilities

- Destriping software – removes artificial striping in infrared bands
- Direct Broadcast Google Earth (DBGE)
  - Software to create jpgs and KML for true color MODIS 250 m data

Current IMAPP Status

AIRS products – Atmospheric Infrared Sounder

- AIRS/AMSU/HSB Level 1 and Level 2 v5.2 (with JPL – 3x3 pixels)
- AIRS Level 2 profiles (UW – single pixel clear sky only)
- MODIS/AIRS utilities package
  - MODIS/AIRS collocations
  - AIRS cloud mask based upon the collocated MODIS mask
  - AIRS all sky retrievals
- AIRS L1B HDFEOS to BUFR utility software
  - Written by Nigel Atkinson, packaged and distributed by UW

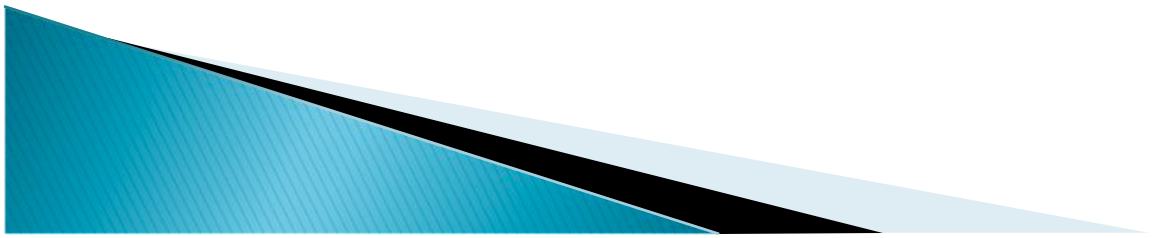
AMSR-E products – RSS L1B software

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

Current IMAPP Status

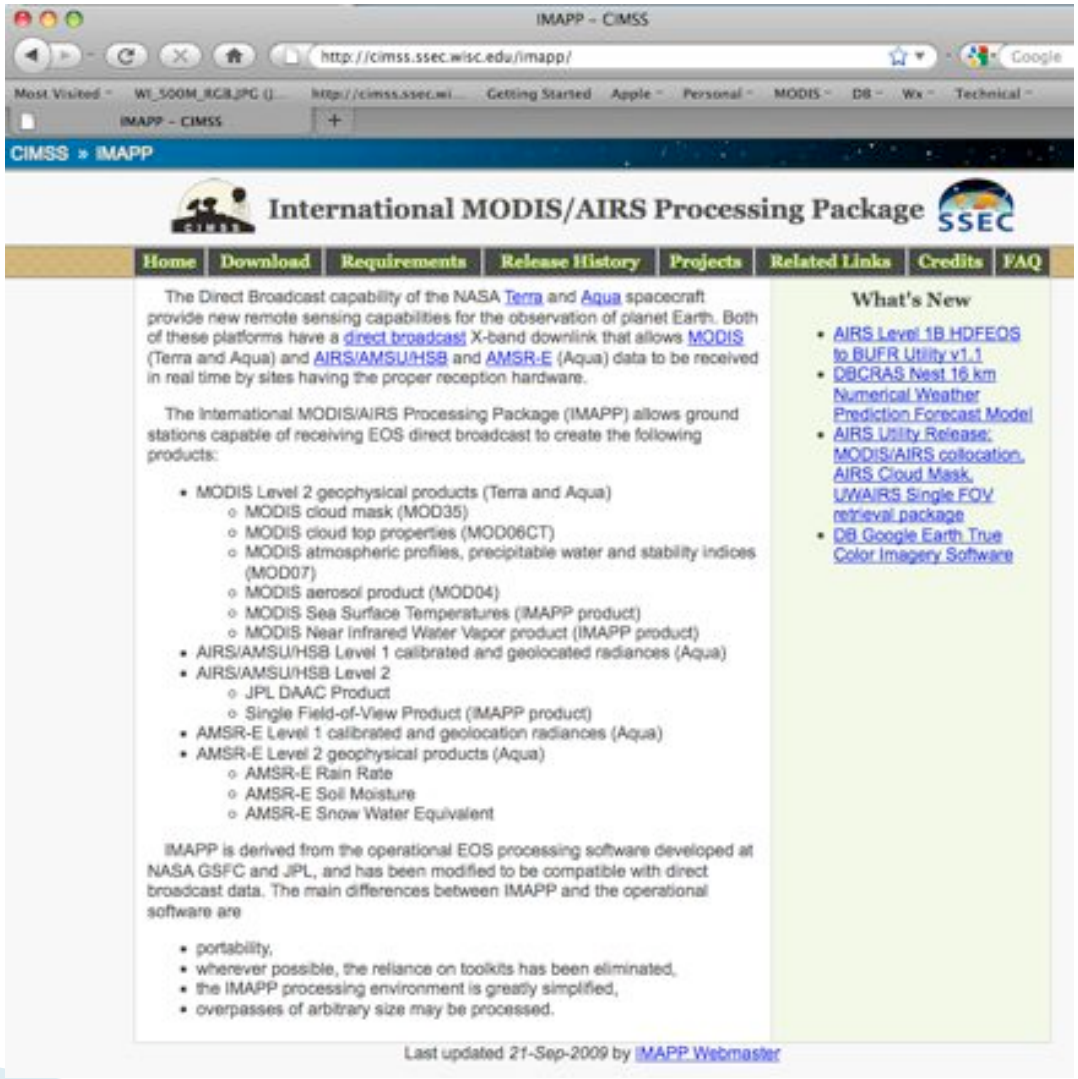
DB CRAS (Numerical Weather Assimilation and Forecast Model)

- Domain centered on DB station – 48 km grid
- Assimilates IMAPP MOD07 and MOD06CT products
- Produces standard NWP gridded fields as well as forecast satellite IR and WV imagery
  - Used by some US NWS forecasters in AWIPS
- Nest centered within coarse model domain
  - 16 km resolution
  - 48 hour forecast

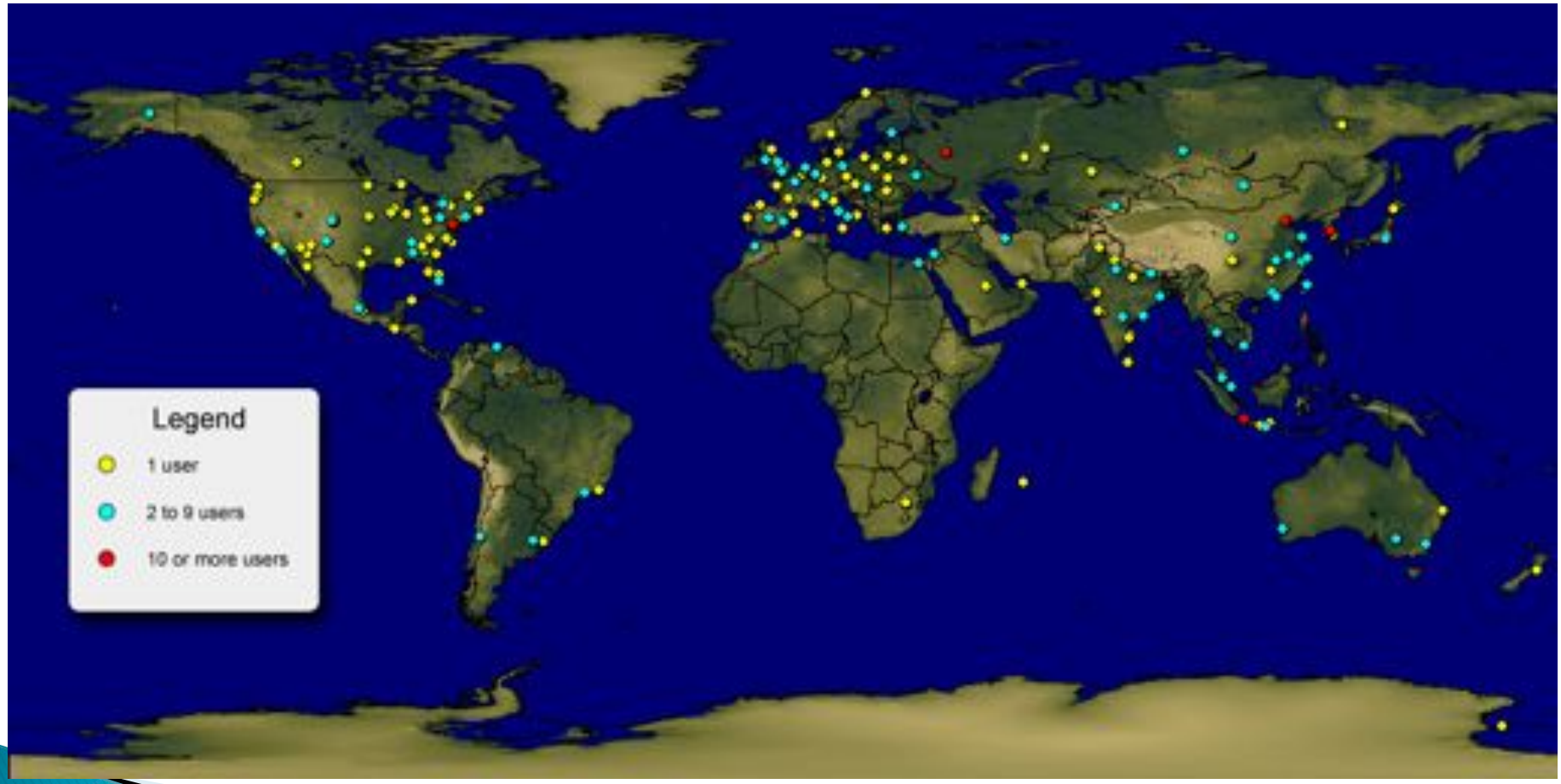


IMAPP Web Site

- Over 600 people have registered since October 2007



Location of IMAPP registrants Representing 55 countries



Since 2007

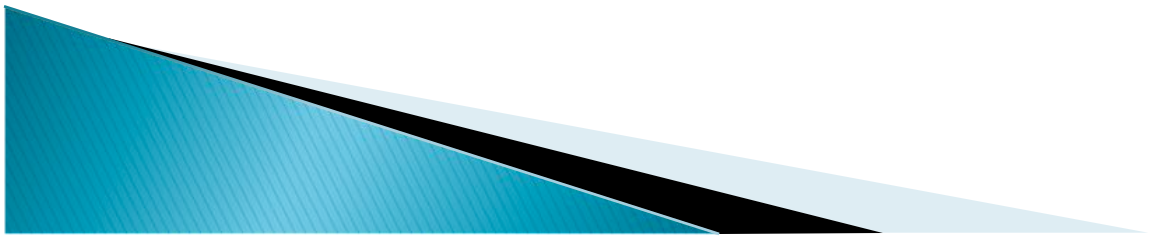
DB Applications – MODIS

Huge Variety

- Including Fires (detection and burned area), etc., etc., etc.

Weather Observation and Forecasting

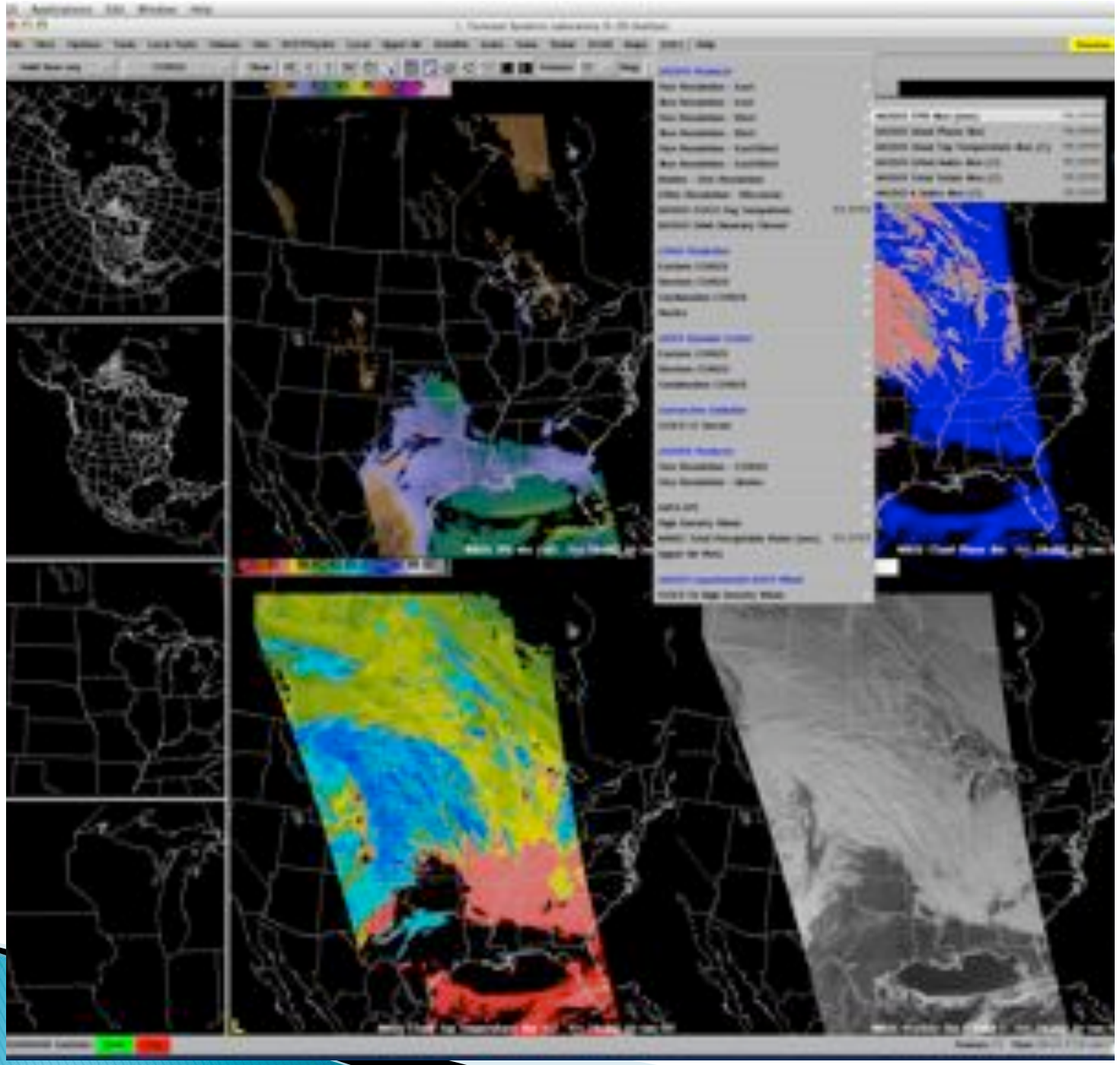
- Compliment to Geostationary
  - Higher Spatial Resolution (data at 250 m – 1 km, products at 250 m – 5 km)
  - Unique spectral bands (such as 1.38 μm)
  - New products (such as cloud phase)
  - Preparation for next generation of geo instruments
- Key for forecasts is timeliness of data
  - DB can supply this

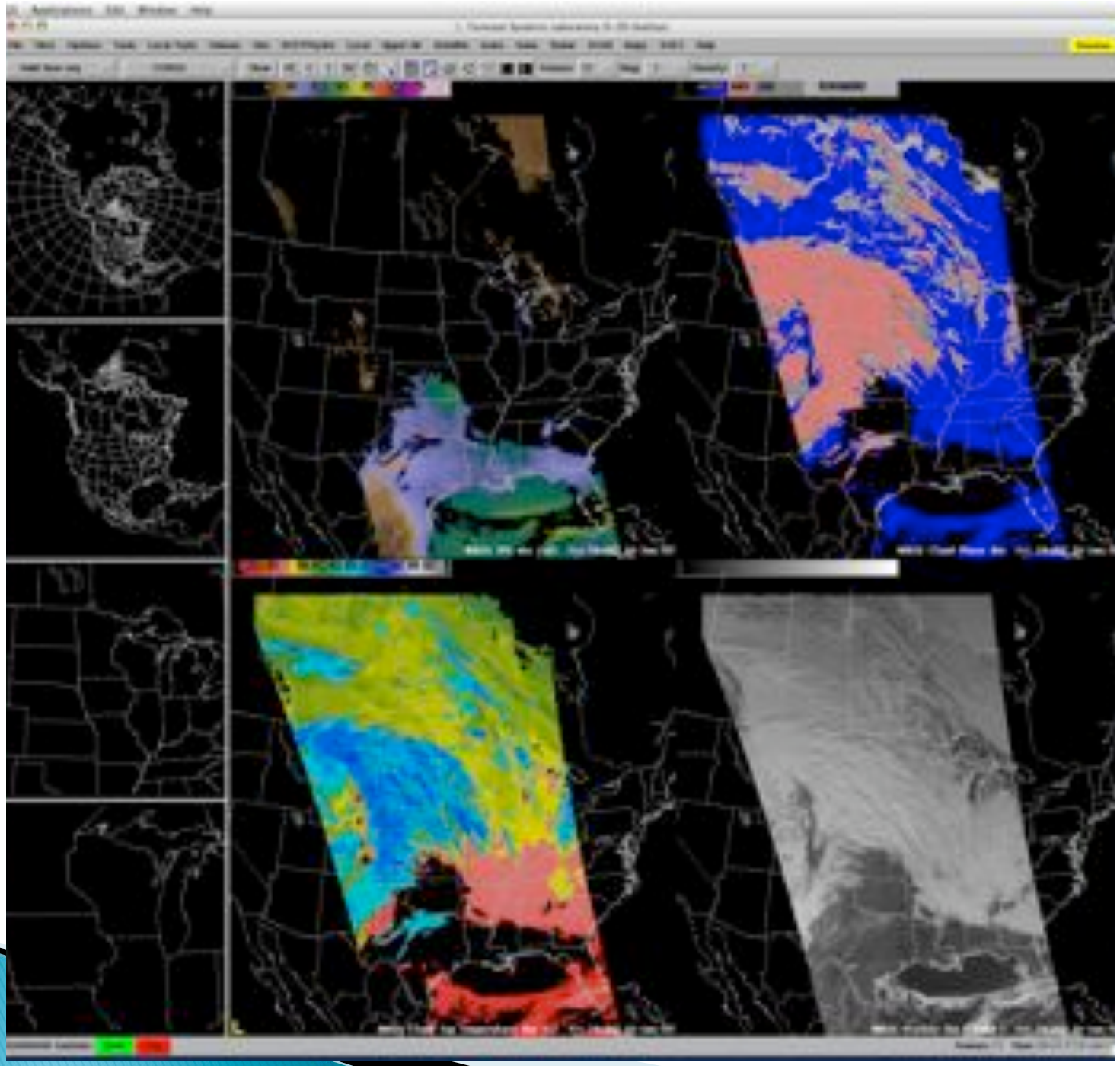


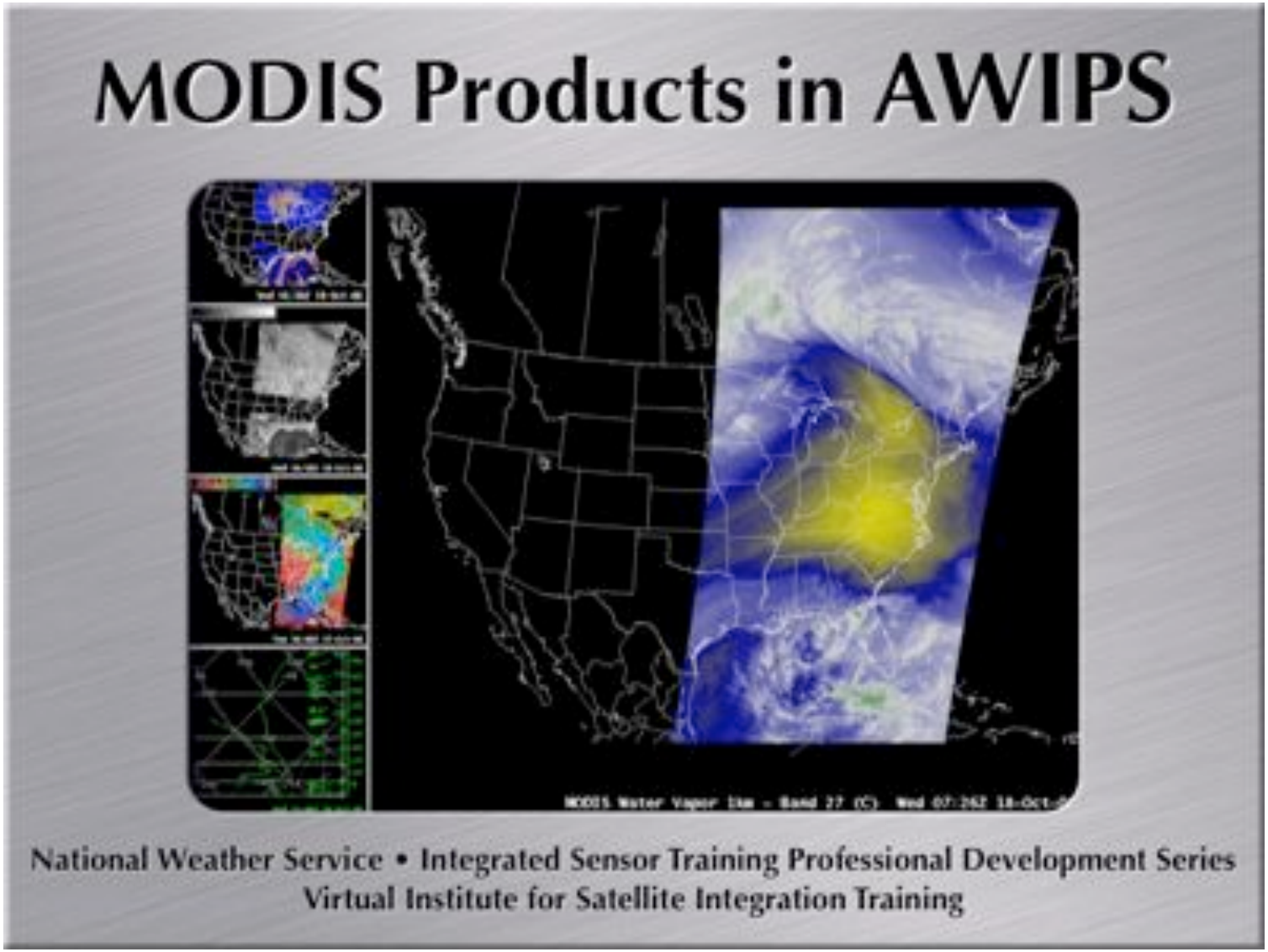
Can Polar Orbiter Data Really Be That Useful to Forecasters?

Support of US National Weather Service Forecasters

- University of Wisconsin began providing Direct Broadcast MODIS products NWS in June 2006
- 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), Land Surface Temperature, Fog Product
  - 5 km
    - Cloud Top Pressure, Total Precipitable Water, Cloud Phase, Stability Indices
- True Color 250 m Imagery

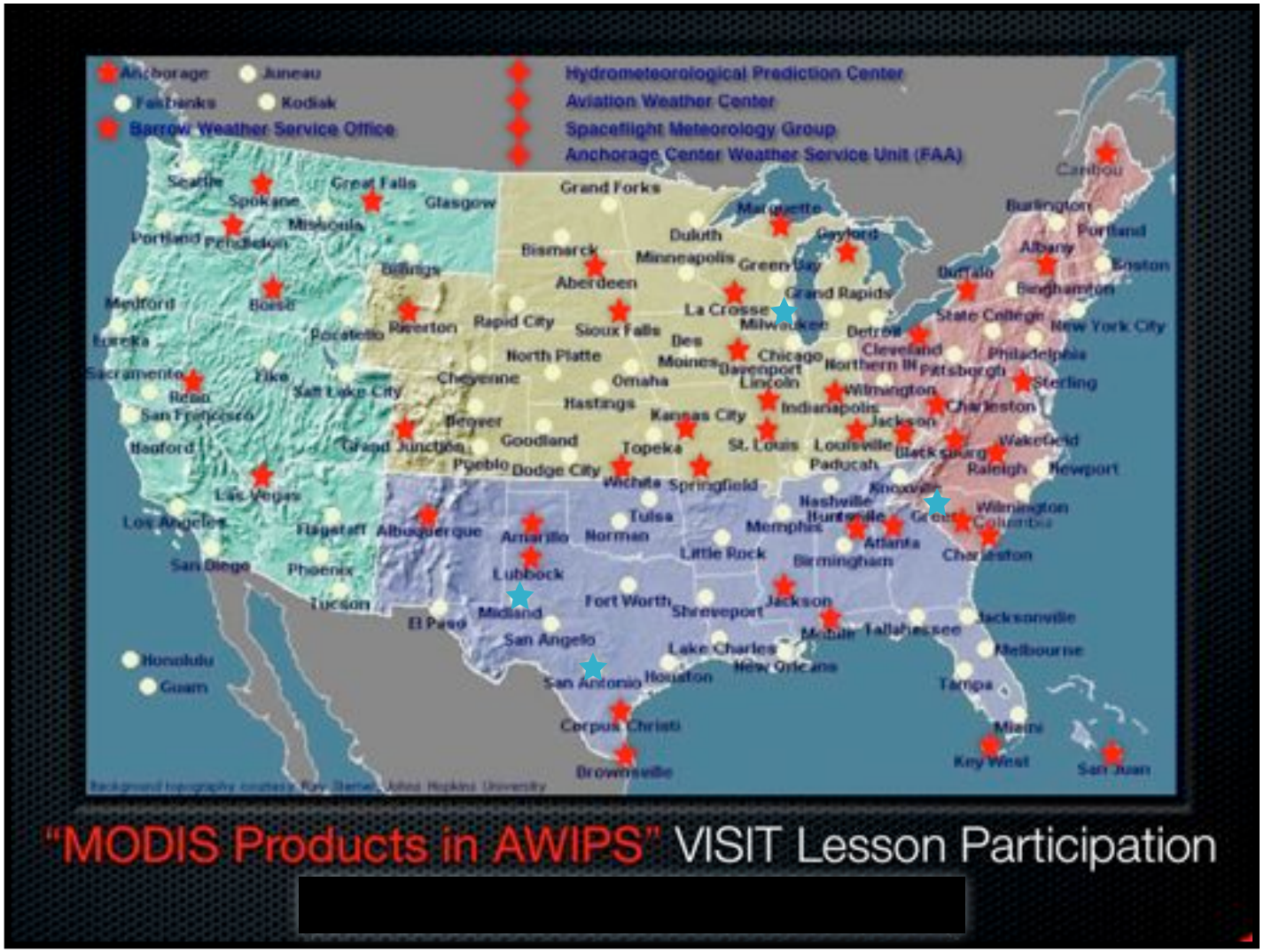






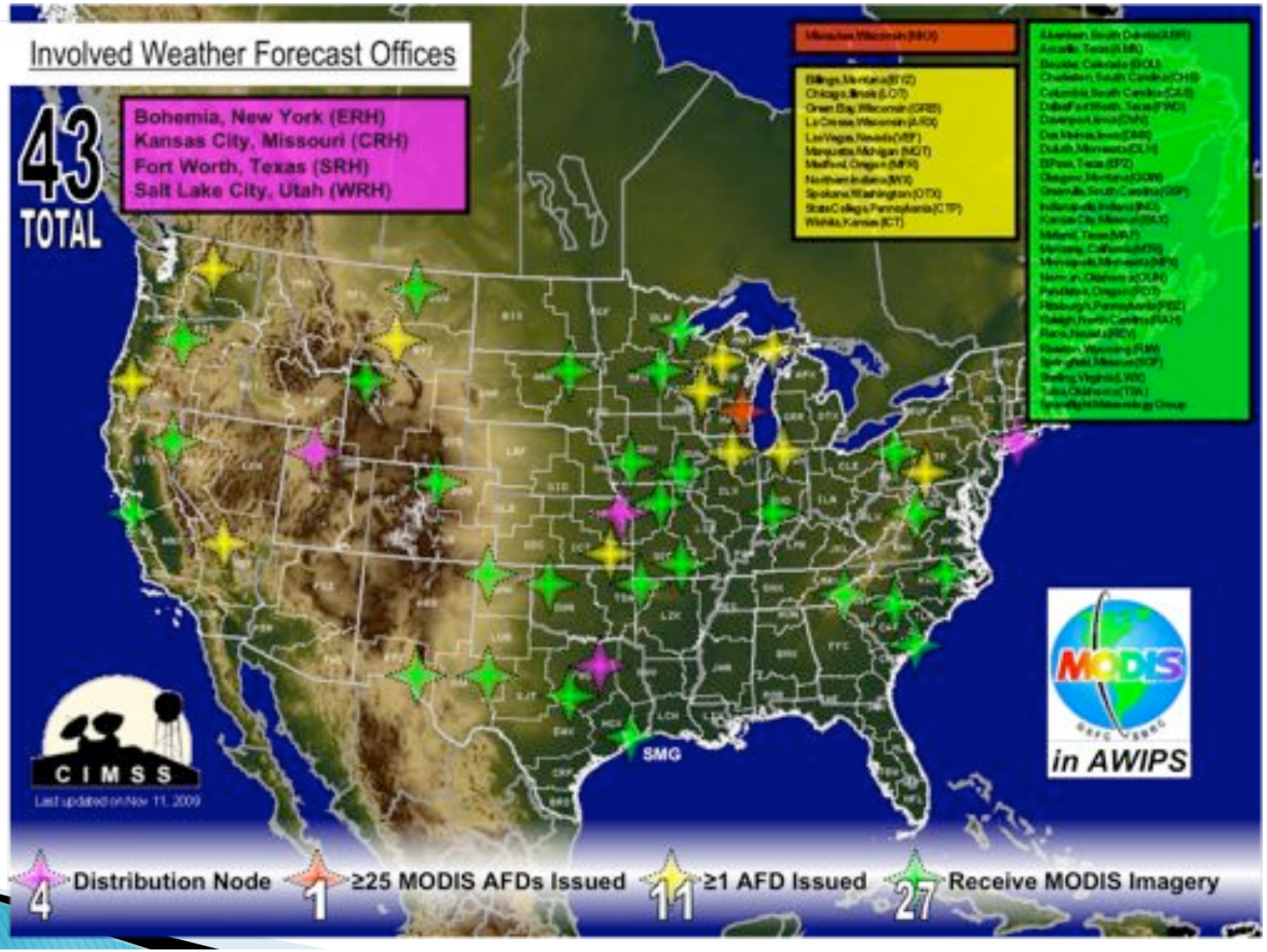
Virtual Institute for Satellite Integration Training (VISIT) lesson – offered since October 2006

MODIS Products in AWIPS



53 NWS forecast offices participating so far

University of Wisconsin Direct Broadcast MODIS Data used by the National Weather Service



MODIS products have been mentioned in Area Forecast Discussions 151 times

MODIS Products in AWIPS

AREA FORECAST DISCUSSION NATIONAL WEATHER SERVICE
MILWAUKEE/SULLIVAN WI
422 AM CDT FRI AUG 3 2007

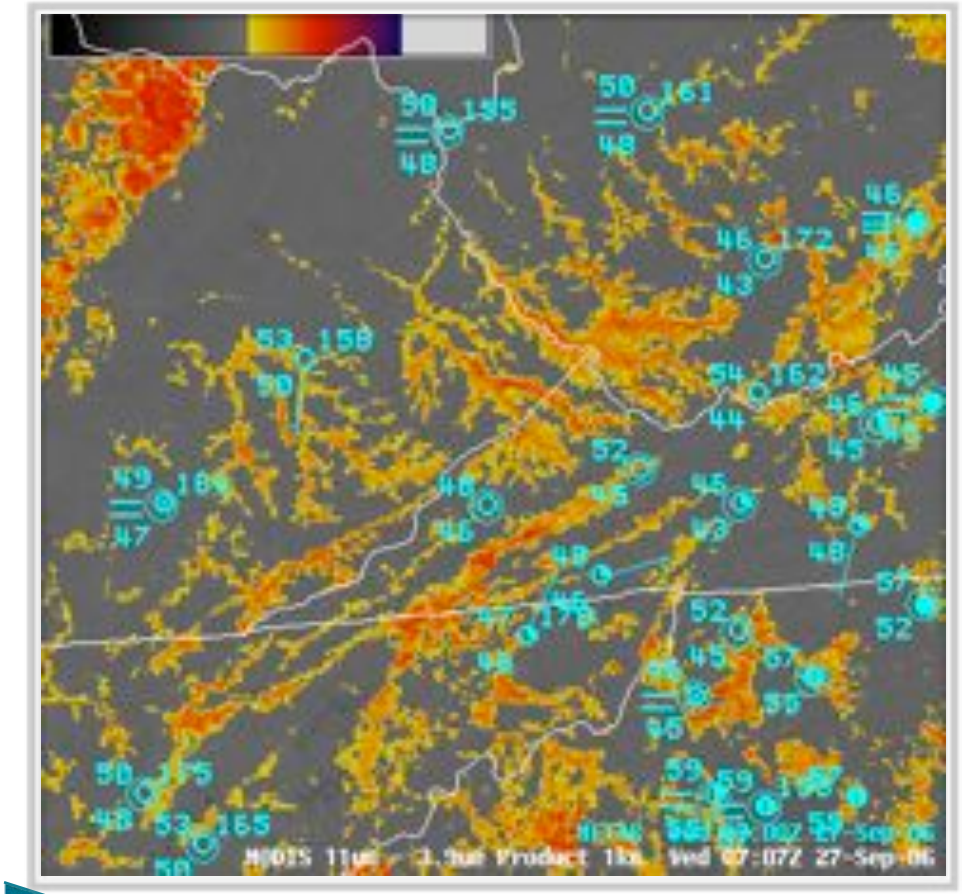
DISCUSSION...FORECAST FOCUS ON COOLER AND MUCH DRIER CONDITIONS TODAY...THEN PRECIPITATION CHANCES THIS WEEKEND THROUGH NEXT WEEK.

00Z 500/300MB ANALYSIS INDICATED A CLOSED UPPER LOW INVOF OF HUDSON BAY WITH A BROAD UPPER HIGH CENTERED NEAR THE 4-CORNERS AREA...VERY TYPICAL LOCATION FOR THIS TIME OF YEAR. PLACEMENT OF THESE FEATURES PRODUCING A DEEP...DRY NWLY FLOW OVER THE NRN PLAINS/GREAT LAKES REGION. AT THE SFC...WEAK TROF/COLD FRONT CONTINUES TO PUSH SOUTHEAST OF WI...ALLOWING SOME MUCH DRIER AIR TO FILTER INTO THE AREA. IN FACT...04Z 4KM MODIS PW SOUNDER SHOWING PWS FALLING AOB 0.40" OVER MN/NRN WI CORRESPONDING WITH A BROAD AREA OF UPPER 40S-LOW 50S SFC DWPTS. 1KM MODIS LAKE SFC TEMP PRODUCT INDICATING NARROW RIBBON OF UPWELLING ALONG WRN SHORE OF LK MICHIGAN DUE TO OFFSHORE WINDS. IR IMAGERY EARLY THIS MORNING INDICATING CRYSTAL CLEAR SKIES OVER THE ENTIRE STATE OF WI.

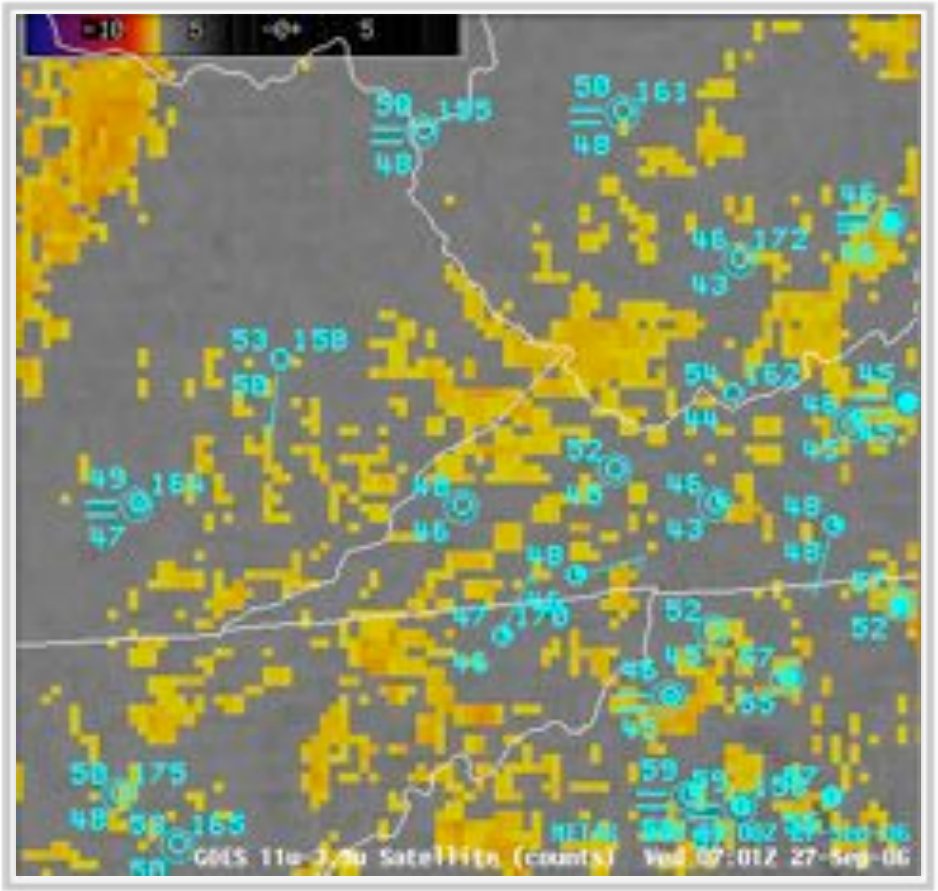
MODIS has been mentioned in 151 NWS Area Forecast Discussions to date

MODIS Imagery in AWIPS

Fog/stratus product (11.0μm – 3.7μm)



1-km MODIS



4-km GOES

Improved fog/stratus detection capability

AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE STATE COLLEGE PA
158 AM EDT WED SEP 2 2009

.NEAR TERM /UNTIL 11 AM THIS MORNING/...

IDEAL RADIATIONAL COOLING UNDER LARGE SFC ANTICYCLONE WILL PROVIDE ANOTHER CHILLY MORNING ACROSS THE REGION. OBSERVED DEWPTS SUGGEST MINS WILL BE A FEW DEGS WARMER THAN LAST NIGHT...WITH THE COLDEST READINGS /UPPER 30S/ FOUND ACROSS THE USUAL COLD SPOTS IN THE NORTH-CENTRAL MTNS.

11-3.9U AND 1KM MODIS SATL IMAGERY DEPICTING DENDRITIC PATTERN OF SHALLOW...LOCALLY DENSE RIVER VALLEY FOG AND STRATUS BEGINNING TO DEVELOP OVR CENTRAL PENN EARLY THIS MORNING. XPC THE DENSE FOG TO INC IN CVRG THROUGH SUNRISE WITHIN THE RIVER/ STREAM VLYS AS THE BLYR CONTS TO COOL. A LOOK BACK AT YESTERDAYS VIS LOOP SUGGESTS FOG AND STRATUS WILL DISSIPATE BTWN 14-15Z...GIVING WAY TO AM/SUNNY SKY.

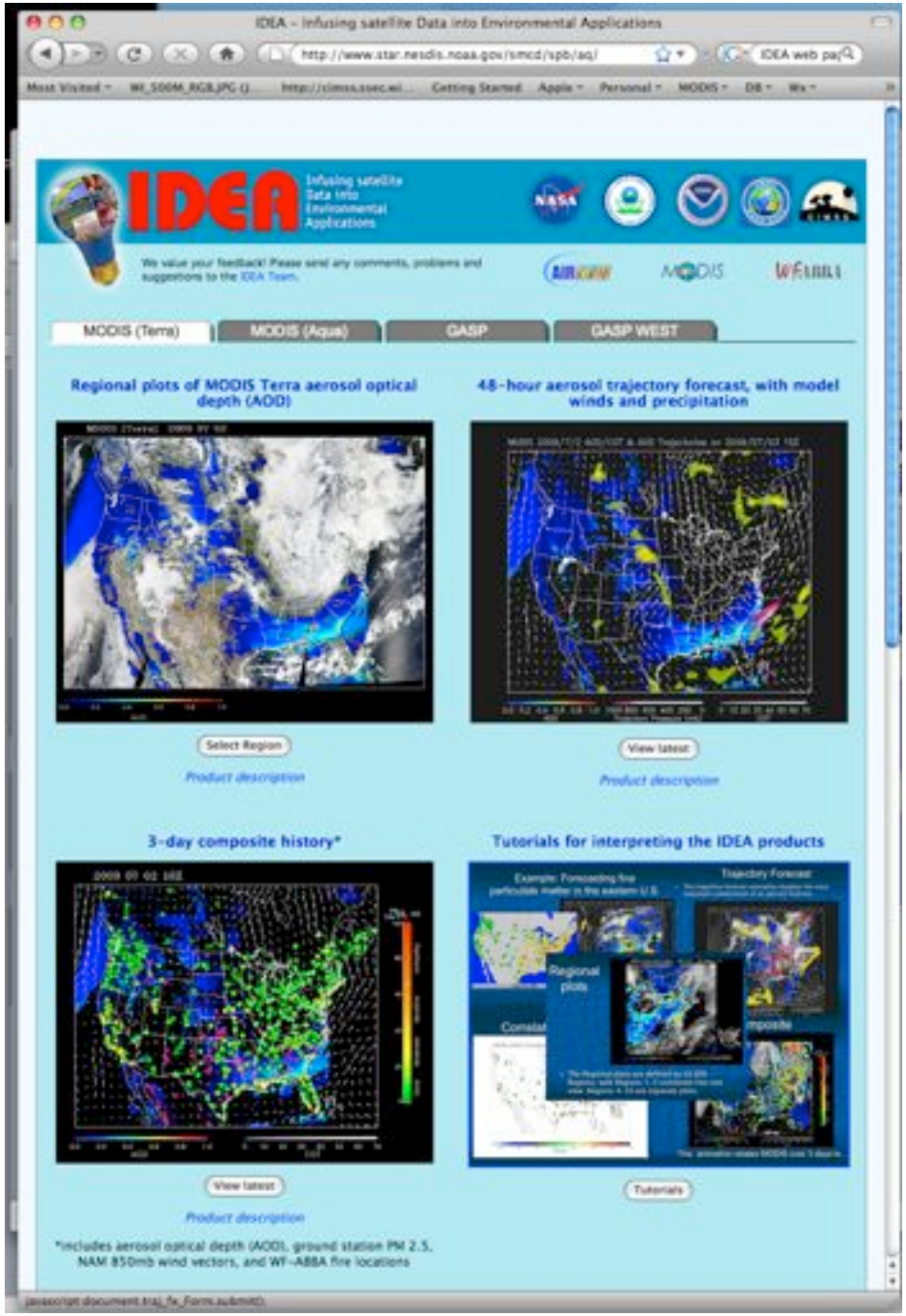
How do we know MODIS data has an impact?

- 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

Infusing Satellite Data into Environmental Applications

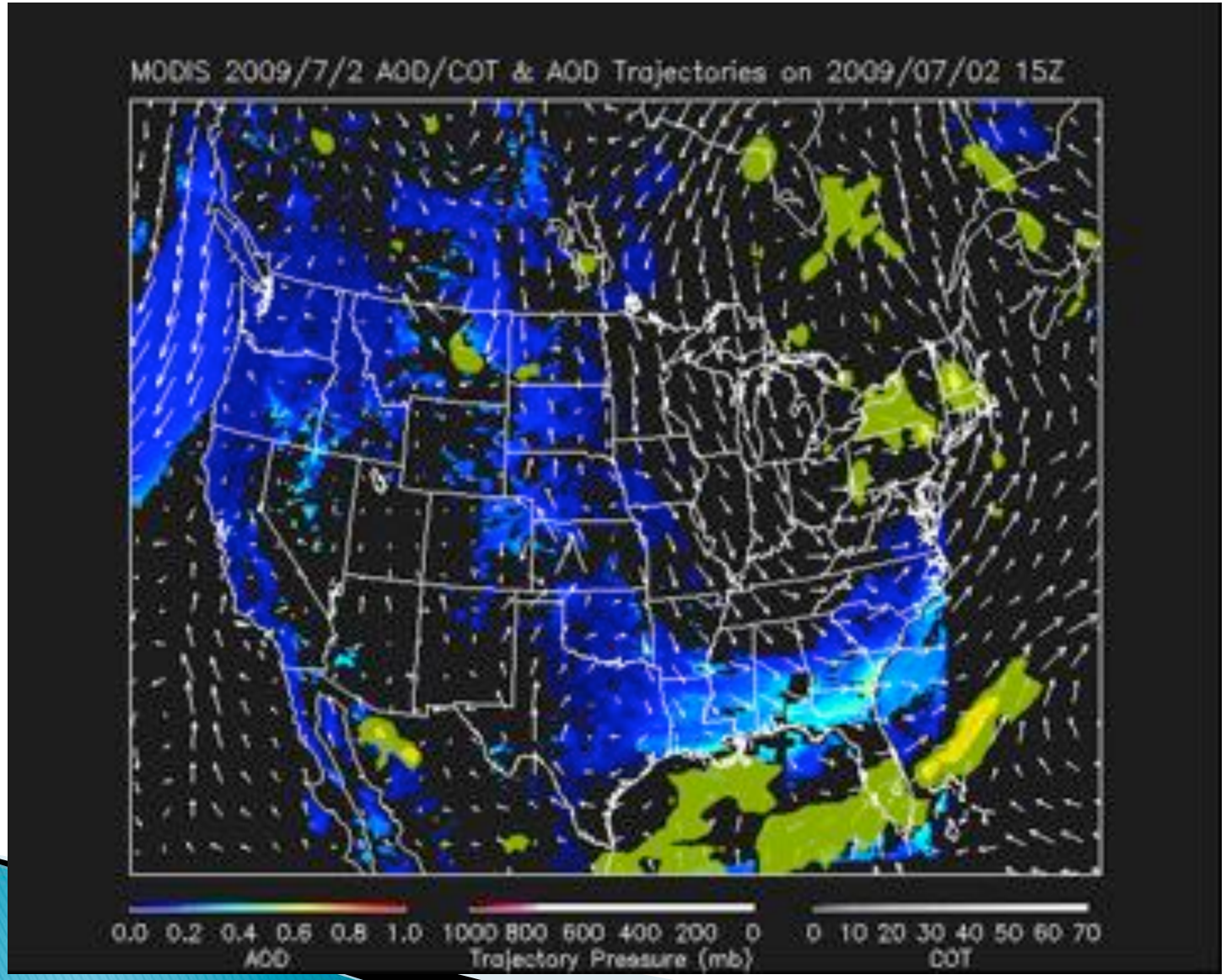
NASA–EPA–NOAA partnership to improve air quality assessment, management, and prediction by infusing (NASA) satellite measurements into (EPA, NOAA) analyses for public benefit.

UW DB testbed for NOAA operations



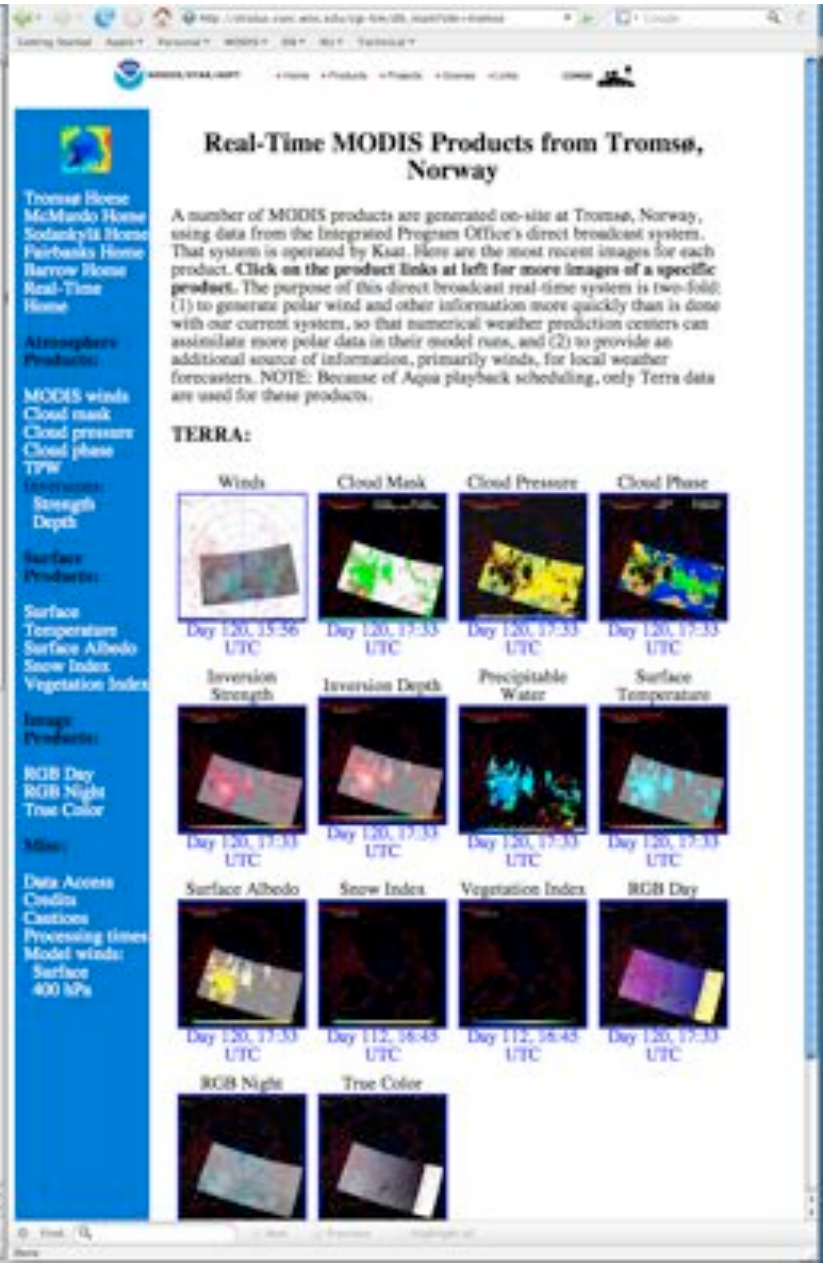
http://www.star.nesdis.noaa.gov/smcd/spb/aq/

48 Hour Trajectory Forecast



Other Global Users

IMAPP Products Used for Forecasting at the Poles



Vendor Distributions

- **SeaSpace Corporation**

•Kongsburg Satellite Services

Description:

MODIS Cloud Top Temperature Product (1KM)

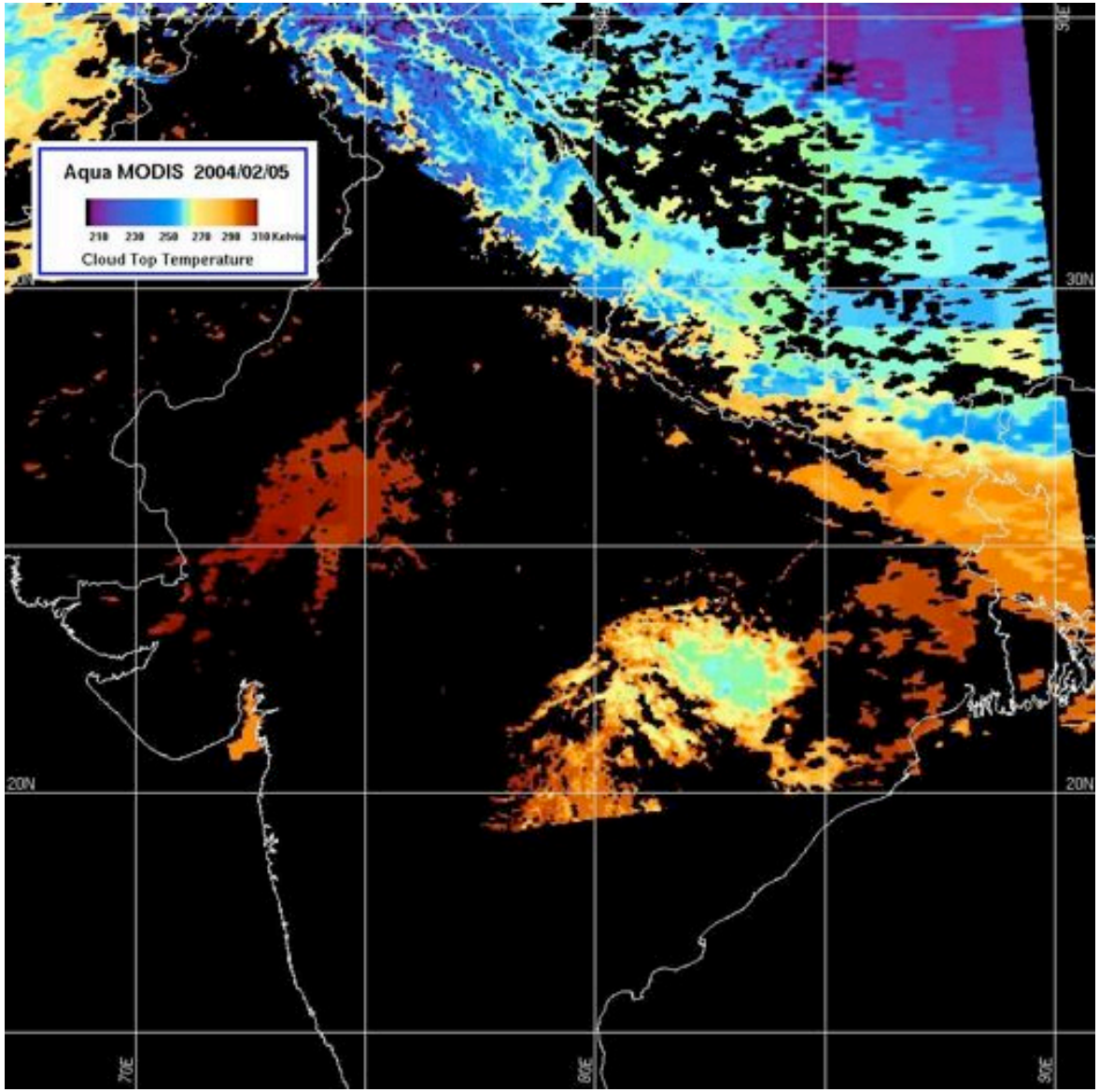
MOD06 Cloud Top product

Cloud Top Temperature

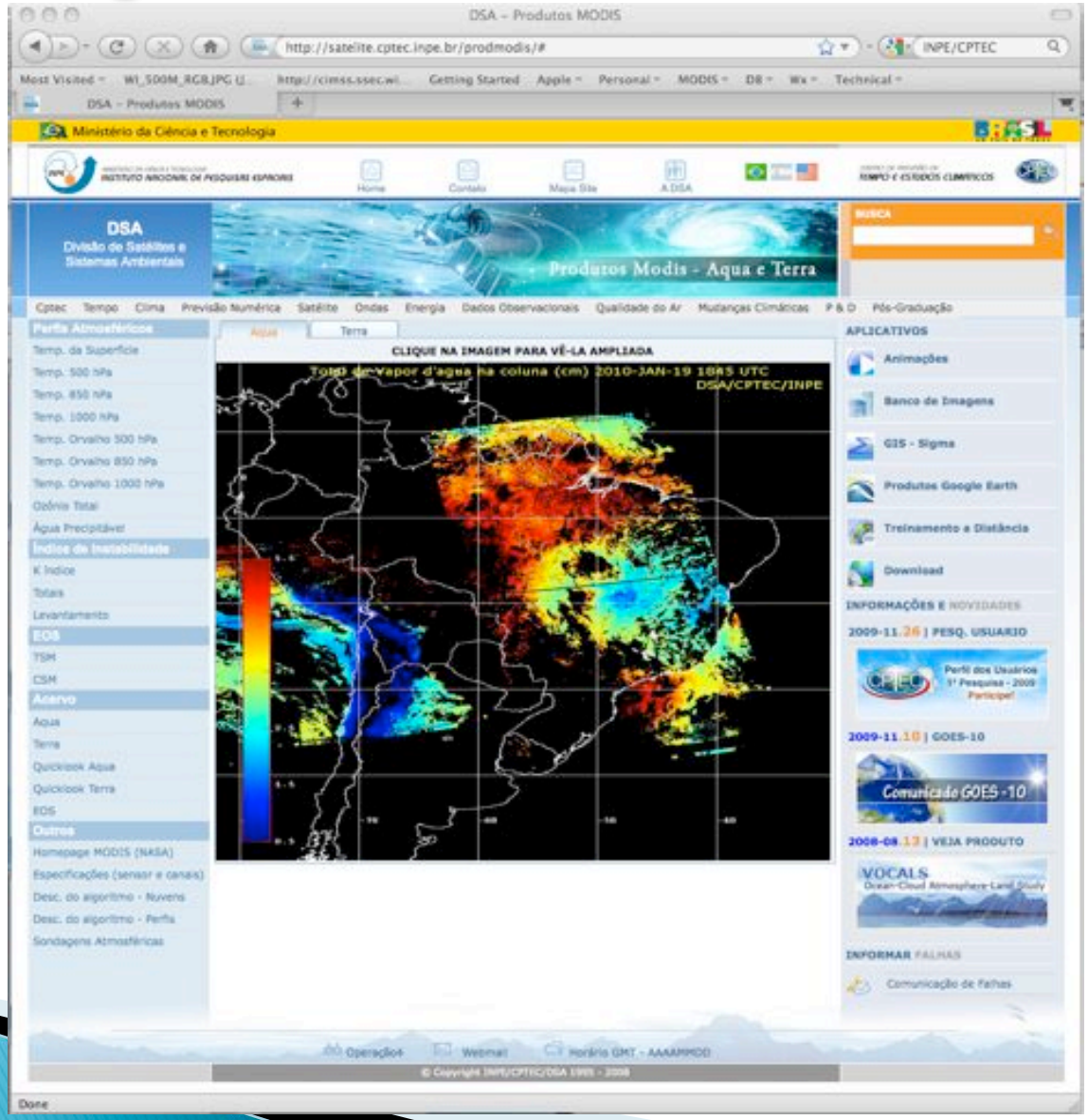
Aqua/MODIS 1000m calibrated data as inputs to the MOD06 algorithm – Automated supervised classification scheme

Estimates cloud top temperatures

SeaSpace Example:
5 February 2005

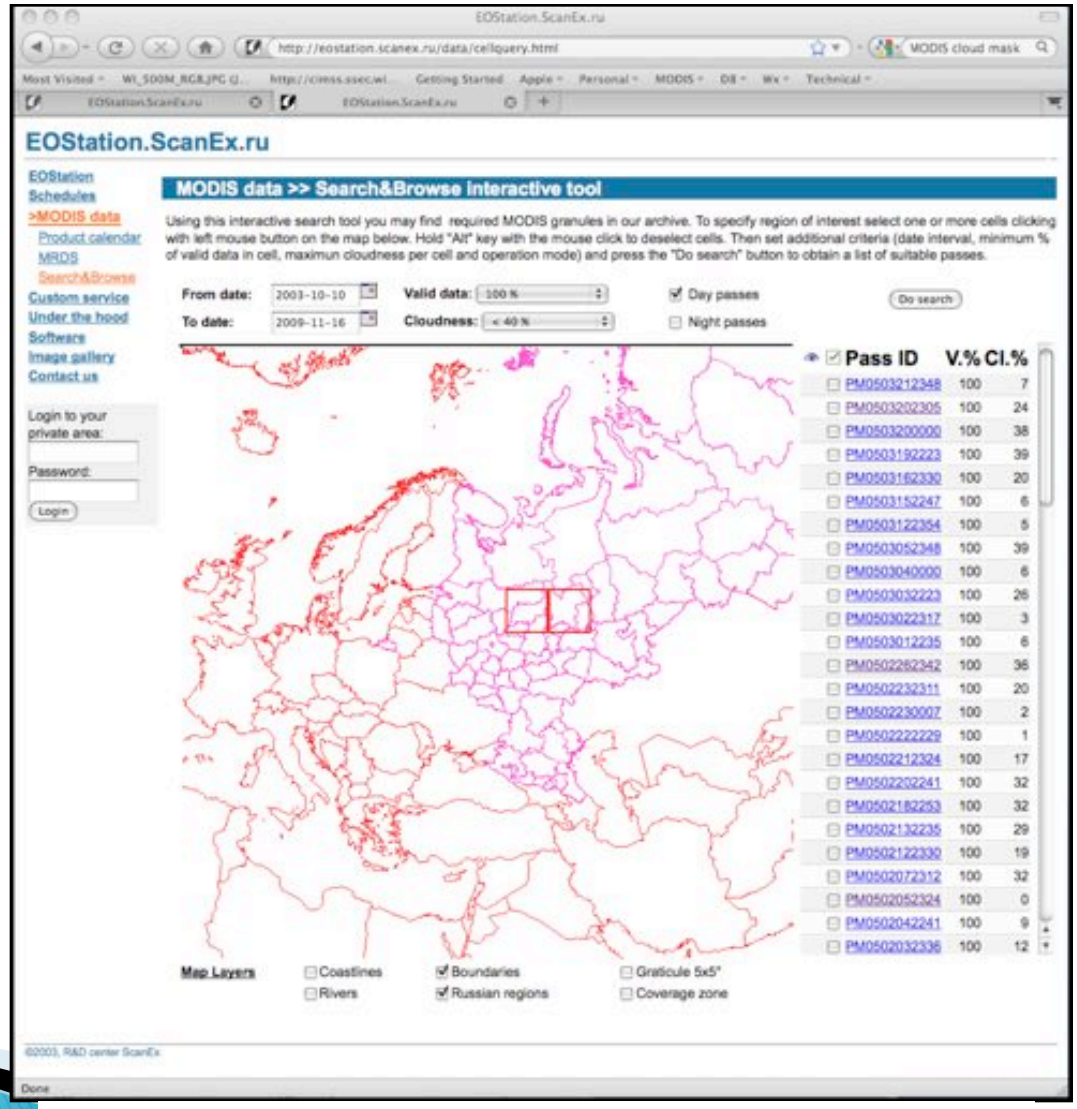


INPE/CPTEC Real Time Page Supporting Forecasting, Assimilation and Climate Research



AQUA MODIS
TPW
19 Jan 2010

Using MODIS cloud mask to interactively choose DB scenes

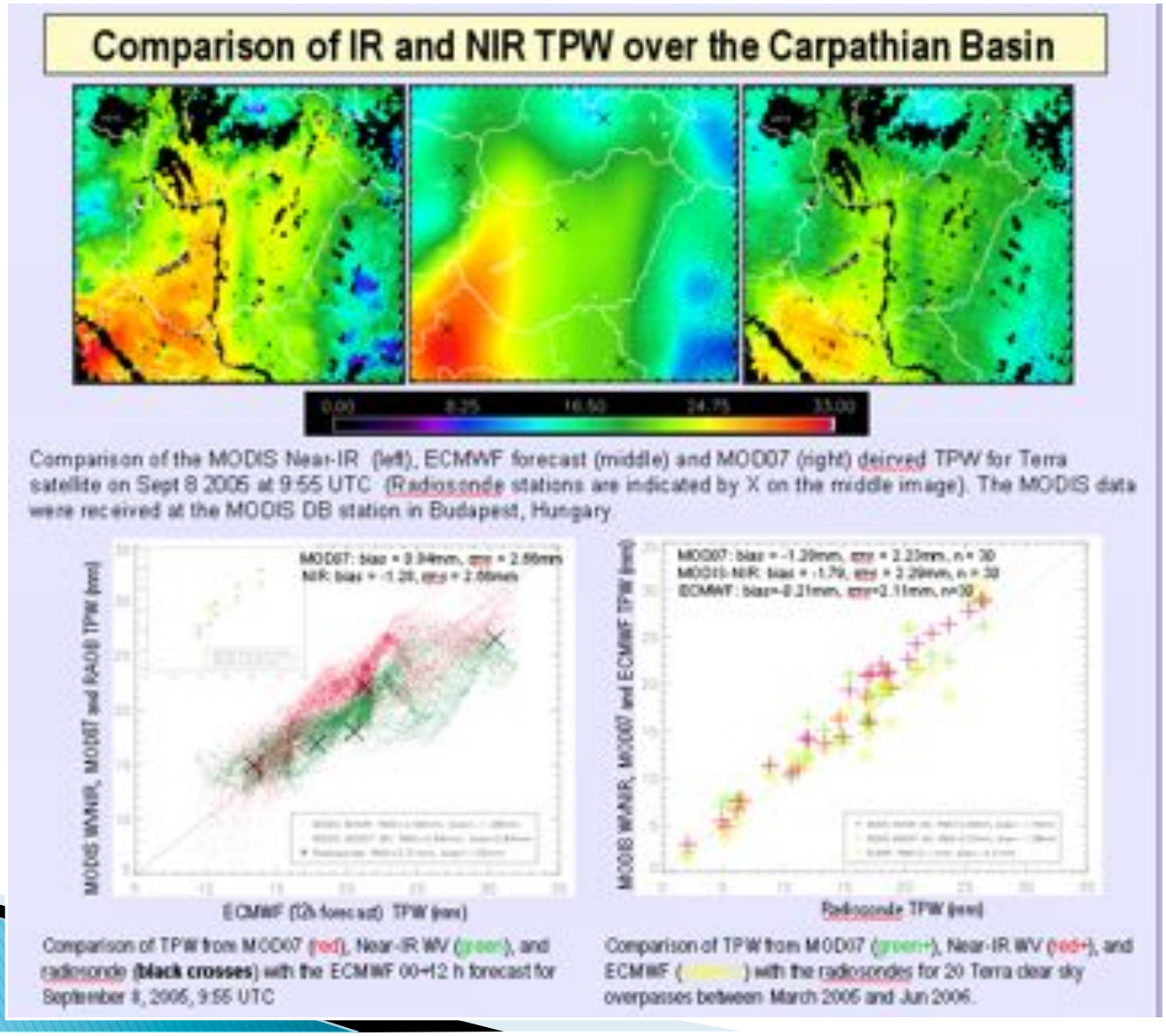


ScanEx
Russia

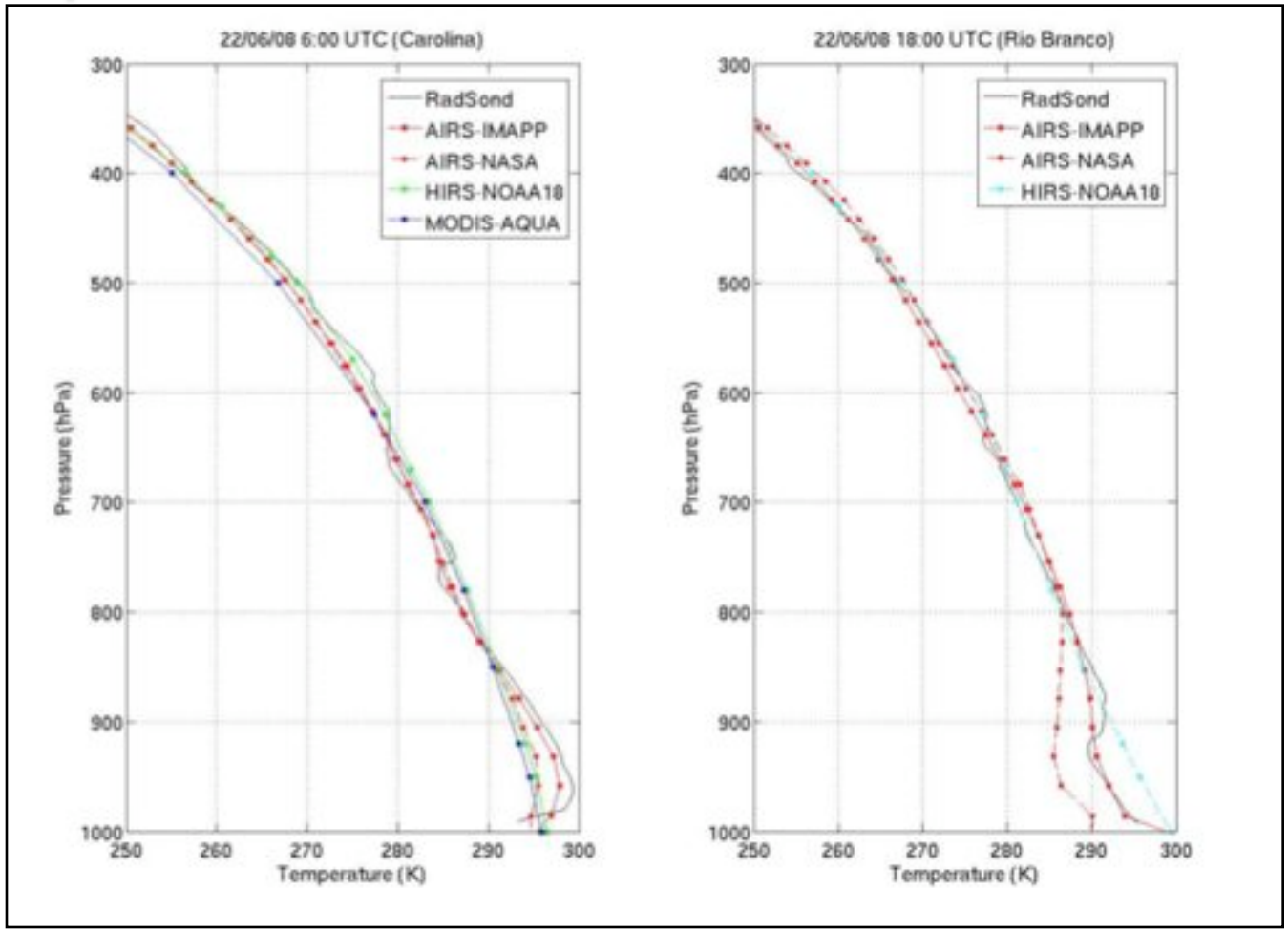
http://eostation.scanex.ru/data/cellquery.html

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.



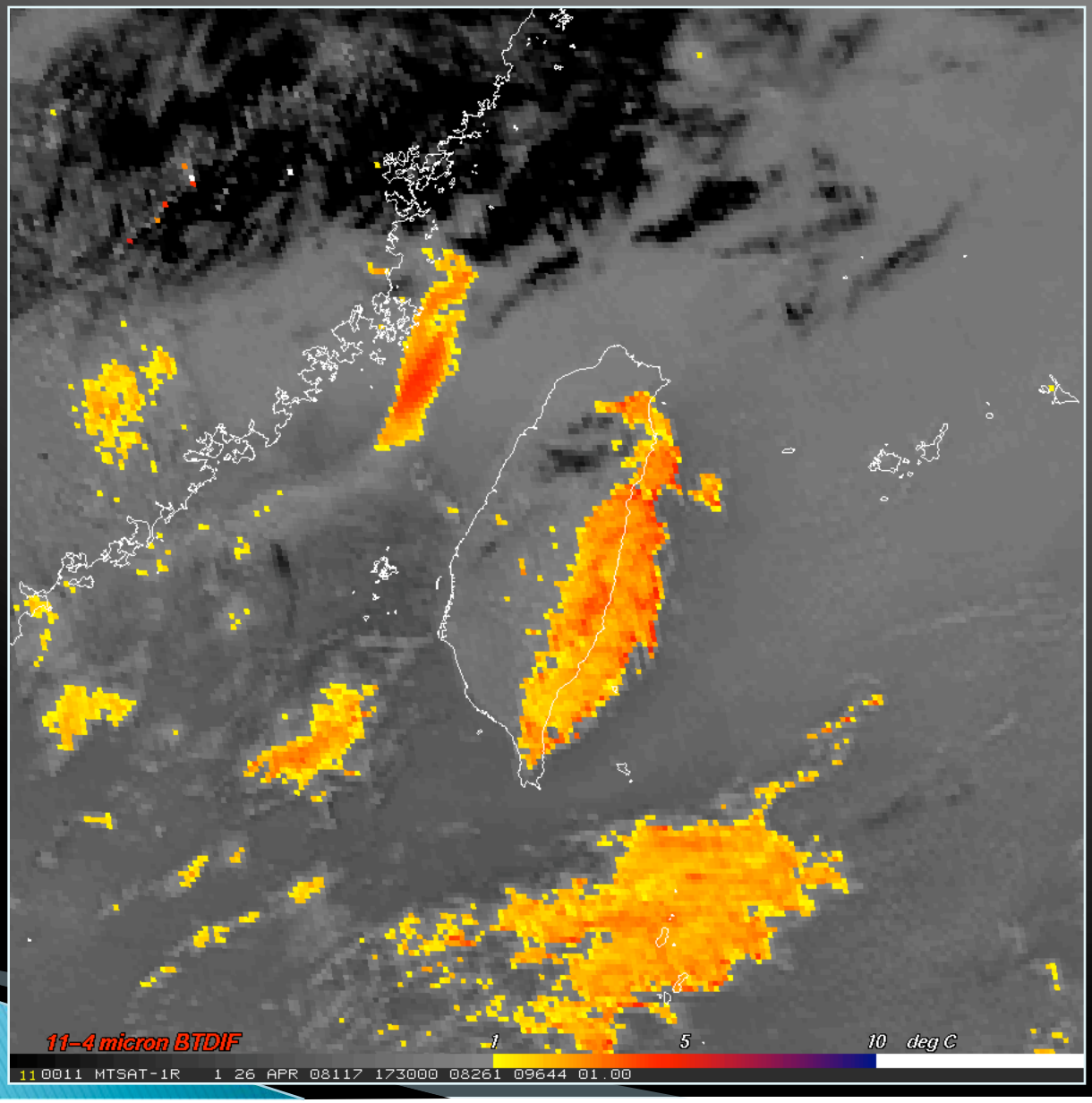
Comparison of Real Time Retrievals in Brazil



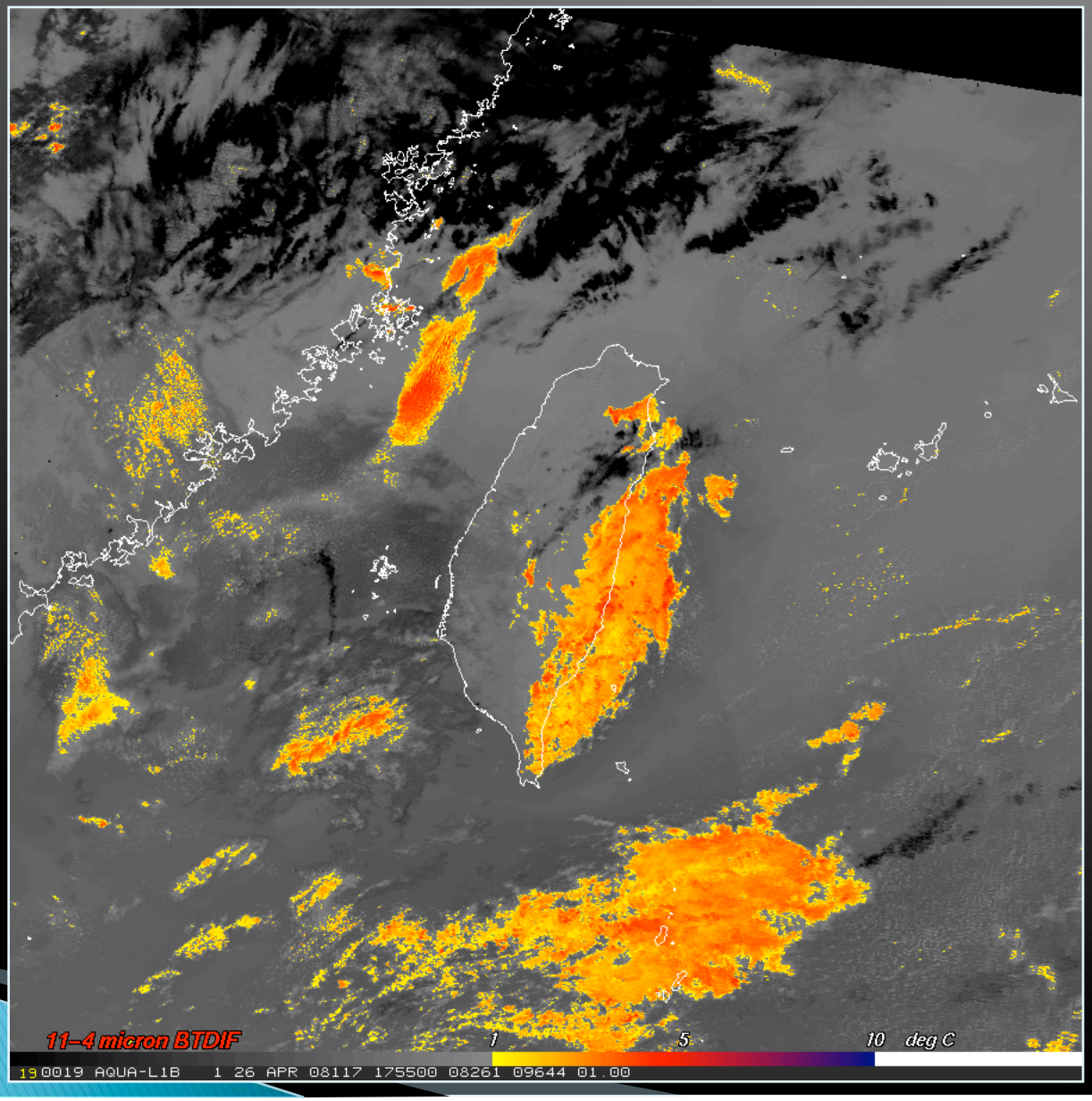
Vertical profiles of temperature retrieved for different sensors and algorithms compared with two radiosondes from the MiniBarca campaign, performed by CPTEC/INPE personnel from June 2008.

Fog Detection

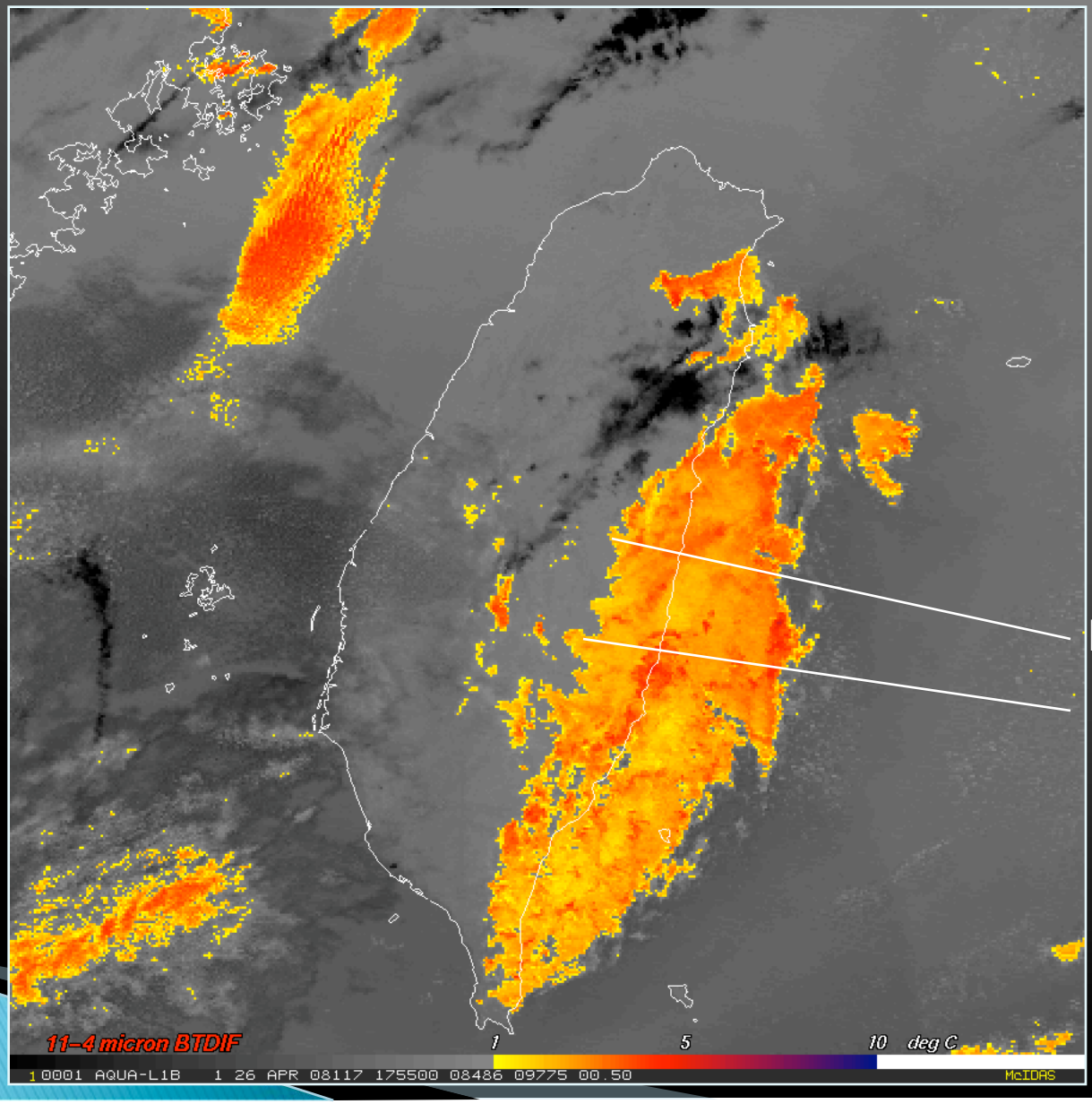
Example MTSAT Low Cloud Fog Product



Example MODIS Low Cloud Fog Product

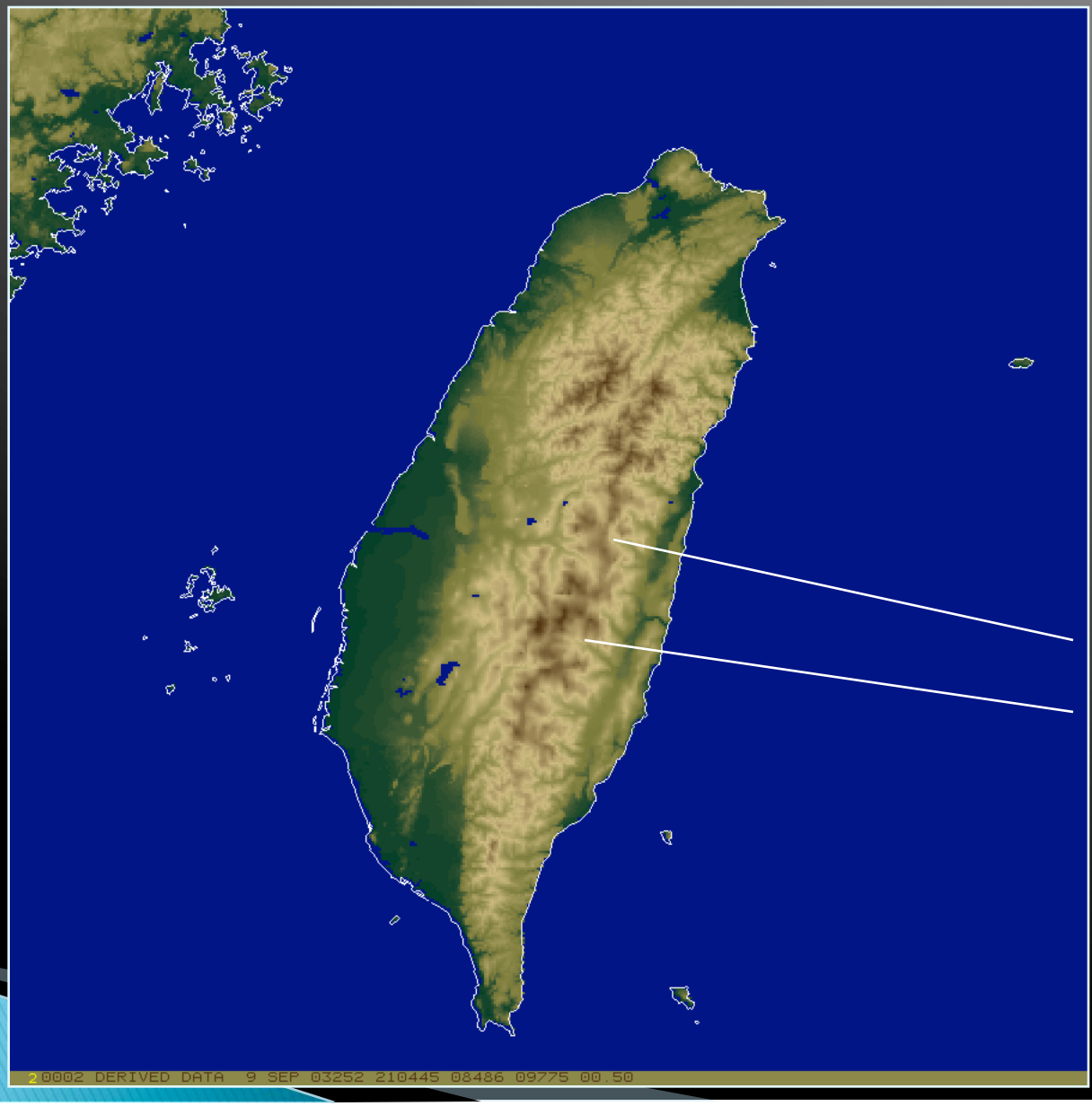


MODIS Fog and Topography



Fog entering into valleys

MODIS Fog and Topography



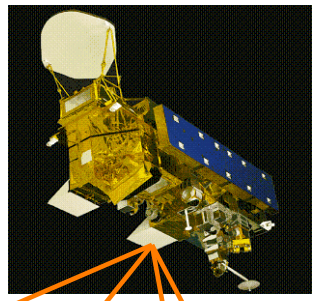
Fog entering into valleys

Numerical Weather Prediction

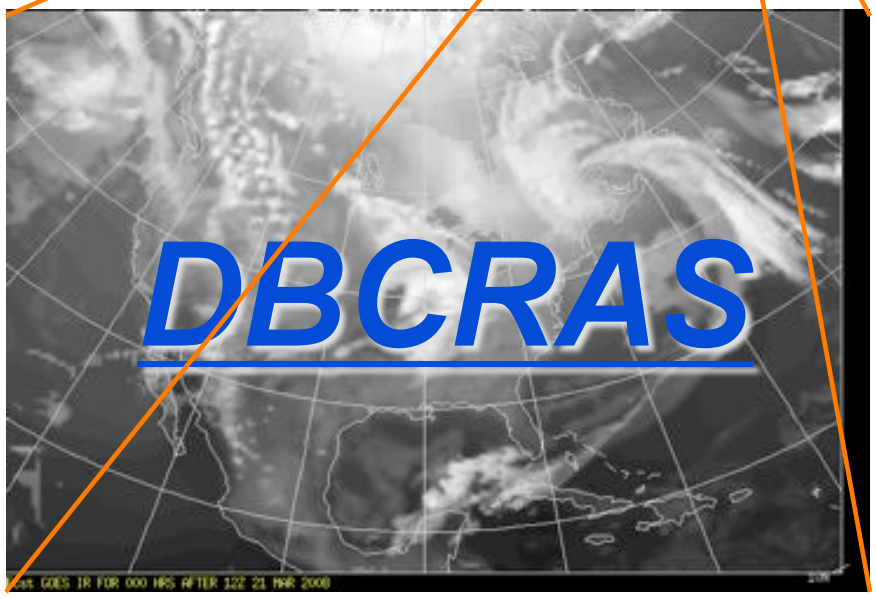
Good Grief, what is this doing here?

The Cooperative Institute for Meteorological Satellite Studies
University of Wisconsin, Madison

The Direct Broadcast Version of the CIMSS Regional Assimilation System for Global Users

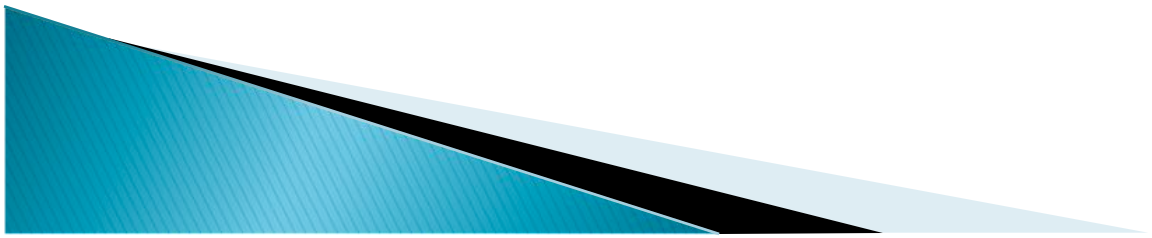


Bob Aune
Advanced Satellite Products Branch,
Cooperative Research Program
Center for Satellite Applications and Research
DOC/NOAA/NESDIS



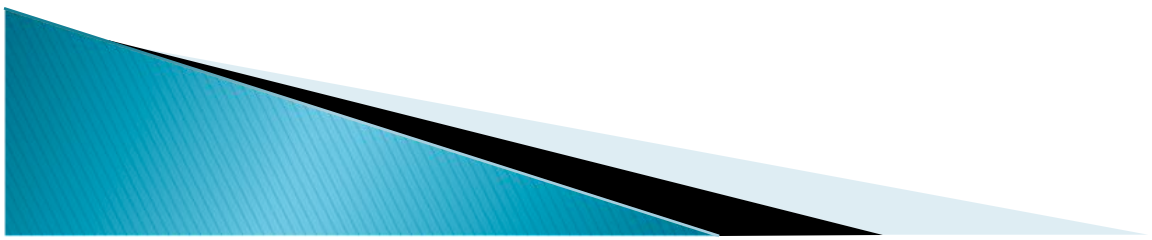
Why should I care about DBCRAS?

- Configurable anywhere in the world
  - One time initial domain set-up. You provide central latitude/longitude
- Can run on any modest linux platform
- Produces standard meteorological products
  - Temperature, Moisture, Precipitation, Winds
- Provides unique products
  - Forecast water vapor and IR window satellite imagery



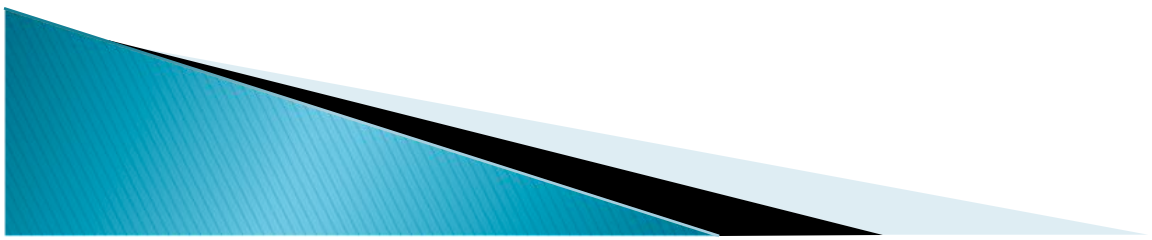
Why should I care about DBCRAS?

- Uses MODIS Products to improve the depiction of clouds and moisture in the initial model conditions
  - MOD07 Total Precipitable Water Vapor
  - MOD06 Cloud Top Pressure, Cloud Emissivity
- Others only assimilate satellite clear radiances
- Requires efficient and reliable internet connection
  - ≈ 500MB of ancillary data required per model run

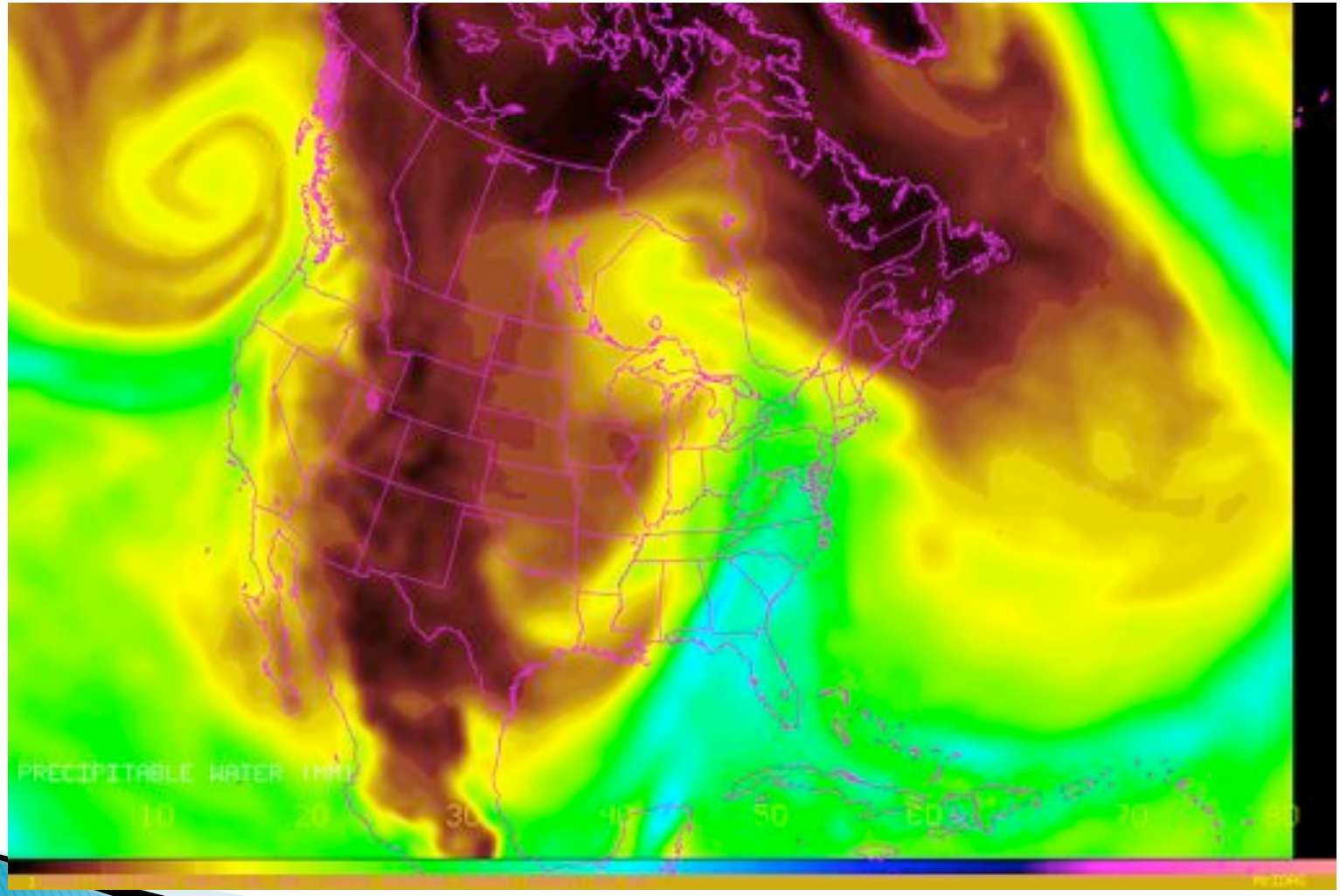


Why should I care about DBCRAS?

- Products created at 48 km resolution out to 72 hours
- Automatically creates forecast imagery
- Nest at 16 km out to 48 hours

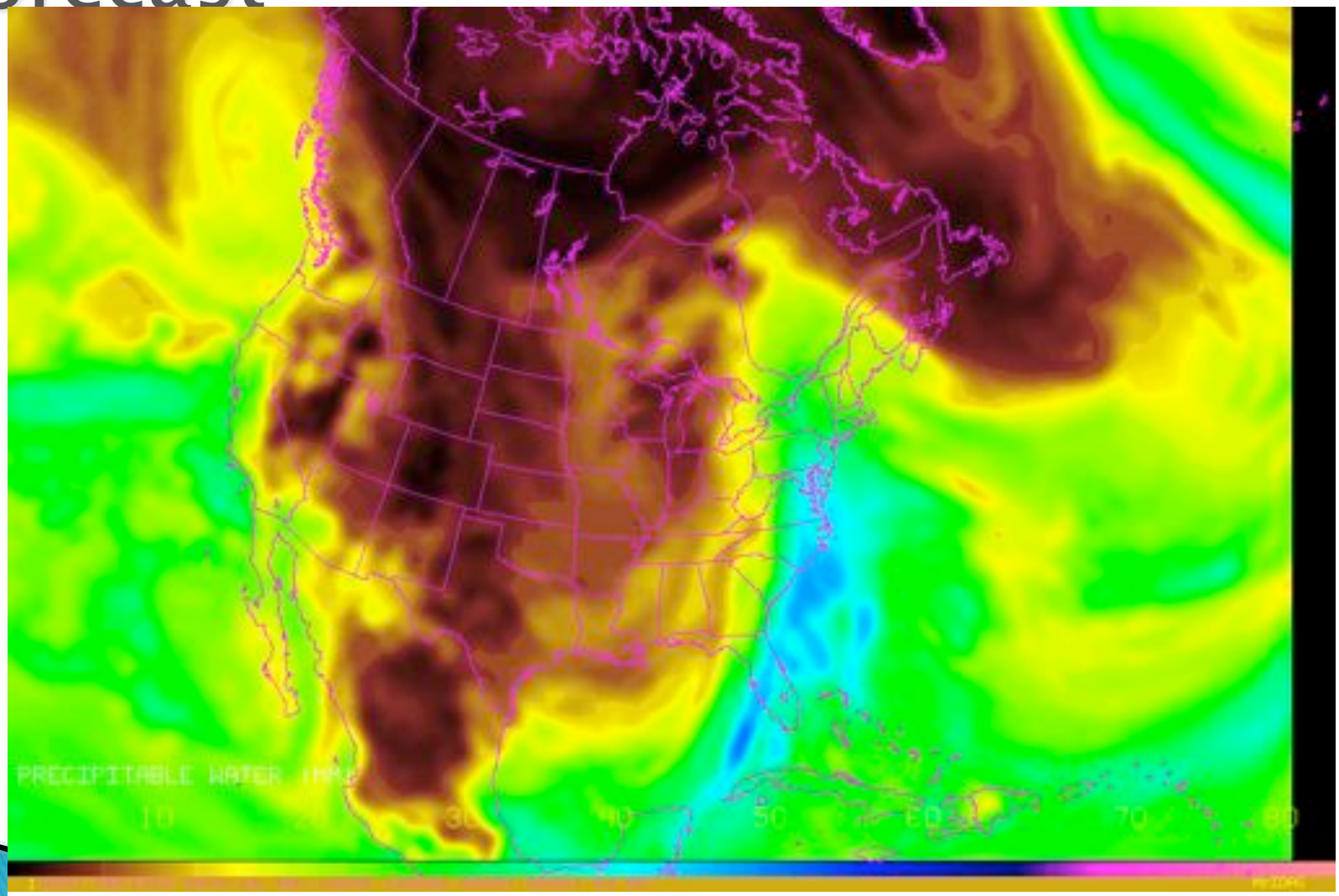


DBCRAS 12 Hour Spin-up Showing MODIS Product Assimilation Effect



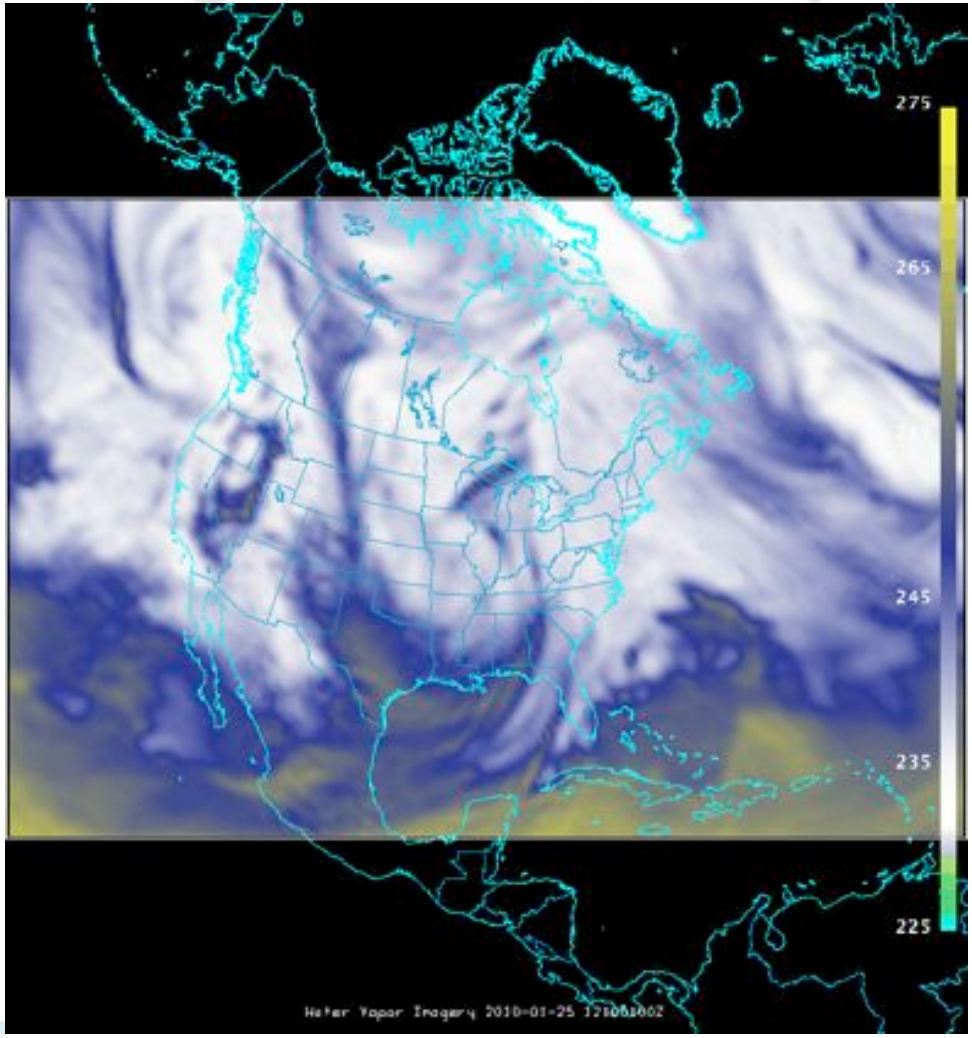
DBCRAS 12 hour Pre-forecast 48 km resolution 00 UTC 25 January 2010

DBCRAS Precipitable Water Forecast



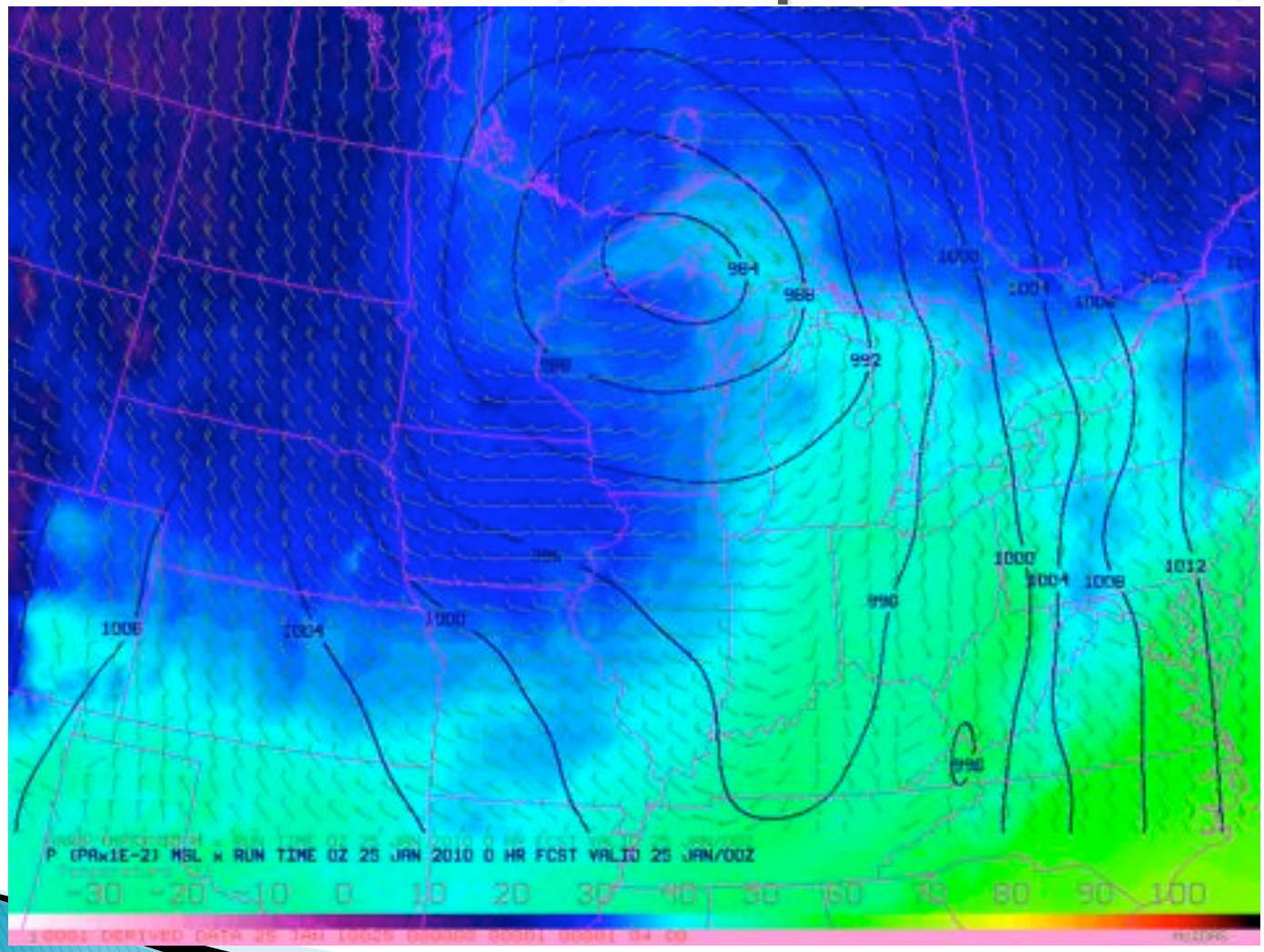
DBCRAS 72 hour Forecast 48 km resolution 12 UTC 25 January 2010

DBCRAS Forecast Water Vapor (6.7 micron) Brightness Temperatures



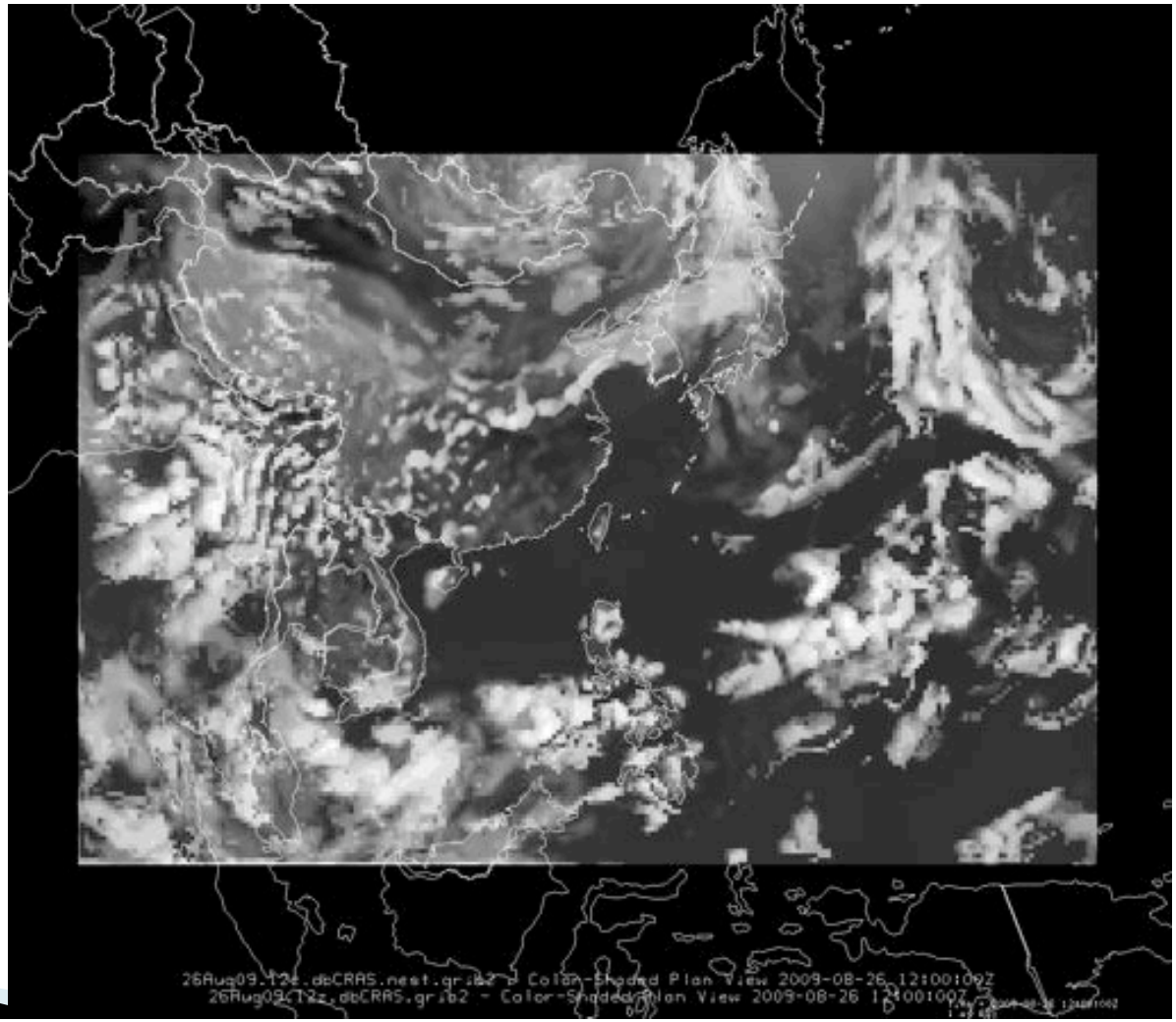
DBCRAS 72 hour Forecast 48 km resolution 12 UTC 25 January 2010

DBCRAS NEST Forecast SLP, 850 mb winds, temperatures (F)



DBCRAS 48 hour Forecast 16 km resolution 00 UTC 25 January 2010

DBCRAS 48 km +16 km Nest used by Taiwan CWB

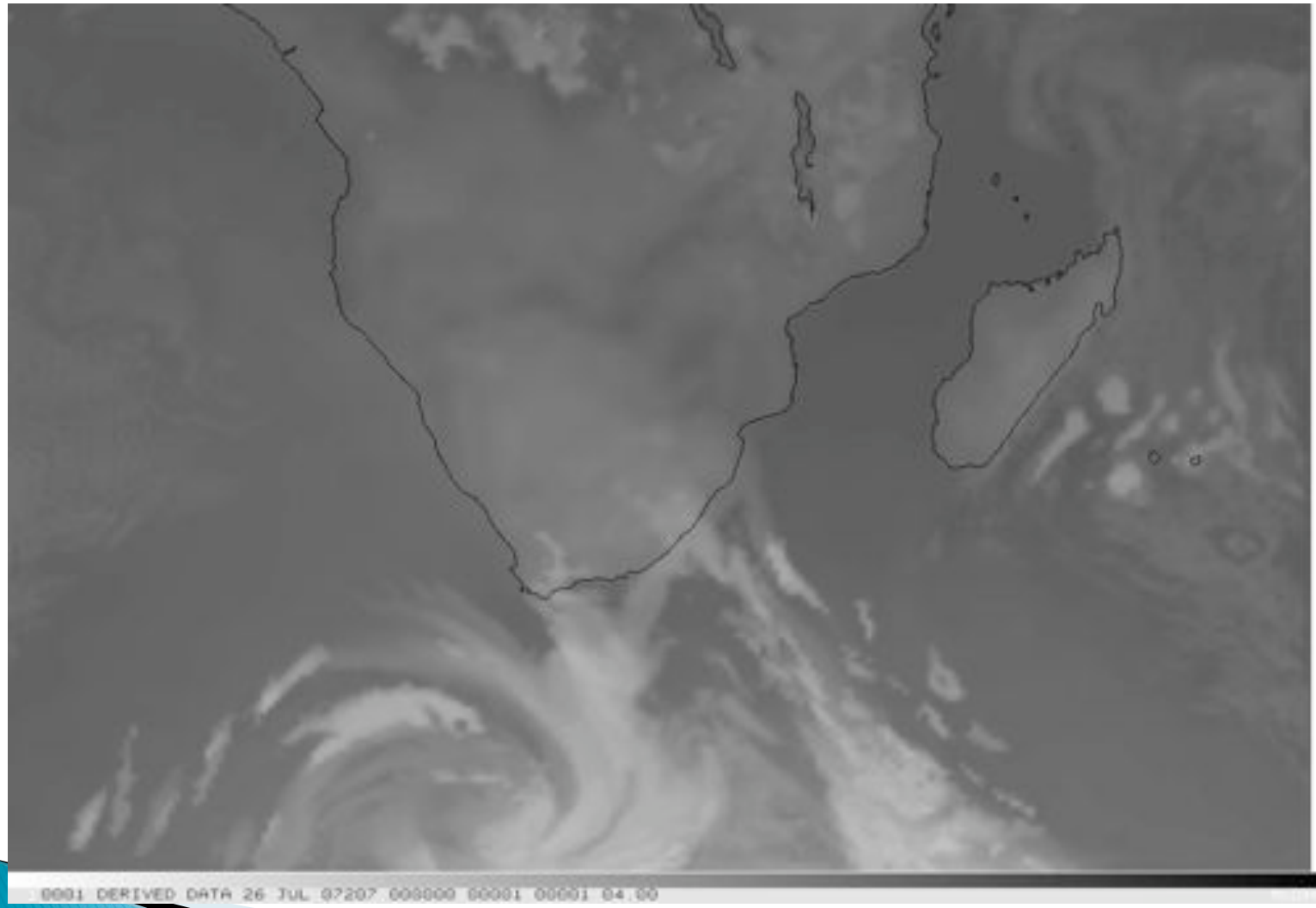


DBCRAS 72 hour Forecast IR Brightness Temperatures 12 UTC 26 Aug 2009

Applications

- Why is this important?
  - Information provided that cannot be obtained from anywhere else – especially small/poor countries
    - 2009-08-21_11:02:08","Ricardo","Alcafuz","ricardo@meteochile.cl","Chilean Weather Service","To implement DBCRAS over Chile”
- Weather Forecasting
  - We know it has been installed and run at:
    - Italy
    - Hungary
    - Brazil
    - South Africa *
    - Taiwan

DBCRAS IR Window



DBCRAS 72 hour Forecast 11 μm Brightness Temperatures 00 UTC 26 July 2007

Global Outreach

Direct Broadcast Workshops

Web site: http://cimss.ssec.wisc.edu/dbs/

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

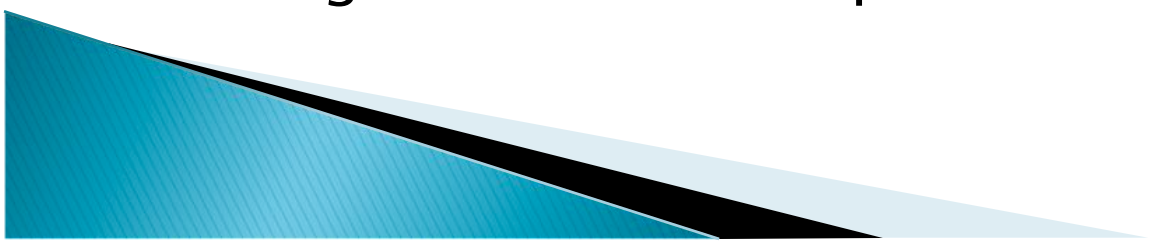
IGARSS Short Course 4: MODIS direct broadcast data for enhanced forecasting and real-time environmental decision making

Why is this important?

- Teach the principles of remote sensing to foster the next generation of scientists
  - Building on the work of Paul Menzel
  - 3 students from schools/workshops at UW now
- Promote the use of Satellite data
  - Lectures and hands-on labs determined by student interest – atmospheric products stressed
  - Lectures, labs, data and software freely distributed
  - How can the data better lives?
- Encourages international collaborations
- Web site contains all materials used in courses: http://cimss.ssec.wisc.edu/dbs/

Radiative Transfer and Cloud Products

- Cloud mask tests provide good overview of MODIS bands
  - Individual and bi-spectral tests take advantage of absorption/scattering of clouds/land/atmosphere
  - Labs include hands on exploration of bands and student evaluation of cloud mask algorithm for their (usually DB) scene
- Others
  - Cloud phase – bi-spectral test and temperature sensitivity
  - Fog detection – bi-spectral test and IR emissivity



Case Study

FleetWatch 2005
THE DEFINITIVE TRUCKING SITE

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BEWARE THE FOG

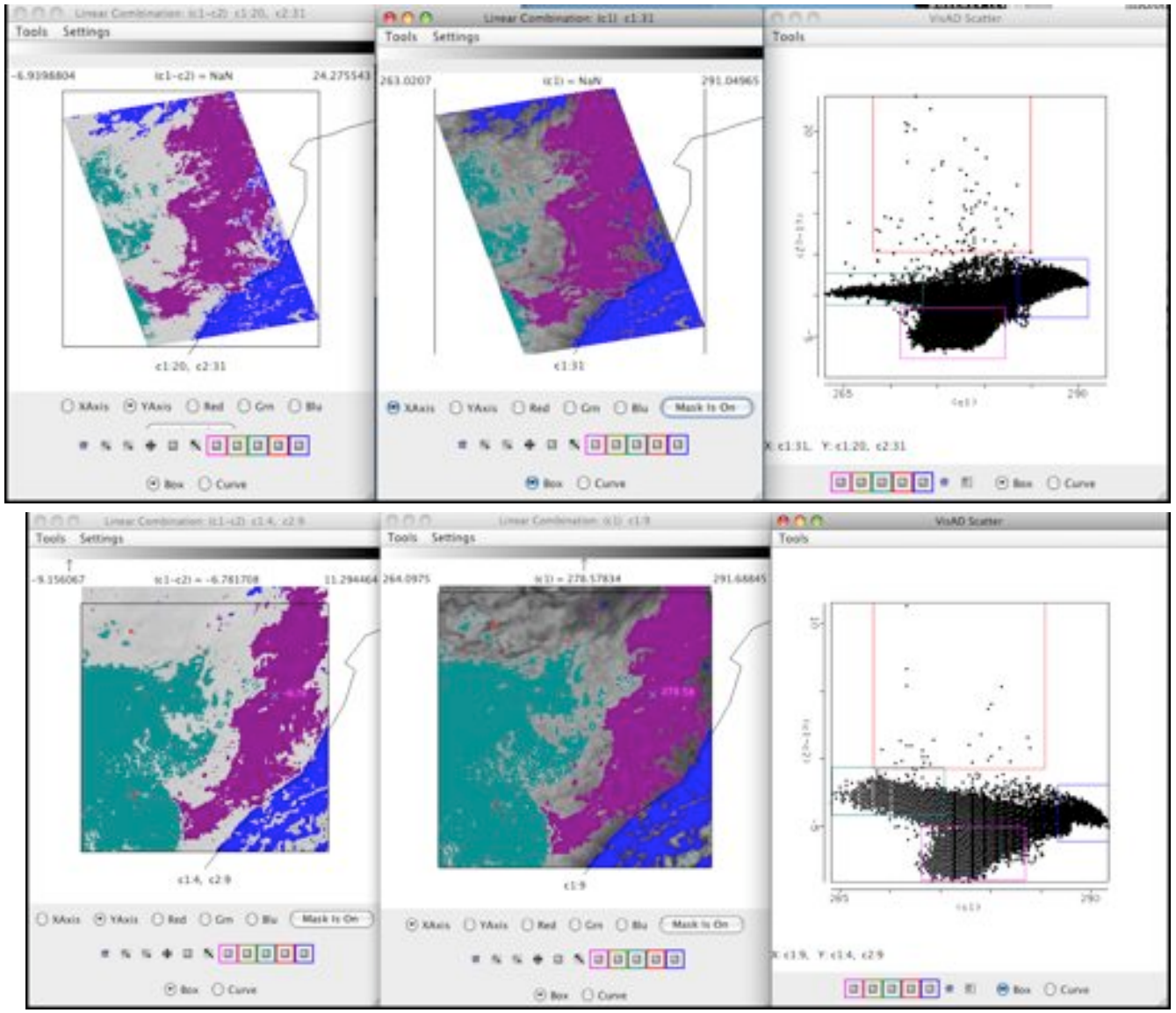
Summertime in South Africa is a dangerous season for road users. The rain pelts down, the roads get slippery, the December holidays bring greater volumes of traffic on our national roads and the festive season pours hordes of drinkers behind their steering wheels. When one considers winter time on our roads, one imagines the odd bit of ice or snow here and there with not much else to pose an 'out-of-the-ordinary' threat to road safety. How wrong this is! A recent report of an accident on the N12 suggests that winter may be even 'sillier' than summer' and highlights the need for drivers to exhibit extreme caution and slow down their speed when they come into foggy or misty conditions writes *Paul Collings*.

The N12 between Mpumalanga and Gauteng is a well traversed heavy truck route. Witbank is a mining town on this route and famous for its coal and other raw materials. For some reason, it hasn't been famous for its fog - until now that is.

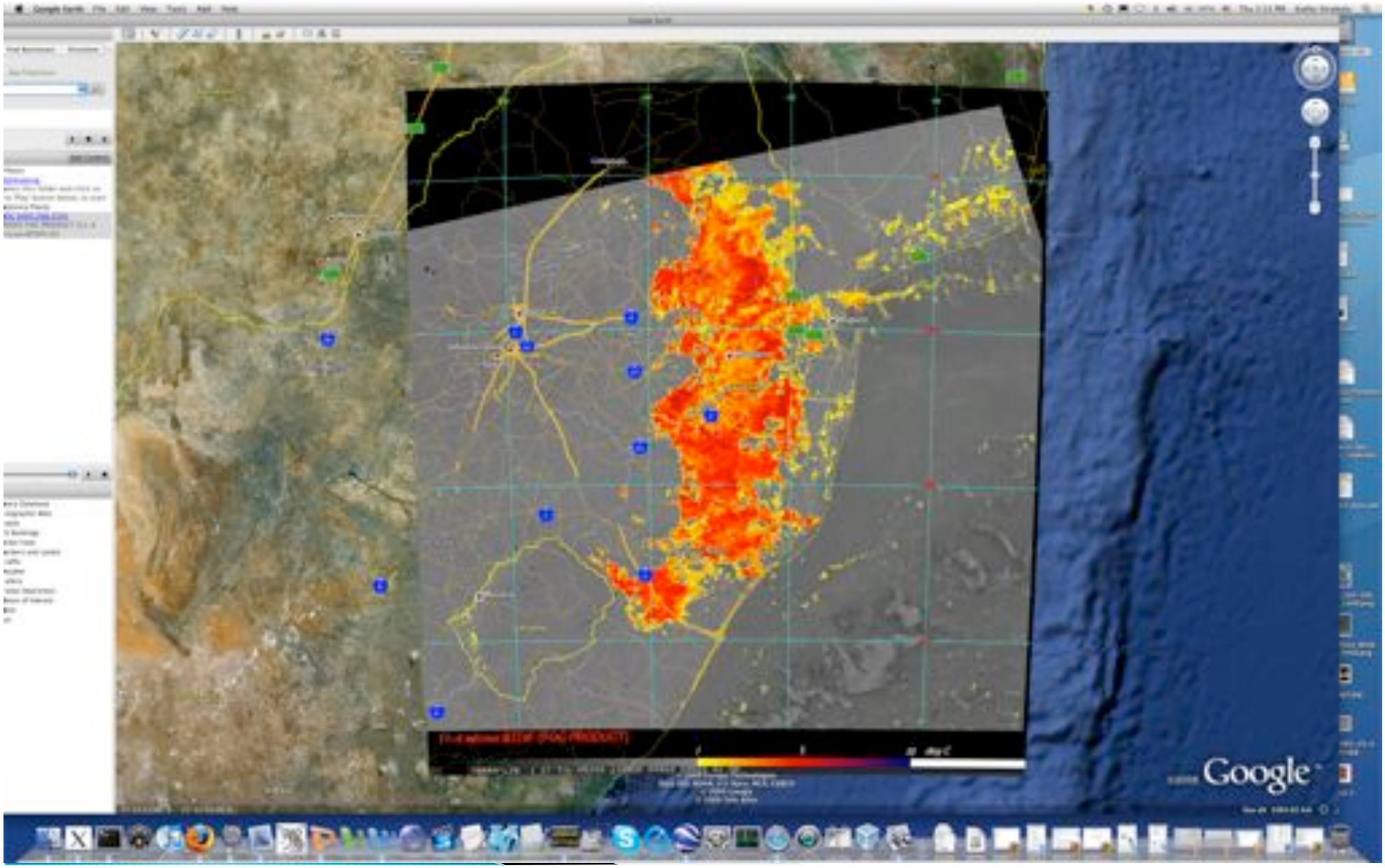
On Thursday July 28th, in a fog bank where visibility was down to 2m on certain stretches of the N12, 12 trucks and two light vehicles were involved in a pile-up. Thankfully, no one was killed but there were several seriously injured drivers and passengers. The cost to the vehicle owners is still being tallied but you can bet your bogey, accidents like these don't come cheap. **(pictures at the bottom of this page)**

According to SAPS Inspector Benny Kotze, "there's a 20km stretch of the N12 as it passes through Witbank where the fog gets very dense. Visibility is always limited and on that particular day, it was reduced to between 50m and 2m."

MODIS and SEVIRI Fog Detection



Fog Product in Google Earth



Student Presentations

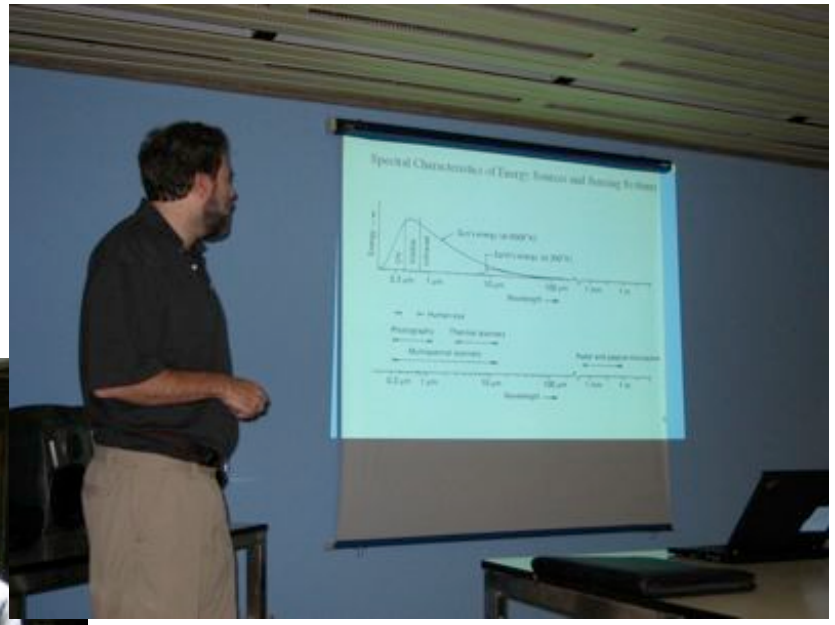
Nanjing, China 2004

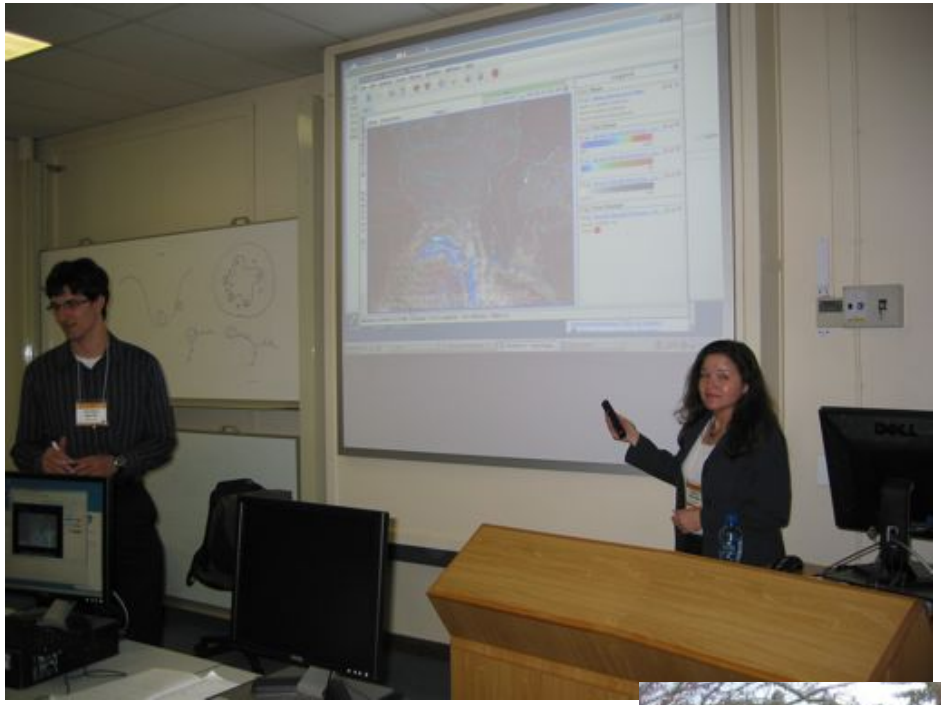
Nanjing 2004

Andenes, Norway 2006

Pretoria, South Africa 2006

Sao Paulo, Brazil 2008





Stellenbosch, South Africa 2009

Conclusions

- Aqua and Terra direct broadcast products are being used by many countries for a wide variety of environmental applications
- The free distribution of data, products, software and visualization tools has promoted the creative use of the data
- We hope that future DB packages will do the same for future missions