

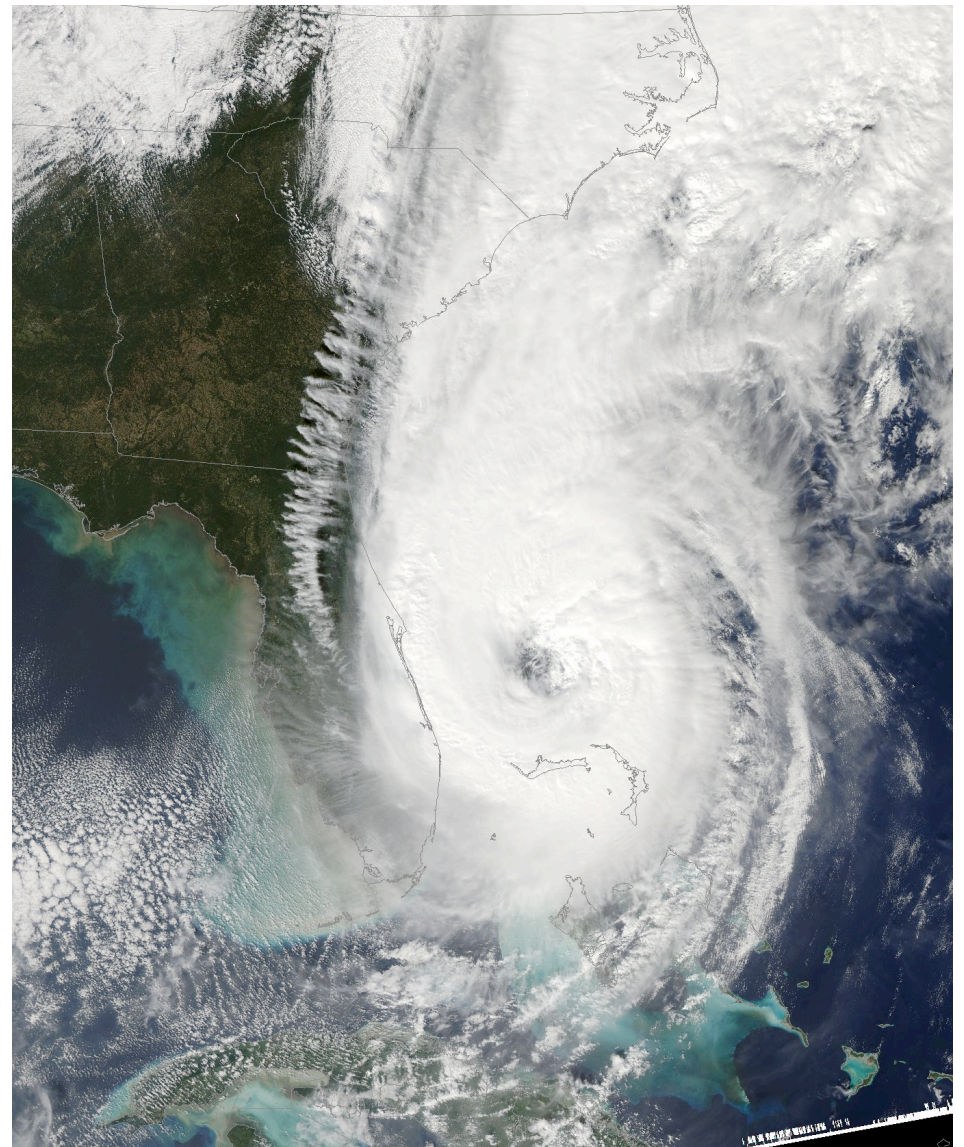
Real-Time Applications of Direct Broadcast Data from Aqua and Terra

Liam Gumley, Allen Huang,
Kathy Strabala

Space Science and
Engineering Center

University of Wisconsin-
Madison

3 August 2006
IGARSS 2006 Denver



Hurricane Wilma, 24 Oct. 2005, Aqua DB 1

Image Credits

**V. Gershenzon and A. Shumilin,
ScanEx Moscow**

C. Smith, ACRES

J. Key, NOAA/NESDIS

K. Strabala, UW/CIMSS

G. Cabrera, CONAE

G. Jedlovec, NASA/MSFC

R. DeAbreu, CIS

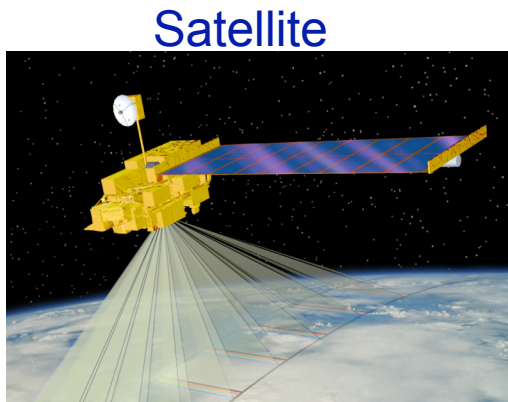
G. Leshkevich, NOAA/GLERL



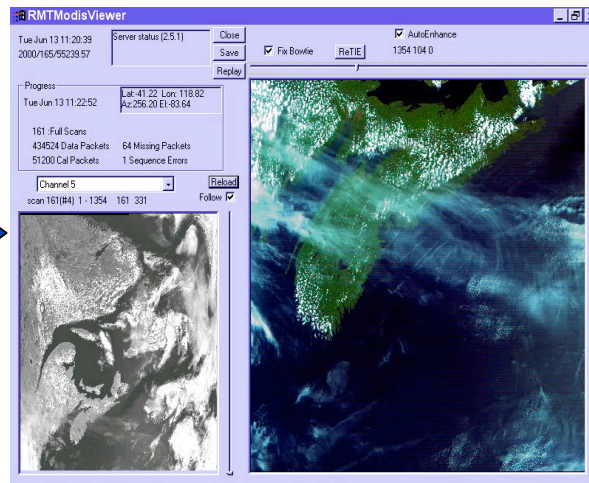
Q: What is Direct Broadcast (DB)?

A: Transmission of Earth Observations from Satellite to Ground Station in Real-Time

- For Terra and Aqua, signal is unencrypted and freely available (no license required)
- Processing software is freely available
- All aspects of ground processing, product development, and data distribution are under local control



Ground Station



Processing Software



Products and Applications³

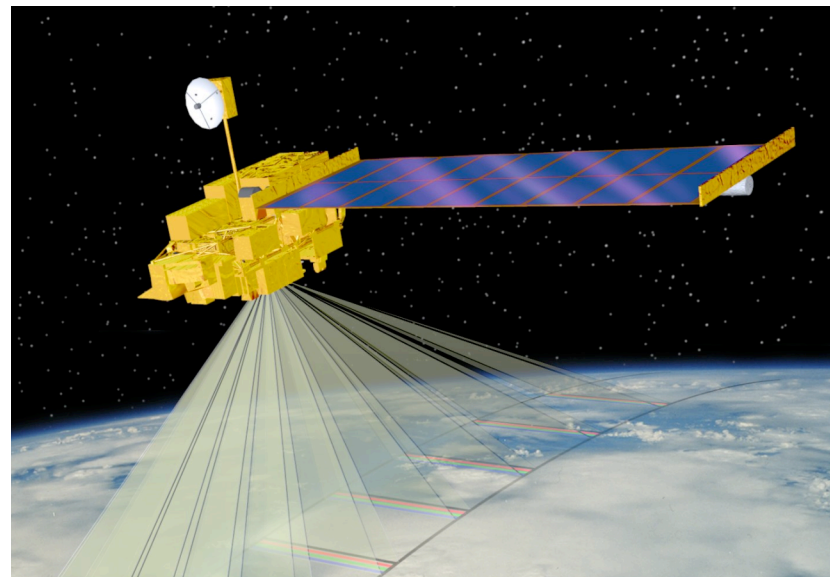
Terra

Launched: Dec. 18, 1999
10:30 am descending



ASTER: Hi-res imager
CERES: Broadband scanner
MISR: Multi-angle imager
MODIS: Multispectral imager
MOPITT: Limb sounder

Only MODIS is available by DB



Aqua

Launched: May 4, 2002

1:30 pm ascending



AIRS: Infrared sounder

AMSR-E: Microwave scanner

AMSU: Microwave scanner

CERES: Broadband scanner

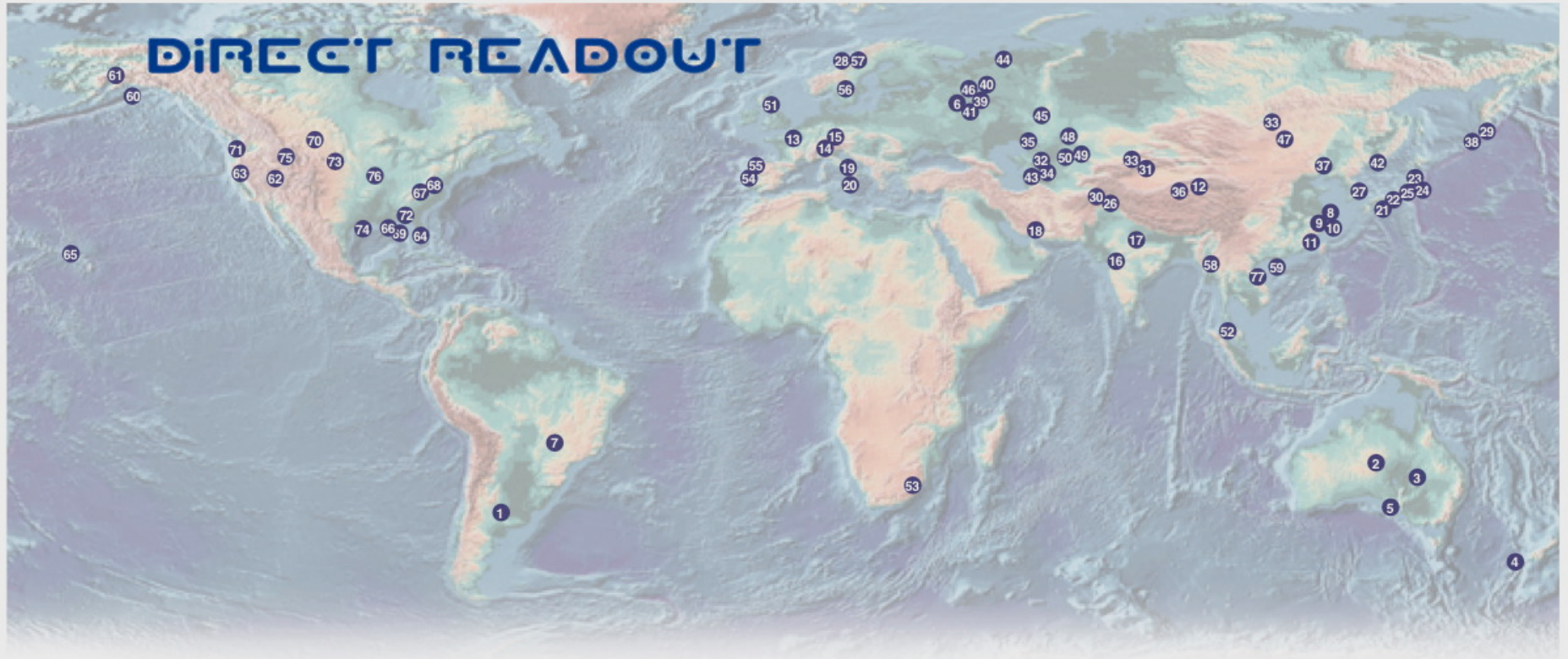
HSB: Microwave sounder

MODIS: Multispectral imager

All sensors are available via DB



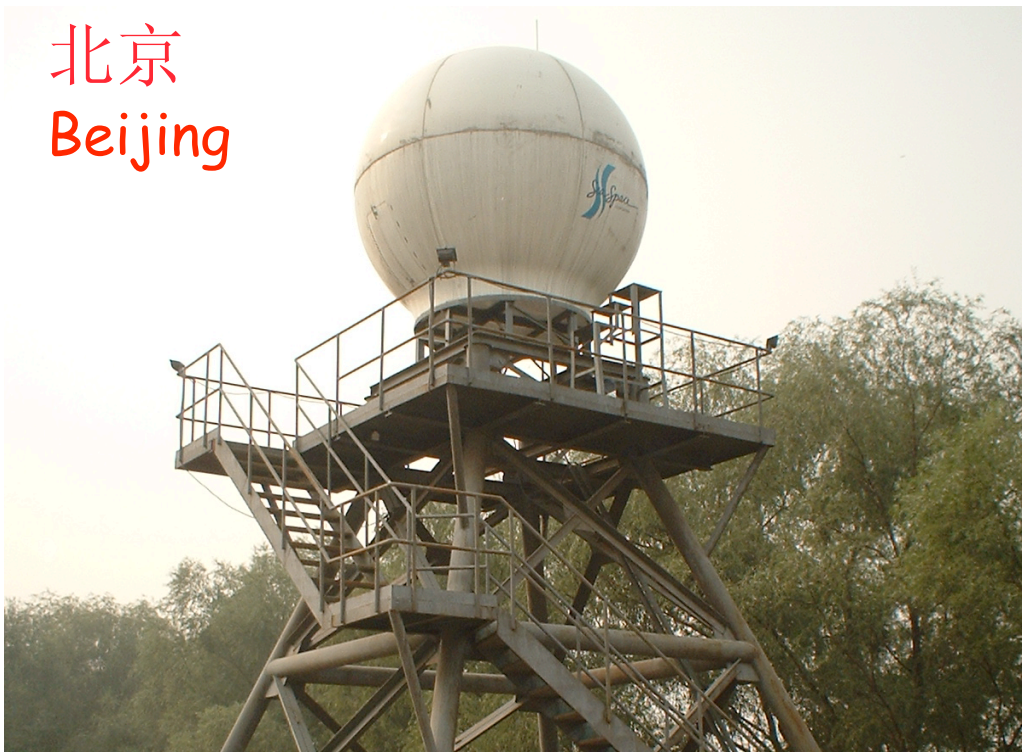
EOS Direct Broadcast Sites



More than 150 ground stations around the world

(not all are shown on this map from Nov. 2003)

北京
Beijing



Moscow



Madison



Benevento

Advantages of DB:

- Facilitates access to advanced sensors, precursor to NPP/NPOESS
- Local control and autonomy gives users freedom to tailor operations
- Timeliness for responding to natural hazards and providing information for decision makers.
- Local researchers are free to develop and refine algorithms tuned for local conditions

**Direct Broadcast Applications
described in this presentation:**

**Ice Monitoring
Bushfire Detection
Weather Forecasting
Polar Winds**

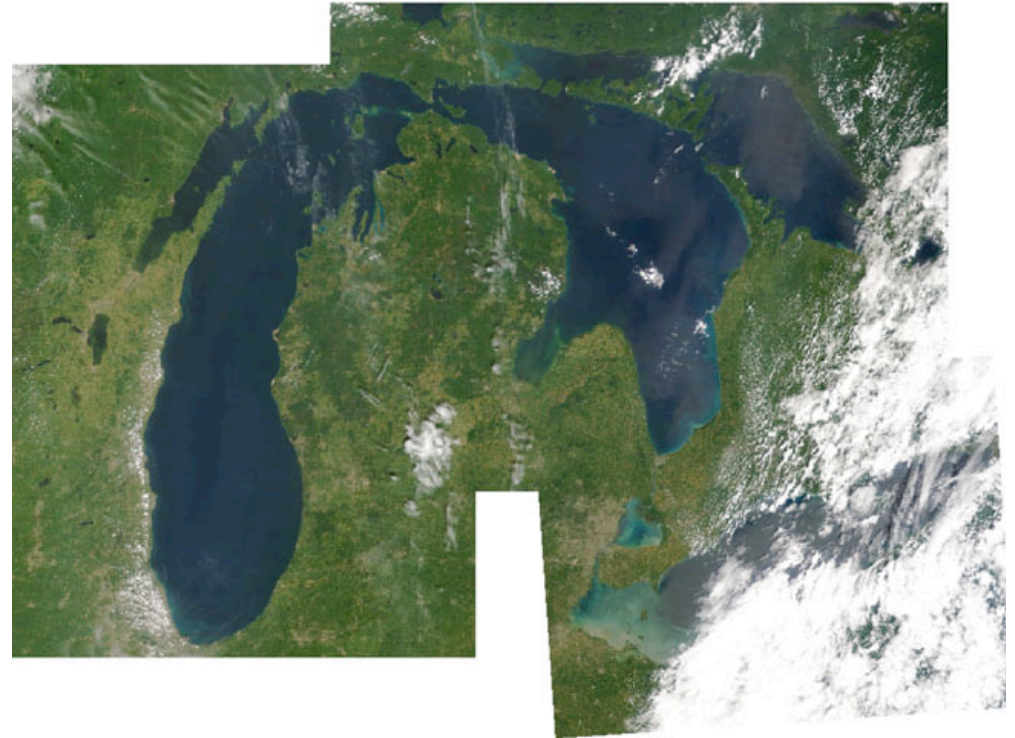
Application: Ice Monitoring

Realtime MODIS GeoTIFF products Ice Monitoring

Aqua and Terra MODIS 250 meter true color images are produced daily at SSEC for each of the Great Lakes, Hudson Bay, and Northeast Canada.

GeoTIFF format in UTM projection (GIS compatible).

NOAA Coastwatch, National Ice Center, and Canadian Ice Service download the images in realtime.



[What's New](#)
[CW Overview](#)

Welcome to the NOAA CoastWatch Great Lakes Node

[AVHRR Imagery](#)

[GLSEA](#)

[Contour Maps](#)

[GOES Imagery](#)

[RADARSAT](#)

[MODIS Imagery](#)

[Ocean Color](#)

[Image Products](#)

[In Situ Data](#)

[GLFS](#)

[Statistics](#)

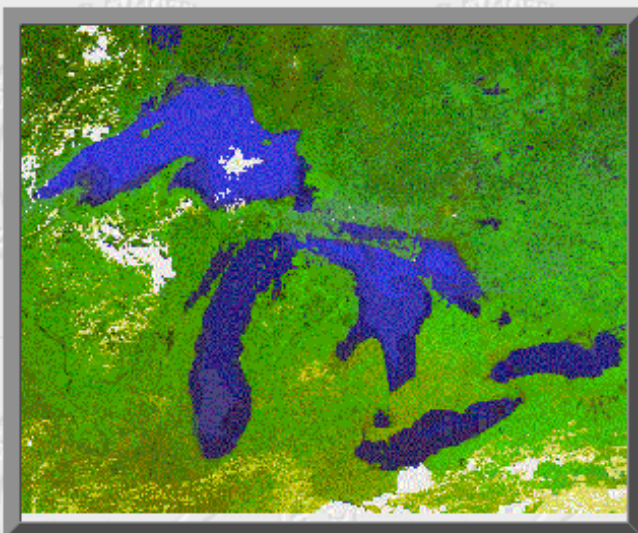
[JAVA GIS](#)

[Image Archive](#)

[Software](#)

[Documentation](#)

[Validation](#)



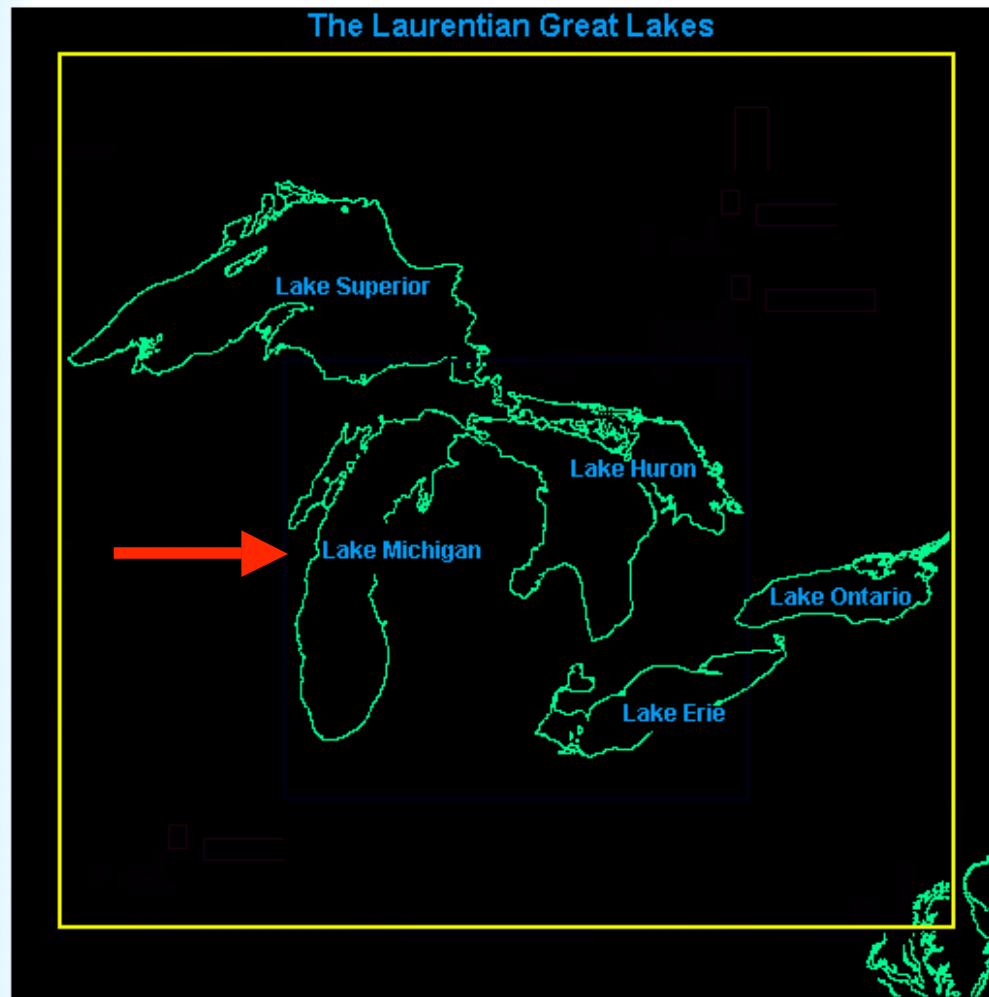
Great Lakes CoastWatch Node
NOAA/Great Lakes Environmental
Research Laboratory
2205 Commonwealth Blvd.
Ann Arbor, MI 48105-2945
Fax: 734-741-2055
<http://coastwatch.glerl.noaa.gov>

[George A. Leshkevich,](#)
Manager

[Songzhi Liu,](#)
Operations Assistant

[Disclaimer](#)

[Home](#) > [Region Map](#)



[Lake Superior](#)

[Lake Michigan](#)

[Lake Huron](#)

[Lake Erie](#)

[Lake Ontario](#)

click in map or links

For current MODIS imagery, click in region of interest

MODIS data acquired by [direct broadcast](#) and processed at the [Space Science and Engineering Center](#),
University of Wisconsin-Madison

[Home](#) > [Region Map](#) > Lake Michigan

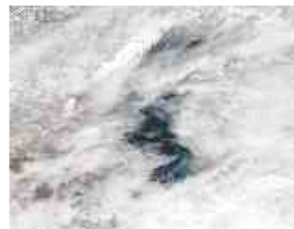
NOAA CoastWatch - Great Lakes Region

Lake Michigan MODIS Imagery - True Color, 250 m Resolution

Current time: 03/24/2005 14:17:55 GMT

Page: 1 of 4

[1](#) [2](#) [3](#) [4](#)



03/23/2005 18:17 GMT



03/23/2005 16:38 GMT



03/22/2005 19:12 GMT



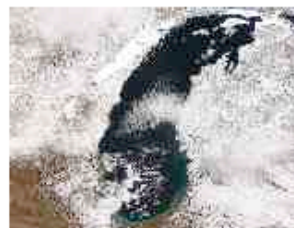
03/22/2005 17:33 GMT



03/22/2005 15:56 GMT



03/21/2005 18:29 GMT



03/21/2005 16:50 GMT



03/20/2005 19:24 GMT



03/20/2005 16:08 GMT

MODIS data acquired by [direct broadcast](#) and processed at the [Space Science and Engineering Center](#),
University of Wisconsin-Madison

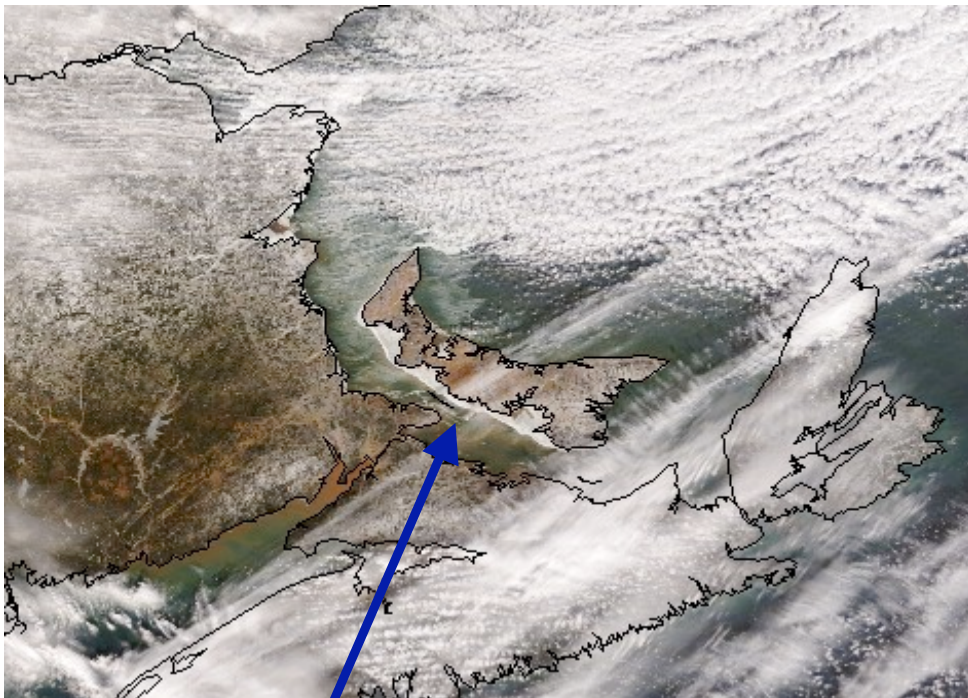


Canadian Ice Service integrates MODIS into operational data stream for ice monitoring

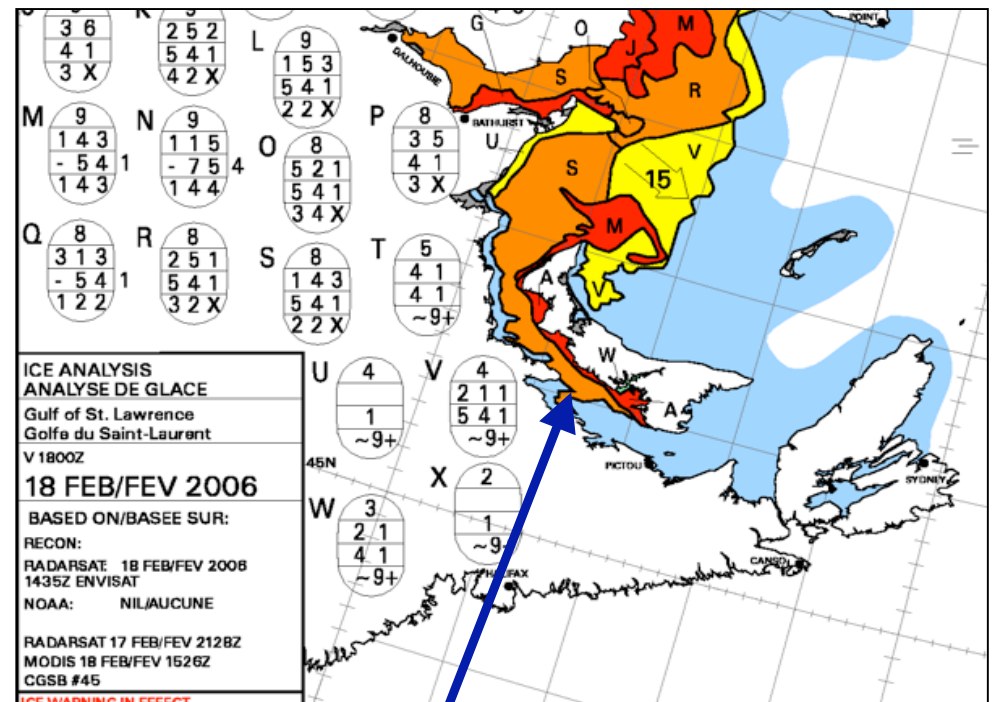
CIS data suite includes RadarSat and Envisat (SAR); AMSR, QuikScat and SSM/I (microwave); MODIS, OLS, NOAA and GOES (visible images).

- MODIS supplements SAR data in clear sky conditions.
- 250 meter resolution true color GeoTIFF images are obtained daily from SSEC for Great Lakes, Hudson Bay, Labrador coast, and Gulf of St. Lawrence.

MODIS helps to define ice boundary along southern Prince Edward Island



MODIS DB image 2006/02/18 15:26 UTC

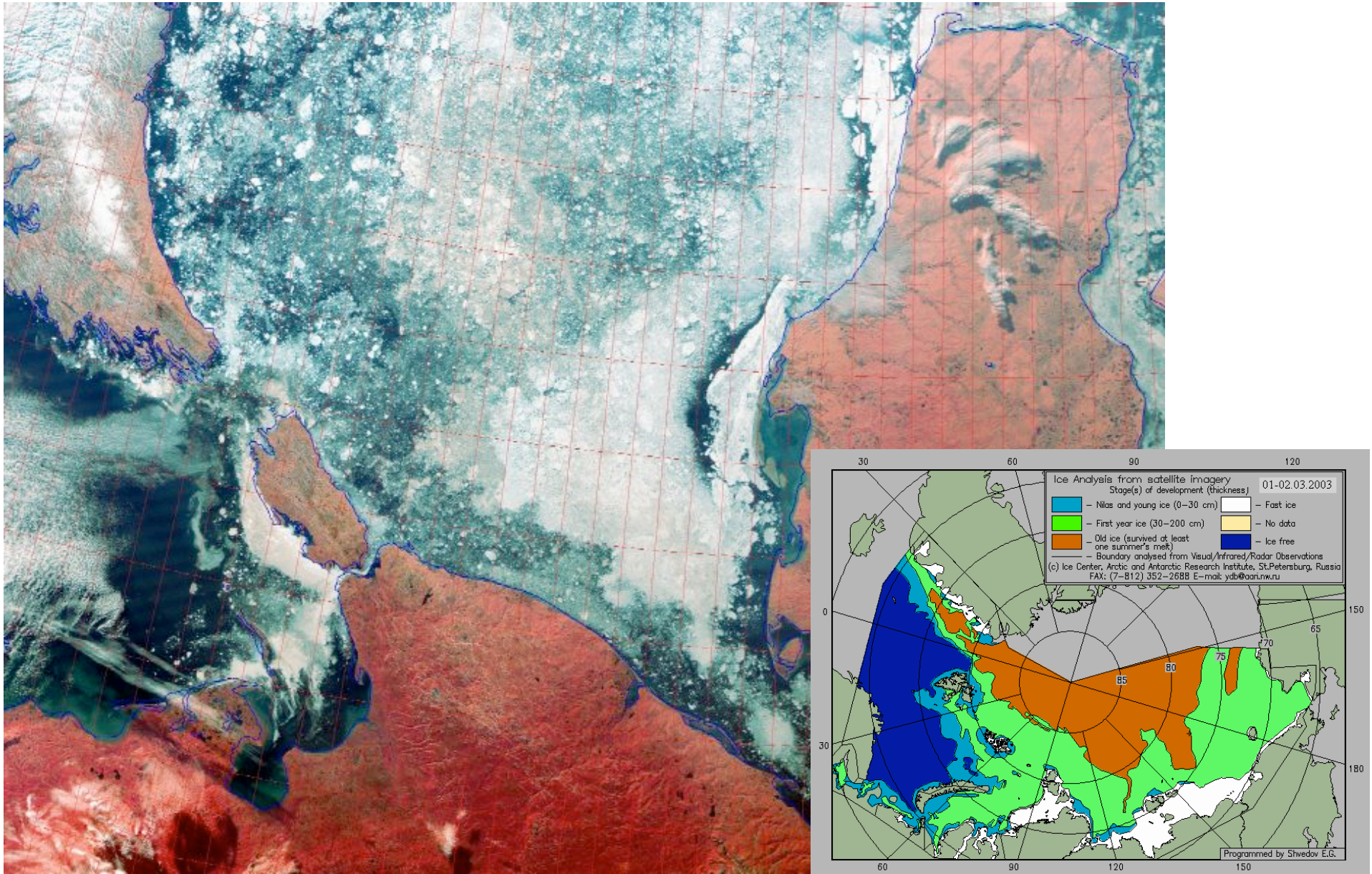


CIS Ice Analysis 2006/02/18

The network of EOScan™ ground stations for MODIS data acquisition



Operational sea ice monitoring



Arctic and Antarctic Research Institute (St.Petersburg) supplies weekly ice charts using data from NOAA-*, Terra and Meteor-3M satellites.

Application: Bushfire Detection

Sentinel Hotspots:

Joint project developed
Department of Defence, CSIRO
and Geoscience Australia

Sentinel Hotspots is an internet-
based mapping tool designed to
provide timely fire location data to
emergency service managers across
Australia



ACRES MODIS Data from Geoscience Australia

Geoscience Australia provides online Near Real Time (NRT) ACRES MODIS data from Terra & Aqua.

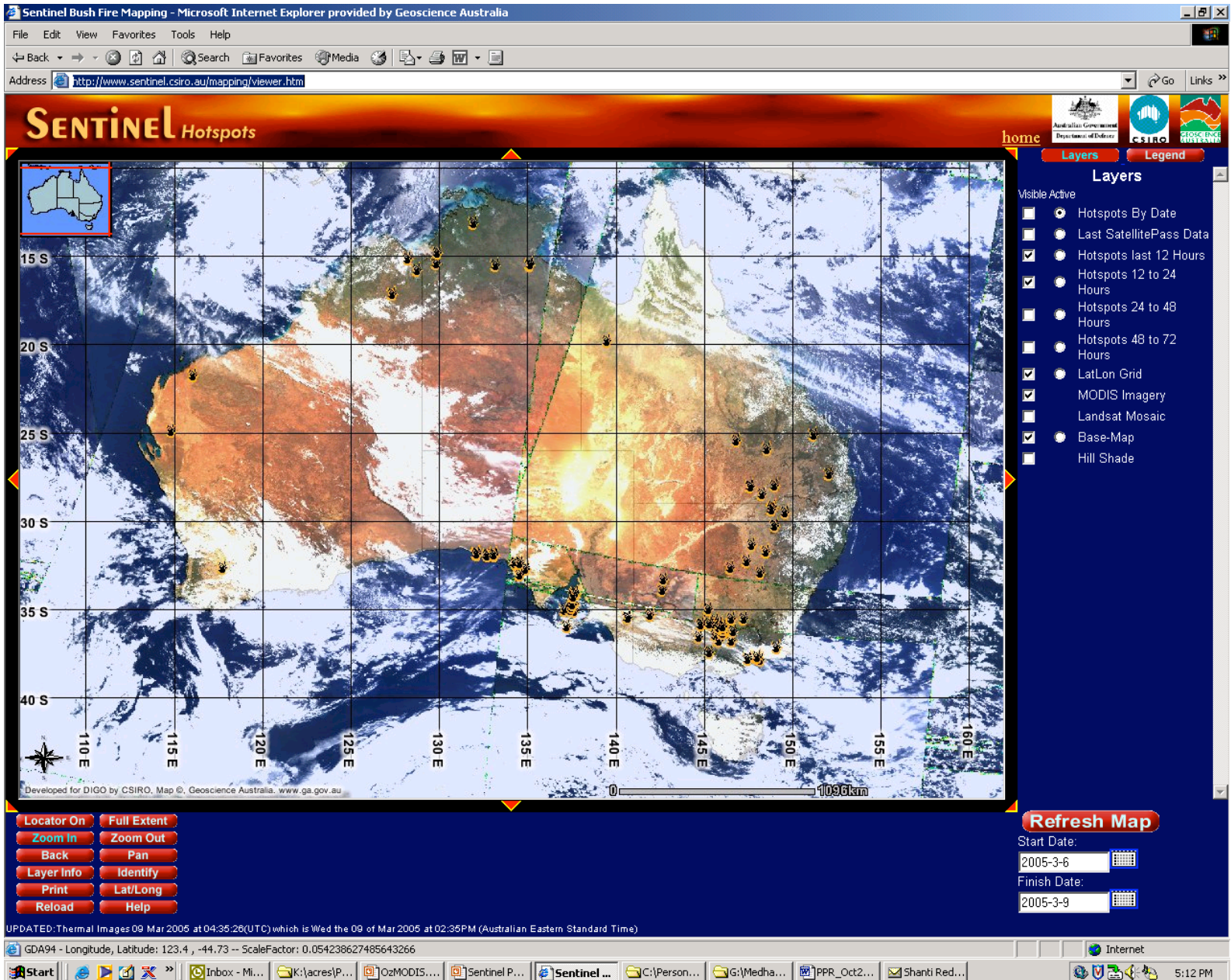
ACRES MODIS products are available in satellite path orientation (Level 1B), or map oriented (Lambert Conformal projection).

MODISL1DB is used to generate ACRES MODIS Level 1B NRT data.

ACRES MODIS map oriented products are generated using MRTSwath.

Sub pixel registration of multi-temporal ACRES MODIS Terra map oriented products is being achieved on a consistent basis.

Sentinel Hotspots (Department of Defence, CSIRO & Geoscience Australia)



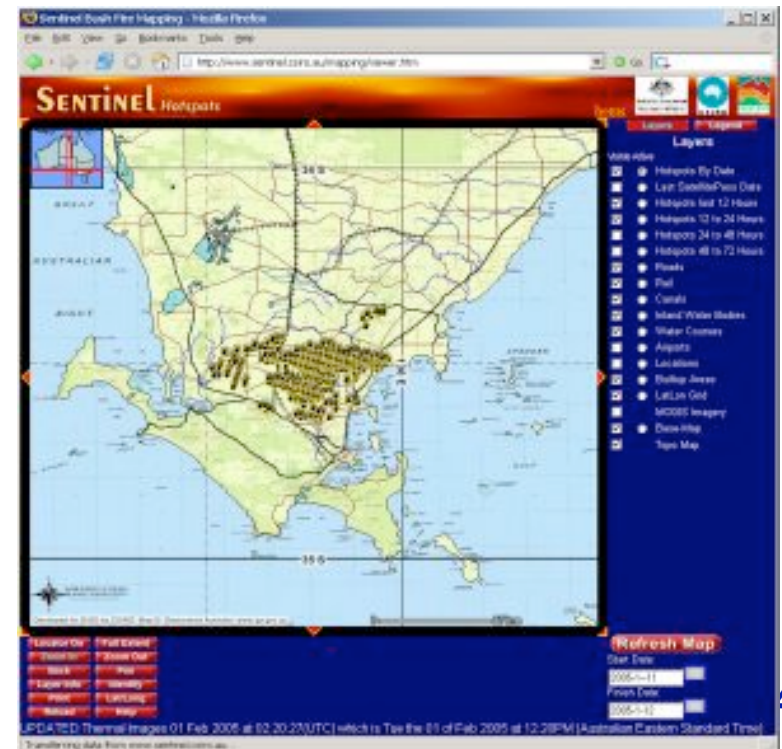
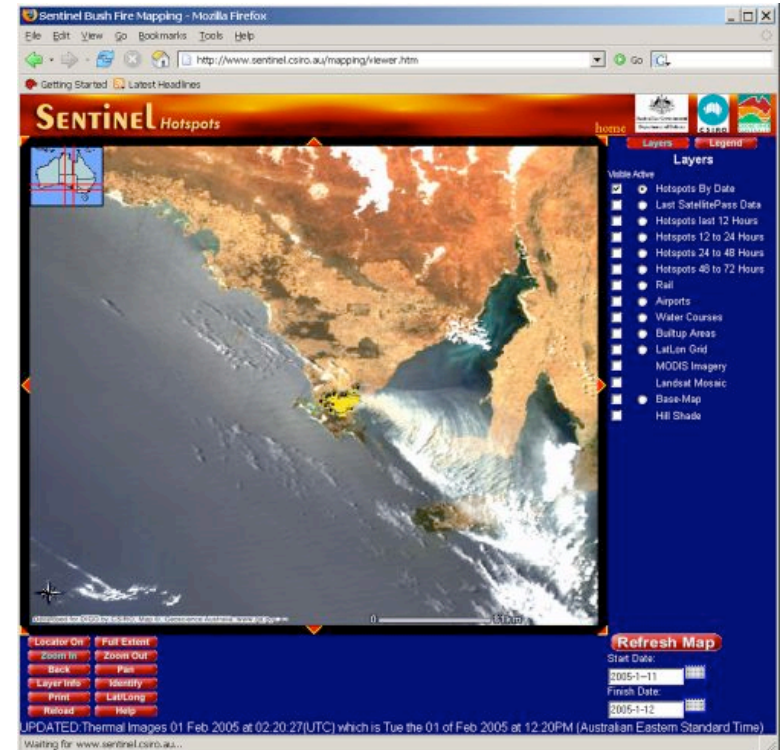
<http://www.sentinel.csiro.au/mapping/viewer.htm>

Jan. 2005 Case Study

Fire hotspot mapping

- On 11 Jan. 2005 a major fire emergency took place on the Eyre Peninsula in South Australia, killing 9 people.
- Sentinel was used in fire-fighting operations to help prevent even greater loss of life and property destruction
- Over the past several years, in numerous fire emergencies, Sentinel Hotspots has come to be relied upon by fire fighting agencies nationwide.

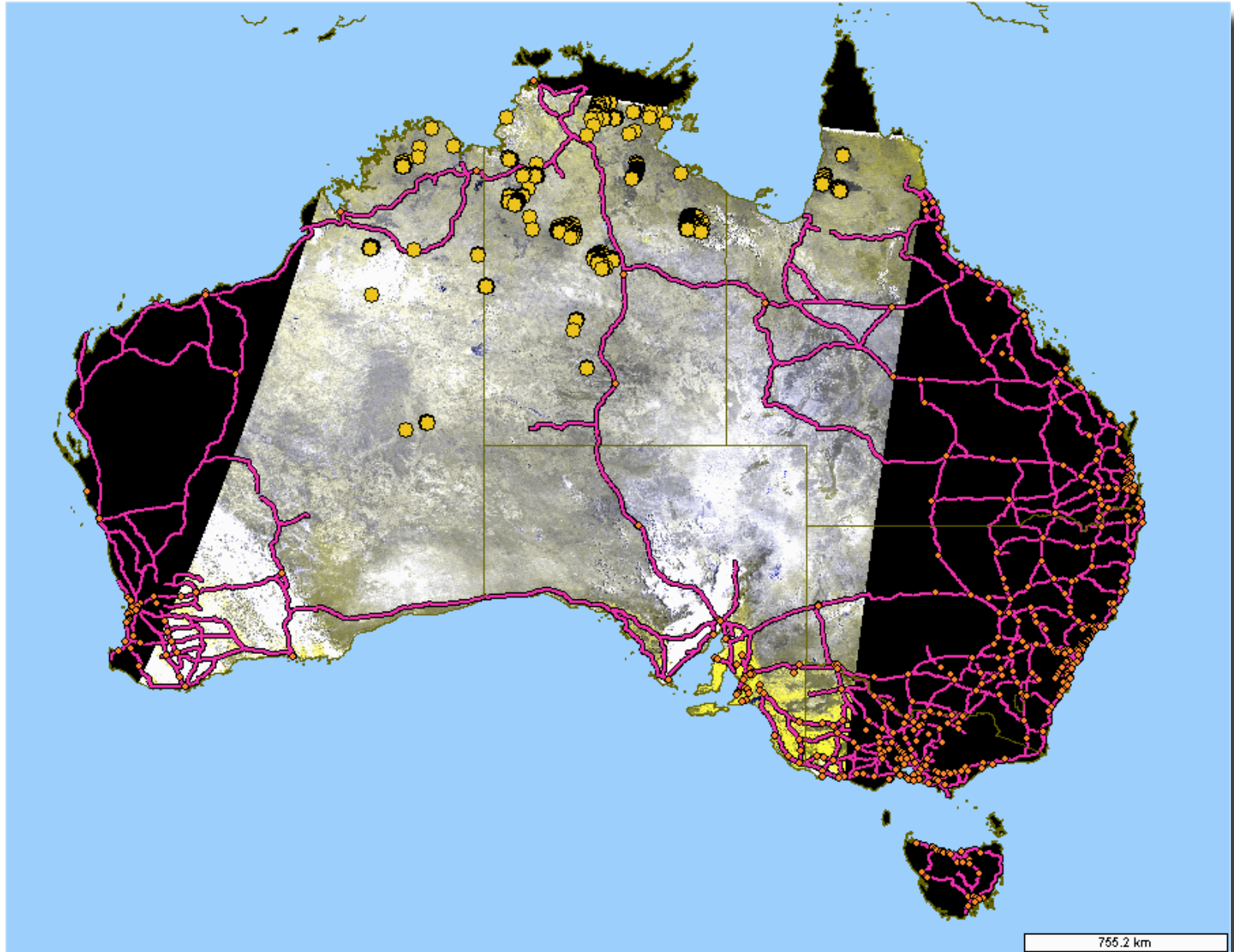
The Sentinel Fire Mapping website is regarded as a service of National Significance.



Near Real Time Hotspots and Images for Burnt Area, Smoke and Cloud Identification

available on-line
within 1h of
acquisition

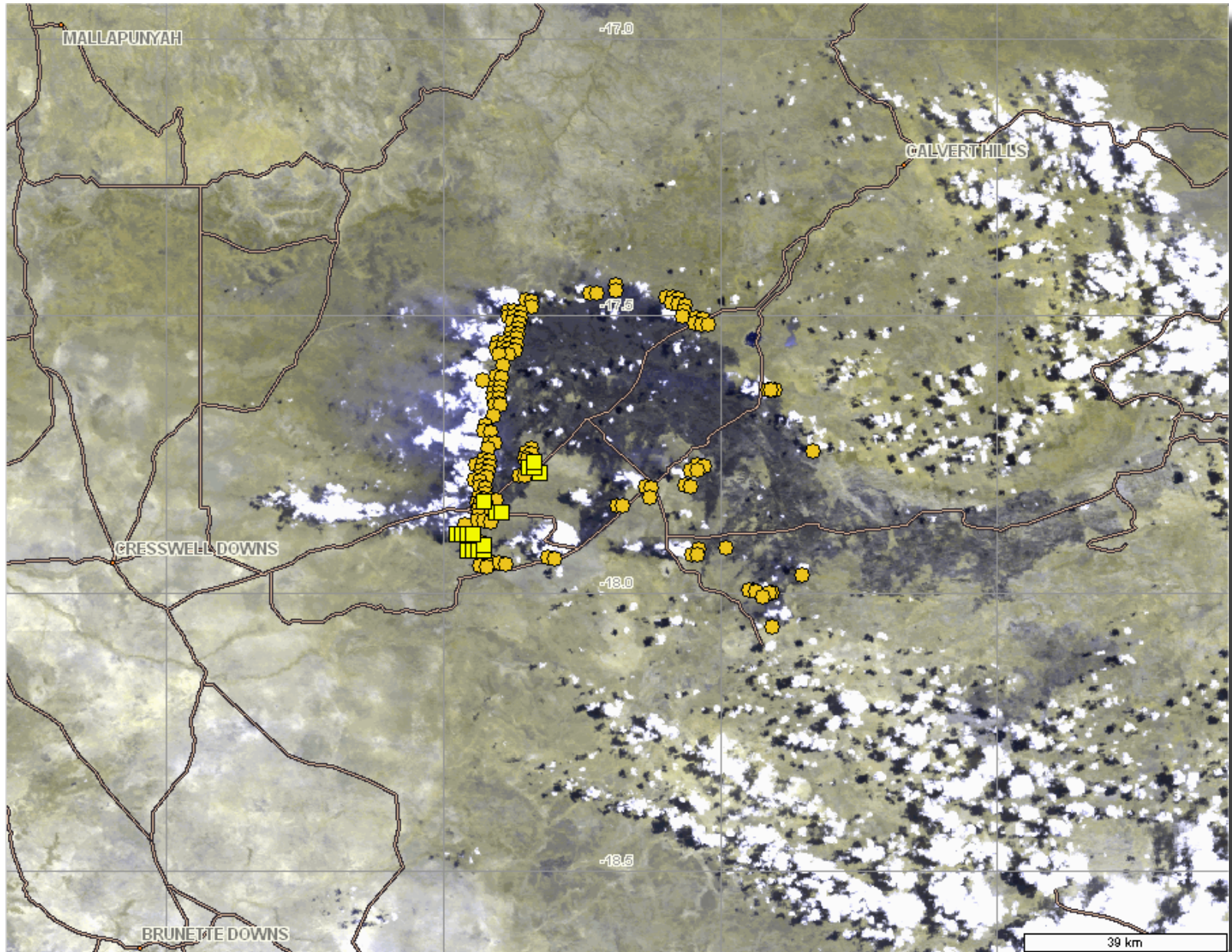
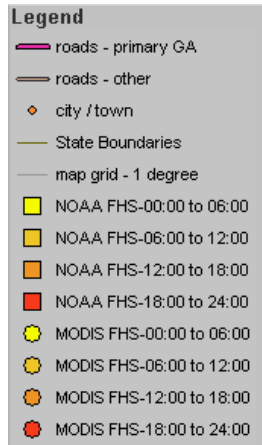
06/10/04
09:20WST



Near Real Time Hotspots and Images for Burnt Area, Smoke and Cloud Identification

available on-line
within 1h of
acquisition

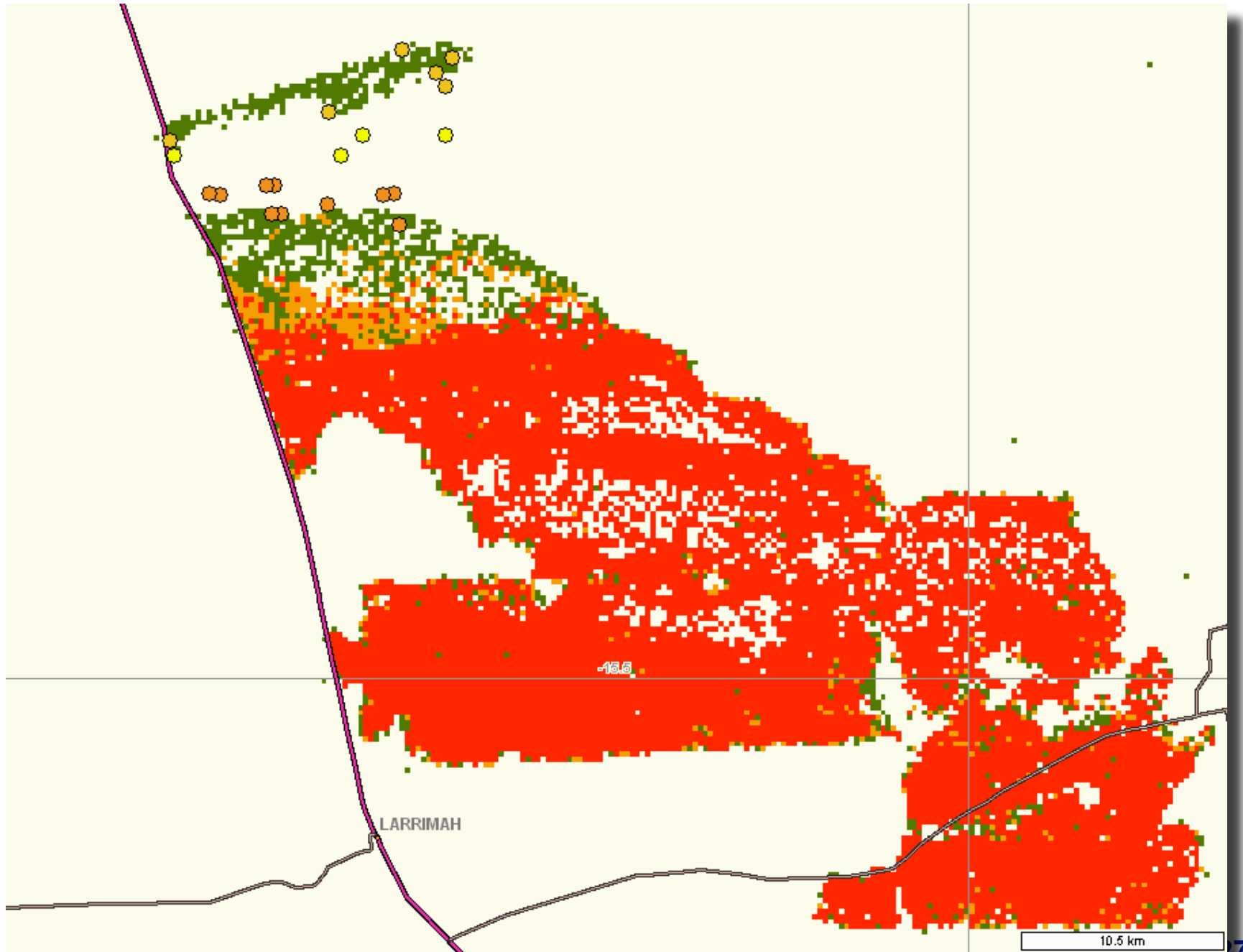
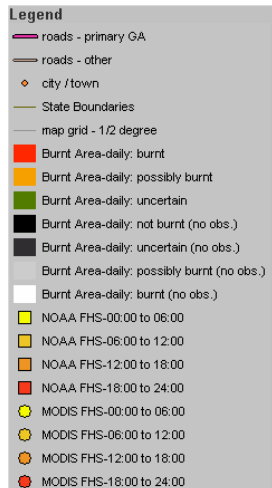
06/10/04
09:20WST



Near Real Time Daily Burnt Area Maps

available on-line
within 3-6h of
acquisition

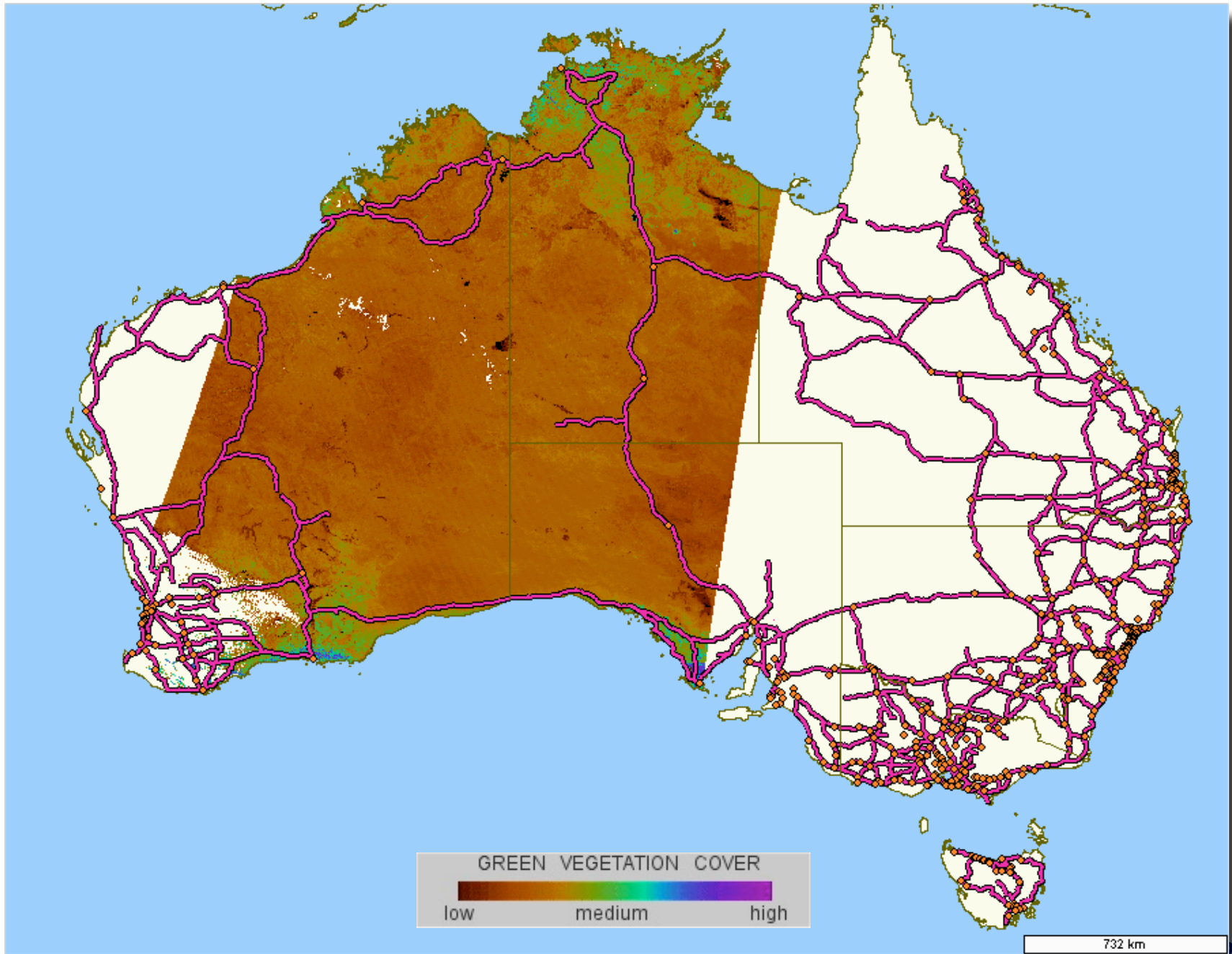
24/09/04
08:57WST



Near Real Time NDVI Maps (DAILY)

available on-line
within 2h of
acquisition

2 different
stretches





Córdoba Ground Station. (ETC – CETT)

Córdoba Ground Station started operations in 1997 with the reception of satellite data from Landsat 5, ERS 1/2 and SPOT

Today the Station acquires data from more than 15 satellites and delivers an average of 1000 high level products per month.





CETT- September-28-2005

Application: Weather Forecasting

EOS DB Products Provided to NWS by NASA MSFC

The Short-term Prediction Research and Transition (SPoRT) Center at NASA MSFC applies EOS measurements and Earth science research to improve the accuracy of short-term (0-24 hr) weather prediction at the regional and local scale.

MODIS and AMSR-E products are provided to 6 NWS Forecast Offices in near real-time for analysis in AWIPS to address issues including:

- Convective initiation
- Morning minimum temperatures
- Fog and low cloud detection
- Sea/land breeze convection
- Coastal precipitation mapping

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



SPORT Products Provided to WFOs

MODIS products from Aqua and Terra:

- 4 times / day – 30-45 minutes latency
- 8-10 channels
- TPW, cloud mask, cloud height, stability

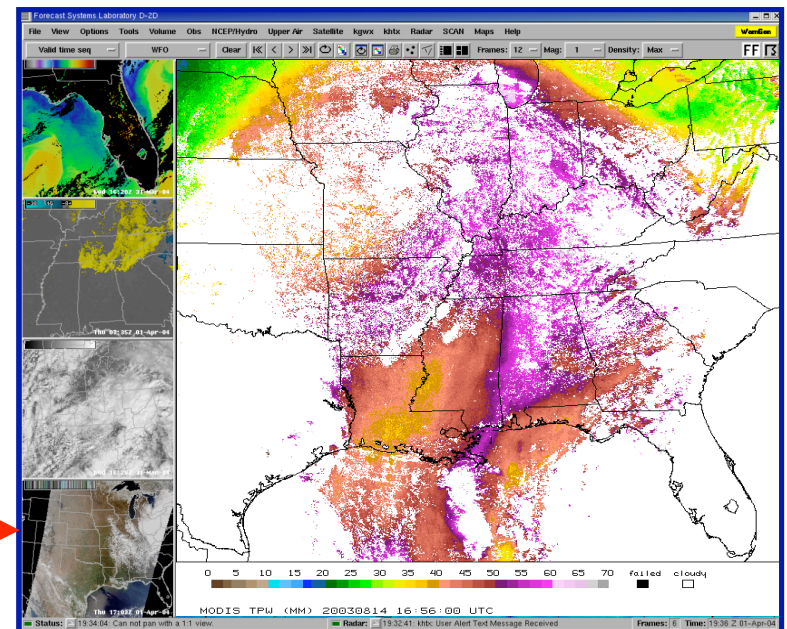
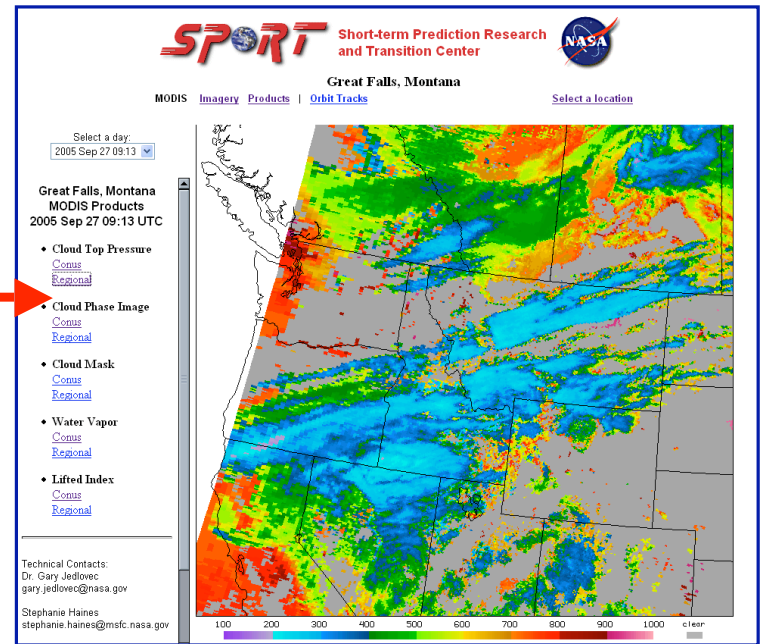
Level 1 radiances are used to generate additional products for WFOs:

- color composites
- cloud/fog products
- LST
- snow maps

AMSR-E products to coastal offices:

- rain rate and convective fraction
- Level 1 AMSR-E Tbbs are used to generate additional products over the ocean (TPW, ocean wind speed, SST)

All SPoRT data are provided in AWIPS

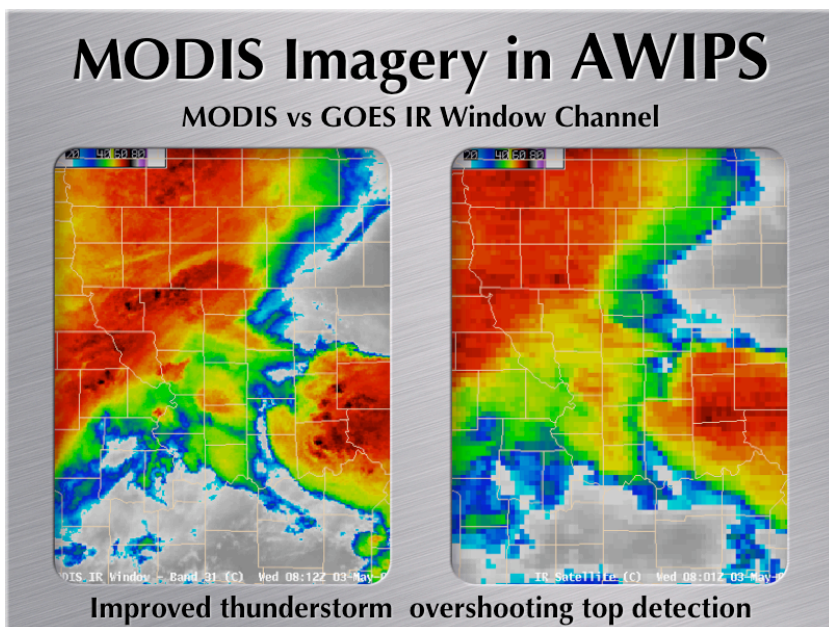


SSEC MODIS Products served to NWS

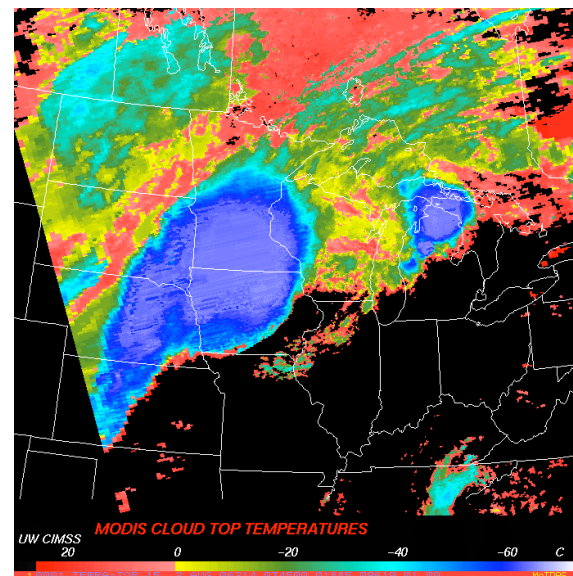
SSEC is working with NWS Lacrosse and Sullivan forecast offices to bring real-time MODIS products into daily operations.

SSEC began generating AWIPS compatible MODIS product images in near real-time in May 2006, and started routine insertion into the Central Region AWIPS data stream on 30 June 2006.

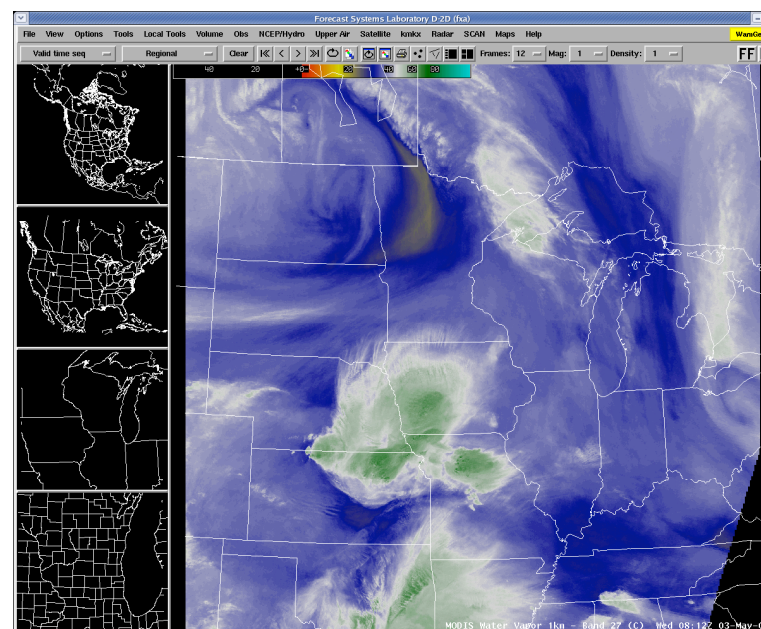
COMET training module for MODIS in AWIPS



MODIS cloud top temperature over NWS WI forecast region



MODIS water vapor channel in AWIPS



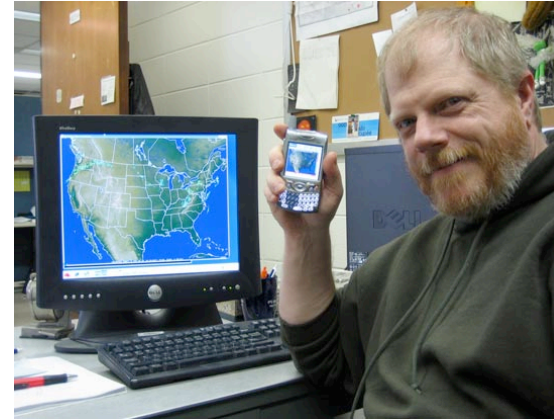
MODIS Real-Time Images for PDAs (Russ Dengel)

Satellite images, radar loops, forecasts, road conditions are reformatted for PDA size displays and made available in real-time.

MODIS True Color images are created from every daytime pass in PDA format; latest image is always available.

Users: Firefighters,
Police, Pilots,
Commuters...

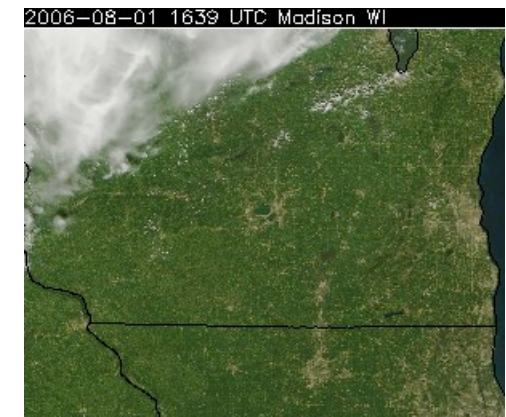
www.ssec.wisc.edu/data/paw/



Radar MOS Menu
Denver, CO NWS Zone Forecast
415 AM MDT WED AUG 02 2006
TODAY...MOSTLY SUNNY IN THE MORNING...THEN PARTLY CLOUDY WITH ISOLATED THUNDERSTORMS IN THE AFTERNOON. HIGHS IN THE LOWER 80S. CHANCE OF THUNDERSTORMS 20 PERCENT.
TONIGHT...PARTLY CLOUDY WITH ISOLATED THUNDERSTORMS IN THE EVENING...THEN MOSTLY CLEAR AFTER MIDNIGHT. LOWS IN THE MID 50S. CHANCE OF THUNDERSTORMS 20 PERCENT.
THURSDAY...PARTLY CLOUDY. A 20 PERCENT CHANCE OF THUNDERSTORMS IN THE AFTERNOON. HIGHS IN THE MID 80S. SOUTHEAST WINDS 10 TO 15 MPH IN THE AFTERNOON.
THURSDAY NIGHT...PARTLY CLOUDY WITH A 20 PERCENT CHANCE OF



Carrib> -Zoom Radar> Animate Alerts> ON Menu
REAL TIME
Clouds WED AUG 2 12:45 PM (AST)



Application: Polar Winds

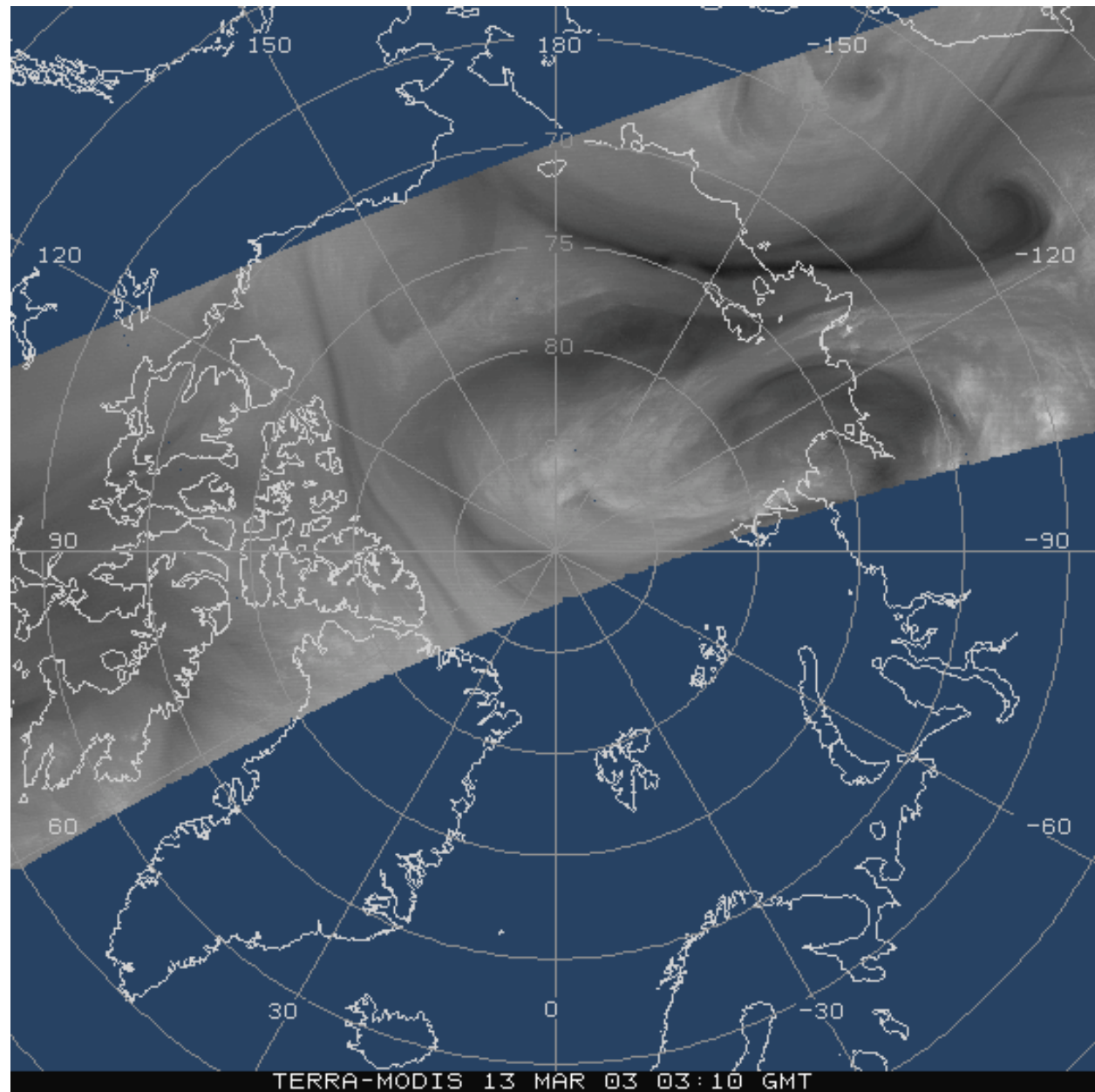
MODIS Passes over the Poles Allow Feature Tracking

Consecutive passes (100 minutes apart) depict atmospheric motion.

Band 27 ($6.7\ \mu\text{m}$) tracks motion in troposphere (clear and cloudy).

Band 31 ($11.0\ \mu\text{m}$) tracks cloud motions only.

Initial demonstration in 2002 used MODIS data from NOAA “bent pipe”.



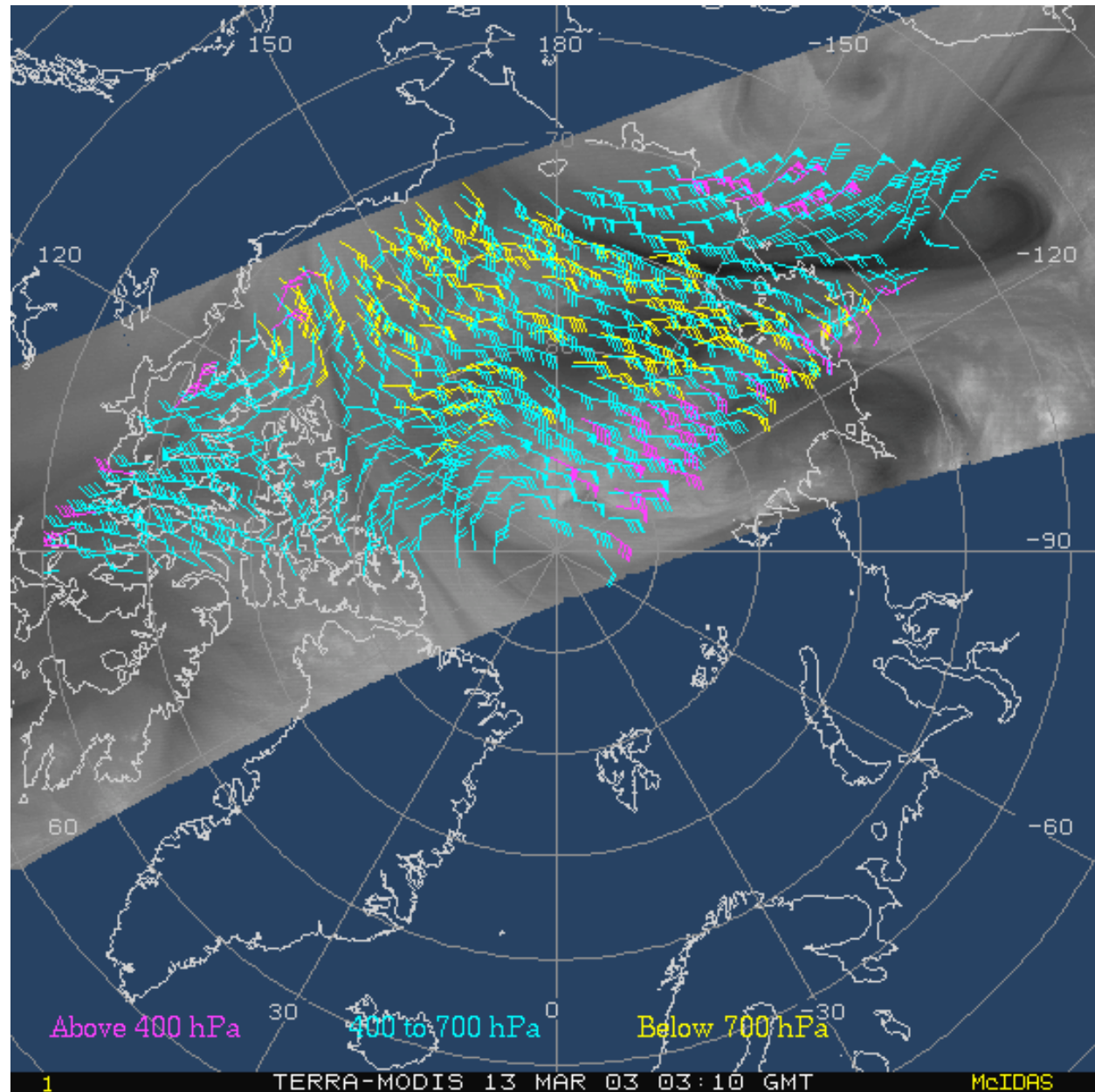
MODIS Polar Wind Vectors can be derived automatically

Wind vectors are generated using automatic feature tracking software developed for GOES.

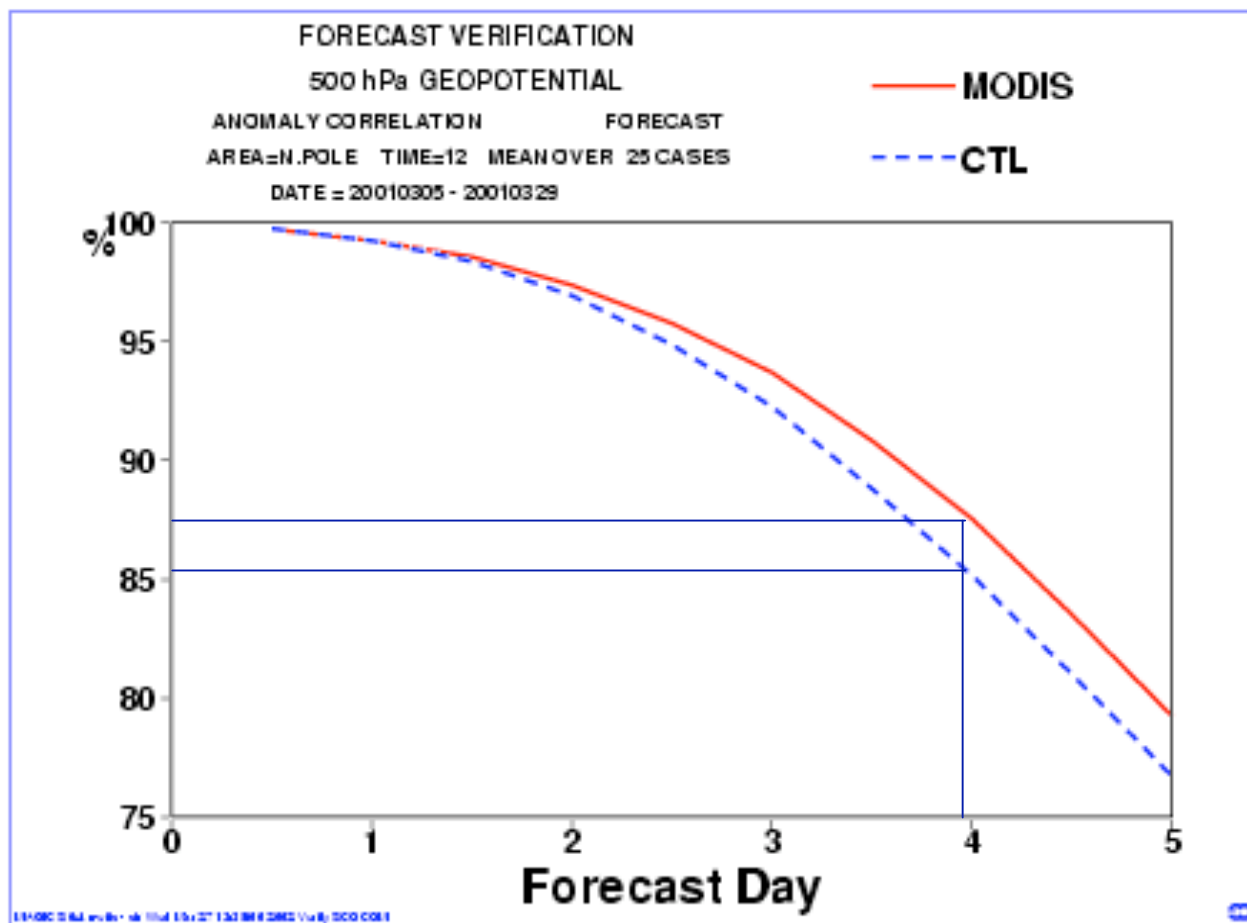
6.7 μm heights are assigned based on forecast atmospheric profile.

11.0 μm heights are assigned based on window brightness temperature or CO₂ cloud height.

Winds are automatically quality controlled.



Positive impact on forecast demonstrated by ECMWF



NWP Centers using MODIS Polar Winds Operationally:

ECMWF, GMAO, JMA, CMC, FNMOC, UKMO, DWD, NCEP/EMC

MODIS polar winds are filling observing system void

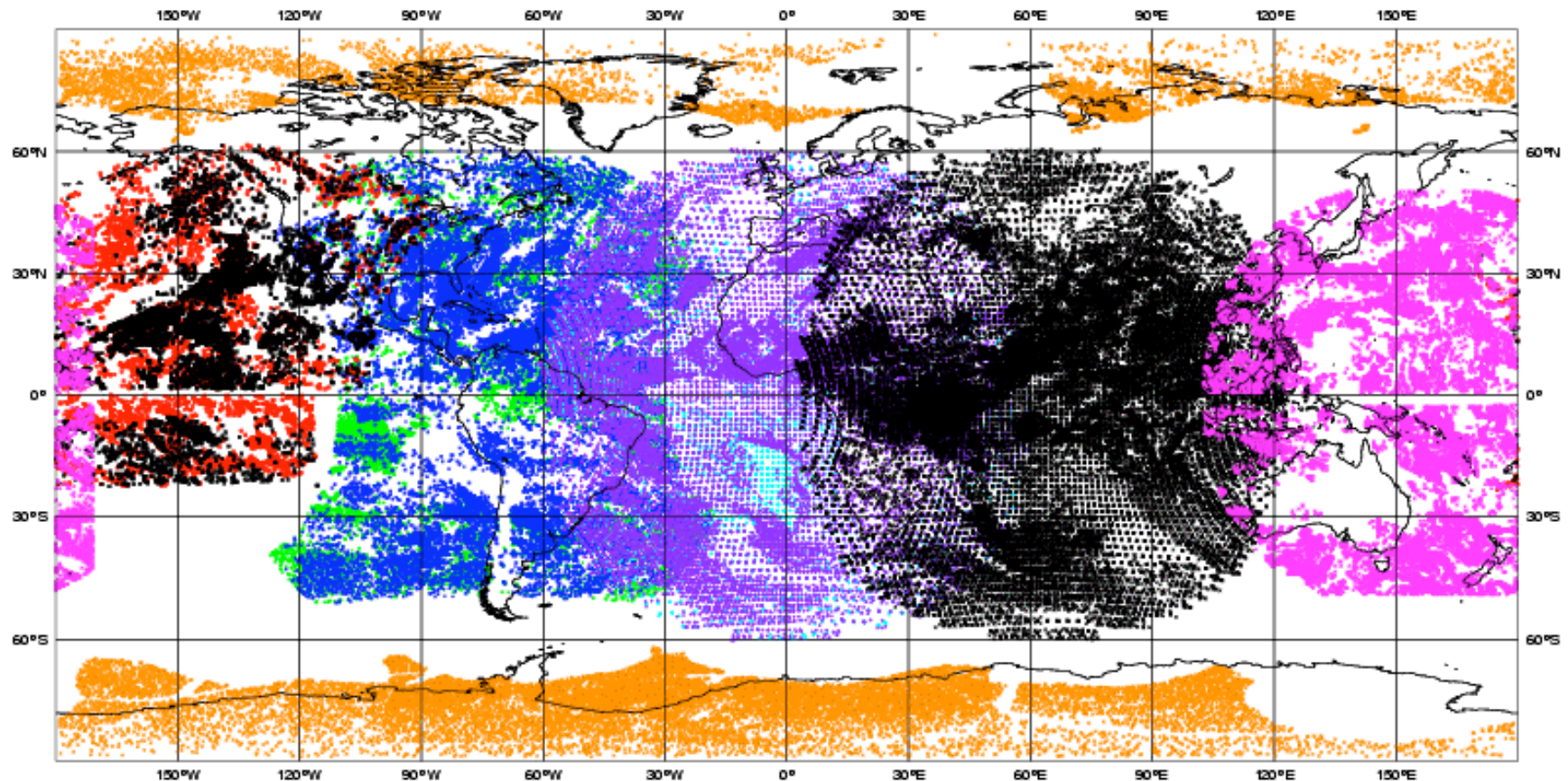
Obs Type

- | | | | | |
|-------------------|-------------------|------------------|------------------|----------------|
| • 14160 GOES12_IR | • 18701 GOES12_WV | • 5825 GOES10_IR | • 5369 GOES10_WV | • 9009 MET7_IR |
| • 23566 MET7_WV | • 0 MET7_VIS | • 36665 MET5 | • 14600 GOES9 | • 19417 MODIS |

ECMWF Data Coverage (All obs) - SATOB

16/JUN/2004; 00 UTC

Total number of obs = 147312



Problem: Latency in Data Available from Bent Pipe

MODIS winds from NOAA “Bent Pipe” system do not meet 3 hour cut-off time for regional/limited area data assimilation systems due to latency in NOAA “Bent Pipe” data feed.

Solution: Direct broadcast high-latitude X-band stations

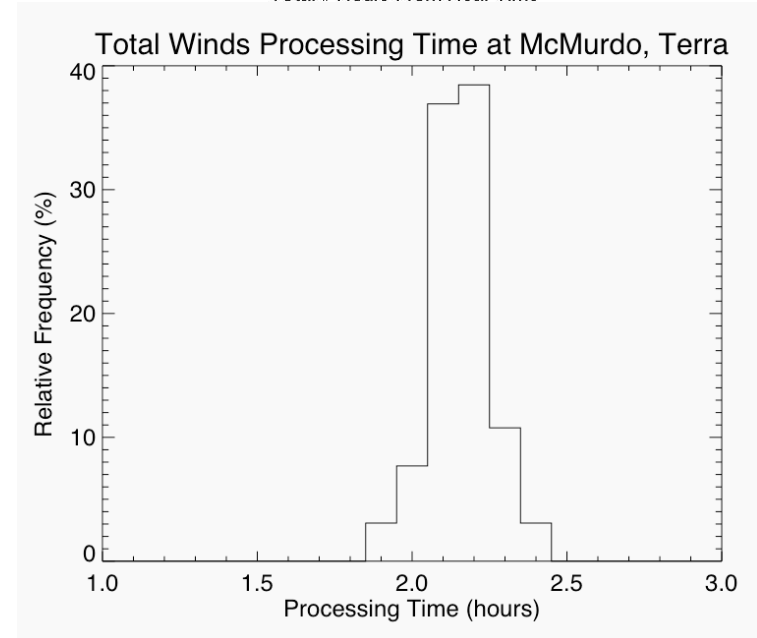
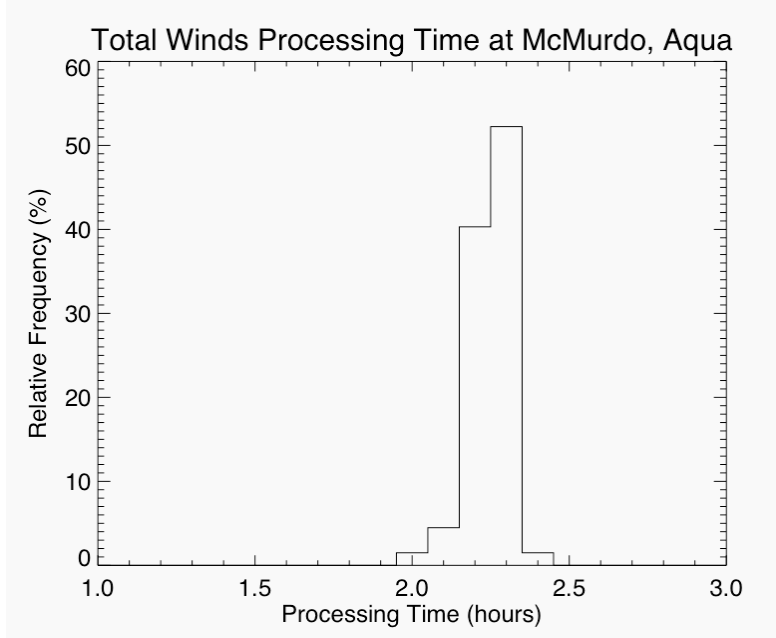
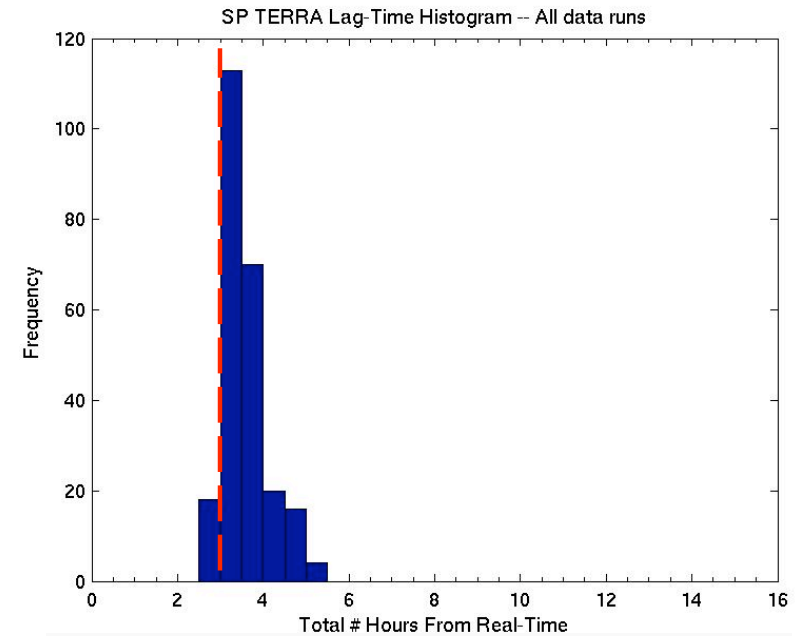
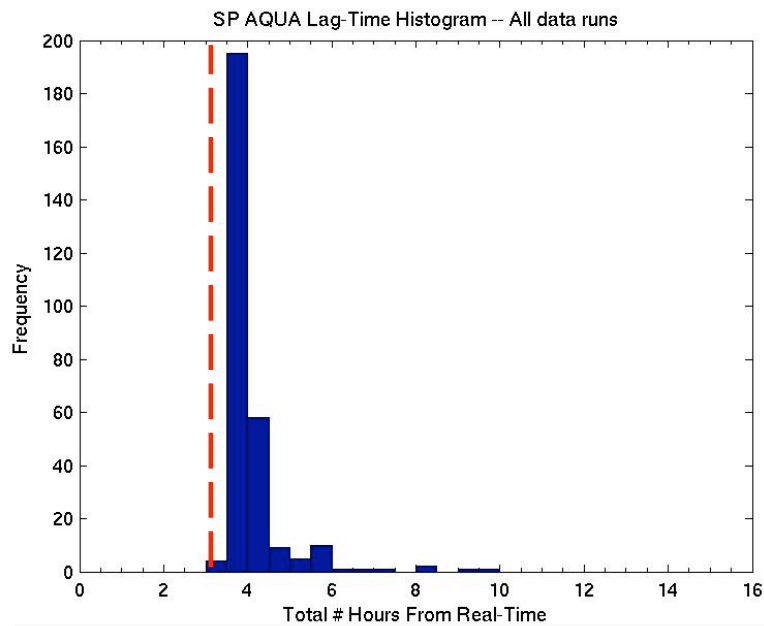
Northern Hemisphere:
Svalbard (KSAT)



Southern Hemisphere:
McMurdo (NSF)



Direct Broadcast Winds Improve Latency to less than 3 hours



Processing times are for the middle image in a 3-orbit triplet. Actually processing time from image acquisition to availability of wind vectors is 100 minutes (1.67 hrs) less than shown. MODIS images are available (image acquisition to level 1b) in 20-30 minutes. Winds processing takes an additional 10-15 minutes.

Current Products at McMurdo

(all MODIS):

Winds

Cloud mask*

Cloud pressure*

Cloud phase*

Total precipitable water*

Inversion strength

Inversion depth

Ice/snow surface temperature

Ice/snow albedo

Planned products:

Ice motion (MODIS + AMSR-E)

Ice age

Cloud optical properties

*IMAPP/MODIS Science Team products

<http://stratus.ssec.wisc.edu/db/mcmurdo>

Mozilla Firefox Beta 1

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

SSEC webmail Netscape Mail Unisys MeteoStar CIMSS Weather Yahoo News BBC News

http://stratus.s...in?site=mcmurdo

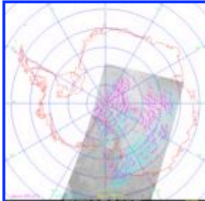
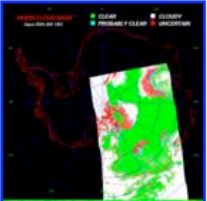
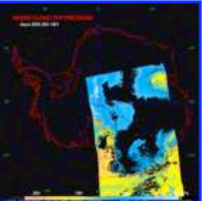
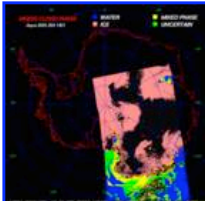
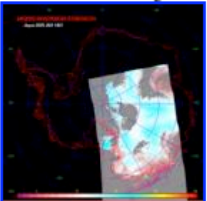
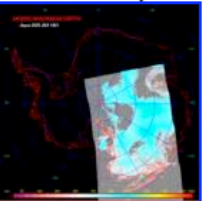
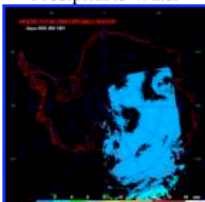
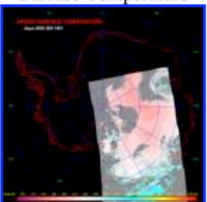
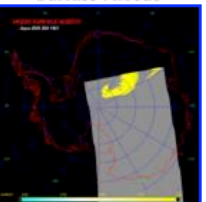
Bookmarks

NESDIS/STAR/ASPT Home Products Projects Scenes Links CIMSS

Real-Time MODIS Products from McMurdo

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.

AQUA:

 Winds Day 269, 12:22 UTC	 Cloud Mask Day 269, 14:01 UTC	 Cloud Pressure Day 269, 14:01 UTC
 Cloud Phase Day 269, 14:01 UTC	 Inversion Strength Day 269, 14:01 UTC	 Inversion Depth Day 269, 14:01 UTC
 Precipitable Water Day 269, 14:01 UTC	 Surface Temperature Day 269, 14:01 UTC	 Surface Albedo Day 269, 14:01 UTC

TERRA:

Note: The McMurdo system is currently experiencing a problem with Terra MODIS acquisition.

Winds Cloud Mask Cloud Pressure

Summary

Aqua and Terra Direct Broadcast ground stations are running operationally on every continent (including Antarctica).

More than 150 stations around the world are acquiring, processing, and distributing products to local consumers.

Unencrypted data, open formats, and freely available processing software have contributed to the widespread adoption of EOS DB data.

National agencies are using EOS DB products for real-time operational decision support.

With support from NOAA Integrated Program Office, support for the DB community will continue into the NPP/NPOESS era.