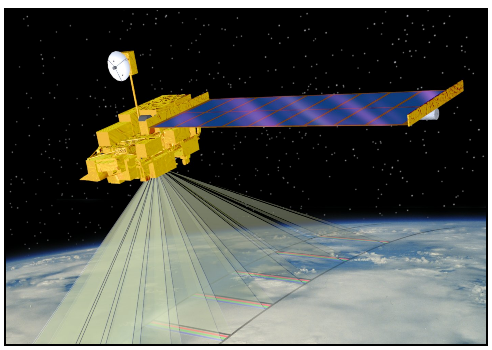
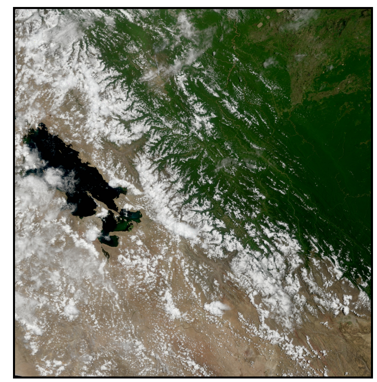
DB Product Applications

2011 WMO RA V Workshop
Citeko, Bogor, Indonesia
22 September 2011
Part 1



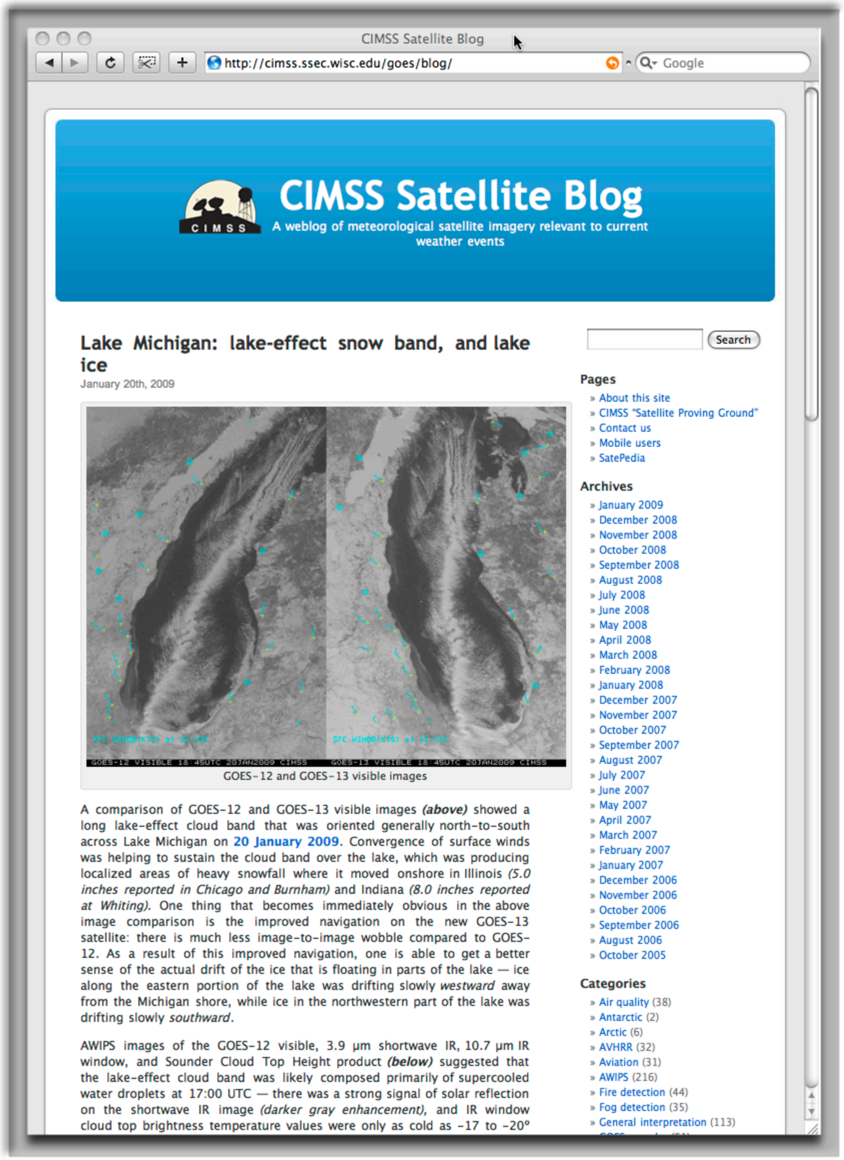


Kathleen Strabala
Cooperative Institute for Meteorological Satellite Studies
Space Science and Engineering Center
University of Wisconsin-Madison

Sources

- Publications
- Conferences and Conference Papers
- User Feedback including US National Weather Service
- CIMSS satellite blog – Scott Bachmeier
  – http://cimss.ssec.wisc.edu/goes/blog/

SSEC Satellite Blog



cimss.ssec.wisc.edu/goes/blog

MODIS DB Applications

- Huge Variety

- Weather Observation and Forecasting
  - Originally thought of as research satellite
  - 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 true color imagery)
    - Preparation for next generation of geo instruments
  - Key for forecasts is timeliness of data
    - UW provides NWS with data end to end within 1 hour of start of pass time.
  - Post analysis – timeliness not as important
  - Temporal coverage is limiting

MODIS DB Applications

- Public Safety and Public Interest
  - Nighttime Fog Detection
  - Snow/Ice Detection
  - Fires
  - Severe Weather
- Aviation Interest
  - Everything clouds
    - Cloud composition, Height and Temperature
  - Turbulence
  - Ash Detection
- Numerical Weather Prediction
  - IMAPP DCRAS
- Aerosols
  - Detection
  - IDEA
- Others

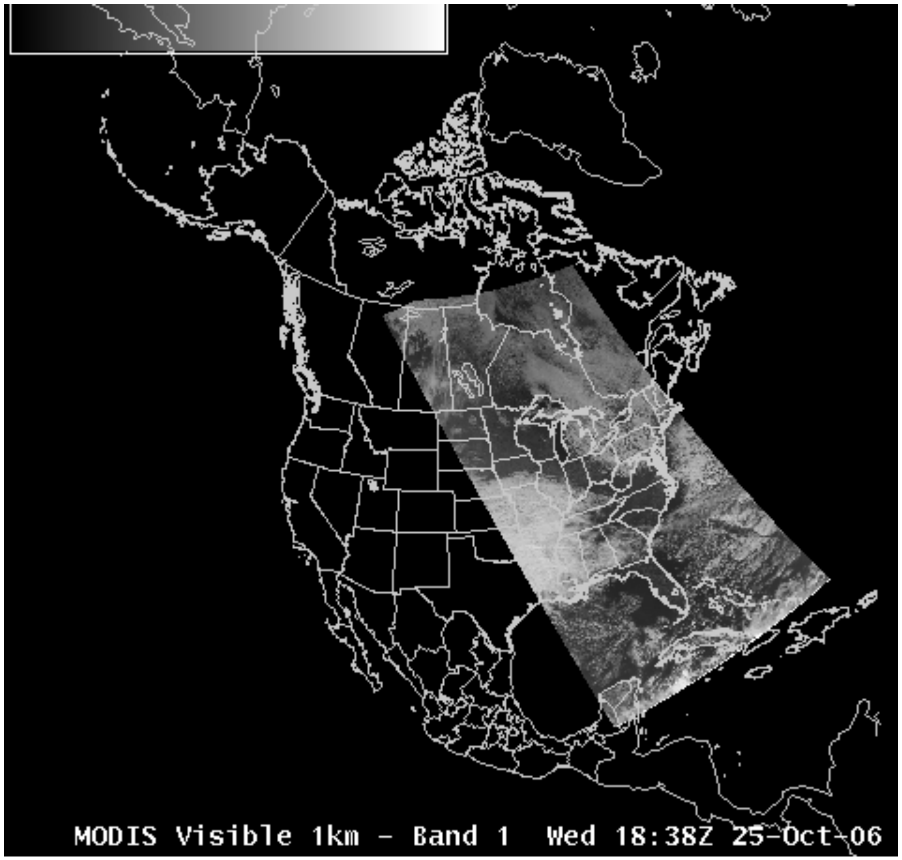
Weather and Forecasting

Complimentary to Geostationary

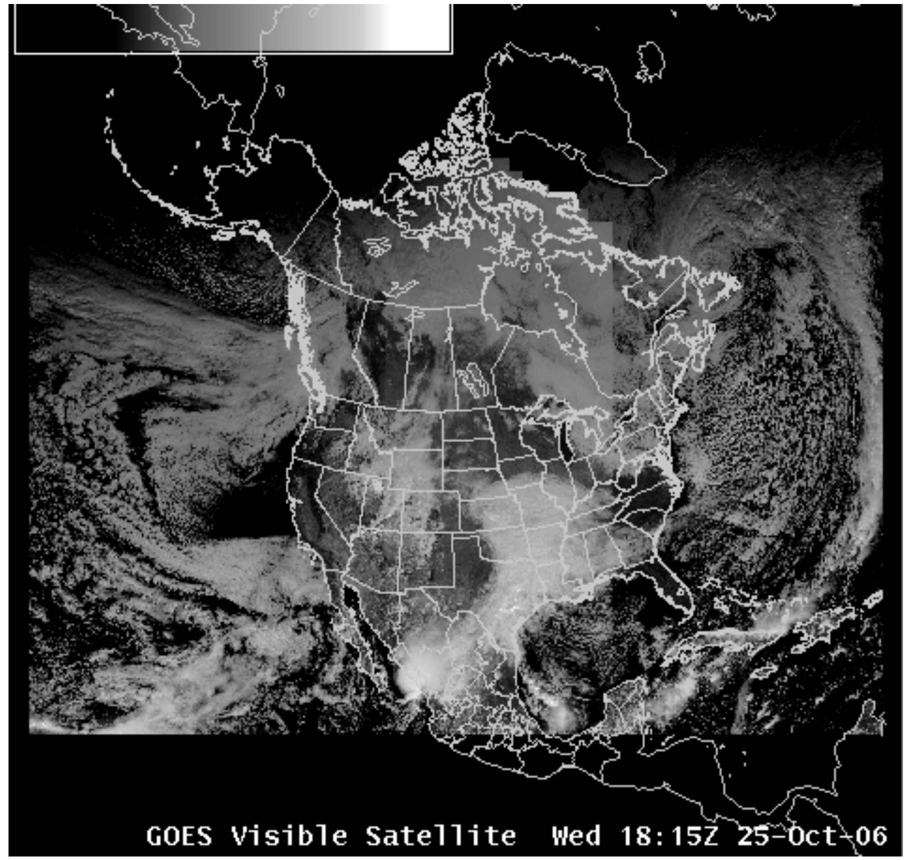
Example of Improved Spatial Resolution

MODIS Imagery in AWIPS

Band 1: Visible channel (0.6µm)



MODIS visible channel



GOES visible channel

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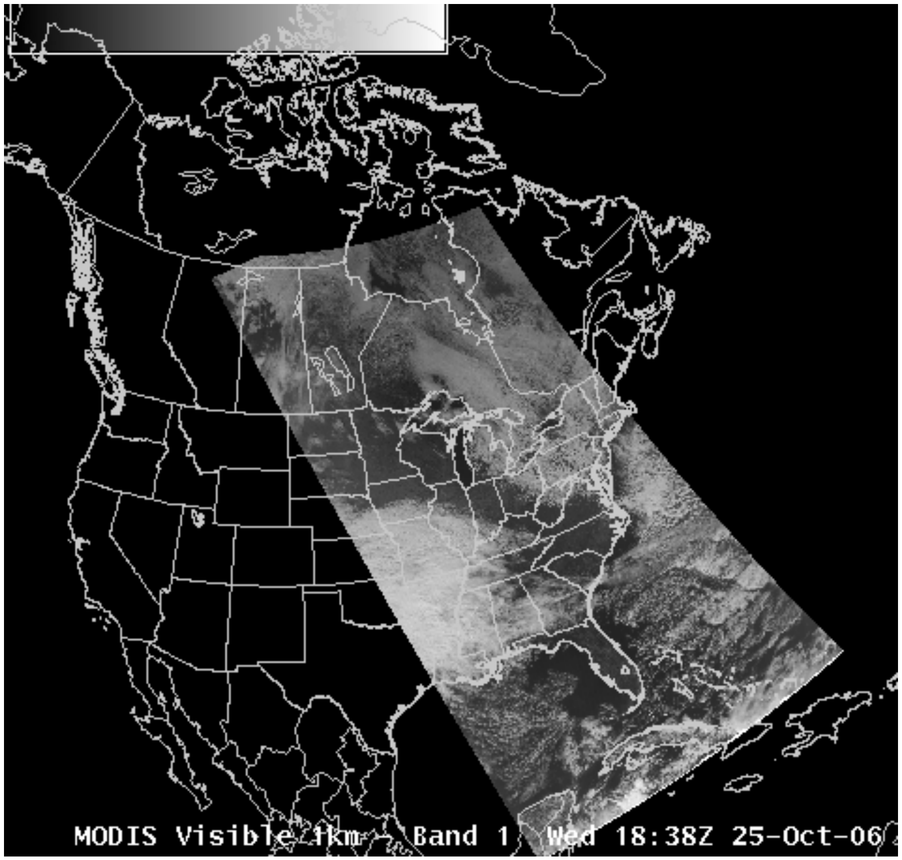
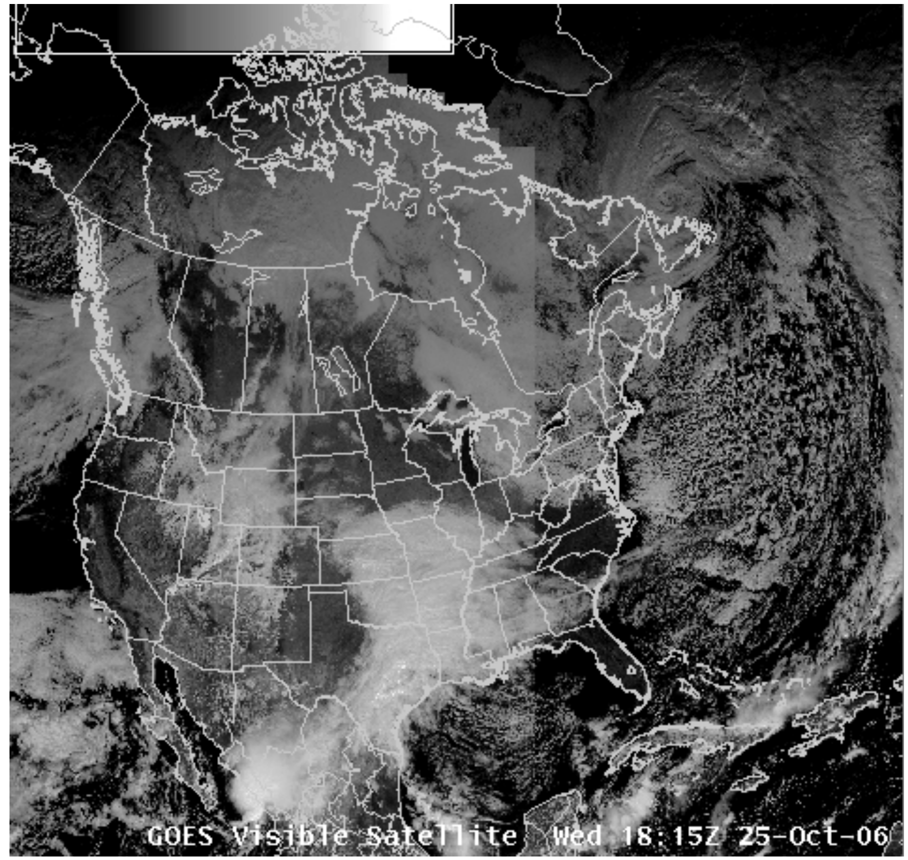


MODIS visible channel



GOES visible channel

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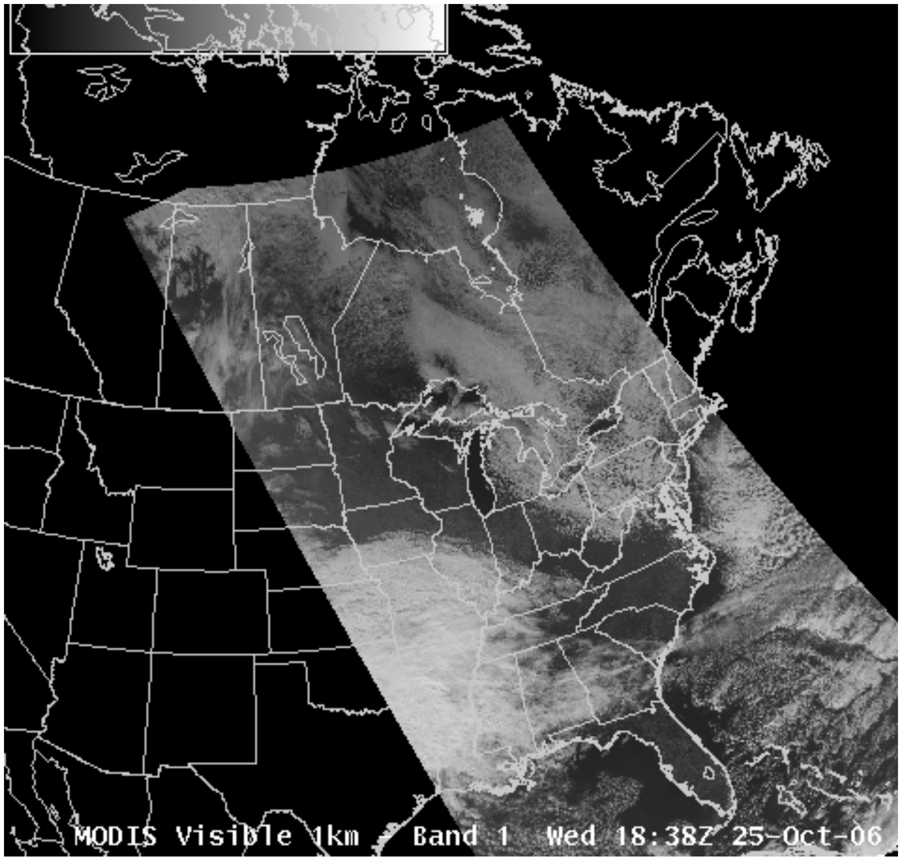
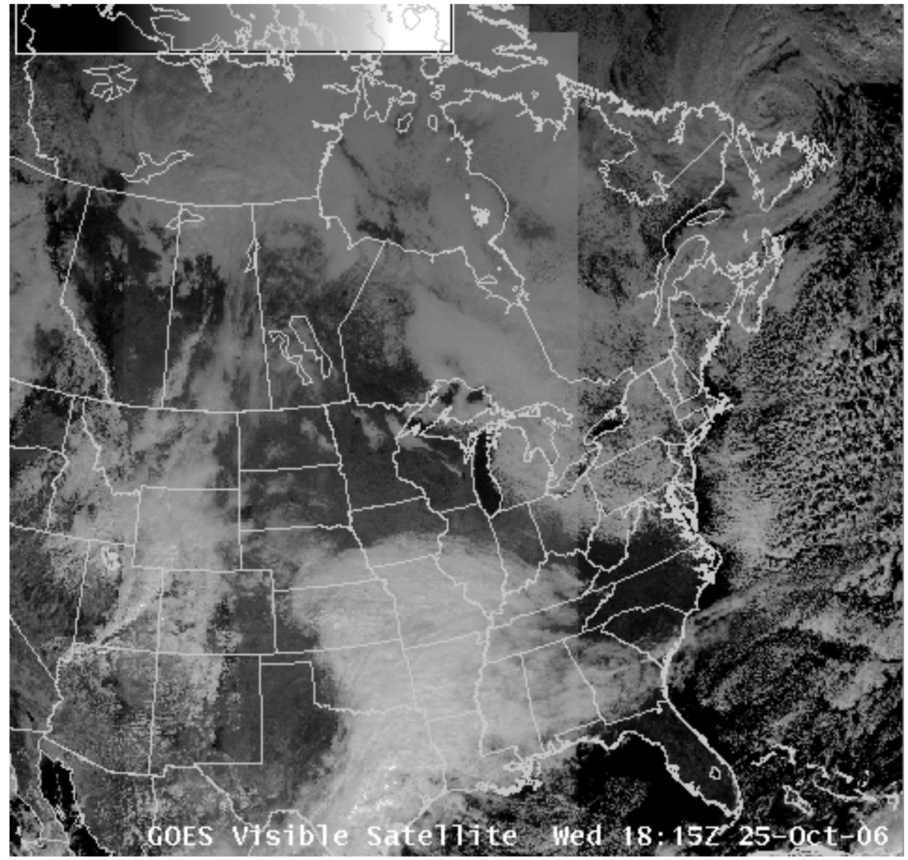


MODIS visible channel



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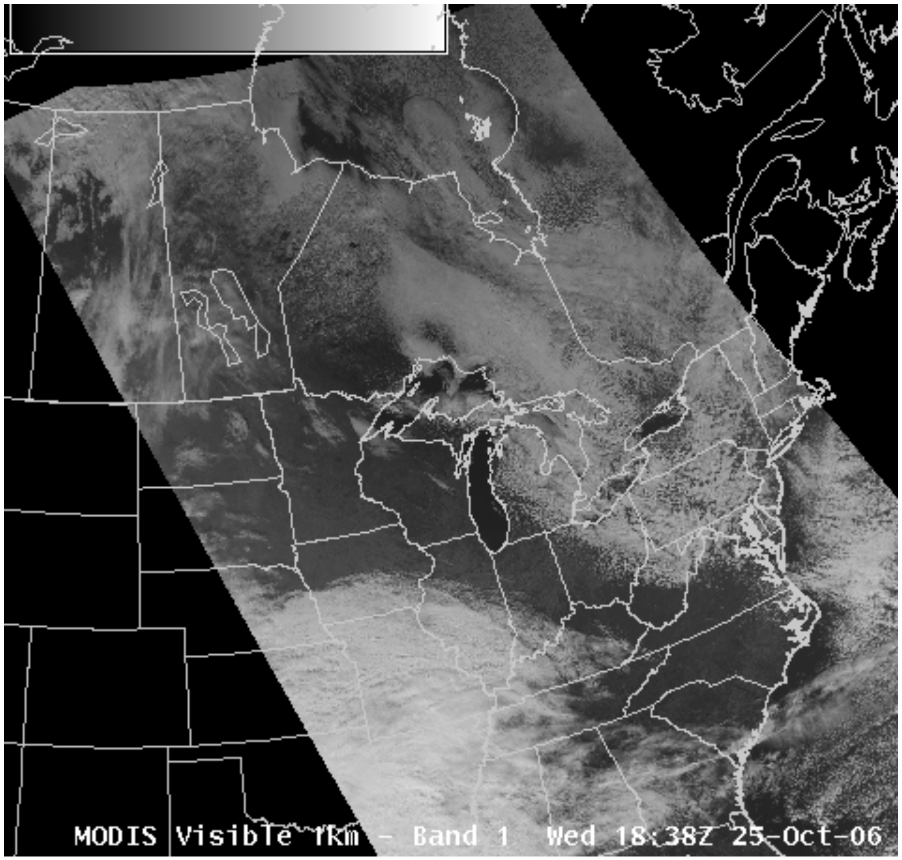
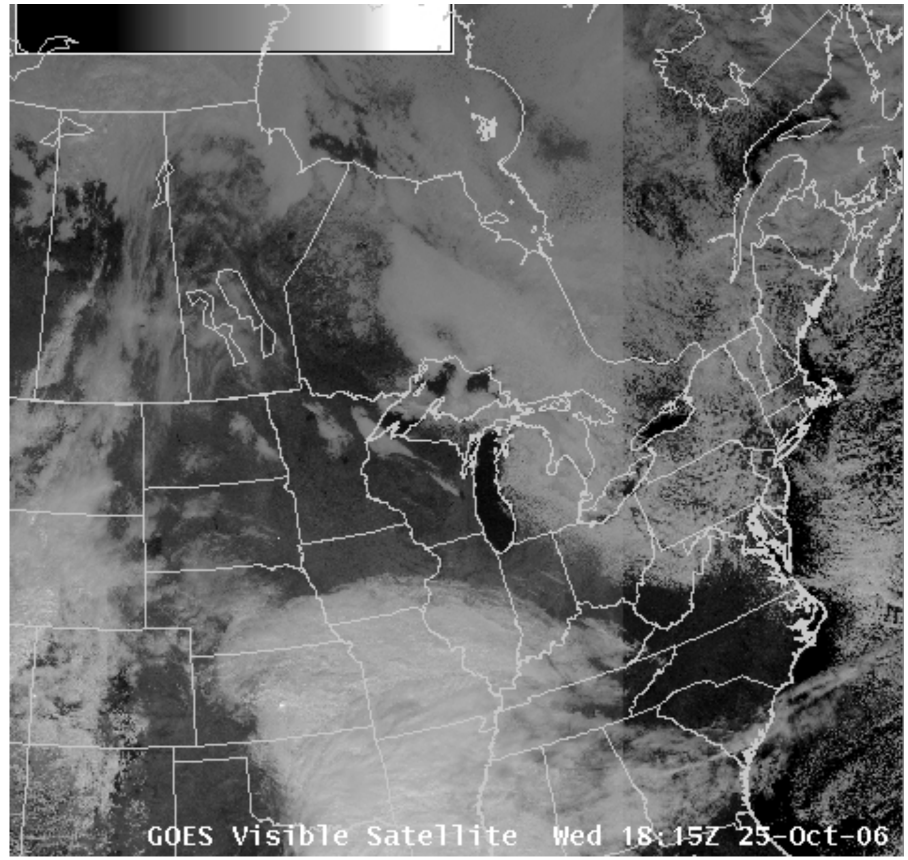


MODIS visible channel



GOES visible channel

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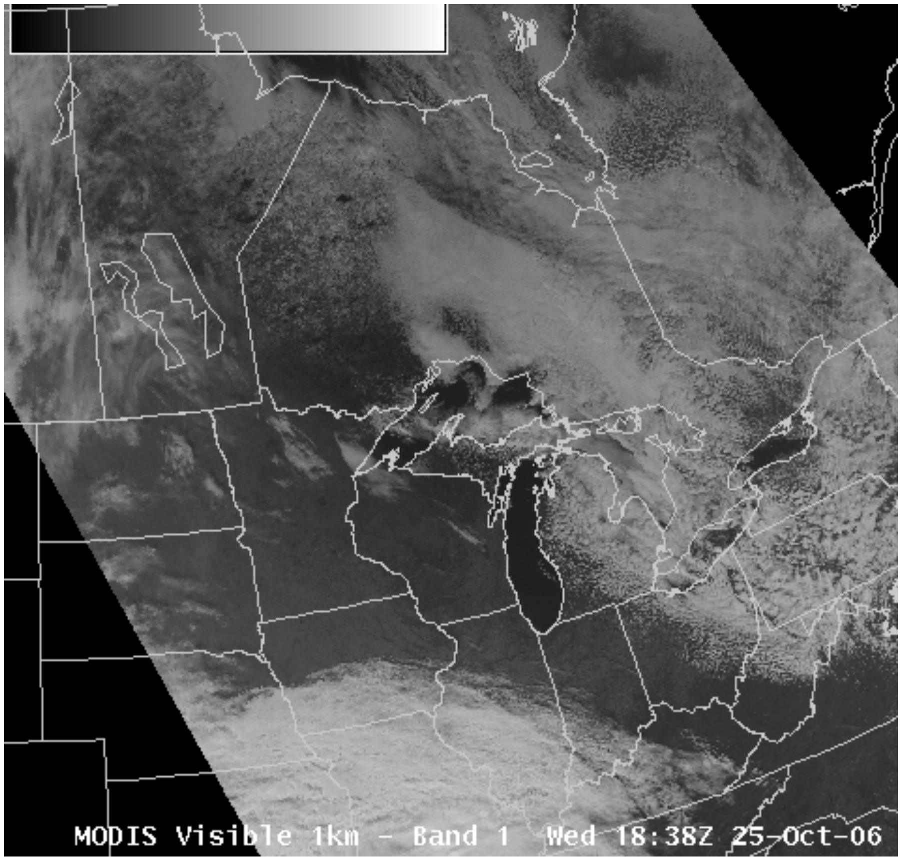
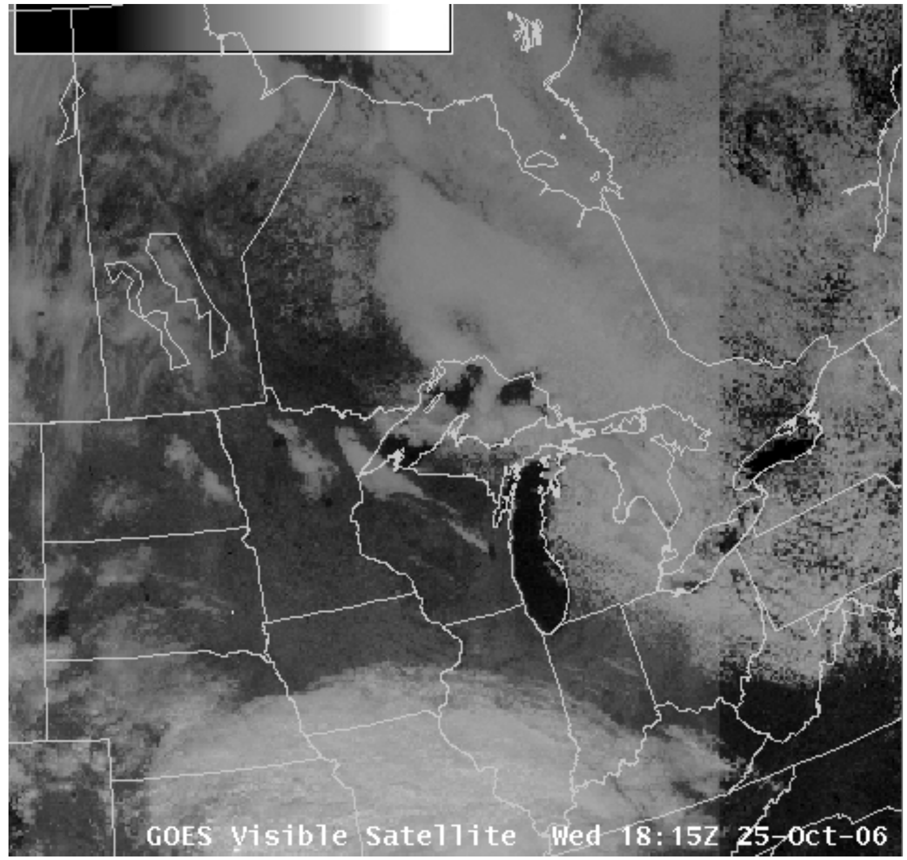


MODIS visible channel



GOES visible channel

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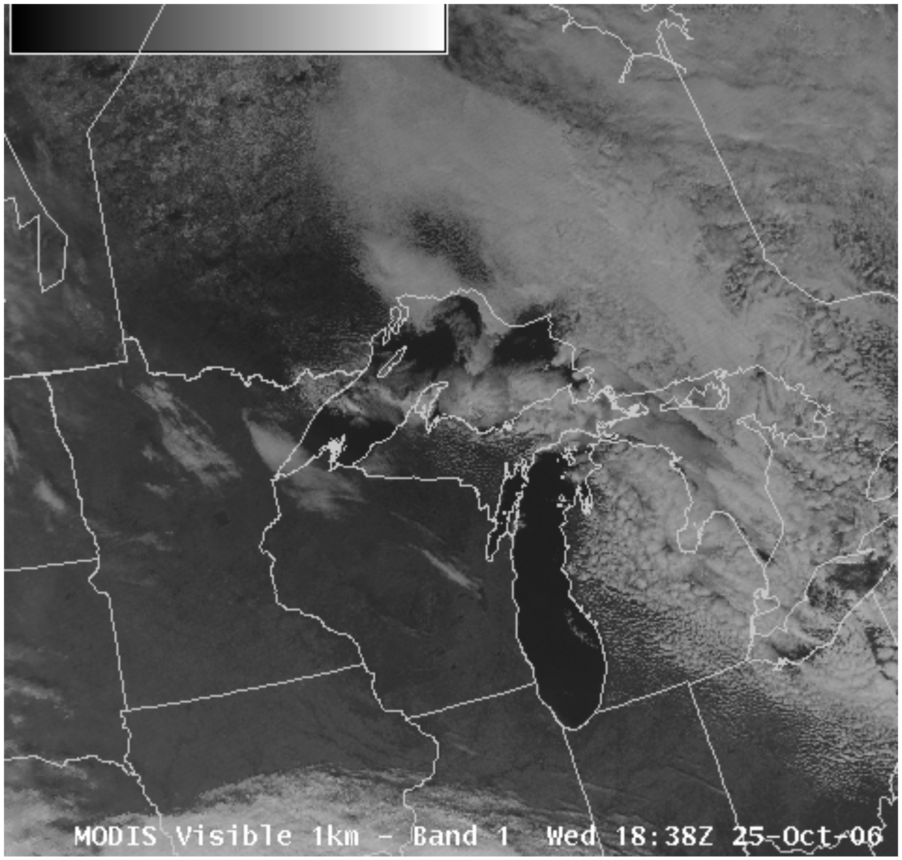
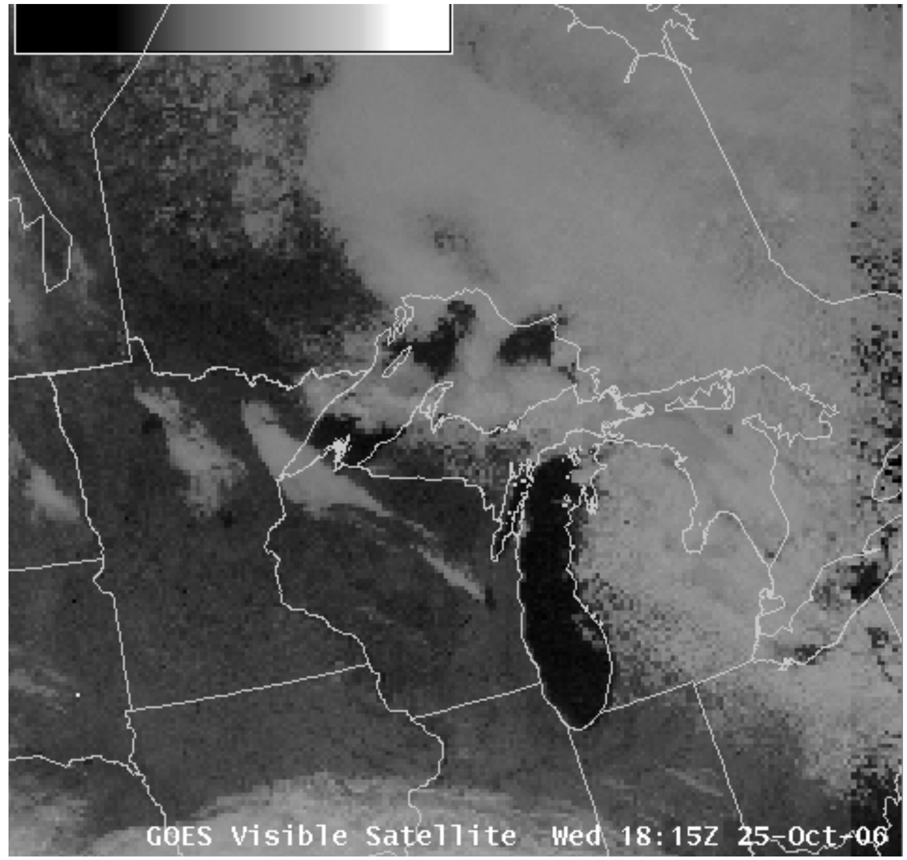


MODIS visible channel



GOES visible channel

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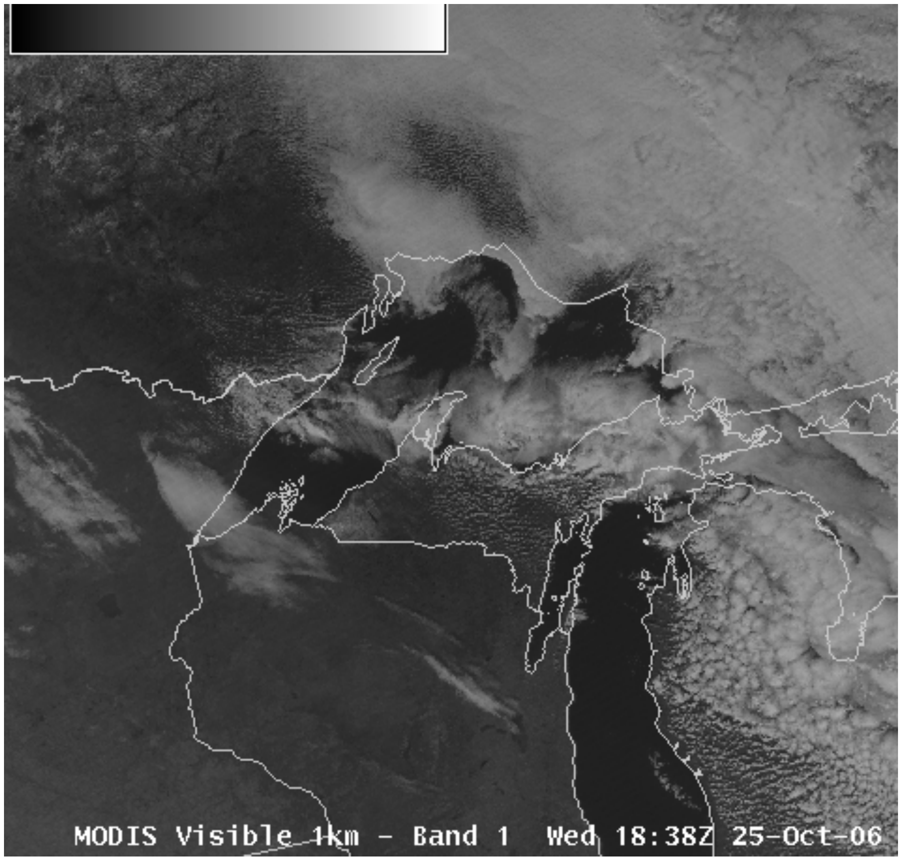
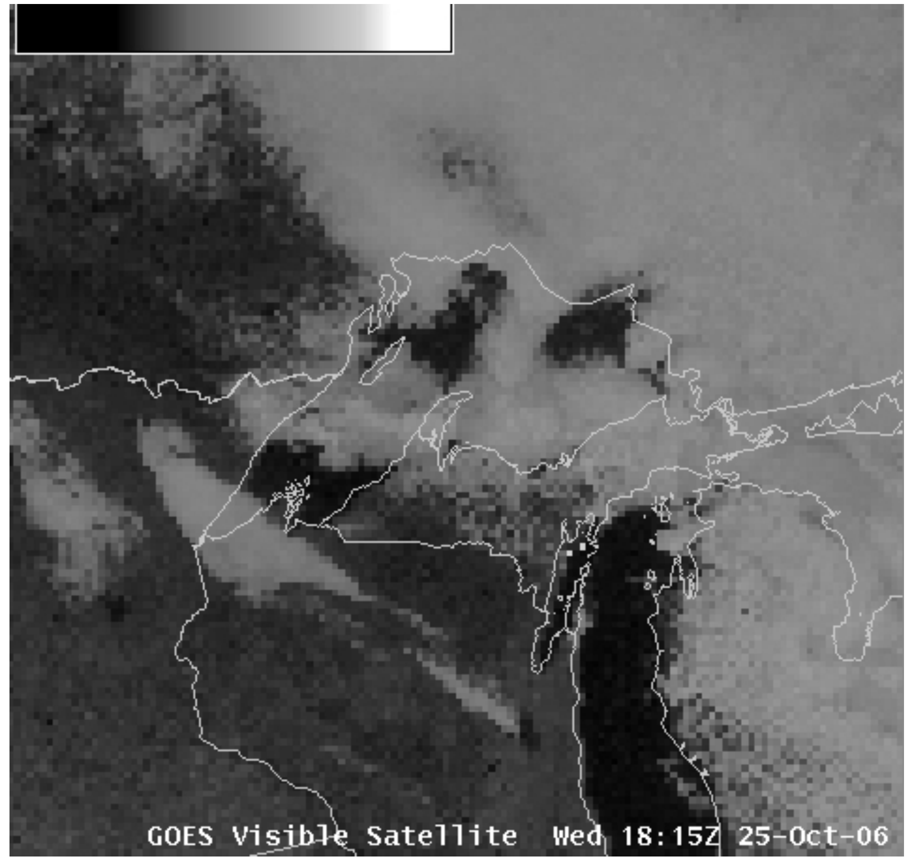


MODIS visible channel



GOES visible channel

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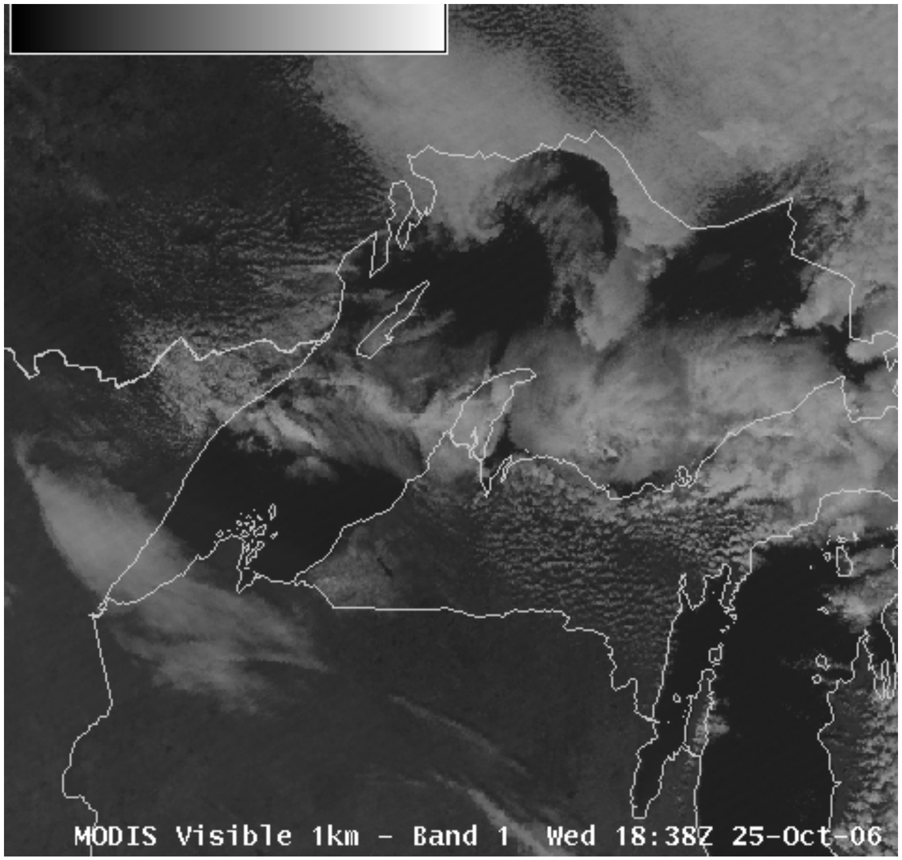
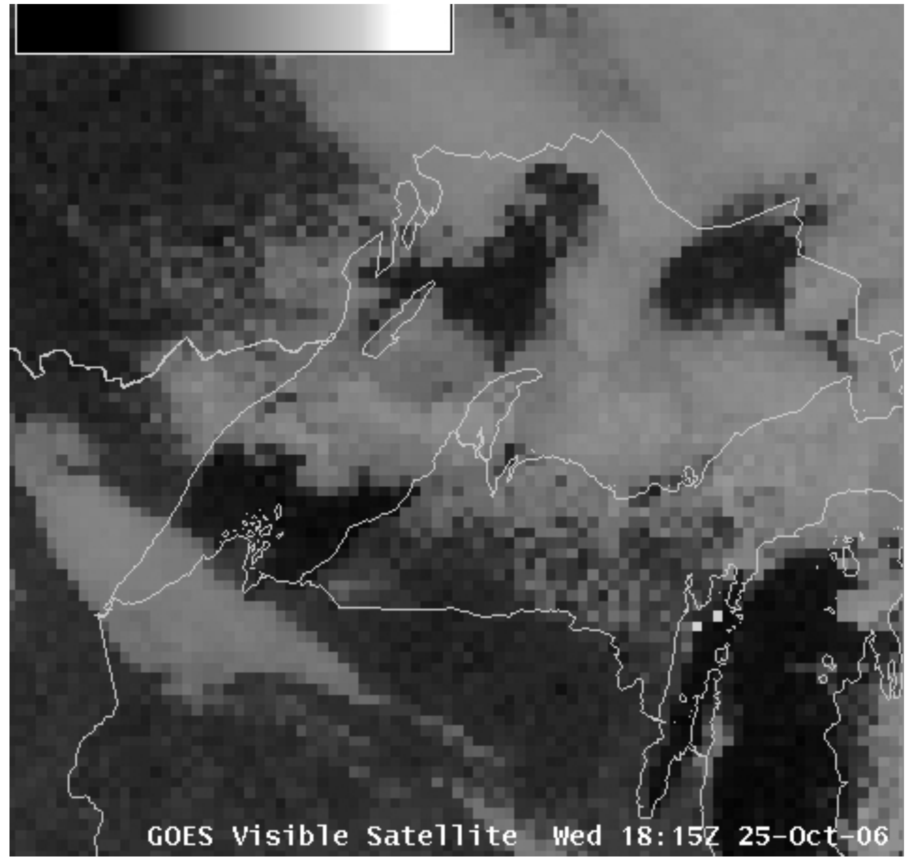
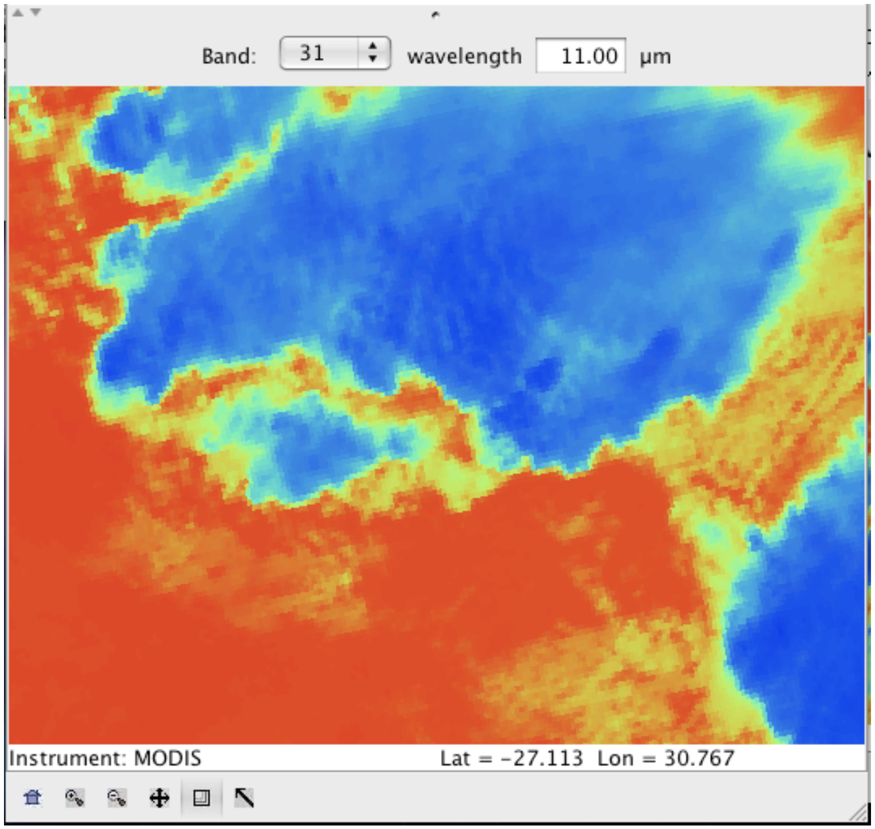


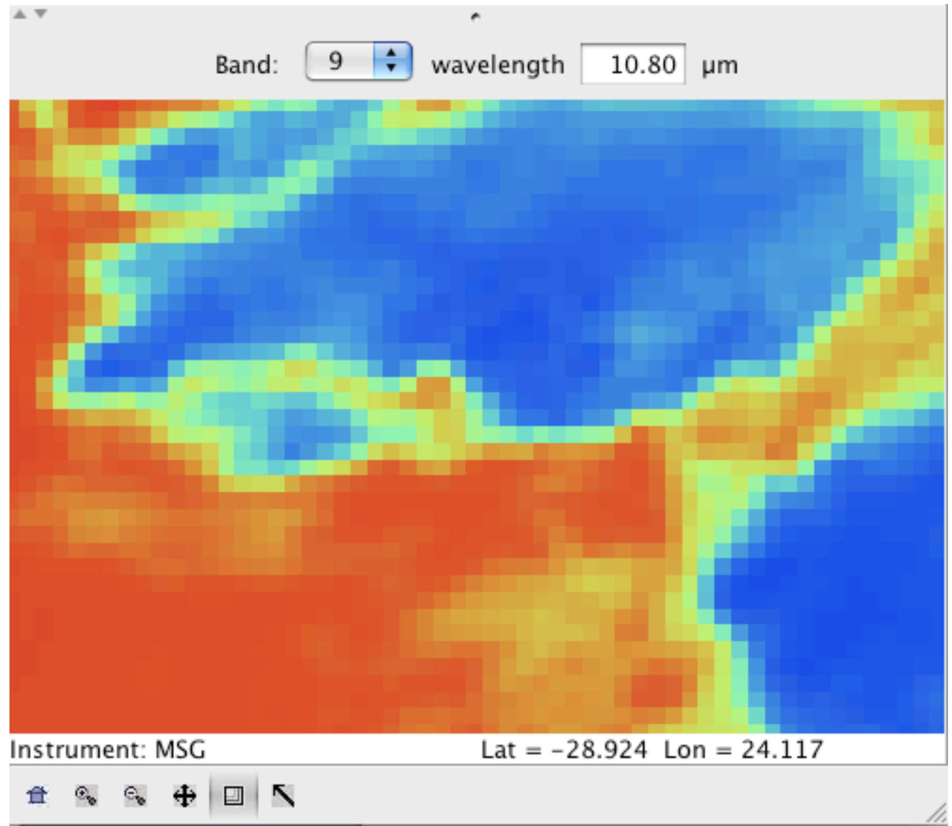
MODIS visible channel



GOES visible channel

MODIS versus SEVIRI





How Important Is Spatial Resolution?

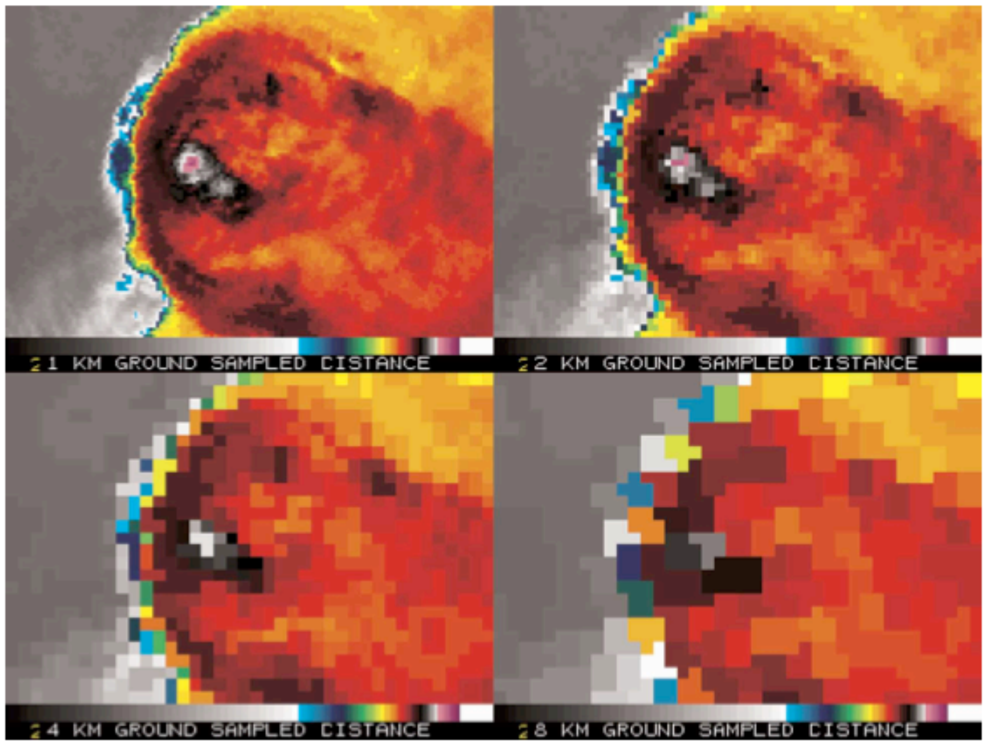


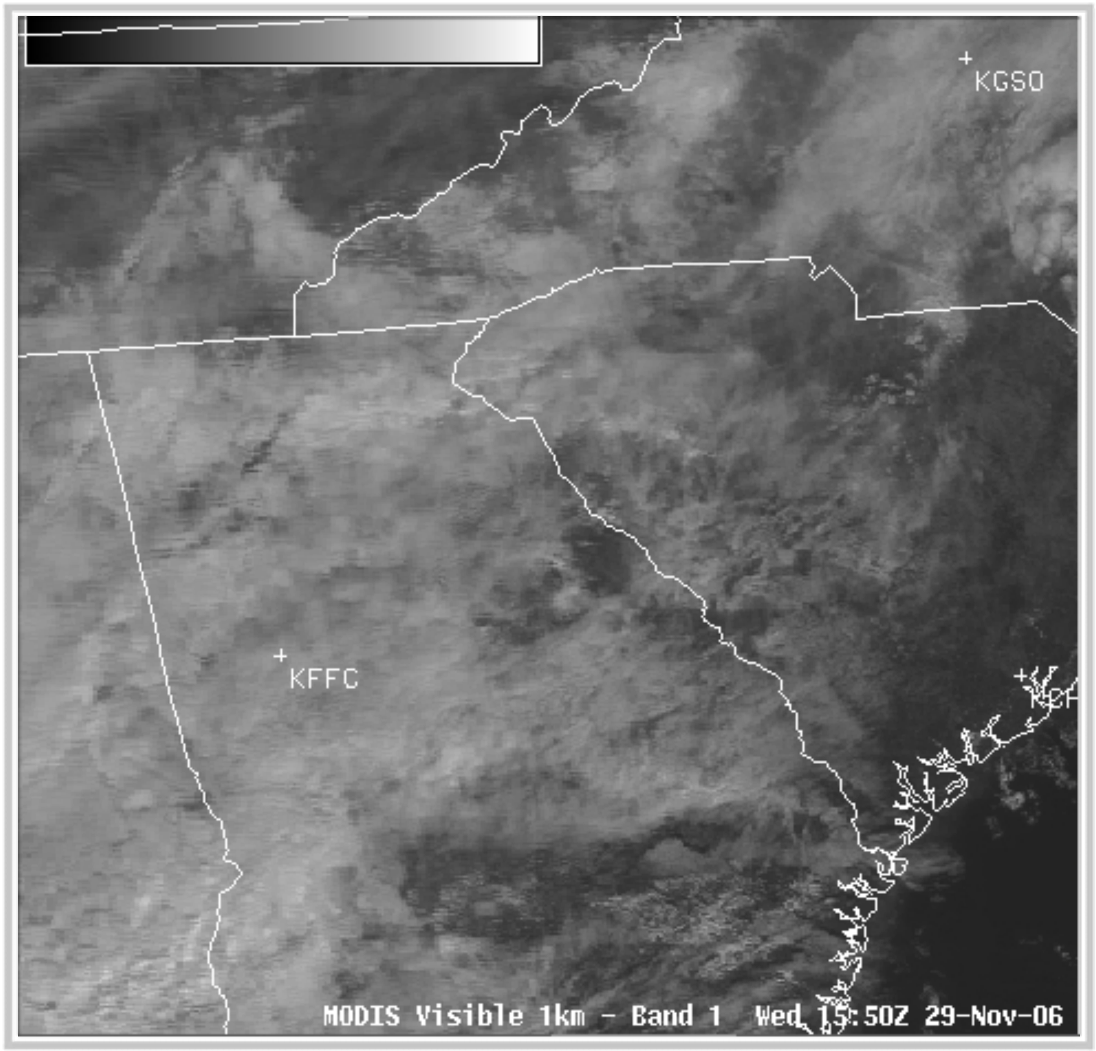
FIG. 3. Zoomed-in image of an enhanced-V feature located over northeast OK observed from enhanced LEO satellite imagery at 2218 UTC 6 May 2003 for 1-, 2-, 4-, and 8-km ground-sampled distances. The purple and white colors in the location of the updraft and overshooting top represent colder BTs, while the surrounding black and red colors represent warmer BTs.

A Quantitative Analysis of the Enhanced-V Feature in Relation to Severe Weather, Jason C. Brunner, Steven A. Ackerman, A. Scott Bachmeier, and Robert M. Rabin. Weather and Forecasting Volume 22, Issue 4 (August 2007) pp. 853–872

Example of Increased Spectral Resolution

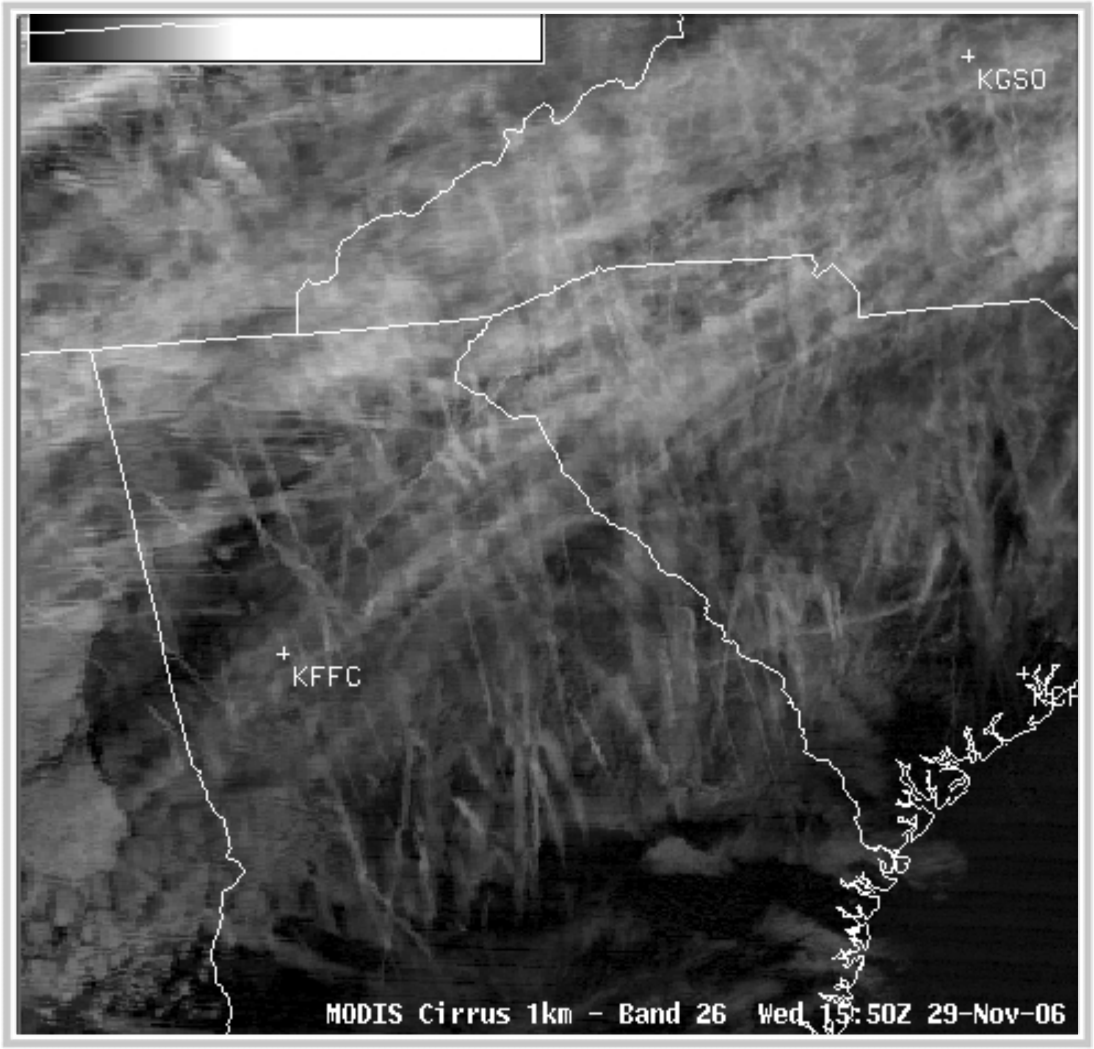
MODIS Imagery in AWIPS

Band 26: Cirrus detection (1.38 µm)



MODIS Imagery in AWIPS

Band 26: Cirrus detection (1.38 µm)

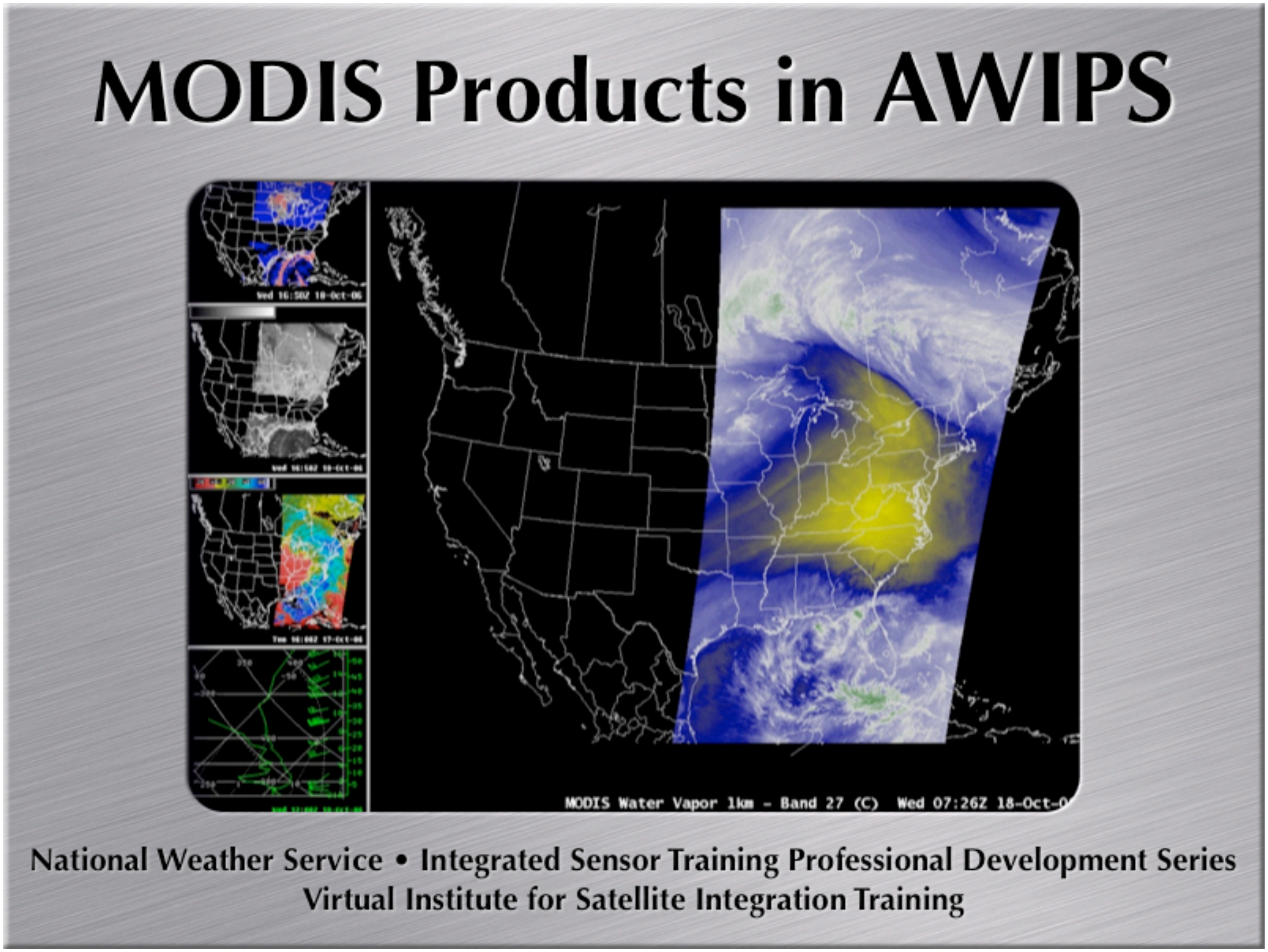


Can Polar Orbiter Data Really Be That Useful to Forecasters?

US National Weather Service

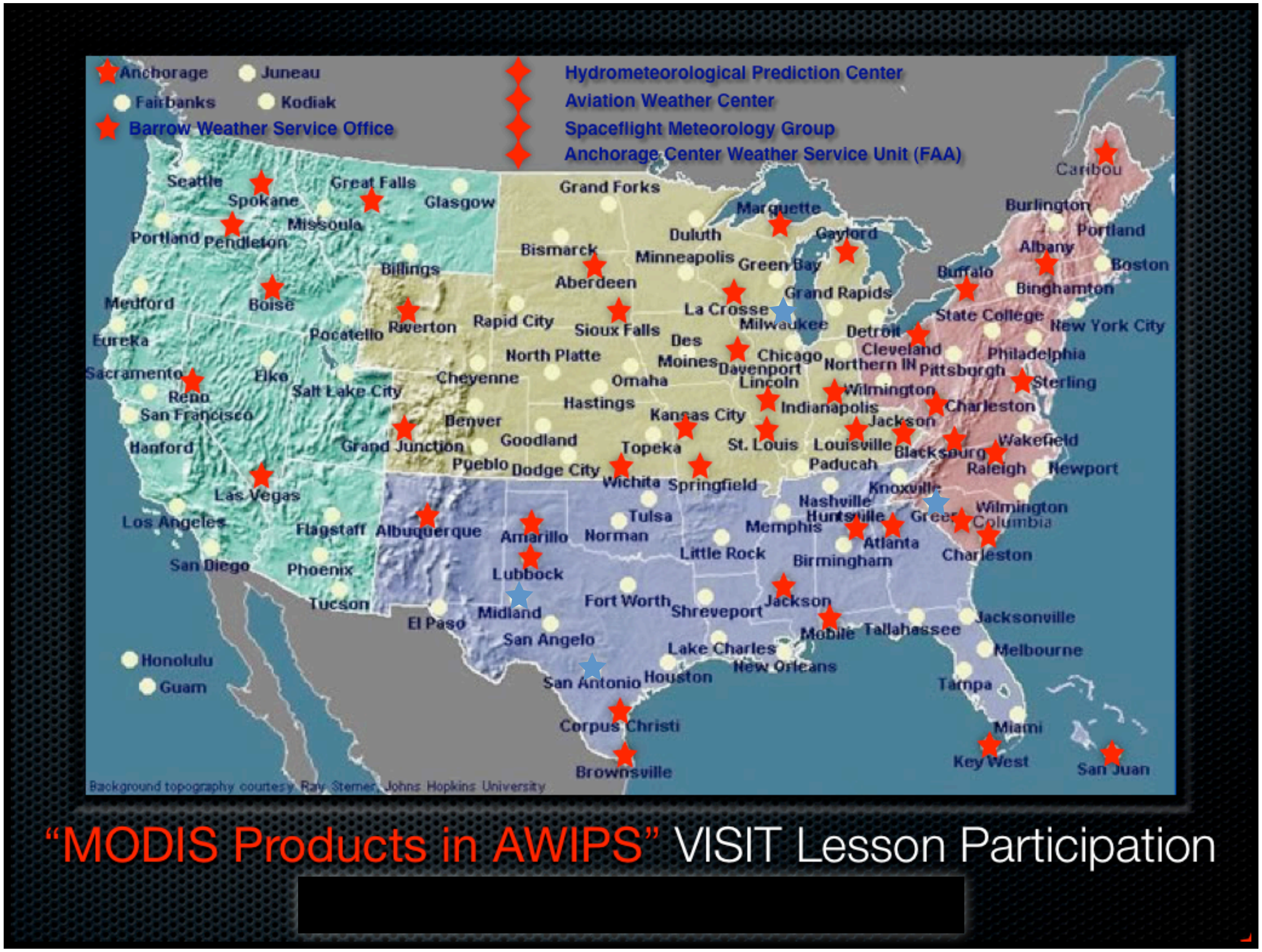
- University of Wisconsin providing Direct Broadcast MODIS products NWS in June 2006
- Reflectances and Brightness Temperatures
    - Bands 1 (.68 µm), Band 26 (1.38 µm), Band 7 (2.1 µm)
    - Band 20 (3.7 µm), Band 27 (6.7 µm), Band 31 (11 µm)
- Products
  – 1 km
    - Sea Surface Temperature, NDVI,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

  – 5 km
    - Cloud Top Pressure, Total Precipitable Water, Cloud Phase
- True Color 250 m Imagery



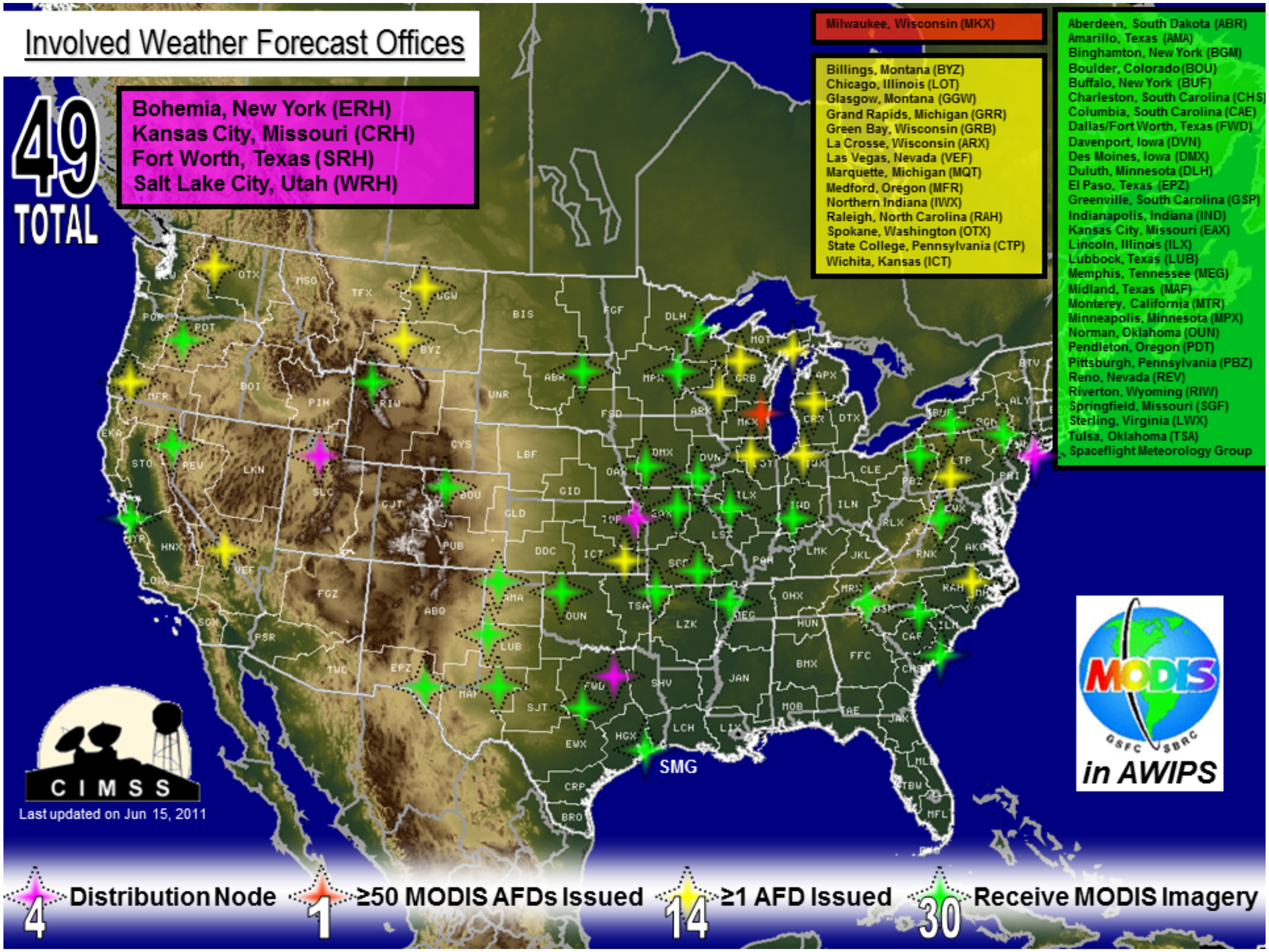
Virtual Institute for Satellite Integration Training (VISIT) lesson - offered since October 2006

MODIS Products in AWIPS

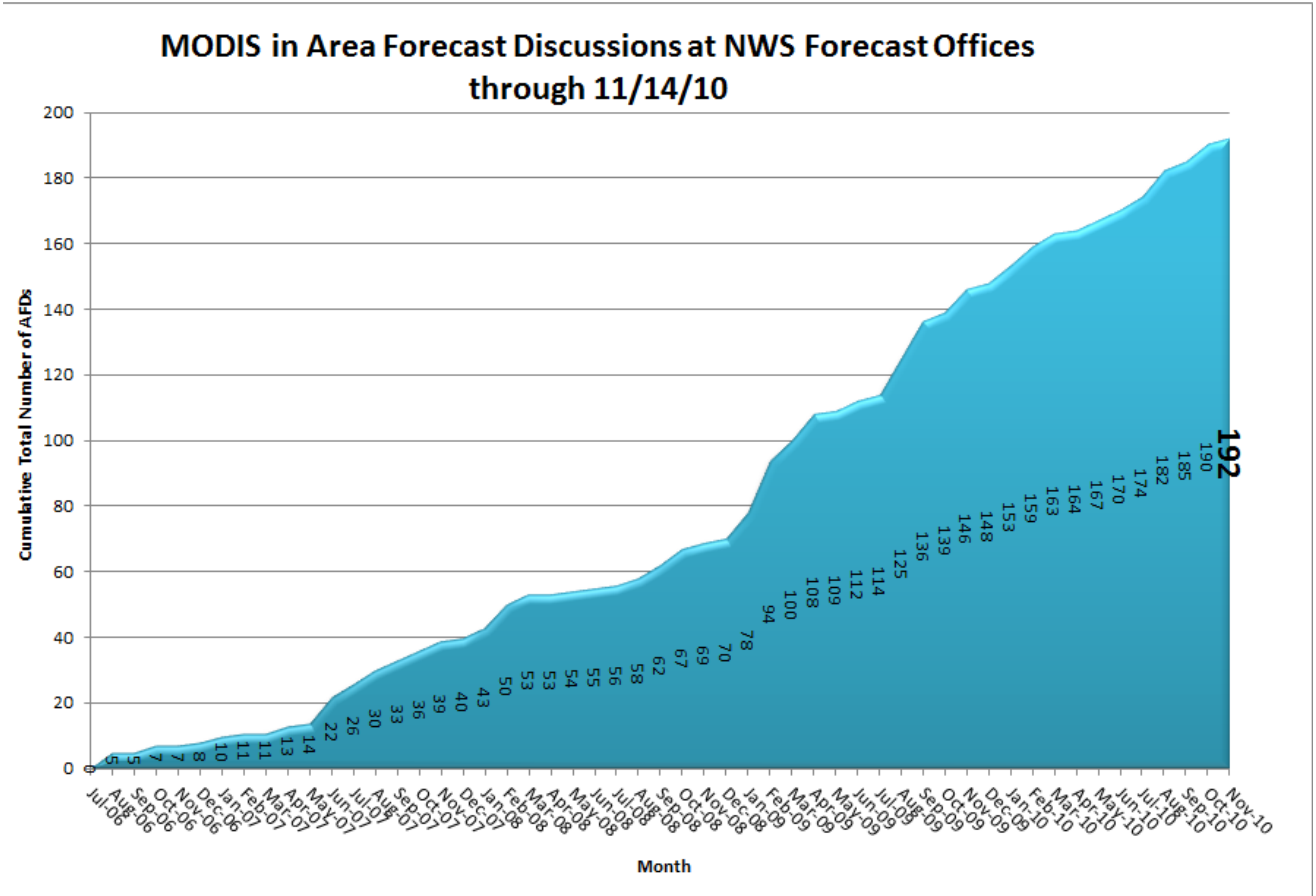


53 NWS forecast offices participating so far

MODIS Products in AWIPS



49 NWS forecast offices have added CIMSS MODIS imagery to their local AWIPS



MODIS in Area Forecast Discussions at NWS Forecast Offices
through 11/14/10
Cumulative Total Number of AFDs
Month
0
20
40
60
80
100
120
140
160
180
200
Jul-06
Aug-06
Sep-06
Oct-06
Nov-06
Dec-06
Jan-07
Feb-07
Mar-07
Apr-07
May-07
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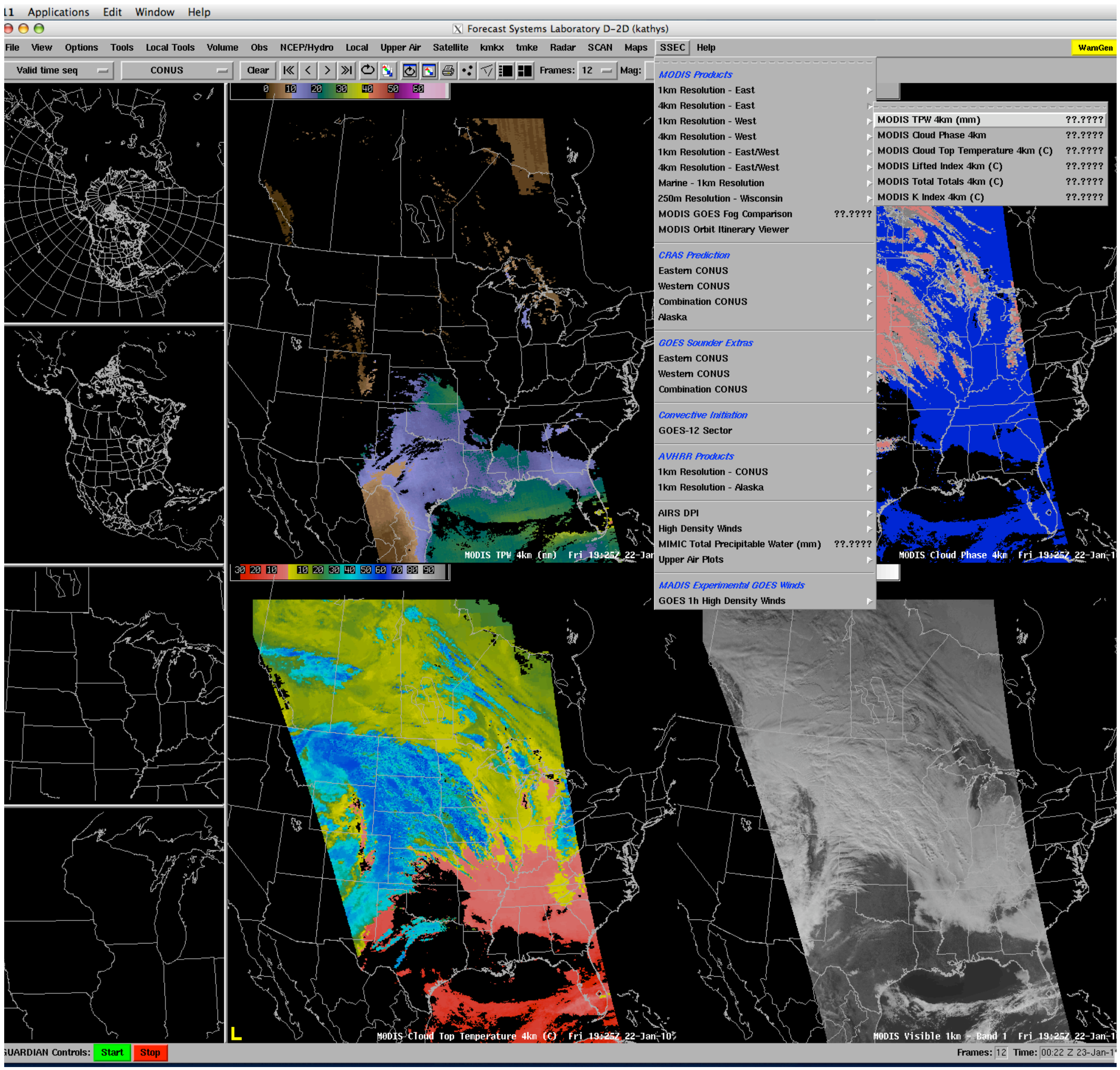
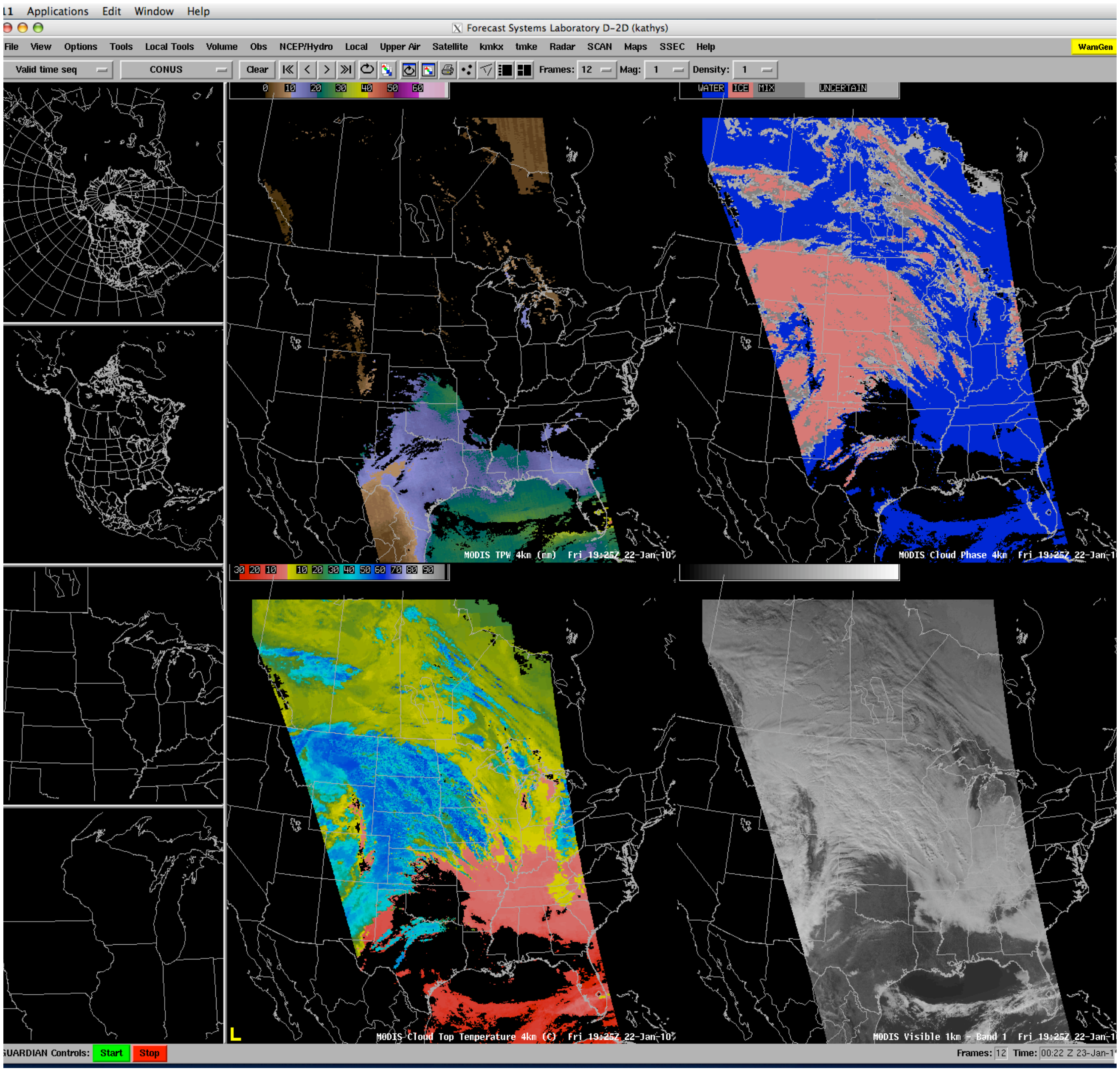
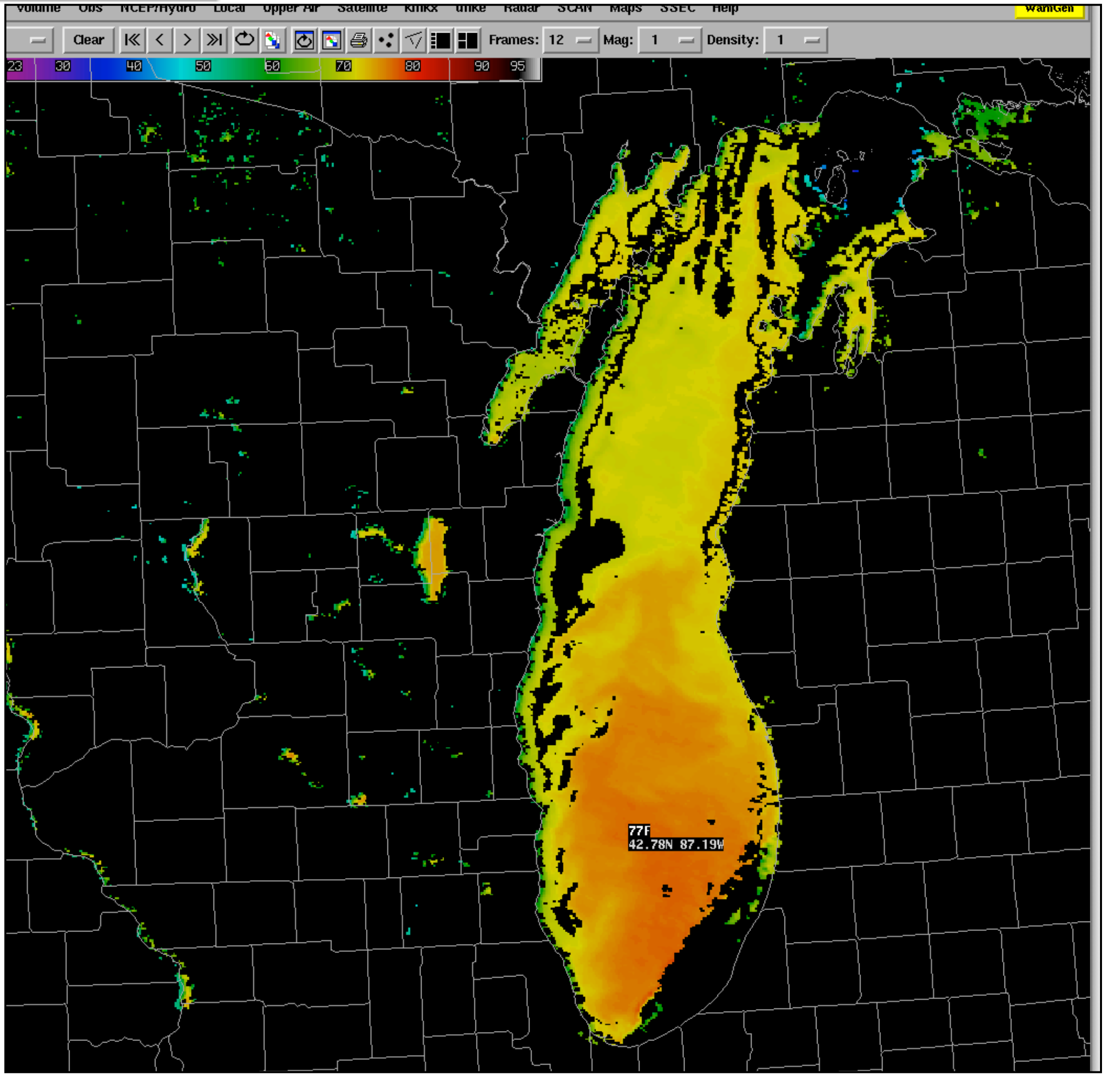
MODIS Supports Operational Forecasters



MODIS Supports Operational Forecasters



AFD using MODIS



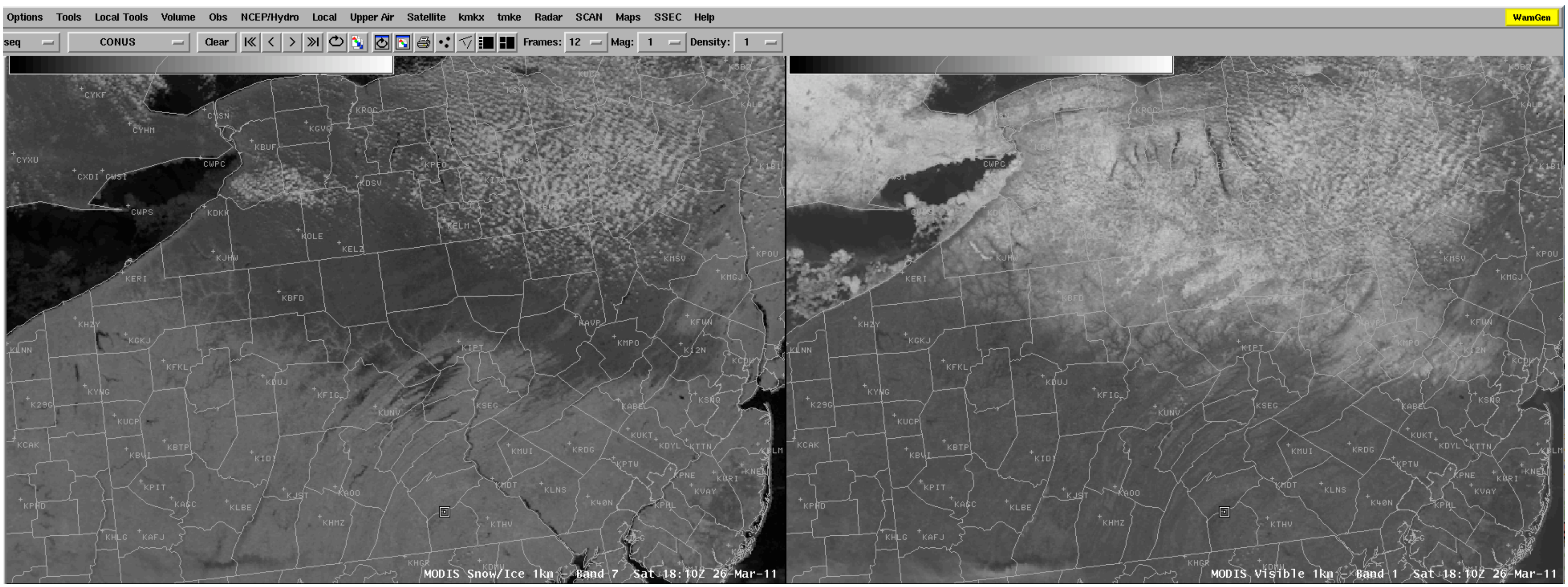
AREA FORECAST DISCUSSIONNATIONAL WEATHER SERVICE MILWAUKEE/SULLIVAN WI
228 AM CDT WED AUG 25 2010

.MARINE...LATEST MODIS AND AVHRR SATELLITE IMAGERY SHOW NEARSHORE SST IN THE 66 TO 71 DEGREE RANGE...WITH MID 70S AT MID-LAKE. LOW LEVEL COLD AIR ADVECTION RESULTING IN STEEPENING LAPSE RATES WL ALLOW NW WINDS TO INCREASE TO 15 TO 20 KNOTS THIS AFTN. A FEW GUSTS INTO THE 20 TO 25KT RANGE ARE POSSIBLE THIS AFTN. WINDS VEER TO THE NORTH TNGT WITH A SECONDARY SURGE OF LOW LEVEL COOL AIR ADVECTION CLIPPING LOWER LAKE MI. GUSTS EXCEEDING 20 KNOTS MAY CONTINUE TOWARD THE OPEN WATERS WITH LIGHTER WINDS AT THE SHORE. WIND SPEEDSSETTLE DOWN ON THU AS SFC HIGH PRES APPROACHES.

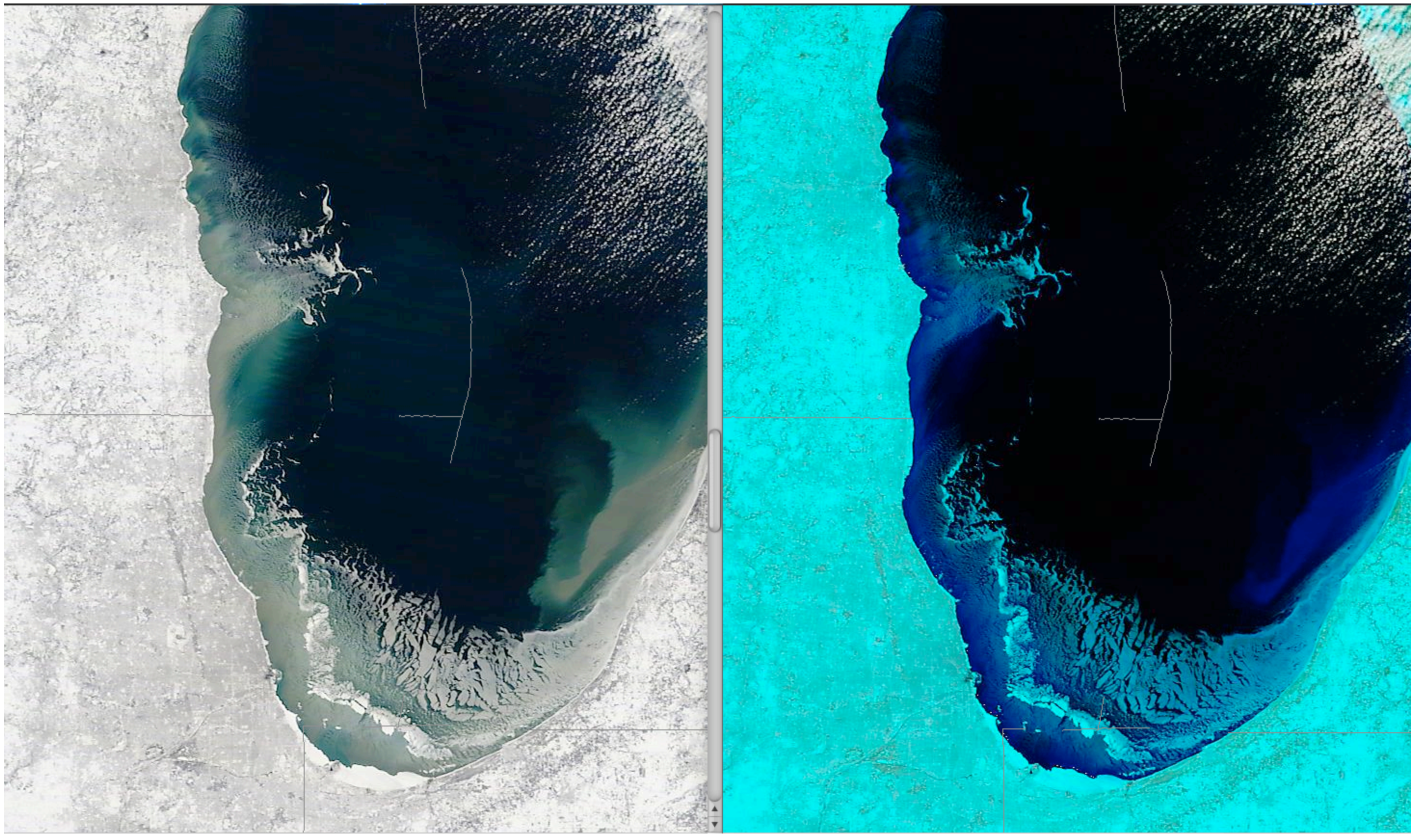
Forecasting Low Temperatures

AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE STATE COLLEGE PA
442 AM EDT SUN MAR 27 2011

.SHORT TERM /6 PM THIS EVENING THROUGH 6 PM MONDAY/...ANOTHER VERY CHILLY NIGHT IN STORE FOR THE REGION WITH MINS ARND 15F BLW NORMAL. RIDGE OF HIGH PRESSURE WILL PROVIDE THE CLEARSKIES...*LGT WINDS AND DRY AIR TO ALLOW FOR GOOD RADIATIONAL COOLING. LOWS SHOULD RANGE FROM THE SINGLE DIGITS ACROSS THE SNOW COVERED N MTNS /MODIS BAND 7 IMAGERY SHOWS EXTENT OF SNOW COVER BEAUTIFULLY/*...TO ARND 20F IN THE SOUTH.



Waterway Navigation



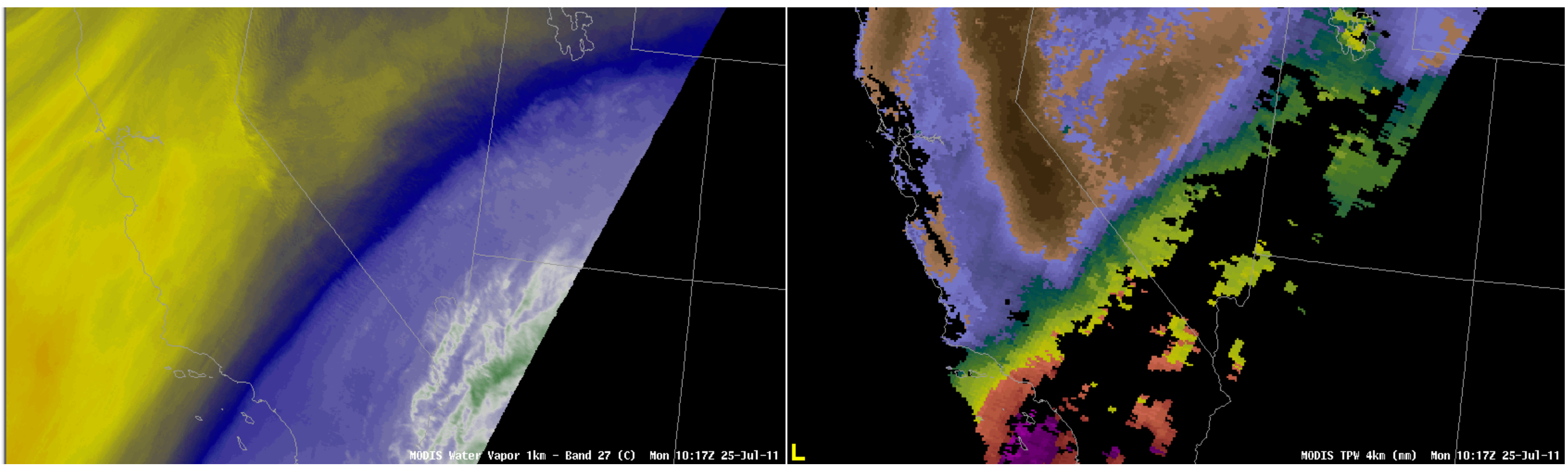
AREA FORECAST DISCUSSION NATIONAL WEATHER SERVICE MILWAUKEE/SULLIVAN WI 330 AM CST SAT FEB 5 2011

MARINE...WEST WINDS TO REMAIN BELOW SMALL CRAFT ADVISORY CRITERIA AS WEAK LOW PRESSURE MOVES INTO THE SOUTHERN LAKE MICHIGAN REGION. ***FALSE COLOR MODIS IMAGERY WHICH SHOWS ICE/SNOW VS WATER INDICATES ICE COVERAGE OVER LAKE MICHIGAN IS NOT AS EXTENSIVE AS THE VISIBLE IMAGERY WOULD SUGGEST. SOME OF THIS COULD BE SLUSHY ICE OR POSSIBLY MORE OF A TURBIDITY DIFFERENCE WITH THE PRIOR BRISKWINDS.***

Support for Fire Weather Forecasts

AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE SALT LAKE CITY UT
1024 AM MDT MON JUL 25 2011

.FIRE WEATHER...MODIS WATER VAPOR IMAGERY INDICATES THAT PRECIPITABLE WATER VALUES APPROACHING ONE INCH HAVE PUSHED AS FAR NORTH AS THE SOUTHERN WASATCH FRONT THIS MORNING. THIS SURGE OF MOISTURE IS ALSO BRINGING EXTENSIVE CLOUD COVER TO CENTRAL AND NORTHERN UTAH THIS MORNING….WITH DEEP MOISTURE MOVING NORTH BELIEVE THAT RISK FOR DRY THUNDERSTORMS IS LIMITED PRIMARILY TO THE LEADING EDGE OF THE MOISTURE SURGE ACROSS NORTHERN UTAH...ALTHOUGH FEEL COVERAGE OF POTENTIAL DRY STORMS WOULD BE LIMITED

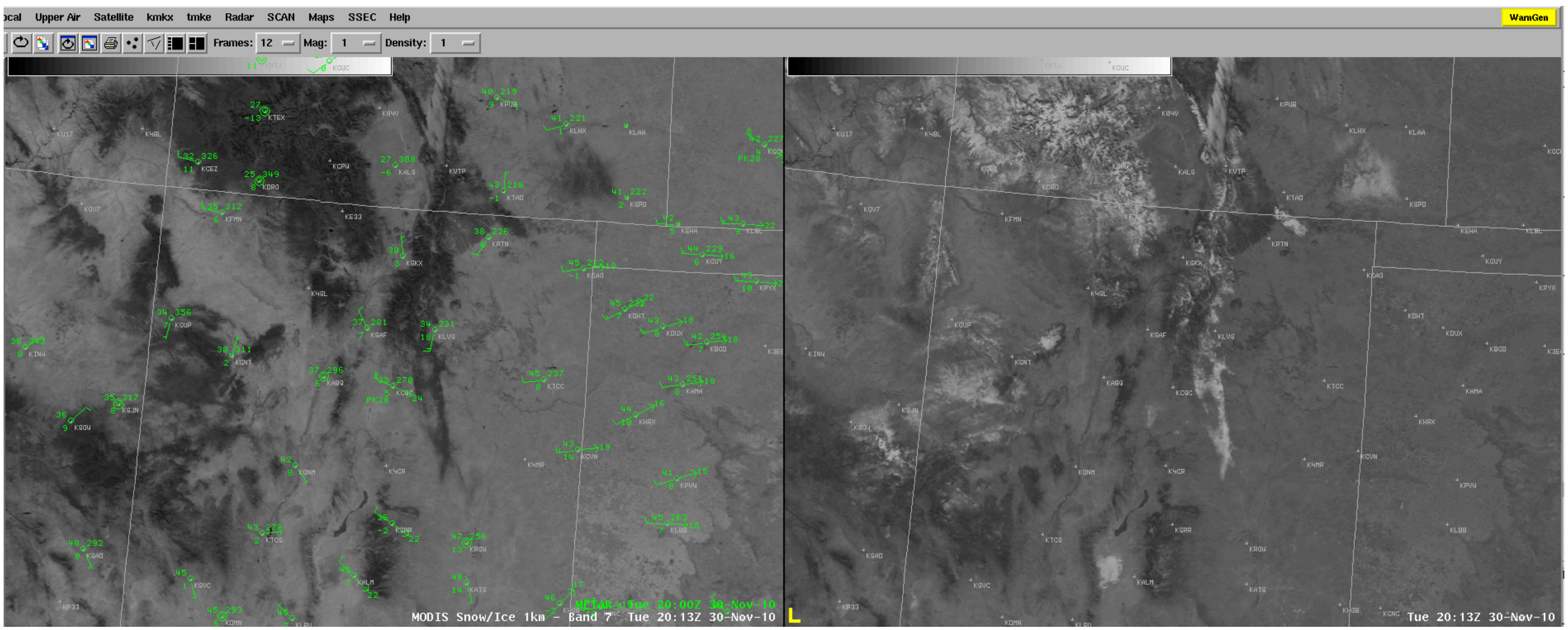


MODIS Imagery from UW SSEC Antenna 10:17 UTC 25 July 2011

Assessing Fire Danger

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

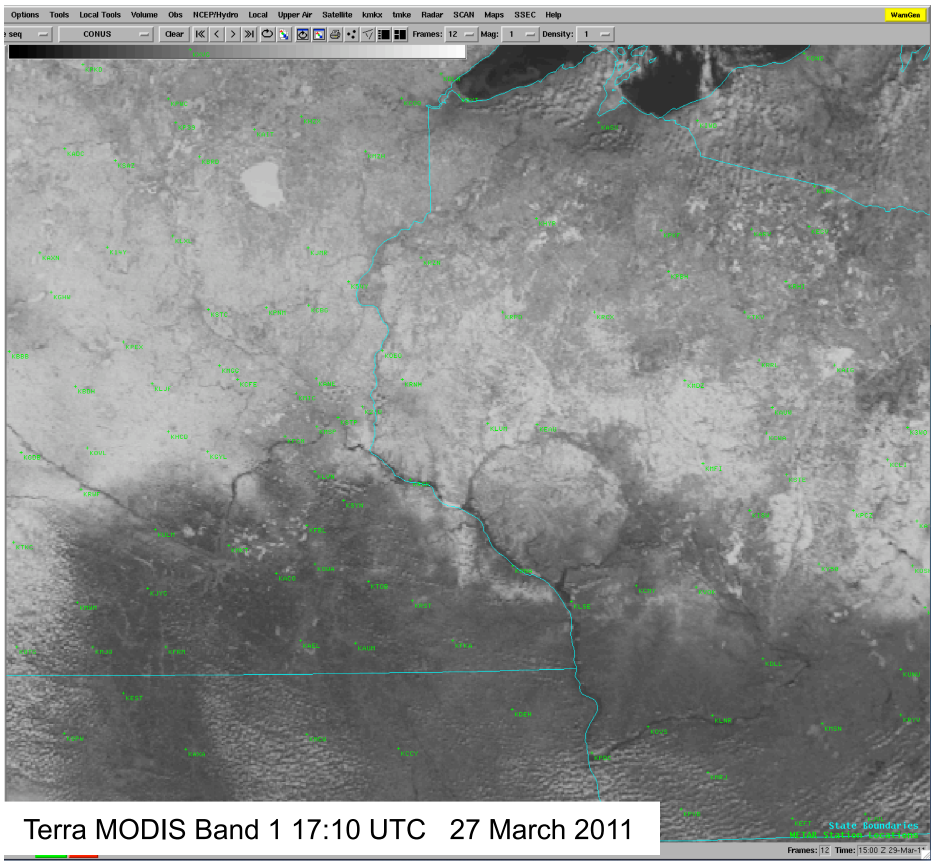
.FIRE WEATHER...ONLY MINOR CHANGES TO OVERALL FORECAST THROUGH THE WEEKEND. A 1016MB LEE TROUGH OVER THE PLAINS HAS ALLOWED WESTERLY DOWNSLOPE WINDS TO DOMINATE THE AREA...THUS TEMPS ARE MUCH WARMER AND WINDS SLIGHTLY BREEZIER. AN ISOLATED AREA OF MARGINAL CRITICAL FIRE WX CONDITIONS WILL DEVELOP BTWN 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.

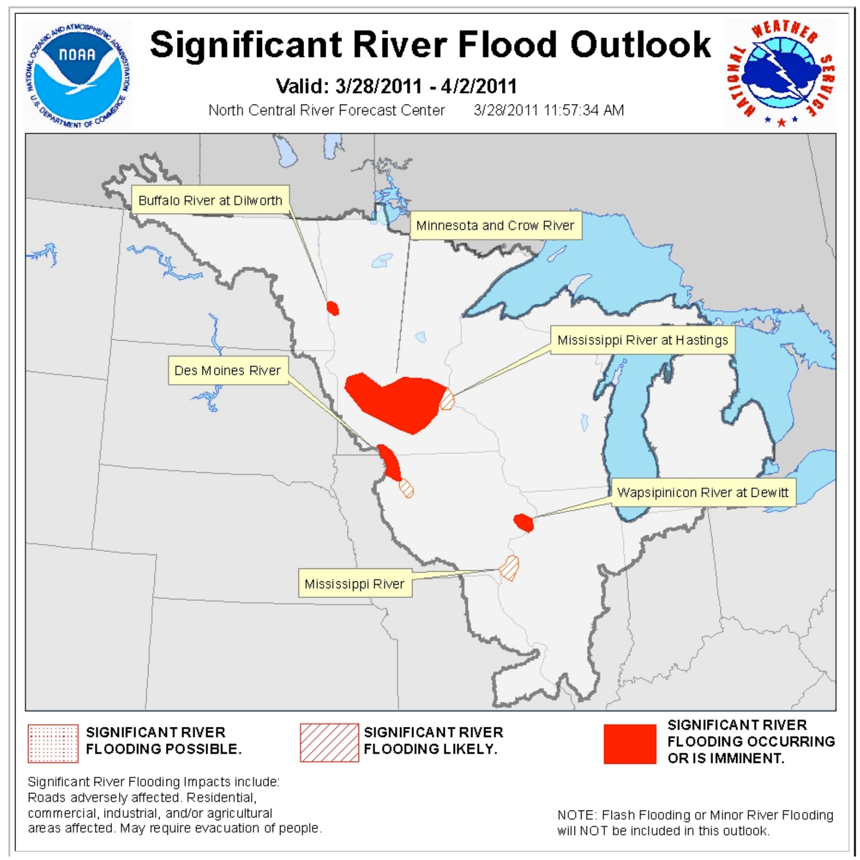


Flood Forecasting

AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE TWIN CITIES/CHANHASSEN MN
422 AM CDT TUE MAR 29 2011

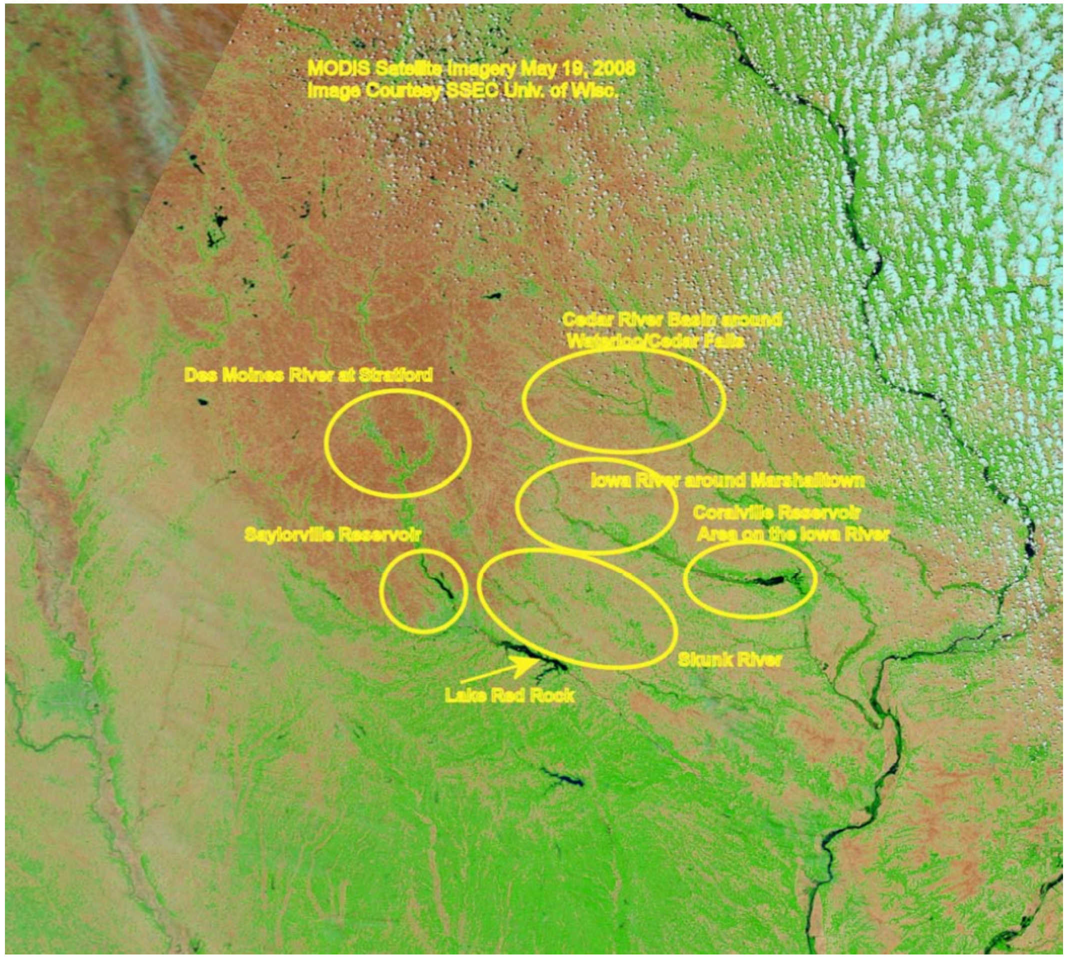
HYDROLOGY...MODIS SATELLITE PASSES OVER THE PAST COUPLE DAYS SHOW LITTLE SNOW COVER IN SOUTHERN MN...SOUTH OF THE MINNESOTA RIVER. THE EXCEPTIONIS IN THE MINNESOTA RIVER VALLEY NORTHEAST OF A LINE FROM NEW ULM TO PIPESTONE...WHERE THE EFFECT OF LAST WEEKS SNOWFALL IS STILL QUITE EVIDENT. **LATEST NOHRSC 48-HR CHANGE IN SNOW WATER EQUIVALENT SHOWS BETWEEN A TRACE AND 0.20 INCH LOSS SINCE SATURDAY ACROSS ALLOF MN AND WI...DESPITE WELL BELOW NORMAL TEMPERATURES - THE LATE MARCH SUNSHINE IS PLAYING A ROLE IN THIS SLOW MELT…**





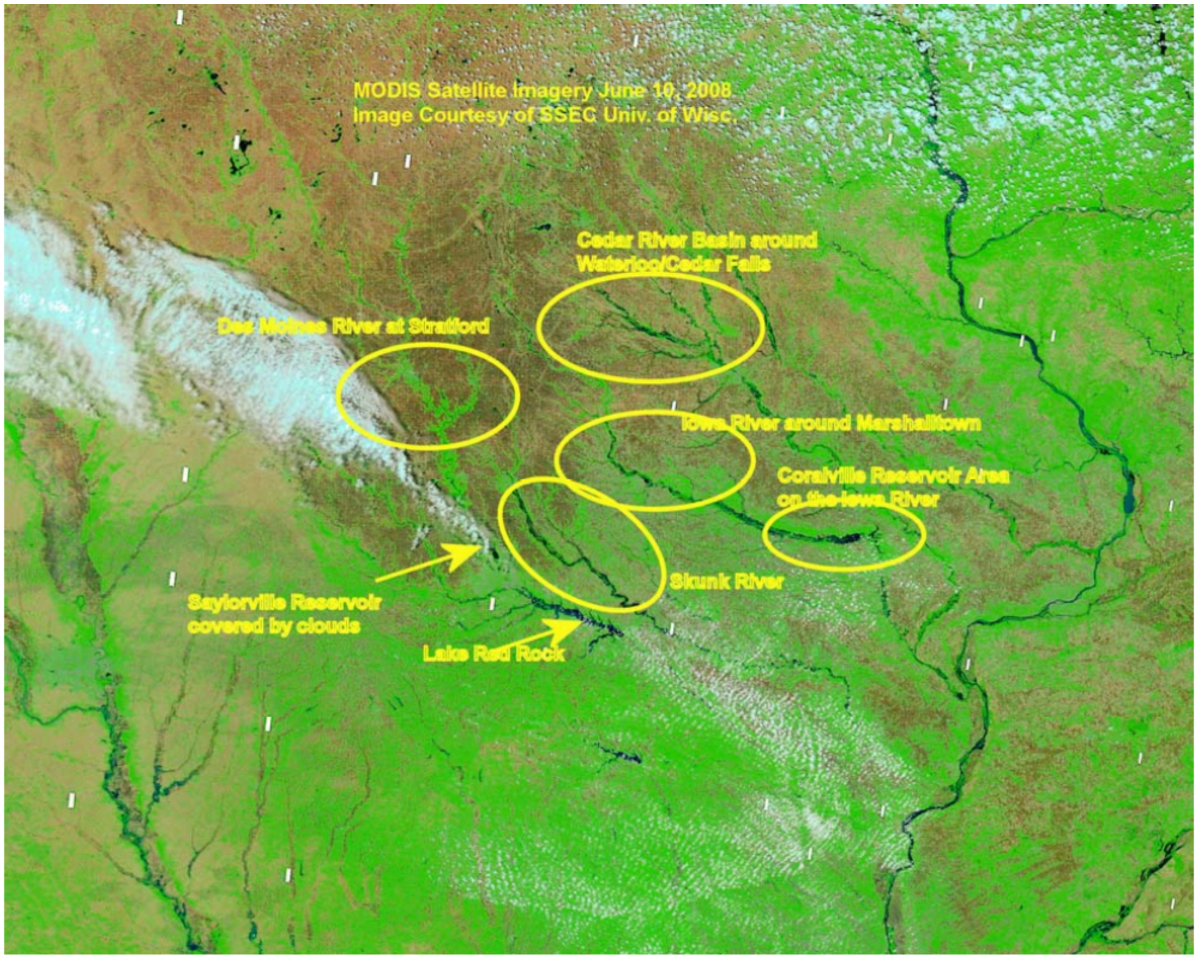
Flooding Extent

MODIS Flooding Imagery Comparison Between May 19 and June 10, 2008 Across Iowa from NWS Des Moines

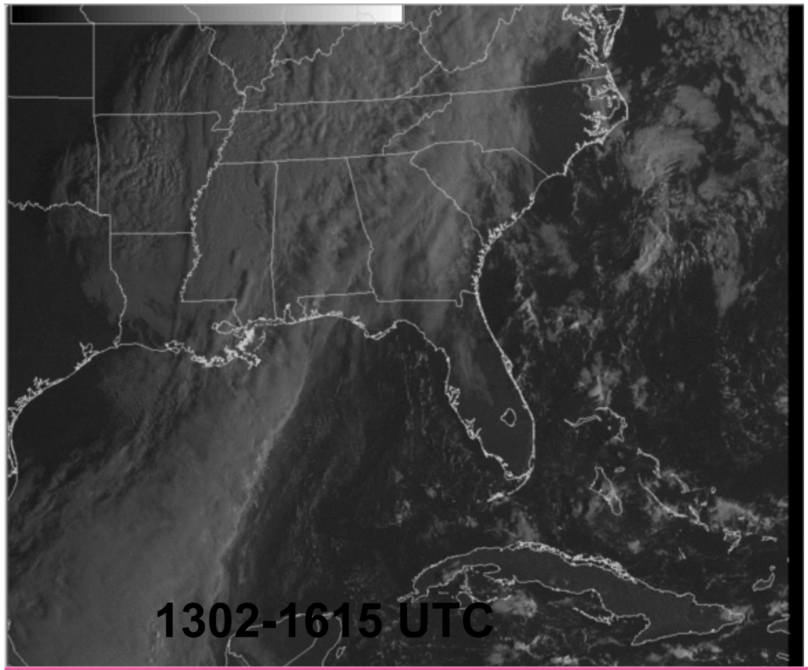


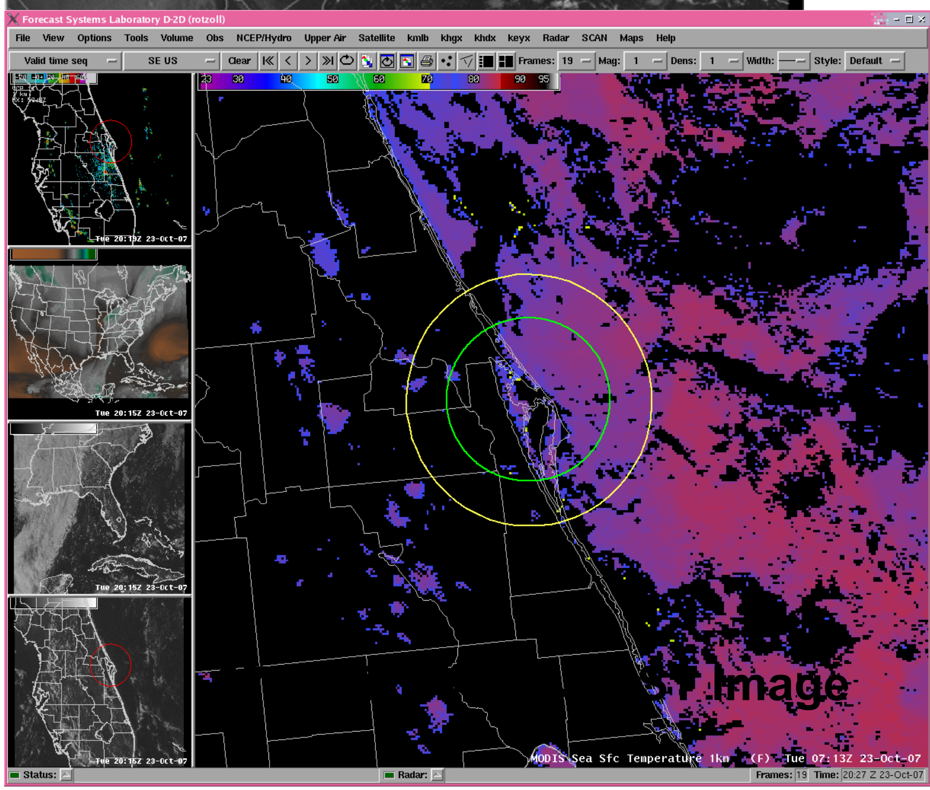
Flooding Extent

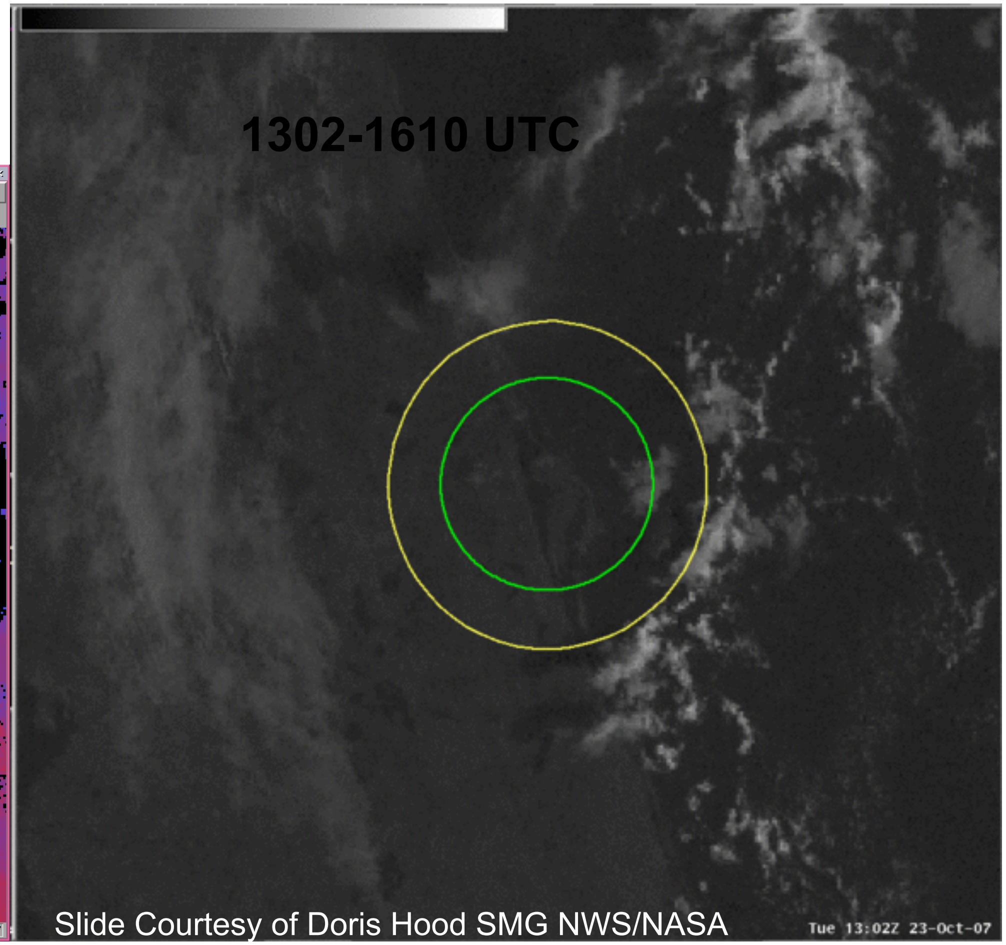
MODIS Flooding Imagery Comparison Between May 19 and June 10, 2008 Across Iowa from NWS Des Moines



Support for Space Shuttle Launch
Oct 23, 2007
1038 am CDT







How to Create Useful Products For End User

- Products that need to be cloud cleared
  - Land Surface Temperature, Simplified NDVI and EVI, IMAPP SST
  - Cloud Mask Bits must be extracted
- To remove the bow-tie effect, reprojection is required
- Some products require scaling:
  - Must use scale/add offset to unpack values

Applying Cloud Mask

- Steps to apply cloud mask:

  1). Read cloud mask

  48 bits per pixel (6 bytes)

  Bits 1-3 provide pixel cloud mask

  2). Extract bits - right justified

Bit 0	Cloud mask determined	0=not determined
		1=determined
Bits 1-2	Cloud mask confidence	00=cloudy
		01=uncertain
		11=probably clear
		10=confident clear

Applying Cloud Mask

3). Read other relevant bits cloud mask

1st byte contains processing path information

Bit 3	Day/Night Flag	0=Night/1=Day
Bit 4	Sun glint flag	0=Yes/1=No
Bit 5	Snow/Ice Background	0=Yes/no
Bits 6-7	Land/water Flag	00=Water
		01=Coast
		11=Desert
		10=Land

Applying Cloud Mask

4). Apply Mask:

SST – land, desert, snow/ice free, clouds (confident and probably clear)

LST – water, clouds (confident clear and probably)

NDVI - water, snow free, clouds (confident and probably clear)

How do I do this?

Bitwise manipulation - Programming languagues have bitwise manipulations, including unix (ibits).

Nighttime Fog Detection

Nighttime Fog Detection

- Why is This Important?
  - Low visibilities and low cloud ceilings can be hazardous to transportation operators on land, sea and air

Airport covered by fog

31st July 2010

THICK fog and low cloud caused chaos at Rockhampton Airport yesterday where many flights were delayed.

FLIGHTS DELAYED: Thick fog covered Rockhampton yesterday morning and caused chaos at the airport.

CHRIS ISON CI--

About a dozen flights had problems at the airport, which was one of a number on Australia's eastern coast affected.

Most flights were either departing for or arriving from Brisbane.

Rockhampton weather forecaster Mike Marrinan yesterday said the fog restricted visibility to about 100m.

Mr Marrinan said more fog was forecast for this morning.

He said the fog was caused by the moisture.

"The fog was about the thickest we've had this year," Mr Marrinan said.

He said conditions, particularly night-time minimums, had been well above the average for July.

The current average minimum is about four degrees warmer than the long-term norm of just under

AustralianWeatherNews

Noteworthy synoptic observations for Sunday, 1 August 2010 I prepared 0158 EST, 02/08/10

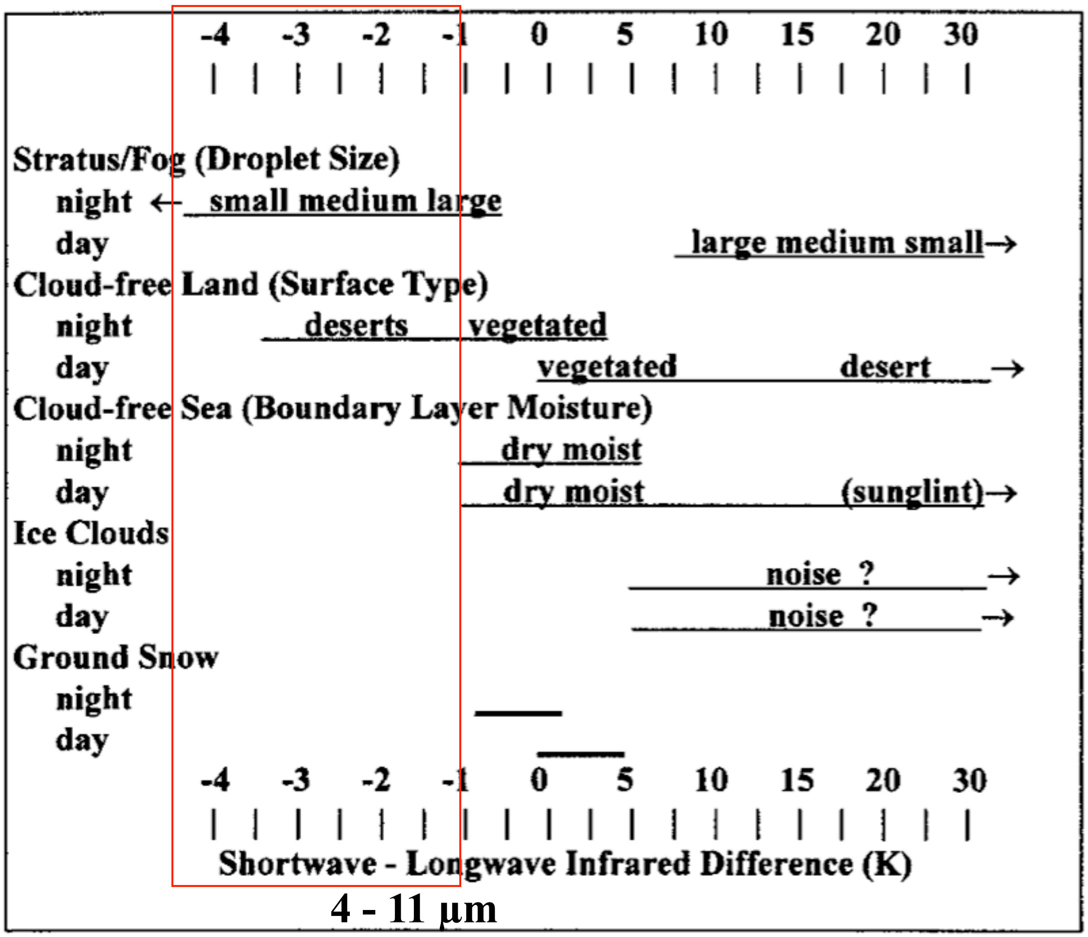
Go to the archive for this page for last MONDAY TUESDAY WEDNESDAY THURSDAY FRIDAY SATURDAY SUNDAY.
Return to LATEST REPORT

Max	Var	Min	Var	Grs Min	Rainfall		Station	Mth/ Date	Time local	Cloud amounts & types				Wind	Temp	Dew Pt	Rel Hum	Pressure	Weather Description		Vis	Comments
°C	°C	°C	°C	°C	mm/ hr	mm/ hr				Tot Cov	Low Cloud(base m x 100)	Mid	High	Dir °/ km/h	°C	°C	%	hPa/ 3hr tendency	Pre-sent	Past	km	
Western Australia																						
003 West Kimberley																						
30.0	-0.3	18.6	+3.6	17	2/24	Tr/3	BROOME AIRPORT	0801	0900	◐	⦶ 3/SE		-	110/24	21.4	18.2	82	1019.0 ⁄ 1.2	)•(		40.0	-
30.0	+0.4	23.0	+8.1	-	-	-	CYGNET BAY	0801	0900	◐	-	-	-	130/41	25.0	18.7	68	1018.1 ⁄ 1.2	○	◐ ◐	30.0	/
013 Interior																						
14.0	-14.8	-	-	-	36/6	36/6	BALGO HILLS	0801	1500	●	⦶ --- 6/E		-	110/08	12.7	12.2	97	1023.4	••	• •	5.0	-
Northern Territory																						
014 Northern Rivers																						
35.0	+2.5	23.0	+8.3	23	-	-	KATHERINE AVIATION MUSEUM	0801	0900	◐	◐ -/E		-	110/15	25.1	18.7	68	-	○	◐ ◐	20.0	-
37.0	+3.5	24.0	+8.0	22	-	-	MANGO FARM	0801	0900	◐	◐ -/-		-	130/18	27.0	21.3	71	1015.8 ⁄ 1.2	○	◑ ◑	30.0	-
35.0	+3.0	23.0	+9.7	-	-	-	MCARTHUR RIVER MINE	0801	0900	-	-	-	-	170/15	23.9	12.5	49	1019.6 ⁄ 1.3	-	-	-	-
-	-	22.8	+9.5	-	-	-	MCARTHUR RIVER MINE	0801	1200	-	-	-	-	150/21	27.6	12.8	40	1018.8 ∖ 0.8	-	-	-	-
32.0	+0.9	22.0	+9.8	20	-	-	WOLLOGORANG	0801	0900	◐	◐ -/W		-	140/13	23.5	13.0	52	1021.4 ⁄ 1.9	○	◐ ◐	50.0	-
015 Northern Plateau--Barkly/Alice Spgs																						
19.0	-8.3	11.0	+1.9	10	-	-	ALI CURUNG	0801	0900	○	-	-	-	090/18	15.1	4.9	50	1026.9 ⁄ 2.4	○	○ ○	40.0	-
15.9	-9.1	-	-	-	-	-	JERVOIS	0801	0000	-	-	-	-	170/09	12.9	9.8	81	1026.9	-	-	-	-
16.0	-9.0	11.0	+4.2	9	Tr/24	-	JERVOIS	0801	0900	◐	◐ -/W		-	150/18	13.3	6.1	62	1030.1 ⁄ 2.3	○	◐ ◐	50.0	-
16.6	-8.3	-	-	-	-	-	TERRITORY GRAPE FARM	0801	0000	-	-	-	-	140/11	12.7	8.8	77	1026.2	-	-	-	-
16.0	-8.6	-	-	-	0.1/6	0.1/6	WATARRKA	0801	1500	●	● 10/NW	-	-	160/18	15.3	2.6	42	1027.5 ∖ 1.6	○	, ,	15.0	barom read at 1500 by to
South Australia																						
018 Western Agricultural																						
16.5	+1.2	-	-	-	-	4/3	NEPTUNE ISLAND	0801	0000	-	-	-	-	240/65	11.9	7.8	76	1016.5 ✓ 0.8	-	-	-	-
-	-	-	-	-	11/18	0.2/3	NEPTUNE ISLAND	0801	0300	-	-	-	-	240/63	11.5	3.3	57	1019.2 ⁄ 2.6	-	-	-	-
-	-	-	-	-	-	-	NEPTUNE ISLAND	0801	0330	-	-	-	-		240/63	11.5	5.2	65	1019.8	-	-	-
023 Adelaide plains and Mt Lofty Ranges																						
15.8	+0.0	-	-	-	-	2/3	ADELAIDE AIRPORT	0801	0000	●	● 3/W	-	-	260/39	10.9	9.7	92	1017.5		▽ ◐	4.0	-
-	-	-	-	-	22/18	11/3	MOUNT LOFTY	0801	0300	-	-	-	-	270/21	4.7	4.7	100	-	-	-	-	-
025 Murray Mallee and Upper Southeast																						
16.1	-	-	-	-	-	8/3	LAMEROO (AUSTIN PLAINS)	0801	0000	-	-	-	-	320/28	9.3	9.2	99	1015.7	-	-	-	-
-	-	-	-	-	-	9/21	LAMEROO COMPARISON	0801	0600	●	● -/W		-	200/18	7.0	5.9	93	1017.9	••	◑ ◑	0.0	-
026 Lower Southeast																						
16.0	+1.8	7.0	-1.4	-	8/24	8/18	ROBE COMPARISON	0801	0900	◐	◐ 3/SW	-	-	230/74	10.7	6.5	75	1018.5 ⁄ 3.3		▽ ◐	7.0	-
13.0	-1.2	-	-	-	2/6	2/6	ROBE COMPARISON	0801	1500	◕	◕ 6/SW	-	-	230/65	12.0	4.8	61	1023.0 ⁄ 2.0	∞	▽ ◑	5.0	-
Queensland																						
033 Central Coast - east																						
26.8	-	-	-	-	-	-	SAMUEL HILL AERO	0801	0000	●	-	-	-	Calm	17.5	17.5	100	1021.0 ∖ 0.2	-	-	0.2	-
035 Central Highlands																						
29.0	+5.3	17.0	+9.5	14	-	-	BRIGALOW RESEARCH STN	0801	0900	●	-	-	-	130/02	18.9	16.2	84	-	○	◐ ◐	35.0	-
28.0	+5.3	16.0	+9.6	14	Tr/24	-	TAROOM POST OFFICE	0801	0900	●	-	-	-	230/08	17.0	13.5	80	1025.2 ✓ 1.7	○	◐ ◐	50.0	-
039 South Coast Curtis																						
28.0	+5.3	15.0	+8.5	13	-	-	MONTO TOWNSHIP	0801	0900	⦶	-	-	-	230/04	18.9	13.1	69	-	○	○ ○	30.0	-
-	-	-	-	-	-	Tr/3	ROCKHAMPTON AERO	0801	0600	◔	◔ — 0/W	-	-	350/05	16.9	16.7	99	1021.6 ✓ 0.8	≡	≡ ≡	0.1	-
29.0	+4.1	16.0	+9.5	-	-	-	THANGOOL AIRPORT	0801	0900	○	-	-	-	150/13	20.5	12.0	58	1024.0 ⁄ 1.3	○	◑ ◑	40.0	-
-	-	15.6	+9.1	-	-	-	THANGOOL AIRPORT	0801	1200	●	-	-	-	220/11	24.0	12.6	49	1022.3 ∖ 1.7	-	-	-	-
040 South Coast Moreton & Brisbane																						
27.0	+3.6	16.0	+8.9	-	-	-	GYMPIE	0801	0900	-	-	-	-	180/08	19.2	11.5	61	1023.8 ⁄ 1.9	-	-	-	-
-	-	16.1	+9.0	-	-	-	GYMPIE	0801	1200	-	-	-	-	210/08	20.7	10.2	51	1022.2 ∖ 1.6	-	-	-	-
27.0	+4.6	17.0	+9.2	-	-	-	NAMBOUR DPI	0801	0900	-	-	-	-	090/02	18.0	12.0	68	1023.8 ✓ 1.6	-	-	-	-
-	-	17.3	+9.5	-	-	-	NAMBOUR DPI	0801	1200	-	-	-	-	Calm	19.3	12.3	64	1022.0 ∖ 1.7	-	-	-	-
043 Maranoa																						
25.0	+2.8	13.0	+8.7	-	-	-	INJUNE POST OFFICE	0801	0900	◐	◐ 6/SW	-	-	200/15	14.2	9.0	71	1026.2 ⁄ 1.7	○	◐ ◐	50.0	-

Fog/Stratus Detection

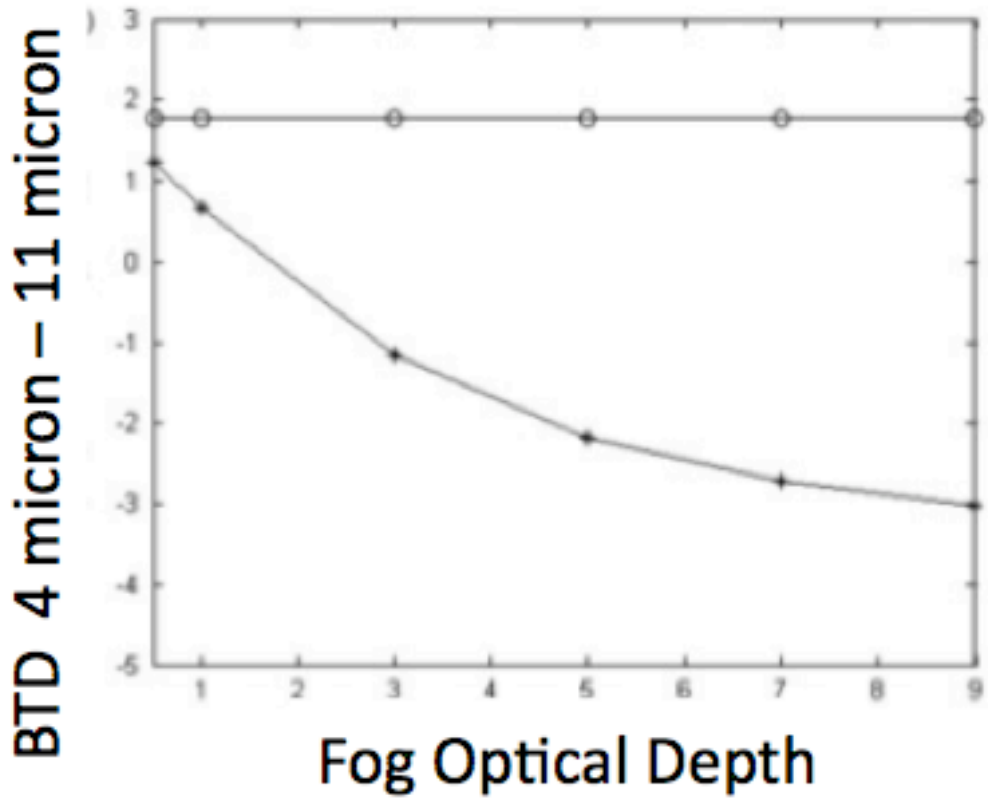
- Simple Brightness Temperature Difference
  - 4 µm - 11 µm Brightness Temperature Difference (BTDIF)
- Takes advantage of water cloud emissivity difference between the wavelengths
  - 4 µm opaque water cloud emissivity less than 1
  - 11 µm opaque water cloud emissivity ≈ 1
  - Leads to water cloud 4 µm BT < 11 µm BT
- Simple threshold < -1 means opaque water cloud
  - BTDIF image enhancement leads to quick stratus cloud and/or fog identification (orange, red to purple)
- Nighttime only
  - Solar reflectance component can dominate 4 µm signal

4-11 micron BTDIF



Lee, T. F., F. J. Turk, and K. Richardson, 1997: Stratus and fog products using GOES-8-9 3.9 μm data. Wea. Forecasting, 12, 664-677.

Relationship of BTD and Optical Depth



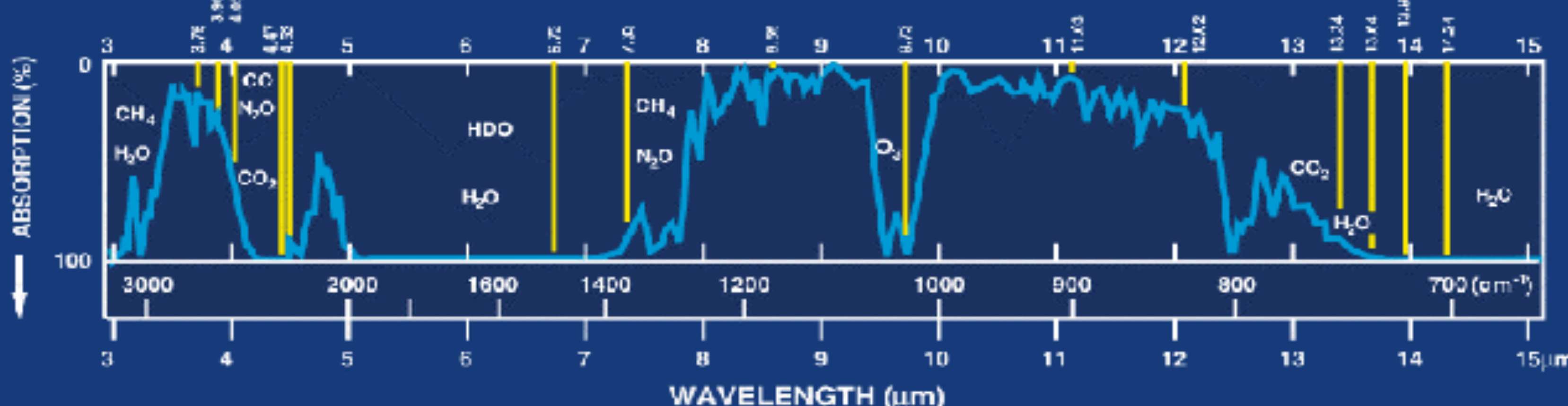
Variation of brightness temperature (K) with fog optical depth for (a) TIR channel 10.8 µm, (b) MIR channel 3.9 µm channel during night (—+— fog, —o— no fog).

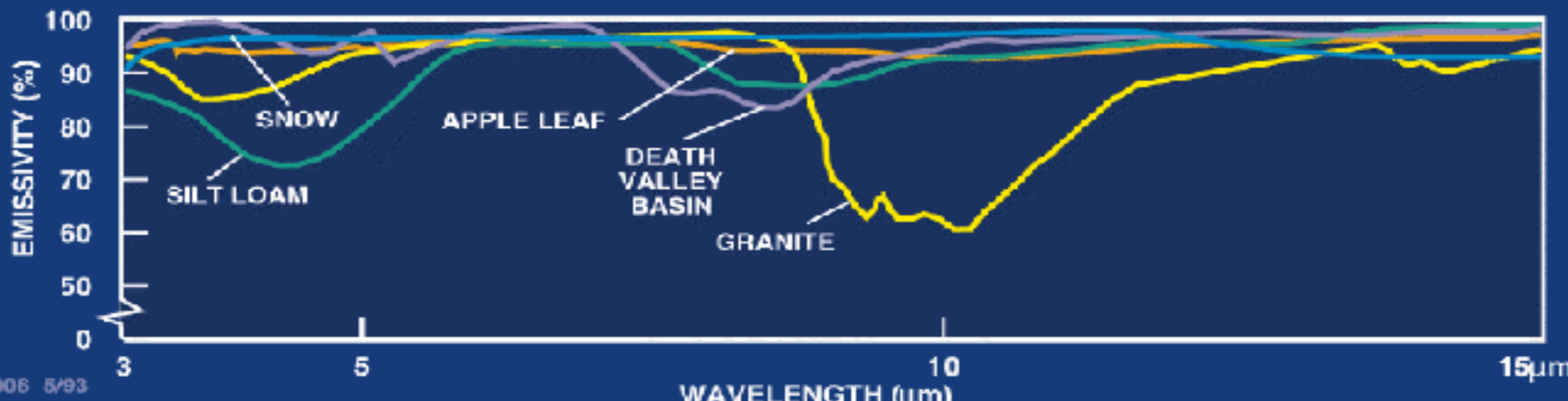
Chaurasia, S., Sathiyamoorthy, V., Paul Shukla, B., Simon, B., Joshi, P. C. and Pal, P. K. (2011), Night time fog detection using MODIS data over Northern India. Meteorological Applications, 18: n/a.doi: 10.1002/met.248

Algorithm Limitaions

- Silicate soils
  - Emissivity variations in silicate soils can cause false positives
- Higher layer clouds obscure low cloud signal
- Single detection threshold

LAND - THERMAL RADIATION



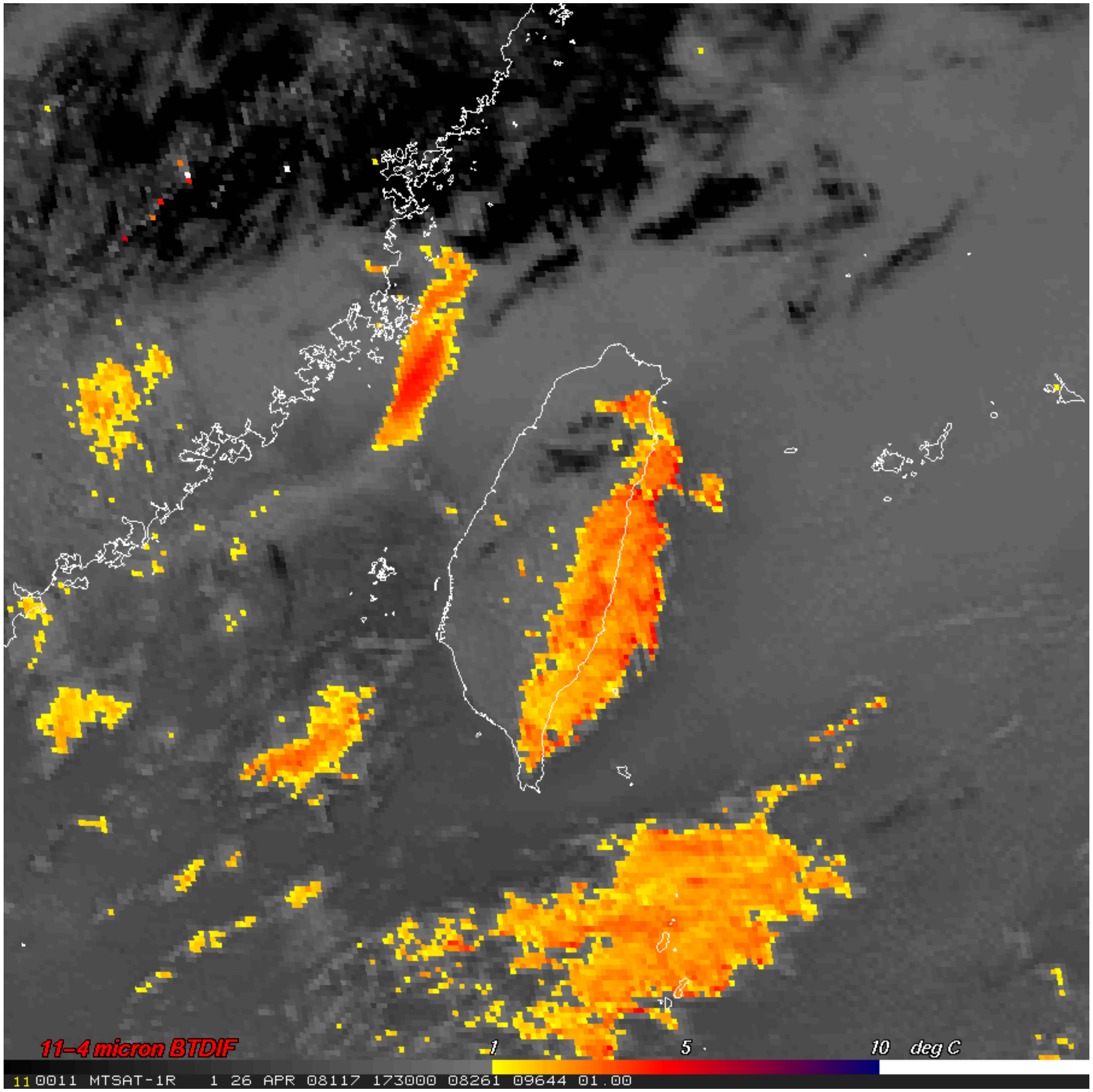


C351.006 5/93

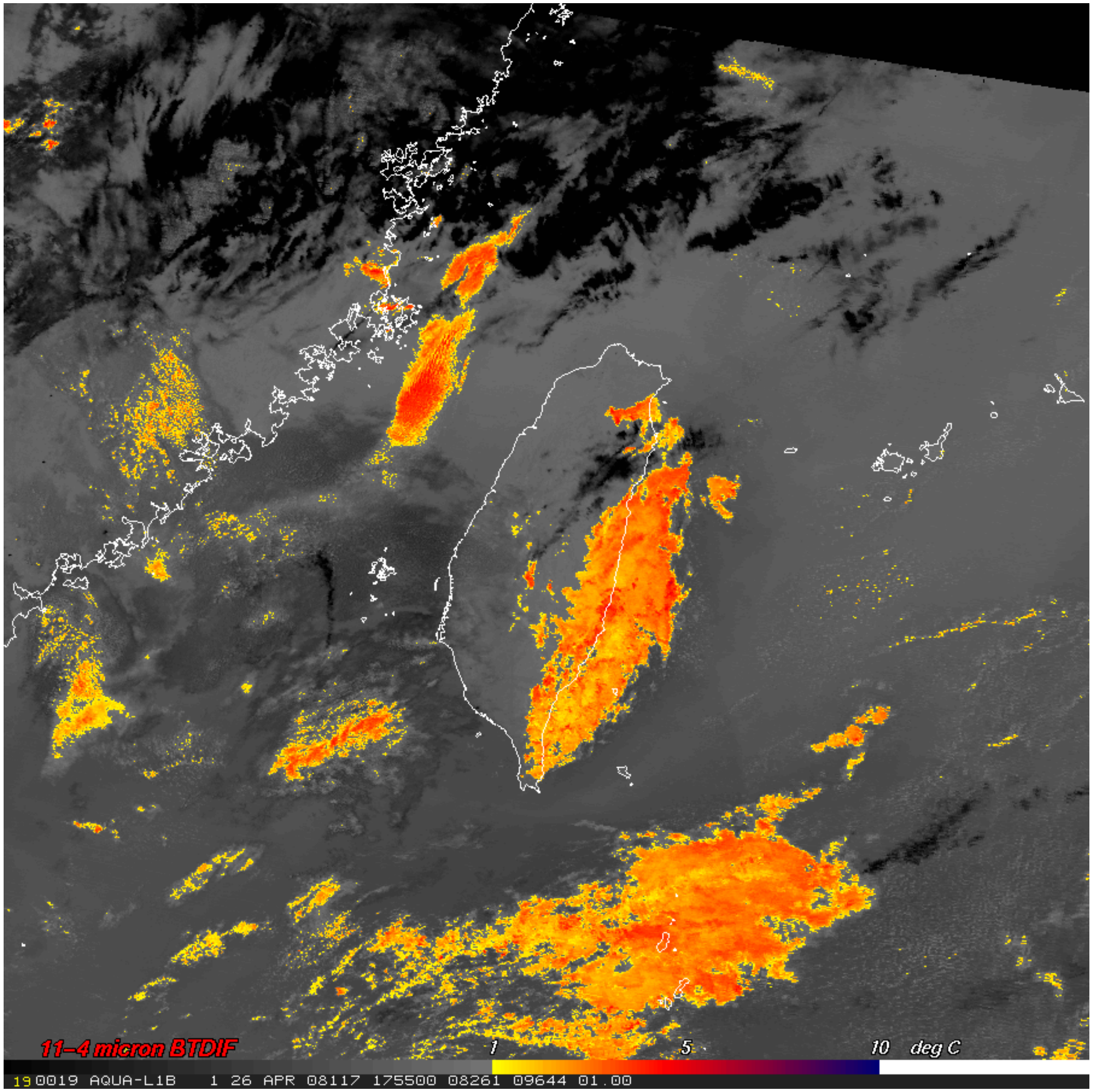
Algorithm Strengths

- Easy to implement
- Validated
  - Used by US National Weather Service for many years
- Provides nighttime information when:
  - No visible data
  - Temperatures of surface and cloud layers can be very close
- Implementation on Geo and Leo means it combines the strengths of both instruments
  - High temporal resolution of Geostationary
  - High spatial resolution of MODIS

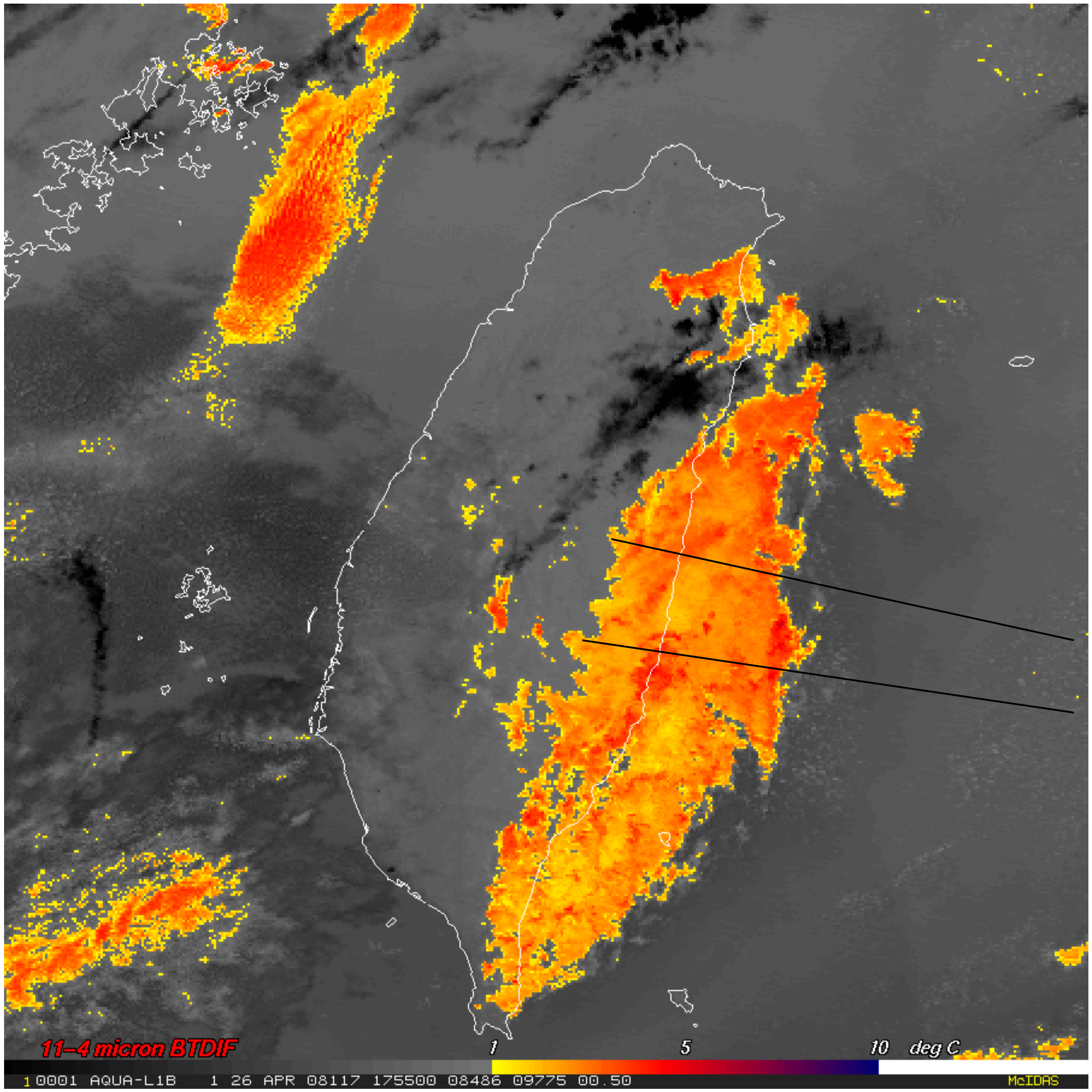
Example MTSAT Low Cloud Fog Product



Example MODIS Low Cloud Fog Product

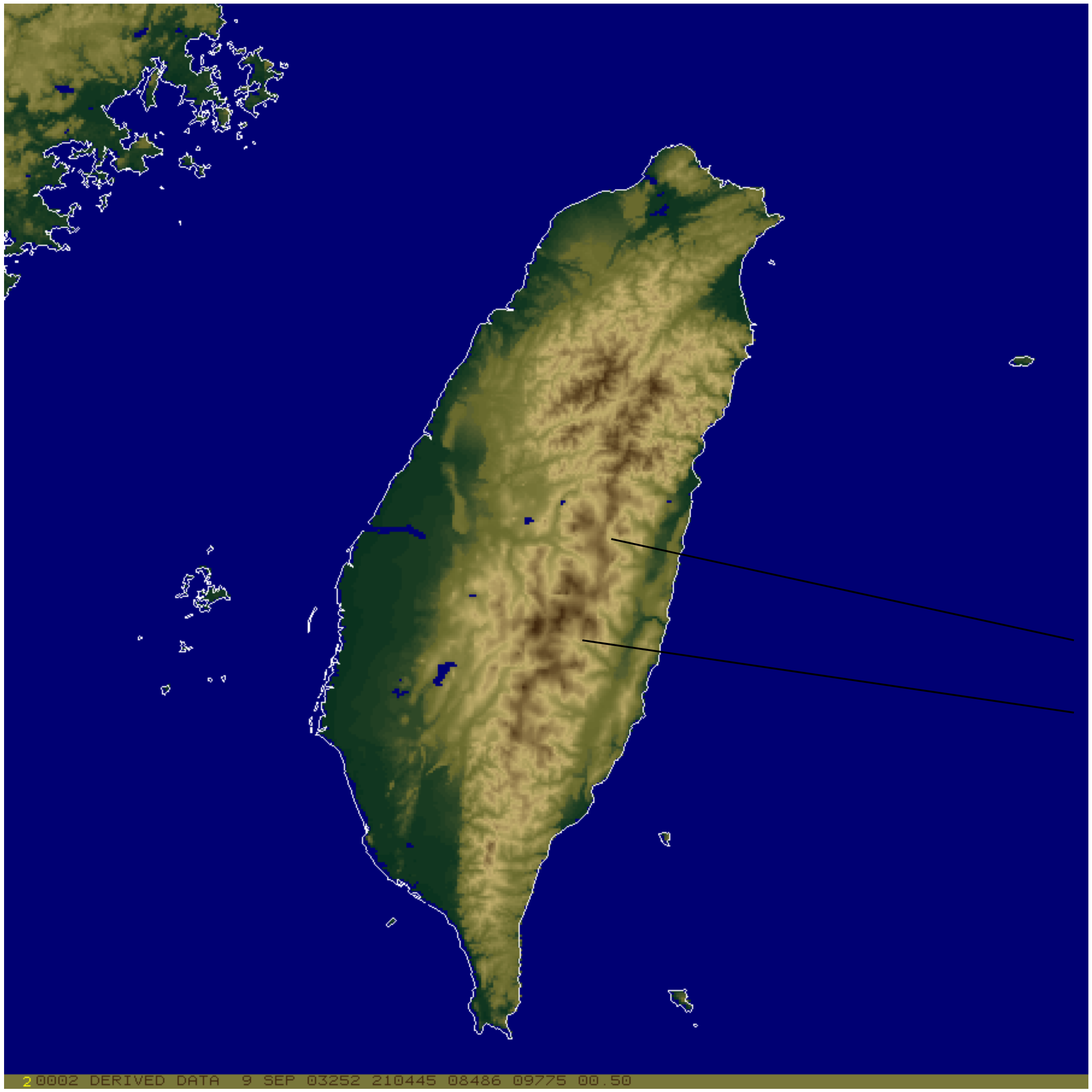


MODIS Fog and Topography



Fog entering into valleys

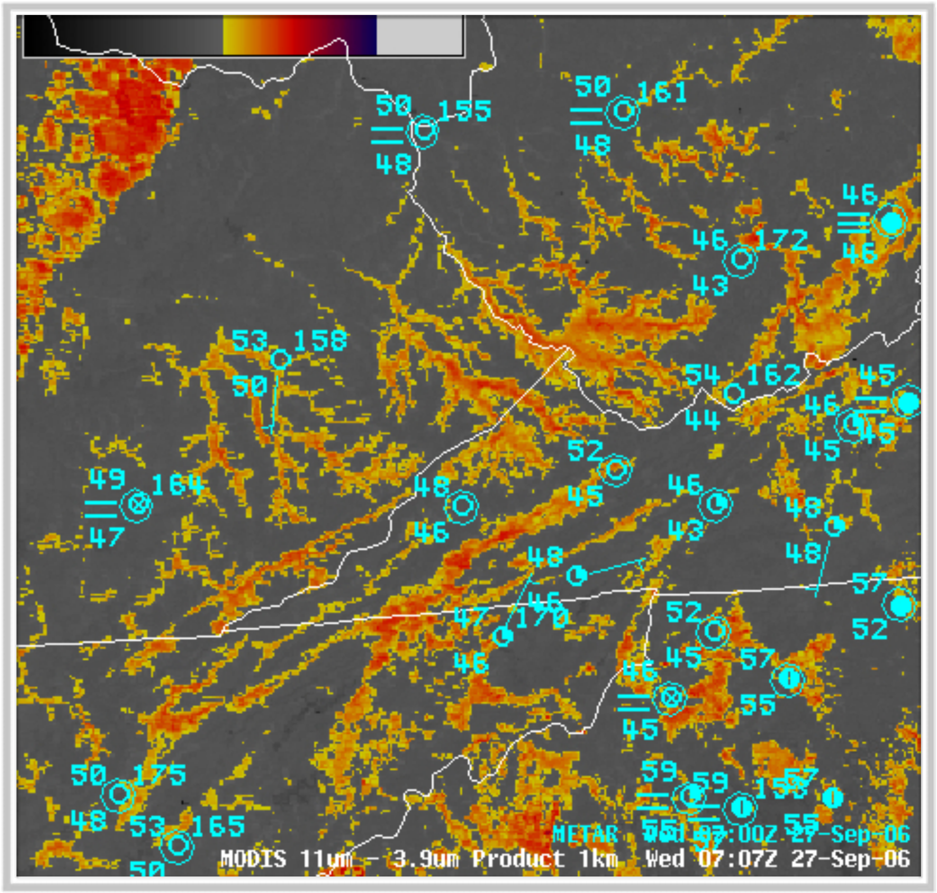
MODIS Fog and Topography



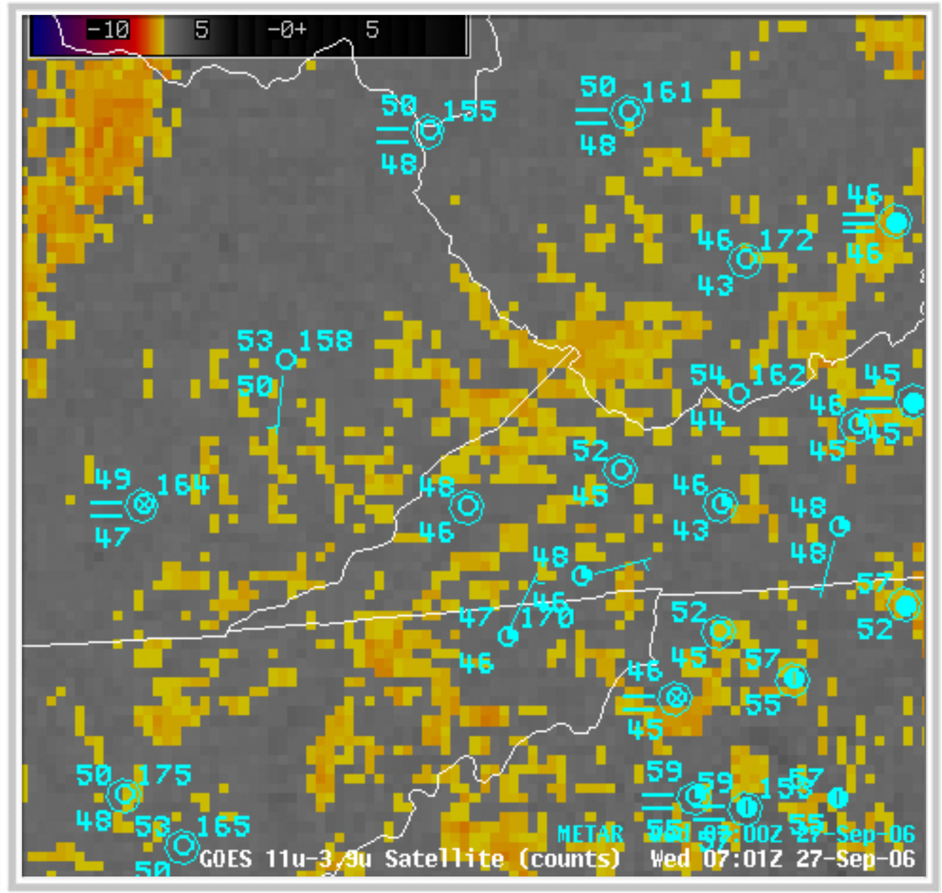
Fog entering into valleys

MODIS Imagery in AWIPS

Fog/stratus product (11.0μm - 3.7μm)



1-km MODIS



4-km GOES

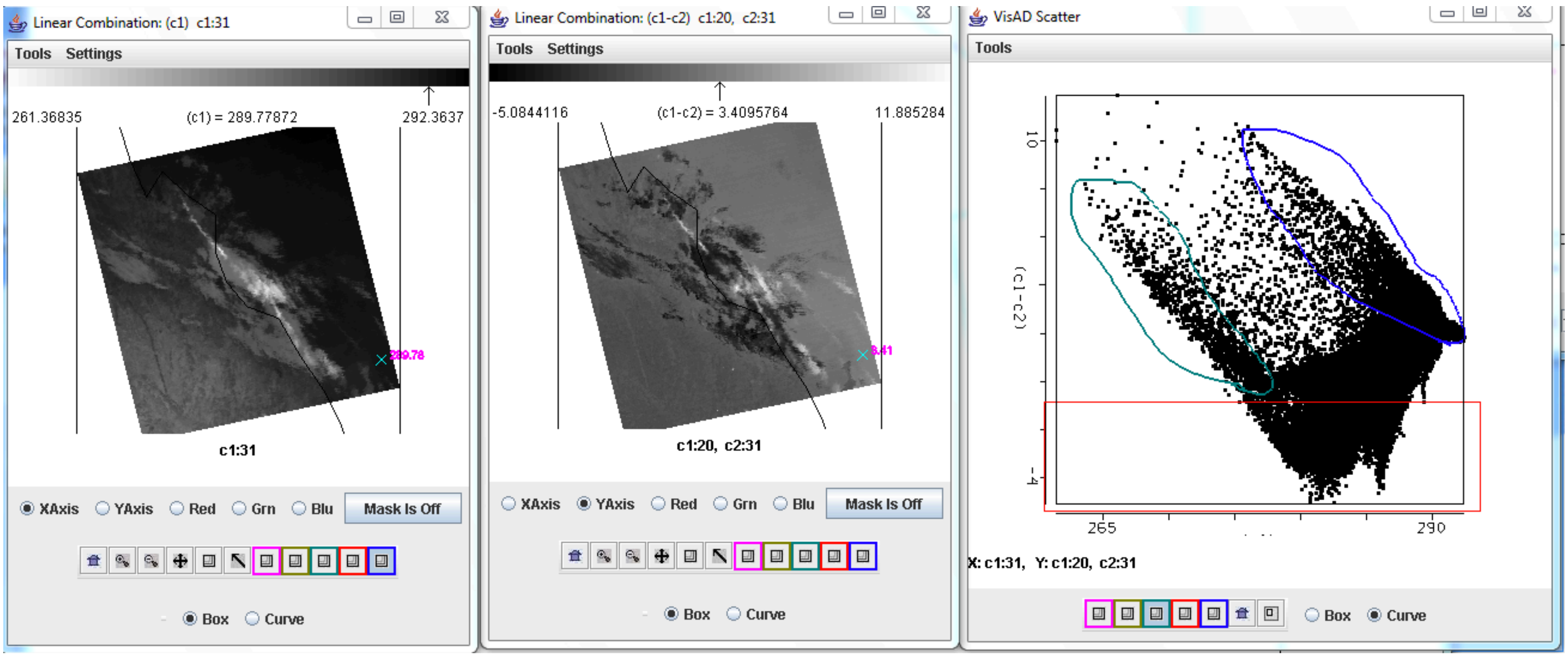
Improved fog/stratus detection capability

MODIS Products in AWIPS

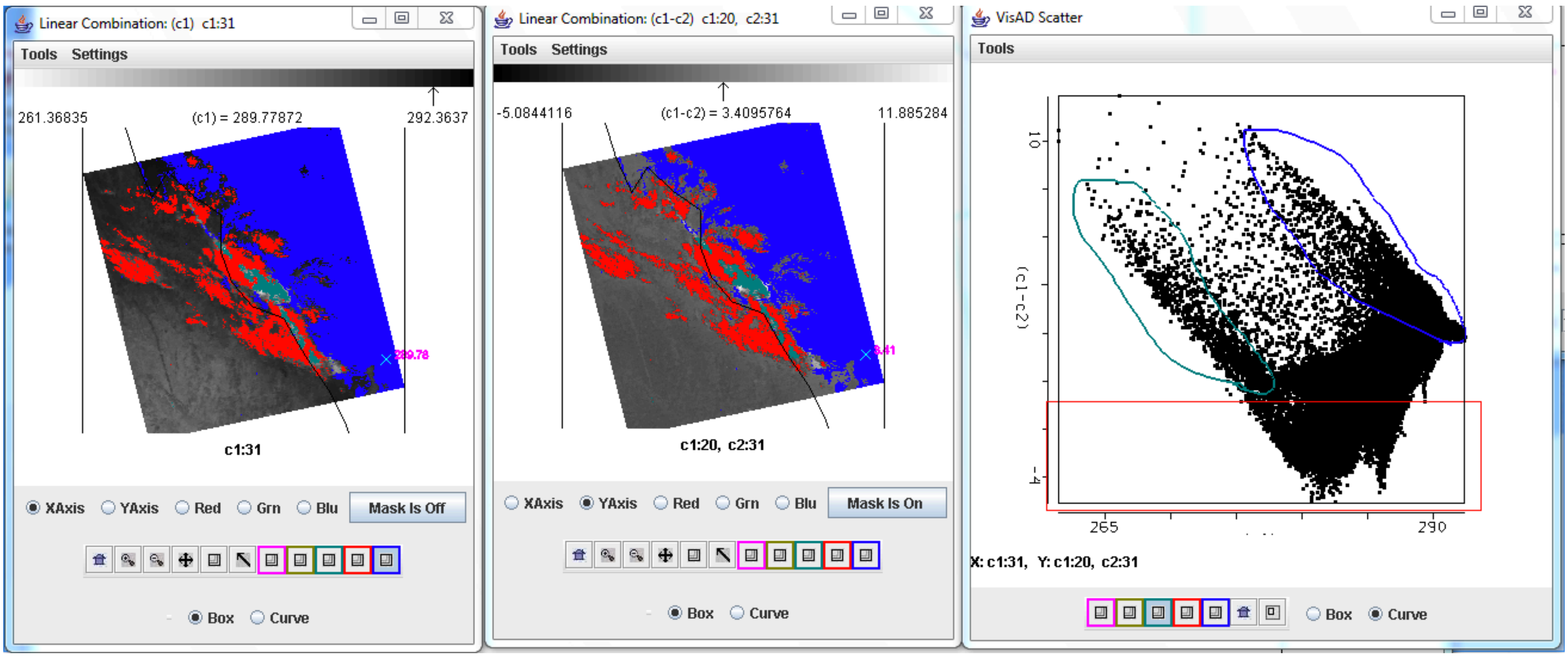
AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE STATE COLLEGE PA
526 AM EDT FRI SEP 16 2011

.NEAR TERM /UNTIL 6 PM THIS EVENING/...
EARLY AM MODIS 11-3.7UM IMAGERY SHOWING DENDRITIC PATTERN OF FOG IN THE DEEP RIVER VALLEYS OF THE ALLEGHENY MTNS. THE NORMALLY COLDER SPOTS NORTH OF I-80 COULD ACTUALLY SEE A FREEZE THIS AM. /JOHNSONBURG 31F AT 08Z/. HOWEVER...BASED ON CURRENT OBS...IT LOOKS LIKE THE VAST MAJORITY OF CENTRAL PA WILL BOTTOM OUT BETWEEN THE M30S AND L40S.

MODIS Fog Detection



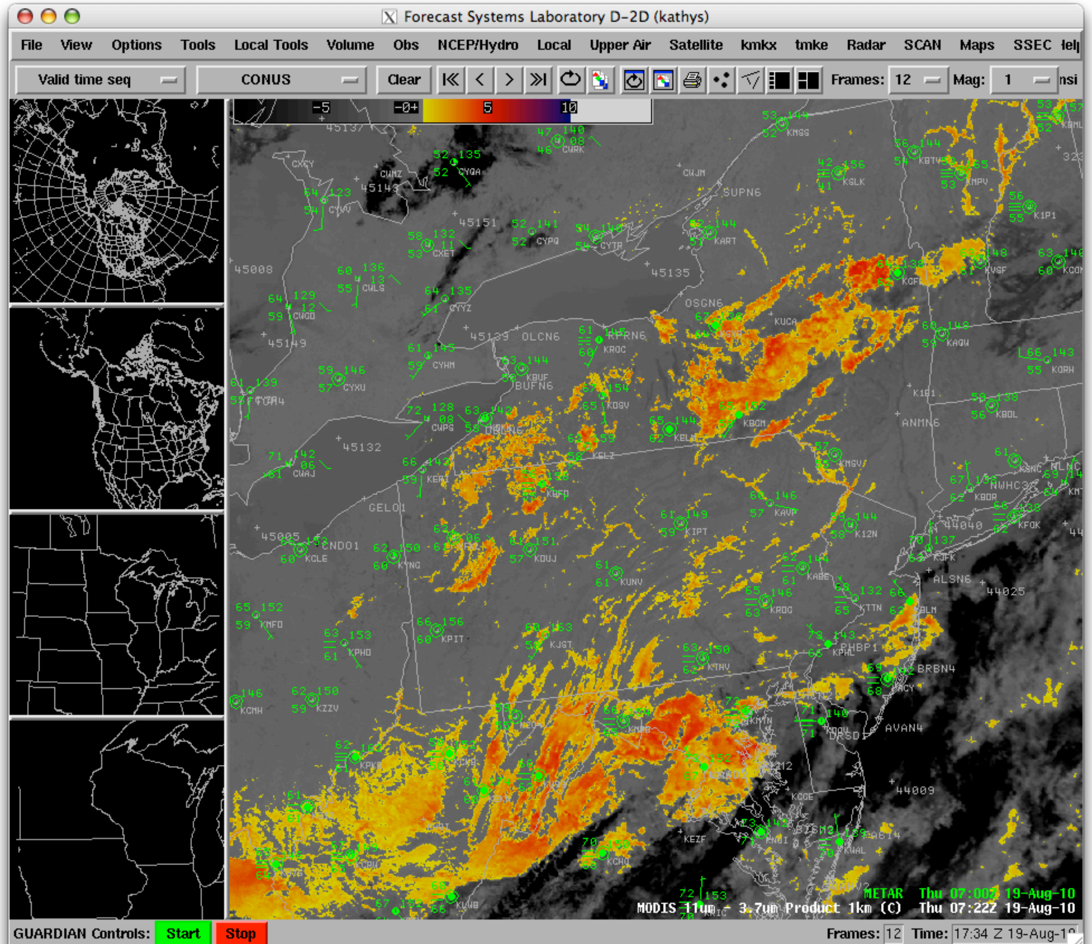
MODIS Fog Detection



Is This Product Useful?

- Operational Fog Detection System was Installed at the Taiwan Central Weather Bureau in November 2009

Recent AFD using MODIS



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.

http://shanghaiist.com/2011/02/23/27-car_pile_up_as_shanghai_hit_by_f.php

Most Visited WI_500M_RGB.JPG (J... http://cimss.ssec.wi... Getting Started Apple Personal MODIS DB Wx Technical

27-vehicle pile up as Shanghai hit...

OUR CITIES: London

shanghaiist

ADVERTISE DATING EVENTS PHOTOS VIDEOS JOBS WORK FOR US FACEBOOK TWITTER WEIBO SUMMARY

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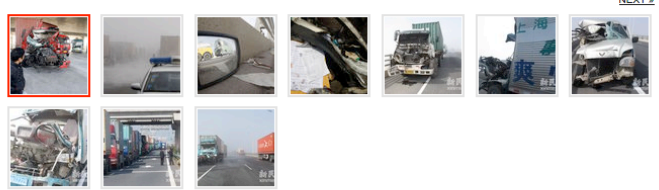
It seems you've come to us via a web search. Please consider bookmarking us, subscribing to our RSS feed, or checking out this week's most popular stories.

27-vehicle pile up as Shanghai hit by fog, 3 dead

NEXT »



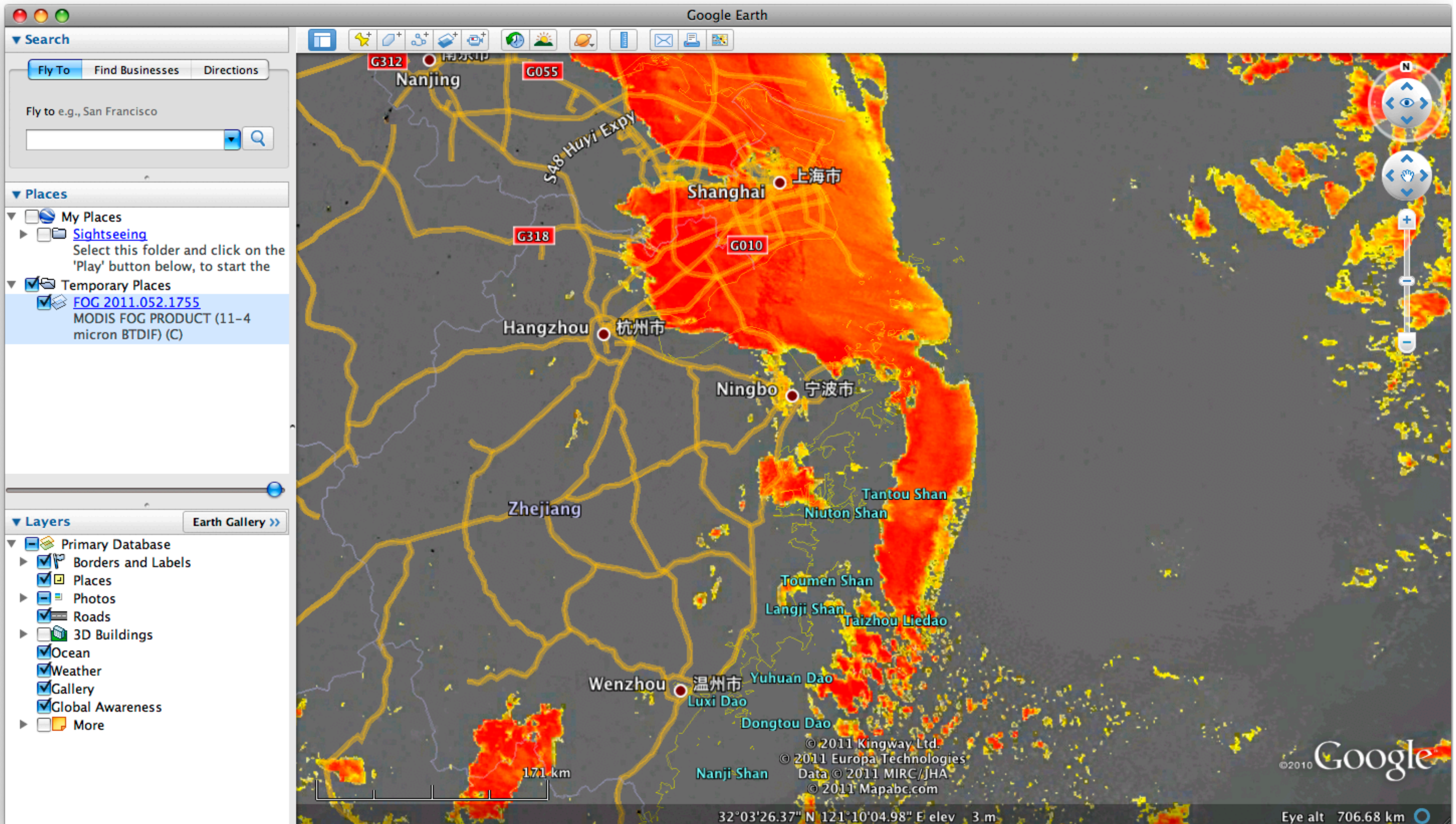
Yesterday morning at around 7am a massive pile up occurred on the Donghai Bridge connecting Shanghai to the port of Yangshan. Three people were killed and another 15 injured when a chain collision involving 27 vehicles resulted from Shanghai's worst fog in six months.

Visibility at the time of the accident was said to be less than 100 meters. Traffic resulting from the collisions eventually stretched for nearly 30 kilometers back towards Shanghai, and initially caused delays as rescue workers rushed to the scene. Helicopters were called in, but were ultimately unable to help because of the fog.

Most of the vehicles involved were container trucks. Two truck drivers and a bus driver lost their lives in the accident; the rest of the injured are in stable condition. Shanghai police had reduced speed limits on the highway to 50 km/h in anticipation of the fog the night before.

More fog is expected in the city today and tomorrow. Drive safe!

Fog Product in Google Earth



References

- Chaurasia, S., Sathiyamoorthy, V., Paul Shukla, B., Simon, B., Joshi, P. C. and Pal, P. K. (2011), Night time fog detection using MODIS data over Northern India. Meteorological Applications, 18: n/a.doi: 10.1002/met. 248

- Ellrod, Gary P. and A. Scott Bachmeier, 2003: Inter-comparison of GOES and MODIS Imagery in the Analysis of Fog and Stratus, 12 Conference on Satellite Meteorology and Oceanography, P1.15, Long Beach California.

- Eyre, J. R., J. L. Brownscombe, and R. J. Allam, 1984: Detection of fog at night using Advanced Very High Resolution Radiometer (AVHRR) imagery. Meteorological Magazine, 113, 266-275.

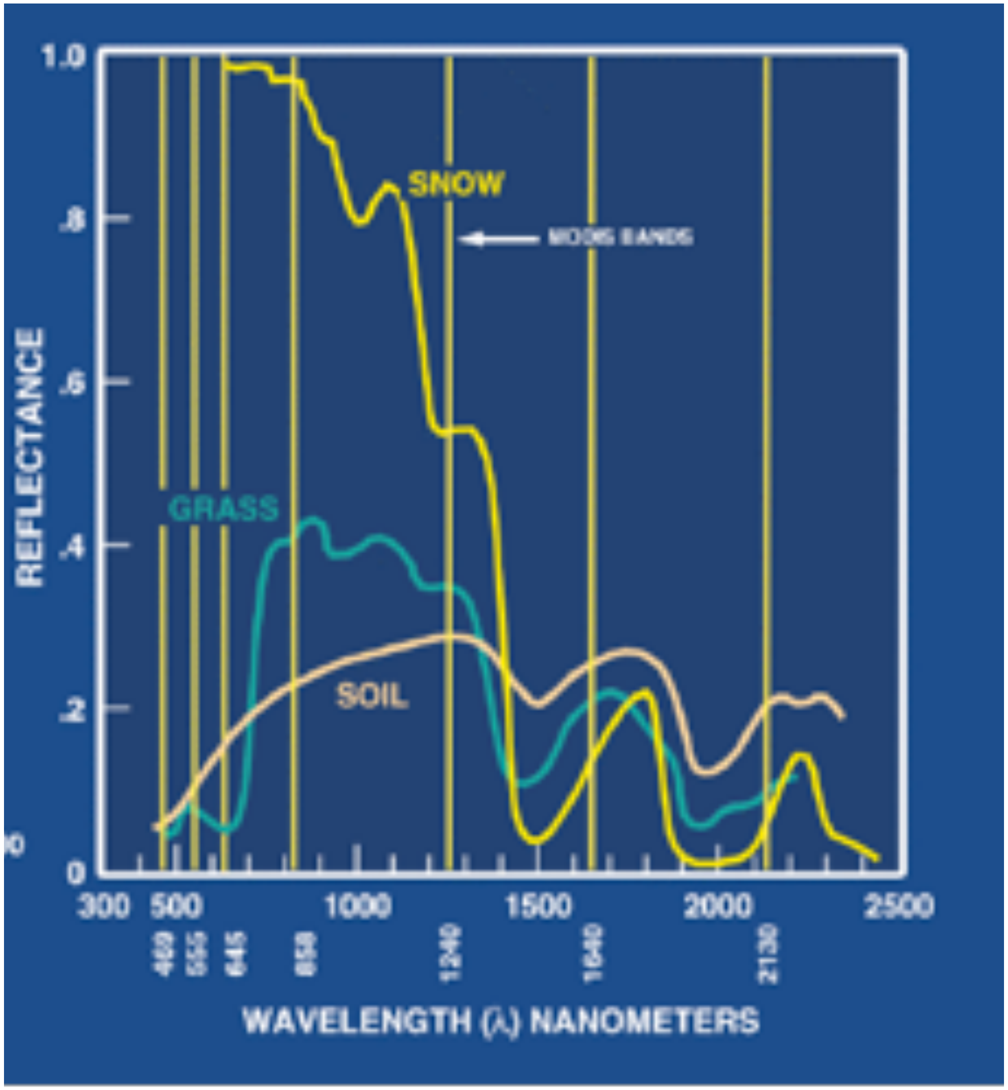
Snow and Ice Detection

Snow and Ice Detection

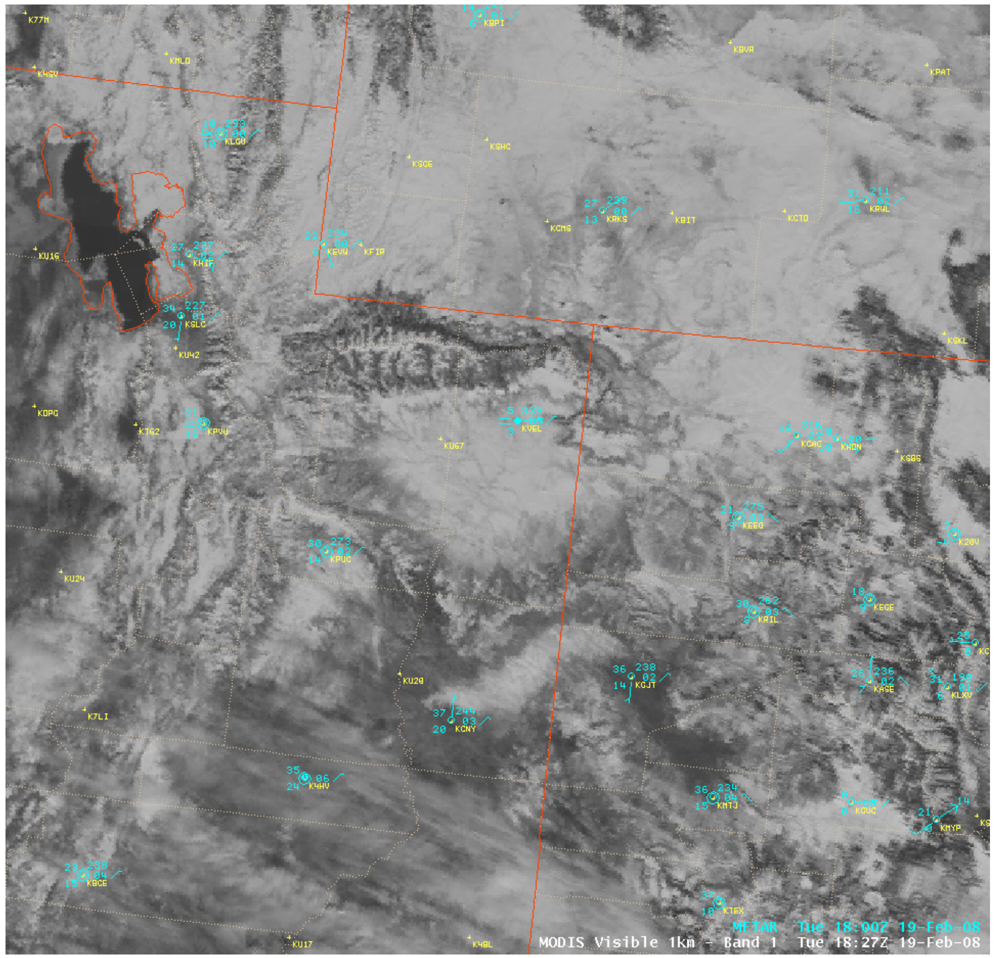
- Take advantage of change of absorption properties of snow and ice in visible and near-infrared region
- Normalized Difference Snow Index (NDSI)
  - similar to the normalized-difference vegetation index (NDVI)
  - Snow has strong visible reflectance but absorbs strongly in the short-wave IR
    - Band 4 (.56 µm) – Band 6 (1.6 µm) (or 7 -2.1µm for Aqua)

    - Band 4 (.56 µm) + Band 6 (1.6 µm) (or 7 - 2.1µm for Aqua)
  - Hall DK, Riggs GA, Salomonson VV. 1995. Development of methods for mapping global snow cover using Moderate Resolution Imaging Spectroradiometer (MODIS) data. *Remote Sensing of Environment* ***54: 127 – 140.***

MODIS – Snow/Ice and Ice Clouds



Discriminating Ice from Clouds

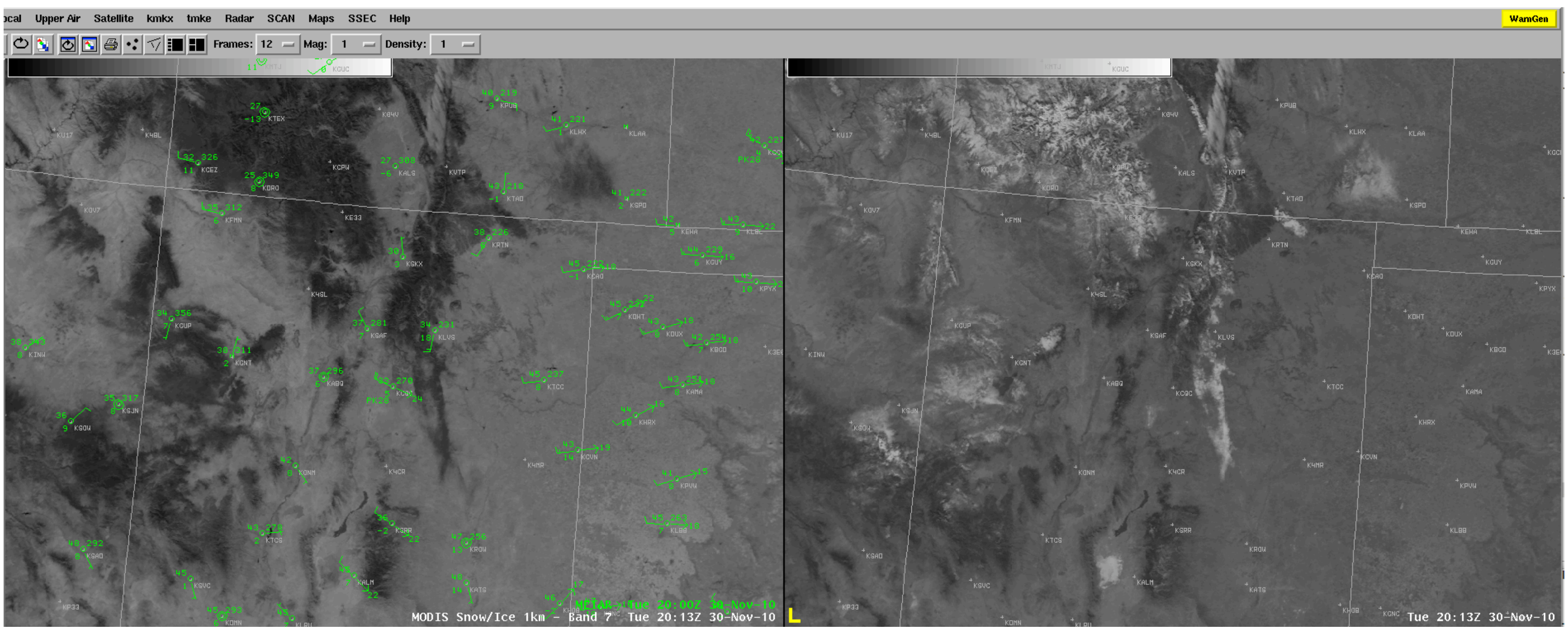


Why is this important?

Assessing Fire Danger

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

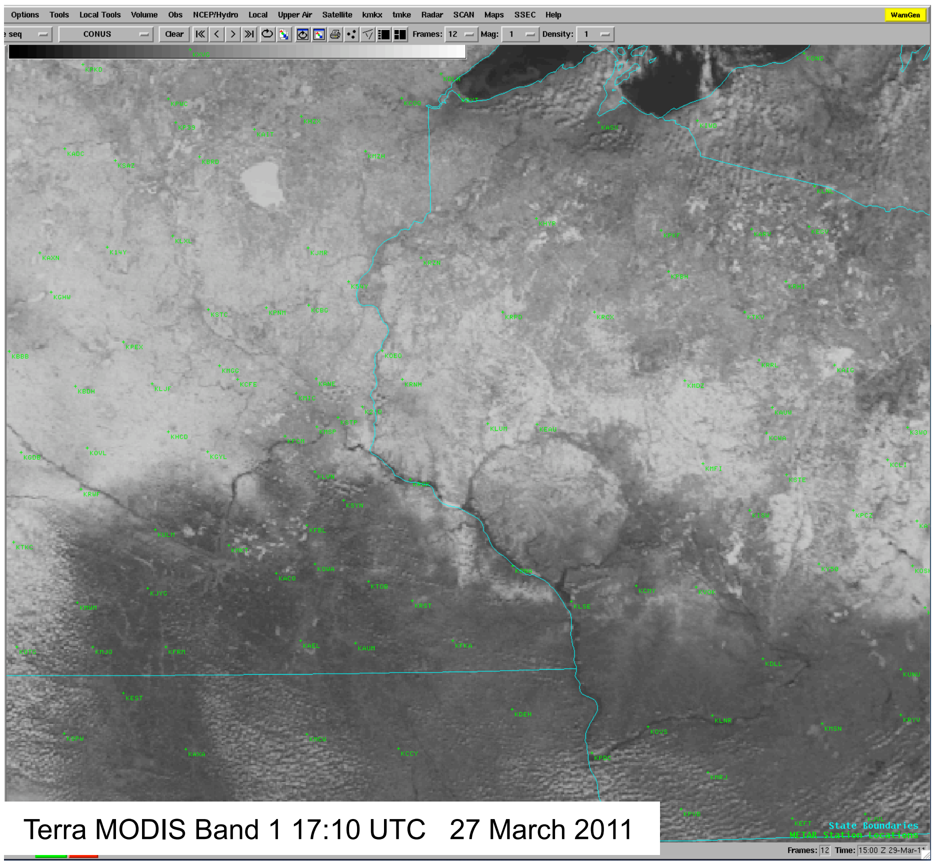
.FIRE WEATHER...ONLY MINOR CHANGES TO OVERALL FORECAST THROUGH THE WEEKEND. A 1016MB LEE TROUGH OVER THE PLAINS HAS ALLOWED WESTERLY DOWNSLOPE WINDS TO DOMINATE THE AREA...THUS TEMPS ARE MUCH WARMER AND WINDS SLIGHTLY BREEZIER. AN ISOLATED AREA OF MARGINAL CRITICAL FIRE WX CONDITIONS WILL DEVELOP BTWN 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.

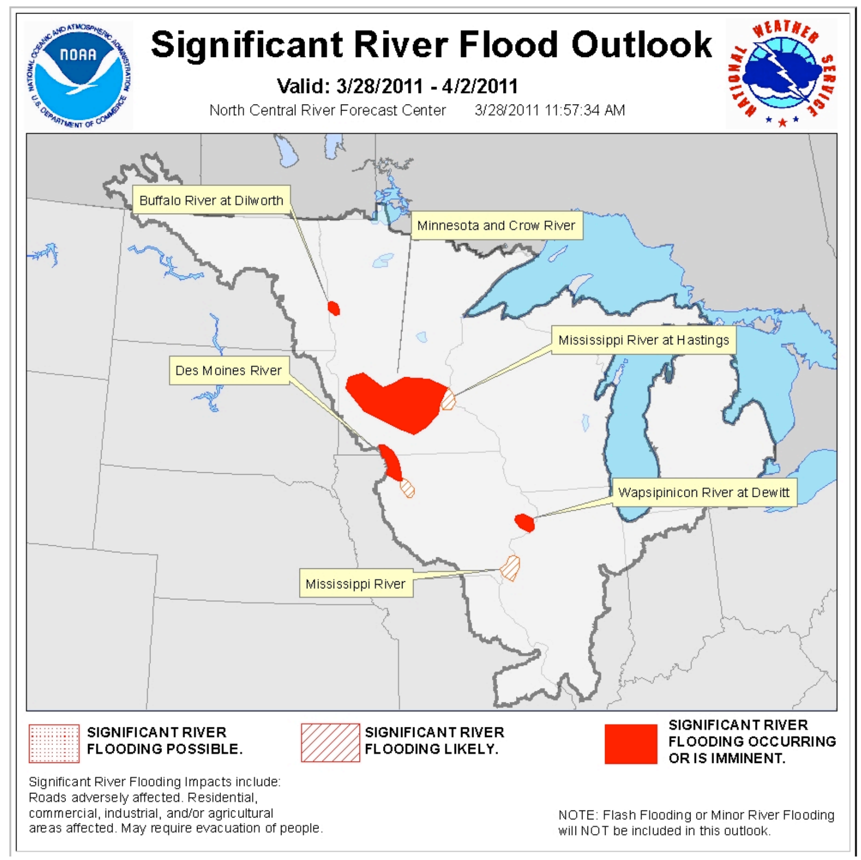


Flood Forecasting

AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE TWIN CITIES/CHANHASSEN MN
422 AM CDT TUE MAR 29 2011

HYDROLOGY...MODIS SATELLITE PASSES OVER THE PAST COUPLE DAYS SHOW LITTLE SNOW COVER IN SOUTHERN MN...SOUTH OF THE MINNESOTA RIVER. THE EXCEPTIONIS IN THE MINNESOTA RIVER VALLEY NORTHEAST OF A LINE FROM NEW ULM TO PIPESTONE...WHERE THE EFFECT OF LAST WEEKS SNOWFALL IS STILL QUITE EVIDENT. **LATEST NOHRSC 48-HR CHANGE IN SNOW WATER EQUIVALENT SHOWS BETWEEN A TRACE AND 0.20 INCH LOSS SINCE SATURDAY ACROSS ALLOF MN AND WI...DESPITE WELL BELOW NORMAL TEMPERATURES - THE LATE MARCH SUNSHINE IS PLAYING A ROLE IN THIS SLOW MELT…**





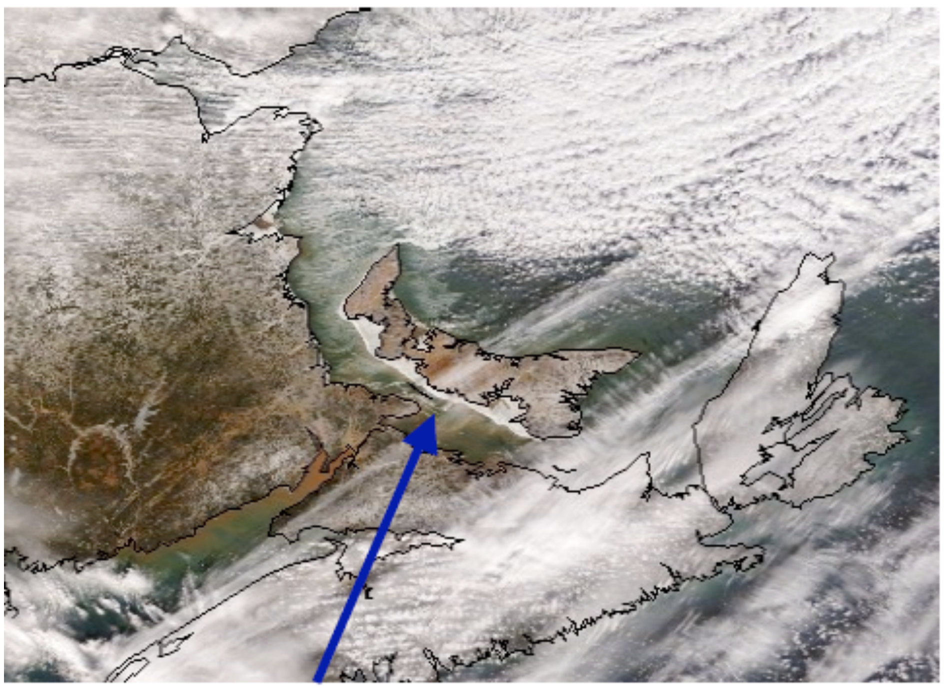
Canadian Ice Service integrates MODIS into operational data stream for ice monitoring

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

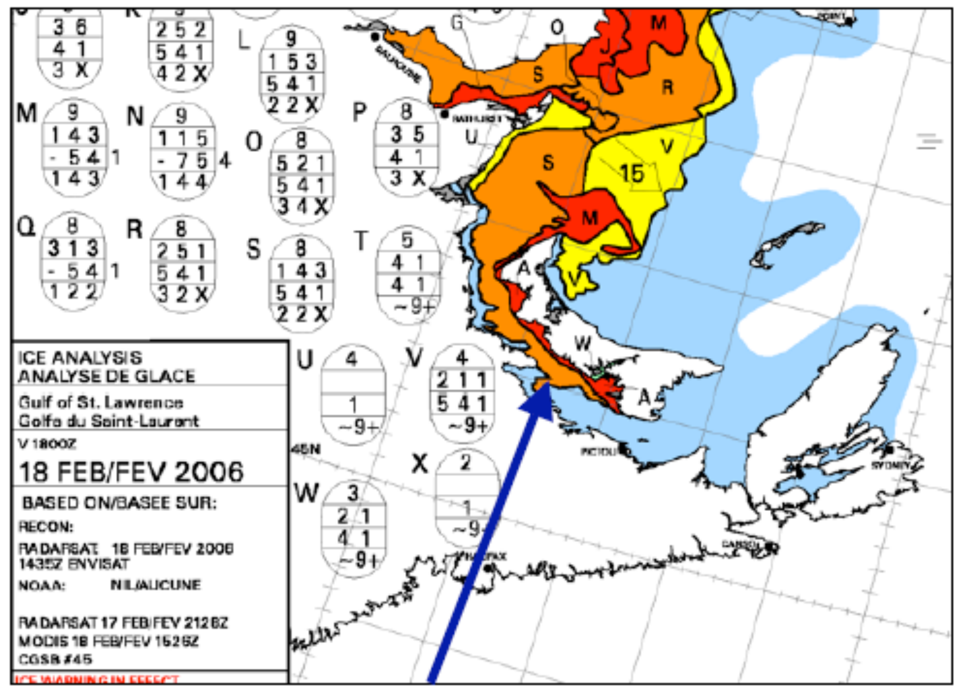
•MODIS supplements SAR data in clear sky conditions.

• 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

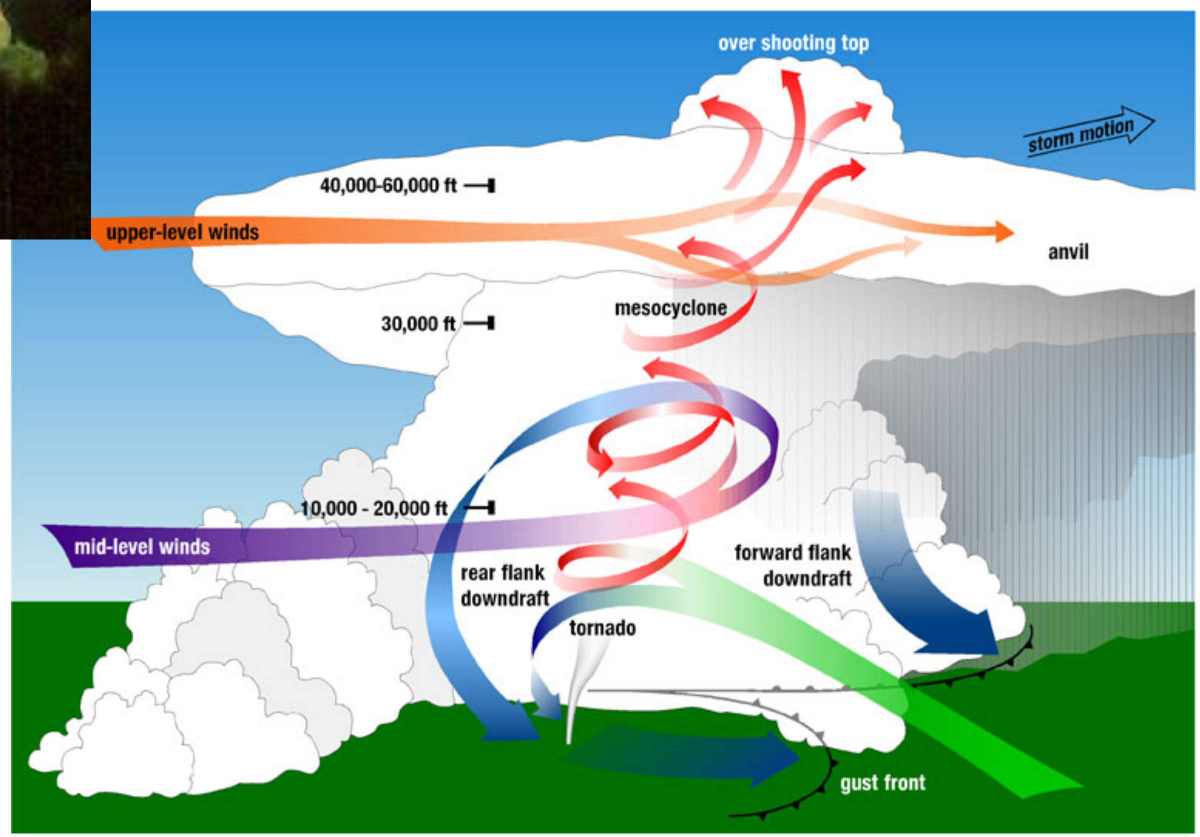
Severe Weather

Extreme Winds, Thunderstorms, Rainfall, Hail

Thunderstorms

- Characteristics of Severe Weather as Observed from Satellite
  – Overshooting Tops
  – Gravity Wave Generation

Overshooting Top

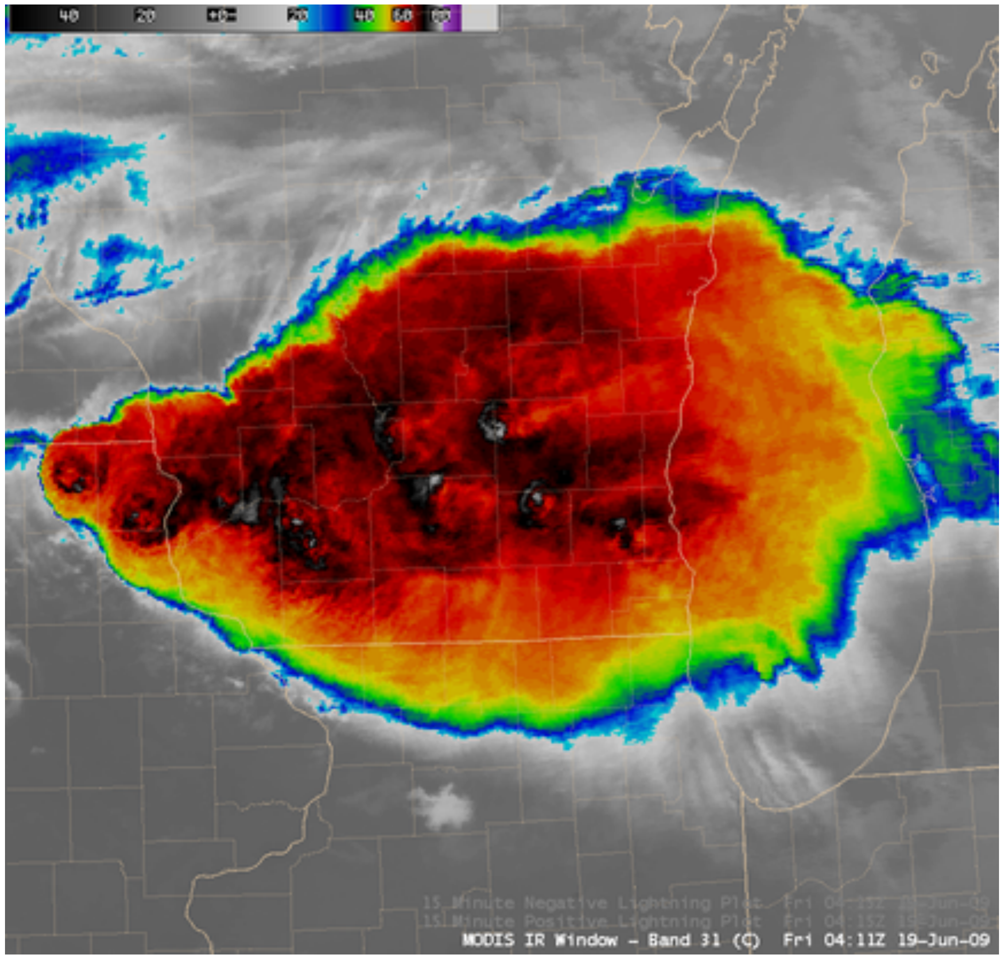


A dome-like protrusion above a thunderstorm anvil, representing a very strong updraft and hence a higher potential for severe weather with that storm. A persistent and/or large overshooting top often is present on a supercell.

Severe Thunderstorm Example 1

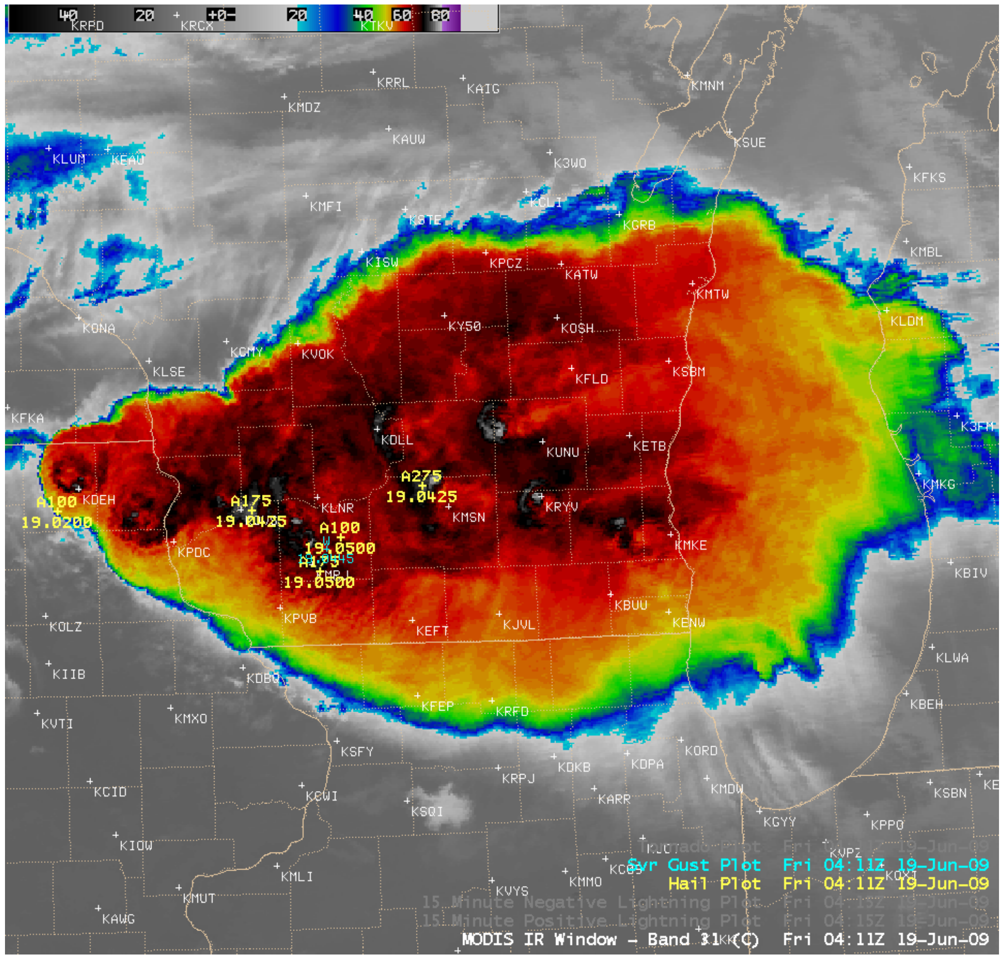
Including
Lightning
Detection

04:11 UTC
19 June 2009



During the 15-minute interval ending at 04:15 UTC this storm produced over 900 lightning strikes

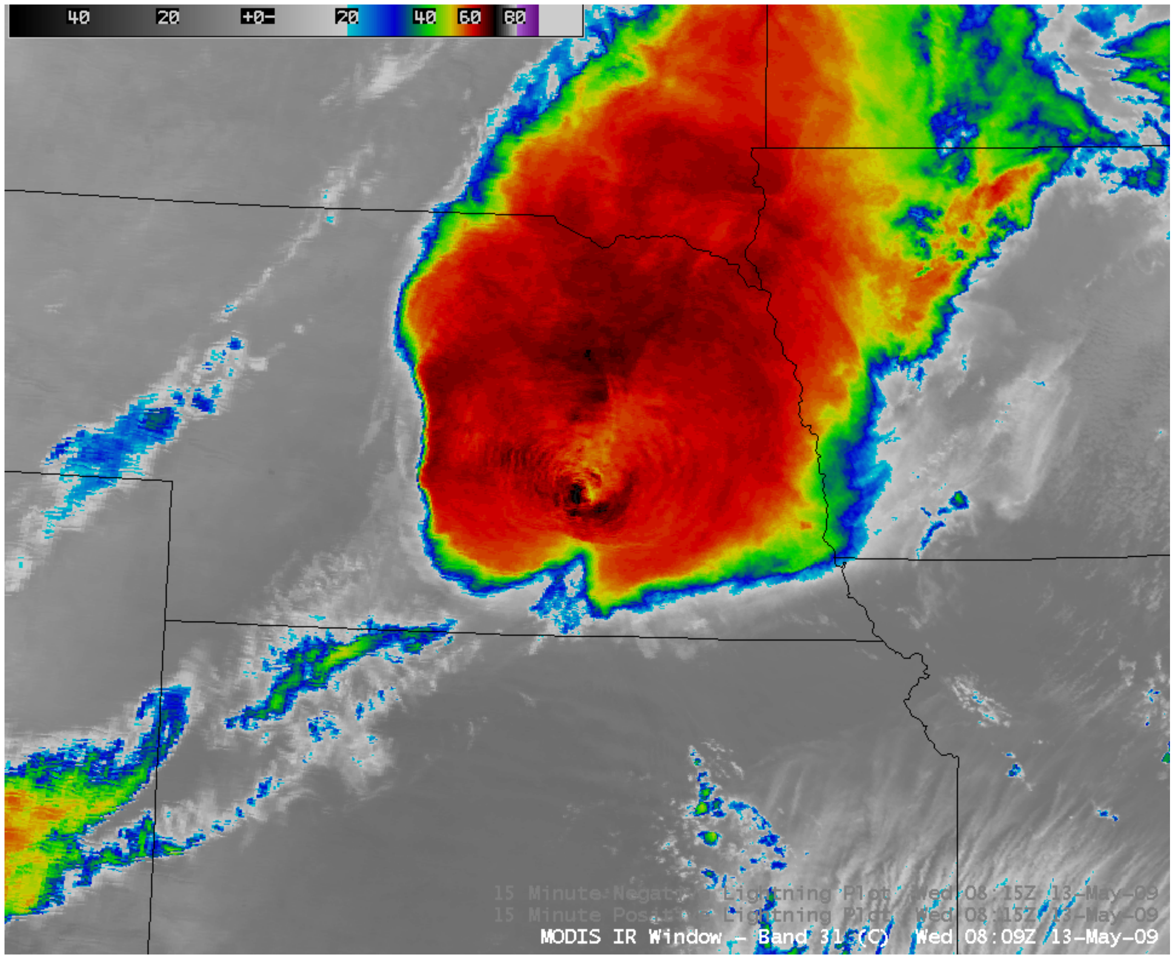
Severe Thunderstorm Example 1



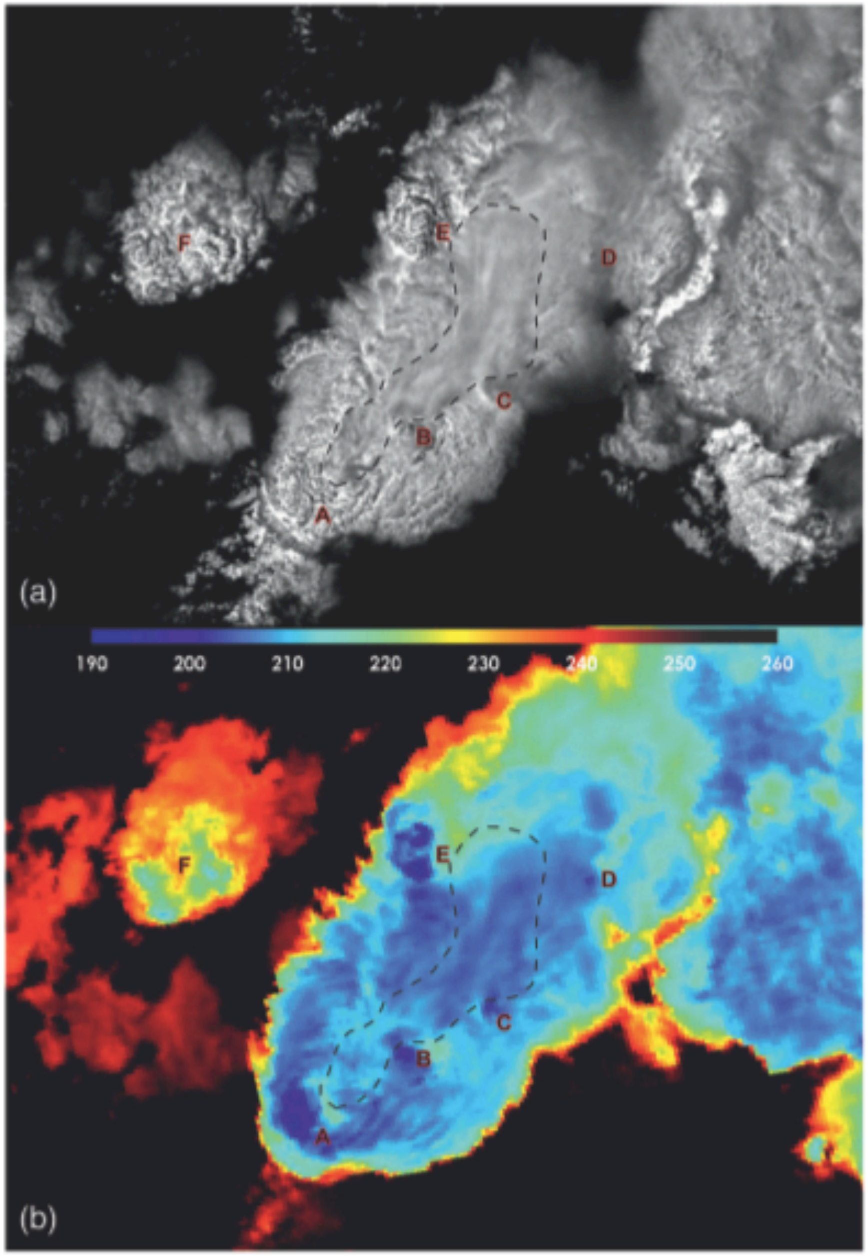
Including Severe Winds and Hail Reports
04:11 UTC
19 June 2009

During the 15-minute interval ending at 04:15 UTC this storm produced over 900 lightning strikes

Severe Thunderstorm Case 2

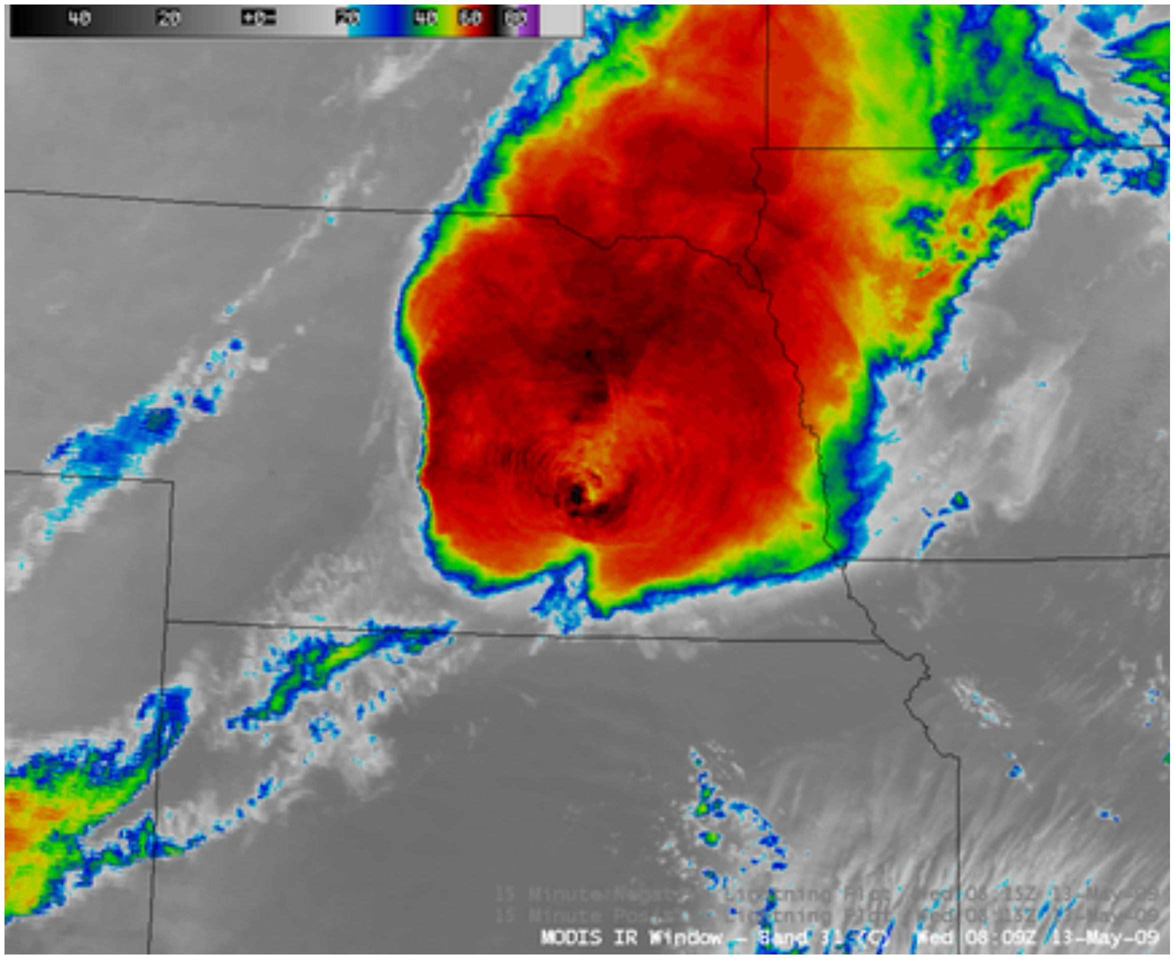


Including Lightning and Hail Reports 13 May 2009



Bedka, K., Brunner, J., Dworak, Feltz, W., Otkin, J. and T. Greenwald: 2010. Objective Satellite-Based Detection of Overshooting Tops Using Infrared Window Channel Brightness Temperature Gradients, Journal of Applied Meteorology and Climatology, Vol. 49, pp. 181-202.

Severe Thunderstorm Case 2

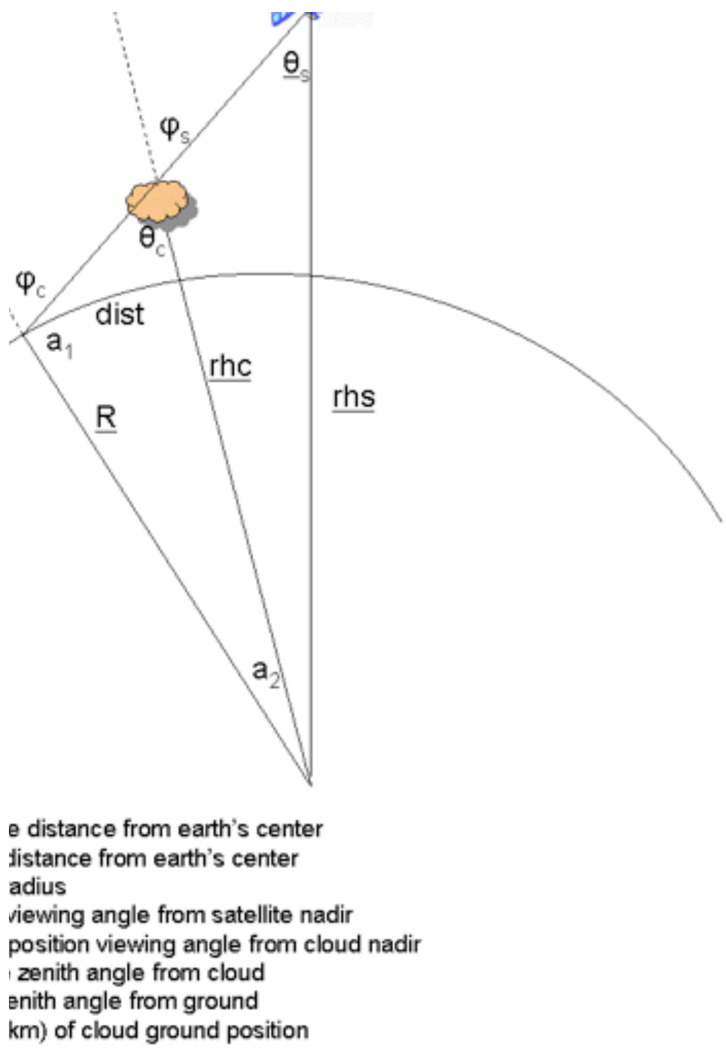


Comparison
MODIS
versus
GOES
13 May 2009

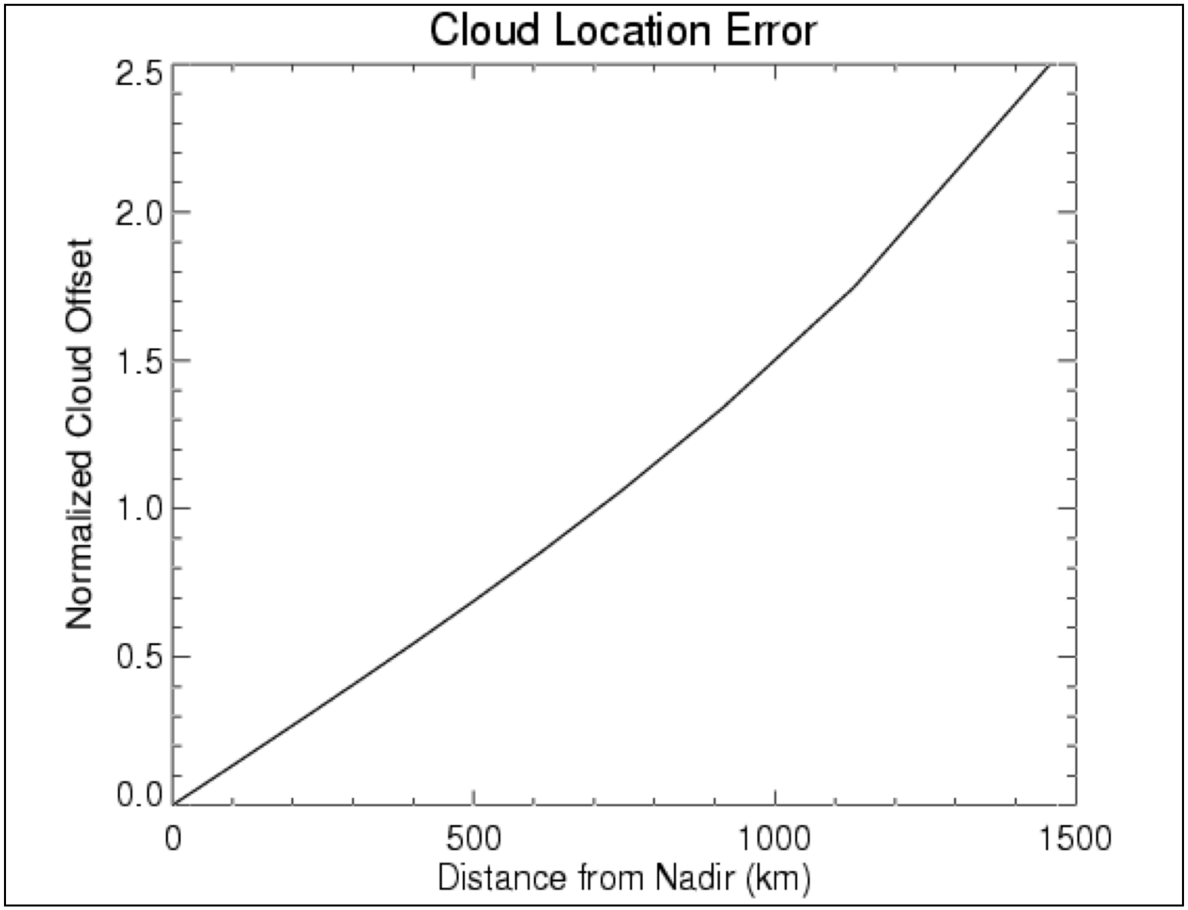
Parallax

- The apparent displacement of a feature above ground that results from non-nadir viewing angles.
- Fortunately, there has been shown to be a relationship between cloud displacement, cloud height and distance from nadir
- Cloud top pressure (hPa) is part of the MOD06 product, and cloud height will be a part of the collect 6 product

Schematic Diagram of the Geometry used in Parallax Correction



Estimating Parallax Error
Dave Santek



So if you have a cloud at a pixel that was 1000 km from nadir, the parallax correction would be 1.5 x the height of the cloud. Ex: 4 km x 1.5 = 6 km   10 km x 1.5=15 km

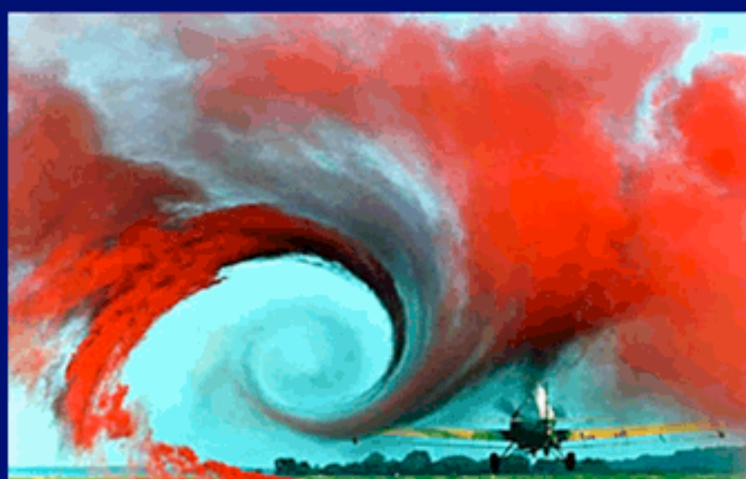
Aviation Applications

Turbulence, Clouds, Ash Detection

Atmospheric Turbulence

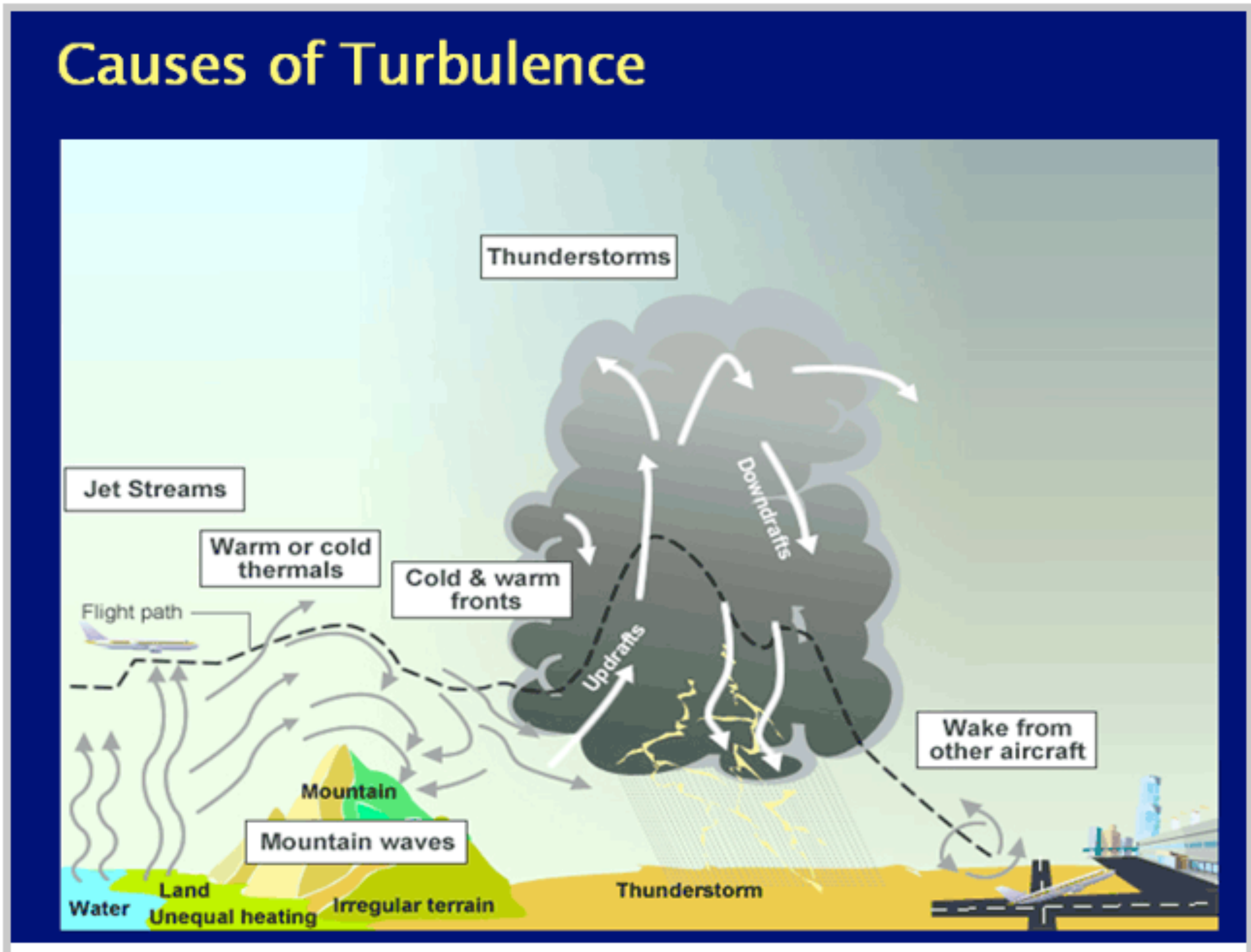
What is Turbulence?

This smoke pattern shows turbulence as rapid, abrupt and chaotic changes in the speed and direction of air flow.

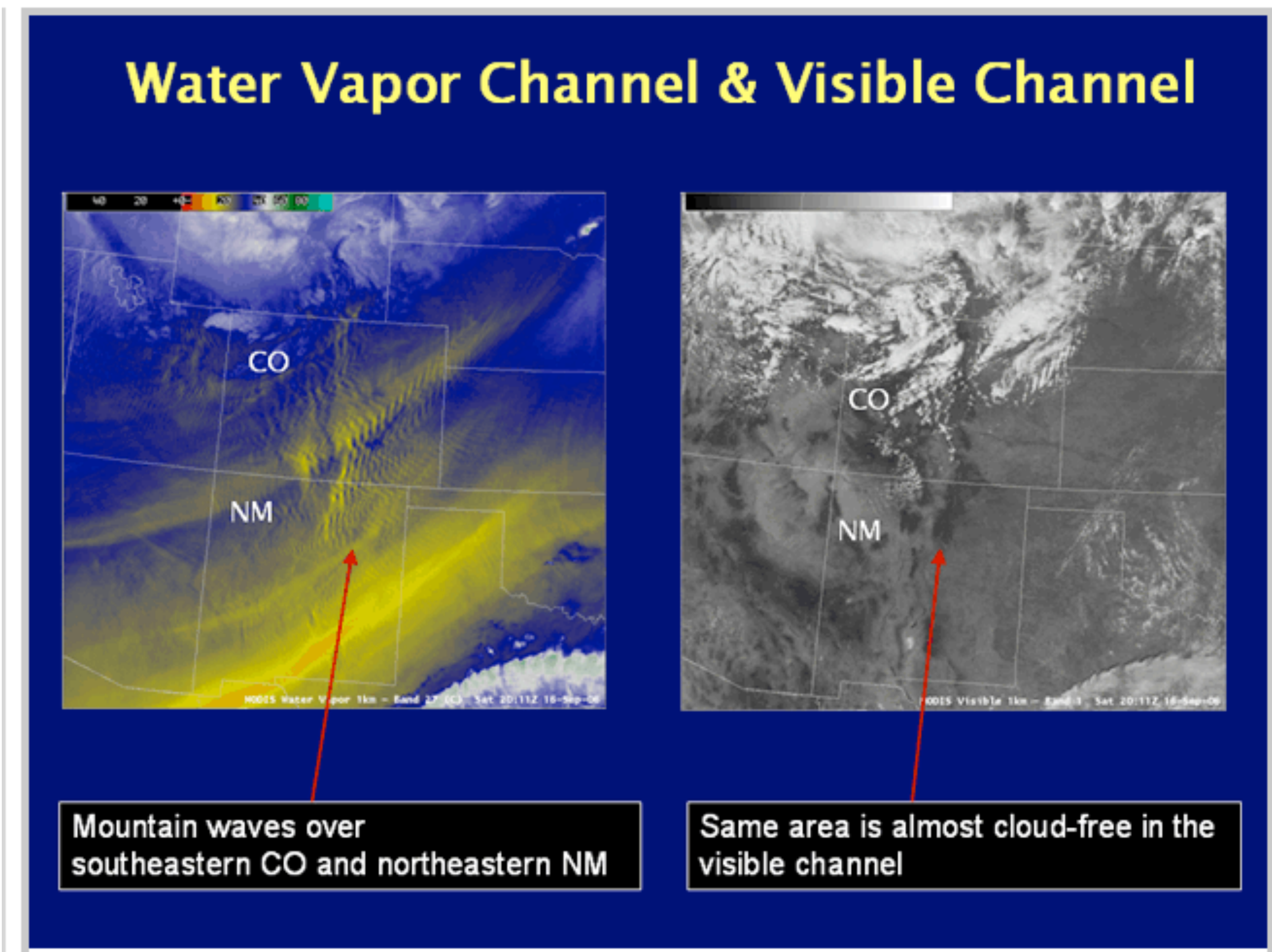


Colored smoke is used to show “wake turbulence” generated by an aircraft upon take-off or landing.

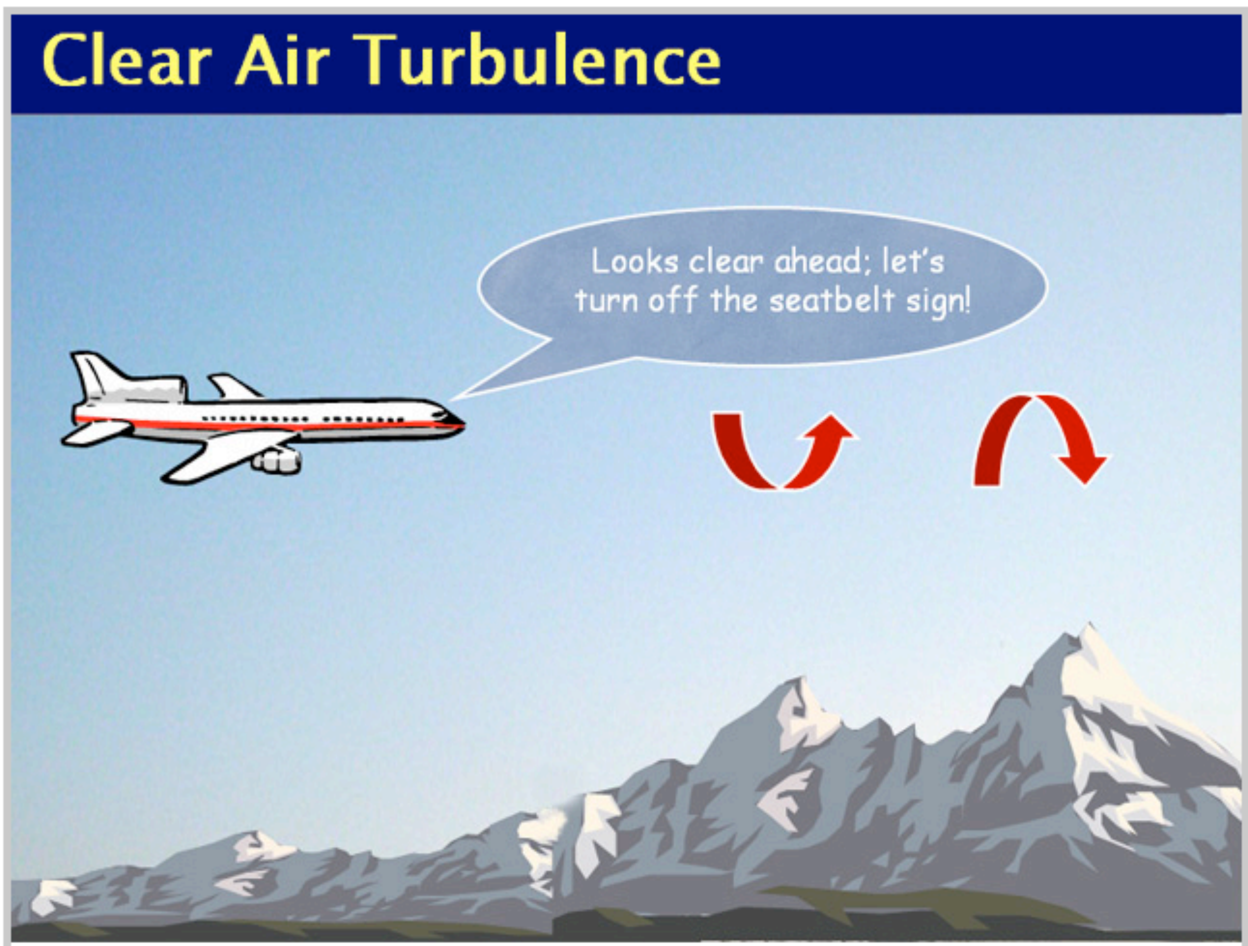
Atmospheric Turbulence



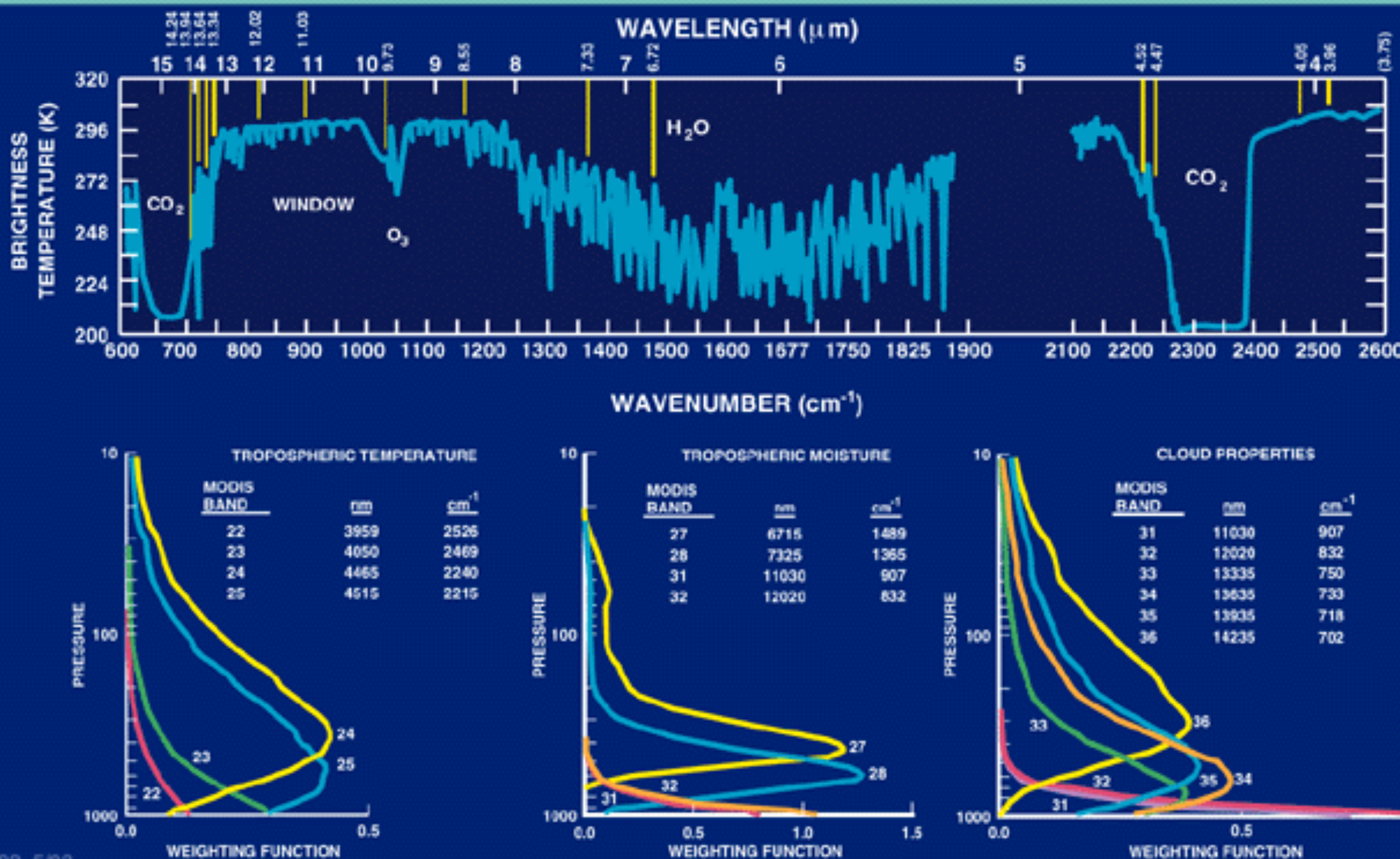
Why is 6.7 μm Important for the Detection of Turbulence?



Why is This Important?

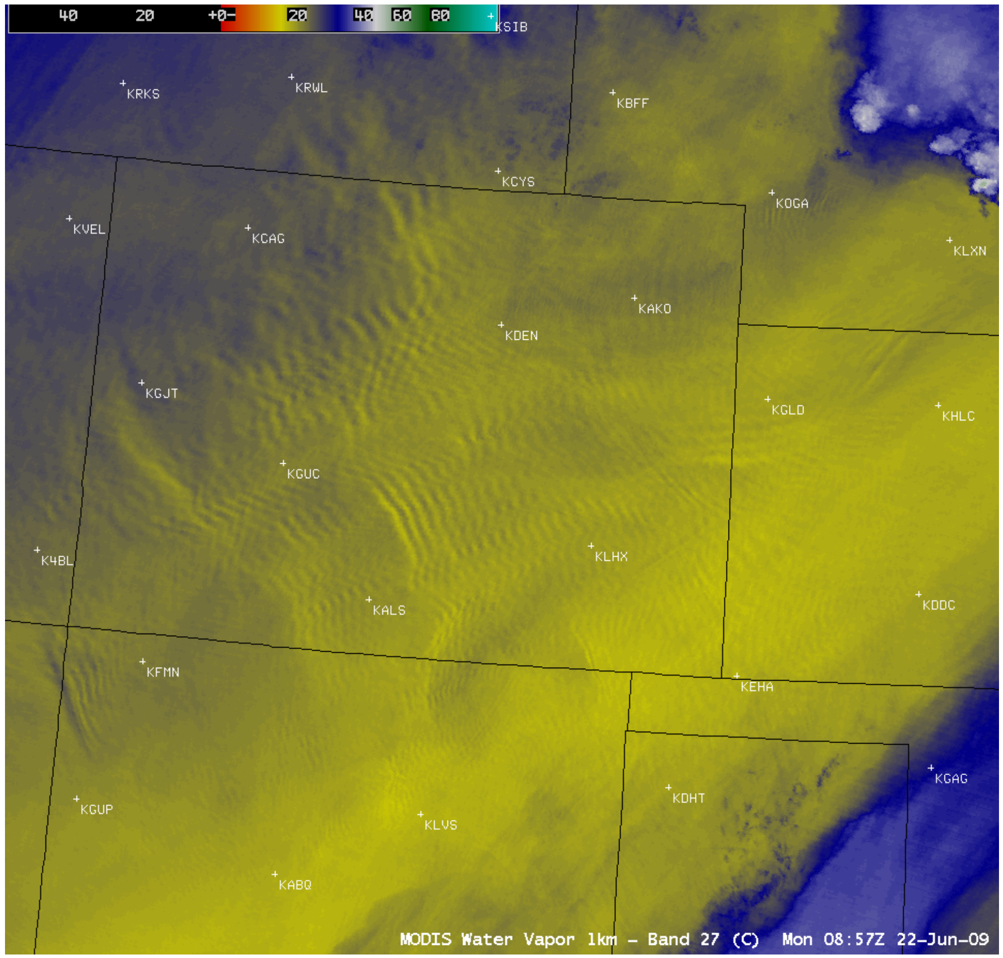


ATMOSPHERE - THERMAL RADIATION

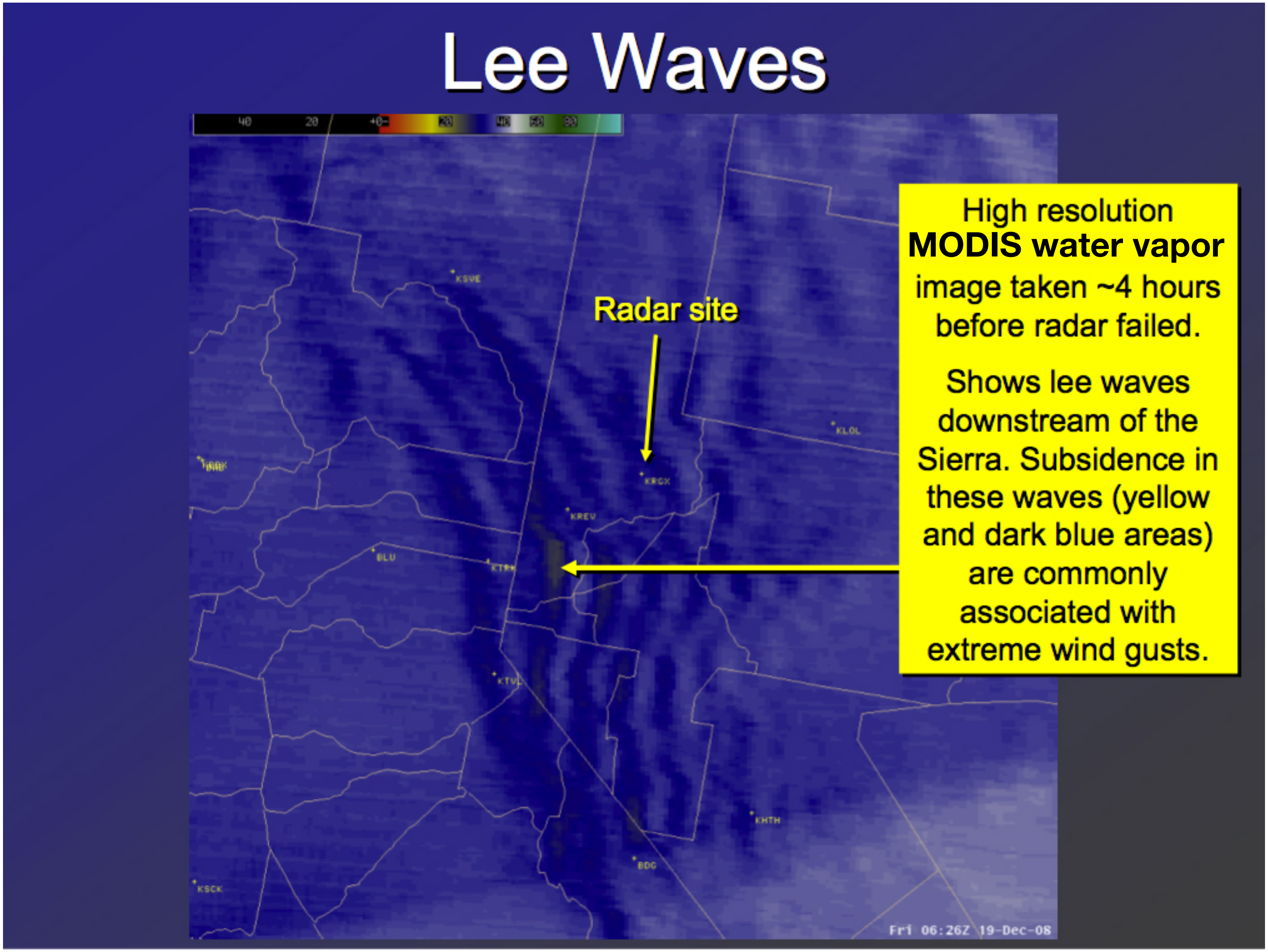


E351.002 5/93

Mountain Wave Clouds in Clear Air



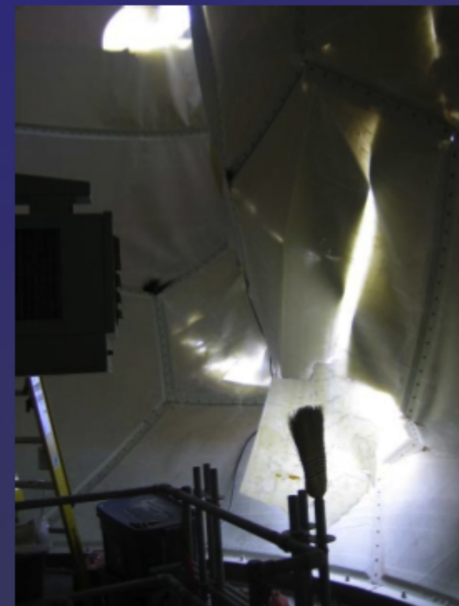
MODIS and
GOES
08:57 UTC
22 June 2009

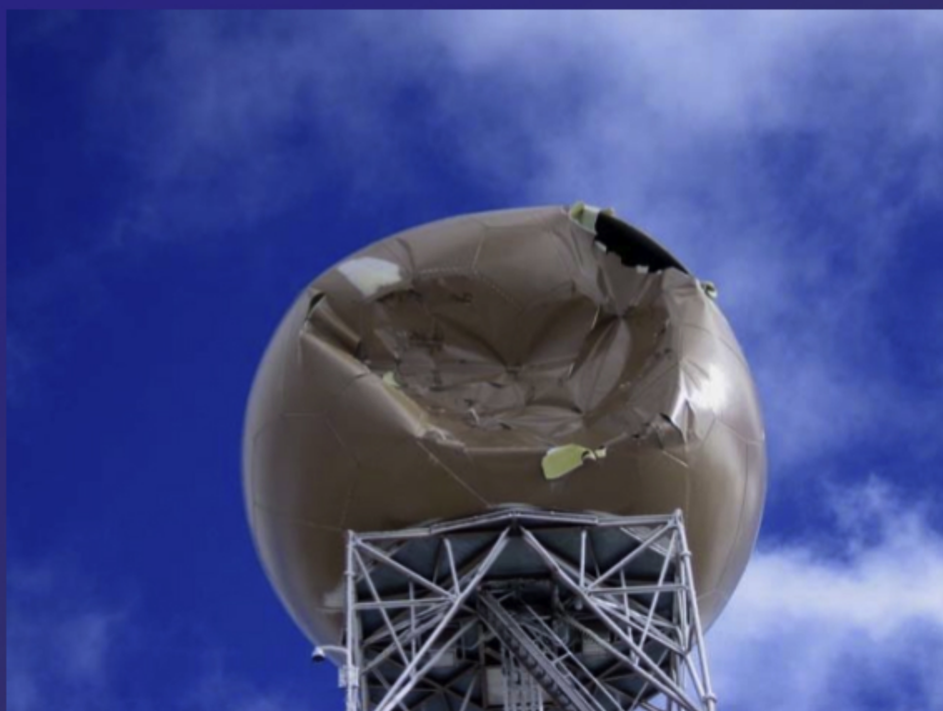


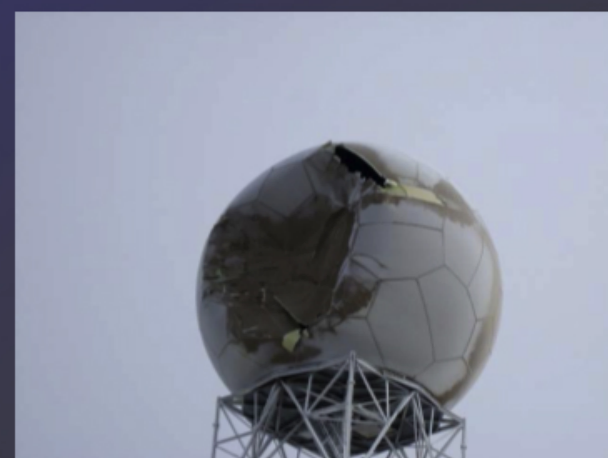
(credit: NWS forecast office, Reno NV)

Photos

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



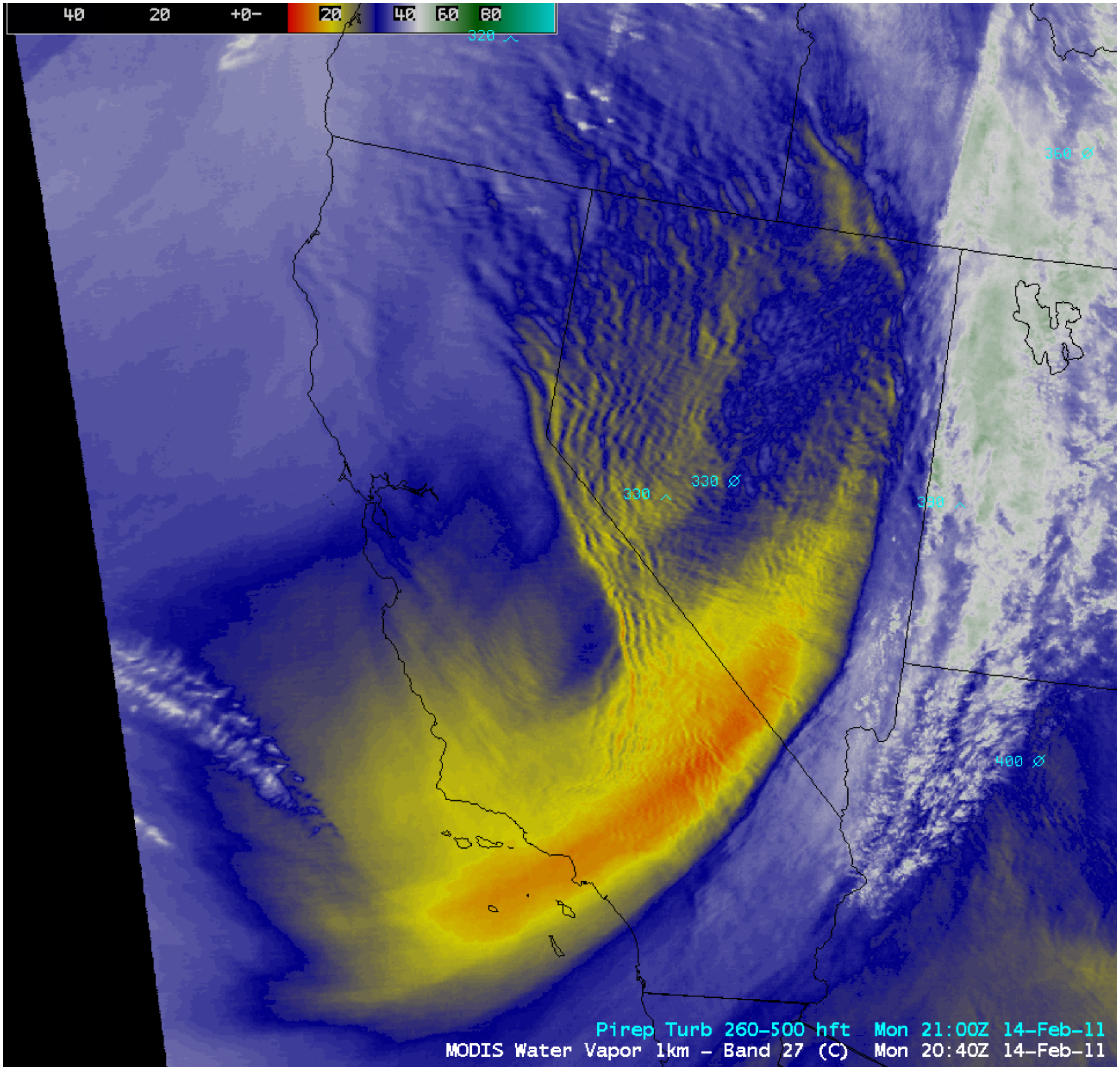




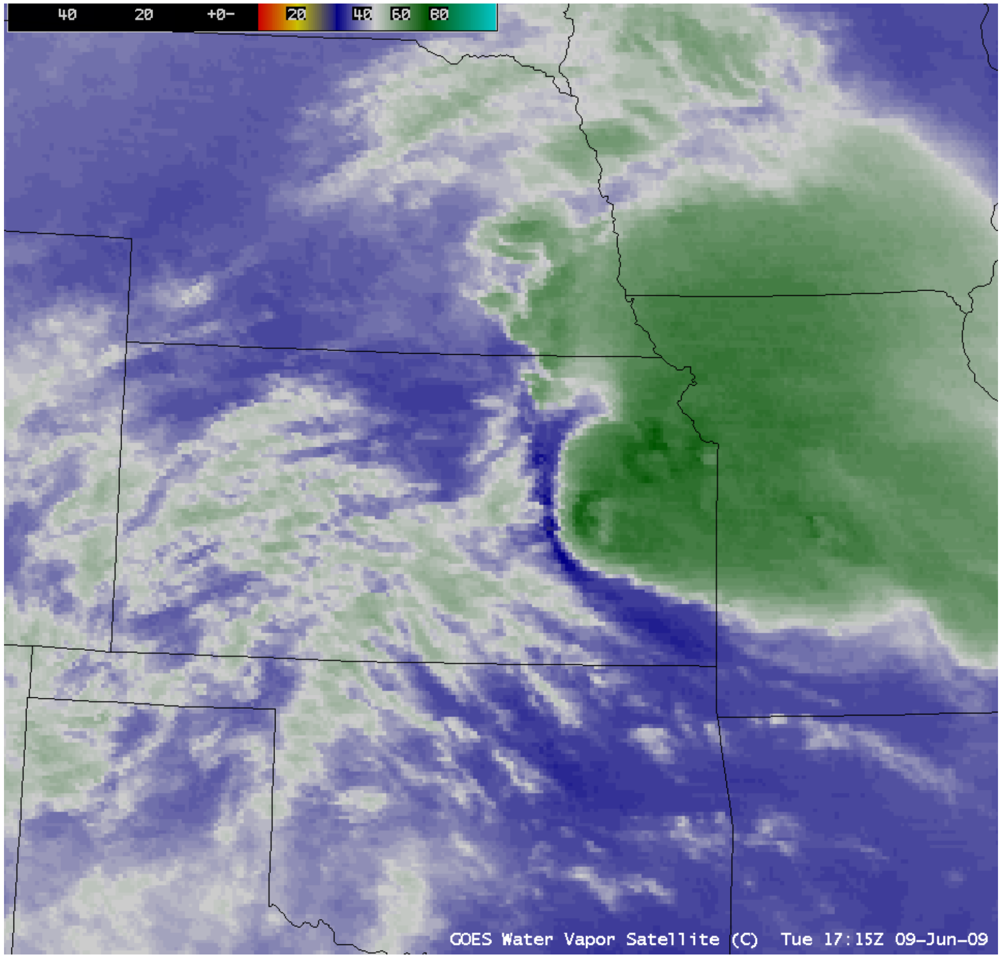
(credit: NWS forecast office, Reno NV)

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 FRONTPASSED. 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.

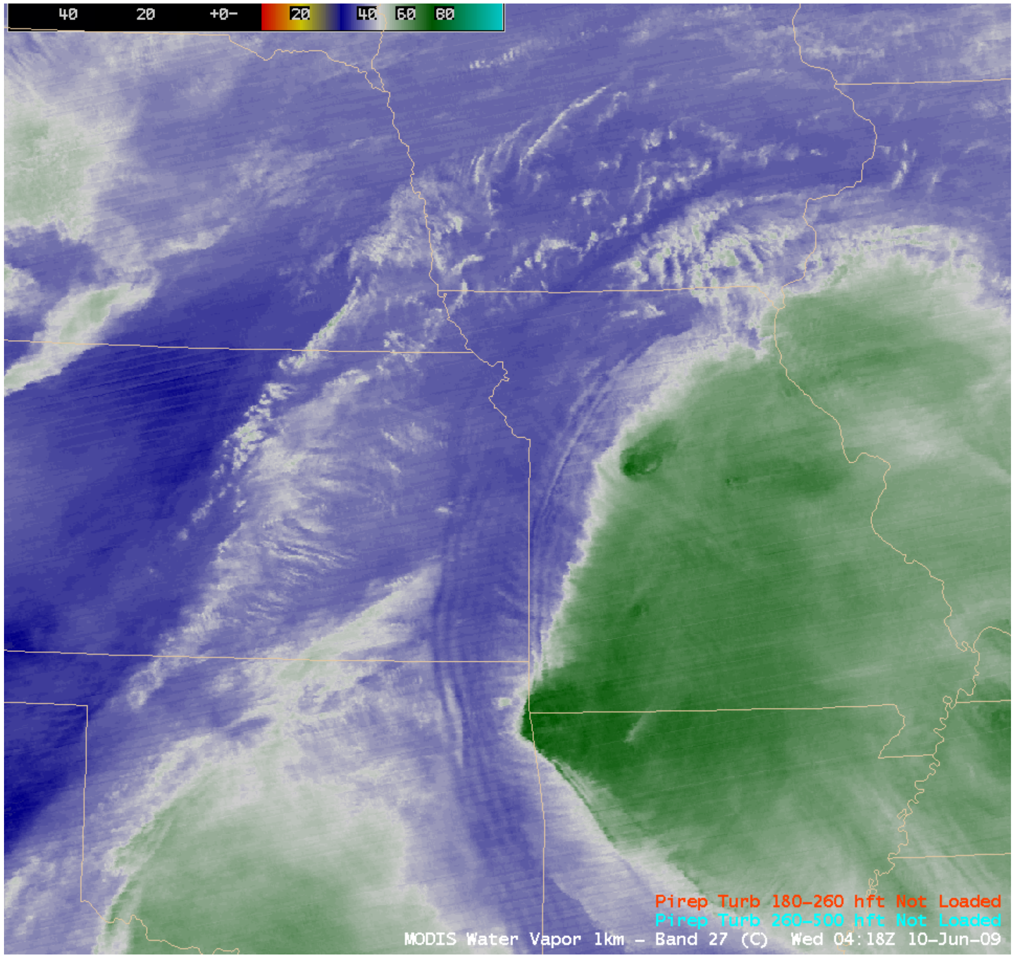

40 20 +0- 20 40 60 80
Pirep Turb 260-500 hft Mon 21:00Z 14-Feb-11
MODIS Water Vapor 1km - Band 27 (C) Mon 20:40Z 14-Feb-11

Turbulence Not Just from Orography



MODIS 6.7µm
Water Vapor
Band
17:15 UTC
9 June 2009

Turbulence Not Just from Orography



MODIS 6.7 µm
Water Vapor
Band
04:18 UTC
10 June 2009

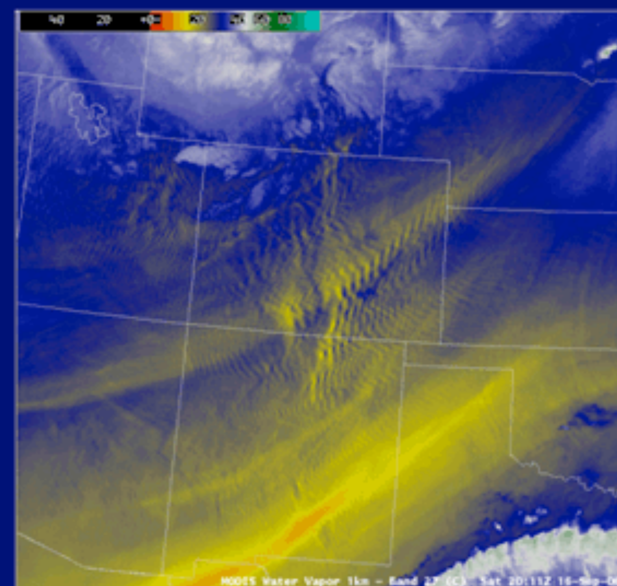
Why is 6.7 µm Important for the Detection of Turbulence?

Summary

Turbulence is a significant hazard to aviation, and satellite imagery can sometimes be a helpful tool in turbulence detection.

Mountain waves are one common cause of turbulence, and water vapor channel imagery has the ability to detect areas where this type of turbulence may be present.

The typical "herringbone" signature of mountain waves often occurs in clear (cloud-free) air, making the water vapor channel the only tool for accurate turbulence detection in those cases.



MODIS WV and Turbulence

- Nathan Uhlenbrock, S. A. Ackerman, W. F. Feltz, R. D. Sharman, and J. R. Mecikalski, 2006: **The use of MODIS water vapor imagery, NWP model analysis, and pilot reports to diagnose turbulent mountain waves.** 12th Conference on Aviation Range and Aerospace Meteorology, the 86th AMS Annual Meeting, P8.4.

MODIS WV and Turbulence

turbulent lee waves, and points to the necessity for using remote sensing to monitor lee waves.

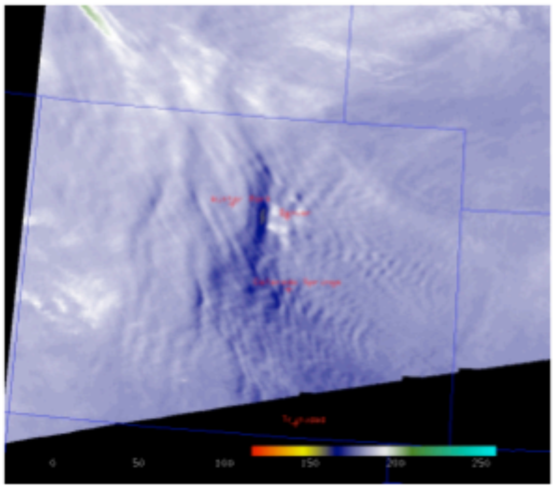


Figure 3: Aqua MODIS channel 27 at 1950Z on 06 March 2004 over Colorado.

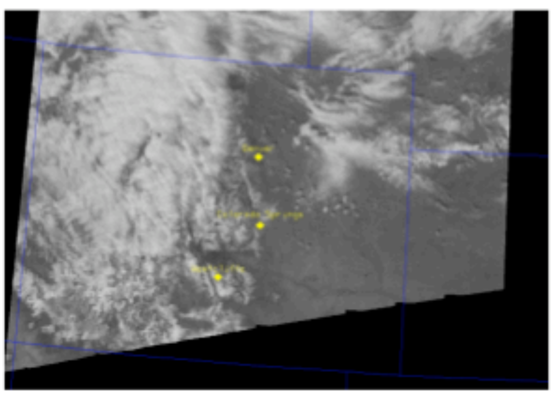


Figure 4: Aqua MODIS channel 1 scan at 1950Z on 06 March 2004 over Colorado.

amount of interference present in the waves, are lost in the lesser resolution GOES image (4km at nadir).

The next set of data obtained was the archived RUC model output for the time the waves were seen in the imagery. The archived model output was obtained through the NOMADS data access web interface maintained by the National Climatic Data Center (NCDC). The model output was analyzed using Unidata's Integrated Data Viewer (IDV). Figure 5 shows a cross section of the zonal winds through the atmosphere above Colorado at 1900Z on 06 March 2004. The cross section was taken along the 39th parallel from 114° W to 102° W. The display clearly shows that the across-mountain wind speeds were increasing steadily with height, thus satisfying the speed shear requirement for lee wave formation.

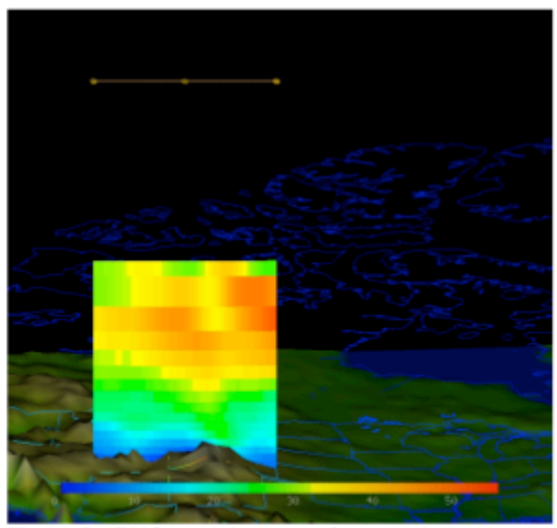


Figure 6: RUC model output of zonal winds over Colorado at 1900Z on 06 March 2004 in IDV.

Also, the lee wave signatures on the most turbulent days seem to have a consistently different appearance than the lee waves seen on the less turbulent days. The waves on turbulent days appear more complicated in nature with many crossing wave fronts and a good deal of wave interference. The waves on less turbulent days appear to be more linear in shape and distribution with clear and well-defined troughs and crests. It is postulated that certain patterns in the water vapor imagery can be used to detect turbulent mountain waves. However, the ideal situation would be the ability to forecast the occurrence of the waves.

With the combination of model data and satellite imagery, it may be possible to forecast lee waves. An algorithm could be developed that would define prone areas for mountain waves based on the wind and stability data from the model output. The algorithm could then monitor the satellite imagery from these areas for the development of lee waves. As a safety net, the algorithm could also input pilot reports of turbulence as a secondary first alert data source.

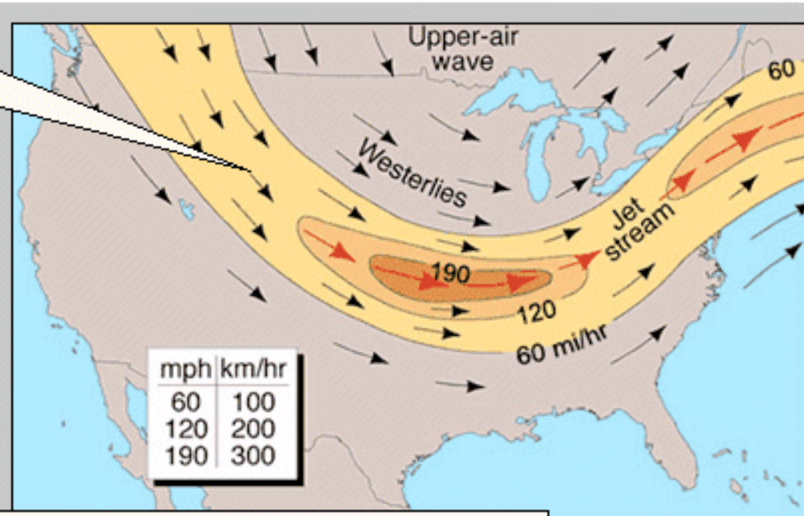
In order for this method to work, the satellite imagery must be of adequate spatial and temporal resolution to capture the lee waves. At present, satellites only come with one capability or the other, i.e., good spatial resolution or good temporal resolution. This situation will be remedied in the near future with the launch of the next generation GOES satellite, the GOES-R. This satellite will include the Advanced Base-Line Imager, or ABI, with 2km spatial resolution in the water vapor channel as opposed to the current 4km resolution

More With Water Vapor

What is the Jet Stream?

Page 1 of 7

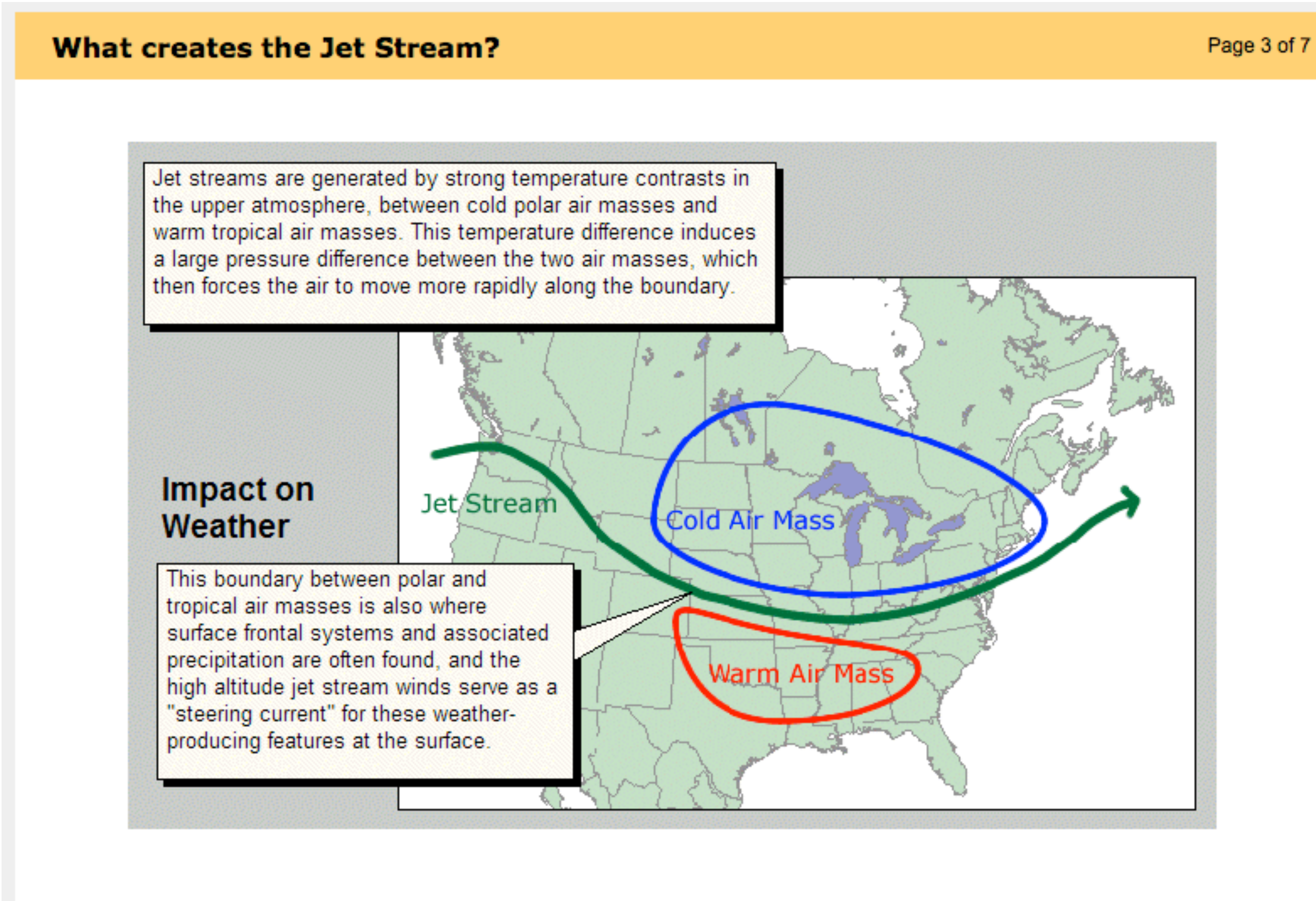
The jet stream is a high velocity current of air found in the upper levels of the atmosphere. Generally seen at altitudes of 6-12 miles above the Earth's surface, this fast-moving "river of air" can be several hundred miles in width, but is only about 1-2 miles deep.



Wind Speeds within the Jet Stream

Wind speeds within the core of the jet stream are often greater than 150 mph, but can occasionaly reach speeds exceeding 300 mph (maximum wind speeds within the jet core have been reported as high as 400 mph!). The strongest wind speeds are not continuous along the jet stream, but rather are focused within embedded velocity maxima known as "jet streaks". Multiple jet streaks are often present along the axis of a jet stream as it circles the Earth.

Jet Stream and Water Vapor



Atmospheric Turbulence