Advancements in GOES-R/JPSS Aviation Research and Operational Use

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Co-Chair GOES-R Aviation Algorithm Working Group

Cooperative Institute for Meteorological Satellite Studies (CIMSS), University of Wisconsin – Madison, U. S. A.

AMS ARAM 2011 – Los Angeles, CA

GOES-R Aviation Algorithm Working Group

AWG Aviation Team Co-Chairs : Ken Pryor, Wayne Feltz
Funded by GOES-R Program Office

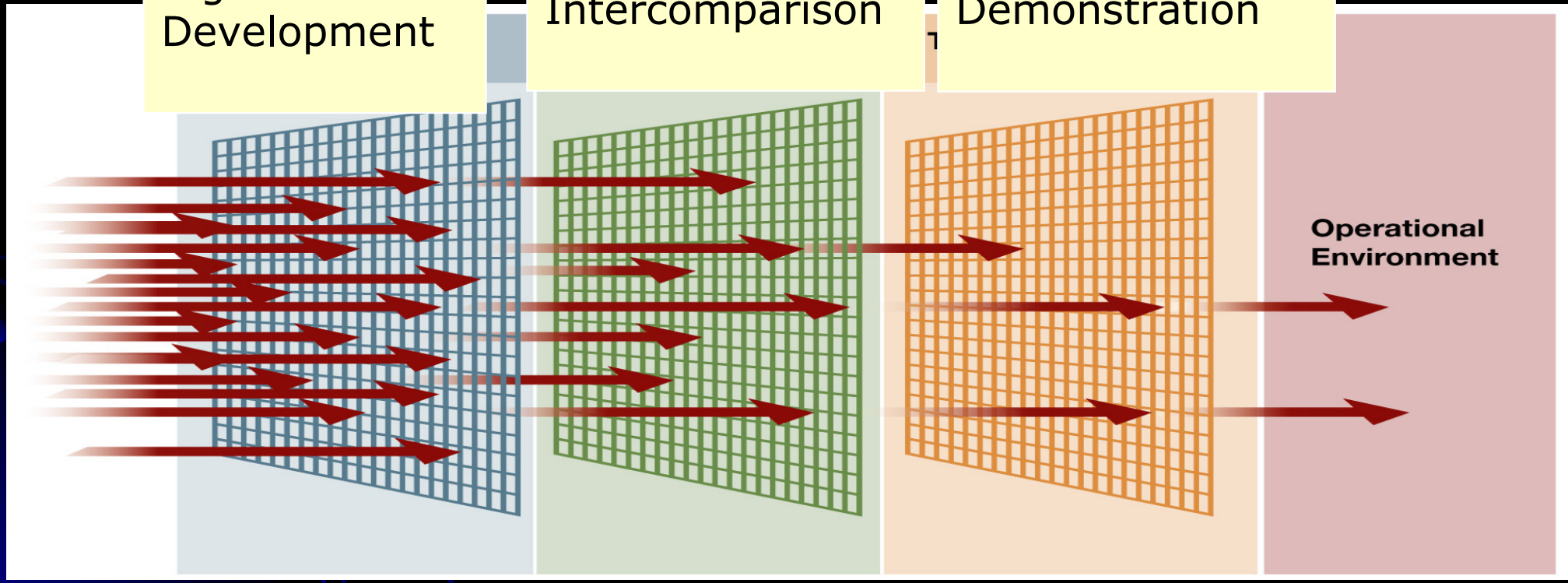
- *Convective Initiation*
  - *John Mecikalski (Lead)*
  - *Wayne MacKenzie*
  - *Kris Bedka*
- *Enhanced-V/Overshooting top detection*
  - *Kristopher Bedka (Lead)*
  - *Jason Brunner*
  - *Wayne Feltz*
- *Turbulence*
  - *Anthony Wimmers (Lead)*
  - *Wayne Feltz*
- *Volcanic ash - > Baseline*
  - *Mike Pavolonis (Lead)*
  - *Justin Sieglaff (Support)*
- *SO_2*
  - *Mike Pavolonis (Lead)*
  - *Andrew Parker (Support)*
- *Visibility*
  - *Brad Pierce (Lead)*
  - *Wayne Feltz*
- *Aircraft Icing*
  - *Bill Smith, Jr. (Lead)*
- Fog/Low Cloud
  - Mike Pavolonis (Lead)
  - Corey Calvert (Support)

Algorithm Research to Operations Process

GOES-R Risk Reduction Exploratory Algorithm Development

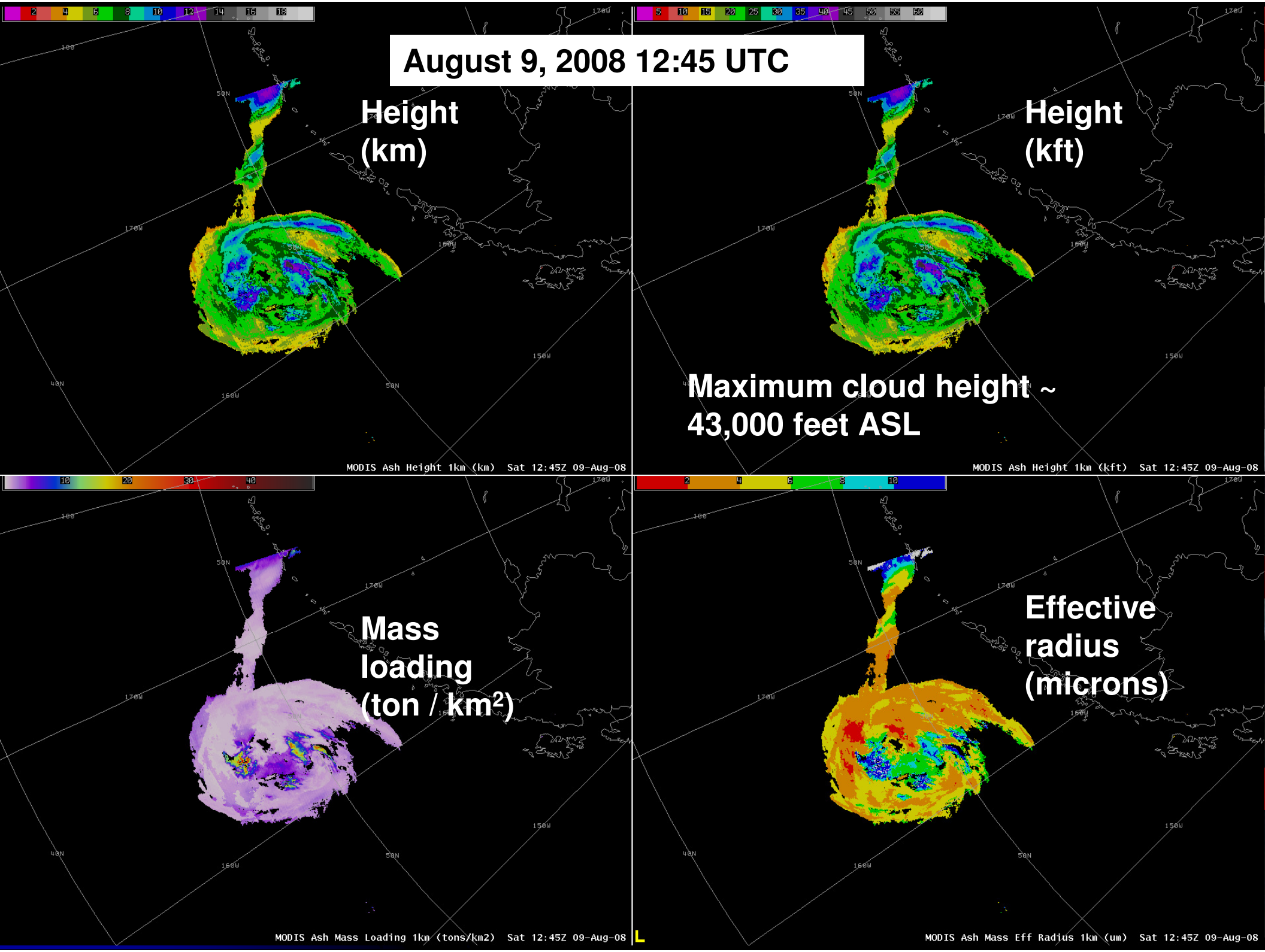
AWG Algorithm Candidate Development & Intercomparison

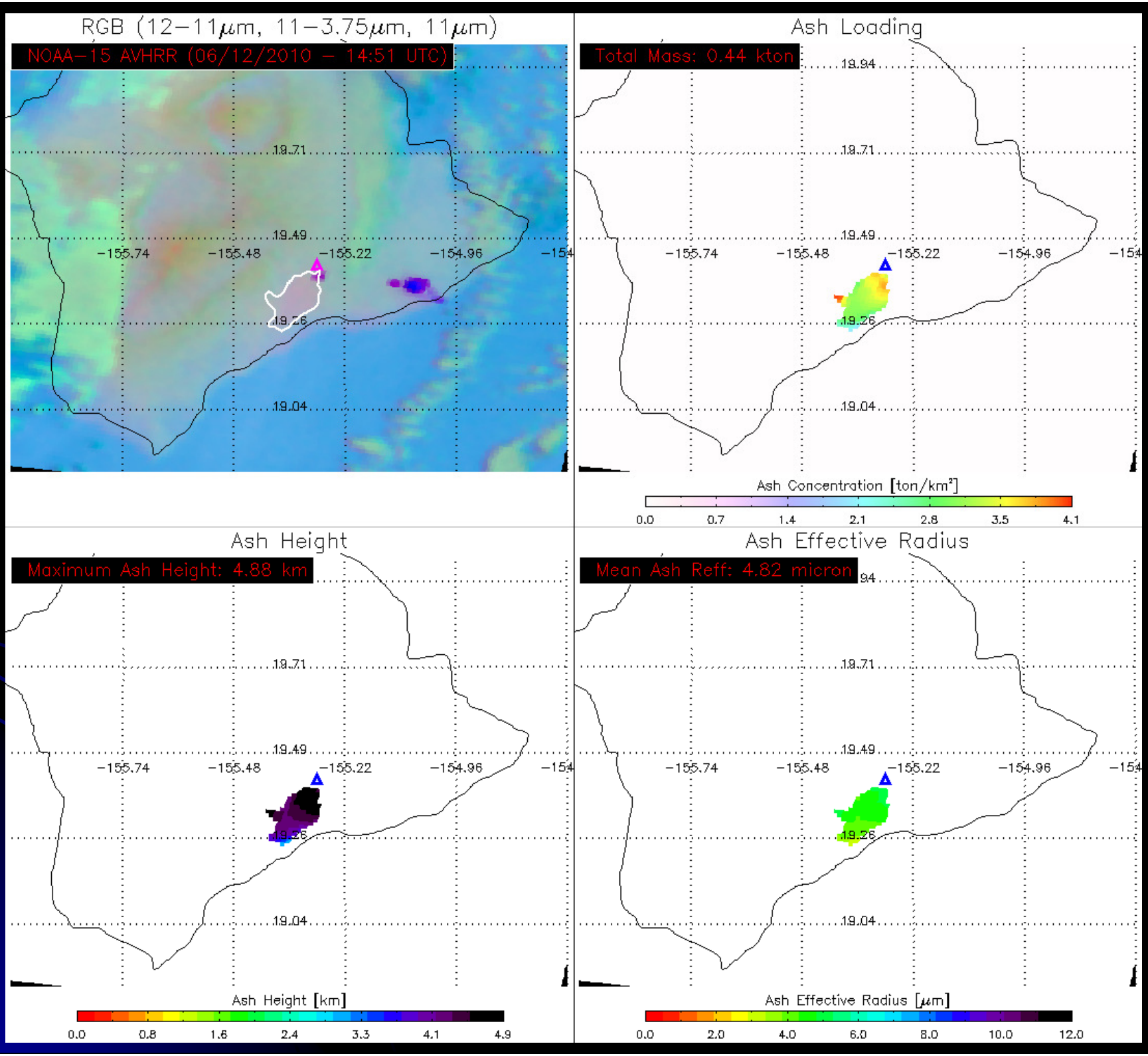
AWG Algorithm Selection and Proving Ground Demonstration



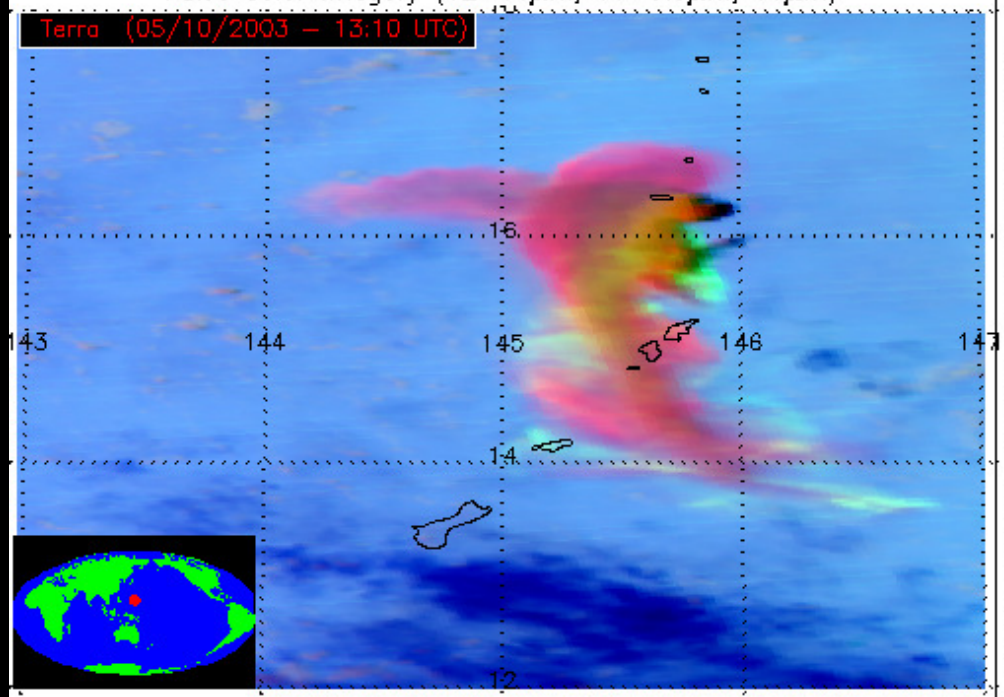
GOES-R Volcanic Ash

Kuril Islands N of Japan - ISS

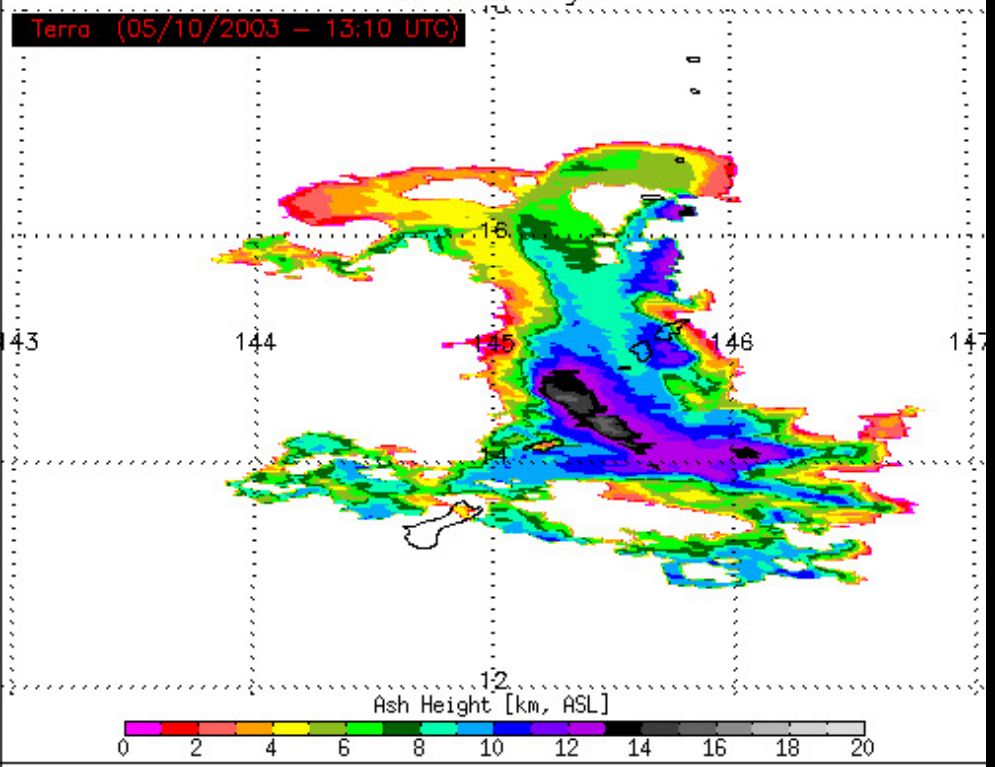

August 9, 2008 12:45 UTC
Height (km)
Height (kft)
Maximum cloud height ~ 43,000 feet ASL
Mass loading (ton / km²)
Effective radius (microns)
MODIS Ash Height 1km (km) Sat 12:45Z 09-Aug-08
MODIS Ash Height 1km (kft) Sat 12:45Z 09-Aug-08
MODIS Ash Mass Loading 1km (tons/km2) Sat 12:45Z 09-Aug-08
MODIS Ash Mass Eff Radius 1km (um) Sat 12:45Z 09-Aug-08


RGB (12−11μm, 11−3.75μm, 11μm)
NOAA−15 AVHRR (06/12/2010 − 14:51 UTC)
Ash Loading
Total Mass: 0.44 kton
Ash Concentration [ton/km²]
0.0 0.7 1.4 2.1 2.8 3.5 4.1
Ash Height
Maximum Ash Height: 4.88 km
Ash Height [km]
0.0 0.8 1.6 2.4 3.3 4.1 4.9
Ash Effective Radius
Mean Ash Reff: 4.82 micron
Ash Effective Radius [μm]
0.0 2.0 4.0 6.0 8.0 10.0 12.0
19.94
19.71
19.49
19.26
19.04
−155.74
−155.48
−155.22
−154.96

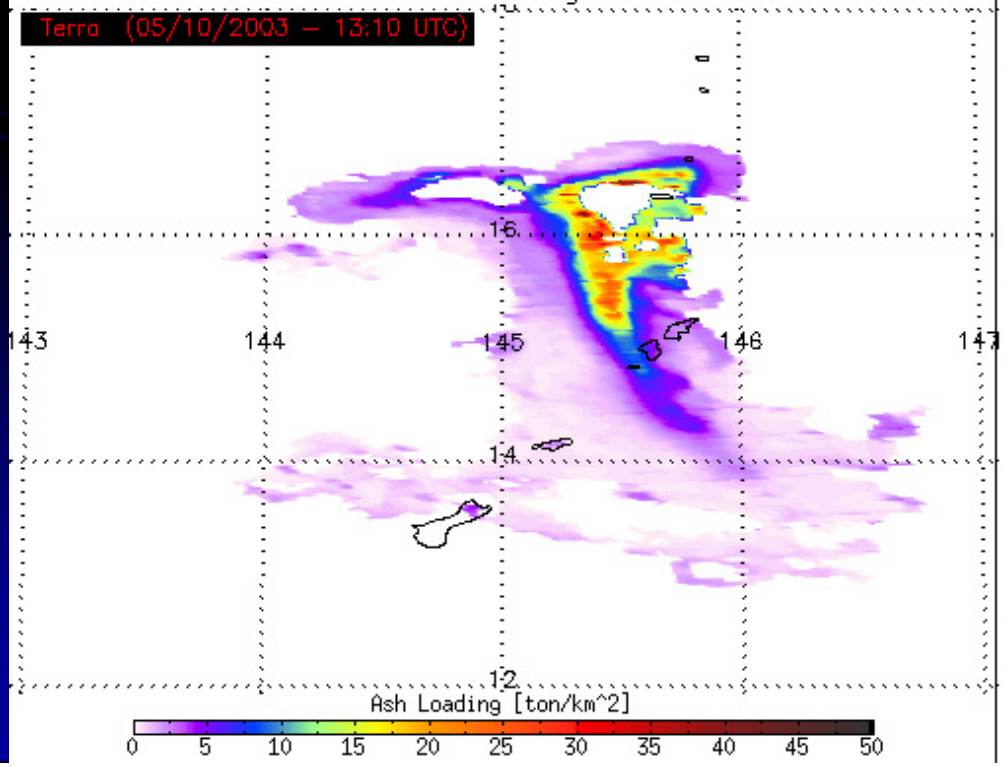
False Color Imagery (12−11μm, 11−8.5μm, 11μm)



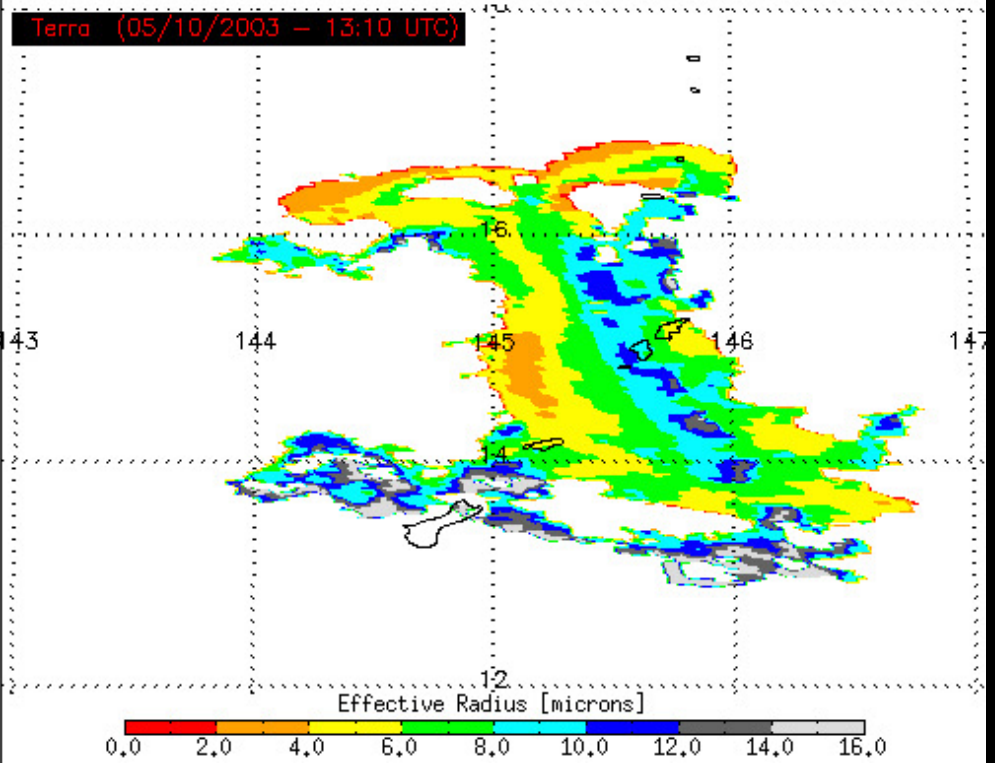
Ash Cloud Height



Ash Loading

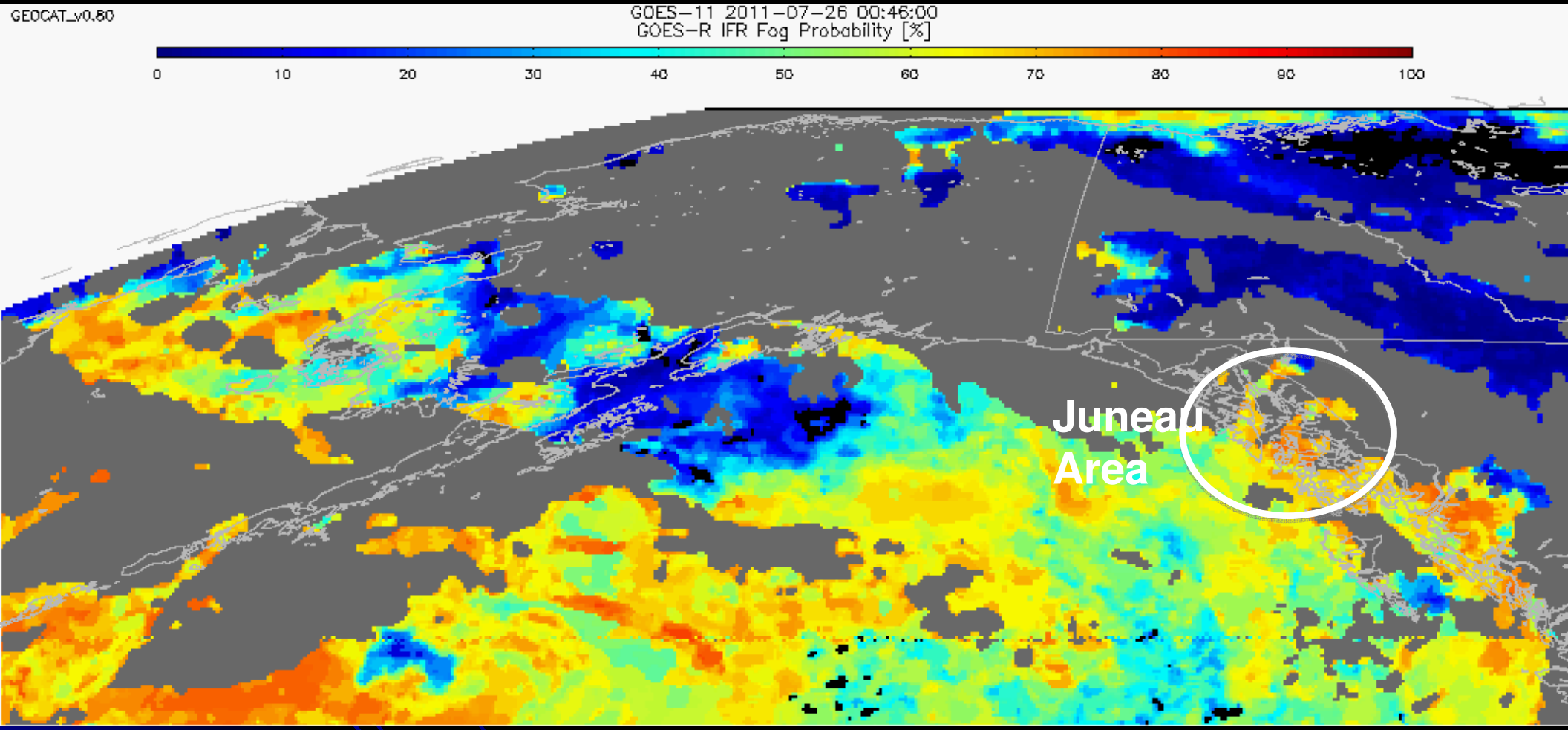


Ash Effective Radius



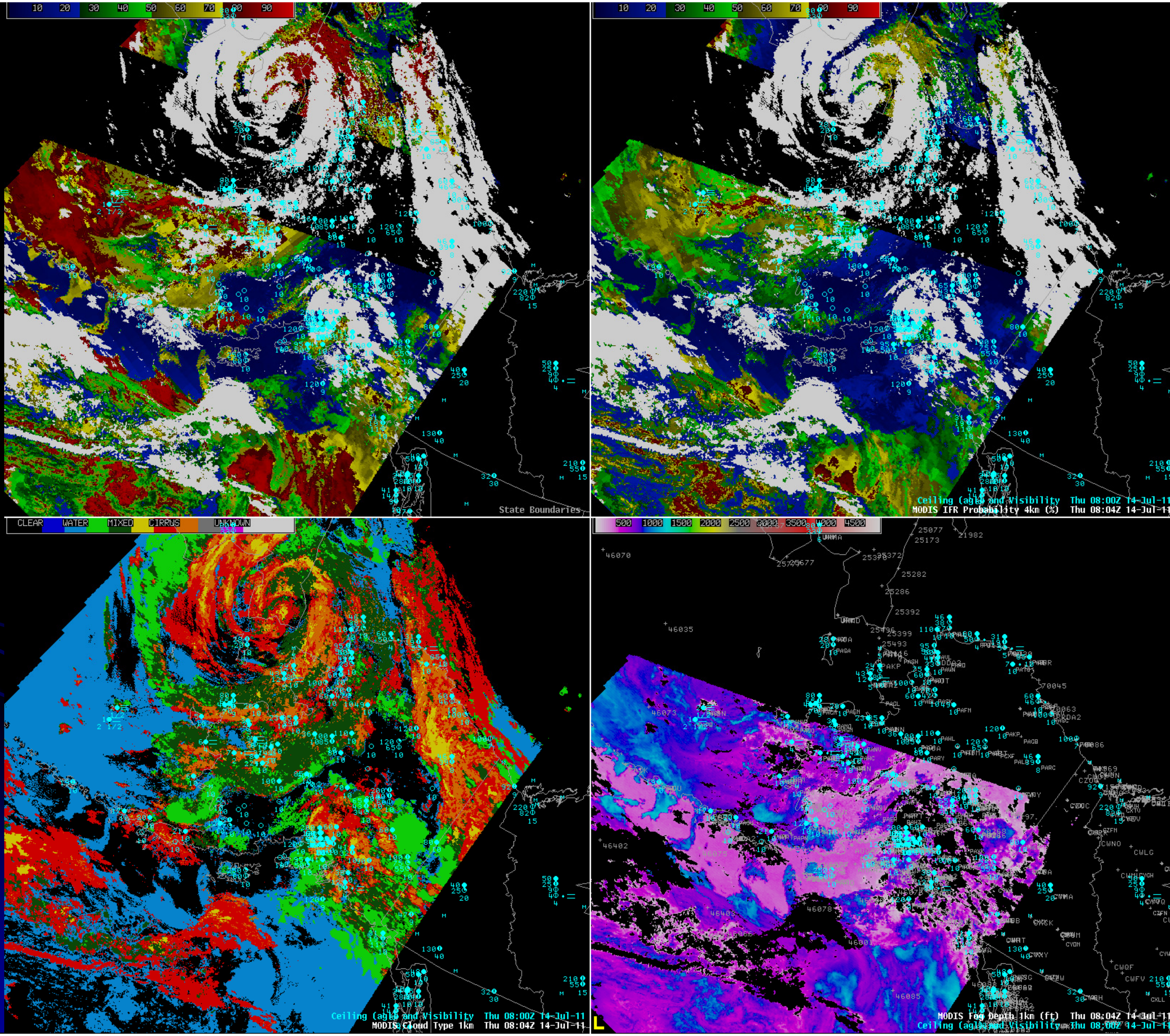
Low Cloud, Fog, and Cloud Type

Aborted Landing!
July 26, 00:46 UTC



MVFR Probability

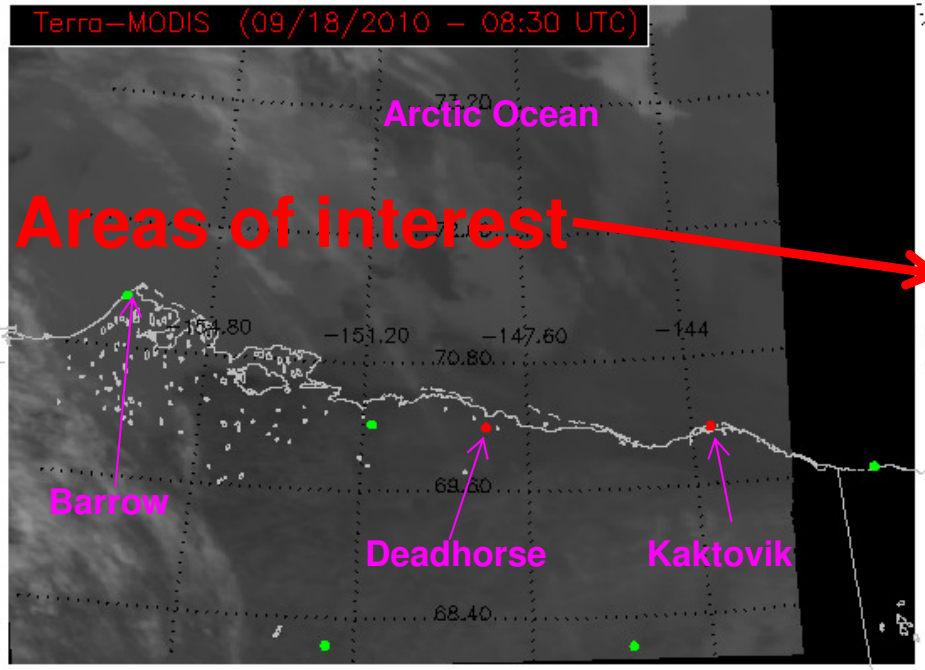
IFR Probability



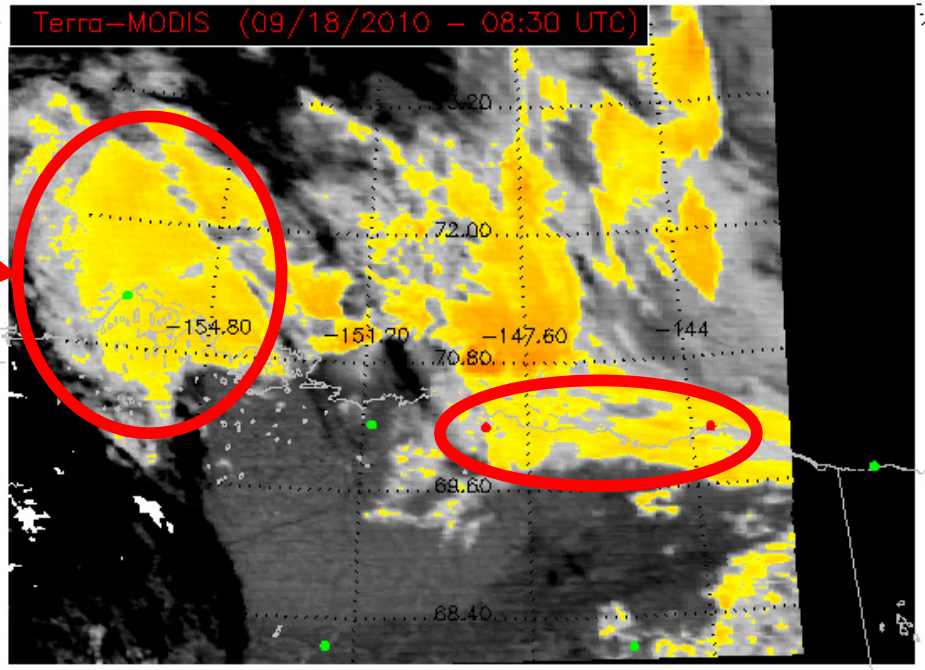
Cloud Type

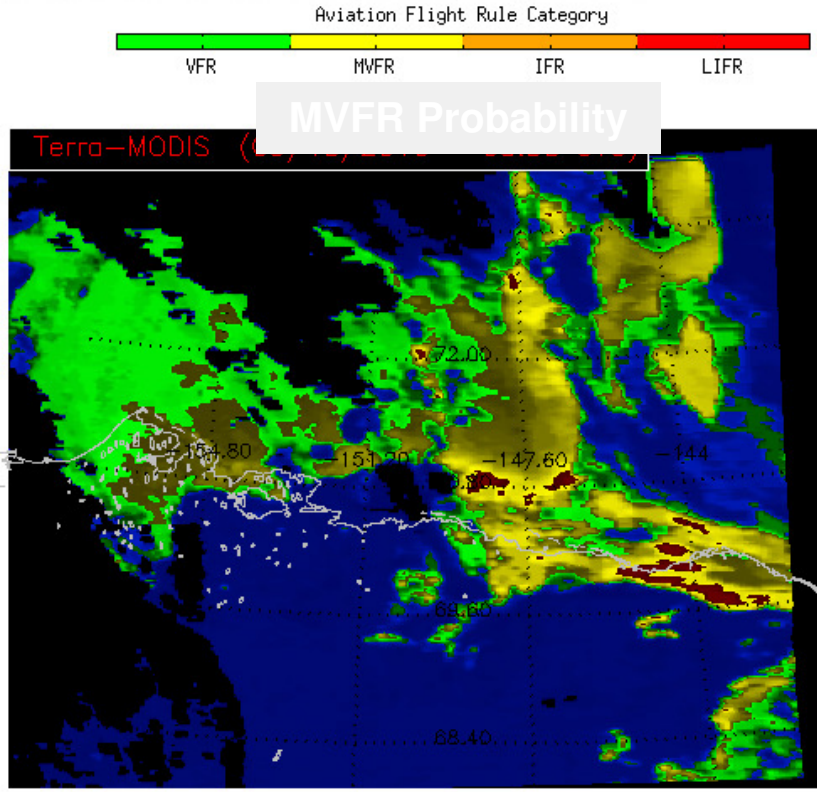
FLS Depth

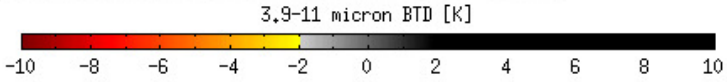
11μm Brightness Temperature



3.9–11 micron BTD

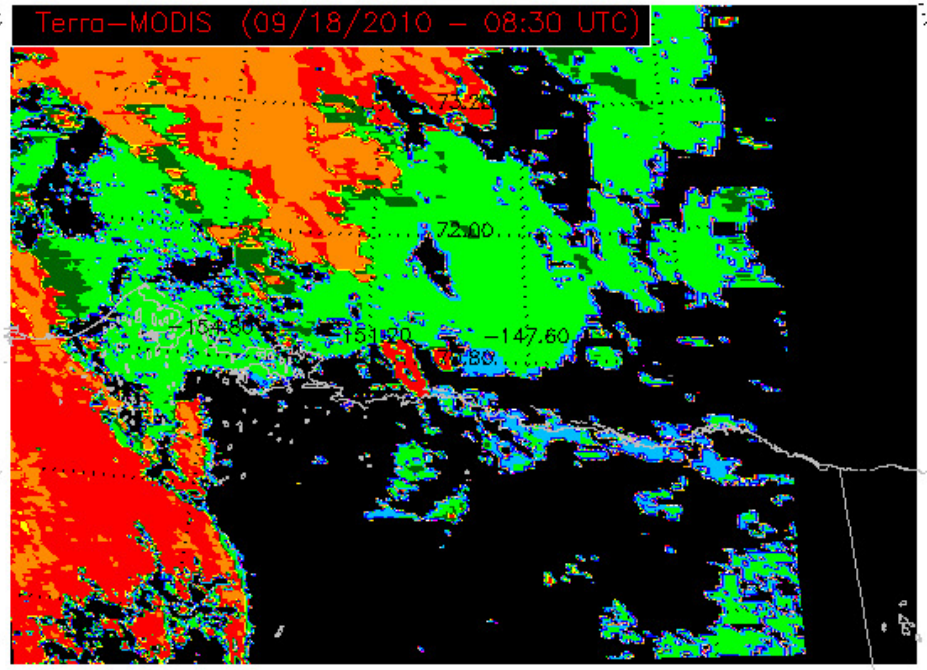




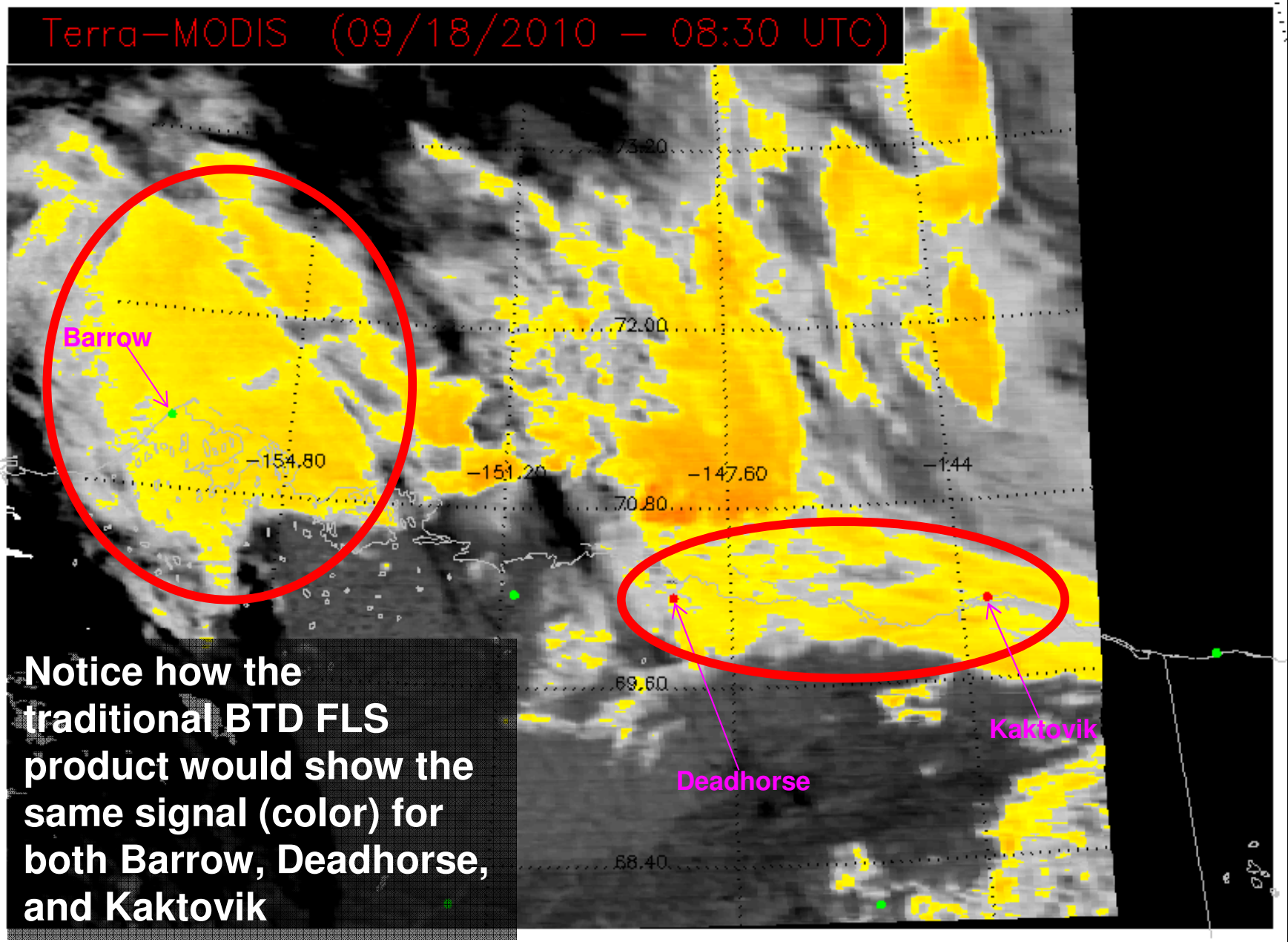


MVFR Probability

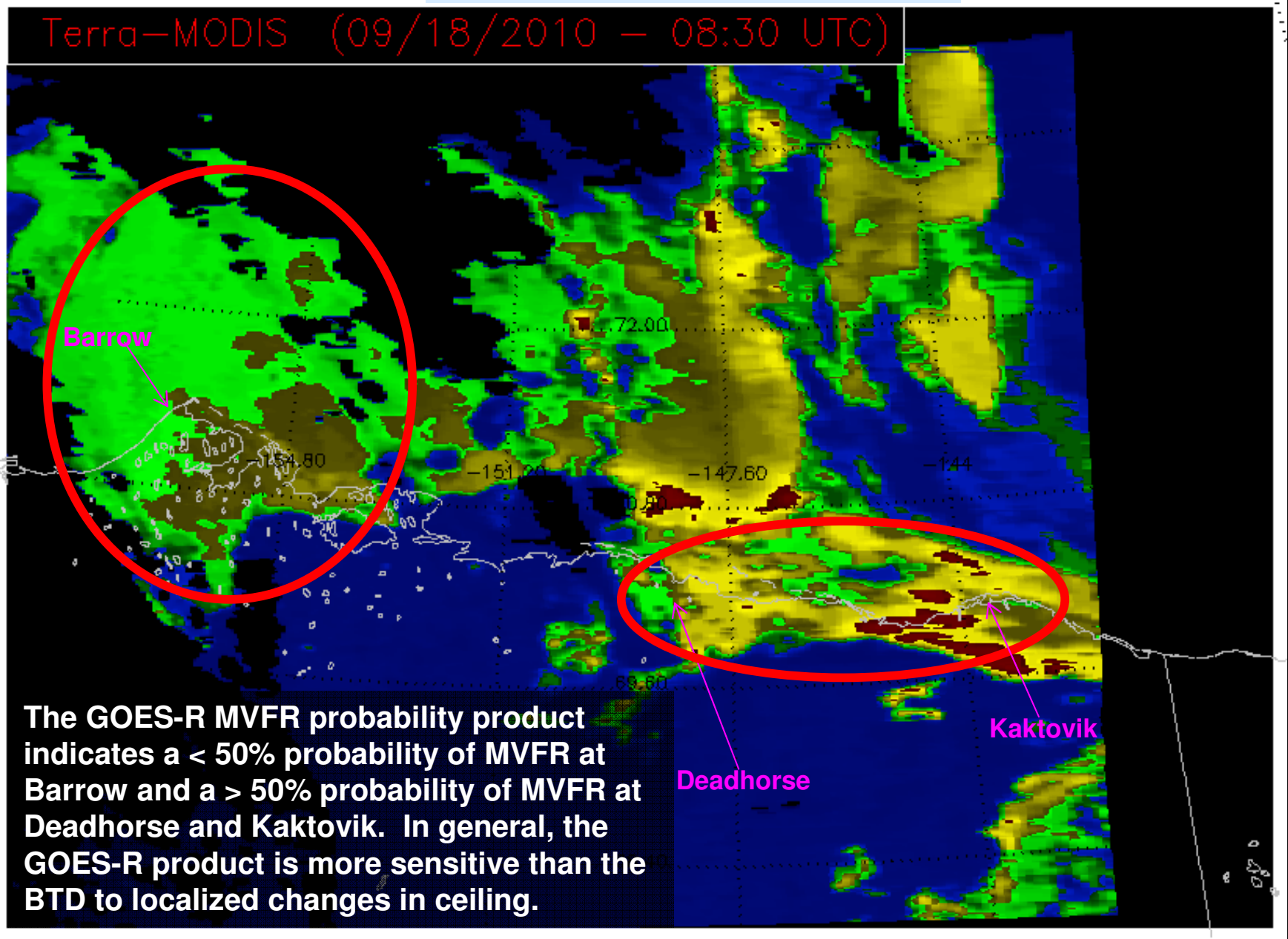
Cloud Type



3.9–11 micron BTD

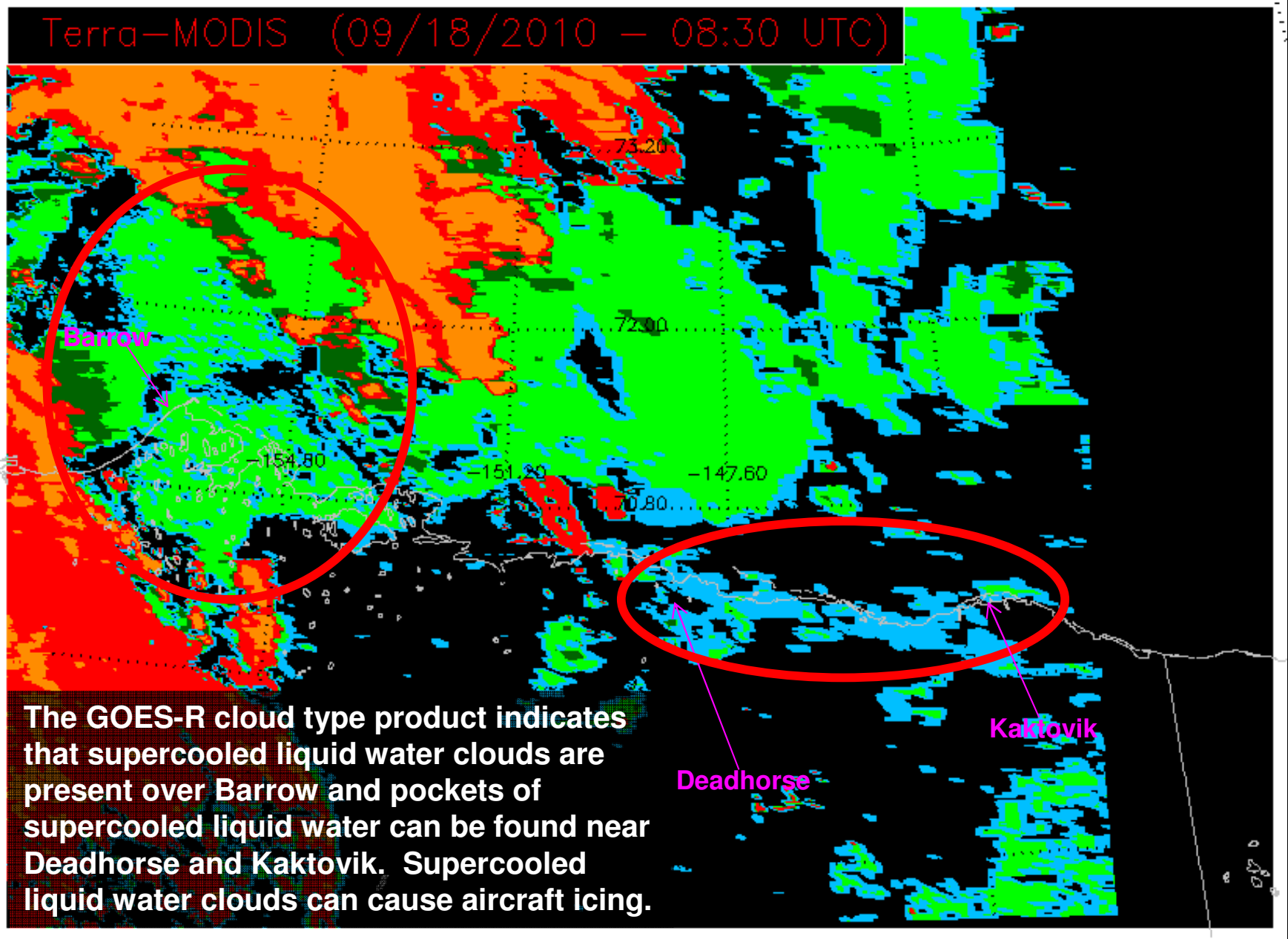


MVFR Probability

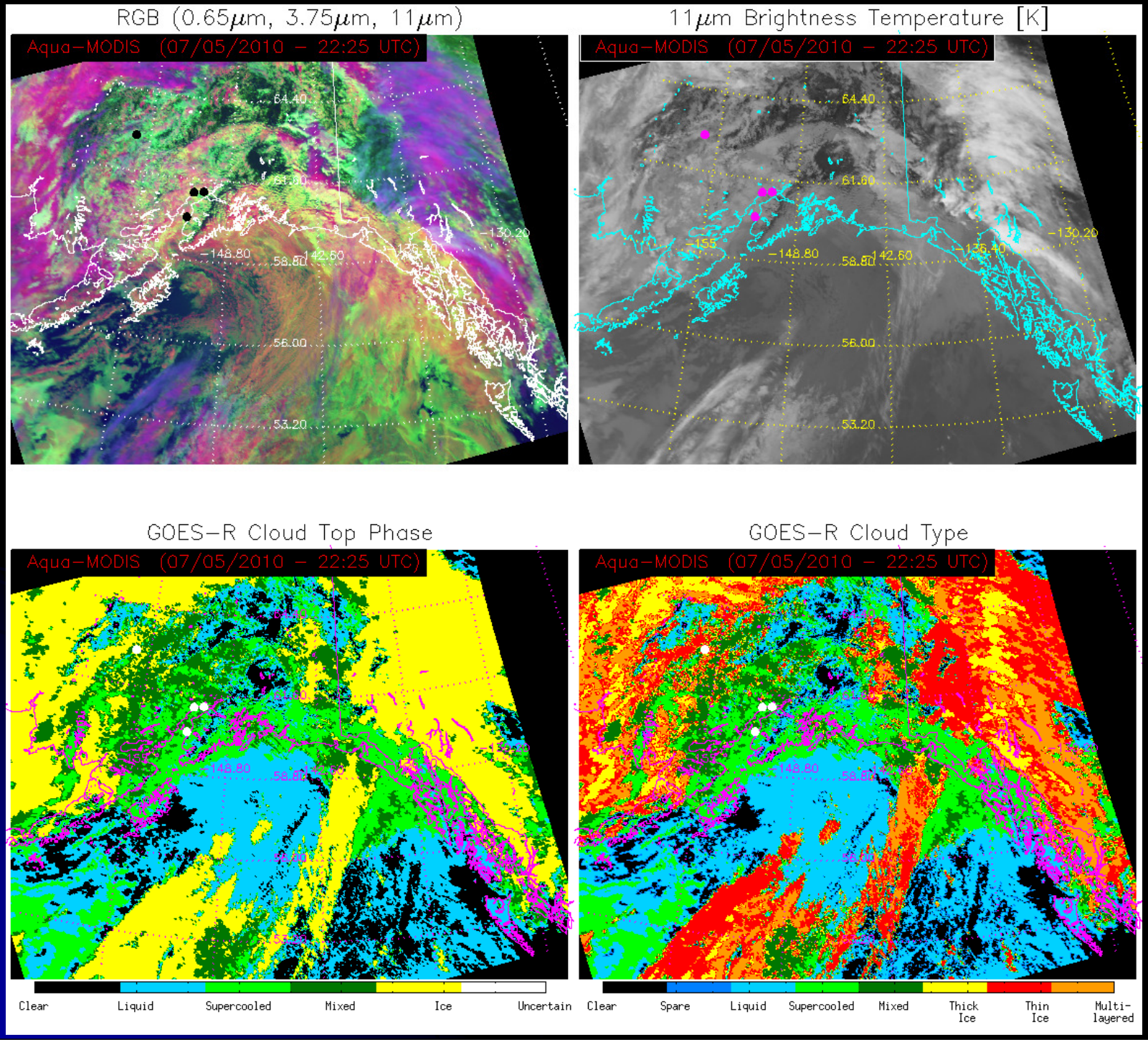


The GOES-R MVFR probability product indicates a < 50% probability of MVFR at Barrow and a > 50% probability of MVFR at Deadhorse and Kaktovik. In general, the GOES-R product is more sensitive than the BTD to localized changes in ceiling.

Cloud Type


Terra–MODIS (09/18/2010 – 08:30 UTC)
73.20
72.90
70.80
-154.80
-151.20
-147.60
Barrow
Deadhorse
Kaktovik
The GOES-R cloud type product indicates that supercooled liquid water clouds are present over Barrow and pockets of supercooled liquid water can be found near Deadhorse and Kaktovik. Supercooled liquid water clouds can cause aircraft icing.
Cloud Type
Clear
Spare
Water
SC
Mixed
Thick ice
Thin ice
Multilay
Spare
Uncertain

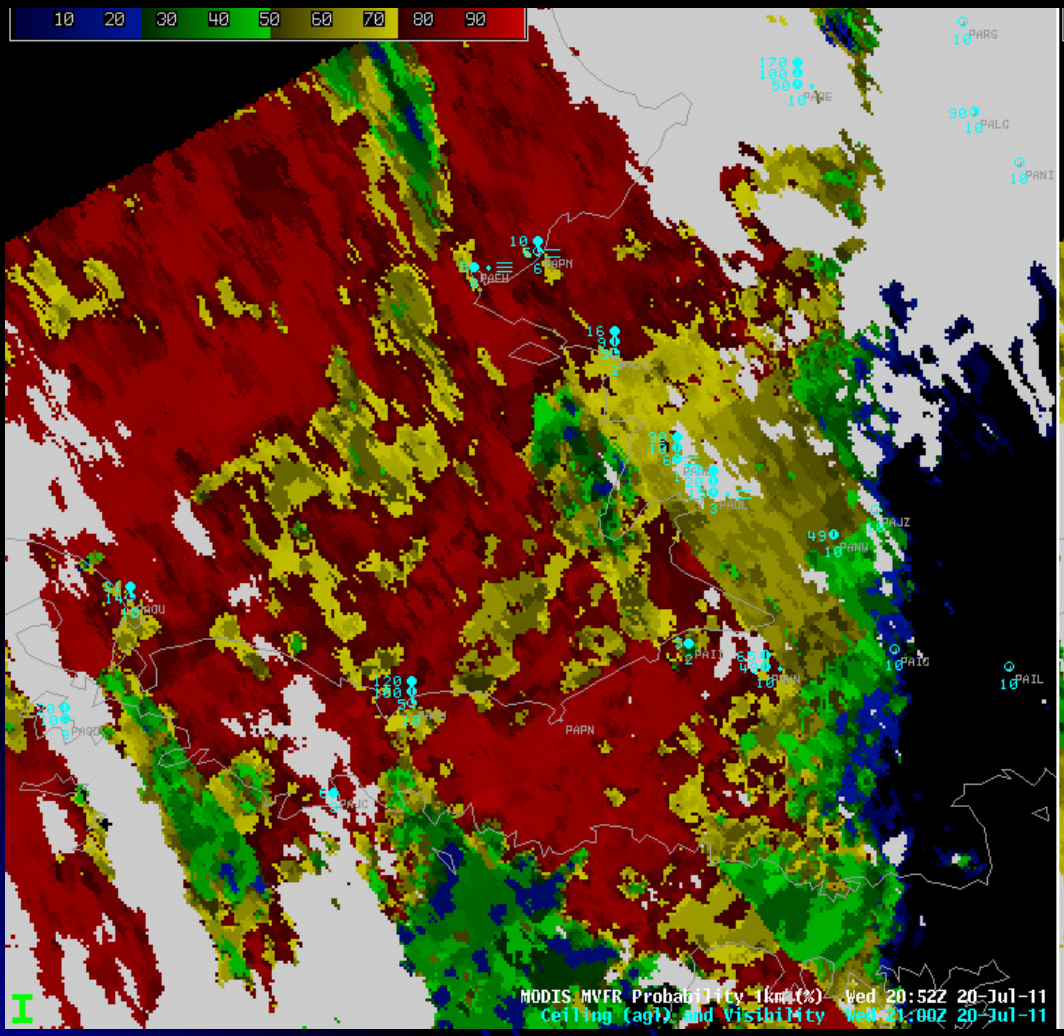
Aqua-MODIS (July 05, 2010, 22:25 UTC)



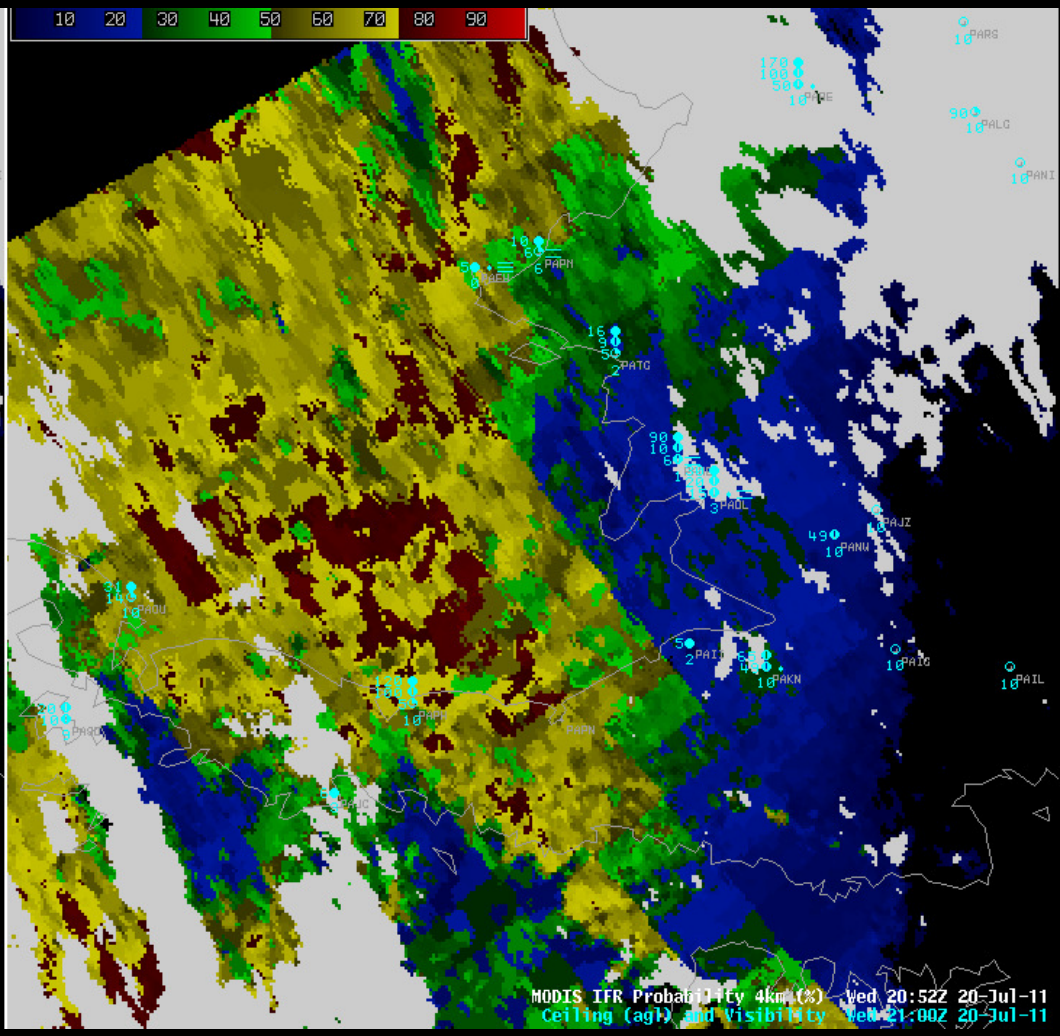
- **Icing reports are denoted by the filled circles.**
- **All pilot reported occurrences of aircraft icing are coincident with supercooled liquid water or mixed phase clouds.**

July 20, 2011 (20:52 UTC)

MVFR Probability



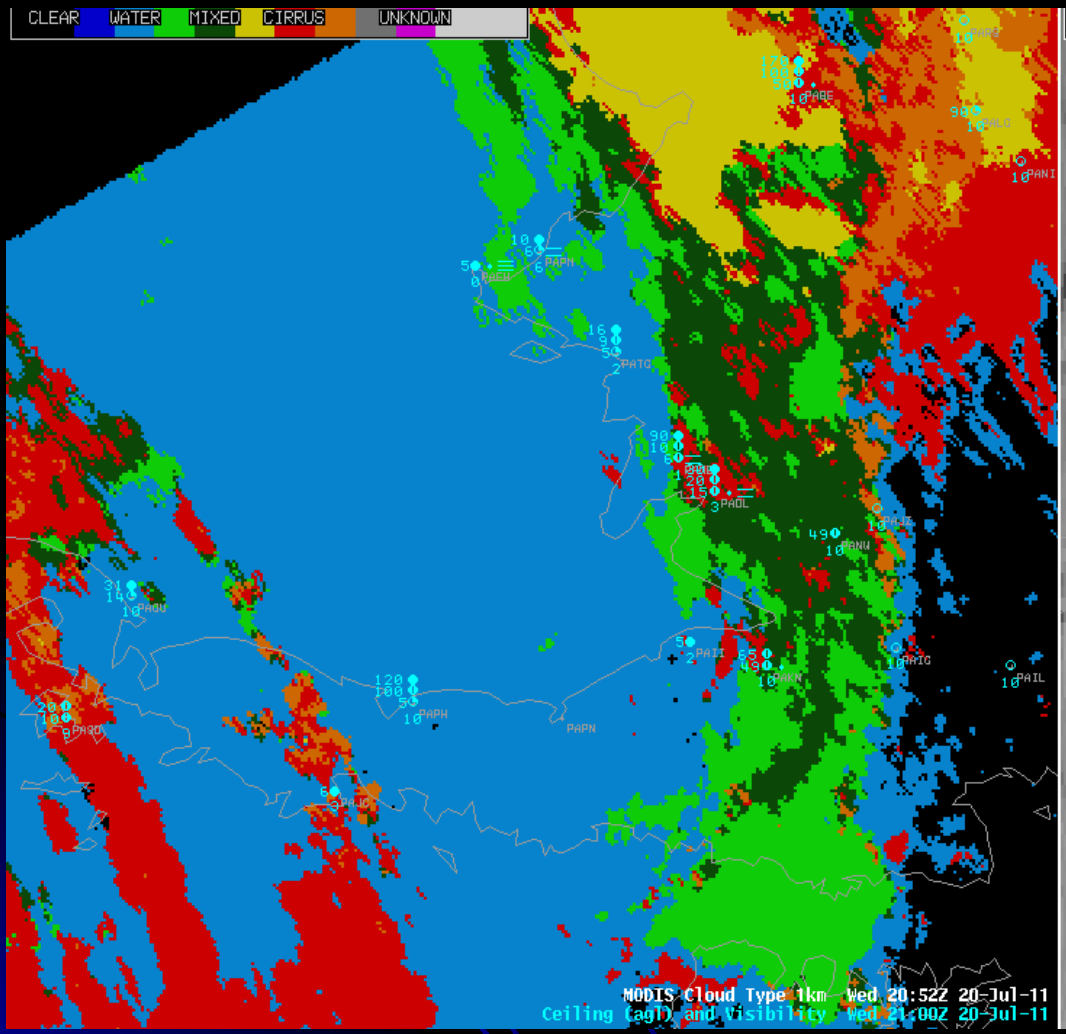
IFR Probability



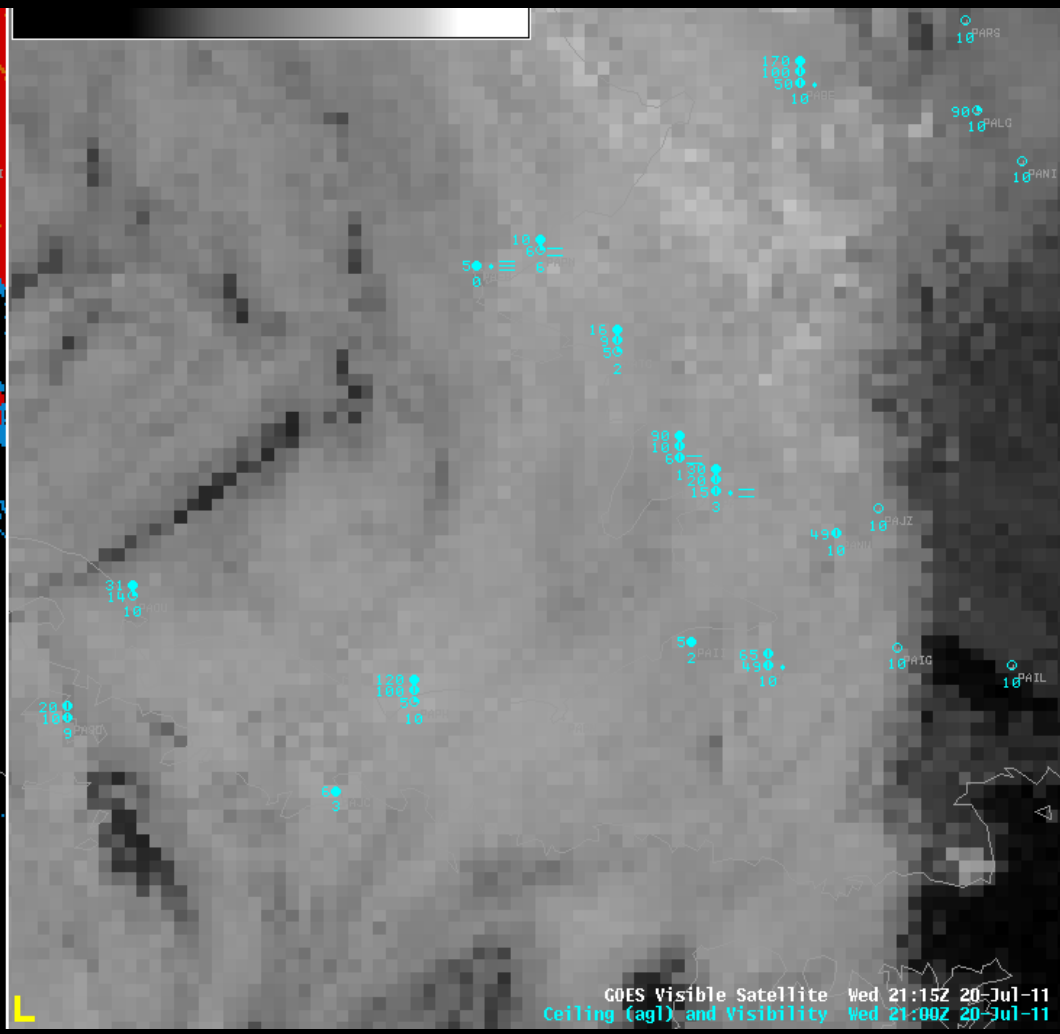
Location of higher MVFR and IFR probability agree well with surface observations of ceiling

July 20, 2011 (20:52 UTC)

Cloud Type

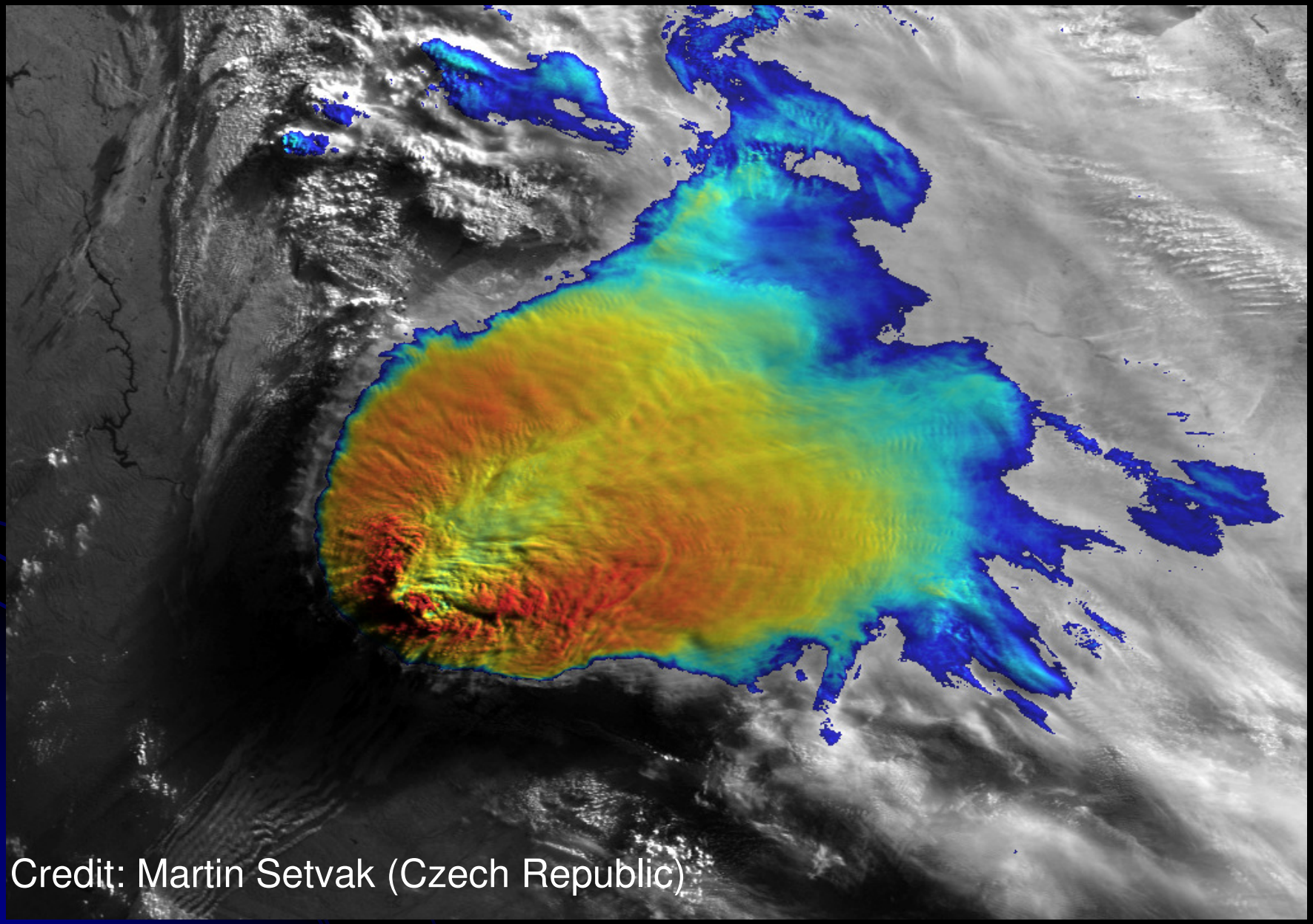


GOES Visible Image

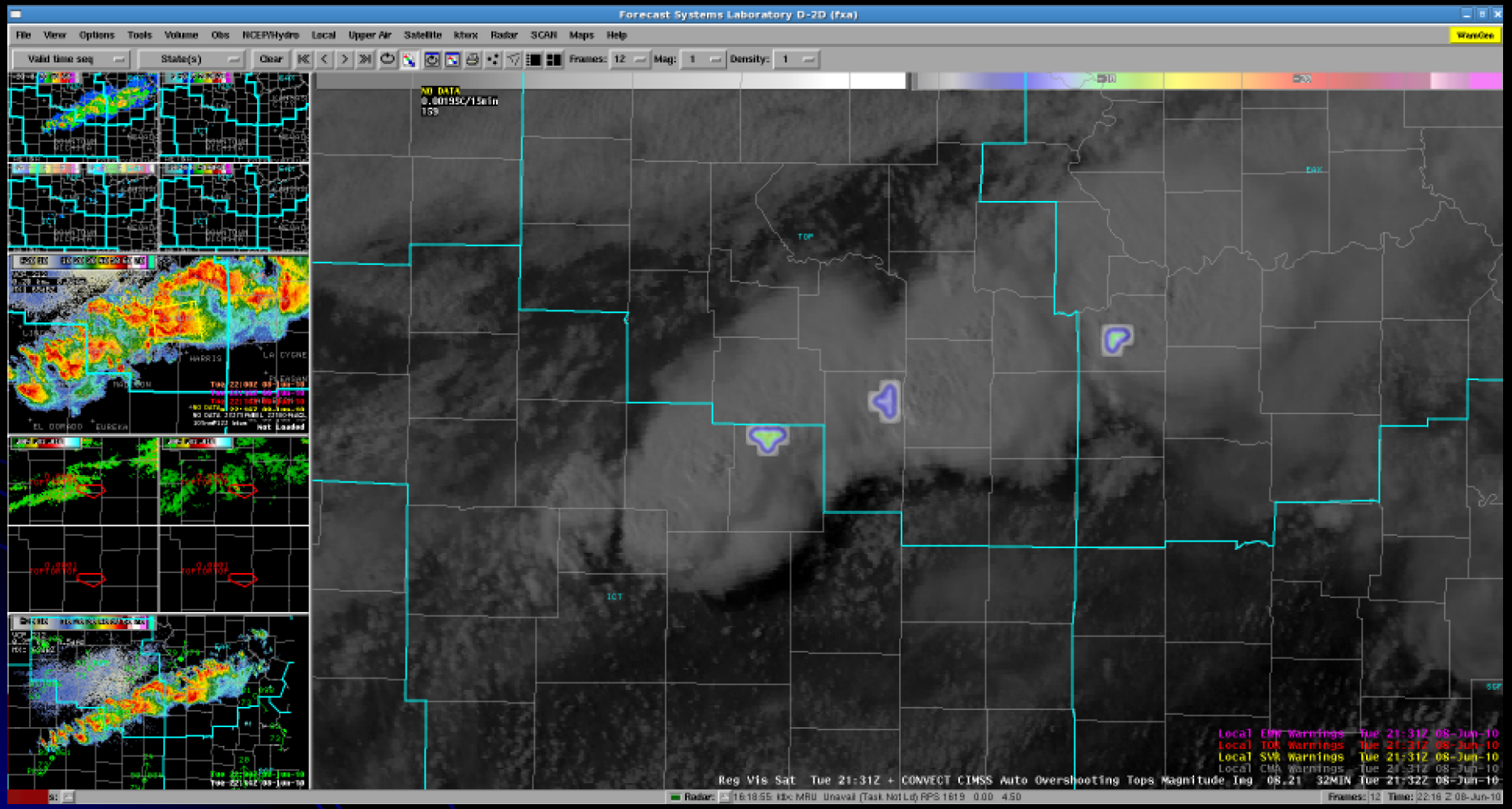


It is difficult to infer MVFR and IFR conditions (away from surface observations) just using GOES visible imagery.

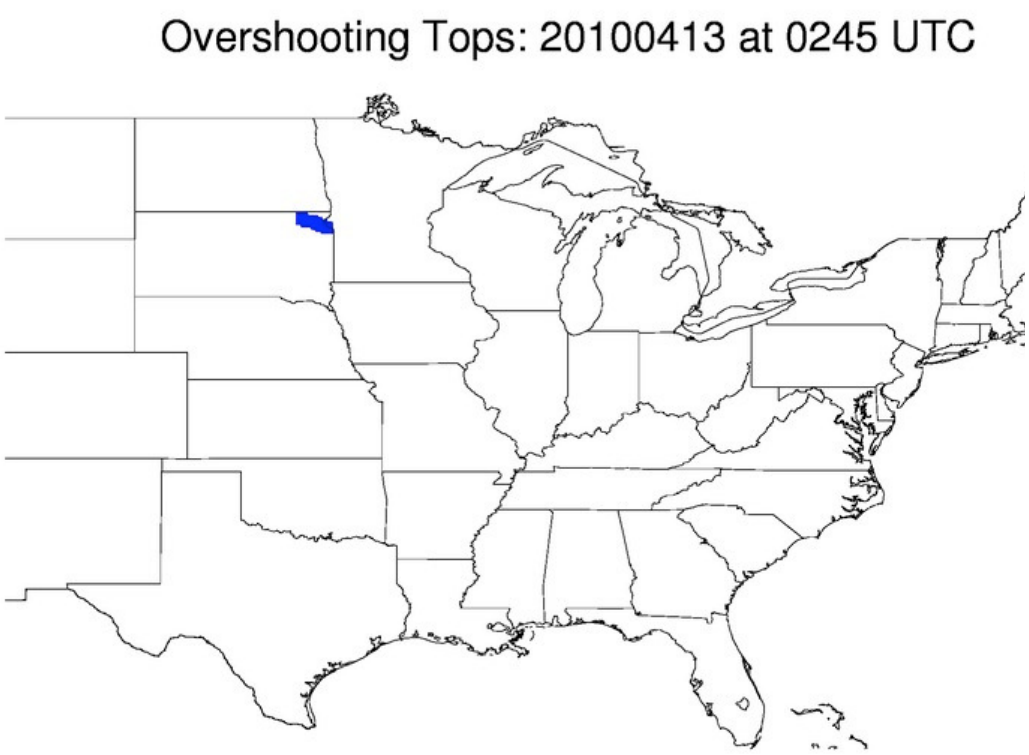
GOES-R Overshooting-Top

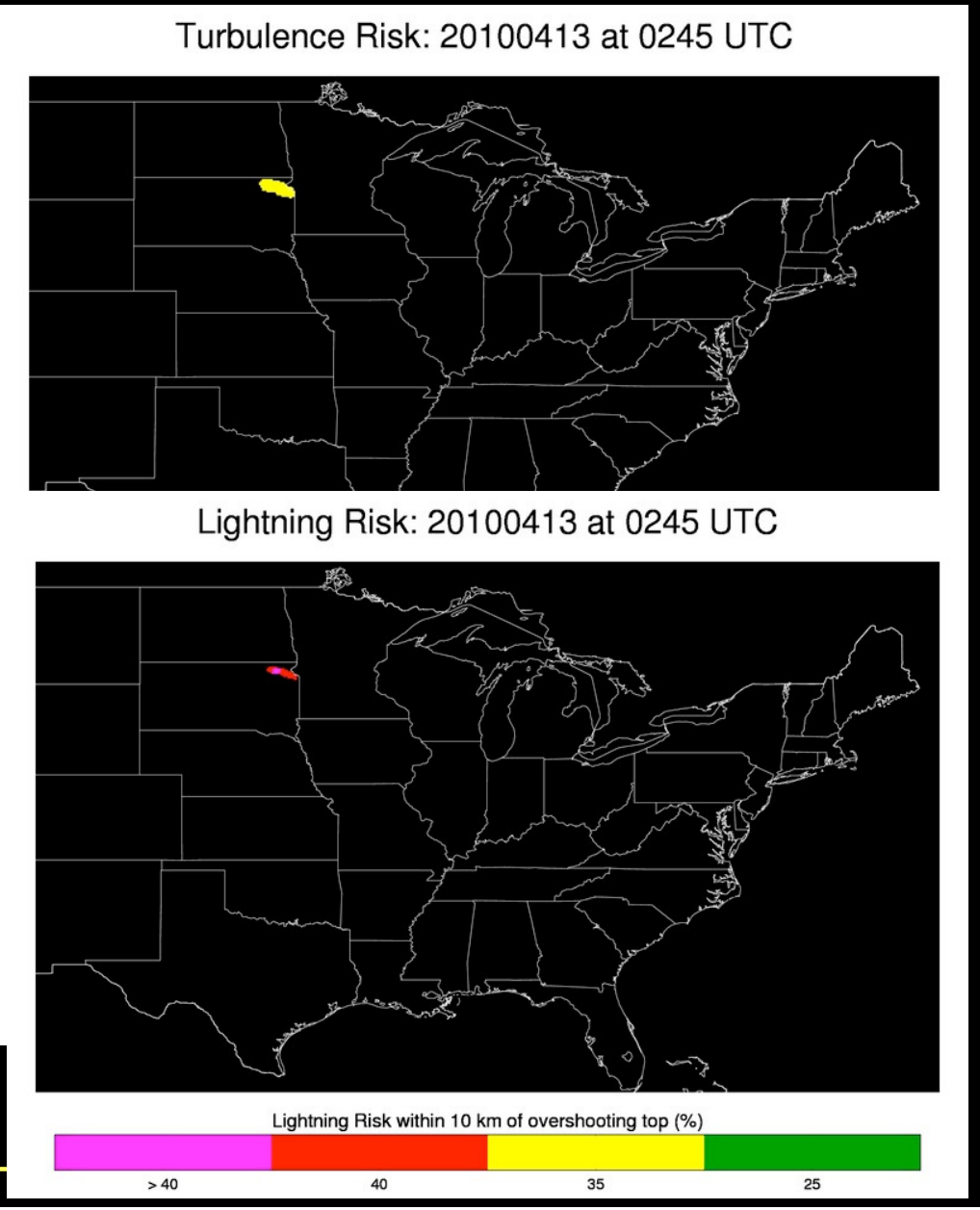


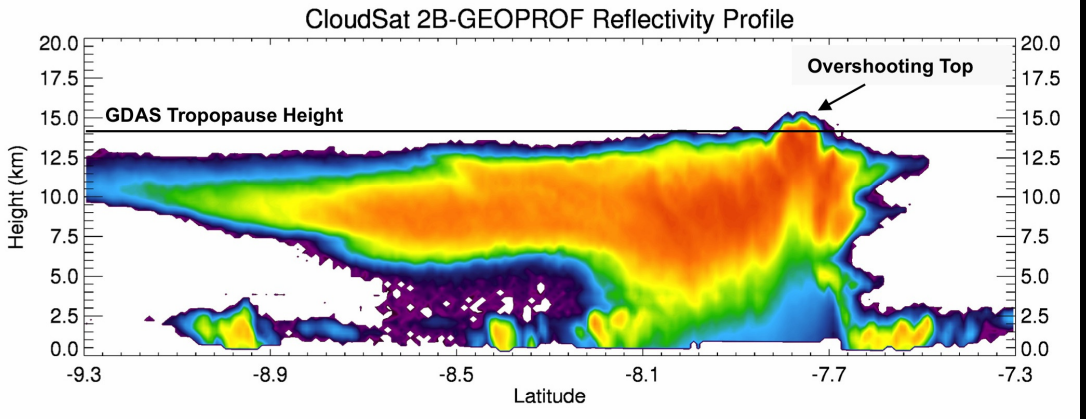
GOES Objective Overshooting-top Detection

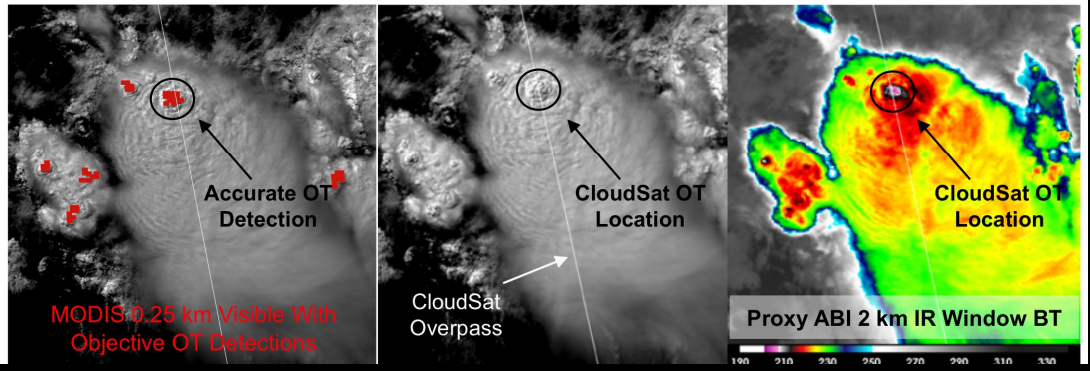


GOES Proxy Overshooting Top (OT) and Decision Support Detection









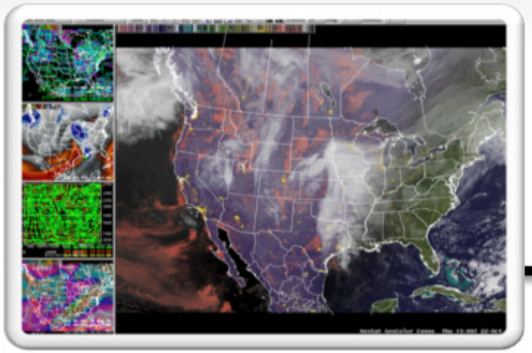
- **Overshooting tops (OTs) are the product of deep convective storm updrafts with sufficient strength to rise above the storms' equilibrium level and penetrate into the lower stratosphere**

- **OTs appear as small clusters of very cold pixels relative to the surrounding thunderstorm anvil**
  - Infrared (IR) temperature gradients (i.e. texture) are combined with NWP information to accurately detect OTs during day/night using current and future satellite sensors (Bedka et al. 2010)

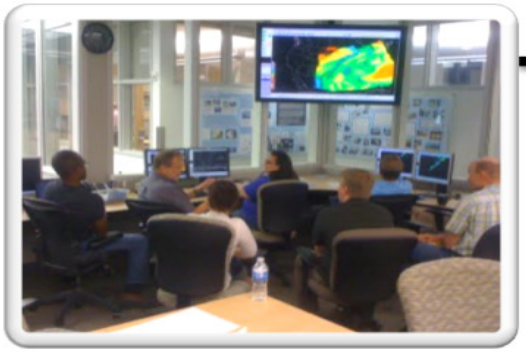
- **Detection product being evaluated within the 2010 SPC Spring Experiment via the GOES-R Proving Ground and the NCAR Global Atmospheric Turbulence Decision Support System for Aviation**

OT Detection Method	OT Pixel FAR	ABI OT Detection Product Maximum Acceptable FAR Requirement	OT Top Region POD	Number of OT Detection Pixels Along CloudSat Track
IR-Texture (Applied to Synthetic ABI)	**16.1%**	**25%**	**74.6%**	**940** ***(114 Global OT Events)***
IR-Texture (Applied to Current GOES and SEVIRI)	**18.3%**	**N/A**	**57.6%**	***252 (59 OT Events)***
WV-IR BT Diff > 0 K (Currently Operational At Aviation Weather Center)	**81.2%**	**25%**	**99.1%**	**15079** ***(114 Global OT Events)***

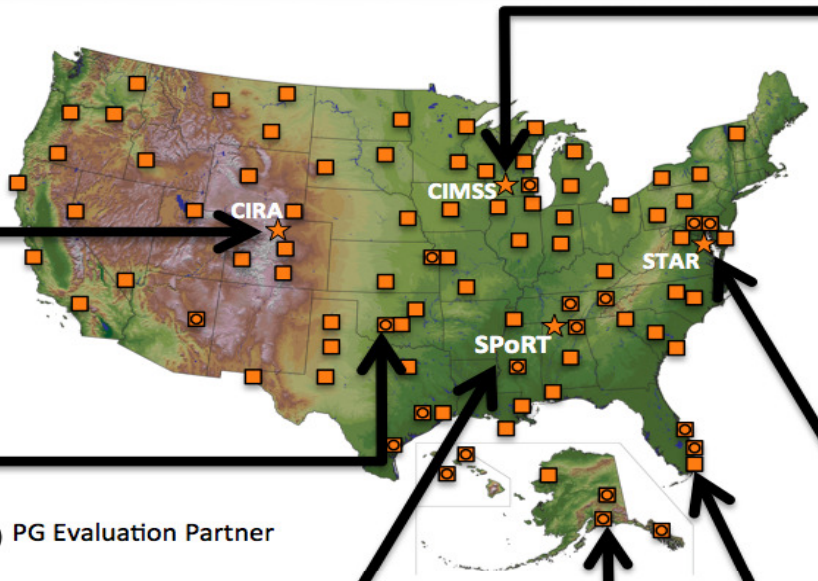
GOES-R Proving Ground



CIRA - Ft. Collins, CO
ABI Simulated Natural Color



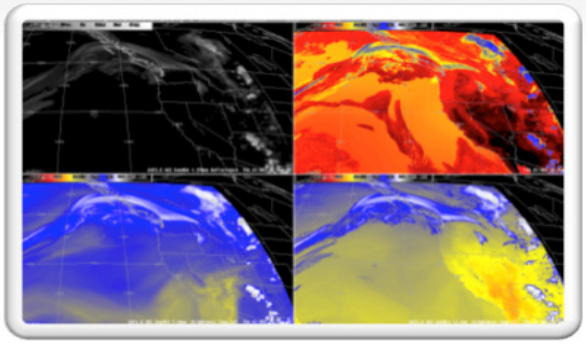
SPC – Oklahoma City, OK
Nearcast Training at the Hazardous Weather Testbed



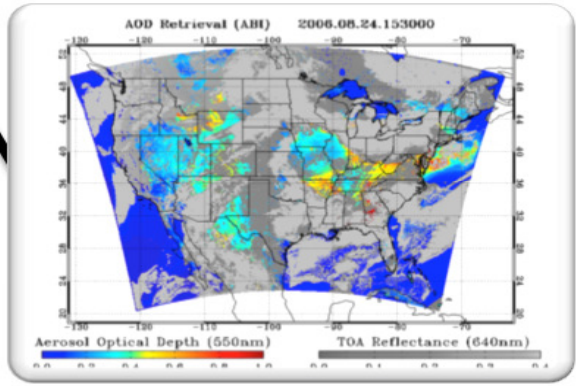
PG Evaluation Partner

PG Product Development Partner

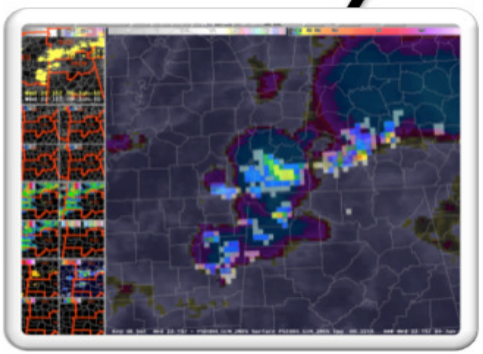
Cooperative Institute



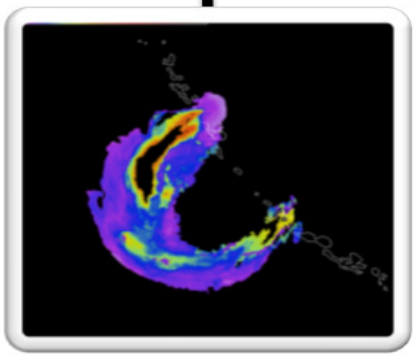
CIMSS – Madison, WI
Simulated ABI Bands



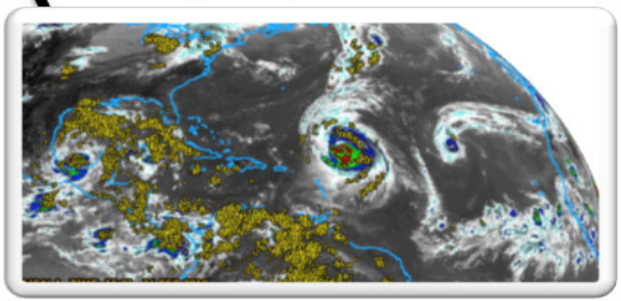
STAR – Camp Springs, MD
Aerosol Optical Depth Product



SPoRT – Huntsville, AL
GLM Lightning Flash Density



AFC – Anchorage, AK
Volcanic Ash Product



NHC – Miami, FL Rapid Intensification Index

July 2011

GOES-R and NWS

- The PGEB and the National Weather Service have identified a set of GOES-R Products as “Warning Related” products which directly contribute to NWS Warning Mission (Save Lives & Property).
- The GOES-R PG activities will first focus on the AWG version of these algorithms/products for demonstration due to their classification.
- The Aviation Products are:

Volcanic Ash: Det. and Height
Aircraft Icing Threat
Convective Initiation
Enhanced "V"/Overshooting Top Detection
Low Cloud and Fog
SO2 Detection

2011 Demonstrations

- Storm Prediction Center (SPC) and NOAA's Hazardous Weather Testbed (HWT)
- National Hurricane Center (NHC)
- Aviation
  - Aviation Weather Center (AWC)
  - Alaska Aviation Weather Unit (AAWU)
  - NWS Regions
- High Latitude Testbed and Alaska Region
- WFO-level demonstrations (MKX, BOU, CYS…)

UW-CIMSS and ASPB GOES-R Products Baseline & Option 2

Demonstration Product (contacts)	Category	PG Testbed Activity
Cloud and Moisture Imagery (WRF ARW simulated) (Schmit/Feltz) - 2010	Baseline	HWT, OPC, HPC -Added visible channel -Alaska and Hawaii domains in future?
UW Convective Initiation (Sieglaff/Feltz) - 2009	Option 2 GIMPAP funded proxy -> UAH CI	HWT, AWC, PAC-Hawaii -GOES-W now available -Ice mask (no CI detection possible)
Overshooting-Top/Enhanced-V (Bedka/Feltz) - 2010	Option 2	HWT, OPC, AWC - Optimal in RSO but limited
Hurricane Intensity Estimate (Velden/Olander) - 2010	Baseline	NHC
Fire Detection (Schmidt) - 2010	Baseline	HWT - New intensity field

UW-CIMSS and ASPB GOES-R Products Baseline & Option 2

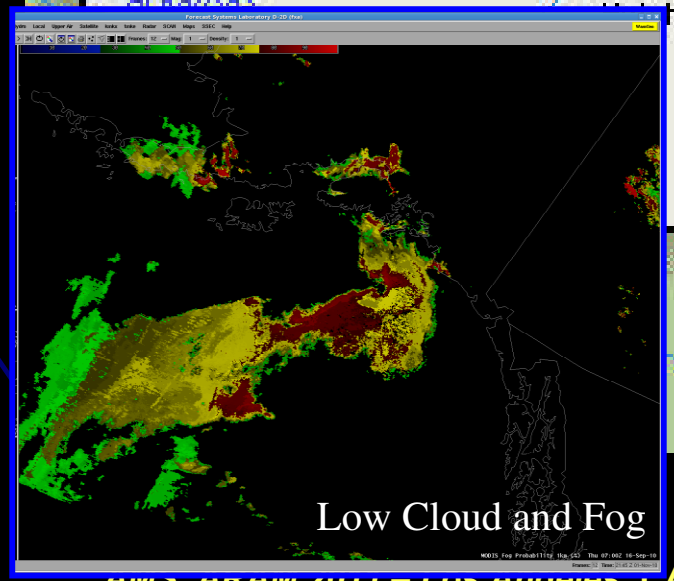
Demonstration Product (contacts)	Category	PG Testbed Activity
Volcanic Ash location/height/loading (Pavolonis) - 2010	Baseline	HLT-Alaska/AAWU, AWC, PAC-Hawaii - MODIS/AVHRR derived
SO2 (Pavolonis) – 2011	Option 2	HLT-Alaska, AAWU/AAWU, AWC, PAC-Hawaii - MODIS/AVHRR derived
Low cloud/Fog (Pavolonis) - 2011	Option 2	HLT-Alaska/AAWU, AWC - GOES/MODIS/AVHRR
Cloud phase/typing (Pavolonis) - 2011	Baseline	OPC, HLT-Alaska/AAWU - GOES/MODIS/AVHRR
Cloud Height/temperature/mask (Heidinger) – 2011	Baseline	OPC, HLT-Alaska/AAWU - GOES/MODIS/AVHRR
Total Precipitable water/Atmospheric Stability (Schmit) - 2012	Baseline	OPC, PAC, HWT (delayed until 2012)

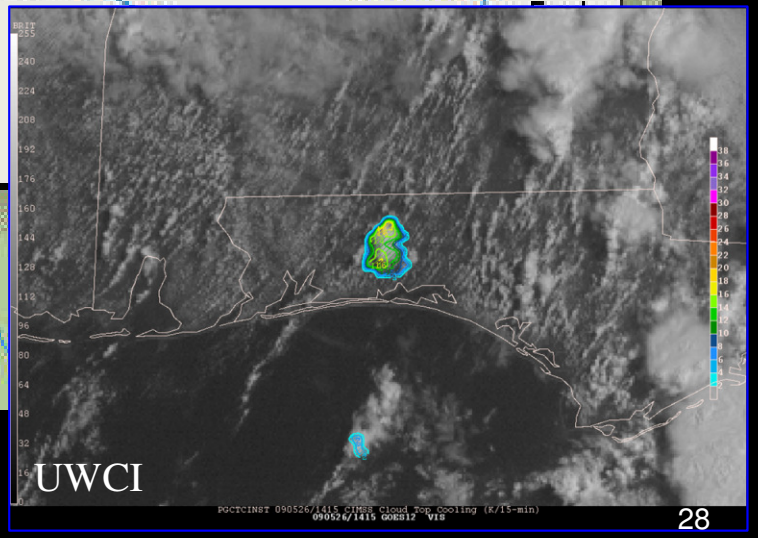
Aviation Weather

- **Aviation Weather Center (Kansas City) – New GOES-R hire**
  - Products
    - Convective Initiation and Nearcasting
    - Volcanic Ash: Detection and Height; SO2 Detection
    - Aircraft Icing Threat
    - Low Cloud and Fog
    - WRF Lightning Threat
- **AK Aviation Weather Unit (Anchorage)**
  - Products
    - Volcanic Ash: Detection and Height; SO2 Detection
    - Low Cloud and Fog
    - Cloud Top Height
- **NWS Regions**
  - Starting with WR WFOs and CWSUs – followed by expanding to other regions.

Ongoing Demonstrations 2011
Aviation Weather Experiment

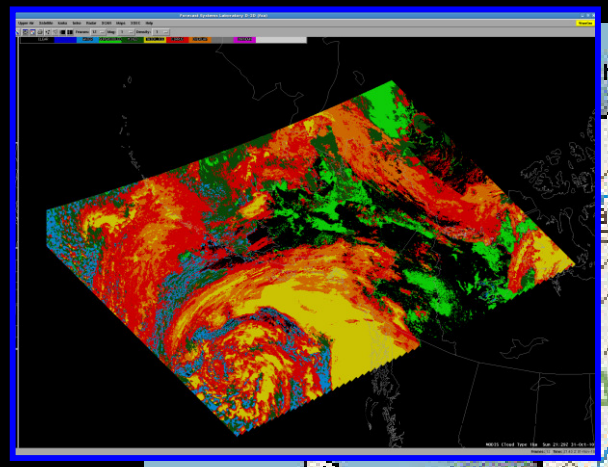
Location
-Aviation Weather Center, Kansas City, KS
Focus
-Aviation
Products
-Low Cloud and Fog
-SO2 Detection
-Volcanic Ash Detection and Height
-Aircraft Icing Threat
-UW Convective Initiation
-Nearcasting Model
Duration
-1 Jun – 31 Oct (TBD) 2011

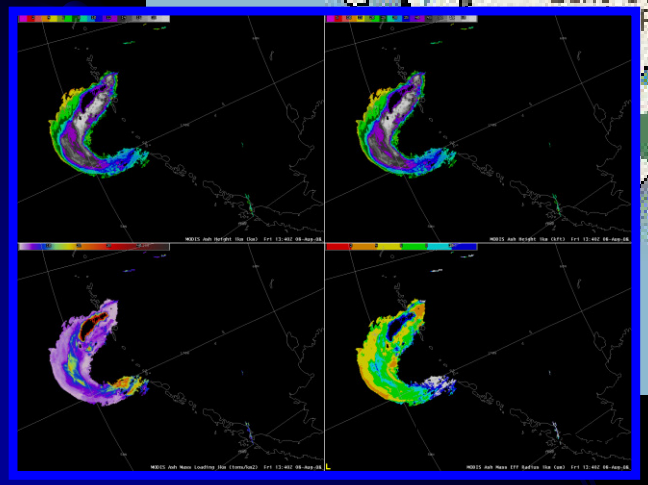

Low Cloud and Fog


UWCI

Ongoing Demonstrations 2011

High Latitude and Arctic Experiment





Location

-Alaska Region

- GINA
- WFO Fairbanks
- WFO Anchorage
- WFO Juneau
- AAWU

Focus

-Snow/Cloud/Ash/Aviation

Products

-Cloud Mask

-Cloud Phase

-Low Cloud and Fog

-SO2 Detection

-Volcanic Ash Detection and Height

Duration

- 6 Dec 2010 – 31 Aug 2011

GOES-R Proving Ground

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Resources

- Proving Ground Products List (Table)
  - CIMSS NOAA Testbed Support Products
  - CIRA Products
  - SPoRT
  - Air Quality (UMBC)
- Meetings and Presentations
- Teleconferences
- Proving Ground Partners
- GOES-R Advanced Baseline Imager (ABI) Bands
- GOES-R ABI Sample Product Table
- GOES-R ABI Weighting Function Examples

UW/CIMSS NOAA Proving Ground Testbed Decision Support Products

Description	Contact	Training	Quicklooks	Validation	Satellite Platform	Testbed	Forecaster Comments	Product Type	AWIPS Setup
Convective Initiation(UWCI)	Wayne Feltz	UWCI (Visit) UWCI (ppt)	Convective Decision Support	Convective Initiation Products	GOES Imager	HWT, AWC, PR	Link	Product Variant	Instructions
Overshooting Top (OTTC) and Enhanced-V	Wayne Feltz Kris Bedka	OTTC (PPT) OTTC and Enhanced-V (Visit)			GOES Imager, MODIS/AVHRR	HWT, HLT	Link	AWG Proxy	
WRF Simulated Radiances (ABI Simulated Radiances)	Justin Sieglaff	WRF (PDF)	WRF			HWT		Risk Reduction	
WildFire ABBA (WFABBA)	Chris Schmidt				GOES Imager	HWT		AWG Proxy	
NearCast	Ralph Petersen	UW NearCasting (VISIT)	NearCast		GOES Imager, GOES Sounder	HWT	Link	Risk Reduction	Instructions
Volcanic Ash	Mike Pavolonis	Ash (ppt) Ash (Visit)			MODIS, SEVIRI	AAWU, AWC, HLT, PR		AWG Proxy	Instructions
Low Clouds/Fog	Mike Pavolonis	Fog(Training) Quick Facts			MODIS-Alaska, GOES-CONUS	AAWU, AWC, HLT		AWG Proxy	
Cloud Type	Mike Pavolonis	TBD			MODIS-Alaska, GOES-CONUS	AAWU, HLT, OPC		AWG Proxy	See Contact
SO_2	Mike Pavolonis	TBD			MODIS	AAWU, AWC		AWG Proxy	See Contact

Testbed Legend

http://cimss.ssec.wisc.edu/goes_r/proving-ground/SPC/SPC.html

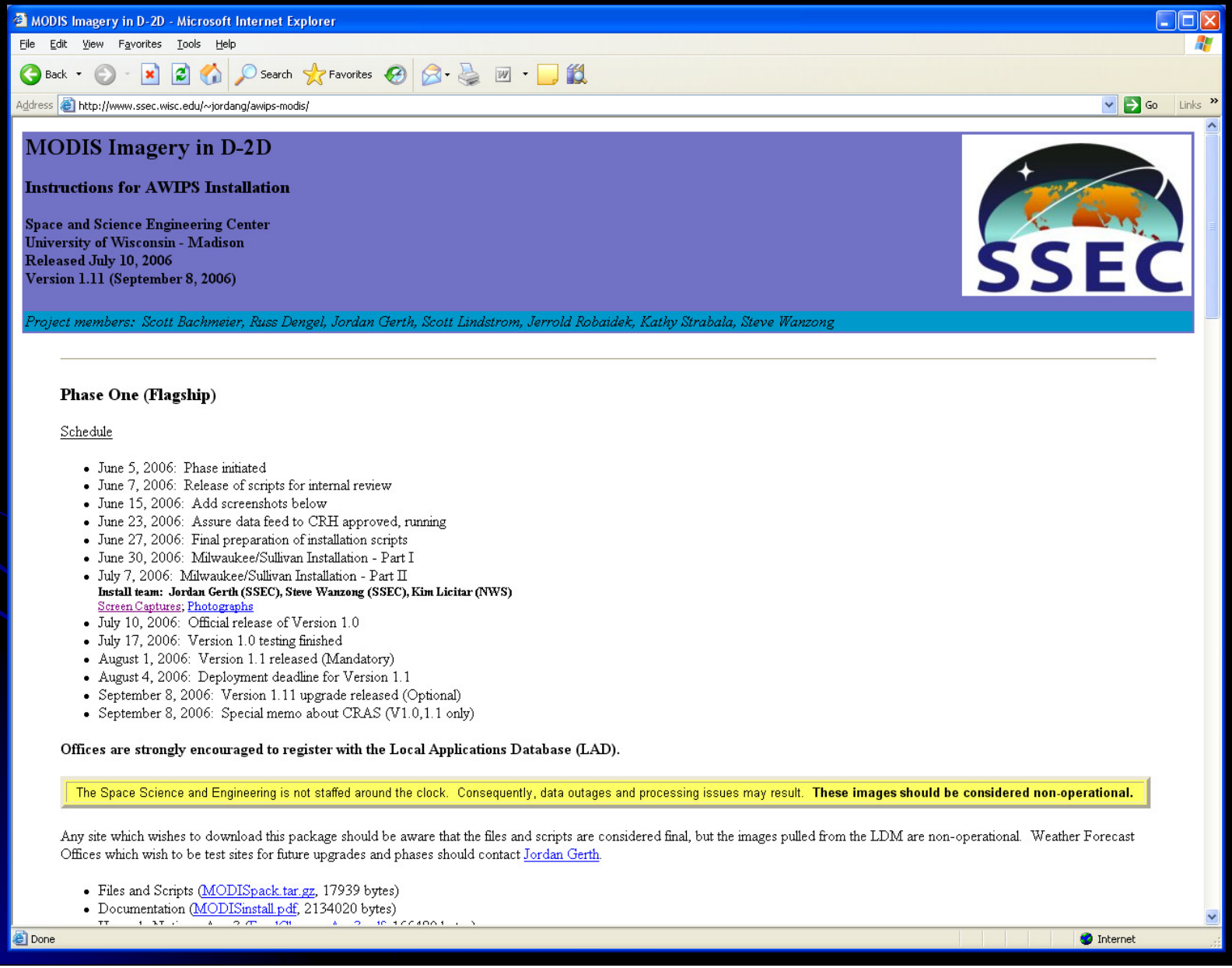
UW/CIMSS Tropical Proving Ground Decision Support Products for the National Hurricane Center

Description	Contact	Training	Data Page	Validation	Satellite Platform	Product Type
Tropical Overshooting Tops	Sarah Monette	TOT	Tropical Overshooting Tops		SEVIRI	AWG Proxy
Hurricane Intensity Estimation (HIE)	Tim Olander		HIE		SEVIRI	AWG Proxy

Real-time Access

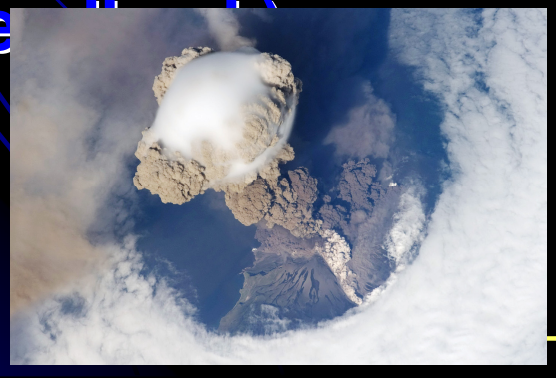
Instructions Available Online

http://cimss.ssec.wisc.edu/~jordang/awips-modis/



GOES-R Volcanic Ash Product Evaluation

- The GOES-R ash cloud height, mass loading, and effective particle radius products developed by the AWG were made available to the NWS AK Region in February 2011 using MODIS
- Three live training sessions (conducted by M. Pavolonis and J. Sieglaff) were conducted between March 9 and April 1, 2011 (a total of 18 people from the NWS AK Region participated)
- Two interesting cases have been observed since the training was conducted (AAWU SOO has provided

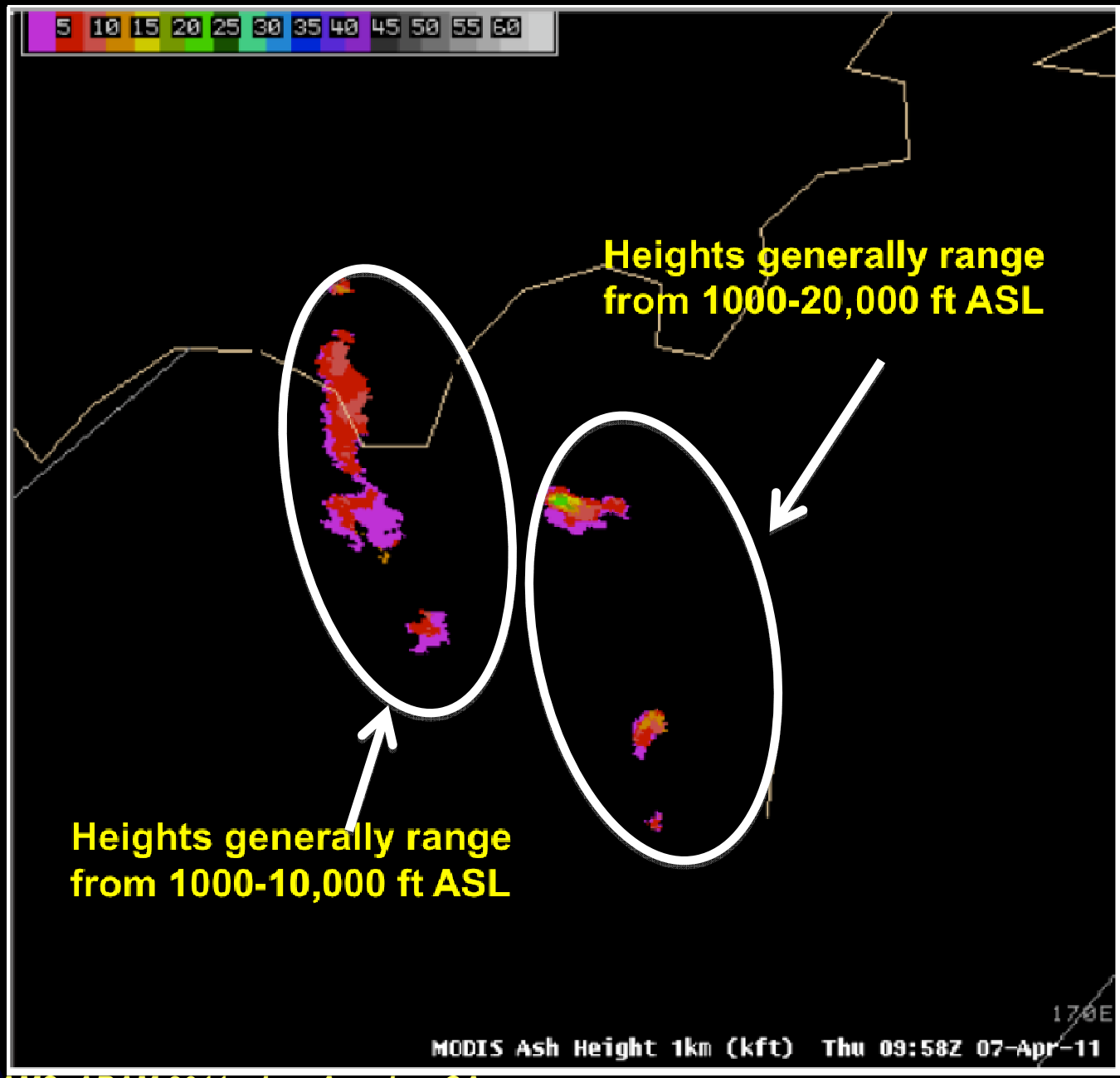



ystem
8:20 PM
Thu 16 Sep 2010 20:20 UTC
Thu 16 Sep 2010 20:20 GMT
Alarm/Alert
Text 1: MKEWRKASH
Text 2
Text 3
Text 4
test.jpg (JPEG Image, 1096x992 pixels) - Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://www.ssec.wisc.edu/~mpav/test.jpg
Most Visited Red Hat Red Hat Magazine Red Hat Network Red Hat Support
RGB (12−11μm, 11−3.75μm, 11μm)
NOAA−18 AVHRR (08/08/2008 − 14:35 UTC)
Ash Loading
Total Mass: 486.75 kton
Ash Concentration [ton/km²]
0.0 4.3 8.6 13.0 17.3 21.6 25.9
Ash Effective Radius
Mean Ash Reff: 5.91 micron
Text 1: MKEWRKASH
File Edit Options Version Tools Scripts Products Help
AFOS Browser Load History WMO Search Enter Editor Accum Update Obs Clear
AFOS Cmd:
WMO and AWIPS queries are not supported in practice mode
ZCZC MKEWRKASH ALL
TTAA00 KMKE 162004
...THIS IS A TEST...
@**********GENERATING VOLCANIC CLOUD WARNINGS********** DATE:
08/08/2008
TIME: 14:35 UTC
SATELLITE: NOAA-18 AVHRR
L1B FILENAME: NSS.HRPT.NN.D08221.S1435.E1448.B1658686.GC
ORBIT NUMBER: 1658686
NUMBER OF ASH CLOUD WARNINGS: 1
NUMBER OF VOLCANIC CB WARNINGS: 0
NUMBER OF VOLCANIC HOT SPOT WARNINGS: 0
****
VOLCANIC ASH CLOUD FOUND
RADIATIVE CENTER (LAT, LON): 51.855, -175.294
MEAN VIEWING ANGLE (DEGREES): 53.47
MEAN SOLAR ZENITH ANGLE (DEGREES): 100.96
NEARBY VOLCANOES:
SERGIEF(32.06 KM)
KASATOCHI(38.71 KM)
KONIUJI(42.13 KM)
GREAT SITKIN(62.37 KM)
ATKA(95.31 KM)
FALSE ALARM POTENTIAL: 0 OUT OF 276994
MAXIMUM HEIGHT: 10.9 KM (35890.07 FT)
MEAN TROPOPAUSE HEIGHT: 10.9 KM (35917.70 FT)
MEDIAN EFFECTIVE RADIUS: 5.05 MICRON
TOTAL MASS: 486.67 KTONS
TOTAL MASS OF FINE ASH: 9.45 KTONS
TOTAL AREA: 58982.00 KM^2
****
$$
[Terminal]
test.jpg (JPEG Image, 1096x992 pixels) - Mozilla ...
Control
WRKASH

April 7, 2011: Kizimen and Sheveluch Volcanic Ash Clouds

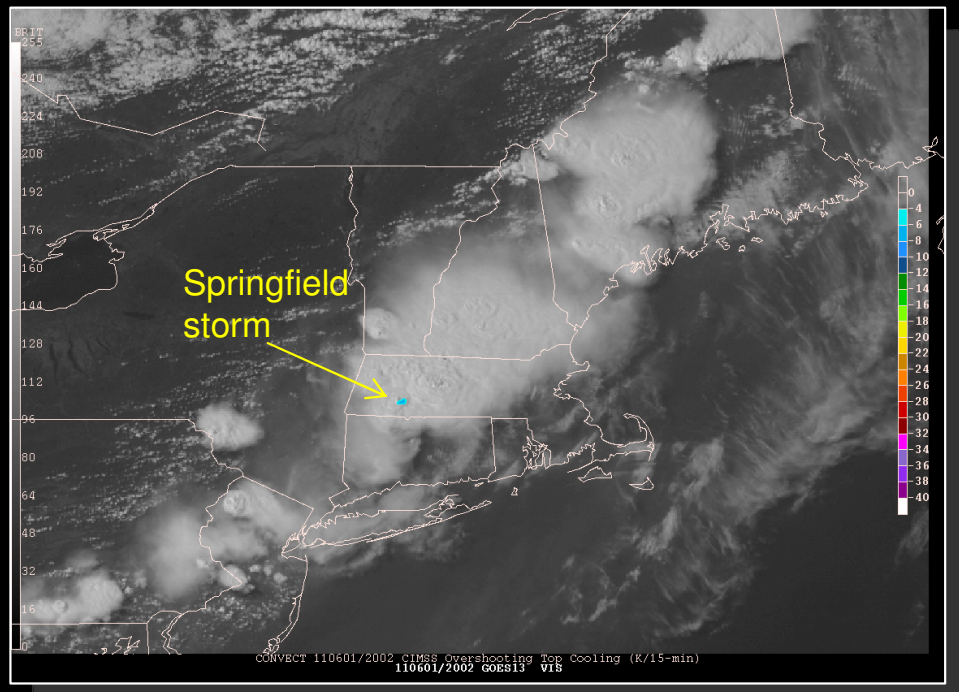
Feedback from Nathan Eckstein (AAWU SOO): "The (GOES-R) ash heights from Kizimen were in good agreement, not only with Tokyo VAAC who was doing the forecasting, but also with the wind analysis from 500mb wind."

Nathan also commented about the potential uses for the effective radius product and how the products can be used to initialize HYSPLIT



Overshooting Top Detection

- The GOES-R Overshooting Top Detection (OTD) algorithm identified an overshooting top at NOAA's Hazardous Weather Testbed with the severe thunderstorm and tornado that in Springfield, MA on June 1, 2011
- The OTD singled out the most intense thunderstorm cell out of a very large storm complex over Southern and Central New England.
- At the HWT Experimental Warning Program and Convective Initiation desk the NWS forecasters were alerted to a developing severe storm with 28 minute lead time before the first tornado report.



GOES-R HWT BLOG

The GOES-R Proving Ground at NOAA's Hazardous Weather Testbed

Wireless Network Authenticatio... | Heartbeat | Problem loading page | The GOES-R Proving Ground at ...

http://goesrhwt.blogspot.com/search?updated-max=2011-05-16T11%3A18%3A00-05%3A00&max-results=7

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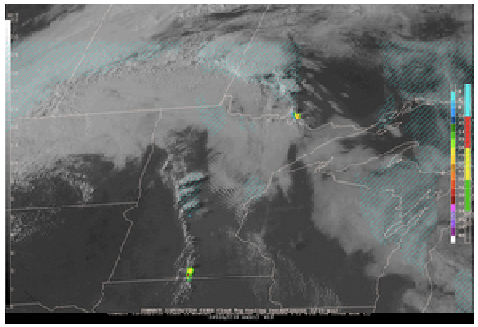
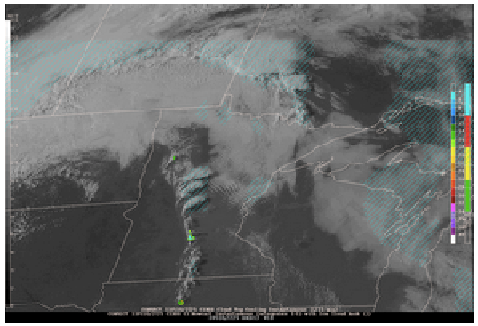
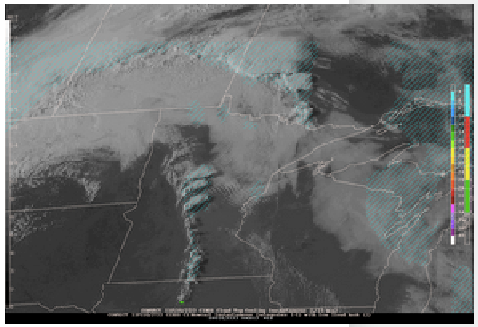
UW-Madison CIMSS convective initiation, overshooting-top, and nearcasting update

GOES-R proxy University of Wisconsin convective initiation (UWCI), overshooting-top/enhanced-V, WRF ARW simulated data and nearcasting fields have been flowing in a smooth manner into the EFP via N-AWIPS for forecast discussion integration. UWCI did indicated individual cells developing along north-south boundary in MN yesterday afternoon (10 May 2011).







24-hour UWCI indications, overshooting-tops, and NLDN lightning data from 12 UTC 20110510 - 12 UTC 20110511 below:

http://goesrhwt.blogspot.com/

Joint Polar Satellite System User Engagement & Feedback

NPP October 25, 2011 launch

NWS- Alaska Region use DB software from CIMSS to provide feedback on:

- Cloud products, snow, ice, volcanic ash, aerosols
- Soundings

NASA-SPORT will directly engage more than 20 NOAA /NWS Weather Forecast Offices to facilitate use of NPP data and to provide feedback on VIIRS and CrIMSS products.

NRL NEXSAT – uses VIIRS Imagery and EDRs for environmental assessments.

Summary

- 100% Aviation ATBDs have been delivered to GOES-R Program Office in July 2011

- Strenuous validation is required to meet specification within GOES-R Mission Requirements Document (NOAA GOES-R AWG)

- Vested interest in providing GOES-R/JPSS like products in hands of forecasters through Proving Grounds (example: Aviation Weather Center and HWT Testbed) (NOAA GOES-R/JPSS PG)

- Most of these science product requirements are being "fused" into operational venue (examples below), path to NEXGEN imperative *(NASA ROSES critical!)*
  - Turbulence – GTG-N
  - Convective initiation - CoSPA
  - Icing - CIP
  - Volcanic Ash – VAACs