Marco Fulle - www.stromboli.net

Multi-sensor Satellite Algorithm Development for Volcanic and Fog Hazards

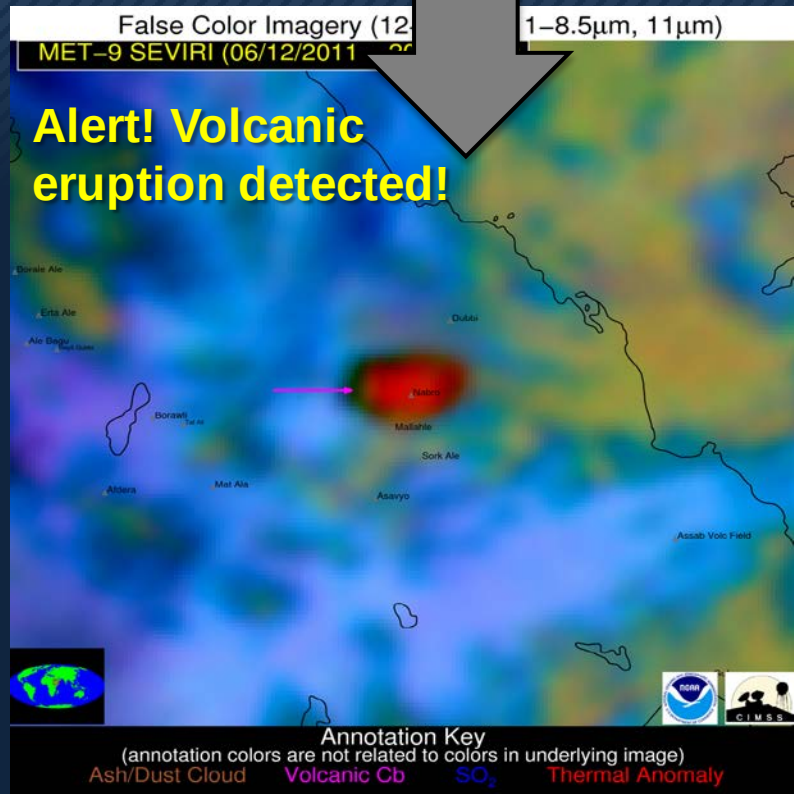
Michael Pavolonis

(NOAA/NESDIS/STAR)

Justin Sieglaff, John Cintineo, Corey Calvert, Shane Hubbard, and Bill Bellon

(UW-CIMSS)

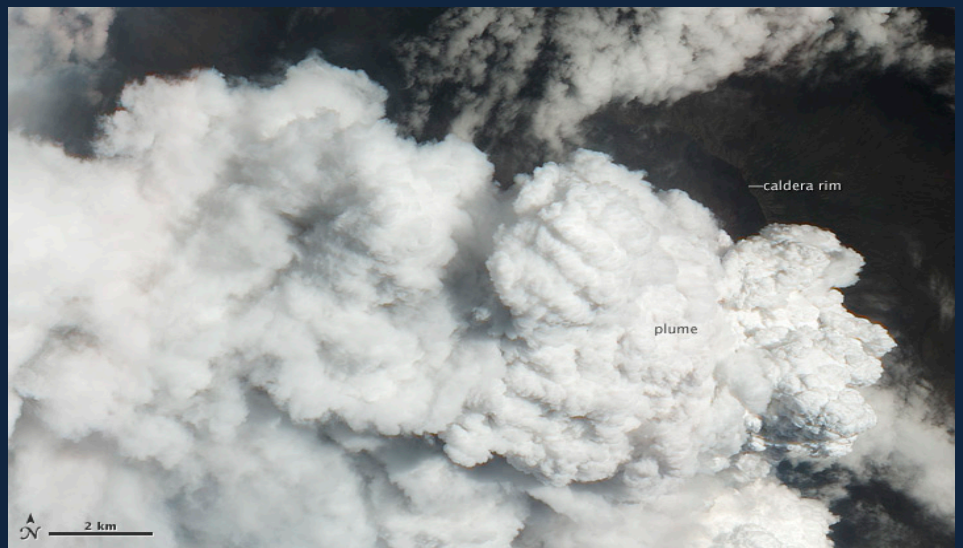
Collecting large volumes of satellite data alone does not directly address any natural hazard problem, the satellite data must be converted into actionable information using science and computers.

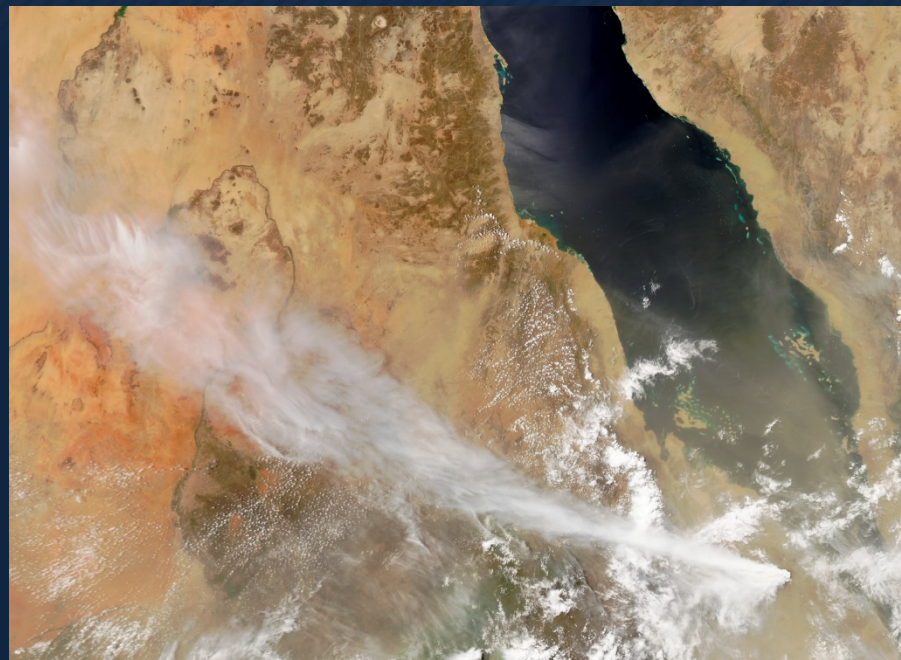


2. First detection of volcanic eruptions

Nabro volcano in Eritrea erupted explosively for the first time in recorded history on June 12, 2011

The eruption went undetected for 7.5 hours!





14 June 2011 Last updated at 09:35 ET

Share

Eritrea eruption: Clinton cuts short African tour

BBC NEWS AFRICA

A plume of smoke from an erupting volcano in southern Eritrea, seen at top, centre, is carried by winds blowing across northern Ethiopia on Monday

The US secretary of state has cut short a three-nation tour of Africa following a volcano eruption that has created an ash cloud over parts of East Africa.

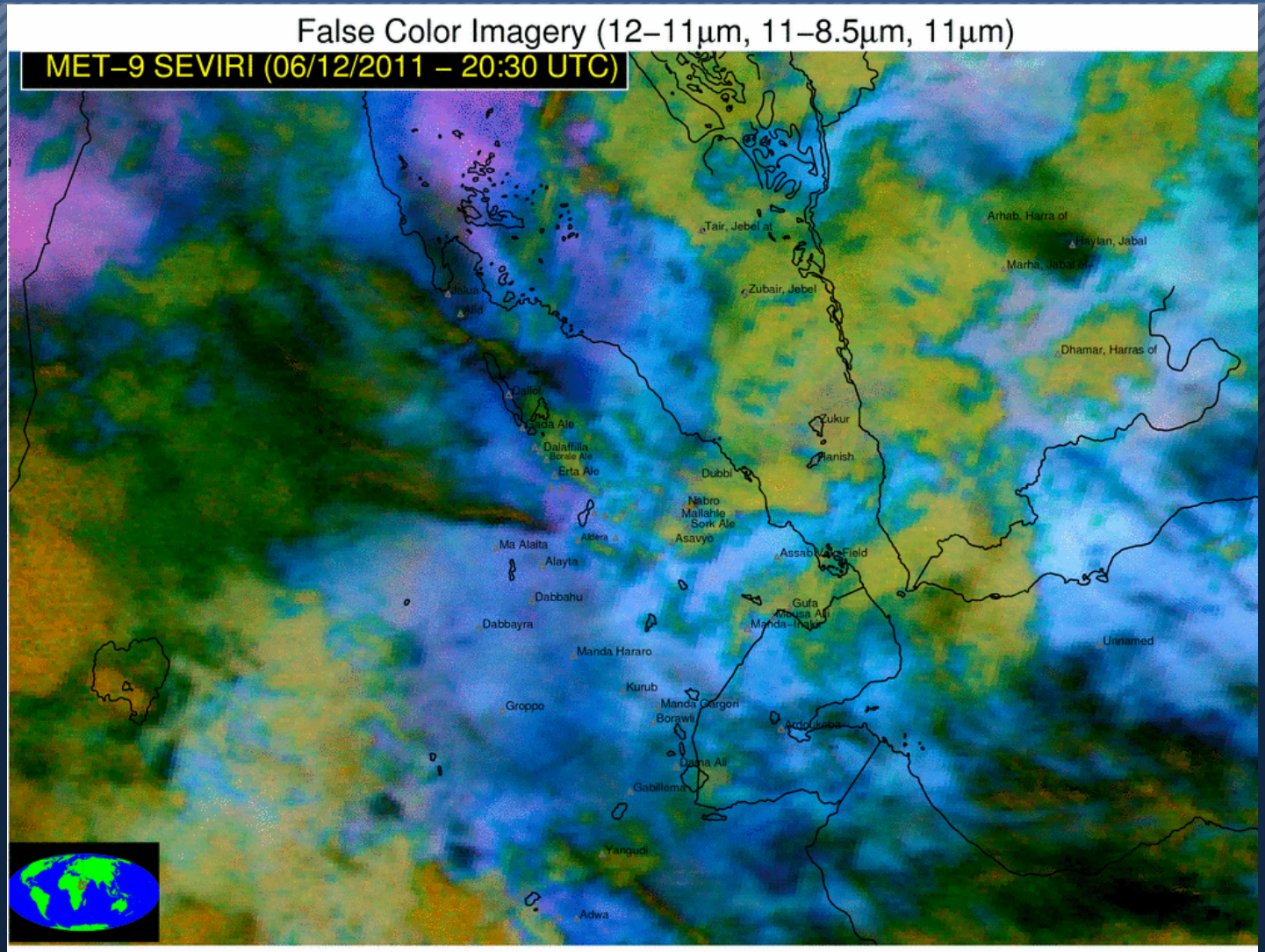
Hillary Clinton arrived in the Ethiopian capital on Monday for an address to the African Union.

US officials said the decision was taken because the cloud was due to move towards Addis Ababa.

The cloud, triggered by an eruption in Eritrea, has led to the cancellation of some flights to East Africa.

The German airline Lufthansa cancelled flights to both Eritrea and neighbouring Ethiopia.

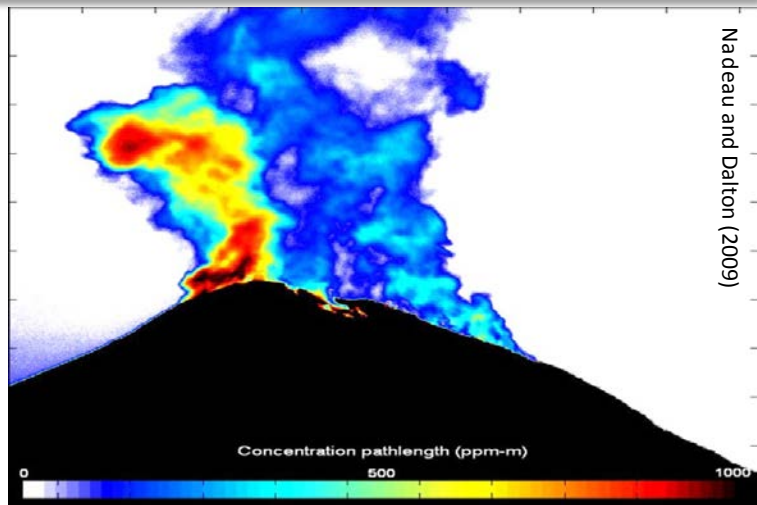
The NOAA volcanic eruption alerting tool was able to detect the eruption within 15 minutes of the start time and generate an alert



1). Ash dominated volcanic plumes – Semi-transparent clouds dominated by volcanic ash. Lightning is usually not present in these clouds.

2). Ice topped umbrella clouds – These cloud are mostly observed during a major eruption. A spectral based volcanic ash signal is usually initially absent because the ash is encased in ice and/or the cloud is opaque. Lightning is often present in these clouds.

3). SO_2 clouds – Sulfur dioxide clouds (SO_2 gas is invisible to the eye) that may or may not contain volcanic ash. Some eruptions produce large amounts of SO_2 and very little ash and vice-versa.

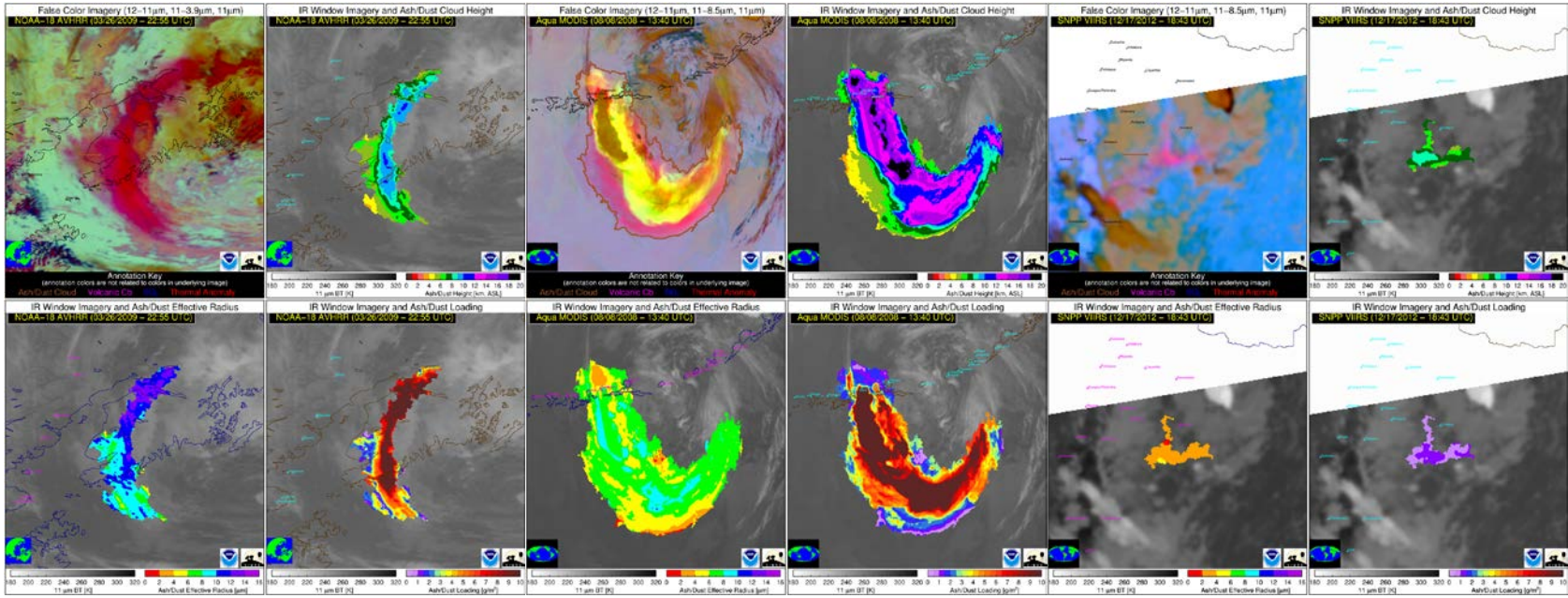


Nadeau and Dalton (2009)

Making Full Use of the Space-based Observing System for Volcanic Cloud Monitoring

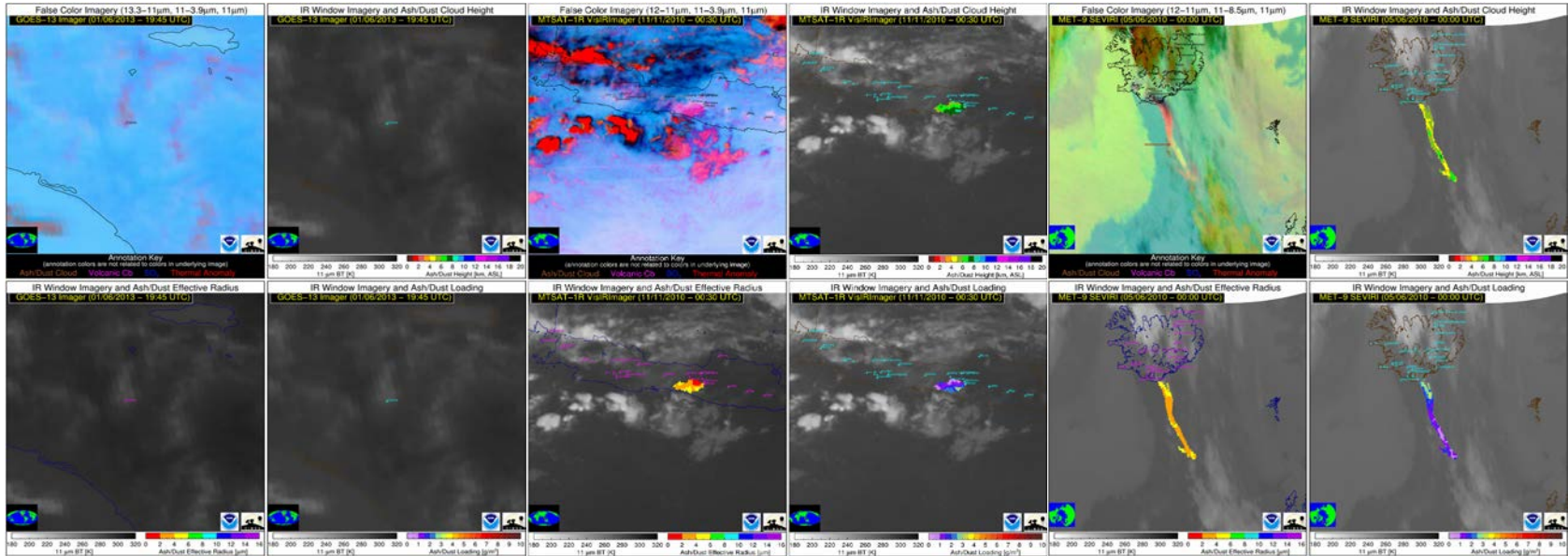
LEO

NOAA and MetOp AVHRR | **Terra and Aqua MODIS** | **SNPP-VIIRS**



GEO

GOES-13-15 | **MTSAT-(1r and 2)** | **Met-(8,9,10) SEVIRI**



Summary of Products and Techniques

- **End products: ash probability, ash top height, mass loading, effective particle radius, volcanic cloud alerts, cloud vertical growth rate anomalies, volcanic thermal anomalies**

- **Techniques: probabilistic cloud object based ash detection, optimal estimation retrieval of ash cloud properties (ash height, mass loading, and effective radius), multi-sensor cloud tracking to improve ash detection and cloud property retrieval**

- **Ash detection does not rely on robust "split-window" signature and is designed to emulate a skilled human analyst (good probability of detection, very low false alarm rate)**

- **Value added applications: plume medial axis transformation and polygon fitting**

Identifying "restless" volcanoes

Satellite measurements

↓

Scientific computer algorithm

↓

Identification of volcanoes that are most likely to erupt

↓

Automated alert to users

Using weather satellite data, an unusually large ground temperature was identified at Kelut volcano and an alert was automatically generated

From: Mike Pavolonis NOAA Federal
Subject: **NOAA/CIMSS Volcanic Cloud Alert**
Date: February 13, 2014 10:09:05 AM CST
To: Mike Pavolonis NOAA Federal

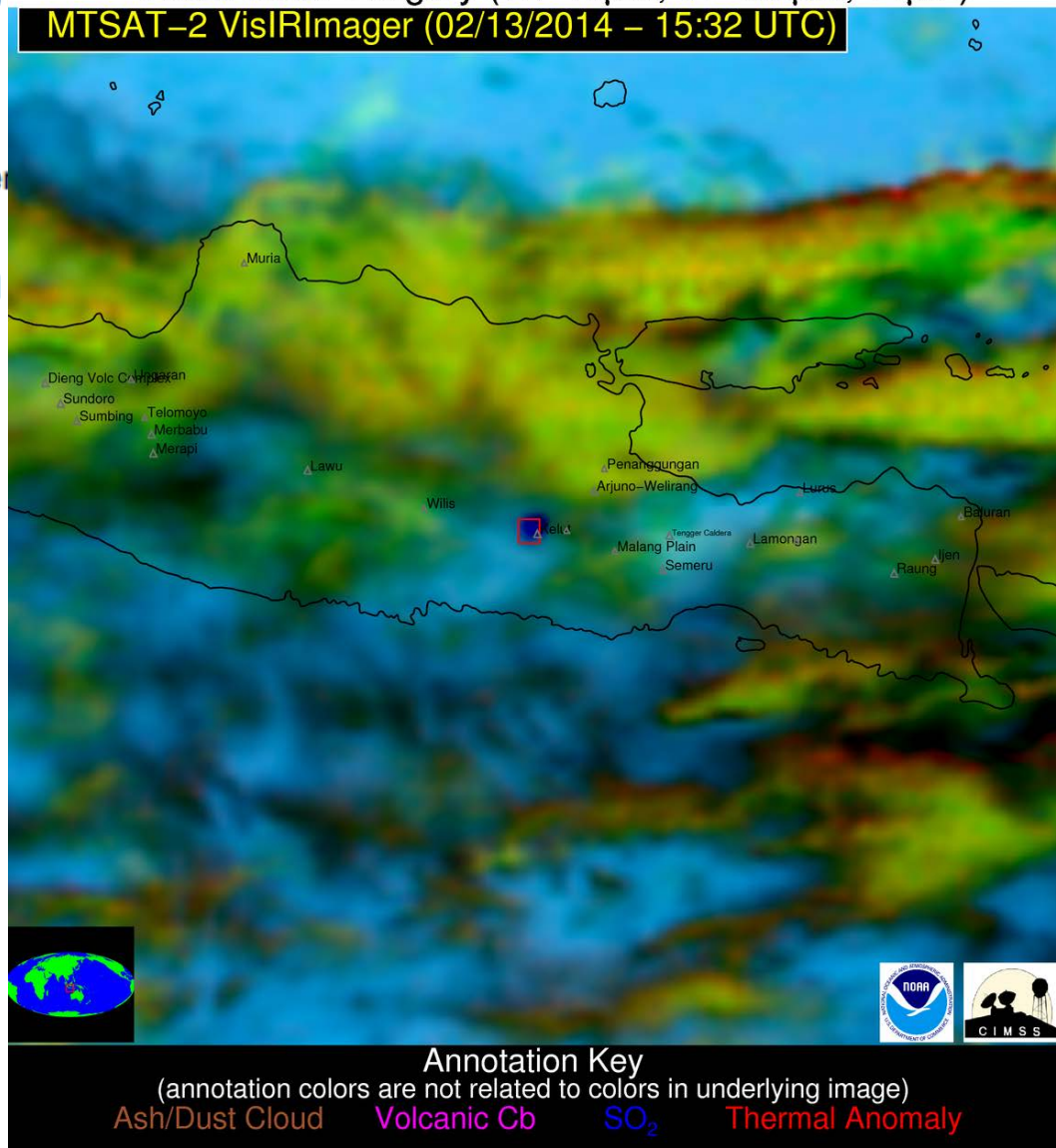
@**********VOLCANIC ALERTS**********
STARTING DATE/TIME OF IMAGE: 2014-02-13 15:32:00 [U
PRIMARY INSTRUMENT: MTSAT-2 Vis/IR_Imager
WMO SPACECRAFT ID: 172
LOCATION/ORBIT: GEO
L1 FILE: mtsat02_1_2014_044_1532.area.gz
VOLCANO DATABASE: /data/common//VOLCAT_DATA/aler
NUMBER OF ASH CLOUD ALERTS: 0
NUMBER OF VOLCANIC Cb ALERTS: 0
NUMBER OF VOLCANIC THERMAL ANOMALY ALERTS: 1
NUMBER OF SO2 CLOUD ALERTS: 0

REPORT WITH IMAGES:
http://volcano.ssec.wisc.edu/alert/report/12211

POSSIBLE VOLCANIC THERMAL ANOMALY FOUND
Alert Status: New Alert Object
Latitude of Radiative Center: -7.920 [degrees]
Longitude of Radiative Center: 112.268 [degrees]
Mean Viewing Angle: 39.18 [degrees]
Mean Solar Zenith Angle: 151.86 [degrees]
Nearby Volcanoes (meeting alert criteria):
Kelut(4.67 km)
Maximum 3.8 um Brightness Temperature: 310.37 [K]
Maximum 3.8 um Thermal Anomaly: 20.80 [K]
Total Area: 89.30 [km^2]

Geographic Regions of Nearby Volcanoes: Java
VAAC Regions of Nearby Volcanoes: Darwin
FIR Regions of Nearby Volcanoes: Unknown

False Color Imagery (12–11μm, 11–3.9μm, 11μm)



30 minutes later…

July 20, 2014 – VIIRS ash alert using GINA DB

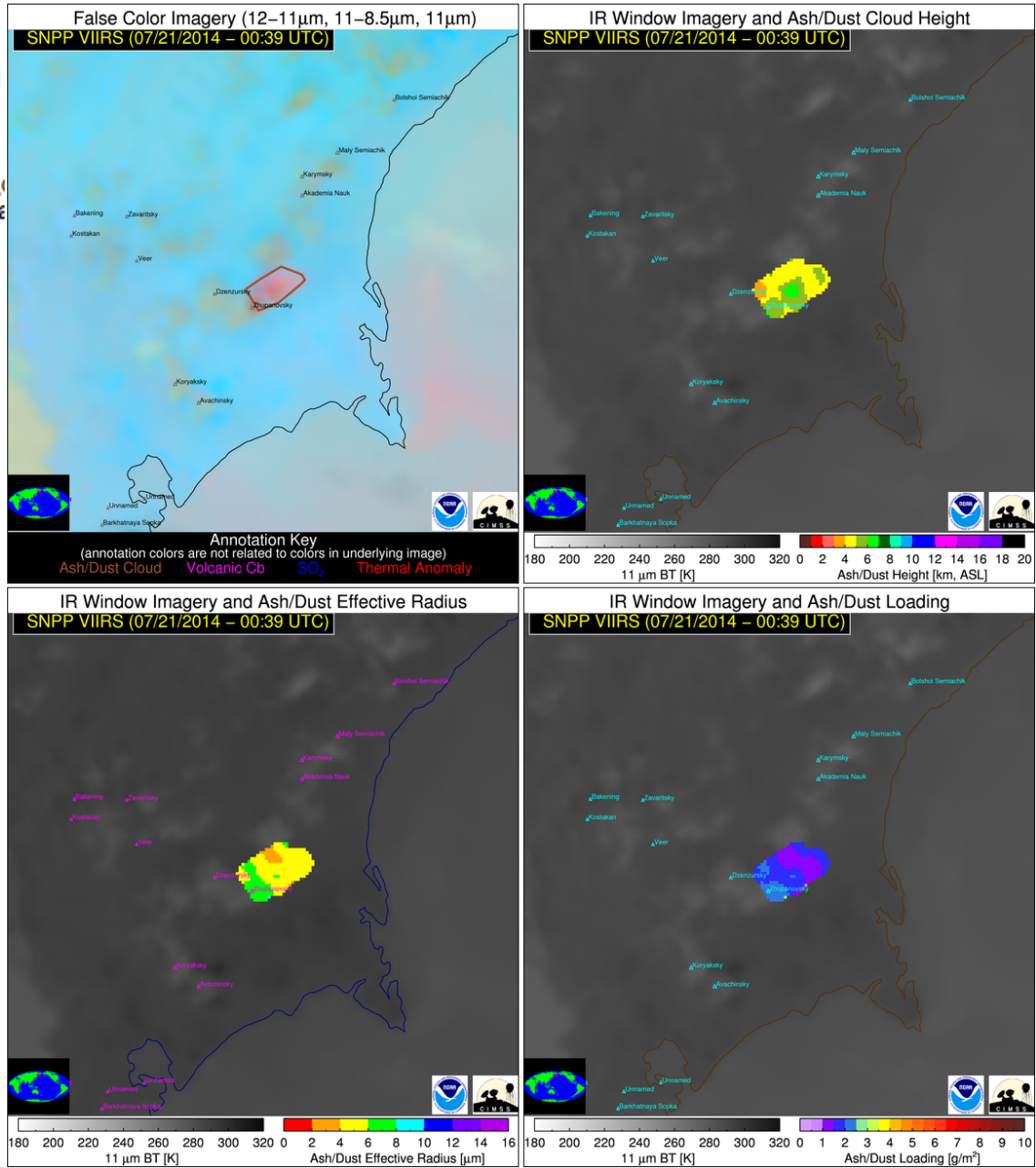
From: volcano.alerts-noreply@ssec.wisc.edu
Subject: **NOAA/CIMSS Volcanic Cloud Alert**
Date: July 20, 2014 8:32:32 PM CDT
To: Mike Pavolonis NOAA Federal

@**********VOLCANIC ALERTS**********
STARTING DATE/TIME OF IMAGE: 2014-07-21 00:39:59 [UTC]
PRODUCTION DATE/TIME OF ALERT: 2014-07-21 01:30:46 [UTC]
PRIMARY INSTRUMENT: NPP VIIRS
WMO SPACECRAFT ID: 224
LOCATION/ORBIT: LEO
L1 FILE: SVM14_npp_d20140721_t0039587_e0047048_b14140_
VOLCANO DATABASE: /data/common//VOLCAT_DATA/alerts/Volca
NUMBER OF ASH CLOUD ALERTS: 1
NUMBER OF VOLCANIC Cb ALERTS: 0
NUMBER OF VOLCANIC THERMAL ANOMALY ALERTS: 0
NUMBER OF SO2 CLOUD ALERTS: 0

REPORT WITH IMAGES:
http://volcano-test.ssec.wisc.edu/alert/report/15755

POSSIBLE VOLCANIC ASH CLOUD FOUND
Alert Status: New Alert Object
Alert Confidence: HIGH
Latitude of Radiative Center: 53.653 [degrees]
Longitude of Radiative Center: 159.302 [degrees]
Mean Object Date/Time: 2014-07-21 00:39:59 [UTC]
Mean Viewing Angle: 64.60 [degrees]
Mean Solar Zenith Angle: 34.40 [degrees]
Nearby Volcanoes (meeting alert criteria):
Zhupanovsky(12.41 km)
Dzenzursky(25.15 km)
Akademia Nauk(38.05 km)
Karymsky(45.26 km)
Avachinsky(54.22 km)
Cloud Object Probability: 100.00000 [%]
Median Probability of Object Pixels: 99.33333 [%]
Percent Unambiguous Pixels: .17695 [%]
Maximum Height [AMSL]: 7.6 [km] (24913.46 [ft])
90th Percentile Height [AMSL]: 6.5 [km] (21437.82 [ft])
Mean Tropopause Height [AMSL]: 12.1 [km] (39781.88 [ft])
Total Mass: .000699 [Tg]
Median Effective Particle Radius: 4.70 [um]
Total Area: 418.09 [km^2]

Geographic Regions of Nearby Volcanoes: Kamchatka



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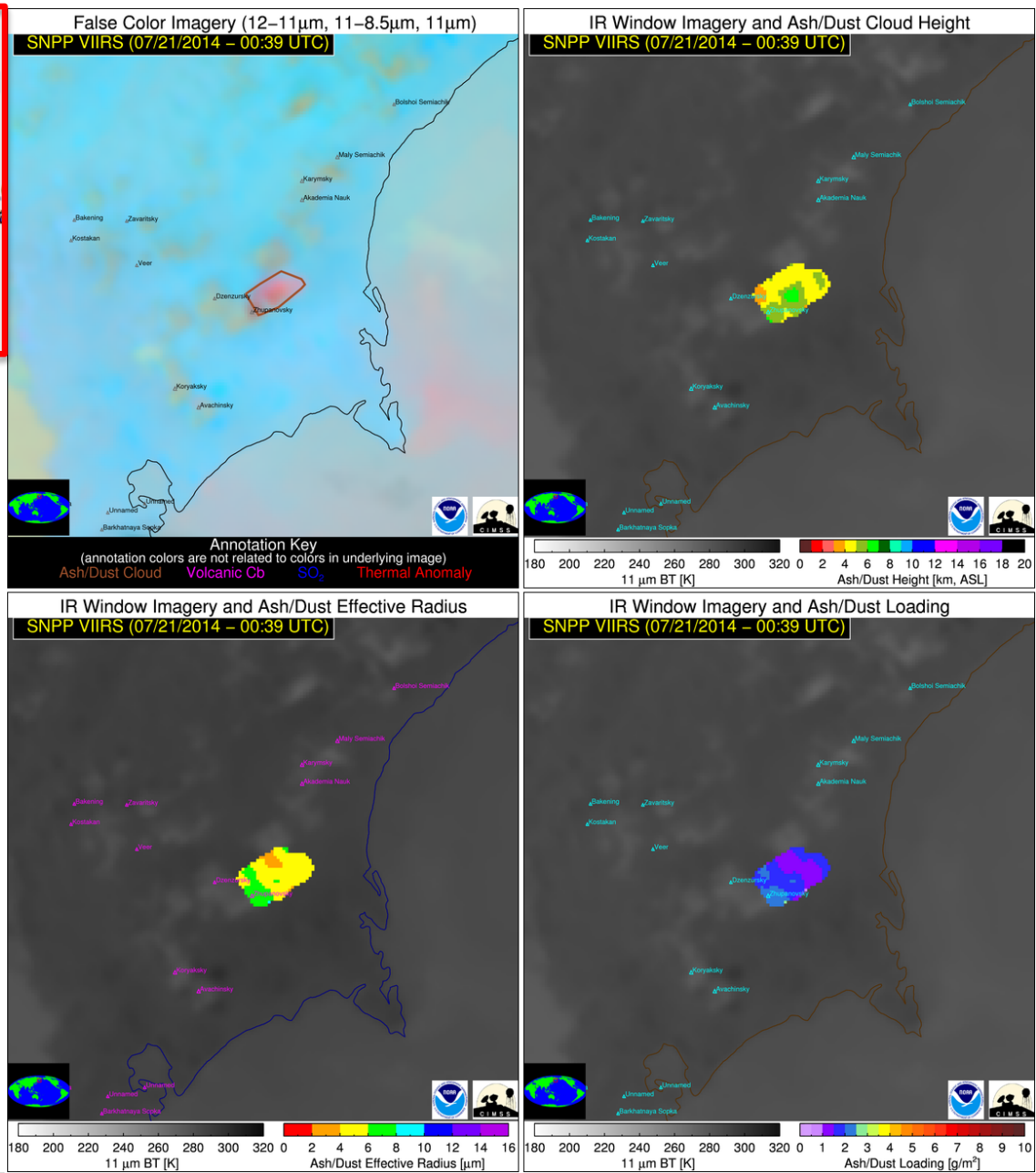

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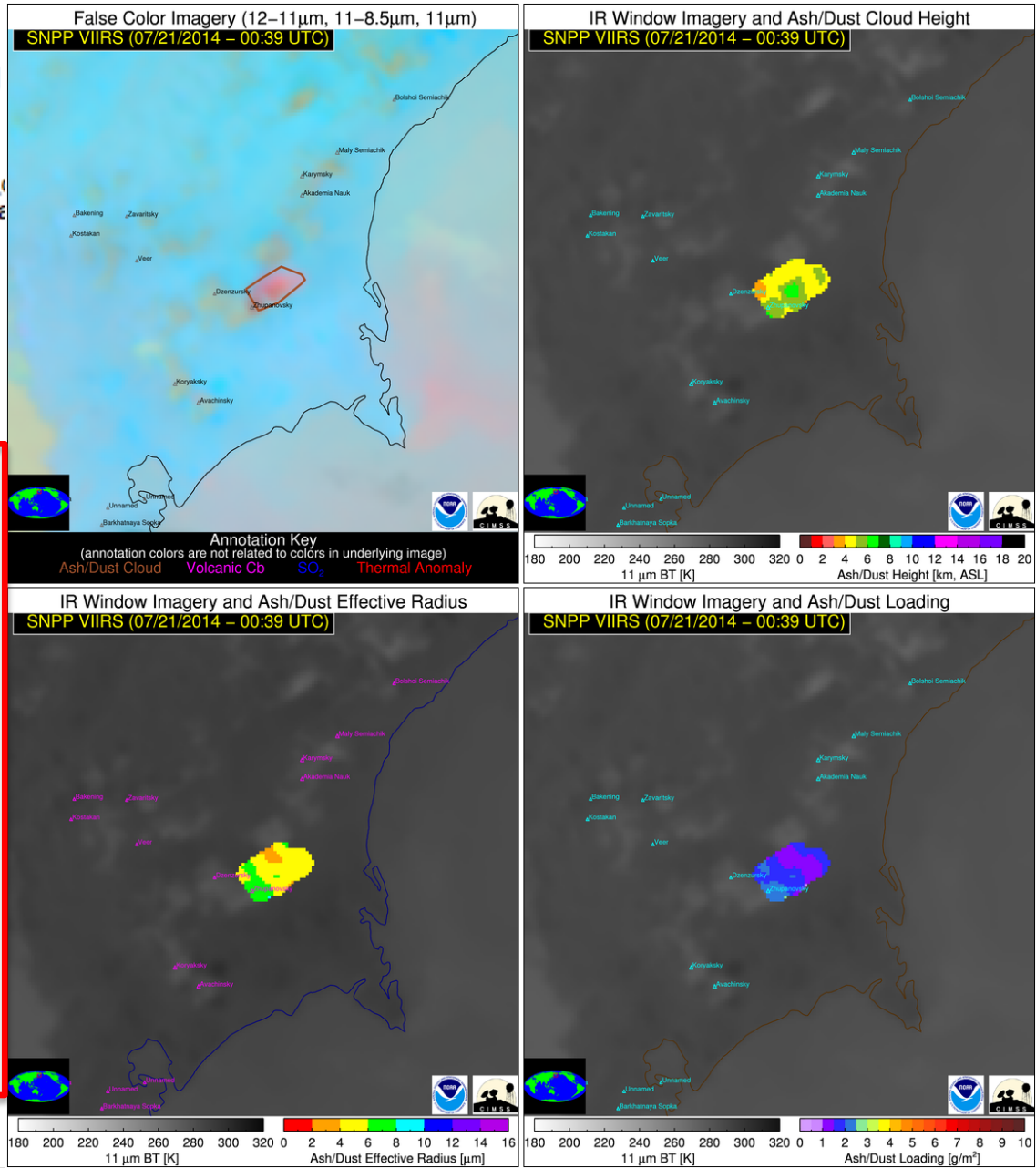

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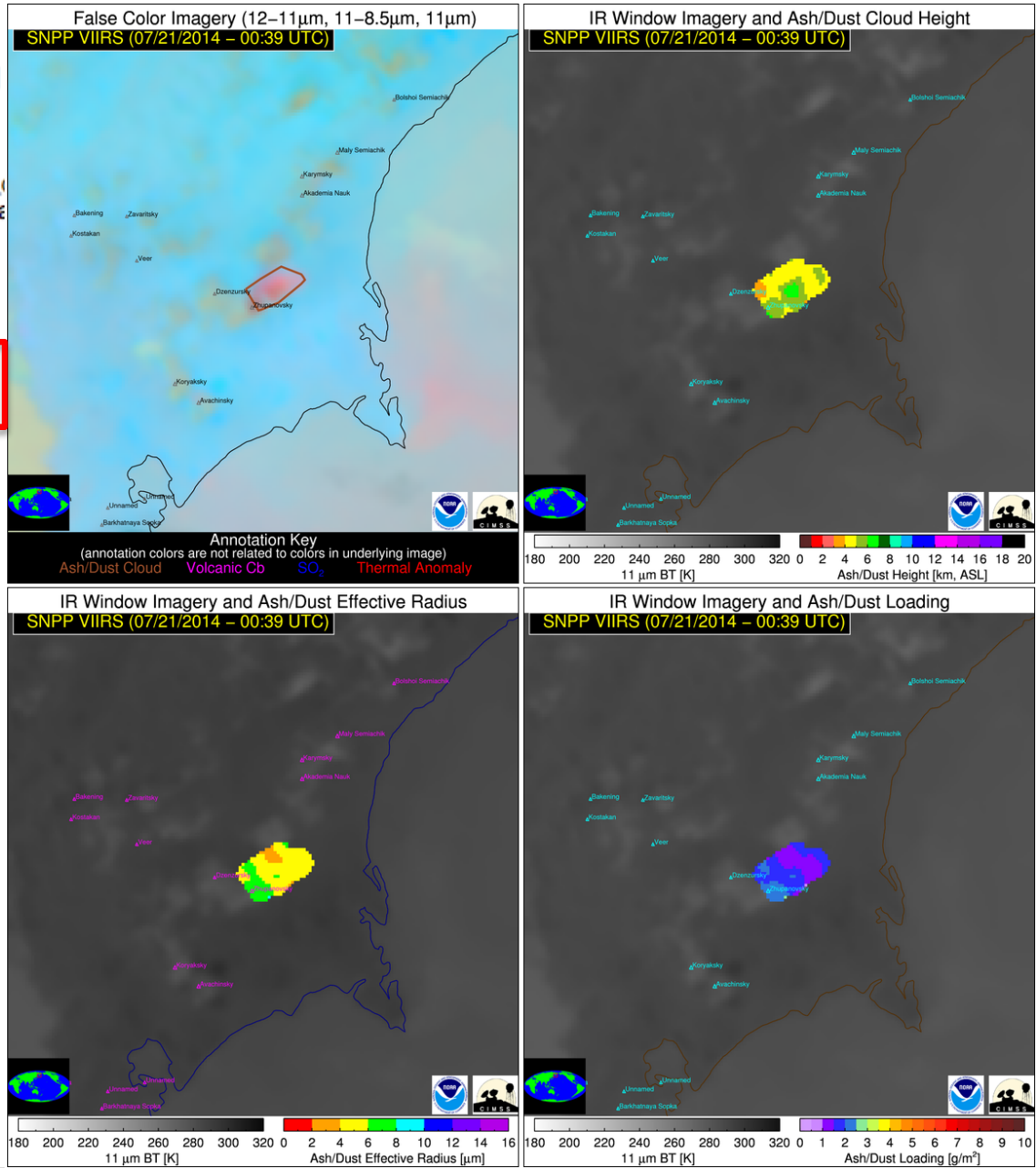


http://volcano.ssec.wisc.edu

Volcanic Cloud Monitoring -- NOAA/CIMSS (BETA)

http://volcano.ssec.wisc.edu/alert/report/14713

Amazon Apple (113) Yahoo! eBay News (1,455)

CIMSS » Volcanic Cloud Monitoring » Event Alerts » 2014-06-19

Volcanic Cloud Monitoring — NOAA/CIMSS (BETA)

Home | Satellite Imagery | Alerts | Tutorials | Admin | Logout (mpav@ssec.wisc.edu)

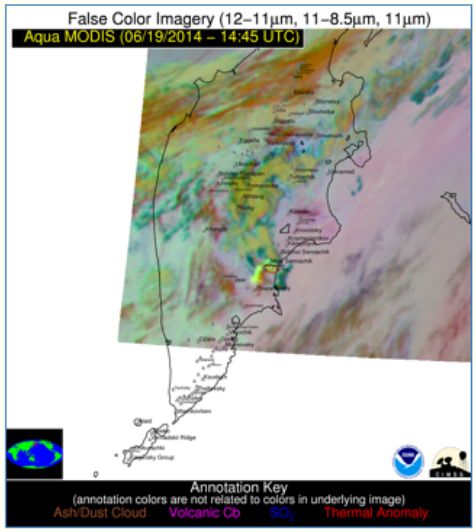
Volcanic Cloud Alert Report

Date:	2014-06-19
Time:	14:45:00
Production Date And Time:	2014-06-19 18:17:34 UTC
Primary Instrument:	Aqua MODIS

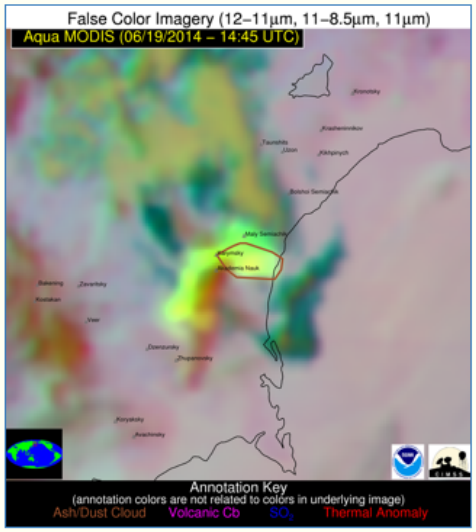
More details ▼

Possible Volcanic Ash Cloud

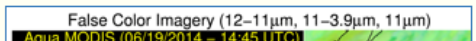
View event imagery »

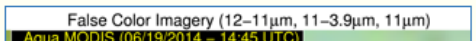


False Color Image (12-11, 11-8.5, 11)



False Color Image (12-11, 11-8.5, 11) [zoomed-in]





Alert Status	New Alert Object
Radiative Center (Lat, Lon):	54.032 °, 159.487 °
Mean Viewing Angle	55.75 °
Mean Solar Zenith Angle	100.31 °
Nearby Volcanoes (meeting alert criteria):	Karymsky (3.13 km) Akademia Nauk (5.92 km) Maly Semiachik (16.30 km) Bolshoi Semiachik (46.88 km) Zhupanovsky (54.03 km)
Cloud Object Probability	100.00000 %
Median Probability Of Object Pixels	98.80333 %
Percent Unambiguous Pixels	27.86300 %

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VOLCANO DATABASE: /data/common//VOLCAT_DATA/alerts/Volca
NUMBER OF ASH CLOUD ALERTS: 1
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REPORT WITH IMAGES:
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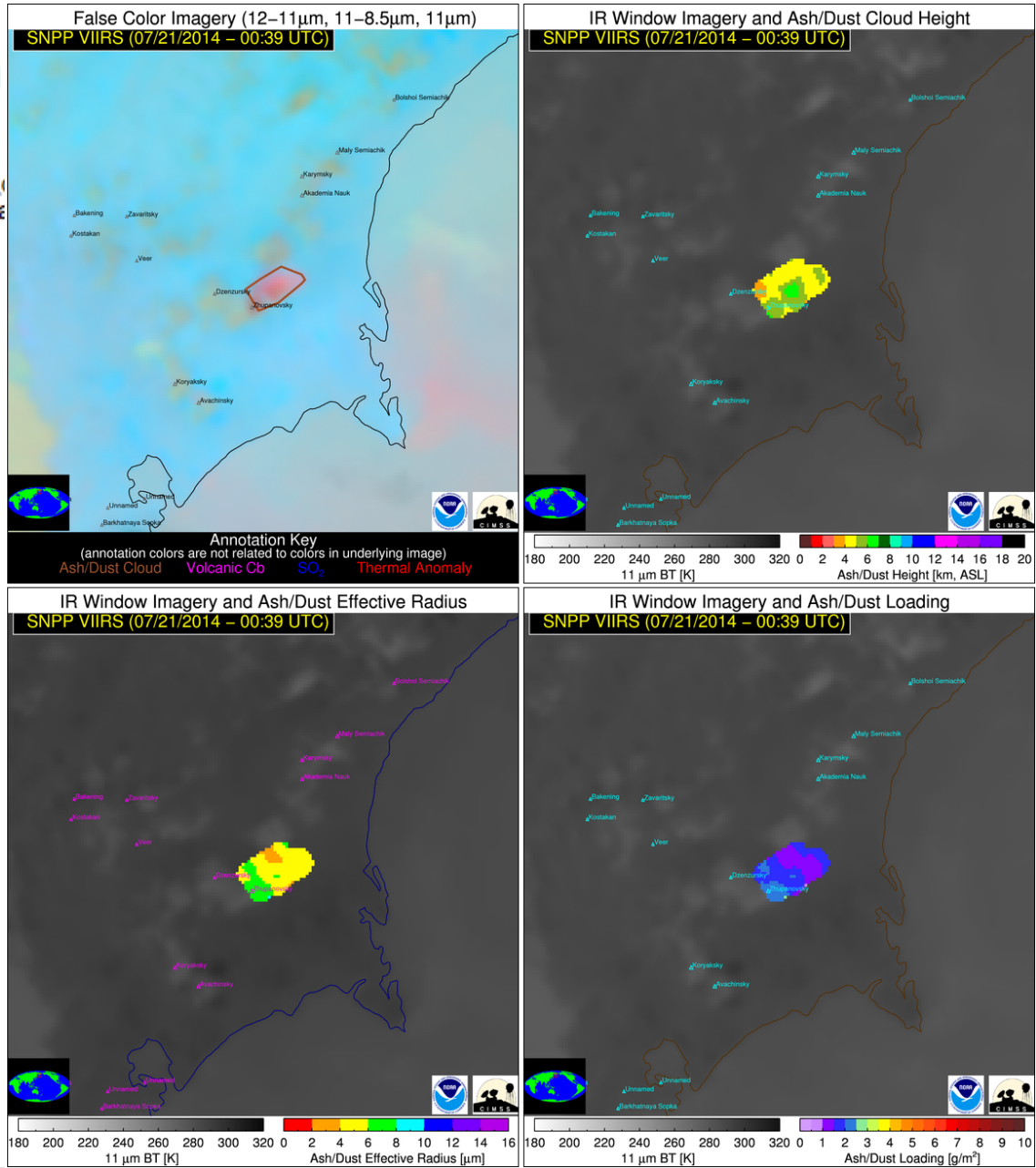

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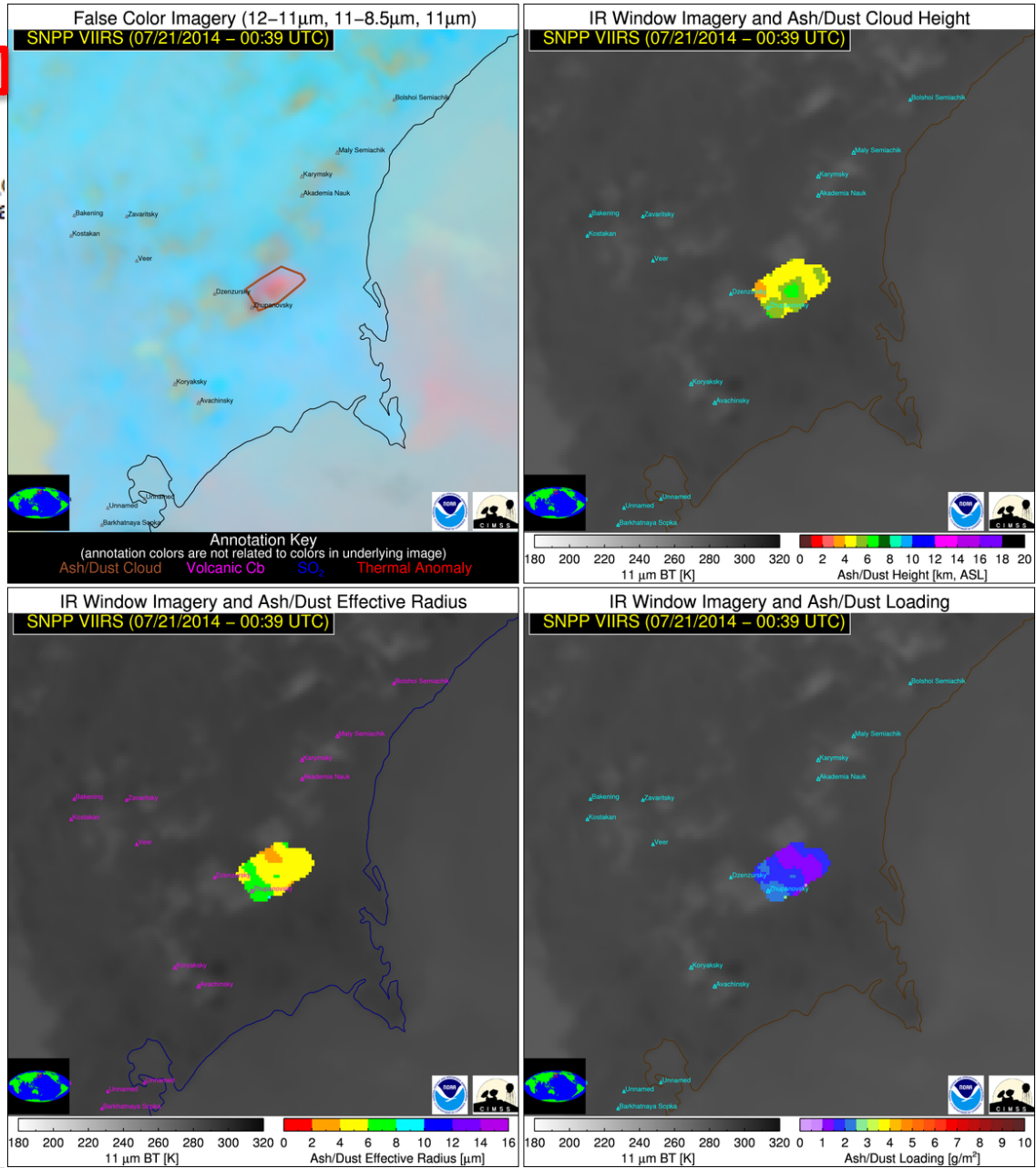
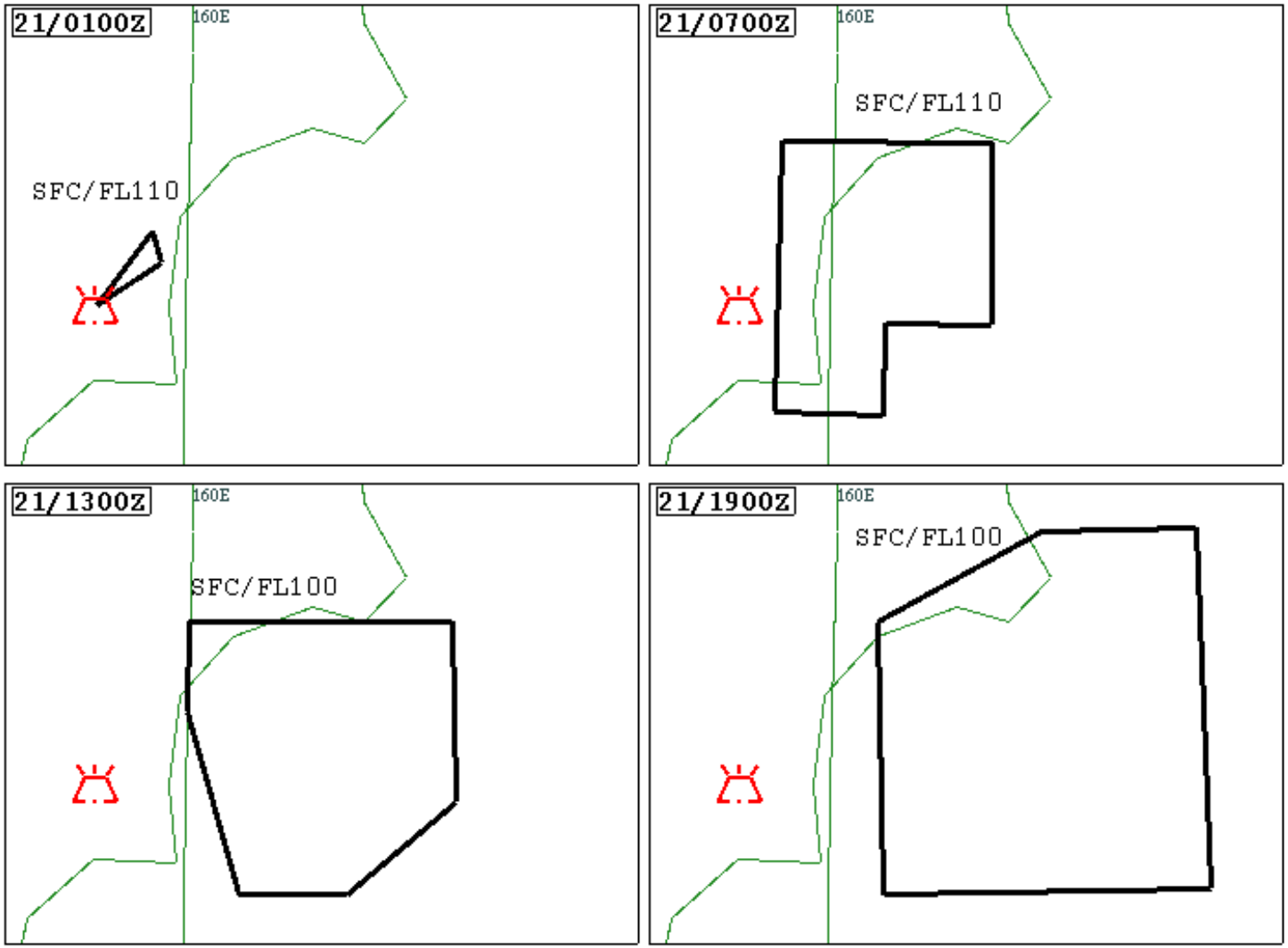
Total Area: 418.09 [km^2]

Geographic Regions of Nearby Volcanoes: Kamchatka



VOLCANIC ASH ADVISORY INFORMATION IN GRAPHICAL FORMAT MODEL VAG



VA ADVISORY
DTG: 20140721/0147Z
VAAC: TOKYO
VOLCANO: ZHUPANOVSKY 1000-12
AREA: RUSSIA
SUMMIT ELEV: 2958M
ADVISORY NR: 2014/31

INFO SOURCE: MTSAT-2
AVIATION COLOUR CODE: NIL
ERUPTION DETAILS: POSS ERUPTION OBS AT 20140721/0100Z FL110 EXTD NE
RMK: NIL
NXT ADVISORY: 20140721/0600Z

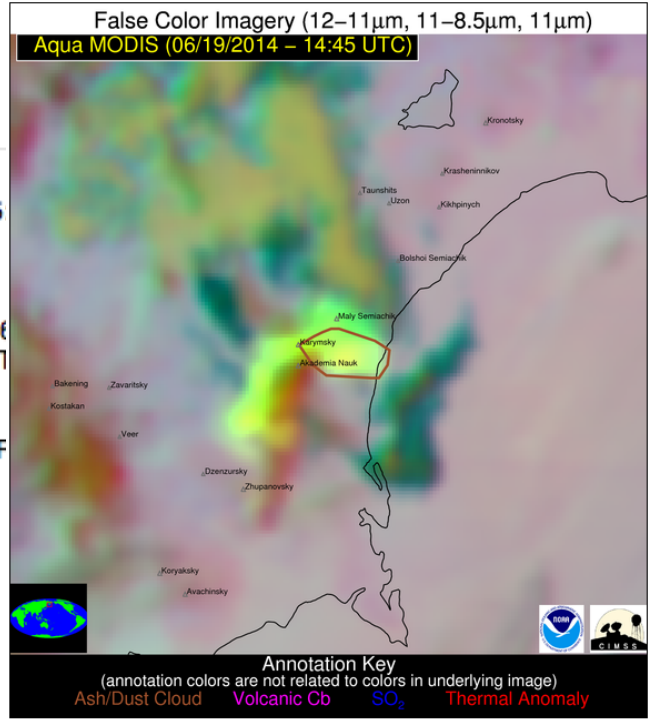
From: Mike Pavolonis NOAA Federal
Subject: **NOAA/CIMSS Volcanic Cloud Alert**
Date: June 19, 2014 1:20:22 PM CDT
To: Mike Pavolonis NOAA Federal

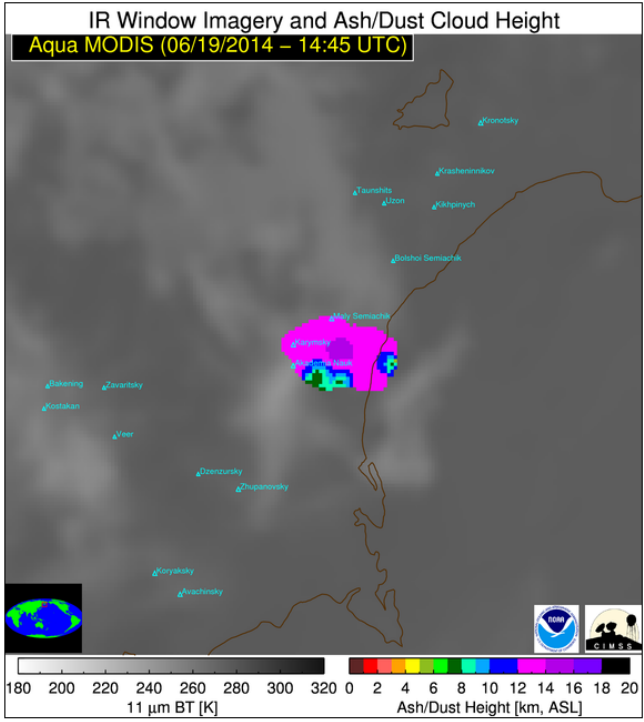
@**********VOLCANIC ALERTS**********
STARTING DATE/TIME OF IMAGE: 2014-06-19 14:45
PRIMARY INSTRUMENT: Aqua MODIS
WMO SPACECRAFT ID: 784
LOCATION/ORBIT: LEO
L1 FILE: MYD021KM.A2014170.1445.005.201417016
VOLCANO DATABASE: /data/common//VOLCAT_DAT
NUMBER OF ASH CLOUD ALERTS: 1
NUMBER OF VOLCANIC Cb ALERTS: 0
NUMBER OF VOLCANIC THERMAL ANOMALY ALEF
NUMBER OF SO2 CLOUD ALERTS: 0

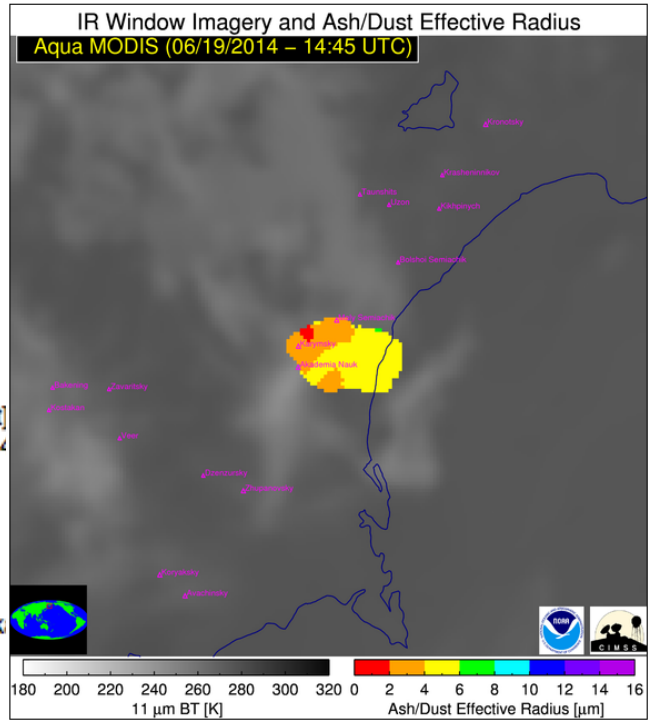
REPORT WITH IMAGES:
http://volcano.ssec.wisc.edu/alert/report/14713

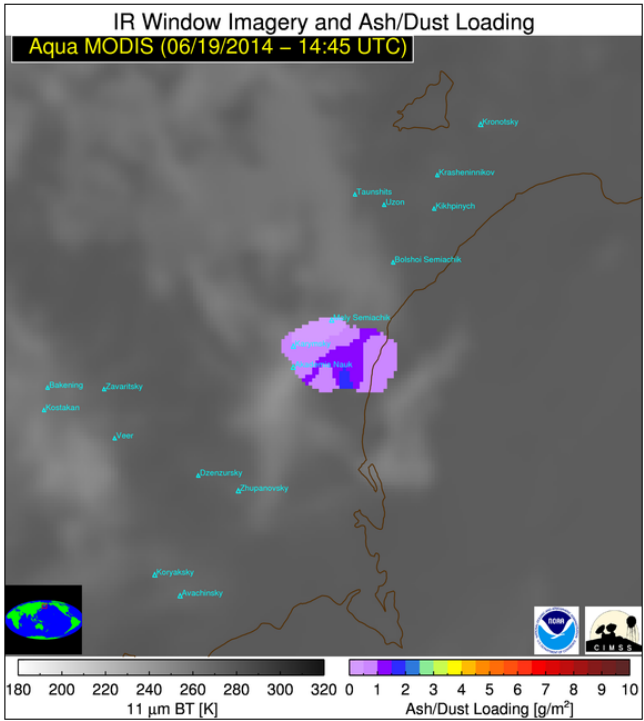
POSSIBLE VOLCANIC ASH CLOUD FOUND
Alert Status: New Alert Object
Latitude of Radiative Center: 54.032 [degrees]
Longitude of Radiative Center: 159.487 [degrees]
Mean Viewing Angle: 55.75 [degrees]
Mean Solar Zenith Angle: 100.31 [degrees]
Nearby Volcanoes (meeting alert criteria):
Karymsky(3.13 km)
Akademia Nauk(5.92 km)
Maly Semiachik(16.30 km)
Bolshoi Semiachik(46.88 km)
Zhupanovsky(54.03 km)
Cloud Object Probability: 100.00000 [%]
Median Probability of Object Pixels: 98.80333 [%]
Percent Unambiguous Pixels: 27.86300 [%]
Maximum Height [AMSL]: 15.2 [km] (49772.89 [ft])
90th Percentile Height [AMSL]: 14.2 [km] (46474.05 [ft]
Mean Tropopause Height [AMSL]: 11.8 [km] (38864.34
Total Mass: .000559 [Tg]
Median Effective Particle Radius: 4.35 [um]
Total Area: 623.73 [km^2]

Geographic Regions of Nearby Volcanoes: Kamchatk
VAAC Regions of Nearby Volcanoes: Tokyo
FIR Regions of Nearby Volcanoes: Unknown

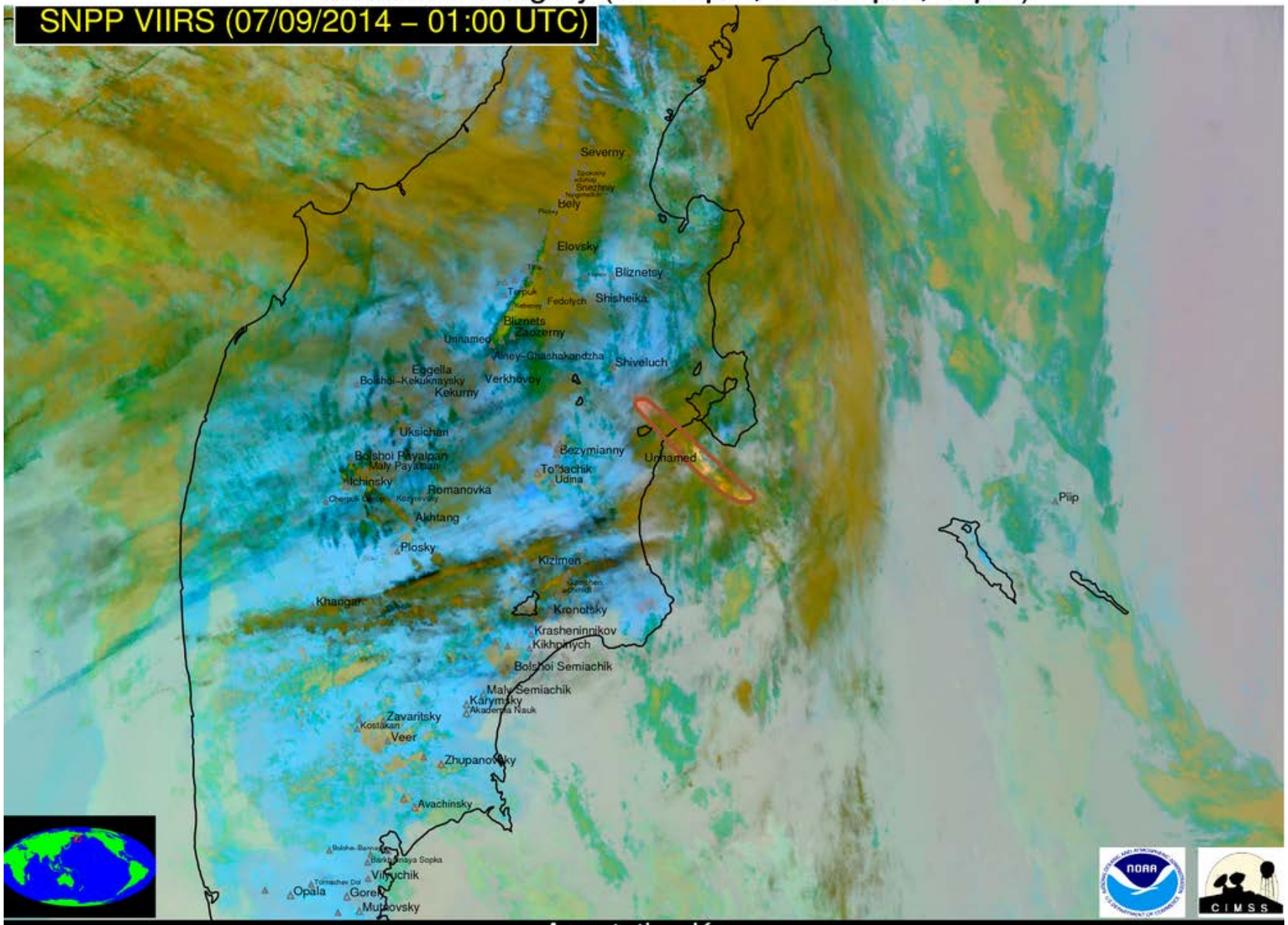




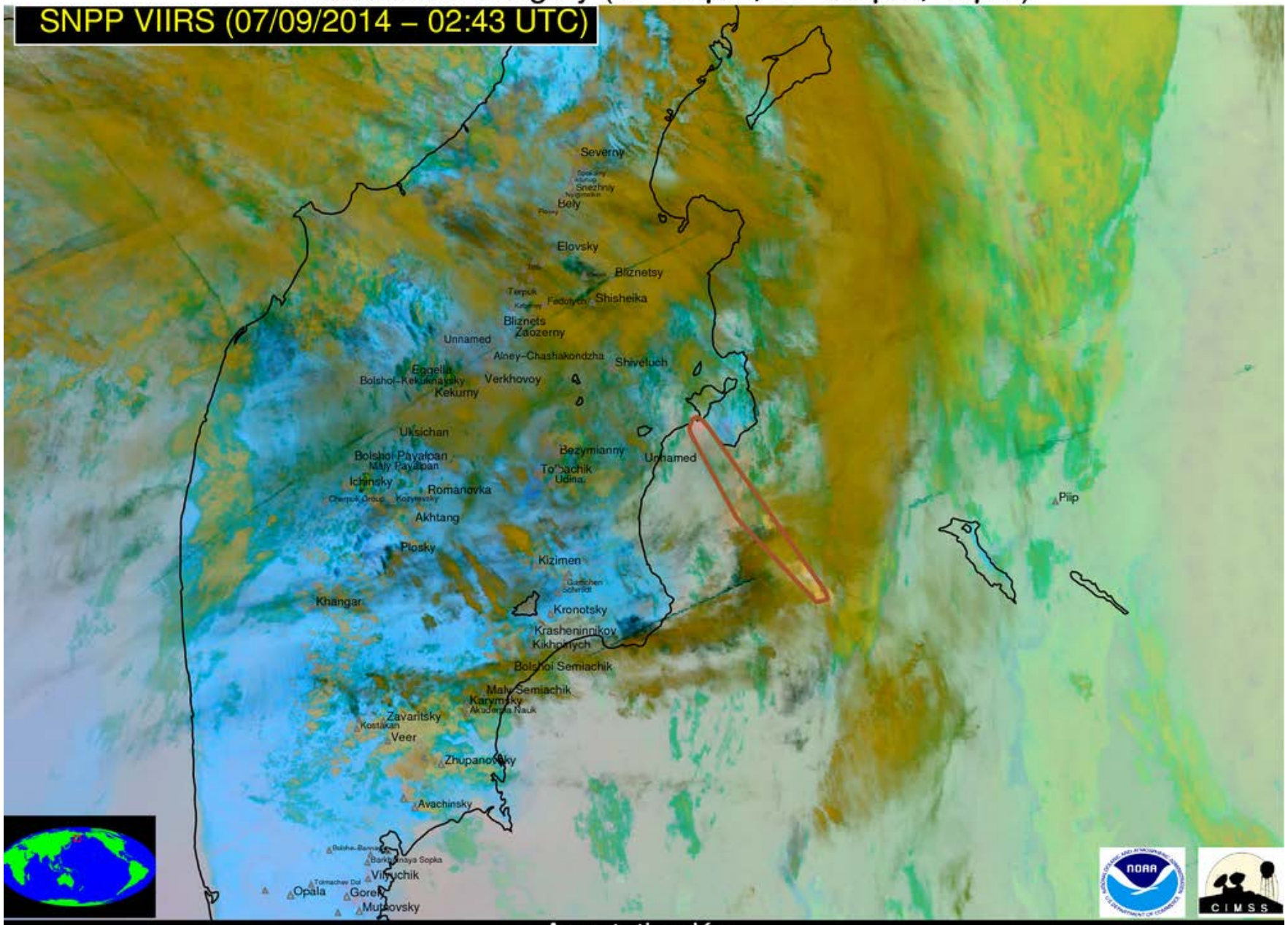




False Color Imagery (12–11μm, 11–8.5μm, 11μm)

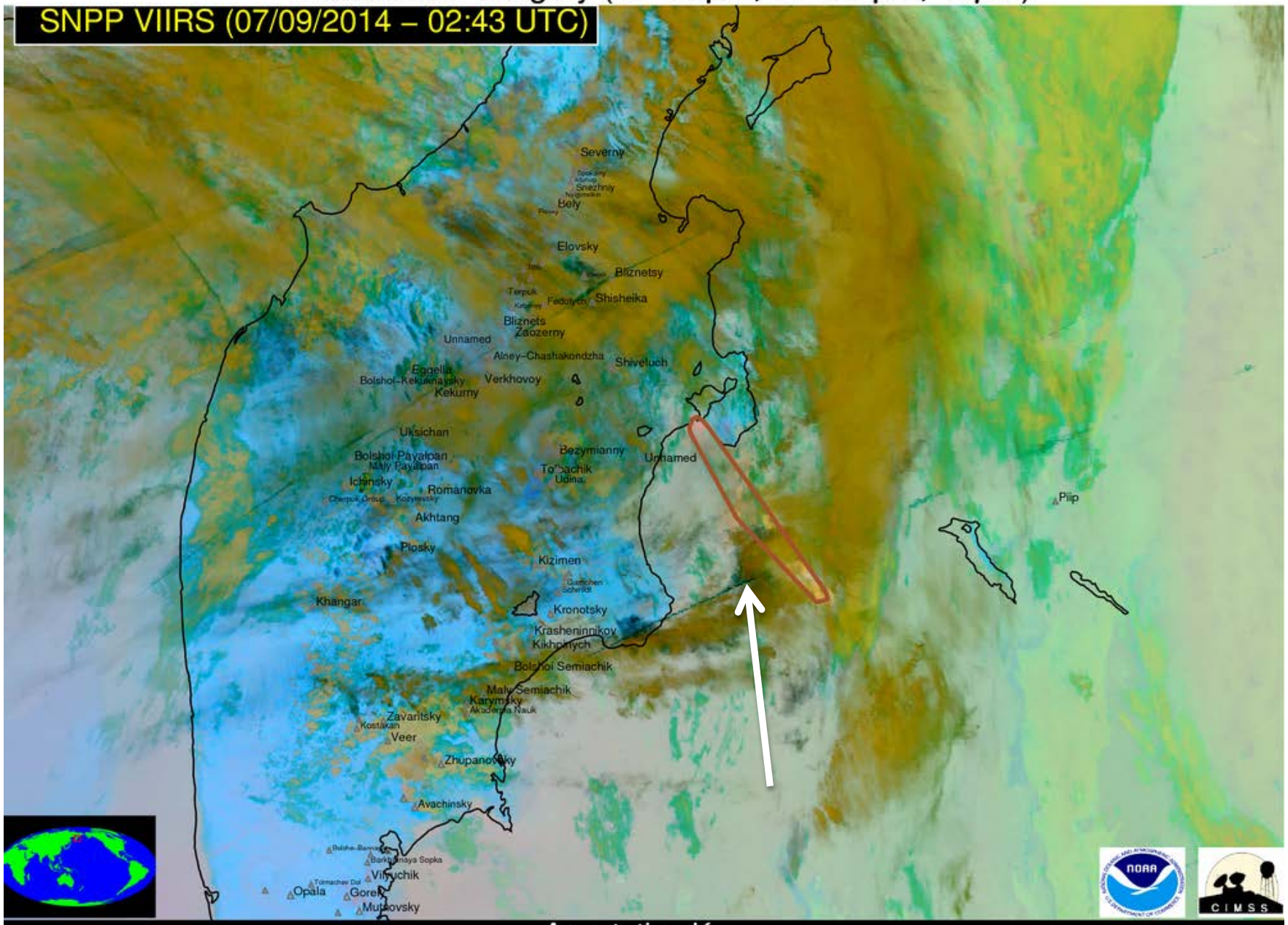


False Color Imagery (12–11μm, 11–8.5μm, 11μm)



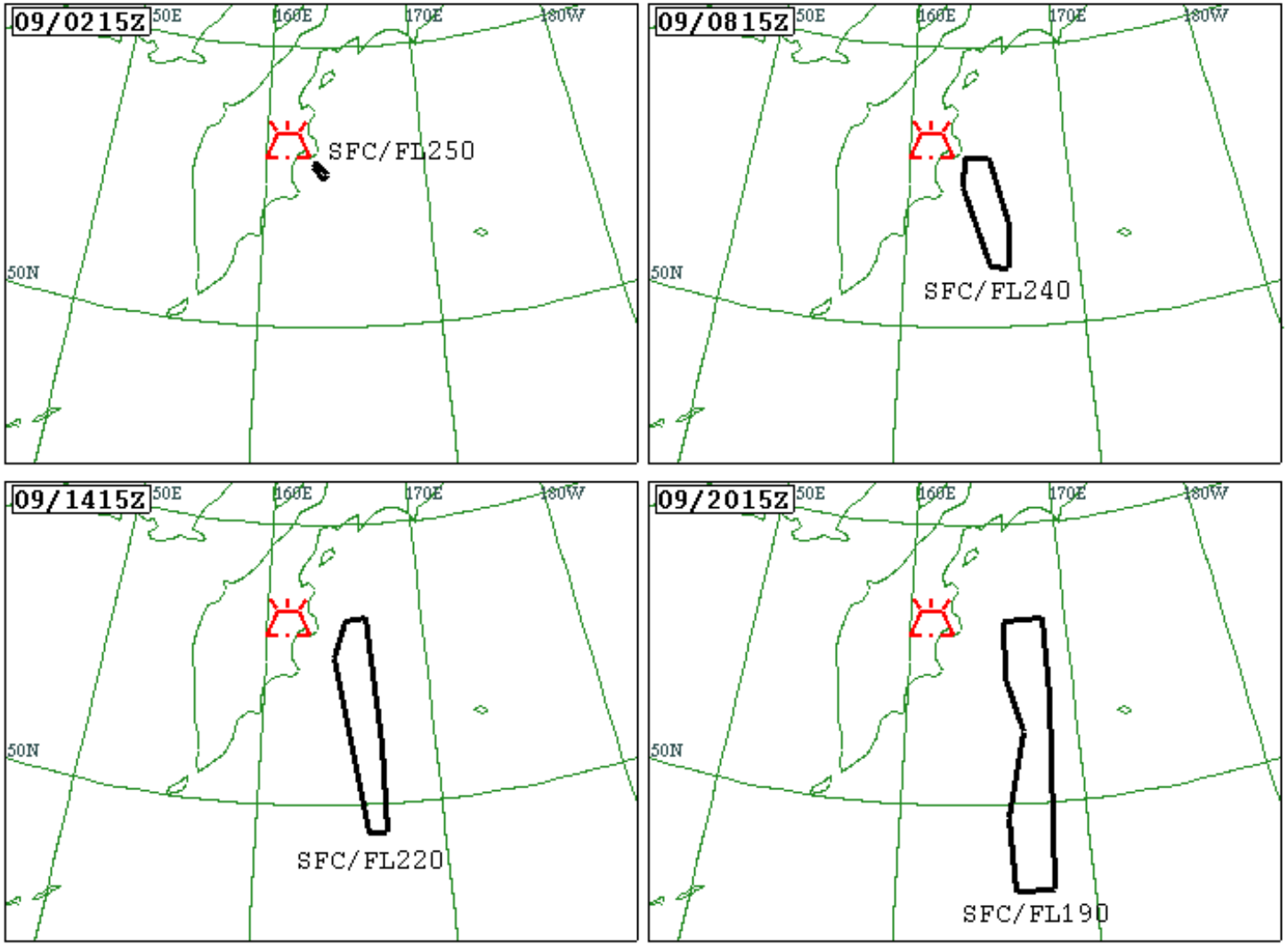
Annotation Key
(annotation colors are not related to colors in underlying image)
Ash/Dust Cloud Volcanic Cb SO_2 Thermal Anomaly

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



Annotation Key
(annotation colors are not related to colors in underlying image)
Ash/Dust Cloud Volcanic Cb SO_2 Thermal Anomaly

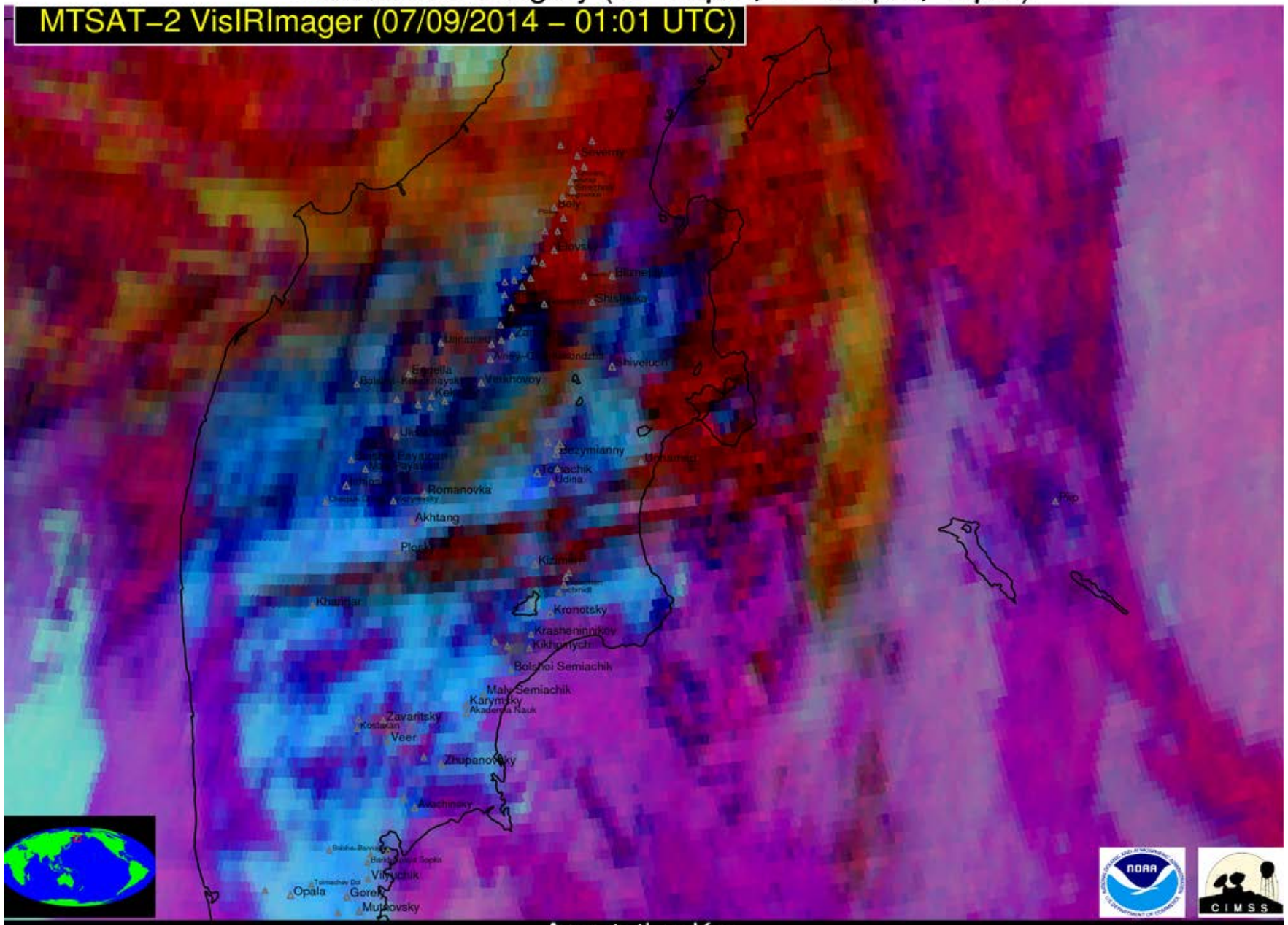
VOLCANIC ASH ADVISORY INFORMATION IN GRAPHICAL FORMAT MODEL VAG



VA ADVISORY
DTG: 20140709/0310Z
VAAC: TOKYO
VOLCANO: SHEVELUCH 1000-27
AREA: RUSSIA
SUMMIT ELEV: 3283M
ADVISORY NR: 2014/87

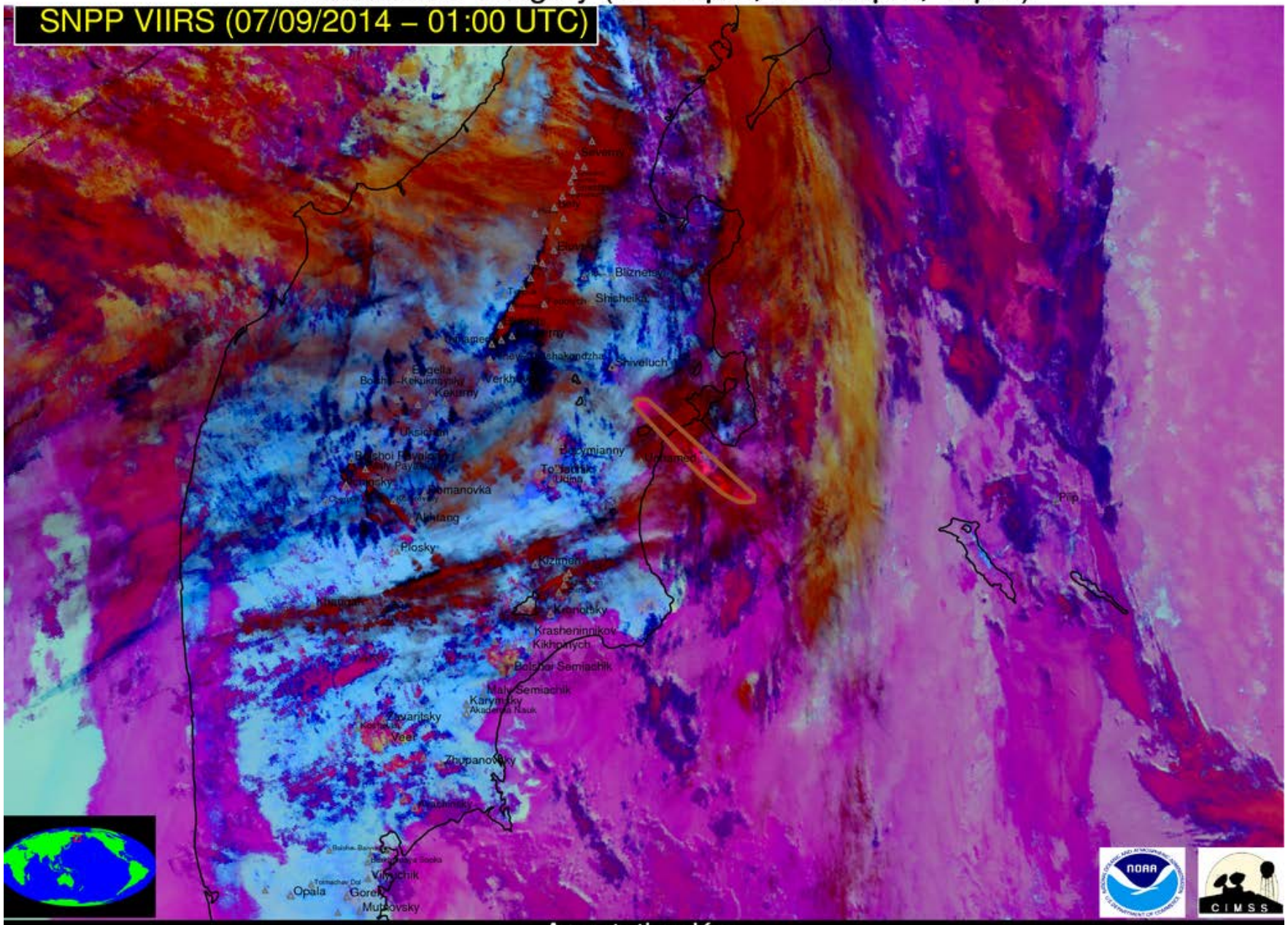
INFO SOURCE: MTSAT-2
AVIATION COLOUR CODE: NIL
ERUPTION DETAILS: POSS ERUPTION OBS AT 20140709/0000Z FL250 EXTD SE
RMK: NIL
NXT ADVISORY: 20140709/0600Z

False Color Imagery (12–11μm, 11–3.9μm, 11μm)



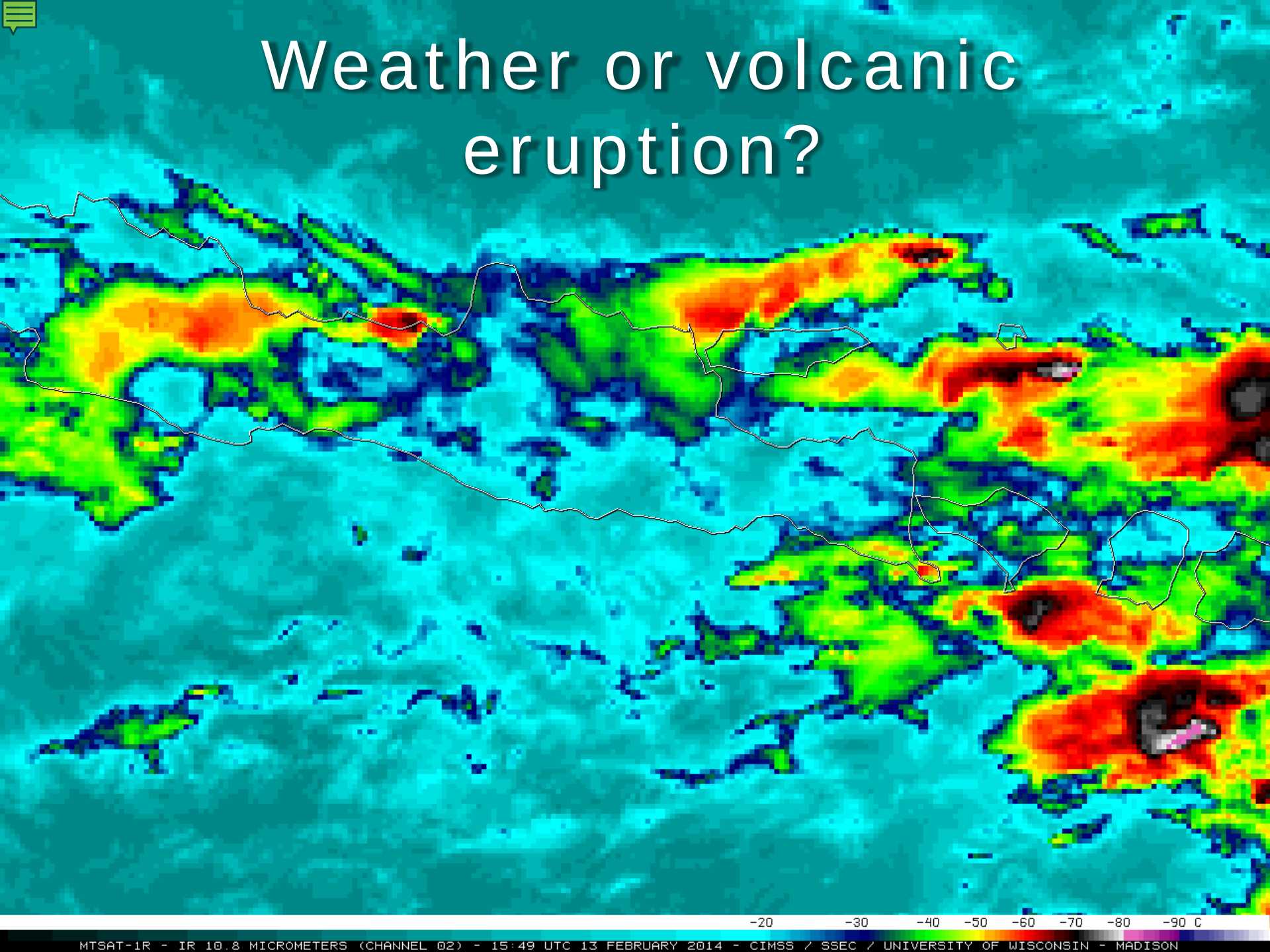
Annotation Key
(annotation colors are not related to colors in underlying image)
Ash/Dust Cloud Volcanic Cb SO_2 Thermal Anomaly

False Color Imagery (12–11μm, 11–3.9μm, 11μm)

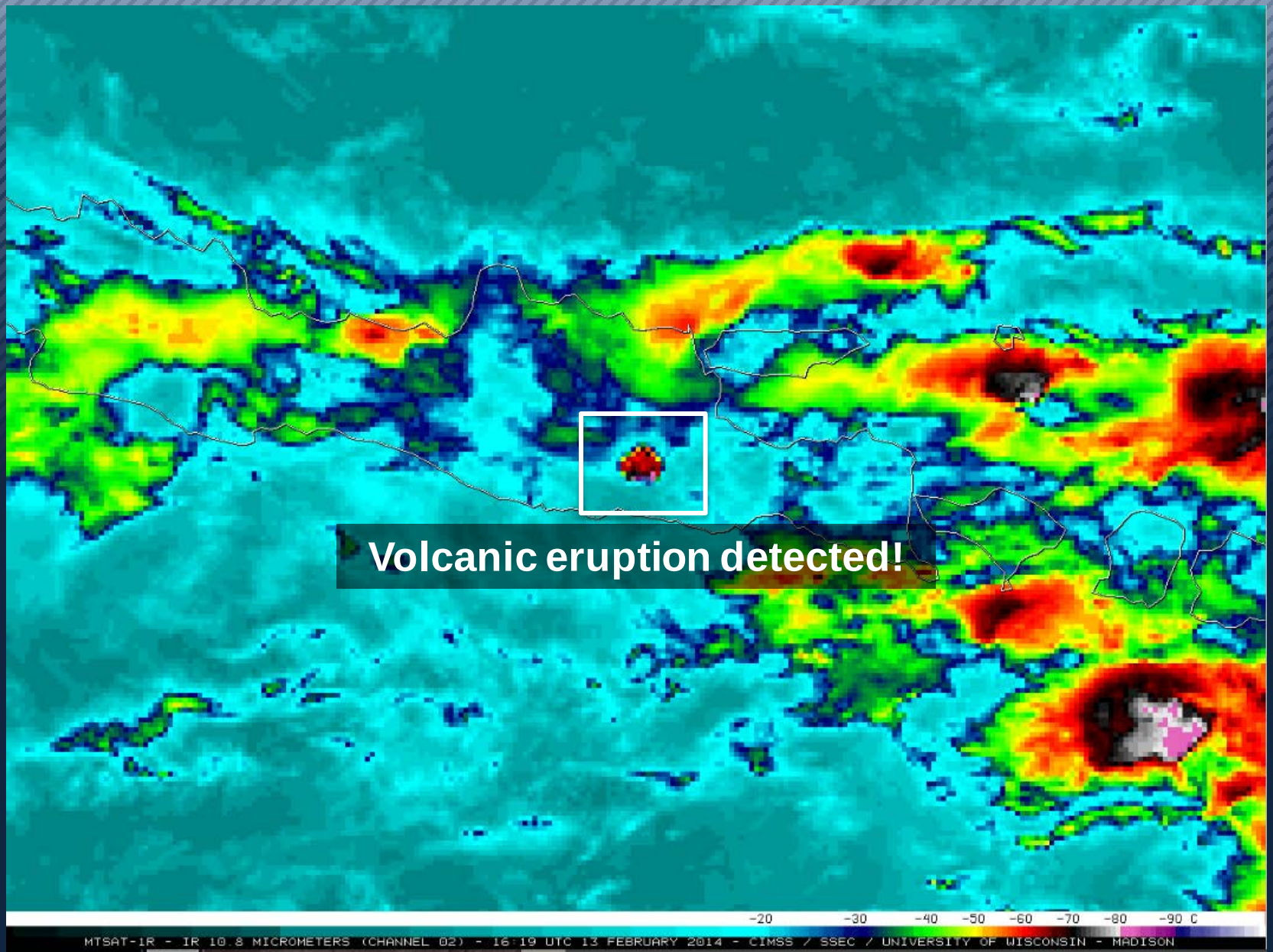


Annotation Key
(annotation colors are not related to colors in underlying image)
Ash/Dust Cloud Volcanic Cb SO_2 Thermal Anomaly

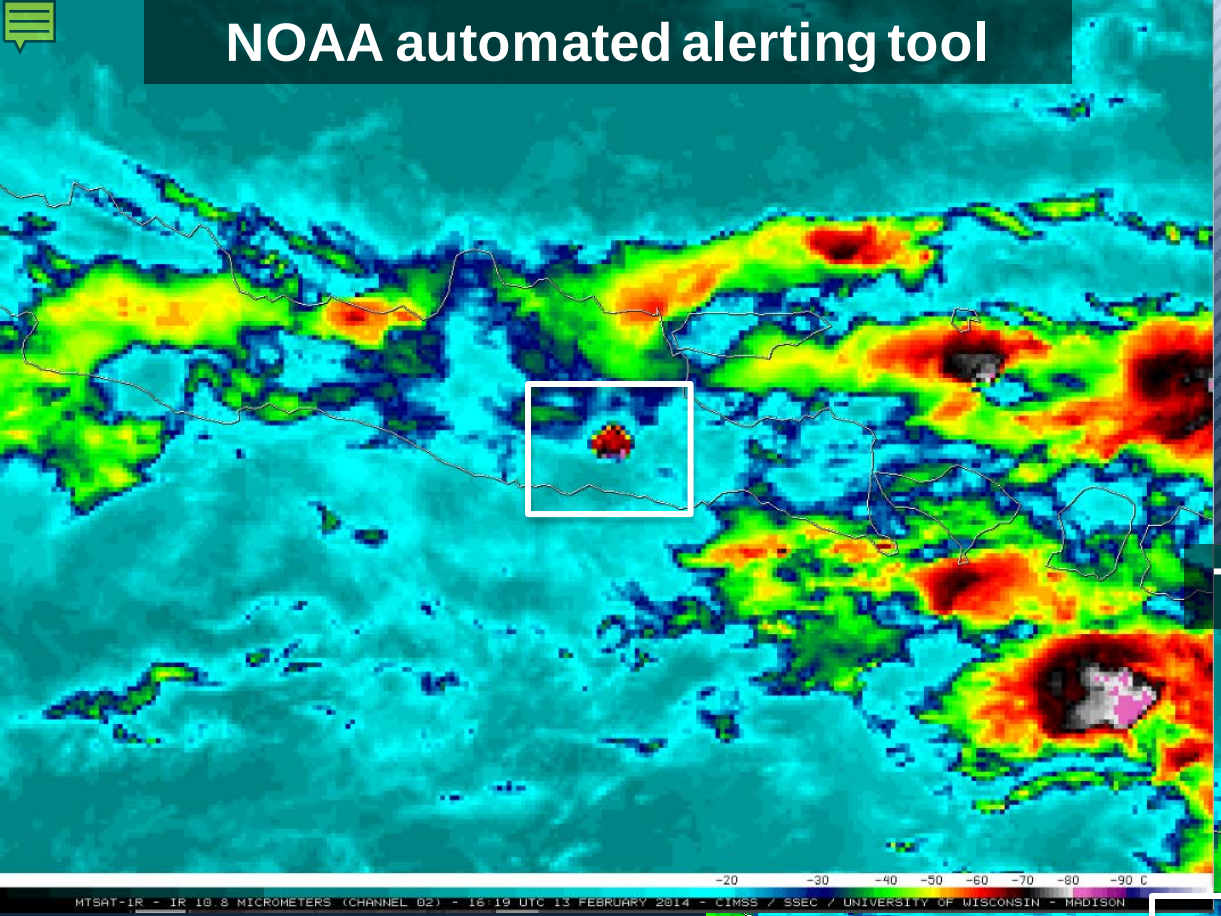
Weather or volcanic eruption?



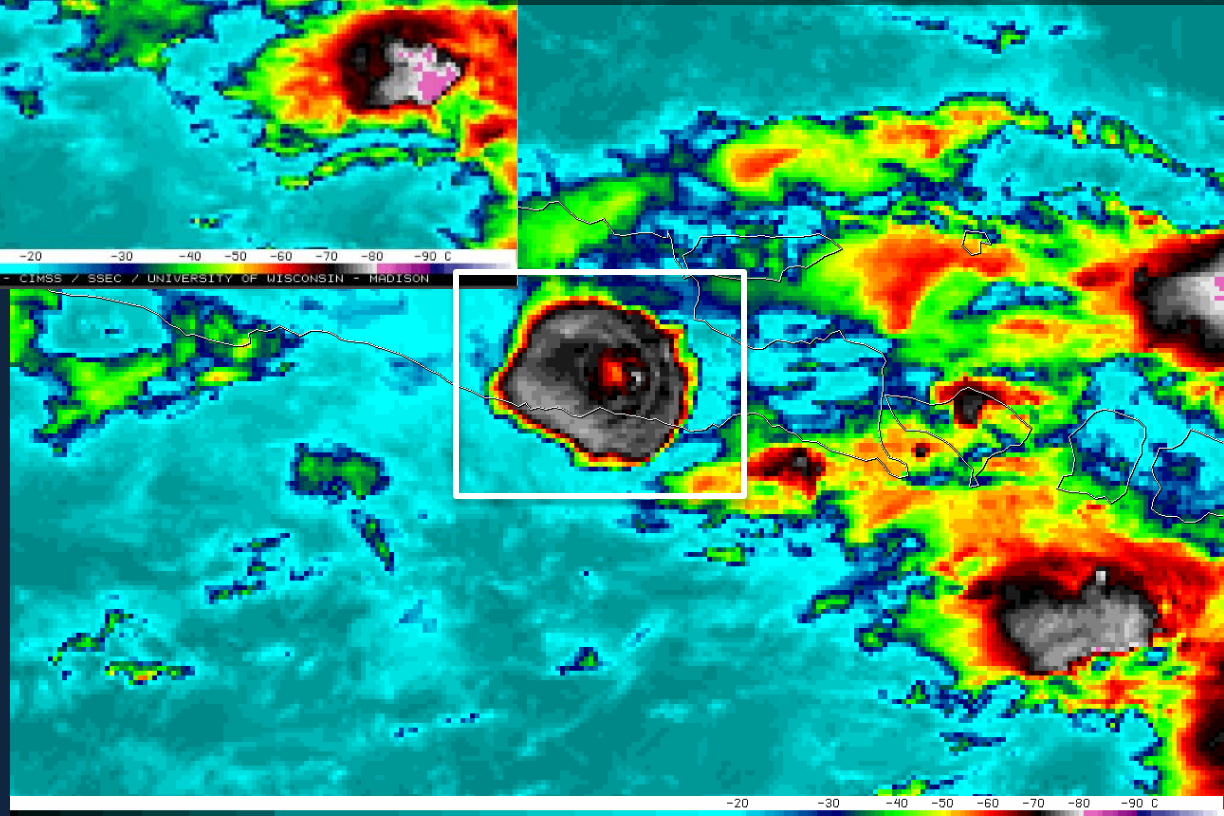
Automated system is able to detect Kelut eruption about 60 minutes sooner than standard operational tools



NOAA automated alerting tool



Traditional tools (+ 1 hour)



@**********VOLCANIC ALERTS**********
STARTING DATE/TIME OF IMAGE: 2014-02-13 16:19:00 [UTC]
PRODUCTION DATE/TIME OF ALERT: 2014-02-14 16:49:44 [UTC]
PRIMARY INSTRUMENT: MTSAT-1r Vis/IR_Imager
WMO SPACECRAFT ID: 171
LOCATION/ORBIT: GEO
L1 FILE: mtsat01_1_2014_044_1619.area.gz
VOLCANO DATABASE: /data/common/VOLCAT_DATA/al
NUMBER OF ASH CLOUD ALERTS: 0
NUMBER OF VOLCANIC Cb ALERTS: 1
NUMBER OF VOLCANIC THERMAL ANOMALY ALERTS:
NUMBER OF SO2 CLOUD ALERTS: 0

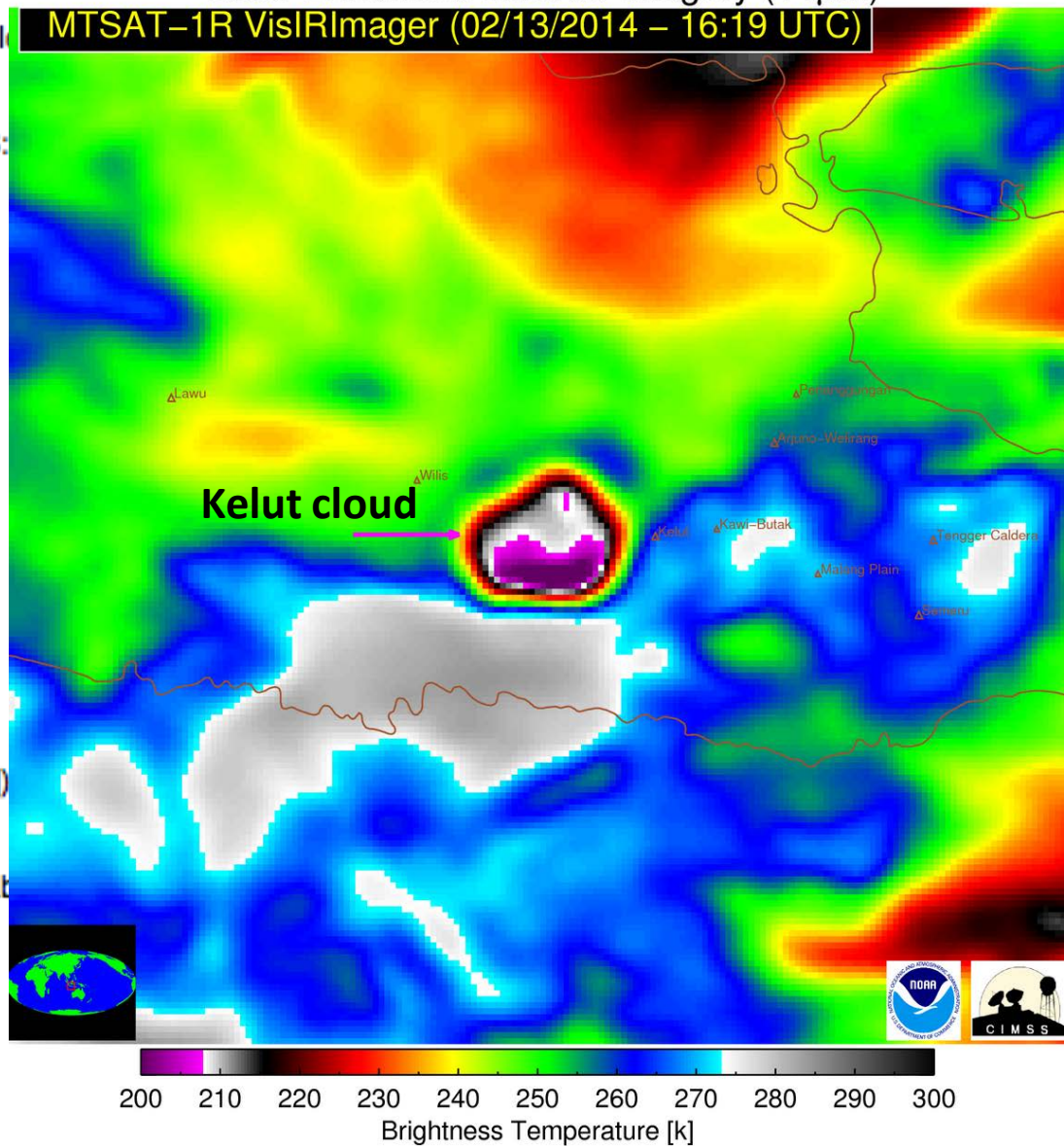
REPORT WITH IMAGES:
http://volcano.ssec.wisc.edu/alert/report/12238

POSSIBLE VOLCANIC ERUPTION DETECTED
Alert Status: New Alert Object
Latitude of Radiative Center: -8.012 [degrees]
Longitude of Radiative Center: 112.265 [degrees]
Mean Viewing Angle: 33.92 [degrees]
Mean Solar Zenith Angle: 157.44 [degrees]
Nearby Volcanoes (meeting alert criteria):
Kelut(9.99 km)
Kawi-Butak(23.00 km)
Maximum Height [AMSL]: 21.2 [km] (69649.79 [ft])
90th Percentile Height [AMSL]: 19.2 [km] (62995.20 [ft])
Mean Tropopause Height [AMSL]: 16.4 [km] (53783.42 [ft])
Trend in IR Brightness Temperature: -53.16 [K]
Vertical Growth Rate Time Interval: 10 [minutes]
Vertical Growth Rate Anomaly: 24.75 [number of stddev at
Total Area: 1270.01 [km^2]

Geographic Regions of Nearby Volcanoes: Java
VAAC Regions of Nearby Volcanoes: Darwin
FIR Regions of Nearby Volcanoes: Unknown

Kelut eruption is detected in a timely manner

Color Enhanced Infrared Imagery (11μm)



@**********VOLCANIC ALERTS**********
STARTING DATE/TIME OF IMAGE: 2014-02-13 16:19:00 [UTC]
PRODUCTION DATE/TIME OF ALERT: 2014-02-14 16:49:44 [UTC]
PRIMARY INSTRUMENT: MTSAT-1r Vis/IR_Imager
WMO SPACECRAFT ID: 171
LOCATION/ORBIT: GEO
L1 FILE: mtsat01_1_2014_044_1619.area.gz
VOLCANO DATABASE: /data/common/VOLCAT_DATA/al
NUMBER OF ASH CLOUD ALERTS: 0
NUMBER OF VOLCANIC Cb ALERTS: 1
NUMBER OF VOLCANIC THERMAL ANOMALY ALERTS:
NUMBER OF SO2 CLOUD ALERTS: 0

REPORT WITH IMAGES:
http://volcano.ssec.wisc.edu/alert/report/12238

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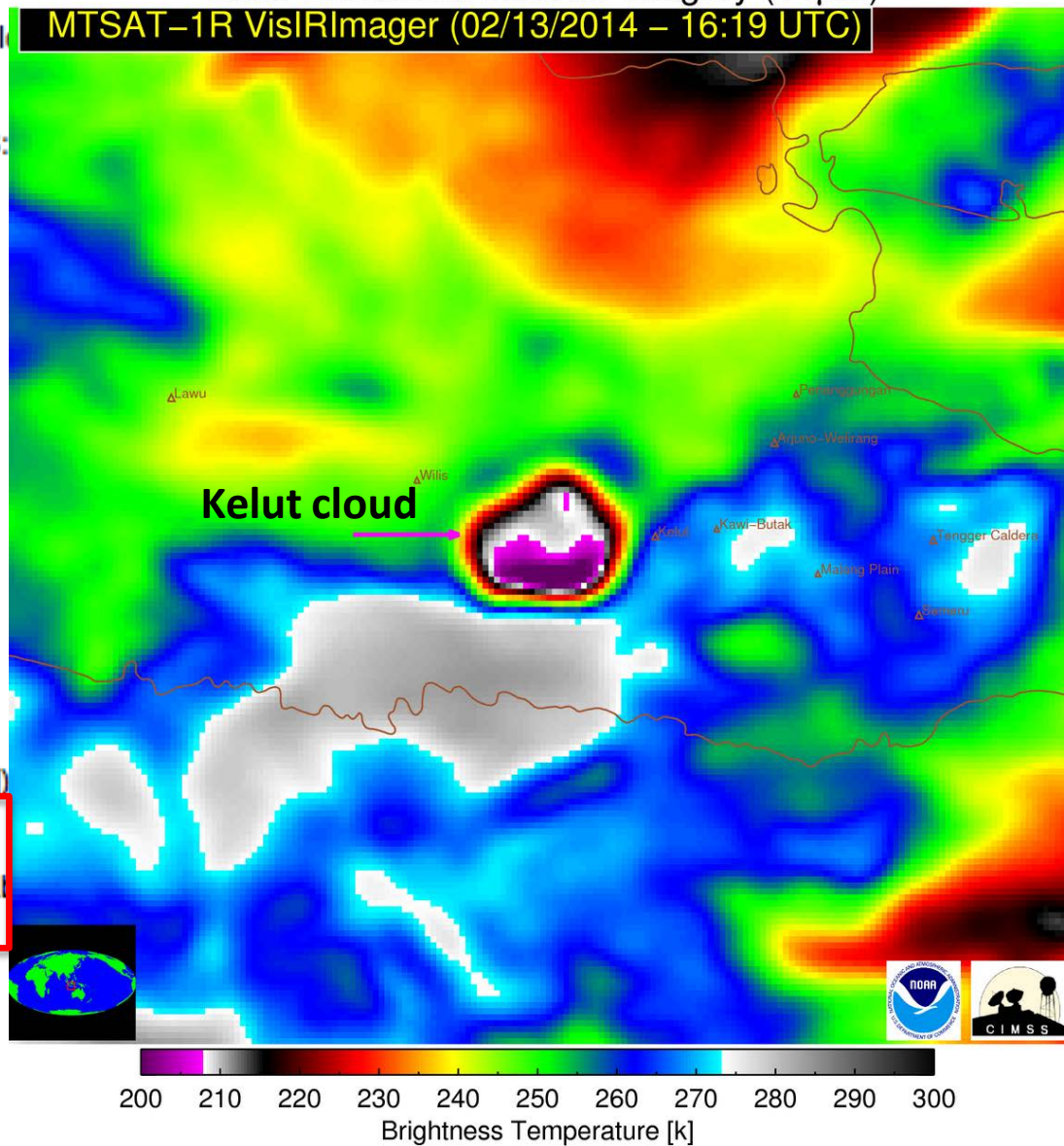
VAAC Regions of Nearby Volcanoes: Darwin
FIR Regions of Nearby Volcanoes: Unknown

Kelut eruption is detected in a timely manner

Color Enhanced Infrared Imagery (11μm)



The next generation of GEO satellites are very well suited for automated detection of volcanic eruption through cloud object growth rate analysis!

NUMBER OF VOLCANIC Cb ALERTS: 1
NUMBER OF VOLCANIC THERMAL ANOMALY ALERTS:
NUMBER OF SO2 CLOUD ALERTS: 0

REPORT WITH IMAGES:
http://volcano.ssec.wisc.edu/alert/report/12238

POSSIBLE VOLCANIC ERUPTION DETECTED
Alert Status: New Alert Object
Latitude of Radiative Center: -8.012 [degrees]
Longitude of Radiative Center: 112.265 [degrees]
Mean Viewing Angle: 33.92 [degrees]
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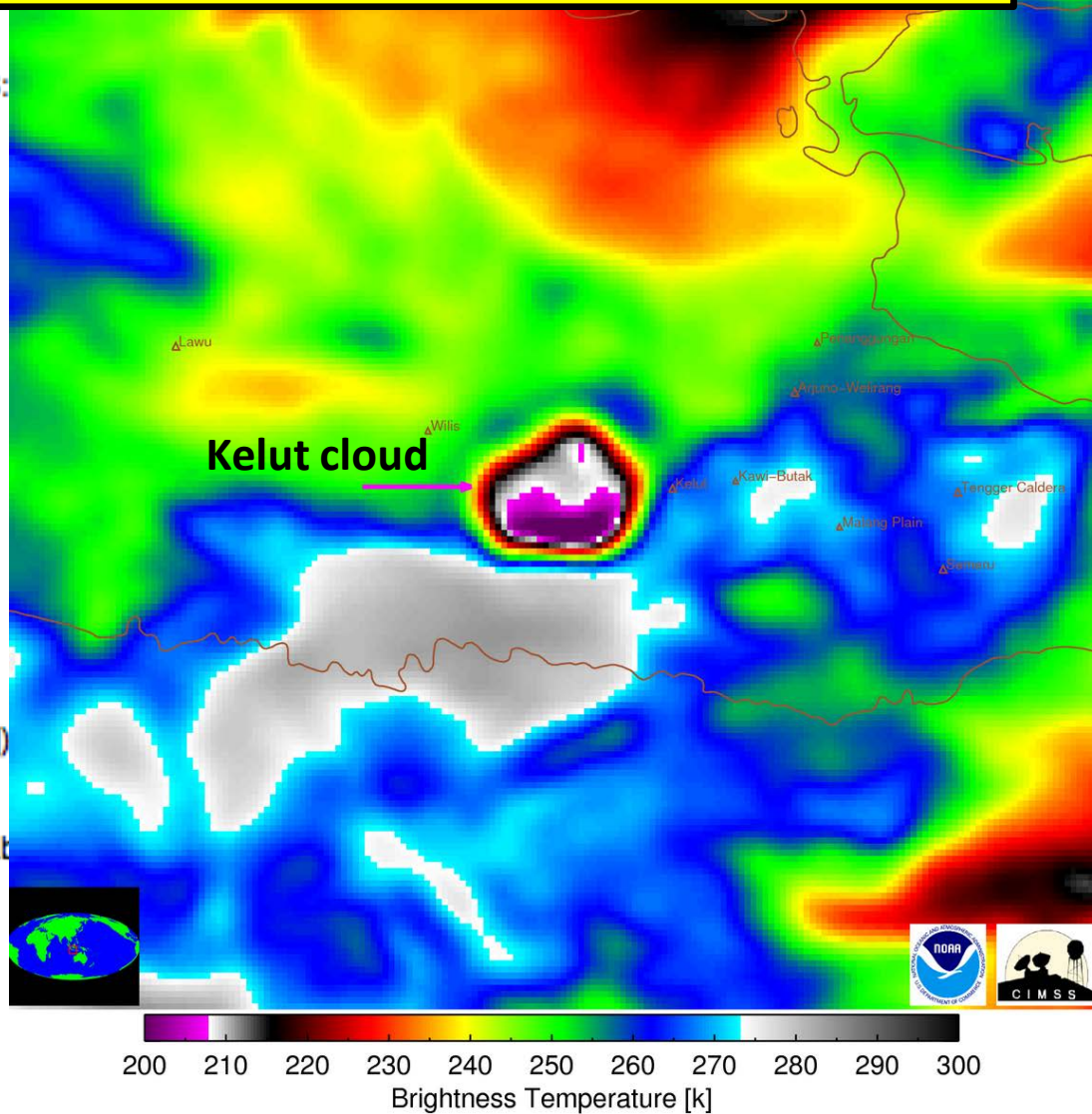
Maximum Height [AMSL]: 21.2 [km] (69649.79 [ft])
90th Percentile Height [AMSL]: 19.2 [km] (62995.20 [ft])
Mean Tropopause Height [AMSL]: 16.4 [km] (53783.42 [ft])
Trend in IR Brightness Temperature: -53.16 [K]
Vertical Growth Rate Time Interval: 10 [minutes]
Vertical Growth Rate Anomaly: 24.75 [number of stddev at
Total Area: 1270.01 [km^2]

Geographic Regions of Nearby Volcanoes: Java
VAAC Regions of Nearby Volcanoes: Darwin
FIR Regions of Nearby Volcanoes: Unknown



Sarigan Volcano

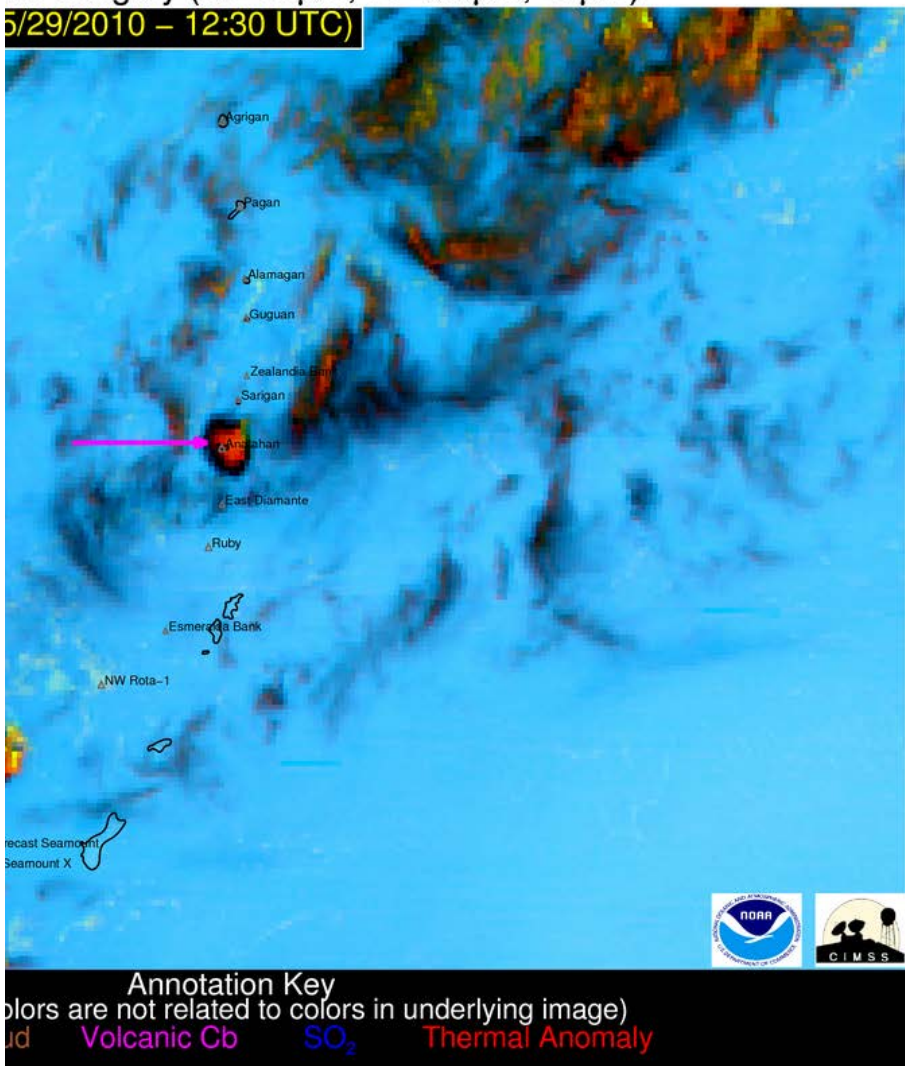
May 29, 2010 – 12:30 UTC

@**********VOLCANIC ALERTS**********
STARTING DATE/TIME OF IMAGE: 2010-05-29 12:30:00 [UTC]
PRODUCTION DATE/TIME OF ALERT: 2014-07-25 20:05:34 [UTC]
PRIMARY INSTRUMENT: MTSAT-1r Vis/IR_Imager
WMO SPACECRAFT ID: 171
LOCATION/ORBIT: GEO
L1 FILE: mtsat01_1_2010_149_1230.HRIT.noremap.area.gz
VOLCANO DATABASE: /data/common/VOLCAT_DATA/alerts/Volcat
NUMBER OF ASH CLOUD ALERTS: 0
NUMBER OF VOLCANIC Cb ALERTS: 1
NUMBER OF VOLCANIC THERMAL ANOMALY ALERTS: 0
NUMBER OF SO2 CLOUD ALERTS: 0

POSSIBLE VOLCANIC ERUPTION DETECTED
Alert Status: New Alert Object
Alert Confidence: HIGH
Latitude of Radiative Center: 16.27 [degrees]
Longitude of Radiative Center: 145.77 [degrees]
Mean Object Date/Time: 2010-05-29 12:38:28 [UTC]
Mean Viewing Angle: 20.4 [degrees]
Mean Solar Zenith Angle: 134.3 [degrees]
Nearby Volcanoes (meeting alert criteria):
Anatahan(1.2 km)
Maximum Height [AMSL]: 13.9 [km] (45505 [ft])
90th Percentile Height [AMSL]: 13.2 [km] (43210 [ft])
Mean Tropopause Height [AMSL]: 16.5 [km] (54122 [ft])
Trend in IR Brightness Temperature: -56.1 [K]
Vertical Growth Rate Time Interval: 60 [minutes]
Vertical Growth Rate Anomaly: 3.5 [number of stddev above mean]
Total Area: 1328.0 [km^2]

Geographic Regions of Nearby Volcanoes: Mariana Is-C Pacific
VAAC Regions of Nearby Volcanoes: Washington
FIR Regions of Nearby Volcanoes: Unknown
---

lor Imagery (12–11μm, 11–3.9μm, 11μm)



May 29, 2010 – 12:30 UTC

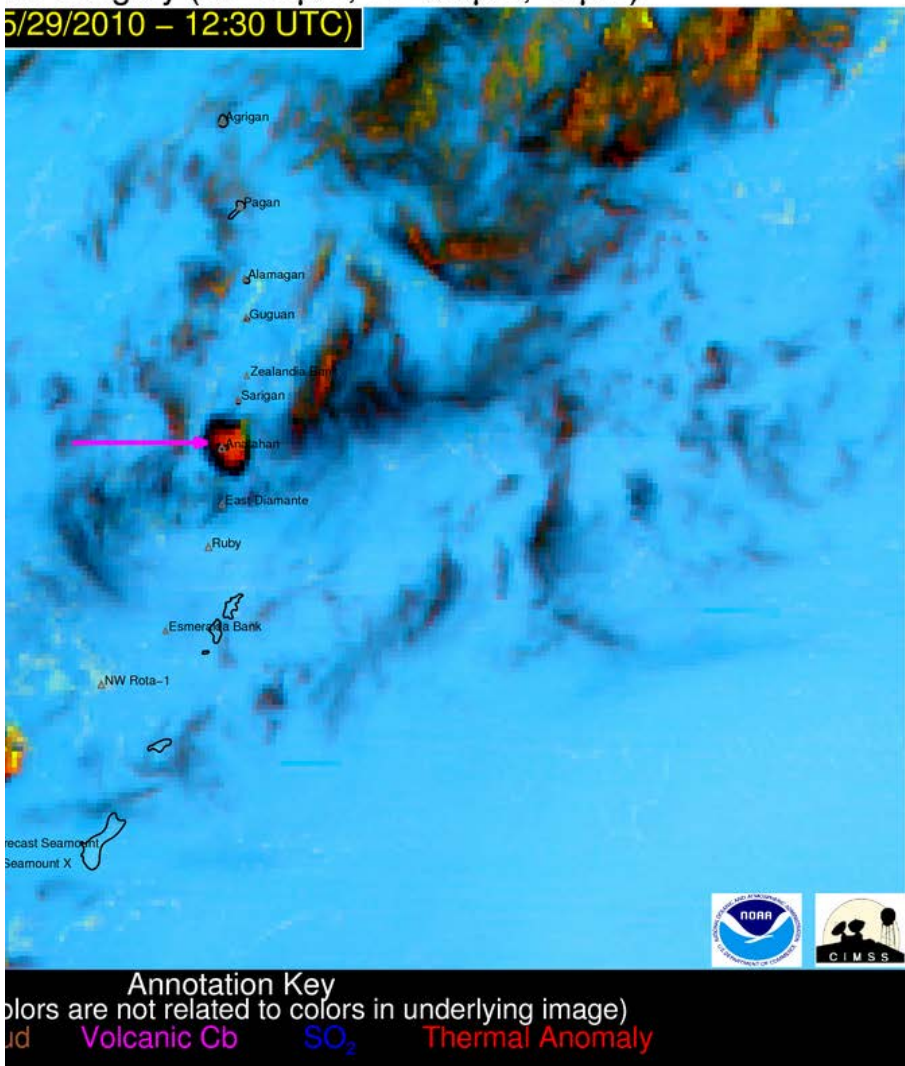
@**********VOLCANIC ALERTS**********
STARTING DATE/TIME OF IMAGE: 2010-05-29 12:30:00 [UTC]
PRODUCTION DATE/TIME OF ALERT: 2014-07-25 20:05:34 [UTC]
PRIMARY INSTRUMENT: MTSAT-1r Vis/IR_Imager
WMO SPACECRAFT ID: 171
LOCATION/ORBIT: GEO
L1 FILE: mtsat01_1_2010_149_1230.HRIT.noremap.area.gz
VOLCANO DATABASE: /data/common/VOLCAT_DATA/alerts/Volcat
NUMBER OF ASH CLOUD ALERTS: 0
NUMBER OF VOLCANIC Cb ALERTS: 1
NUMBER OF VOLCANIC THERMAL ANOMALY ALERTS: 0
NUMBER OF SO2 CLOUD ALERTS: 0

POSSIBLE VOLCANIC ERUPTION DETECTED
Alert Status: New Alert Object
Alert Confidence: HIGH
Latitude of Radiative Center: 16.27 [degrees]
Longitude of Radiative Center: 145.77 [degrees]
Mean Object Date/Time: 2010-05-29 12:38:28 [UTC]
Mean Viewing Angle: 20.4 [degrees]
Mean Solar Zenith Angle: 134.3 [degrees]
Nearby Volcanoes (meeting alert criteria):
Anatahan(1.2 km)
Maximum Height [AMSL]: 13.9 [km] (45505 [ft])
90th Percentile Height [AMSL]: 13.2 [km] (43210 [ft])
Mean Tropopause Height [AMSL]: 16.5 [km] (54122 [ft])
Trend in IR Brightness Temperature: -56.1 [K]
Vertical Growth Rate Time Interval: 60 [minutes]
Vertical Growth Rate Anomaly: 3.5 [number of stddev above mean]
Total Area: 1328.0 [km^2]

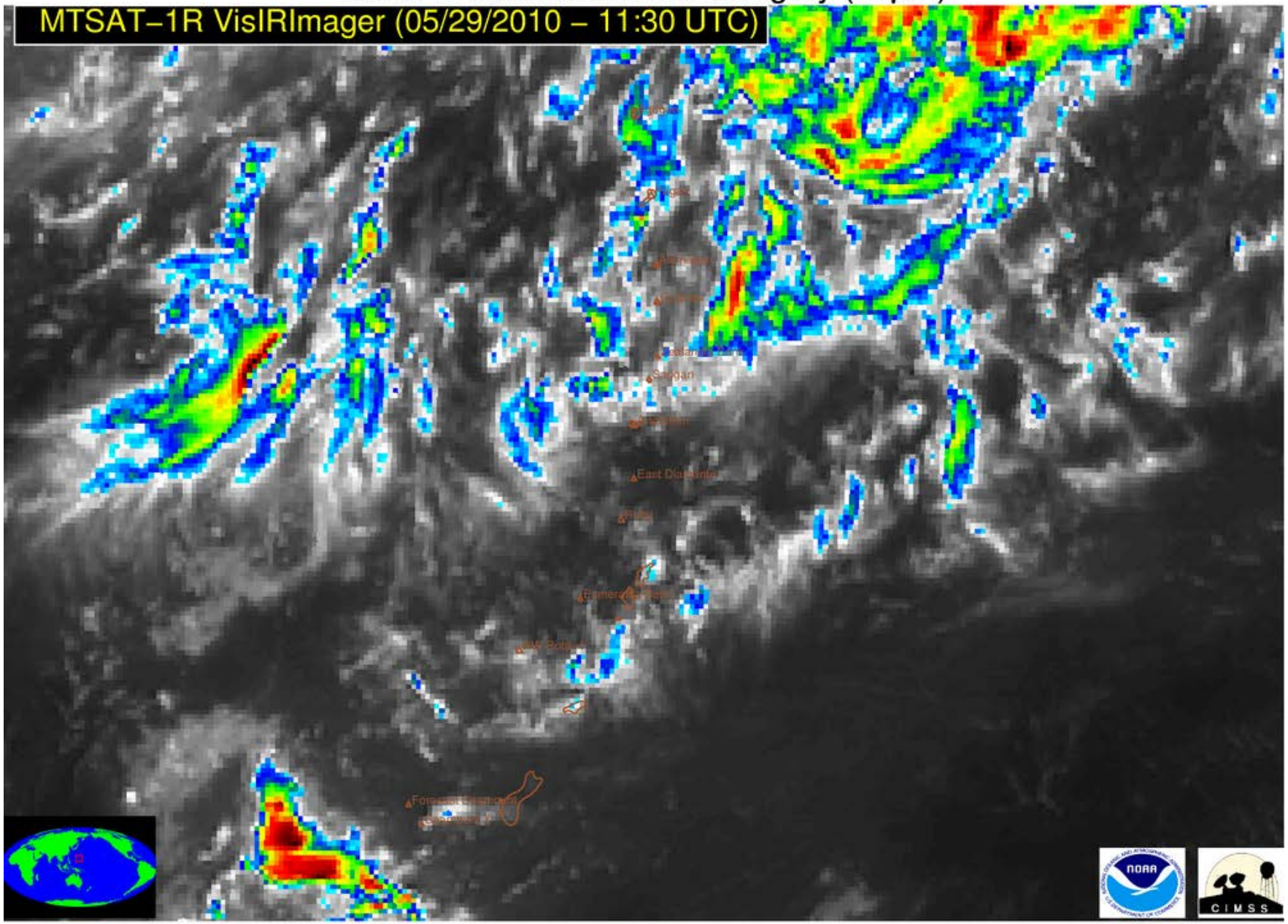
Geographic Regions of Nearby Volcanoes: Mariana Is-C Pacific
VAAC Regions of Nearby Volcanoes: Washington
FIR Regions of Nearby Volcanoes: Unknown

---

lor Imagery (12–11μm, 11–3.9μm, 11μm)



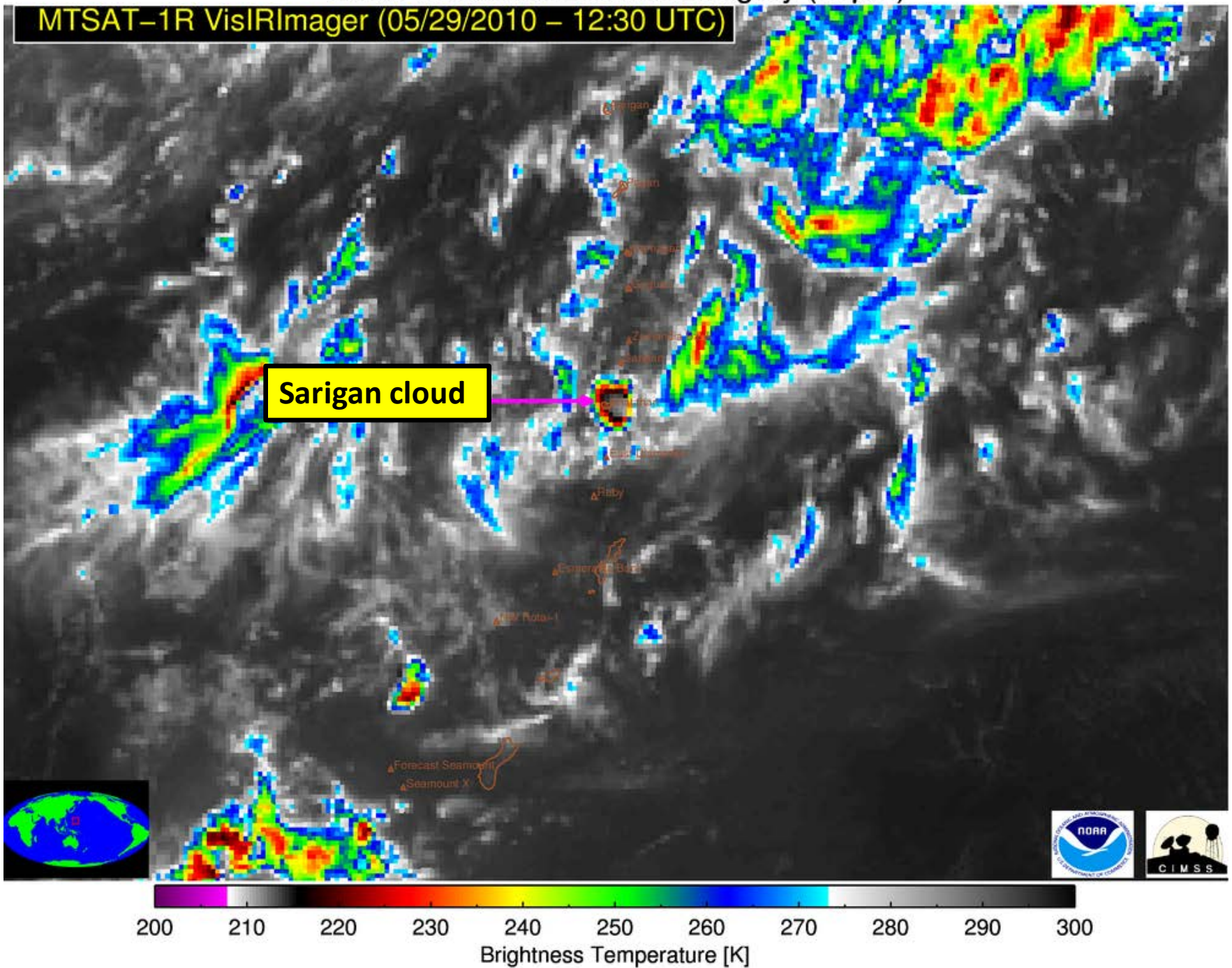
Color Enhanced Infrared Imagery (11μm)



200 210 220 230 240 250 260 270 280 290 300

Brightness Temperature [K]

Color Enhanced Infrared Imagery (11μm)



FVXX22 KNES 291323
VA ADVISORY
DTG: 20100529/1323Z

VAAC: WASHINGTON

VOLCANO: ANATAHAN 0804-20
PSN: N1621 E14540

AREA: MARIANA.ISLANDS

SUMMIT ELEV: 2585 FT (788 M)

ADVISORY NR: 2010/001

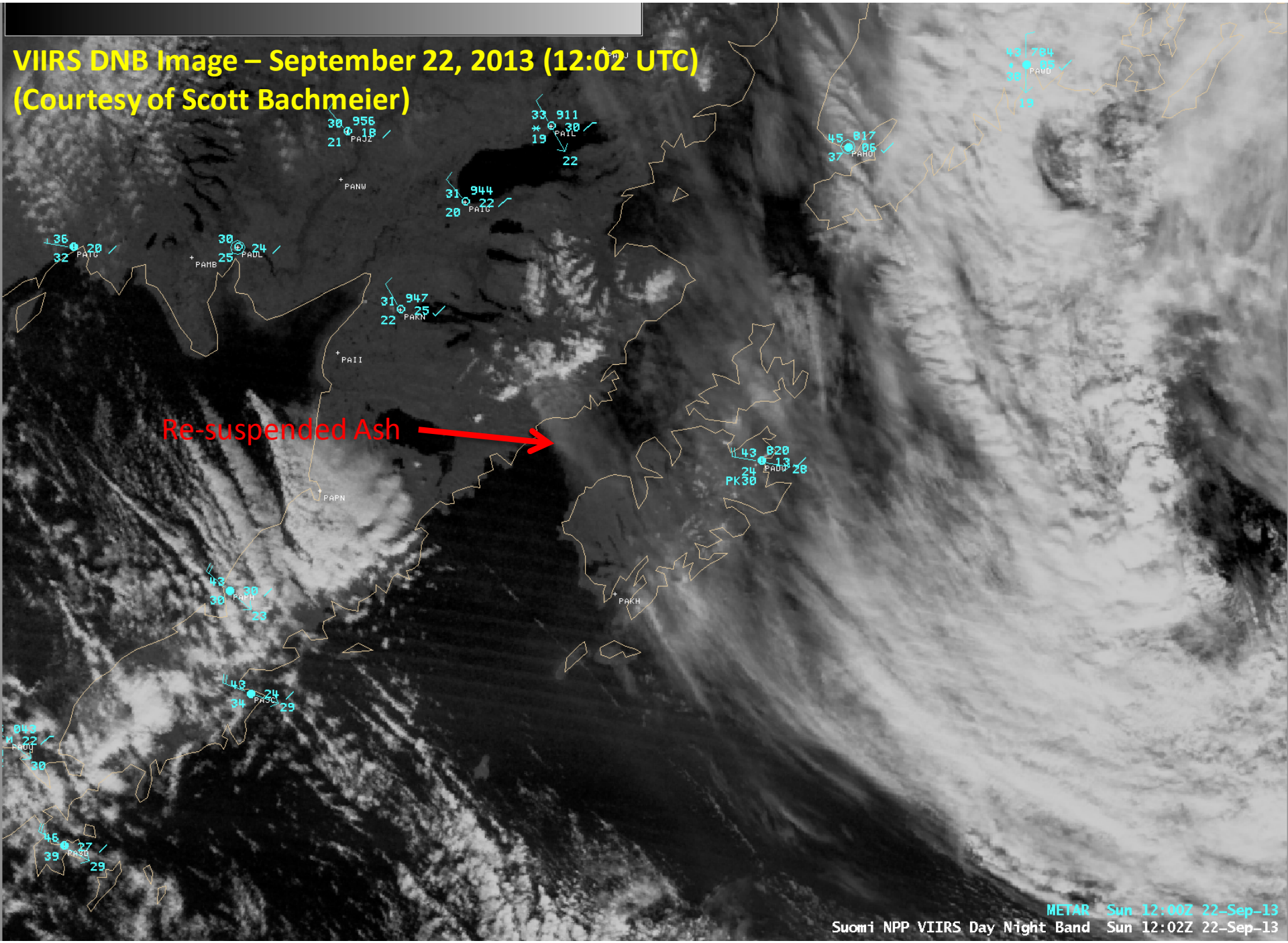
INFO SOURCE: GUAM MWO. GOES-11.

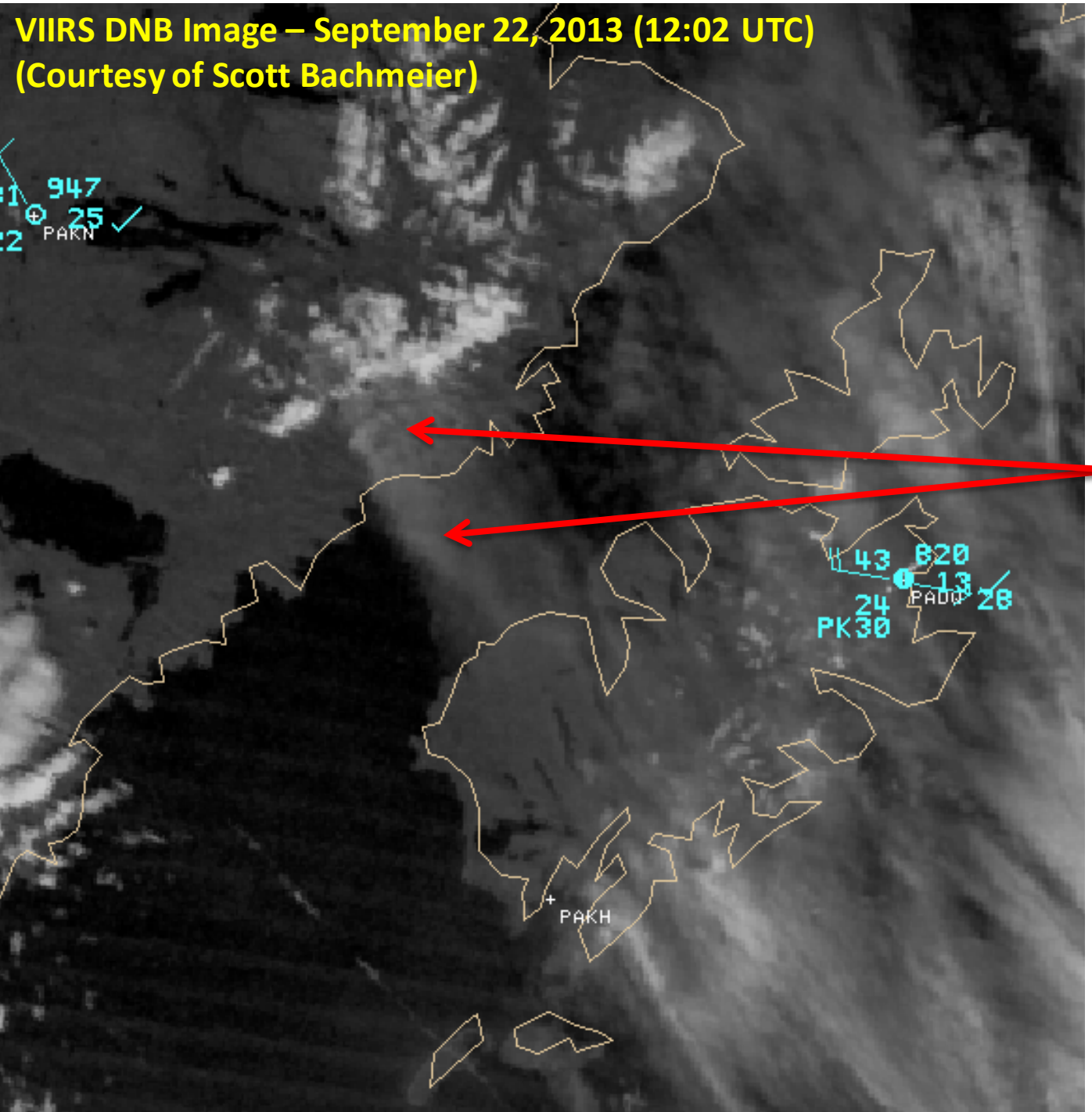
ERUPTION DETAILS: LOUD NOISE REPORTED AND CLOUD
SEEN IN IR IMAGERY

RMK: WE HAVE RECEIVED INFORMATION SUGGESTING A
POSSIBLE VA EMISSION. WE WILL GATHER FURTHER
INFORMATION AND ISSUE A FULL ADVISORY AS SOON AS
POSSIBLE.

NXT ADVISORY: AS SOON AS POSSIBLE

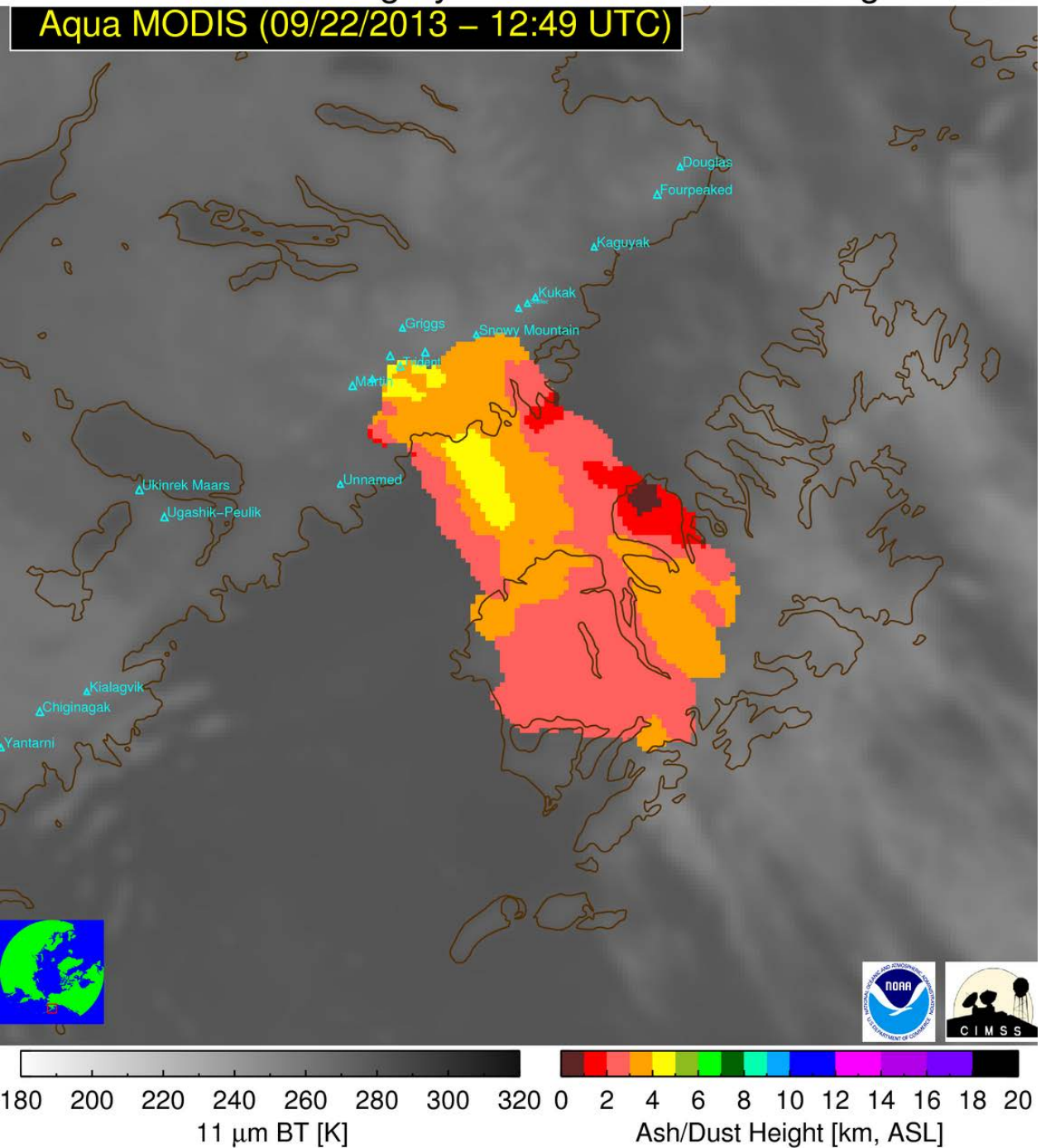
VIIRS DNB Image – September 22, 2013 (12:02 UTC)
(Courtesy of Scott Bachmeier)



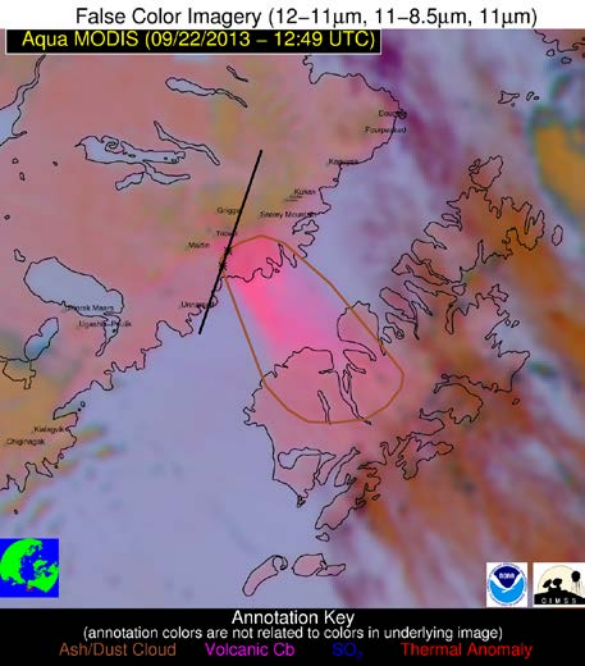


Textural attributes of VIIRS DNB image implies greater vertical structure in same regions where the NOAA/NESDIS/STAR ash cloud heights are greatest

IR Window Imagery and Ash/Dust Cloud Height



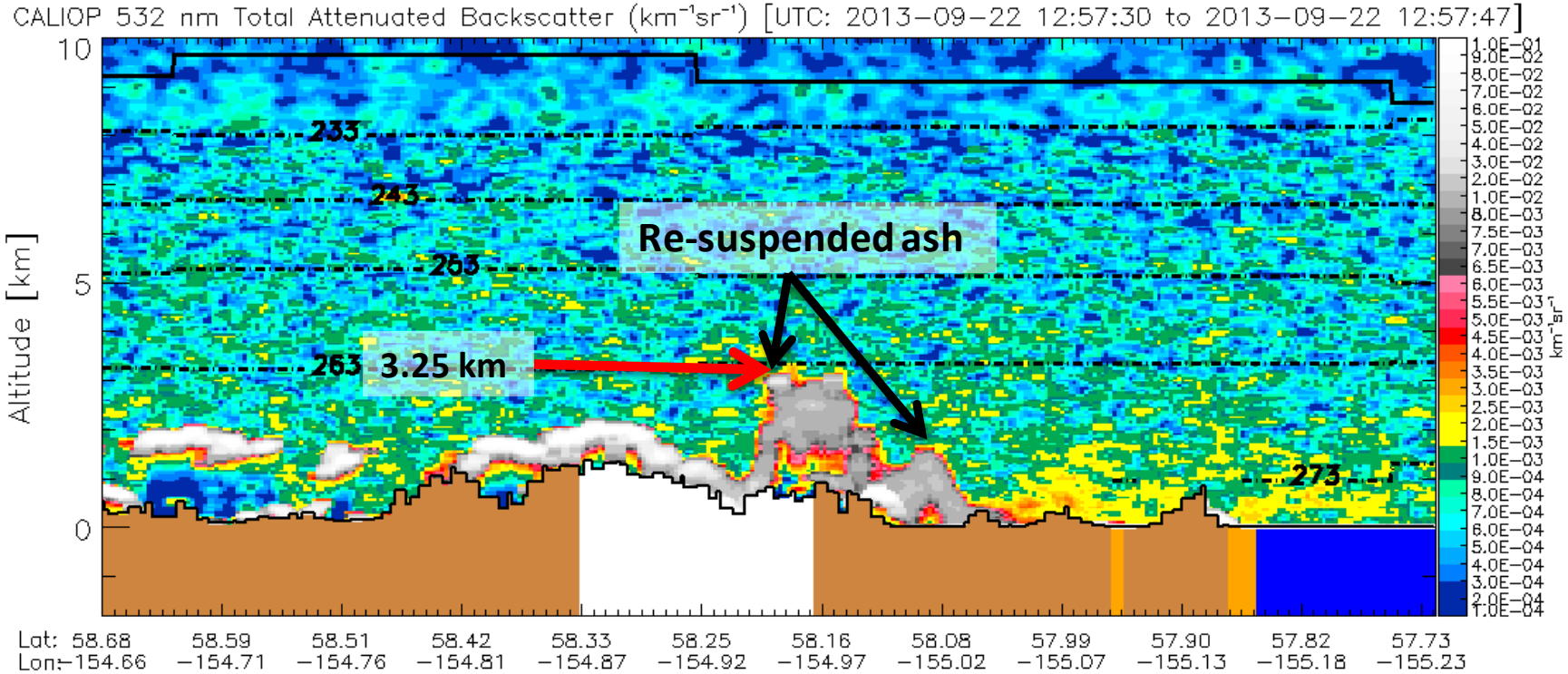
Given the accurate cloud vertical boundary information provided by CALIOP and textural information provided by the VIIRS DNB, the NOAA/NESDIS/STAR cloud height estimates appear to be quite reasonable.



CALIPSO Overpass – September 22, 2013 (12:57 UTC)

The re-suspended ash in the very far northwestern portion of the cloud (near the source region), that was discernable in passive infrared satellite data, extended from the surface up to 3.25 km (~10,600 ft) ASL based on CALIOP data. Unfortunately, no other CALIPSO overpasses occurred during this event.

Thanks to NASA Langley for providing expedited CALIPSO data



Alert subscription service will be opened to all VAACs and collaborators for beta testing this summer

CIMSS » Volcanic Cloud Monitoring » Alert Subscriptions

Volcanic Cloud Monitoring — NOAA/CIMSS

Home | Sector Imagery | Alerts | Subscriptions | Tutorials | Logout (justins@ssec.wisc.edu)

Add Alert Subscription

Note: you may only subscribe to 5 subscriptions.

Send alerts to me via:	○ **SMS:** _____ *(Only alpha-numeric characters as well as spaces, dashes, plus signs and parentheses are allowed)* ○ **Email:** _____

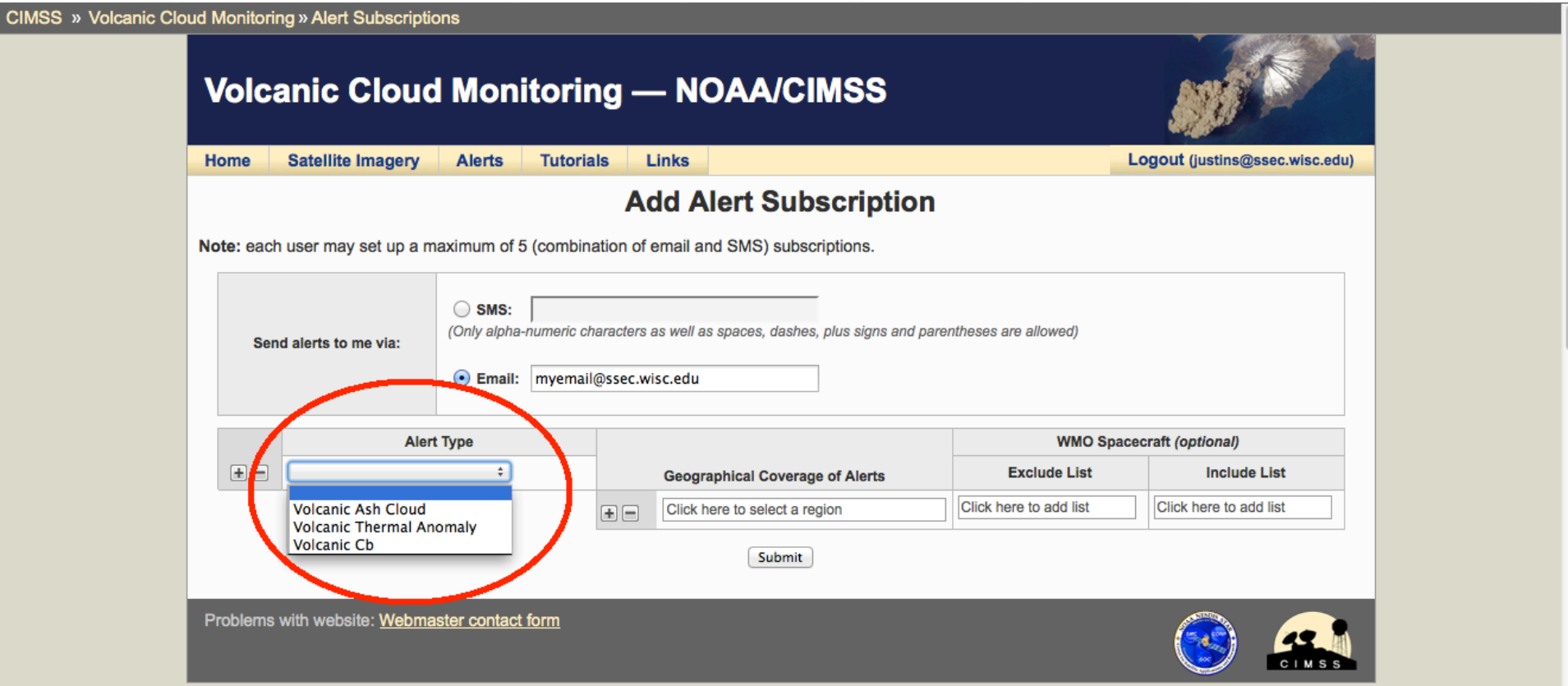
	Alert Type	Region	WMO Spacecraft	
			Exclude List	Include List
[+] [−]	[ ]	[+] [−] Click here to select a region	Click here to add list	Click here to add list

Submit

Problems with website: Webmaster contact form

CIMSS

Alert subscription service will be opened to all VAACs and collaborators for beta testing this summer



Alert subscription service will be opened to all VAACs and collaborators for beta testing this summer

CIMSS » Volcanic Cloud Monitoring » Alert Subscriptions

Volcanic Cloud Monitoring — NOAA/CIMSS

Home | Satellite Imagery | Alerts | Tutorials | Links | Logout (justins@ssec.wisc.edu)

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Note: each user may set up a maximum of 5 (combination of email and SMS) subscriptions.

Send alerts to me via:	SMS: *(Only alpha-numeric characters as well as spaces, dashes, plus signs and parentheses are allowed)* Email: myemail@ssec.wisc.edu

Alert Type	Geographical Coverage of Alerts	WMO Spacecraft *(optional)*	
		Exclude List	Include List
Volcanic Ash Cloud	Volcanic Region / VAAC Region Select a region Update	Click here to add list	Click here to add list

Submit

Problems with website: Webmaster contact form

Alert subscription service will be opened to all VAACs and collaborators for beta testing this summer

CIMSS » Volcanic Cloud Monitoring » Alert Subscriptions

Volcanic Cloud Monitoring — NOAA/CIMSS

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Send alerts to me via:

- SMS:
  (Only alpha-numeric characters as well as spaces, dashes, plus signs and parentheses are allowed)
- Email: myemail@ssec.wisc.edu

Alert Type	Geographical Coverage of Alerts	WMO Spacecraft *(optional)*	
		Exclude List	Include List
Volcanic Ash Cloud	Volcanic Region / VAAC Region Select a region Update	GOES-13 GOES-14 GOES-15 MODIS-Terra Update List	Click here to add list

Submit

Problems with website: Webmaster contact form

Alert subscription service will be opened to all VAACs and collaborators for beta testing this summer

CIMSS » Volcanic Cloud Monitoring » Alert Subscriptions

Volcanic Cloud Monitoring — NOAA/CIMSS

Home | Satellite Imagery | Alerts | Tutorials | Links | Logout (justins@ssec.wisc.edu)

Add Alert Subscription

Note: each user may set up a maximum of 5 (combination of email and SMS) subscriptions.

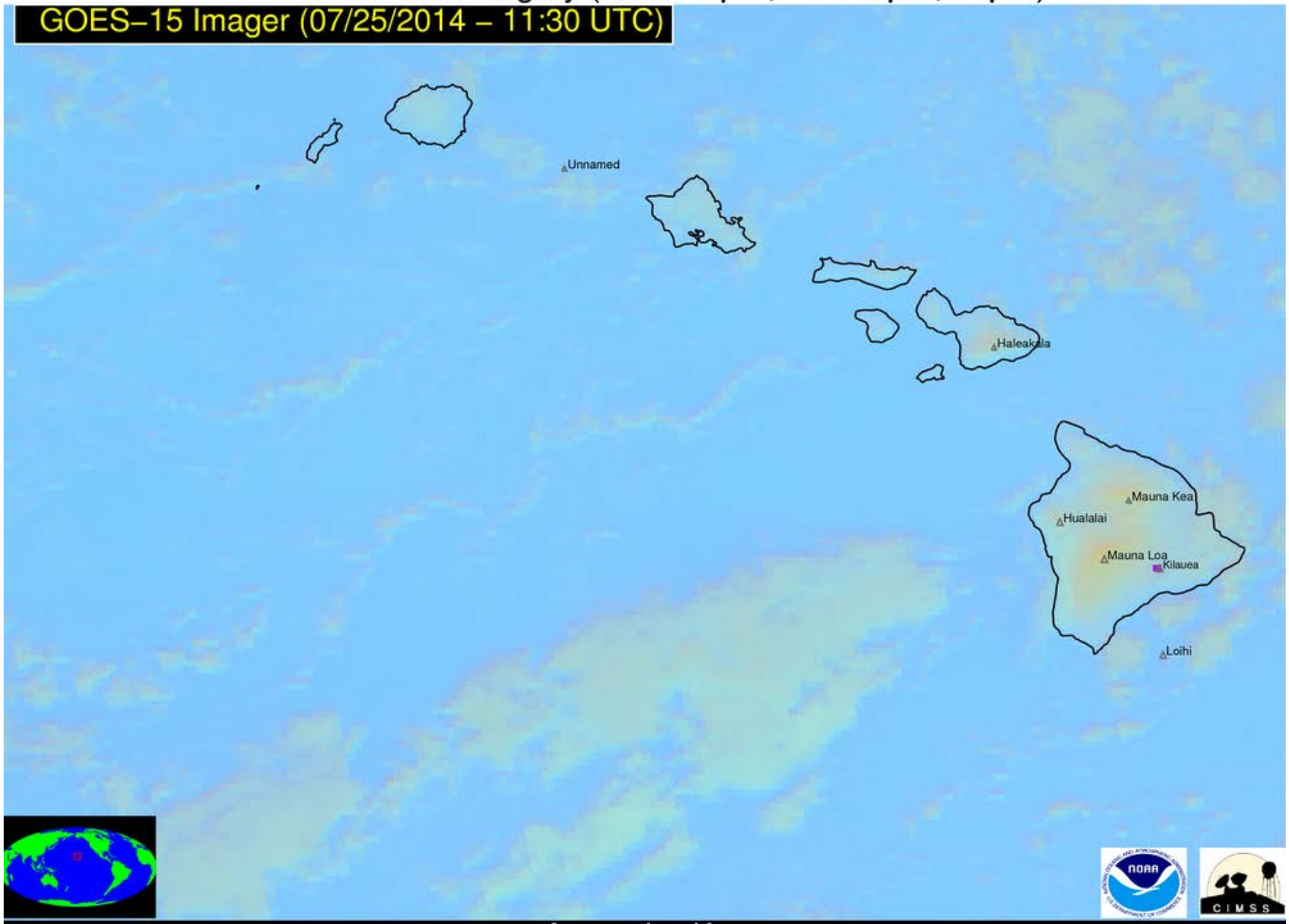
Send alerts to me via:	
	○ **SMS:** _____ *(Only alpha-numeric characters as well as spaces, dashes, plus signs and parentheses are allowed)*
	◉ **Email:** myemail@ssec.wisc.edu

	Alert Type	Geographical Coverage of Alerts	WMO Spacecraft *(optional)*	
			Exclude List	Include List
[+] [−]	Volcanic Ash Cloud	○ Volcanic Region ◉ VAAC Region Select a region Update	GOES-13 GOES-14 GOES-15 MODIS-Terra Update List	Click here to add list

Submit

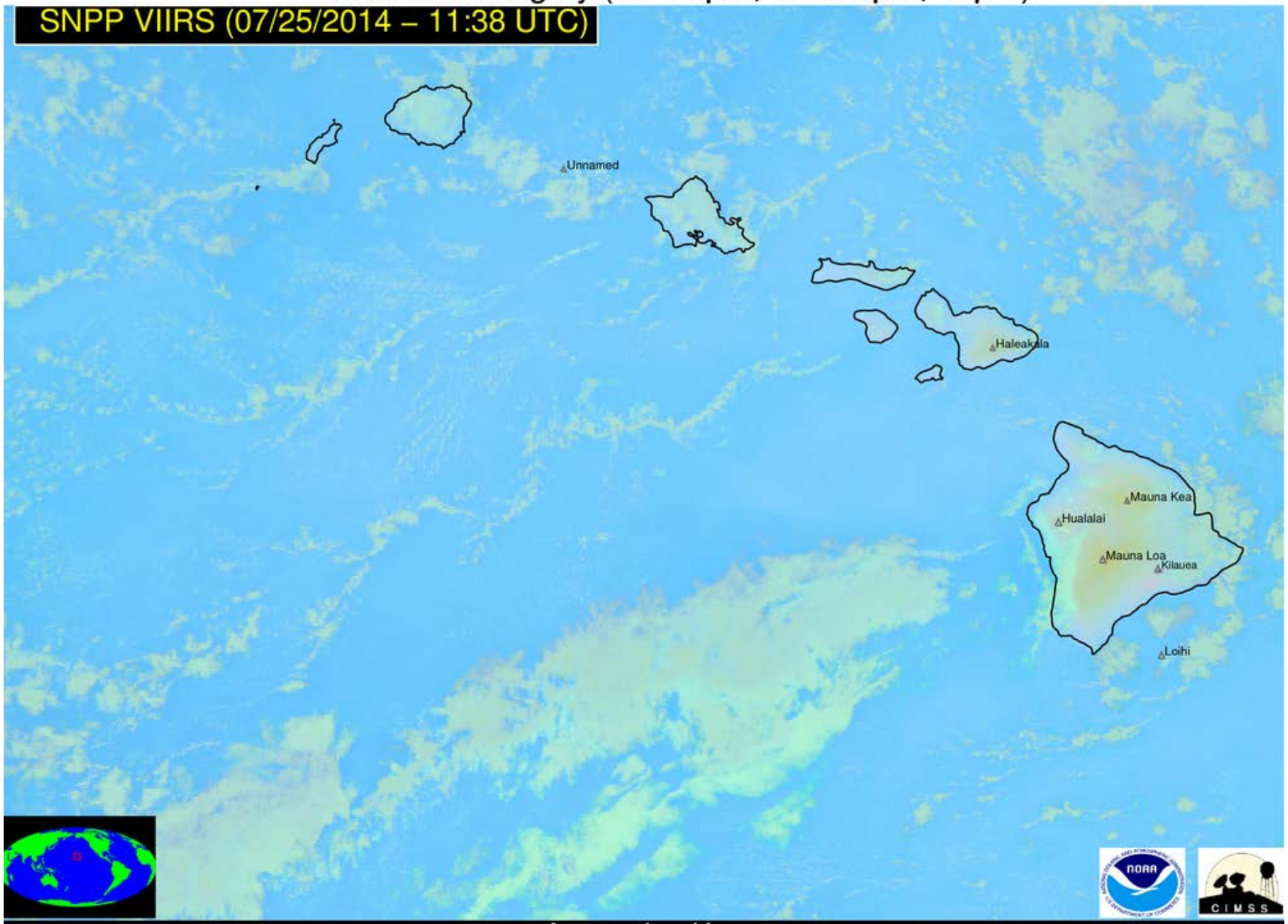
Problems with website: Webmaster contact form

False Color Imagery (13.3–11μm, 11–3.9μm, 11μm)



Annotation Key
(annotation colors are not related to colors in underlying image)
Ash/Dust Cloud Volcanic Cb SO_2 Thermal Anomaly

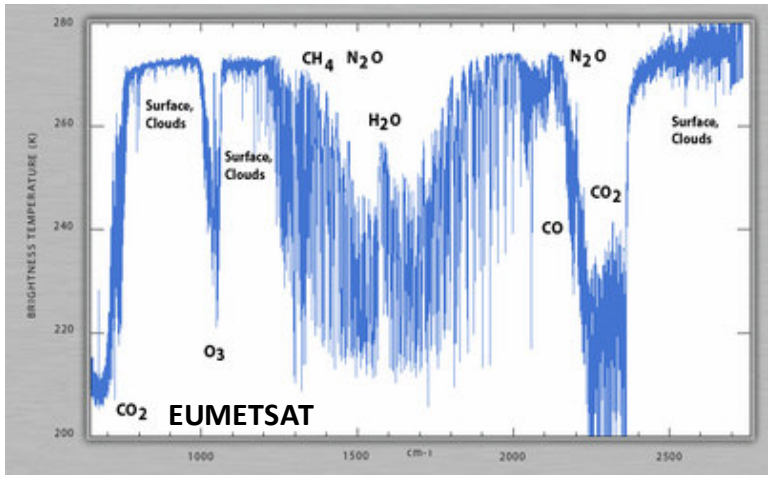
False Color Imagery (12–11μm, 11–3.9μm, 11μm)



Annotation Key
(annotation colors are not related to colors in underlying image)
Ash/Dust Cloud Volcanic Cb SO_2 Thermal Anomaly

Example Procedure for Combining Measurements from Different Sensors on the Same Spacecraft

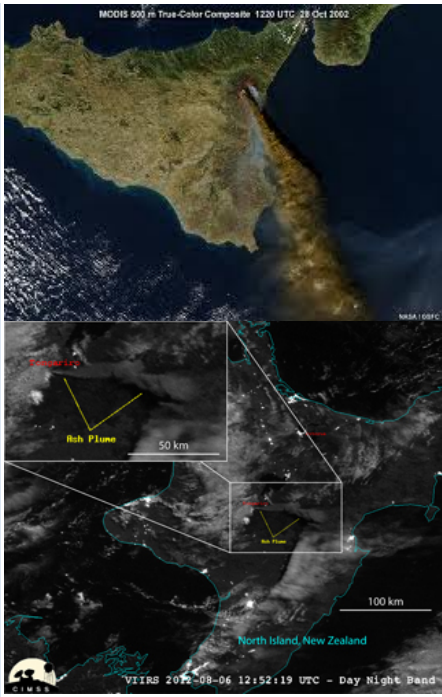
1). Perform volcanic cloud retrieval using hyperspectral sounder (e.g. CrIS, IASI, AIRS)



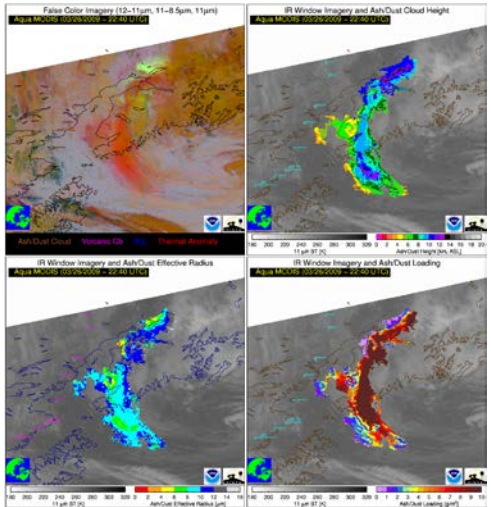
2). Perform retrieval using high spatial resolution imager (e.g. VIIRS, AVHRR, MODIS)

a. use hyperspectral retrieval as first guess

b. fill in important spectral gaps (e.g. LW CO_2) needed for high quality retrieval by interpolating from sounder spatial resolution to imager spatial resolution

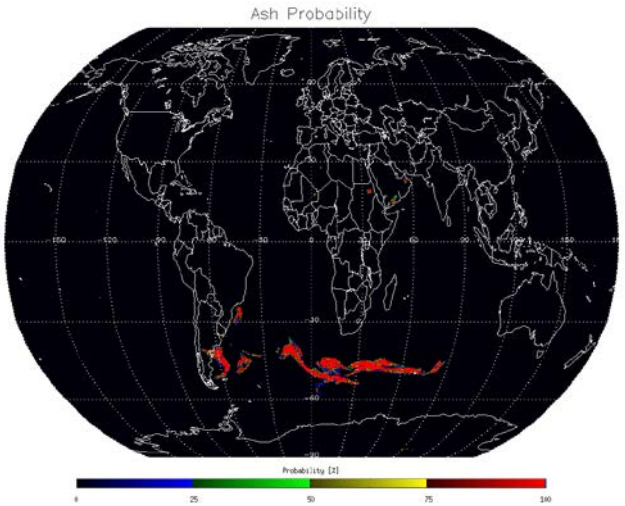


The end result is a high spatial resolution product that is more accurate because hyperspectral information was incorporated into the retrieval!



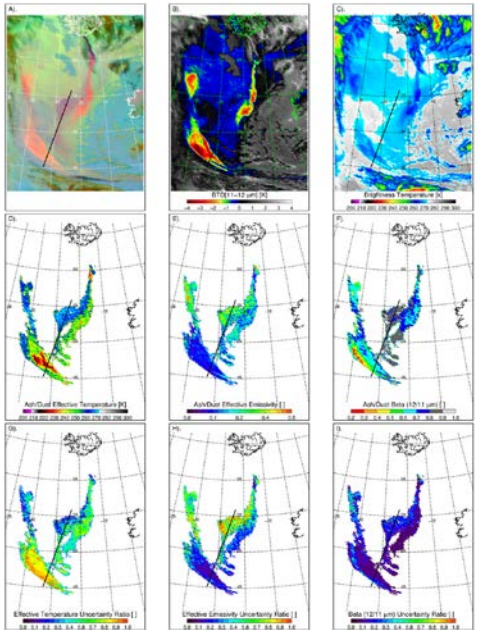
Example Procedure for Combining Measurements from Different Sensors on <u>Different</u> Spacecraft (e.g. LEO/GEO)

High quality retrieval results from LEO sensors are used as a first guess into GEO sensor retrievals, which generally have less spectral information to work with.



The end result is a high temporal resolution product with an accuracy similar to that achievable from LEO sensors (information from LEO is "transferred" to GEO).

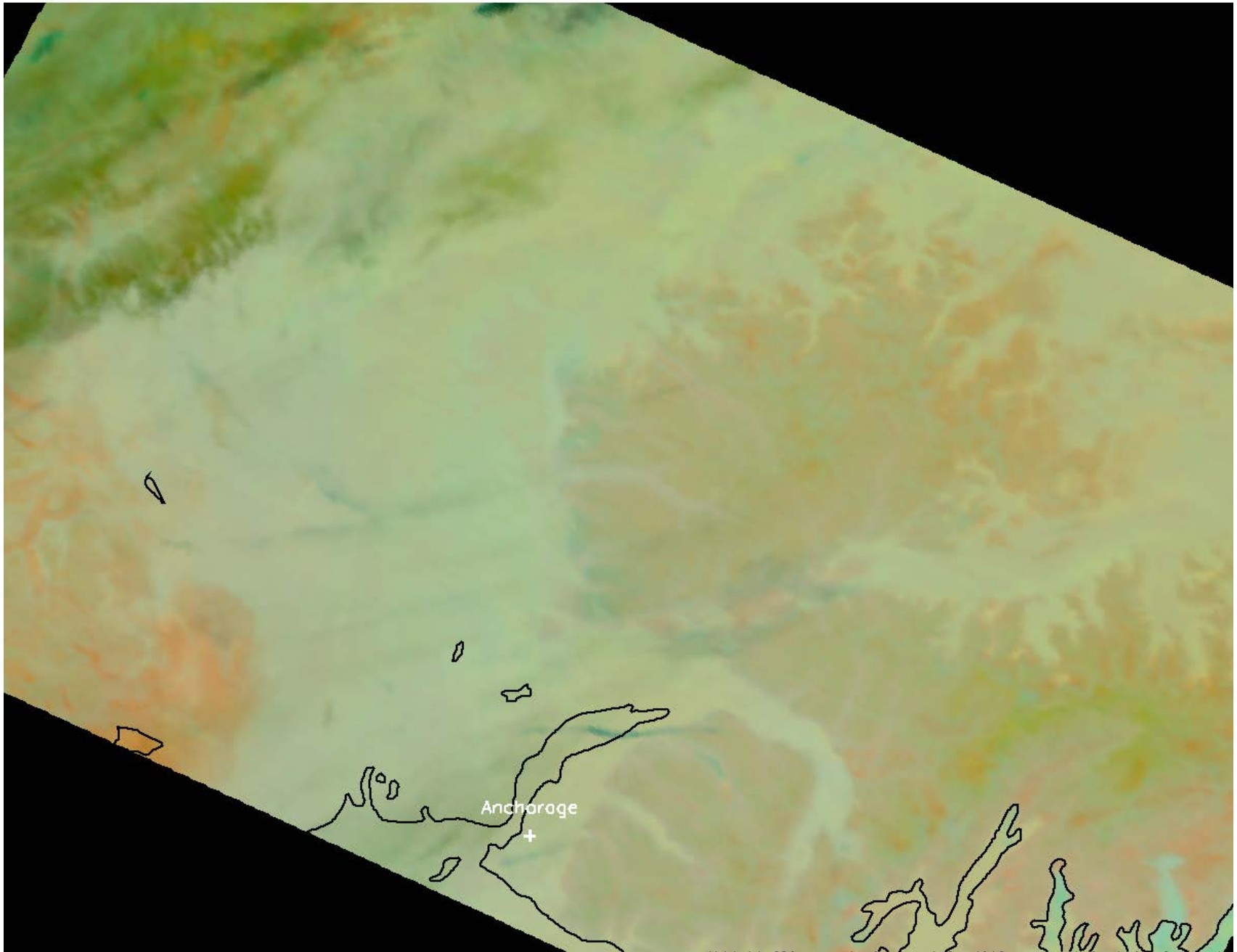
A relatively recent LEO overpass of the cloud is required though!



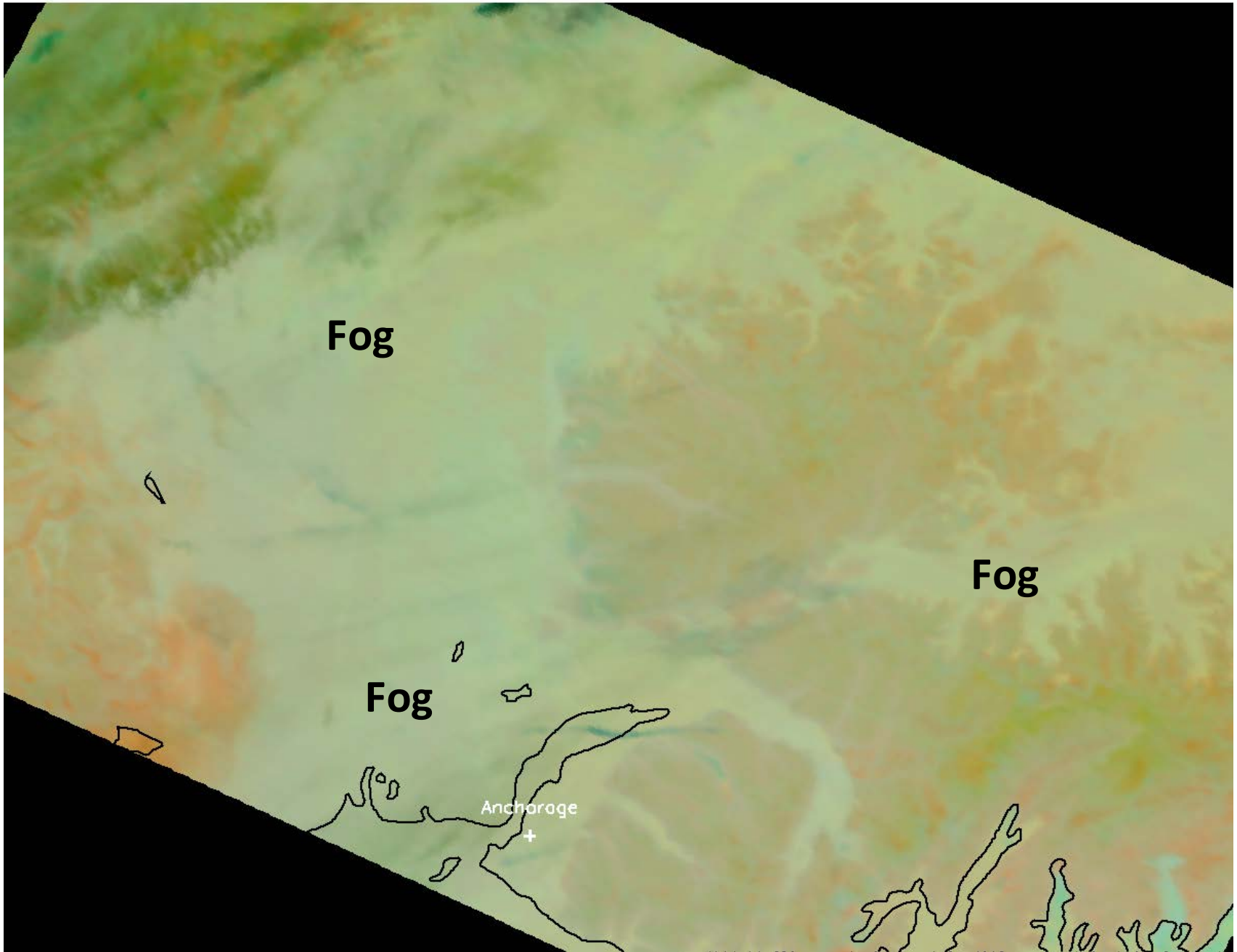
Future Plans

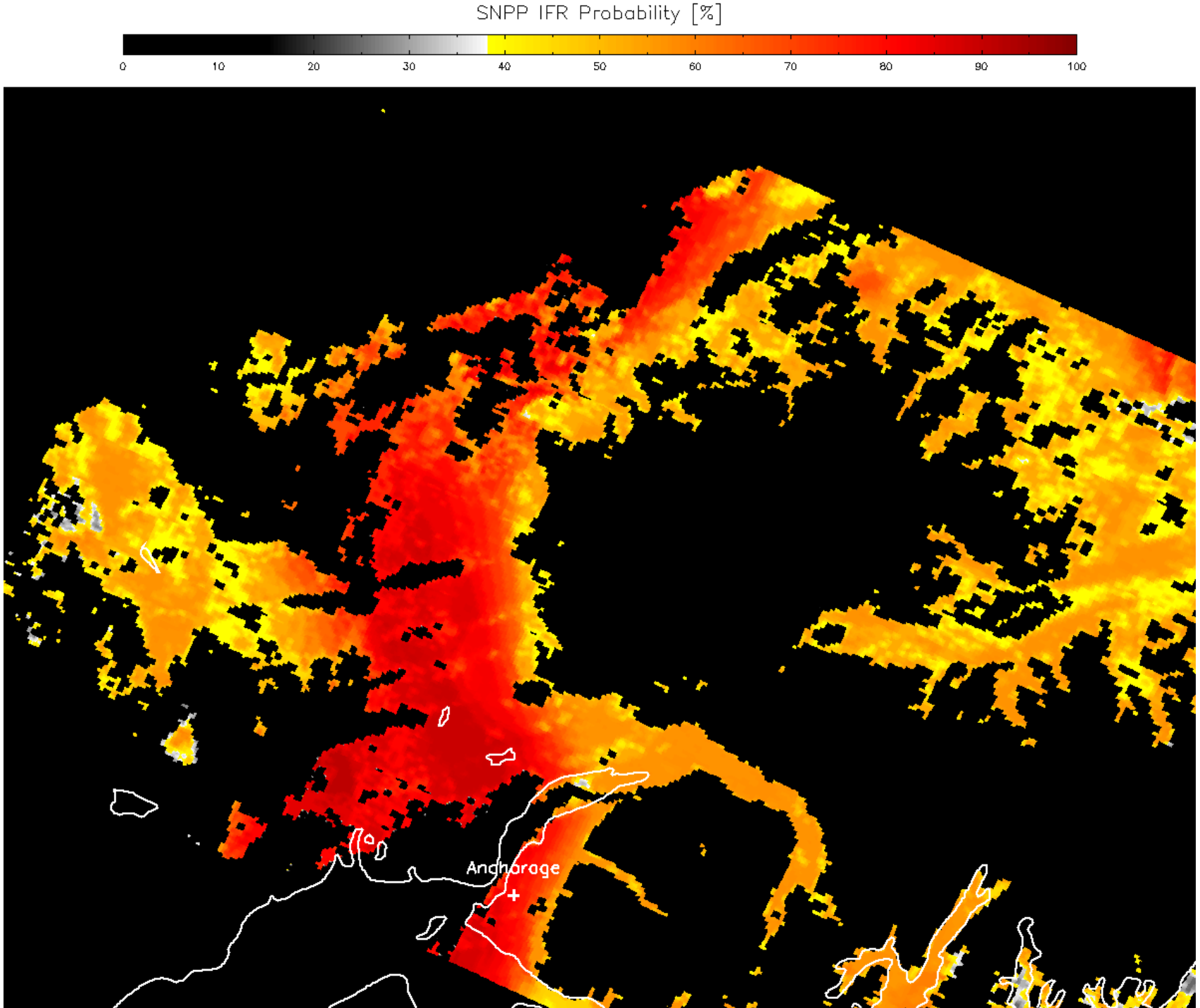
- Alerting service from “experimental” system at the UW will be made available to VAAC’s this summer and additional users at a later time (SCOPE-Nowcasting, CEOS DRM activities, and Satellite Proving Ground activities)
- SCOPE-Nowcasting inter-comparison activity
- Integration with HYSPLIT
- New GOES-R project with USGS to integrate additional satellite and non-satellite data sources (hyperspectral IR, lightning, infrasound, seismic, etc…)
- NDE transition

December 8, 2013 – 12:59 UTC



December 8, 2013 – 12:59 UTC




SNPP IFR Probability [%]
0
10
20
30
40
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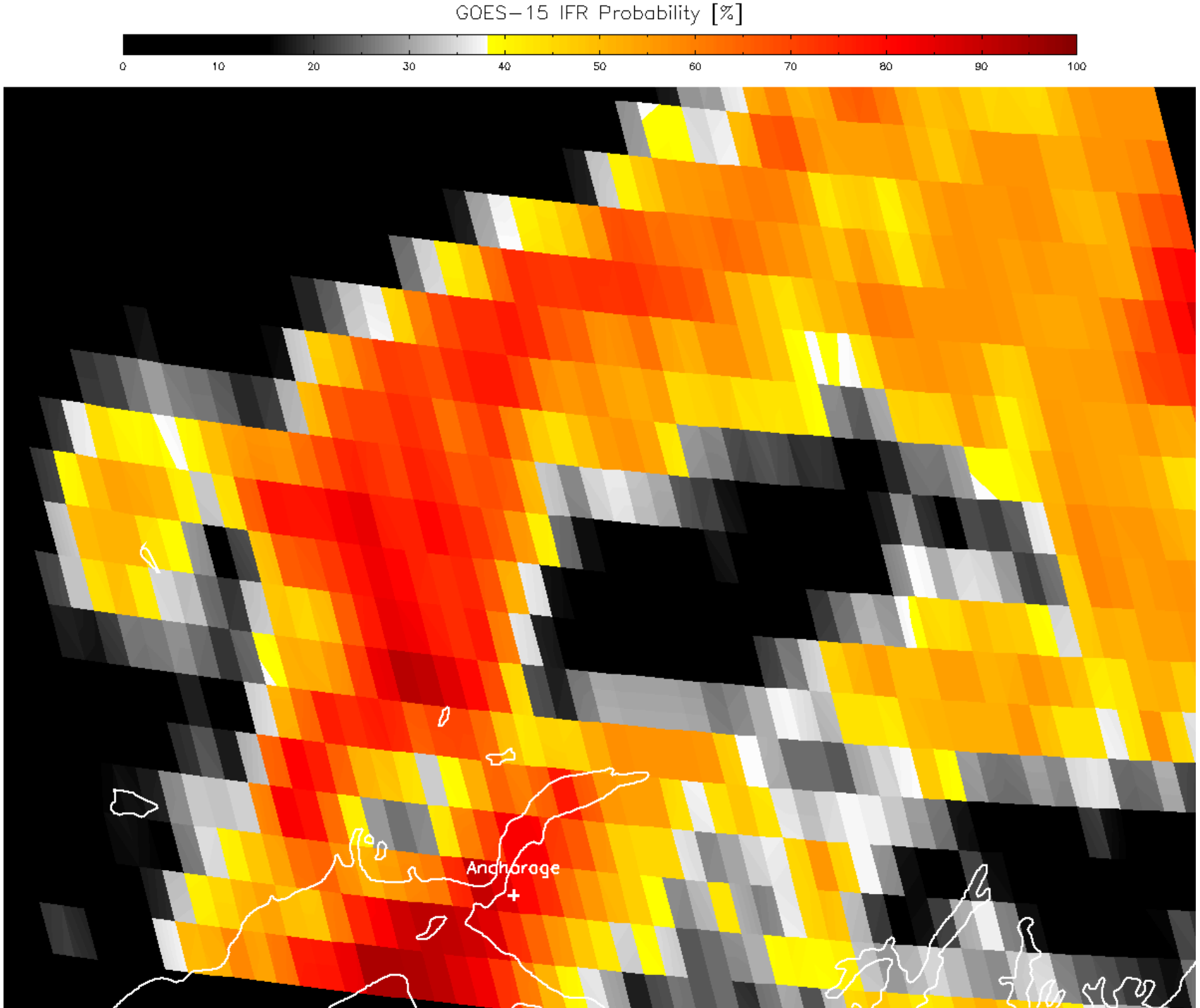
80
90
100
Anchorage


GOES−15 IFR Probability [%]
0
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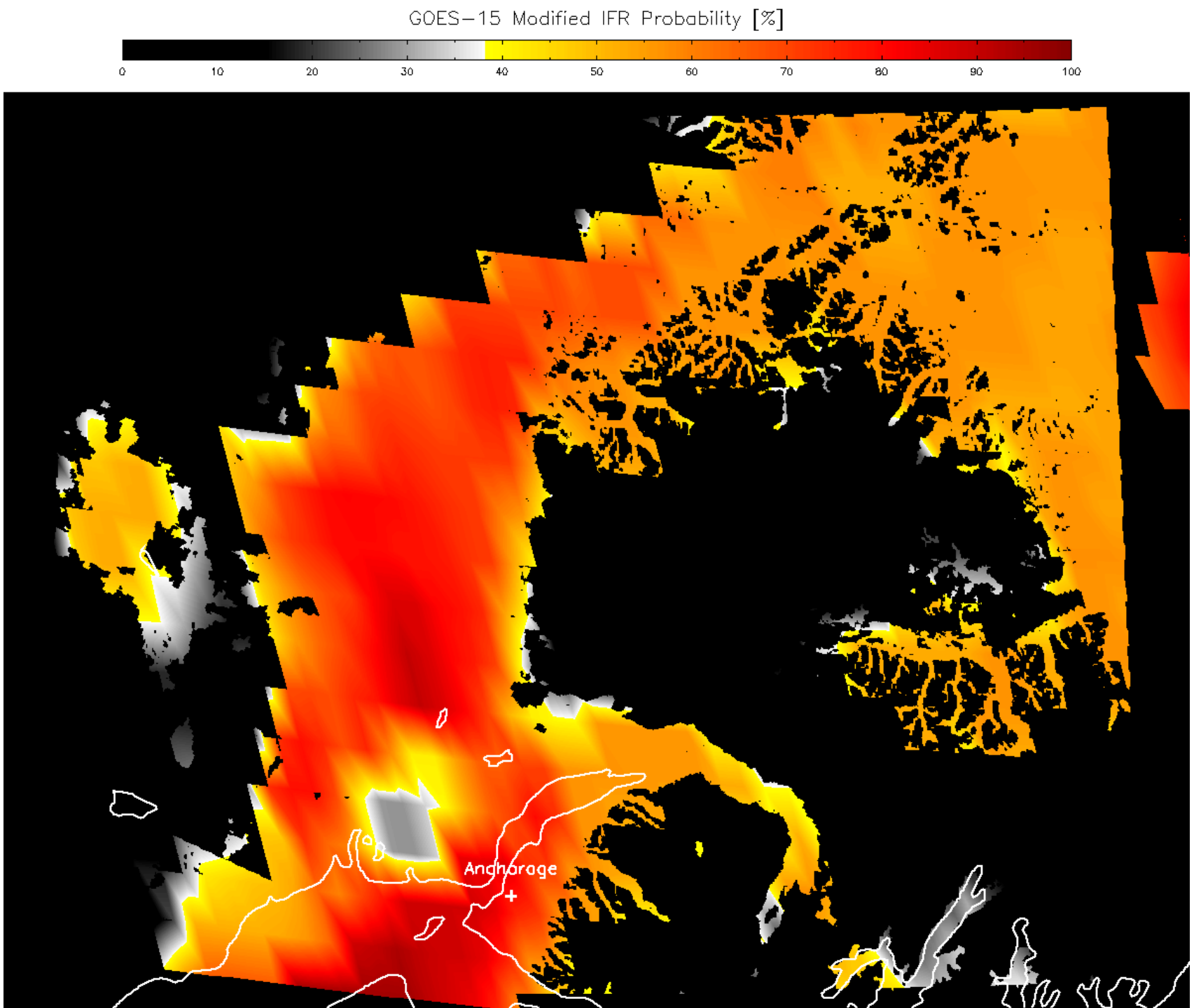
Anchorage


GOES−15 Modified IFR Probability [%]
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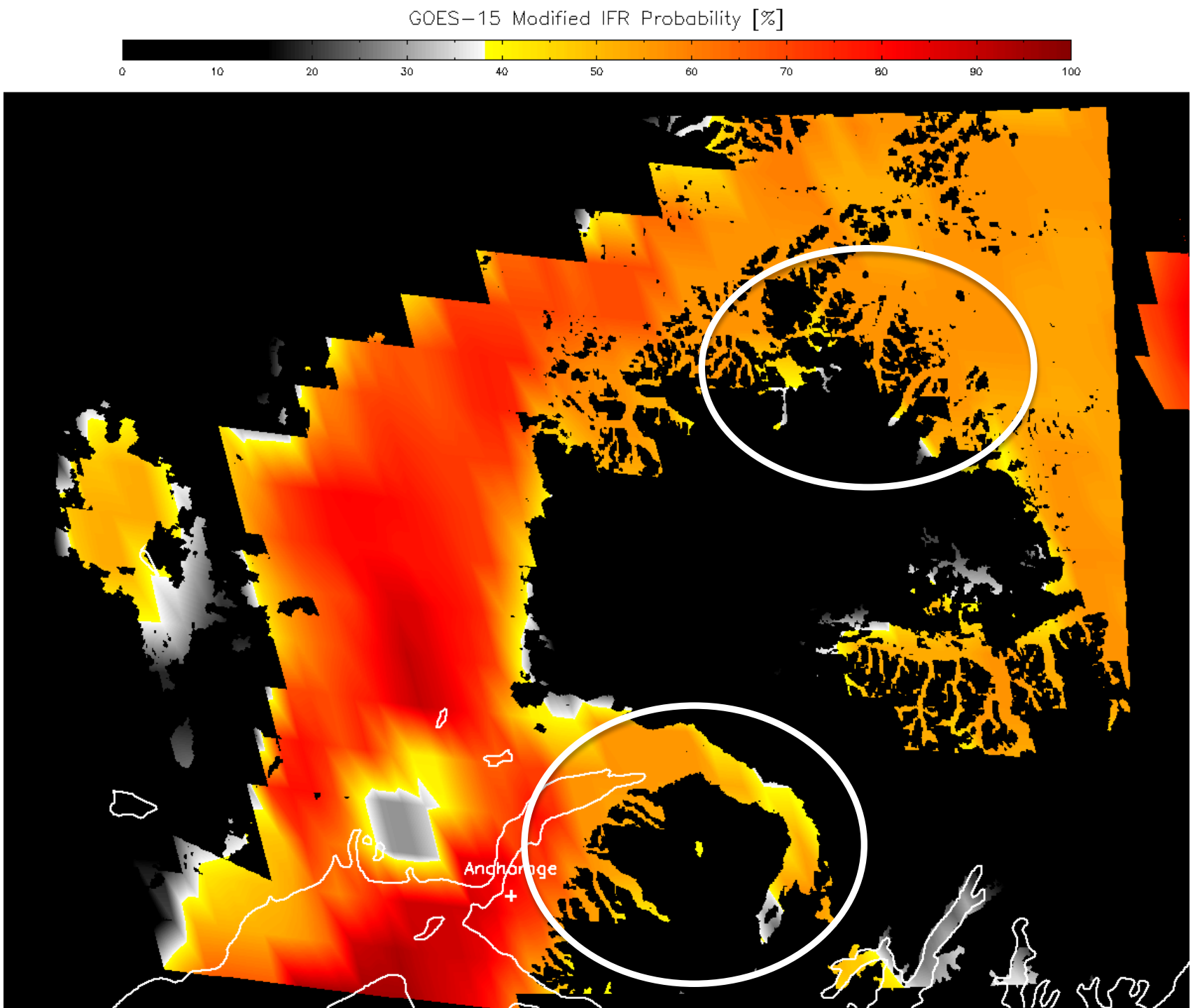
Anchorage


GOES−15 Modified IFR Probability [%]
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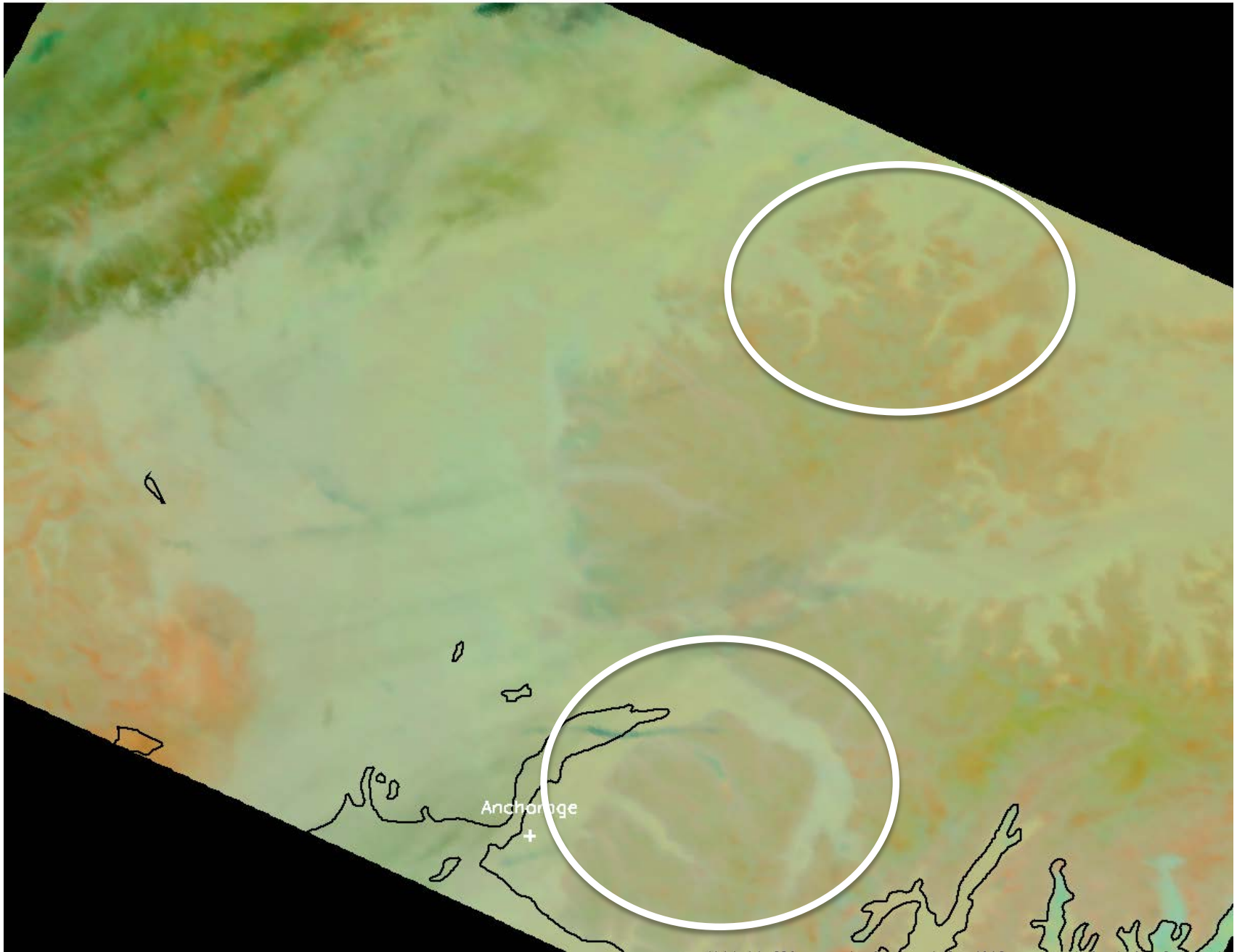
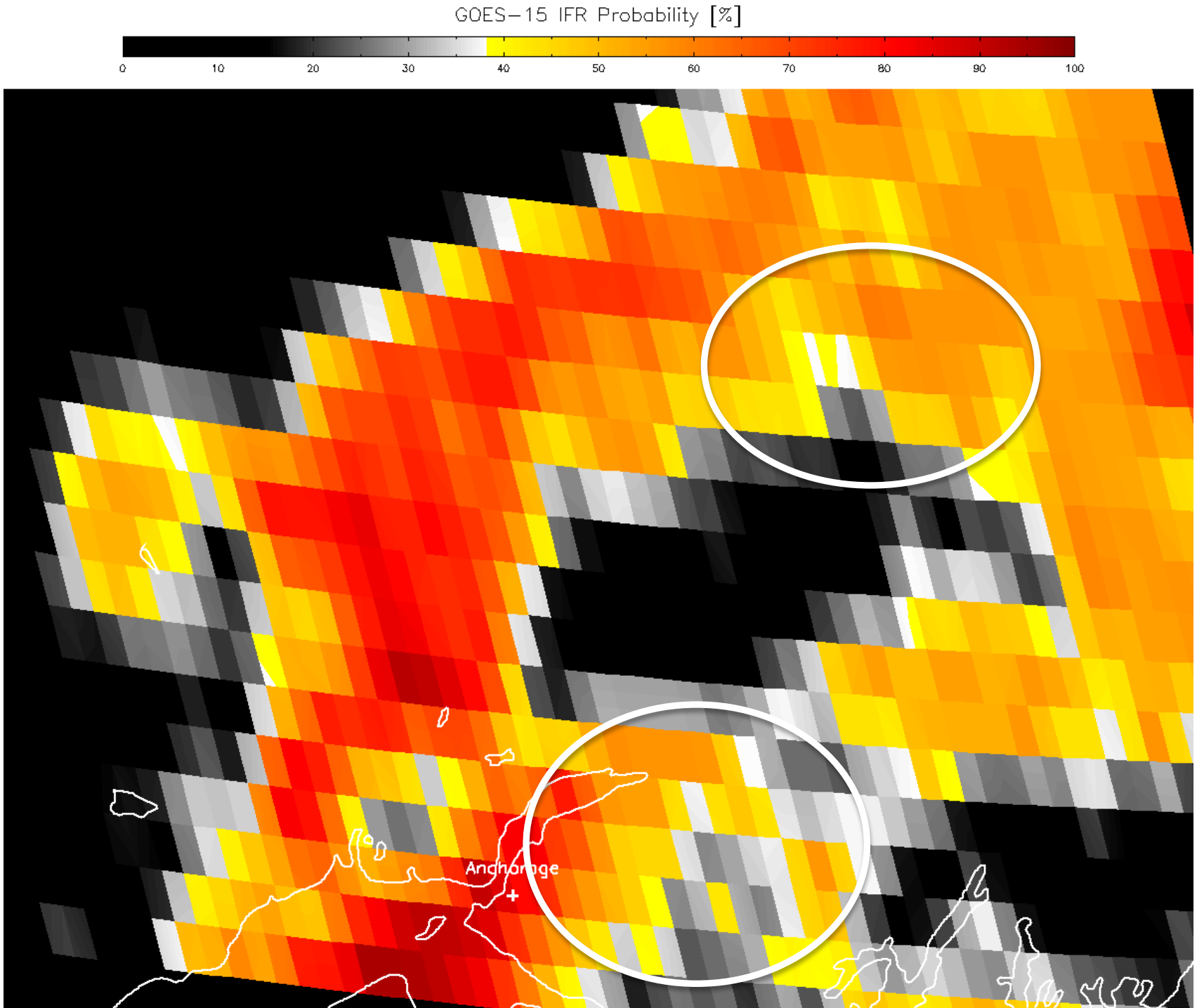
Anchorage

SNPP RGB (11−12μm BTD/8.5−11μm BTD/11μm BT)




GOES−15 IFR Probability [%]
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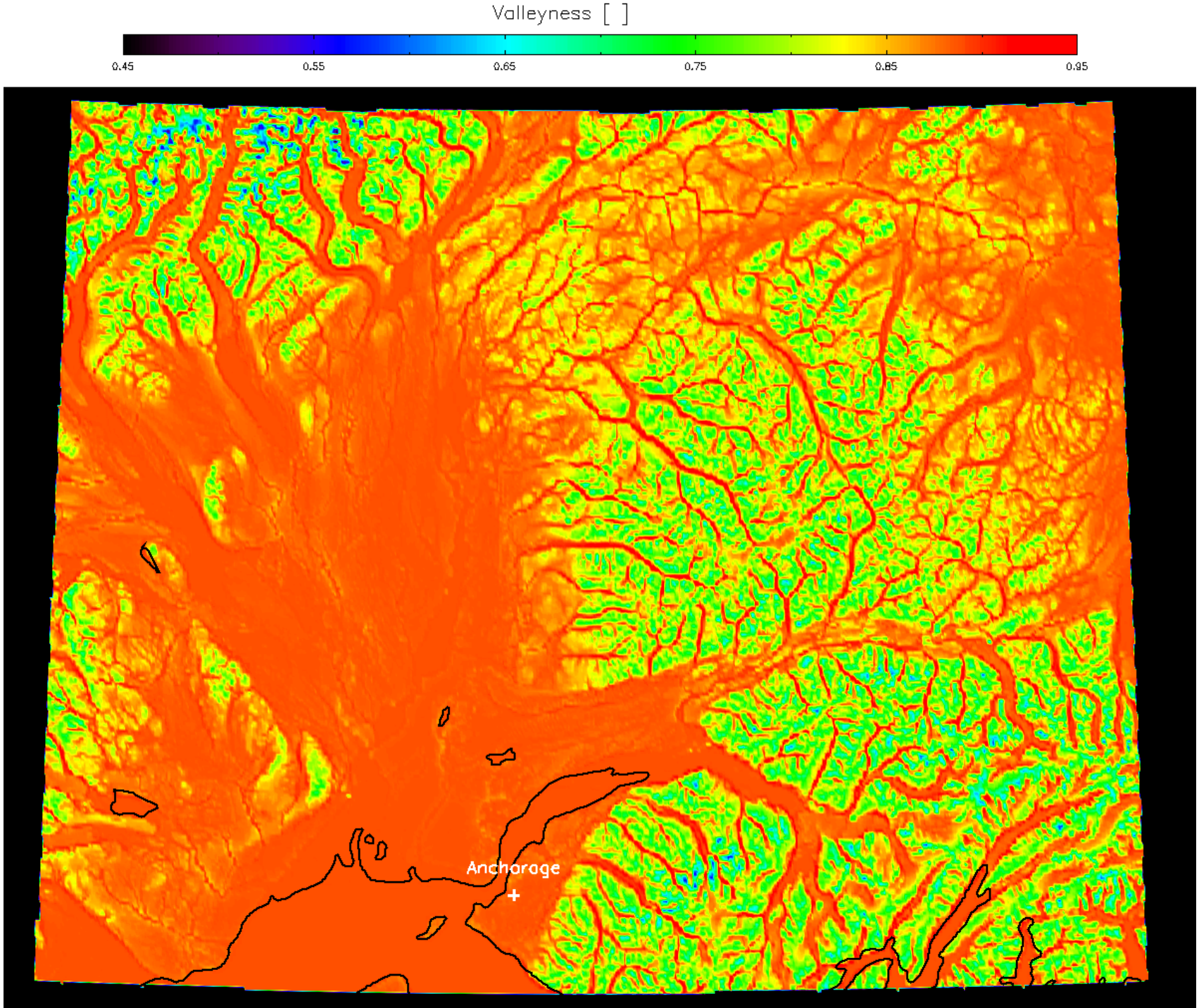
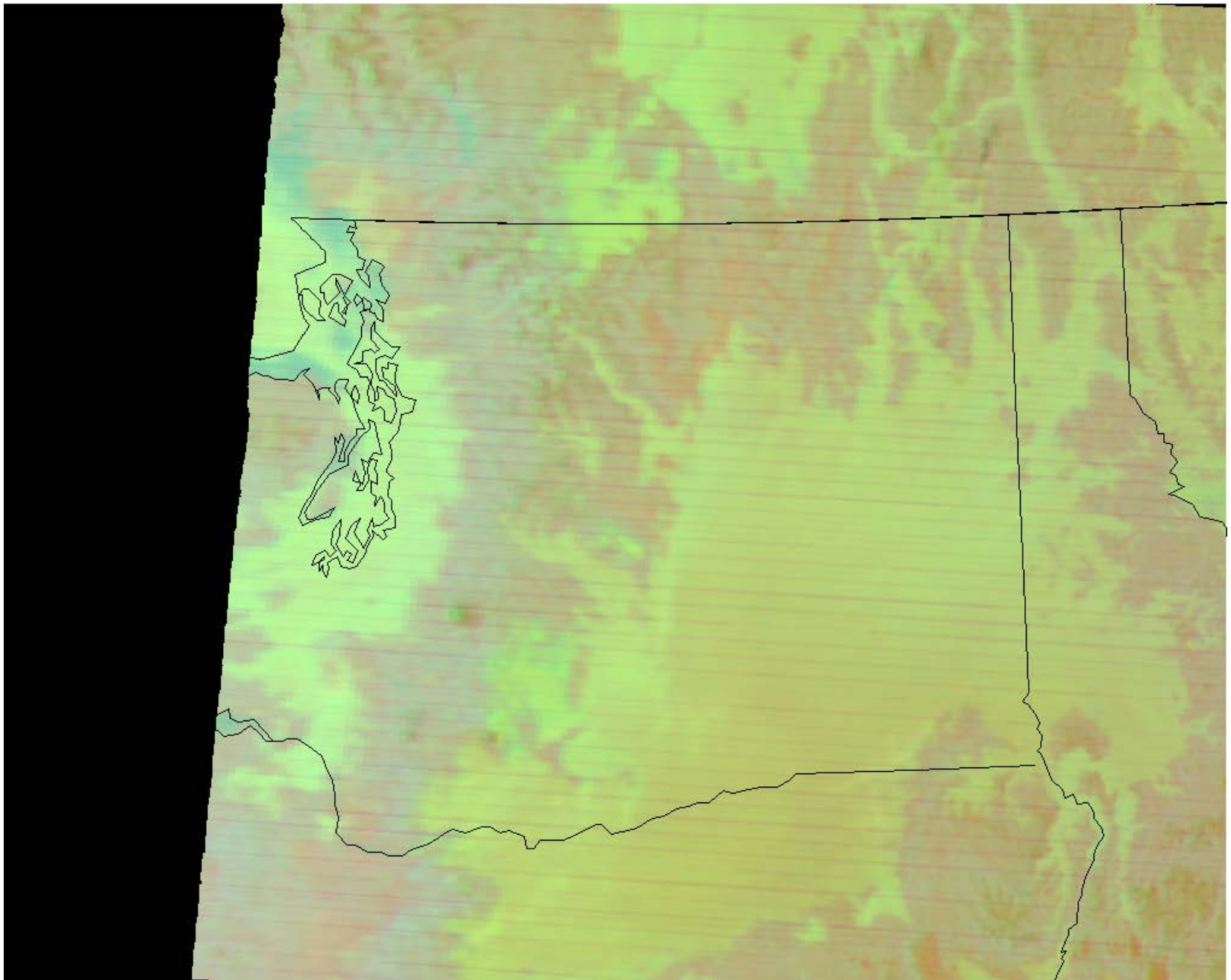
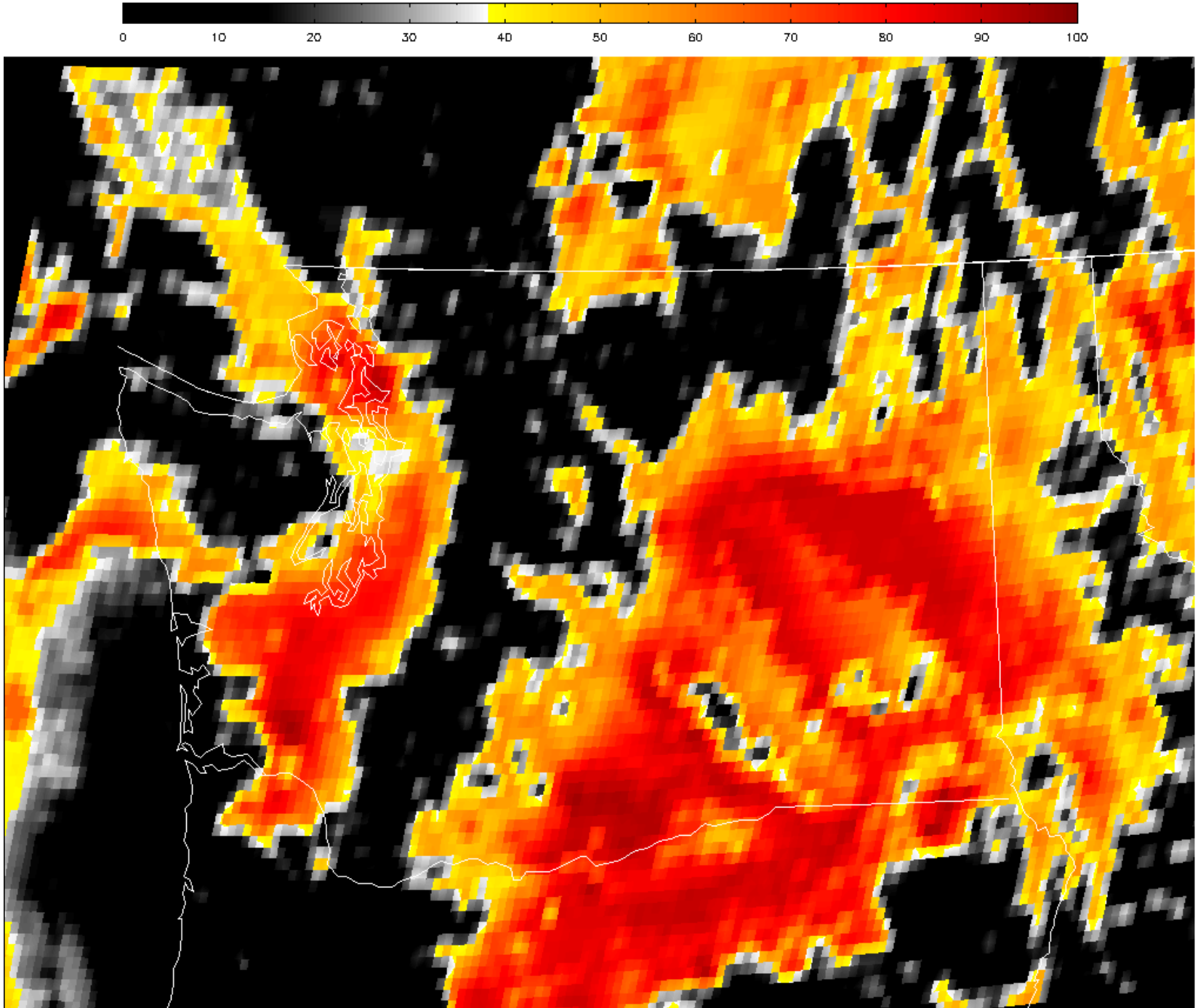
Anchorage


Valleyness [ ]
0.45
0.55
0.65
0.75
0.85
0.95
Anchorage

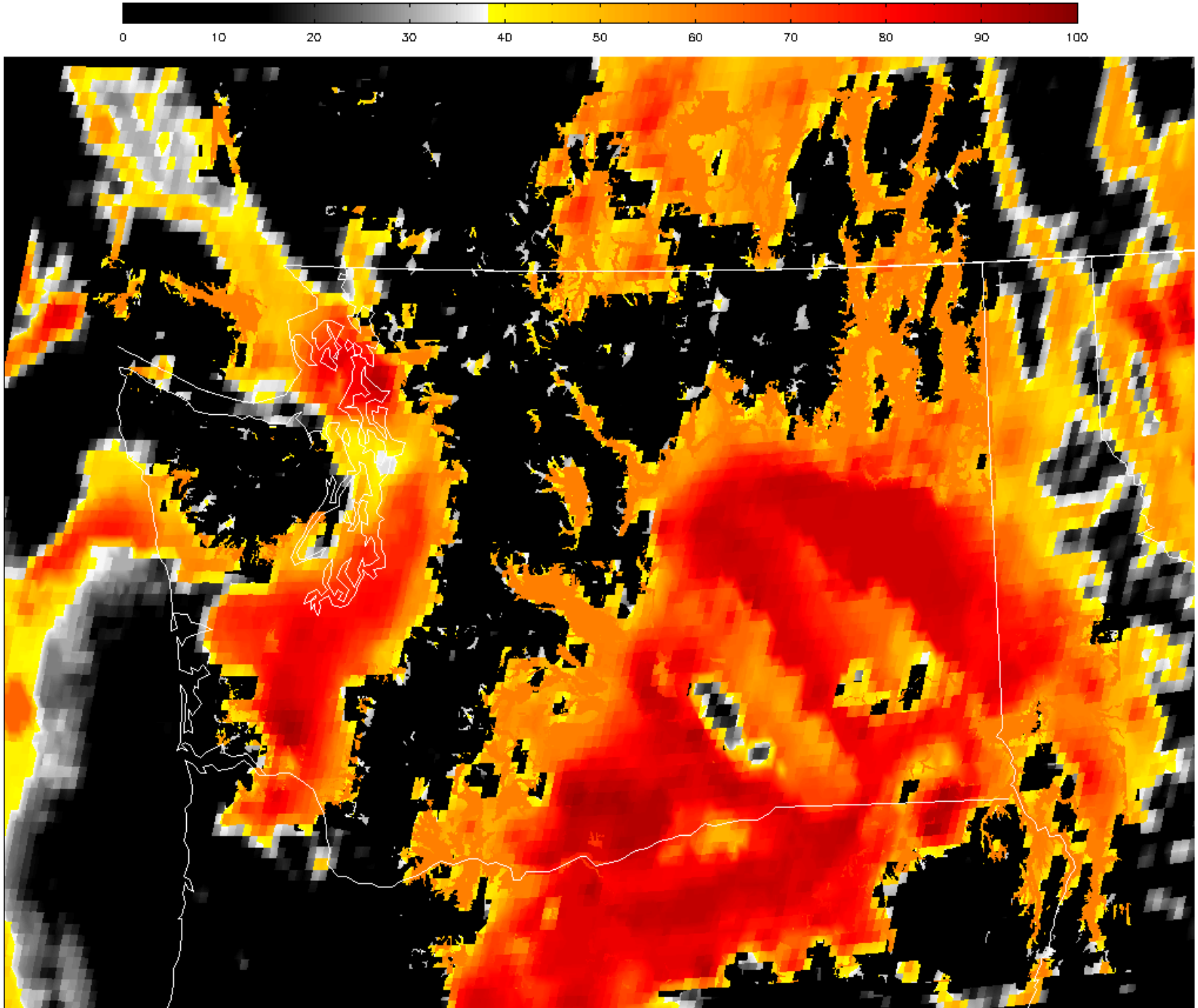
MODIS RGB (11−12μm BTD/8.5−11μm BTD/11μm BT)

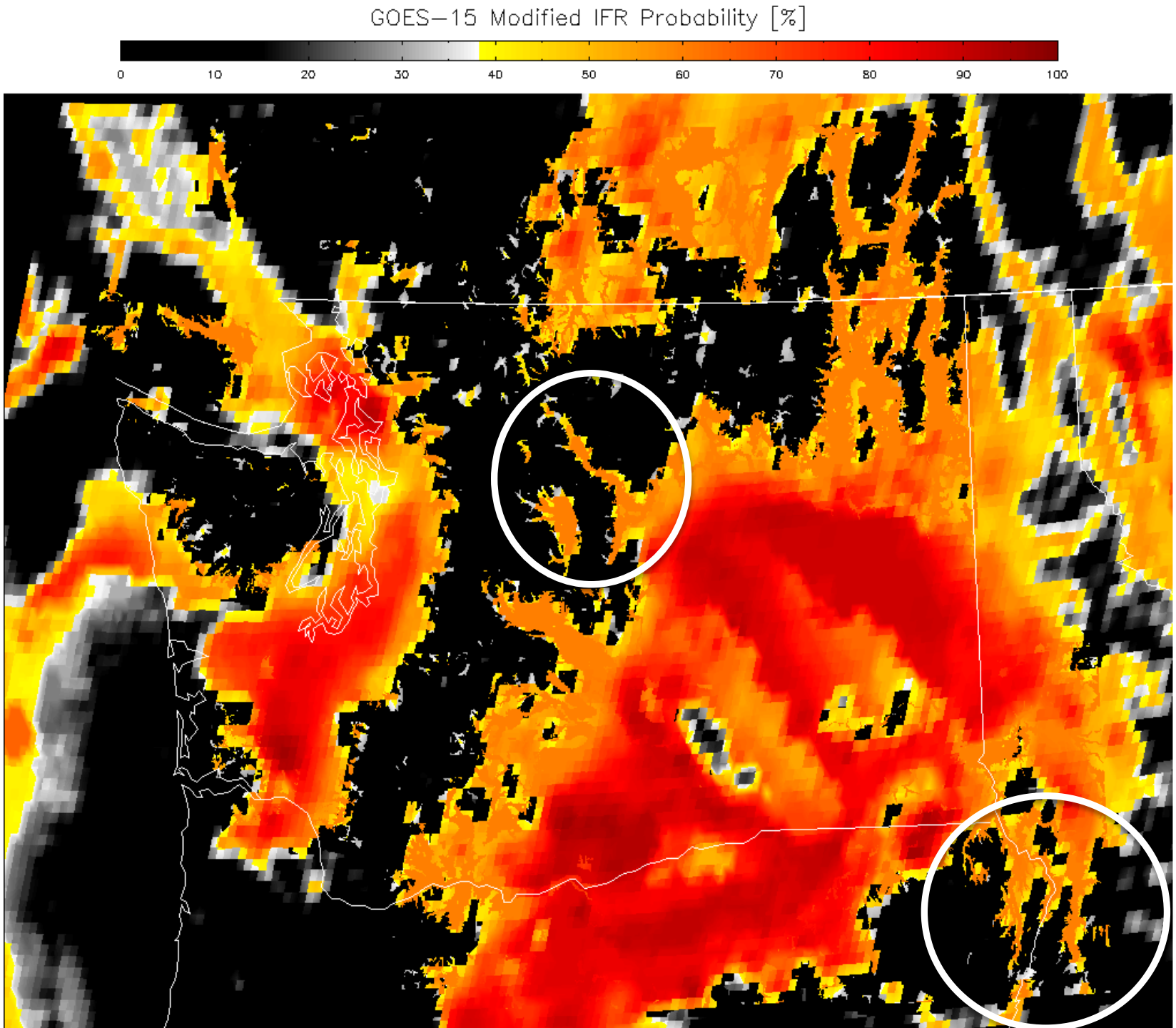


GOES−15 IFR Probability [%]



GOES−15 Modified IFR Probability [%]




GOES–15 Modified IFR Probability [%]
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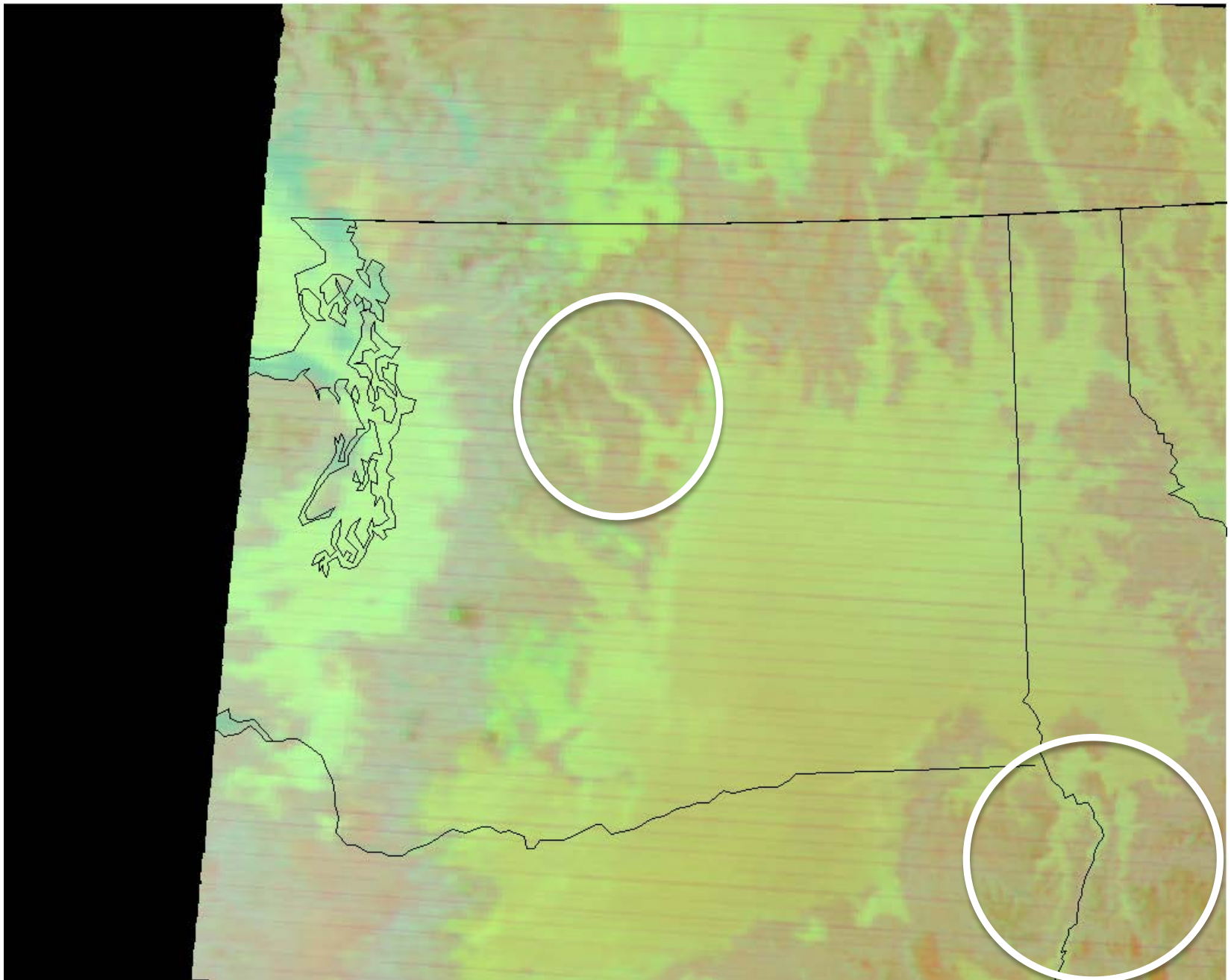
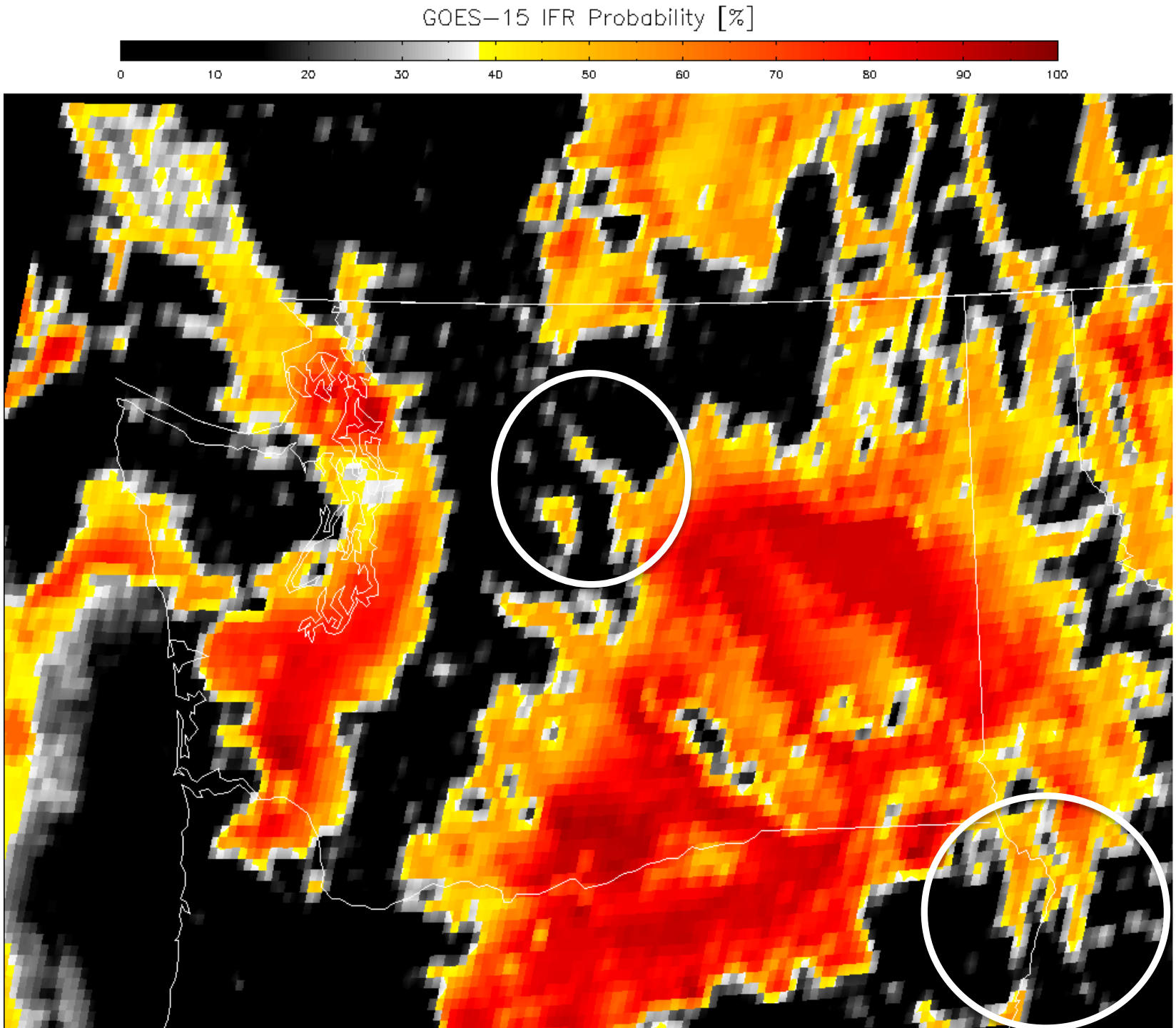
MODIS RGB (11−12μm BTD/8.5−11μm BTD/11μm BT)




GOES−15 IFR Probability [%]
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100

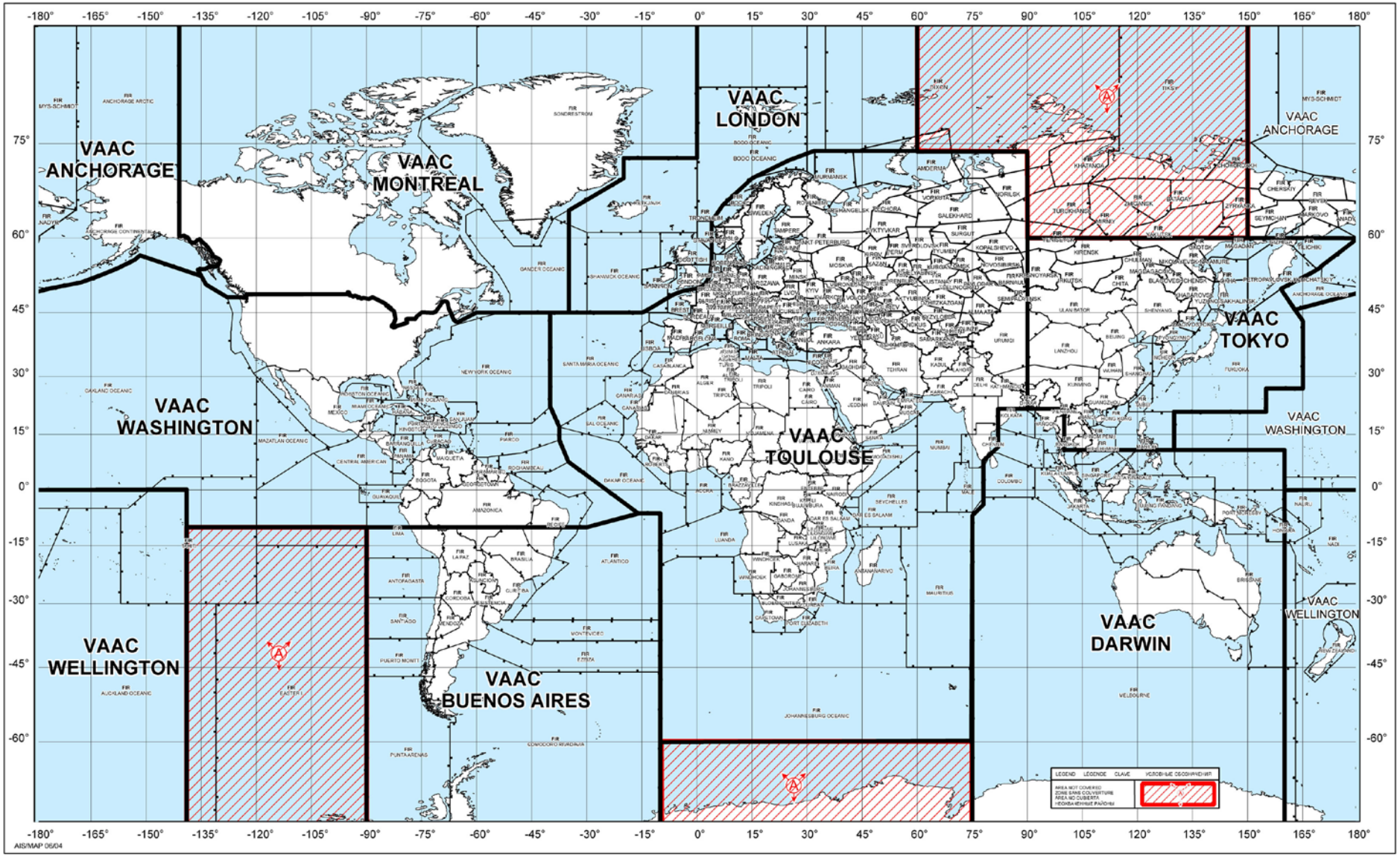
Questions?

Marco Fulle - www.stromboli.net

Back-up slides

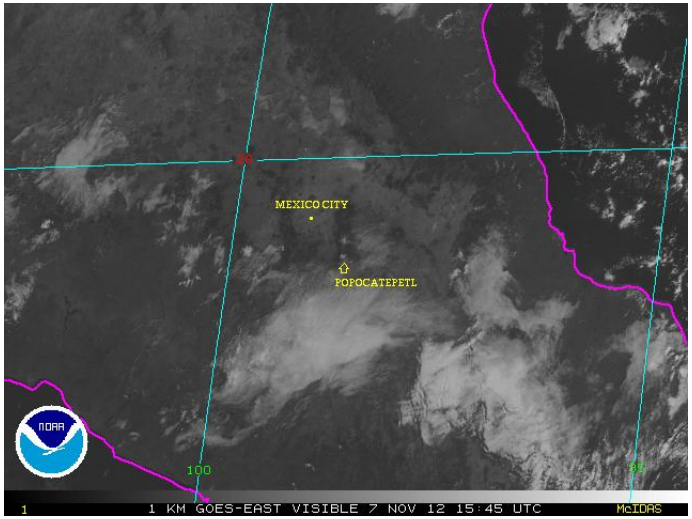
Rueters

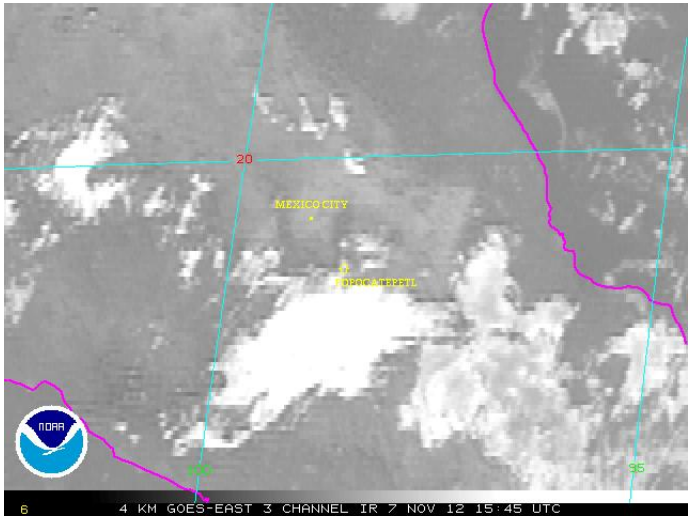
CURRENT STATUS OF ICAO VOLCANIC ASH ADVISORY CENTRES (VAAC) - AREAS OF RESPONSIBILITY
SITUATION ACTUELLE DES CENTRES OACI D'AVIS DE CENDRES VOLCANIQUES (VAAC) - ZONES DE RESPONSABILITÉ
ESTADO ACTUAL DE LOS CENTROS DE AVISOS DE CENIZAS VOLCÁNICAS (VAAC) DE LA OACI - ÁREAS DE RESPONSABILIDAD
СУЩЕСТВУЮЩЕЕ РАСПРЕДЕЛЕНИЕ КОНСУЛЬТАТИВНЫХ ЦЕНТРОВ ИКАО ИО ВУЛКАНИЧЕСКОМУ ПЕПЛУ(VAAC) - РАЙОНЫ ОТВЕТСТВЕННОСТИ



Volcanic Ash Requirements

Heritage NOAA volcanic ash products are imagery based and qualitative





In preparation for GOES-R, the volcanic ash requirements were re-defined and are now quantitative (ash cloud height and mass loading)

Name	User & Priority	Geographic Coverage (G, H, C, M)	Vertical Resolution	Horizontal Resolution	Mapping Accuracy	Measurement Range	Measurement Accuracy	Product Refresh Rate/Coverage Time (Mode 3)	Product Refresh Rate/Coverage Time (Mode 4)	Vendor Allocated Ground Latency	Product Measurement Precision
Volcanic Ash: Detection and Height	GOES-R	Full Disk	3 km (top height)	2 km	1 km	0 - 50 tons/km^2	2 tons/km^2	Full disk: 15 min	Full disk: 15 min	430 sec	2.5 tons/km^2

Channels Used in NOAA Algorithms

A temporal history of detected ash clouds is used to help ensure good consistency from image to image regardless of the sensor

Sensor	Channels used
AVHRR	0.65, 3.75, 11, and 12 µm
COMS	0.65, 3.9, 6.7, 11, and 12 µm
FY2	0.65, 3.9, 6.7, 11, and 12 µm
GOES	0.65, 3.9, 6.7 11, and 12 µm
GOES-R ABI	0.65, 3.9, 6.7, 7.3, 8.5, 11, 12, and 13.3 µm
Himawari-8/9	0.65, 3.9, 6.7, 7.3, 8.5, 11, 12, and 13.3 µm
MODIS	0.65, 3.75, 7.3, 8.5, 11, 12, and 13.3 µm
MTSAT	0.65, 3.9, 6.7, 11, and 12 µm
SEVIRI and MTG	0.65, 3.9, 6.2, 7.3, 8.5, 11, 12, and 13.3 µm
VIIRS	0.65, 3.75, 8.5, 11, and 12 µm

***The same software is used for all sensors.

From: Mike Pavolonis NOAA Federal
Subject: **NOAA/CIMSS Volcanic Cloud Alert**
Date: June 3, 2014 10:02:47 PM CDT
To: Mike Pavolonis NOAA Federal

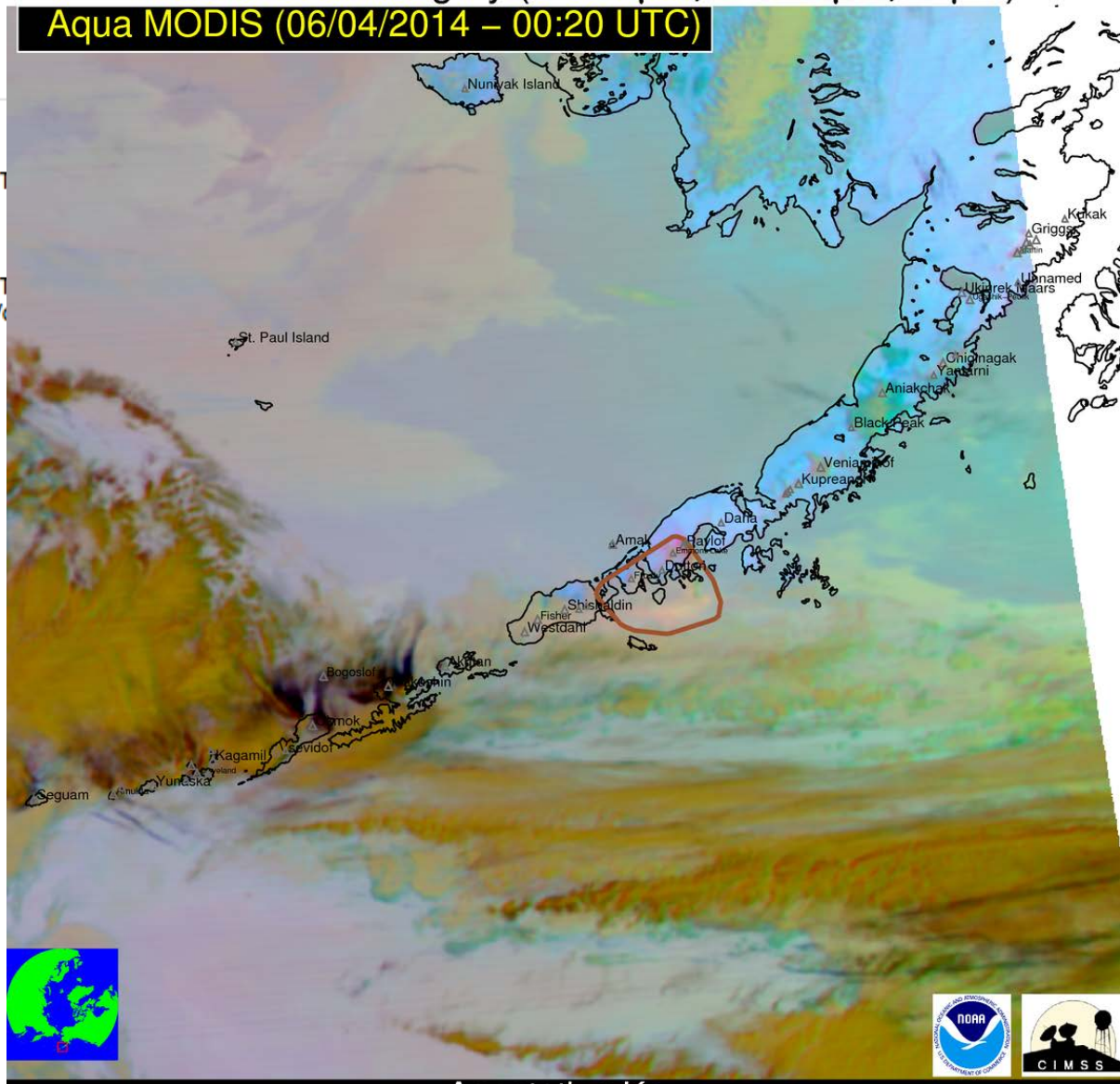
@**********VOLCANIC ALERTS**********
STARTING DATE/TIME OF IMAGE: 2014-06-03 22:45:00 [UTC]
PRODUCTION DATE/TIME OF ALERT: 2014-06-04 03:01:19 [UT
PRIMARY INSTRUMENT: Aqua MODIS
WMO SPACECRAFT ID: 784
LOCATION/ORBIT: LEO
L1 FILE: MYD021KM.A2014154.2245.005.2014155014054.NRT
VOLCANO DATABASE: /data/common//VOLCAT_DATA/alerts/V
NUMBER OF ASH CLOUD ALERTS: 1
NUMBER OF VOLCANIC Cb ALERTS: 0
NUMBER OF VOLCANIC THERMAL ANOMALY ALERTS: 0
NUMBER OF SO2 CLOUD ALERTS: 0

REPORT WITH IMAGES:
http://volcano-test.ssec.wisc.edu/alert/report/11945

POSSIBLE VOLCANIC ASH CLOUD FOUND
Alert Status: New Alert Object
Latitude of Radiative Center: 55.373 [degrees]
Longitude of Radiative Center: -162.005 [degrees]
Mean Object Date/Time: 2014-06-03 22:45:00 [UTC]
Mean Viewing Angle: 54.07 [degrees]
Mean Solar Zenith Angle: 32.46 [degrees]
Nearby Volcanoes (meeting alert criteria):
Emmons Lake(5.90 km)
Pavlof(8.88 km)
Pavlof Sister(13.54 km)
Dutton(28.41 km)
Dana(58.12 km)
Cloud Object Probability: 100.00000 [%]
Median Probability of Object Pixels: .00000 [%]
Percent Unambiguous Pixels: .02882 [%]
Maximum Height [AMSL]: 8.3 [km] (27347.90 [ft])
90th Percentile Height [AMSL]: 6.2 [km] (20186.51 [ft])
Mean Tropopause Height [AMSL]: 11.8 [km] (38867.68 [ft])
Total Mass: .013838 [Tg]
Median Effective Particle Radius: 4.05 [um]
Total Area: 12419.03 [km^2]

Geographic Regions of Nearby Volcanoes: Alaska Peninsula
VAAC Regions of Nearby Volcanoes: Anchorage
FIR Regions of Nearby Volcanoes: Unknown

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



Annotation Key
(annotation colors are not related to colors in underlying image)
Ash/Dust Cloud Volcanic Cb SO_2 Thermal Anomaly

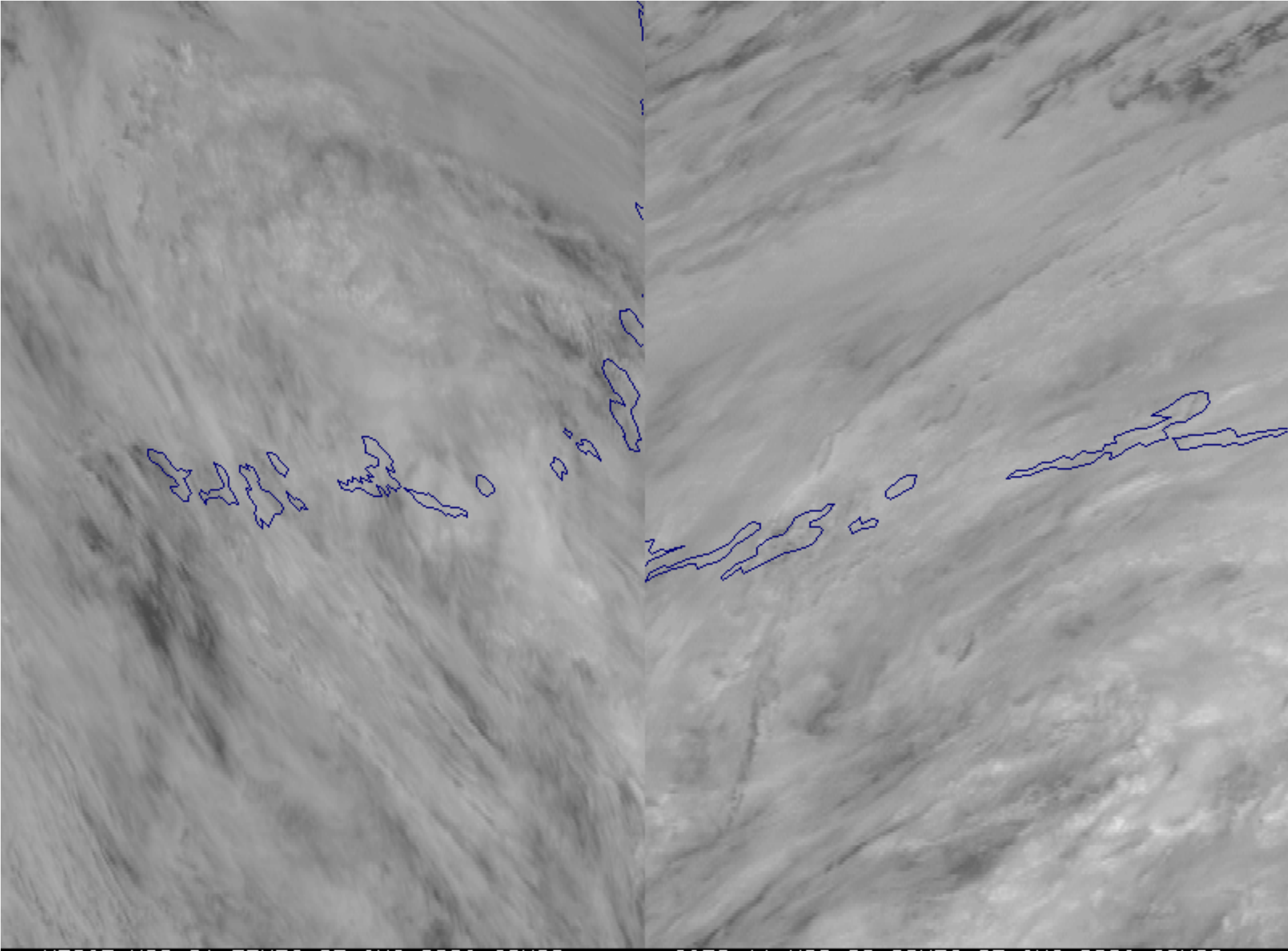
Primary Limitations

- Volcanic ash must be the highest cloud layer
- The products will be degraded if L1 sensor data is degraded
- The ash cloud properties, and to a lesser extent, the ash detection results, will be more accurate if determined from a more advanced sensor (methods are being explored to address this issue)
- The selection criteria applied to cloud objects generally works well, but is still being refined
- Low level ash plumes that have a very similar temperature as the surface or warmer than the surface will often be missed by our ash detection algorithm at the present time

Marco Fulle - www.stromboli.net

Analysis of 2008 Kasatochi eruption

Rueters


MTSAT VIS 21:57UTC 07 AUG 2008 CIMSS
GOES-11 VIS 22:00UTC 07 AUG 2008 CIMSS

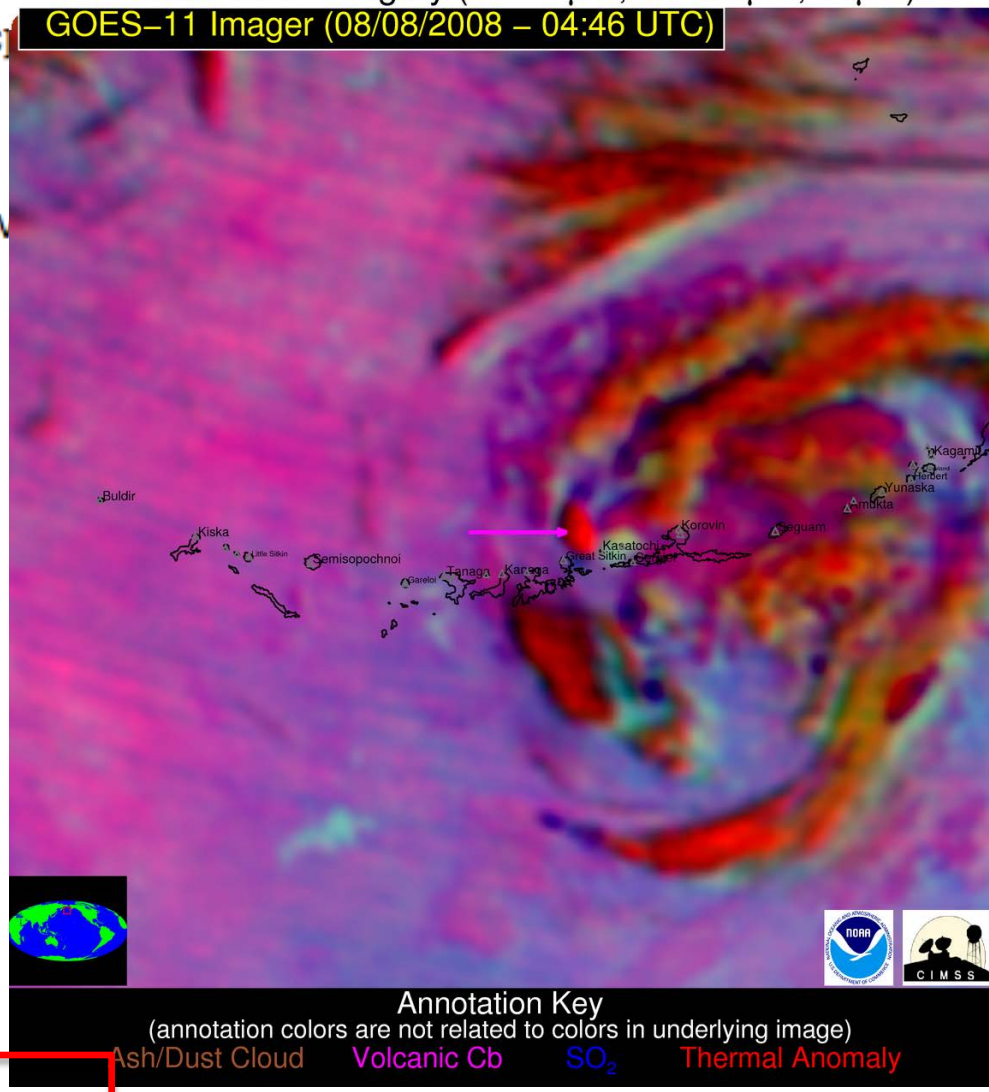
@**********VOLCANIC ALERTS**********
STARTING DATE/TIME OF IMAGE: 2008-08-08 04:45:59 [UTC]
PRIMARY INSTRUMENT: GOES-11 Imager
WMO SPACECRAFT ID: 255
LOCATION/ORBIT: GEO
L1 FILE: goes11_1_2008_221_0446.area.gz
VOLCANO DATABASE: /data/common/VOLCAT_DATA/alerts/V
NUMBER OF ASH CLOUD ALERTS: 0
NUMBER OF VOLCANIC Cb ALERTS: 1
NUMBER OF VOLCANIC THERMAL ANOMALY ALERTS: 0
NUMBER OF SO2 CLOUD ALERTS: 0

REPORT WITH IMAGES:
http://volcano.ssec.wisc.edu/alert/report/10614

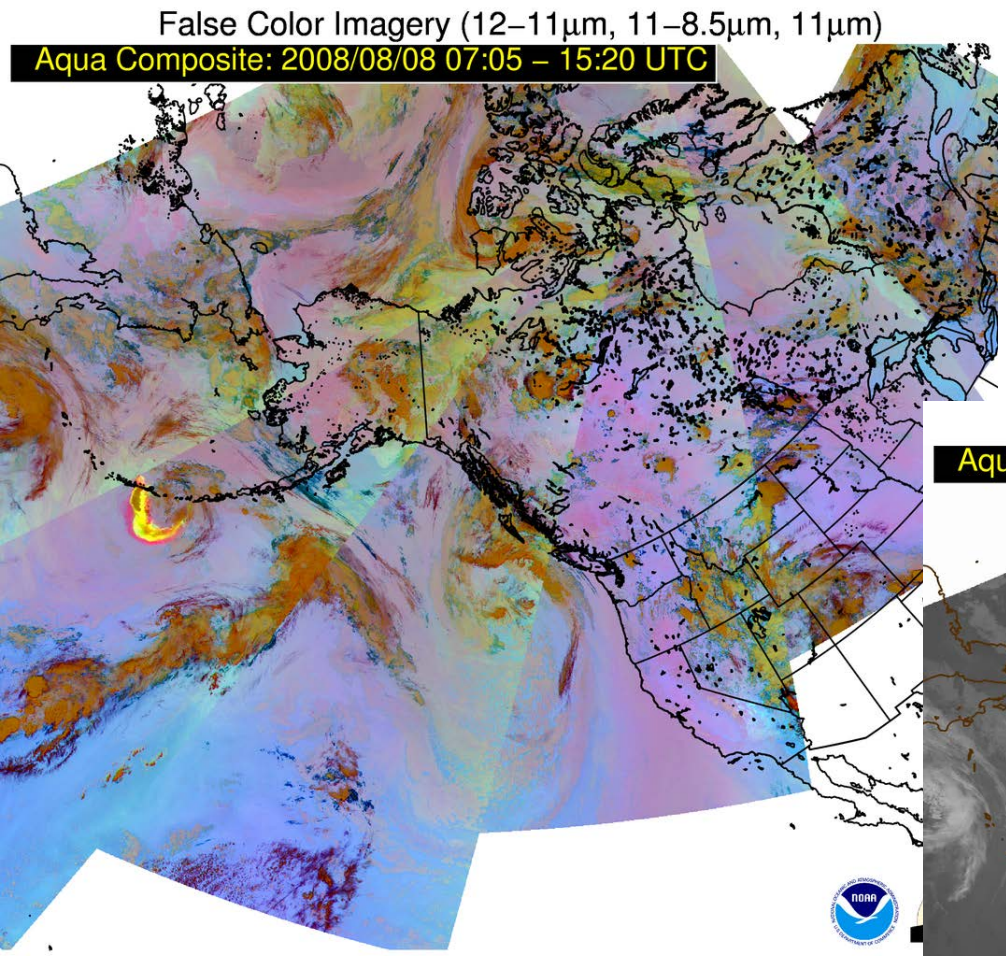
POSSIBLE VOLCANIC ERUPTION DETECTED
Alert Status: New Alert Object
Latitude of Radiative Center: 52.161 [degrees]
Longitude of Radiative Center: -175.397 [degrees]
Mean Viewing Angle: 71.30 [degrees]
Mean Solar Zenith Angle: 67.53 [degrees]
Nearby Volcanoes (meeting alert criteria):
Kasatochi(7.84 km)
Koniuji(19.03 km)
Maximum Height [AMSL]: 13.7 [km] (45112.91 [ft])
90th Percentile Height [AMSL]: 13.2 [km] (43433.68 [ft])
Mean Tropopause Height [AMSL]: 10.6 [km] (34680.12 [ft])
Trend in IR Brightness Temperature: -44.67 [K]
Vertical Growth Rate Time Interval: 16 [minutes]
Vertical Growth Rate Anomaly: 13.99 [number of stddev above mean]
Total Area: 1045.84 [km^2]

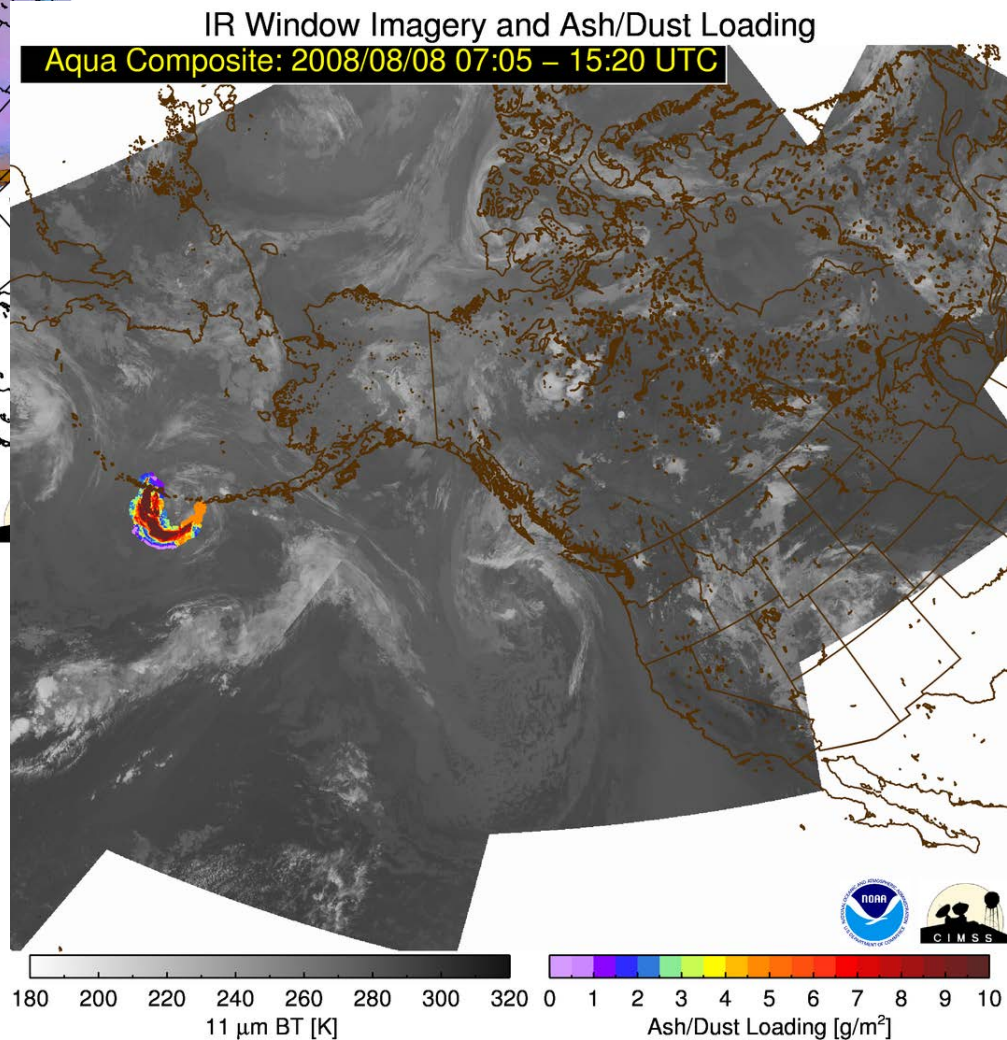
Geographic Regions of Nearby Volcanoes: Aleutian Is
VAAC Regions of Nearby Volcanoes: Anchorage
FIR Regions of Nearby Volcanoes: Unknown

False Color Imagery (12–11μm, 11–3.9μm, 11μm)



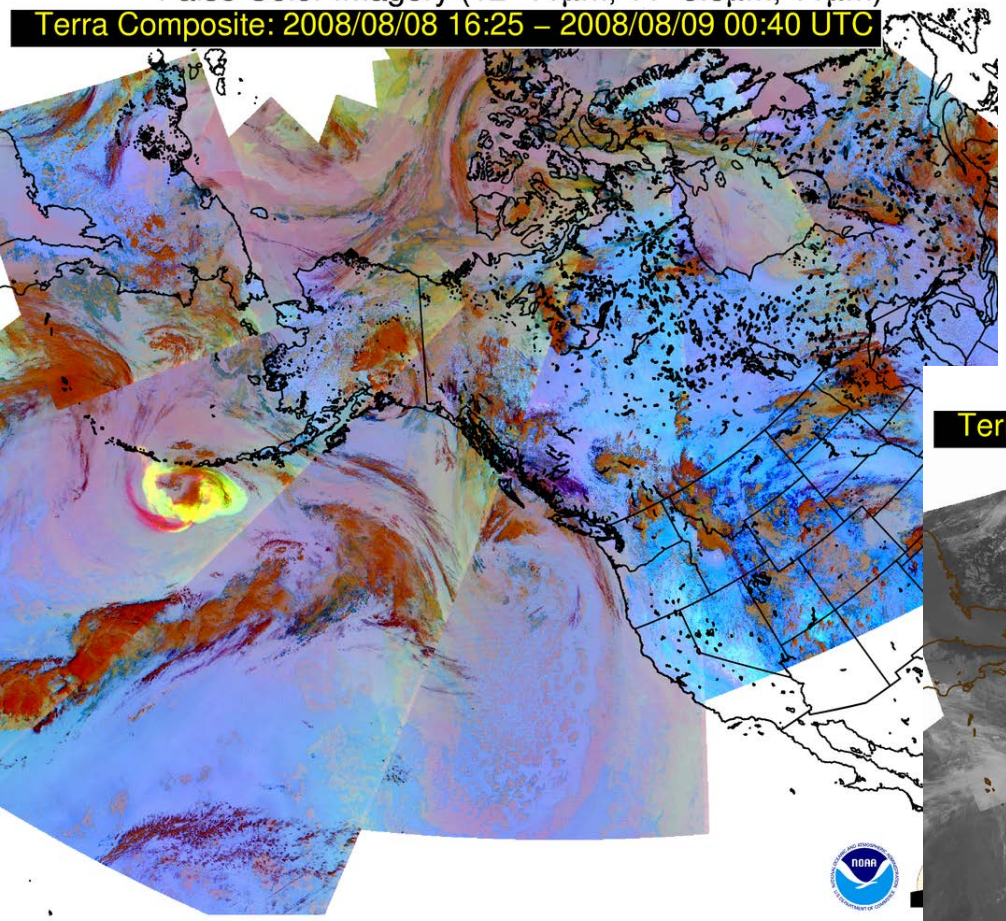
Aqua MODIS descending node
August 8, 2008 (UTC)





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

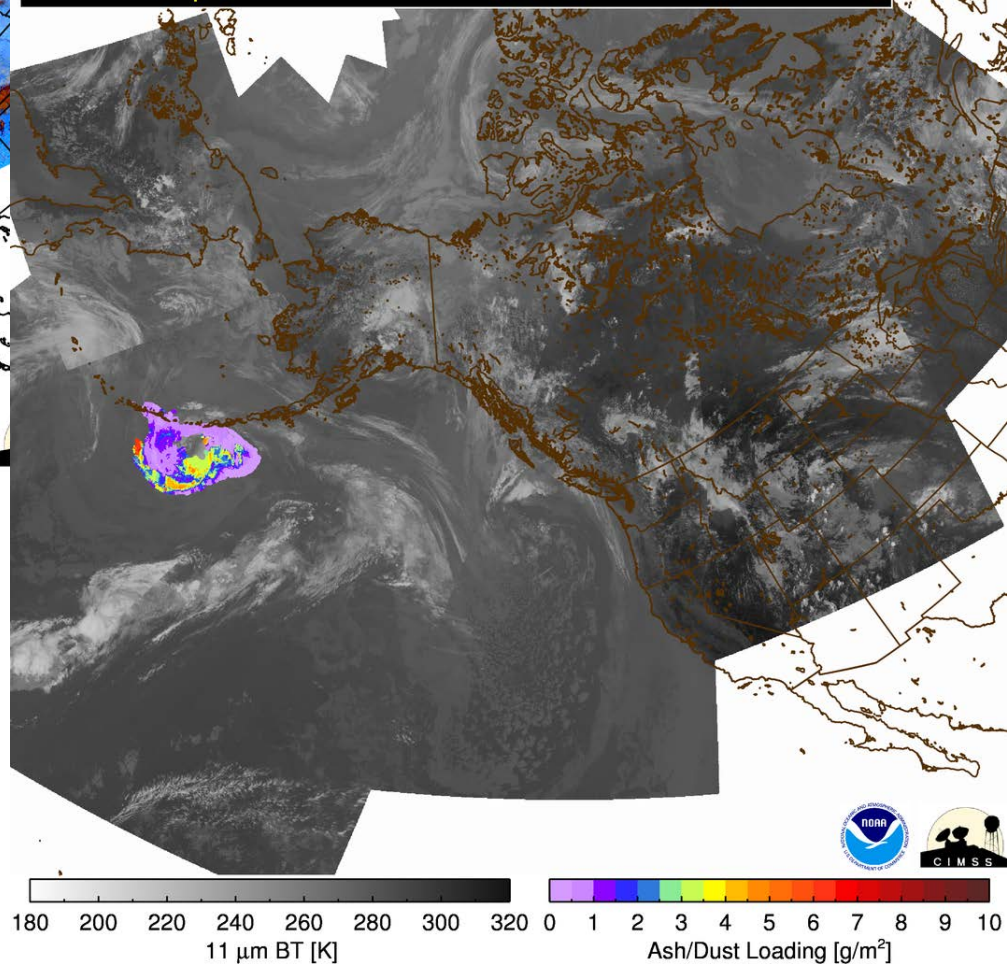
Terra Composite: 2008/08/08 16:25 – 2008/08/09 00:40 UTC



Terra MODIS descending node
August 9, 2008 (UTC)

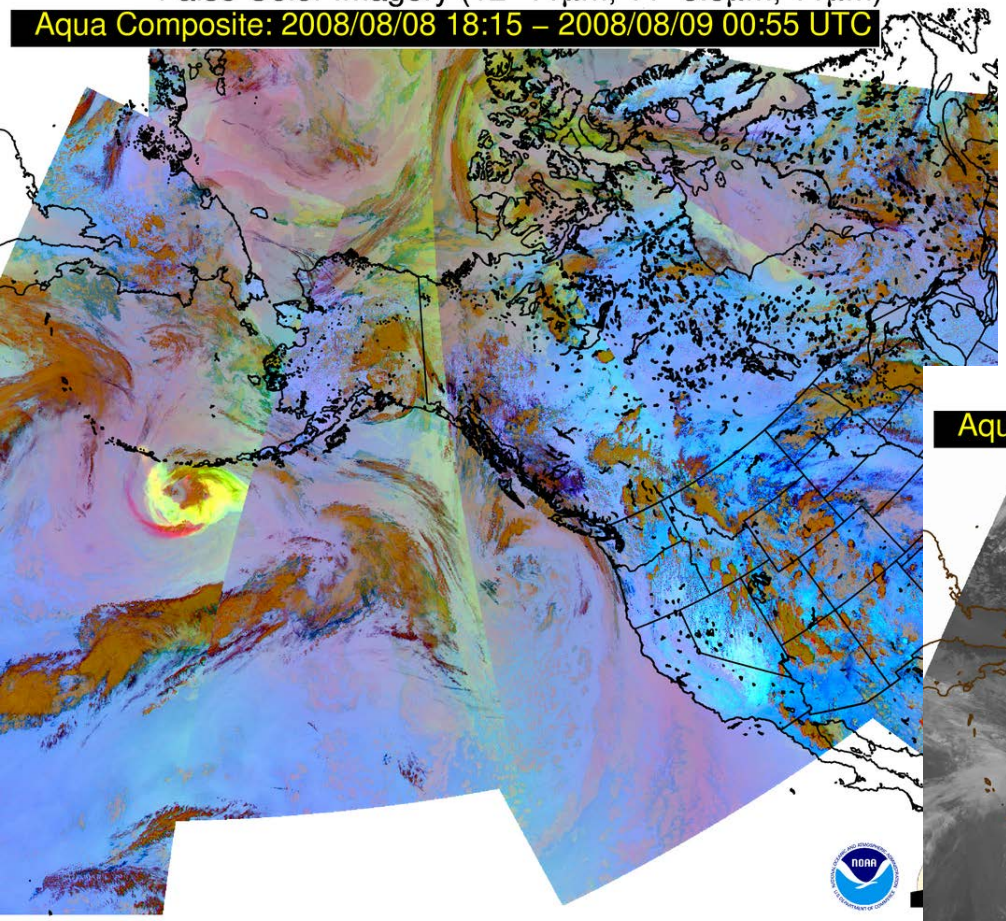
IR Window Imagery and Ash/Dust Loading

Terra Composite: 2008/08/08 16:25 – 2008/08/09 00:40 UTC



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

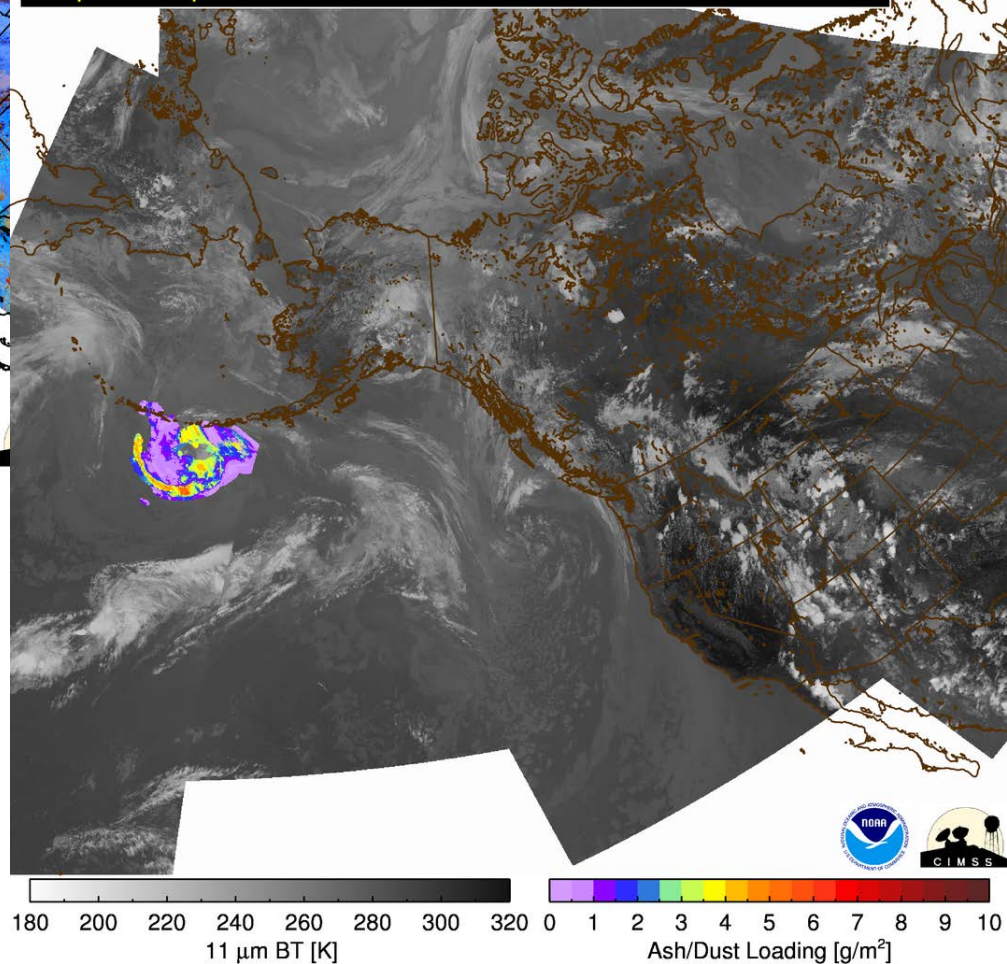
Aqua Composite: 2008/08/08 18:15 – 2008/08/09 00:55 UTC



***Aqua* MODIS ascending node**
August 9, 2008 (UTC)

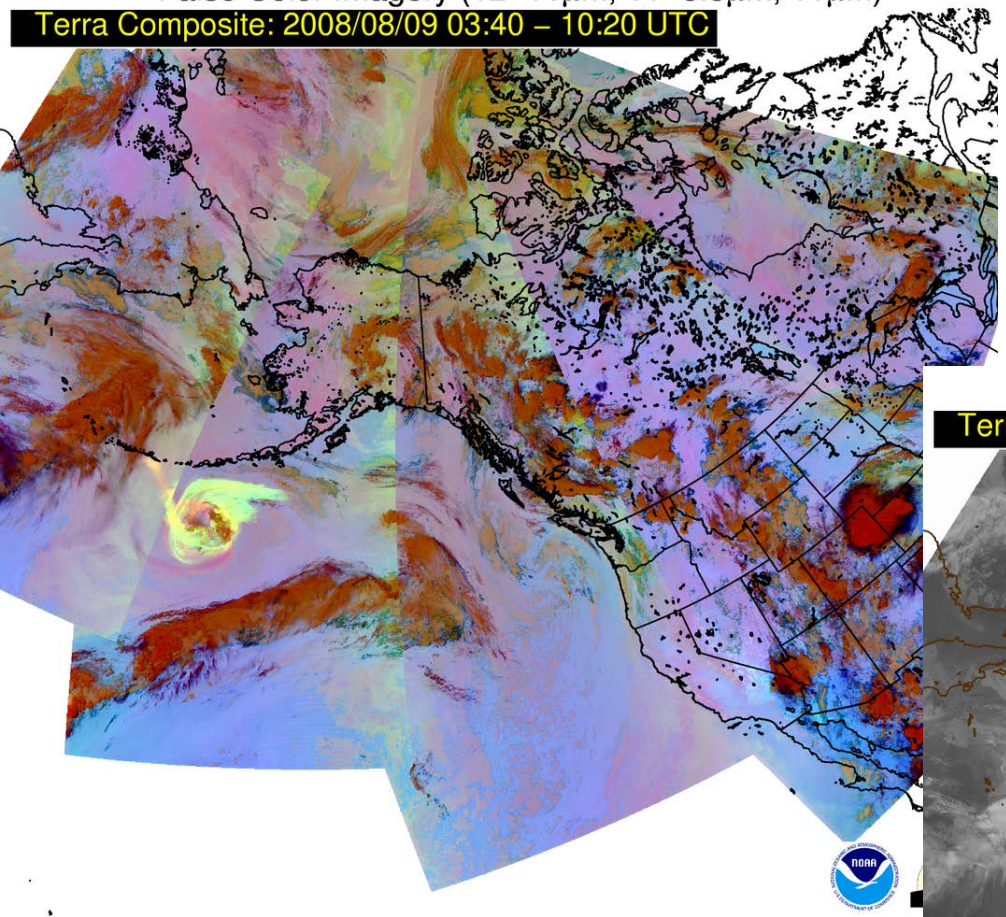
IR Window Imagery and Ash/Dust Loading

Aqua Composite: 2008/08/08 18:15 – 2008/08/09 00:55 UTC



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

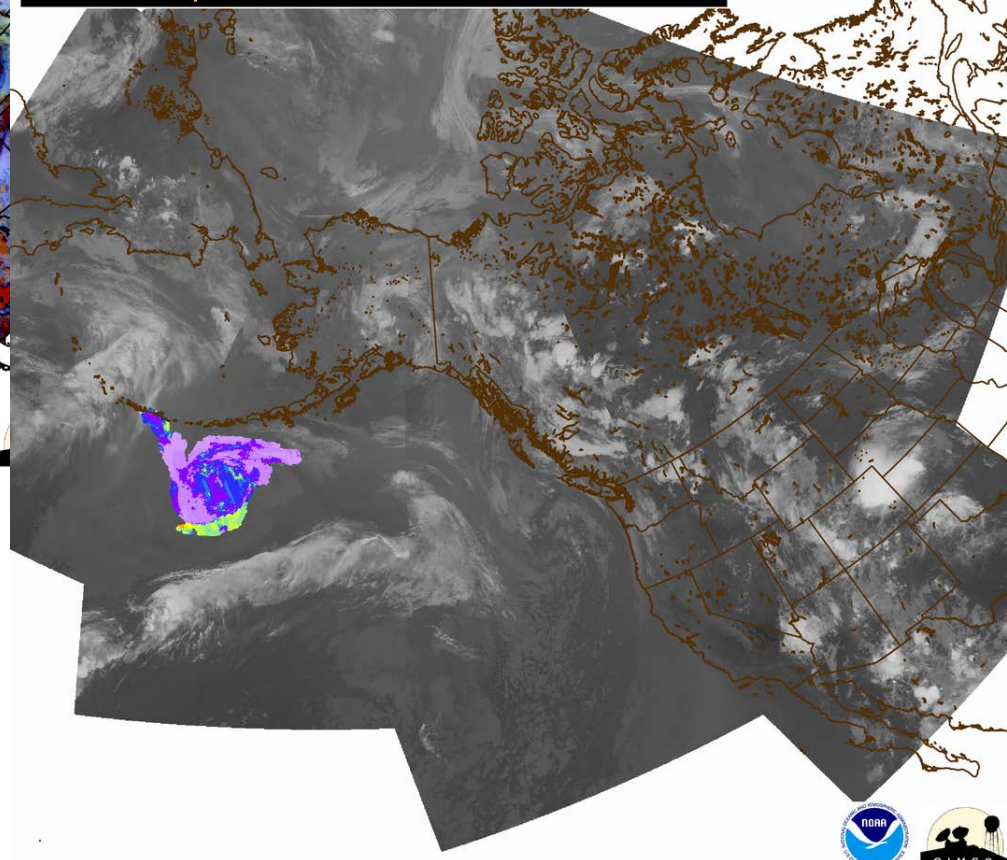
Terra Composite: 2008/08/09 03:40 – 10:20 UTC



Terra MODIS ascending node
August 9, 2008 (UTC)

IR Window Imagery and Ash/Dust Loading

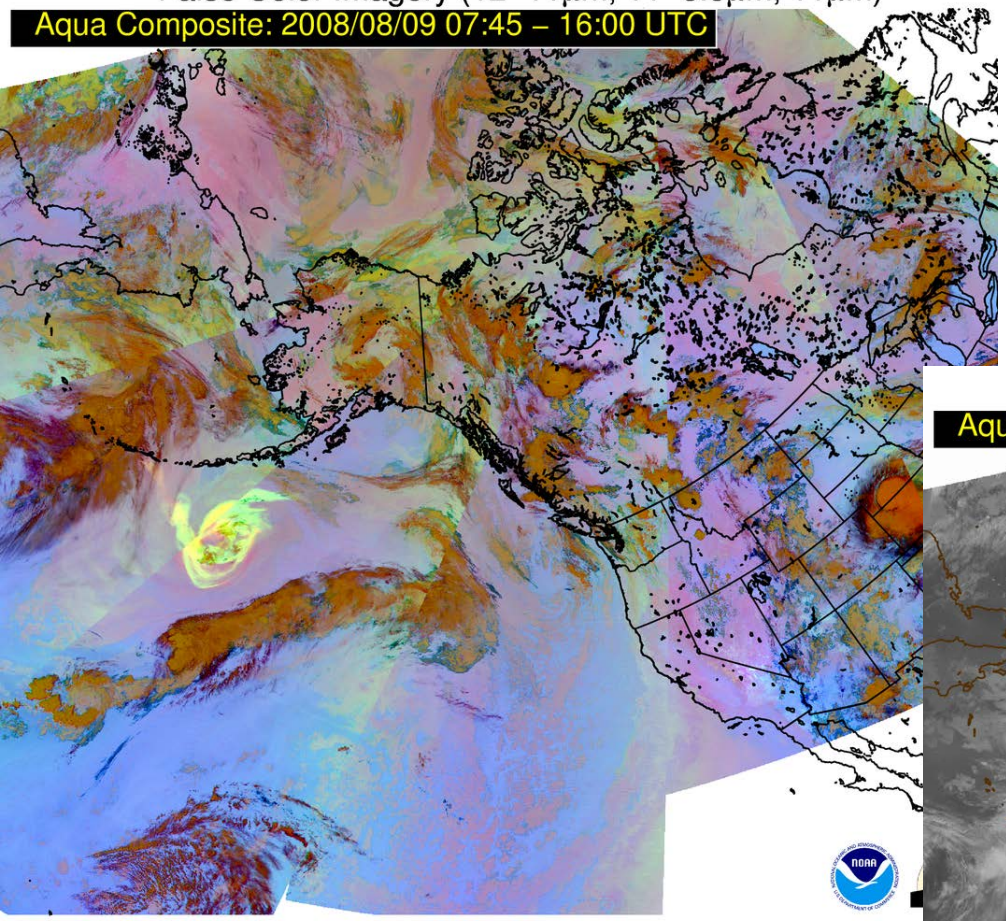
Terra Composite: 2008/08/09 03:40 – 10:20 UTC



180 200 220 240 260 280 300 320
11 μm BT [K]

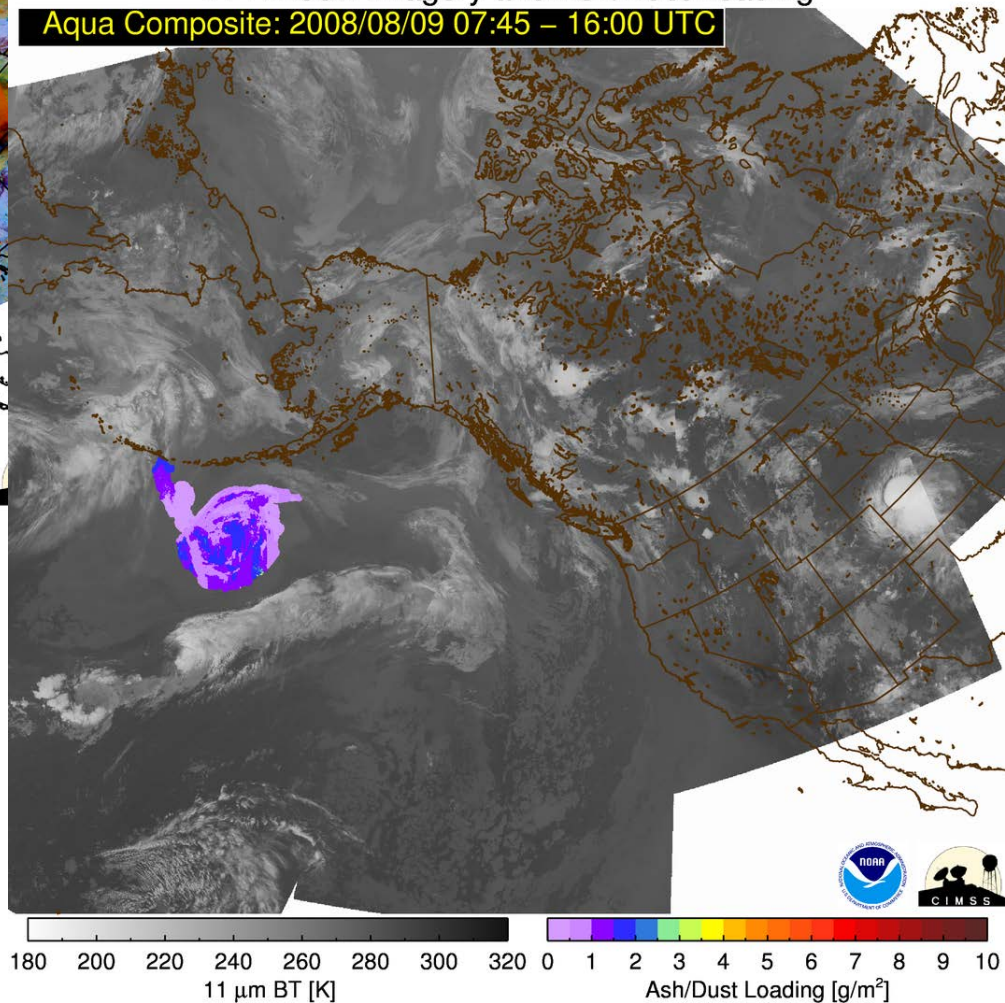
0 1 2 3 4 5 6 7 8 9 10
Ash/Dust Loading [g/m^2]

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

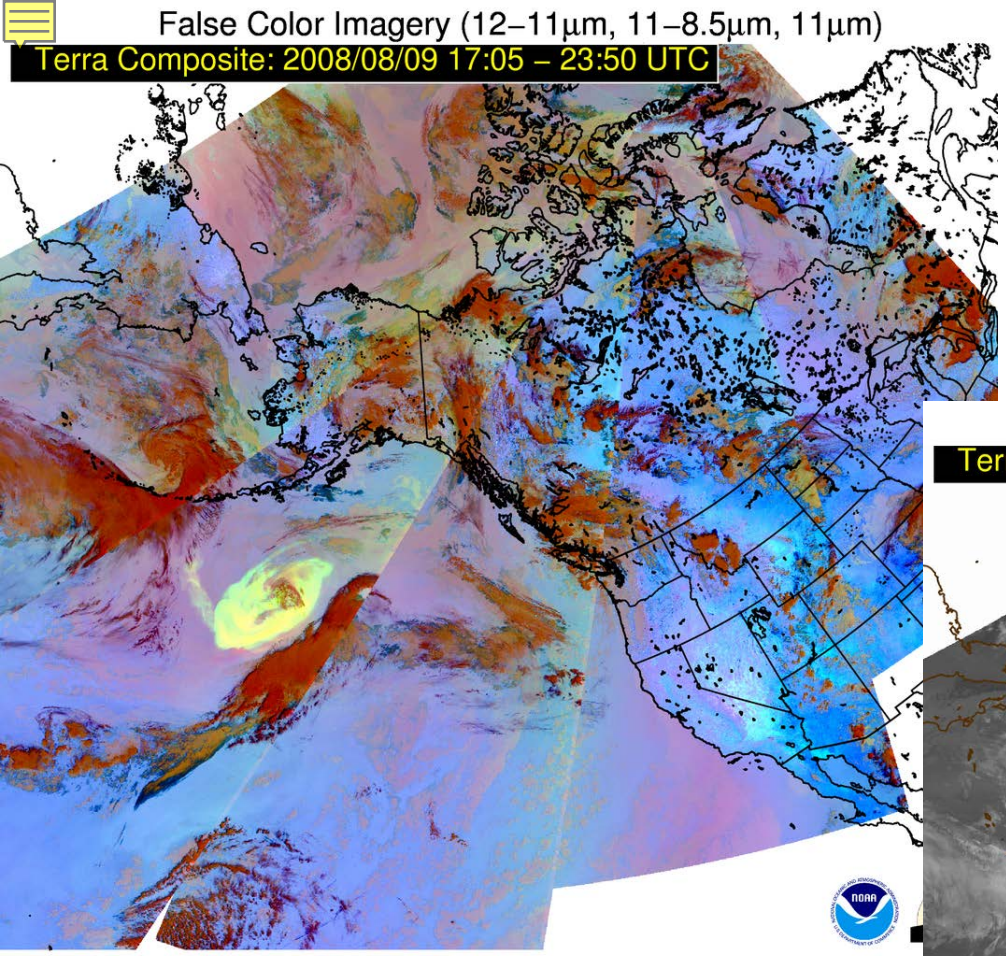


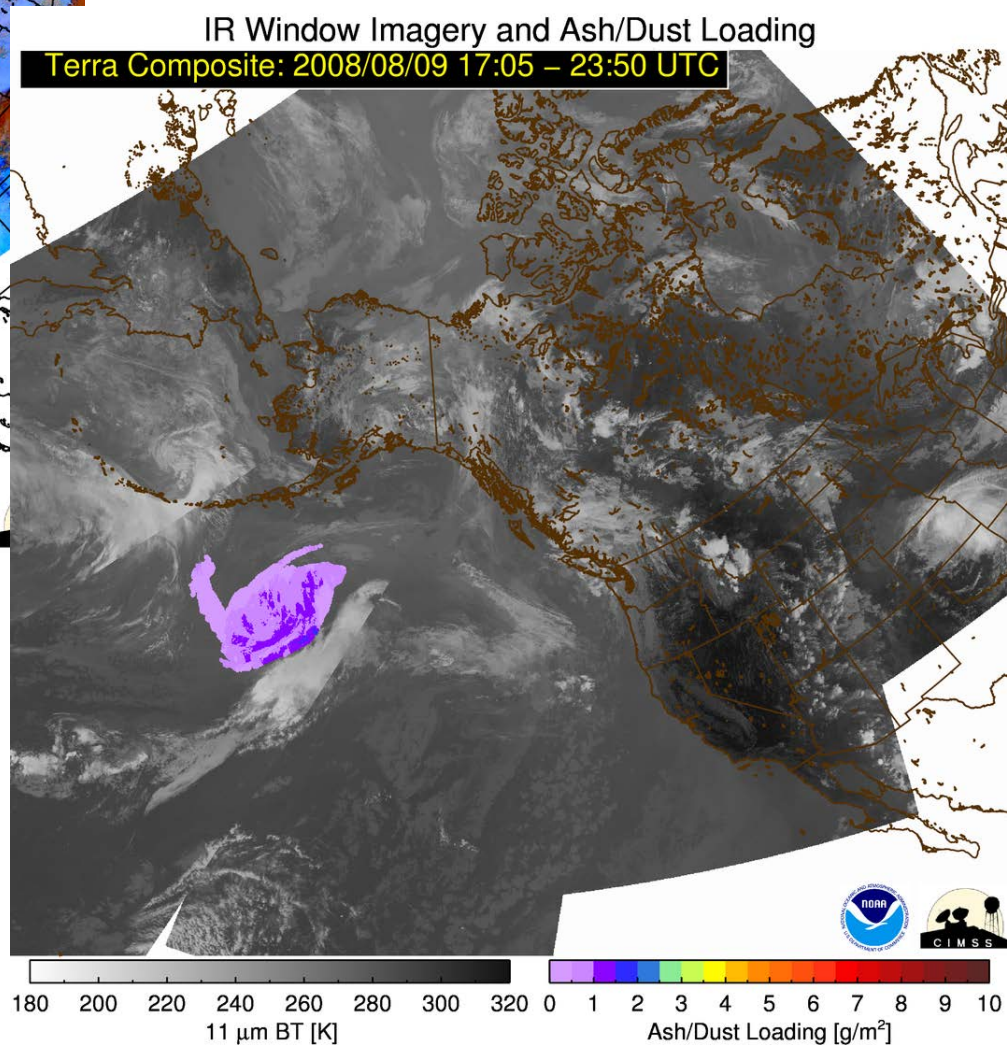
***Aqua* MODIS descending node**
August 9, 2008 (UTC)

IR Window Imagery and Ash/Dust Loading



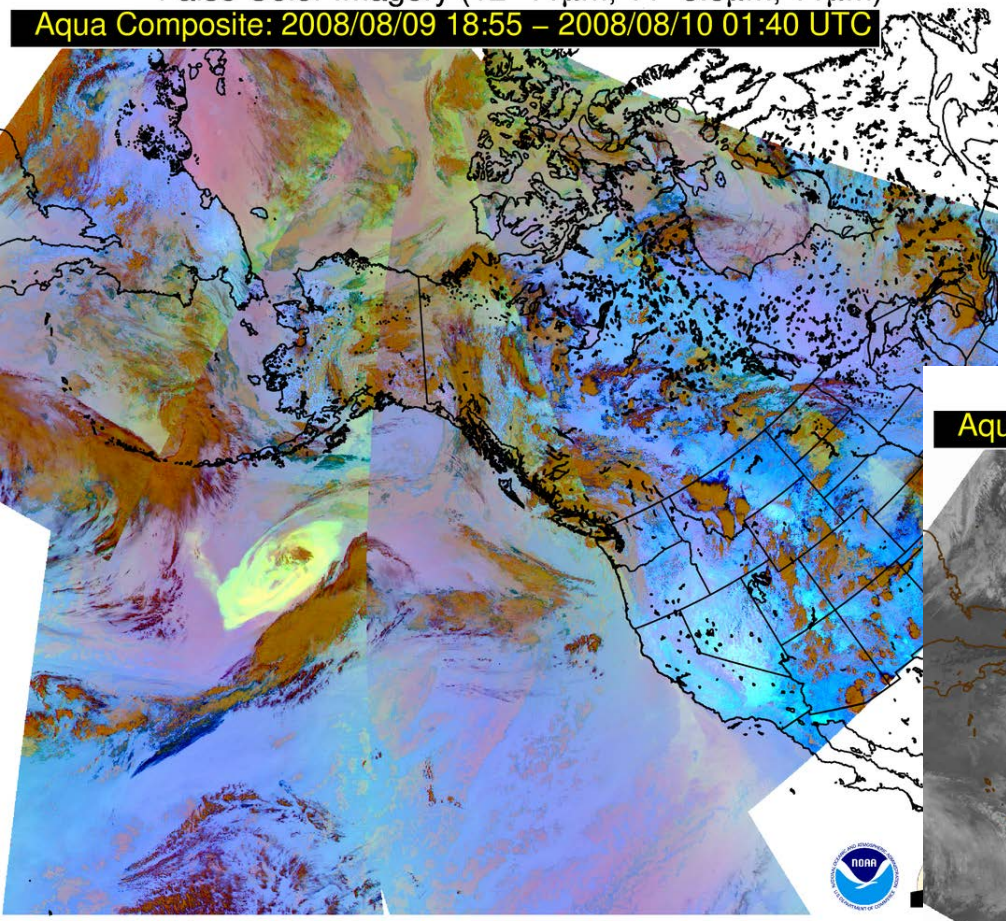
Terra MODIS descending node
August 9, 2008 (UTC)





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

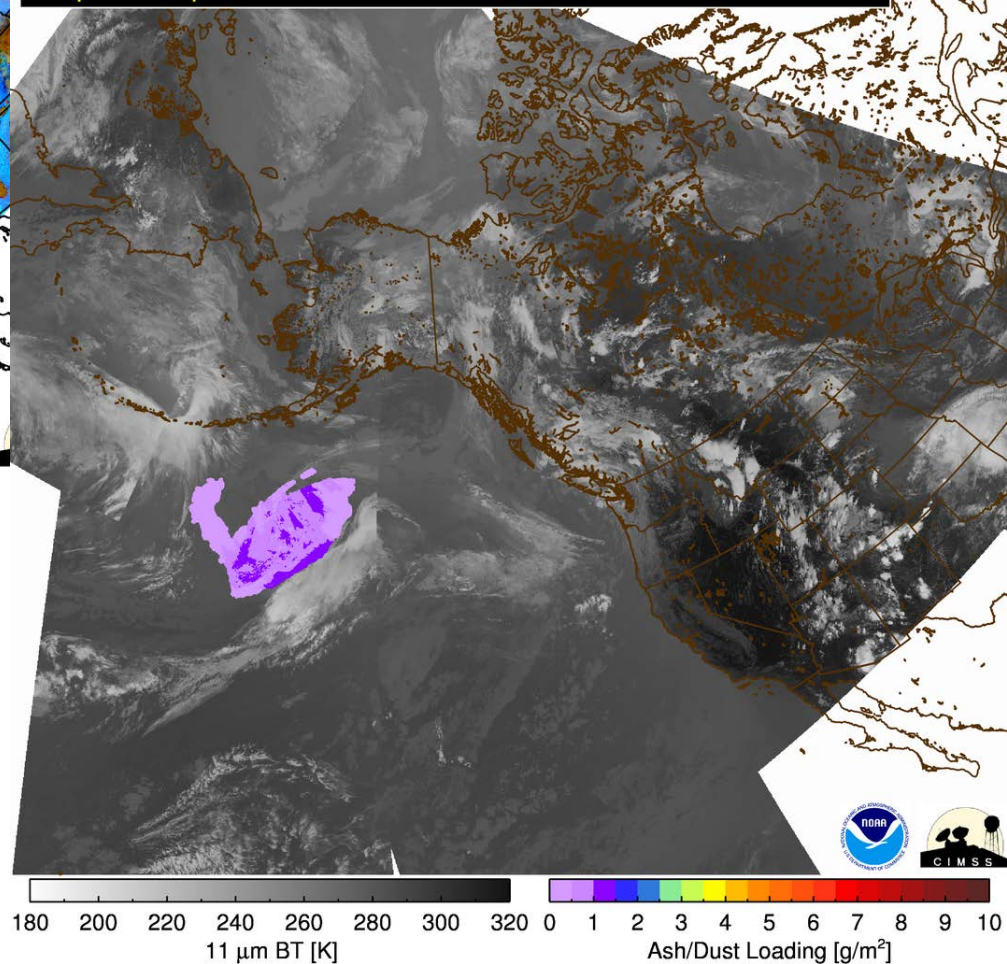
Aqua Composite: 2008/08/09 18:55 – 2008/08/10 01:40 UTC



***Aqua* MODIS ascending node**
August 10, 2008 (UTC)

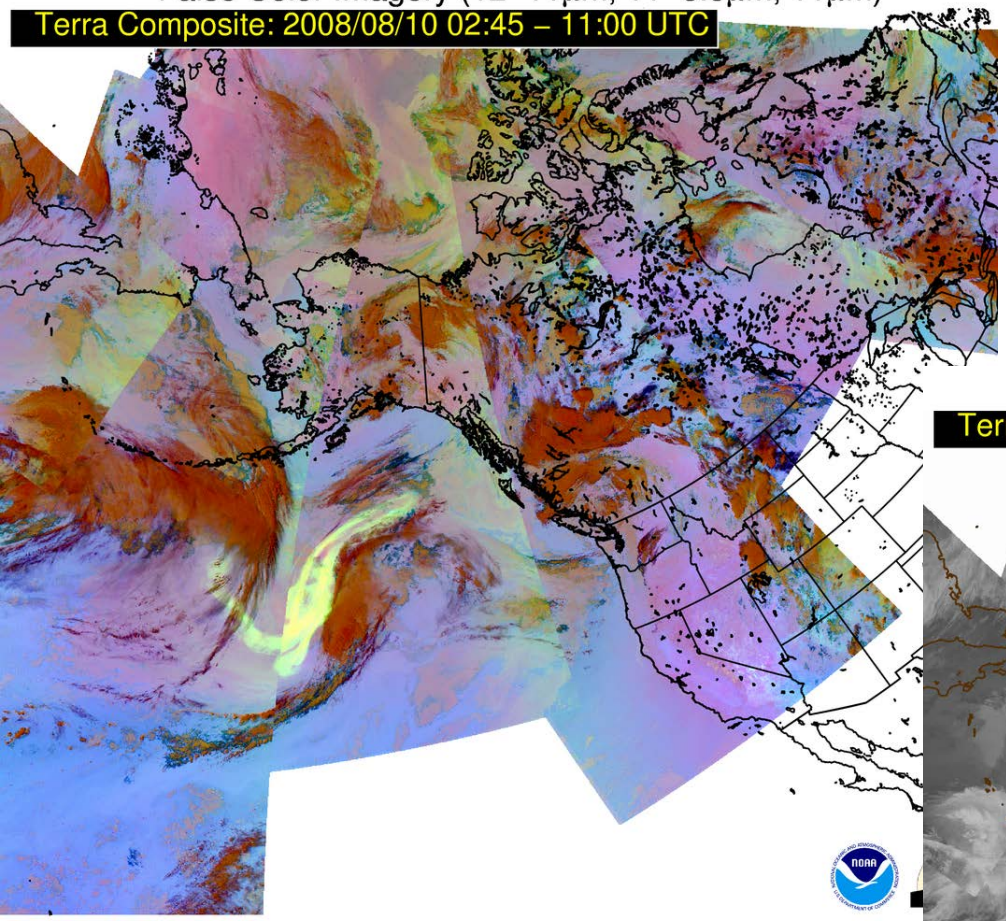
IR Window Imagery and Ash/Dust Loading

Aqua Composite: 2008/08/09 18:55 – 2008/08/10 01:40 UTC



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

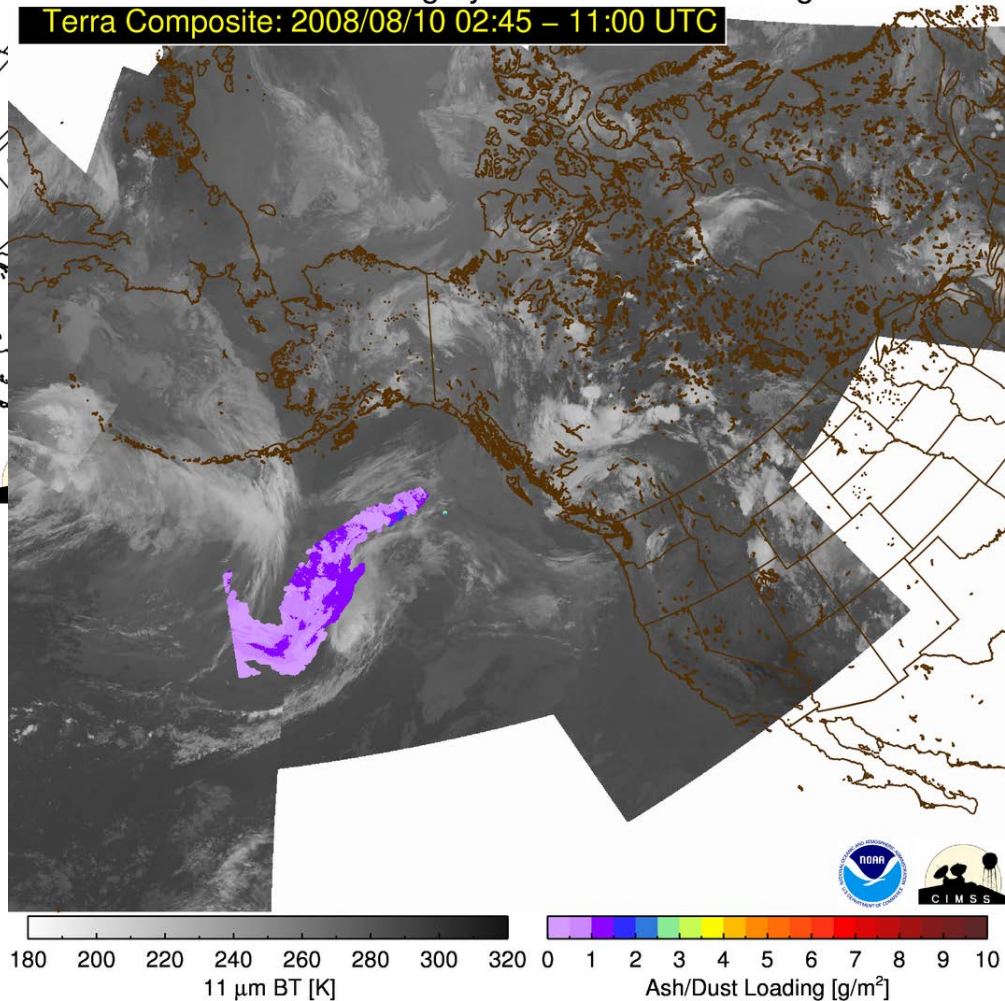
Terra Composite: 2008/08/10 02:45 – 11:00 UTC



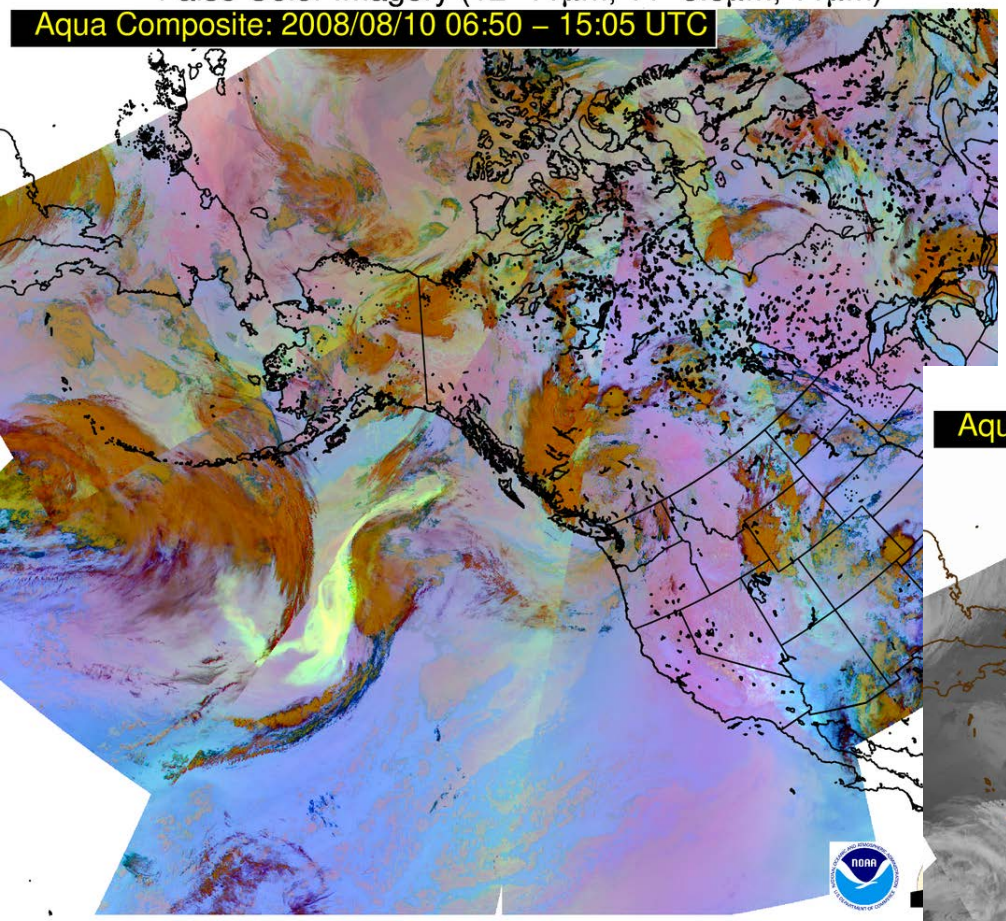
Terra **MODIS ascending node**
August 10, 2008 (UTC)

IR Window Imagery and Ash/Dust Loading

Terra Composite: 2008/08/10 02:45 – 11:00 UTC

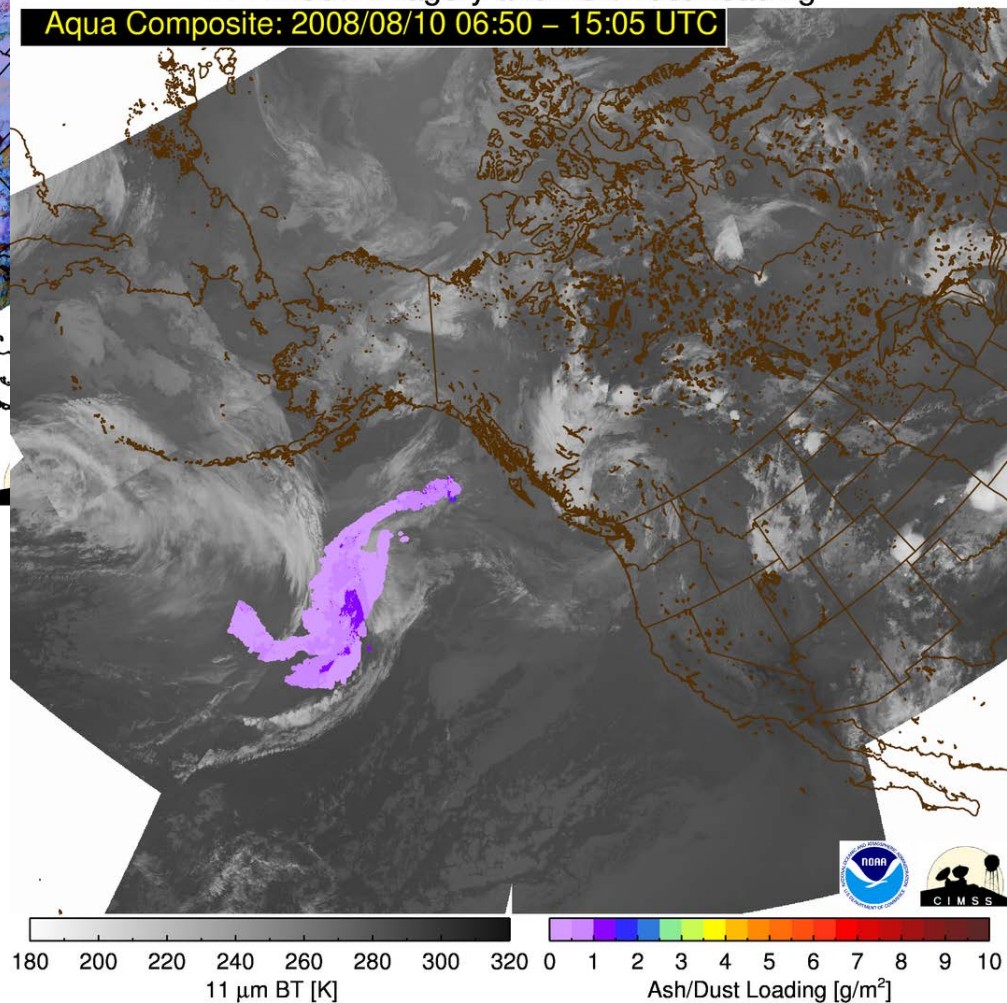


False Color Imagery (12–11μm, 11–8.5μm, 11μm)

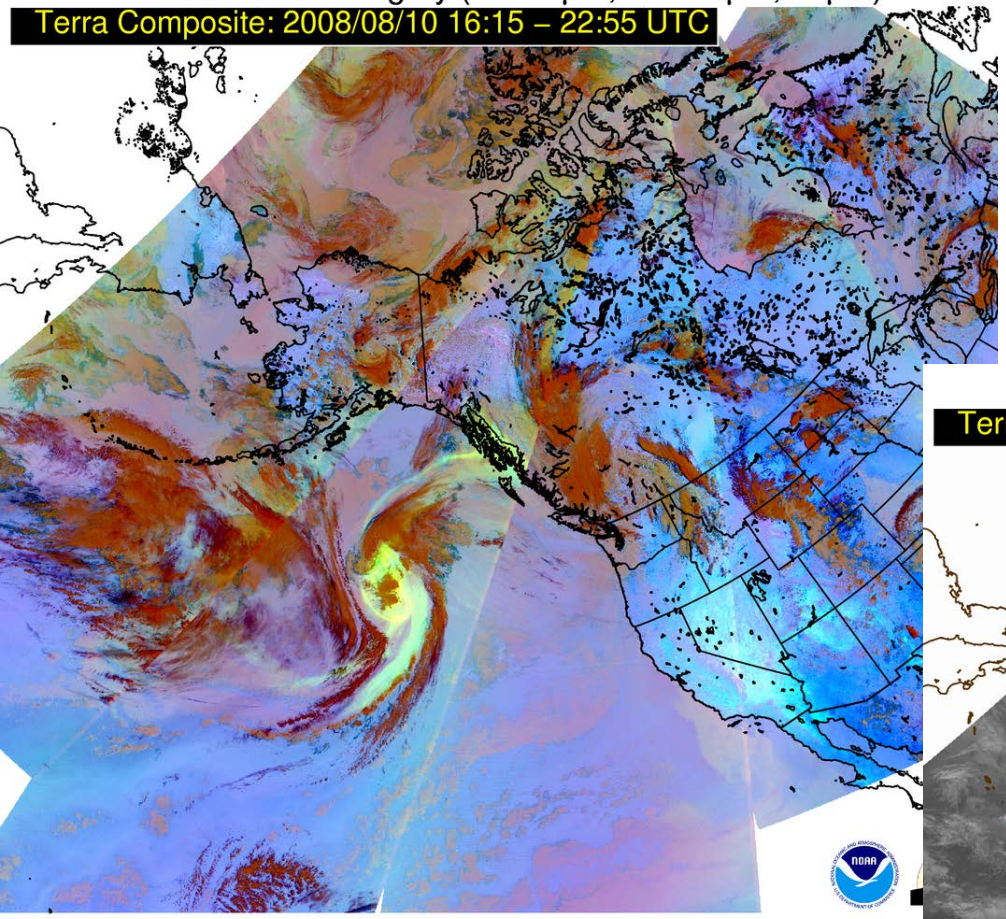


***Aqua* MODIS descending node**
August 10, 2008 (UTC)

IR Window Imagery and Ash/Dust Loading

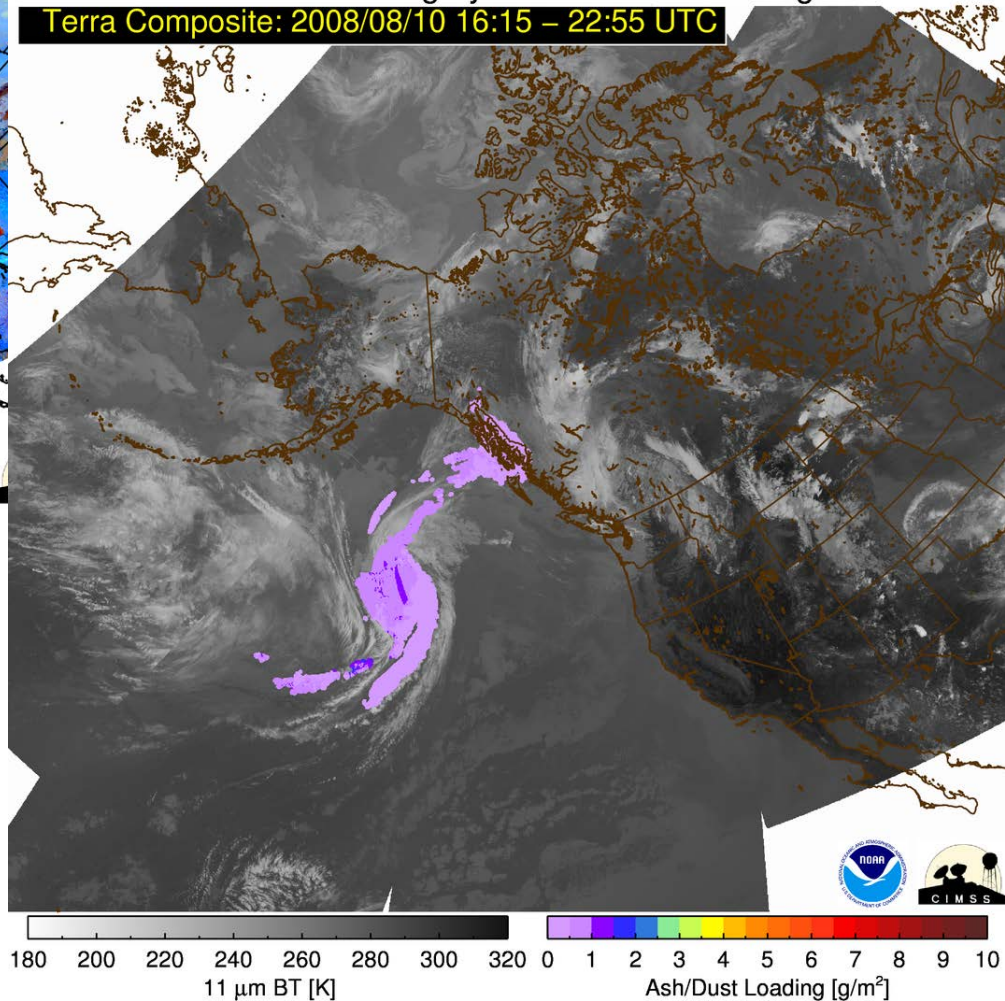


False Color Imagery (12–11μm, 11–8.5μm, 11μm)

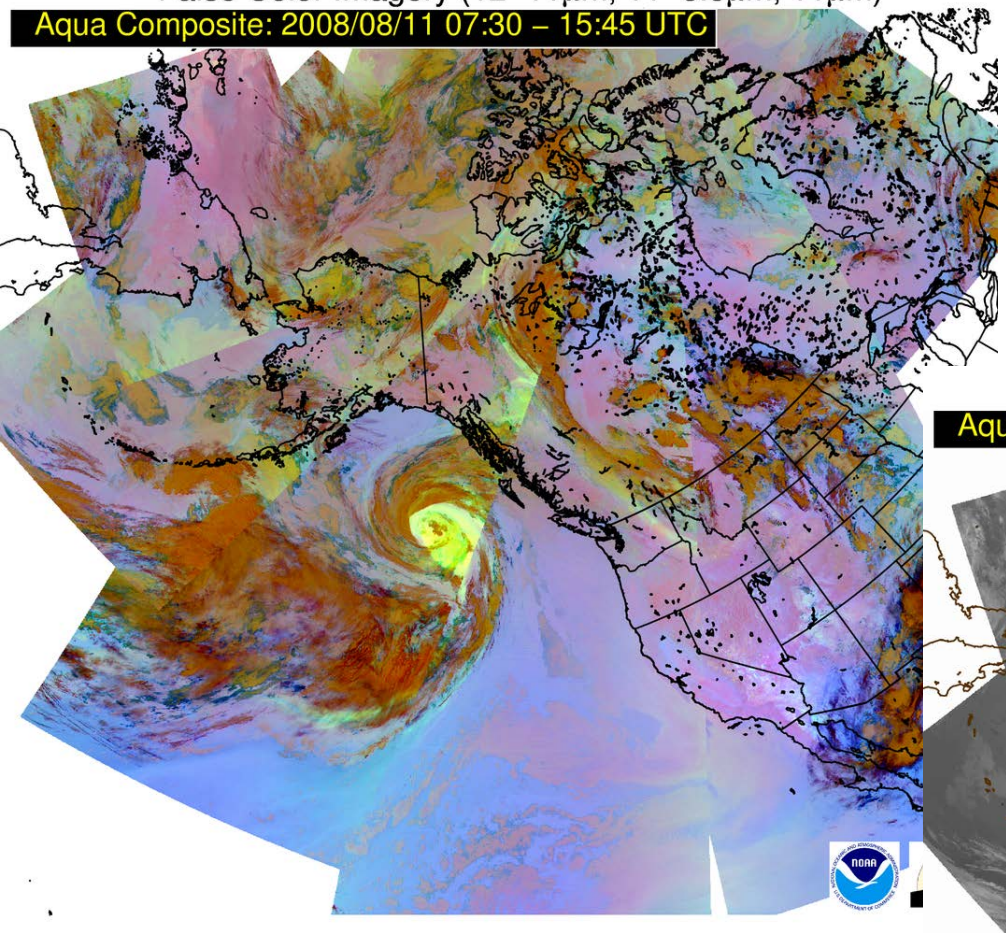


***Terra* MODIS descending node**
August 10, 2008 (UTC)

IR Window Imagery and Ash/Dust Loading

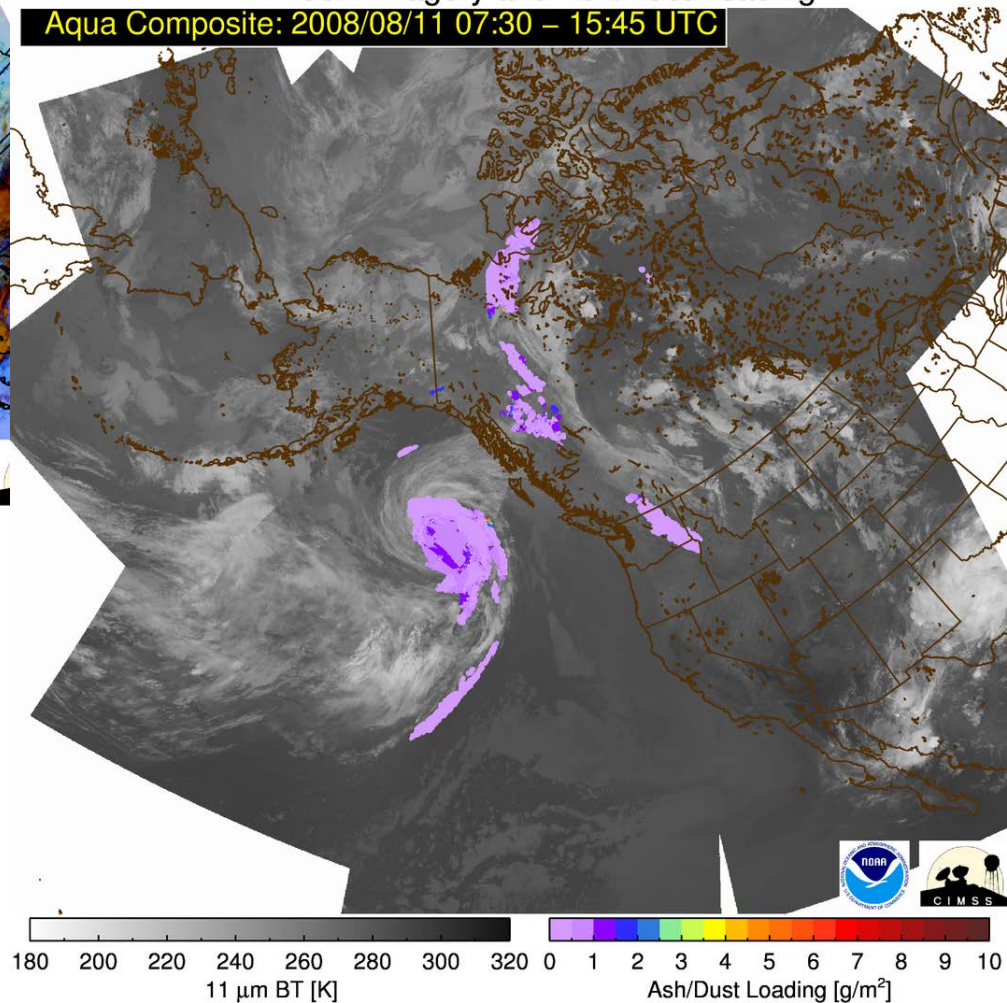


False Color Imagery (12–11μm, 11–8.5μm, 11μm)



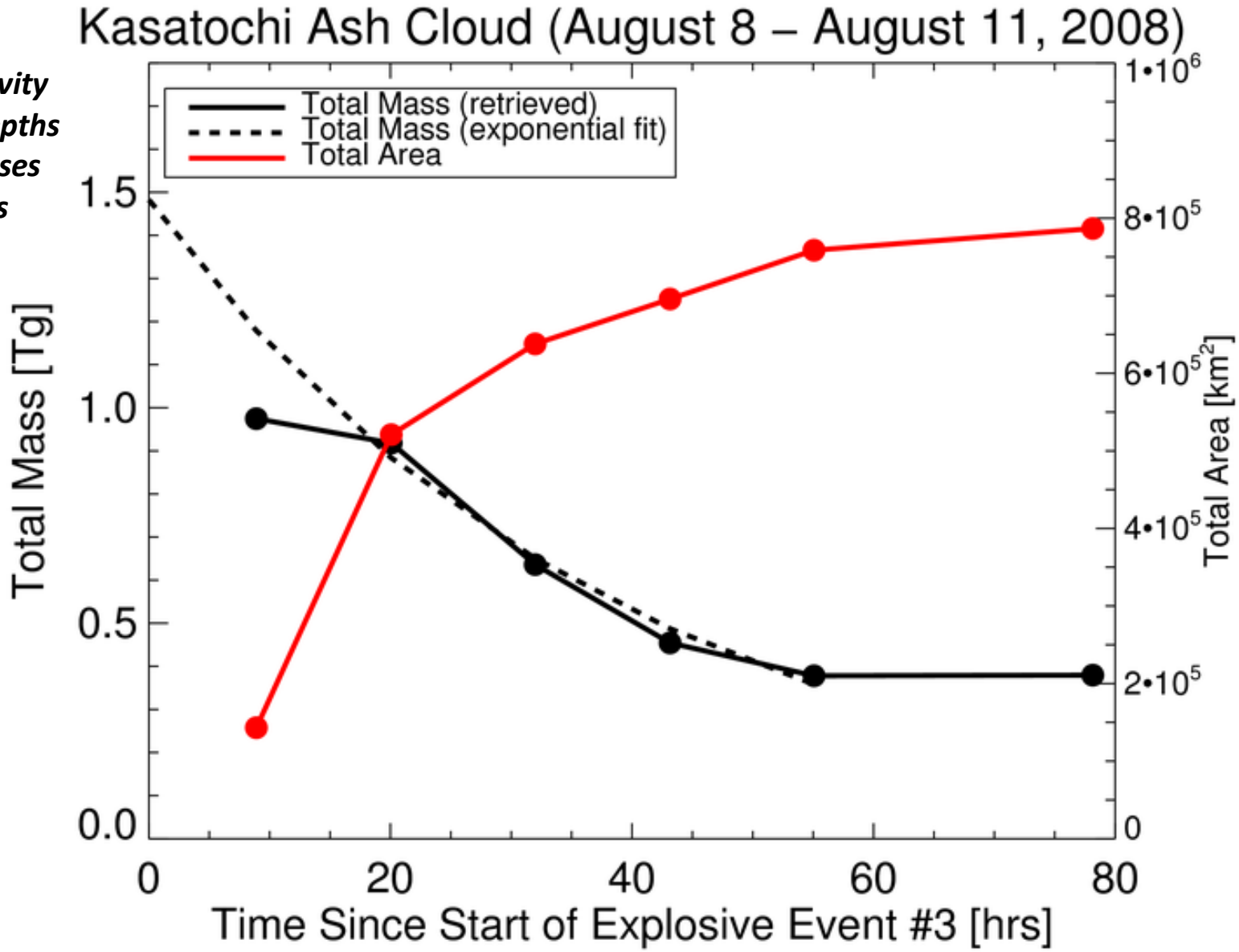
***Aqua* MODIS ascending node**
August 11, 2008 (UTC)

IR Window Imagery and Ash/Dust Loading

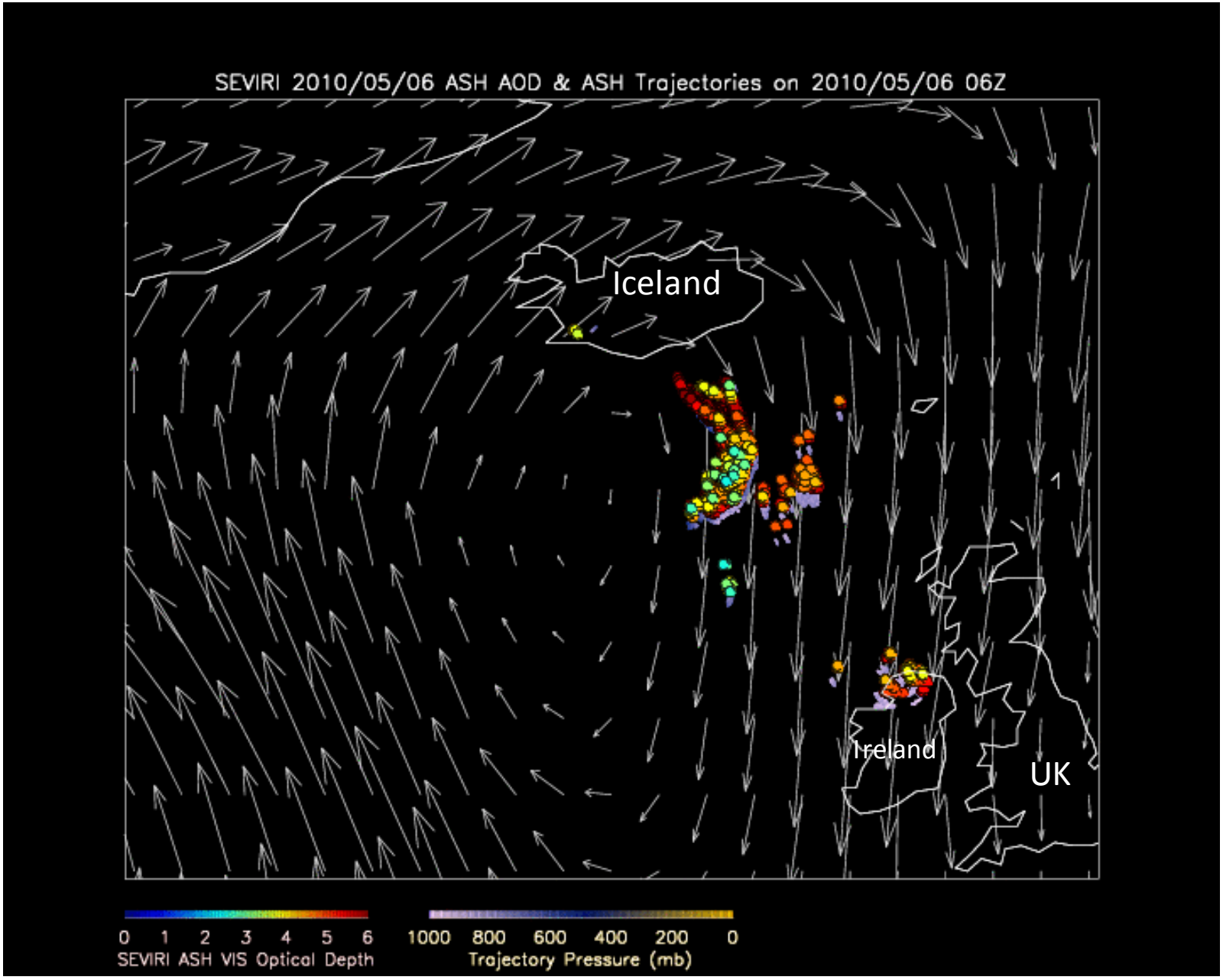


Total mass and area time series

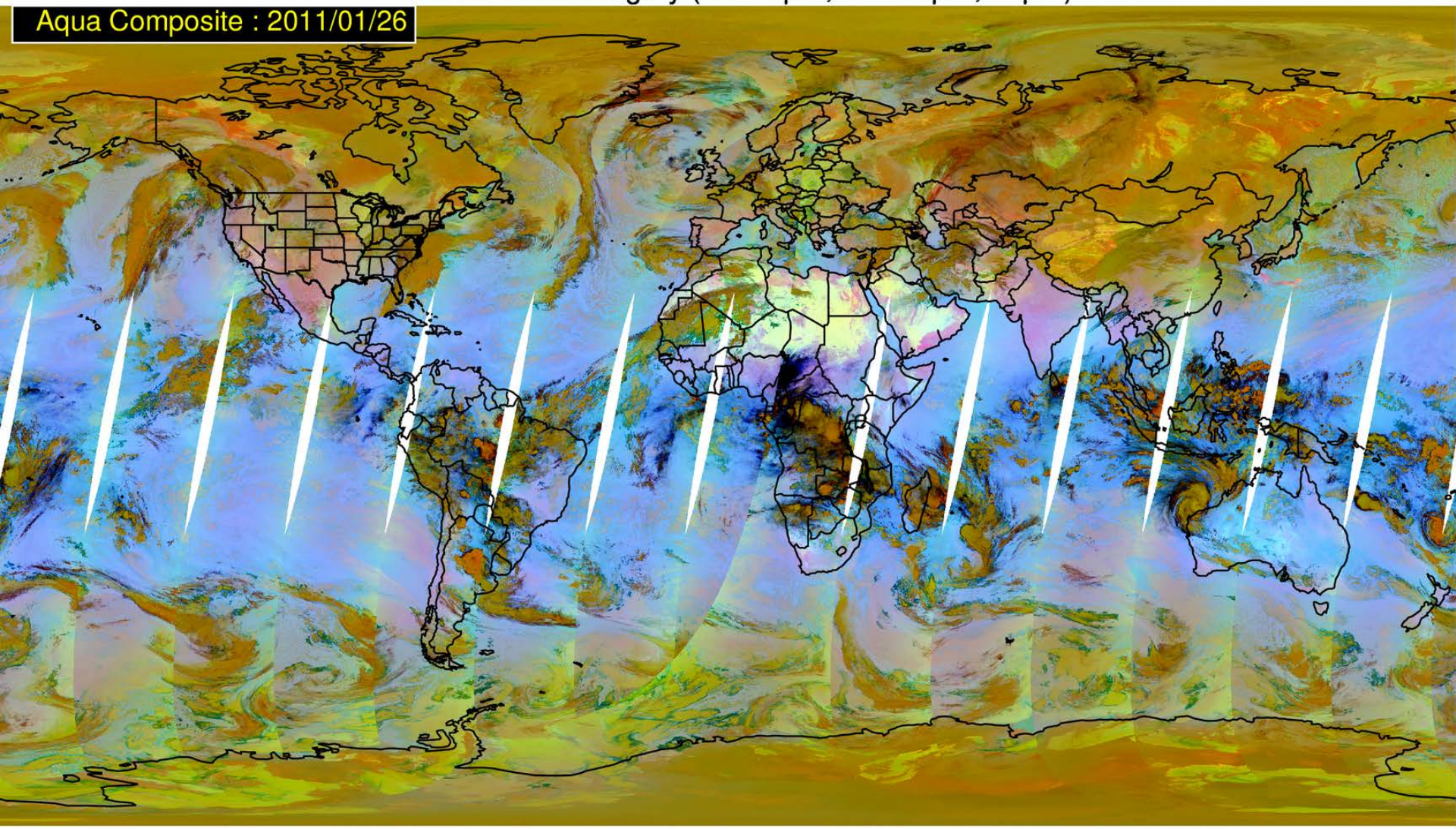
The limited sensitivity to large optical depths in the IR likely causes the first total mass value to be underestimated



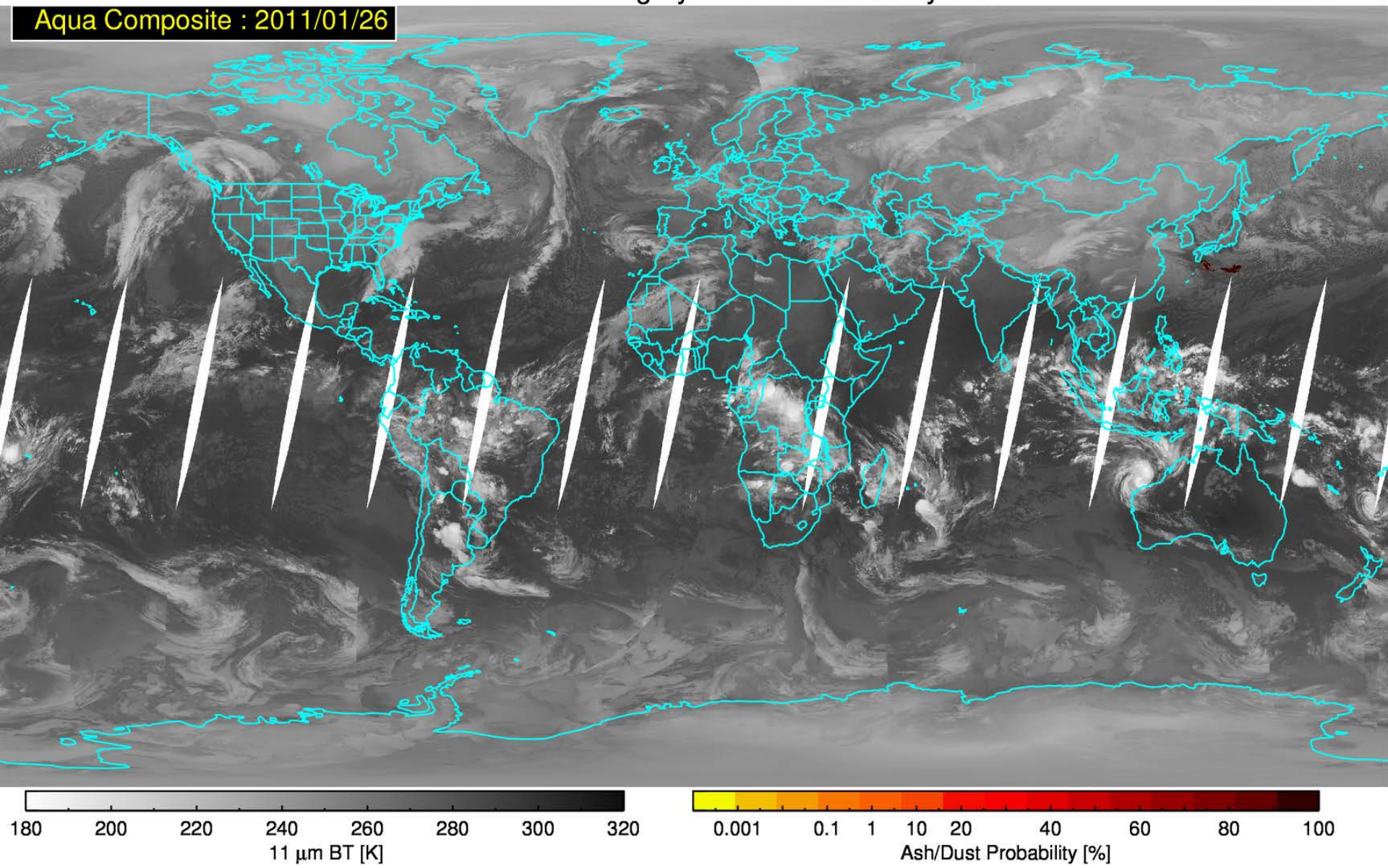
Improving ash cloud forecasts



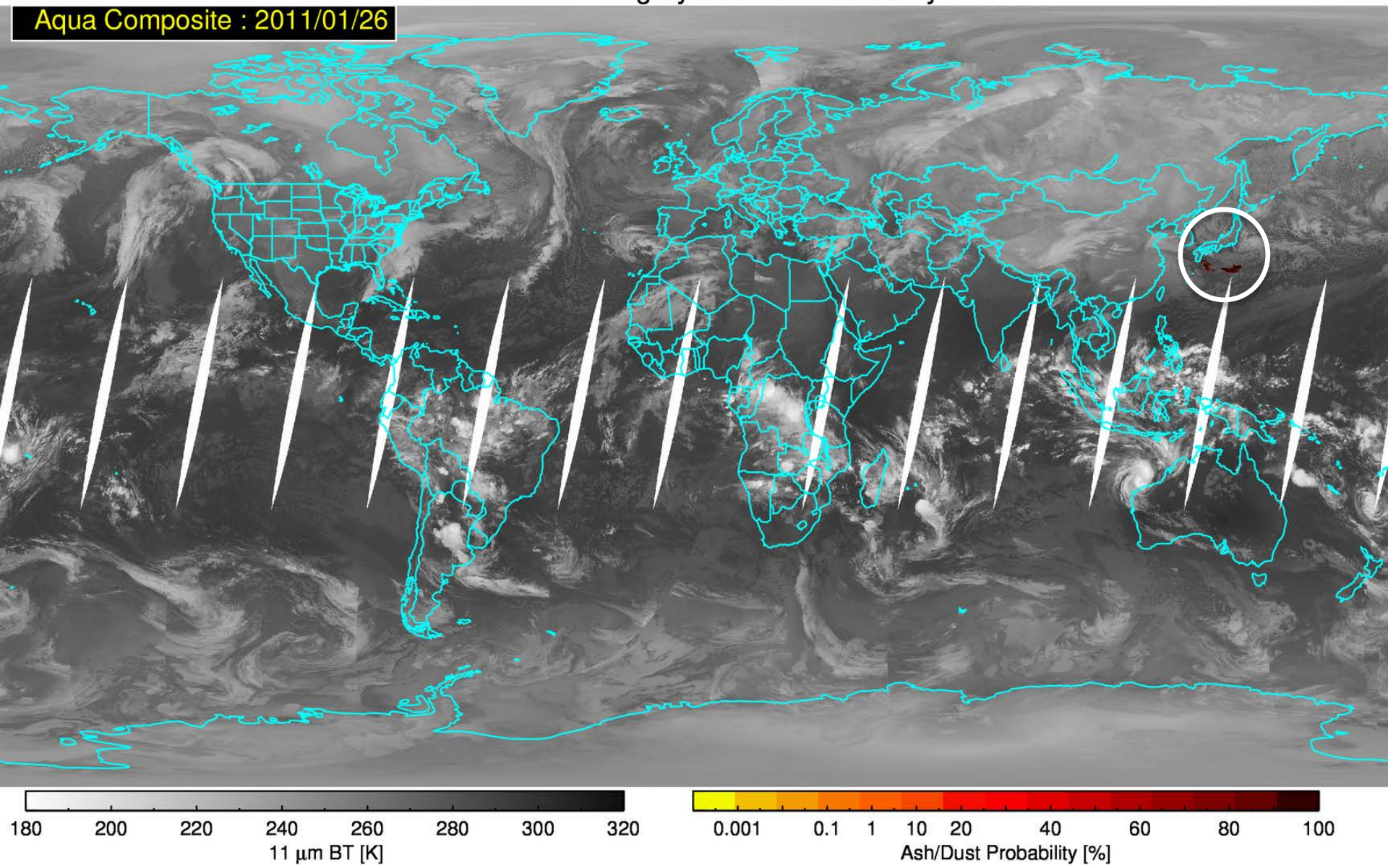
False Color Imagery (12−11μm, 11−8.5μm, 11μm)

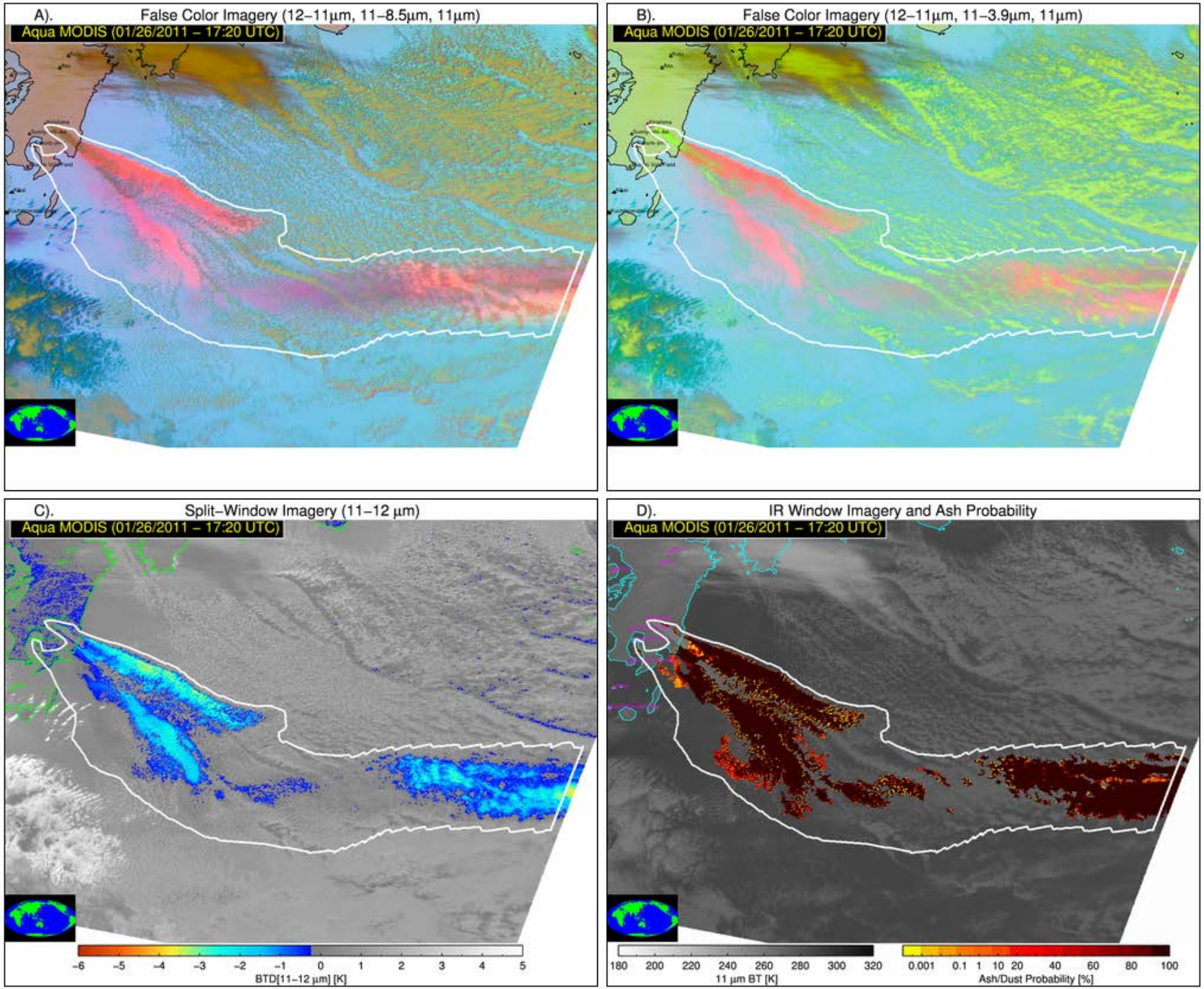


IR Window Imagery and Ash Probability

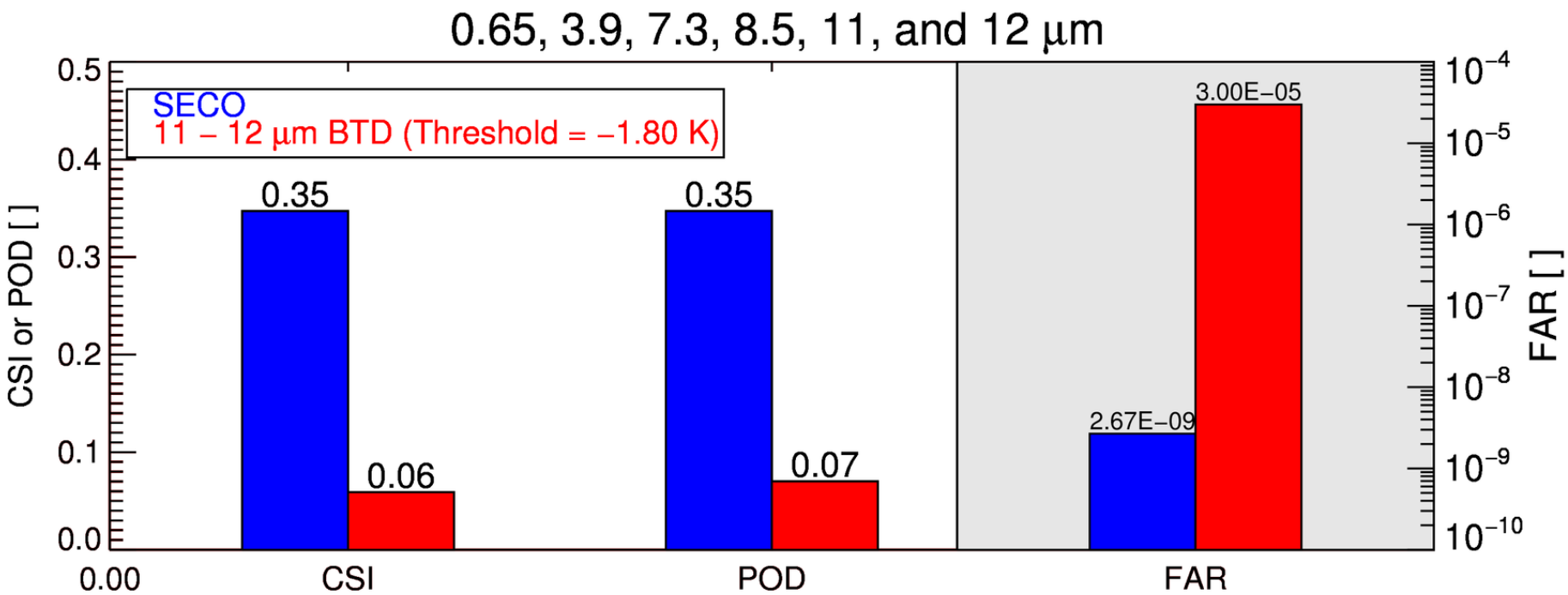


IR Window Imagery and Ash Probability



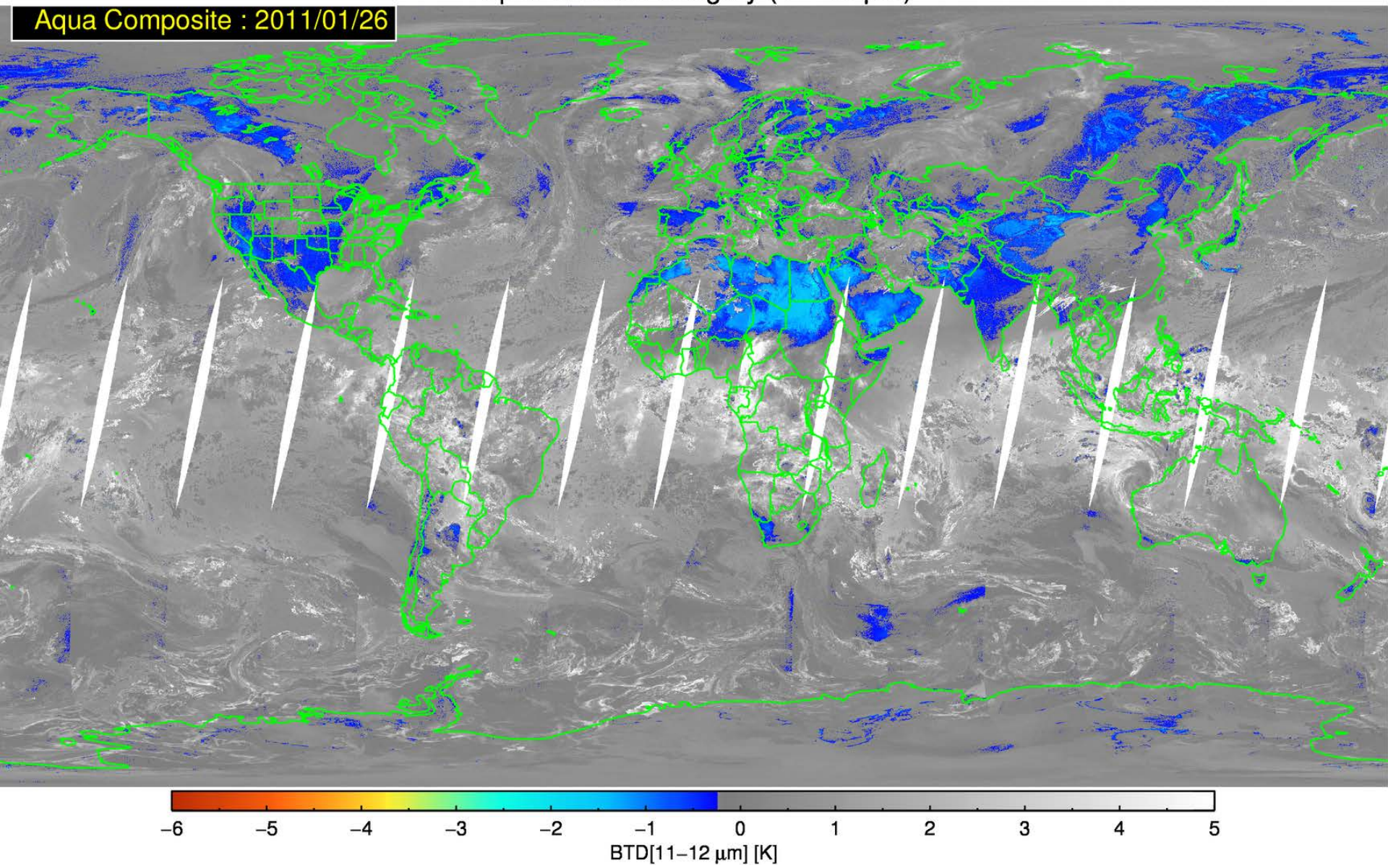

A).
False Color Imagery (12–11μm, 11–8.5μm, 11μm)
Aqua MODIS (01/26/2011 – 17:20 UTC)
B).
False Color Imagery (12–11μm, 11–3.9μm, 11μm)
Aqua MODIS (01/26/2011 – 17:20 UTC)
C).
Split–Window Imagery (11–12 μm)
Aqua MODIS (01/26/2011 – 17:20 UTC)
-6 -5 -4 -3 -2 -1 0 1 2 3 4 5
BTD[11–12 μm] [K]
D).
IR Window Imagery and Ash Probability
Aqua MODIS (01/26/2011 – 17:20 UTC)
180 200 220 240 260 280 300 320
11 μm BT [K]
0.001 0.1 1 10 20 40 60 80 100
Ash/Dust Probability [%]

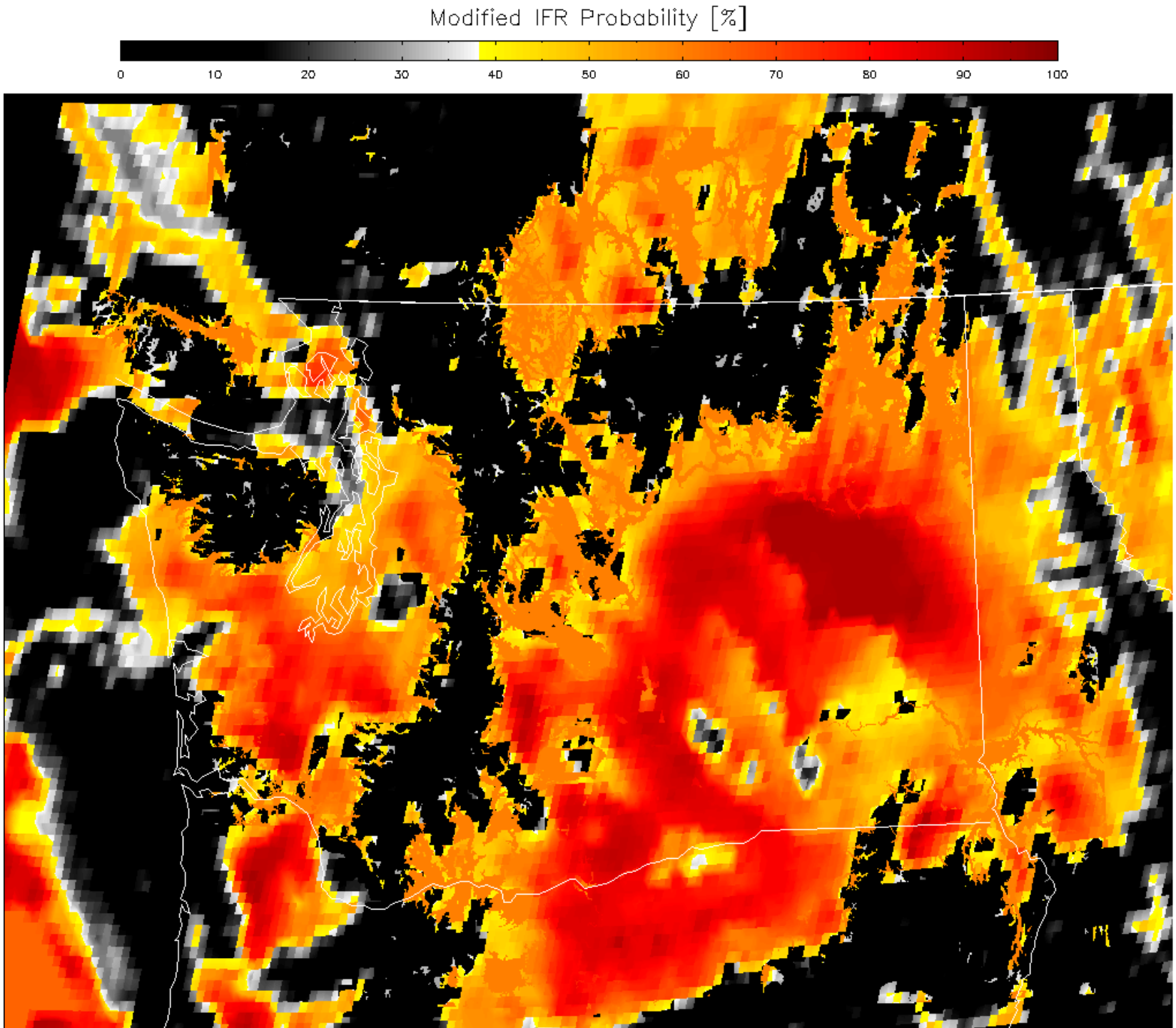
Global Performance

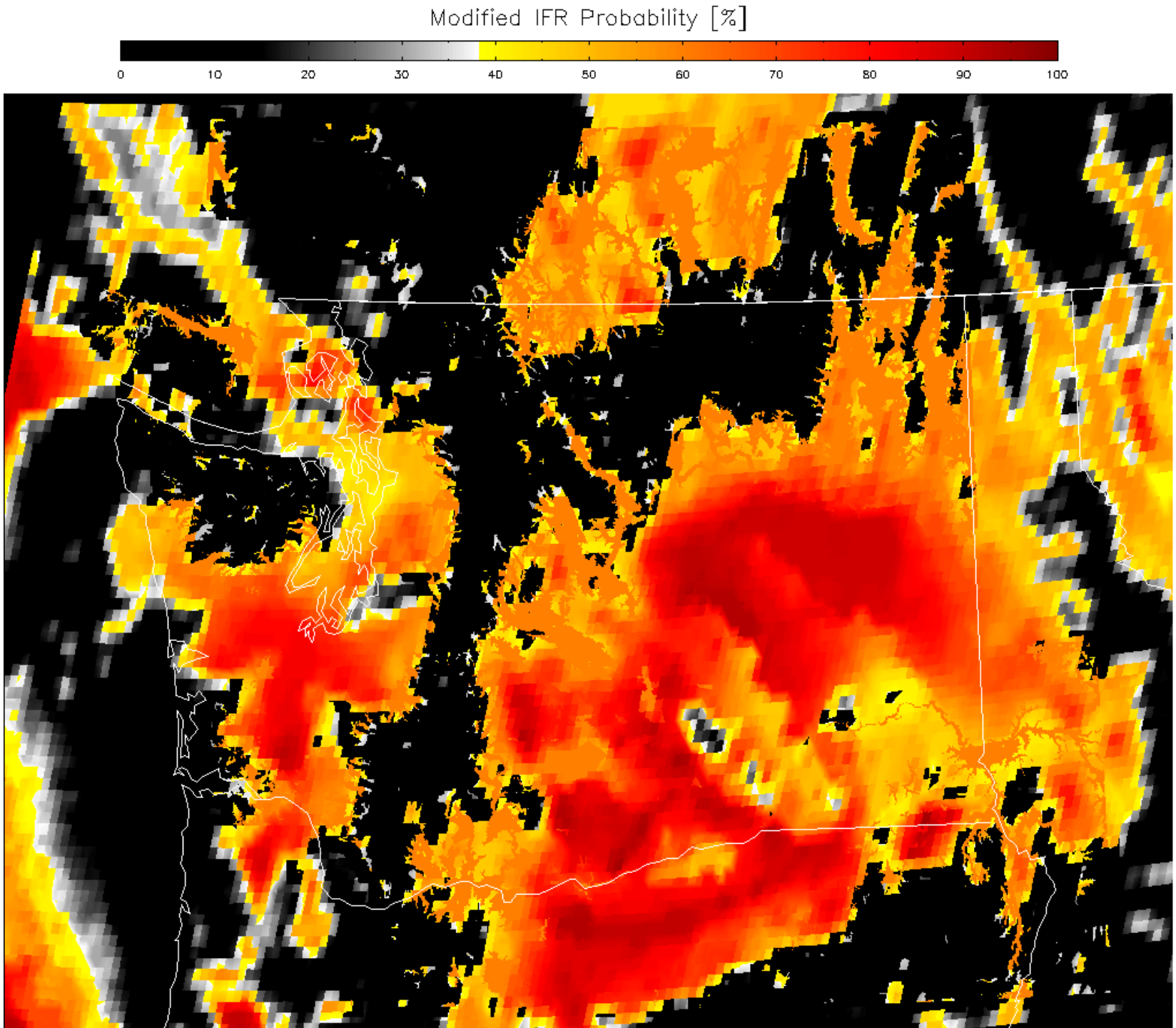


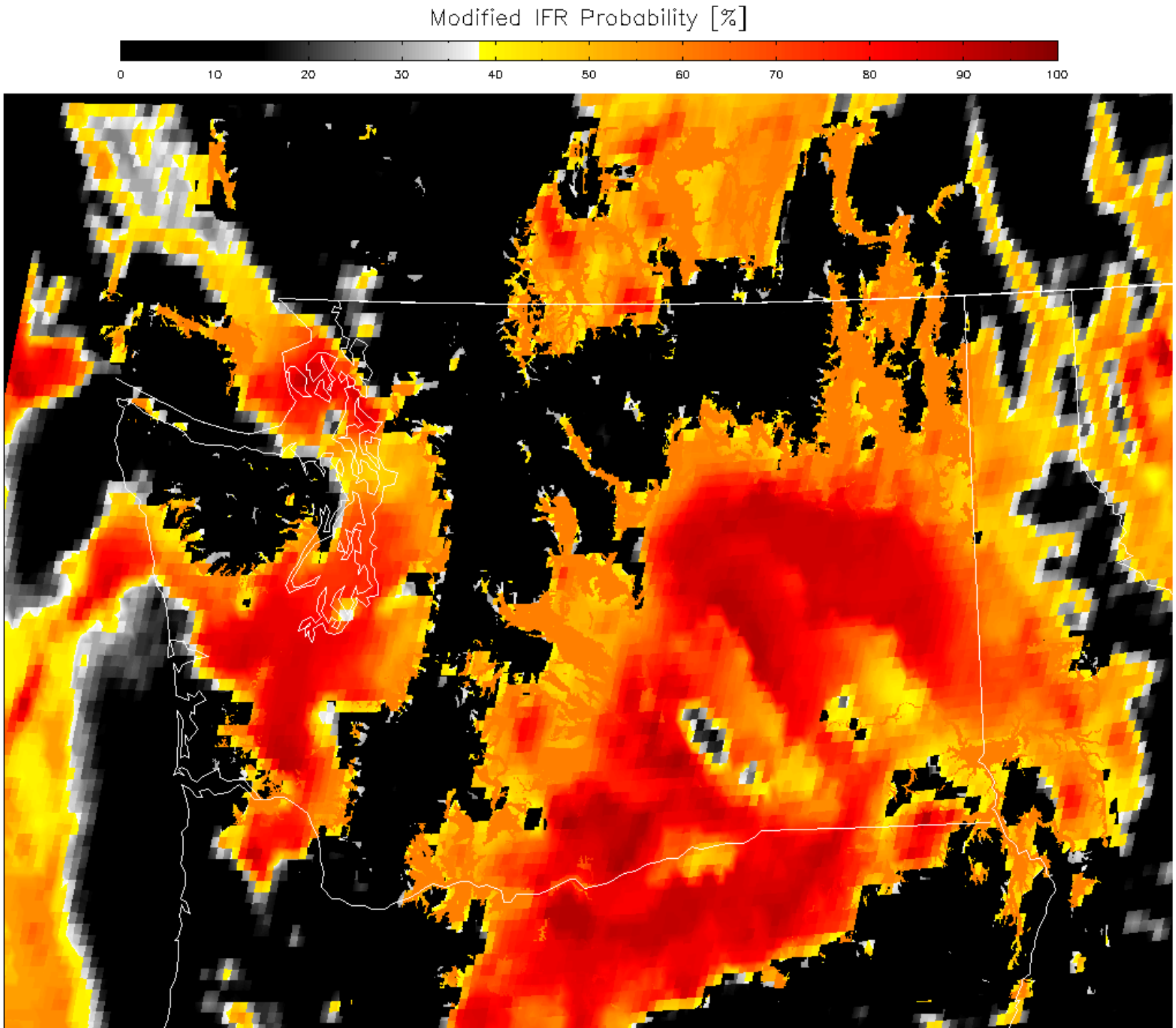
The SECO method resulted in no false alarms other than in very close proximity to the manually analyzed ash cloud boundary, while the "split-window" method produced many more false alarms despite the incredibly conservative optimized threshold of -1.80 K.

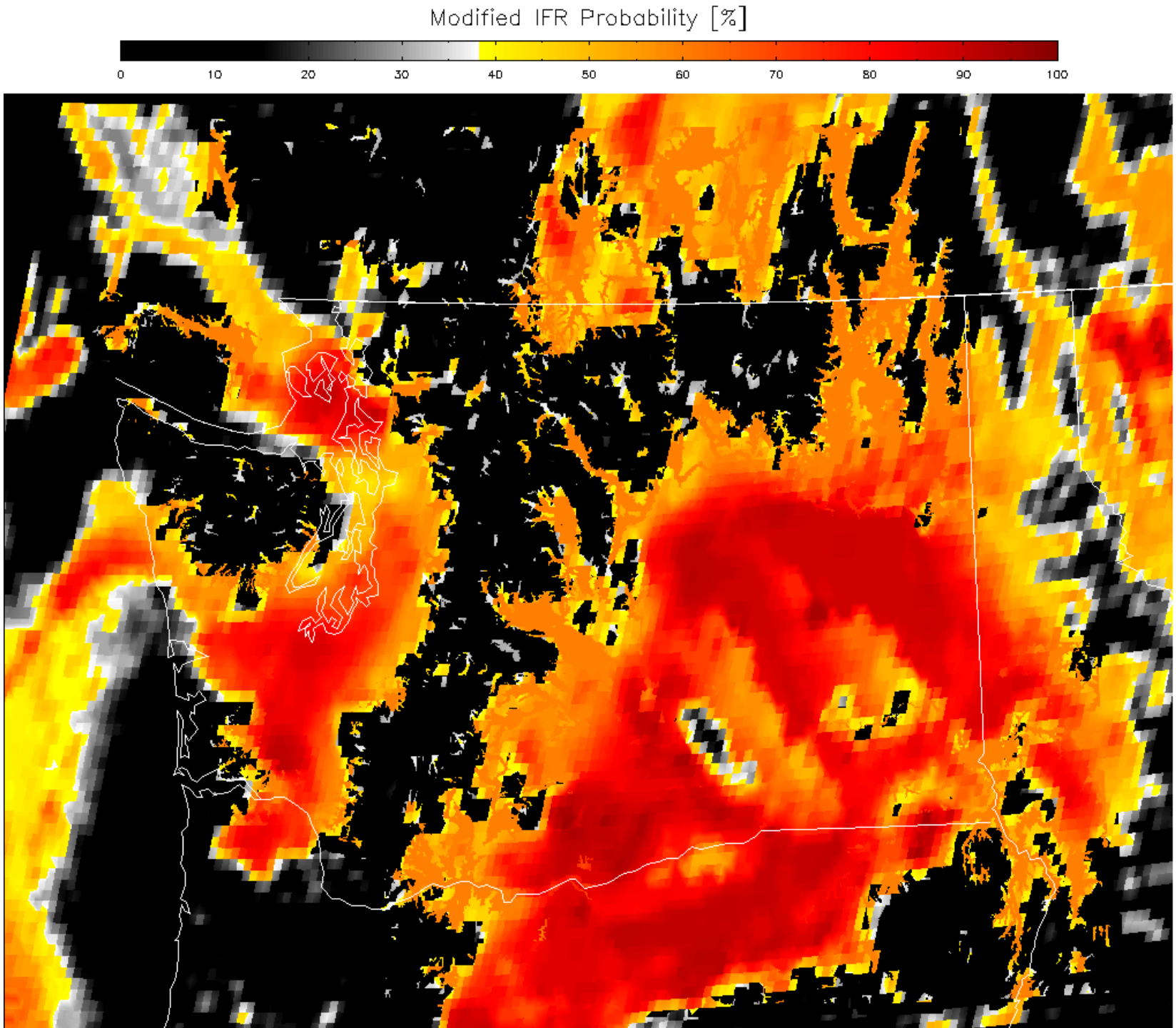
Split−Window Imagery (11−12 μm)




Modified IFR Probability [%]
0
10
20
30
40
50
60
70
80
90
100


Modified IFR Probability [%]
0
10
20
30
40
50
60
70
80
90
100


Modified IFR Probability [%]
0
10
20
30
40
50
60
70
80
90
100


Modified IFR Probability [%]
0
10
20
30
40
50
60
70
80
90
100