

Marco Fulle - www.stromboli.net

The Development of JPSS Volcanic Cloud Applications

Michael Pavolonis

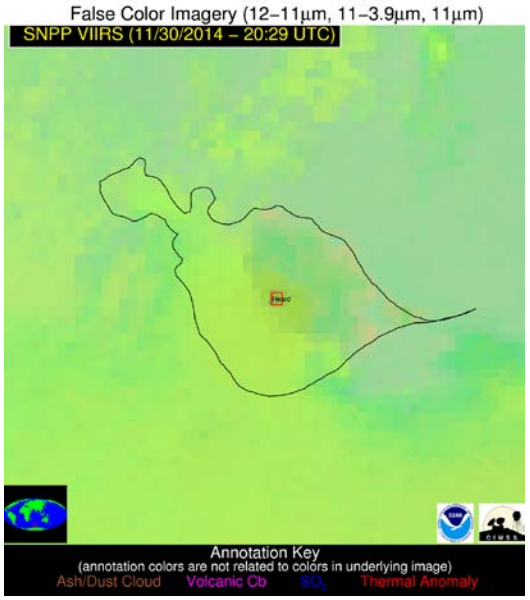
(NOAA/NESDIS/STAR)

Justin Sieglaff, and John Cintineo

(UW-CIMSS)

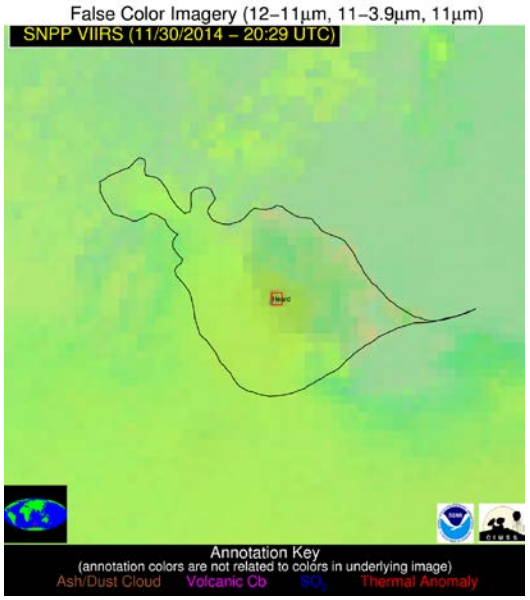
Development of a Multi-sensor System

1). Unrest Alerts

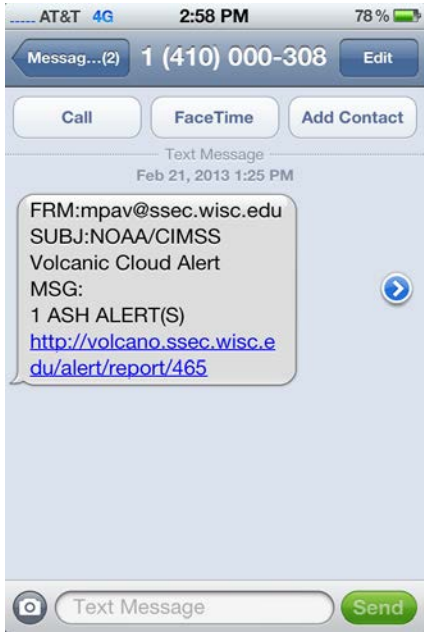


Development of a Multi-sensor System

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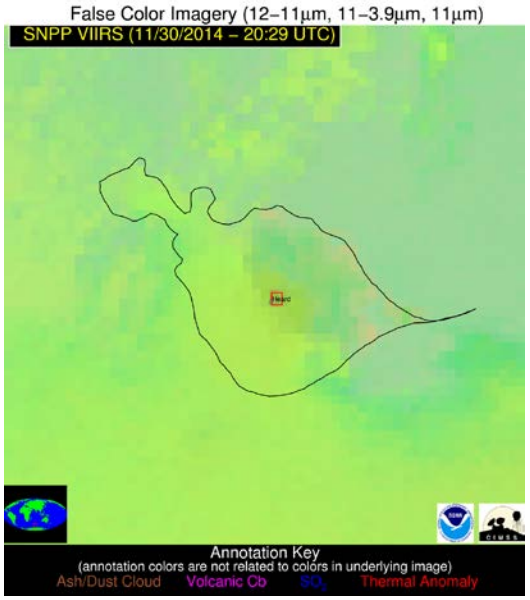


2). Eruption Alerts

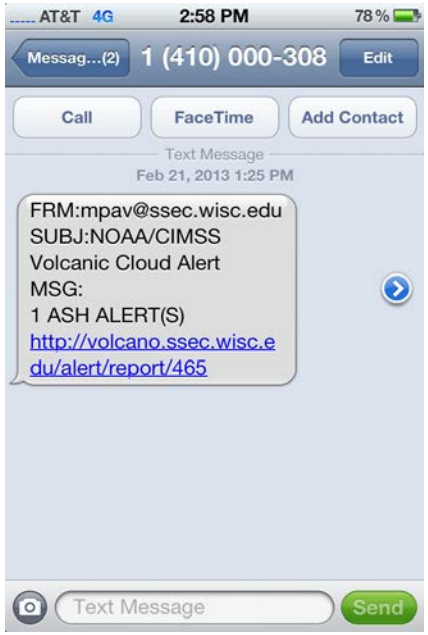


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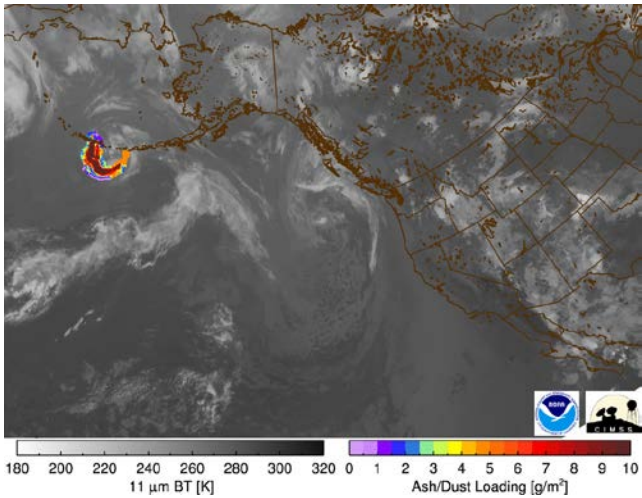
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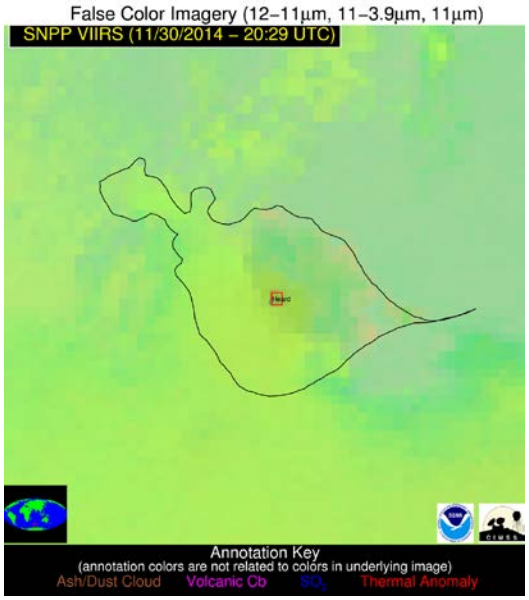


3). Volcanic Cloud Tracking

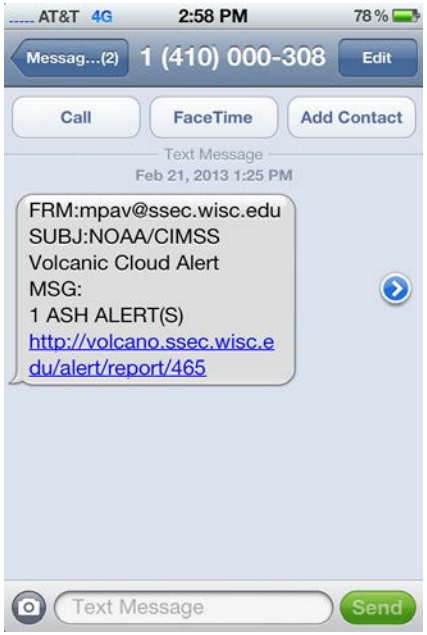


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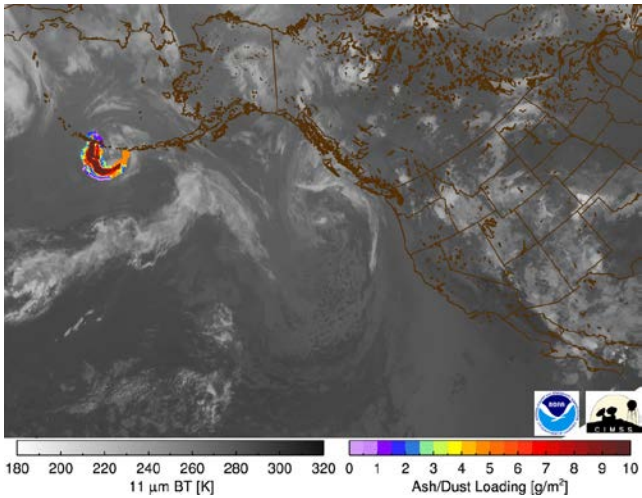
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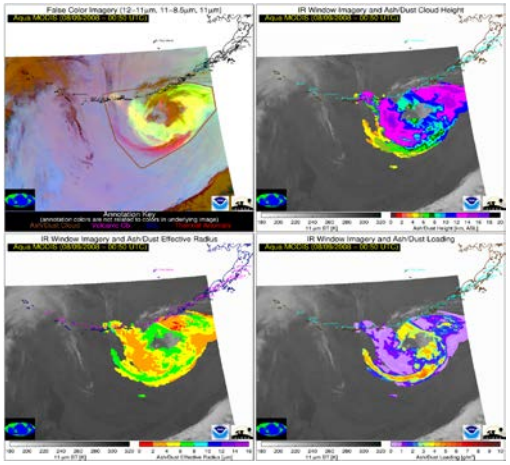
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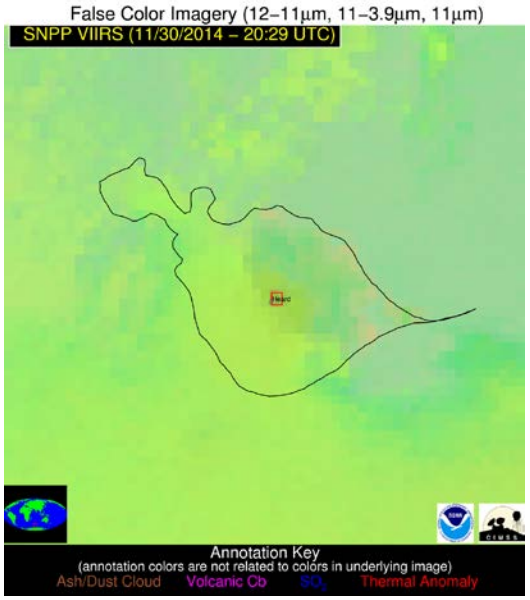


4). Volcanic Cloud Characterization

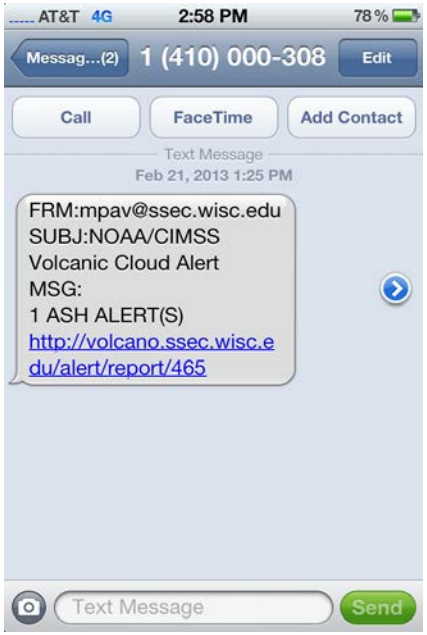


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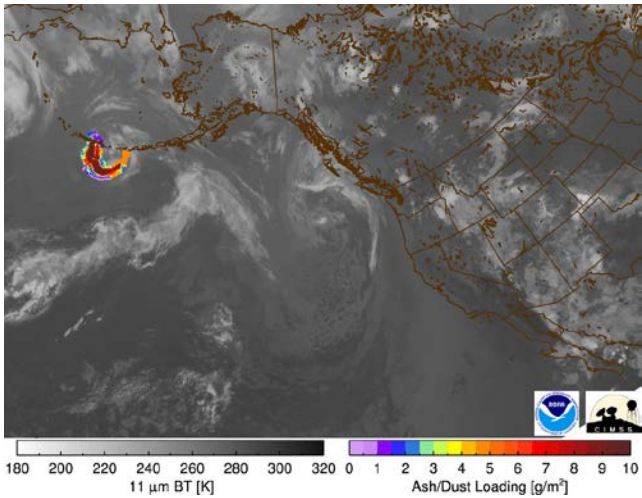
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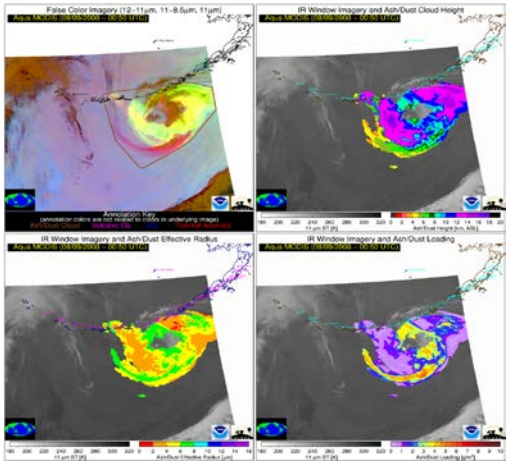
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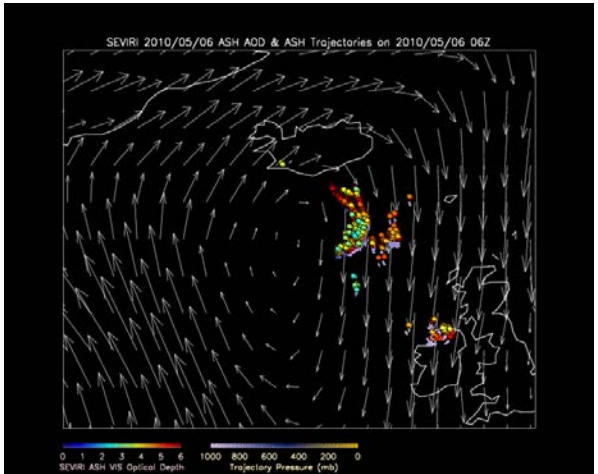
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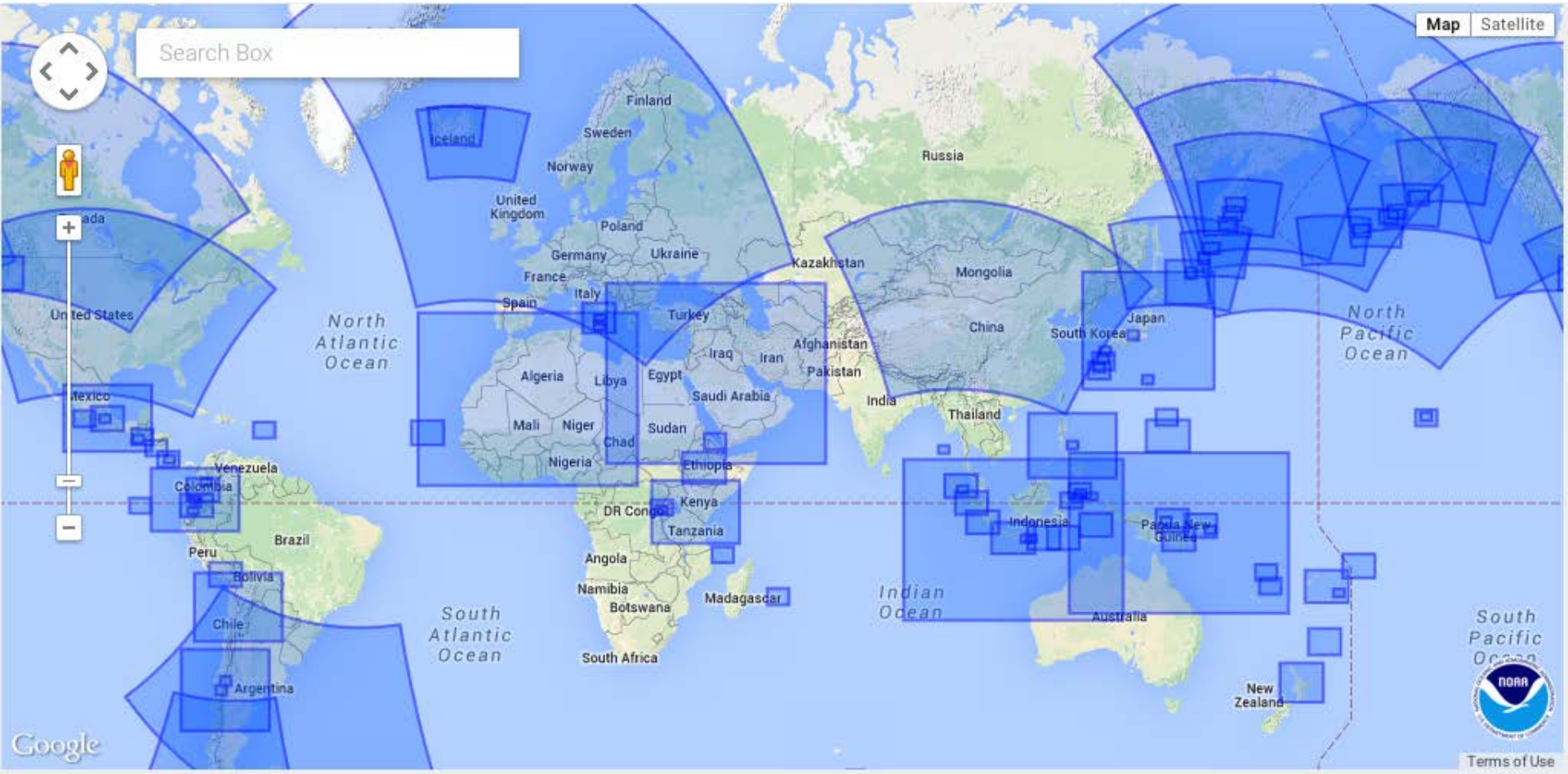
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5). Dispersion Forecasting



http://volcano.ssec.wisc.edu



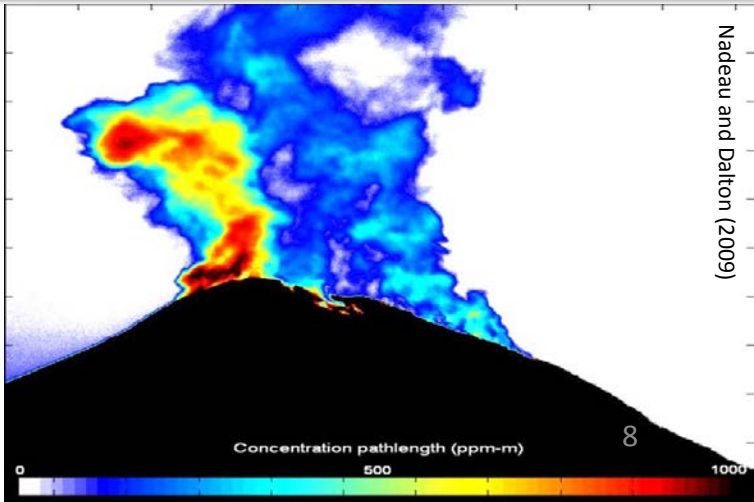
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2). Ice topped umbrella clouds – These cloud are mostly observed during a major eruption. A spectral based volcanic ash signal is usually initially absent because the ash is encased in ice and/or the cloud is opaque. Lightning is often present in these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



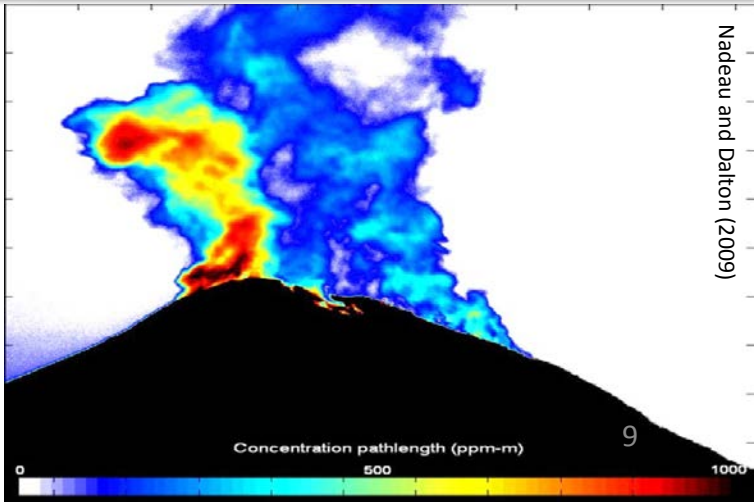
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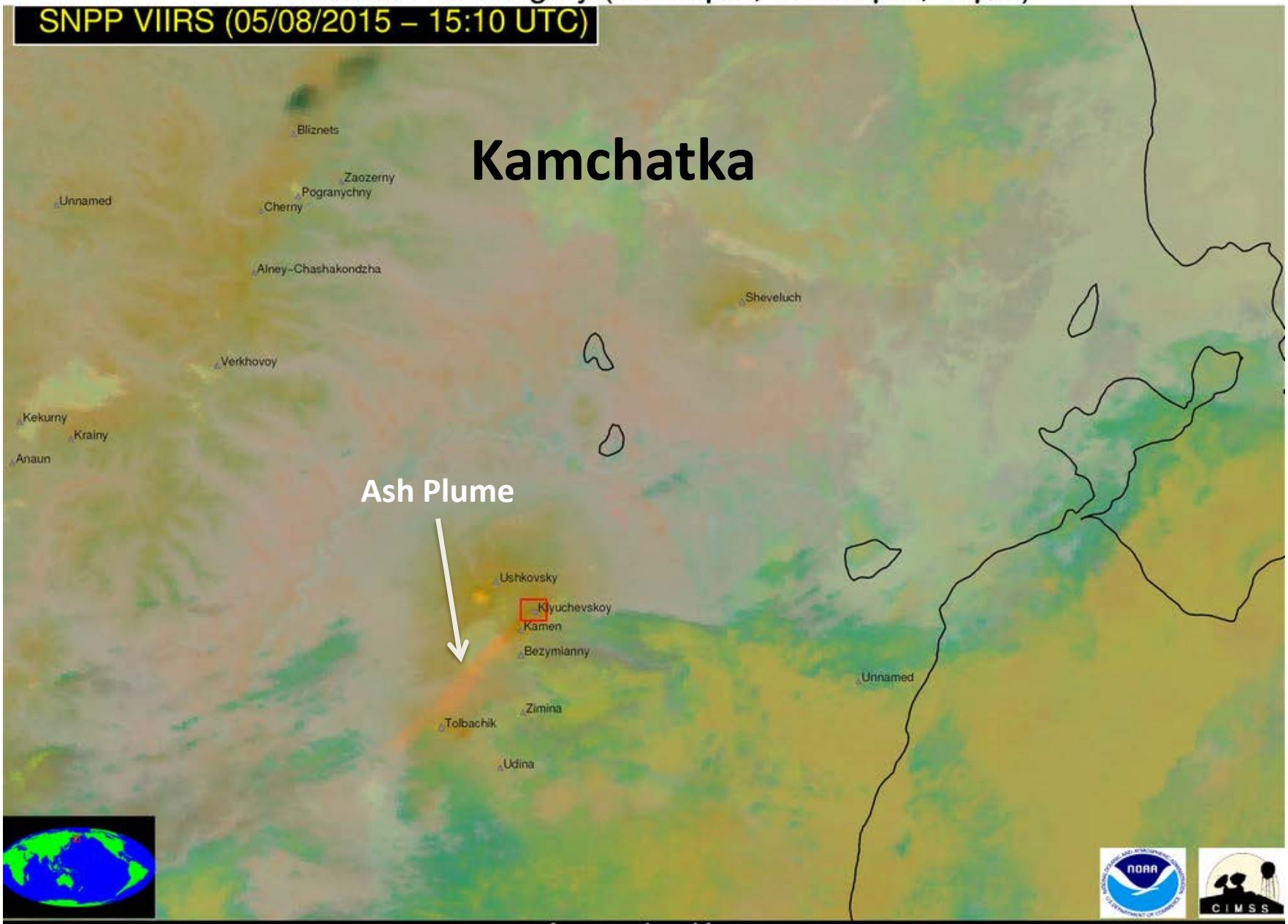
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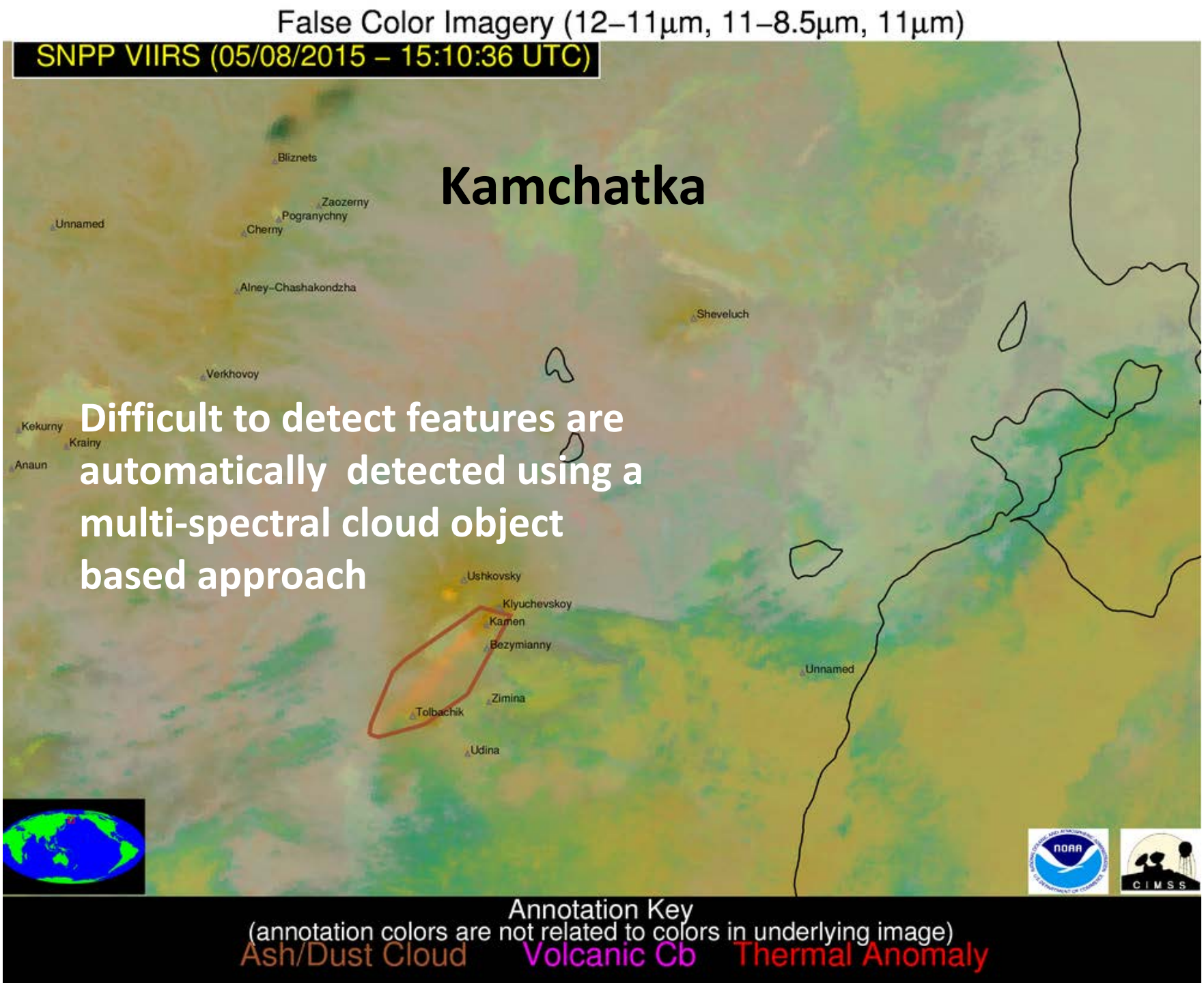
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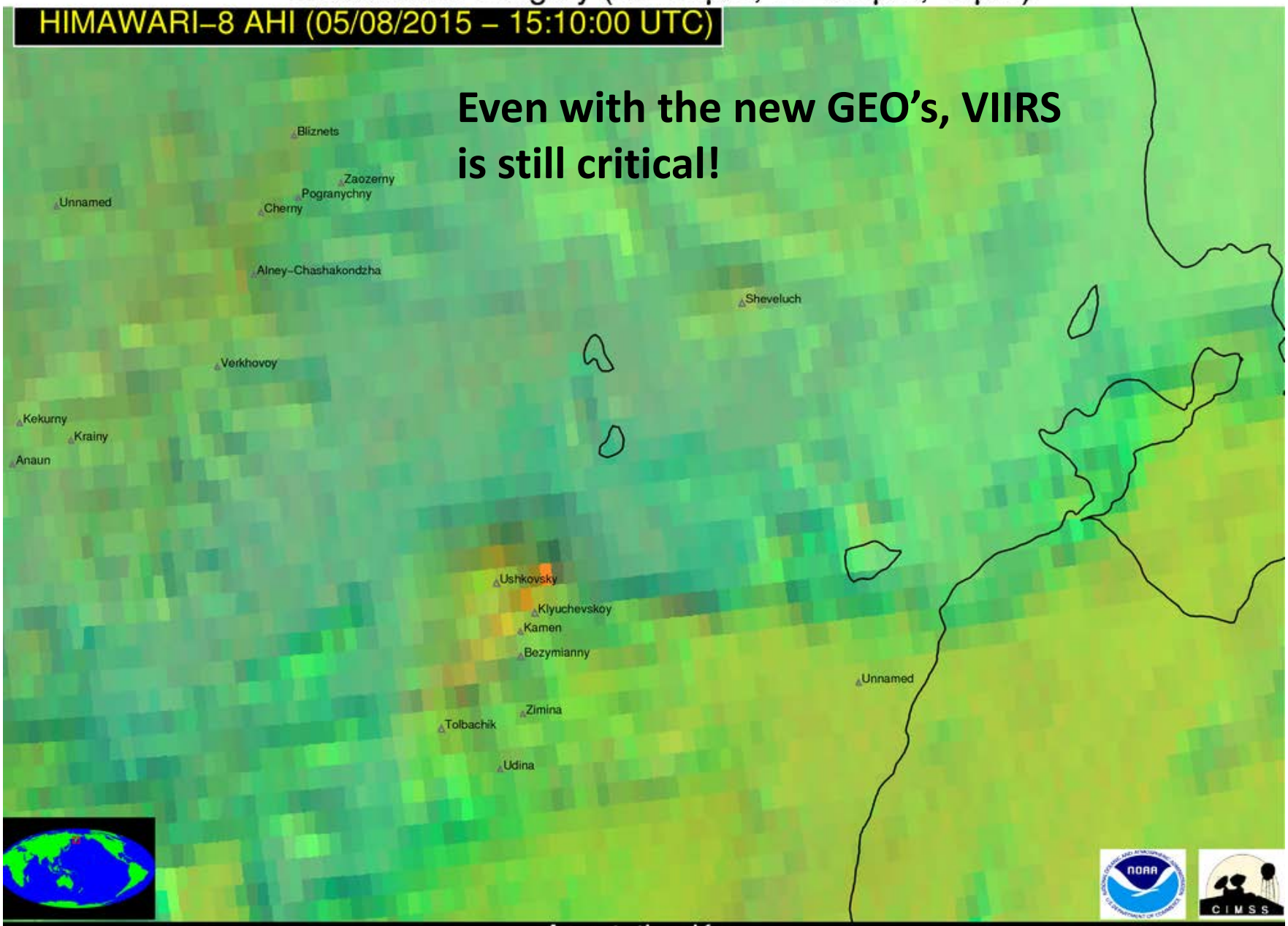


False Color Imagery (12–11μm, 11–8.5μm, 11μm)



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


False Color Imagery (12–11μm, 11–8.5μm, 11μm)
SNPP VIIRS (05/08/2015 – 15:10:36 UTC)
Kamchatka
Difficult to detect features are automatically detected using a multi-spectral cloud object based approach
Bliznets
Zaozerny
Pogranychny
Unnamed
Cherny
Alney-Chashakondzha
Sheveluch
Verkhovoy
Kekurny
Krainy
Anaun
Ushkovsky
Klyuchevskoy
Kamen
Bezymianny
Unnamed
Zimina
Tolbachik
Udina
NOAA
CIMSS
Annotation Key
(annotation colors are not related to colors in underlying image)
Ash/Dust Cloud
Volcanic Cb
Thermal Anomaly


False Color Imagery (12–11μm, 11–8.5μm, 11μm)
HIMAWARI–8 AHI (05/08/2015 – 15:10:00 UTC)
Even with the new GEO's, VIIRS is still critical!
Bliznets
Zaozerny
Pogranychny
Unnamed
Cherny
Alney-Chashakondzha
Sheveluch
Verkhovoy
Kekurny
Krainy
Anaun
Ushkovsky
Klyuchevskoy
Kamen
Bezymianny
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Zimina
Tolbachik
Udina
NOAA
CIMSS
Annotation Key
(annotation colors are not related to colors in underlying image)
Ash/Dust Cloud
Volcanic Cb
Thermal Anomaly

Detect and Alert

Within our automated alerting system, VIIRS identifies the most volcanic ash clouds due to its enhanced sensitivity to small-scale features (even at large viewing angles)

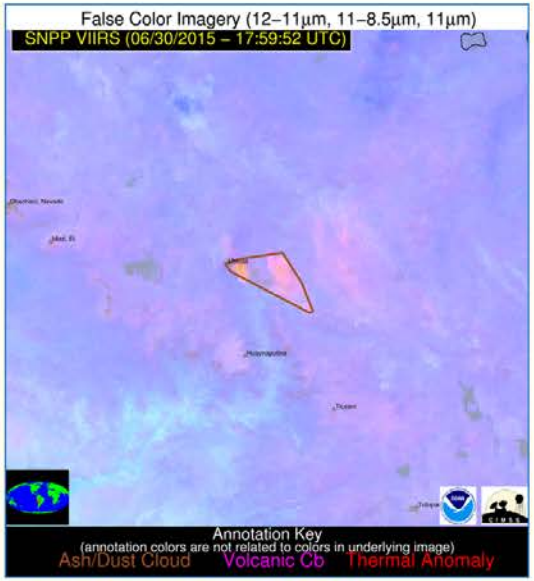
Volcanic Cloud Alert Report

DATE:	2015-06-30
TIME:	17:59:52
Production Date and Time:	2015-06-30 21:29:46 UTC
PRIMARY INSTRUMENT:	NPP VIIRS

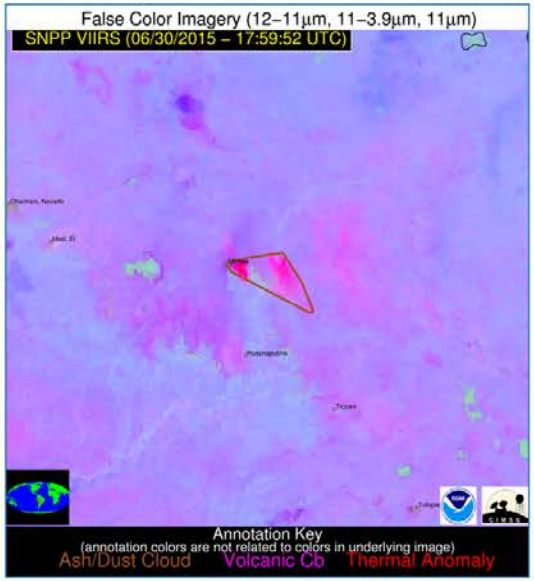
More details ▼

Ubinas (Peru): June 30, 2015

Possible Volcanic Ash Cloud



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

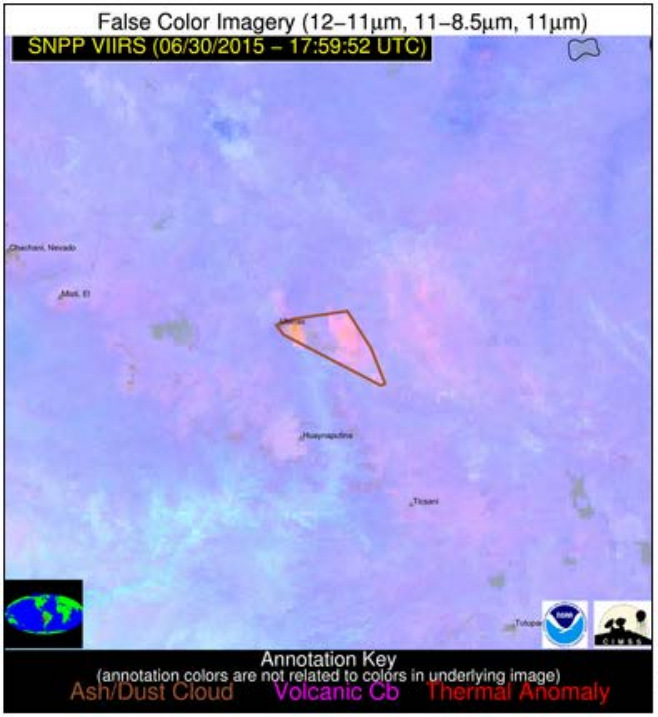


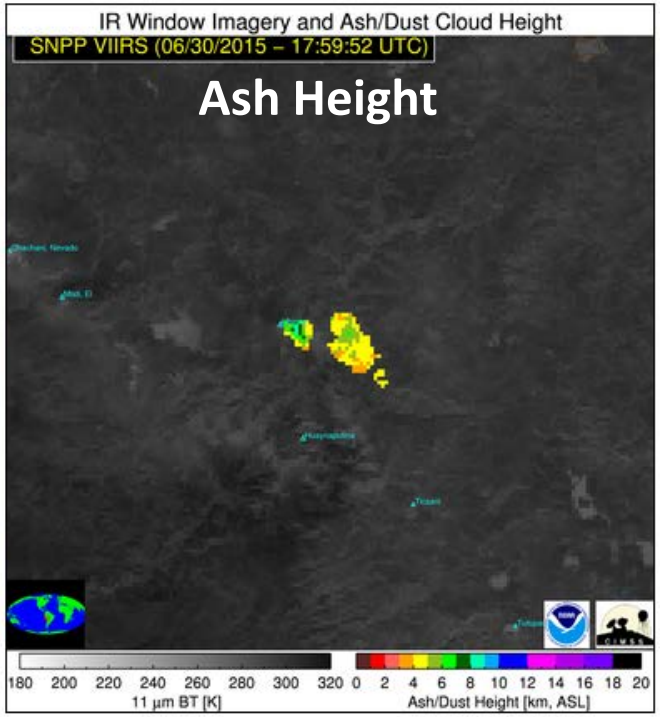
False Color Image (12-11, 11-3.9, 11) [zoomed-in]

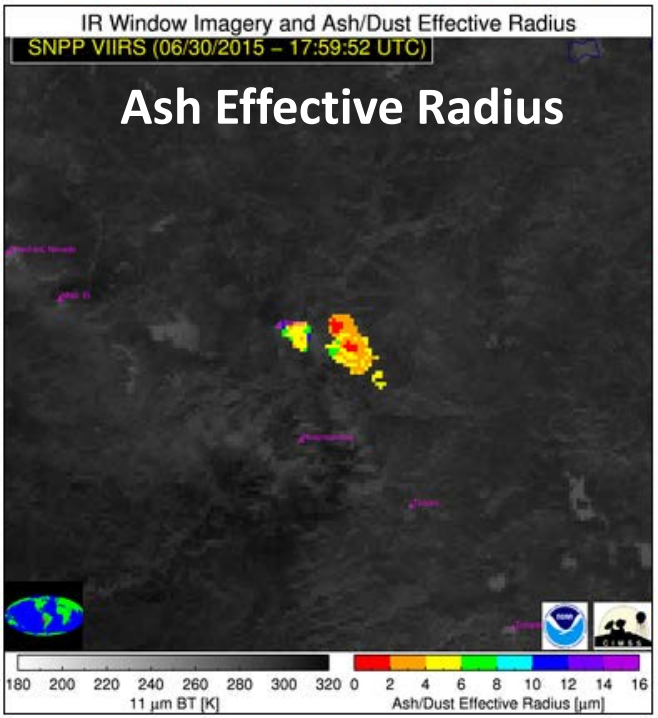
Basic Information

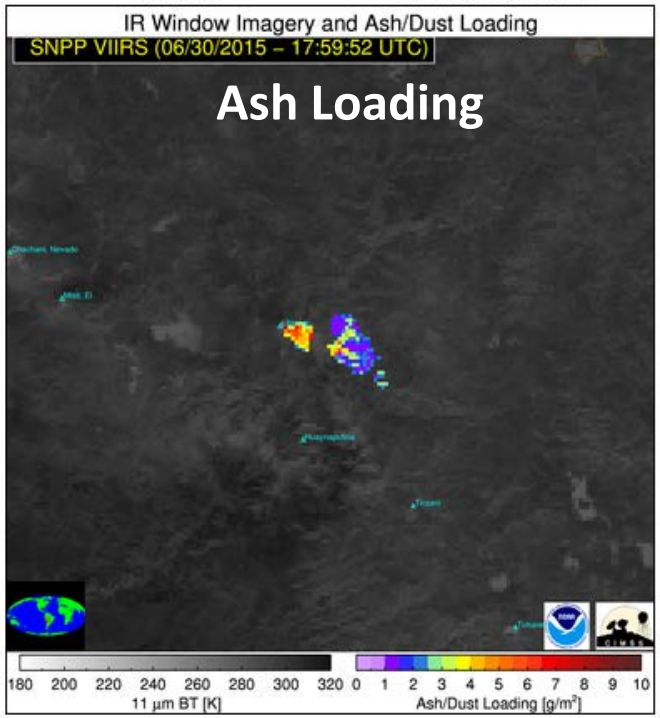
Volcanic Region(s)	South America
Country/Countries	Peru
Volcanic Subregion(s)	Peru
VAAC Region(s) of Nearby Volcanoes	Buenos Aires
Mean Object Date/Time	2015-06-30 17:59:52UTC
Radiative Center (Lat, Lon):	-16.350 °, -70.900 °
Nearby Volcanoes (meeting alert criteria):	Ubinas (0.00 km) Huaynaputina (28.70 km) Misti, El (54.50 km) Ticsani (55.30 km) Chachani, Nevado (69.40 km)
Maximum Height [AMSL]	9.30 km; 30512 ft
90th Percentile Height [AMSL]	5.60 km; 18373 ft
Mean Tropopause Height [AMSL]	16.50 km; 54134 ft

Show More ▲ | View all event imagery »





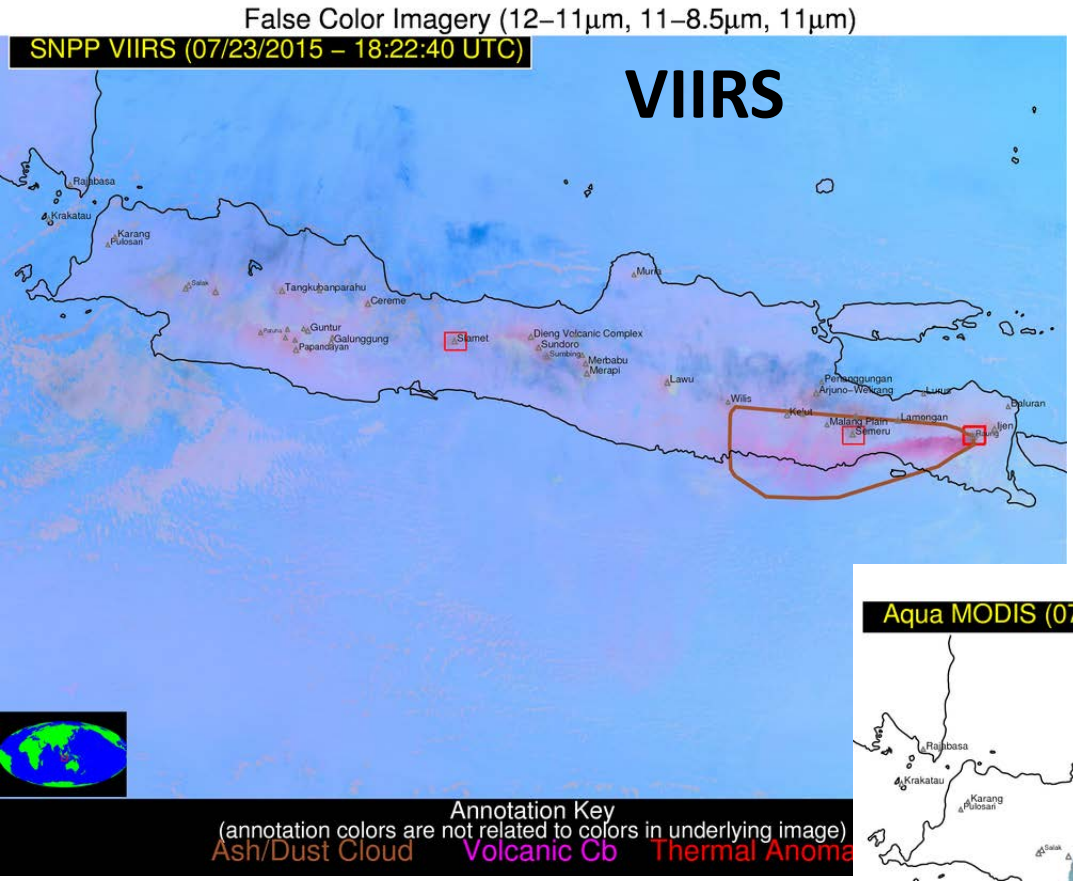


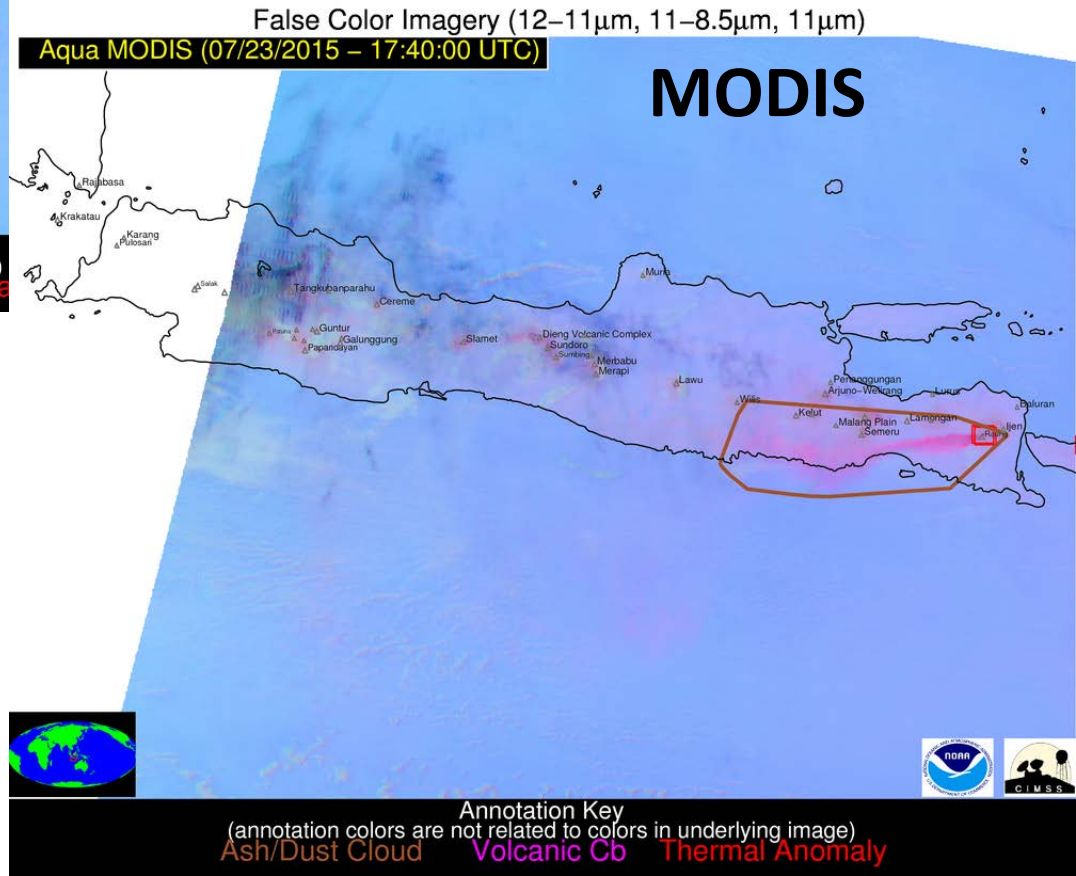


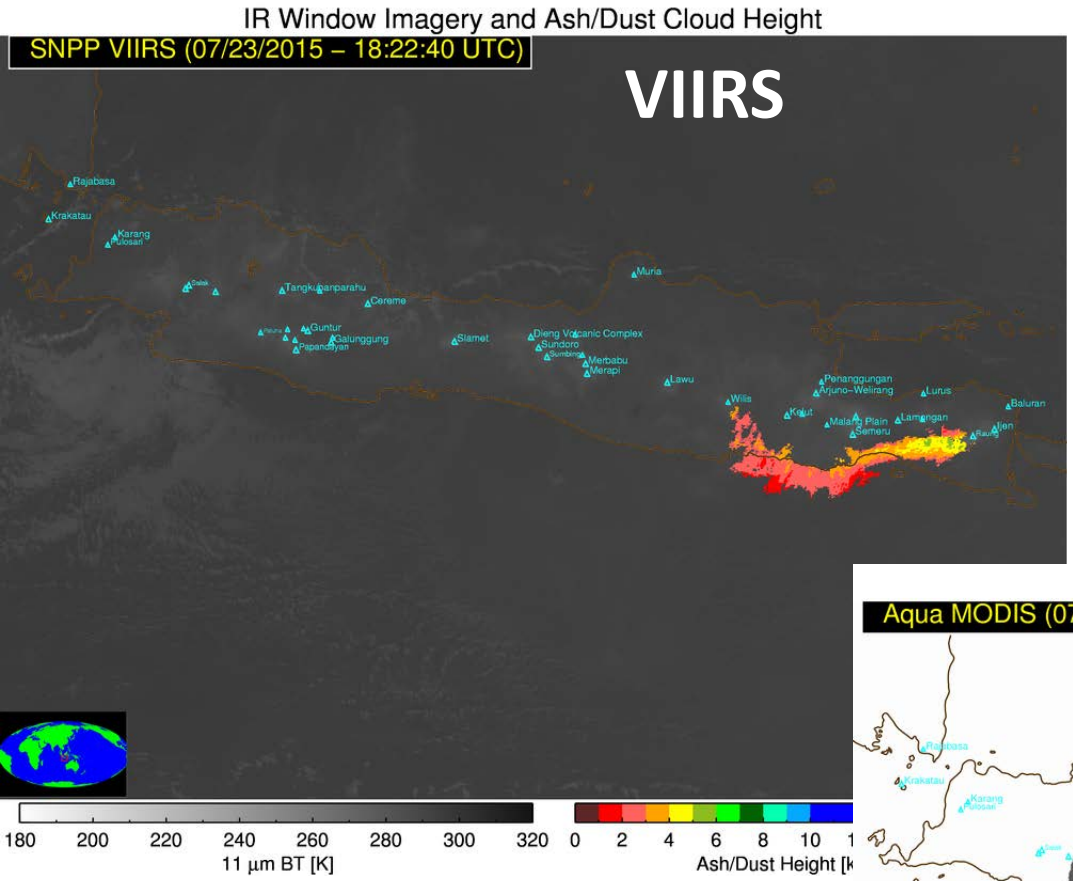
Detect and characterize

Ubinas (Peru): June 30, 2015

Raung (Indonesia)
July 23, 2015

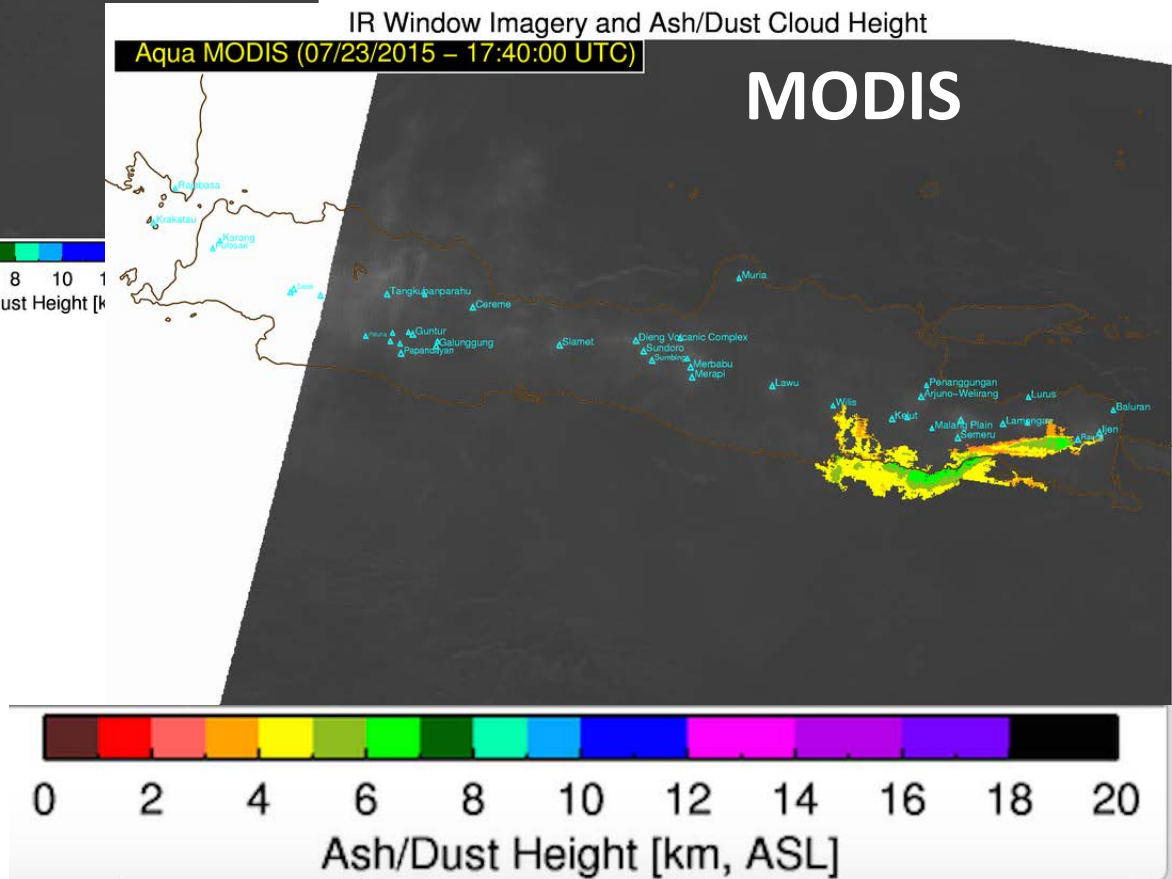




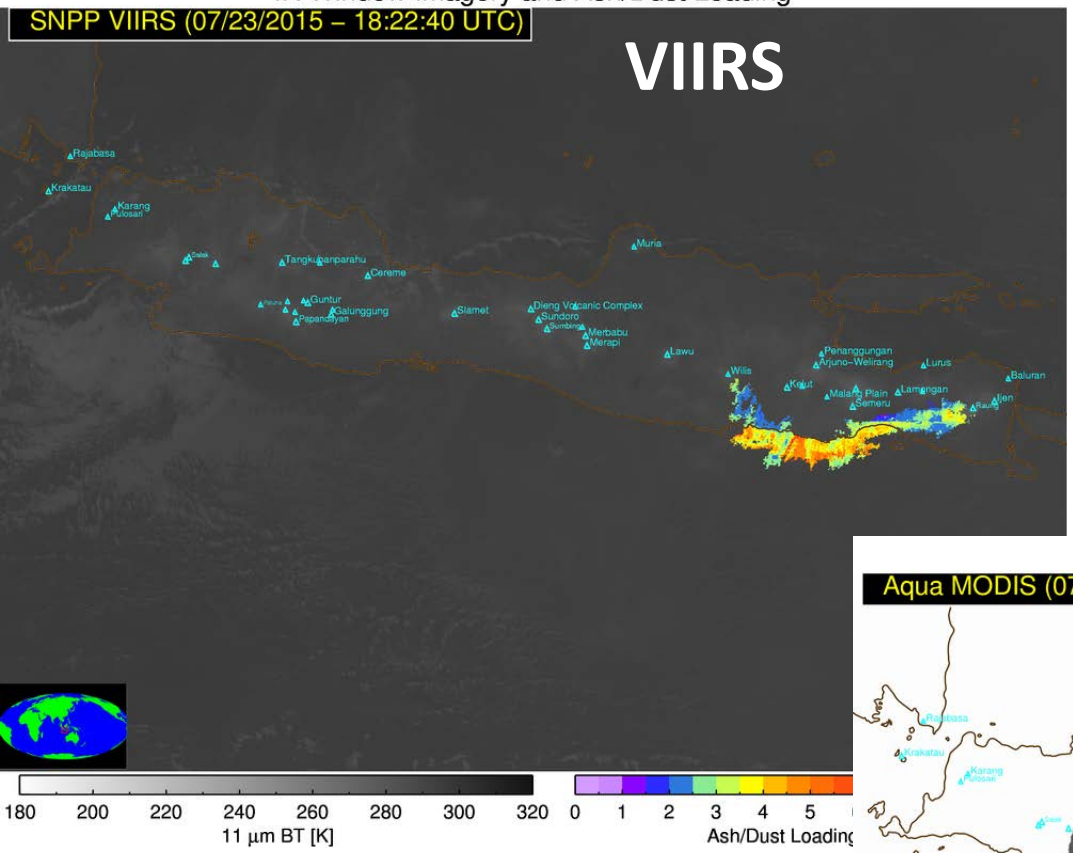


Raung (Indonesia)
July 23, 2015

Ash Cloud Height



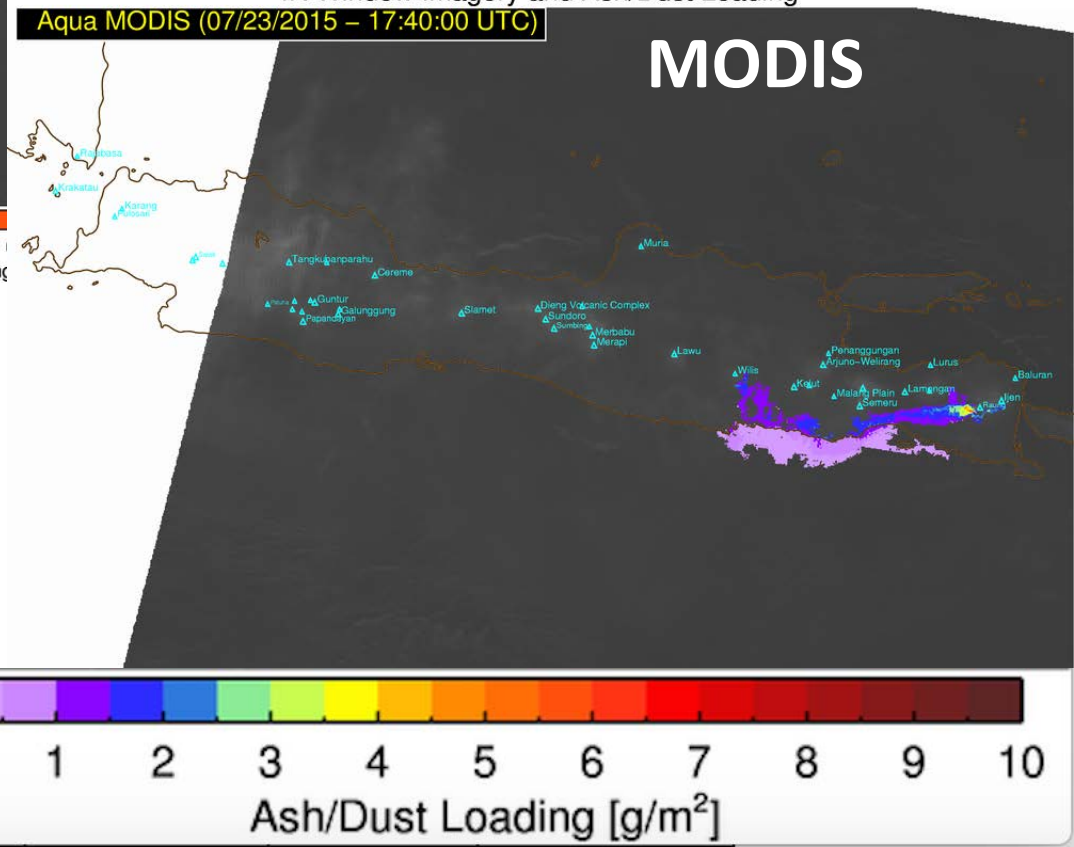
IR Window Imagery and Ash/Dust Loading



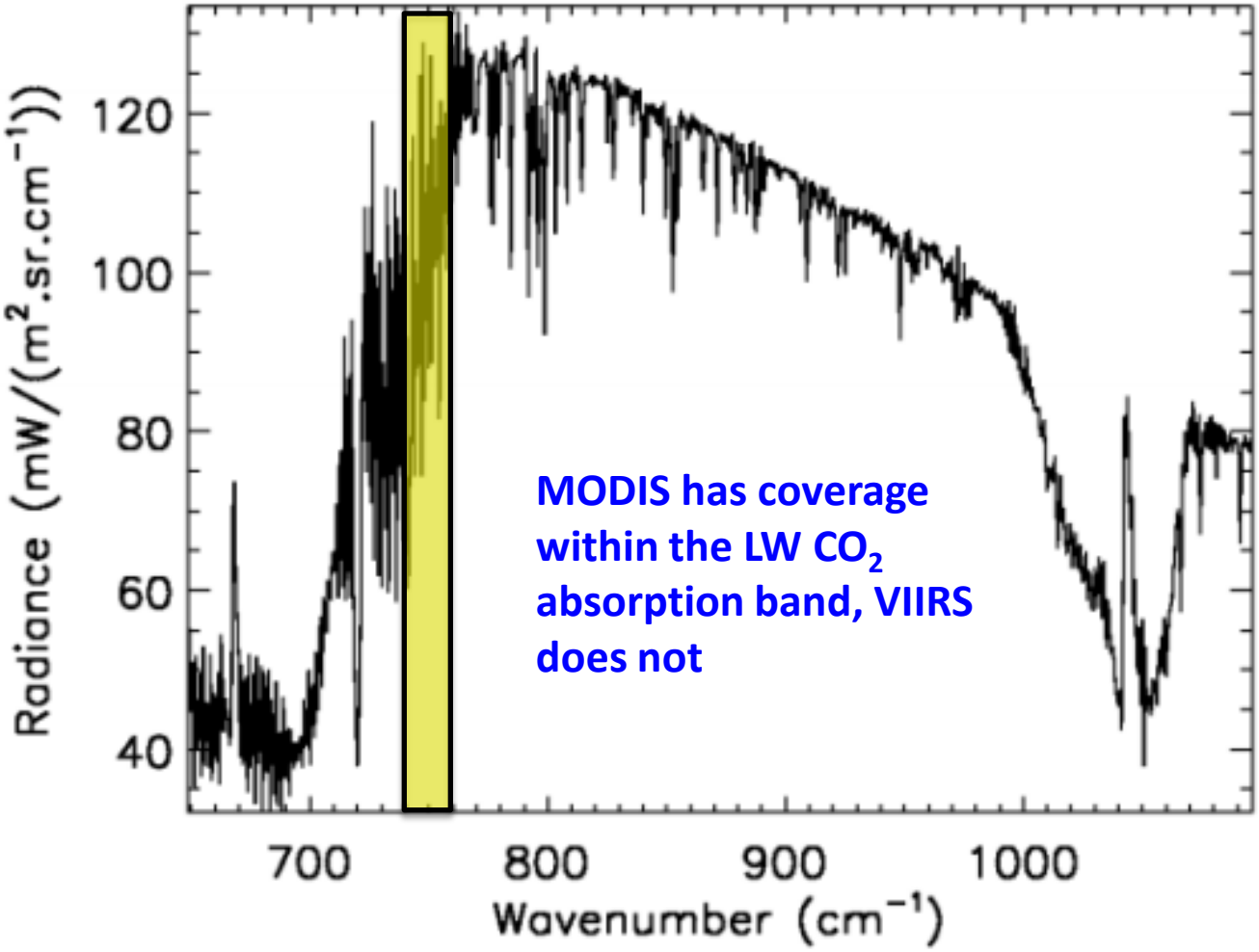
Raung (Indonesia)
July 23, 2015

Ash Mass Loading

IR Window Imagery and Ash/Dust Loading



Absorption channels are needed to gain sensitivity to cloud height - VIIRS + CrIS can be used to obtain high quality IR-based cloud property retrievals



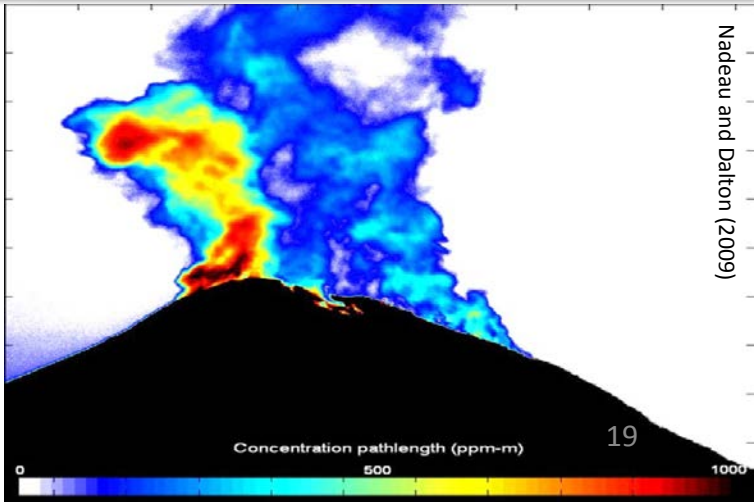
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Calbucco, Chile
April 22-23, 2015

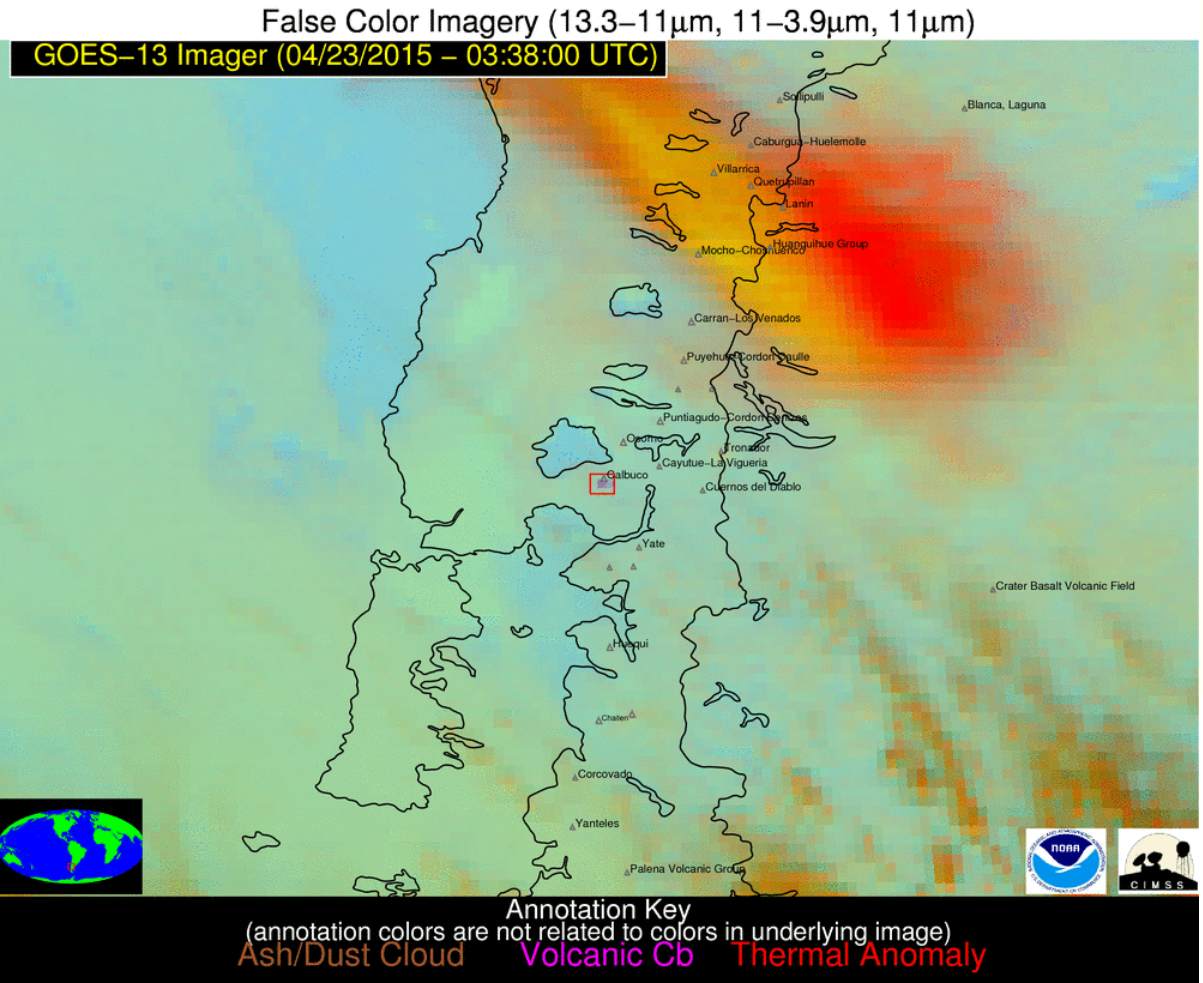






Geostationary satellites are needed for timely detection of explosive eruptions, but JPSS adds significant value – benefit of a multi-sensor/ multi-orbit approach

Possible Volcanic Cb

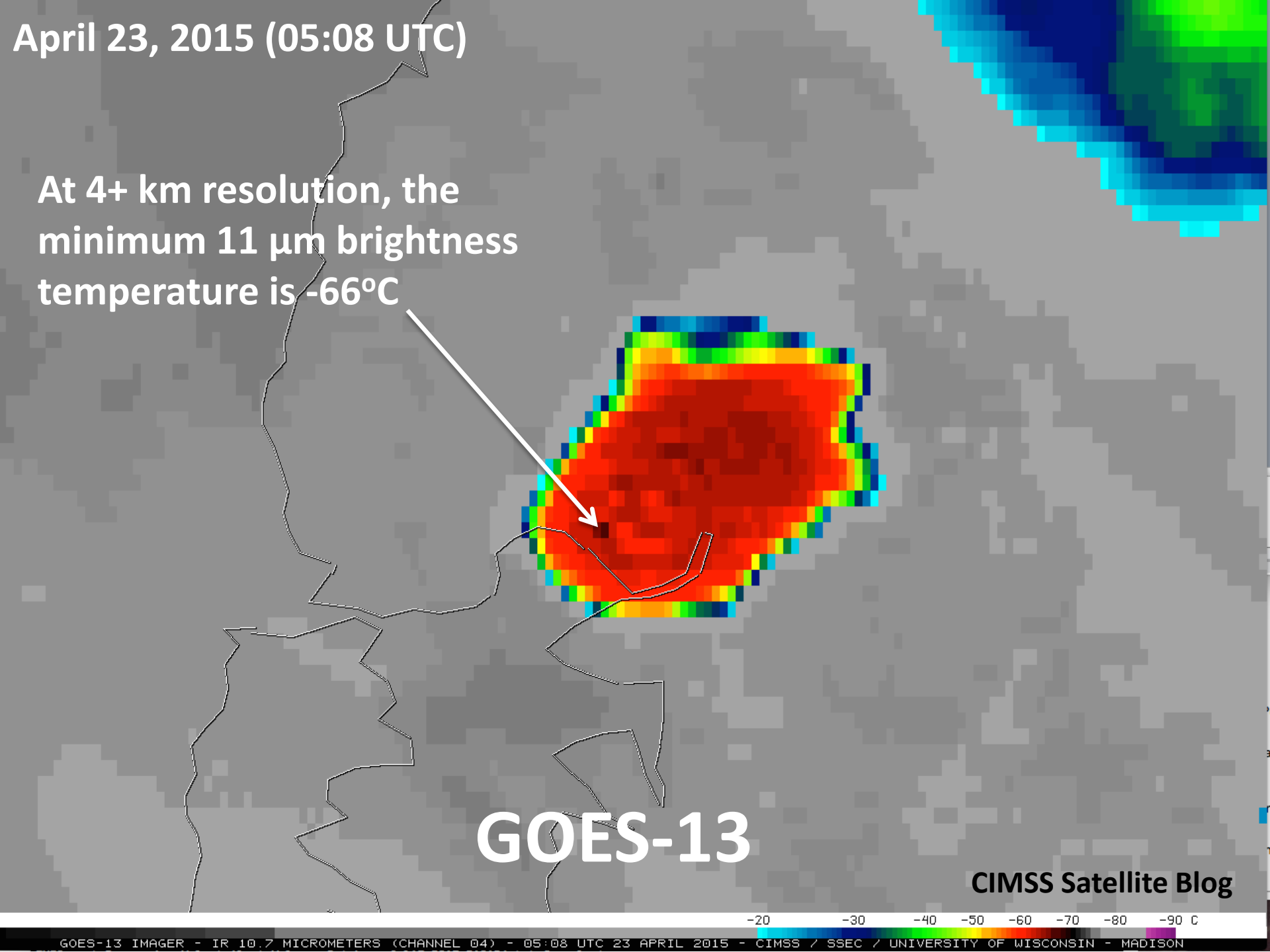


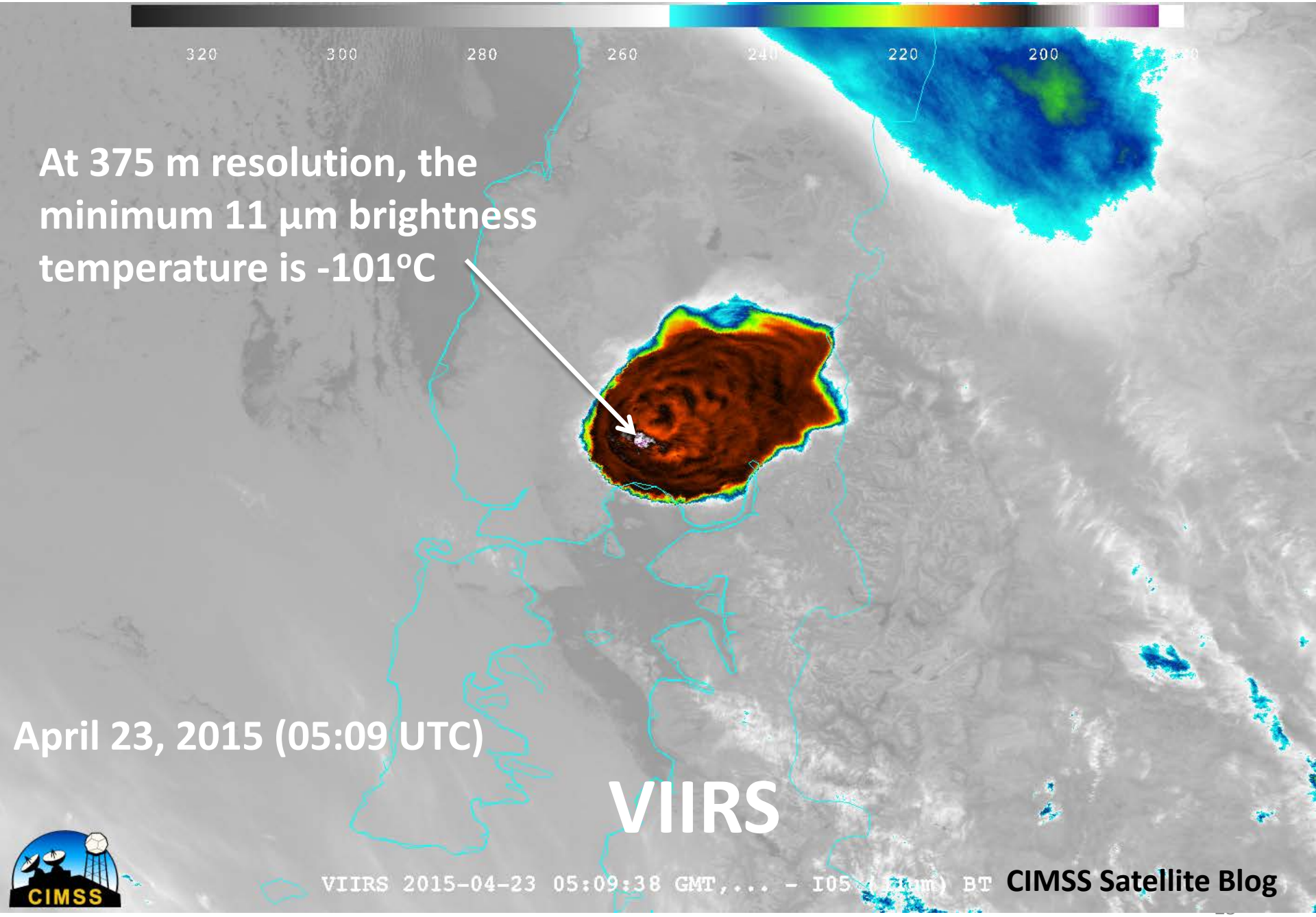
Basic Information

VAAC Regions of Nearby Volcanoes	Buenos Aires
Mean Object Date/Time	2015-04-23 04:11:48UTC
Radiative Center (Lat, Lon):	-41.310 °, -72.570 °
Nearby Volcanoes (meeting alert criteria):	Calbuco (3.20 km)
Trend in IR Brightness Temperature	-59.50 °C
Vertical Growth Rate Time Interval	30 minutes
Vertical Growth Rate Anomaly	11.50 number of stddev above mean
Total Area	515.00 km^2

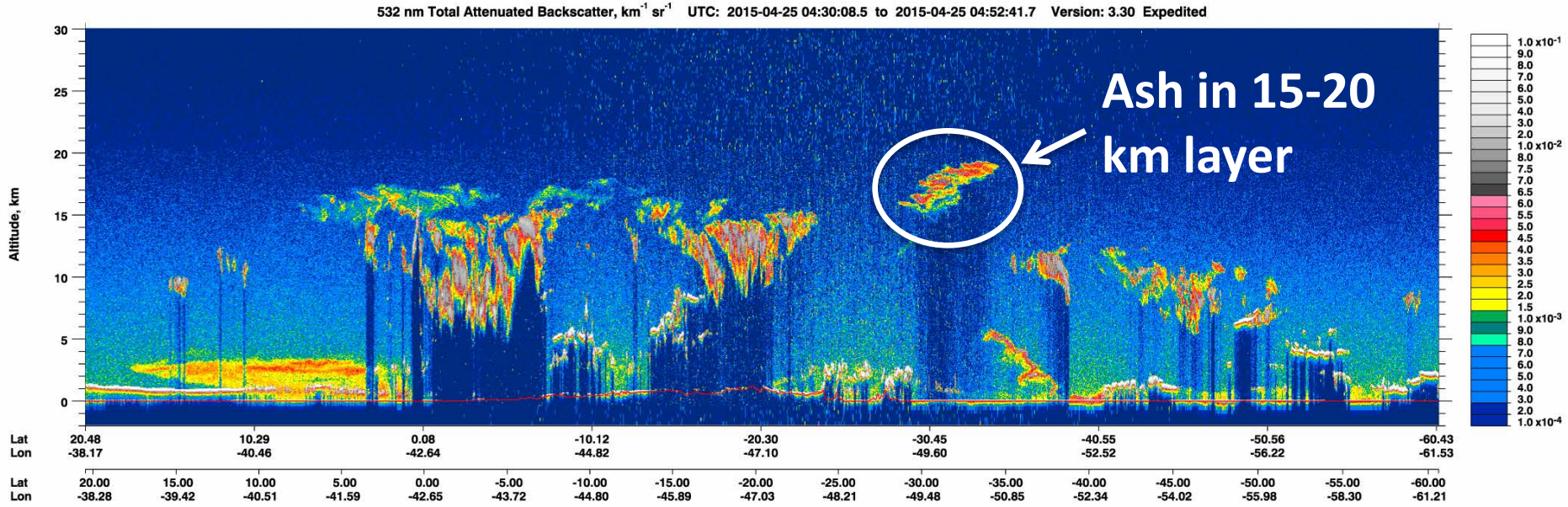
Additional Information

Alert Status	New Alert Object
Mean Viewing Angle	48.10 °
Mean Solar Zenith Angle	149.50 °
Maximum Height [AMSL]	11.70 km; 38386 ft
90th Percentile Height [AMSL]	11.10 km; 36417 ft
Mean Tropopause Height [AMSL]	12.10 km; 39698 ft
Geographic Regions of Nearby Volcanoes	Chile-S


April 23, 2015 (05:08 UTC)
At 4+ km resolution, the minimum 11 µm brightness temperature is -66°C
GOES-13
CIMSS Satellite Blog
-20 -30 -40 -50 -60 -70 -80 -90 C
GOES-13 IMAGER - IR 10.7 MICROMETERS (CHANNEL 04) - 05:08 UTC 23 APRIL 2015 - CIMSS / SSEC / UNIVERSITY OF WISCONSIN - MADISON


320
300
280
260
240
220
200
At 375 m resolution, the minimum 11 µm brightness temperature is -101°C
April 23, 2015 (05:09 UTC)
VIIRS
VIIRS 2015-04-23 05:09:38 GMT,... - I05 (µm) BT
CIMSS
CIMSS Satellite Blog

NASA's CALIOP lidar later verified that ash was present at least up to 20 km!



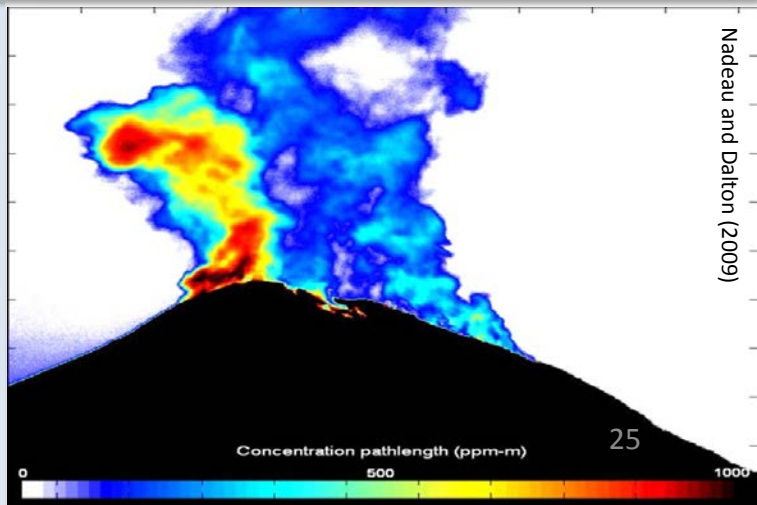
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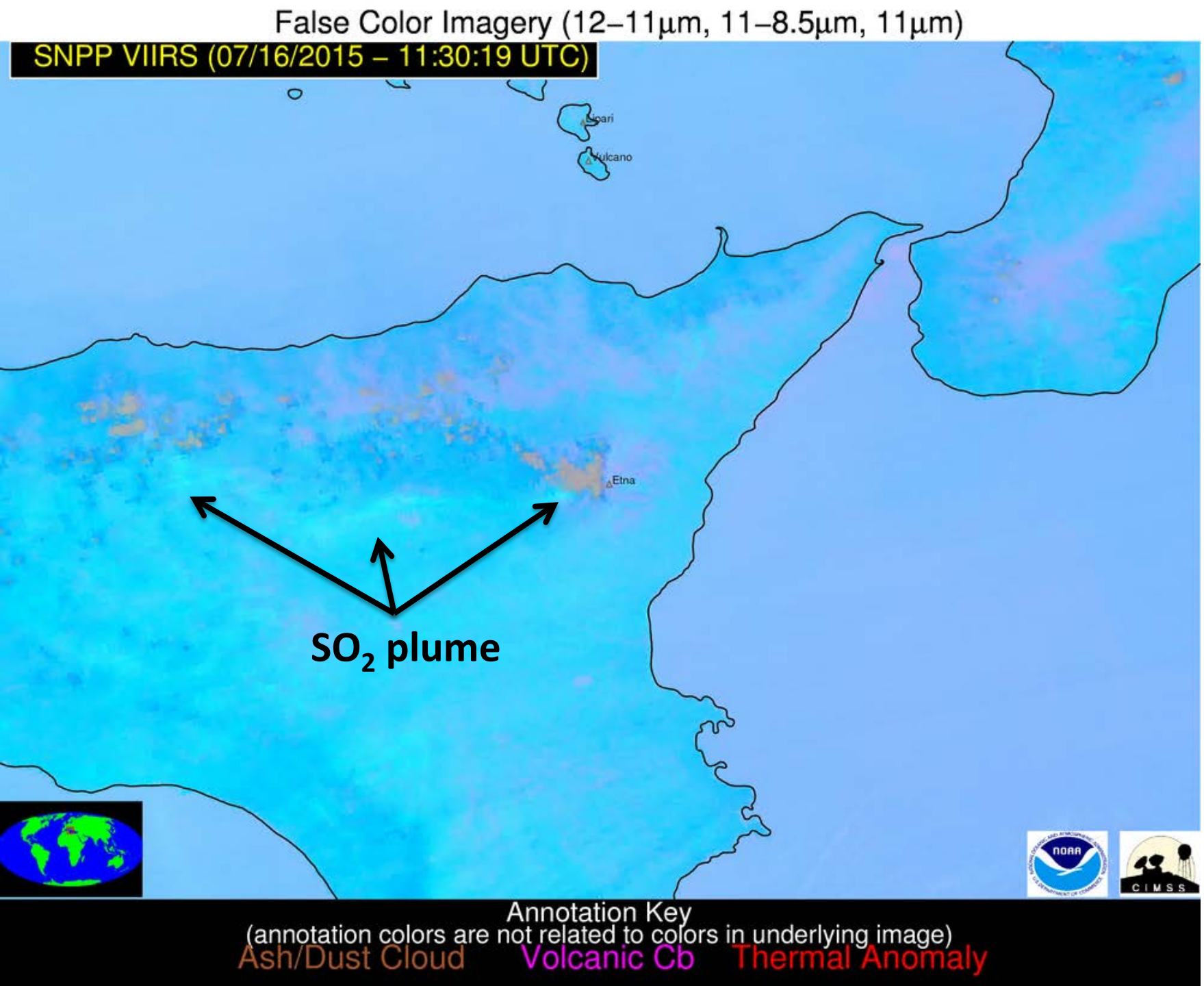


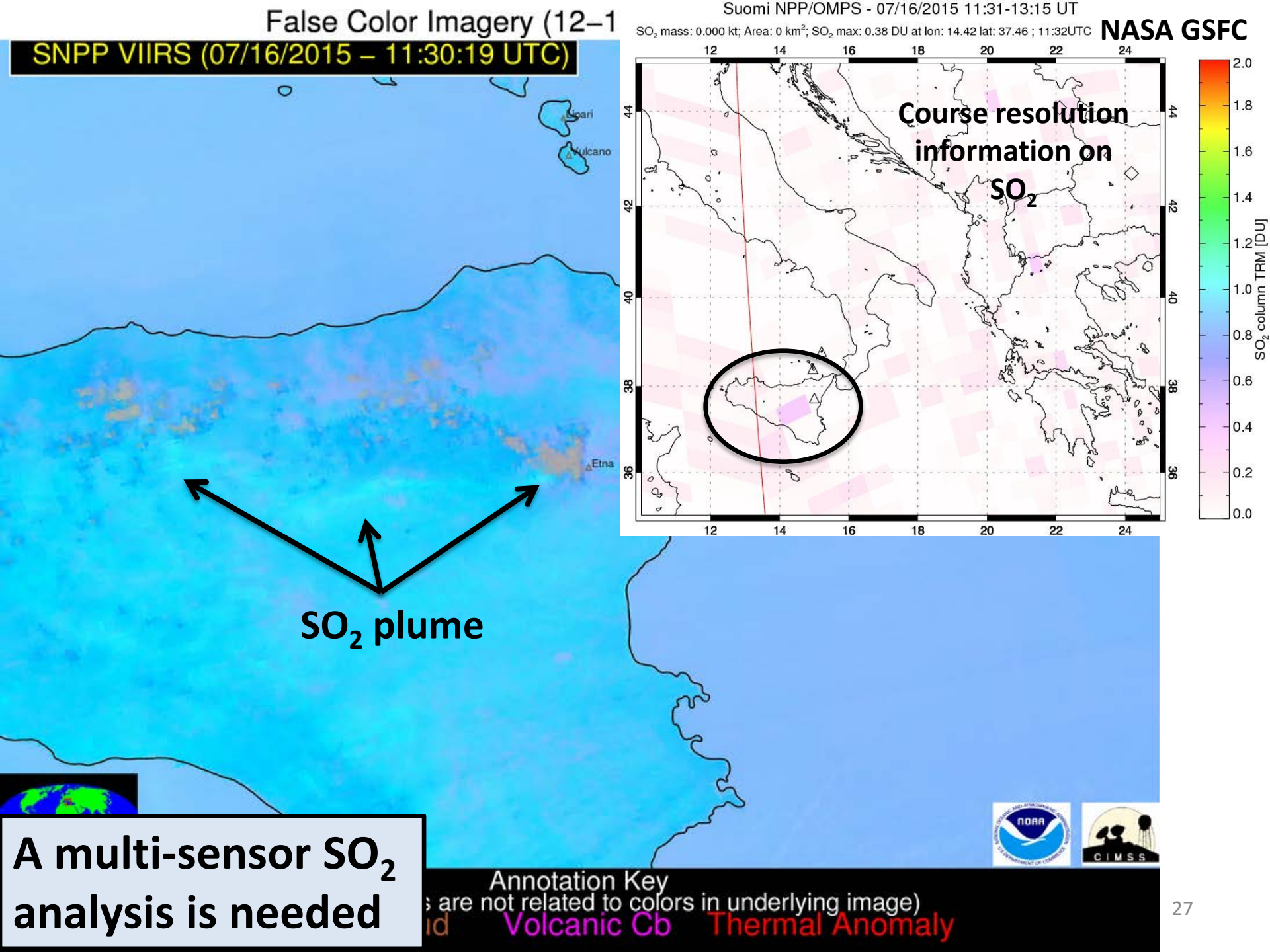
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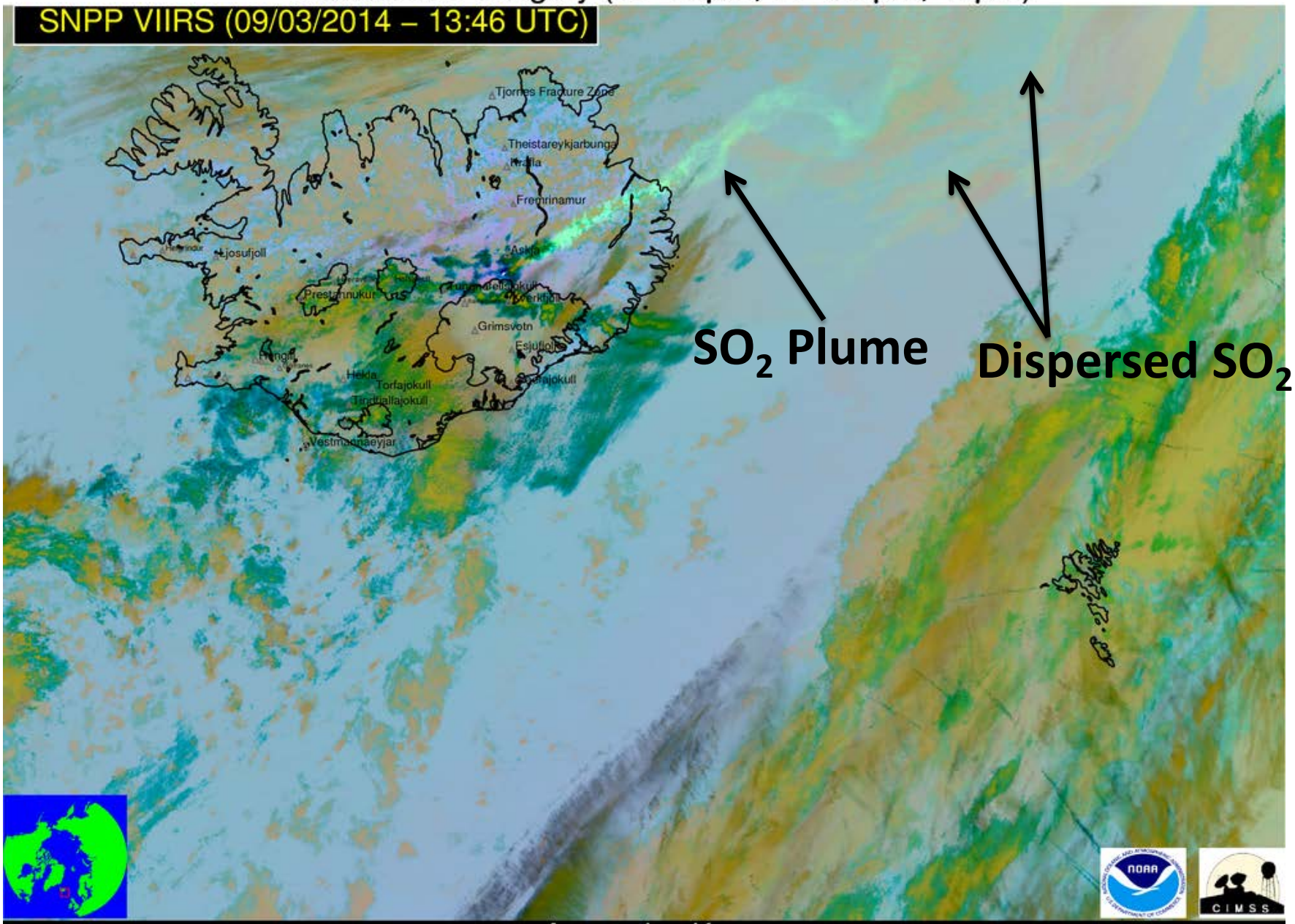



False Color Imagery (12–11μm, 11–8.5μm, 11μm)
SNPP VIIRS (07/16/2015 – 11:30:19 UTC)
Stromboli
Vulcano
Etna
SO2 plume
NOAA
CIMSS
Annotation Key
(annotation colors are not related to colors in underlying image)
Ash/Dust Cloud
Volcanic Cb
Thermal Anomaly

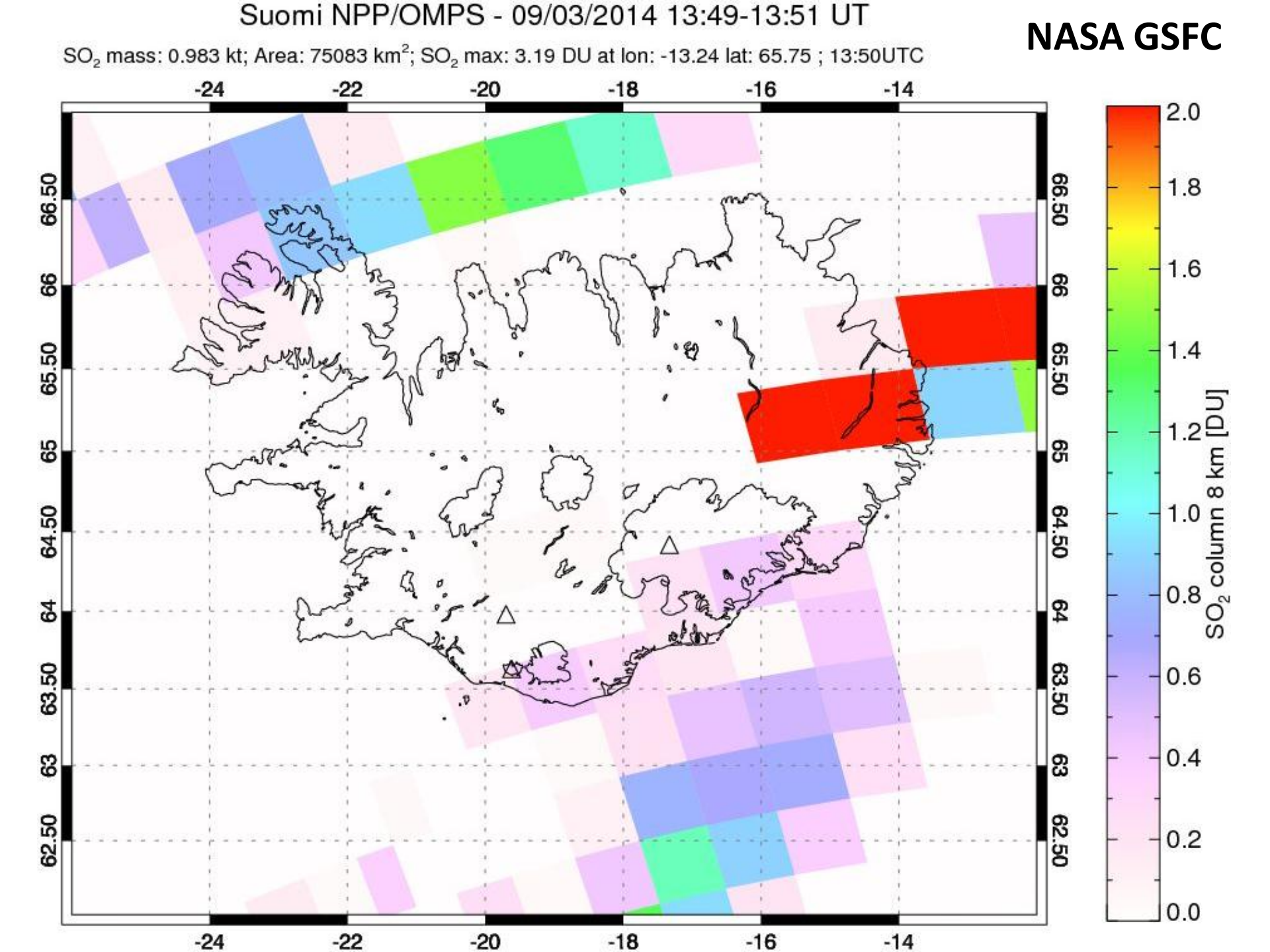


A multi-sensor SO_2 analysis is needed

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


Suomi NPP/OMPS - 09/03/2014 13:49-13:51 UT
SO2 mass: 0.983 kt; Area: 75083 km2; SO2 max: 3.19 DU at lon: -13.24 lat: 65.75 ; 13:50UTC
NASA GSFC
-24
-22
-20
-18
-16
-14
66.50
66
65.50
65
64.50
64
63.50
63
62.50
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
SO2 column 8 km [DU]

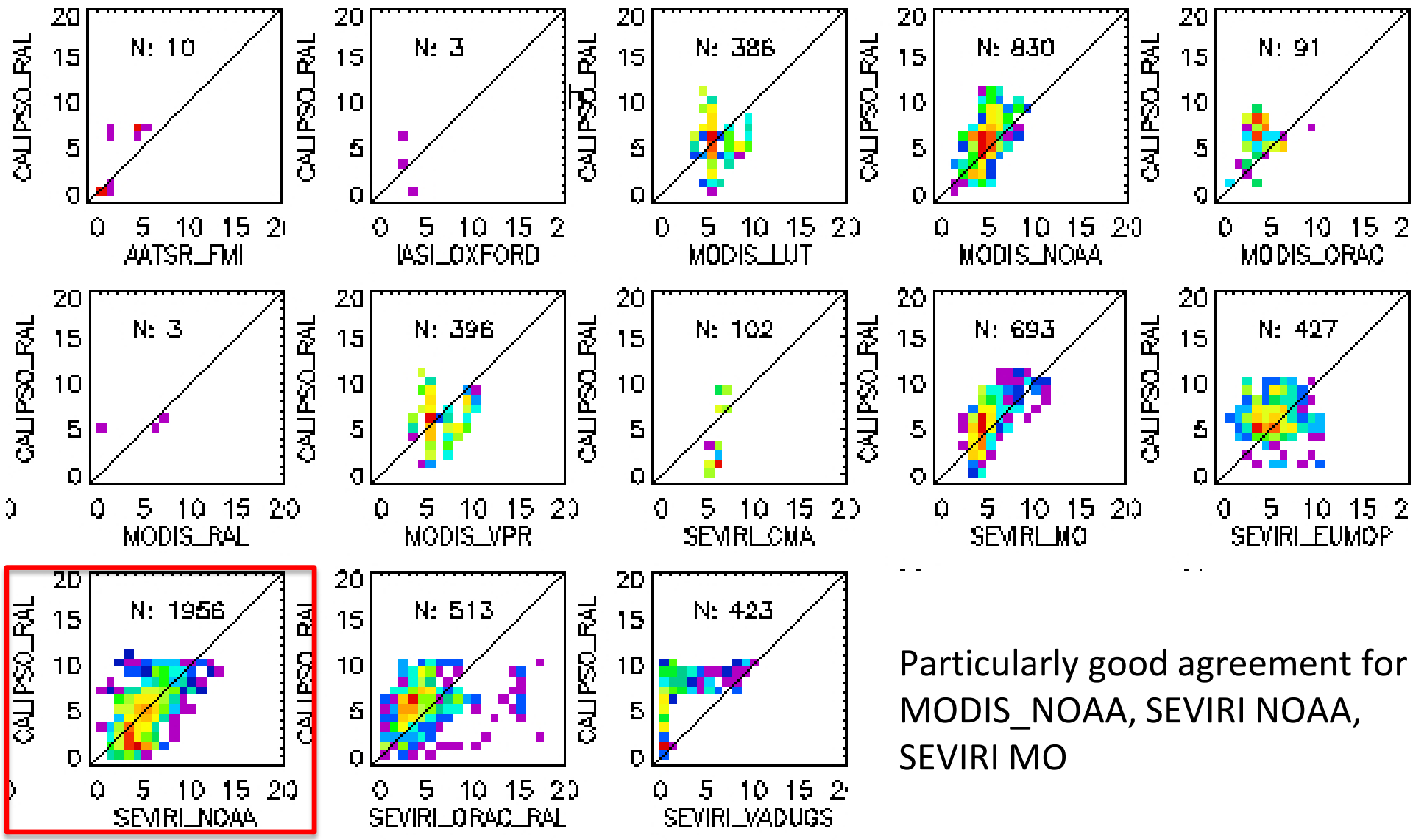


WMO Intercomparison of Satellite-based Volcanic Ash Retrieval Algorithms Workshop

29 June - 2 July 2015
The Pyle Center
University of Wisconsin-Madison

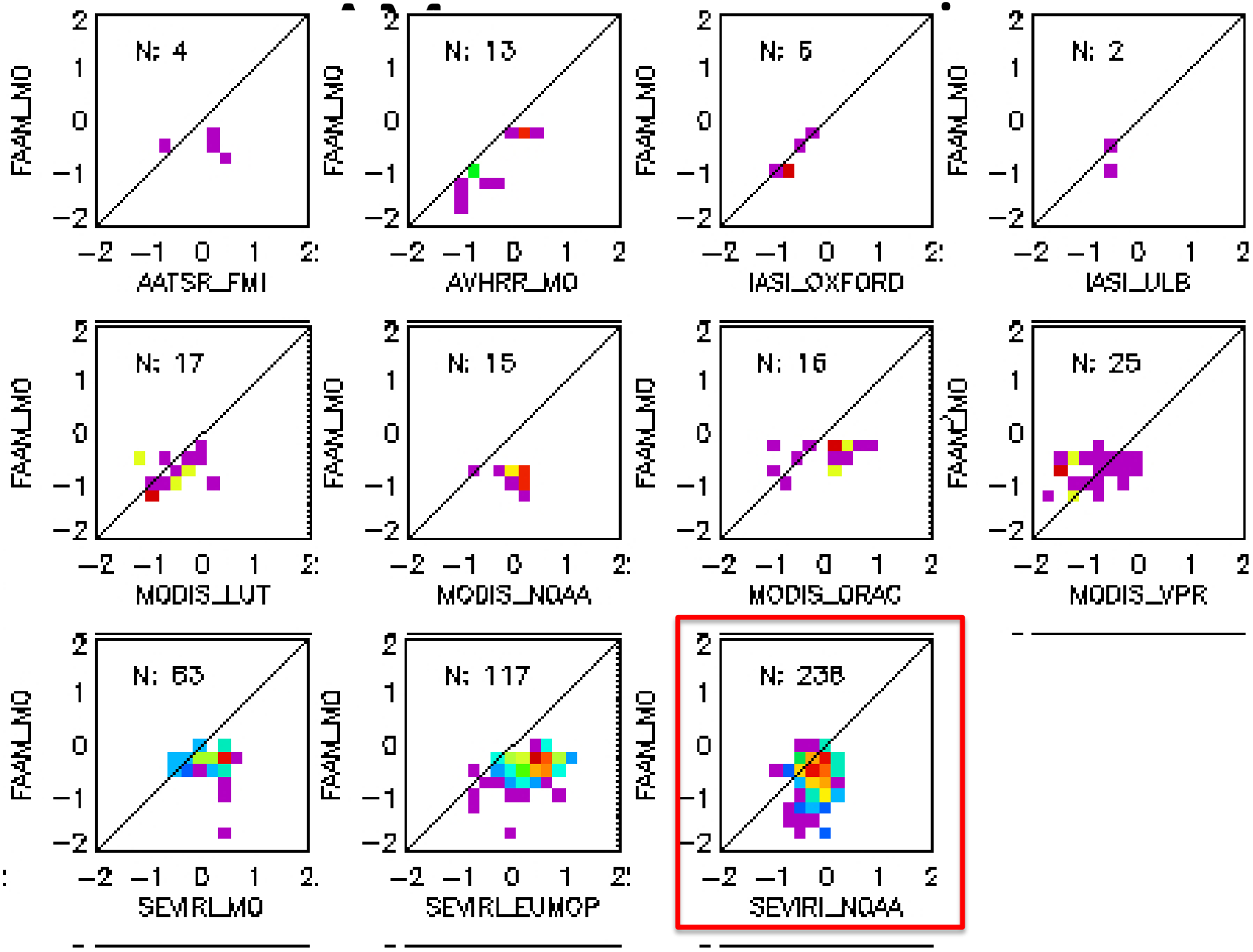


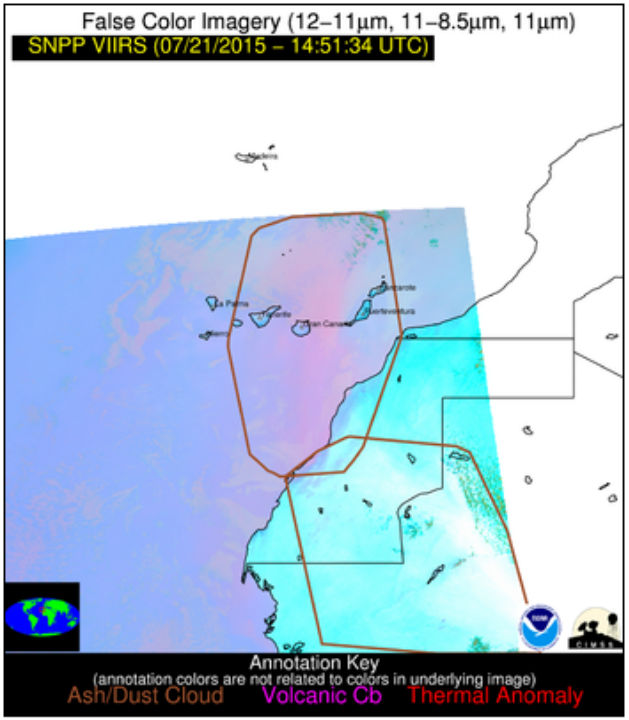
CALIOP Ash Cloud Height Validation

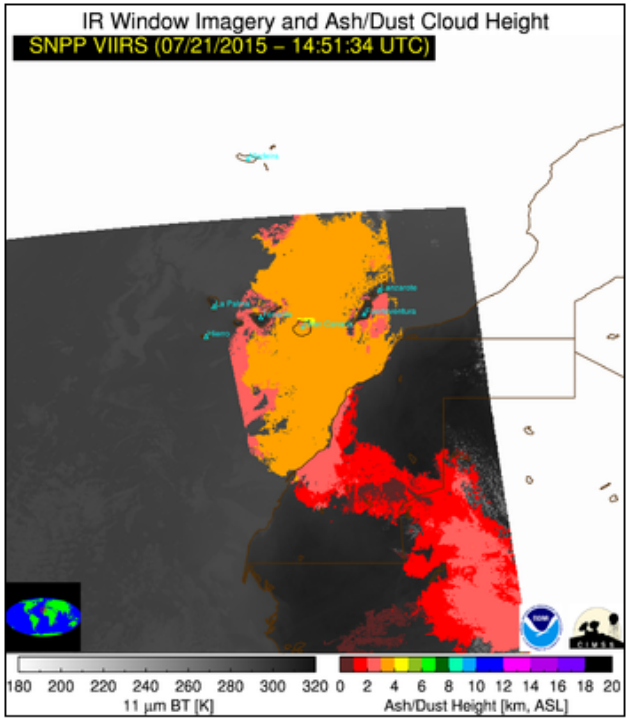


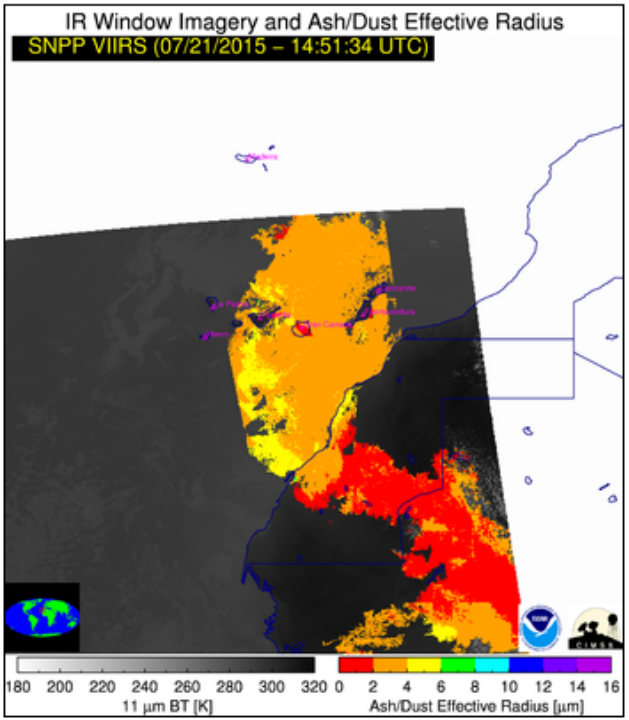
Particularly good agreement for MODIS_NOAA, SEVIRI NOAA, SEVIRI MO

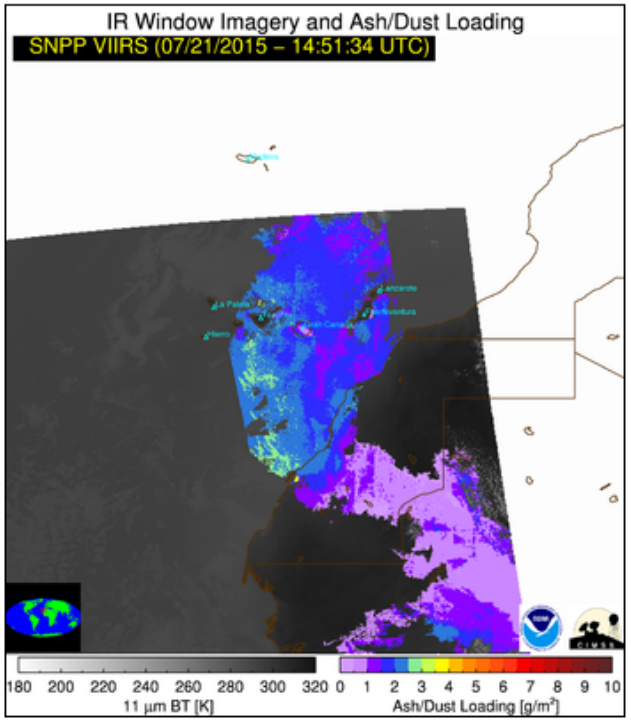
Aircraft-based Ash Mass Loading Validation









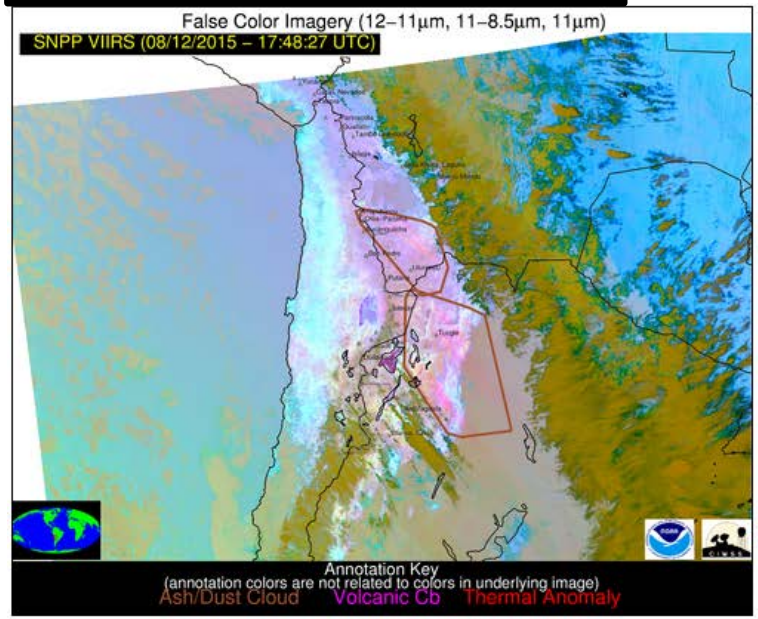


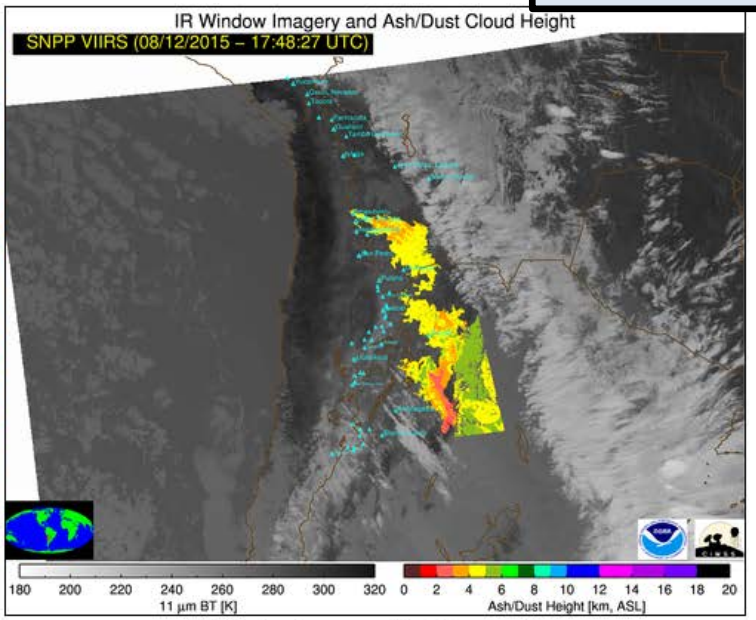
Application to desert dust

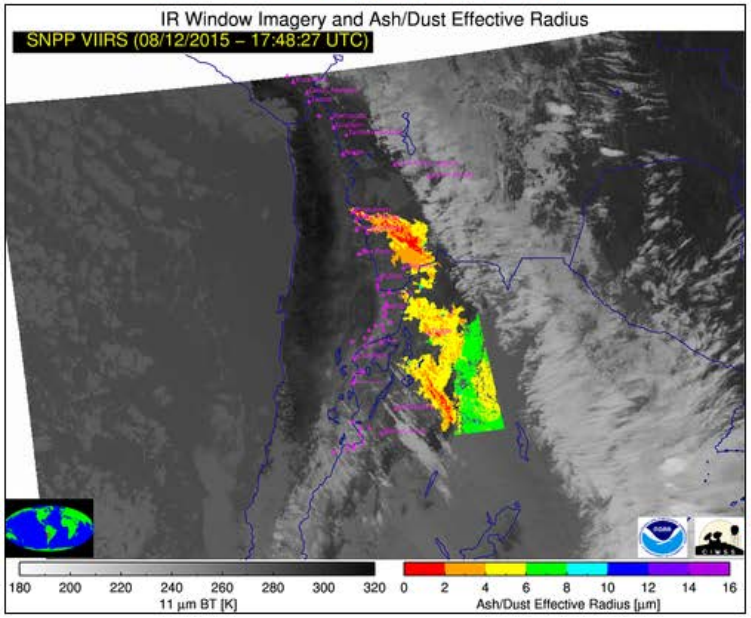
Day and night, Land and water

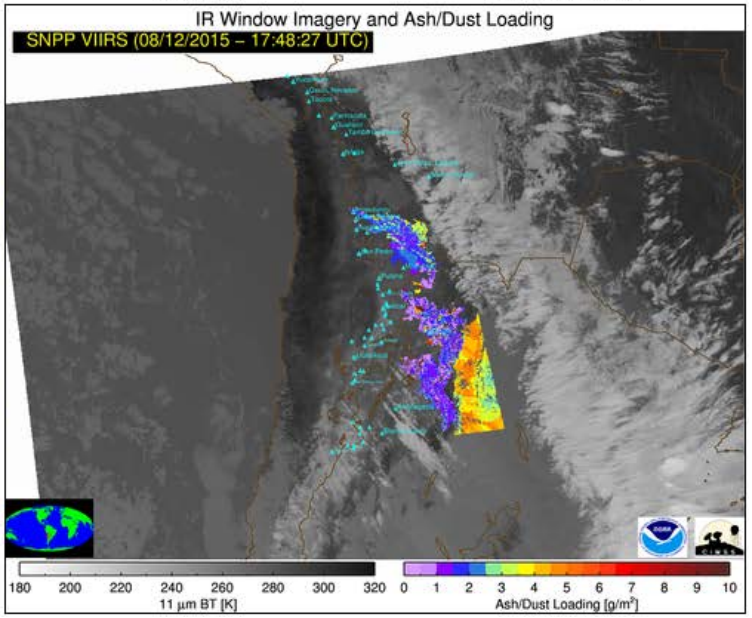
Application to desert dust

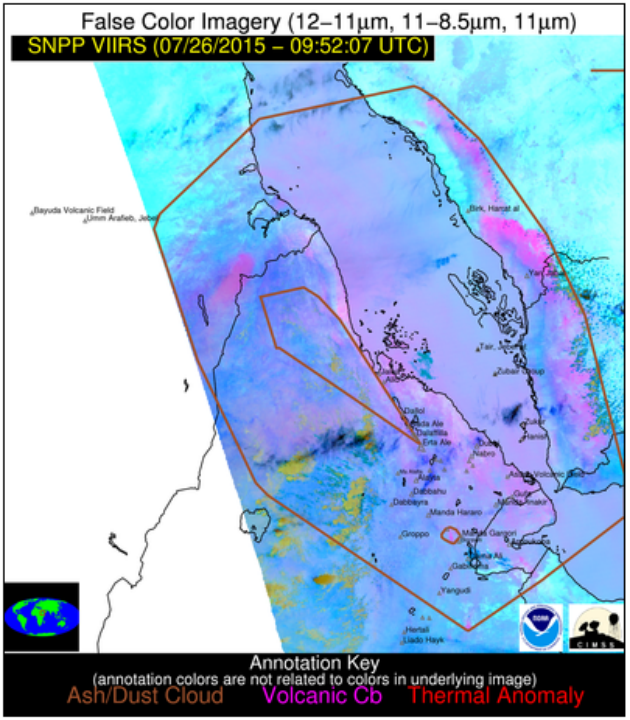
Day and night, Land and water

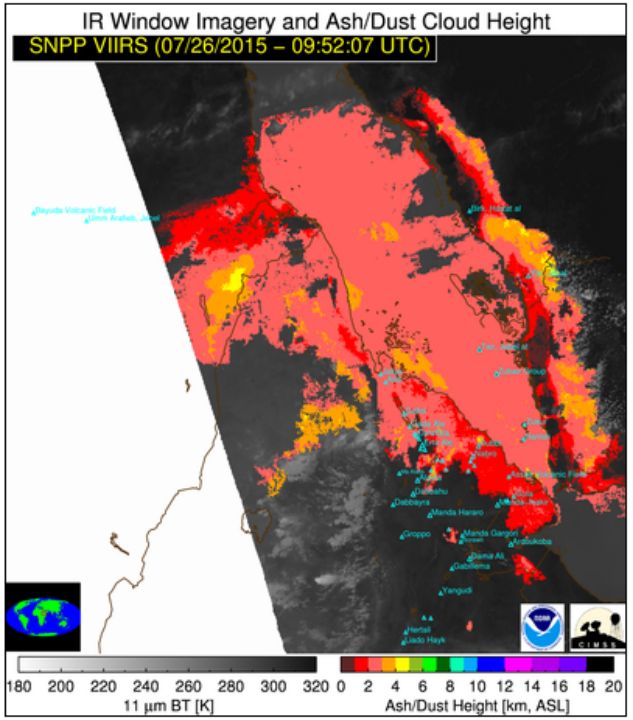


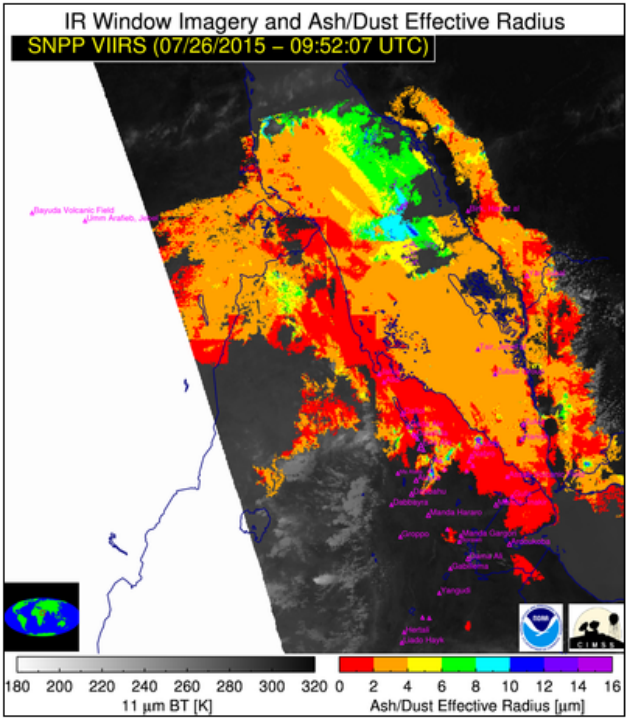


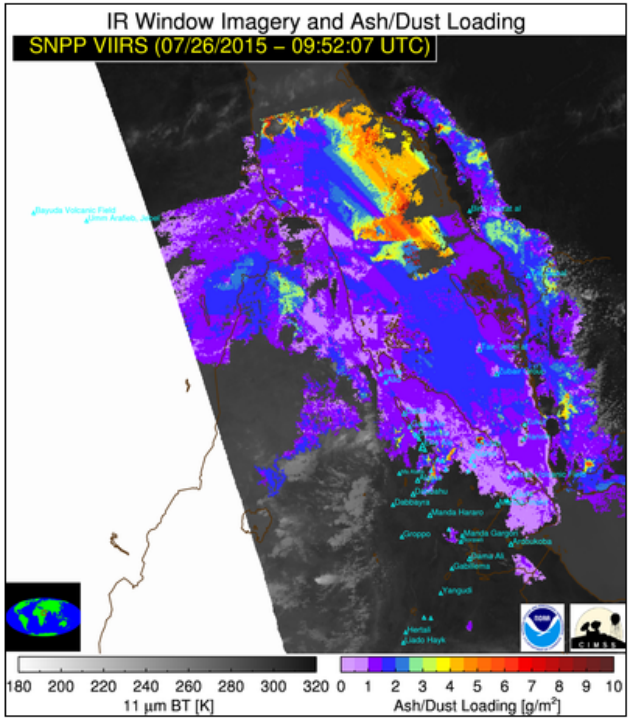












Application to desert dust

Day and night, Land and water

Summary

- **In the era of "Big Data" automation is critical for generating environmental intelligence for mitigating natural hazards**
- **Low latency (< 20 minutes) data are critical (need to utilize DB sites to the fullest extent)**
- **The IDPS aerosol and VCM products are not well suited for volcanic cloud applications across the full spectrum of cloud types. The JPSS Risk Reduction projects are a significant improvement, but the multi-sensor VOLCAT system is the long-term solution.**







References

- Pavolonis, M. J., W. F. Feltz, A. K. Heidinger, and G. M. Gallina, 2006: A daytime complement to the reverse absorption technique for improved automated detection of volcanic ash. J.Atmos.Ocean.Technol., 23, 1422-1444.

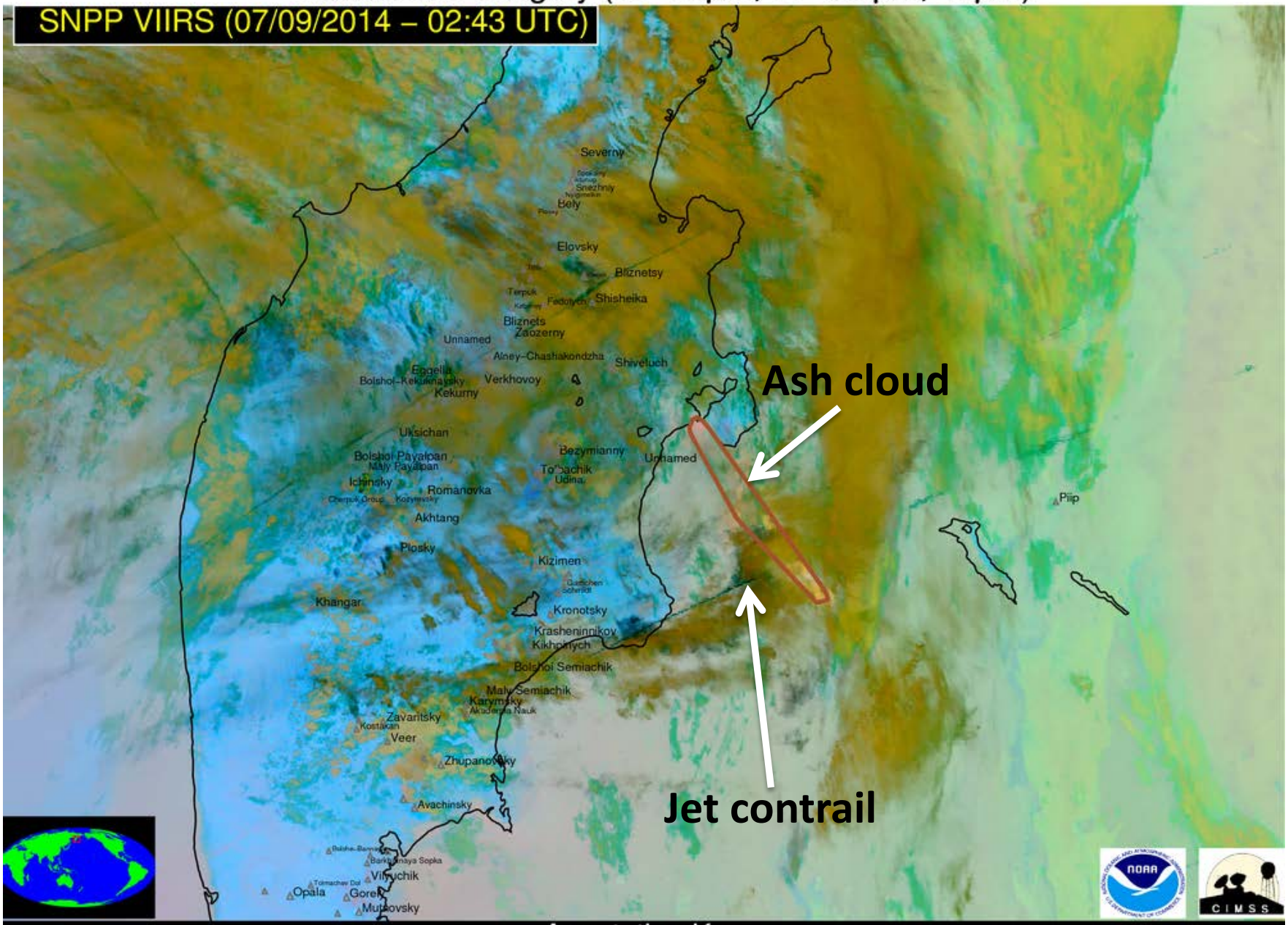
- Pavolonis, M. J., 2010: Advances in Extracting Cloud Composition Information from Spaceborne Infrared Radiances-A Robust Alternative to Brightness Temperatures. Part I: Theory. Journal of Applied Meteorology and Climatology, 49, 1992-2012, doi:10.1175/2010JAMC2433.1 ER.

- Pavolonis, M., A. Heidinger, and J. Sieglaff, 2013: Automated retrievals of volcanic ash and dust cloud properties from upwelling infrared measurements, J. Geophysical Research, 118(3), 1436-1458.

- Pavolonis, M., J. Sieglaff, and J. Cintineo (2015a), Spectrally Enhanced Cloud Objects (SECO): A Generalized Framework for Automated Detection of Volcanic Ash and Dust Clouds using Passive Satellite Measurements, Part I: Multispectral Analysis, Journal Geophysical Research, In Press.

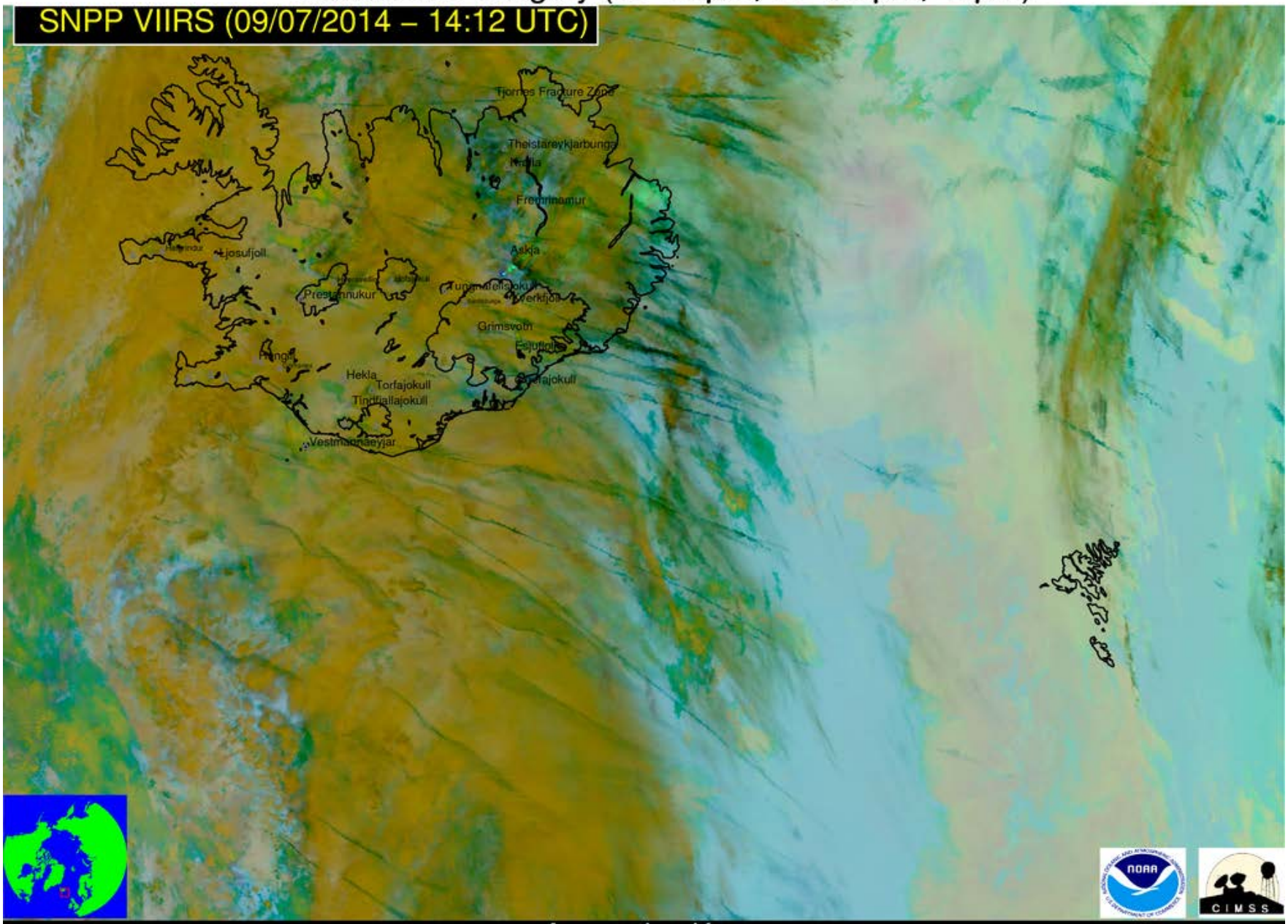
- Pavolonis, M., J. Sieglaff, and J. Cintineo (2015b) Spectrally Enhanced Cloud Objects (SECO): A Generalized Framework for Automated Detection of Volcanic Ash and Dust Clouds using Passive Satellite Measurements, Part II: Cloud Object Analysis and Global Application, Journal Geophysical Research, In Press.

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



Kelut Eruption (February 13, 2014)

112°E 113°E

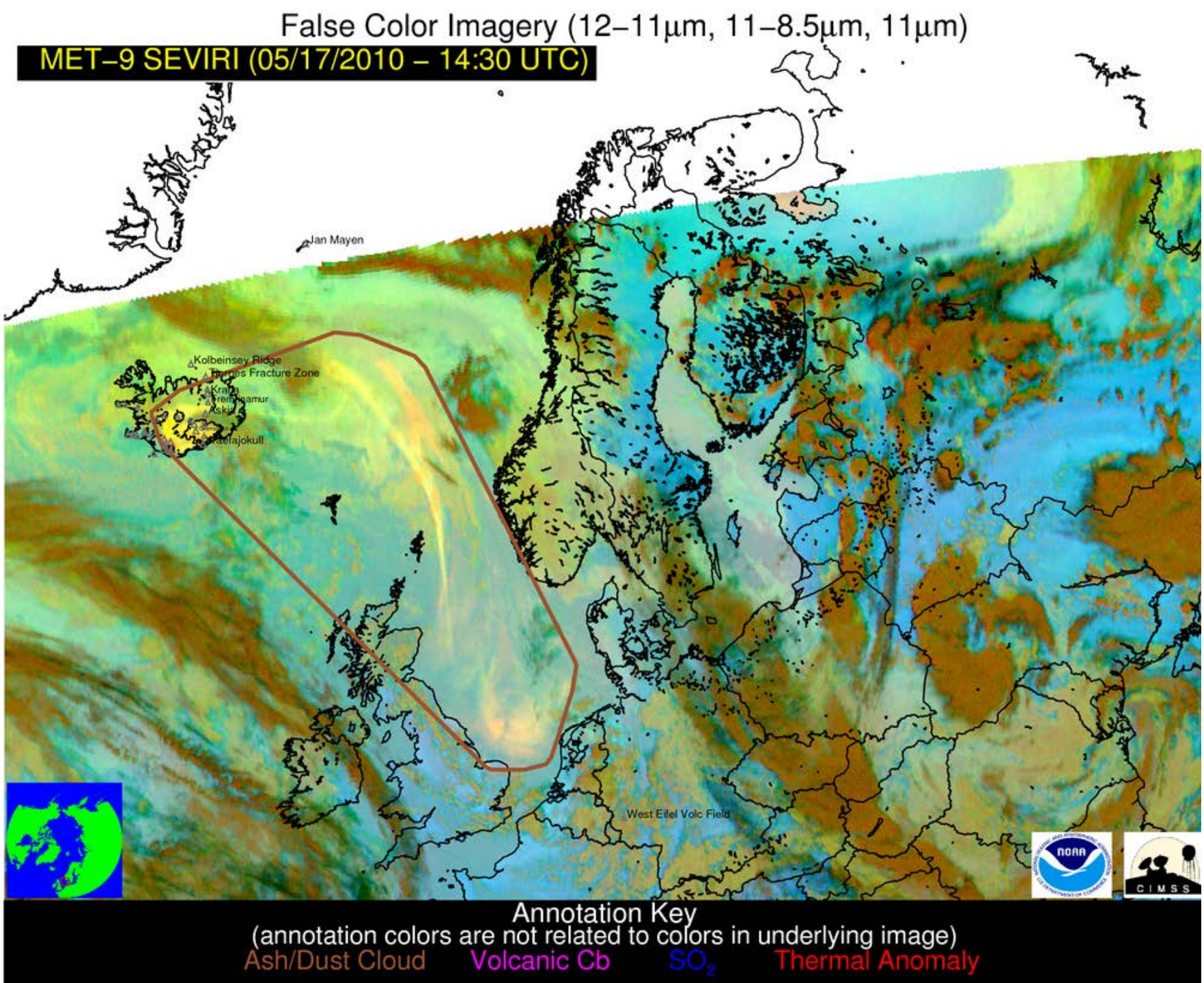
7°S 8°S 9°S

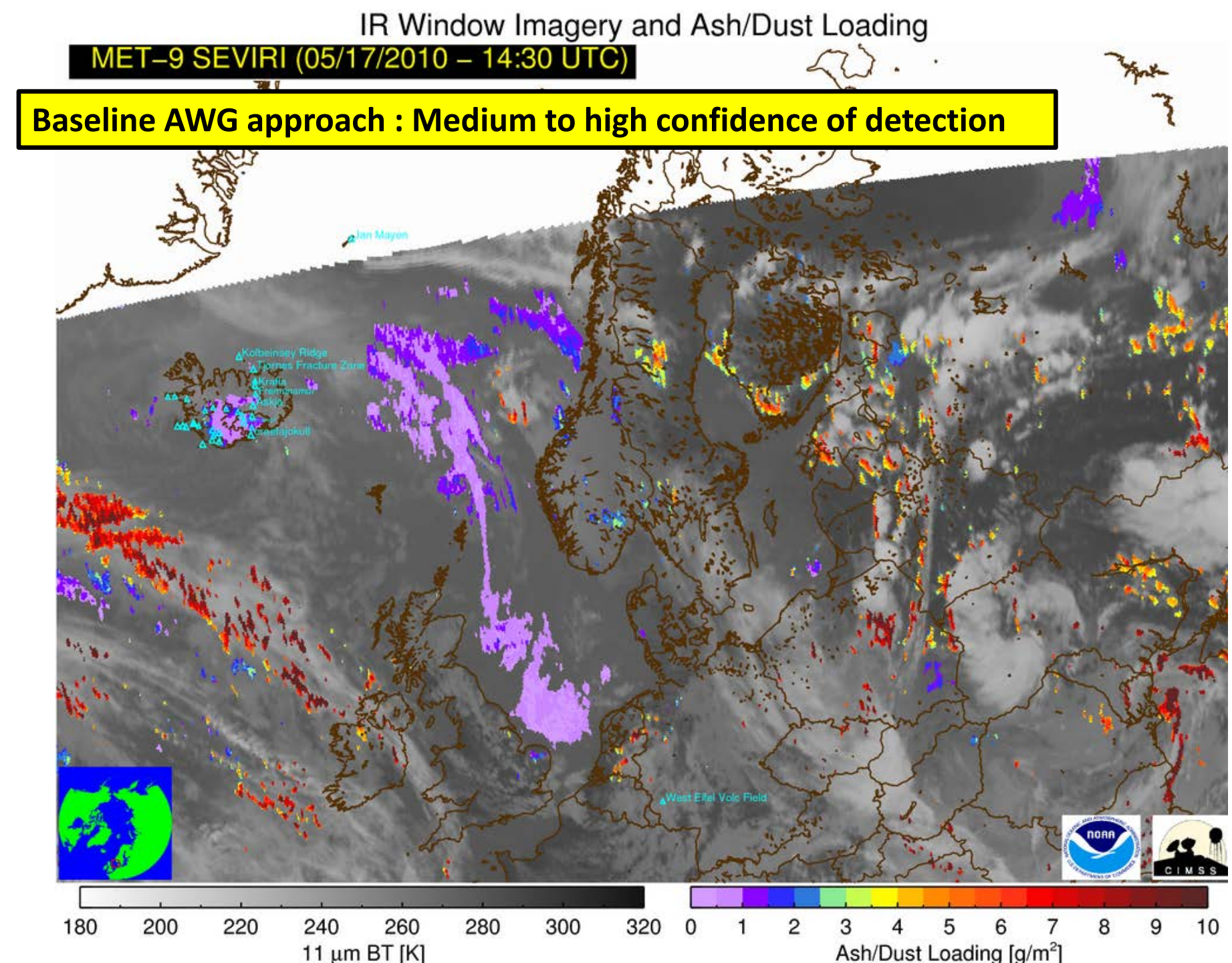
111°E 112°E

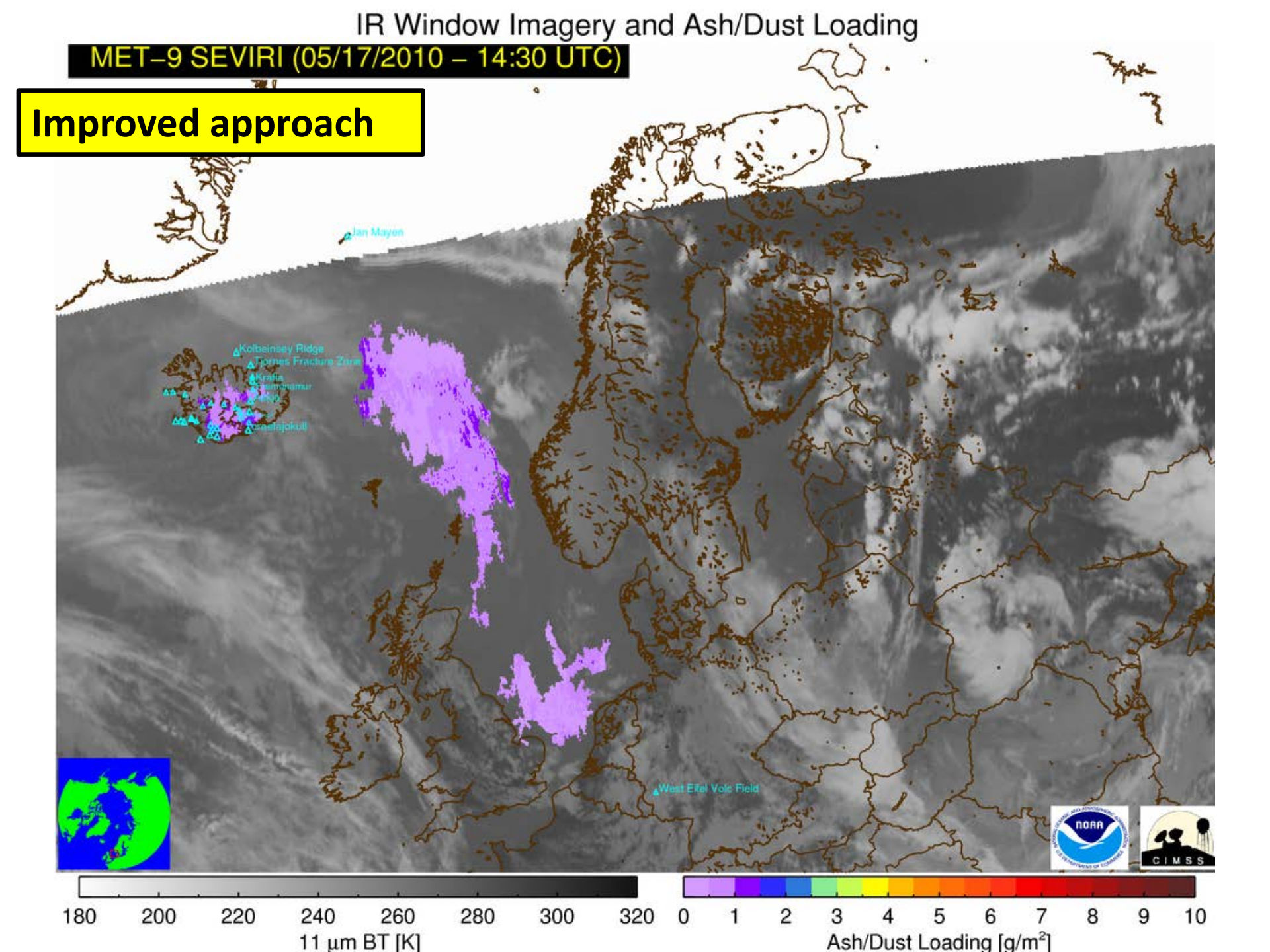
50 km

2014-02-13 17:30 UTC VIIRS Suomi-NPP
Martin Setvák, CHMI

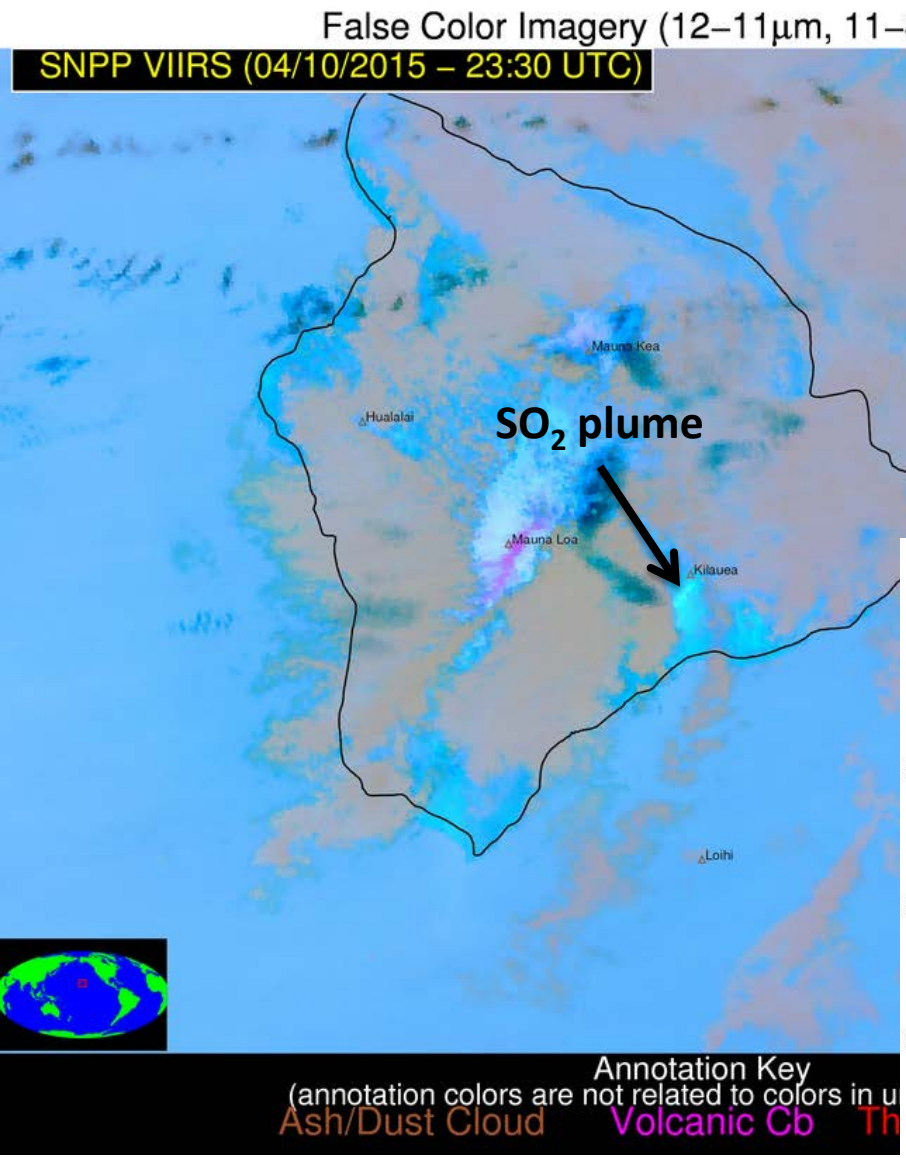
Martin Setvak

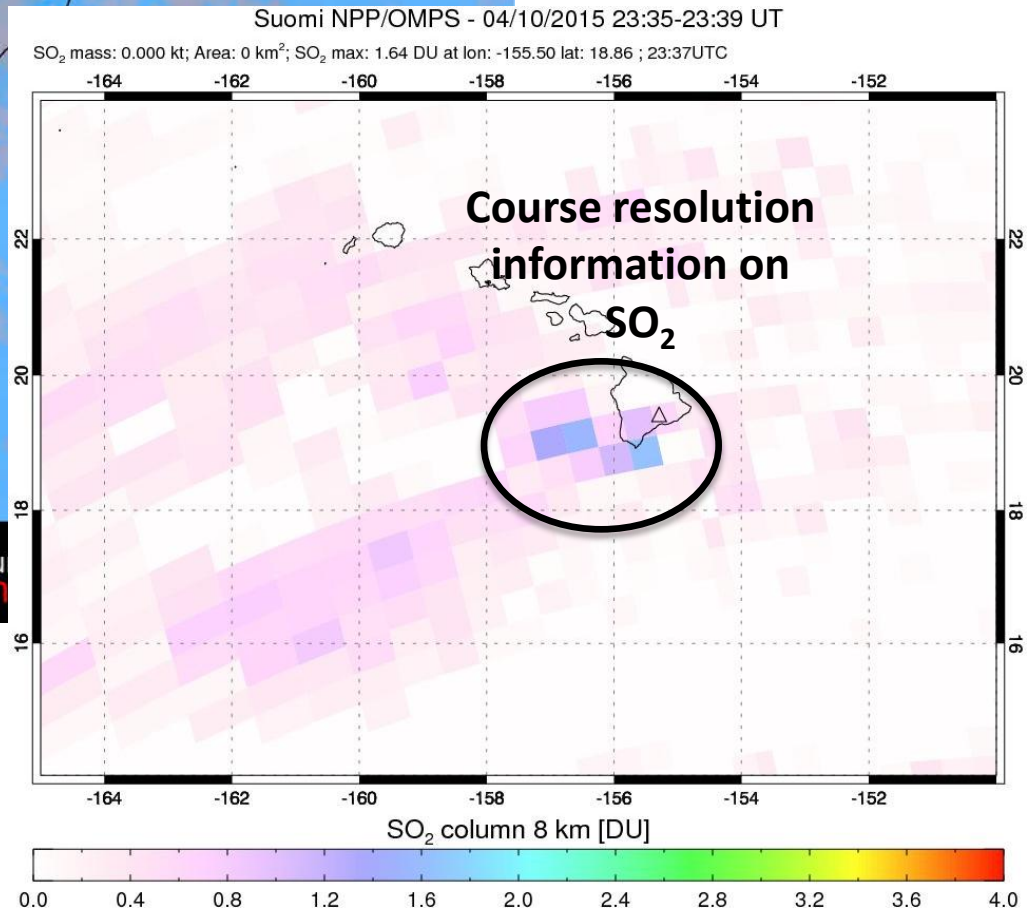

False Color Imagery (12–11μm, 11–8.5μm, 11μm)
MET–9 SEVIRI (05/17/2010 – 14:30 UTC)
Jan Mayen
Kolbeinsey Ridge
Kraka
Askja
West Eifel Volc Field
NOAA
CIMSS
Annotation Key
(annotation colors are not related to colors in underlying image)
Ash/Dust Cloud
Volcanic Cb
SO2
Thermal Anomaly


IR Window Imagery and Ash/Dust Loading
MET–9 SEVIRI (05/17/2010 – 14:30 UTC)
Baseline AWG approach : Medium to high confidence of detection
Jan Mayen
Kolbeinsey Ridge
Tjornes Fracture Zone
Askja
Eyjafjallajokull
West Eifel Volc Field
NOAA
CIMSS
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/m2]

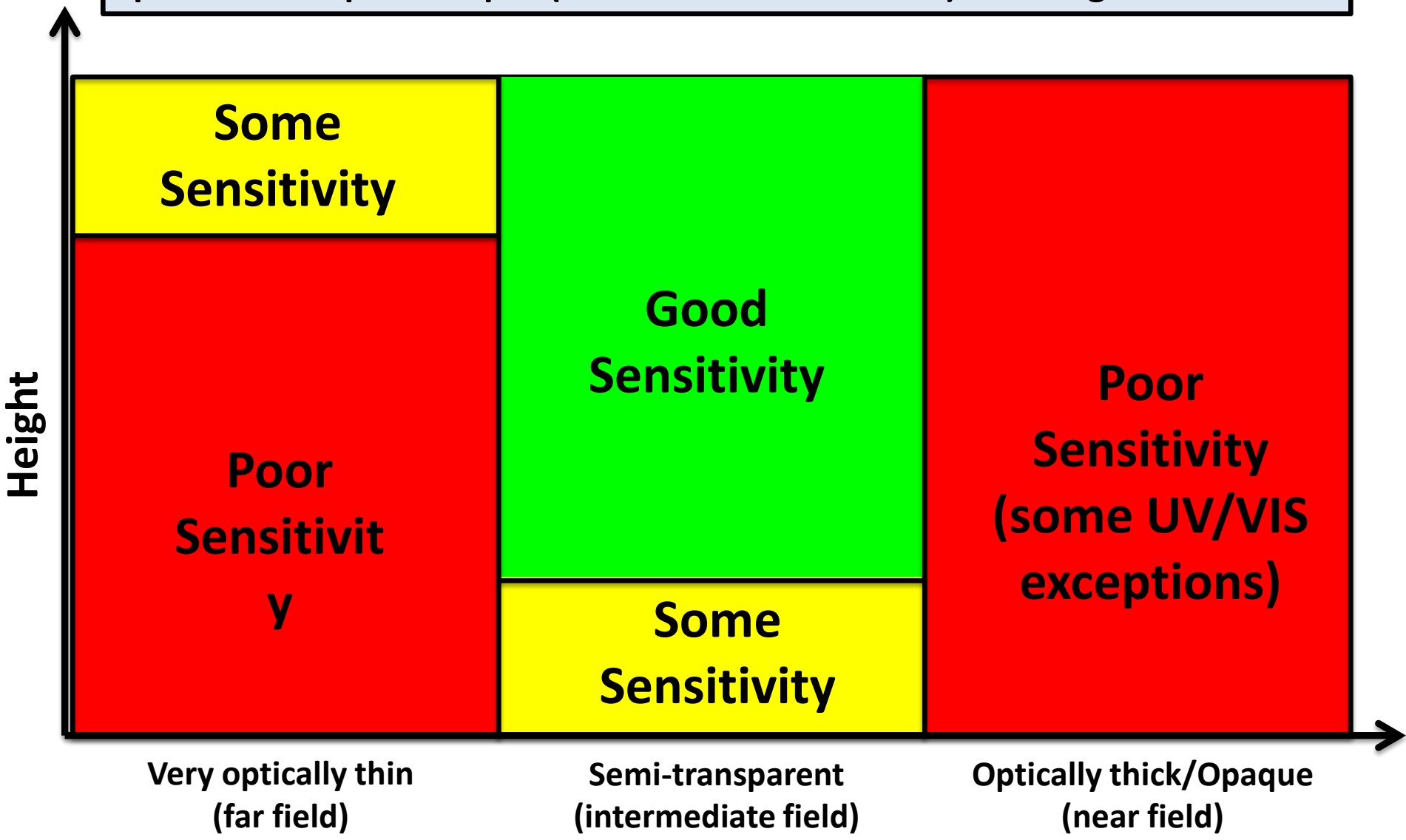

IR Window Imagery and Ash/Dust Loading
MET–9 SEVIRI (05/17/2010 – 14:30 UTC)
Improved approach
Jan Mayen
Kolbeinsey Ridge
Tjornes Fracture Zone
Krafla
Hamarinn
Hekla
Oraefajokull
West Eifel Volc Field
NOAA
CIMSS
180 200 220 240 260 280 300 320
11 μm BT [K]
0 1 2 3 4 5 6 7 8 9 10
Ash/Dust Loading [g/m²]

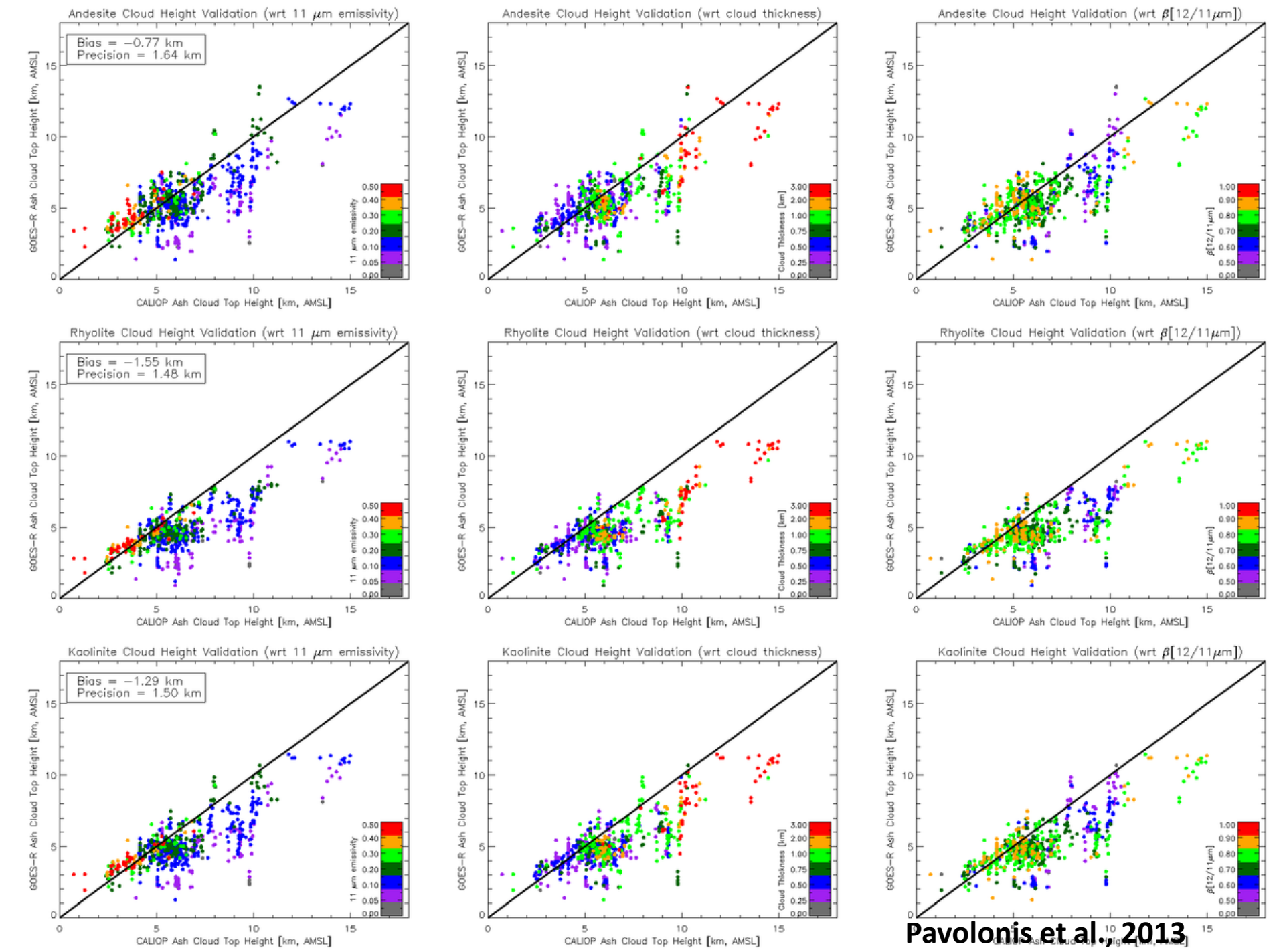
A multi-sensor SO_2 analysis is needed



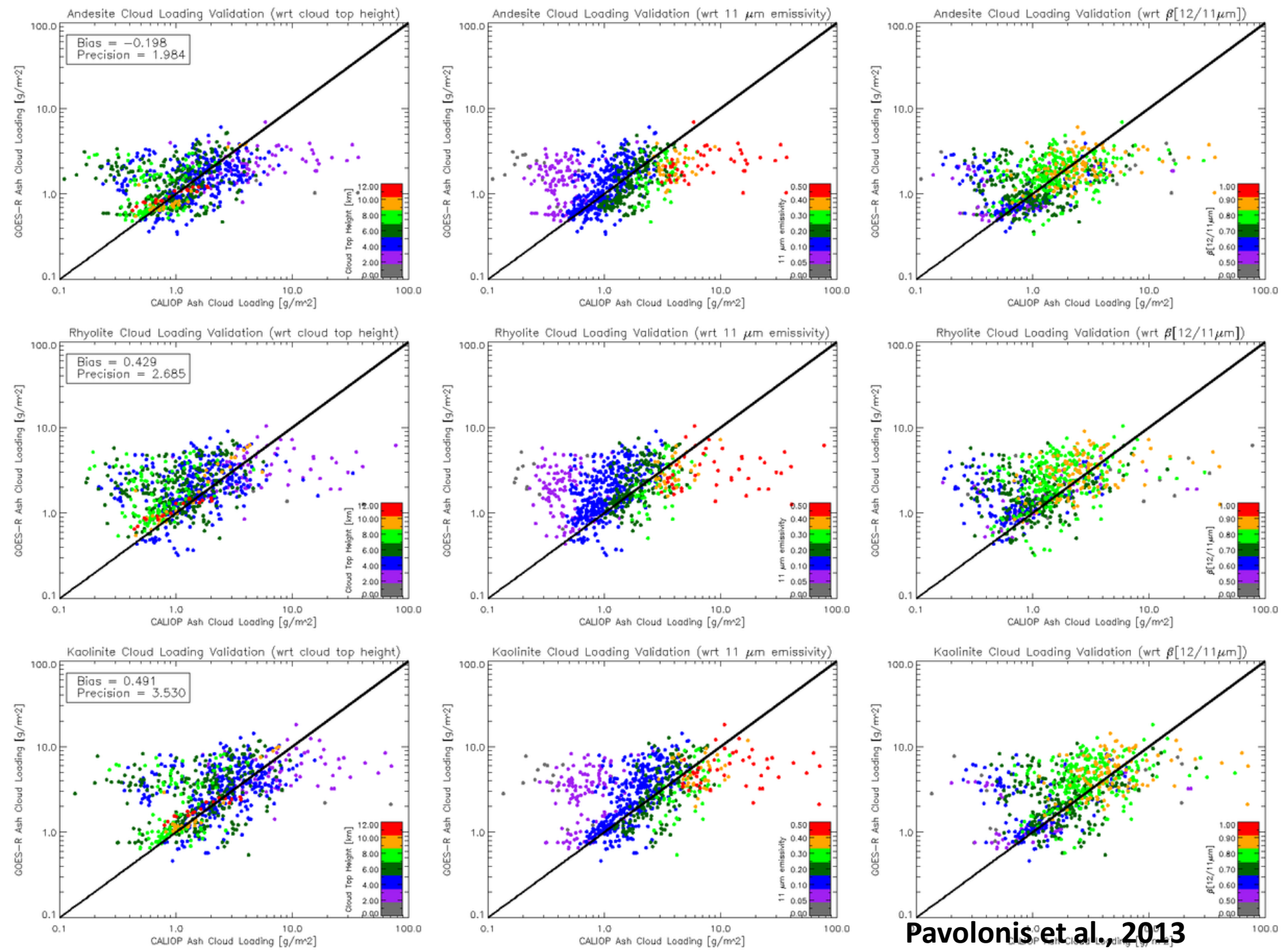


More consistent ash detection capabilities are needed across the spectrum of optical depth (down to detection limit) and height

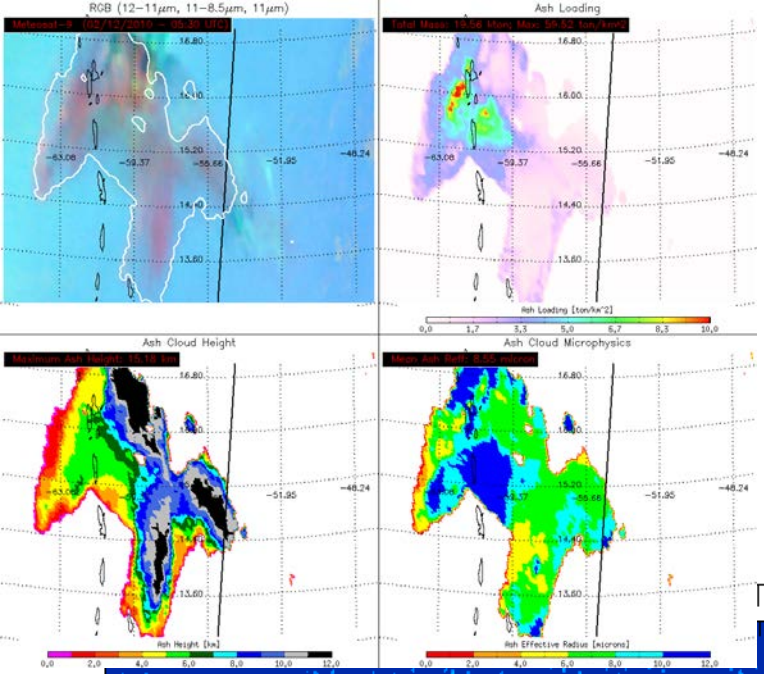




Pavolonis et al., 2013



Pavolonis et al., 2013



- **Single channel IR window**
- **11/13.3 μm retrieval**
- **11/12 μm retrieval**
- **11/12/13.3 μm retrieval**

Ash cloud

