





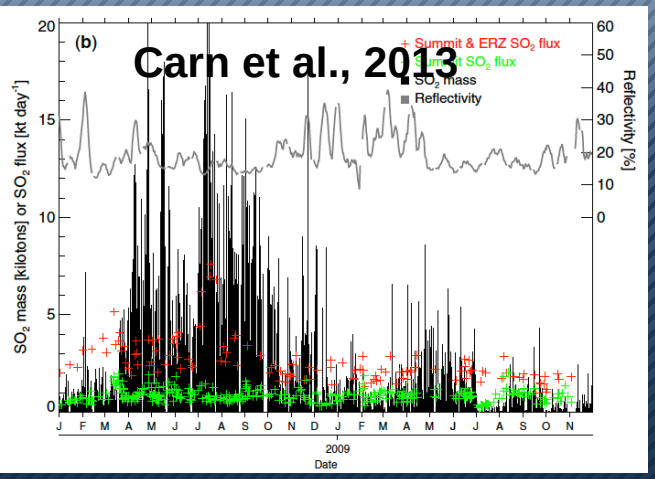

Development of Multi-sensor JPSS SO_2 Products for Volcanic Cloud Monitoring

Michael J. Pavolonis

NOAA/NESDIS/STAR

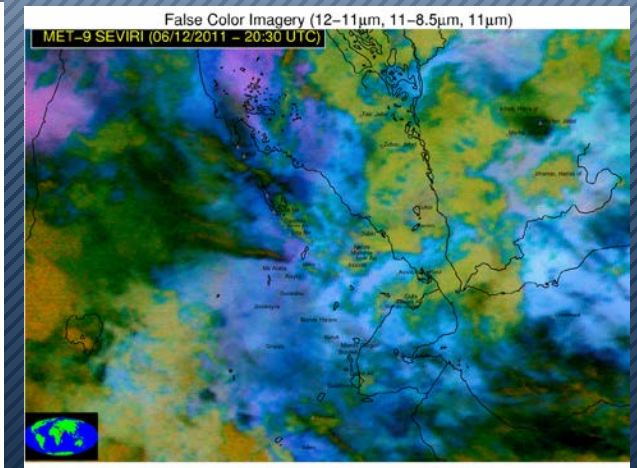
Motivation

Volcano Monitoring



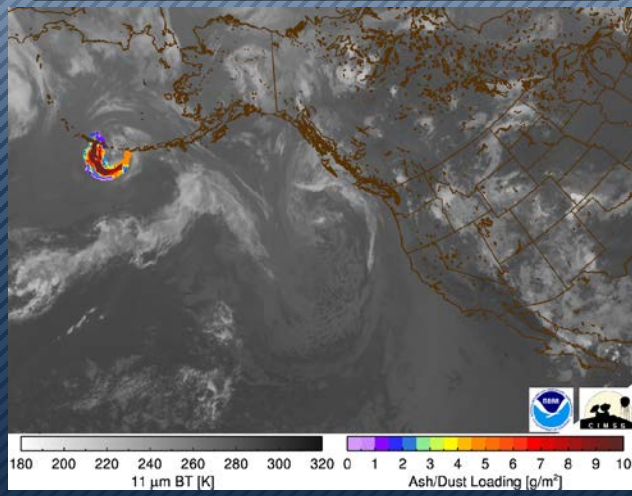
Carn et al., 2013

Hazard Avoidance

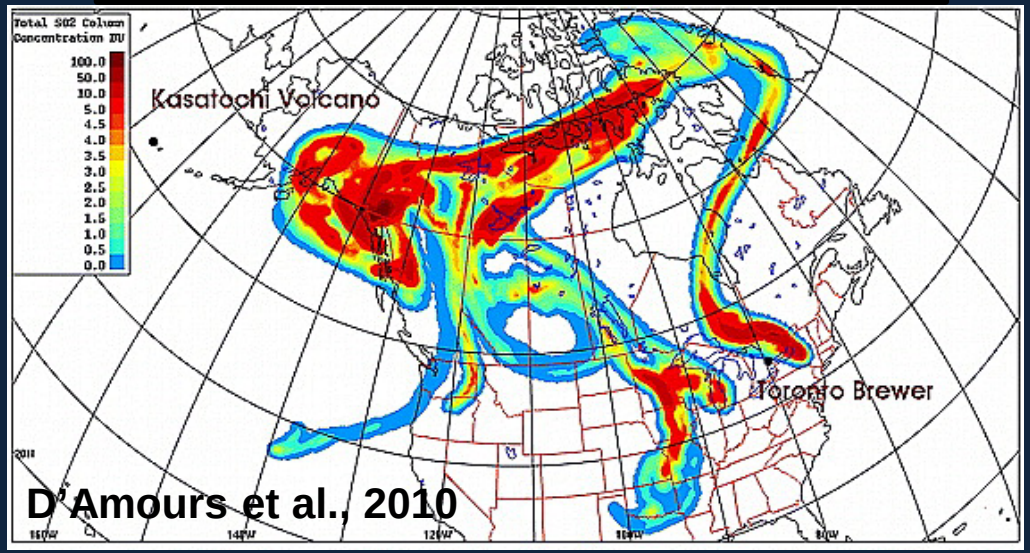


2011 Nabro Eruption

Volcanic Ash Tracking

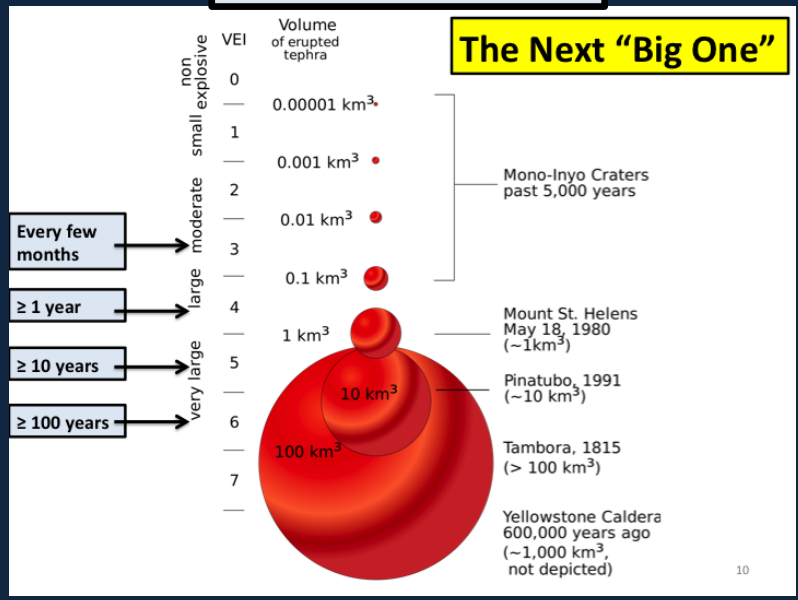


Dispersion and Transport Modeling



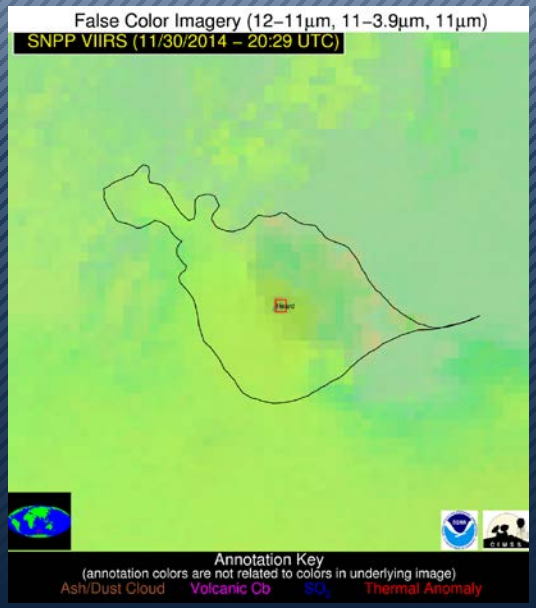
D'Amours et al., 2010

Climate



VOLcanic Cloud Analysis Toolkit (VOLCAT)

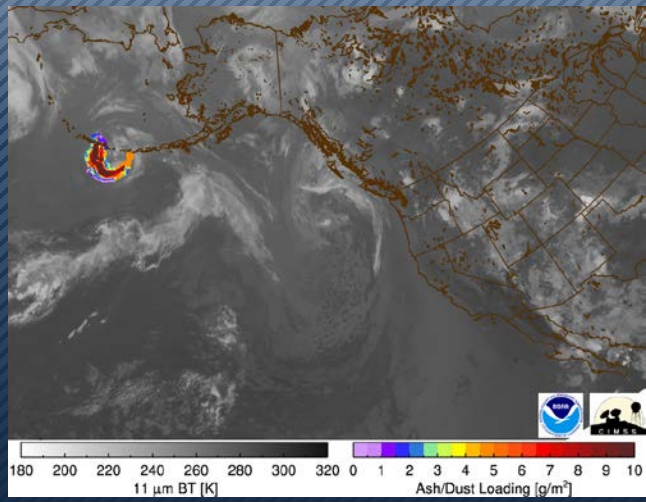
1). Unrest Alerts



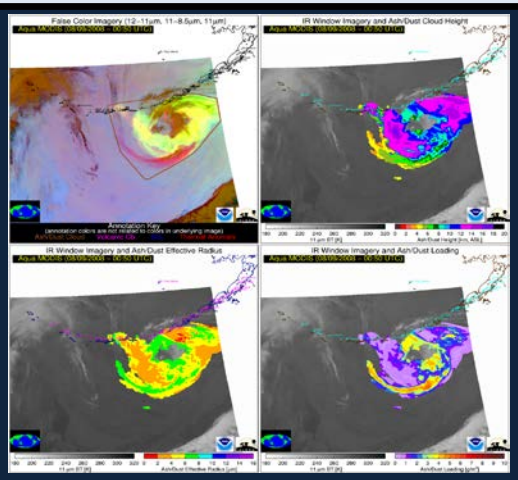
2). Eruption Alerts



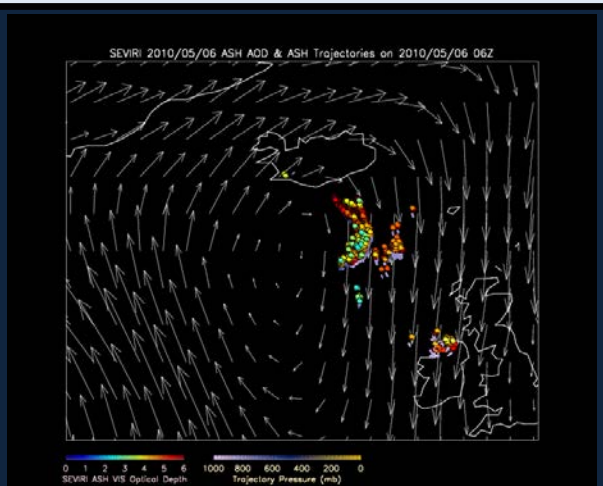
3). Volcanic Cloud Tracking



4). Volcanic Cloud Characterization



5). Dispersion Forecasting



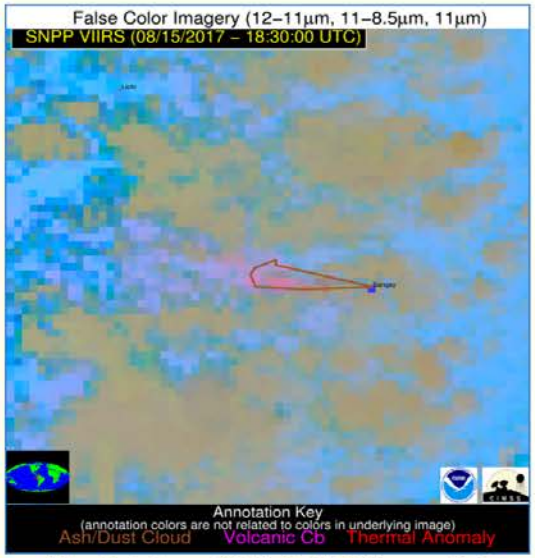
Example NRT Volcanic Ash Alerts from VOLCAT

Volcanic Cloud Alert Report

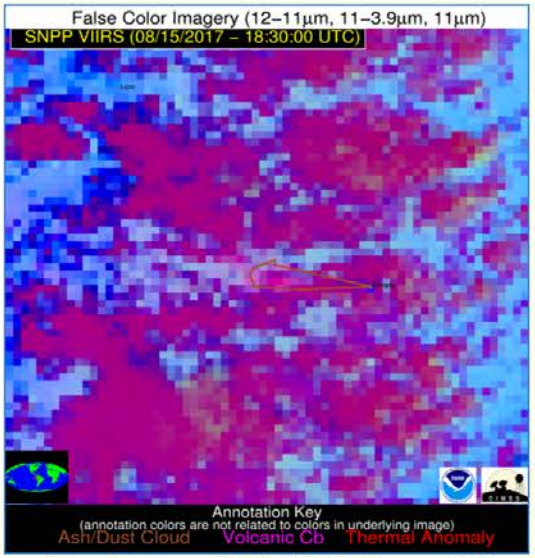
Date:	2017-08-15
Time:	18:30:00
Production Date and Time:	2017-08-15 20:18:05 UTC
Primary Instrument:	NPP VIIRS

More details ▼

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

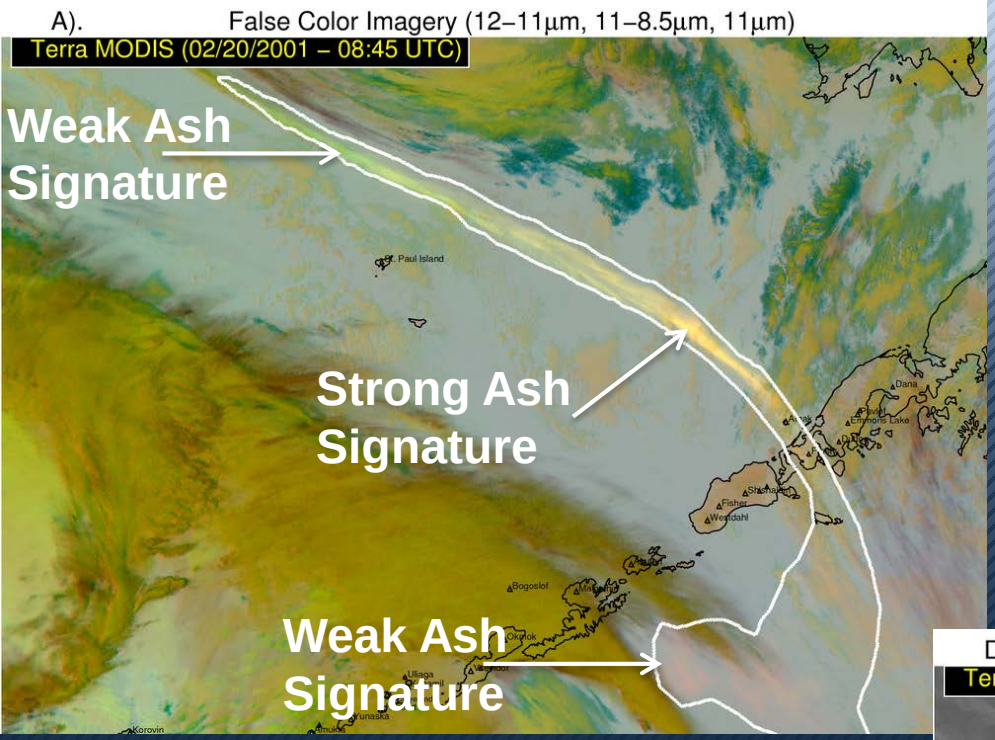
Volcanic Region(s)	South America
Country/Countries	Ecuador
Volcanic Subregion(s)	Ecuador
VAAC Region(s) of Nearby Volcanoes	Washington
Identification Method	Plume
Mean Object Date/Time	2017-08-15 18:34:06UTC
Radiative Center (Lat, Lon):	-2.010°, -78.340°
Nearby Volcanoes (meeting alert criteria):	Sangay (0.00 km) Licto (39.30 km) Tungurahua (60.90 km) Chimborazo (80.10 km) Quilotoa (142.80 km)
Maximum Height [AMSL]	7.20 km ; 23622 ft
90th Percentile Height [AMSL]	6.60 km ; 21654 ft
Mean Tropopause Height [AMSL]	16.50 km ; 54134 ft

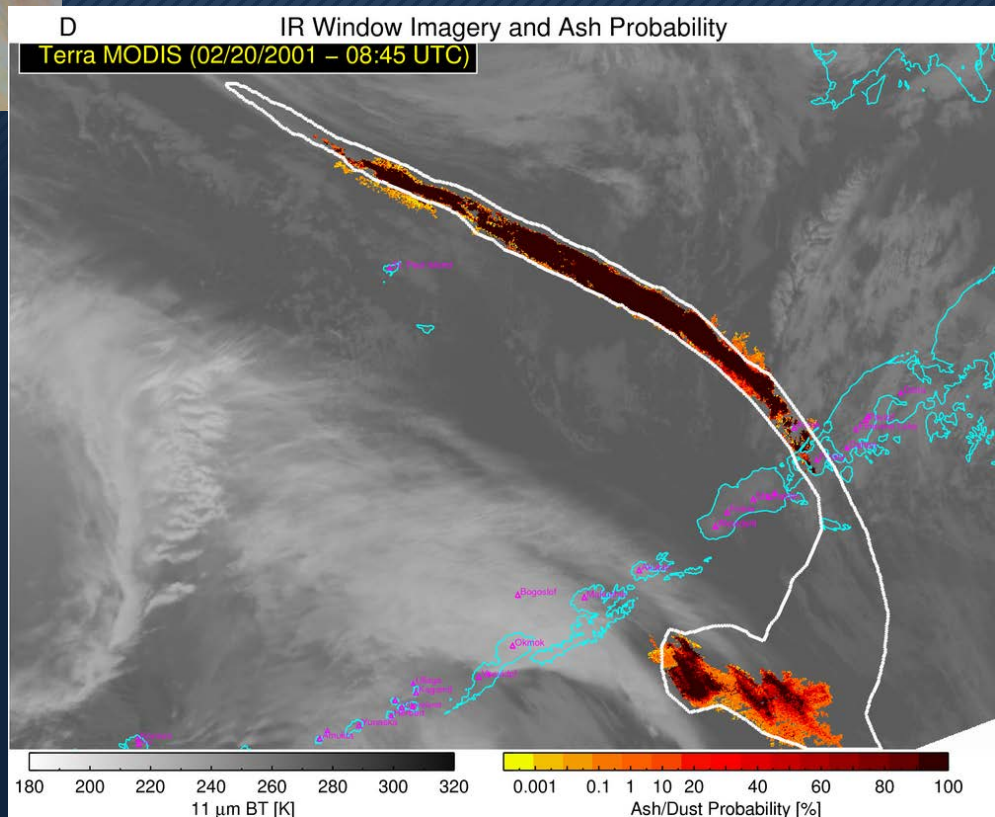
Show More ▲ | View all event imagery »

Sangay
(not detected with ABI)

Spatial Analysis: Cloud Objects

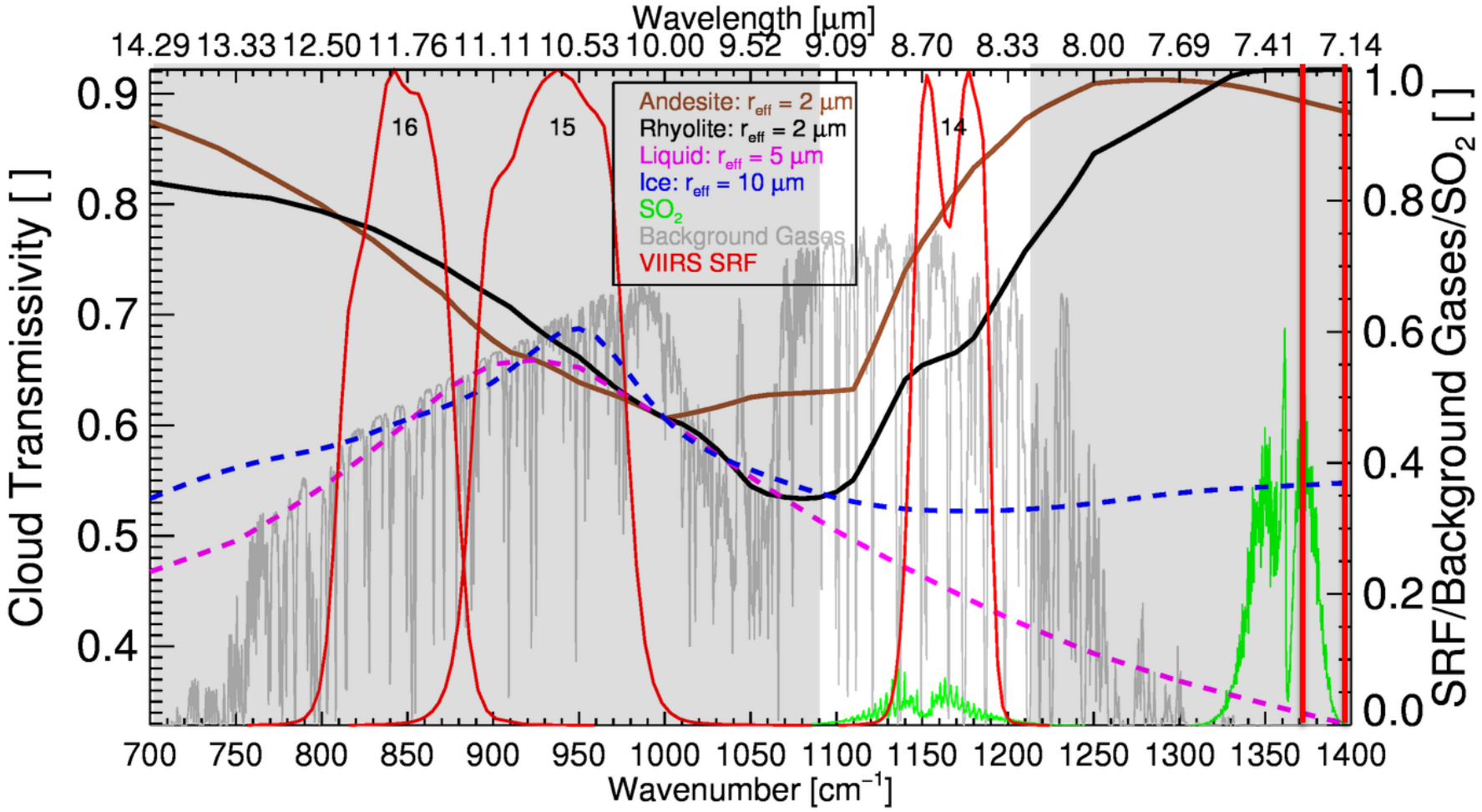
volcanic clouds, spectral metrics are used to estimate ash probability





Pavolonis et al. (2015a);
Pavolonis et al. (2015b)

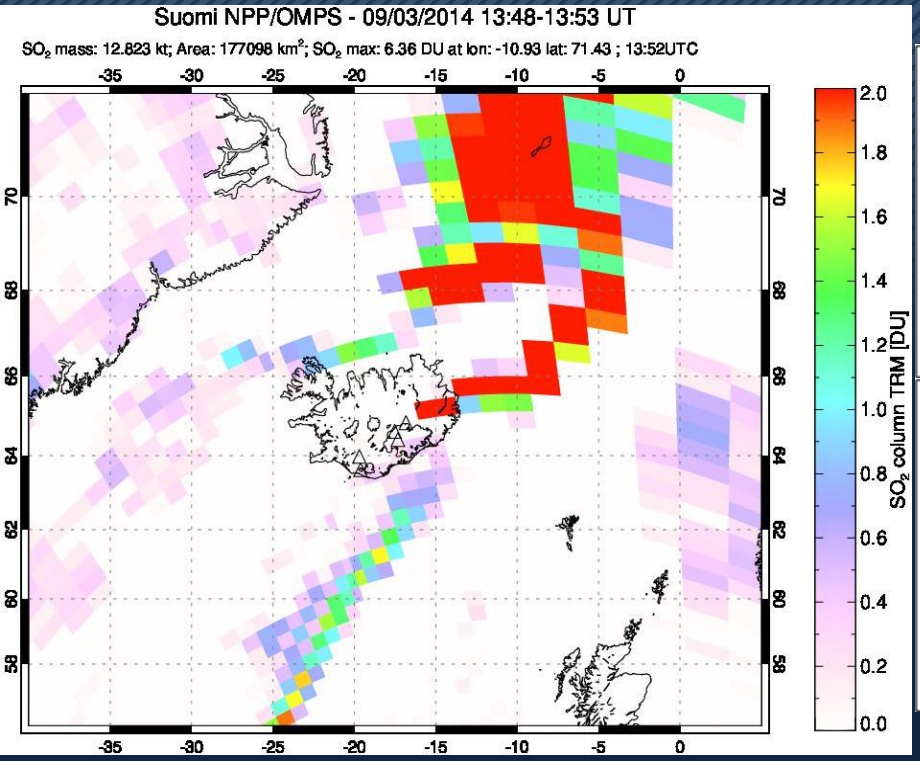
JPSS – Infrared Capabilities



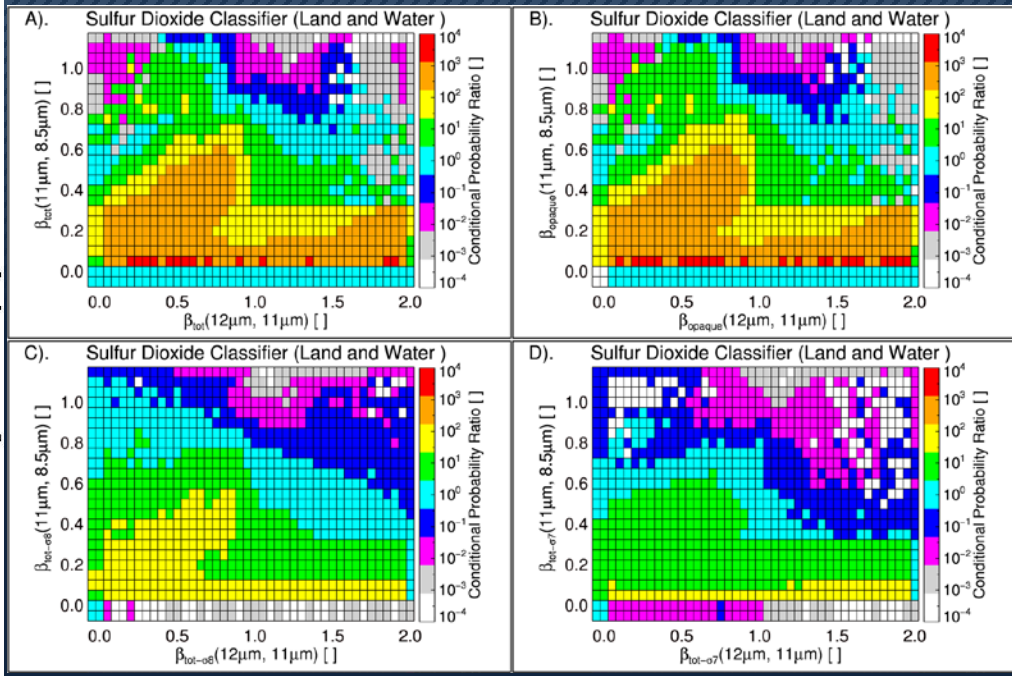
BTD SO_2 = BT(1407.50 cm^{-1}) – BT(1371.25 cm^{-1})

VIIRS SO_2 Probability: Naïve Bayesian Classifier

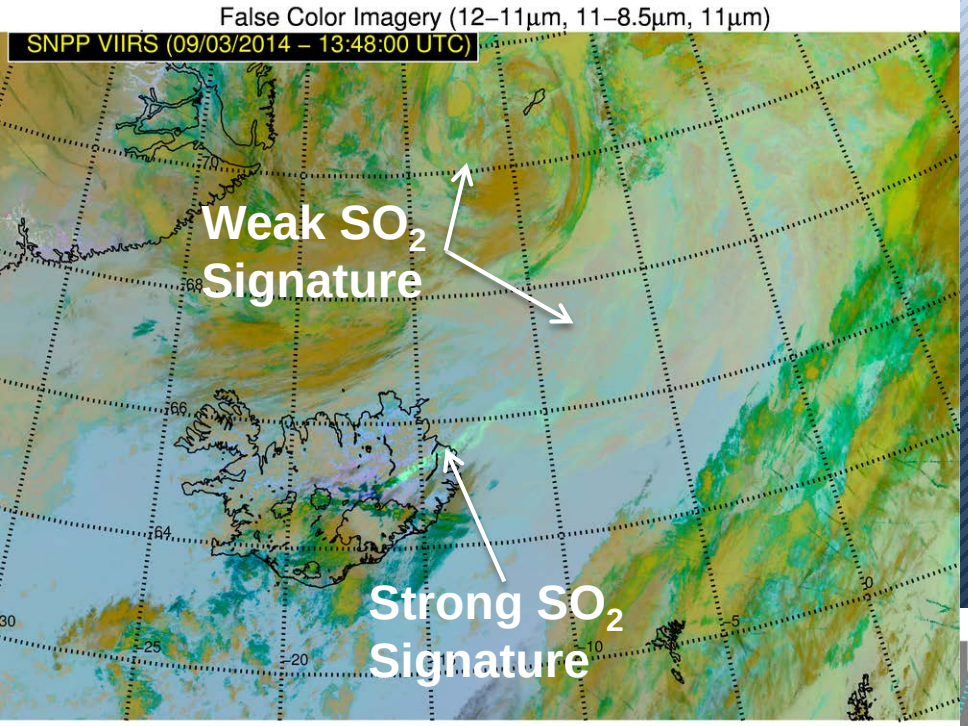
***A priori* Probability:** CrIS SO_2 BTD mapped to VIIRS swath and smoothed



Class Conditional Probabilities: Multivariate predictors trained using manual analysis of many volcanic events

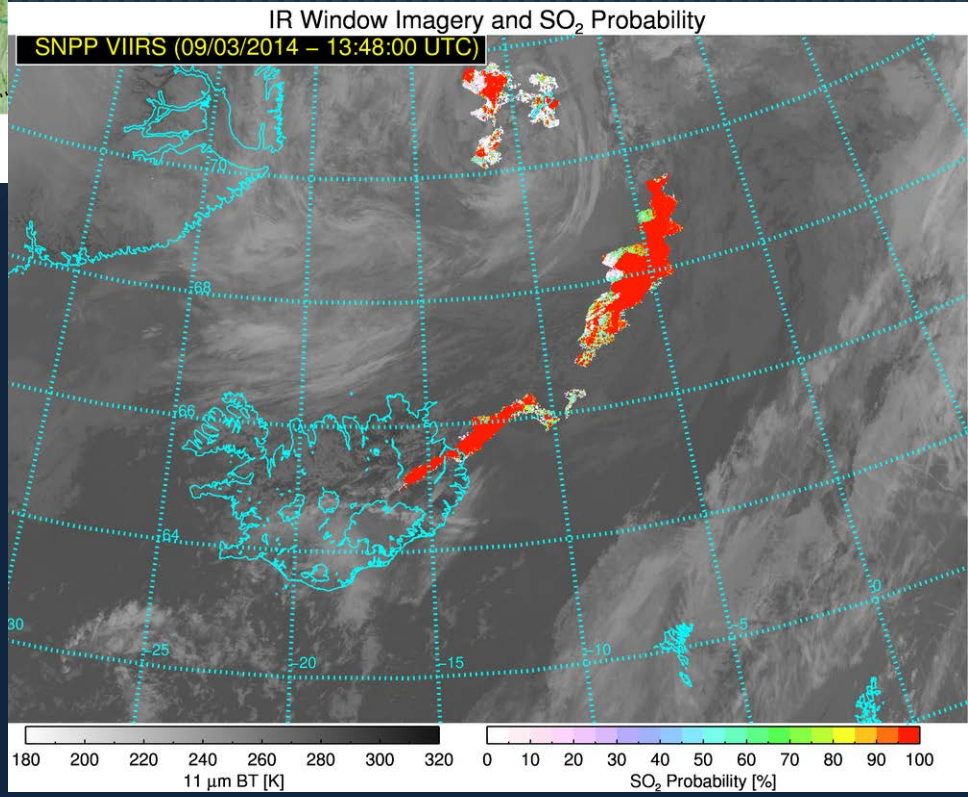


The VIIRS predictors capture the influence of SO_2 absorption on 8.5 µm and the lack there of at 11 and 12 µm.

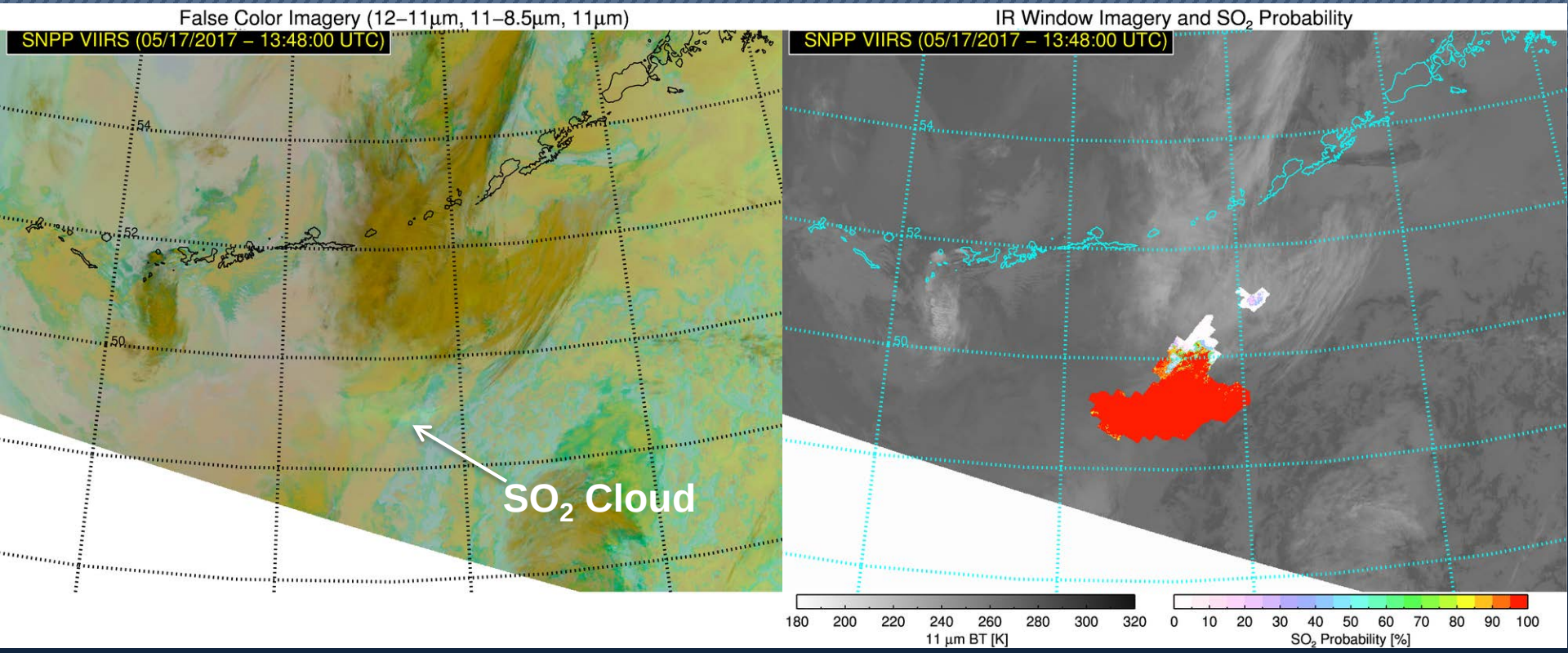


VIIRS SO_2 objects that contain spectrally robust VIIRS and/or CrIS SO_2 spectral signatures are selected

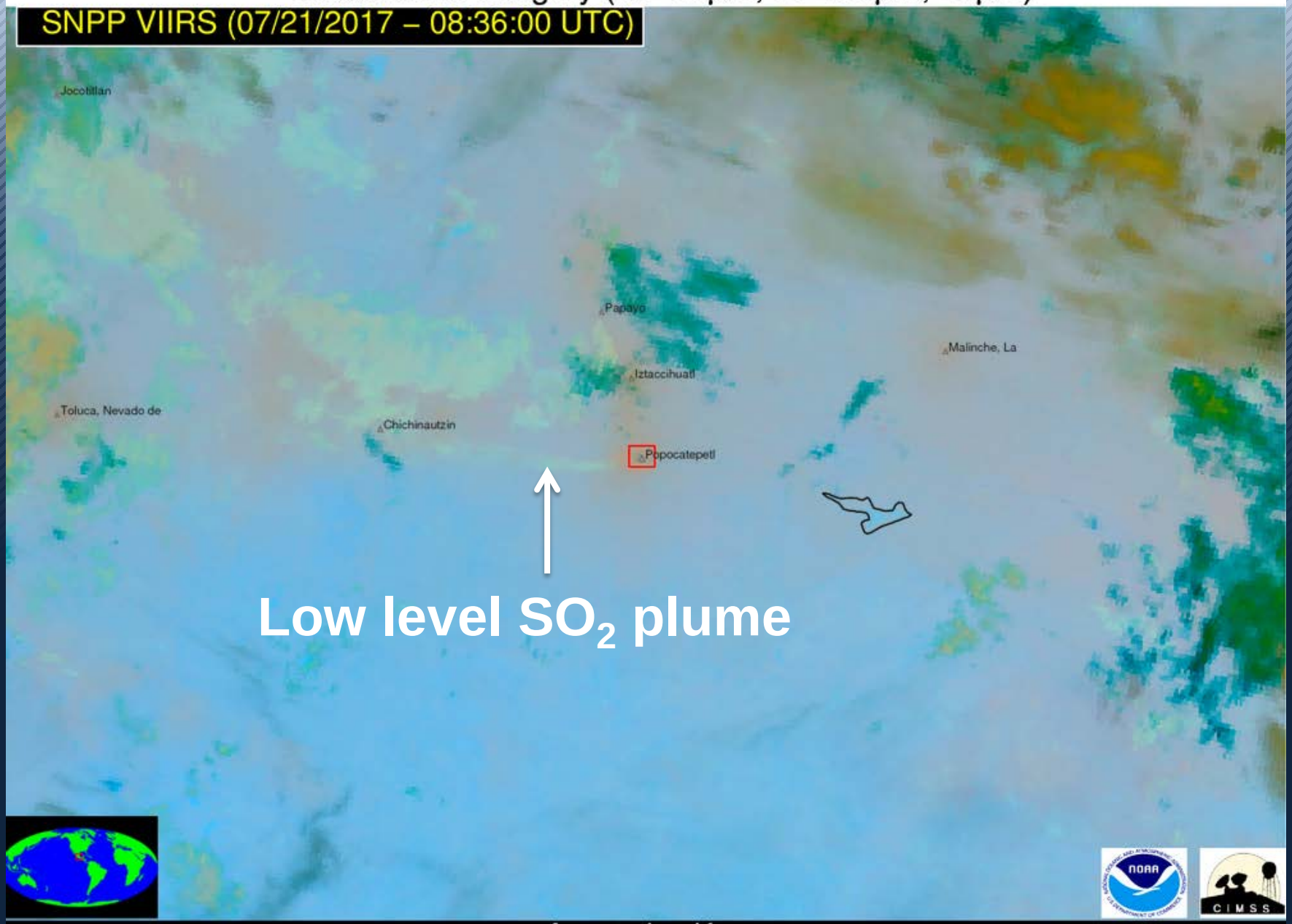
VIIRS contributions are minimal in the northern parts of the SO_2 cloud

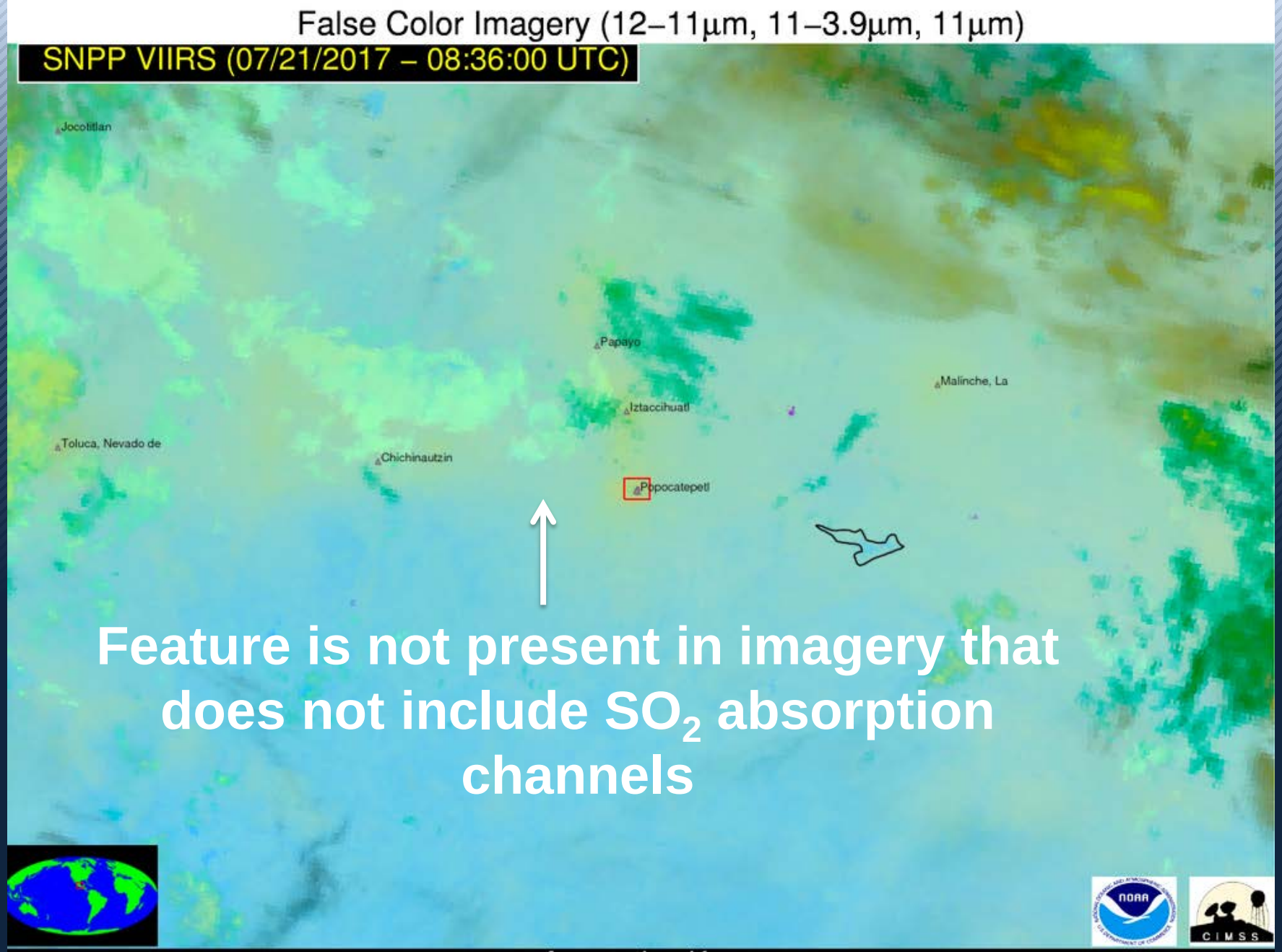


Bogoslof (Alaska)



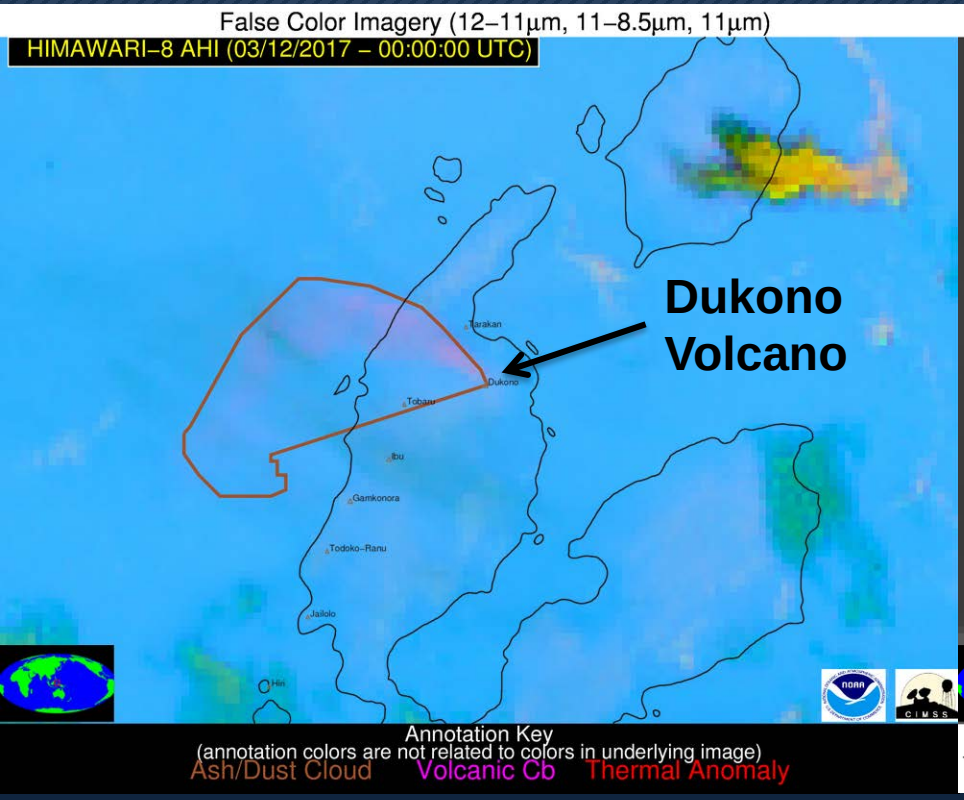
For well dispersed SO_2, OMPS and CrIS will have the greatest influence on results, but displaying SO_2 information on VIIRS images stills add value for users.

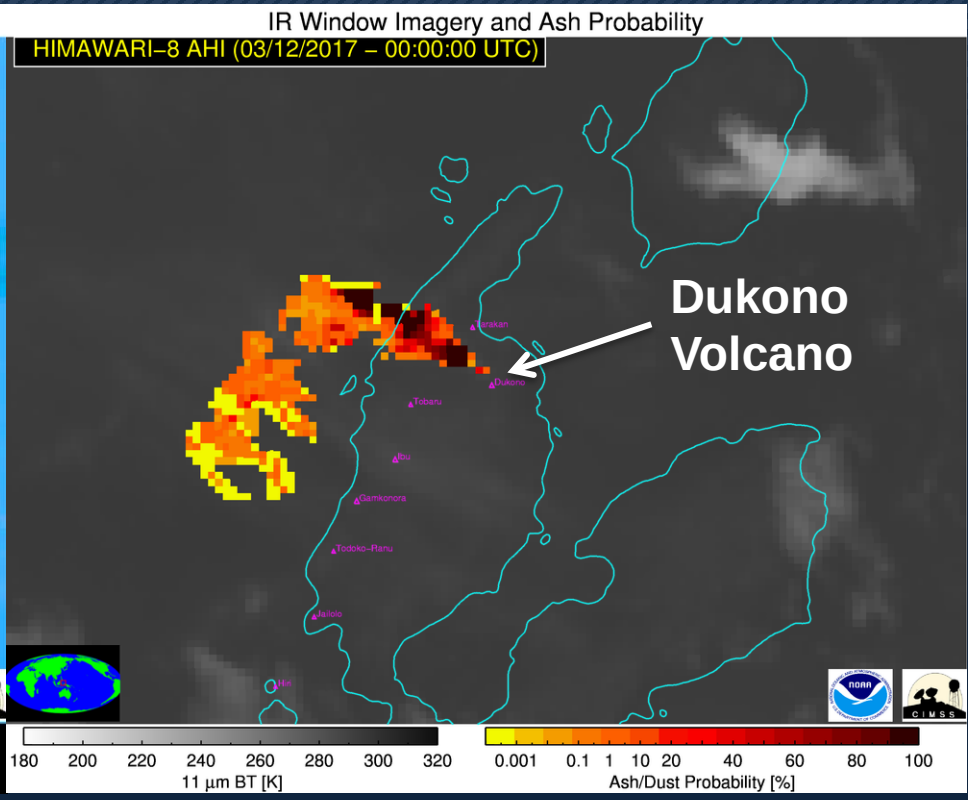

False Color Imagery (12–11μm, 11–8.5μm, 11μm)
SNPP VIIRS (07/21/2017 – 08:36:00 UTC)
Jocotitlan
Papayo
Malinche, La
Iztaccihuatl
Toluca, Nevado de
Chichinautzin
Popocatepetl
Low level SO_2 plume
NOAA
CIMSS
Annotation Key
(annotation colors are not related to colors in underlying image)
Ash/Dust Cloud
Volcanic Cb
Thermal Anomaly

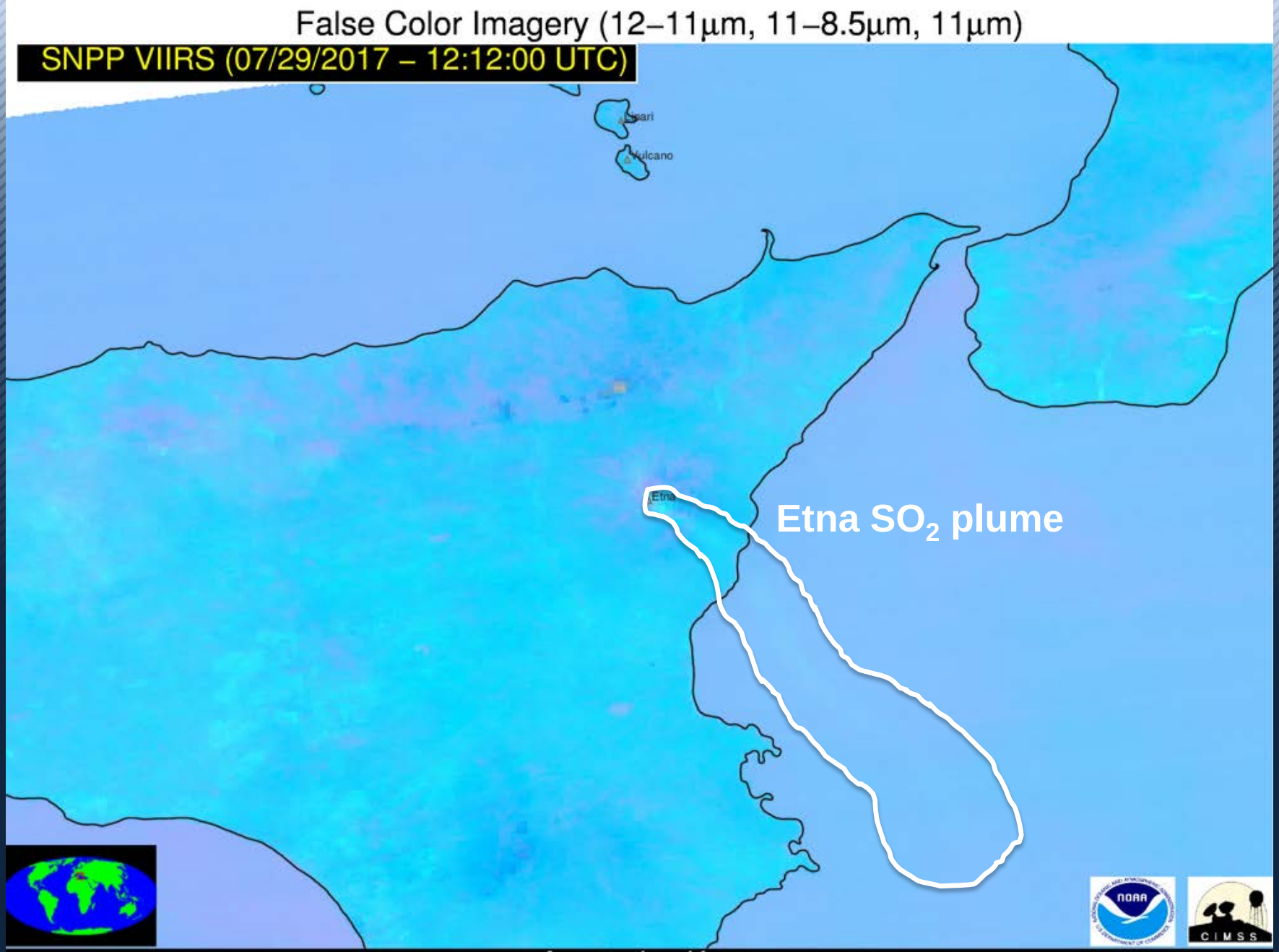

False Color Imagery (12–11μm, 11–3.9μm, 11μm)
SNPP VIIRS (07/21/2017 – 08:36:00 UTC)
Jocotitlan
Papayo
Malinche, La
Iztaccihuatl
Toluca, Nevado de
Chichinautzin
Popocatepetl
Feature is not present in imagery that does not include SO_2 absorption channels
Annotation Key
(annotation colors are not related to colors in underlying image)
Ash/Dust Cloud
Volcanic Cb
Thermal Anomaly

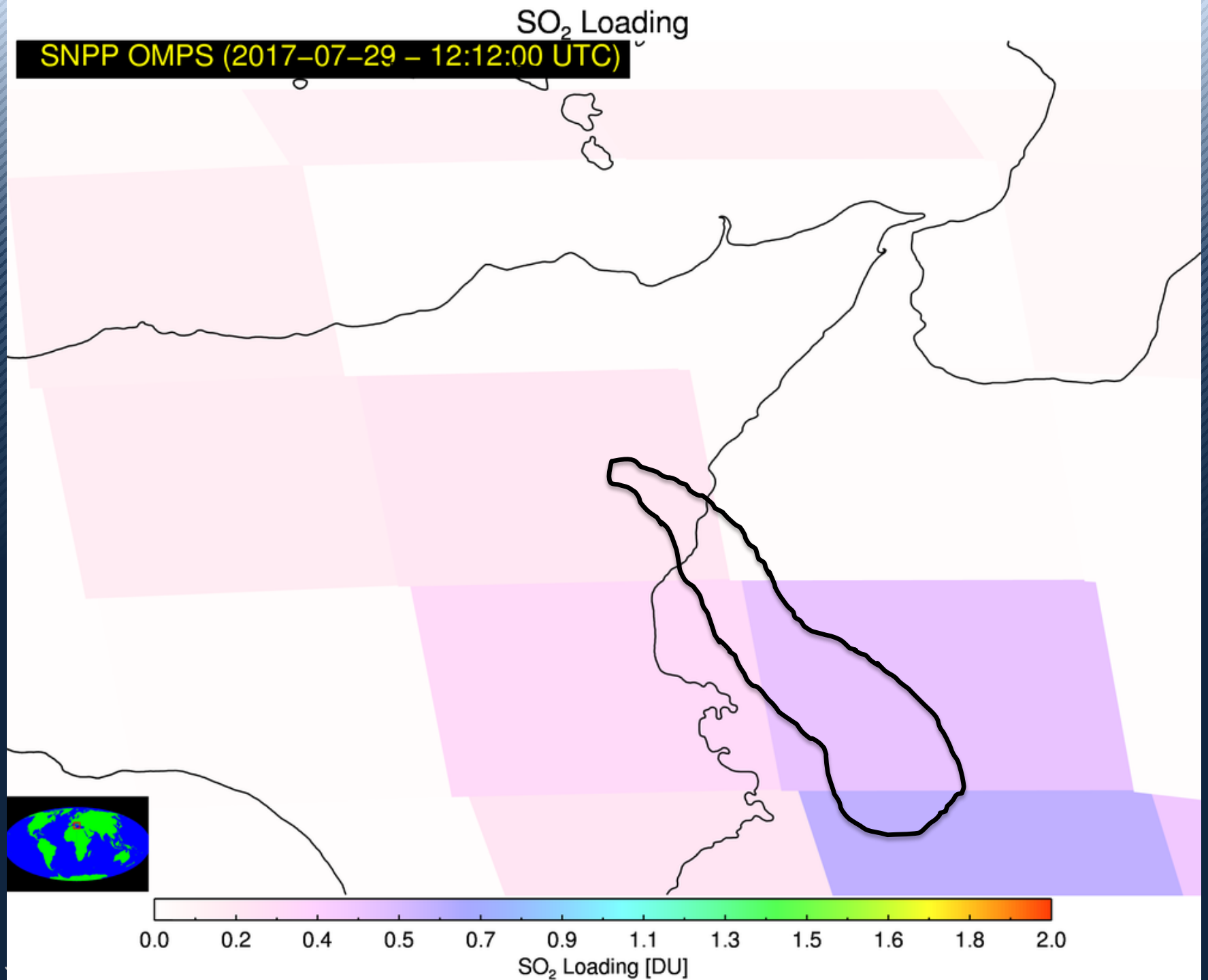
Spatial – Geometric Properties

Most everyday volcanic ash emissions have a weak multi-spectral signature. They are identifiable in imagery due to the combination of spectral signature and plume like shape.

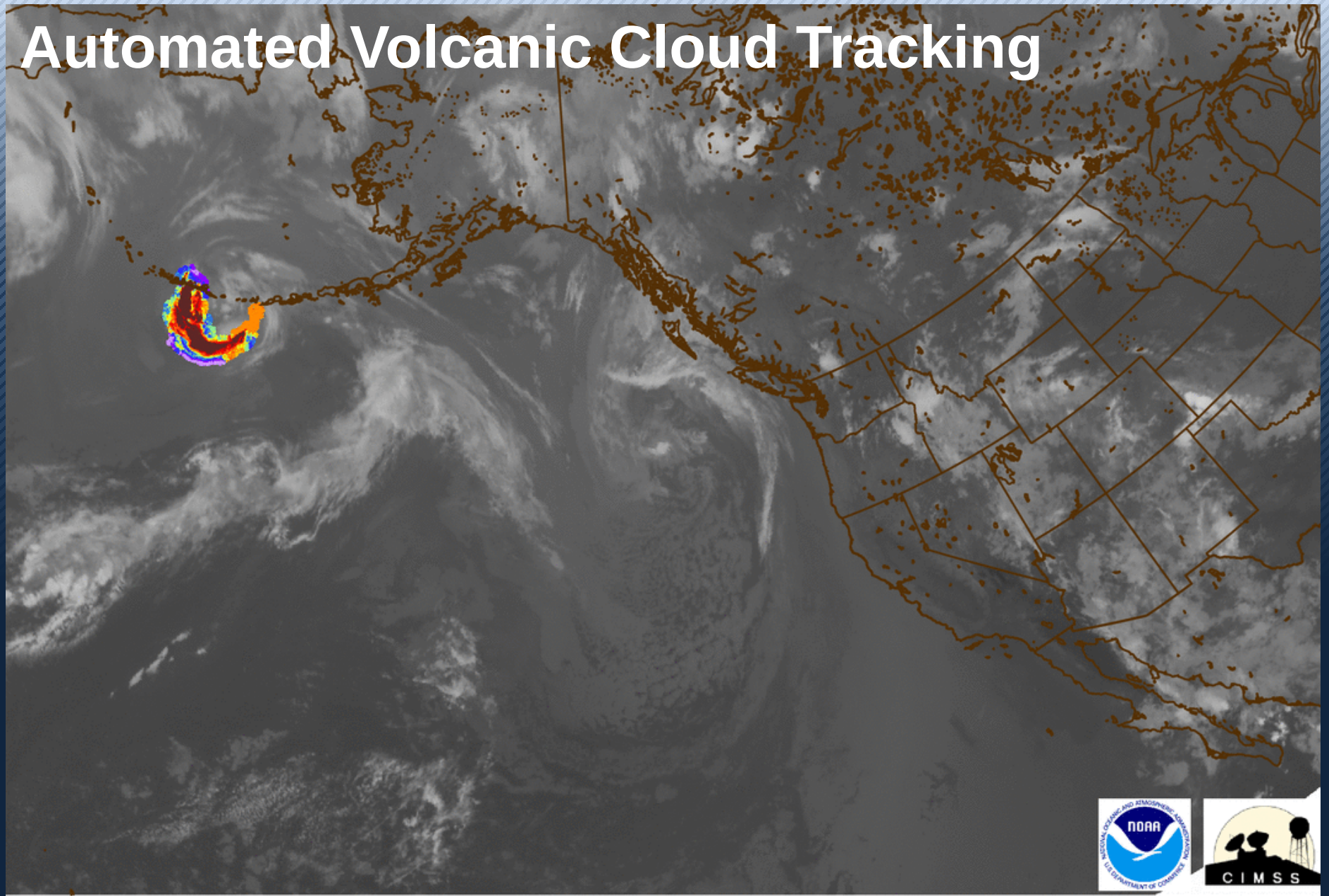




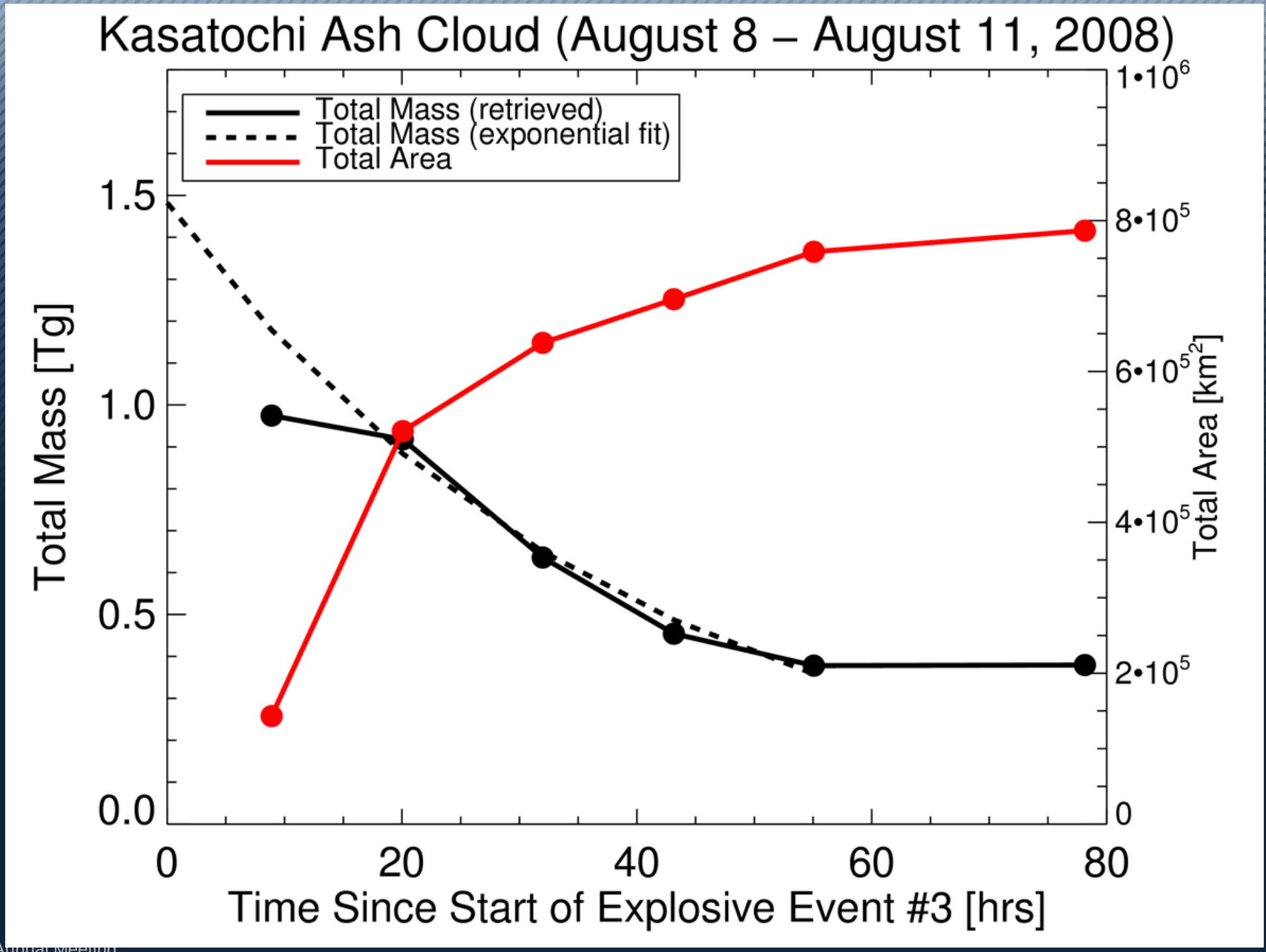

False Color Imagery (12–11μm, 11–8.5μm, 11μm)
SNPP VIIRS (07/29/2017 – 12:12:00 UTC)
Stromboli
Vulcano
Etna
Etna SO_2 plume
NOAA
CIMSS
Annotation Key
(annotation colors are not related to colors in underlying image)
Ash/Dust Cloud
Volcanic Cb
Thermal Anomaly


SO2 Loading
SNPP OMPS (2017-07-29 – 12:12:00 UTC)
0.0
0.2
0.4
0.5
0.7
0.9
1.1
1.3
1.5
1.6
1.8
2.0
SO2 Loading [DU]

Automated Volcanic Cloud Tracking



Automated Volcanic Cloud Time Series

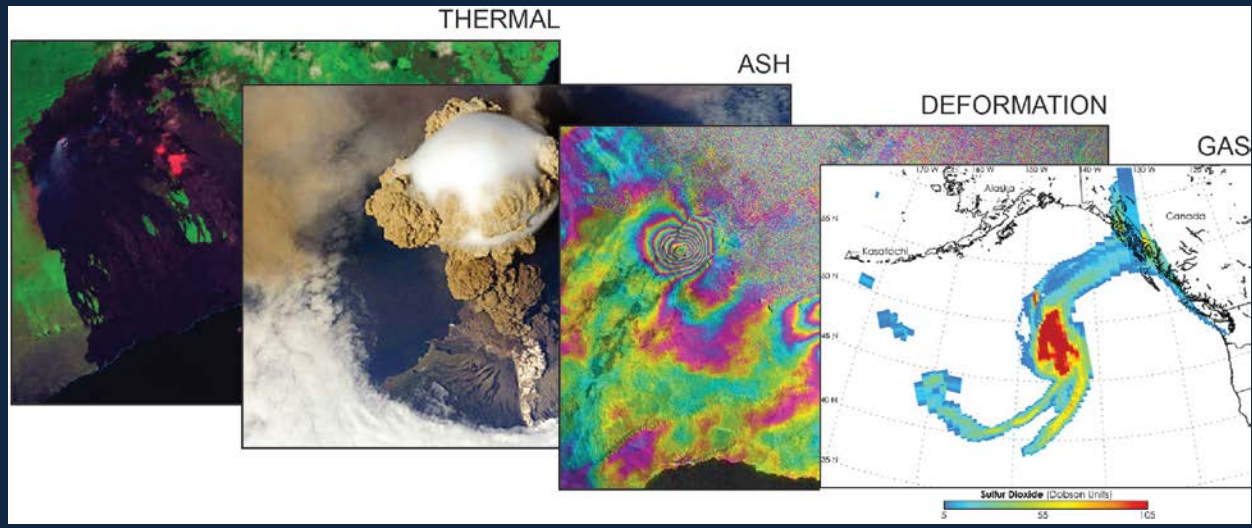


Collaboration

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Juliet Briggs (U. Bristol)
Simon Carn (Mich. Tech)
Julie Griswold (USGS)
Brenda Jones (USGS)
Sue Louglin (British Geological Survey)
Taryn Lopez (UAF)
Paul Lindgren (JPL)
Franz Meyer (UAF)
Mike Pavolonis (NOAA)
Ivan Petiteville (ESA)
Kevin Reath (Cornell)
Dave Schneider (USGS)
Greg Vaughan (USGS)
Christell Wauthier (Penn St.)
Rick Wessels (USGS)
Rob Wright (U. Hawaii)

USGS Powell Center

USGS
science for a changing world



Ongoing Work

So Far: Primary focus on accurately quantifying the horizontal bounds of volcanic SO_2 clouds

Continuing Work: Incorporation of OMPS, merged SO_2 loading estimates, merged SO_2 alerts and time series (including GOES-R)

User interactions: Close relationship with NOAA VAAC's, USGS, and many international partners

Other Collaborations: NOAA ARL (HYSPLIT) group

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, **120**, 7813-7841.

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, **120**, 7842-7870.