The Development of JPSS Volcanic Cloud Applications

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Development of a Multi-sensor System

1). Unrest Alerts

False Color Imagery (12–11μm, 11–3.9μm, 11μm)
Development of a Multi-sensor System

1). Unrest Alerts

2). Eruption Alerts
Development of a Multi-sensor System

1). Unrest Alerts

2). Eruption Alerts

3). Volcanic Cloud Tracking
Development of a Multi-sensor System

1). Unrest Alerts
2). Eruption Alerts
3). Volcanic Cloud Tracking

4). Volcanic Cloud Characterization
Development of a Multi-sensor System

1). Unrest Alerts

2). Eruption Alerts

3). Volcanic Cloud Tracking

4). Volcanic Cloud Characterization

5). Dispersion Forecasting
http://volcano.ssec.wisc.edu
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). $\text{SO}_2$ clouds – Sulfur dioxide clouds ($\text{SO}_2$ gas is invisible to the eye) that may or may not contain volcanic ash. Some eruptions produce large amounts of $\text{SO}_2$ and very little ash and vice-versa.
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False Color Imagery (12–11μm, 11–8.5μm, 11μm)

SNPP VIIRS (05/08/2015 – 15:10 UTC)

Kamchatka

Ash Plume

Annotation Key
(abbreviation colors are not related to colors in underlying image)
Ash/Dust Cloud
Volcanic Cb
Thermal Anomaly
Difficult to detect features are automatically detected using a multi-spectral cloud object based approach.
Even with the new GEO’s, VIIRS is still critical!
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

Possible Volcanic Ash Cloud

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 17:59:52 UTC
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)
- Tiscani (56.30 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]: 16.60 km; 54134 ft

Ubinas (Peru): June 30, 2015
Detect and characterize

Ubinas (Peru): June 30, 2015
Raung (Indonesia)
July 23, 2015
Raung (Indonesia)
July 23, 2015
Ash Cloud Height
Raung (Indonesia)
July 23, 2015
Ash Mass 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.

MODIS has coverage within the LW CO$_2$ absorption band, VIIRS does not.
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Geostationary satellites are needed for timely detection of explosive eruptions, but JPSS adds significant value – benefit of a multi-sensor/multi-orbit approach.
At 4+ km resolution, the minimum 11 μm brightness temperature is -66°C
At 375 m resolution, the minimum 11 μm brightness temperature is -101°C.
NASA’s CALIOP lidar later verified that ash was present at least up to 20 km!
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SO₂ plume

Annotation Key
(annotation colors are not related to colors in underlying image)
Ash/Dust Cloud  Volcanic Cb  Thermal Anomaly
A multi-sensor SO₂ analysis is needed.
False Color Imagery (12–11μm, 11–8.5μm, 11μm)

SNPP VIIRS (09/03/2014 – 13:46 UTC)

SO₂ Plume
Dispersed SO₂

Annotation Key
(Annotation colors are not related to colors in underlying image)

Ash/Dust Cloud  Volcanic Cb  SO₂  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
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

[Graphs showing scatter plots for different datasets, with labeled axes and titles.]
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


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

SNPP VIIRS (09/07/2014 – 14:12 UTC)

Annotation Key
(annotation colors are not related to colors in underlying image)

Ash/Dust Cloud  Volcanic Cb  SO₂  Thermal Anomaly
Kelut Eruption (February 13, 2014)
False Color Imagery (12–11 μm, 11–8.5 μm, 11 μm)

MET-9 SEVIRI (05/17/2010 – 14:30 UTC)

Annotation Key
(Annotation colors are not related to colors in underlying image)
Ash/Dust Cloud  Volcanic Cb  SO₂  Thermal Anomaly
Baseline AWG approach: Medium to high confidence of detection
Improved approach
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.
Andesite Cloud Loading Validation (wrt cloud top height)

Bias = -0.198
Precision = 1.984

Andesite Cloud Loading Validation (wrt 11 μm emissivity)

Andesite Cloud Loading Validation (wrt β(12/11 μm))

Rhyolite Cloud Loading Validation (wrt cloud top height)

Bias = 0.429
Precision = 2.685

Rhyolite Cloud Loading Validation (wrt 11 μm emissivity)

Rhyolite Cloud Loading Validation (wrt β(12/11 μm))

Kaoilinite Cloud Loading Validation (wrt cloud top height)

Bias = 0.491
Precision = 3.530

Kaoilinite Cloud Loading Validation (wrt 11 μm emissivity)

Kaoilinite Cloud Loading Validation (wrt β(12/11 μm))
- Single channel IR window
- 11/13.3 µm retrieval
- 11/12 µm retrieval
- 11/12/13.3 µm retrieval

Ash cloud