Full-chemistry Volcanic Fog Forecast over Hawaii

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A pulse of magma moving through Kīlauea's east rift zone
Kilauea Volcano over the Hawaii Island

(Source: Hawaiian Volcano Observatory: http://hvo.wr.usgs.gov)
Methodology for Modeling Volcanic Emissions

- In-Situ SO$_2$ Measurement
  - Hawaiian Volcano Observatory

- Daily web update
  - NOAA Air Resources Lab

- Pre-processor
  - Graph showing SO$_2$ emissions time series

- Emission Processing
  - Map showing SO$_2$ emissions

- SO$_2$ measurement
  - Correlation Spectrometer (COSPEC);

- Simple plume rise:
  - Distributed from ground to 100 m above;
Plume Rise of Volcanic Emissions

Make it simple since we know so little about it…

- Multiple and moving emitting points;
- Emitting point below surface;
- Dynamic magma movement;
- Difficult to implement plume rise algorithms, such as Briggs (1972).
Kilauea SO$_2$ Emissions

(Source: Hawaiian Volcano Observatory: http://hvo.wr.usgs.gov)
Model Configurations

- **Volcano SO2 emissions:**
  - Summit Emissions: 650 - 800 tons/day;
  - East Rift Zone: ~400 tons/day;

- **Model (National Air Quality Forecast Capability (NAQFC))**
  - CMAQ 5.0.2 CB05-AQ-AERO6 gas, aqueous and aerosol chemistry

- **NAQFC’s Hawaii Domain**
  - 80 x 52 grid cells (All islands and surrounding water)

- **Horizontal resolution:** 12x12 km²
- **Vertical level:** 35 layers

- **Meteorological inputs**
  - NAM( NMM-B) 12 km

- **Lateral boundary conditions**
  - GEOS-Chem precursors with Hilo monthly mean ozonesonde
Model Predicted Total Column SO₂ (DU)
at 12Z, 07/11/2017
OMPS SO₂ Total Column (DU)

2017-07-11 20:55:00

Model SO₂ Total Column (DU)

2017-07-11 21:00:00

(OMPS SO₂ data is downloaded from NASA retrievals, https://so2.gsfc.nasa.gov)
OMPS SO$_2$ Total Column (DU)

Model SO$_2$ Total Column (DU)
compared to surface SO₂ monitoring data

8/24/2017
Effects on Air Quality

SO$_2$

O$_3$

Sulfate

Nitrate

H$_2$O$_2$
Summary

- With the proper volcano SO₂ emission, we have capability to predict the Hawaii SO₂ plume, which is comparable to the surface measurements.

- OMPS SO₂ retrievals are comparable to the model results. After suitable Cal/Val, it can be used to verify/assimilate Hawaii volcano SO₂ concentration or emission.

- There are still uncertainties in the volcano emissions, such as plume heat fluxes etc, which can be adjusted with the proper satellite retrieval, such as FRP.
Future Works

1. Apply the similar OMPS SO$_2$ product to verify/assimilate the power-plant SO$_2$ emissions, which is the major SO$_2$ source over CONUS.

2. As SO$_2$ is the precursor of sulfate, we should be able see PM2.5 and AOT enhancement in the downstream areas, which can be verified with the VIIRS AOT product.