Using Satellite Observations to Evaluate the AeroCOM Volcanic Emissions Inventory and the Dispersal of Volcanic \( \text{SO}_2 \) Clouds in MERRA
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Overview

*AeroCom Volcanic Emissions Inventory* is used as a volcanic input to climate models by describing the:

- Daily SO₂ Emission for a given volcano
- Estimate of the Cloud Top Altitude

Extends back to 1930s, but most of the detailed information extends to the satellite remote sensing period, back to 1979.

*In select case studies, large differences have been observed between the Modern-Era Retrospective Analysis for Research and Applications (MERRA) and SO₂ observations from the Ozone Monitoring Instrument (OMI)*

*Shown to better understand the nature of these differences:*

- Comparison of AeroCom Inventory vs. MERRA input
- Aerocom Cloud Top Estimates vs. Back Trajectory Height Estimates
- MERRA Simulated SO₂ dispersal vs. OMI Observed SO₂ dispersal
Emission altitude and timing can be estimated from **back trajectories from observations**

The Trajectory Transport Test:
A trajectory has successfully described the transport of an SO$_2$ measurement if it arrives within a minimum distance of the volcano.

The **Distance of Closest Approach**

\[ r^{*}(\theta, t^{*}) \]

\( \theta \) - the theta height of that trajectory
\( t^{*} \) - is the time of closest approach

**Derive Emission Probability Distribution Functions (PDFs) from those trajectories that arrive within a minimum distance of the volcano**
SO$_2$ Explosive Eruption Case Studies:

Kasatochi 2008

Okmok 2008

Soufriere Hills 2006

Sierra Negra 2005
AeroCom Volcanic Emission Inventory: Select Cases

- **Soufriere Hills 2006**
  - SO2 Emissions [Kg/day]
  - Days: 5/20/06, 5/21/06, 5/22/06, 5/23/06, 5/24/06, 5/25/06

- **Kasatochi 2008**
  - SO2 Emissions [Kg/day]
  - Day: 8/8/08

- **Sierra Negra 2005**
  - SO2 Emissions [Kg/day]
  - Days: 10/24/05, 10/25/05, 10/26/05, 10/27/05, 10/28/05, 10/29/05, 10/30/05

- **Okmok 2008**
  - SO2 Emissions [Kg/day]
  - Days: 7/12/08, 7/13/08, 7/14/08, 7/15/08, 7/16/08, 7/17/08, 7/19/08, 7/20/08
How well do the derived height profiles compare to those assumed in the GEOS-5/GOCART MERRA Run?
SO$_2$ Emission Height-Time PDF
Soufriere Hills

GOCART SO₂ Emissions

Cloud Top

Assumed Profile

Pressure Level (mb)

Altitude (km)

2006-05-19
2006-05-20
2006-05-21

Time/Date
Kasatochi

GOCART SO$_2$ Emissions

Pressure Level (mb)

2008-08-08

Time/Date

Altitude (km)
SO$_2$ Emission Height-Time PDF
GOCART SO$_2$ Emissions

Okmok
How do satellite observations compare to the simulated SO$_2$ dispersal?

**Soufriere Hills**

- OMI SO2
- GEOS-5/GOCART

**Sierra Negra**

- OMI SO2
- GEOS-5/GOCART
Model vs. Satellite: There is a large disagreement seen in Sierra Negra and Soufriere Hills and better agreement with Kasatochi and Okmok.
Concluding Remarks

• The assumed profile of 1/3 the column between cloud top and volcano summit
  – Appears incorrect for several eruptions
  – May be pushing SO2 into the lower trop creating incorrect dispersal/loss rates in MERRA (Soufriere Hills)

• Comparing dispersal rates of MERRA vs. OMI can be misleading as continuous emission can give the appearance of longer dispersal rates (Sierra Negra)

• Need to more directly compare OMI and MERRA.