Mt. Etna SO₂ fluxes from PlumeTraj analysis of TROPOMI data

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PlumeTraj

- A pixel-based trajectory analysis of an SO₂ cloud (Pardini et al., 2017, 2018)
- A back-trajectory analysis is performed through the Hybrid Single-Particle Lagrangian Integrated Trajectory model HYSPLIT yielding emission parameters such as plume height and injection time for each pixel
- The satellite data is then corrected using the retrieved plume heights i.e. the VCs are interpolated using the retrieved plume heights.
- For each plume pixel the SO₂ load is computed
- https://www.sciencedirect.com/science/article/pii/S0377027318301896
- https://www.sciencedirect.com/science/article/pii/S037702731630244X

Results Etna July 2018



Ground-based SO2 flux measurements

- Two methods for SO2 flux quantification: Automatic scanning and traverses, both using UV absorption spectroscopy
- Primary goal of volcano observatory is to detect a large change in degassing. Volcanic gas fluxes can change by orders of magnitude before and during eruptions, so high precision and accuracy are not really needed. Errors in scanning systems typically quoted at ~50% but can be higher due to scattering, geometry and plume velocity uncertainties
- Comparing with satellite data may be apples and oranges.
- Traverse data are more robust, and can be performed with better constraints. We did multiple traverses this week on Etna
- Salerno et al., 2009
- https://www.sciencedirect.com/science/article/pii/S0377027309000791

Comparison TROPOMI (PlumeTraj) and FLAME between July 5 and 16 (where data was available).



Fair agreement for July 5 (a), 7 (c), 8 (d), 10(f) and 12 (h)

Grey envelop depicts uncertainty from TROPOMI VCD, PlumeTraj plume heights and injection times

GFS 0.25 degree resolution data yields lower fluxes than GDAS 0.5 degree resolution data as fewer pixels are back-traced to the vent.

Reason for difference might be that GFS is forecast data whereas GDAS contains actual measurements (e.g. from balloon, satellite)



Time (LICT)

TROPOMI vs. ground traverse, 25 September – 28 September 2018



Example for 26/9/2018

Driving traverse of Etna plume (blue: complete track, orange: traverse) with an upward looking USB 2000 spectrometer + IFIT along track shown on map

TROPOMI input data

PlumeTraj results (with 0.5 degree GDAS meteo data)



Time (UCT)

TROPOMI input data

PlumeTraj results (with 0.5 degree GDAS meteo data)



Conclusions

- OK agreement between TROPOMI and Ground fluxes, but:
- Some large discrepancies are unexplained
- Need to deconvolve the error budgets using both TROPOMI and ground
- Neither dataset is perfect so we need more effort to improve the quality of ground-based data to ensure a high quality data

We need to push a little harder to achieve better understanding of error budgets, most easily done with a few more campaigns of traverses and improved plume velocity calculations, which are now being deployed in Catania

TROPOMI SO₂ data will be very widely used for volcanic degassing studies, the higher spatial resolution is a real game changer, so high quality robust validations are essential. Etna is an ideal place for this as we can work with the observatory to improve both ground and space-based flux measurements.