A new archive including radio occultation profiles collocated with the largest SO_2 volcanic eruptions between 2006 and 2016

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Abstract

Explosive volcanic eruptions can generate ash and SO_2 clouds reaching the stratosphere and dispersing on a global scale. These volcanic events are at the origin of many hazards such as aircraft engine damages, ash fallouts, acid rains, short-term climate changes and health threats. Monitoring volcanic clouds altitude and dispersion over time is thus of primary importance to mitigate these hazards. When it comes to global monitoring satellite techniques have proven to be the most efficient at tracking volcanic aerosols in the atmosphere. However, satellite data are scattered amongst the different institutes and agencies acquiring and processing them, and their retrieval is time-consuming.

Here we present a multi-sensor archive collecting spatial and temporal information about volcanic SO_2 clouds generated by the 11 largest eruptions in between 2006 and 2016. We archived and collocated the SO_2 vertical column density estimations from three different satellite instruments (AIRS, IASI and GOME-2), the Global Navigation Satellite Systems (GNSS) Radio Occultations (RO), and the aerosol type from the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP). We also provide information about the cloud-top height from three different algorithms including the bending angle anomaly due to the presence of the cloud. The dataset is gathering 206 days of SO2 data, collocated with 44180 backscatter profiles and 64764 radio occultation profiles.

This new archive allows an easy access to the datasets according to the users' needs and its applications will impact many fields of volcanology and atmospheric physics, such as numerical modelling and climate studies. The data described here are published with a DOI at https://doi.org/10.5880/fidgeo.2020.016.

Background

We use for this work:

- The SO_2 retrievals from Atmospheric Infrared Sounder (AIRS) [1], Infrared Atmospheric Sounding Interferometer (IASI) [2], and the Global Ozone Monitoring Experiment 2 (GOME-2) [3], all providing horizontal and temporal information on SO_2 concentrations;
- The SO_2 cloud altitude estimations from IASI [4], the Cloud-Aerosol LIdar with Orthogonal Polarization (CALIOP) backscatter [5] and the Global Navigation Satellite System (GNSS) Radio Occultation (RO) [6];
- The cloud aerosol subtype information from CALIOP;
- The atmospheric properties such as temperature, pressure and humidity from GNSS RO profiles.

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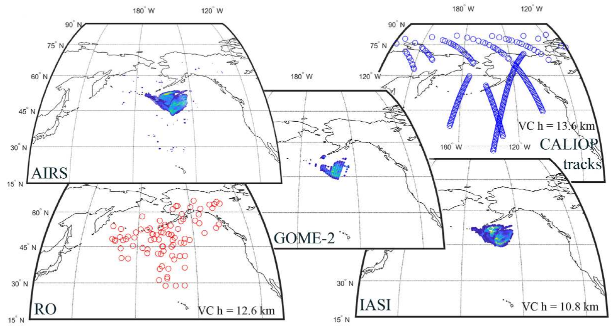


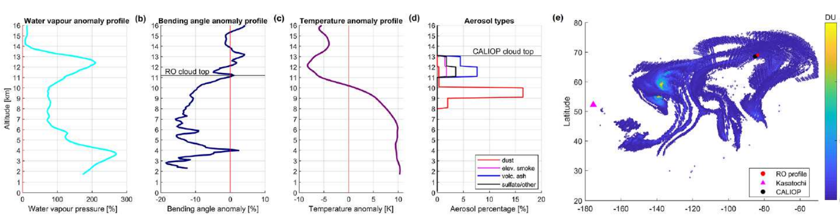
Example of data collocation and data use for the Kasatochi 2008 eruption

Methodology and Results

Data collection and collocation

Volcano	CALIOP		AIRS		IASI		GOME		RO	
	# of profiles	# of days covered	# of granules	# of days covered	# of scanning lines	# of days covered	# of scanning lines	# of days covered	# of profiles	# of days covered
Calbuco	12495	30	350	30	42740	30	20992	5	5362	31
Eyjafjallajökull	3569	16	76	16	3980	16	164369	16	2624	17
Grímsvötn	6268	21	147	8	49824	20	833541	21	6007	21
Kasatochi	12897	23	247	13	103622	21	650031	23	17045	23
Kelut	72	2	1	1	1313	1	2575	1	83	2
Merapi	1053	11	27	10	4919	15	80193	16	984	17
Nabro	2463	11	123	12	59359	11	638316	9	7131	14
Okmok	5678	23	32	11	2931	18	737981	26	13255	26
PCC	0	0	76	11	21528	11	369992	11	664	12
Sarychev	11563	34	127	17	83533	35	1035931	36	16522	36
Tolbachik	617	7	9	2	5390	5	22133	5	449	7

RO profiles are spatially collocated at 0.2° and temporally at 12h with SO_2 detection from AIRS, IASI and GOME-2. We also collocated the RO with the CALIOP backscatter, when possible. RO reference climatology is computed on 5° latitude bands using RO covering the period 2001-2017. These CALIOP products are collocated at 0.2° and 1h with AIRS, IASI and GOME-2 for the purpose of confirming the presence of certain aerosol types simultaneously with SO_2.



Case study Kastochi 2008.
RO profiles corresponding to the CALIOP aerosol type profile collocated with the SO_2 estimation from IASI

Cloud top heigths comparison

Volcano	RO-CALIOP altitude average (km)	#	RO-IASI altitude average (km)	#	IASI-CALIOP altitude average (km)	#
Calbuco	4.2	39	3.4	867	4.9	308
Eyjafjallajökull	0.3	1	3.7	30	3.5	29
Grímsvötn	0.9	5	3.7	136	2.4	75
Kasatochi	1.3	70	1.2	3855	1.6	997
Kelut	/	0	1.7	20	/	0
Merapi	1.5	1	2.7	127	2.2	70
Nabro	3.4	9	4.3	609	3.6	204
Okmok	3.3	2	1.8	143	2.5	22
Puyehue-Cordón Caulle	/	0	1.6	193	/	0
Sarychev	1.5	24	1.5	1519	2.8	227
Tolbachik	/	0	3.0	68	/	0

The difference in cloud-top estimations is due to the different sensitivities and vertical resolution of the instruments. Moreover, the number of collocations between RO and CALIOP is much smaller than the collocations RO-IASI and IASI-CALIOP. For AIRS, IASI and GOME-2 the uncertainty may depend on different parameters, such as thickness of the volcanic cloud and amount of aerosols which are needed to retrieve the cloud top. Furthermore, the measurement noise of instruments increases over time due to instrument degradation.

This archive is the first comprehensive archive with quantitative information of large SO_2 volcanic clouds. The user can compare the SO_2 estimation from three different algorithms, to check the cloud structure by downloading the collocated CALIOP sub-tracks and to analyze the impact of the volcanic cloud on the atmospheric vertical structure with the RO profiles.

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