Study of the sulphur cycle in volcanic plumes from the joint analysis of complementary POLDER and OMI polar-orbiting satellite observations of both gas and particles

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ABSTRACT :

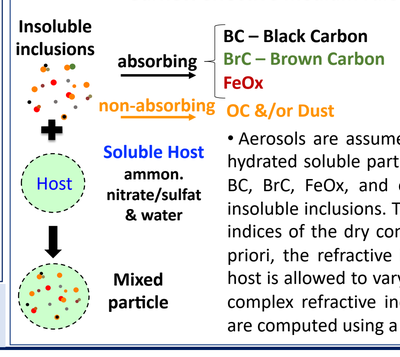
SO_2 emitted from the volcano converts into secondary **Sulphate aerosols** (SO_4^{2-}) by a series of complex chemical and physical atmospheric processes. There are some publication that report the qualitative detection of volcanic sulphate aerosol using IASI satellite observations (Karagulian et al., JGR 2010, Clarisse et al., 2013) but there is no evidence available for the quantitative detection of sulphate aerosol from the polar orbiting satellite observation so far in our knowledge. In this work, we jointly analyzed the **OMI SO_2 column amount** (SO_2 CA) (to constrain sulfur-rich emissions and identify the volcanic plume dispersion) and multi-wavelength, multi-angle and polarization **POLDER** satellite observation (retrieved using the **GRASP** algorithm) that are specifically sensitive to fine mode particles such as sulphate aerosols (**for characterization of aerosols components and it's optical properties**) to further understand the Sulphur cycle and ash presence in the volcanic plume over **Kilauea.** The unique geographical features, meteorological conditions and continues ongoing degassing since 1983 (both passive and active) helps in better understanding of the volcanic aerosols such as sulphate and ash particles and their physio chemical properties.

DATA & METHODOLOGY

OMI: SO_2 CA
Overpass time: 13:45 LT
Spatial resolution : 13*24km

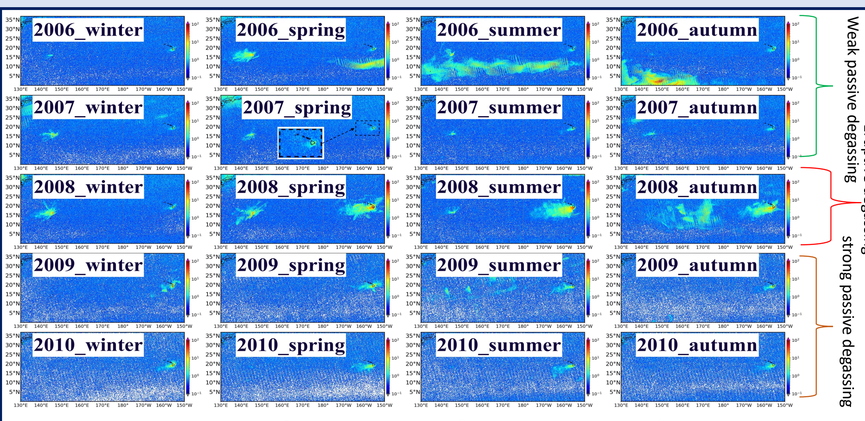
PARASOL :
Overpass time : 13:30 LT
Spatial resolution 5.3 * 6.2 km
Spectral resolution : 9

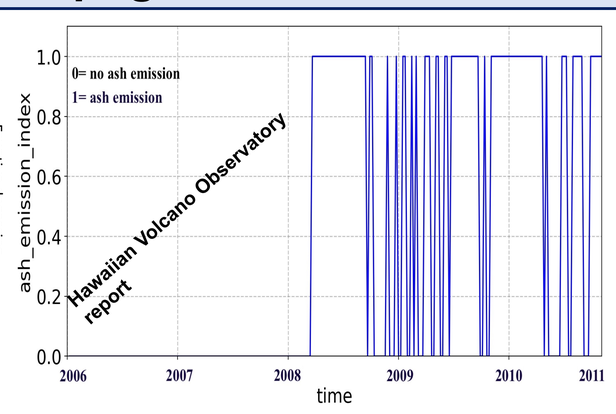
POLDER/GRASP/Components algorithm
[Li et al., PhD thesis 2018; Li et al., 2019, ACP]
Particles mixture assuming Maxwell Garnett effective medium rule



- Aerosols are assumed to be mixtures of hydrated soluble particles embedded with BC, BrC, FeOx, and other non-absorbing insoluble inclusions. The complex refractive indices of the dry components are fixed a priori, the refractive index of the soluble host is allowed to vary with hydration. The complex refractive indices of the mixture are computed using a mixing rule.

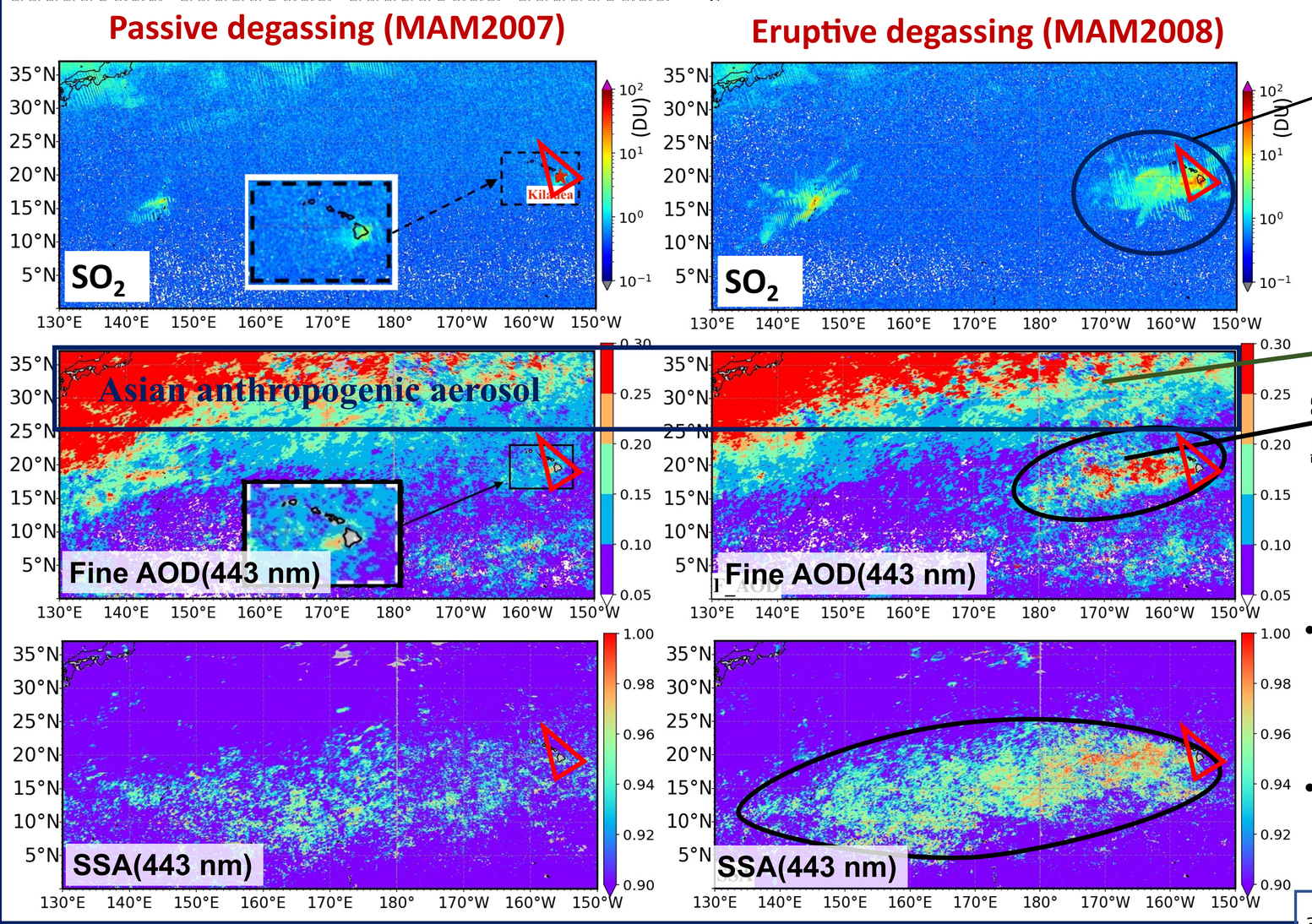
1. Characterization of volcanic and anthropogenic Asian aerosols over Kilauea

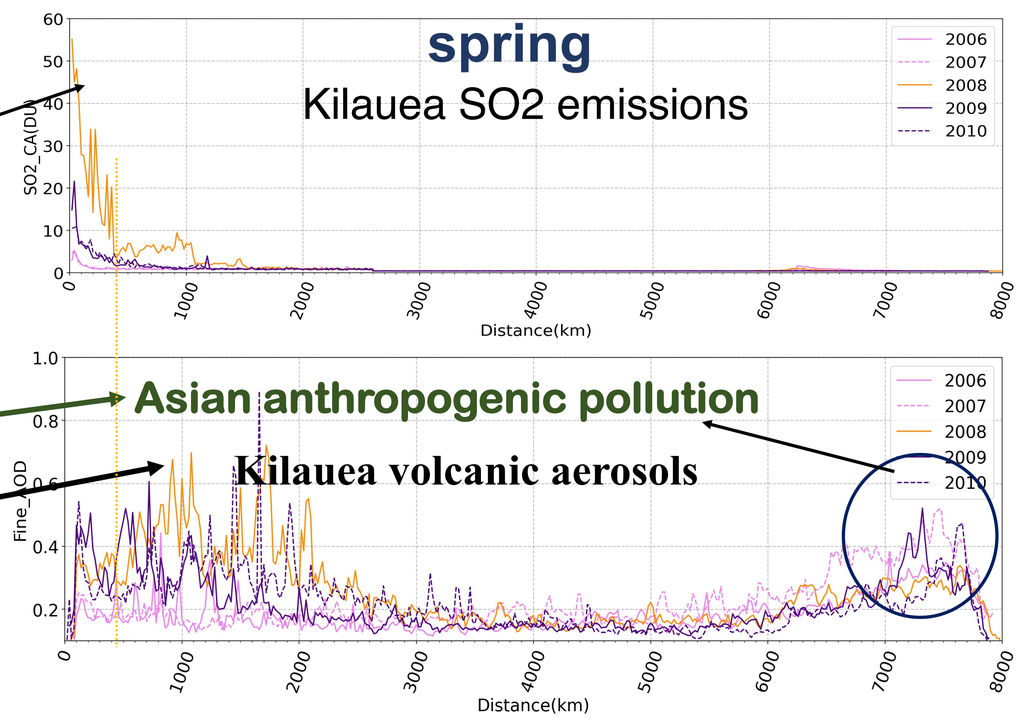




- Increase in **SO_2 CA** since 2008 Spring indicates beginning of an explosive eruption over Kilauea which is persistent till the end of the year.
- The ash emission is quite persistent after the beginning of the eruption over Kilauea (Hawaiian Volcano Observatory (HVO).
- The collocating pixels of **Fine AOD** and **SSA** from POLDER with **SO_2 CA** indicates the dominance of fine mode volcanic aerosol (more likely sulphate) over Kilauea.

Passive degassing (MAM2007) | **Eruptive degassing (MAM2008)**

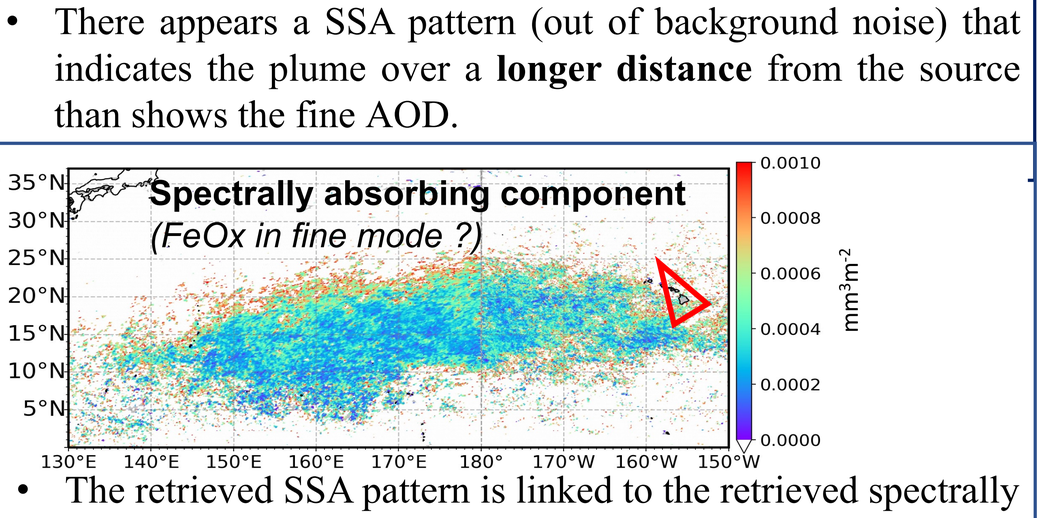




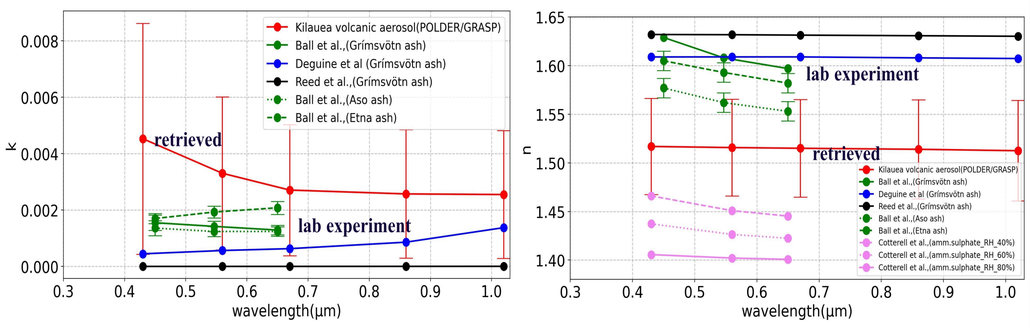
- There is a notable transport of **Asian aerosols** during spring over the island (AOD>0.25, SSA(0.75-0.85)) and it's clearly distinguishable from the **volcanic plume** where the **SSA** is relatively higher (***0.94-1***).
- There appears a SSA pattern (out of background noise) that indicates the plume over a **longer distance** from the source than shows the fine AOD.

2. A complex mixture of volcanic particles (sulfate and ash) from Kilauea derived from GRASP/POLDER retrievals

- There is a significant **increase** in **fine soluble** and **fine insoluble** vol. concentration after the beginning of eruption and No contribution of **coarse mode particles** were detected.



- The retrieved SSA pattern is linked to the retrieved spectrally absorbing component in fine mode (the source signal can be BrC or rather FeOx or similar).



- The imaginary RI within the plume during **spring 2008** is slightly **higher** than the values for pure ash detected in lab experiments, but RI retrievals at low AOD should be interpreted carefully, the imaginary RI has increasing tendency when lack of sensitivity. The **real RI** is lower then the pure ash – can indicate the presence of sulfates.
- So what really the fine insoluble can be: sulphate coated ash?

Conclusion :

- The joint analysis of gas and particle concentration over Kilauea helps in unambiguous detection of the volcanic gas and related aerosol over the region.
- The analysis of optical properties over the region indicates possible opportunity to further verify the presence of sulfate coated ash over the region.

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