Master 2: Research Training 2023-2024

Laboratory: LOA (Laboratoire d'Optique Atmosphérique, Université de Lille)

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Eventually CaPPA Work Package: WP3, WP4, WP2

The size of aerosols from major volcanic eruptions and megafires: a key to understanding their impact on climate

Stratospheric sulfate aerosols play a key role on atmospheric chemistry, Earth's radiation budget and climate, but their size distribution, a critical parameter in climate models, is generally poorly known (Marshall et al. 2022). To address such gap, we have recently developed a novel method of analysis of AERONET (AErosol RObotic NETwork) ground-based remote sensing measurements. Synergy with various Low Earth Orbit (TROPOMI, IASI), geostationary (HIMAWARI-8/AHI) and active LIDAR (CALIOP) satellite observations, has allowed for tracking the growth and multi-year global persistence of stratospheric sulfate aerosols from the 2022 Hunga Tonga-Hunga Ha'apai explosive eruption, a record-breaking eruption in the satellite era (Boichu et al., JGR 2023). Thanks to the coverage of the worldwide open-access AERONET network of sun/sky/lunar photometers, we provide, with improved spatial and temporal resolutions, the size distribution of sulfate aerosols, which are often larger in size than background fine particles. Hence, our new method allows for separating the signature of volcanic aerosols from those of background particles coexisting in the atmospheric column. This makes it possible to identify volcanic aerosols and accurately describe their microphysical and absorption properties, as function of plume age, for timescales ranging from days to years.

Taking advantage of this new method, we propose to a motivated Master student to retrospectively investigate the multi-decadal archive of AERONET data (1993-today) in order to analyse extreme events with a potential climate impact, such as major eruptions or megafire smoke events. If an extreme event takes place during the internship, the student will be naturally involved in the analysis. The use of the recently-developed open-access AERIS VOLCPLUME web portal (Boichu and Mathurin, 2022) will support the joint analysis of ground-based photometric and satellite observations to track the dispersion of aerosols from their point of emission, and study their physico-chemical evolution in the atmosphere.

This internship is within the framework of Horizon Europe FAIR EASE and AERIS VOLCPLUME projects in collaboration with DATA TERRA Research Infrastructure, AERIS/ICARE and FORM@TER National Data and Services Centres. It also contributes to the ACTRIS Research Infrastructure and CaPPA labex.

This Master study could be extended by a PhD thesis focusing on aerosols from extreme atmospheric events, with different open perspectives including: developments of refined retrieval algorithms of AERONET data, joint analysis of ground-based Raman multi-wavelength LIDAR observations from the ATOLL platform in Lille, and possibly climate modeling in collaboration with METEOFRANCE to simulate their impact on climate. The AERONET program is a federation of ground-based remote sensing aerosol networks established by NASA and the French national service of observations PHOTONS/AERONET at the University of Lille (LOA). A collaboration with the NASA group can therefore be envisaged.

Key words: Aerosols, volcanic eruptions, megafire smoke, climate, size distribution, AERONET, photometry, satellite, VOLCPLUME web portal

Requirements: Background in physics, environmental sciences, computer science or equivalent. Strong interest in data analysis, atmospheric and climate studies. Experience in programming (Python is preferred).

References:

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Marshall, L.R., Maters, E.C., Schmidt, A., Timmreck, C., Robock, A., Toohey, M. (2022), "Volcanic effects on climate: recent advances and future avenues". *Bulletin of Volcanology*. 84(5):54. doi: 10.1007/s00445-022-01559-3