UP 2: Volcanic Effects on Atmosphere and Climate

Time: Wednesday 11:00–12:30 Location: MOL/0213

Invited Talk UP 2.1 Wed 11:00 MOL/0213

Volcanic radiative forcing: past and future — •Anja Schmidt — Institute of Atmospheric Physics (IPA), German Aerospace Center (DLR), Oberpfaffenhofen, Germany — Meteorological Institute, Ludwig Maximilian University of Munich, Munich, Germany — Yusuf Hamied Department of Chemistry, University of Cambridge, Cambridge, United Kingdom

Volcanism is a major driver of climate variability and has played a critical role in the long-term evolution of Earth*s atmosphere and habitability through the release of gases including sulfur species, water, carbon dioxide, and halogens. In this talk, I will summarize my work on volcanic radiative forcing exerted by volcanic eruptions of different magnitudes in the past and in the future. The general mechanisms by which volcanic eruptions affect climate are well understood today. Until recently, research efforts have mainly been focused on the direct radiative, dynamical and chemical effects of sulfate aerosol particles formed by large-magnitude explosive eruptions such as Mt. Pinatubo in 1991. However, eruptions much smaller in magnitude than 1991 Mt. Pinatubo routinely decrease the transparency of the stratosphere to a degree that a cooling effect is discernible in upper tropospheric temperature measurements. I will make a case for the need to include these small-magnitude eruptions in climate model simulations. In addition, I will show that global warming can affect both eruptive column dynamics and the volcanic sulfate aerosol lifecycle and thus the radiative forcing and climate effects of future volcanic eruptions.

UP 2.2 Wed 11:30 MOL/0213

Reduction of average stratospheric aerosol size after volcanic eruptions — •Felix Wrana[1], Ulrike Niemeier[2], Sandra Wallis[1], and Christian von Savigny[1] — [1]Institute of Physics, University of Greifswald, 17489 Greifswald, Germany — [2]Max Planck Institute for Meteorology, 20146 Hamburg, Germany

The evolution of the size distribution of stratospheric aerosols after volcanic eruptions is still not understood very well, due to the temporal sparsity of in situ measurements, the low spatial coverage by ground based observations and the difficulties to derive aerosol size information from satellite measurements. To contribute to this ongoing research, we show data from our aerosol size retrieval using SAGE III/ISS solar occultation measurements. Using a three wavelength extinction approach the parameters of assumed to be monomodal lognormal particle size distributions are retrieved.

Surprisingly we find that some volcanic eruptions can lead to a decrease in average stratospheric aerosol size, in this case the 2018 Ambae eruptions and the 2019 Ulawun eruptions, while other eruptions have a more expected increasing effect on the average particle size, like the 2019 Raikoke eruption. We show how different parameters like the median radius, the absolute mode width and the number density evolve after the mentioned eruptions.

Additionally, as a part of our ongoing research to understand the underlying mechanisms controlling the observed aerosol size reduction, we show simulations of the aforementioned volcanic eruptions using the aerosol-climate model MAECHAM5-HAM.

UP 2.3 Wed 11:45 MOL/0213

A miniaturized chemiluminescence ozone monitor for drone-based measurements in volcanic plumes — •Maja Rüth[1], Ellen Bräutigam[1], Jonas Kuhn[1], Nicole Bobrowski[1], Ulrich Platt[1], and Christopher Fuchs[2] — [1]Institute for Environmental Physics, Heidelberg University, Germany — [2]ETH Zürich, Switzerland

Volcanic plumes contain reactive halogen species, especially bromine monoxide (BrO), which catalyzes ozone (O3) destruction. Therefore, local O3 depletion is commonly assumed inside volcanic plumes and has also been measured to varying degrees at different volcanoes in several studies. However, a calculation comparing atmospheric mixing with the rate of O3 destruction suggests no significant reactive halogen catalysed O3-loss (1% or less) in the plume. So far, O3 and its distribution in volcanic plumes have only been insufficiently determined since commonly used ultraviolet (UV) absorption O3 monitors show interference with sulphur dioxide (SO2), an abundant volcanic gas.

This problem can be overcome by using a chemiluminescence (CL) O3 monitor, which has no known interference from trace gases abundant in volcanic plumes. However, field measurements with former CL O3 monitors are challenging, as they were heavy and bulky.

Here we report on a lightweight version of the instrument (1 kg, shoebox size), which can be mounted onto a drone. In particular, we describe the design advances making the reduction in weight and size possible and present first test measurements. By allowing the instrument to be carried by a drone into the plume, this opens up completely new measurement strategies.

UP 2.4 Wed 12:00 MOL/0213

Highly resolved volcanic SO2 emission flux measurements with imaging Fabry-Perot interferometer correlation spectroscopy — •Jaro Heimann[1], Alexander Nies[1,2], Christopher Fuchs[1,3], Jonas Kuhn[1], Nicole Bobrowski[1,4], and Ulrich Platt[1] — [1]Institute of Environmental Physics, Heidelberg University, Germany — [2]CNRS/University Orleans, France — [3]ETH Zurich, Zurich, Switzerland — [4]INGV, Catania, Italy

Imaging Fabry-Perot interferometer (FPI) correlation spectroscopy (IFPICS) is a robust and mobile imaging technology, to study volcanic trace gas emissions with high temporal resolution and accuracy. The FPI provides a periodic transmission spectrum which is matched to the periodic narrowband absorption structure of the target trace gas (due to vibronic excitations in the UV). From the resulting data an image of trace gas column density can be inferred via an instrument model. Since the image acquisition takes about 2.4s for an image, it is possible to calculate emission fluxes on this timescale.
Here we present SO2 flux measurements from July 2022 at Mt. Etna with an IFPICS instrument with a detection limit of $\approx 5e17\,molec/cm^2$ at 4 Megapixel spatial and 2.4s temporal resolution, e.g. a mean flux of 418 ± 138 t/day^{-1} for the 15th of July 2021 between 08:17 and 10:13 UTC. We will furthermore discuss uncertainties and challenges of the technique.

UP 2.5 Wed 12:15 MOL/0213

Impact of a strong volcanic eruption on the summer middle atmosphere in UA-ICON simulations — •Sandra Wallis[1], Hauke Schmidt[2], and Christian von Savigny[1] — [1]University of Greifswald, Greifswald, Germany — [2]Max Planck Institute for Meteorology, Hamburg, Germany

Explosive tropical volcanic eruptions are able to inject large amounts of sulfur dioxide into the stratosphere. Sulfur dioxide mostly converts to sulfate aerosols that can increase the temperature of the lower stratosphere and subsequently alter the stratospheric circulation. This was directly observed after the strong Pinatubo eruption in 1991. The impact on the mesosphere is less well understood, mainly because of a lack of strong eruptions during the satellite era and sparse observations of the middle atmosphere before. Few measurements, however, hint to an increase in mesospheric temperatures after the Pinatubo eruptions. We investigate dynamical mechanisms that could explain such observations by simulating the response of the middle atmosphere to an idealized tropical eruption that emitted twice as much sulfur dioxide as the Pinatubo in 1991 using the upper-atmospheric icosahedral nonhydrostatic (UA-ICON) model. We focus on the first austral summer after the eruption and find a significant warming of the polar summer mesopause of up to 15-21 K. Our study indicates that this mesospheric warming is mainly due to vertical coupling through wave-mean flow interaction in the summer hemisphere and potentially enhanced by interhemispheric coupling (between the winter stratosphere and the summer mesosphere).