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Simulating long-range air pollution transport from the 2014-2015 Holuhraun eruption at Bárðarbunga volcano (Iceland) using ECMWF ERA5 meteorological reanalysis

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The Holuhraun flood lava eruption at Bardarbunga volcano (Iceland, 2014-15) emitted prodigious amounts of sulfur dioxide (SO_2) into the lower troposphere, ranking fifth in the eruptive SO_2 emission sources over the past decades. Multiple short-lived air pollution episodes resulting from this eruption were observed in western Europe. Recent studies (e.g. Schmidt et al., JGR, 2015, Boichu et al., ACP, 2016) have highlighted the current challenges faced in simulating accurately the long-range transport and the concentrations of volcanic SO_2 at ground-level over such large geographical areas.

With the aim of improving the results of air quality simulations, we here evaluate how model-simulated surface mass concentrations are impacted by the type of reanalysis (NCEP, ECMWF operational data, ECMWF Era Interim, ECMWF ERA5) used to force mesoscale numerical weather prediction models. Meteorological fields computed using WRF (Weather Research and Forecasting) model are used to force the CHIMERE Eulerian regional chemistry-transport model which allows to describe the atmospheric dispersal of the volcanic SO_2 cloud. Our model results are compared with SO_2 column amount observations from spaceborne sensors (OMI, OMPS, IASI) as well as SO_2 ground-level mass concentrations recorded at multiple stations of air quality monitoring in France, UK and the Netherlands.

We find large differences in model-simulated surface SO_2 mass concentrations depending on the type of reanalysis, leading to significantly different long-range transport of the volcanic pollutants as well as differences in boundary layer dynamics, which affect deposition and downward transport of pollutants. In terms of simulating the long-range transport of pollutants and their impacts on air quality, we show that ECMWF performs better than NCEP reanalysis data. Among the various ECMWF products (Operational Data, Era Interim, ERA5), the recently released ERA5 reanalysis, with much enhanced spatial and temporal resolutions and improved assimilation of weather observations, allows to reach the best agreement between modeled and observed surface mass concentrations.