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THE INFLUENCE OF THE HOLUHRAUN ERUPTION SO_2 EMISSIONS ON THE AUSTRIAN AIR QUALITY

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Abstract: The Holuhraun 2014 eruption released for several months large amounts of SO_2 into the atmosphere. During September 2014, the meteorological conditions favored a fast transport towards Europe which led to increased SO_2 ground-level concentrations in Austria, exceeding national regulatory levels. FLEXPART atmospheric transport calculations were performed with eight emission scenarios. All calculations represent well the transport pathway from Iceland to Austria but the maxima at ground level are often early (1 to 5 hours) with respect to the measurements, especially for the stations at the lee side of the Alps. The run with 6.5 km a.s.l injection height, non-linear vertical mass distribution and 112 kt/day SO_2 flux gives in general the best results. Regions to the north east, the Alpine region and the south-east of Austria are the most affected with modeled and measured concentrations above the Austrian regulatory 200 μgm^{-3} threshold for half-hourly values. Exposure of population is fairly low since most of the highly populated regions are outside the path of the plume except for the regions in Styria and Burgenland to the south-east. Daily averages are of no concern in terms of health, even considering the potential prolonged exposure given the 31% frequency of such transport pattern from Iceland to Austria.

Key words: *Holuhraun, atmospheric transport, FLEXPART, exposure*

INTRODUCTION

The Holuhraun SO_2 emissions in September 2014 led to increased concentrations at ground level in Austrian regions, especially in those regions at the south-east and on the lee side of the Alps. The Austrian air quality network captured an increase in the SO_2 concentrations, up to two orders of magnitude above the usual anthropogenic originated measurements.

DATA

A climatological study, following strict quality assurance criteria, of the SO_2 measured data has allowed the identification of 56 stations with clear (ratio with respect to the baseline of 10 or more) measurements of SO_2 originating from the Holuhraun eruption both on the upwind and lee sides of the Alps. These stations have been clustered according to the measured concentration time series for the 22nd of September, providing 5 clusters with different behaviour. These clusters have been used to discuss both measurements and model results.

METHOD

Atmospheric transport backtracking and correlation analysis from measurements at two clear sky mountain stations, Jungfraujoch and Sonnblick, shows that the most significant emission period to generate the enhanced ground level concentrations in Austria was that from 16 to 19 September. For this emission period, simulations with the Lagrangian atmospheric dispersion model FLEXPART (Stohl et al., 2005) have been performed, using different emission scenarios with variations in the SO_2 flux quantity and its vertical distribution and injection height. The calculation with an injection height of 6.5 km a.s.l and a non-uniform vertical mass distribution with a peak between 4 and 5 km a.s.l and 112 kt daily emission flux is the one representing best the measurements, whereas the other calculations, with different assumed emission characteristics, do not to represent the measurements that well, with some stations showing zero modeled SO_2 concentrations where measurements would be expected. However,

the statistical metrics per run vary too little to consider the differences between the selected emission scenarios significant.

RESULTS

The measurements show that the areas at the eastern tip of the Alps and towards the south-east of Austria are the regions with larger ground-level concentrations, with measured exceedances of the national half-hourly threshold level. FLEXPART captures reasonable well the magnitude of the peaks but with a general overestimation partly due to the limitation in the chemical reactions implemented (Figure 1a and b). Correlations largely increase when the lagging between measurements and modeled values is taken into account. The lagged cross-correlations are useful due to a common problem of all the performed FLEXPART simulations: the advancement of the simulated plume with respect to the measurements. The plume arrives too early (mostly between 1 and 3 hours) at the measurement locations. This is especially visible for the stations located at the lee side of the Alps (**Figure 1a**). The effect is due to a non-accurate representation of the flow driven by the ECMWF data and is not a problem that can be tackled without using different meteorological data. We also performed further analyses (not shown) using the high resolution NWP model WRF (the Weather Research and Forecasting Model) driven as well with ECMWF data. This did not improve the problematic time shift, neither was it corrected by using data from the National Centers for Environmental Prediction (NCEP) Global Forecast System (GFS). In addition, the duration of the plume impact is smaller in the FLEXPART calculations, leading to sharper plumes missing the behavior of most of the stations in Styria and Carinthia, with many of them showing a wide (more than 5 hours) observation peak, spanning, station-dependent, from 10:00 to 23:00 UTC September 2014.

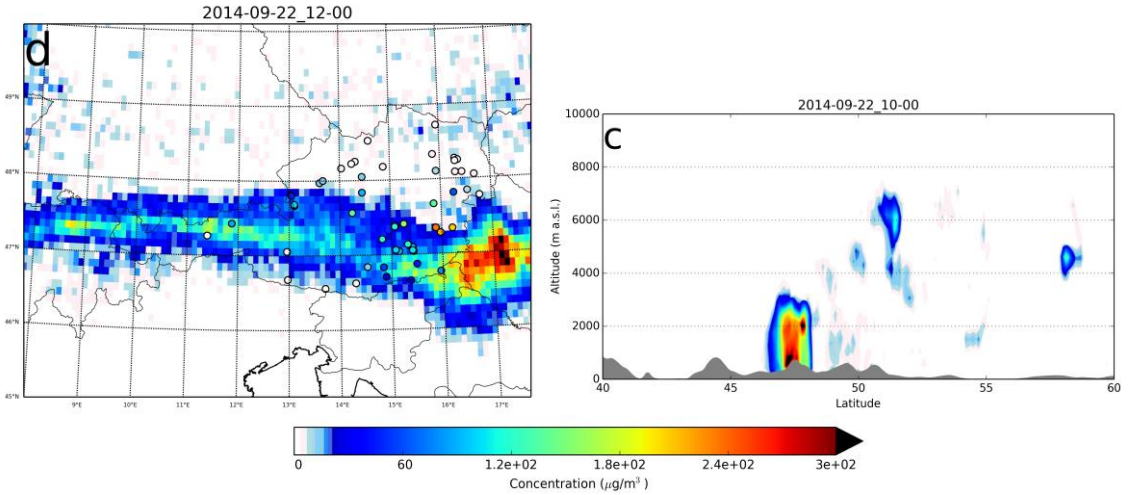

Figure 1: a: Modeled and measured (dots) SO_2 concentrations over Austria at 12:00 UTC.
b: Modeled SO_2 concentrations for a cross section at longitude 16°E at 10:00 UTC.

The cross section of the transport of the plume (**Figure 1b**) shows the areas where the plume is entrained downwards by a combination of post-frontal subsidence, diurnal mixing and, on the lee side of the Alps, a Foehn-like flow. This combination of effects, together with the large but low level emissions of Holuhraun, led to unusually high SO_2 concentrations in Austria. One of the causes of the concentration overestimation may be the lack of aqueous-phase chemistry for SO_2 in the FLEXPART model which, for such low level emissions, with transport within the lower troposphere, may be a significant loss process. Data from the German station Hohenpeissenberg has been used to have a crude estimate of how such a loss process could contribute by looking at SO_2 and H_2SO_4 measurements, yielding an approximate 20% of the total SO_2 possibly being in the liquid phase.

Although the half-hourly threshold level was exceeded in Austria, with five stations above the 200 μgm^{-3}, the annual averages were of no concern. Even extrapolating the effects of the Holuhraun eruption

considering a frequency of occurrence of the same transport pattern of 31% per year, the exposure of the population poses no significant risks, assuming the same flux, according to the current European and Austrian regulations. Nevertheless, the levels could be high enough to yield winter averages above 20 μgm^{-3}; concentrations that are detrimental to ecosystems.

REFERENCES

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