1 Introduction

The formation of the ~~e~~E arth's volcanic~~ally~~ activities have always shaped the earth surface and influenced ~~the~~ atmospheric processes. The first things that come to mind when thinking about volcanoes are the dramatic consequences of a major volcanic eruption. But volcanoes influence our lives in more than this way. Volcanic gases can effect the weather (timescales of days to weeks) or the climate (timescales of months to years)[1]. Examples are the lake eruption in Iceland (1783-1784) followed by a very hot summer and a cold winter in central Europa[2] and the eruption in 1815 ~~of Tambora in Indonesia~~ Tambora eruption, indonesia which caused the "year without summer" in 1816.

Considering ~~the~~ plate tectonics of earth most volcanoes are caused by diverging or converging of the continental plates and therefore located at the margins of the continental plates. Another possibility for occurrence of volcanoes is the ~~the~~ interior of continental or oceanic ~~shelves~~plates.[3] as well as during passing degassing phases
The most abundant volatile species released during a volcanic eruption are water vapour (H_2O; relative amount of the plume: 50%-90%) and carbon dioxide (CO_2; relative amount of the plume: 1%-40%)[4]. But the short effects of those two gases are rather ~~low~~ since the~~re~~ir effect on atmospheric composition is negligibly due to the high abundance of atmospheric H_2O and CO_2. But on timescales of the age of the earth the volcanic emission of H_2O and CO_2 are the source of our current atmosphere.[5]
A typically volcanic plume consists of many different gases alongside H_2O and CO_2 sulfur dioxide (SO_2) contributes with 1%-25% to the plume, hydrogen sulfide (H_2S) with 1%-10% and hydrogen chloride with (HCl) 1%-10%. Furthermore there are trace gases for example carbon disulfide (CS_2), carbon sulfide (COS) carbon monoxide (CO) hydrogen fluoride (HF) ~~and~~ hydrogen bromide (HBr)[4]
A decrease of stratospheric ozone (O_3) has been observed after the eruption of El Chickon in 1982 and the eruption of ~~m~~Mount Pinatubo 1991. A depletion stratospheric O_3 results in ozone holes. The depletion comes from volcanic aerosols which serve anthropogenic chlorine/bromine into more reactive forms[6]. Volcanic gases can alter the radiative balance of the earth in timescales relevant for climate change due to scatter and absorption of solar radiation[5].
The gas composition of the volcano plume change with activity and could be a indication for the processes inside the earth.

In this work we are particularly interested in the ratio of BrO and SO_2. The halogen sulfur ratio is a proxy for volcanic processes. Therefore we make the assumption that the ratio of BrO and SO2 contains informations about its degassing source depth. A change in BrO/SO2 prior to eruption was observed at Etna and Nevado del Ruiz.

To gain further knowledge about ~~the~~ volcanoes the Network for Observation of Volcanic and Atmospheric Change (NOVAC) was installed. NOVAC is a Network of DOAS ~~I~~instruments located next to about 30 volcanoes in Asia America, Africa and Europe. At ~~every~~ volcano there are two to four DOAS Instruments installed, recording ~~record~~ back-scattered solar radiation spectra at different viewing angles.
NOVAC is a network which produces a large amount of data and we have the chance to evaluate long time periods which is a unique opportunity to study correlations of the trace gases.
Since the conditions at volcanoes are rough, the instruments need to be rather simple to keep the maintenance cheap and to assure a longer lifetime of the instruments. ~~So we need to waive on~~ temperature stabilization even at the expense of the quality of the data.

One possibility to measure the volcanic trace gases is to use Differential Optical Absorption Spectroscopy[7]. DOAS exploit the wavelength dependency of the absorption of light. Here the gas emissions can be retrieved from the quotient of the absorption signal of the volcanic plume and a reference region. This will be explained in a further chapter.

The reference region, is usually treated as free of volcanic trace gases. If the reference region is for any reason contaminated by volcanic trace gases, the reference spectrum has to be replaced by a volcanic-gas-free reference. Alternative spectra could be for example a theoretical solar atlas spectrum or a volcanic-gas-free reference spectrum recorded in the temporal proximity(eg. a day before) by the same instrument. The first option comes with the drawback of reduced precision, as the instrumental effects have to be modeled and added to the retrieval. The reduction in precision is acceptable for the SO retrieval, but not suitable for a BrO retrieval because then most data would be below the detection limit. For the second option, the alternative reference spectrum should have been recorded at similar conditions with respect to meteorology ~~and~~ radiation ~~as well as~~ in ~~the~~ temporal prox-

imity due to instrumental changes with time and ambient conditions. We combined both options in order to achieve both, enhanced accuracy but still maximum possible precision of the SO2 and BrO retrievals. We present an algorithm which finds the optimal reference spectrum automatically. As first step, a possible SO2 contamination of the standard reference is checked by a comparison with the theoretical solar atlas. If a contamination is detected, as second step, the algorithm picks a volcanic-gas-free reference (beforehand automatically checked for contamination) from another scan.

~~In this work we are~~ mainly dealing with data from Tungurahua in Ecuador in the timespan of 01.08.2008 to 30.07.2009. Later on, we will also show the results of Nevado del Ruiz a volcano located in Colombia.

References

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