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Earth System Science Data Discussions

# *Interactive comment on* "Synoptic Analysis of a Decade of Daily Measurements of $SO_2$ Emission in the Troposphere from Volcanoes of the Global Ground-Based Network for Observation of Volcanic and Atmospheric Change" *by* Santiago Arellano et al.

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General Comments:

This is a very well-written, comprehensive paper describing the NOVAC project and database. Furthermore, it puts this project in context in the history of remote sensing observations of volcanic SO2 emissions. It goes well beyond the stated purpose of a "Presentation of an inventory of daily SO2 flux measurements in NOVAC program" after



standardized analysis of spectra and ECMWF reanalysis winds. References are provided to virtually all the important research in this area. It will be an excellent reference for users of the database.

The NOVAC program with routine daily monitoring is an advance over the episodic nature of the previous ground and airborne campaigns in response to explosive eruptions. The authors are to be commended for their extensive efforts to characterize volcanic so2 emissions. While satellites are able to measure even the largest eruptions, passive degassing has remained out of reach, at least until now when TropOMI and the new GEMS geostationary instrument have the ground resolution to detect air pollution levels of SO2. Thus, it will be interesting to see future comparisons.

Ground-based measurements of volcanic SO2 mass are challenging due to changing winds, emission rates, plume size, and cloud and lighting conditions. The dual-beam ScanDOAS instruments are a step forward in automating the data collection. Protocols for observations at the stations are described in detail, as are quality control measures. Steps taken to compensate for changing conditions are described. A post-processing program to assure uniform evaluation of data collected from diverse stations and operators is described.

The sources of error due to the challenging measurement conditions are discussed in some detail. A conservative approach for quality over quantity of observations placed in the database is advocated. Criteria for inclusion of measurements are discussed.

In Sec. 2, I am bothered by treating the word "data" as singular, as in "Data is transferred via a serial port. . ." (line 180, and again in line 189) in the scientific literature. I realize in non-scientific literature "data" can describe a single collection of facts, etc., but I learned to use "datum" for singular measurements and "data" for multiple points.

Sec. 3. Results

Figure 3, consisting of 32 plots of station data, is impossible to read and should be

presented in two or more sub-figures. In Fig. 5 (mis-referenced as fig. 4) the series of annual emissions from 12 volcanoes is compared with OMI data. These 12 panels are just legible on a printed page.

Steps to deal with the problem of calculating long-term emission budgets from irregular sets of data are discussed. The adopted policy of filling missing days by interpolation is understandable but problematic.

Sec. 3.3

The Chalmers data repository website includes site coverage maps, links to the data, and a link to the appropriate GVP page. The documentation seems thorough and includes data use agreements. This is user friendly and seems very well done.

Sec 4.2 Ground-based vs. space-based observations

Even on a log scale the differences between NOVAC and OMI annual emissions are large and the explanations are not convincing. I would think the failure of OMI in separating emissions from two nearby volcanoes would not be important as ground observers certainly will notice emissions from the other volcano, as noted. Limitations of NOVAC data to daytime hours cannot explain factors of 2 - 4 differences even given the high variability of emissions. In line 451ff "whereas OMI could in principle detect. . ." OMI can in fact detect any emissions that have occurred day or night prior to the overpass. However, one has to account for chemical or physical losses in order to calculate instantaneous emission rates and totals. As stated, an in-depth study of discrepancies is certainly needed. This section detracts from the otherwise excellent presentation of the research work. I suggest reworking or removing this section.

Perhaps treating the two datasets as complementary will help explain the differences, as alluded to in the conclusions. It could be that the real value of NOVAC may be in characterizing the continuing low-level background emissions of volcanoes. Any thoughts of validating older satellite data appear to be gone. However, if the suggestion



that low-level background emissions dominate the global volcanic SO2 budget is borne out, then this effort will have been successful.

In the Conclusions section, I am happy to see that Charlie Schnetzler, et al,'s idea of augmenting (or replacing) the qualitative VEI with a quantitative SEI as a measure of eruption sizes has not been totally forgotten (line 504).

The "Author contribution" section acknowledging the roles of team members is certain to be appreciated and is a valuable addition to the paper.

Detailed comments

line 158. "within <10km" is redundant. Use either "within" or "<".

line 237: "hPa", not "Pa".

line 319. "Fig. 5", not "fig. 4".

line 431. "Fig. 5", not "fig. 4".

line 858. "are", not "is".

Figures.

Fig. 2. Two sections of this figure are redundantly labeled "(a)". I assume one of those is actually (b). Please correct this.

Fig. 3. Individual plots are illegible without magnification. Suggest splitting into two or more figures.

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