# Review of GMD-2024-2941 « Assimilation of volcanic sulfur dioxide products from IASI and TROPOMI into the chemical transport model MOCAGE: case study of the 2021 La Soufrière Saint-Vincent eruption "

In this article, the authors assimilate observations of $SO_2$ total column from two different sensors (TROPOMI and IASI) into the MOCAGE CTM, in order to provide forecasts of volcanic plume for the VAACs. The topic is of importance, and the paper is well written and easy to read. The authors show a good command of the subject, and the article show promise, but I think it can be improved further. I have a few important questions, which amounts to a major revision. These key points are, in my opinion:

- The system described here has been designed to work only for this eruption, as mentioned by the authors themselves in the conclusion, because of the setting of the background error standard deviation (lines 239-240). If applied, say, to the Pinatubo eruption, adding increments between 9 and 21 km altitude will probably give a very wrong profile. Isn't it possible to design a system that doesn't need the manual input of this key information about injection height? Ideally, aerosol layer height information should be used.

- The main objective of the MOCAGE CTM in the VAACs is to provide forecasts of the aerosol layer (ash or sulphuric acid). I understand that ash in not in the scope of this article. However, the aerosol validation aspect Is treated very shortly, as compared to the $SO_2$ aspect. The volcanic signal is small as compared to the tropospheric aerosol signal for this eruption, which complicates things. The authors should try to either find and compare against retrievals which clearly show a volcanic signal for this eruption (OMPS-LP possibly), or chose another eruption for which the aerosol signal has been extensively documented, such as the Hunga Tonga eruption of 15/1/2022.

- Finally, if I understand correctly (please correct me if I am wrong), the observations assimilated here are really $SO_2$ total colum, not volcanic $SO_2$. There are some possibilities to discriminate the volcanic from the non volcanic signal in $SO_2$ total column observations (use of threshold, of flags from the data provider). If the focus of this work is to forecast $SO_2$ from volcanic eruptions, and not from pollution or from fires, some efforts should be carried out to assimilate observations that represent the volcanic signal, not the whole signal.

A bit less important

- Some important aspects of how the data assimilation is carried out (observational error, background error, correlation lengths) are missing or partly missing. Please refer to details in the specific comments.
- Why GOME-2 observations of TC $SO_2$ have not been used for evaluation, or actually for assimilation?

## Specific comments

- Title: the version of the MOCAGE CTM used for this work should be included in the title
- Lines 1-4: as explained later, aren't the VAACs more interested in ash/sulfate aerosols than $SO_2$? The interest in $SO_2$ is mainly as the precursor of sulfate particles, no?
- Lines 49-57, IFS-COMPO (IFS for atmospheric composition) is used for the MACC/CAMS projects. The "MACC" and "CAMS" systems are really IFS-COMPO. TCSO2 from TROPOMI is operationally assimilated in CAMS since October 2020. Please rephrase this part as I find it confusing
- Line 58 "large amount": are there any quantitative evaluation of the amount of SO2 released?
- Lines 123 – please provide some justifications as to why these flags only have been included. Any study of the impact of using only one/two flags?
- Lines 128-138: why was the layer height product not used to adjust background error statistics and thus add increments preferentially at the "right" altitude?
- Line 163 : what is "accident mode"?
- Line 192 : please detail "many vertical levels"
- Lines 195-198 : what exactly is assimilated? I suppose TC O3 and AOD? Please detail a bit
- Line 230-231 : "For TROPOMI, observation error covariance is directly computed from satellite data" : how is this done? And what is the result?
- Lines 230-235 : it would be good to have a plot that compares the observational error variance for the case study
- Lines 230-235 : what correlation length have been used for the obs covariance matrix?
- Lines 236-240 : what values have the background error variance as compared to the obs error variances for the two sensors?
- Line 246: I think this sentence should come at the end – backed by the conclusion reached before.
- Lines 310-313 : There are other aerosol observations to compare against than MODIS AOD : vertical profiles of extinction from CALIPSO, OMPS-LP etc…

- Line 315 : this evaluation approach is unusual and very nice to see. But it should maybe be restricted to observations that have not been assimilated. If you use assimilated observations to evaluate your analysis, then this is not independent validation.