

Near real-time assimilation of volcanic sulphur dioxide from different instruments in the MOCAGE model

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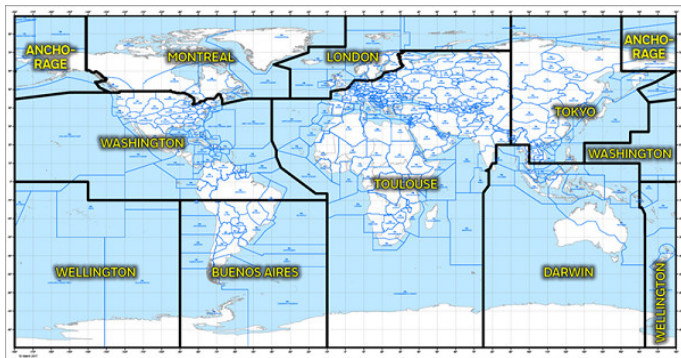
Introduction

Problem with particles released during eruptions

Large amounts of ash and SO₂ are released during volcanic eruptions. The crossing of a plume poses a particular threat to aircraft.

Role of VAAC

Météo France is responsible for one VAAC. Its purpose is to predict in near real time the transport of volcanic plumes (ash and SO₂) and allow aircraft pilots to avoid them.



MOCAGE

MOCAGE is an operational CTM allowing to forecast the composition of the atmosphere on both global and regional domains.

Operation of the Toulouse VAAC

A simplified version of the CTM MOCAGE is run to predict ash dispersion. For now, SO₂ satellite observations are only used by the forecasters to monitor and nowcast the behaviour of volcanic SO₂ plumes.

Objectives

Assimilate volcanic SO₂ total column product from different satellites (TROPOMI and IASI) and study the improvement of the forecast initialized by assimilation outputs.

Configuration of MOCAGE

Model configuration in this study

Global domain with a 1° resolution

Hourly meteorological forcing provided by ARPEGE model

Hourly 3D-VAR

3 simulations:

- assimilation of TROPOMI SO₂ total column product distributed by Eumetsat
- assimilation of IASI SO₂ total column product available in Aeris database
- assimilation of observations from both instruments

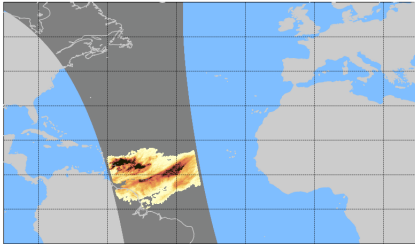
Validation with OMI observations

La Soufrière Saint Vincent eruption - 11th April 2021

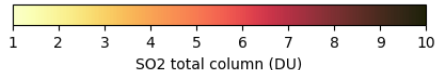
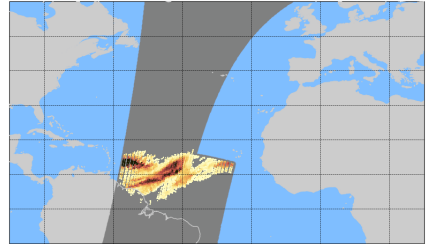
Several explosions between the 9th and the 12th April 2021.
SO₂ plume crossed the Atlantic Ocean and reached Africa.

SO₂ total column observed by:

TROPOMI on 11th April 2021 at
16UTC

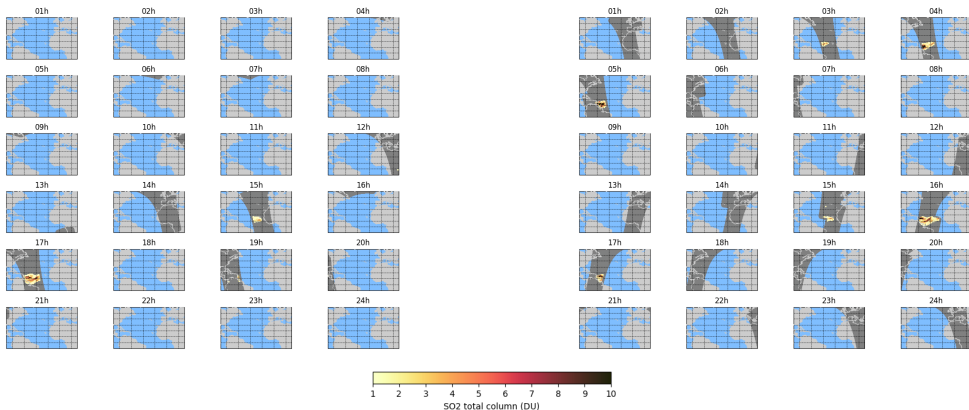


IASI B and C on 11th April 2021 at
13UTC



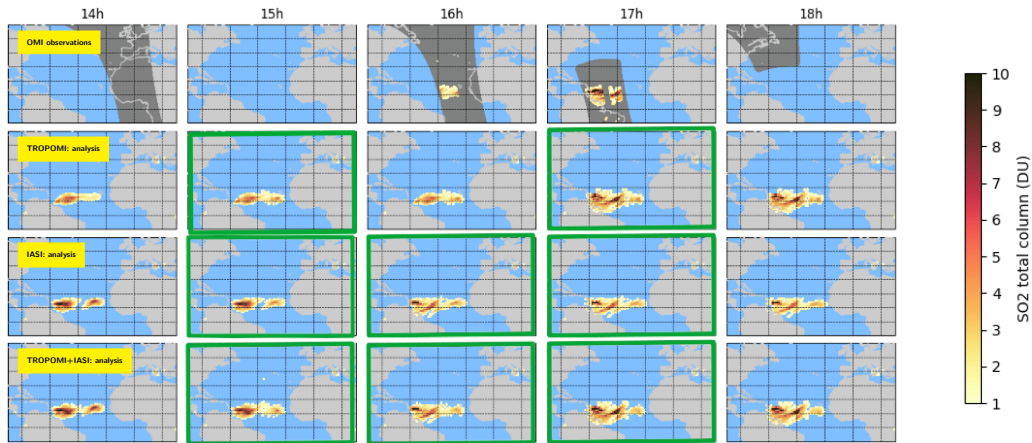
La Soufrière Saint Vincent eruption - 11th April 2021

SO₂ total column observations on 11th April 2021



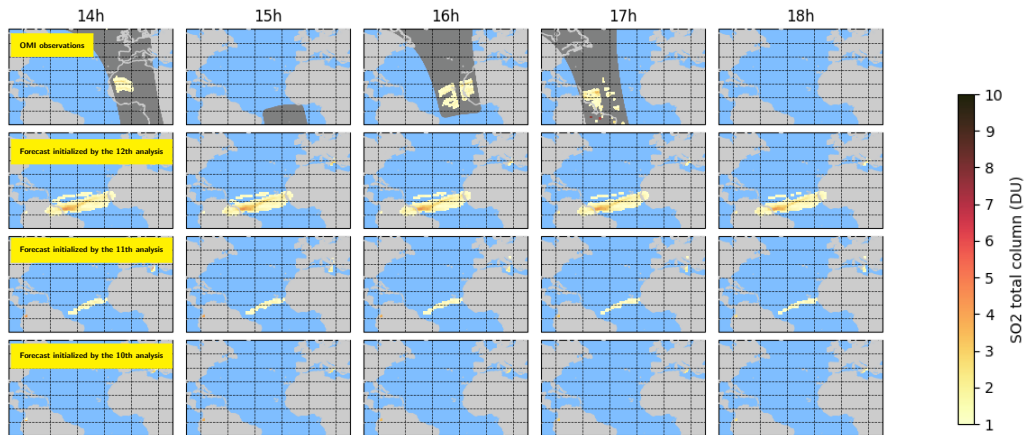
Tropomi passes over the plume only once a day whereas IASI passes over the plume twice a day

La Soufrière Saint Vincent eruption - 11th April 2021



IASI and TROPOMI complement each other. Moreover, structures modeled thanks to the assimilation are observed by OMI.

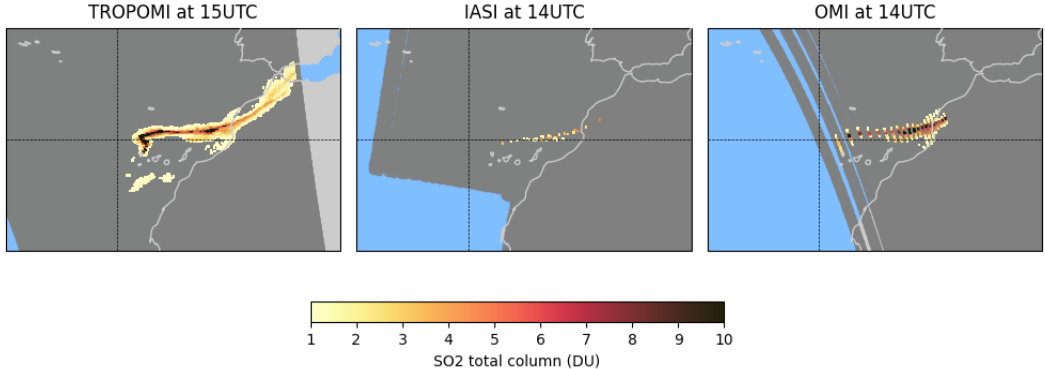
La Soufrière Saint Vincent eruption - Forecast initialized by TROPOMI and IASI data assimilation outputs for the 13th April 2021



Maps represent SO₂ total column forecasts at different terms for the 13th April 2021. Assimilating volcanic SO₂ total columns improves forecasts in short term.

Cumbre Vieja eruption - 25th September 2021

Eruption between 19th September and 13th December 2021
SO₂ plume is rarely above 5km of height



When SO₂ plume is under 5km, IASI has some difficulties to observe SO₂ total column

Conclusion

- Assimilating SO₂ total column in MOCAGE is very useful for the users of the Toulouse VAAC.
- Assimilation of SO₂ total column allows to improve forecasts in short term.
- Assimilating data provided by IASI allows to correct more often the modeled plume. Nevertheless, IASI has some difficulties to observe SO₂ total column for a plume under 5km of altitude.
- Assimilating data provided by TROPOMI allows to correct the modeled plume once a day but it is modeled even if the SO₂ plume is under 5km.
- Assimilating data from both instruments allows to correct the modeled plume at least once a day.

Soon operational

TROPOMI SO₂ assimilation should become operational in November 2022.

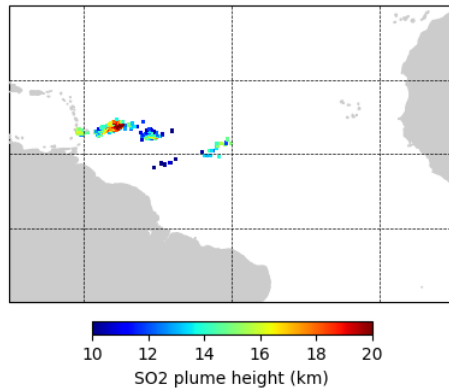
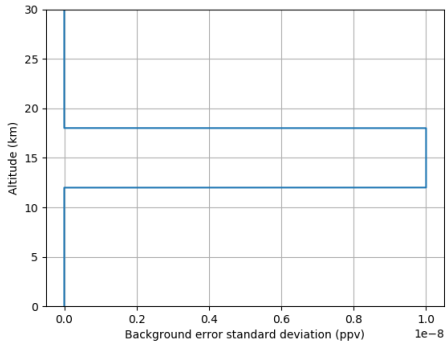
Perspectives

- Assimilating data provided by other satellites. The best option would be to assimilate data provided by geostationary satellites.
- Use information on SO₂ plume heights. This information is already available for IASI and TROPOMI.

Thank you for your attention

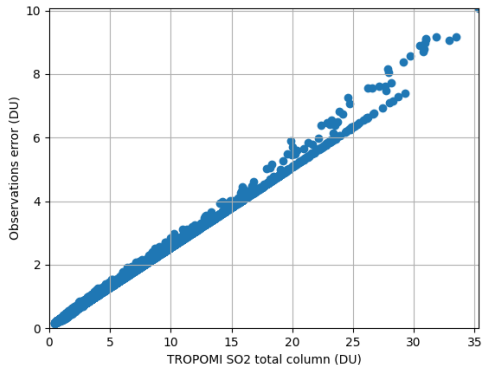


Choice of the background error matrix

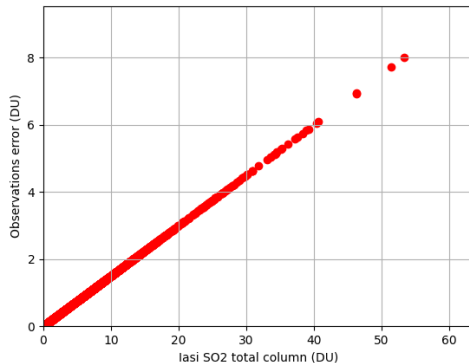


Background error covariance is a profile containing strong values between 12 and 18km. Tropomi Layer Height shows a SO2 plume at this height.

Choice of the observation error matrix



Observation error is directly read in the Tropomi files. Uncertainties are around 25%.



For IASI assimilation, we use 15% of the observations as observation errors.