Impact of the Christmas 2018 Mount Etna Eruption on the regional air quality

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Objective and methodology

Modeling study to analyse the impact of an eruption on the regional air quality. Focus on the Mediterranean region under the influence of the Mount Etna (24/12/18 eruption)

Impact in the free troposphere :

- SO_2 tropospheric column concentration
- Sulfate aerosol tropospheric column concentration

Impact at the surface

- SO_2 surface concentration
- Sulfate aerosol surface concentration
- Sulfur deposition (wet and dry deposition, sedimentation)

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Mount Etna eruption in December 2018

Beginning of the eruption : 24/12/18 at 10h45UTC
Persistent degassing during several days after the eruption
Large amount of SO_2 emitted

Time series of the Christmas Mount Etna eruption parameters, from the 24th of December to the 29th of December. SO_2 flux in kg/s (red line) are obtained from DOAS FLAME (FLux Automatic MEasurements) networks. Plume height in meter (blue line) are derieved from SEVERI. Data provided by INGV.

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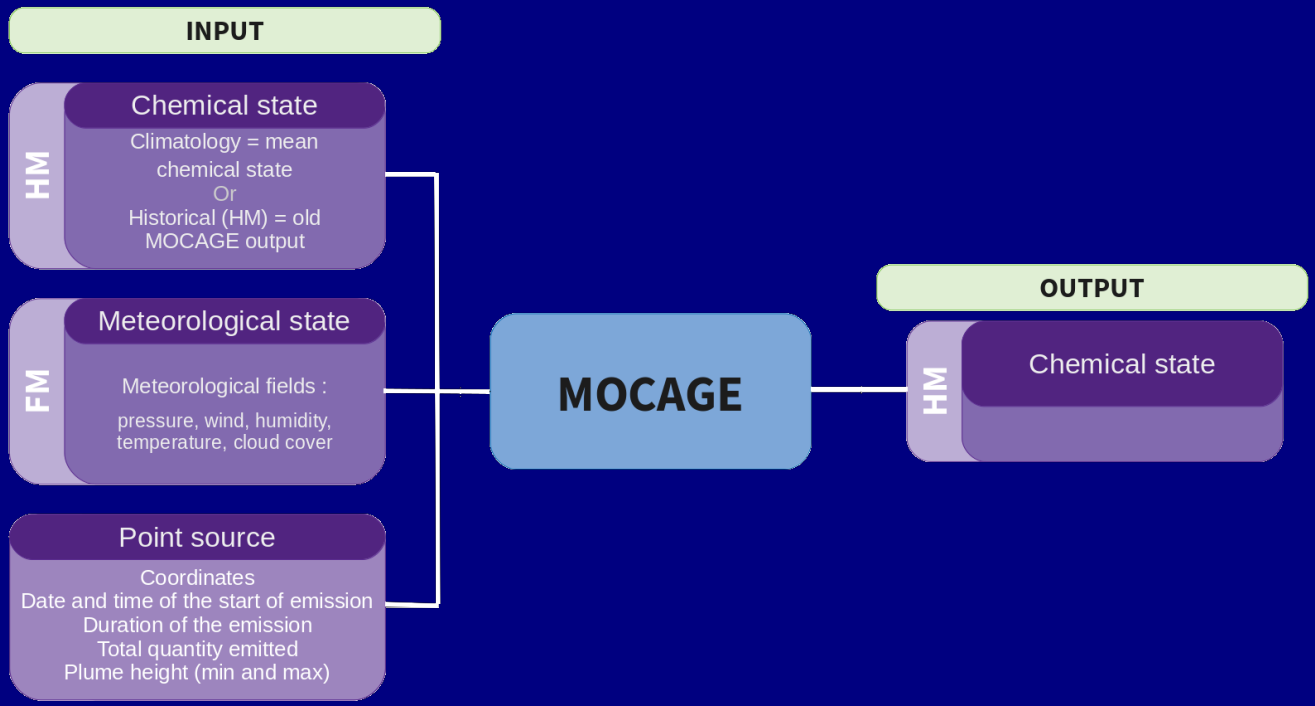
Tool : Chemistry-transport model MOCAGE



- 47 σ-hybrid vertical levels from surface to 5 hPa
- 7 levels in the planetary boundary level, 20 in the free troposphere and 20 in the stratosphere
- Chemical scheme : RACM for the troposhere and REPROBUS for the stratopshere
- Possibility to input a ponctual source point emission : *e.g.* a volcanic eruption

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Description of the simulations

Run between 24/12/18 00UTC to 01/01/19 00UTC
Mediterranean domain [16.1°N to 51.9°N, -19.9°E to 39.9°E]
Horizontal resolution 0.2°x 0.2°
Hourly meteorological forcing from ARPEGE operational weather forecast model

- NOERUPT : Anthopogenic and biogenic emissions
- ERUPT : Anthropogenic and biogenic emissions + Mount Etna eruption

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Validation against TROPOMI SO_2

Satellite information

On board the Copernicus Sentinel-5 Precursor satellite
Near polar, sun-synchronous orbit : one daily crossing around 12 :00 over the Mediterranean region
Spatial resolution : 3.5 x 7 km at nadir
Retrieval of several gases and aerosols species from UV-Visible to SWIR bands.

Dataset used

Data provided by BIRA-IASB
Vertical column density of SO_2 for a plume altitude at 7 km w.r.t. sea level and associated averaging kernels to get vertical sensitivity of the measurements

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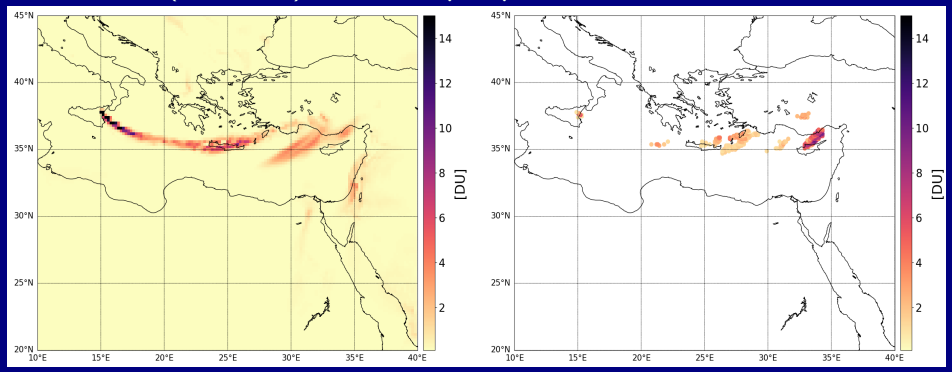
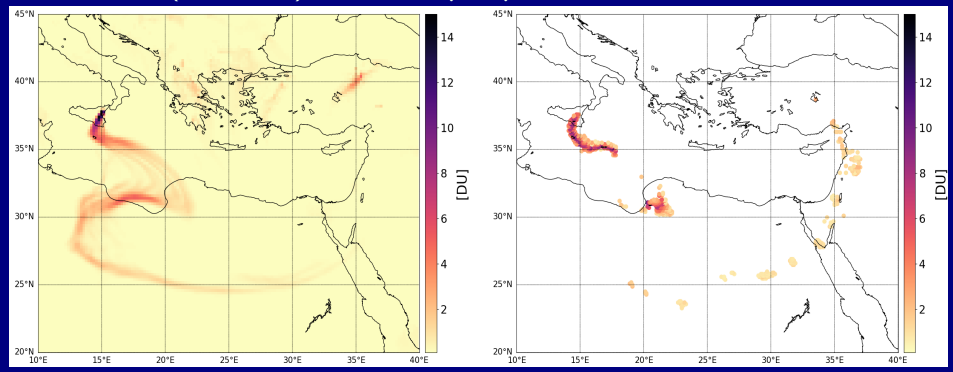
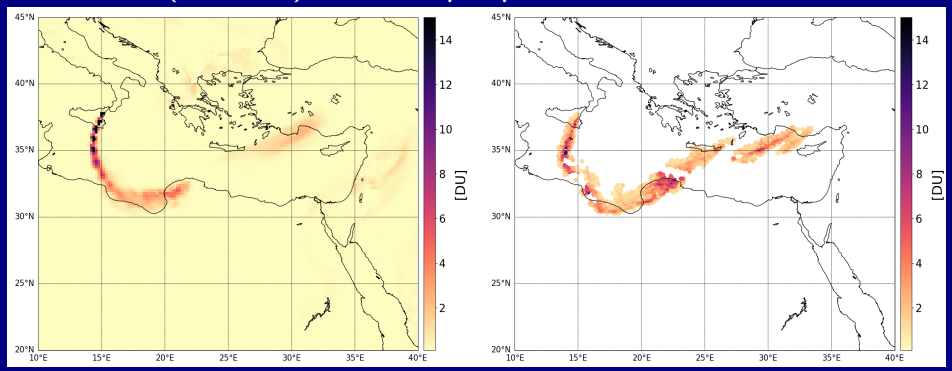
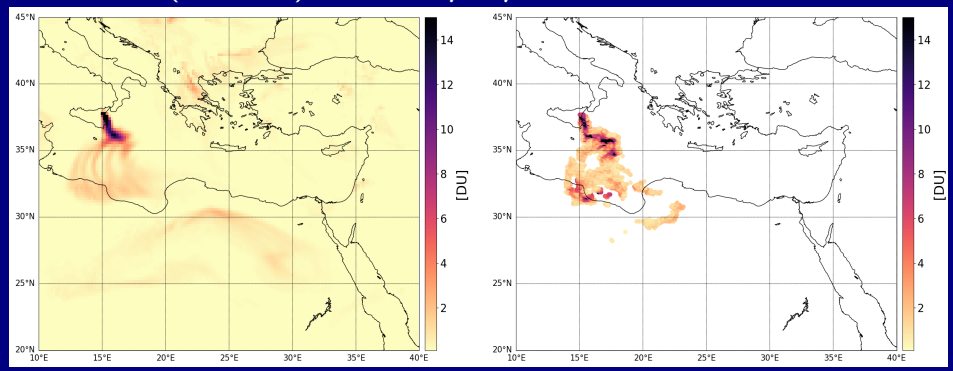
Validation against TROPOMI SO_2









Comparison between ERUPT simulation and TROPOMI

Good model performance of the transport of the plume, but slight shift in the location. Similar SO_2 concentration, but with overestimation near the emission source (possibly linked to TROPOMI underestimation due to volcanic ashes) and small underestimation far from the source (stronger dispersion of the plume) by the model.

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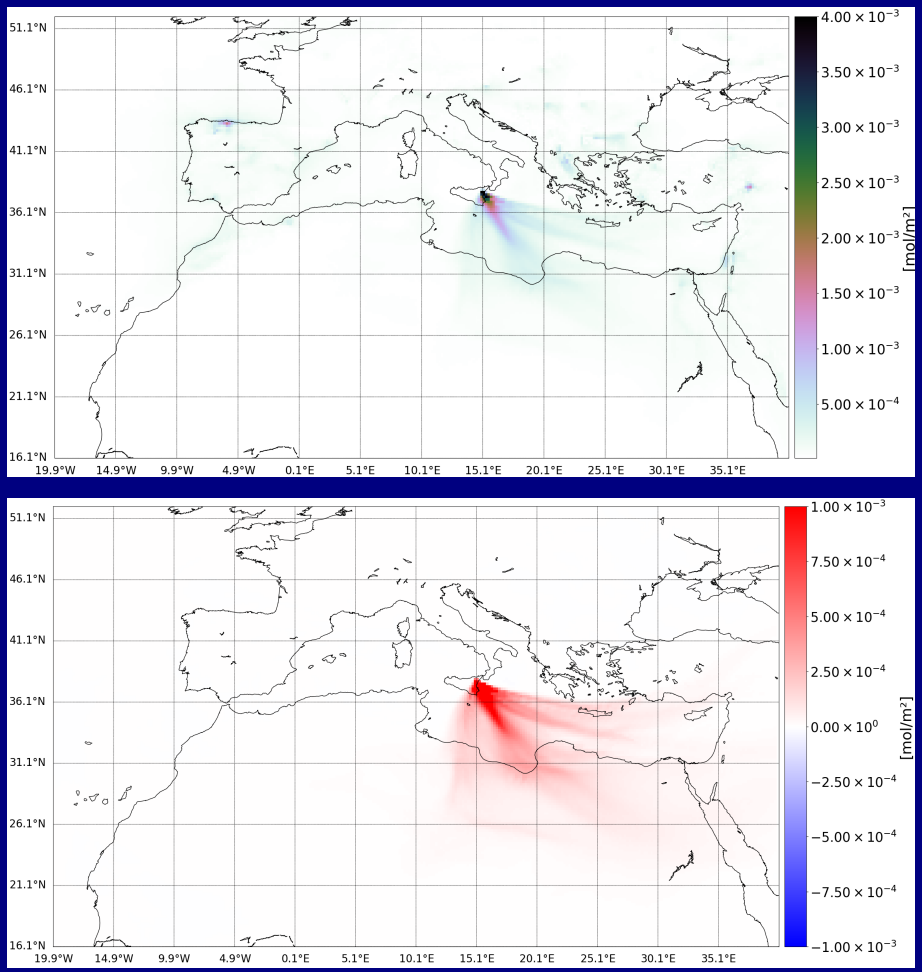
Impact on the SO_2 burden



(Top) Daily mean averaged over the whole simulation period SO_2 total column in mol/m^2 in ERUPT run and (bottom) absolute difference between ERUPT and NOERUPT run of the SO_2 total column in mol/m^2.

- Complex transport of the plume → wide dispersion cone
- SO_2 rapidly transformed into sulfate aerosol → spatially limited impact
- Almost no signature at the surface (figures not shown) → limited impact on the air quality

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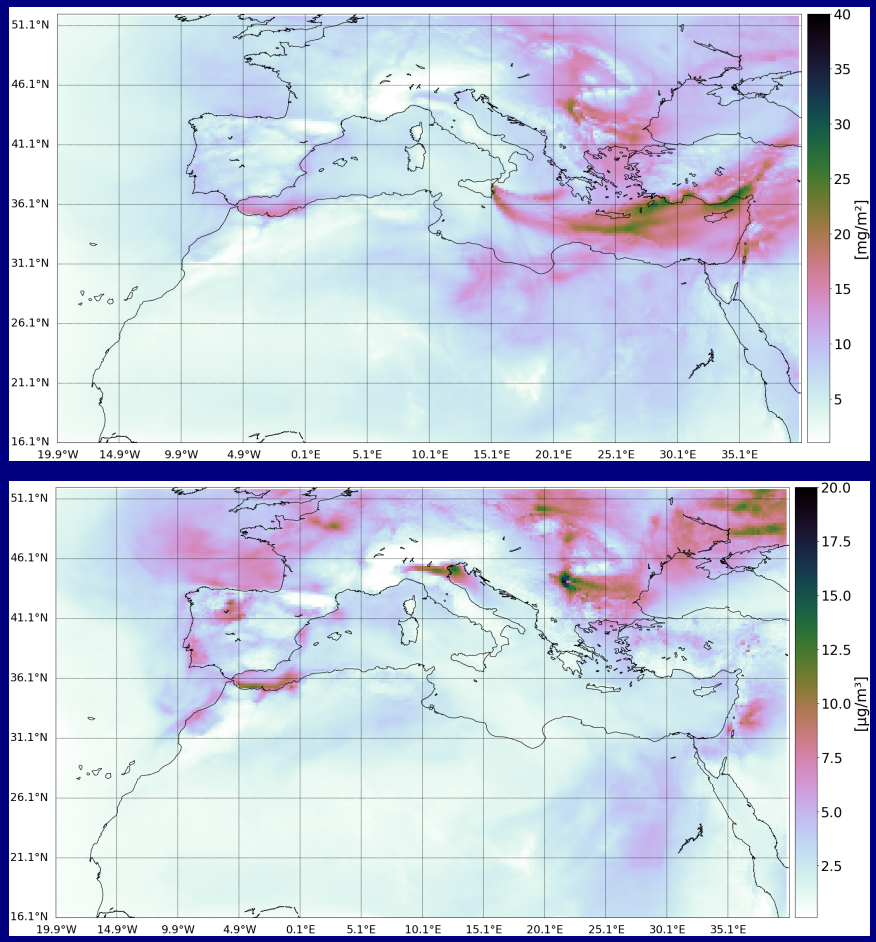
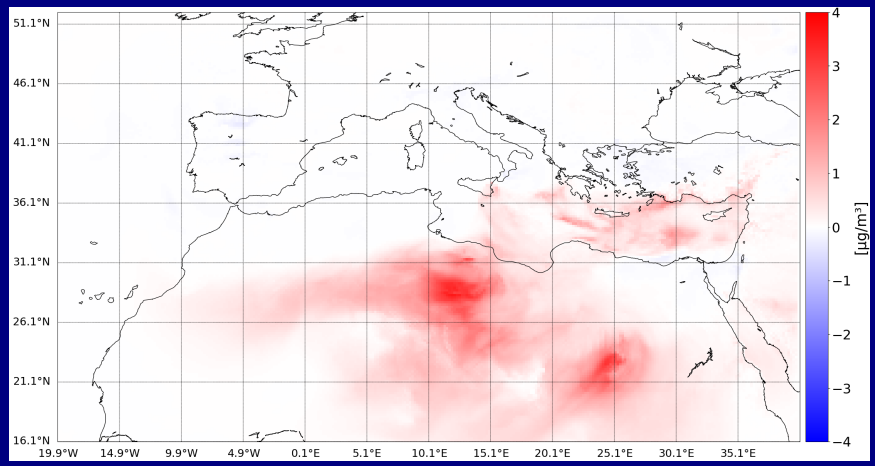
Impact on the sulfate burden



MOCAGE ERUPT run daily mean averaged over the whole simulation period sulfate (top) total column concentration in mg/m^2 and (bottom) surface concentration in $\mu g/m^3$.



Absolute difference between ERUPT and NOERUPT runs of the sulfate surface concentrations in $\mu g/m^3$

- Strong impact in the free troposphere with plume transported eastward (Fig. left-top)
- Small signature of the volcancic plume at the surface, especially in Egypt, Turkey and the East Mediterranean Sea (Fig. left-bottom)
- Differences of around 2 $\mu g/m^3$ $\rightarrow$ not negligible, small impact on the regional air quality (Fig. right)

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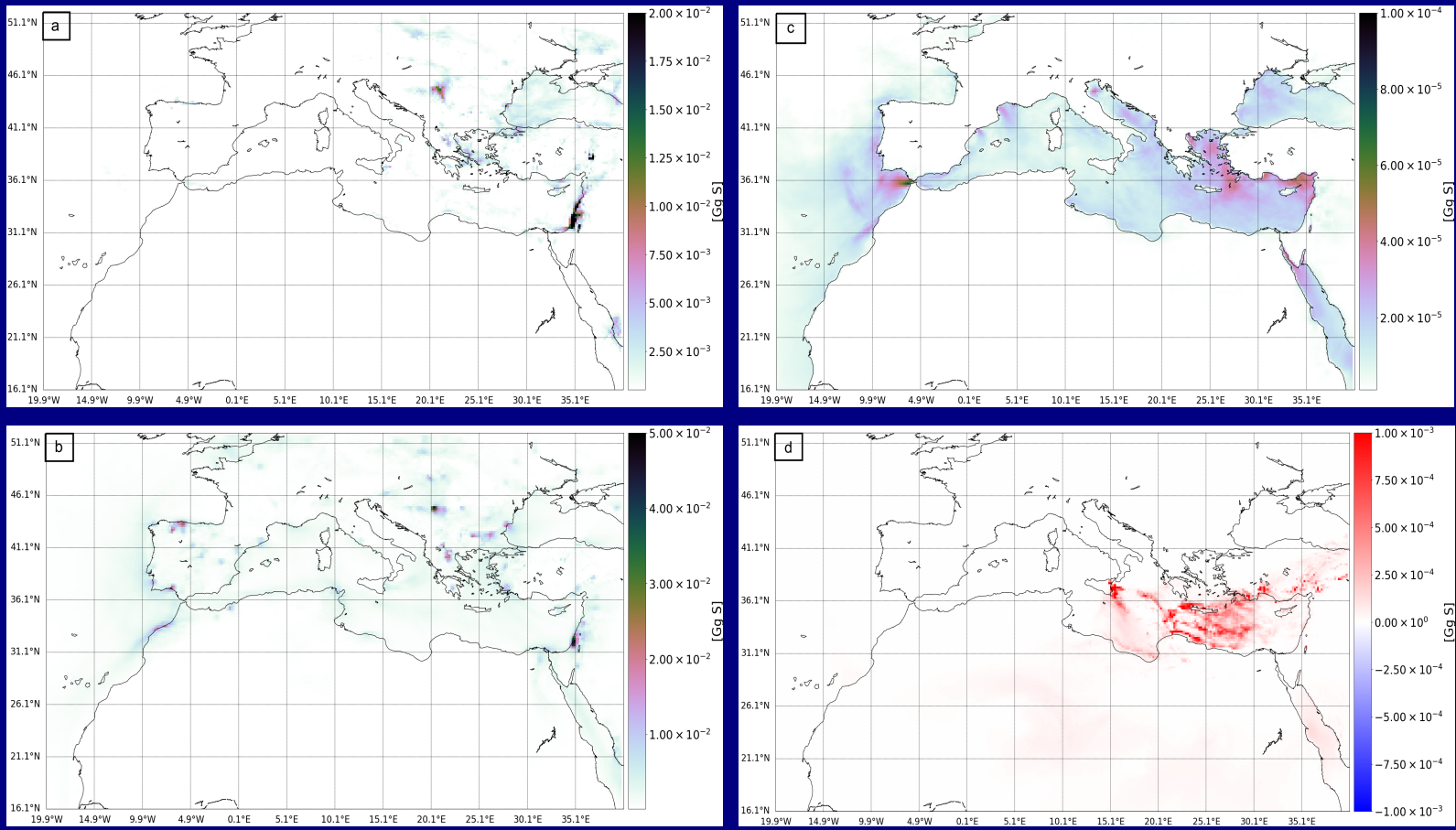
Impact on the sulfur deposition



MOCAGE ERUPT run, daily mean averaged over the whole simulation period sulfur (a) wet deposition, (b) dry deposition and (c) sedimentation in Gg S. (d) Absolute difference between ERUPT and NOERUPT of the total sulfur deposition in Gg S.

- Deposition mostly by wet and dry deposition, sedimentation is negligible
- Differences located over the sea, Turkey and a bit in the Sahara
- Volcanic sulfur deposition not negligible

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Conclusion and Perspectives

Conclusion

- Good representation of the plume transport by the model → good agreement with TROPOMI observations, useful for the validation
- Volcanic eruption influence strongly the free tropsphere burden in sulfur species concentrations
- SO_2 rapidly transformed into sulfate aerosol → almost no volcanic SO_2 signature at the surface, but volcanic sulfate aerosols have an impact
- Sulfur deposition due to the eruption not negligible

Perspectives

- Analyse more accurately on a daily scale to specify the plume impact on the air quality
- Look at the regional sulfur budget and analyse the volcanic eruption contribution
- Run sensitivity tests on the altitude of injection and SO_2 emission quantity to even better model SO_2 compared to TROPOMI
- Run a simulation without volcanic eruption but quiescent degassing to make a comparison

Any questions ? Contact claire.lamotte@meteo.fr

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