Modelling new particle formation in a passive volcanic plume using a new parameterisation in WRF-Chem - effects on climate-relevant variables at the regional scale

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Introduction / Context

- **New particle formation** (NPF) is an important **source** of aerosol **particles** at global scale, including, in particular, cloud condensation nuclei (**CCN**);

- **Volcanic plume conditions** remain **poorly documented** but **promote the occurrence of NPF**, as recently evidenced in the volcanic eruption plume of the Piton de la Fournaise (Rose at al. 2019) and in the passive degassing plumes of Etna and Stromboli (Sahyoun et al. 2019);

- A deeper comprehension of such **natural processes** is essential to assess their **climate-related effects** at **present days** but also to better define **pre-industrial conditions** and their variability in **climate model simulations**.

Objectives of the project

Further quantify the formation of new particles in a volcanic plume and assess the effects of the process at a regional scale.

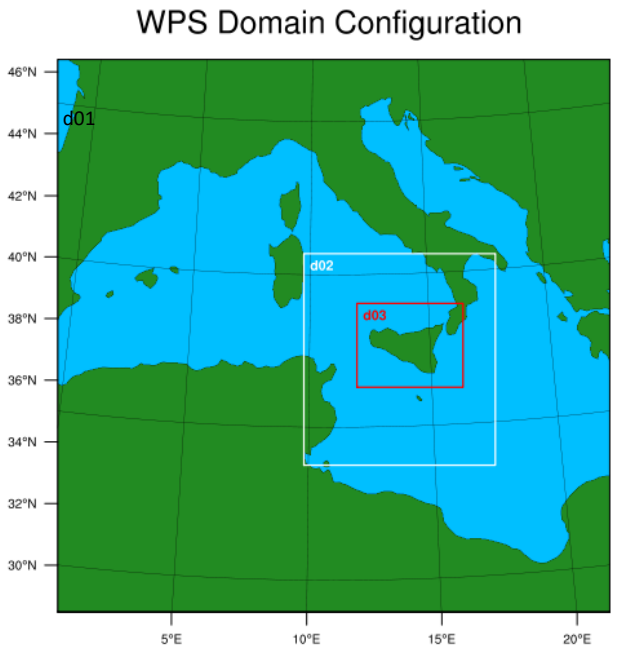
- **Strong connection** between **the cluster formation rate** and **sulphuric acid** (SA) concentration was evidenced based on airborne measurements performed in the passive degassing plumes of Etna and Stromboli by Sahyoun et al. (2019), who derived a **new parameterisation of nucleation** for these specific conditions;

- The new parameterisation was introduced in the **model WRF-Chem**, and the **flight ETNA13** described in detail in Sahyoun et al. (2019) was used as a case study to evaluate the effect on the prediction of the **cluster formation rate** and **particle number concentration** in various size ranges, including CCN (i.e. climate-relevant) sizes.

The model / simulations

Configuration of the model

- WRF-Chem version 3.9
- 3 nested domains (1km resolution for d03);
- Aerosol module: MOSAIC with 12 bins (1 nm – 10µm) ;
- Chemical mechanism: SAPRC99 , no aqueous phase chemistry;
- Meteorological conditions: ERA-Interim (forcing every 6 hours);
- Continuous SO_2 flux released from Etna grid point, representing a total of 0.4 kT/day, consistent with observations (Carn et al., 2017).



Description of the simulations

Simulation S1

Uses the parameterisation of J corresponding to **activation mechanism** (Kulmala et al., 2006; Sihto et al., 2006) available in WRF-Chem

$$J = 2.0\times10^{-6}\,[SA]$$

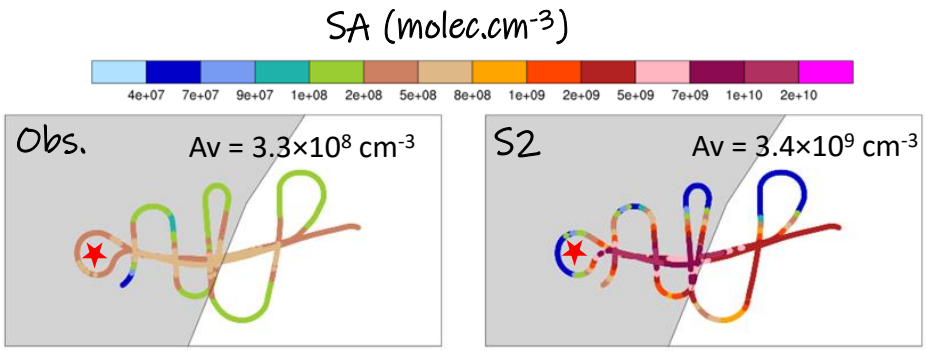
Simulation S2

Uses the **new parameterisation** of J derived by Sahyoun et al. (2019) in the volcanic plume of Etna

$$J = 1.844\times10^{-8}\,[SA]^{1.12}$$

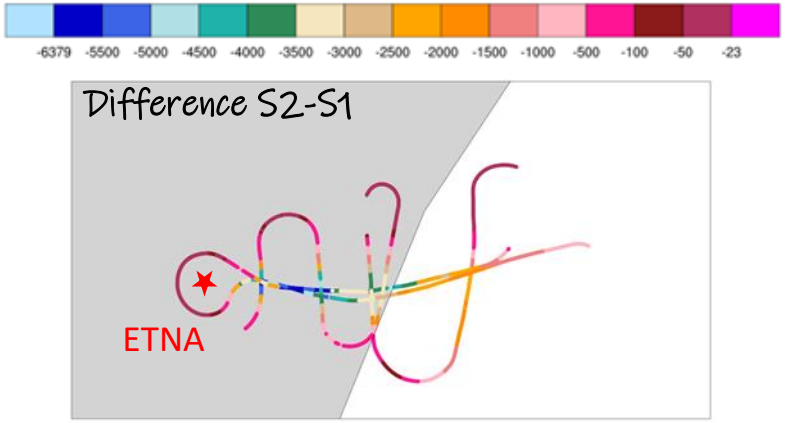
The model / simulations

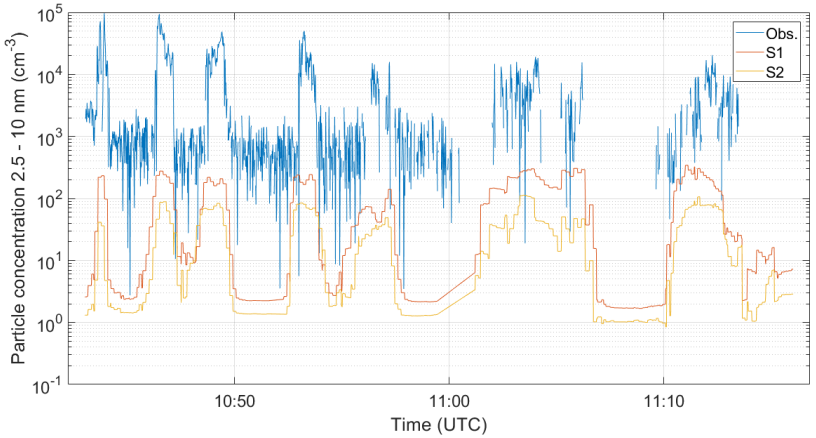
1 Comparison of measured vs simulated SA levels along the flight path (figures shown for S2 only)



- **Variations** are **well reproduced** by the model;
- However, **absolute concentrations** predicted by the **model** are slightly **higher** compared to observations, due to overestimation of SO_2 levels.

2 Effect of the new parameterisation on the cluster formation rate (J) and particle concentration





As expected, the **new parameterization** leads to **decreased formation rates** compared to S1. Also, predictions of J in S2 are on average higher compared to measurements (not shown), which is consistent with overestimated SA in the model;

However, in spite of higher J, **particle concentration in the range 2.5 – 10 nm** seems to be significantly **underestimated in the model**.

WHY?

Future work

- Perform new simulations with adjusted SO_2, to better match observed levels;
- Investigate the discrepancy between measured and predicted particle concentration in the range 2.5-10 nm. Can it be related to the treatment of early particle growth in the model?
- Investigate the effect of the new parameterization on particle concentration at larger particle sizes; what is the contribution of the volcanic source compared to other sources?

Post doc position!

1 year, starting no later than Nov. 2020
@ Laboratoire de Météorologie Physique (LaMP), Clermont-Ferrand, France

Candidate profile: background in **atmospheric sciences** (physics and/or chemistry) and a **strong expertise in modelling** will be valuable, in specific with WRF-Chem.

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Deadline for application: June 15th