SHORT TERM SCIENTIFIC MISSION (STSM) – SCIENTIFIC REPORT

The STSM applicant submits this report for approval to the STSM coordinator

Action number: CA16202 (inDust)
STSM title: Improving dust module performance in air quality forecasting in Portugal
STSM start and end date: 26-11-2018 to 30-11-2018
Grantee name: Michael Russo

PURPOSE OF THE STSM/

Currently, I am a PhD student and research fellow in the GEMAC research group, from the University of Aveiro in Portugal. My work here focuses on the study of regional air quality and the delivery of the air quality forecasting service for the Portuguese environmental protection agency. The current air quality modelling system used for the forecasting service is composed by the meteorological model WRF and the chemistry transport model CHIMERE. This numerical modelling system was already extensively applied and validated with success for the Portugal domain, and has been used for operational forecast and long-term air quality assessment since 2005. It is also being used in multiple ongoing projects (such as the AIRSHIP project, http://airship.web.ua.pt/en/project) in the group and for my PhD.

In line with my current work, the main objective of my stay at the BSC was to gain knowledge in earth sciences and modelling environments, focusing on improvements of dust forecasting and overall model performance, during the PRACE course “Earth Sciences Simulation Environment”, in order to optimize the forecasting service and extend the forecasting time period.

Using what was taught in the course, various tests were performed using the WRF-CHIMERE modelling system, which is the numerical modelling system that operates daily to produce air quality forecast for Portugal. These tests were made to achieve the following objectives:

- Improve modelling performance (optimization of computation parallelization processes) to produce daily forecasts
- Test alternative model setups to improve dust forecast

DESCRIPTION OF WORK CARRIED OUT DURING THE STSM

During the course, we started by learning the differences between running code in serial and parallel, executing some code to test these differences. So before any kind of change in the input data and model optimization, parallelization of the CHIMERE model was tested and runs were performed on multiple nodes (instead of a single node, which is the method currently employed). The analysis of the run times showed that the model took longer to simulate each day, possibly due to a limitation in the communication speed between nodes. After these tests, I applied what was being taught at the course, I tested different domains,

saw how they would change the results and runtime on the model, and changed some pre and post processing of the data used. Later on, I was presented with some examples of how to apply and analyse the results of the tool Paraver, which is a visual inspection tool used to understand possible limitations of a model run. Using what I learned from the examples, my plan is to apply a tool similar to Paraver to the CHIMERE simulations, to investigate where the bottleneck is occurring when running on multiple nodes. Finally, I consolidated and gained some knowledge in optimization of post processing resulting model data and data manipulation that will be used to incrementally optimize my CHIMERE simulations.

DESCRIPTION OF THE MAIN RESULTS OBTAINED

After the preliminary tests without changing the input data, the next step was to test different domains, taking into account the new-resolution of the AVN prognostic global model delivered by NOAA, which are used to initiate the numerical simulations. This will allow us to start the forecasting simulations with higher resolution domains, and reach the Portugal domain with a finer resolution. With this, the dust forecasting capabilities of the model and simulation times could possibly be improved, and increase the forecasting period to three days (presently only 2 days of forecast). In detail, the simulation domains were altered from the current three domain setup (d01 - 127x127 km over Europe, d02 - 9x9 km over the Iberian Peninsula and d03 - 3x3 km focused on Portugal) to a two domain setup (d01 - 25x25 km for Europe and d02 5x5 km for Portugal, see Figure 1).

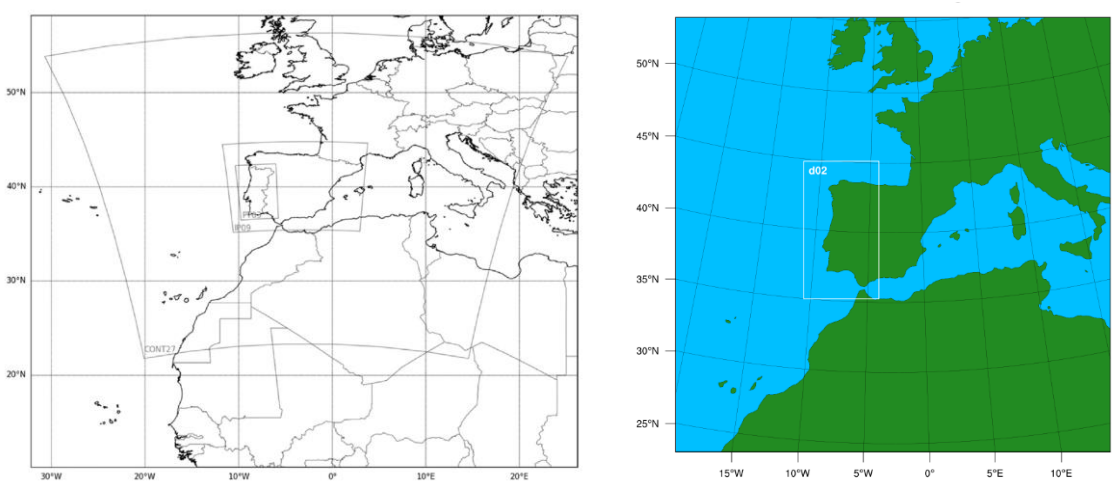

Figure 1. Old simulation domains (left, d01 - 127x127 km over Europe, d02 - 9x9 km over the Iberian Peninsula and d03 - 3x3 km focused on Portugal) and new simulation domains (right, d01 - 25x25 km, Northern Africa and most of Europe, and d02 - 5x5 km, Portugal).

The overall area of the domains remained largely the same, but the increase in resolution of the largest domain from 127x127 km to 25x25 km could provide better dust forecasting results. The results showed a negligible increase in the accuracy of the results was found. Additionally, the simulation time for each day increased from 5-6 hours to 8 hours, which also means that daily forecasting of a three-day period would take too long, not allowing any leeway in simulation times. Applying some of the optimization procedures that were presented during the course, such as decreasing the amount of variable stored at the end of the simulation and adjusting the memory used for each run, the simulations performed with the new domains were reduced to a manageable 5 hours.

For the short-term future regarding my specific work, the main objective will be to validate the new domain setup for the three-day forecasting period, specifically to test which setup is more accurate for air quality and dust forecasting on the third day.

FUTURE COLLABORATIONS (if applicable)

The work developed will provide optimizations to the operational air quality forecasting system that produces daily prognostics of dust and other pollutants for Portugal domain. In fact, the Portuguese Agency of Environment is using this forecasting service to support the alerts of dust and air pollution events that occurs every year in Portugal.

There is a continuous need to improve model performance since the model evaluation exercises (that are performed every month and year) indicates that the modelling system underestimates the episodes, in particular dust events (peaks). In this sense, a new modelling setup (with higher resolution domains) was tested in order to evaluate how this can improve dust prediction and extend the forecasting period to the 3-days horizon.

Finally, the CHIMERE dust forecasting results will be compared to what is currently being done at the BSC for the Iberian Peninsula, and subsequently what is made available by the SDS-WAS programme.

These objectives of improving dust prediction are completely in the scope of the InDUST COST, and I am thankful for the opportunity of this STSM for letting me gain valuable knowledge and achieve these goals.