Chapter 13
Extensive Comparison Between a Set of European Dust Regional Models and Observations in the Western Mediterranean for the Summer 2012 Pre-ChArMEx/TRAQA Campaign

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Abstract The present analysis focuses on the model capability to properly simulate long-range Saharan dust transport for summer 2012 in the Western Mediterranean. The present contribution shows an intercomparison of a set of 9 European regional dust model simulations. An exhaustive comparison of model outputs against other

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models and observations can reveal weaknesses of individual models, provide an assessment of uncertainties in simulating the dust cycle and give additional information on sources for potential model improvement. The model outputs are compared against a variety of both ground-based and airborne in situ and remote sensing measurements performed during the pre-ChArMEx/TRAQA field campaign. For this kind of study, multiple and different observations are combined to deliver a detailed idea of the structure and evolution of the dust cloud and the state of the atmosphere at the different stages of the event.

13.1 Introduction

Surrounded by mountains and several continents and affected by different types of pollution, the Mediterranean Sea is a natural laboratory for studying the variability of the chemical composition in the lower atmospheric layers and the interaction between pollutants from distant regions. The Chemistry-Aerosol Mediterranean Experiment (ChArMEx, http://charmex.lsce.ipsl.fr) is a French initiative which set up an international coordinated experimental and modelling effort based on the most updated tools, for an assessment of the present and future state of the atmospheric environment in the Mediterranean Basin, and of its impact on the regional

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climate, air quality, and marine biogeochemistry. The target is short-lived particulate and gaseous tropospheric trace species which are the cause of poor air quality events, have two-way interactions with climate, and impact the marine biogeochemistry, in a context of strong regional anthropogenic and climatic pressures.

Atmospheric aerosols in the north-western Mediterranean region are mainly composed by sea salt, anthropogenic pollution (from industrialized high populated coastal cities) and Saharan dust aerosols. The present study focuses on the analysis of the model capability to properly simulate long-range Saharan dust transport during summer 2012 in the Western Mediterranean. Moreover, the use of ensemble forecasts to improve event predictability is analysed.

13.2 Methods

The present study uses 9 regional dust models that are run at different centres in Europe which are presented in Table 13.1. All models produced 24 h forecasts beginning at 0UTC (except RegCM and Aladin-CCM, which are not forced by meteorological fields every 24 h) in order to investigate their performance and ability to predict the dust outbreaks over the Mediterranean from 1st June to 31st August 2012. Various model output fields at 3-hourly resolution were processed for comparative purposes. The research teams at the modelling centres configured their

Table 13.1 Summary of the main features of the 9 regional models included in the present contribution

Dust model	Institution	Meteo driver initial fields	Spatial resolution	Radiative feedbacks
ALADIN-Dust	CNRM-GAME	ARPEGE ARPEGE	24 km × 24 km 70 layers	No
ALADIN-CCM	CNRM-GAME	ERA-Interim/ERA-Interim	50 km × 50 km 31 layers	Yes
BSC-DREAM8b v2	BSC-CNS	ETA NCEP-FNL	0.33° × 0.33° 24 Eta-layers	Yes
CHIMERE	LISA, LMD and INERIS	ECMWF ERA-Interim	0.25° × 0.25° 15 σ-layers	No
COSMO-MUSCAT	TROPOS	COSMO GME	0.25° × 0.25° 40 σ-layers	Yes
MESO-NH	Laboratorie d'Aerologie	ECMWF ERA-Interim	15 km × 15 km 15 σ-layers	Yes
MOCAGE	CNRM-GAME, Meteo-France and CNRS	ARPEGE ERA-Interim	0.2° × 0.2° 47 σ-layers	No
NMMB/BSC-Dust	BSC-CNS	NMMB NCEP-FNL	0.25° × 0.25° 40 σ-layers	No
RegCM	Laboratorie d'Aerologie	ECMWF ERA-Interim	25 km × 25 km 23 layers	Yes

own model experiments. Therefore, the horizontal and vertical resolution, domain size, driving boundary conditions, dust field initial conditions, land surface conditions, dust emission and deposition parameterizations as well as dust physical and optical properties vary between the models. Some of these features are summarised in Table 13.1.

The numerical weather prediction and European air quality communities have for some time been exploring the potential of multi-model ensembles to enhance understanding of forecast uncertainty. Similarly, a multi-model median product is also generated from the set of different predictions of the dust models interpolated to a common grid mesh.

The model outputs are compared against a variety of both ground-based and airborne in situ and remote sensing measurements performed during the pre-ChArMEx/TRAQA field campaign (Attié et al. 2014). The model outputs are also compared with satellite aerosol products, which provide a description of the spatial aerosol distribution over the basin. These observational datasets provide a complete set of exceptional quantitative constraints for model simulations of this period.

13.3 Results and Discussions

The aerosol optical depth (AOD) model intercomparison for summer 2012 (1st June–31st August) shows that the intensity and the spread of the Saharan dust intrusion over Europe reproduced by the models present large differences. Not only do dust emission schemes rely on various assumptions, but also their implementation within a regional model presents challenges. Significant biases are found between different regional models even when they have the same dust emission scheme implemented. Following (Basart et al. 2009), the dust AOD comparison against 4 AERONET sun photometers (Barcelona, Palma de Mallorca, Avignon and Lampedusa) shows that the set of models are able to reproduce the seasonal AOD variability with correlations >0.6 except for the climate model RegCM (not shown here). In this respect, the multi-model median product shows the best results (with correlation >0.8).

On late June 2012, a strong dust outbreak (with origin over Algeria) was observed over the Western Mediterranean coinciding within the intensive ChArMEx/TRAQA experimental campaign (Dulac et al. 2013; see Fig. 13.1). High aerosol concentrations were observed between 1 and 5 km by CALIPSO and LOAC flights from Martigues (France) meanwhile desert dust was predicted in altitudes <5 km (above sea level, a.s.l; see Fig. 13.1) with maximum dust concentrations at $\sim$3.5 km (not shown here). Aerosols at high altitudes (between 3 and 7 km a.s.l.) were not predicted by the dust models. Observations and air-mass backward trajectories confirmed that these upper aerosols were associated to forest fires with origin in the south-eastern Iberian Peninsula as confirmed by.

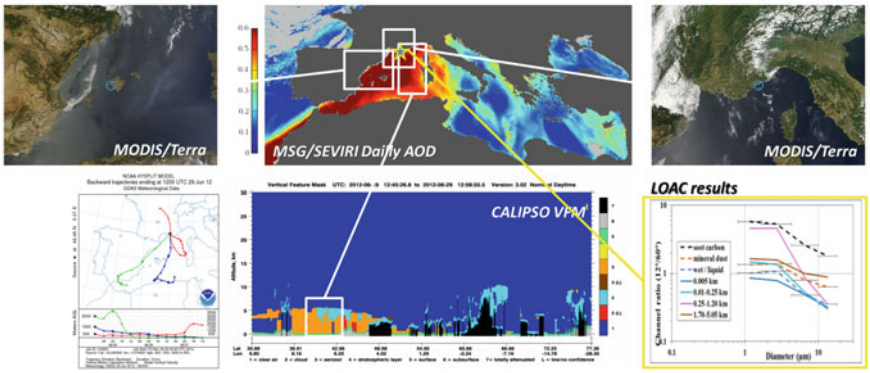

Fig. 13.1 Satellite and ground-based observations as well as backtrajectories at Martingues (at arrivals at 500, 1500 and 3000 m a.s.l.) collected during 29th June 2012

These preliminary results demonstrate that the dust models are useful to complement dust-related observations over the total aerosol load, understand the dust processes and predict the impact of dust. Moreover, it is shown the potential use of multi-model ensembles to enhance understanding of forecast uncertainty.

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References

Attié JL, Ravetta F, Durand P, El Amraoui L, Di Biaggio C, Dulac F, Sicard M, Renard J-B, Fleury L, Bourdon A, Verdier N (2014) Transport of pollution and air quality experiment over the Mediterranean basin (TRAQA/ChArMEx campaign). In: EGU general assembly conference abstracts, vol 16. p 12125

Basart S, Pérez García-Pando C, Cuevas E, Baldasano Recio JM, Gobbi P (2009) Aerosol characterization in Northern Africa, Northeastern Atlantic, Mediterranean basin and Middle East from direct-sun AERONET observations

Dulac F, Nicolas JB, Sciare J, Mallet M, Léon JF, Pont V, … Ravetta F (2013) The summer 2012 Saharan dust season in the western Mediterranean with focus on the intense event of late June during the Pre-ChArMEx campaign. In: EGU general assembly conference abstracts, vol 15, p 12108