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Series C: Environmental Security

Air Pollution Modeling and its Application XXII

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(dry deposition, wet deposition, sedimentation, convective mixing) have been extended from the dust module [5], while the aerosol water-uptake has been introduced as a specific process for SSA. The water uptake is parameterized following Chin et al. [1].

Q: With respect to dust, did you compare DREAM and NMMB/BSC-Dust model results? What is better?

A: The new NMMB/BSC-Dust model performs better in emission regions. A more physically based emission scheme has been implemented in the model (see [5]), and the results of the system have improved compared with BSC-DREAM8b. Indeed, a positive impact on the dust transport is identified. The Northern Africa-Middle East-Europe Regional Center of the WMO Sand and Dust Storm Warning Advisory and Assessment System is providing compared dust forecast of different models. Quantitative evaluation is performed there for several dust models, among them several versions of the DREAM model and NMMB/BSC-Dust.

Chapter 54
Sea-Salt Aerosol Forecasts Over the Mediterranean Sea Evaluated by Daily Measurements in Lampedusa from 2006 to 2010

Pavel Kishcha, Boris Starobinets, Roberto Udisti, Silvia Becagli, Alcide di Sarra, Slobodan Nickovic, and Pinhas Alpert

Abstract Detailed knowledge of sea-salt aerosol (SSA) space-time variations is essential for a deeper understanding of the process of SSA loading in the atmospheric boundary layer. In order to reproduce variability of SSA concentrations over the Mediterranean Sea, the regional DREAM-Salt model has been running daily at Tel-Aviv University since February 2006 (http://wind.tau.ac.il/salt-ina/salt.html). The model performance in producing accurate SSA forecasts over the Mediterranean Sea was evaluated using a 5-year record (2006–2010) of daily SSA mass concentration measurements at the island of Lampedusa. Model-vs.-measurement comparisons showed a distinct dependence of model performance on wind direction. On average, for wind direction from 30° to 300°, the model performance was quite acceptable. It was characterized by a relatively high correlation of over 0.65 and a rather small mean bias. For north winds (0°–30°, and 300°–360°), some discrepancy between modeled and measured SSA concentrations was observed. This was characterized by the model underestimation of SSA measurements and a rather low correlation between model data and measurements. Probably, for north winds, SSA production in the surf zone, located in the vicinity of the monitoring site, contributed to observed SSA concentrations.

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D.G. Steyn et al. (eds.), *Air Pollution Modeling and its Application XXII*, NATO Science for Peace and Security Series C: Environmental Security, DOI 10.1007/978-94-007-5577-2_54, © Springer Science+Business Media Dordrecht 2014

Keywords Marine aerosol • Sea-salt aerosol forecast • Aerosol modeling

54.1 Introduction

Marine aerosol is mechanically produced by breaking waves during whitecap formation [6]. As soon as SSA is introduced by wind into the boundary layer, SSA can contribute to the intensity of Mediterranean storms by changes in the energy balance, as it does in intensifying tropical hurricanes [2]. In order to reproduce variability of SSA concentrations over the Mediterranean Sea, the regional DREAM-Salt model has been running daily at Tel-Aviv University since February 2006. In our previous studies, the model performance over the open sea was indirectly verified by comparing modeled SSA concentrations with wave height measurements collected by the ODAS Italia one buoy and the Llobregat buoy in the Western Mediterranean [5]. In addition, modeled concentrations were compared directly with SSA measurements taken at the island of Lampedusa in the Central Mediterranean [4]. In the current study, the DREAM-Salt model performance in simulating the main temporal features of SSA distribution was evaluated against a long-term record of daily SSA measurements taken at the Mediterranean island of Lampedusa over the 5-year period 2006–2010.

54.2 Sea-Salt Aerosol Model and Measurements

The DREAM-Salt prediction system has been producing daily forecasts of 3-D distribution of sea-salt aerosol concentrations over the Mediterranean model domain 20°W–45°E, 15°N–50°N [4, 7]. The model incorporates parameterizations of all major phases of the atmospheric sea-salt aerosol cycle such as: diffusion, advection, gravitational settling, and wet removal of sea-salt aerosols. DREAM-Salt has 0.3° horizontal resolution, and 24 vertical levels. And eight particle size bins ranging from 1 to 8 μm. Forecasts are made once every day, starting from the 12:00 UTC objective analyses and providing forecasts up to 72 h ahead. The NCEP/Eta regional atmospheric model drives the aerosol. The sea-salt emission scheme defines the lower boundary condition using the source function of Erickson et al. [3]. In our model setup, we used N = 8 particle size bins (1.0–1.5, 1.5–2.5, 2.5–3.5, 3.5–4.5, 4.5–5.5, 5.5–6.5, 6.5–7.5, and 7.5–8.5 μm). The mass going into each of the eight particle size bins is in percentages 0.5, 1.5, 6.0, 11.0, 16.0, 19.0, 21.0, and 25.0 of the total source, respectively. Note that the dependence of SSA productions and size distributions on relative humidity was not included in the model.

In order to evaluate the model performance over the Mediterranean Sea, numerical simulations of sea-salt aerosol (SSA) were compared with sea-salt ground-based measurements taken at the tiny Mediterranean island of Lampedusa, Italy, during the

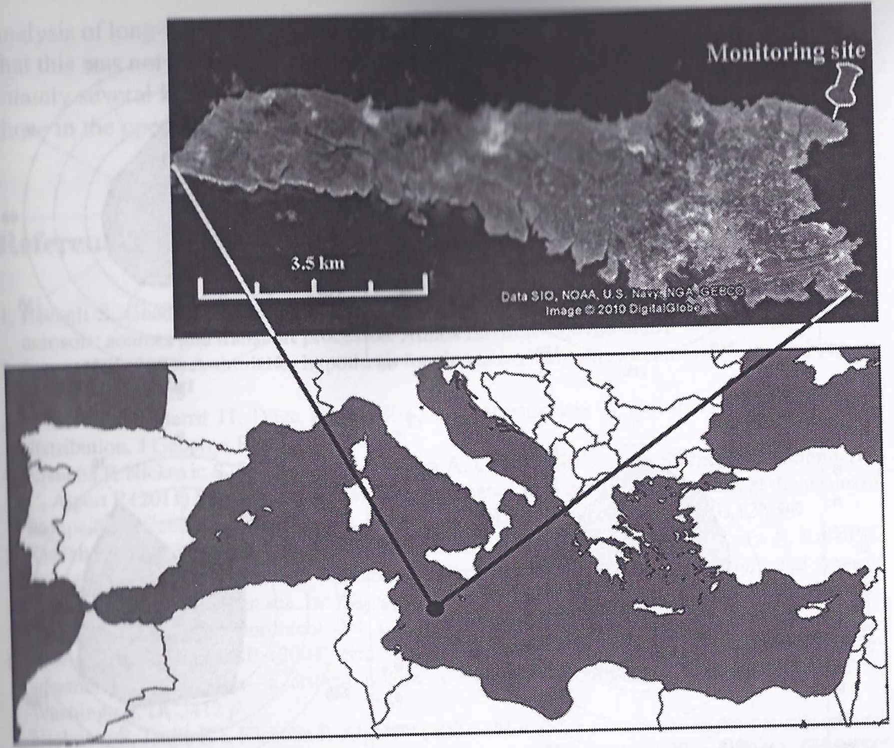

Fig. 54.1 A map of the Mediterranean Sea with a map of the island of Lampedusa with the monitoring site (*the grey place mark*)

5-year period 2006–2010. Lampedusa, which measures several kilometers across, is located far from any land areas and is characterized by clean air without industrial pollution. The monitoring site is located at approximately 10 m from the north-east coastline of Lampedusa, at 50 m elevation (Fig. 54.1). SSA measurements were based on chemical analysis of PM10 measurements on a daily basis. SSA concentration was calculated as the sum of the weight of $ssNa^+$ (i.e. sea salt Na^+), Cl^-, $ssCa^{2+}$, and $ssMg^{2+}$ [1].

54.3 Results and Discussion

Shown in Figs. 54.2a and c, polar diagrams of measured SSA mass concentration and wind speed reveal their maximum under north winds. This can be explained by the location of the monitoring site near the northern coast. Strong north winds create a surf zone, within which sea-waves, approaching the coastline, start breaking. SSA production in the surf zone, located in the vicinity of the monitoring site, can

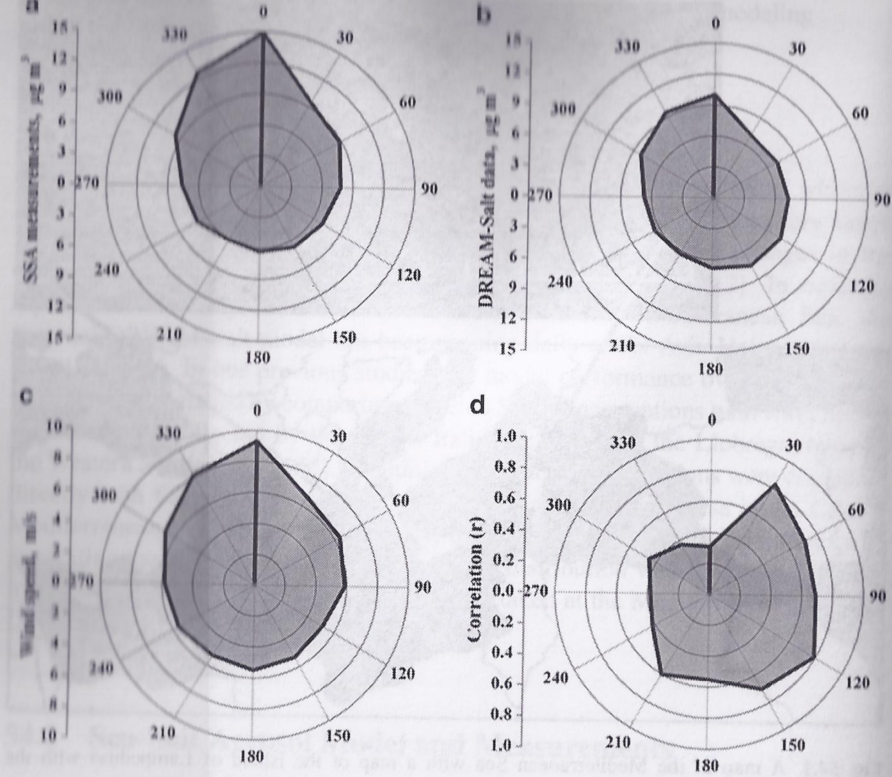

Fig. 54.2 Polar diagrams of 5-year (2006–2010) mean values of **(a)** measured SSA mass concentration, **(b)** DREAM-Salt modeled SSA concentration, and **(c)** measured wind speed, as a function of wind direction. **(d)** is the polar diagram of correlation between daily measured and modeled SSA concentrations over the 5-year period under consideration as a function of wind direction. All diagrams are *centered* at the monitoring site in Lampedusa

contribute to observed SSA concentrations. Our regional model could not take into account the effects of surf zones; this results in some model underestimation of measured SSA concentrations under north winds (Figs. 54.2a, b).

Moreover, model-vs.-measurement comparisons on a daily basis at Lampedusa over the 5-year period under consideration showed that the correlation between model data and measurements depended on wind direction (Fig. 54.2d). On average, for wind direction from 30° to 300°, the model performance was characterized by a relatively high correlation of over 0.65. For north winds (0°–30°, and 300°–360°), a rather low correlation between model data and measurements was observed. This was because of the aforementioned additional source of SSA aerosol production in the surf-zone, which was not included in the model.

The island of Lampedusa was chosen for the model evaluation because it was considered to have open sea measurement conditions. However, based on our analysis of long-term SSA measurements during the period 2006–2010, it was found that this was not the case. Despite the relatively small size of Lampedusa of approximately several kilometers across, measurement conditions there are not exactly as those in the open sea, because SSA concentrations depend on wind direction.

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Questions and Answers

Questioner Name: Douw G. Steyn

Q: You mentioned the possibility of a sea-breeze at Lampedusa having an effect not captured in your model. I think Lampedusa is too small an island to generate a true sea-breeze. So do the data show existence of a sea-breeze?

A: Yes. In general, there are two requirements for sea-breeze formation. First, the natural wind flow due to high- and low-pressure systems must be weak, and the middle of an anticyclone is, therefore, an ideal region for this to occur. Second, the land must be significantly warmer than the sea by approximately 5 °C or more. These two requirements are fulfilled in Lampedusa in the summer months, when sea-breezes take place. Note that sea-breeze winds are relatively weak over such a small island as Lampedusa, and can not produce high sea-salt aerosol concentrations. However, these sea-breeze winds are capable of carrying sea-salt aerosol particles produced by breaking waves near the coastline to the monitoring site. Due to its coarse resolution, our model can not take sea-breeze processes into consideration.