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Air Pollution Modeling and its Application XXI

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Chapter 51
Sea-Salt Aerosol Forecasts Compared with Wave Height and Sea-Salt Measurements in the Open Sea

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Abstract Sea-salt aerosol (SSA) could influence the Earth's weather and climate acting as cloud condensation nuclei. In spite of the importance of SSA effects on the Earth's climate and weather, there were no measurements of sea-salt aerosols in the open sea. At Tel-Aviv University, 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–45E, 15 N–50 N (http://wind.tau.ac.il/salt-ina/salt.html). In order to evaluate the model performance in the open sea, daily modeled sea-salt aerosol concentrations were compared directly with sea-salt ground-based measurements taken at the tiny island of Lampedusa, in the Central Mediterranean. In order to further test the robustness of the model, the model performance over the open sea was indirectly verified by comparing modeled SSA concentrations with wave height measurements collected by the ODAS Italia 1 buoy. Model-vs.-measurement comparisons show that the model is capable of

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producing realistic SSA concentrations and their day-to-day variations over the open sea, in accordance with observed wave height and wind speed.

Keywords Marine aerosol • Sea-salt aerosol forecast • Mediterranean Sea

51.1 Introduction

In the open sea, where sea-salt aerosol is mainly produced, its concentration and impact on the Mediterranean climate and weather could be significant under strong winds. Model-based forecasts of SSA, daily produced in Tel-Aviv University could be helpful, providing valuable information about space and time distributions of sea-salt aerosols. In this study we tested the robustness of the SSA forecasts by comparing directly with SSA measurements at the island of Lampedusa (Central Mediterranean), and indirectly by comparing SSA forecasts with sea-wave height, given that the main factors for SSA production in the open sea are sea waves and associated winds.

51.2 Methodology

Numerical simulations of sea-salt aerosol presented in this study were conducted using a version of the DREAM dust aerosol model [2, 5] with embedded SSA component (DREAM-Salt) [3, 4]. 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 (Fig. 51.1, left panel). The model has 0.3° horizontal resolution, 24 vertical levels, and eight

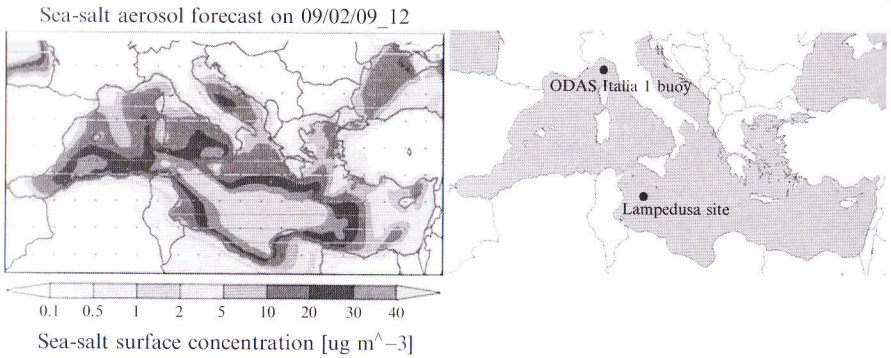

Fig. 51.1 *Left panel* – an example of *SSA* forecast on February 9, 2009. *Right panel* – a map of the Mediterranean Sea with the monitoring site in Lampedusa and the ODAS Italia 1 buoy (the *black* place marks)

particle size bins ranging from 1–8 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. [1]. DREAM-Salt incorporates parameterizations of all other major phases of atmospheric sea-salt aerosol life such as: diffusion, advection, gravitational settling, and wet removal of sea-salt aerosols.

In order to evaluate the model performance over the open sea, the 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 2-year period from 2007–2008 (Fig. 51.2) [3]. In Lampedusa, the conditions of SSA measurements are considered similar to those in the open sea, given the small dimensions of the island.

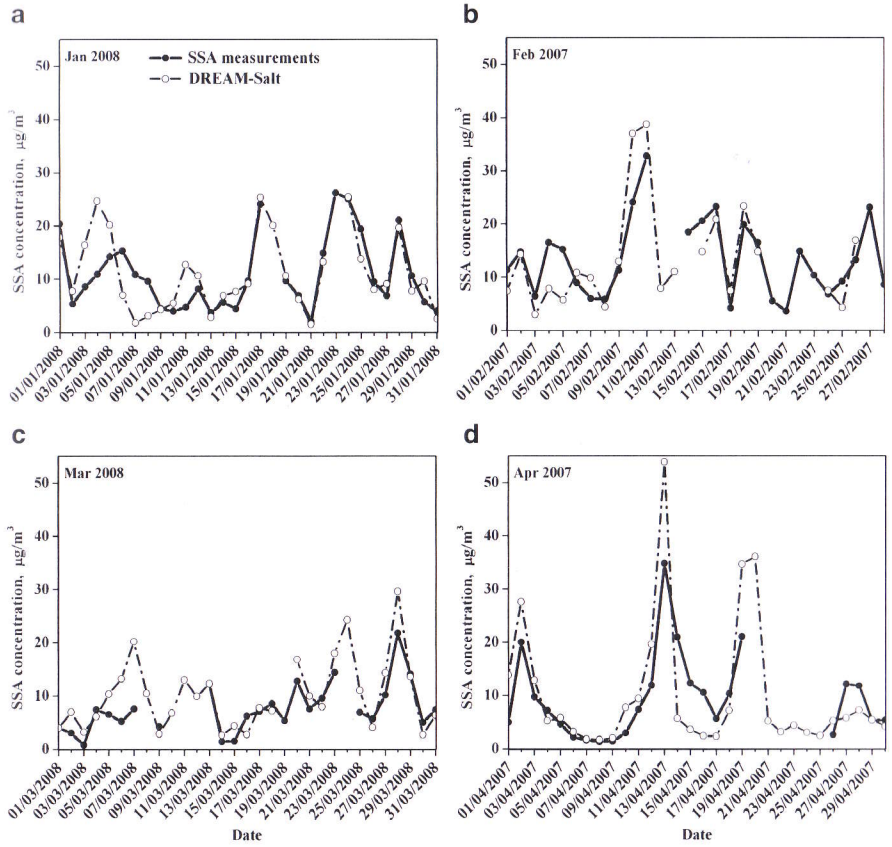

Fig. 51.2 Examples of the comparison between modeled sea-salt concentrations and measurements in Lampedusa

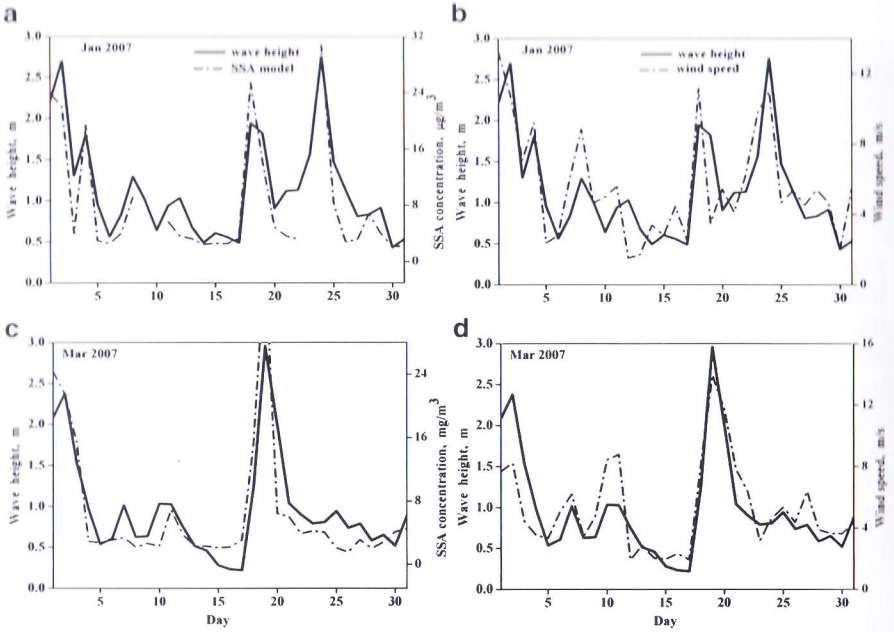

Fig. 51.3 Examples of the comparison (*left panel*) between modeled sea-salt concentrations and wave height, and (*right panel*) between buoy-measured wind speed and wave height

The ODAS Italia 1 spar buoy in the Ligurian Sea of the Western Mediterranean basin, located at approximately 75 km far from the coast, provided us with information about wave height and sea-surface wind [7]. Since the buoy is positioned offshore, it is exposed to winds and waves without any shield by the surrounding orography [6]. Daily data are available for the periods July 2006–August 2007, August 2008–December 2008, and March 2009–September 2009. The model performance has been indirectly verified by comparing modeled SSA concentrations with observed wave height taking into account that the main factors for SSA production in the open sea are sea waves and associated winds (Fig. 51.3).

51.3 Results and Discussion

Direct model-vs.-measurement comparisons at Lampedusa show a relatively high correlation of 0.7 between model data and measurements for all 380 days used in the analysis; a rather low mean bias of -0.5 μg/m^3; and a mean normalized bias less than 20% [3]. Therefore, the model was capable of producing reasonable SSA concentrations and their day-to-day variations over the open sea.

Quite a good correspondence between wind speed and wave height measured at the ODAS Italia 1 buoy is clearly seen in Fig. 51.3, indicating that most sea-waves were created by the observed strong winds. As surface winds are used as a key parameter for sea-salt production in the model SSA parameterization, one could expect that the good correspondence between wind speed and wave height should be accompanied by a good correspondence between modeled SSA concentrations and wave height. Indeed, the examples shown in Fig. 51.3 demonstrate quite a good correlation between modeled SSA – concentrations and wave height at the monitoring site. In general, as estimated for all 540 days used in the analysis, the model performance was considered acceptable: it was characterized by a relatively high correlation of 0.78 between modeled SSA – concentrations and wave height. The correlation between observed wind speed and wave height was estimated to be as much as 0.82. This is an indirect indication that, over the open sea, the model produced realistic day-to-day time variations of SSA-concentrations, in line with observed day-to-day variations of wind speed and wave height.

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