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A model for the atmospheric fate of sea salt particles incoastal areas

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Aerosol particles affect climate by scattering and absorbing radiation (Charlson et al., 1992), and may affect the heat budget. Among them, the particles generated at the air-sea interface by wave breaking represent a major component of the natural aerosol (Andreae, 1995). Sea-spray aerosols are mechanically produced by the interaction between wind and wave: when the wind speed increases beyond a critical value, waves break to dissipate the excess of energy. This is accompanied by the occurrence of whitecaps (Monahan and O'Muircheartaigh, 1980) and the primary marine aerosol production is directly related to the whitecap fraction. Air entrained into the water breaks up into bubbles, which may be transported to depths of several meters. When the bubbles rise and reach the surface, they burst and produce two kinds of droplets : film drops and jet drops (Blanchard, 1963; Blanchard, 1983; Resch and Afeti, 1991; Resch and Afeti, 1992).
Sea-salts dominate atmospheric deposition in maritime regions (Gustafsson and Franzen, 1996; Farrell et al., 1995). However, the fate of marine aerosol particles in the marine atmosphere is still largely unknown. A model for the aerosol transport in coastal areas is then of great interest for a large number of applications among them, climate change and studies on air and water quality. Tedeschi and Piazzola (2011) presented the development of the Marine Aerosol Concentration Model (MACMod), which is a 2D unsteady model dedicated to the atmospheric transport of marine aerosols in the Marine Atmospheric Boundary Layer. However, such a transport model needs to implement an accurate source term for the sea-salt particles. Uncertainties on the sea-salt source function are still large (see Lewis and Schwartz, 2004). In particular, in coastal areas, the sea-spray production through breaking waves depends on both the fetch and the wind speed conditions. In this study, we propose to improve the MACMod model predictions by introducing an accurate sea-salt source function. To this end, the MACMOD model was implemented in the Mediterranean coast using aerosol data measured during an experimental campaign conducted in the French coastal Mediterranean area in 2008 on board the French oceanographic vessel "Atalante." Using the aerosol size distributions measured in different geographical locations south off the French coastal zone, a new source term has been introduced in MACMOD. The Monahan et al. (1986) formulation, depending both on the aerosol radius and the whitecap fraction, has been revisited. First, a separated approach is used for both the film and jet drops, accounting for the different radius modes. Then, a new sea-state dependent model is used for the whitecap fraction. The simulations were then validated with the help of aerosol size distributions recorded on board the ship "Atalante" for different meteorological conditions.