Geophysical Research Abstracts
Vol. 15, EGU2013-3975, 2013
EGU General Assembly 2013

Impact of the decrease in anthropogenic aerosols since the 1980s on the Mediterranean climate variability and trends using a fully coupled regional climate system model

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Various natural and anthropogenic aerosols observed over the Mediterranean region show a strong spatio-temporal variability and a large variety in aerosol physical-chemical and optical properties. Through their interactions with solar and thermal radiations, they have significant effects on the regional climate. Since the 1980s, a decrease of sulfate aerosol concentration has been observed over Europe leading to an increase of incoming solar radiation reaching the surface, which is known as the brightening period. The aim of the present work is to investigate the consequences of this aerosol trend on the Mediterranean climate, and its role in the observed changes since thirty years, using a fully coupled regional climate system model (RCSM). This RCSM includes the atmospheric regional climate model ALADIN-Climate, the regional ocean model NEMOMED8, the land surface model ISBA and the river routine scheme TRIP. This approach enables to take into account the high-frequency feedback of the sea surface temperature (SST) on the atmosphere, as well as the river-ocean-atmosphere feedback. Aerosols are included in ALADIN-Climate through monthly interannual climatologies, coming from a combination of satellite-derived and model-simulated products, and considered as the most possible relevant estimation of the atmospheric aerosol content for the five most relevant species (sea salt, desert dust, sulfates, black and organic carbon aerosols). Simulations with the forcing of the ERA-INTERIM reanalysis have been carried out over the period 1979-2009, with and without the trend in sulfate aerosols. The scattering of the incoming solar radiation by sulfate aerosols lead to important changes over the Mediterranean climate. Comparisons between both simulations and observations have been realized for different atmospheric and oceanographic parameters. Adding the aerosol trend enables to better reproduce the increase of solar radiation at the surface. The results for temperature also show that sulfate aerosols explain 25% of the observed warming. For the Mediterranean Sea, SST and air-sea fluxes have also been modified by this evolution in the sulfate aerosol content.