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Impacts of climate on summertime air quality in the Mediterranean: past assessment and future scenarios

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Climate change impacts on air quality may affect long-term air quality planning. However, the policies aimed at improving air quality have not accounted for the variations in the climate (Steiner et al., 2006; Racherla and Adams, 2006). Furthermore, the coarse horizontal resolution of current global climate-chemistry simulations does not permit an estimate of the effects of climate change on tropospheric photooxidant distributions on the regional scale (Forkel and Knoche, 2006).

The goal of this study is to determine how concentrations of atmospheric pollutants (mainly focusing on ozone and particulate matter) respond to changes in climate over the Mediterranean by using the regional modelling system WRF-CMAQ-DREAM as implemented in the MareNostrum supercomputer. The domain of study covers an area of 4940 km x 2640 with a horizontal resolution of 20 km and a vertical resolution of 32 layers in the troposphere. In order to isolate the possible effects of climate change on the ground concentrations of photochemical pollutants in the Mediterranean, the assumption of unchanged anthropogenic emissions (derived from EMEP emissions) was implemented. Three simulations (MareNostrum total simulation time of 108500 cpuŢh) corresponding to past climate variations under summertime conditions (August months of years 1960, 1980 and 2000 -control year-) have been performed and compared. Also, two future scenarios corresponding to the year 2030 SRES A1B and B1 Intergovernmental Panel on Climate Change scenarios following Unger et al. (2006) were investigated with the meteorology corresponding to the control year. Meteorological conditions were driven by NCEP reanalysis. The metrics used include

maximum 1-hr concentrations, monthly means and number of exceedances of the thresholds established in the European legislation. The results for the control year where evaluated against background stations data from EMEP network, depicting an accurate behaviour in the entire domain of the study.

The maximum 1-hr ozone concentration variation ranges from -20 to 70 ug m-3 in the August months of the period studied depending on the region of the domain. The main increases are achieved in northern Italy, meanwhile the largest decreases in the ozone mixing ratios are found over Greece and the Aegean Sea. The rest of the domain depicts slight increments in the summertime maximum 1-hr concentration. The summertime average concentration depicts a marked gradient from the central Mediterranean (where increases in the ground-level ozone mixing ratio reach 30 ug m-3) to the extremes of the domain, where no noticeable increases or even slight decreases are observed. The number of exceedances of the maximum 1-hr ozone threshold (180 ug m-3) has progressively increased in the months of August of the years 1960-1980-2000 in the central Mediterranean; meanwhile the number of exceedances has decreased over the eastern coast and the Aegean Sea. A very similar pattern is observed for the summertime sulphate concentrations.

Last, the response of air quality to a future evolution of emissions has been studied by using the SRES A1B and B1 scenarios for the year 2030. Present-day meteorology has been used in both simulations to isolate the effects of varying emissions. The 1-hr maximum concentrations in the Mediterranean reduce in the whole domain for the B1 scenario; as a consequence, the number of hours when the 1-hour threshold is exceeded substantially decreases in the entire Mediterranean, but mostly in the central part of the domain. For instance, in southern Italy the number of 1-hr ozone exceedances for the month of August is reduced (around 100 hours for the A1B scenario and over 250 hours for the same period for the B1 scenario).

Hence, the complex topography of the Mediterranean causes pronounced regional patterns and differentiated behaviour of the Western, Central and Eastern basins. The assumption of unchanged emissions leads to an increase of the mean concentrations of pollutants in most regions, which may be driven by an enhanced secondary production as a consequence of the temperature increase in the period of study and the higher pressures extending towards eastern regions observed for summertime 1960, 1980 and 2000.