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Future local and remote influences on Mediterranean ozone air quality and climate forcing

Steve Arnold (1,2), Maria Val Martin (3), Louisa Emmons (2), Alex Rap (1), Colette Heald (4), Jean-Francois Lamarque (2), and Simone Tilmes (2)

(1) Institute for Climate and Atmospheric Science, School of Earth and Environment, University of Leeds, United Kingdom (s.arnold@see.leeds.ac.uk), (2) Atmospheric Chemistry Division, National Center for Atmospheric Research, Boulder, CO., USA., (3) Department of Atmospheric Science, Colorado State University, Fort Collins, CO., USA., (4) Department of Civil and Environmental Engineering and Department of Earth, Atmospheric and Planetary Sciences, MIT, Cambridge, MA., USA.

The Mediterranean region is expected to display large increases in population over the coming decades, and to exhibit strong sensitivity to projected climate change, with increasing frequency of extreme summer temperatures and decreases in precipitation. Understanding of how these changes will affect atmospheric composition in the region is limited. The eastern Mediterranean basin has been shown to exhibit a pronounced summertime local maximum in tropospheric ozone, which impacts both local air quality and the atmospheric radiation balance. In summer, the region is subject to import of pollution from Northern Europe in the boundary layer and lower troposphere, from North American sources in the large-scale westerly flow of the free mid and upper-troposphere, as well as import of pollution lofted in the Asian monsoon and carried west to the eastern Mediterranean in anticyclonic flow in the upper troposphere over north Africa. In addition, interactions with the land-surface through biogenic emission sources and dry deposition play important roles in the Mediterranean ozone budget. Here we use the NCAR Community Earth System Model (CESM) to investigate how tropospheric ozone in the Mediterranean region responds to climate, land surface and global emissions changes between present day and 2050.

We simulate climate and atmospheric composition for the year 2050, based on greenhouse gas abundances, trace gas and aerosol emissions and land cover and use from two representative concentration pathway (RCP) scenarios (RCP4.5 & RCP8.5), designed for use by the Coupled Model Intercomparison Project Phase 5(CMIP5) experiments in support of the IPCC. By comparing these simulations with a present-day scenario, we investigate the effects of predicted changes in climate and emissions on air quality and climate forcing over the Mediterranean region. The simulations suggest decreases in boundary layer ozone and sulfate aerosol throughout the tropospheric column over the Mediterranean under both RCP scenarios, and a significant increase in ozone between 5-10km. Using tagged regional NO_y and tropospheric ozone tracers, we show that this ozone increase is coincident with an increase in easterly import of ozone and precursors in upper tropospheric outflow from Asian monsoon convection in 2050. We present a breakdown of the projected Mediterranean ozone changes by precursor source (anthropogenic and biogenic), and contributions due to changes in climate. Finally, we estimate the implications of the predicted changes in tropospheric composition for Mediterranean air quality and climate in 2050, and the consequences for the effectiveness of European policies aimed at protecting the region's climate and public health.