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Establishing the common patterns of future tropospheric ozone under diverse climate change scenarios

Pedro Jimenez-Guerrero (1), Juan J. Gómez-Navarro (2), Sonia Jerez (3), Raquel Lorente-Plazas (1), Rocio Baro (1), and Juan P. Montávez (1)

(1) Department of Physics, IUIOyN, Regional Campus of International Excellence "Campus Mare Nostrum", University of Murcia, Spain (pedro.jimenezguerrero@um.es), (2) Helmholtz-Zentrum Geesthacht, Germany, (3) University of Lisbon, Portugal

The impacts of climate change on air quality may affect long-term air quality planning. However, the policies aimed at improving air quality in the EU directives have not accounted for the variations in the climate. Climate change alone influences future air quality through modifications of gas-phase chemistry, transport, removal, and natural emissions.

As such, the aim of this work is to check whether the projected changes in gas-phase air pollution over Europe depends on the scenario driving the regional simulation. For this purpose, two full-transient regional climate change-air quality projections for the first half of the XXI century (1991-2050) have been carried out with MM5+CHIMERE system, including A2 and B2 SRES scenarios.

Experiments span the periods 1971-2000, as a reference, and 2071-2100, as future enhanced greenhouse gas and aerosol scenarios (SRES A2 and B2). The atmospheric simulations have a horizontal resolution of 25 km and 23 vertical layers up to 100 mb, and were driven by ECHO-G global climate model outputs. The analysis focuses on the connection between meteorological and air quality variables.

Our simulations suggest that the modes of variability for tropospheric ozone and their main precursors hardly change under different SRES scenarios. The effect of changing scenarios has to be sought in the intensity of the changing signal, rather than in the spatial structure of the variation patterns, since the correlation between the spatial patterns of variability in A2 and B2 simulation is $r > 0.75$ for all gas-phase pollutants included in this study. In both cases, full-transient simulations indicate an enhanced enhanced chemical activity under future scenarios.

The causes for tropospheric ozone variations have to be sought in a multiplicity of climate factors, such as increased temperature, different distribution of precipitation patterns across Europe, increased photolysis of primary and secondary pollutants due to lower cloudiness, etc. Nonetheless, according to the results of this work future ozone is conditioned by the dependence of biogenic emissions on the climatological patterns of variability. In this sense, ozone over Europe is mainly driven by the warming-induced increase in biogenic emitting activity (vegetation is kept invariable in the simulations, but estimations of these emissions strongly depends on shortwave radiation and temperature, which are substantially modified in climatic simulations). Moreover, one of the most important drivers for ozone increase is the decrease of cloudiness (related to stronger solar radiation) mostly over southern Europe at the first half of the XXI century. However, given the large uncertainty isoprene sensitivity to climate change and the large uncertainties associated to the cloudiness projections, these results should be carefully considered.