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A physics ensemble of air quality-climate change projections over southwestern Europe for the 21st century

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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 aerosol concentrations through modifications of gas-phase chemistry, transport, removal, and natural emissions.

Therefore, the goal of this contribution is the analysis of the impacts of climate change on air quality levels in southwestern Europe. For that, an eight-members multi-physics ensemble of regional air quality-climate simulations performed by coupling the atmospheric regional model MM5 with the CHIMERE chemistry transport model has been performed. Experiments span the periods 1971-2000, as a reference, and 2071-2100, as a future enhanced greenhouse gas and aerosol scenario (SRES A2). The atmospheric simulations have a horizontal resolution of 30 km and 23 vertical layers up to 100 mb, and were driven by ECHAM5 global climate model outputs. This ensemble is the result of combination two of the available options for cumulus (Grell and Kain-Fritsch), microphysics (Simple Ice and Mixed Phase) and PBL (Eta and MRF) parameterizations within MM5. The analysis focuses on the connection between meteorological and air quality variables.

The results indicate that for 2-m temperature the spread observed in the simulations is caused by changes in the PBL scheme (being negligible the changes in other parameterizations). Overall, the MRF scheme for the PBL provokes the highest temperature increase (and also the highest absolute values), meanwhile the Eta scheme leads to the minimum variation and values. The average rise in the temperature is about 2.5 K for wintertime and up to 6 K during the summertime over southwestern Europe; however, it should be highlighted that the spread of these results is up to 50% of the estimated warming.
The precipitation spread is caused both by the selection of the PBL scheme and the cumulus parameterization, especially during the August-October period. The most important change signals are increases of about 40 mm/month in the eastern Iberian Peninsula in summer, where convective precipitation dominates, and a generalized reduction in the rest of sites/seasons up to 50%. However, the spread in the simulated data with the different schemes may achieve 100% in the aforementioned area. That implies even disagreement in the change signals between the ensemble members.

The impacts of temperature on air quality are related to the dependence of gaseous-phase pollution and aerosols on this variable. The spread affecting the temperatures conditions the levels of secondary pollutants such as ozone, sulfates or secondary organic aerosols (SOA). Generally, the higher temperatures contribute to the decomposition of ammonium nitrate, remaining in the gas phase in all the simulations. Further, the changes in precipitation have a strong effect in the frequency of the washout and therefore in the levels of aerosols; this effect is not so important for gas- phase compounds. Thus, spreads affecting precipitation projections also propagate into notable spreads regarding air quality projections. Other changes in future meteorological variables, especially those changes in ventilation (wind speed, mixing height), have stronger effects on aerosols than on gaseous pollutants because of their lower background concentrations.

Since the studied parameterized processes and air pollutants transport and dispersion are closely tied to-

gether, the spreads strongly affect atmospheric variables on the projections for air quality. Results further unveil the propagation of uncertainties from the meteorological projections into future air quality and claim for future studies aimed at deepening the knowledge about the parameterized processes, and, last, reducing uncertainties.