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

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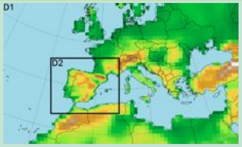
One of the most important components of climate simulation models, especially of RCMs, are the parameterization schemes. When coupled to CTMs, they can constitute an important source of uncertainty for air quality projections. While multi-model ensembles of regional climate simulations have been widely performed and investigated in an attempt to evaluate and overcome intermodel-related uncertainties, few studies deal with similar multi-physics ensembles for elucidating intramodel uncertainties (Jerez et al., 2011a;2011b).

Objective:

To conduct a comparative numerical modelling study of air quality projections from a climatic perspective using a multi-physics ensemble of MM5-CHIMERE simulations.:
1. Do the multi-physics ensemble mean and associated spread change for present-day and future climates?
2. Can we isolate the leading processes causing the largest spread?



Sim	PBL	CML	MIC
1	Eta	Grell	Simple Ice
2	MRF	Grell	Simple Ice
3	Eta	Kain-Fritsch	Simple Ice
4	MRF	Kain-Fritsch	Simple Ice
5	Eta	Grell	Mixed Phase
6	MRF	Grell	Mixed Phase
7	Eta	Kain-Fritsch	Mixed Phase
8	MRF	Kain-Fritsch	Mixed Phase

Simulated periods: 1970-2000 and 2070-2100 (A2 SRES) Driving conditions for MM5 from **ECHAM5-Run1**

CHIMERE parameterizations:
Chemical Mechanism → MELCHIOR2
Aerosol chemistry → Inorganic (thermodynamic equilibrium with ISORROPIA) and organic (MEGAN SOA scheme) aerosol chemistry
Natural aerosols → dust, re-suspension and inert sea-salt
BC → LMDz-INCA+GOCART

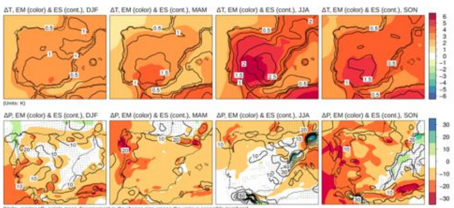
Further descriptions in Jiménez-Guerrero et al., 2011

The ensemble mean (EM) and spread (ES; the maximum difference among all the ensemble members in the projected changes) will characterize the intramodel uncertainty relative to the mean projected changes.

In order to isolate the effect of changing the physical option for a particular parameterized process, we propose a methodology based on ***subensembles*** (subgroups) of simulations. These subensembles are given by fixing the PBL, the CML or the MIC scheme to one of the two options considered.

Thus, for example, the difference between the MRF-subensemble mean and the Eta-subensemble mean depicts the impact of changing the PBL scheme (i.e. its contribution to the total ensemble spread). From here we can identify the leading schemes (LS).

Ensemble mean projected changes and associated spread



The results indicate that for 2-m temperature the spread observed in the simulations is caused by changes in the PBL scheme over land (although other parameterizations outstand at times). Overall, the MRF scheme for the PBL provokes the highest temperature increase (and also the highest values in each period), whereas 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 CML parameterization where the largest spread appears. 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 sign of the change between the ensemble members.

Jerez, S., J.P. Montávez, P. Jiménez-Guerrero, J.J. Gómez-Navarro, R. Lorente, E. Zorita, 2011a. *Assessment of the role of the parameterization schemes from a multi physics ensemble of present-day climate simulations over the Iberian Peninsula*. Clim. Dyn. Submitted.

Jerez, S., J.P. Montávez, J.J. Gómez-Navarro, J. Fernández, R. Lorente, J.A. García-Valero, P. Jiménez-Guerrero, 2011b. *A multi-physics ensemble of climate change projections over the Iberian Peninsula: mean changes, uncertainties and leading processes*. Clim. Dyn. Submitted.

Jiménez-Guerrero, P., J.J. Gómez-Navarro, S. Jerez, R. Lorente-Plazas, J.A. García-Valero, J.P. Montávez, 2011. *Isolating the effects of climate change in the variation of secondary inorganic aerosols (SIA) in Europe for the 21st century (1991-2100)*. Atmos. Environ. 45(4), 1059-1063, doi: 10.1016/j.atmosenv.2010.11.022.

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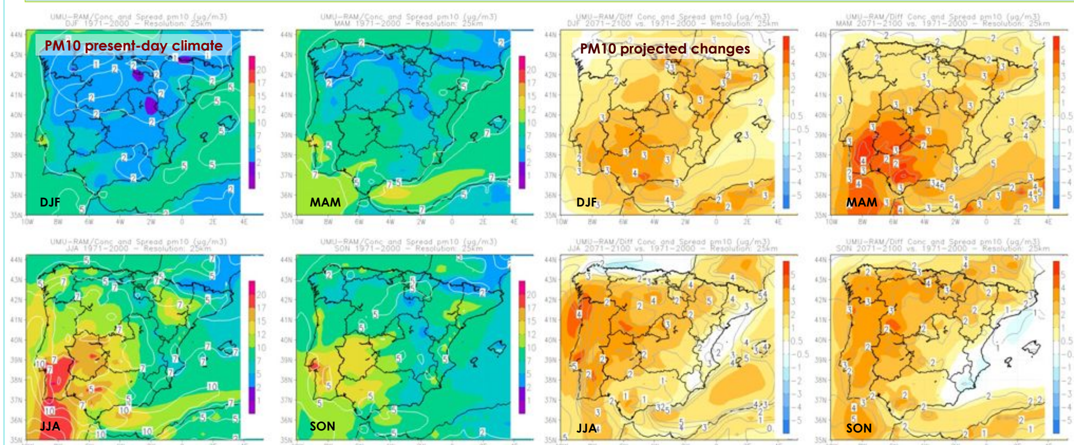
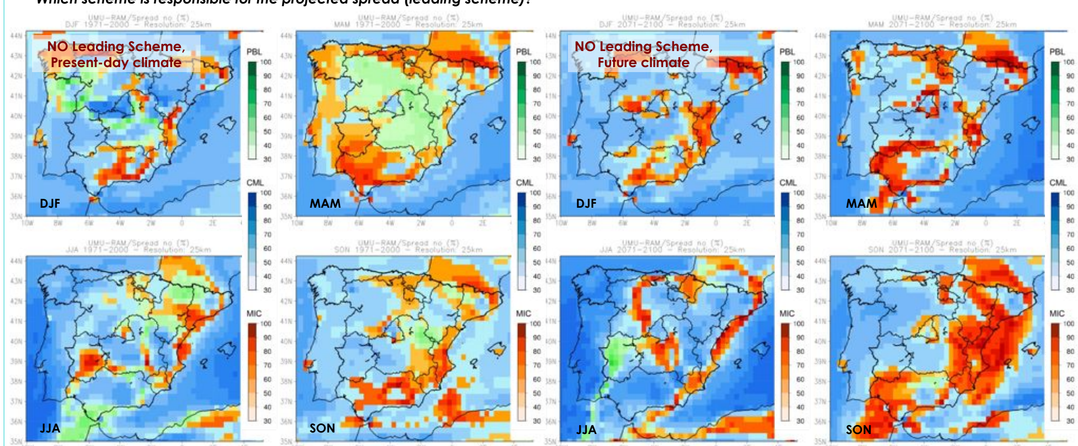
Spreads depict different patterns for present-day climate, future climate; and they are also different to the spread of the projected changes of PM10 levels and appear much more in the spring and summer season, when they represent above 100% of the ensemble mean-projected change for PM10. This spread also indicates a high uncertainty in the sign of the projected change.



Which scheme is responsible for the projected spread (leading scheme)?



Results: what have we learnt?

1. **Climate change impacts gas-phase compounds and aerosols.** The increase in PM10 levels may be driven by an enhanced secondary production as a consequence of the temperature increase, the changes in precipitation patterns, the decrease of the mixing heights hampering the dilution of pollutants and the stagnant conditions (Jiménez-Guerrero et al., 2011).
2. Therefore, spreads affecting atmospheric variables also affect the **air quality patterns, which show a great sensitivity to the physical configuration of the RCM model.** In the case of aerosols, the leading schemes for present and future periods and for projected changes are quite similar (CML scheme, not shown), while the PBL and MIC schemes add importance under future conditions for gaseous pollutants (as shown for NO).
3. It is thus worthy to underline that although some processes could deserve little attention when simulating the climatology of a given period, their influence gains relevance when projecting future climate changes.

The results from Jerez et al. (2011a; 2011b) indicate that for 2-m temperature the spread observed in the simulations is caused by changes in the PBL scheme. The precipitation spread is caused both by the selection of the PBL scheme and the CML parameterization