CityZen

megaCITY - Zoom for the Environment

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PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Evaluation of ensemble approach and validity of the results

Over the course of the project, several coordinated modelling studies were conducted. Two of them involved most of the modelling partners of the consortium: the 10yr hindcast of air quality (AQ) trends and variability over Europe (Bolchem, Chimere, Emep, Eurad, Mozart and OsloCTM2), and 2030 projections of air quality policy measures (with the same six partners). Also more bilateral activities were conducted: quantification of import/export fluxes around the main air pollution hotspots (Bolchem, Chimere, Eurad, WRF/Chem), development of scale bridging techniques (nudging: Bolchem, grid stretching: Chimere, time-varying boundary conditions: Chimere / Mozart / OsloCTM2).

However, an “ensemble” approach in the usual meaning of the term in the atmospheric modelling community was not implemented in the framework of the above activities. Partly because of the too small size of the sample of models involved. But also, because agreeing on a common approach that would be feasible, scientifically meaningful, and optimal for the different model tools involved, has proved impossible. Nevertheless, the above-mentioned activities were accompanied by a number of model intercomparison and model evaluation tasks. We believe these tasks contribute directly the evaluation of the *multi-model* approach and the validity of the results.

The 10 year AQ hindcast initiative is very relevant here as it involved six atmospheric chemistry and transport models (four regionals and two globals: Bolchem, Chimere, Emep, Eurad, Mozart and OsloCTM2) and includes a thorough model evaluation subtask. This study appeared recently in Atmospheric Chemistry and Physics Discussions (Colette et al., 2011) and the abstract is copied at the end of the present deliverable. The reader is referred to Section 4 that is of particular relevance here as it includes a detailed investigation of the performances of all six models when compared to surface observations.

In a nutshell, significant differences where found: Eurad and Bolchem producing very high NO2 levels while the other models produced the usual strong negative bias given the horizontal resolution used (about 50km). Daily mean O3 was overestimated by all models but Bolchem, which is also a commonplace feature: daily maximum O3 being usually better modelled, but this metric was not available in global model output fields. A negative bias for total PM10 was also obtained for Emep and Chimere. Eurad and Bolchem were found to perform slightly better but only at the cost of much worst scores for Ammonium, Sulphate and Nitrate.

Nevertheless, we concluded that none of the models was an outlier, and all of them could be considered as “state-of-the-art”, giving strength in the modelled envelope of air quality trends discussed in the remainder of the paper.

In addition to this investigation of model scores, maps of modelled OX (as the sum of Ozone and Nitrogen dioxide) are provided in (Colette et al., 2011). They illustrate well the relative reactivity of each model. A closer look at the maps of average and standard deviation of O3 for the months of June, July and August over the 1998-2007 decade provided on Figure 1 and Figure 2, respectively, is also insight full. It confirms that summertime O3 build-up over populated areas is smaller for Bolchem and Mozart. The maps of O3 climatology of Figure 1 also illustrate well the relatively large spread between models. Furthermore the variability is also quite different across the various CTMs (Figure 2). Bolchem and Eurad display a large variability of ozone over a much larger areas than the other models, with high values modelled over large part of the Mediterranean. Only Mozart displays a similar feature, which was expected given its spatial resolution. Otherwise the order of magnitude of the standard deviation is similar for Chimere, Emep and OsloCTM2.

The evaluation of the ensemble can also be quantified by looking at the rank or Talagrand diagram provided on Figure 3. As explained by (Vautard et al. 2006), the rank diagram is a useful tool to investigate the representativeness of the ensemble. Besides the fact that the ensemble mean or median of several models shall be biased or not, an important quality for the ensemble is its equaprobability (the fact that the observation shall not be systematically closer to a given ensemble member). The rank diagram is derived by sorting the realisations of a proxy (say the O3 daily mean at a given station and for a given day) for all 6 ensemble members plus the observation. The rank is then the position of the observation within these sorted values (respectively zero or six if all models overestimate or underestimate the observation). This operation is repeated for all days of the decade and all stations in Europe and the occurrence of each rank is counted and represented on Figure 3 as histograms. Here we also display the rank diagram for unbiased estimates (where we withdrawn the average, model-dependant, bias from each of the ensemble members).

The rank diagram for the raw daily mean O3 (in black) is skewed toward low values. It indicates that the observed values are systematically closer to the ensemble member at the bottom end of the distribution. When using unbiased daily mean O3 (in white), the rank diagram looks much better. Even if it exhibits a U-shape, reflecting a slight underestimation of the ensemble spread.

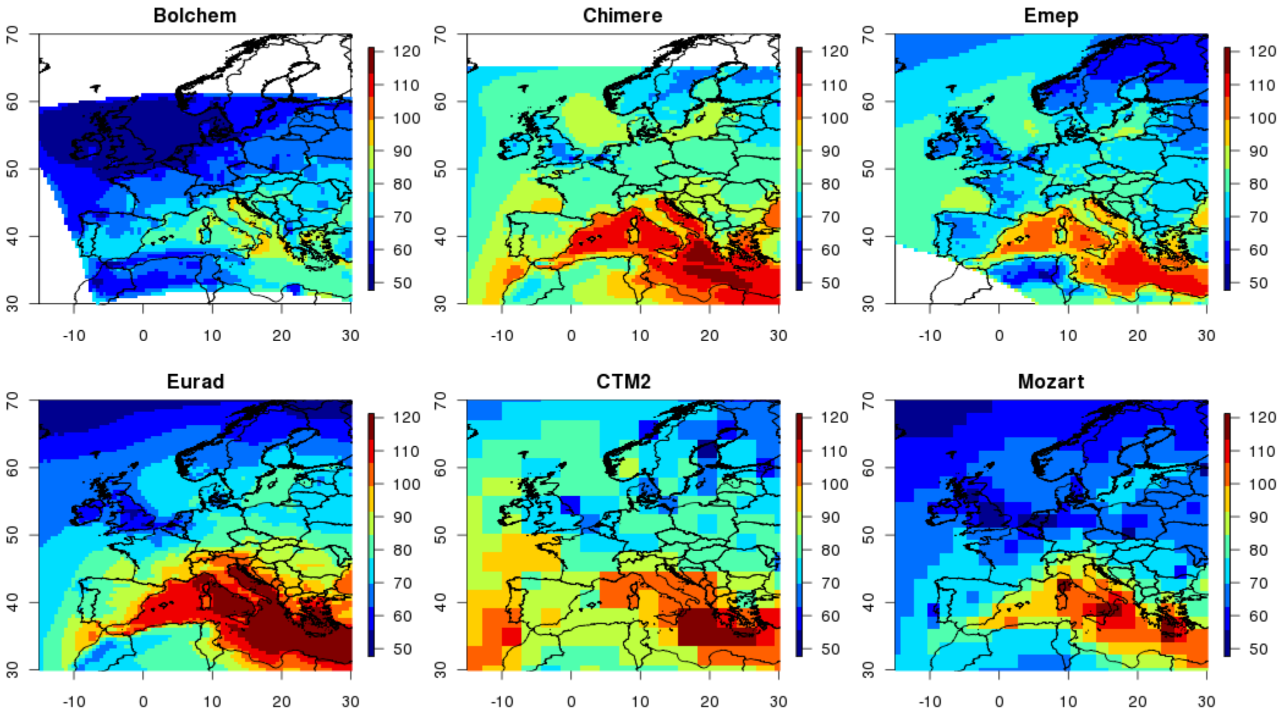

Figure 1: Average modelled O3 (µg/m3) for each model over the months of June, July and August and the 1998-2007 decade.

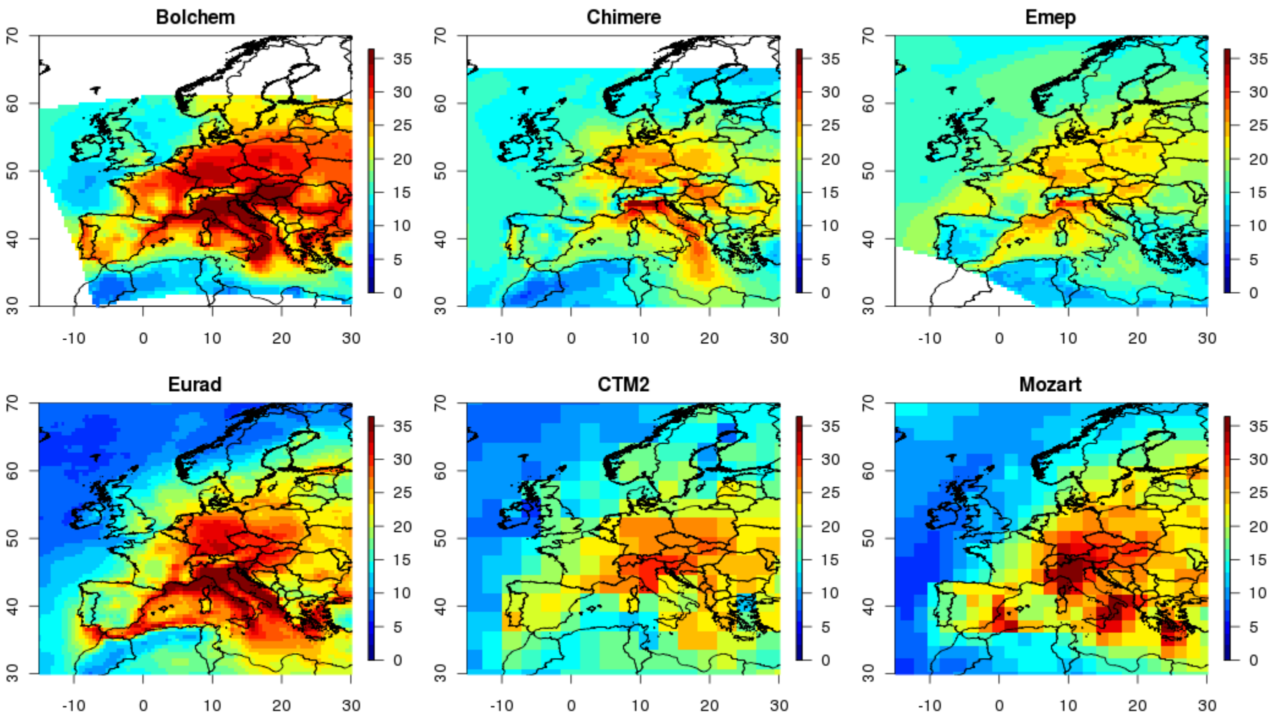

Figure 2: Standard deviation of monthly de-trended O3 (µg/m3) for each model over the months of June, July and August and the 1998-2007 decade.

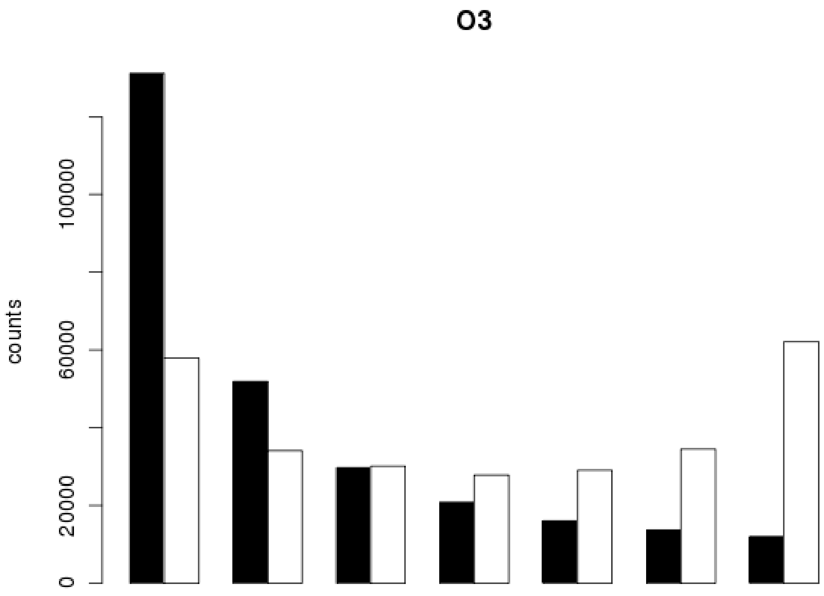

Figure 3: Rank diagram for the 6-CTMs ensemble for daily mean O3 in June, July and August, for the raw modelled values (black) and the unbiased estimates (white).

References

Colette A., C. Granier, Ø. Hodnebrog, H. Jakobs, A. Maurizi, A. Nyiri, B. Bessagnet, A. D'Angiola, M. D'Isidoro, M. Gauss, F. Meleux, M. Memmesheimer, A. Mieville, L. Rouïl, F. Russo, S. Solberg, F. Stordal, and Tampieri, F.: Air quality trends in Europe over the past decade: a first multi-model assessment, Atmos. Chem. Phys. Discuss., 11, 19029-19087, 2011

Vautard, R., et al. (2006), Is regional air quality model diversity representative of uncertainty for ozone simulation?, Geophys. Res. Lett., 33, L24818, doi:10.1029/2006GL027610.

Air quality trends in Europe over the past decade: a first multi-model assessment.

Colette, A., C. Granier, Ø. Hodnebrog, H. Jakobs, A. Maurizi, A. Nyiri, B. Bessagnet, A. D'Angiola, M. D'Isidoro, M. Gauss, F. Meleux, M. Memmesheimer, A. Mieville, L. Rouïl, F. Russo, S. Solberg, F. Stordal, F. Tampieri, Atmos. Chem. Phys. Discuss., 11, 1–58, 2011

Direct link: http://www.atmos-chem-phys-discuss.net/11/1/2011/doi:10.5194/acpd-11-1-2011

Abstract

We discuss the capability of current state-of-the-art chemistry and transport models to reproduce air quality trends and inter annual variability. Documenting these strengths and weaknesses on the basis of historical simulations is essential before the models are used to investigate future air quality projections. To achieve this, a coordinated modelling exercise was performed in the framework of the CityZEN European Project. It involved six regional and global chemistry-transport models (Bolchem, Chimere, Emep, Eurad, OsloCTM2 and Mozart) simulating air quality over the past decade in the Western European anthropogenic emissions hotspots.

Comparisons between models and observations allow assessing the skills of the models to capture the trends in basic atmospheric constituents (NO2, O3 and PM10). We find that the trends of primary constituents are well reproduced (except in some countries – owing to their sensitivity to the emission inventory) although capturing the more moderate trends of secondary species such as O3 is more challenging. Apart from the long term trend, the modelled monthly variability is consistent with the observations but the year-to-year variability is generally underestimated.

A comparison of simulations where anthropogenic emissions are kept constant is also investigated. We find that the magnitude of the emission-driven trend exceeds the natural variability for primary compounds. We can thus conclude that emission management strategies have had a significant impact over the past 10 years, hence supporting further emission reductions strategies.