

# Future global tropospheric ozone changes and impact on European air quality

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**Introduction:** In the next decades, the atmospheric composition will be affected by major changes in anthropogenic emissions (due to the increasing number of megacities in emergent countries) and climate changes. In order to investigate the impacts of these changes on the tropospheric composition, several simulations were performed in the framework of the Photocomp experiment. This study relied on the global emission scenarios developed by the IASA institute. The general circulation model LMDz-INCA was involved in this experiment among 25 state of the art global atmospheric chemistry models. Here, we examine the impact of these future scenarios on western European surface O<sub>3</sub>, using a down-scaling approach from a global into a regional chemistry-transport model and to determine the relative contribution of long-range transport of O<sub>3</sub> and its precursors with respect to the European emission control strategy is investigated.

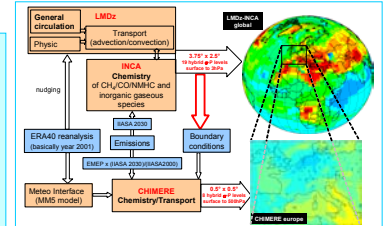


Figure 1: Configuration of the system coupling LMDz-INCA and CHIMERE used in this work

## 1. Method

A global climate-chemistry model (LMDz-INCA) is coupled with a regional chemistry transport model (CHIMERE) dedicated to air quality studies (Fig. 1) and focused over western Europe. Hence, the coarse results of the global model are used as boundary conditions in the sub-continental model. The global simulations are done using the IASA emissions datasets for the **current legislation scenario (CLE)** considering for each country the already planned emissions control policy, the **maximum technically feasible reduction scenario (MFR)** and the **SRES-A2 scenario provided for the third assessment report of IPCC**. The sub-continental simulations use the EMEP emissions rescaled to the 2030 scenario. A reference simulation is performed using the present-day emissions (CLE 2000 in LMDz-INCA and EMEP 2001 in CHIMERE).

## 2. Scenarios and global ozone changes

Considering the ensemble mean results integrated over the whole globe (Stevenson et al. JGR, 2006 and Dentener et al. EST, 2006):

- the **CLE scenario**, which can be considered as 'likely perspective', leads to an increase of 1.7 ppbv of global surface O<sub>3</sub> (Fig. 2, upper right panel)
- the **MFR scenario**, considered as the 'most optimistic' alternative, leads to a decrease of 1.8 ppbv of global surface O<sub>3</sub> (Fig. 2, lower left panel)
- the scenario **SRES-A2**, considered as the 'most pessimistic' hypothesis, infers an increase of 4.4 ppbv of global surface O<sub>3</sub> (Fig. 2, lower right panel)

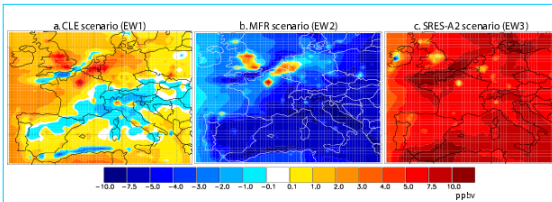


Figure 3: Monthly mean surface O<sub>3</sub> changes in July 2030 (compared with July 2001) simulated over Europe, with CHIMERE for (a) the "current legislation" scenario; (b) the "maximum feasible reductions" scenario; (c) the SRES-A2 scenario.

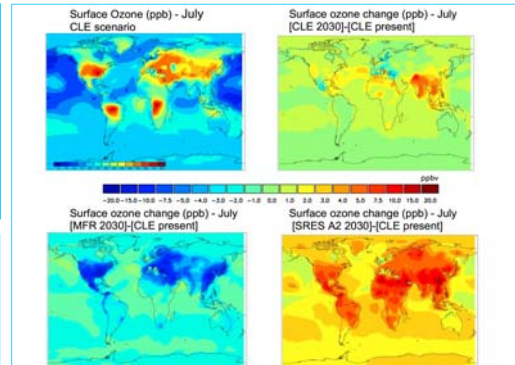


Figure 2: Mean surface ozone concentrations (upper left) simulated by LMDz-INCA for July considering the CLE scenario for present day and surface ozone changes for the CLE2030 scenario (upper right), MFR scenario (lower left) and SRES-A2 scenario (lower right).

## 3. Relevance of the present-day regional simulation

The comparison of the simulated daily O<sub>3</sub> maxima with observations over 244 European stations shows a rms of 9.14 ppbv and a correlation (r) of 0.826 over the summer period. The standard deviation ratio ( $\sigma_{\text{mod,CLE2000}}/\sigma_{\text{obs}}$ ) of 0.88 was found illustrating the ability of CHIMERE to simulate the O<sub>3</sub> variability over Europe with confidence.

## 4. Surface ozone in 2030

Whereas the CLE2030 emissions modifications lead to an increase of surface O<sub>3</sub> at the global scale, the changes are more contrasted over Europe (Fig. 3, left panel). An increase greater than 4 ppb over areas with high density of population (e.g. in the vicinity of Paris, London, Manchester, Düsseldorf, Bruxelles, Milan, Cracovie) is observed and accompanied by a general increase of 0.1 to 4 ppb over the North of Europe whereas a decrease of 0.1 to 3 ppb is found over most of the continental part of South Europe.

The MFR scenario (Fig. 3, middle panel) implies a general reduction of surface O<sub>3</sub> in 2030 for July greater than 2 ppb over the major part of Europe. Nevertheless, the O<sub>3</sub> levels are, as in the CLE scenario, increased of a few ppb over Northern high emission spots. The pessimistic SRES-A2 scenario (Fig. 3, right panel) leads globally to an increase, exceeding 5 ppb, of the monthly mean surface O<sub>3</sub> in July over European continental area.

## 5. Role of European emissions policy versus global emission changes

Model simulations considering separately the emission changes and the global boundary condition changes were carried out (Fig. 5). In the "current legislation" scenario, the global modifications of emissions would imply a slight increase of continental surface O<sub>3</sub> over Europe (typically 1 to 3 ppb). On the contrary, the European legislation adopted to protect Europe's air quality would lead to the reduction of O<sub>3</sub> level over the most part of continental Europe, mainly in the South, where O<sub>3</sub> level could be decreased by 0.1 to 4 ppb. Only the Northern highly inhabited areas, where the O<sub>3</sub> production is VOC limited, would see the rise of their ozone level from 0.1 to 5 ppb typically. **Over Europe, the surface O<sub>3</sub> response results from the competing effects of long-range transport of pollutants and reduced regional photochemical production. The efforts done by the European Union to limit precursor emissions despite the assumption of economic growth could thus be significantly competed by the global emissions changes and intercontinental transport in the near future.**

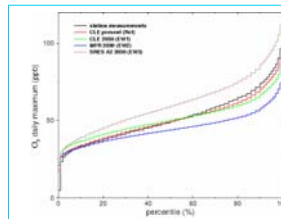


Figure 4: Distribution of daily O<sub>3</sub> maximum percentiles computed over 244 European ground based stations using 2001 measurements (black) and for CHIMERE results for present-day run (red); 2030 CLE run (green); 2030 MFR run (blue); 2030 SRES-A2 run (brown).

## 5. Distribution of the changes

The percentiles (Fig. 4) supports the decrease in the occurrence of extreme values (minima as well as maxima) for the CLE scenario. Hence, the interval between the 10<sup>th</sup> and 90<sup>th</sup> percentiles is decreased by 6.3 ppbv from the present day run to the CLE2030 run (with differences of respectively 2.7 and 3.6 for the 10<sup>th</sup> and 90<sup>th</sup> percentiles) indicating, as far as O<sub>3</sub> levels are concerned, a general improvement of the air quality.

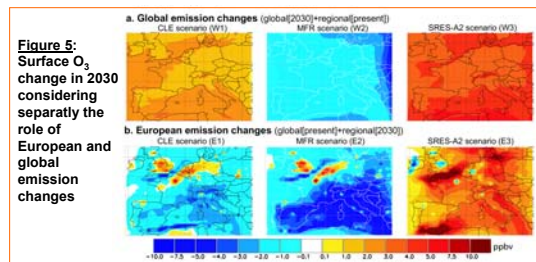


Figure 5: Surface O<sub>3</sub> change in 2030 considering separately the role of European and global emission changes

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