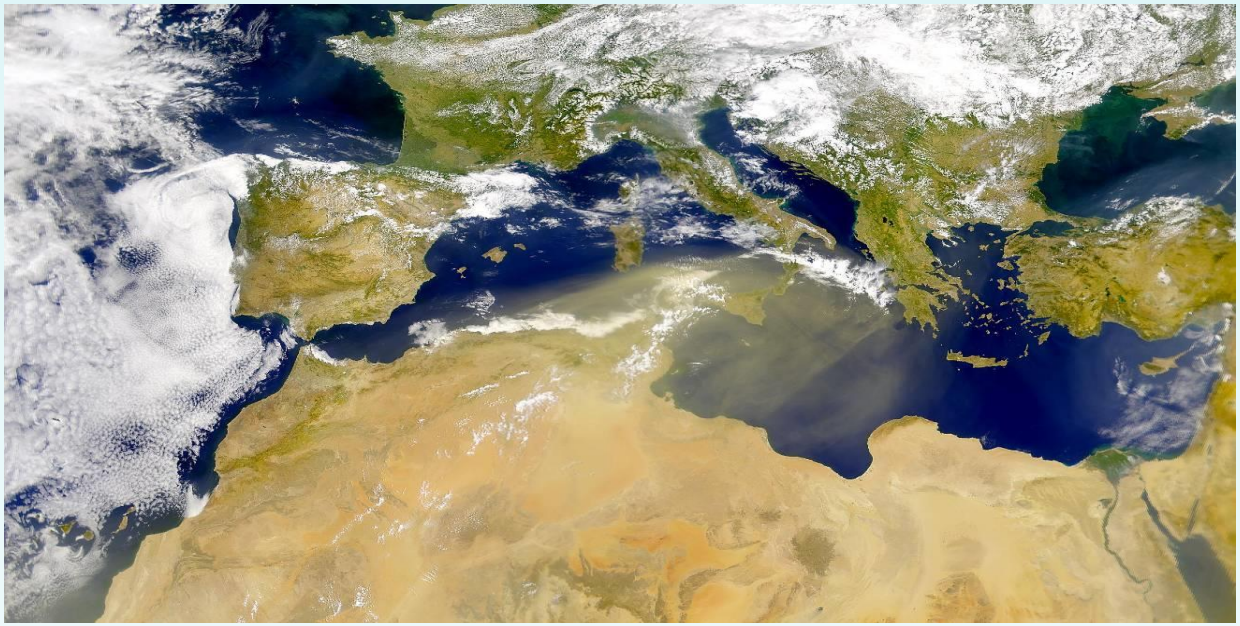
Regional climate chemistry interactions and modelling in the Mediterranean region

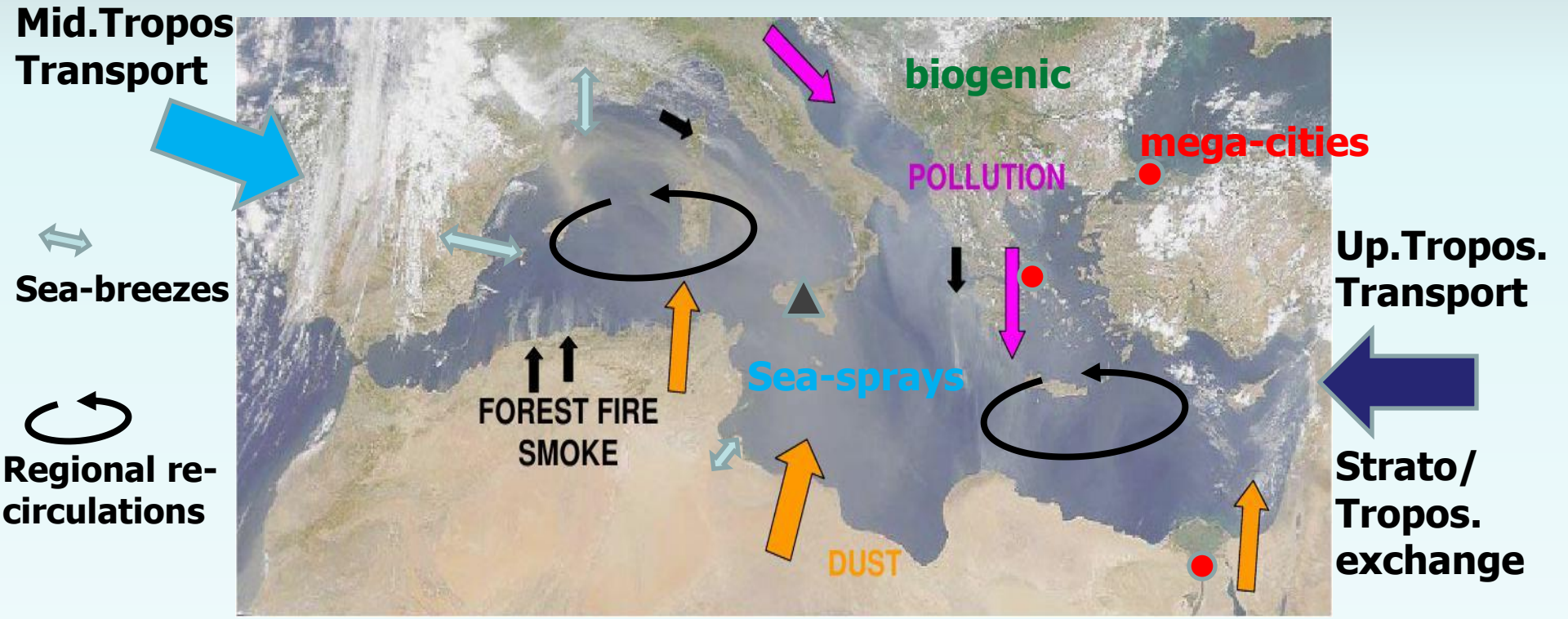
F. Solmon (LA-OMP/ ICTP)

Thanks to L. El Amraoui, P. Nabat, N. Elguindi, M. Mallet, F. Dulac , S. Somot …

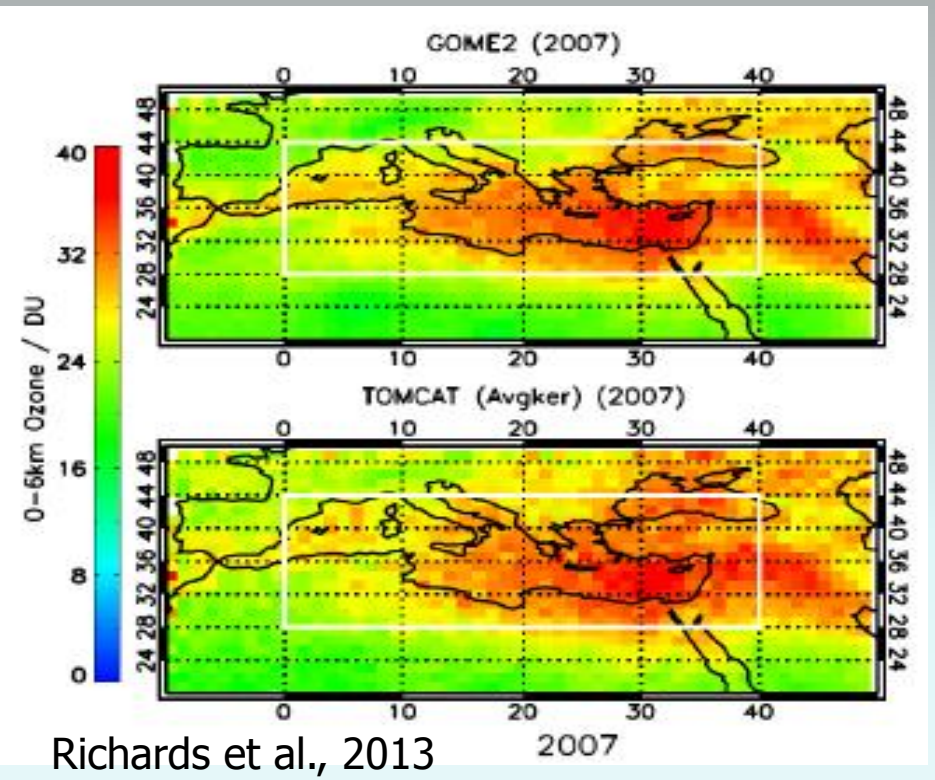


Atmospheric chemistry in the Mediterranean region

- ❑Diversity of sources of primary gases and particles (anthropogenic and natural).
- ❑Active photochemistry (ozone and secondary aerosol formation)
- ❑ Diversity of chemical transport pathways

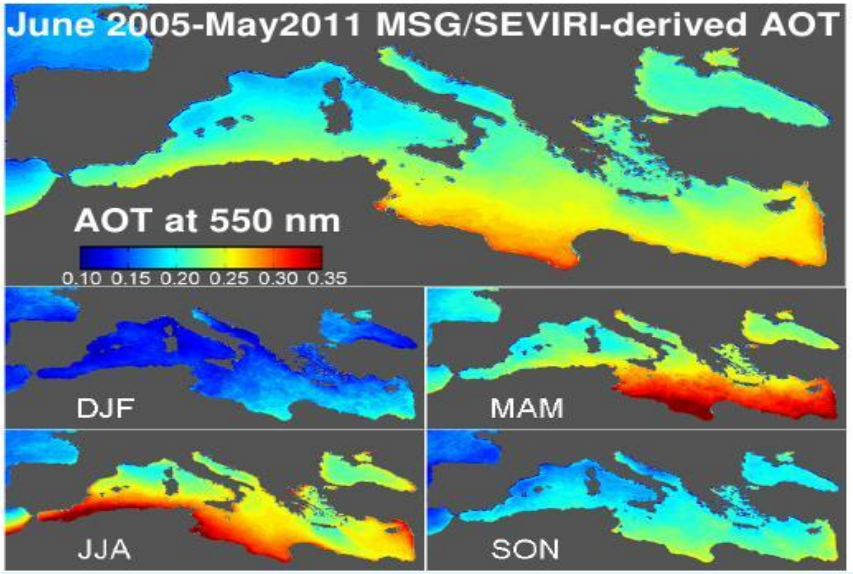


Hot spot for ozone



Richards et al., 2013

… and aerosol

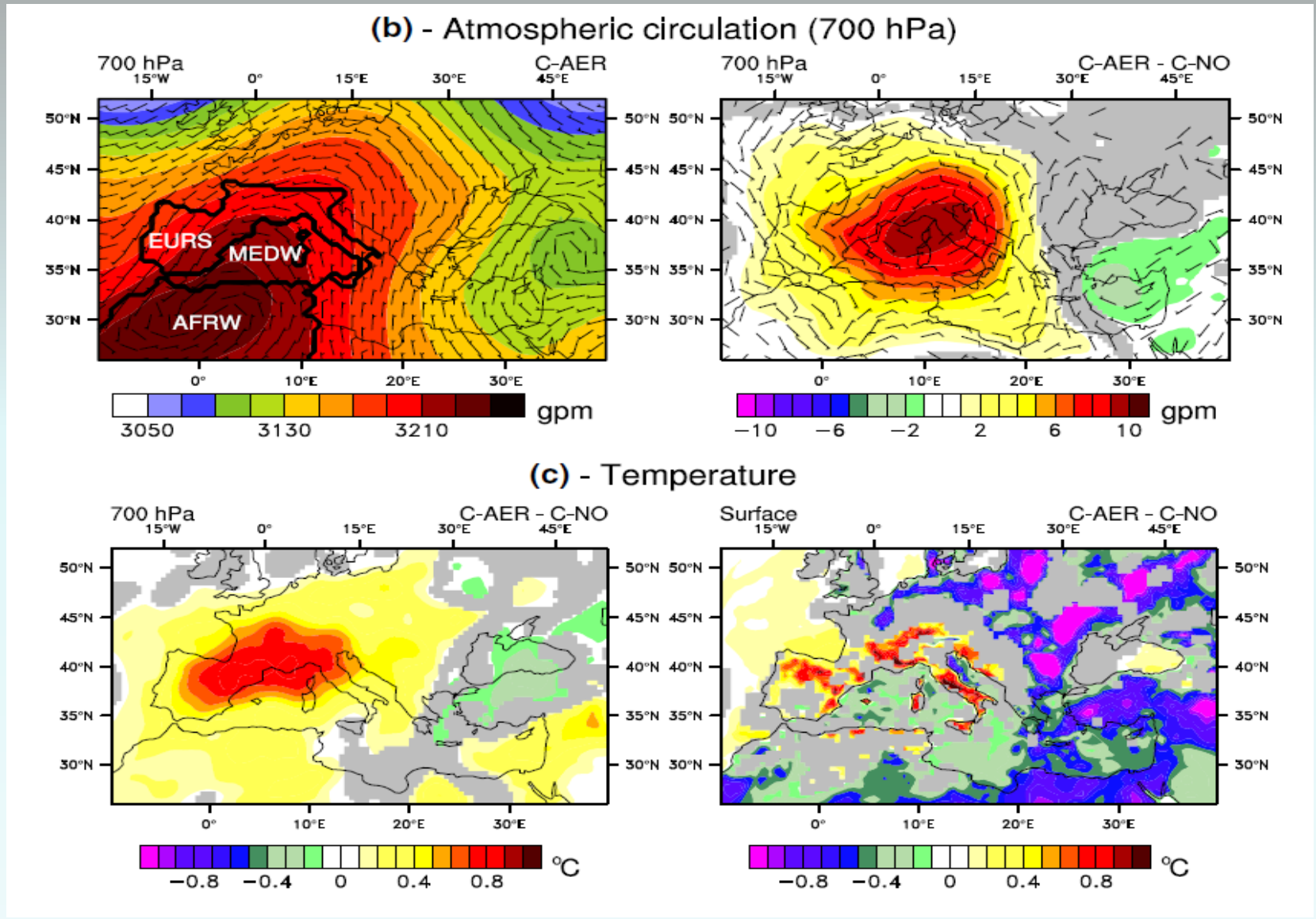


From MedCliVar book, Lionello

Impacts

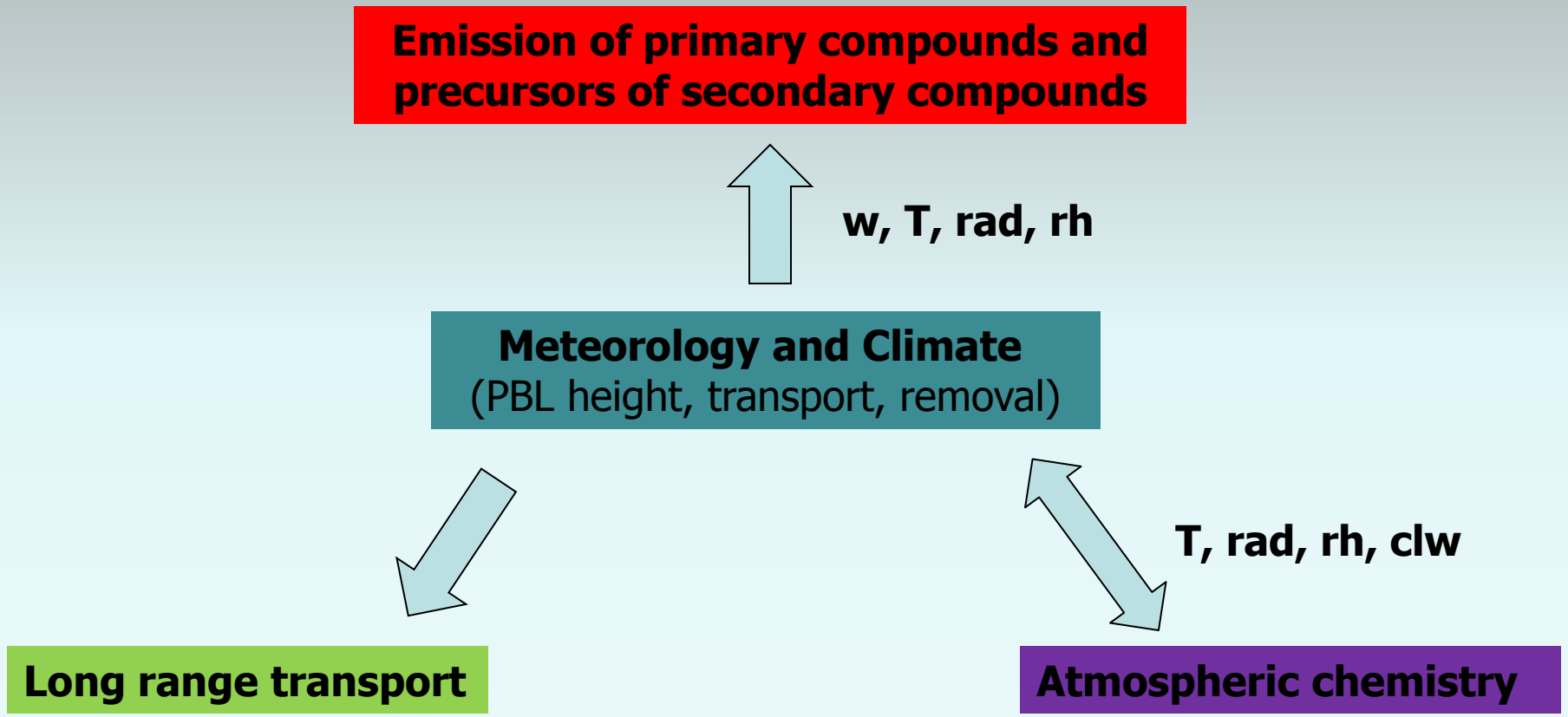
- **Air quality**
- **Regional radiative forcing and climate**
- **Biogeochemistry (deposition , PAR)**

e.g.: Role of dust on regional climate (Nabat et al., Clim. Dyn., 2015)



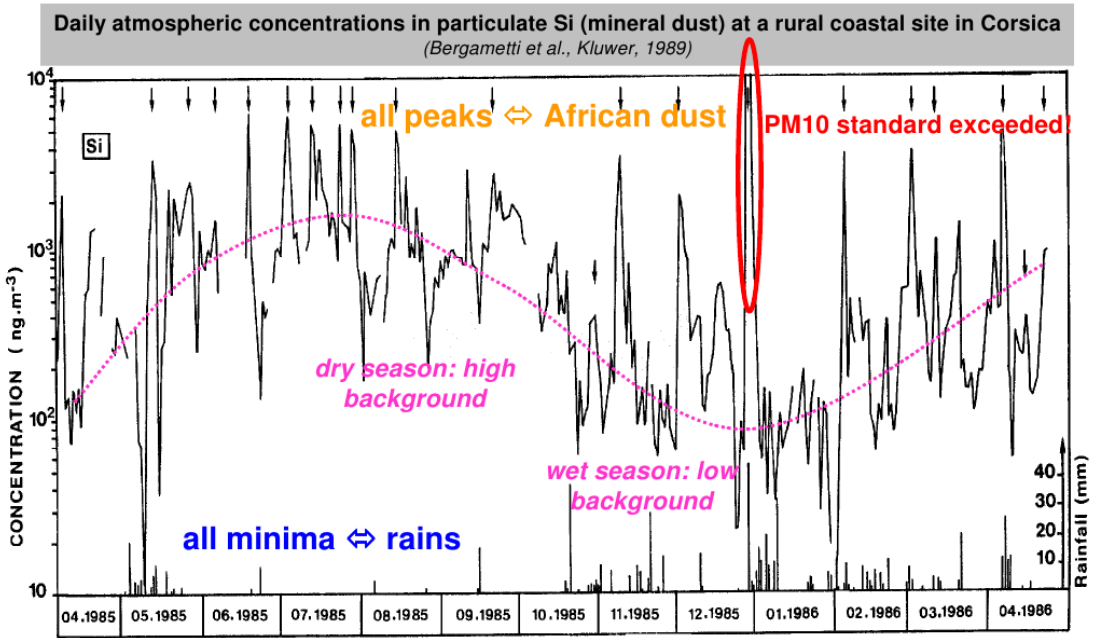
Based on CNRM-RCSM4 simulations, June 2006 heatwave

The variability of gases and aerosol concentrations is controlled by :

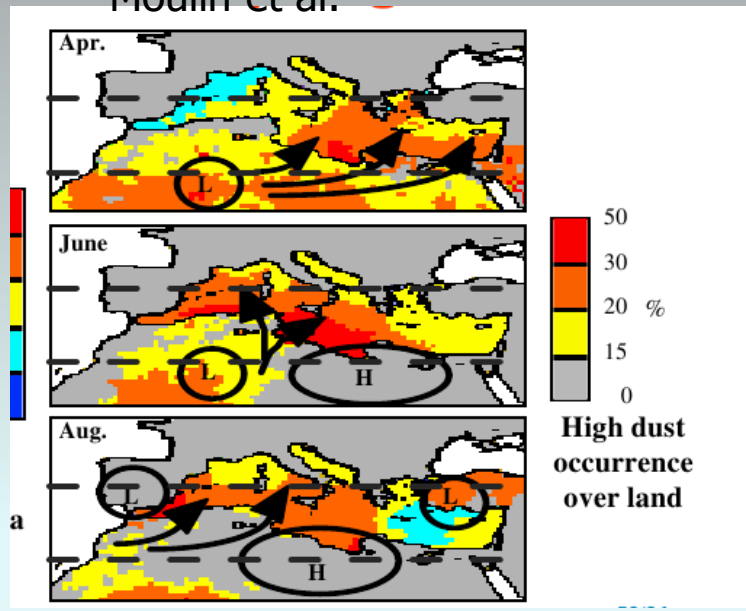


Jacobs et al., 2009

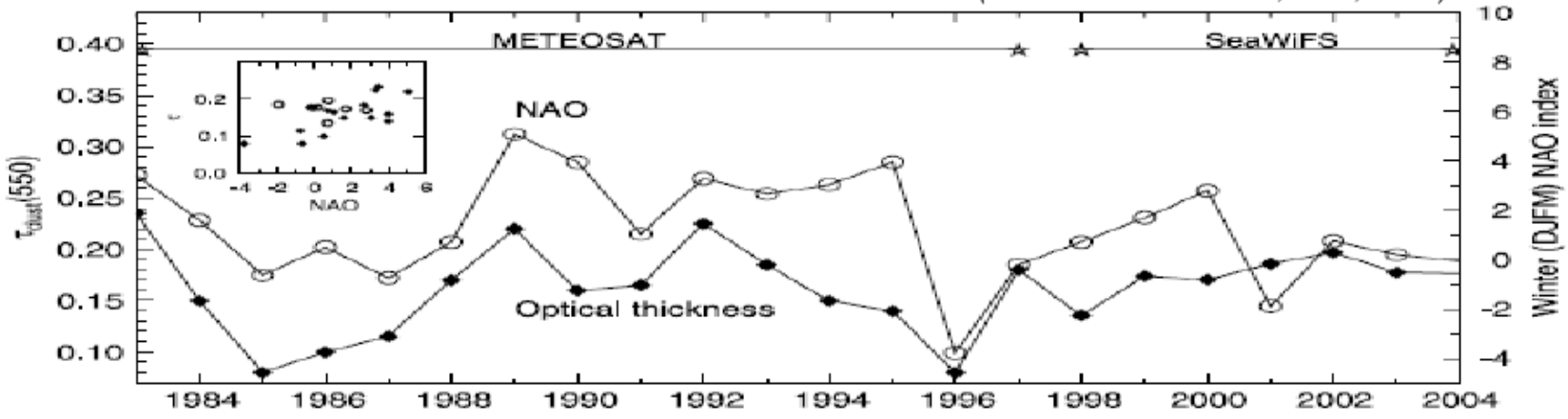
Example : Variability of dust aerosol



Moulin et al.



(Antoine and Nobileau, JGR, 2006)



Emission change in the future ?

Anthropogenic emissions evolution.

Consider different scenarios based on socio-economic projections for different activity sectors. Prescribed to models.

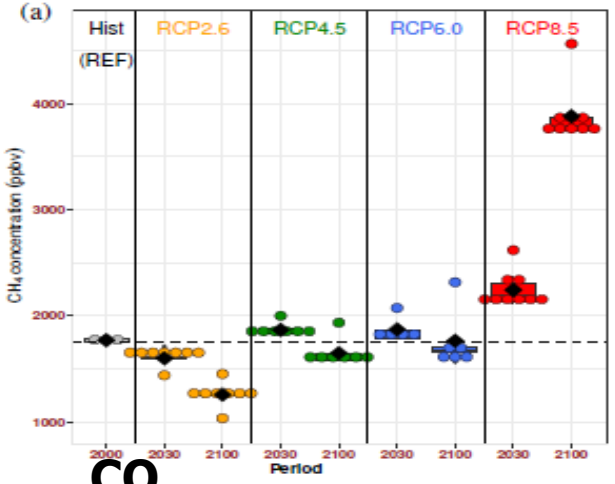
Perturbation of natural (or semi-natural) emissions through climate, land use , ecosystem/agrosystem changes

Possibly parameterized in models, e.g. dust and sea salt emission, biogenic VOC emissions, wildfires, ..

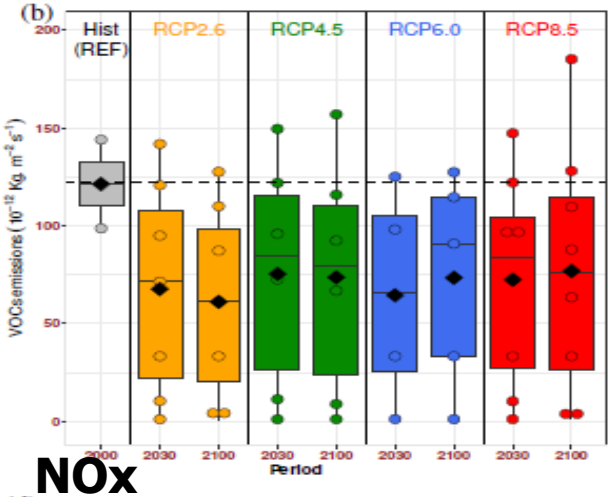
ACCMIP/ RCP emission scenarios for the Mediterranean region

from Jaidan et al., ACPD, 2017

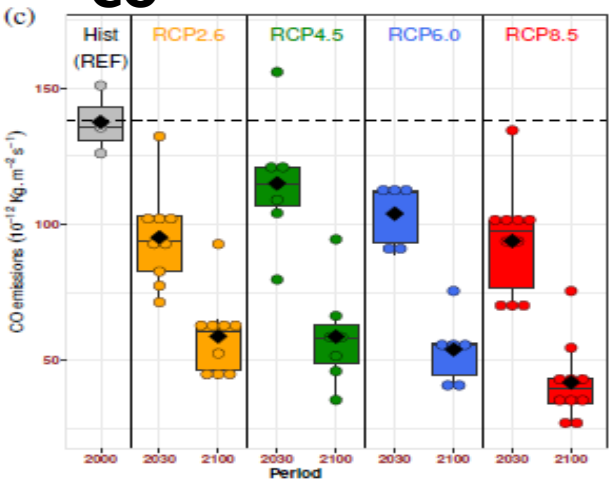
CH4



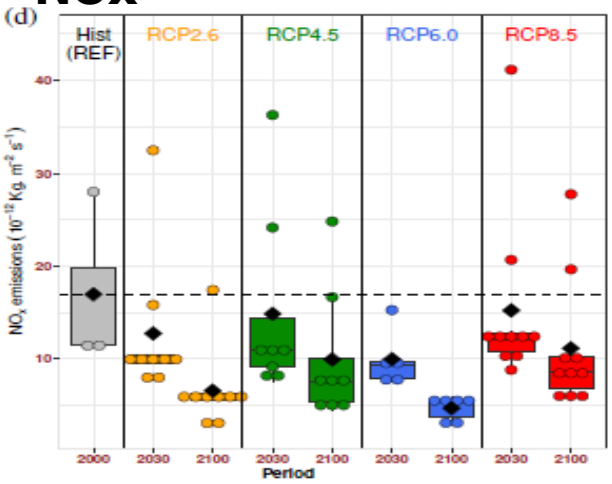
VOC



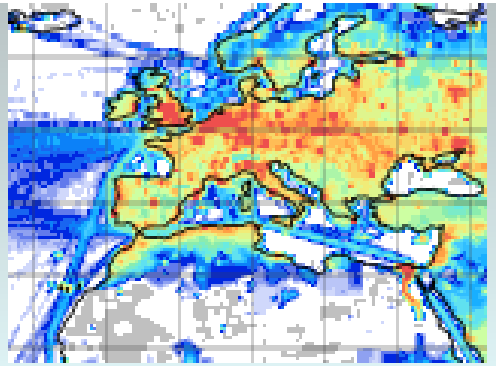
CO



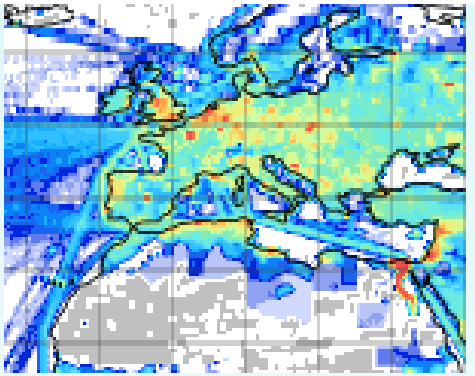
NOx



HIST 1990-2010



RCP 4.5 2040-2060



Seen from 11 global models

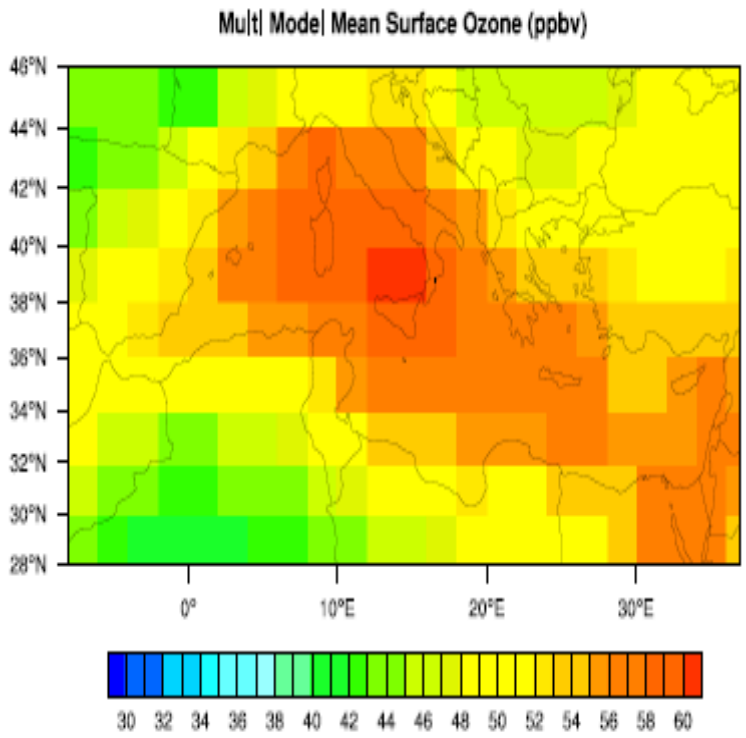
Lamarque et al.,2010
Van Vuuren et al., 2011

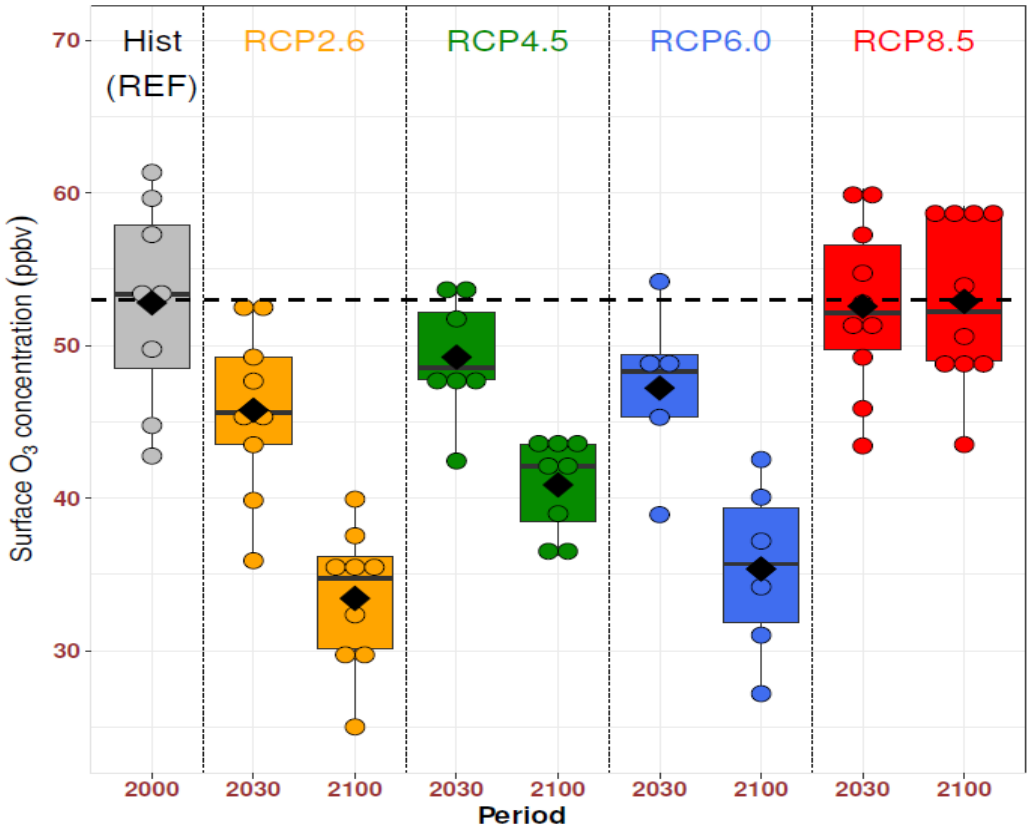
JJA mean Surface Ozone changes over the Mediterranean basin

Seen by ACCMIP models:

Atmospheric Chemistry and Climate Model Intercomparison Project (ACCMIP) outputs from 11 global models

Jaidan et al., ACPD, 2017

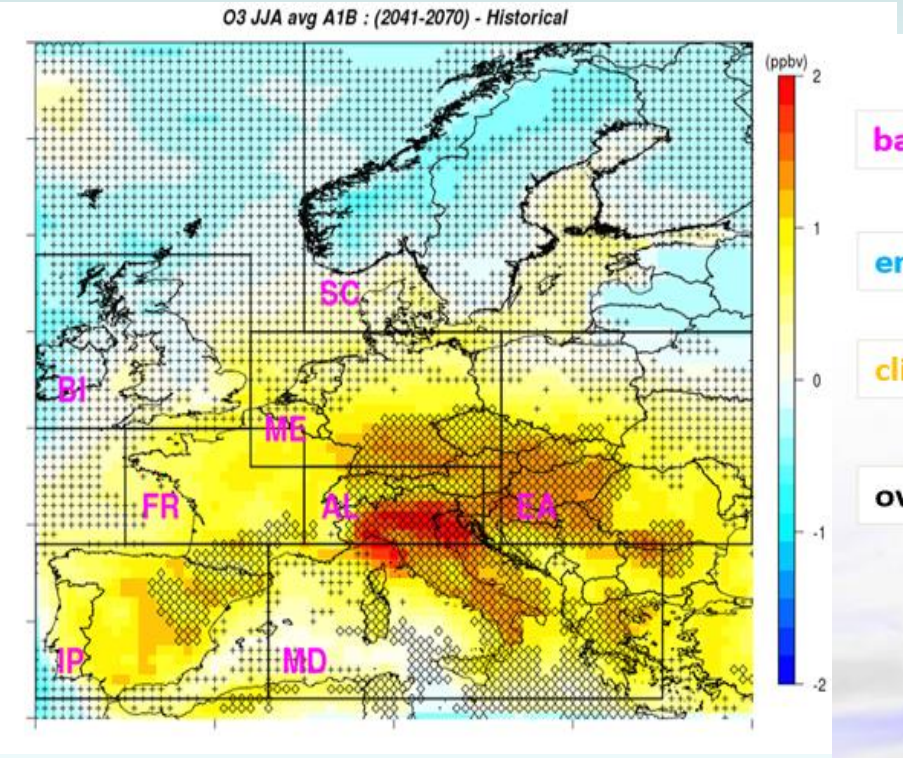


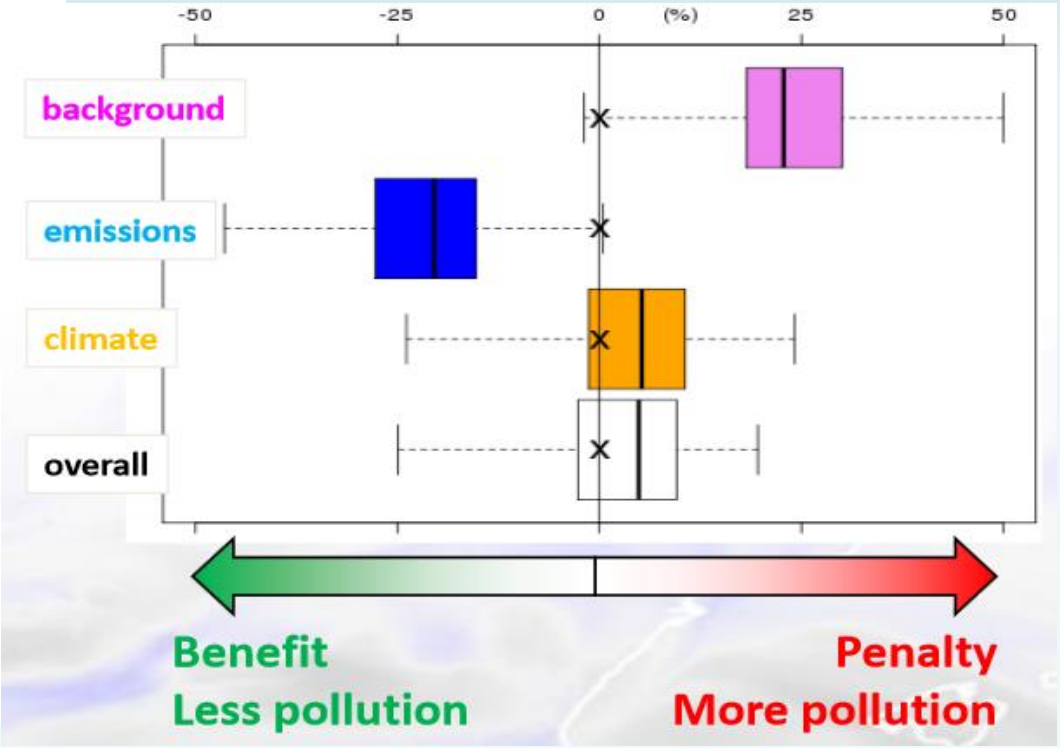


Air quality : The ozone climate penalty

Colette et al., ERL, 2015 ; Lemaire et al., 2016

driving chemistry-transport models with future climate projections while holding the ozone precursor emissions (anthropogenic) constant



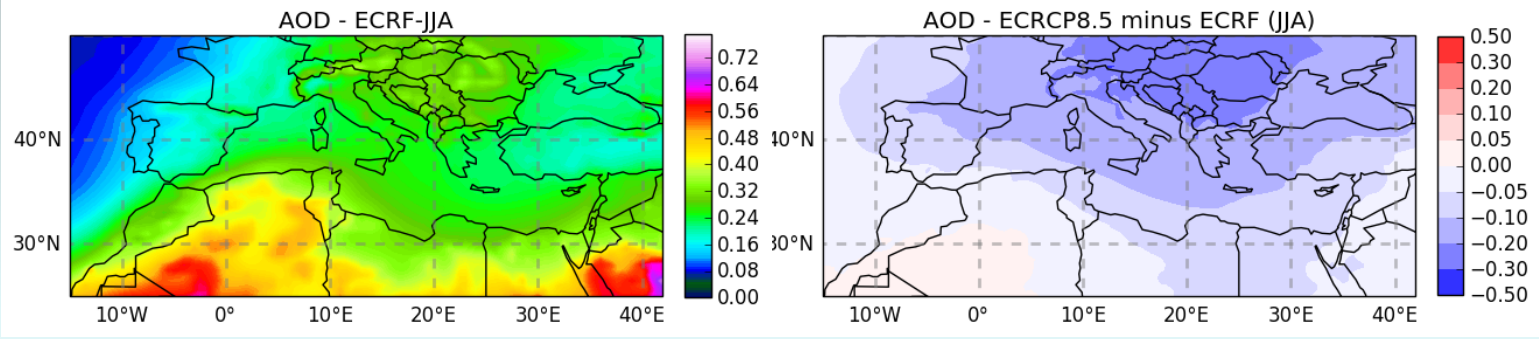


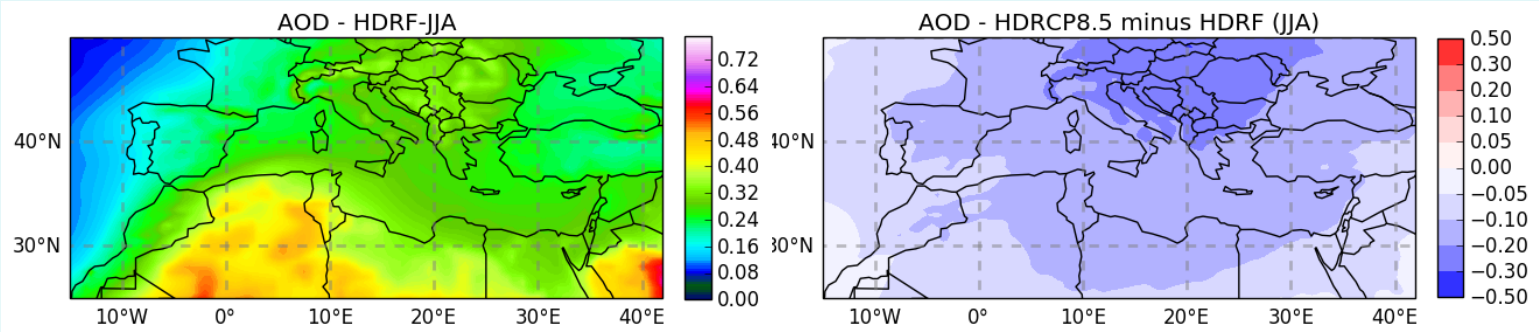
Aerosol change

Seen by two regional climate models with simplified aerosol scheme (SO4/BC/OC) and on-line dust and sea salt emission/ transport

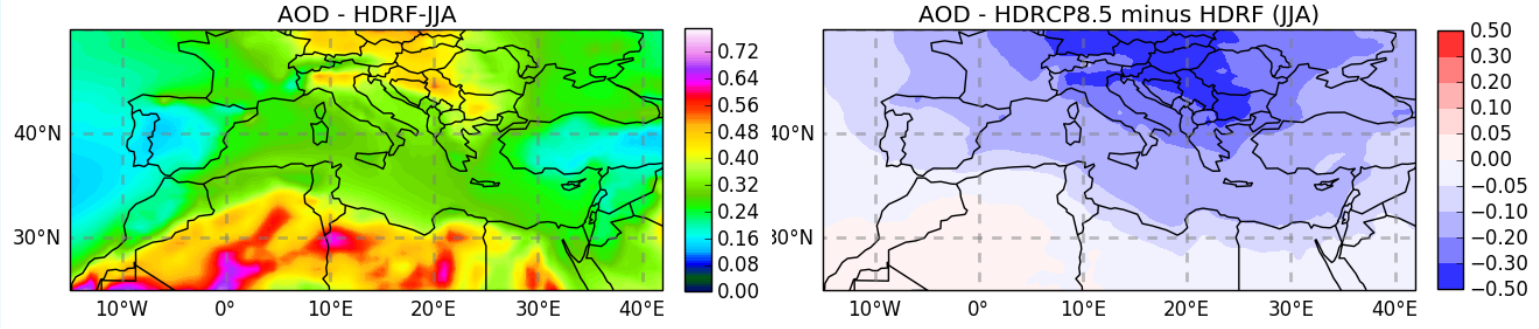
AOD change ([2080-2100] – [1990-2010]) RCP8.5

ICTP/ RegCM



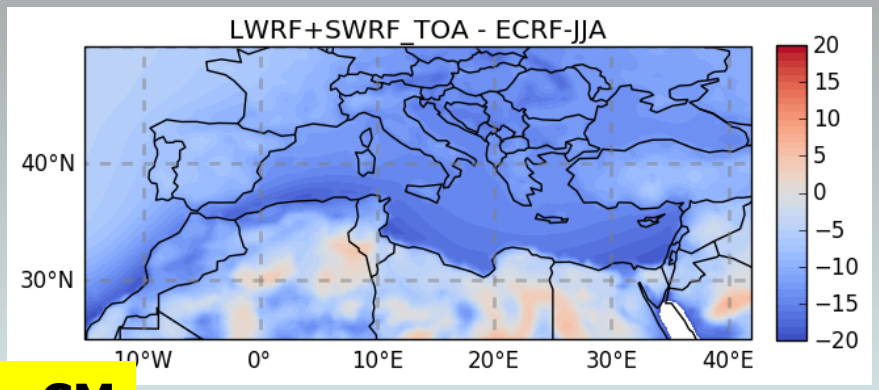


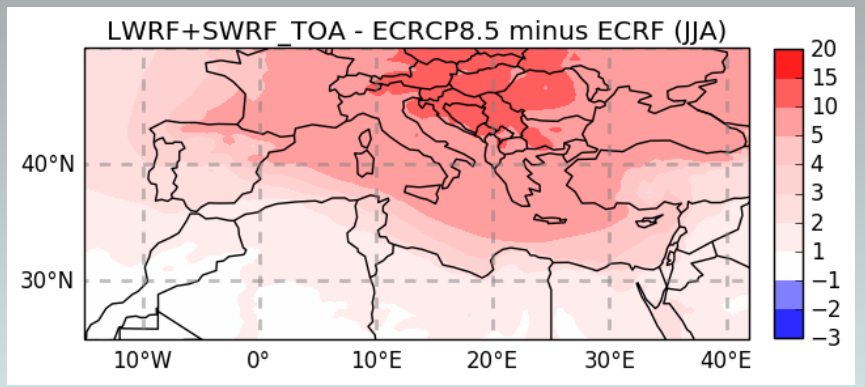
CNRM/ Aladin

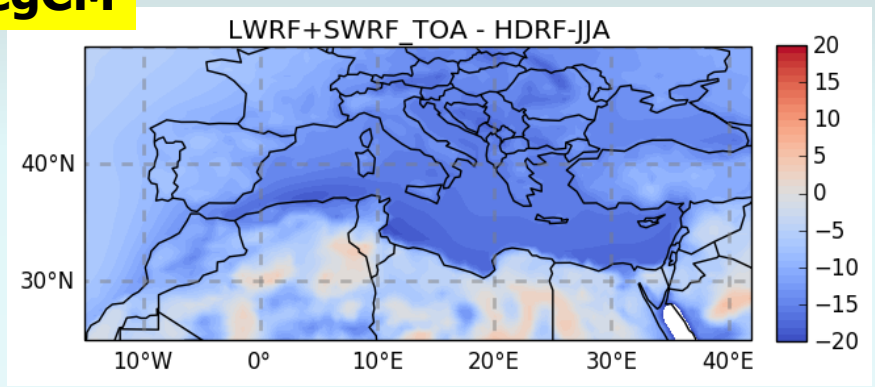


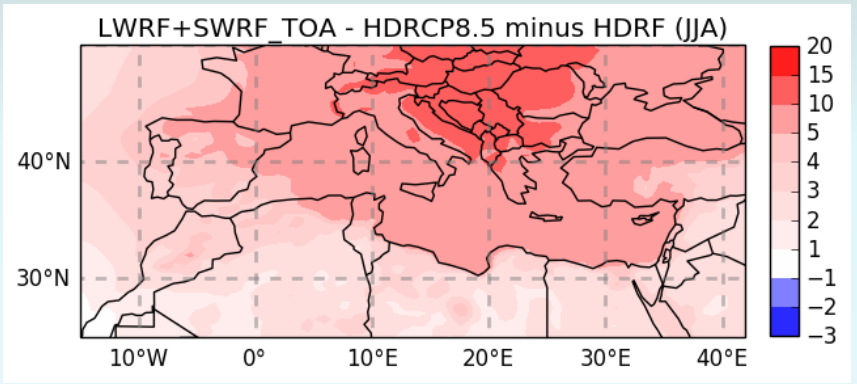
Total aerosol radiative forcing change TOA JJA

RegCM









- **Driven by anthropogenic emission reduction over Europe and possibly regional climate change (uncertain).**
- **Regional enhancement of global warming due to decreased dimming aerosol effect.**
- **No significant dust change simulated.**

Conclusion

Some components of the change in atmospheric chemistry are highly uncertain (e.g. evolution of biogenic emissions, land use change, wildfires).

The analysis of the evolution of deposition, extreme events , exposure time (…) is required for impact studies.

Important subregional factors for pollution impacts : e.g. sea breeze / pollution recirculation in coastal or mountain areas.

➡ **Promising results from high resolution CORDEX runs (Drobinski et al., 2017)**

Simulating dust emission change might require higher RCM resolution / improvement of subgrid scale parametrisation and must take into account the impact of landuse change

Perspectives

Intercomparison of atmospheric chemistry simulations based on regional climate modelling. Ensemble data sets.

Med-CORDEX Aerosol Flagship Pilot study

ChArMEx modelling intercomparison work package

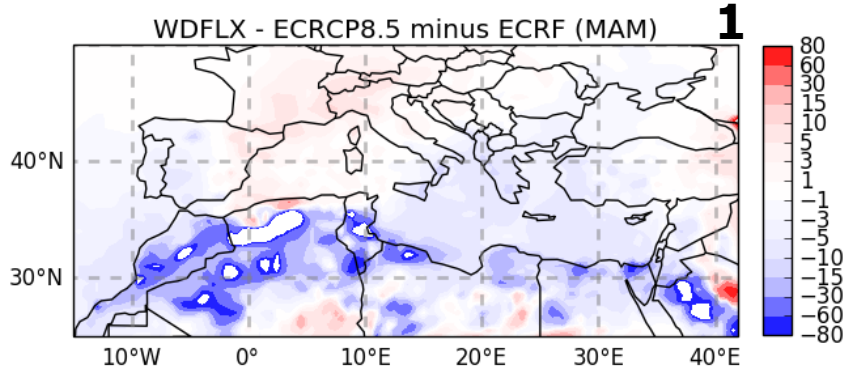
Info on simulation protocols :
fabien.solmon@aero.obs-mip.fr
marc.mallet@meteo.fr
pierre.nabat@meteo.fr

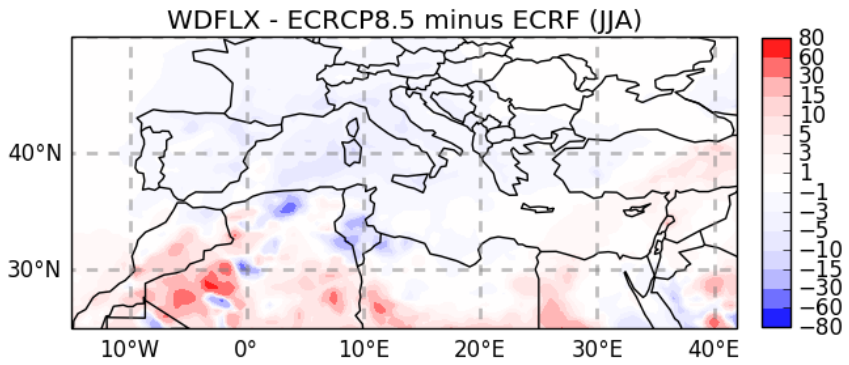
Thank you

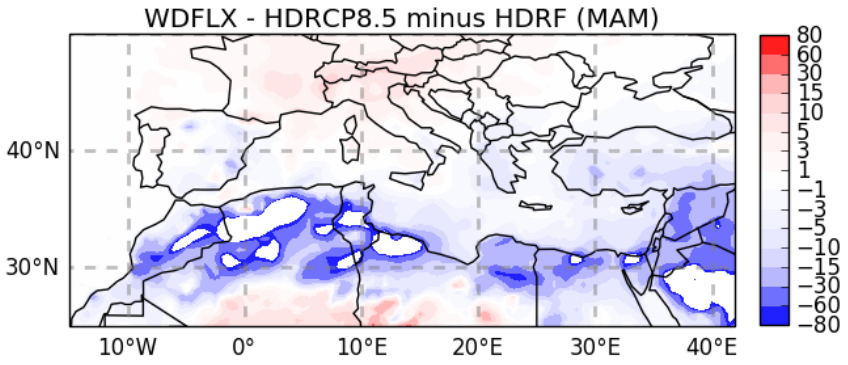
Dust wet deposition change (JJA)

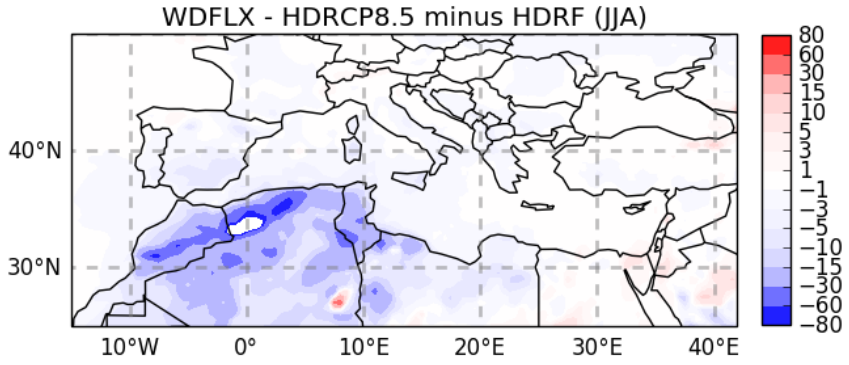
MAM **mg.m-2.day-1** **JJA**

Reg.









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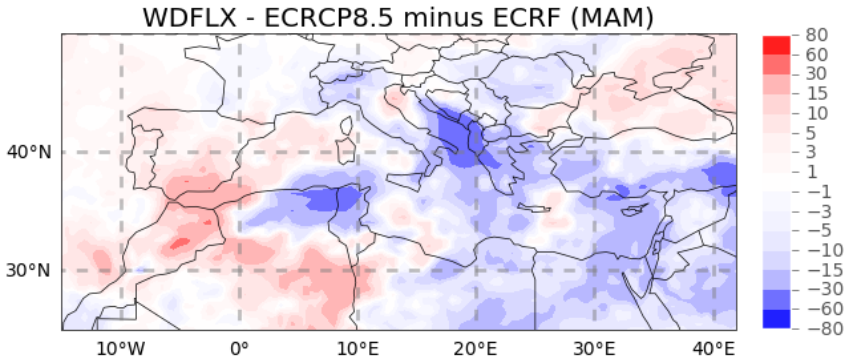
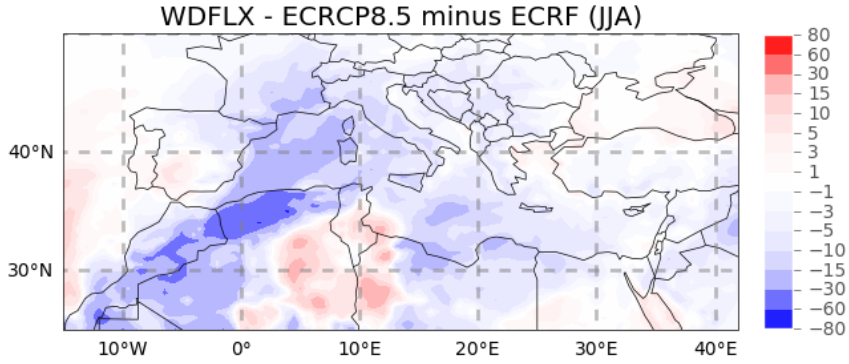
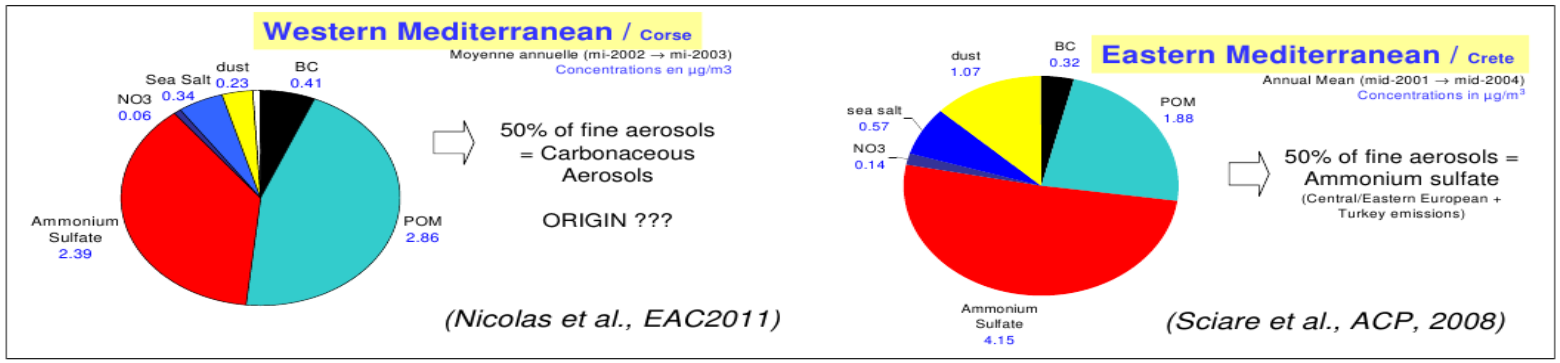




Modelling of atmospheric chemistry/ aerosols in Mediterranean regions : a number of challenges !

Example 2 : Secondary aerosol formation

Secondary aerosol particles dominate the fine (PM2.5) particulate fraction



⇨ **Sulfate dominate in the eastern basin**
Organics dominate in the northwestern basin

Relevance of PM2.5 for air quality, ecosystem impact, and climate (direct and indirect effects)