Météo-France update

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9th ICAP Meeting, Lille France

1. The MOCAGE model

2. The latest operationnal version

3. On going and future work

4. Data assimilation update

5. Work on aerosol source inversion

5. Conclusion

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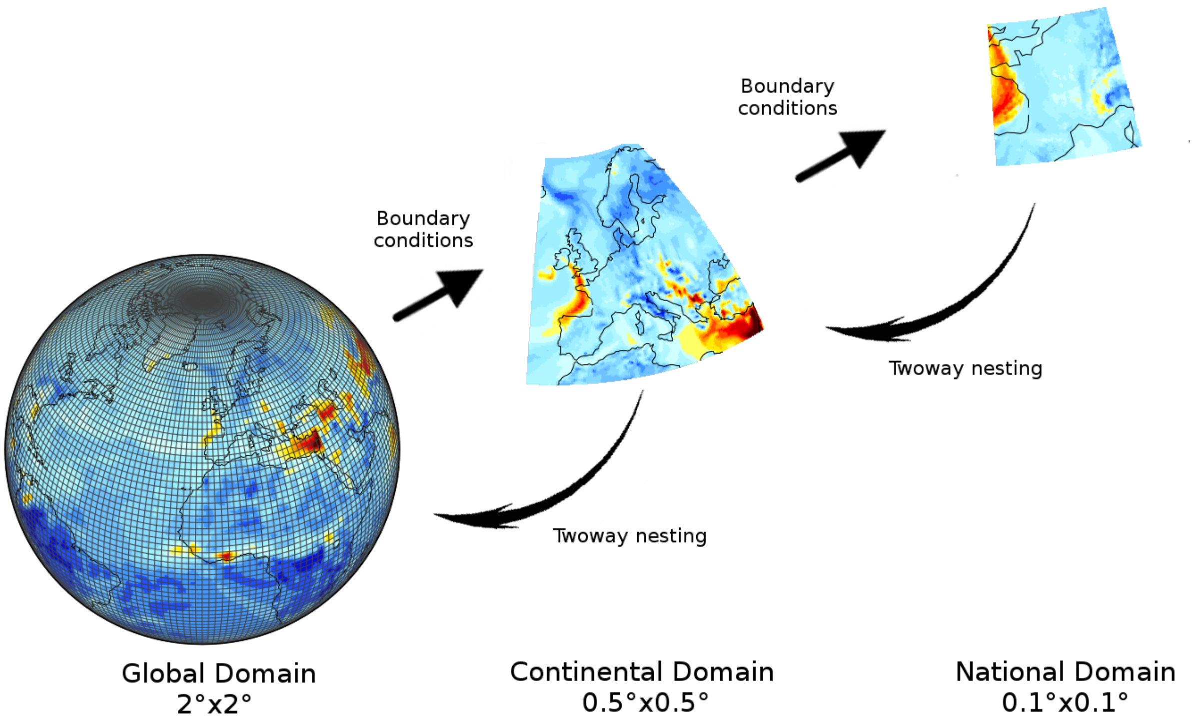
The MOCAGE model : general features

- Off-line Chemistry Transport Model
- Semi-lagrangian transport scheme with convection (Bechtold et al., 2001) and diffusion (Louis, 1979)
- Two-ways nesting capabilities
- 47 σ-hybrid vertical levels from surface up to 5 hPa



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The MOCAGE model : aerosols

- Chemical scheme RACM (troposphere) and REPROBUS (stratosphere)
- 95 gaseous species, 55 photolysis, 322 chemical reactions
- 4 primary aerosols :
  - Desert Dust : dynamic emissions (Marticorena and Bergametti, 1995)
  - Sea Salt : dynamic emissions (Gong, 2003 and Jaeglé, 2011)
  - Black Carbon : emission inventory (MACCity)
  - Primary Organic Carbon : emission inventory (MACCity)
- Secondary Inorganic Aerosols computed with ISORROPIA (v2.1)
- Sectionnal representation using 6 bins for each aerosol

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The latest operationnal version

- On January 31st a new version of the model was implemented
- Global domain 2°x2° → 1°x1°
- Complete operationnal configuration is now :
  - Global domain at 1°x1°
  - European domain at 0.5°x0.5°
  - France domain at 0.1°x0.1°
- Diurnal cycle for Isoprene
- Desert dust distribution is now issued from Kok (2011)

The latest operationnal version : Dust distribution

- Previous distribution was Alfaro et al. (1998)
- Desert dust distribution is now issued from Kok (2011) :

$$\frac{dV_d}{dlnD_d} = \frac{D_d}{c_v}\left[1 + erf\left(\frac{ln\left(D_d/D_s\right)}{\sqrt{2}ln\sigma_s}\right)\right] exp\left[-\left(\frac{D_d}{\lambda}\right)^3\right]$$

D_s	σ_s	λ	C_v
3.4 µm	3.0	12 µm	12.62 µm

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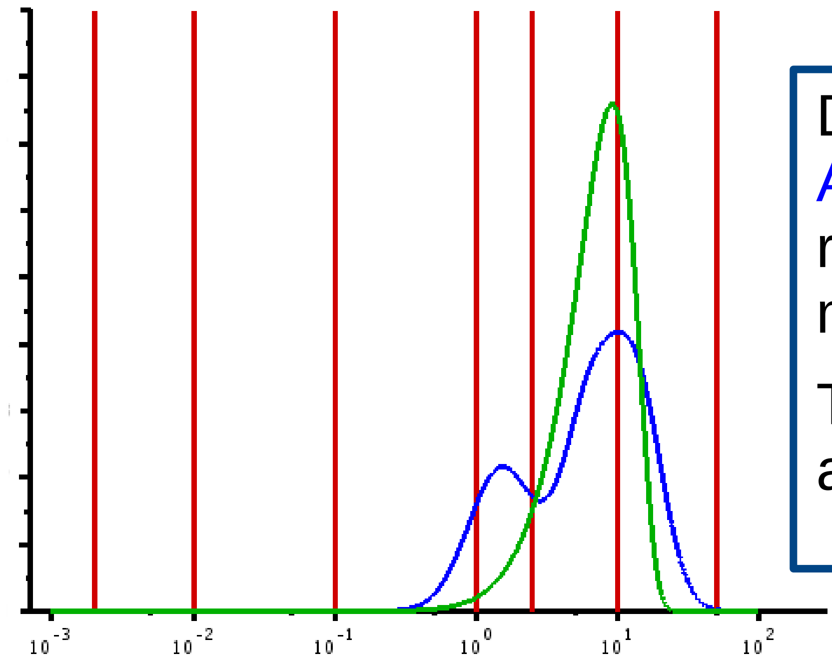

Distribution for the desert dust using Alfaro et al. (1998) and Kok (2011).The red bars represents the section in the model.

There are now less very big particles and less small particles.

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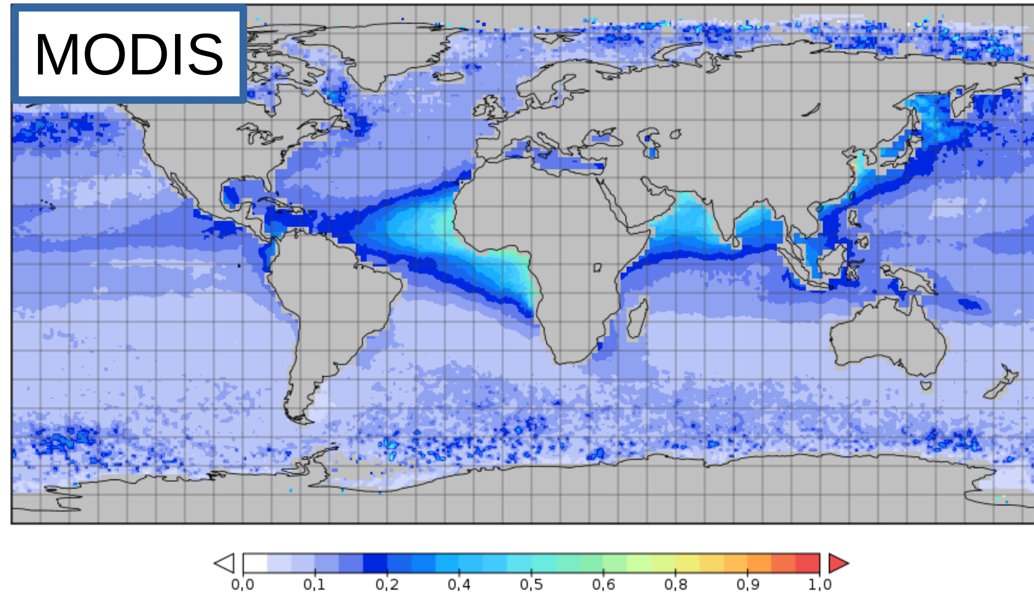
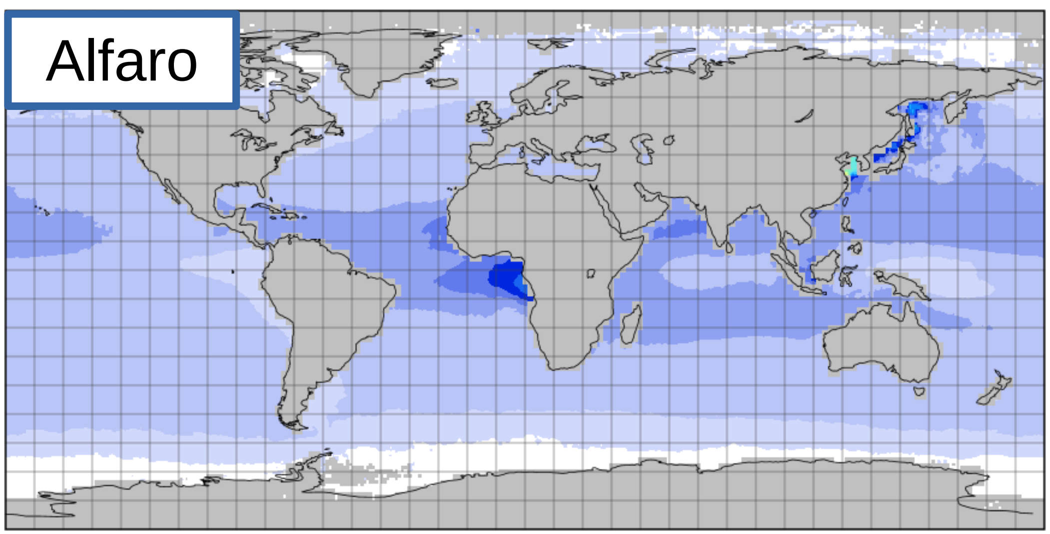
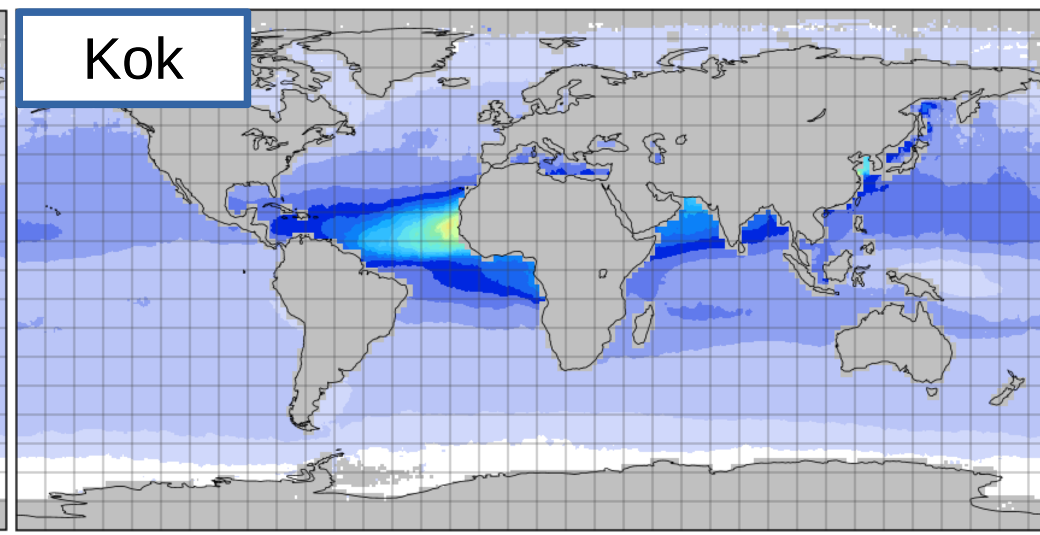
The latest operationnal version : Dust distribution

Mean annual AOD for 2012 :

- The mean AOD is improved using the Kok distribution for desert dusts
- Simulation made at 2°x2° resolution



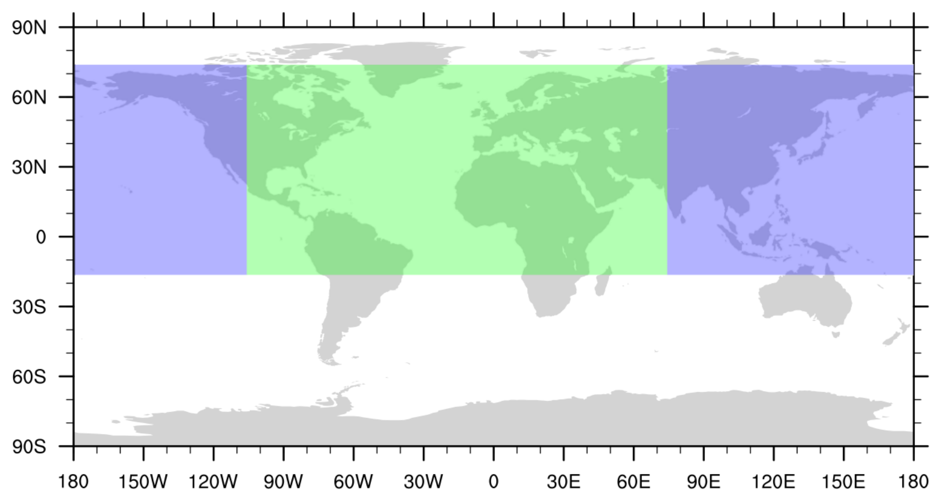


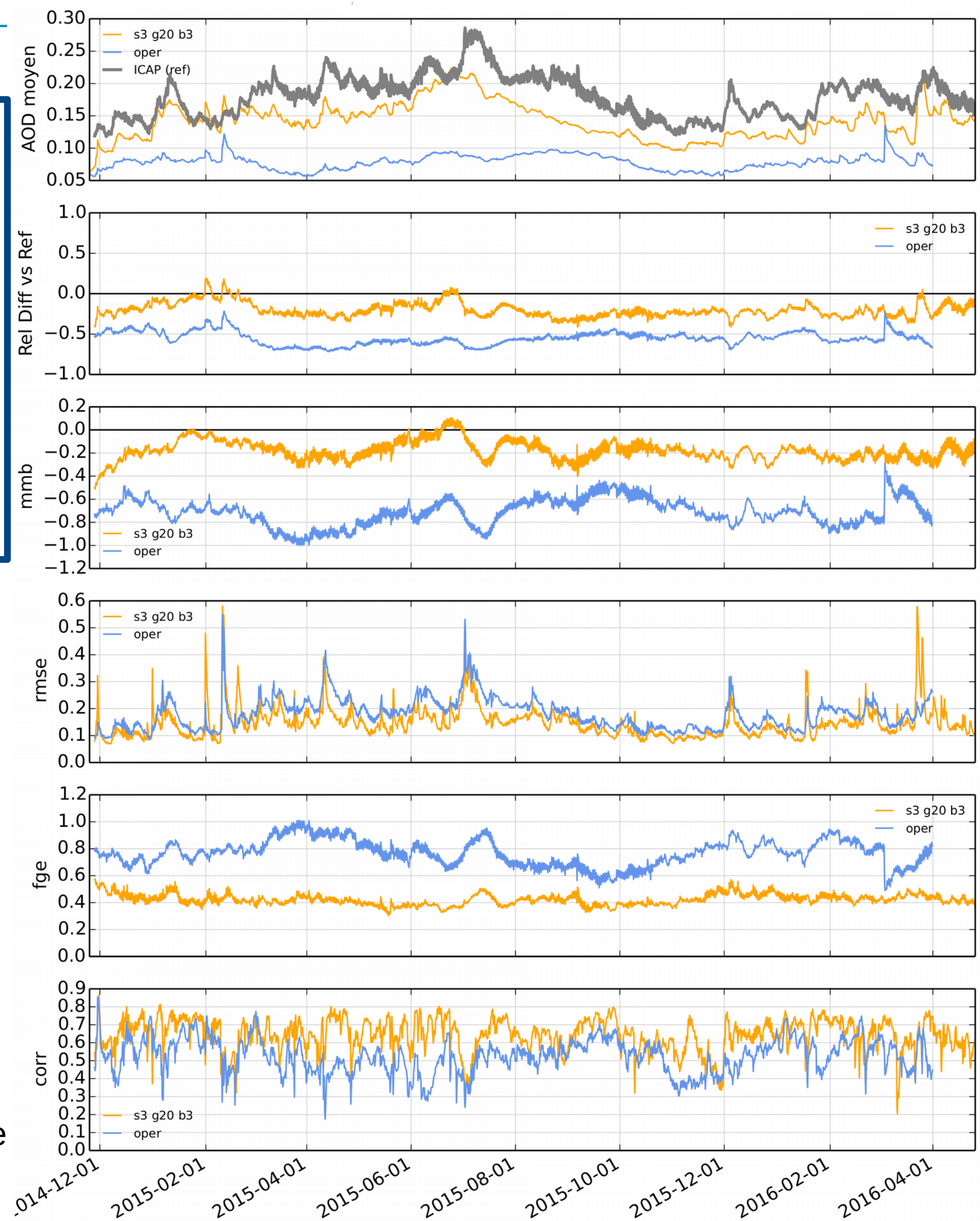


The latest operationnal version : Dust distribution

Validation against ICAP ensemble :

- Over the green zone on the figure
- The use of the Kok ditribution shows an improvement of the results when comparing to ICAP ensemble





Météo-France update

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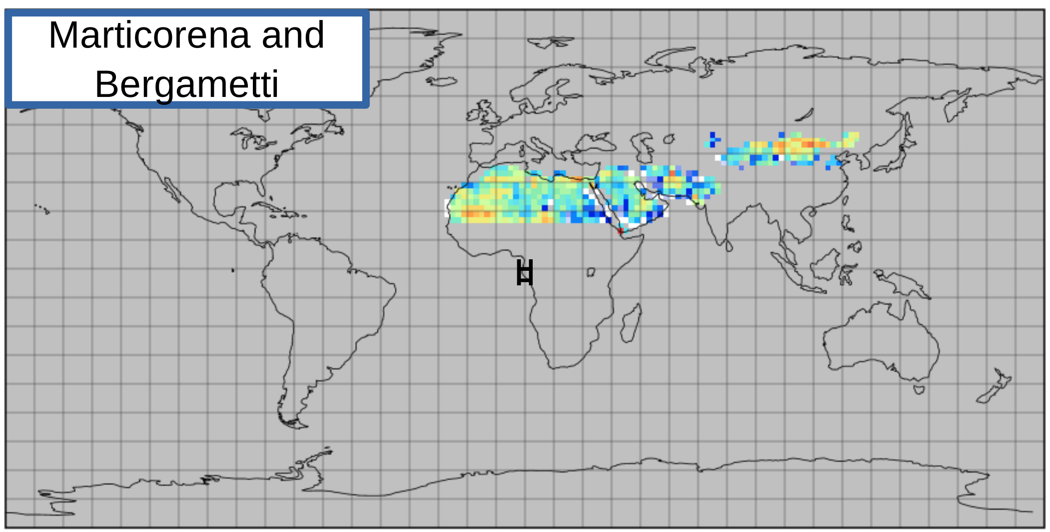
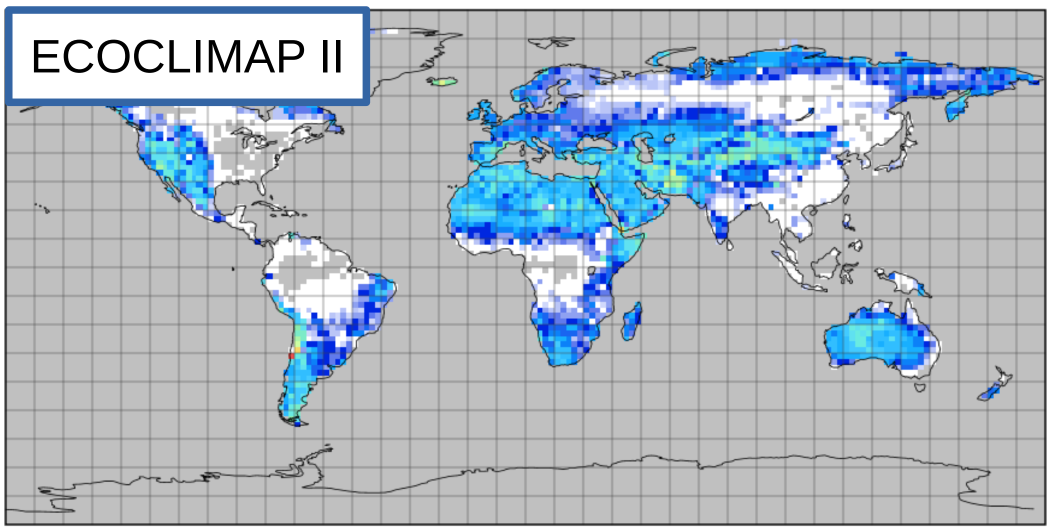
On going and future work

- ISORROPIA (V2.1) has been partially rewritten with F90 and modules, allowing an easy and trusty parallelisation.
  - MOCAGE is around 14 times faster with this new version.
  - This improvement will allow us to work on the equilibrium assumption
- Secondary Organic Aerosols will be implemented into MOCAGE. Two schemes will be tested :
  - A simple parameterization based on CO emissions (Spracklen et al., 2011) → anthopogenic
  - The SOAP module developped at CEREA (Couvidat et Sartelet, 2015) → anthropogenic and biogenic

On going and future work

- Use of the emission height into GFAS product instead of fixed emission heights
- New emission of desert dust using ECOCLIMAP II (Kaptue Tchuente at al., 2010) instead of Marticorena and Bergametti (1995) database.





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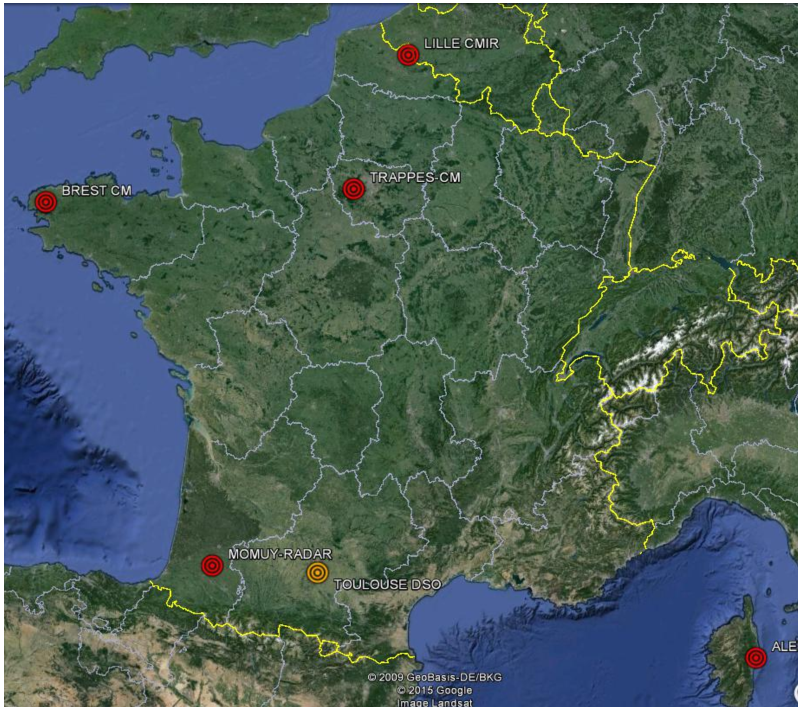
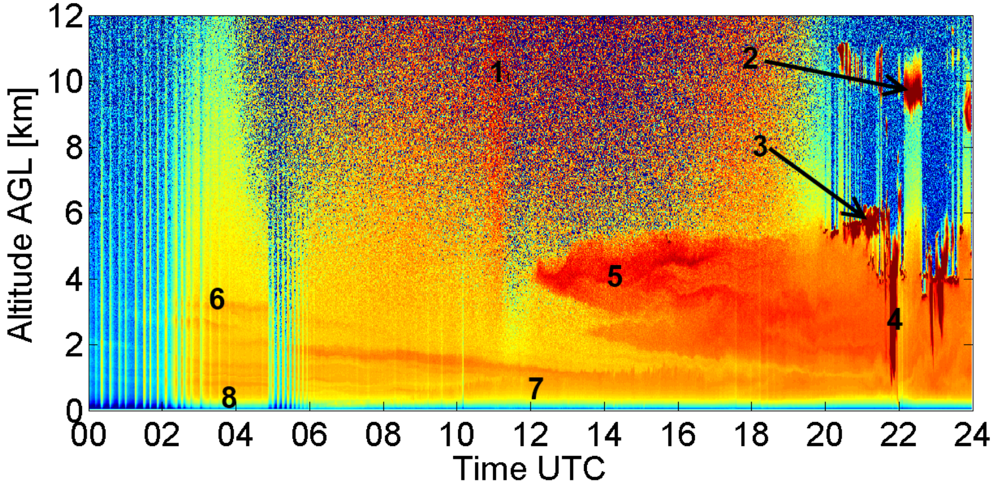
Data Assimilation update

- In 2016, Météo-France bought and installed 6 lidars (Mini-MPL) :
  - 5 fixed : Brest, Trappes, Lille, Aleria and Momuy
  - 1 mobile that stays in Toulouse when not used for an emergency or an exercise
- At the end of 2017, the data should be available on the EPROFILE network



$\log_{10}(Pr^2)$ [u.a.] (voie //) - MiniMPL (λ=532 nm)

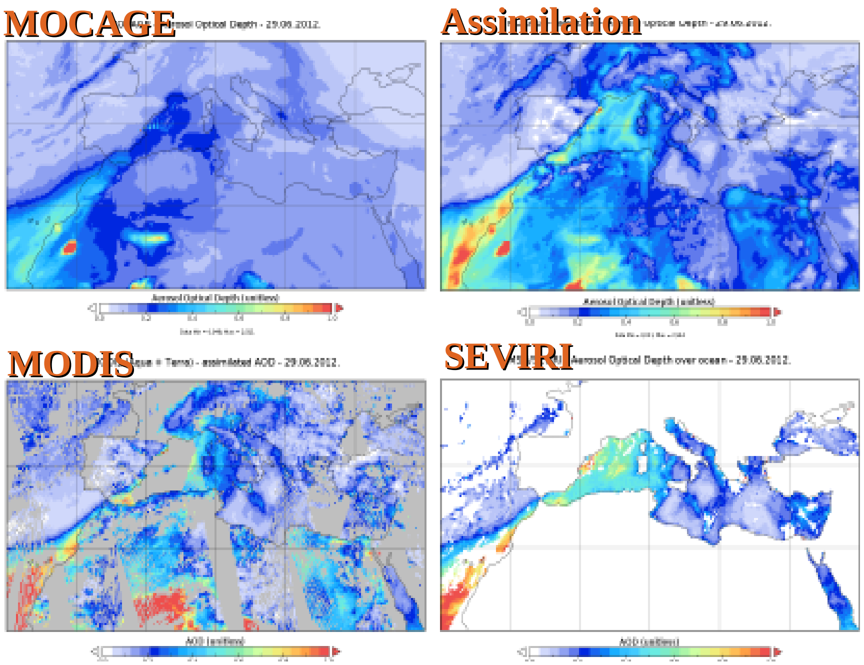
Toulouse, France - 2012-06-27



1 noise
2 high altitude clouds
3 medium altitude clouds
4 rain shower
5 Saharan desert dust
6 residual boundary layer
7 diurnal boundary layer
8 system overlap

Data Assimilation update

- The MOCAGE System is able to assimilate:
  - Aerosol Optical Depth (AOD) measurements
  - Lidar Signals : Backscatter Coefficient, Extinction Coefficient, Normalized Backscatter signal from ground, satellite, airplane (up or down)
  - Total concentration (in 3D) as a control variable



- Plan to assimilate the lidar network data and Callipso measurements
- Plan to assimilate AODs (eg MODIS) on a global scale
- Prepare assimilation of geostationnary satellite data (Seviri products, FCI)

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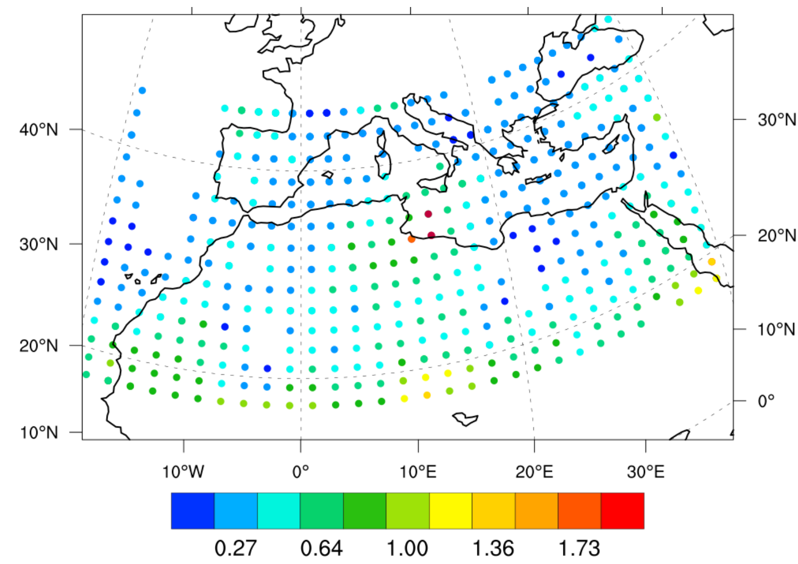
Work on inversion of aerosol emissions

- The need to better understand aerosols emissions because of significant uncertainties (on the global and even more on the regional/local scale)
- The inversion could be applied on different aerosols events (desert dust outbreaks, volcanic ash, biomass burning, etc)
- Improving of the modelled emissions and the model forecast
- Using of global, high resolution (spatial and temporal) observations to constrain emissions → Aerosol Optical Depth (AOD) is the most adapted choice
- Our system MOCAGE-Valentina uses the variational 4D-Var method :

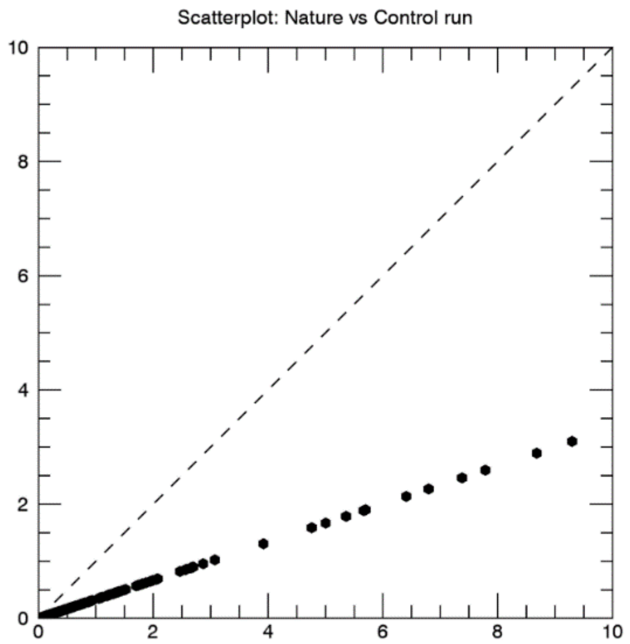
$$J(x) = \frac{1}{2}\|x_b - x\|^2_{B^{-1}} + \frac{1}{2}\|y - \mathcal{H}(\mathcal{M}(x))\|^2_{R^{-1}}$$

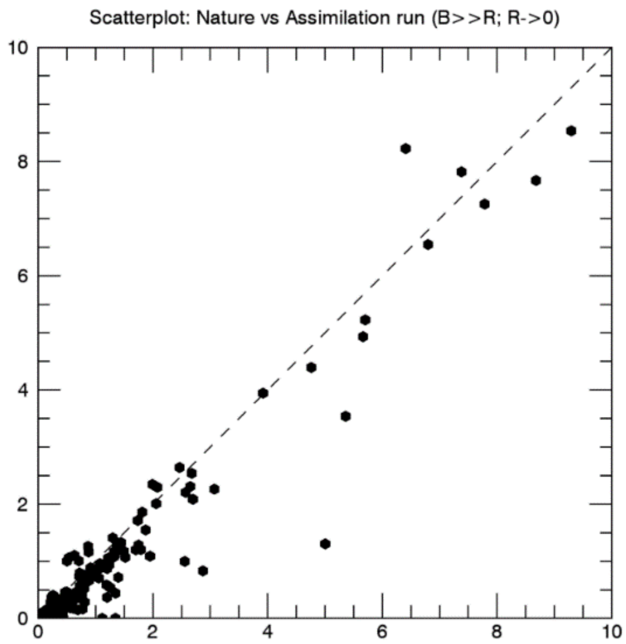
MODIS AOD Observations



Work on inversion of aerosol emissions

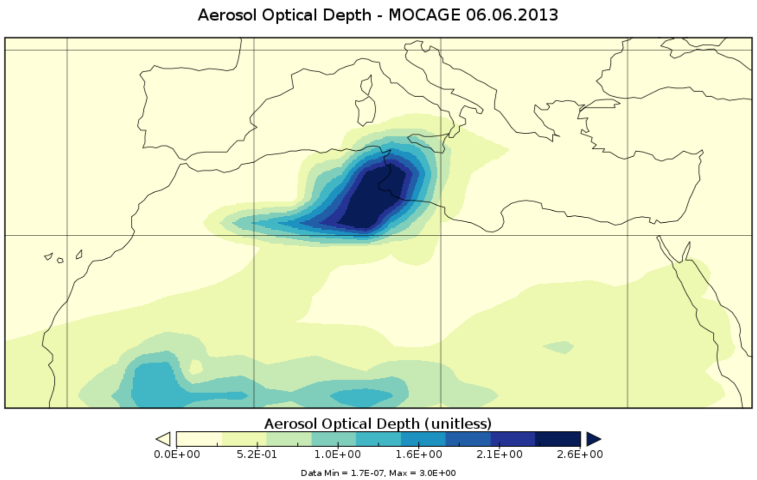
- Can AOD observations really improve modelled emissions this way?
- Inversion with synthetic AOD generated with perturbed emissions (« Truth ») to validate the method
  - Fixed perturbation: -70% of the modeled emissions

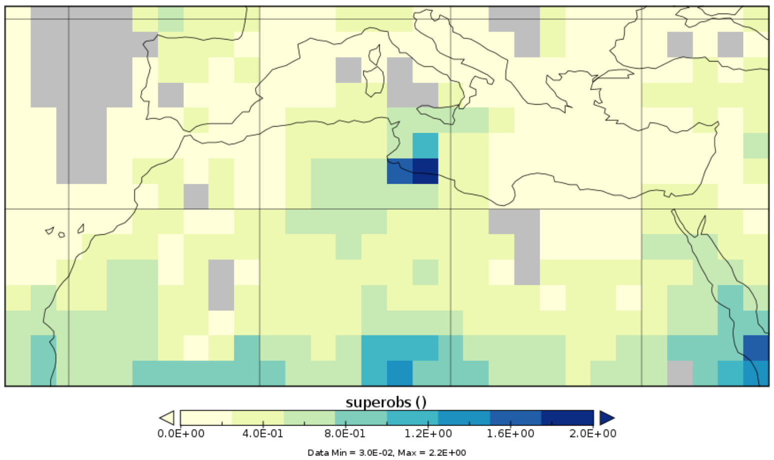




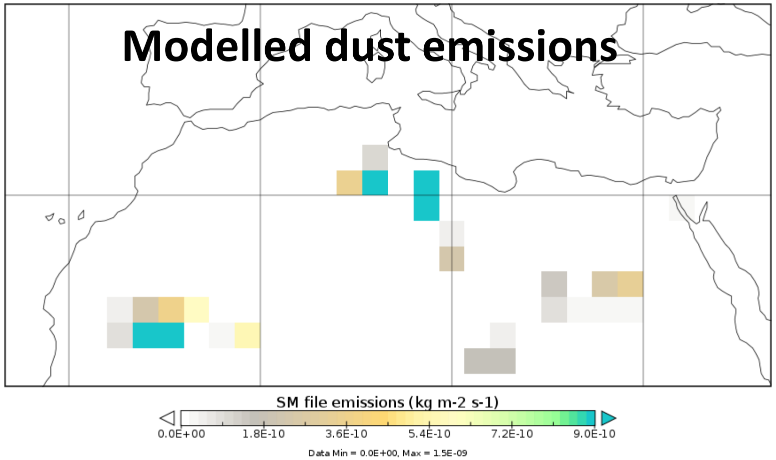
Work on inversion of aerosol emissions

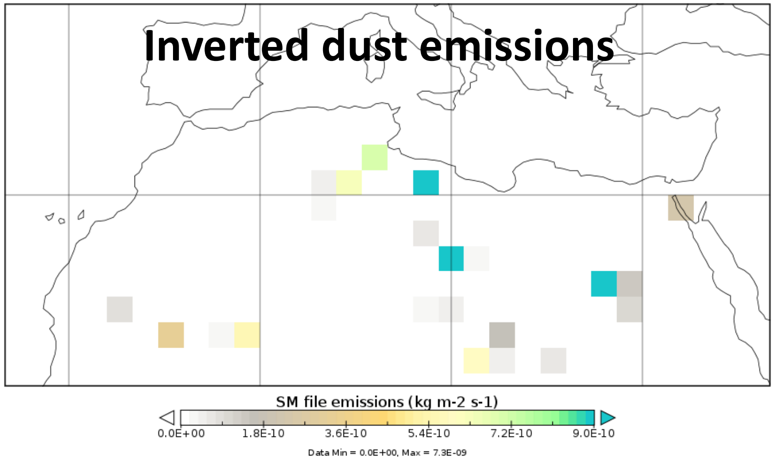
- An example of desert dust aerosols emission inversion in the system MOCAGE-Valentina (CNRM-CERFACS)
- From **modeled aerosols** and **MODIS observed AOD** …





- … the system is able to make a correction of the dust emission field





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Conclusion

- New version of the operationnal model :
  - Better resolution
  - New distribution for desert dust
  - Improved results
- On going work on desert dust emissions
- Work on Secondary Organic Aerosols
- Projects on aerosol data assimilation of AOD and lidar signal

Thank you for your attention !

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