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Validation of th chemistry-transport model MOCAGE using satellite observations

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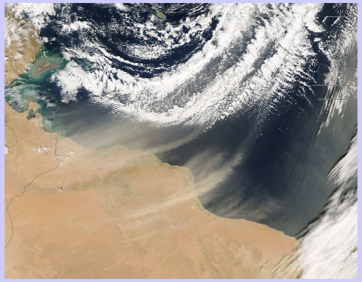
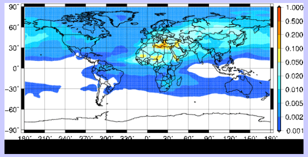
Introduction



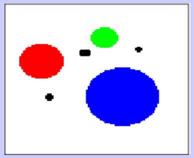
Due to their scattering and absorbing properties, aerosols affect solar and terrestrial radiations, modifying Earth's radiative balance. Therefore, they may have an important role in climate change. In order to quantify the impact of aerosols on this change, it is important to consider aerosols in climatic simulations. The Chemistry-Transport Model of Météo-France MOCAGE reproduces the composition of atmosphere (three-dimensional gazes and aerosols concentrations). A validation of MOCAGE results is necessary if we want to couple it with a climatic model.

Thanks to satellites, global data are at our disposal: satellites measure backscattered radiation and calculate the aerosol optical thickness. Considering that the particles are spherical and determining the complex refractive index according to aerosol type (black carbon, desert dust…) and wavelength [Torres, 2002], this parameter is linked to aerosol concentrations. Using a Mie code, aerosol optical thickness is calculated by this model. Comparing measured and computed data, we can globally validate MOCAGE results. This study shows that three-dimensional aerosols fields calculated by MOCAGE are reliable and can be used by a climatic model.

How to calculate AOT in MOCAGE



Monthly mean of Aerosol Optical Thickness (November 2004)



Aerosols are considered as an external mix

Aerosol optical thickness is the integral of the aerosol extinction coefficient over a path length through the atmosphere:

$$\tau = b_{ext}.z$$

where z is the atmosphere depth in meters. b_{ext} depends of aerosol size D_p, number concentration N and extinction coefficient Q_{ext}:

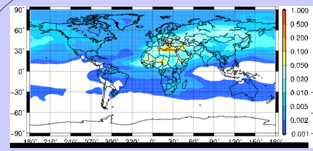
$$b_{ext} = \frac{\pi}{4} D_p^2 N Q_{ext}$$

We have chosen to calculate Qext using the Mie theory, aerosols are considered as spheres and refractive indices have been found in the literature.

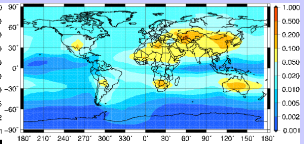
Considering that our aerosols are modelised as an external mix (as shown above), and that aerosols are separated in bins (in each bin, aerosols have the same size), we can assume that:

$$\boxed{\tau = \sum_{i \in bins} b_{ext}(i).z}$$

Comparisons with GACP results



Monthly mean of AOT calculated by MOCAGE (November 2004)



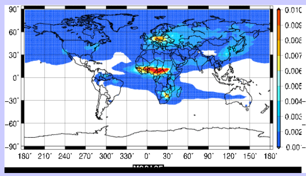
Monthly mean of AOT from GACP project (November)

These figures show the monthly mean of Aerosol Optical thickness calculated by MOCAGE for November 2004 (on the left) and the climatology of AOT for November 2004 from GACP Project. The Global Aerosol Climatology Project (GACP) was established in 1998 as part of the NASA Radiation Sciences Program and the Global Energy and Water Cycle Experiment (GEWEX). A major outcome of this collective research effort is a 23-year global aerosol climatology compiled from channel-1 and -2 AVHRR data and supplemented by data from other satellites, field observations, and chemical-transport modelling.

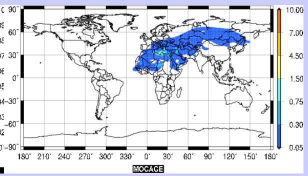
GACP results show the impact of desert dust over North Africa and Asia. In MOCAGE, only Saharan dust are taken into account. Consequently, it is normal to underestimate AOT over Asia. Over South America and South Africa, the high values of AOT are due to Black Carbon emitted by biomass burning. Values calculated by MOCAGE are too low. This underestimation can be linked with a bad refractive index used to calculate AOT or to an underestimation of Black Carbon emissions.

These comparisons have shown us that our model gives good results considering desert dust but underestimates the effect of Black Carbon on AOT.

MOCAGE results: Black carbon and Dersert dust



Monthly mean of Black carbon in g/m^2 (November 2004)

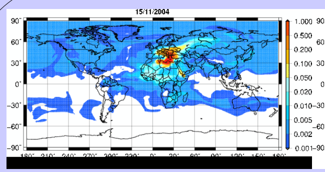


Monthly mean of Desert dust in g/m^2 (November 2004)

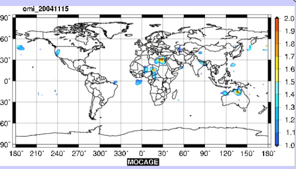
MOCAGE is the Chemistry-Transport Model of Météo-France and it has been used to represent the transport of aerosol during the year 2004. MOCAGE can represents not only gaseous species but also aerosol. It is a global model with an horizontal resolution of 2°x2° and 47 vertical levels (from the surface to 5hPa). Transport is ruled by a semi-lagrangian scheme for all species. A special treatment is realised for aerosols. Main sinks for these particles are considered: sedimentation, wet deposition and dry deposition.

Two aerosol species are considered in our model: Black caron and Desert dust. Considering Black carbon, we have used IPCC emissions which consider anthropogenic and biogenic emissions: sources linked with industrial activities and biomass burning. Considering desert dust, MOCAGE has been coupled with a module of dynamic source of dust emissions [Marticorena and Bergametti, 1995], [Marticorena et al., 1997]. Emissions are restricted to an area covering Sahara, the Arabian peninsula and the Middle East (36°N - 12°N; 17°W - 78°E).

Comparisons between MOCAGE and OMI



Aerosol Optical Thickness calculated by MOCAGE (15 November 2004)



Aerosol Index observed by OMI (15 November 2004)

These figures show the Aerosol Optical Thickness (AOT) calculated by MOCAGE (on the left) and the aerosol index observed by the Ozone Monitoring Instrument (OMI) on Aura satellite (on the right) for 15 November 2004. The aerosol index is a measure of how much the wavelength dependence of backscattered UV radiation from an atmosphere containing aerosols differs from that of a pure molecular atmosphere.

On MOCAGE results, AOT values around 1 covers an area aver East Mediterranean sea. These high values of AOT is linked with a strong lift of Saharan dust over Libya. This amount of aerosol coincides with high values of aerosol index observed by OMI at the same date.

This first comparison between MOCAGE and OMI observations shows that desert dust are well seen on the two maps. But, Black carbon provokes an increase of AOT aver the South of Africa which is not seen by OMI.

The study of AOT retrieved by OMI observations will allow us to improve the comparisons and the validation of our model results.

Conclusions and perspectives

The main objective of our study is to use satellite observations to validate the representation of aerosols concentrations by our model MOCAGE. Satellite observations allow us to compare results from the observations at a global scale, that is impossible with in-situ observations. But satellites don't directly measure aerosol concentrations but Aerosol Index or Aerosol Optical Thickness (AOT). So we have to study aerosol optical properties to deduct AOT from MOCAGE aerosols concentrations. Comparisons with OMI measurements and GACP results show us that we have to improve the impact of Black Carbon on AOT in MOCAGE results. But desert dusts shows a good behaviour in our model.

The utilisation of satellite data will allow us to validate our model and the impact of aerosols on optical thickness. Once the validation finished, we could use our aerosols fields in a climate model to better represent the direct and indirect aerosol effects on Earth radiative balance.

References

B. Marticorena, G. Bergametti, B. Aumont, Y. Callot, C. N'Doumé and M. Legrand (1997), Modelling the atmospheric dust cycle : 2-Simulations of Saharan dust sources, *J. Geophys. Res.*, 102, 4387-4404.

Peuch V.-H., M. Amodei, T. Barthet, M.-L. Cathala, B. Josse, M. Michou and P. Simon(1999), MOCAGE, Modèle de Chimie Atmosphérique à Grande Echelle, *Proceedings of Météo-France workshop on atmospheric modelling*, december 1999, 33-36.