Validation of the chemistry-transport model MOCAGE using satellite observations

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1 ABSTRACT

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 gases 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.

2 CONTEXT OF THE STUDY

Aerosols have a preponderant role in various domains: their optical properties impact on the evolution of the climate. That’s the reason why the knowledge of aerosol behaviour is really important. To study the evolution of aerosol concentration in the atmosphere, modelisation is one solution. Aerosol can be separated in five families:

- Carbonaceous aerosols (Black carbon and Organic carbon), the sources are anthropogenic and biogenic,
- Desert dust, the sources are linked with the wind and with the nature of the soil (arid or semi-arid area),
- Particles linked with the sulphur cycle,
- Secondary organic aerosols, they are not directly emitted but they are the results of organic aerosols with gaz,
- Marine salts.

Black carbon and desert dust are the more absorbing species in the troposphere. So we have concentrated on these two aerosols species.

3 PRESENTATION OF MOCAGE

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, particles fall because of their own weight. Sedimentation velocity is calculated from Stokes law.
- wet deposition [Langner and Rodhe, 1991], which considers impaction of droplets under the cloud, and coagulation in the cloud.
- dry deposition [Nho-Kim et al., 2004], parametrized as a function of particle size and density, surface properties and micro-meteorological conditions near the surface.

Considering desert dust, their emission fluxes mainly depend of wind velocity and characterization of the surface. So, modelisation of this specie is totally dependent of how the emissions are represented. In order to have precise data of emission fluxes, MOCAGE has been coupled with a module of dynamic source of dust emissions [Marticorena and Bergametti, 1995], [Marticorena et al., 1997]. This module take into account wind near the surface and humidity in superficial layers of soil. In this study, we have focused on Saharan dust
affecting the Western America. Consequently, only Saharan dust are considered. Emissions are restricted to an area covering Sahara, the Arabian peninsula and the Middle East (36°N - 12°N; 17°W - 78°E).

Considering Black carbon, we have used IPCC emissions which consider anthropogenic and biogenic emissions: sources linked with industrial activities and biomass burning.

MOCAGE doesn’t calculate directly aerosol optical thickness. So, particles have been considered as spherical and we have used a Mie code to calculated the aerosol optical thickness.

4 COMPARISONS WITH OMI DATA

Fig. 1 shows a comparison between aerosol index measured by OMI (Ozone Monitoring Instrument) onboard EOS-AURA satellite and AOT calculated by MOCAGE at the same date (2004/11/15 00H UTC). The AOT measured by OMI are not yet available so aerosol index is used. That’s why the scales are not the same between the two maps. Nevertheless, we can say that the strong source of desert dust observed by OMI over the Libyan territory is well represented by MOCAGE.

![OMI comparison](image)

Fig. 1: Comparisons between aerosol index observed by OMI (top) and the AOT calculated by MOCAGE (bottom), 2004/11/15 00H UTC.

Such a comparison is just an example of the validation made on MOCAGE results. Satellite observations allow us to verify that our data are coherent with the reality all over the globe. Comparisons are also made over monthly means to study our results over long period (one year for example).
5 CONCLUSIONS

Modelisation of aerosols concentrations are very useful to take account of their optical properties in the variations of the radiative balance of the atmosphere. Nevertheless, MOCAGE results have to be validated on a global scale. In-situ observations are very useful but their geographical spread is not sufficient. That’s the reason why comparisons with satellite data are crucial. The first results of the validation of MOCAGE by OMI data are an example of the work we have to do to verify that our representation of aerosols is good.

This illustration underlines that modelisation and satellite observations are complementary if we want to improve the knowledge of the impact of aerosols on the climate change.

6 REFERENCES


