Enhance of radiative forcing under mixed aerosol conditions

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Despite of atmospheric aerosols have a crucial impact on climate the level of scientific knowledge of the radiative forcing of these atmospheric components (direct, semi-direct and indirect effects) has still large uncertainties (IPCC, 2007). The effects of these atmospheric constituents depend largely on its composition. Thus, on global scale, the direct effect of sulphates is estimated to be –0.4±0.2 Wm^{-2}, organic carbon, –0.05±0.05 Wm^{-2}, soot, +0.20±0.15 Wm^{-2}, while aerosol radiative forcing of natural origin such as biomass burning and mineral dust are +0.03±0.12 Wm^{-2} and –0.1±0.2 Wm^{-2} respectively. As it can be observed uncertainties are still high, so it is necessary to increase the knowledge of their radiative properties and to quantify their effects on radiative balance.

Among the different types of aerosols in the atmosphere, desert mineral dust plays a fundamental role in the energy balance of the Earth-atmosphere system due to its high emission rate, between 1000 and 2150 $Tg \cdot yr^{-1}$ (Satheesh and Moorthy, 2005; IPCC, 2007), and the broad area over which it extends, causing the "global dust belt" (~5ºN-40ºN) (Prospero *et al.*, 2002). In this regard, recent studies have focused on determining the radiative forcing of pure mineral dust (García, 2009), but a few have evaluated the effect when it is mixed with other species such as biomass burning or urban-industrial aerosols. These cases are especially important because the radiative properties of this atmospheric constituent change. For example, the mixture with particles from biomass burning increases the absorption of the mineral dust, resulting in greater impact of this component in the atmospheric radiative balance of the Earth-atmosphere system (Arimoto *et al.*, 2006). In this regard, for example, Derimian *et al.* (2008) found that in some cases the mixture of mineral dust and biomass burning aerosols can reduce the solar radiation reaching the surface almost twice more efficiently than dust only.

In this study we have estimated the direct radiative forcing (ΔF) of these aerosols, through modelling solar fluxes using the properties derived by the AERONET network. It has been observed that, in oceanic and vegetative covers (surface albedo, SA, <0.30), the aerosol effect at the top of atmosphere (TOA) is always cooling Earth-atmosphere system, regardless of the aerosol nature. On average, ΔF ranges between 24±14 Wm^{-2} (aerosol optical depth, AOD, at 0.55 μm, 0.37±0.24) for pure urban-industrial aerosols, registered in East Asia region, and 34±18 Wm^{-2} (AOD=0.83±0.42) for the mixture of the mineral dust and biomass burning particles, observed in Central Africa region. In the intermediate range of SA (0.30-0.50) the TOA radiative effect depends on the aerosol absorption properties. Thus, aerosols with single scattering albedo at 0.44 μm lower than ~0.85 lead to a warming of the system, with ΔF of –10±12 Wm^{-2} for the mixture of mineral dust and biomass burning and –13±10 Wm^{-2} for pure mineral dust. At the bottom of atmosphere (BOA) the maximum ΔF values are associated to the higher AOD levels obtained for the mixture of mineral dust and biomass burning aerosols (–130±44 Wm^{-2} with AOD=0.83±0.42 for SA<0.30). In both mixed conditions, the mixtures are more efficient (ΔF per unit AOD), in general, than the pure aerosols both at the BOA and TOA.

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Arimoto, R., Y.J. Kim, Y.P. Kim, P.K. Quinn, T.S. Bates, T.L. Anderson, S. Gong, I. Uno, M. Chin, B.J. Huebert, A.D. Clarke, Y. Shinozuka, R.J. Weber, J.R. Anderson, S.A. Guazzotti, R.C. Sullivan, D.A. Sodeman, K.A. Prather and I.N. Sokolik (2006), *Global and Planetary Change*, 52, 23–56.

Derimian, Y., J.-F. Léon, O. Dubovik, I. Chiapello, D. Tanré, A. Sinyuk, F. Auriol, T. Podvin, G. Brogniez and B.N. Holben (2008), *J. Geophys. Res.*, 113, D00C09.

García, O.E. (2009), *Estudio de las propiedades radiativas de los aerosoles atmosféricos mediante técnicas de teledetección. Forzamiento Radiativo*, Doctoral Thesis, University of La Laguna, Spain.

Intergovernmental Panel on Climate Change (IPCC) (2007), Geneva, Switzerland.

Prospero, J.M., P. Ginoux, O. Torres, S.E. Nicholson and T.E. Gill (2002), *Rev. Geophys.*, 40.

Satheesh, S.K., and K.K. Moorthy (2005), *Atmos. Environ.*, 39, 2089-2110.