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Three-dimensional pathways of Saharan dust influenced by African easterly waves and cold air intrusions

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The Sahara is the world's largest source of mineral dust in the atmosphere, which is a key player of the Earth system. Desert dust layers impact the radiative budget, atmospheric stability, cloud properties, chemical balances and air quality depending on the altitude at which they are transported. Over the Sahara, the three-dimensional (3D) distribution of dust is closely linked to dust uplifting mechanisms and its redistribution in the vertical, driven by the main atmospheric dynamical actors in the region. A better understanding of these mechanisms is very important for assessing the 3D budget of Saharan dust, which is currently highly uncertain. However, observations of the 3D distribution of desert dust are highly scarce and particularly over the Sahara where they exclusively rely on satellite remote sensing. Indeed, the two-dimensional (2D) distribution of dust is standardly observed: either its horizontal distribution in terms of aerosol optical depth from e.g. MODIS, OMI, IASI measurements and also in this last case mean dust layer altitudes or latitudinal transects of vertical profiles of dust from the CALIOP lidar.
In order to overcome this limitation, we have developed a so-called AEROIASI new satellite approach for retrieving the 3D distribution of desert dust from thermal infrared spectra measured by IASI. This method uses full radiative transfer calculations from the KOPRA model and an auto adaptive TikhonovPhilipstype regularization for deriving vertical profiles of dust extinction coefficient at 10 μm for most cloudfree IASI pixels, both over land (including bright desert surfaces) and ocean. The dust vertical distribution derived from AEROIASI agrees remarkably well with along track transects of CALIOP spaceborne lidar vertical profiles as well as with aerosol optical depth derived from AERONET sun photometer measurements over West Africa.
We use AEROIASI to investigate the role of the main dynamic actors in the vertical redistribution of dust over the Sahara during June 2011. We find a major role of the African easterly waves and cold air intrusions as those from the West African monsoon, affecting directly or indirectly the vertical distribution and propagation of major dust plumes. Cold pools generated by mesoscale convective systems are as well a major mechanism for uplifting dust over the Sahel and Southern Sahara. In the present study, we will present the full 3D distribution of dust observed by AEROIASI and the link with these major dynamic actors of the region.