Qilong Min
Atmospheric Sciences Research Center (ASRC)

Sponsor: National Science Foundation (NSF)
Dates: December 15, 2011 – November 30, 2012
Amount: $134,224

Impact of Sahara Dust Layers on Convective Cloud Development and Precipitation over the Tropical Eastern Atlantic Ocean

Intellectual Merit

The indirect effect currently produces the greatest uncertainty in climate predictions among all known climate forcing mechanisms. Although tropic deep convective cloud systems have great impacts on large scale circulation, few studies investigate the aerosol impacts on deep convective cloud systems. To improve our understanding of the aerosol indirect effect, and to better quantify their role in regional and global climate changes requires innovative approaches. The overarching goal of this proposal is to utilize comprehensive observation analysis and cloud resolving simulations using Weather Research and Forecast (WRF) model coupled with a spectral bin microphysics (SBM) scheme to assess how mineral dust affects the development of tropical deep convective cloud systems, and to understand mechanisms responsible for the observed changes of dust indirect effect. The combination of our integrated satellite and in-situ data from multiple instruments/platforms and our innovative analysis techniques will greatly benefit research community to address key questions of aerosol-cloud interaction and to develop and validate the realistic representation of aerosol-cloud-precipitation interactions in advanced models on regional and global climate model-grid scales.

Broader Impact

As one of the major sources of aerosols, Saharan dust can be transported across the tropical North Atlantic and into the Caribbean region as well as into Europe. Dust affects cloud properties by the semi-direct effect through changing the radiative heating, and by the indirect effect through acting as cloud condensation nuclei (CCN) and ice nuclei (IN). The heterogeneous nucleation imposed by dust occurs at warmer temperature in a deep convective cloud could potentially change the vertical profile of latent heat, and the vertical distribution of supercooled water. These changes in the tropical deep convective systems will have substantial impacts on large scale circulation as well. Nevertheless, the aerosol-cloud interaction is the least understood aspect in the climate system, of which our understanding of the impact of aerosols on mixed-phase and ice clouds by acting as ice nuclei (IN) is the poorest. It is vital to have comprehensive observations and model simulation to assess and understand the physical processes of the indirect and semi-direct effects of dust aerosols on clouds. The outcomes of this proposed work will complement our understanding of aerosol-cloud-climate interactions and benefit the climate community to estimate of the contribution of dust to climate change. Through student training and education outreach, students from various levels will gain some understanding on current climate issues.

Specifically, two major outcomes are expected from this proposed effort, i.e., (1) the mechanisms responsible for the observed changes in convective core, stratiform/anvil, and precipitation from the dust-free sector to the dust sector, and (2) an estimation of the changes in cloud properties and precipitation imposed by dusts on the deep convective clouds.