Trans-Atlantic Dust Deposition (TADD)

A Proposed Model Analysis under the AEROCOM Phase III Experiments

Point of Contact:

Hongbin Yu, NASA Goddard Space Flight Center

Hongbin.Yu@nasa.gov, 301-614-6209

1. Objectives

- To assess model simulations of trans-Atlantic dust transport and deposition;
- To identify major model deficiencies in simulating the dust transport and deposition.

2. Background

Airborne deposition of mineral dust and associated nutrients could fertilize ocean ecosystems and influence ocean biogeochemical cycles and climate. Model simulations of dust deposition depend strongly on the highly parameterized representations of a suite of dust processes with little constraints. In recent years, several intensive field campaigns have acquired new datasets of microphysical and optical properties of African dust. Satellite remote sensing observations have been applied to characterize the three-dimensional distributions of dust and estimate the dust deposition and loss frequency along the trans-Atlantic transit on a decadal time scale. It is imperative to integrate these new in situ and remote sensing datasets with long-term data from ground-based networks in the region to systematically assess model simulations of dust deposition and identify major deficiencies of dust models.

3. Proposed Model Analysis

This proposed analysis will not require specific model experiments but use the monthly output from the existing AeroCom model experiments, such as Historic, ACRI, or UTLS, that includes the following size-segregated quantities of dust (a) concentrations (3-D), extinction profiles (3-D, 0.55 and 10 μm), (b) optical depth (2-D, 0.55 and 10 μm), and (c) dry/wet depositions (2-D). In addition, total precipitation from each model is also needed. The dust size should at least include the PM1, PM2.5, PM10, and total.

4. Observations

The output from the AeroCom models will be evaluated/compared with the remote sensing data and derived products and in-situ/ground-based measurements described below.

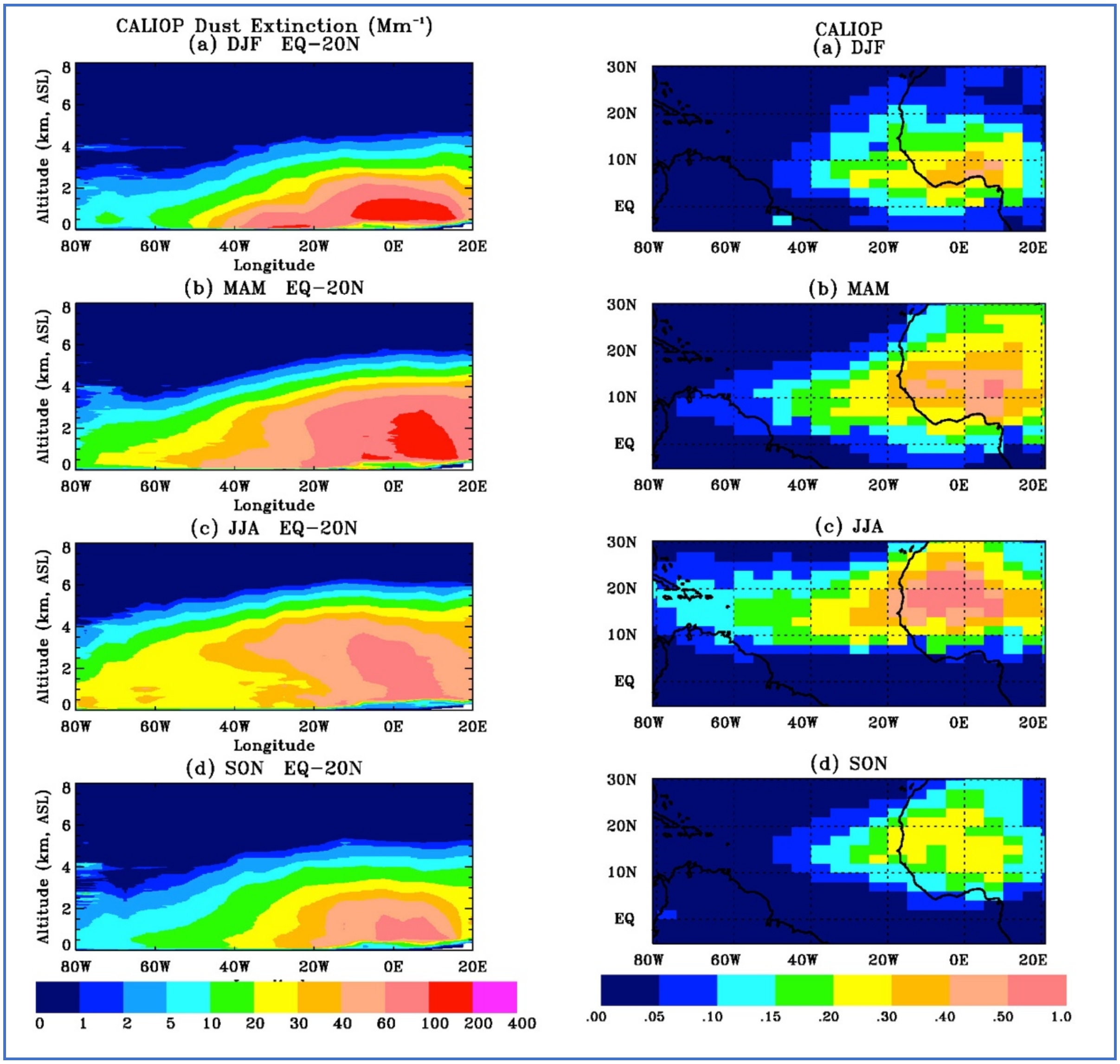
4.1. Remote-sensing based dust optical depth (DOD)

Dust particles are generally large in size and have irregular shape, yielding a low fine-mode fraction or FMF and Angstrom exponent, a high non-spherical fraction and particulate depolarization ratio or PDR, and predominant signal at the thermal infrared channels. As listed in a table below, several methods have been developed to derive dust optical depth (DOD) from remote sensing measurements of AOD and particle properties.

Sensor	**Technique**	**Observables**	**Method of Deriving Dust**
CALIOP CATS	polarization lidar	Vert. profiles & particle shape (PDR)	PDR-based *(Yu et al., 2015)*
MODIS	multiple wavelengths	AOD & particle size (FMF, Angstrom Exp.)	<u>Ocean:</u> based on Dark Target FMF *(Yu et al., 2009)* <u>Land:</u> based on Deep Blue retrievals *(Ginoux et al., 2012)*
MISR	multi-angle, multi-wavelengths	AOD & particle shape	Non-spherical AOD
IASI	thermal IR	AOD at 10 μm & height info	DOD = AOD at 10 μm
Sun photometer (AERONET)	Multiple wavelengths	Spectral AOD, Angstrom exponent, fine and coarse AOD	AOD @1020 nm Coarse-mode AOD

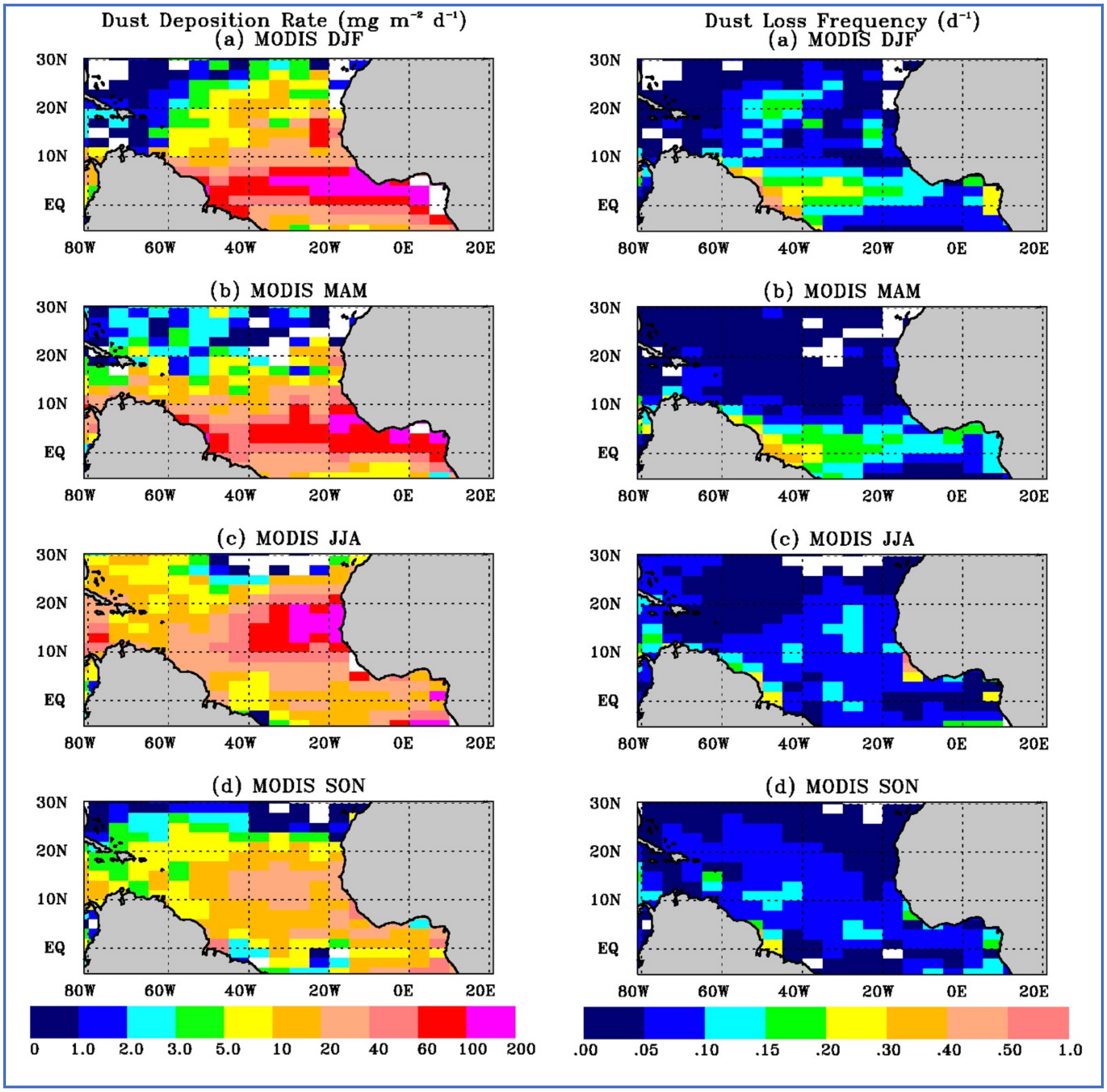
4.2. Dust vertical profiles

The CALIOP/CALIPSO (since June 2006) and CATS/ISS (2015-2017) provide measurements of aerosol backscatter/extinction and PDR with complementary spatial and temporal coverage. While CALIOP measures aerosol at 532 nm and 1064 nm, CATS measures only at 1064 nm. IASI/MetOP (since July 2007) also provides the dust layer height. The figure below shows the 2007-2016 climatology of dust extinction vertical distribution (left, averaged over 0-20N latitudes) and DOD distribution (right) from West Africa to Caribbean Basin.



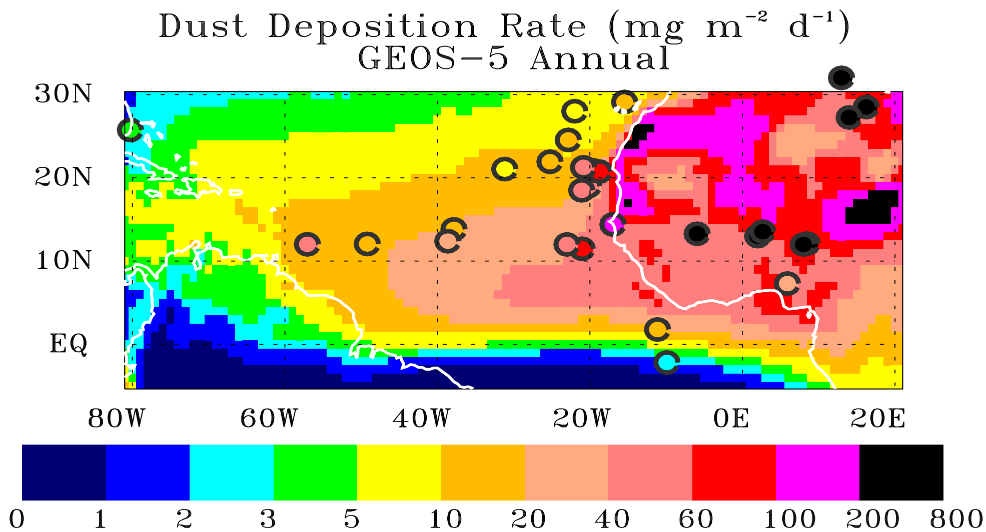
4.3. Satellite-based dust deposition and loss frequency

The dust deposition and loss frequency (a ratio of deposition rate to dust loading, measuring the efficiency of dust removal processes) have been derived from the CALIOP, MODIS, MISR, and IASI observations spanning over 2007-2016, as described in Yu et al. [2019, to be submitted]. The figure below shows an example of dust deposition rate (left) and loss frequency (right) derived from the MODIS DOD observations complemented by vertical profile of dust extinction from the CALIOP.



4.4. Surface-based climatology of dust deposition

This is an update to a compilation by *Abani et al. (2014)* with an inclusion of several recent measurements published in literature. A map below depicts locations and the yearly dust deposition flux of 33 sites overlying on the GEOS-5 simulation, which could evolve with additional observations during the analysis.



4.5. Aircraft measurements of dust microphysical and optical properties

Dust microphysical and optical properties, such as particle size distribution and mass extinction efficiency (MEE), have been acquired in recent years through several field campaigns in the region, including the FENNEC, AER-D, SALTRACE *[Ryder et al., 2013, 2018; Weinzierl et al., 2017]*. They will be used to assess model simulations of dust size and MEE, and facilitate the interpretation of model simulations of DOD and dust deposition.

4.6. Surface dust concentrations

In the region, there exist several long-term observations of dust/PM_{10} concentrations, including Barbados, Miami, Cayenne, Canary Islands, and four stations (M'Bour, Bambey, Cinzana, and Banizoumbou along the Sahelian dust transect in the frame of the AMMA program).

4.7. GPCP rainfall

GPCP rainfall will be used to assess model performance of simulating precipitation field and its effects on the dust deposition and loss frequency.