The Global Dust Aerosol Modeling System at the National Centers for Environmental Prediction

Dongchul Kim[1], Ho-Chun Huang[1] , You-Hua Tang[1], Sarah Lu[1], Pius Lee[1,7], Marina Tsidulko[1], Jeff McQueen[2], Mian Chin[3], Thomas Diehl[3], Arlindo da Silva[3], Paula Davison[4], Ivanka Stajner[5], and William R. Stockwell[6]

Introduction

- Dust aerosols are naturally emitted and affect the climate and degrade air quality. Long-range transport from the Saharan desert has been found to affect air quality forecasts over the US.
- Recently, NASA GOCART aerosol model was coupled in an off-line manner with the NOAA/NCEP Global Forecasting Model System (GFS-GOCART) to produce preliminary forecasts of dust aerosols. Simulations are made and analyzed for a Saharan dust event in July 2009.
- Observations of Aerosol Optical Depth (AOD) from AERONET, MODIS, MODIS deep blue retrievals and CALIPSO total attenuated backscatter are used to evaluate dust forecasts during this episode.

Global Forecast System (GFS)

- **Resolution**
  - T382 horizontal resolution (~35 km)
  - Hybrid σ-p coordinate
  - 64 layers from surface to ~ 0.2 mb
- **Simplified Arakawa-Schubert Convective Scheme**
- **Initial conditions** (both atmos, and land states)
  - NCEP Global Data Assimilation System (GDAS)

GOCART Model Component

- **1x1 degree horizontal resolution**
- **Advection:** semi-Lagrangian (Lin and Rood 1996)
- **Boundary layer turbulent mixing:** 2nd order closure scheme (Helfand and Labraga1988)
- **Dry deposition:** Resistance method (Wesely 1989; Walcek et al. 1986)
- **Wet deposition:** Rainout (Giorgi and Chameides 1986), washout (Dana and Hale 1976), convective scavenging with moist convection (Allen et al. 1996), and evaporation below the cloud
- **Dust in 5 bins by radius (µm)**
  [0.1 – 1.0],[1.0 – 1.8],[1.8 – 3.0],[3.0 – 6.0],[6.0 – 10.0]

Dust Source Flux (P. Ginoux et al., 2001)

$$Source\,Flux_p = \begin{cases} S\,s_p\,u_{10}^2\,(u_{10} - u_t) & u_{10} > u_t \\ 0 & otherwise \end{cases}$$

S : Source function s_p: fraction of clay and silt size

u_{10}: wind speed at 10 m u_t: threshold wind velocity

$$u_t = \begin{cases} A\sqrt{\dfrac{\rho_p - \rho_a}{\rho_a} g\Phi_p}\,(1.2 + 0.2\log_{10} w_t) & if\ w_t < 0.2 \\ \infty & otherwise \end{cases} ,$$

A : constant=6.5 w_t: surface wetness

Φ_p : particle diameter ρ_p, ρ_a : particle and air density

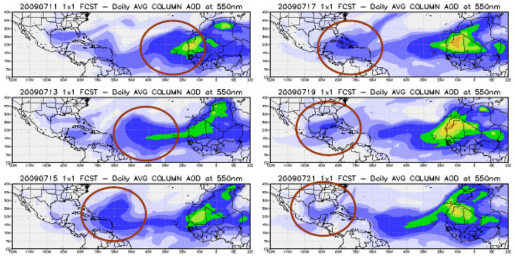
Acknowledgement: NASA MODIS, AERONET, OMI, and CALIPSO TEAM

Affiliations

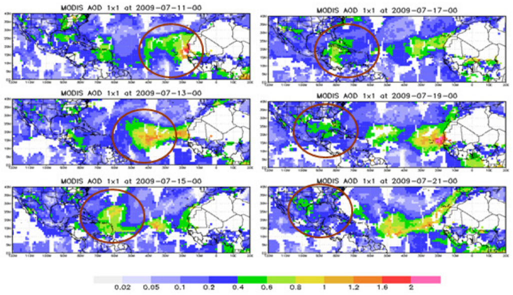
[1] Scientific Applications International Corporation, Camp Springs, MD
[2] NOAA National Centers for Environmental Prediction, Camp Springs, MD
[3] NASA Goddard Space Flight Center, Greenbelt, MD
[4] Office of Science and Technology, National Weather Service, Silver Spring, MD
[5] Noblis, Inc. Falls Church, VA
[6] Howard University, Washington DC
[7] NOAA ARL, Silver Spring, MD

Comparisons between GFS-GOCART derived dust AOD and MODIS total AOD for July, 2009

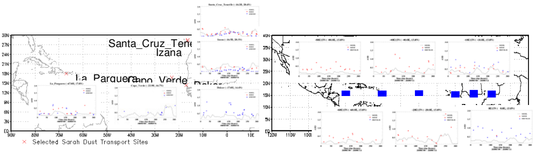
GFS-GOCART AOD



MODIS AOD



Time Series of Dust AOD over the Plume Path



Discussion and Summary

- GFS-GOCART successfully simulates the spatial extent and evolution of the dust plume pattern even though modeled AOD is about 50% lower than MODIS AOD. Substantial differences are seen among AOD values from different sensors.
- Over the source regions spatial patterns of enhanced AOD in GFS-GOCART compare well with AOD retrievals from MODIS Deep-Blue and OMI. However, substantial discrepancies in AOD magnitude suggest that emission and scavenging processes may need to be further investigated.
- Vertical distributions of GFS-GOCART aerosol extinction coefficients agree well with the vertical distributions of the CALIPSO retrieved total attenuated backscatter.

Modeled and Observed Dust AOD over Land

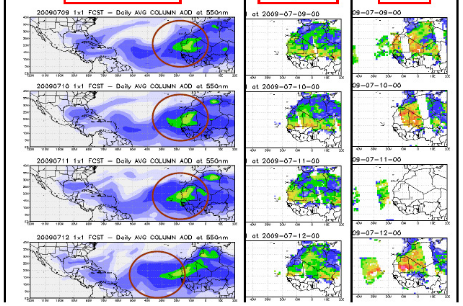
GFS-GOCART | Deep Blue | OMI

July 9, 2009

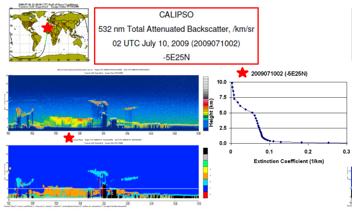
July 10, 2009

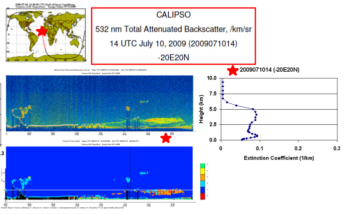
July 11, 2009

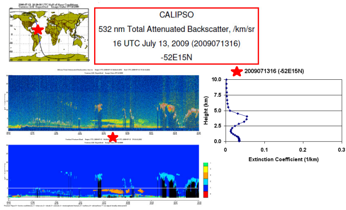
July 12, 2009

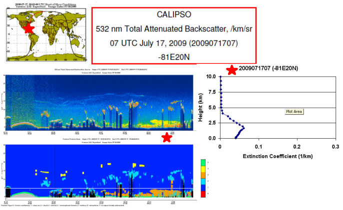


Vertical Profiles of the Modeled and CALIPSO Observed Dust plume


CALIPSO
532 nm Total Attenuated Backscatter, /km/sr
02 UTC July 10, 2009 (2009071002)
-5E25N


CALIPSO
532 nm Total Attenuated Backscatter, /km/sr
14 UTC July 10, 2009 (2009071014)
-20E20N


CALIPSO
532 nm Total Attenuated Backscatter, /km/sr
16 UTC July 13, 2009 (2009071316)
-52E15N


CALIPSO
532 nm Total Attenuated Backscatter, /km/sr
07 UTC July 17, 2009 (2009071707)
-81E20N