Nearly a Decade of CALIPSO Observations of Asian and Saharan Dust Properties near Source and Transport Regions


NASA Langley Research Center
NASA Goddard Space Flight Center

AGU 2015 Fall Meeting, San Francisco, CA

A52F-08
12/18/2015
Dust Studies: Motivation

Observations suggest a doubling of dust over much of the globe during the 20th century (Mahowald et al., 2010).

Contributes to the aerosol direct and indirect radiative forcing.

Affects African Easterly Waves and the development of tropical storms.

Dust-radiation interactions are known to enhance convective strength.

Dust is a source of nutrients for both phytoplankton (Fe) and the Amazon basin (P) [Yu et al. 2015].

Dust emission rates have increased in North Africa since 1950’s (Mukhopadhyay and Kreycik, 2008).

CALIPSO’s measurements of dust properties are robust and the length of the record is significant both seasonally and inter-annually.

Measurements useful for assimilation (into) and validation of dust transport models.
Outline

CALIPSO’s automated detection of clouds and aerosols

Product description

Climatologies of dust distributions (2006-2013)

Optical characteristics of the dust layers in source and transport regions

Above cloud retrievals of dust properties

CALIPSO is in its 10th year of a 3 year mission ~ 3.3 Lifetimes!!

April 28th, 2006 ~ 0200 PST
CALIPSO lidar reveals the 3-D characteristics of dust transport across Atlantic Ocean.

We used 2007-2013 CALIPSO data to estimate dust import into and export from Amazon Basin.

27.7 million tons of dust is deposited in the Amazon rainforest annually.

The Saharan dust feeds the Amazon rainforest with an estimated 22,000 tons of phosphorus, replenishing the leak of this plant-essential nutrient by rains and flooding.

Yu et al., GRL 2015
Mean Annual Nighttime Dust AOD (Jun –May)
Mean Seasonal Dust Nighttime Dust AOD (2006-2015)
Mean Seasonal Dust Daytime Dust AOD (2006-2015)
Mean Monthly Nighttime Dust AOD (2006-2015)
Seasonal Diurnal AOD Differences

MAM

JJA

SON

DJF

AOD(day) - AOD(night)

-0.5 -0.4 -0.3 -0.2 -0.1 0.0 0.1 0.2 0.3 0.4 0.5
Opaque Water Cloud Constrained Retrievals (Hu et al. 2007)

\[
\tau_{aerosol} = -\frac{1}{2} \ln \left( \frac{\gamma'_{WC,SS}}{\gamma'_{WC,SS,NA}} \right)
\]

\( \gamma'_{WC,SS} = \left( \frac{1 - \delta_I}{1 + \delta_I} \right)^2 \)

\( \delta_I = \) layer integrated depolarization ratio

\[
S_{WC} \approx 18.9 \text{ sr} \pm 0.25 \text{ sr} \quad \text{(Hu et al. 2006)}
\]

\( Liu \ et \ al. \ 2014 \ ACP)\)
Mean Seasonal Nighttime Polluted Dust AOD (2006-2015)
Mean Monthly Nighttime Polluted Dust AOD (2006-2015)
Study Domains: Source and Transport Regions

- **Source Region**: Lat 0° to 40°, Lon -20° to 20°
- **Transport Region**: Lat 0° to 40°, Lon -80° to -20°
Seasonal Fraction Saharan Dust Aerosol Layers (2007-2013)

Fraction = \frac{\text{Dust} + \text{Polluted Dust}}{\text{All Aerosol Layers}}
MERRA Winds and Dust AODs

Seasonal mean 700 hPa wind vectors for 2006-2013 from MERRA

MERRA monthly analysis data were provided by the Giovanni online data system, developed and maintained by the NASA GES DISC
MERRA monthly analysis data were provided by the Giovanni online data system, developed and maintained by the NASA GES DISC.

Seasonal mean 900 hPa wind vectors for 2006-2013 from MERRA
Changes in pure dust particle shape

The dust volume depolarization ratio is fairly uniform throughout the source and transport regions. VDR is varies between 0.14 to 0.11 from the source to the transport regions.
Changes in mixed dust particle shape

Off the coast the VDR decreases linearly with distance away from the source.

VDR is varies between 0.12 to 0.06 from the source to the transport regions.

2006-2013
The monthly maximum is in June 2010 (~0.62) and the minima in Dec 2009 and Nov 2011 (~0.066)