Sand and Dust Storm Research
General Overview

WMO Sand and Dust Storm Warning and Assessment System (SDS-WAS)

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Global process
based on local origins

Driven by and
interacting with the atmosphere

Afghanistan dry lake dust sources
MODIS 2, June 2001

Source: S. Kinne MPI, Hamburg, Germany
Intense Dust Storm Episode
February 18, 2011
DUST IS OFTEN PRODUCED BY COLD POOLS ASSOCIATED WITH STRONG CONVECTION

from Knippertz et al., JGR, 2007
Richardson's "Forecast Factory": a pioneering attempt to predict weather

...In 1922, Lewis Fry Richardson developed the first numerical weather prediction (NWP) system. Richardson's method, based on simplified versions of Bjerknes' "primitive equations" of motion and state (and adding an eighth variable, for atmospheric dust) reduced the calculations required to a level where manual solution could be contemplated. His own attempt to calculate weather for a single eight-hour period took six weeks and ended in failure....
Dust models predict atmospheric dust process

- Dust component on-line driven by atmospheric models
- Parameterization of all major atmospheric dust phases
  - Emission
  - Turbulent mixing
  - Long-range transport
  - Wet/dry deposition
Dust emission process depends on:

- soil texture
- near-surface turbulence
- soil wetness
Integrated System Components:

Forecast Models

18 UTC, 7 May 2002 30-hr forecast

NASA A-Train MODIS CALIPSO

European PM10

Surface-based LIDAR

GALION

Surface-based AOD

GAW/AERONET/SKYPNET

WMO CG-6 Side Meeting, 25 May 2011, Geneva
Assimilation
MODIS AOD in ECMWF MACC

Saharan dust outbreak: 6 March 2006

Model simulation  Assimilation  MODIS

Aerosol optical depth at 550nm

Cape Verde

Assimilation
Simulation

March 2006
Impacts of Sand and Dust

- Human Health (asthma, infections, meningitis in Africa, valley fever in the America’s)
- Agriculture (negative & positive impacts)
- Marine productivity
- Aviation (air disasters)
- Ground Transportation
- Industry (Semi-conductor, Tourism, etc)
Impact on Radiation

Figure 10. Vertical cross-sections between latitudes 30°N and 40°N along longitude 12°E of (a) the extinction coefficient at 550 nm from RAD and (b) the atmospheric temperature difference between RAD and CTR on the 12 April 2002 at 1200 UTC. (c) Horizontal distribution of 2m temperature difference over the whole domain.
Can desert dust explain the outgoing longwave radiation anomaly in the UK operational model over the Sahara? Haywood, et al., JGR 2003

Figure 1. The July 2003 monthly mean for (a) $\text{OLR}_{\text{Met7}}$, (b) $\text{OLR}_{\text{model}}$, and (c) $\text{OLR}_{\text{model}} - \text{OLR}_{\text{Met7}}$. The monthly mean consists of the average of the monthly mean of the OLR diagnosed at 0000 UTC, 0600 UTC, 1200 UTC, and 1800 UTC. Units are Wm$^{-2}$. See color version of this figure in the HTML.
Importance of mineral composition in desert soils

- Fe and P embedded in dust → ocean nutrients

- Cloud ice nucleation sensitive to mineral composition

- Hypothesis: Fe as an enhancement factor in meningitis outbreaks (Thompson, 2008)
ATMOSPHERIC IRON PROCESSING

Diagram showing the processing of iron in the atmosphere, with links to radiation, clouds, mineralogy, pollution, and size distribution.
Clay soils

Fe-containing minerals
A(I,J); 4km

Silt soils
TUNIS (CNN) 7 May, 2002, 17:44 GMT -- An EgyptAir jet crashed on a hillside outside Tunisia's capital, killing 18 people, a government official said…

…Weather was foggy and rainy at the time, with sandstorms blowing in from the Sahara Desert. …
Predicted dust load (μg m⁻²)  Predicted cross-section dust concentration (μg m⁻³)

Features of the case:
- Major Mediterranean dust storm
- Fast moving system
- More than 5 mg m⁻³ in the elevated dust cloud core!

Site of the accident

Tunisian dust storm captured by MODIS
Source: Steven D. Miller, NRL, Monterey
Pre-SDS-WAS history

- **Late 80’s:**
  - First demonstration that SDS dynamic simulations are possible

- **90’s:**
  - First satellite products capable to detect SDS
  - First successful daily SDS forecast test
  - First long-term daily SDS forecasts

- **2000’s:**
  - Fast developments in dust observations and forecasting models
Brief SDS-WAS history

- **2004**: Beijing, China: International Symposium on SDS & a WMO Experts **Workshop** on SDS.

- **2005**: More than 40 Member countries indicated interest to cooperate in SDS-WAS.

- **2006**: Beijing, China meeting: established the Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) activities.

- **2007**: the **14th WMO Congress** endorsed launching of the SDS-WAS

- **2011**: WWRP JSC approved the SDS-WAS Implementation Plan (2011-2015)
SDS-WAS Activity Nodes and countries expressed interest to cooperate
SDS-WAS: A Federated System of Regional Nodes: Modelling, Research, Observations and Users
WWRP/GAW SDS-WAS Mission

To enhance the ability of countries to deliver:

- timely and quality forecasts of SDS
- observations of dust aerosols
- Provide information and knowledge to users through
  - an international partnership of research and transfer of experimental products to operations