Smoke and Dust Research and Development

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Scientific goal: Improve modeling capabilities to simulate smoke and dust

Better National Air Quality Forecast Capability (NAQFC)

- Develop, implement and test algorithms
- Improve model performance
- Gain insight on the emission, transport, dispersion and deposition processes involved in the simulation of smoke and dust
- Integrate conceptual understanding of atmospheric processes using models and ambient measurements
Smoke Forecast System

- Experimental testing phase began March 28, 2006
- Run daily at NCEP as part of the Air Quality Forecast Guidance to produce a 24-hr analysis and a 48-hr forecast

Daily Procedure

- Satellite detection of fire location and heat released
- Calculation of emissions
- HYSPLIT run
- Statistics calculation
- Web distribution

Rolph et al., 2007
Approach:

Forest fires and release height

2215 to 0000 UTC on 23-24 September 2006

1100 to 1630 UTC 24 September 2006

Smoke column from the HYSPLIT model (blue) and satellite based Hazardous Mapping System (orange)
Approach:
HYSPLIT vs. MISR observed plume rise

Fire locations

Base case

\[ y = 0.2007x + 668.48 \]
\[ R^2 = 0.1115 \]

1.25 *PBL

\[ y = 0.3751x + 880.65 \]
\[ R^2 = 0.1221 \]
Argentina’s NWS uses HYSPLIT to predict smoke

- As part of a Memorandum of Understanding between ARL and the Argentinean National Weather Service
Dust from North Africa

Part of a Memorandum of Agreement with the University of Huelva, Spain
HYPLIT Dust Storm Prediction System

- Developed at ARL
- Inputs
  - 12 km sigma level NAM meteorology
  - 0.25 deg monthly threshold friction velocity ($u^*t$) and soil dust density ($K$)
  - Grid cell dust area ($Ad$)
- Emission Algorithm
  - $Q = q Ad$
  - $q = K f(u^*)$
  - $f(u^*) = u^* - u^*t$
  - particles are emitted when $u^* > u^*t$
  - Emissions only occur with no rain
- HYPLIT configuration
  - Time step fixed at 6 minutes
  - Maximum particle duration 48 h
  - Concentrations layers 0-100m and 0-5 km
  - Horizontal resolution 0.10 degrees (10 km)
  - Dry and wet deposition for mono-modal dust particle of 4 um diameter and 2.5 g/cc
  - Domain 25N-50N and 125W-65W
  - Full 3D particle mode 500,000 maximum
  - About 1000 possible sources
  - At least 1 particle per source per time step

Annual Average Threshold Friction Velocities

Average ($\mu g \ m^{-3}$) for June - July 2007  
Draxler et al., 2010

4/15/2011 Air Resources Laboratory
Global dust HYSPLIT
Approach:

Development of CMAQ Dust Module - FENGSHA

A physical-based model built from long-term U.S. dust observations

\[ F = \sum_{i=1}^{M} \sum_{j=1}^{N} K \times A \times \frac{\rho}{g} \times S_i \times SEP \times u_* \times \left( u_*^2 - u_{*i,j}^2 \right) \]

Initial tests show considerable improvement of air quality and climate modeling

Dust model codes have been adopted by the latest CMAQ model (v5.0) and will be released to the public by US EPA;
Dust transport over Antarctica

Total columnar dust concentrations modeled by HYSPLIT initialized by the active dust sources detected by MODIS on February 26 2005 and emission duration constrained by surface visibility measurements. Outputs are shown for February 27 (left), March 03 (center) and March 09 (right). Lighter colors indicate higher concentrations.
Indicators of Success

- **Peer reviewed papers:**

- **Operations:**
  - Smoke Forecast System; customer: NWS
  - Dust Storm Prediction System; customer: NWS
  - HYSPLIT emergency response system, including volcanic ash and wildfire smoke; customer: Argentinean NWS

- **Memorandum of Agreements:**
  - Argentinean National Weather Service
  - University of Huelva, Spain.
Collaborators
Future directions

- Improve fire release height estimations using satellite derived emissions.
- Implement and test new smoke and dust algorithms developed under lagrangian-based (HYSPIT) paradigm into eulerian based models (CMAQ) and vice versa for future application in to the National Air Quality Forecast Capability.
- Continue strengthening international collaboration.