## Smoke and Dust Research and Development

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## ARL Laboratory Review May 3-5, 2011



#### 4/15/2011

## **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

ARL/NESDIS EXPERIMENTAL SMOKE FORECAST Air Concentration (ug/m3) Layer Average 0 m and 5000 m Integrated from 0600 10 Apr to 0700 10 Apr 11 (UTC) PM25 Release started at 0600 10 Apr 11 (UTC)



### Daily Procedure

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

Rolph et al., 2007



Smoke column from the HYSPLIT model (blue) and satellite based Hazardous Mapping System (orange)

## **Approach:**

## **HYSPLIT vs. MISR observed plume rise**



# HYSPLIT height [m]

NOAA

#### MISR height [m]

#### MISR height [m]

## Argentina's NWS uses HYSPLIT to predict smoke





4/15/2011

## **Dust from North Africa**

NOA



Part of a Memorandum of Agreement with the University of Huelva, Spain 4/15/2011 Air Resources Laboratory

## **HYSPLIT 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

#### HYSPLIT 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

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## **Global dust HYSPLIT**







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NOAA

## **Approach:**

**Development of CMAQ Dust Module - FENGSHA** 

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

$$\mathbf{F} = \sum_{i=1}^{M} \sum_{j=1}^{N} K \times A \times \frac{\rho}{g} \times S_{i} \times SEP \times u_{*} \times (u_{*}^{2} - u_{*ti,j}^{2})$$

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:

• Journal of Geophysical Research, Weather and Forecasting, Atmospheric Research, Atmospheric Chemistry and Physics, Geophysical Research Letters.

#### • 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







RE

Eniversidad

de Huelva







## Unión Europea



Centro Internacional de Estudios y Convenciones Ecológicas y Medioambientales



## **Future directions**

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