Towards PM2.5 predictions at NOAA: early developments for dust predictions

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EPA AIRNow Conference, Addison TX, *March 4, 2009*

Airborne dust

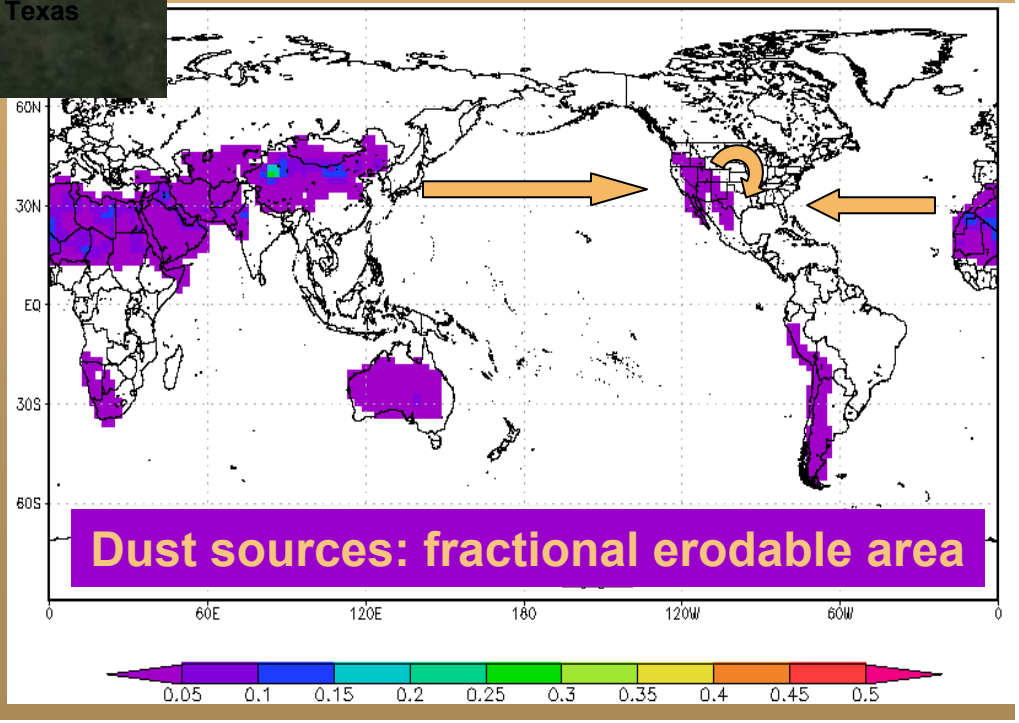
Dust storm approaching Stratford, Texas. Dust bowl surveying in Texas
NOAA George E. Marsh Album, www.photolib.noaa.gov

Impacts:

- Health and safety
- Transportation
- Direct and indirect impacts on climate and weather
- Ocean biogeochemistry

Dust in the US:

- North American
- Asian
- Saharan



Testing global GFS-GOCART dust simulation

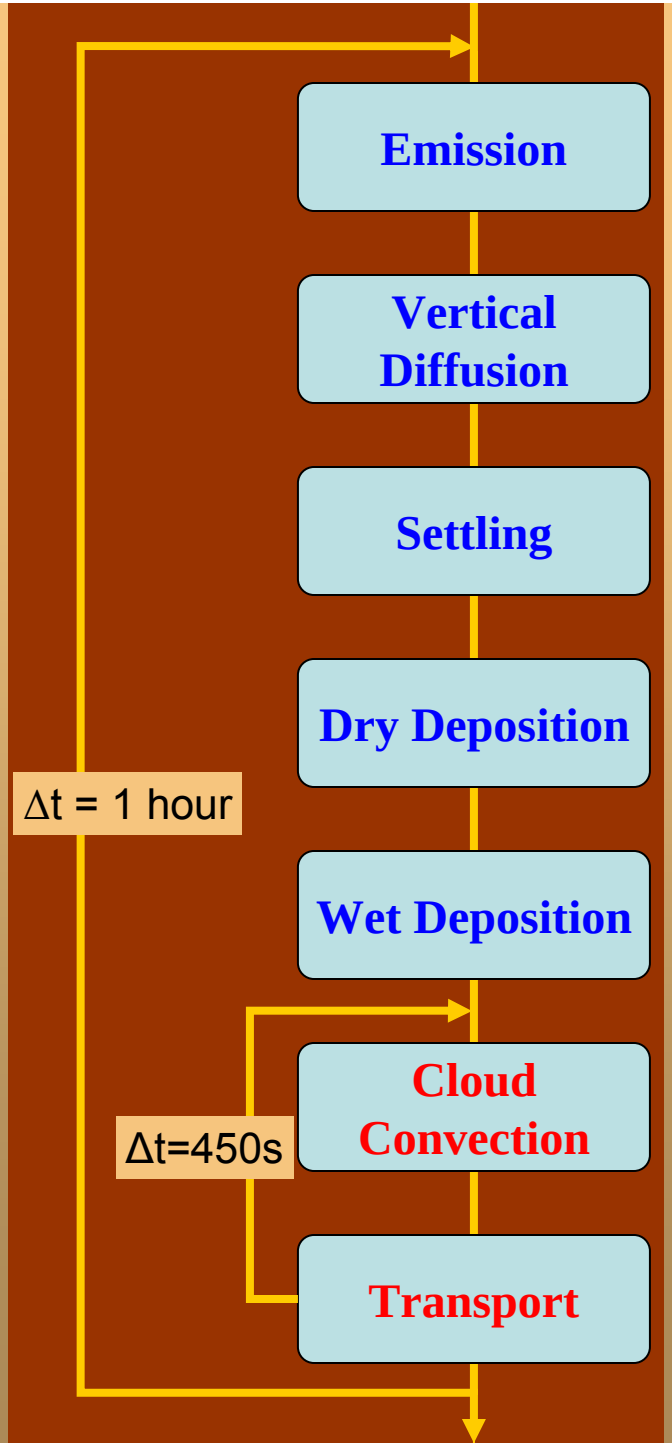
GFS configuration:

- T126L64 (~1°x1°)
- 48 hours free forecast
- Relaxed Arakawa-Schubert scheme (RAS) for convective cumulus parameterization

GOCART configuration:

- 5 dust size bins by radius:
  - 0.1 – 1.0 μm
  - 1.0 – 1.8 μm
  - 1.8 – 3.0 μm
  - 3.0 – 6.0 μm
  - 6.0 – 10.0 μm
- May 1 2006 – June 30 2007

- *Huang et al (AGU 2008)*



Depends on surface topographic depression, surface wetness, and surface wind speed (Ginoux et al. 2001)

Boundary layer turbulent mixing (Helfand and Labraga 1988)

Depends on particle size and air viscosity (Fuchs 1964)

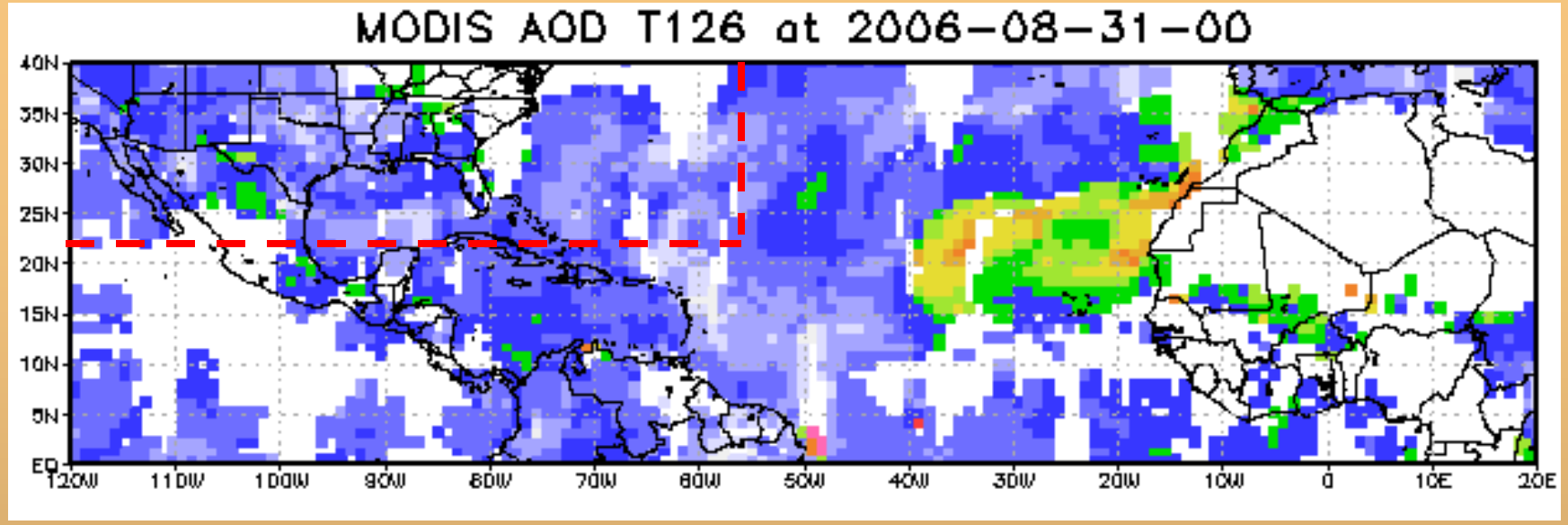
The resistance method (Wesely 1989; Walcek et al. 1986)

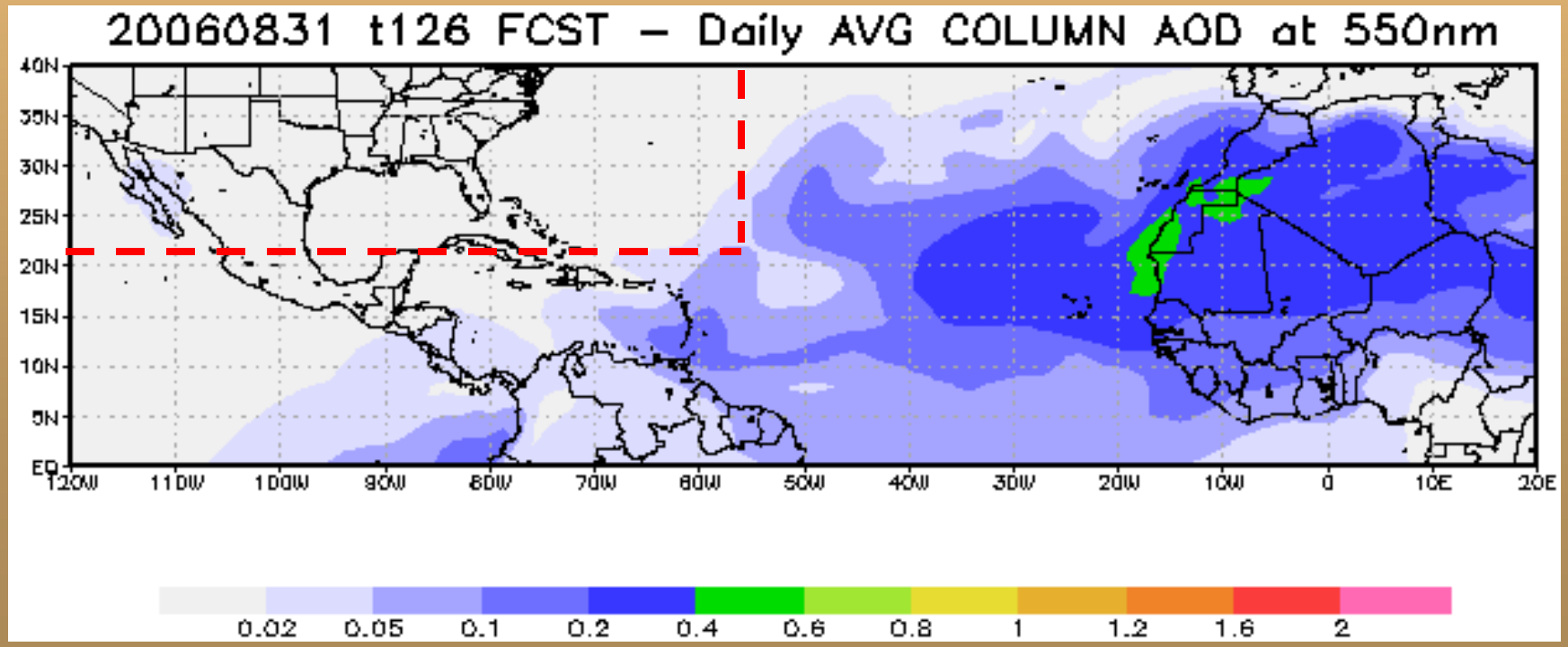
Rainout (Giorgi and Chameides 1986), washout (Dana and Hale 1976), convective scavenging with moist convection (Allen et al. 1996), and evaporation below the cloud

Calculated using archived cloud mass flux (Allen et al. 1996)

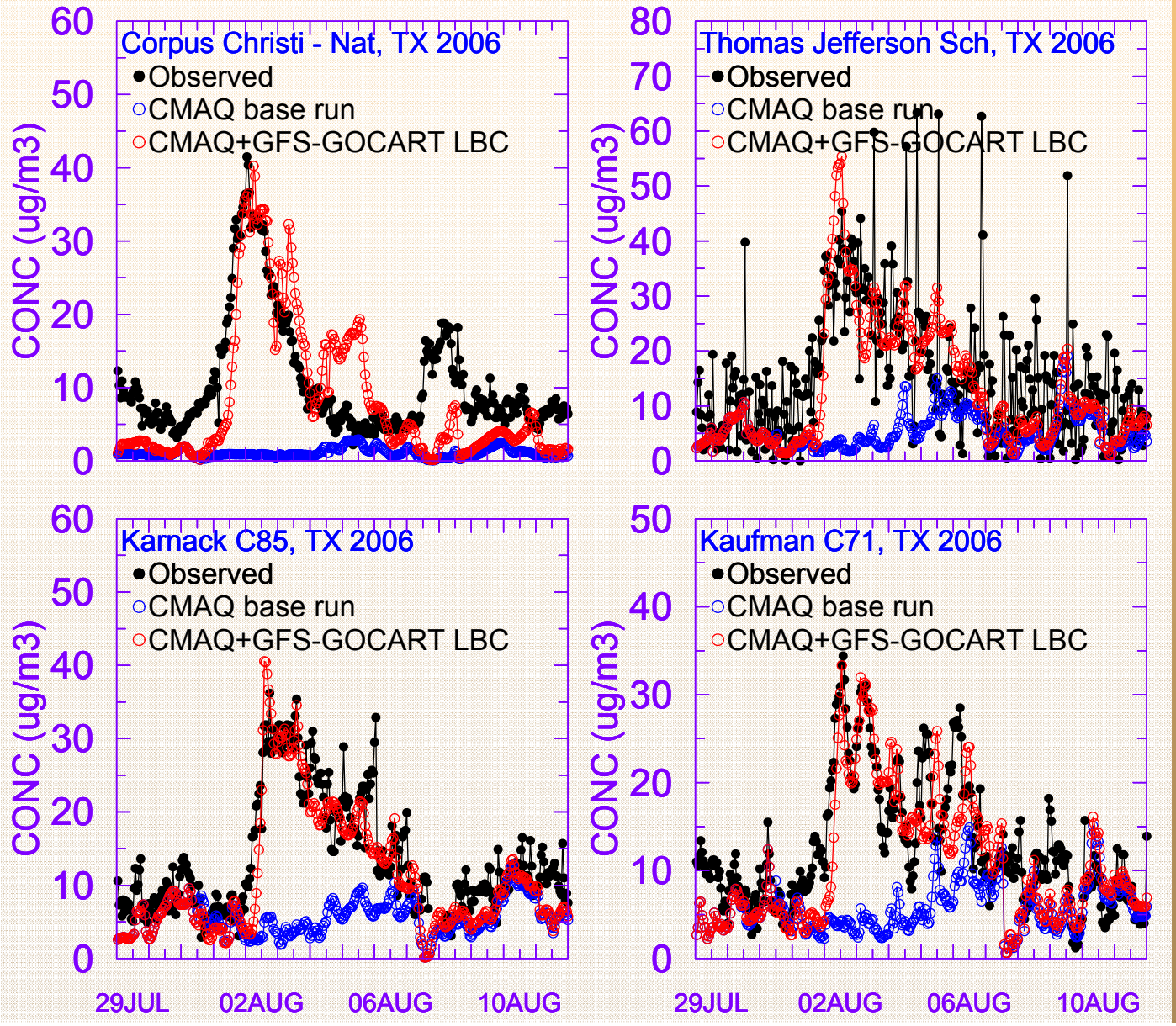
Flux form semi-Lagrangian (Lin and Rood 1996)

Saharan dust


MODIS AOD T126 at 2006-08-31-00
40N
35N
30N
25N
20N
15N
10N
5N
EQ
120W
110W
100W
90W
80W
70W
60W
50W
40W
30W
20W
10W
0
10E
20E


20060831 t126 FCST - Daily AVG COLUMN AOD at 550nm
40N
35N
30N
25N
20N
15N
10N
5N
EQ
120W
110W
100W
90W
80W
70W
60W
50W
40W
30W
20W
10W
0
10E
20E
0.02
0.05
0.1
0.2
0.4
0.6
0.8
1
1.2
1.6
2

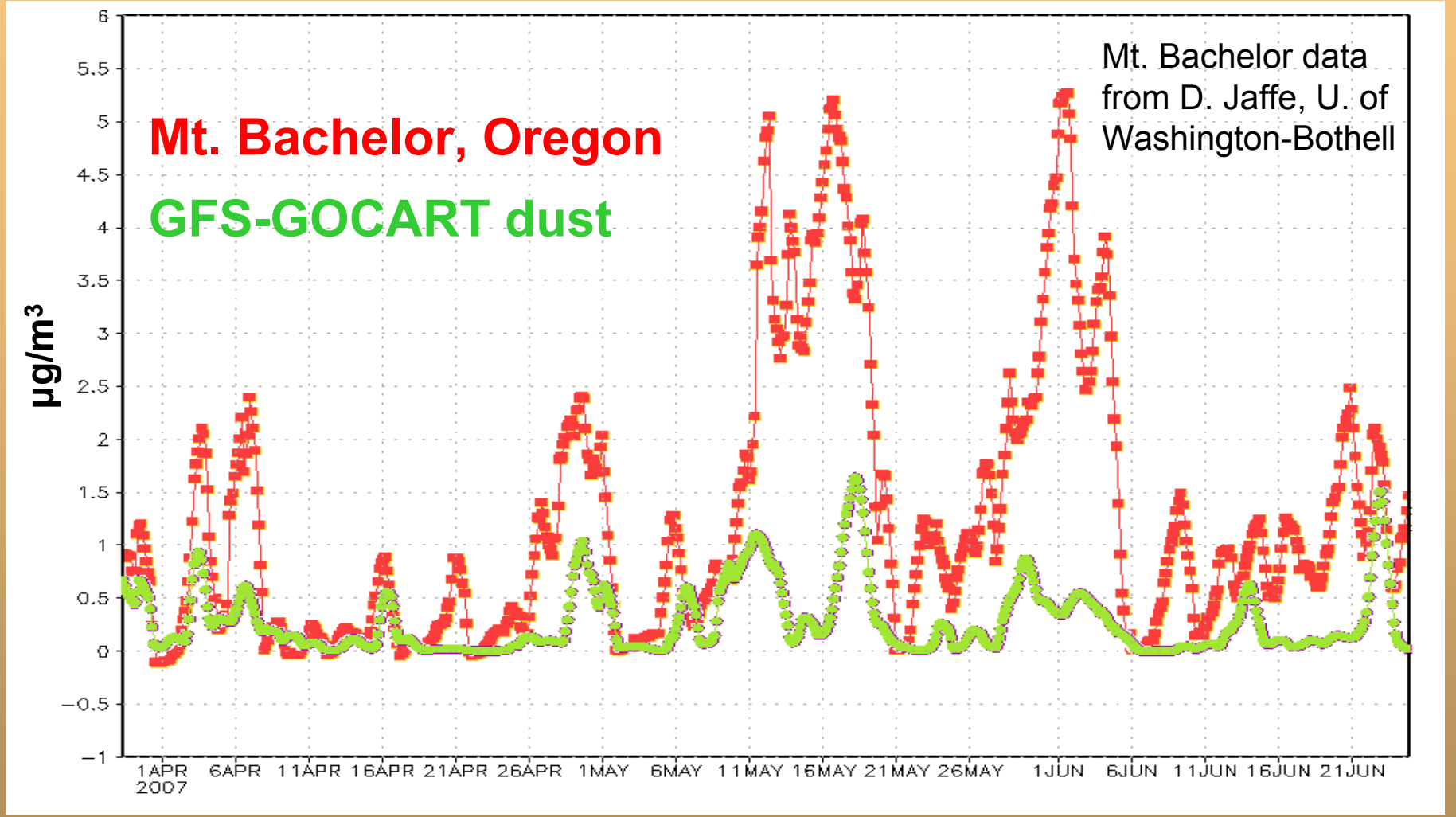
Surface PM2.5 over Texas



- Aerosols in the CMAQ run with lateral boundary conditions from GFS-GOCART (red) reproduce the timing and the magnitude of the enhanced PM2.5
- The enhancement in PM2.5 starting on August 2 aligns with transport of Saharan dust across the Atlantic
- *Tang et al (CMAS 2008)*

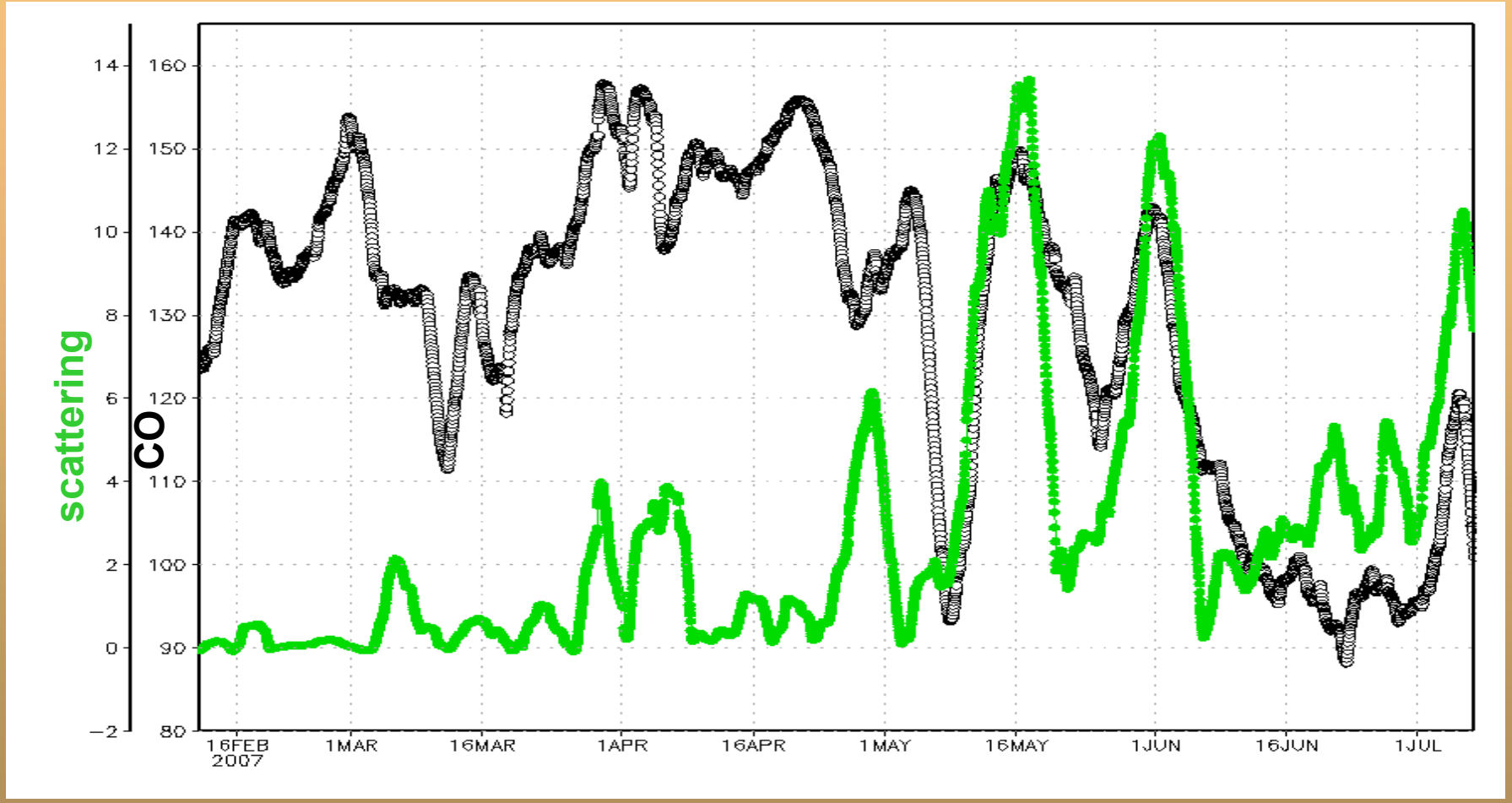
Pacific Northwest

Submicron aerosol



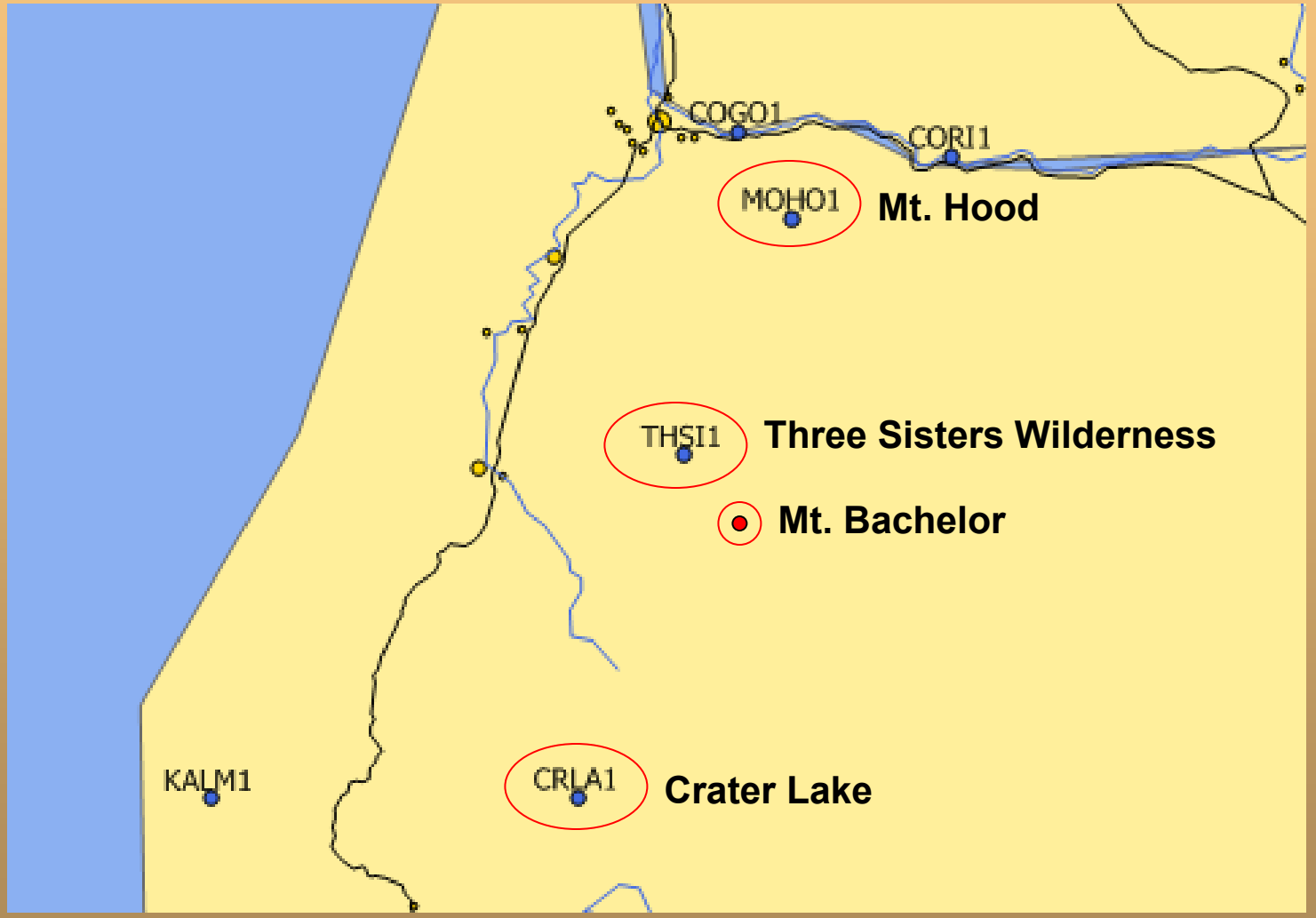
- Daily averages of Mt. Bachelor aerosol and GFS-GOCART dust
- Enhanced GOCART dust → stronger Mt. Bachelor scattering
- Mt. Bachelor scattering can be enhanced without enhanced GOCART dust
- GOCART dust is ~25% of calculated aerosol concentrations at Mt. Bachelor

Submicron aerosol scattering and CO at Mt. Bachelor



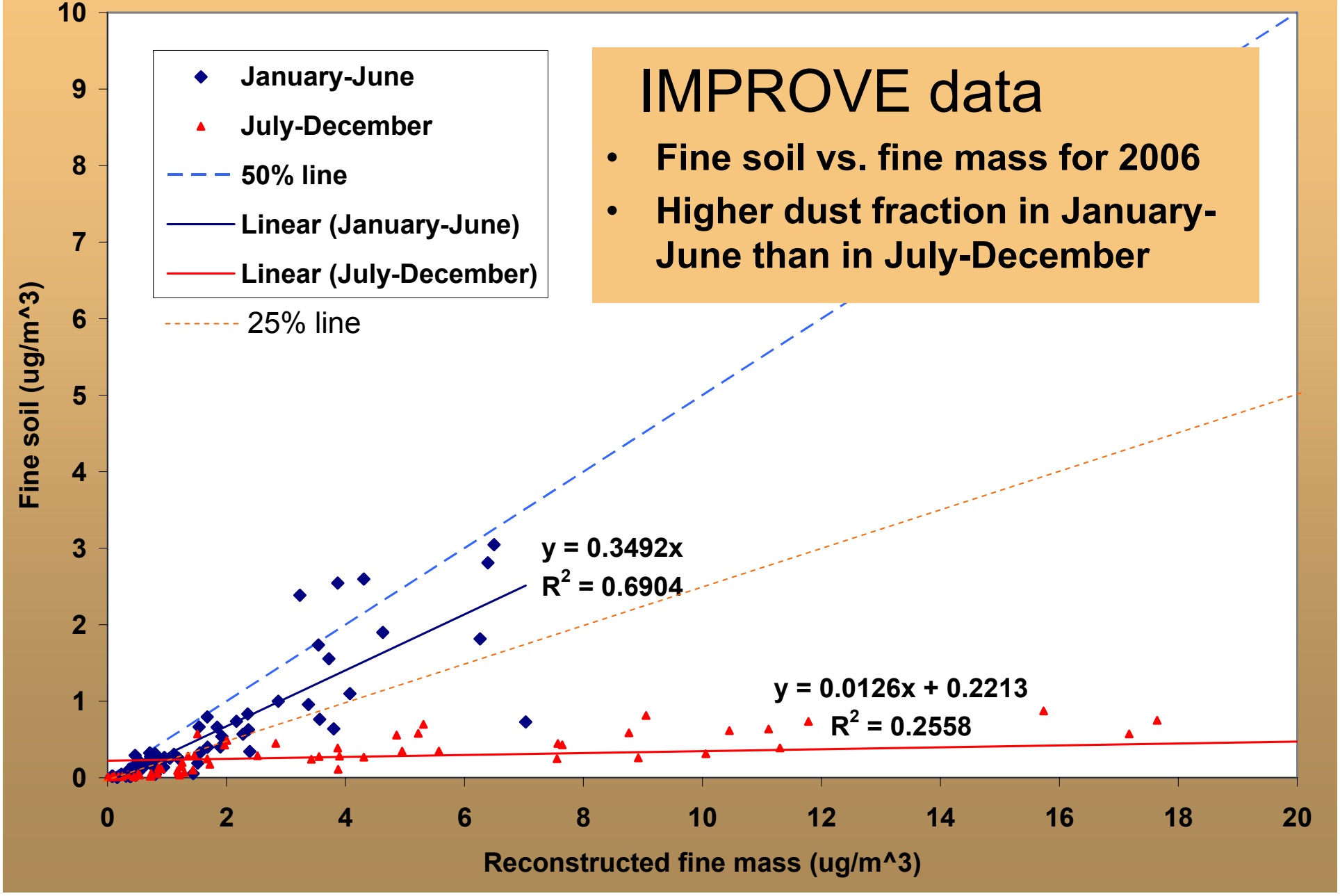
- For most events when scattering is enhanced, carbon monoxide (CO) is enhanced as well → dust is not likely to be the major aerosol component

The Interagency Monitoring of Protected Visual Environments (IMPROVE) network



- Speciated data provide **concentration and composition** of fine particulate matter.

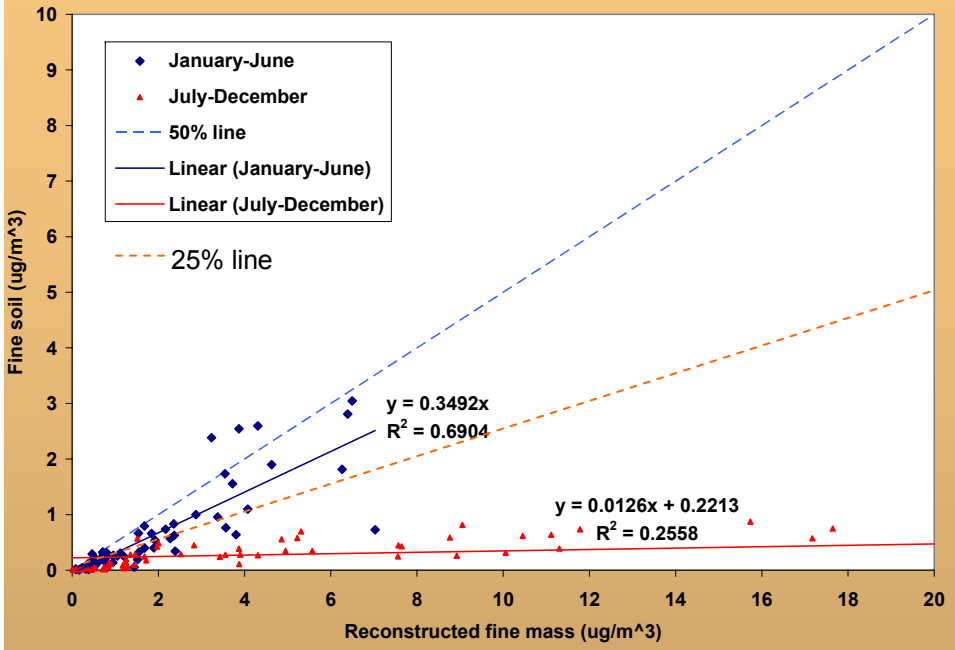
Crater Lake (43N, 122W, 1996m)



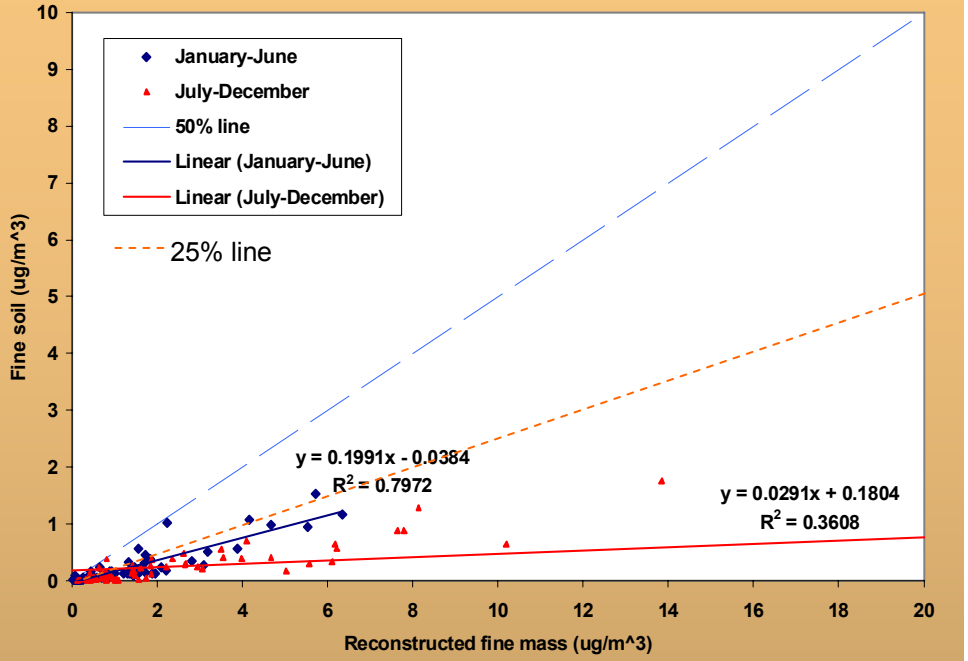
IMPROVE data

- **Fine soil vs. fine mass for 2006**
- **Higher dust fraction in January-June than in July-December**

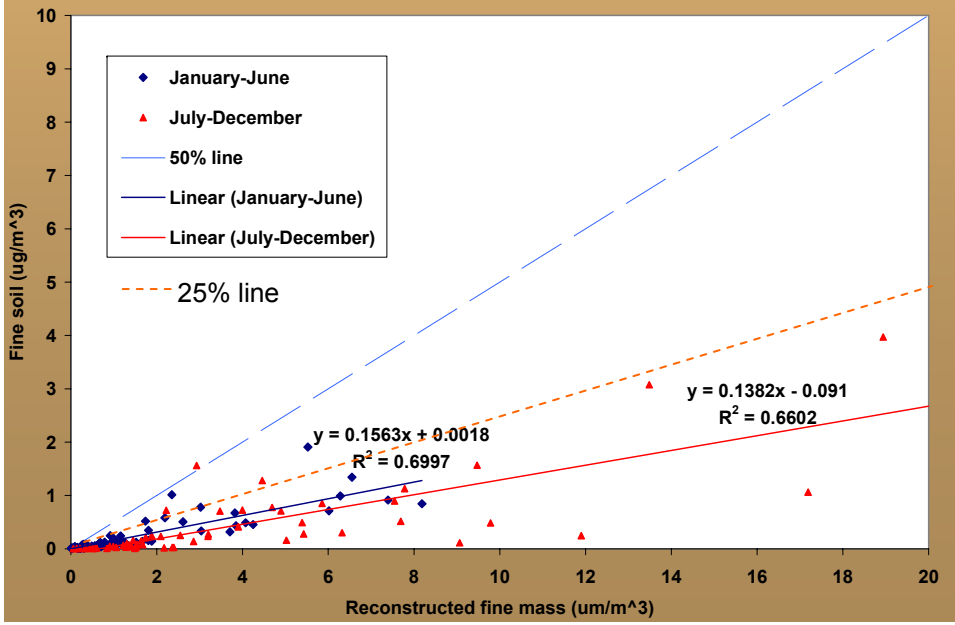
Crater Lake (43N, 122W, 1996m) Year 2006



Mount Hood (45N, 122W, 1531m) Year 2006



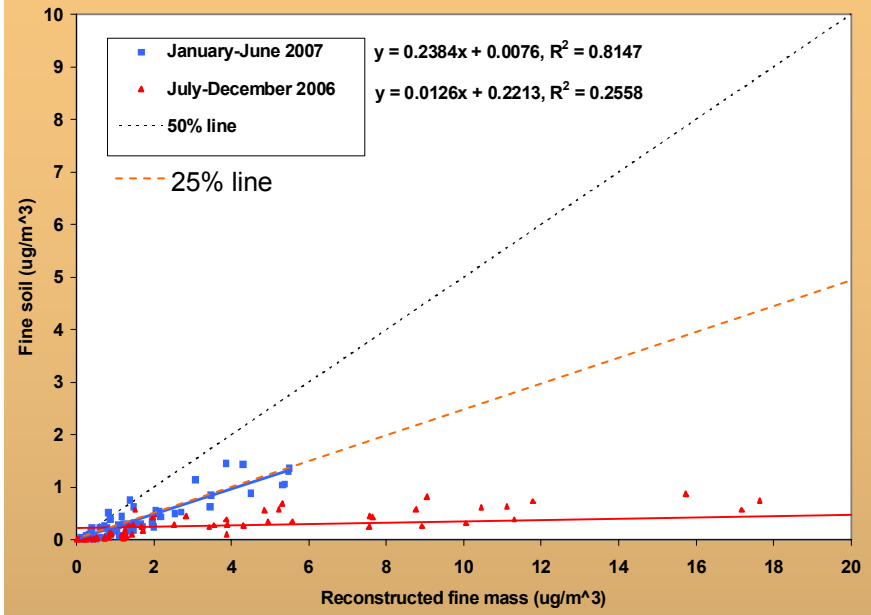
Three Sisters Wilderness (44N, 122W, 885m) Year 2006



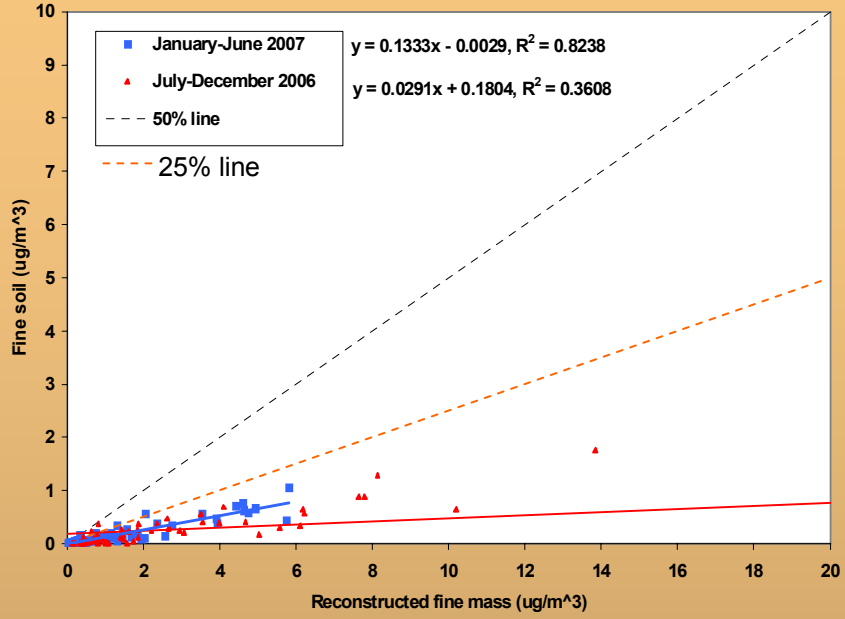
IMPROVE data for 2006

- **Three sites in Oregon**
- Fine soil vs. fine mass
- Higher dust fraction in January-June than in July-December
- **For January-June dust fraction is higher at higher altitude**

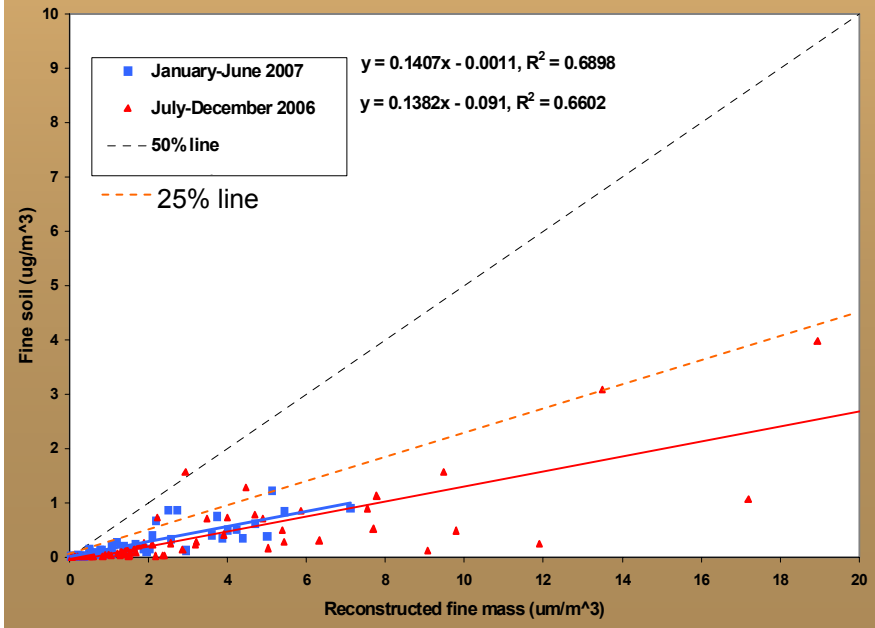
Crater Lake (43N, 122W, 1996m)



Mount Hood (45N, 122W, 1531m)



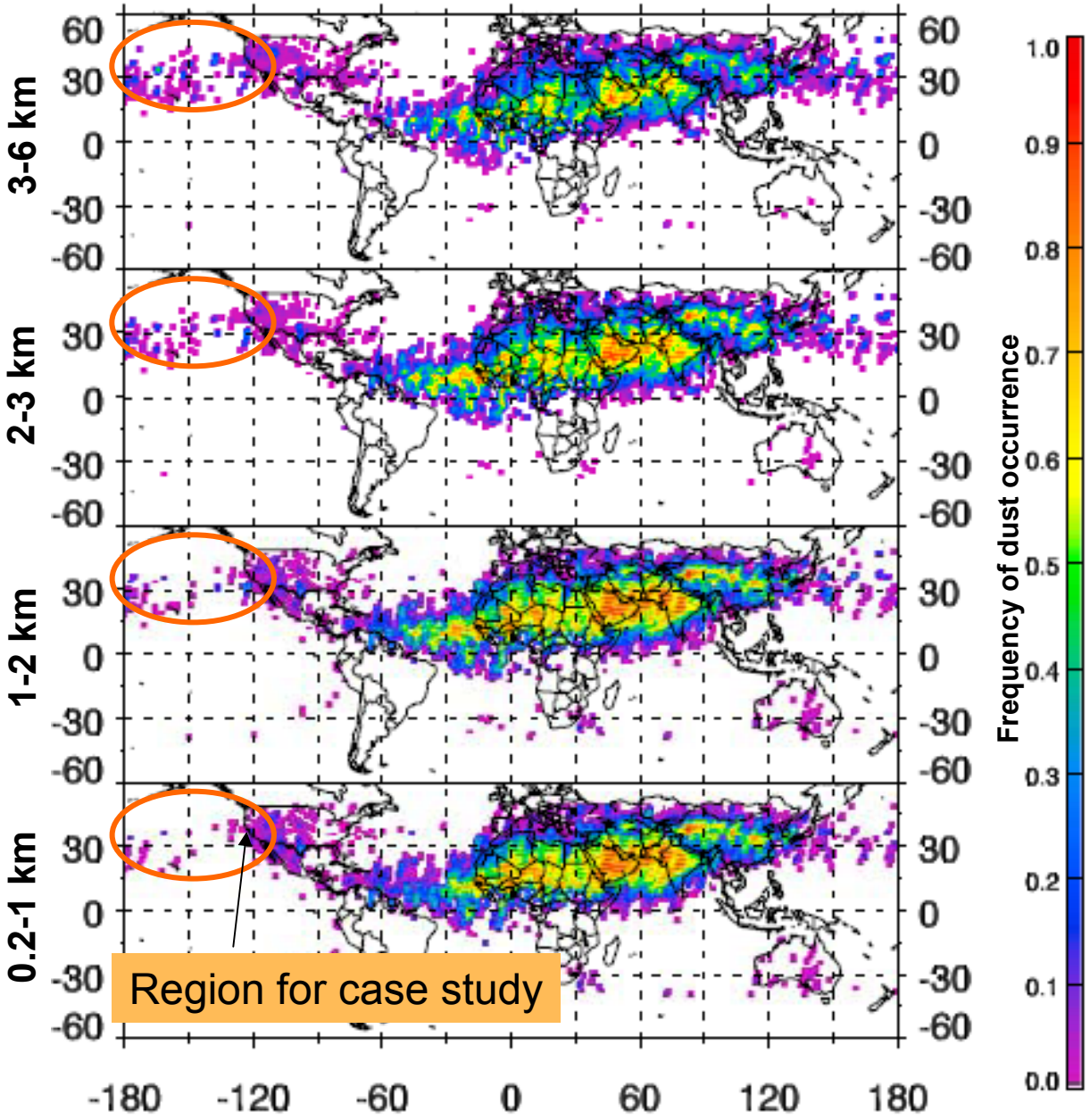
Three Sisters Wilderness (44N, 122W, 885m)



IMPROVE data for 2007

- **Higher dust fraction in January-June 2007 than in July-December 2006**
- For January-June:
  - Correlations are higher in 2007,
  - Dust fractions are higher in 2006 for Crater Lake and Mt. Hood

Dust frequency from CALIPSO

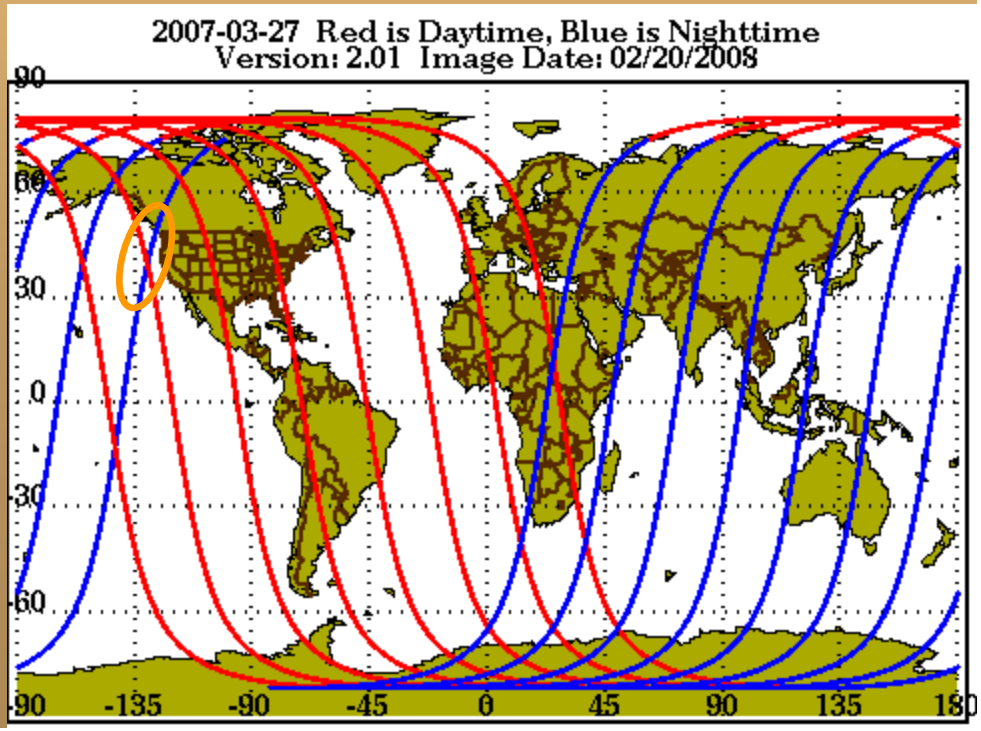


- Maps for **spring 2007** (March-May) were produced using nighttime cloud-free Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) data
- Over eastern Pacific **dust frequency increases with altitude** (within orange ovals)
- Figure from *Liu et al. (JGR 2008)*

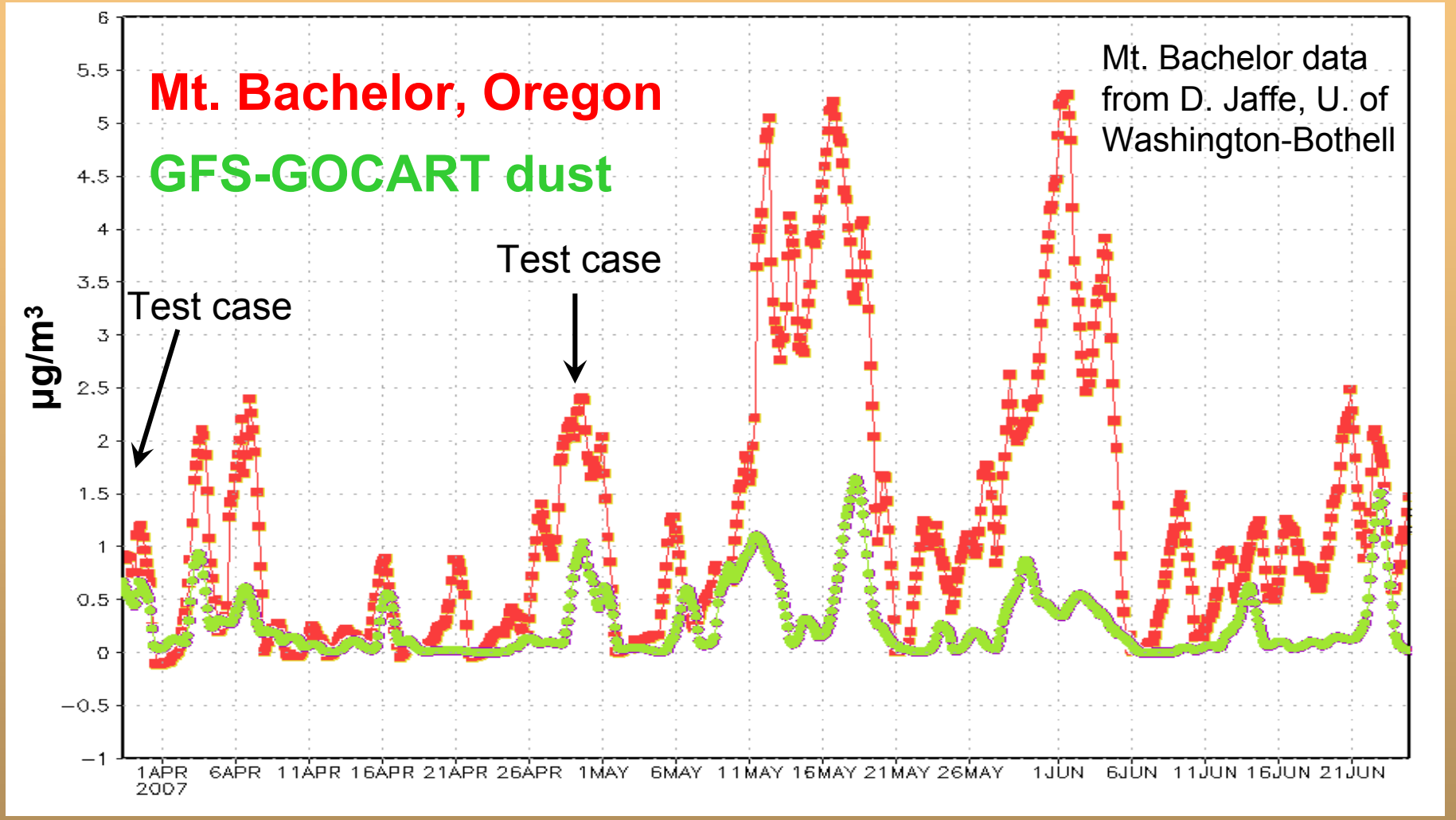
GOCART vs CALIPSO comparisons

Identify cases:

- Enhanced scattering measurements and enhanced GOCART dust at Mt. Bachelor
- CALIPSO nightime data showing aerosol layers not obscured by clouds
- CALIPSO data near Mt. Bachelor or a few days earlier over the eastern Pacific

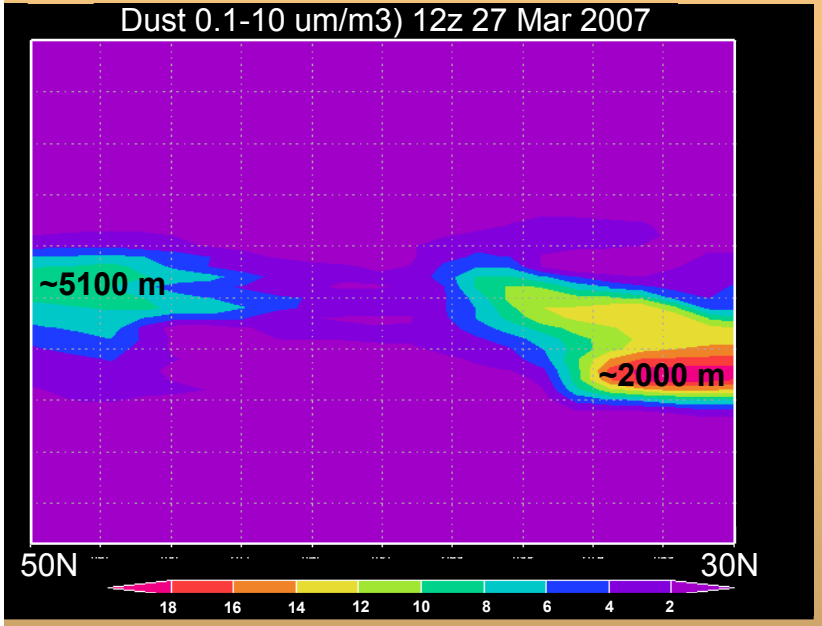


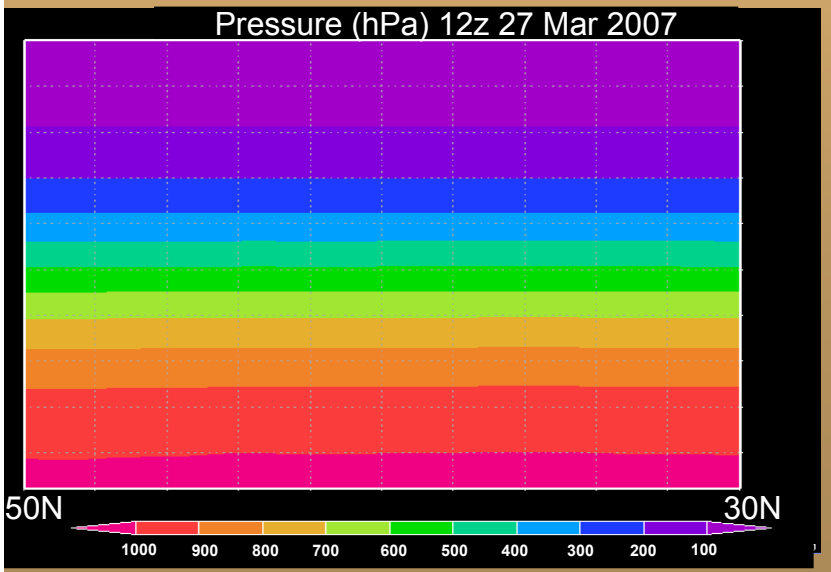
Submicron aerosol

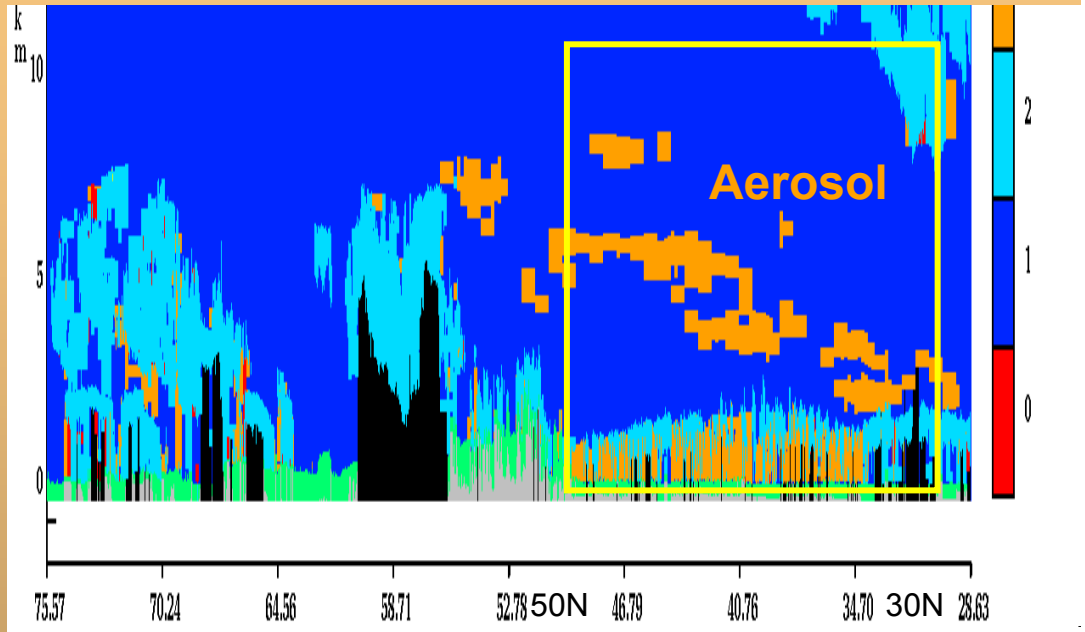


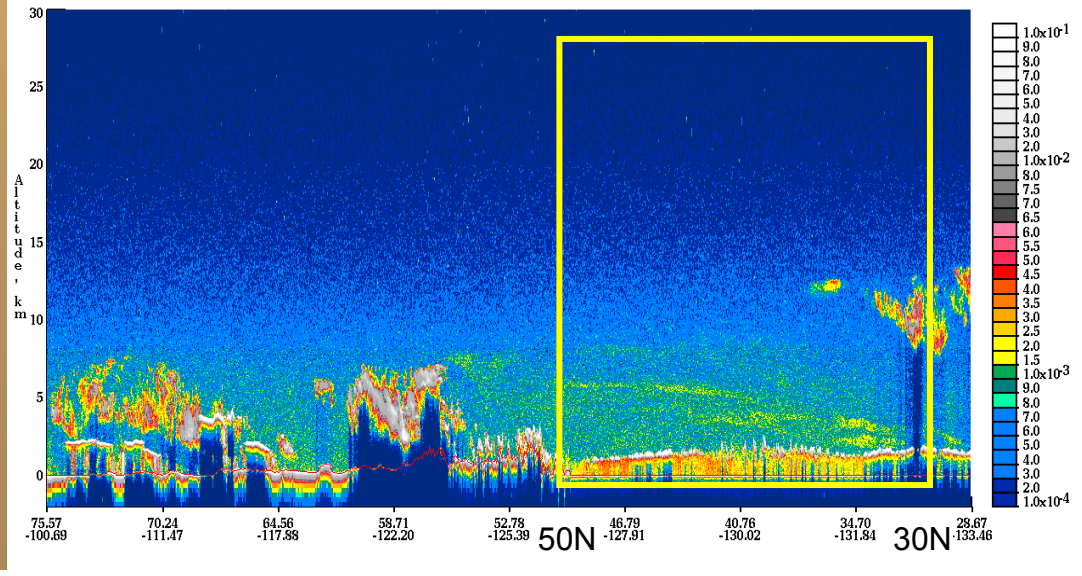
- **Daily averages of Mt. Bachelor aerosol and GFS-GOCART dust**
- **Mt. Bachelor observatory is at 43.98ºN, 121.69ºW, ~2.7 km altitude**

GOCART vs CALIPSO



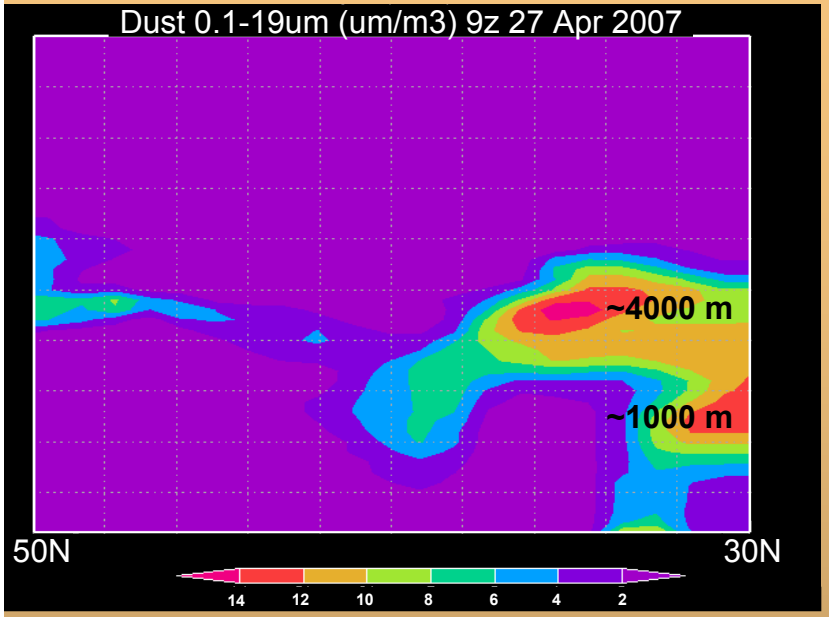


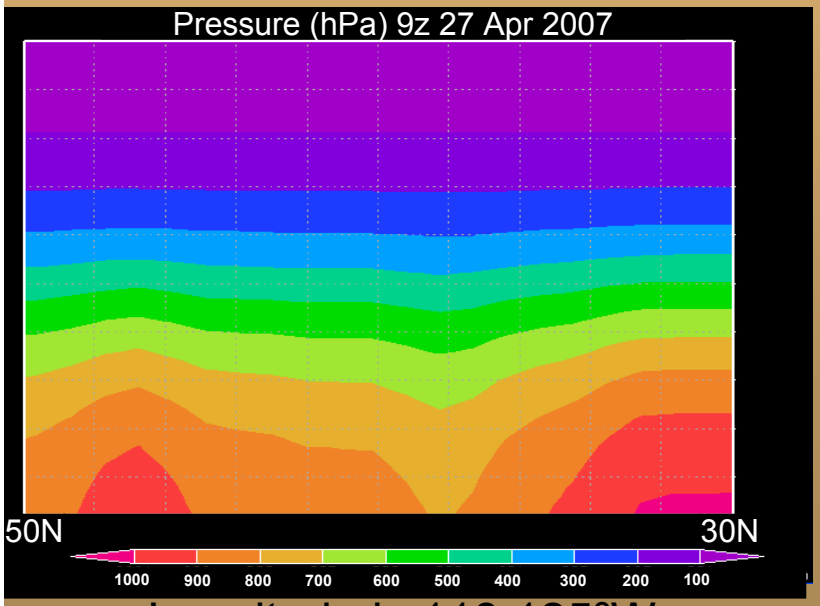


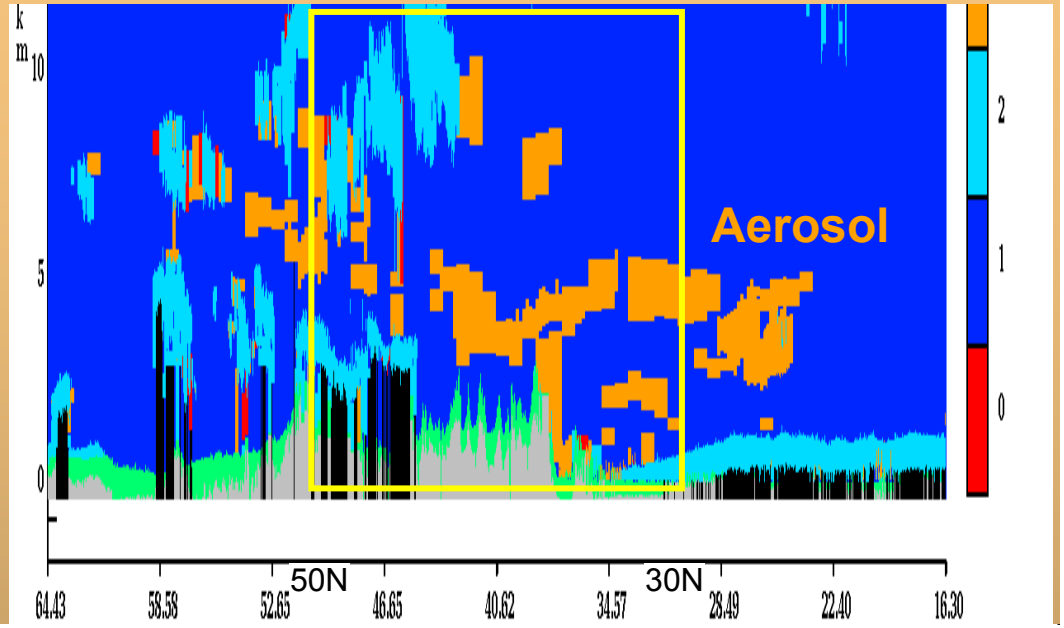


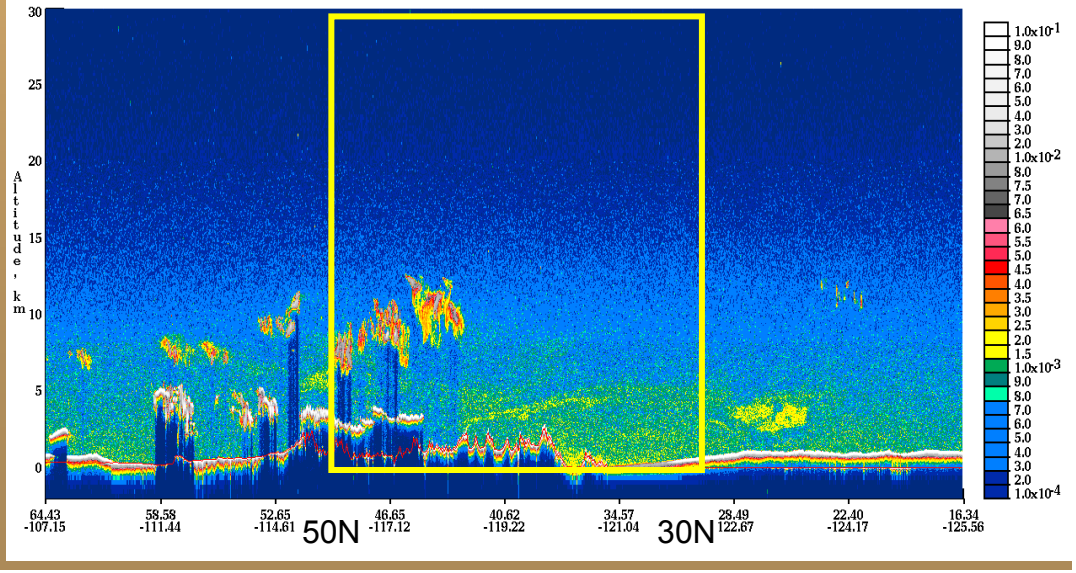
Longitude is 129.375ºW

GOCART vs CALIPSO









- Longitude is 118.125°W

Summary

- **Global simulations** of dust are available from GFS-GOCART
- Enhanced surface PM associated with **cross-Atlantic transport** of **Saharan dust** was reproduced in CMAQ aerosol simulation with boundary conditions from the global GOCART simulation

Pacific Northwest:

- When submicron dust is enhanced in **GOCART** then measured scattering is typically enhanced at **Mt. Bachelor**
- GOCART dust is **~25%** of Mt. Bachelor aerosol
- **Dust** frequency over eastern Pacific in CALIPSO data and fraction of aerosol that is dust in IMPROVE data over Oregon **increase with** increasing **altitude**
- For a couple of cases of enhanced dust at Mt. Bachelor, qualitative **comparison of CALIPSO and GOCART** vertical sections reveal similar **altitude of aerosol/dust layers**

Plans

- Prediction of fine dust (< 2.5 μm) for the United States
- Further quantitative evaluation of GFS-GOCART

Longer-term:

- Prediction capability for fine aerosol
- Use of dynamic boundary conditions