

Modeling and Data Analysis of 2011 Phoenix Dust Storm

Aishwarya Raman and Ave Arellano
Dept of Atmospheric Sciences, University of Arizona
aishwaryaraman@email.arizona.edu

with help from Michael Leuthold (UoA), NWS Tucson and WRF-Chem team

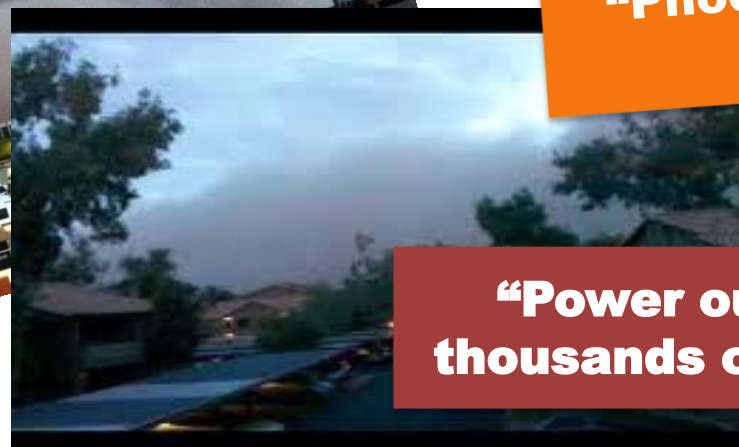
The Phoenix Haboob of July 5th, 2011

<http://www.mikeolbinski.com/storms>

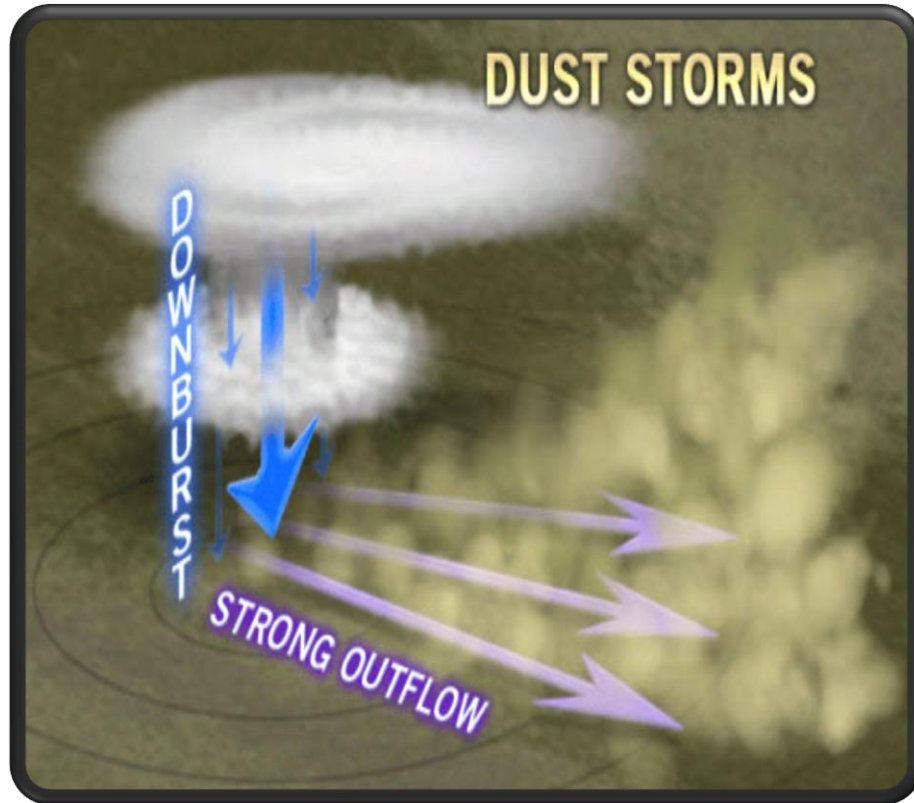


100+ Dust storms in 10 years --- 20+ in 2011

(Data source : NCDC storm database; NWS reports)



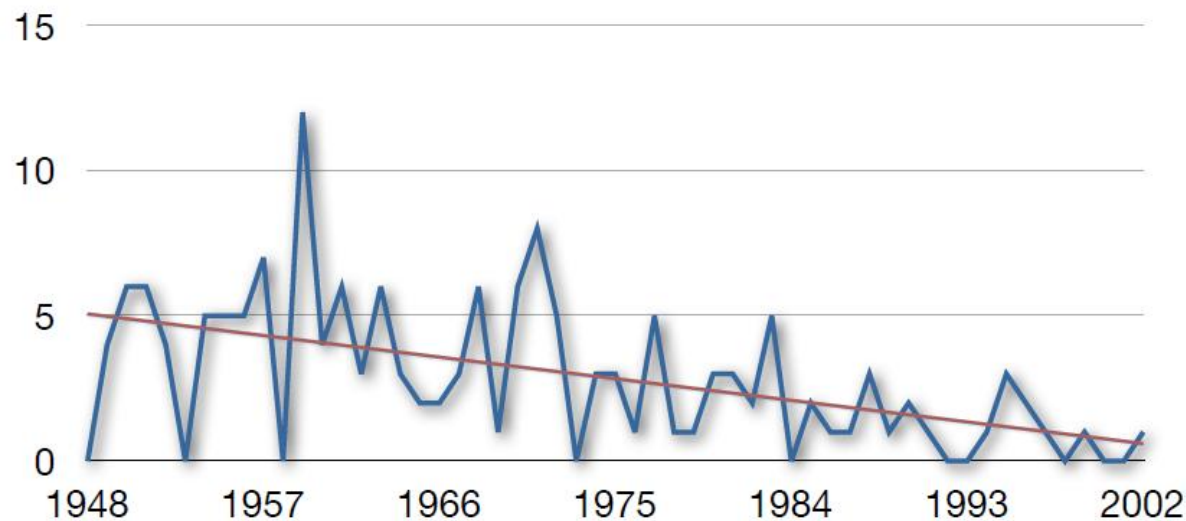
What happens during Phoenix Haboobs?



- Summer time mesoscale convective system
- Formation of thunderstorm cells and severe downburst
- Cold pool formation and propagation

Annual Frequency of Phoenix Dust Storms

(1948-2002, Jeff Davis/NWS)



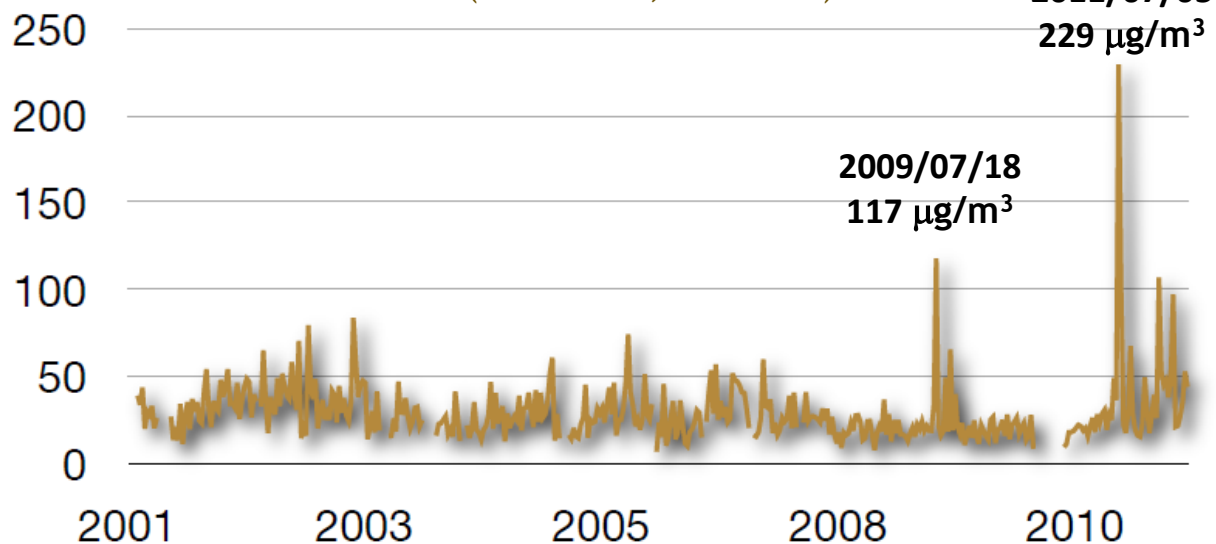
*Limited studies
of Arizona haboobs
after 2000*

(e.g. Nickling et al. 1984,
McCollum et al. 1995)

Does the future
hold more
intense
dust storms?

Summertime PM₁₀ ($\mu\text{g}/\text{m}^3$) Over Phoenix

(2000-2011, IMPROVE)



Research Objectives

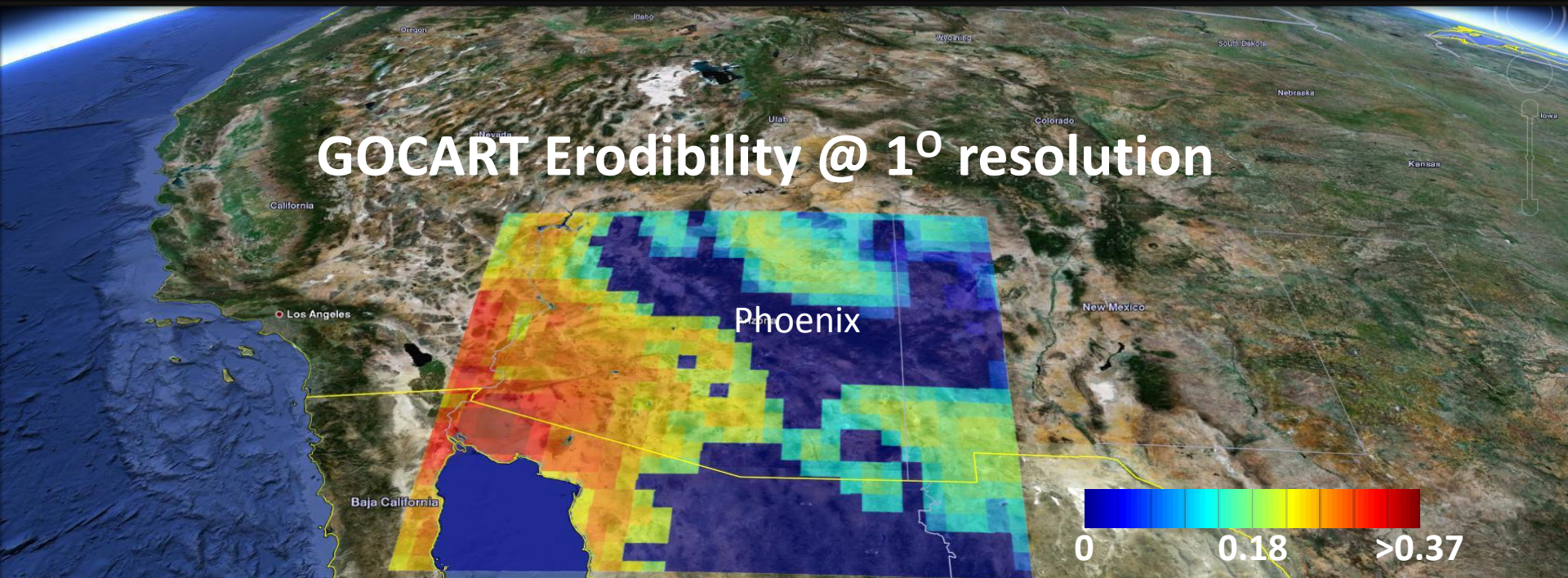
1. Develop a prototype dust forecasting system with sufficient spatio-temporal resolution for Arizona haboobs
2. Evaluate the performance of WRF-Chem in simulating the formation and propagation of key processes driving the July 5, 2011 Phoenix haboob
3. Assess current limitations associated with the development and evaluation of this system

WRF V3.4.1 Configuration

Simulation Period	2011/07/03 00Z to 2011/07/08 23Z
Microphysics	Morrison Microphysics, double moment scheme
Shortwave and Longwave radiation	RRTMG
Boundary Layer scheme	Mellor-Yamada-Janjic (Eta) TKE
Land surface model	NOAH
Surface Layer	Monin-Obukhov (Janjic Eta) scheme

- ***Use one-way nesting @ 5.4km (outer), 1.8km (inner) resolution***
- ***Initial and boundary conditions for meteorology from NCEP 6-hourly FNL analysis @ 1° resolution.***

WRF-Chem V3.4.1 Configuration

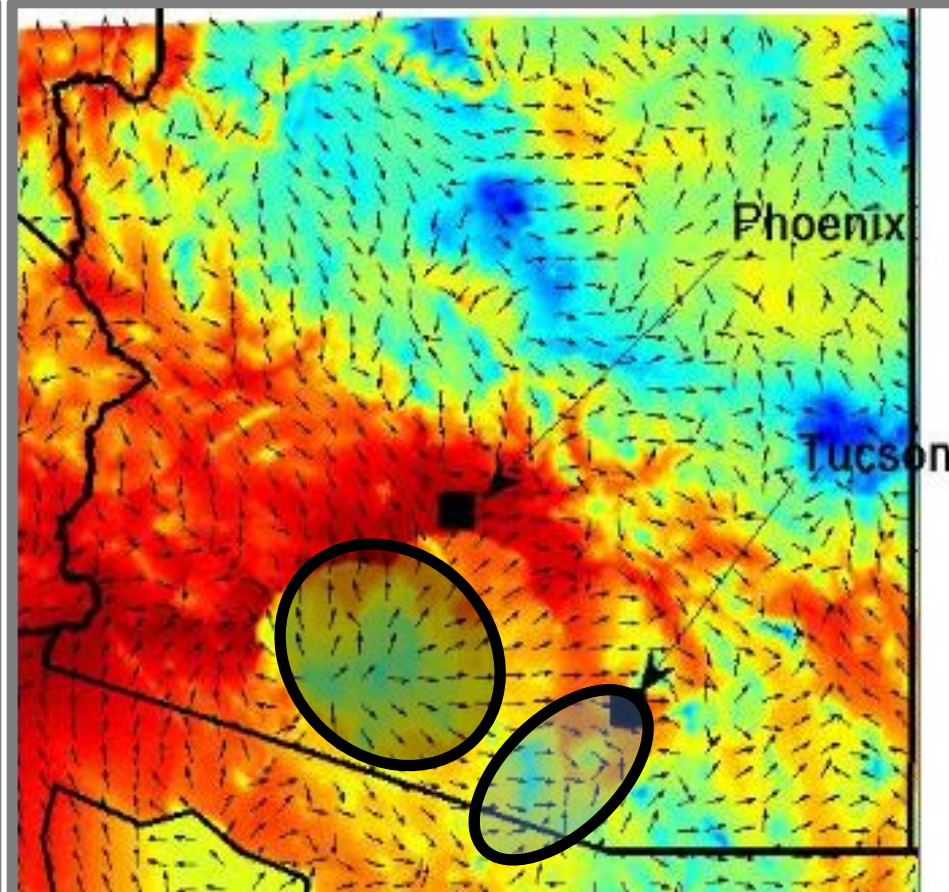
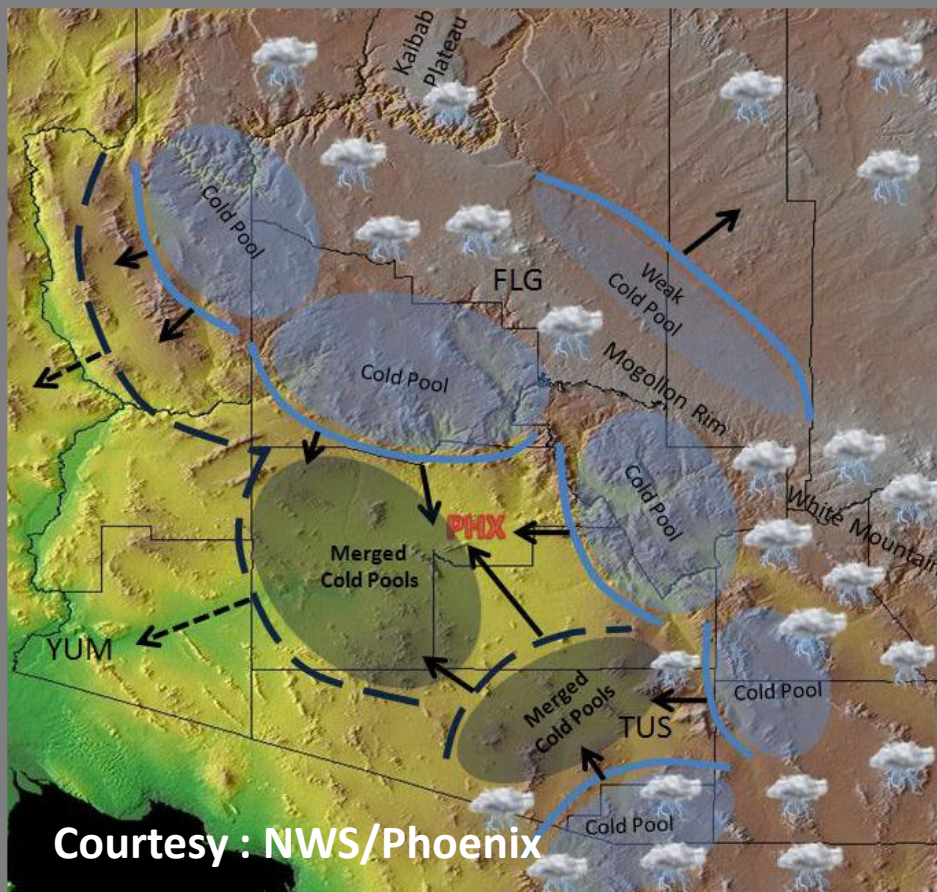


- Initial and boundary conditions for chemistry from MOZART (NCAR/ACD c/o Louisa Emmons)
- Chem Opt = GOCART-SIMPLE
- NEI 2005 anthropogenic emissions
- AFWA dust emission scheme (Sandra Jones)

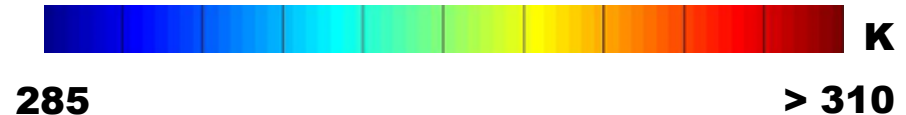
Meteorological Simulation Results

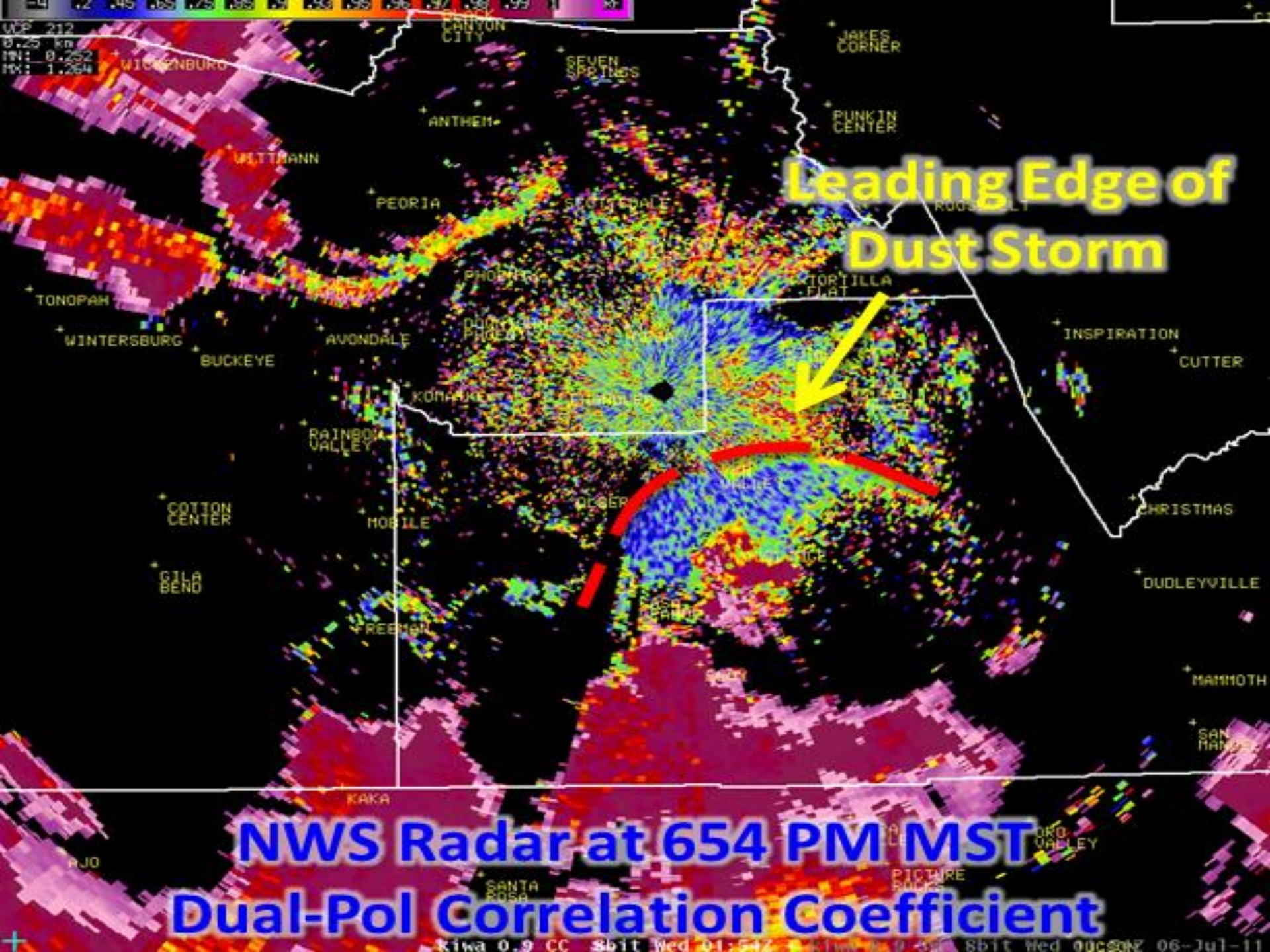
Conceptual Diagram of Cold Pool Formation and Movement

WRF-Chem Simulated Cold Pool
(2011/07/05 7pm Local Time)



**Strong SE winds $23-25\text{ms}^{-1}$
and cold pool development !**





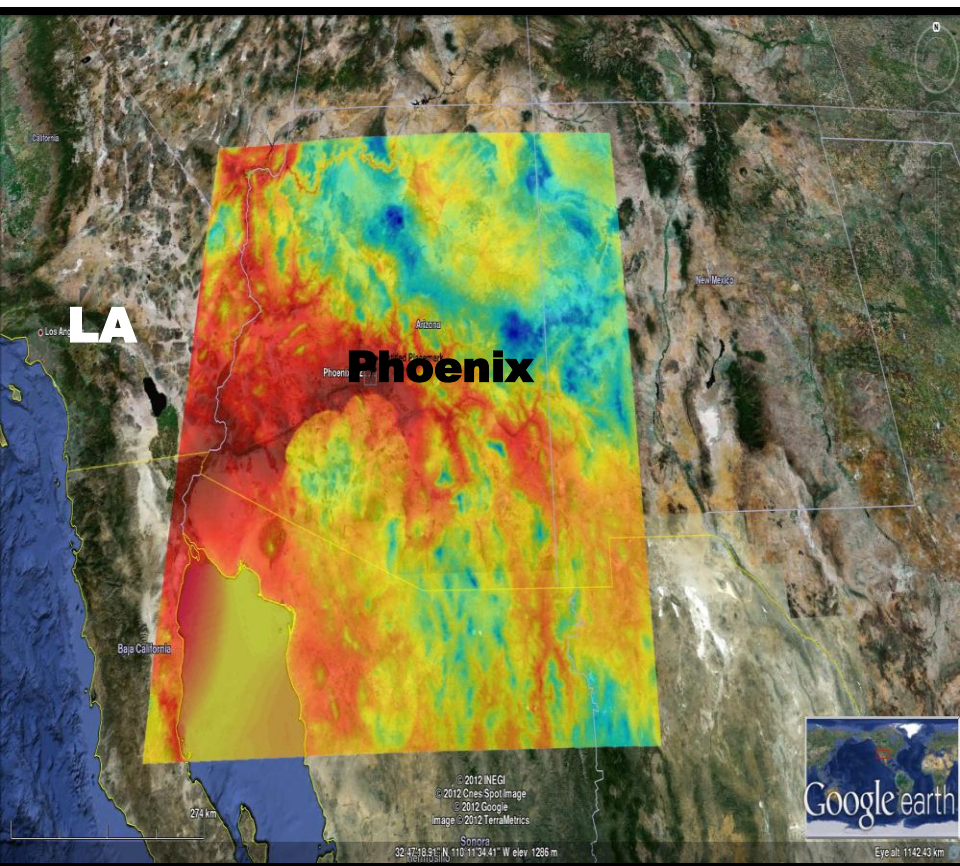
**Leading Edge of
Dust Storm**

NWS Radar at 654 PM MST
Dual-Pol Correlation Coefficient

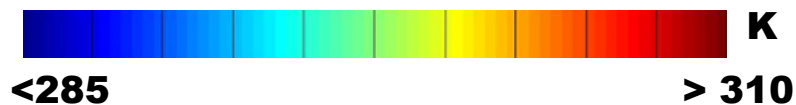
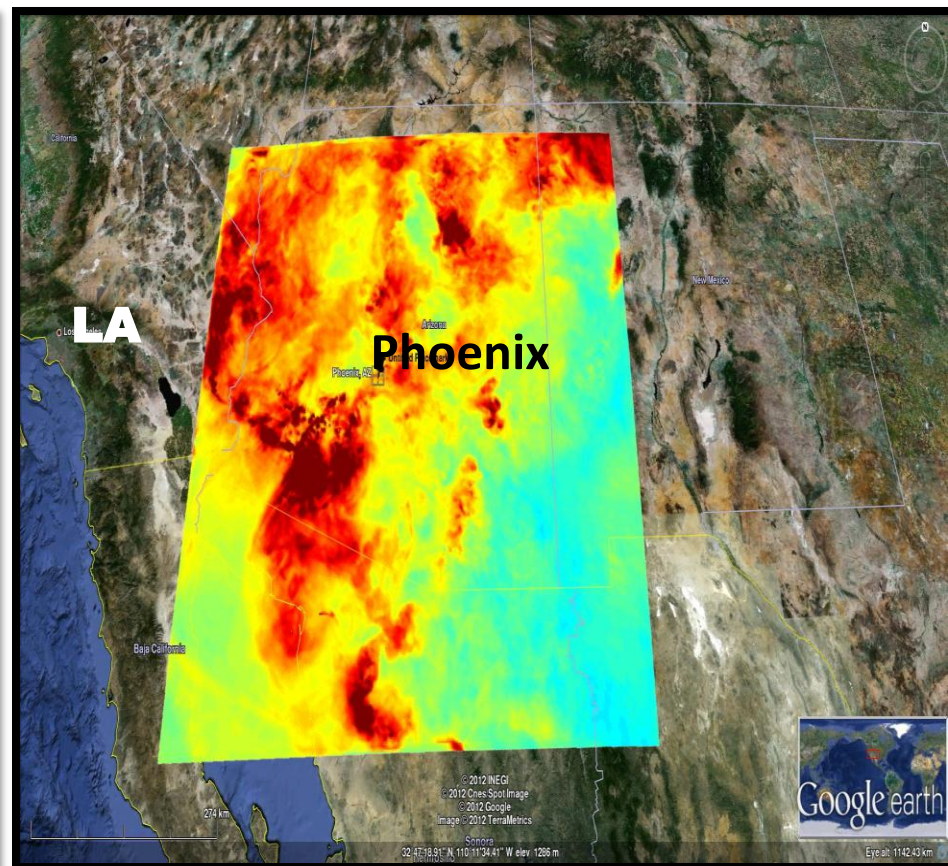
kiwa 0.9 CC 8bit Wed 01:54Z kiwa 0.9 CC 8bit Wed 00:54Z 06-Jul-11

Aerosol Simulation Results

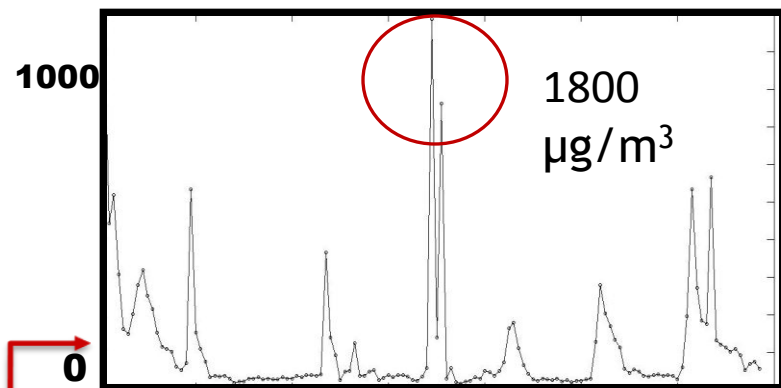
WRF-Chem Simulated downburst
(2011/07/05 @ 7pm Local Time)



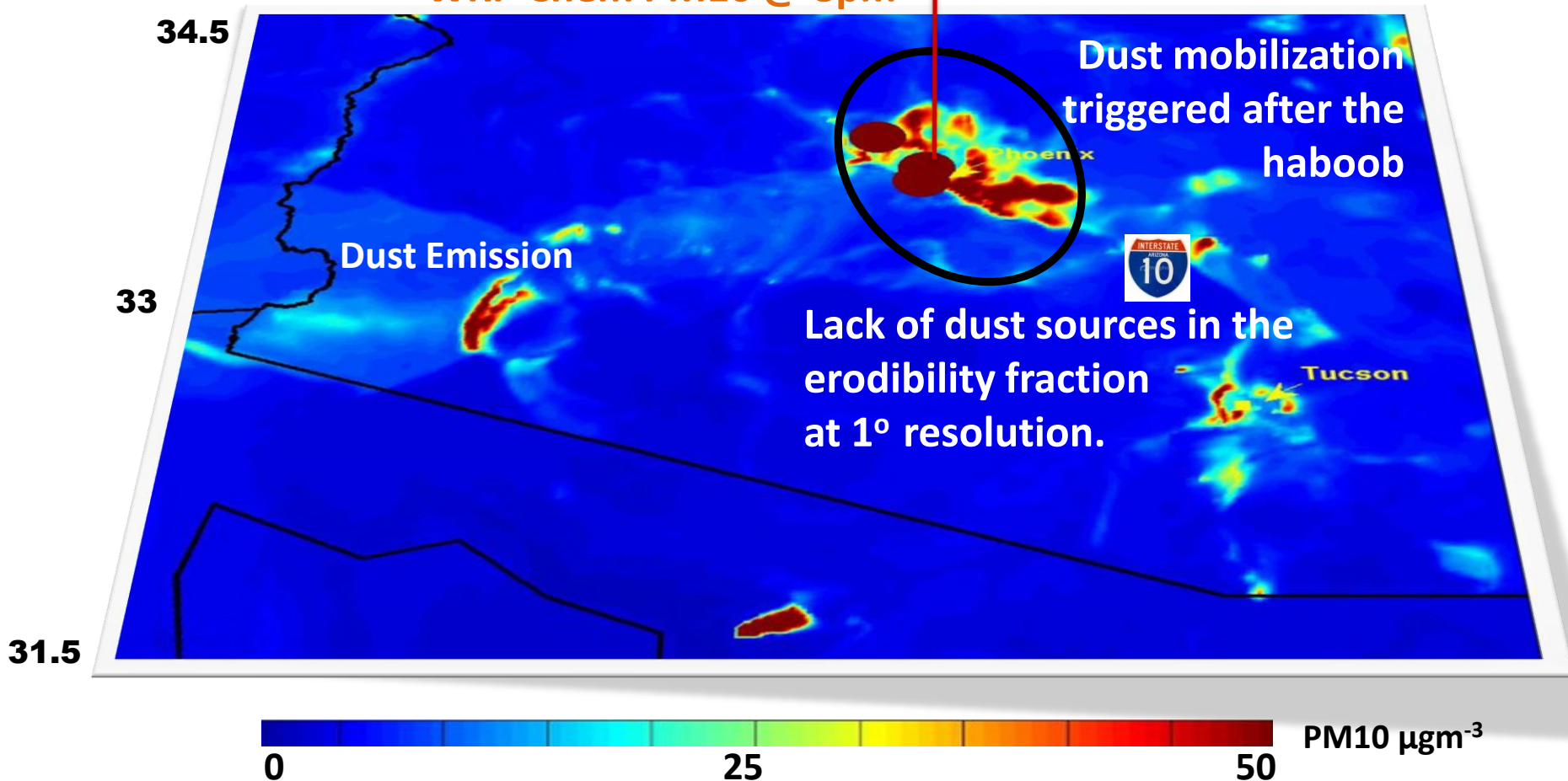
WRF-Chem Simulated AOD
(2011/07/05 @ 8pm Local Time)



- Modeled PM10 captures the pattern but underestimates the magnitude.
- Need to understand the dust sources in Arizona for such highly local yet massive dust events.

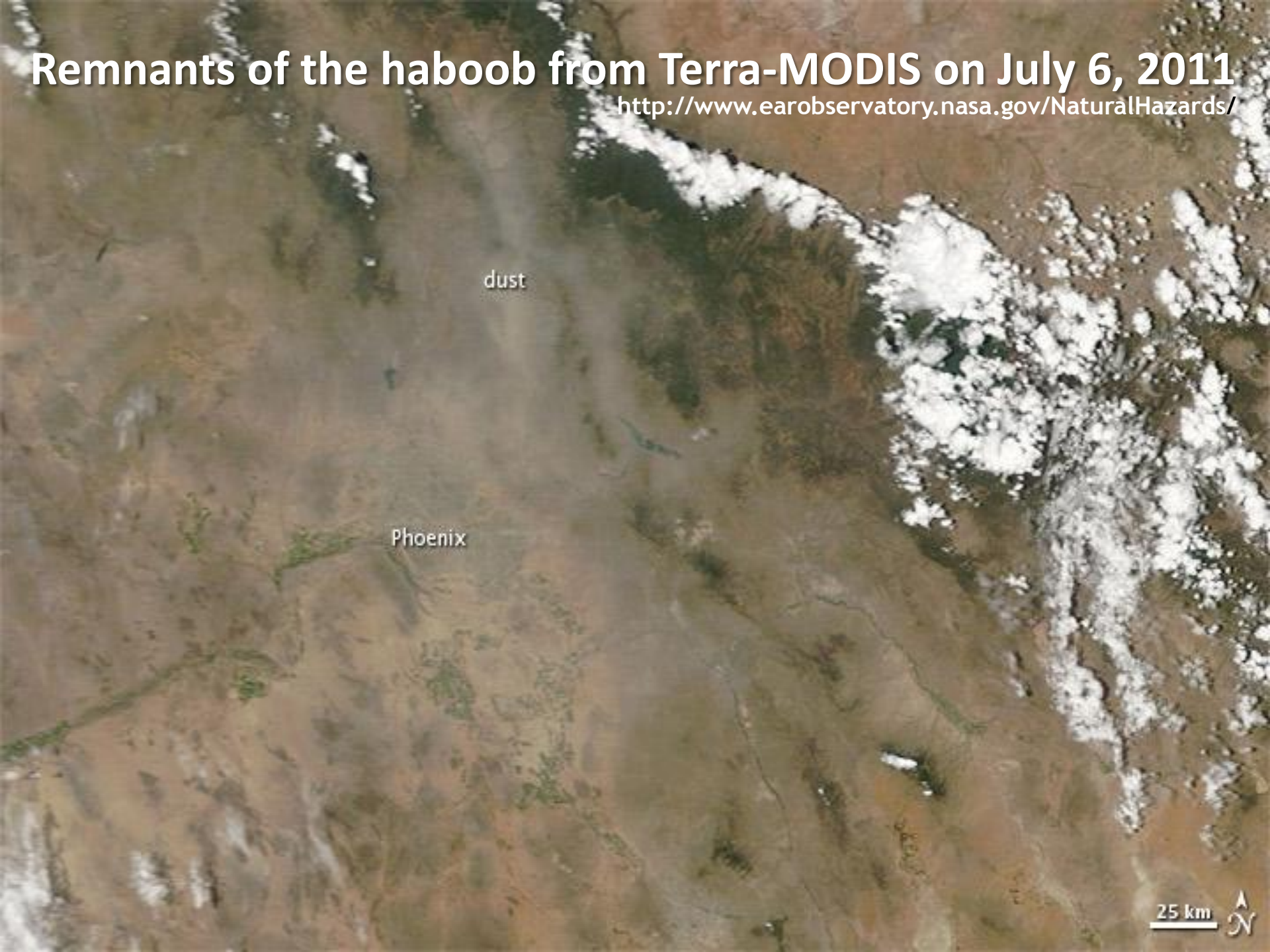


WRF-Chem PM10 @ 8pm



Remnants of the haboob from Terra-MODIS on July 6, 2011

<http://www.earthobservatory.nasa.gov/NaturalHazards/>



Phoenix

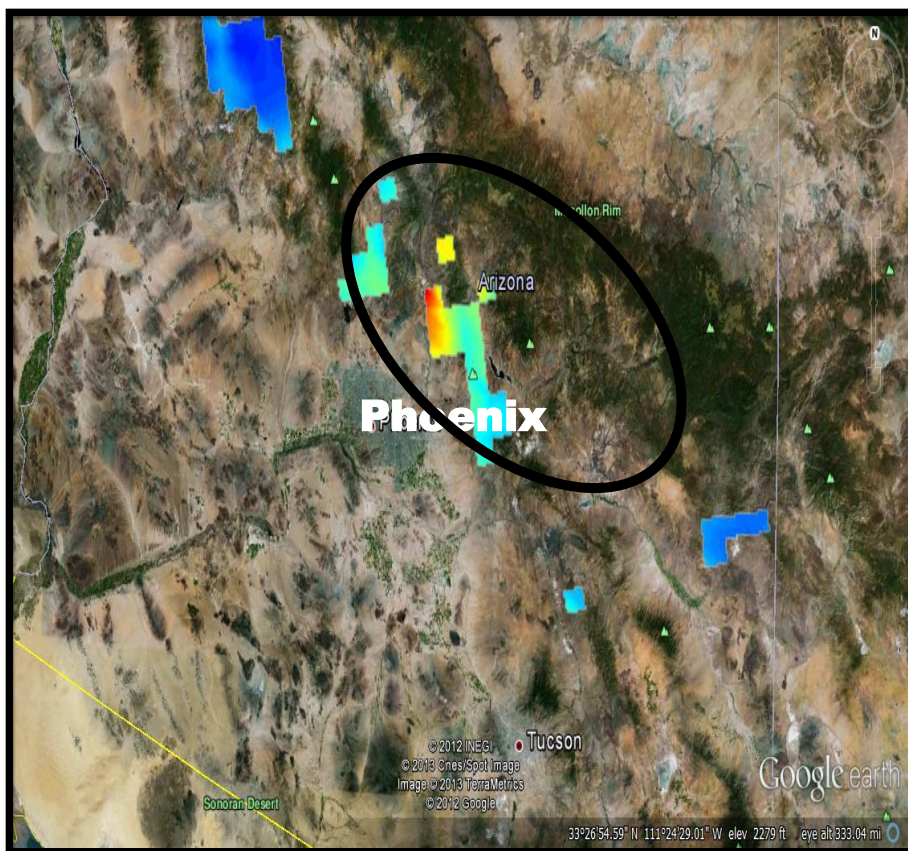
dust

25 km

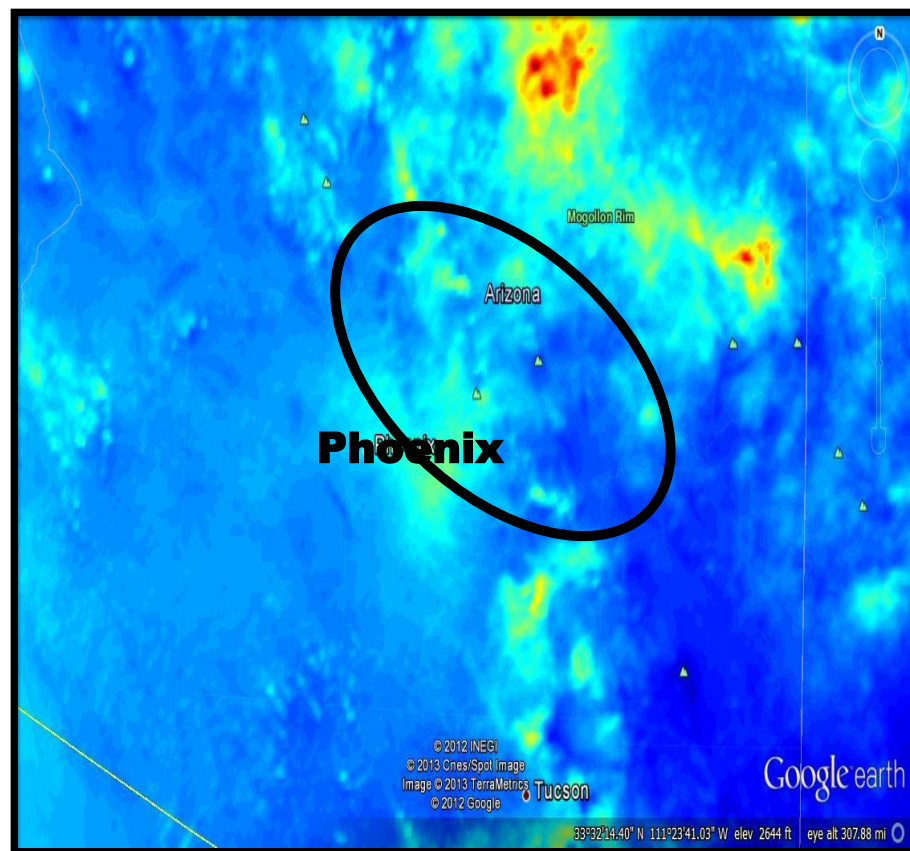


- High AOD observed over North east of Phoenix by TERRA and AQUA MODIS on 6th July , 2011.
- Potential for dust transport to lower free troposphere
- Integration of surface PM10 and satellite retrievals

**Aqua MODIS Level 2 AOD
(2011/07/06)**



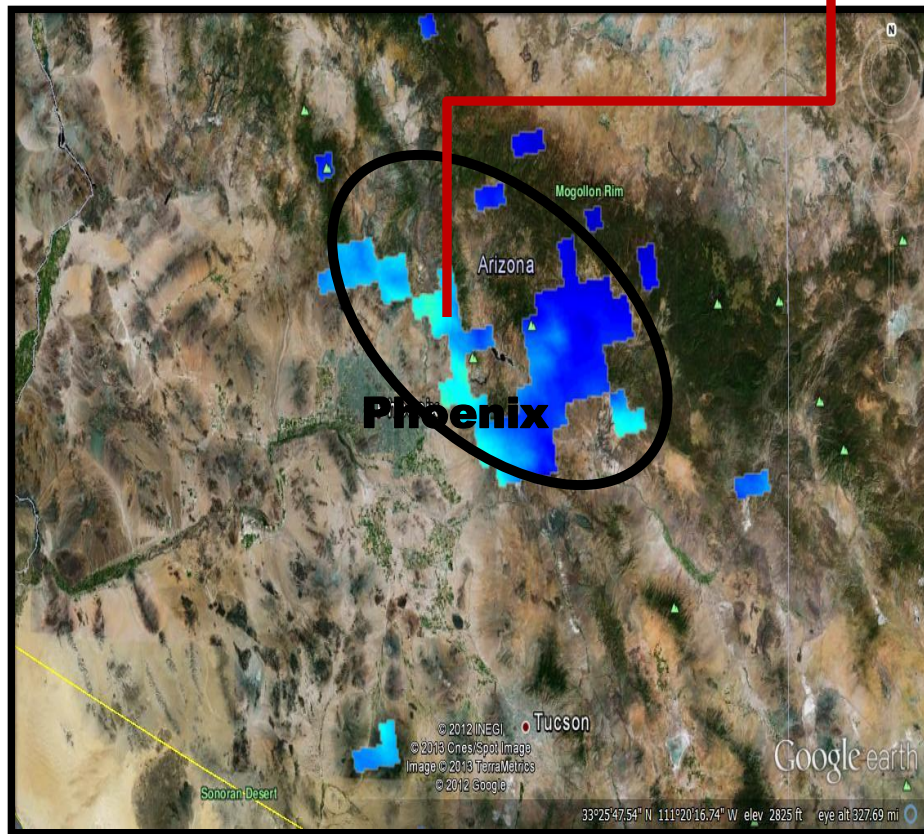
**WRF-Chem simulated AOD
(2011/07/06)**



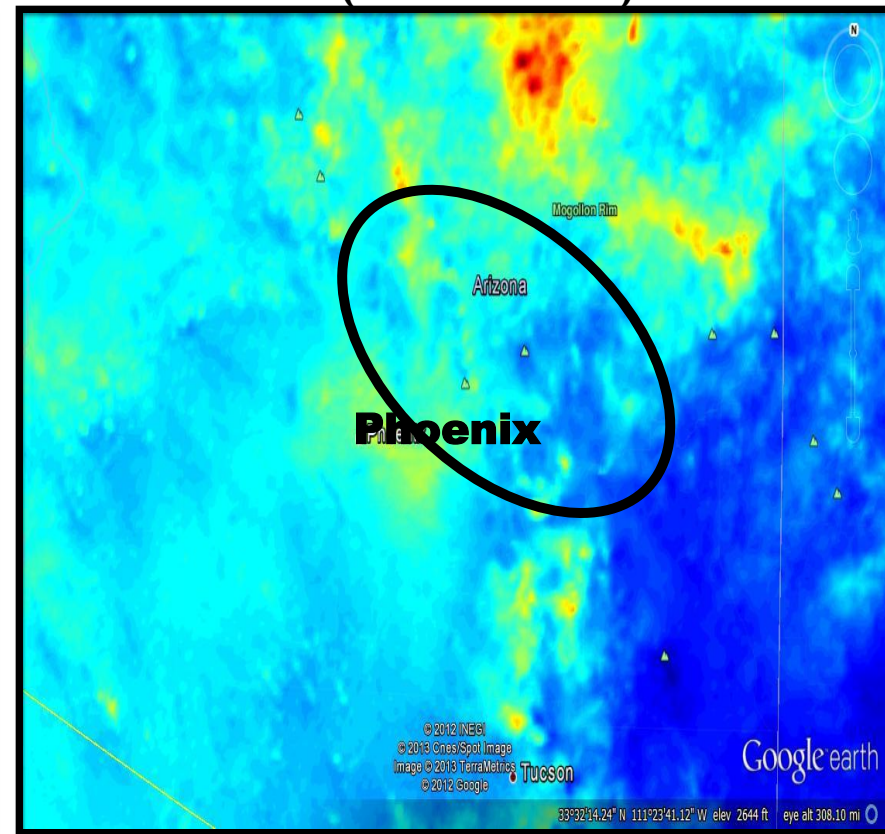
Fate of dust from the haboob

Likely to be dust remnants from the haboob
(dust pathways supported by HYSPLIT back trajectory runs)

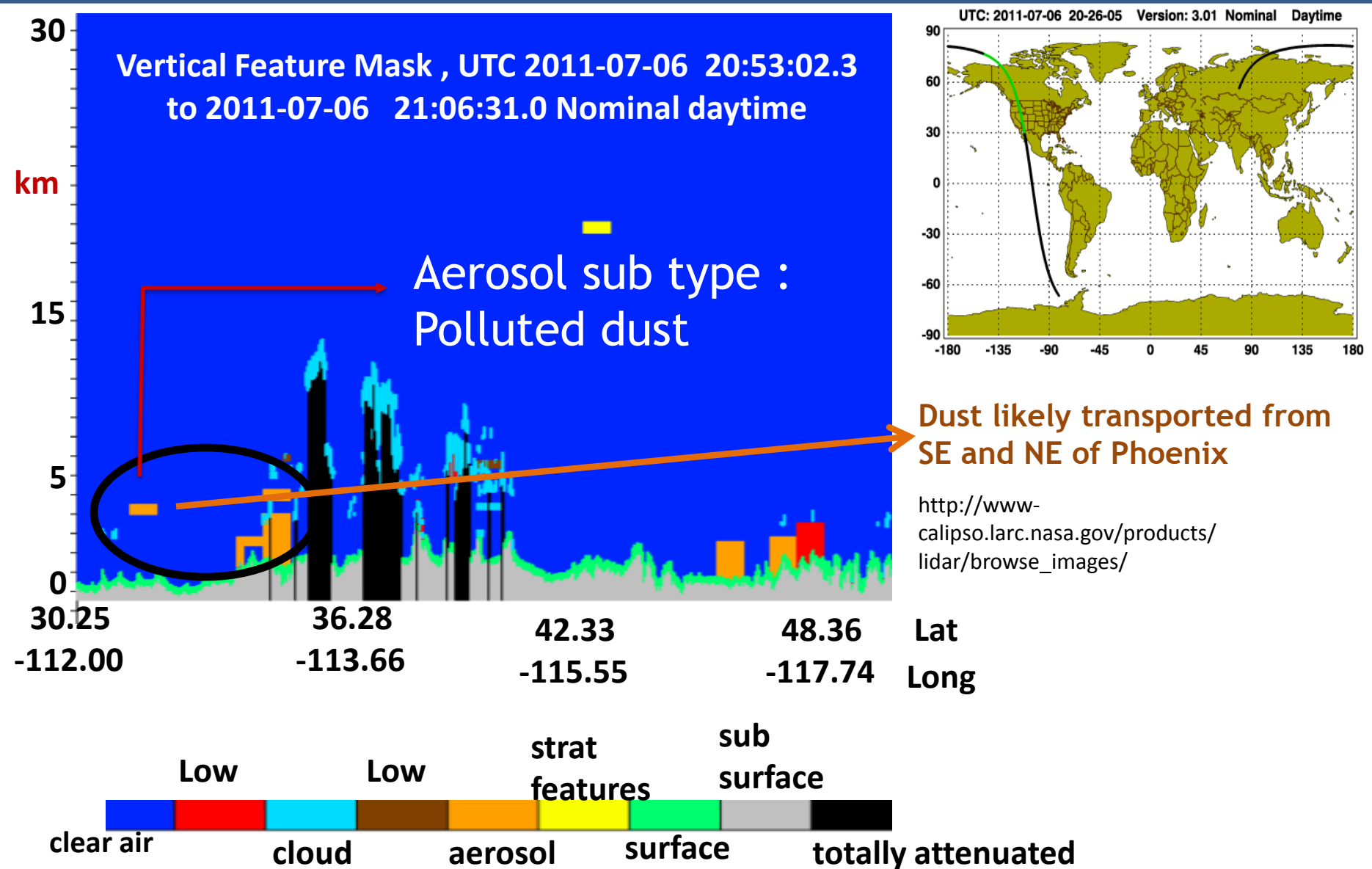
Aqua MODIS AOD
(2011/07/08)



WRF-Chem simulated AOD
(2011/07/08)



Aerosol observation over Phoenix from Calipso - July 6 , 2011



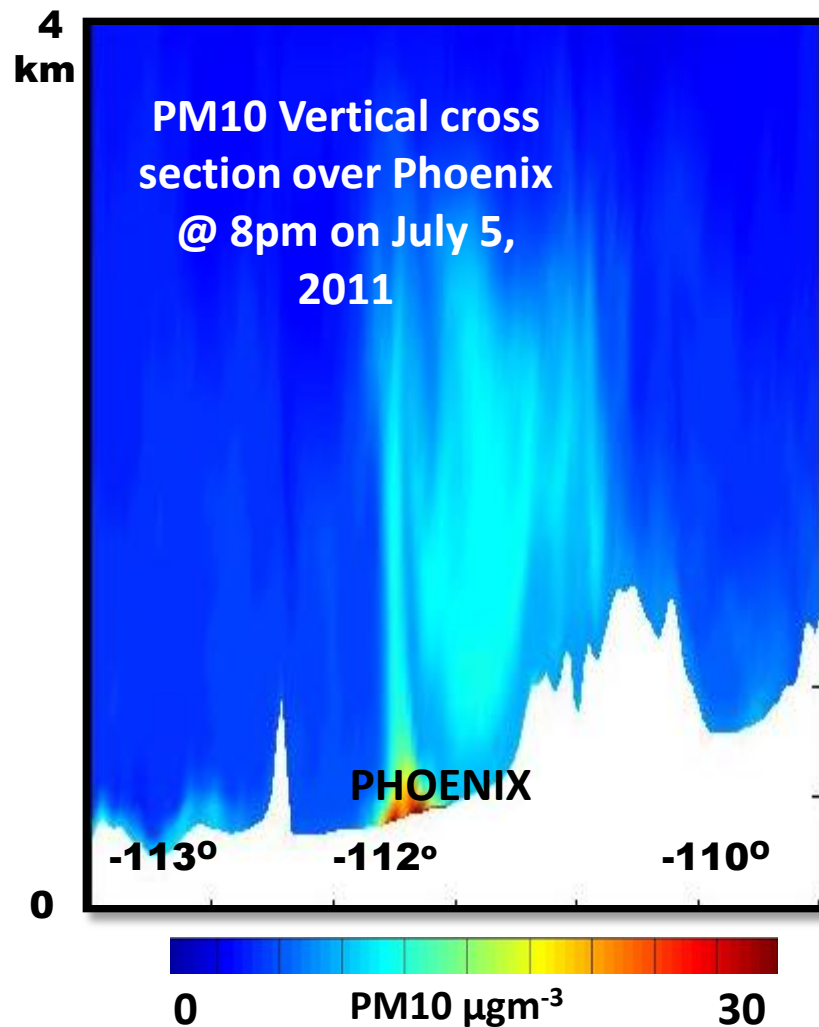
Summary and Future work

- Our initial work shows that WRF-Chem/GOCART (from 'out of the box') is able to capture the meteorology and downburst events associated with the haboob.

- However AOD and PM10 magnitudes appear to be underestimated.

- Need of the hour : Satellite observations with high spatio-temporal coverage. Polar orbiting satellites are not sufficient.

- Future research will focus on modeling and exploration of other potential datasets for land use and evaluation of vertical profiles of dust concentration from such local and massive haboobs.



Thank you

Contact :

aishwaryaraman@email.arizona.edu

NWS office,
Phoenix

