Characterizing the distributions and sources of aerosols during atmospheric river landfall in the western U.S.

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Motivation

- Atmospheric rivers (ARs) are prominent features of the global water cycle. These relatively narrow filaments of warm and moist air are responsible for about 90% of the global poleward moisture transport from the tropics.
- ARs formed over the North Pacific have been connected to heavy precipitation, flooding, and snowpack variability when they cross over the western US, and contribute to 30% to 50% of annual precipitation. Up to three-quarters of persistent droughts along the US West Coast have been ended by a landfalling AR storm.
- Transpacific transport of aerosols is evident in observations and model simulations. They have important impacts on regional air quality as well as radiative forcing and regional hydrological cycles in the United States.
- Two interesting scientific questions are:
  1. What are the characteristics and sources of aerosols during AR landfall over the West Coast?
  2. How do the synoptic conditions along with the ARs change aerosol distributions?

Experiment Design

- Quasi-global simulations for 2010-2014 using periodic boundary conditions in the zonal direction, with 360×145 grid cells (180°W-180°E, 65°S-80°N) at 1° horizontal resolution; Meteorology nudged to GFS reanalysis
- MOSAIC 8-bin aerosol mechanism
- GOCART dust emission scheme
- Morrison 2-moment microphysics and Kain-Fritsch cumulus parameterizations for aerosol transport and wet-scavenging.

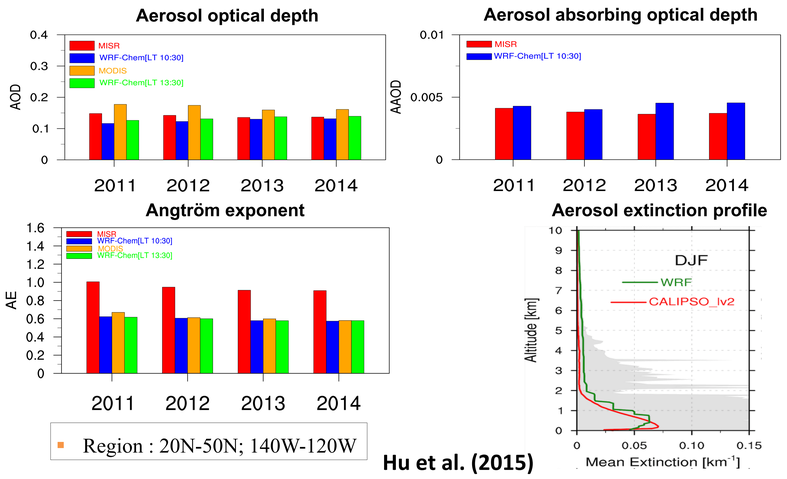
Definition of atmospheric river

AR is defined based on the definition in Ralph et al. (2004) as contiguous objects with:

1. Vertically integrated precipitable water > 2 cm;
2. Wind speed at surface > 12 m/s;
3. Length > 2000 km and Width < 1000 km;
4. Make landfall.

Results and Discussion

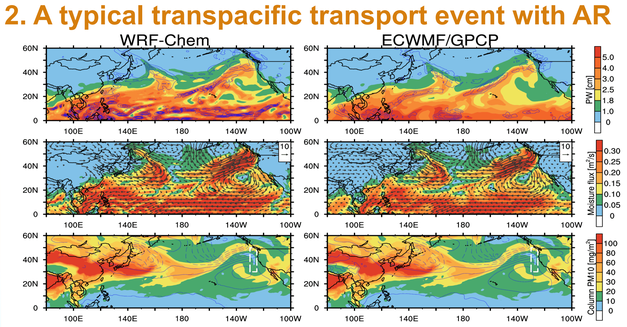
1. Evaluation of aerosol simulation near the West Coast



- Region : 20N-50N; 140W-120W

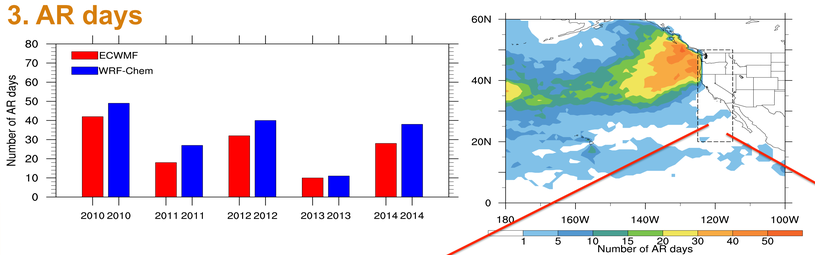
Hu et al. (2015)

2. A typical transpacific transport event with AR

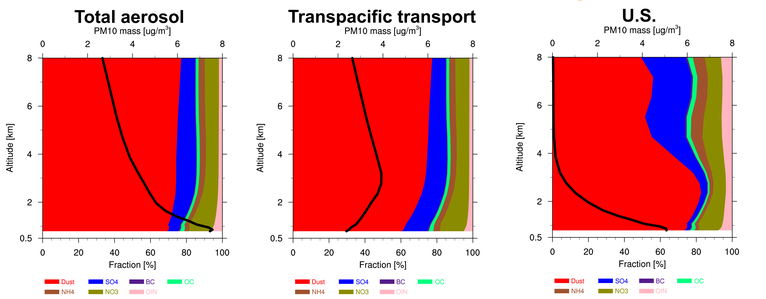


January 24, 2012

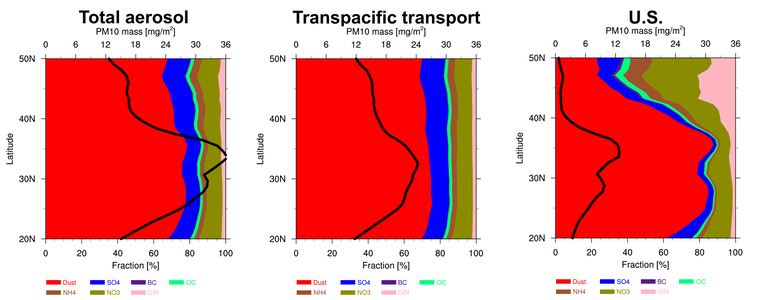
3. AR days



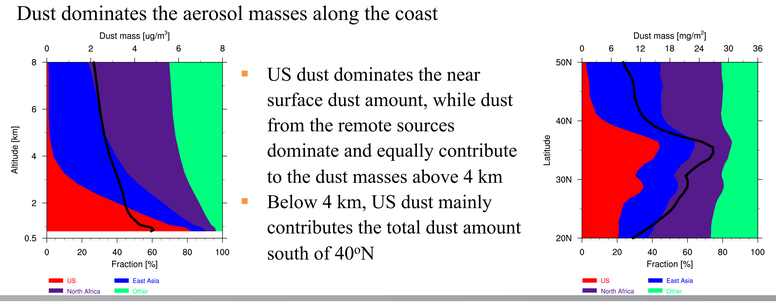
4. Characteristics and sources of aerosols during AR landfall



- Transpacific transport dominates the aerosol sources above 2km
- The US source dominates the aerosol contributions near the surface
- Dust dominates the aerosol masses from the surface to 8 km

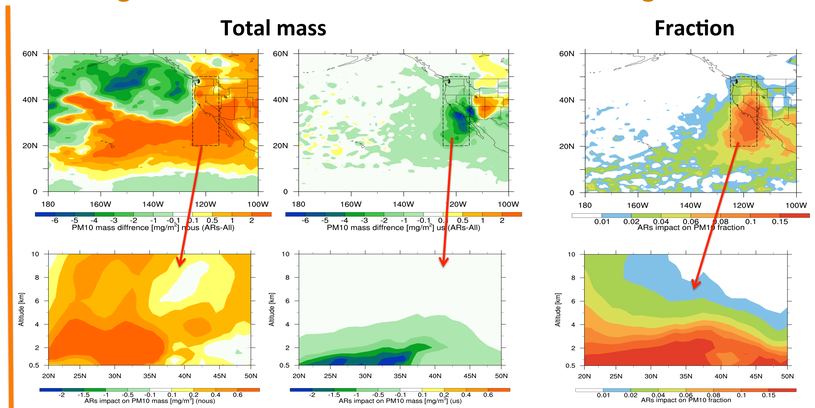


- Transpacific transport dominates the aerosol sources north of 40°N
- Aerosol masses are maximum around 32°N along the coast
- Dust dominates the aerosol masses along the coast

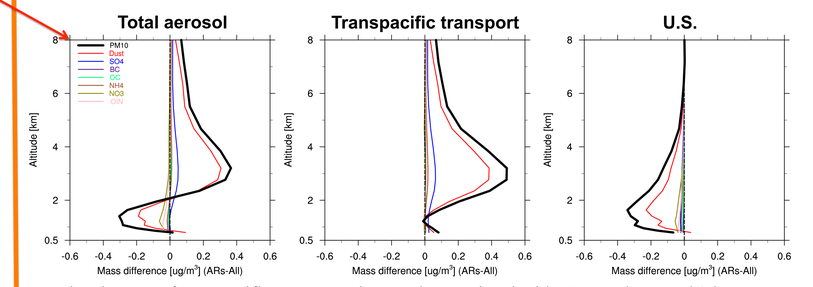


- US dust dominates the near surface dust amount, while dust from the remote sources dominate and equally contribute to the dust masses above 4 km
- Below 4 km, US dust mainly contributes the total dust amount south of 40°N

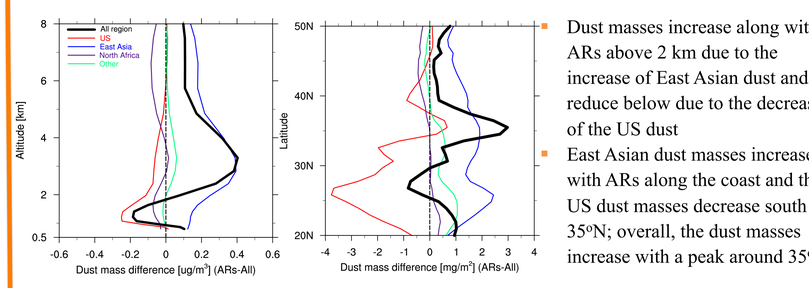
5. Changes of aerosols over the West Coast along with ARs



- During AR events, transpacific transported aerosols are more abundant while the US contribution is reduced over the west coast
- The changes of aerosol masses during ARs are mainly located south of 40°N



- The changes of transpacific transported aerosols associated with ARs peak around 3 km; overall, during AR events, aerosol masses are reduced below 2 km and enhanced above.



- Dust masses increase along with ARs above 2 km due to the increase of East Asian dust and reduce below due to the decrease of the US dust
- East Asian dust masses increase with ARs along the coast and the US dust masses decrease south of 35°N; overall, the dust masses increase with a peak around 35°N

Conclusion

- **WRF-Chem can well simulate the ARs and aerosol distributions near the US west coast;**
- **Transpacific transport dominates the aerosol sources above 2 km, while the US source dominates the aerosol contributions near the surface; dust dominates the aerosol masses;**
- **Transpacific transport dominates the aerosol contributions north of 40°N; aerosol masses are maximum around 32°N along the coast; dust dominates the aerosol masses along the coast;**
- **US dust dominates the near surface dust amount, while dust from the remote sources dominates above 4 km; US dust mainly contributes the total dust amount to the south of 40°N;**
- **Associated with ARs, the transpacific transported aerosols increase but the US contribution decreases over the west coast; the overall change of aerosols is mainly he north of 40°N and below 6 km; the aerosol masses decrease below 2 km and increase above;**
- **Associated with ARs, dust masses above 2 km increase due to the increase of East Asian dust and decrease of dust masses below 2 km due to the decrease of US dust; East Asian dust masses increase along the coast and the US dust decrease to the south of 35°N; overall, the dust masses increase with the peak around 35°N**

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