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Aerosol Effects on Clouds and Precipitation: Insights from CalWater 2015 and a Multi-year Quasi-global Simulation of Trans-Pacific Transport of Aerosols

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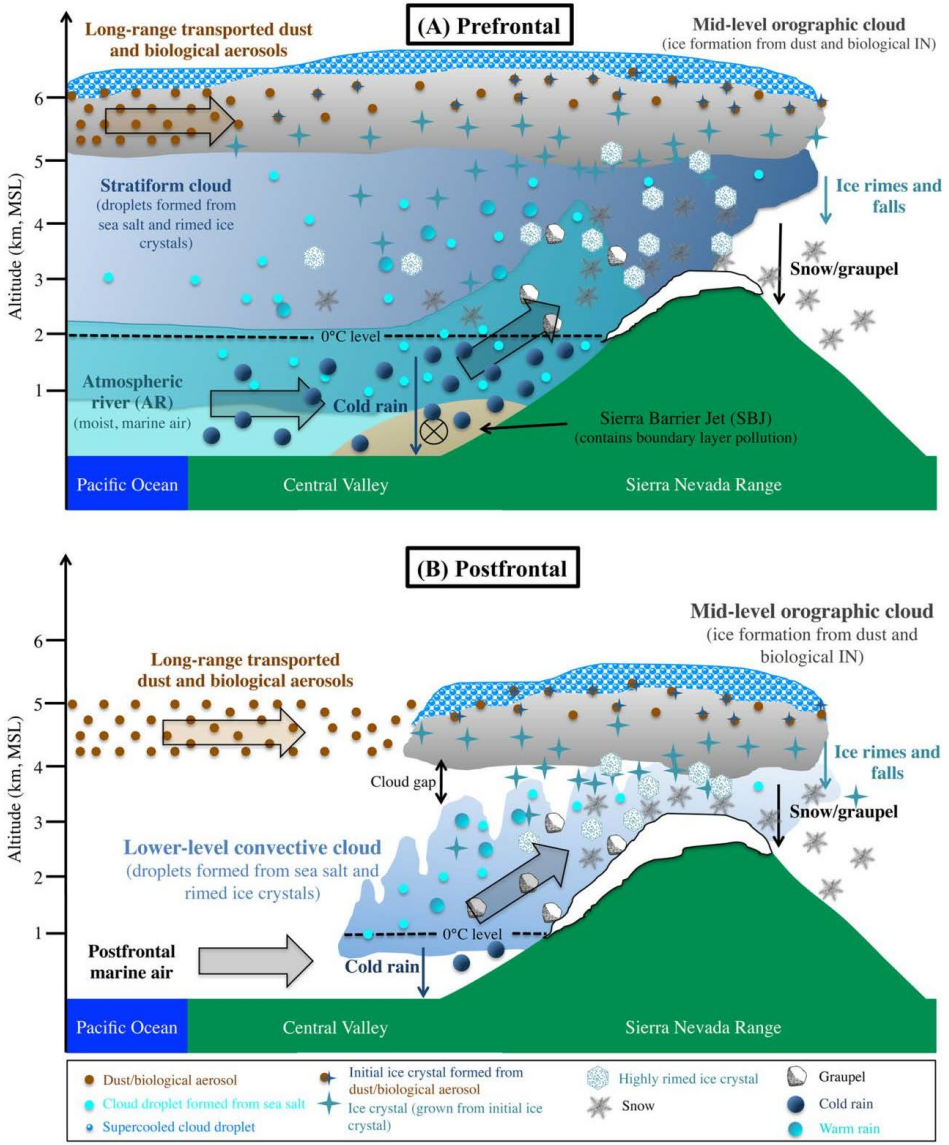
2016 International Atmospheric Rivers Conference, August 8 - 11, 2016, La Jolla, CA

Dust effects identified from in-situ measurements during CalWater 2011

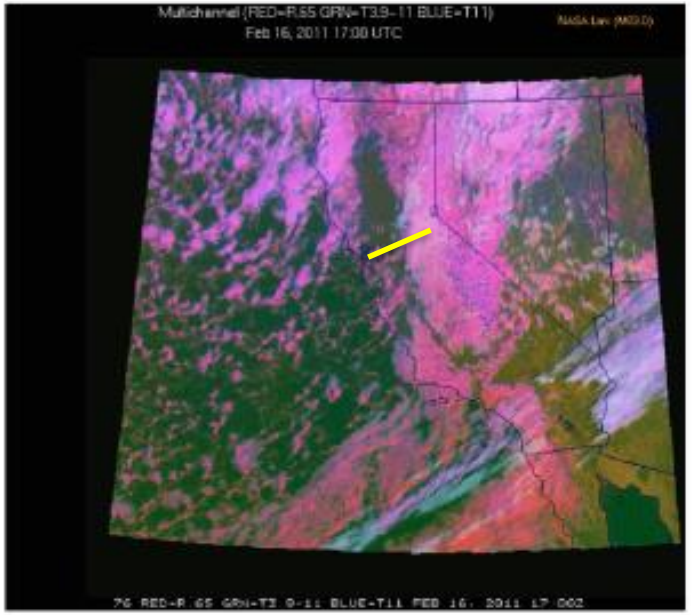
- During an AR event, dust and biological particles from long-range transport influence ice nucleation in mid-level orographic clouds and precipitation forming processes



(Creamean et al. 2013, Science)

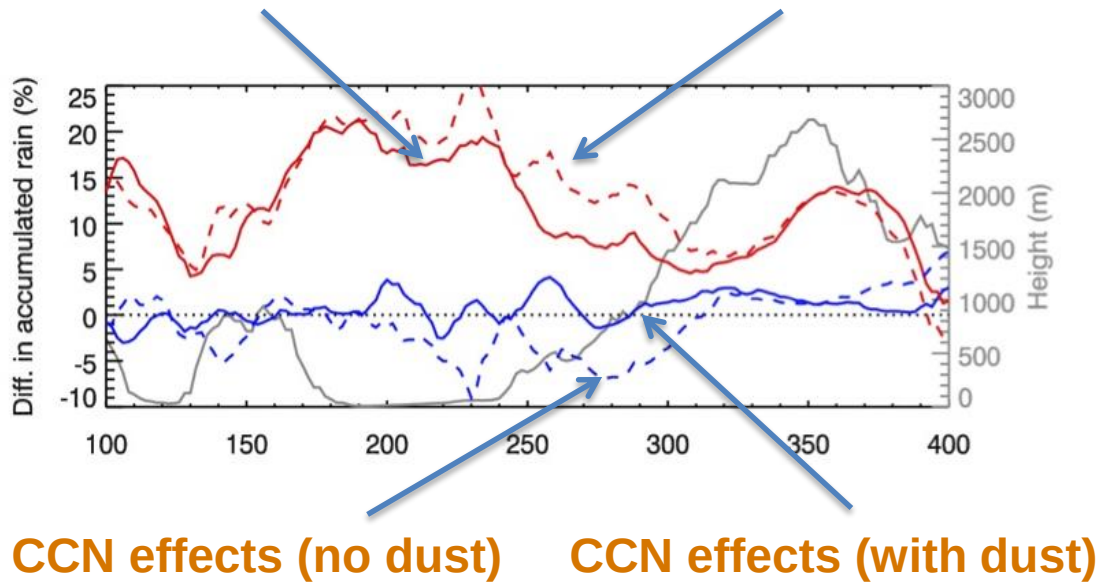
Modeling quantifies aerosol effects on precipitation

(a) FEB16



17:00 UTC on Feb. 16

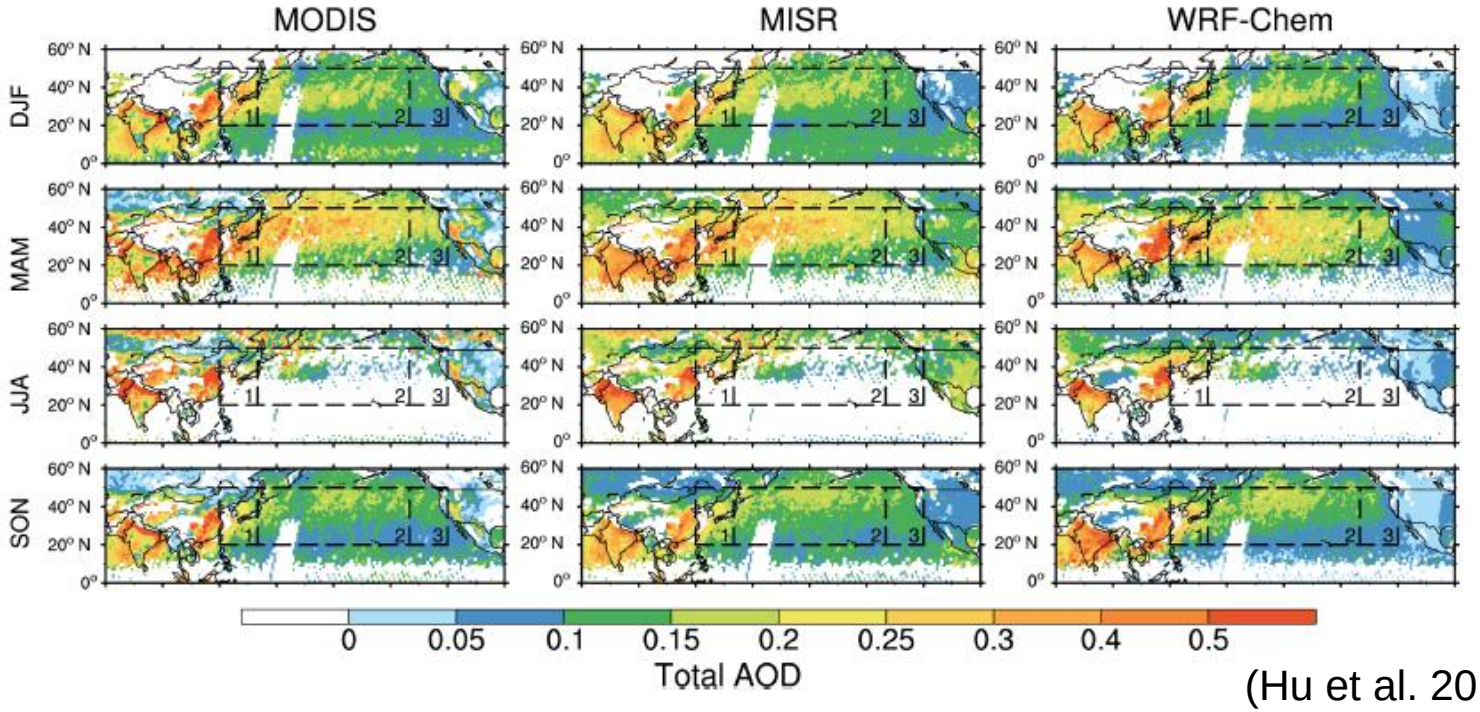
(Fan et al. 2014, ACP)



- Dust increases precipitation (mainly snowfall) by up to 20%, with larger effects under polluted conditions
- Pollution aerosols (CCN) suppress precipitation by about 5% without dust, but when dust is present, CCN enhance precipitation

Modeling trans-pacific dust transport

- What are the contributions from trans-pacific transport to total dust mass in the western US?
- Are more dust transported across the Pacific during ARs?
- Performed quasi-global WRF-Chem simulations for 2010-2014 at 1º horizontal resolution; nudging of winds to the GFS reanalysis

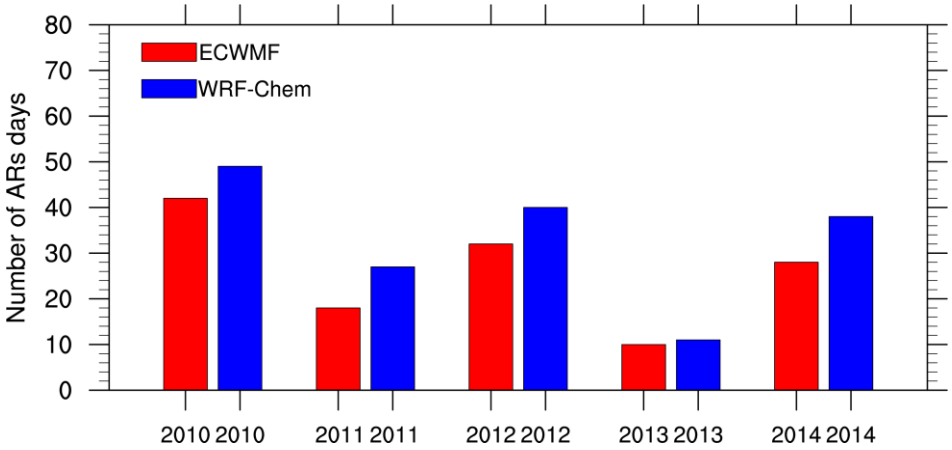


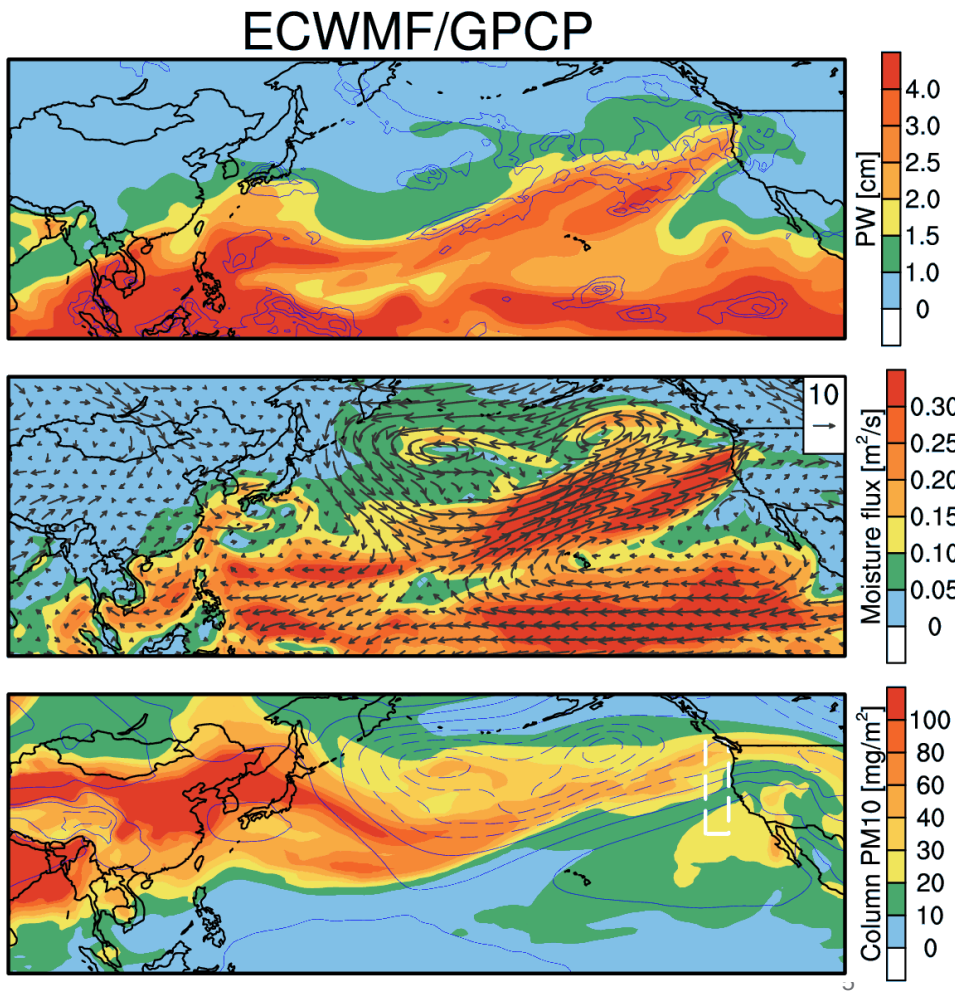
(Hu et al. 2016, GMD)

ARs statistics are reasonably simulated

A typical trans-pacific transport event with an atmospheric river on January 19, 2012

Number of days with landfalling ARs between 30N – 55N (October – March)

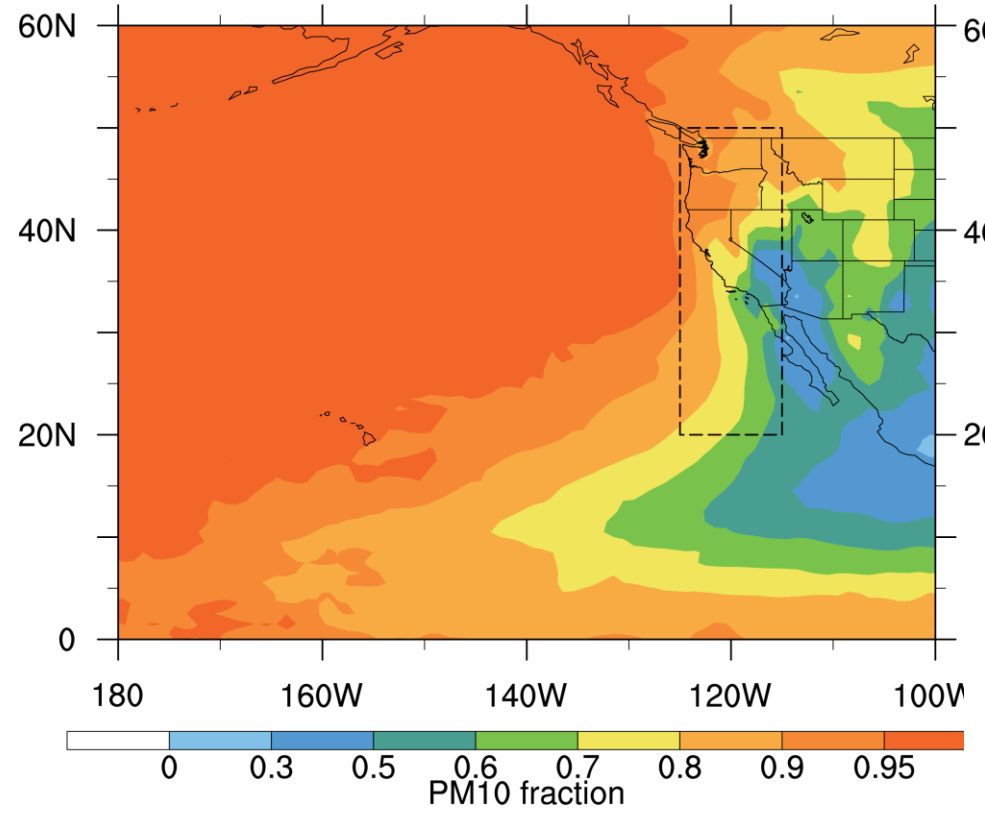




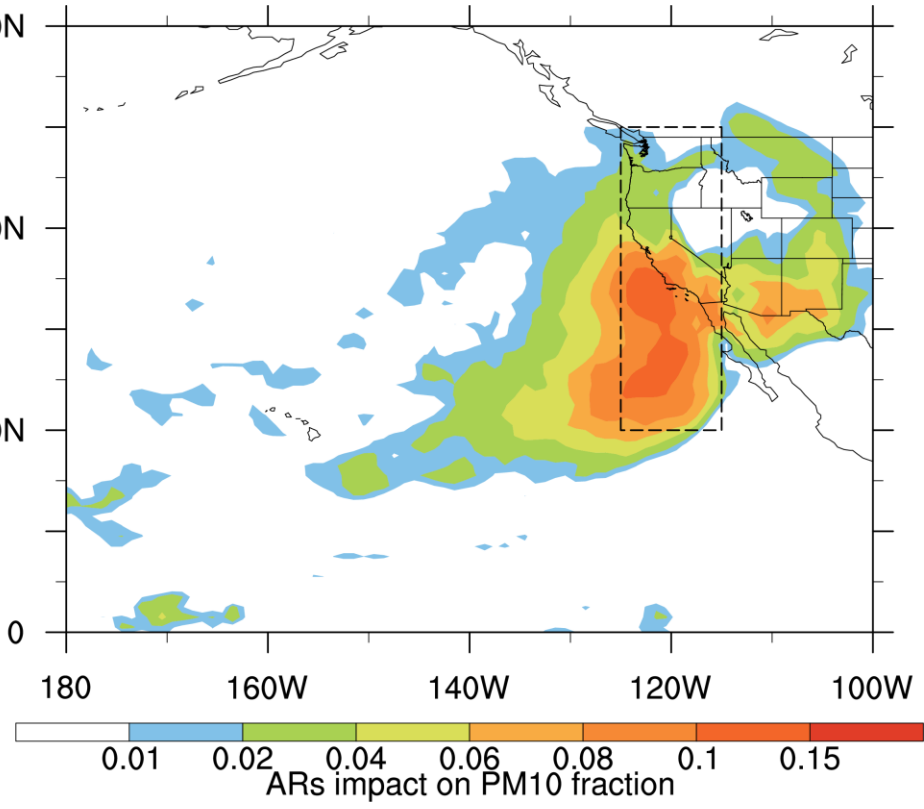
Trans-pacific and AR contribution to total dust mass

- Trans-pacific dust transport contributes more to total dust mass during AR days than the average, particularly in CA

Trans-pacific contribution to total dust mass (October – March)



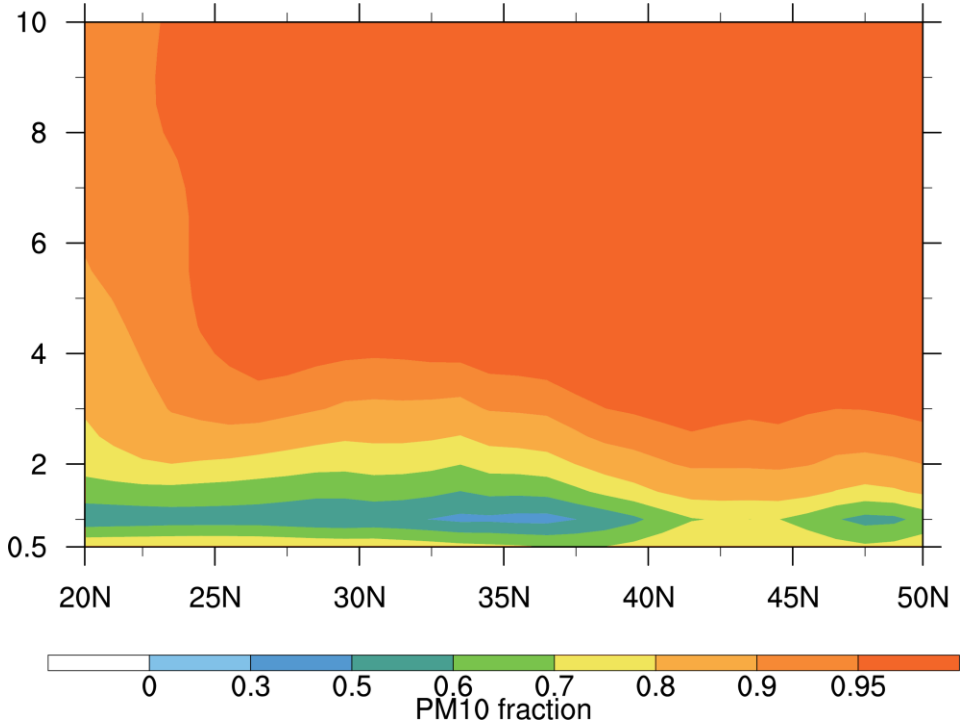
Difference between AR and average trans-pacific contribution to total dust mass (October – March)



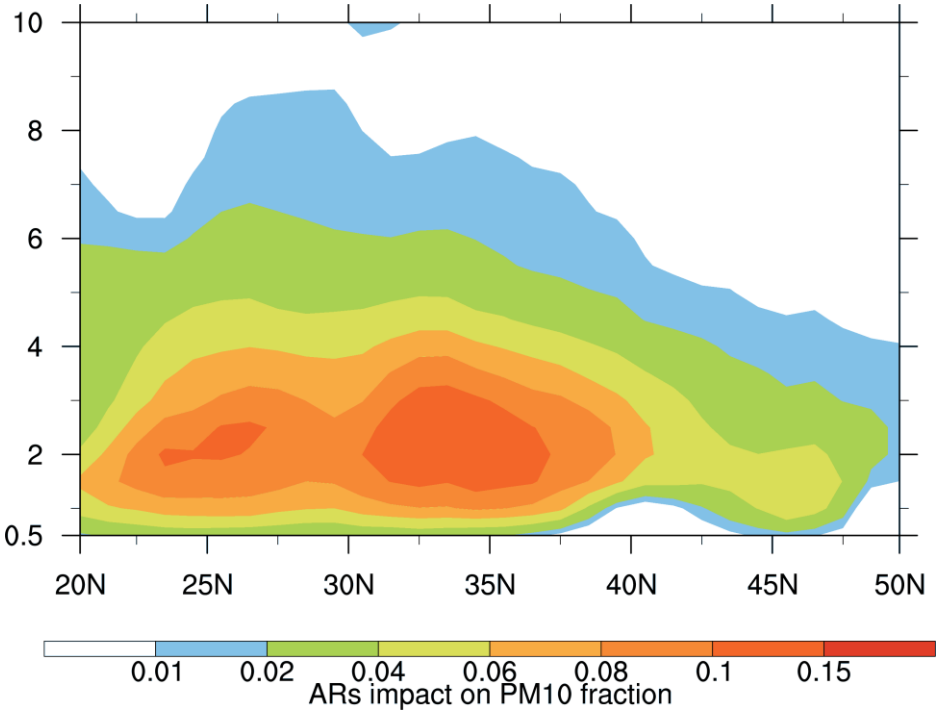
Trans-pacific and AR contribution to dust in western US

- Trans-pacific transport contributes more to total dust mass during AR than the average, particularly between 1 – 4 km in altitude

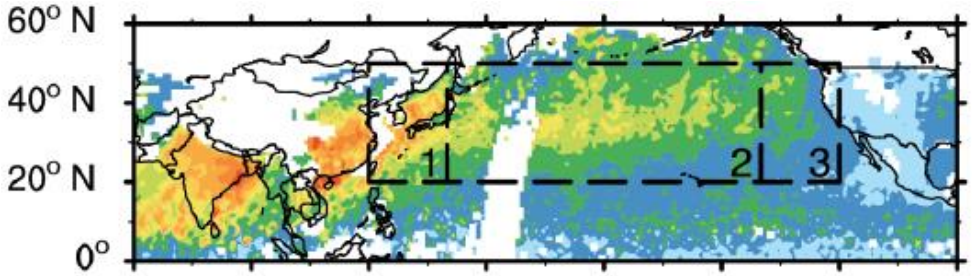
Trans-pacific contribution to total dust mass (October – March)

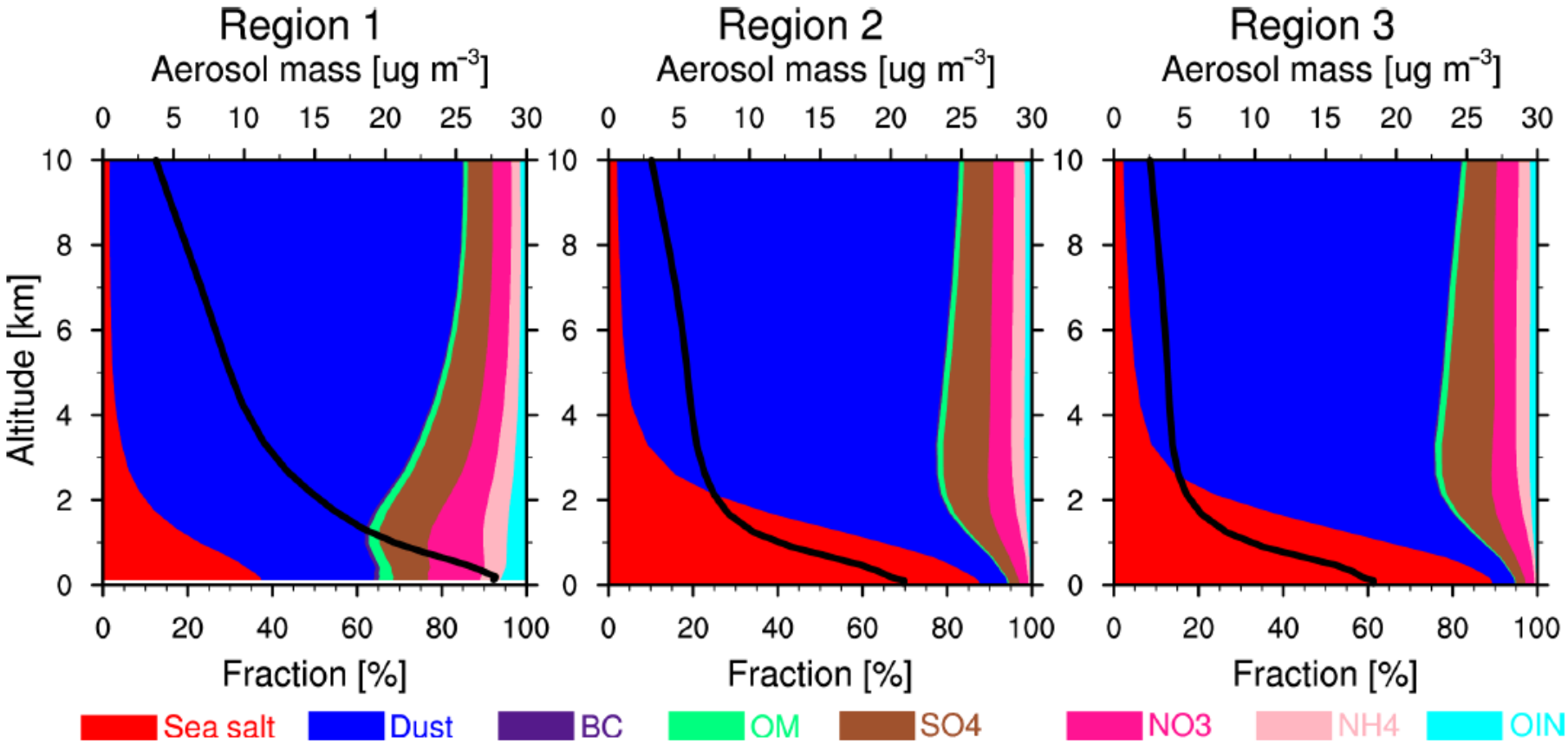


Difference between AR and non-AR trans-pacific contribution to total dust mass (October – March)

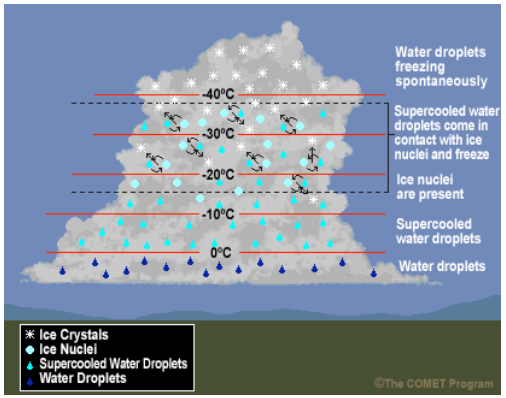


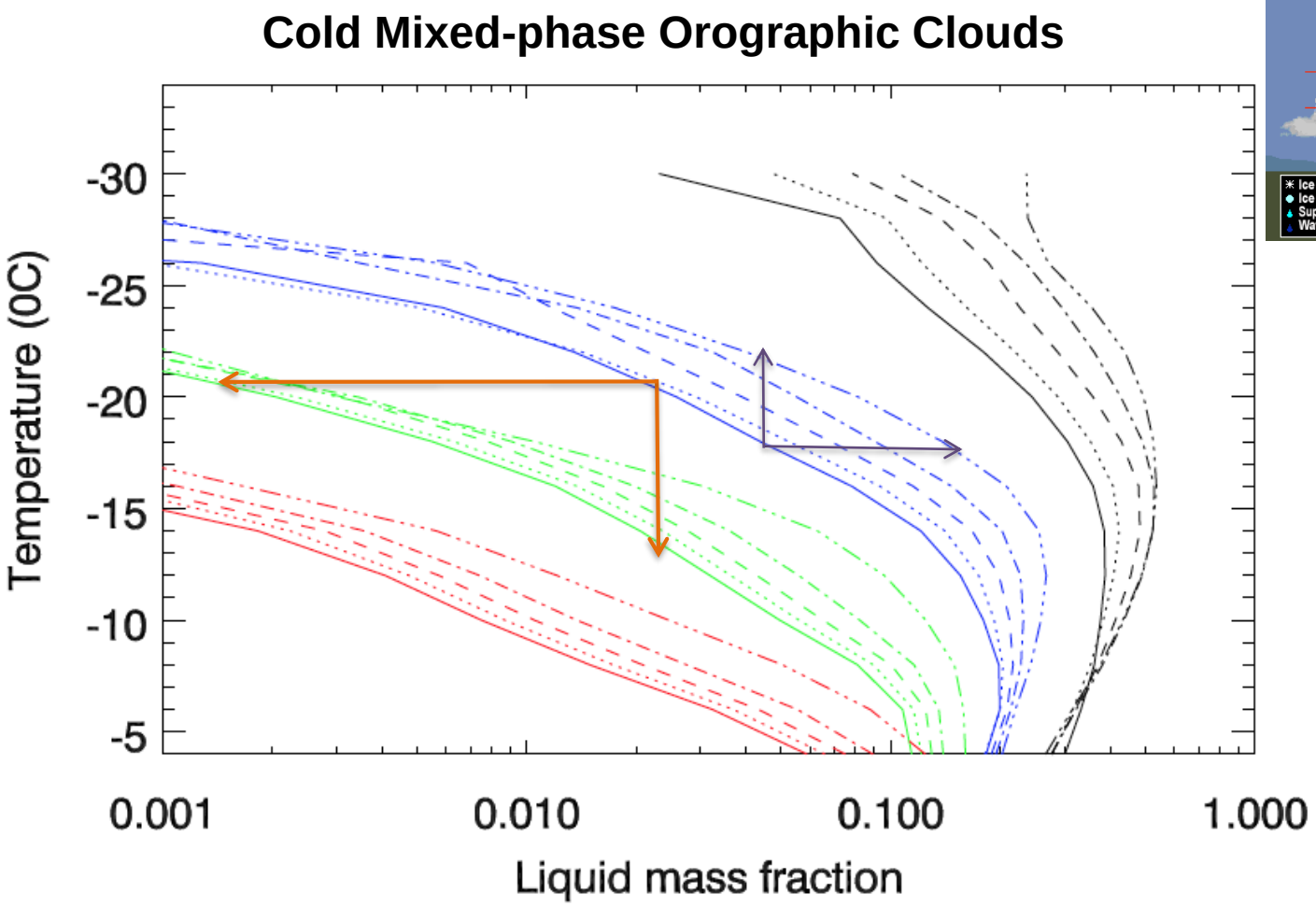
Dust dominates aerosol mass at altitudes above 2 km





CCN and IN impacts on supercooled liquid and cloud phase





An AR event during CalWater 2015

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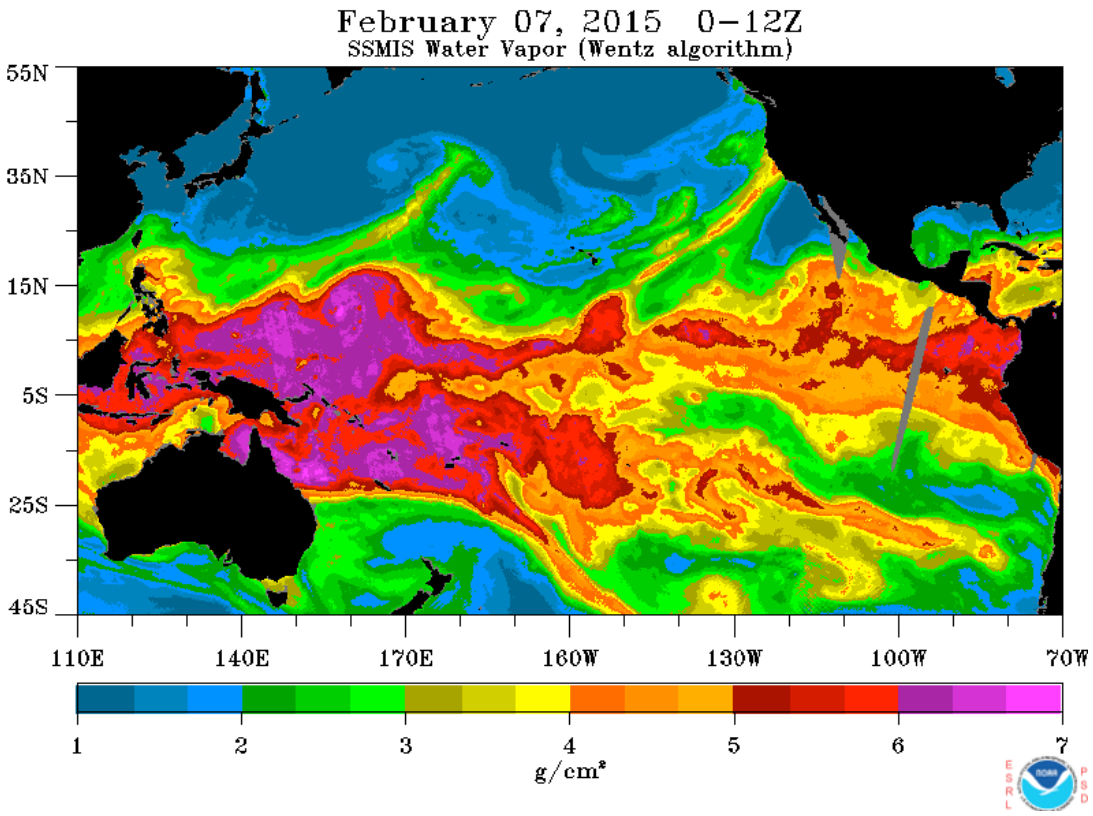
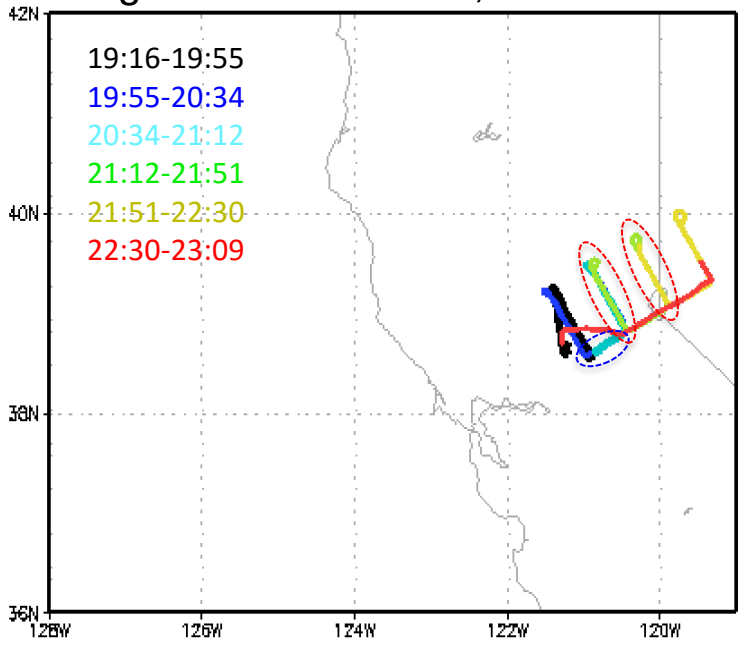


DOE ARM Aerial Facility (AAF)

Flight Track on Feb 7, 2015



Supercooled liquid in orographic clouds at -38ºC

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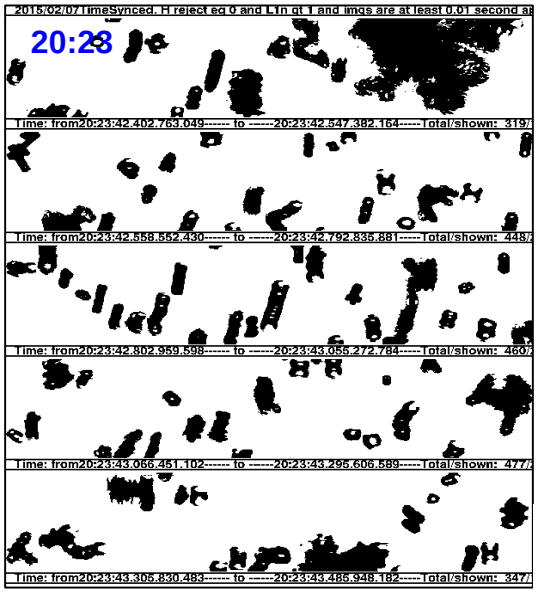

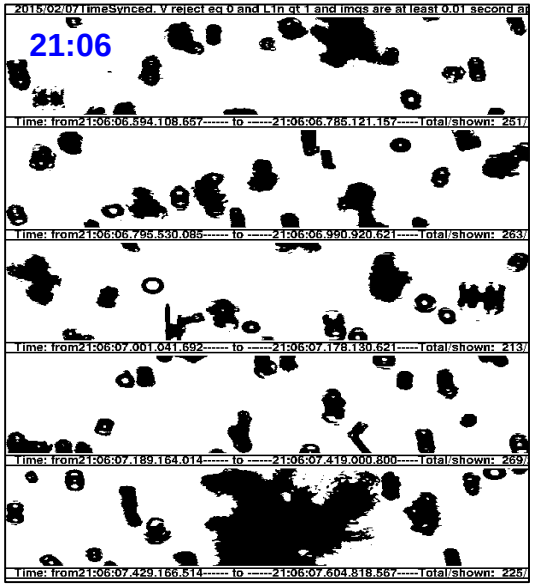

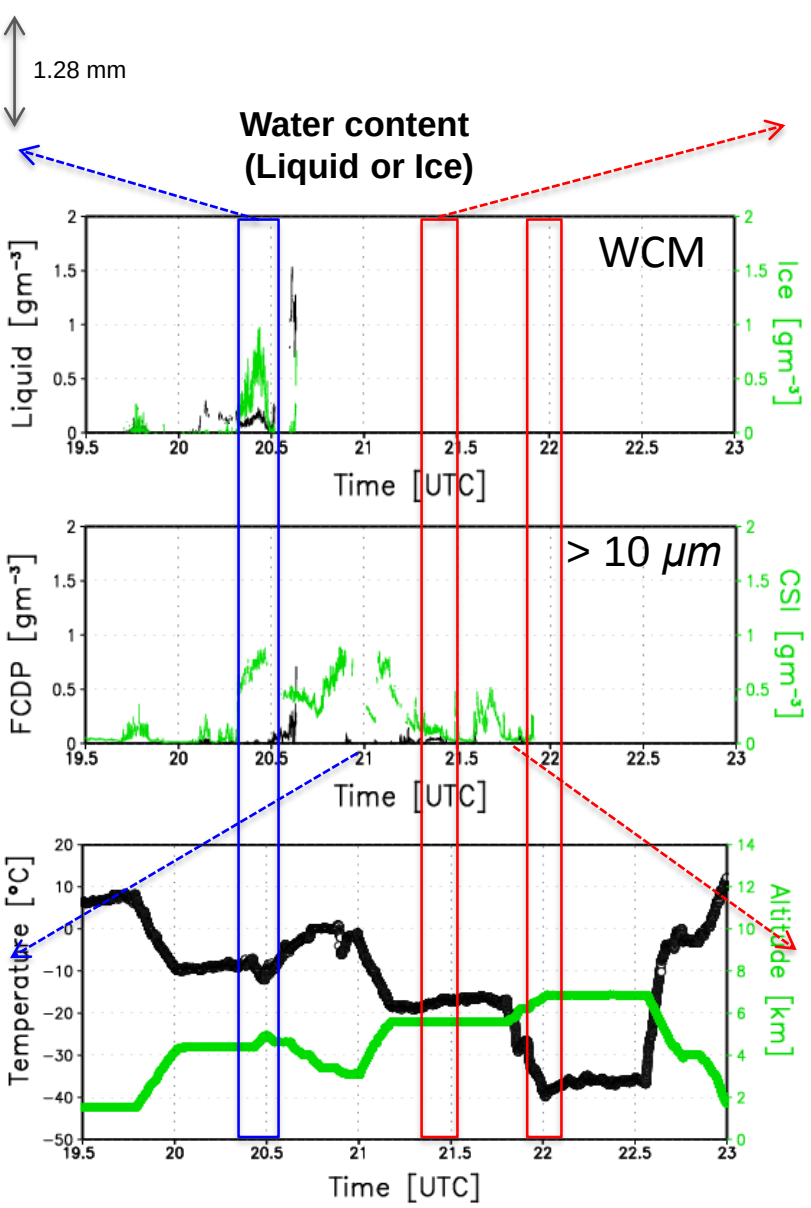

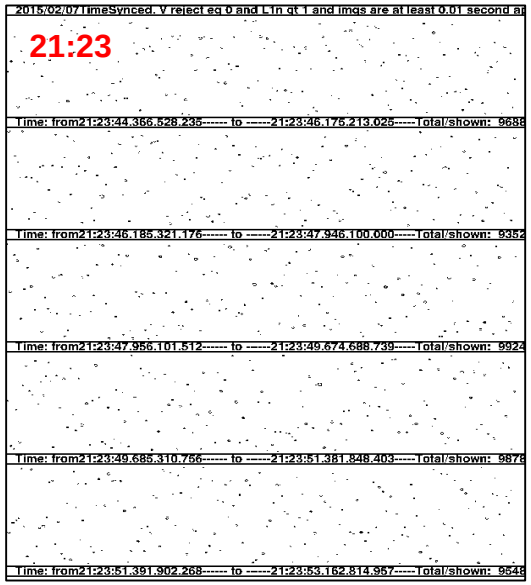

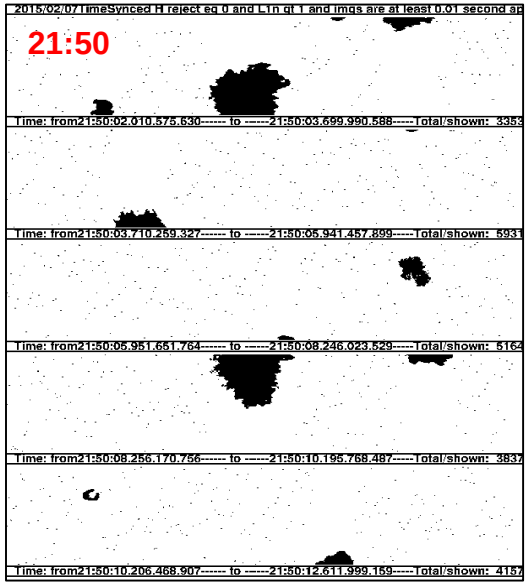

Long-range transported BC and OC

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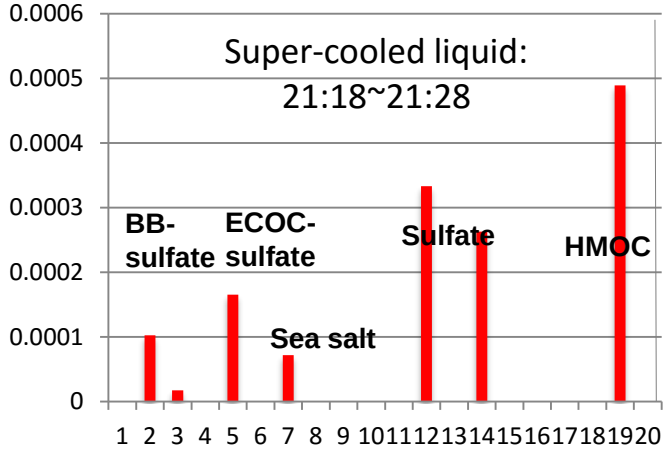
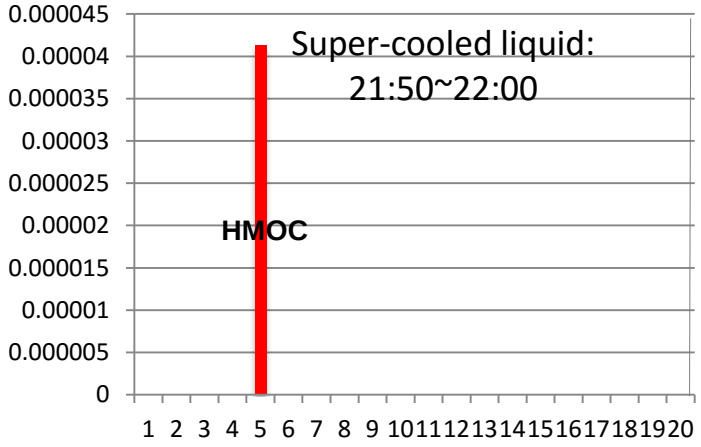
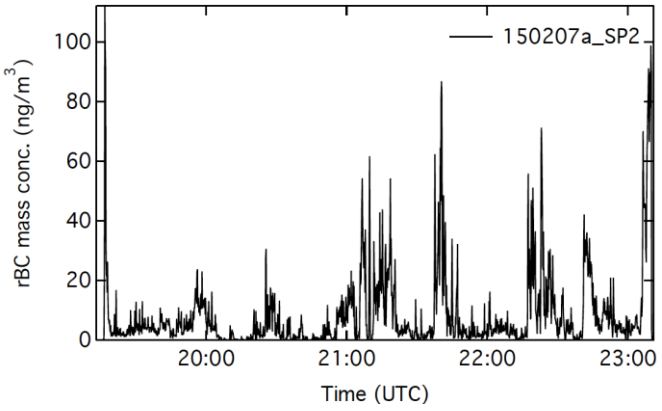
- Measurements of aerosol chemical composition, BC concentration, and light absorption suggest the presence of aerosols with low hygroscopicity

Aerosol chemical composition

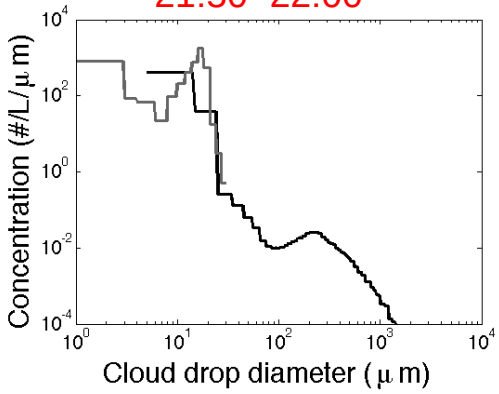




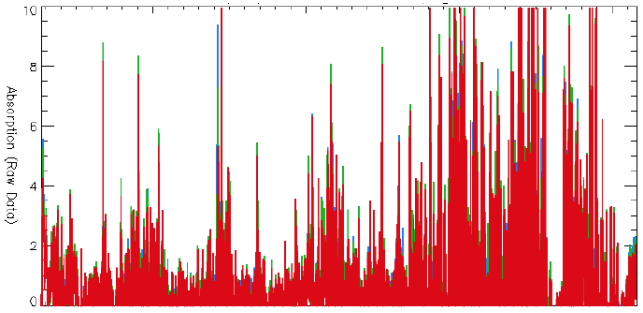
BC concentration

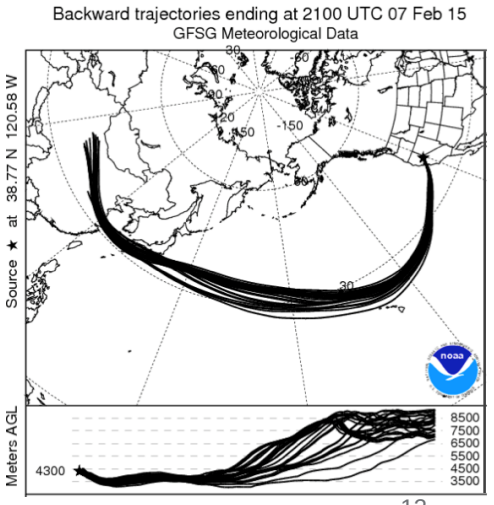


Super-cooled liquid:
21:50~22:00



Light absorption coefficient





Summary

- Trans-pacific transport contributes > 70% of the total dust mass in central CA and PNW in the cold season
- On AR days, trans-pacific transport contributes even more to the total dust mass, particularly in CA and between 1 – 3 km in altitude
- On average, dust dominates the aerosol mass in the Pacific ocean above 2 km
- By altering the composition of CCN and IN, trans-pacific aerosols have important effects on clouds and precipitation associated with ARs
- However, the aerosol composition from trans-pacific transport is variable, and its differing impacts on precipitation need to be better understood