



NOAA RESEARCH • ESRL • PHYSICAL SCIENCES DIVISION

Linking Aerosols and Precipitation

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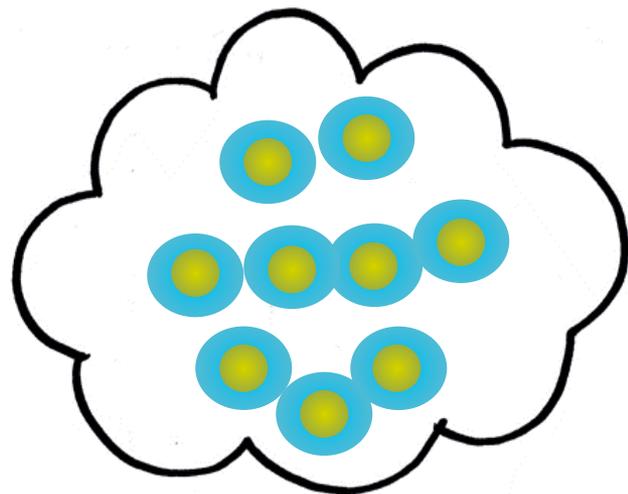
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How Can Aerosols Influence Precipitation?

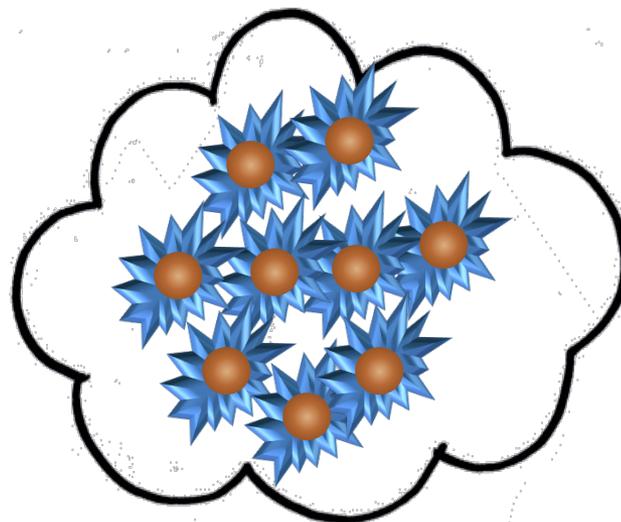
Cloud Condensation Nuclei (CCN)

Suppress/delay the onset of precipitation



Ice Nuclei (IN)

Enhance precipitation

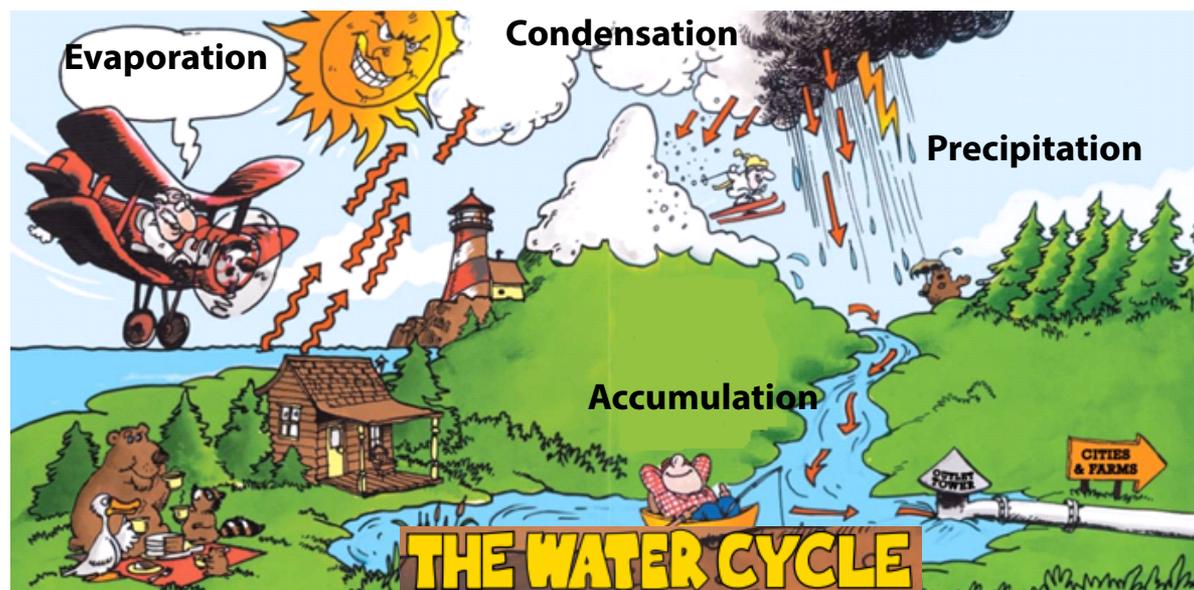


Cloud-aerosol-precipitation interactions = CAPI

Aerosol Impacts on Weather

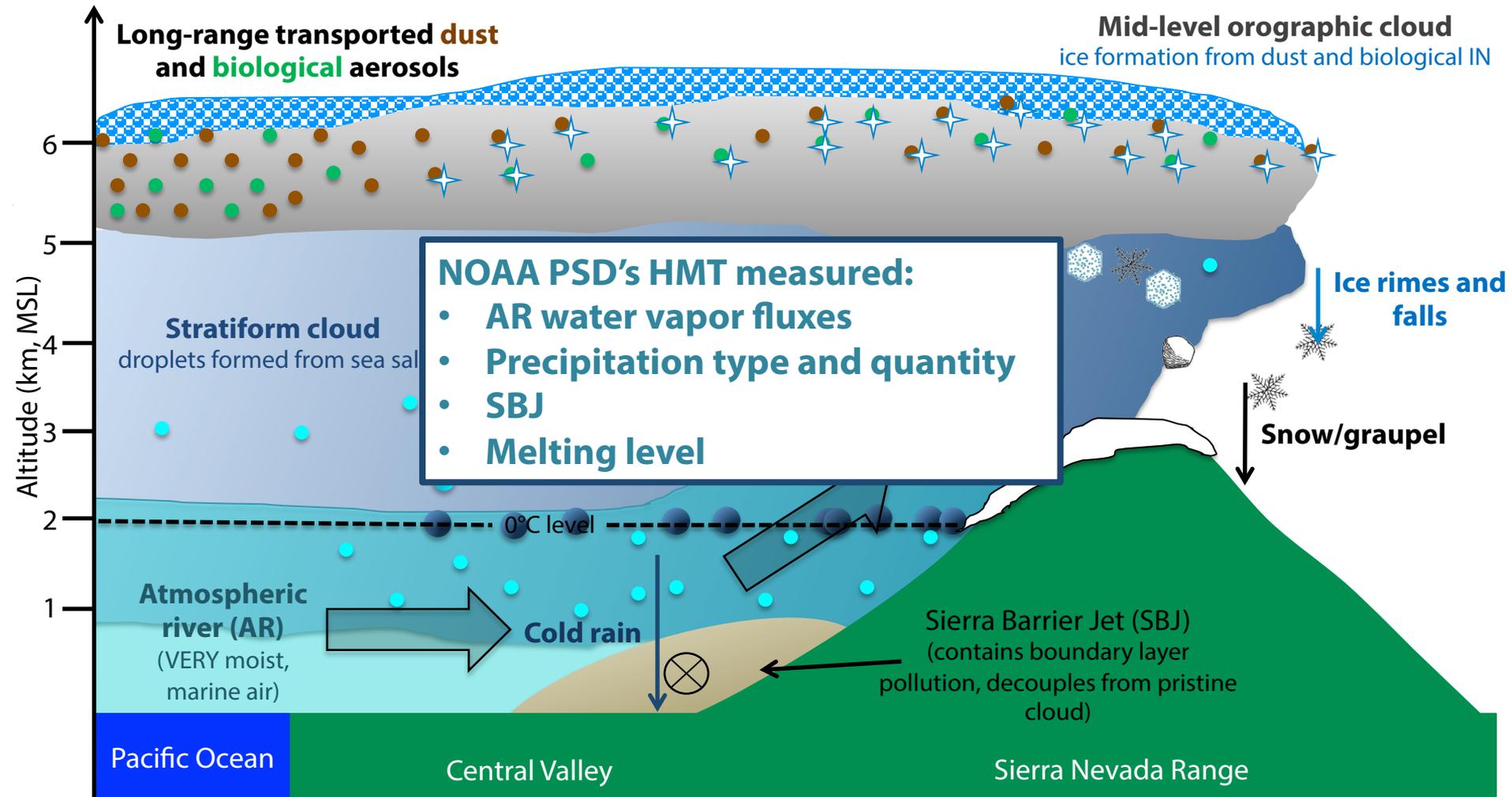
- CCN can deprive us of water (i.e., high concentrations from urban pollution)
- IN can supply water (snowpack in mountains)
- Results from modeling CAPI vary greatly based on changes in aerosol size, number, and chemistry
- Competing effects of CCN and IN on weather, what is the outcome with both?

Therefore, a better understanding of the effects of CCN/IN and their sources on weather is needed



<http://www.swrcb.ca.gov/>

CAPI Discoveries during CalWater 2011



Creamean, J. et al. *Science* **2013**, 339, 1572-1578.

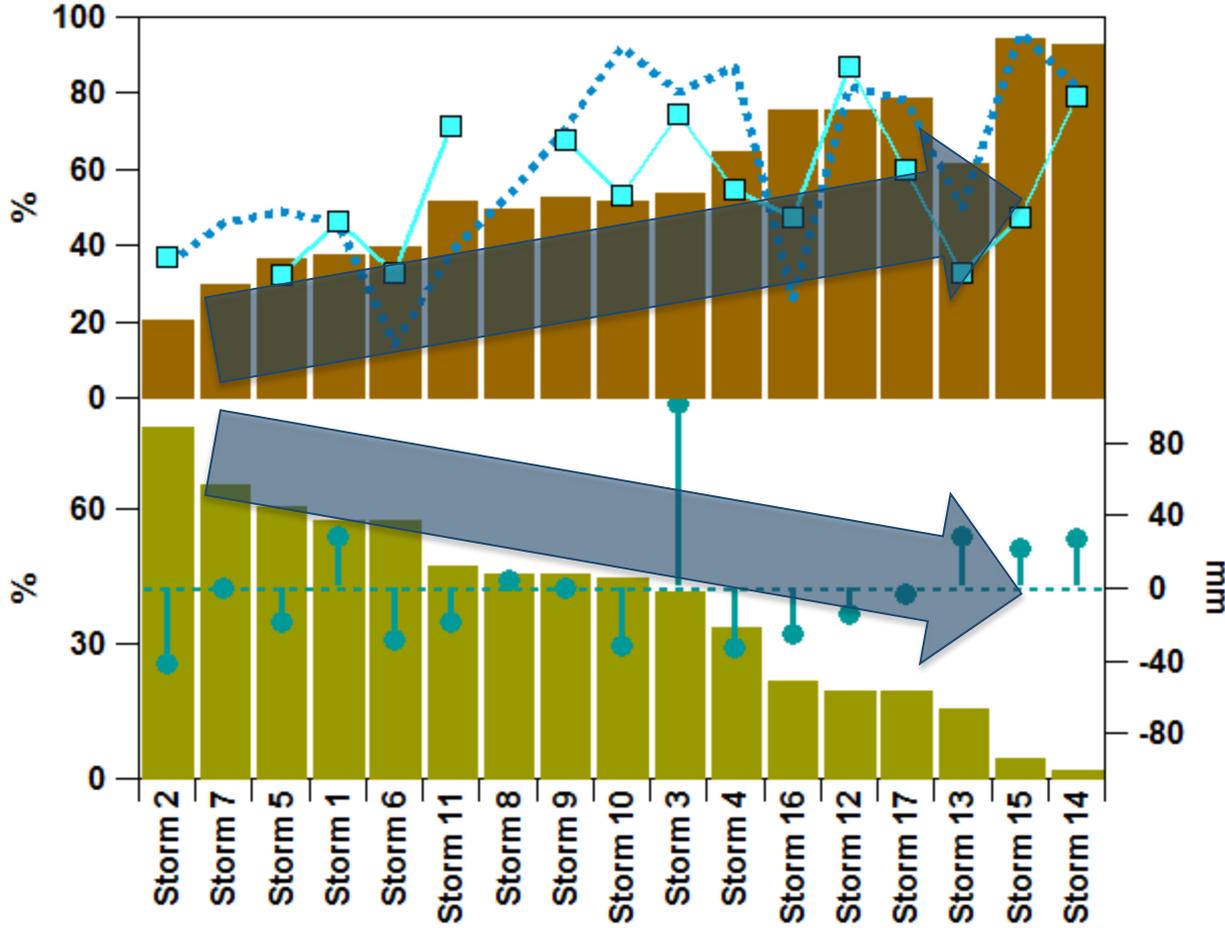
Linking Aerosols and Precipitation in California

■ Dust and bioparticles, ■ Pollution and biomass burning particles,
 - - - Ice-induced precipitation, - - - In-cloud ice, ● Precipitation deviation

Time periods with more “IN” and less “CCN” particles in precipitation corresponded to:

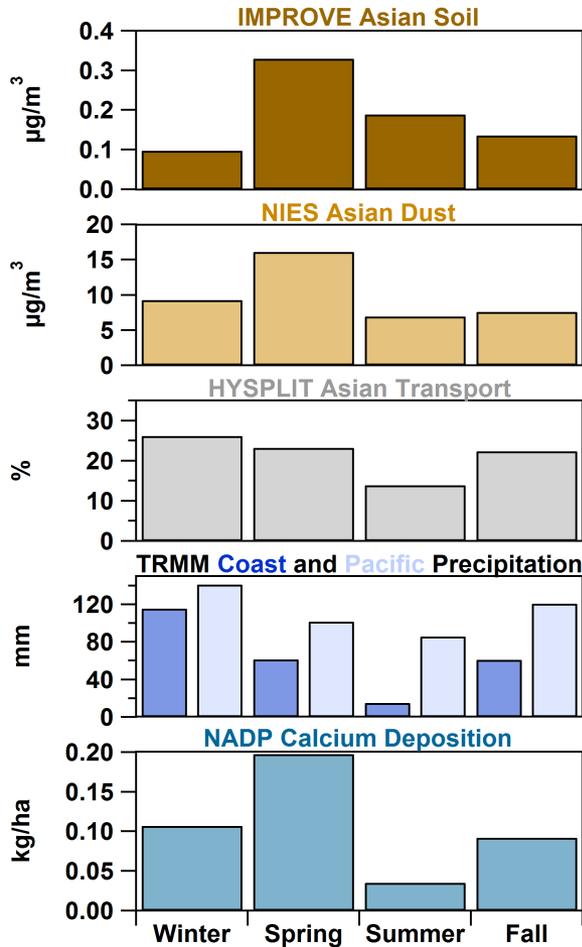
1. More in-cloud ice
2. More precipitation that formed as ice
3. Positive precipitation deviation (from the average from all storms)

Overall, demonstrates different cloud nuclei affect precipitation type and amount over the CA mountains.

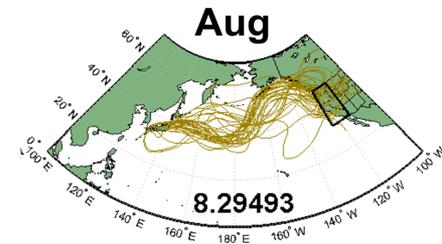
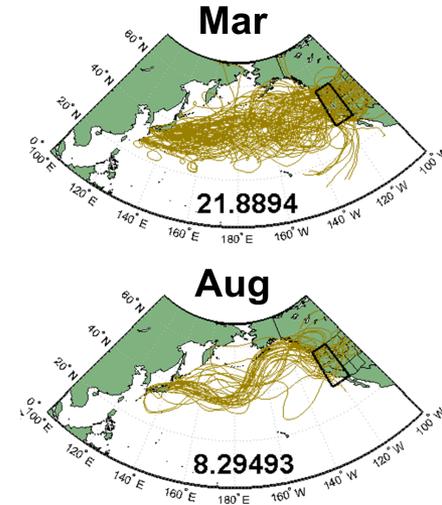
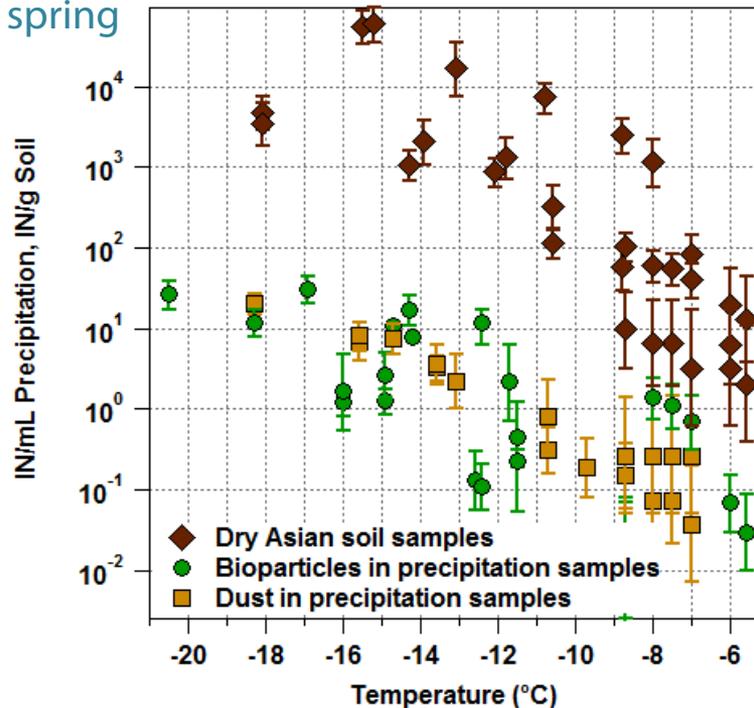


Creamean, J. et al. *Atmospheric Chemistry and Physics Discussions*, 2015, 15, 931-964.

Finding Sources and IN Properties of Aerosols



- Dust in Asian outflow region and U.S. west coast peak in spring
- Transport of dust more likely in winter
- Most precipitation in the winter
- Most dust tracer (calcium) deposition in spring



- Dust and bio particles found in California rain and snow samples, and dust collected in Asia, are efficient IN

Creamean, J. et al. *Journal of Geophysical Research-Atmospheres*, **2014**, 119, 12171-12185.

Creamean, J. et al. *Atmospheric Chemistry and Physics Discussions*, **2015**, 15, 931-964.

Summary and Future Directions

- **Our research has focused on how aerosols, specifically those found in California, influence weather, with emphasis on how clouds and precipitation form**
 - Ice nuclei (IN) enhance precipitation
 - Cloud condensation nuclei (CCN) suppress precipitation
- **Aerosols are poorly or not at all constrained in weather and climate models, especially operational models**
 - We need a better representation of aerosols to accurately predict water cycle
- **Future directions include:**
 - Evaluation of cloud-aerosol-precipitation interactions (CAPI) from CalWater 2015 observations
 - Investigation of CAPI in other environmentally fragile and remote regions, such as the San Juan Mountains and the southwest US, and the Arctic, where aerosols could have a very large impact on weather