CalWater

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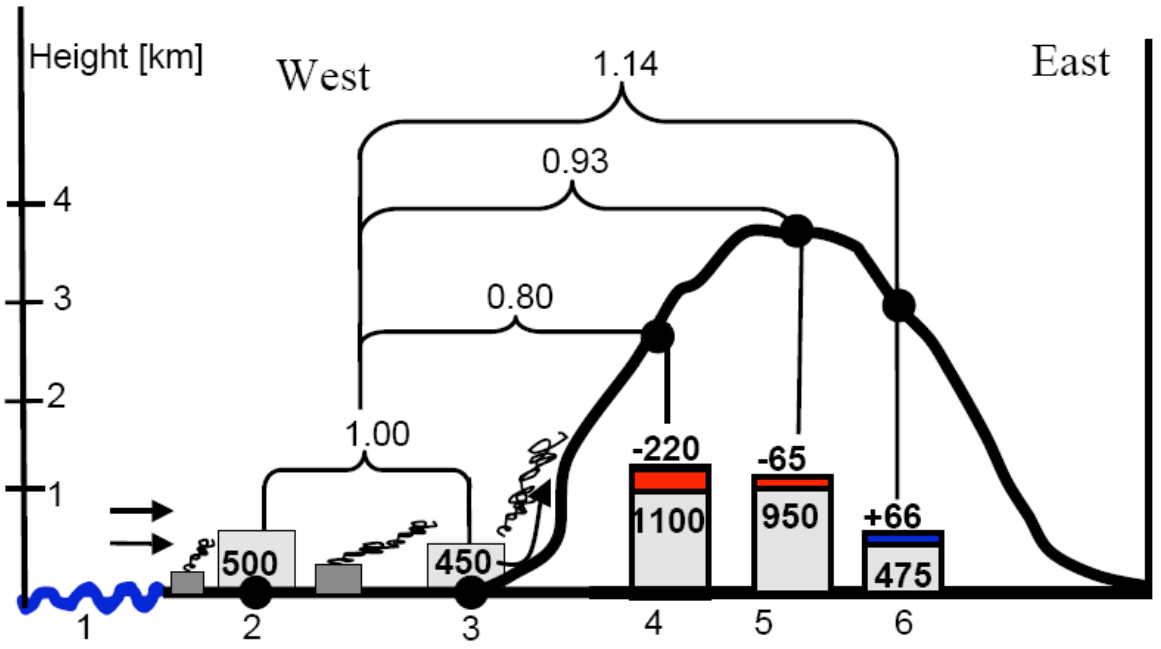
Outline

- Motivation for the CalWater study
- Field study in 2005
- Initial CalWater field campaign in 2009
- Comprehensive 2010-2011 CalWater field study
- Future activities

Development of Climate Projections for California

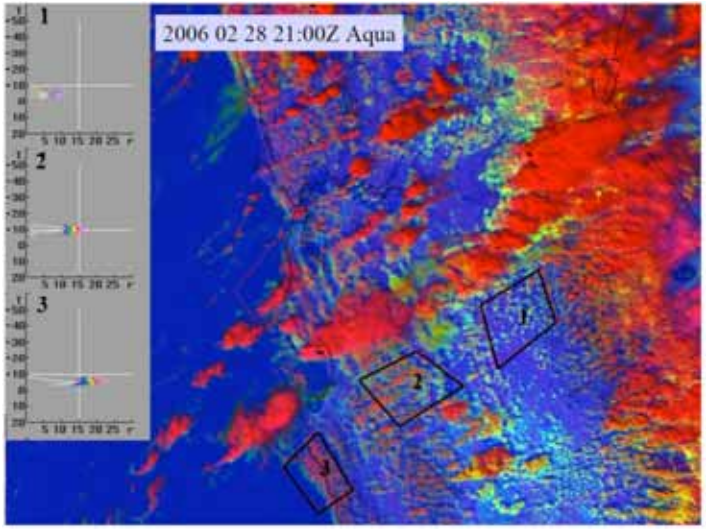
- In 2003 we commissioned a study to explore the role of aerosols in our regional climate
  - Effects of anthropogenic aerosol particles and their precursor gases on California and South Coast Climate. Mark Jacobson. Stanford
    - Reduction of precipitation in the Sierra Nevada
    - Reduction in surface temperatures
- In 2006 we started to investigate how “dark particles” may reduce the reflectivity of snow
  - The effects of agriculture and snow impurities on climate and air pollution in California. Mark Jacobson. Stanford
    - Irrigation has increased night-time temperatures but decreased day-time temperatures
    - Effect of dark particles (black carbon) relatively minor (modeling February)



Givati and Rosenfeld, J. Applied Meteorology, 2004

Field Study in 2005

- Use of small research aircraft
- Development of a new 2D model to simulate the interactions of aerosols with clouds
- Huge number of CCN in the Fresno/Bakersfield area
- Results seem to confirm the suppression of precipitation by aerosols



Source: Rosenfeld, D., W. L. Woodley, D. Axisa, E. Freud, J. G. Hudson, and A. Givati (2008), Aircraft measurements of the impacts of pollution aerosols on clouds and precipitation over the Sierra Nevada, J. Geophys. Res., doi:10.1029/2007JD009544

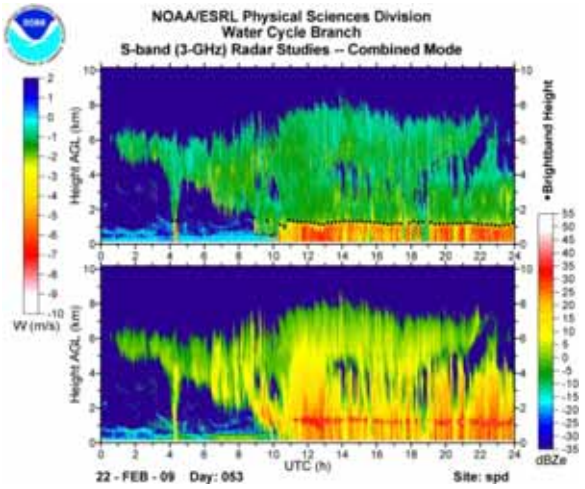
CalWater

• Develop a stronger understanding of aerosol sources and processes impacting cloud properties and precipitation in California

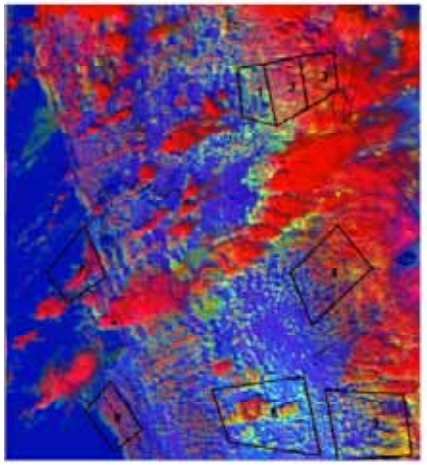
• Simultaneously measure aerosols, meteorology, and cloud microphysics

Key question: Are there differences in the aerosols that lead to (more/less) rain, snow, or no precipitation?

S-band Radar



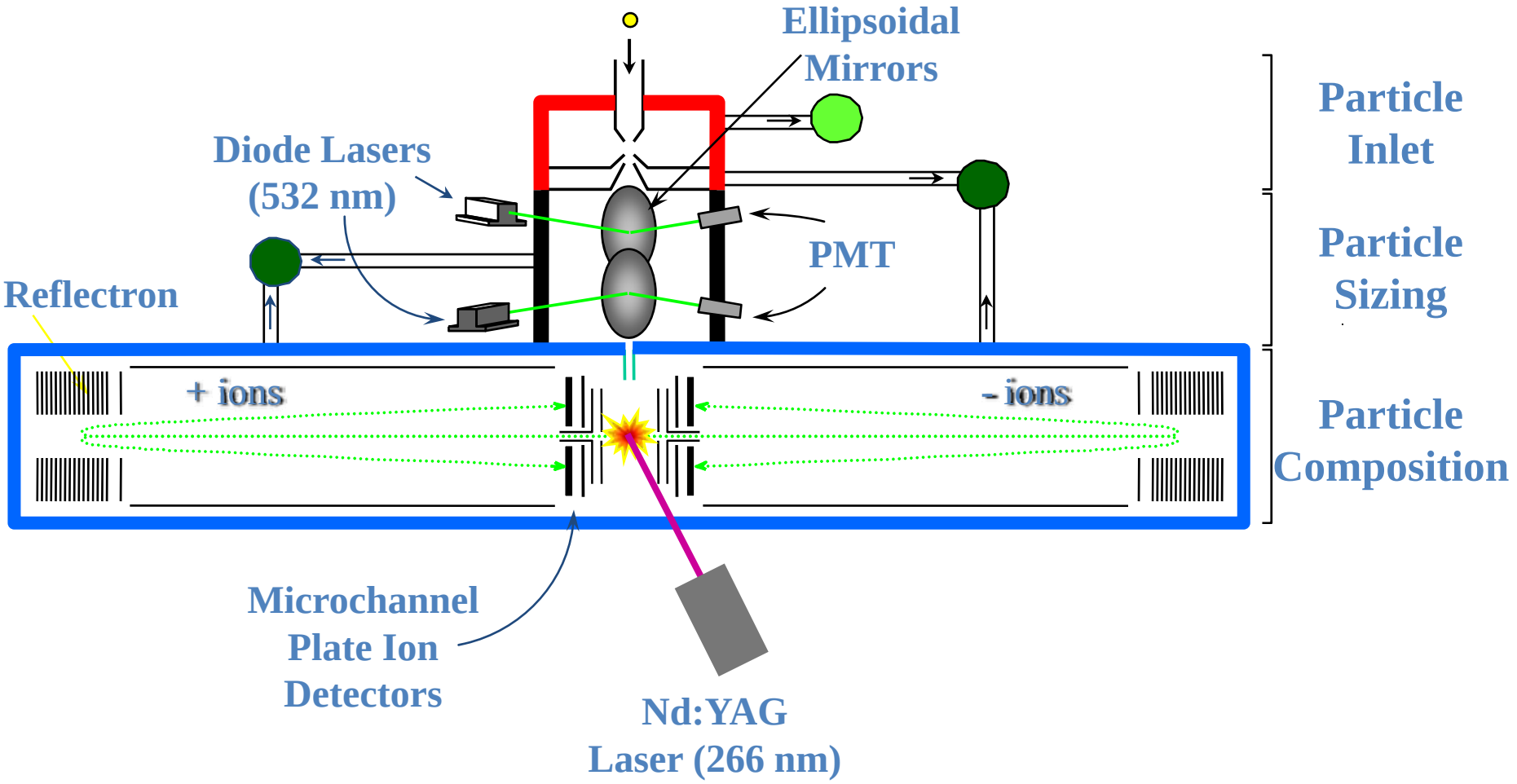
Satellite



In-situ measurements

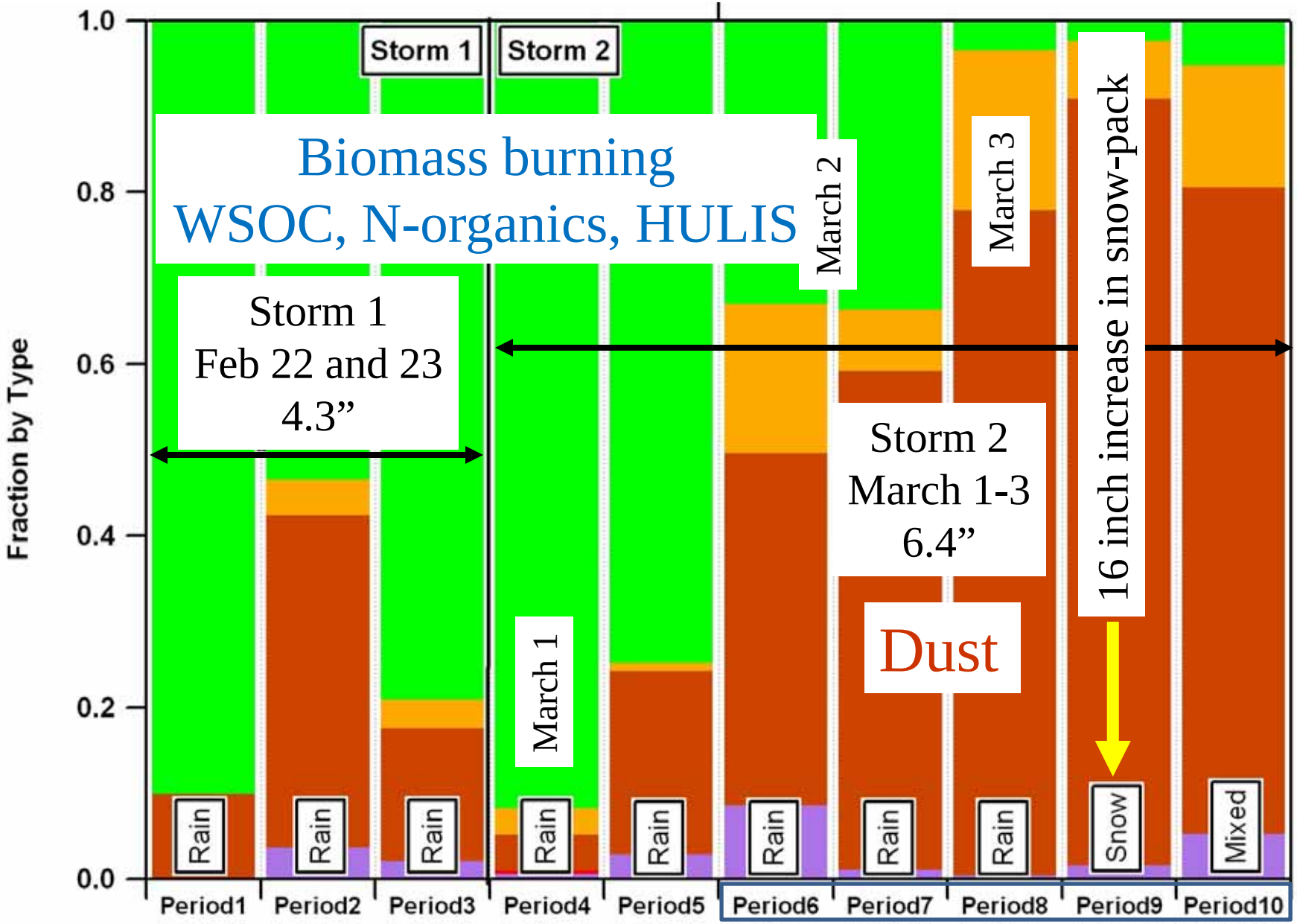
PI: Prof. Kim Prather

In-situ Individual Particle Analysis Aerosol Time-of-Flight Mass Spectrometry



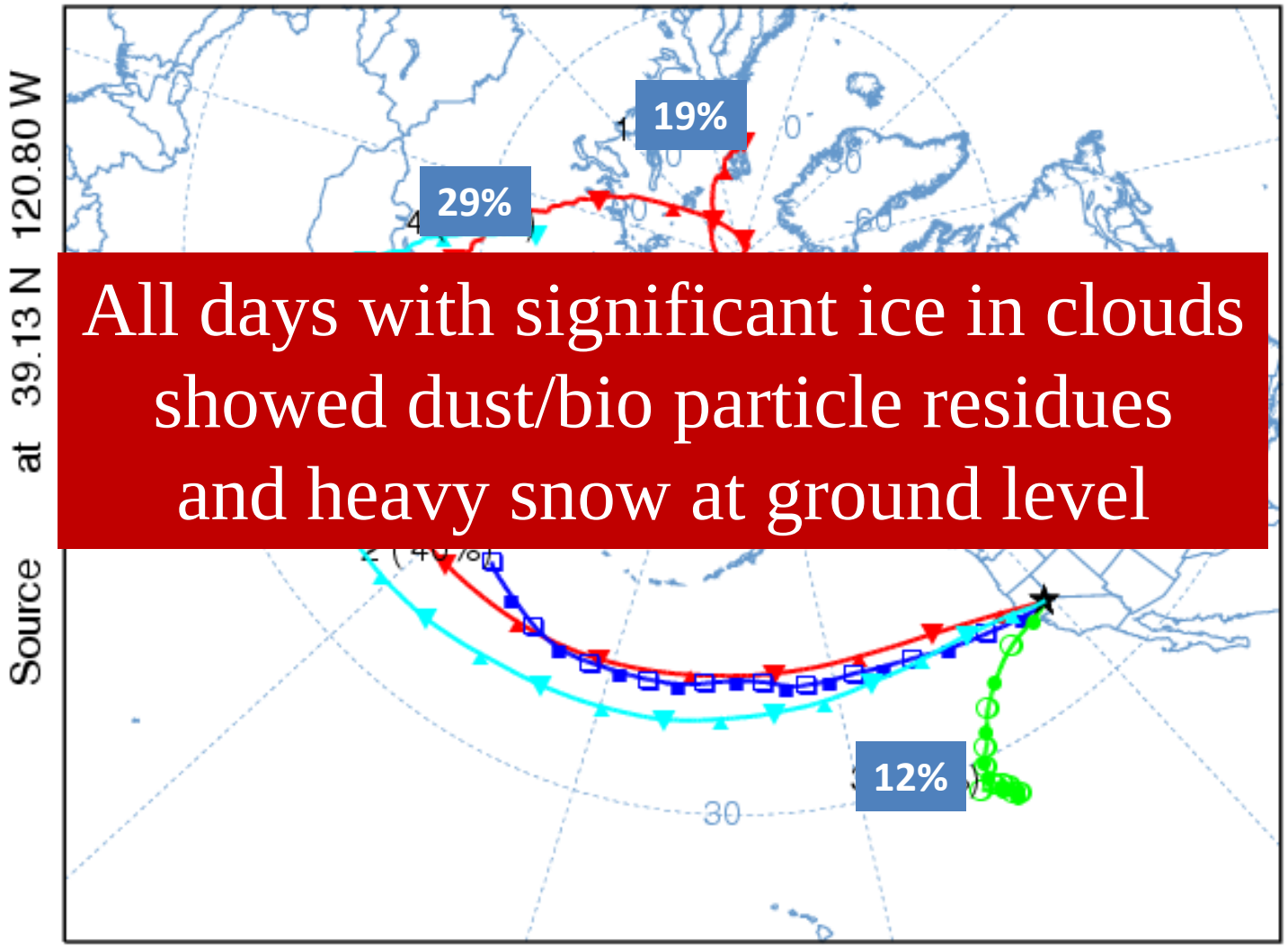
Gard, E.; Mayer, J. E.; Morrical, B. D.; Dienes, T.; Fergenson, D. P.; Prather, K. A. *Anal. Chem.* **1997**, *69*, 4083-4091.

Precipitation Chemistry (Calwater-2009)



Rain and snow melt (Insoluble residue) chemistry

2011 HYSPLIT back trajectories

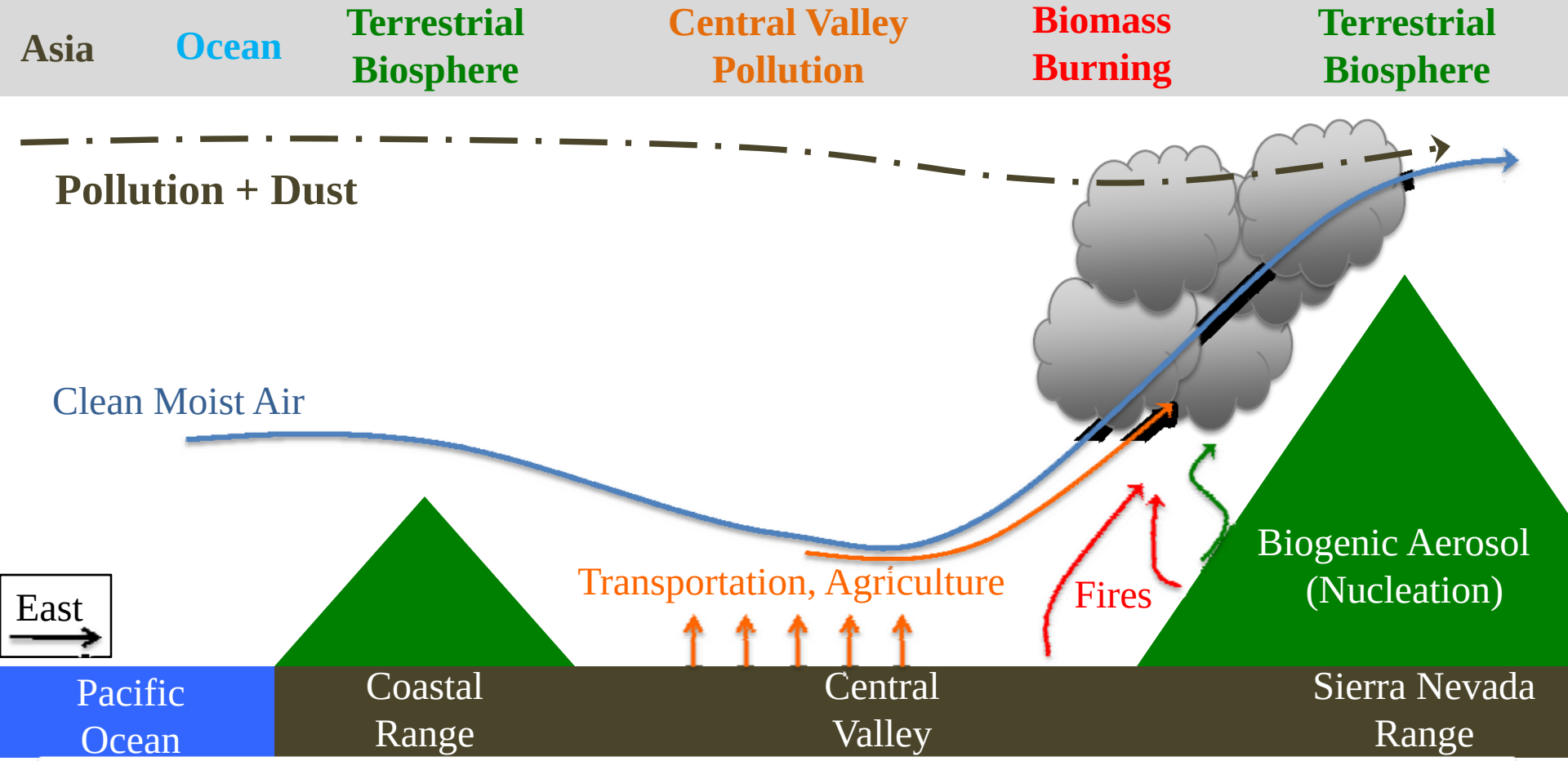


Preliminary results from Prof. Kim Prather's group

Measurements aloft confirmed the role of dust as IN

Orographic Precipitation in California

Possible Sources of Cloud Condensation Nuclei (CCN) and Ice Nuclei (IN)

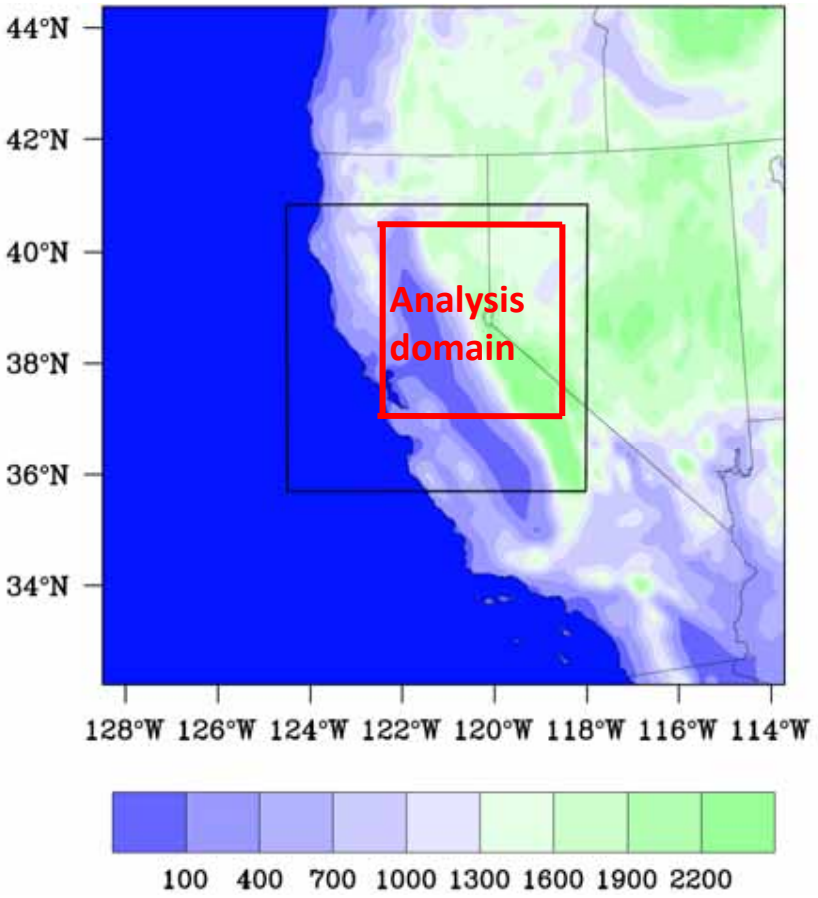


What are the important sources of CCN and IN in the Sierra Nevada?

Rosenfeld et al., JGR, 2008 (SUPRECIP-2005)
Creamean et al., Environ. Sci. Technol., 2011

Simulation setup (Ruby Leung: PNNL)

- WRF was used with spectral bin microphysics (included heterogeneous ice nucleation linked with IN) at 2 km resolution
- Each simulation was performed for 2 days with dust applied only on the second day



Source: Ruby Leung. PNNL

Preliminary Results

- On Feb 15 -16:
  - Increasing CCN x 3 reduces precipitation on the windward side with little change on the lee side of the mountains
  - Note: Similar results reported by Saleeby and Cotton*

* Saleeby, Cotton, Fuller, 2011. The Cumulative Impact of Cloud Nucleation Aerosol on Orographic Snowfall in Colorado. Journal of Applied Meteorology and Climatology. October.

Conclusions (CalWater-2011)

Preliminary results from Prof. Prather's group

- Transported dust and bioparticles detected in clouds as well as precipitation/snow samples along Sierra range
- Long range transport appears to play a role in bringing in aerosols that influence clouds and possibly precipitation in California
- Ice concentrations show strong correlation with dust and bioparticles

- Why is there more precipitation/snow when there is more ice/dust/bio/IN?—Modeling (PNNL)
- Are the dust and pollution affecting precipitation predictions (type/amount of precip)?—Weather predictions
- How typical are trajectories and results in 2011?
- Is early transport of dust/pollution going to become the "norm" in in a warming climate?

Future Activities

- Finish the analyses and see what they tell us and then decide what is next for the CEC
- Planning for the 2014 (?) CalWater phase has started (NOAA)
- Based on the results of the LBNL study develop a new estimation of the role of dark particles on the already observed trend towards an early melting of snow in the Sierra Nevada
- Could reducing aerosols be an adaptation strategy?

Acknowledgments

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More Info:
http://atofms.ucsd.edu/content/calwater-2011
http://esrl.noaa.gov/psd/calwater
http://caice.ucsd.edu