Digital Inversion and Initial Analysis of Nephelometer Data from the CHAPS Campaign

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GCEP End of Summer Presentation

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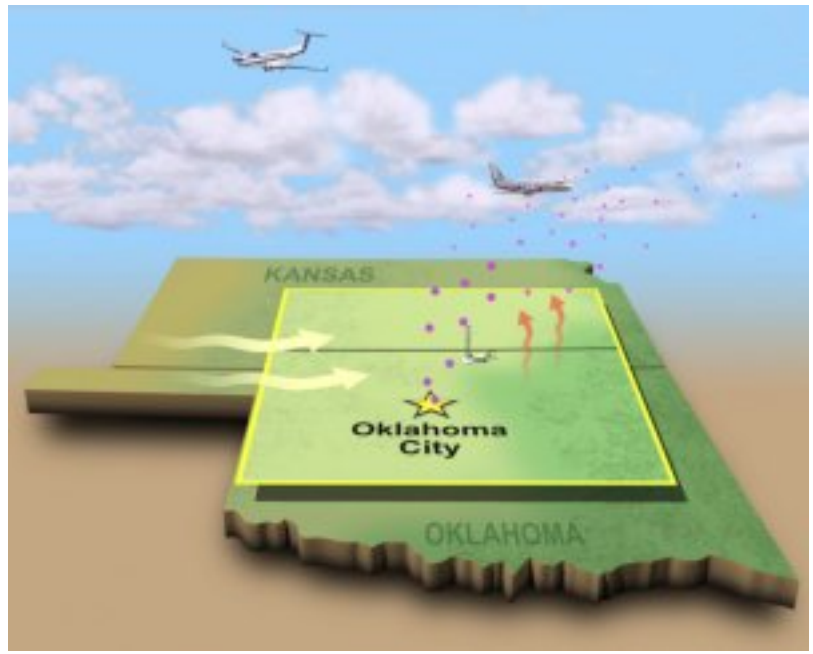
CHAPS – Cumulus Humilis Aerosol Processing Study

- DOE ASP campaign conducted in June 2007 in the vicinity of Oklahoma City
- Sought to characterize and contrast optical and cloud nucleating properties of aerosol above and below clouds, in and out of an urban plume
- Flew the Gulfstream-1 aircraft, equipped with an array of instrumentation, below, in, and above cloud, upwind and downwind of the OKC plume



From http://asp.labworks.org

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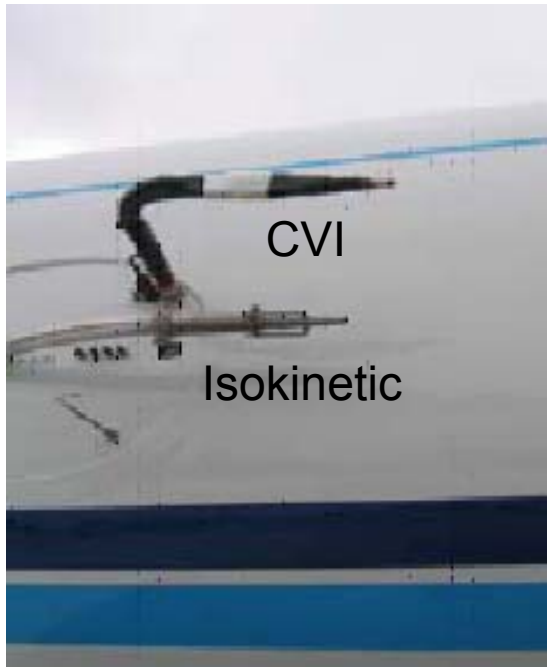
What is a nephelometer?

- Measures total and back scatter of light by aerosol at three wavelengths
  - Useful for calculating single scattering albedo
- Two inlets on the G-1 aircraft – the isokinetic inlet and the counter flow virtual impactor (CVI) inlet
  - CVI inlet designed to collect only larger particles, i.e. cloud droplets
  - Isokinetic inlet designed to collect ambient and interstitial aerosol



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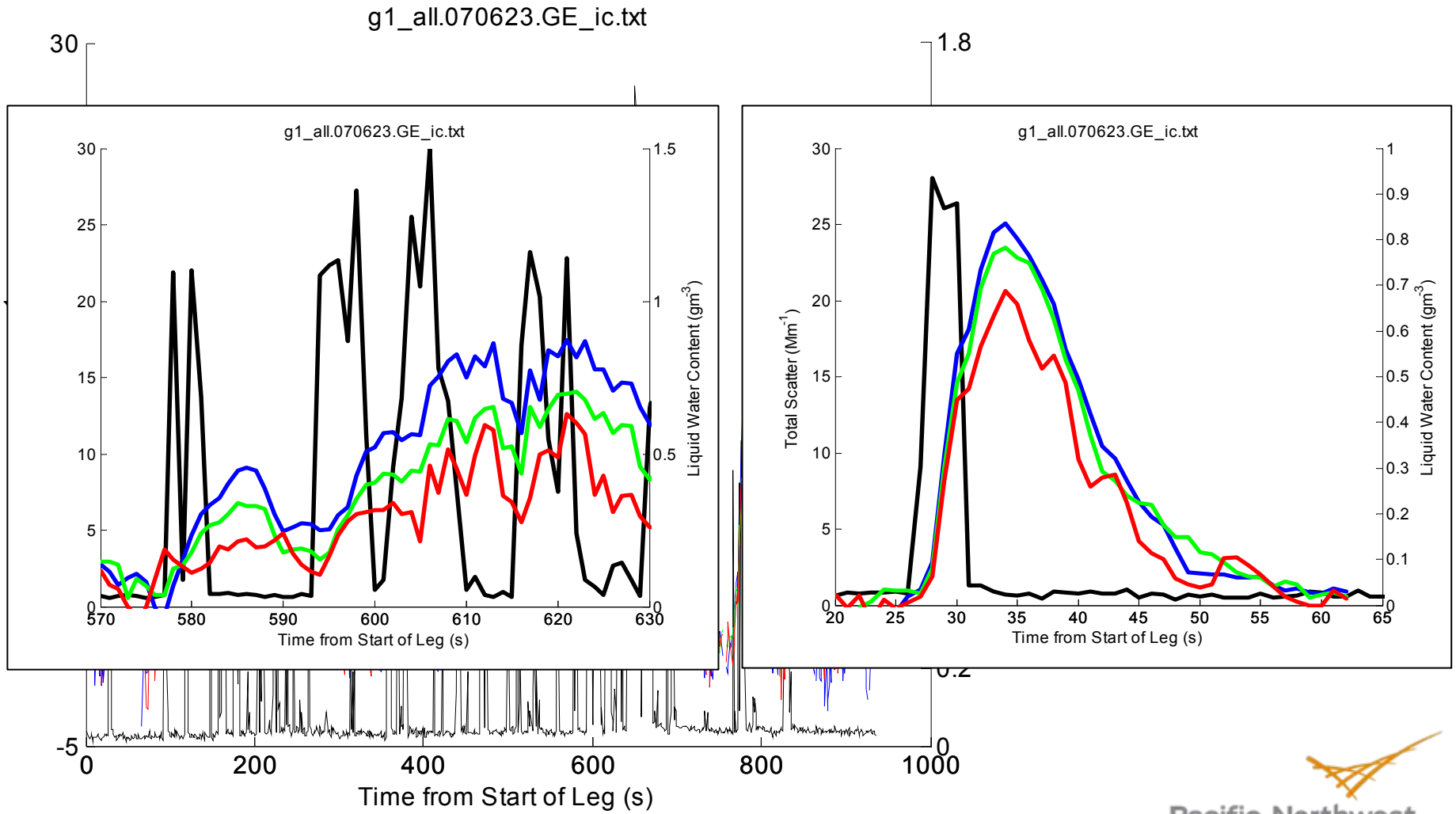
The nephelometer has a slower time response than other instruments on board



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Exponential curves can be modeled by linear first order differential equations

$$y(t) = Ce^{-t/\tau} + y_\infty$$

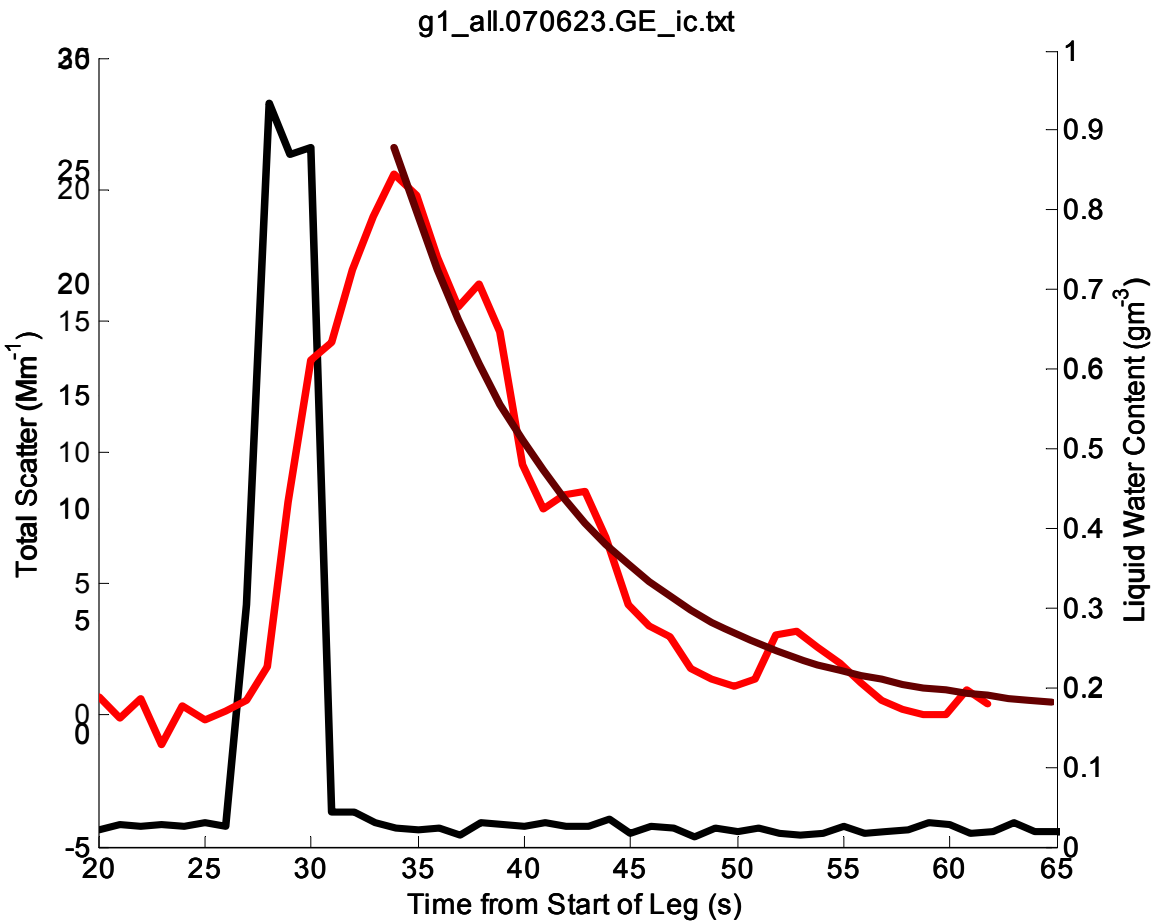
$$\frac{dy}{dt} = -\frac{1}{\tau}(y - y_\infty)$$

$$\Delta y = -\frac{\Delta t}{\tau}(y - y_\infty)$$

$$\Delta y = -\frac{\Delta t}{\tau} y + \frac{\Delta t}{\tau} y_\infty$$

Visual Check of the Time Constant

- CVI inlet
  - τ = 8.3s
- Isokinetic inlet
  - τ = 2.2s



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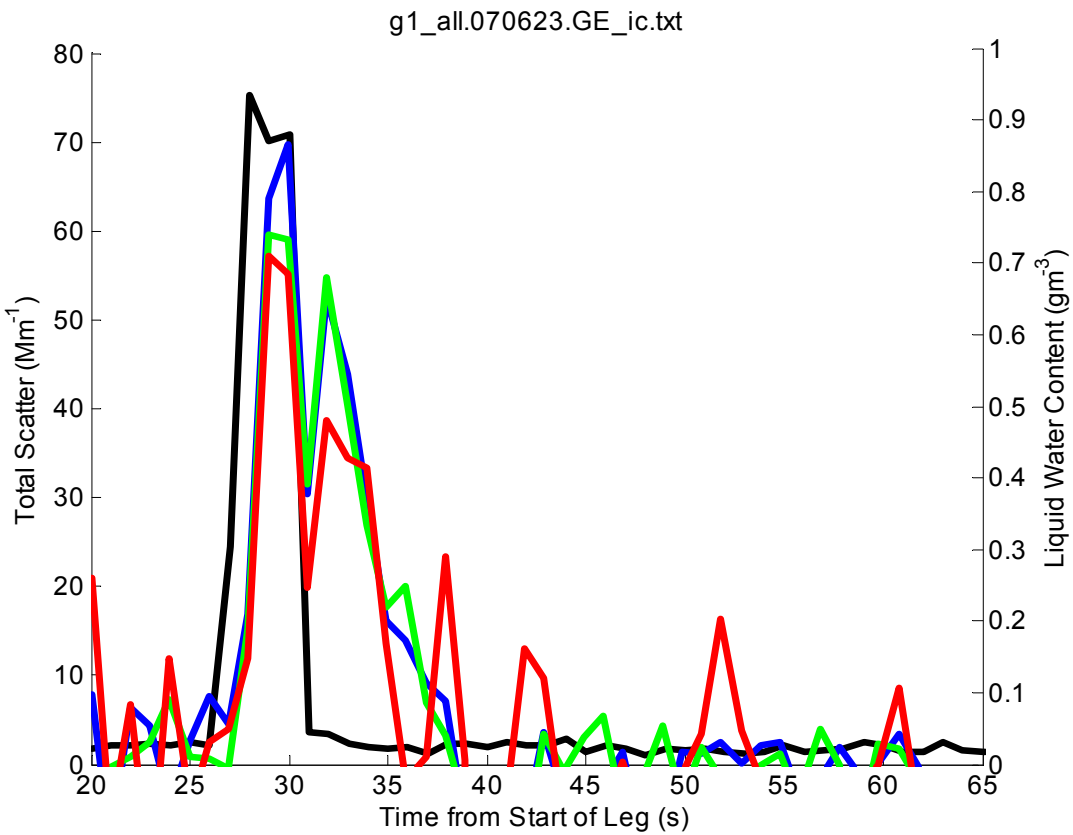
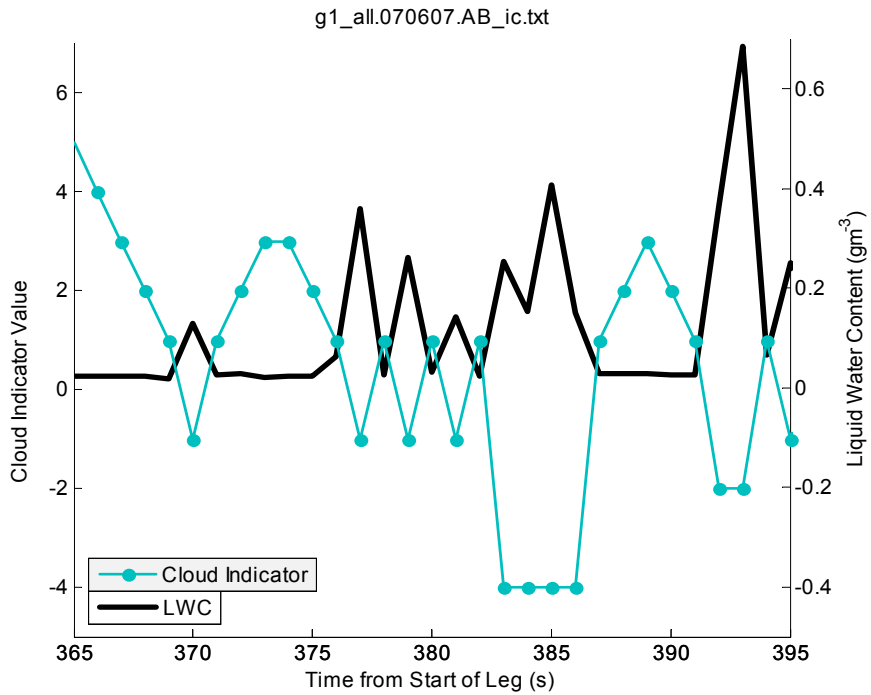
Application of the Time Constant



- Peaks in scatter now align more closely with peaks in liquid water content
- More noise

Cloud Indicator

- Clouds defined based on the liquid water content
- For out-of-cloud, the indicator gives distance (in seconds) to the nearest cloud
- For in-cloud, the indicator gives the negative value of the cloud width



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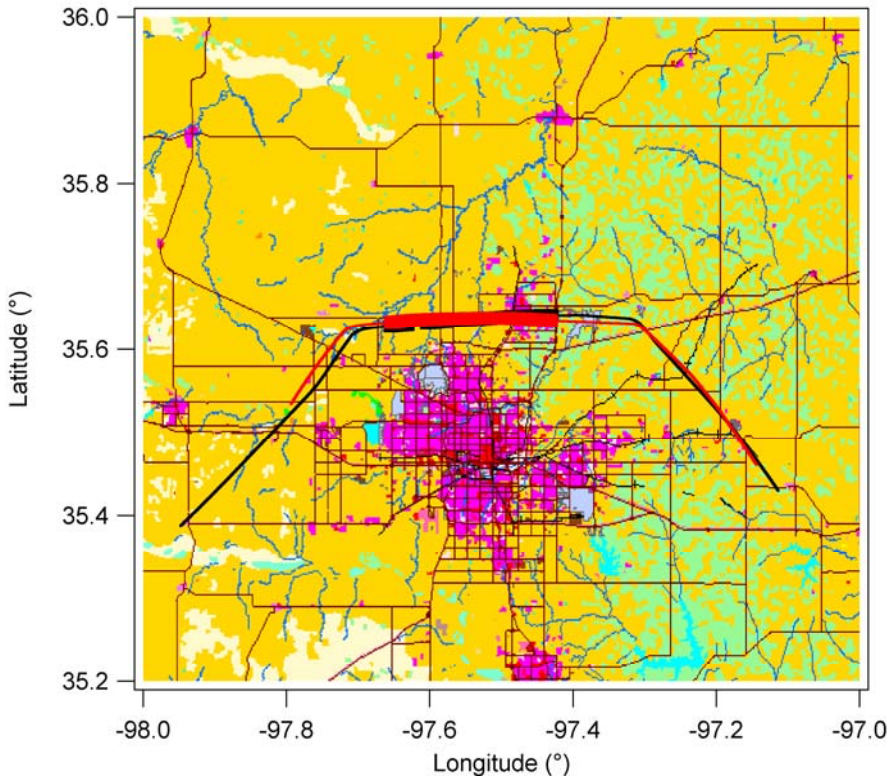
In-cloud Plume Indicator

- A plume flag already existed based on carbon monoxide levels in the below-cloud legs
- If the air being drawn into the cloud from below is in the plume, the cloud itself can be considered in plume
- Located the plume in cloud based on the geometric location of the below-cloud plume flag



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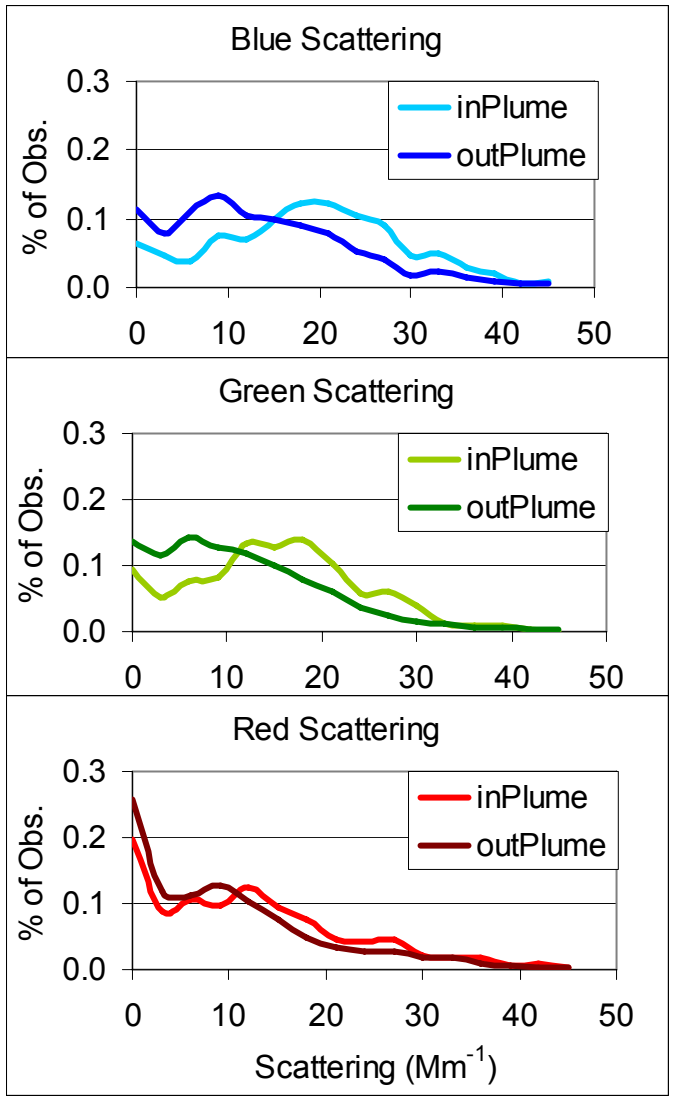
In- and Out-of-plume Total Scattering Comparisons



- In-cloud data from the CVI inlet
- Significant shift is seen to higher values in the plume at the blue and green wavelengths, but not at the red wavelength
- Angstrom exponent changes from 1.2 out-of-plume to 1.4 in-plume
- Suggests a change in the size distribution of the particles

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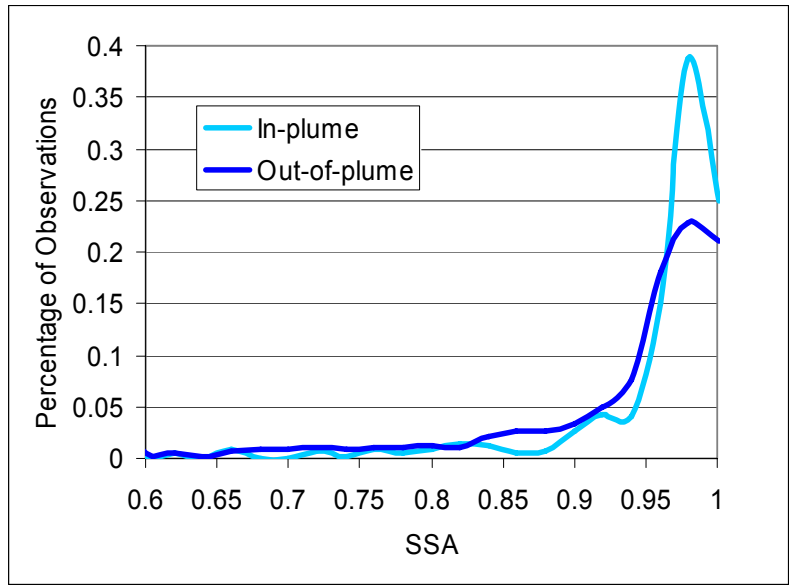
In- and Out-of-Plume Single Scattering Albedo Comparisons

- In-cloud data from the CVI inlet
- $$SSA = \frac{scatter}{scatter + absorption}$$
- Change in shape of distribution
  - More low SSA values out-of-plume than in-plume, suggesting more darker particles out-of-plume
  - Aged particles are generally darker and more likely to be found outside the fresh plume



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Conclusions

- Digital inversion of the total scattering data gives a better measure of the peak scattering in clouds, but amplifies the noise.

- Using this data, we can see that total scattering is higher and that the SSA distribution changes in plume, suggesting shifts in size distribution and age of particles.

Thank you!

- Dr. Will Shaw
- Dr. Larry Berg
- everyone at PNNL who made this an enjoyable experience

- Dr. Jeff Gaffney
- Dr. Nancy Marley
- Dr. Milton Constantin
- and all with the GCEP SURE program for the funding and support