Do Polluted Clouds Have Sharper Cloud Edges?

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Importance of understanding aerosol-to-cumulus transition

- Cumulus clouds increase heat and moisture transport from the surface to the free troposphere, and strongly influence atmospheric state variables and cloud cover.
- It remains challenging to model their transitions to stratocumulus or deep convection
- Cumulus clouds are also strongly affected by ambient aerosols

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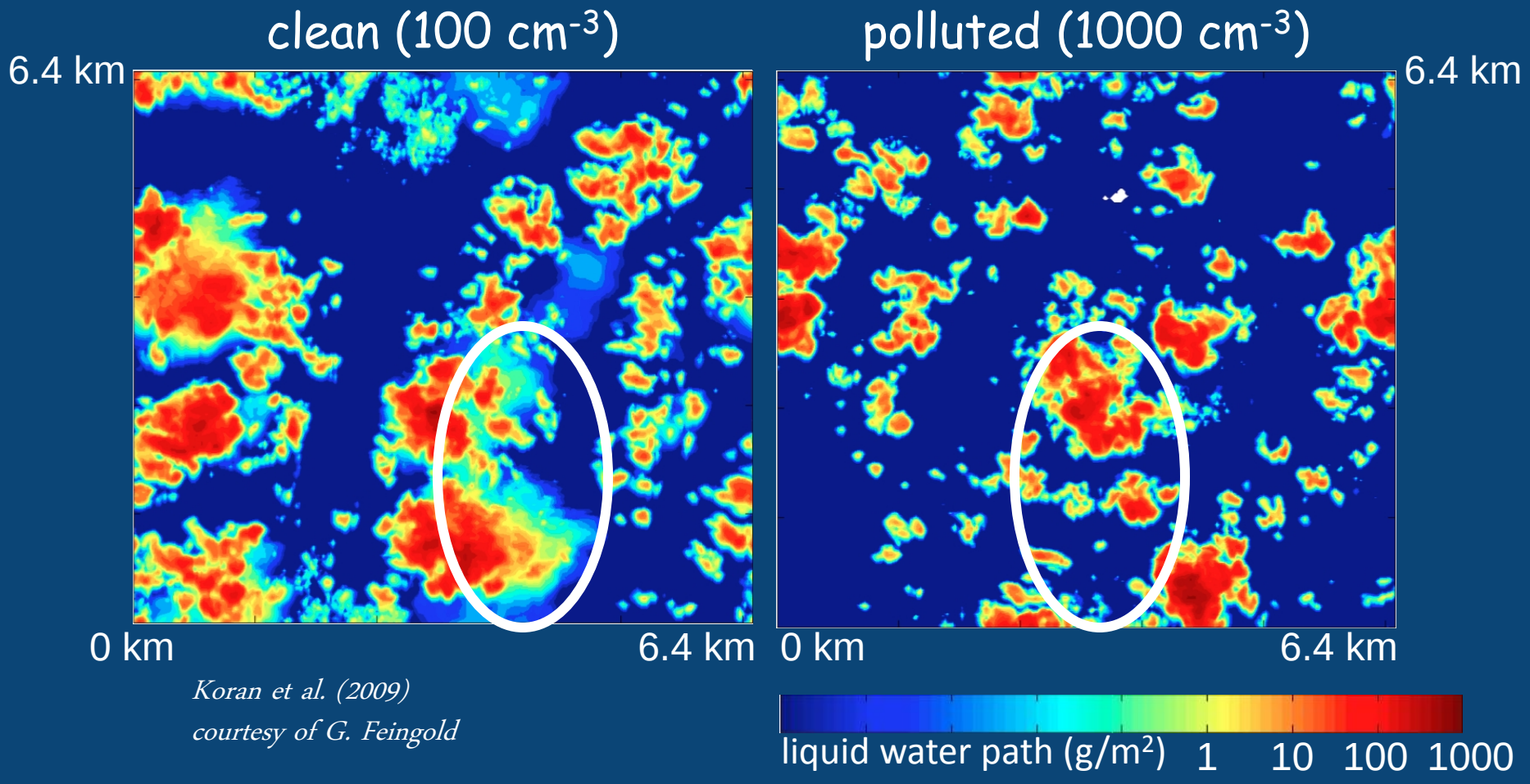
Clouds in more polluted air have sharper edges

- due to faster evaporation of the smaller cloud droplets

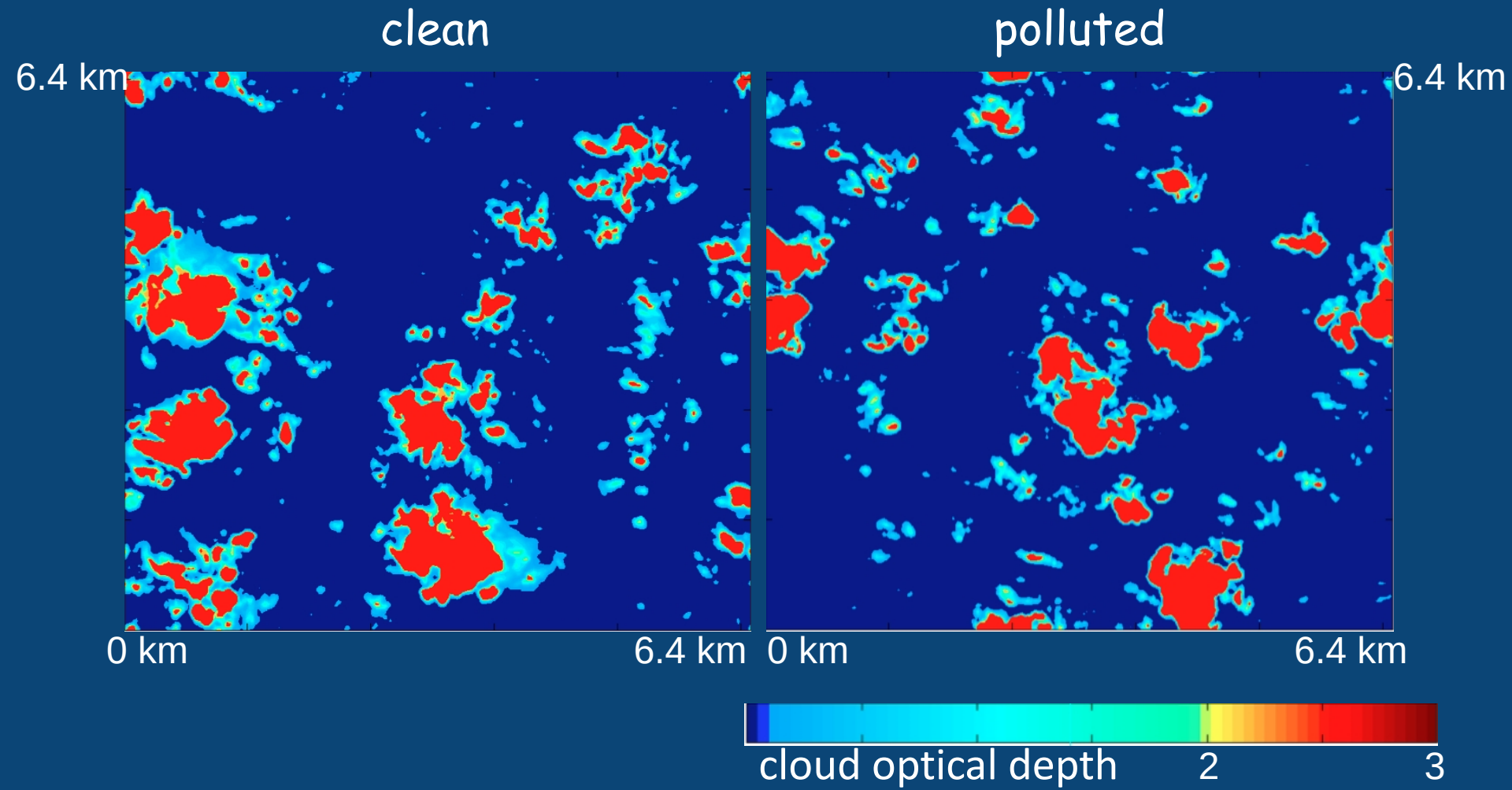


Koran et al. (2009)
courtesy of G. Feingold

Our aim

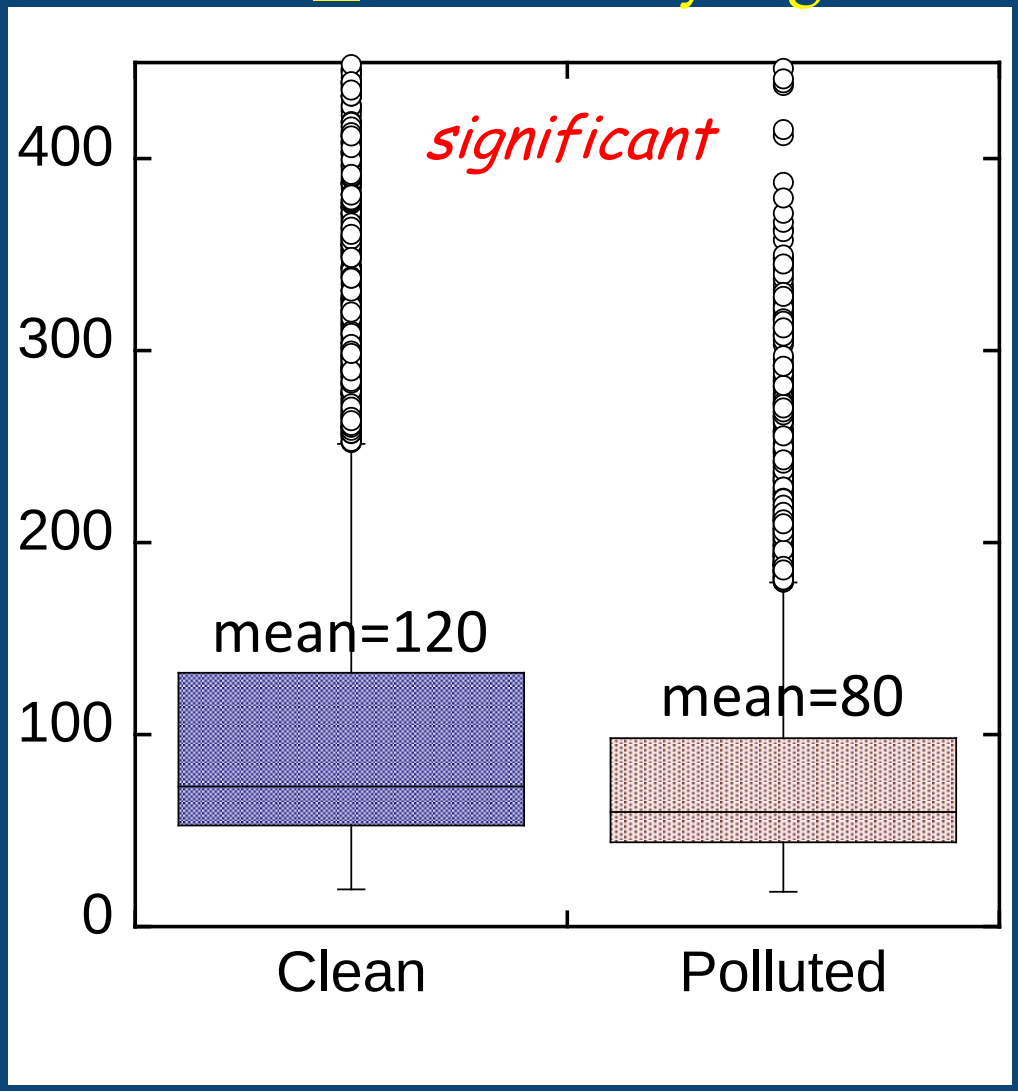
- To investigate whether observations support this finding that clouds in polluted environments have sharper cloud edges

Defining cloud edge width as the distance from clear sky to cloud optical depth of 2



Mean difference in cloud edge width between clean and polluted cases is statistically significant

cloud edge width (m)



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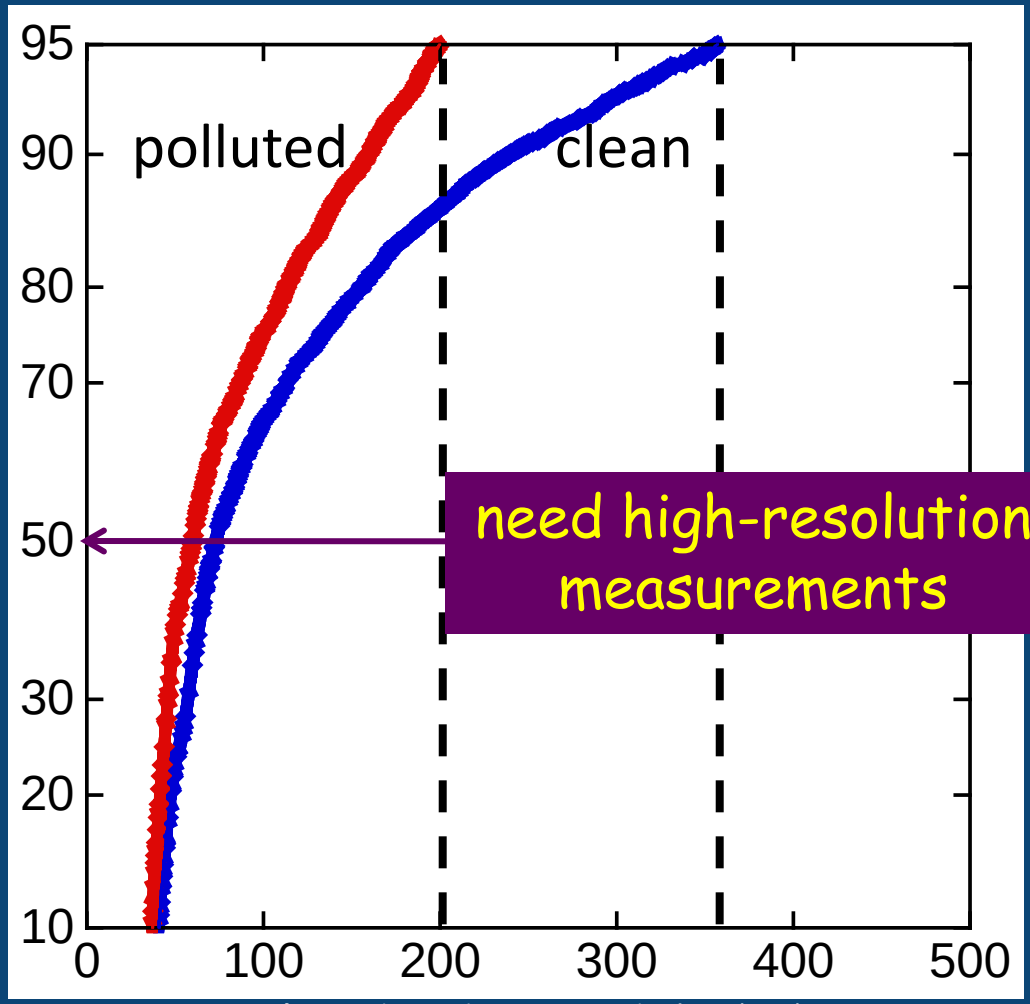
LES: 95% clouds have cloud edges within 200-m in the polluted case; 350-m in the clean case



Measuring cloud edge width using cloud optical depth retrieved from 2NFOV

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2-channel Narrow-Field-Of-View radiometer:
1-s, 1.2° FOV, 673 (RED) & 870 (NIR) nm

We focus on three AMF campaigns

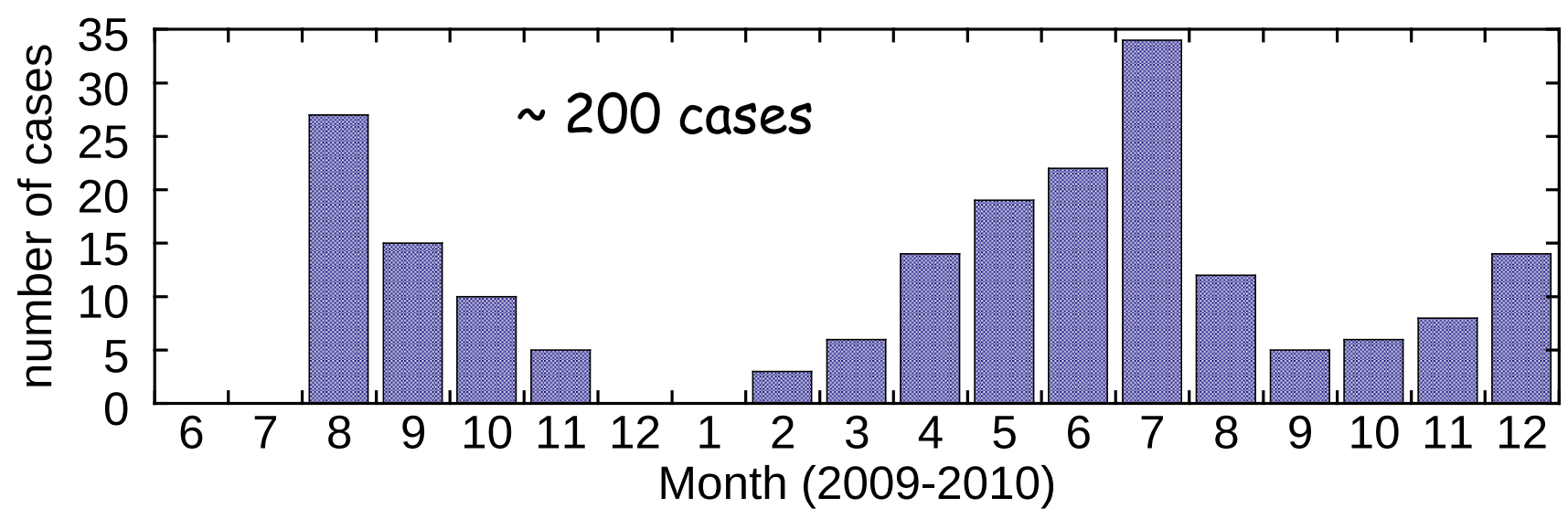
courtesy of ARM Climate Research Facility's Photostream

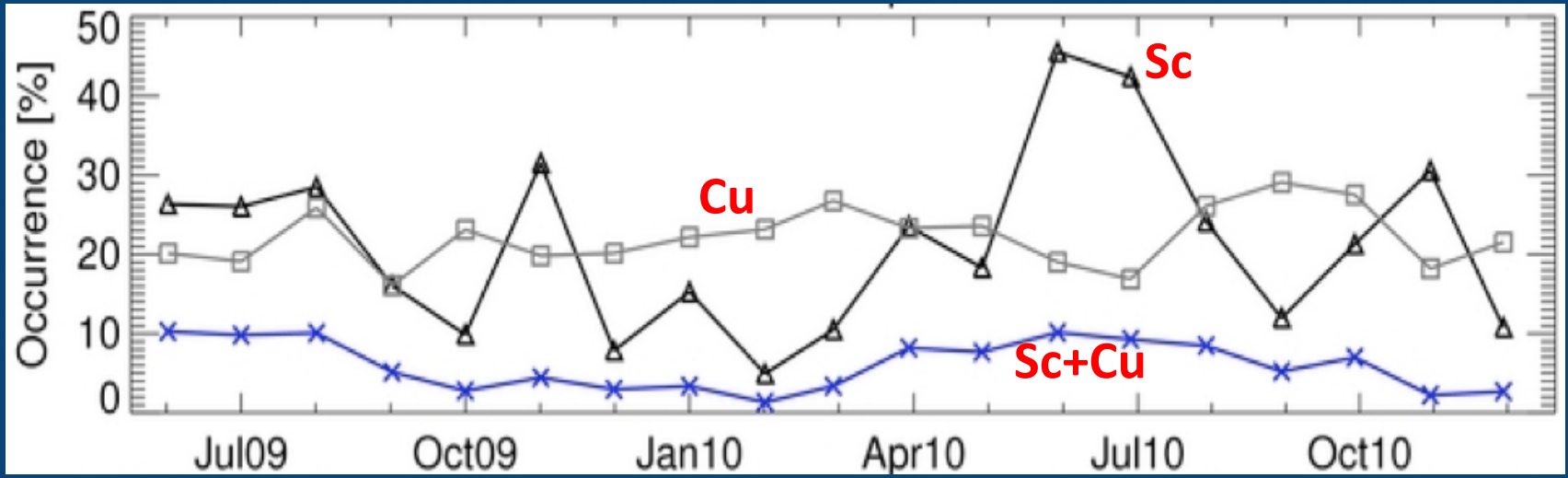
We focus on low, non-precipitating clouds

- Radar/lidar data – cloud base height < 2 km
- Microwave radiometer – liquid water path
- Aerosol observing system – aerosol light scattering
- Merged sounding – wind speed at cloud layers
- 2NFOV – clouds should be big enough and away from each other with an at least 20-sec time interval

thanks to people who involve and provide these data products

Seasonal distribution of Azores cases



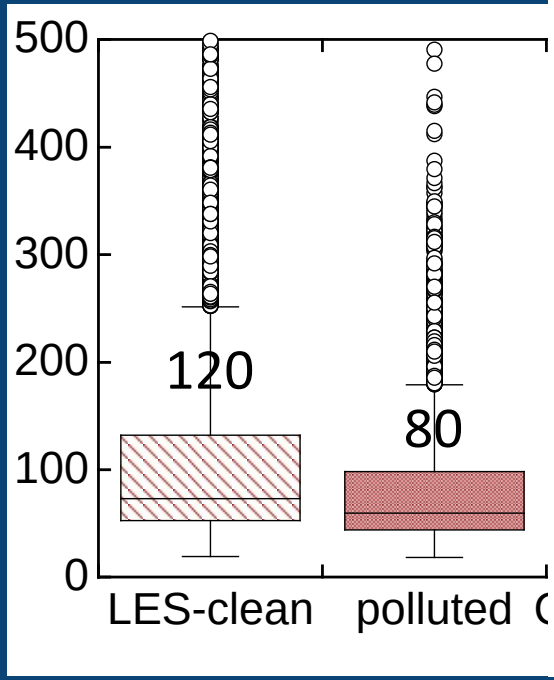


courtesy of Jasmine Rémillard, Pavlos Kollias

Compare cloud edge width statistics between simulations and observations

Cloud edge width as a function of aerosol light scattering

LES	
7300	5800



significant *not significant*

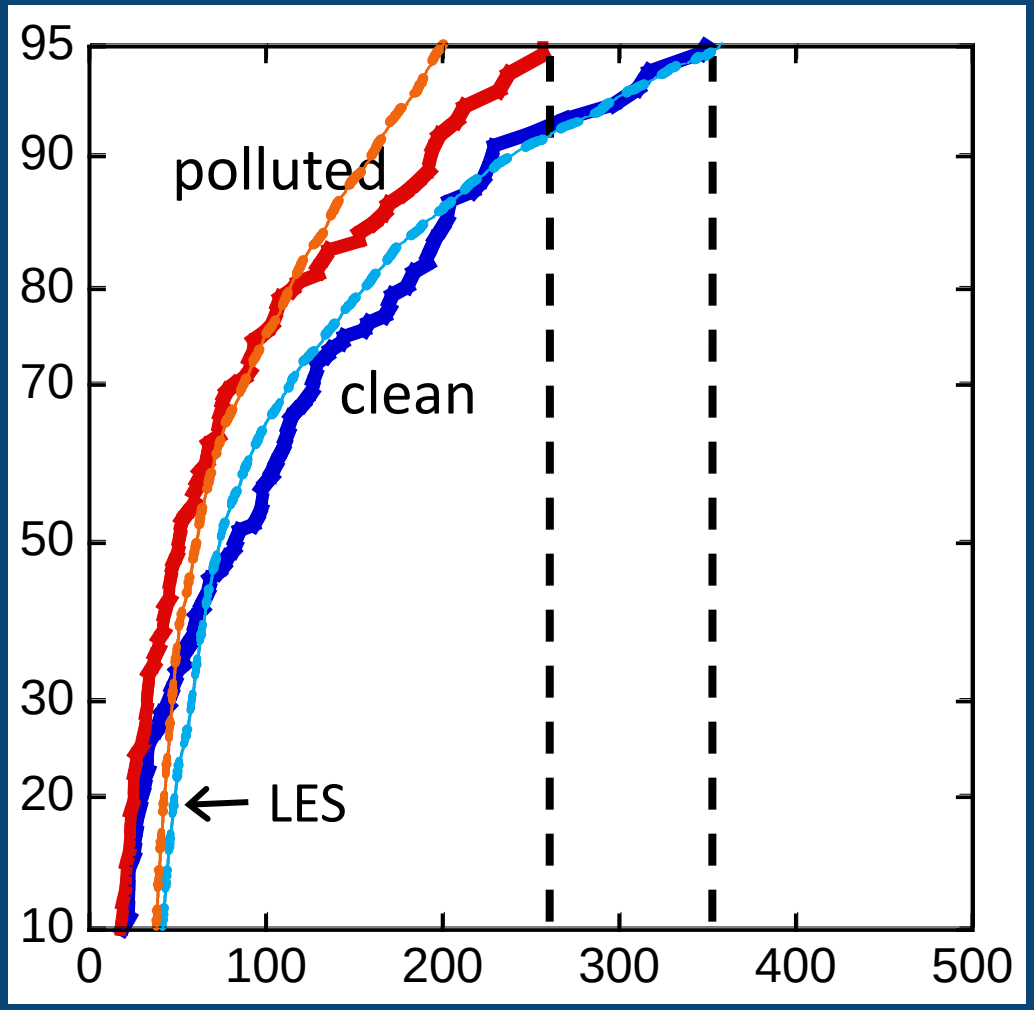
y-axis: Range of cloud edge width (m)

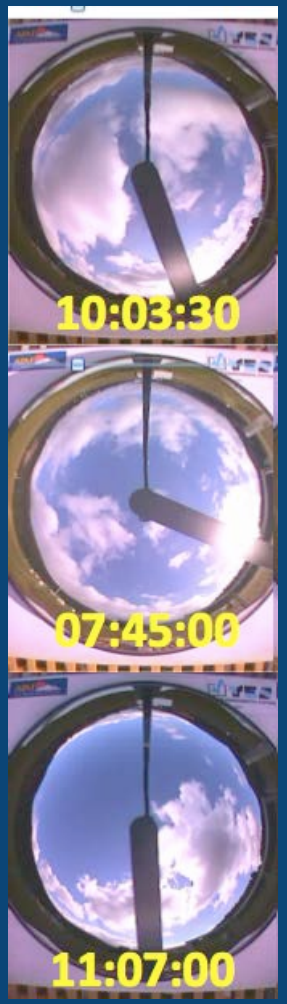
observations: threshold in aerosol light scattering 50 Mm^{-1}

COPS: 95% clouds have cloud edges within 250-m in polluted cases; 350-m in clean cases

COPS

cumulative probability (%)

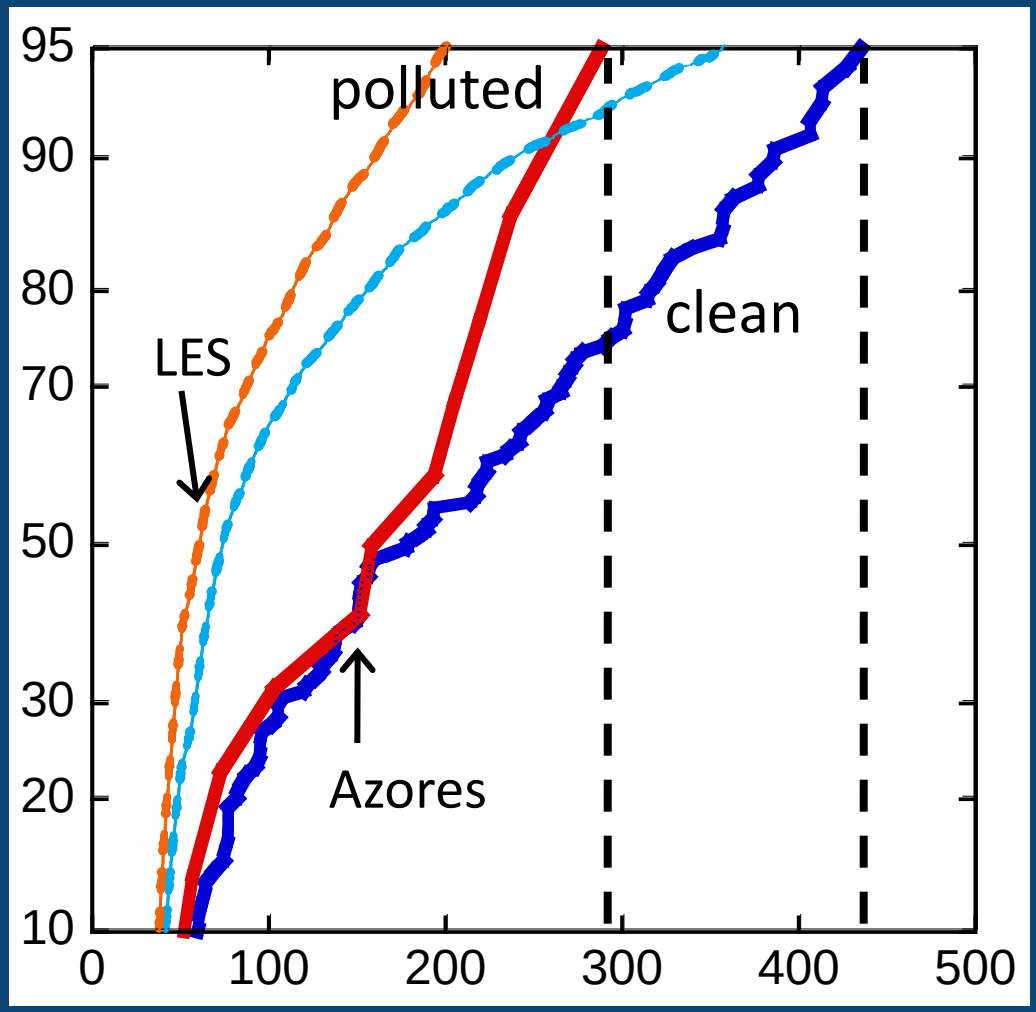


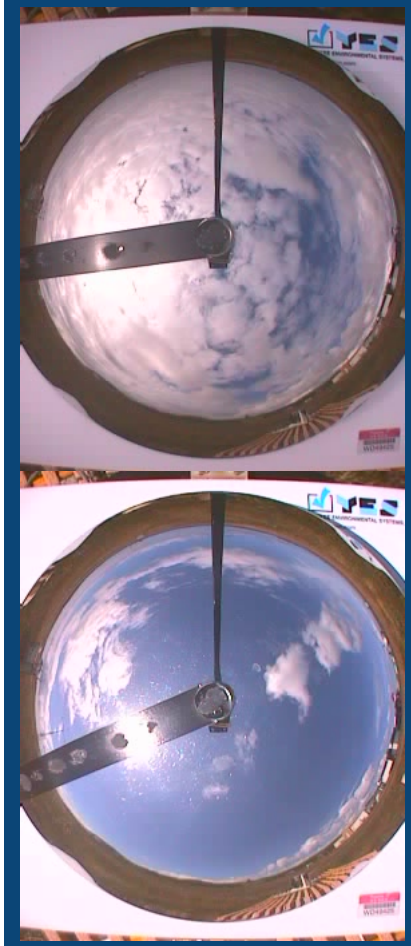


Azores: 95% clouds have cloud edges within 300-m in polluted cases; 450-m in clean cases

Azores

cumulative probability (%)





Summary

- Observations show that clouds in more polluted air have sharper cloud edges, but statistical significance is not always met
- The distribution of cloud edge width in simulations is similar to that observed in COPS, not Azores
- We plan to relax criteria of case selections to allow us to stratify cases based on meteorological factors