Insights into possible cloud effects on aerosols from MODIS

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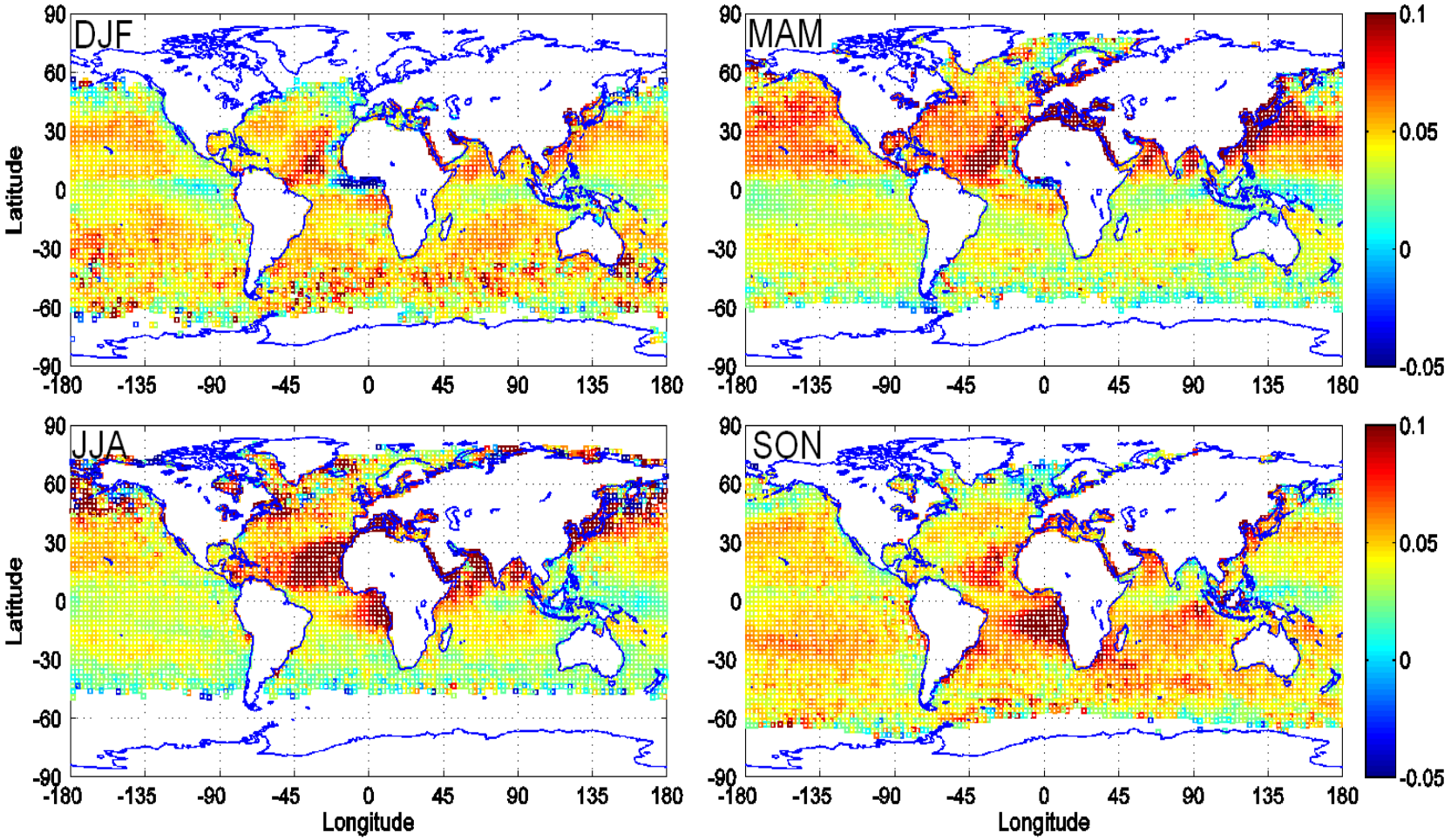
Method

- Use MODIS L2 aerosol product
  - Produced for 10x10 km^2 "scenes"
  - Cloudy pixels (0.5x0.5 km^2) within scene are removed using MODIS cloud mask. Cloud cover reported for each "scene"
  - Aerosol properties (only τ used here) retrieved for remaining cloud-free pixels
- Bin retrievals by scene cloud fraction
  - For a given region/season, construct an enhancement as $\Delta\tau = \tau_{CF.85} - \tau_{CF.15}$ where $\tau_{CF.X}$ is the mean AOD for scenes with cloud fraction of X
  - Normalized enhancement $\varepsilon = (\tau_{CF.85} - \tau_{CF.15})/\tau_{CF.15}$

Absolute enhancement

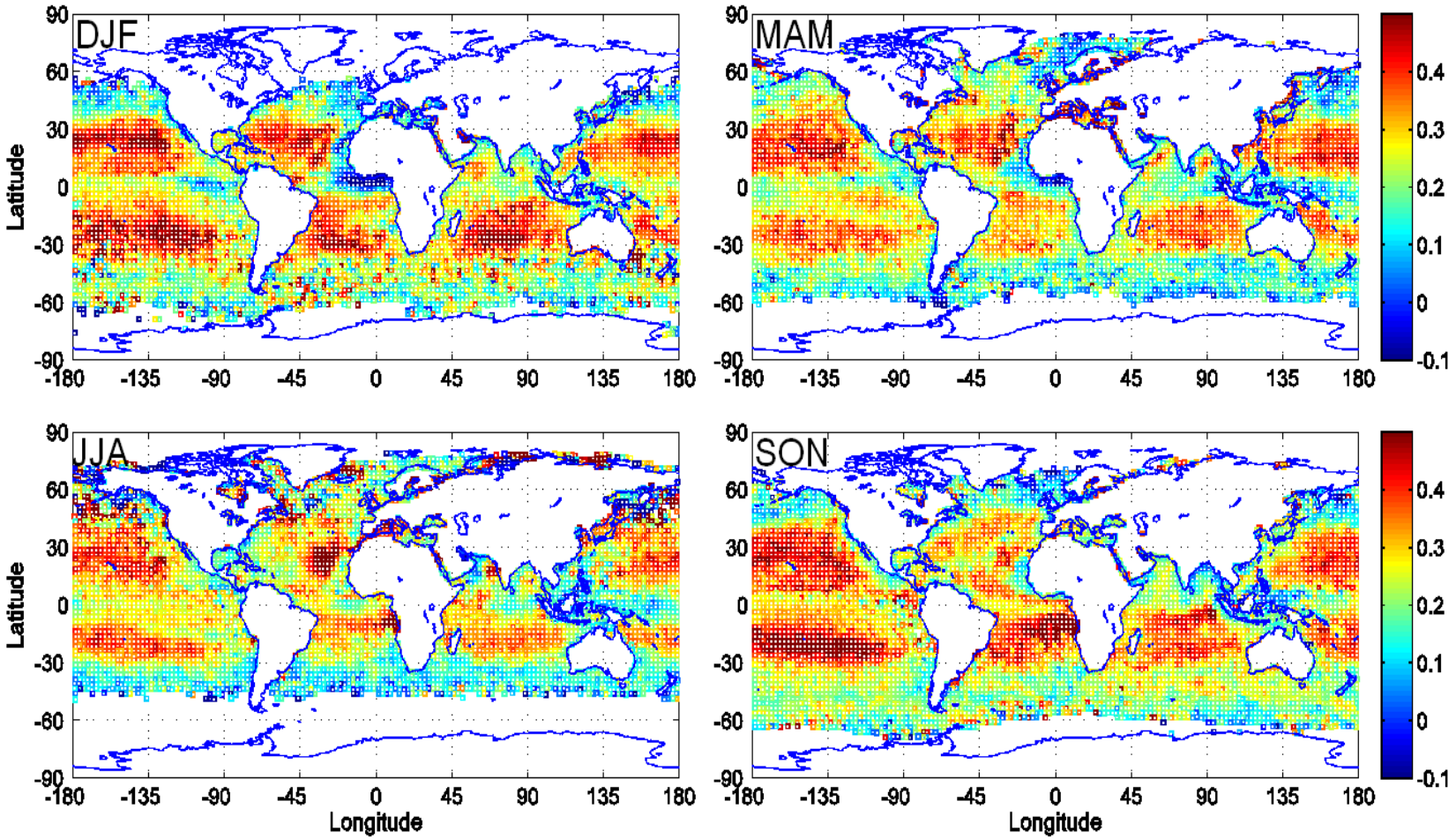
$$\Delta\tau = \tau_{CF.85} - \tau_{CF.15}$$



Strong seasonality, zonal asymmetry, larger in regions of high AOD

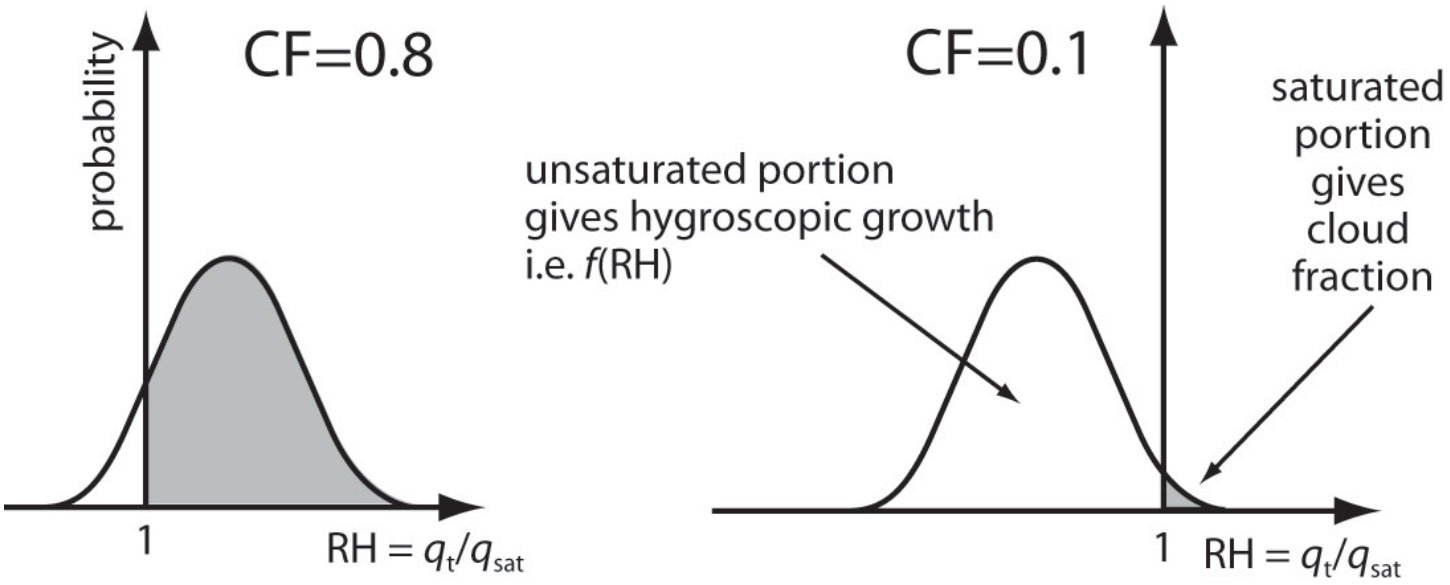
Relative enhancement

$$\varepsilon = (\tau_{CF.85} - \tau_{CF.15})/\tau_{CF.15}$$



Zonal symmetry, not a function of mean AOD, no strong seasonality

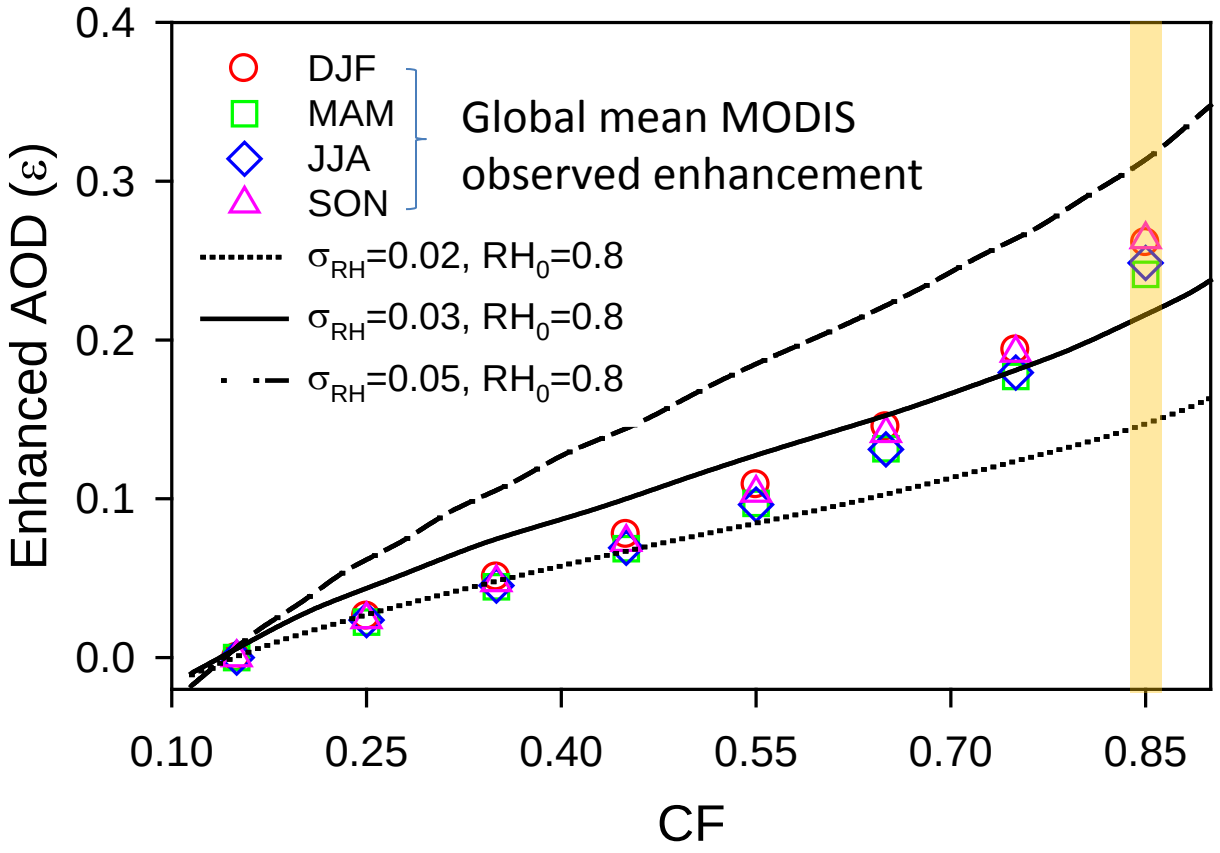
Simple model linking hygroscopic aerosol growth to cloud cover through RH pdf



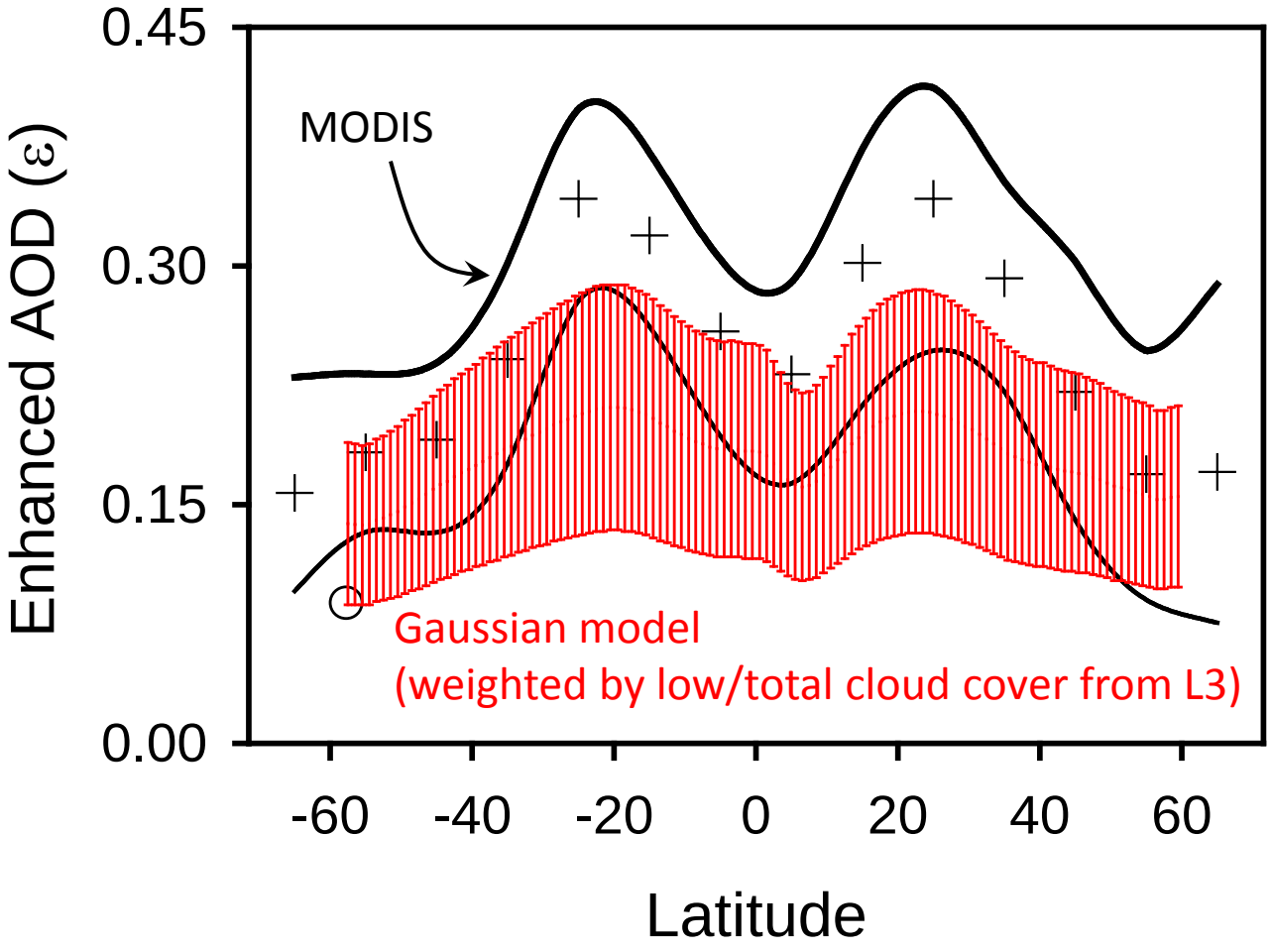
- Assume pdf of RH in a given region is Gaussian with fixed width
- Dry AOD fixed
- Cloud cover (CF) is determined from saturated fraction of pdf
- Clear sky RH distribution determined from unsaturated fraction of pdf
  - Use this to determine hygroscopic growth assuming aerosol growth factor of Kiehl et al. (2000)
- Since mean RH controls both CF and clear sky RH distribution, the enhancement of aerosol scattering is related to CF

Model and observed AOD enhancement

- Model results depend upon standard deviation of RH within MODIS scene
  - Estimated to be in range 2-5% for 10 km scale using aircraft data from several campaigns
- General consistency between model and observations suggesting that hygroscopic growth likely explains a significant fraction of AOD enhancement in cloudy environments



Zonally-averaged obs and model



Latitudinal variation may be explained by distribution of high cloud cover which masks true enhancements

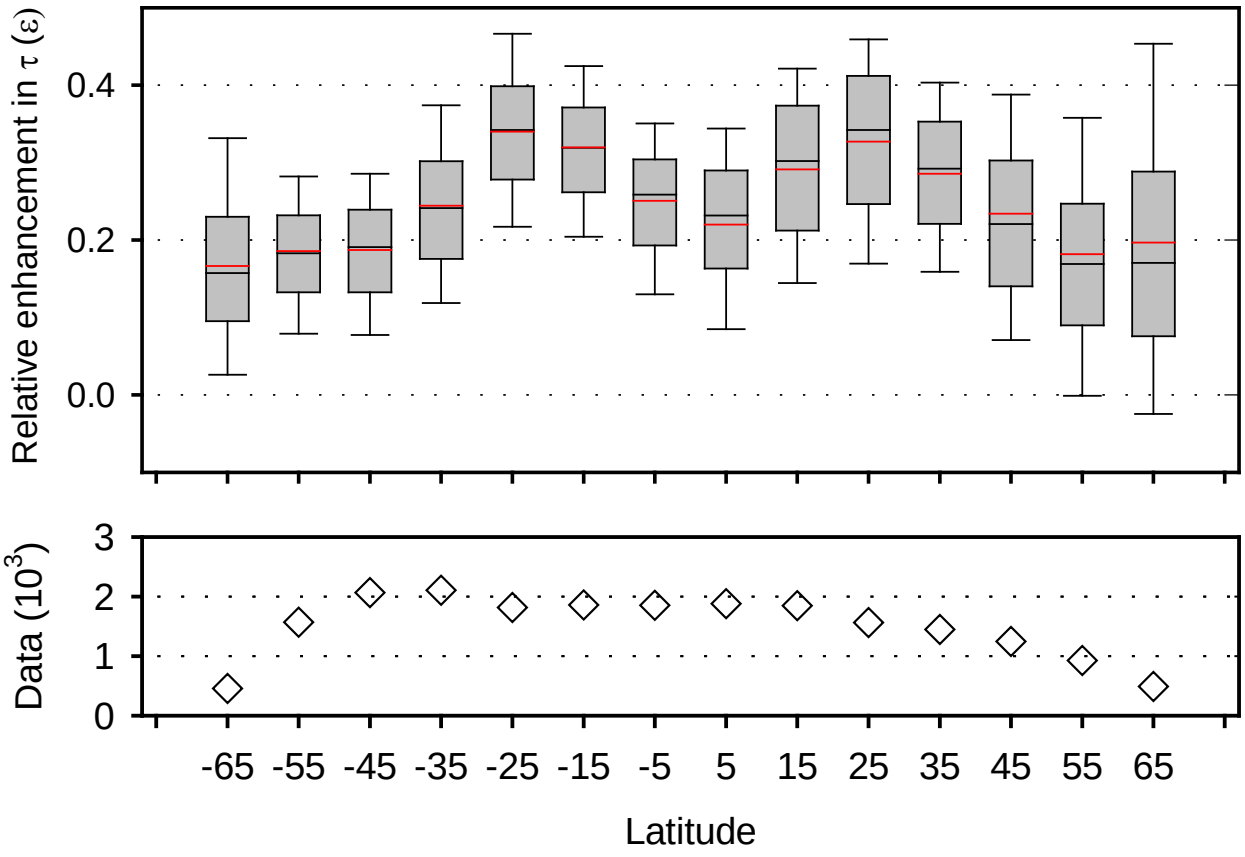
Conclusions

- Simple Gaussian model
- Hygroscopic growth likely responsible for significant fraction of AOD enhancement in clear regions in the vicinity of clouds

ASR Opportunities

- All measurements needed to tackle the hygroscopic growth problem are available in ARM
  - Cloud fraction from TSI
  - Aerosol extinction from HSRL
  - Humidity variability in clear skies from Raman lidar

Zonal dist


Relative enhancement in τ (ε)
0.4
0.2
0.0
Data (10^3)
3
2
1
0
-65
-55
-45
-35
-25
-15
-5
5
15
25
35
45
55
65
Latitude