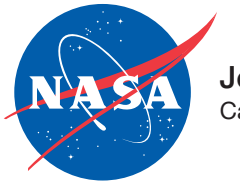

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Global Spectroscopic Survey of Cloud Thermodynamic Phase 2005-2015

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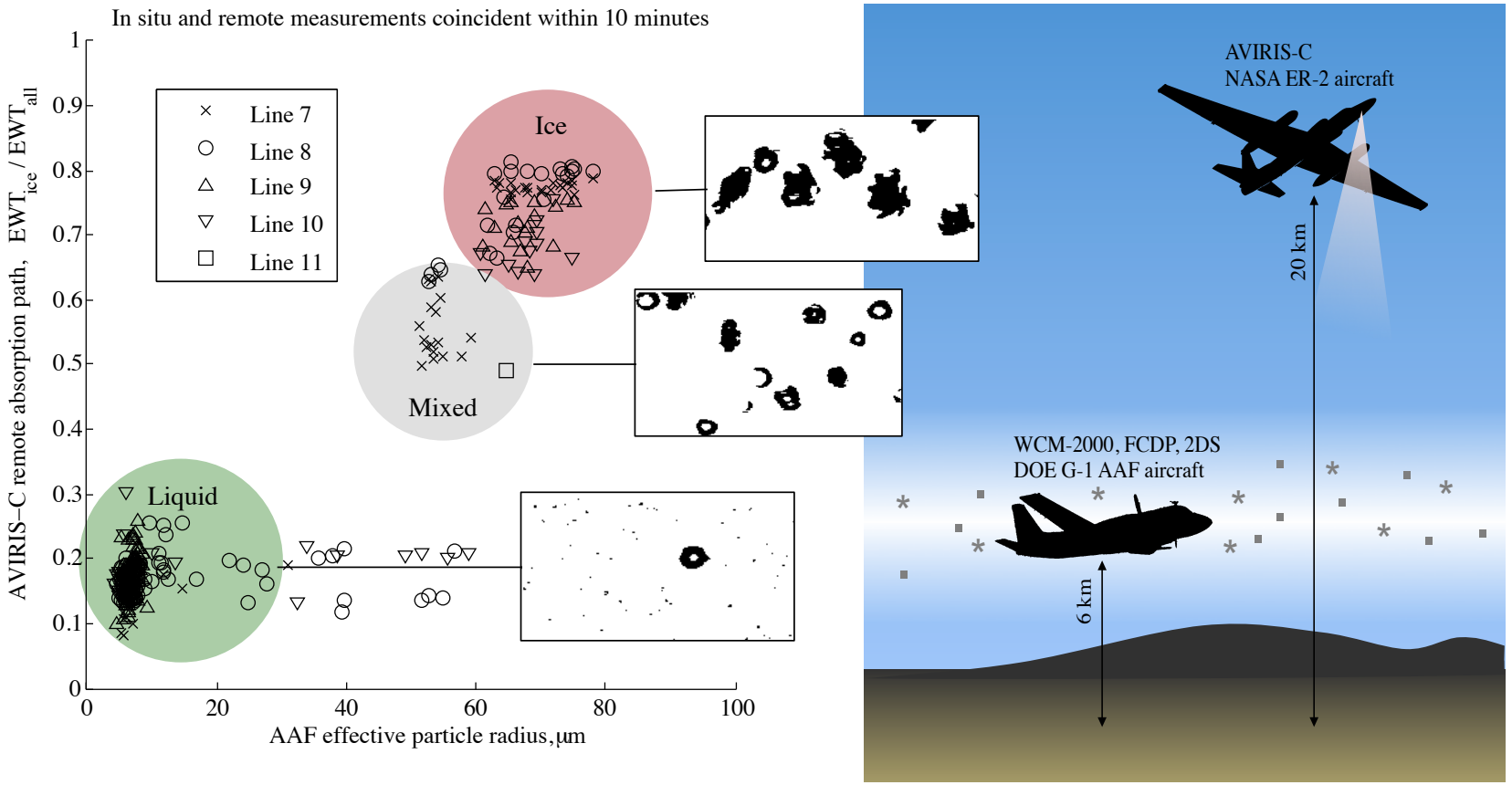
Why study cloud thermodynamic phase?

- Important for Earth's climate and planetary radiation budget (Chylek 15 et al., 2006; Martins et al., 2011; Ehrlich et al., 2008; Tan and Storelvmo, 2016).
- Clouds are shifting poleward in the Northern and Southern Hemisphere extratropical storm tracks (Bender et al., 2012; Marvel et al., 2015; Norris et al., 2016).
- Climate model experiments with forcing from increased CO_2 have shown losses of cloud ice phase and gains of cloud liquid phase (Ceppi and Hartmann, 20 2015; McCoy et al., 2015).
- Spatial partitioning of ice and liquid particles within clouds can change Global Climate Model (GCM) predictions of future warming by over 1 degree Celsius (Tan et al., 2016).
- Traditional observations only resolve phase at 1km or coarser.

Spectroscopic cloud phase retrieval
[Thompson et al., JGR-Atmospheres 2015]



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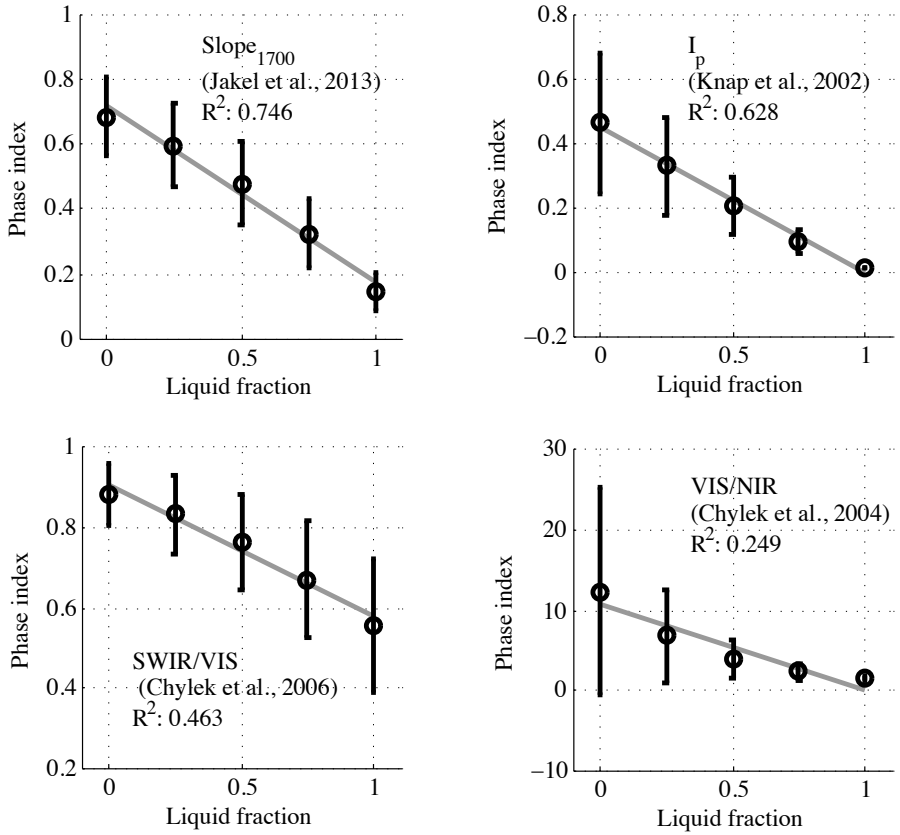
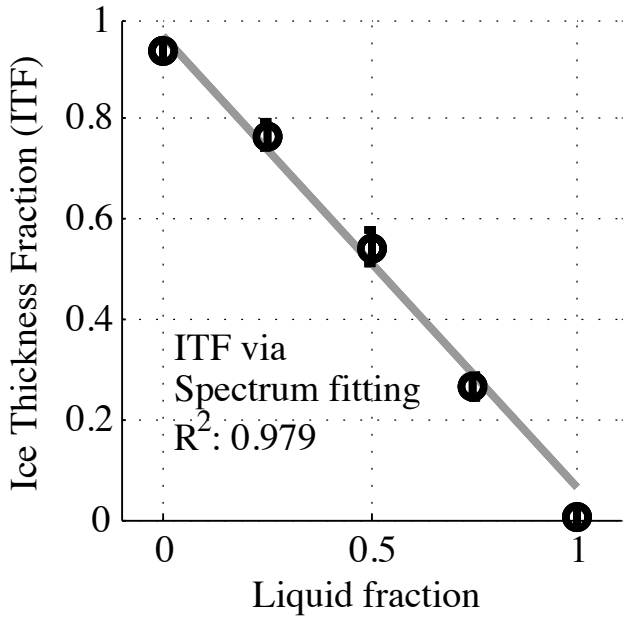
Simulation performance

Multiband



Spectroscopic



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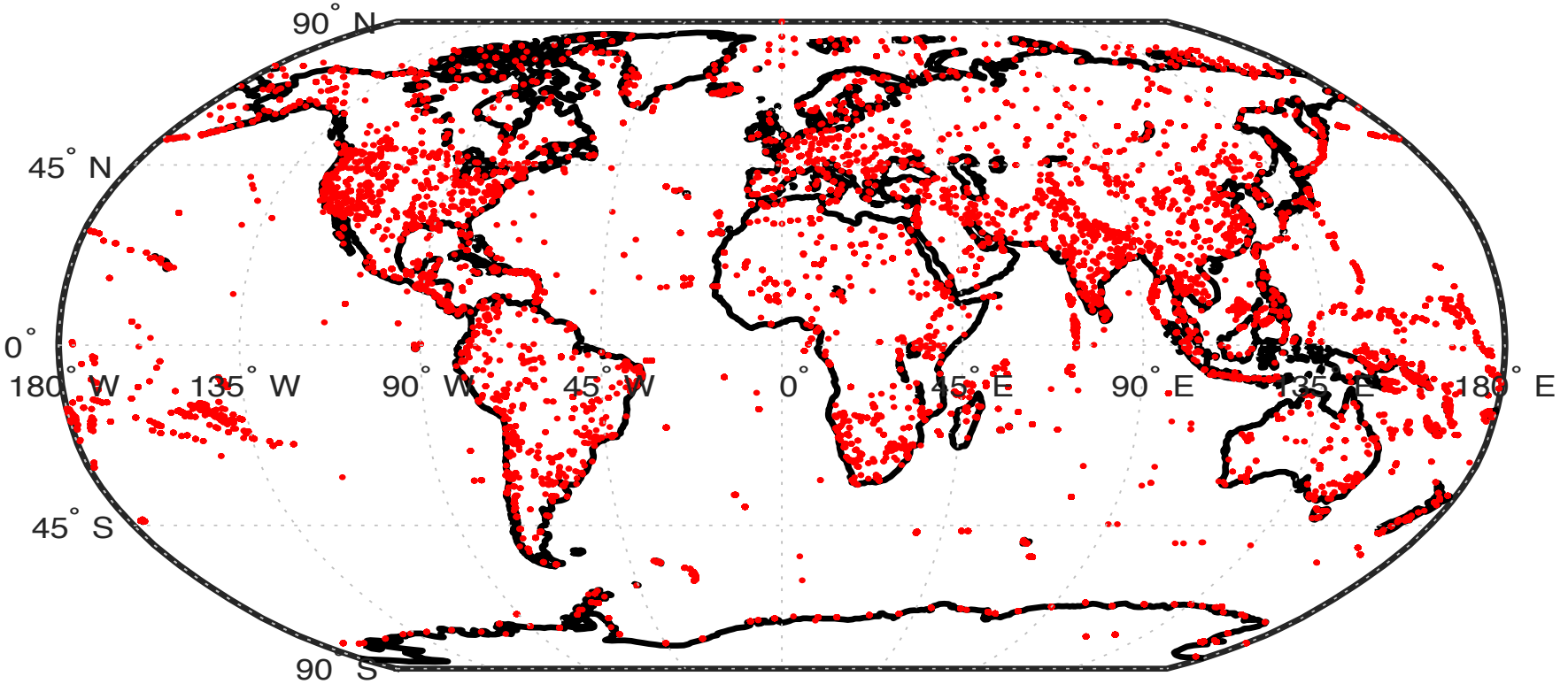
Hyperion Archive, 2005-2015
> 48,000 scenes



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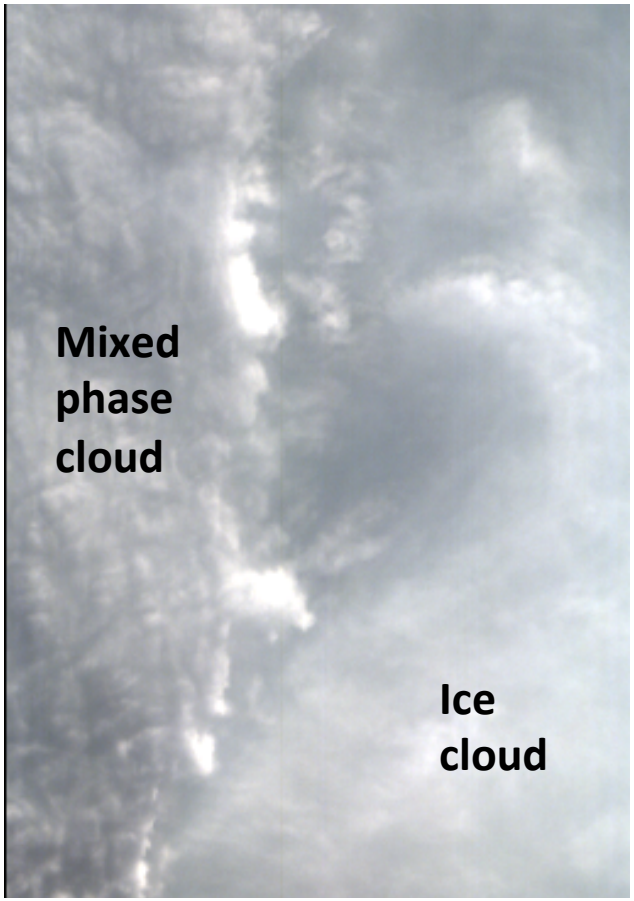
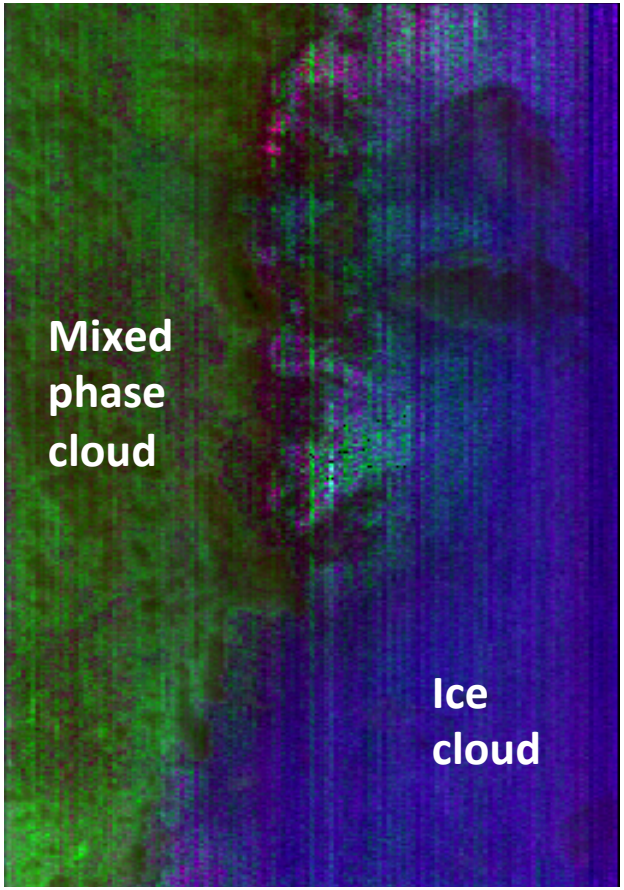
Example Cloud Phase Maps

Blue and green color channels indicate liquid and ice optical path lengths.
30 meter spatial sampling. Full acquisitions are 256x3918 pixels.





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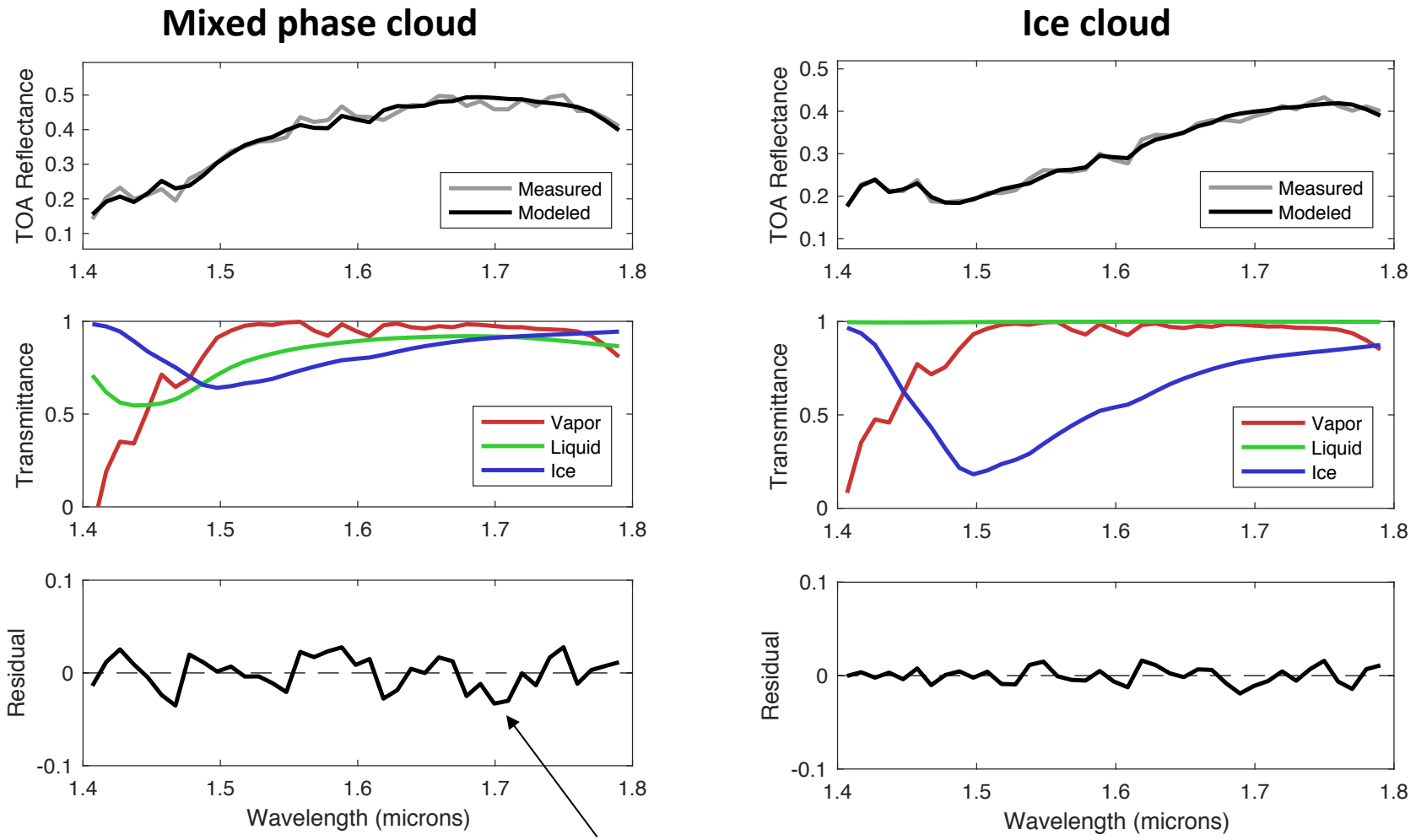
Spectrum fits from example image



Typical fits are better than our (conservative) noise estimate

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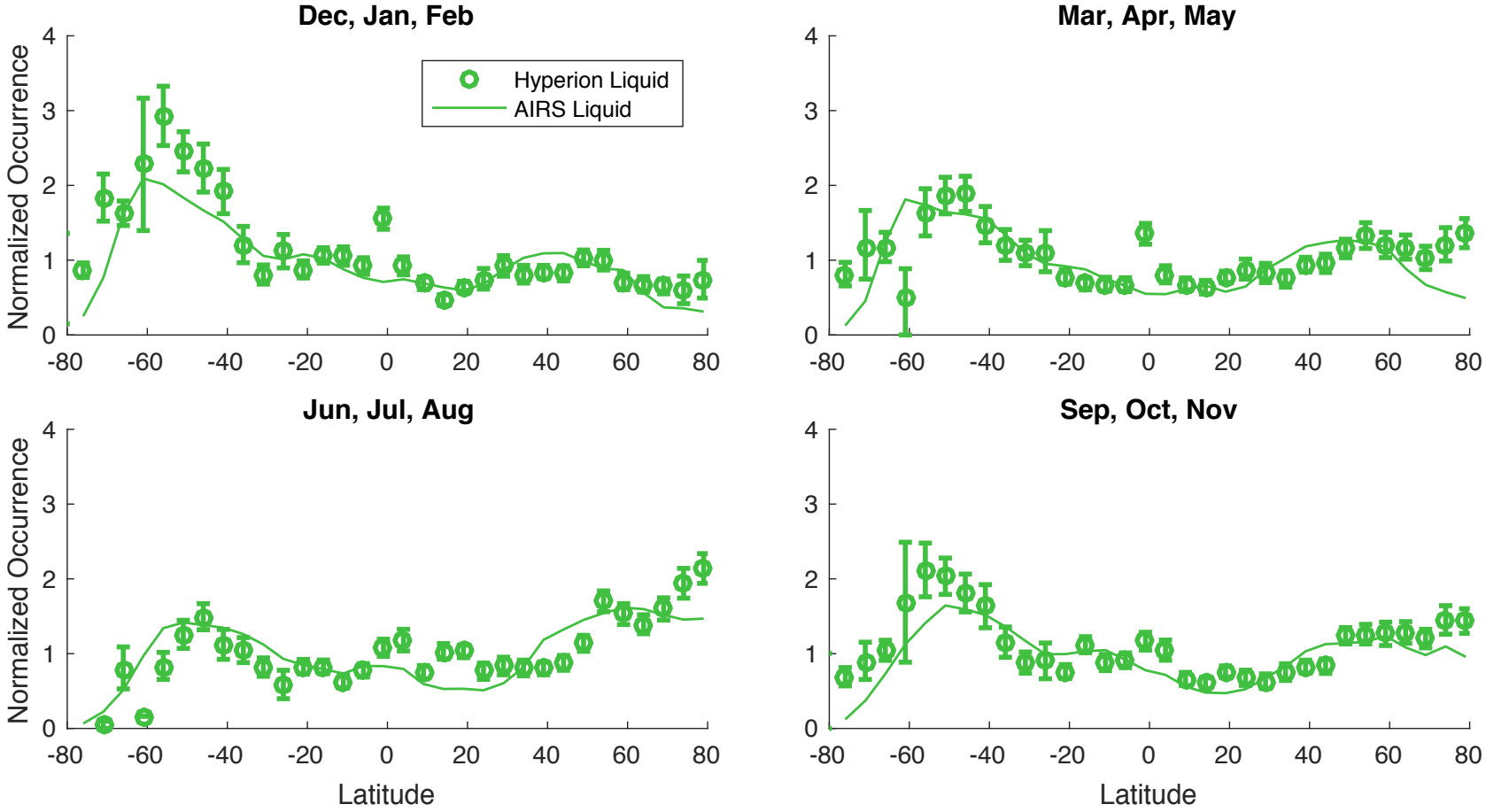
Latitude Trends: Liquid

Error bars are 95% confidence intervals via nonparametric bootstrap.
AIRS estimates use 0.1 cloud fraction threshold



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Latitude Trends: Ice

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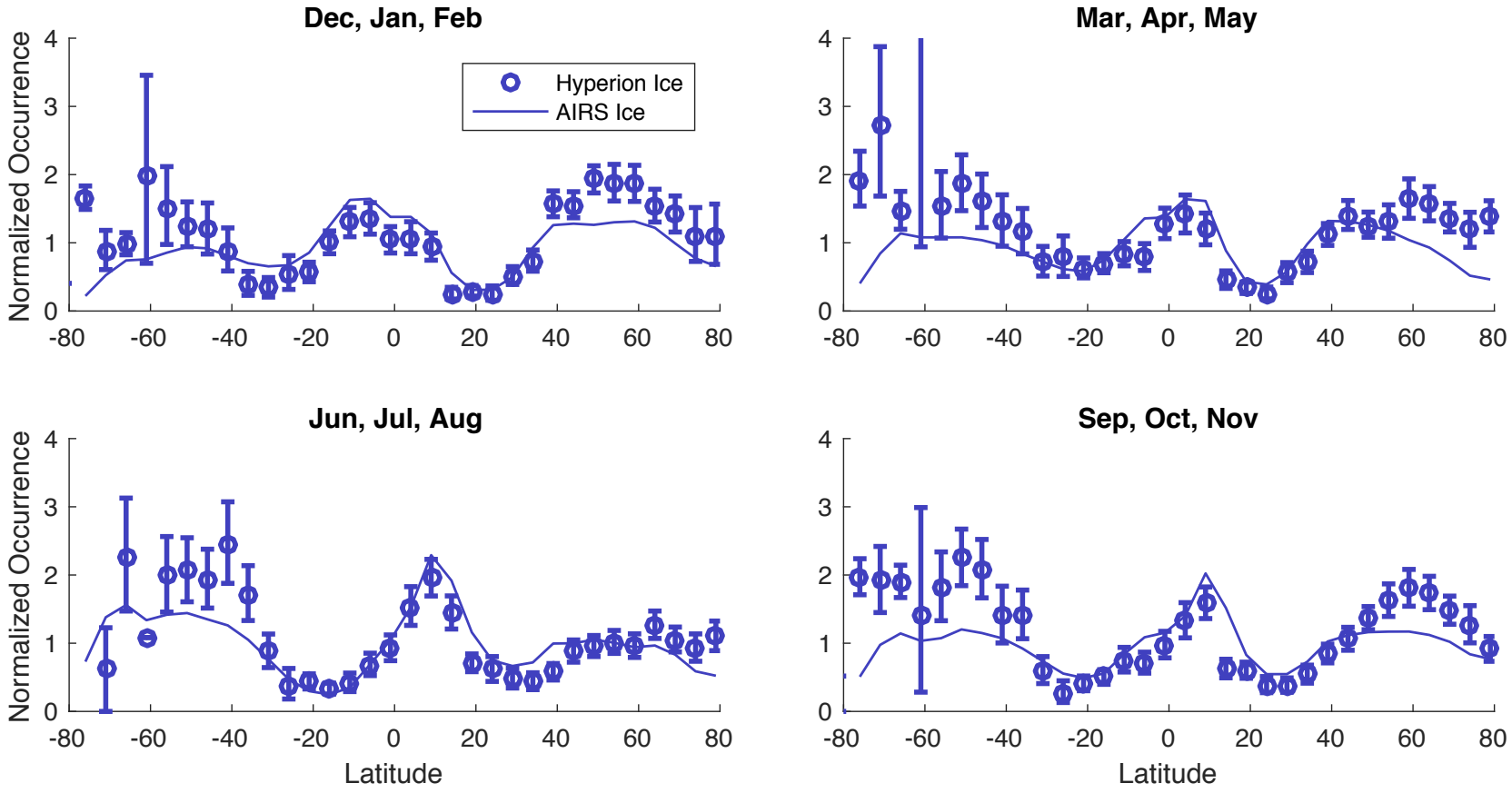

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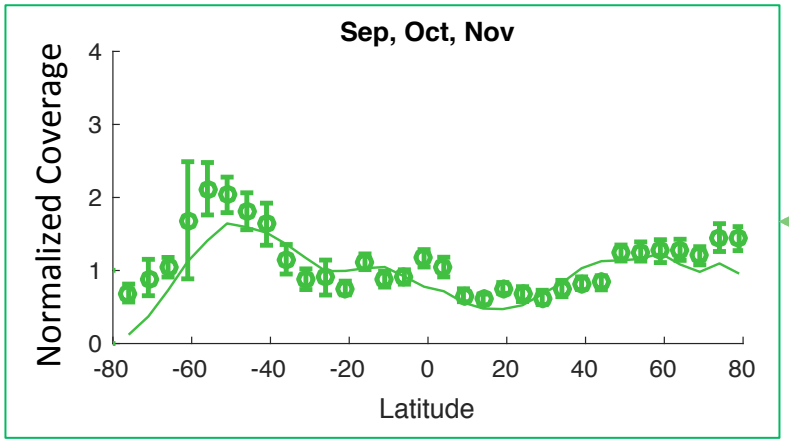
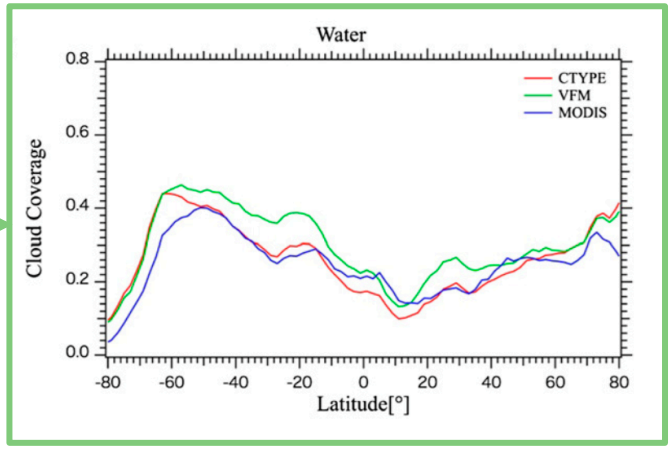
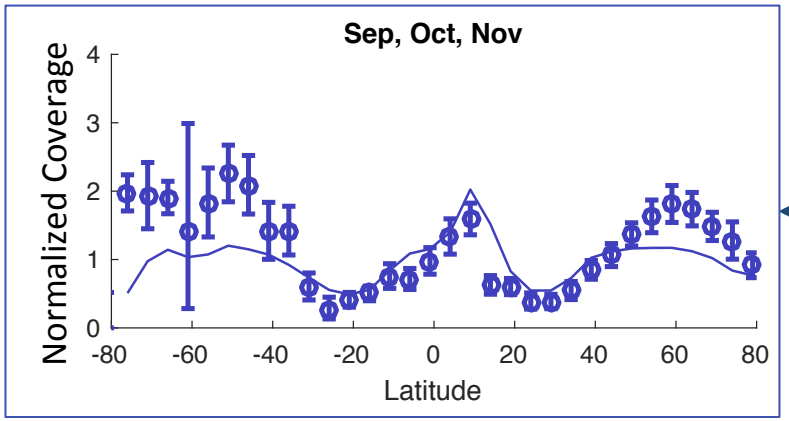
Comparison vs. Hirakata et al. 2014

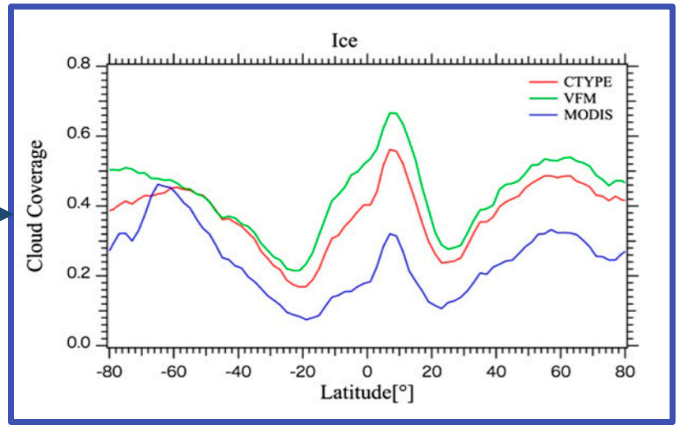
Hyperion 2005-2015



Hirakata et al. (Sep-Nov)







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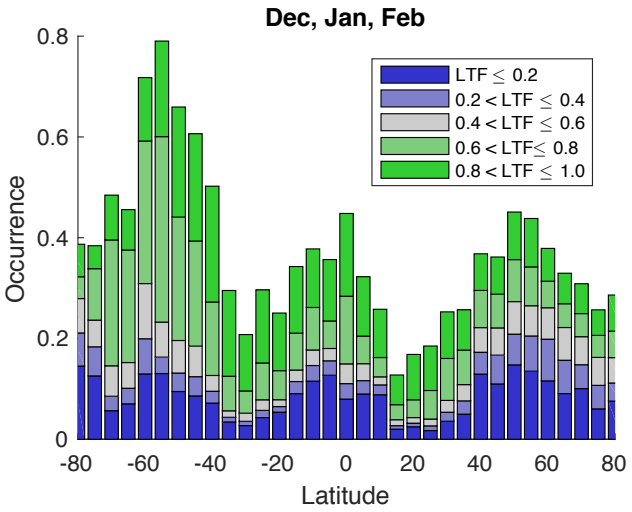
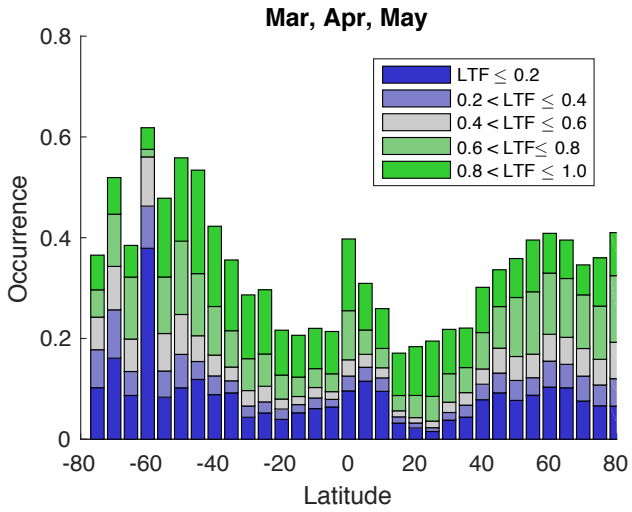
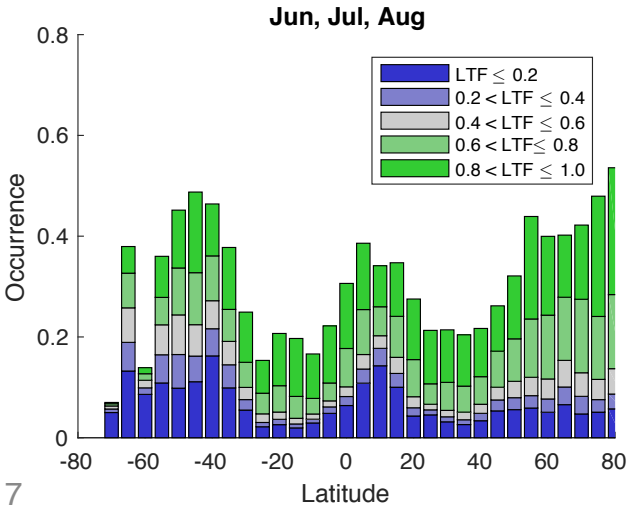
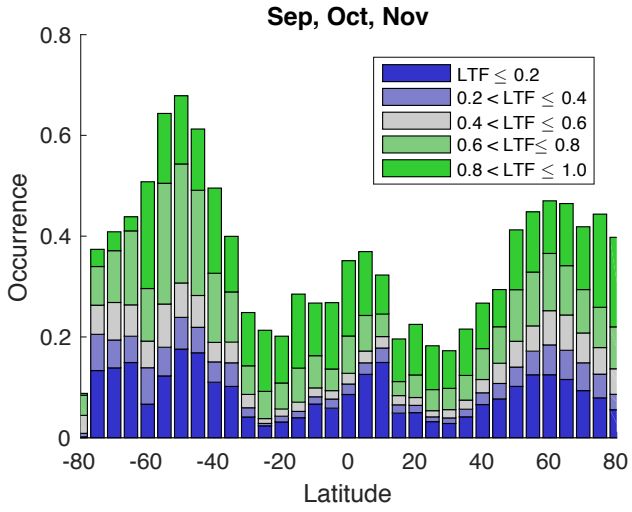
Intermediate phases (Liquid Thickness Fraction)









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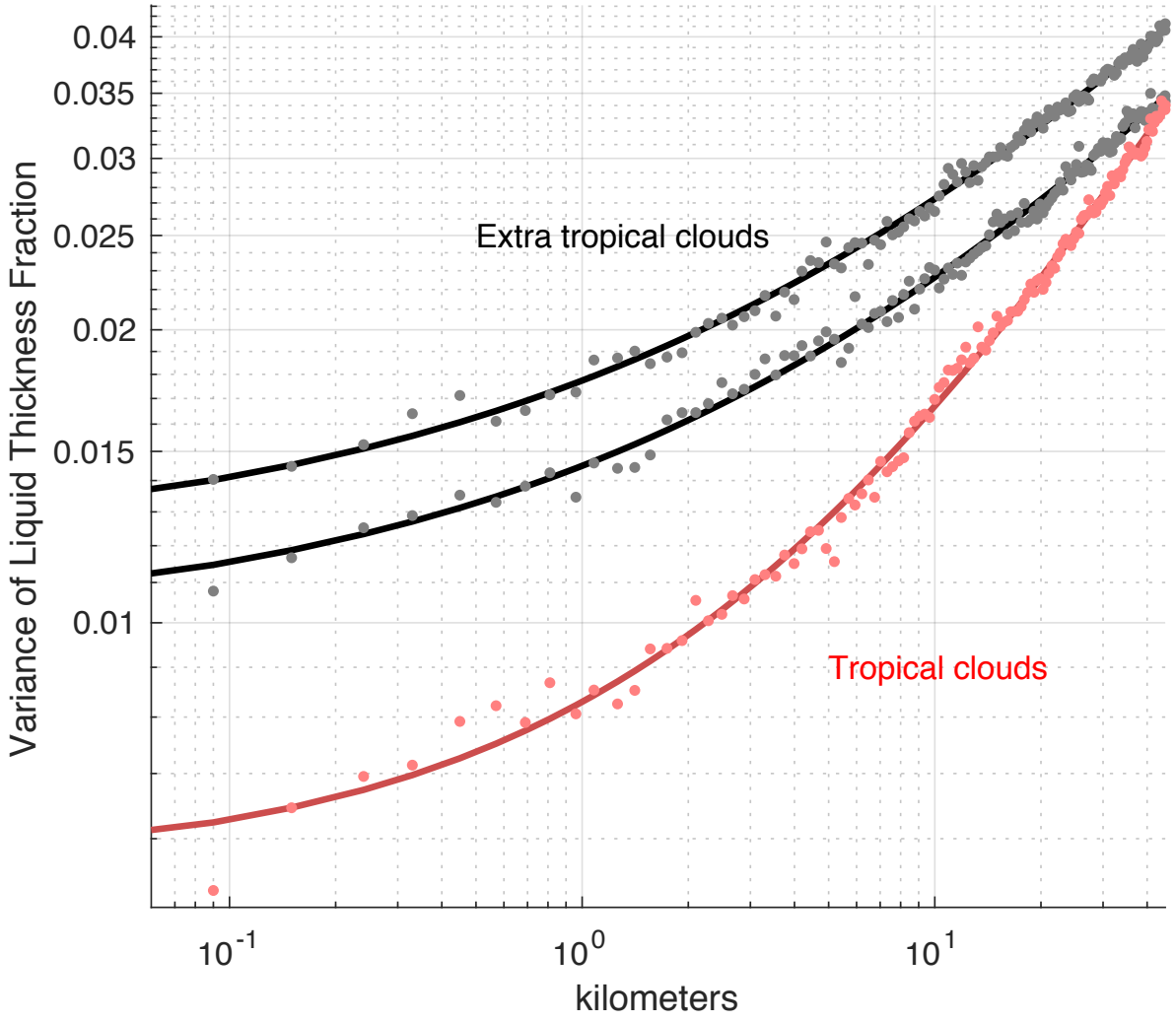
Variogram Spatial Scale Analysis



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Conclusions

1. First global high spatial resolution survey of cloud thermodynamic phase.
2. Spatial correlations follow a power law.
3. Approximately 50% measurable variance is determined at length scales of 6km.
4. Significant spatial variability appears at scales far below the resolution of typical GCMs.
5. Noise-equivalent measurement error of 7.5-11% in the liquid thickness fraction for different latitudinal zones

Addenda

- Caveat: Measurements are spatially biased, favor land over ocean.
- Continuous monitoring in the future is a new potential application for global mapping spectrometers
- Onboard analysis could enable continuous “always on” mapping

Thanks!

- The Hyperion team
- NASA Earth Science
- Calwater-2 flight planning incl. Ian McCubbin, AirMSPI and DOE Airborne ARM facility for assistance with original validation (Thompson et al., JGR 2016)

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