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New AIRS Version 6 cloud products: cloud thermodynamic phase, cirrus cloud optical thickness and effective diameter

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Thanks to: Shaima L. Nasiri, Evan M. Manning, Bryan A. Baum, Hongchun Jin, Mathias M. Schreier, Qing Yue, Eric J. Fetzer, Kuo-Nan Liou, Robert Oliphant, Steve S. C. Ou, Yoshihide Takano, and many others

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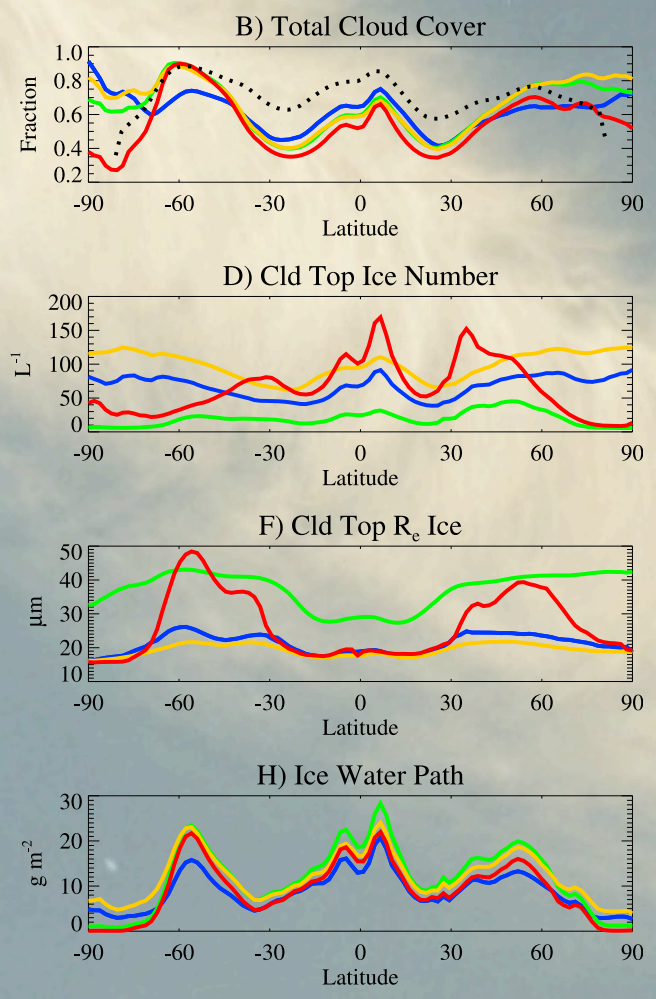
Some Science Motivation - 1



- New generation of climate models with explicit cloud microphysics
- e.g., NCAR CAM5 (Gettelman et al., 2010, JGR, figure to left)
- Treatment of ice nucleation has large impacts on simulated fields

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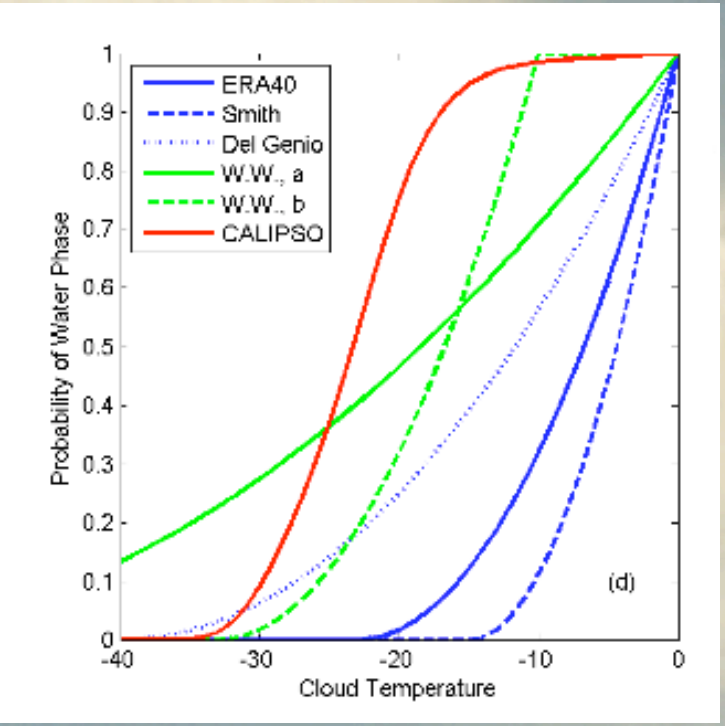
Some Science Motivation - 2



- Cloud thermodynamic phase poorly characterized in observations and climate models
- e.g., Hu et al. (2010), JGR
- Recent work has shown importance of mid-latitude storm tracks in cloud-climate feedback (Zelinka et al., 2011, J. Clim. submitted)

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Summary of New Version 6 Cloud Products

- Optimal estimation retrieval (post-processor) of:
  - *ice cloud effective diameter* (D_e)
  - *ice cloud optical depth* (OD)
  - *ice cloud top temperature* (T_{cld})
  - *cloud thermodynamic phase*

- SARTA+D4S uses AIRS L2 inputs to define atmosphere, surface, and a priori
  - single-layered cloud only; Baum et al. (2007) ice scattering models; ~60 channels in 8–15 μm region

- Chi-squared fits (observed vs. simulated radiances) and scalar averaging kernels (AKs) >> "user friendly" Quality Control (*Best*, *Good*, and *Bad*)

- Retrievals on AIRS FOVs identified as ***possibly*** and ***likely*** containing ice (see previous talk by H. Jin)

Quality Control Flags

- Both OD and T_{cld} have *Best*, *Good*, and *Bad* indicators
  - Best: chi-squared < 10 and AK > 0.8
  - Good: chi-squared > 10 or AK < 0.8
  - Bad: chi-squared > 10 and AK < 0.8
- D_e only has *Good* and *Bad* – the hardest parameter to retrieve
  - Good: chi-squared < 10 and AK > 0.8
  - Bad: chi-squared > 10 or AK < 0.8
- Quality control indicators are **neither** absolute **nor** quantitative

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Example granule-scale retrievals and quality control

September 6th, 2002, Granule #44

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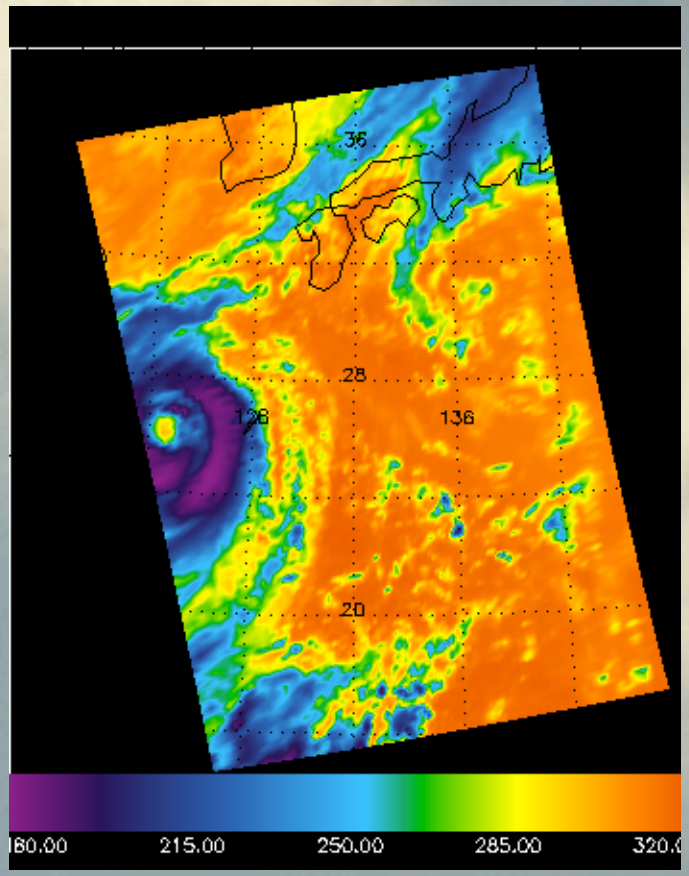
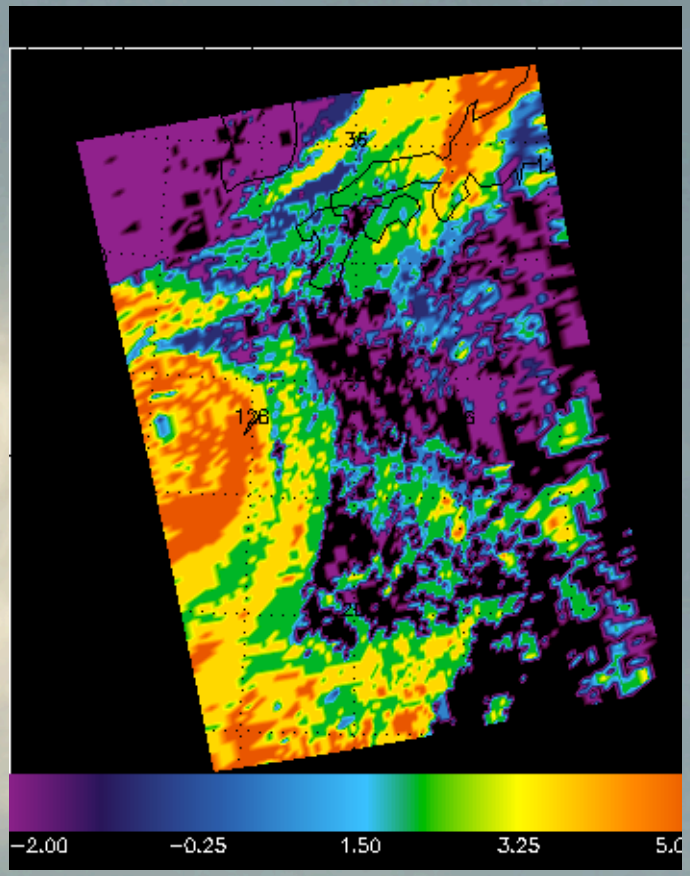
A mixture of cloud types and high scene complexity

T_b @ 1231 cm^{-1}



No cloud, liquid, unknown,
ice1, ice2, ice3, ice4



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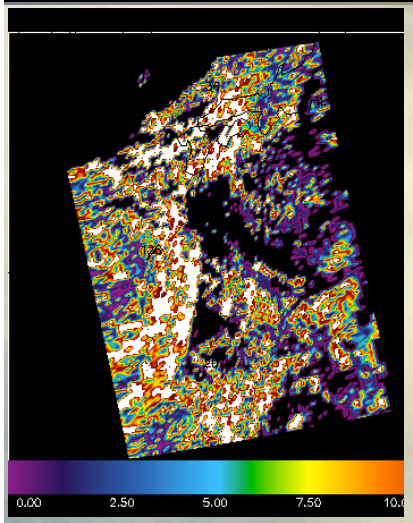
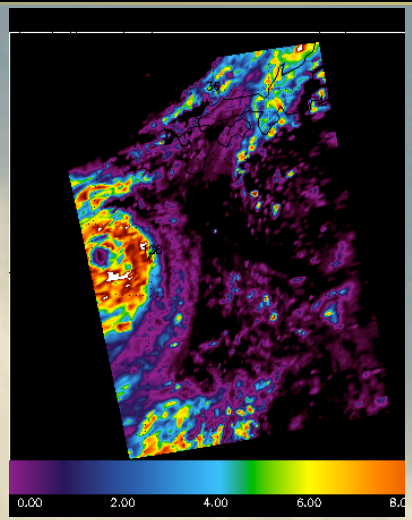
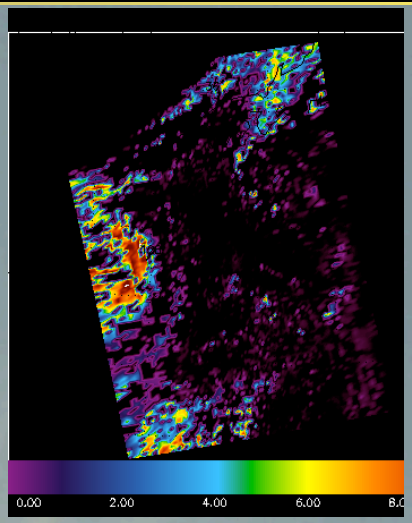
Quality Control Example for OD



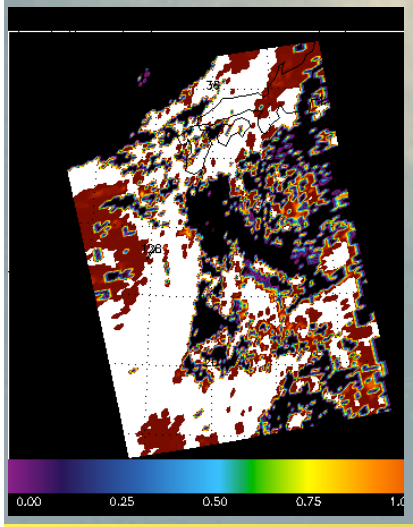
Chi-squared fit



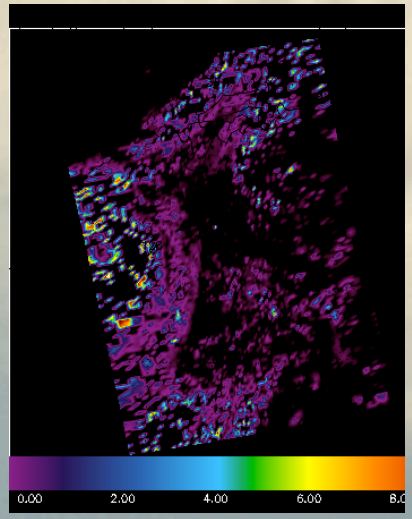
"All" OD



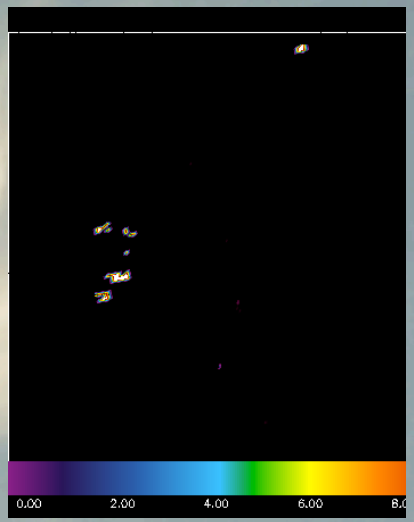
Best OD



Averaging Kernel



Good OD



Bad OD

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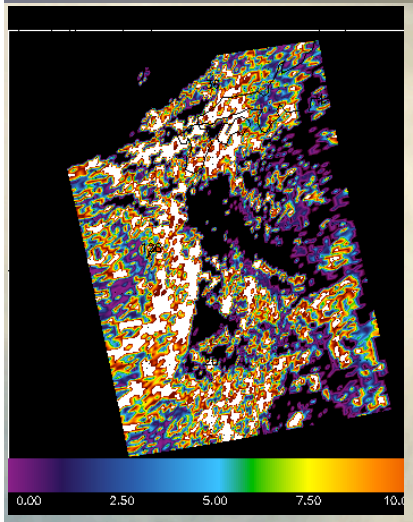
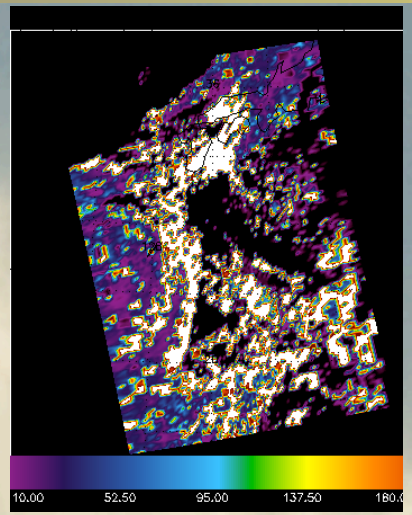
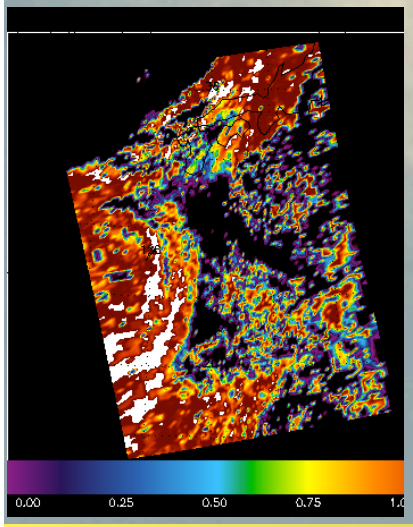
Quality Control Example for D_e



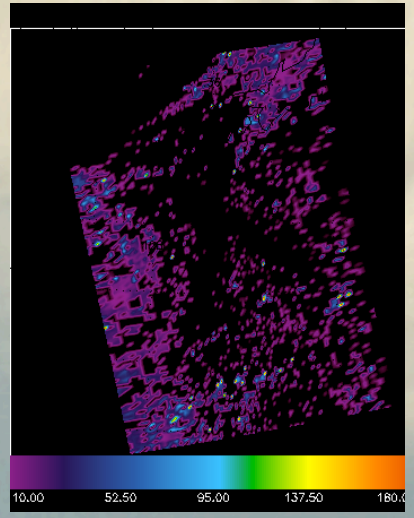
Chi-squared fit



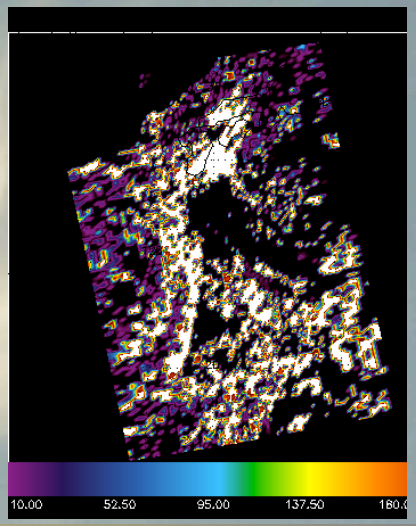
"All" D_e



Averaging Kernel



Good D_e



Bad D_e

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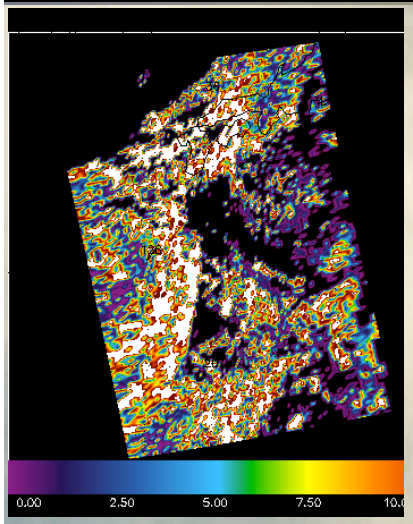
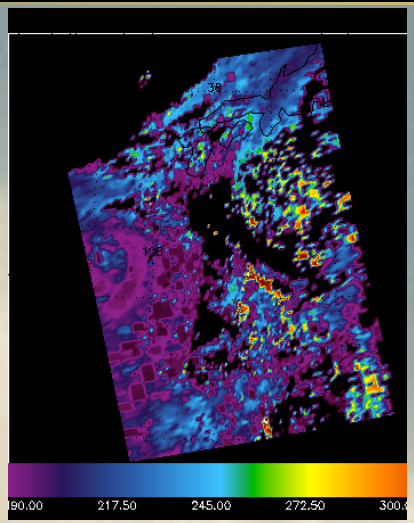
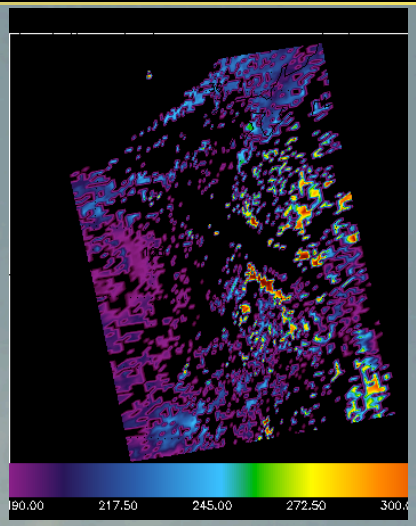
Quality Control Example for T_{CLD}



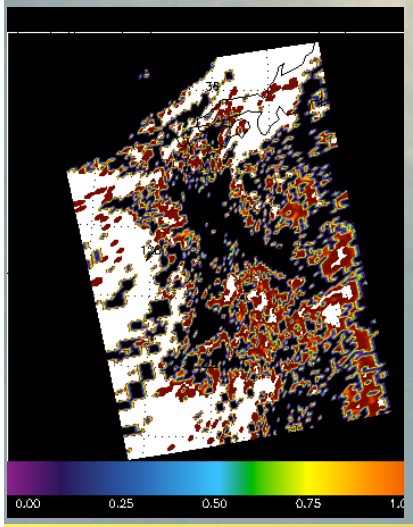
Chi-squared fit



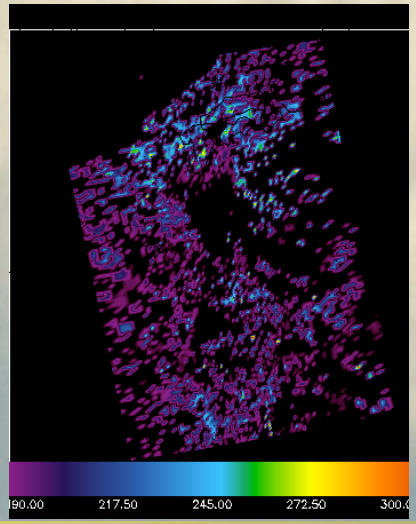
"All" T_{CLD}



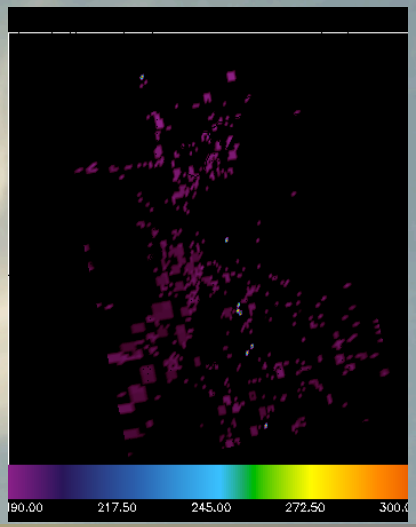
Best T_{CLD}



Averaging Kernel



Good T_{CLD}



Bad T_{CLD}

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Zonal Averages/Standard Deviations of OD, D_e, and T_{CLD}

For January 2007 and June 2008

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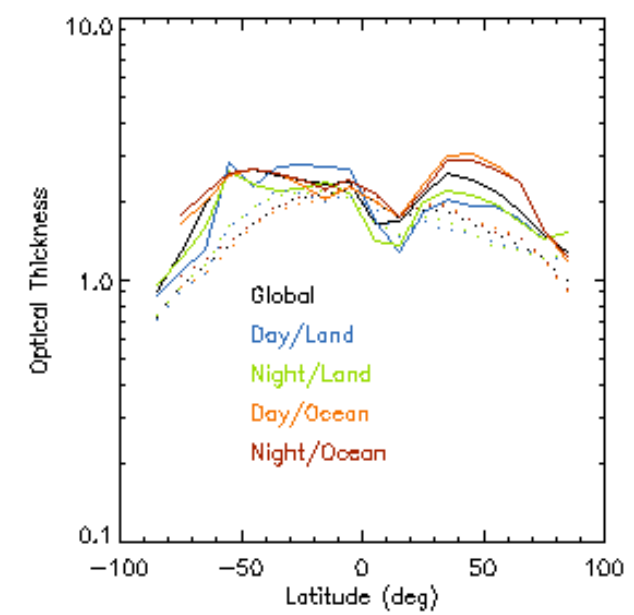
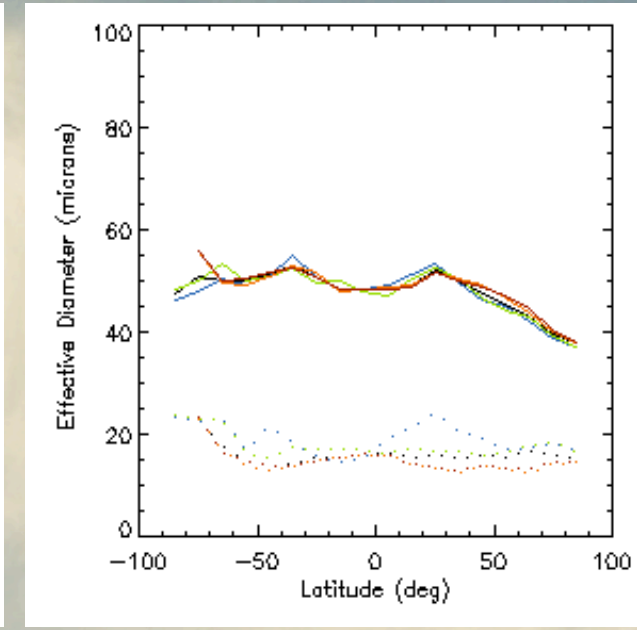
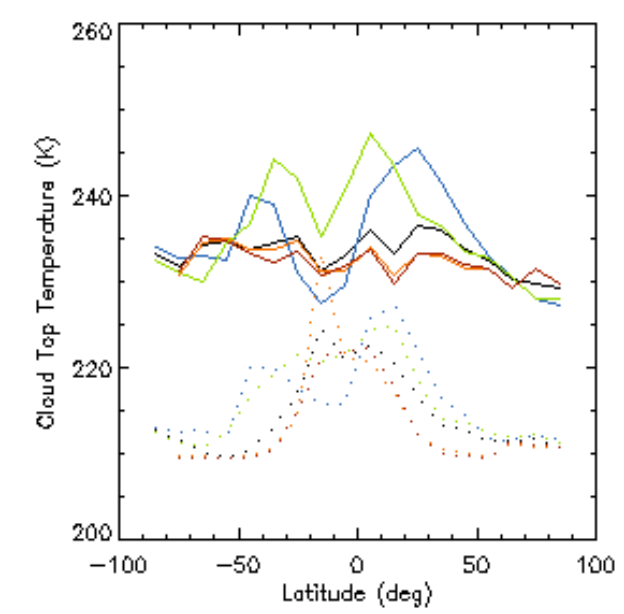
Zonal Averages/Standard Deviations for Jan 2007







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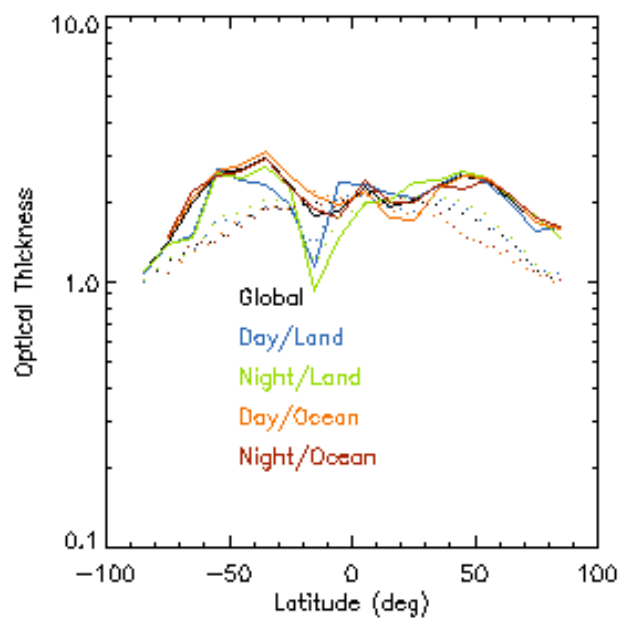
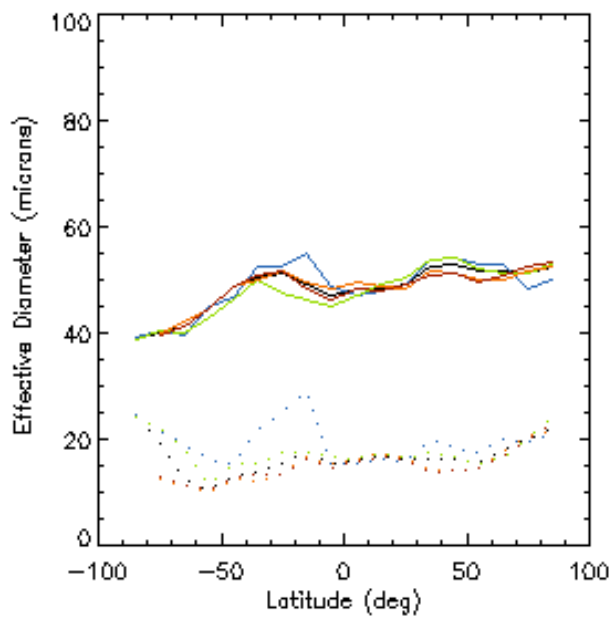
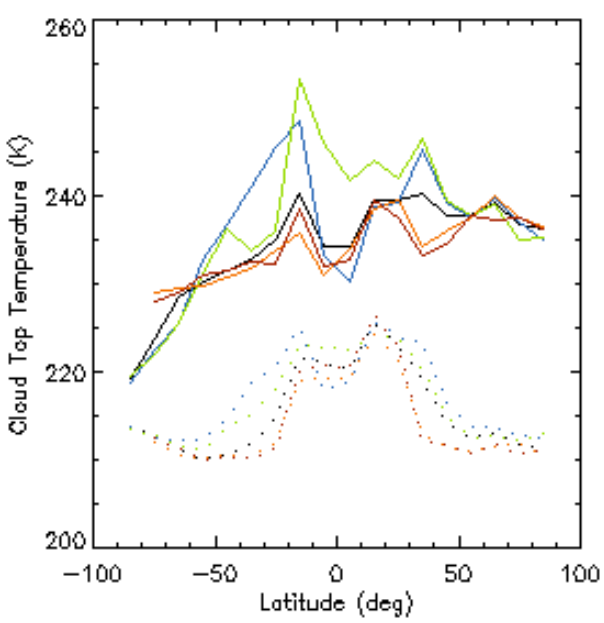
Zonal Averages/Standard Deviations for June 2008







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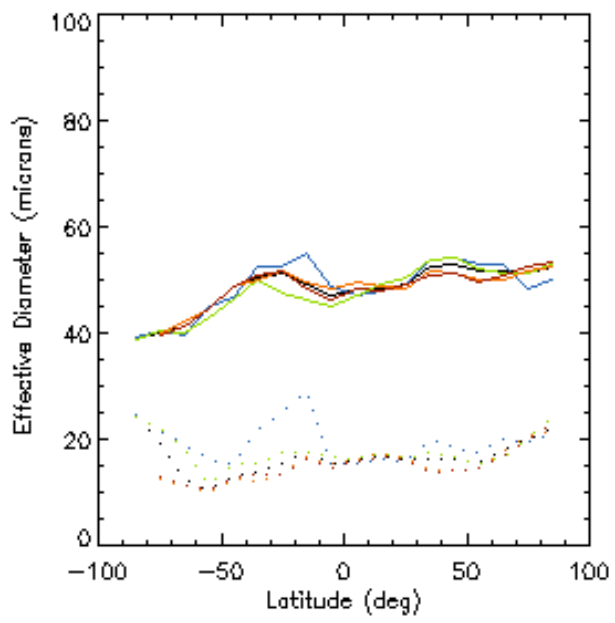
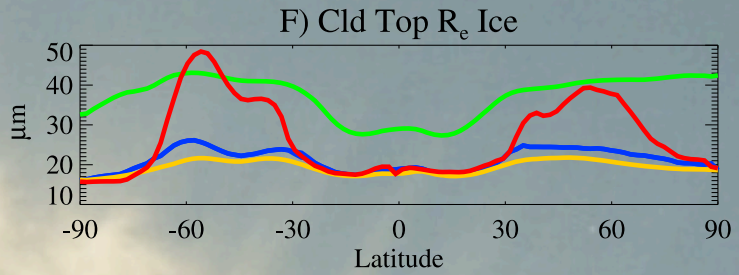
AIRS vs. CAM5 in the zonal mean





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AIRS vs. CAM5

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Global joint histograms of AIRS retrievals

For January 2007 and June 2008

Divided into "Global", "Tropical", "NH Midlats", "SH Midlats, "NH Polar", and "SH Polar"

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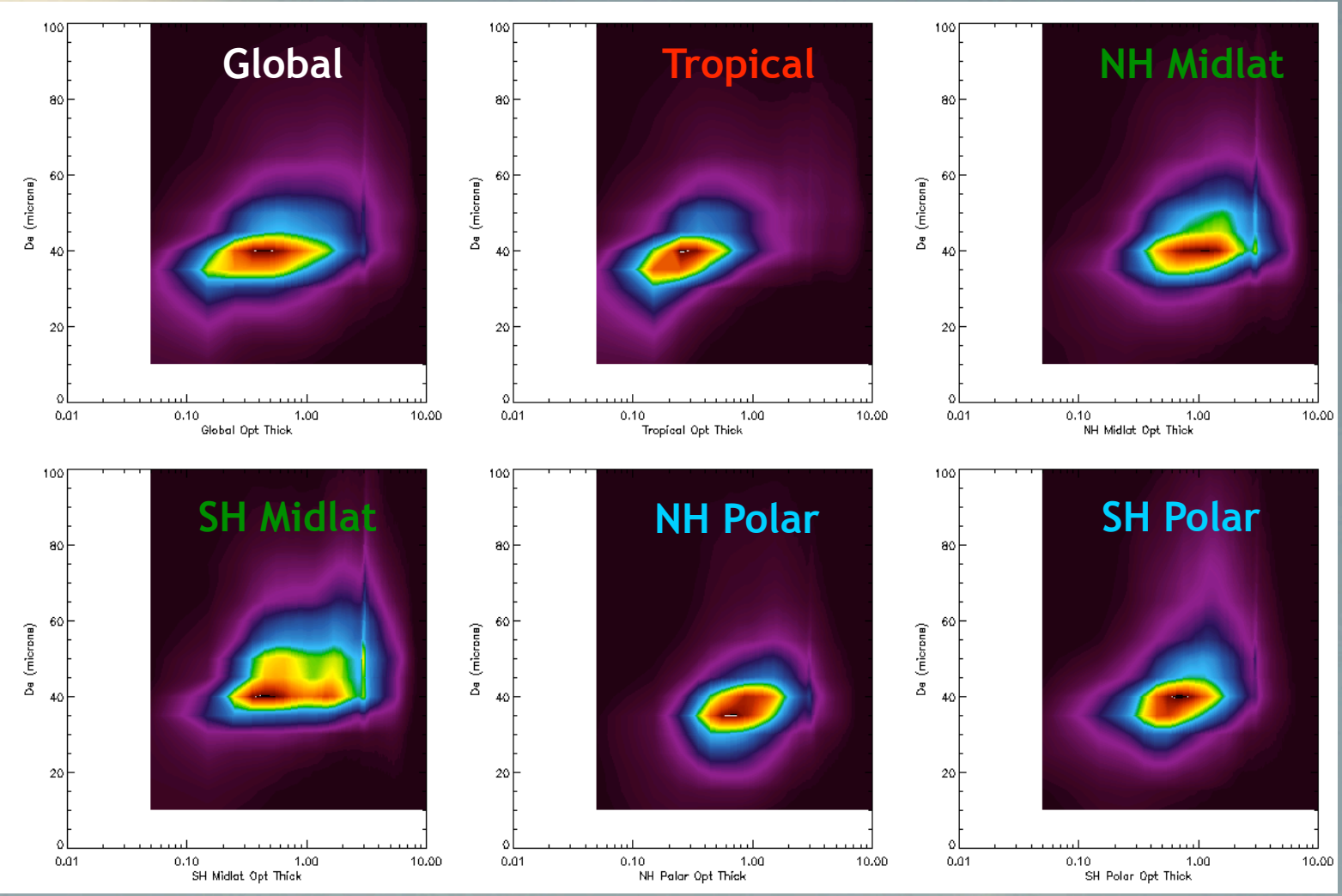
OD & D_e joint histograms for Jan 2007



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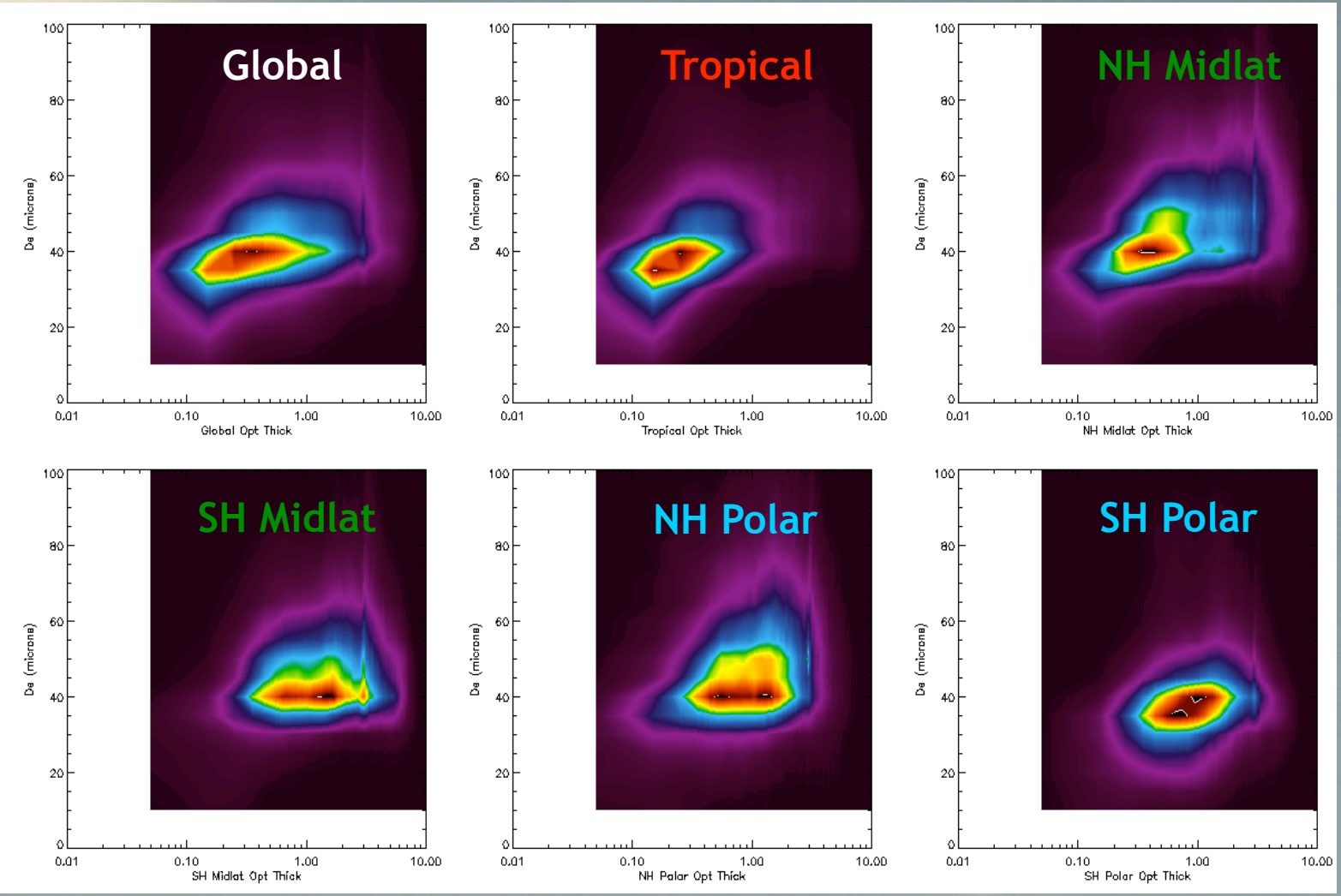
OD & D_e joint histograms for June 2008



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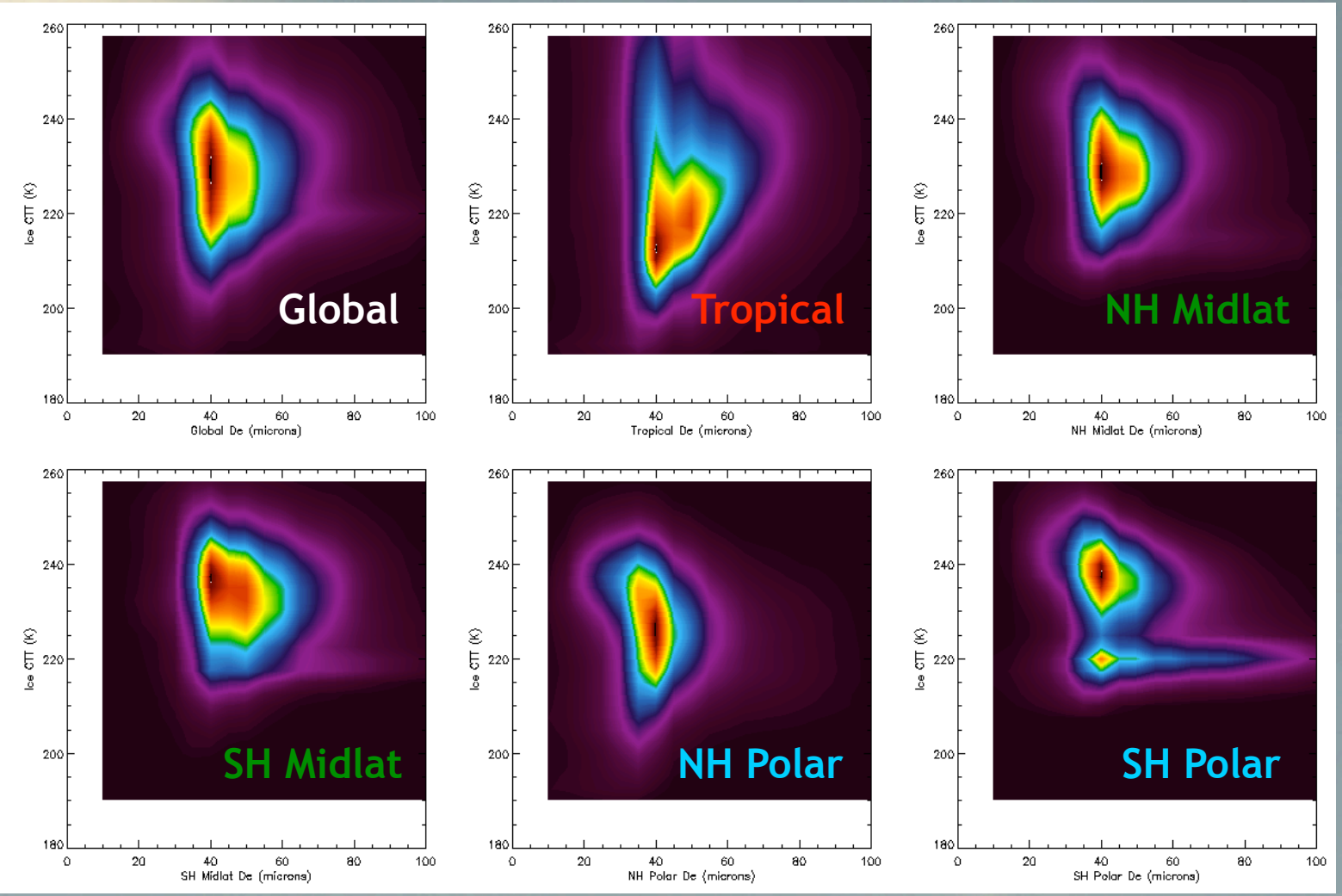
D_e & T_{CLD} joint histograms for Jan 2007



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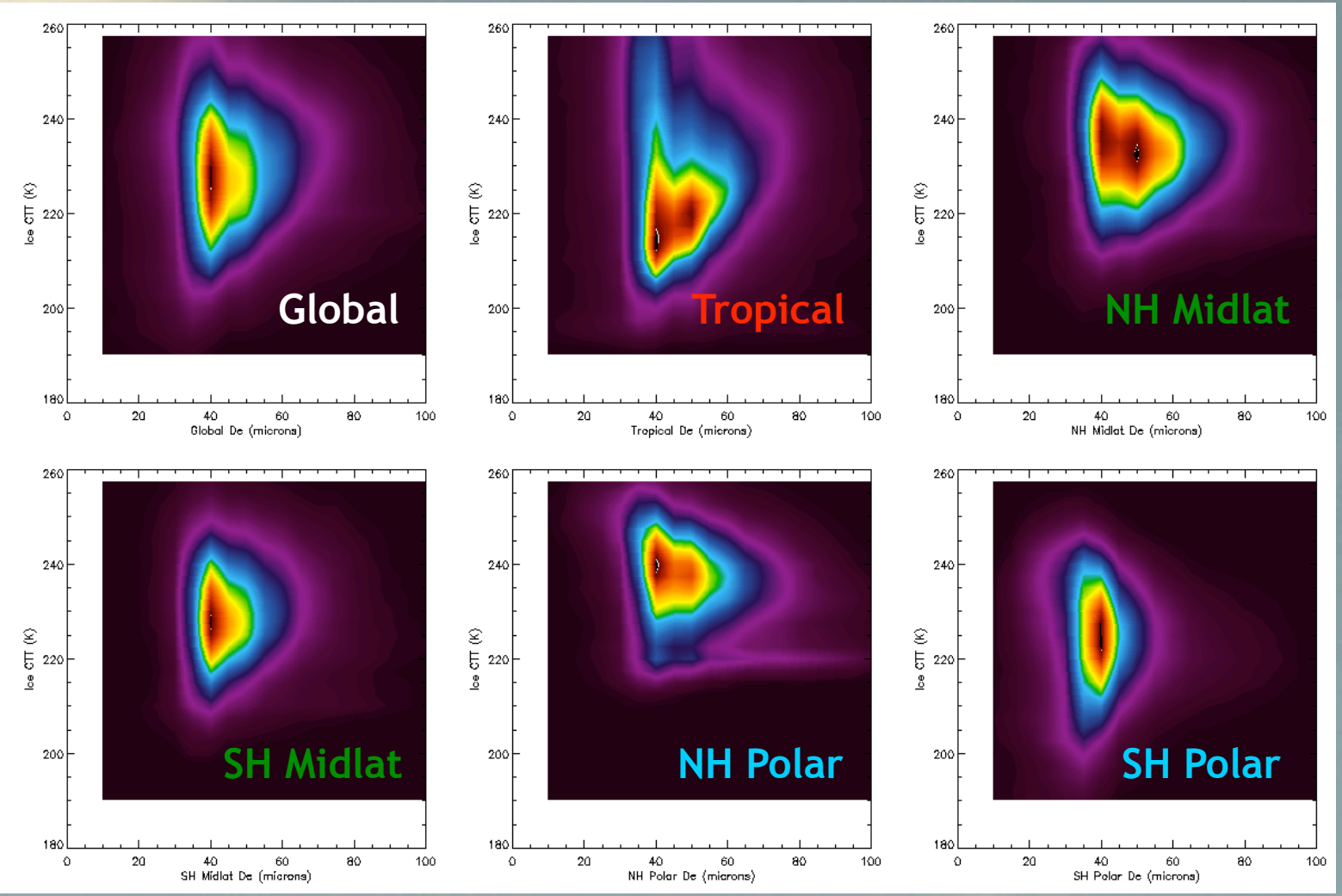
D_e & T_{CLD} joint histograms for June 2008



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Pixel-scale comparisons of MODIS and AIRS OD and D_e

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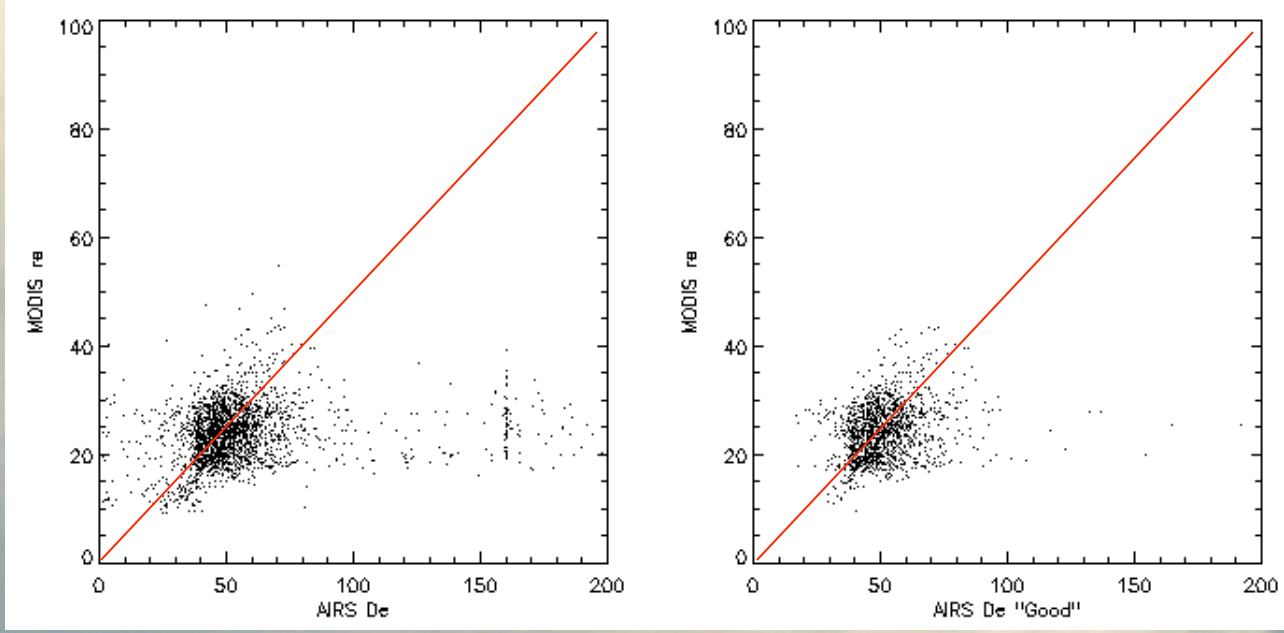
MODIS (r_e) vs. AIRS (D_e) (daytime only)



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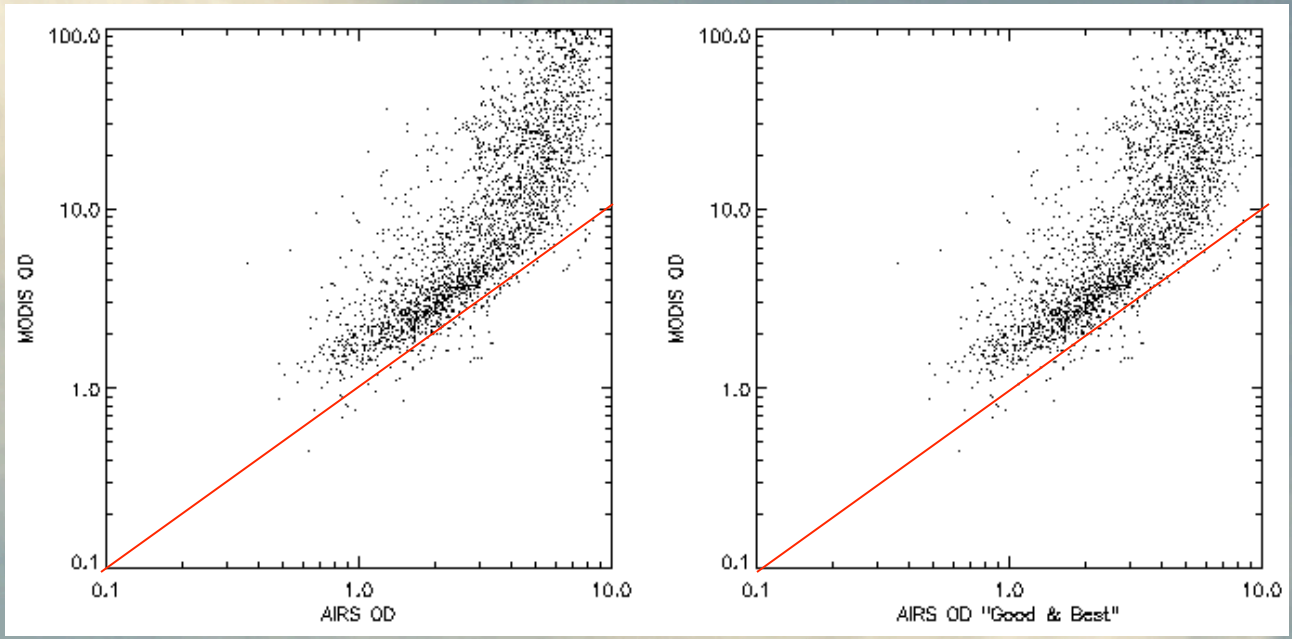
MODIS vs. AIRS OD (daytime only)



Summary and discussion

- New cloud phase/ice cloud products show substantial promise for limited time periods
- “Arbitrary” quality control shows skill and leverages error/ information provided by retrieval methodology
- Tantalizing differences between day/night, land/ocean, winter/ summer, different latitude bands
- Zonal structure offers constraint on treatment of CAM5 ice microphysics
- Version 6 for entire AIRS mission will enable process-based studies/ composites of cloud microphysical properties

Present and future work

- Rigorous comparisons to MODIS cloud products
- Additional comparisons to TOVS, ISCCP, in situ data (when available)
- Extend to CrIS and IASI?
- Multi-layer cloud retrievals an issue
- A future idea: run retrieval concurrently with cloud-clearing during L2 retrieval?