New AIRS Cloud Top Microphysical Retrievals

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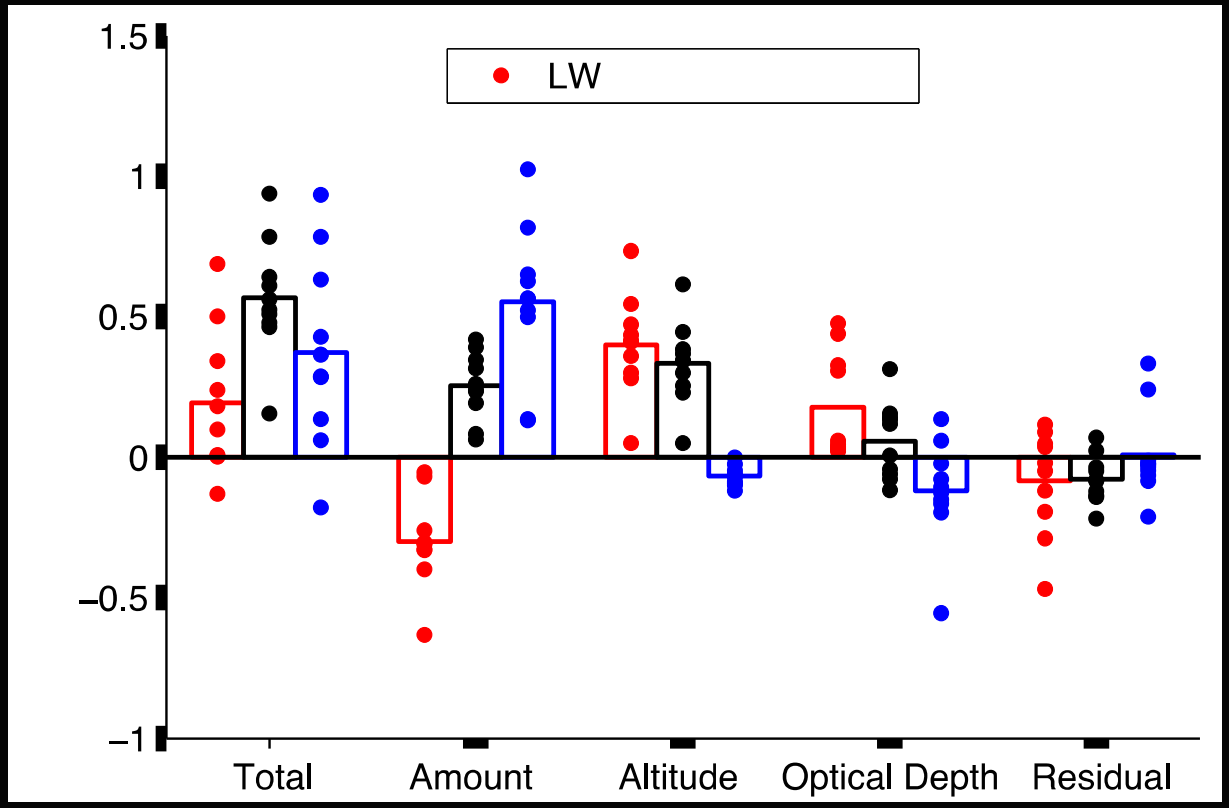
Why Isn’t the Existing Set of Satellite Cloud Products Sufficient?

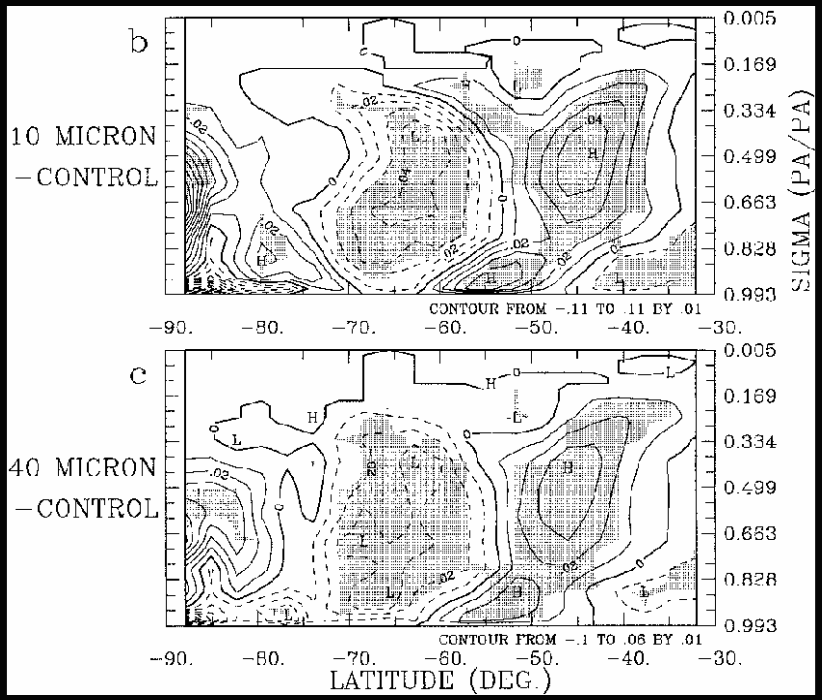
- Cloud feedback uncertainty remains the largest challenge for improving the realism of climate model projections (IPCC)
- Clouds couple a series of very complex radiative (solar and infrared), thermodynamic (temperature, water vapor, precipitation) and dynamic (winds) processes
- New generation of climate models with explicit cloud microphysics
- Continued advancements in NWP satellite data assimilation (lots of ITSC presentations)
- Obvious (not so obvious) capabilities of new sensors/sensor synergy
- Cloud/scene type observing strengths/weaknesses among different sensors

Cloud-Climate Feedbacks in IPCC Models can Differ in Sign and Magnitude



Zelinka et al. (2012), J. Climate (in press)

Local Cloud Changes May Lead to Global-Scale Feedback Responses



- Make all Antarctic clouds “ice” in NCAR CCM2 and set D_e = 10 or 40 μm
- Cloud/circulation changes well outside Antarctica — even in NH

Lubin et al. (1998), J. Climate

Summary of New AIRS 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: ice, liquid, unknown*
- These are ***different*** from AIRS standard product retrieval
- Retrieval heritage from Tropospheric Emission Spectrometer (TES) instrument team
- SARTA+D4S RT model; AIRS L2 atmospheric inputs and a priori surface, and single-layered cloud; Baum et al. (2007) 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 restricted to AIRS FOVs identified as *possibly* or *likely* containing ice

Summary of New AIRS Version 6 Cloud Products

- Both OD and T_{cld} have *Best*, *Good*, and *Bad* indicators

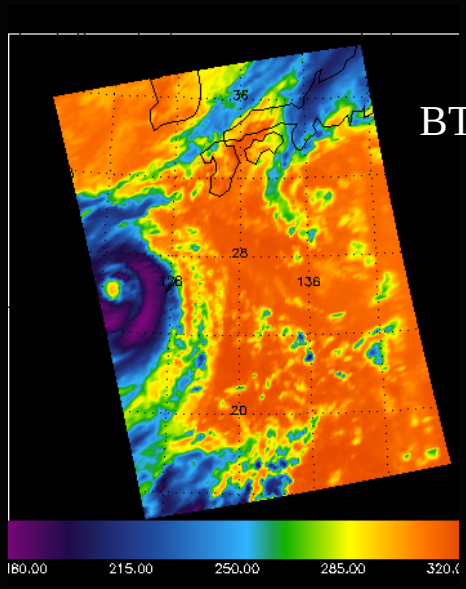
  Best: chi-squared < 10 and AK > 0.8
  Good: chi-squared > 10 or AK < 0.8
  Bad: chi-squared > 10 and AK < 0.8

- D_e only has *Good* and *Bad* – the hardest parameter to retrieve

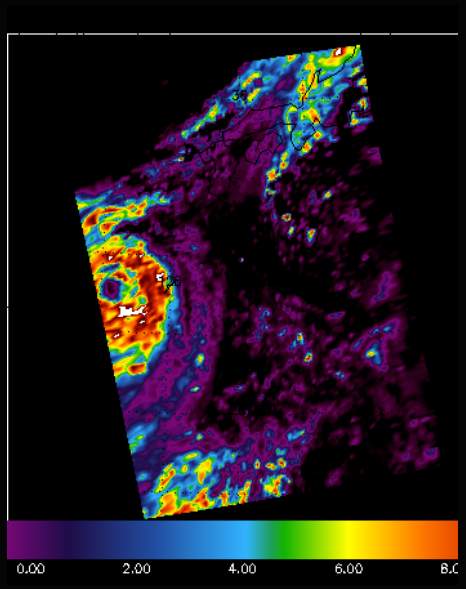
  Good: chi-squared < 10 and AK > 0.8
  Bad: chi-squared > 10 or AK < 0.8

- Quality control indicators are not absolute nor quantitative

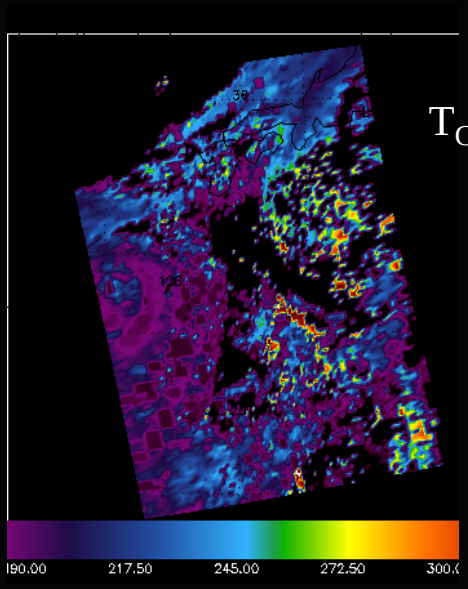
An Example AIRS Granule



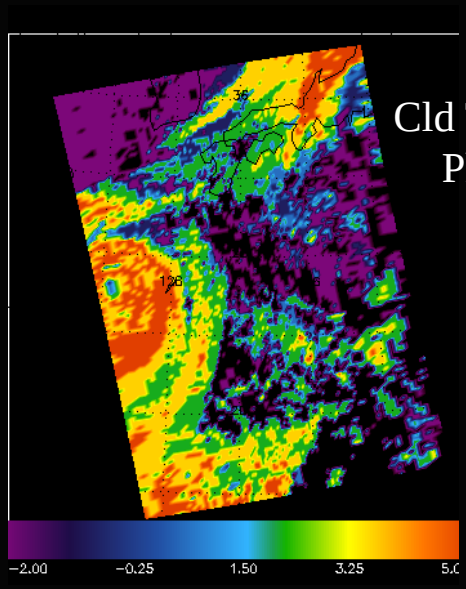
BT @ 960



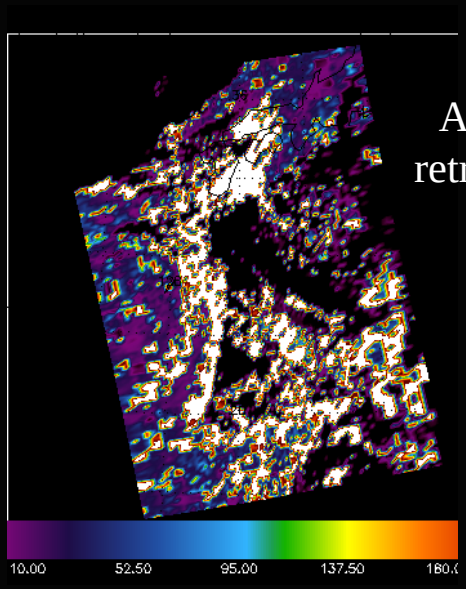
OD



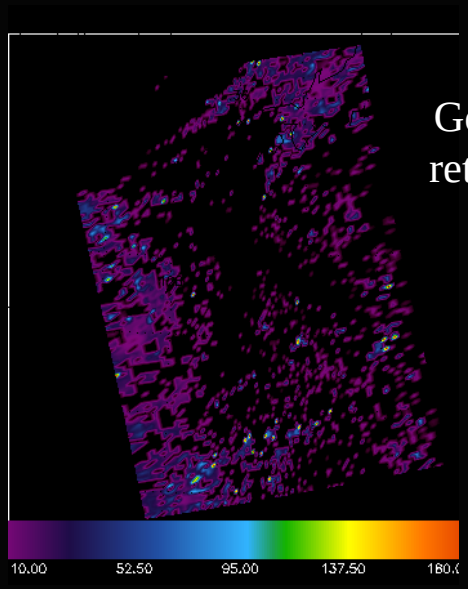
T_{CLD}



Cld Therm Phase



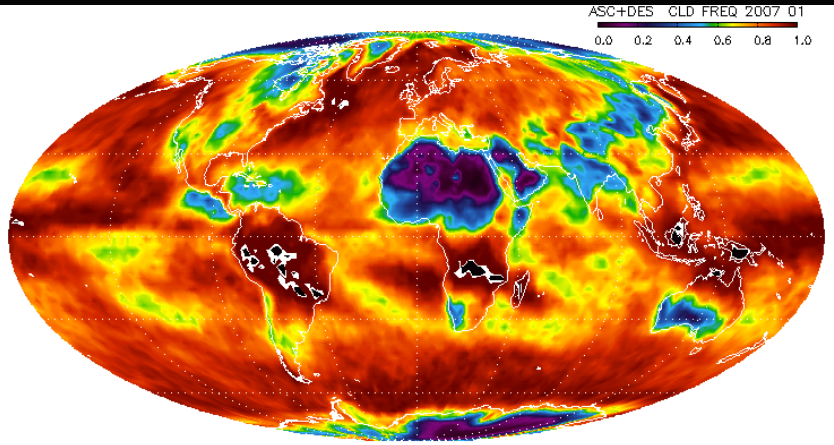
All D_e retrievals



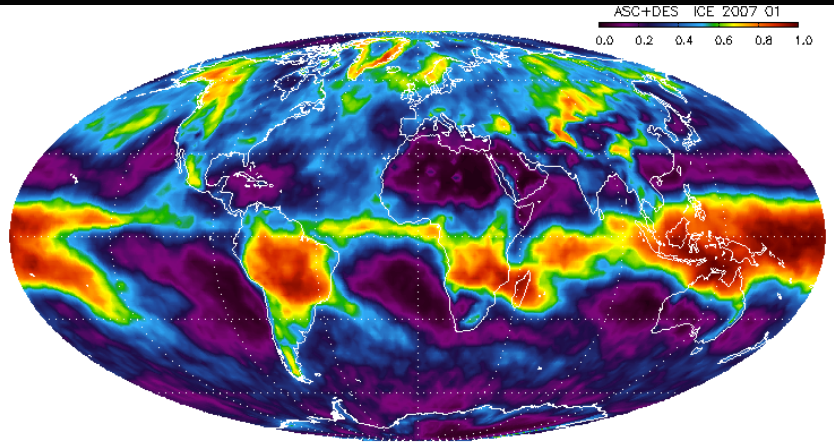
Good D_e retrievals

January 2007 Cloud Frequency/Phase

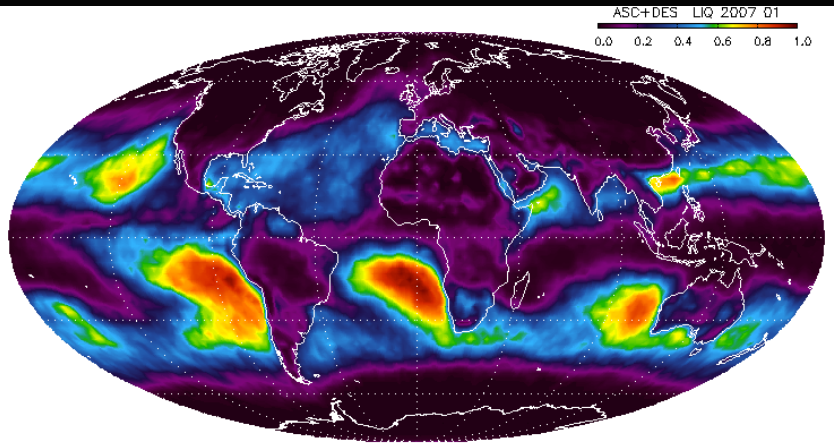
Cloud Freq (ECF > 0.01)



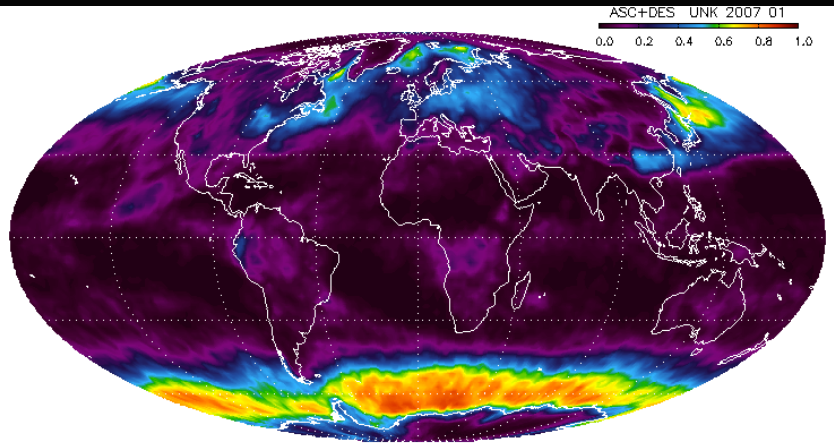
Ice



Liquid

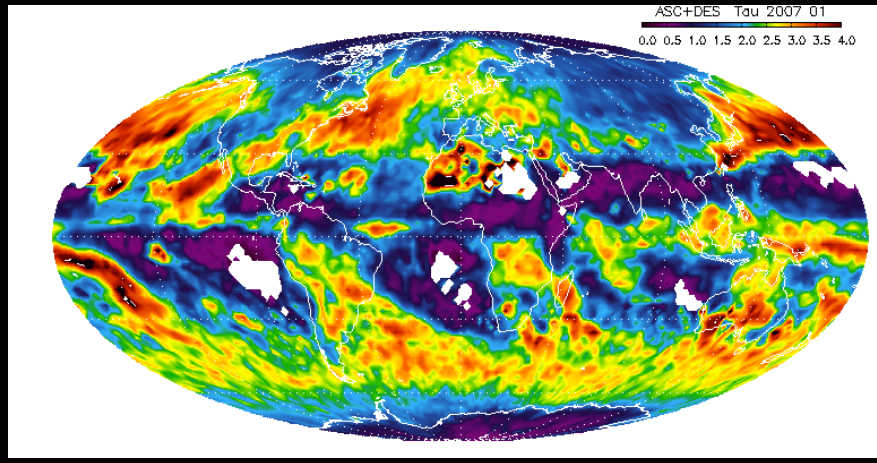


Unknown

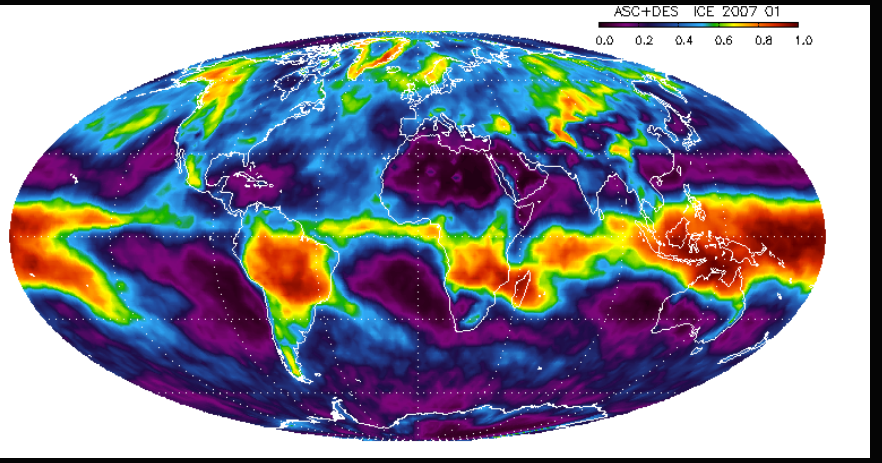


January 2007 ice cloud τ, D_e, and T_C

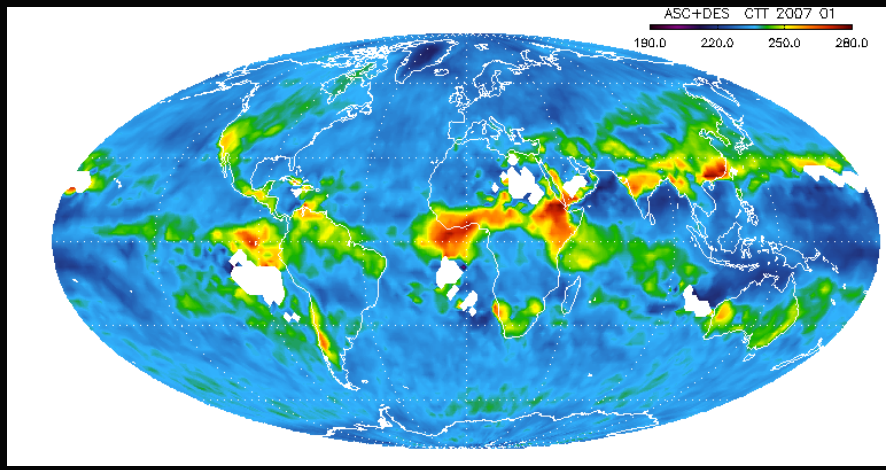
τ



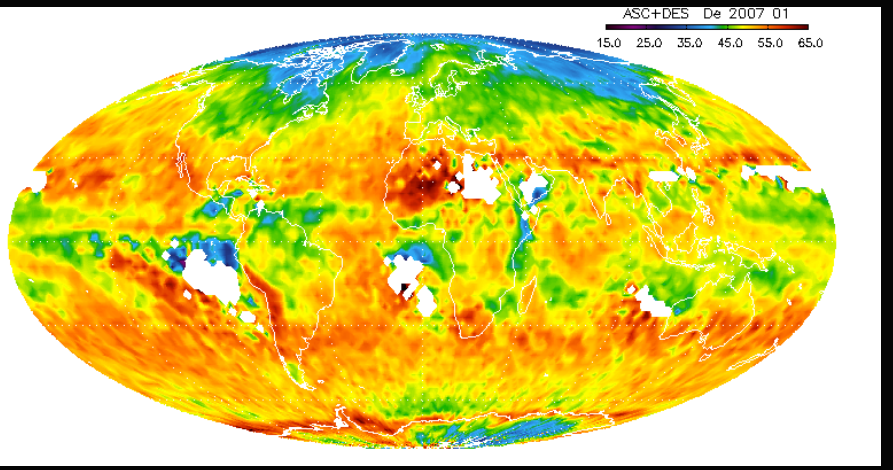
Ice



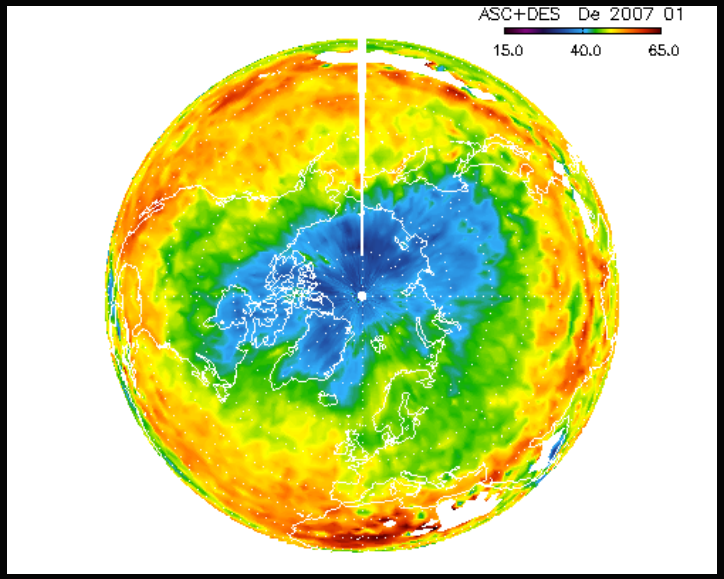
T_C

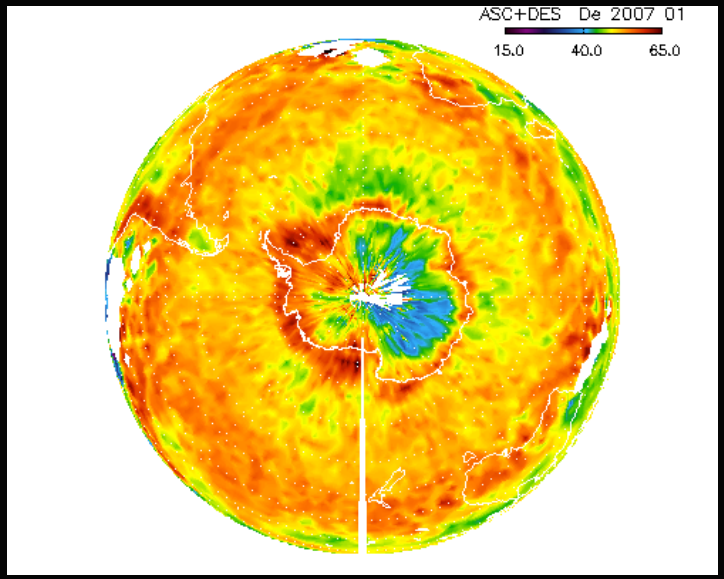


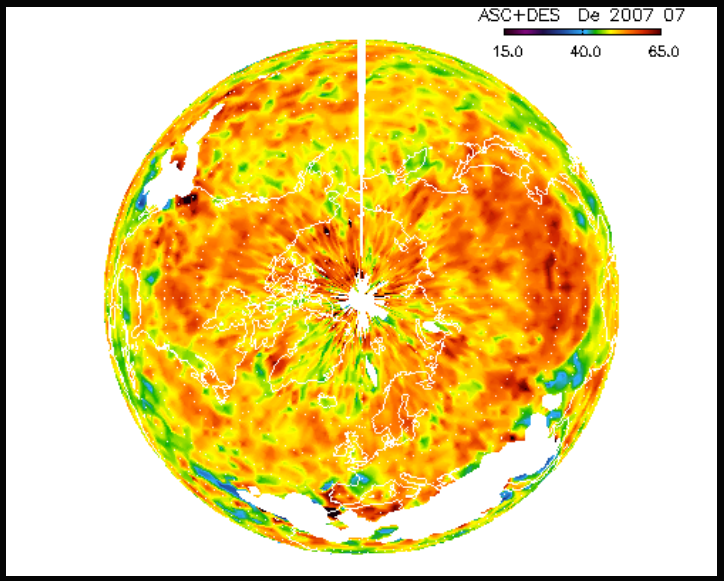
D_e

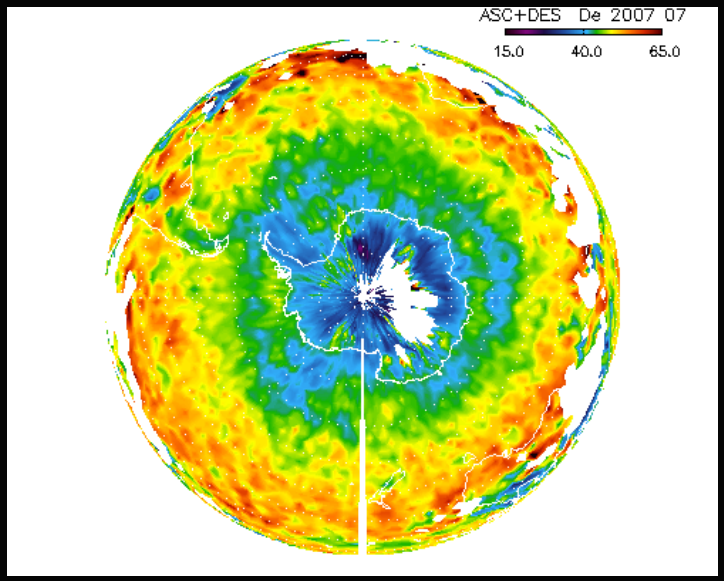


Seasonal variations of D_e in polar regions

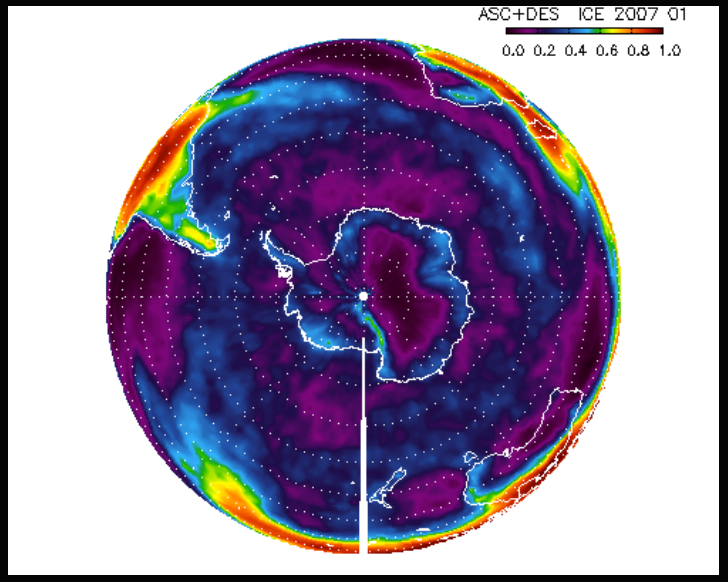


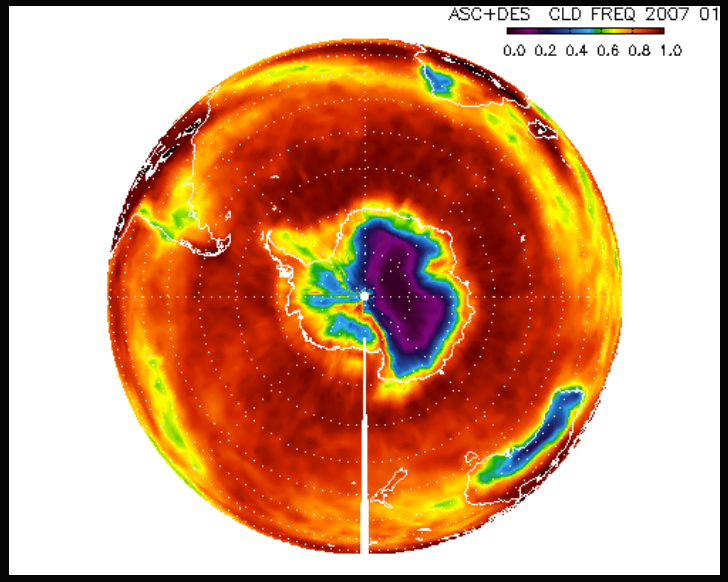


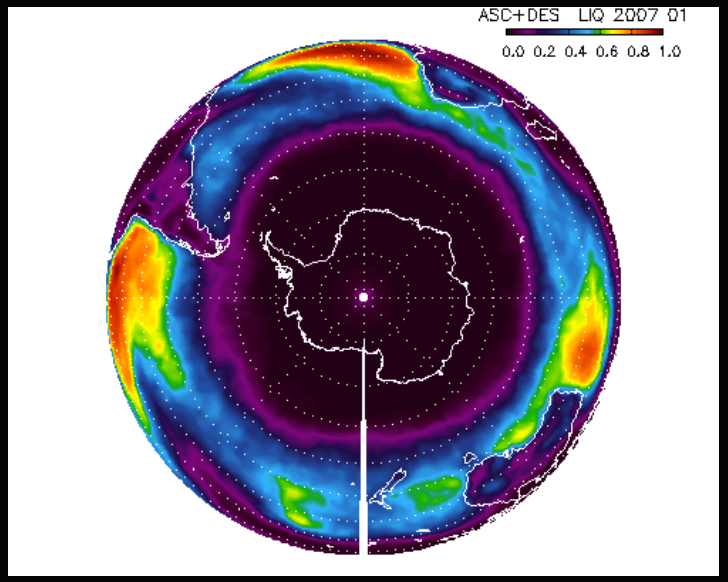


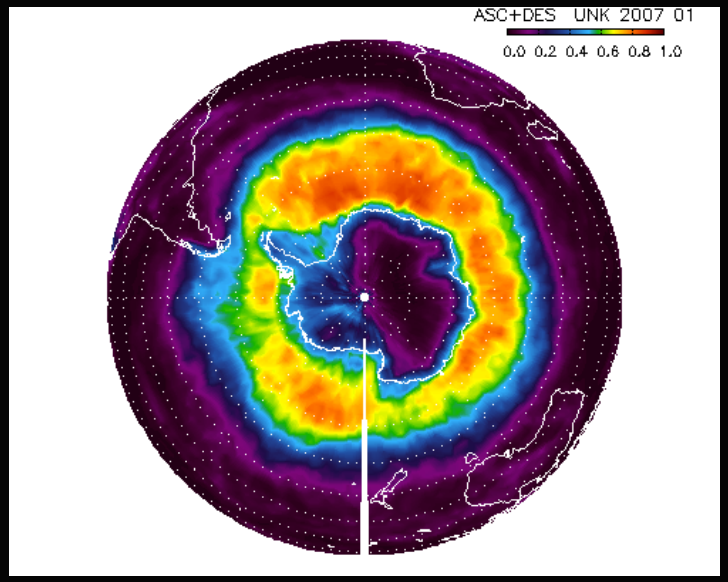


Complex cloud phase structures around Antarctica

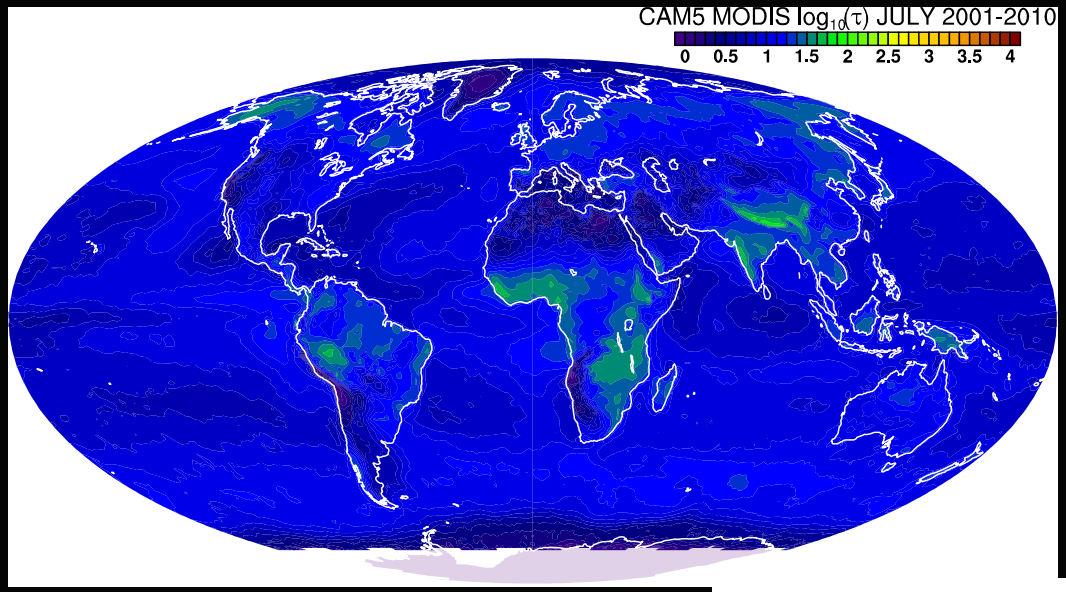


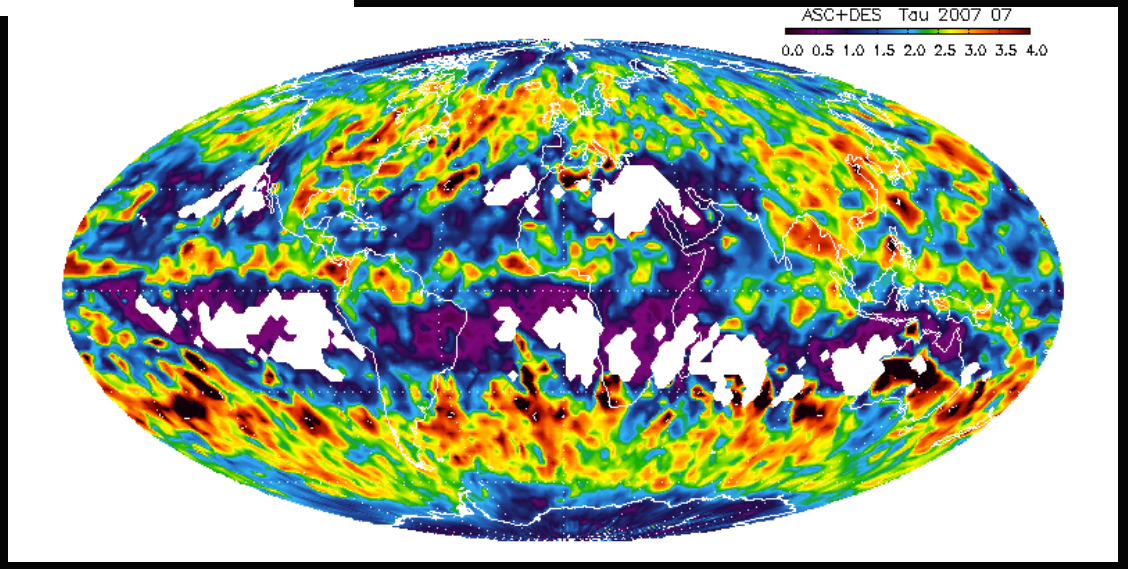






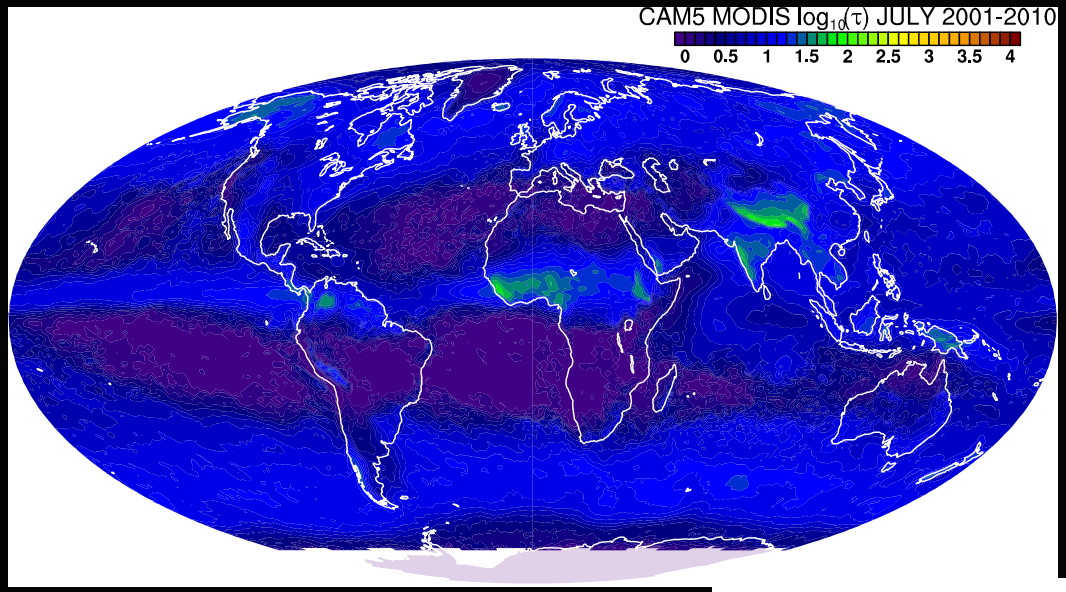
CAM5 and AIRS OD Comparisons

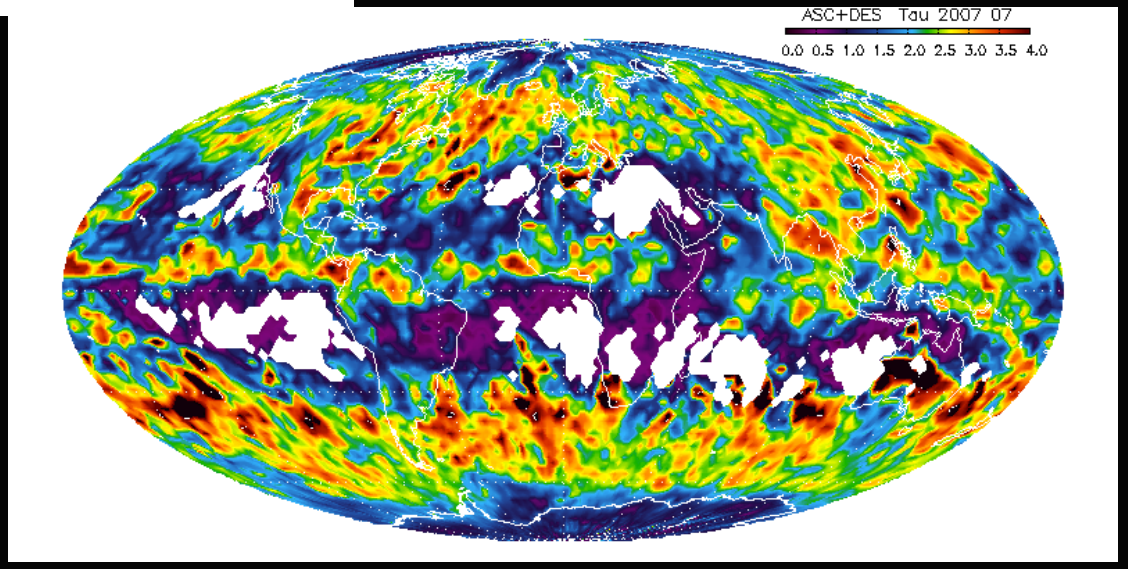




CAM5 output from B. Medeiros

CAM5 and AIRS OD Comparisons





CAM5 output from B. Medeiros

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 geographical and temporal differences
- Version 6 for entire AIRS mission will enable process-based studies/composites of cloud microphysical properties
- AIRS cirrus products offer constraint on treatment of CAM5 ice microphysics
- Scene complexity remains an issue (e.g., multi-layer clouds)
- CrIS and IASI synergy