Version 6 cloud Thermodynamic Phase, Cirrus Cloud Optical Thickness, and Effective Diameter

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With many thanks to co-authors and colleagues:

V. T. Dang, E. J. Fetzer, H. Jin, E. Manning, S. L. Nasiri, R. Oliphant, S. C. Ou, M. M. Schreier, Q. Yue, B. A. Baum, and others…

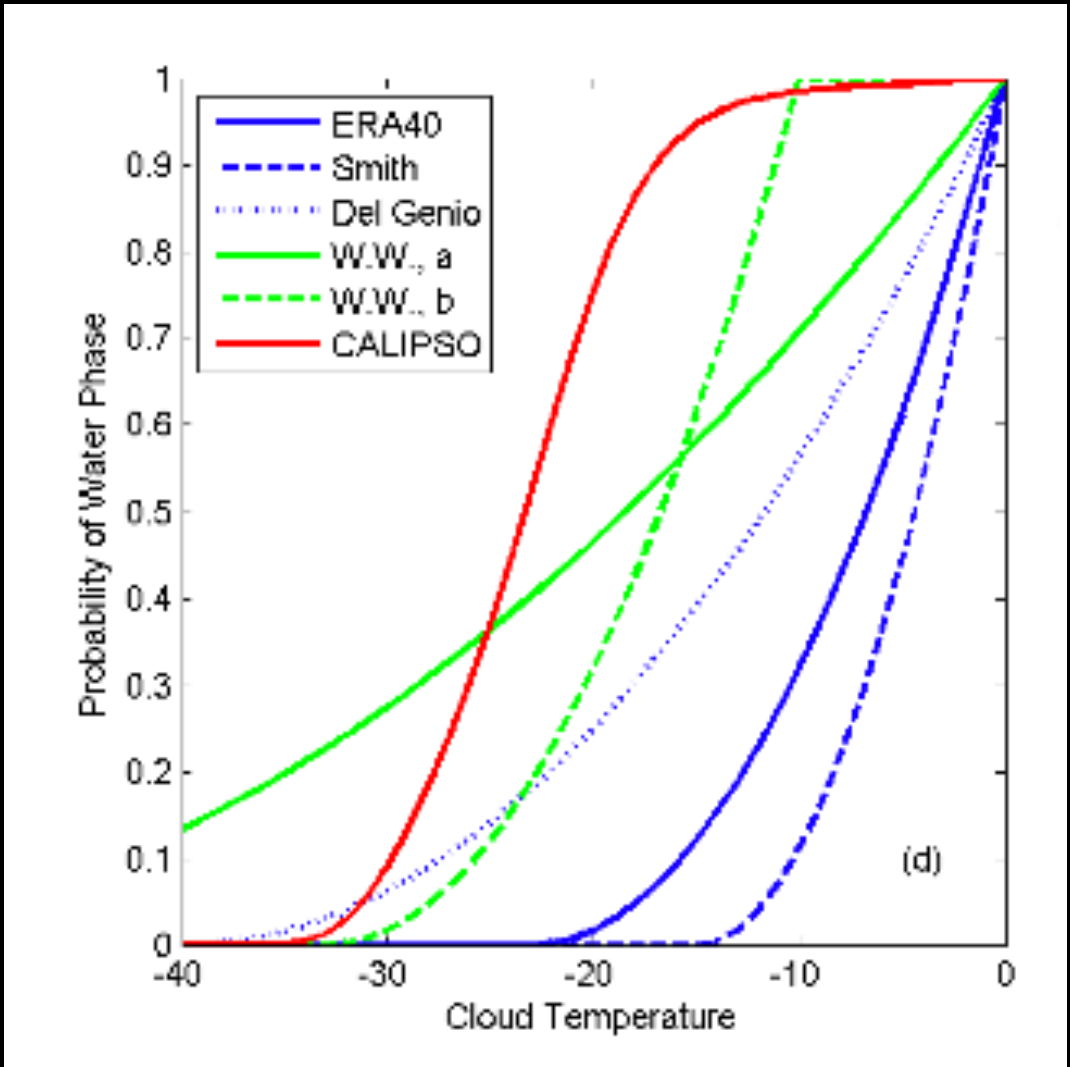
AIRS Science Team Meeting
Pasadena, CA
Wednesday, April 27th, 2011

New Proposed Cloud Products for V6

- **Cloud thermodynamic phase**
  - Ice (4 categories), liquid, and unknown
  - Validation/comparisons in progress with CALIOP phase
  - Developed by S. L. Nasiri and H. Jin at Texas A&M Univ.
  - Cloud phase and cloud heterogeneity: MODIS and AIRS
  - ***Very fast for L2 processing***

- **Cirrus cloud τ, D_e, and T_c**
  - Start with AIRS L2 FOVs with "ice clouds" according to phase mask
  - Single-layered cloud retrieval using SARTA+D4S
    - Ou et al., (2011), JGR (submitted)
  - All inputs from AIRS L2: T(z), q(z), T_{sfc}, T_{cld}, ε
  - Uses ice cloud models of Baum et al. (2007), JAMC
  - Optimal estimation retrieval adopted from TES group (thanks to Bill Irion)
  - Also retrieve cloud top temperature
  - ***Not so fast for L2 processing***

Why cloud thermodynamic phase with AIRS?



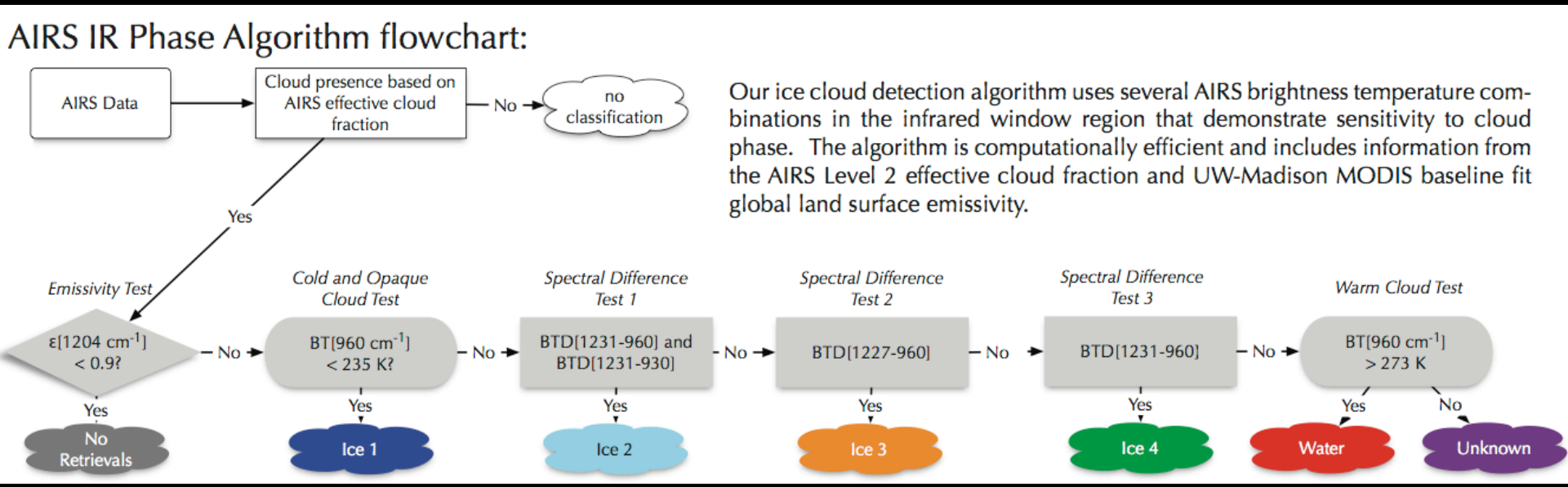
Significant disagreement among remote sensing data sets and climate models

Big disagreement in high latitude storm tracks: perhaps an area in which AIRS can excel

High latitudes a key issue for climate sensitivity

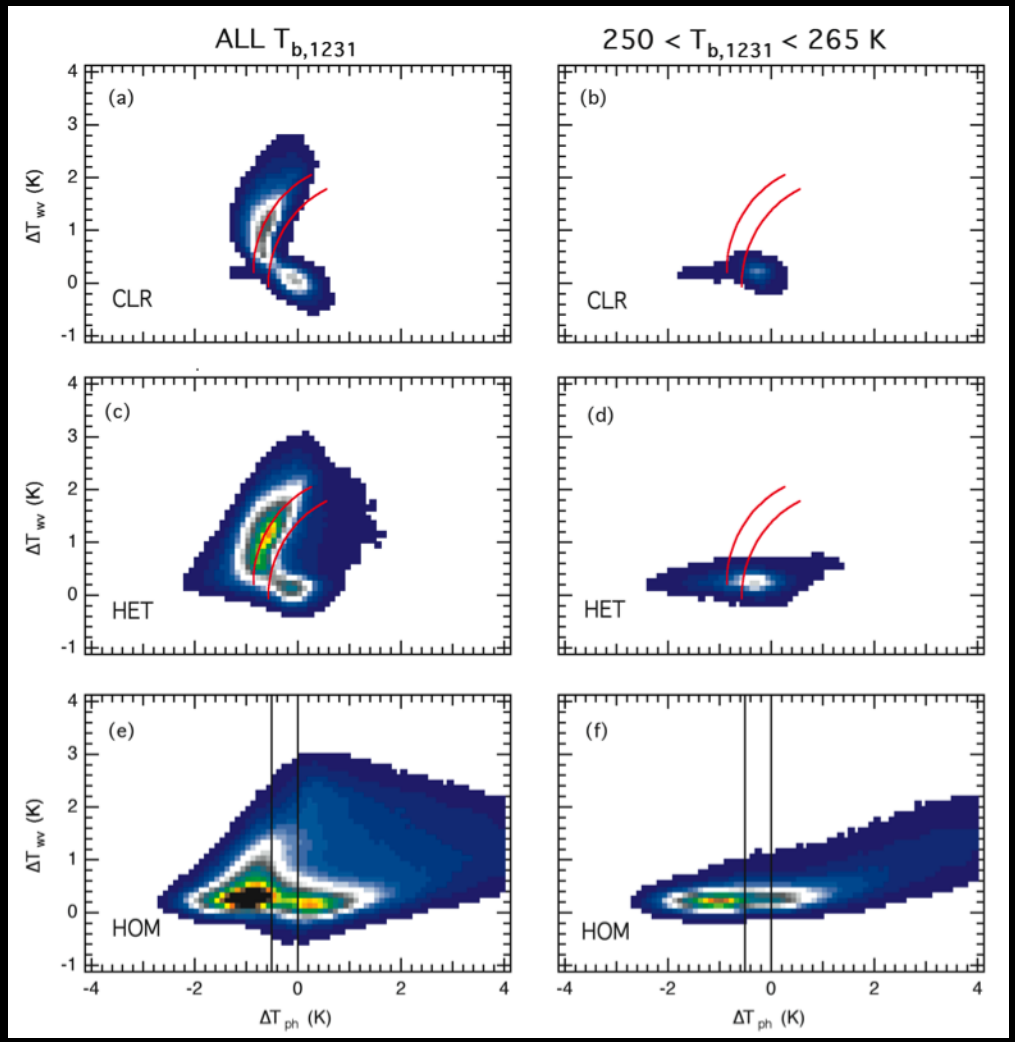
Hu et al. (2010), *J. Geophys. Res.*

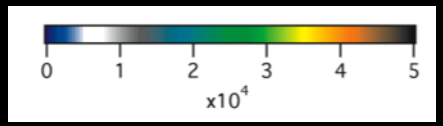
AIRS IR Phase Algorithm



Credit: H. Jin and S. Nasiri (Texas A&M Univ.)

Clear/Cloud Phase vs. Water Vapor BTD



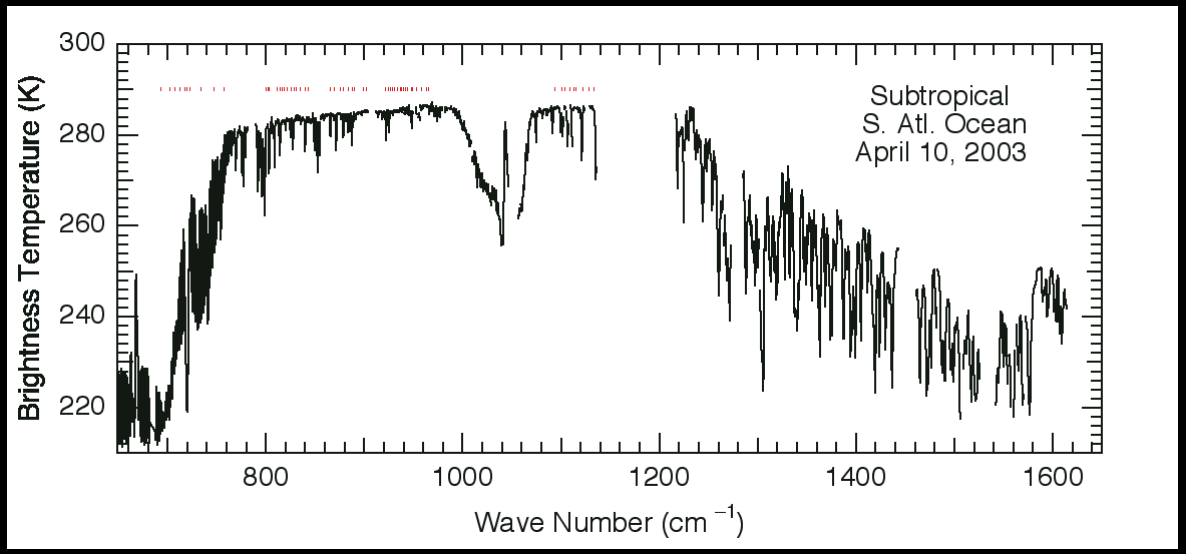


Kahn et al. (2011), *J. Geophys. Res.* (in review)

Why cirrus products with AIRS?

- **Highly underutilized capability of hyper-spectral IR**
  - Lots of sensitivity/case studies published over years
  - No operational retrieval…yet
  - Community "demands" we provide products
- **Complements capabilities of MODIS**
  - VIS/near-IR retrieval (daytime only)
  - AIRS can do day/night with mid-IR
  - Potential synergies between AIRS+MODIS regarding clouds/cloud-clearing
- **Faster, efficient, accurate RT/retrieval methodologies have advanced**
  - SARTA+D4S
  - Optimal estimation retrieval from TES adopted for this approach
    - Avg kernels tells us when we have no information, i.e., when not to "trust" retrieval
- **High potential for meaningful validation & multi-sensor synergy**
  - MODIS, CloudSat & CALIPSO very powerful combination

A few details about the cirrus retrievals



Current set = 58 channels

Tested as few as 11 & as many as ~400

Speed & accuracy trade-offs; chan noise considerations

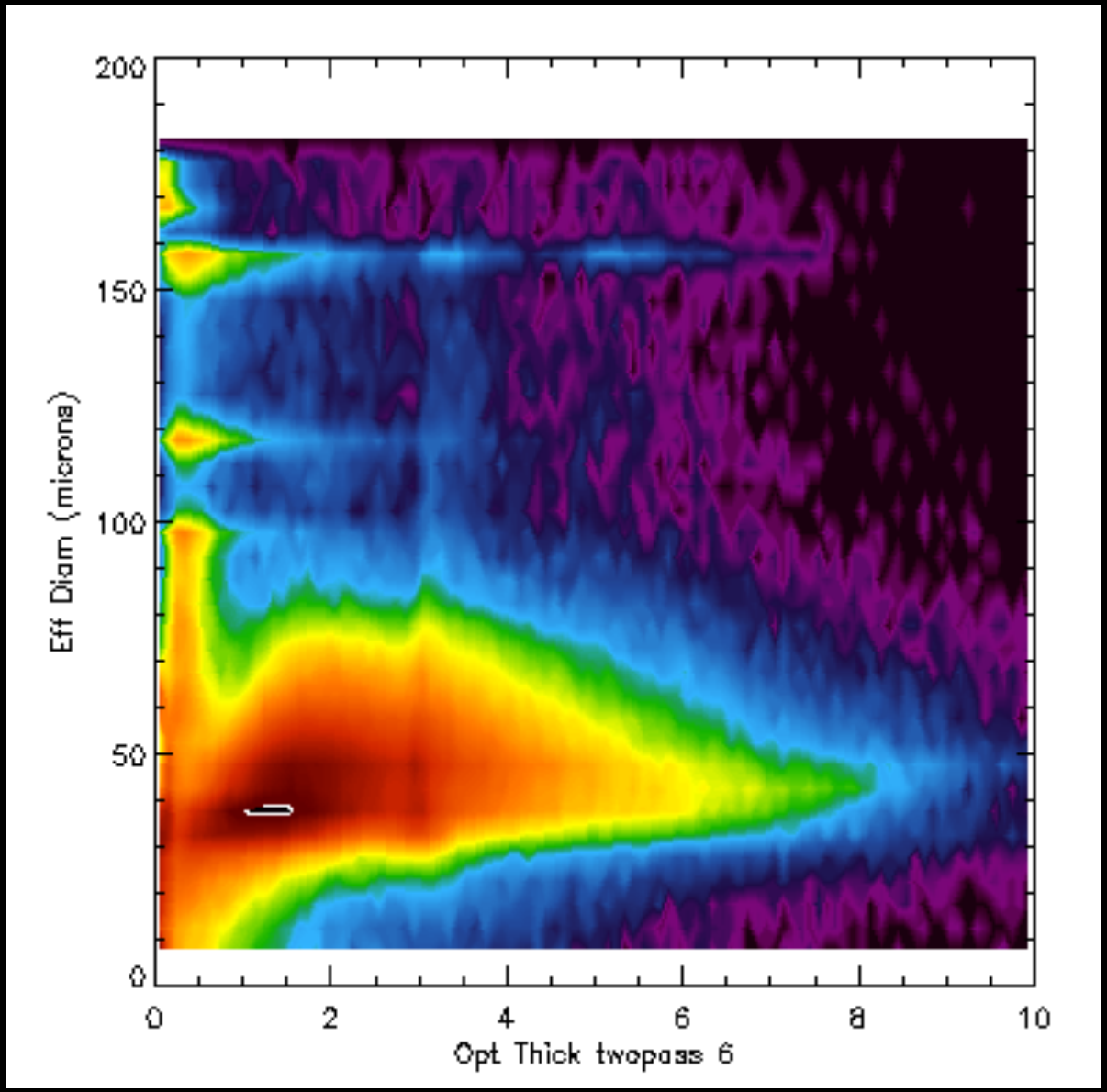
Tropospheric Emission Spectrometer (TES) code adapted to SARTA+D4S

Retrieve τ, D_e, and T_c; report scalar averaging kernels for each variable; fitting chi-squared

Assumptions about a priori (τ = 3.0, D_e = 30 μm, T_c from AIRS L2)

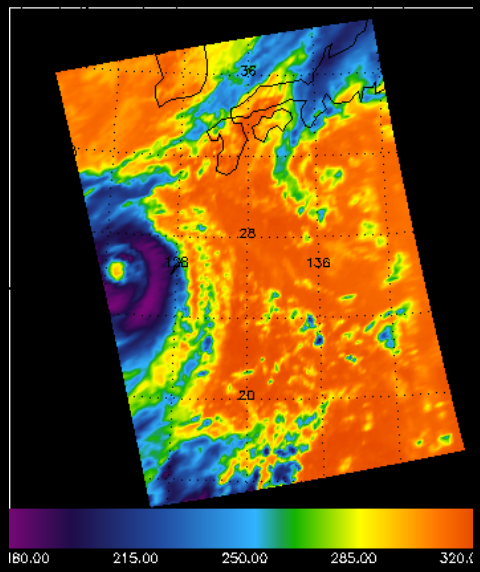
Assumptions about co-variances not well determined (could use MODIS)

Optical thickness vs. De for 09-06-2002

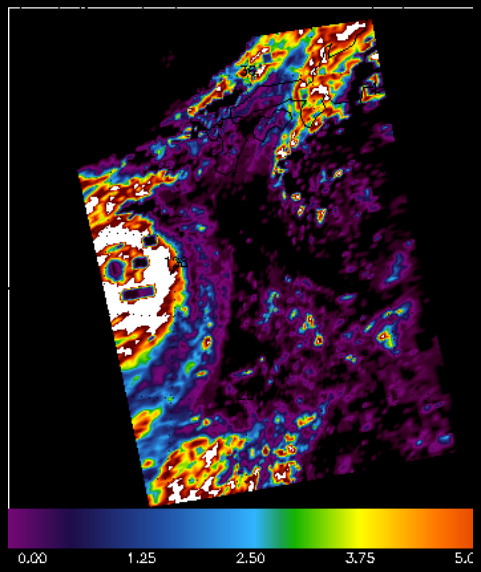


09–06–2002 Granule 044

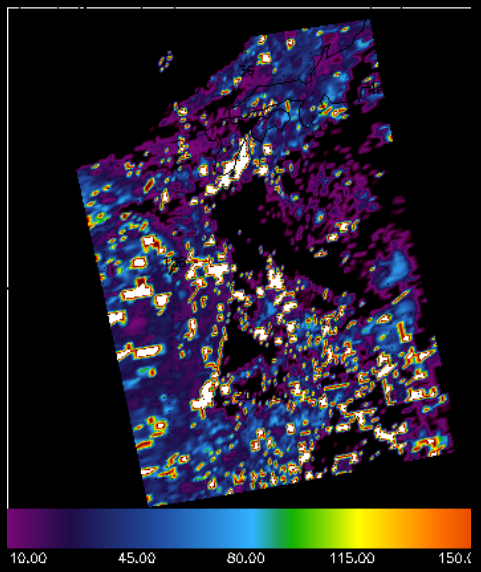
BT @ 1231



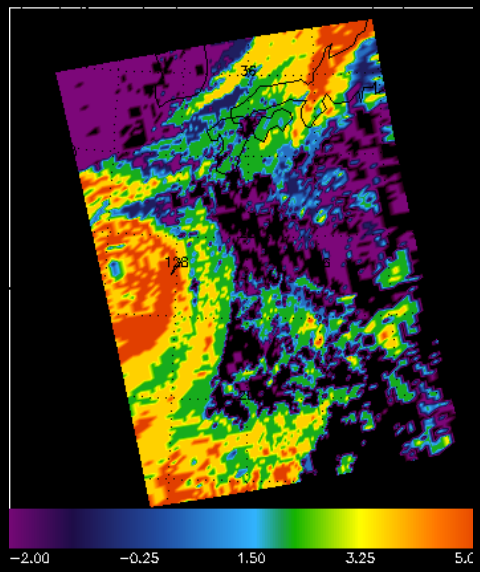
Optical Thickness



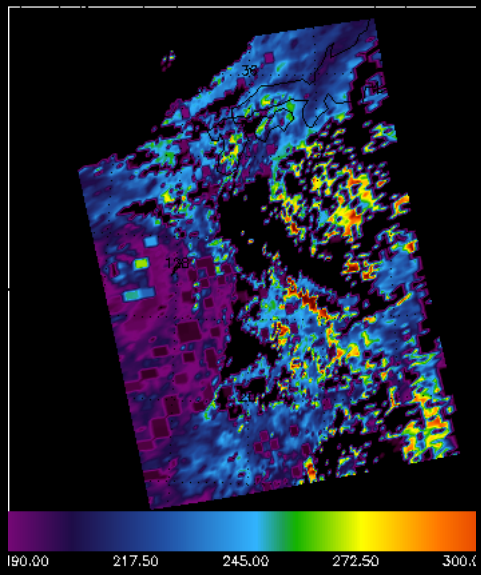
Effective Diameter (μm)



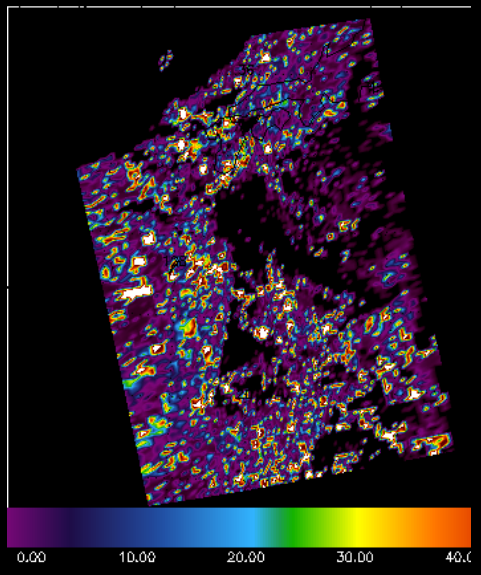
Cloud Phase



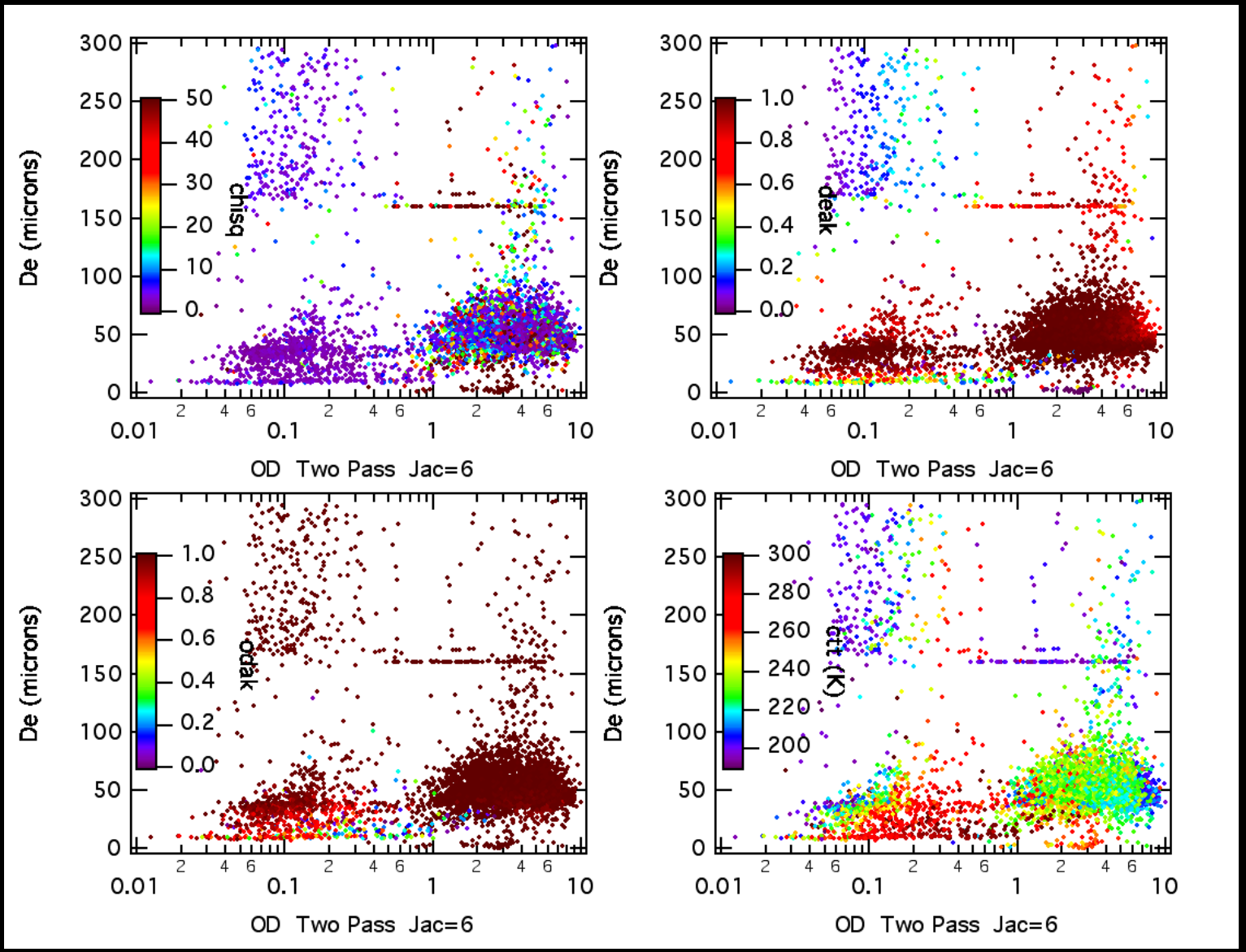
“Effective” Cld Top Temp



Chi-squared Residual



Combination of AK and x2 can tell us if retrieval is good or not



Priorities for V6

- **Speed it up: about as expensive as rest of L2 retrieval**

  Reduce/optimize channel selection

  "Cheat" on Jacobian calculation, convergence criterion, others?

- **Test with new AIRS FOV resolution cloud top temperature**

- **Quality control**

  Recipe for "Use" & "Don't Use"? What about "Best", "Good", "Don't Use"?

  Mix of Aks, χ^2, presence of multi-layered clouds, less certain ice phase categories, etc.

Very encouraging first results!!!

- **L2 Support at Goddard or JPL-produced products?**
- **Need to think about L3 – should we wait until V7? Better to do off-line and initially "in-house"?**
- **Comparisons with CloudSat, CALIPSO, MODIS, etc.**
- **Increasing complexity of geophysical scenes**

  Multi-layered clouds

  Dust & dust + clouds

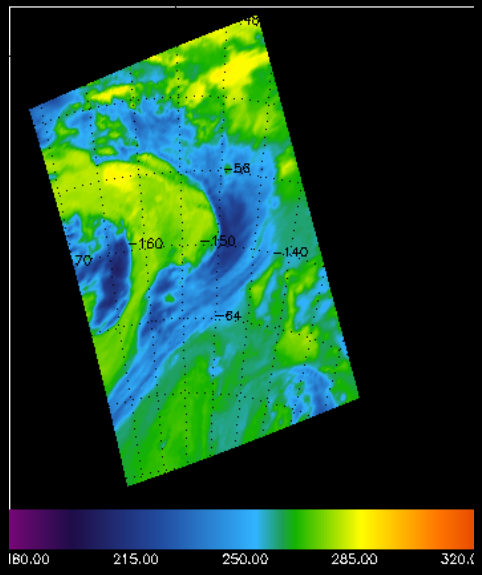
  What about full-blown MODIS+AIRS retrievals starting with L1B?

  Many others…

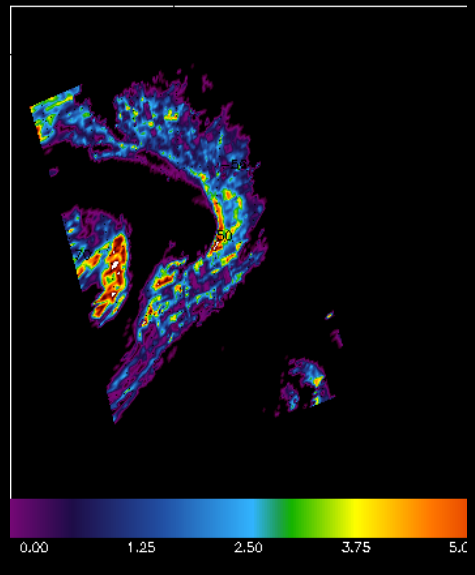
Thanks!

09–06–2002 Granule 007

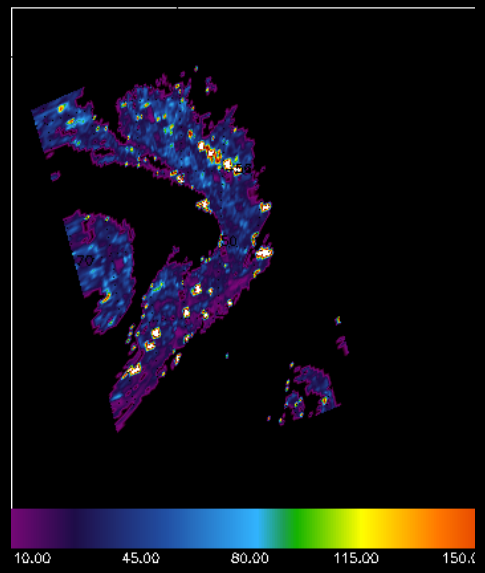
BT @ 1231



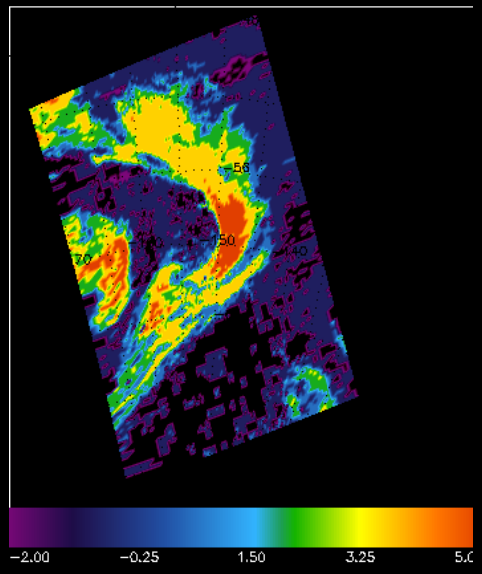
Optical Thickness



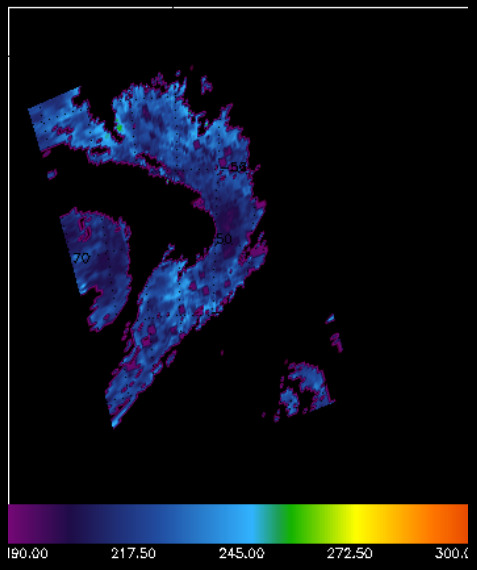
Effective Diameter (μm)



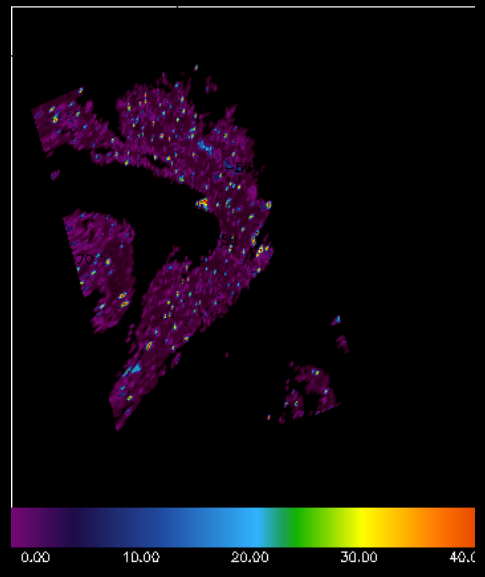
Cloud Phase



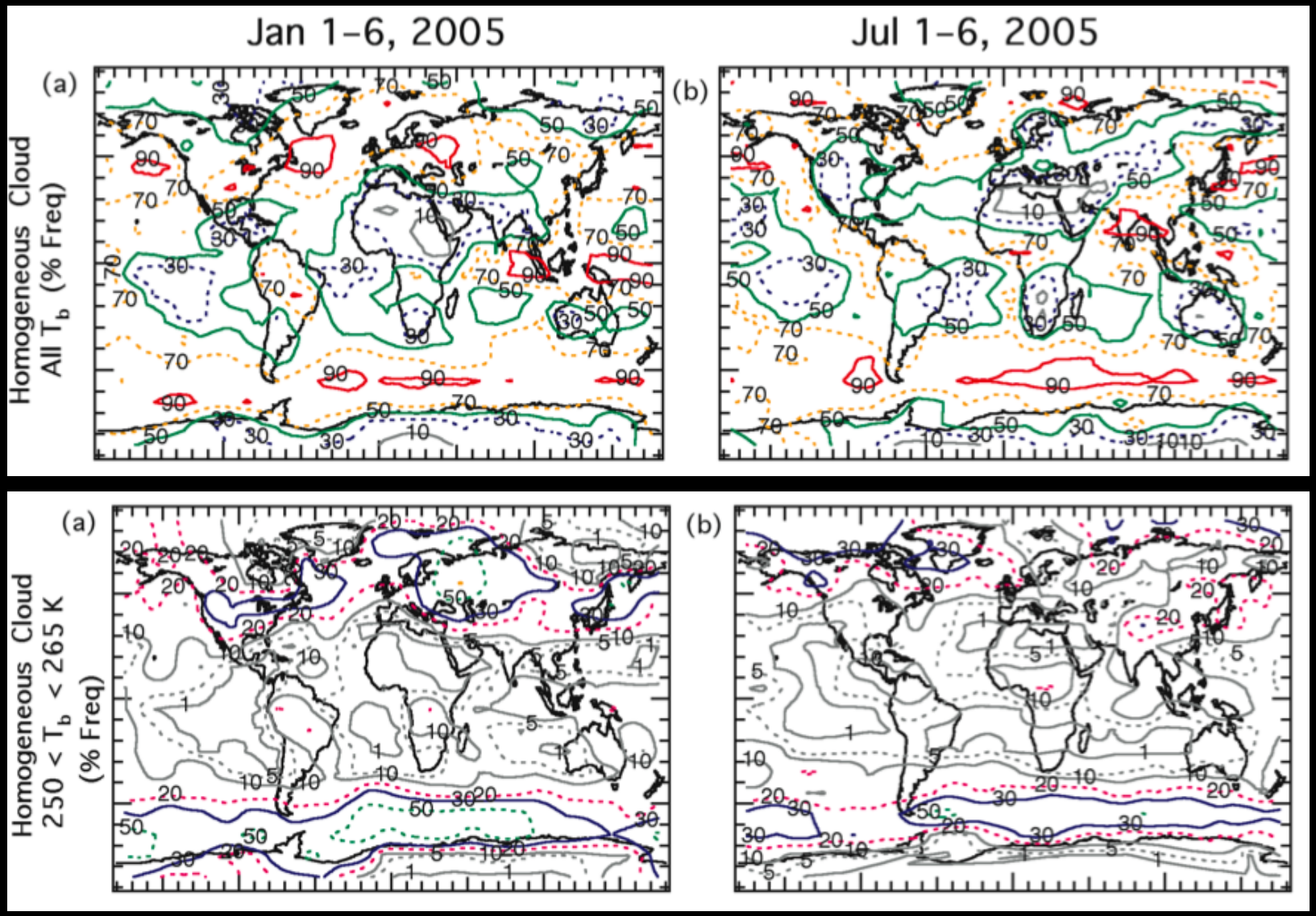
“Effective” Cld Top Temp



Chi-squared Residual

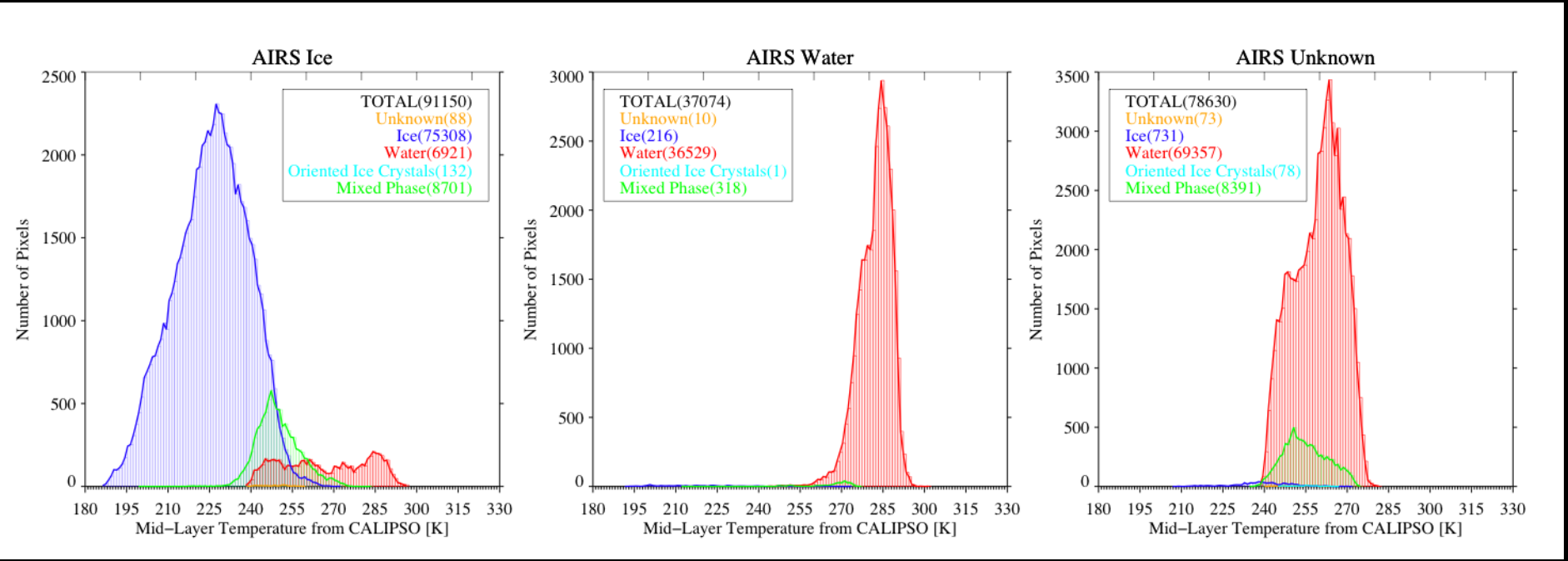


30-50% of High Latitude Clouds "Homogeneous" for Difficult BT Range 250–265 K



Kahn et al. (2011), *J. Geophys. Res.* (in review)

Cloud Phase from AIRS/CALIPSO



Credit: H. Jin and S. Nasiri (Texas A&M Univ.)