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

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With many thanks to co-authors and colleagues:


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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 \( \tau, D_e, \) 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: \( T(z), q(z), T_{sfc}, T_{cld}, \epsilon \)
  - 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.
Our ice cloud detection algorithm uses several AIRS brightness temperature combinations in the infrared window region that demonstrate sensitivity to cloud phase. The algorithm is computationally efficient and includes information from the AIRS Level 2 effective cloud fraction and UW-Madison MODIS baseline fit global land surface emissivity.
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 $\tau$, $D_e$, and $T_c$; report scalar averaging kernels for each variable; fitting chi-squared

Assumptions about a priori ($\tau = 3.0$, $D_e = 30$ $\mu$m, $T_c$ from AIRS L2)

Assumptions about co-variances not well determined (could use MODIS)
Optical thickness vs. De for 09-06-2002
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, $\chi^2$, 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!
30-50% of High Latitude Clouds “Homogeneous” for Difficult BT Range 250–265 K

Cloud Phase from AIRS/CALIPSO

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