

Cloud properties from AIRS

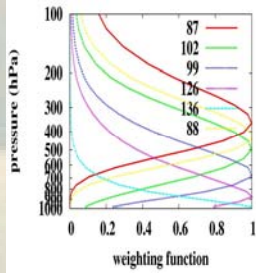
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Multi-spectral cloud detection

Microwaves probe through clouds
Difference between T_b 's with channels sounding similar depths of atmosphere should be negligible for clear sky

$T_b(151) - T_b(\text{AMSU}_1 - \theta_0, \text{air}) > \text{Thr}(\theta_0, \text{air})$ peak: 1800Pa
 $T_b(2106) - T_b(\text{AMSU}_1 - \theta_0, \text{air}) > \text{Thr}(\theta_0, \text{air})$ peak: 1800Pa
 $T_b(2123) - T_b(\text{AMSU}_1 - \theta_0, \text{air}) > \text{Thr}(\theta_0, \text{air})$ peak: 4000Pa
 $T_b(1947) - T_b(\text{AMSU}_1 - \theta_0, \text{air}) > \text{Thr}(\theta_0, \text{air})$ peak: 4000Pa
 $T_b(2106) - T_b(\text{AMSU}_1 - \theta_0, \text{air}) > \text{Thr}(\theta_0, \text{air})$ peak: 4000Pa
 $T_b(2110) - T_b(\text{AMSU}_1 - \theta_0, \text{air}) > \text{Thr}(\theta_0, \text{air})$ peak: 4000Pa
 $T_b(2110) - T_b(\text{AMSU}_1 - \theta_0, \text{air}) > \text{Thr}(\theta_0, \text{air})$ peak: 930Pa
 $T_b(2112) - T_b(\text{AMSU}_1 - \theta_0, \text{air}) > \text{Thr}(\theta_0, \text{air})$ peak: 930Pa

$T_b(787) - T_b(2226) - \theta_0, \text{air}) > \text{Thr}(\theta_0, \text{air})$ low
 $T_b(787) - T_b(2233) - \theta_0, \text{air}) > \text{Thr}(\theta_0, \text{air})$ low
 $T_b(308) - \Sigma_n T_b(\text{AMSU}_1) - \theta_0, \text{air}) > \text{Thr}(\theta_0, \text{air})$ mid
 $T_b(309) - \Sigma_4 T_b(\text{AMSU}_1) - \theta_0, \text{air}) > \text{Thr}(\theta_0, \text{air})$ mid
 $T_b(2106) - \Sigma_4 T_b(\text{AMSU}_1) - \theta_0, \text{air}) > \text{Thr}(\theta_0, \text{air})$ mid
 $T_b(2110) - \Sigma_4 T_b(\text{AMSU}_1) - \theta_0, \text{air}) > \text{Thr}(\theta_0, \text{air})$ mid
 $T_b(2112) - \Sigma_4 T_b(\text{AMSU}_1) - \theta_0, \text{air}) > \text{Thr}(\theta_0, \text{air})$ low



C. Crevoisier 2004; C. Pierangelo 2005

- AIRS L2 atmospheric profiles given per golf ball (9 spots)
- use 21 T levels (surface - 106 hPa) and 8 H₂O layers (surface - 162 hPa),
- H₂O scaling for proximity recognition: factor 2
- choose closest TIGR profile and then those within 1.05*dist_{min}, max 3 iterations
- initial cloud detection
- cloud property retrieval per spot

Cloud property retrieval

like TOVS Path-B retrieval (Stubenrauch et al. J. Climate 1999):

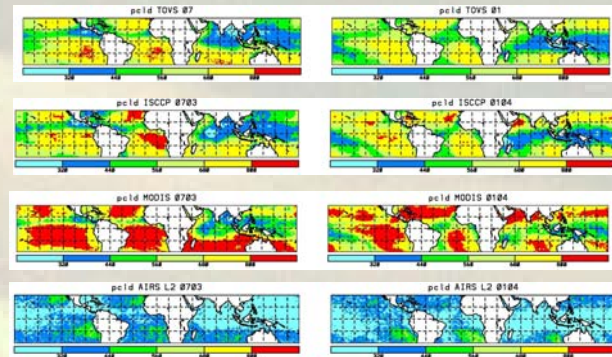
- use AIRS L2 atmospheric profiles (Susskind et al. 2003) to find closest TIGR atm. profiles
- compute I_{cd} and I_{cl} from these TIGR profiles
- compute eff. cloud emissivity for 30 pressure levels as : (using 5 channels along the 15 μm CO₂ absorption band)

$$N_e(p_k) = \sum_{i=1}^5 \frac{I_{\text{at}}(\lambda_i) - I_{\text{cp}}(\lambda_i)}{I_{\text{at}}(p_k, \lambda_i) - I_{\text{cl}}(\lambda_i)}$$

- minimize weighted $\chi^2(p_k) \Rightarrow p_{\text{cd}}, N_e$ (weights take into account temp. profiles uncertainties)
- eff. cloud amount (ECA) = $N_e * \text{cloud fraction}$

Datasets for comparison

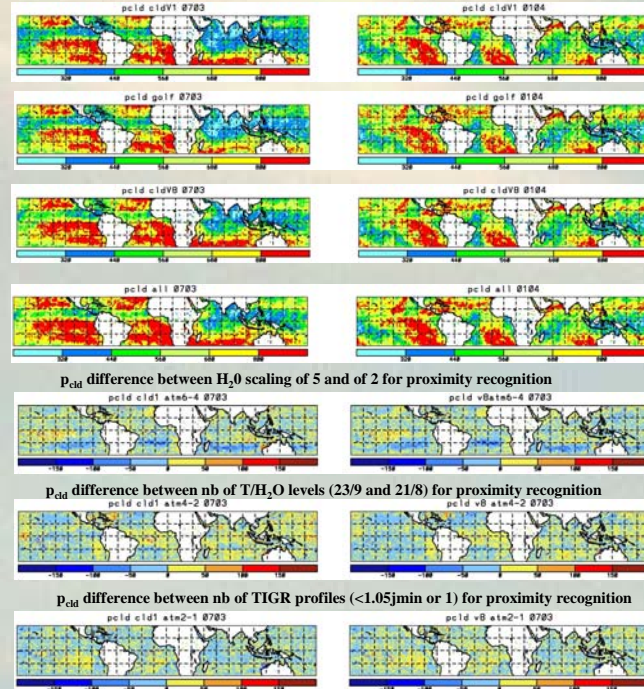
- AIRS July 2003, January 2004; 30°N-30°S ocean, nighttime (computed bias adjustment coefficients)
- TOVS Path-B NOAA10-12 July 1987-1994 and January 1988-1995 (Stubenrauch et al. 2006)
- ISCCP for same period, ISCCP July 2003, January 2004 (Rossow & Schiffer 1999)
- MODIS MOD08-M3: p_{cd} during daytime (Menzel & Strabala 1997)
- AIRS L2 version 3: p_{cd} of highest cloud (max 2 layers) (Susskind et al. 2003)



good agreement between TOVS and ISCCP, with TOVS more sensitive to cirrus clouds than ISCCP (Stubenrauch et al. J. Climate 1999, 2006)

clouds from MODIS on average much lower, due to better spatial resolution or too many clouds? clouds from AIRS L2 much higher

p_{cd} from AIRS LMD retrieval reveals the structures of high clouds in the tropics (like TOVS) and of low clouds, especially in SH subtropics, like MODIS



p_{cd} difference between H₂O scaling of 5 and of 2 for proximity recognition

pcld cl d1 atm6-4 0703 pcld v8 atm6-4 0703

p_{cd} difference between nb of T/H₂O levels (23/9 and 21/8) for proximity recognition

pcld cl d1 atm4-2 0703 pcld v8 atm4-2 0703

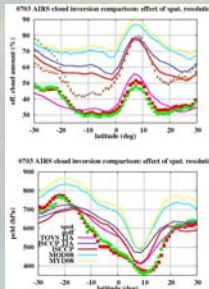
p_{cd} difference between nb of TIGR profiles (<1.05jmin or 1) for proximity recognition

pcld cl d1 atm2-1 0703 pcld v8 atm2-1 0703

Effect of spatial resolution, of atmospheric profiles and of cloud detection

Effect of spatial resolution:

average radiances over cloudy spots and do cloud property retrieval per golf ball (like in TOVS Path-B)



latitudinal behavior of ECA and p_{cd} follows that of TOVS climatology,

MCA(AIRS) > MCA(TOVS)
HCA(AIRS) < HCA(TOVS) in tropics

Worsening spatial resolution:

slightly more HCA and less LCA in tropics

Stronger cloud detection:

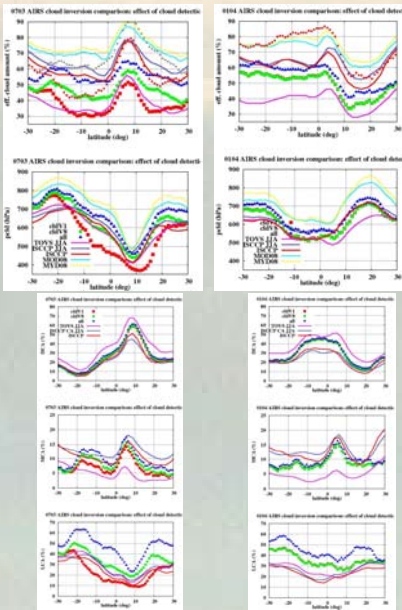
less latitudinal range of ECA and p_{cd}
increasing LCA

Choice in atmospheric profiles:

less important for latitudinal behavior
H₂O scaling has effect on MCA in SH subtropics

Effect of cloud detection:

1) stronger cloud detection (V8) and 2) use all spots (100% cloudy) for cloud property retrieval



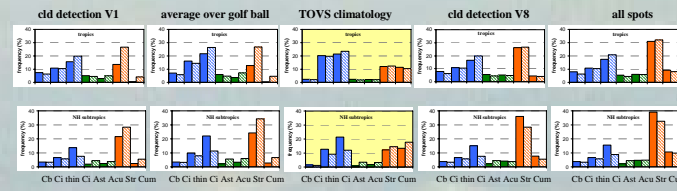
Conclusions and Outlook

30°N-30°S: AIRS cloud property retrieval over ocean, using TOVS Path-B-like approach, leads to p_{cd} and ECA similar to TOVS and ISCCP

MODIS p_{cd} however is much larger and AIRS L2 p_{cd} is much smaller

remaining uncertainties:

- too many thick low clouds in the winter subtropics: probably due to wrong cloud detection
- more thick high clouds than TOVS and less Cirrus: could be a spatial resolution effect
- slightly more midlevel clouds than TOVS (between TOVS and ISCCP): wait for results of TOVS reanalysis with TIGR-2000



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Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center,
Cooperative Institute for Meteorological Satellite Studies, 2006.