Cloud properties from AIRS

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Multi-spectral cloud detection

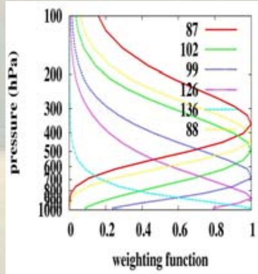
Microwaves probe through clouds
Difference between T_B's with channels sounding similar depths of atmosphere should be negligible for clear sky

$|T_B(151) - T_B(AMSU_8) - \delta(\theta_v,\varepsilon_s,air)| > Thr(\theta_v,\varepsilon_s,air)$ *peak: 180hPa*
$|T_B(2106) - T_B(AMSU_8) - \delta(\theta_v,\varepsilon_s,air)| > Thr(\theta_v,\varepsilon_s,air)$ *peak: 180hPa*
$|T_B(213) - T_B(AMSU_6) - \delta(\theta_v,\varepsilon_s,air)| > Thr(\theta_v,\varepsilon_s,air)$ *peak: 400hPa*
$|T_B(1947) - T_B(AMSU_6) - \delta(\theta_v,\varepsilon_s,air)| > Thr(\theta_v,\varepsilon_s,air)$ *peak: 400hPa*
$|T_B(2106) - T_B(AMSU_6) - \delta(\theta_v,\varepsilon_s,air)| > Thr(\theta_v,\varepsilon_s,air)$ *peak: 400hPa*
$|T_B(2110) - T_B(AMSU_6) - \delta(\theta_v,\varepsilon_s,air)| > Thr(\theta_v,\varepsilon_s,air)$ *peak: 400hPa*
$|T_B(2110) - T_B(AMSU_5) - \delta(\theta_v,\varepsilon_s,air)| > Thr(\theta_v,\varepsilon_s,air)$ *peak: 930hPa*
$|T_B(2112) - T_B(AMSU_5) - \delta(\theta_v,\varepsilon_s,air)| > Thr(\theta_v,\varepsilon_s,air)$ *peak: 930hPa*

$|T_B(787) - T_B(2226) - \delta(\theta_v,\varepsilon_s,air)| > Thr(\theta_v,\varepsilon_s,air)$ *low*
$|T_B(787) - T_B(2333) - \delta(\theta_v,\varepsilon_s,air)| > Thr(\theta_v,\varepsilon_s,air)$ *low*

$|T_B(308) - \Sigma\, a_i T_B(AMSU_i) - \delta(\theta_v,\varepsilon_s,air)| > Thr(\theta_v,\varepsilon_s,air)$ *mid*
$|T_B(309) - \Sigma\, d_i T_B(AMSU_i) - \delta(\theta_v,\varepsilon_s,air)| > Thr(\theta_v,\varepsilon_s,air)$ *mid*
$|T_B(2106) - \Sigma\, e_i T_B(AMSU_i) - \delta(\theta_v,\varepsilon_s,air)| > Thr(\theta_v,\varepsilon_s,air)$ *mid*
$|T_B(2110) - \Sigma\, f_i T_B(AMSU_i) - \delta(\theta_v,\varepsilon_s,air)| > Thr(\theta_v,\varepsilon_s,air)$ *mid*
$|T_B(2112) - \Sigma\, f_i T_B(AMSU_i) - \delta(\theta_v,\varepsilon_s,air)| > Thr(\theta_v,\varepsilon_s,air)$ *low*

C. Crevoisier 2004; C. Pierangelo 2005



Cloud property retrieval

like TOVS Path-B retrieval (*Stubenrauch et al. J. Climate1999*):

- use AIRS L2 atmospheric profiles *(Susskind et al. 2003)* to find closest TIGR atm. profiles
- compute I_{cld} and I_{clr} from these TIGR profiles
- compute eff. cloud emissivity for 30 pressure levels as :
  (using 5 channels along the 15 µm CO_2 absorption band)

$$N\varepsilon(p_k) = \sum_{i=4}^{8} \frac{I_m(\lambda_i) - I_{clr}(\lambda_i)}{I_{cld}(p_k,\lambda_i) - I_{clr}(\lambda_i)}$$

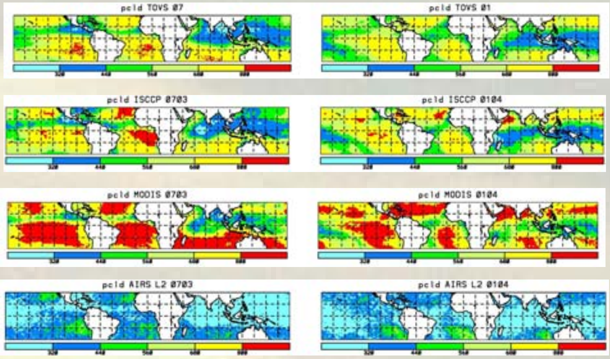
- minimize weighted $\chi^2(p_k) \Rightarrow p_{cld}, N\varepsilon$
  (weights take into account temp. profiles uncertainties)

  eff. cloud amount (ECA) = Nε * cloud fraction

- AIRS L2 atmospheric profiles given per golf ball (9 spots)
- use 21 T levels (surface – 106 hPa) and 8 H_2O layers (surface - 162 hPa),
- H_2O 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

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_{cld} during daytime** *(Menzel & Strabala 1997)*
- **AIRS L2 version 3: p_{cld} 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)*

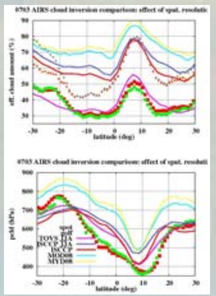
clouds from MODIS on average much lower, due to better spatial resolution or too many clouds?

clouds from AIRS L2 much higher

p_{cld} 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

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_{cld} 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:

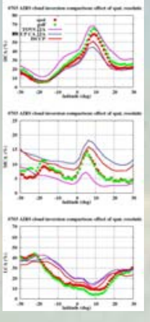
less latitudinal range of ECA and p_{cld}

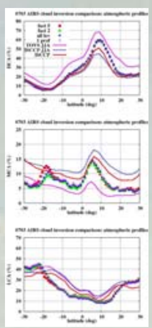
increasing LCA

Choice in atmospheric profiles:

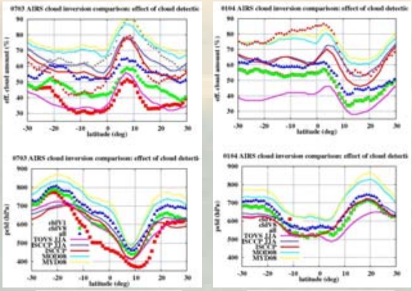
less important for latitudinal behavior

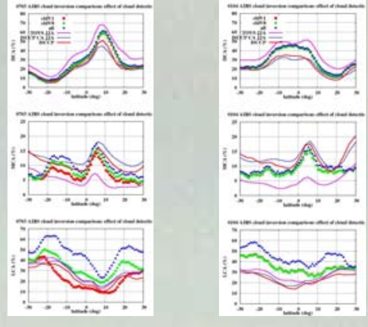
H_2O scaling has effect on MCA in SH subtropics

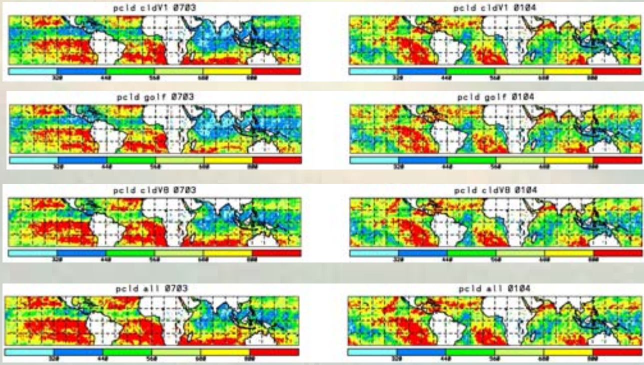




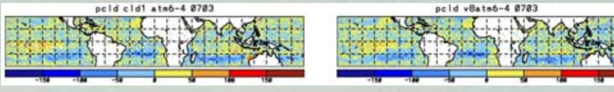
Effect of cloud detection:
1) stronger cloud detection (V8) and 2) use all spots (100% cloudy) for cloud property retrieval



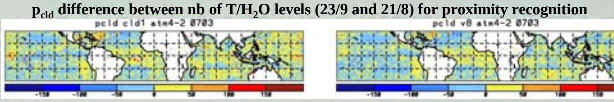




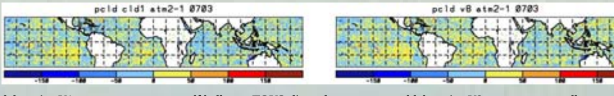
p_{cld} difference between H_2O scaling of 5 and of 2 for proximity recognition



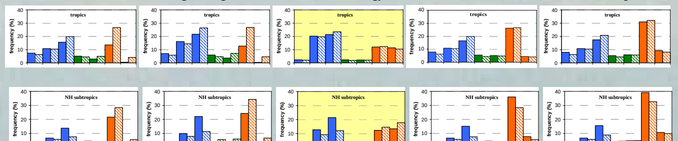
p_{cld} difference between nb of T/H_2O levels (23/9 and 21/8) for proximity recognition



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



cld detection V1 **average over golf ball** **TOVS climatology** **cld detection V8** **all spots**



Cb Ci thin Ci Ast Acu Str Cum Cb Ci thin Ci Ast Acu Str Cum Cb Ci thin Ci Ast Acu Str Cum Cb Ci thin Ci Ast Acu Str Cum Cb Ci thin Ci Ast Acu Str Cum

(July: plain/January: hatched)

Conclusions and Outlook

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

MODIS p_{cld} however is much larger and AIRS L2 p_{cld} 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**

The MODIS data were acquired using the GES-DISC Interactive Online Analysis Infrastructure (Giovanni) as part of the NASA's Goddard Earth Sciences Information Services Center (DISC).

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