Estimations of vertically averaged cloud water temperature using HSB data: simulated results

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Background

• Cloud vertical structure (e.g. top & bottom temperature) has important effects on surface longwave radiation.

• Recent studies show that high frequency microwave measurements have sufficient sensitivity on cloud water temperature.

• Humidity Sounder for Brazil (HSB) on Aqua will provide good opportunity to observe these properties globally.

• HSB channels: 150, 183±1, 183±3, & 183±7 GHz.
Fig. 17.8 Zenith opacity of the US Standard Atmosphere (1976 model) for surface temperature $T_0 = 288$ K and surface pressure $P_0 = 1020.5$ mbar for the moist atmosphere ($\rho_0 = 3$ and $10$ g m$^{-3}$) and 1013 mbar for the O$_2$ atmosphere (from Smith, 1982).
Combined Data

- Aqua (PM orbit): HSB + MODIS (+ AMSR)
- HSB Cross-track scan (±50°, total 90 pixels).
- FOV: 1.1° (16.3 ~ 25.4 km)
- Column water vapor
- IR: cloud top temperature Tc, cloud cover
- VIS: cloud cover, optical depth
- AMSR: cloud liquid water amount, SST, wind speed
Atmospheric Profile for Simulation

- McClatchey et al. (1972): Tropical, midlatitude summer, US standard and midlatitude winter.
- NOAA 1988 radiosonde measurements: clear & cloudy conditions
- Cloud water amount:
  Minnis et al. (1995) and random values
- Random sea surface wind speed
Radiative Transfer Model

- Two stream absorption and emission based microwave radiative transfer model [Lin et al. 1998].
- Water absorption coefficients: Mie calculations using water refractive index of Ray [1972].
- Surface emissivity: SST, WS, salinity and whitecap Cox & Munk slope statistics
- Water vapor absorption coefficients: Liebe [1989] (MPM89), line-by-line calculation
Thickness tests: Hc=1, 4, 7km
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Retrieval Scheme

1. Lookup table

initialization: SST, WS, CWV

MWRTM simulation of Tb values, changing LWP, Tw

$$\sum (T_{b_{SIMU}} - T_{b_{OBS}})^2 = \text{mini}$$

output Tw

2. Linear regression
noises in parameters $< 1\sigma$
‘bad’ data
Random LWP simulation
Conclusions

- The HSB Tb values are considerably affected by both LWP and cloud water temperature. From low to high moderate thick (0.1mm) clouds in US standard profile, the Tb changes are about 5 and 10K at 150 and 183±3 GHz, respectively. For thick clouds (0.5mm), these values increase to ~10 and 20K, respectively.

- For the clouds with the same averaged cloud water temperature, the Tb differences are generally small (within ~2K) if cloud physical thickness is less than 3km.
Conclusions (cont’)

• The RMS errors in cloud vertically averaged temperature are about 9~13K for the simulated NOAA 1988 data set.

• Retrievals using 2-channel lookup table have about the same accuracy as those from empirical method.

• Combined with IR cloud top measurements, cloud base temperature may be estimated with RMS errors about the same as the mean water temperature.

• More study on physical retrieval is needed.