Validation of Climate Sounding Algorithm Cloud Heights

William L. Smith1,2, Elisabeth Weisz1, and Melissa Yesalusky2
1University of Wisconsin-Madison 2 Hampton University
CALIPSO/CloudSat Science Workshop (28-31 July 2009, Madison, WI)

A Hyperspectral Vertical Resolution Profile Technique That Enables the Use of the Infrared Radiance Spectrum to Define the Cloud Height with High Accuracy

The Technique

Use rapidly produced “Clear-trained” and “Cloud-trained” EOF regression IR hyperspectral sounder retrievals of surface skin temperature, effective cloud optical depth, and atmospheric temperature and moisture profiles to specify cloud top altitude, cloud attenuation, clear atmospheric thermodynamic profile above the cloud, and thermodynamic profile below thin or scattered cloud (i.e., cloud effective optical depth < 1.5 and emissivity > 88%, or an effective cloud transmissivity > 35 %, and a cloud induced temperature attenuation < 15 K).

- Optically thin cloud height is specified as the highest altitude where an isolated peak in the “clear-trained” relative humidity profile is > 75%.
- Cloud optical depth is obtained from cloudfield EOF regression operator. Cloud emissivity/transmissivity is defined from cloud top temperature and the maximum difference between cloud-trained and “clear-trained” retrievals beneath the cloud tops.
- Atmospheric profile below the cloud is specified as the “clear-trained” retrieval.

Inter-comparison Criteria

(AIRS, CALIPSO, and CloudSat co-located fields of view)

CloudSat Filtered Comparisons
- MODIS Clear Probability = 0%
- IIR FOV average radiance difference ≤ 1 %
- CALIPSO Number of Cloud Layers ≤ 2

CloudSat Filtered Comparisons
- MODIS Clear Probability = 0%
- IIR FOV average radiance difference ≤ 1 %
- CALIPSO Number of Cloud Layers ≤ 2
- CALIPSO – CloudSat Highest Cloud Pressure Difference ≤ 50-hPa

Conclusion

- The hyperspectral vertical resolution profile technique enables the entire spectrum of radiance to be used to define the cloud height with relatively high accuracy.
- AIRS temperature (AIRS-T) and AIRS relative humidity (AIRS-RH) profile retrievals are able to specify the tops of relatively opaque and optically thin cloud layers, respectively.
- Comparisons of AIRS-T and AIRS-RH Cloud Top Pressures with co-located CALIPSO and CloudSat Cloud Pressures reveal the following:
  - The scatter of AIRS-T Vs CALIPSO and AIRS-T Vs CloudSat is similar to that of CALIPSO Vs CloudSat
  - AIRS-T agrees better with CloudSat than it does with CALIPSO
  - AIRS-RH helps sense the height of optically thin cirrus cloud missed by most IR window and CO2 channel cloud height sensing techniques.
  - The correspondence between AIRS-T with CALIPSO is improved when a CALIPSO – CloudSat highest cloud height difference filter is applied to the data set
- Much of the scatter between the IR-profile cloud heights and those from CALIPSO and CloudSat are believed to be due to the different FOVs of the instruments.
- The atmospheric profiles associated with the hyperspectral profile cloud heights compare well with ECMWF analyses of temperature and water vapor.