



Cloud Parameters from a Combination of Infrared and Microwave Satellite Measurements

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Main Objective

Performance of IASI cloud detection, cloud top and cloud thickness retrieval using AIRS data.

Validation based on MODIS data.



Cloud Detection Scheme

- AMSU/AIRS test
- AIRS Spectral Signature of Clouds



AMSU /AIRS TEST

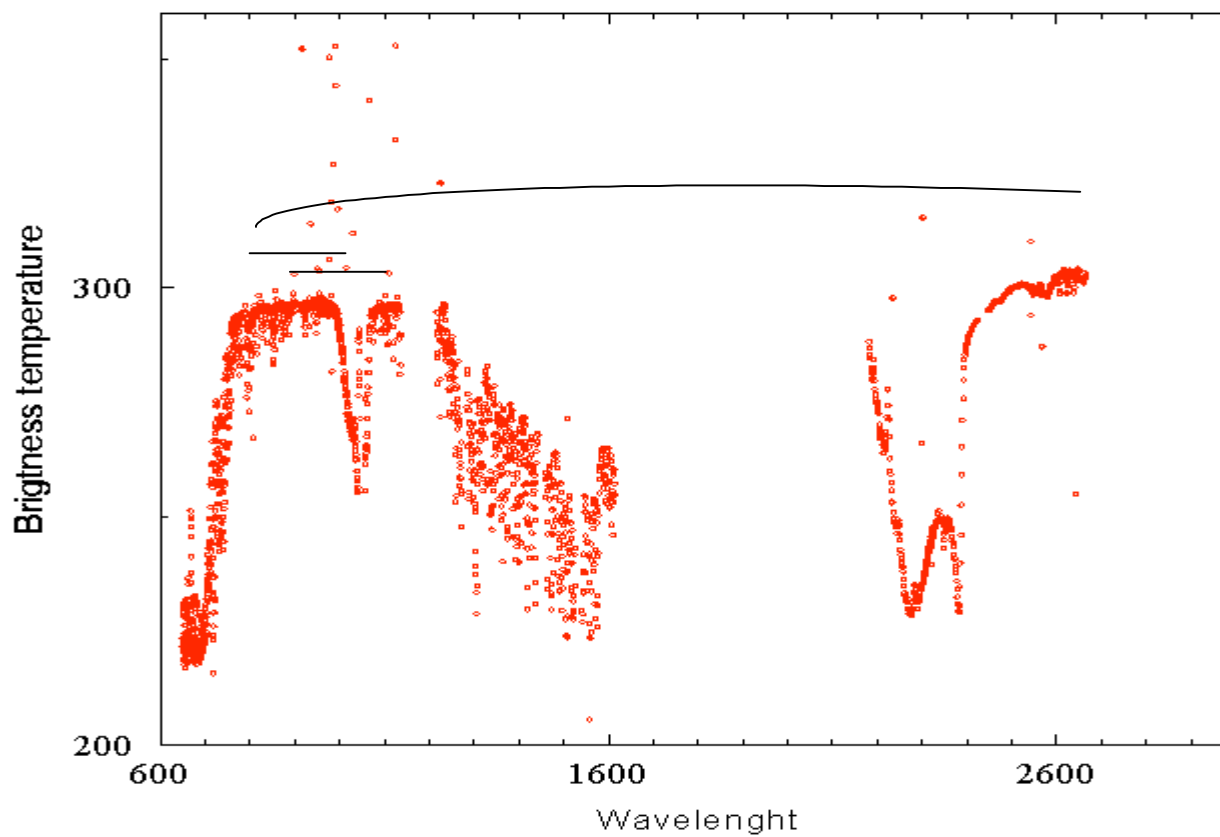
AMSU channel 4,5,6 and 7 are used to predict AIRS channels
at
909.9, 1080.2, 2419.6 and 2563.9.

AIRS FOV is labeled cloudy if the:

$$\text{predicted AIRS} - \text{measured AIRS} > 3$$



Clear AIRS Brightness Temperature





CLEAR and CLOUDY RADIANCE SIMULATIONS

Using the line-by-line Hartcode* , RTTOV** and RT3*** forward models, spectral clear radiances and spectral cloudy radiances are calculating for different cloud types.

* F. Miskolczi, R. Rizzi, R. Guzzi, M. Bonzagni, in IRS'88: Current Problems in Atmospheric Radiation, A. Deepak Publishing, pp. 388-391 (1989)

** Eyre J.R., 1991: A fast radiative transfer model for satellite sounding systems, ECMWF Tech. Memo. 176.

*** K. F. Evans and G. L. Stephens, J. Quant. Spectros. Radiat.Transfer,46,412-423(1991).

*** R. Amorati and R. Rizzi, Radiances simulated in the presence of clouds by use of a fast radiative transfer model and a multiple-scattering scheme, Applied Optics,41, n.9 (2002)



RT3 CODE

RT3 code solves the radiative transfer equation with the adding and doubling method taking into account the multiple scattering. Polarized radiation is considered in term of Stokes parameters under the hypothesis of a plane parallel and vertically inhomogeneous atmosphere including both thermal and solar sources.

Spectral properties of atmosphere gases are computed using Hartcode and RTTOV, while the extinction and scattering coefficients, the single scattering albedo and the Lagrange coefficients to expand the scattering matrix are computed for a gamma-modified size distribution of cloud particles (water and ice) using a Mie code.

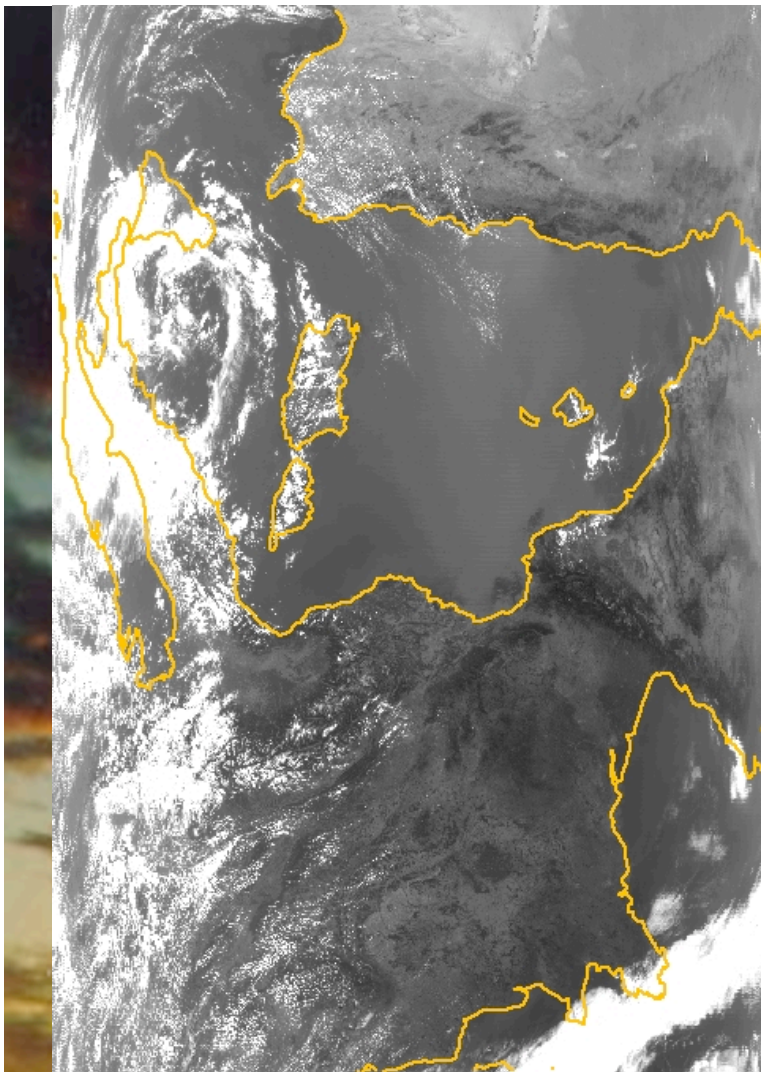


Validation based on collocated MODIS data

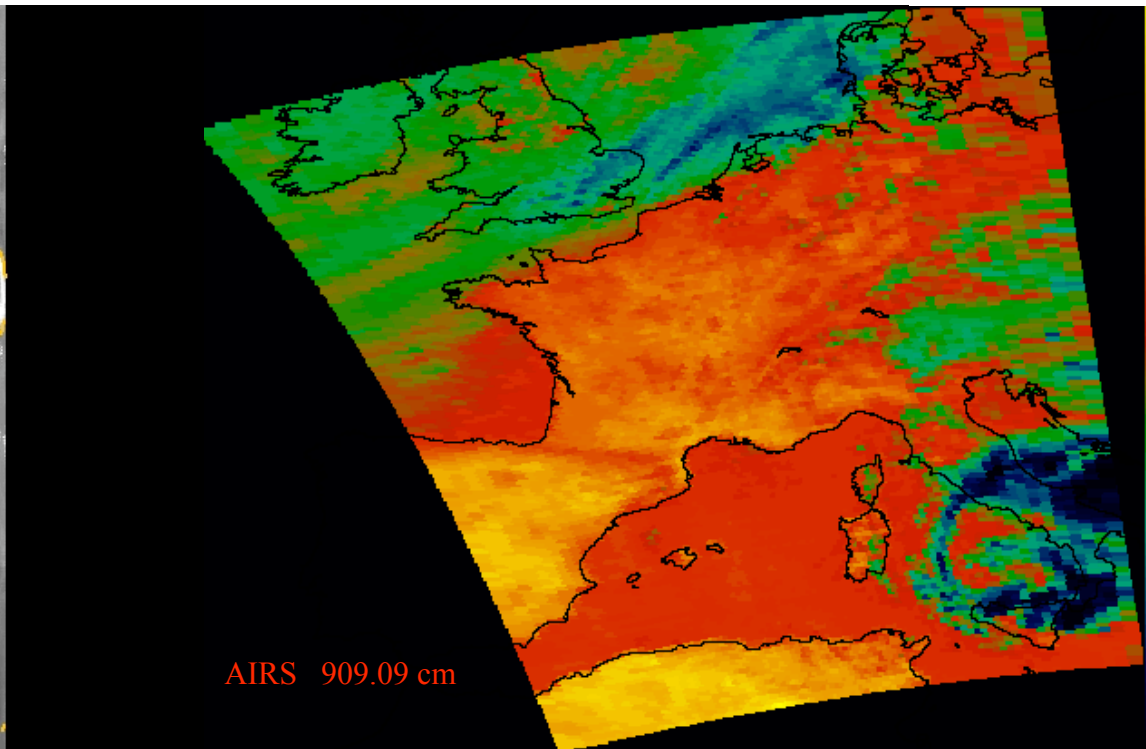
The MODIS (Moderate-Resolution Imaging Spectroradiometer and AIRS (Atmospheric Infrared Sounder) instruments differ in both spatial and spectral resolution.

MODIS measures Earth radiances in two visible bands at 250m resolution, in five other visible bands at 500 m resolution and the remaining bands at 1 km resolution.

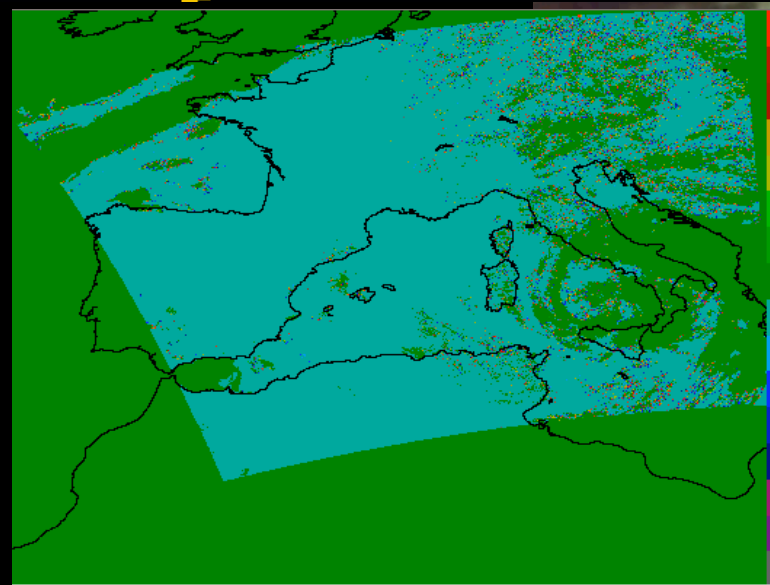
Cloud detection is performed at 1 km resolution for all scenes and also at 250 m in daytime only.



Modis band 3



AIRS 909.09 cm



Modis cloud mask



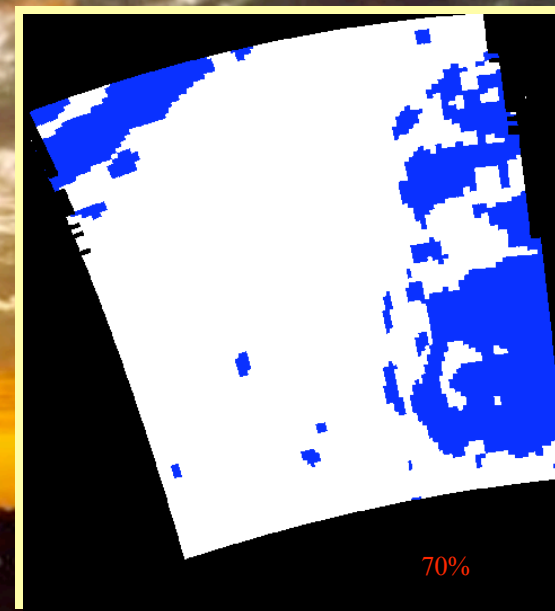
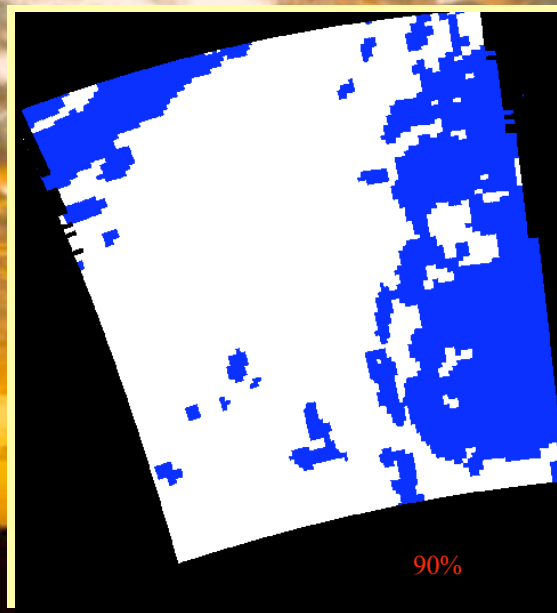
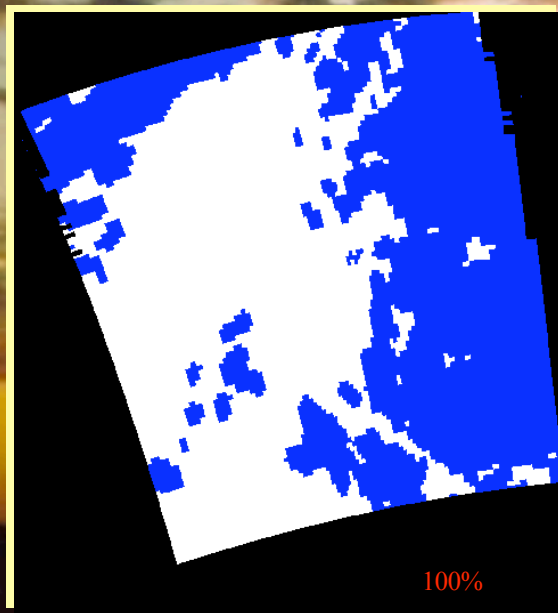
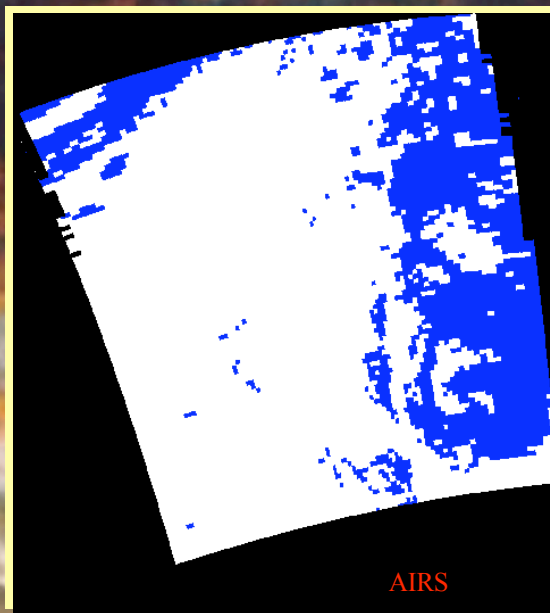
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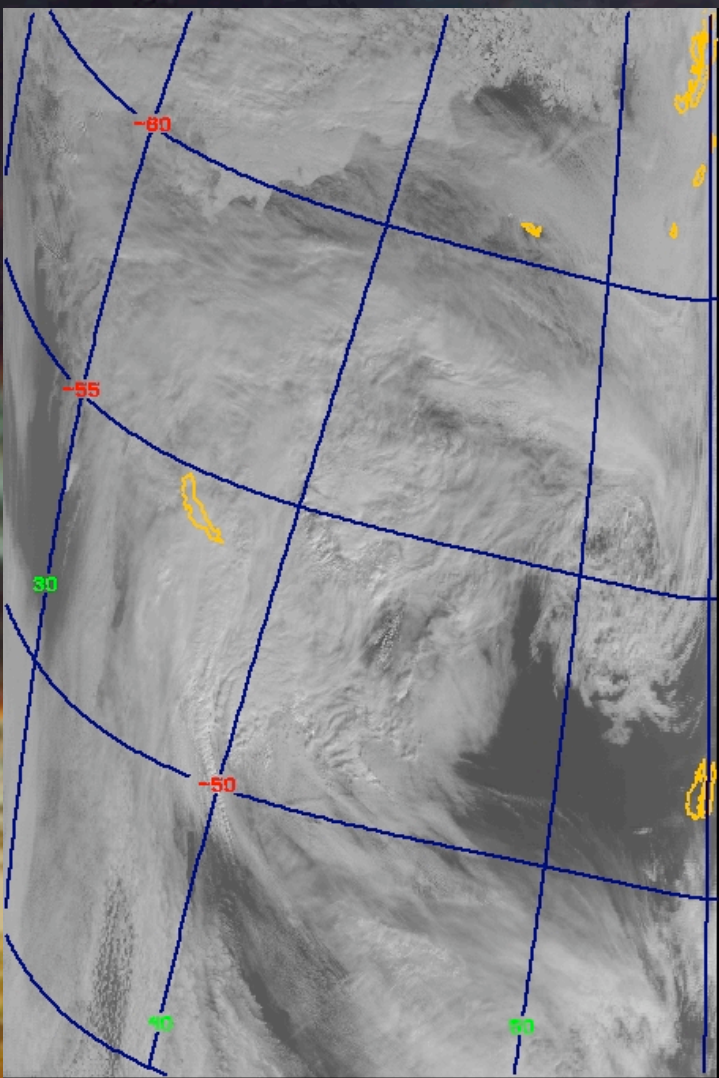
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McIDAS

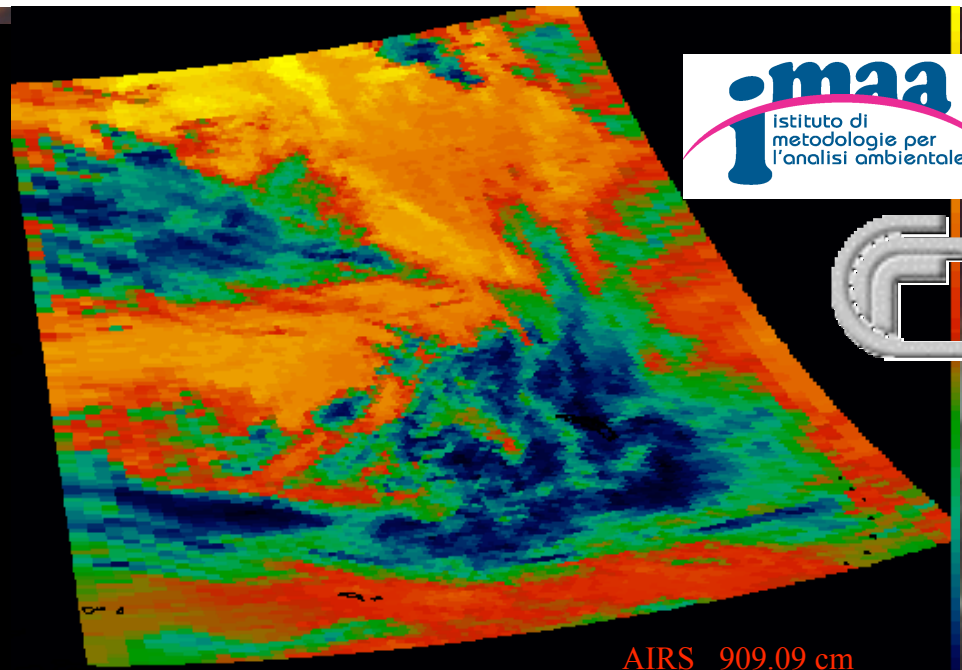


AIRS and MODIS collocated cloud mask

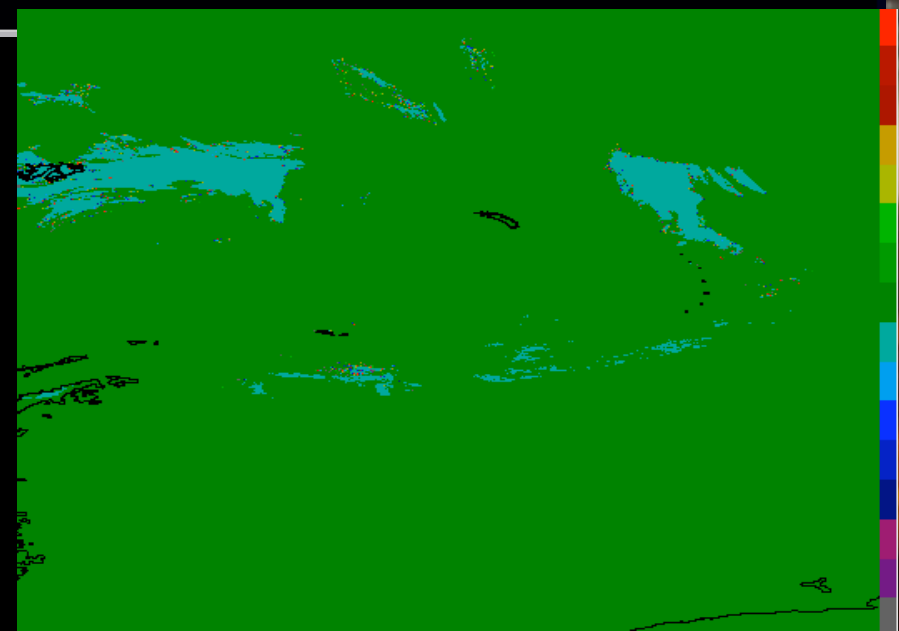




Modis band 3



AIRS 909.09 cm

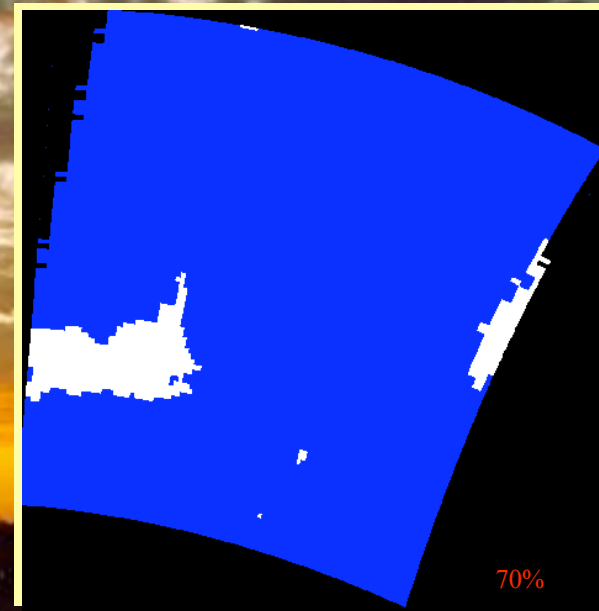
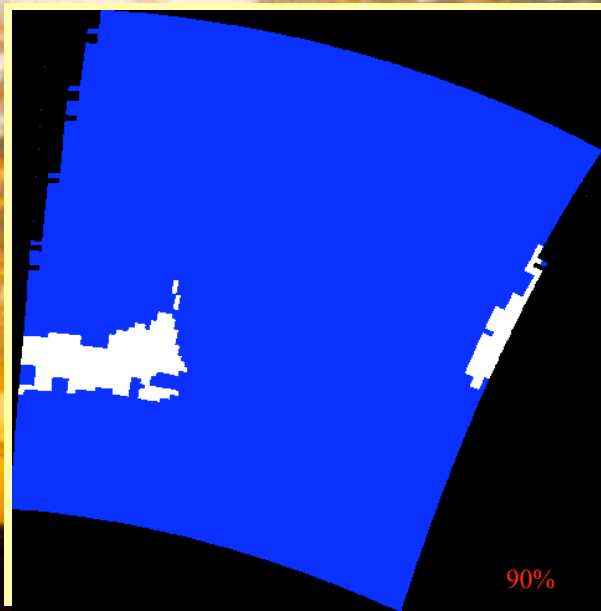
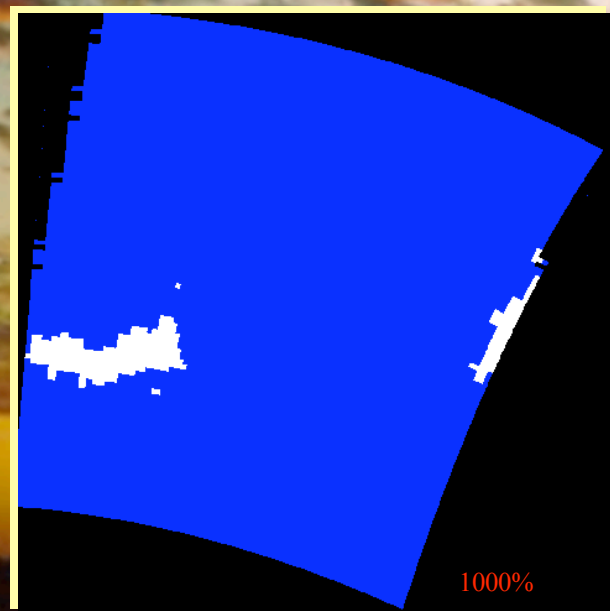
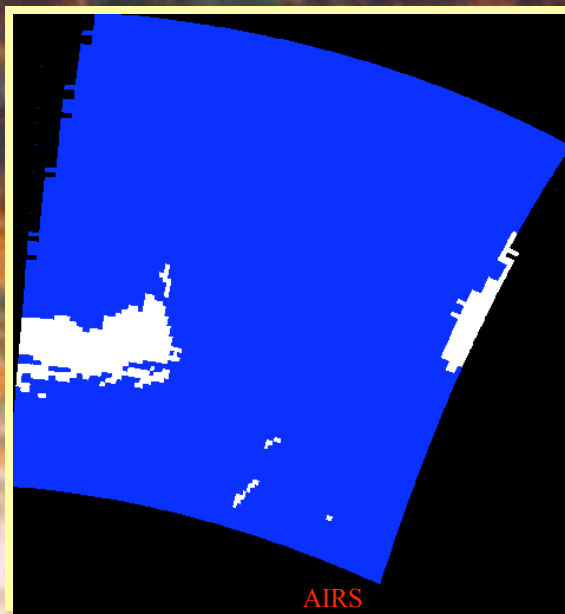


Modis cloud mask

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AIRS and MODIS collocated cloud mask





AIRS/AMSU CLOUD DETECTION VALIDATION

30 granule **FOVs detected exactly**

70%

82.7%

90%

95.8%

100%

92.3%



CLOUD TOP HEIGHT : Single Cloud Level

CO2 slicing method.

The method selected all the pairs of channel in the (700 – 753 cm^{-1}) absorption band whose weighting functions peak between **200 mb and 900 mb**, that best satisfy the radiative transfer equation for all the spectral channels.



Clear AIRS Radiance

Kriging cloud clearing

This schema does not require any assumptions on cloud top pressure, temperature profile. Our procedure is based only on the measurements which have been detected as clear at the cloud detection step and on statistical optimal estimation techniques.

The root mean square error of the Kriging clear brightness temperatures estimates is well below **0.5 °K** for any AIRS channels.



Cloud Thickness



Cloud water content (CWC, liquid or ice) from AMSU measurements has been estimated using a neural network based algorithm.

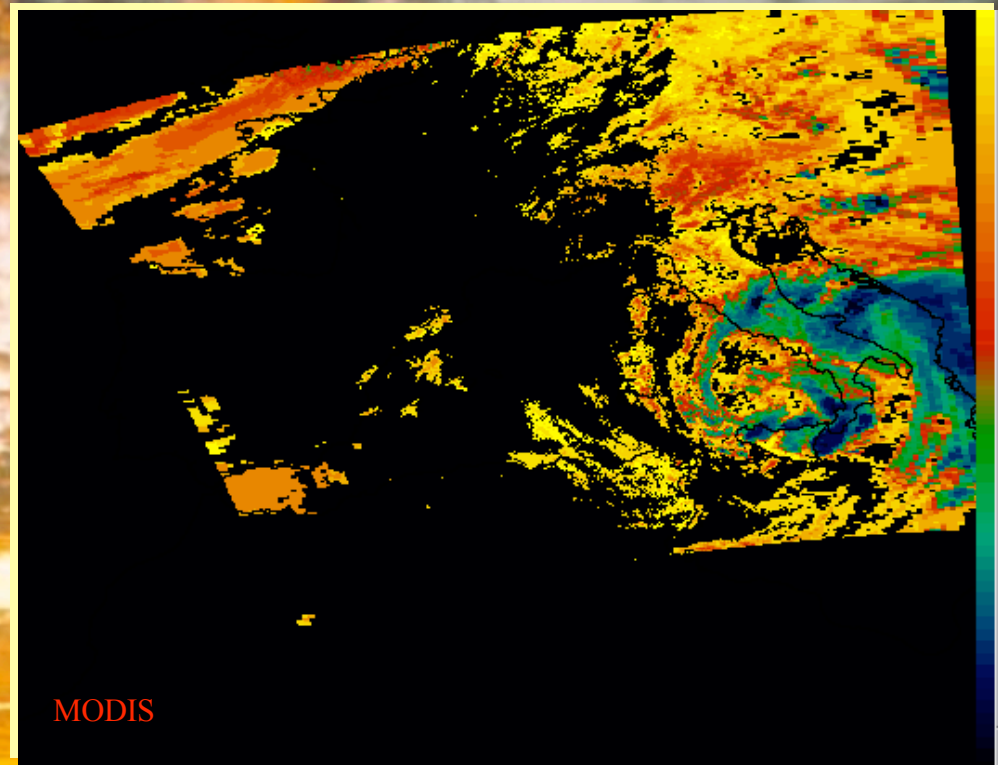
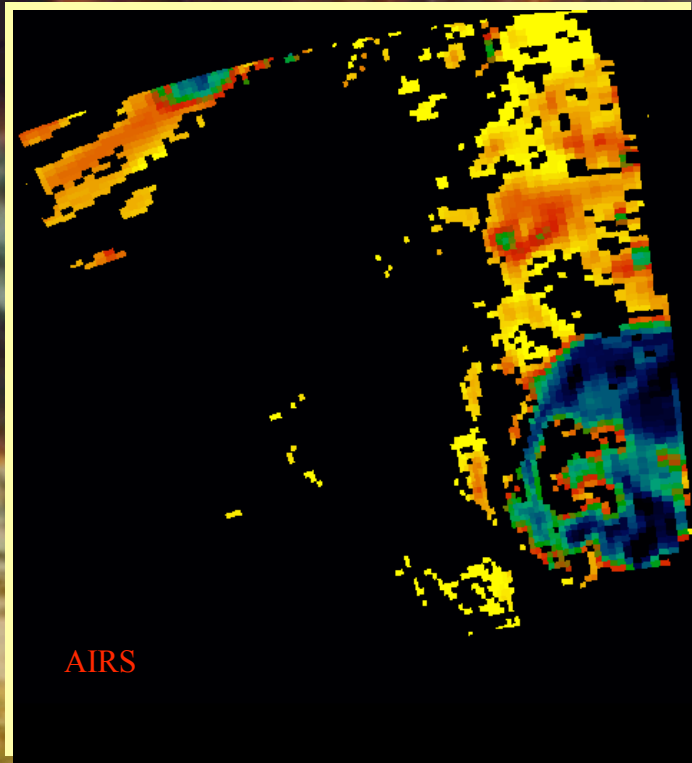
Water and temperature profile from lidar or AIRS/AMSU or ECMWF has been used.

Surface emissivity is adjusted according to the surface type.

Modified RT3 code searches for the best solution: simulated brightness temperature are compared to the observed AIRS and AMSU data. If the difference between the observed and the estimated reach a minimum, the retrieval process finished.

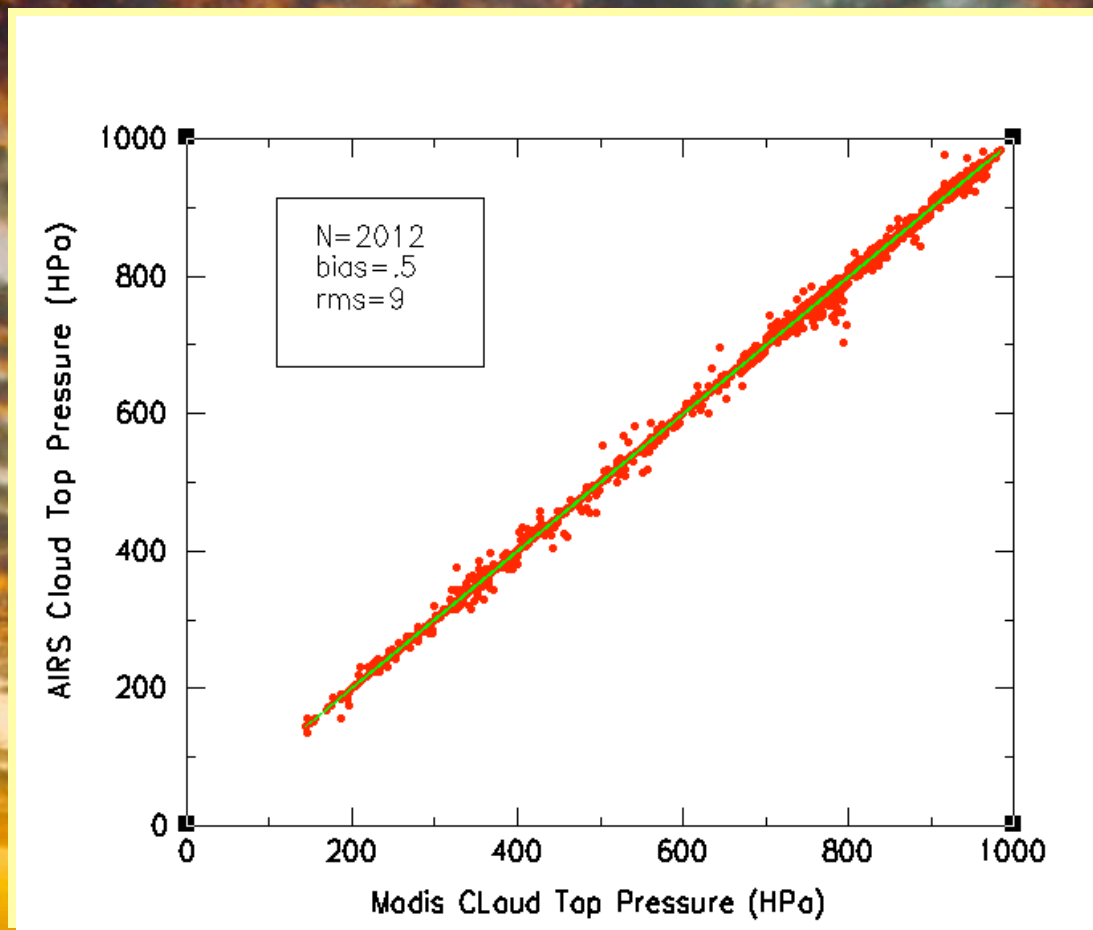


AIRS and MODIS Top Pressure



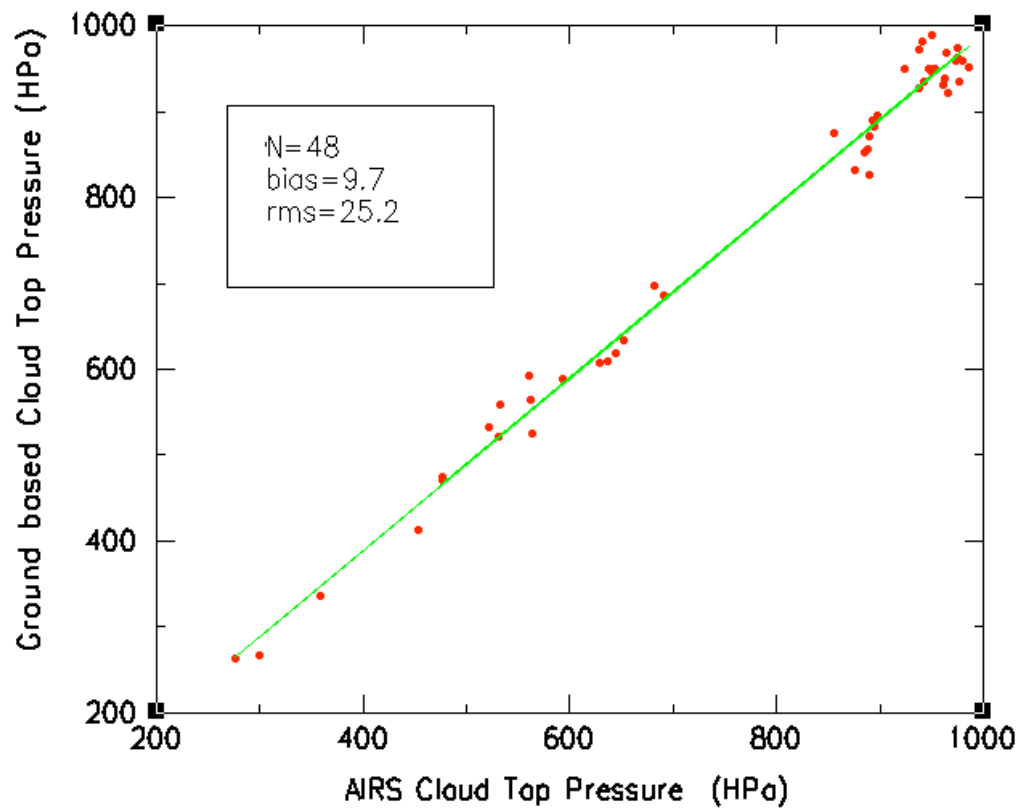


Cloud Top Pressure: Single Cloud Level



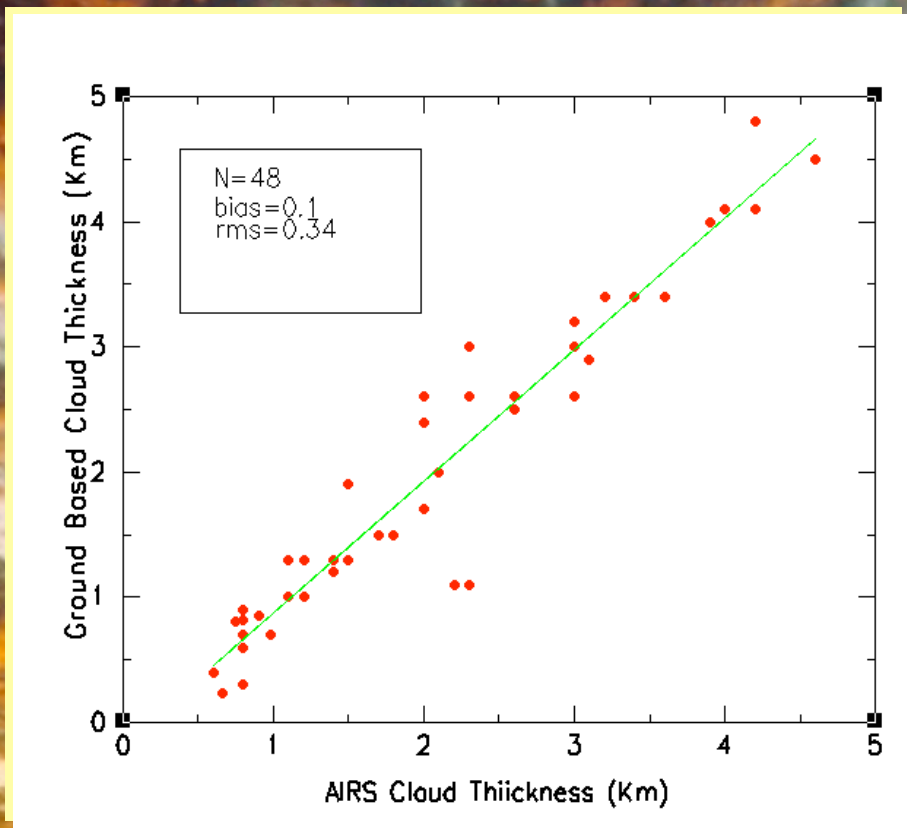


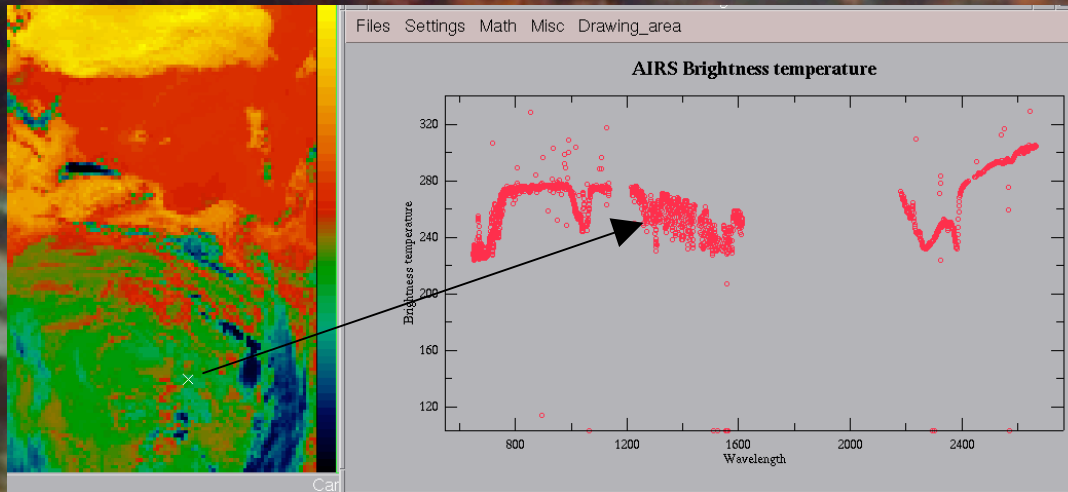
Validation based on lidar and radar data





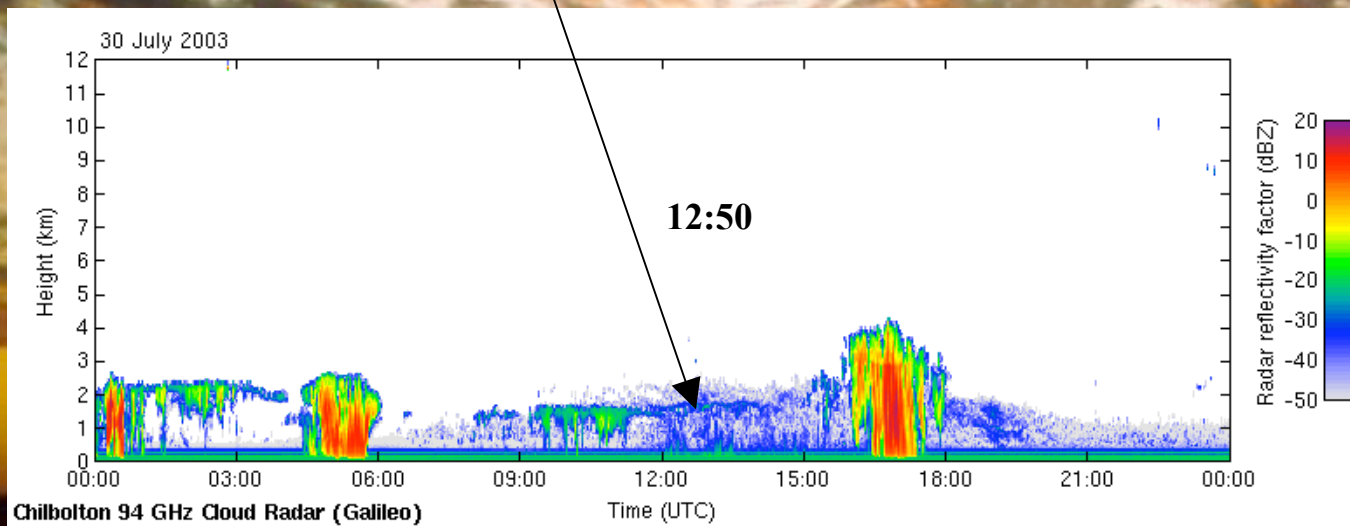
Cloud Thickness: Single Cloud Level





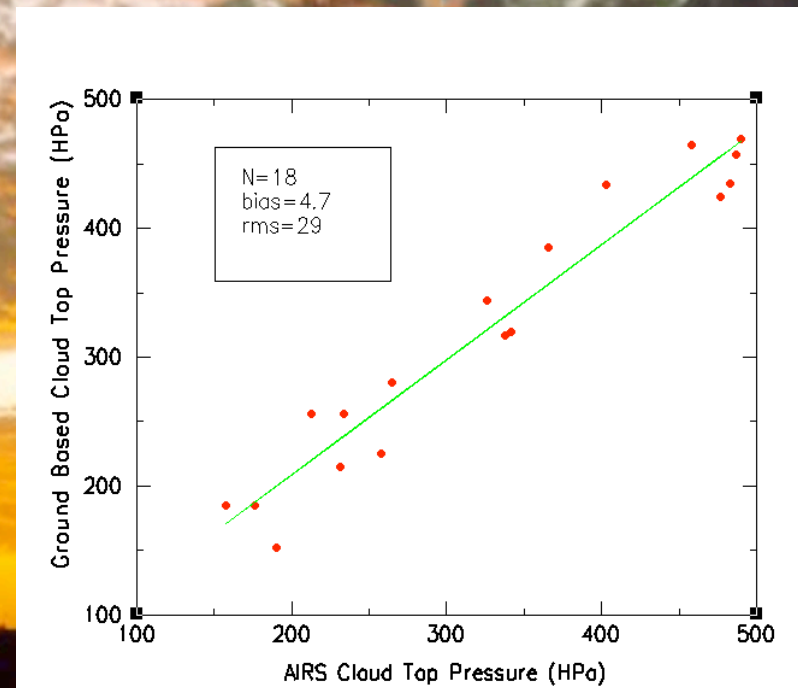
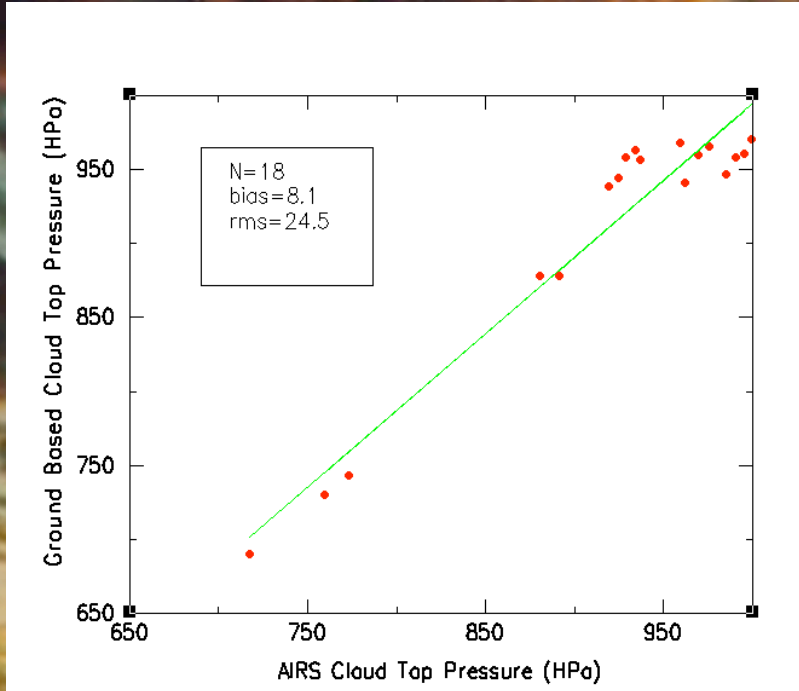
$T_c = 2.2 \text{ km}$

Cloud Thickness = 2.4 km



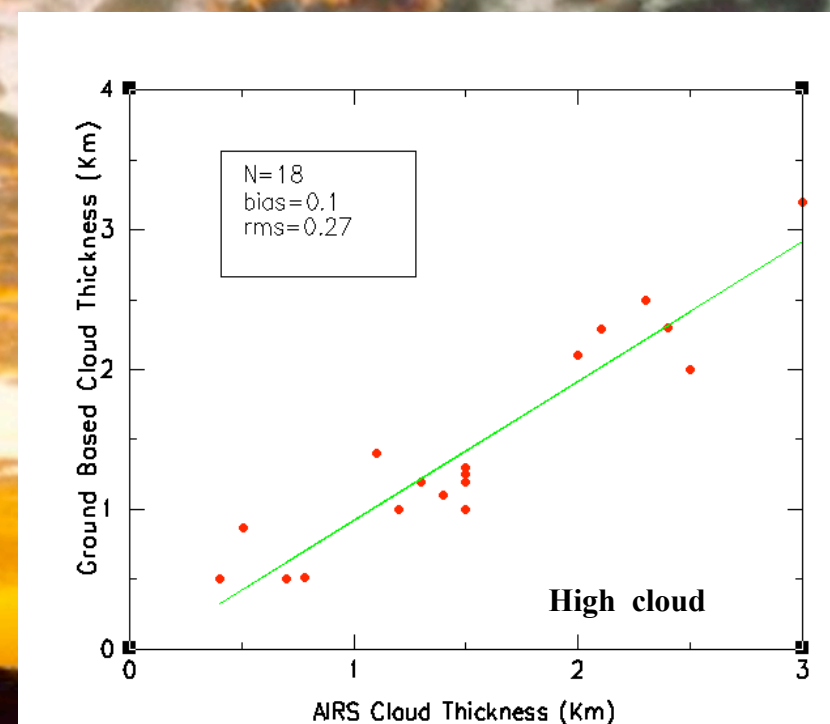
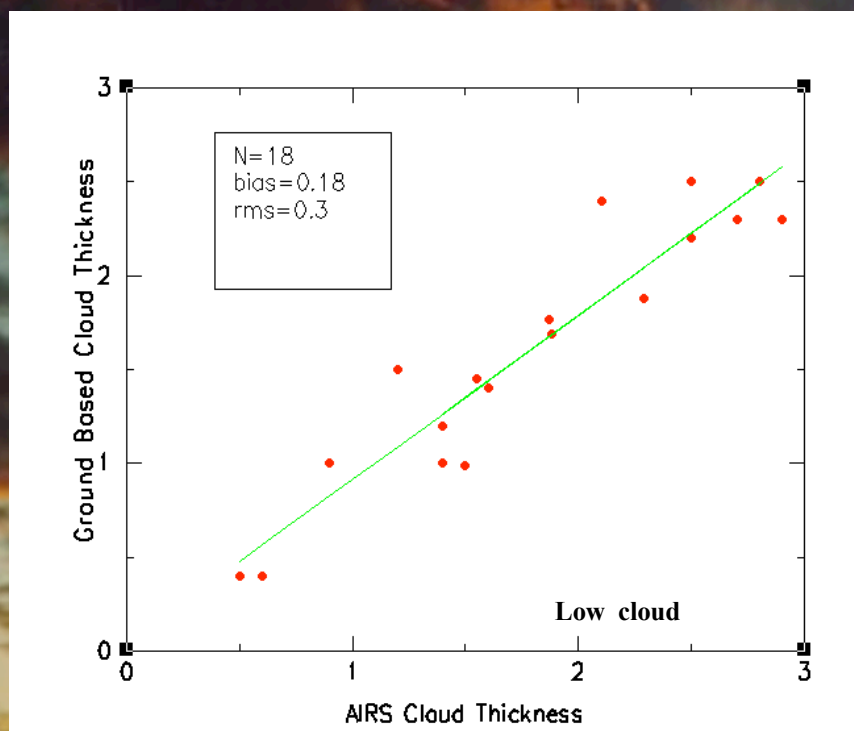


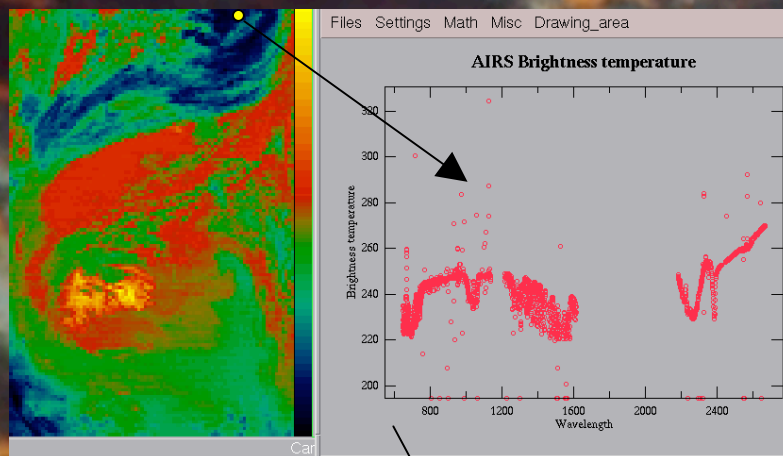
CLOUD TOP HEIGHT : Two Cloud Level





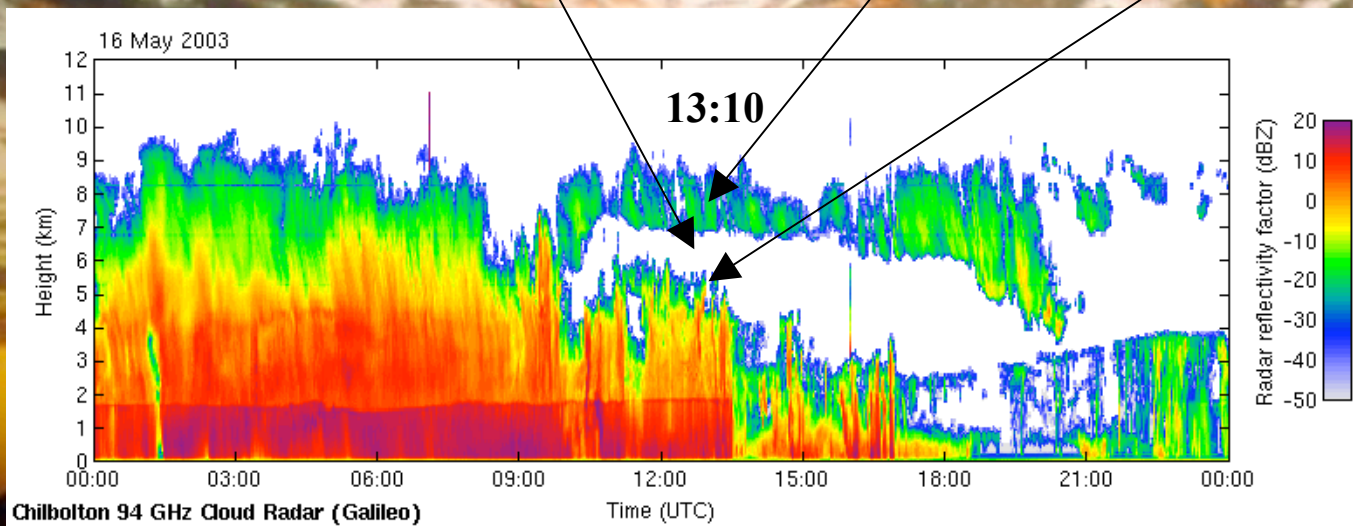
Cloud Thickness: Two Cloud Level





Tc=8.9 km
Cloud Thickness =2.1km

Tc=5.6 km
Cloud Thickness =5.6 km





Conclusion and Future Work

- AMSU data and high spectral resolution AIRS sounders data can greatly be improved retrieval cloud parameters.
- Cloud mask validation based on MSG (SEVIRI) data.
- Validation, based on ground based measurements, will be extend to a large data set.