Cloud Parameters from Infrared and Microwave Satellite Measuremets

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Main Objective

Investigation of Horizontal and Vertical clouds distribution using infrared and microwave data (AIRS and spatial and temporal collocated AMSU)

AIRS Cloud Detection Scheme

- **AMSU/AIRS regression tests**
- **AIRS Spectral Signature of Clouds**

AMSU /AIRS TEST

AMSU channel 4,5,6 and 9 are used to predict AIRS channels at

909.9, 1080.2, 2419.6 and 2563.9.

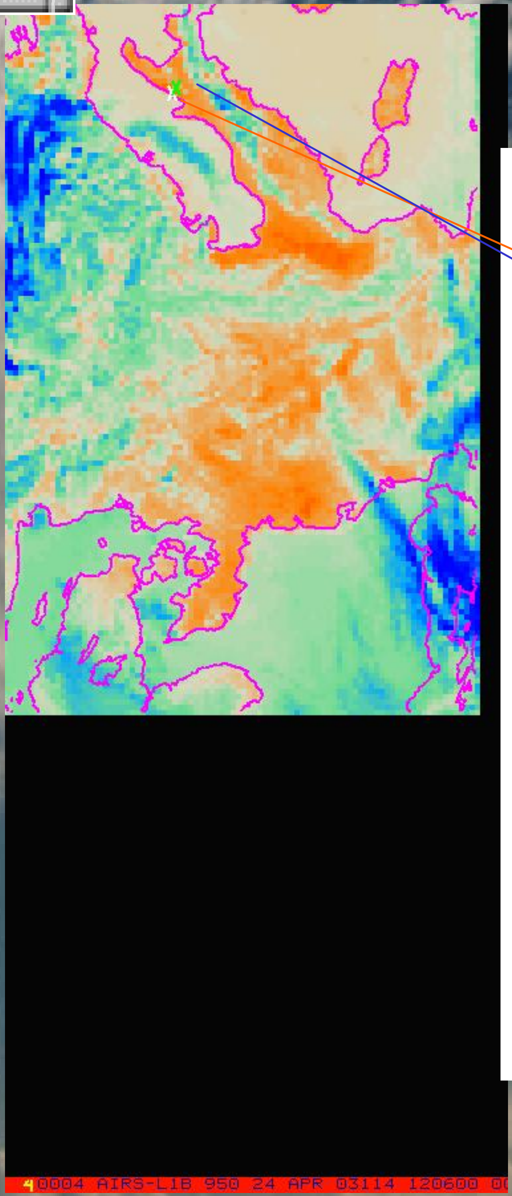
AIRS FOV is labeled cloudy if the:

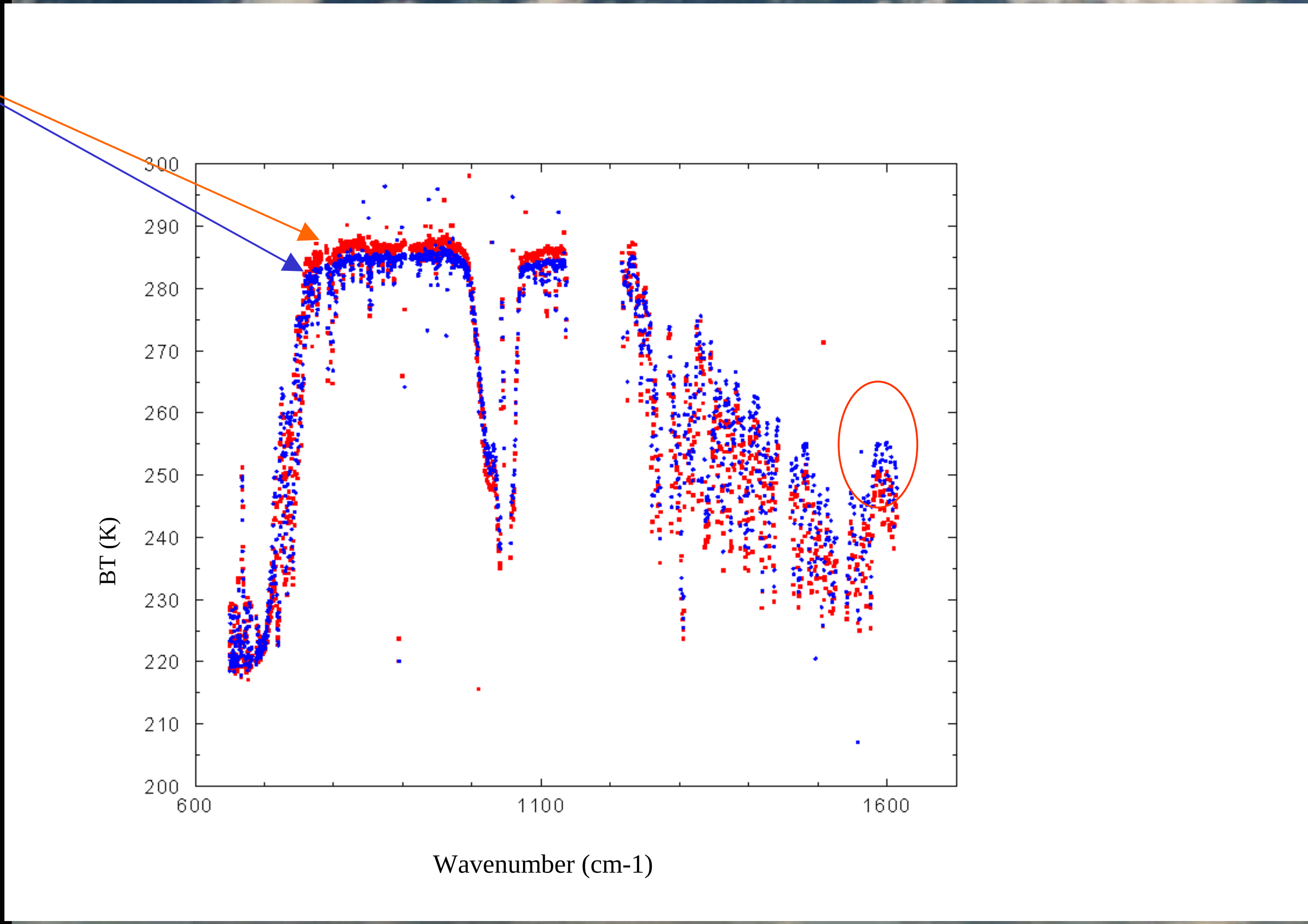
predicted AIRS - measured AIRS > 3 K

AIRS Spectral Signature of Clouds

- **Windows Channel Tests**
- **AIRS Inter-channel Regression Tests**
- **Test for Polar Regions**
- **Horizontal Coherency Test (Windows channel and water absorption band)**

Horizontal Coherency Test





AIRS Cloud Mask Validation using MODIS and SEVIRI data

MODIS CLEAR FOVS PERCENTAGE	FOVS DETECTED EXACTLY
70 %	84.1 %
90 %	96.3 %
100 %	90.7 %

SEVIRI CLEAR FOVS PERCENTAGE	FOVS DETECTED EXACTLY
70 %	86.3 %
90 %	96.7 %
100 %	93.7 %

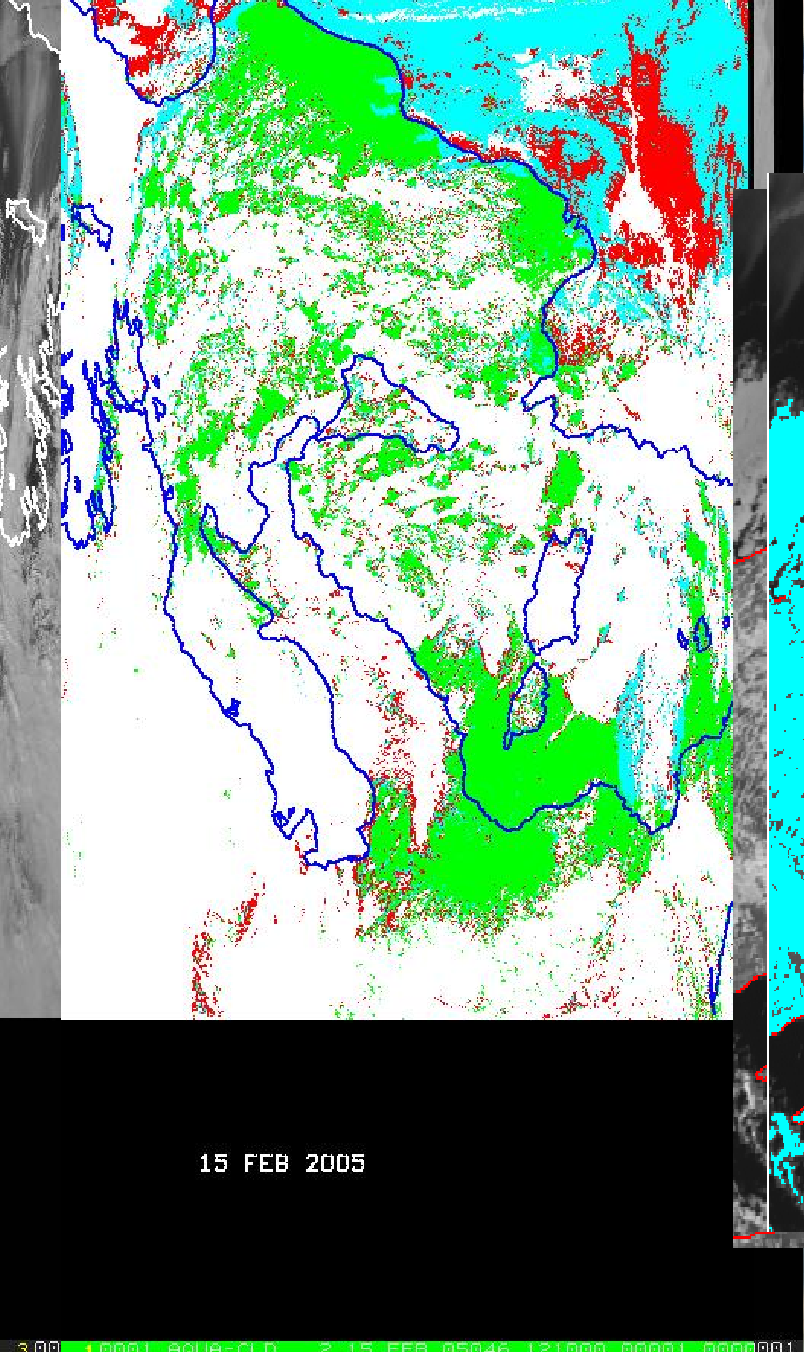
MODIS and SEVIRI

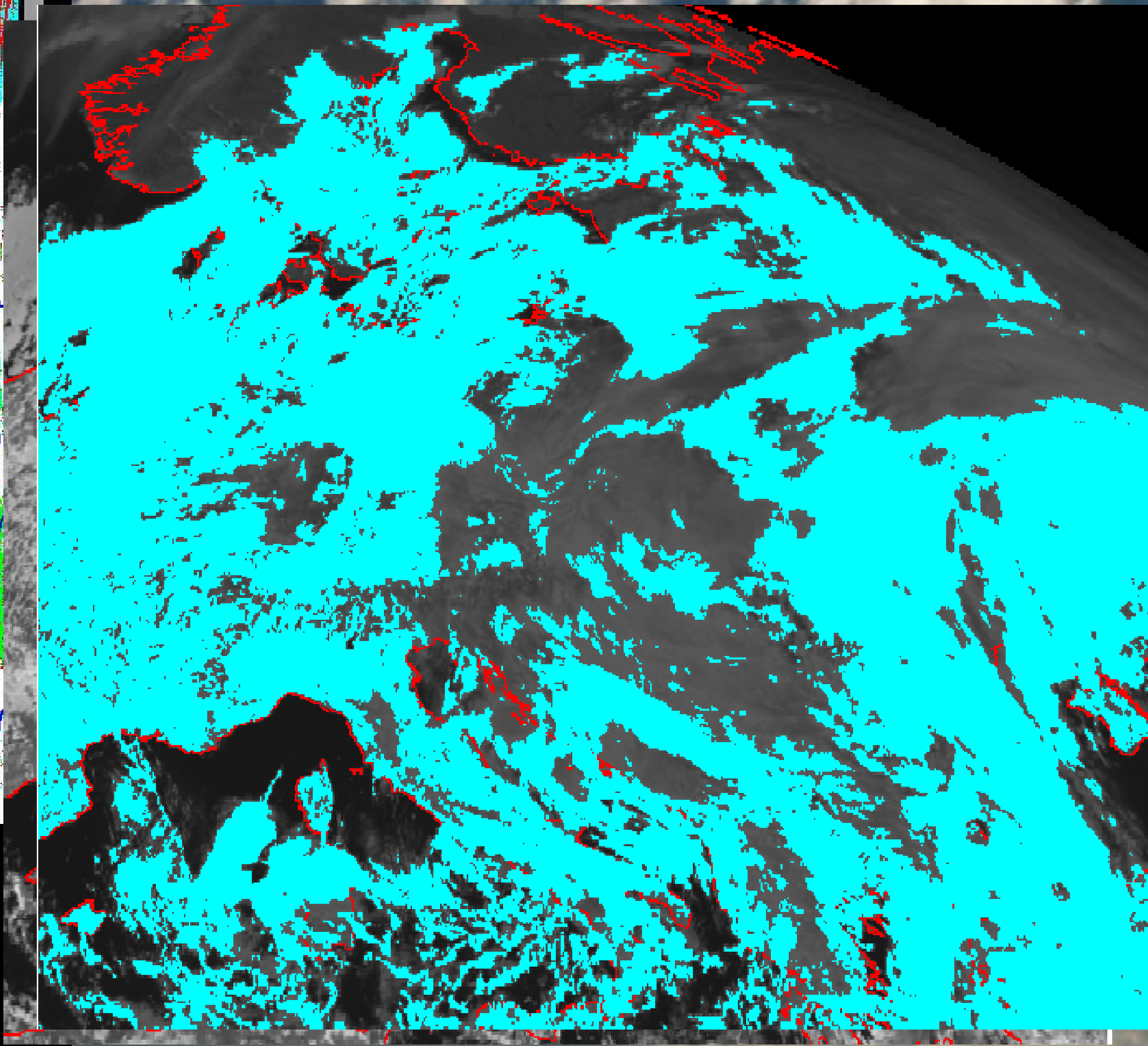
FOVS DETECTED IN THE SAME WAY
95.4 %

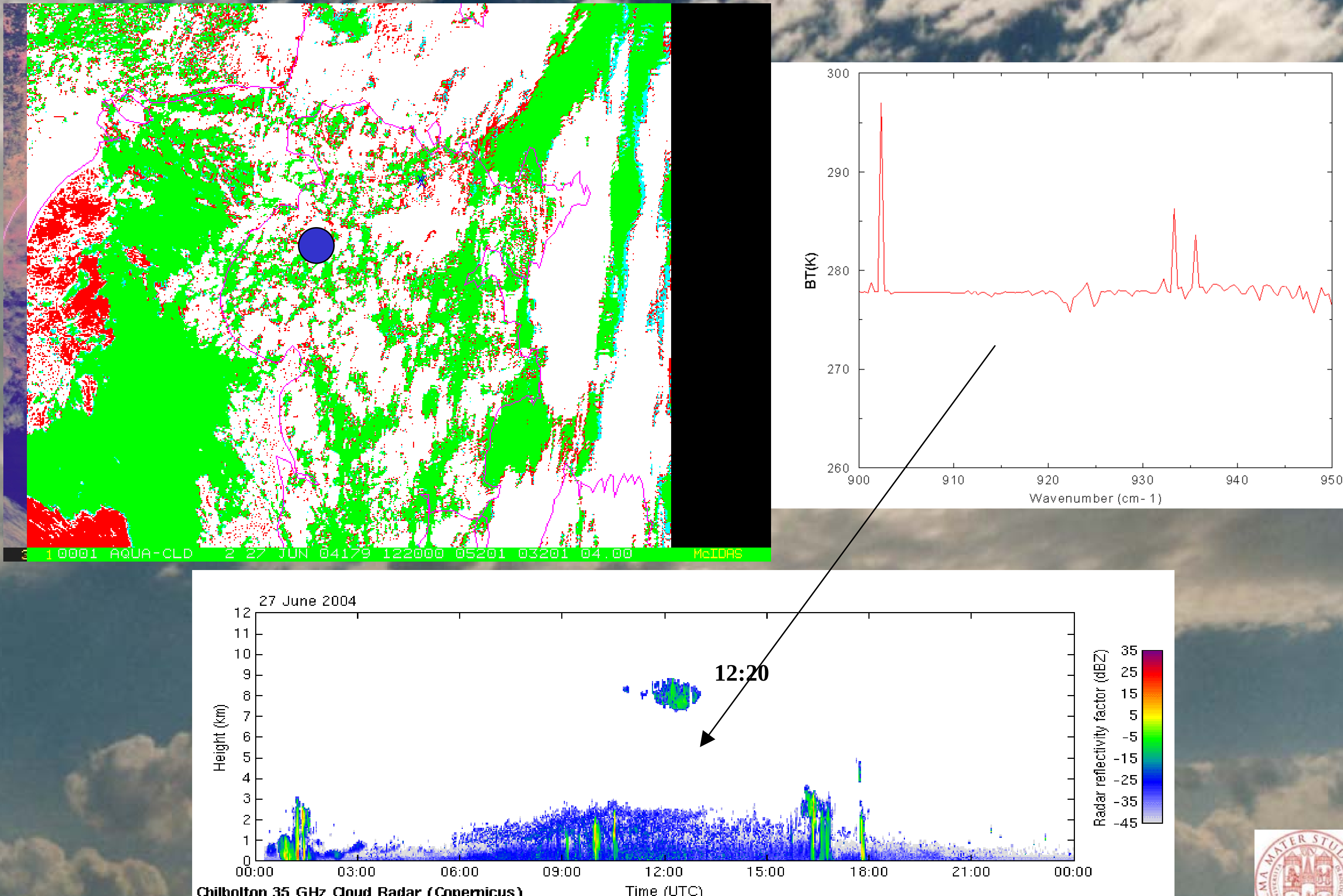
DATA SET

SEVIRI	DATA
28 OCT 2004	DAY/NIGHT
20 NOV 2004	DAY
10 DEC 2004	DAY/NIGHT
15 JAN 2005	NIGHT
15 FEB 2005	DAY
20 MAR 2005	DAY/NIGHT
15 APR 2005	NIGHT
01 MAY 2005	DAY/NIGHT

1500 AIRS and MODIS granules


15 FEB 2005
3 00 1 0001 AQUA-CLD 2 15 FEB 05046 121000 00001 0000 001




1 0001 AQUA-CLD 2 27 JUN 04179 122000 05201 03201 04.00
McIDAS
BT(K)
Wavenumber (cm- 1)
27 June 2004
12:20
Height (km)
Time (UTC)
Radar reflectivity factor (dBZ)
Chilbolton 35 GHz Cloud Radar (Copernicus)

Multilayered clouds

In this study we investigate the errors in CO2-slicing cloud top pressure retrievals due to the presence of multilayered clouds. When multi cloud layers are present, the CO2 slicing retrievals result in cloud top pressures located somewhere between the upper and lower cloud layers.

We use two different tecniques to identify multilayered clouds.

- To detect multilayered clouds, we use a technique which identifies MODIS pixels that contain thin cirrus overlying lower-level water clouds. Our approach uses the 2.13 µm band reflectance (for daytime), the 8.5 and 11 µm band brightness temperatures and the MODIS retrieved CO2 silicing as a function of observed 11-µm BT .
- Multilayered clouds are identified as those cloudy FOVs that have significant differences between the IR and MW cloud height

Infrared Cloud Top Height

T(IR) => CO2 slicing method

Clear Radiances => Kriging cloud clearing

Temperature and Humidity Profiles => ECMWF

Microwave Cloud Top Height

A lookup table for clear and cloudy AMSU/B brightness temperature was produced. To estimate LWP, Cloud water content (CWC, liquid or ice), and T(MW), T(IR) is used to selected a value of T(MW) and LWP from the lookup table to start AMSU simulation.

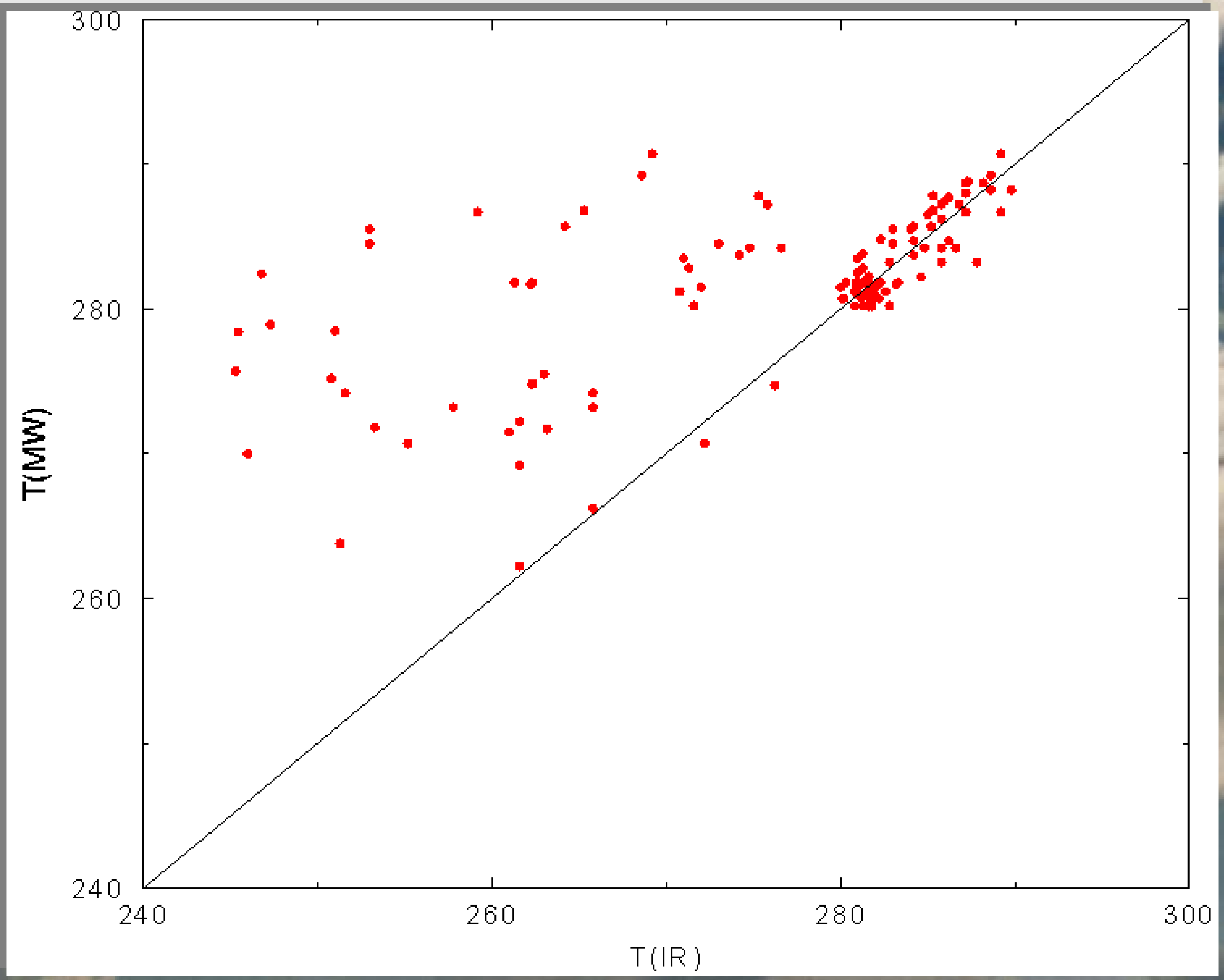
If the difference between the observed and the estimated reaches a minimum, the retrieval process finishes, otherwise the cloud top is moved down and the steps are repeated.

CLEAR and CLOUDY RADIANCE SIMULATIONS

Spectral properties of atmosphere gases and clear radiances are computed using RTTOV*, while cloud radiances for different cloud types are computed using RT3.**

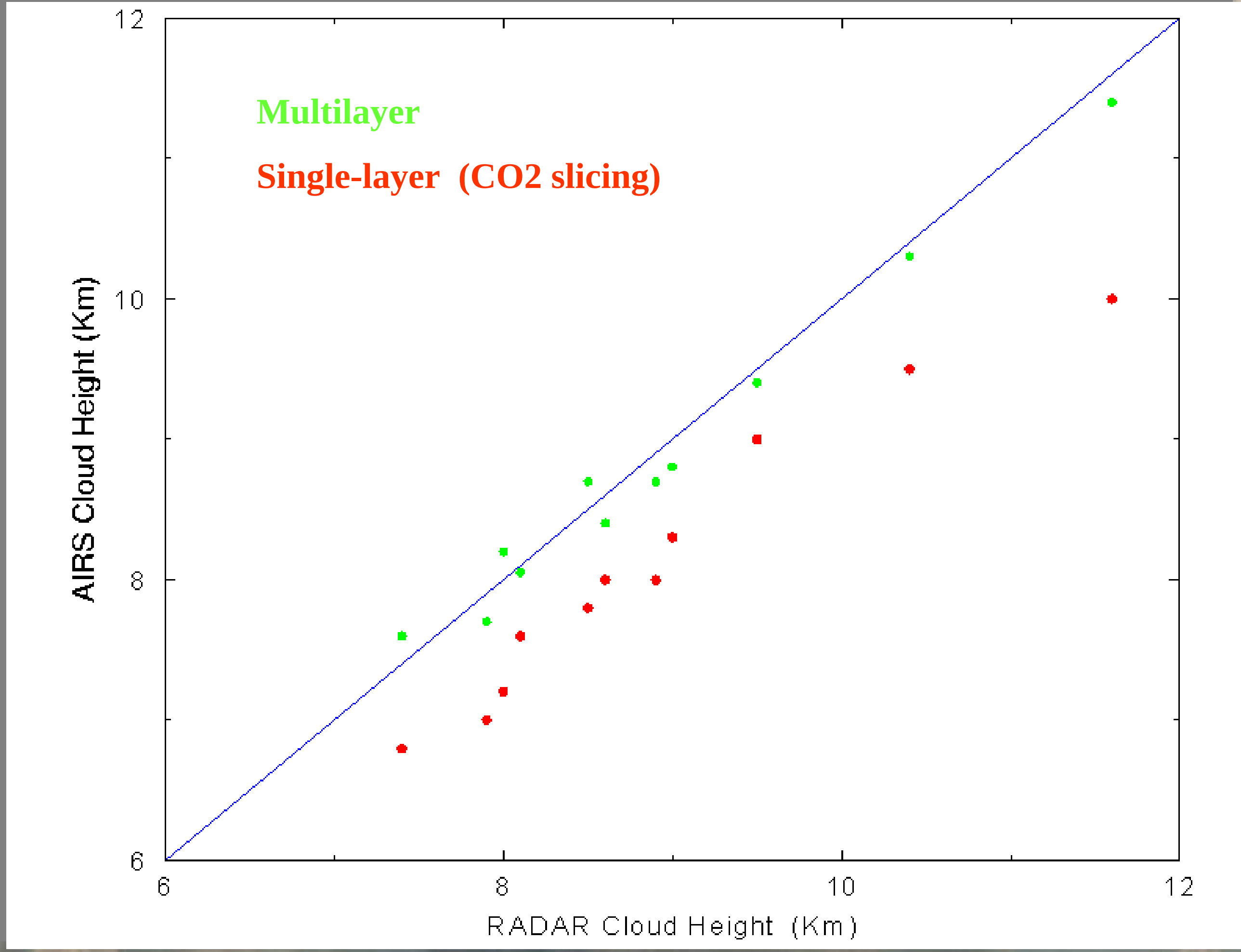
*** Eyre J.R., 1991: A fast radiative transfer model for satellite sounding systems, ECMWF Tech. Memo. 176.**

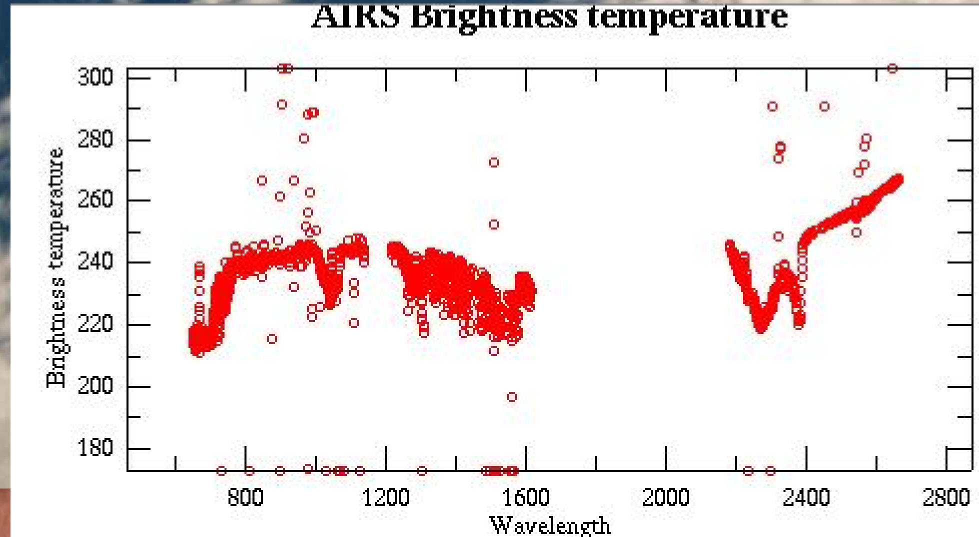
**** R. Amorati and R. Rizzi, Radiances simulated in the presence of clouds by use of a fast radiative transfer model and a multiple-scattering scheme, Applied Optics,41, n.9 (2002)**


300
280
260
240
T(MW)
240
260
280
300
T(IR)

Cloud Top Height Estimation

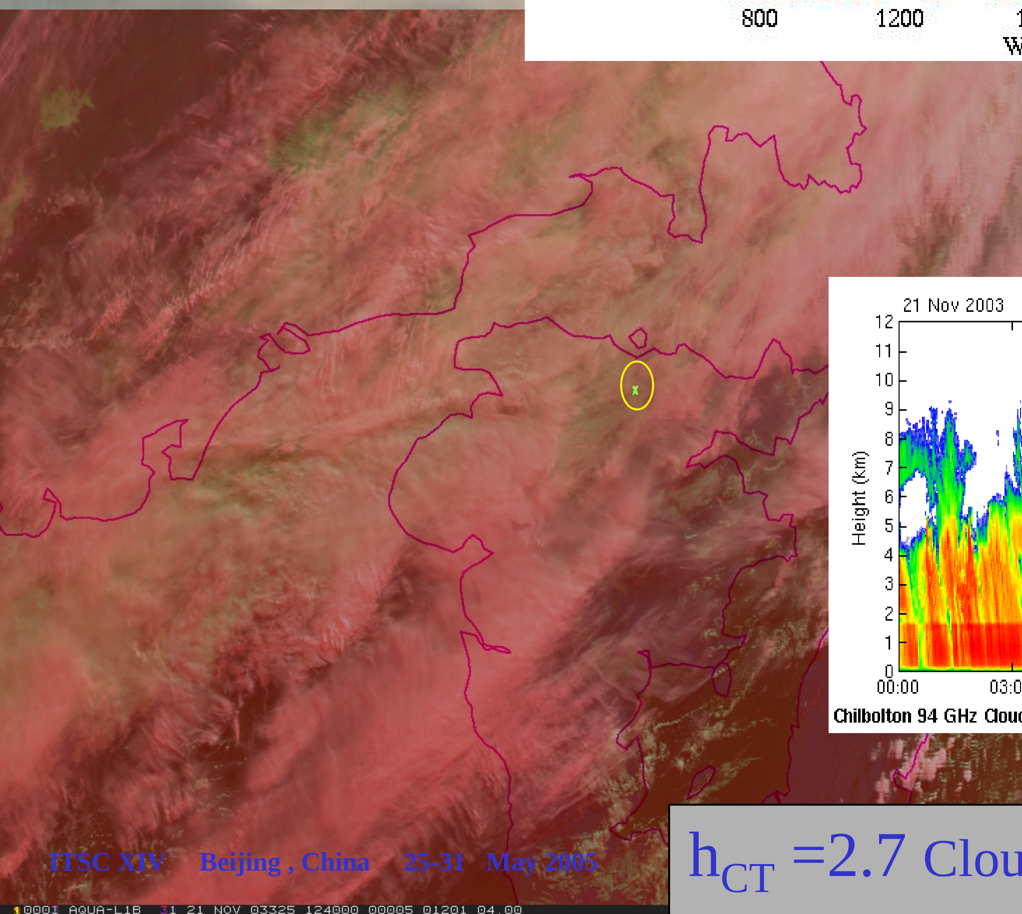
Modified RT3 code searches for the best solution: simulated brightness temperature are compared to the observed selected 300 AIRS channels. Cloud top estimated using CO2 slicing method is used to start simulation. If the difference between the observed and the estimated reaches a minimum, the retrieval process finishes, otherwise the cloud top is moved up.

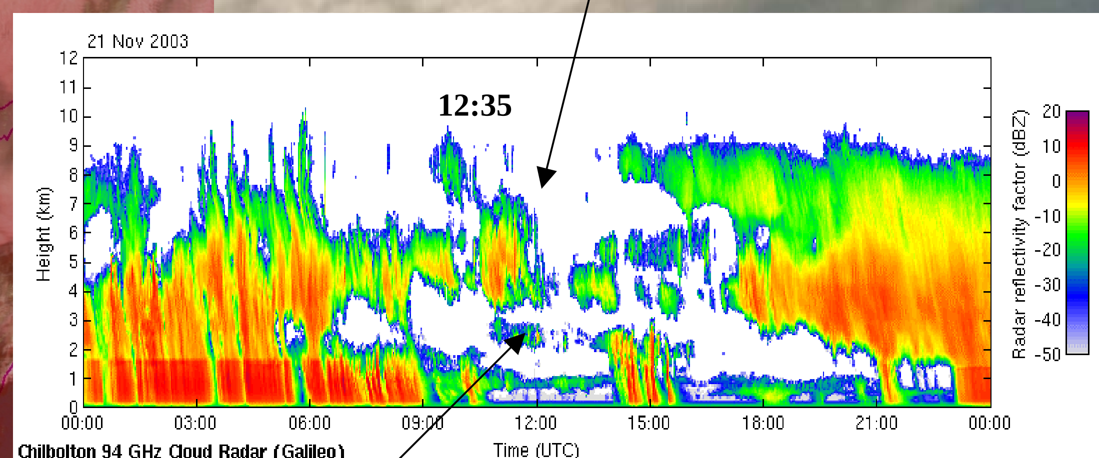

Multilayer
Single-layer (CO2 slicing)
AIRS Cloud Height (Km)
RADAR Cloud Height (Km)
6
8
10
12
6
8
10
12



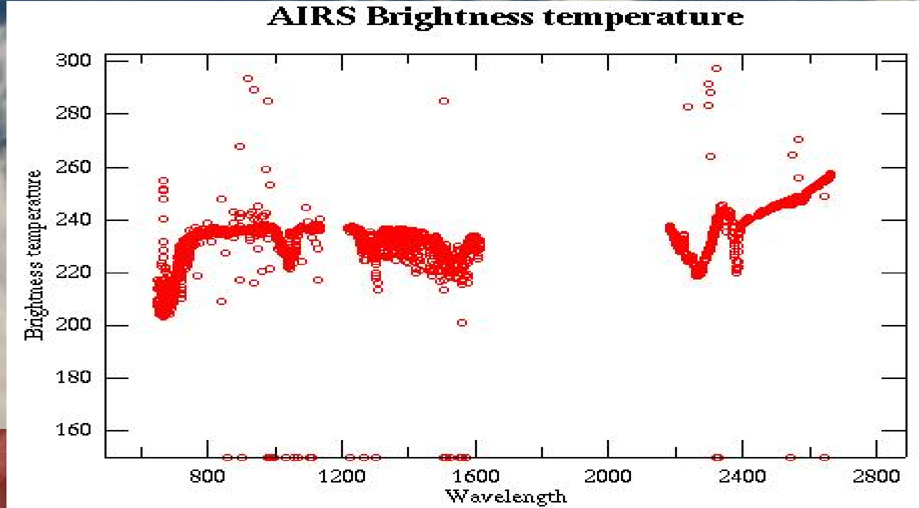
h_{CT}=6.5 km

h_{CT} =7 km Cloud Thickness =3.1 km



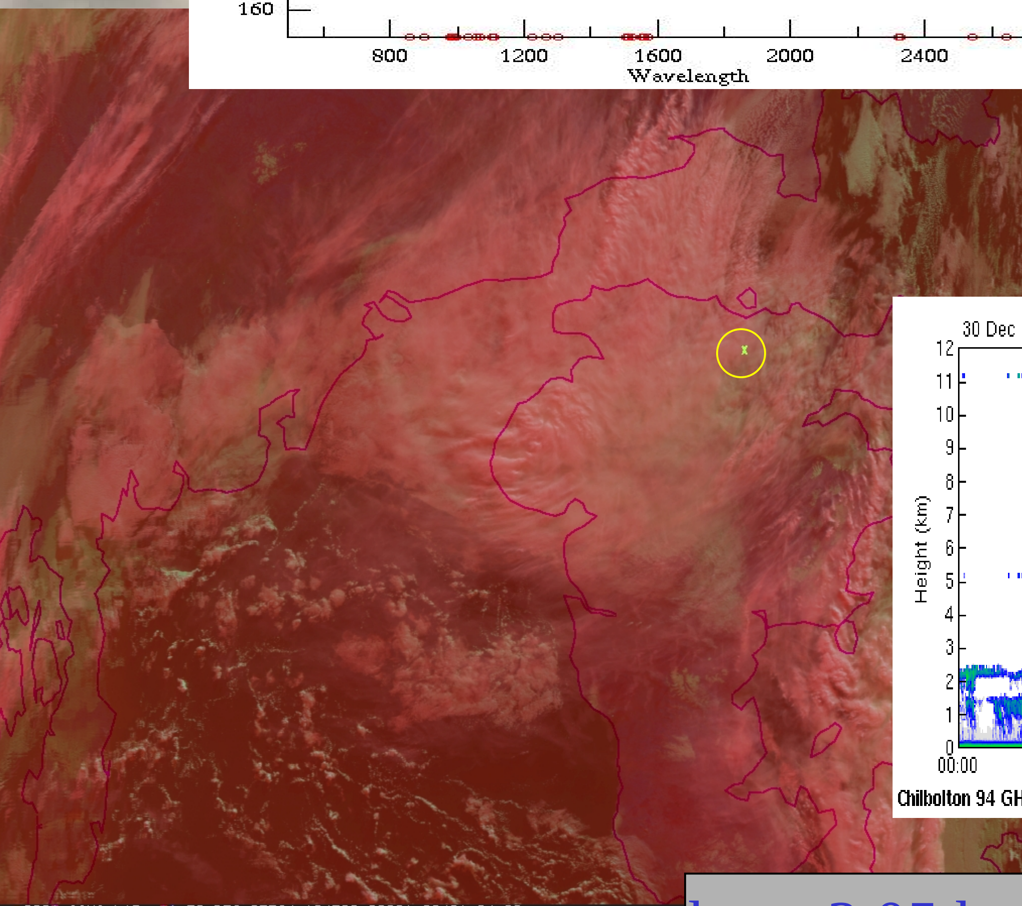


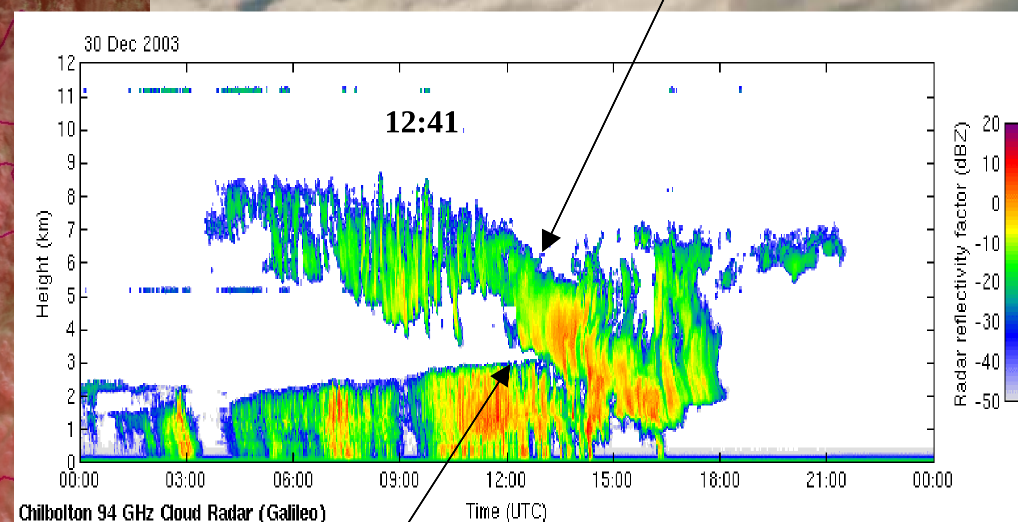
h_{CT} =2.7 Cloud Thickness=1 km



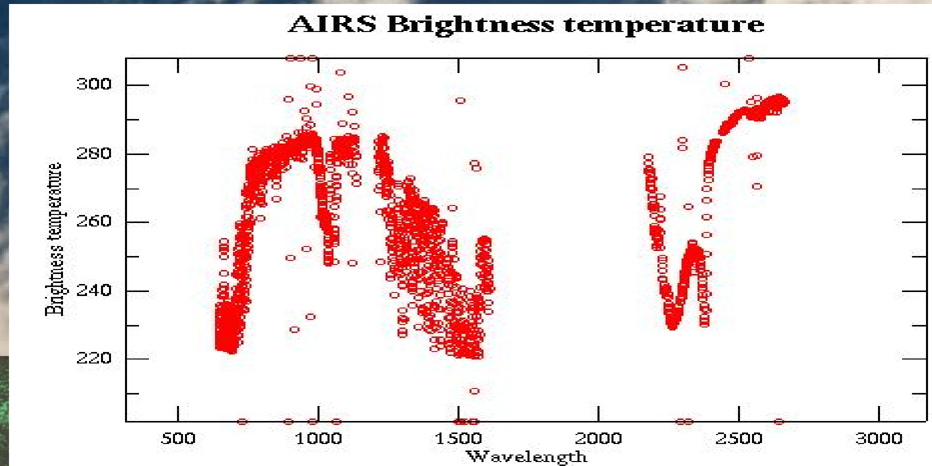
h_{CT} =6.3 km

h_{CT} =7.4 Cloud Thickness =2.3 km

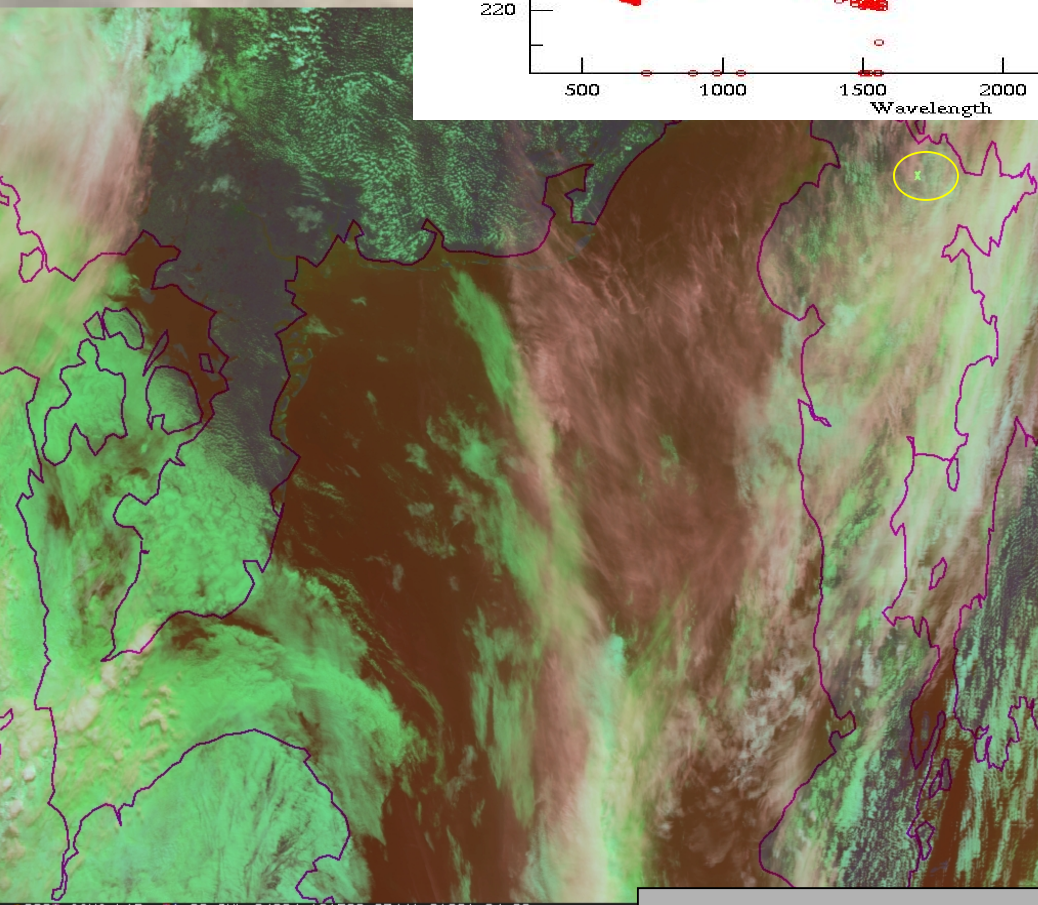




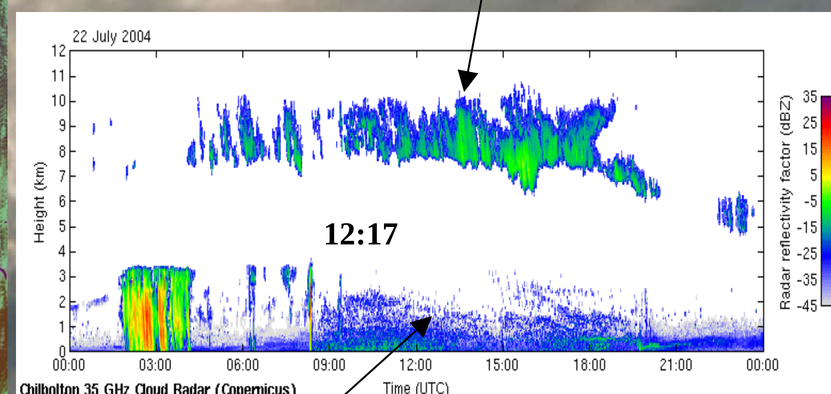
h_{CT} =3.05 km Cloud Thickness =3 km



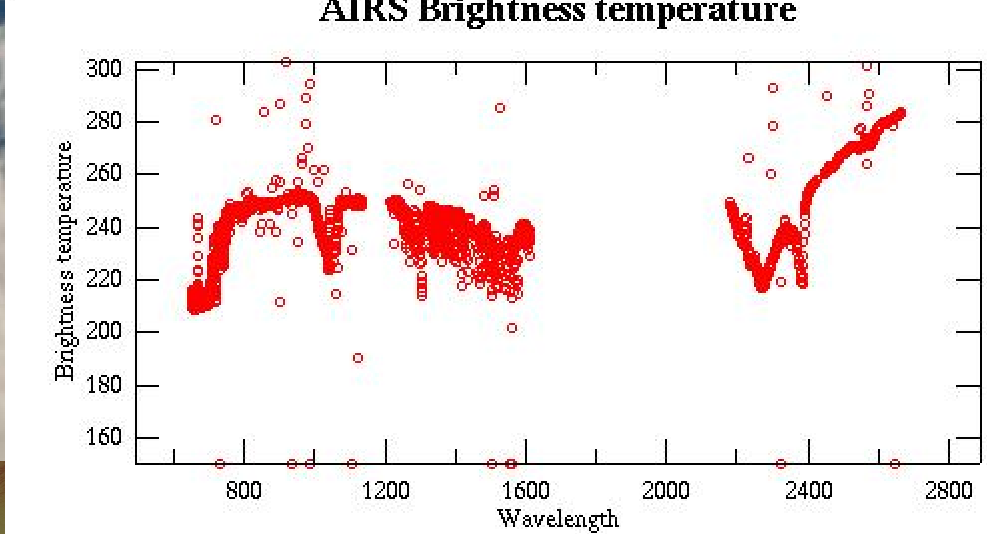
h_{CT} =9.1km



h_{CT} =9.0 km Cloud Thickness =1.8 km

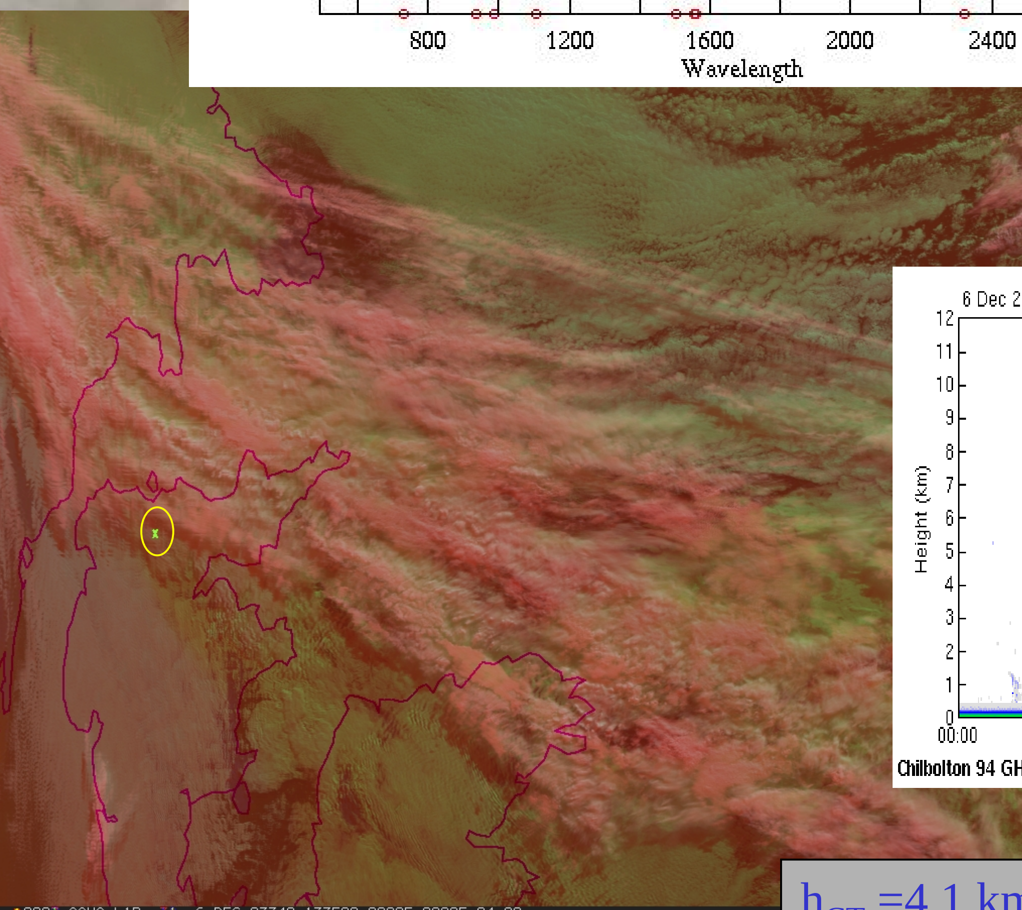


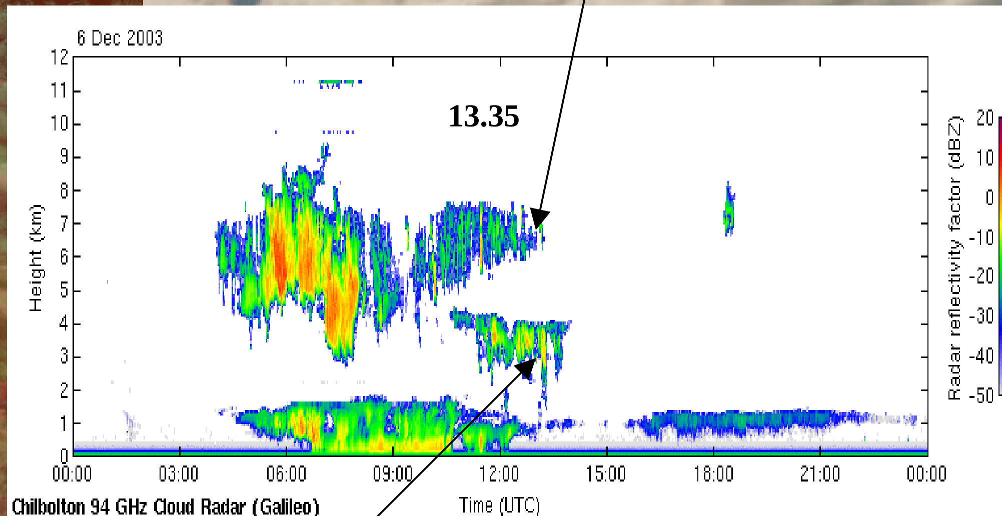
h_{CT} =1.0 km Cloud Thickness =0.8 km



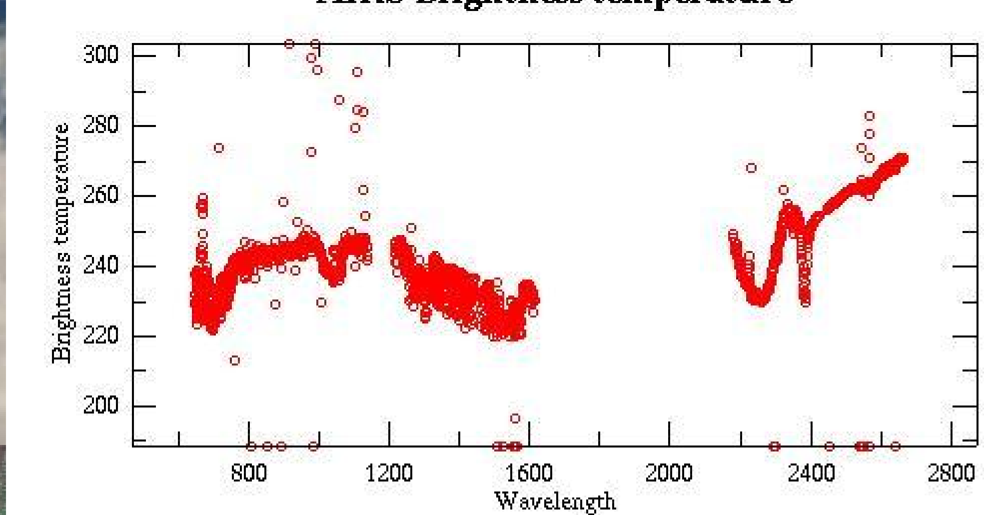
h_{CT} =6.2 km

h_{CT} =6.7 km Cloud Thickness =1.4 km





h_{CT} =4.1 km Cloud Thickness =1.2 km



LWP(Kg/m2)

MW	AMSU	ECMWF
0.09	0.12	0.11

IWV(Kg/m2)

MW	AMSU	ECMWF
31.9	30.5	29.7

ICW g/m3

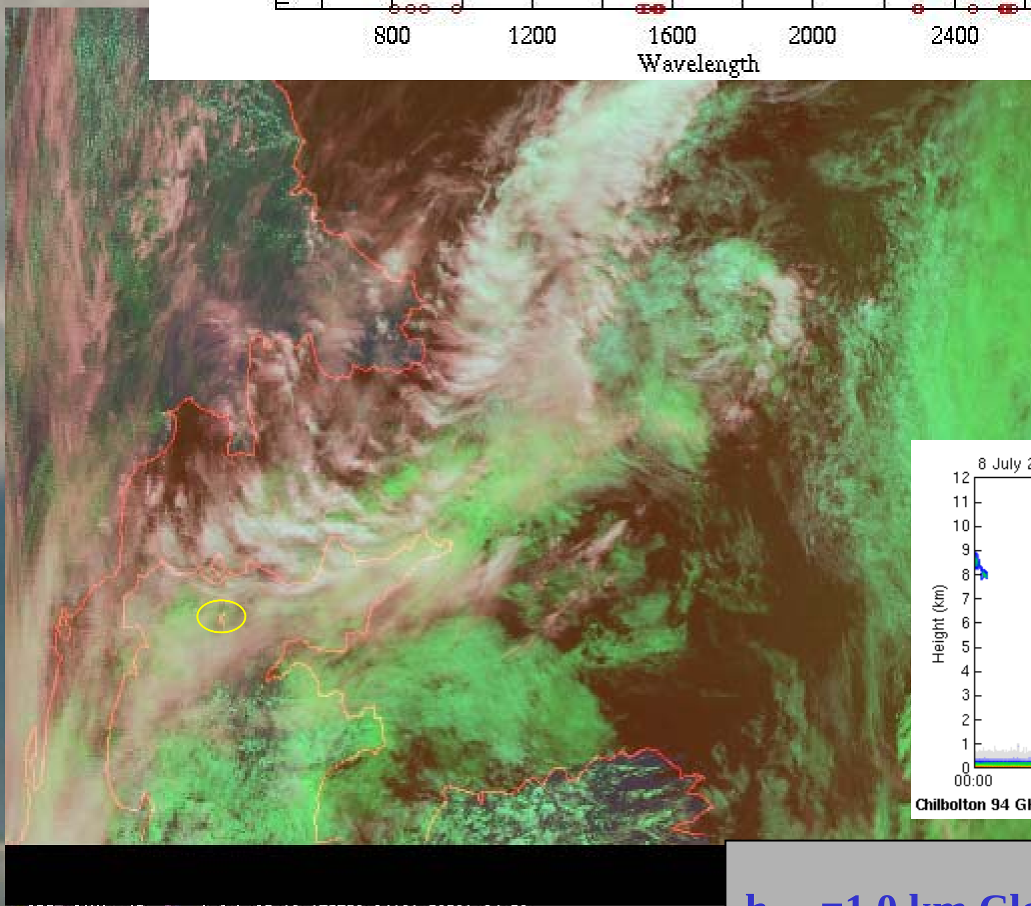
AMSU	RADAR
0.026	0.019-0.03

r_{e1} (micron)

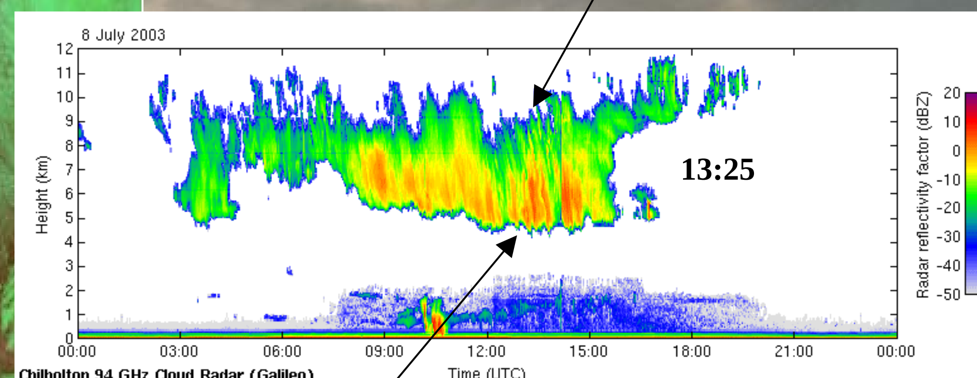
Sat	Radar
12	8 -14

r_{e2} micron

Sat	Radar
40	50



h_{CT} =9.5 km Cloud Thickness =4.3 km



h_{CT} =1.0 km Cloud Thickness =0.8 km

CONCLUSION AND FUTURE WORK

• A proper combination of infrared and microwave measurements could be useful to determine the cloud coverage, the vertical cloud structure and composition in all weather conditions.

• Validation of cloud parameters, based on ground based measuremets, will be extend to a large data set.