



Physical Retrieval from IASI

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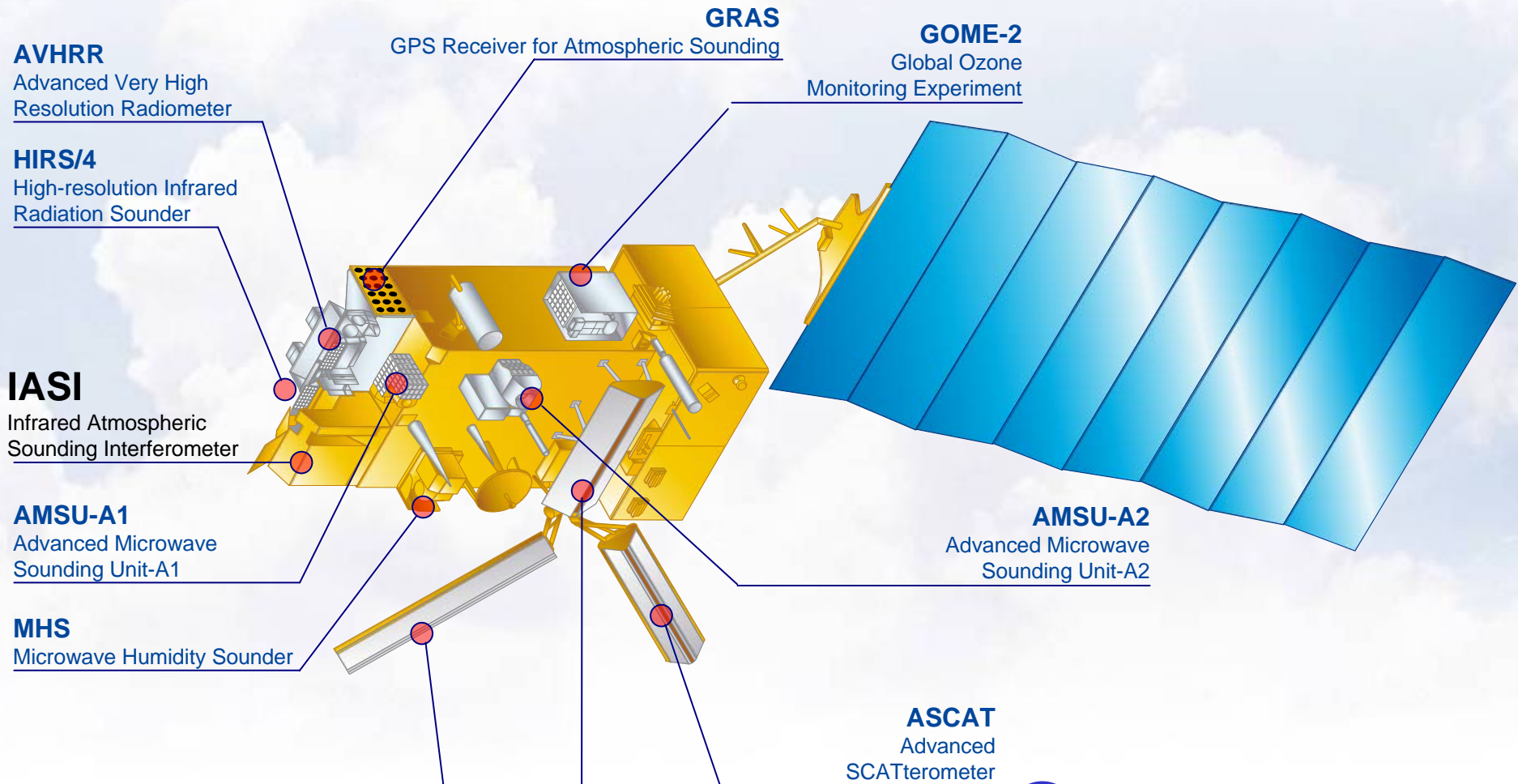


Infrared Atmospheric Sounding Interferometer (IASI)



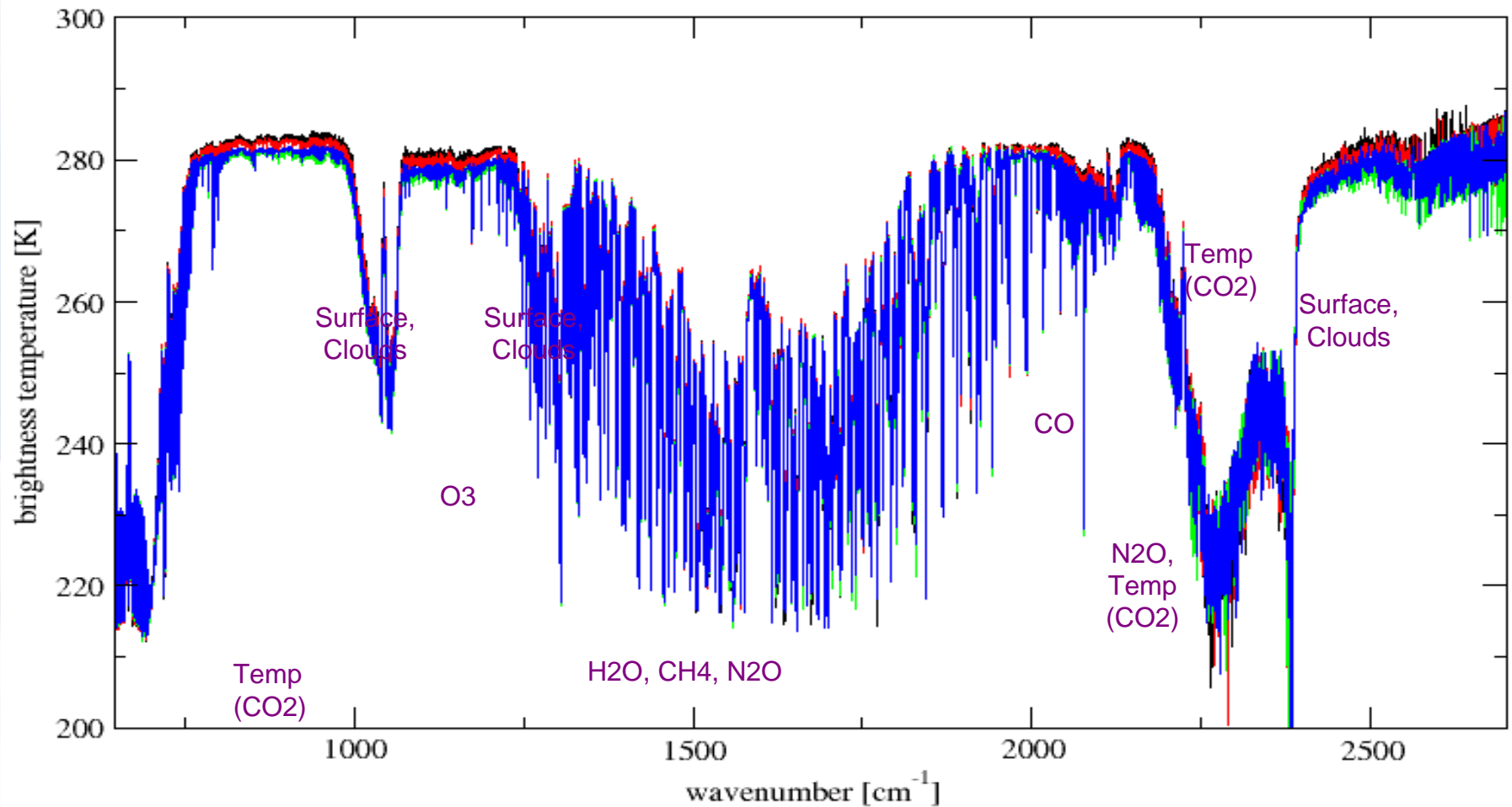
- Michelson-Interferometer 8461 spectral samples
- IFOV diameter 12 km (nadir)
- Scan interval (horiz.) 25 km (nadir)
- Swath width $\pm 48.33^\circ$ (2200 km)
- Spectral domain 645 - 2760 cm^{-1} (3.6 – 15.5 μm)
- Spectral resolution 0.5 cm^{-1}
- Radiometric resolution 0.07 - 0.7 K (bands 1, 2)
- Absolute calibration < 0.3 K
- Data rate 1.5 Mbit/s
- Internal imager 10-12 μm
- Temperature- and humidity profiles, O_3 , CO, CO_2 , CH_4 , N_2O , ...

EUMETSAT Polar System



First IASI spectra on 29 November 2006

L1 Products operational since 16 July 2007



Retrieved parameters and retrieval methods

T profile W profile T surface	Regression from PC scores, Optimal estimation
Cloud fraction Cloud top pressure Cloud top temperature	Colocated AVHRR cloud mask / CTT, CO2 slicing, Optimal estimation
Ozone (4 thick layers)	ANN, PC regression, Optimal estimation
CO, CO2, N2O, CH4 columns	ANN, Optimal estimation
Surface emissivity	Sea: Masuda (empirical from wind speed) Land: PC regression, database

Operational IASI L2 Processing

- About 28 GB of IASI L1C data to process per day
- 1296000 spectra per day
- 15 spectra per second
- 9 IBM Power 4 dual CPU nodes running at 1.2 Ghz

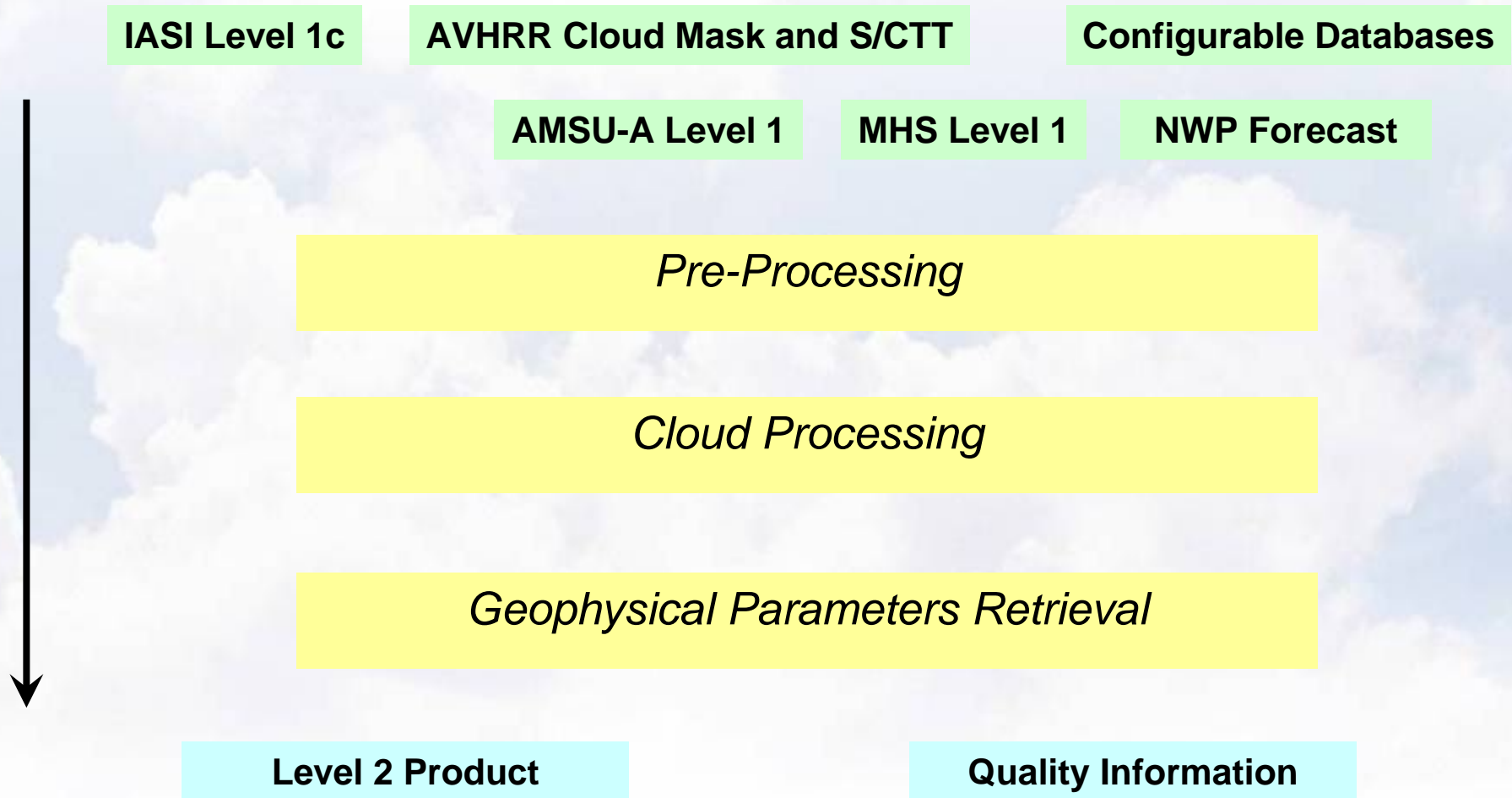
Meeting timeliness and throughput constraints is a challenge.

GS1 Operational

GS2 Validation

GS3 Test (no live NWP feed)

IASI level 2 product generation



INPUT DATA

- IASI L1C (infrared radiances, AVHRR co-registration)
- AVHRR SCE (cloud mask, C/STT)
- AMSU-A L1B (microwave radiances)
- MHS L1B (microwave radiances)
- ECMWF Forecast (T, W, O, Ts, u, v, sp)
- Configuration (Processing choices, thresholds, parameters, regression coefficients, etc.), 0.17 Gb
- RTIASI coefficients, 0.67 Gb
- GTOP30 and IGBP, 2.67 Gb

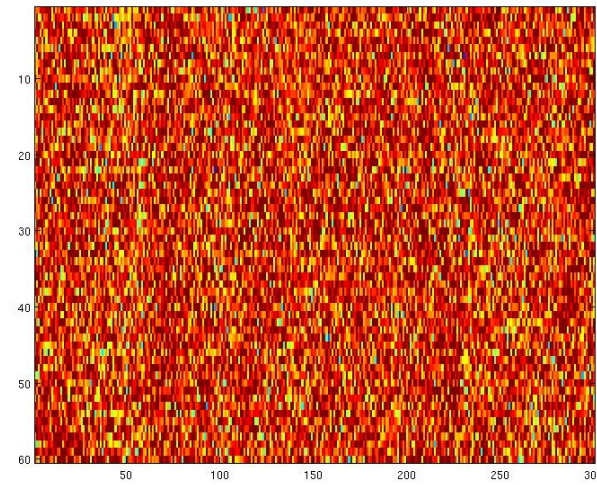
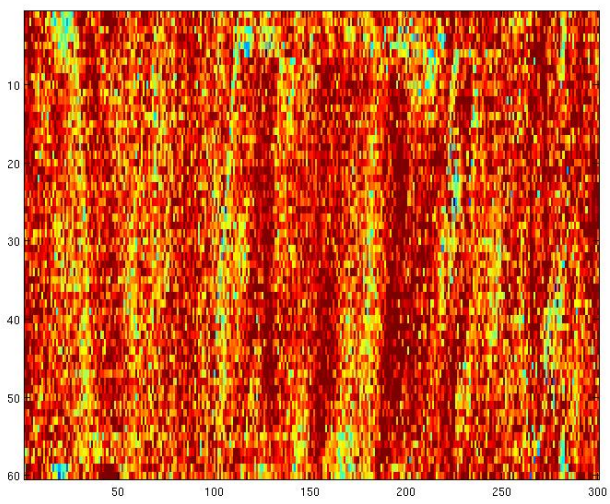
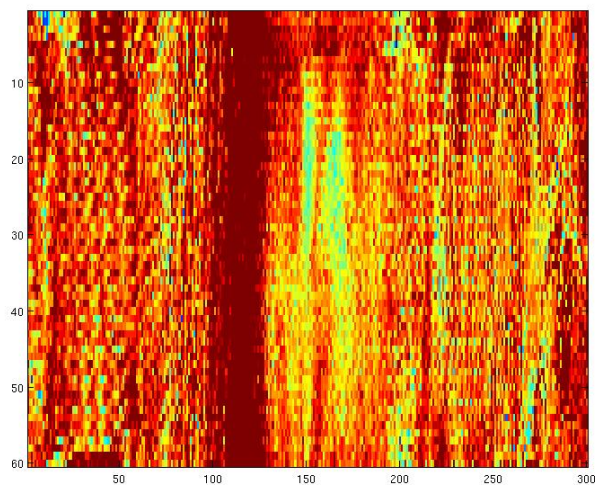
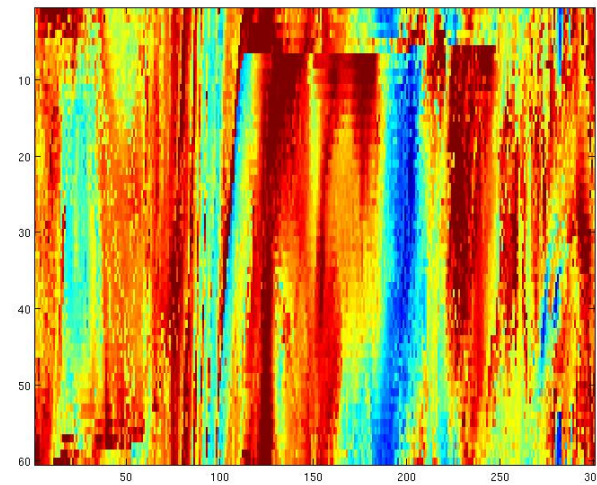
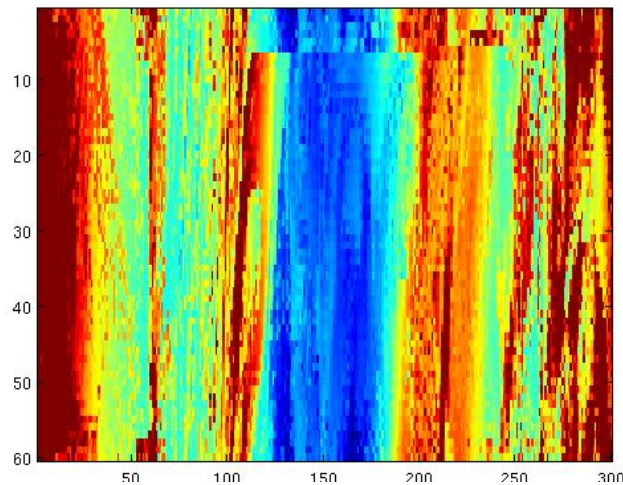
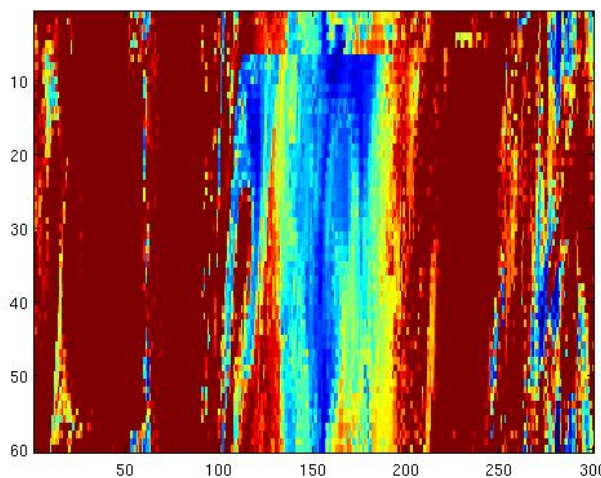
Properties of the Operational IASI L2 Processor (1/2)

- For a best use of IASI measurements the level 2 processing combines IASI with concurrent measurements of AVHRR and AMSU-A to detect clouds and to derive cloud parameters
- IASI stand-alone processing is used for geophysical parameters retrieval
- Inclusion of NWP forecast
 - Surface pressure as reference for the profiles to be retrieved
 - Surface wind speed over sea for the calculation of surface emissivity
 - Temperature and water-vapour profiles for cloud detection and CO₂-slicing

Forward model

- RTIASI-4
 - 235 selected channels
 - 3 fold speed up from simple code optimisations
 - Scope for more by exploiting sparsity of optical depth regression coefficients. (don't spend time multiplying with zeroes)
 - Abstract FRTM interface (Jacobian check, composition with statevector representation)
-
- PCRTM (363+328+827 Monochromatic channels)
 - RTTOV-9

All information contained in a small number of PC scores PC1, PC2, PC10, PC20, PC40 and PC100

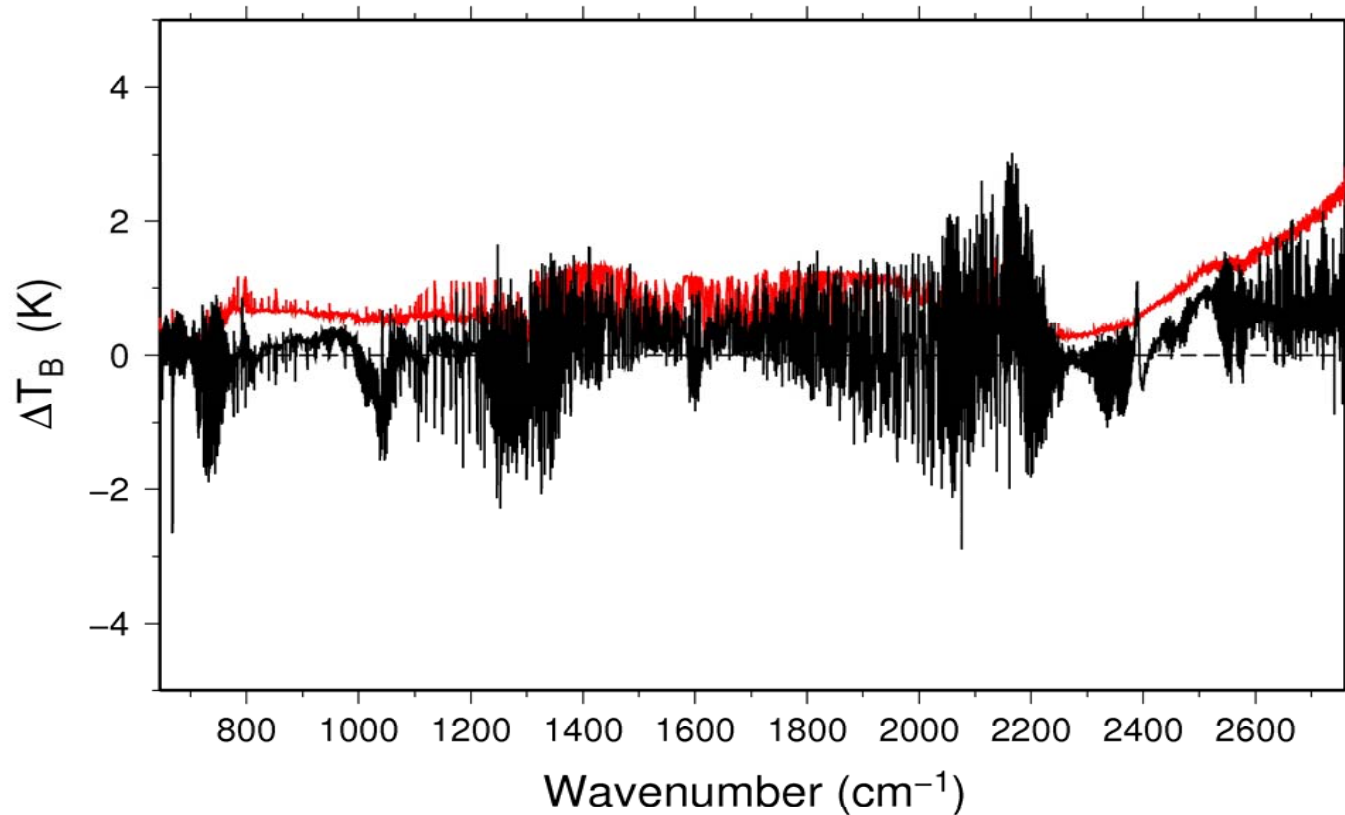


Properties of the Operational IASI L2 Processor (2/2)

- Different retrieval methods are implemented so that the best configuration can be chosen based on validation results, so far:
 - EOF regression retrieval using all spectral samples of bands 1 and 2 for temperature and moisture retrieval, surface temperature, emissivity, and ozone columns
 - Iterative retrieval based on 235 spectral samples
- Band 3 has been removed from temperature and humidity sounding
 - Insufficient capabilities to include solar radiation (too time consuming)
 - NLTE effects not modeled
 - Suffers from high noise compared to bands 1 and 2

Bias correction

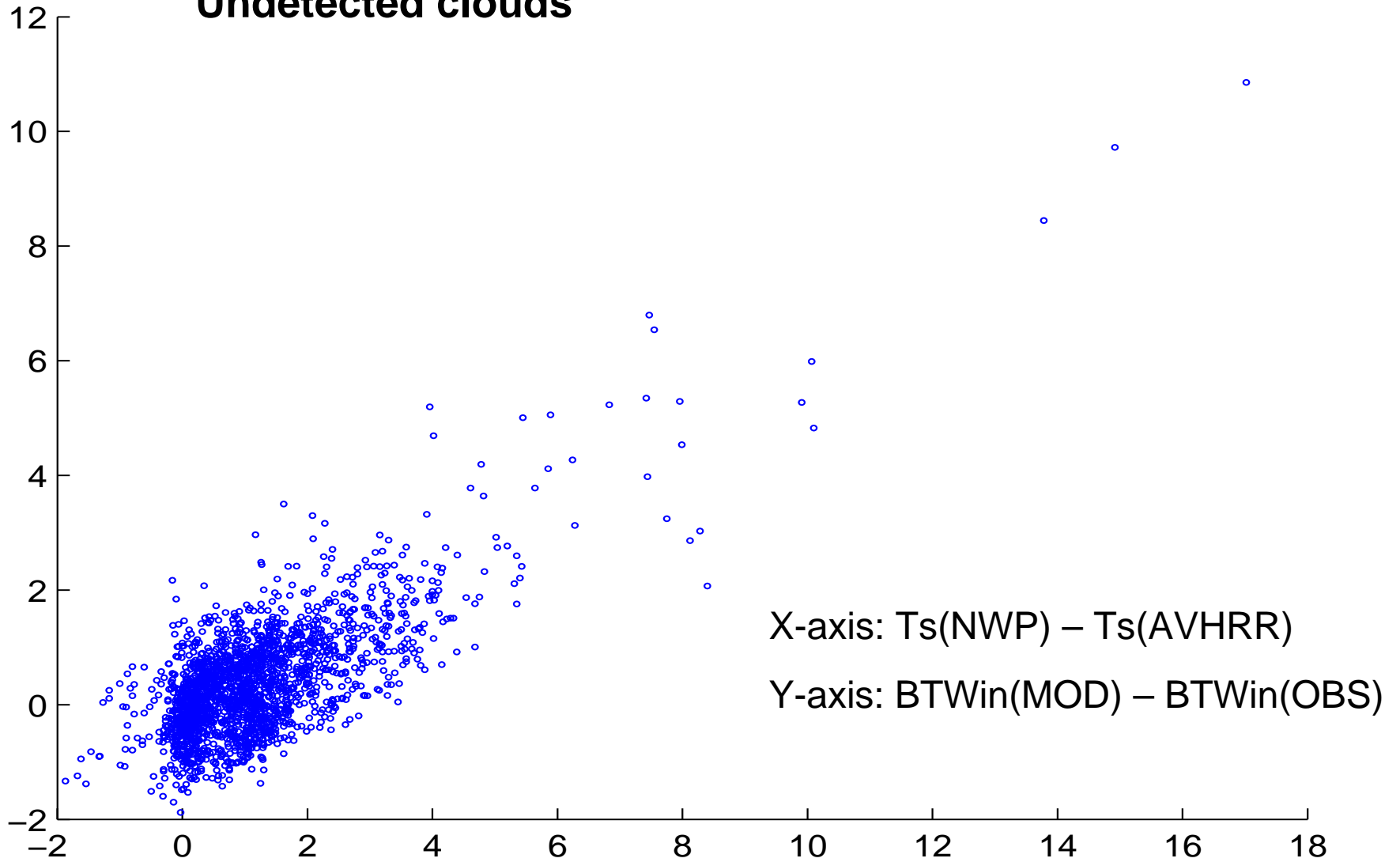
ΔT_B (OBS-MOD) mean and stddev



Flat bias correction based on co-located ECMWF short range forecast and AVHRR SST.

Clear IFOVs over sea at night.

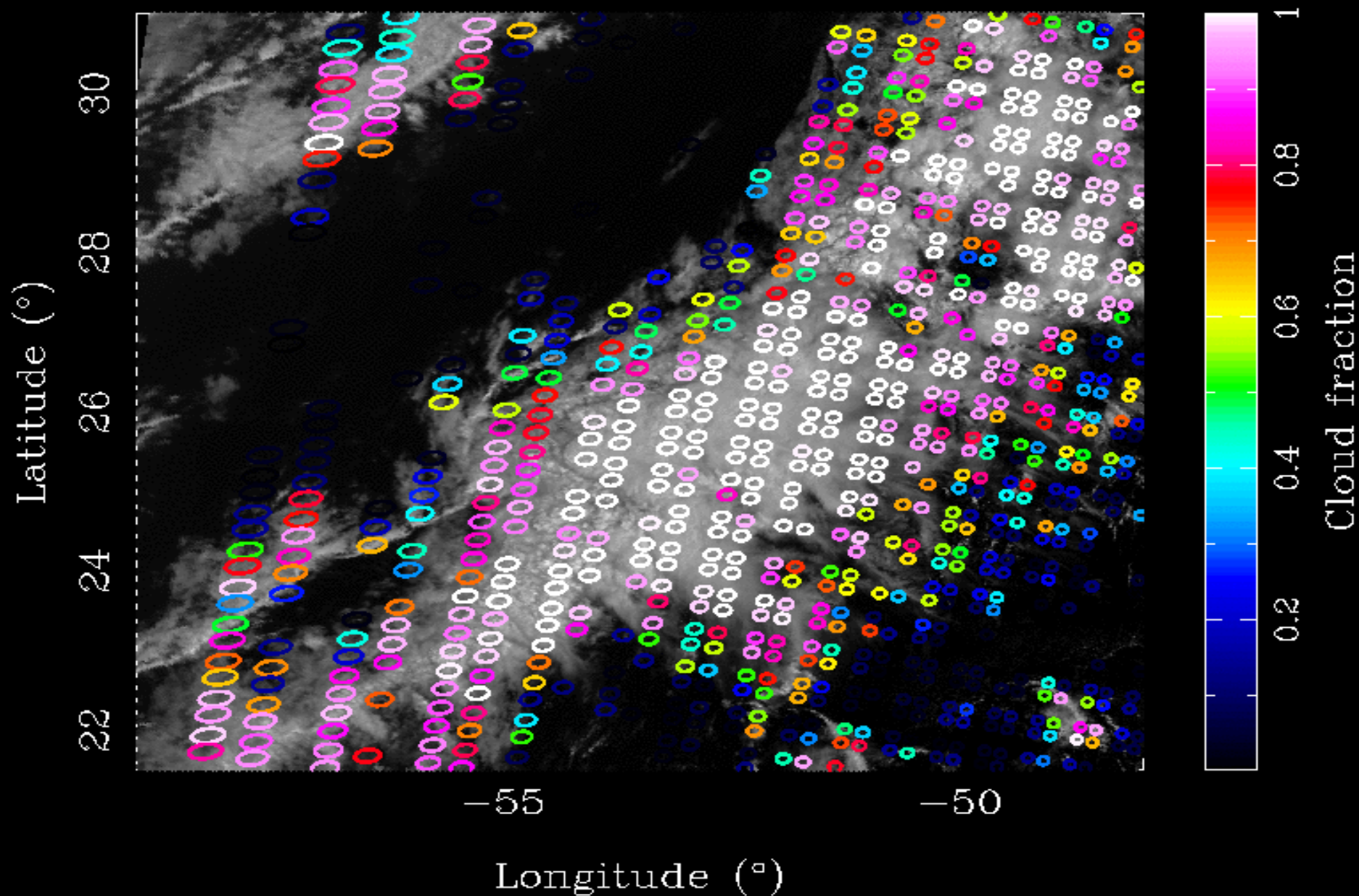
Undetected clouds



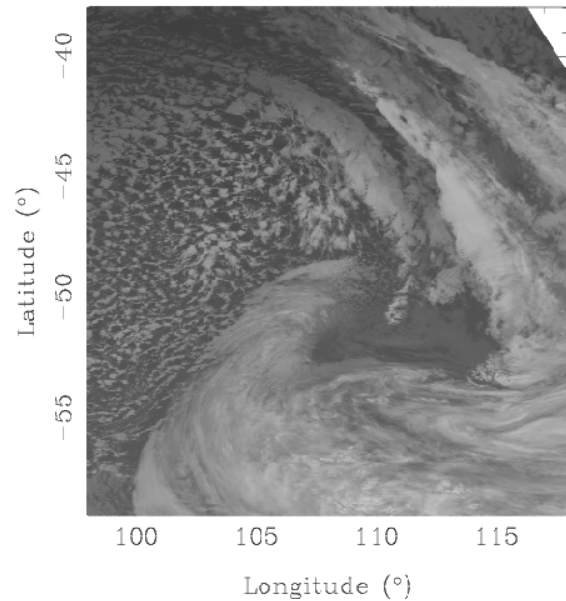
IASI L2 optimal estimation overview

Radiative transfer model	RTIASI-4 (235 channels)
Jacobian	AD reverse mode (adjoint)
Observation error covariance matrix	Diagonal
Background error covariance matrix	Fully dense*
Max number of iterations	5 (normally 3-4 needed)
Convergence criteria	Norm of cost function gradient (followed by BT residual check)
Number of parameters	92(+2) → 182(+2)
Using profile EOFs	No
Background	Climatology (9 latitude zones)
First guess	PC regression
Iteration method	Marquardt-Levenberg

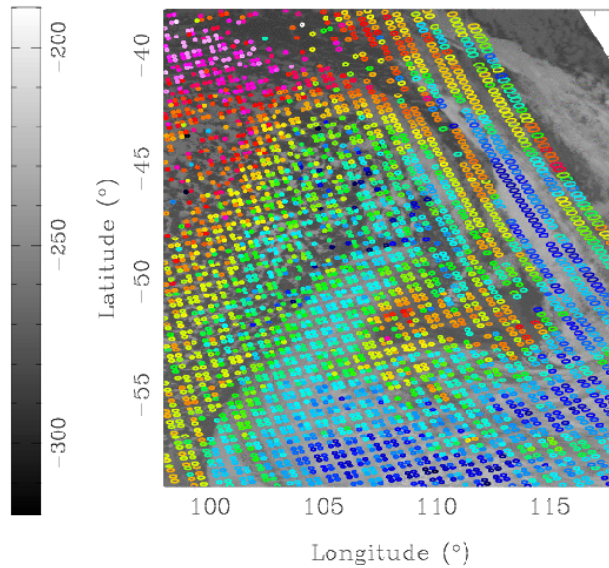
AVHRR/0.6, cold front, all CFR, IASI 20070418124454Z



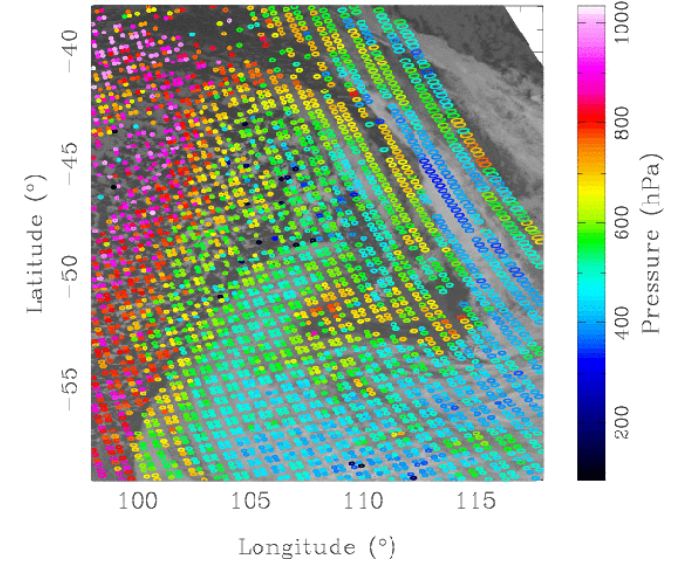
Cloud parameters retrieval



AVHRR: 10.8 μm

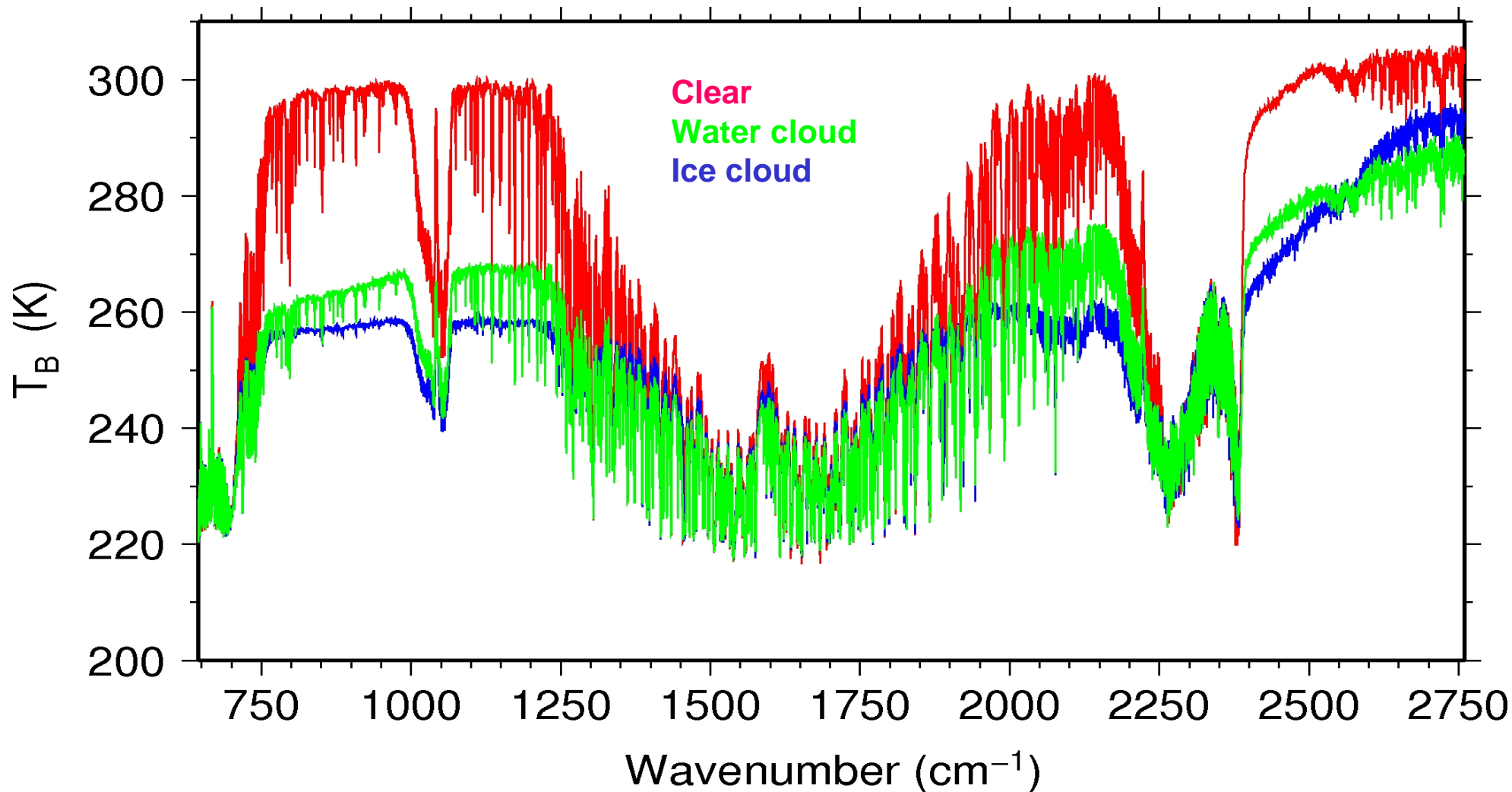


IASI:
Cloud top temperature

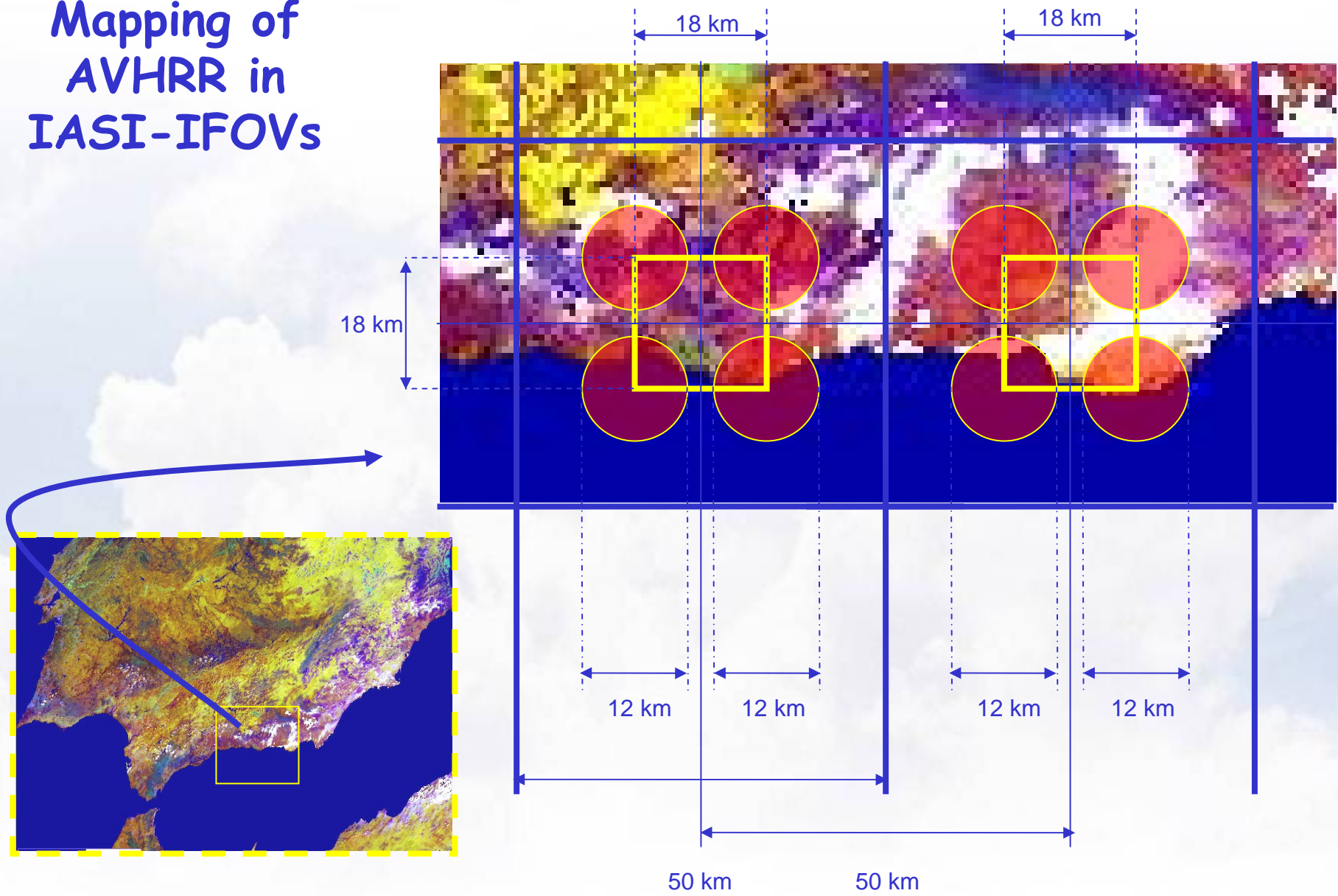


IASI:
Cloud top pressure

Discrimination of ice and water clouds



Mapping of AVHRR in IASI-IFOVs

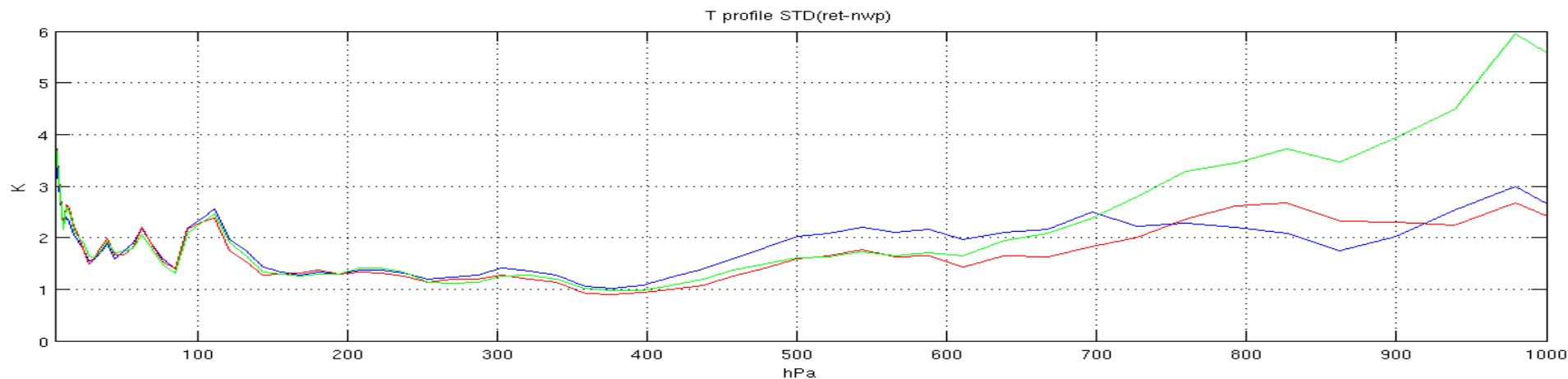
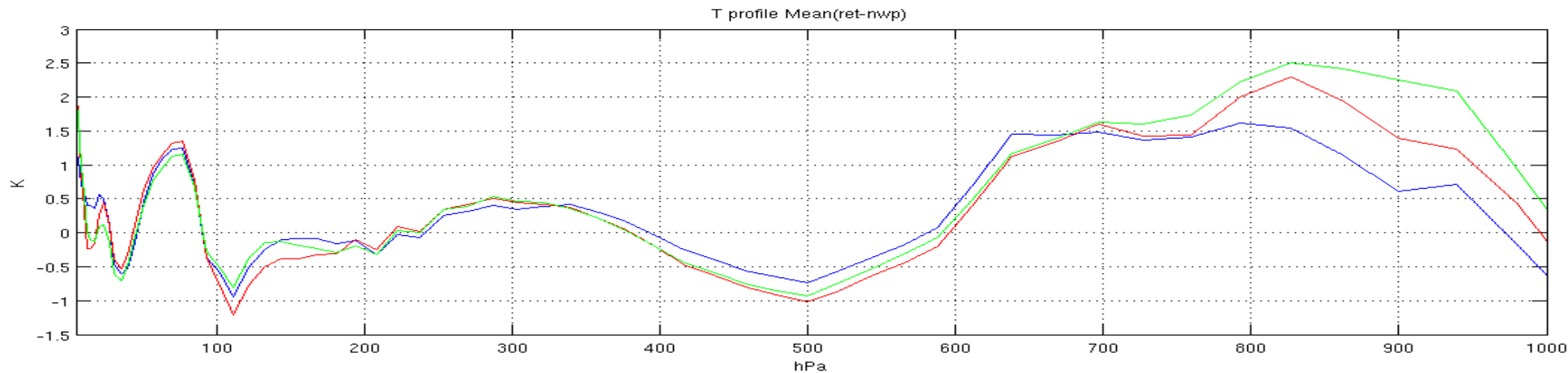


Cloudy retrievals

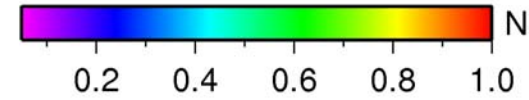
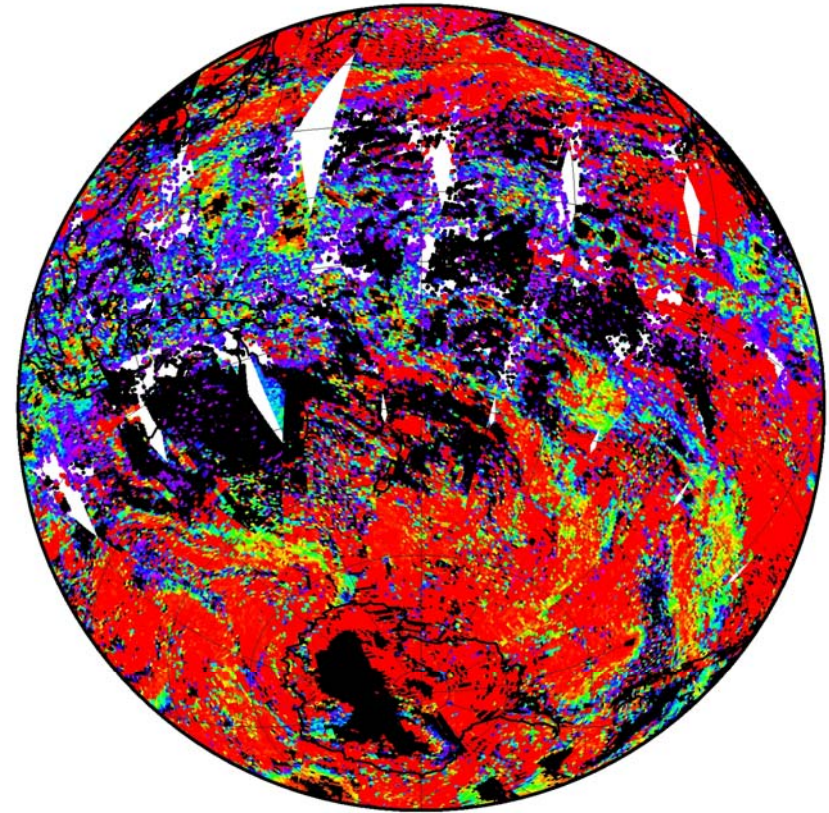
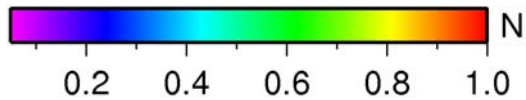
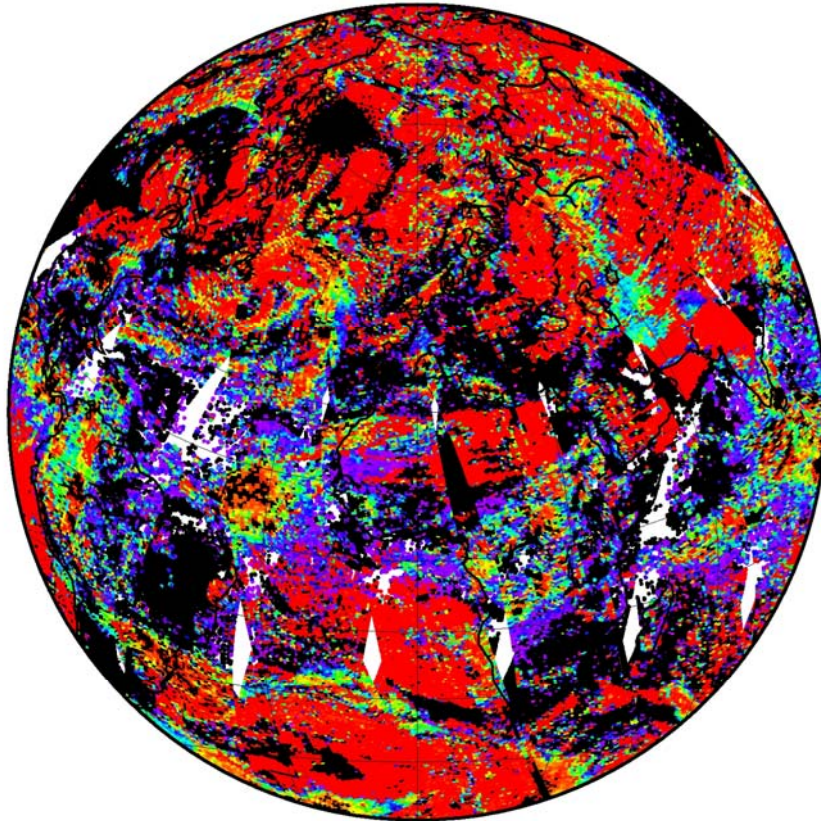
- Cloud top pressure and cloud fraction included in statevector (for cloud fractions between 0.1 and 0.9)
- [Variational cloud clearing.]

Temperature profile statistics. Cloudy retrievals over sea.

Blue COV_cf = 1, red COV_cf = 0.1, green COV_cf = 0.01



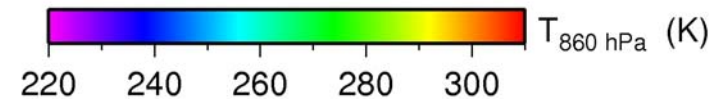
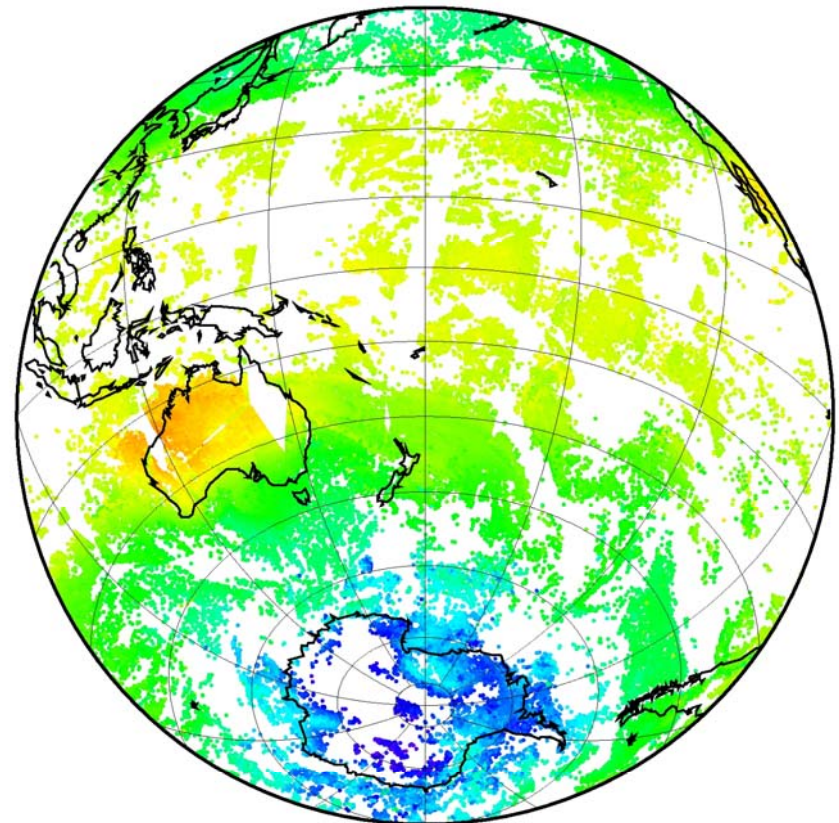
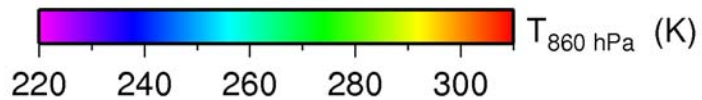
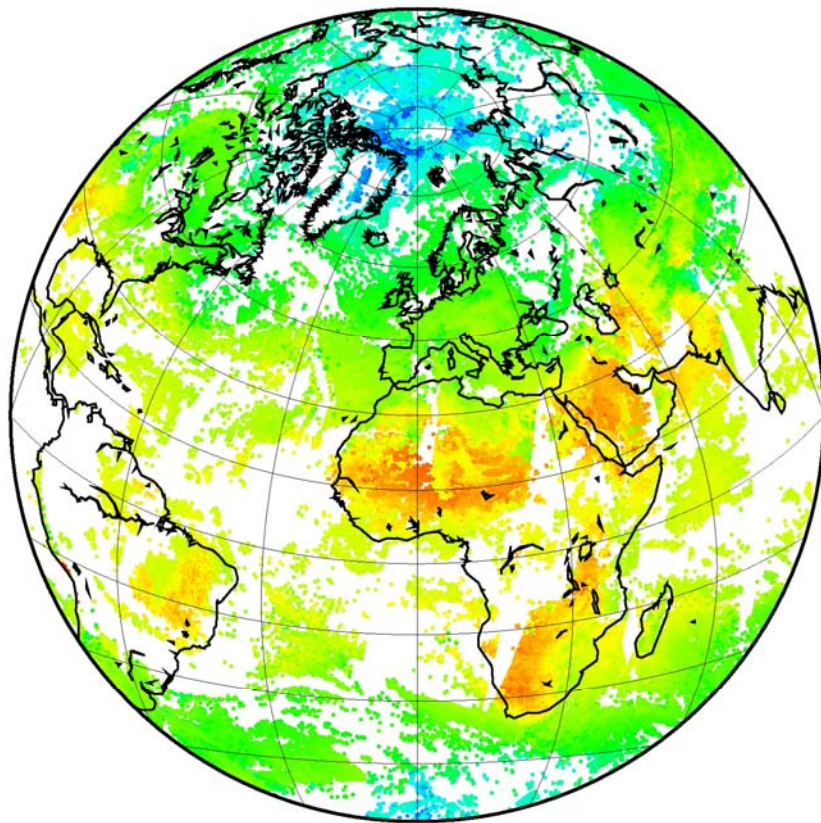
Cloud Cover - 16 October 2007



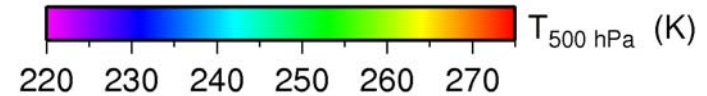
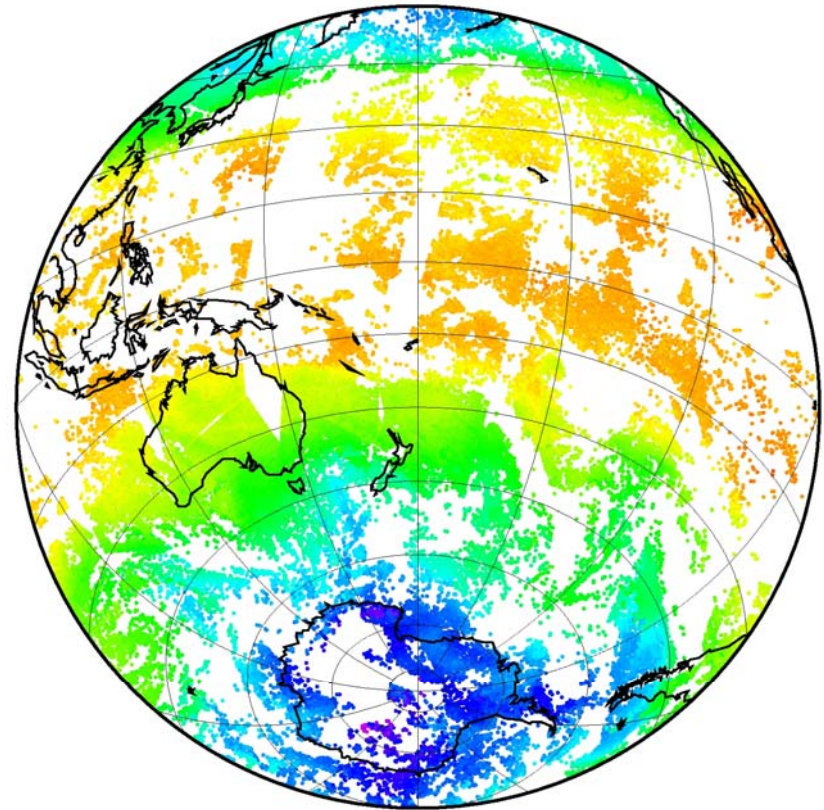
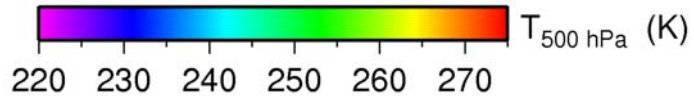
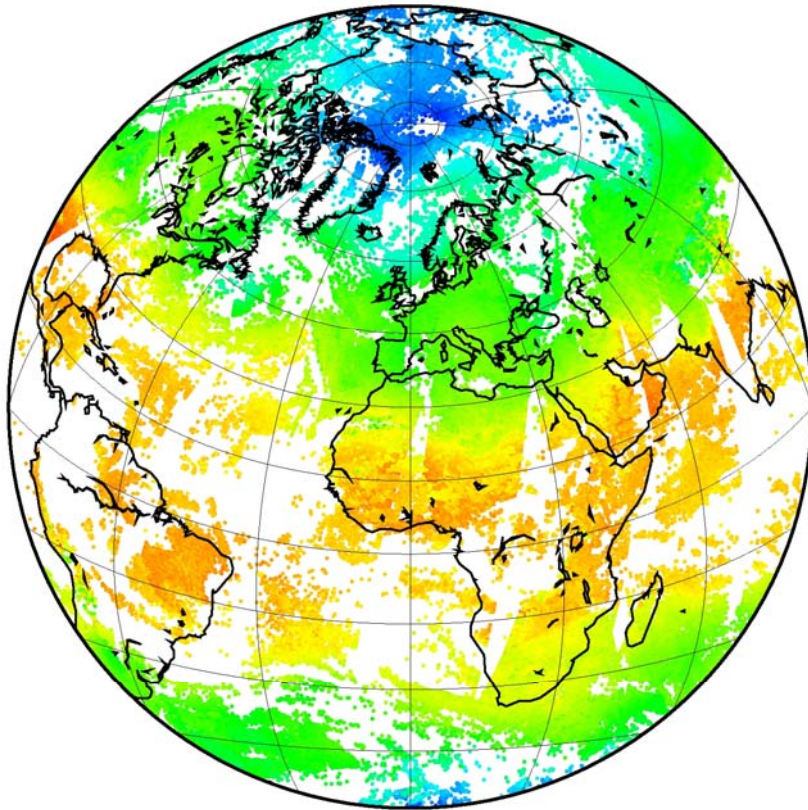
Number of Soundings in Global Datasets

- The fraction of clear or almost clear IASI soundings:
 - $N < 2\%$: 15% (varies between 12 and 24% among different orbits)
 - $N < 5\%$: 16%
- Fraction of useful soundings depending on atmospheric level
 - 860 hPa: 52%
 - 700 hPa: 54%
 - 500 hPa: 62%
 - 300 hPa: 90%
 - 200 hPa: 95%

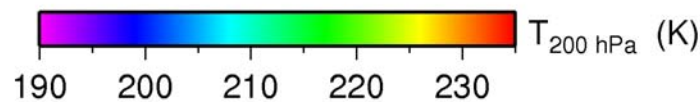
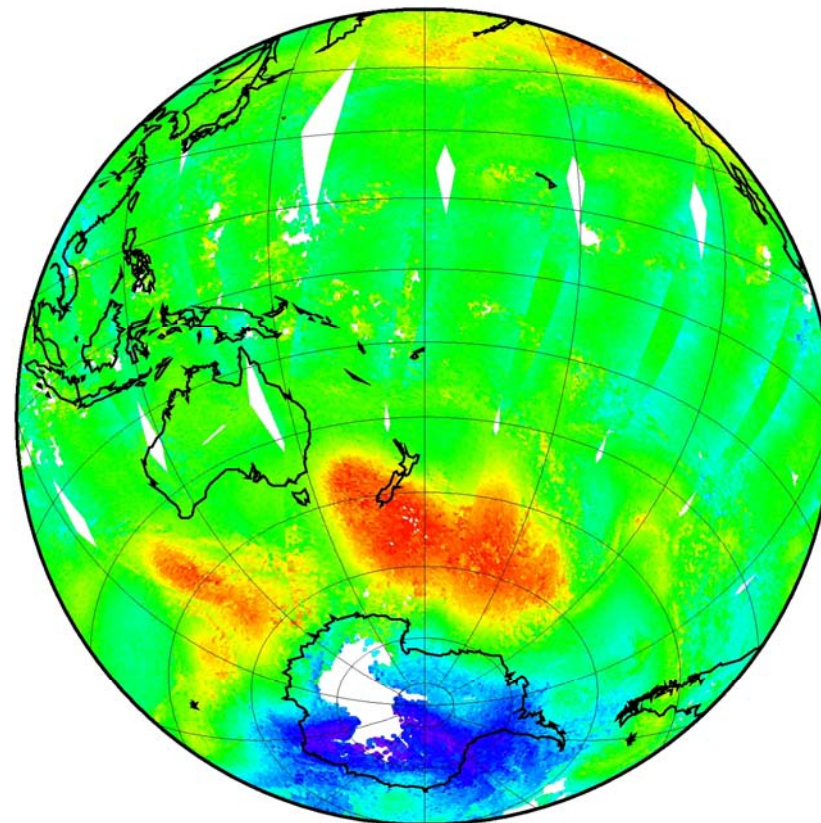
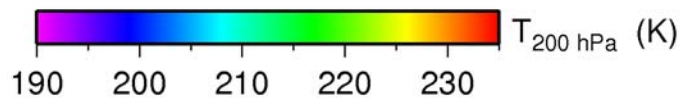
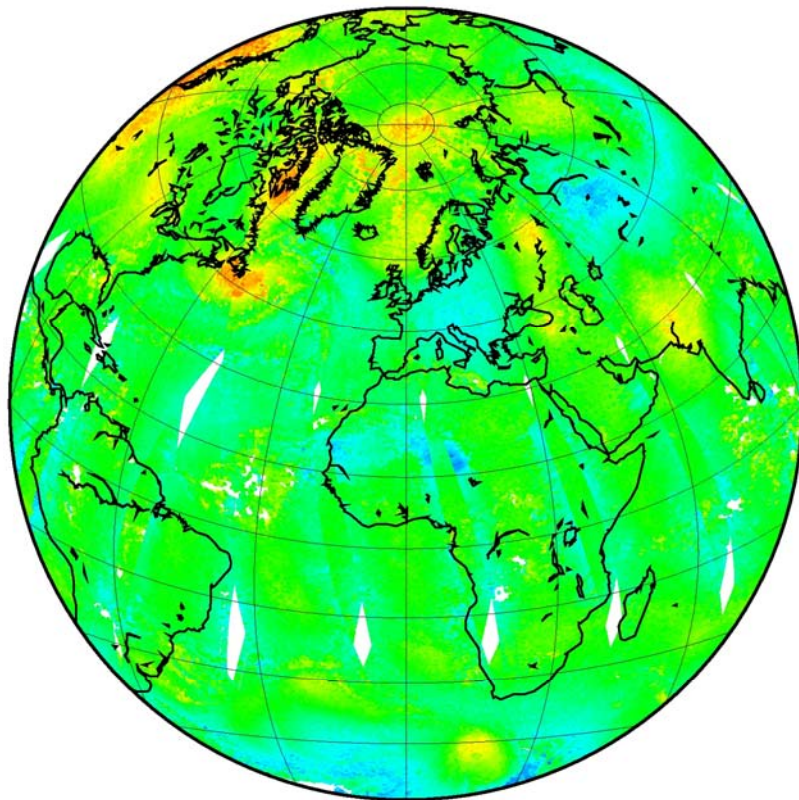
Temperature at 860 hPa: 16 October 2007



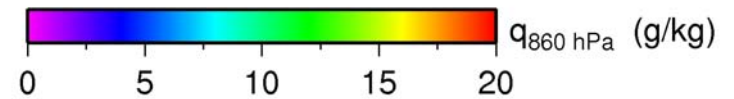
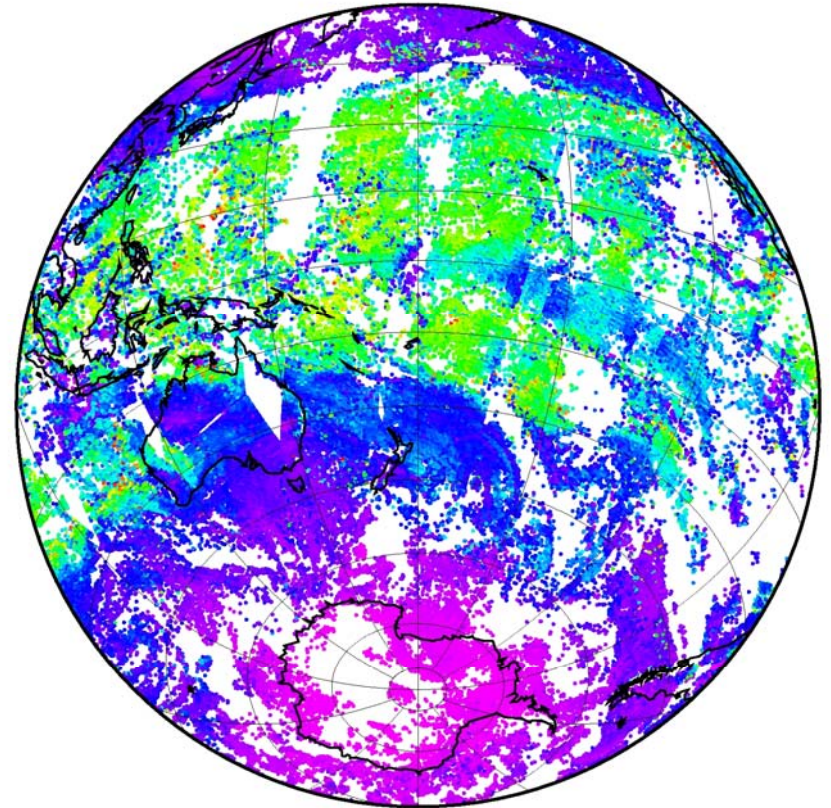
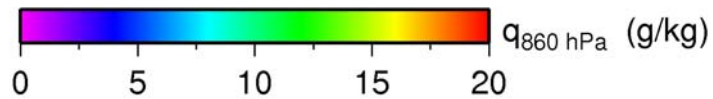
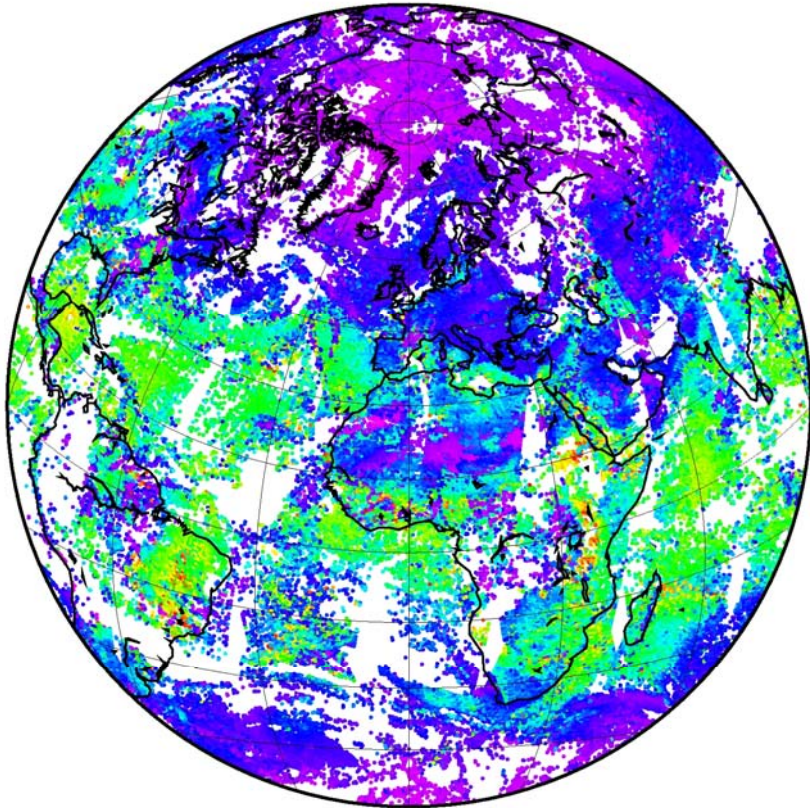
Temperature at 500 hPa: 16 October 2007



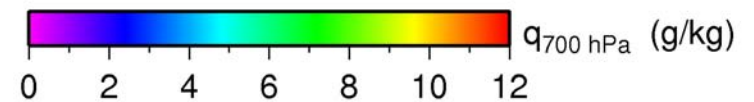
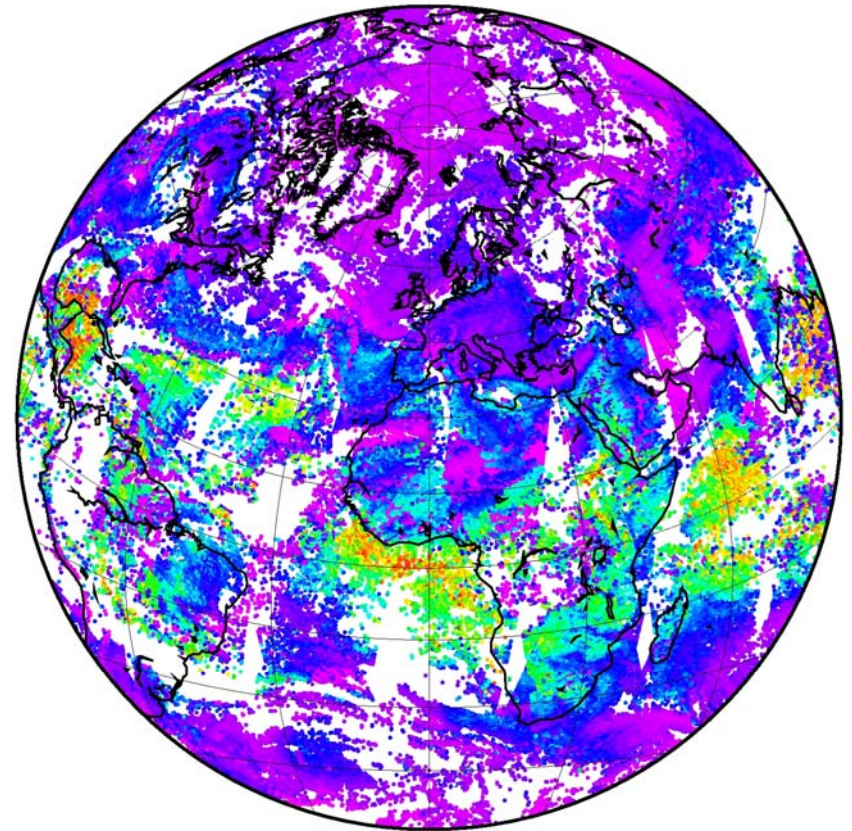
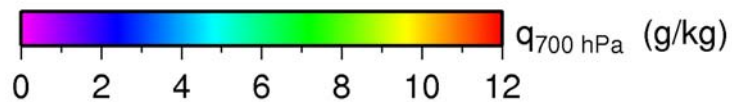
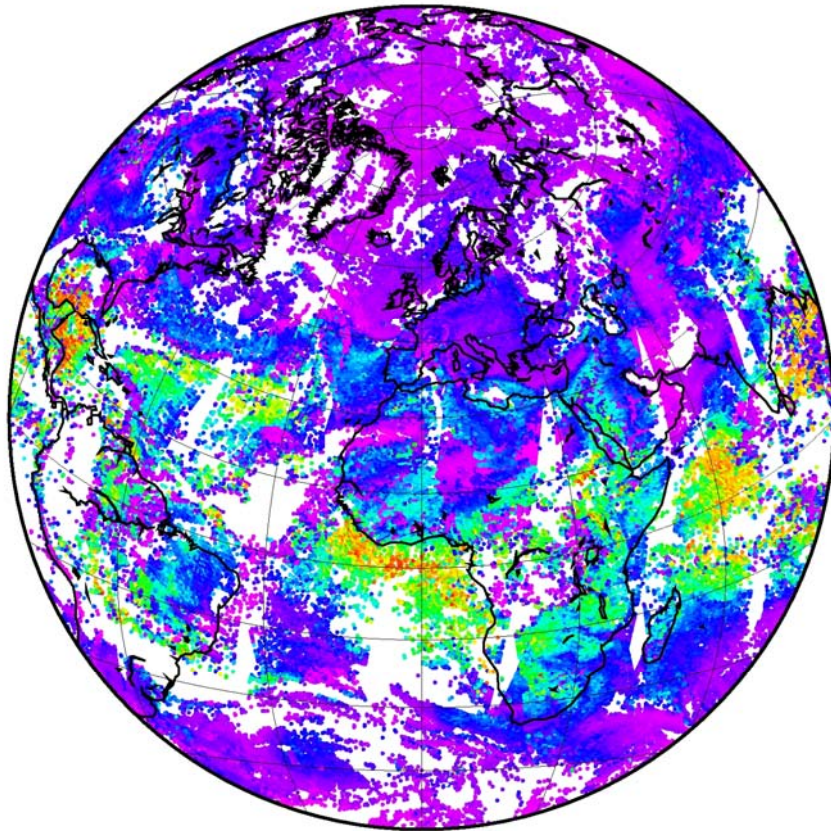
Temperature at 200 hPa: 16 October 2007



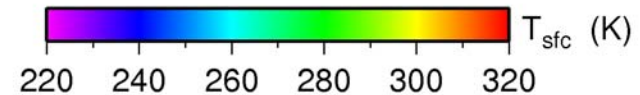
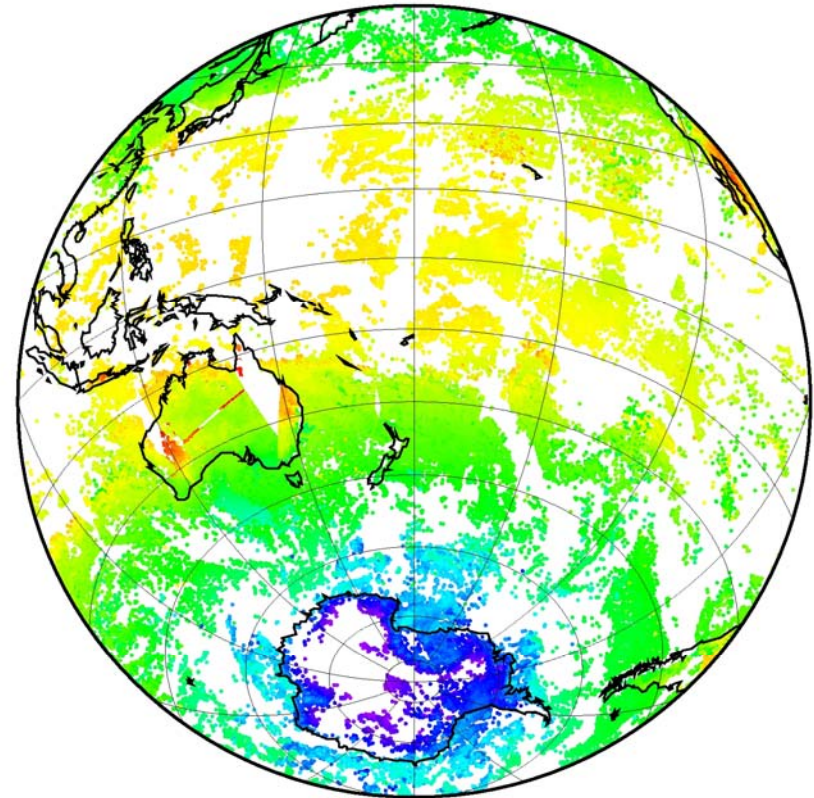
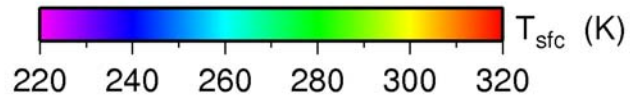
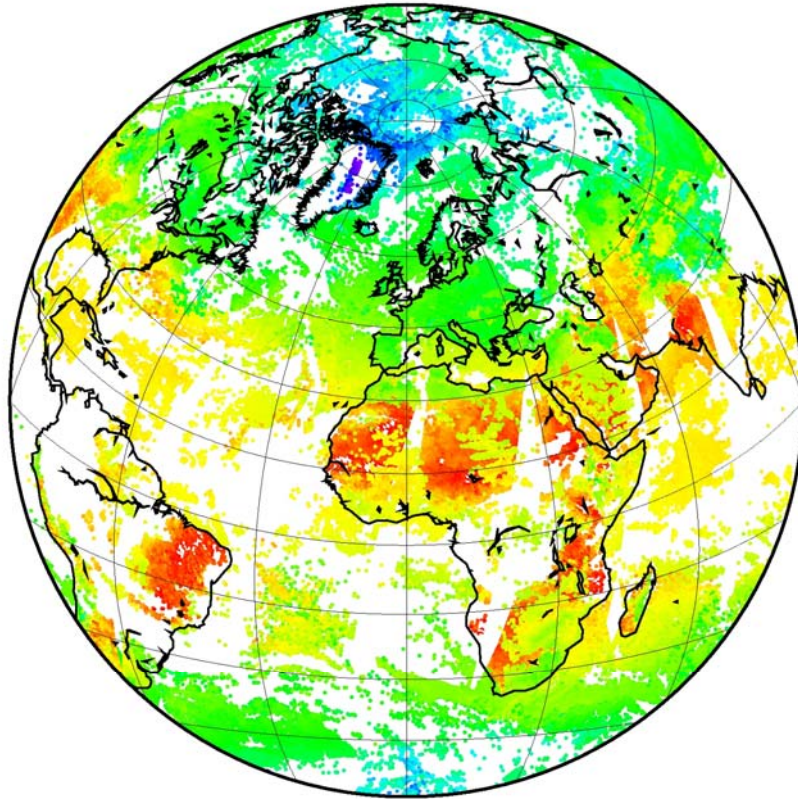
Specific Humidity at 860 hPa: 16 October 2007



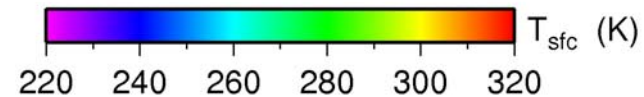
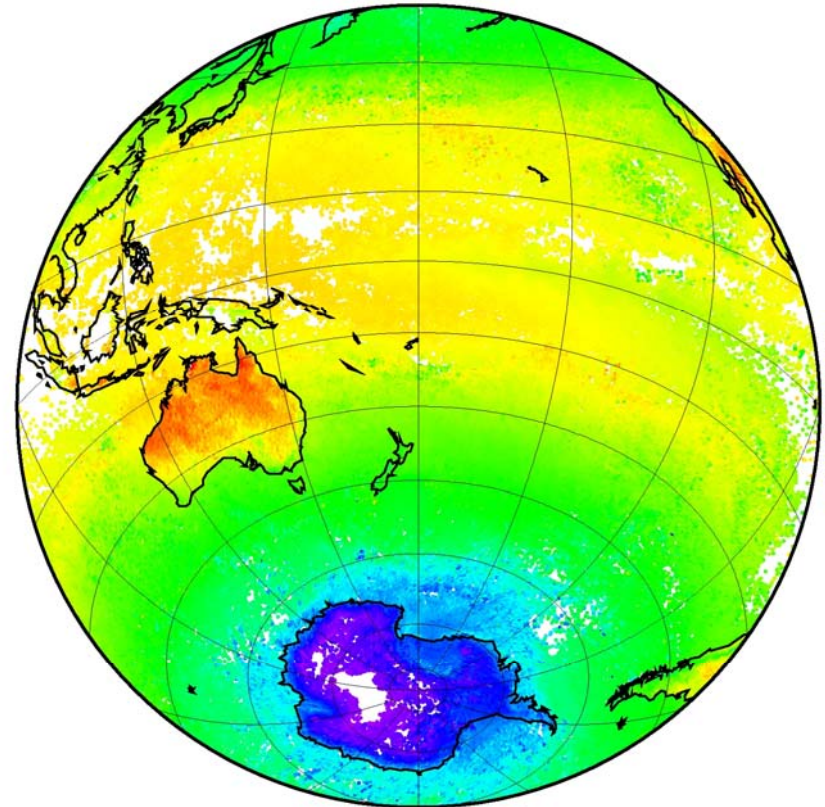
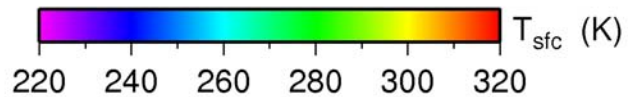
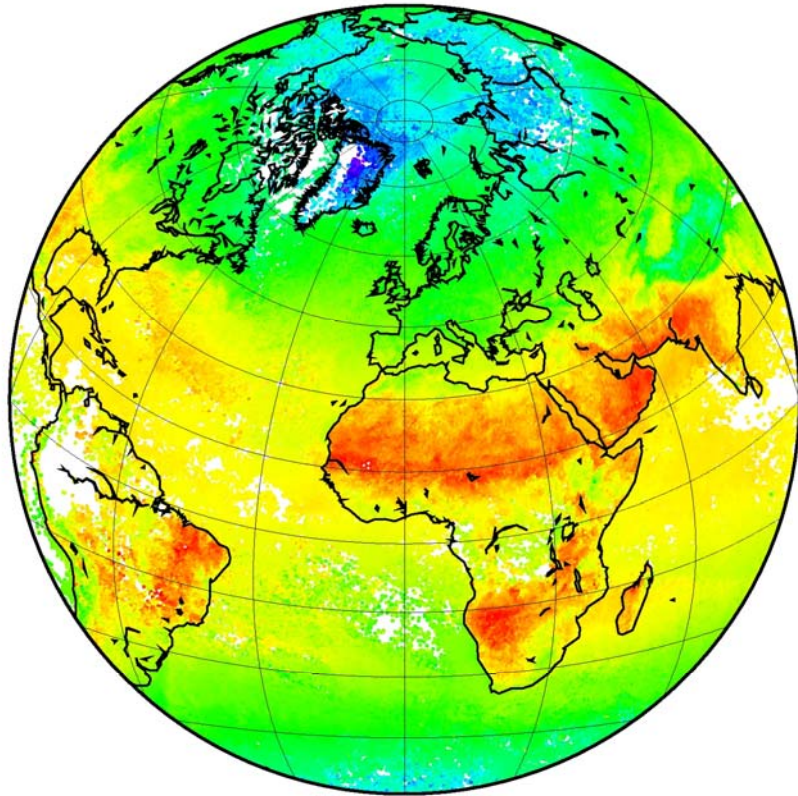
Specific Humidity at 700 hPa: 16 October 2007

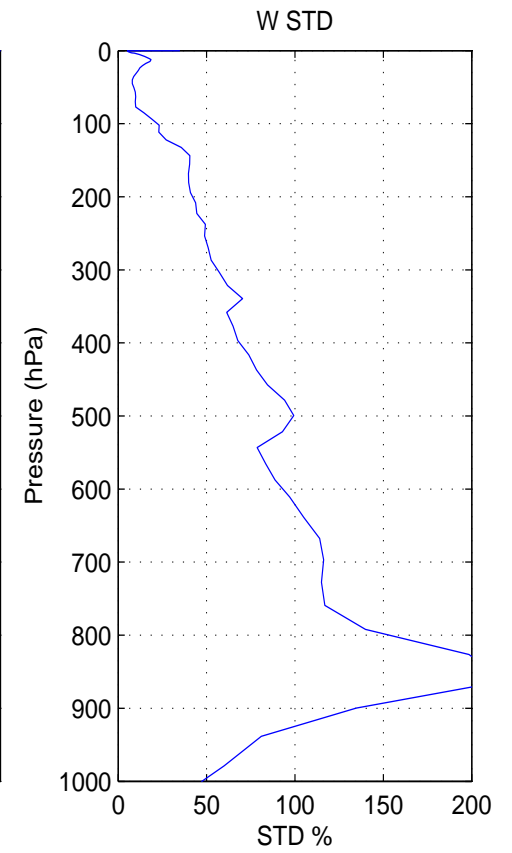
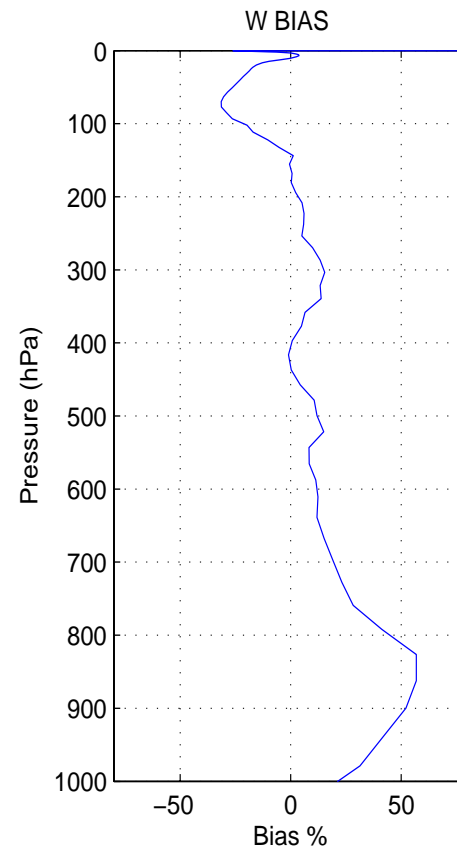
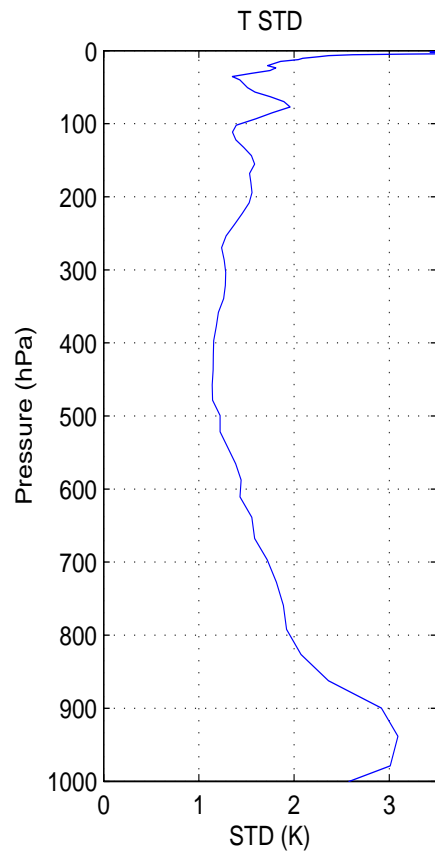
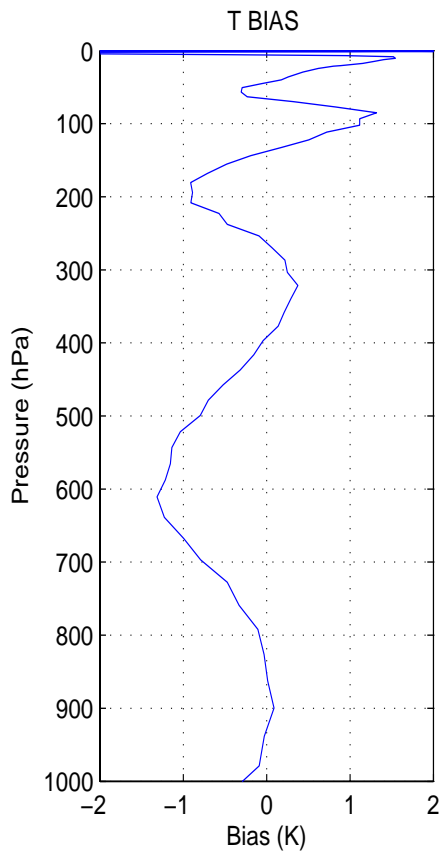


Surface Skin Temperature: 16 October 2007



10 Day Average SST: 16-25 October 2007





IASI L2 v4.0 \leftrightarrow ECMWF Clear sky (land and sea), 54037 cases from 5/11

Surface skin temperature (compared against ECMWF and AVHRR SST)

SEA 0.63K 1.91K

SEA 1.27K 1.76K

LAND 0.18K 5.48K

LAND -0.29K 1.47K



Validation Campaigns

- Met Office, airborne campaign, North Sea,
 - 2 February 2007
- JAIVEx, Gulf of Mexico, Oklahoma CART site
 - 18 April – 4 May 2007
- RV Polarstern
 - 12 April – 4 May 2007
 - 26 October – 26 November 2007
- Arctic Observatory Sodankylä, FMI, Finland
 - 4 June – 5 September 2007
- Richard Aßmann Observatory Lindenberg, DWD, Germany
 - 1 June – 31 August 2007

Validation Campaign at FMI Arctic Observatory Sodankylä



- 4 June – 5 September 2007
- Observations:
 - 360 PTU sondes
 - 40 ozone sondes
 - 7 CFH sondes
 - MW radiometry WV column
 - GPS WV column
 - Brewer columnar ozone
 - Aerosol optical depth
 - Surface meteorological observations
- Data have been post-processed and quality controlled by cross-comparison



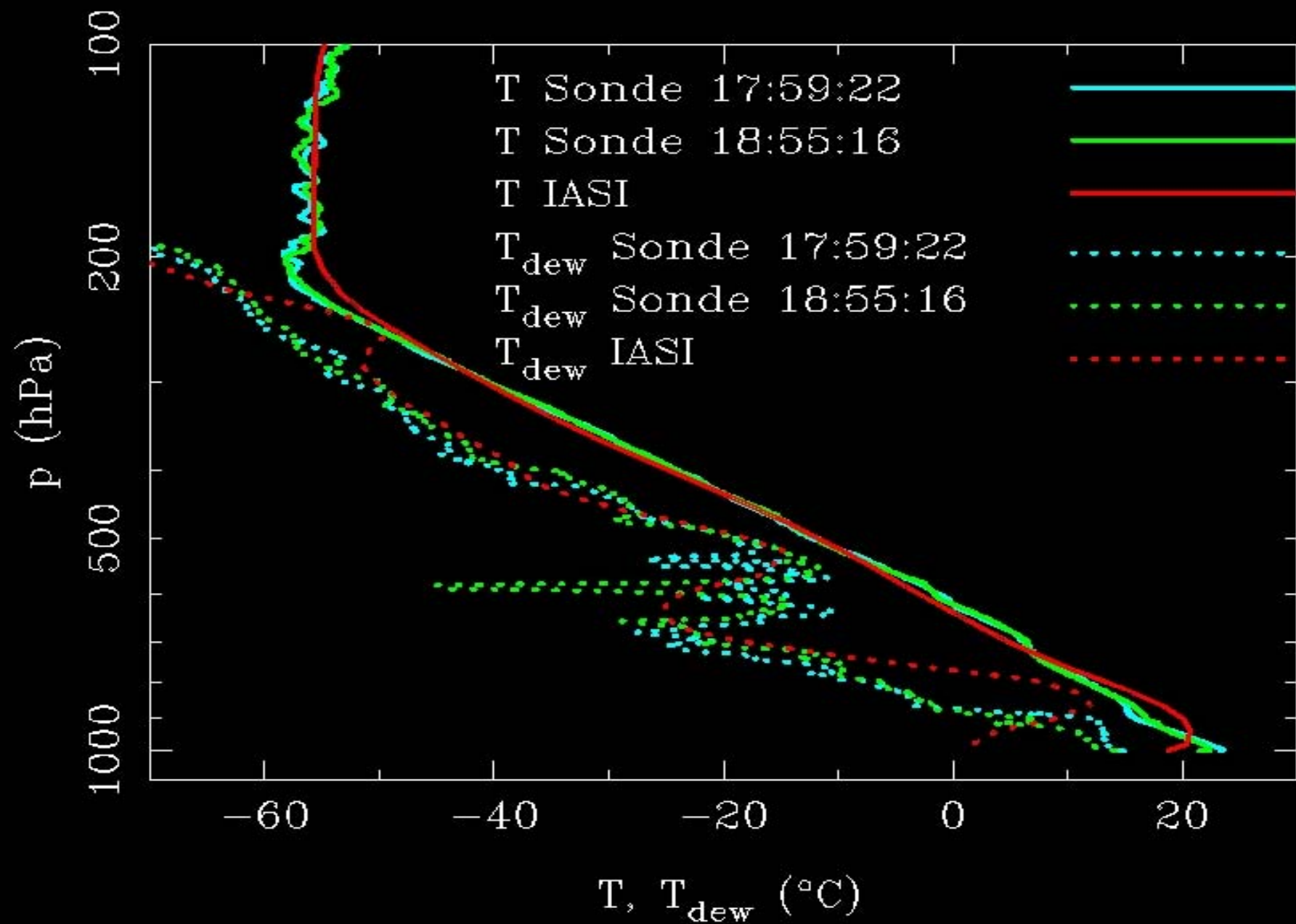
Validation Campaign at DWD Laboratory Lindenberg



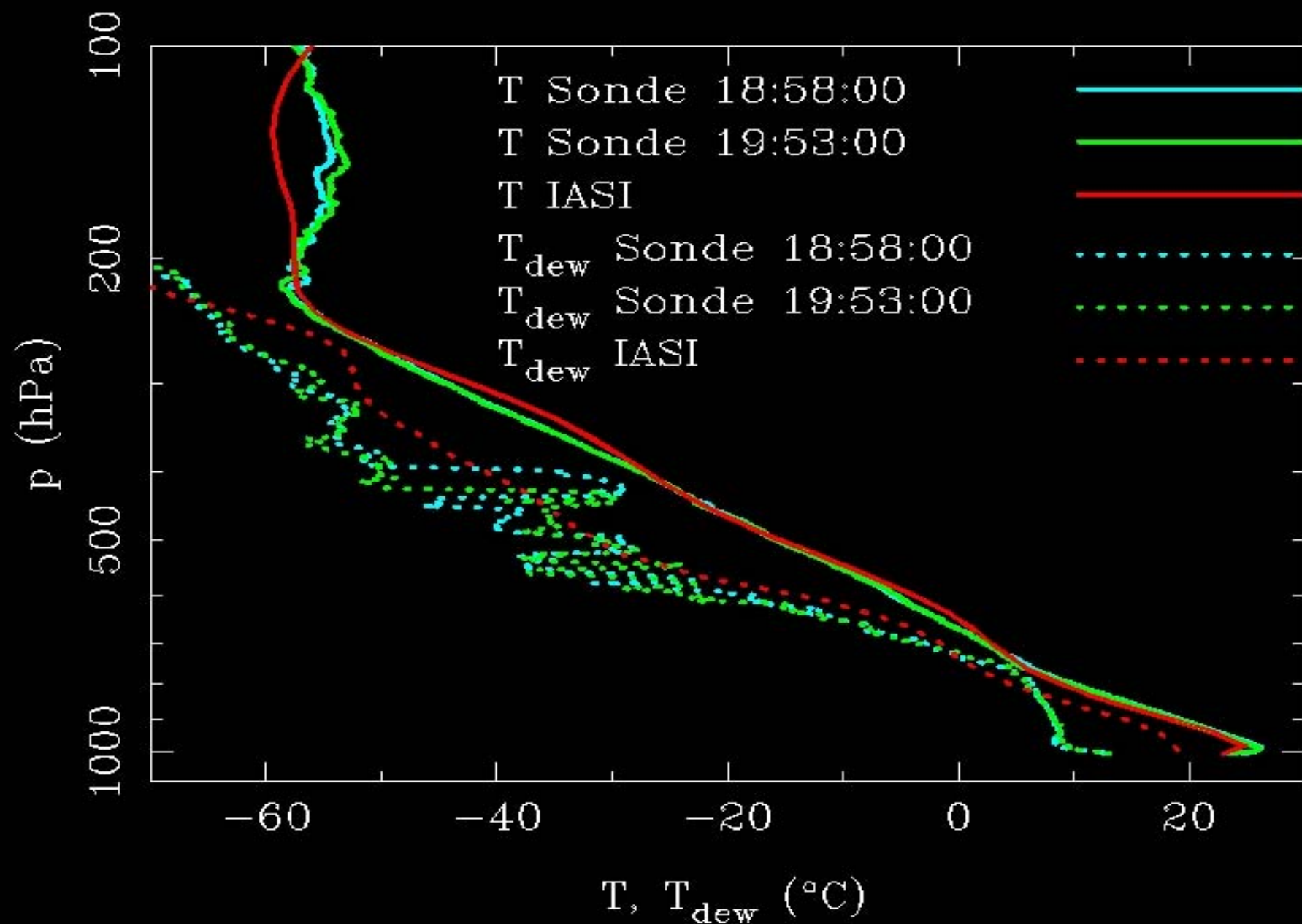
- 1 June – 31 August 2007, to be continued in winter 2007/2008
- Observations:
 - 290 additional PTU sondes
 - 36 ozone sondes
 - 34 reference sondes
 - Raman lidar (WV)
 - MW radiometry
 - GPS WV column
 - Brewer columnar ozone
 - Aerosol optical depth
 - Ka-band cloud radar
 - Ceilometer
 - Surface meteorological observations
- Data have been post-processed and quality controlled by cross-comparison



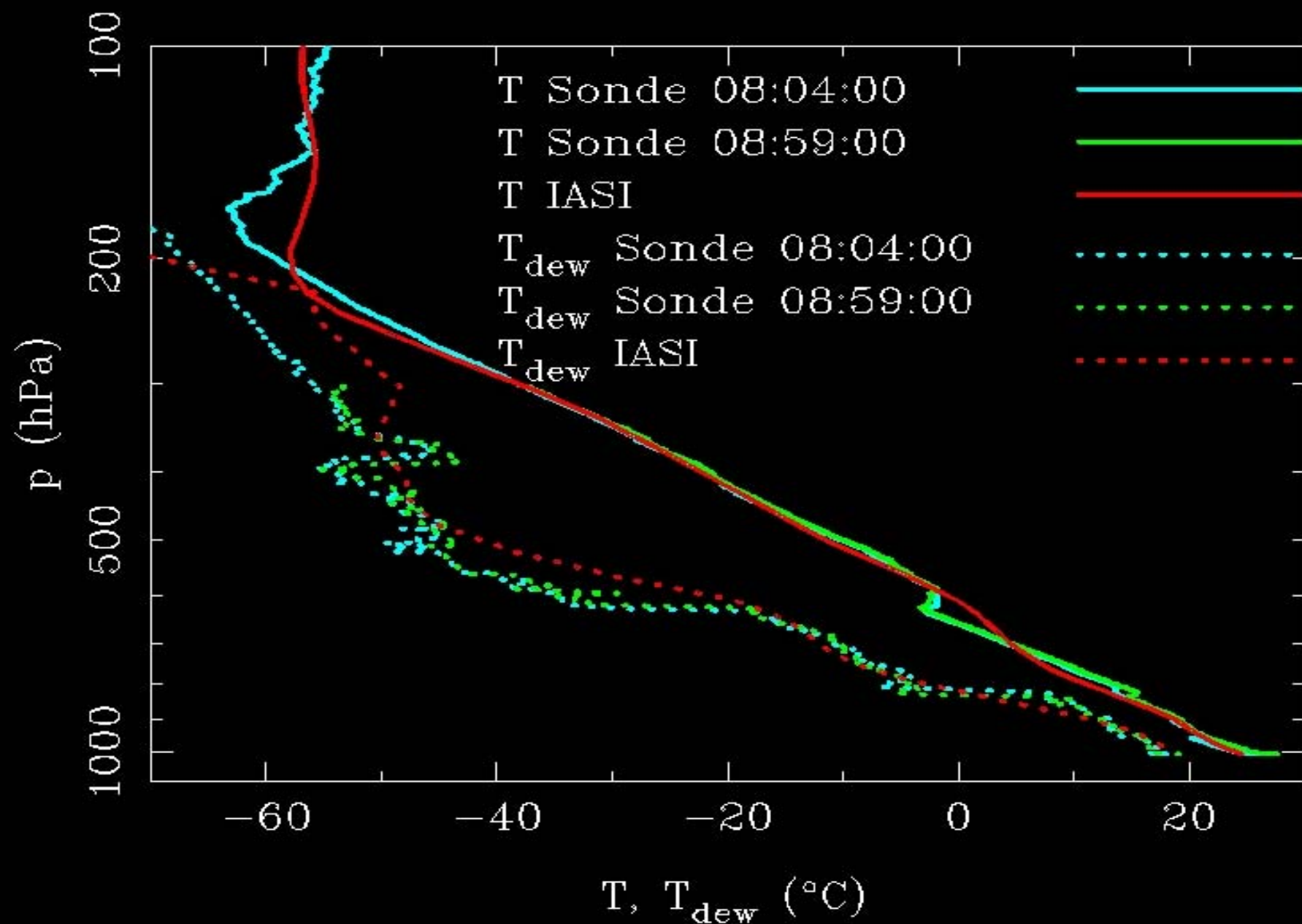
Sodankyla 2007/08/08 18:59:15



Lindenberg 2007/06/08 19:58:01



Lindenberg 2007/07/15 09:04:42



Dissemination to Users

- The product is broken down into 5 streams:
 - TWT: Atmospheric temperature profiles, atmospheric water vapour profiles, surface skin temperature
 - OZO: Atmospheric ozone
 - CLP: Cloud parameters
 - TRG: Atmospheric trace gases CO, CH₄, N₂O, CO₂
 - EMS: Land surface emissivity
- IASI level 2 products (in BUFR) will be disseminated via EUMETCast and GTS
- The trial dissemination of level 2 products has started on 25 September 2007, including TWT and CLP

Conclusion

- The instrument is stable and provides level 1 data operationally, allowing to derive level 2 products
- Level 2 products are being validated against short-range forecast fields and against data from dedicated field campaigns
- The trial dissemination of level 2 products has started
- Still much to improve, but hopefully IASI L2 will become operational soon.