Operational IASI Level 2 Processing

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4th Workshop on Advanced High Spectral Resolution Infrared Observations
EUM/MET/VWG/08/0380 Issue 1, 14/09/2008

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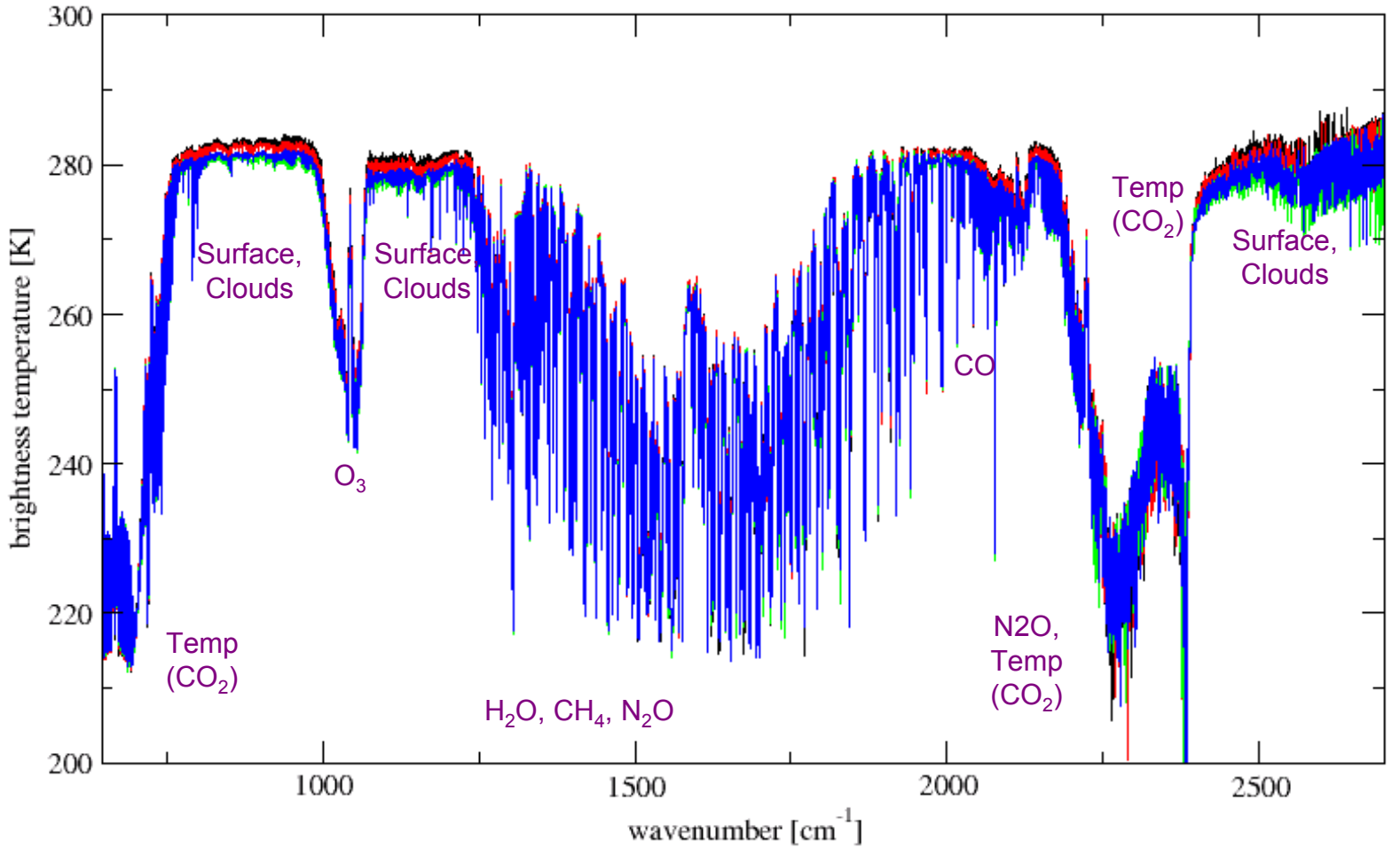
First IASI spectra on 29 November 2006
L1 Products operational since 29 May 2007



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IASI level 2 product generation

IASI Level 1c

AVHRR Cloud Mask and S/CTT

Configurable Databases

ATOVS Level 2

AMSU-A Level 1

MHS Level 1

NWP Forecast

Pre-Processing

Cloud Processing

Geophysical Parameters Retrieval

Monitoring Information

Level 2 Product

Quality Information

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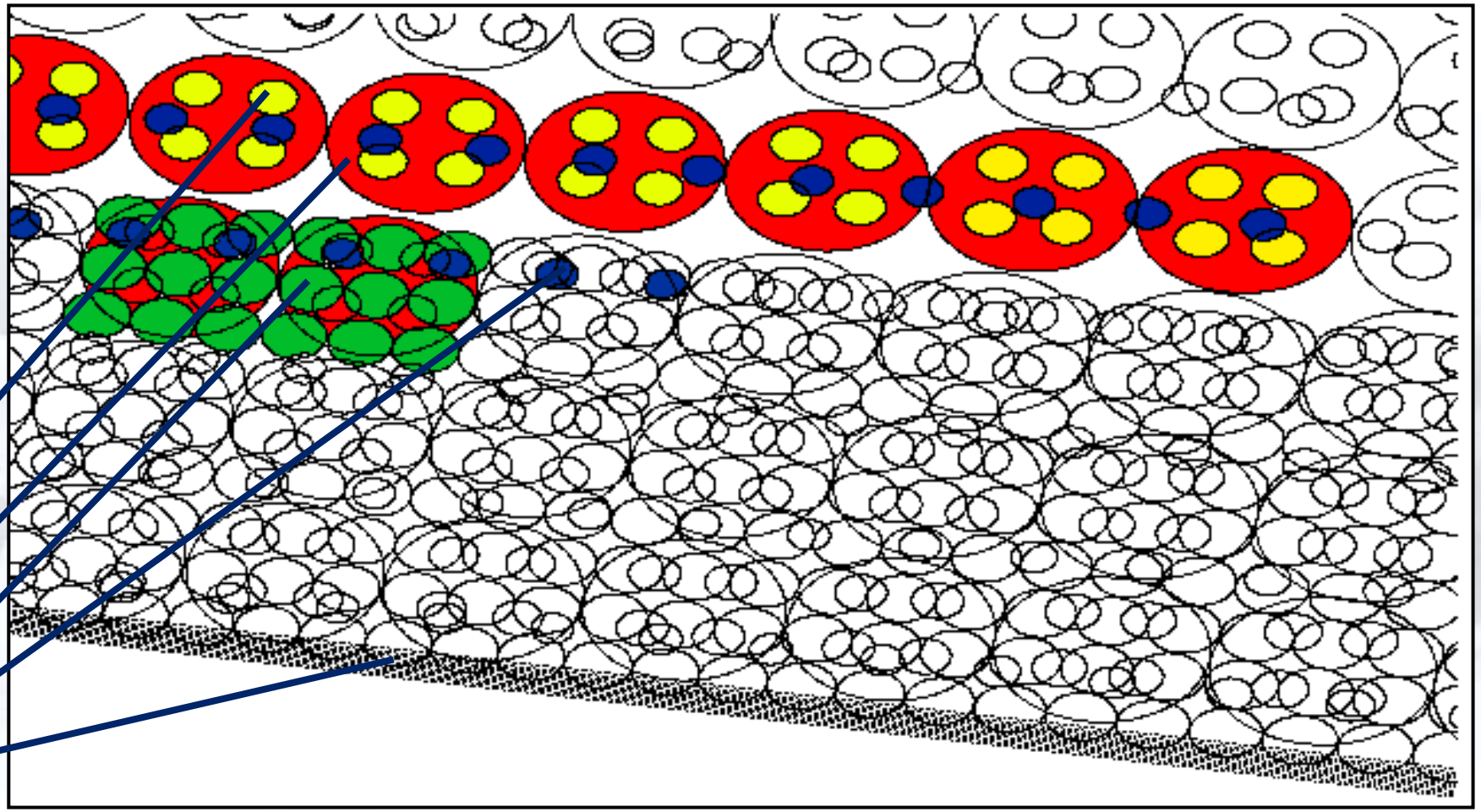
Properties of the Operational IASI L2 Processor (1/3)

- 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

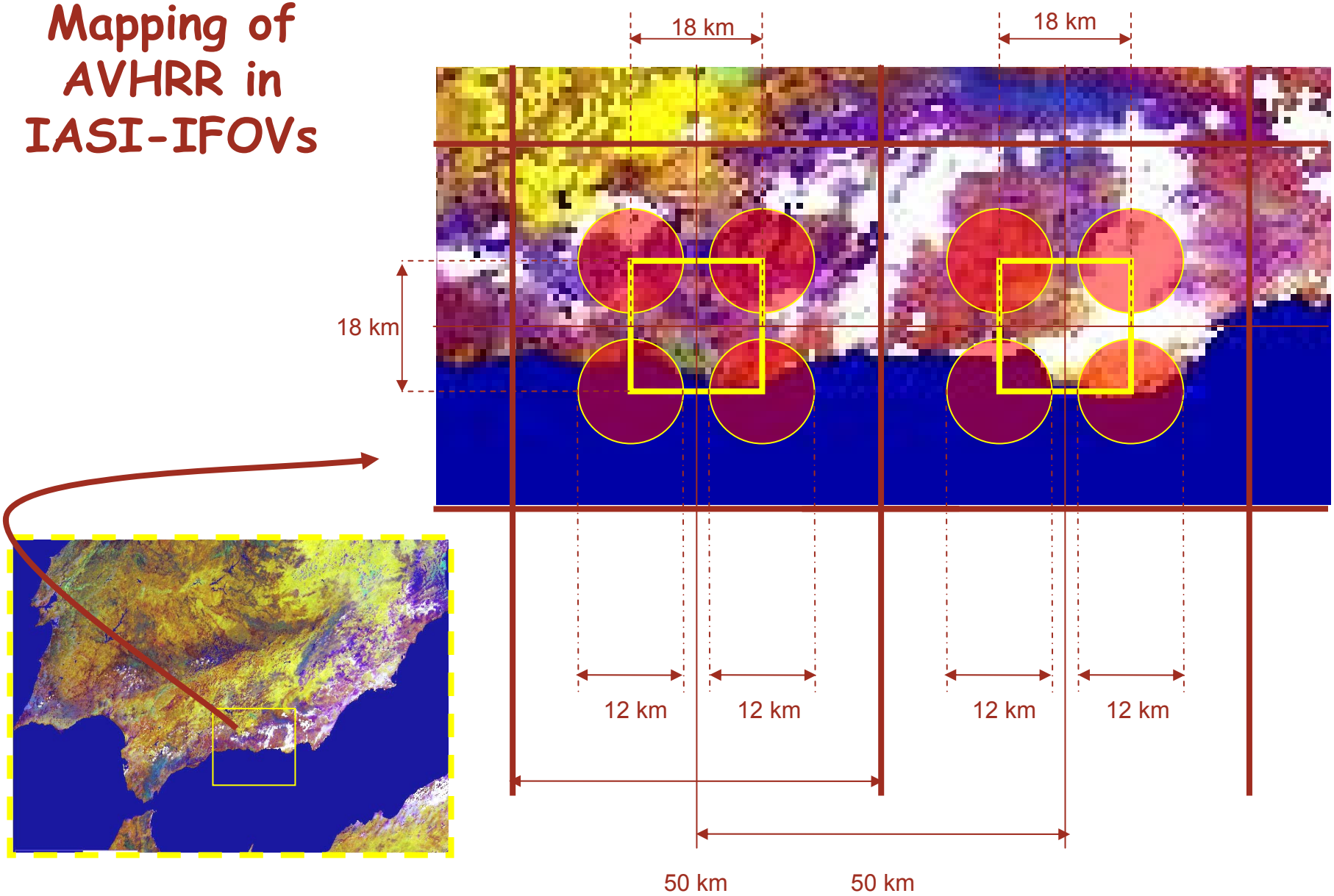
- IASI stand-alone processing is used for geophysical parameters retrieval

- 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 CO_2-slicing
  - **No conditioning of profile retrieval with NWP forecast**

Scan patterns of the instruments



Mapping of AVHRR in IASI-IFOVs



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Properties of the Operational IASI L2 Processor (2/3)

- Processing is steered by configuration settings (80 configurable auxiliary data sets), which allows for optimisation of PPF
  - Most of the settings have been refined during commissioning, based on validation results

- Online quality control supports the choice of best processing options in case of partly unavailable IASI data or corrupt side information (data from other instruments or NWP forecast)

- A number of flags are generated steering through the processing and giving quality indicators; 42 flags are specified, which are part of the product, a sub-selection directly relevant for the user is disseminated with the product; an error covariance (or part of it) will be included in future

Properties of the Operational IASI L2 Processor (3/3)

- Different retrieval methods are implemented so that the best configuration can be chosen based on validation results and operational constraints:
  - EOF regression retrieval for temperature and moisture retrieval, surface temperature, emissivity, and ozone columns
  - Artificial neural network retrieval using a selection of spectral samples for trace gas retrievals
  - Iterative retrieval using a selection of spectral samples for temperature and humidity profiles as well as surface and cloud parameters
- The retrieval can be configured to chose among the retrieval schemes or to combine them

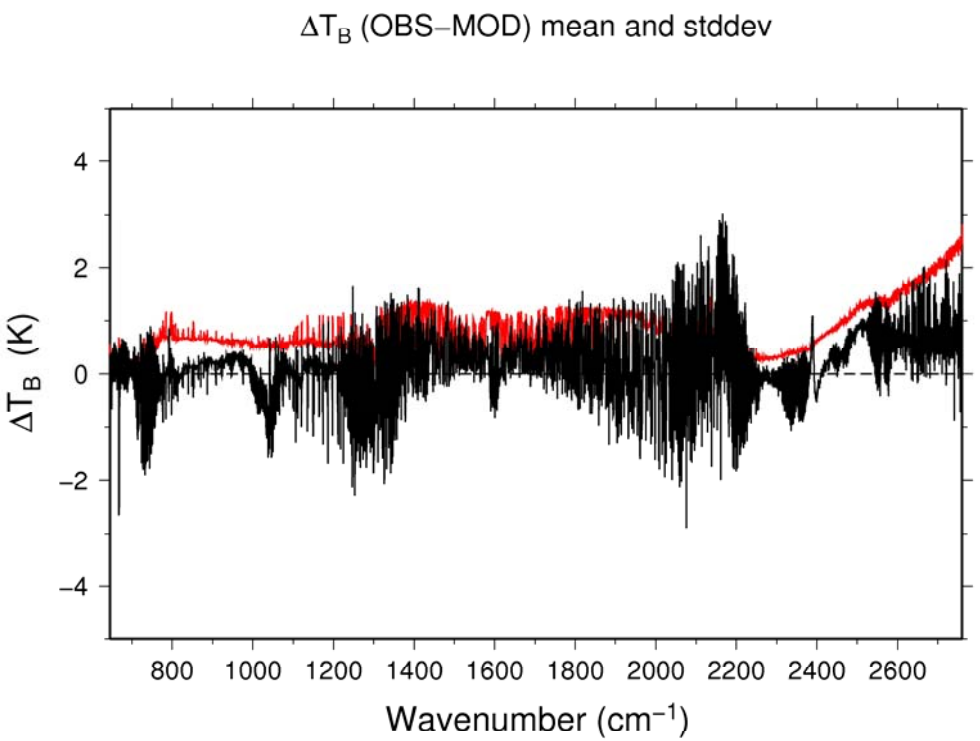
Geophysical parameters retrieval: state vector to be derived

- The state vector to be retrieved consists of the following parameters
  - Temperature profile at high vertical resolution
  - Water vapour profile at high vertical resolution
  - Ozone columns in deep layers (0-6km, 0-12 km, 0-16 km, total column)
  - Land or sea surface temperature
  - Surface emissivity at 12 spectral positions
  - Columnar amounts of N_2O, CO, CH_4, CO_2
  - Cloud amount
  - Cloud top temperature and pressure
  - Cloud phase
- In case of clouds and elevated surface the state vector has to be modified
- The iterative retrieval provides error covariances, part of it is included in the product

Preprocessing

- Validation of incoming data
  - Examination of quality flags in IASI L1C, AMSU-A, MHS, AVHRR Scenes Analysis
  - Check of radiances against valid bounds
  - Check of geolocation against valid bounds
  - Check of NWP forecast against valid bounds and for completeness
- Mapping of AMSU-A, MHS, AVHRR, and NWP to IASI IFOV
- Extraction of land-sea mask and surface topography and mapping to IASI IFOV
- Bias correction of IASI radiances
- Correction for ISRF shift in case of inhomogeneous scenes
- Calculation of IPSF-weighted fractional cloud cover from AVHRR
- Calculation of IPSF-weighted surface and cloud top temperatures from AVHRR

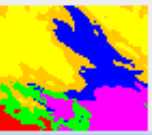
Correction of systematic errors



- Retrieval, CO_2-slicing, and cloud detection use radiative transfer calculations as basis
- Prerequisite for the functionality of the retrieval is a good representativity of the measurements by simulated radiances
- Systematic errors:
  - Approxmations necessary for fast calculations
  - Insufficient knowledge of spectroscopic data
  - Erroneous input data
- Systematic fit of models to IASI measurements

Location and Geometry | IASI Spectrum | Radiance Analysis

	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	No Class
Color							
Coverage	80.75%	16.72%	0.00%	0.00%	2.53%	0.00%	0.00%
Gravity Y	-0.642	-0.822	0.000	0.000	-0.916	0.000	0.000
Gravity Z	0.666	0.379	0.000	0.000	0.306	0.000	0.000
Radiance_1	2.090 ...	3.405 ...	0.000 ...	0.000 ...	4.319 ...	0.000 ...	0.000 ...
Radiance_2	2.377 ...	4.818 ...	0.000 ...	0.000 ...	6.409 ...	0.000 ...	0.000 ...
Radiance_3a	0.082 ...	0.181 ...	0.000 ...	0.000 ...	0.242 ...	0.000 ...	0.000 ...
Radiance_3b	0.000 ...	0.000 ...	0.000 ...	0.000 ...	0.000 ...	0.000 ...	0.000 ...
Radiance_4	0.001 ...	0.001 ...	0.000 ...	0.000 ...	0.001 ...	0.000 ...	0.000 ...
Radiance_5	0.001 ...	0.001 ...	0.000 ...	0.000 ...	0.001 ...	0.000 ...	0.000 ...



AVHRR Radiance Analysis inside IASI

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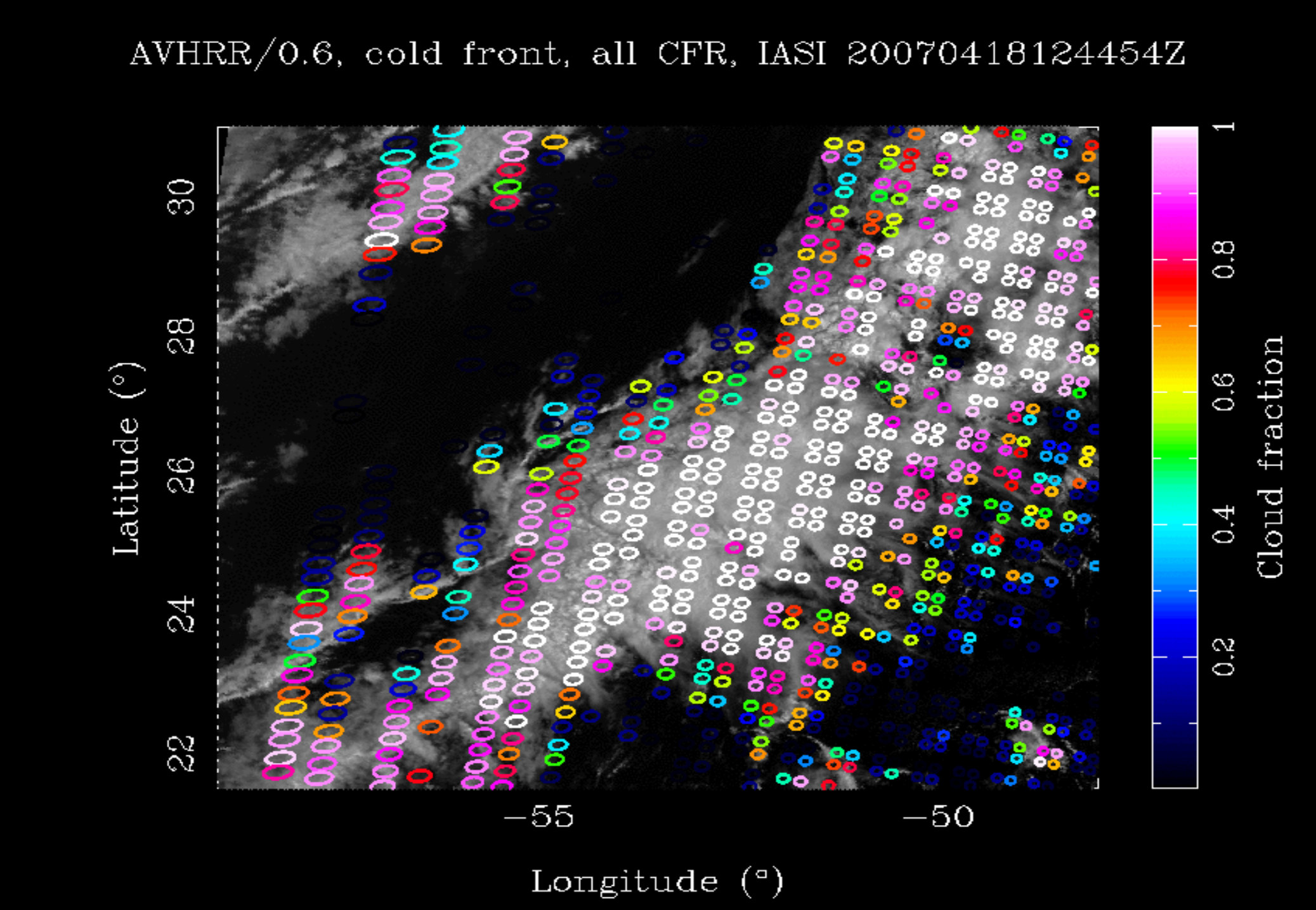
Cloud processing: cloud detection

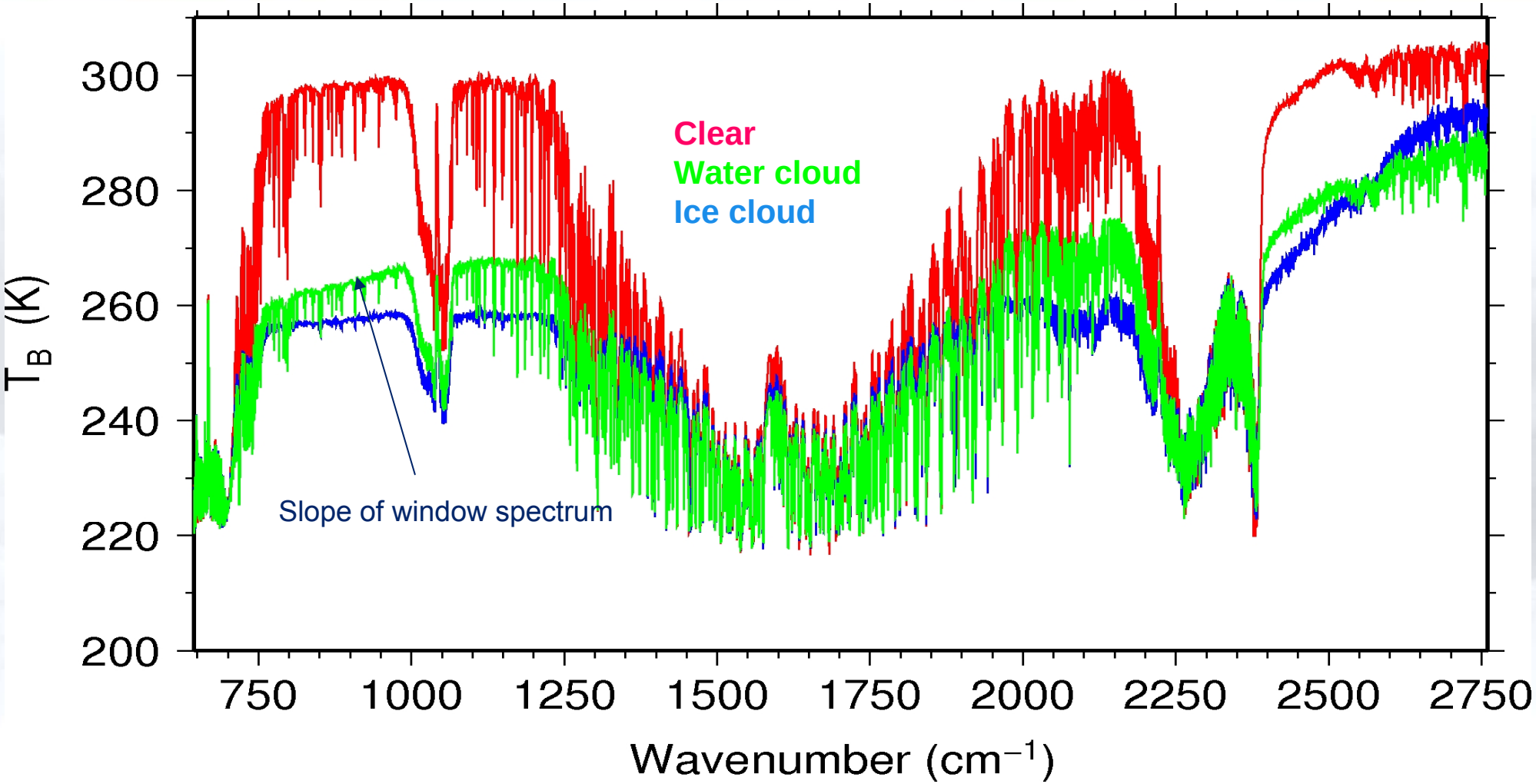
- AVHRR-based cloud detection using Scenes Analysis from AVHRR Level 1 processing
- Combined IASI / ATOVS cloud detection: 2 inter-channel regression methods
- IASI stand-alone cloud detection
  - Window-channel test based on calculated clear-sky radiance spectra
  - 2 IASI inter-channel regression tests
  - Horizontal coherence test
  - Thresholds on principal component scores
  - Window cross-correlation test
  - Threshold test for clouds over elevated polar regions
  - Threshold test for detection of dust storms

Cloud processing: cloud parameters retrieval

- Cloud fraction (CO_2-Slicing)
- Cloud top pressure and temperature (CO_2-Slicing)
- Cloud phase: examination of slope of window spectra


AVHRR/0.6, cold front, all CFR, IASI 20070418124454Z
Latitude (°)
22
24
26
28
30
−55
−50
Longitude (°)
Cloud fraction
0.2
0.4
0.6
0.8
1

Discrimination of ice and water clouds



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Geophysical parameters retrieval (1/2)

- An EOF regression retrieval using 500 principal component scores representing the spectra of bands 1 and 2 for temperture and humidity retrieval, surface temeprature, land surface emissivity, and ozone columns
- An artificial neural network retrieval is based on a selection of IASI spectral samples and a guess temperature profile; the derived parameters are CO, CH_4, N_2O, CO_2
- An iterative maximum probability retrieval, based on the Levenberg-Marquardt iteration utilising 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

Geophysical parameters retrieval (2/2)

- Iterative retrieval
  - Initialised with results from the first retrievals (EOF regression, ANN) and cloud parameters from CO_2-slicing
  - Background from climatology
  - Includes K-matrix version of RTIASI-4

- Different conditions require modification of state vector
  - Full state vector without cloud parameters in clear situations
  - Reduced state vector in case of elevated surface
  - Full state vector including cloud parameters in case of slightly cloudy conditions (< 20% cloud coverage)
  - Reduced state vector when cloud fraction exceeds 20%, retrieval only above cloud top

- Simultaneaous retrieval of all state vector elements
  - Operational contraints allow currently only for 5 iterations (non-convergence in some cases)

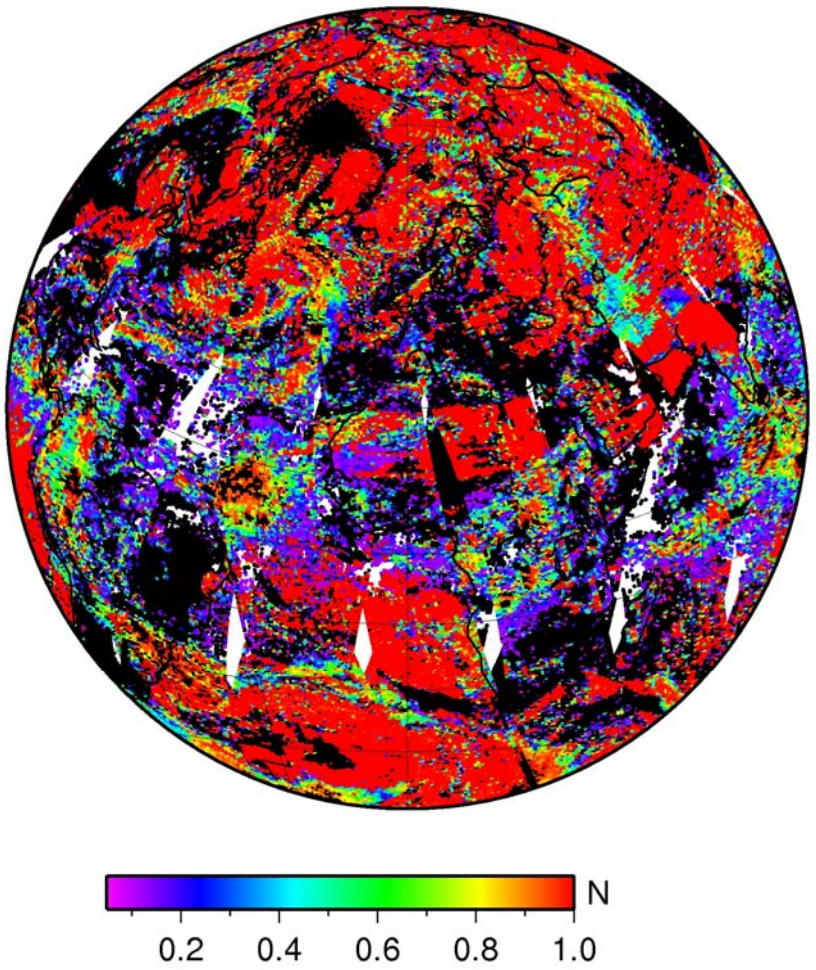
Flag collection (1/2)

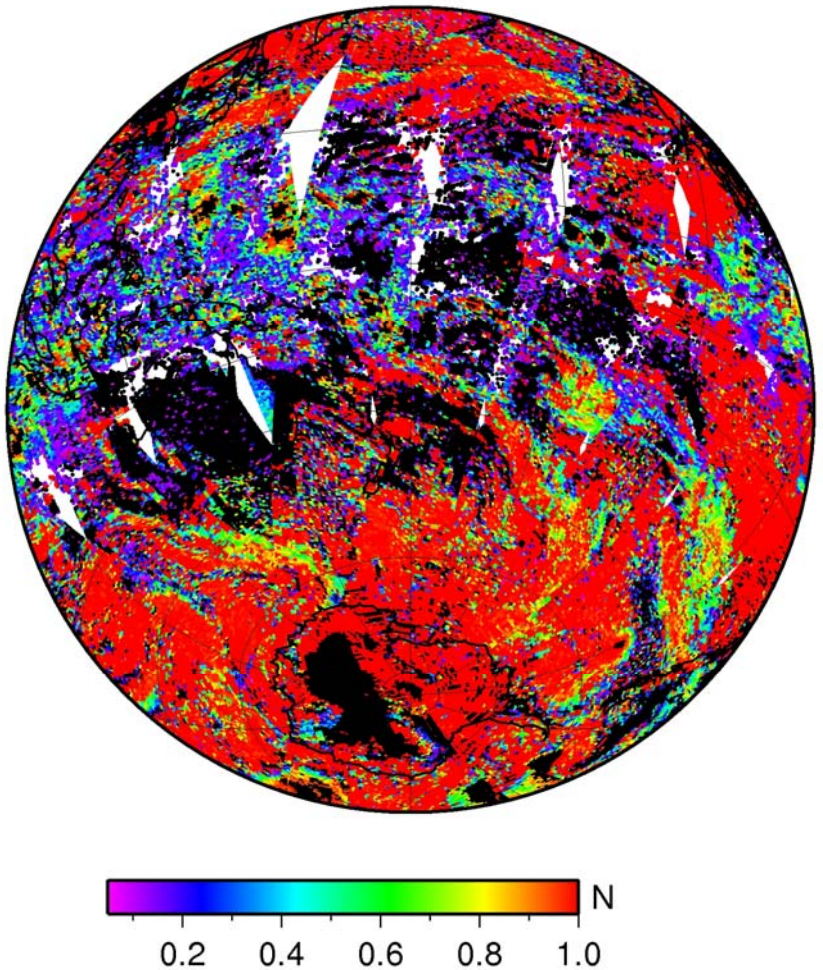
- A collection of 42 flags is part of the product
- Very important information for the user
  - Which data, in which quality entered the product generation?
  - Which methods have been used and how was the product generated?
  - What is the product quality?
- Examination of the flags is mandatory in the utilisation of the product
  - Ignorance of the flags will lead to dissatisfaction of users

Flag collection (2/2)

- Validity and quality of the input data: 13 flags
- Information on cloud processing: 9 flags
- Information on day/night, sun-glint, land/sea: 3 flags
- Retrieval choice and settings: 8 flags
- Retrieval quality: 9 flags
- Definition of flags is given in
  - Annex D of the IASI L2 Product Generation Specification
  - Section 4.3.3 of the IASI L2 Products Guide

Cloud Cover – 16 October 2007





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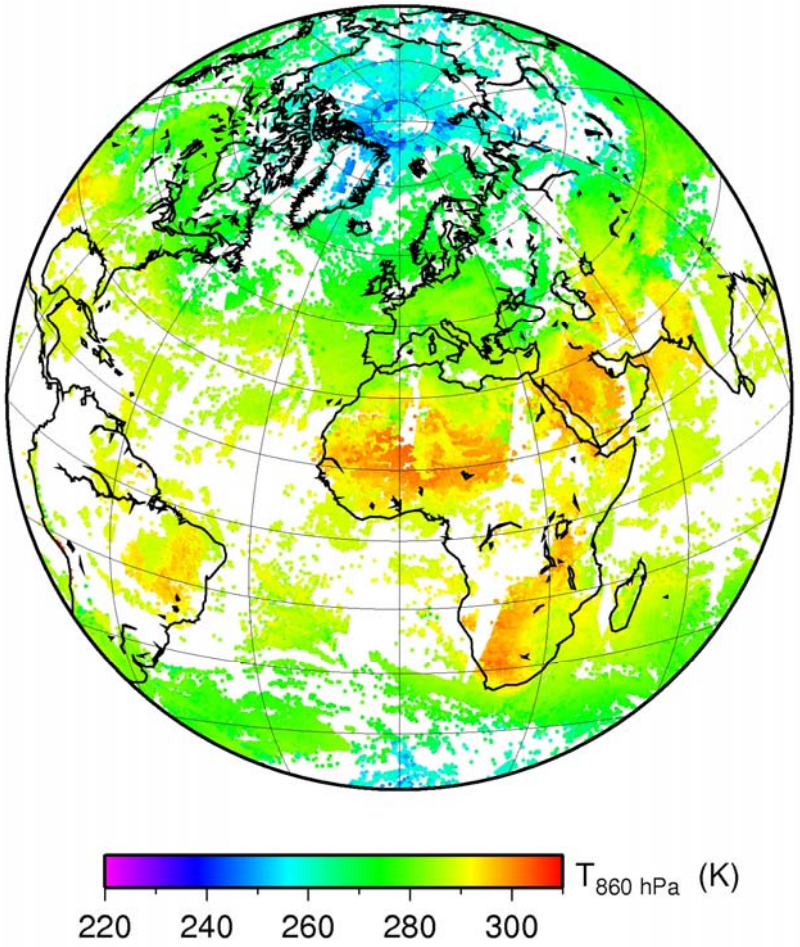
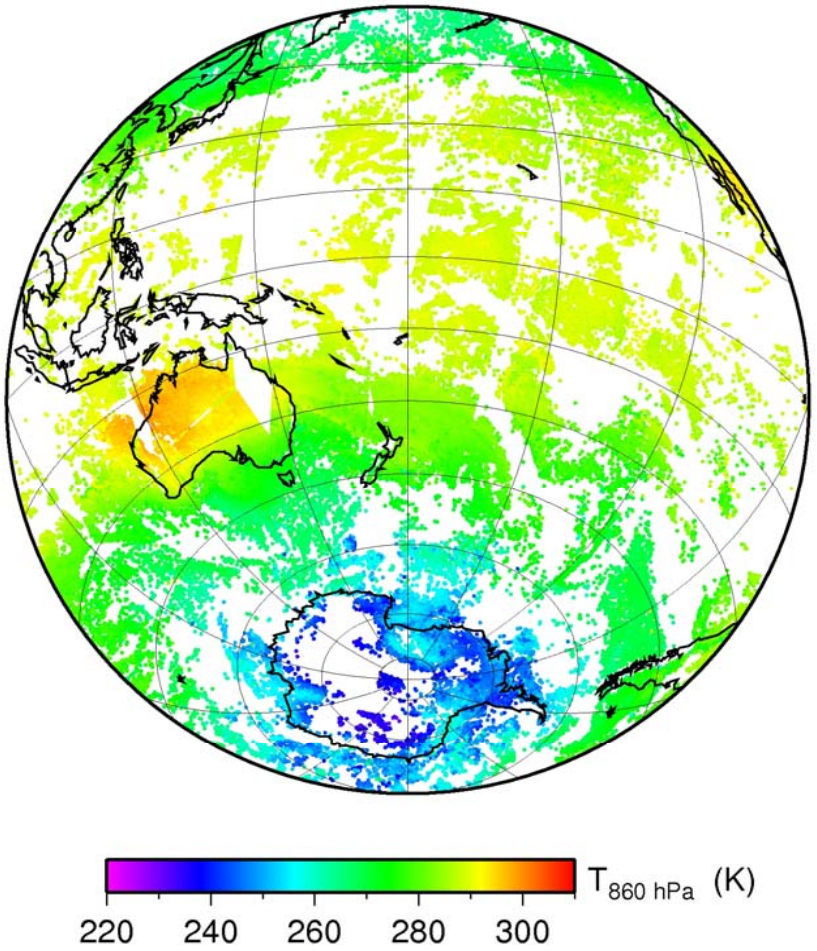
Number of Soundings in Global Datasets

- IASI soundings are possible in clear or nearly clear fields of view
  - Clear retrievals are best
  - Gradual degradation of retrievals below cloud top with increasing cloud amount
  - Retrievals above cloud top are almost as good as clear ones
- 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



N < 5%



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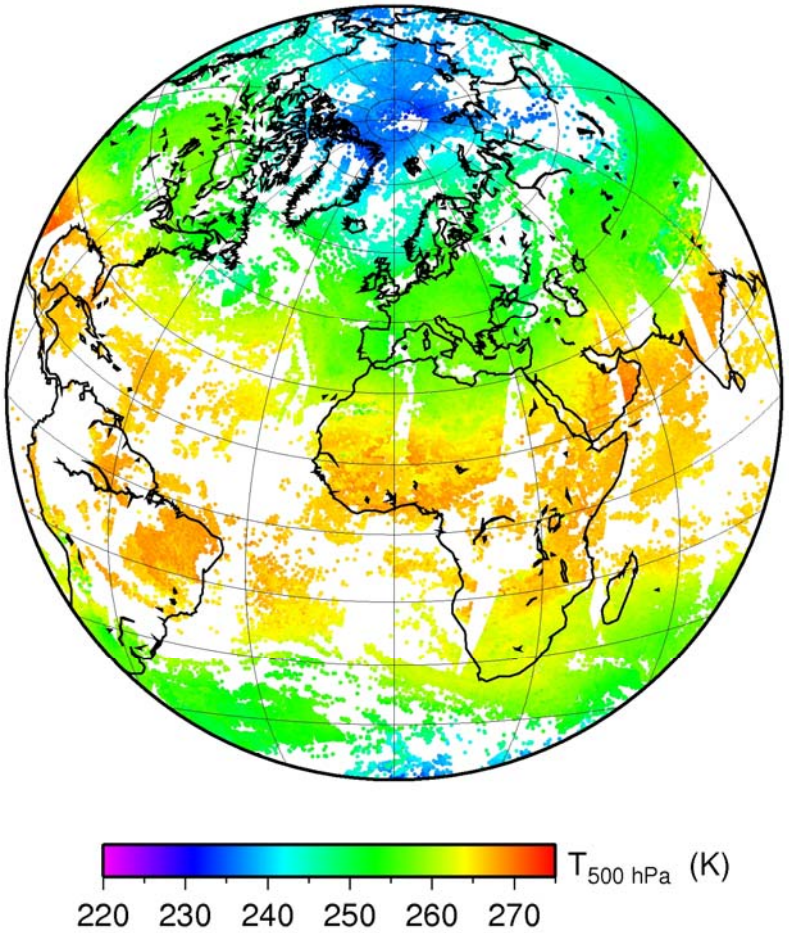
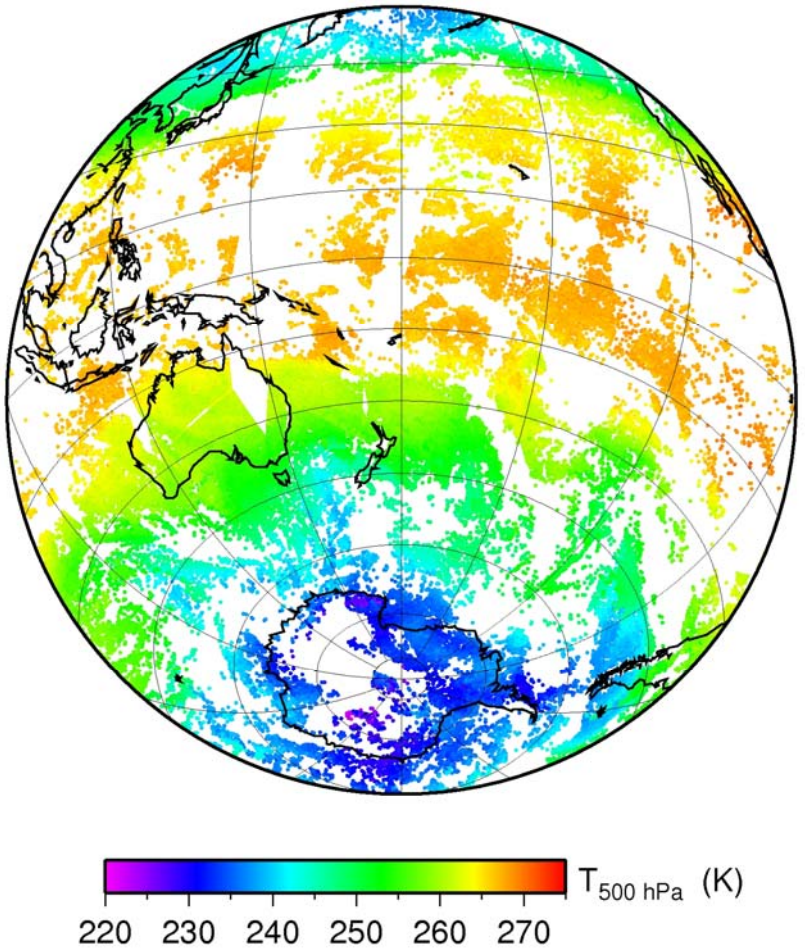
Temperature at 500 hPa: 16 October 2007



N < 5%



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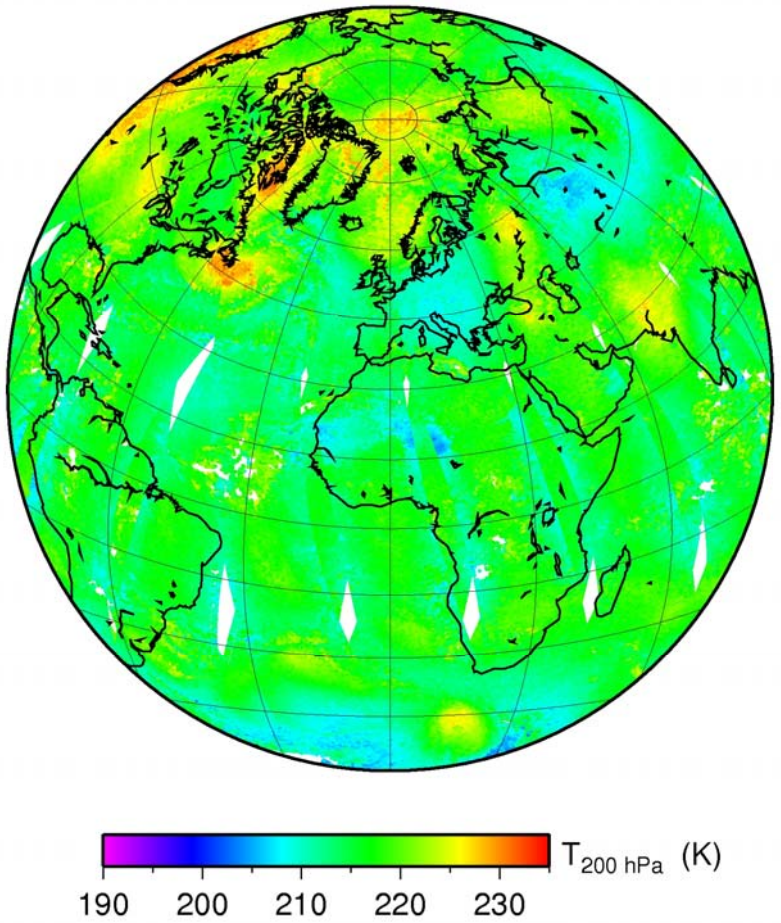
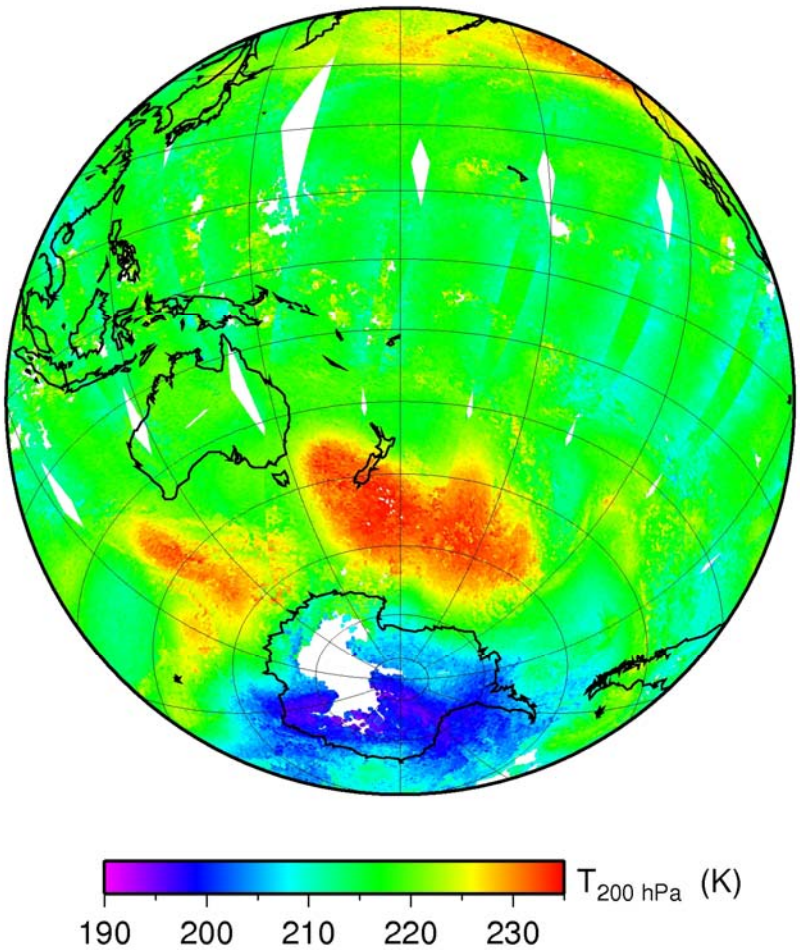
Temperature at 200 hPa: 16 October 2007



N < 5%



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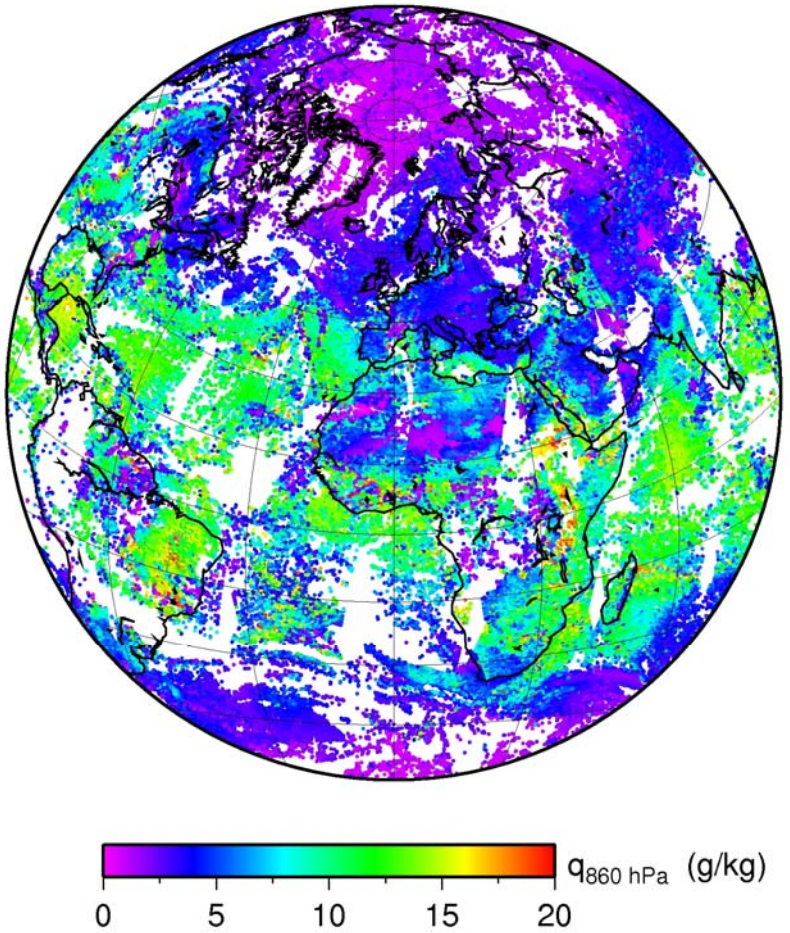
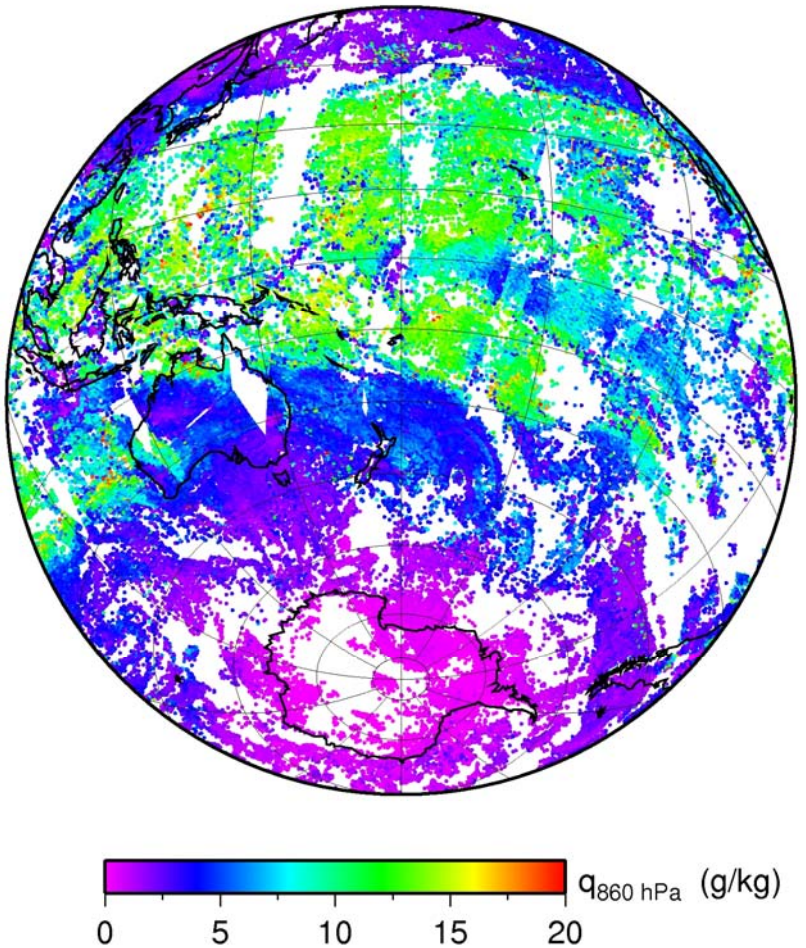
Specific Humidity at 860 hPa: 16 October 2007



N < 20%



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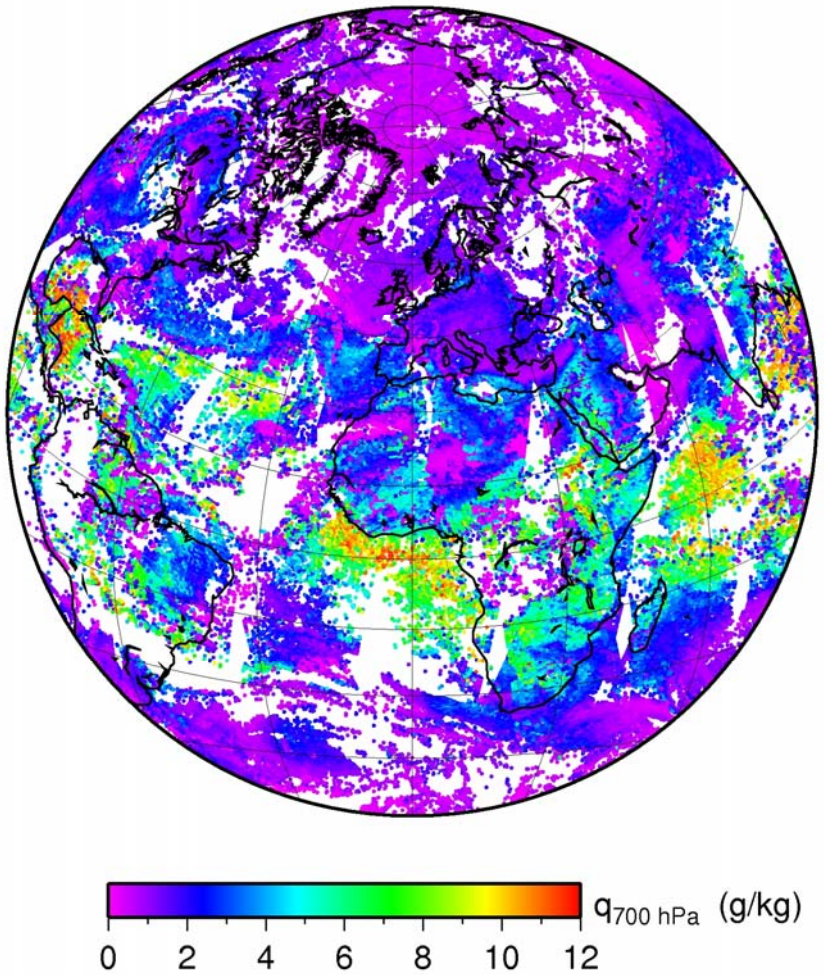
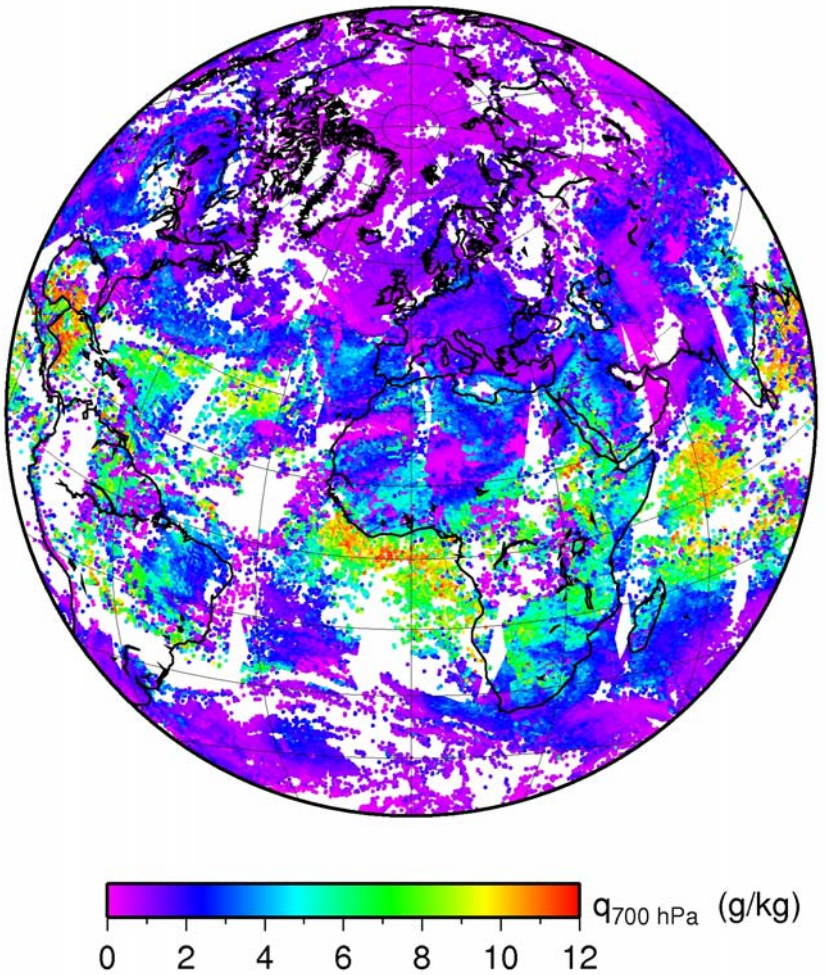
Specific Humidity at 700 hPa: 16 October 2007

N < 20%





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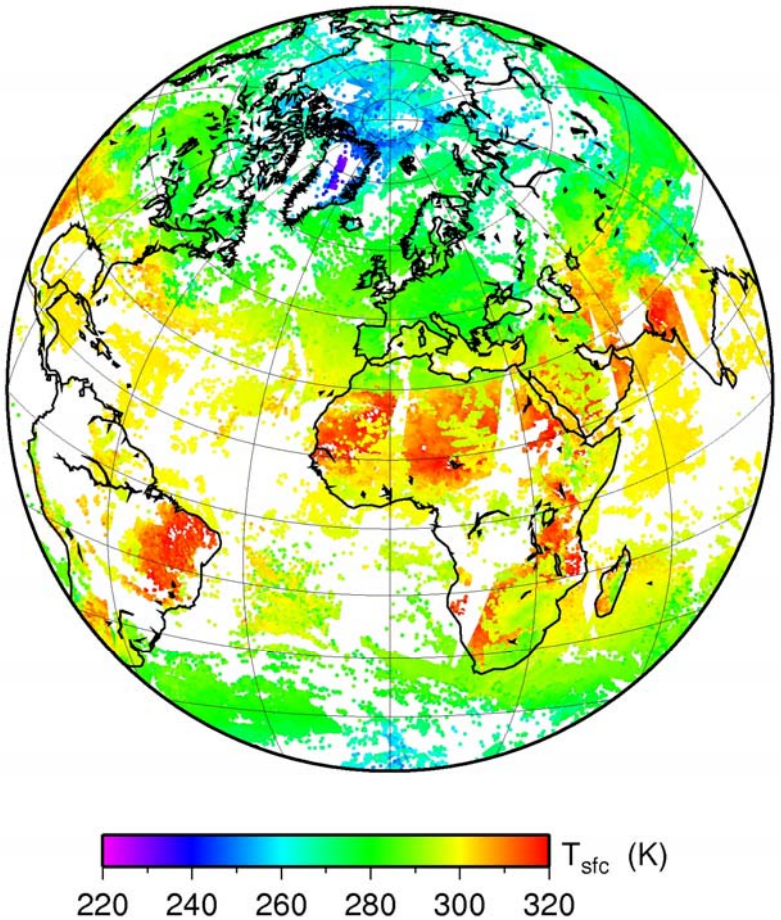
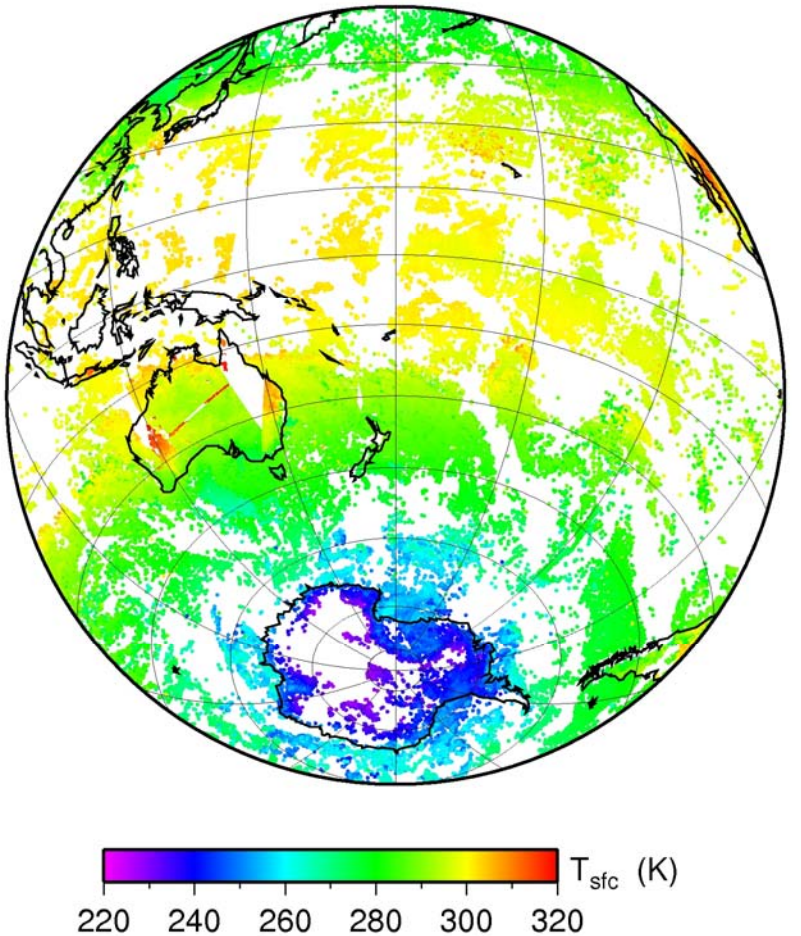
Surface Skin Temperature: 16 October 2007



N < 5%



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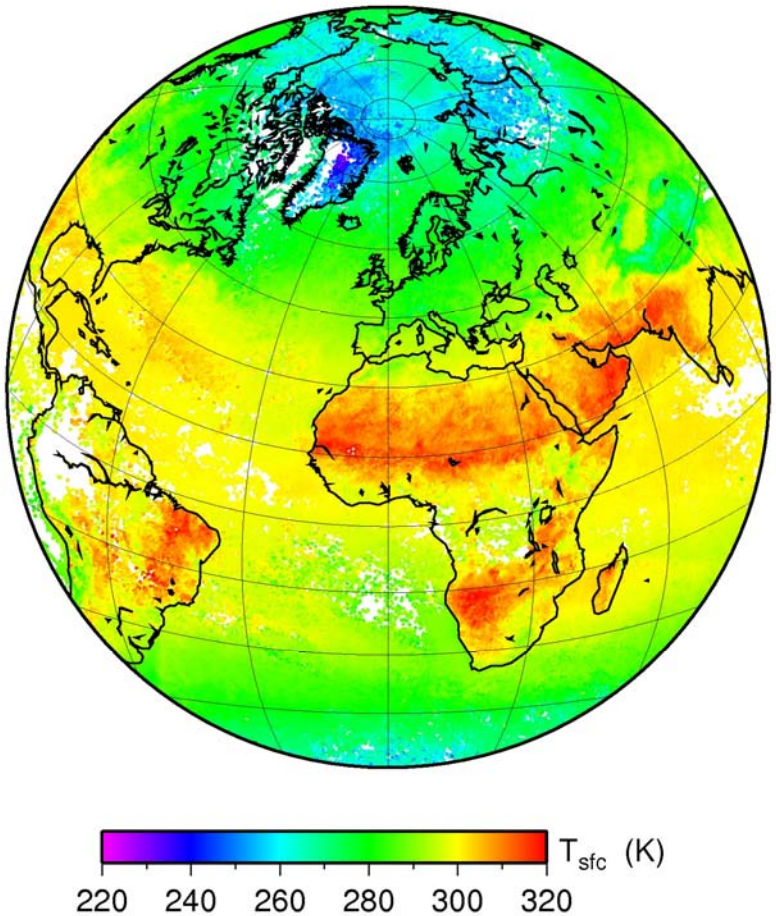
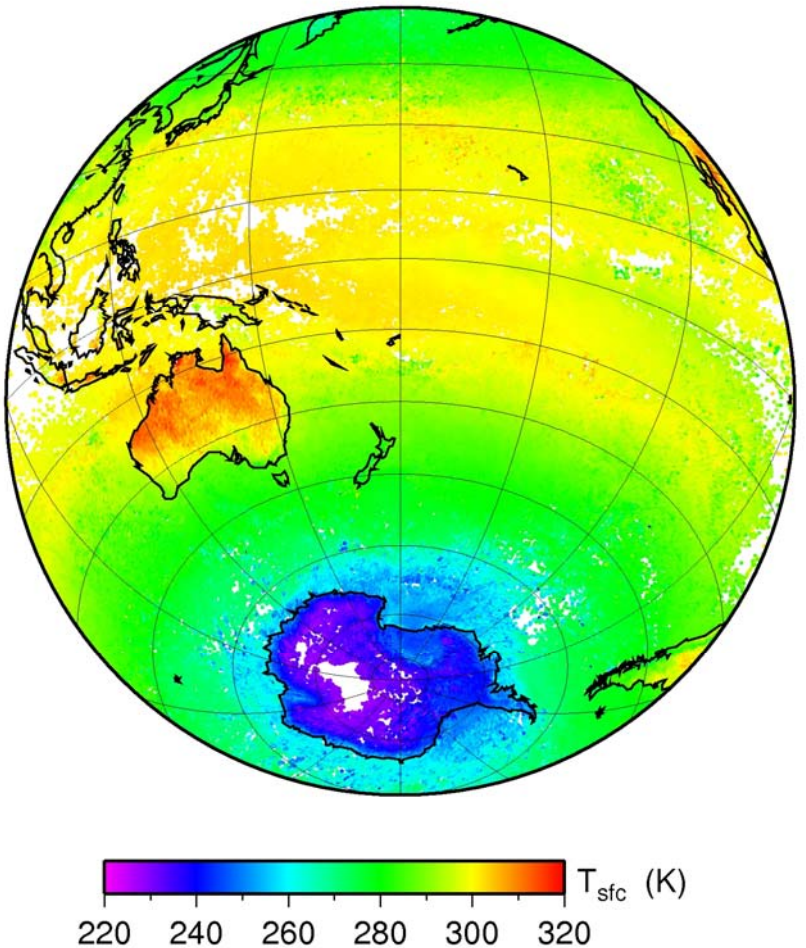
10 Day Average Sfc. Skin Temp.: 16-25 October 2007



N < 5%



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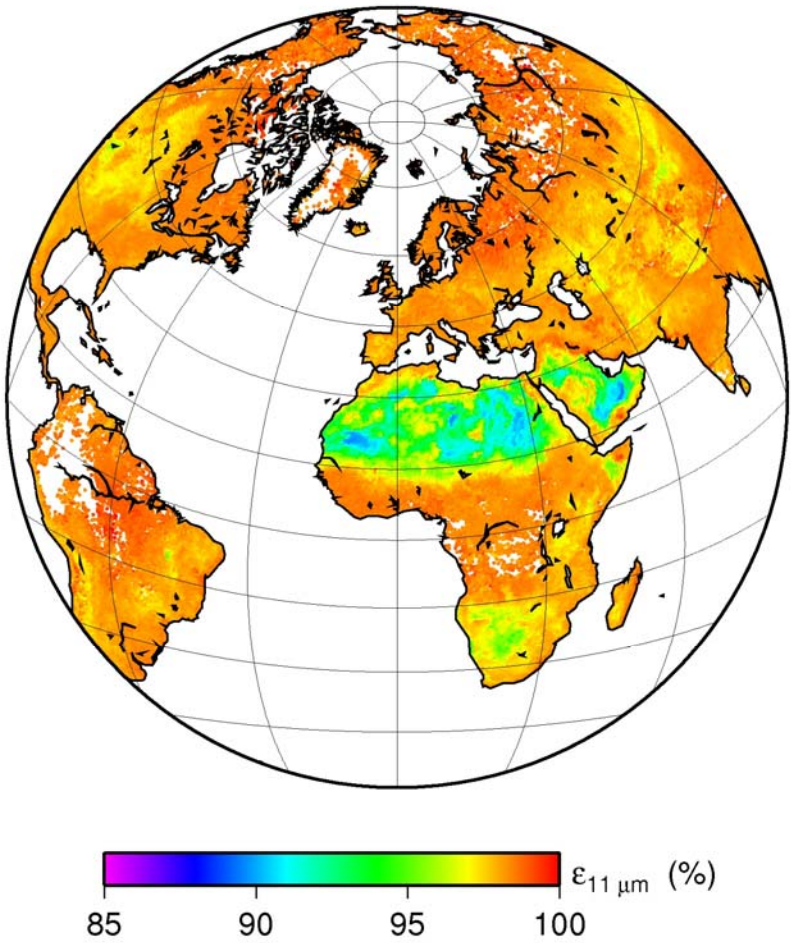
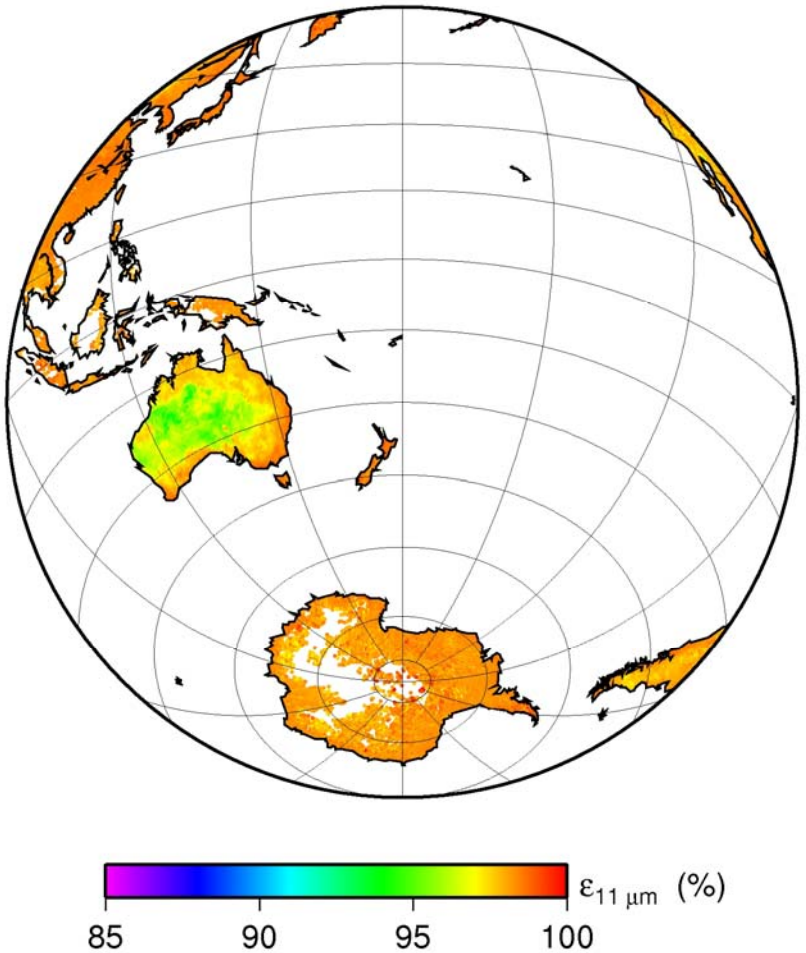
15 Day Average Emissivity at 11 μm: 16-30 October 2007

N < 5%





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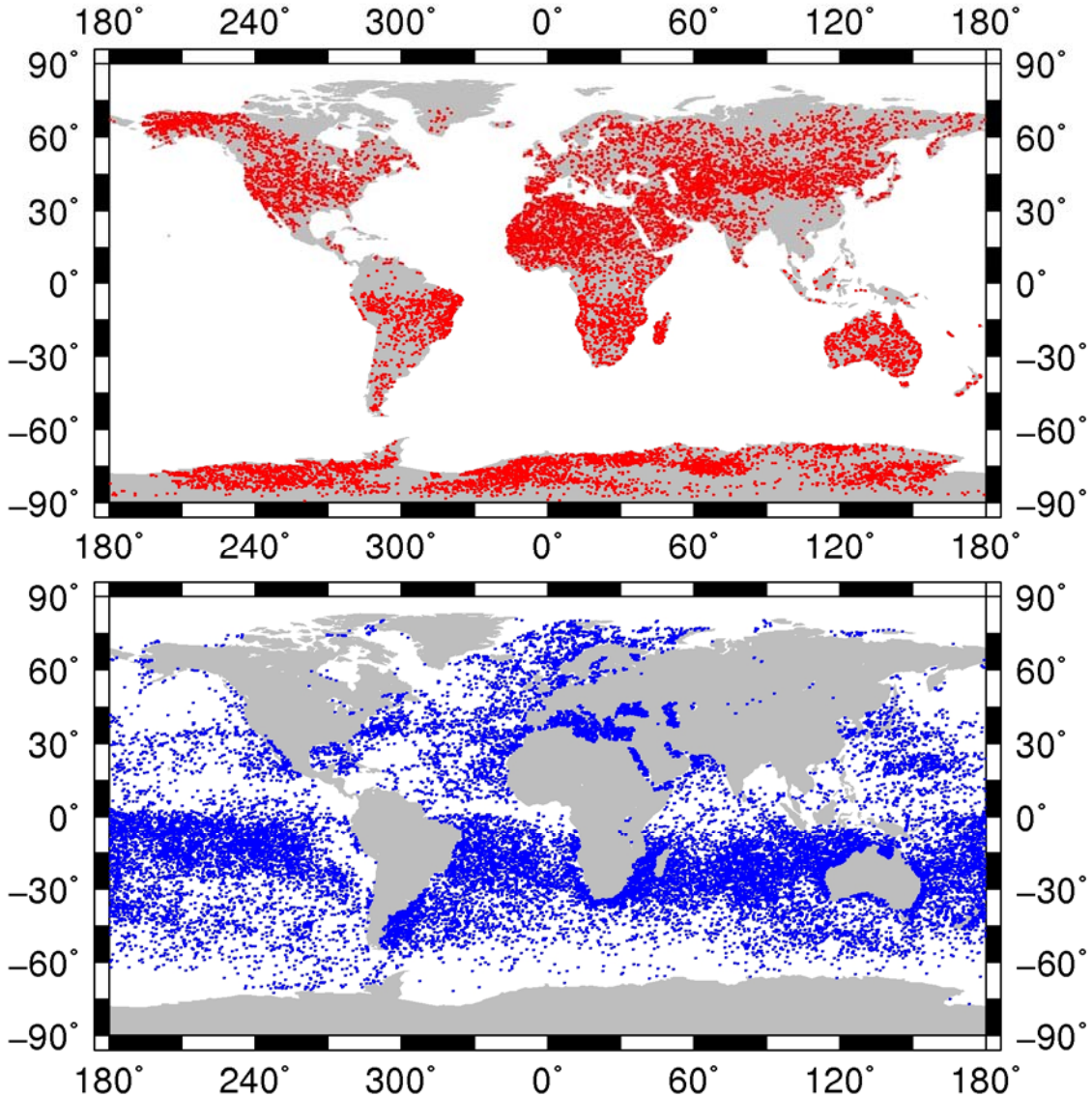

Comparison: ECMWF versus IASI

Clear situations
May – June 2007

Land: 1330 match-ups

Ocean: 21810 match-ups

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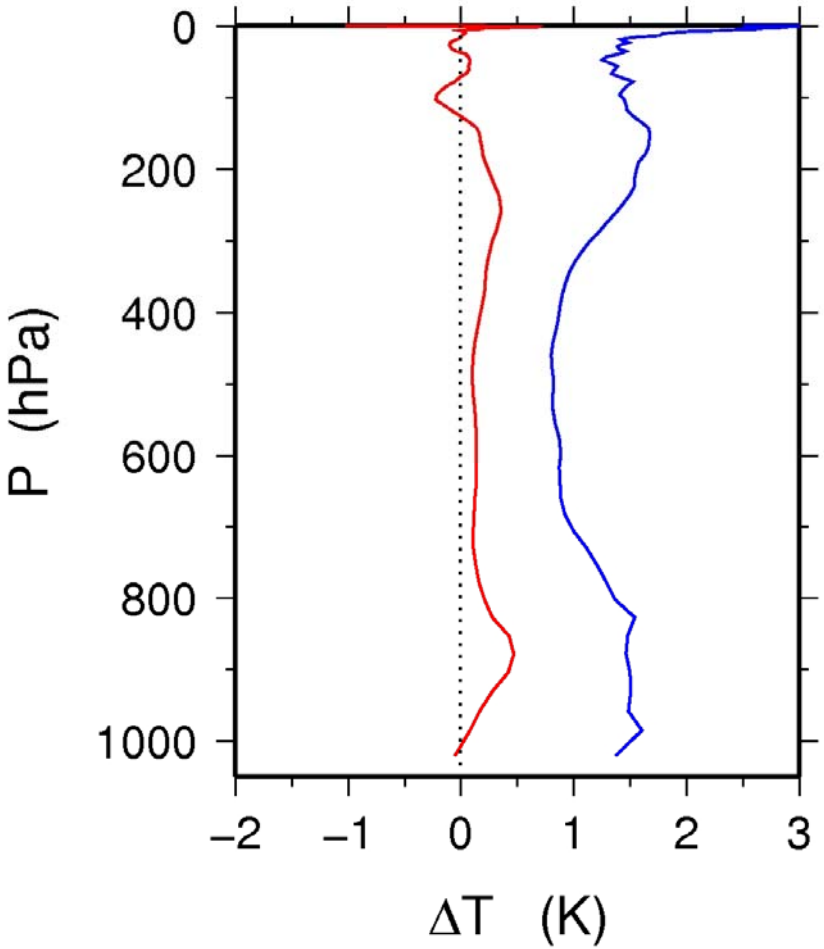
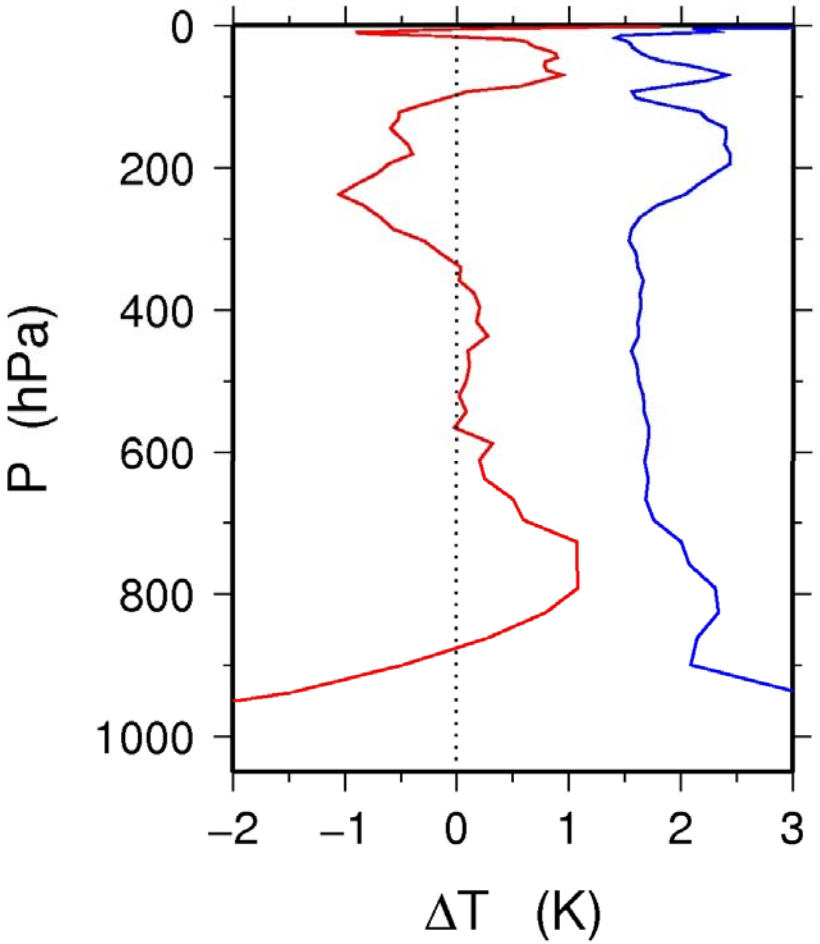
Comparison: ECMWF – IASI L2 (EOF regression)

Ocean



Land



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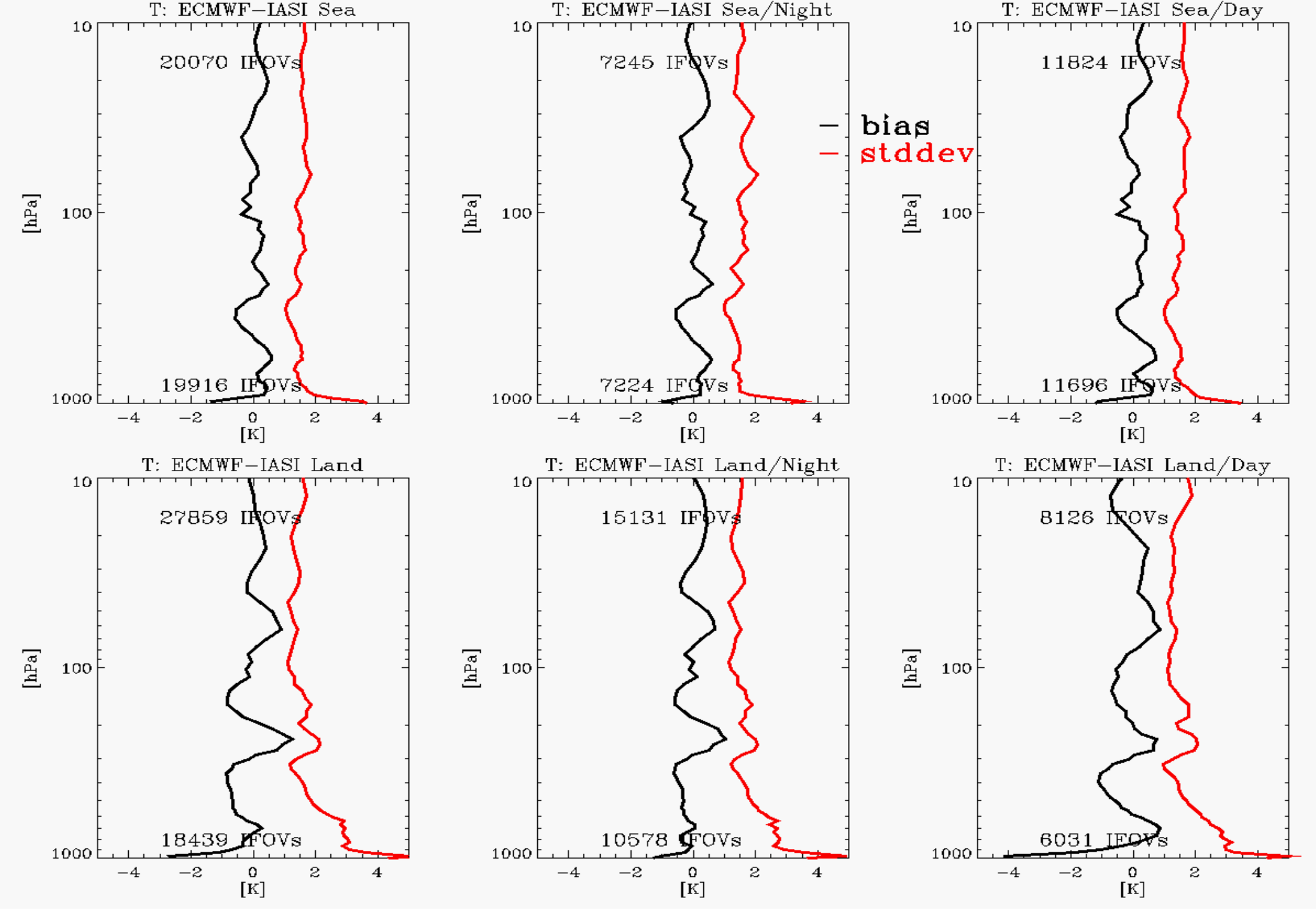
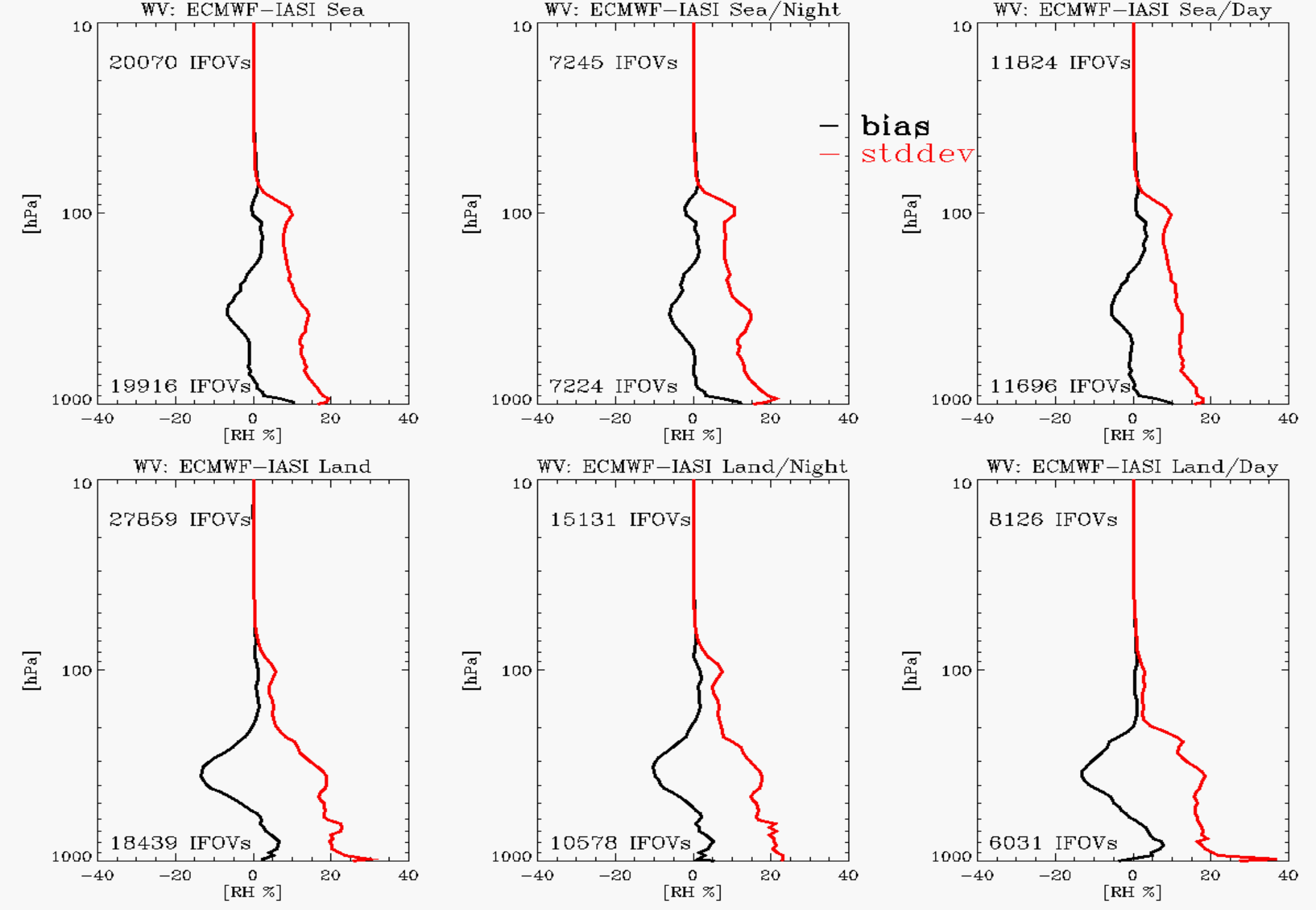
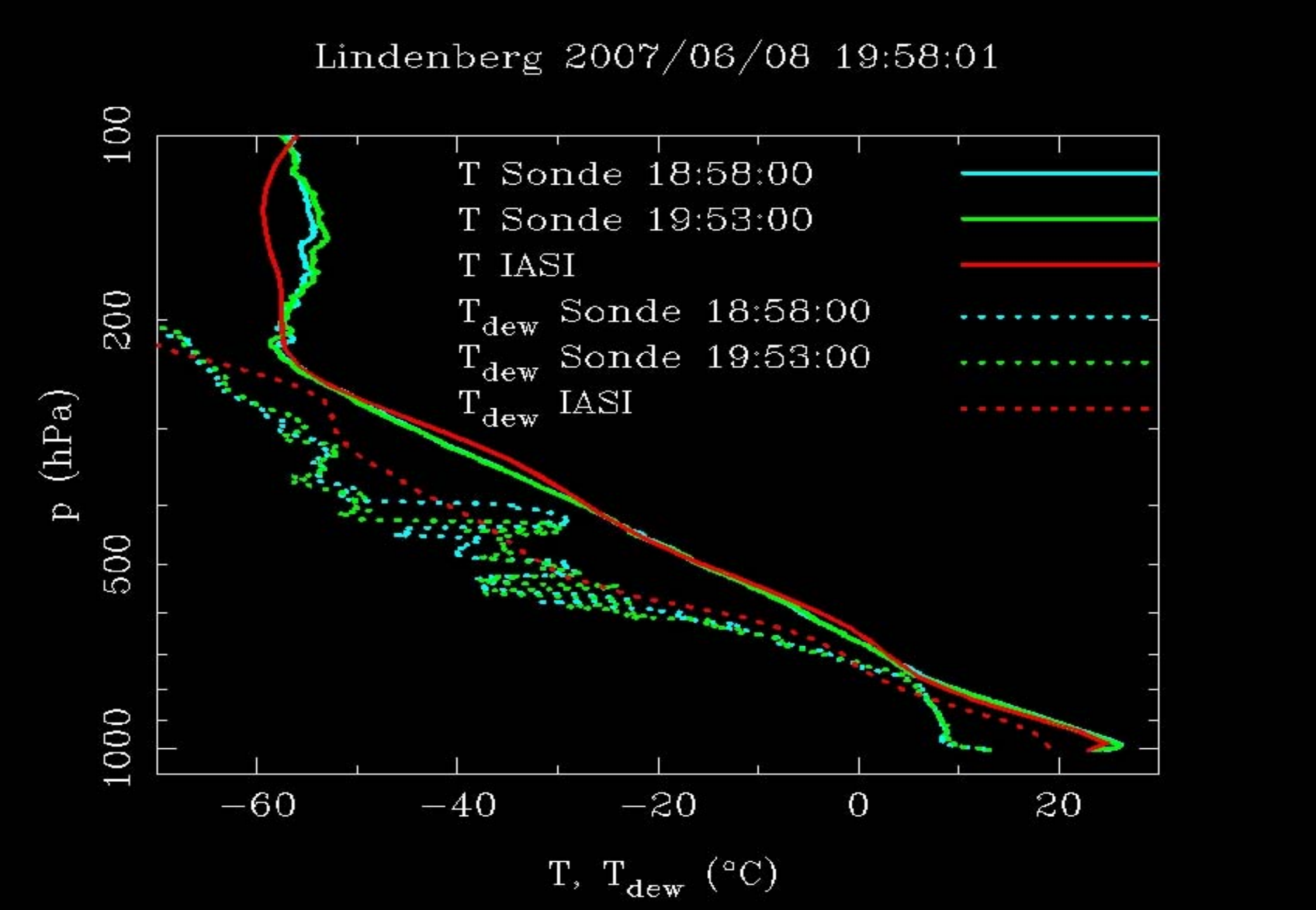

T: ECMWF−IASI Sea
20070 IFOVs
19916 IFOVs
T: ECMWF−IASI Sea/Night
7245 IFOVs
7224 IFOVs
T: ECMWF−IASI Sea/Day
11824 IFOVs
11696 IFOVs
bias
stddev
T: ECMWF−IASI Land
27859 IFOVs
18439 IFOVs
T: ECMWF−IASI Land/Night
15131 IFOVs
10578 IFOVs
T: ECMWF−IASI Land/Day
8126 IFOVs
6031 IFOVs
[hPa]
[K]
10
100
1000
−4
−2
0
2
4

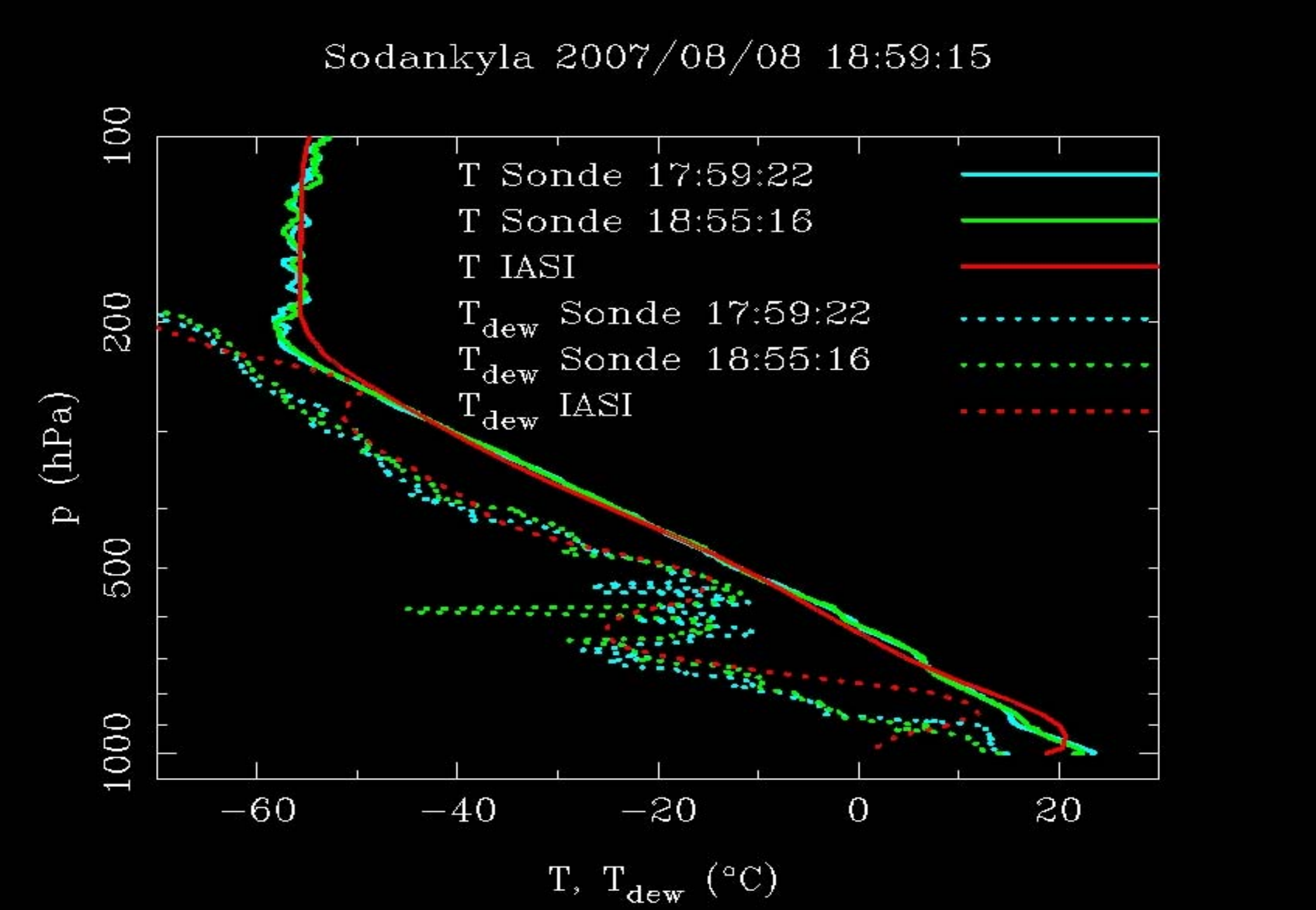

WV: ECMWF−IASI Sea
20070 IFOVs
19916 IFOVs
WV: ECMWF−IASI Sea/Night
7245 IFOVs
7224 IFOVs
WV: ECMWF−IASI Sea/Day
11824 IFOVs
11696 IFOVs
WV: ECMWF−IASI Land
27859 IFOVs
18439 IFOVs
WV: ECMWF−IASI Land/Night
15131 IFOVs
10578 IFOVs
WV: ECMWF−IASI Land/Day
8126 IFOVs
6031 IFOVs
bias
stddev
[hPa]
[RH %]
10
100
1000
−40
−20
0
20
40

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, continuing during clear situations

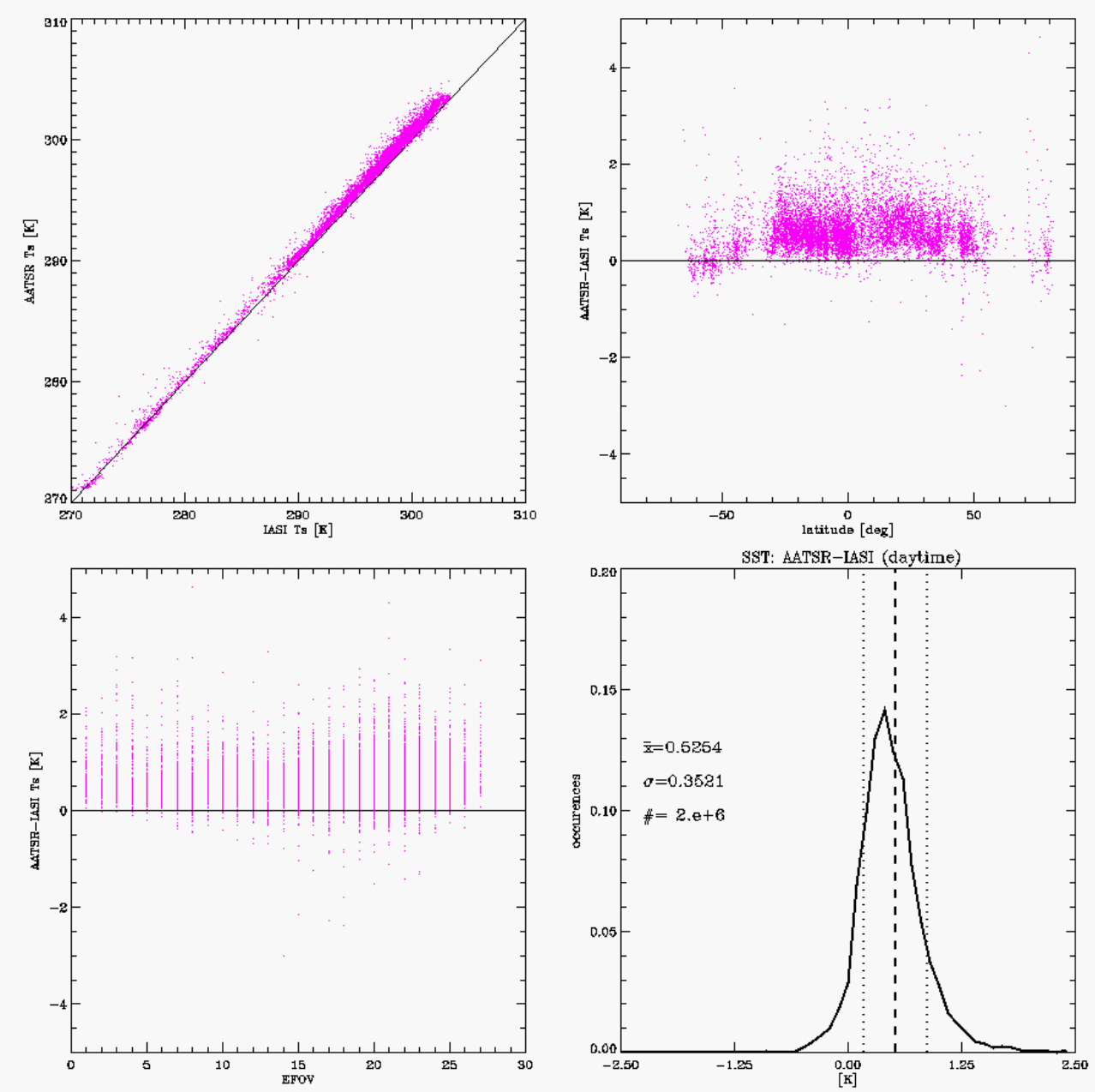
- See presentations by Xavier Calbet and Nikita Pougatchev


Lindenberg 2007/06/08 19:58:01
T Sonde 18:58:00
T Sonde 19:53:00
T IASI
T_dew Sonde 18:58:00
T_dew Sonde 19:53:00
T_dew IASI
p (hPa)
100
200
500
1000
−60
−40
−20
0
20
T, T_dew (°C)


Sodankyla 2007/08/08 18:59:15
T Sonde 17:59:22
T Sonde 18:55:16
T IASI
T_dew Sonde 17:59:22
T_dew Sonde 18:55:16
T_dew IASI
p (hPa)
100
200
500
1000
−60
−40
−20
0
20
T, T_dew (°C)

Systematic validation against radiosondes

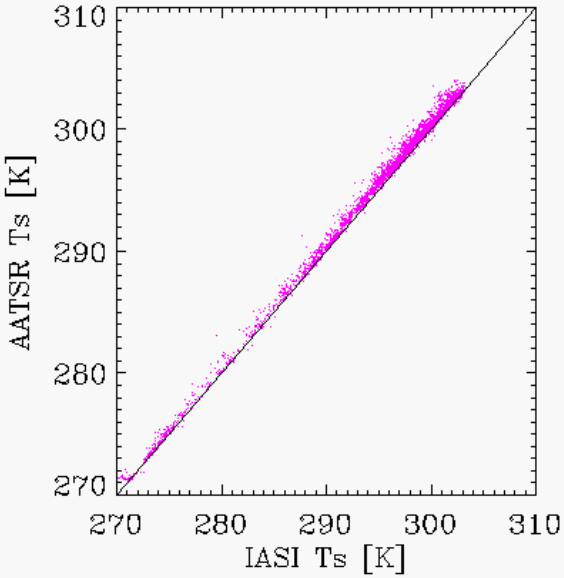
- Considering components of the error budget is important to isolate errors in IASI retrieval
- Temporal variability of the atmosphere between IASI sounding and duration of the radiosonde ascent can be important when radiosonde is not launched closely to the satellite overpass
- Spatial variability of the atmosphere between IASI sounding and radiosonde trajectory is increased by displacement of the radiosonde during its ascent
- Errors in radiosonde measurements need to be characterised
- IASI profile retrievals are made on a fine vertical grid that is not compatible with the averaging kernels of the sounding
- See presentation by Nikita Pougatchev

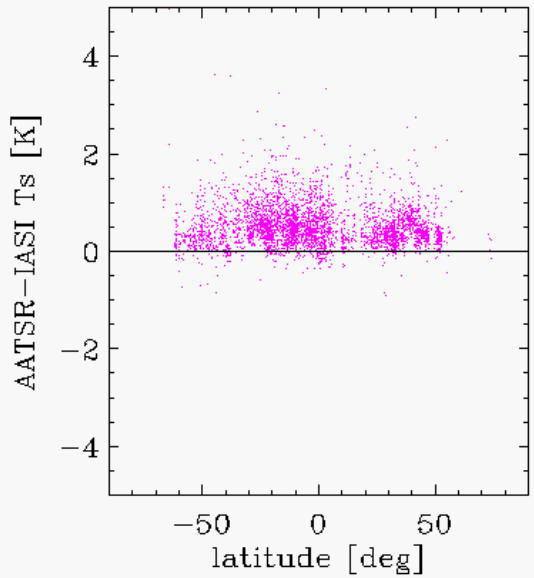


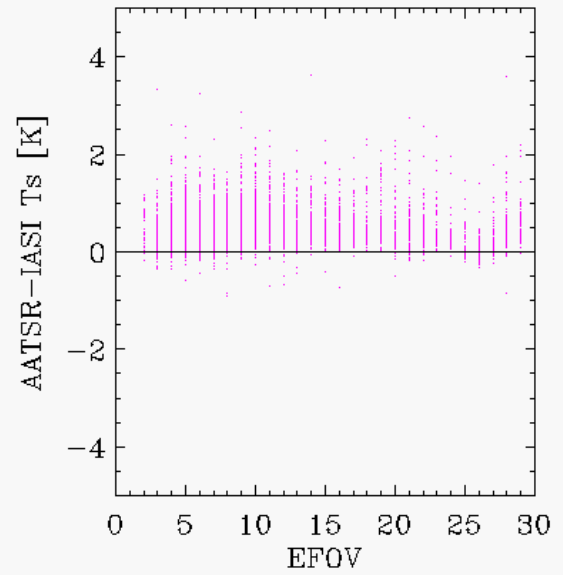
Validation: SST, daytime against AATSR@Envisat

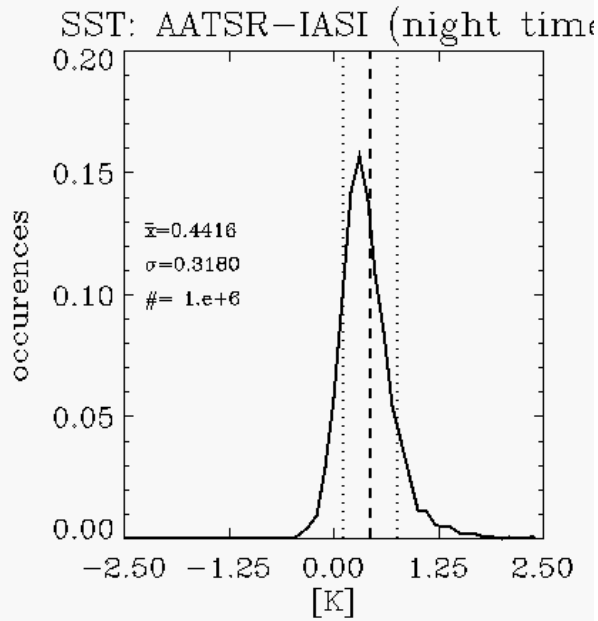
Bias: –0.52 K
Std. Dev.: 0.35 K
Nb. Match-ups: 200000
20 orbits in 08/2007
$\Delta t < 40$ min

EUMETSAT





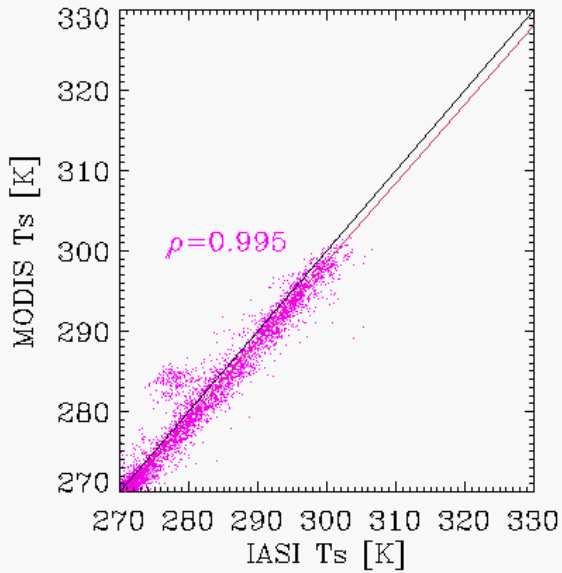


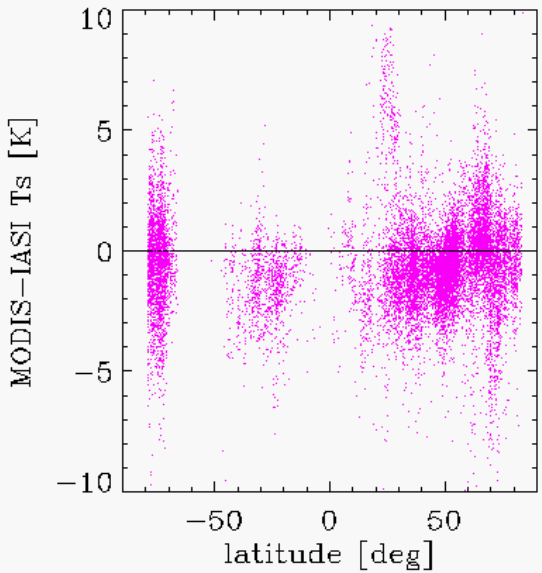


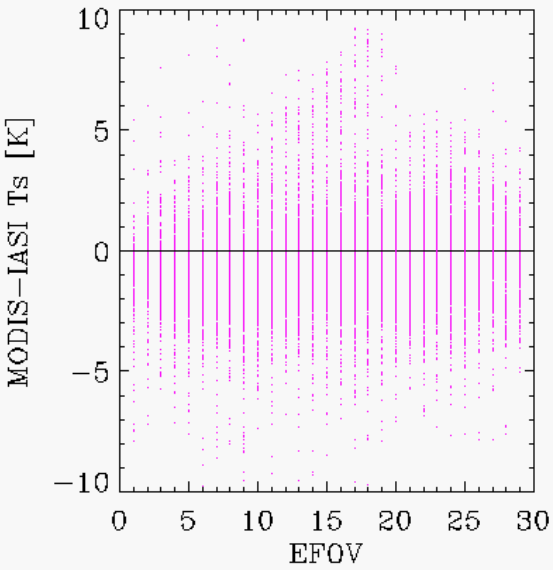
Validation: SST, nighttime against AATSR@Envisat

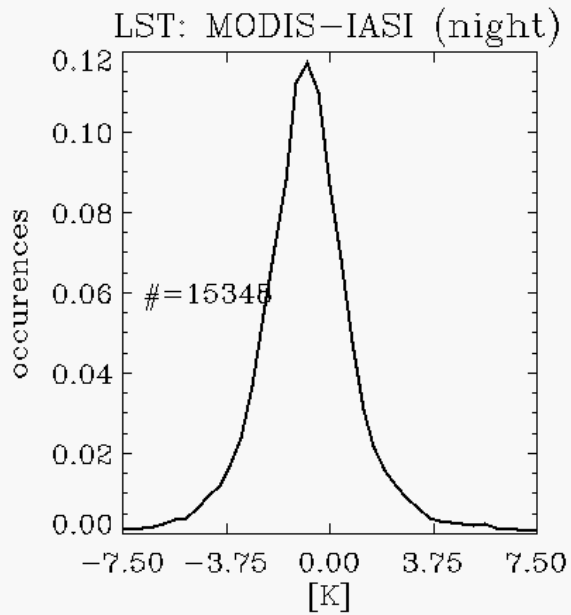
Bias: –0.44 K
Std. Dev.: 0.32 K
Nb. Match-ups: 100000
20 orbits in 08/2007
$\Delta t < 40$ min

EUMETSAT





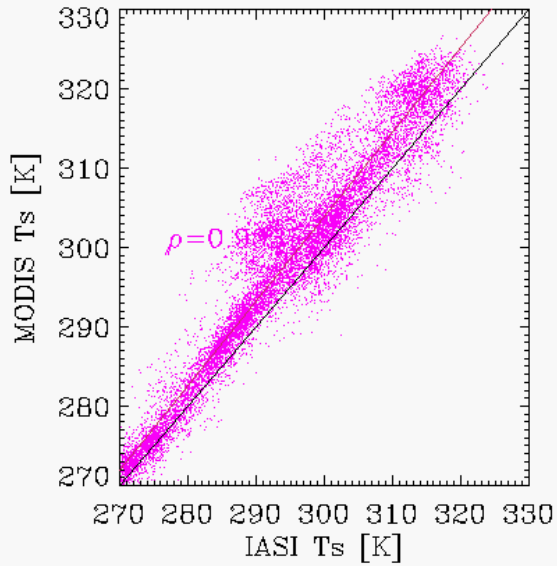


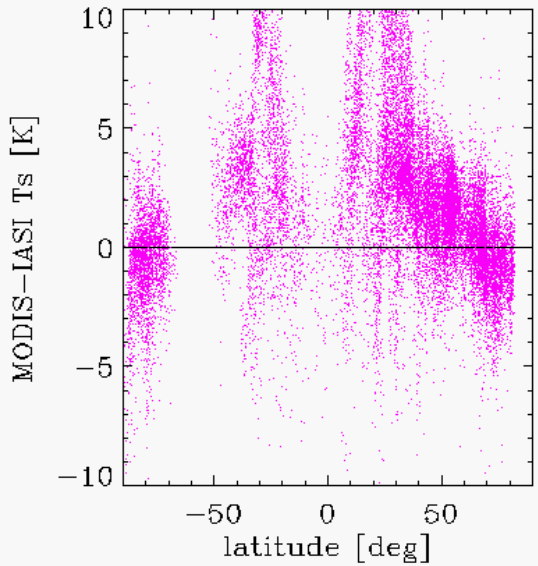


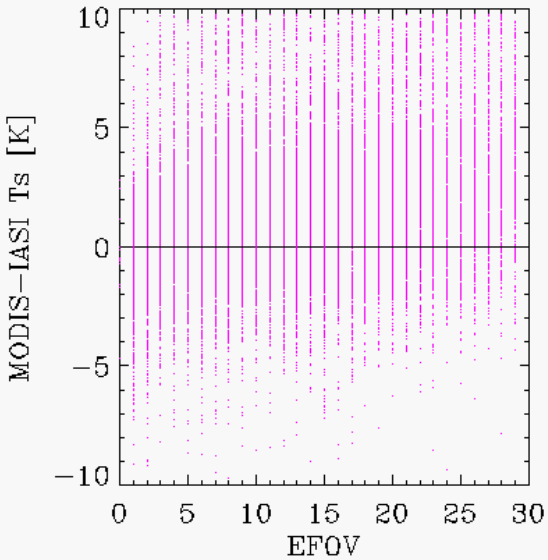
Validation: LST, nighttime against MODIS@Terra

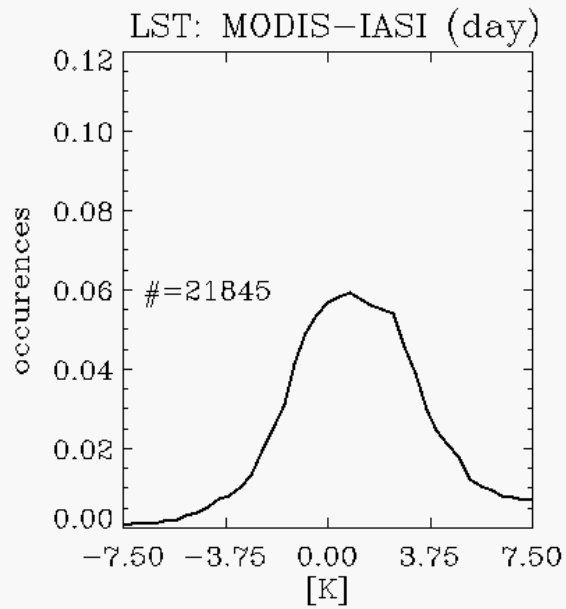
Bias: 0.5 K
Std. Dev.: 1.1 K
Nb. Match-ups: 15348
One day

EUMETSAT





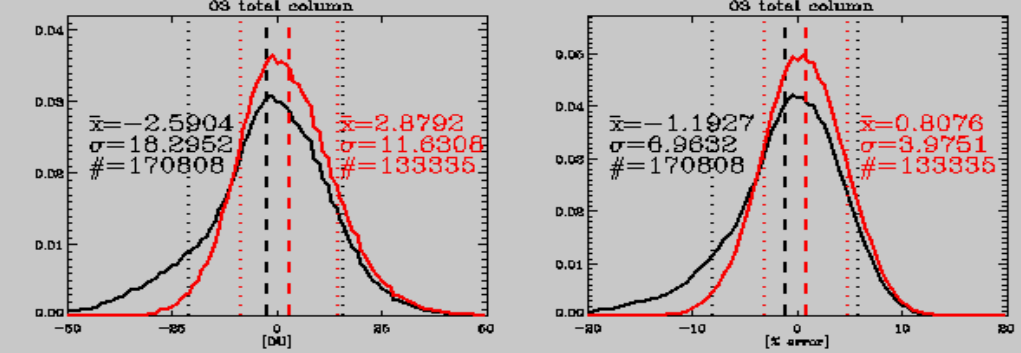


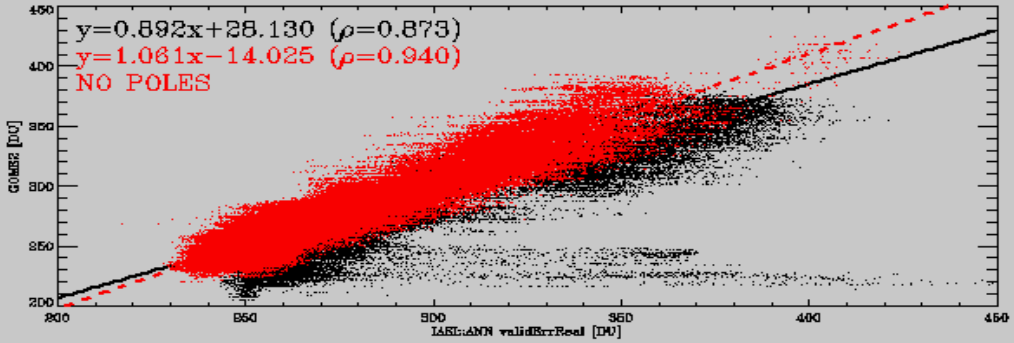


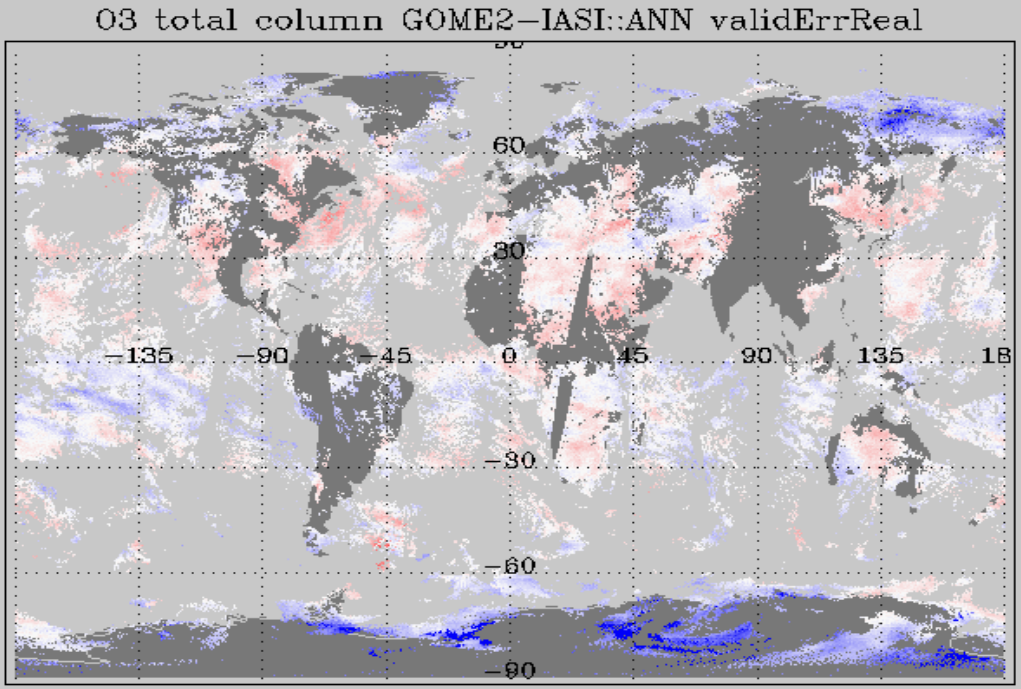
Validation: LST, daytime against MODIS@Terra

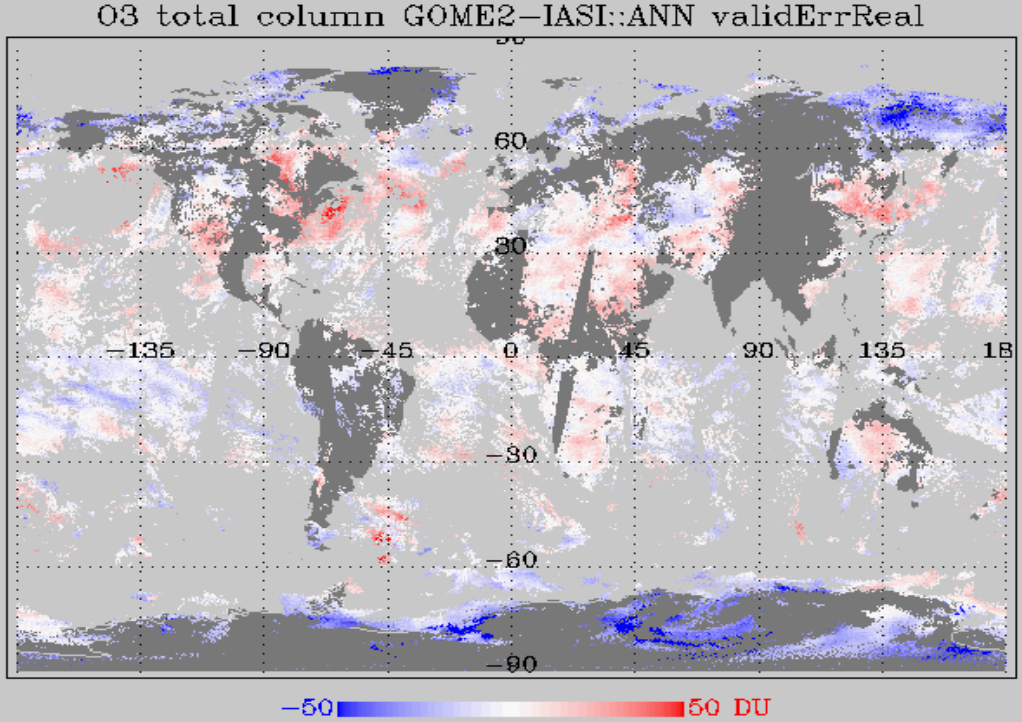
Bias: — 1.2 K
Std. Dev.: 2.2 K
Nb. Match-ups: 21845
One day

EUMETSAT



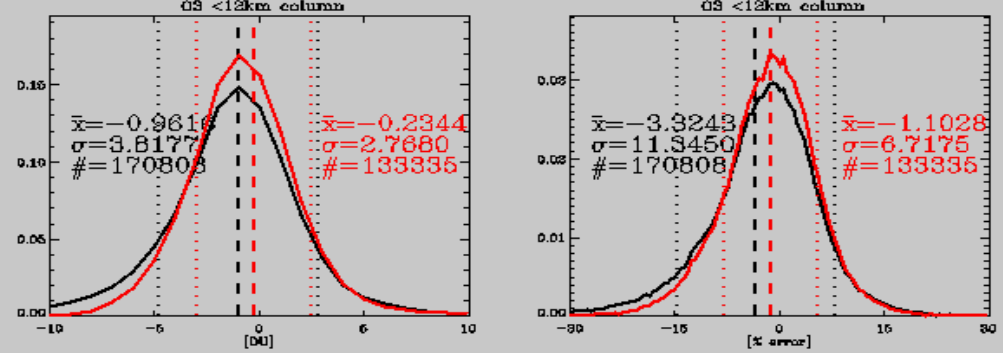


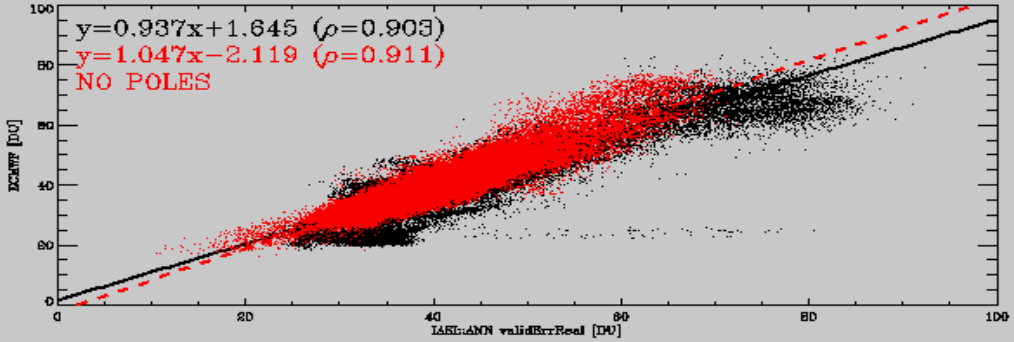


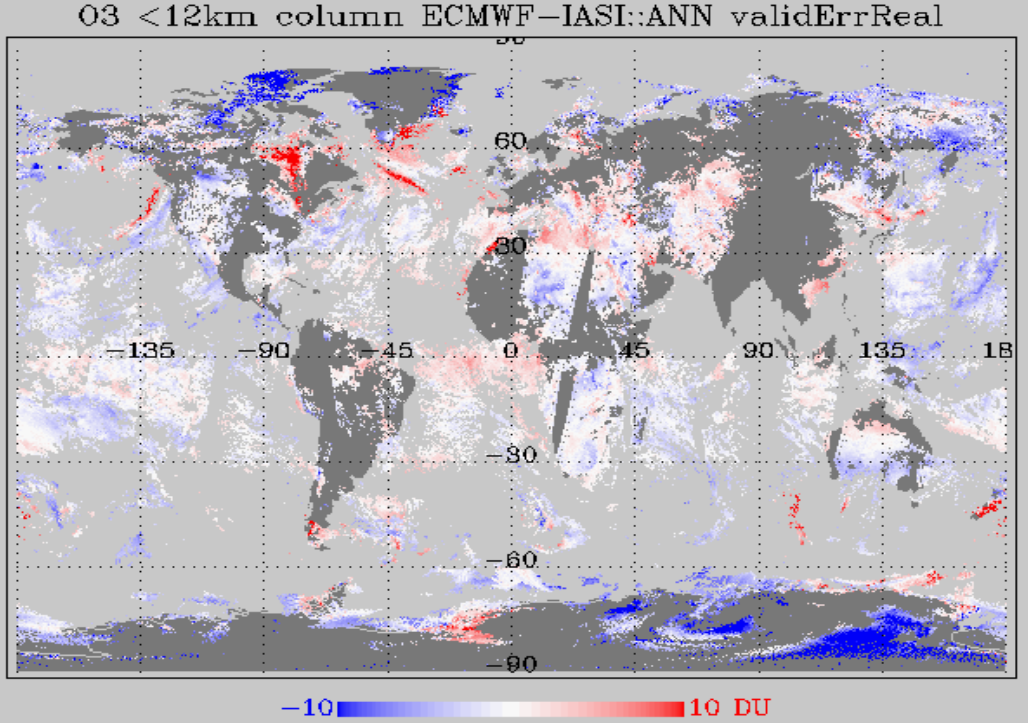


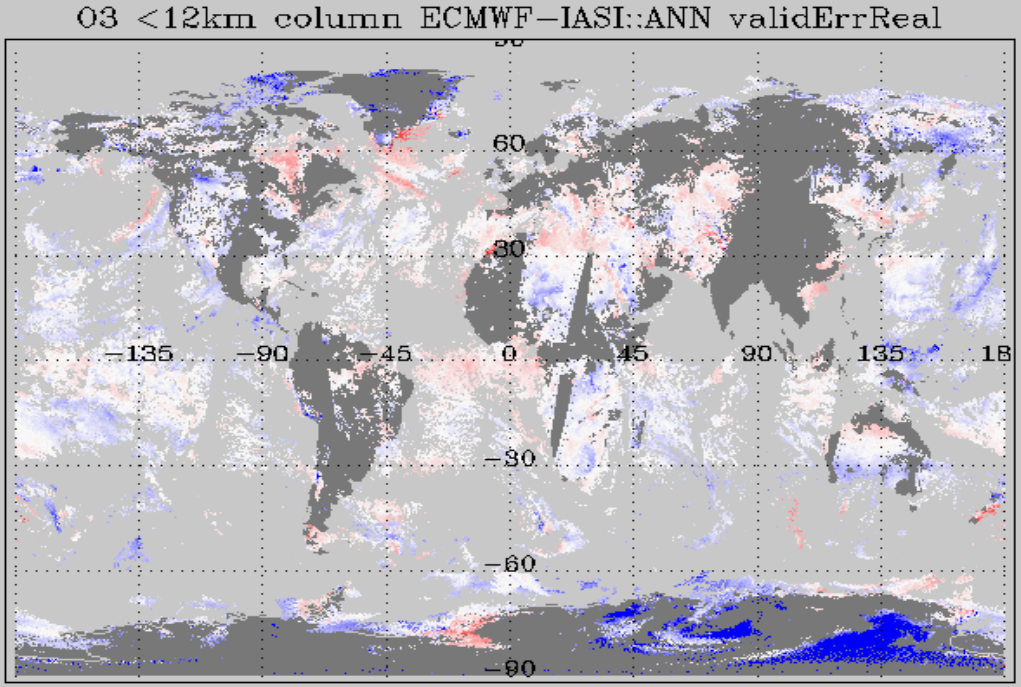
170808 IFOVs within 12 orbits from dates :
20070622

Validation: O_3 Column against *GOME-2*









170808 IFOVs within 12 orbits from dates :
20070622

Validation: O_3 Partial Column < 12 km against ECMWF

Dissemination to users

- IASI Level 1c data dissemination started on 29 May 2007
  - Full spectra via EumetCast and to NOAA
  - 300 selected spectral samples via GTS
- The IASI L2 NRT 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, CH_4, N_2O, CO_2
  - EMS: Land surface emissivity
- IASI level 2 products are disseminated via EUMETCast and GTS
- The operational dissemination of level 2 products has started on 28 April 2008
- All products are accessible from the UMARF in native and HDF formats

Outlook

- Beyond the initial “day-1 processing” a number of construction areas exist
- Need for improvement of humidity retrievals
  - Possible separation of temperature and humidity retrievals
- Implementation faster radiative transfer model in iterative retrieval
  - Use of PCRTM
- Analysis of novel cloud detection and characterisation methods
  - Artificial neural networks
  - Variational cloud detection
- Work on improvement of cloudy retrievals
  - Inclusion of microwave soundings
  - Treatment on non-black clouds in iterative retrieval

more info: www.eumetsat.int

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