Generation and assimilation of IASI level 2 products

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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**

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

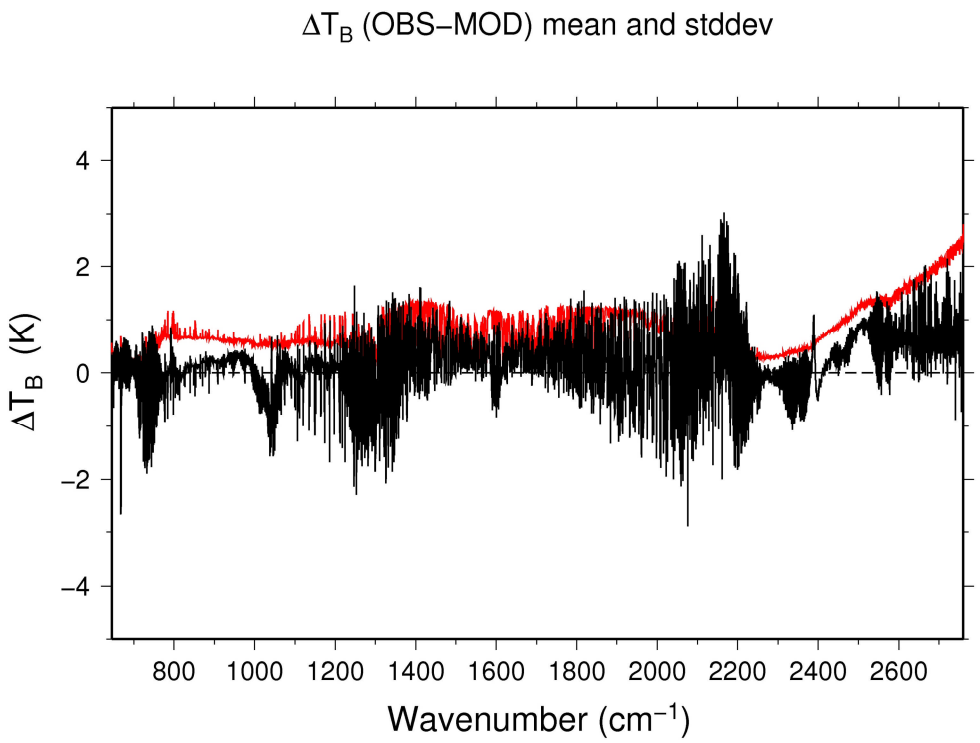
- In case of clouds and elevated surface the state vector has to be modified

- 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

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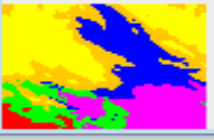
Location and Geometry | IASI Spectrum | Radiance Analysis

	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

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

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

Operational status

- IASI L2 PPF Version 4.3.2 runs on GS-1, as described in IASI L2 PGS, and generates products for NRT dissemination

- Products are broken down in 5 IASI L2 BUFR products

– **Atmospheric temperature**	**TWT, operational**
– **Atmospheric water vapour**	**TWT, operational**
– **Surface temperature**	**TWT, operational**
– **Cloud parameters**	**CLP, operational**
– **Atmospheric ozone**	**OZO, pre-operational**
– **Trace gases**	**TRG, pre-operational: CO**
– **Surface emissivity**	**not disseminated yet**

- All products are available from UMARF in non-NRT mode
  - Associated error covariances are only available from UMARF

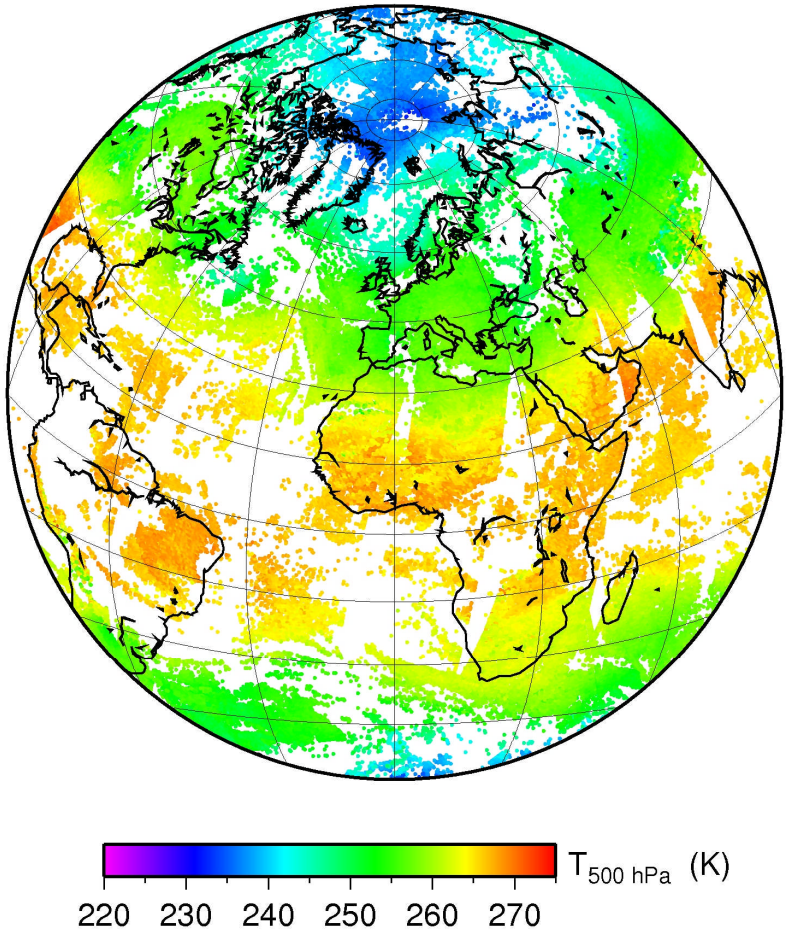
Validation status (1/2)

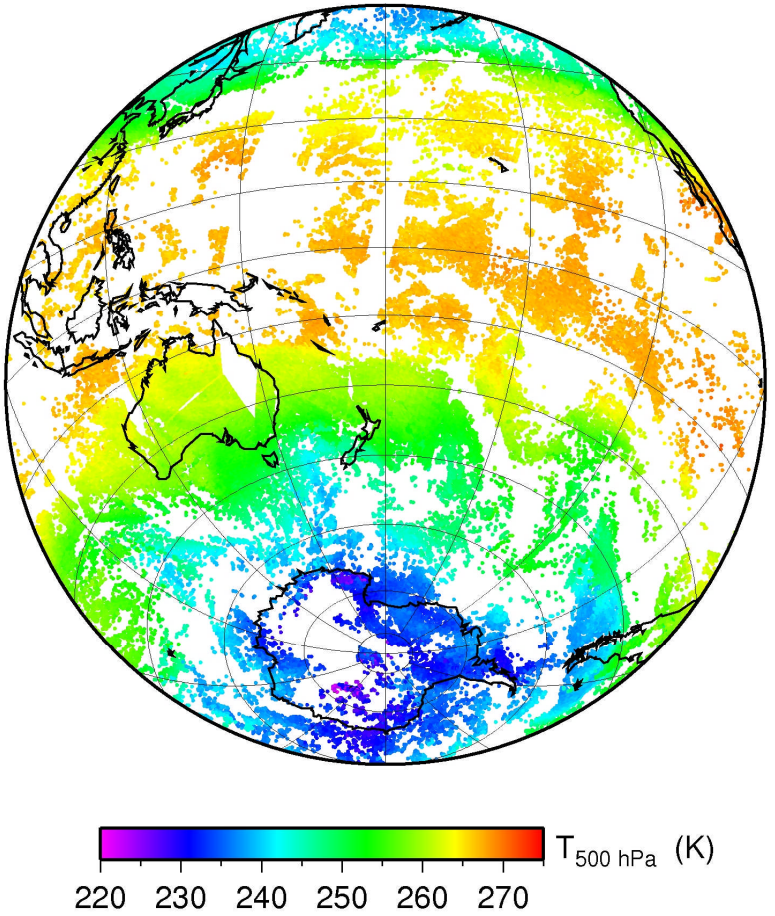
- **Temperature and water vapour profiles**
  - ECMWF analyses
  - Radiosonde measurements from validation campaigns
- **Sea surface temperature**
  - AATSR@Envisat
- **Land surface temperature:**
  - MODIS@Terra
  - LSA SAF radiometric surface temperature measurements in Gobabeb
- **Ozone**
  - GOME-2
  - Ozone sonde measurements
- **Carbon monoxide**
  - MOPITT@Terra

Validation status (2/2)

- **Cloud detection and phase**
  - Visual analysis of AVHRR imagery
- **Cloud fraction**
  - Visual analysis of AVHRR imagery
  - Cloud observations from validation campaign
- **Cloud top pressure**
  - Cloud radar measurements from validation campaign
- **Nitrous oxide**
  - Chemical transport model
- **Carbon dioxide**
  - No validation yet
- **Methane**
  - No validation yet

Temperature at 500 hPa: 16 October 2007





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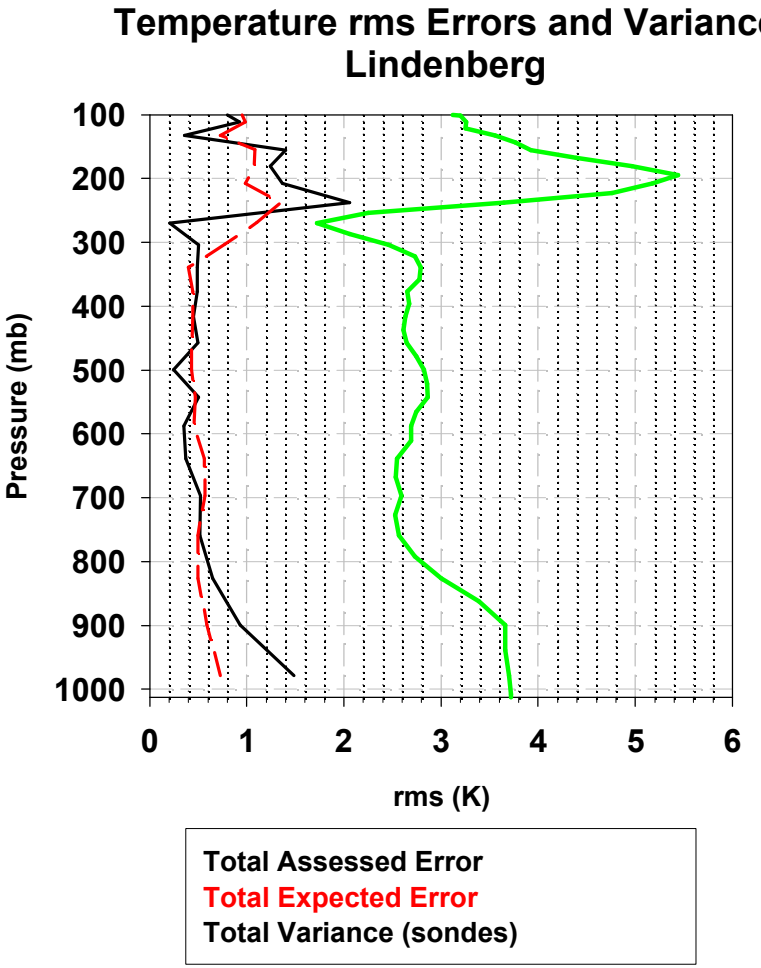
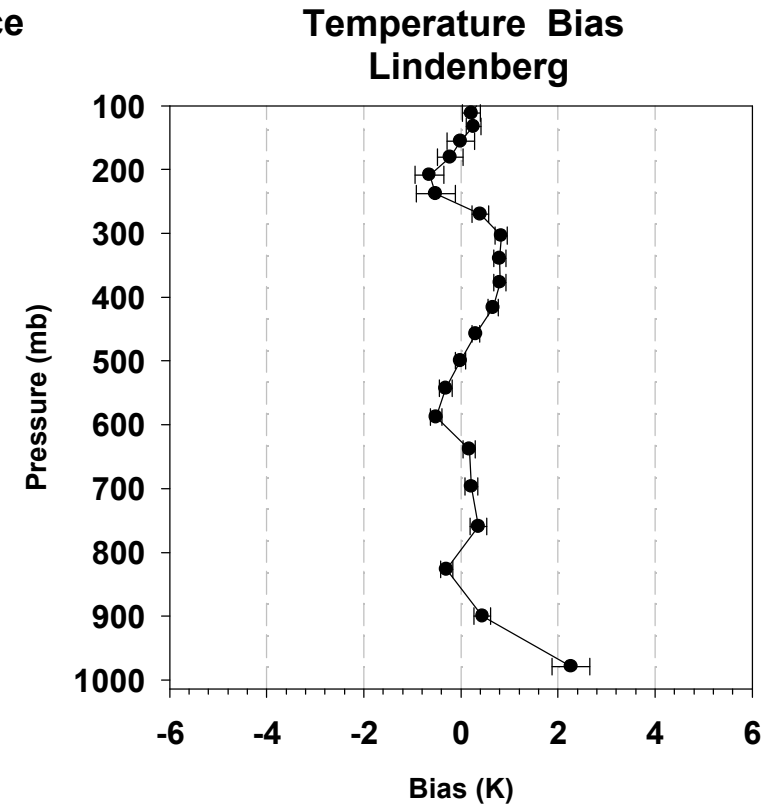
Validation examples: atmospheric temperature





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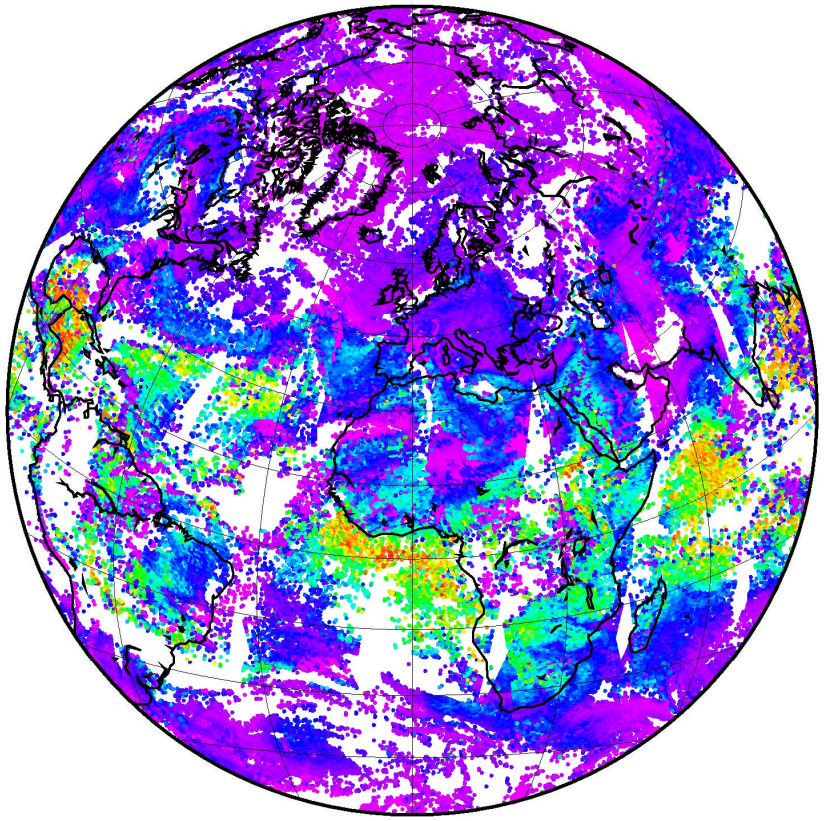
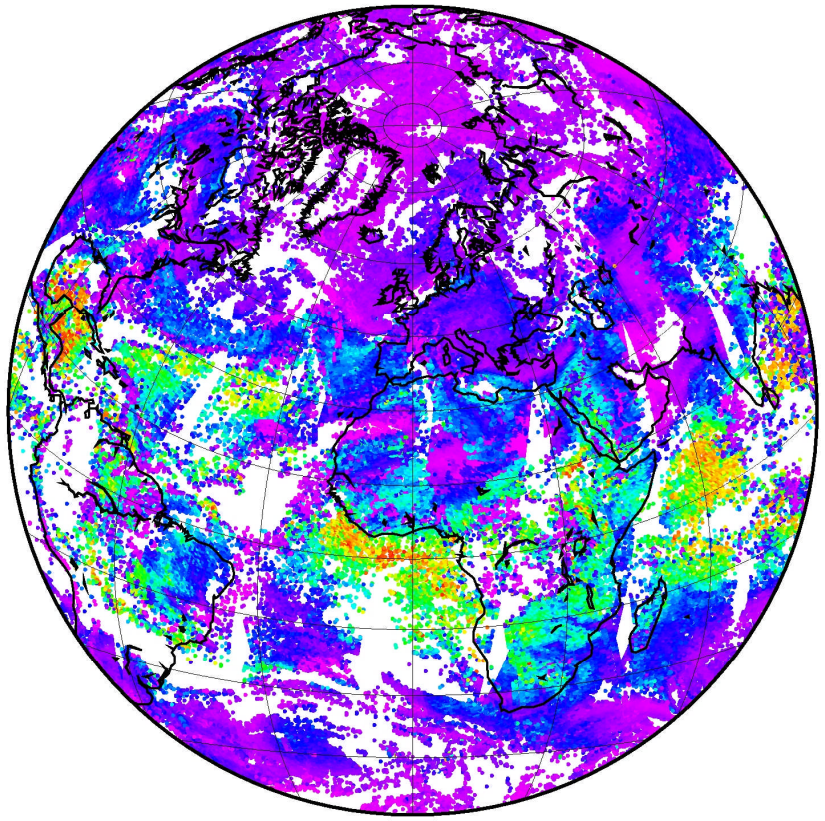
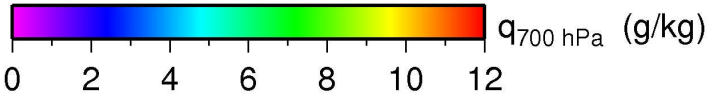
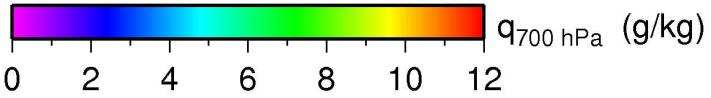
Specific Humidity at 700 hPa: 16 October 2007

N < 20%









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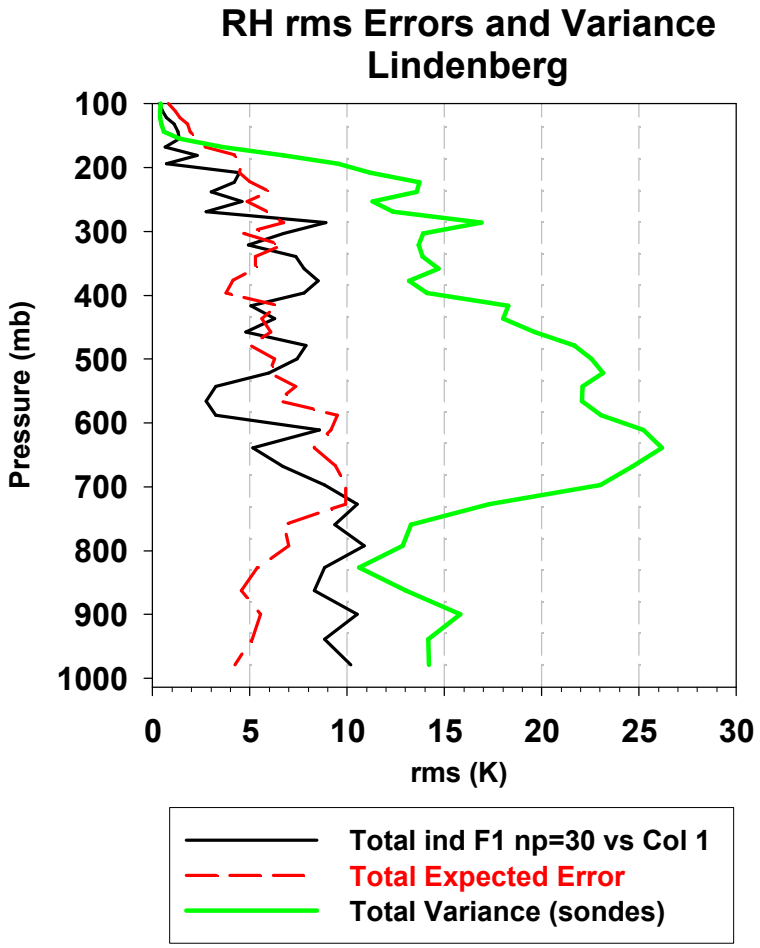
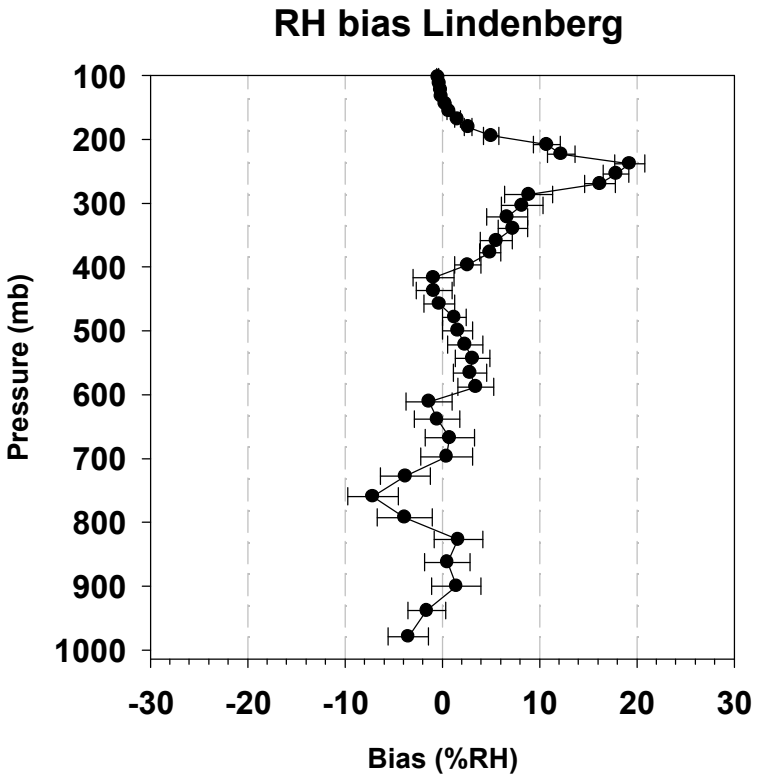
Validation examples: atmospheric water vapour





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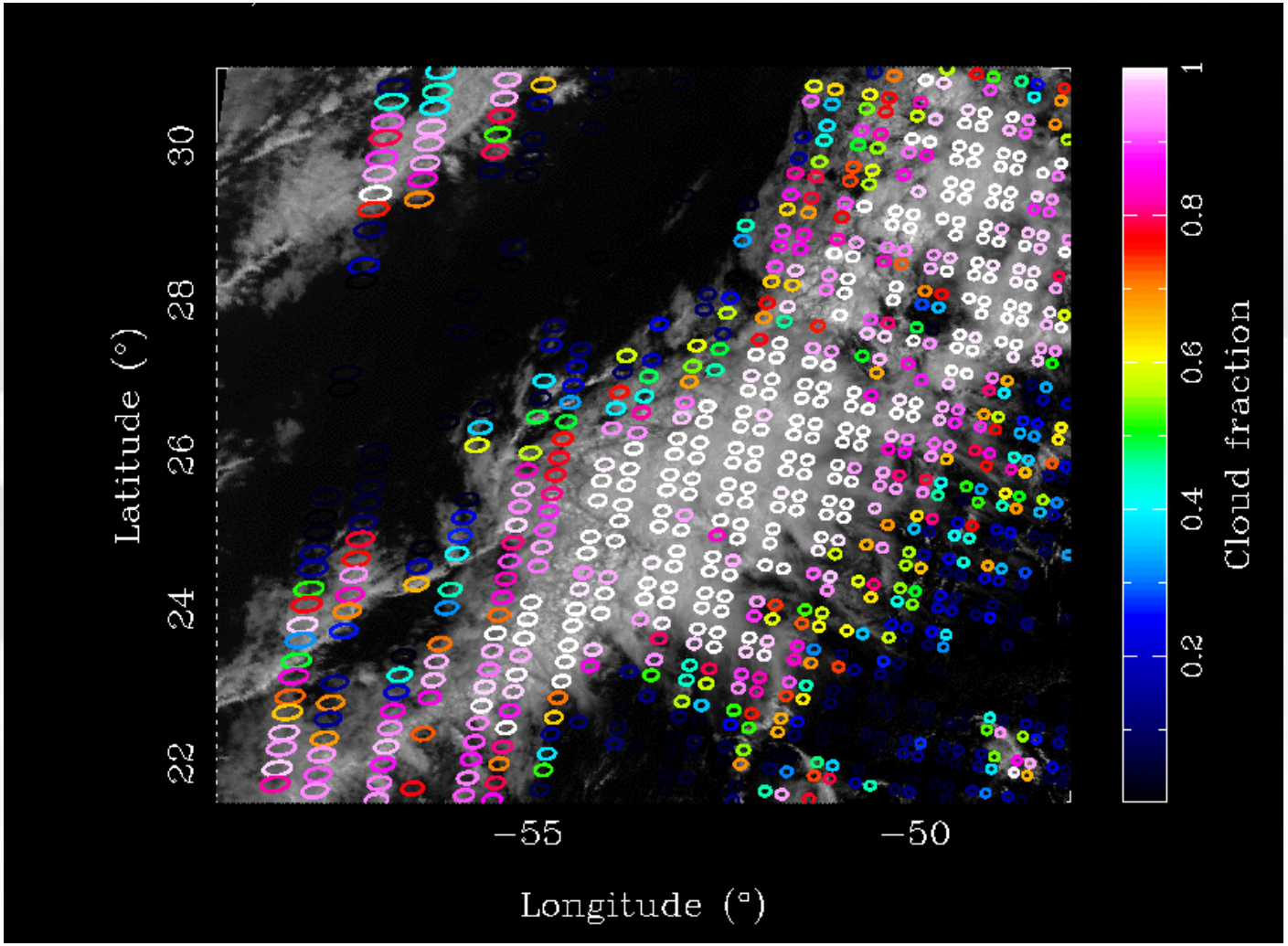
Validation examples: cloud fraction



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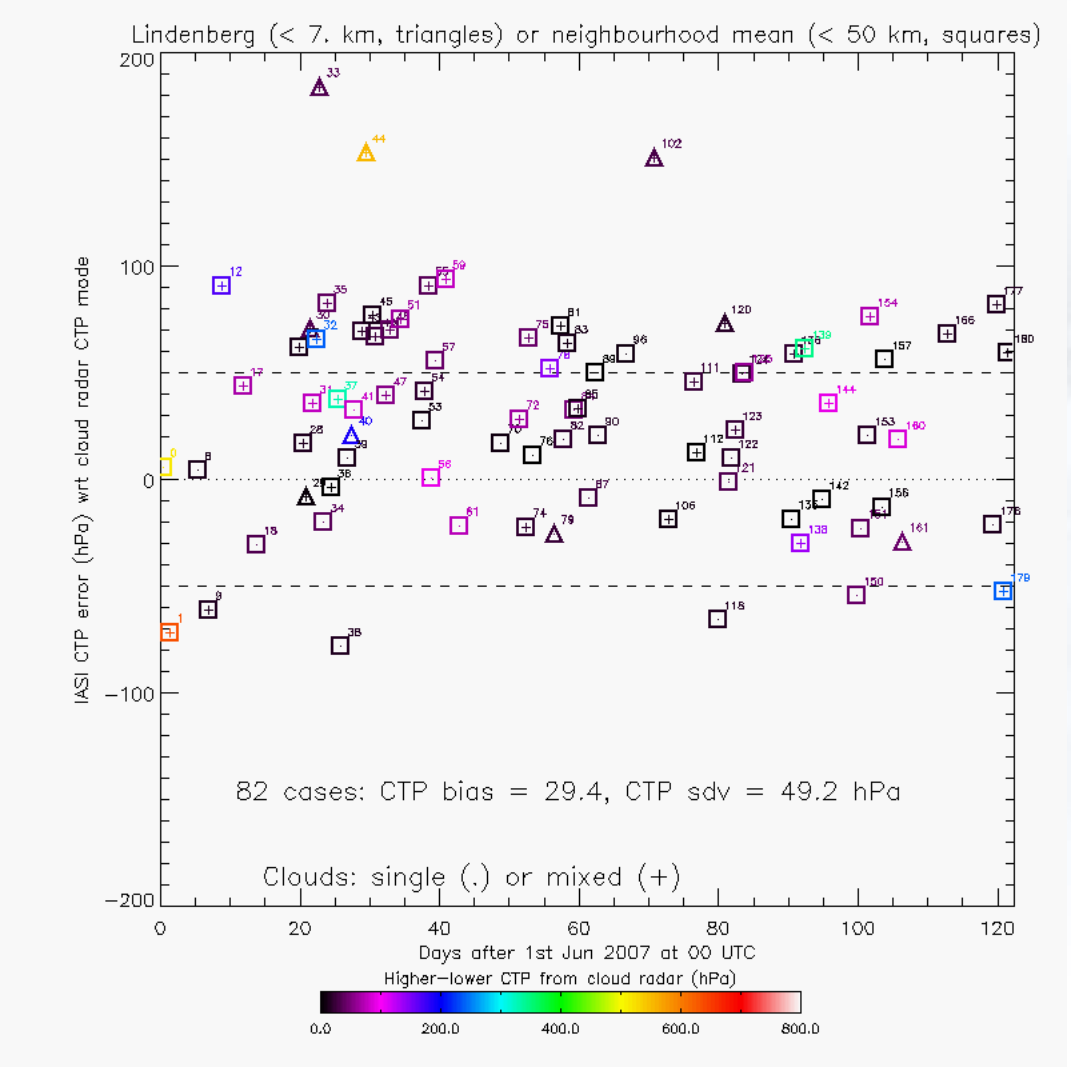
Validation examples: cloud top pressure



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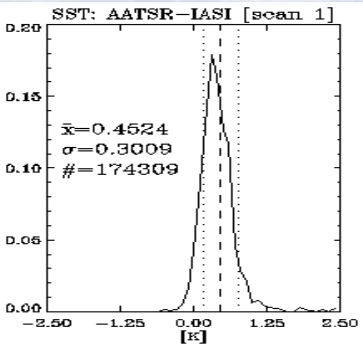
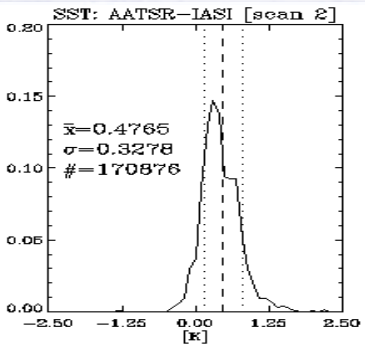
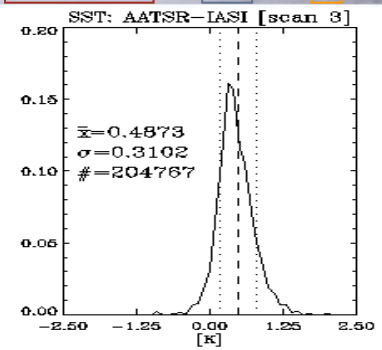
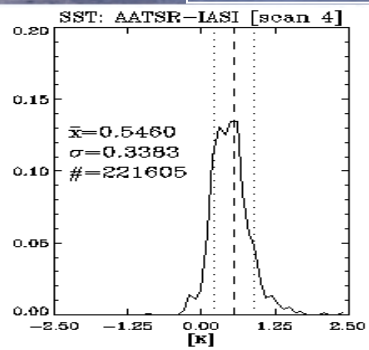
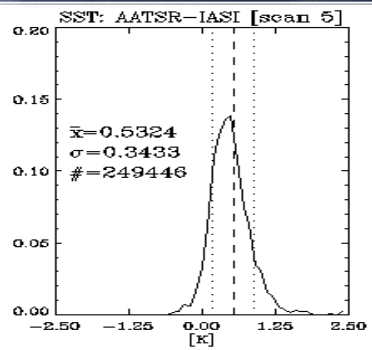
Validation examples: sea surface temperature

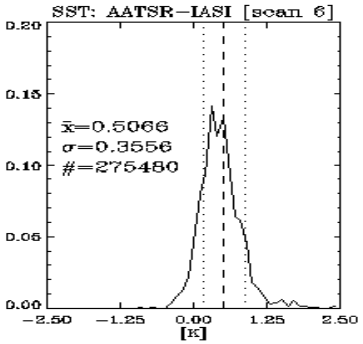


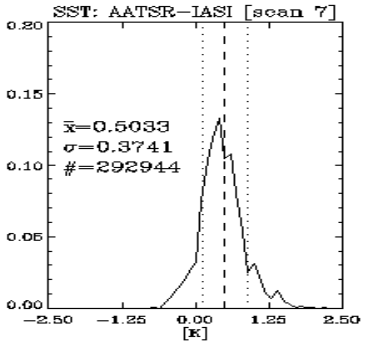


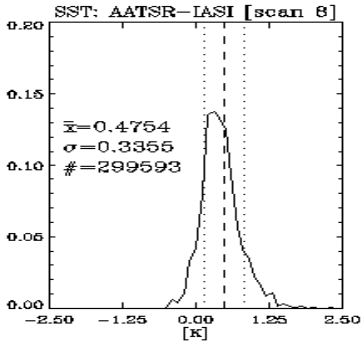


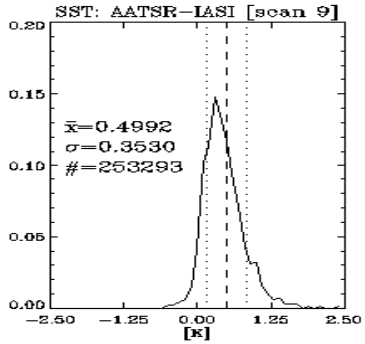


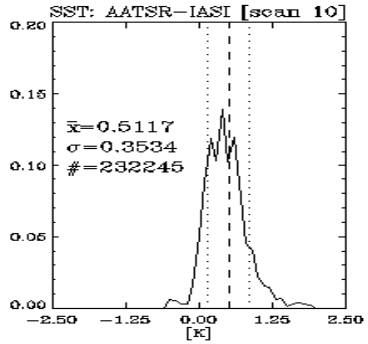


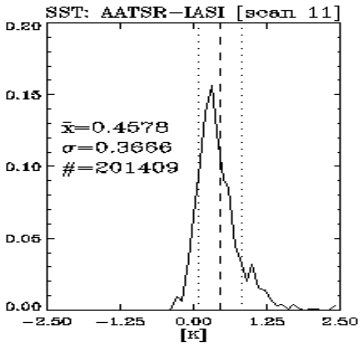


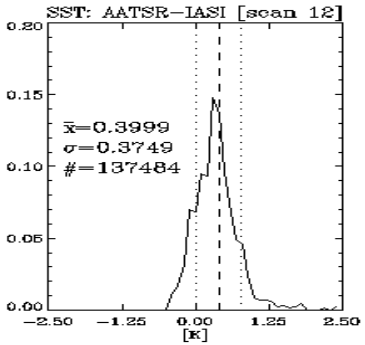


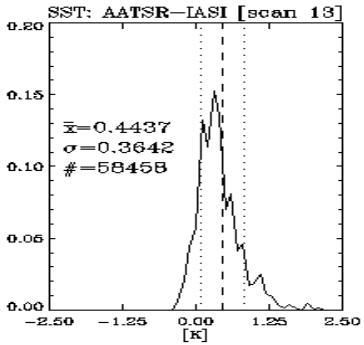


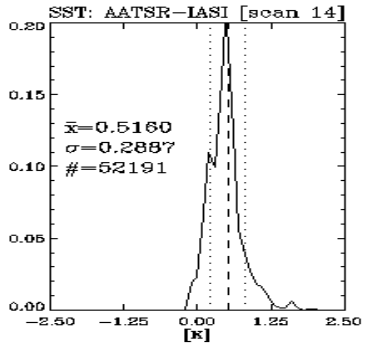


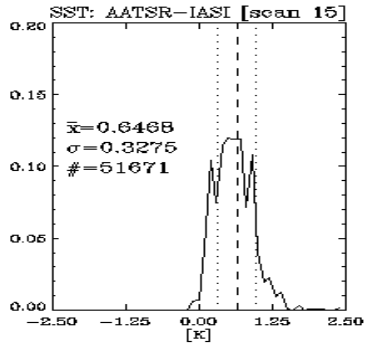












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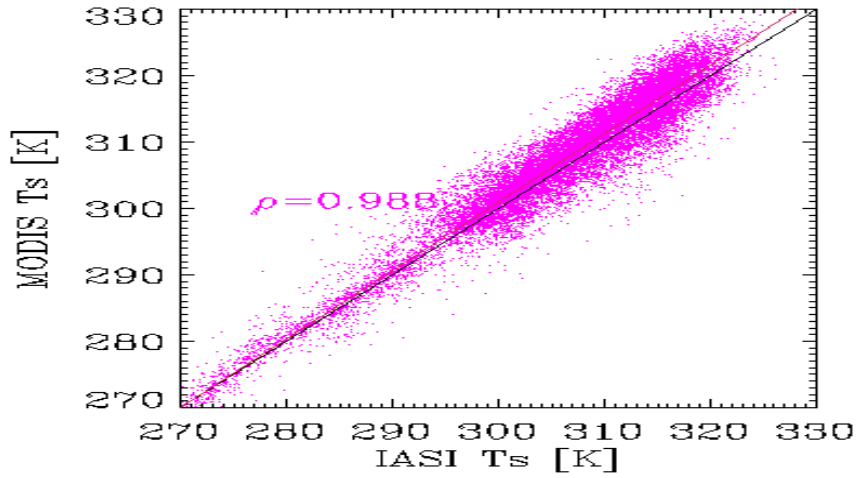
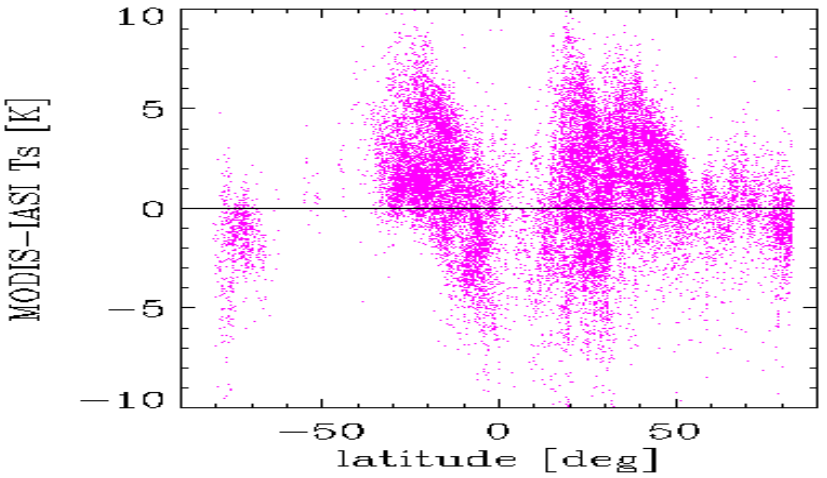
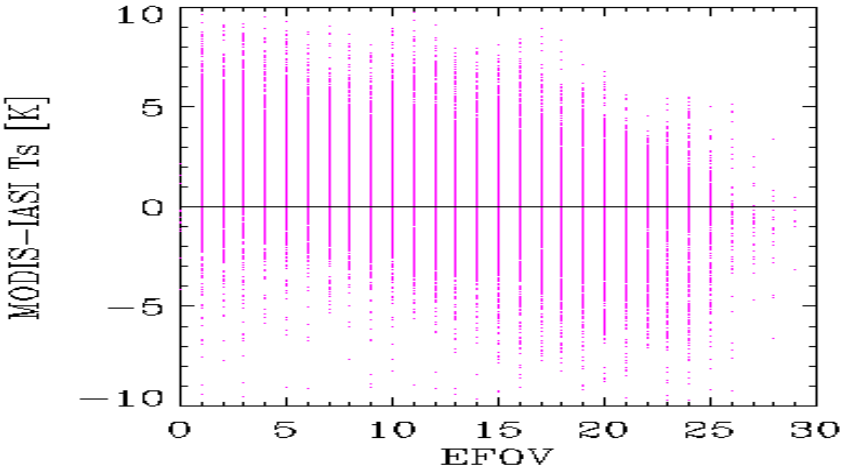
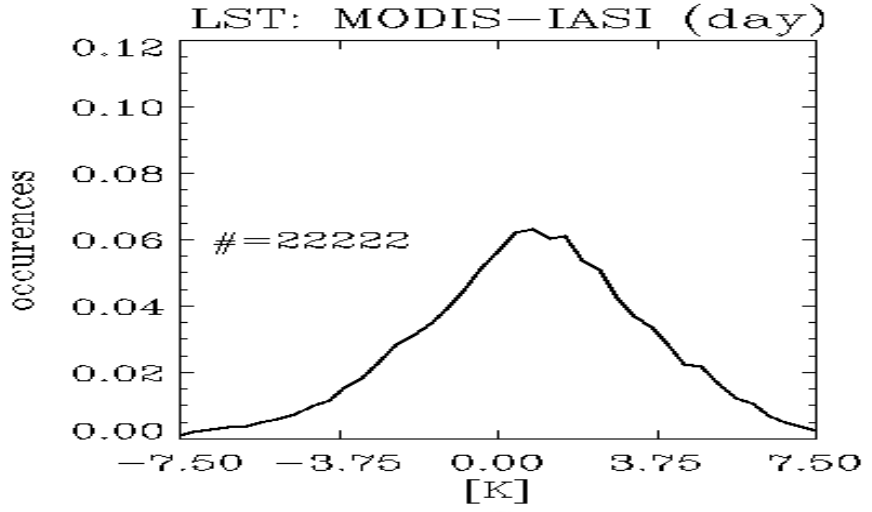
Validation examples: land surface temperature









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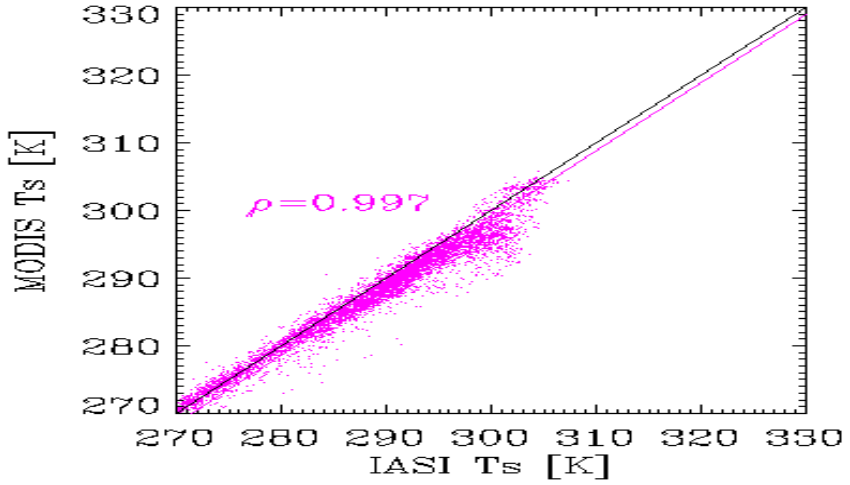

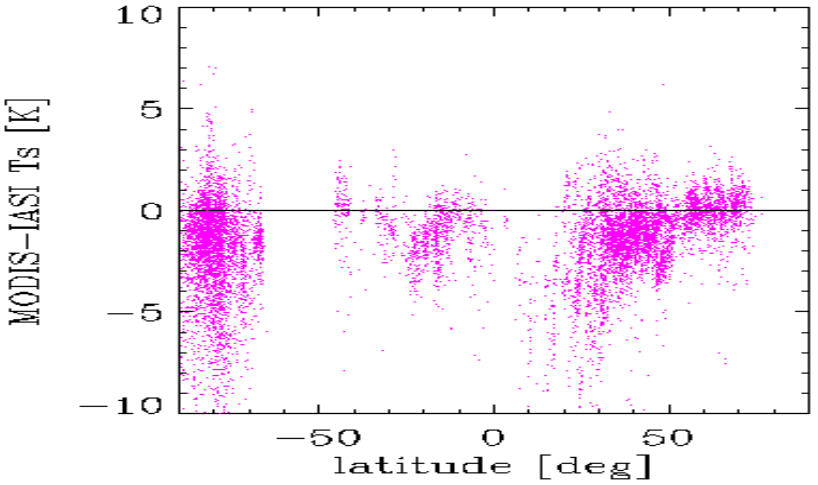

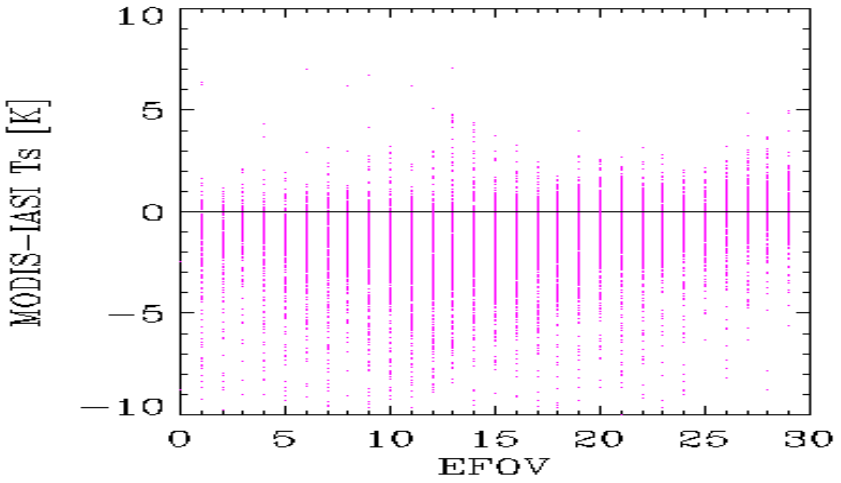

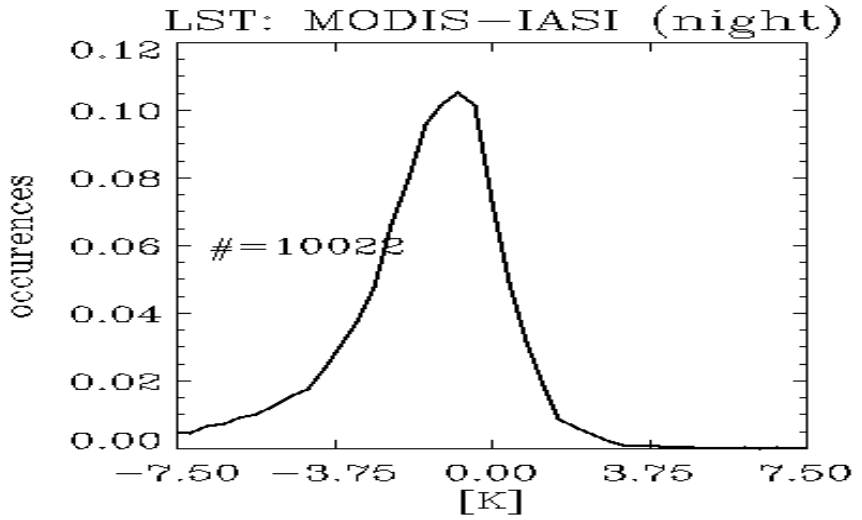

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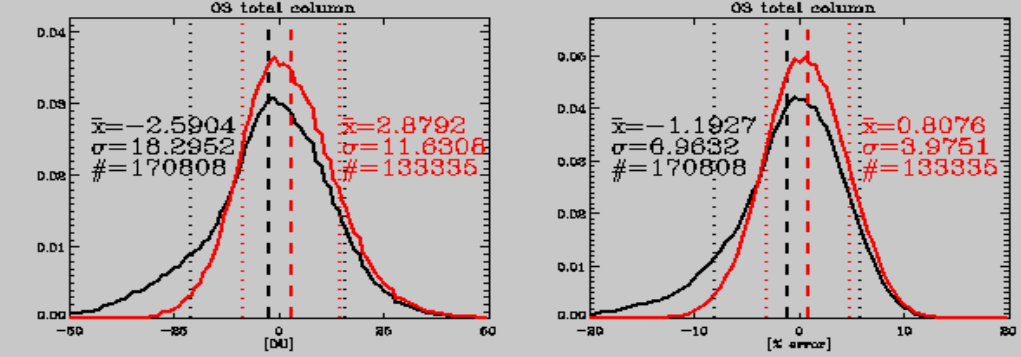
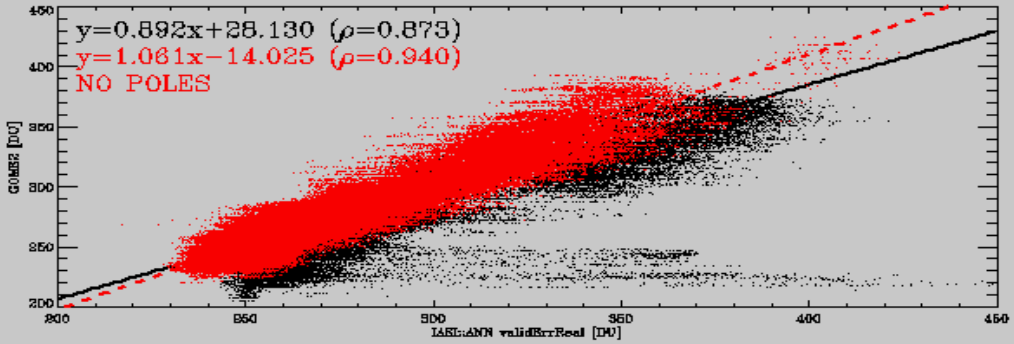
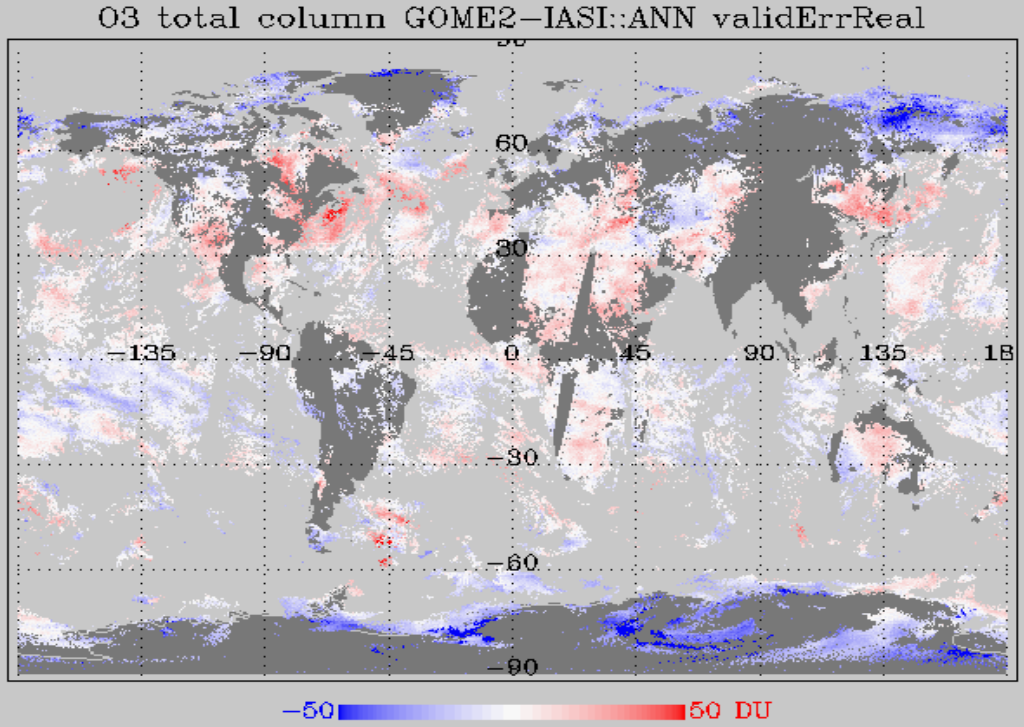
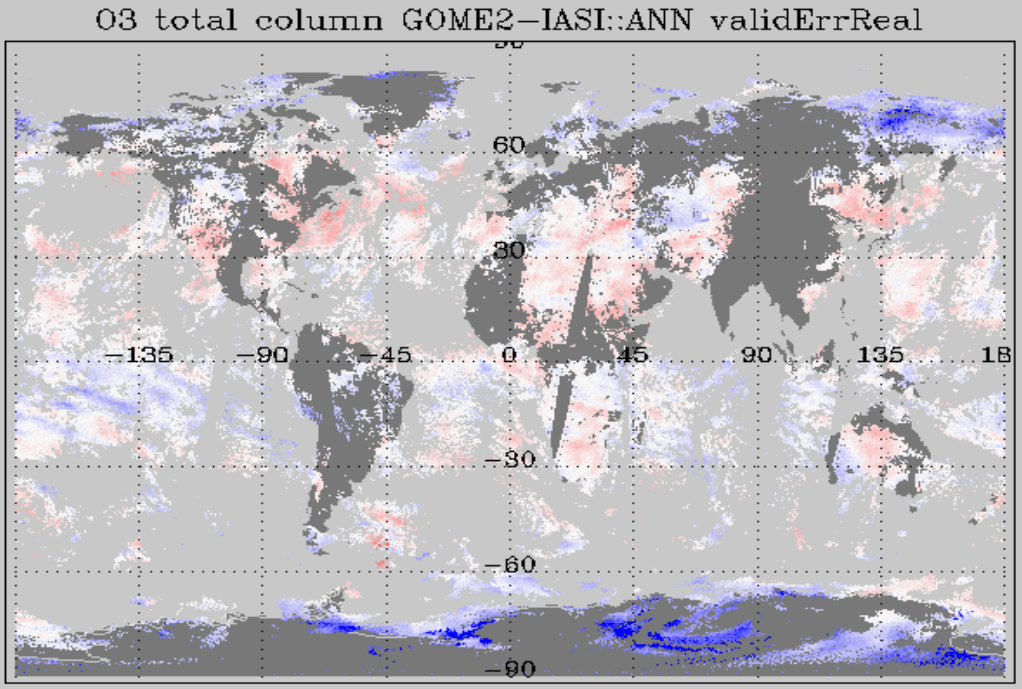


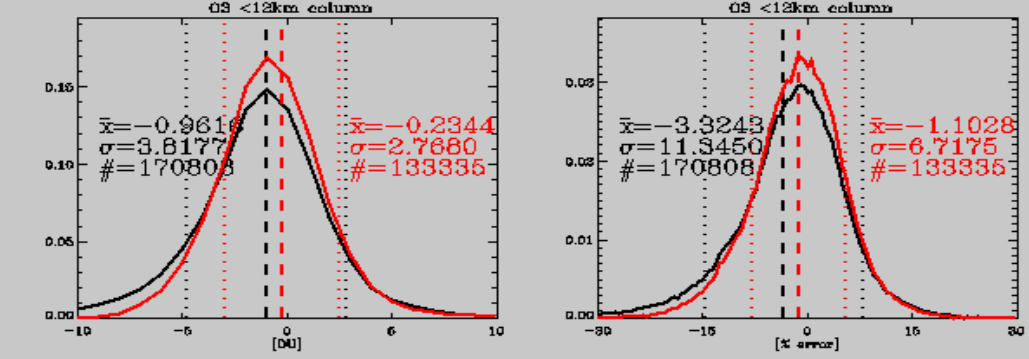


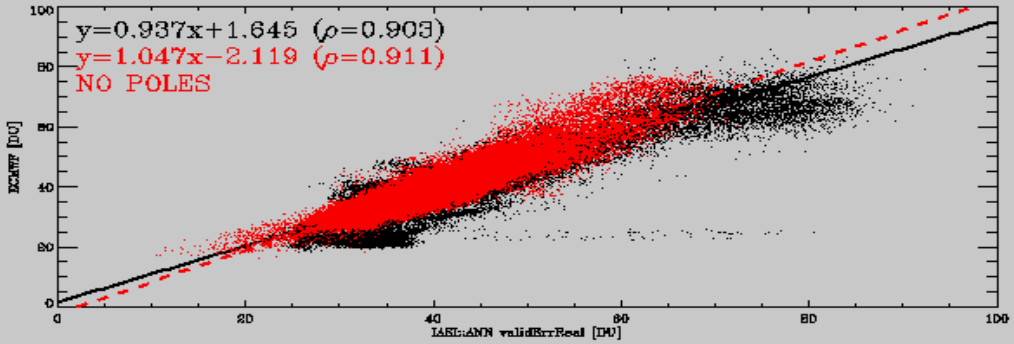


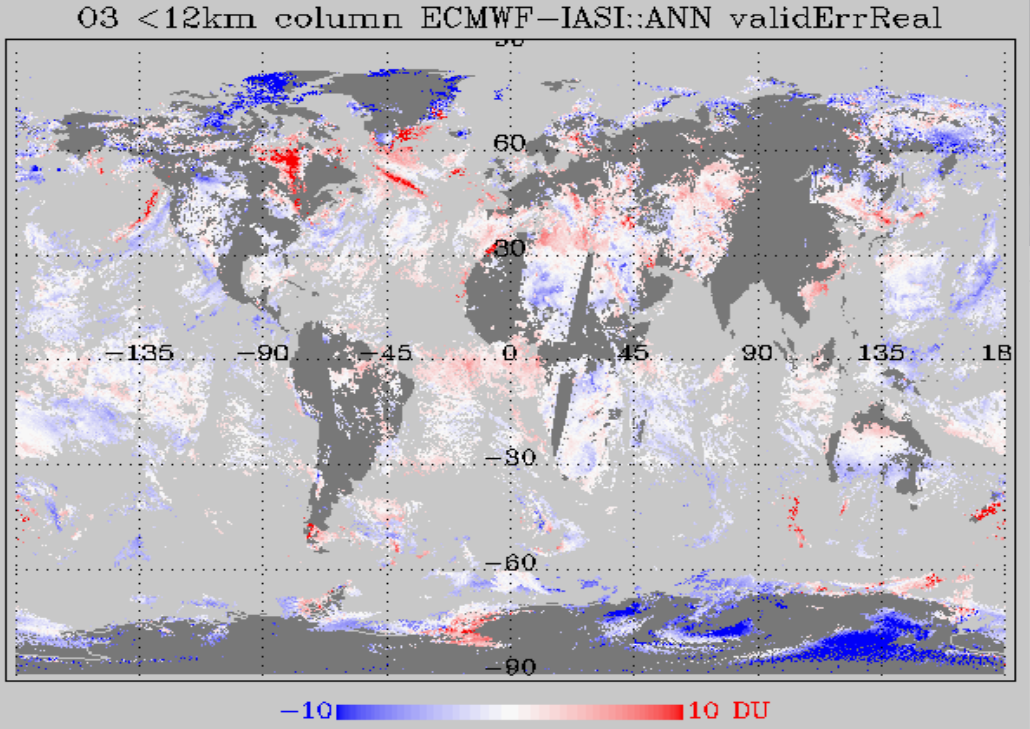


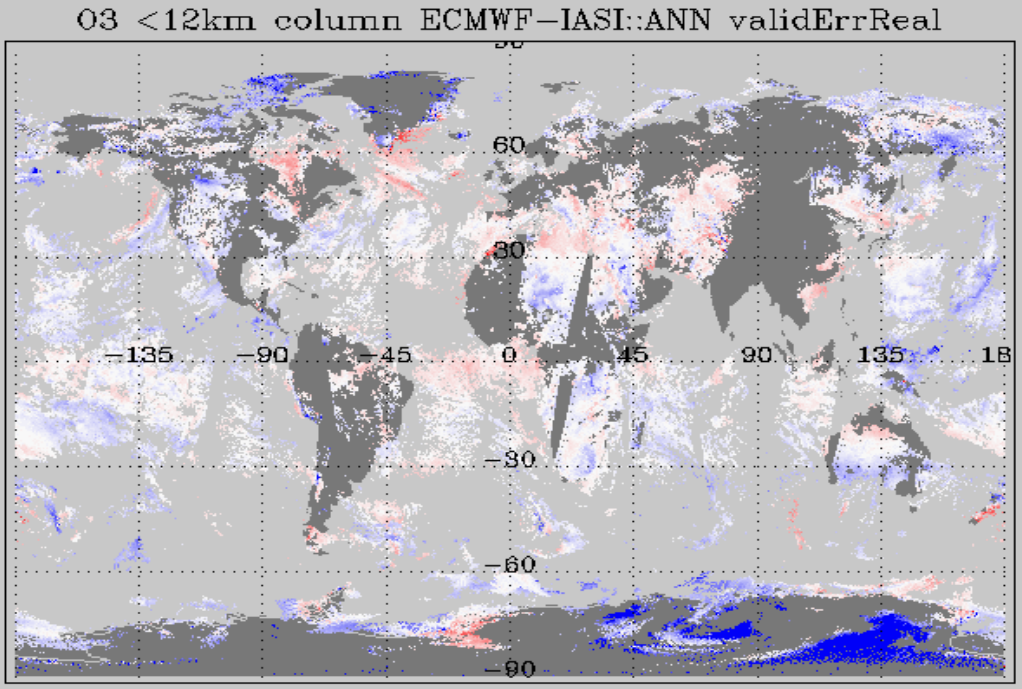
170808 IFOVs within 12 orbits from dates :
20070622

Validation example
O_3 Column against GOME-2





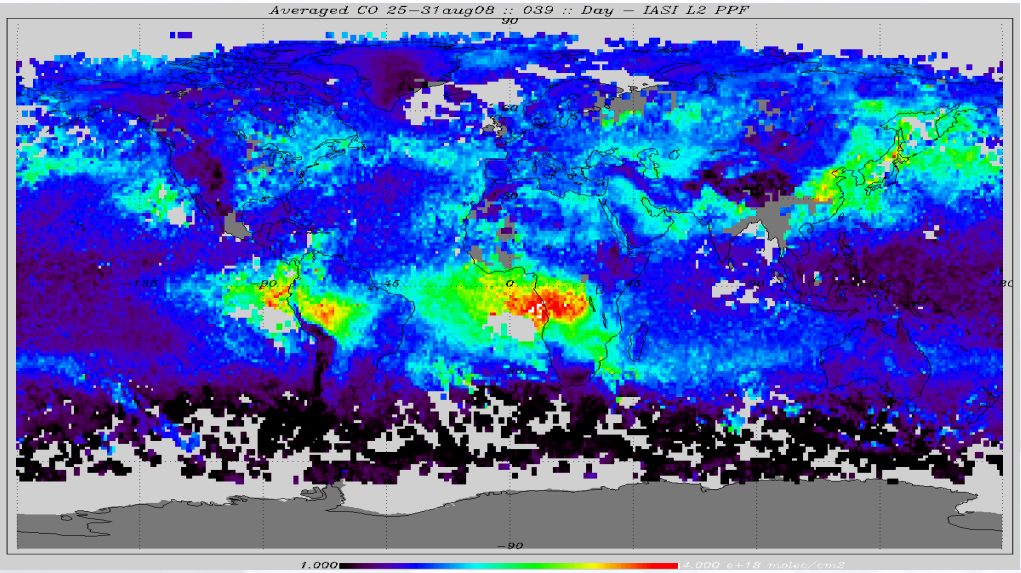


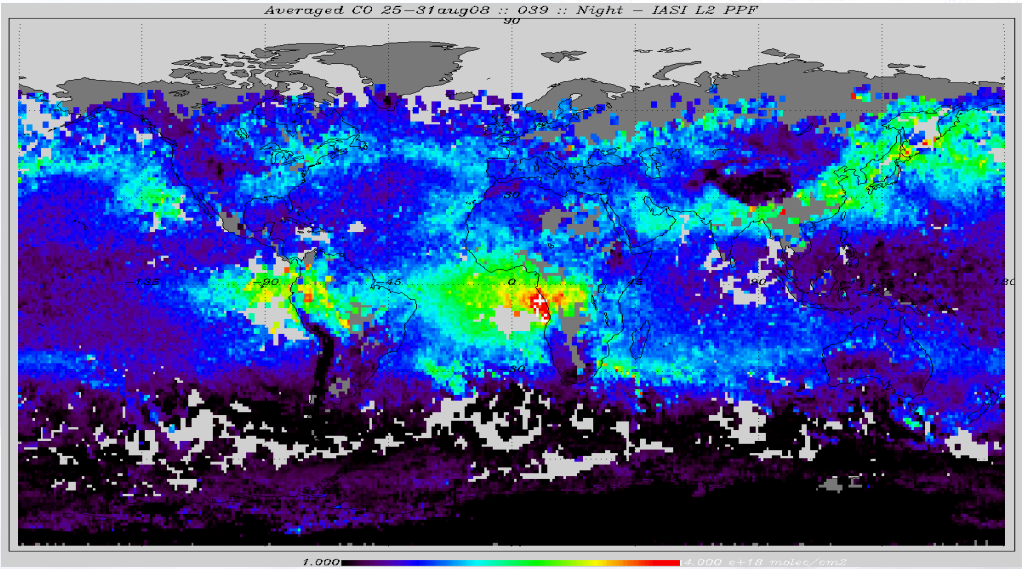


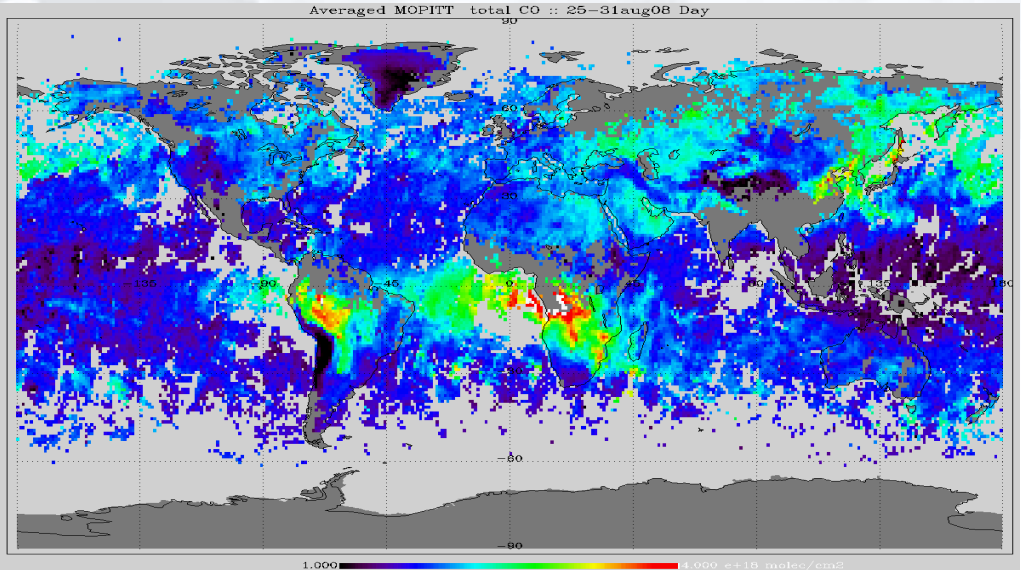
170808 IFOVs within 12 orbits from dates :
20070622

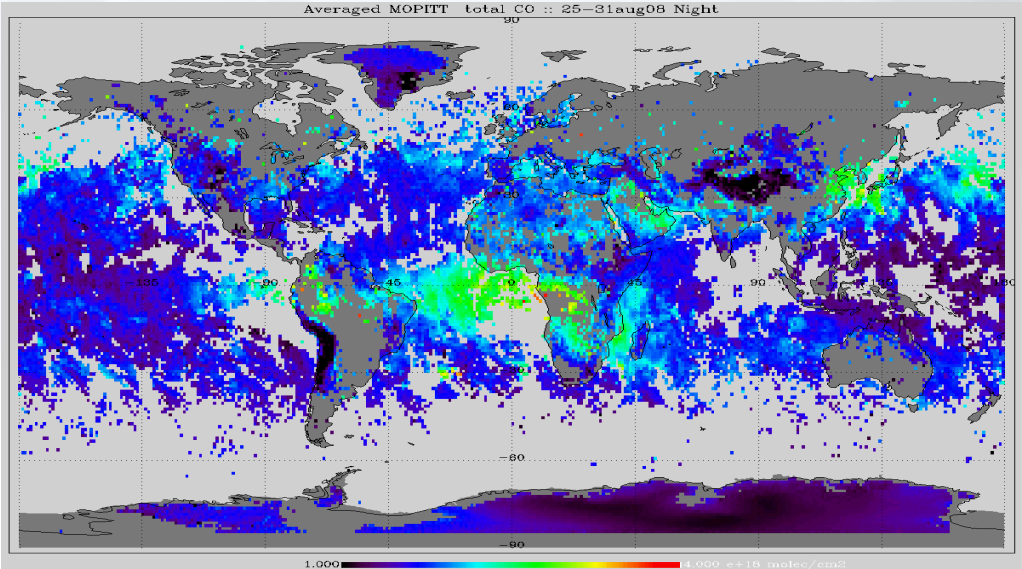
Validation example
O_3 Partial Column < 12 km
against ECMWF

Carbon monoxide: comparison IASI - MOPITT
25 - 31 August 2008

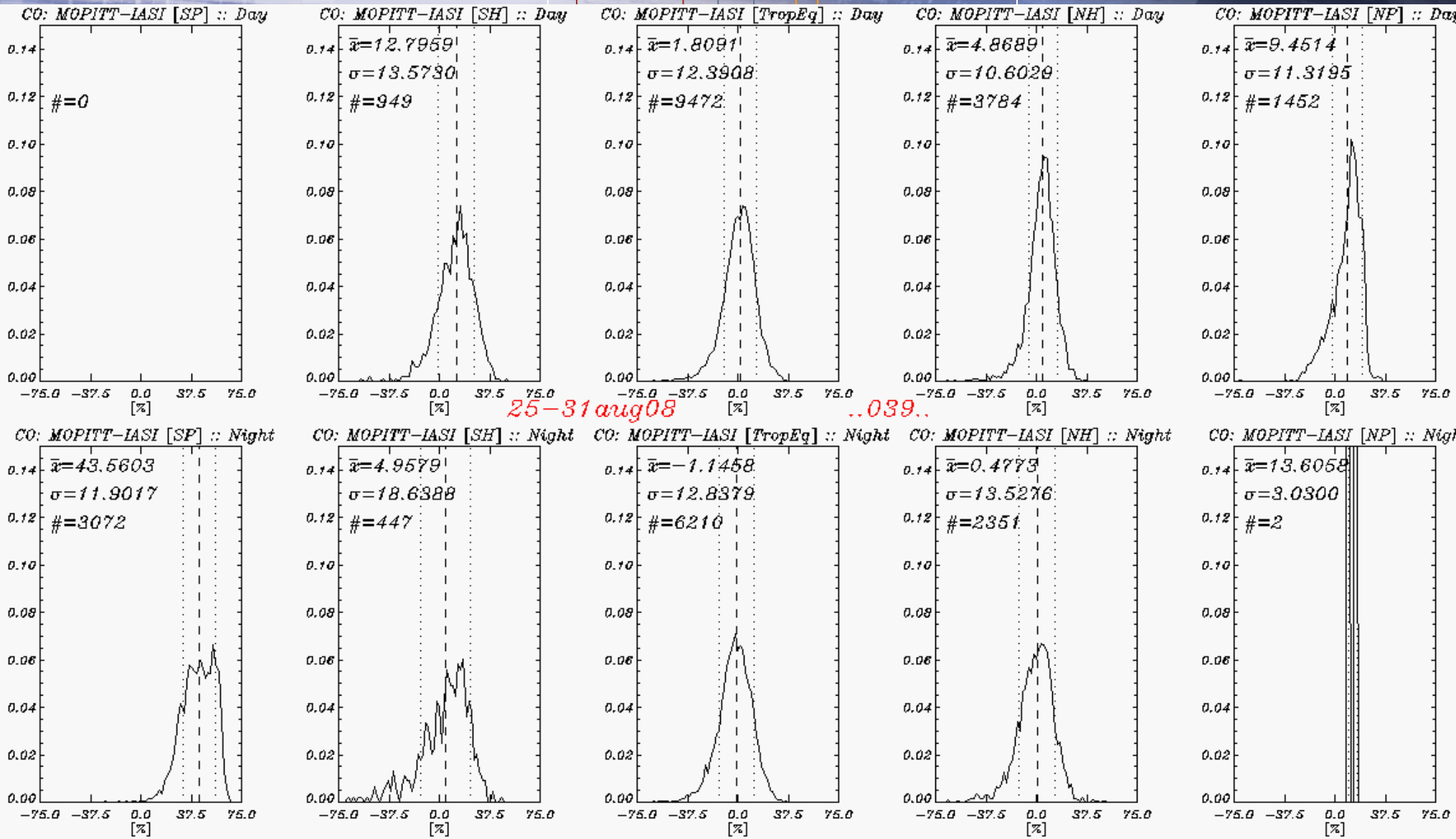








Validation example: carbon monoxide
Comparison against MOPITT



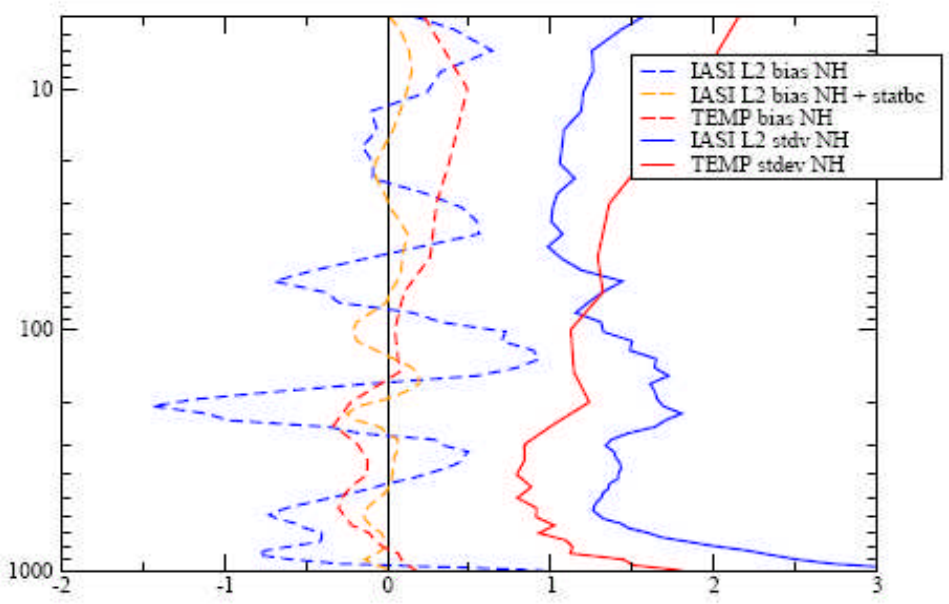
ECMWF - IASI L2 assimilation experiments

Evaluation of the impact of IASI level-2 products (temperature and humidity retrievals) and comparison to level-1 radiance assimilation

- Estimation of level-2 product error covariance statistics from product-model departures
- Bias-correction defined on 10-degree latitude/longitude grid.
- Baseline (conventional + AMV)
- Study period: July-August 2008

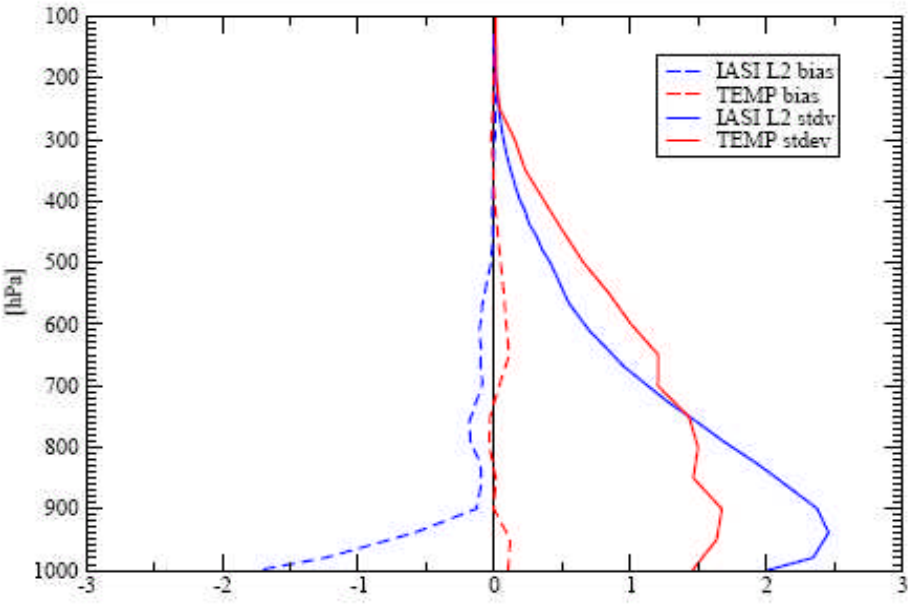
Temperature and humidity biases and standard deviations from first guess (IASI and radiosonde)

Temperature biases and error stdev-s



[K]

Specific humidity biases and error stdev-s

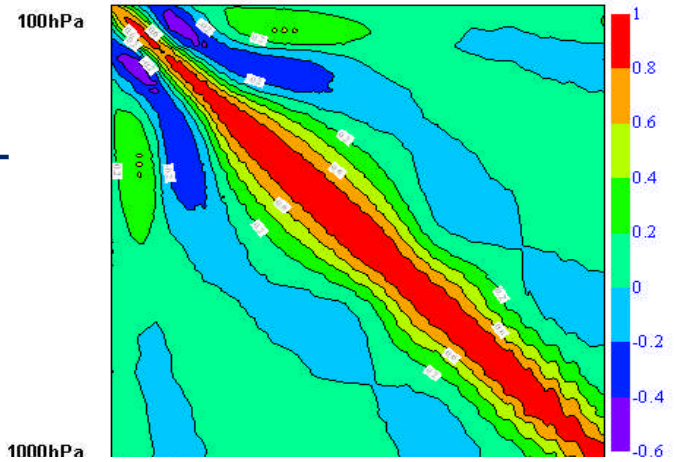


[g/kg]

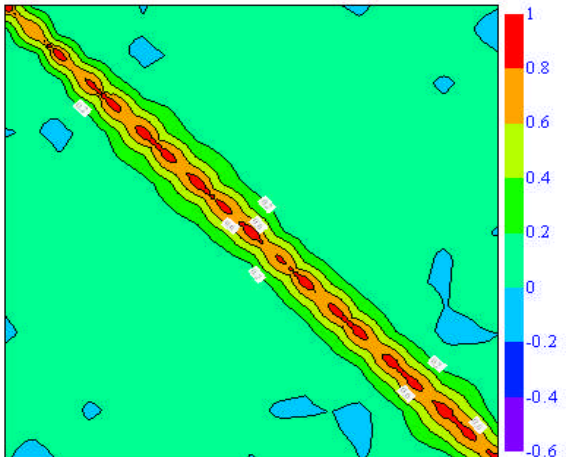
EUMETSAT

Usage of vertical error correlations mandatory for IASI L2

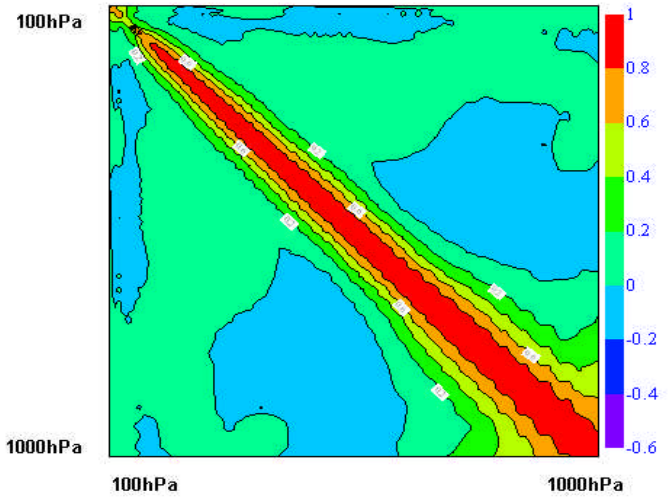
IASI L2: T



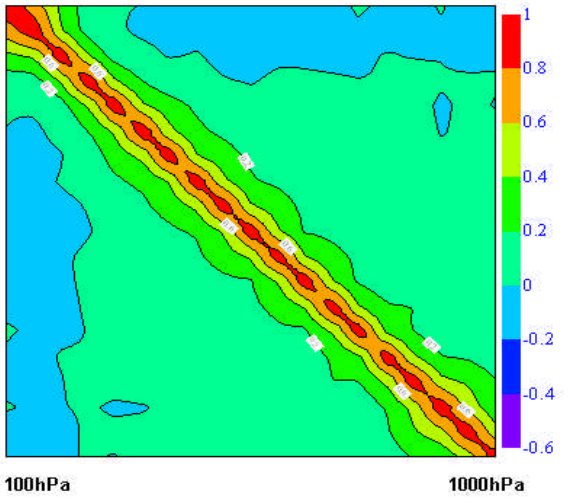
Radiosonde: T



IASI L2: q



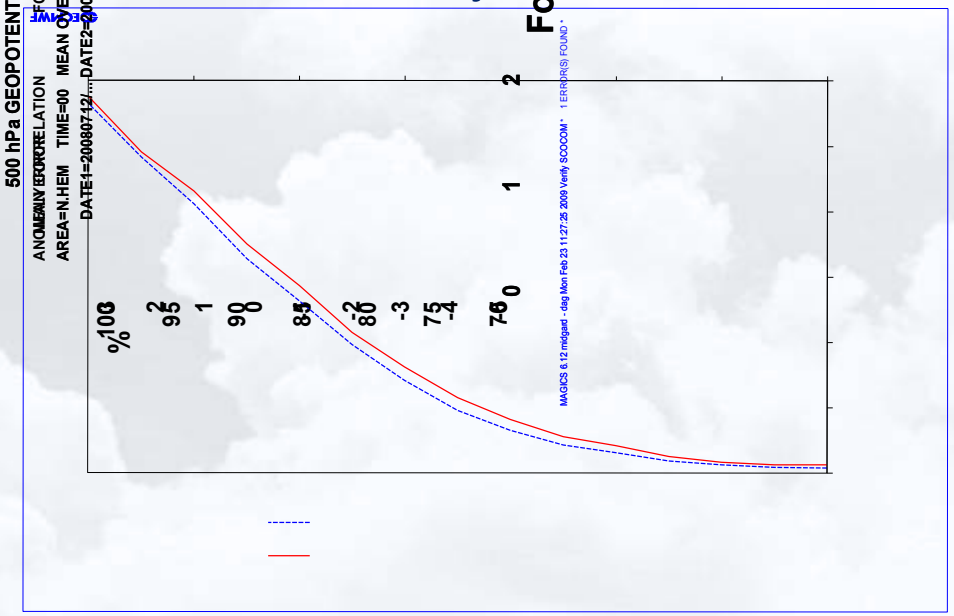
Radiosonde: q



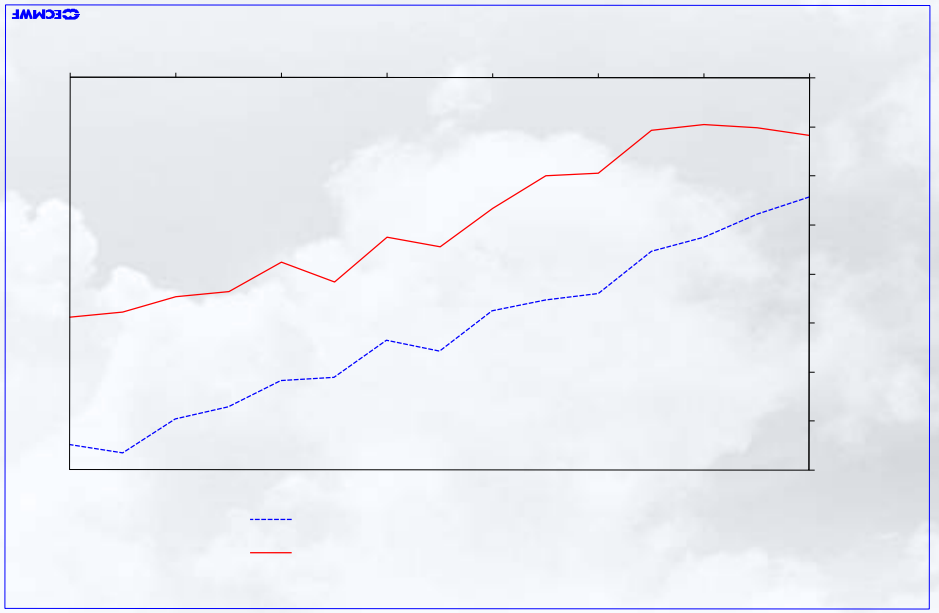
EUMETSAT

Impact of accounting for vertical error correlations on scores

Anomaly correlation



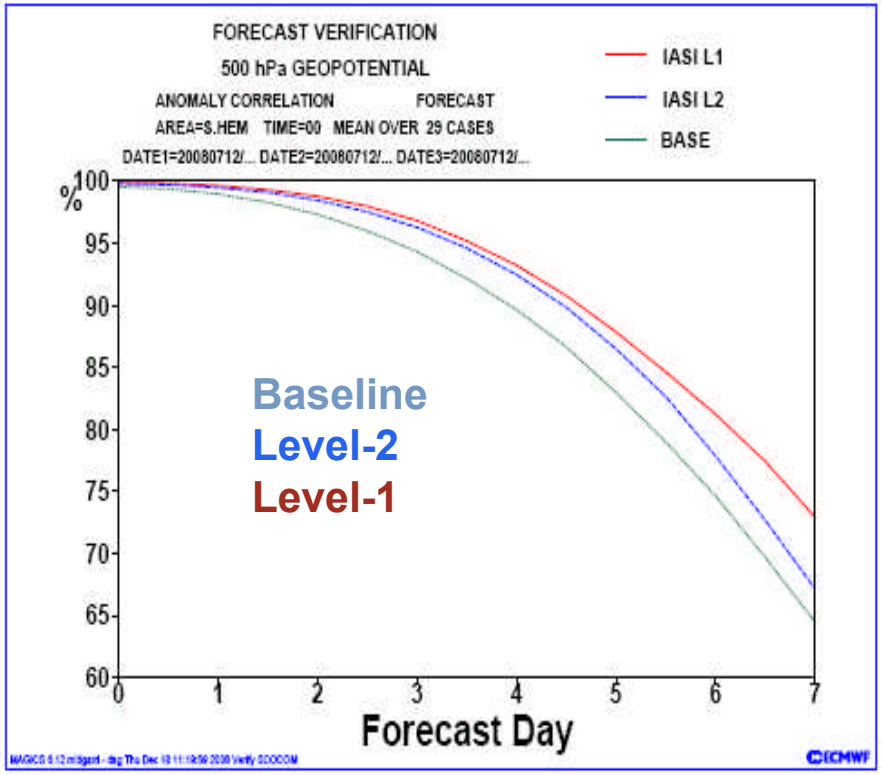
Bias



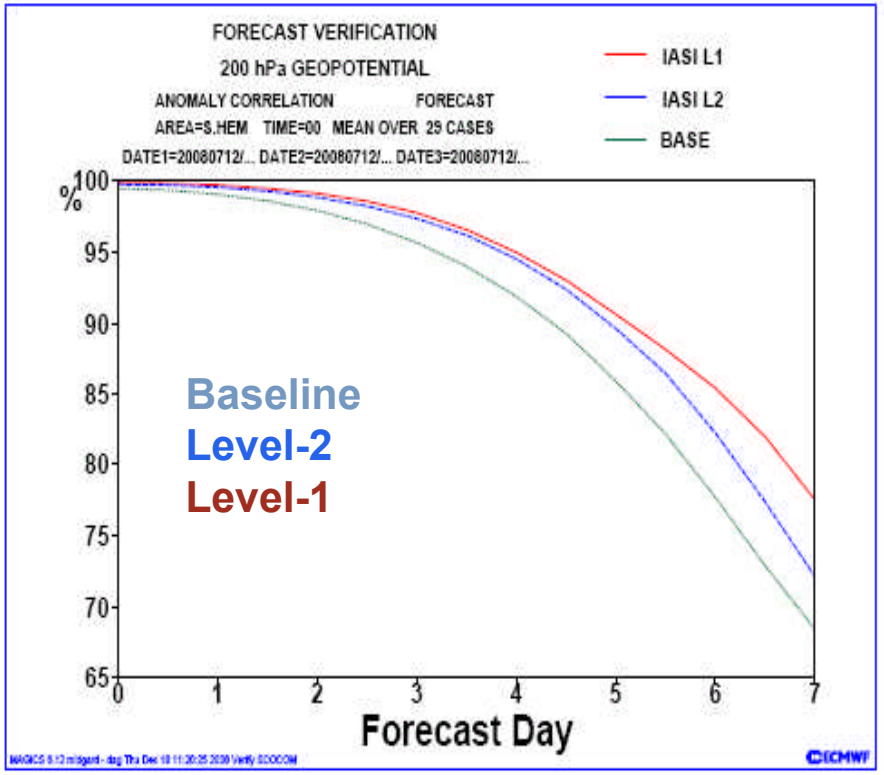
EUMETSAT

Geopotential height forecast skill (Southern hemisphere)

500 hPa

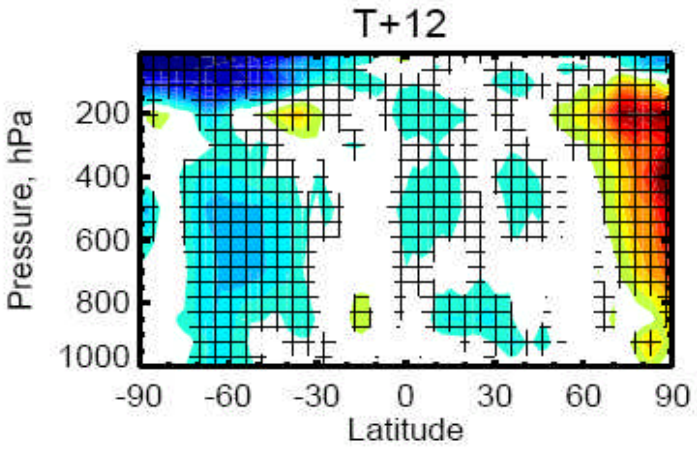


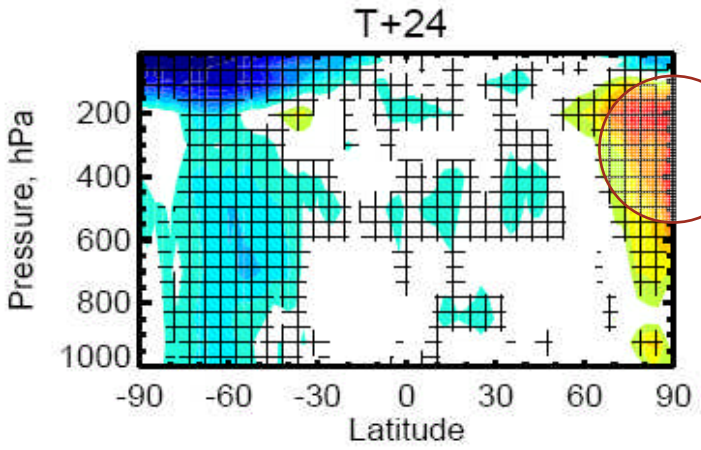
200 hPa

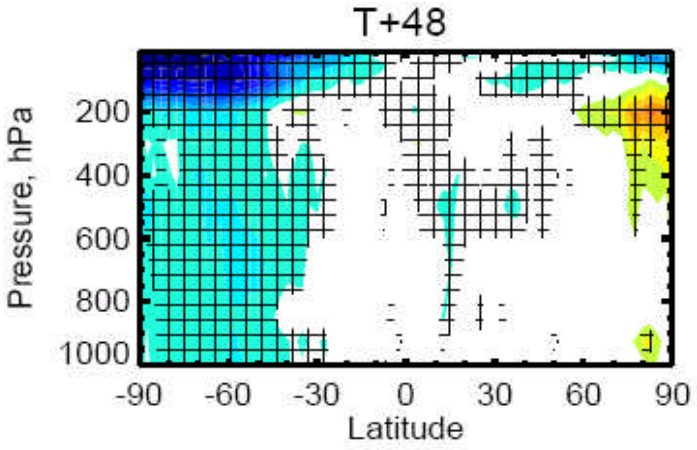


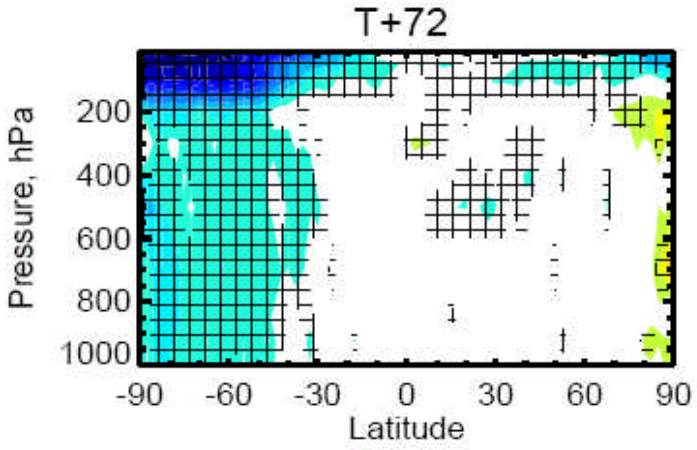
EUMETSAT

Temperature forecast skill







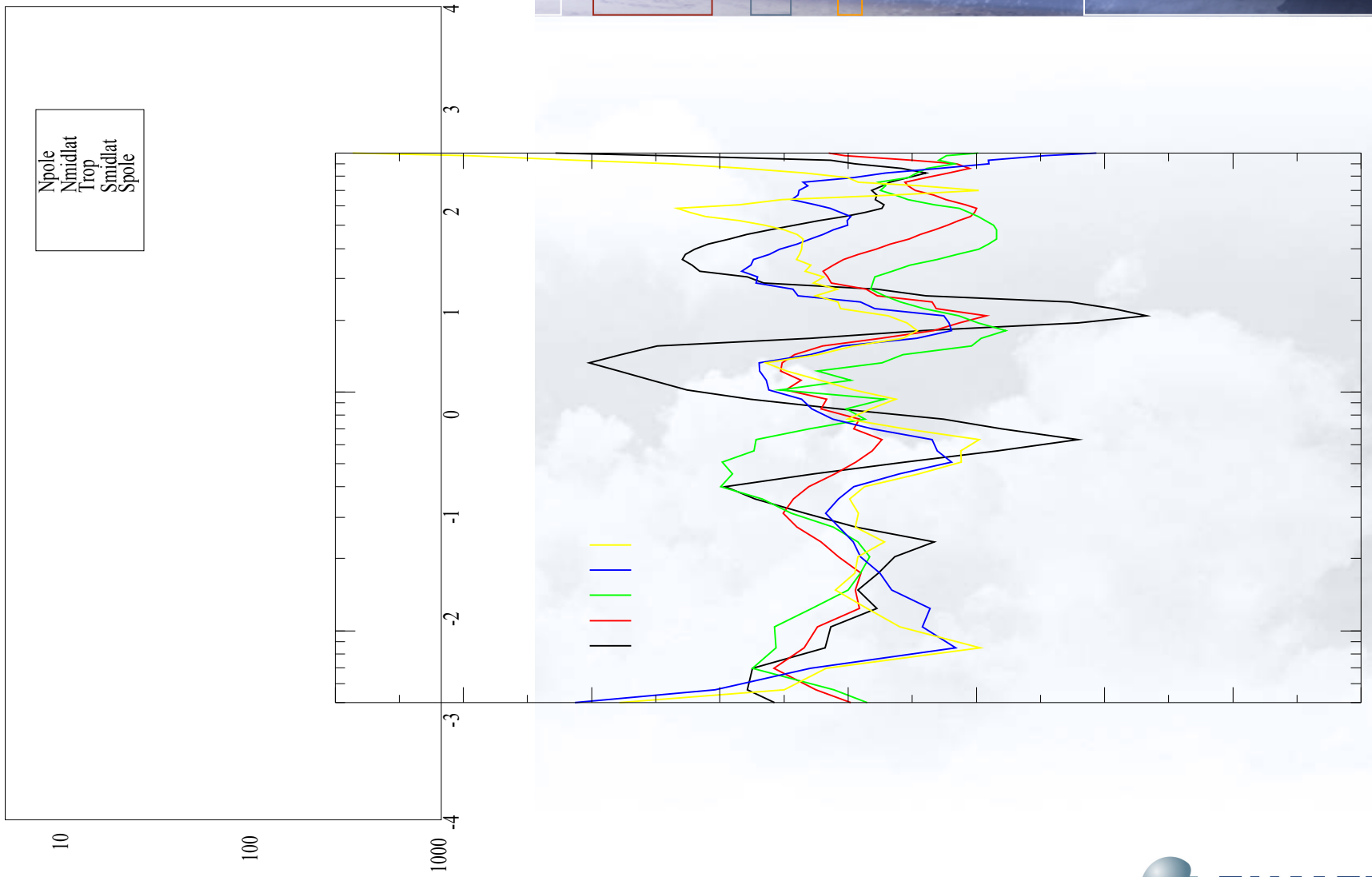


?

See next two slides

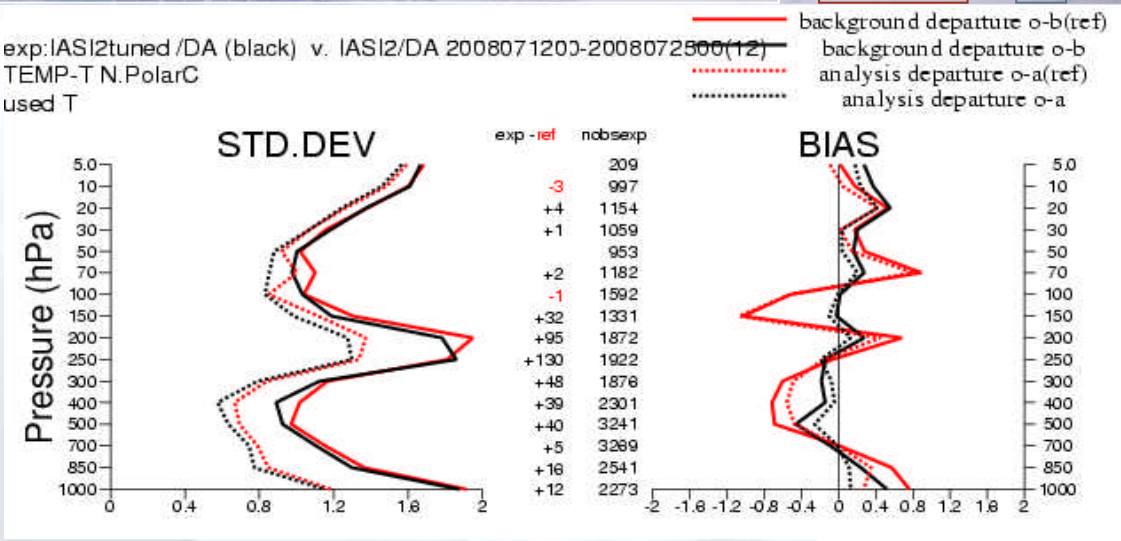
EUMETSAT

lence of temperature biases



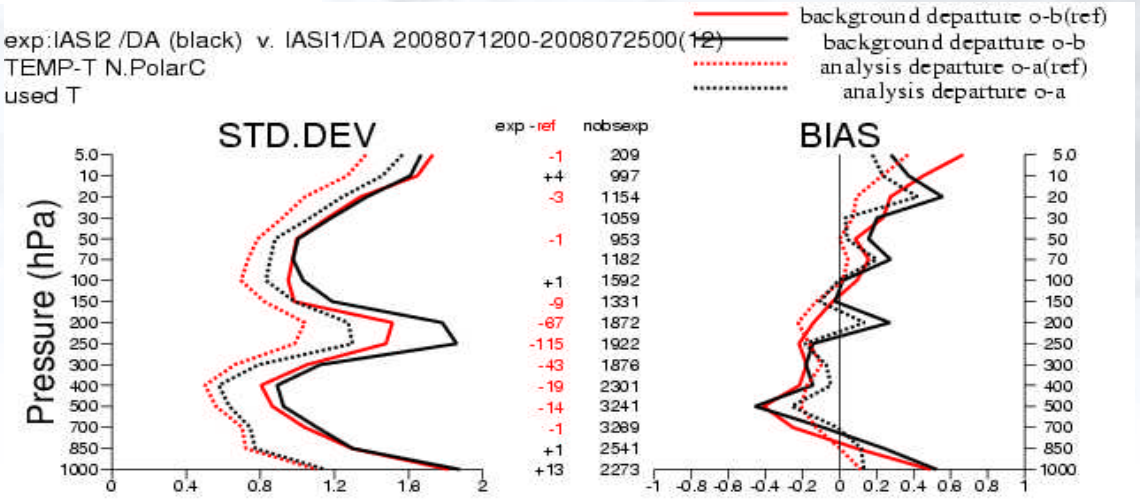
EUMETSAT

Impact of tuning temperature biases



North-Pole area **before** tuning

North-Pole area **after** tuning



EUMETSAT

Summary of IASI L2 OSE results

- Baseline was a weak observation system with conventional and AMV data only
- Large biases in the IASI L2 data were handled with a flat brute-force bias correction on a 10° longitude/latitude grid
- Significant positive impact is obtained for temperature in the Southern hemisphere that lasts into the medium range
- Significant negative impact is obtained near the North Pole that weakens with forecast range and disappears after day 3
- Significant positive impact is obtained for relative humidity, lasting up to 3-4 days, especially in the Southern hemisphere
- Assimilation of IASI L2 data performs less well than assimilation of IASI L1 data
- Exercise is to be repeated with data from upgraded IASI L2 PPF

Ongoing work

- Monitoring against ECMWF forecast has been set up for identifying peculiarities
  - Detection of scan-angle dependent biases in temperature profiles
- Removal of cloud tests which are redundant or underperforming
- Handling of CO_2 slicing in case of multiple cloud formations
  - Inclusion of information from AVHRR radiance analysis
- Contribution to retrieval inter-comparison exercise coordinated by Met Office
  - Focus on learning lessons to improve water-vapour retrieval