IASI* Product Generation, Products, and Data Access

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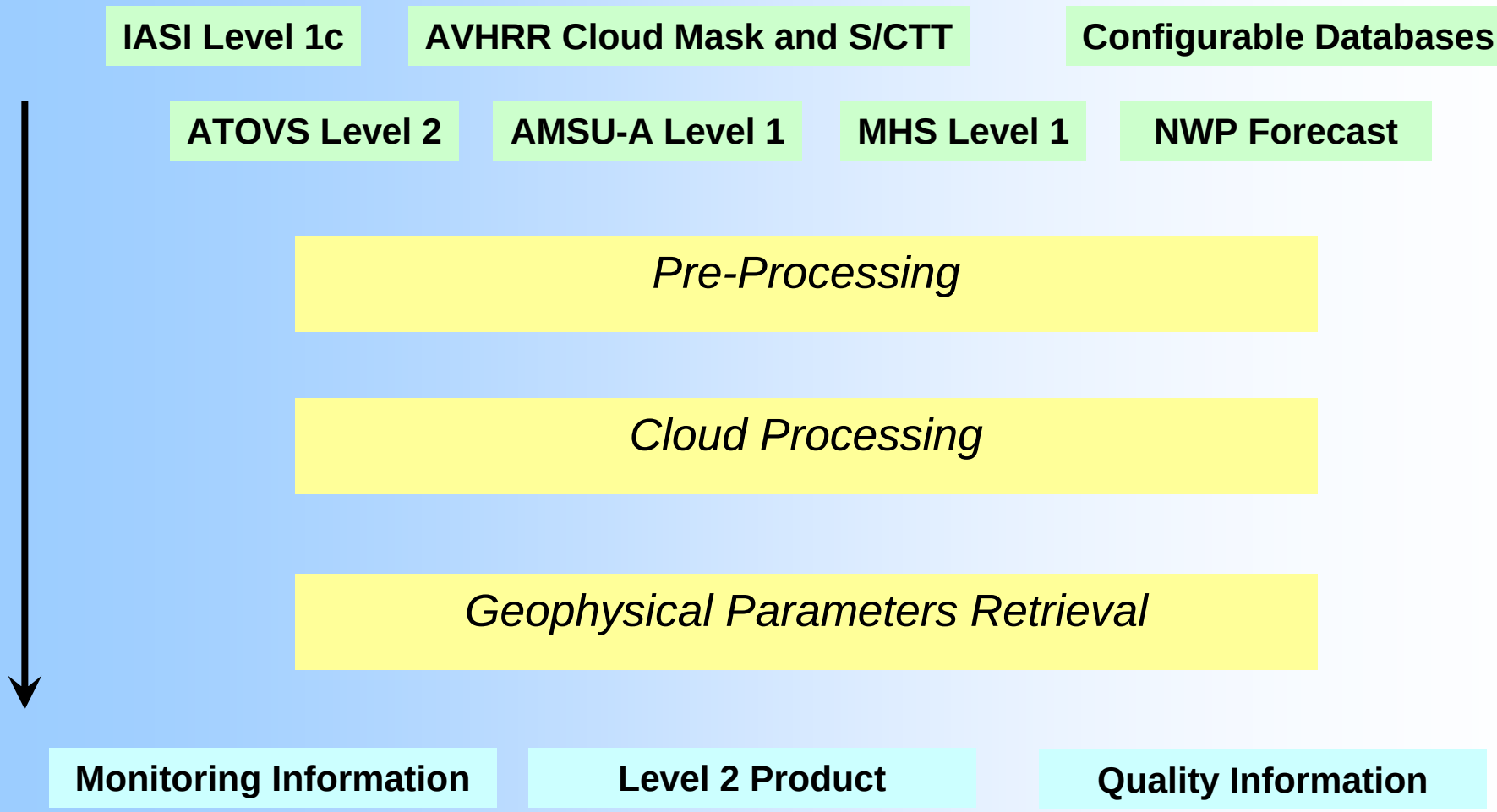
EUMETSAT

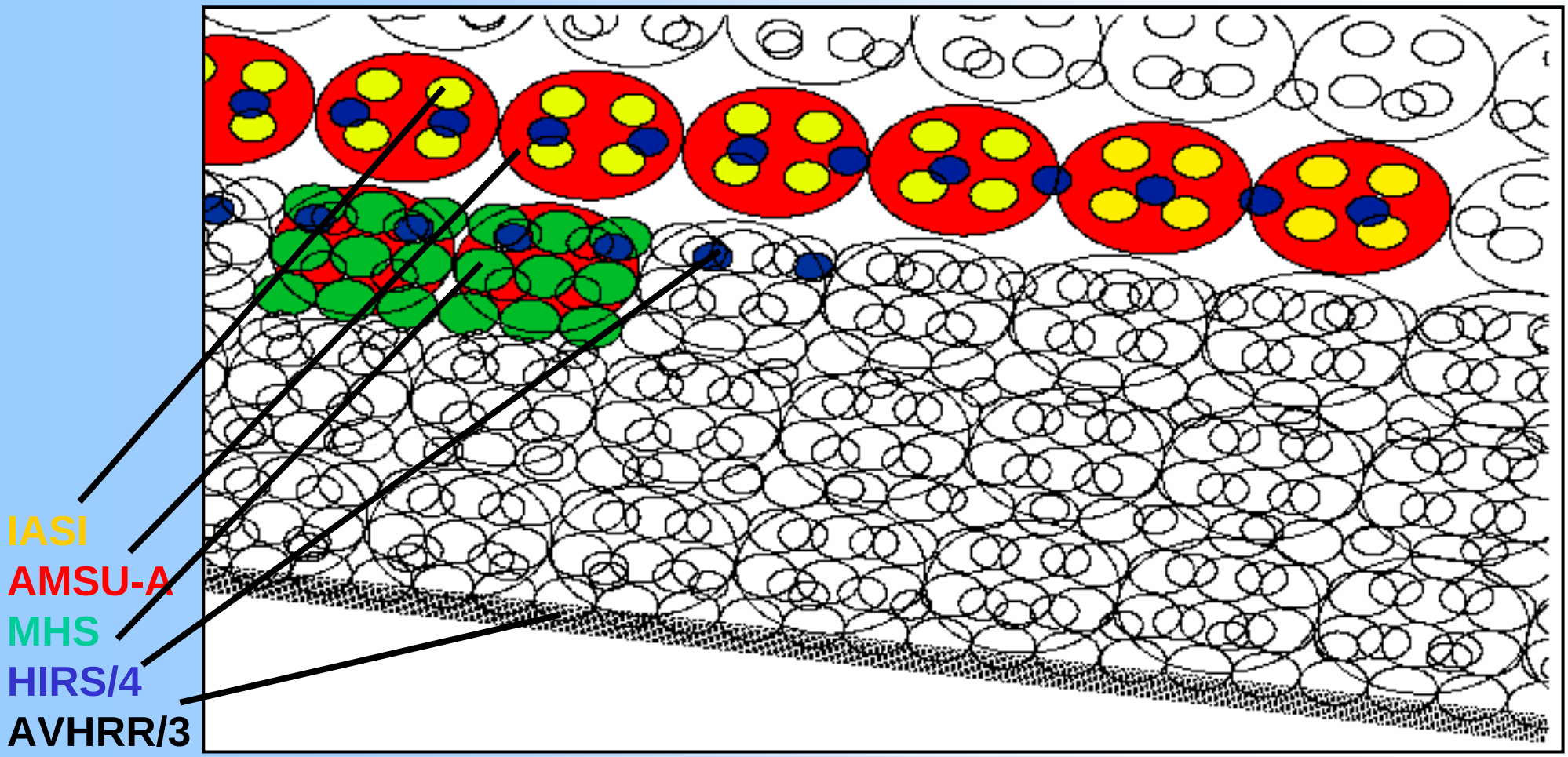
*Infrared Atmospheric Sounding Interferometer

Metop - fully integrated

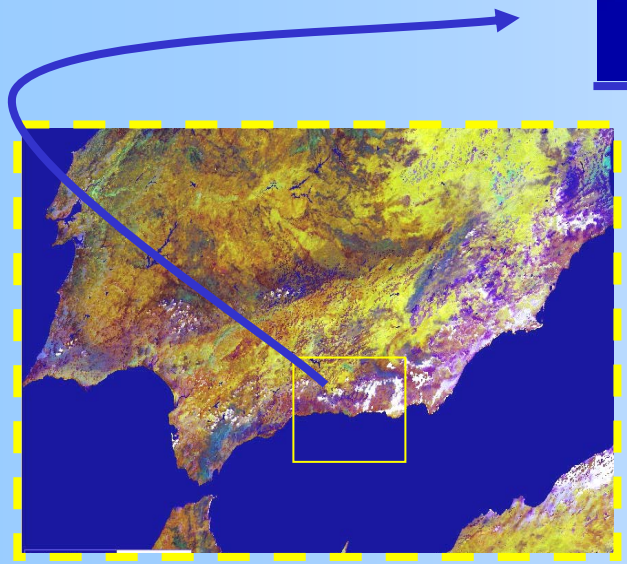
IASI Level 2 Product Generation
High Level Break-Down

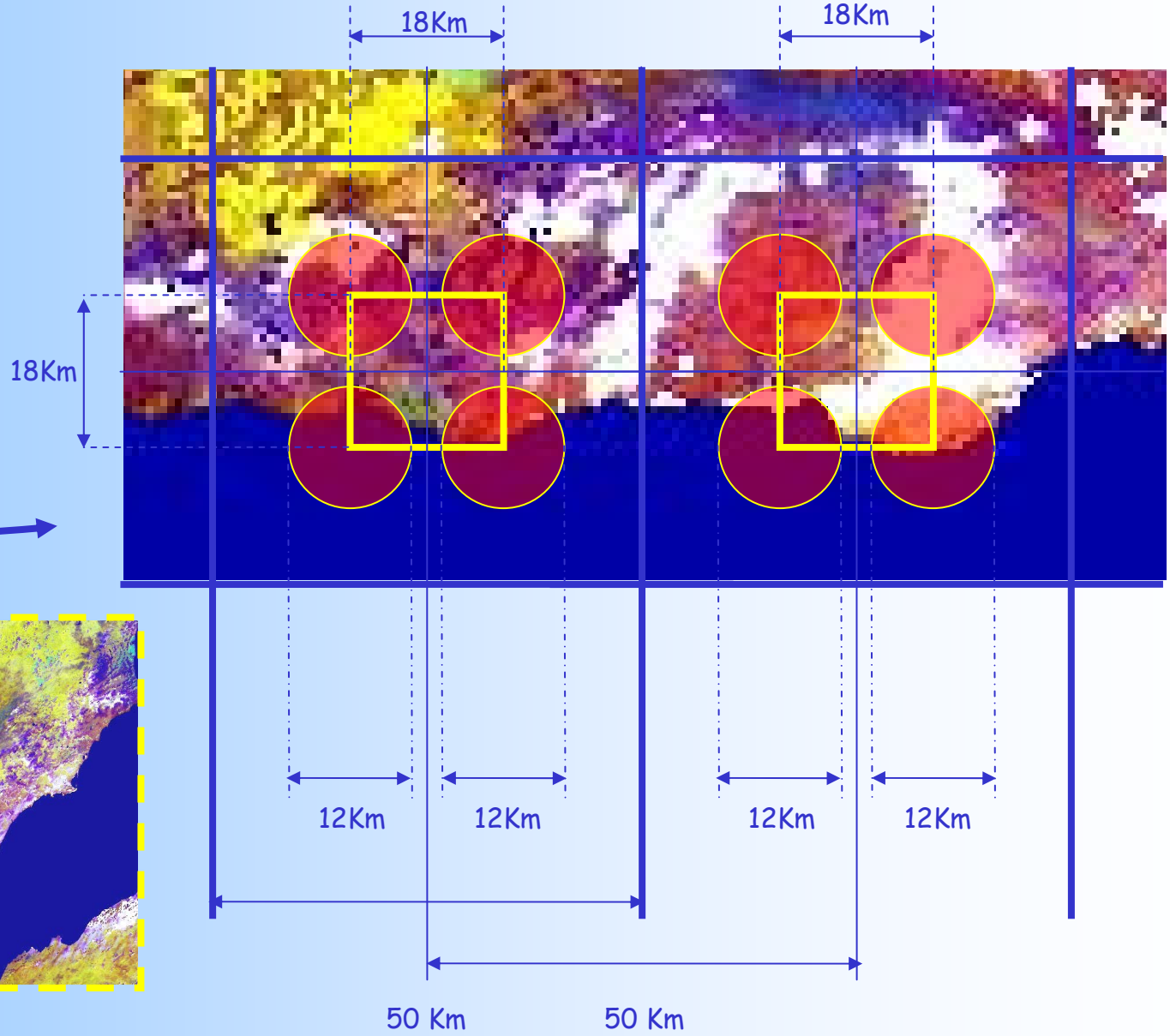


Instruments' Fields of View



Mapping of AVHRR to IASI IFOV





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

- For a best use of IASI measurements the level 2 processing can combine IASI with concurrent measurements of AVHRR, AMSU-A, MHS, and ATOVS Level 2 products

- IASI stand-alone processing is possible if other measurements are not available, or if Product Processing Facility is explicitly configured to exclude other instruments

- NWP forecast is included to provide surface pressure as reference for the profiles to be retrieved and surface wind speed over sea for the calculation of surface emissivity

- Optionally, the NWP forecast profiles of temperature, water vapour and ozone can be used to initialise and/or constrain the retrieval

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

- Processing is steered by configuration settings (80 configurable auxiliary data sets), which allow for optimisation of the Product Processing Facility before and during commissioning

- 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)

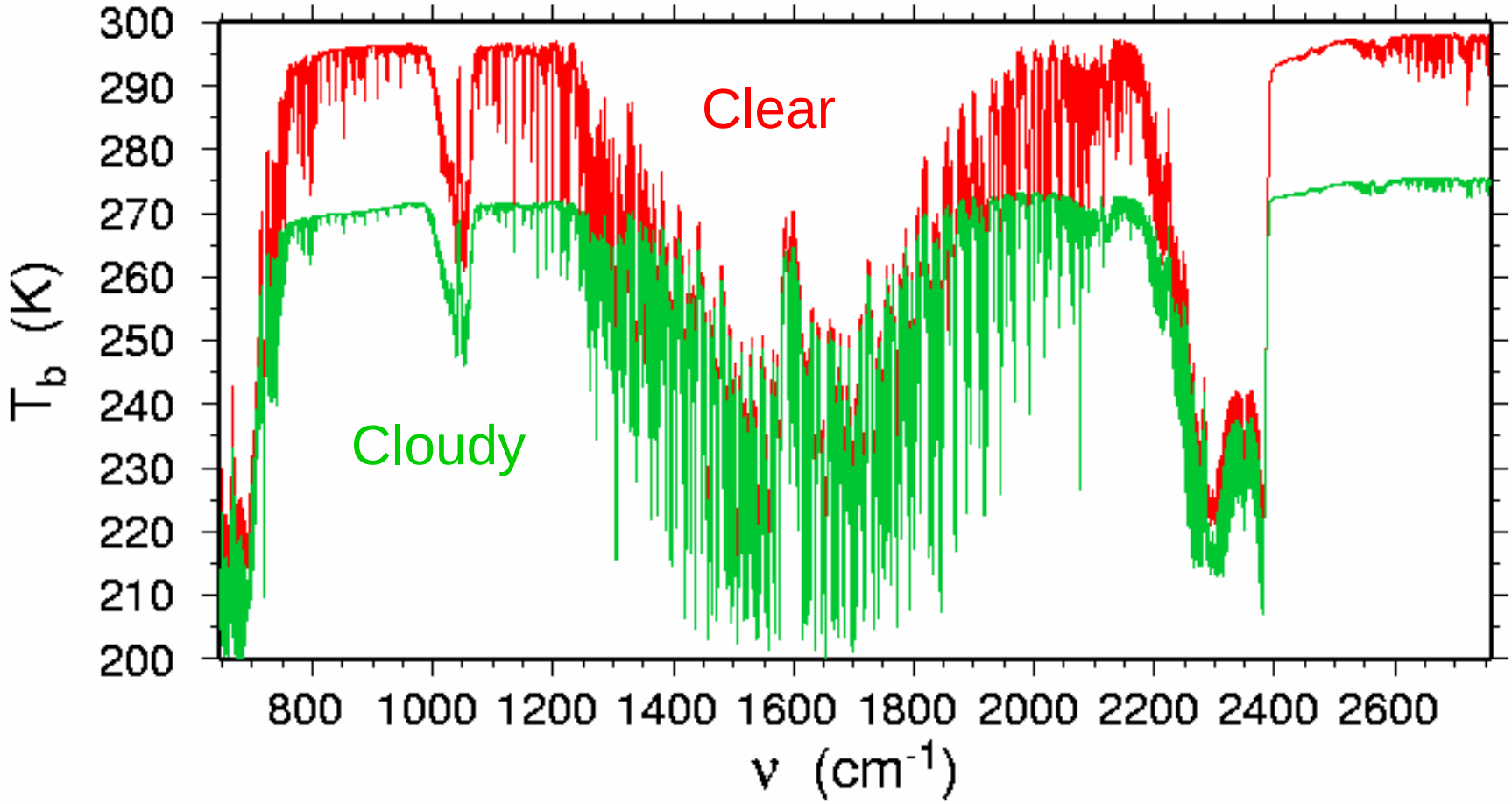
- Besides error covariances a number of flags are generated steering through the processing and giving quality indicators; 40 flags are specified, which are part of the product

Cloud Processing

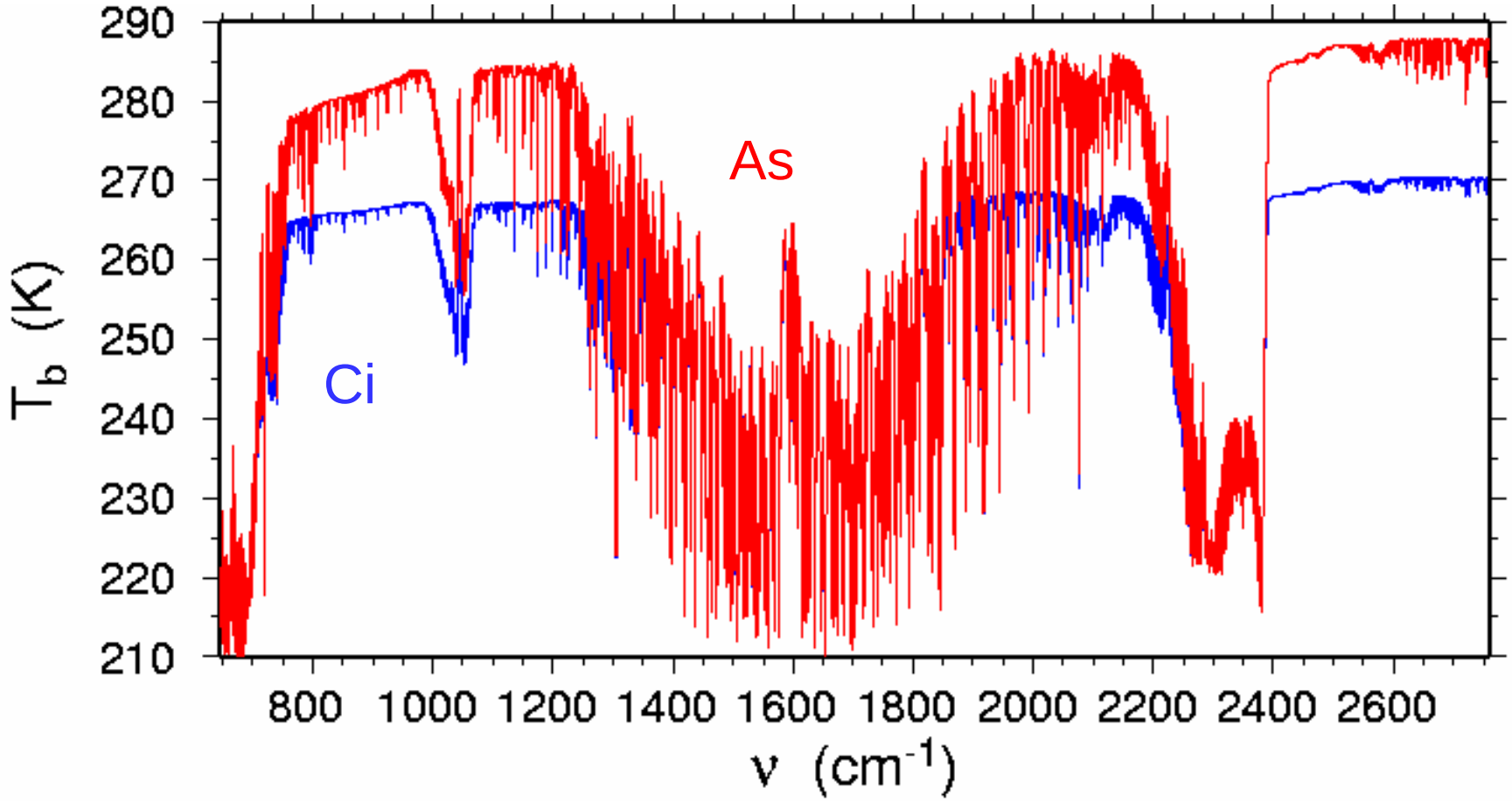
- Cloud detection
  - AVHRR-based cloud detection using Scenes Analysis from AVHRR Level 1 processing
  - Combined IASI / ATOVS cloud detection
  - IASI stand-alone cloud detection

- Cloud parameters retrieval
  - Cloud fraction
  - Cloud top height
  - Cloud phase

Clear and Cloudy IASI Spectra



Discrimination between Ice and Water Clouds



Geophysical Parameters Retrieval
State Vector to be Retrieved

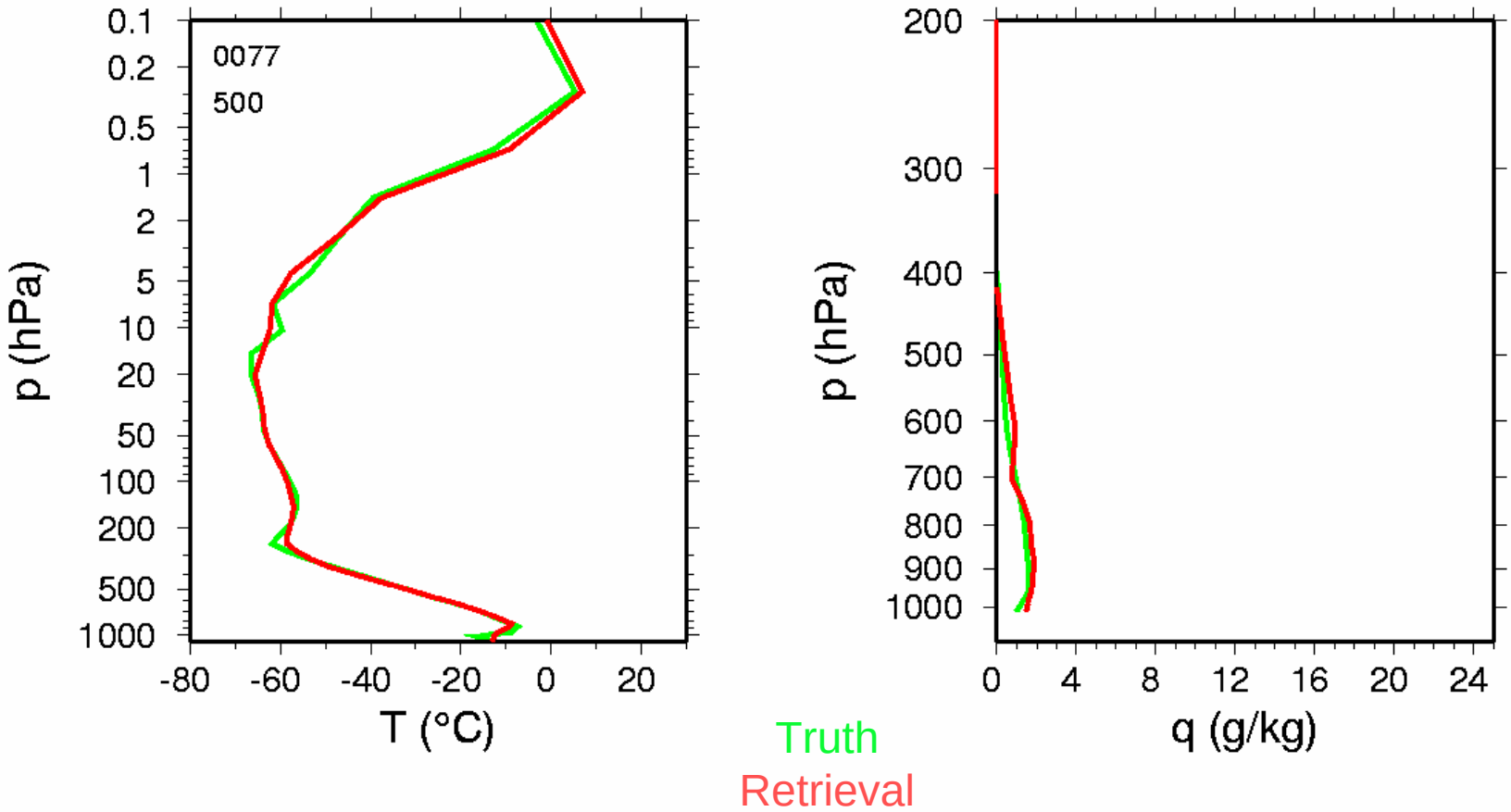
- The state vector to be retrieved consists of the following parameters
  - Temperature profile at a minimum of 40 levels
  - Water vapour profile at a minimum of 20 levels
  - Ozone columns in deep layers (0-6km, 0-12 km, 0-16 km, total column)
  - Land or sea surface temperature
  - Surface emissivity at 12 spectral positions
  - Columnar amounts of N_2O, CO, CH_4, CO_2
  - Cloud amount (up to three cloud formations)
  - Cloud top temperature (up to three cloud formations)
  - Cloud phase
- In case of clouds and elevated surface the state vector has to be modified

- The level 2 product contains the state vector along with information on quality and processing options and compressed error covariance

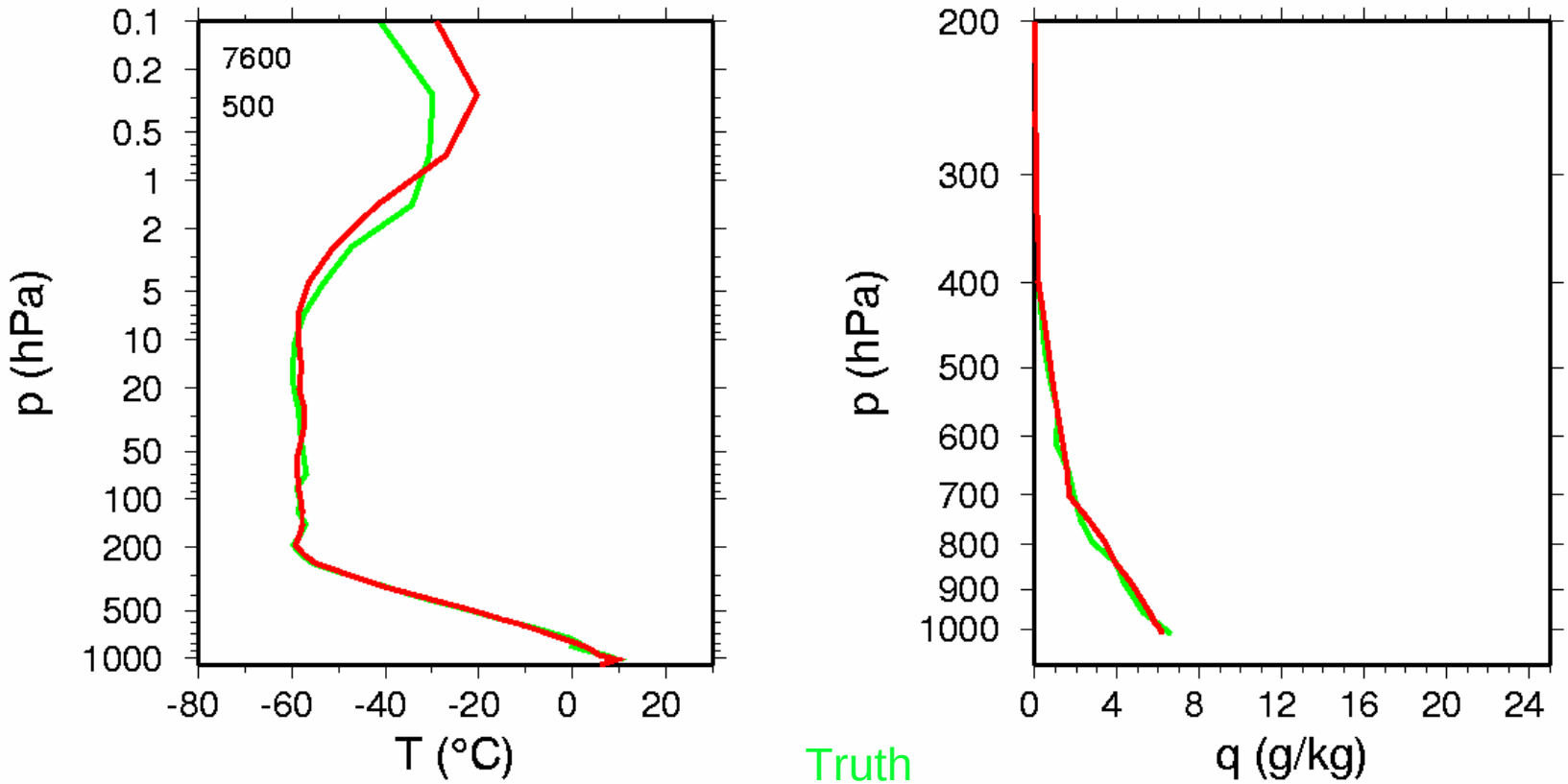
Geophysical Parameters Retrieval
First Retrieval

- Spectra PC scores regression for temperature and water-vapour, and ozone profiles, surface temperature, and surface emissivity
- Artificial neural network (multi-layer perceptron) for trace gases (optionally also for temperature, water-vapour and ozone, depends on configuration setting)
- The results from the first retrieval may constitute the final product or may serve as input to the final, iterative retrieval; the choice depends on configuration setting and on quality of the first retrieval results

Retrieval Simulation: Example for Single Retrieval Arctic Atmosphere



Retrieval Simulation: Example for Single Retrieval Mid-Latitude Atmosphere



Final, Iterative Retrieval

- Simultaneous iterative retrieval, seeking maximum probability solution for minimisation of cost function by Marquardt-Levenberg method, using a subset of IASI channels, combined to super-channels
- Initialisation with results from first retrieval
- Other choices of initialisation may be selected, depending on configuration setting and availability (e.g. NWP forecast, climatology, ATOVS Level 2 product)
- Background state vector from climatology, ATOVS Level 2 product, adjacent retrieval, or NWP forecast, depending on configuration and availability
- State vector to be iterated depends on cloud conditions and configuration setting (clear, cloudy, variational cloud clearing)

Super-Channel Composition

- Search for highly correlated radiances among all IASI spectral samples (noise-normalised radiances) and collect them in clusters
  - No need to have adjacent spectral samples
  - Correlation must be pre-determined at certain level: determines the number of clusters

- Determine a lead channel in each cluster: Radiance and Jacobians will only be calculated for lead channel radiances $y_L(\mathbf{x})$

- Represent the measured radiance ${y_L}^m$ of a cluster by a weighted average of all radiance samples which are members of the same cluster
  - Weights consist of regression coefficients, taking into account the correlation and the noise of the respective sample
  - Errors include measurement and regression errors

$$y_L^m = \frac{1}{N}\sum_{i=1}^{N} a_i + b_i y_i^m$$

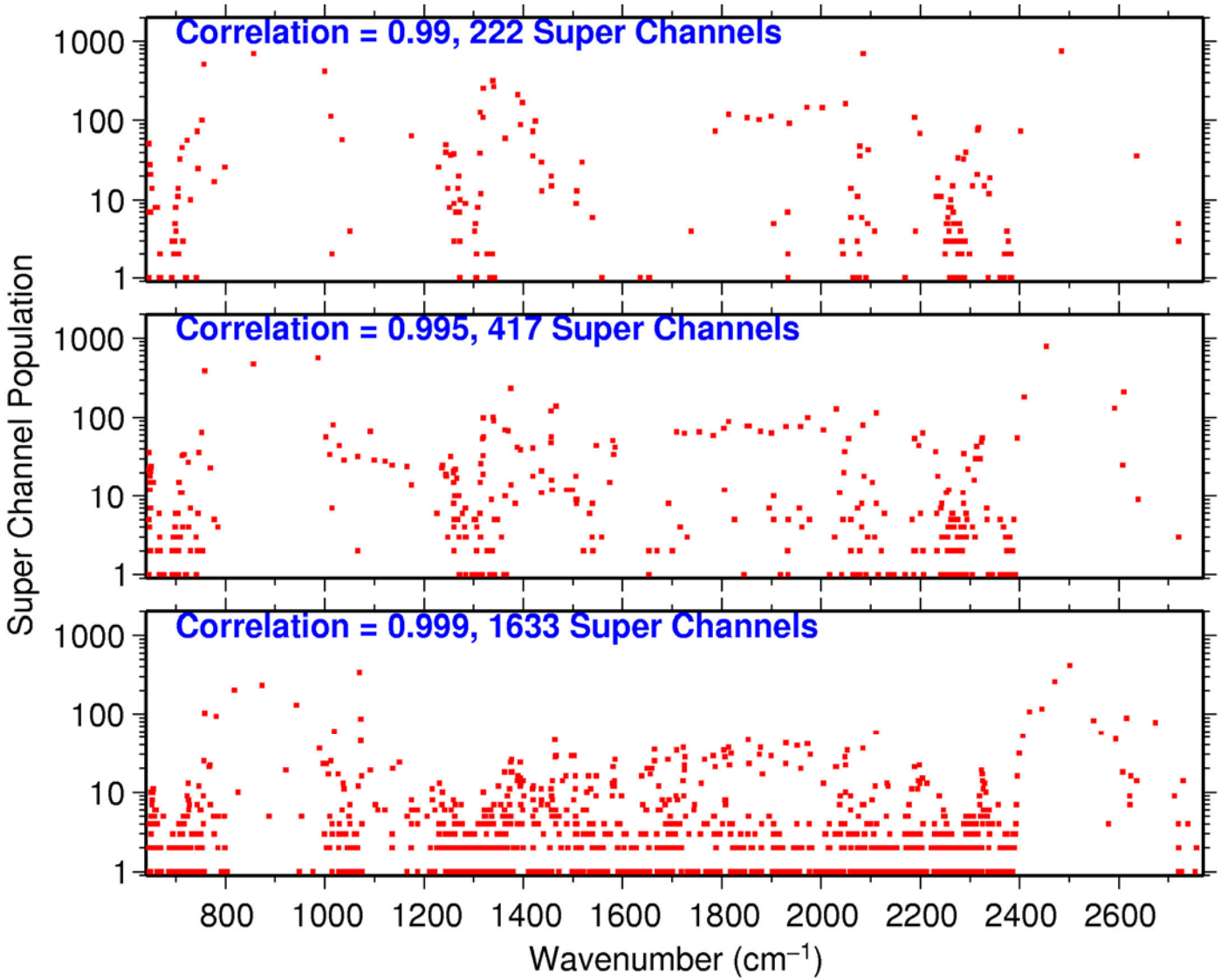
Radiative Transfer Simulations and Super-Channel Clustering

- For a set of 53980 situations RTIASI-5 simulations have been carried out, assuming a random selection of possible scan angles
- The resulting radiance spectra (apodised) have been normalised with the corresponding noise
- A correlation analysis is done between spectral samples
  - All samples with a correlation higher than a threshold are retained in the respective cluster
  - The assumed thresholds vary between 0.95 and 0.999
- The lead sample is regressed against all other member samples of a cluster to obtain weighting coefficients and error estimates

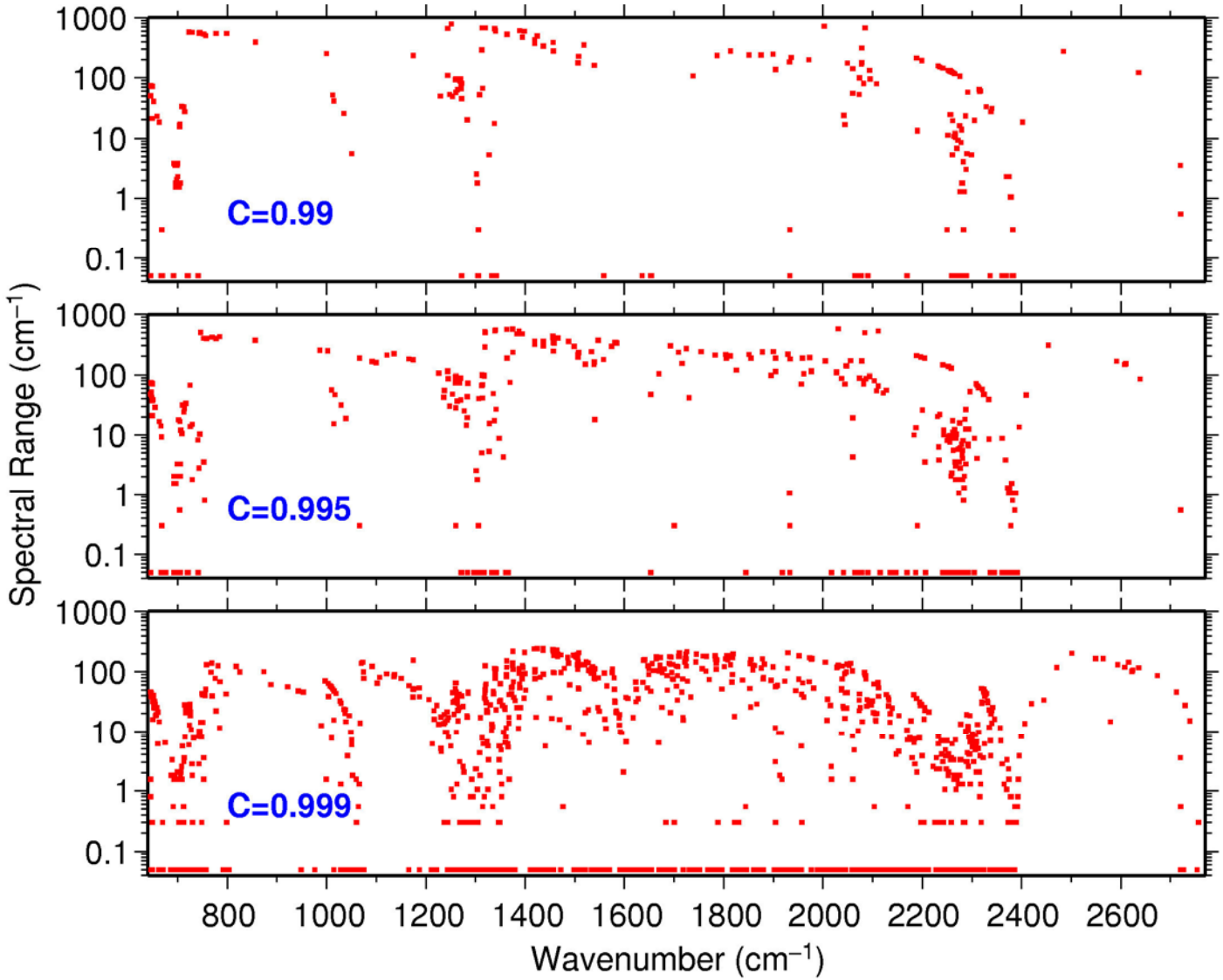
Super-Channel Properties

Correlation	Number of Super-Channel Clusters
0.95	47
0.98	113
0.99	222
0.995	417
0.999	1633

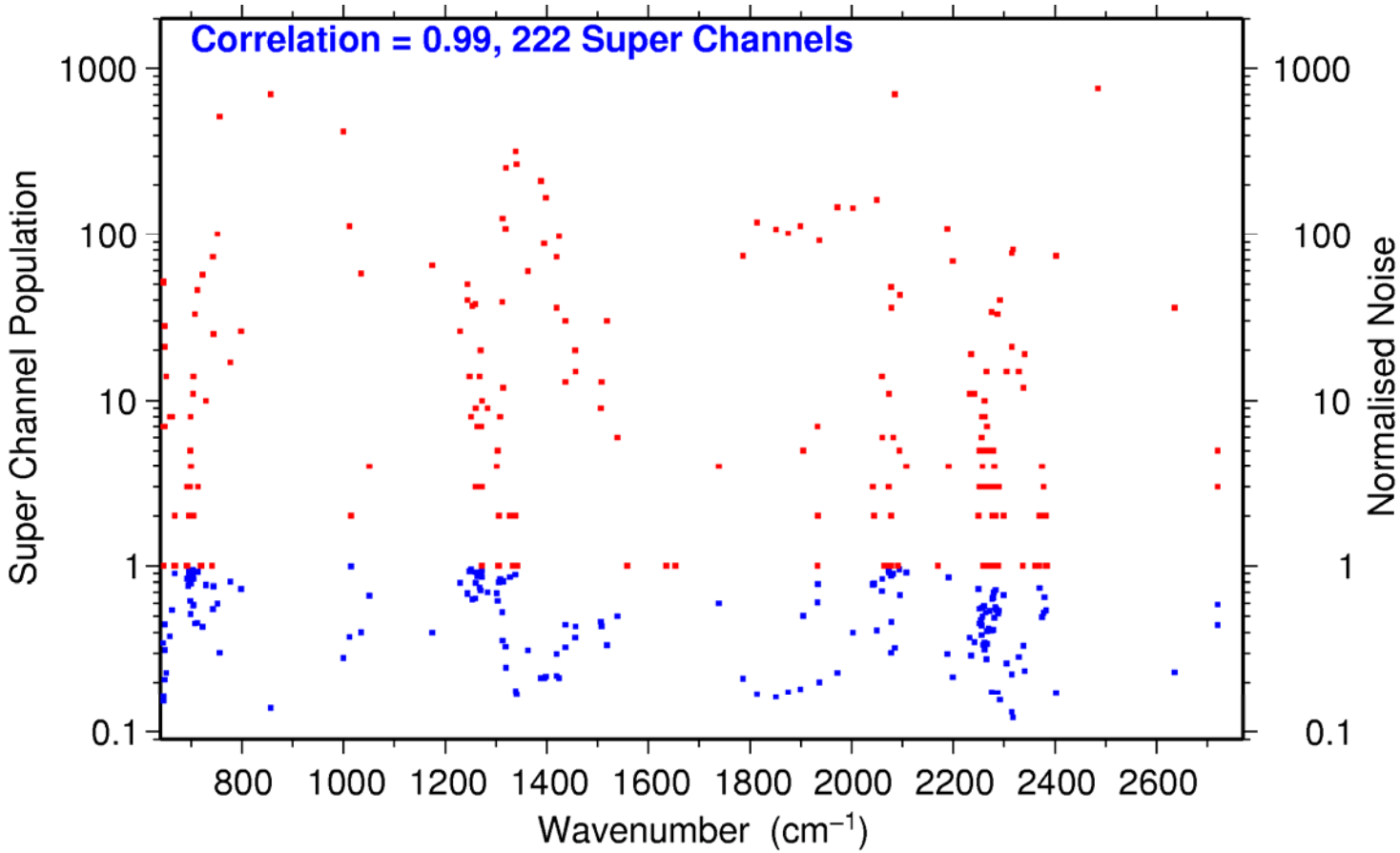
Population of Super-Channel Clusters



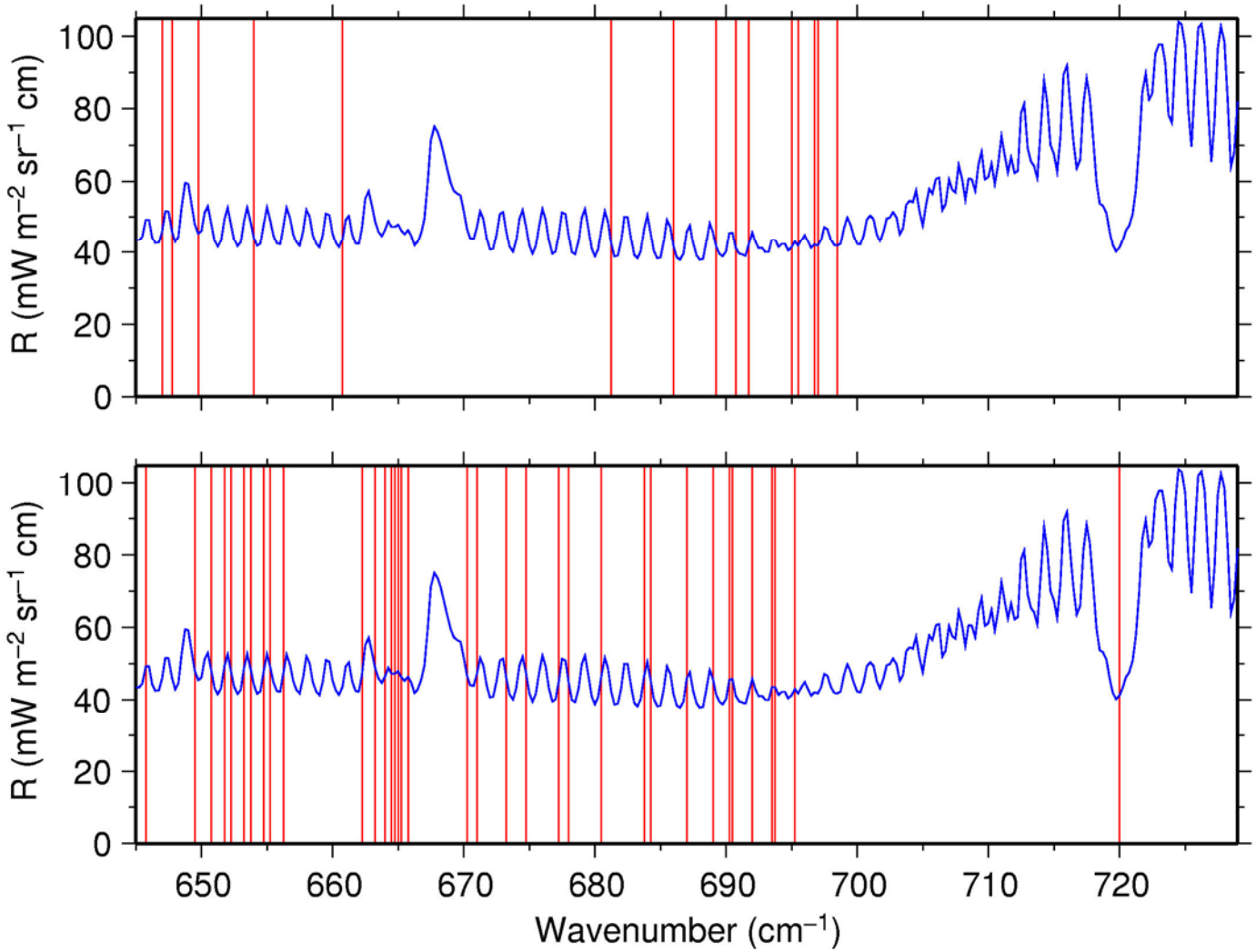
Spectral Range Covered by Super-Channel Clusters



Population of Super-Channel Clusters and Noise Reduction



Examples of Super-Channel Clusters



Correlation: 0.995

Cluster 6:
15 samples
Lead: 647 cm^{-1}

Cluster 3:
36 samples
Lead: 645.75 cm^{-1}

Test with AIRS Data: Preparation

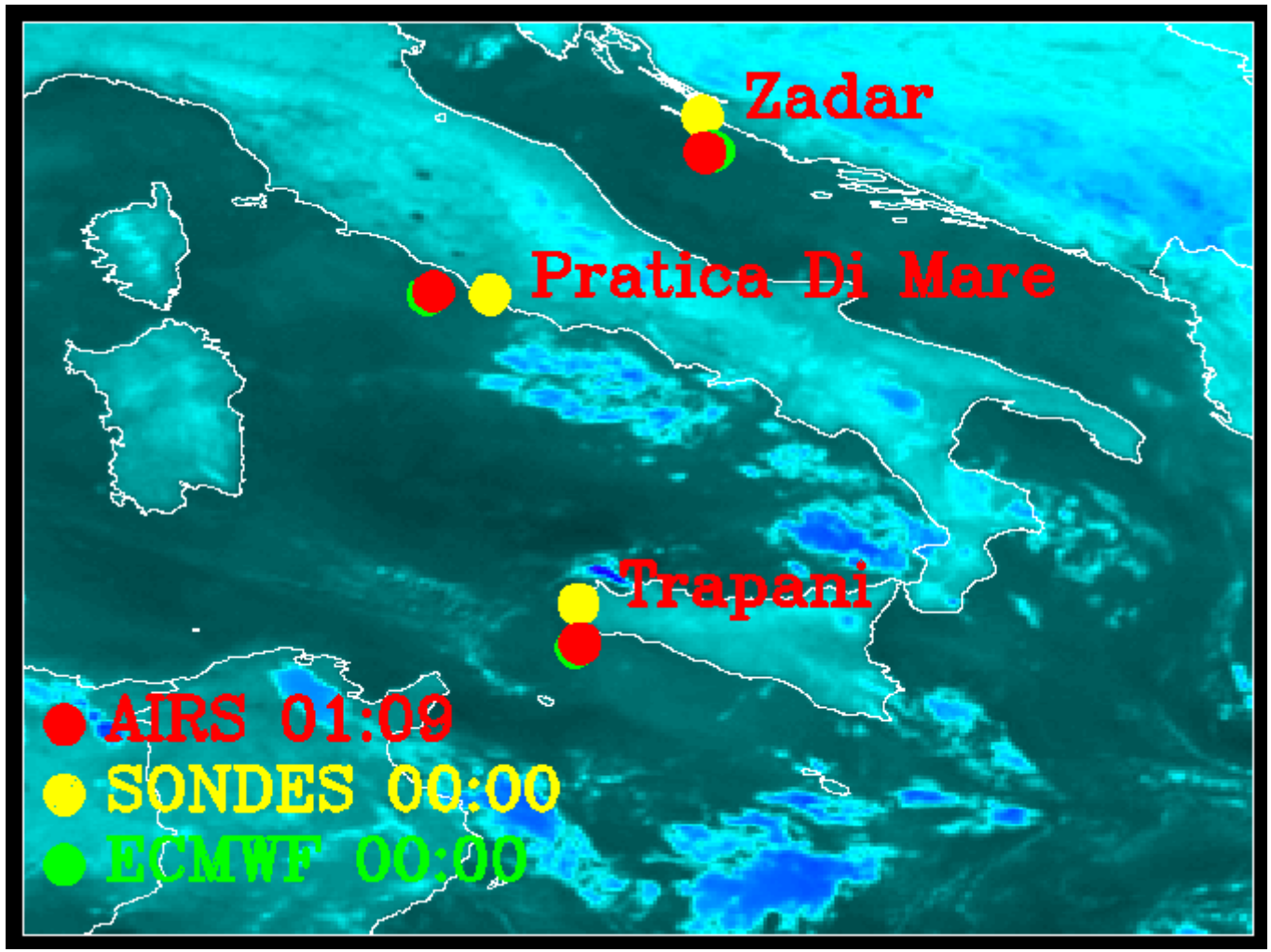
- The retrieval schemes have been tested extensively with real AIRS data and compared to co-located ECMWF forecasts and radiosonde measurements, focusing on temperature and water-vapour retrievals

- Modification of the processing scheme:
  - Replacement of RTIASI by RTTOV-8 or SARTA in variational retrieval
  - Bias correction (additive constant per channel) based on global set of RT forward calculations with ECMWF forecast and co-located AIRS
  - Modification of EOF regression coefficients: adaptation to AIRS spectral and radiometric characteristics
  - Use of all “good” AIRS channels in first guess and variational retrievals, i.e. excluding black-listed channels with excessive noise characteristics
  - Adaptation of cloud detection schemes

- Case studies in clear and cloudy situations with data from the EAQUATE campaign in summer 2004

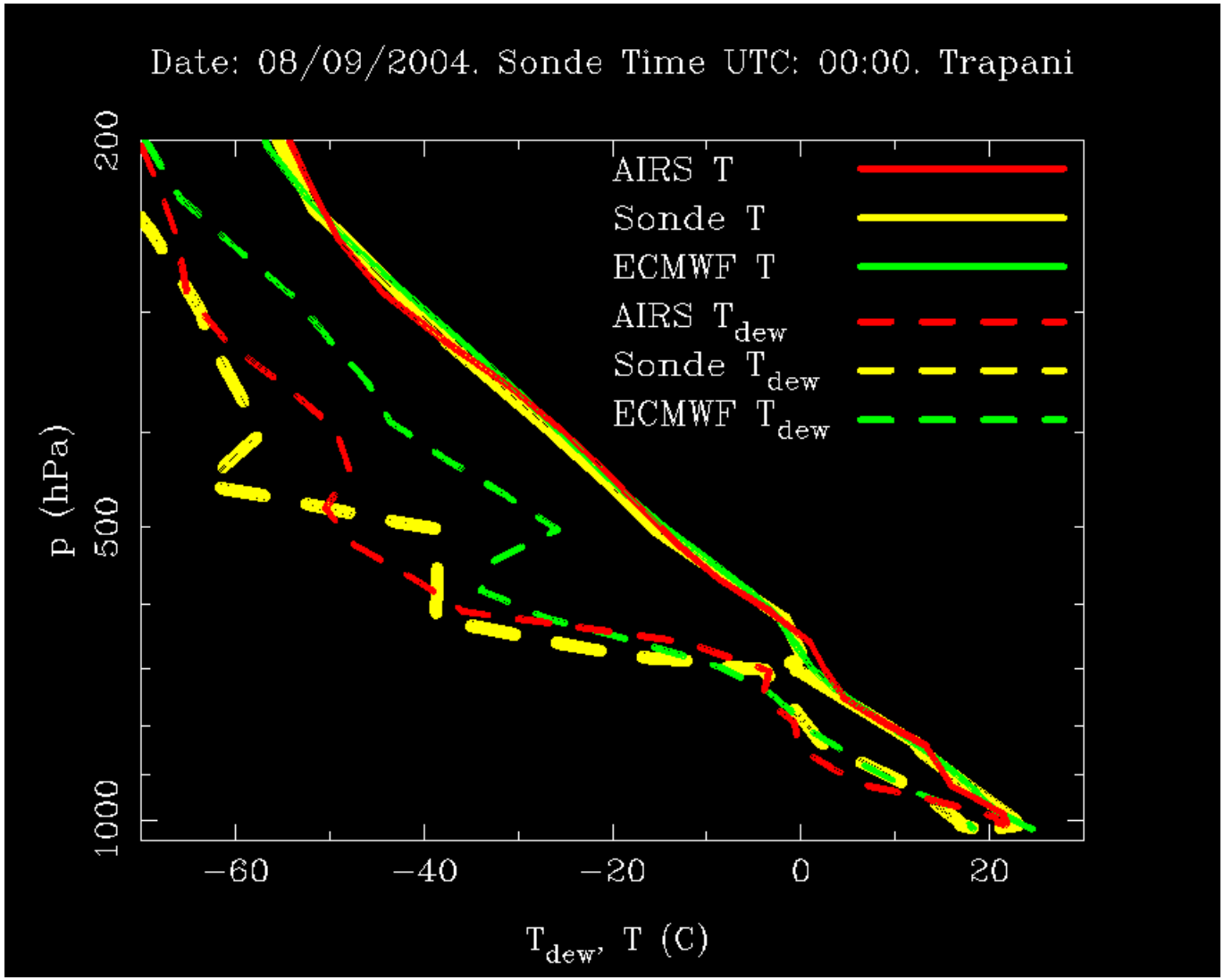
EAQUATE Radiosonde Locations

- MSG Ch 9
- 8 August 2004, 01:12 UTC



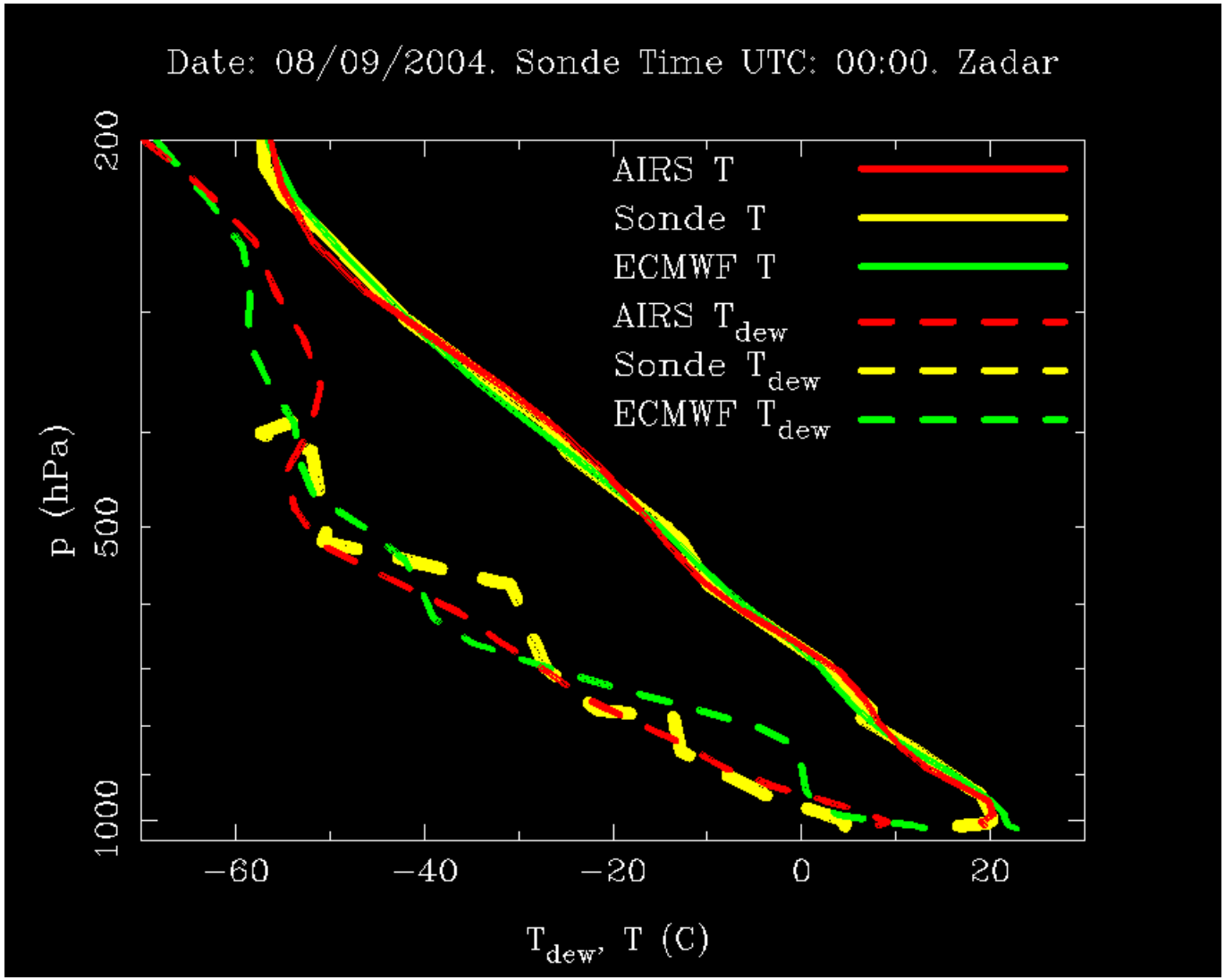
Inter-Comparison: Trappani

- EOF first guess
- No background
- Physical constraint
- 69 minutes time difference



Inter-Comparison: Zadar

- EOF first guess
- No background
- Physical constraint
- 69 minutes time difference



Test with AIRS Data: Results

- Difference in retrieval performance using RTTOV or SARTA can be removed by appropriate bias correction
- Initialisation of variational retrieval with results from first retrieval yields better retrieval performance than initialisation with climatology
- Climatology as background leads to results strongly biased towards climatology and prevents the detection of fine structure
- Physical constraints towards sub-adiabatic temperature profiles and non-saturated humidity profiles provide good performance
- First guess is important for variational retrieval, the EOF regression is already highly performing
- Introduction of a proximity constraint requiring the variational retrieval to stay close to first guess provides best results

IASI Data Transmission and Processing

- Satellite to ground transmission:
  - On-board storage and direct broadcast to local users
  - Down-link of global data to Svalbard receiving station after each completed orbit
  - Transmission of data to EUMETSAT Headquarters at Darmstadt

- Data processing at EPS Core Ground Segment:
  - Generation of Level 1 products (decommutation, calibration, apodisation, geo-location, and mapping of imagery)
  - Generation of Level 2 products (geophysical parameters)

- Distribution to users:
  - Near-real time transmission of products to users (Level 1: 2.25 hours, Level 2: 3 hours) via satellite broadcast (EUMETCast)
  - Distribution of sub-sampled data (spatially, and spectrally in case of L1) via GTS to WMO users (same timeline as NRT transmission)
  - Storage in Unified Archival and Retrieval Facility (UMARF) for later access by users (7 hours after measurement)

Timeline for IASI Data Validation

- Metop-A launch: 17 July 2006
- IASI switch-on: 21 July 2006
  - Followed by CNES Cal/Val Phases A and B
  - A: Instrument activation and evaluation/system technical evaluation
  - B: Early validation of Level 1 products
- First IASI measurements: 31 August 2006
- Reference orbit for off-line testing available: 2 December 2006
- Early Level 1 products available: 28 December 2006
- CNES Cal/Val Phase C: In-depth validation of Level 1 Products
- Completion of Level 1 validation: 10 March 2007
- Start of Level 2 validation: 29 January 2007
- Completion of Level 2 validation: 21 May 2007