

IASI on Metop

Operational Level 2 Processor

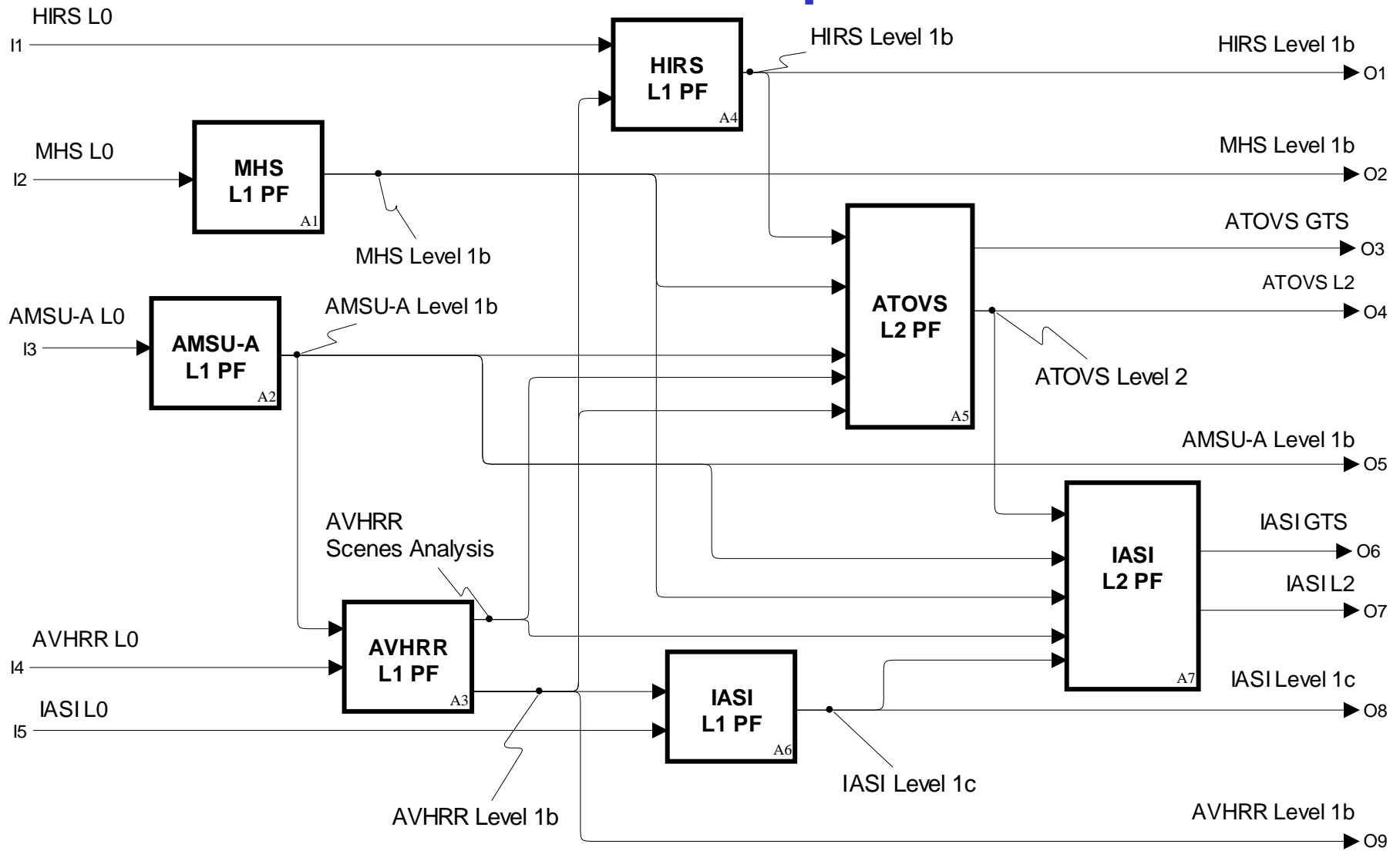
EPS End User Requirements and IASI Objective

- The main purpose of IASI is to deliver **temperature** and **water vapour** profiles for NWP at accuracies of 1K or 5%, respectively, at a high vertical resolution
- Cloud parameters to be derived from IASI include **cloud fraction**, **cloud top temperature**, **cloud height**, and **cloud phase**
- **Surface skin temperature** over land and ocean are to be derived from IASI along with a **surface emissivity** characterisation over land
- **Trace gases** that will be derived from IASI are **ozone profiles** and columnar amounts of **carbon monoxide (CO)**, **carbon dioxide (CO₂)**, **nitrous oxide (N₂O)**, and **methane (CH₄)**

Properties of the Operational IASI L2 Processor

- 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 (see next slide)
- IASI stand-alone processing is possible if other measurements are not available, or if PPF 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

PPF Chain Interdependencies



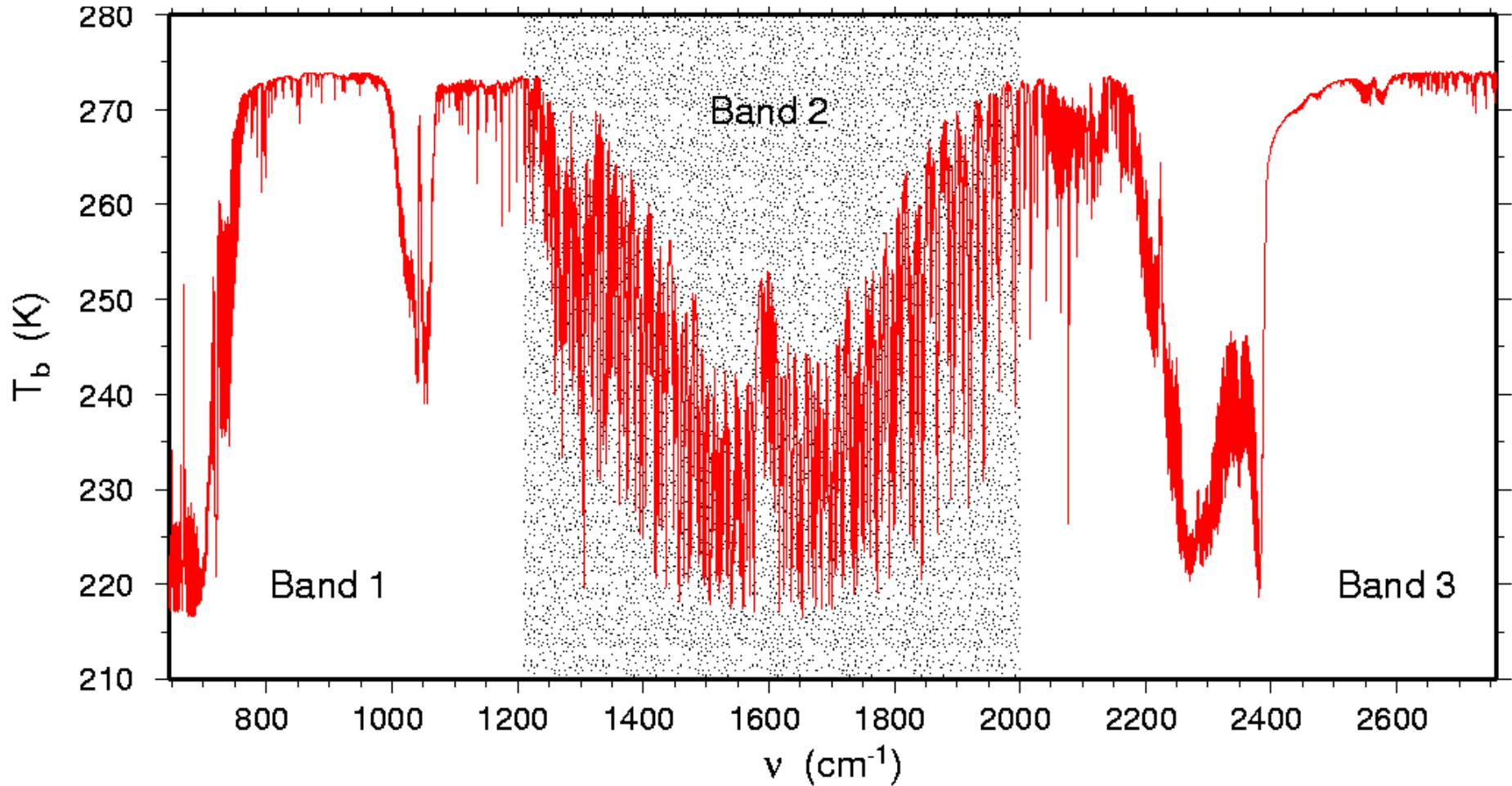
Properties of the Operational IASI L2 Processor (cont.)

- Processing is steered by configuration settings (80 configurable auxiliary data sets), which allows for optimisation of PPF 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

Properties of the Operational IASI L2 Processor (cont.)

- All 8461 IASI “channels”, covering the spectral region from 645 to 2760 cm^{-1} are used in the retrieval to maximise the retrieved information (see next slide)
- PPF supports nominal and degraded instrument modes (e.g. failure of single detectors/bands)
- Bias control by radiance tuning via configuration

IASI Spectral Bands



IASI Level 2 Product Generation High Level Break-Down Structure

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

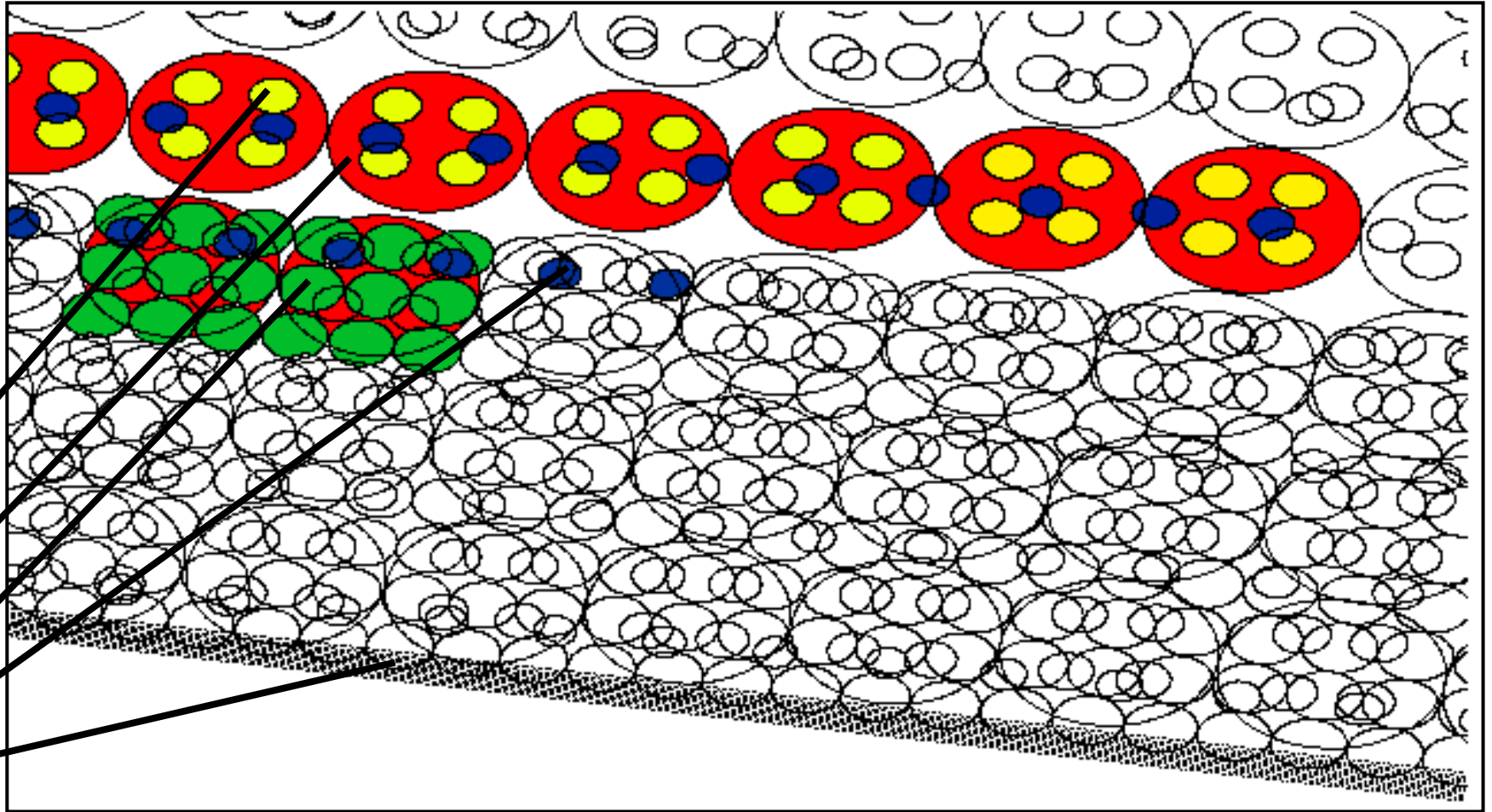
Quality Information

Pre-Processing

Acceptance and Validation of Data

- All input data will be accepted and checked against valid bounds
- Invalid or missing data will be flagged
- Further processing depends on availability of data, processing will proceed if possible with available data, even if incomplete (e.g. IASI stand-alone processing is foreseen)
- Use of redundant information in the case of IASI: Highly correlated channels can be used, where available, if measurements of single channels are invalid or missing
- Tuning coefficients will be applied to the measurements for removal of bias between calculated and measured radiances

Instruments' Fields of View



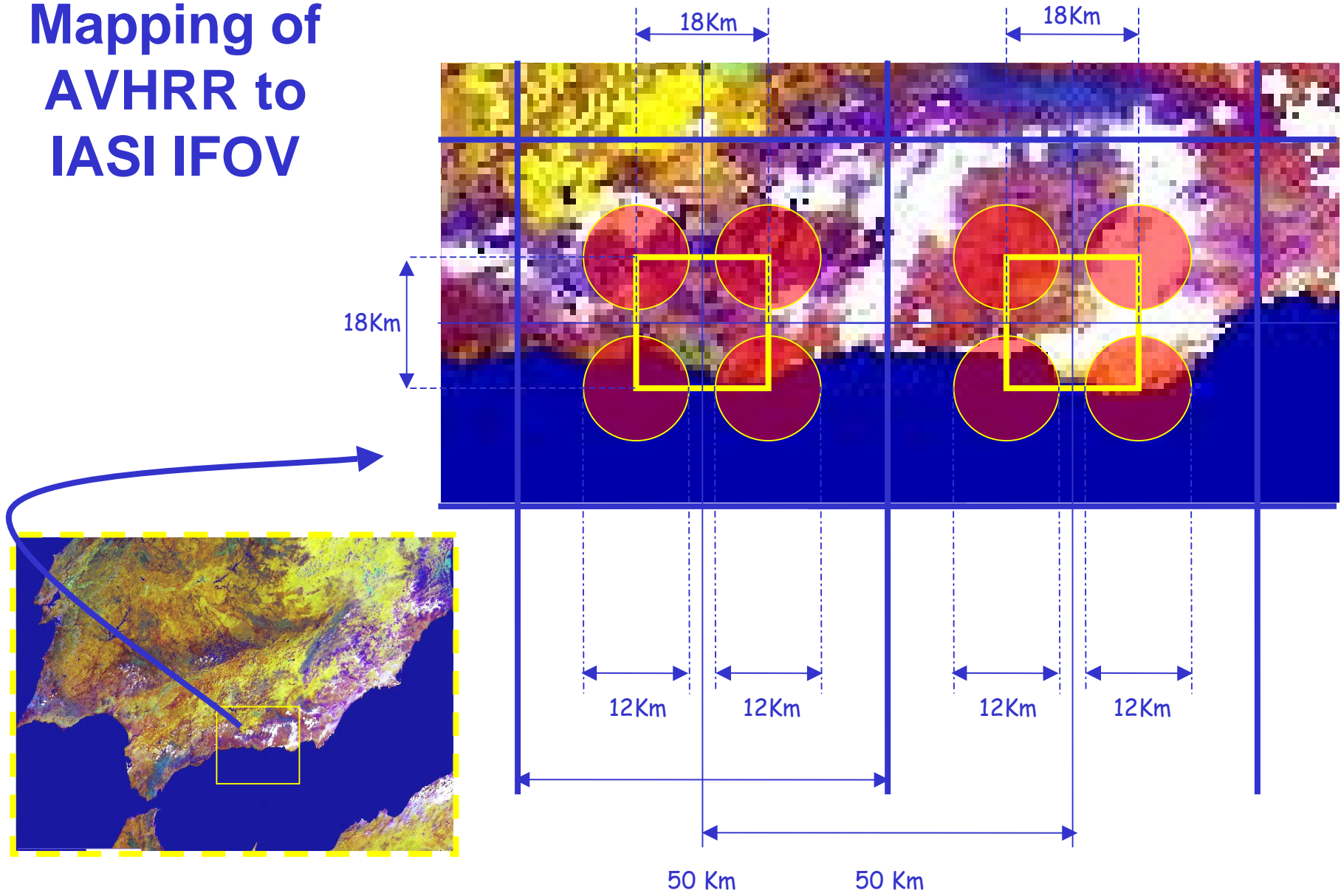
IASI
AMSU-A
MHS
HIRS/4
AVHRR/3

Pre-Processing

Mapping of other Data to IASI

- Extraction of auxiliary data (e.g. land mask, topography), and mapping to IASI IFOV,
 - calculation of IPSF-weighted land/sea fractions
 - calculation of IPSF-weighted surface height
 - determination of surface height variability
- Co-registration of AMSU-A, MHS, and ATOVS Level 2 data with IASI IFOV
 - depending on distance, nearest neighbour, average or bi-linear interpolation is chosen
- Mapping of AVHRR Scenes Analysis (cloud mask, surface temperature, cloud-top temperature) to IASI IFOV (see next slide)
 - calculation of IPSF-weighted cloud fractions of different cloud formations
 - calculation of IPSF-weighted cloud top and surface temperatures

Mapping of AVHRR to IASI IFOV



Pre-Processing

Mapping of other Data and Preparation of Retrieval

- Matching AVHRR scenes analysis with AVHRR radiance analysis (part of IASI L1c product) to locate cloud and surface formations in IASI IFOV
- Correction of IASI radiances with respect to ISRF changes due to non-homogeneity in IASI IFOV
- Initial choice of setting for cloud processing and retrieval procedures, depends on configuration setting, environmental conditions (cloud amount, surface type, elevation), data availability, and data quality

Cloud Detection and Cloud Parameters Retrieval

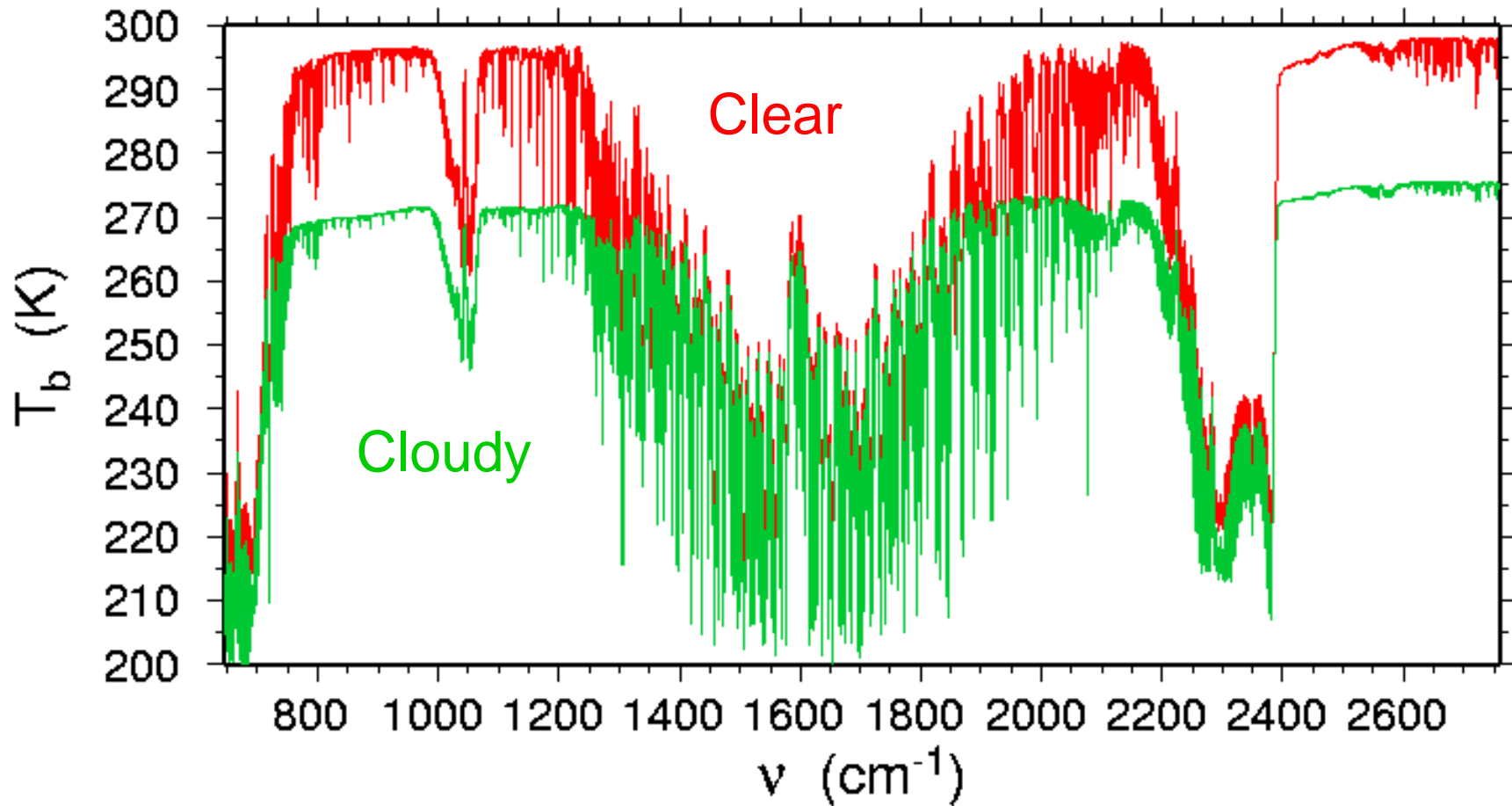
- AVHRR-based cloud detection using Scenes Analysis from AVHRR Level 1 processing
- Combined IASI / ATOVS cloud detection
- IASI stand-alone cloud detection
- Determination of cloud-top pressure and cloud amount using the CO₂ slicing method, adapted to hyper-spectral measurements

Cloud Detection Methods

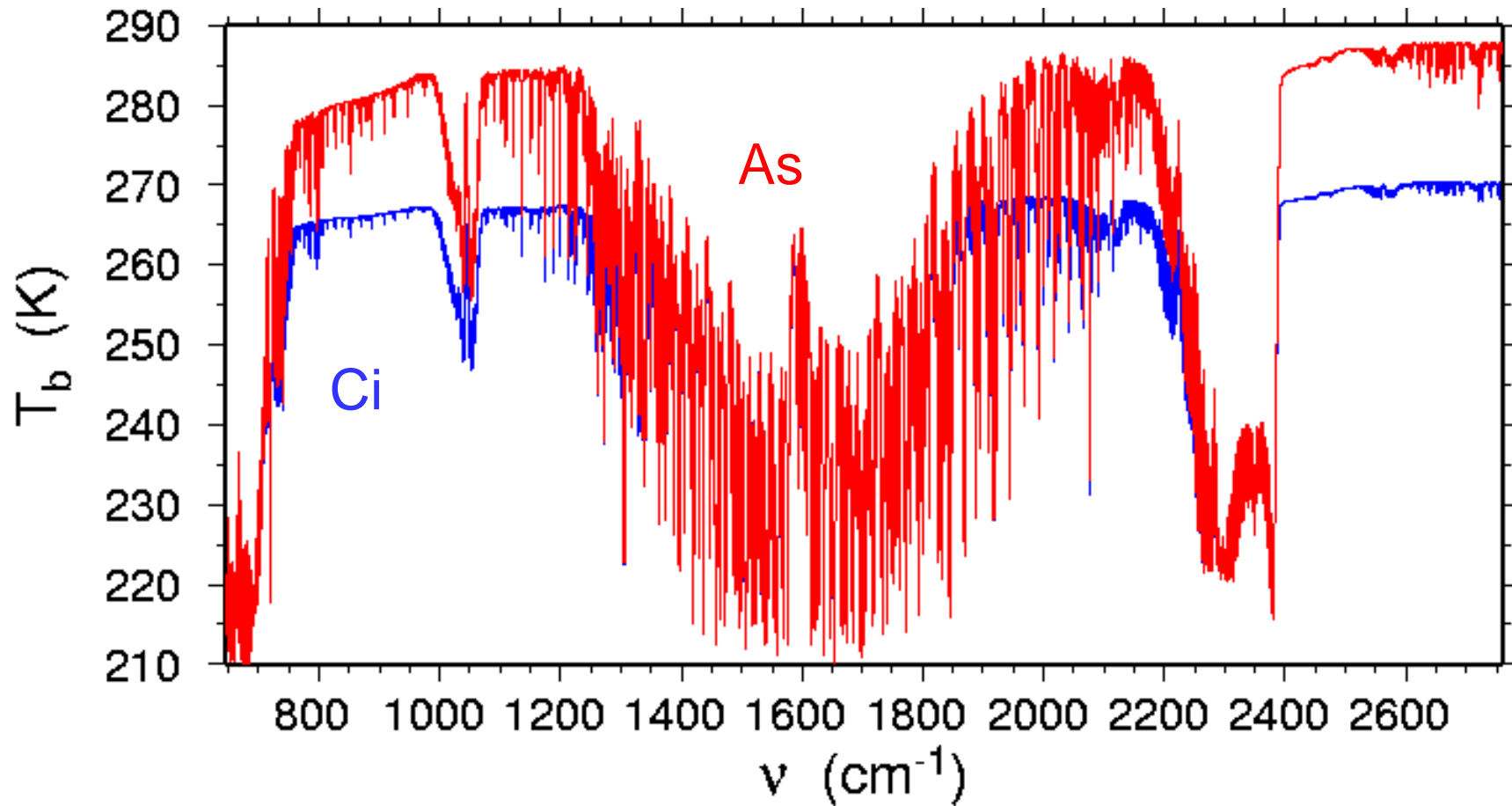
No single cloud detection method is able to reliably detect clouds under all conditions; thus, a number of methods are employed to be used concurrently

- Window channel threshold tests
- Empirical multi-channel methods, based on inter-channel regressions using IASI or IASI together with AMSU-A
- Test of horizontal coherence in atmospheric window
- Spectral cross-correlation test in atmospheric window region
- Projection of IASI spectra on to empirical orthogonal functions of clear spectra and test against threshold
- Threshold test over elevated polar regions using window-channel differences
- Threshold test on window channel differences to detect desert dust storms
- Threshold test on window channel differences to detect thin cirrus clouds

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 N₂O, CO, CH₄, CO₂
 - 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

Geophysical Parameters Retrieval

First Retrieval

- EOF 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

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)

Level 2 Product

- The IASI Level 2 Product contains the following information per sounding
 - State vector
 - Covariance matrix (compressed)
 - Flag Collection
 - Pointer to configuration setting
 - Location and time information
 - Scan geometry
- Details are described in the “EPS Programme IASI Level 2 Product Format Specification” (current release: Issue 6, Rev. 1)
- The level 2 product is disseminated to the users within 3 hours after the measurements via NRT terminals
- All level 2 products will be archived in the Unified Meteorological Archiving Facility (UMARF) at EUMETSAT HQ

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October-4 November 2003. Madison, WI, University of Wisconsin-Madison, Space Science and
Engineering Center, Cooperative Institute for Meteorological Satellite Studies, 2003.