Atmospheric Composition Measurements from the EUMETSAT Polar System (EPS) and plans for Post-EPS

EUMETSAT

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Summary

1. MetOp
2. GOME-2 on MetOp
3. IASI on MetOp
4. Plans for post-EPS

MetOp payload

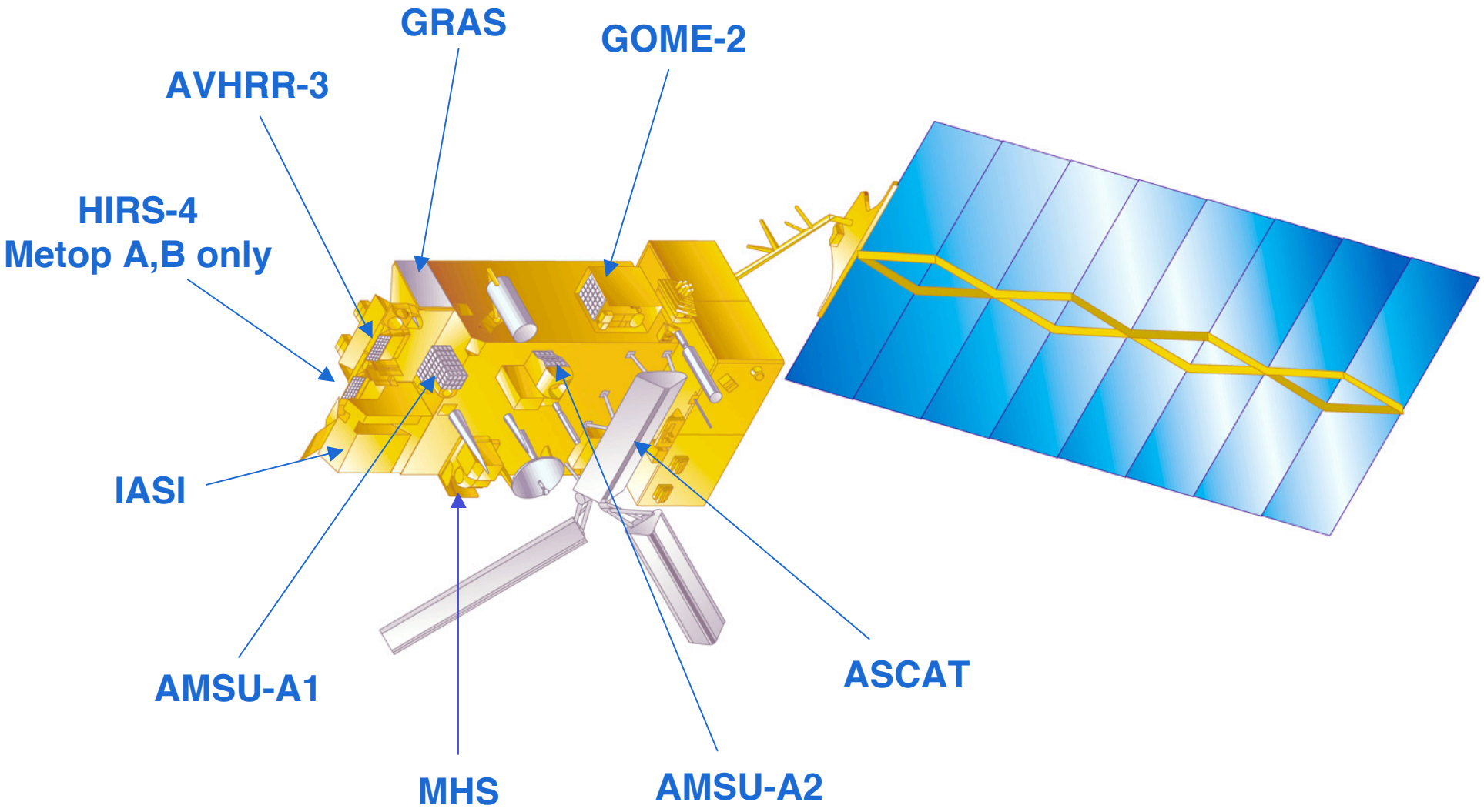
⇒ ESA / EUMETSAT / CNES

-	GOME-2	UV/VIS scanning spectrometer	O3 & trace gases...
-	ASCAT	C-band radar scatterometer	wind over oceans
-	GRAS	GPS satellite receiver (occultation)	T & H2O profiles
-	MHS	Microwave radiometer 89/190 GHz	H2O profiles
-	IASI	FTIR spectrometer (nadir)	T, H2O, O3, CO2...
-	DCS/Argos	Data collection from remote stations	
-	S&R	Data collection from emergency transmitters	

⇒ NOAA / NASA

-	AVHRR	high-spatial resolution VIS/IR imager	clouds, sea ice,...
-	HIRS	VIS/IR filter-wheel radiometer	T/p profiles, O3
-	AMSU-A	Microwave radiometer for 50 GHz O2 line	T/p profiles
-	SEM	Particle radiation monitor	

MetOp: Satellite and Met-Instruments



Metop - fully integrated

GOME-2 on MetOp

⇒ European Operational Global Ozone Monitoring on-board MetOp 1-3 satellites in 2006 to 2020

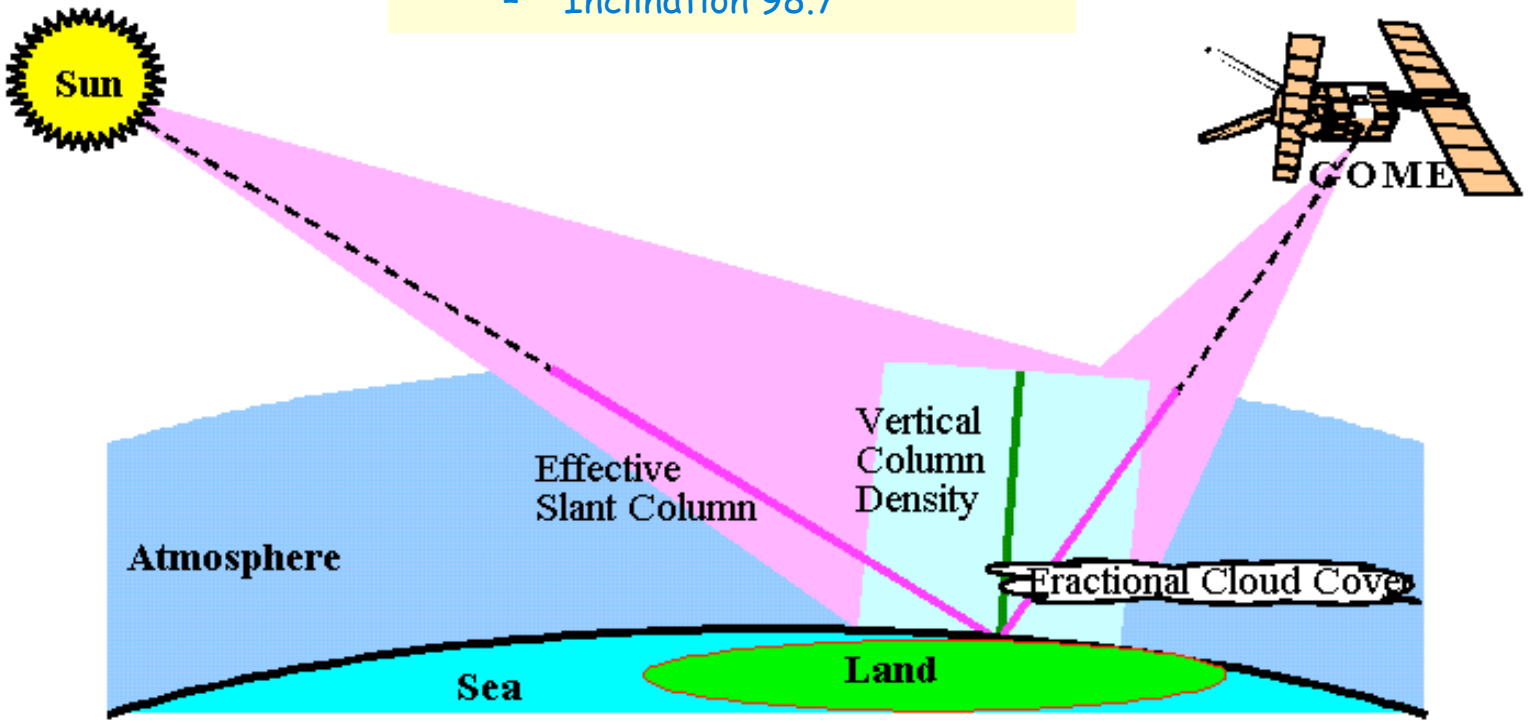
⇒ GOME-1 launched on-board ERS-2 in April 1995, still operational, provides
- trace gas total columns (ozone, NO2, SO2, BrO, OClO, HCHO,…)
- ozone profiles; aerosol, cloud, polarisation information

⇒ Improvements for GOME-2
- polarisation measurement of s- and p-polarised light in 15 bands
- white light source
- improved calibration approach
- numerous small improvements
- furthermore, adaptations to different satellite environment were needed.

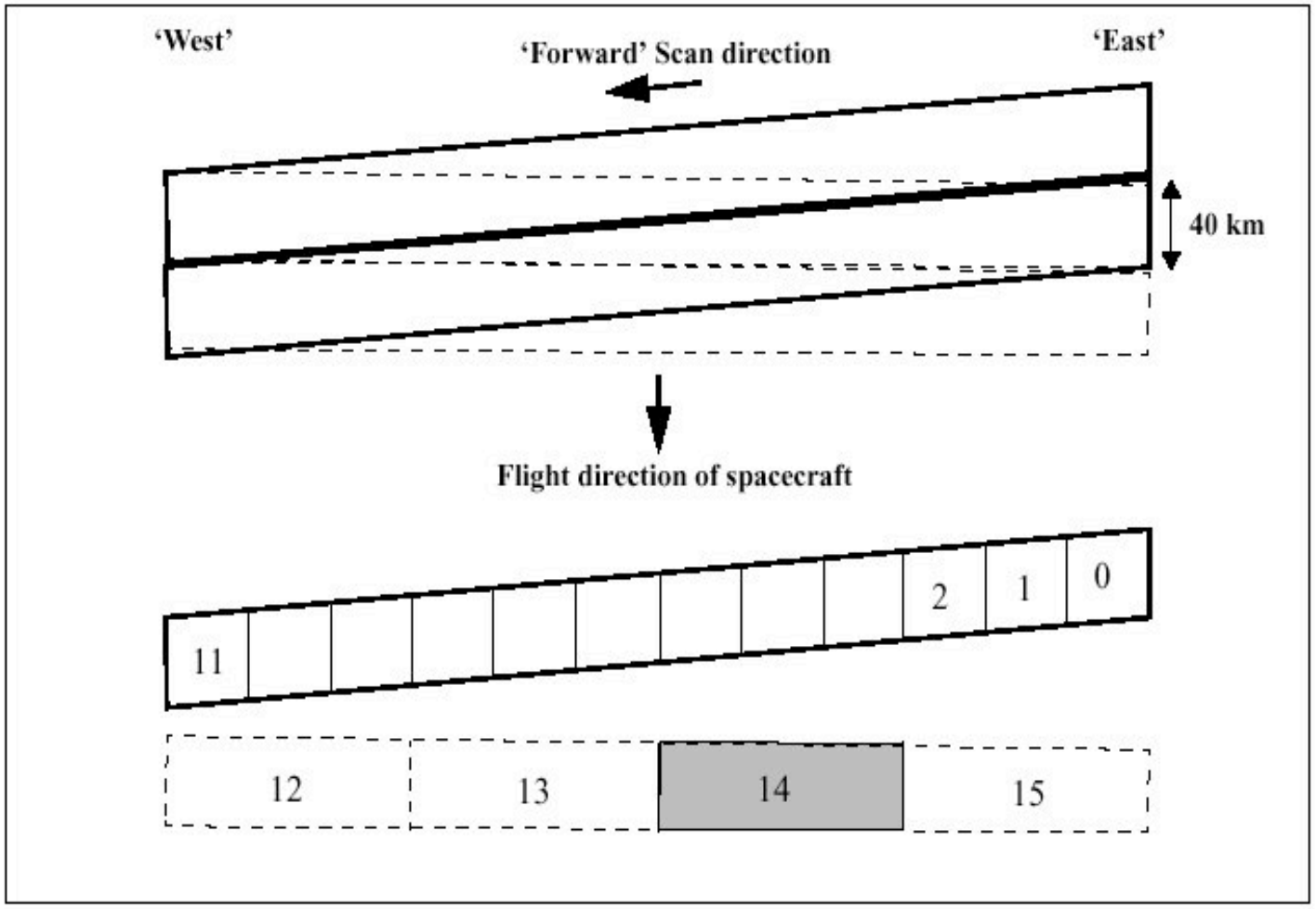
GOME-2 Measurement Principle

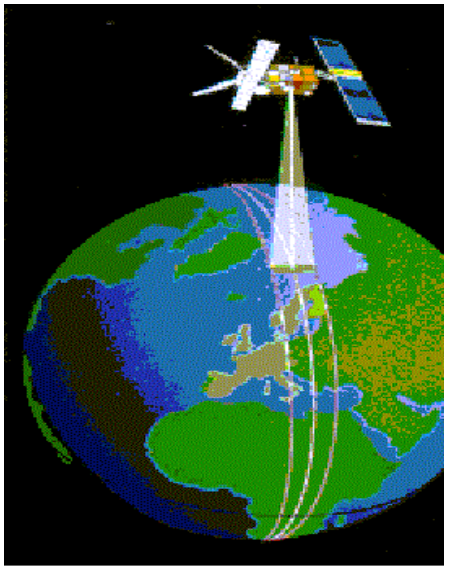
⇒ Mission orbit:

- near-polar sun synchronous
- 5 days repeat cycle
- descending node: 09:30
- mean altitude 825 km
- Inclination 98.7°



GOME-2 Scan Pattern





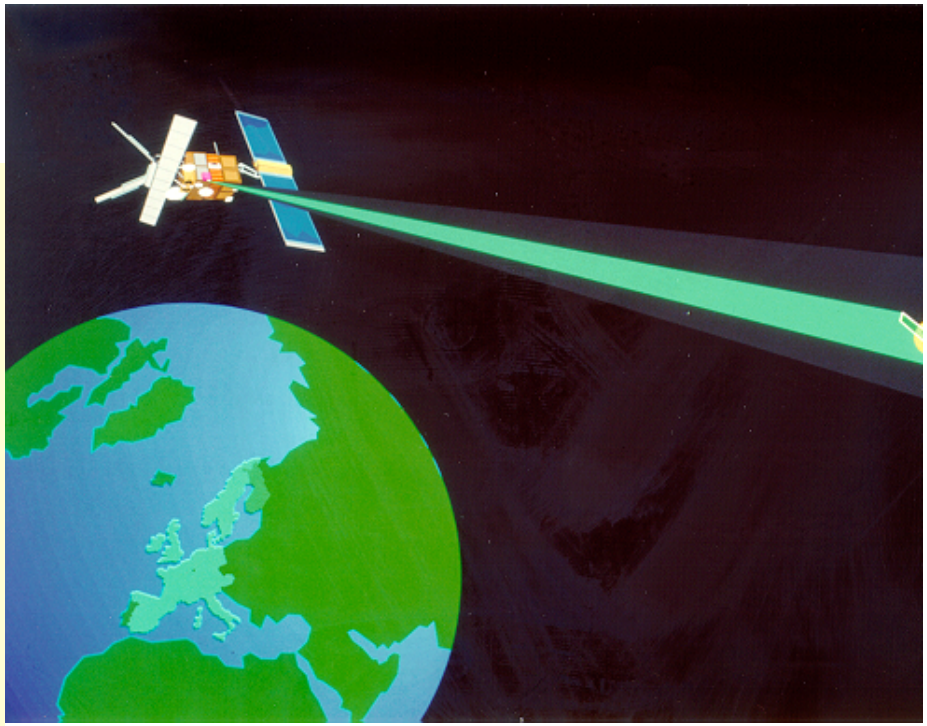
Forward scan
1920 km
duration 4.5 s
integration time
187 ms

24 ground pixels
size 40 * 80 km^2

PMU pixel size
192 ground pixel
size 40 * 10 km^2

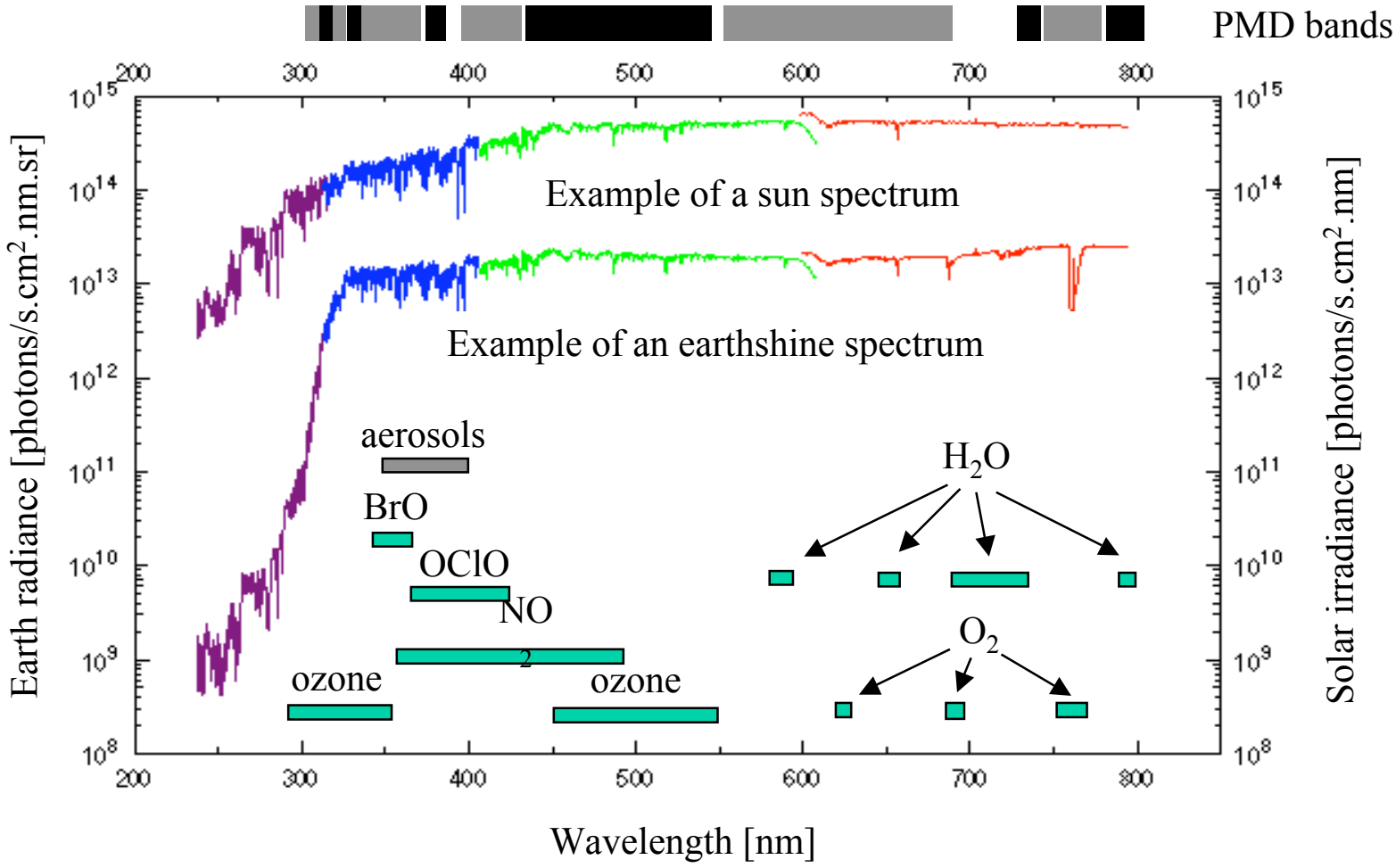
GOME-2 In-flight calibration

Illustration of moon calibration



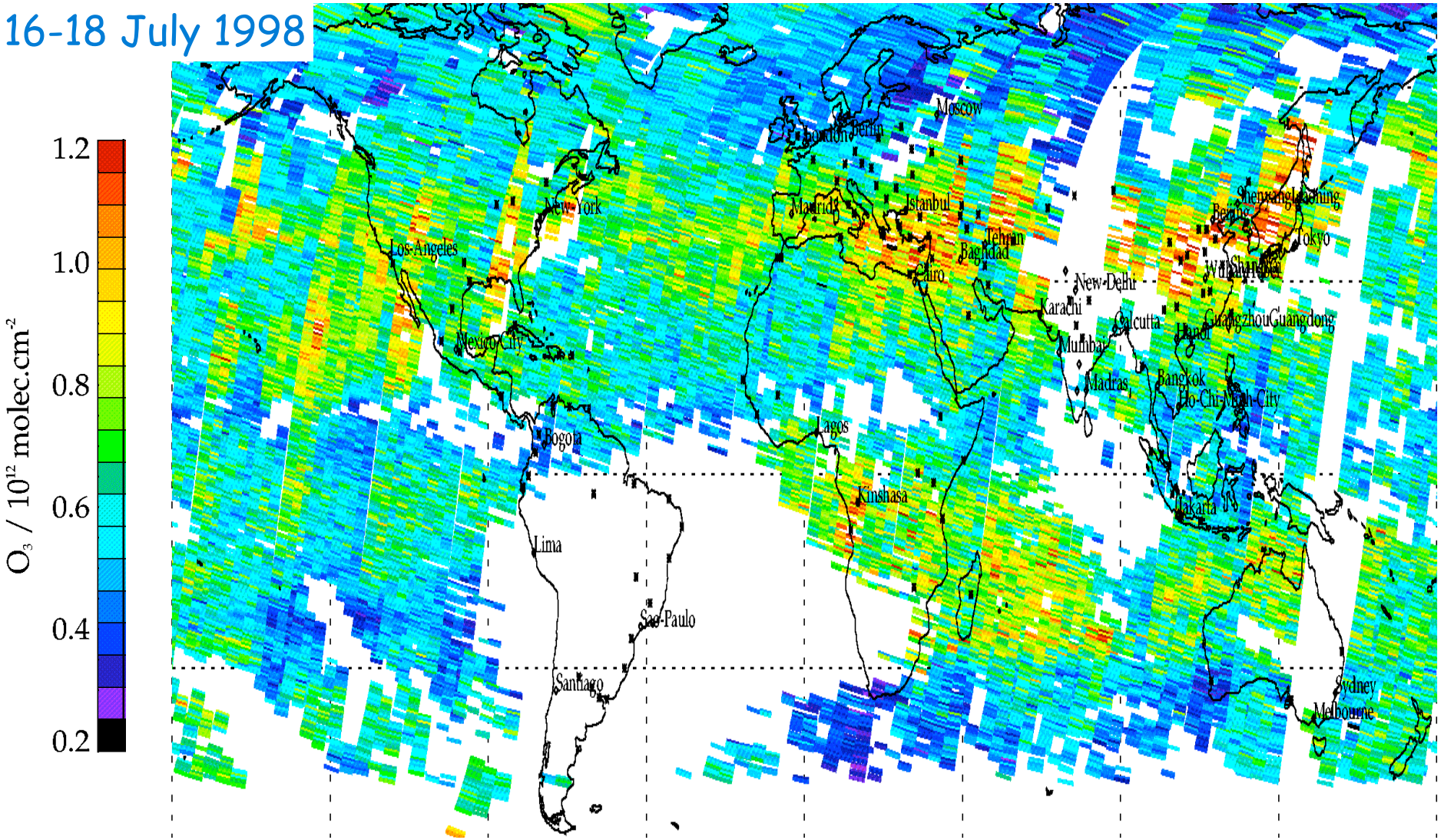
⇒ daily sun calibration
⇒ daily spectral calibration
⇒ daily dark signal characterisation
⇒ daily white light source characterisation
⇒ monthly calibration
  - spectral calibration
  - diffuser monitoring
  - engineering parameters
⇒ moon calibration

GOME-2 Spectral Bands

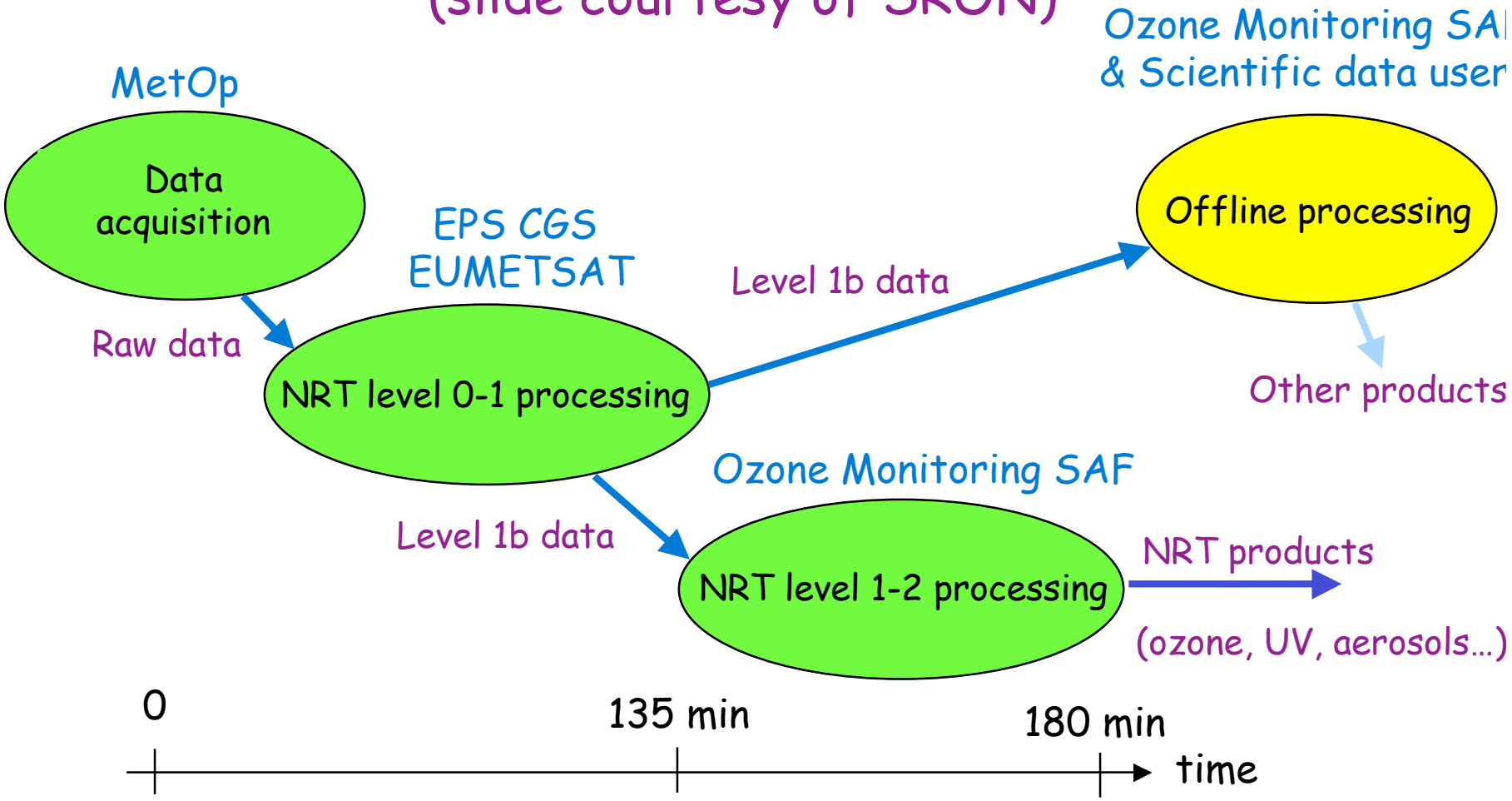


GlobalTropospheric O3 from GOME-1 - R. Siddans, RAL, private comm

16-18 July 1998



GOME-2 Data Processing (slide courtesy of SRON)



IASI Mission and Measurement Principles

Mission

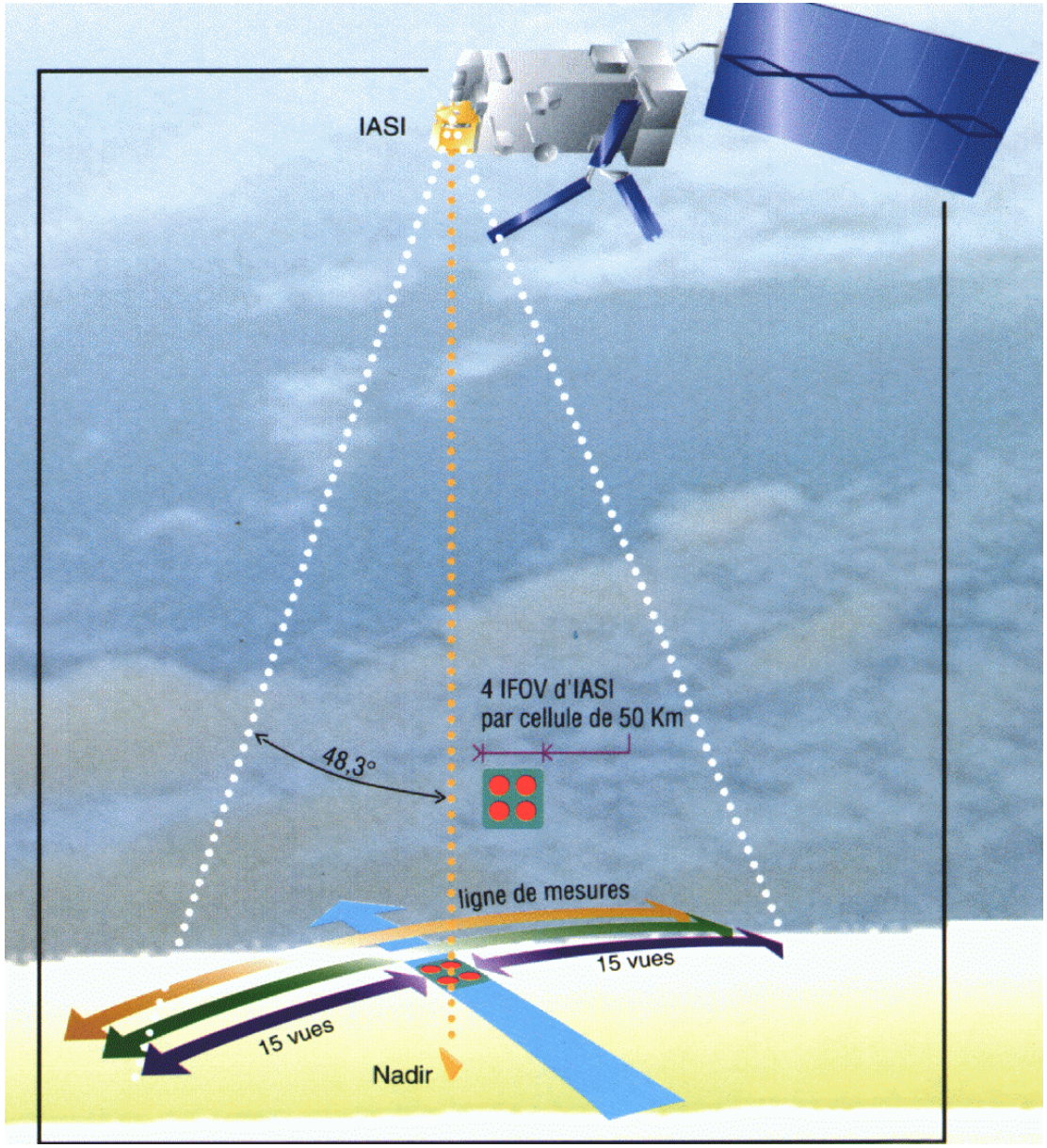
Primary mission objective → temperature and humidity profiles with improved accuracy and vertical resolution (1K and 10% @ 1 km vertical resolution, respectively)

Further mission objectives are related to the measurement of trace gases (ozone, methane, carbon monoxide, ...) as well as surface and cloud properties

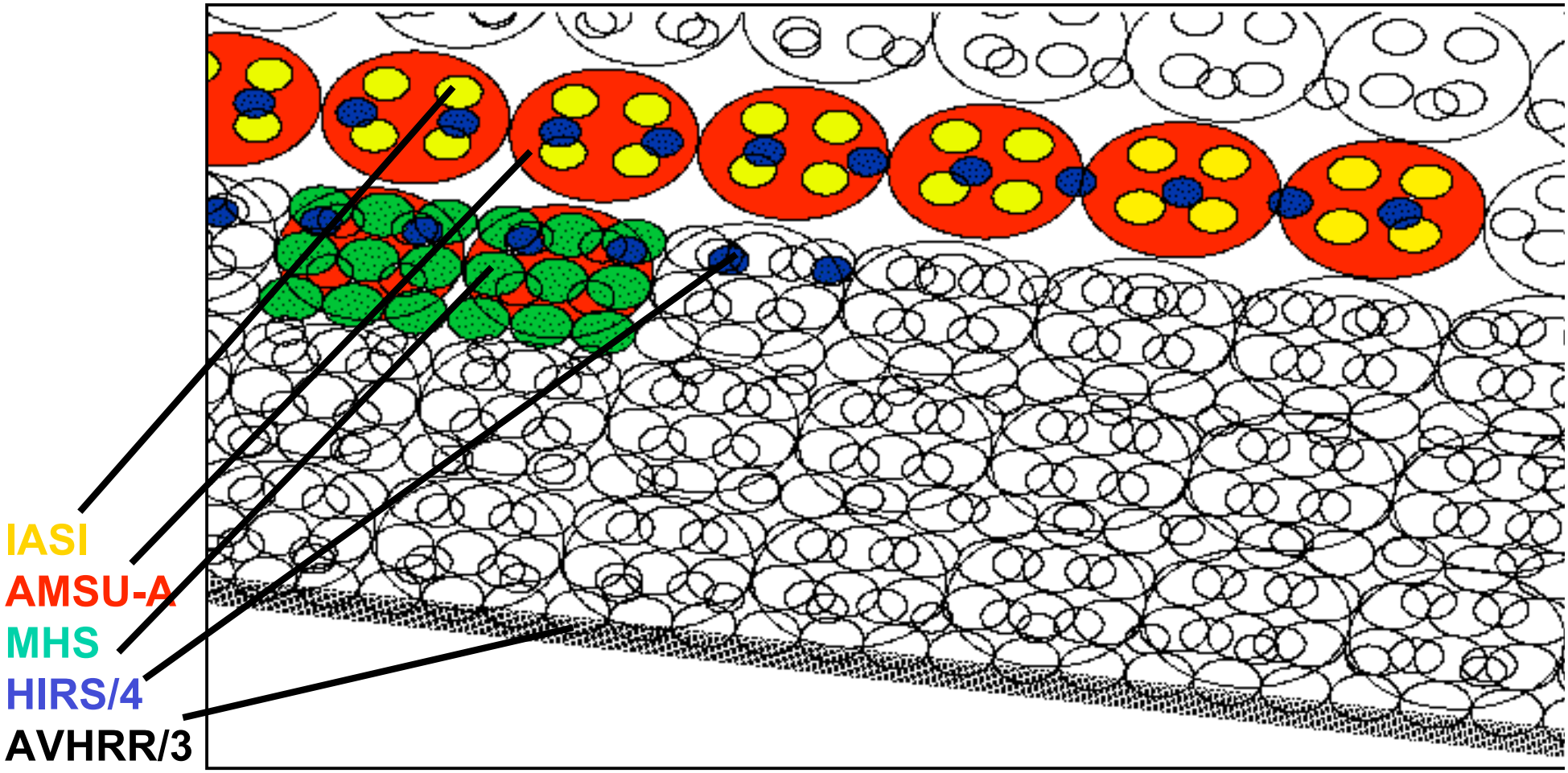
Technique

IASI is based on a Michelson interferometer.
Spectral range 3.6 to 15.5 μm (645 to 2760 cm-1)
Spectral sampling: 0.25 cm-1 giving 8461 spectral samples
Spectral resolution after apodisation: 0.5 cm-1

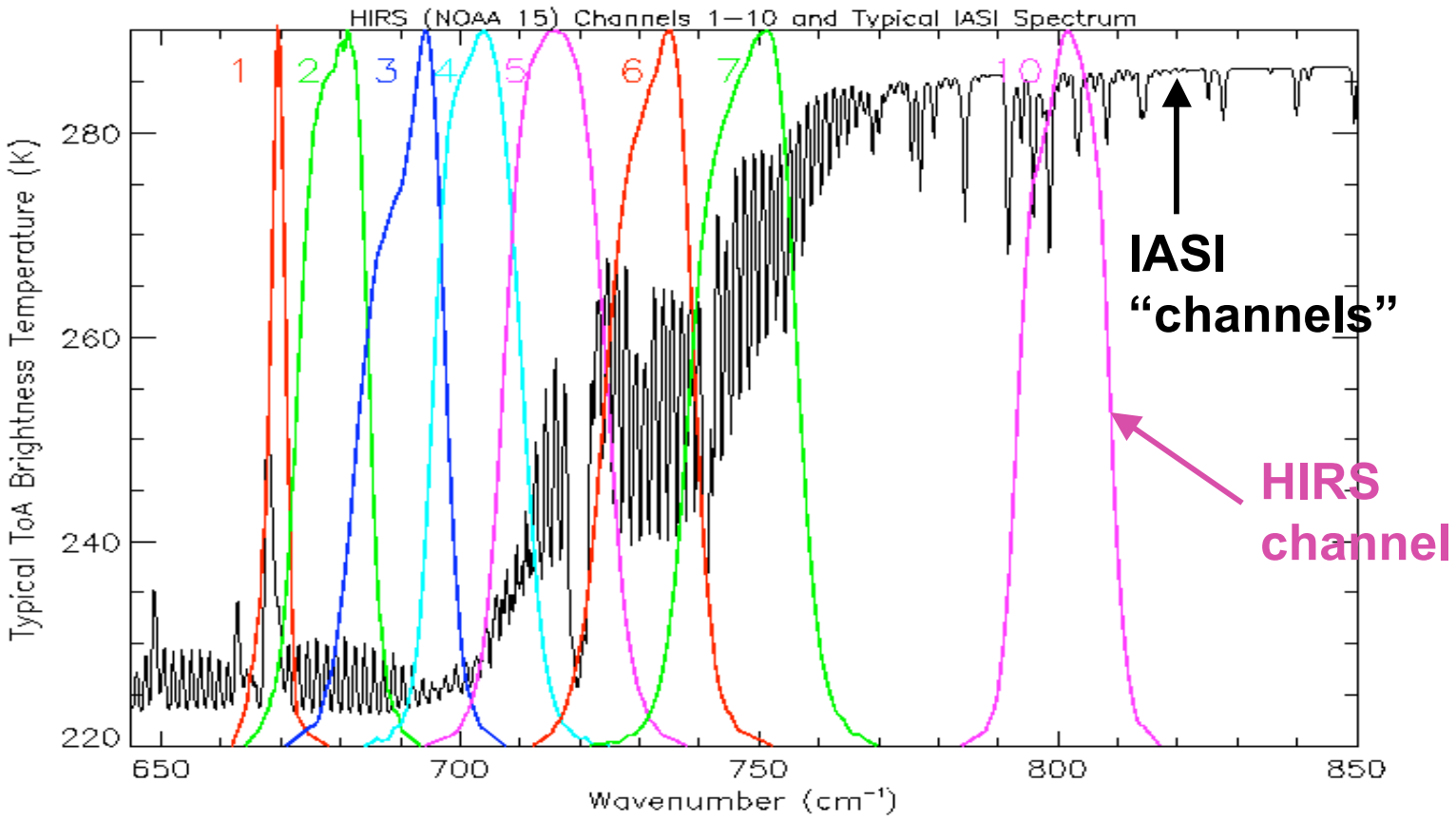
IASI is nadir-viewing and across track scanning.
30 fields-of view along the scan line are sampled in 2×2 matrices of circular fields of view with a diameter of 12 km


IASI
4 IFOV d'IASI
par cellule de 50 Km
48,3°
ligne de mesures
15 vues
15 vues
Nadir

IASI Field of View



Comparison of IASI and HIRS Spectra



HIRS 19 channels versus IASI 8461 spectral samples

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: 2.15 h, Level 2: 3 h) via satellite broadcast (EUMETCast)
- Distribution of sub-sampled data via GTS to WMO users
- Storage in Unified Archival and Retrieval Facility (UMARF) for later access by users

Geophysical Parameter Retrieval

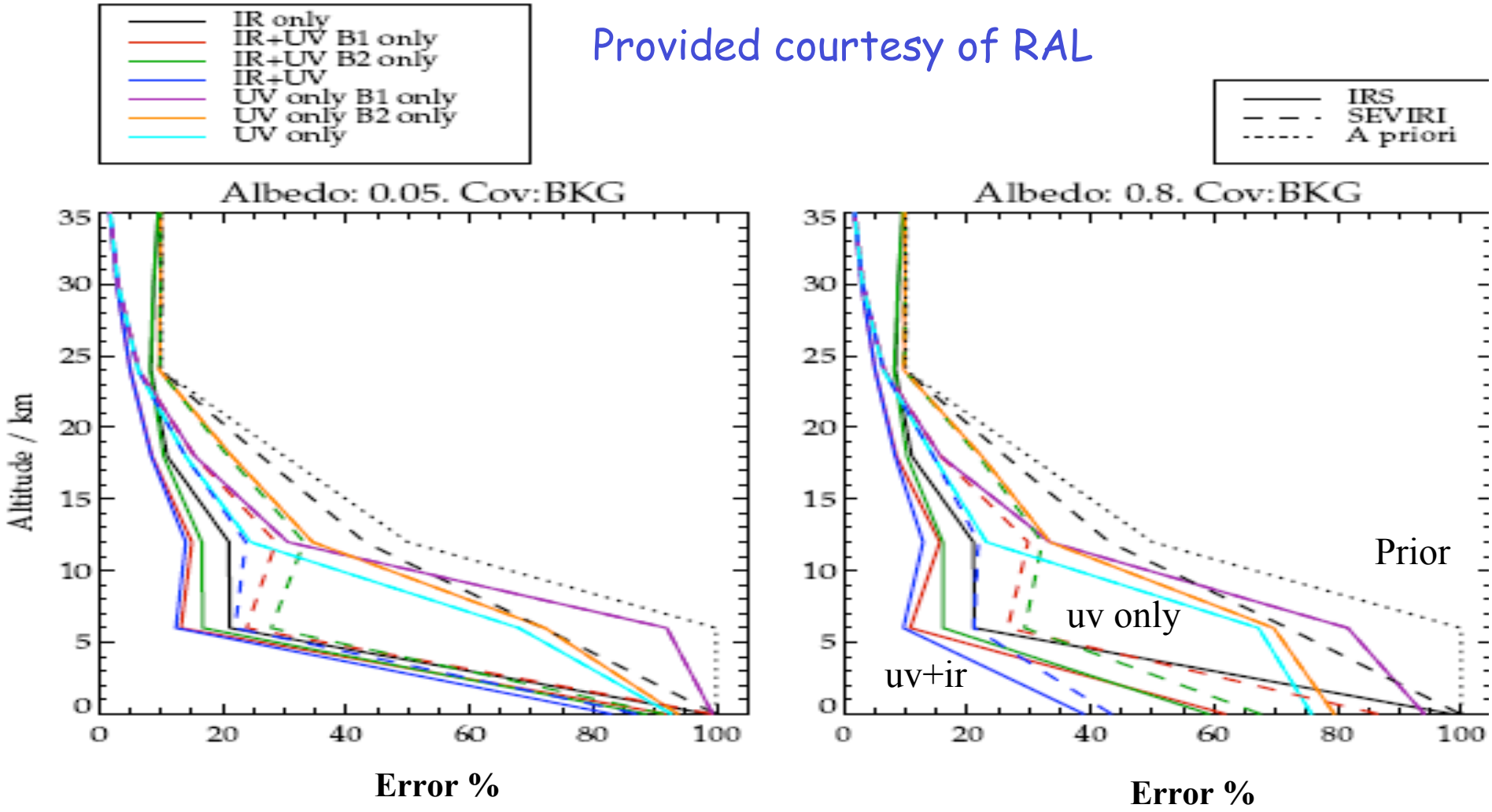
⇒ The state vector to be retrieved consists of the following parameters
- Temperature profile at a minimum of 40 levels
- Water vapour profile at a minimum of 20 levels
- Ozone columns in deep layers (0-6km, 0-12 km, 0-16 km, total column)
- land or sea surface temperature
- surface emissivity at 12 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

⇒ Additionally off-line scientific products are anticipated

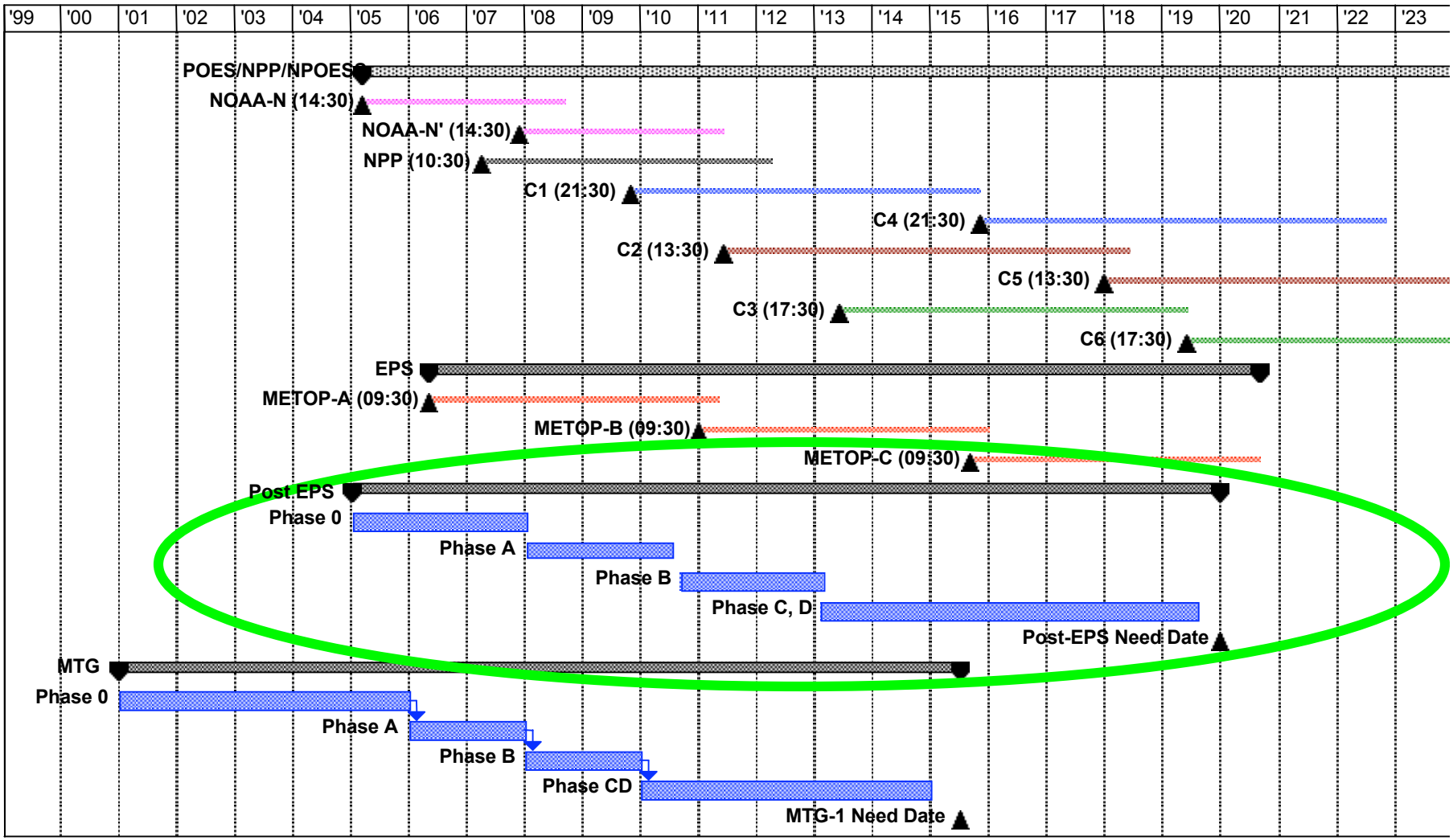
Ozone Profile Retrieval from Nadir-uv & -ir Combination

Provided courtesy of RAL

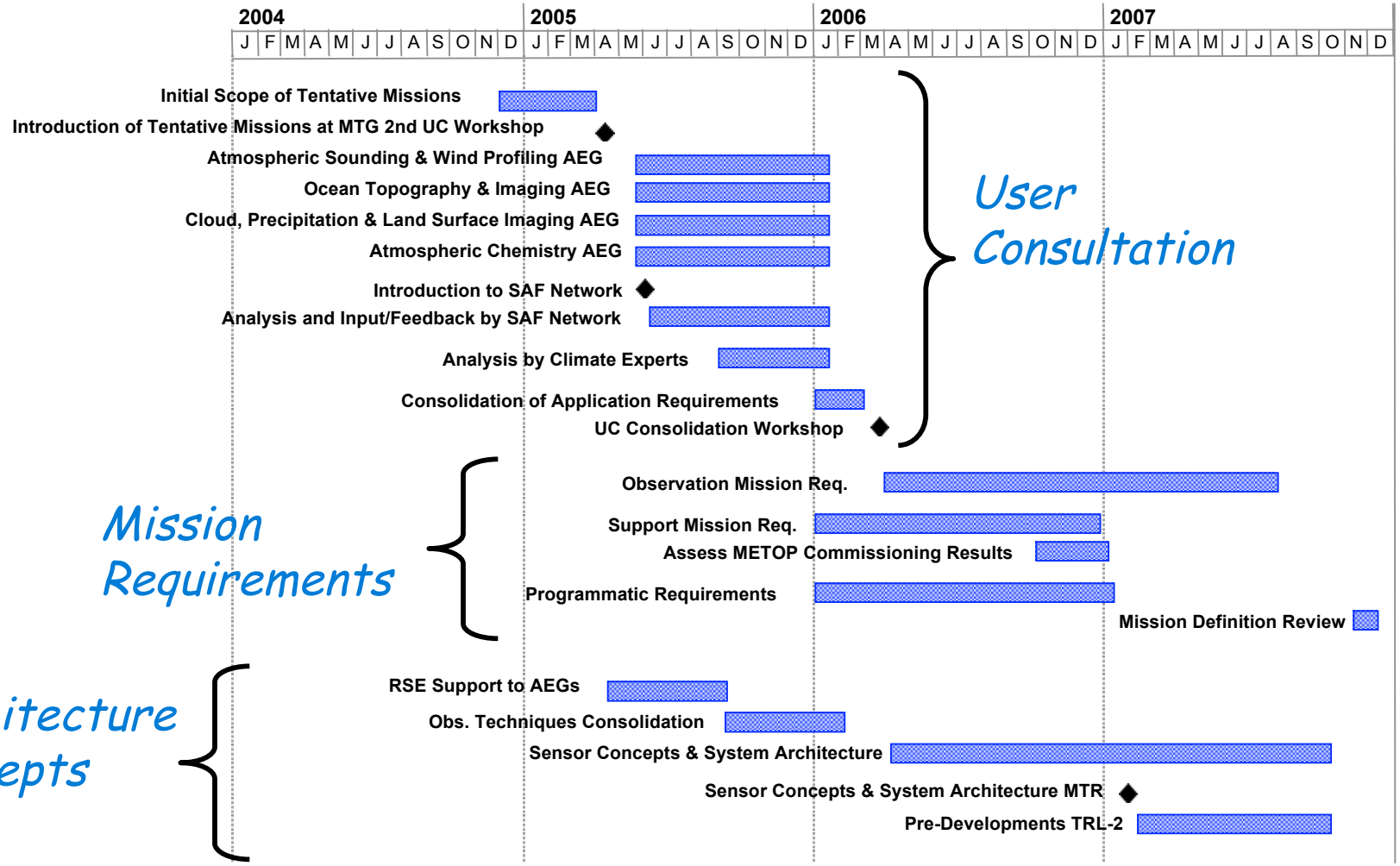


Prior error = ECMWF forecast error covariance

Post-EPS Overall Planning - the follow on to MetOp beyond 202



Post-EPS Phase Planning



Application Experts Groups

⇒ Support of EUMETSAT user consultation towards Post-EPS

⇒ Analysing the needs of EUMETSAT users in the 2020+ timeframe
- Starting with MTG Position Papers
  - Global numerical weather prediction
  - Regional numerical weather prediction
  - Now-casting
- Analysing the evolution of those applications
- Taking account of further applications:
  - Operational oceanography
  - Atmospheric chemistry and carbon cycle (protocol monitoring and air quality)
  - Land surface analysis at large scale
  - Climate monitoring

⇒ Formulation of EUMETSAT user needs: Position Papers

Atmospheric Chemistry Mission: Approach to Generating Requirements

⇒ Generated by a dedicated Application Expert Group (AEG)

⇒ Heritage
- Integrated Global Atmospheric Chemistry Observations (IGACO) Report from the IGOS Atmospheric Chemistry Theme Partners
- ESA commissioned CAPACITY study to define the Geophysical Data Requirements for an Operational Atmospheric Chemistry Monitoring Mission

⇒ Requirements specified for satellite observations only

⇒ Prioritisation per application remaining aware of observing feasibility

Atmospheric Chemistry Mission: User Data Requirements Tables

⇒ Ozone & Surface UV
- Priority 1 (protocol/forecast): O3 stratosphere/UT profile & column
- Priority 2 (assessment): stratospheric ClO, BrO, HNO3 & aerosol (heterogeneous chemistry)

⇒ Composition – Climate
- Priority 1: O3 & H2O profiles; trop CH4 (emissions)
- Priority 2: CO2 (emissions); trop CO & NO2 (chemistry);
- stratospheric N2O/CH4 (circulation); AOD & cirrus

⇒ Pollution & Air Quality
- Priority 1 (regulation/AQ index) O3, NO2, CO, SO2, AOD
- Priority 2 (forecast): H2O, H2CO, aerosol type

Points on Mission Concept

⇒ Considering data reqs for the three applications and drawing on the extensive assessment of observing techniques for CAPACITY, two points noted re mission concept:

⇒ Nadir-viewing uv-swir and ir spectrometers complementary in (a) near-surface sensitivity and (b) detectable constituents

- Requirements for near-surface observations of trace gases and aerosol addressed by this combination

⇒ Limb-viewing mm-wave and ir spectrometers complementary in (a) cirrus sensitivity and (b) detectable constituents

- Requirements for vertical profiling addressed optimally by combination of limb- and nadir-sounding