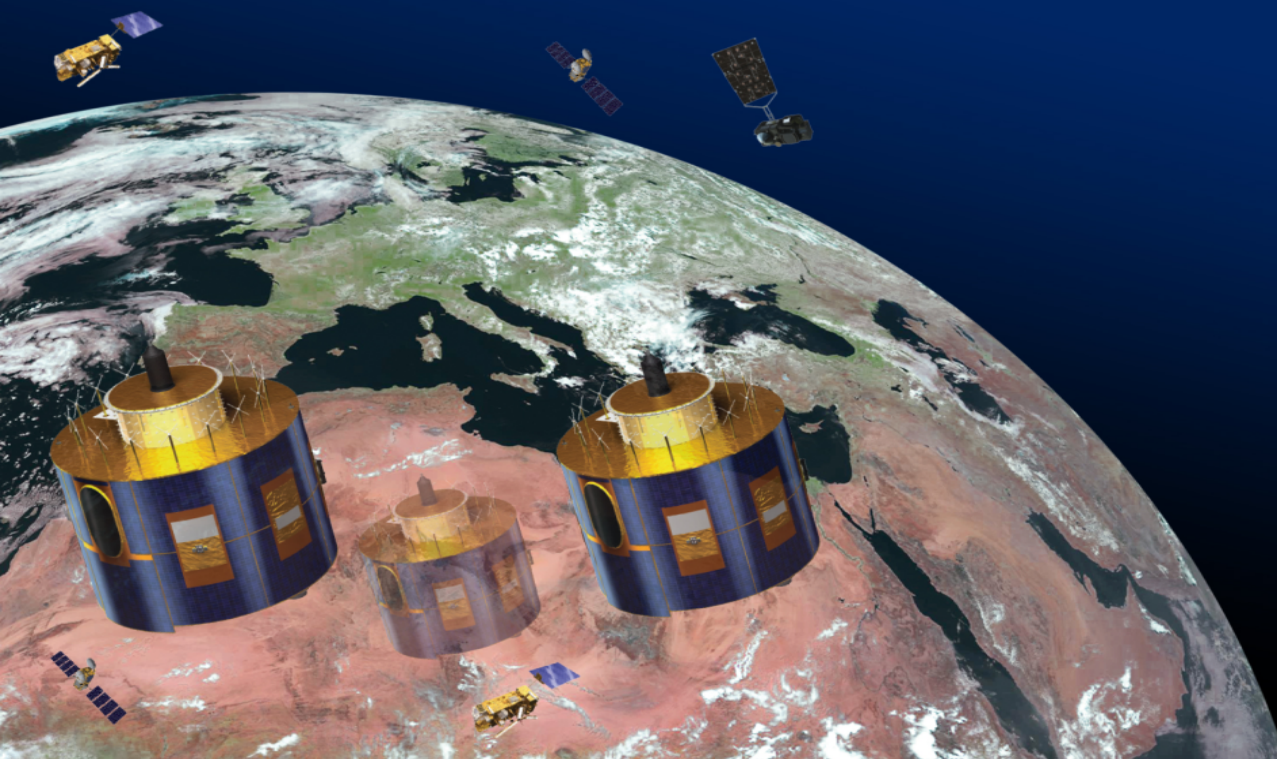


# Scientific Roadmap for the Development of Hyperspectral Infrared (HSIR) Products: White Paper status update

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# White paper: content

## 1) Main users

## 2) Relevant mission

## 3) Hyperspectral level 1

- ✓ Operations: Consolidation of the IASI products
- ✓ Getting ready for EPS-SG (IASI-NG) and facing the MTG-IRS challenges

## 4) Hyperspectral level 1 – Principal Components

## 5) Hyperspectral level 2

- ✓ Operational baseline and activities for EPS
- ✓ Specificities to face EPS-SG and MTG-IRS challenges

## 6) Support elements

## 7) Timelines

# 1) Main users

## **1. Numerical Weather Prediction (NWP)**

- **Global NWP**
- **Regional NWP**

## **2. Nowcasting**

## **3. Atmospheric Composition and Chemistry, Air quality forecasting**

## **4. Intercalibration and reprocessing**

## 2) Relevant missions

### **EUMETSAT missions**

- ✓ Polar Orbiting Satellites (EPS, EPS-SG)
- ✓ Geostationary Satellites (MTG)

### **Partner/ third party missions**

- ✓ NOAA and NASA (Suomi-NPP, NOAA-19, NOAA-20, ...)
- ✓ China Meteorological Administration (FY-3D, FY-4, ...)
- ✓ RosHydroMet (Meteor)

### 3) Hyperspectral level 1: polar missions

**IASI L1 products:** Two processing chains to maintain (On-board with the radiometric calibration, and on-ground with the spectral calibration) which require:

- ✓ Daily monitoring to assess the IASI L0 and L1 products quality
- ✓ Support to operations:
  - ✓ Regular instrument operations support (Instrument + on-board processing)
  - ✓ Metop-C commissioning
  - ✓ Metop-A end-of-life activities
- ✓ Preparation of the possibility to loose some instrument performances
  - Study on having the cloud information without AVHRR

**IASI-NG activities:** To take into account the new technology (Mertz interferometer and new on-board processing) and the stringent requirements of having half radiometric noise compared to IASI, twice better spectral resolution than IASI.

EUMETSAT responsibility:

- ✓ Take the ownership of the IASI-NG processing
- ✓ Develop a daily monitoring tool
- ✓ Support the ground segment activities whenever it is necessary

### 3) Hyperspectral level 1: MTG

#### Main challenges:

- ✓ New mission (new technology, huge amount of data...), new user community (stringent timeliness for different applications)
- ✓ Different instrument → different calibration processing sequence (Radiometric calibration, Spectral calibration)
- ✓ Different calibration measurement pattern (Spectral calibration every 30 min, radiometric calibration target every 15 min, stray light, ...)

#### EUMETSAT responsibilities:

- ✓ Generation of the required documentation (ATBD, Level 1 Processing Specification, PFS)
- ✓ Development of IRS performance tool IRASS (IRS Radiometric And Spectral Simulator)
- ✓ Development of IRS L1 reference processor (L1RP)
- ✓ Test data generation
- ✓ Follow up and testing of the operational IRS L1 processing Facility called: IDPF-S

IASI	IASI-NG	IRS
<u>Instrument</u> Single laser	<u>Instrument</u> Multiple lasers Field compensation (hardware)	<u>Instrument</u> Multiple lasers
<u>On-board processing</u> Non-Linearity correction Spike detection Radiometric calibration	<u>On-board processing</u> Non-Linearity correction Spike correction	<u>On-board processing</u> Non-Linearity correction Spike correction Filed compensation (software)
<u>L1 processing</u>  Spectral calibration  Spectral Resampling  Spectral shape removal and apodisation	<u>L1 processing</u>  Spectral calibration and shape removal  Apodisation  Resampling  Radiometric Calibration	<u>L1 processing</u>  Apodisation  Radiometric Calibration  Spectral calibration  Resampling  Spectral shape removal

## 4) Hyperspectral level 1: Principal Components

**IASI L1 Principal Components are available to users since February 2011**

**IRS L1 products will be disseminated as Principal Components**

### **Main activities:**

- Monitor and maintain PC scores service with global eigenvectors
- Implement full noise normalisation matrix to enhance the signal / noise separation
- Interactions and collaboration with the users to increase awareness and preparation for the use of PC scores (external studies identified in PDIP)
- Study practicalities of hybrid approach, where the global eigenvectors are supplemented with a few local eigenvectors of the residuals

## 5) Hyperspectral level 2: operational baselines

Generation of the required geophysical products from EUMETSAT current and future hyperspectral missions, at the required accuracy.

Same type of measurements:

- Common algorithms and S/W functions where applicable and feasible

But also

- Targeted studies and developments for IASI, IASI-NG, MTG-IRS

Critical:

- Geophysical validation and monitoring capabilities for L2 products



# 5) Hyperspectral level 2: EPS

## General IASI L2 products status and activities:

- ✓ To maintain and monitor the operational T, q, Ts, CO, clouds
- ✓ To validate the pre-operational emissivity, O<sub>3</sub>, SO<sub>2</sub>
- ✓ To raise the maturity of the demonstrational green-house gases, incl. ext. studies
- ✓ Integrate EUMETSAT AC SAF products (upcoming O<sub>3</sub>, HNO<sub>3</sub>, Ash, NH<sub>3</sub>)
- ✓ Evolve products upon user feed-back

## Upcoming specific programme activities:

- ✓ Metop-C commissioning
- ✓ Instrument aging, especially the companion microwave
- ✓ Metop-A end-of-life activities

➔ Streamlined monitoring and algorithm reconfiguration is key

Product	2018	Production status	2021	Purpose
Atmospheric Temperature				Thermodynamic, Regional service, Input to AC and AMV processors
Atmospheric Humidity				
Sea Surf. Temperature				GHRST, climate, input further L2
Land Surf. Temperature,				Key for accurate sounding, e.g. humidity in low troposphere, O <sub>3</sub>
Land surface emissivity				
Cloud detection,				Integral to L2 processing and L1 assimilation
Cloud top height, fraction				Input to wind products, Climate
O <sub>3</sub> *				AC monitoring, input to AMV
CO*				AQ monitoring
SO <sub>2</sub> *				AQ monitoring, Air traffic
HNO <sub>3</sub> *				AQ monitoring
CO <sub>2</sub>				GHG monitoring, input to Temp. retrieval
CH <sub>4</sub>				GHG monitoring
N <sub>2</sub> O				GHG monitoring
Ash *				AQ monitoring, air traffic
NH <sub>3</sub> *				AQ monitoring
* EUM AC SAF products		Demonstrational Pre-operational Operational		

## 5) Hyperspectral level 2: EPS-SG

Most of the EPS/IASI processing algorithms are directly transposed into the EPS-SG context but:

- ✓ There are opportunity to optimize the processing with common functions, *i.e. work towards a common HSIR L2 approach for all missions*
- ✓ Some “new” products are to be development (e.g. cloud micro-physics)
- ✓ There are more challenging product requirements (precision) then for IASI

## 5) Hyperspectral level 2: MTG-IRS

### **Need dedicated attention to exploit the mission to its full extent:**

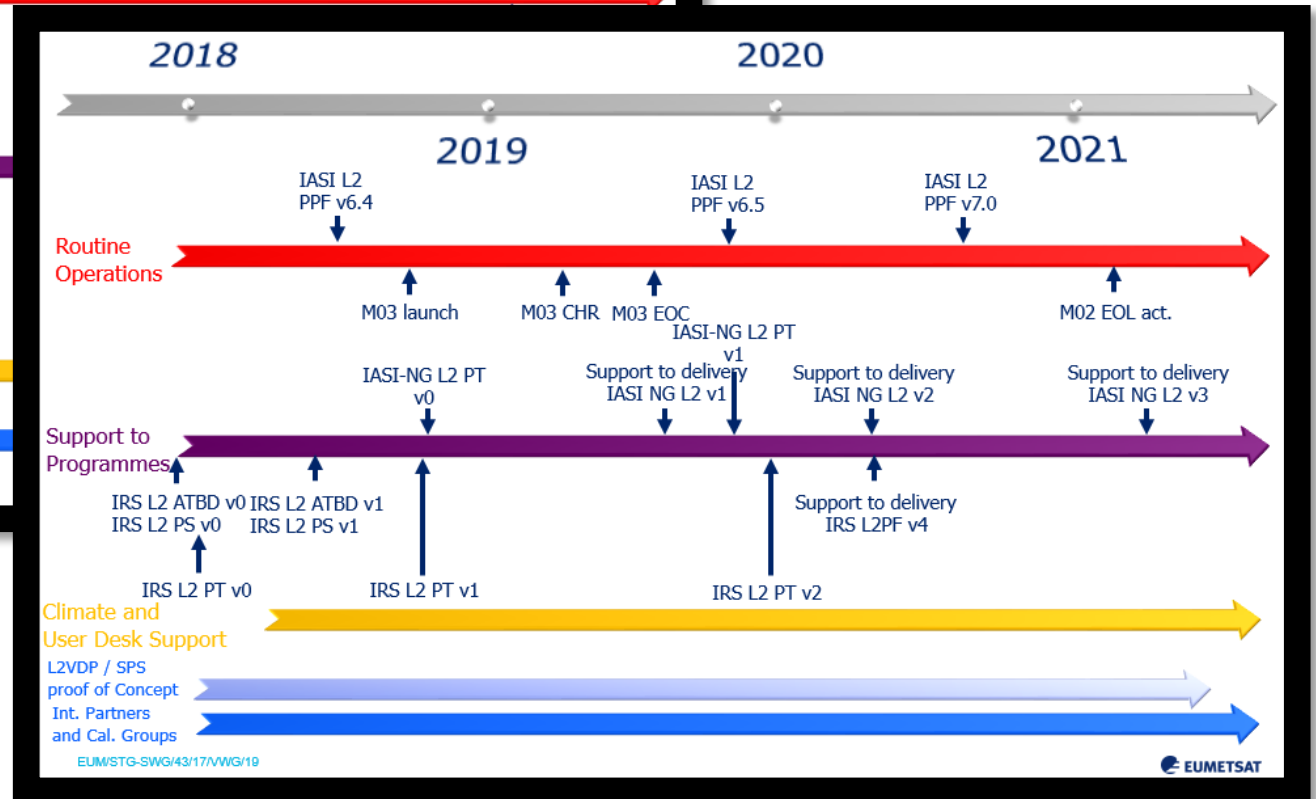
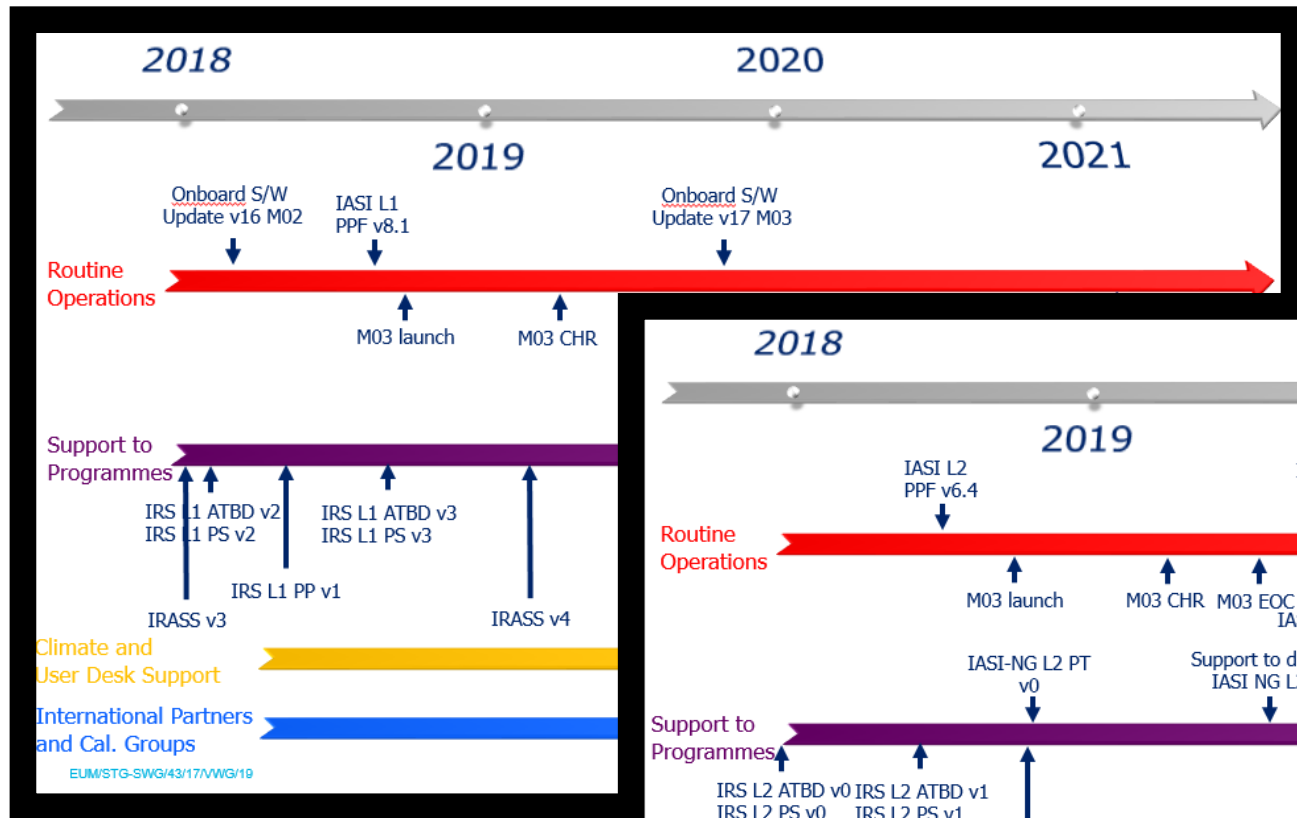
- ✓ The viewing geometry introduces more slanted views:
  - Products performance and applications at high angles?
  - Ensure fast radiative transfer at those angles, including surface emissivity modelling
- ✓ Parallax effects need to be treated to provide vertical profiles to Users
- ✓ Coarser spectral coverage and resolution
  - Study effect on expected sounding performance
  - What operational Atmospheric Composition products can be envisaged?
- ✓ Opportunities vs LEO mission:
  - Higher spatial resolution
  - Higher temporal sampling

→ Many elements already identified as external studies in the PDIP

## 6) Support elements

- ✓ **Radiative Transfer (R/T) Models**
- ✓ **Fiducial Reference Data**
  - ✓ **Spectroscopy**
  - ✓ **Ground based Observations**
  - ✓ **Dedicated *in situ* observations**
  - ✓ **Airborne Campaigns of opportunity**

# 7) Timelines



# Summary

## **The white paper of the Scientific Roadmap for the Development of Hyperspectral Infrared Products addresses:**

- ✓ Operational hyperspectral level 1, level 2 activities
- ✓ Future mission challenges, exploiting the commonalities when possible
- ✓ User needs

**The white paper will be distributed shortly to the IRS-MAG and the ISSWG**

**SWG will receive the white paper in July 2018**