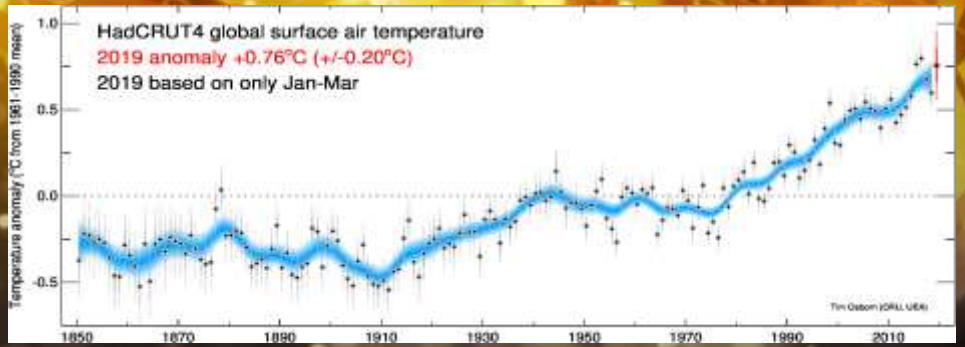
The Far-infrared Outgoing Radiation Understanding and Monitoring (FORUM) Mission

forum

→ UNDERSTANDING HOW EARTH IS LOSING ITS COOL



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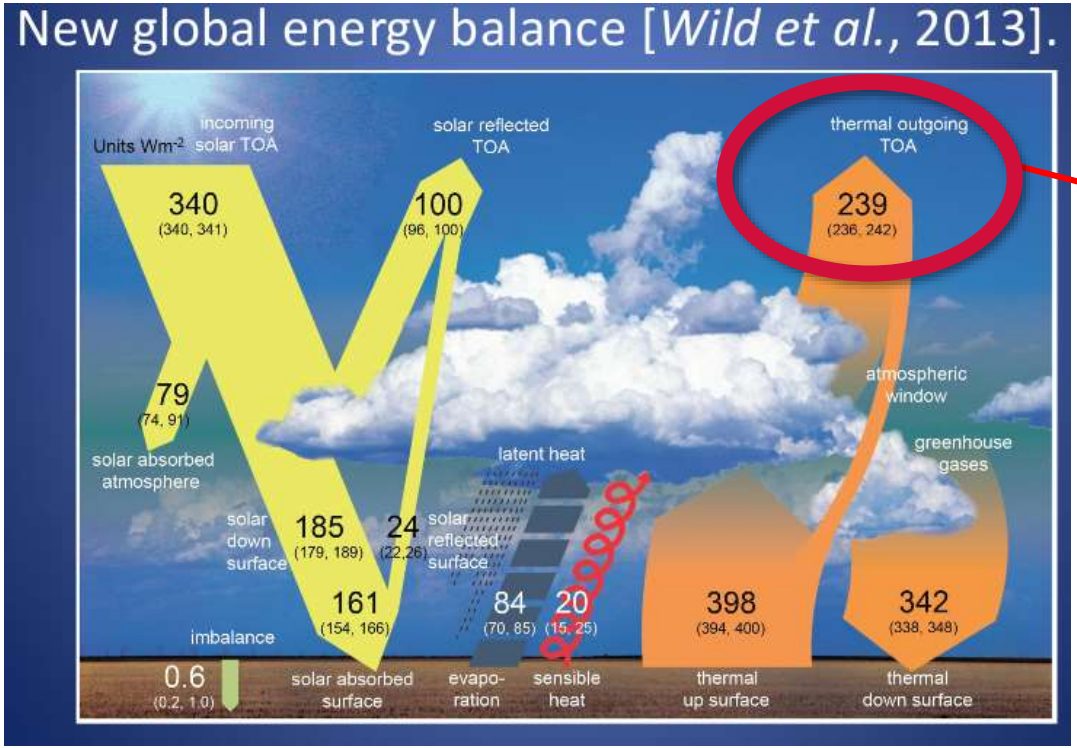
and the FORUM Team
INO- CNR, Italy

ITSC - ASWG
16 June 2021

FORUM is the 9th Earth Explorer ESA Mission

Far-infrared **O**utgoing **R**adiation **U**nderstanding and **M**onitoring

Climate is Driven by the Earth's Radiation Budget

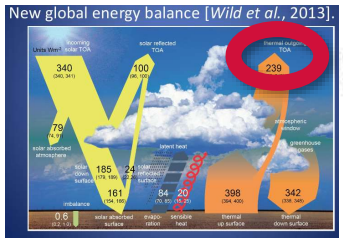


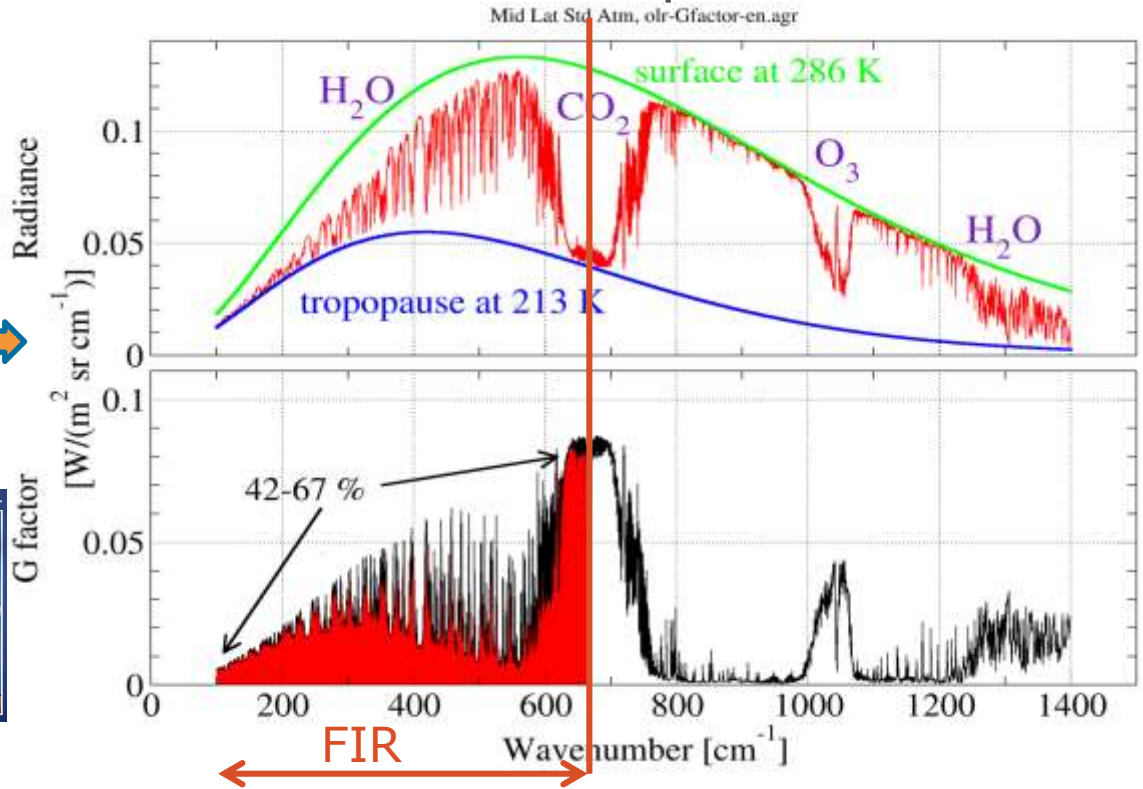
Outgoing
Longwave
Radiation

Energy TOA imbalance = Incom. solar – Solar refl. – Thermal outgoing = +0.5±1 W/m^2

The Far Infrared Component of the OLR

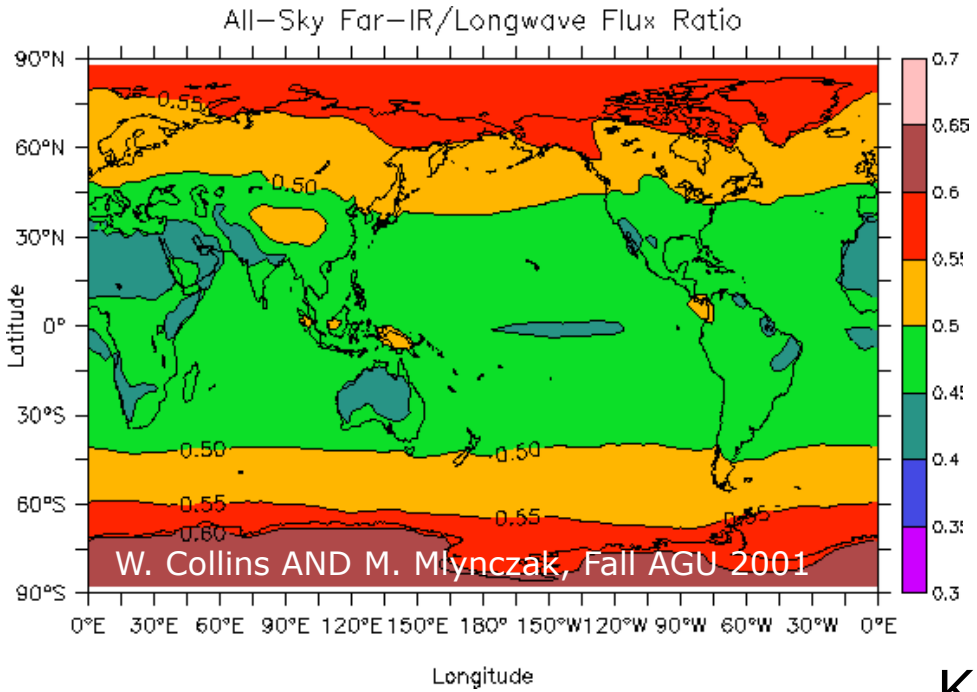
Far infrared / Far IR / FIR → 100–15 μm → 100–667 cm^{-1} → 3–20 THz



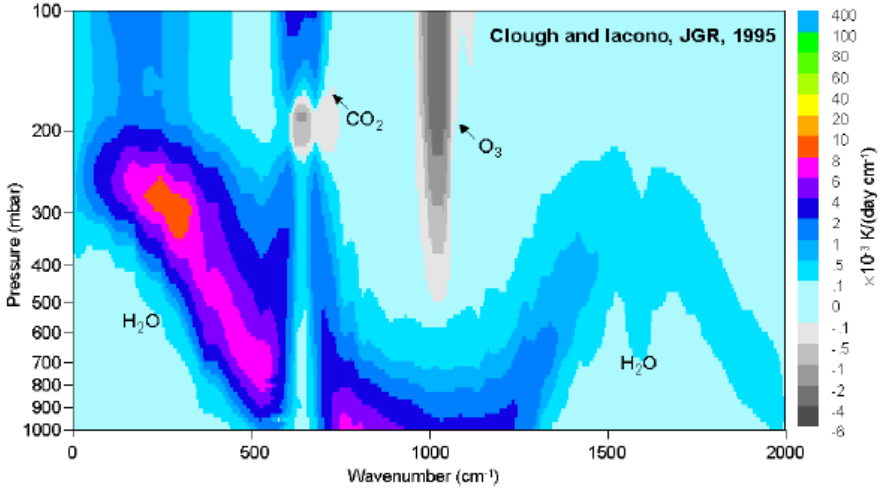


The Earth is a Far Infrared Body

Spatial distribution of emitted energy



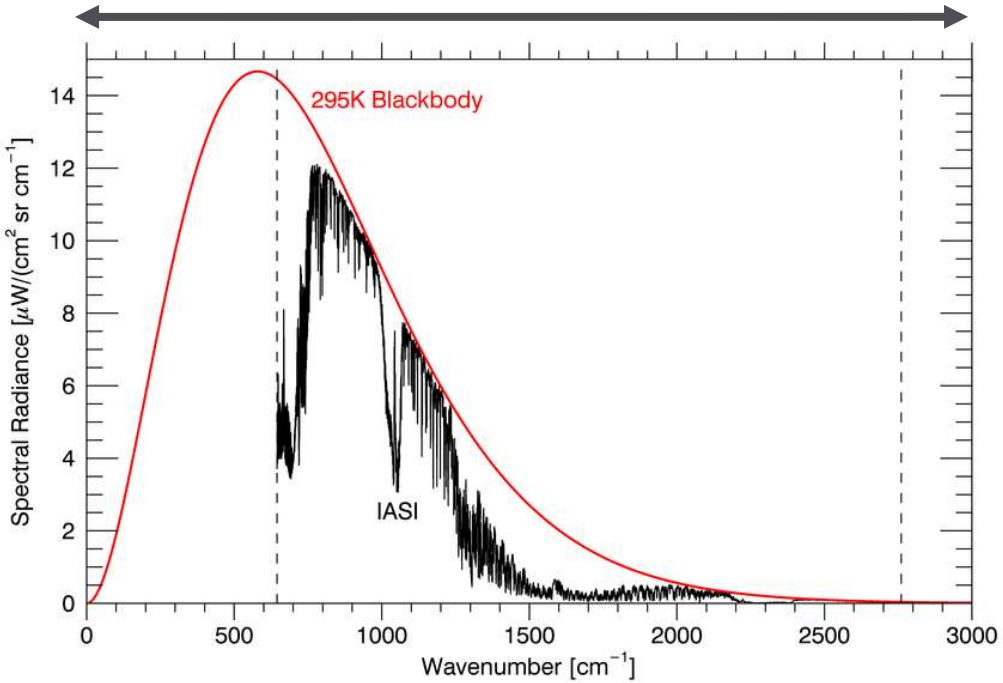
Vertical distribution of atmospheric cooling rate



Key driver of atmospheric dynamics

The Current FIR Missing Piece

Integrated OLR (since 1975,
e.g. ERBE, CERES, GERB, ScaRaB)



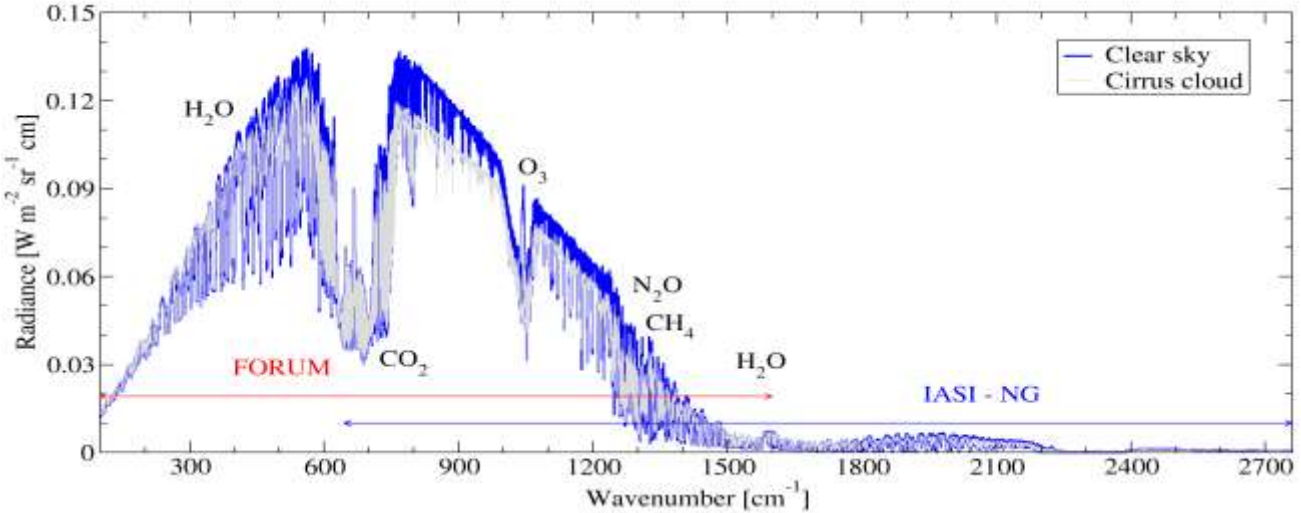
Spectral mid-infrared
(since 2002)

Spectral FIR in 1970s
(<10 months through)

No FIR observations below
400 cm^{-1}

The goal of FORUM is to fill this critical gap

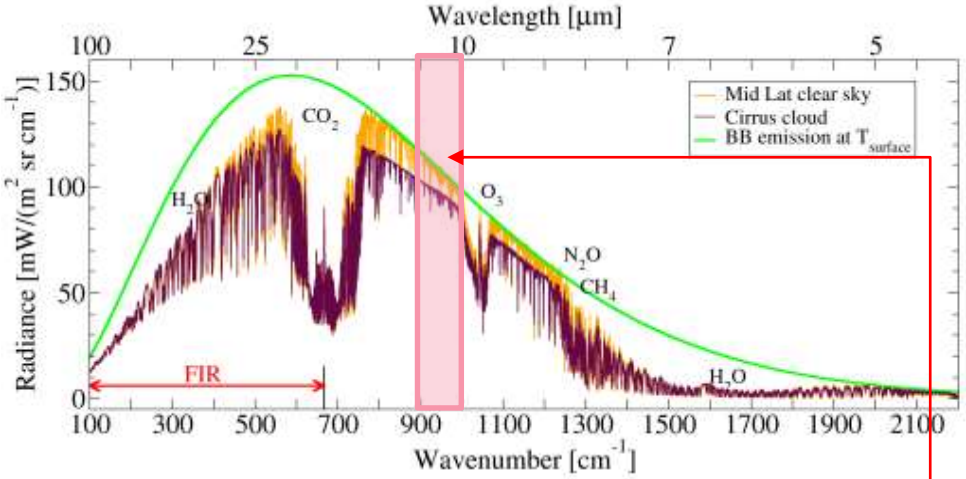
How FORUM will cover this Gap ?



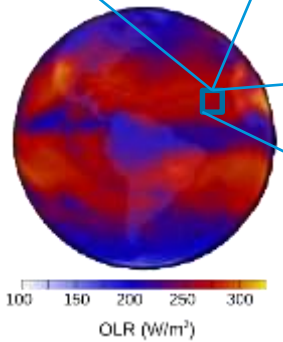
- Reducing FIR uncertainty in models (**Understanding**)
- Identifying climate signatures in the spectrum to better link observed variations to key underlying physical processes driving climate change (**Monitoring**)

Measurement Concept

Measurement of the spectrally-resolved radiance emitted by the Earth at Top-of-Atmosphere



Spectrometer
FORUM
Sounder
Instrument
FSI



Thermal imager
FORUM
Embedded
Imager
FEI

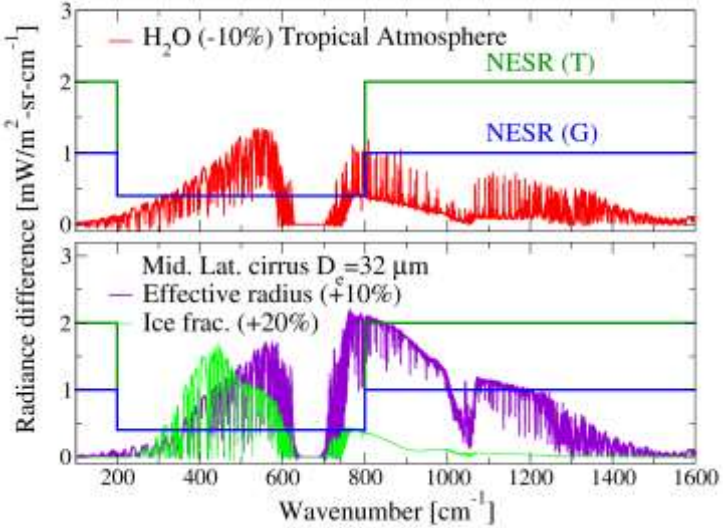
Single spectral channel in the thermal IR sensitive to surface and clouds for scene heterogeneity characterisation

FSI Requirements

Spectral range	100 – 1600 cm^{-1}
Spectral resolution (FWHM)	≤ 0.5 cm^{-1}
Temperature applicable range	190 – 300 K (180 – 310 K)

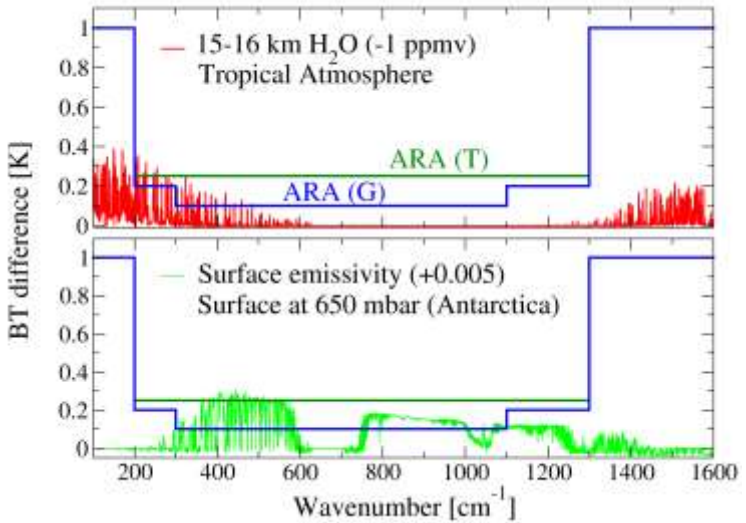
Noise Equivalent Spectral Radiance

NESR



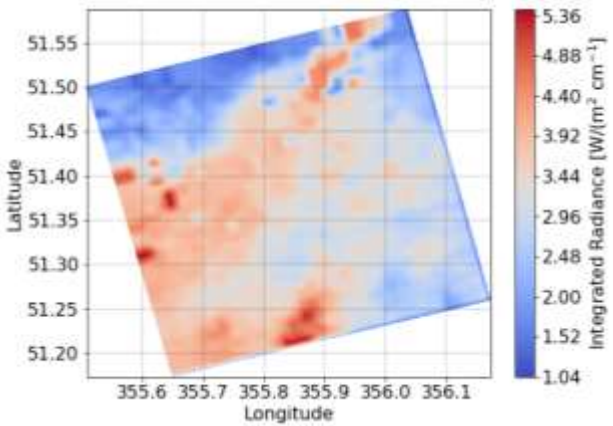
Absolute Radiometric Accuracy 0.1K @3σ

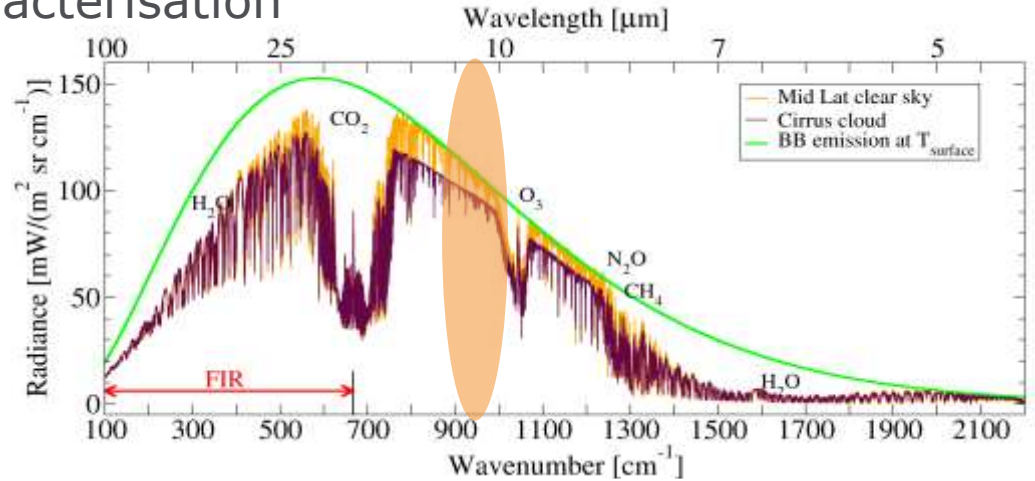
ARA



FEI Requirements

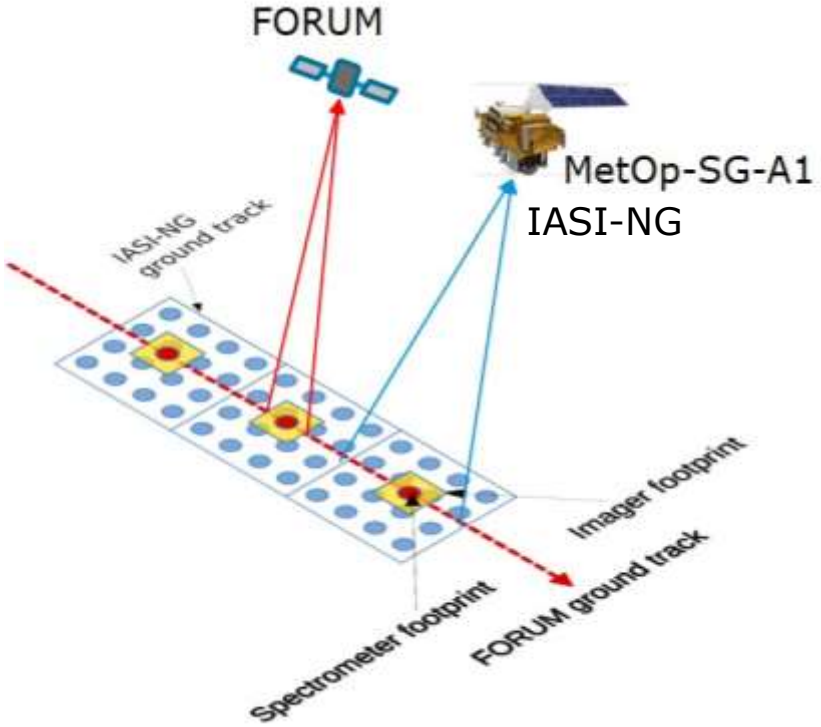
For scene inhomogeneity characterisation





Imager Requirements	
Applicable temperature range	190 – 300 K (180 – 325 K)
Spectral channel	11.5 ± 1 µm (G) / 10.5 ± 0.75 µm (T)
NEDT and RxRA	0.3 K (G) / 0.8 K (T) at 210 K
Absolute calibration accuracy	1 K (G) / 2 K (T)

FORUM will fly close to MetOp-SG



Loose formation with MetOp-SG-A1
within 100 km (G) / 300 km (T) and < 1 min

Satellite LEO, SSO at 9:30 LTDN, alt. 830 km

Nadir-looking observations
Spectrometer
- single circular pixel Ø = 15 km

Thermal imager
- 36x36 km^2
- resolution = 750 m

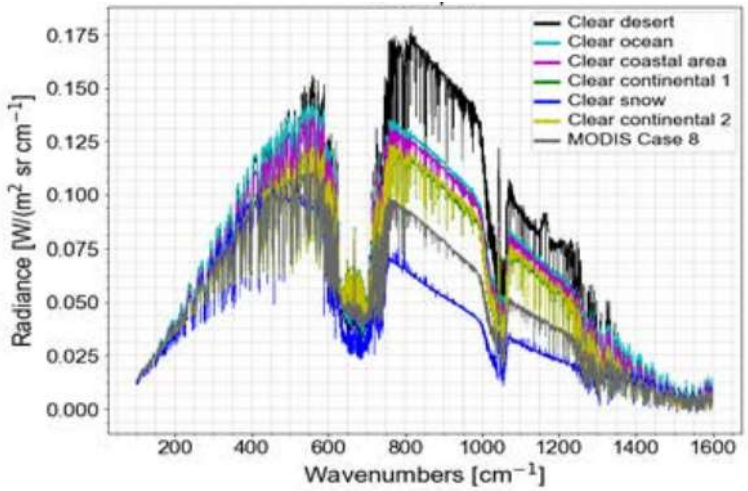
Along-track sampling step < 100 km

Nominal lifetime = 5 years to resolve seasonal & inter-annual variability

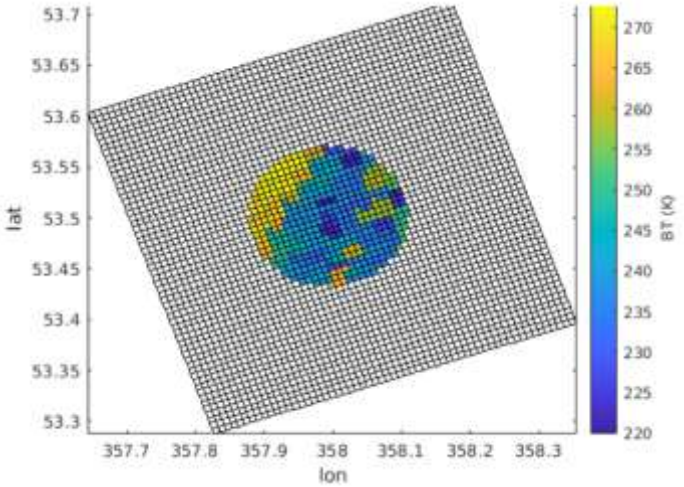
Level 1 Products: Spectra / Images

Spectrally, radiometrically calibrated, and geolocated spectral radiances and thermal images

Spectrometer Level-1c



Imager Level-1b



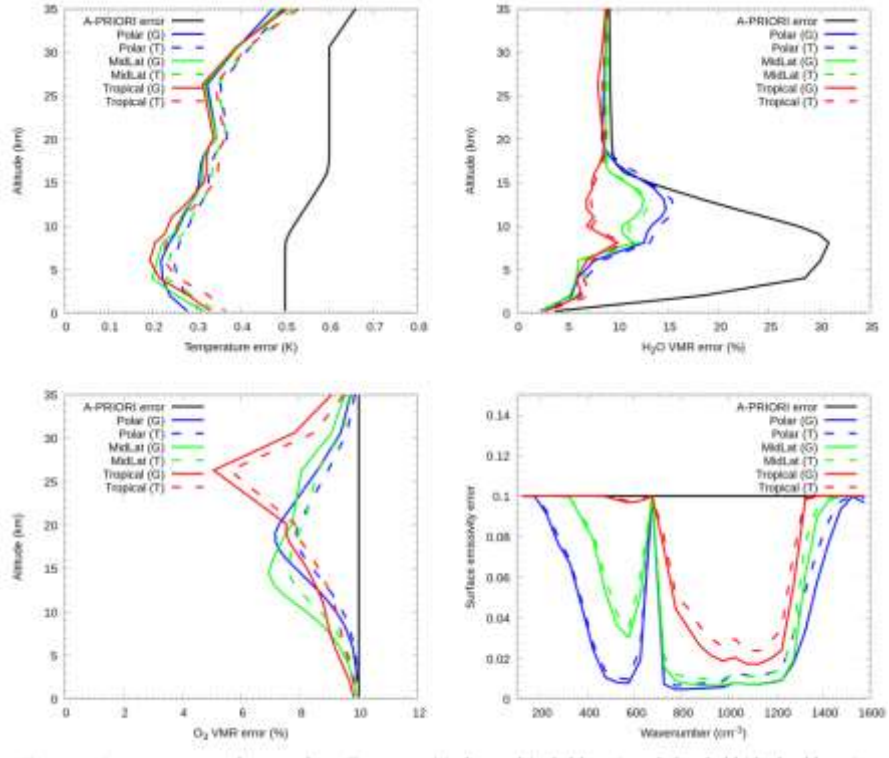
From RfMS fig.7.14, 7.17: https://esamultimedia.esa.int/docs/EarthObservation/EE9-FORUM-RfMS-ESA-v1.0-FINAL.pdf

Level 2 Products: Geophysical Parameters

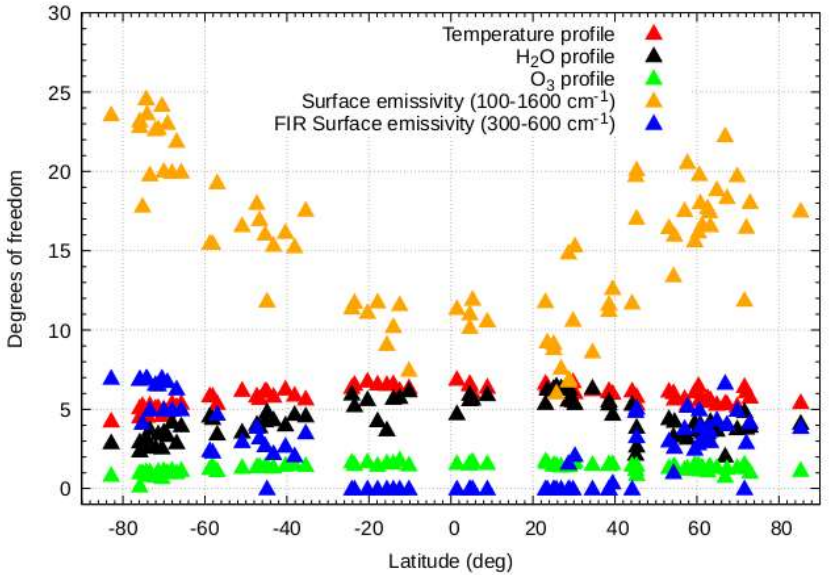
All-sky broadband spectral flux	FIR OLR extended to broadband with IASI-NG
Water vapour profile	Vertical profiles of H_2O concentration with 15 % maximum uncertainty at 2 km vertical resolution
Surface emissivity	In the 300–600 cm^{-1} for polar regions. Maximum uncertainty of 0.01 on 50 cm^{-1} spectral grid
Ice water path (IWP)	Maximum uncertainty of 20 g/m^2 (20% for thin clouds)
Cloud Top Height (CTH)	Maximum uncertainty of 1 km
Effective particle size diameter	Maximum uncertainty of 20%

Level 2 Performance Study

Vertical profiles and surface emissivity

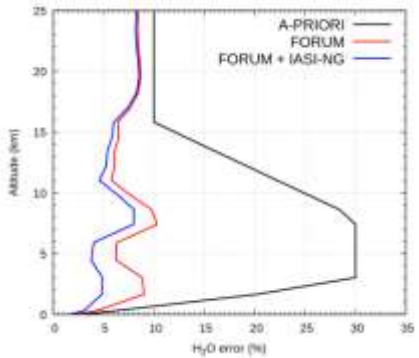


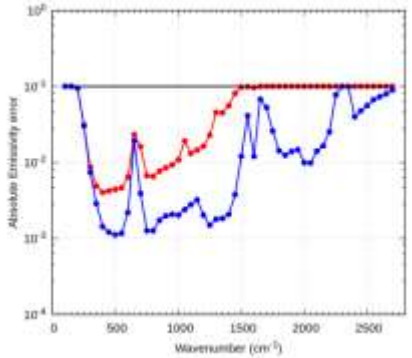
Degrees of freedom



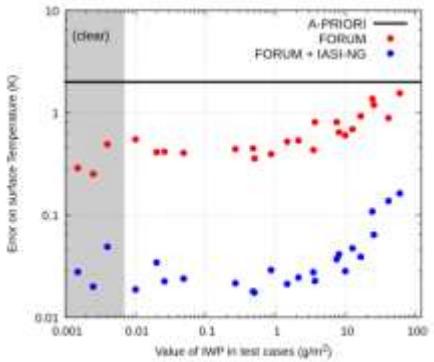
From M. Ridolfi et al. 2020, doi:10.3390/rs12091496

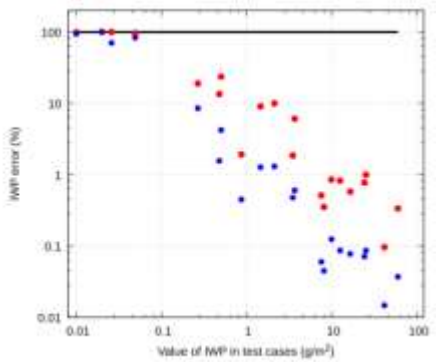
Level 2 Performance Study – Synergy with IASI-NG

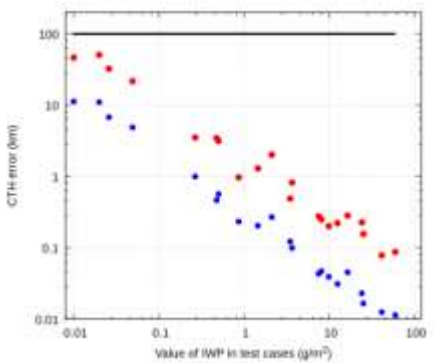


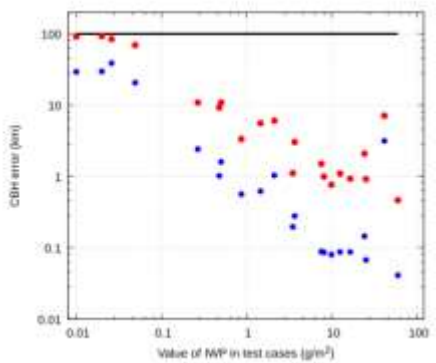


Cloud properties









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Programmatic aspects

- Industrial Phase A/B1 2018-2021 with two consortia in competition
- Pre-development studies on the most critical parts are almost complete

Launch -> 2026 Q3

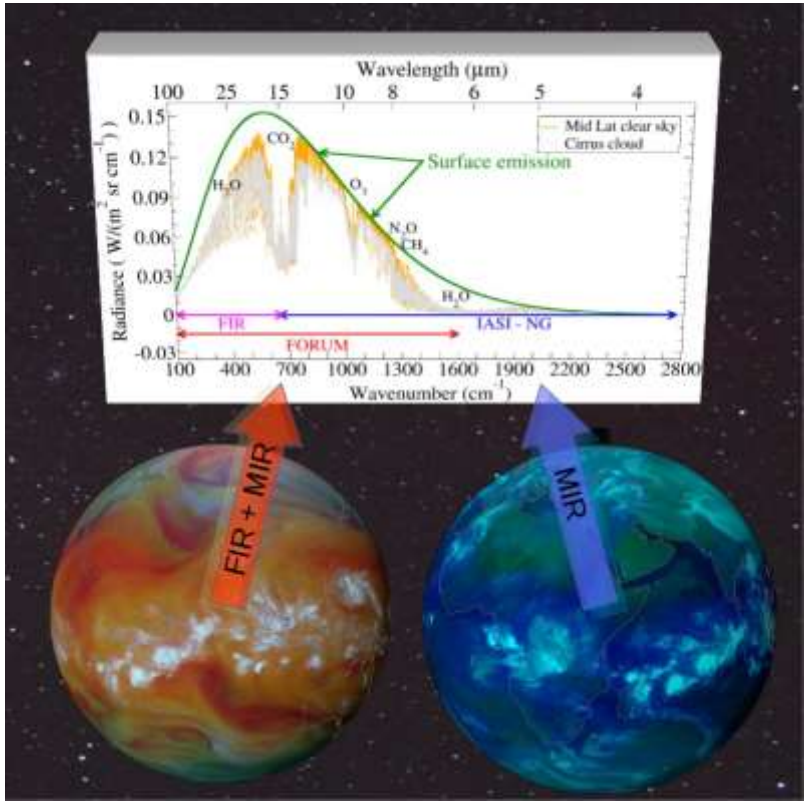
FORUM Team and Current Studies

ESA Team and the **Mission Advisory Group** → Mission preparation
https://www.forum-ee9.eu/scientific-team/

ESA preparatory studies

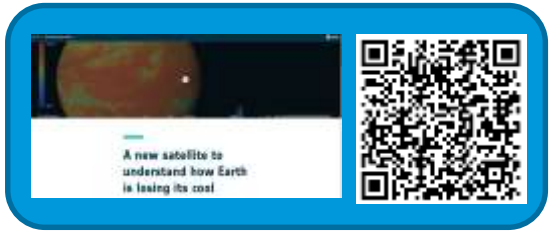
Other preparatory initiatives with measurements of the FIR from high altitude ground-based (CNR-Italy), aircraft (IC-UK) and stratospheric balloons (NASA-USA/ASI-Italy)

FORUM will be a new Eye to look at the Earth



FORUM scientific webpage

ESA Official FORUM webpage



Android APP