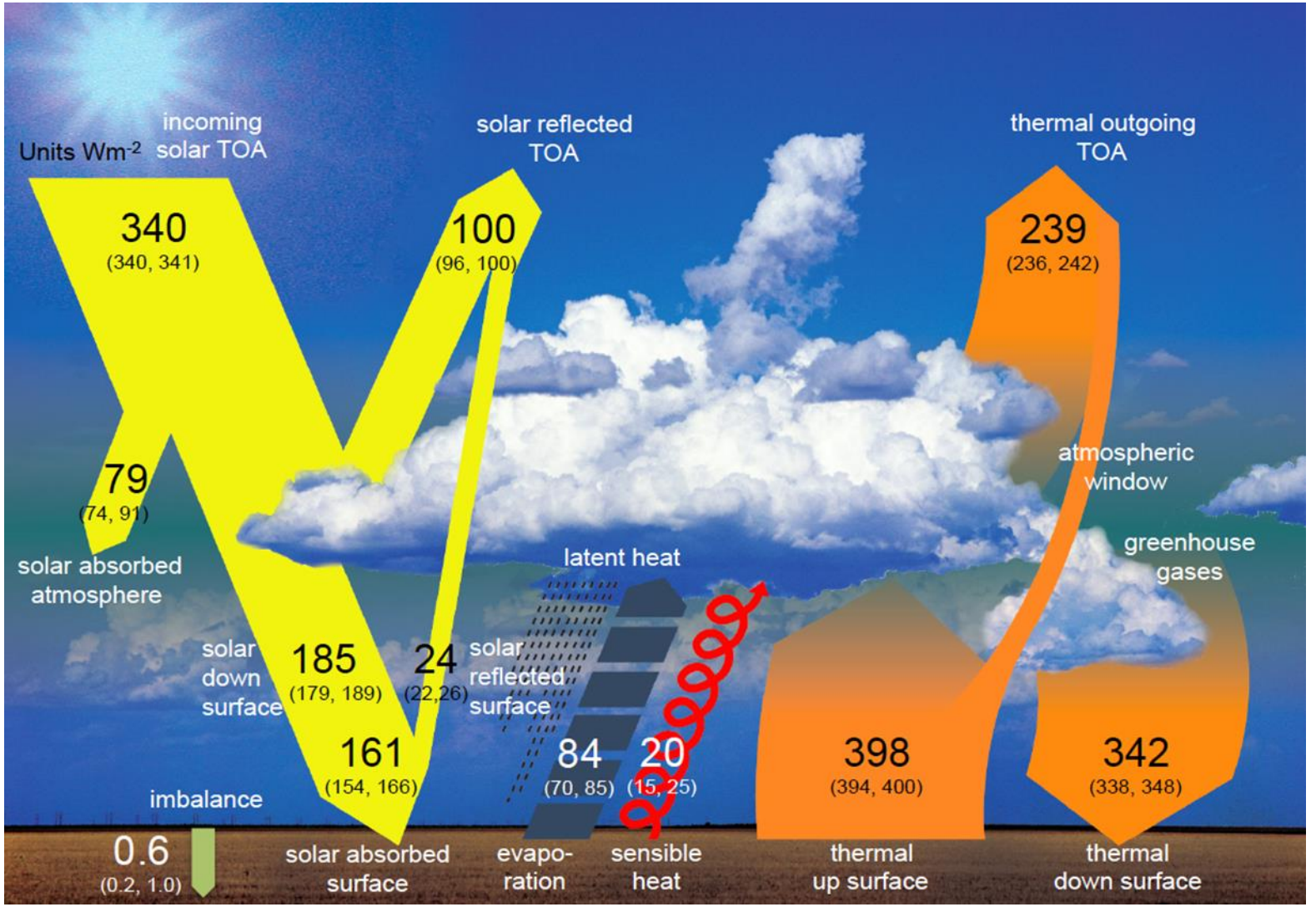
# ESA’s ninth Earth Explorer mission FORUM

## Characterising the far-infrared spectrum of Earth’s outgoing long-wave radiation

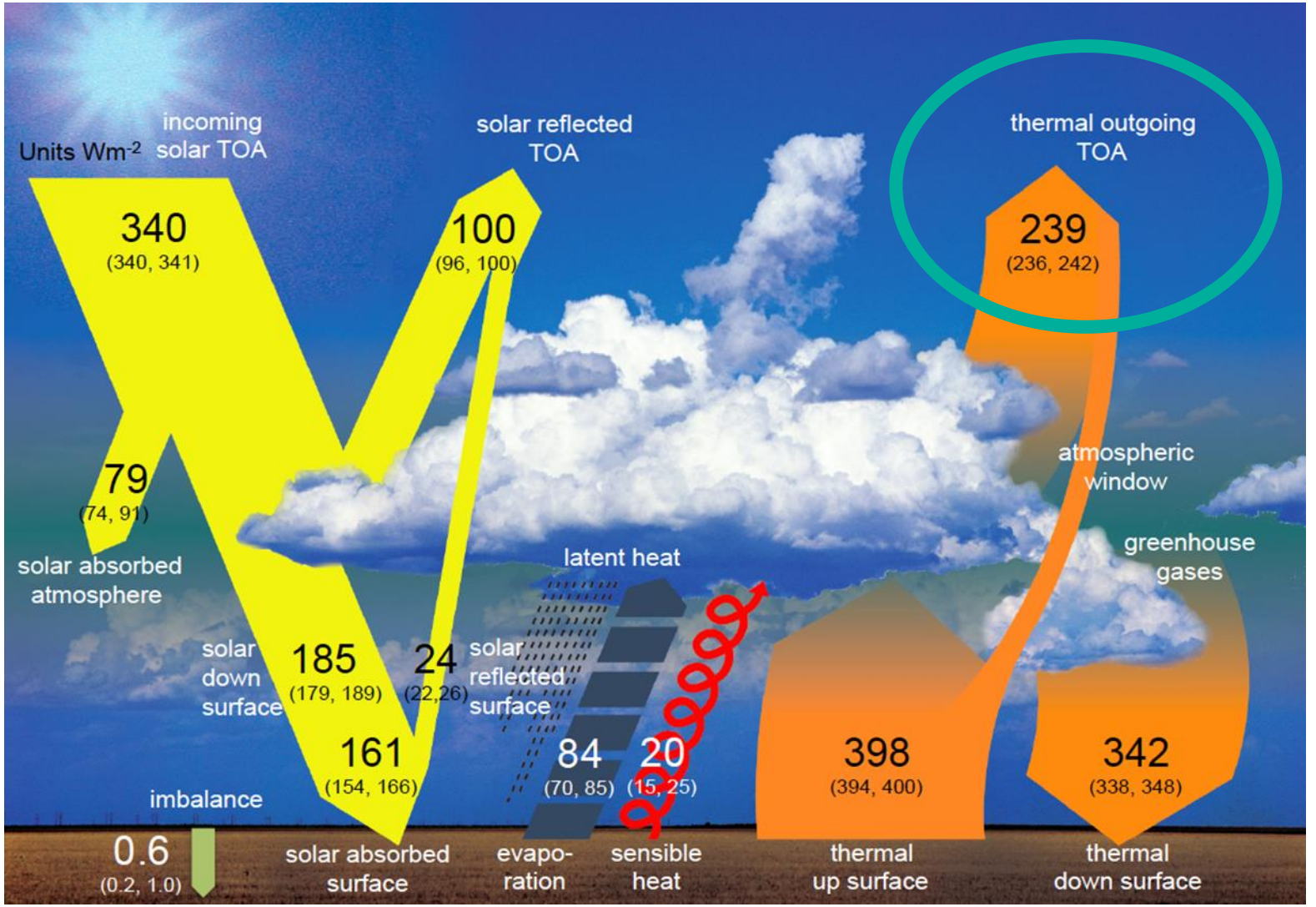
**Laura Warwick,** Hilke Oetjen, Dirk Schuettemeyer & the FORUM Mission Advisory Group

# Earth's Radiation Budget



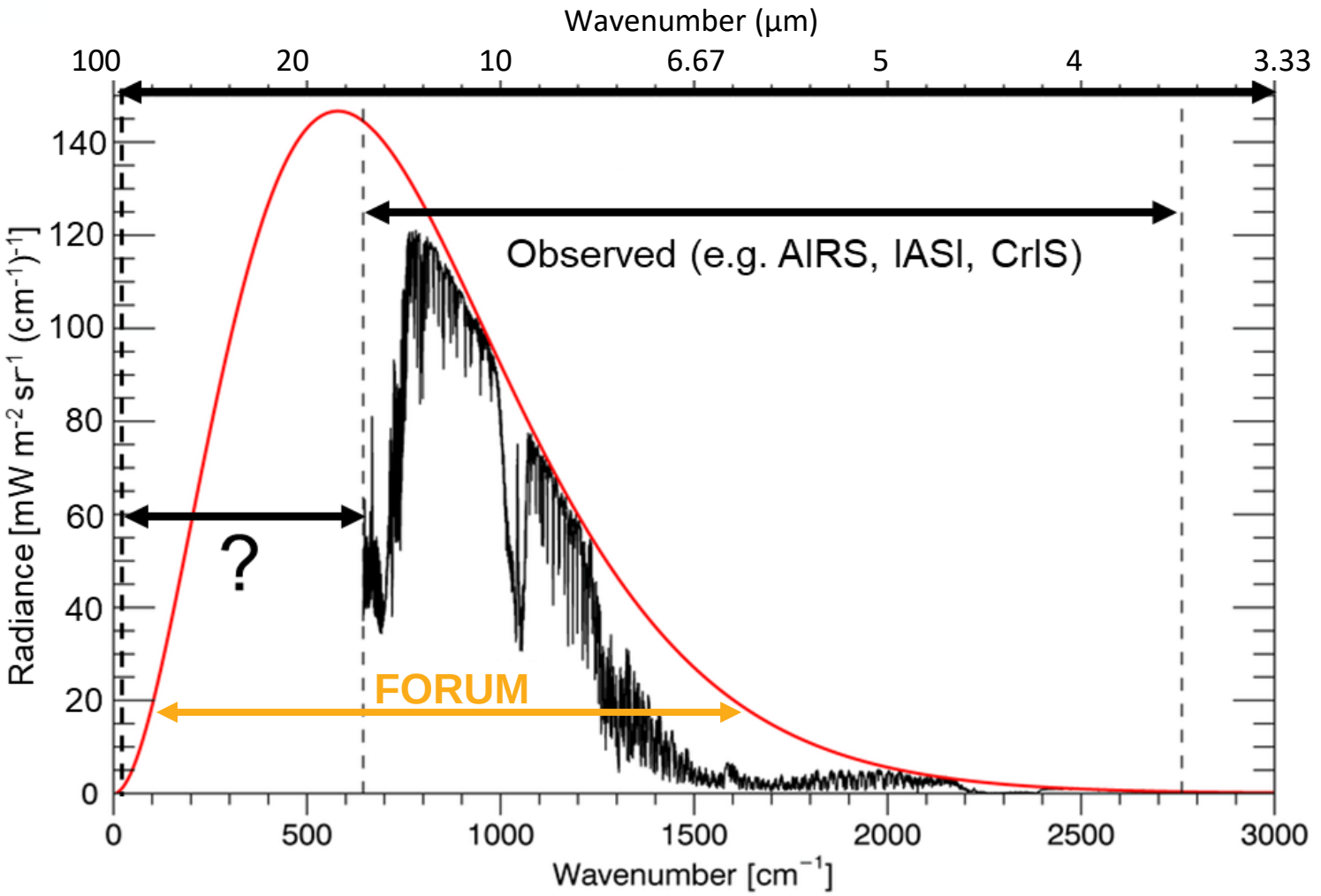

Knowledge of the Earth's **energy budget** and the **processes** that govern it is key to understanding the Earth's current and future **climate**

# Earth's Radiation Budget




**FORUM** will deepen our understanding of the **thermal outgoing radiation** by measuring the outgoing spectrum in the **far-infrared**

# FORUM – ESA's Thermal Radiation Mission



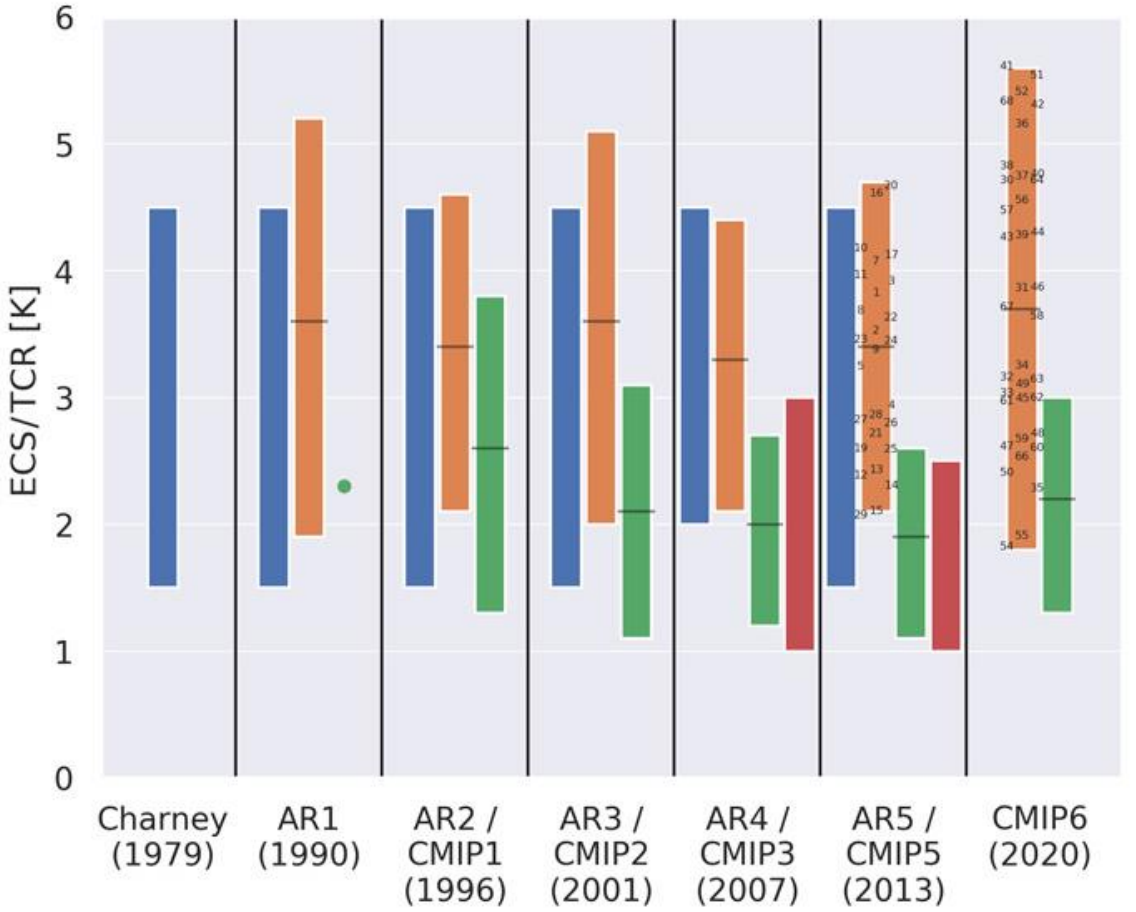

FORUM will be the **first** mission to measure Earth's outgoing spectrum in the **far-infrared** at high resolution

# The importance of spectral resolution

Climate models show a wide **range** of **climate sensitivities**

This leads to **uncertainty in future climate projections**

This spread is **not improving** with time




ECS = Equilibrium Climate Sensitivity (instant 2x $CO_2$)

TCR = Transient Climate Response (1% increase of $CO_2$ per year)

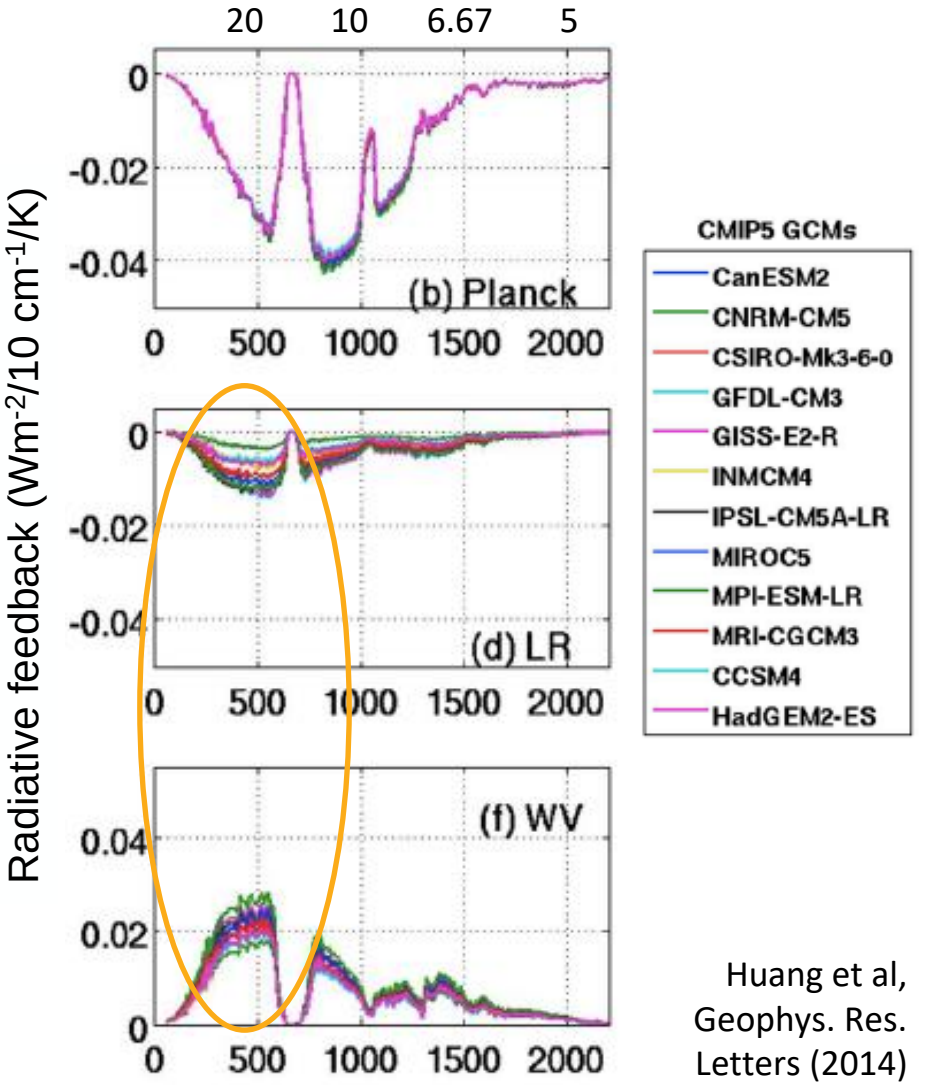
Meehl et al. Science Advances (2020)

# The importance of spectral resolution

Climate models show a wide **range** of **climate sensitivities**

By looking at the **spectral performance** of the models we can **diagnose** the reasons for the differences

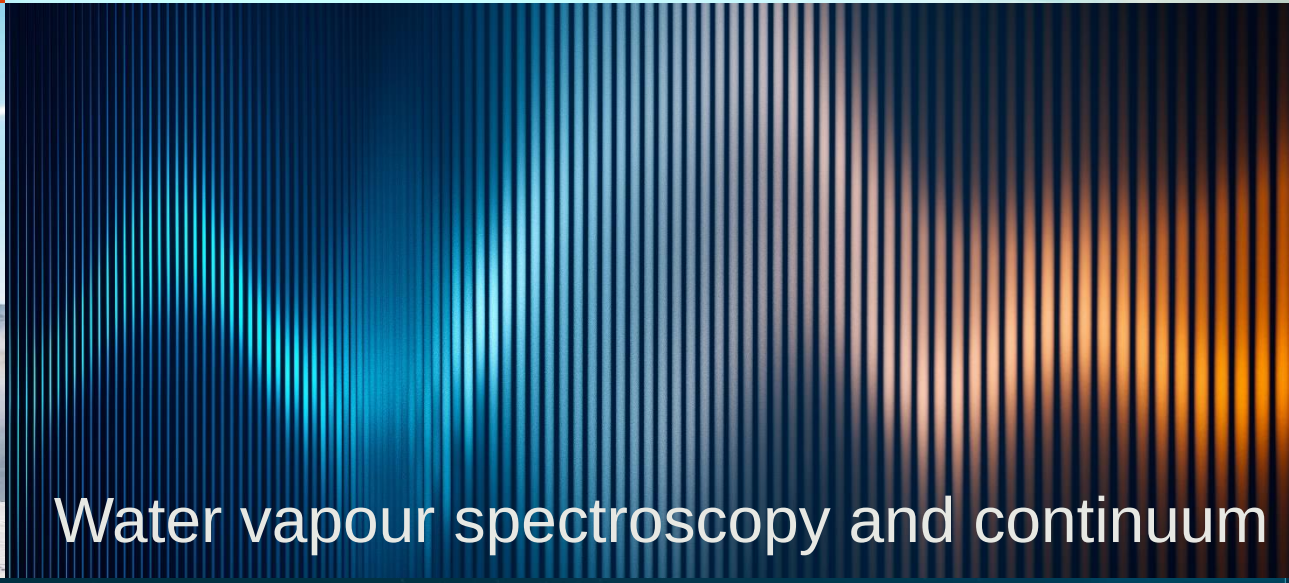
**FORUM** will provide **key measurements** for this work




Huang et al, Geophys. Res. Letters (2014)

# Unique information in the far-infrared

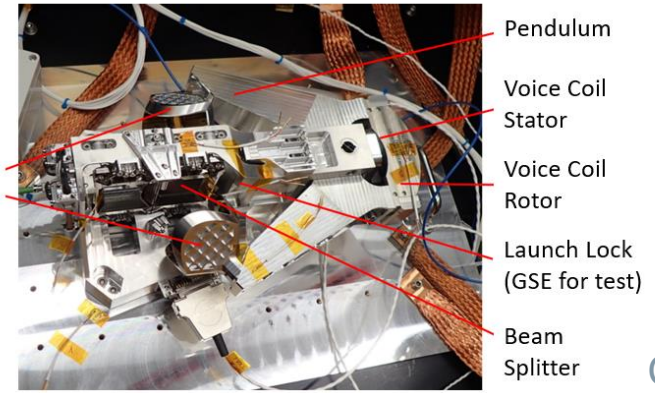


# FORUM Instruments

## FORUM Sounding Instrument

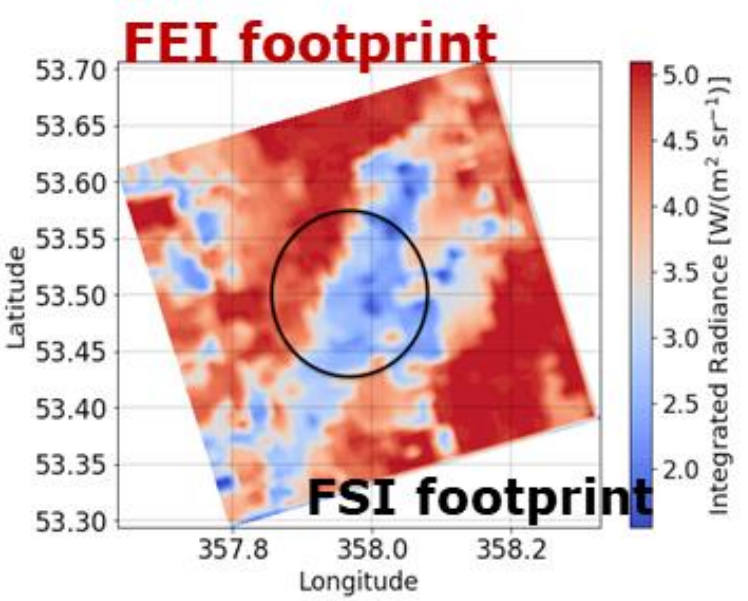
| Fourier Transform Spectrometer | | |
|---|---|---|
| Spectral Range | 6.25 – 100 µm (100 – 1600 $cm^{-1}$) | |
| Spectral Resolution | 0.5 $cm^{-1}$ | |
| Calibration Accuracy | 0.1 K | |
| Noise Equivalent Spectral Radiance | 300 – 1100 $cm^{-1}$ | 0.4 $mW/(m^2\ sr\ cm^{-1})$ |
| | elsewhere | 1 – 2 $mW/(m^2\ sr\ cm^{-1})$ |




Courtesy of OHB

## FORUM Embedded Imager

| Single Band Imager | |
|---|---|
| Spectral Range | 9.5 – 13.5 µm |
| Calibration Accuracy | 1 – 2 K |



# FORUM Orbit

## Orbit

**Polar, Sun-synchronous**, average altitude of **830 km**, mean local solar time at the descending node of 09:30, **29-day repeat-cycle**. FORUM orbits in loose formation with MetOp-SG(1A).

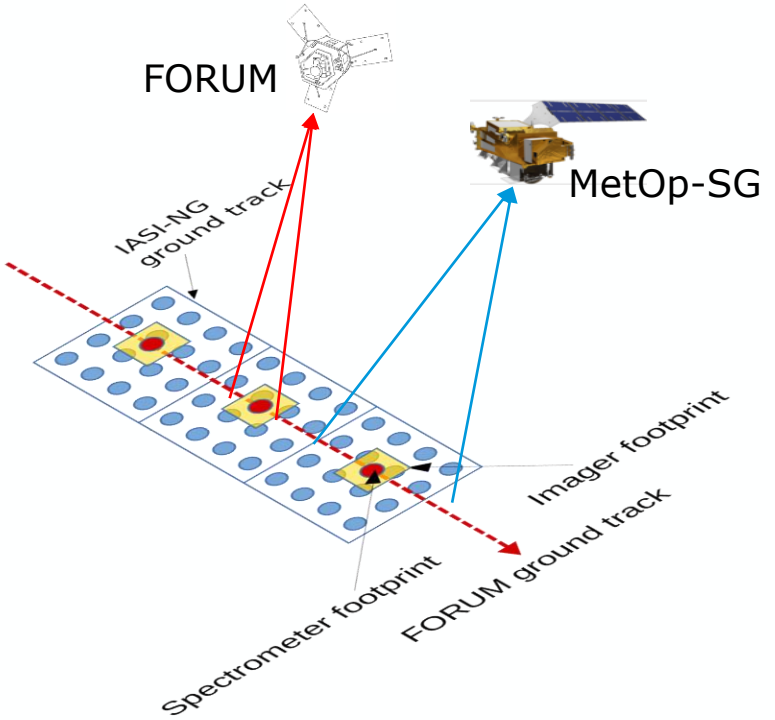
## Ground-samples

### Sounder

**15 km round pixel every 100 km**

### Imager

**36 km × 36 km with 750 m horizontal resolution**




The METOP-SG-A series carries:

- Infrared Atmospheric Sounding Interferometer (IASI-NG)
- Visible/Infrared Imager (METimage)
- Microwave Sounder (MWS)
- Radio Occultation (RO)
- Multi-viewing, multi-channel, multi-polarisation Imager (3MI)
- Sentinel-5

# FORUM Satellite

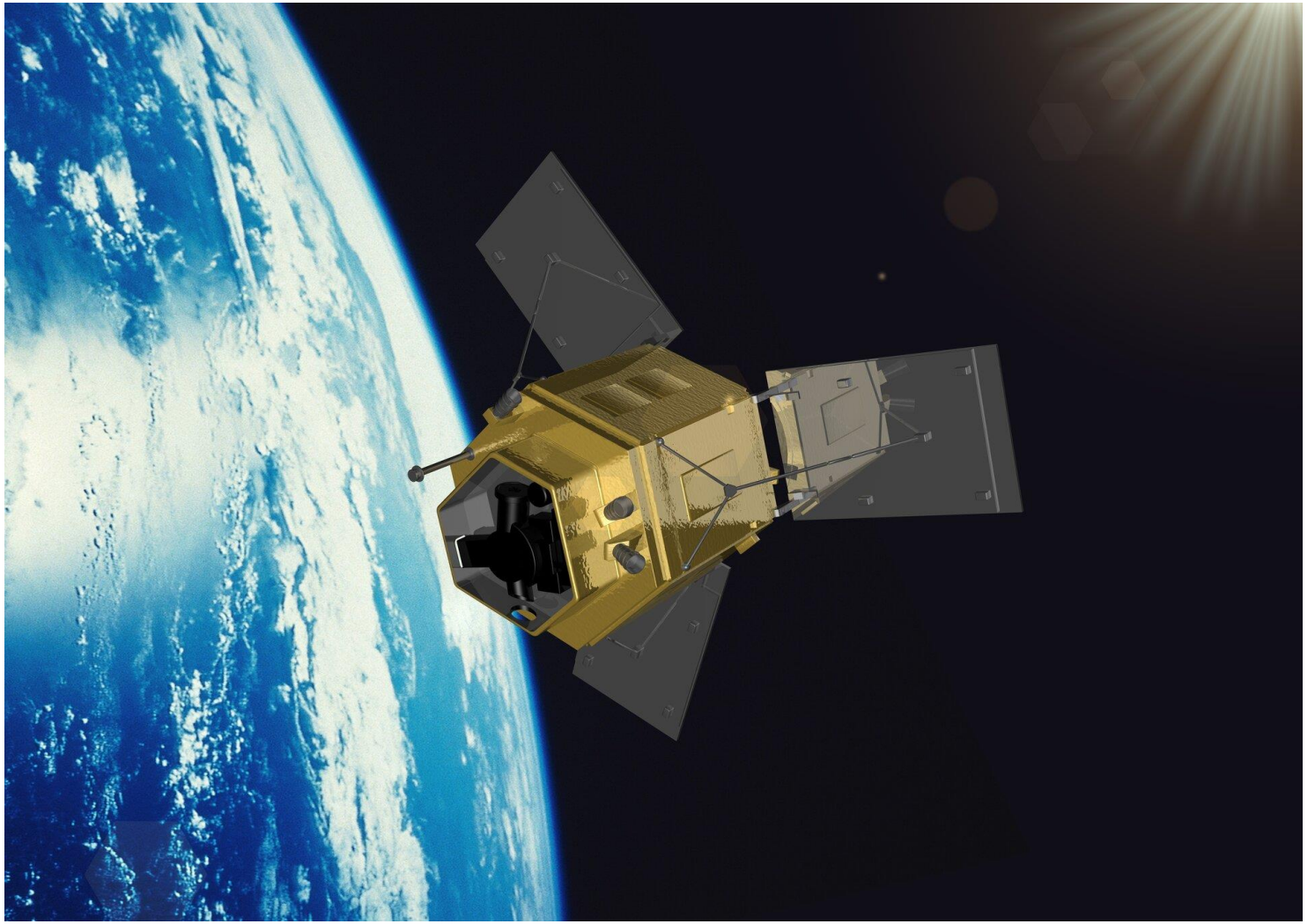
**Launch**
2027

**Rocket**
Vega C from Europe's Spaceport in French Guiana

**Satellite**
2.3 m high, and 5 m diameter

**Mass**
944 kg (including 82 kg fuel)

**Life**
Minimum of 5 years



# FORUM will provide

- a **highly accurate** (0.1 K at 3σ) global dataset of **far-infrared radiances** to validate present-day climate in **climate models** and to validate numerical weather prediction models
- an enhanced sensitivity to **ice cloud particle size and shape**
- a characterisation of mid-upper tropospheric/ lower stratospheric **water vapour**
- the ability to retrieve far-infrared **surface emissivity** in low-humidity
- the ability to test and improve the **water vapour continuum** models and **spectroscopy** (e.g. water vapour, CO2)
- an improved detection of optically thin **ice clouds**
- the ability to assess and improve the spectral consistency (between the mid-infrared and far-infrared) of **ice cloud microphysical models**

# Ongoing Scientific Activities

## ESA is supporting scientific work to ensure FORUM can fulfil its mission objectives

End-to-end simulator and level 2 prototype processor development

UNIRAS airborne demonstrator

FIRMOS-B balloon-borne demonstrator

FINESSE ground-based emissivity measurements

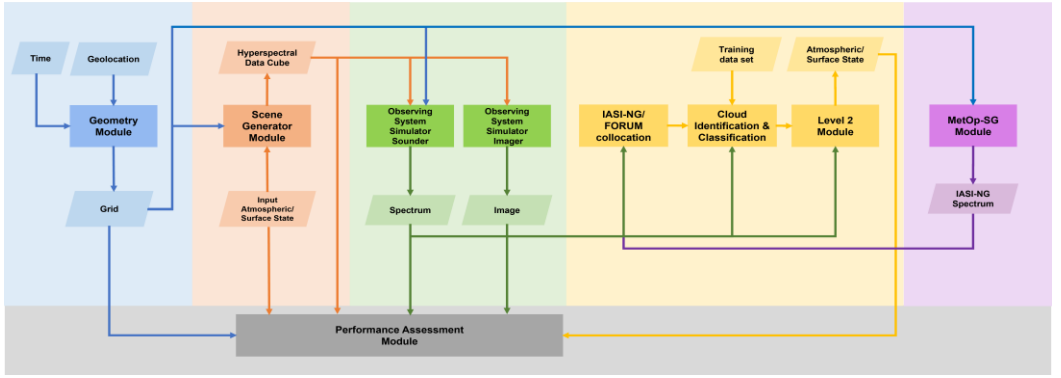



Photo credit: Luca Palchetti
https://www.forum-ee9.eu/transat-2024/

## Active communities across member states and beyond

**Mission Advisory Group:**

Luca Palchetti (INO-CNR, IT)
Helen Brindley (Imperial College London, UK)
Stefan A. Buehler (University of Hamburg, DE)
Dorothee Coppens (EUMETSAT, INT)
Bianca M. Dinelli (ISAC-CNR, IT)
Jeremy Harrison (NCEO, UK)
Elsa Jacquette (CNES, FR)
Laurent Labonnote (University of Lille, FR)
Quentin Libois (Météo-France, FR)
Marco Ridolfi (University of Bologna, IT)
Martin Riese (Forschungszentrum Jülich, DE)
Roger Saunders (Met Office, UK)

**ESA science team:**

Hilke Oetjen, Dirk Schuettemeyer, Laura Warwick.

# FORUM Session
# Thursday 15:50 – 18:10
## See also posters in P4 and P8