

# living planet symposium | BONN 23–27 May 2022

TAKING THE PULSE  
OF OUR PLANET FROM SPACE



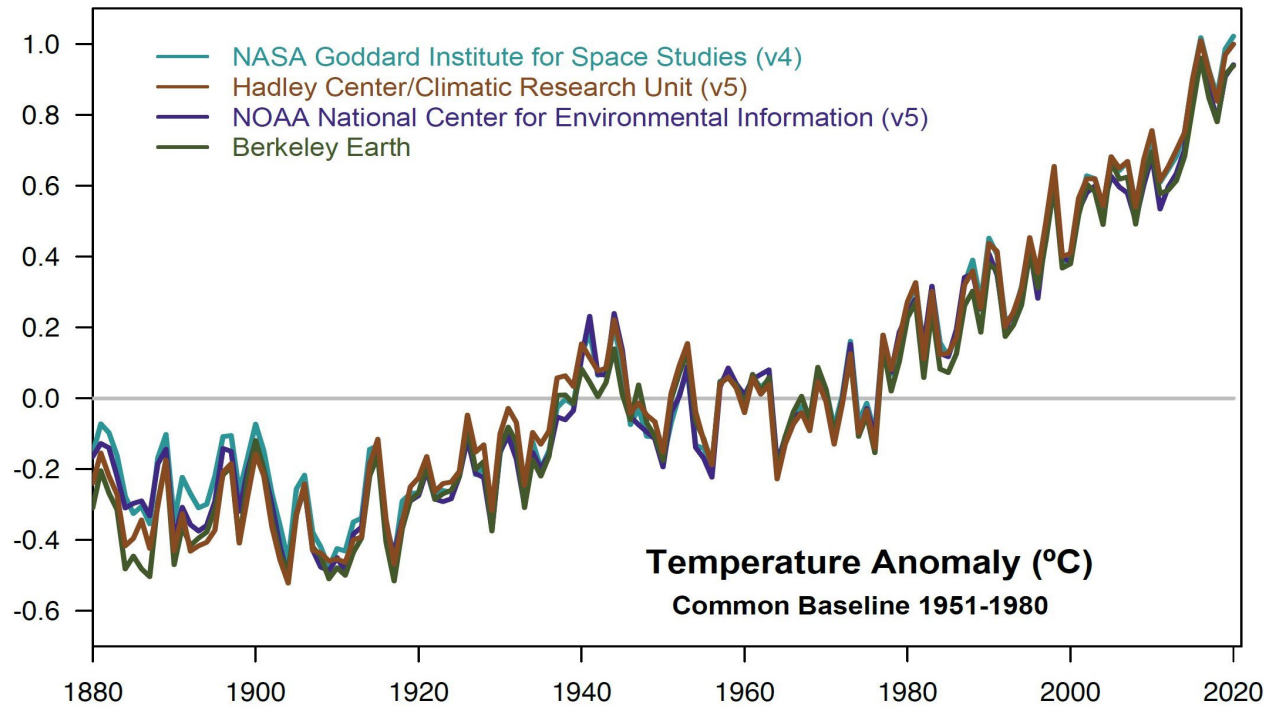
## Making the case for FORUM: Scientific rationale and current status

Helen Brindley, Imperial College London and NCEO

27<sup>th</sup> May 2022

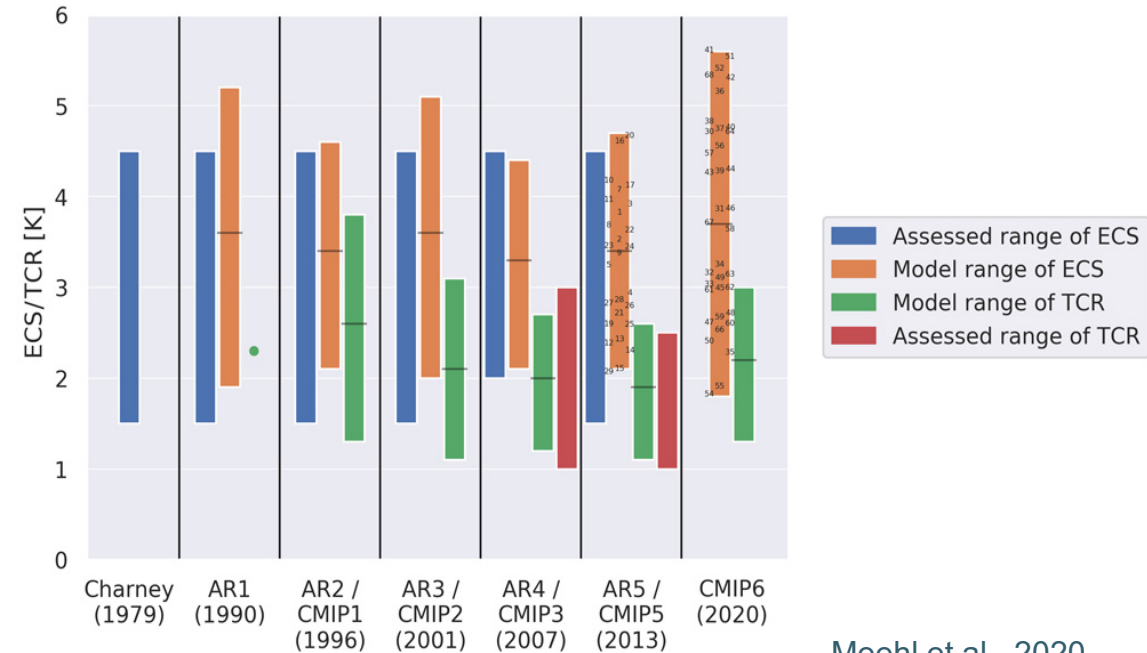


# The context for FORUM



NASA GISS/Schmidt, 2021

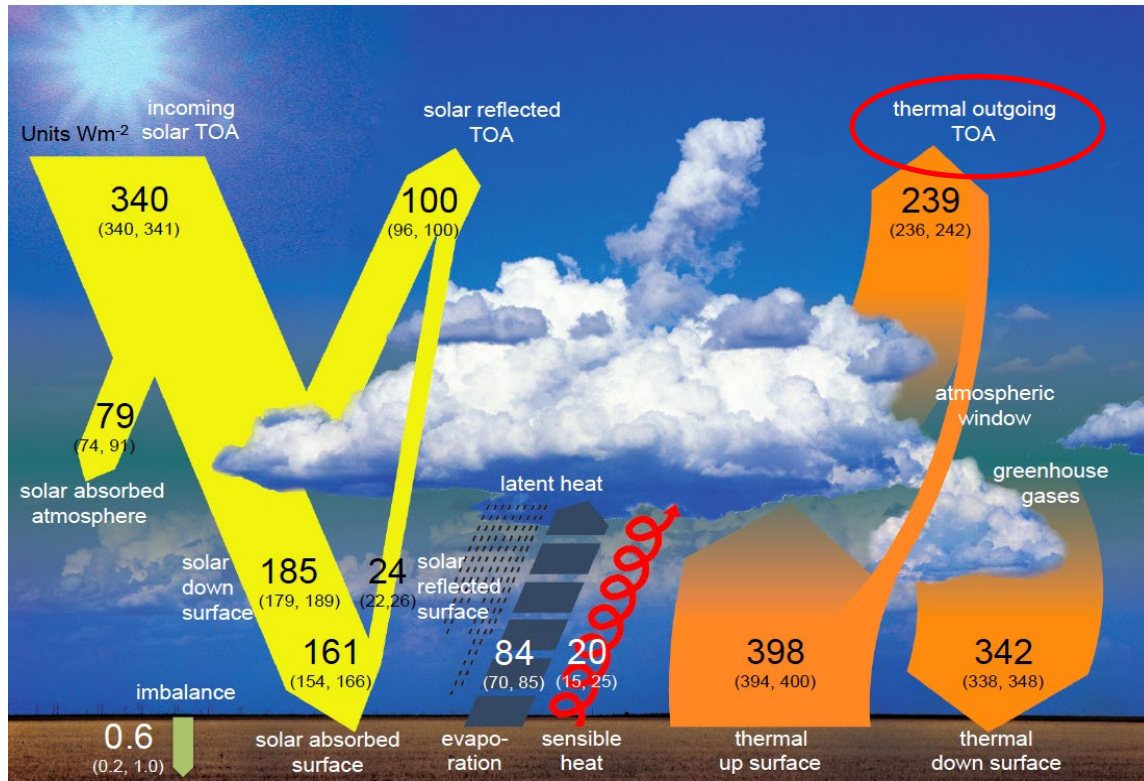
Equilibrium climate sensitivity (gregory method) and transient climate response



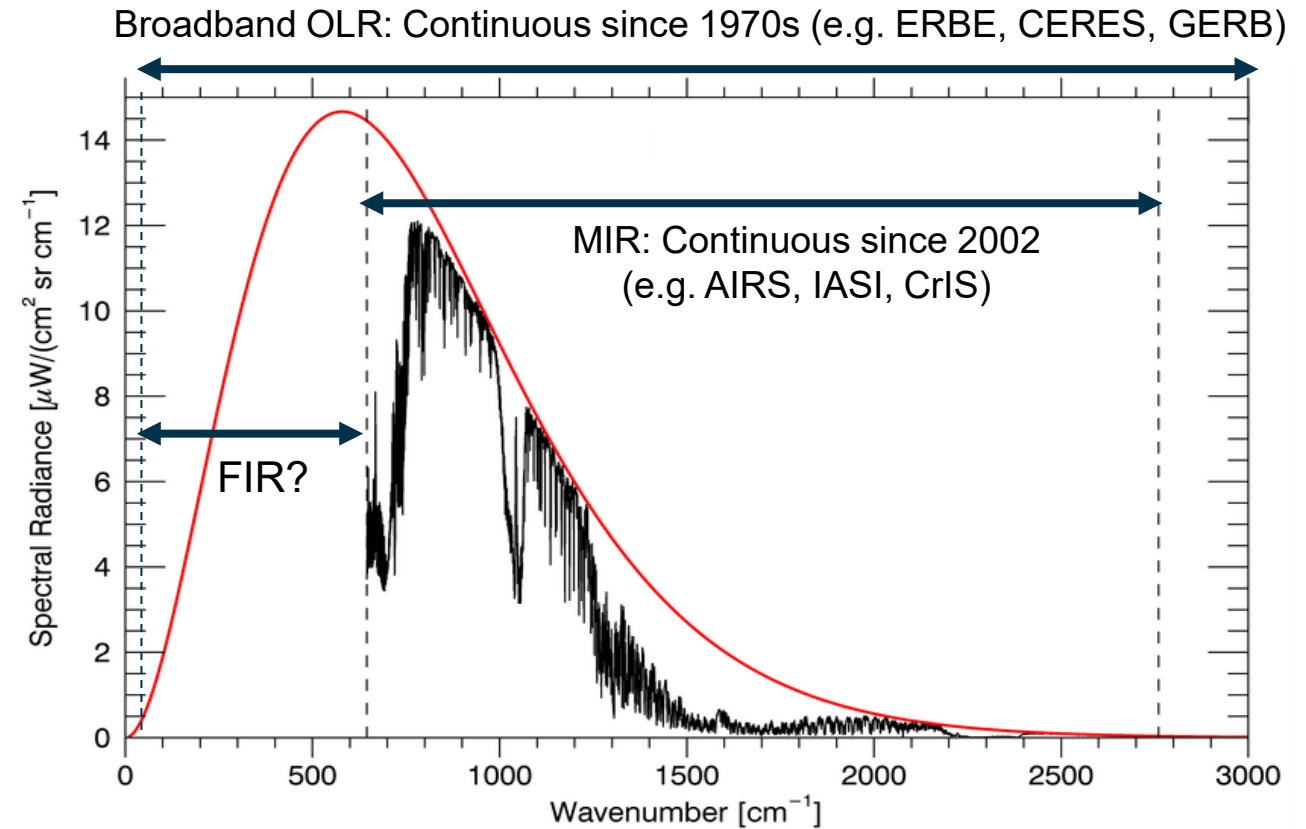
Meehl et al., 2020

- The Earth is losing its cool: 8 out of the last 10 years are the warmest since modern records began
- Climate models match the historical temperature record well but the future trajectory remains uncertain
- **FORUM** will make unique measurements of the **Earth's outgoing energy spectrum** to help reduce this uncertainty

# Driving the climate: the Earth's radiation budget

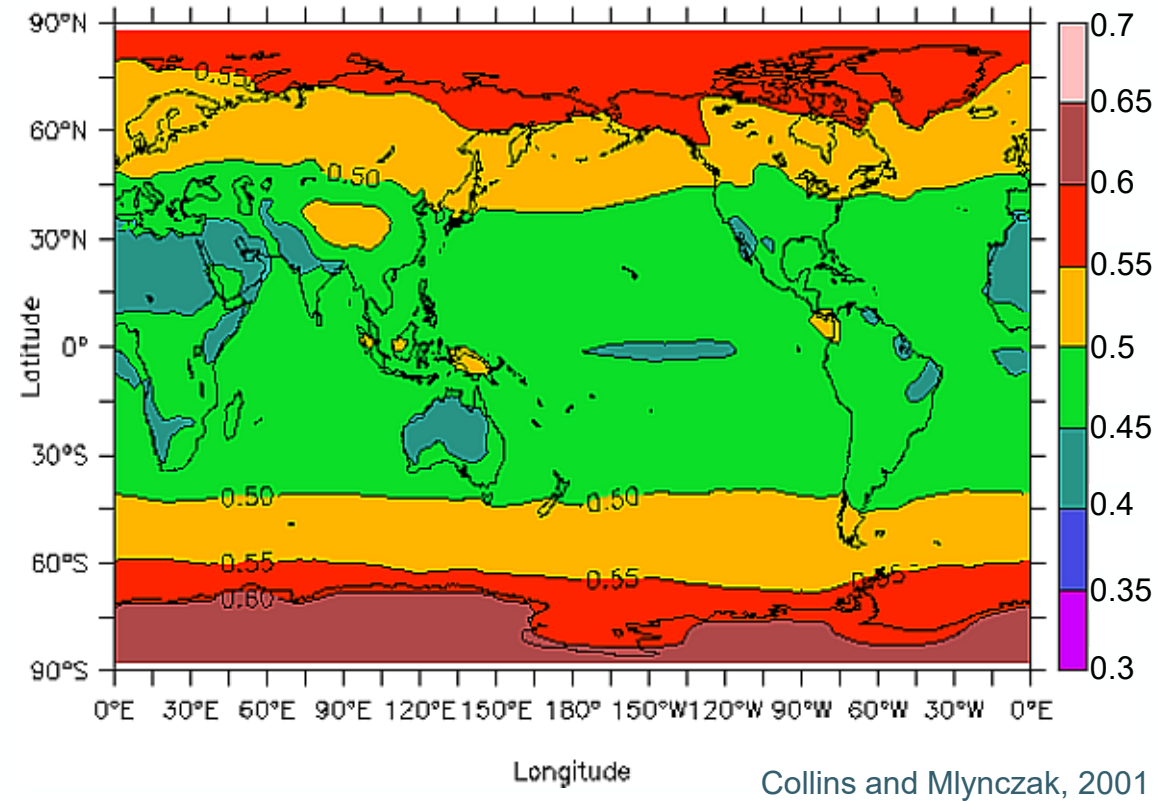
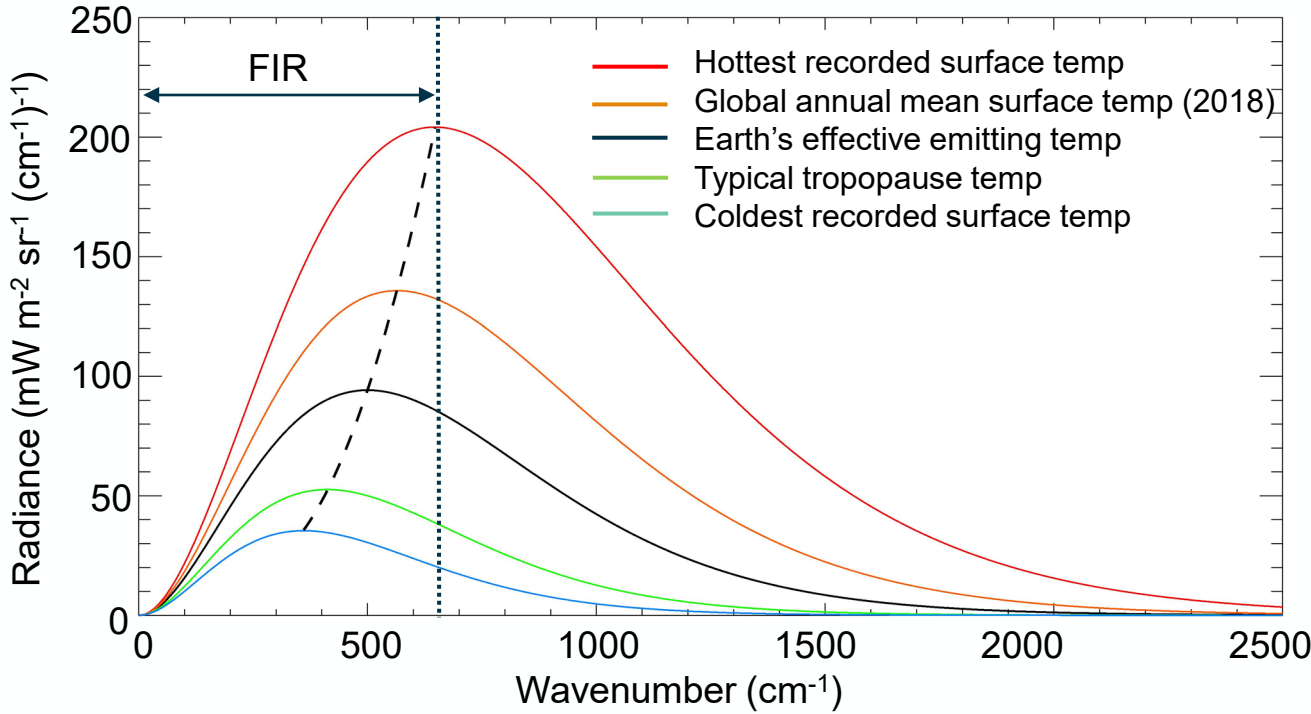


Wild et al., 2013



- Surface temperature is fundamentally driven by the Earth's radiation (im)balance at the TOA
- The Earth cools via the emission of longwave to space: this outgoing longwave radiation (OLR) spectrum contains the fingerprints of key greenhouse gases, cloud and the surface.
- **We have no sustained, systematic measurements of the OLR in the far-infrared (FIR): FORUM will fill this gap**

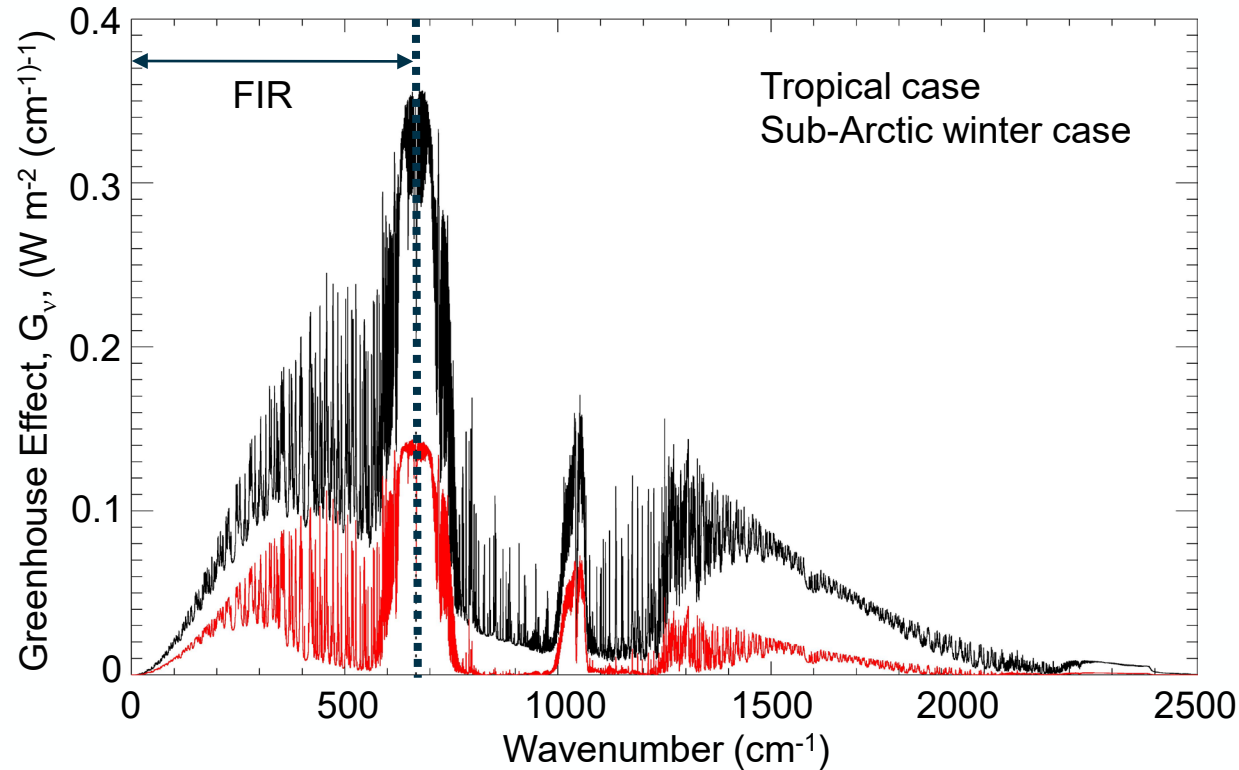
# Why is the far-infrared so special?



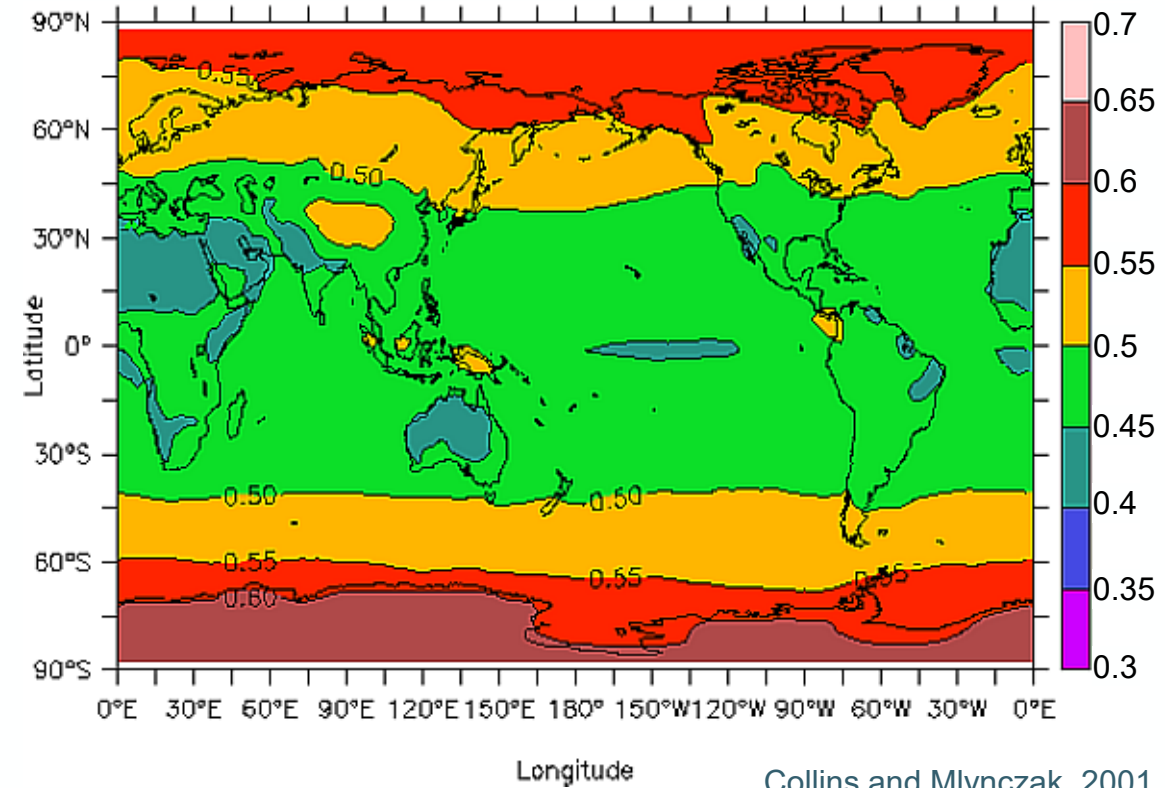
- Over the temperature range of the Earth's surface and atmosphere, **peak energetic emission** is seen in the FIR
- On the global mean, more than 50 % of the Earth's OLR is predicted to occur within the FIR



# Why is the far-infrared so special?



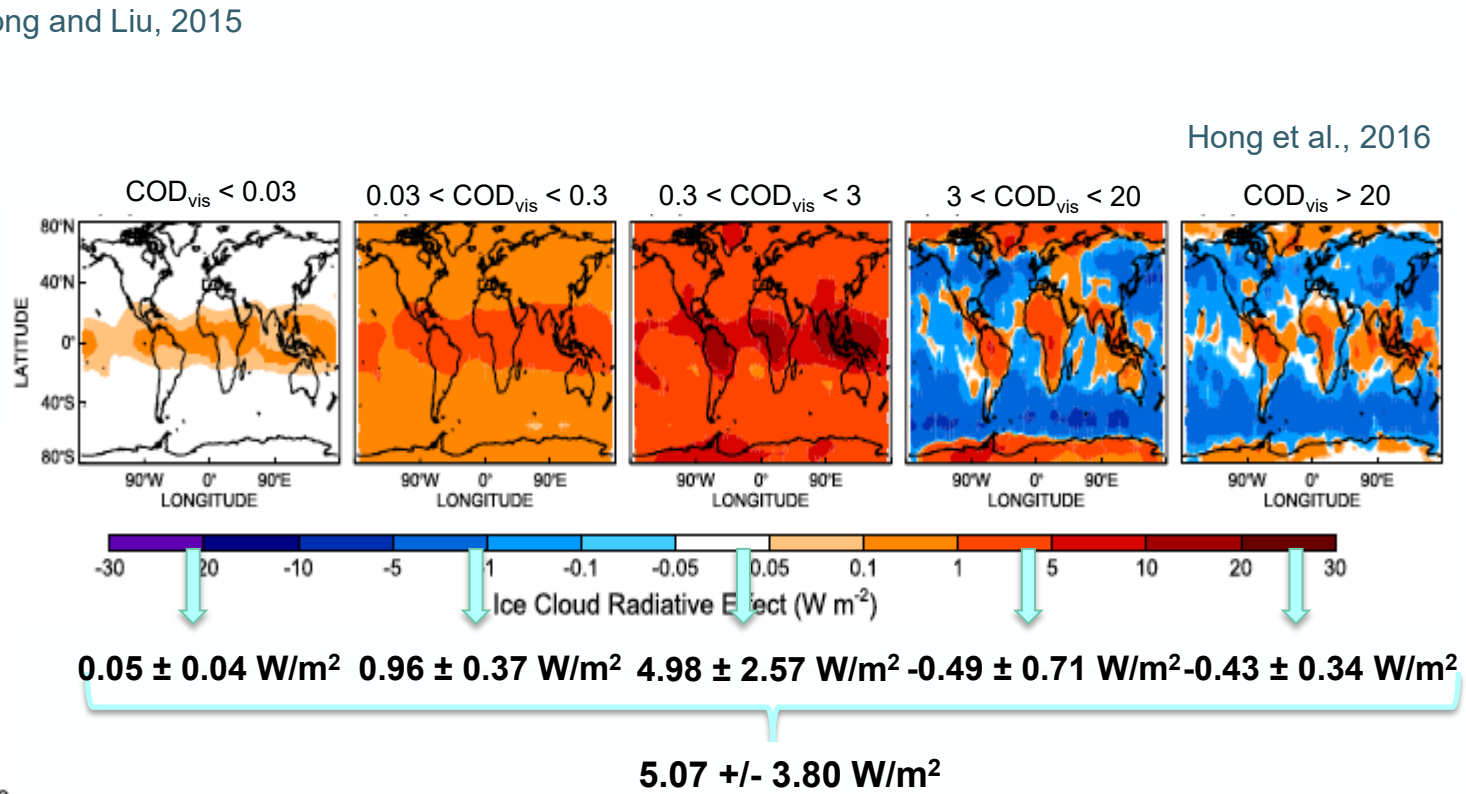
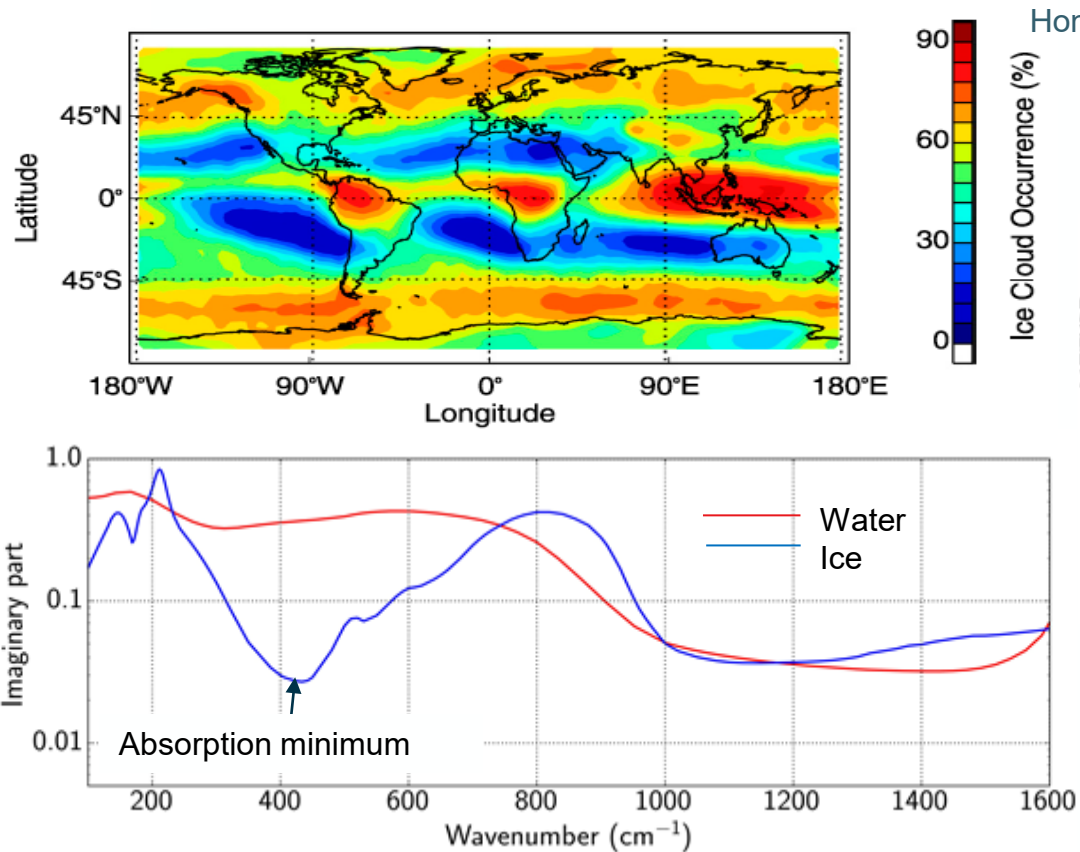
Brindley and Harries, 1998



Collins and Mlynczak, 2001

- Over the temperature range of the Earth's surface and atmosphere, **peak energetic emission** is seen in the FIR
- On the global mean, more than 50 % of the Earth's OLR is predicted to occur within the FIR
- ~ 50 % of clear-sky greenhouse trapping within this region due primarily to absorption by water vapour

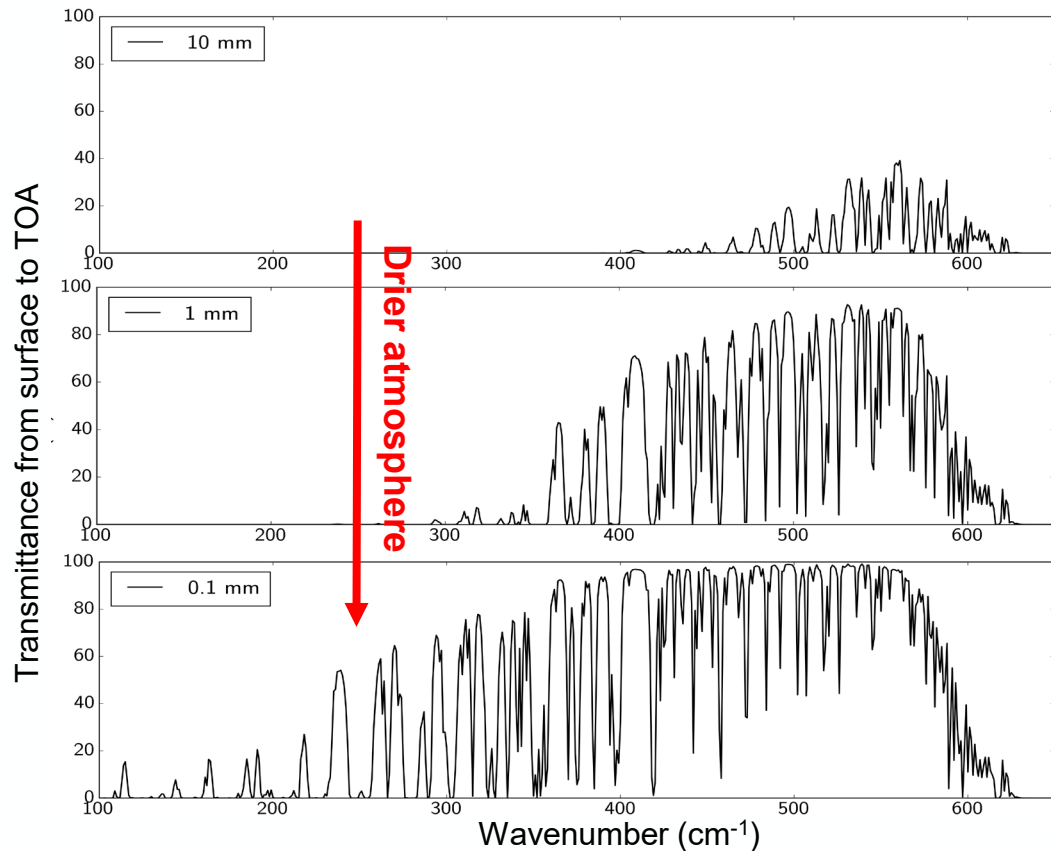
# Why is the far-infrared so special?



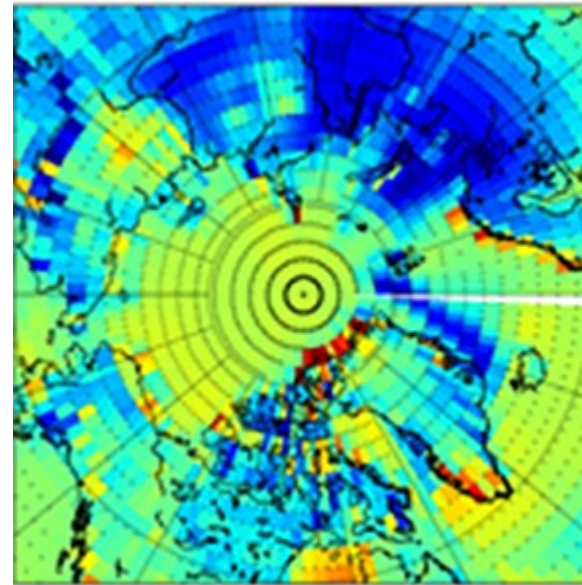
- Optically thin ice clouds are prevalent across the globe. The refractive index of ice has specific features in the FIR that imply the region will contain unique information about particle size and habit
- Simulations suggest these ice clouds have a strong longwave warming effect. Calculations typically assume specific ice cloud properties and these may not be valid in the FIR



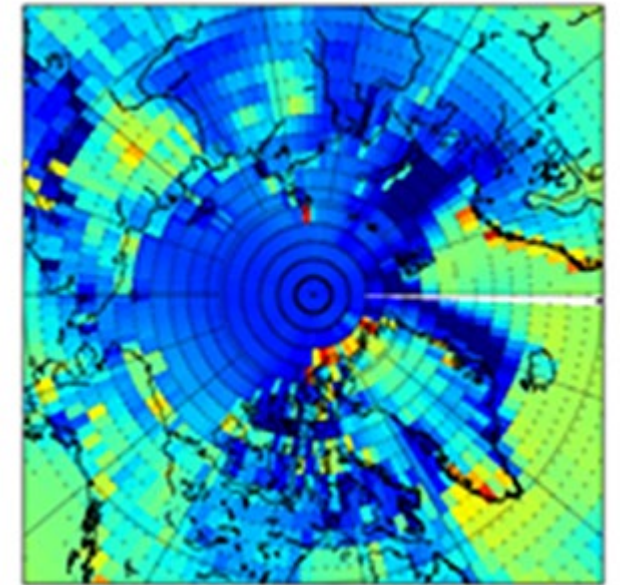
# Why is the far-infrared so special?



DJF  $\Delta T_{\text{skin}}$  CESM – ERA, updated spectral emissivity



DJF  $\Delta T_{\text{skin}}$  CESM – ERA, standard emissivity



Kuo et al., 2018

- In cold, dry regions micro-windows in the FIR open and surface emission can reach space
- Including spectrally varying FIR surface emissivity has a marked impact on persistent Arctic cold-pole biases
- Very limited retrievals of FIR emissivity: FORUM observations will significantly improve spatio-temporal coverage

## Research Objective

- to evaluate the role of the far-infrared in shaping the current climate and thus reduce uncertainty in predictions of future climate change

by

- building a **highly accurate global dataset of far-infrared radiances** for validation of the present-day state as captured by Earth system models (Level 1c)
- using these measurements to **understand and constrain the processes** that control far-infrared radiative transfer and hence the Earth's Greenhouse Effect
- **updating the parametrisations** of these processes for implementation in radiative transfer codes, and ultimately in Earth system models
- **characterising critical feedback mechanisms**

Additional benefit for **ice cloud, surface emissivity** and **water vapour retrievals** (Level 2)



# Preparatory science: Airborne infrastructure

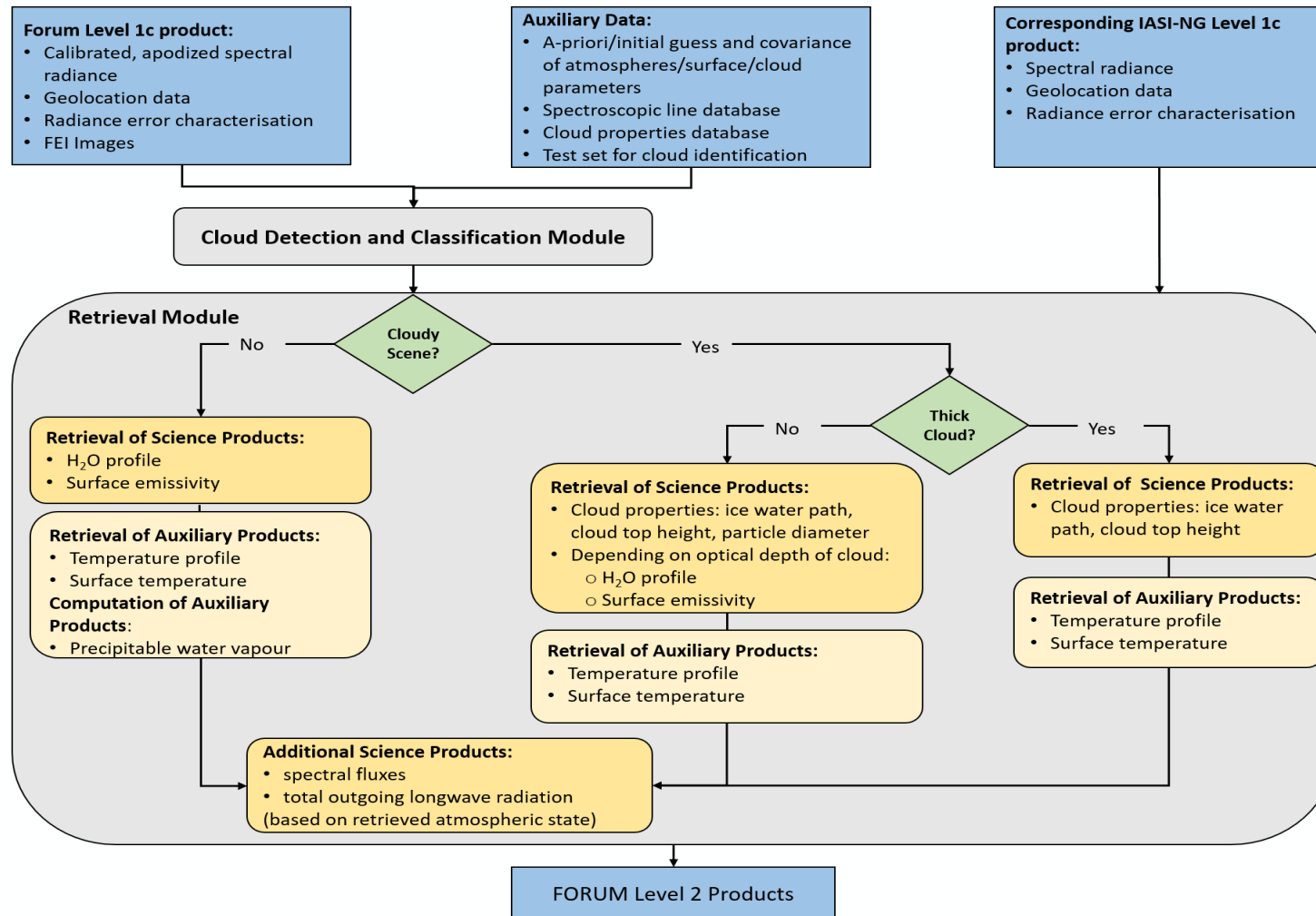
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Aircraft based UNIRAS



Balloon based FIRMOS





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## The FORUM end-to-end simulator project: architecture and results

Luca Sgheri<sup>1</sup>, Claudio Belotti<sup>2</sup>, Maya Ben-Yami<sup>3</sup>, Giovanni Bianchini<sup>2</sup>, Bernardo Carnicero Dominguez<sup>3</sup>, Ugo Cortesi<sup>4</sup>, William Cossich<sup>5</sup>, Samuele Del Bianco<sup>4</sup>, Gianluca Di Natale<sup>2</sup>, Tomás Guardabrazo<sup>6</sup>, Dulce Lajas<sup>3</sup>, Tiziano Maestri<sup>5</sup>, Davide Magurno<sup>5</sup>, Hilke Oetjen<sup>3</sup>, Piera Raspollini<sup>4</sup>, and Cristina Sgattoni<sup>1</sup>

- <sup>1</sup> IAC – CNR, Via Madonna del Piano 10, 50019 Sesto Fiorentino (FI), Italy
- <sup>2</sup> INO – CNR, Via Madonna del Piano 10, 50019 Sesto Fiorentino (FI), Italy
- <sup>3</sup> ESA – ESTEC, Keplerlaan 1, 2201 AZ Noordwijk, the Netherlands
- <sup>4</sup> IFAC – CNR, Via Madonna del Piano 10, 50019 Sesto Fiorentino (FI), Italy
- <sup>5</sup> Physics and Astronomy Department, University of Bologna, Bologna (BO), Italy
- <sup>6</sup> Deimos Space SLU, Ronda de Pte. 19, 28760 Tres Cantos, Madrid, Spain

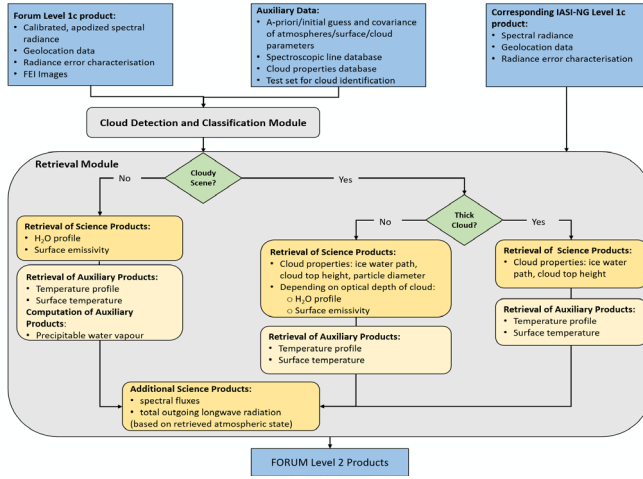
Correspondence: Luca Sgheri (l.sgheri@iac.cnr.it)

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 Revised: 3 November 2021 – Accepted: 3 December 2021 – Published: 3 February 2022

- Performance assessment (verification/trade-offs)
- Tool for tracing uncertainties
- Testbed for further L2 processor development
- Can exploit existing and new observations



# Preparatory science: L2 Processor development & test



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Atmospheric Measurement Techniques EGU

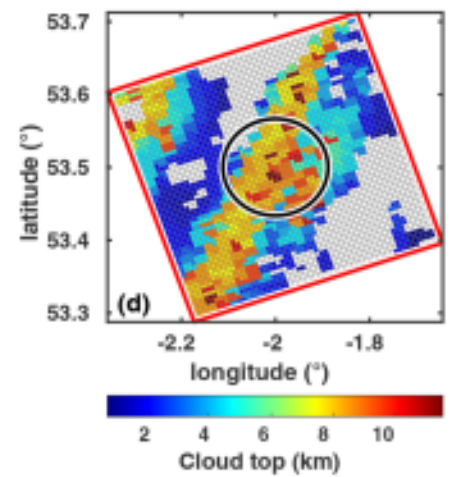
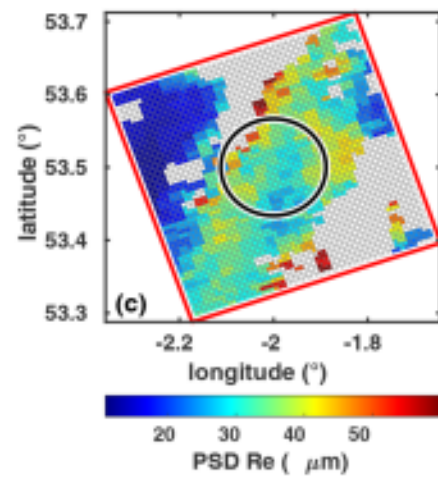
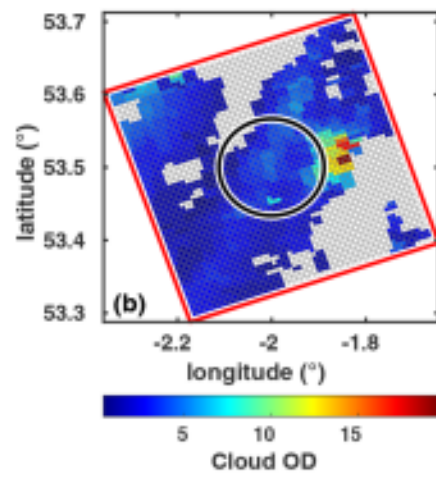
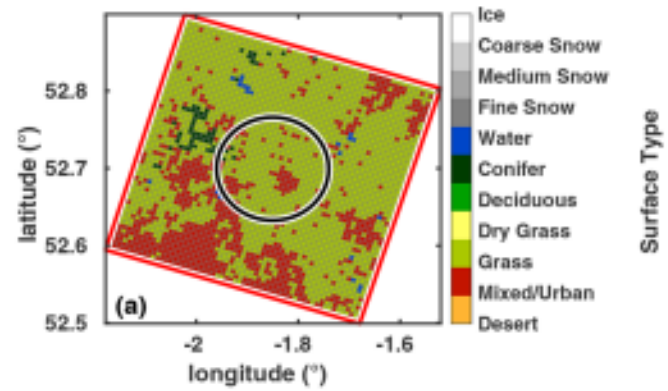
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<sup>1</sup>IAC – CNR, Via Madonna del Piano 10, 50019 Sesto Fiorentino (FI), Italy  
<sup>2</sup>INO – CNR, Via Madonna del Piano 10, 50019 Sesto Fiorentino (FI), Italy  
<sup>3</sup>ESA – ESTEC, Keplerlaan 1, 2201 AZ Noordwijk, the Netherlands  
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- FORUM will provide truly unique observations of the Earth's outgoing longwave radiation, systematically and accurately measuring the far-infrared spectrum with high spectral resolution for the first time
- Theory suggests these observations will have benefit for both directly constraining theoretical predictions of OLR and for the retrieval of improved and novel geophysical datasets
- However, this is an unexplored region so we must be ready to revise our theoretical expectations based on what we see when the mission launches in 4-5 years time
- We have lots of exciting preparatory work to do before then!