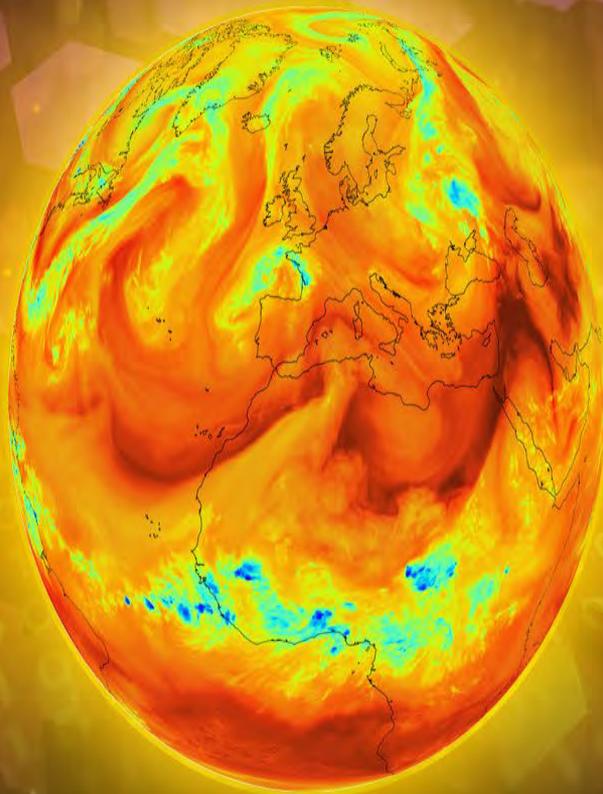


Far-infrared Outgoing Radiation Understanding and Monitoring



forum

→ UNDERSTANDING HOW
EARTH IS LOSING ITS COOL

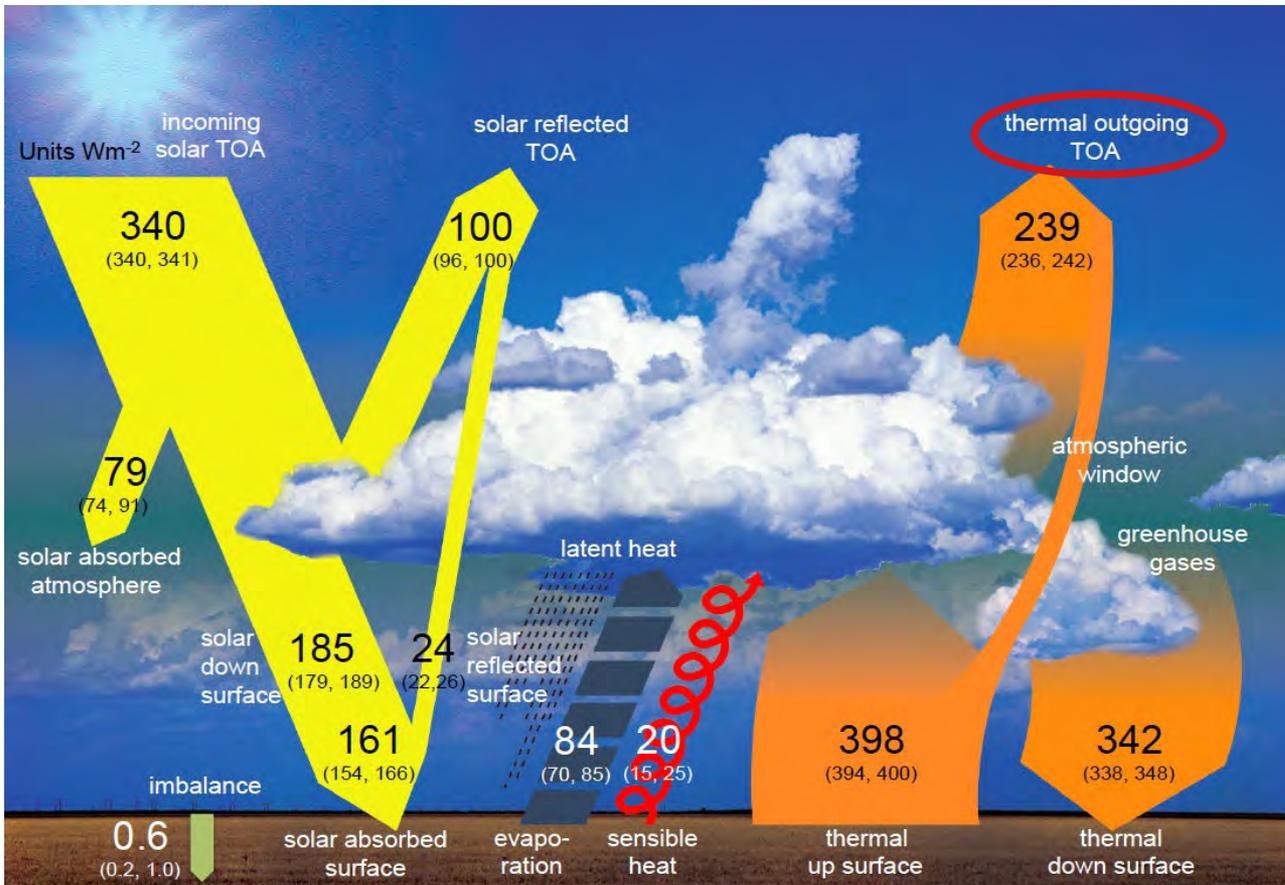
Helen Brindley (& many others)
NCEO Imperial College, London

Overview

- What is FORUM: Science Drivers & Objectives
- Proposed Mission Concept
 - Instrument Payload & Specifications
 - Scientific Products
- Current status



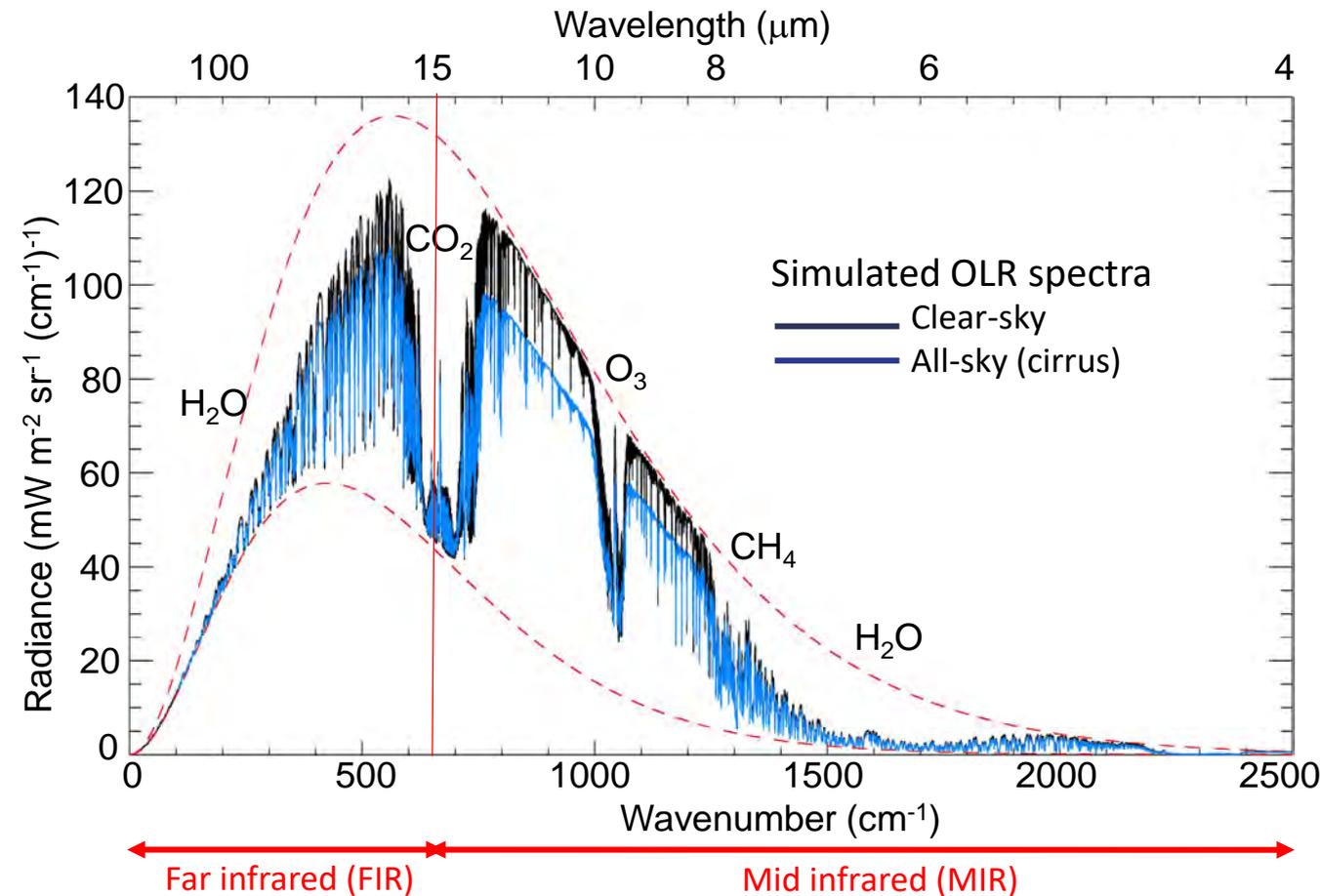
Driving the climate: the Earth's radiation budget



Earth's climate is fundamentally driven by the **Earth's radiation (im)balance at the top of the atmosphere (TOA)**

Anthropogenic increases in greenhouse gases reduce the outgoing longwave radiation (OLR) such that the **Earth-system warms to restore balance**

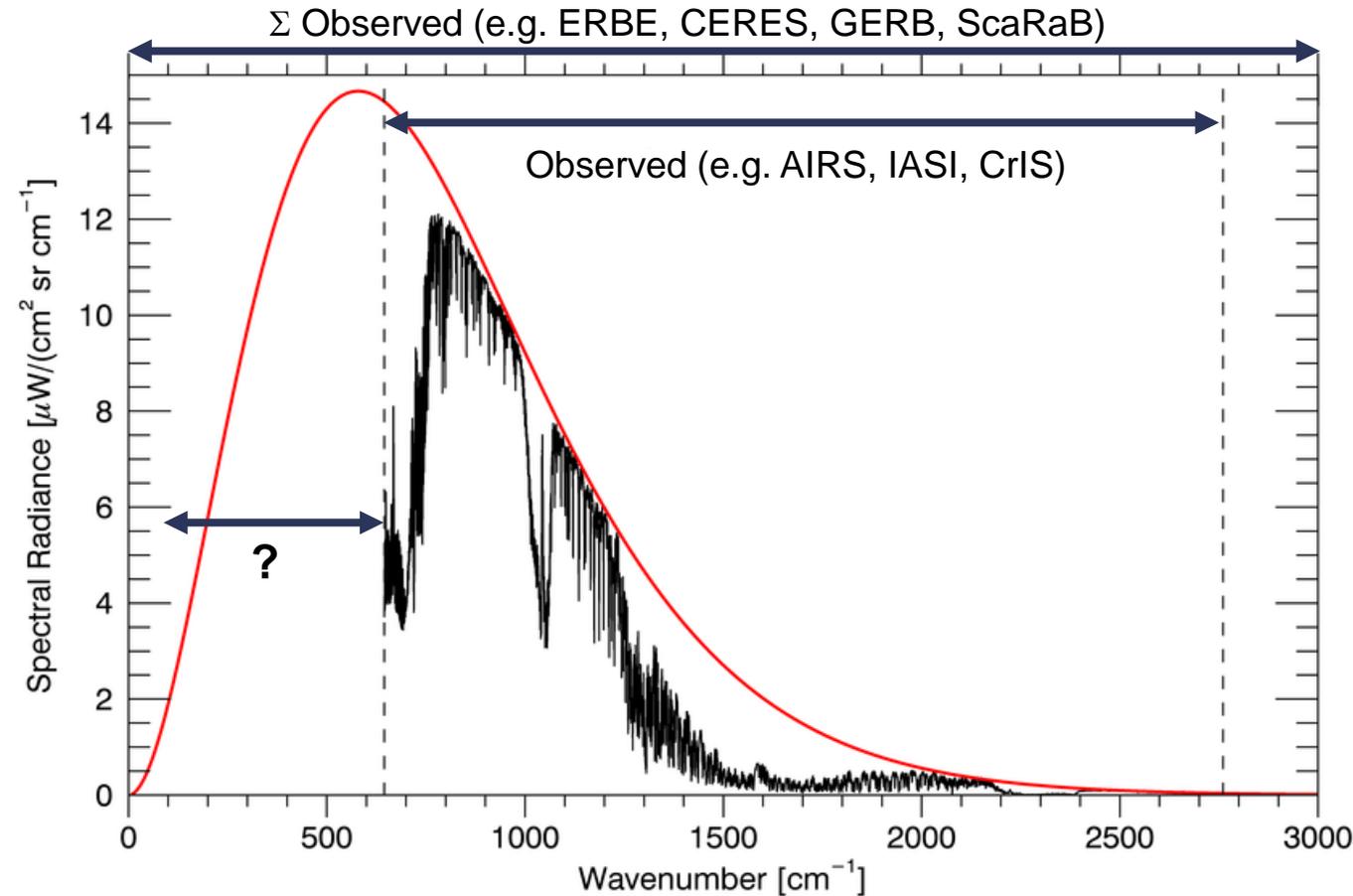
Outgoing Longwave Radiation: the spectral dimension



At any given location in space and time the OLR spectrum is determined by the **surface** and **atmospheric properties**.

It implicitly contains the fingerprints of **key greenhouse gases** and, where present, **cloud**.

The missing piece: Far-infrared spectral radiation



The FIR contributes **~ 50 %** to the total OLR

Airborne measurements and simulations imply the FIR contains important information on **water vapour, cloud, and polar surface climate forcing and feedbacks**

The region has never been measured spectrally from space: FORUM will fill this gap.

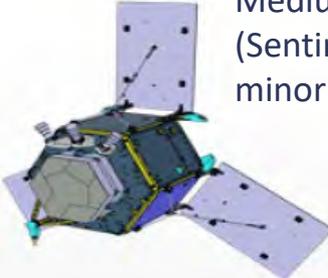
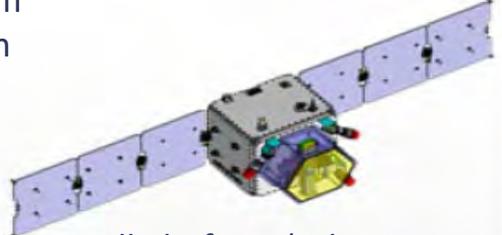
Two competing mission concepts

Details correct as of Mission Selection (ongoing developments through Phase B1)

Concept A

Concept B



| Concept A | Concept B |
|--|---|
|  <p>Medium platform (Sentinel 5p with minor changes)</p> |  <p>Small platform (Adaptation of Proteus 150/300)</p> |
| <p>Mass: ~850 kg Power: ~430W</p> | <p>Mass : ~570 kg Power : ~440 W</p> |
| <p>Instruments: Fourier Transform Spectrometer (FSI) Imager (FEI)</p> | |
| <p>Nominal Lifetime: 4 years → Capability to extend to 6</p> | |
| <p>Orbit: SSO at 830 Km; LTDN at 9;30 a.m.</p> | |
| <p>Loose formation with MetOP-SG-A1.</p> | |

Payload and measurement requirements

2 instruments – Sounder and Imager

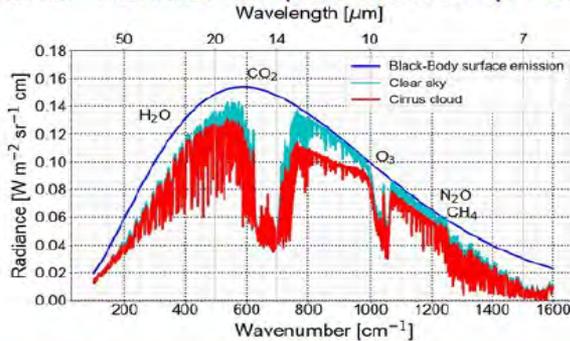
FORUM Sounding Instrument (FSI)

What for?

Spectrally resolved measurement of the Top-of-atmosphere (TOA) spectrum in the **infrared from 100 to 1600 cm^{-1}** (100 μm to 6.25 μm)

How?

SPECTROMETER
Fourier Transform Spectrometer (FTS)



Spectral Resolution FWHM: (0.36 cm^{-1}) [0.5 cm^{-1}]

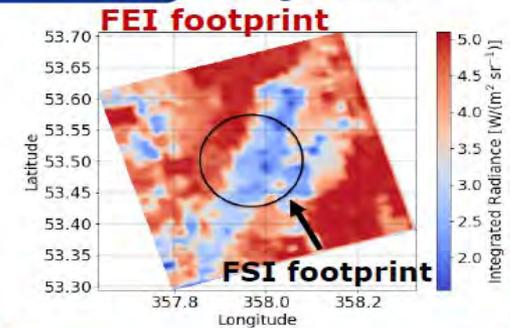
FORUM Embedded Imager (FEI)

What for?

Scene uniformity
Assessment

How?

THERMAL IMAGER
Single band



Single channel: 10.5 μm (FWHM: 1.5 μm)

Radiometric Accuracy **3 σ**
(Goal) [Threshold]

300-1100 cm^{-1} : (0.1 K) [0.25 K]
200-300 cm^{-1} : (0.2 K) [0.25 K]
1100-1300 cm^{-1} : (0.2 K) [0.25 K]
Elsewhere: (1, 1 K)

Radiometric Precision
(Goal) [Threshold]

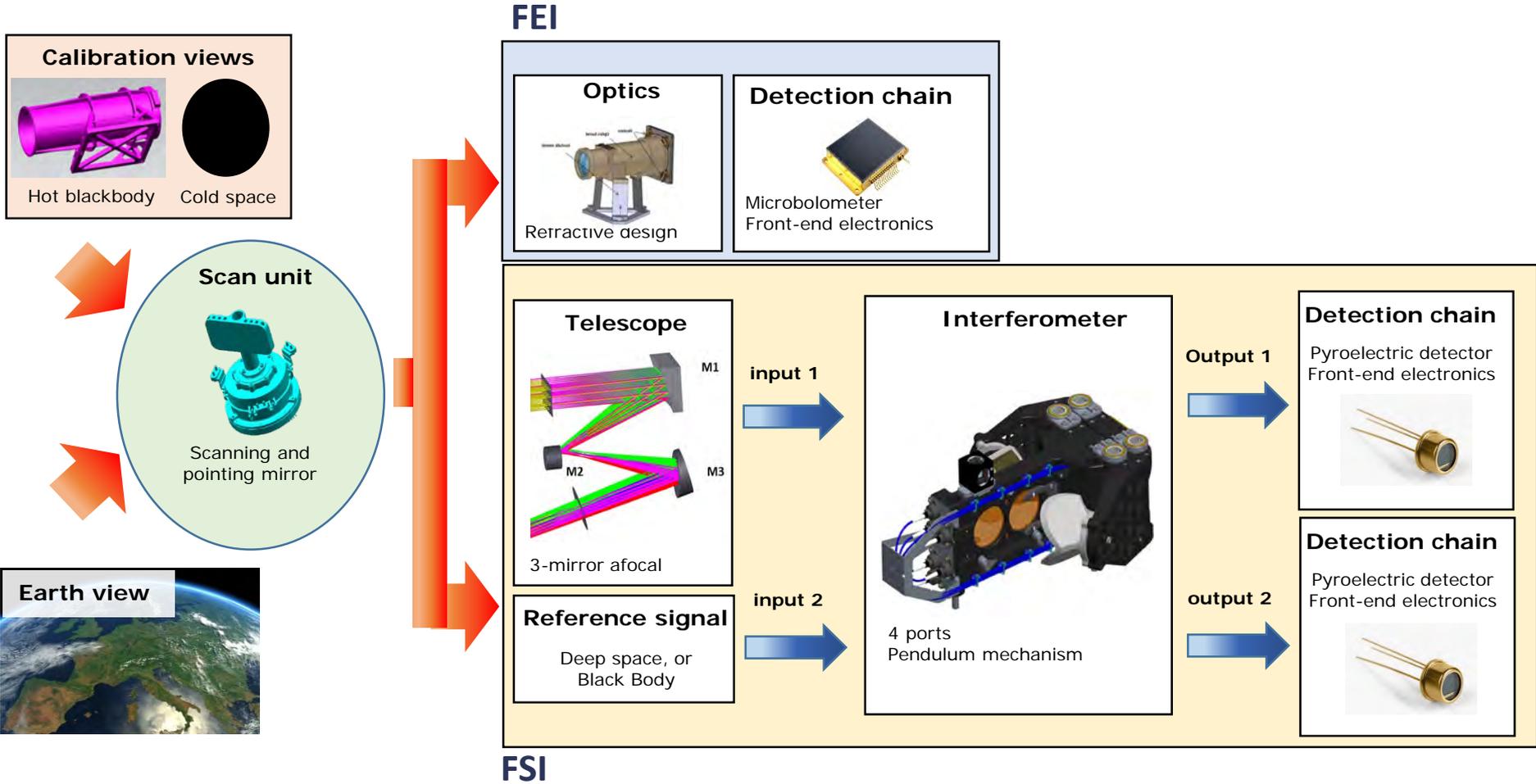
200-800 cm^{-1} : (0.4) [0.6] $\text{mW}/(\text{m}^2 \text{sr cm}^{-1})$
Elsewhere: (<1.0) [2.0] $\text{mW}/(\text{m}^2 \text{sr cm}^{-1})$

Radiometric accuracy (1 K) [3 K]

NeDT (at 210 K) (0.3 K) [0.8 K]

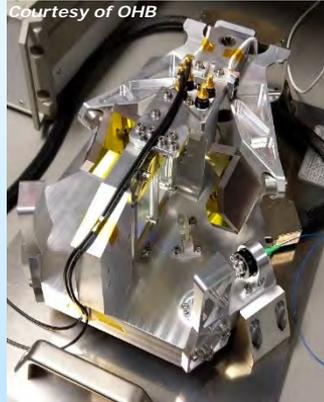
Payload: Concept description

Similar payload concepts for both consortia



FSI Technical Developments

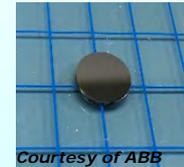
Interferometer mechanism



Breadboard

Micro-vibration test

Speed stability test



Beamsplitter



Manufacturing

Coating

WaveFront Error,
Transmission

Thermal cycling

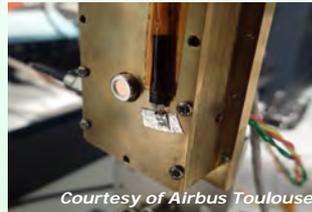
Detection chain



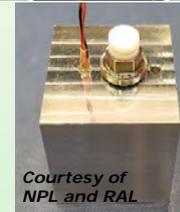
Breadboard

Noise measurement

Detector response



Courtesy of MICOS and PTB



Blackbody



Coating choice

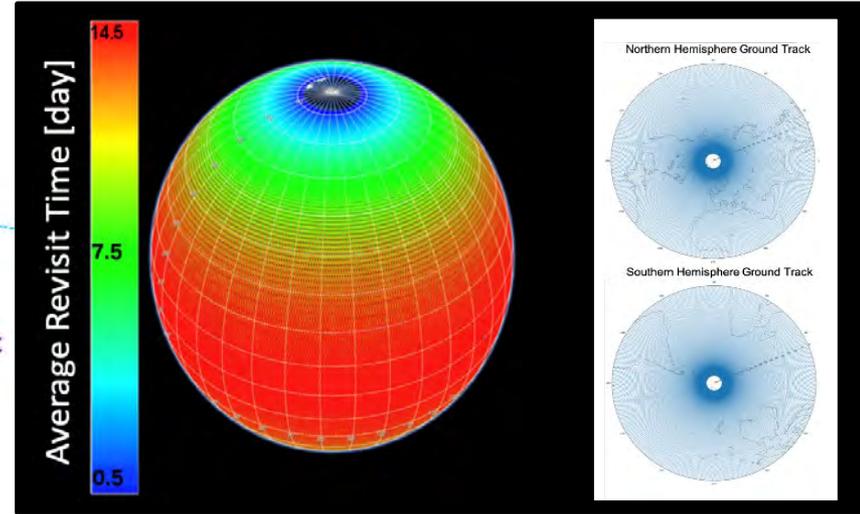
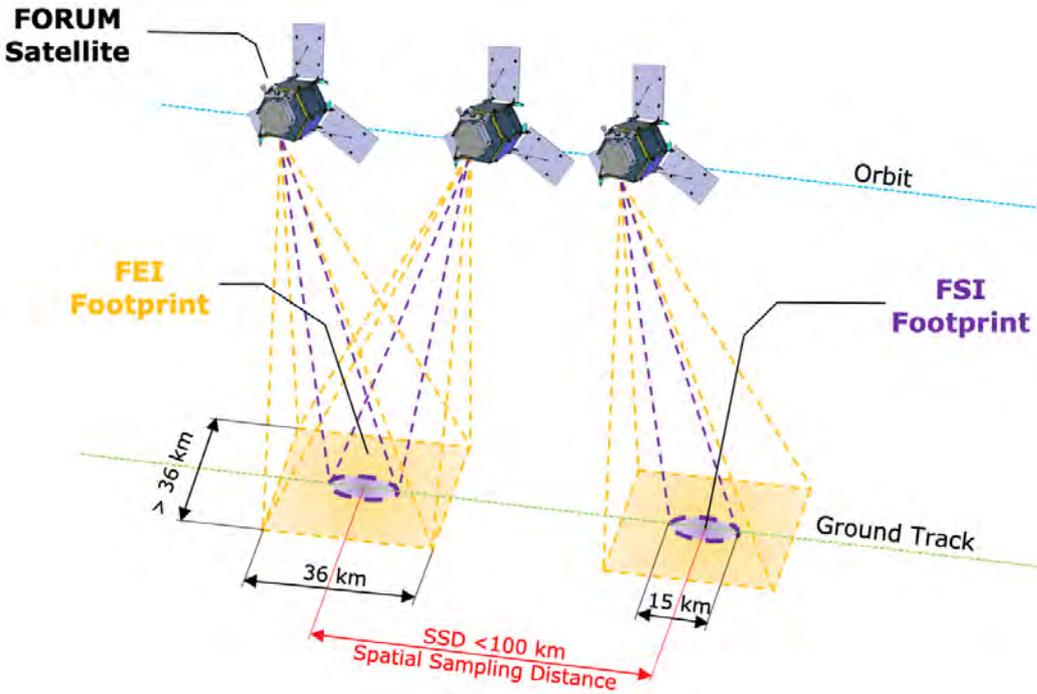
Emissivity test

Environmental tests

Phase change cell

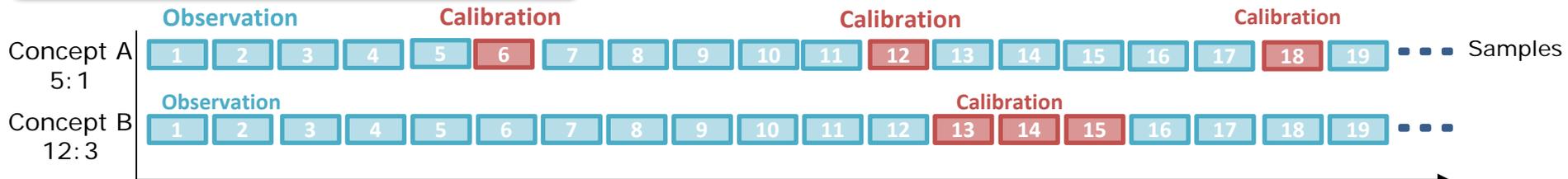
Ongoing work in all 4 areas to raise TRL to 5 by the end of Phase B1 (October 2020)

Observation Concept - sampling



Stop and stare: 14 s sounder dwell time
Loose formation with MetOp-SG-A1 to
obtain full IR spectrum (with IASI-NG)

Earth Sampling sequence



Level 1 and Level 2 Products

| Level 1 Products | Product Definition |
|--|--|
| Spectrometer Level-1b | Spectrally and radiometrically calibrated spectral radiance in the 100-1600 cm^{-1} band. |
| Imager Level-1b | Thermal images radiometrically calibrated and geolocated with preliminary pixel classification. |
| Spectrometer Level-1c | Spectrally and radiometrically calibrated spectral radiance, resampled to a fixed spectral grid. Radiometric, spectral and geometric uncertainties appended. |
| Level-2 Products | Product Definition and Uncertainty Requirement |
| All-sky/Clear-sky broadband and spectral flux | FORUM Level-1c FIR OLR extended to broadband with the Level-1c from IASI-NG |
| Water vapour profile | Vertical profiles of water vapour with 15 % max uncertainty at 2 km vertical resolution |
| Surface emissivity | Surface emissivity from 300–600 cm^{-1} for polar regions. Uncertainty of 0.01 on 50 cm^{-1} spectral grid |
| Ice water path | Integrated ice water content with maximum uncertainty of 20 g/m^2 |
| Cloud Top Height | Altitude of the top of the cloud with maximum uncertainty of 1 km |
| Particle size diameter | Effective diameter of particles with maximum uncertainty of 20% |

Current Status

Phase B1 Oct 2019 - Oct 2020

- Consortia proceed in competitive mode before one is selected moving into Phase B2

Parallel activities (and extending beyond B1)

- Refinement of mission requirements (with industry)
- Refinement of End-to-End simulator
- Continued analysis of data collected in Phase A
- Airborne demonstrator instrument refinement/design
- Identification of suitable scientific campaigns

HEMERA CFP2: Timmins, 2022 FIRMOS-B and GLORIA



Phase A data analysis

