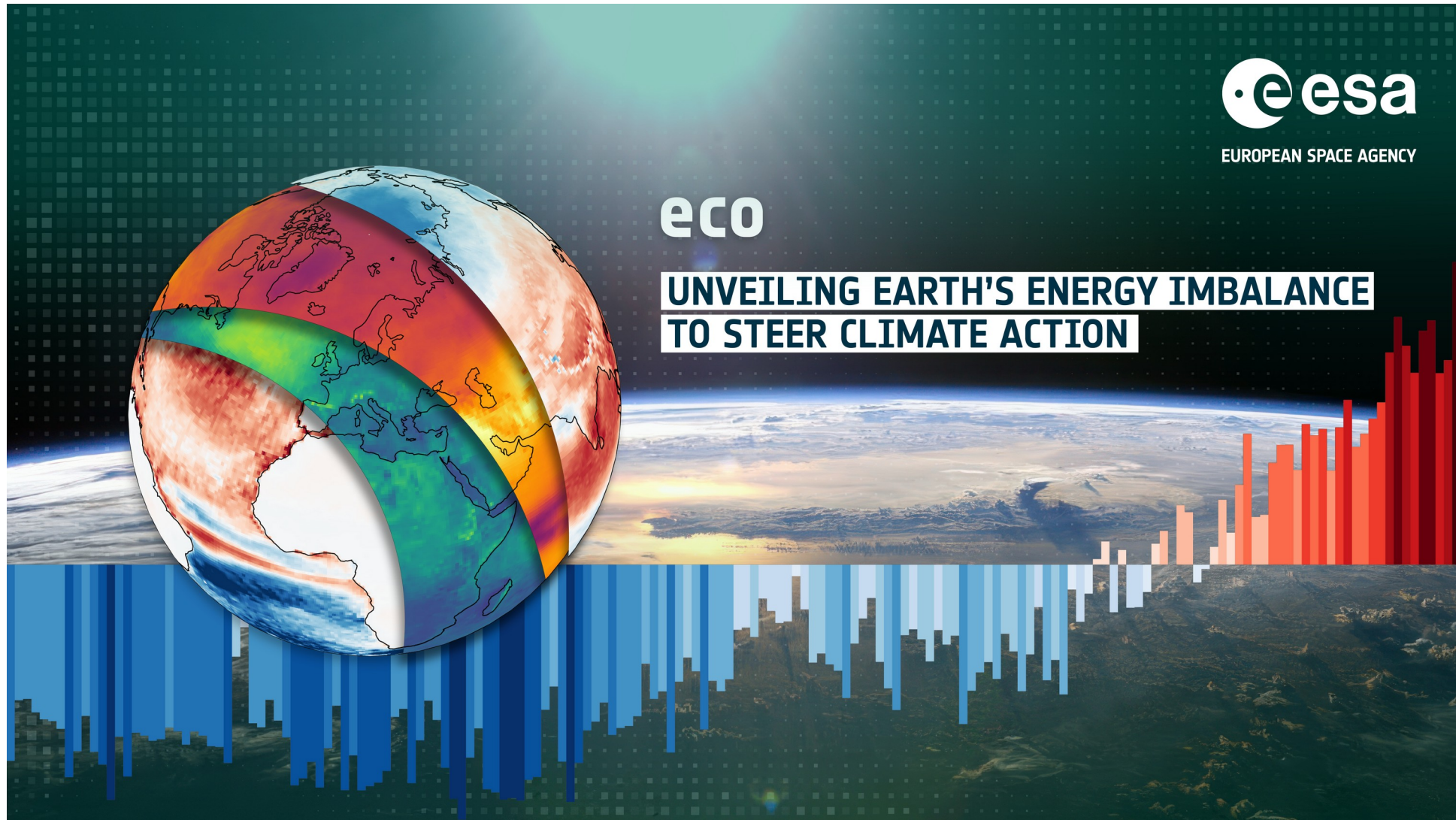


The Earth Climate Observatory (ECO) ESA Earth Explorer 12 space mission candidate for the monitoring of the Earth Energy Imbalance (EEI)



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MPI-M

Jochem Marotzke

Lille University

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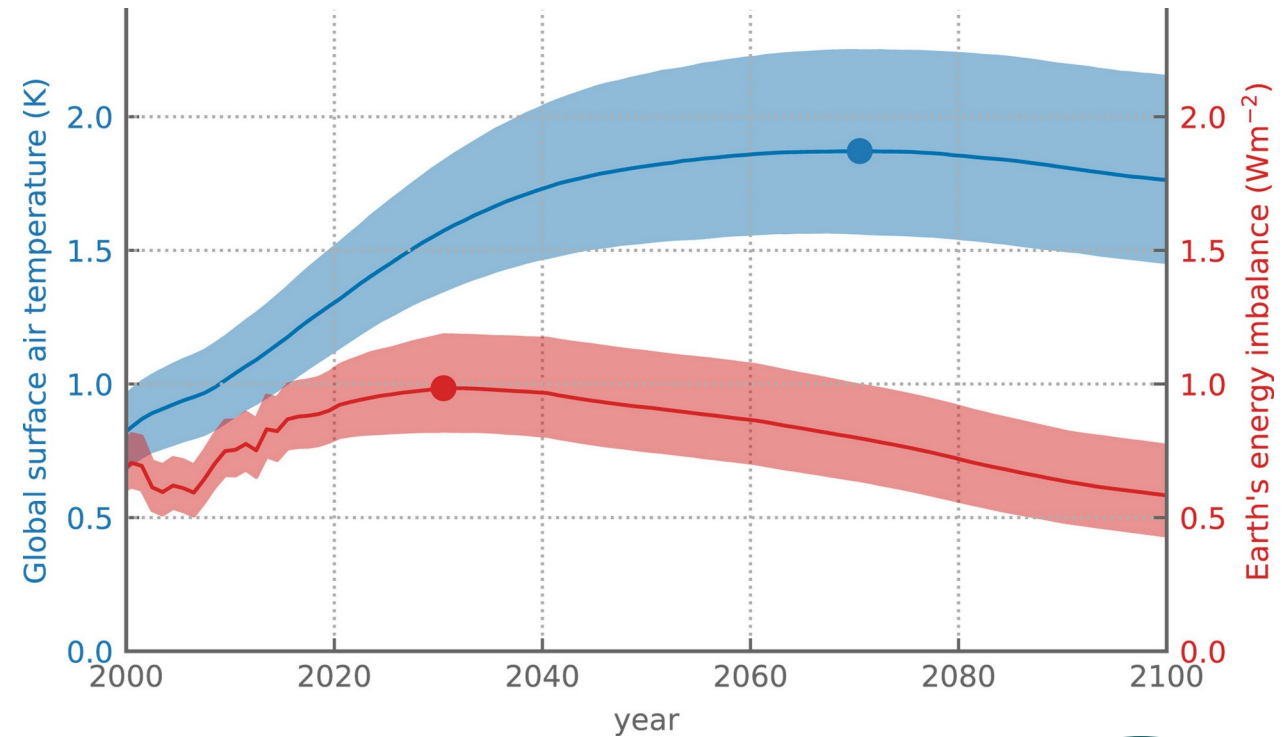
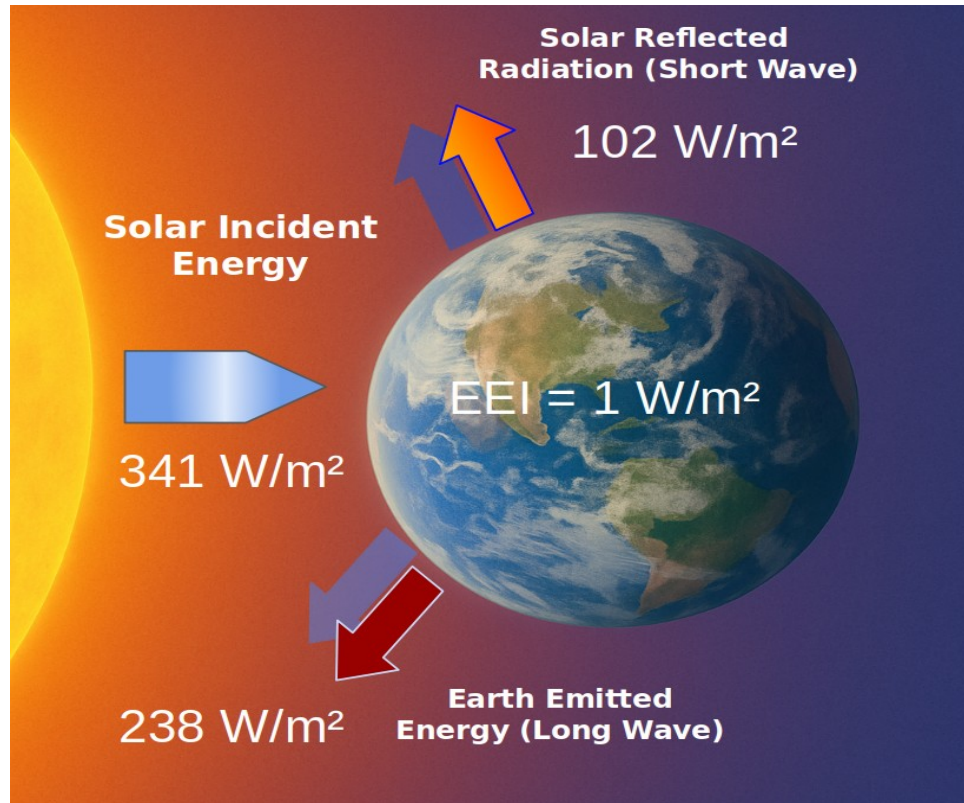
University of Leicester

Tim Trent

Leipzig University

Manfred Wendisch

Scientific motivation and goals



$$\begin{aligned} \text{EEI}(t) &= \text{Solar Incoming} - \text{Total Outgoing} \\ &= \text{RFnet}(t) - kT(t) \end{aligned}$$

$$T(t) = \text{EEI}(t) \cdot h(t)$$



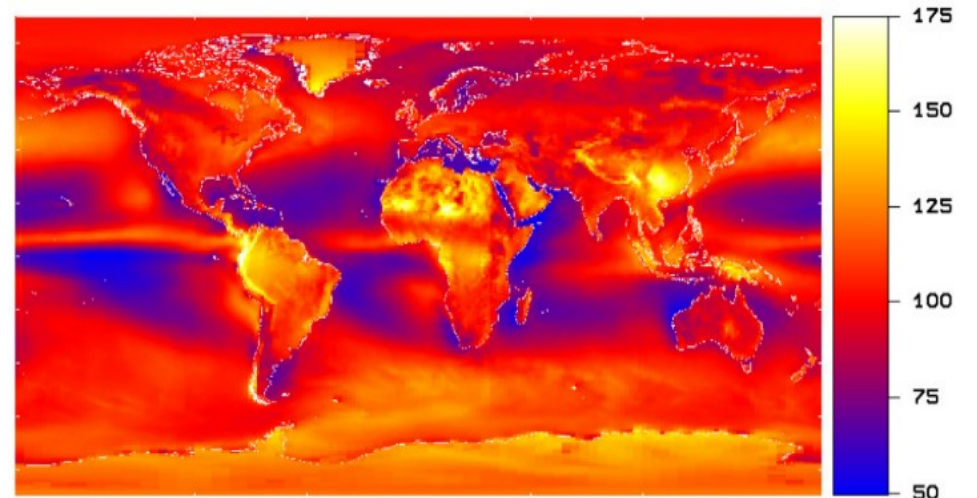
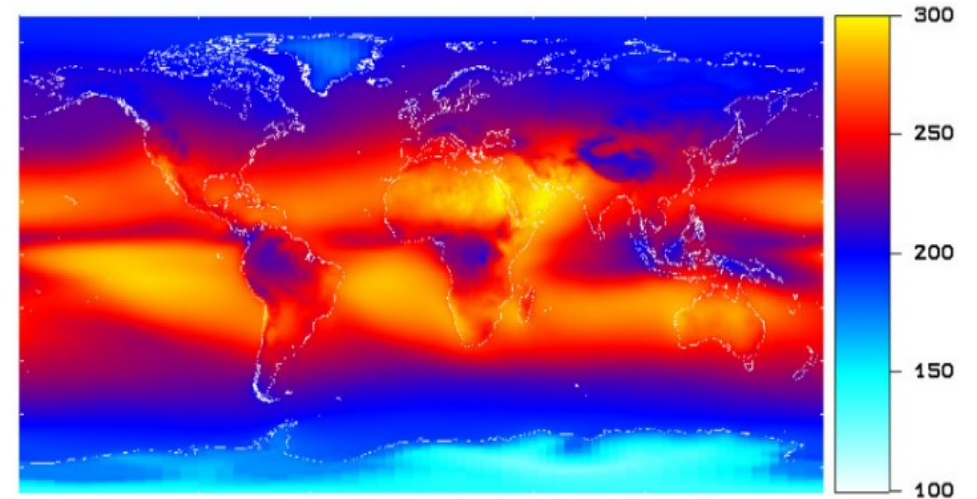
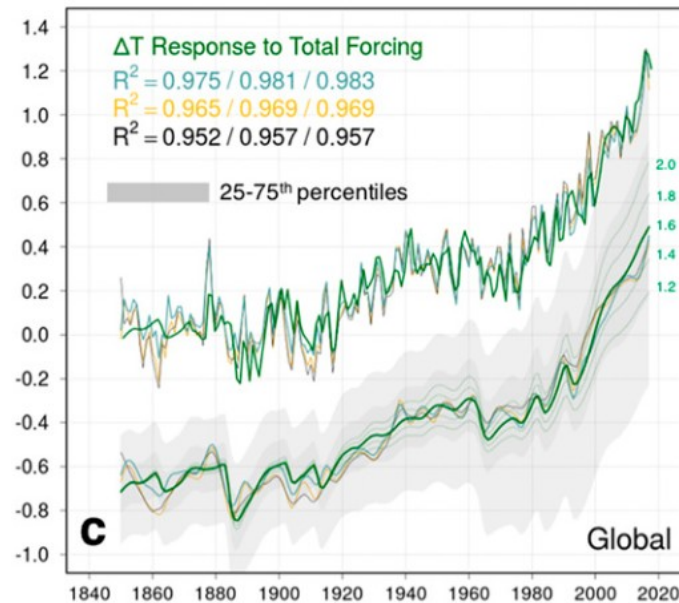
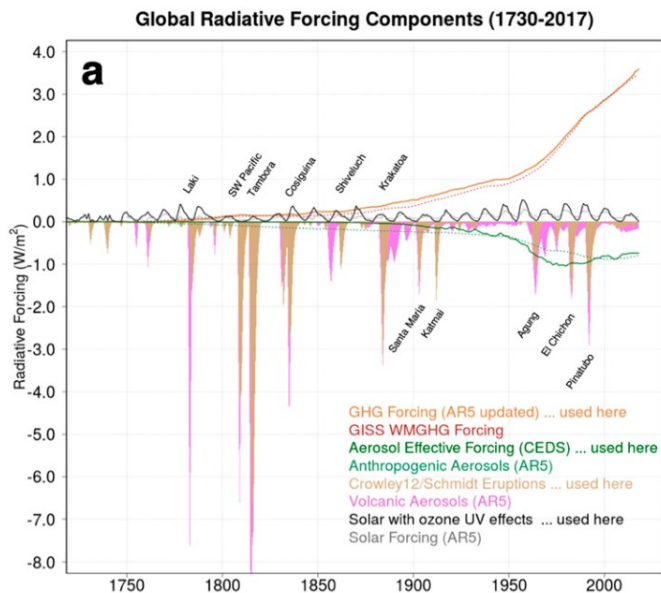
Scientific motivation and goals

Climate modelling challenges:

Need to advance further understanding of **radiative forcing and feedback** processes

Need for high-res observation of Earth outgoing radiation (RSR, OLR) to **improve and validate climate models**

ERBE, SCARAB, CERES, GERB, Libera missions but these missions were **not designed to measure EEI**



[Haustein et al, 2019] J. Climate, 2019, 32.16: 4893-4917.

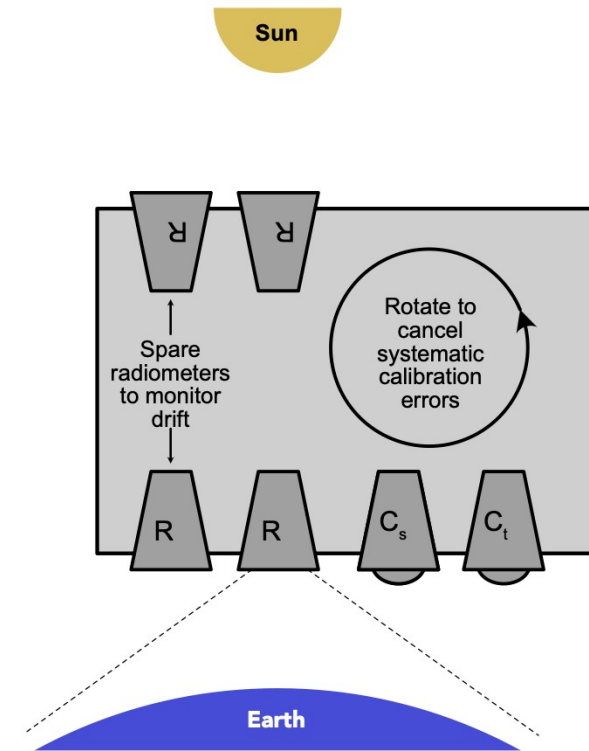
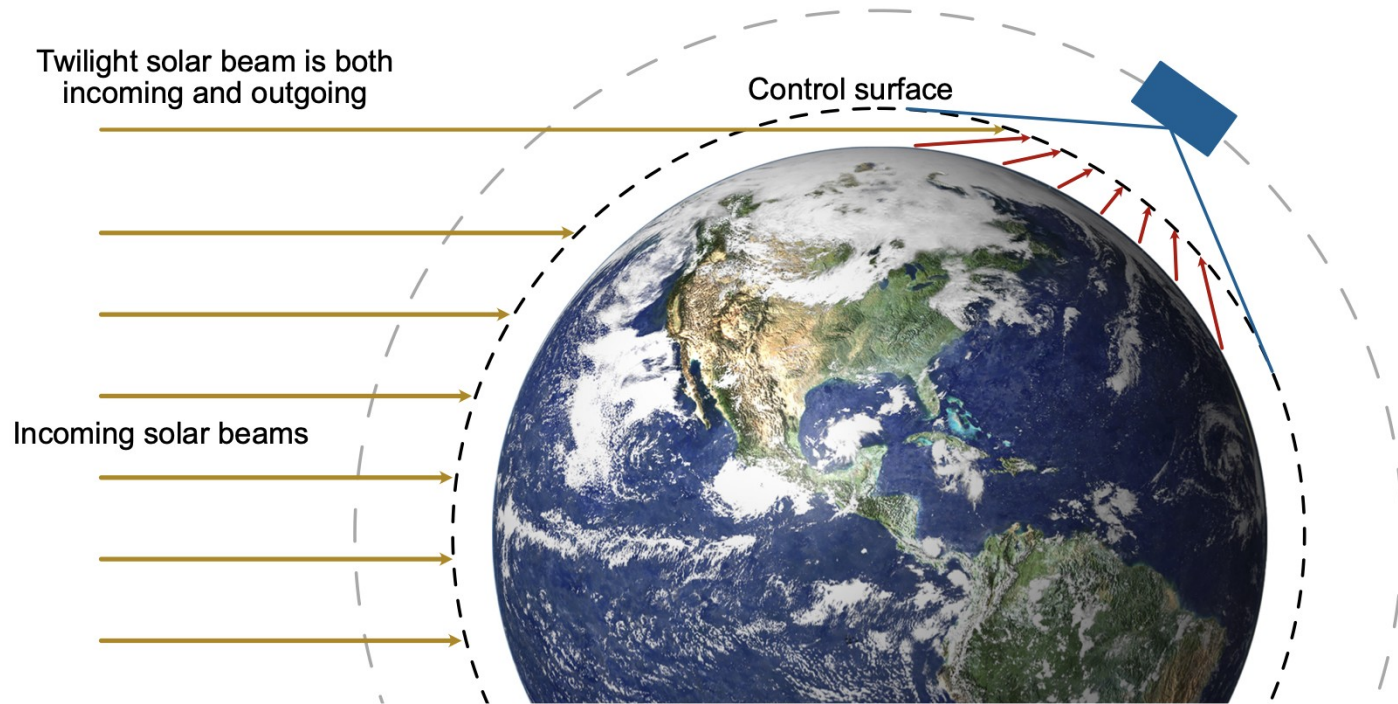
ECO primary mission objectives

MO #1: Quantify and directly monitor the **global annual mean Earth Energy Imbalance** with a **goal accuracy of 0.3 W/m²** (a fraction of the imbalance currently estimated around 1W/m²).

MO #2: Quantify and monitor at the **monthly scale** and at **kilometric resolution** the **Total Outgoing Radiation (TOR)** fluxes, with a **goal accuracy of 0.5 W/m²** for both components in the **short-wave (RSR)** and **long-wave (OLR)**.

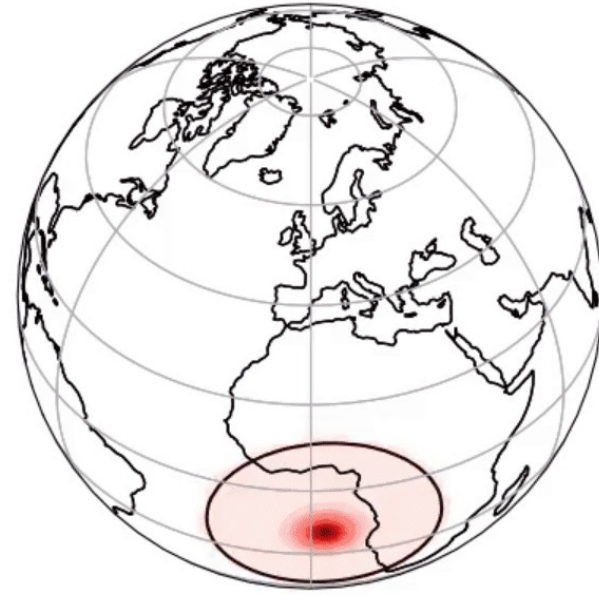
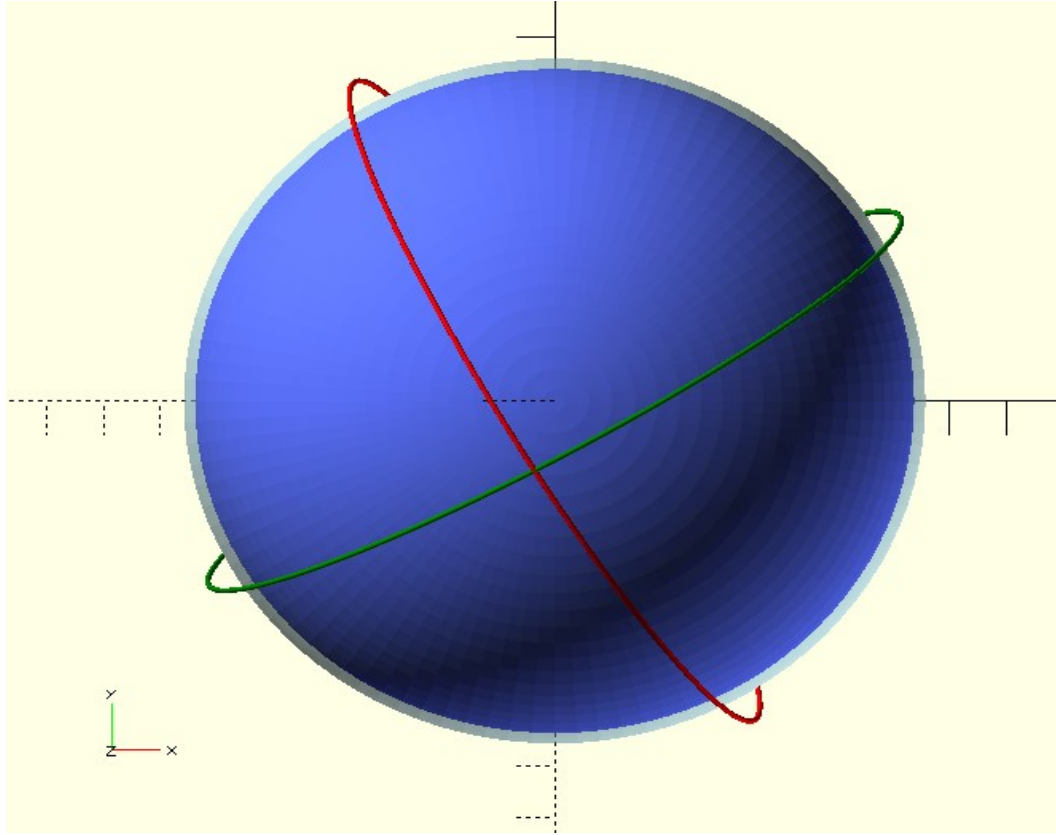
ECO will, for the **first time**, **directly monitor the Earth Energy Imbalance**, providing feed-back on the holistic effects of Earth actions, at policy-commensurate timescales.

ECO will provide **unique** insights into the **Earth energy intake and Radiation Budget**, ensuring **step-change** improvement of long-term climate data records at unprecedented spectral and spatio-temporal resolution, addressing **fundamental scientific questions** and serving **urgent societal needs**.



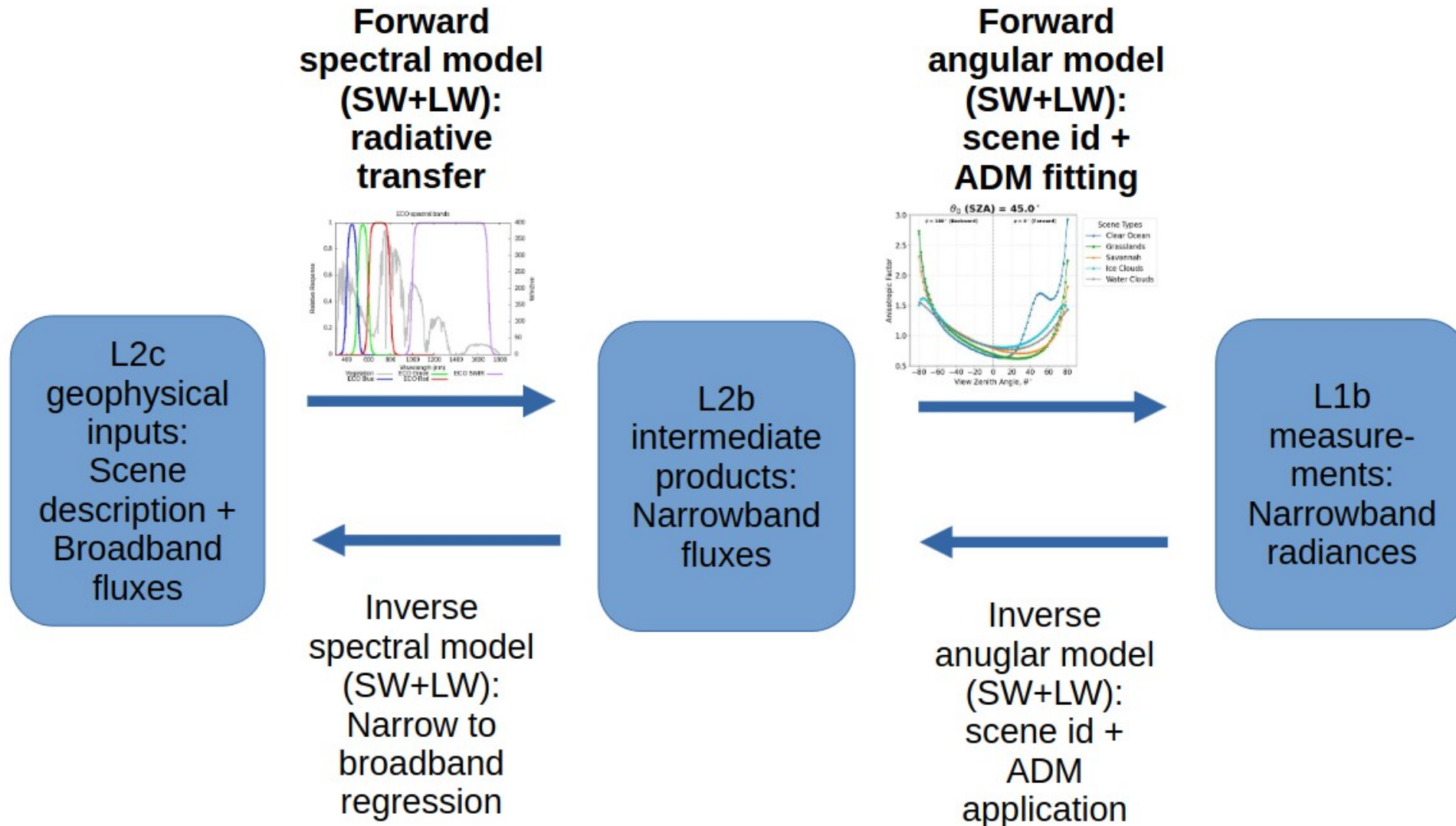
- Nadir and zenith viewing dedicated inter-calibrated radiometers for Total Solar Irradiance and Earth's Total Outgoing Radiation
- Redundant radiometers for ageing correction
- Wide field of view cameras for high resolution ERB (1-5km, limb-to-limb)

2 orbit constellation

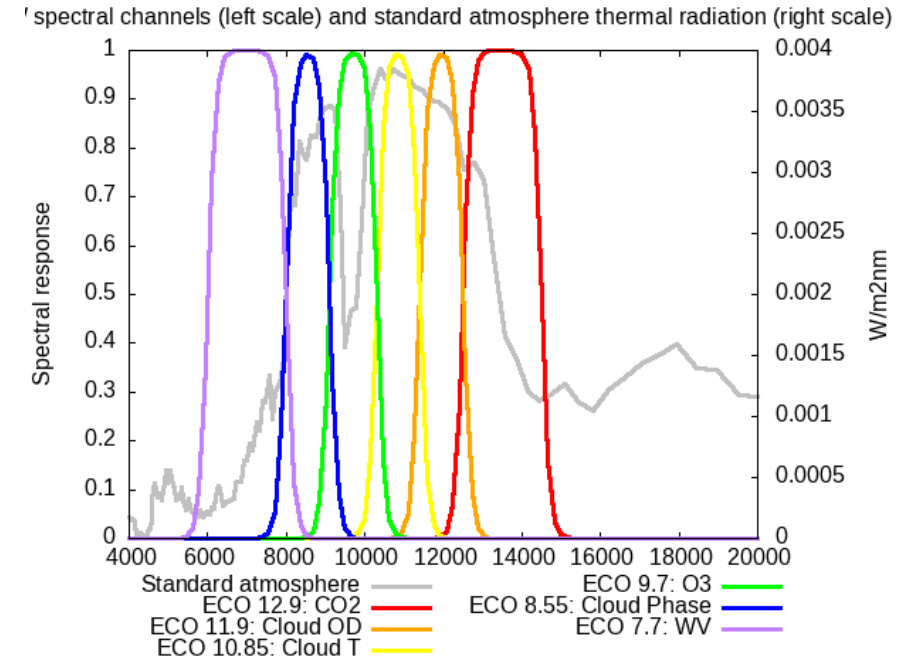
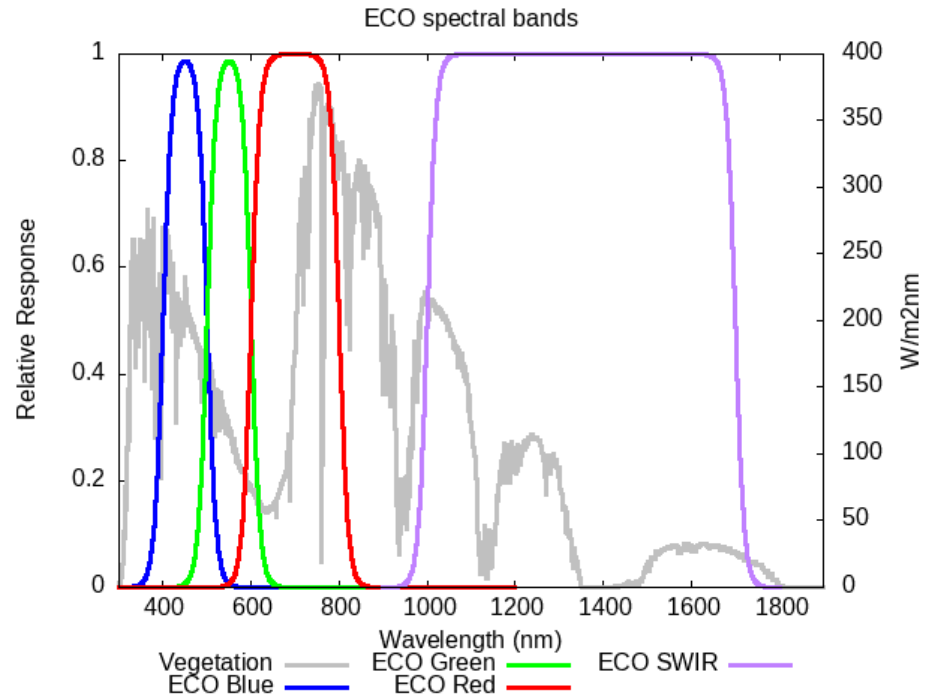


Orthogonal 82° orbits: full diurnal cycle sampled in 1.5 months + polar coverage with cameras

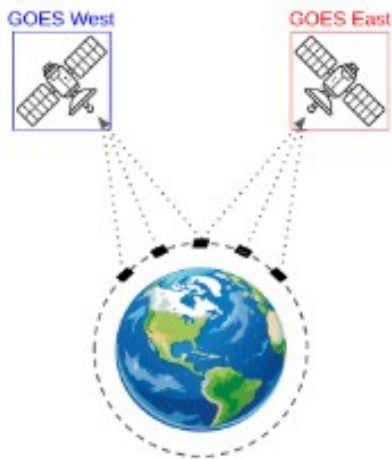
MO2 (ERB) forward/inverse modelling



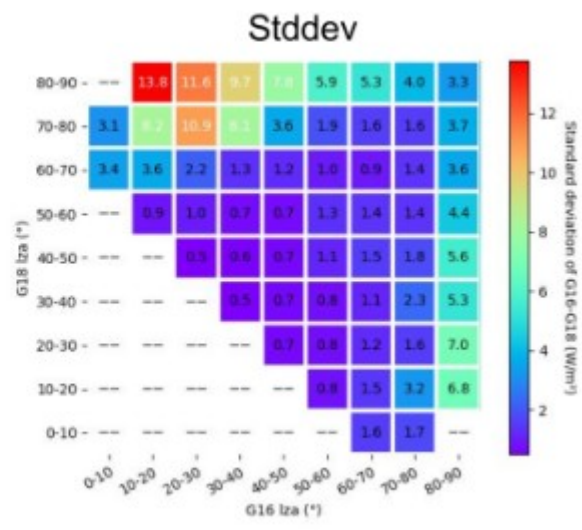
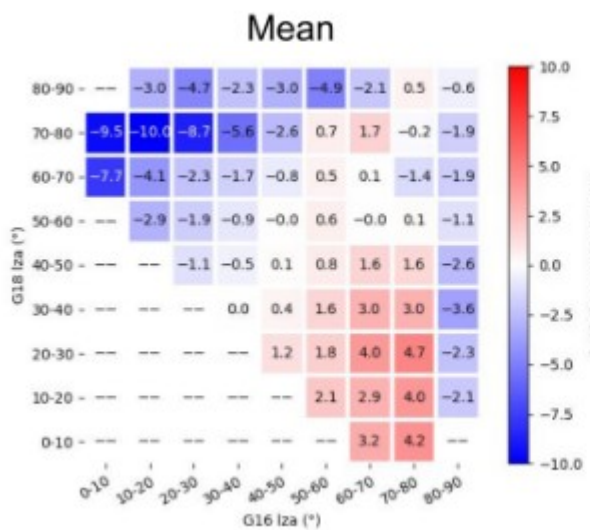
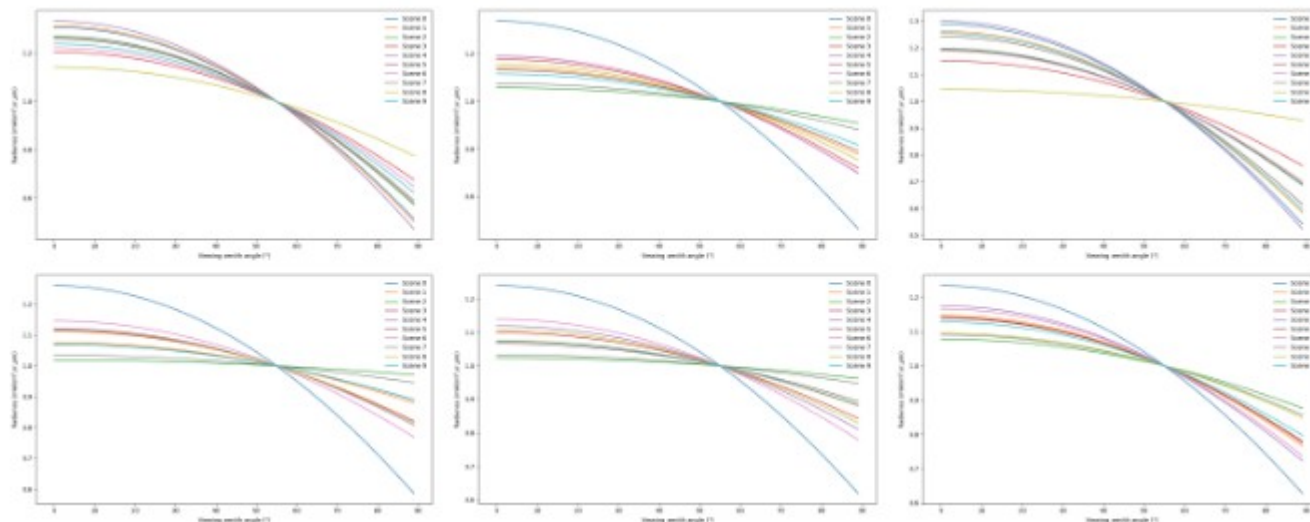
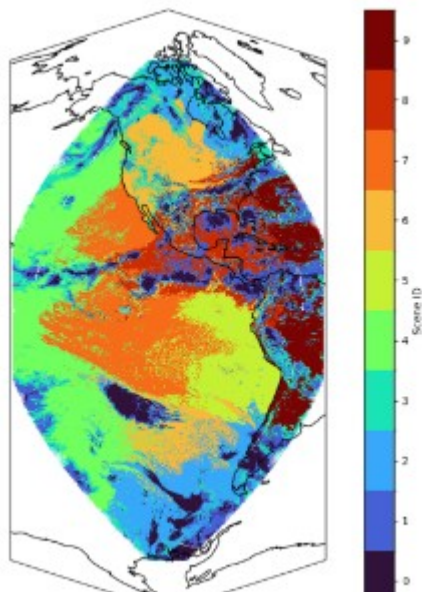
Narrow to Broadband regressions



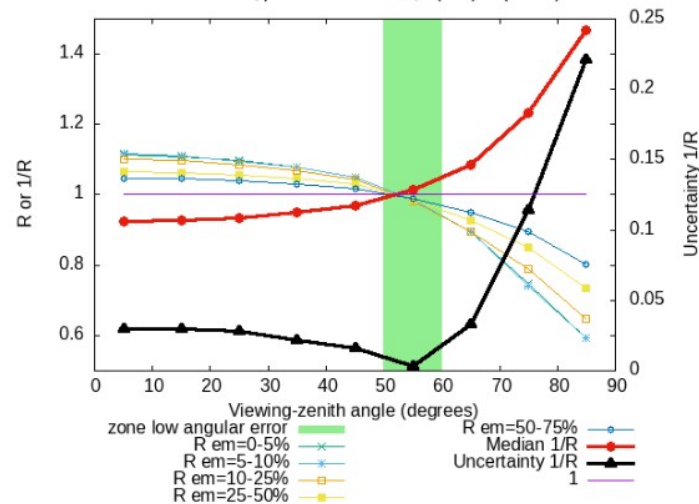
- Applied on narrowband fluxes → decoupled from angular conversion
- SW: 4 spectral channels, uncertainty: 0.6 % = 0.6 W/m²
- LW: 10 spectral channels, uncertainty: 1.5 % = 3.7 W/m²



LW angular conversion



CERES/TRMM LW ADMs, pw = 2.57-4.63 cm, T(surf)--T(Cloud) = 56-64.9 K



- Uncertainty at 55° vza: 0.8 W/m²

Preliminary results: MO1 annual mean EEI requirement/error budget

Treshold	0.7 W/m²
Goal	0.3 W/m²
Bottom-up error	0.36 W/m²
Solar intrusions & control surface altitude	0.25 W/m²
Earth-Sun radiometer intercalibration	0.23 W/m²
Earth sampling error, including anisotropy	0.13 W/m ²
Sun sampling error	0.01 W/m ²

Preliminary results: MO2 monthly mean ERB requirement/error budget

RSR Treshold	2 W/m ²
RSR Goal	0.5 W/m ²
RSR Bottom-up error (L3)	0.8 W/m ²
RSR Bottom-up error (L2)	2.7 W/m ²
RSR L2 angular	2.4 W/m²
RSR L2 spectral	1.2 W/m ²
RSR L2 noise	0.4 W/m ²

OLR Treshold	2 W/m ²
OLR Goal	0.5 W/m ²
OLR Bottom-up error (L3)	0.8 W/m ²
OLR Bottom-up error (L2)	4.3 W/m ²
OLR L2 spectral	3.7 W/m²
OLR L2 noise	2.1 W/m²
OLR L2 angular	0.5 W/m ²

MO2 Temporal sampling error not yet evaluated: to be studied during Phase A.

Summary

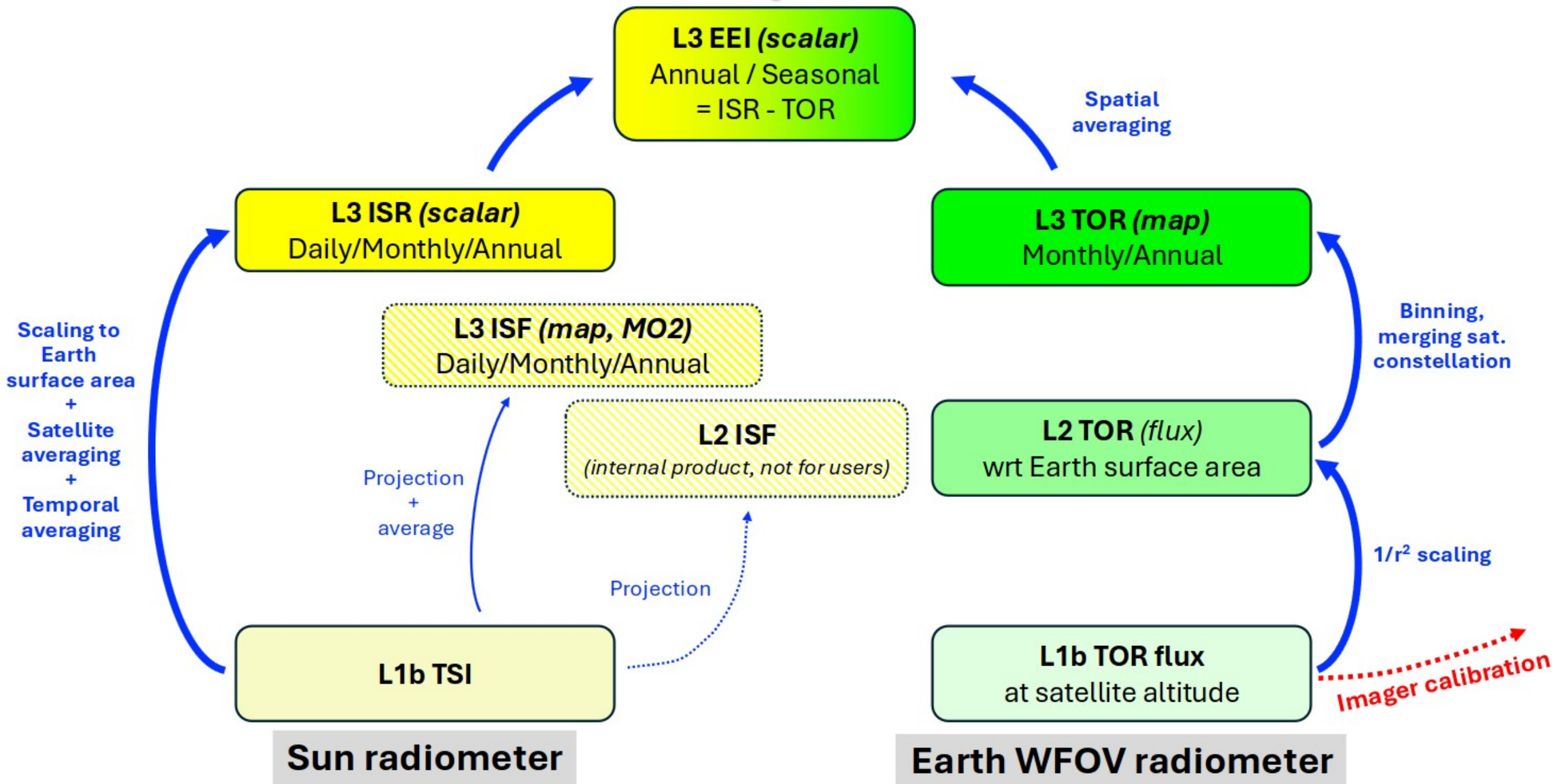
- The **Earth Climate Observatory (ECO)** is a concept for an innovative new space mission for the measurement of the **annual mean Earth Energy Imbalance (MO #1)** and the monitoring of the **high-resolution Earth Radiation Budget (MO #2)**.
- ECO will allow **fundamental scientific advances in understanding Climate Change**, and respond to the **urgent societal need of Climate Action**.
- **Unique capabilities:**
 - **Inter-calibrated sun-earth observation.**
 - **Sampling full diurnal cycle at 1.5 monthly mean level.**
 - **Innovative multispectral cameras with full angular coverage.**
- Current assessment **confirms feasibility**.
- EE12 selection for Phase A will be decided at

You can voice your support for ECO!

Earth Explorer 12 User Consultation Meeting
7–8 July 2026 | Tallinn, Estonia


EUROPEAN SPACE AGENCY

ECO MO1 products



ECO MO2 products

