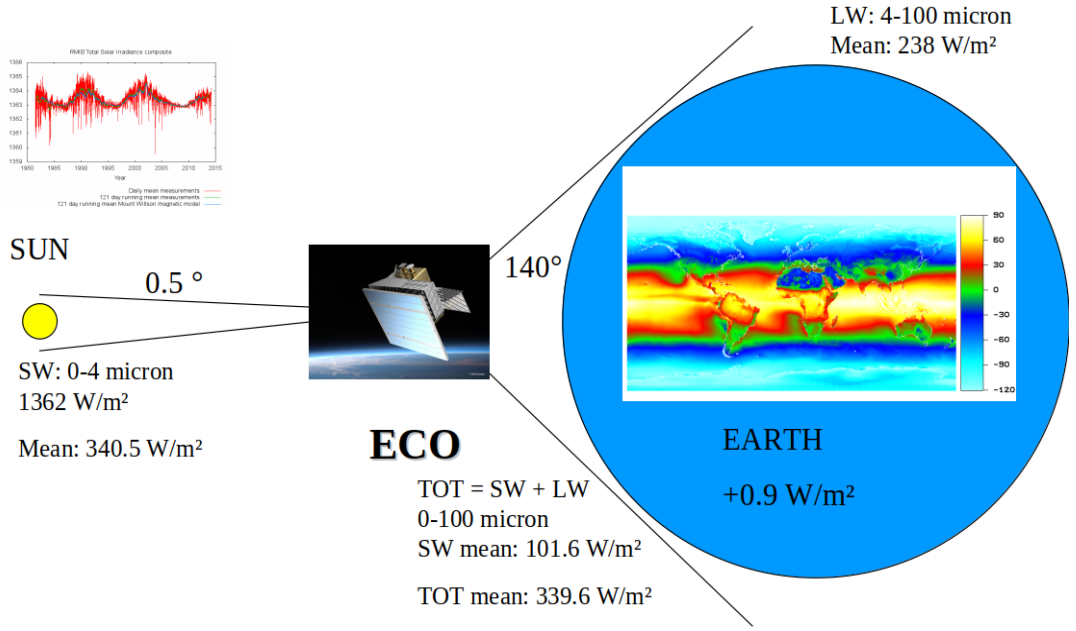
Earth Climate Observatory (ECO)



A European space mission concept for the monitoring of the Earth Energy Imbalance needed for a predictive understanding of climate change

Royal Observatory of Belgium

VRIJE UNIVERSITEIT BRUSSEL

KMI

BIRA-IASB

Stockholm University

SMHI

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Monitoring of EEI is required for predictive understanding climate change

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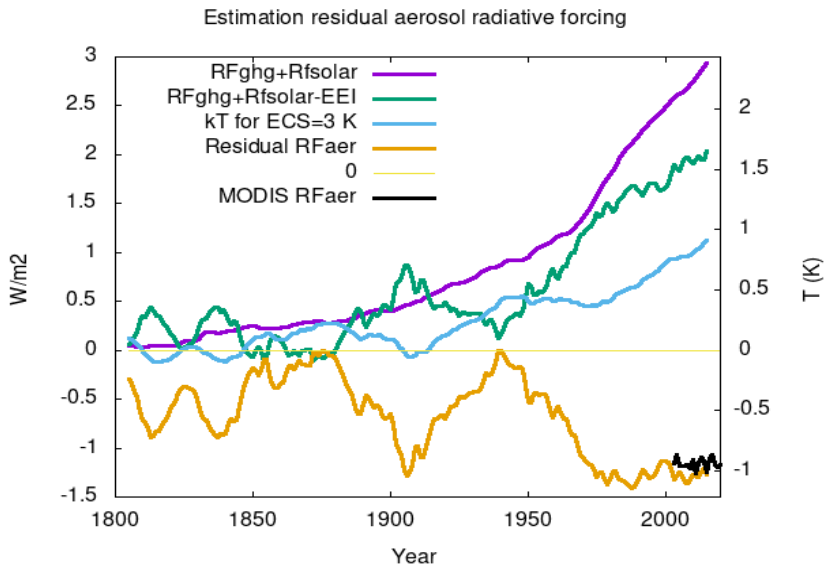

EEI= RFghg+Rfsolar+RFaer– kT

T(t) =EEI(t) * h(t)

- Requirement EEI measurement:

Absolute accuracy 0.1 W/m²

Stability 0.1 W/m²dec

[Hansen et al, 2005] Hansen, J., Nazarenko, L., Ruedy, R., Sato, M., Willis, J., Del Genio, A., ... & Tausnev, N. (2005). Earth's energy imbalance: Confirmation and implications. science, 308(5727), 1431-1435.

[Von Schuckmann et al, 2016] Von Schuckmann, K., Palmer, M. D., Trenberth, K. E., Cazenave, A., Chambers, D., Champollion, N., ... & Wild, M. (2016). An imperative to monitor Earth's energy imbalance. Nature Climate Change, 6(2), 138-144.

Climate is changing due to Earth Energy Imbalance (EEI)

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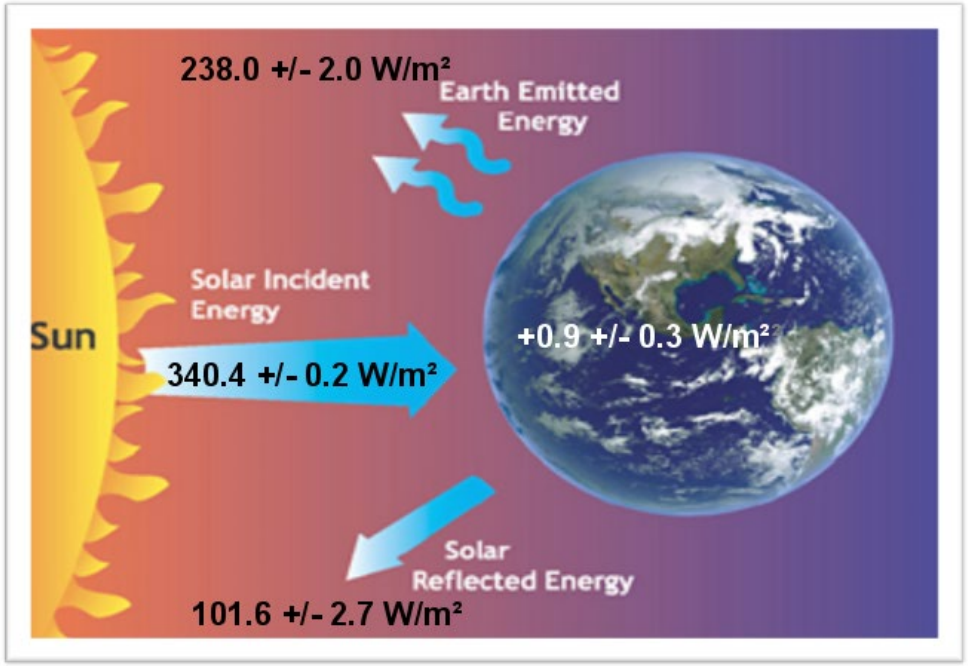
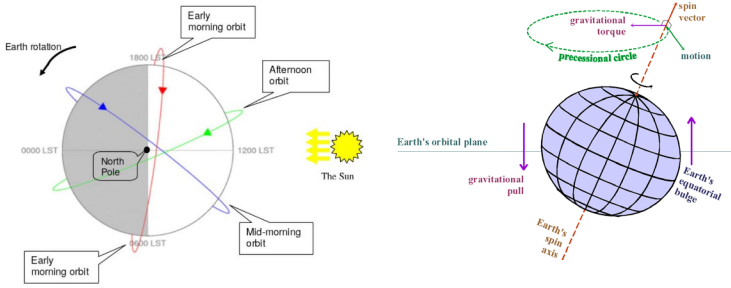
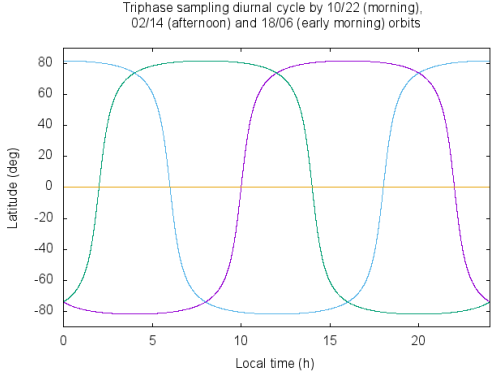


- Earth Energy Imbalance = Incoming Solar Energy – Outgoing Terrestrial Energy
- Difficult to measure directly because difference of two nearly equal quantities
- → Solution: Differential measurement with single instrument = wide field of view radiometer

Sampling diurnal cycle



Report of the WMO Tiger team (2013), Assessment of the benefits of a satellite mission in an early morning orbit



- Triphase sampling with sun synchronuous satellites
  - **10/22 (morning):** European continuity NASA Ceres Terra after 2026
  - 02/14 (afternoon): NASA Ceres + FO
  - 18/6 (early morning)
- Precessing orbit with inclination 82° : global coverage, 90 days sampling diurnal cycle

Conceptual satellite design

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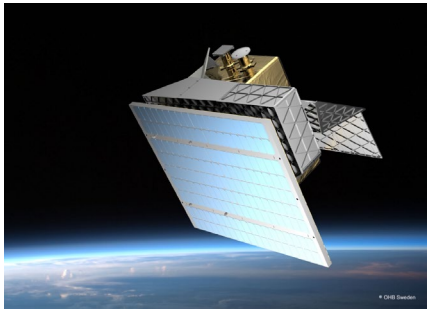

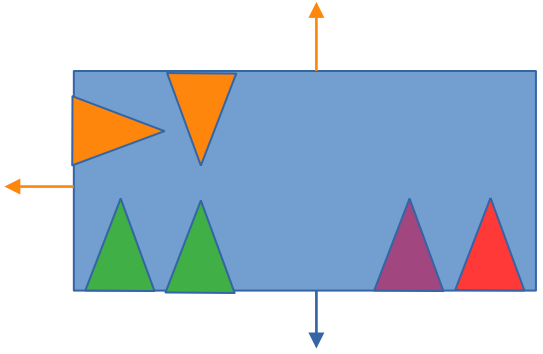

- Universal satellite design to cover earth and sun observation from all possible orbits
- Earth pointing instruments: 2 radiometers+2 cameras, solar instruments: 2 radiometers
- Payload: 12 W, 12 kg, 12 dm^3, 315 kbit/s -> cost effective small satellite is adequate

Space radiometer heritage

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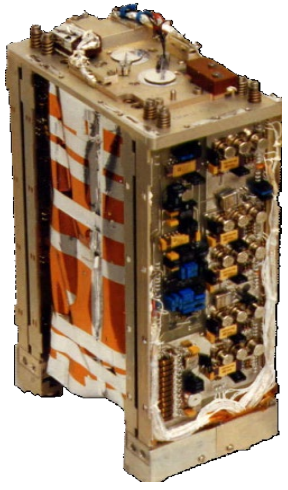

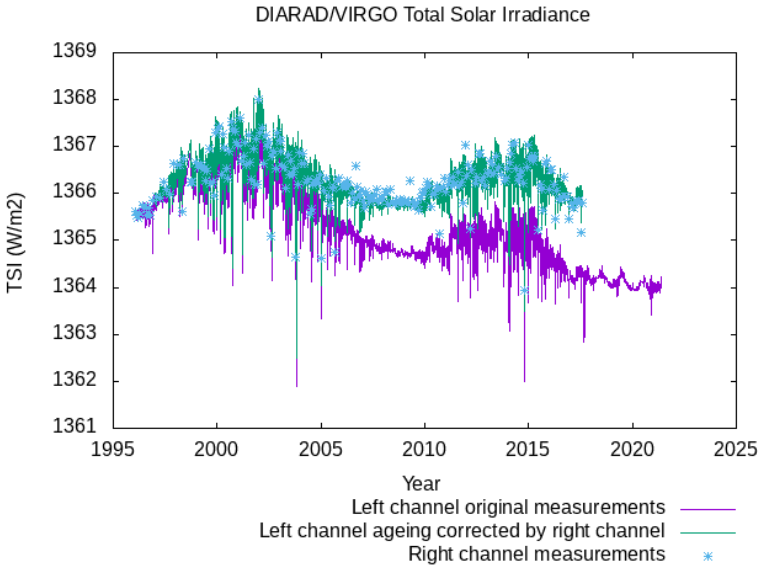

DIARAD/VIRGO on SOHO:

Solar radiometer making high quality observations from space since more than 25 years

ECO will provide continuity for TSI observations

Adaptation to wide field of view

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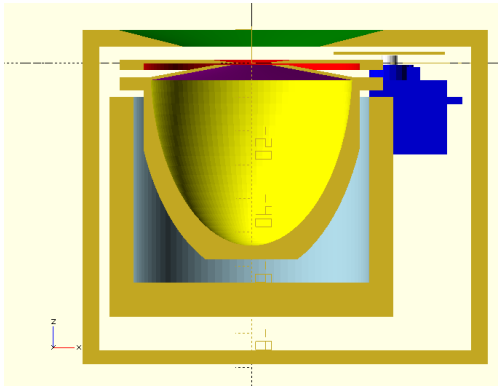

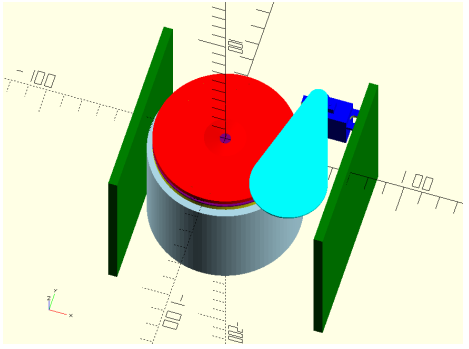

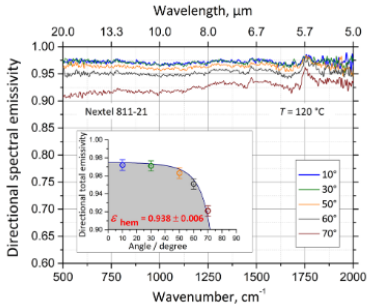

- Wide opening angle ~140° needed for observing the earth from limb to limb
- Space heritage Nextel 811-21 black paint is absorptive from UV to FIR
- Prototype is being developed by ROB and VUB

Schifano, L., Smeesters, L., Geernaert, T., Berghmans, F., & Dewitte, S. (2020). Design and analysis of a next-generation wide field-of-view earth radiation budget radiometer. Remote Sensing, 12(3), 425.

Adibekyan, A., Kononogova, E., Monte, C., & Hollandt, J. (2017). High-accuracy emissivity data on the coatings Nextel 811-21, Herberts 1534, Aeroglaze Z306 and Acktar Fractal Black. International Journal of Thermophysics, 38(6), 1-14.

Visible wide field of view camera

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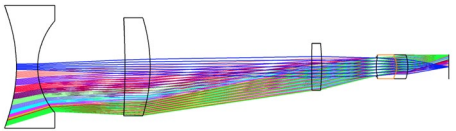

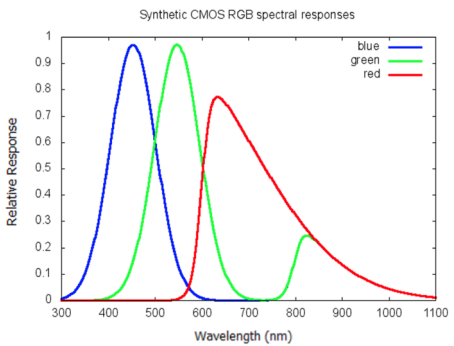

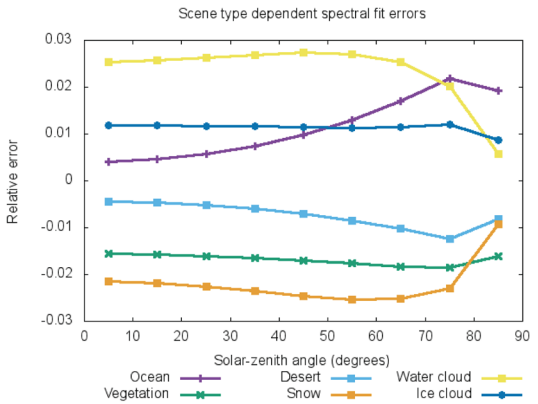

- Need for high resolution observation reflected solar radiation
- CMOS detector, COTS: RGB without NIR blocking filter (accuracy: 3%),
- Fish-eye lense: COTS or custom-design

Schifano, L., Smeesters, L., Berghmans, F., & Dewitte, S. (2020). Optical system design of a wide field-of-view camera for the characterization of earth's reflected solar radiation. Remote Sensing, 12(16), 2556.

Thermal wide field of view camera

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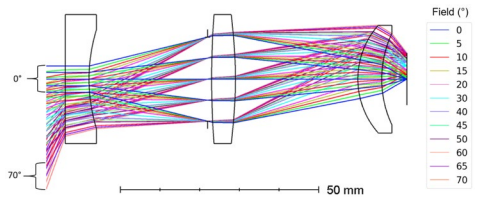

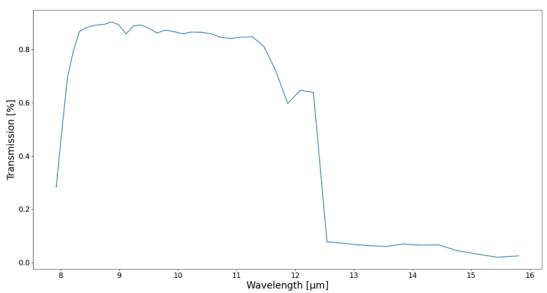

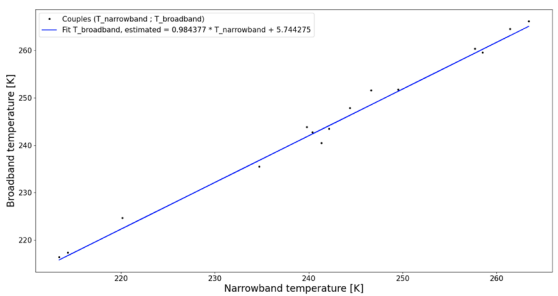

- Need for high resolution observation emitted radiation
- Lynred (F) detector 1024 × 768, 17 µ or 12 µ
- Fish-eye lense: COTS or custom-design

Schifano, L., Smeesters, L., Berghmans, F., & Dewitte, S. (2021). Wide-field-of-view longwave camera for the characterization of the earth's outgoing longwave radiation. Sensors, 21(13), 4444.

Earth Climate Observatory (ECO)

A measurement of the Earth Energy Imbalance with unprecedented accuracy and stability, needed for a predictive understanding of climate change, is possible thanks to a dedicated space mission design.

Key elements space mission:
- differential sun-earth measurement
- 4-satellite constellation for sampling diurnal cycle

Interested to join the ECO team ? Let me know
steven@dewitte@oma.be

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