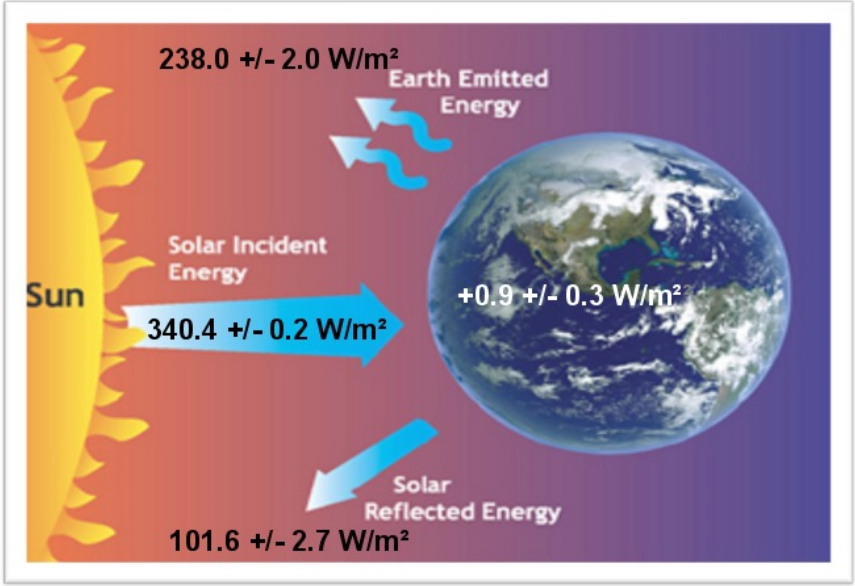
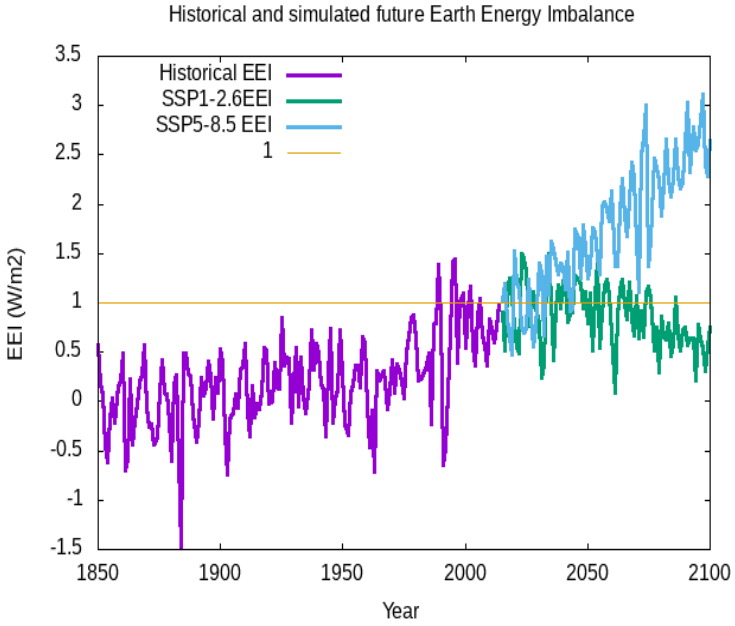
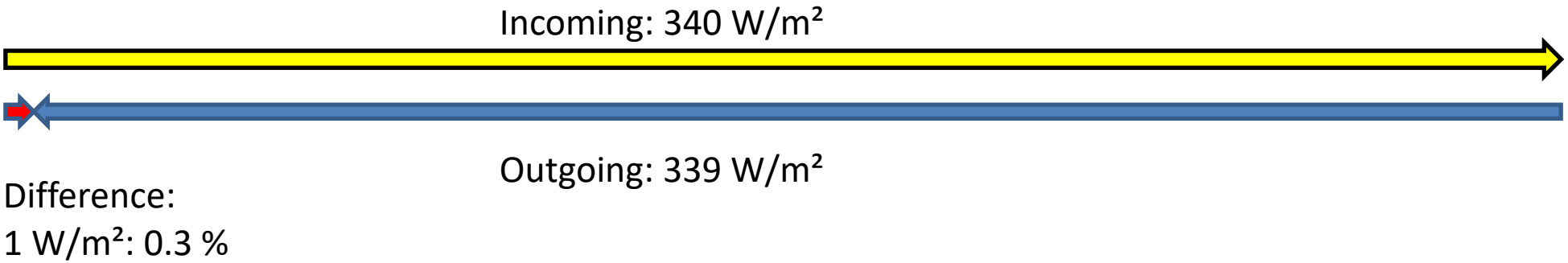
Earth Climate Observatory (ECO): key uncertainties





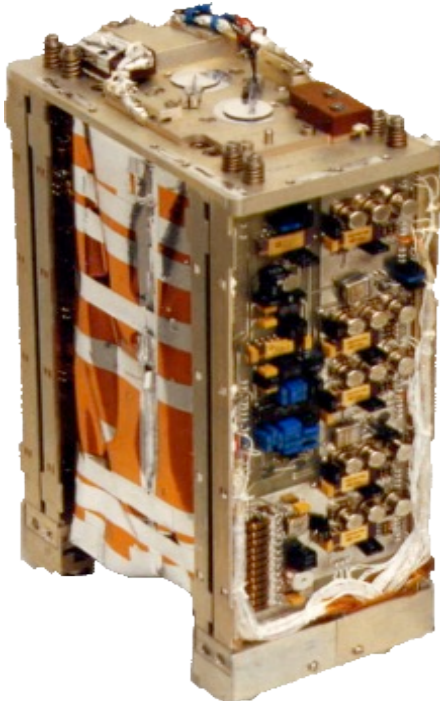
S. Dewitte - ROB, Y. Zhang – ROB/Xi'an University
T. Mauritsen, T. Hocking – Stockholm University
14/10/2022

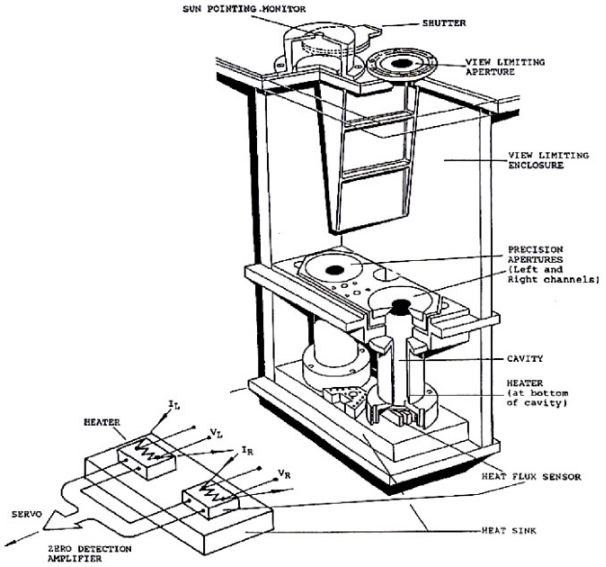
Fundamental measurement problem

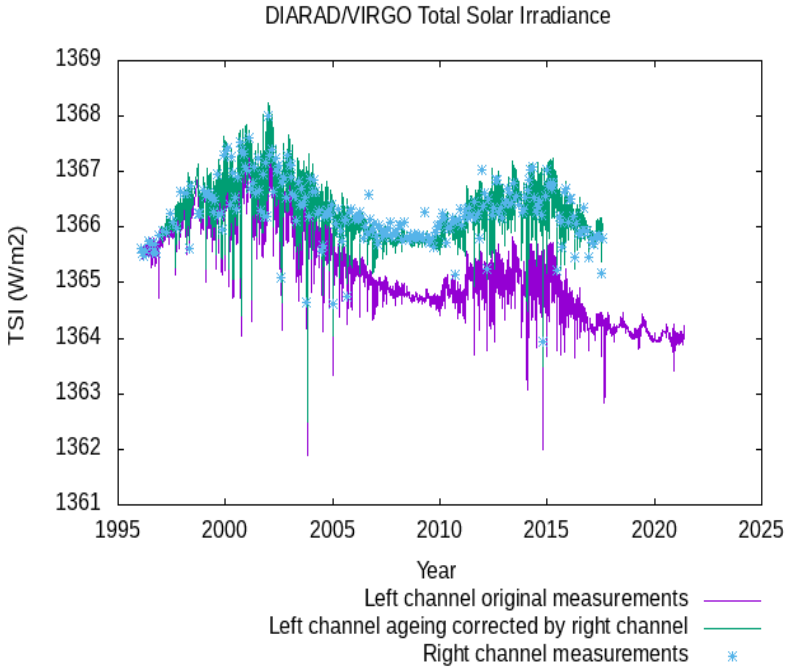


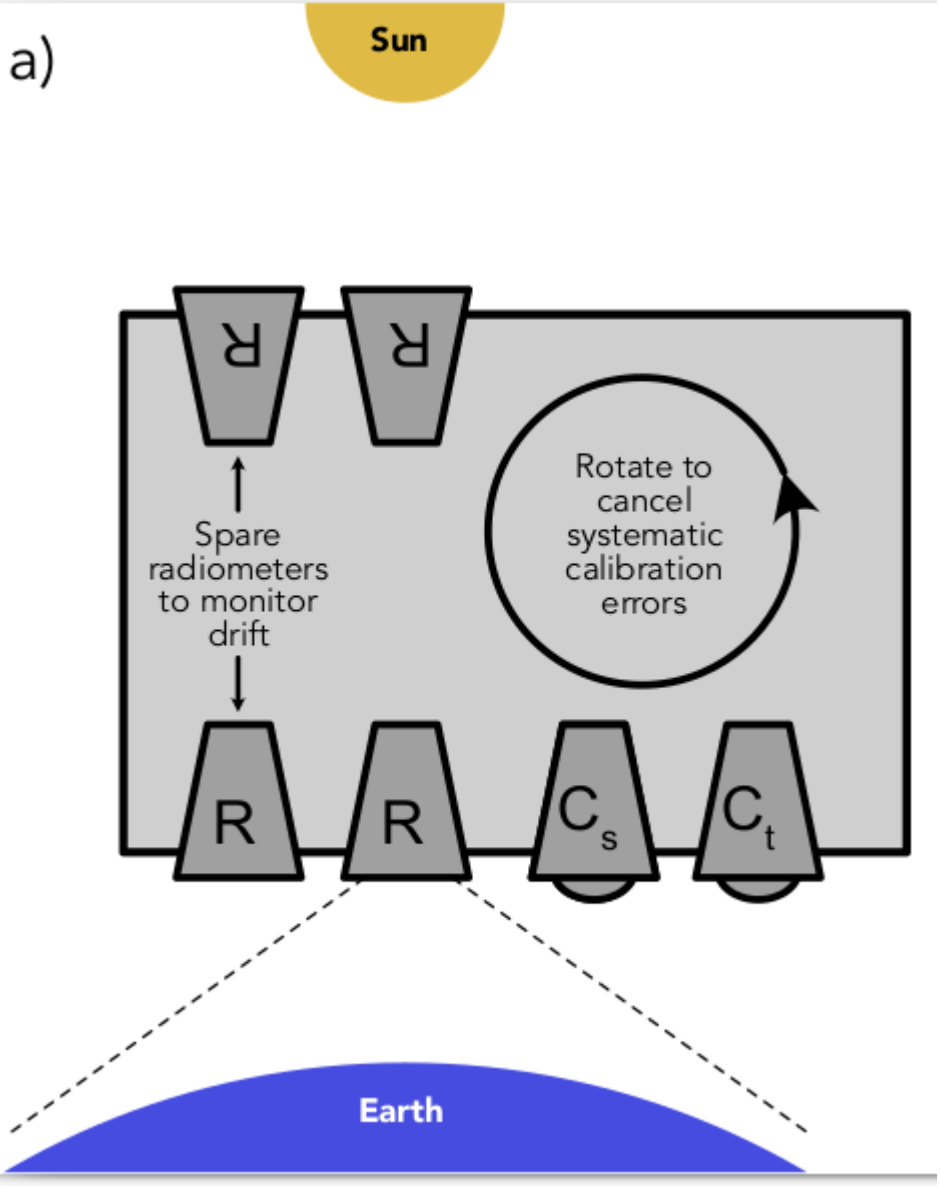
Differential measurement with single instrument is needed.

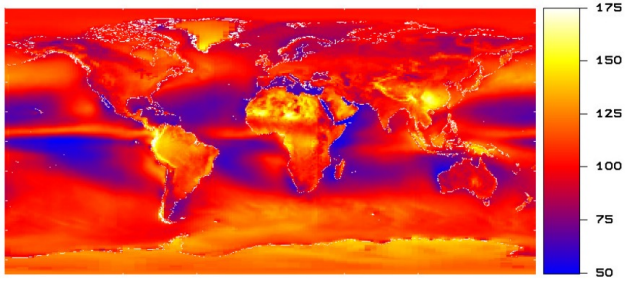
DIARAD/VIRGO radiometer has proven stability for measurement incoming solar radiation



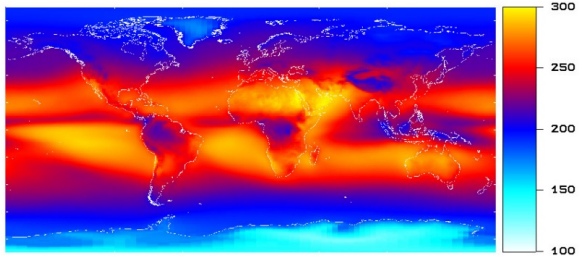








CMOS RGB camera for high resolution observation Reflected Solar Radiation



Microbolometer thermal camera for high resolution observation Outgoing Longwave Radiation

View limiting aperture defines 140° opening angle

Knife edge precision aperture

Front plate protects baffle from direct solar heating

Thermal isolation baffle- front plate

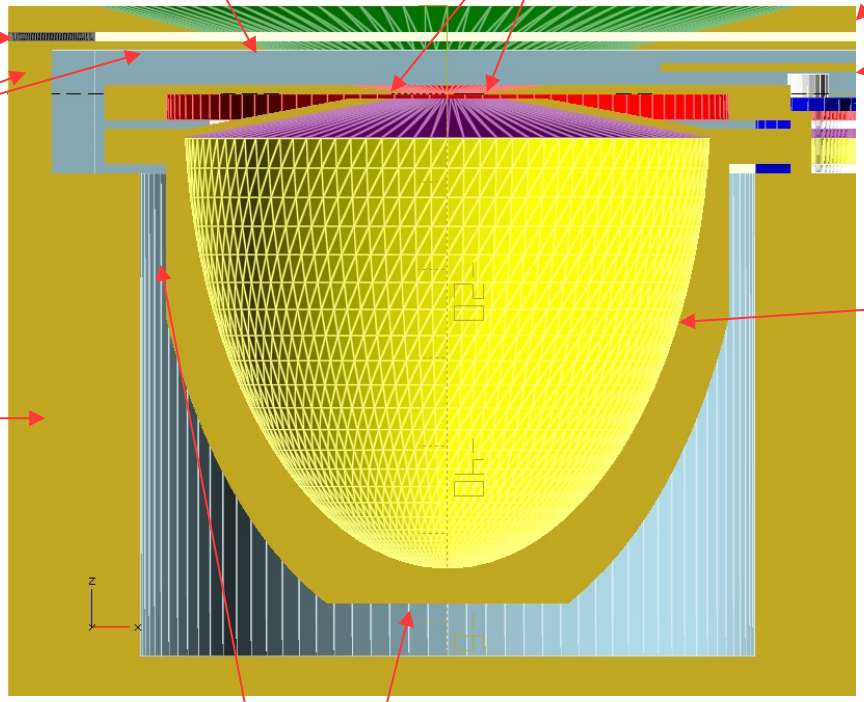
Open shutter

Baffle: thermally connected to housing

Thermal isolation between cavity and housing

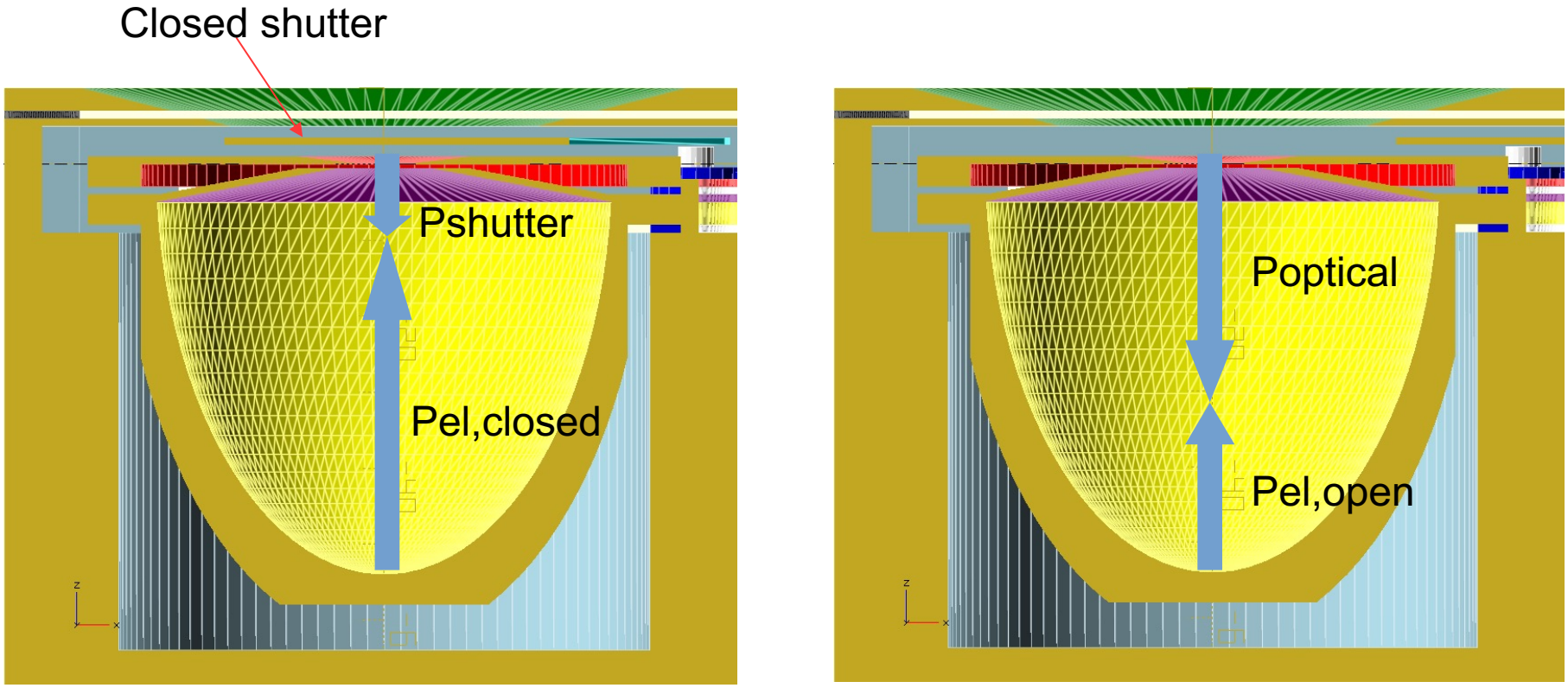
Cavity: elliptical shape for optical cosine response Reflection = 75 ppm +/- 10 ppm

Housing: thermally regulated



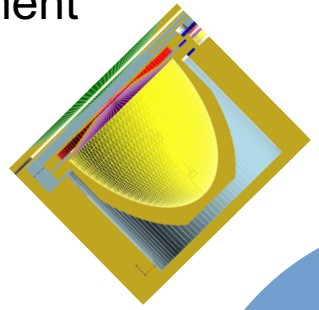
Electrical heaters

Differential shutter operation

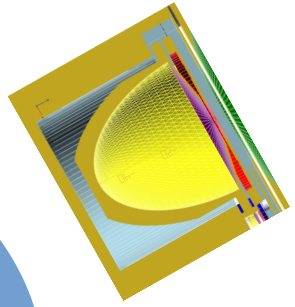


Pel,closed + Pshutter = Pel,open + Poptical

Space observation:
Poptical=0,
measurement
Pshutter

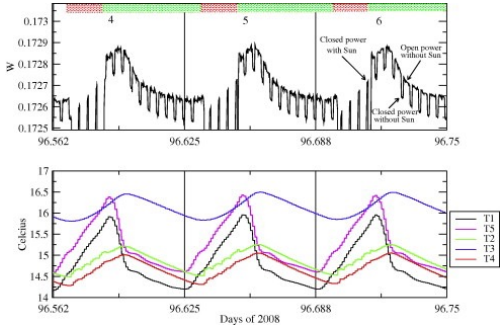


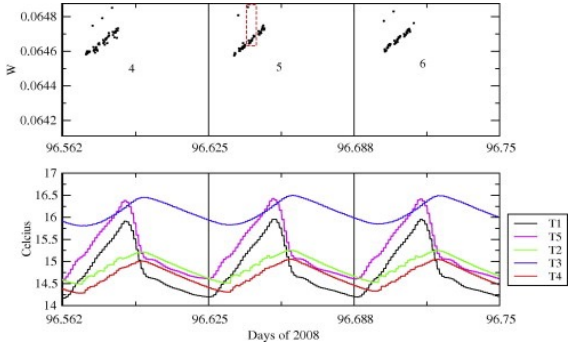
Sun observation:
Poptical=Psun



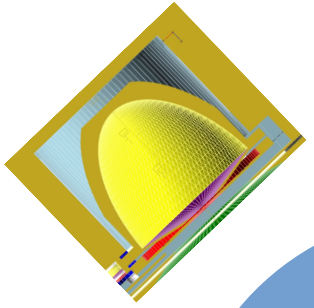
Sun

Earth

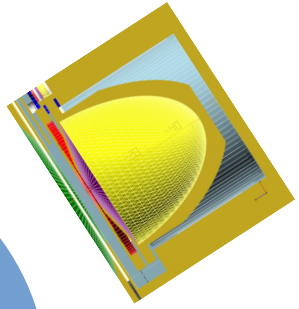




Earth observation:
Poptical=Pearth,night

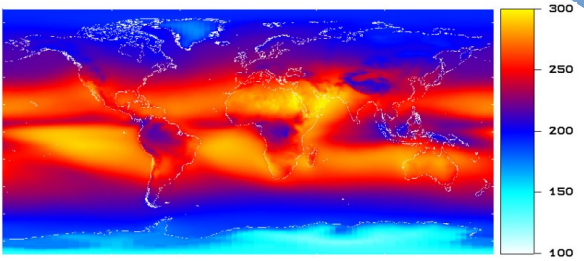


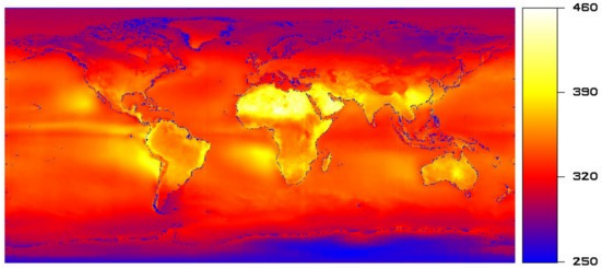
Earth observation:
Poptical=Pearth,day

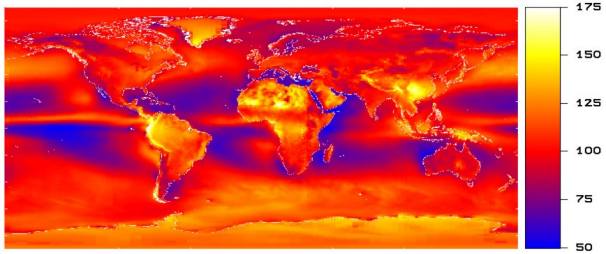


Sun

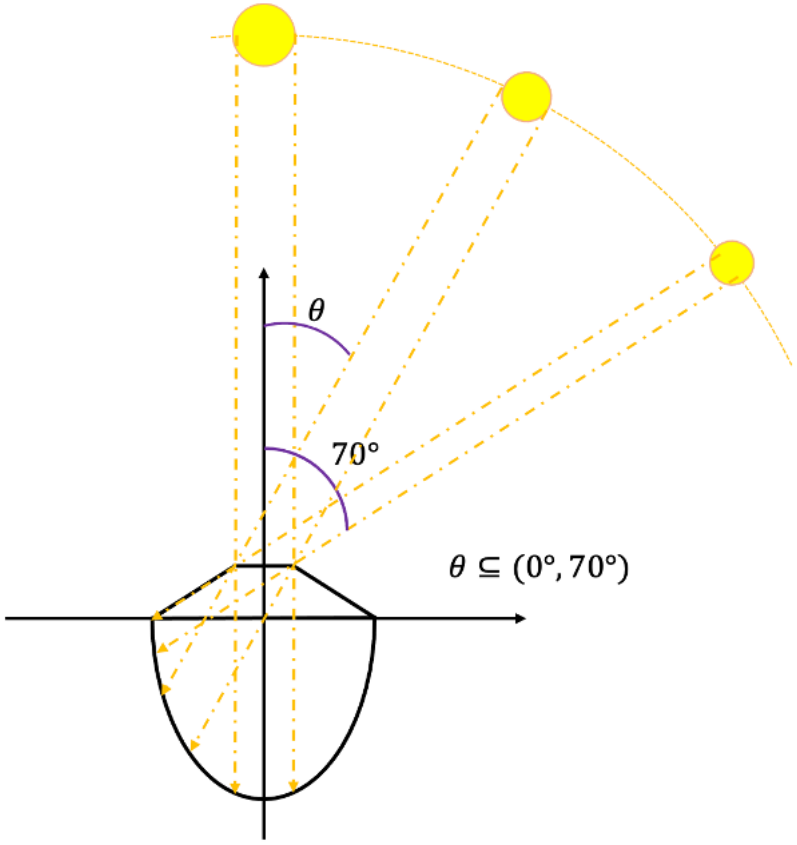
Earth

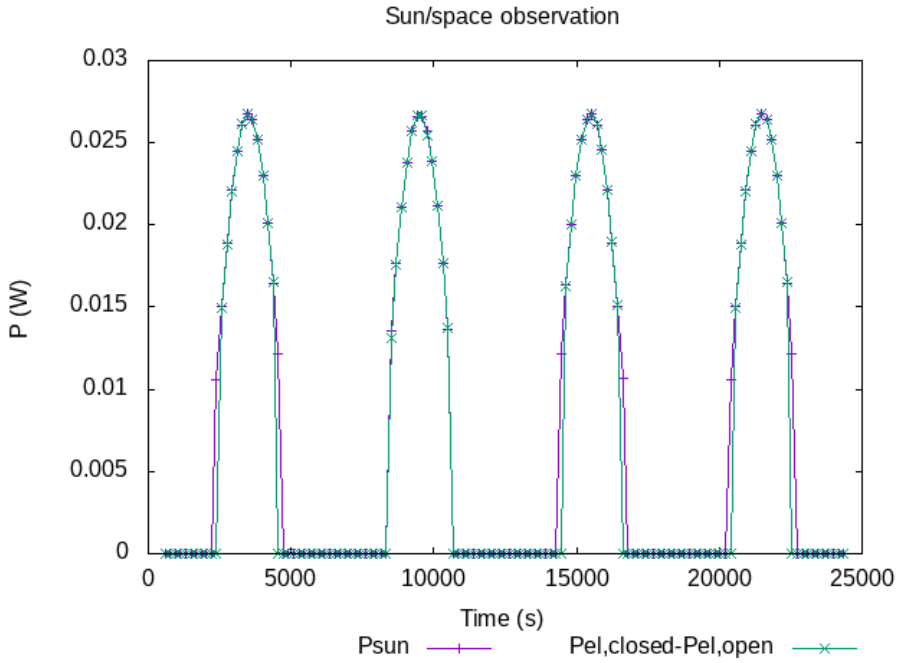






Simulated sun/space observations



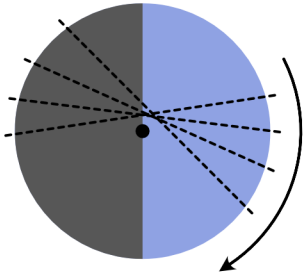


ΔPel/Psun stable within 240 ppm

Preliminary results: Radiometer sun-earth intercalibration error budget

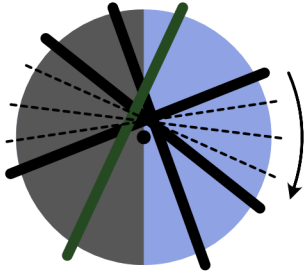
Total	**350 ppm = 0.12 W/m²**
Cavity absorption	10 ppm = 0.003 W/m²
Position dependence	240 ppm = 0.08 W/m²
Electrical power	100 ppm = 0.03 W/m²

Space/time sampling: orbit options



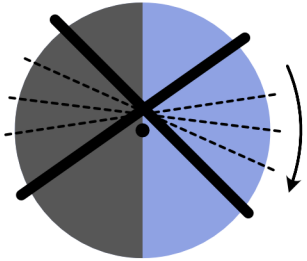
1- 2 satellites in precessing orbits:

- Excellent sampling of diurnal cycle on annual time scale
- Only annual means
- Single point of failure
- Mapping difficult



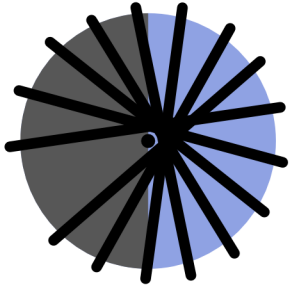
3-4 sun-synchronous + 1-2 precessing:

- Excellent sampling of diurnal cycle on annual time scale
- Cloud feedback monitoring
- Insensitive to failure



2 sun-synchronous + 1-2 precessing:

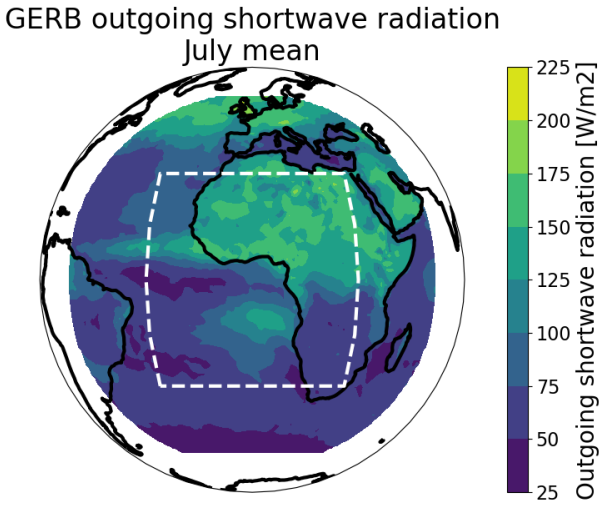
- Good sampling of diurnal cycle on annual time scale
- Monthly means + mapping possible
- Intercalibration
- Sensitive to failure

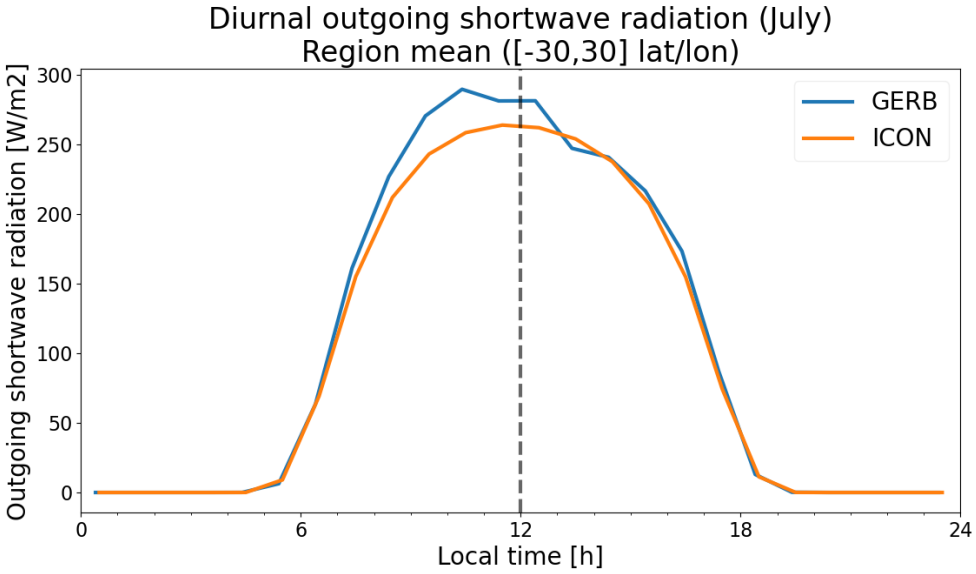


8 or more sun-synchronous:

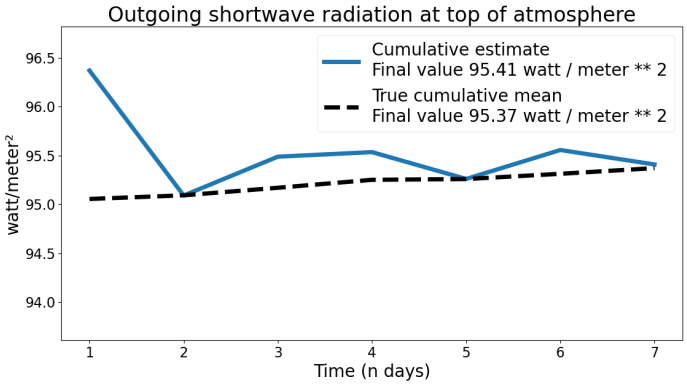
- Excellent sampling of diurnal cycle on daily time scale
- Overlap of footprints, also in tropics
- Excellent mapping
- Robust to failure

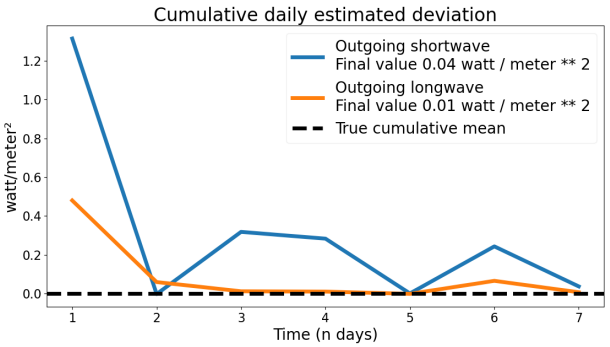
GERB observations and ICON model diurnal cycle

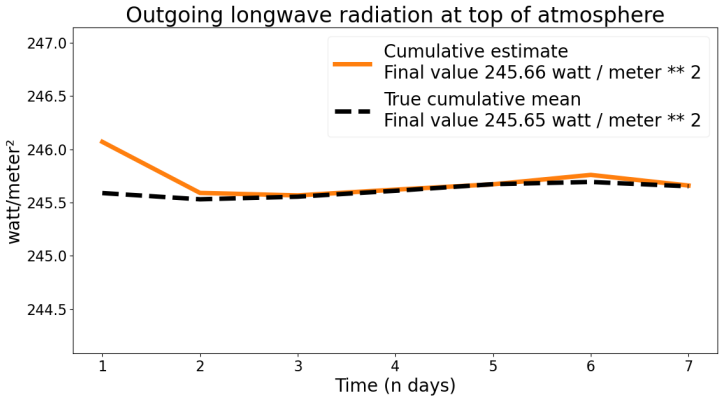




Simulation with 12 orbits 90° inclination



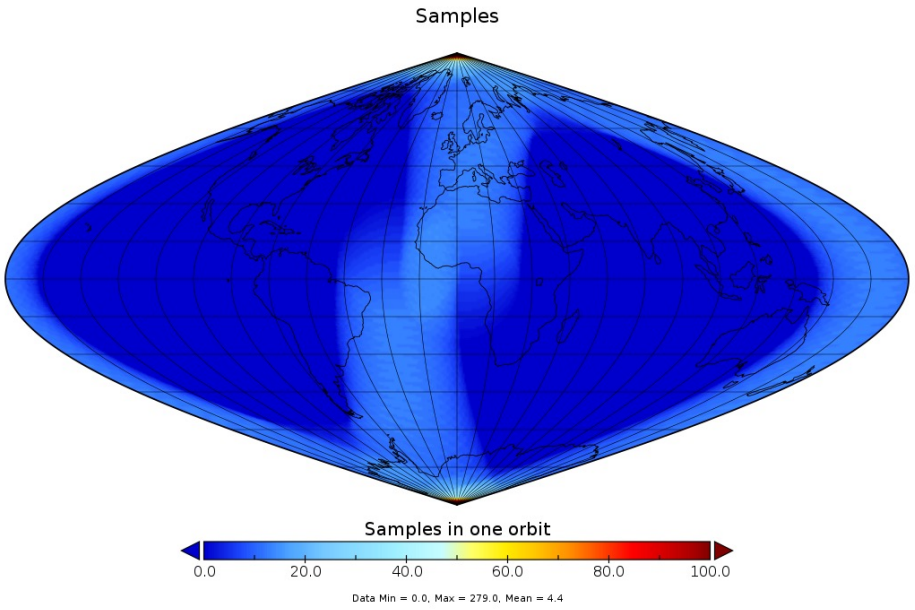




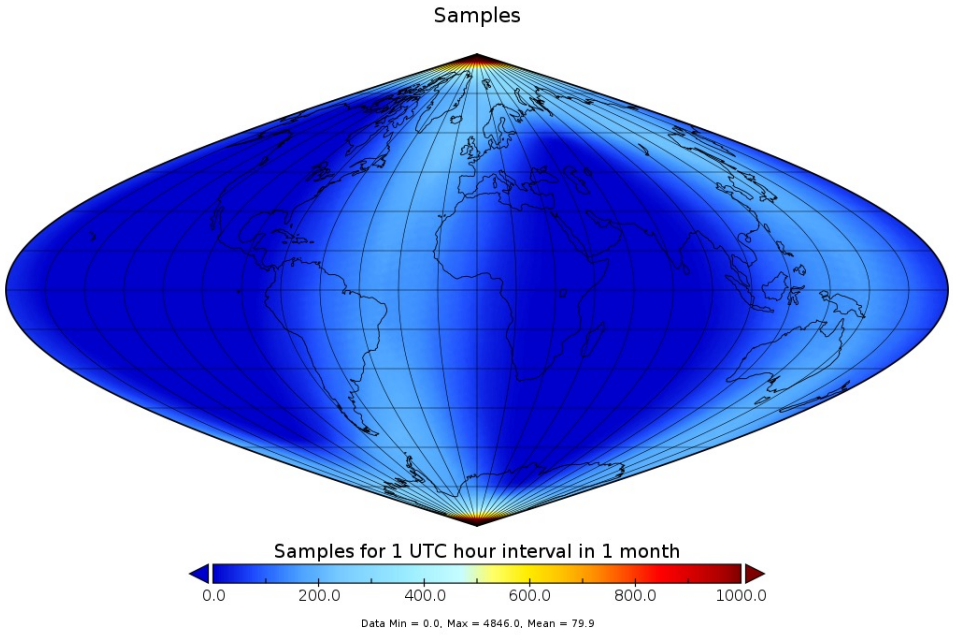
- Input: ICON model fluxes

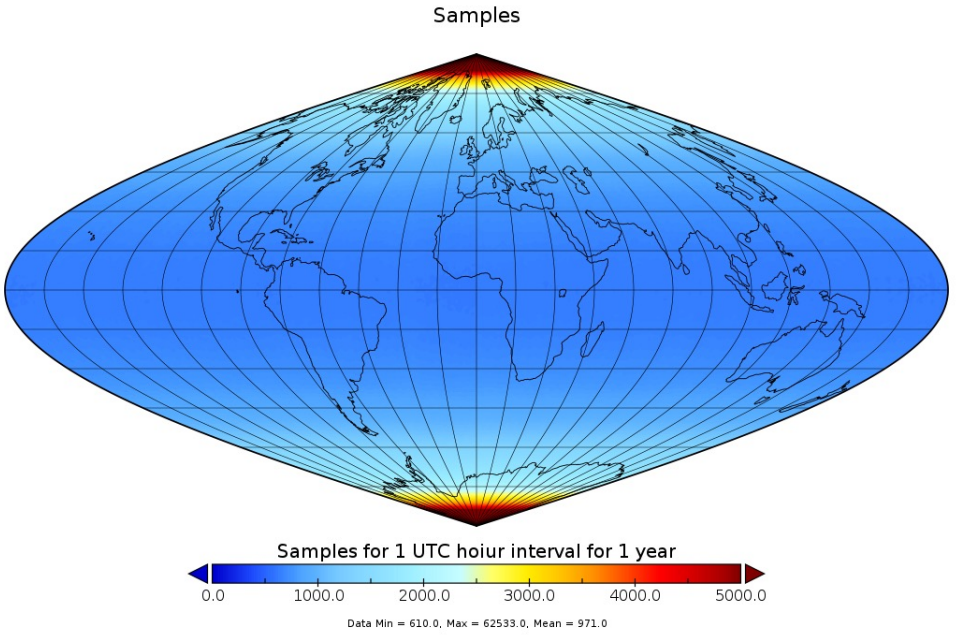
Precessing orbit

- Precession period = ½ year
- Altitude = 600 km
- Inclination = 82.2 °
- Global coverage
- Full diurnal cycle sampled every 3 months (season)



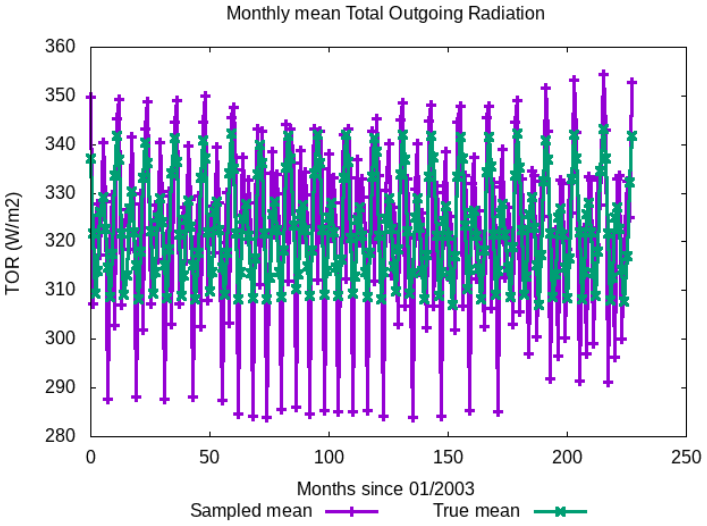
Monthly/yearly sampling for fixed UTC hour interval





Simulated error on Earth Energy Imbalance

Input data: Ceres Syn Monthly Hourly Terra+Aqua, 01/2003-12/2021 (19 years)



Error on global annual mean: RMS 0.2 W/m², Max 0.31 W/m²

Preliminary results: EEI error budget

Total	**1262 ppm = 0.43 W/m²**
Sun-earth intercalibration	350 ppm = 0.12 W/m²
Sampling (1 satellite)	912 ppm = 0.31 W/m²

Conclusions

- Monitoring of the Earth Energy Imbalance is needed for predictive understanding climate change.
- The Earth Climate Observatory (ECO) is a concept for an innovative new space mission for the measurement of the Earth Energy Imbalance
- Key elements:
  - Differential sun-earth observation
  - Adequate sampling diurnal cycle at annual mean level
- Preliminary estimate absolute accuracy annual mean EEI: 0.43 W/m²

Royal Observatory of Belgium

VUB VRIJE UNIVERSITEIT BRUSSEL

KMI

BIRA-IASB

Stockholm University

SMHI

LEGOS

LATMOS

remote sensing
an Open Access Journal by MDPI

IMPACT FACTOR 5.349
CITESCORE 7.4 SCOPUS

Special Issue "Earth Radiation Budget and Earth Energy Imbalance"

Guest Editors: Dr. Steven Dewitte

Deadline: **30 April 2023**
Website: https://www.mdpi.com/journal/remotesensing/special_issues/earth_radiation_budget
Submission Link: https://susy.mdpi.com/user/manuscripts/upload/?journal=remotesensing

If you have any questions, please feel free to contact Niki Liu(niki.liu@mdpi.com).