



ASSIMILA



**National Centre for
Earth Observation**
NATURAL ENVIRONMENT RESEARCH COUNCIL

Operational User Requirements for benchmark sensors such as TRUTHS

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European Space Agency



Traceable Radiometry Underpinning Terrestrial Helio-Studies (TRUTHS)

- Proposed operational Earth Observation **ESA Earth Watch** mission planned launch in the 2026 to 2028 timeframe
- Space based **climate mission**: calibration observatory for climate benchmarking and intercalibration in the solar spectral region
- Provide **fiducial reference data set from orbit in the SW solar domain**. Measuring incoming and reflected solar radiation 10 times more accurately (traceable to SI units) than is currently possible.
- Provide **absolute reference data** for in orbit cross-calibration, absolute anchor point providing a basis for climate quality data records from other sensors and pinning down their uncertainties
- Enable solar spectral benchmark of the current climate state against which to monitor change



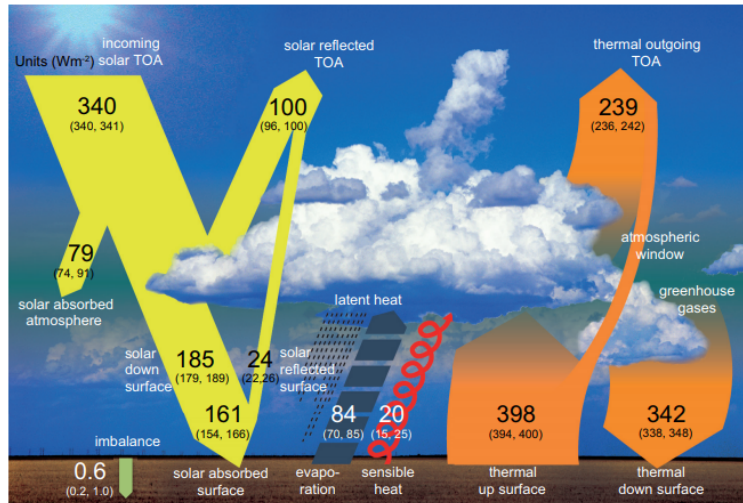
Mission Products

- ❑ L1: Earth-reflected Spectral Radiance (ToA), Solar Spectral Irradiance, Lunar Spectral Irradiance – all in the range 320nm to 2450nm;
- ❑ L1: Total Solar Irradiance integrated in the range 200nm to 30000nm;
- ❑ L2: Spectral Surface Reflectance, at ground level (320nm to 2450nm);
- ❑ Inter-calibration coefficients & match-up products for TBD other sensors.

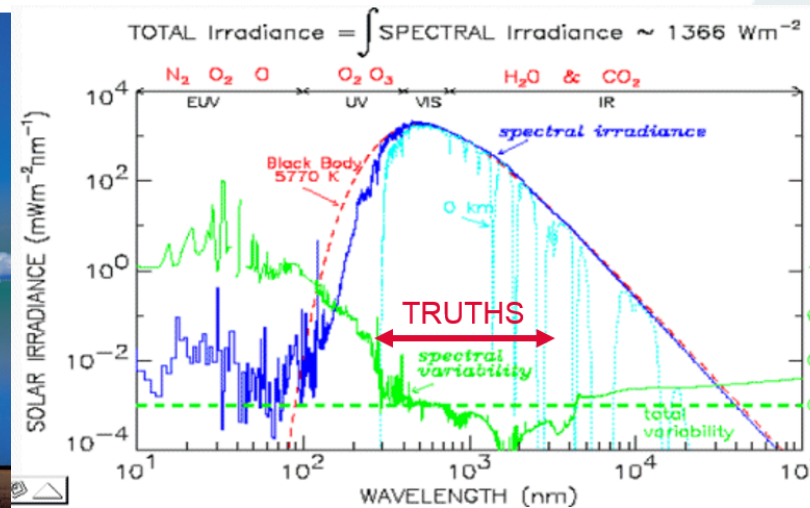
➔ **Climate benchmark,
solar measurement**

➔ **Earth science**

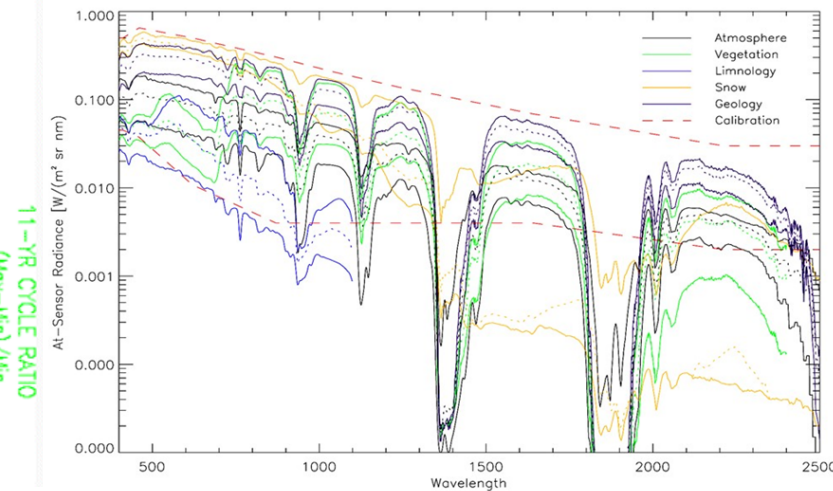
➔ **Cross-calibration**



Radiation balance



Solar spectral irradiance



Surface reflectance

Proposed observations

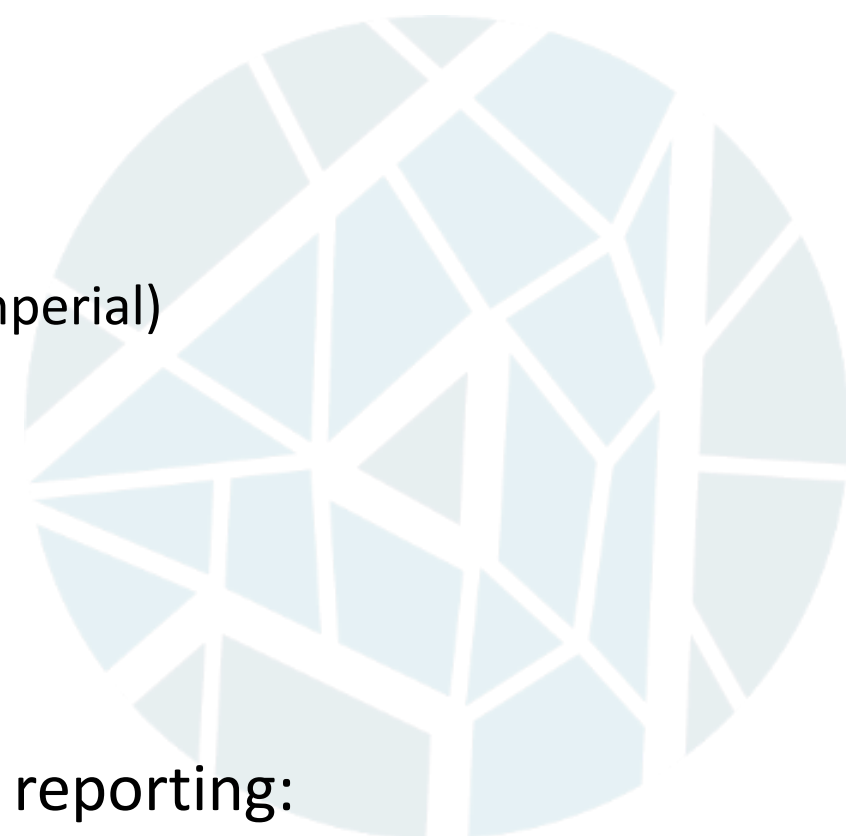
Parameter	Spectral range / μm	Spectral resolution / nm	GIFOV / m	SNR	Sampling	Uncertainty / % (2σ)
Earth Spectral Radiance	0.32 - 2.4	~5 to 10	~50 250	~300 (Vis-NIR) >2000 Blue	Global nadir 50-100 km swath + multi-angle	0.3
Total Sol Irradiance (TSI)	0.2 – 35	NA	NA	>500	Daily	0.02
Solar/Lunar Spectral Irradiance (SSI)	~0.30 - 2.4	1 to 10	NA	>300	Daily	0.3
Surface Reflectance	0.32 - 2.4	~5 to 10	~50 250	~300 (Vis-NIR) >2000 Blue	Global nadir + multi-angle	<1

The TRUTHS design is driven by:

- ❑ **Radiometric demands** of the climate application → *Payload and calibration*
- ❑ **Orbit:** optimal sampling to quantify the climate and facilitate cross-calibration → *Satellite and launch*

User Requirements Study for SI Traceable Measurements of Incoming and Reflected Spectrally Resolved Solar Radiance and Irradiance

- ESA initiated Study
- Proposed consortium:
 - UK NCEO (Universities Leicester and Imperial)
 - Assimila (UK)
 - Rayference (Belgium)
 - PMOD (Switzerland)
- Planned start October 2019
- 6-month study length
- Important milestone for preliminary reporting:
 - Ministerial Council Meeting SPACE19+, 27-28 November 2019

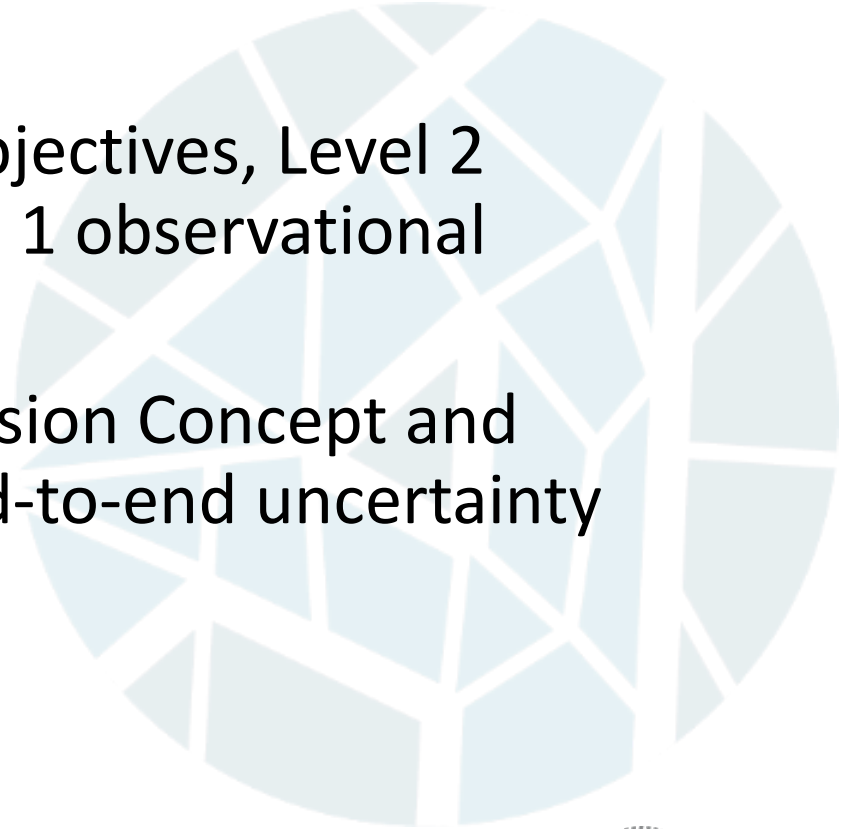


Study objectives

- Identify Operational Climate Users Requirements on Spectrally Resolved Radiances and Solar Irradiance measurements and other associated level 2 products
- Evaluate mission objectives and give traceability between user requirements and level 1 measurements. Recommend mission modifications as appropriate
- Process will formalize and establish consistency between instrument characteristics and operational user community requirements following accepted ESA practices
 - establish and justify **user requirements**, focusing on European operational community, for an **operational mission** providing high absolute accuracy SI traceable measurements of the Earth reflected solar radiance and solar irradiance
 - establish **scientific readiness** and capacity to exploit the products such as reference baseline measurements of the state of the planet for benchmarking, model evaluation and change detection
 - determine feasibility and **capacity to exploit SI traceable space-based reference calibration** to develop an interoperable and SI traceable global earth observing system and demonstrate end to end intercalibration accuracy for an example instrument

Tasks

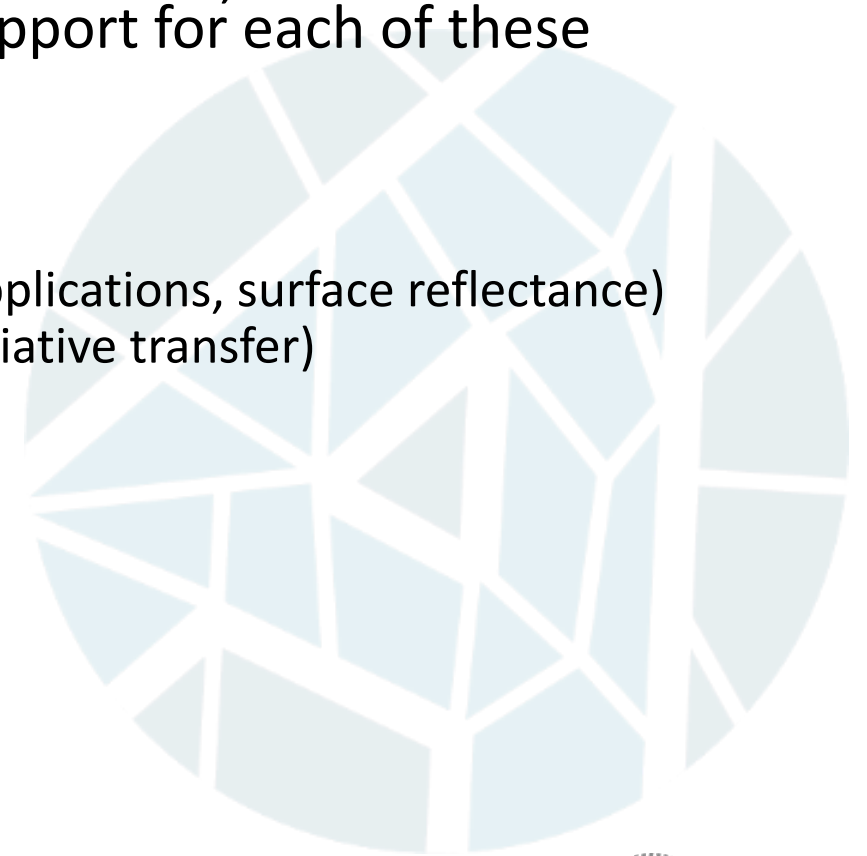
- Task 1: Definition of User Requirements
- Task 2: Definition of End-to-End Mission Objectives, Level 2 Geophysical Observation and trace to Level 1 observational requirements
- Task 3: Revision of the current TRUTHS Mission Concept and requirements. Demonstration case and end-to-end uncertainty analysis for cross calibration
- Task 4: Recommendations



Task 1: Definition of User Requirements expected process

- Identify users for climate benchmarking, model evaluation, inter-calibration and other applications and the associated scientific support for each of these
- Definition of operational user requirements
 - For climate benchmarking
 - Satellite intercalibration
 - Product 'ground' truth (e.g. ocean colour, vegetation applications, surface reflectance)
 - Model evaluation and testing (climate model, NWP, radiative transfer)
- Survey via Structured user interviews
- Detailed Use cases:
 - ECVs (land cover, oceans, atmosphere)
 - Analysis Ready Data
 - Solar Rad / ERB
 - Operational inter-calibration
 - Radiative transfer model evaluation improvements

→ *OUTPUT User Requirements Document v1*



Task 2: Definition of End-to-End Mission Objectives, Geophysical Observation (L2) and L1 Requirements

- Definition & justification of end-to-end mission objectives
 - traceable to user requirements
 - Focusing on synergies between climate and satellite intercalibration operational activities
- L2 (geophysical variable) requirements traceable to user requirements
- L1 requirements traceable to L2 requirements

→ *OUTPUT User Requirements Document v2*

Task 2: Current End-to-End Mission Objectives, L2 & L1

- Currently Stated objectives:
 - operational space-based climate calibration hyperspectral observatory
 - Facilitate climate-quality Earth observing system
 - SI-traceable benchmark of the state of the climate for model testing and against which to monitor change
- Proposed Level 1
 - Global nadir & multi angle Earth Spectral radiances 0.3% $k=2$
 - 0.32 to 2.3 μm at 5 to 10 nm; 50m footprint
 - Weekly libration sampled Lunar spectral irradiance 0.3% $k=2$
 - 0.32 to 2.3 μm at 5 to 10 nm
 - Daily Total solar irradiance 0.02% ($k=2$)
 - 0.2 to 35 μm
 - Solar spectral irradiance 0.2% ($k=2$)
 - 0.32 to 2.45 μm at 1 to 10 nm resolution
- Proposed Level 2
 - Surface reflectance and related products
 - Calibration coefficients
 - Absolute calibration reference datasets (lunar, calibration sites & targets)
 - Climate benchmark product



Task 3: Revision of the current TRUTHS Mission Concept

- Review Mission Requirements Document with URD
- Mission delta recommendations
- Detailed demonstration case with end to end uncertainty estimate for the inter-calibration of TRUTHS with a future multi- or hyperspectral instrument
 - Candidate missions
 - Intercalibration approaches

→ *OUTPUT TRUTHS Missions Review Document*

Anticipated process

- Review of existing services and key literature
- Identify and survey key users and scientific support (European & wider international community)
 - European Operational: Met Centres: UK Met Office & ECMWF; Climate data providers (e.g. C3S, CMSAF, EUMETSAT); product providers (ocean colour, vegetation)
 - Wider international: Operational applications, climate benchmarking, scientific support and readiness
- Survey via structured interviews at targeted users
- Testing requirements with key scientific experts
- User workshop (TBD)
- Identify missions for cross calibration demonstration case
- Preliminary findings and draft URD for ESA ministerial in November this year
- Final reports end Feb 2020

