

# TRUTHS - an introduction

**T**raceable

**R**adiometry

**U**nderpinning

**T**errestrial- &

**H**elio-

**S**tudies

**Establishing an operational earth observation satellite mission that will create a space-based climate and calibration observatory**

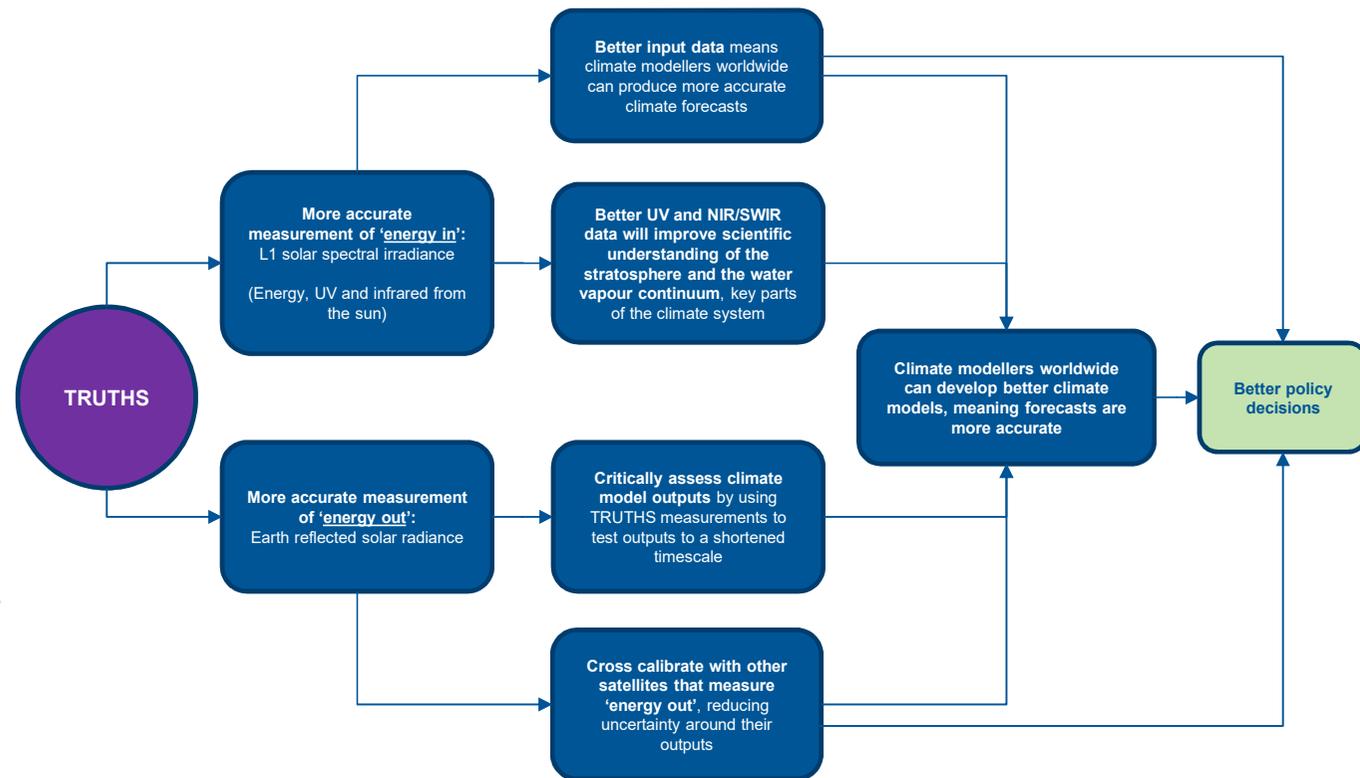
**NPL Science Lead  
Professor Nigel Fox**

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# What is the TRUTHS mission?

**TRUTHS stands for: *Traceable Radiometry Underpinning Terrestrial- & Helio- Studies***

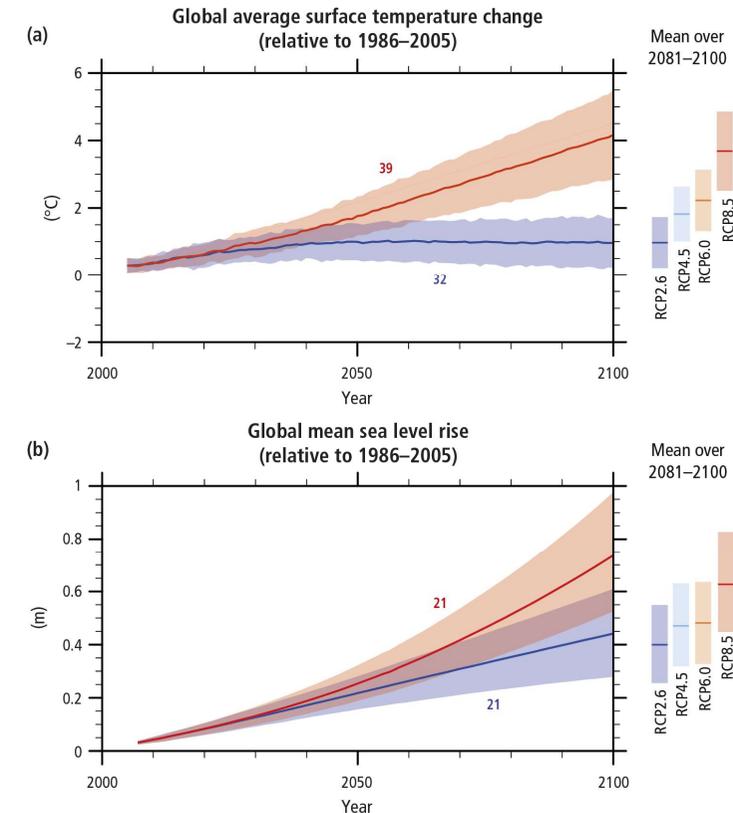
- TRUTHS is a UK Space Agency (UKSA) sponsored, European Space Agency (ESA) operational earth observation satellite mission that will create a space-based climate and calibration observatory
- TRUTHS will establish a climate observation system which measures both the incoming and reflected solar energy that drives the climate system and will deliver a 10 fold increase in data accuracy compared to existing systems



**TRUTHS ensures robust evidence to facilitate timely decisions of policy makers**

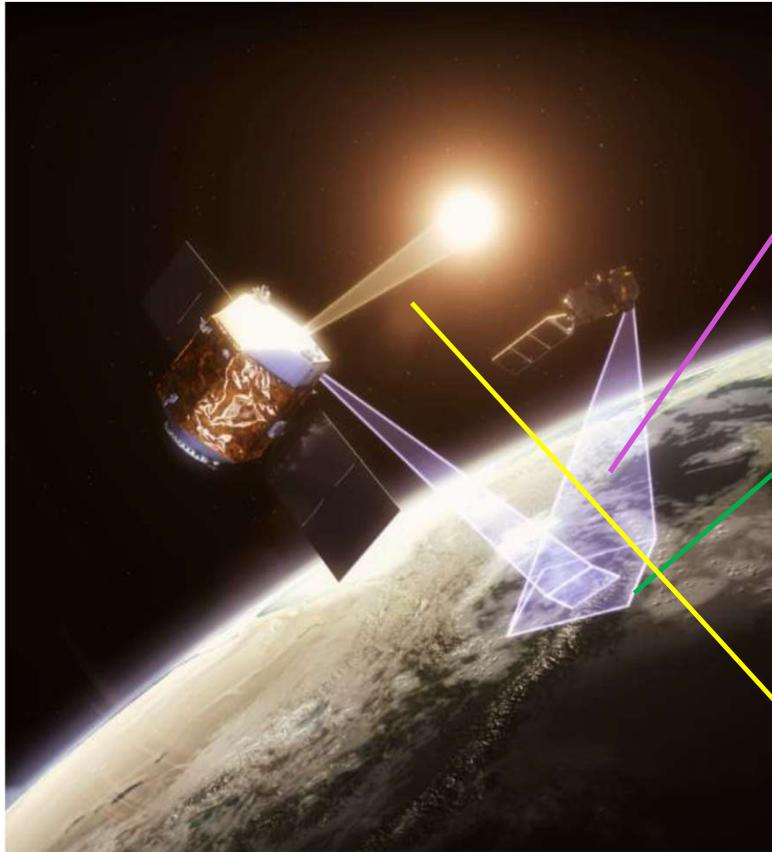
# Why TRUTHS matters - The climate challenge

- **TRUTHS will deliver the world's first SI-traceable laboratory in space, improving the quality, reliability and accuracy of the data collected**
- This improvement in data quality is vital to climate modelling because
  - Climate policies are driven by complex theoretical predictions that are balanced against the need for sustaining economic growth and quality of life
  - Greater accuracy of observations sensitive to climate, particularly where they can have a non-linear feedback such as amount and type of cloud or albedo (reflectance) e.g. Snow enables improved inputs and critical testing of climate models– leading to increased confidence required to drive policy
  - TRUTHS unprecedented accuracy enables us to detect the signal of climate change (above natural variability) in the shortest possible timeframe
  - TRUTHS will accurately benchmark the state of the climate system now from which change can be detected in the future
    - The proposed mission is nominally 5-7yrs
    - Repeat mission(s) will provide data on the 10-20 year timescale required to observationally detect climate trends



**Climate models predict warming but with large variance on how much?**

# What will TRUTHS deliver?



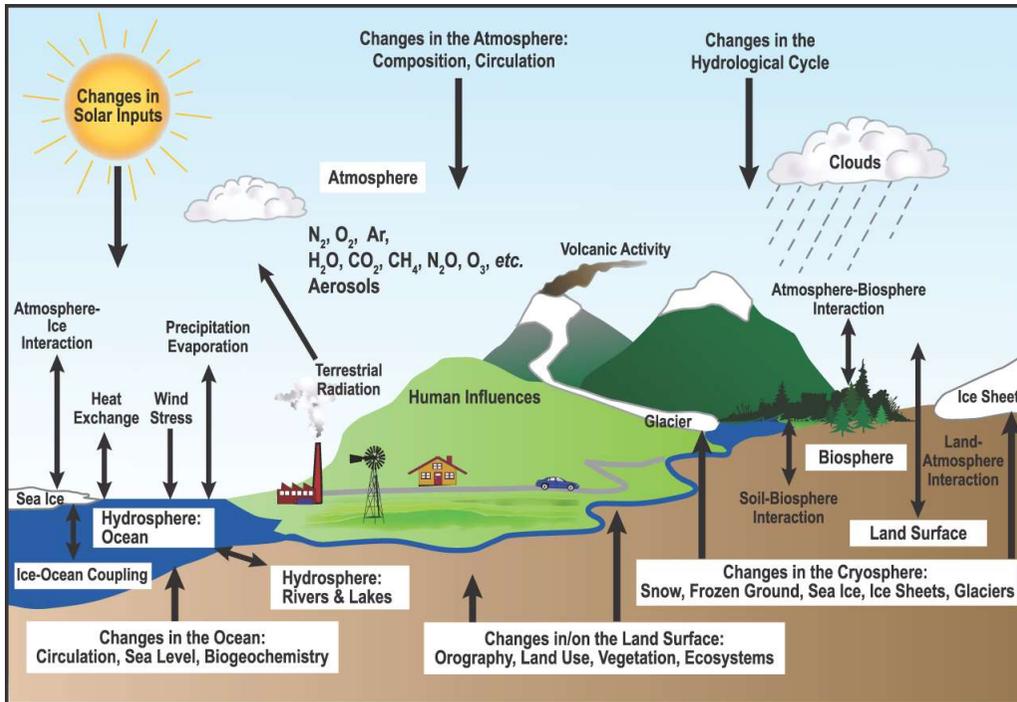
TRUTHS is an **operational climate-focused mission**, delivering

**Climate benchmarking:** enhance by an order-of-magnitude our ability to estimate the Earth radiation budget (and attributions) through direct measurements of incoming & outgoing energy,

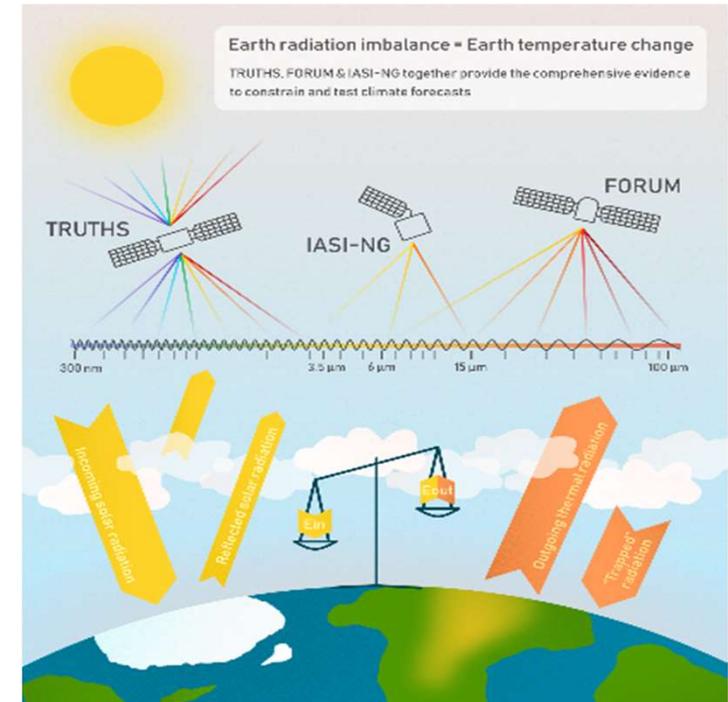
**Satellites cross-calibration:** establish a 'metrology laboratory in space' to create a fiducial reference data set to cross-calibrate other sensors and improve the quality of their data, robustly anchored to an SI reference in space.

SI-traceable measurements of the **solar spectrum** to address direct science questions and climate.

# What can TRUTHS help us understand



TRUTHS data will also help understand efficiency and status of natural sinks of Carbon dioxide (forests and oceans) and support monitoring of land use change and agriculture amongst many others



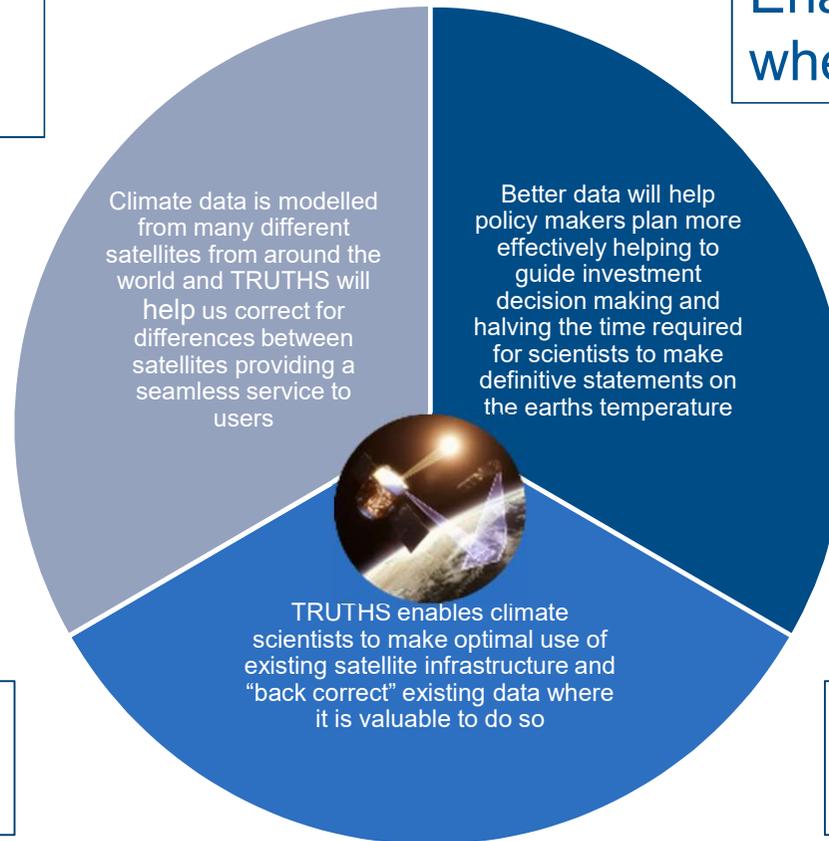
TRUTHS is a complementary mission to other satellite based earth observation missions providing a more complete picture of the Earth's radiation imbalance which drives global warming

# How will TRUTHS help deliver on the challenges of climate modelling

Helps us understand the climate



Increases confidence in satellite data



Enables data access when & where we need it



Sentinel 3 – ESA.net

Makes the most of our investments in satellites

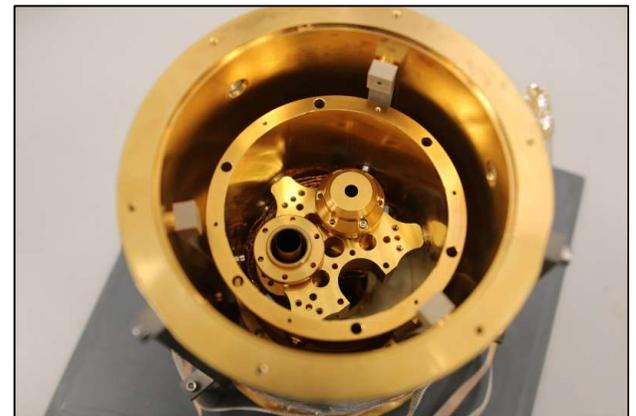
# What makes TRUTHS different to other hyperspectral missions?

**At the Heart of TRUTHS is the Cryogenic Solar Radiometer (CSAR) which utilises the measurement system used in labs around the world in space and enables the disruptive differentiator of TRUTHS is its on-board calibration system**

- TRUTHS includes an on-board calibration system, that replicates the SI-traceable calibration chain employed in National Measurement Institutes globally
  - No reliance on assuming maintenance of pre-flight performance, or modelled degradation
  - TRUTHS payload and calibration system carries the on-board standard which operates at temperatures below  $-220\text{ }^{\circ}\text{C}$
- Regular recalibration on-board ensures SI-traceability is maintained and usual drifts in the optical components can be corrected.

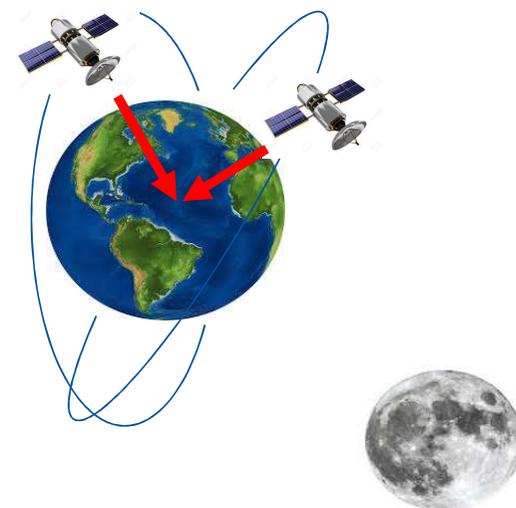


Professor Nigel Fox, NPL



A model system of the Cryogenic Solar Radiometer (CSAR) which is central to the TRUTHS mission

# What data will TRUTHS generate

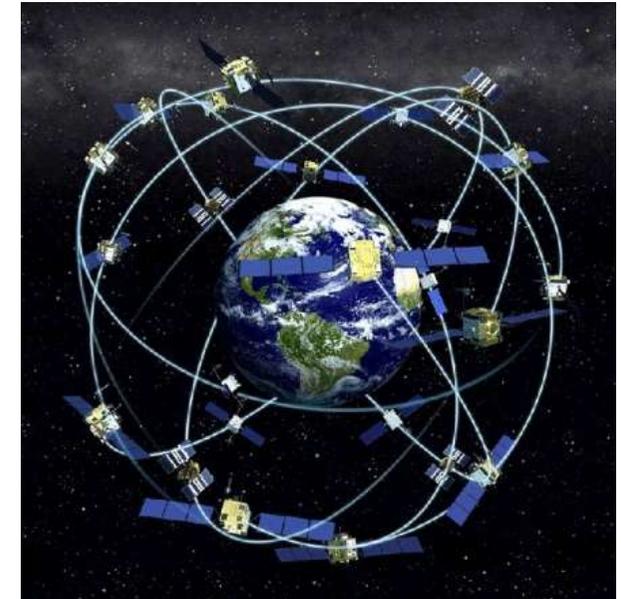


- TRUTHS mission development will start in spring 2020 with a launch date planned for 2026-28 followed by operations for a further 5-8 yrs
- The mission's hyperspectral imaging spectrometer will deliver ~5Tbytes of data a day
- TRUTHS is an agile platform that points to observe the Sun and Moon as it passes over the poles and then continually samples the sun-lit Earth with a spatial resolution of 50m TRUTHS flies in a novel orbit which allows it to simultaneously view the same scene as other satellites regularly
- This enables TRUTHS to increase confidence in data from other EO satellites through in-flight reference cross-calibration
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Data Products:	Uncertainty
Total Solar Irradiance (0.2 um to >30 um, integrated)	0.02%
Solar spectral irradiance (320 nm to 2450 nm)	0.3%
Lunar spectral irradiance (320 nm to 2450 nm)	0.3%
Earth-reflected spectral radiance (320 nm to 2450 nm)	0.3%
Spectral surface reflectance (320 nm to 2450 nm)	<1%

# What else will TRUTHS enable?

- As well as providing a showcase of UK technology, the TRUTHS mission will help to inspire the next generation of scientist and engineers
- Utilisation of the data will build upon UK strengths in data analytics and Artificial intelligence
- Maintain UK and European scientists at the forefront of climate and environmental studies
- Underpin new commercial markets in climate and Earth observation services – ensuring a level playing field
- Encourage low cost access to space facilitating interoperability and harmonisation of not only public funded satellites but commercial constellations of microsats



# How does TRUTHS fit with NPL's other space and earth observation activity

- Developing calibration standard and methods for pre-flight calibration of satellites based on the use of a revolutionary tuneable laser
  - <https://www.npl.co.uk/earth-observation/satellite-instrumentation>
- Developing quality assurance systems to enable users of EO data to readily assess 'fitness for purpose'
  - <https://www.npl.co.uk/earth-observation/climate-data-traceability>
- Establishing 'test-sites' and methods in deserts, forests and oceans to provide SI-traceable post-launch calibration and validation of satellites
  - <https://www.npl.co.uk/research/earth-observation/vegetation-test-site-characterisation>
  - <https://www.radcalnet.org/#/>
- Coordinating Europe's metrology institutes in climate and earth observation
  - <https://www.euramet.org/publications-media-centre/news/>
- **NPL is also developing high accuracy optical clocks for next generation space positioning systems and in many other disciplines**
  - <https://www.npl.co.uk/time-frequency/optical-atomic-clocks>