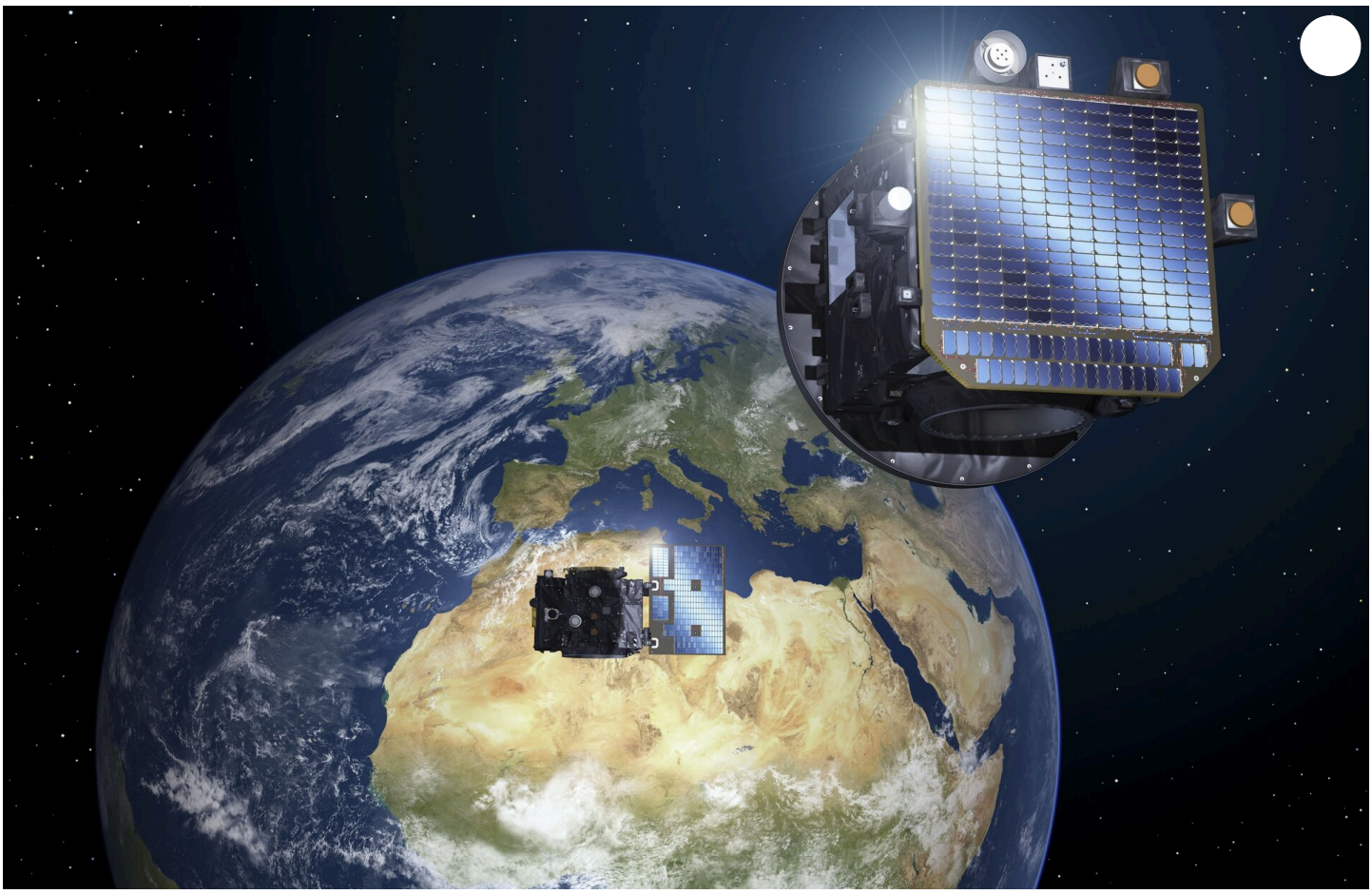

ENABLING & SUPPORT

Proba-3 will constantly measure Sun’s energy output

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Proba-3 is such an ambitious mission that it needs more than one single spacecraft to succeed. In order for Proba-3’s Coronagraph spacecraft observe the Sun’s faint surrounding atmosphere, its disk-bearing Occulter spacecraft must block out

the fiery solar disk. This means Proba-3's Occulter ends up facing the Sun continuously, making it a valuable platform for science in its own right.

The sunward side of the Occulter therefore hosts a dedicated instrument that will maintain a continuous measurement of the Sun's total energy output, known as the total solar irradiance, which is a essential variable for climate studies.

The shoebox-sized Davos Absolute Radiometer, DARA, has been supplied to the mission by the Physical Meteorological Observatory Davos, PMOD, in Switzerland.

— Proba-3 Occulter and Coronagraph spacecraft

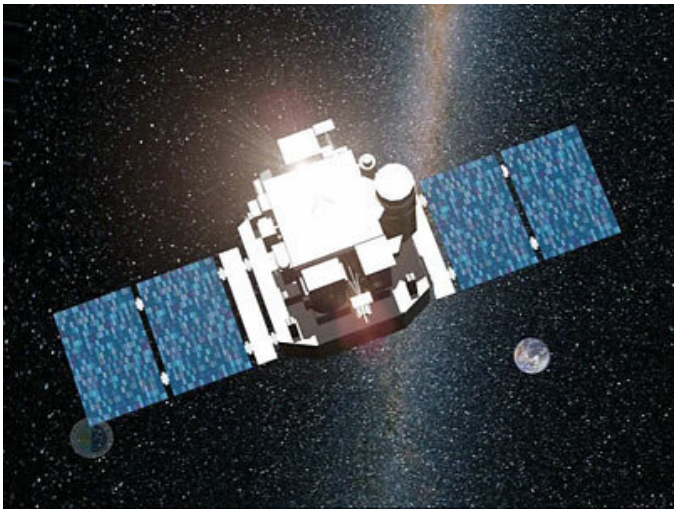
— DARA undergoing ground testing

"Researchers used to talk about the 'solar constant' but in fact it is always changing slightly," explains Wolfgang Finsterle, DARA Principal Investigator at PMOD. "And it's essential to keep track of the total solar irradiance, because it is the dominant energy input to the surface of the Earth. It amounts to something like 99.978% of the energy available on Earth, including the conserved solar energy stored in coal and oil. It drives all the dynamic processes of Earth's climate, so even the tiniest variations are hugely significant."

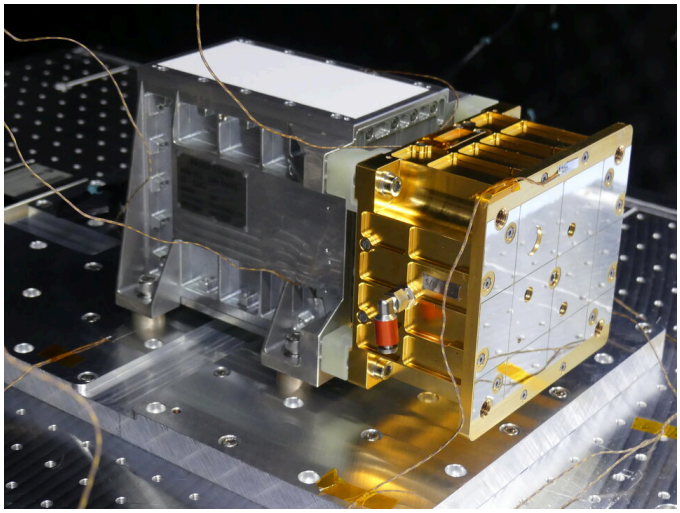
The mountain-based PMOD has been studying total solar irradiance for more than a century, initially with ground-based instruments and then from the 1970s deploying space-based radiometers to acquire a continuous dataset. The World Meteorological Organization has mandated PMOD as the World Radiation Centre to calibrate radiation measurements across global UN monitoring programmes.

Wolfgang adds: "Total solar irradiance varies along with the 11-year cycle of solar activity, and one of the most obvious ways to look for long-term energy drift is to compare total solar irradiance between consecutive solar minimia.

"This requires a long time-series of data, ideally coming from multiple instruments because single radiometers will undergo degradation in sensitivity from the hard ultraviolet in the Sun's rays they are continuously exposed to. That said any degradation is very gradual: the radiometer aboard the ESA-NASA SOHO solar observatory for instance, which was launched in back 1995, is still working satisfactorily."



— SOHO solar observatory



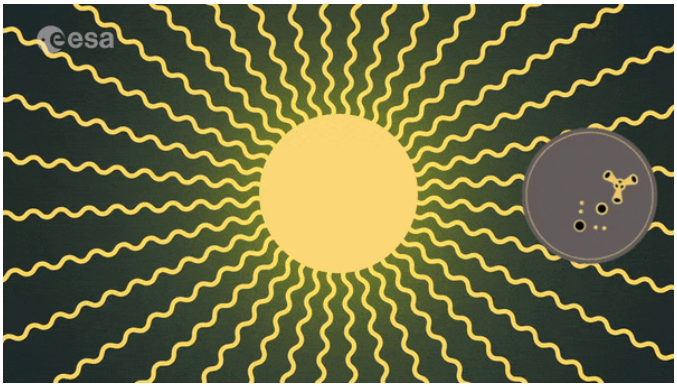
— DARA instrument

DARA’s basic operating principle is simple. The radiometer possesses a 5-mm diameter cavity made from black-painted silver, possessing low temperature emissivity. For 15 seconds at a time sunlight warms the interior of the cavity, then a shutter blade automatically closes at its entrance.

For the next 15 seconds electric heat maintains the cavity’s previous temperature – and the energy needed to maintain this temperature is extrapolated to the unit of total solar irradiance which is watts per metre squared.

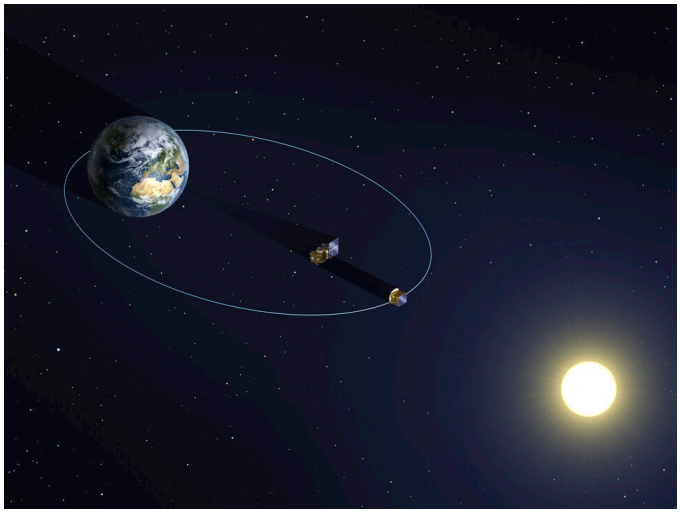
This process continues for the entire lifetime of the instrument – the actuated shutter design employed in DARA has been tested for millions of opening and closings in PMOD’s vacuum chamber.

“DARA is an improvement on previous radiometer designs with an optimised cavity design to minimise unwanted straylight and a multi-channel measuring system for self-calibration,” adds Wolfgang. “This generation of instrument also possesses a fully digital control loop, allowing the possibility of experimenting with higher frequency observations.



— Proba-3

Two versions of this radiometer design have already flown, notes Werner Schmutz of PMOD, who oversaw its development: “A compact version called CLARA flew on Noway’s NorSat-1 CubeSat in 2017, remaining operational to this day, while a



— Proba-3 orbit

previous DARA is serving aboard the Chinese FY-3E weather satellite, launched in 2021. So we have high confidence in the design, which can operate whenever the Proba-3 Occulter is pointed at the Sun within half a degree of accuracy.”

The main difference between Proba-3’s DARA and previous radiometers will be its very elongated orbit, which will carry it 60 000 km above Earth’s surface. DARA can automatically adjust to slight changes in the size of the solar disk based on how far it is away – which are also due to Earth’s yearly elliptical orbit around the Sun. All the radiometer needs to know is its position in space and its data gathering compensates for the shift.

— Eclipse-making double-satellite Proba-3

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