SERB, a nanosatellite to study the Sun and the Earth

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1 – Abstract

Within the past decade, satellites constellations have become possible and practical. One of the interest to use a satellites constellation is to measure the true Earth Radiation Imbalance, which is a crucial quantity for testing climate models and for predicting the future course of global warming. This measurement presents a high interest because the 2001–2010 decade has not shown the accelerating pace of global warming that most models predict, despite the fact that the greenhouse-gas radiative forcing continues to rise. All estimates (ocean heat content and top of atmosphere) show that over the past decade the Earth radiation imbalance ranges between 0.5 to 1 W.m². Up to now, the Earth radiation imbalance has not been measured directly. The only way to measure the imbalance with sufficient accuracy is to measure both the incoming solar radiations (total solar irradiance) and the outgoing terrestrial radiations (top of atmosphere outgoing longwave radiation and shortwave radiation) onboard the same satellite, and ideally, with the same instrument. The incoming solar radiations and the outgoing terrestrial radiations are of nearly equal magnitude of the order of 340.5 W.m⁻². The objective is to measure these quantities over time by using differential Sun-Earth measurements (to counter calibration errors) with an accuracy better than 0.05 W.m⁻². It is also necessary to have redundant instruments to track aging in space in order to measure during a decade and to measure the global diurnal cycle with a dozen satellites. Solar irradiance and Earth Radiation Budget (SERB) is a potential first in orbit demonstration satellite. The SERB nano-satellite aims to measure on the same platform the different components of the Earth radiation budget and the total solar irradiance. Instrumental payloads (solar radiometer and Earth radiometers) can acquire the technical maturity for the future large missions (constellation that insure global measurement cover) by flying in a CubeSat. This paper is intended to demonstrate the ability to build a low-cost satellite with a high accuracy measurement in order to have constant flow of data from space.

2 – Scientific objectives

The « SERB nano-satellite » is a future innovative proof-of-concept, with three main science goals:

1°: to extend the Total Solar Irradiance (TSI) variability measurement with a long-term stability (10 years) better than 0.05 W.m⁻²
2°: to monitor the Solar Spectral Irradiance (SSI) at 215 nm (Herbert solar continuum) with a long-term stability (10 years) better than 3.4x10⁻³ W.m⁻².nm⁻¹
3°: to establish a radiation balance of the Earth with an accuracy better than 1% and link with the imbalance (between 0.5 and 1 W.m⁻²)

- Influence of solar variability on Earth climate and regional effects.
- Dynamical amplification of the stratospheric solar response.
- Earth’s Energy Imbalance characterizes how close the system to equilibrium.
- The imbalance at TOA is too small to measure from space.
- Top of the atmosphere (TOA) measurements of radiation from space can track changes over time but lack absolute accuracy.
- All estimates (ocean heat content and TOA) show that over the past decade the energy imbalance ranges between 0.5 and 1 W.m⁻².
- Energy Imbalance is a mean to solve problems of the 21 century climate change.

3 – The SERB nano-satellite prototype

Launch schedule: 2027
- Launch vehicle: PSLV, Vega, DNEPE, Soyuz
- Target Orbit: Highly-synchronous Orbit at 800 km
- Low time at ascending node: 11:00 UT
- Orbit inclination: 96.21°
- ADCS
- Nadir pointing: 0°
- Further Objectives: to fly with LATMOS 10 nanosatellites.

4 – Conclusions

The SERB nano-satellite aims three main scientific objectives in connection with the observations of the Earth and the Sun. Scientific requirements are established.

- The first step of our program is to develop an innovative proof-of-concept nano-satellite. The nanosatellite will become a debris. At an altitude of 600 km, the orbit would naturally decay within the allotted 25 years. Thus, the rule of the 25 years to avoid space debris is respected.
- The second step is to launch a minimum of 10 nanosatellites to obtain a global distribution of Earth fluxes.
- Use of nano-satellite is an interesting tool for quickly addressing key scientific problems.
- A cost-effective means for the flight demonstration of new spacecraft and instrument design concepts and hardware.
- An opportunity to develop scientific research, engineering, and project management capabilities.
- The capability for a timely response to targets of opportunity.
- An opportunity for international cooperative missions.
- Small satellites constellation (cost optimization) for resolution and revisit time to mean to solve problems of the 21 century climate change.

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