Radiation Budget Instrument (RBI) for JPSS-2

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ABSTRACT

Radiation Budget Instrument (RBI) will be one of five instruments flying aboard the JPSS-2 spacecraft, a polar-orbiting sun-synchronous satellite in Low Earth Orbit. RBI is a passive remote sensing instrument that will follow the successful legacy of the Clouds and Earth's Radiant Energy System (CERES) instruments to make measurement of Earth's short and longwave radiation budget.

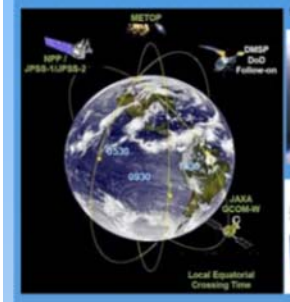
The goal of RBI is to provide an independent measurement of the broadband reflected solar radiance and Earth's emitted thermal radiance by using three spectral bands (Shortwave, Longwave, and Total) that will have the same overlapped point spread function (PSF) footprint on Earth. To ensure precise NIST-traceable calibration in space the RBI sensor is designed to use a visible calibration target (VCT), a solar calibration target (SCT), and an infrared calibration target (ICT) containing phase change cells (PCC) to enable on-board temperature calibration. The VCT is a thermally controlled integrating sphere with space grade Spectralon covering the inner surface. Two sides of the sphere will have fiber-coupled laser diodes in the UV to IR wavelength region. An electrical substitution radiometer on the integrating sphere will monitor the long term stability of the sources and the possible degradation of the Spectralon in space. In addition the radiometric calibration operations will use the Spectralon diffusers of the SCT to provide accurate measurements of Solar degradation. All those stable on-orbit references will ensure that calibration stability is maintained over the RBI sensor lifetime.
For the preflight calibration the RBI will view five calibration sources – two integrating spheres and three CrIS (Cross-track Infrared Sounder) –like blackbodies whose outputs will be validated with NIST calibration approach. Thermopile are the selected detectors for the RBI. The sensor has a requirement to perform lunar calibration in addition to solar calibration in space in a way similar to CERES instruments approach.

To monitor climate change and to get stable and traceable results, it is critical to assure stable calibration over instrument lifetime.
Exelis has been awarded a contract by NASA to build the Radiation Budget Instrument for JPSS-2.

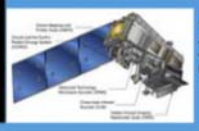
JPSS (Joint Polar Satellite System)

JPSS is a partnership between NOAA and NASA. It is the next generation polar-orbiting operational environmental satellite system and consists of five satellites: Suomi-NPP, JPSS-1, JPSS-2, FF-1(Free Flyer-1), FF-2 (Free Flyer-2).

JPSS implements US civil commitment inter-agency and international agreements to afford a 3-orbit global coverage (image credit: NOAA, NASA)



JPSS-1, a clone of the Suomi-NPP (also referred to as SNPP) satellite, image credit: NOAA, NASA.



Instruments on JPSS-1, (image credit: NOAA, NASA.)

NASA's Strategic Goals

Strategic Goal

Advance understanding of Earth and develop technologies to improve the quality of life on our home planet.

Objective:

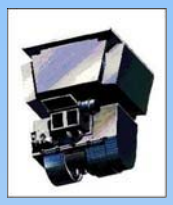
Advance knowledge of Earth as a system to meet the challenges of environmental change, and to improve life on our planet. Credit: NASA Strategic Plan 2014, pp.25.

Researchers in Langley's Science Directorate help advance our understanding of Earth's atmosphere and climate. Langley's Atmospheric Science Data Center houses the world's most comprehensive collection of atmospheric data. A series of instruments developed by LaRC for NASA's Earth Observing System, known collectively as the Clouds and the Earth's Radiant Energy System mission, or CERES, is a source of information about global climate. This is among several Earth observation projects that LaRC is leading.

Earth is changing on all spatial and temporal scales. The purpose of NASA's Earth science program is to develop a scientific understanding of Earth's system and its response to natural or human-induced changes and to improve prediction of climate, weather, and natural hazards.

Clouds and the Earth's Radiant Energy System (CERES)

CERES instruments are now collecting data on three separate satellite missions, including the EOS Terra and Aqua observatories and now also on the Suomi National Polar-orbiting Partnership (S-NPP) observatory. CERES FM 6 will fly on the JPSS-1 spacecraft. The Radiation Budget Instrument (RBI) is the CERES follow-on sensor and is scheduled to fly on the JPSS-2 satellite mission.

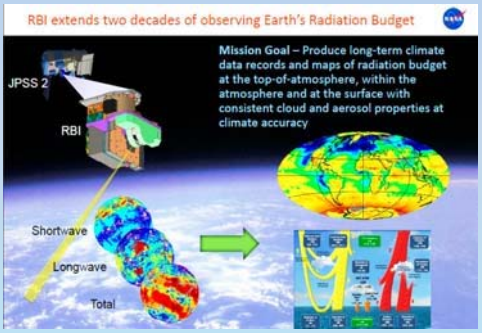


http://ceres.larc.nasa.gov/index.php
image credit: NASA

The CERES instrument has three channels -- a shortwave channel to measure reflected sunlight, a longwave channel to measure Earth-emitted thermal radiation in the 8-12 μm "window" region, and a total channel to measure all wavelengths of radiation. Onboard calibration sources include a solar diffuser, a tungsten lamp system with a stability monitor, and a pair of blackbodies that can be controlled at different temperatures.

RBI Instrument, image credit: EXELIS

Similarly, the RBI instrument has three channels – shortwave, longwave, and total. It will have an on-orbit calibration system to facilitate detection of responsivity changes in each channel. The system includes an Infrared Calibration Target, Solar Calibration Target, and Visible Calibration Target with diode lasers.



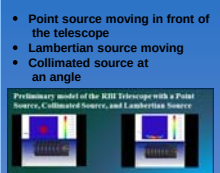
RBI Instrument on JPSS-2, image credit: EXELIS

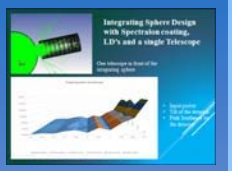
The definitions for the radiometric measurements for RBI instrument are specified according to NIST evaluation of measurements data guide which gives an expression of uncertainties – type A and type B evaluation of standard uncertainties, combined standard uncertainties, and expanded uncertainties as well as appropriate coverage factors (NIST technical note 1297).

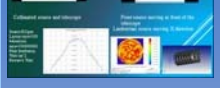
Models and measurements

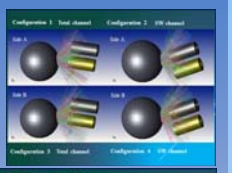
ZEMAX MODELS:

- Point source moving in front of the telescope
- Lambertian source moving
- Collimated source at an angle

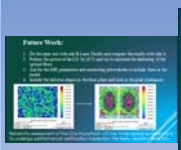


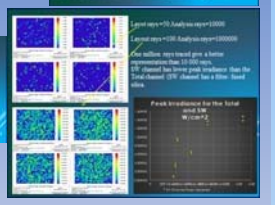






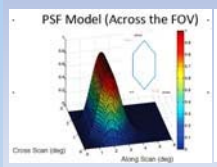
The two telescopes: SW and Total are rotating in front of the integrating sphere (Visible calibration target (VCT))

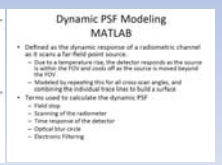




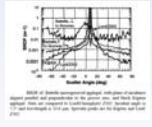
MATLAB MODELS:

- Point spread function (PSF)





Low reflectivity "black" surfaces have a number of applications for space-borne instruments. They are used in telescope housings and baffles where stray light reduction is vital. Reflectivity measurements have been done on Z 302 paint coupons.



Data are from paper "Review of black surfaces for space-borne infrared systems", by M. J. Persky, Lincoln Laboratory. Similar measurements have been done in the lab for Z 302 paint coupons. The actual data cannot be presented because of EAR, and ITAR regulations.

CONCLUSIONS

RBI is a new instrument with a very advanced design – it has new filters, new detectors, new calibration targets. In order to maintain continuity with CERES data we will carefully model every module and component and make sure the performance will be as expected.

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