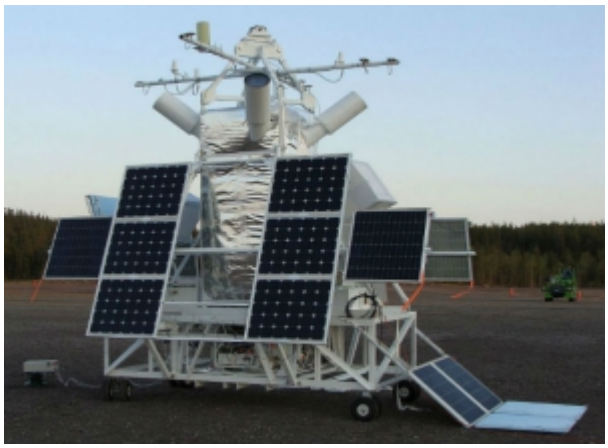
Solar Irradiance CubeSat Using Avantes Spectrometer for Test Flight



The University of Colorado, Boulder project for Research at high-Altitude on Distributed Irradiance Aboard an iNexpensive CubeSat Experiment (RADIANCE), sponsored by the University Corporation for Atmospheric Research (UCAR) is preparing for a two-week test flight aboard the Arctic HiWind Gondola.

RADIANCE Project

The CU Bachelor's program in Aerospace Engineering offers senior students the opportunity to work on projects for real world customers. The RADIANCE project was proposed by the High-Altitude Observatory (HAO), part of the National Center for Atmospheric Research (NCAR). The RADIANCE team, lead by Engineering Fellow, Jenny Kampmeier was selected from among the aerospace engineering student applicants.

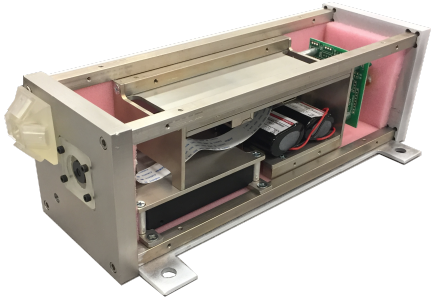
The purpose of the RADIANCE project is to develop a 3U CubeSat prototype made entirely of commercial off-the-shelf (COTS) components. The ultimate goal is to develop the means to provide climate scientists with reliable continuous solar irradiance data using CubeSats that are inexpensive and easy to mass produce and calibrate.

Maintaining a continuous record of solar irradiance data is important to climate scientists studying the effects of solar radiation on Earth's climate. The available historical record of irradiance data dates to November 1978 with the launch of the Nimbus-7 spacecraft, but funding and development delays, launch schedules, and even instrument failure have led to gaps in the record.

Additionally, current methods for measuring solar irradiance using active cavity electrical substitution radiometry and involve massively funded space missions such as the TIM instrument aboard the NASA SORCE spacecraft. Each previous irradiance instrument is unique and developed by different agencies, thus calibration can vary widely. For this reason, even available data is inconsistent.

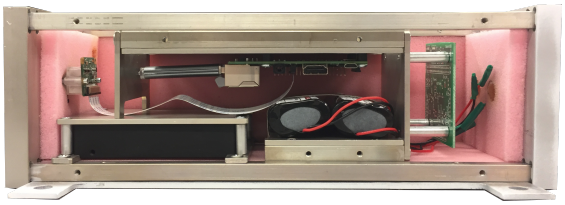
Design Challenge

The 3U CubeSat programgives scientists and researchers the means to deploy a standardized payload on a space flight mission. The 3U payload, where one "U" represents 1000cm3, measures 10cm x 10cm x 30cm and must house the full complement of sensors, power supply, data handling, and command processor for deployment on the HiWind Gondola flight.



In addition to strict weight and size limitations, this project also required the use of commercially available off the shelf parts within an equally strict budget. Other constraints notwithstanding, operational requirements would still need to be met.

The environmental conditions aboard the HiWind Gondola require the team to include thermal systems to maintain operational conditions during ascent, descent and during the flight itself. In addition to irradiance measurements, and still solar images, the RADIANCE CubeSat will also collect other environmental data, like temperature and humidity, and record attitude by measuring the off-sun angle.



The primary goal of the RADIANCE project, of course, is to gather valuable solar irradiance measurements. The minimum criteria for success is to obtain wide-spectra measurements between 250-1000nm at the rate of 1 spectra/ minute during the duration of the flight. The ability to perform wide-spectrum irradiance measurements, within all of the other limitations and parameters, was centered around the choice of spectrometers.

Spectrometer Selection

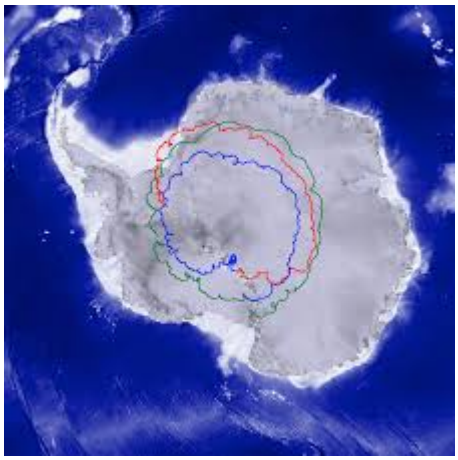
Through peer recommendation and research, the RADIANCE team discovered Avantes spectrometers. Working closely with Damon Lenski, General Manager of Avantes, Inc., the RADIANCE team selected the AvaSpec-MINI which has a back-thinned CCD linear array 2048 pixel detector and provides resolution up to 0.1 nm. The team was initially drawn to the Mini because of the price. “We had a budget of $5000 to complete the entire project.” Project Member, Jeremy Muesing says, “Other companies that produce spectrometers small enough to fit inside our form factor quoted prices outside our budget.”

While it may have been price considerations that initially led the team to select the Avantes’ AvaSpec-MINI spectrometer, the team has been more than pleased with the performance of the instrument. The project scope required irradiance spectra measurements in the 250-1000nm range, but the MINI delivers the full range of UV/VIS spectra of 200-1100nm. “We are getting a slightly larger range, and our customer is always happy whenever we can provide more scientific data,” Muesing says.

The Mini weighs just 174g and is roughly the size of a deck of cards (94.5x67x19.5mm), making this ultra-low stray light device easily integratable. The RADIANCE team also took advantage of Avantes’ demo program for code development and worked closely with Avantes engineers to perfect calibration and integration of the AvaSpec-Mini.

Arctic HiWind Gondola Mission

The 3U CubeSat RADIANCE project passed design review and has a prototype now in testing. The final phase of this project will be to deploy this 3U payload during a 2-week circumpolar high-altitude balloon flight aboard the HiWind Gondola, circling the Antarctic continent at an altitude of 40 km.



To meet project requirements, the payload is expected to tolerate and operate in adverse environmental conditions during ascent, flight, and descent, survive landing, and operate on power independent of the HiWind Gondola. It shall record solar irradiance data at greater than the required 1 nm resolution (AvaSpec-MINI achieves resolution of 0.1nm), and exceeding the 250-1000nm spectrum target. The RADIANCE CubeSat will also store all collected spectra and ambient environmental data on a durable data storage device for easy retrieval.

This highly anticipated maiden flight for the RADIANCE CubeSat is scheduled to take place Winter of 2017-2018 and will mark the completion of this phase of the RADIANCE project.

RADIANCE Path to Space

The HiWind RADIANCE deployment appears on track to exceed expectations. Encouraged by the apparent progress of the CU design team in developing mass-producible Irradiance CubeSats using commercially available components, HAO and NCAR already have plans to continue development for space-readiness.

The path to space will not be without its own challenges, however. The thermal system for a space ready RADIANCE CubeSat will need to be reconfigured to cool the instrument, and direct heat away from the payload rather than heat the instrument during ascent. A space payload would additionally need to incorporate at least three reaction wheels to control attitude, an adjustment controlled by the HiWind during high altitude testing.

Nonetheless, the sponsors of the RADIANCE project seem likely to have favorable results in the next phase of development of a lost cost solar irradiance measurement standard and toward a future in which solar irradiance data will be complete and accessible for future climate research.

Avantes is a Proud Advocate of Climate Research

To learn more about this or other irradiance applications or to discover the capabilities of Avantes' OEM integrations contact your local distributor or sales engineer today. You might just find out why Jeremy Muesing of the RADIANCE team said "Working with Avantes was incredible! I cannot tell you how many times we've had conversations about what a great manufacturer Avantes is. We were impressed by how responsive their sales and support team was in our interactions. They have gone above and beyond helping us with this project."