Radiation Dosimetry Experiment (RaD-X): High-Altitude Balloon Flight Mission for Improving the NAIRAS Model

Christopher J. Mertens¹, Erica J. Alston¹, Tore Straume², Brad Gersey³, Terry C. Lusby², Ryan B. Norman¹, Guillaume P. Gronoff⁴, W. Kent Tobiska⁵, and Rick Wilkins³

¹NASA Langley Research Center, ²NASA Ames Research Center, ³Prairie View A&M University, ⁴Science Systems and Applications, ⁵Space Environment Technologies

NAIRAS Model

- NASA Nowcast of Atmospheric Ionizing Radiation for Aviation Safety (NAIRAS) Model
  - Prototype operational model
  - Running in real-time at the NASA Langley Research Center since April 2013
- Distinguishing Features
  - Real-time physics-based, deterministic, global model
  - Real-time inclusion of both galactic cosmic radiation (GCR) and solar energetic particle (SEP) radiation
  - Real-time solar-magnetospheric effects on geospace radiation environment
  - Real-time meteorological data (NCEP/GFS)

RaD-X Science

Goals and Objectives

- **Goal 1**: Improve NAIRAS model by characterizing energy deposition of cosmic ray primary (CR) particles
  - **Objective 1**: Measure dosimetric quantities in the upper atmosphere above the Pfotzer maximum to isolate CR primaries
  - **Objective 2**: Utilize dosimeters that can isolate proton and heavy-ion CR primaries and atmospheric neutrons
- **Goal 2**: Identify low-cost atmospheric radiation dose measurement solutions for global, continuous monitoring
  - **Objective 3**: Characterize the relationship between silicon-based dosimetric measurements and radiobiological response

High-Altitude Measurements

Taking data at high altitude above the Pfotzer maximum provides a direct measurement of CR primaries, permitting the separations of discrepancies due to source uncertainties from discrepancies caused by the ensemble of complex physical processes at aircraft flight altitudes

- The radiation environment in the upper atmosphere above the Pfotzer maximum is a large source of uncertainty for radiation exposure at aircraft flight altitudes (Lindborg et al., 2004)
- Model/measurement comparisons at aircraft altitudes point out discrepancies, but do little to reveal a causal source of discrepancy due to variation in composition and energy of the radiation environment with atmospheric depth

Instrument Selection

The choice of dosimeters was motivated by:
- Ability to separate CR primary protons and heavy-ion contributions by combining measurements at two float altitude regions (Region-A and Region-B shown below)
- Viable low-cost dosimeters for continuous, global monitoring of radiobiological response (direct measurement or empirical fit)

- **TEPC**: Industry standard microdosimeter provides radiation protection (operational) dose measurement, which is defined as ambient dose equivalent [ICRU, 2010; ISO, 2012].
- **Liulin**: Silicon-based LET spectrometer that permits identification of protons at Region-A and separation of heavy-ion contributions at Region-B.
- **TID**: Teledyne total ionizing dose (TID) detector that is mostly sensitive to charged particles at RaD-X altitudes. Viable silicon-based dosimeter for continuous, global radiation monitoring. Requires empirical fit to TEPC ambient dose equivalent to characterize radiobiological response.
- **RaySure**: Viable silicon-based microdosimeter “emulator” which is easy to manufacture. Internal calibration directly computes ambient dose equivalent.

POC: Christopher.J.Mertens@nasa.gov

RaD-X Mission

Mission and Instrument Parameters

- **Platform**: High-Altitude Balloon
- **Launch Site**: Fort Sumner, NM
- **Mission Duration**: 24-hours
- **Temporal Sampling**: 1-5 minutes
- **Launch Readiness Date**: September 2015
- **Instruments**: (1) TEPC, (2) Teledyne TID dosimeter, (3) Liulin LET spectrometer, and (4) RaySure microdosimeter emulator
- **Measurement Uncertainty**: < 30%
- **Instrument TRL**: All components TRL 6 or higher

Concept of Operation

Science Payload and Gondola

Milestones and Science Activities

- **Project Milestones**
  - Selection Conference (08/20/2013)
  - Kickoff (10/31/2013)
  - SRR: Systems Requirements Review (02/19/2014)
- **Near-Term Science Activities**
  - Modeling instrument and radiation shielding environment (05/2014)
  - PDR: Preliminary Design Review (05/2014)
  - Dosimeter Beam Test and Calibration (08/2014)