Radiation Data Portal: Enhancing Data Discoverability and Analysis for Understanding Space Radiation in Earth Environment

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Introduction to Radiation Data Portal

The impact of radiation dramatically increases at high altitudes in the Earth's atmosphere and in space. Therefore, monitoring and access to radiation environment measurements are critical for estimating the radiation exposure risks of aircraft and spacecraft crews and the impact of space weather disturbances on electronics. Addressing these needs requires reliable access to multi-source radiation environment data and enhanced visualization and search capabilities. The Radiation Data Portal provides an interactive web-based application for convenient search and visualization of in-flight radiation measurements.

Access the Radiation Data Portal at https://data.nas.nasa.gov/helio/portals/rdp/ or use a QR-code above

Radiation Portal Data Sources:

- The Automated Radiation Measurements for Aerospace Safety (ARMAS) data, augmented with the integrated flight parameters and environment. The ARMAS project utilizes a micro-dosimeter integrated into a data processing and communication package to measure and report the absorbed dose rates at a one-minute cadence. ARMAS data are publicly available from Space Environment Technologies (SET, (https://sol.spacenvironment.net/ARMAS_Archive/).
- GOES Soft X-ray (SXR) radiation in the 0.5-4 Å and 1-8 Å channels. The Radiation Portal currently uses calibrated 1-min averaged GOES fluxes available from the National Oceanic and Atmospheric Administration National Centers for Environmental Information archive (NOAA NCEI, https://satdat.ngdc.noaa.gov/). Each measurement during the flight is connected to the nearest-time SXR measurement.
- Integrated GOES proton flux measurements. The Portal utilizes 5-min integrated calibrated measurements of the proton fluxes above the 1 MeV - 100 MeV also available via the NOAA NCEI archive (https://satdat.ngdc.noaa.gov/). Each measurement during the flight is connected to the closest-in-time GOES measurement.

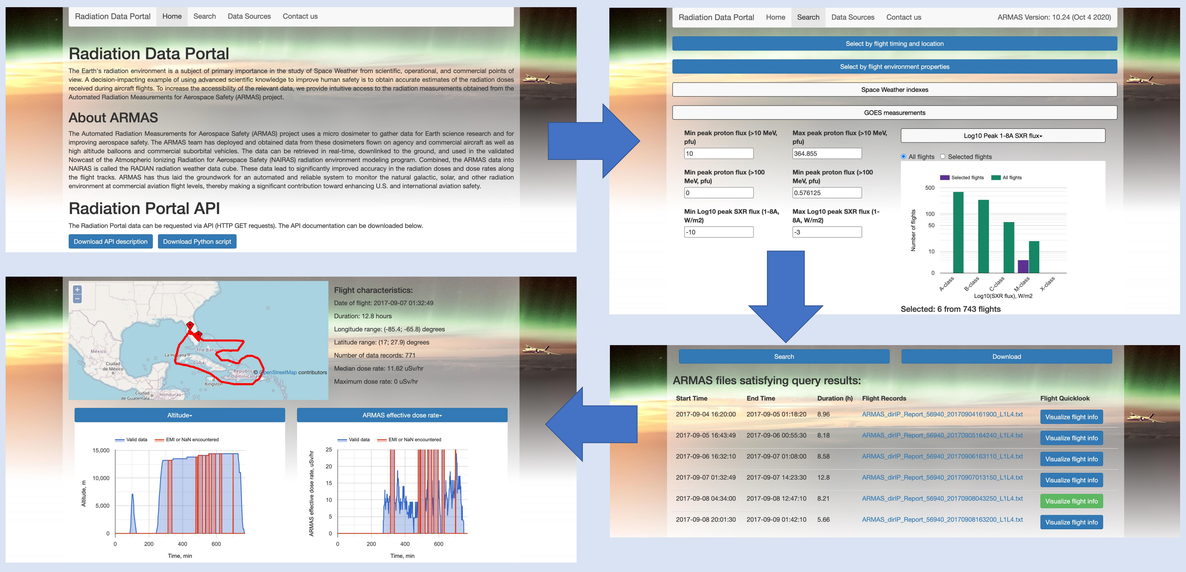

Figure 1. *Illustration of the Radiation Data Portal web application, from the portal home page to the flight query result.*

Radiation Data Portal Features:

- The data sources are loaded to a MySQL relational database. The database structure is optimized for fast data retrieval.
- The Application Programming Interface (API) and Python routines have been developed to retrieve the database records directly, without interaction with the web interface.
- The application search engine contains a variety of filters (flight location and timing, environmental and dosimetric properties) allowing a user to customize flight selection.
- The search process and flight summary are supported by dynamic histograms of the flight parameters implemented with the Google Charts API and OpenLayers map API.

Expansion of Radiation Data Portal

Within the NASA HITS 2022 program grant, we are expanding the portal. Our specific goals are:

- Inclusion of additional radiation measurement sources (NASA ACE & DSCOVR, NASA CDAWeb geomagnetic activity data, ground-based neutron monitor measurements, measurements of cosmic ray muons, etc.). The entity relationship diagram is presented in Figure 2.
- Expansion of ARMAS flight data catalog and enhancement of NAIRAS dose rate modeling by using run-on-request flight trajectory tool
- Adaptation of the existing data visualization capabilities to the new data sets and improving the search engine
- Creation of the ML-ready data set for in-flight radiation prediction

We envision that the Radiation Data Portal will enhance our knowledge about solar-terrestrial interactions and Space Weather and that it will grow into a comprehensive collaborative effort involving many sides of our diverse community.

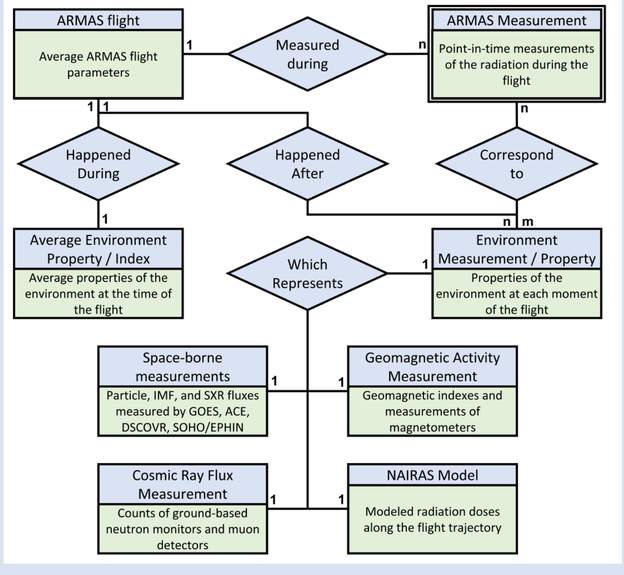

Figure 2. *The entity relationship diagram of the enhanced Radiation Data Portal*

Analysis of Radiation Measurements in Earth Atmosphere

ARMAS Measurements During an Enhanced Solar Proton Environment

- There are six ARMAS flights that occurred during Solar Proton events (SP-enhanced conditions). An SP event is defined as an increase of the >10 MeV proton flux above the 10 pfu (particle flux unit) level.
- All SP-enhanced flights were performed in September 2017 in a confined geographic region. We collected the flights that happened in the same region during September 2016 – September 2018 when no SP events were observed (SP-low group).
- The Student's and Welch's t-tests demonstrate that there is no statistically-significant difference between the ARMAS/NAIRAS* ratios and median effective dose rates for SP-enhanced and SP-low groups of flights (see Figure 3 for distributions). *NAIRAS: Nowcast of Aerospace Ionizing Radiation System.
- Possible explanations: 1) most of energetic protons were in the low-energy tail and did not penetrate deep into the atmosphere; 2) the data-driven NAIRAS model captures much of what ARMAS is measuring.

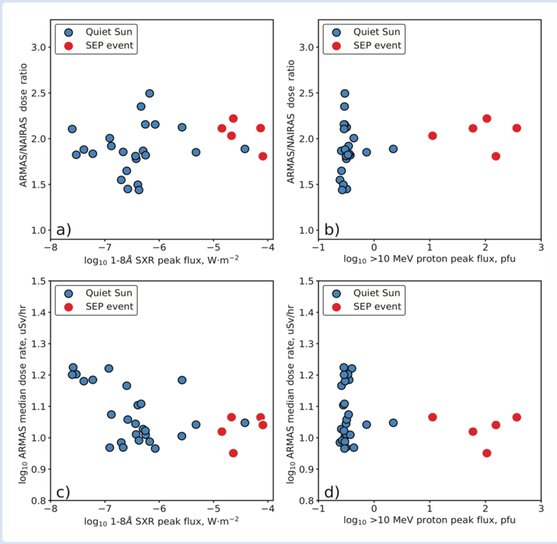

Figure 3. *Correlations between the total dose ratios of ARMAS to NAIRAS to X-ray flux (panel a) and proton flux above 10 MeV (b). Dependence of the ARMAS median effective dose rate from the X-ray flux (panel c) and proton flux above 10 MeV (d).*

Statistical Analysis of ARMAS measurements

- Our goal is to perform a statistical analysis of the measured ARMAS dose rates and compare them with the predictions of the NAIRAS v1 model at different locations (geomagnetic latitudes and altitudes) and states of solar and geomagnetic activity (geomagnetic indexes and solar cycle phase)
- Our preliminary results indicate that the disagreements between the NAIRAS v1 model and ARMAS data increase at lower geomagnetic latitudes (Figure 5) and vary with the solar cycle phase (Figure 7). The disagreement also typically increases with the height.

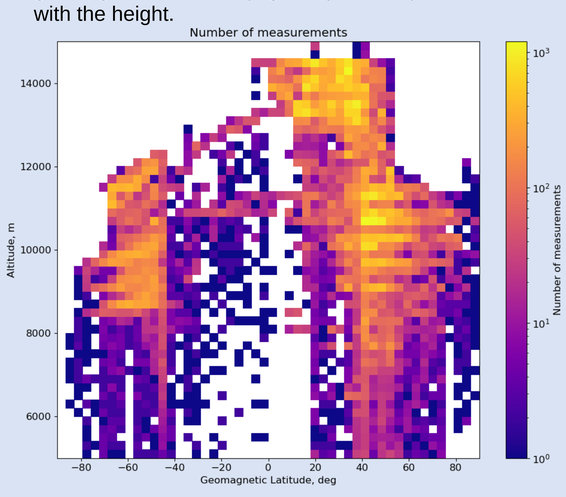

Figure 4. *Coverage of ARMAS data by geomagnetic latitude and altitude (2013-2020).*

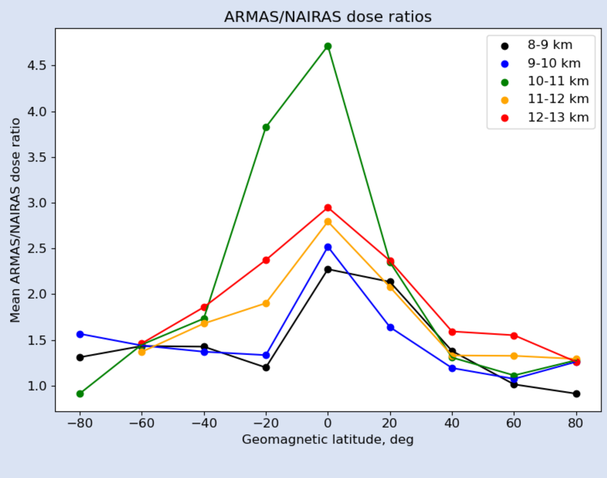

Figure 5. *Mean ARMAS / NAIRAS v1 dose ratios as functions of the geomagnetic latitude.*

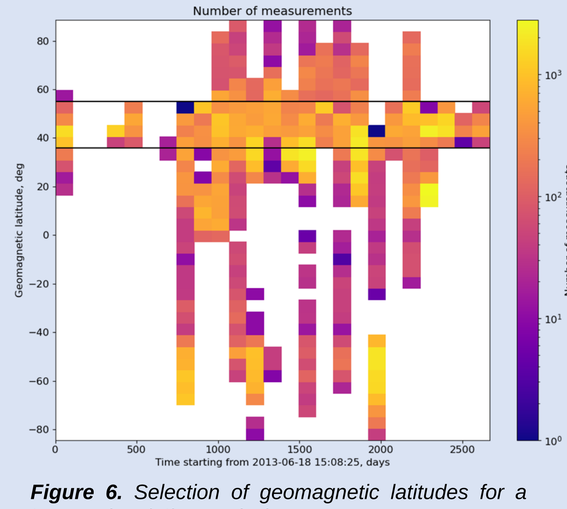

Figure 6. *Selection of geomagnetic latitudes for a temporal variation analysis.*

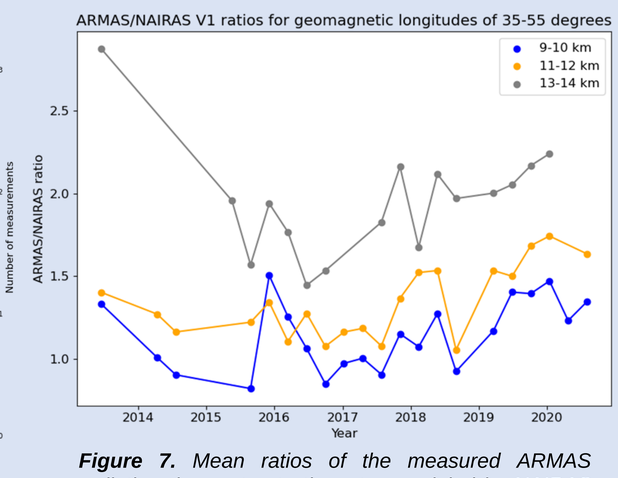

Figure 7. *Mean ratios of the measured ARMAS radiation dose rates to the rates modeled by NAIRAS v1 at geomagnetic latitudes of 35-55 degrees as functions of height and time.*

Acknowledgements

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