Impact of the May 2024 Gannon Storm on Low Earth Orbit dosimetric quantities

comparisons of the NAIRAS model –real time and re-analysis– with ISS data

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Abstract

The solar storm of May 2024, the Gannon storm, led to a display of aurora over the globe. One of the less known effects of that storm is on the radiation doses in low-Earth orbit: it first led to a Forbush decrease in dose rates. After that, a Solar Energetic Particle (SEP) event increased the total dose suffered near the international space station.
The Nowcast of Aerospace Ionizing RAdiation System (NAIRAS) model predicts dosimetric and radiative flux quantities for assessing human radiation exposure levels and radiation effects on flight electronic systems from the surface of the Earth to deep space. It runs in near-real-time at the CCMC, but also has a run-on-request that allows for a more precise computation thanks to carefully processed data. NAIRAS was able to compute the effects of the Gannon storm at the ISS in real-time and provide ideas of the doses encountered by the astronauts and the experiments in and outside of the station. In this work, we show the simulations of the doses encountered during the storm and compare them with several measurements at the ISS.
This work shows the capabilities of NAIRAS to address the problem of the SEP events at low Earth orbit and its real-time capabilities.

I - The Nowcast of Aerospace Ionizing RAdiation System (NAIRAS) Model

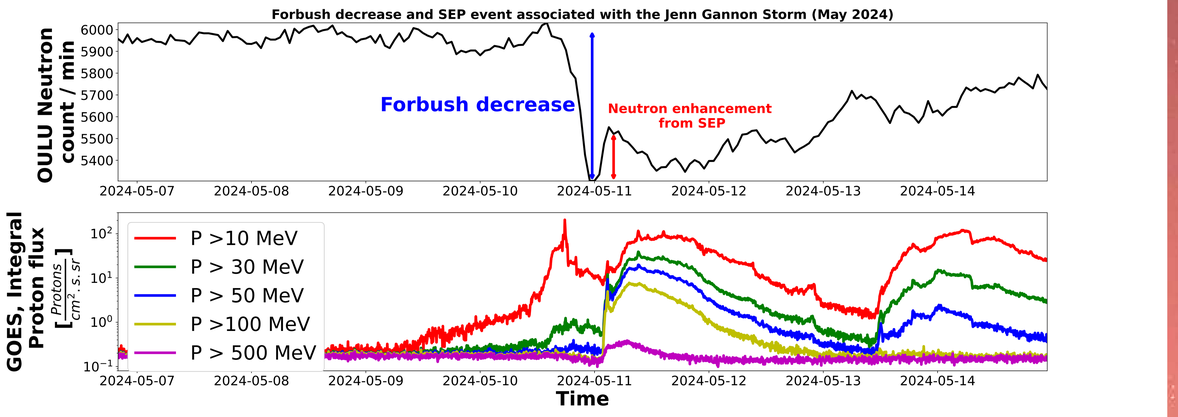
- Global ionizing radiation environment model [4]
- Physics-based HZETRN (High Charge (Z) and Energy TRaNsport)
- Real-time solar-magnetospheric effects on radiation (cutoff model[2])
- Realtime view at CCMC https://bit.ly/NAIRAS-products

Real-time: Run-on-Request:

New Improvements

- Improved SEP dose nowcast and forecast
- Extend to low-Earth orbit (LEO) environment
- Single-Event Effects (SEE) radiation risk assessment quantities
- Run-on-Request (RoR) @ CCMC
- Real-time and historical capabilities for Run-On-Request [3, 5]

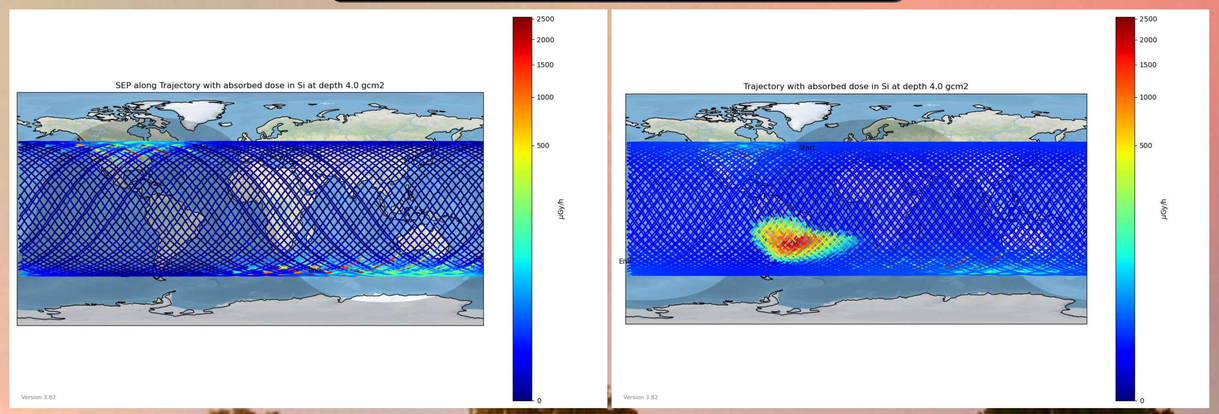
II - The Gannon Storm



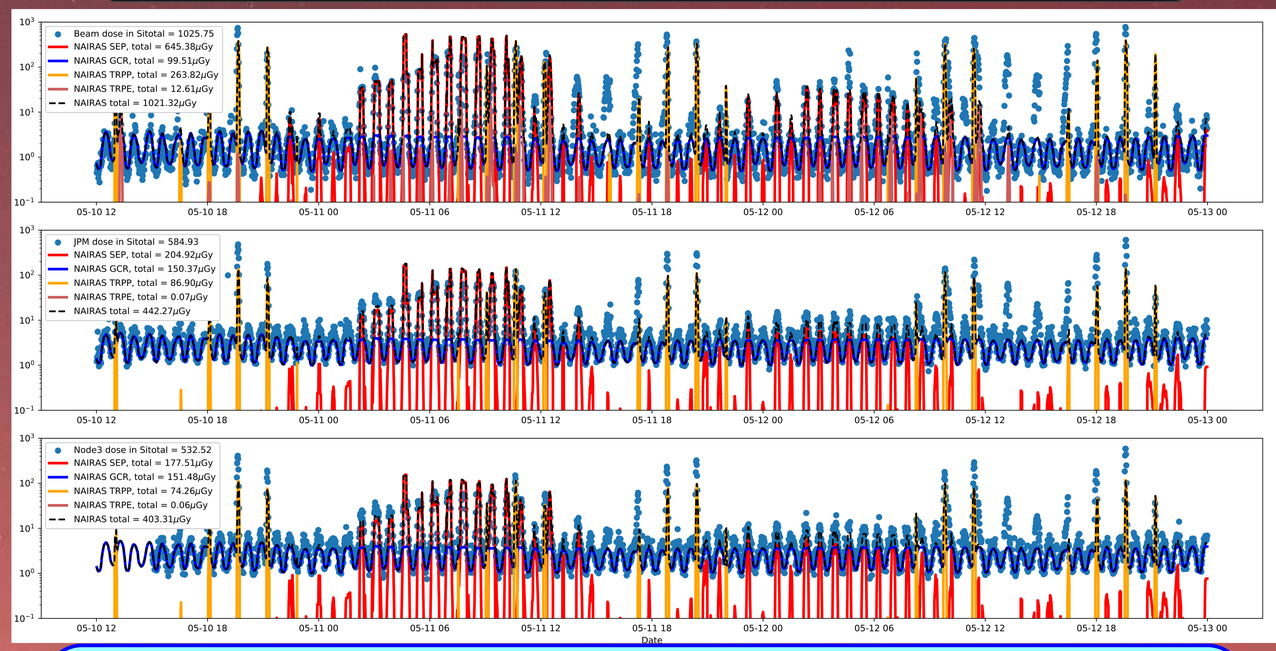
- Ganonon storm
- SEP event: see fitting of the GOES data with NAIRAS at the Mertens et al and Phoenix et al. posters!
- NAIRAS simulates both the SEP and the trapped particles at ISS location

Animations of the Gannon storm and the SEP event with NAIRAS: effects on the cutoff rigidity and the dose

III - Modeling the ISS dose: SEP-only and Total

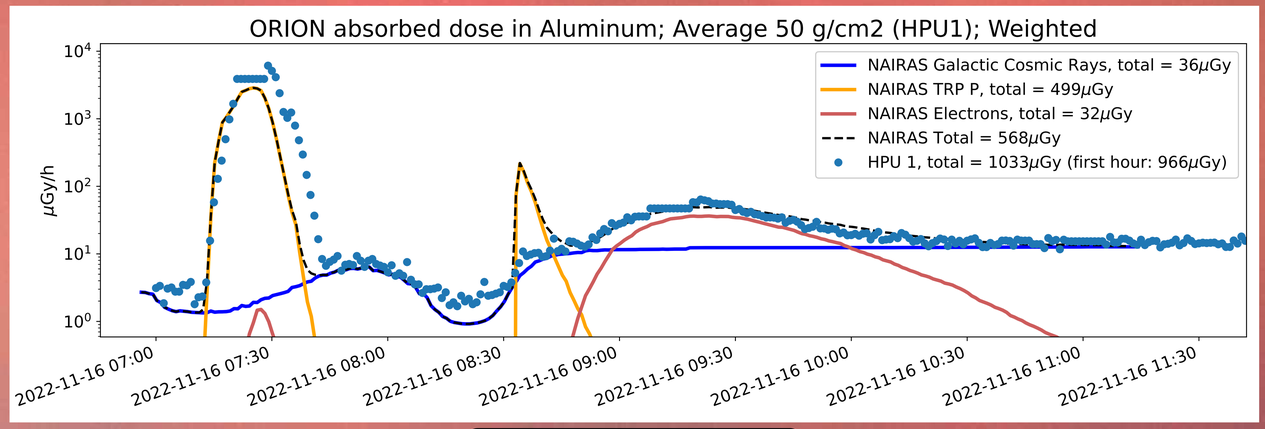


IV - Comparison with ISS data: validation of SEPs observations, trapped particles, and GCR



- NAIRAS provides the GCR, trapped protons/electrons, and SEP dose
- The dosimeters are located in 3 different ISS modules: Beam, JPM, and Node 3
- Each module has an average shielding depth (≈4 g/cm^2 for Beam, and ≈20 g/cm^2 for the others)
- NAIRAS can approximate the dose for each module
- Low shielding depth means high trapped particles dose
- High shielding depth means high GCR dose
- The real dose is a combination of both. The average shielding depth is not enough to estimate the dose
- A fitting of the different shielding computations to the measurements is necessary when no cumulative shielding distribution is available

BONUS - Comparison with ARTEMIS 1 [1]



Discussion and Conclusion

- NAIRAS is able to nowcast and re-analyze spacecraft operations
- Near real-time analysis of the ISS during the Gannon storm was performed
- Excellent comparison with the measurements for the SEP event
- Differences due to radiation belt model and shielding estimation
- The run-on-request allows to compute the dose for past an present space missions
- Estimation of dose of crew and instrument from near space up to free space thanks to trapped particle model
- NAIRAS is also used to compute dose in airplane

References

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