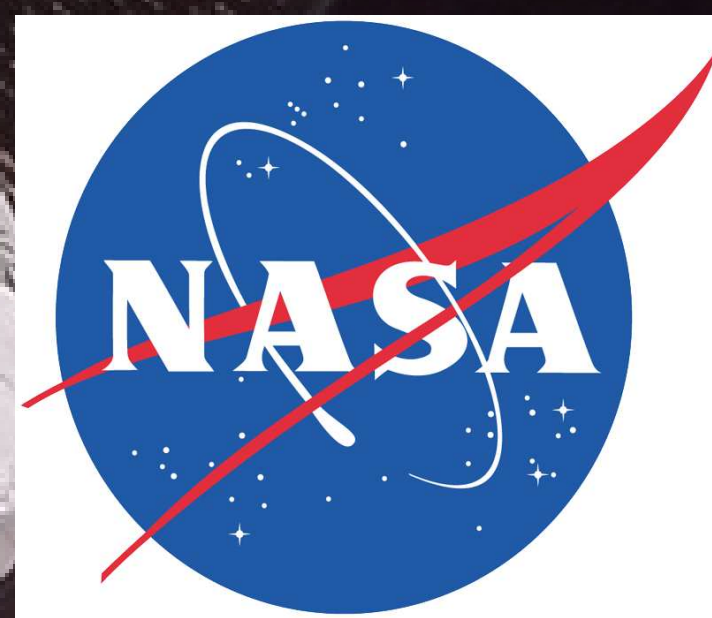




Comparison of the Nowcast of Aerospace Ionizing Radiation System (NAIRAS) with ISS measurements

Effects of Trapped Particles and Solar Energetic Particle Events

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Abstract

The Nowcast of Aerospace Ionizing Radiation System (NAIRAS) is a sophisticated physics-based model that has been providing real-time global predictions of cosmic radiation exposure, pertinent to both galactic and solar sources, to air travelers for a decade. The utility of NAIRAS, however, extends beyond the atmospheric ionizing radiation environment. The recently developed NAIRAS 3.0 version demonstrates an expansion of its domain to the space radiation environment. This extension incorporates an additional trapped inner belt proton source, coupled with altitude-dependent and rigidity-dependent geomagnetic shielding for galactic cosmic rays (GCR) and solar energetic particle (SEP) protons. The latest version of NAIRAS operates in two modes: real-time global predictions of the atmospheric radiation environment and a user-specified run-on-request service for global dosimetric calculations or predictions of dosimetric and particle flux quantities along user-uploaded flight path. It is available to the public at the Community Coordinated Modeling Center (CCMC). In this work, we present the validation exercises that have been conducted using the Automated Radiation Measurements for Aerospace Safety (ARMAS) onboard the International Space Station (ISS), thereby establishing NAIRAS's efficacy in predicting space radiation exposure. As such, NAIRAS 3.0 holds significant potential for human safety and technological advancement in aerospace travel and exploration.

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

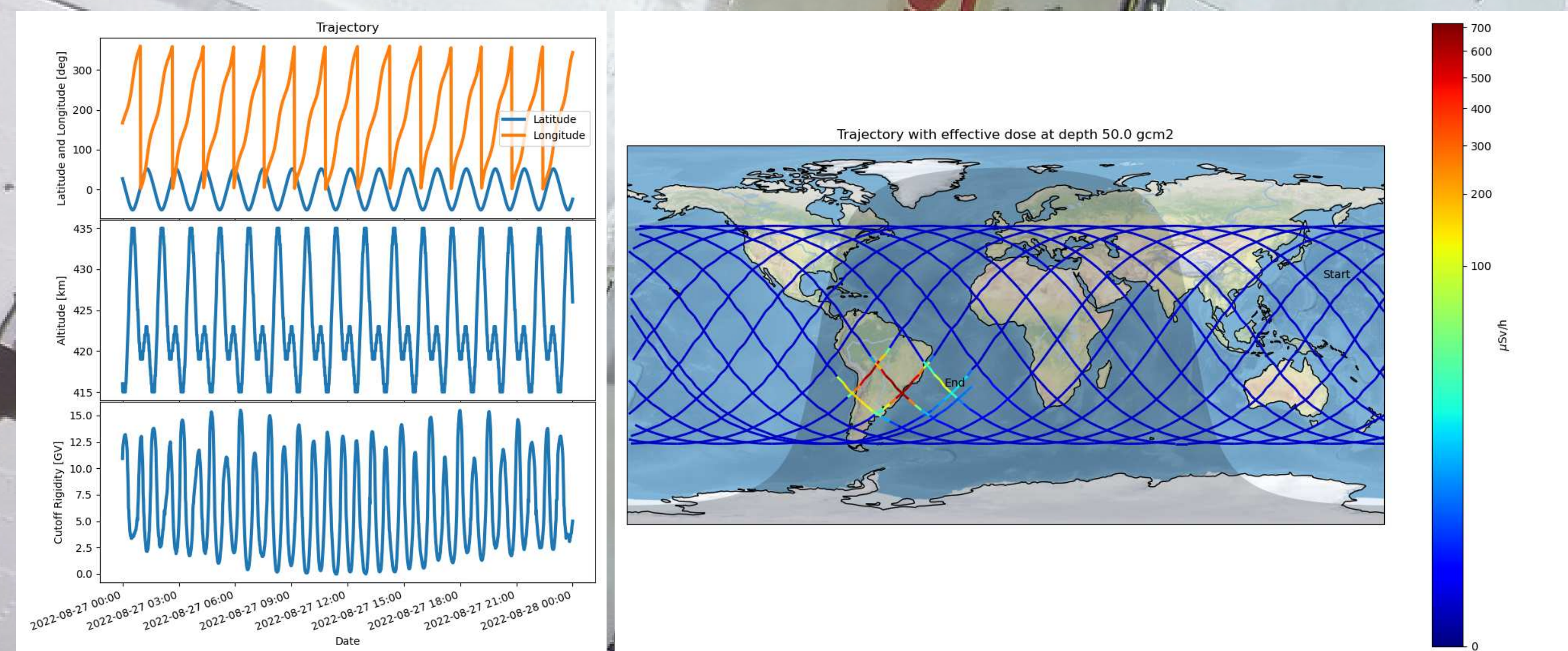
- Global ionizing radiation environment model [4]
- Physics-based HZETRN (High Charge (Z) and Energy TRAnsport)
- Real-time solar-magnetospheric effects on radiation (cutoff model[1, 2])
- Realtime view at CCMC <https://bit.ly/NAIRAS-products>

New Improvements

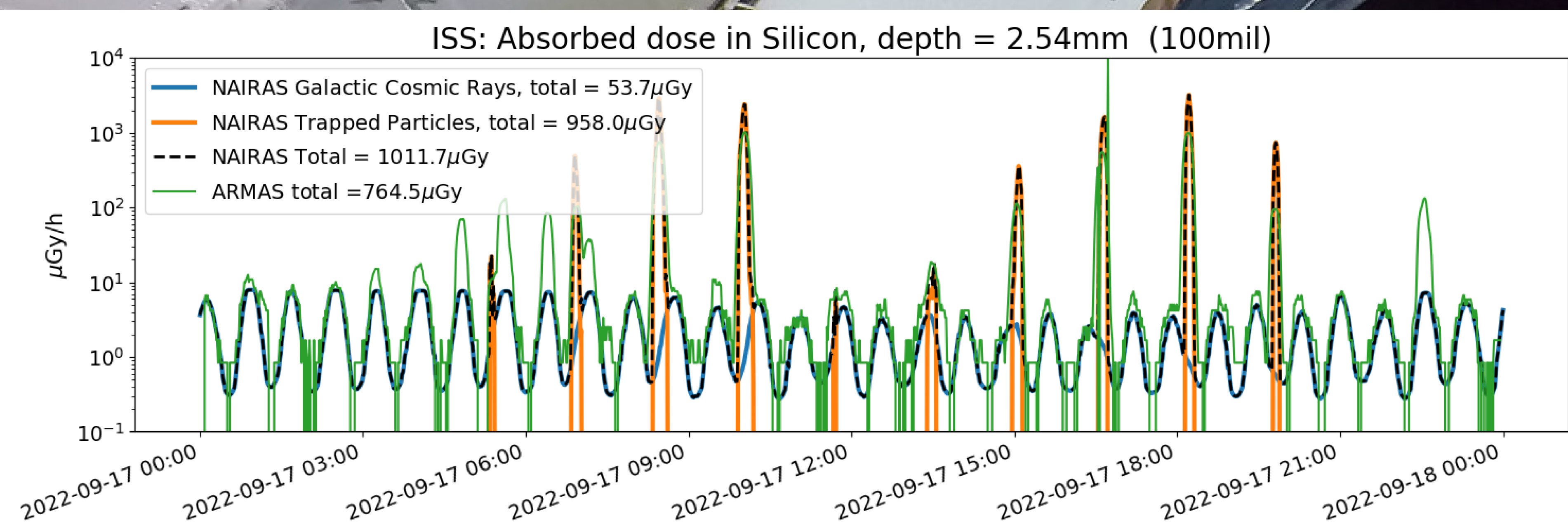
- Improved SEP dose nowcast and forecast
- Extend to low-Earth orbit (LEO) environment
- Single-Event Effects (SEE) radiation risk assessment quantities
- Run-on-Request (RoR) @ CCMC
- Real-time and historical capabilities for Run-On-Request [3]

Real-time:  Run-on-Request: 

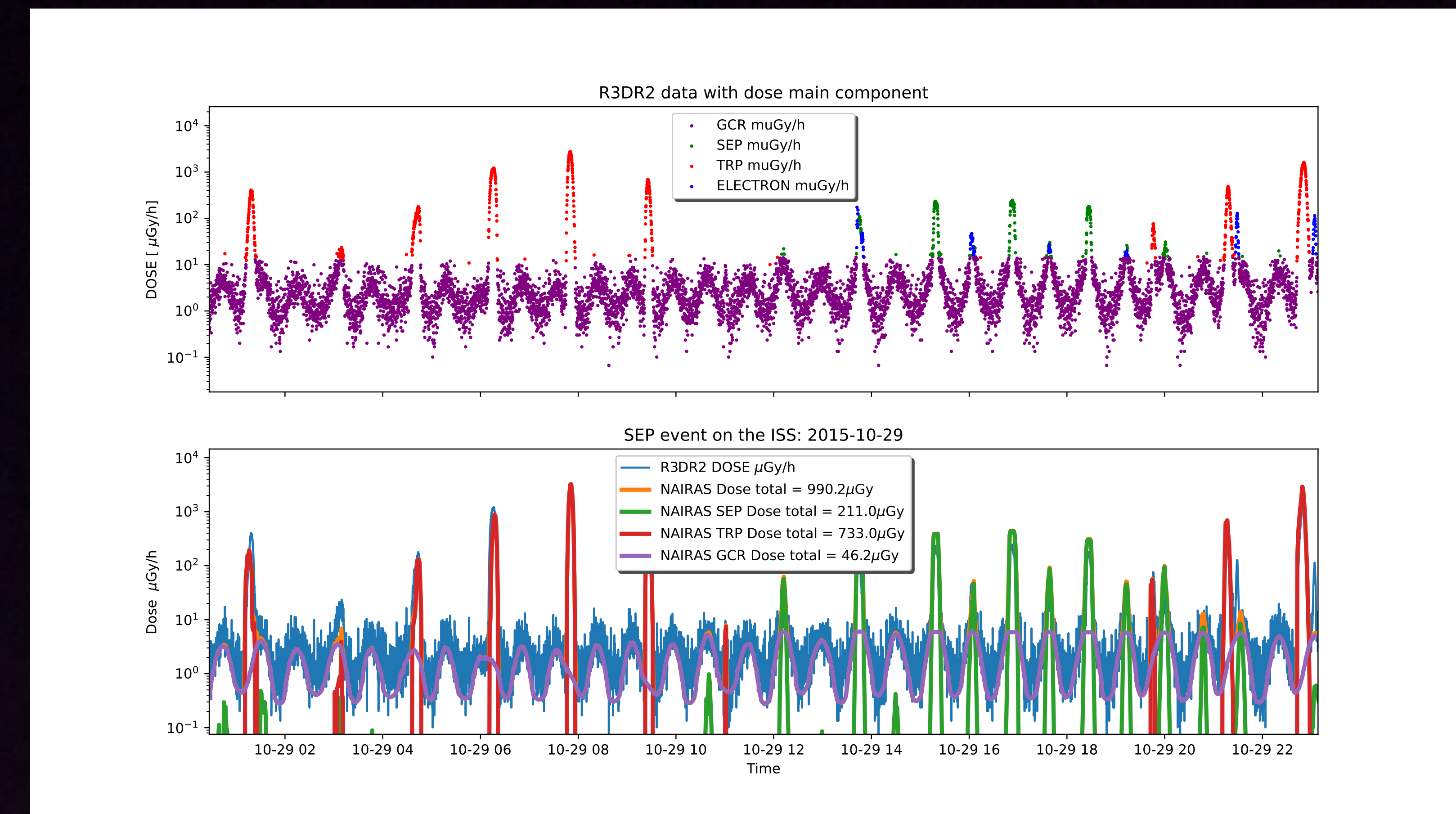
II - Space trajectory: ISS



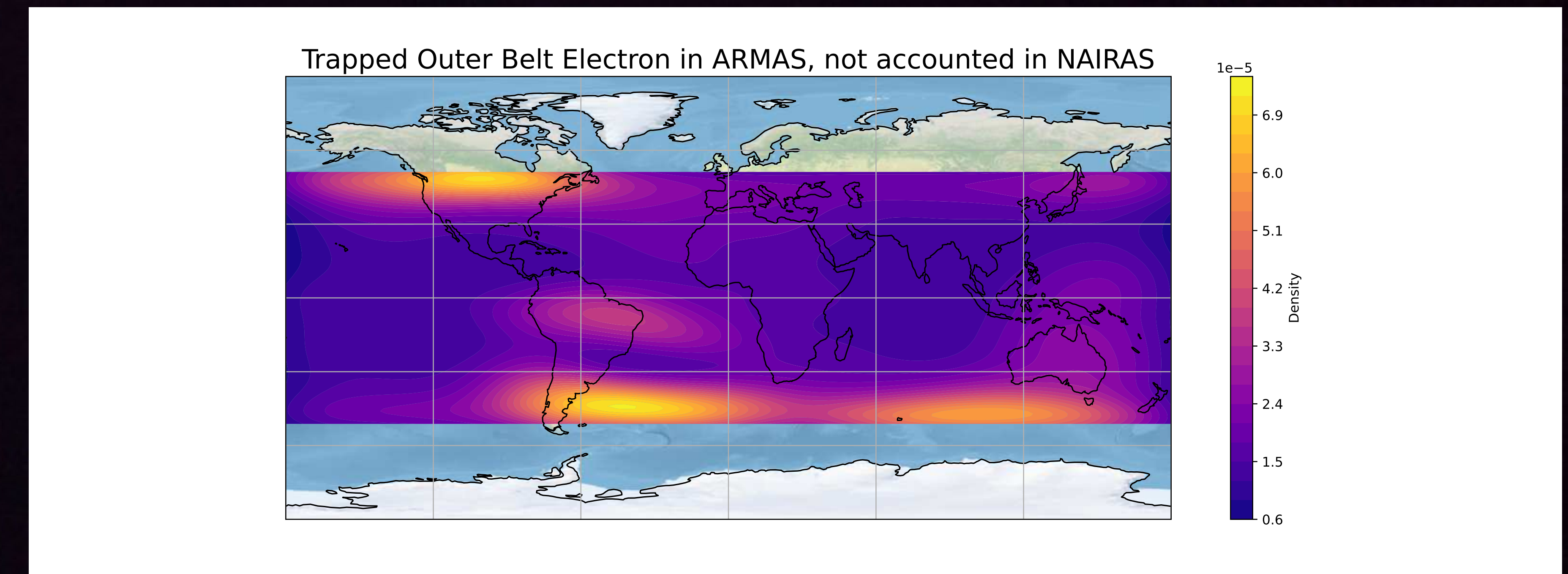
III - Comparison with ARMAS onboard the ISS



IV - Comparison with R3DR2 (Liulin) onboard the ISS: validation of SEPs observations



V - Main source of uncertainty in the current version: the outer radiation belt (electrons)



Discussion and Conclusion

- NAIRAS is able to nowcast and re-analyze spacecraft operations
- Near real-time analysis of the Artemis-1 mission was performed
- Excellent comparison with the measurements when available
- Differences due to radiation belt model and shielding estimation
- The run-on-request allows to compute the dose for past and present space missions
- Estimation of dose of crew and instrument from near space up to free space thanks to trapped particle model
- It is also used to compute dose in airplane

References

- [1] B. T. Kress, M. K. Hudson, K. L. Perry, and P. L. Slocum. Dynamic modeling of geomagnetic cutoff for the 23-24 November 2001 solar energetic particle event. *Geo. Res. Lett.*, 31(4):L04808, February 2004.
- [2] B. T. Kress, C. J. Mertens, and M. Wiltberger. Solar energetic particle cutoff variations during the 29-31 October 2003 geomagnetic storm. *Space Weather*, 8(5):S05001, May 2010.
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- [4] Christopher J. Mertens, Matthias M. Meier, Steven Brown, Ryan B. Norman, and Xiaojing Xu. NAIRAS aircraft radiation model development, dose climatology, and initial validation. *Space Weather*, 11(10):603–635, October 2013.