

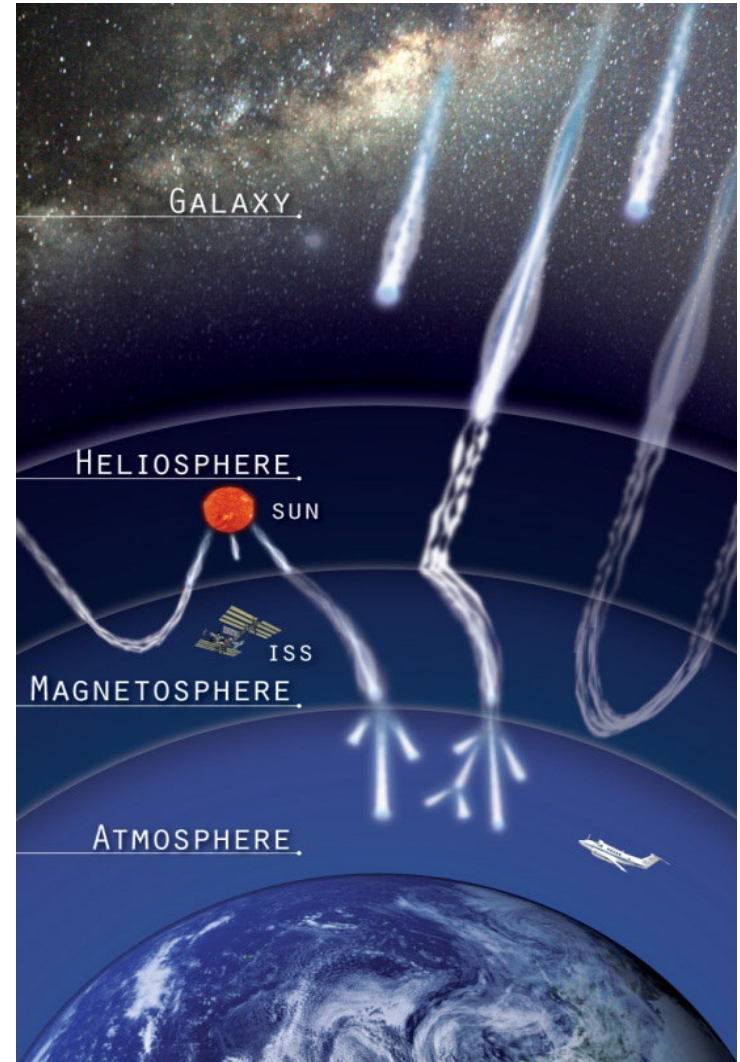
NAIRAS Model Updates

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NAIRAS Model

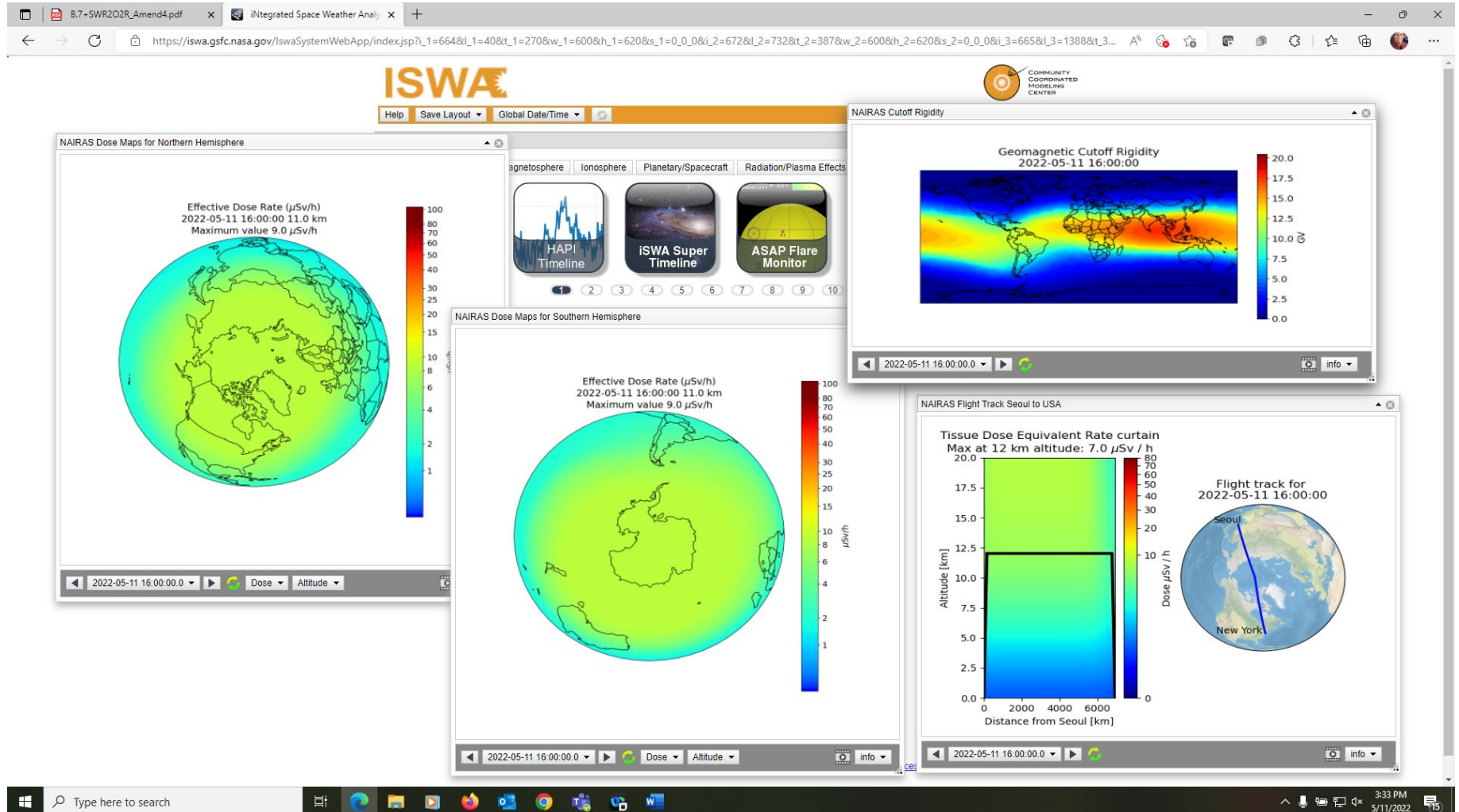
- **Nowcast of Aerospace Ionizing Radiation System (NAIRAS) Model**
 - Running in real-time on NASA computer cluster since 2011, results hosted on Space Environment Technologies server/website
 - Running in real-time at NASA Community Coordinated Modeling Center (CCMC) since 2020
- **Key Model Features**
 - Global atmosphere ionizing radiation environment model
 - Physics-based **HZETRN** (High Charge (Z) and Energy TRAnsport) code
 - Real-time inclusion of solar energetic particle (**SEP**) radiation
 - Real-time solar-magnetospheric effects on radiation (cutoff model *by Kress et al. [2004, 2010]*)
- **New/Current Model Development**
 - Improved SEP dose nowcast/forecast
 - Extend to low-Earth orbit (**LEO**) environment
 - Single-Event Effects (**SEE**) radiation risk assessment quantities
 - Run-on-Request (**RoR**) @ CCMC





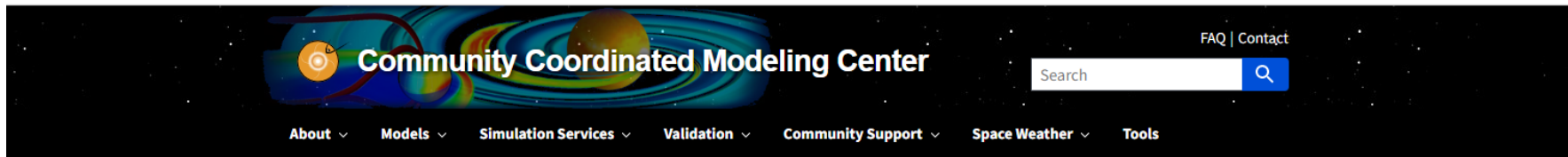
Real-Time NAIRAS @ CCMC

Integrated Space Weather Analysis (iSWA) System





NAIRAS Run-On-Request User Input



Request an NAIRAS Model Run

Please complete the form below. * Indicates a required field.

****You must agree to the [CCMC DATA Collection Consent Agreement](#) in order to submit a run****

Do you give your consent?



YES

Step 3: SELECT OUTPUT PRODUCTS

Global Dosimetric Quantities (selects all three) (?)

- ☒ Global maps of different types of doses at different altitudes
- ☒ Dose quantities along some given flight paths
- ☒ Cutoff rigidity maps

Trajectory Dosimetric, Differential and Integral Flux and Fluence Quantities under Different Shielding (requires additional input parameters on the next page) (?)

Dosimetric Quantities

- ☐ Dosimetric quantities at each trajectory point
- ☐ Time-integrated dosimetric quantities

Integral Flux and Fluence Quantities

- ☐ GCR integral LET flux
- ☐ GCR integral LET fluence
- ☐ Trapped integral proton flux
- ☐ Trapped integral proton fluence
- ☐ SEP integral proton flux (?)
- ☐ SEP integral proton fluence (?)

Differential Flux and Fluence Quantities

- ☐ GCR differential LET flux
- ☐ GCR differential LET fluence
- ☐ Trapped differential proton flux
- ☐ Trapped differential proton fluence
- ☐ SEP differential proton flux (?)
- ☐ SEP differential proton fluence (?)

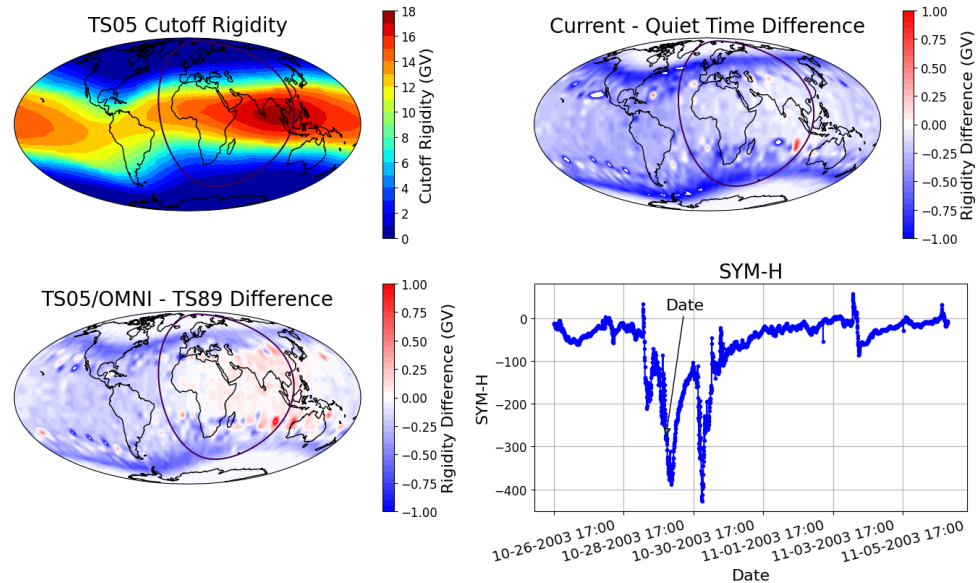


Geomagnetic Cutoff Rigidity Model

- Based on CISM-Dartmouth model with TS05 magnetospheric B-field (*Kress et al., 2010*)
- Added multiple magnetospheric B-field selection capability
 - TS05 → parameterized by solar wind quantities, interplanetary magnetic field (IMF), SYM-H/Dst, and other derivative solar wind quantities
 - T89 → parameterized by the planetary K-index (Kp)
- The TS05 better represents magnetospheric responses to interplanetary disturbances
 - but real-time solar wind parameters available from ACE/DSCOVR 1995+
- Benefits of T89 option
 - NAIRAS can simulate any historical solar-geomagnetic storm event
 - Extend/enhance validation capabilities
 - Provide initial step in forecasting cutoff via Kp-parameter forecast

Halloween 2003 Geomagnetic Storm

Date: 10/29/2003 2100 UT



Top Right: Largest suppression of cutoff (~1 GV) (open-closed field boundary) occurs in dusk sector due to max build-up of partial ring current in TS05 (IMF Bz dependent)

Bottom Left: T89 doesn't well represent max cutoff suppression and cutoff in dusk sector



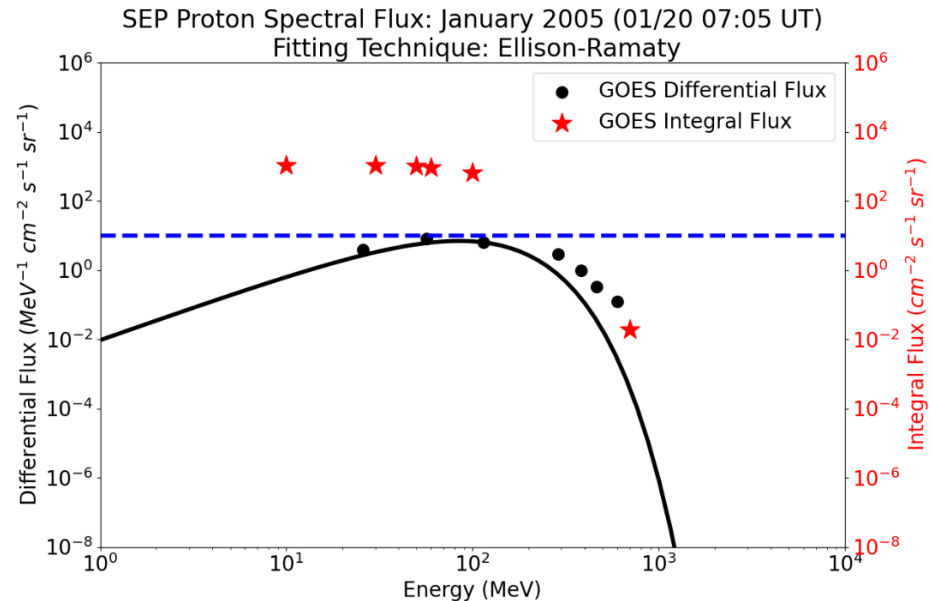
Update to SEP Spectral Fitting

• New Approach

- Fit spectrum to Geostationary Operational Environmental Satellites (GOES) integral proton flux rather than differential flux measurements
- Fit four functional forms to GOES integral proton flux
- Choose solution with minimum chi-square

• Benefits

- Improved robustness
 - Difficulty fitting GOES differential channels at event onset and for weak-to-moderate events
 - Extrapolation beyond highest differential energy channel (~500 MeV) requires introducing arbitrary and subjective criteria
 - 50% or more of SEP effective dose at large material depths (aviation altitudes) comes from > 500 MeV protons
- Preliminary simulations using neutron monitor data suggest fitting to GOES integral proton flux may better represent the relativistic protons during GLEs
- New integral flux fitting approach provides a pathway to develop a SEP proton spectrum forecast



SEP proton spectrum (black line) fit to GOES integral flux and comparison to GOES differential proton flux. Horizontal blue line indicates NOAA/SWPC SEP event threshold for >10 MeV proton flux.



Summary and Conclusions

- **Major NAIRAS Code Deliverables to CCMC**
 - NAIRAS Real-Time Global Dosimetric Quantities (**Publicly Available Now**)
 - NAIRAS RoR Capability (**Publicly Accessible in Fall 2022**)
 - NAIRAS Improved SEP Proton Spectral Fitting Algorithm (**Operational in Fall 2022**)
- **Significant Improvements to NAIRAS Model: Developed, Implemented and Tested**
- **NAIRAS predicts both dosimetric quantities to assess human radiation exposure and differential/flux quantities to assess SEEs in avionic system**
- **SEP Dose Forecast Development**
 - Geomagnetic Cutoff Rigidity Forecast Model (**Under Development**)
 - SEP Proton Spectrum Forecast (**Under Development**)