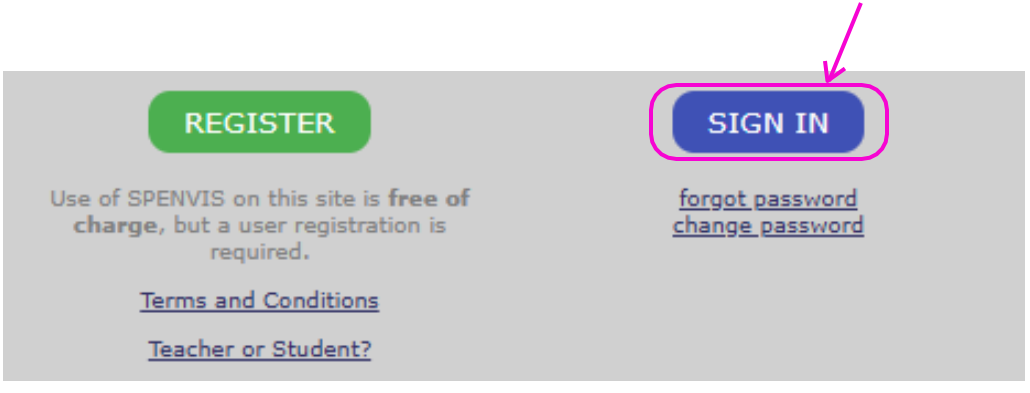
02A – The Natural Space Radiation Environment Guided Activity

ENGR-E 399/599

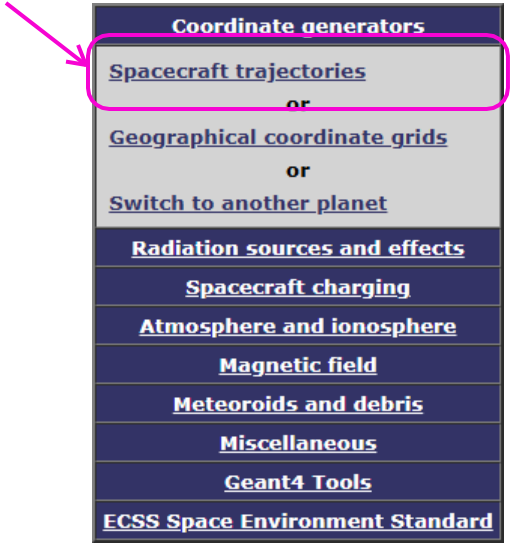
Microelectronics Radiation Effects and Reliability

Sign in to SPENVIS

- https://www.spenvis.oma.be/



Use the Coordinate Generator to create a trajectory



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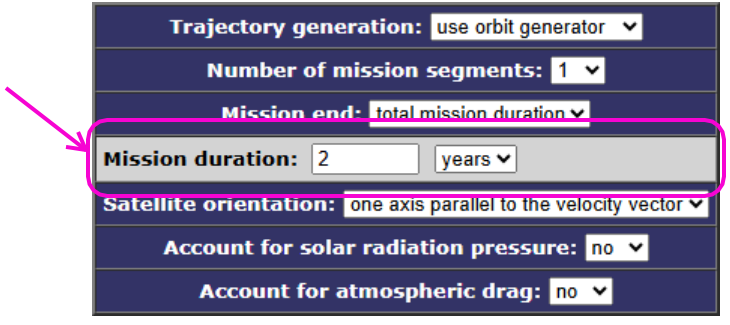

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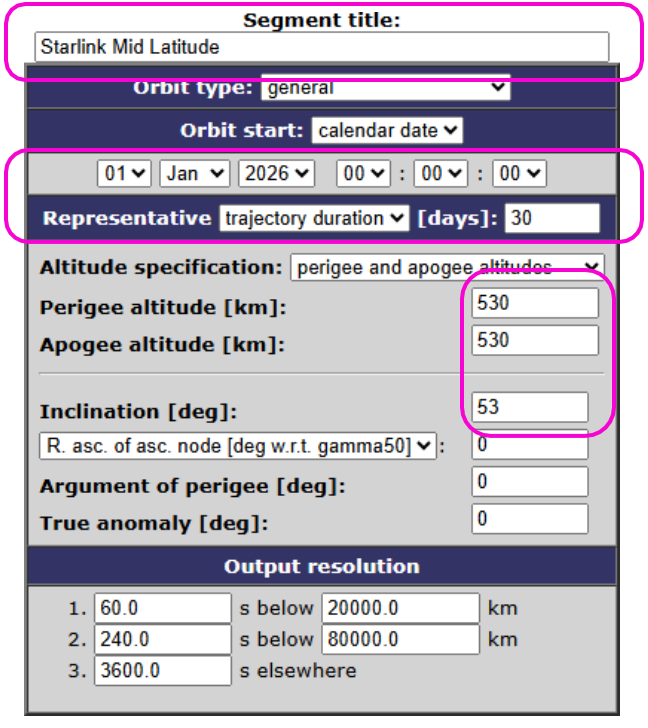
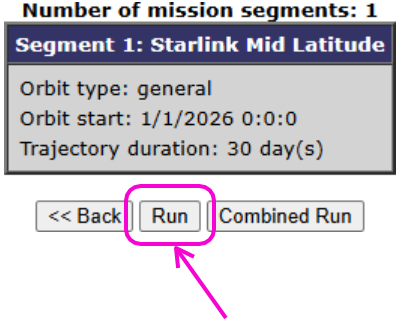
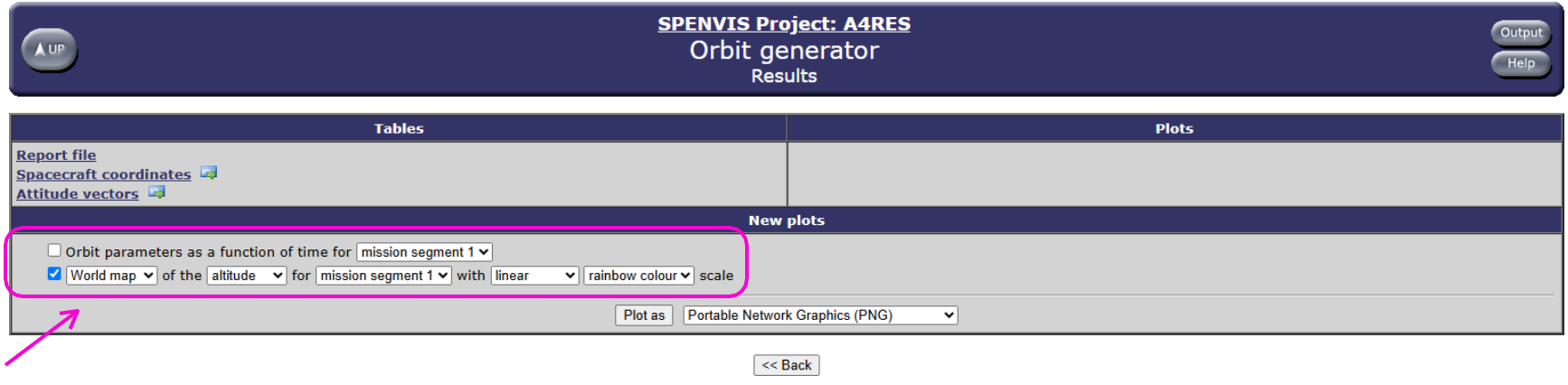
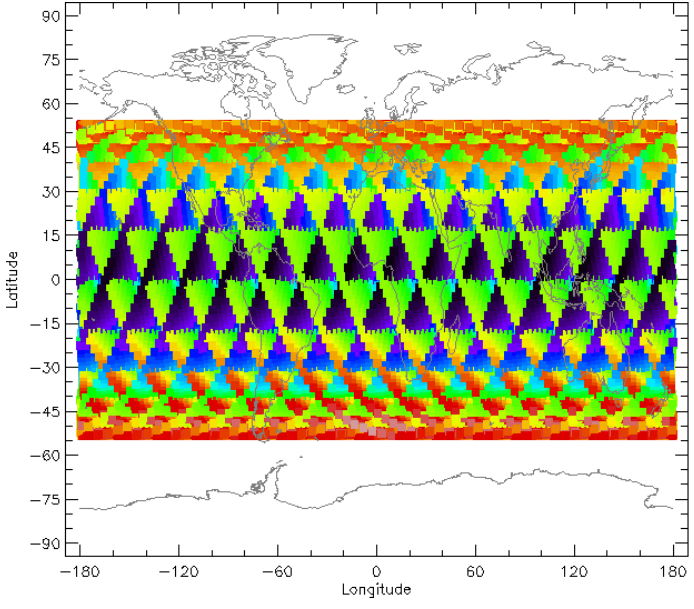


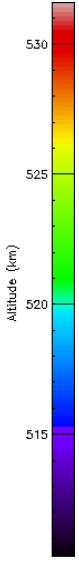


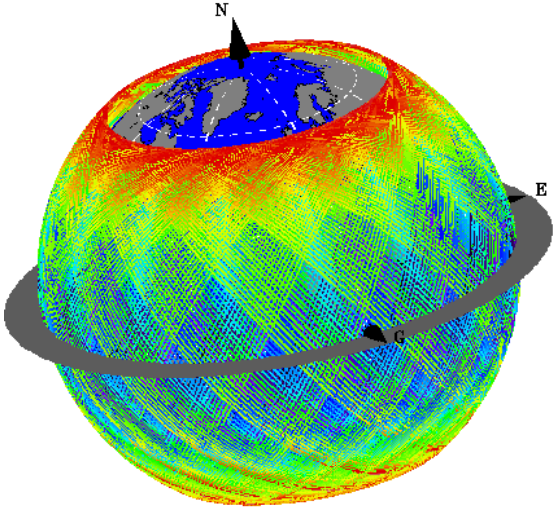
Explore the outputs

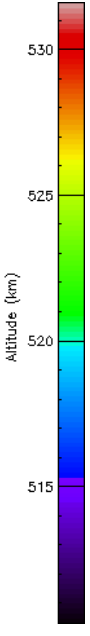


Explore the outputs

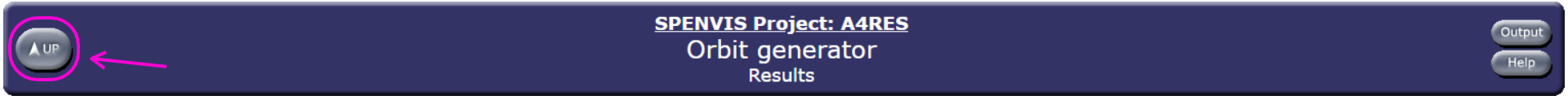




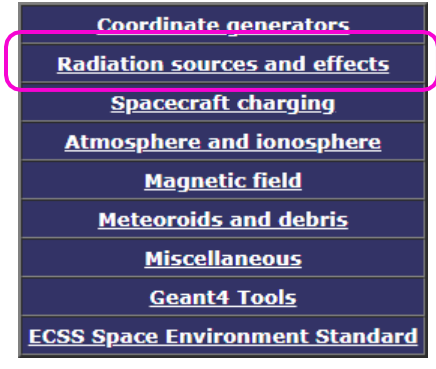


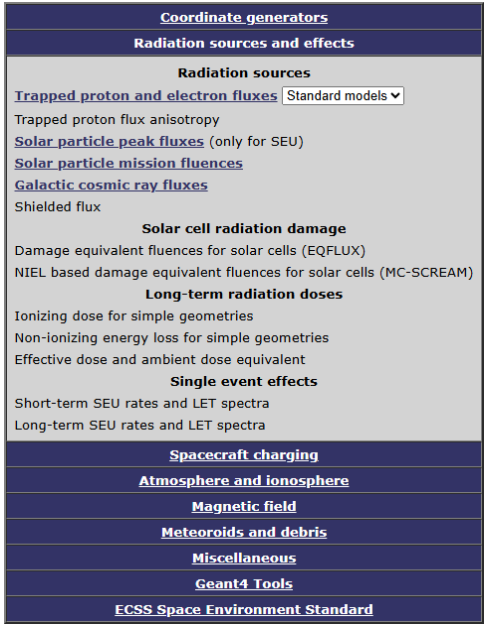


Modeling charged particle populations



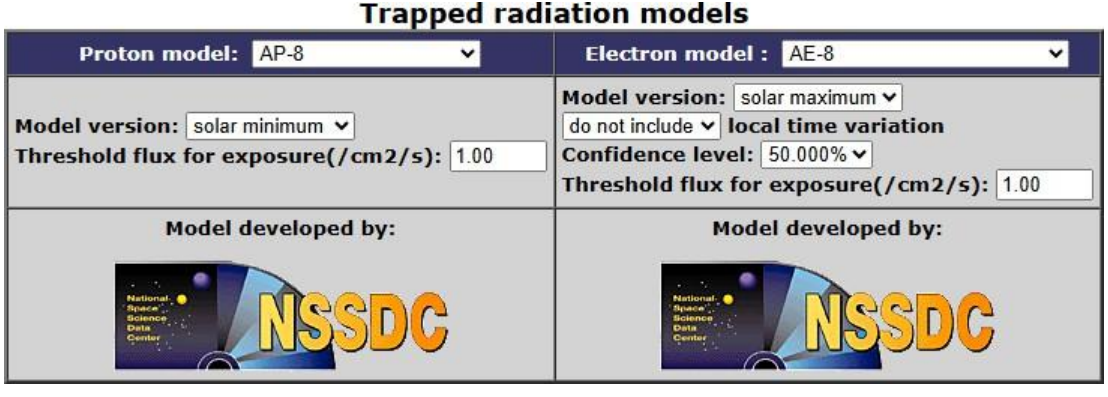
- Click UP and return to Main Menu
- Click RADIATION SOURCES AND EFFECTS
- Let's start with Trapped Particles





Run AP8 / AE8

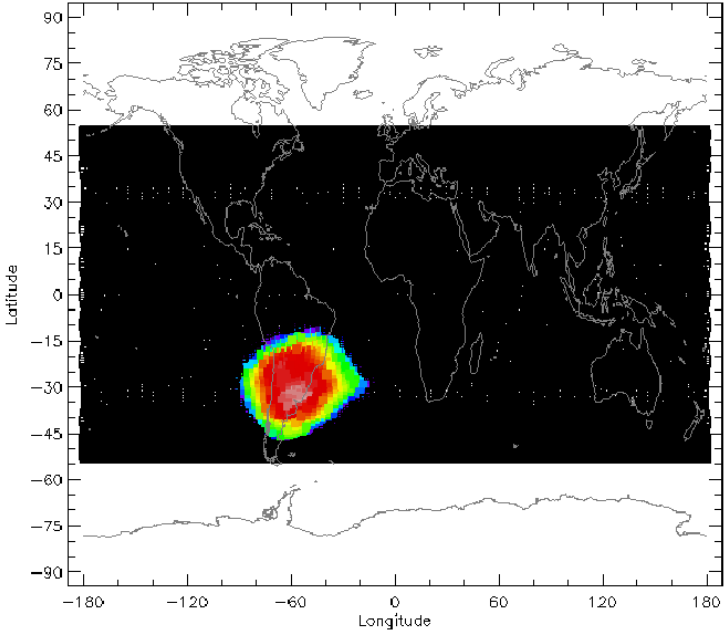
- **SPENVIS includes options for Trapped Particles**
  - IRENE (Ver. 1.50), SSREM, CRRESPRO, …
  - AP8 / AE8 is fast for illustrative purposes

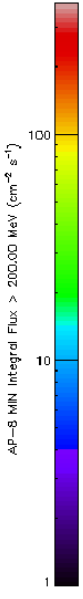


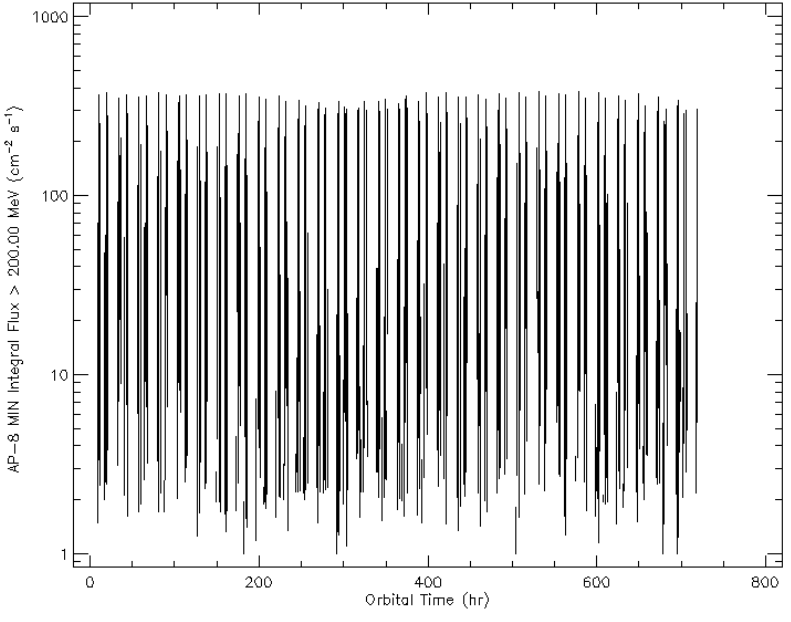
Explore the outputs

- **Generate a Proton spectrum for this mission (flux vs. energy)**
  - Review the Report file
  - [What sort of information is available here?]
- **Generate a Time plot of proton flux >200 MeV for this mission**
- **Generate a World map of proton flux >200 MeV for this mission**
  - [Why 200 MeV?]
  - [What sort of observations can you make?]

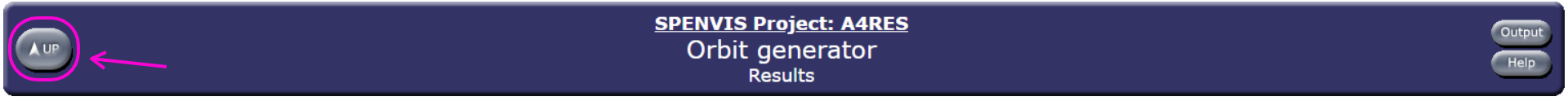
Explore the outputs



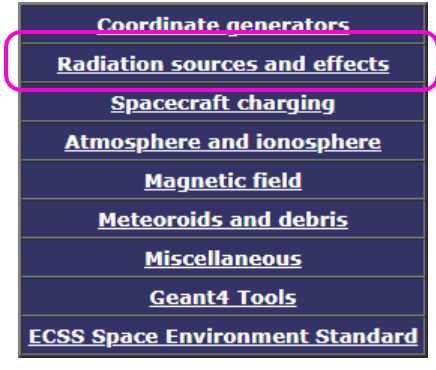


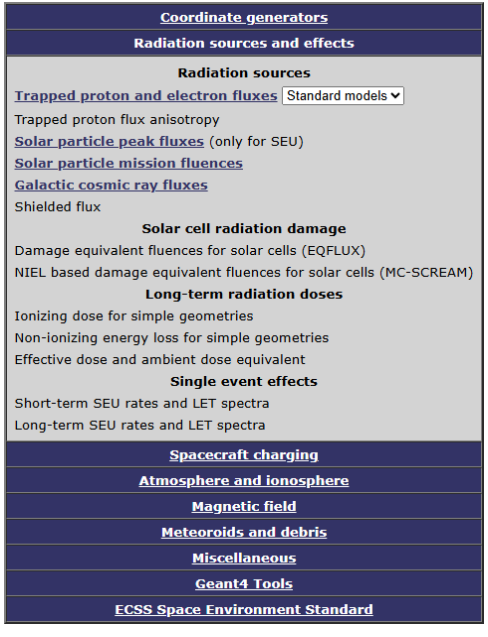


Modeling charged particle populations



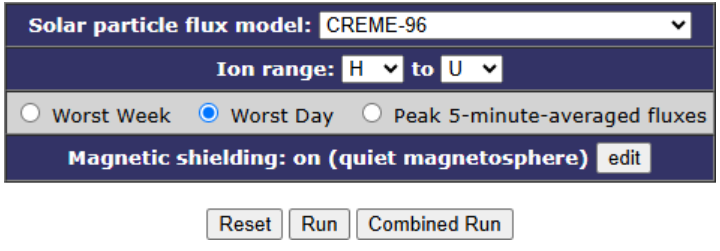
- Click UP and return to Main Menu
- Click RADIATION SOURCES AND EFFECTS
- Let's add Solar particles





Run CREME-96 Worst Day (WD)

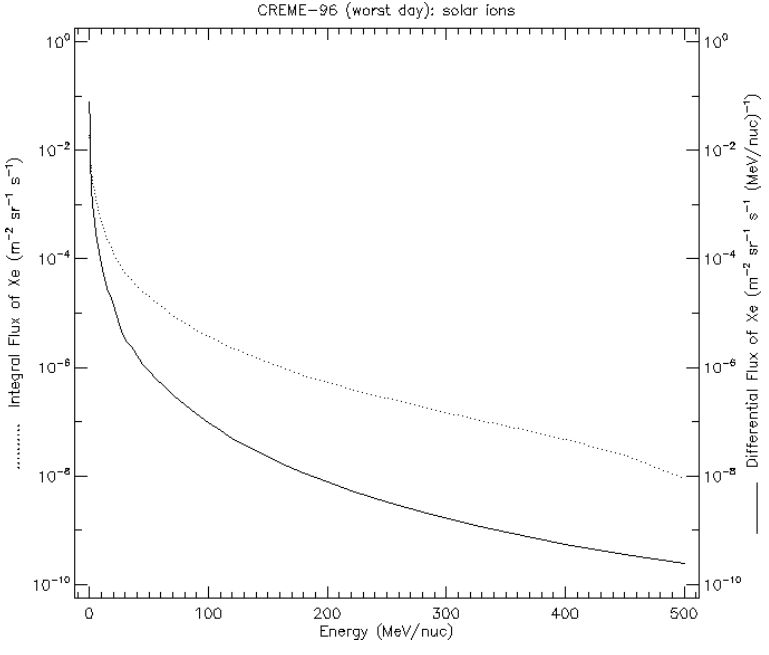
- **Other options available (SAPPHIRE, CREME-86, …)**
- **Why CREME-96?**
  - Compatibility with SIRE-2, CREME-MC, …
- **Leave the Magnetic shielding as defaults**

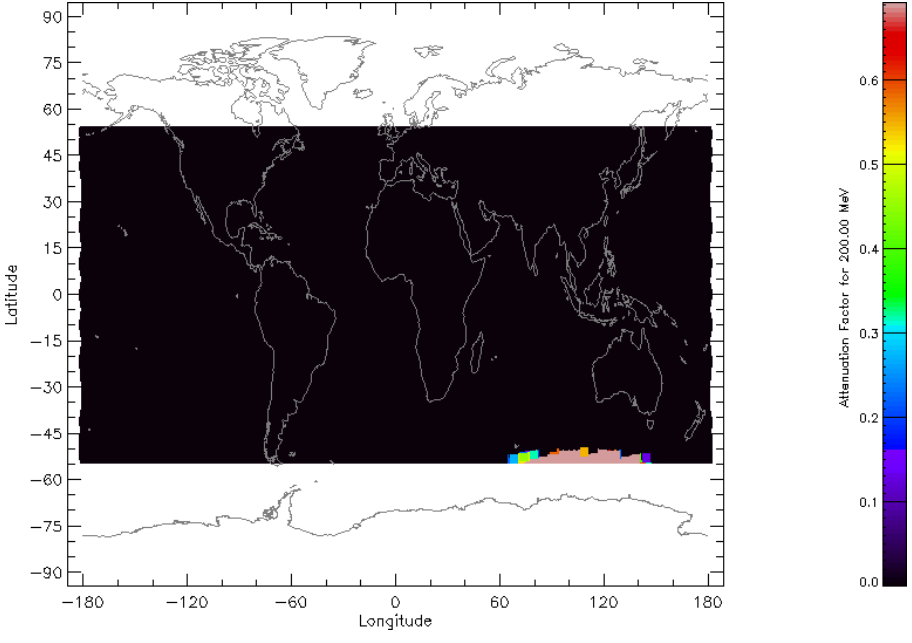


Explore the outputs

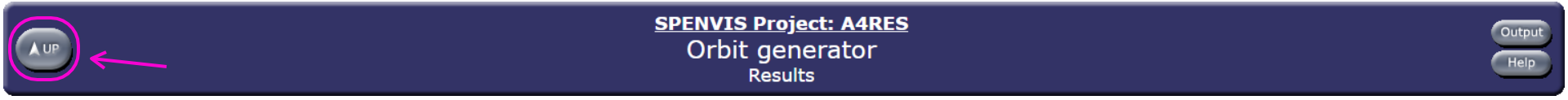
- **Generate a Heavy Ion spectra for Xe (Z=54) for this mission (flux vs. energy)**
- **Generate a World map of proton attenuation factor for >200 MeV for this mission**
  - [Why 200 MeV?]
  - [What sort of observations can you make?]

Explore the outputs

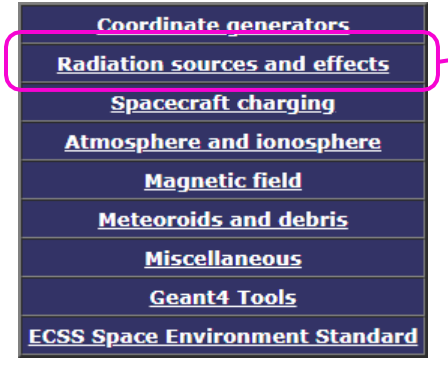


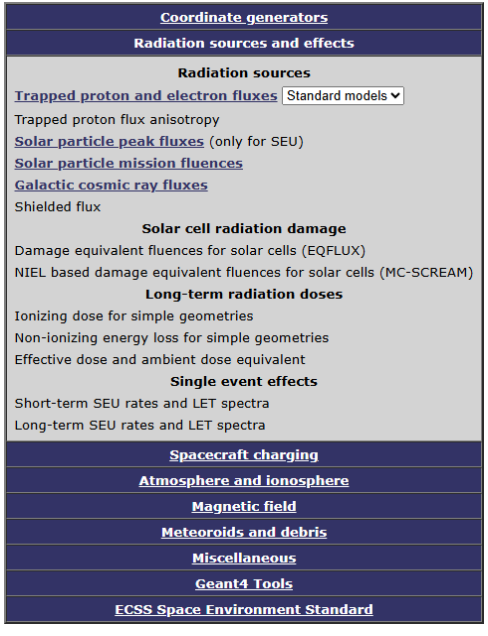


Modeling charged particle populations



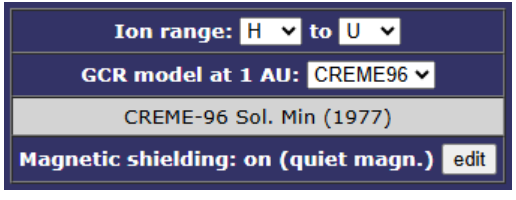
- Click UP and return to Main Menu
- Click RADIATION SOURCES AND EFFECTS
- Let's add GCRs





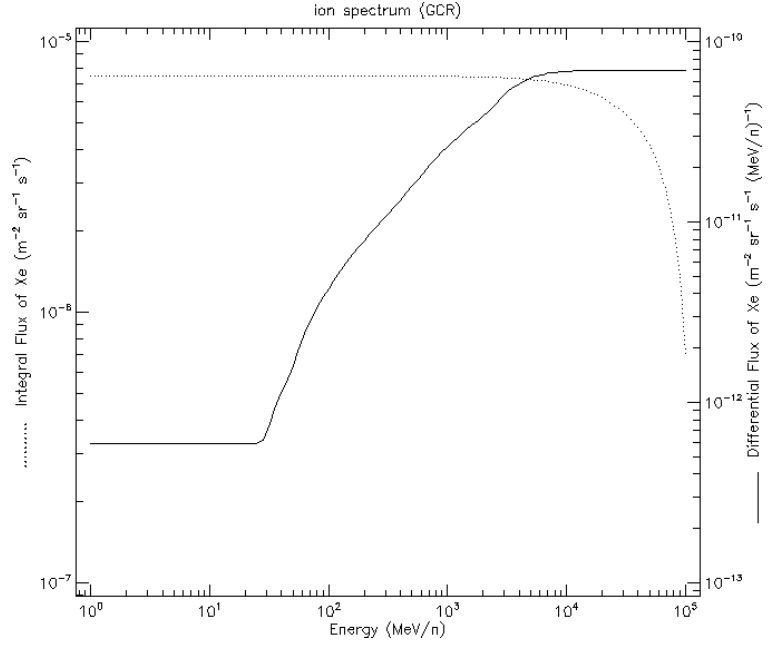
Run CREME-96

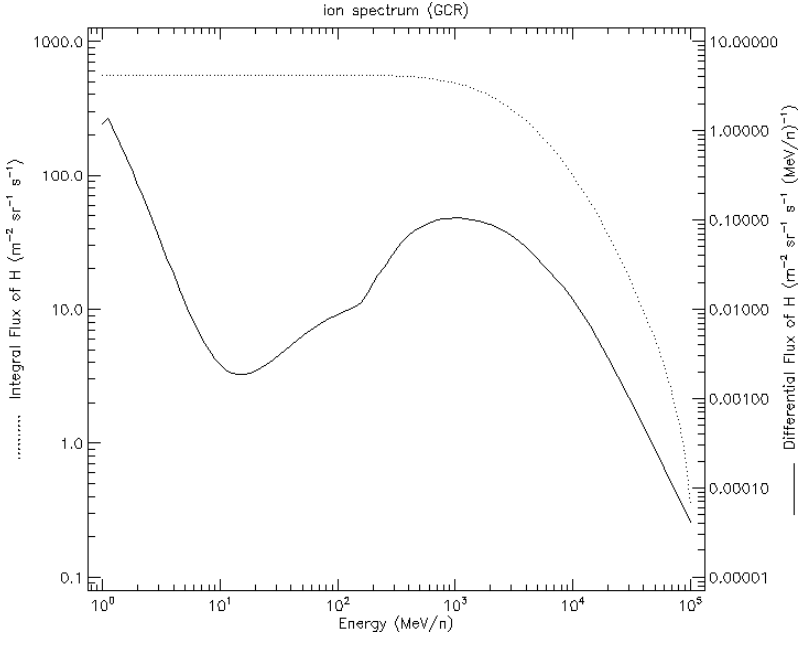
- **Other options available (ISO 15390, CREME-86, Nymmik, …)**
- **Why CREME-96?**
  - Compatibility with SIRE-2, CREME-MC, …
- **Leave the Magnetic shielding as defaults**



Explore the outputs

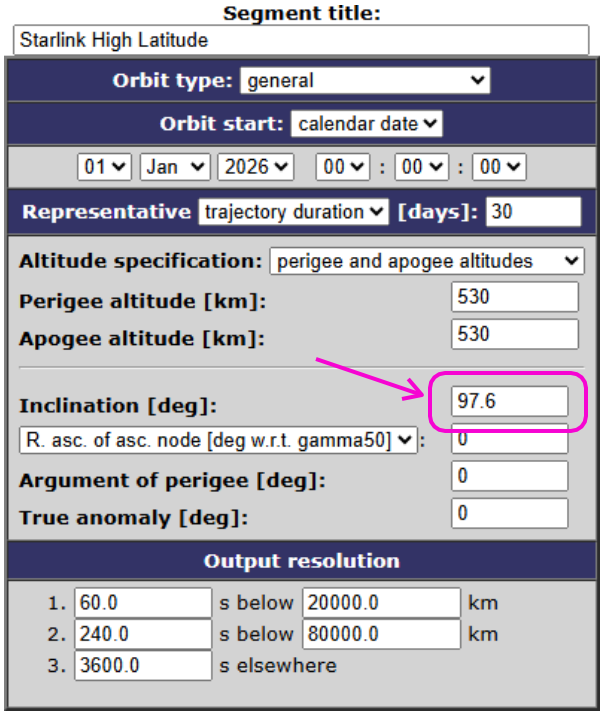
- Generate a Heavy Ion spectra for Xe (Z=54) for this mission (flux vs. energy)
- Generate a Heavy Ion spectra for protons (Z=1) for this mission (flux vs. energy)





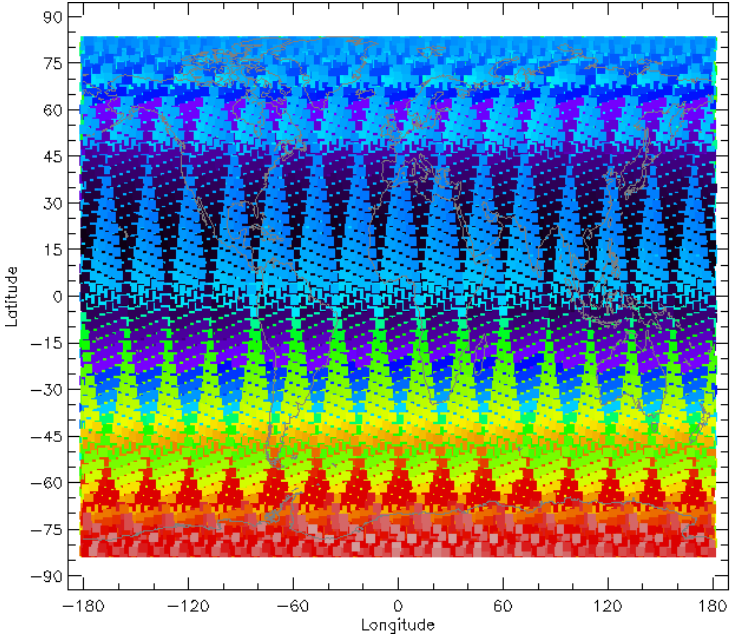
Next steps … on your own

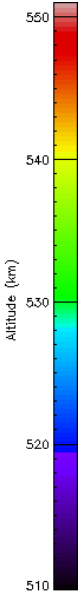
- **As of now we've generated charged particle environments for a notional mid latitude Starlink-like mission**
  - Trapped protons
  - SEP protons and ions
  - GCR protons and ions
- **Repeat this process for a notional high latitude Starlink-like mission (see right)**
- **Generate the same outputs and save so we can compare**

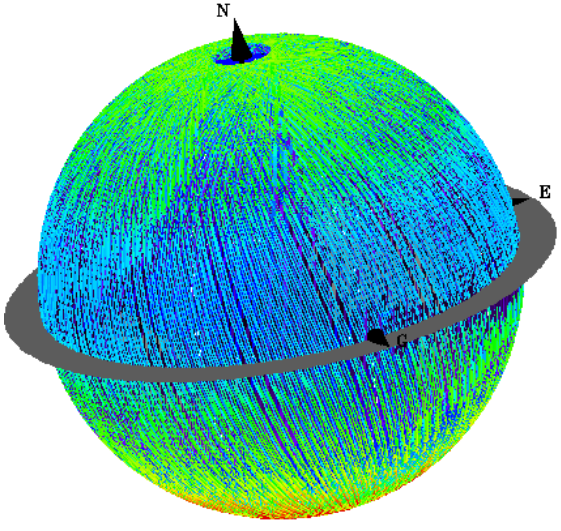


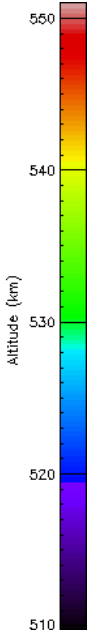
SOLUTION

Trajectory



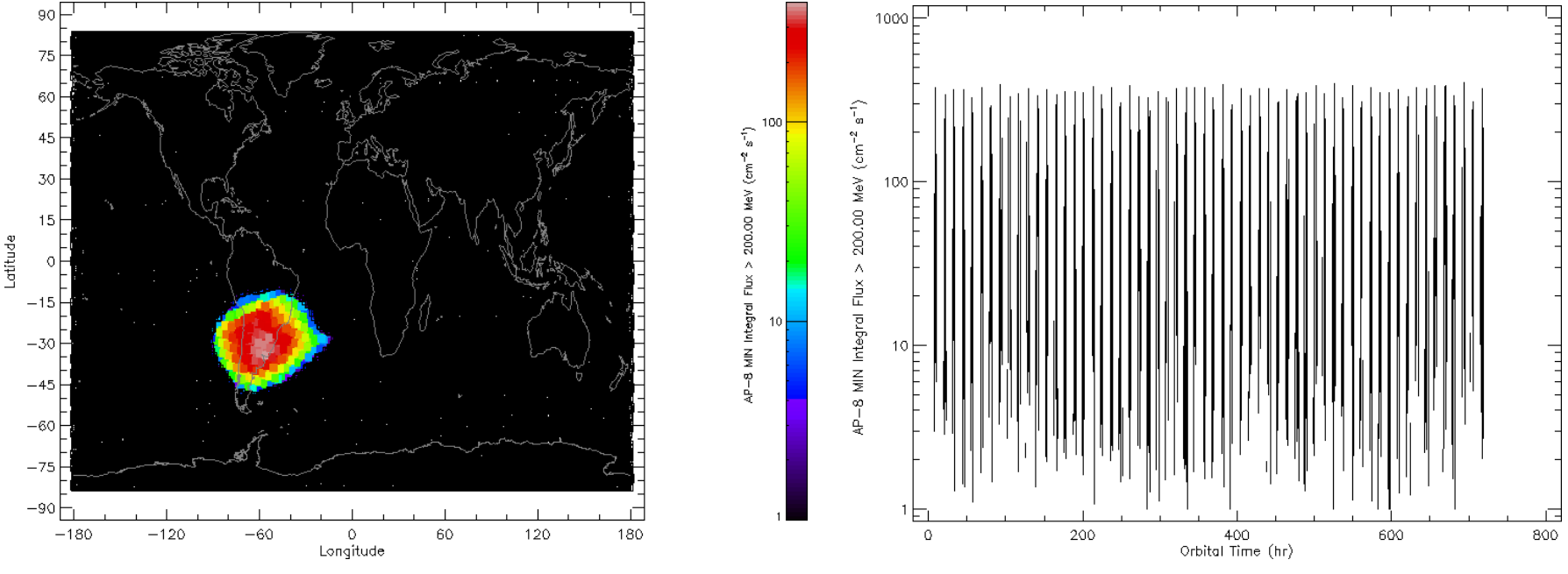






SOLUTION

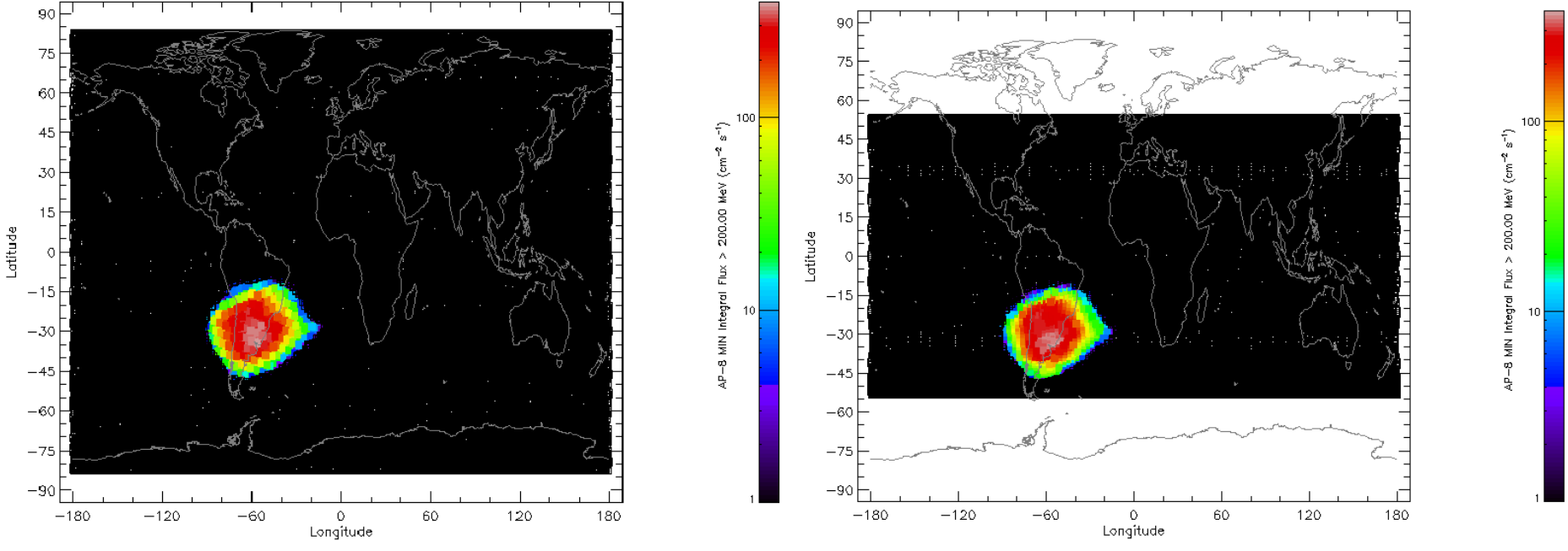
Trapped protons



SOLUTION

Comparisons (Trapped Protons)

- **Make some observations about**
  - Mission / orbit average >200 MeV protons
  - Peak >200 MeV protons



SOLUTION

Comparisons (Trapped Protons)

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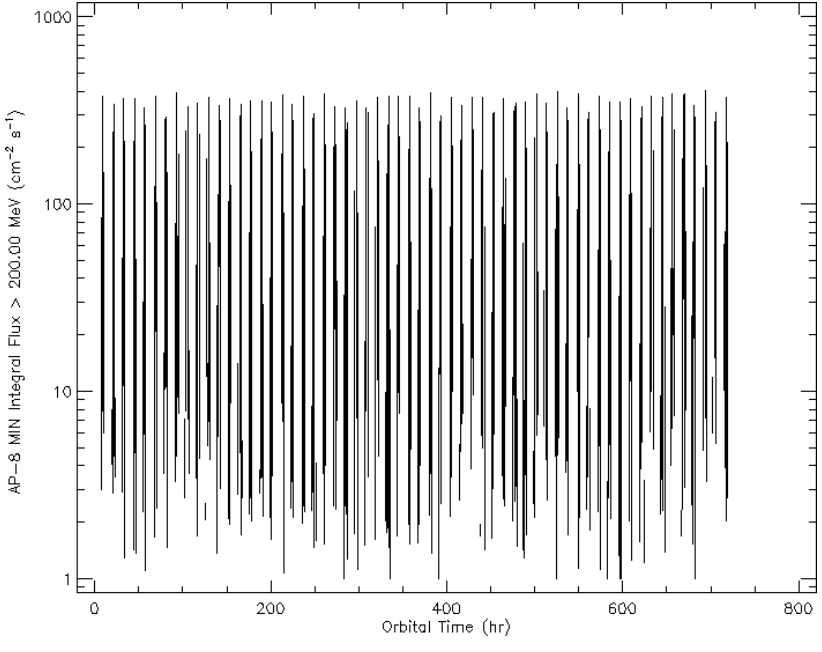
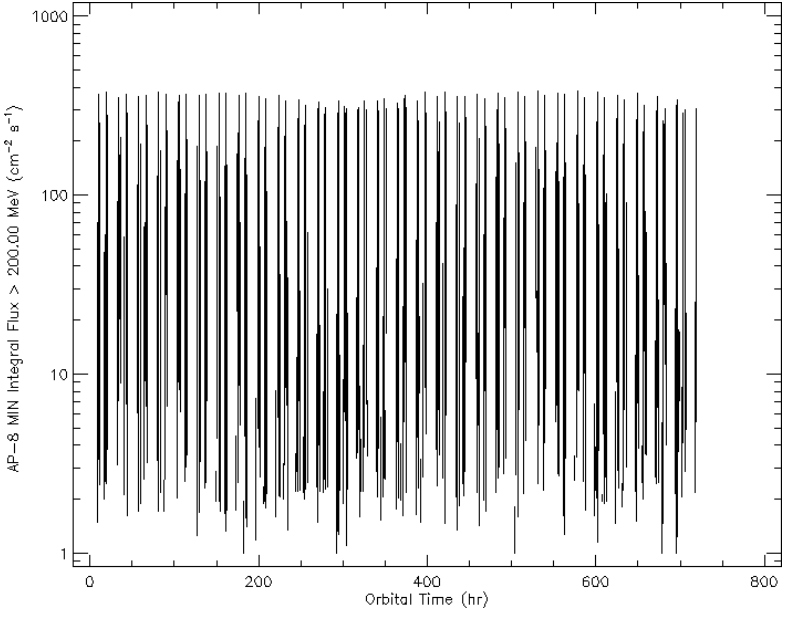
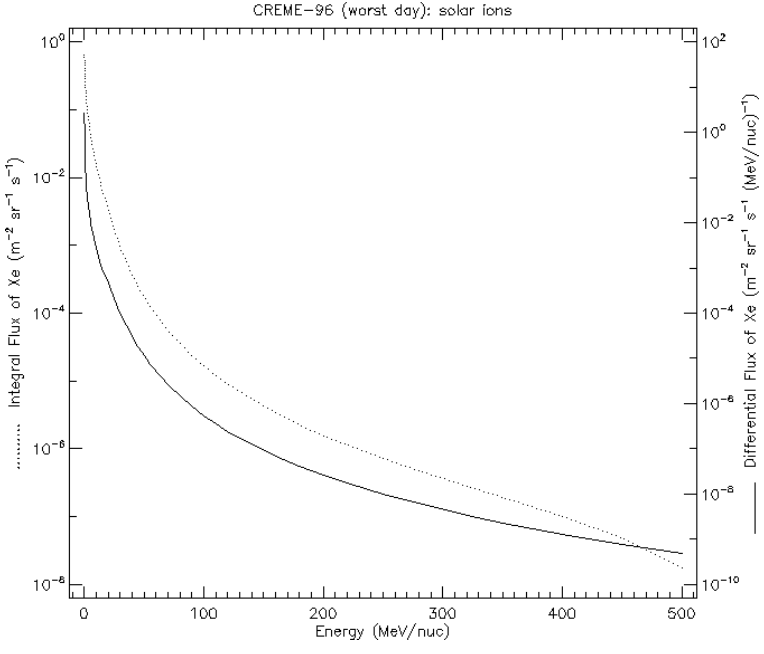
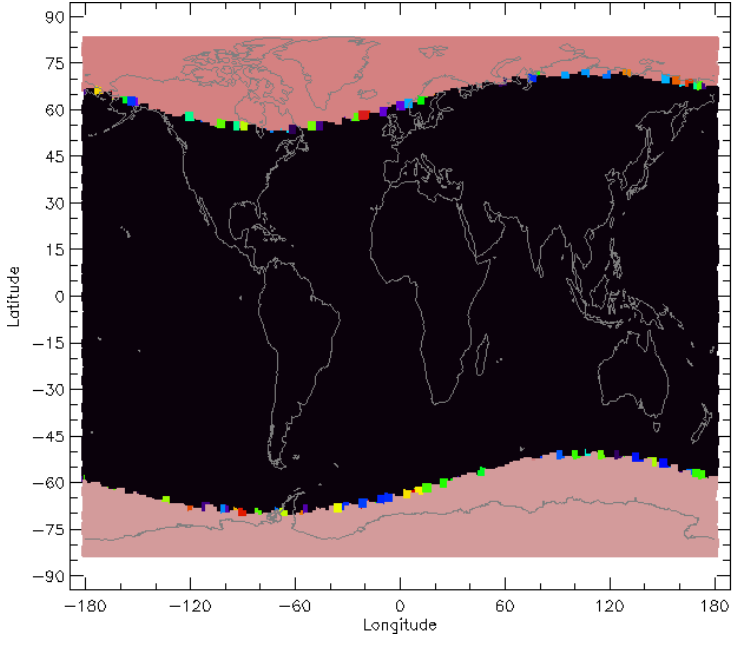


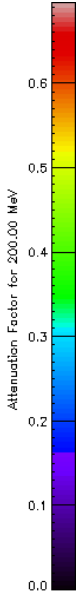


SOLUTION

Worst Day



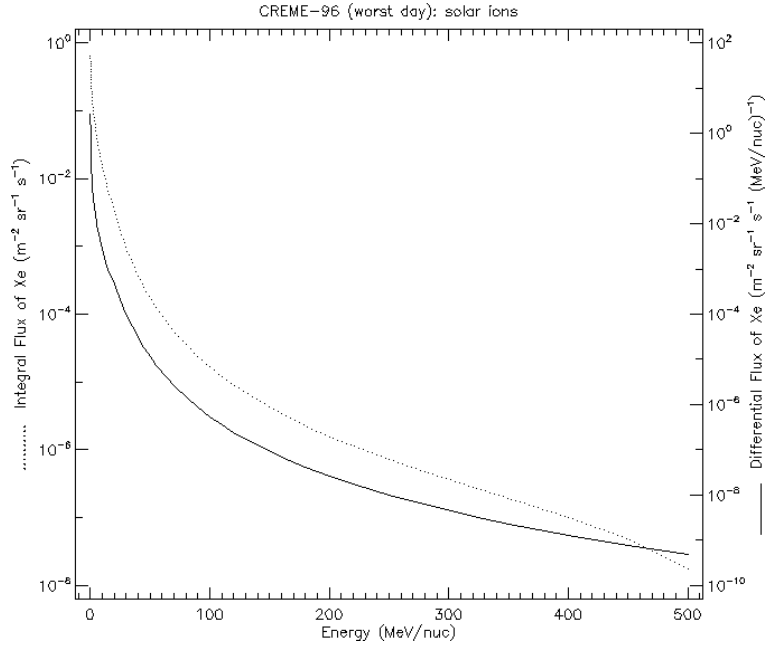


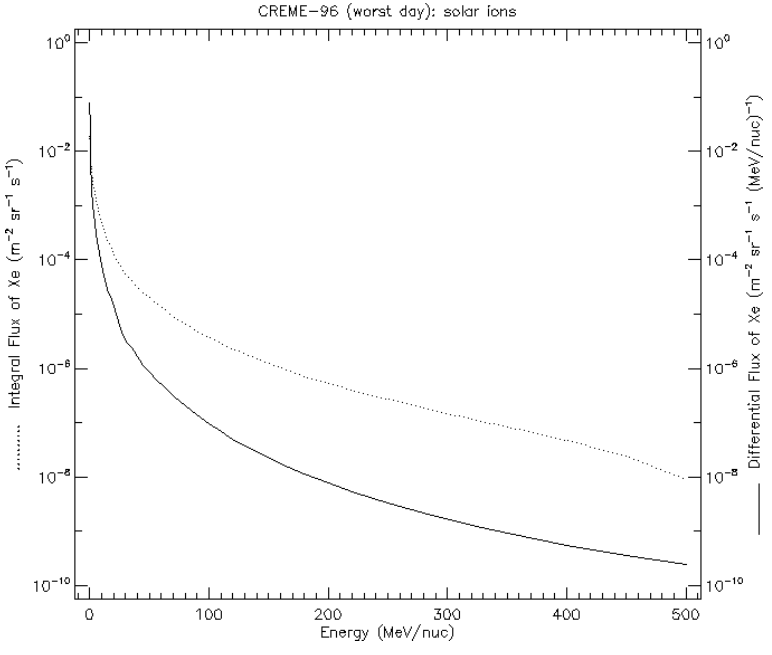


SOLUTION

Comparisons (Worst Day)

- **Make some observations about**
  - Fluxes and energies of Xe ions

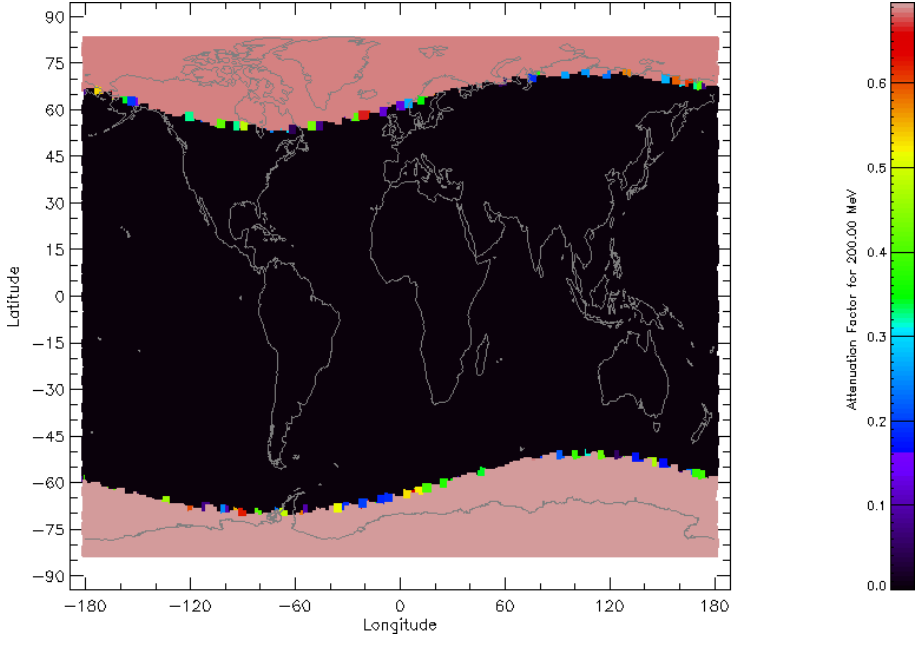


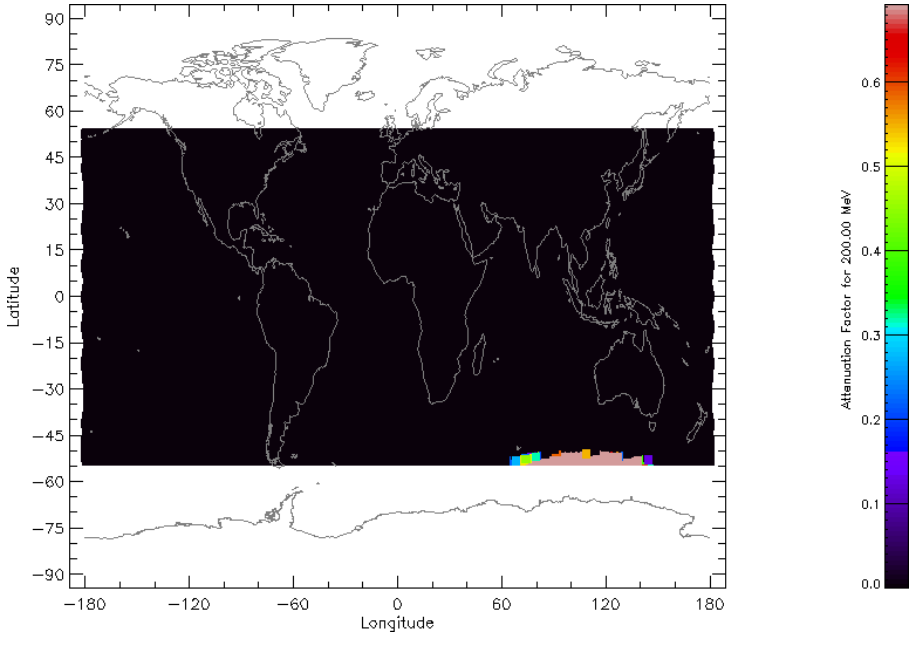


SOLUTION

Comparisons (Worst Day)

- **Make some observations about**
  - Access of >200 MeV protons
  - Is the mission susceptible in a WD environment?

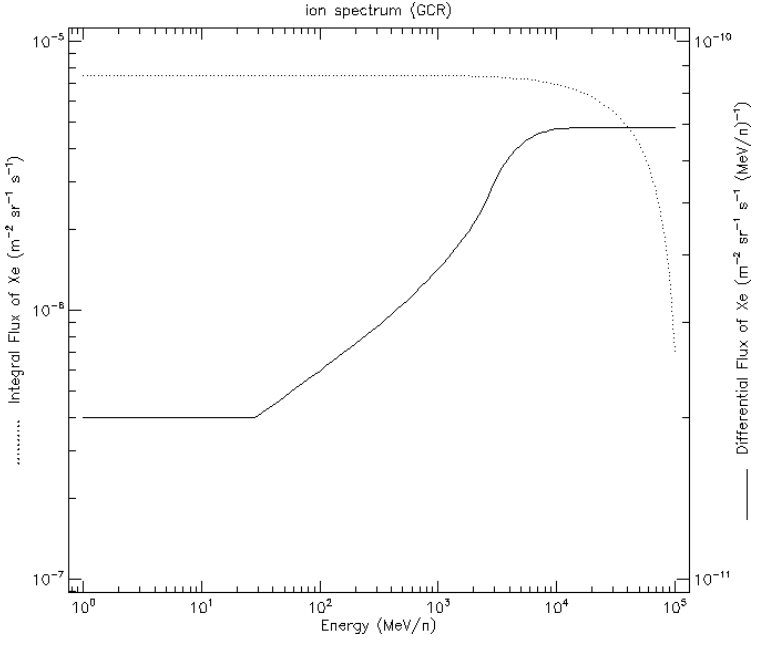


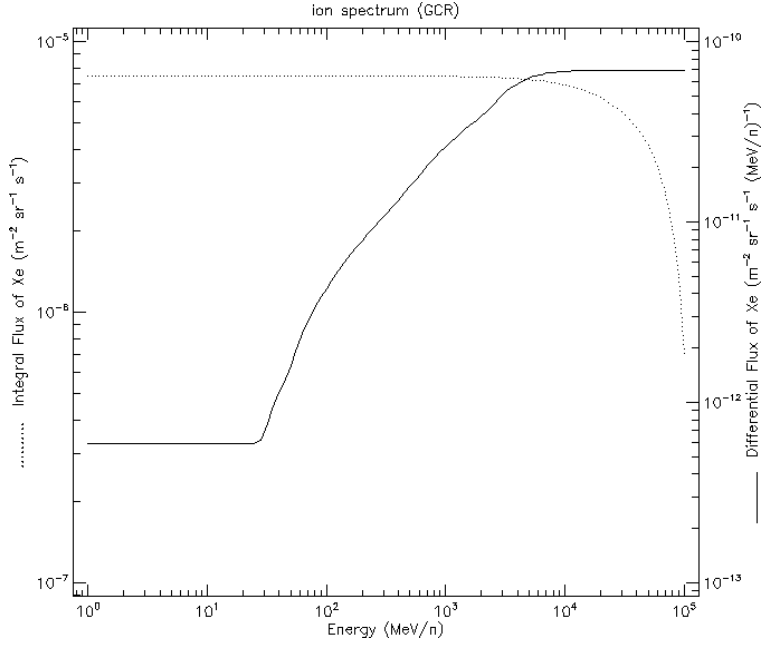


SOLUTION

Comparisons (GCRs)

- **Make some observations about**
  - Fluxes and energies of Xe ions

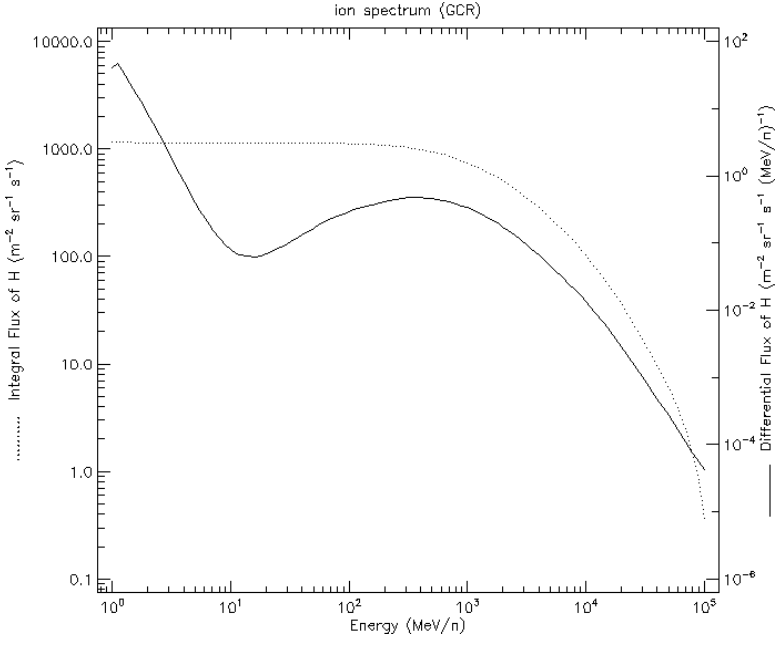


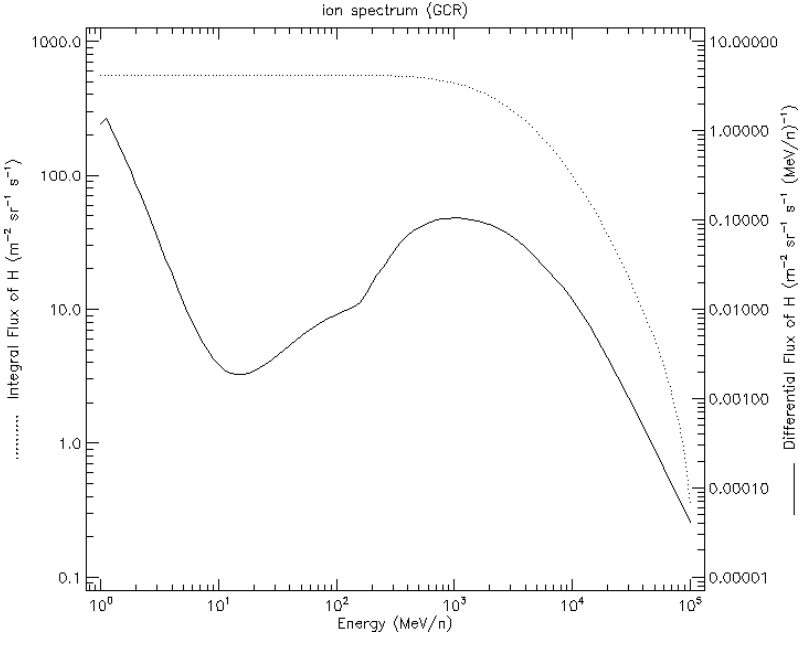


SOLUTION

Comparisons (GCRs)

- **Make some observations about**
  - Fluxes and energies of Xe ions





Homework 2

1. Using SPENVIS, model the following two orbits

- Assume a mission start date of Jan 1, 2026
- Use the following models:
  - Trapped Protons and Electronics: Standard AE-8 (solar max., 50% confidence level), AP-8 (solar min.)
  - CRÉME-96 solar particle model (Worst Day)
  - ESP-PHYCHIC solar particle model for total fluence (95% confidence level)
  - CRÉME-96 galactic cosmic ray model (solar min.)

Polar LEO (POES, IRIDIUM)	
Mission Duration	7 years
Apogee	825 km
Perigee	825 km
Inclination	98.8 deg
RAAN[1]	0 deg
Argument of Perigee	0 deg
True Anomaly	0 deg

HEO (Van Allen Probes, MMS)	
Mission Duration	2 years
Apogee	70000 km
Perigee	2500 km
Inclination	28 deg
RAAN	0 deg
Argument of Perigee	0 deg
True Anomaly	0 deg

[1]Right Ascension of the Ascending Node

Homework 2

2. **Provide the following charts for each mission:**
   - Trapped proton spectra
   - World maps of the trapped proton flux (for >10 MeV and >200 MeV)
   - Solar proton (Z=1) and heavy ion flux spectra for He (Z=2) and Fe (Z=26)
   - World maps of the 200 MeV solar proton attenuation factor
   - Mission average solar proton (Z=1) and heavy ion fluence spectra for He (Z=2) and Fe (Z=26) **from solar particle mission fluences*
   - GCR spectra of protons (Z=1), He (Z=2), and Fe (Z=26)

Homework 2

3. **Name three differences in each of these orbits, as compared to the in-class example of a notional Starlink LEO orbit**
4. **What is the integral flux of trapped protons of energy 1 MeV or greater? What about for 200 MeV or greater?**
5. **For the life of each of these missions, how does the total fluence of solar protons of 200 MeV or greater to compare to the Starlink LEO mission?** Provide the expected ratio (fluence of desired mission)/fluence of Starlink LEO.
6. **Which mission sees the highest flux of GCR of Z=2 and higher? How about Z=26 and higher? Why?**