JOHNS HOPKINS
APPLIED PHYSICS LABORATORY

Natural Space Environment

Mod01a Exercise

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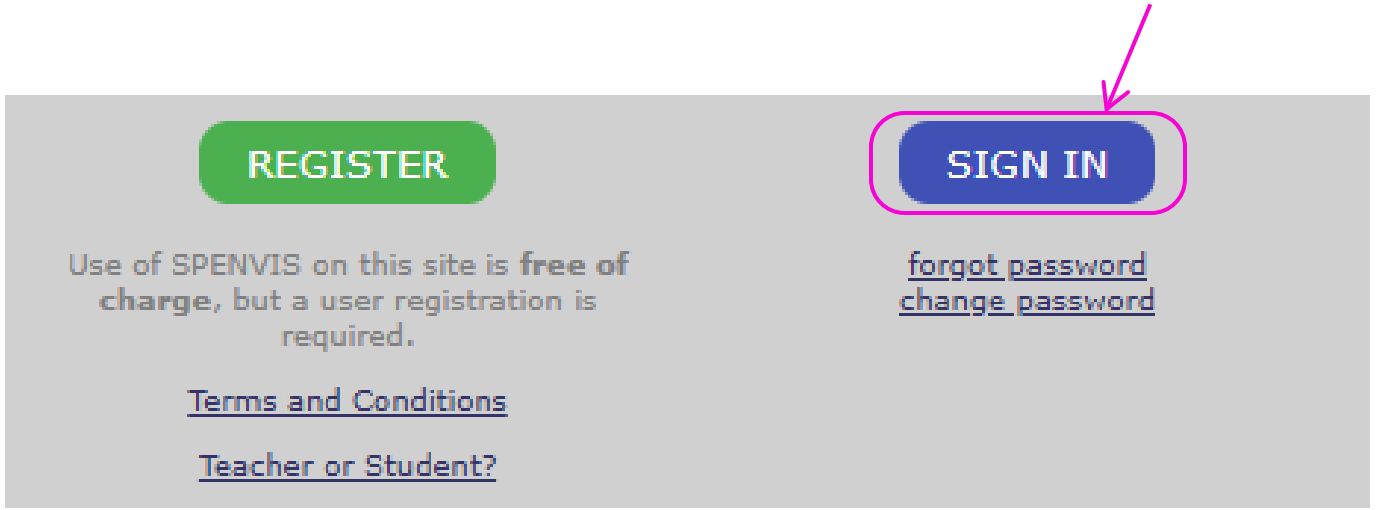
Purpose and objectives

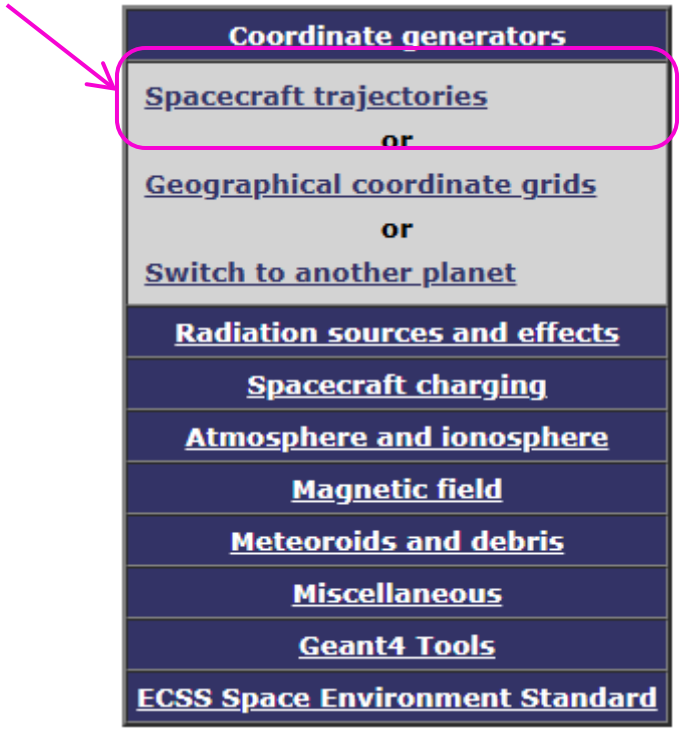
- Introduce the SPENVIS online tool kit
- Use SPENVIS to generate charged particle environments for several reference missions
  - Trapped particles
  - Solar Energetic Particles
  - Galactic Cosmic Rays
- Review resultant environments (compare & contrast)
  - Make observations
- Discuss how these environments will influence SEE test planning

Sign in to SPENVIS

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



Use the Coordinate Generator to create a trajectory



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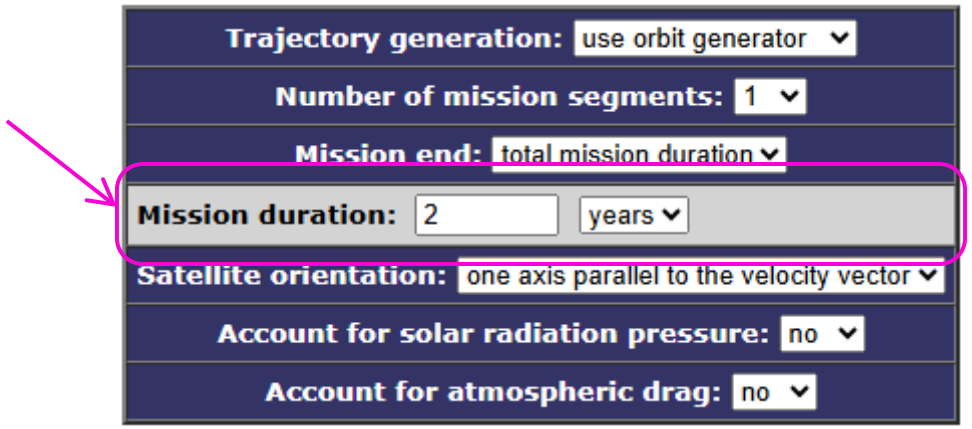
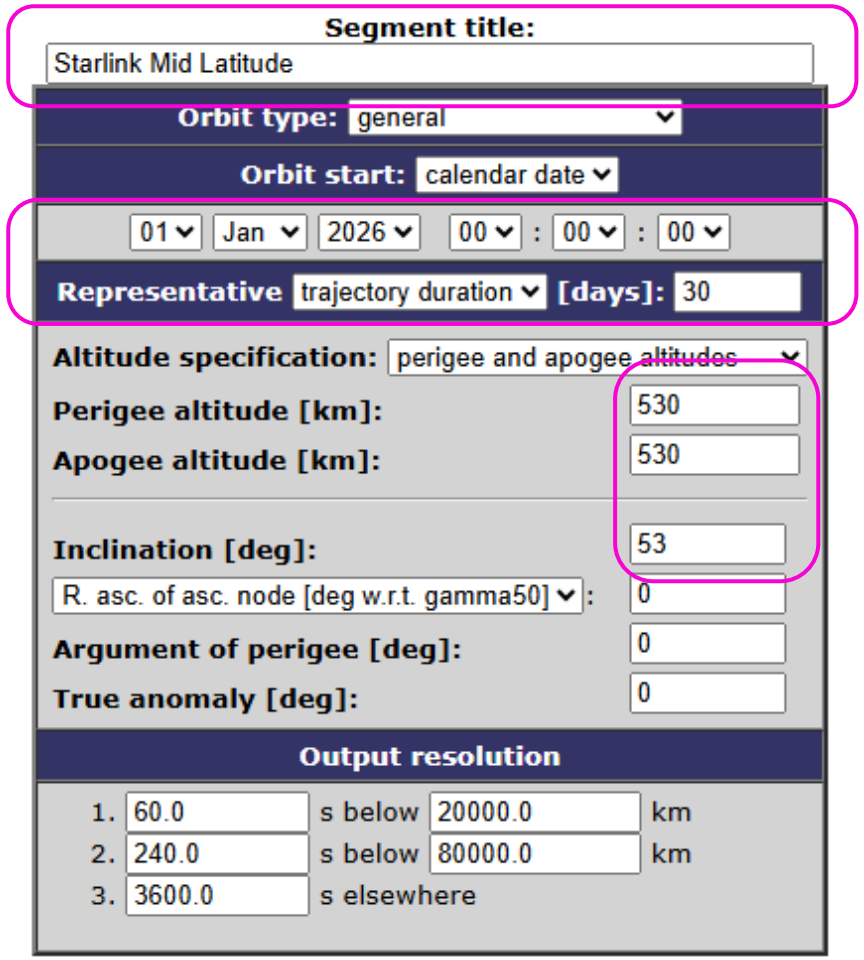
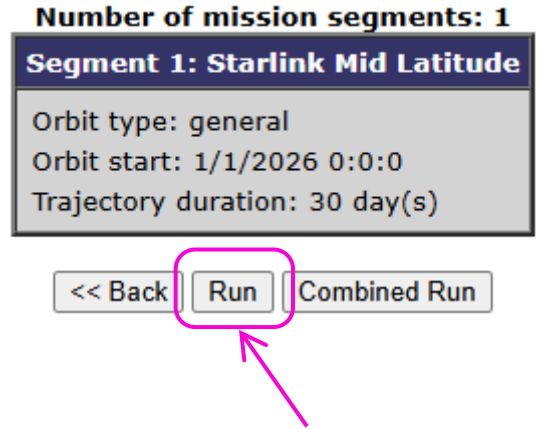
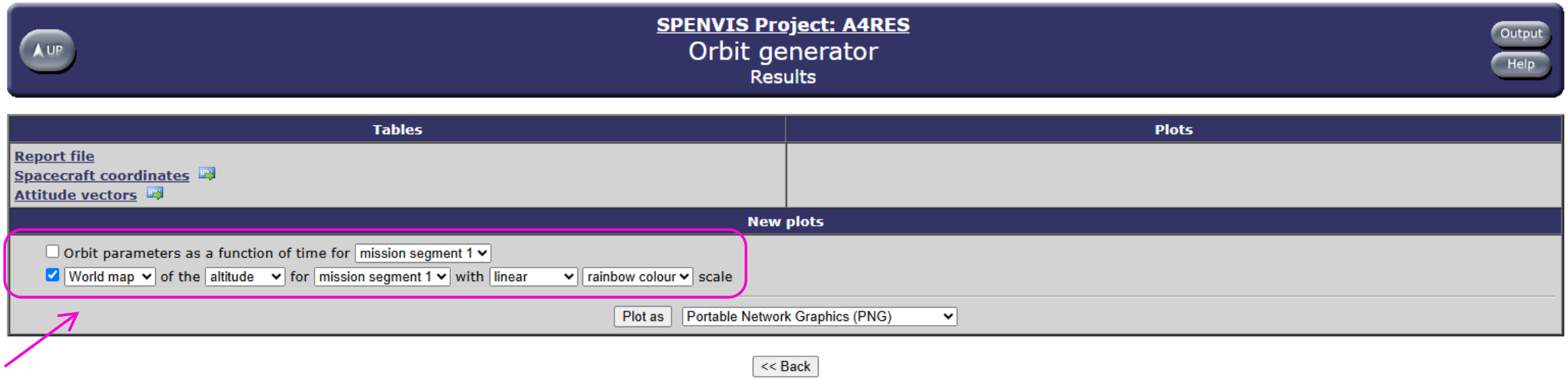


Use the Coordinate Generator to create a trajectory

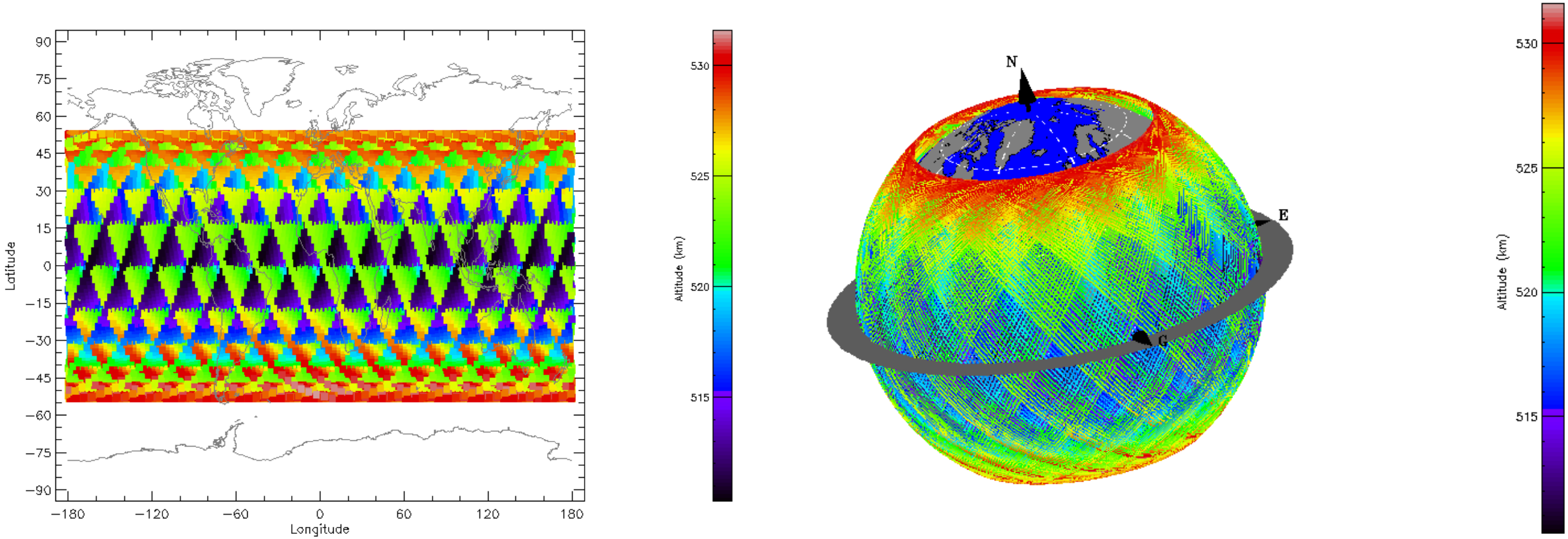




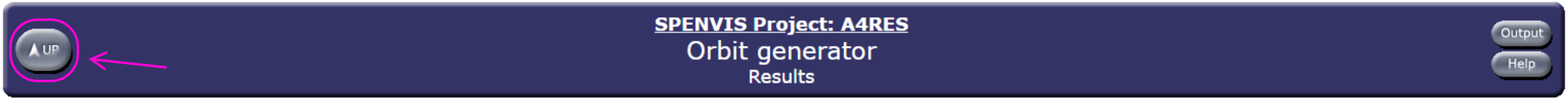
Explore the outputs



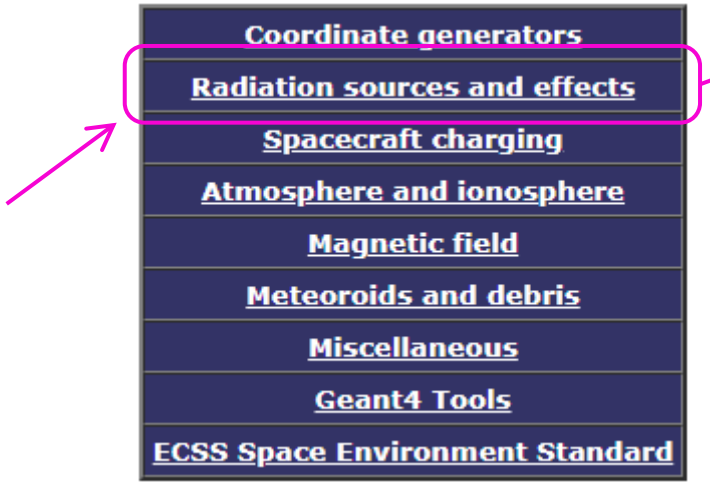
Explore the outputs

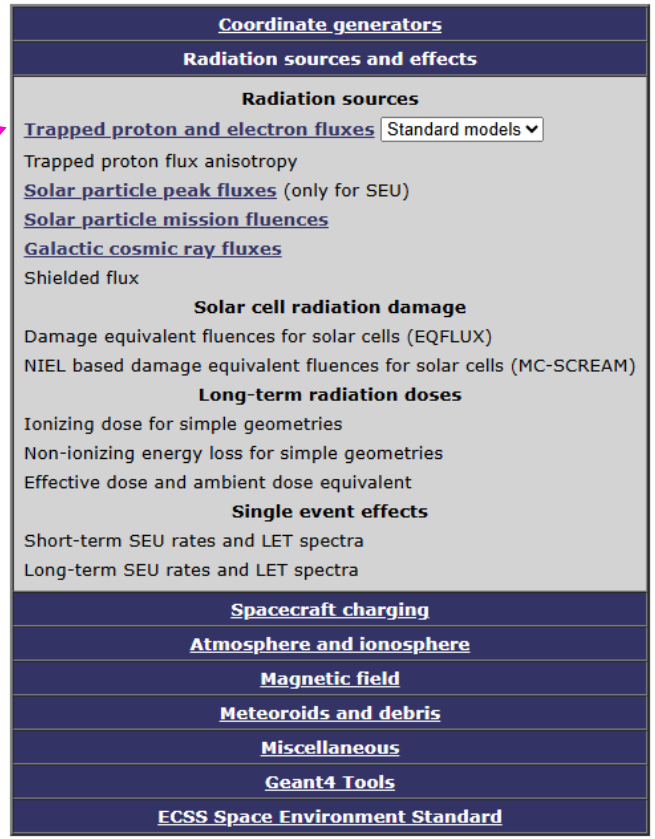


Modeling charged particle populations



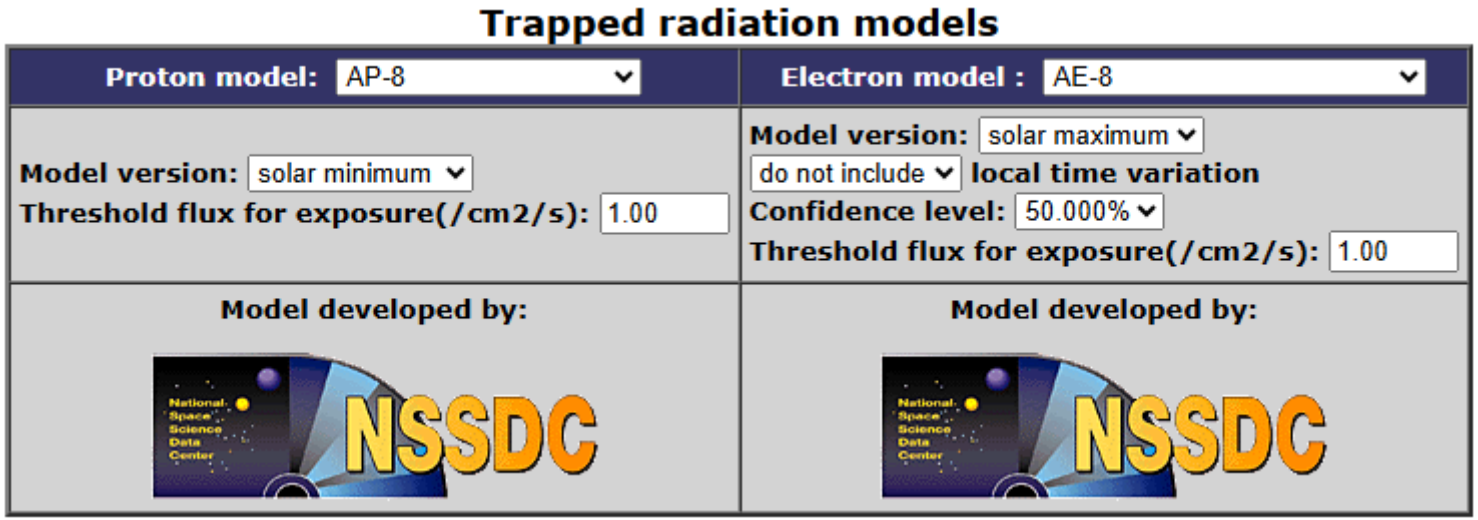
1. Click UP and return to Main Menu
2. Click RADIATION SOURCES AND EFFECTS
3. Let's start with Trapped Particles





Run AP8 / AE8

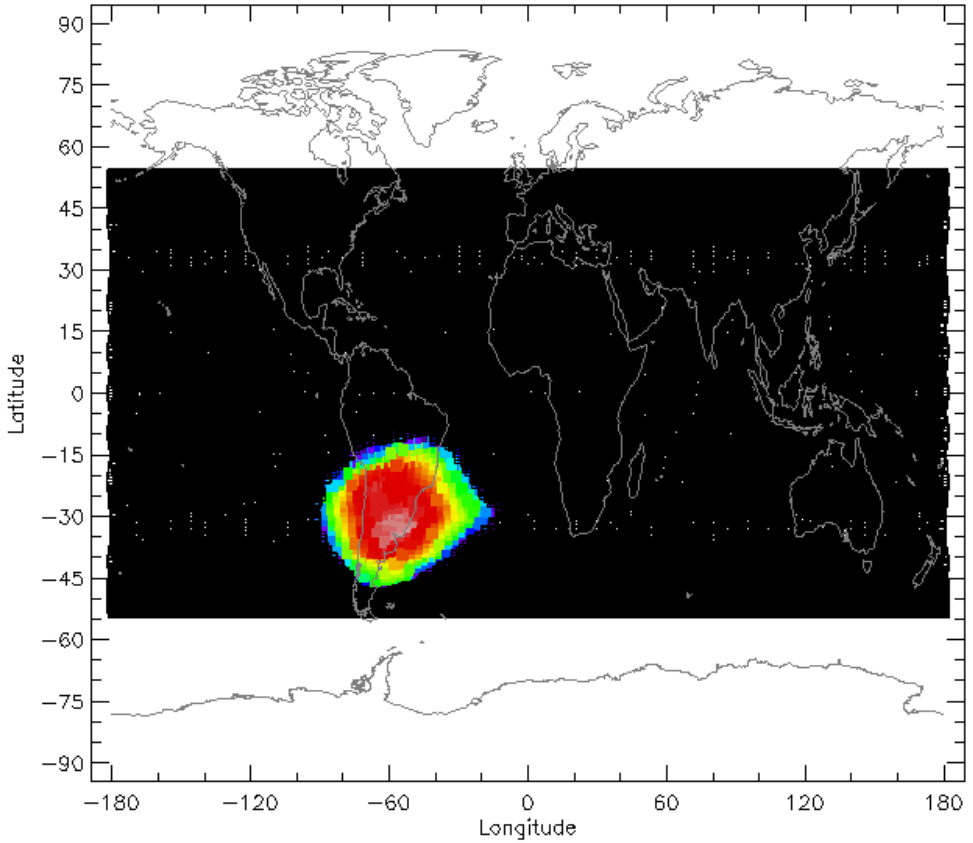
- SPENVIS includes options for Trapped Particles
  - IRENE (Ver. 1.50), SSREM, CRRESPRO, …
- AP8 / AE8 is fast for illustrative purposes

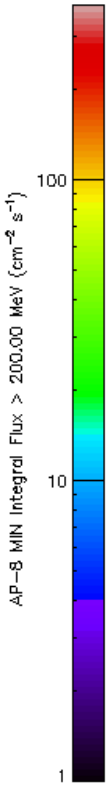


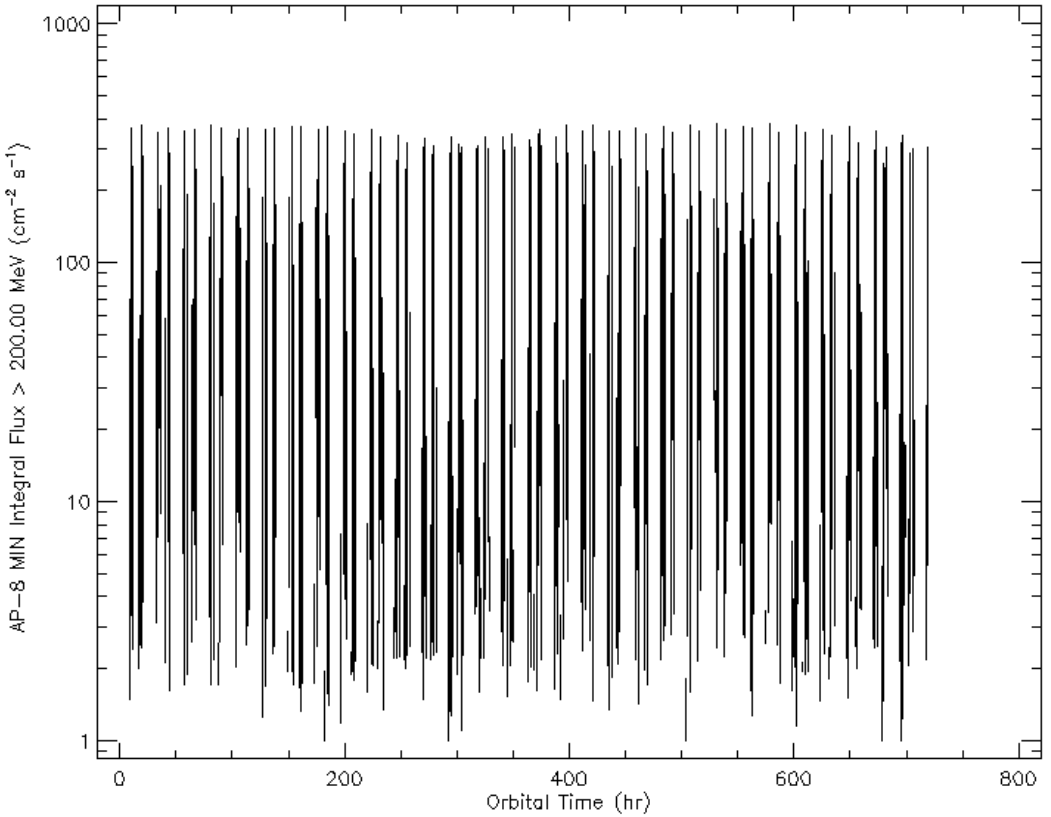
Explore the outputs

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

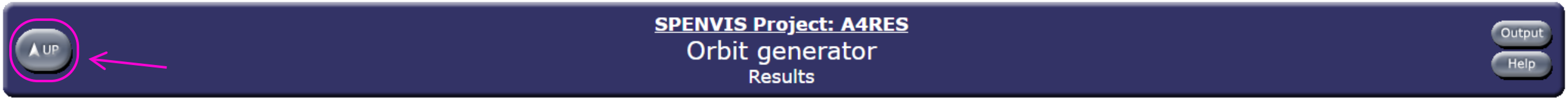
Explore the outputs



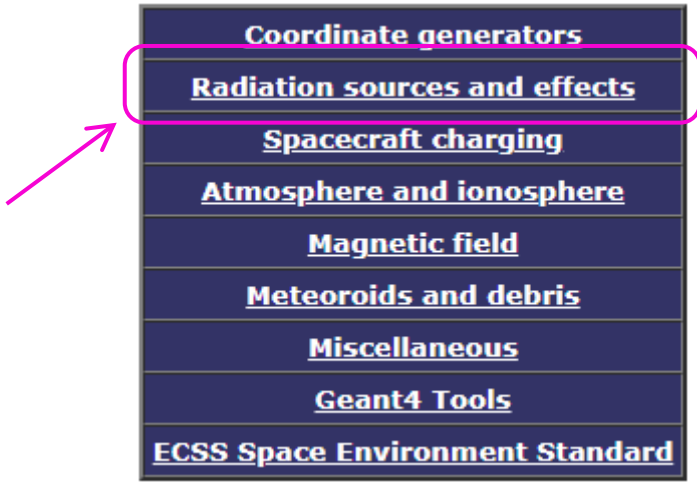


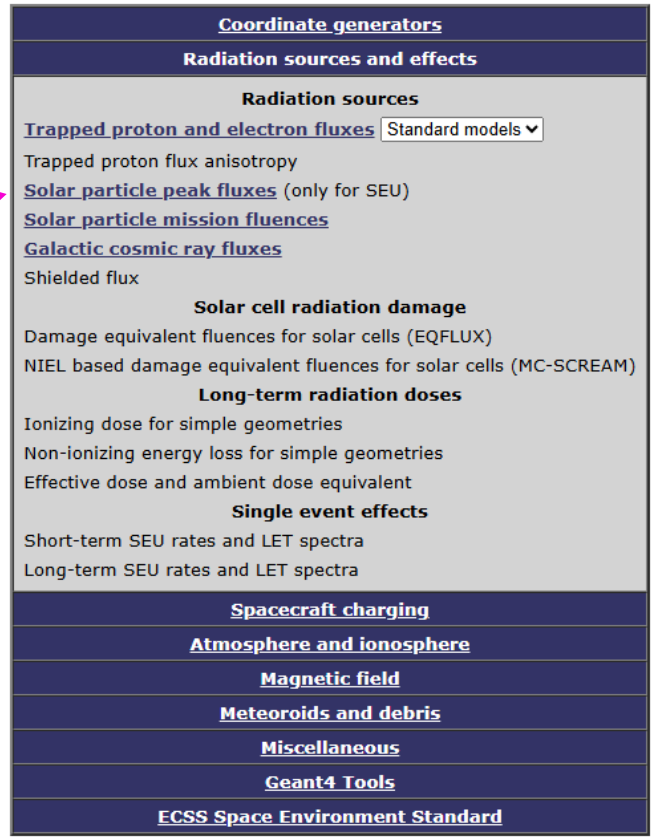


Modeling charged particle populations



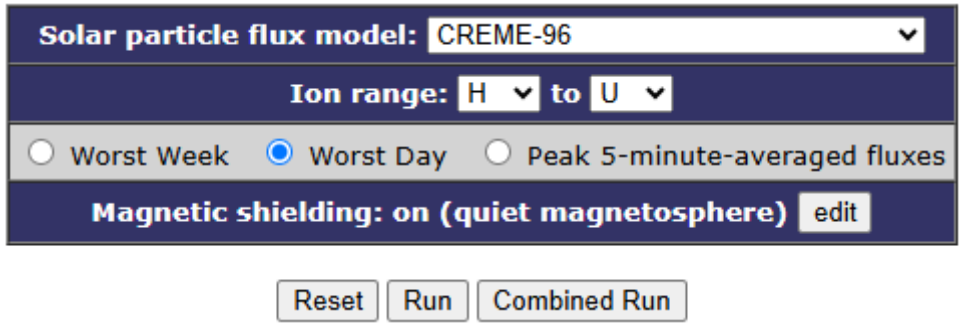
1. Click UP and return to Main Menu
2. Click RADIATION SOURCES AND EFFECTS
3. Let's add Solar particles





Run CREME-96 Worst Day (WD)

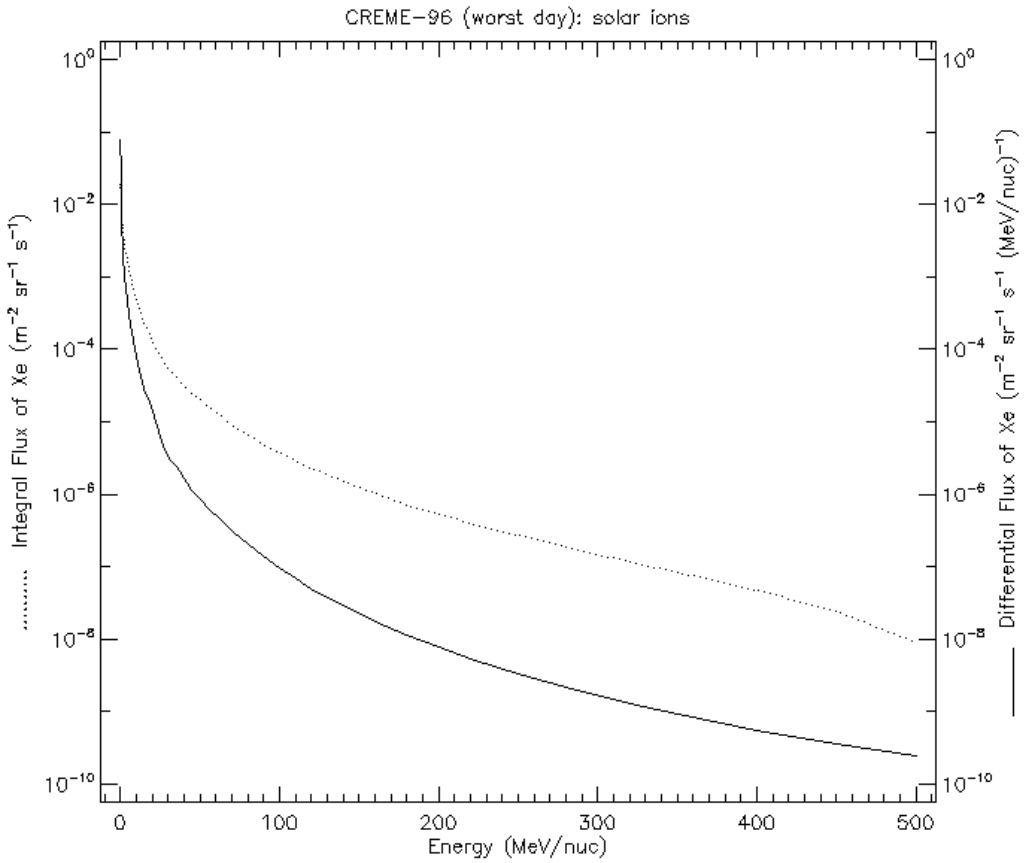
- Other options available (SAPPHIRE, CREME-86, …)
- Why CREME-96?
  - Compatibility with SIRE-2, CREME-MC, …
- Leave the Magnetic shielding as defaults

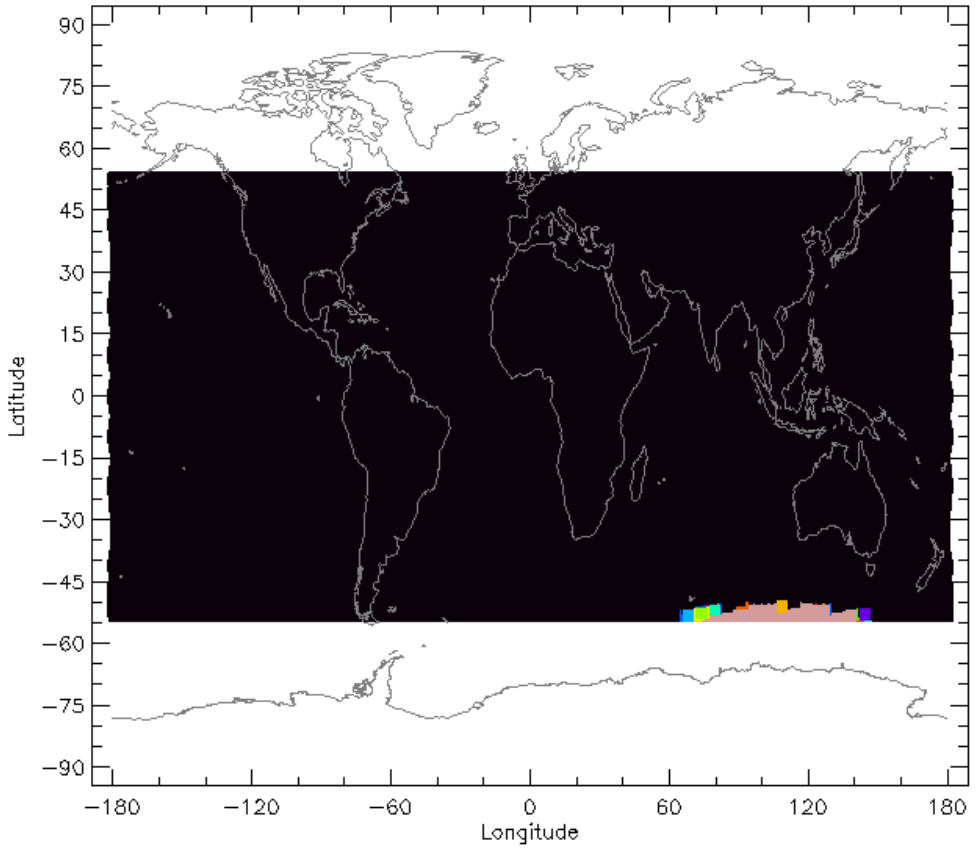


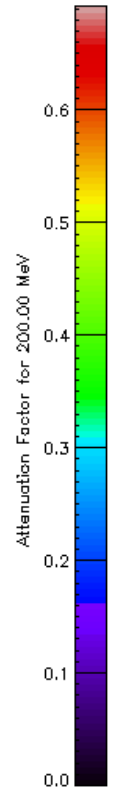
Explore the outputs

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

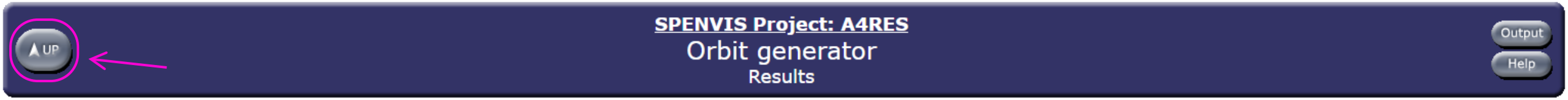
Explore the outputs



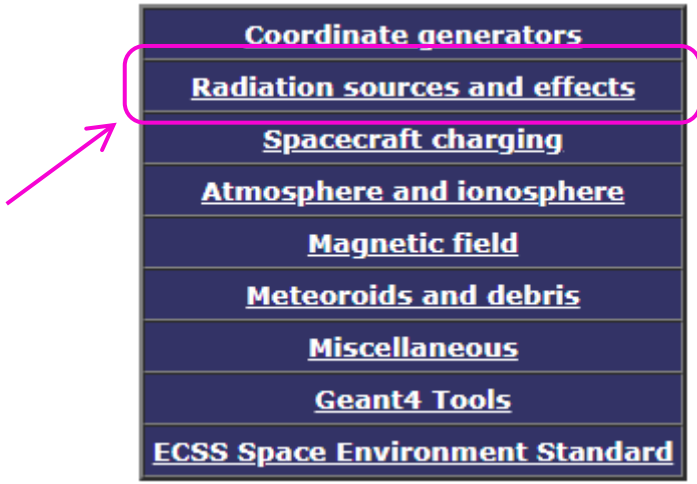


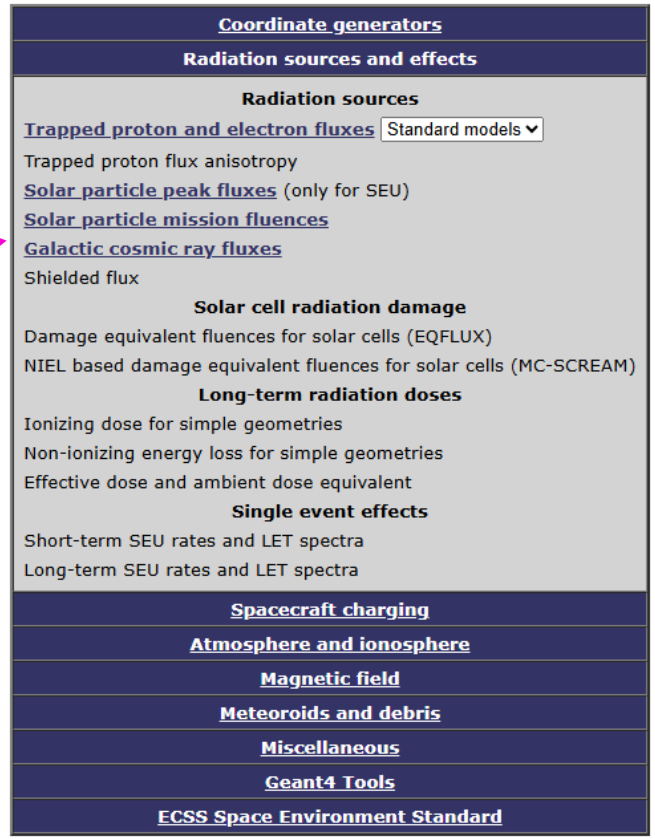


Modeling charged particle populations



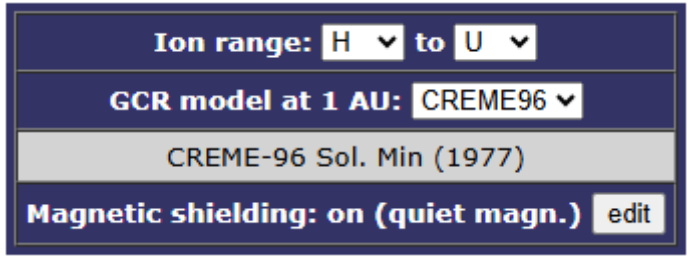
1. Click UP and return to Main Menu
2. Click RADIATION SOURCES AND EFFECTS
3. Let's add GCRs





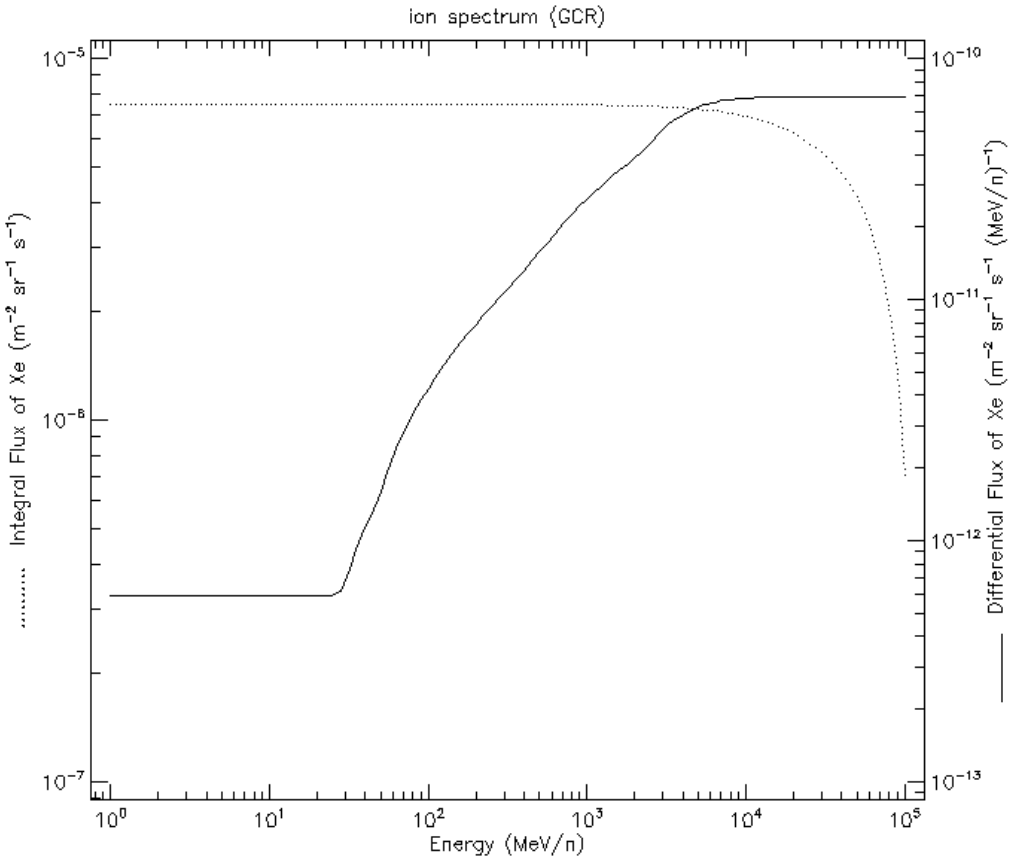
Run CREME-96

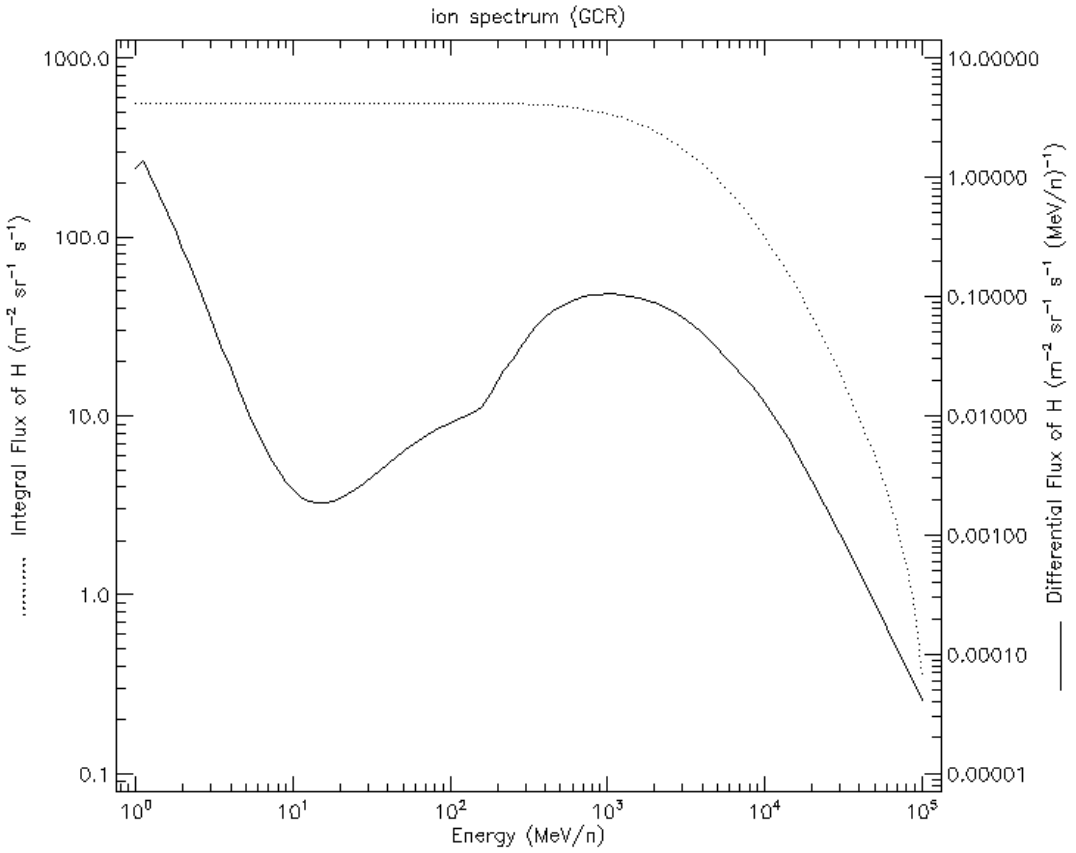
- Other options available (ISO 15390, CREME-86, Nymmik, …)
- Why CREME-96?
  - Compatibility with SIRE-2, CREME-MC, …
- Leave the Magnetic shielding as defaults



Explore the outputs

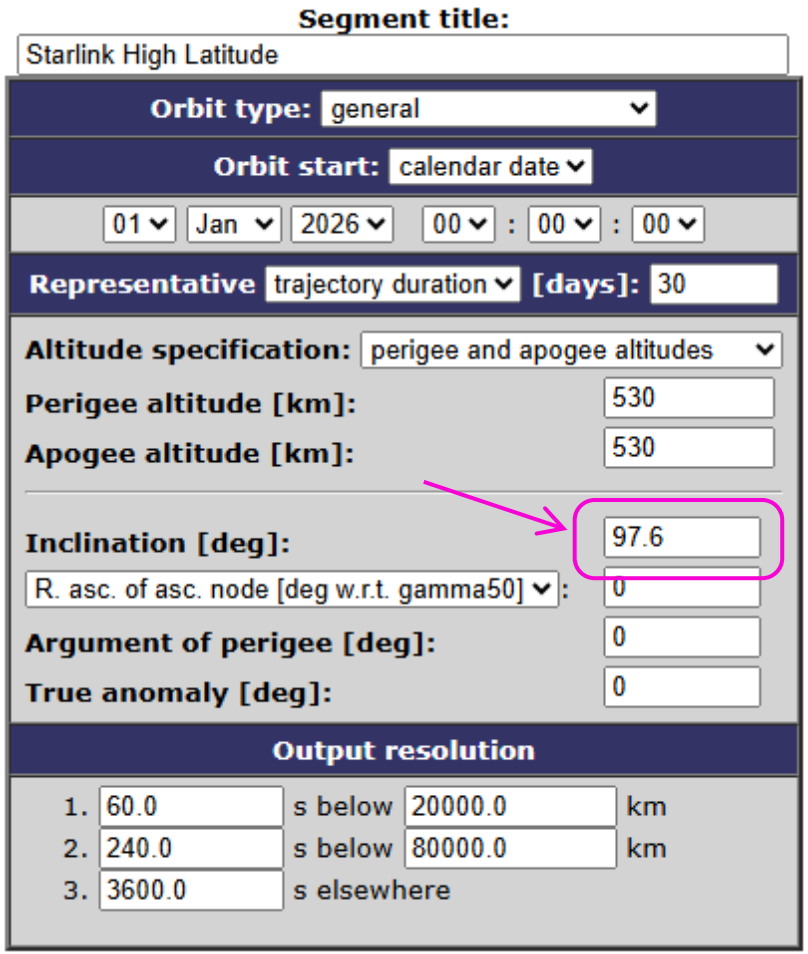
1. Generate a Heavy Ion spectra for Xe (Z=54) for this mission (flux vs. energy)
2. Generate a Heavy Ion spectra for protons (Z=1) for this mission (flux vs. energy)



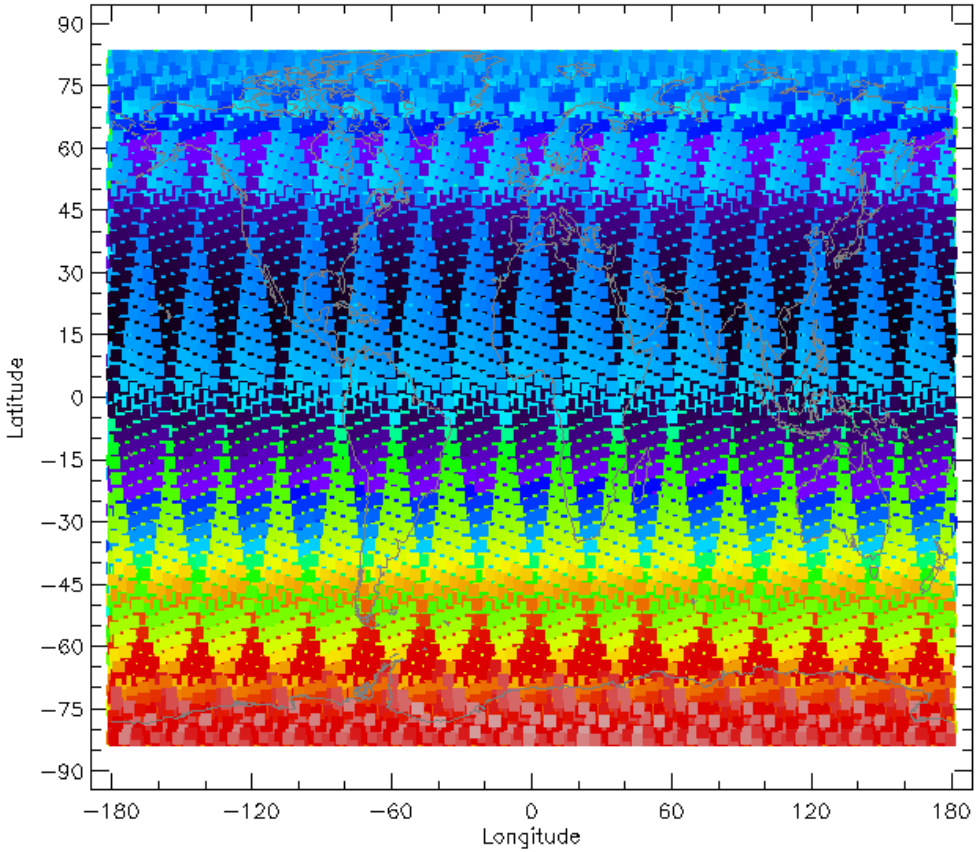


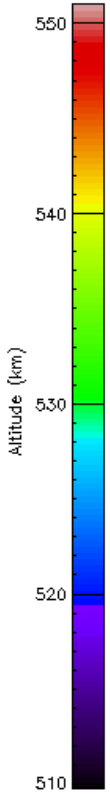
Next steps … on your own

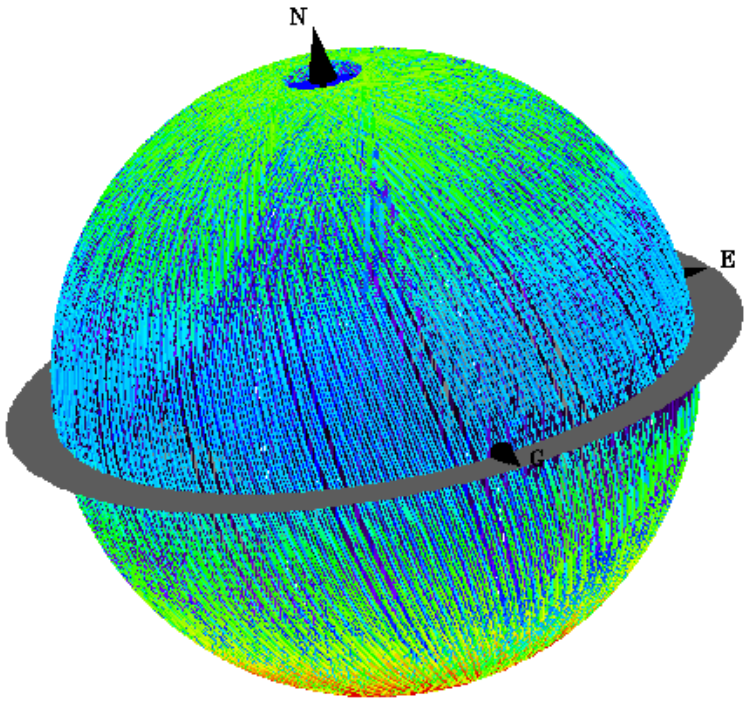
- As of now we've generated charged particle environments for a notional mid latitude Starlink-like mission –
  - Trapped protons
  - SEP protons and ions
  - GCR protons and ions
- Repeat this process for a notional high latitude Starlink-like mission (see right)
  - Generate the same outputs and save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

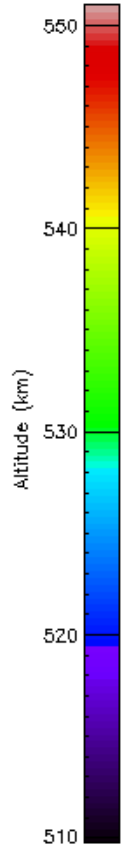


Trajectory

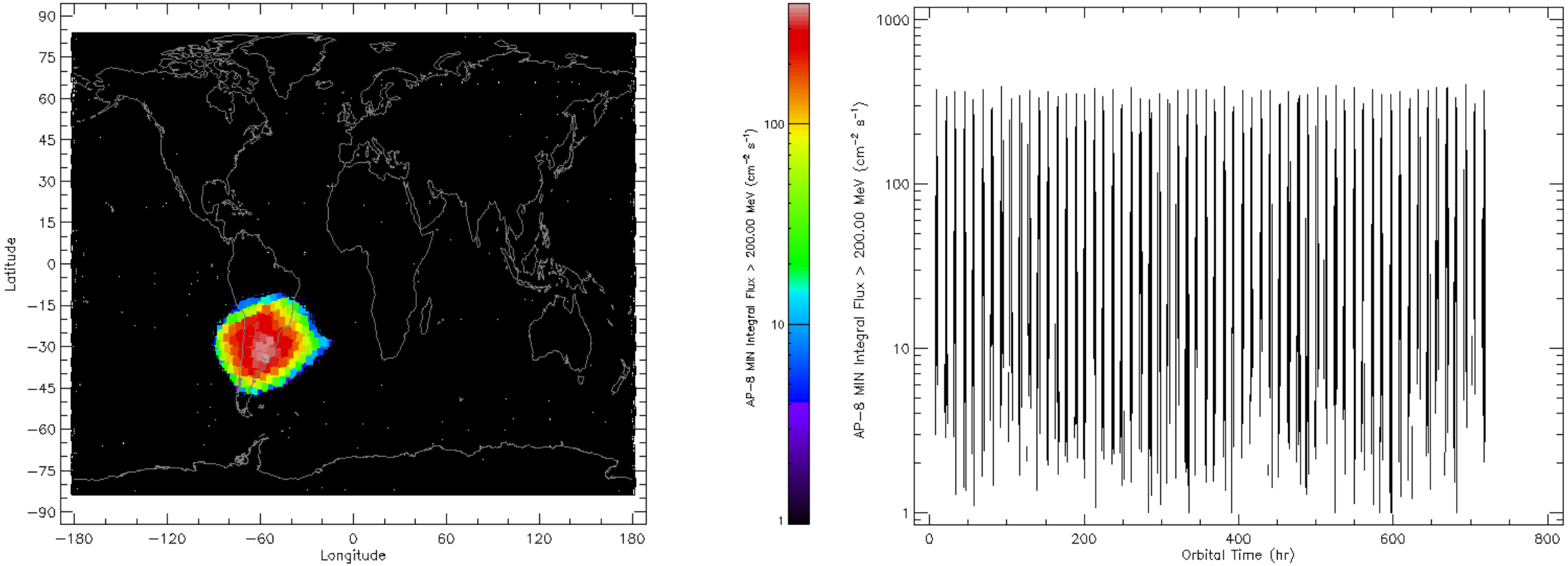

90
75
60
45
30
15
0
−15
−30
−45
−60
−75
−90
Latitude
−180
−120
−60
0
60
120
180
Longitude


550
540
530
520
510
Altitude (km)


N
E

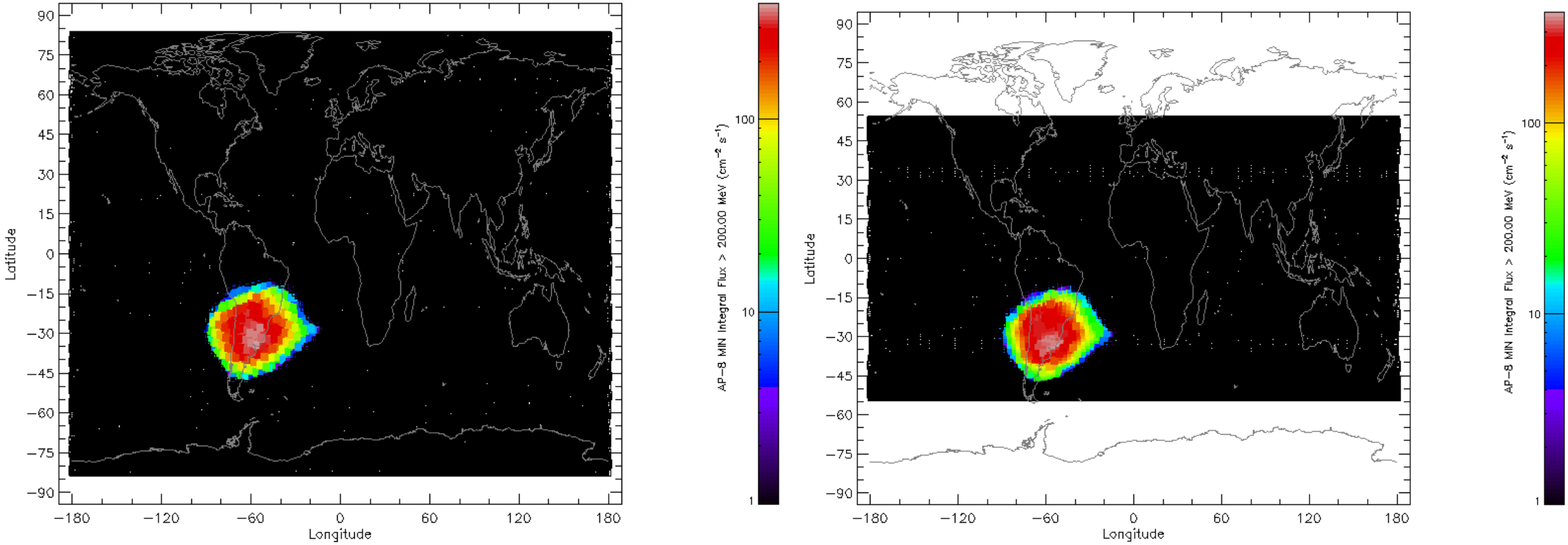

550
540
530
520
510
Altitude (km)

Trapped protons



Comparisons (Trapped Protons)

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



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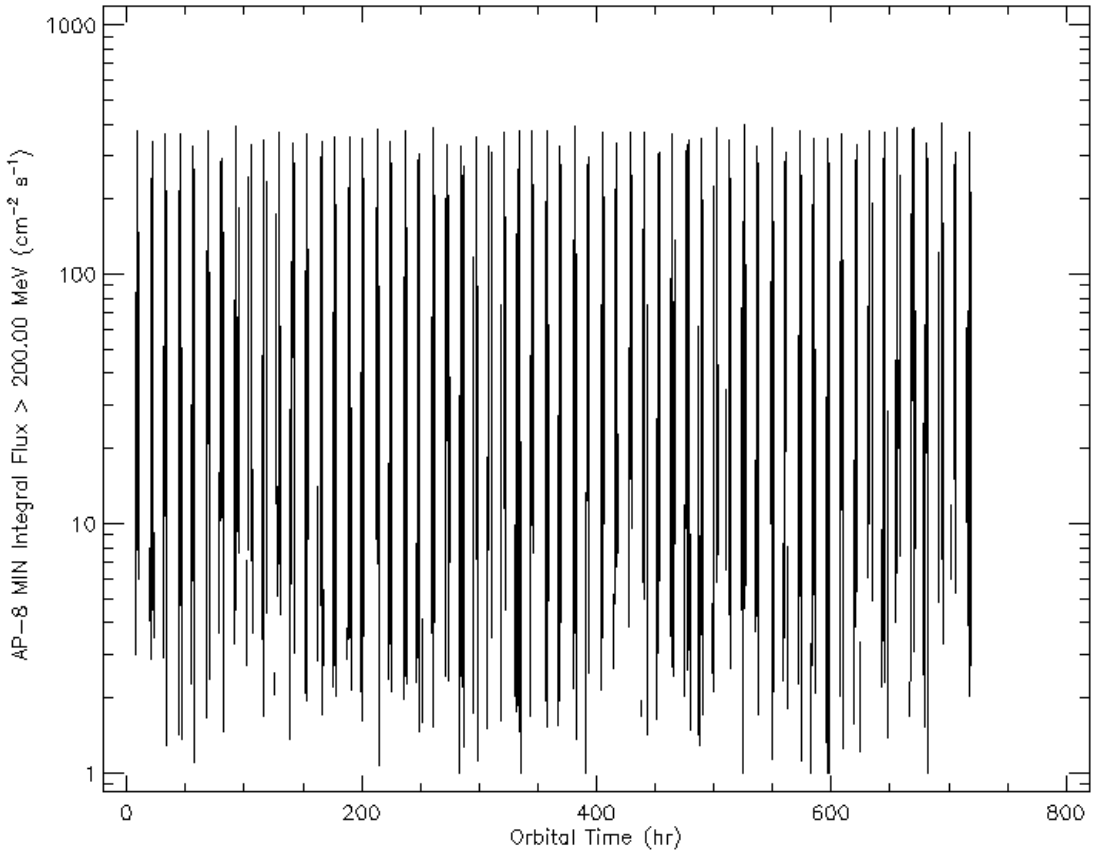
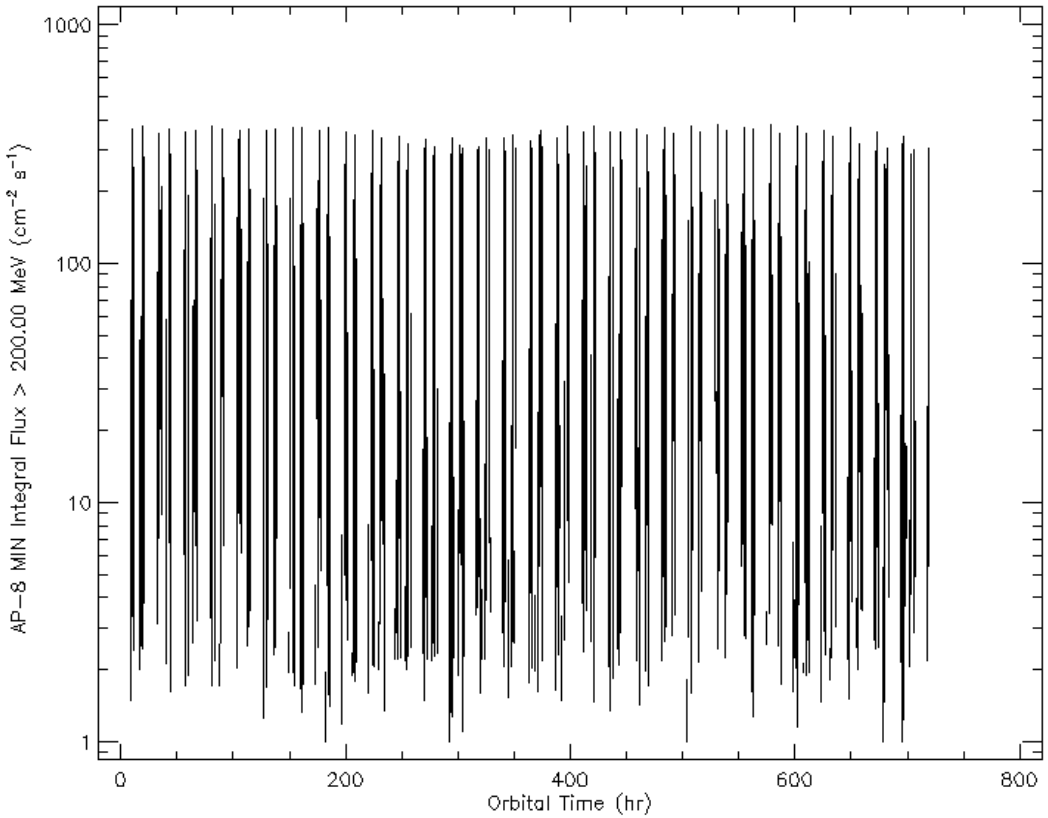
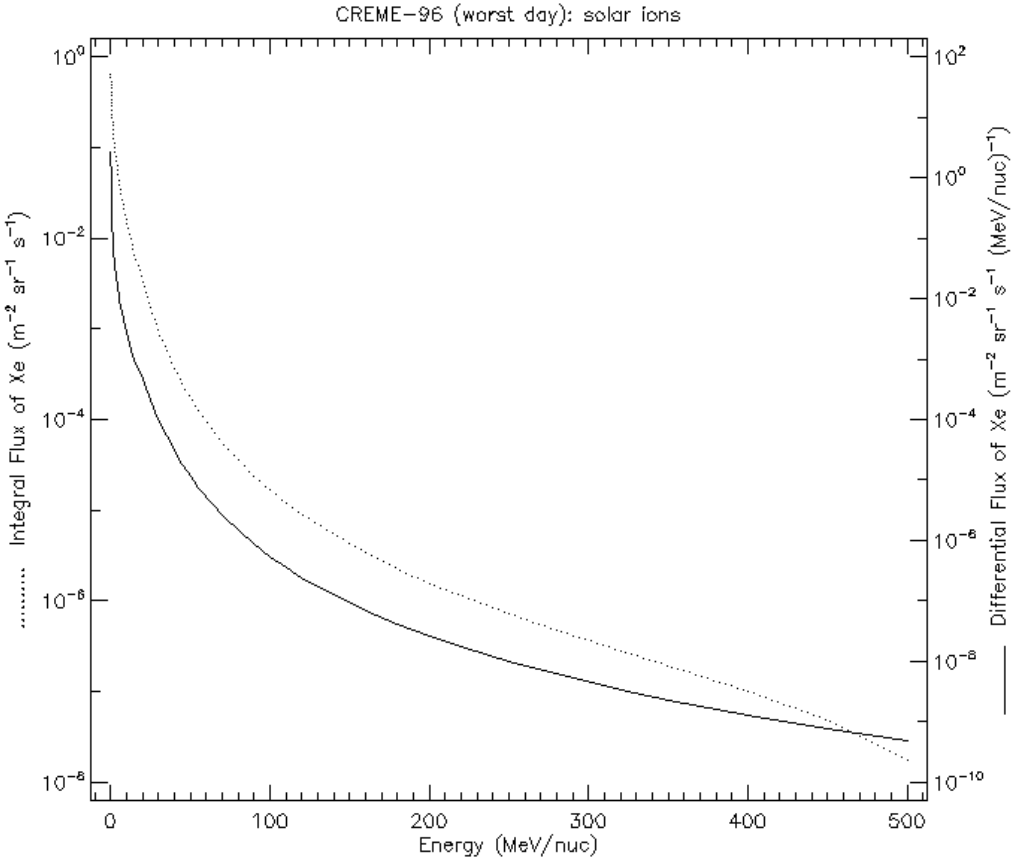
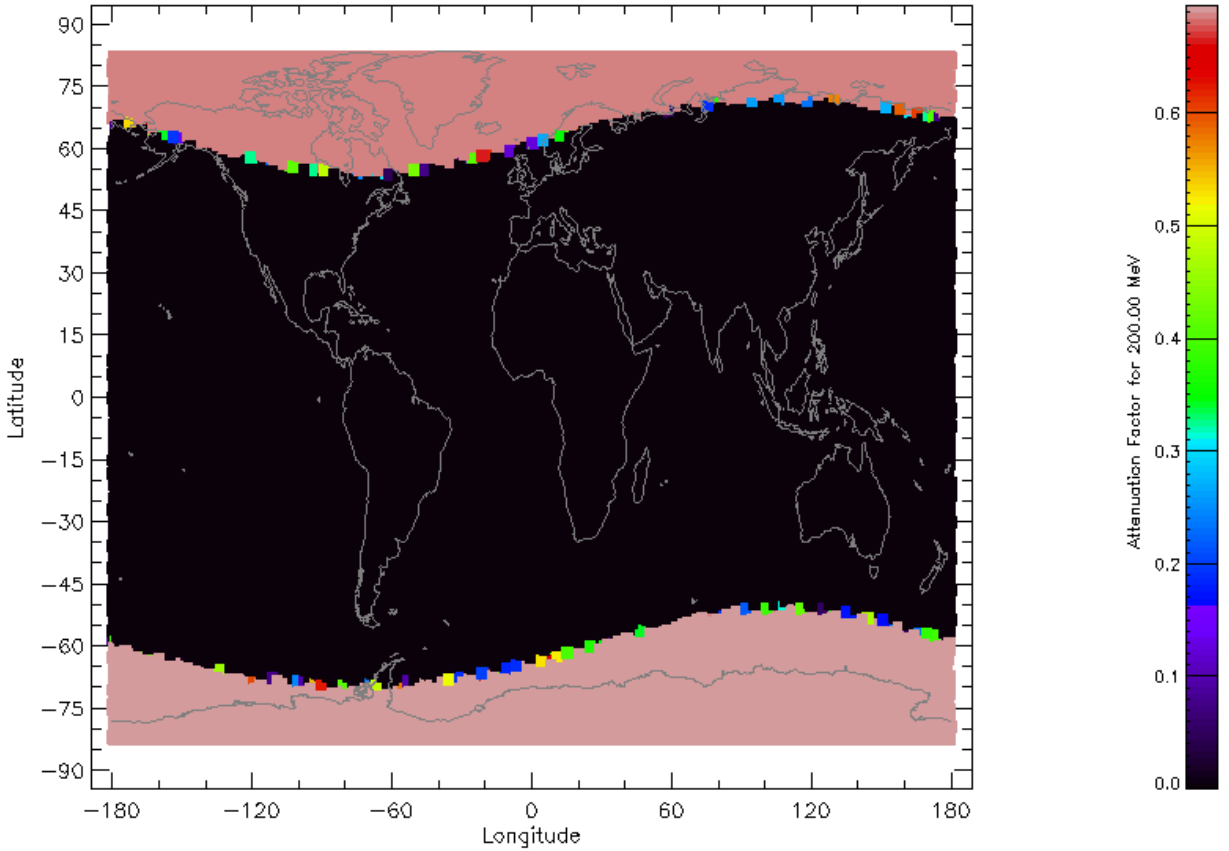




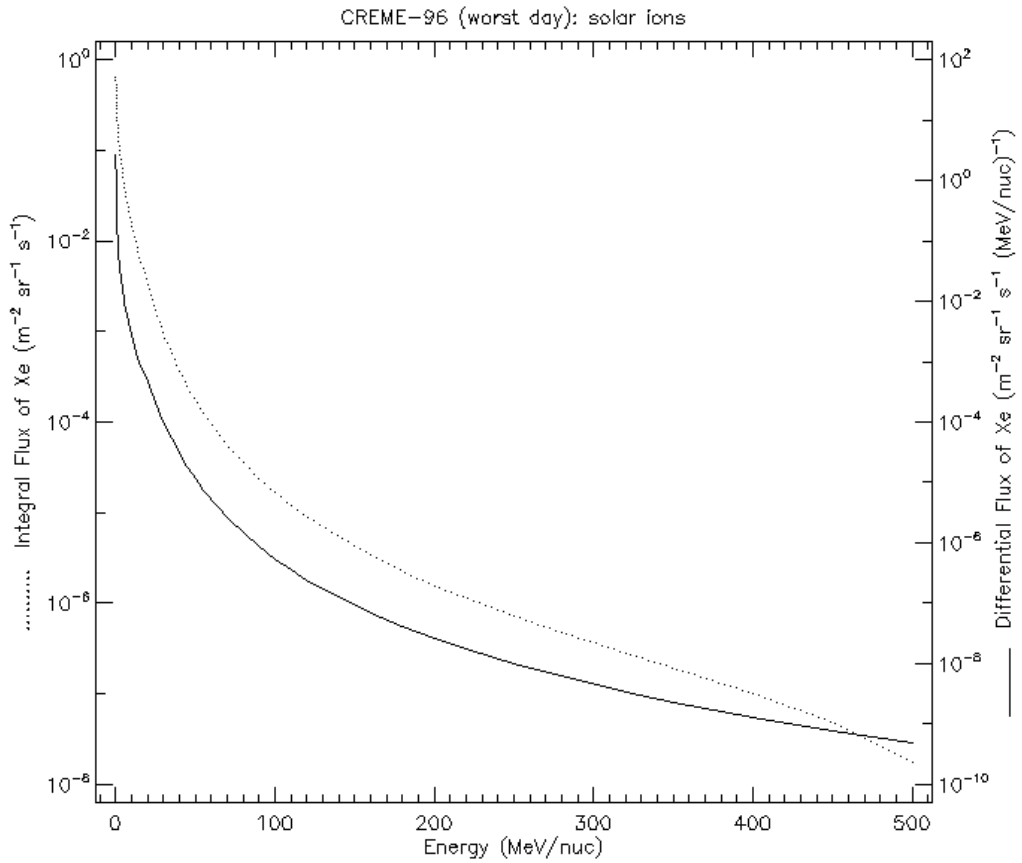
Worst Day

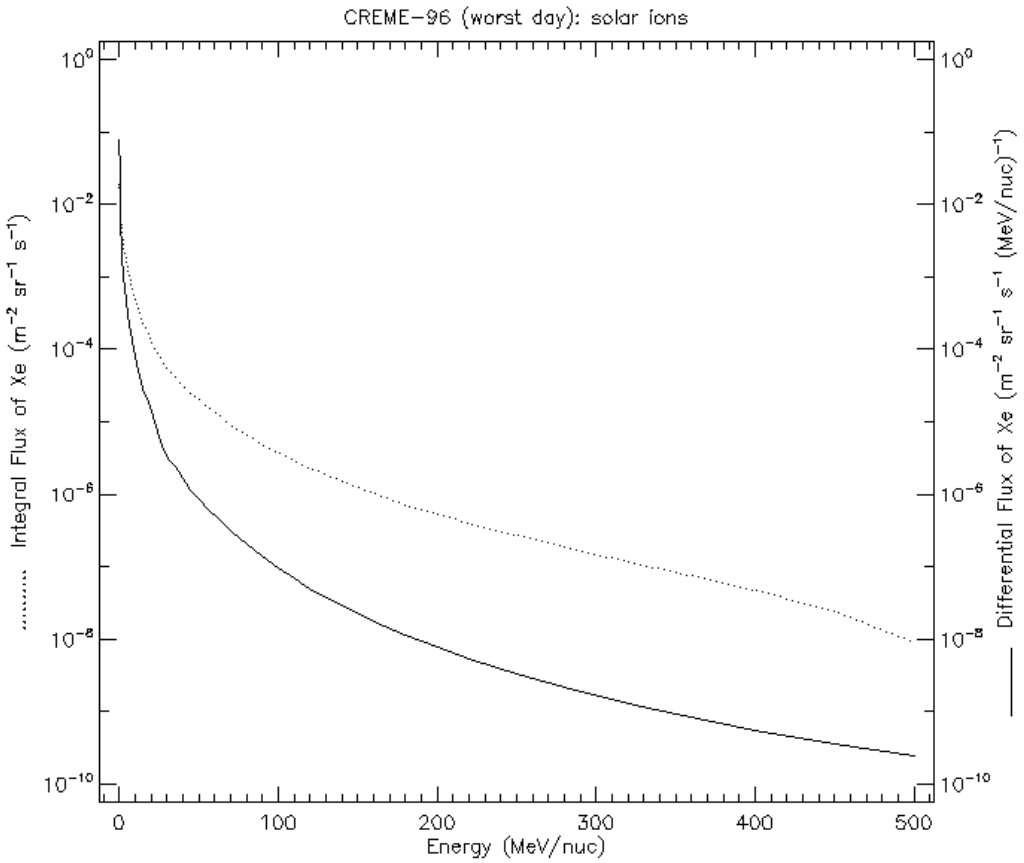

CREME-96 (worst day): solar ions
Integral Flux of Xe (m^{-2} sr^{-1} s^{-1})
Differential Flux of Xe (m^{-2} sr^{-1} s^{-1} (MeV/nuc)$^{-1}$)
Energy (MeV/nuc)
10^{0}
10^{-2}
10^{-4}
10^{-6}
10^{2}
10^{0}
10^{-2}
10^{-4}
10^{-6}
10^{-8}
10^{-10}
0
100
200
300
400
500


Latitude
Longitude
90
75
60
45
30
15
0
−15
−30
−45
−60
−75
−90
−180
−120
−60
0
60
120
180
Attenuation Factor for 200.00 MeV
0.6
0.5
0.4
0.3
0.2
0.1
0.0

Comparisons (Worst Day)

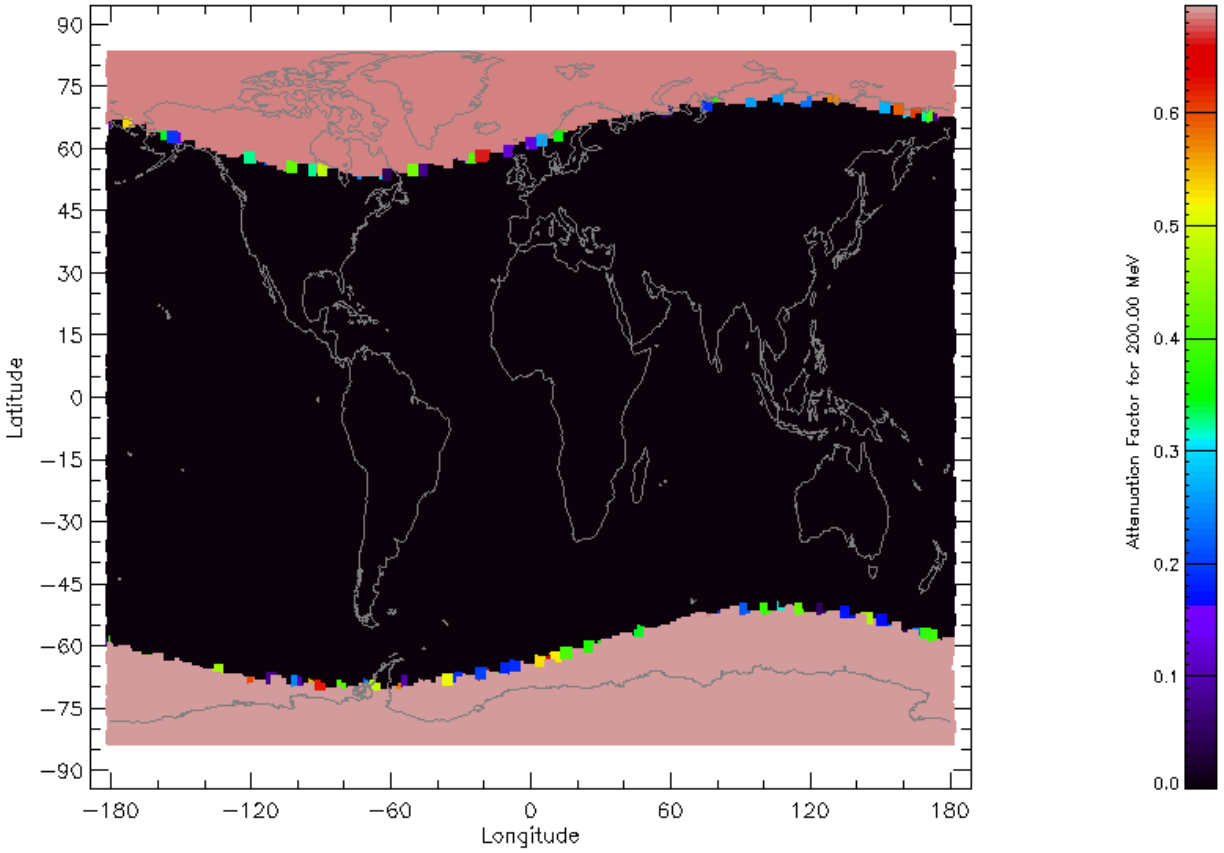
- Make some observations about –
  - Fluxes and energies of Xe ions

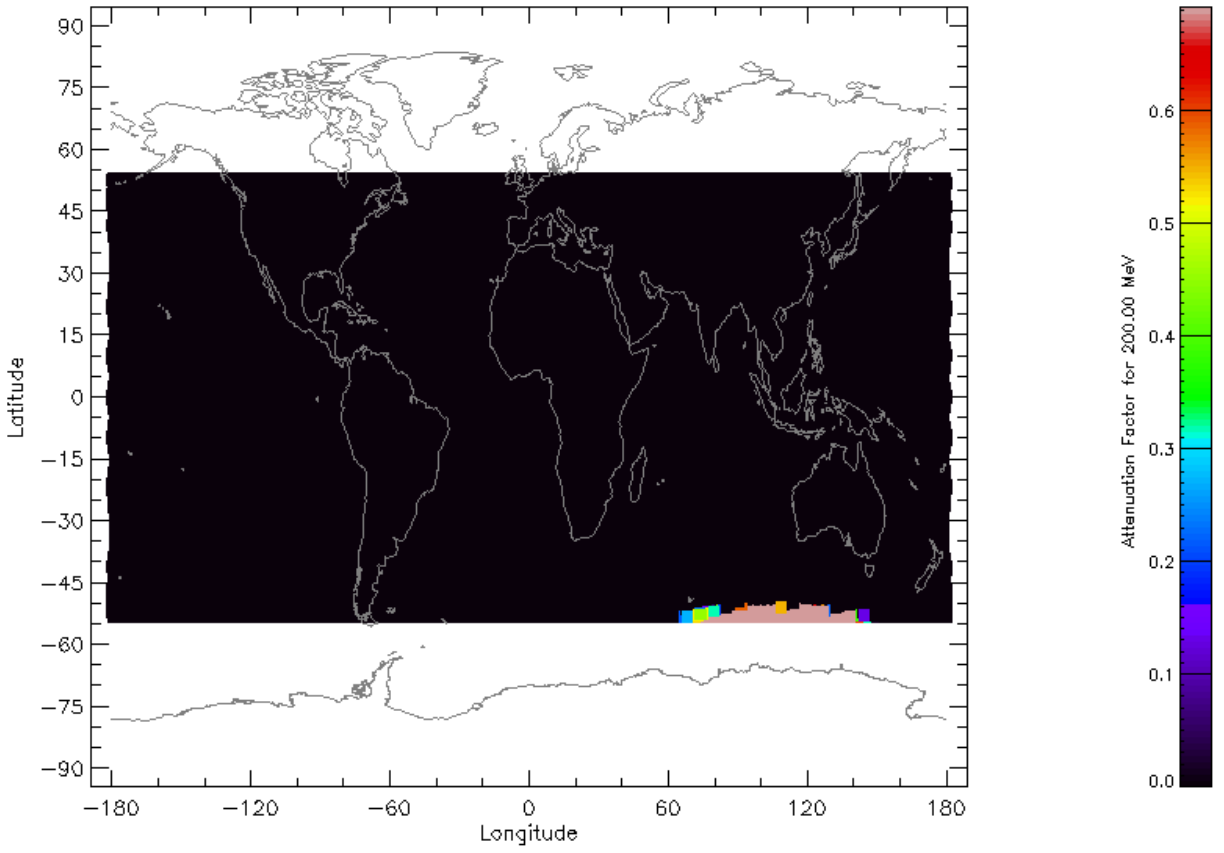




Comparisons (Worst Day)

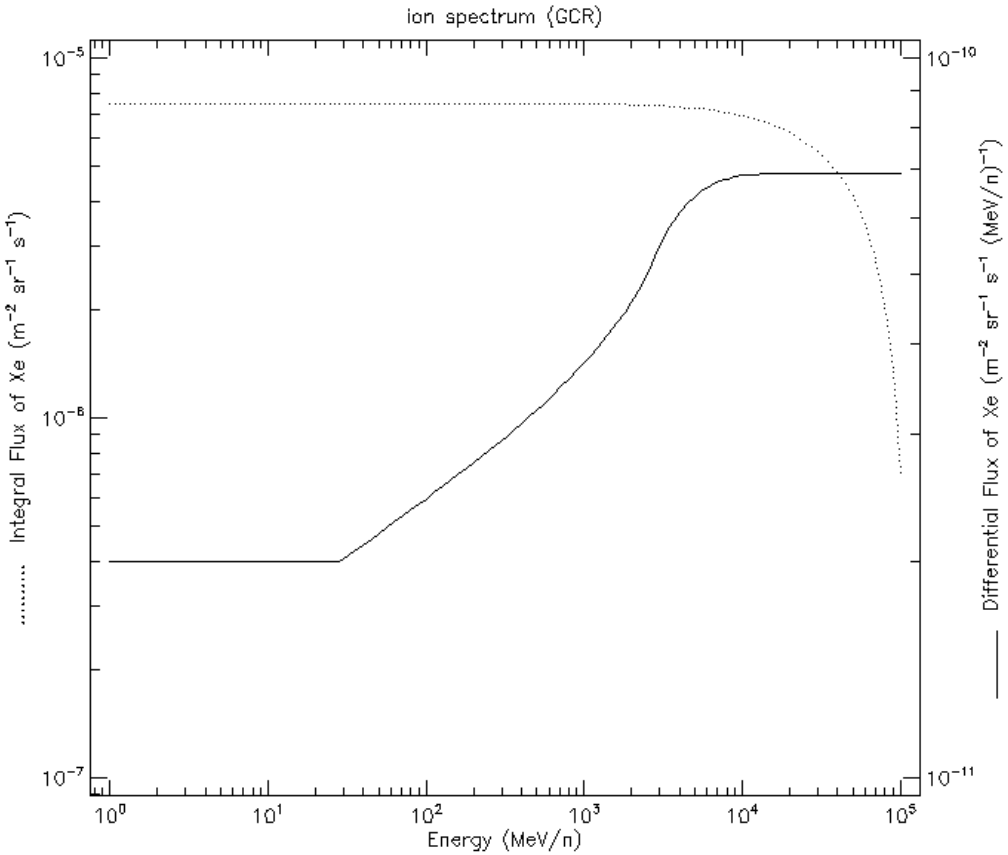
- Make some observations about –
  - Access of >200 MeV protons
  - Is the mission susceptible in a WD environment?

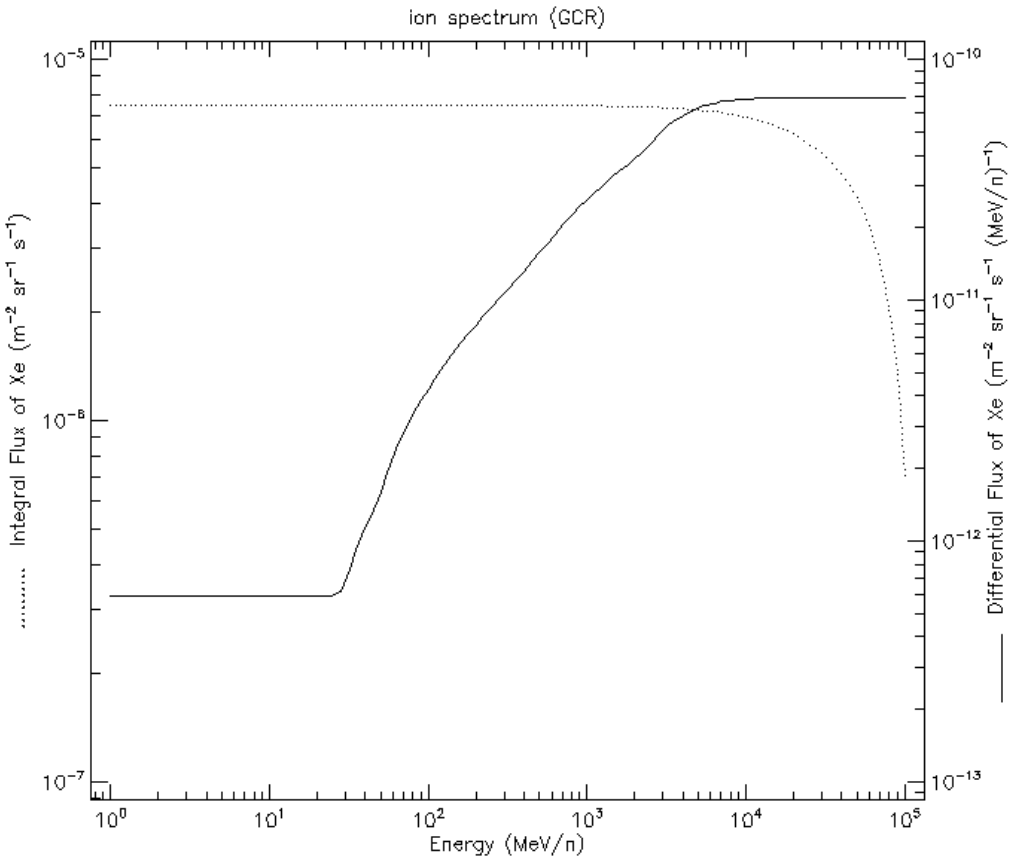




Comparisons (GCRs)

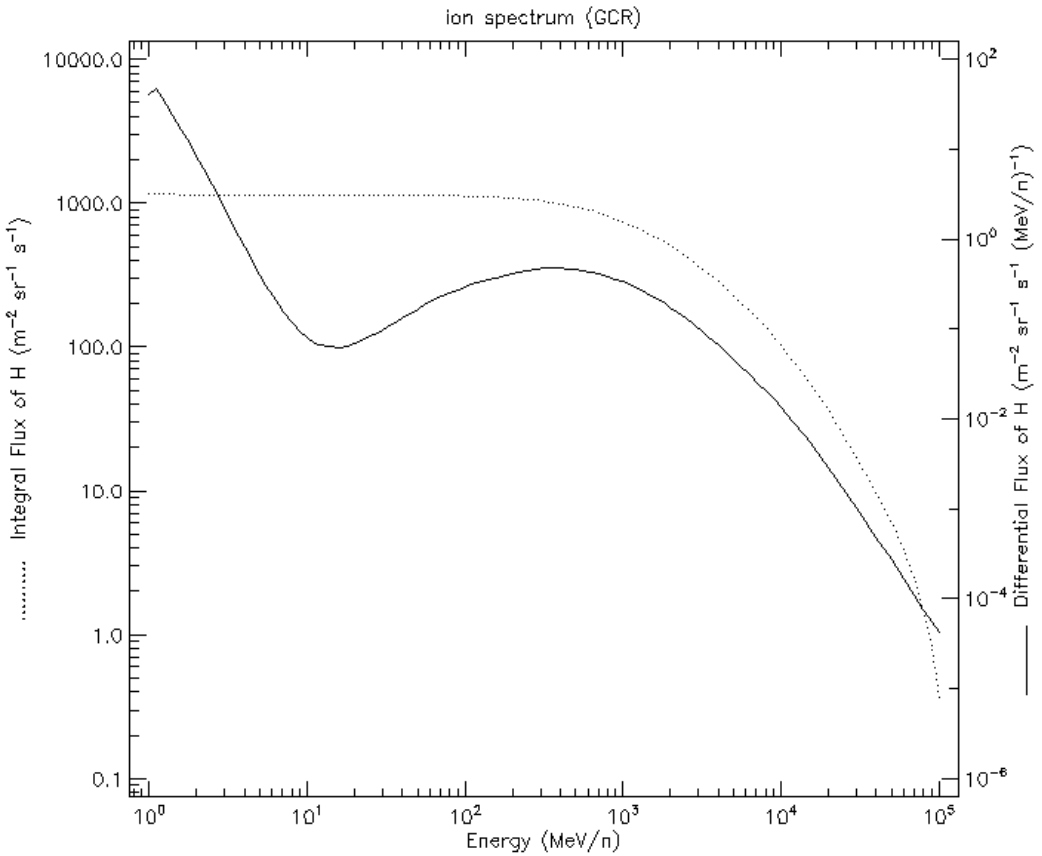
- Make some observations about –
  - Fluxes and energies of Xe ions

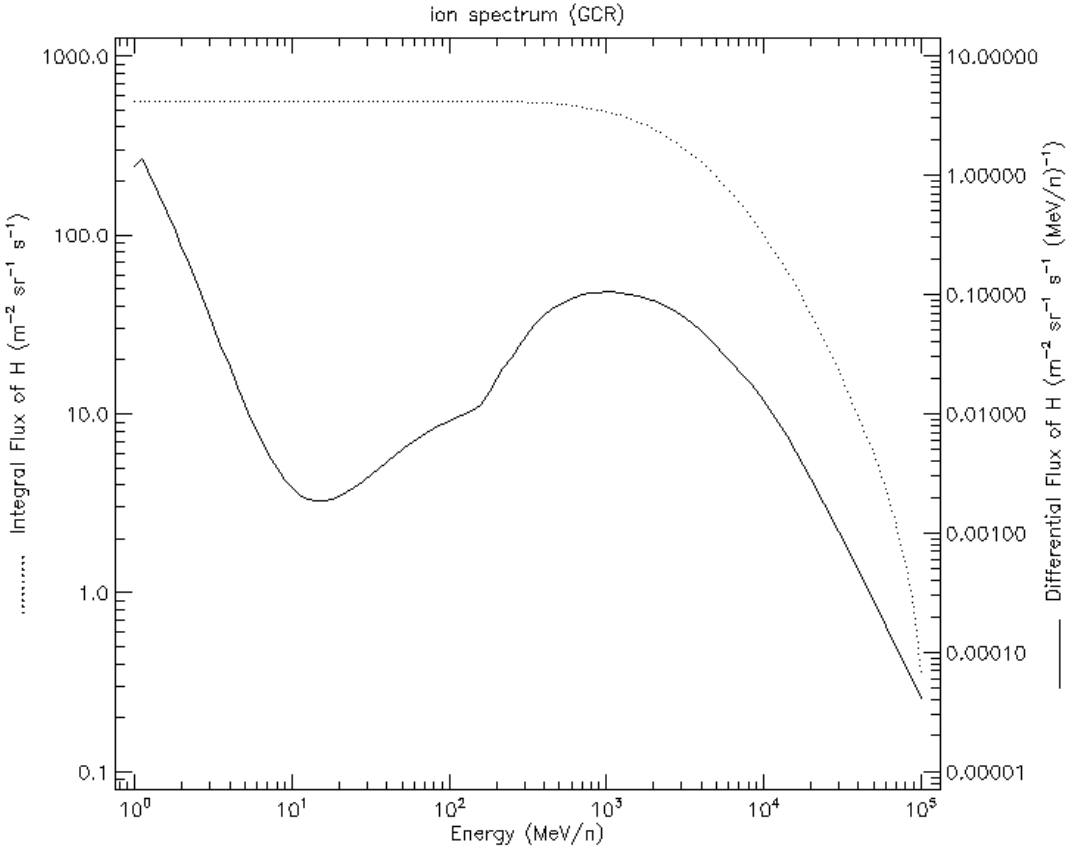




Comparisons (GCRs)

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





Discussion questions

- These are both LEO missions (same 530 km altitude)
  - But inclinations are quite different
- What are the major differences in –
  - SAA passage(s)?
  - Orbit averaged trapped protons?
  - Accessibility of SEP protons / ions?
  - Accessibility of GCR protons / ions?
- How might these environments (and differences therein) drive SEE test planning?
  - For a Class A (exquisite) mission?
  - For a Class D (risky) mission?
- How are these differences likely to impact error rates?
  - For a RT / RH device with onset LET of >30 MeV-cm^2/mg
  - For a non-RT / RH device with onset LET <1 MeV-cm^2/mg

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Natural Space Environment

Mod01a Homework / Assignment

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justin.likar@jhuapl.edu | jlikar1@jhu.edu

Consider a different reference mission

- Missions to GEO, L1 / L2, the lunar surface or cis-lunar space operate either entirely, or mostly, outside of the magnetosphere
- Use SPENVIS to define charged particle environments for such a mission (for ease of SPENVIS operations suggest GEO)
  - Trapped particles
  - Solar Energetic Particles
  - Galactic Cosmic Rays
- Compare / contrast with the reference missions we studied in class
- How might these environments (and differences therein) drive SEE test planning?
  - For a Class A (exquisite) mission?
  - For a Class D (risky) mission?
- How are these differences likely to impact error rates?
  - For a RT / RH device with onset LET of >30 MeV-cm^2/mg
  - For a non-RT / RH device with onset LET <1 MeV-cm^2/mg

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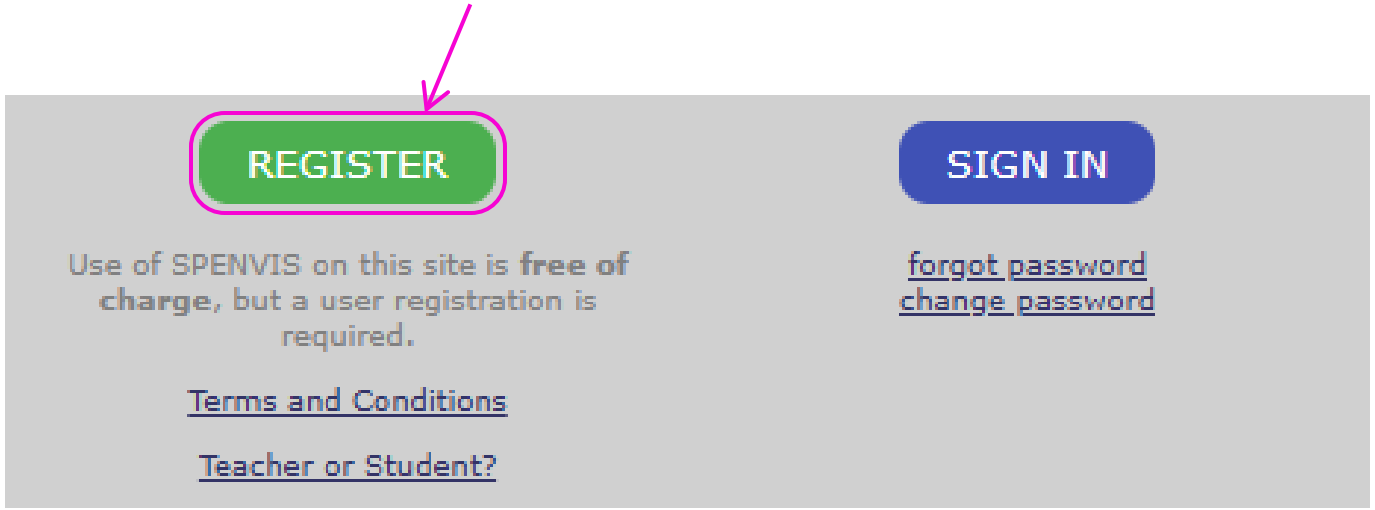
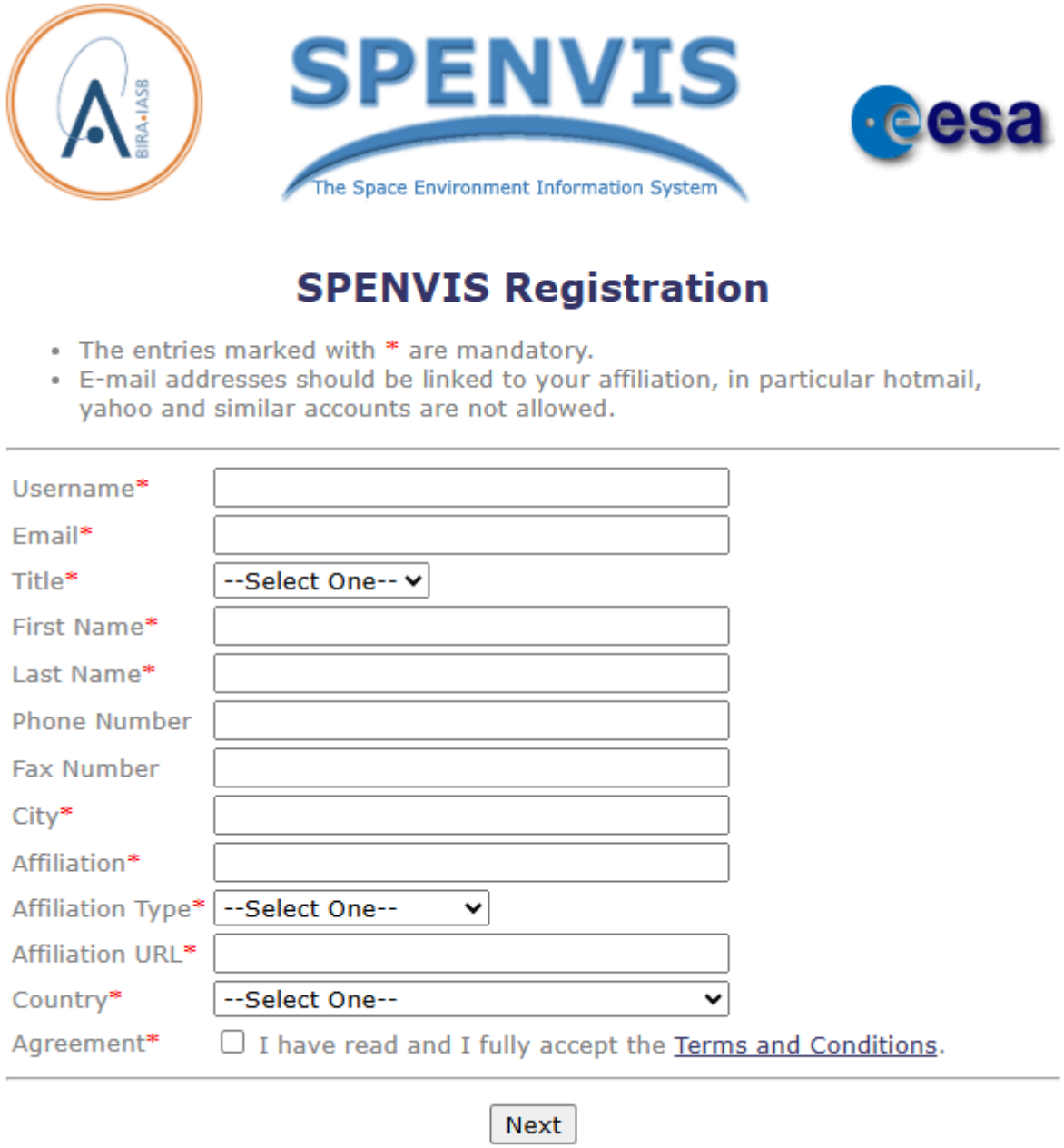
Create an account

1. Navigate to https://www.spenvis.oma.be/
2. Click REGISTER



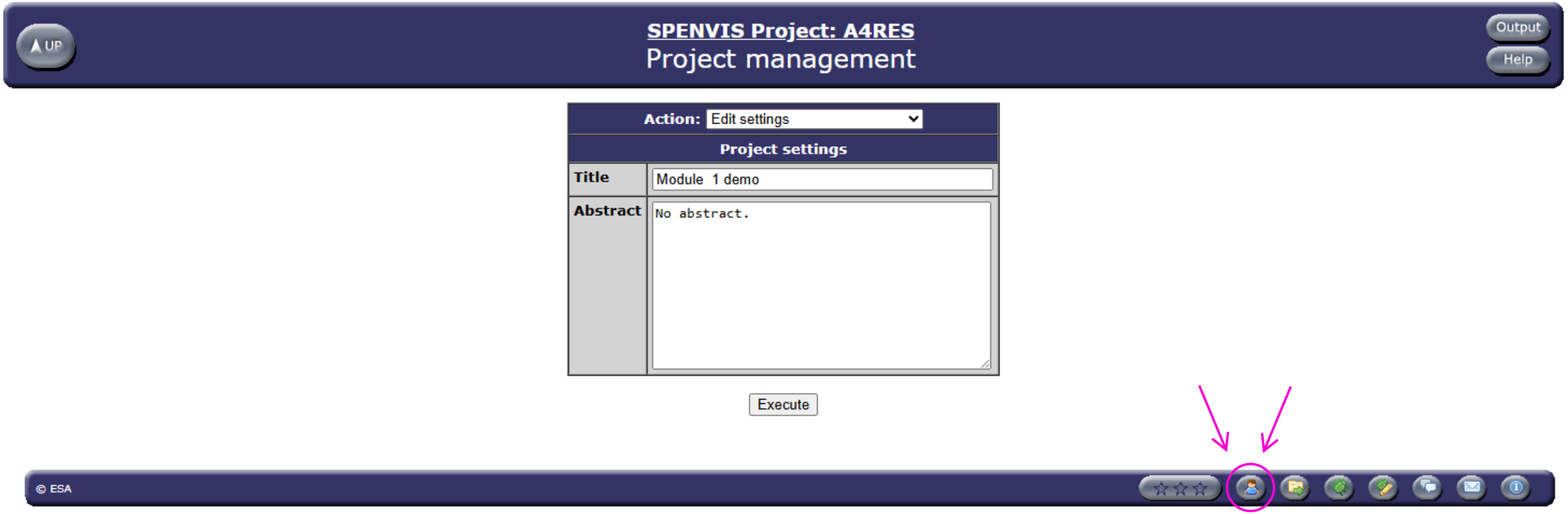
Create an account

1. Supply the requested registration information
2. Wait a few days



Create an account

1. Once access is approved, sign in and navigate to your profile (icon below)



Create an account

1. Set your Level to ADVANCED