A web application for monitoring cosmic rays and solar activity

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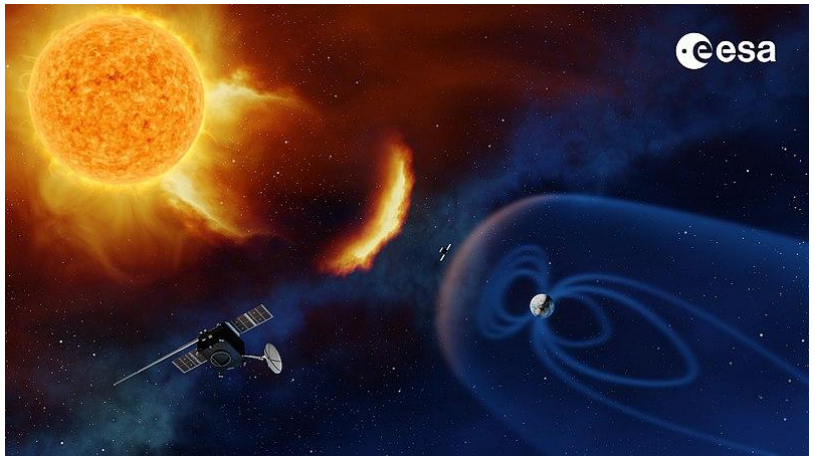
Introduction

- The flux of cosmic rays in the heliosphere is subjected to variations that are related to the Sun's magnetic activity (**solar modulation**).

- Studying solar modulation effect is important to:
  - Understand the physics of cosmic rays (sources, trasport processes, dark matter signatures).
  - Develop predictive models of CR radiation.
  - Characterize the radiation dose received by the astronauts, electronics and experiments in space.

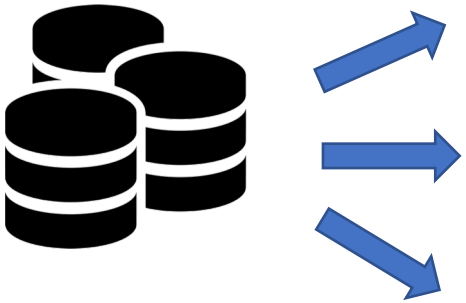


Luca Parmitano during the installation of the AMS-02 UTTPS.

Samantha Cristoforetti on the ISS.

AMS-02 experiment operating on the ISS since 2011.

Data



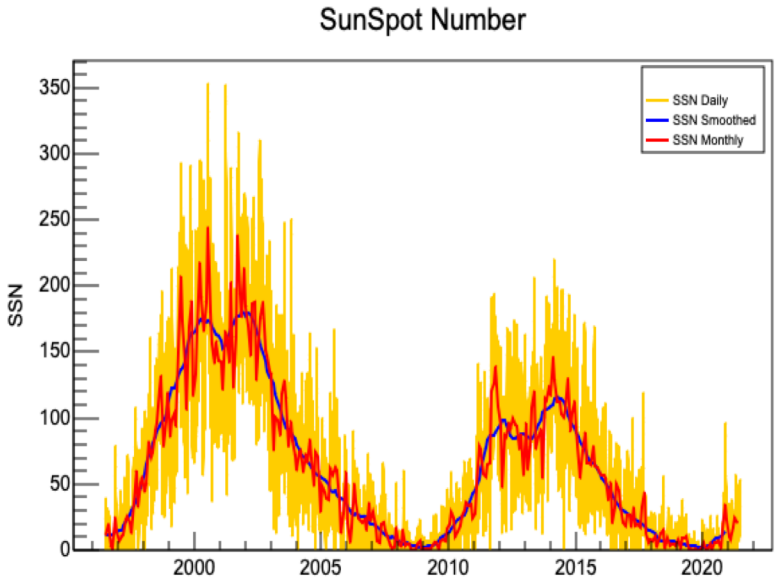
- Sunspot Number
- Tilt Angle of the HCS
- Sun's Polar Field Strenght
- Solar Wind Speed
- Proton Density of Solar Wind
- Neutron Monitor Counting Rates

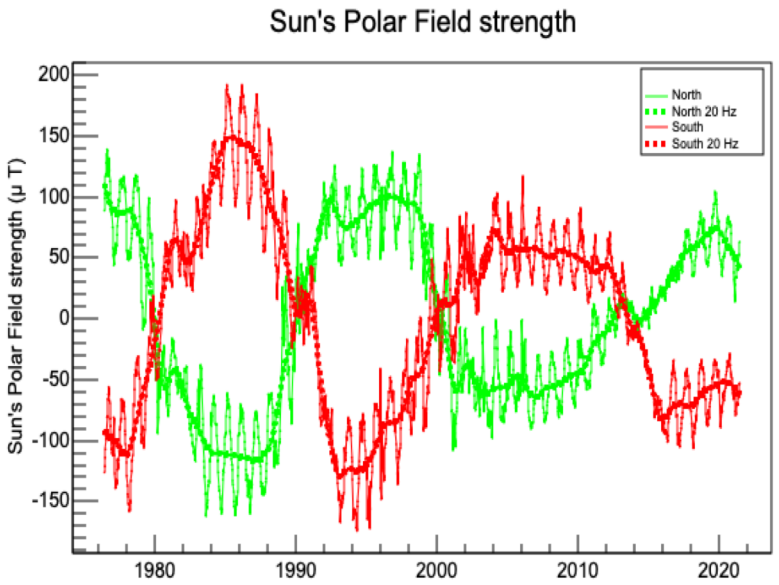
Heliophysics Virtual Observatory

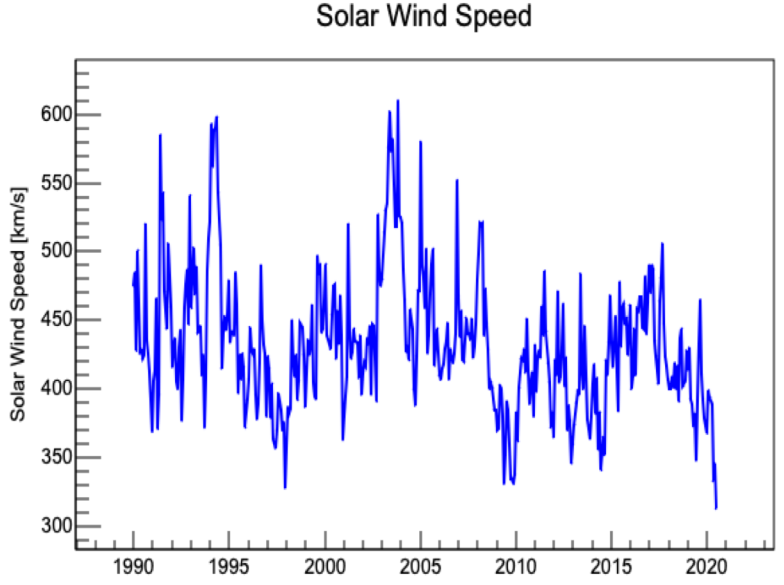
https://crisp.unipg.it/hvo

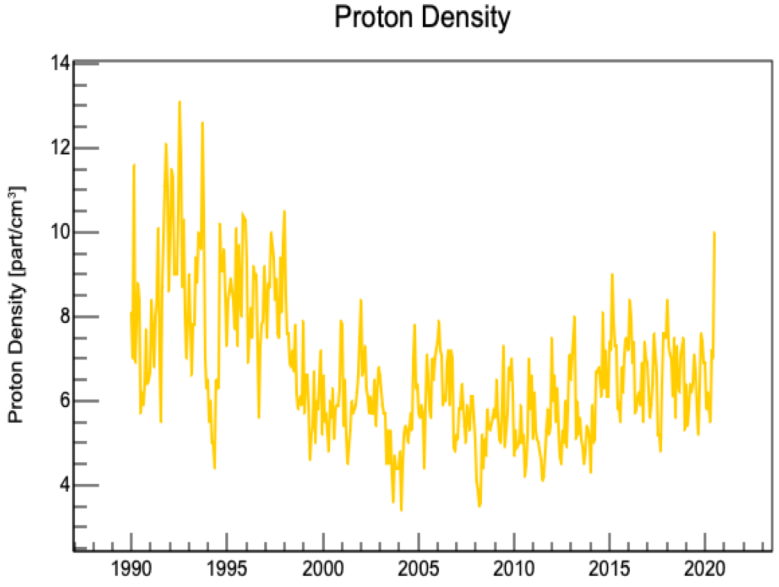
HVO functionalities:

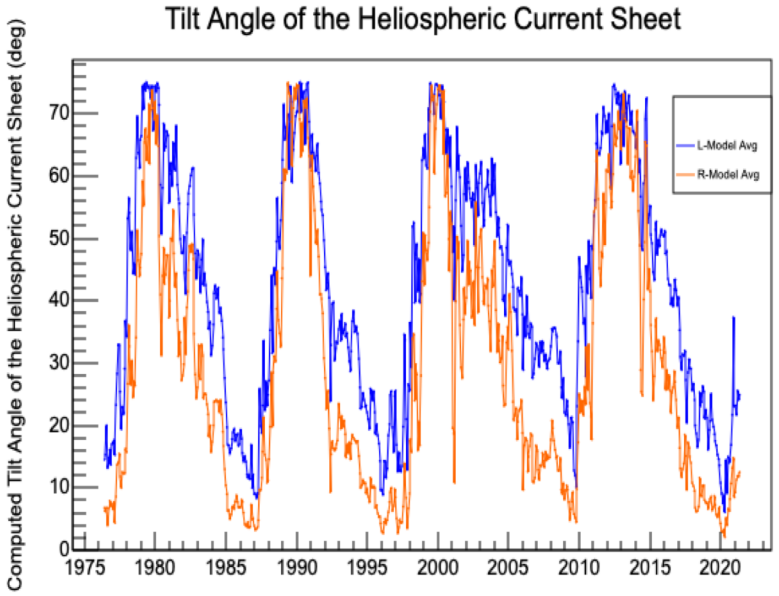
- Automatic daily update
- Visualizing
- Manipulating
- Downloading data and plots in common formats (ROOT object, TXT, CSV or PNG).

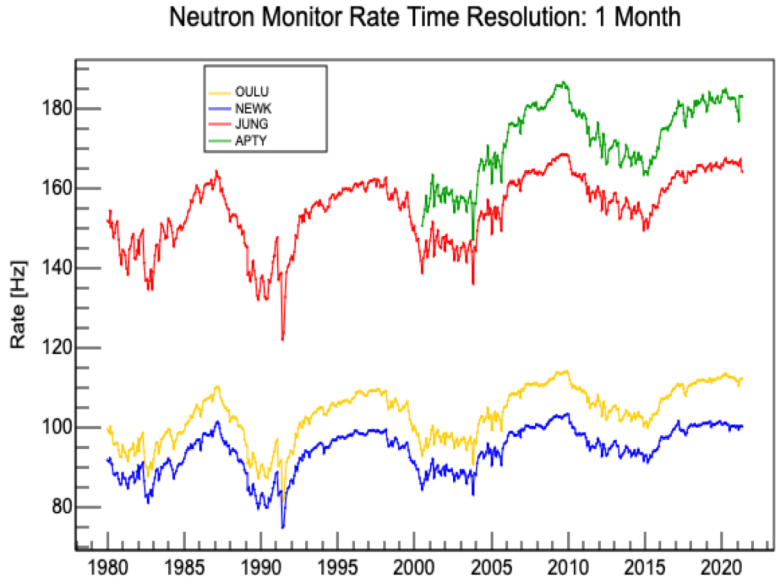

SunSpot Number
SSN Daily
SSN Smoothed
SSN Monthly
SSN
350
300
250
200
150
100
50
0
2000
2005
2010
2015
2020


Sun's Polar Field strength
North
North 20 Hz
South
South 20 Hz
Sun's Polar Field strength (μ T)
200
150
100
50
0
-50
-100
-150
1980
1990
2000
2010
2020


Solar Wind Speed
Solar Wind Speed [km/s]
600
550
500
450
400
350
300
1990
1995
2000
2005
2010
2015
2020


Proton Density
Proton Density [part/cm³]
14
12
10
8
6
4
1990
1995
2000
2005
2010
2015
2020


Tilt Angle of the Heliospheric Current Sheet
L-Model Avg
R-Model Avg
Computed Tilt Angle of the Heliospheric Current Sheet (deg)
70
60
50
40
30
20
10
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


Neutron Monitor Rate Time Resolution: 1 Month
OULU
NEWK
JUNG
APTY
Rate [Hz]
180
160
140
120
100
80
1980
1985
1990
1995
2000
2005
2010
2015
2020

Real-time model for the flux of CR protons

The propagation of CRs in the heliosphere is governed by the Parker Equation.
The Parker Equation in often resolved within the Force-Field approximation.

$$J^p(E,t) = \frac{(E+M_p)^2 - M_p^2}{(E+M_p+\phi(t))^2 - M_p^2} J^p_{\rm lis}(E+\phi(t)),$$

- We have used the new J_{LIS} models based on the latest results from Voyager 1 and AMS-02 C. Corti et al., ApJ 2016.
- We have used the values of the modulation potential (ϕ) reconstructed by Usoskin et al 2011.

The modulation potential can be reconstructed at any epoch t from the quadratic relation between ϕ and Neutron Monitor Count rate R(t).

$$\phi(R(t)) = A + B \cdot R(t) + C \cdot R(t)^2$$

$$\mathrm{t} \longrightarrow \mathrm{R(t)} \longrightarrow \phi(\mathrm{t}) \longrightarrow \mathrm{J(E,t)}$$

FORCE-FIELD MODEL

Last updated date:
6/30/2021

Here we have implemented a method to calculate proton flux at the top of the atmosphere from neutron monitor count rate. See **here** for further information.
to take a screenshot press the button on the lower left side of the canvas.

Click on the Map to check the main characteristics of the NM stations.

Neutron Monitor stations

OULU ☑ JUNG ☐ MXCO ☐
NEWK ☑ HRMS ☐
APTY ☑ MOSC ☐

Time Resolution of Neutron Monitor data 1 Month

Select Energy for Proton Flux Model [GeV]: 1 ➡ E = 1 GeV

Select date range manually

Start Date 1990 9 15

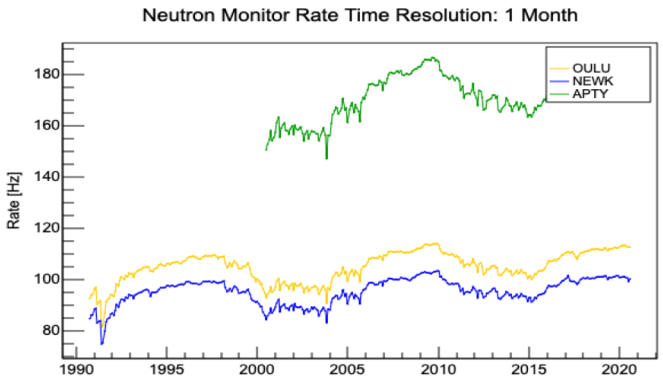
End Date 2020 9 15

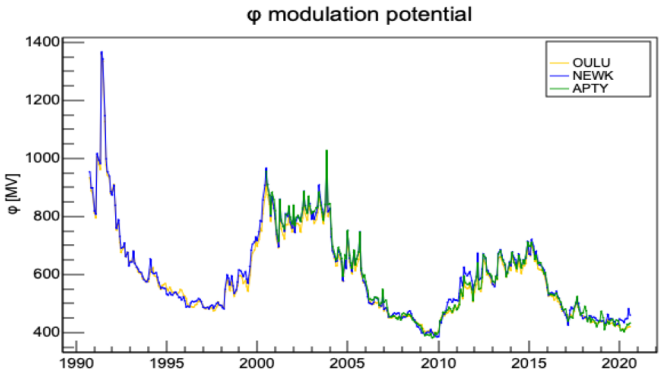
Submit

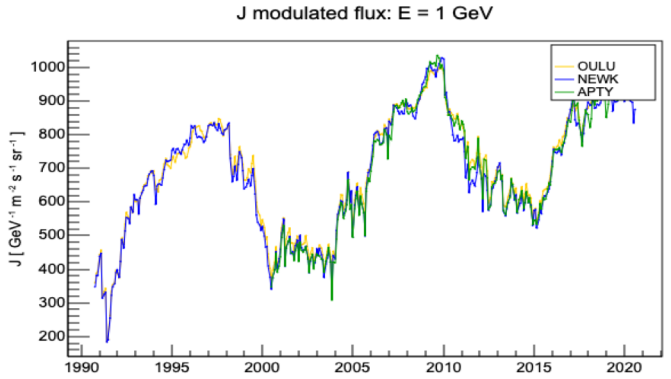
R(t)

ϕ(t)

J(E, t)







Download data ⬅ ROOT File | TXT ZIP | CSV

Future Development

HVO is in its first development phase.

Possible extensions:

- ✓ improvement of the real-time CR flux model (other CR species and other locations in the interplanetary space);
- ✓ Numerical models of CRs transport in the heliosphere;
- ✓ Space Weather data about solar energetic particles (SEP), solar flares and coronal mass ejection (CME).

Thank you