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Perseverance and Ingenuity Space Weather Views

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Presentation Overview

- Suggested future interplanetary SWx capabilities
- Why and When robotic missions need Space Weather (SWx) monitoring
- SWx monitoring resources
- Summary

Future Needs

Since MSL in 2011…

- Still no ability to measure flux of 10s of MeV solar energetic particle (SEP) flux at Mars

  Can NASA get one or more spacecraft with a GOES/SDO/SOHO combo of instruments for SWx monitoring at Mars?

Future Investigations to Pursue

- Still no ability to predict likelihood of SEP events at Mars

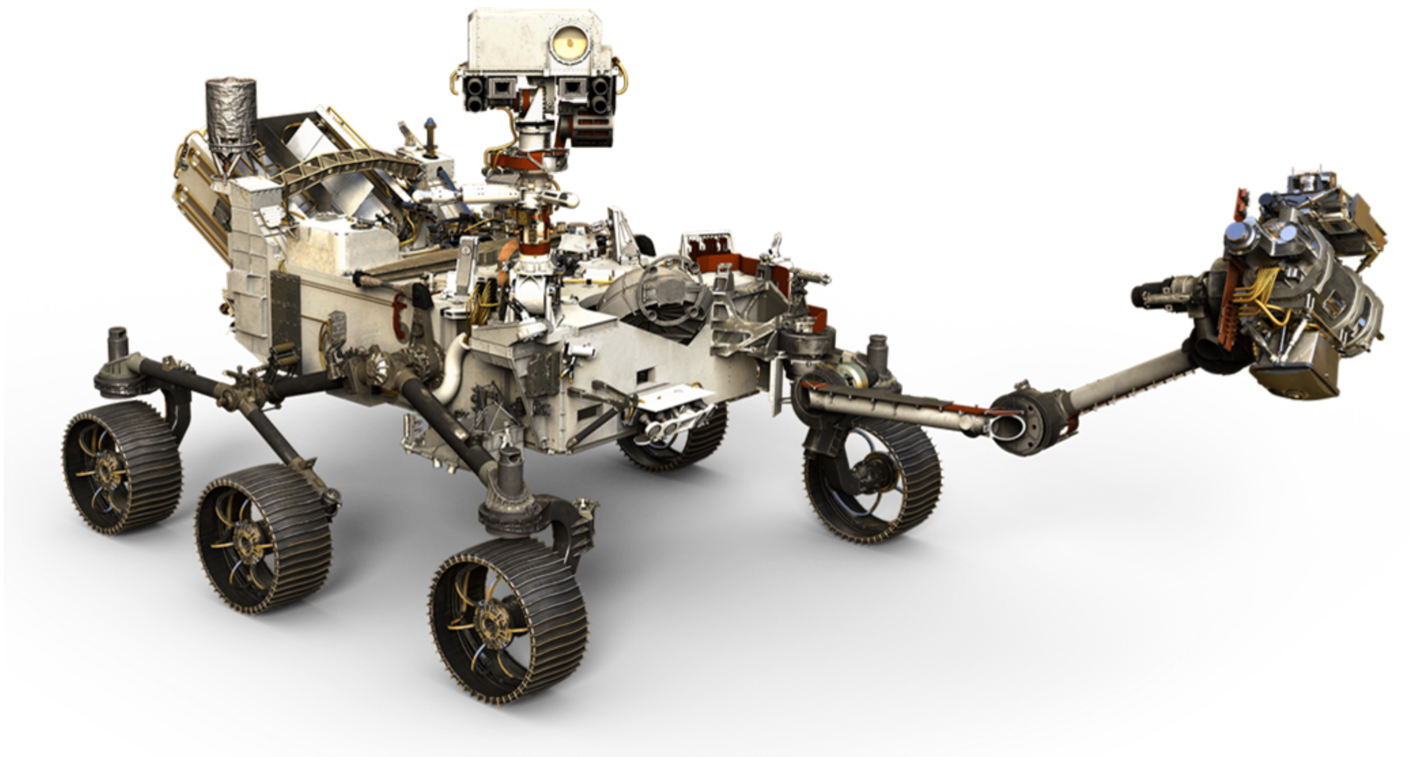
SWPC only provides probabilities with respect to Earth. Will they share their AI algorithm and training data with NASA?

Can Earth CME/SEP paired data be used to predict SEP from observed CMEs?

Can Earth X-ray/SEP paired data be used to predict SEP from observed X-ray events? (I presented some very preliminary work on this at a SWx Workshop several years ago.)

We (JPL) would love to participate in any of these investigations.

The Players



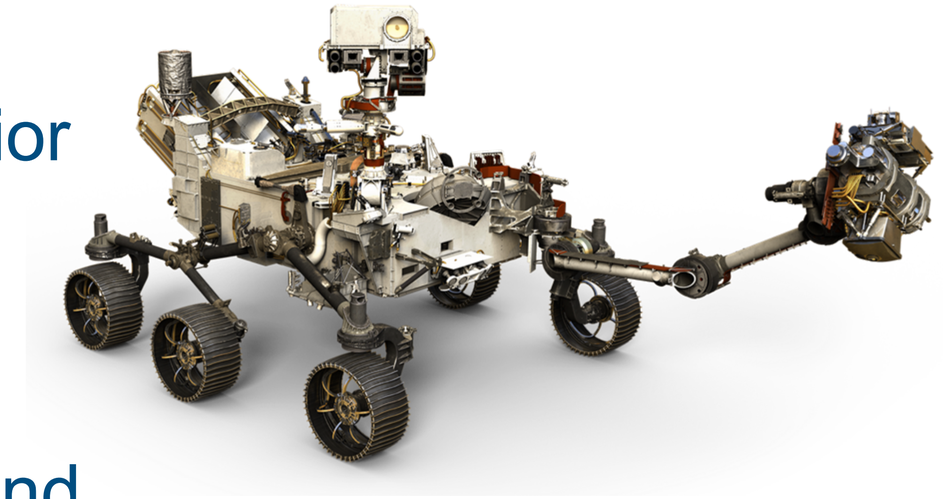
M2020 rover
“Perseverance”

Ingenuity (Ginny) helicopter

Not shown at same scale

The Situation

Perseverance rover needs to know Space Weather (SWx) for approximately 2 weeks prior to Mars arrival.



Goal is to avoid Safe mode

so that it executes Entry Descent and Landing (EDL) rather than miss Mars.

So… No cruise-stage ops

- during Solar Energetic Particle (SEP) events,
- or when risk of SEP is high.

The Situation

Ingenuity needs to know SWx during battery charging (in cruise) and for surface operations.

Goal: Avoid SEU in commercial parts.

So… No helicopter ops

- during SEP events,
- or when risk of SEP is high.

Parts characterization and previous rover experience indicate there will be no issues for Perseverance on Mars' surface.

SWx Clues in Different Views

What we can see and measure from Earth gives us:

X-ray and SEP event probabilities [SWPC]

Active Region locations [various imaging]

Solar wind modeling [CCMC]

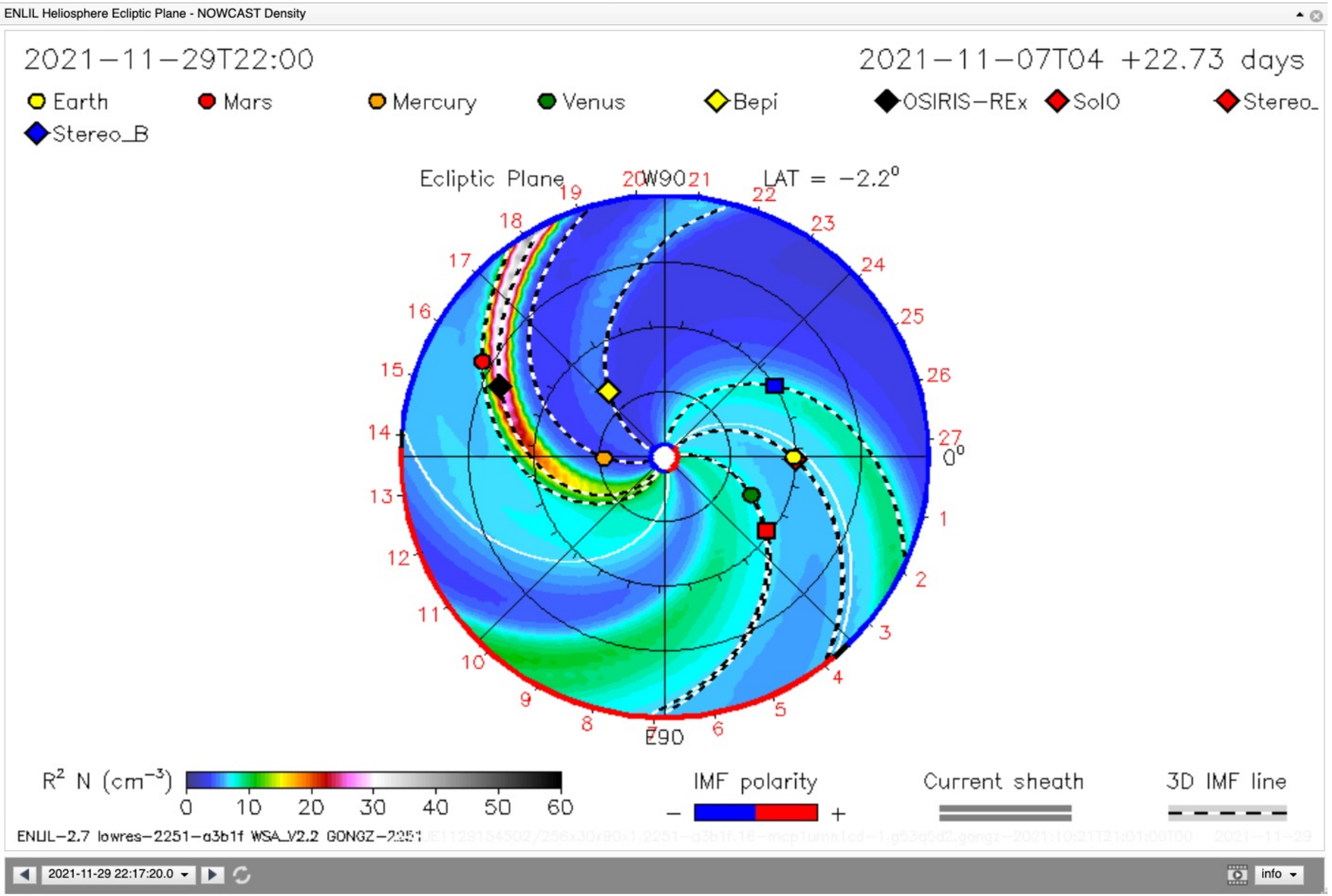
CME events [CCMC DONKI, SIDC CACTUS, SOHO images]

Magnetograms of solar surface [SDO]

Helioseismology [NSO GONG, SDO HMI Farside]

Location, Location, Location

CCMC Solar wind modeling is always handy for gauging connectivity of Sun to Mars through the interplanetary magnetic field (IMF).



https://iswa.ccmc.gsfc.nasa.gov/IswaSystemWebApp/index.jsp?i_1=425&l_1=564&t_1=342&w_1=1285&h_1=867&s_1=2021-11-29%2022:17:20.0_0_10_3

SWx Clues in Different Views

From Mars:

Radiation-induced counts from Mars Odyssey orbiter GRS instrument

From Solar Orbiter:

Ions to ~ 100 MeV http://espada.uah.es/epd/data/plots/quicklook?plot=1&period=monthly

From STEREO-A:

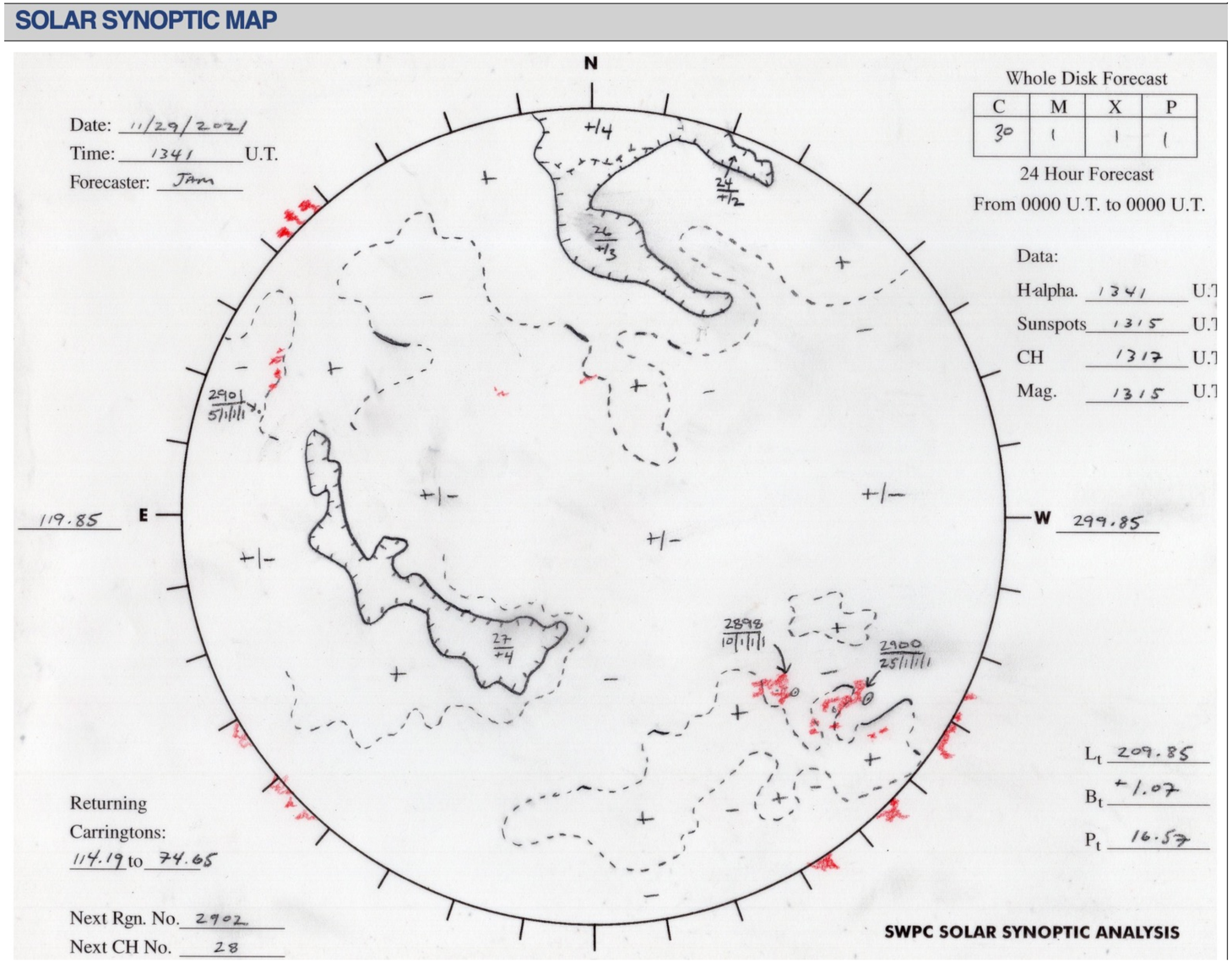
Ions, including protons to ~ 13 MeV

CME views

Location, Location, Location

SWPC gives event probabilities per Active Region

https://www.swpc.noaa.gov/products/solar-synoptic-map



Location, Location, Location

Not all views are useful all the time.

Solar Orbiter *happened* to be in the right place/right time to sample a CME that would later hit Mars; Showed an absence of SEP flux, so not a threat to Mars. Future astronauts shouldn't have to rely on this type of serendipity.

NOAA SWPC provides valuable information:

- X-class X-ray flare probabilities (proxy for SEP probability)

STEREO-A gives an indication of Active Regions not seen from Earth

When Mars is across the Solar System

For about a year, roughly every other year, solar disk that affects Mars SWx cannot be seen from Earth, so Mars SWx information is minimal. We can:

Qualitatively gauge Mars activity by watching for CMEs (speed and frequency).

Monitor the radiation-induced count-rate in Mars Odyssey GRS.

Monitor NSO-GONG and SDO-HMI-Farside modeling.

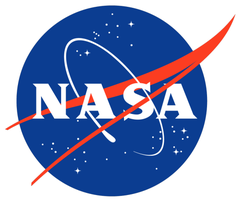
Summary

Mars SWx information is sometimes quantitative, but often only qualitative at best.

Some Earth SWx resources provide applicable information.

Near-real-time science data can sometimes be used, though not necessarily quantitatively or continuously.

Fortunately, robotic missions are designed assuming that NO SWx is available, so operations need not be modified unless there is both an established need and a source of SWx information.



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