Sector Boundary Crossings

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Solar wind density

The Wang-Sheeley-Arge (WSA)-Enlil model of solar wind density also predicts the number of days until the next sector boundary crossing. The model also shows the more dense streams of solar wind which is slow solar wind and twice as dense and more variable in nature than fast solar wind. Other distinguishing characteristics of solar wind types are described in the next section.

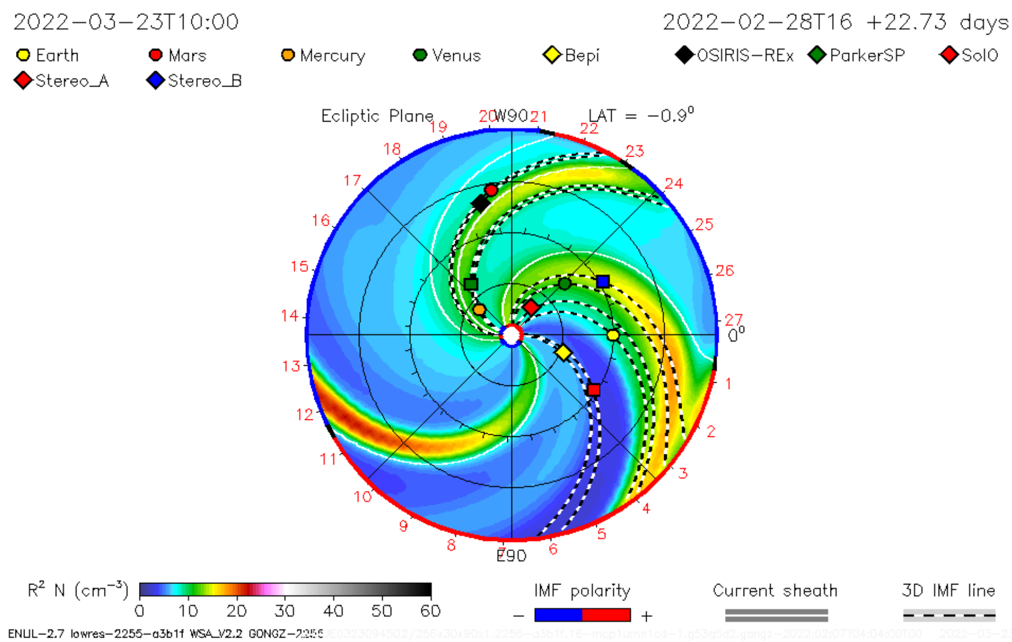


Figure 1: Wang-Sheeley-Arge (WSA)-Enlil model of the current solar wind density. (updated several times a day) *Source:* NASA

Solar wind velocity

The solar wind velocity only considers the stream of solar charged particles with a kinetic energy between 0.5 and 10 keV. These are released from the solar corona and consist mainly of electrons, protons and alpha particles. Relativistic electrons are not considered in solar wind velocity statements. Two fundamental solar wind velocity states can be discerned: the slow and the fast solar wind.

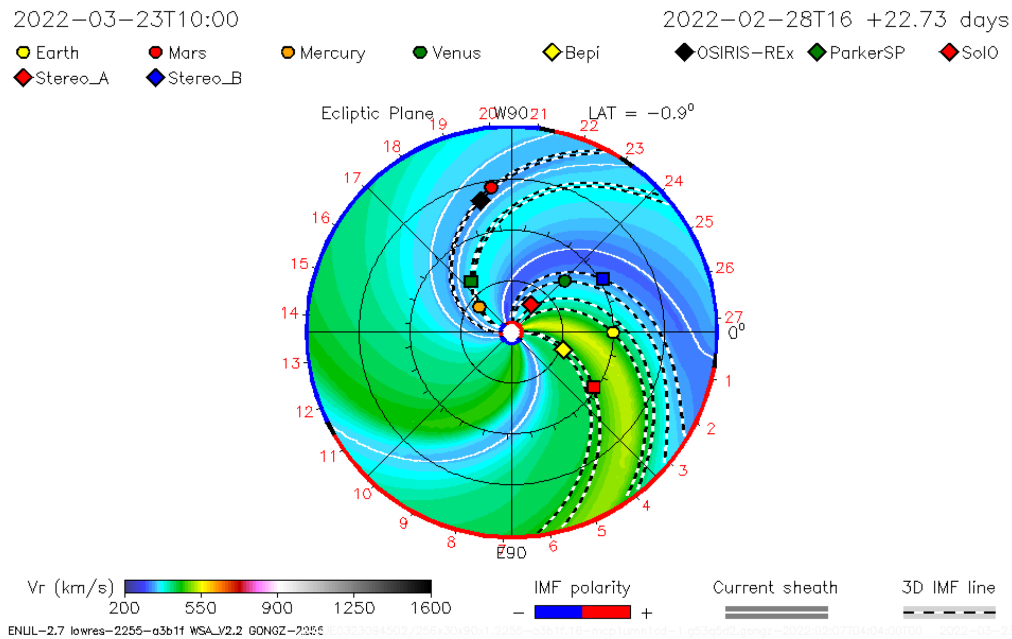


Figure 2: Wang-Sheeley-Arge (WSA)-Enlil model of the current solar wind velocity. (updated several times a day) *Source:* NASA

Slow solar wind

In near-Earth space, the slow solar wind shows a velocity of 300–500 km/s and an extremely high temperature of $1.4–1.6 \cdot 10^6$ K. The slow solar wind composition closely matches that of to the corona where it originates from.

Fast solar wind & CIRs

By contrast, the fast solar wind has a faster velocity of about 750 km/s and a much lower temperature of $8 \cdot 10^5$ K. Its composition is characteristic of the Sun's photosphere, as fast solar wind originates from coronal holes. Coronal holes are funnel-like regions of open magnetic field lines which peer through the Sun's hot chromosphere, and allow one to look down at the cooler photosphere.

> TODO https://www.stce.be/news/269/welcome.html

Relativistic electron fluency

As mentioned before, electrons at relativistic speeds are not taken into account for determining the solar wind velocity. Nonetheless, a non-linear correlation exists between the relativistic electron flux and the solar wind velocity.[1]

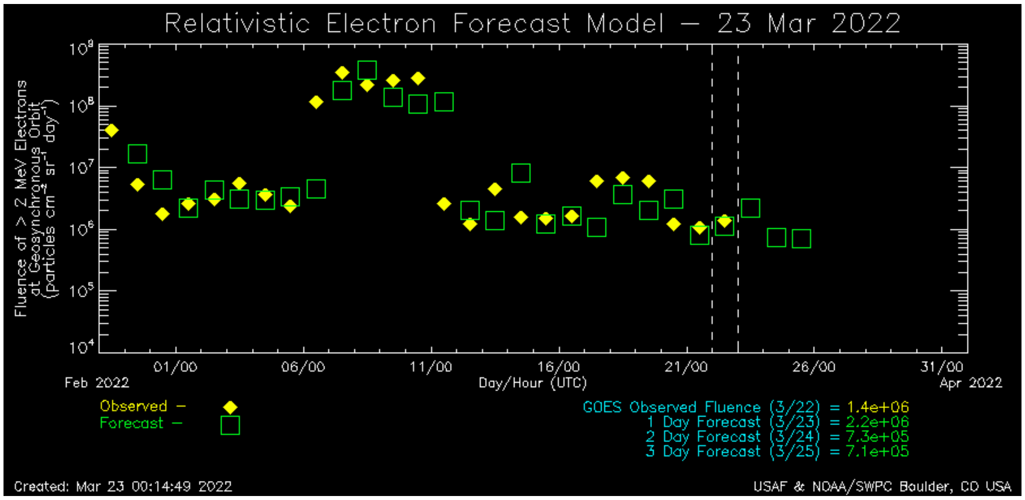
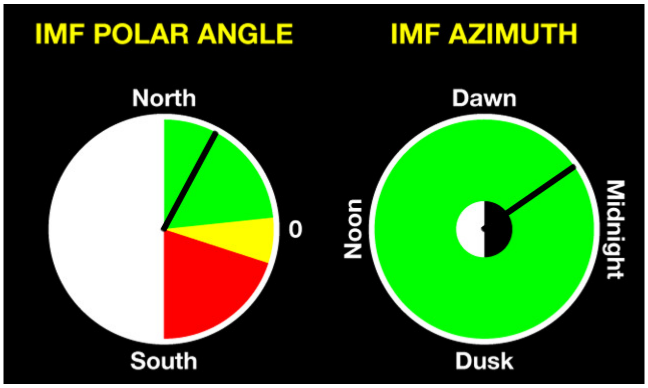
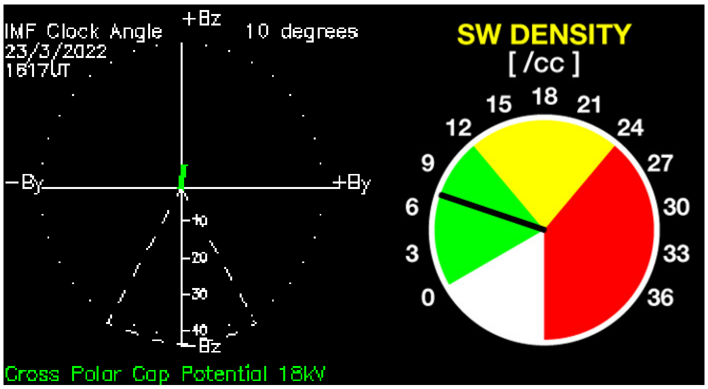


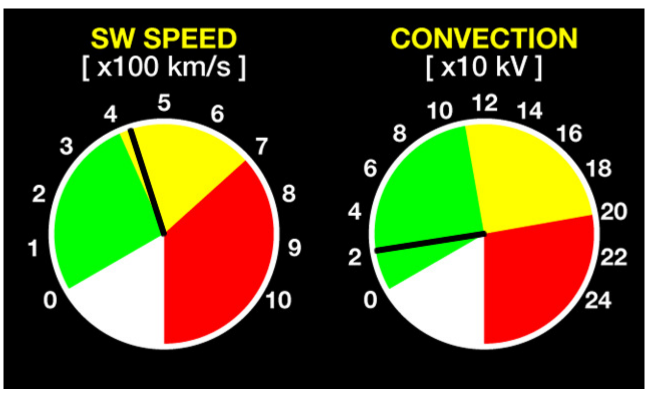
Figure 3: Observed daily relativistic (> 2 MeV) electron fluency and forecast. *Source:* USAF & NOAA

Real-time IMF & solar wind

The solar wind interplanetary magnetic field is a three dimensional vector, $\vec{B}_t$, with components B_x, B_y and B_z. The vertical plane to the ecliptic is the B_y, B_z plane, whereas B_x is the component on the Sun-Earth line. When B_z has a negative or southward orientation, the coupling to the Earth's geomagnetic field is at its strongest. Southward interplanetary magnetic conditions are associated with geomagnetic storm activity.[2] Because when the IMF is southward, antiparallel fields near the magnetospheric subsolar point allow for merging between the IMF and geomagnetic fields. This process increases the transport of solar wind mass, momentum, and energy into the Earth's magnetosphere. This process can also open the magnetosphere to solar energetic particle radiation.[3]







Shown above:

- The polar angle of the interplanetary magnetic field $\vec{B}_t$, indicated in red when the B_z is negative (updated by the minute)
- The real-time interplanetary magnetic field azimuth ϕ, used to detect SBCs. Noon (towards the Sun) corresponds to 0° or 360°, dawn 90°, midnight (away from the Sun) 180° and dusk 270° (updated by the minute)
- The real-time interplanetary magnetic field B_z component (red when negative; updated by the minute)
- The solar wind density (updated by the minute)
- The solar wind speed (updated by the minute)
- The cross polar cap potential (CPCP) or convection potential induced by the solar wind crossing Earth's magnetosphere (updated by the minute)

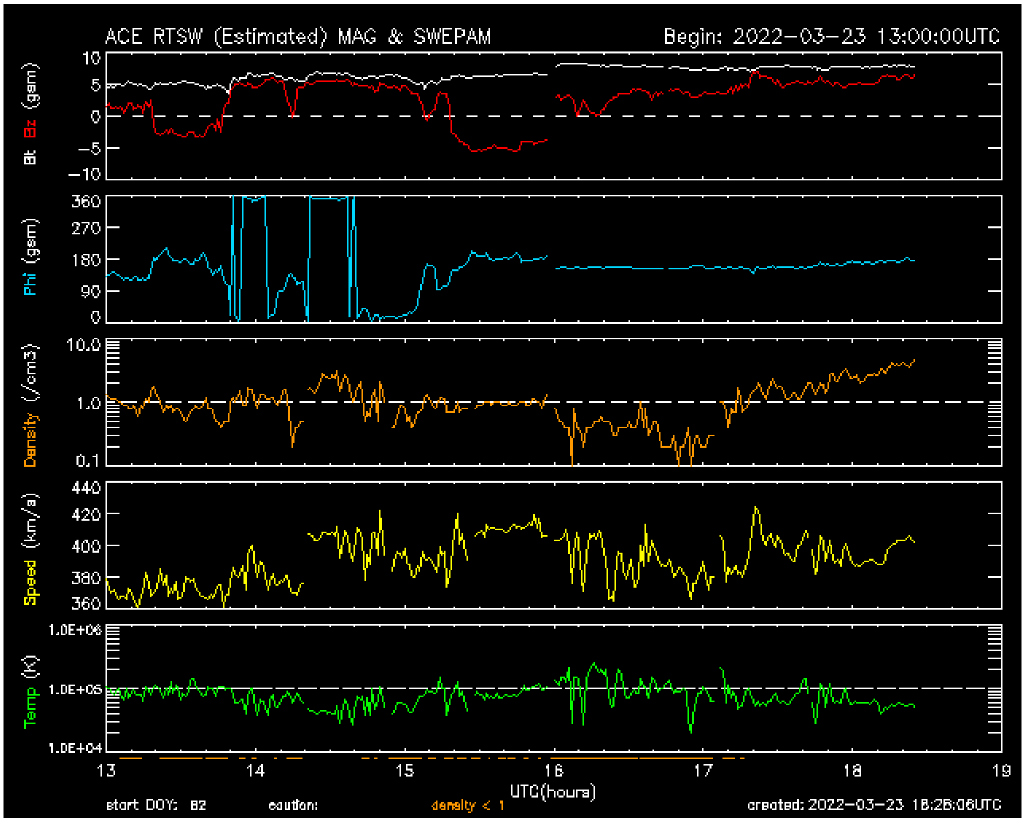


Figure 4: Real-time interplanetary magnetic field and solar wind as measured by the NASA Advanced Composition Explorer (ACE) satellite. Phi is the azimuth of the IMF. (6 hour view; updated by the minute) *Source:* NOAA

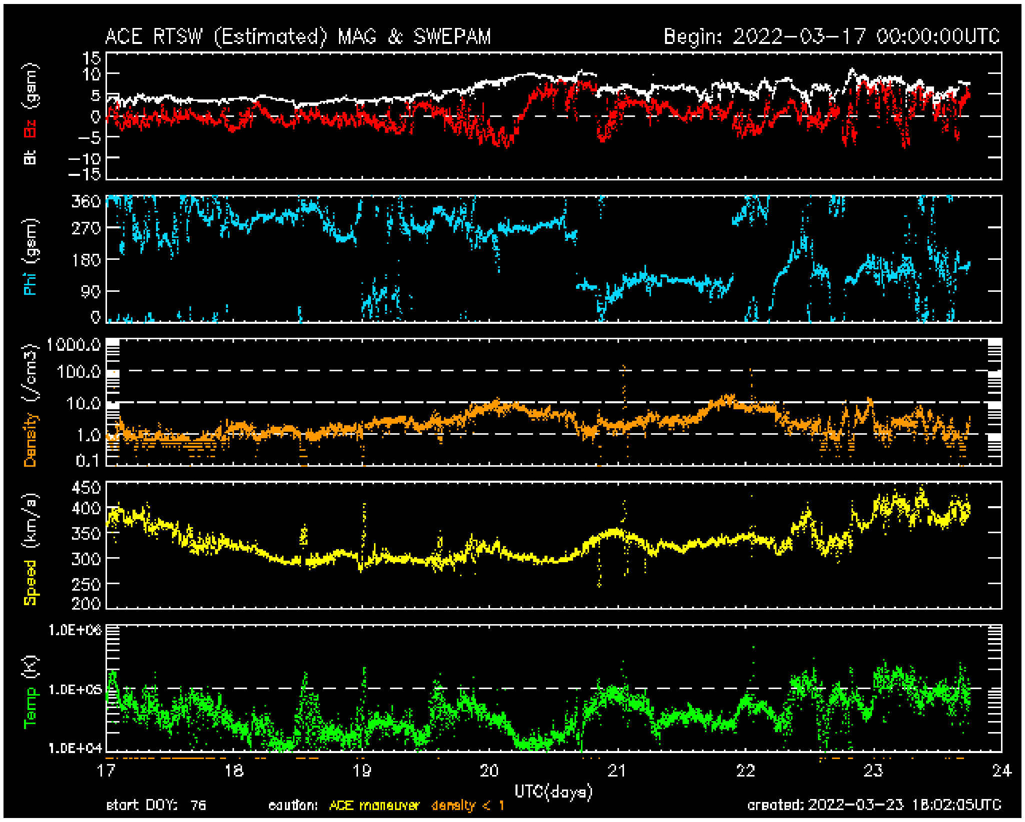


Figure 5: Real-time interplanetary magnetic field and solar wind as measured by the NASA Advanced Composition Explorer (ACE) satellite. Phi is the azimuth of the IMF. (7 day view; updated by the minute) *Source:* NOAA

References

1. Geoffrey D. Reeves, Steven K. Morley, Reiner H.W. Friedel, et al. On the relationship between relativistic electron flux and solar wind velocity: Paulikas and blake revisited. *Journal of Geophysical Research: Space Physics*. 2011;116(A2). doi:10.1029/2010JA015735

2. Solar wind clock angle. http://www.sws.bom.gov.au/Category/Solar/Solar Conditions/Solar Wind Clock Angle/Solar Wind Clock Angle.php

3. Patricia Reiff. Magnetospheric Multiscale (MMS) — Space weather realtime interpretation guide. Published November 2018. http://mms.rice.edu/mms/realtime_guide.php

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