

## The Calm Between the Storms?

Powerful events such as the 2003 Halloween Space Storms obviously affect astronauts, satellites, communication and electrical power systems. But it may seem that the space environment is usually benign and unimportant because such storms are rare. In fact, the constant variation of the space environment makes the time between storms anything but “calm.”

Magnetic active regions on the Sun emerge and decay over days to weeks. The numbers of active regions varies regularly with the 11-year solar cycle, and erratically over longer times up to centuries. The patchy distribution of regions over the Sun produces variation at the 27-day solar rotation period. Many phenomena – emission of light, short wavelength radiation, solar wind, and blocking of cosmic rays – vary significantly with the timescales of the solar magnetism itself, even without storms.

Light from the solar surface directly heats the surface and lower atmosphere. Dark sunspots and bright faculae in magnetic regions alter the emission of light from the surface enough to affect the climate over long intervals.

The corona above magnetic regions is heated to millions of degrees and emits strong X-rays, EUV, and UV radiation. The radiation heats and ionizes the atmospheres of planets, producing our ozone layer, the ionosphere, and the thermosphere. It alters atmospheric chemistry and temperature, which in turn modifies the mixing of molecules over height and latitude. As these layers heat and cool, they become more and less dense, changing the drag that slows satellites until they reenter.

The solar wind, striking Earth’s magnetic field, drives the acceleration of energetic particles that fill the radiation belts. By contrast, Mars has no global magnetic field, and the solar wind directly impacts and strips Mars upper atmosphere. The wind’s magnetic field, constantly reshaped by change on the Sun, can power geomagnetic storms in absence of solar events, with the whole array of energetic particle acceleration, aurora, and disturbances of satellites systems.

The hot corona powers the solar wind, which carries magnetic fields with it. The solar wind magnetism, filling the heliosphere, blocks many of the cosmic ray particles that fill the rest of the galaxy.

Understanding the varying space environment on all timescales is the motive for our Great Observatory and for the new missions planned in this Roadmap. From the climate of Sun and Earth, to travel to other planets, and out to the space between the stars, the Sun-Solar System Connection seeks to predict these variations that we know – and those we have yet to discover.