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To Compare the SWEPAM and EPAM Solar Wind Data-sets for Measurement of Space Weather Disturbance

Shraddha Sharma
Associate Professor,
Department of Physics, SAM Global University, Raisen, India
Email: suryaspace27@gmail.com

Abstract: *The solar cycle, which results in variations in heliospheric characteristics, tilts the Sun's magnetic axis in relation to its spinning axis. Because of heliospheric characteristics, the modulation of the solar wind has changed throughout time, which has affected both the rate and phase of rising solar activity. The essential framework for understanding the space environment and following space weather forecasts is provided by heliospheric properties. Heliospheric research explains the inverse link between particular Solar parameters and Solar wind intensity.*

Key Words: *Solar Cycle, Heliospheric, Modulation, Solar Wind.*

1. INTRODUCTION:

The modulation of the solar wind in the heliosphere region is interpreted by many scientists to follow an 11-year cycle associated with solar activity and cosmic-ray intensity during solar minimum circumstances. To learn more about the space weather disturbances, it is also possible to study the datasets of Solar Wind Electron Proton Alpha Monitor (SWEPAM) and Electron, Proton, and Alpha Monitor (EPAM). Along with the 11-year modulation cycle, previous results show the maximum intensity at which solar wind modulation happens due to following mechanisms.

- Due to Heliospheric Current Sheet (HCS), and drift effects.
- Convection and adiabatic energy loss prolonged solar wind
- Due to propagation of particle perpendicular in the Heliospheric Magnetic Field (HMF).

These mechanisms are influenced by the heliospheric magnetic field's geometrical properties, polarity, intensity, amount of turbulence, and speed. The Sun's magnetic axis is tipped relative to its rotating axis because of the solar cycle, which causes fluctuations in heliospheric properties. The modulation of the solar wind altered over time, because of heliospheric features it can change the phase of the solar magnetic cycle and the amount of increasing solar activity. Heliospheric characteristics offer the fundamental framework for comprehending the space environment and tracking space weather forecasts. The inverse relationship between specific Solar parameters and Solar wind intensity is explained by heliospheric research. It is going to necessary to consider the solar wind modulation in terms of heliospheric characteristics. Information regarding the plasmasphere and the atmosphere of the earth has been revealed by variations in modulation with heliospheric parameters as Sunspot Number, Interplanetary Magnetic Field, Solar wind Velocity, and F10.7 (Solar Radio Flux). For each stage of the solar cycle, the anti-intensity correlation's changes through time and place. Sunspot number variation is a sign of changing solar activity that is dependent on the solar dynamo process. The modification of solar wind brought on by adiabatic slowdown, convection, and diffusion results in distinctive variations between neighboring solar cycles. Thus, the solar field polarity of succeeding activity peaks varies. It is important to take into account how the curvature of the interplanetary magnetic field affects the movement of solar wind in order to comprehend the distinctions between odd and even solar cycles. The charge and sign of the solar magnetic field's polarity throughout the 11- and 22-year modulation cycles both affect the modulation of solar wind. The drift that the solar wind experiences even as it enters the magnetosphere is significantly impacted by large-scale variations in the strength of the solar magnetic field. Additionally, it influences the heliospheric current sheet's tilt. The Advanced Composition Explorer receives the majority of its solar wind data from the Solar Wind Electron Proton Alpha Monitor (SWEPAM) experiment (ACE). With the help of cutting-edge, 3-D plasma instrumentation, these observations enable the direct examination of a variety of solar wind phenomena like coronal mass ejections, interplanetary shocks, and solar wind fine structure. They also provide the context for elemental and isotopic composition measurements made on ACE. They also offer a perfect data set for multi-spacecraft heliospheric and magnetospheric research, where they may be combined with additional, concurrent observations from spacecraft like Ulysses. With separate electron and ion equipment, the SWEPAM observations are done concurrently. It recycled the flight parts from the joint NASA/ESA effort to reduce expenses for the ACE mission. On the other hand, Canadian magnetic observatories in Canada's polar cap, auroral zone, and subauroral zone activities are carrying out analysis of solar wind low-energy energetic particles using data from the Electron, Proton, and Alpha Monitor (EPAM) onboard the Advanced Compositional Explorer spacecraft (ACE) and geomagnetic activity. To measure the initial particle increases and the ensuing geomagnetic activity, coronal mass ejections (CMEs) were utilized. Maximum particle enhancements were shown to be non-linearly linked to maximum geomagnetic activity. Expressions that are easily applied in an operational space weather scenario to quantitatively anticipate geomagnetic disturbance are produced by fitting the data quadratically. A superposed epoch analysis demonstrates that an increase in particle flux level begins hours before geomagnetic activity reaches its peak, supporting the hypothesis that EPAM particles serve as a forerunner for the oncoming geomagnetic effect of CME. This can support the decision-making process when generating a geomagnetic warning after the Sun launches a CME but prior to the shock hitting Earth. The statistical study's findings on the empirical relationships between solar wind low-energy energetic particles and geomagnetic activity can be easily codified and used in operational space weather forecasts to assess the geoeffectiveness of the CME and provide a quantitative forecast for the peak geomagnetic activity in Canada's polar cap, auroral zone, and subauroral zone following the occurrence of a CME.

2. SOLAR WIND MODULATION:

Diffusion is the name for a collective behavior that is characteristic of bigger particles. Diffusion is brought about by the thermal movement of the molecules of the suspending liquid when encompassed or stochastic force is given on particles. Diffusion rates rise with temperature and fall with both particle size and medium viscosity. The diffusion and drift of energetic charged particles in turbulent magnetic fields controls a wide range of high-energy phenomena in astrophysical environments, including solar wind transition, interplanetary transport of solar energetic particles, momentum gain of charged particles by shock waves, and propagation of solar wind in the interstellar medium. It became explained thirty years ago that the tangling of the magnetic lines of force caused by magnetic field turbulence can account for particle diffusion that is normal to the heliospheric magnetic field. Particles follow distinct field lines that are randomly entangled at different length scales. The direction of the steepest slope or grade at a given position is indicated by the plane vector known as the gradient of H at that location. The size of the gradient vector determines how steep the slope is at that location. The curvature, as the name implies, is the deviation of a curve or a surface from a straight line or a plane. The circle, which has a curvature equal to the reciprocal of its radius, serves as the standard illustration of a curve.

The area of the Solar System where the polarity of the Sun's magnetic field switches from north to south is known as the heliospheric current sheet. The interplanetary medium's plasma is affected by the Sun's spinning magnetic field, which shapes the current sheet (solar wind). The polar coronal hole's equilibrium with the solar magnetic axis and the magnetic field's nonradial expansion to produce a uniform field farther from the Sun cause the gradient of a heliospheric magnetic field. Differential rotation occurs at the magnetic field lines' footpoints that are anchored in the photosphere. Assuming that the Sun's magnetic axis rotates firmly at the equatorial rate, differential rotation results in a foot-point moving in heliomagnetic latitude and longitude, which affects how much non-radial expansion it experiences. The basic idea of "field lines on cones" of the Parker field fails in the end, leading to a field line that shifts in heliographic latitude. Drifts caused by gradients and curvatures in the heliospheric magnetic field (HMF) and in the wavy current sheet are significant phenomena that have a significant impact on cosmic-ray modulation and are responsible for the 22-year cycle in cosmic-ray intensities that has been recorded. Reduced demands of precisely simulate the heliosphere, turbulence drift investigation of cosmic-ray modulation is present. The effect of the solar wind on the magnetosphere, which causes the inner magnetosphere to produce an electric field Dawn to dusk aligned the direction of the convection field. The co-rotating thermal plasma drifts orthogonally to both the geomagnetic field and that field within the inner magnetosphere. Magnetic reconnection may be another technique. In the inner magnetosphere's polar regions, a hydro-magnetic dynamo activity may also be feasible. The structure of space weather disturbances has been reasonably well characterized by direct observations made by satellites.

3. DATA ANALYSIS:

The Space Weather Prediction Center (SWPC) of the National Oceanic and Atmospheric Administration (NOAA) in Boulder provides online access to real-time solar wind low-energy energetic particle data from the Electron, Proton, and Alpha Monitor (EPAM) onboard the Advanced Compositional Explorer spacecraft (ACE) (http://www.swpc.noaa.gov/ace/EPAM 7d.html and http://www.swpc.noaa. The EPAM experiment measures the fluxes and directions of electrons over 30 keV and ions above 50 keV as well as the elemental makeup of the ions. It consists of five telescope apertures of three distinct kinds. Through the real time solar wind (RTSW) system, NOAA/SWPC offers ACE data in real time. In order to quantify the bulk flow and kinetic characteristics of the solar wind, state-of-the-art observations of electron and ion distribution functions in three dimensions throughout the whole velocity space are provided by the SWEPAM experiment. The joint NASA/ESA Ulysses mission's Solar Wind Over the Poles of the Sun (SWOOPS) experiment's flight spare instruments are used by SWEPAM. Launched on October 6, 1990, was Ulysses. Using a gravitational help from Jupiter, it was deflected out of the ecliptic plane and onto its current high-inclination polar orbit around the Sun in late February 1992. Since its launch, SWOOPS has run without a hitch, making it possible to explore the solar wind for the first time as a function of helio-atitude.

4. RESULTS:

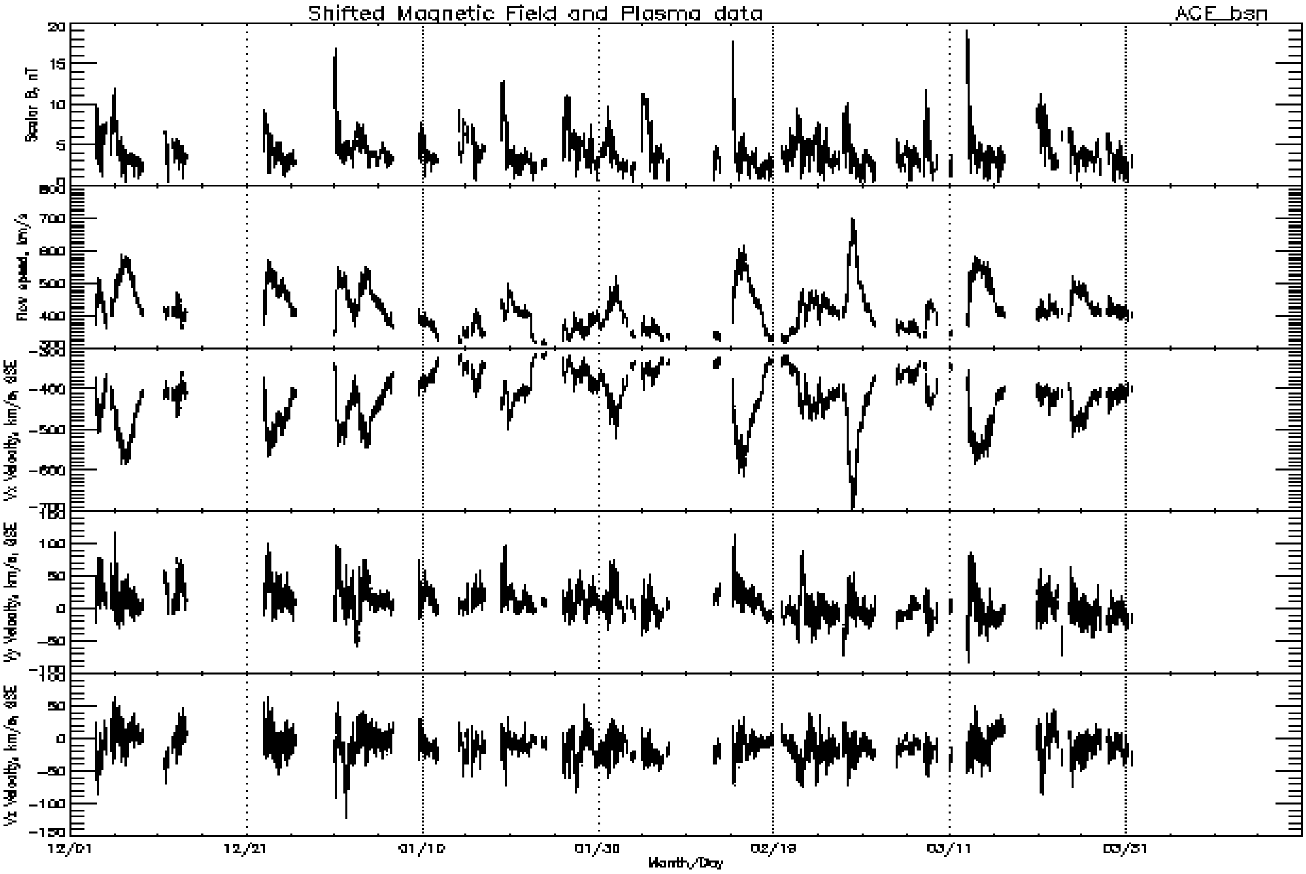

Figure 1 SWEPAM ACE Satellite data from 20081201 to 20090331

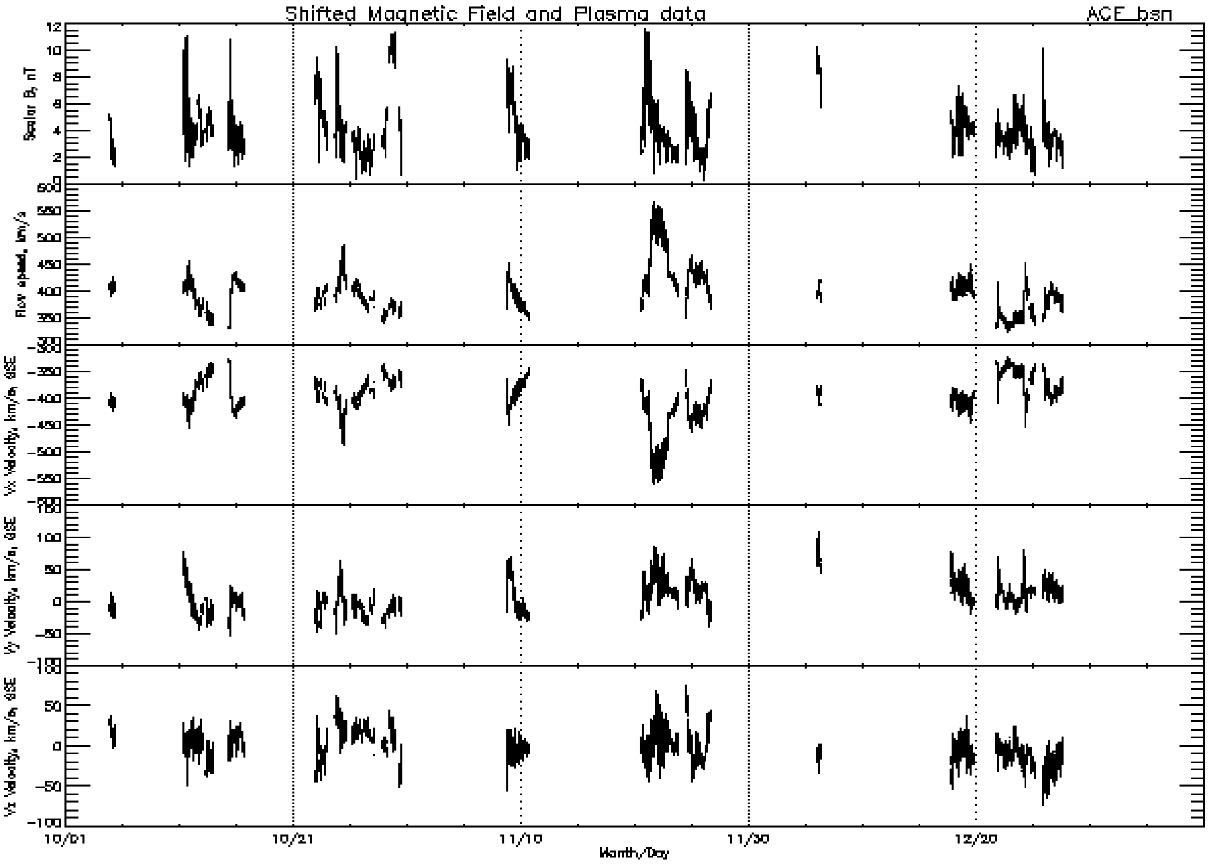

Figure 2 SWEPAM ACE Satellite data from 20091001 to 20091231

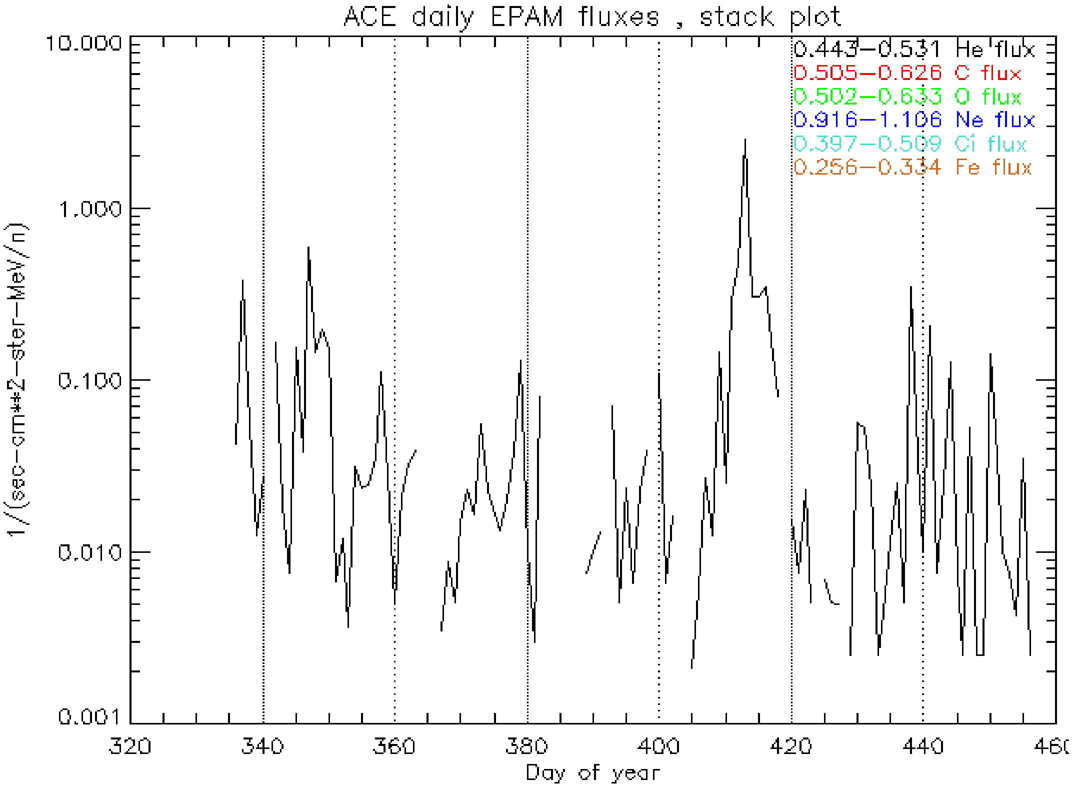

Figure 4 EPAM ACE flux data from 20081201 to 200903310

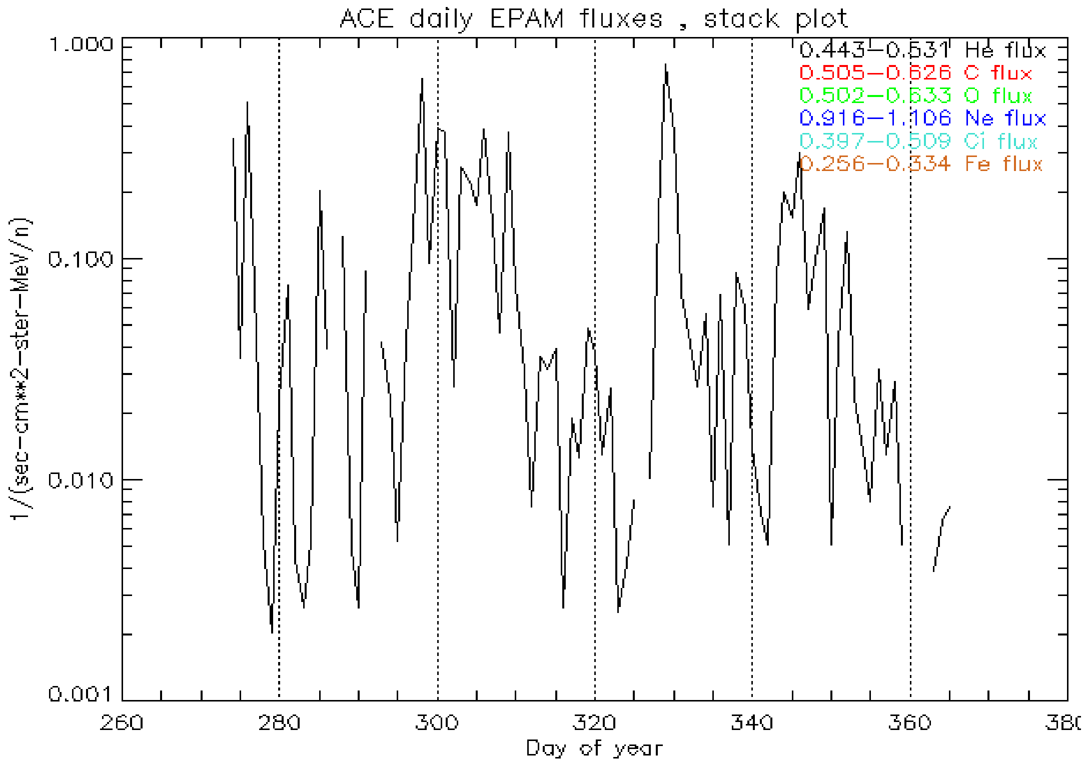

Figure 5 EPAM ACE Satellite flux data from 20091001 to 20091231

5. DISCUSSION:

The SWEPAM/EPAM data from **2008-12-01 to 2009-03-10 and 2009-10-01 to 2009-12-31 have been compare for space weather study. In this period solar data electron and proton** counts shows steep increase in the graph. In points where a steep rise in solar wind intensity during the declining phase of cycle is observed, solar wind goes 6200 to 6800 counts epoch. In the figure 1 and 2 SWEPAM data shows a spotless trend during the descending epoch from **2008-12-01 to 2009-03-10 and 2009-10-01 to 2009-12-31**.Observing above results the time variation of Solar data shows a very non-linear trend during the whole cycle. During the ascending epoch, duration **2008-12-01 to 2009-03-10 and 2009-10-01 to 2009-12-31** were spotless. There has been a steep rise and fall in SSWEPAM/EPAM data in the ascending and declining phases with the highest values of Solar Electron and Proton count achieved during the declining phase. In the duration of **2008-12-01 to 2009-03-10 and 2009-10-01 to 2009-12-31** time variation of Interplanetary Magnetic Field (IMF) during solar cycle 24 shows a steep rise during the initial stage of the ascending epoch and followed regular rise during the whole cycle in the figure 3.

Highest value of interplanetary magnetic field was obtained in the solar day 152. In time variation of solar wind velocity during solar cycle shows small fall in the initial stage of ascending epoch accompanied by a regular rise and fall during the ascending and declining phases of cycle. The highest value of solar windvelocity has been obtained in the declining epoch on this day. The time variation of F10.7 Solar Radio Flux indicates that the initial phase of ascending epoch were spotless. After that, it followed a steep rise and fall in the solar radio flux. In contrast to solar cycle also shows an inverse relationship between solar wind and all solar indices for the entire period of investigation .The zenith of the IMF, F10.7-cm solar radio flux and SWV does not concur precisely with the minimum of the solar wind cycle which shows time-lag in the given time series.

6. CONCLUSION:

Despite belonging to the low-energy category of solar energetic particles (SEP) having energies in the range of 10 keV to 100 MeV, the solar particles measure space weather. Present results suggest that the solar events occurred on the Sun's western hemisphere released particles. Electrons measured by the electron channels on SWEPAM/EPAM have velocity 0.4 times than the speed of light. On the other side, the proton fluctuations linked to disruptions in space weather. SWEPAM/EPAM particle flux levels selected time period, it increases particle fluxes due to geomagnetic disturbance. Thus, the lack of EPAM particle enhancements is an indication that the CME is non-geo-effective. EPAM particle flux enhancements are approaching interplanetary shocks which accelerate the ambient particles of the solar wind, rather than due to consequence of magnetically connected eruptive events on the solar surface.

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