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Study of solar wind using interplanetary scintillation

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Solar magnetic activity in conjunction with solar rotation usually modulates changes in solar wind flows between the Sun and the Earth, and eventually, driving activity in near-Earth space. This is commonly known as “Space weather”. Because of advancement in space technology in near-Earth space, it is alarmingly important to continuously monitor space weather activities. In this pre-text, it is crucial to understand the solar activity variation on the Sun, how do they propagate in the solar wind, and ultimately accessing their impact near 1 AU. The studies of solar activity on the Sun and that near Earth have been studied using ground-based and spacecraft measurements, however, the studies of the variation of solar and solar wind activity between the Sun and 1 AU have been challenging. To our rescue, since 1960’s a technique known as interplanetary scintillation (IPS) has been systematically used to study solar wind activity between 0.26 to 0.82 AU, covering the whole inner heliosphere, via ground-based IPS radio telescopes. First known in 1964, the IPS method is based on the scattering of electromagnetic waves emitted from the distant extra-galactic radio sources when they are traversing through the solar wind plasma and thus resulting in variations of intensity fluctuations of these radio sources. The intensity variations observed is commonly known as IPS. The IPS observations obtained from ground-based radio IPS telescope facility such as the ISEE, Nagoya, Japan are used to obtain a quantity, known as scintillation index ($S^2 = [(< I^2 > - < I >^2)/ < I^2 >]$ where I is the signal intensity), a parameter that measures the solar wind turbulence level. The Sun’s magnetic field is responsible for various solar activity, and therefore, in a large body of work, we have been examined variations in solar photospheric fields, covering the duration from February 1975 to Jun 2022, spanning over the last solar cycles 21-25 and found that solar polar photospheric fields have shown a steady decline in the absolute field strengths beginning from around mid-1990s and continuing until now. Since changes in solar wind flows are tied to the photospheric activity variations, using extensive IPS radio measurements at 327 MHz obtained from ISEE Nagoya, Japan, available since 1983, we have investigated the variations in scintillation index during the last few solar cycles since solar cycle 21. Our analysis showed a similar steady decline in scintillation index since around 1995 indicating a decline in solar wind turbulence level in sync with solar photospheric fields and providing an indirect inner heliospheric signatures of declining solar magnetic activity in solar wind outflows. It is to be noted that the decline in scintillation index as compared in solar cycles 23 and 24 indicates a strong decline in solar cycle 24 and we should remind that the solar cycle 24 has been the lowest amplitude solar cycle among the last few solar cycles. Off recently, the near-Sun measurements have been possible with launches of *Parker’s Solar Probe* (PSP) and *Solar Orbiter* spacecrafts. Thus, the IPS method can be successfully used to study the solar wind activity variations in tandem with the PSP and *Solar Orbiter* observations, as well as using the 1 AU data from the ADITYA-L1 spacecraft, India’s first solar space mission, which in particular, I will discuss in my talk.