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Variation of the interstellar dust flux near 1 AU

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Probes equipped with radio antennas can be valuable tools for measuring dust. When dust grains collide with spacecraft, they generate free charges through the process of impact ionization. Impulsive signals within the voltage waveforms recorded at antenna terminals offer a valuable perspective to study the properties of these particles. The goal of this work is to better understand the dust flux in the interplanetary space by using a dataset generated by radio antennas on board several space probes.

It has been known for decades that the solar system contains a significant amount of dust. The primary dust populations at 1 AU are interplanetary dust (IPD) and interstellar dust (ISD). Commonly, IPD particles are remnants of comets, asteroids, and other celestial bodies. The majority are produced by collisional fragmentation. An additional component is dust particles from interstellar space that stream into the solar system. They contribute significantly to the amount of dust in the outer solar system.

ISD grains were identified for the first time by Ulysses' dust detector. It measured ISD grains in the direction that corresponds to the flow of neutral interstellar hydrogen and helium. The measurements could be explained with ISD that travels at 26 km/s, which corresponds to the solar system's velocity relative to the interstellar medium. Some of the observations also could be explained with the upstream trajectory of the dust flow being at 259° ecliptic longitude and 8° latitude. Based on the orbital motion of the spacecraft with respect to the ISD flux direction, it is possible to differentiate ISD from the dust populations of the solar system. The observed ISD flux is expected to be greatest when the probe's orbital velocity about the Sun is antiparallel to the ISD velocity, creating the highest relative velocity between the probe and the ISD flow. Likewise, when the probe orbital velocity is parallel to the ISD velocity, the relative velocity is lowest, and the flux of measurable ISD should decrease. An in-situ observation of ISD flux illustrates its temporal variability. Several studies suggest a connection between ISD flux variability and solar activity. Solar activity and changes in the heliospheric magnetic field may affect the correlation between ISD flux and the solar cycle. Accordingly, these factors may lead to observable changes in the flux of interstellar dust particles reaching the inner solar system. Understanding the relationship between in-situ measurements of ISD flux and the solar cycle offers insight into the complex interplay between the heliosphere and the interstellar medium.

The data used in this paper were collected from two missions orbiting at 1 AU. We examine data obtained by the WAVES electric field instrument aboard the Wind spacecraft launched in 1994 as well as by the WAVES instrument aboard the twin STEREO satellites, A and B, launched in 2006. The goal of our study is to use the long-term variations to monitor ISD flux at 1 AU over different periods of solar activity. This study will focus on solar cycles 23 and 24, which span more than 20 years since Wind was launched in 1994. Solar cycle 24 is covered by STEREO. During solar minimum, with a solar dipole pointing southward, all three spacecraft recorded ISD flux at 1AU, but before and after that period, the ISD is reduced. As indicated by a decrease of the observed dust impact, it appears that the observed flux of ISD varies with the solar cycle. A change in the polarity of the interplanetary magnetic field during the solar cycle causes small interstellar grains to focus or defocus. Accordingly, dust grains are systematically deflected either toward or away from the solar magnetic equator plane by the solar wind magnetic field, which affects dust dynamics and ISD flux in the inner heliosphere. We will present a simplified model to explain the long-term ISD flux.