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Solar-cycle dependence of selected turbulence quantities at Earth

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Ab initio modulation models require a number of turbulence quantities as input for any reasonable diffusion tensor. While turbulence transport models describe the radial evolution of such quantities, they in turn require observations in the inner heliosphere as input values. To study long-term modulation requires turbulence data over at a least a solar magnetic cycle. As a start we analyze 1-minute resolution data for the N-component of the magnetic field, from 1974 to 2012 (initially using IMP and then ACE data), covering about two solar magnetic cycles. We assume a very simple three-stage power-law frequency spectrum to construct a second-order structure function that is fitted to the data. Apart from an inertial- and an energy range (with the transition between the two denoted by the bendover scale), we assume a cutoff range at small frequencies in order to ensure a finite energy density. The spectrum is forced to be either flat or to decrease with decreasing frequency in the latter range. Given that cosmic rays sample magnetic fluctuations over long periods in their transport through the heliosphere, we average the spectra over at least 27 days. We find that the variance of the N-component has a clear solar-cycle dependence, with smaller values (~6 nT^2) during solar minimum and larger during solar maximum periods (~17 nT^2), well correlated with the magnetic field magnitude, in agreement with previous studies. The inertial range index almost identical to the Kolomogorov value $-5/3$. Our results suggest that the dominant change in the spectrum of fluctuations of the N-component of the magnetic field, over a solar magnetic cycle, is its level. To a good approximation the spectrum retains its shape for scales up to ~100 times the bendover scale, while its level is well correlated with the magnitude of the magnetic field.

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