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Energetic particles and the solar cycle: Impact of solar magnetic field amplitude and geometry on SEPs and GCRs diffusion coefficients

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SEPs are correlated with the 11-year solar cycle due to their production by flares and interaction with the inner heliosphere, while GCRs are anti-correlated with it due to the modulation of the heliospheric magnetic field. The solar magnetic field along the cycle varies in amplitude but also in geometry, causing diffusion of the particles along and across the field lines; the solar wind distribution also evolves, and its turbulence affects particle trajectories.

We combine 3D MHD compressible numerical simulations to compute the configuration of the magnetic field and the associated polytropic solar wind up to 1 AU, with analytical prescriptions of the corresponding parallel and perpendicular diffusion coefficients for SEPs and GCRs. First, we analyze separately the impact of the magnetic field amplitude and geometry for a 100 MeV proton. By varying the amplitude, we change the amplitude of the diffusion by the same factor, and the radial gradients by changing the spread of the current sheet. By varying the geometry, we change the latitudinal gradients of diffusion by changing the position of the current sheets. We also vary the energy, and show that the statistical distribution of parallel diffusion is different for SEPs and GCRs. Then, we use realistic solar configurations, showing that diffusion is highly non-axisymmetric due to the configuration of the current sheets, and that the distribution varies a lot with the distance to the Sun, especially at minimum of activity. With this model, we are thus able to study the direct influence of the Sun on Earth spatial environment in terms of energetic particles.