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A heliospheric hybrid model: hydrodynamic plasma flow and kinetic cosmic ray transport

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We present a new five fluid hybrid model for calculating cosmic ray particle transport and acceleration in a dynamic heliospheric environment. In particular the effects of solar cycle related changes in the solar wind speed on the heliospheric geometry, solar wind flow and cosmic ray distribution are discussed, when a polar-ecliptic asymmetry at the inner boundary is modeled. It is shown that the disappearance of the fast solar wind over the solar poles toward solar maximum influences the geometry of the termination shock which is an important structure for cosmic ray acceleration. For solar maximum conditions, the shock radius is smaller in the polar regions and in the heliospheric tail compared to solar minimum. These changes influence cosmic ray transport and acceleration in these regions, especially for the polarity cycle where positive particles drift in along the heliospheric current sheet. For this polarity cycle, and for both the anomalous and galactic cosmic ray protons, an increase in particle intensities at the shock in the heliospheric tail is computed as the shock moves inward toward the Sun. For the heliospheric nose, it is also shown that both the plasma speed and cosmic ray intensities are relative insensitive to changes in the latitudinal profile of the solar wind speed. Therefore toward solar maximum conditions there is a decrease in the nose-tail asymmetry of the computed cosmic ray distribution compared to solar minimum conditions.