Asymmetries in the Earth's dayside magnetosheath: results from global hybrid-Vlasov simulations

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The magnetosheath is the region bounded by the bow shock and the magnetopause which is home to shocked solar wind plasma. At the interface between the solar wind and the magnetosphere, the magnetosheath plays a key role in the coupling between these two media. Previous works have revealed pronounced dawn-dusk asymmetries in the magnetosheath properties, with for example the magnetic field strength and flow velocity being larger on the dusk side, while the plasma is denser, hotter and more turbulent on the dawn side. The dependence of these asymmetries on the upstream parameters remains however largely unknown. One of the main sources of these asymmetries is the bow shock configuration, which is typically quasi-parallel on the dawn side and quasi-perpendicular on the dusk side of the terrestrial magnetosheath because of the Parker-spiral orientation of the interplanetary magnetic field (IMF) at Earth. Most of these previous studies rely on collections of spacecraft measurements associated with a wide range of upstream conditions that have been processed to obtain the average values of the magnetosheath parameters. In this work, we use a different approach and quantify the magnetosheath asymmetries in global hybrid-Vlasov simulations performed with the Vlasiator model. We concentrate on three parameters: the magnetic field strength, the plasma density and the flow velocity. We find that the Vlasiator model reproduces accurately the polarity of the asymmetries, but that their level tends to be higher than in spacecraft measurements, probably due to the different processing methods. We investigate how the asymmetries change when the IMF becomes more radial and when the Alfvén Mach number decreases. When the IMF makes a 30° angle with the Sun-Earth line instead of 45°, we find a stronger magnetic field asymmetry and a larger variability of the magnetosheath density. In contrast, a lower Alfvén Mach number leads to a decrease of the magnetic field asymmetry level and of the variability of the magnetosheath density and velocity, likely due to weaker foreshock processes.
