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Adapting a multi-grid method to a numerical simulation model of the interaction between the solar wind and the solar wind

Erwan Jariel et al.

Unlike Earth, Venus doesn't have an intrinsic magnetic field shielding it from the solar wind. However, a magnetic field is generated from the interaction of solar wind and the dense atmosphere of the planet. Venus flybys by the BepiColombo mission in October 2020 and August 2021, and by Parker Solar Probe Orbiter, are unique opportunities to further study the interaction between Venus and the Sun.

Observational data are essential in the study of this interaction but they are limited by the mission's trajectory offering a constrained view of the processes that take place. On the other hand, simulations offer a global view of the interactions, allowing us to get results with physical significance that would not have been possible with observational data only. LatHyS is a three-dimensional parallel multi-species model using the hybrid model for that represents the electrons as a massless fluid conserving the neutrality of the plasma, and the ions as macroparticles with variable weights. Ions and electrons are coupled together using the Maxwell equations. Macroscopic plasma parameters determine the evolution of the magnetic field (*Ledvina et al. 2008*). It was developed at LATMOS, Paris, France, for Mars (*Modolo et al. 2005*) and later parallelized (*Modolo et al. 2010*) for performance and optimization purposes. It has the advantage of having a self-consistently calculated ionospheric plasma. LatHyS was recently adapted to the simulations of the interaction between the solar wind and Venus at Toulouse, France (*Aizawa et al. 2022*).

The work conducted aims at adapting a multi-grid method, initially adapted to LatHyS by *Leclercq et al. 2019* for the study of Mars and Ganymede, to the case of Venus. The multi-grid refinement allows a more efficient use of computing resources and an improved accuracy of the simulation thanks to a spatial resolution equivalent to a lower ionospheric plasma scale height.

First, the multi-grid method is presented. Then, simulations using the multi-grid method on the solar w interaction with Venus are conducted, and their results are compared to simulations made using LatHyS single homogeneous grid.

Finally the outputs of the numerical simulations are compared to data on the magnetic field and charge from recent flybys and from the Venus Express mission, that orbited the planet from 2006 to 2014.

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Discussion

to access the discussion