EPSC Abstracts
Vol. 7 EPSC2012-86 2012
European Planetary Science Congress 2012

Plasma vortices and lateral forcing of the Venus upper atmosphere

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Abstract

A statistical analysis of the ion flow near Venus reveals a significant curvature of the flow over the North Pole region. The curved flow of solar wind (H^+) and ionospheric (O^+) ions, results from a combination of an antisunward and lateral solar wind flow, the lateral flow component directed opposite to the Venus orbital motion [1]. The combined antisunward and lateral H^+ and O^+ flow wraps over the planetary atmosphere, from the terminator into the nightside. The lateral flow dominates close to the planet on the nightside. We note that the net lateral flow in the flank/nightside of Venus is in the direction of the Venus atmospheric superrotation. Further down in the Venus plasma tail, the flow inside the induced magnetosphere boundary (IMB) forms a vortex curving tailward. On the other hand, the flow outside IMB in the dense magnetosheath plasma (H^+) is essentially tailward, indicating that the plasma vortex inside IMB comprise planetary ions, their curved motion set up by dayside lateral solar wind forcing of ionospheric ions.
A test of the energy and momentum balance between solar wind H^+ and ionospheric O^+ in the altitude interval 1200 – 600 km, demonstrates a close connection between the energy and momentum gain by O^+ and the energy and momentum delivered by solar wind H^+. The general agreement in direction between the nightside ion flow over the Northern hemisphere, and the retrograde motion of the Venus atmosphere, suggests a connection between the ionospheric O^+ flow and the atmospheric neutral flow. That connection is further strengthened by the fact the O^+ flow velocity in the 200-300 km altitude range aligns with the power law curve describing the atmospheric zonal wind velocity profile versus altitude. The joint ion/neutral wind power-law profile therefore suggests momentum coupling between the ionospheric and atmospheric flow velocity. The fact that the O^+ flow is driven by solar wind forcing leaves us with the question: Is the characteristic zonal wind profile of the Venus atmospheric superrotation a consequence of solar wind forcing? Is the measured ionospheric O^+ mass flow capable of accelerating, and maintaining, a superrotating upper atmosphere at Venus?

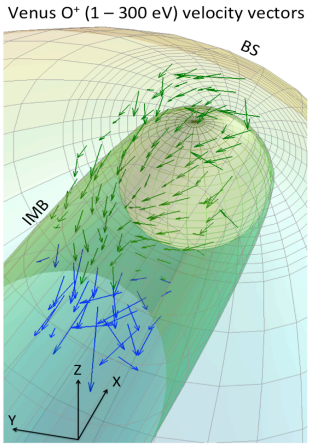

Figure 1: A 3D projection of ≈1-300 eV O^+ flow velocity vectors, averaged in cubic cells of 2000 km width and plotted in the VSO coordinate system. Green and blue arrows mark velocity vectors above and below the ecliptic plane respectively. BS and IMB marks the average Bow-Shock and induced magnetosphere boundary.

References

[1] Lundin, R.; Barabash, S.; Futaana, Y.; Sauvaud, J.-A.; Fedorov, A.; Perez-de-Tejada, H., Ion flow and momentum transfer in the Venus plasma environment, *Icarus*, 215, 2, 751-758, 2