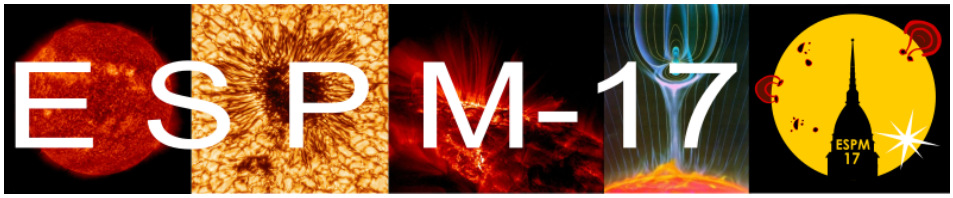

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Cross-scale phase relationship of solar activity with solar wind parameters: a Space Climate focus

Understanding the relationship between solar activity and solar wind is crucial for exploring the interactions among different solar atmospheric layers and the dynamics within the heliosphere. In this work, we used data from five solar cycles to examine the phase relationship between a proxy of solar activity, namely the Ca II K index, and solar wind parameters at 1 AU, such as dynamic pressure and speed. By taking advantage of a powerful tool, the Hilbert-Huang Transform, we decomposed the signals into their intrinsic modes of oscillation and analyzed their phase differences. Despite preserving a certain degree of phase coherence, both solar wind parameters exhibit delayed variations relative to the Ca II K index on space climate scales, showing an anti-phase relationship until 1985, followed by quadrature phase differences. Additionally, we explored how the relationship between the Ca II K index and solar wind parameters varies across different time scales. Our results indicate the presence of a potential bifurcation in the phase-space of the Ca II K index and solar wind speed (dynamic pressure), with the time scale acting as a bifurcation parameter. This suggests that including longer time-scale components enhances the discernibility of their connection. This discovery could be pivotal for understanding the complex interactions between solar activity and solar wind, offering important implications for prediction and interpretation in space climate studies.

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