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Validity and reliability of space weather predictions at Venus, Mars and Comet 67P

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Abstract

Plasma processes at unmagnetized planets and comets strongly depend on the solar wind properties. Prediction of space weather conditions to these targets is necessary to interpret the observations inside such induced magnetospheres. In this paper we describe validation activities of planetary space weather services and define their reliability.

Introduction

The solar wind interaction with the ionosphere of unmagnetized planets and comets is highly important in defining their plasma environment. In order to study this interaction of the solar wind and the planetary plasma environment, ideally one would need measurements both in the solar wind and in the induced planetary magnetosphere the same time. When there is only one spacecraft around the planet or the comet, it cannot perform such simultaneous observations, thus the prediction of solar wind properties and solar events to the different planetary objects becomes important.

Space weather predictions

Space weather predictions to planets and comets are performed in different forms: remote or in-situ data as input, ballistic propagation method or MHD modeling to name a few. Background solar wind, coronal mass ejection (CME) and solar energetic particle predictions must be separated due to their different propagation characteristics.

The Planetary Space Weather Services (PSWS) in the scope of the EU H2020 Europlanet Research Infrastructure [1] aims to provide a comprehensive set of tools including an extended database in order to provide the planetary community easy access to these predictions. Before making them publicly available, extensive validation is performed. In this paper we describe the validation activites of the CDPP Propagation Tool and the CDPP AMDA database for their Venus, Mars and Comet 67P predictions, which is part of the PSWS project.

Validation of predictions

The solar wind predictions for Venus, Mars and Comet 67P can be validated by in-situ solar wind measurements onboard the planetary spacecraft Venus Express (VEX), Mars Express (MEX) and Rosetta while these are located in the undisturbed solar wind. We show how the prediction accuracy depends on the spatial separation of the solar and the planetary or cometary spacecraft.

The predicted arrival times of the interplanetary CME (ICME) signatures at our targets are also tested based on in-situ observations. Even if the planetary spacecraft performs measurements inside the induced magnetosphere during the ICME arrival, we can indirectly derive the timing and duration from its effects on the planetary plasma environment [2].

Reliability of predictions

The reliability of a given planetary space weather prediction depends on several factors: the quality and availability of the input solar wind data, the spatial separation of the observing spacecraft from the target, the limitations of the method with its assumptions, the current heliospheric space weather conditions and so forth. Based on these, we can define both theoretical and empirical reliability factors that can be added as a quality flag to the predicitions. For instance, the large spacecraft separation is a major issue during solar activity maximum, while the assumption of constant bulk velocity during radial

propagation can be fine during quiet solar wind conditions without large gradients.

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