EPSC Abstracts
Vol. 5, EPSC2010-394, 2010
European Planetary Science Congress 2010

The Virtual Wave Observatory: A Portal for Planetary Radio and Plasma Wave Data

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Abstract

In-situ and remote measurements of planetary radio emissions from space and ground-based observatories have yielded valuable insights into planetary and satellite magnetospheres, their interaction with the local plasma environment and their response to external drivers such as the solar wind. The goal of the Virtual Wave Observatory (*VWO*, *http://VWO.nasa.gov*) is to make these wave data searchable, usable and understandable to the scientific community. Through the use of the *SPASE* data model and our work on extending *SPASE* to serve wave data we will make available protocols for accessing, searching and retrieving these data. The *VWO* will also enable searches by context (conditions) and by phenomenon.

1. Introduction

Wave phenomena are ubiquitous throughout the solar system (Figure 1) ranging from freely propagating electromagnetic radiation to plasma wave modes trapped in various plasma regimes and atmospheric gravity waves. Because waves can propagate, wave data obtained at a given observing location may belong to wave oscillations generated locally or from afar. Figure 1 shows the dynamic spectrograms of radio emissions from different planets. Understanding the generation and propagation of such emissions will help determine the physics of planetary magnetospheres.

Plasma wave and radiation data are currently not easily computer-searchable, making the identification of pertinent wave data features for analyses and cross comparisons difficult and laborious. The goal of the Virtual Wave Observatory (*VWO*) *is to make all online-accessible Heliophysics wave data searchable, usable and understandable by the scientific community* [1]. The *VWO* is the latest virtual observatory selected by NASA to help form the Heliophysics Data Environment (*HPDE* [2]).

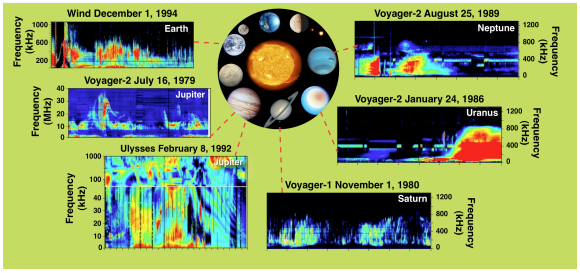

Figure 1: The *VWO* will enable cross-comparison of planetary wave environments.

2. VWO Objectives

The Heliophysics Data and Model Consortium (*HDMC* [3]) is a NASA project and an integral part of the *HPDE* providing *open, easy, uniform, and scientifically meaningful* access to Heliophysics mission data and models. The *HDMC* oversees all Heliophysics mission Resident Archives, data recovery and upgrade projects, and discipline (*x*)-oriented Virtual Observatories (*VxO*s), and leads the *SPASE* consortium <*http://www.SPASE-group.org*> in developing a standard data model for describing Heliophysics metadata.

Like other *VxO*s, the *VWO* will: (1) work with the *SPASE* Consortium to develop the data model and provide wave data terms to the *SPASE* dictionary; (2) describe the metadata of Heliophysics wave data sets using *SPASE*; (3) develop a wave data registry; and (4) develop a web interface for searching, subsetting and retrieving distributed wave data.

Among the Heliophysics data sets *VWO* will describe and search are those from instruments on planetary missions such as *Voyager* PRA & PLS, *Ulysses*

URAP, *Galileo* PWS, and *Cassini* RPWS. In order to support planetary magnetospheric research effectively, we need to develop data search mechanisms that cater to searching and obtaining pertinent wave and ancillary data sets. Because of the context-dependent nature of wave observations, it is often best to select wave data based on geophysical conditions and wave phenomena.

2.1 Searches by Context

In addition to deciding whether selected wave activity is electrostatic (i.e., locally trapped) or electromagnetic (with propagation over distances), considerations must be given to the dependence of wave activity on observer location or viewing geometry, propagating frequency range and whether the wave data were acquired by passive or active observations. Occurrences of natural wave emissions in the magnetosphere are also often dependent on the state (i.e., context) of the magnetosphere, which varies with solar wind, IMF and geomagnetic conditions. Fung and Shao [4] showed recently that magnetospheric state can be specified by a set of suitably time-shifted solar wind, IMF and the multi-scale geomagnetic response parameters. These parameters form a magnetospheric state vector, providing the basis for searching geospace wave data by their context conditions. The correlation of Saturn Kilometric Radiation with the solar wind, as shown by Desch and Rucker [5], illustrates that similar searches by condition may be possible for other planetary magnetospheres.

2.2 Searches by Phenomenon

As shown in Figure 1, there exist numerous wave phenomena in planetary magnetospheres. They appear in different portions of the frequency spectrum, can be electromagnetic or electrostatic, and can have similar source mechanisms. Although wave experts can often identify features relatively easily, it can be a challenge for non-wave experts. To make wave data more understandable and usable by the broader Heliophysics community, the *VWO* will also endeavor to develop capabilities to search wave data by *wave phenomena.* It will be necessary not only to describe these data by their appropriate metadata (in *SPASE*), but also identify them by their associated phenomena. To that end, *VWO* will develop a service to capture data annotations provided by wave experts as they analyze the data. The captured information will then be collected, organized and stored in the *VWO* searchable metadata database. We hope this annotation service will become a useful tool that can also help broaden the *VWO* user base to non-wave experts.

2.3 Cooperation with other VxOs

When performing wave studies, users will likely need to access ancillary data outside the wave data domain (*e.g.,* plasma and dc field data or models). In accordance with *HDMC* objectives, *VWO* will support seamless and transparent interactions with other Heliophysics *VxO*s and data providers. To facilitate effective inter-*VxO* communications, a *SPASE* Query Language (*SPASEQL*) is being developed primarily for *VxO*s to exchange query messages and passing data resources. Since *SPASEQL* is logically based on the *SPASE* data model, it is implementation-neutral. Data providers and distributed data archives can also use *SPASEQL* to interact with *VxO*s. As needed, *VWO* developers will create tools specifically for processing and analyzing wave data.

3. Summary

The Virtual Wave Observatory (*VWO*) is one of the *VxO*s forming the nascent Heliophysics data environment. *VWO* aims to promote and facilitate interdisciplinary research leading to new and deeper understanding of wave processes and their relations to the structures and dynamics of various domains.

References

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