Computational platform of the Mexican Virtual Solar Observatory

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Received: November 7, 2007; accepted: April 6, 2008

Resumen

El Observatorio Virtual Solar Mexicano (MVSO, por sus siglas en inglés) es un proyecto en desarrollo, cuyo objetivo es generar una base de datos producida por simulaciones numéricas asociadas a fenómenos solares. En este trabajo hacemos una descripción de la plataforma computacional del OVSM y explicamos más en detalle el desarrollo de la interfaz gráfica para hacer las simulaciones numéricas remotas, la generación de la base de datos y las herramientas de búsqueda.

Palabras clave: Observatorio Virtual Solar, simulaciones numéricas remotas, bases de datos, eyecciones de masa coronal.

Abstract

The Mexican Virtual Solar Observatory (MVSO) is an ongoing project whose goal is to provide a service based on numerical simulations database that can help to model an interpret solar phenomena. In this paper we describe the computational backbone of the MVSO and explain in detail the development of the graphic user interface to perform Web-based, remote numerical simulations. We also provide tools to handle the handle the generated datasets.

Key words: Virtual Solar Observatory, remote numerical simulations, database, coronal mass ejections.

Introduction

At present specialists in solar physics have access to a great number of space telescopes and earth observatories, which are monitoring the activity on the surface of the Sun. This means a lot of terabytes of information distributed in different locations. With the explosive growth in the Internet and related Information Technologies (IT), it is now possible to link together distributed data archives and analysis software systems. A Virtual Solar Observatory (VSO) is a platform for launching solar physics investigations: it provides access to huge data banks, software systems with user friendly interfaces for data processing, analysis and visualization and even access to computers on which the work can be carried out (Sánchez-Duarte *et al.*, 1997; Dimitoglou *et al.*, 1998; Hill, 2000; IVOA, 2002; VSO, 2005; VSTO, 2006).

The goal of the Mexican Virtual Solar Observatory (MVSO; Santillán *et al.*, 2006; Hernández *et al.*, 2006) is to develop a system able to execute remote numerical simulations through a web interface and store the results into a database, which will be available for all the scientific community.

Development

The MVSO rest on a set of software tools that offer global solutions for Web development. Below we enumerate the tools that were used. The operating system was Linux, the Web server was Apache, SQL (Structure Query Language) and the relational database management system was MySQL, everything was programmed with PHP (Hypertext Pre-Processor). The computational backbone of the MVSO is structured into three stages. The first part is the related to the graphic user interface (GUI), the second part is associated to the remote numerical simulations (RNS) and the third part is the database creation and the search tools.

The implementation is explained in the flowchart of Fig. 1, where the initial step is the user validation and authentication in the system. After this, the user must introduce initial conditions (IC) associated with the physics problem to be simulated. After initial conditions are given, the program searches if these values have been used previously by other user and gives a link to the archive of the previous numerical simulation (NS). If not previous simulation is found, the system starts a new NS.

It is important to mention that the user has the possibility of using only the archives of the database without running a new simulation.

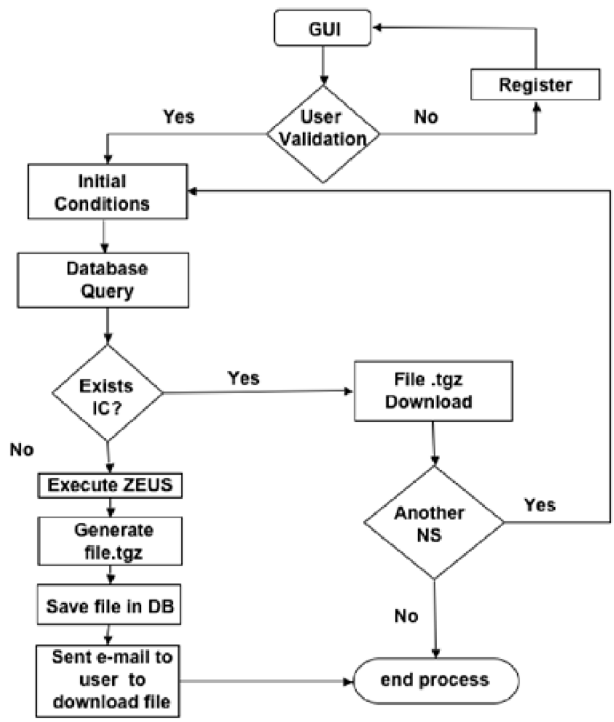

Fig. 1. Flowchart of the computational implementation of the MVSO.

Graphic User Interface

The application implement in the MVSO is the study of the evolution of coronal mass ejections (CME; more details of this perturbations see Hundhausen, 1996) in the interplanetary medium using the numerical code ZEUS-3D (Santillán, *et al.*, 2008). At the moment there are two principal GUI´s in the MVSO, one executes the NS and the other performs a search in the database. In the first case, the GUI is designed to introduce the physical variables related to the Solar Wind (density, velocity and temperature) and the CME, (density, velocity, temperature, injection time and aperture angle; for details visit the MVSO Website); the GUI includes various filters to validate the data integrity and verify that all variables are introduced. The GUI that performs the search in the database is similar at the NS's GUI, because it includes the possibility to obtain the numerical runs by the physical variables, date and username.

Remote Numerical Simulation

Software development for the remote numerical simulation is a group programs with specific tasks. For the evolution of the CME, the IC are added an input file and those are includes in the database together user name and the date. When the NS is done, the program creates one tar file archive compressed with Gnu Zip compression with all output files; the name and location of this file are updated in the database (see MVSO Website). The simulation file includes the physical variables associated to evolution of CME in the interplanetary medium in HDF4 format. Finally the system sends an email to user informing the web address where this file can be downloaded.

Database

The MVSO uses a relational database and the queries are in the standard language, SQL.

At this moment we only service storage of the results form the application of the evolution of CME, however in the future will be easy to include another physics problem. In the CME case the database contains the values for the IC of the simulation associated to the solar wind (temperature, velocity and density); and the CME physics characteristics (temperature, velocity, density, aperture angle and injection time). It also includes user information: name, institution, email and password, output files and date. With this information the user has the possibility to make several kinds of consults of the database, depending on what information he need to get; for example, if the user want search the database by solar wind velocity, only need introduce in the GUI the value in this field and the system get all the files that contain this value, the same case applied if the user want to search by two o more variables. When the user makes a search without any value, the system gets all the NS stored in the database. Finally, the MVSO should include in the future, online visualization tools and the possibility of to be inter-operable with others Virtual Solar Observatories. This point is very important, because the users could have access to numerical simulations and observations of the solar phenomena at one time.

Acknowledgements

We thank X. Blanco-Cano, O López-Cruz, S. Curiel & E. Sohn for their useful comments. This work has been partially supported from DGAPA-UNAM grant IN104306 and CUDI-CONACyT 2007.

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VSTO, Virtual Solar-Terrestrial Observatory, 2006. http://vsto.hao.ucar.edu/.

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