ARTICLE IN PRESS

Planetary and Space Science (xxxx) xxxx–xxxx

Contents lists available at ScienceDirect

Planetary and Space Science

journal homepage: www.elsevier.com/locate/pss

PSUP: A Planetary SUrface Portal

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ABSTRACT

The large size and complexity of planetary data acquired by spacecraft during the last two decades create a demand within the planetary community for access to the archives of raw and high level data and for the tools necessary to analyze these data. Among the different targets of the Solar System, Mars is unique as the combined datasets from the Viking, Mars Global Surveyor, Mars Odyssey, Mars Express and Mars Reconnaissance Orbiter missions provide a tremendous wealth of information that can be used to study the surface of Mars. The number and the size of the datasets require an information system to process, manage and distribute data. The Observatories of Paris Sud (OSUPS) and Lyon (OSUL) have developed a portal, called PSUP (Planetary SUrface Portal), for providing users with efficient and easy access to data products dedicated to the Martian surface. The objectives of the portal are: 1) to allow processing and downloading of data via a specific application called *MarsSI* (Martian surface data processing Information System); 2) to provide the visualization and merging of high level (image, spectral, and topographic) products and catalogs via a web-based user interface (*MarsVisu*), and 3) to distribute some of these specific high level data with an emphasis on products issued by the science teams of OSUPS and OSUL. As the *MarsSI* service is extensively described in a companion paper (Quantin-Nataf et al., companion paper, submitted to this special issue), the present paper focus on the general architecture and the functionalities of the web-based user interface *MarsVisu.* This service provides access to many data products for Mars: albedo, mineral and thermal inertia global maps from spectrometers; mosaics from imagers; image footprints and rasters from the *MarsSI* tool; high level specific products (defined as catalogs or vectors). *MarsVisu* can be used to quickly assess the visualized processed data and maps as well as identify areas that have not been mapped yet. It also allows overlapping of these data products on a virtual Martian globe, which can be difficult to use collectively. The architecture of PSUP data management layer and visualization is based on SITools2 (Malapert and Marseille, 2012) and MIZAR (Module for Interactive visualiZation from Astronomical Repositories) respectively, two CNES generic tools developed by a joint effort between the French space agency (CNES) and French scientific laboratories. Future developments include the addition of high level products of Mars (regional geological maps, new global compositional maps…) and tools (spectra extraction from hyperspectral cubes). Ultimately, PSUP will be adapted to other planetary surfaces and space missions in which the French research institutes are involved.

1. Introduction

The usual mode of carrying out astronomical research of a planetary solar system body has been based on a single astronomer or a small team of astronomers that performs the analysis of a given dataset. Since the beginning of the 21st century, this approach has however undergone a dramatic and very rapid change due to the advances in the space exploration leading to unprecedented flow of data at various spatial scales and multiple wavelengths. In addition, the existence of new archives, high level products resulting from peer-reviewed studies and specific tools allows meaningful comparisons to be made for scientific, planning and educational purposes.

However, it can be difficult to gather, manage and analyze all these data. Mars is a typical case with a tremendous amount of data from

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http://dx.doi.org/10.1016/j.pss.2017.01.016
Received 10 November 2016; Received in revised form 16 January 2017; Accepted 28 January 2017
0032-0633/

Please cite this article as: Poulet, F., Planetary and Space Science (2017), http://dx.doi.org/10.1016/j.pss.2017.01.016

(raw to high level products) coming from various sources and techniques. For instance, global mineralogical and elemental maps of Mars have been produced using a variety of remote sensing techniques including visible/near-infrared (0.3–5.0 µm) imaging spectroscopy (Poulet et al., 2007; Ody et al., 2012, 2013; Carter et al., 2013), thermal (6–50 µm) emission spectroscopy (Bandfield, 2002; Rogers and Christensen, 2007; Koeppen and Hamilton, 2008; Rogers and Hamilton, 2015), gamma ray spectroscopy, and neutron spectroscopy (Boynton et al., 2007; Taylor et al., 2010; Gasnault et al., 2010), with each technique having different sensitivities and limitations. Various image data of the surface are also available including Viking Orbiter (VO) (Carr et al., 1972), the Mars Orbiter Camera (MOC) (Malin et al., 2001) on board Mars Global Surveyor (MGS), the THermal EMission Imaging Instrument (THEMIS) (Christensen et al., 2004) on board Mars Odyssey (ODY), the High Resolution Stereo Camera (HRSC) (Jaumann et al., 2007) on board Mars Express (MEx), the High Resolution Imaging Science Instrument (HiRISE) (McEwen et al., 2007) and the Context Camera (CTX) (Malin et al., 2007) on board the Mars Reconnaissance Orbiter (MRO).

To support their data reduction and use them collectively, web-based interfaces and/or specific tools using Geographic Information Systems (GIS) are being implemented (e.g., Christensen et al., 2009; Erkeling et al., 2016; Tirsch et al., 2016; Oosthoek et al., 2014; Marco Figuera et al., submitted). Similarly, we have developed a package of applications, called PSUP (Planetary SUrface Portal), which provides seamless integration of various existing datasets accessible via web-based user interfaces useful for data analysis as well as for targeting and educational objectives. PSUP was built thanks to a joined effort of two French research institutes, namely the Observatoire des Sciences de l'Univers Paris Sud (OSUPS, composed of Institute d'Astrophysique Spatiale and Géosciences Paris Sud) and the Observatoire de Lyon (OSUL).

In this manuscript we present the current status of PSUP. After an overview of major components of PSUP, we present the various datasets that are available through this portal (section 2). As *MarsSi* has also already been presented to the planetary community (Lozac'h et al., 2015) and a companion paper is dedicated to the detailed description of *MarsSI* (Quantin-Nataf et al., submitted to this special issue), we then focus on *MarsVisu*. We present the user interface and give insights into the layout of the database, the integration of datasets, and the software routines of *MarsVisu*. Afterwards, we illustrate the features of *MarsVisu* by showing some examples. Finally, future development are presented.

2. Components of PSUP

2.1. Overview

PSUP is a web-based interface of two software application platforms for working with spatial data (raster, vector) acquired by various space instruments analyzing the surface of Mars from orbit (http://psup.ias.u-psud.fr/). The first platform of PSUP is *MarsSI* (Martian surface data processing Information System that provides data analysis functionalities to select and download ready-to-use products or to process data through specific and validated pipelines. To date, *MarsSI* handles CTX, HiRISE and CRISM (Compact Reconnaissance Imaging Spectrometer of Mars)) data of MRO, HRSC and OMEGA (Observatoire pour la Minéralogie, l'Eau, la Glace et l'Activité) data of MEx mission and THEMIS data of ODY. The second platform is *MarsVisu* that provides visualization tool of many data products for Mars: image footprints and rasters from the *MarsSI* tool; compositional maps from OMEGA and TES; albedo, emissivity and thermal inertia from OMEGA and TES; mosaics from THEMIS, Viking, and CTX; specific level-4 products (defined as catalogs) such as hydrated mineral sites derived from CRISM and OMEGA data analyses, central peaks mineralogy, CO_2 crocus line… A third and last functionality of PSUP is to archive and distribute the OMEGA data cubes corrected of atmospheric and aerosol contributions with state-of-the-art tools.

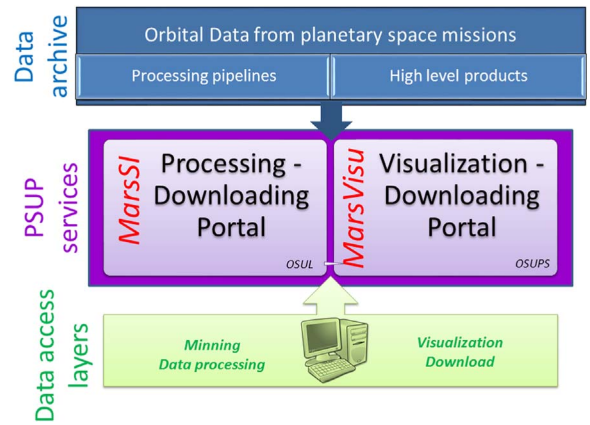

Fig. 1. Block diagram of PSUP including its three major components: data archive, data access layers, and query and compute services.

2.2. Block diagram

The conceptual design of PSUP is based on a system architecture that needs to give efficient access to data and services irrespective of their origin. It can be identified as functional blocks in Fig. 1:

1. data archive (currently of the Martian surface) acquired by numerous remote sensing instruments. They (will) vary considerably in level, implementation and format. Metadata standards are provided a well-defined means to describe archives, data collections as well as services to the user for scientific and educational purposes;
2. data access layer providing the interfaces to all data and services. It is used both to link the data archives and user queries within the framework of various applications of PSUP;
3. web-based applications *MarsSI* and *MarsVisu* providing the user two interfaces to perform various queries and compute services such as data mining, data processing, visualization and downloading. These services provide the tools for information discovery, small and large scale correlation and analysis of disparate datasets to enable science with PSUP.

2.3. Datasets

The data archive block store datasets (at the moment, catalogs, images, hyperspectral cubes, DTM (Digital Terrain Model) of the Martian surface) organized into logically related data collections, as well as metadata describing the archive and its data holdings. While their management is performed by the application Sitools2 (see section 3), access is provided to the user via a web interface or a specific data mining protocol. The public version of PSUP offers quick access to tens of maps and catalogs as well as thousands of individual and hyperspectral images collected from Martian missions. Table 1 summarizes all the available data through the PSUP portal at the time of the writing of the paper. Commonly-used data products (global mosaics of imagers) are integrated, alleviating concerns about downloading, projecting, and converting data in advance. Compositional maps with a special focus on the OMEGA data set are also included. The data generated by the *MarsSI* application (HiRISE and CTX DTM, CTX and HiRISE images, CRISM cubes) have their footprints and their associated metadata available on *MarsVisu*, enabling data management, data access, data information to the user and in the near-future data interoperability. The catalogs are incorporated into the *MarsVisu* and they can be downloaded as vector layers.

The validation and the quality of all PSUP data products are the results of state-of-the-art data reduction and expertise from various