

PVOL2 (The Planetary Virtual Observatory and Laboratory): An improved database of amateur observations of Solar system planets

R. Hueso [ricardo.hueso@ehu.es] (1), J. Juaristi (1), J. Legarreta (2), A. Sánchez-Lavega (1), S. Erard (3), B. Cecconi (3) and Pierre Le Sidaner (4)

(1) Dpto. Física Aplicada I, Escuela de Ingeniería de Bilbao, UPV/EHU, Bilbao, Spain, (2) Dpto. Ingeniería de Sistemas y Automática, Escuela de Ingeniería de Bilbao, UPV/EHU, Bilbao, Spain. (3) LESIA, Observatoire de Paris, CNRS, PSL Research University, UPMC, Université Denis Diderot, 5 Place Jules Janssen, Meudon, France (4) DIO, Observatoire de Paris, CNRS, PSL Research University, 61 Av. de l'Observatoire, Paris, France.

Abstract

The Planetary Virtual Observatory and Laboratory (PVOL) stores and serves publicly through its web site a large database of amateur observations of solar system planets [1, 2]. These images are regularly used for research on solar system astronomy [3] empowering collaborations between amateur and professional astronomers in planetary science in a wide range of topics that extend from studies of the atmospheres of the Giant planets, Venus and Mars to the motions of their satellites. We here document recent major advances in the PVOL database, now called PVOL2 and available since the second half of 2016. PVOL2 contains amateur observations from Mercury to Neptune including the Moon and the Galilean satellites. PVOL2 is also integrated in the VESPA portal (Virtual European Space and Planetary Access) as one general service in VESPA. PVOL can be consulted in <http://pvol2.ehu.eus> or through the VESPA portal in: <http://vespa.obspm.fr/>

1. Introduction

The original PVOL website and the current PVOL2 have been built as a database of amateur observations contributed by a few hundredths of observers. The PVOL2 website offers different searching tools that allow retrieving observations from a particular range of dates, a given observer, particular locations in a planet, movies and animations instead of original images, map projections and many others searching options. Data can be uploaded by amateur astronomers with a personal username and password or can be submitted by e-mail to pvol@ehu.eus. The webpage includes relevant news to amateur

astronomers, short reports, links to major image sources such as ALPO-Japan among others (<http://alpo-j.asahikawa-med.ac.jp/indexE.htm>) and links to relevant websites in pro-am collaborations in Solar System astronomy like the websites of the Juno mission to Jupiter and the Akatsuki mission to Venus. Additionally PVOL2 can be consulted externally from other platforms popular among professional astronomers (like TOPCAT). A very important characteristic of PVOL2 is that it is now fully integrated in the VESPA portal which offers different services to the professional community. VESPA aims to build a Virtual Observatory for Planetary Science, connecting all sorts of data in the field and providing modern tools to retrieve, cross-correlate, and display data and results of scientific analyses. For instance, queries on VESPA of spectra of a particular planet would also show images of that planet in PVOL2 obtained in the time range of the spectra.

2. Data in PVOL2

PVOL2 contains amateur observations of Jupiter since the year 2000 and has been expanding ever since then. It now contains more than 32,300 image registries contributed by about 320 observers. Most of the images are Jupiter observations (72%) followed by Saturn observations (23%). Mercury, Mars and Venus images are available since 2016 and Uranus and Neptune observations, although a minority of the data, are also stored and used for scientific research of these planets [4]. Observations of the Galilean satellites and the Moon are also available and can be used for teaching projects. One new characteristic in PVOL2 is that most of the images uploaded since 2017 are “tagged” so that it becomes easy to find images containing a particular

detail like Jupiter's Great Red Spot or a particular crater on the Moon. We continue to work to include data of more and more amateur observers to make PVOL2 as complete as possible.

3. Science

Advances over the last decade in electronic cameras, image processing software and the popularization of fast-imaging techniques have resulted in a golden era of amateur observations of the Solar System. Planetary observations by amateur astronomers reach a high spatial resolution and the combination of data from many different observers allows a nearly continuous monitoring of these planets. This is particularly important for the study of the atmosphere of Jupiter or the giant planets in general but it is also relevant in the study of other planetary atmospheres like that of Venus. PVOL2 contains a list of scientific publications that have used or are based in amateur data. About 30 scientific publications are listed in PVOL2, including publications in major scientific journals such as *Nature*, *Science*, *The Astrophysical Journal* or *Astronomy & Astrophysics*. These publications cover the following most relevant topics among many others:

- Jovian atmospheric dynamics [5, 6].
- Impacts in Jupiter [7, 8].
- Saturn atmospheric dynamics [9, 10].
- Uranus and Neptune atmospheric dynamics [4, 11].
- Venus global winds [12].
- Atmospheric features in Mars [13].

The current version of PVOL is indented to boost new professional and amateur collaborations in these and other related fields. The PVOL website also hosts a particular project related to the searches of fireball impacts in Jupiter [7, 8].

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