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PSWS Software Development Report

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Responsible WP Leader: CNRS, Nicolas Andre

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Dissemination level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Service)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (excluding the Commission Services)	

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Abstract: A variety of tools (in the form of web applications, standalone software, or numerical models in various degrees of implementation) are available for tracing propagation of planetary and/or solar events through the Solar System and modelling the response of the planetary environment (surfaces, atmospheres, ionospheres, and magnetospheres) to those events. But these tools were not originally designed for planetary event prediction and space weather applications. Additional research and tailoring are required in order to apply them for these purposes. The Software Development phase reported here therefore consisted in adapting and modifying the already existing tools, as well as developing new interfaces and software.

Table of content

1. Summary of PSWS

1.1 PSWS Objectives

Under Horizon 2020, the Europlanet 2020 Research Infrastructure (EPN2020-RI) will include an entirely new Virtual Access Service, WP5 VA1 "Planetary Space Weather Services" (PSWS) that will extend the concepts of space weather and space situational awareness to other planets in our Solar System and in particular to spacecraft that voyage through it. WP5 will make five entirely new 'toolkits' accessible to the research community and to industrial partners planning for space missions: a general planetary space weather toolkit, as well as three toolkits dedicated to the following key planetary environments: Mars (in support of ExoMars), comets (building on success of the ESA Rosetta mission), and outer planets (in preparation for the ESA JUICE mission to be launched in 2022). This will give the European planetary science community new methods, interfaces, functionalities and/or plugins dedicated to planetary space weather in the tools and models available within the partner institutes. It will also create a novel event-diary toolkit aiming at predicting and detecting planetary events like meteor showers and impacts. A variety of tools (in the form of web applications, standalone software, or numerical models in various degrees of implementation) are available for tracing propagation of planetary and/or solar events through the Solar System and modelling the response of the planetary environment (surfaces, atmospheres, ionospheres, and magnetospheres) to those events. But these tools were not originally designed for planetary event prediction and space weather applications. So WP10 JRA4 "Planetary Space Weather Services" (PSWS) will provide the additional research and tailoring required to apply them for these purposes. The overall objectives of this Joint Research Activities will be to review, test, improve and adapt methods and tools available within the partner institutes in order to make prototype planetary event and space weather services operational in Europe at the end of the programme.

1.2 PSWS Participants

PSWS participants are listed below.

Participant	**Permanent personnel**	**Personnel hired by the project**
2. OBSPARIS	Baptiste Cecconi Pierre Le Sidaner Jérémie Vaubaillon	Maxime Paillassa (09/2016-12/2016)
3. UCL	Nicholas Achilleos Geraint Jones	Patrick Guio
4. CNRS	Nicolas André Vincent Génot Alexis Rouillard Pierre-Louis Blelly Aurélie Marchaudon Frédéric Pitout Myriam Bouchemit Jean Lilensten Mathieu Barthélémy	Mikel Indurain (01/2015-12/2015) Arnaud Biegun (04/2016-06/2016) Antoine Goutenoir (10/2016-08/2017)

11. DLR	Daniel Matthiae	
12. ABER	Manuel Grande Tony Cook	Patrick Dixon From 18 July, part time) Zoe Hannah Lee-Payne ()
18. Wigner	Karoly Szego	Andrea Opitz (01/09/2015-31/08/2019, 1/3 time) Zsuzsanna Dálya (02/2016-04/2016, 50%)
19. IAP	Jan Soucek Benjamin Grison	
23. GFI Informatique	Stéphane Caussarieu Laurent Beigbeder Jean-Philippe Toniutti	
28. UPV/EHU	Ricardo Hueso	Jon Juaristi (02/2016-01/2017 and 01/2018-07/2018)
33. SRC PAS	Lukasz Tomasik Mariusz Pożoga Maria Miłodrowska	Piotr Koperski (12/2015-05/2016)

1.3 PSWS Structure

PSWS activities consist of two work packages with Joint Research activities feeding Virtual Access activities. These activities consist of the following tasks:

- JRA (WP10)
  - *Task 1.Coordination (CNRS, ABER)*
  - *Task 2.Adapting available tools and methods for planetary space weather (UCL, CNRS)*
  - *Task 3.Enabling planetary event prediction/ensuring reliability of services (Wigner, OBSPARIS)*
  - *Task 4.Testing space weather connections in the Solar System (IAP, DLR, Wigner RCP)*
  - *Task 5. Alert Service (OBSPARIS, UCL, CNRS, SRC PAS)*
- VA (WP5)
  - *Task 1. Coordination (CNRS, ABER)*
  - *Task 2. Implementation (UCL, ABER, CNRS, SRC PAS)*
  - *Task 3. Detection (UPV/EHU, UCL, ABER)*
  - *Task 4. Liaison (CNRS, SRC PAS)*

1.4. PSWS Toolkits

WP5 will make five entirely new 'toolkits' accessible to the research community and to industrial partners planning for space missions: a general planetary space weather toolkit, as well as three toolkits dedicated to the following key planetary environments: Mars (in support ExoMars), comets (building on success of the ESA Rosetta mission), and outer planets (in preparation for the ESA JUICE mission to be launched in 2022). This will give the European planetary science community new methods, interfaces, functionalities and/or plugins dedicated to planetary space weather in the tools and models available within the partner institutes. It will also create a novel event-diary toolkit aiming at predicting and detecting planetary events like meteor showers and impacts. The PSWS portal can be found at http://planetaryspaceweather-europlanet.irap.omp.eu/ and will be regularly updated.

1.5 PSWS Deliverables and Milestones

PSWS deliverables and milestones are listed below.

D5.1-5.4 Assessment Reports from the VA Review Board PSWS: PM 16, 28, 40, 46

D5.5-5.8 PSWS Annual Report:	PM 12, 24, 36, 48
D5.9 PSWS Validation Report:	PM48
D10.1 PSWS Database Consolidation Report:	PM12
D10.2 PSWS Software Development:	PM30 (this report)
D10.3 PSWS Service Prototype:	PM42
D10.4 PSWS Alert Service:	PM42

M5.1 PSWS Kick-off mtg.:	PM 3 (Minutes)
M5.2 Ext. Rev. Board:	PM 6 (Minutes)
M5.3 PSWS Website:	PM 6 (User review)
M5.4 Coordination Meeting:	PM 15, 27, 36 (Minutes)
M5.5 Pre-release review:	PM 30 (Minutes)
M5.6 Integrated PSWS and Alert Service release:	PM 36 (Review of service)
M5.7 Final meeting:	PM 46 (Minutes)

1.6 PSWS Services

The Planetary Space Weather Services will provide 12 services distributed over 4 different service domains – Prediction, Detection, Modelling, Alerts - having each its specific groups of end users. PSWS WP5 includes 12 services:

A1. 1D MHD Solar Wind Prediction Tool (CNRS)

A2. Propagation Tool (GFI Informatique)

A3. Meteor showers (OBSPARIS)

A4. Cometary tail crossings (UCL)

B1. Lunar impacts (ABER)

B2. Giant planet fireballs (EHU-UPV)

B3. Cometary tails (UCL)

C1. Transplanet – Earth, Mars (Venus), Jupiter (CNRS)

C2. Mars radiation environment (ABER)

C3. Giant planet magnetodiscs (UCL)

C4. Jupiter's thermosphere (UCL)

D. Alerts (CNRS and OBSPARIS)

2. PSWS Software Development

The five PSWS Toolkits consist of 1) a general space weather toolkit, 2) a Mars toolkit, 3) a comet toolkit, 4) an outer planet toolkit, and 5) a planetary diary toolkit. The developments of the associated services will follow four phases (Data Consolidation, Software Development, Service Prototype, Validation). The deliverables of JRA4-PSWS feed into VA1-PSWS.

In this section we report on the achievements and developments done during the Software Development phase for each of our foreseen services.

A variety of tools (in the form of web applications, standalone software, or numerical models in various degrees of implementation) are available for tracing propagation of planetary or solar events through the Solar System and modelling the response of the planetary environment (surfaces, atmospheres, ionospheres, and magnetospheres) to those events. As these tools were usually not originally designed for planetary event prediction or space weather applications, additional development is required for these purposes. The overall objectives of the JRA4-PSWS will be to review, test, improve and adapt methods and tools available within the partner institutes in order to make prototype planetary event/diary and space weather services operational through VA1-PSWS.

The Software Development phase reported here therefore consisted in adapting and modifying the already existing tools, as well as developing new interfaces and software.

2.1 HELIOPROPA

CNRS has developed the HELIOPROPA service for propagating solar wind parameters observed in situ in the vicinity of the Earth to any planets, comets, spacecraft in the Solar System. It relies on a 1D MHD propagation model developed initially by Chihiro Tao. It also enables the user to predict the state of the solar wind at Mars, Jupiter, and Saturn. The online version for runs on request is available http://heliopropa.irap.omp.eu

Achievements during the software development phase:

The service is fully operational. All software development can be accessible at https://gitlab.irap.omp.eu/CDPP/HELIOPROPA and will be made available at http://planetaryspaceweather-europlanet.irap.omp.eu/

2.2 Propagation Tool

GFI Informatique has developed extensions for the CDPP/Propagation Tool dedicated to comets, giant planet auroral emissions, and catalogues of perturbations.

The service is fully operational and available at http://propagationtool.cdpp.eu

2.3 Meteor showers

OBSPARIS is currently developing a service to link the ephemeris of Solar System objects to predictable meteor showers that impact terrestrial planet surfaces or giant planet atmospheres.

Achievements during the software development phase:

- Simulation data released
- Python script for the model released

2.4 TAILCATCHER

The comet tail crossing event search service – Tailcatcher – is operational and working well as a standalone IDL application. We have not completed the web interface for the code however, and in the meantime, can provide results via informal queries that we receive via the email address provided on the service's webpage. As a demonstration of the code's success, it has been already applied to several existing missions, and has returned numerous possible tail crossings events, including ones previously discovered in spacecraft data. We have posted the output for the Ulysses mission to the webpage as an example of the results that the service provides. The cometary tail crossings service provided by UCL-MSSL may be accessed via the following website:

https://www.ucl.ac.uk/mssl/planetary-science/cometanalysis

2.5 Lunar impact detection software

ABER is currently upgrading and converting its already-written giant planet fireball detection software.

Achievements during the software development phase:

- Development of the Video2015 software

- Specifications for the online observational upload website defined

2.6 DeTeCt3.1

UPV/EHU has developed the DeTeCt3.1 software tool designed to analyze amateur video observations of the planets Jupiter and Saturn to find short flashes of light caused by impacts of small size objects. Up to 5 events of this kind have been detected in the past without the use of software tools. However a software tool freely available to the community of amateur astronomers can maximize the chances of finding more of these collisions in current and old data archived by the observers. DeTeCt 3.1. runs on Windows with an easy to use graphic interface. It incorporates several improvements over the previous version of the software making it easier to use, more universal with respect to image formats, and more efficient. The software is available publicly at http://pvol2.ehu.eus/psws. The webpage also contains documentation about the software and how to use it and the source code also documented together with scientific information about these impacts for the general public.

2.7 SOLAR WINDSOCKS

The solar wind speed calculator service – Solar Windsocks - also has operational IDL code under Windows. It takes images obtained by amateurs and professionals and allows them to estimate the solar wind speed at the comet. However, we have found when testing the Solar Windsocks code that its portability to other systems is limited. We are building a web interface so that users can run the service via the web rather than running it locally, and this will also allow us to store results locally in a database (with the users' express permission). Full instructions on the preparation of images for analysis are provided on the service's website for when the online service will be available. We estimate that the online service will be available by the end of February 2018. The cometary tails service provided by UCL-MSSL may be accessed via the following website:

https://www.ucl.ac.uk/mssl/planetary-science/cometanalysis

2.8 TRANSPLANET

CNRS has developed the TRANSPLANET service for quantitative modelling of the high-latitude ionosphere of the Earth, Mars, Venus, and Jupiter. The online version for runs on request is available http://transplanet.irap.omp.eu

Achievements during the software development phase:

The service is fully operational. All software development can be accessible at https://gitlab.irap.omp.eu/CDPP/TRANSPLANET and will be made available at http://planetaryspaceweather-europlanet.irap.omp.eu/

2.9 RADMAREE

CNRS, ABER and DLR have developed the RADMAREE service for modelling of the radiation environment at the surface of Mars. The online version for runs on request is available http://radmaree.irap.omp.eu

Achievements during the software development phase:

The service is fully operational. All software development can be accessible at https://gitlab.irap.omp.eu/CDPP/RADMAREE and will be made available at http://planetaryspaceweather-europlanet.irap.omp.eu/

2.10 MAGNETODISC

CNRS and UCL have developed the MAGNETODISC service for modelling of the magnetic field configuration at Jupiter and Saturn. The online version for runs on request is available http://magnetodisc.irap.omp.eu

Achievements during the software development phase:

The service is fully operational. All software development can be accessible at https://gitlab.irap.omp.eu/CDPP/MAGNETODISC and will be made available at http://planetaryspaceweather-europlanet.irap.omp.eu/

2.11 Jupiter's thermosphere

UCL and CNRS are currently developing the Jupiter's thermosphere model that will be related to the Heliopropa service. It will link simulation outputs from the Jupiter's thermosphere model developed by UCL to predicted solar wind dynamic pressure values.

2.12 ALERTS-PSWS

An Alert service associated with solar wind prediction made using the CDPP Heliopropa service (http://heliopropa.irap.omp.eu), detection of meteor shower, lunar flash and cometary tail crossing, or meteor showers is currently developed by CNRS, OBSPARIS.

This Alert service, is based on **VOEvent**, an international standard proposed by the IVOA and widely used by the astronomy community. The VOEvent standard provides a means of describing transient celestial events in a machine-readable format. VOEvent is associated with VTP, the VOEvent Transfer Protocol that defines the system by which VOEvents may be disseminated to the community. VTP is managed with Comet, a freely available and open source software.

The Alert service developed by CNRS is operational at http://alerts-psws.irap.omp.eu/. All related software development will be accessible at https://gitlab.irap.omp.eu/CDPP/ALERTS and will be made available at http://planetaryspaceweather-europlanet.irap.omp.eu/