EPSC2017

MG2 abstracts

EPSC Abstracts
Vol. 11, EPSC2017-59, 2017
European Planetary Science Congress 2017

An electron transport code independent of the planetary thermosphere

J. Lilensten
IPAG (CNRS-UGA), Grenoble, France (jean.lilensten@univ-grenoble-alpes.fr)

Abstract

Transsolo is a code that describes the transport of the electrons from solar origin of from photoionisation in the upper atmosphere. Up to now, it has been adapted to the Earth, Venus, Jupiter, Uranus, Mars and Titan. However, these adaptations resulted in separate codes and improvements of one did not automatically follow in the others. In the frame of Europlanet, we re-wrote this code in a user-friendly manner to make it independent of the planet, so that it is easy to make measurements in many circumstances.

1. Introduction

Most of the observations of planetary upper atmospheres are their emissions. Some in-situ measurements also provide ion or electron densities, temperatures . . . To calculate these parameters requests to calculate the excitation, ionization and dissociation rates of the different species. In this aim, it is necessary to solve a Boltzmann kinetic transport equation for the electrons (i.e. [4] and references herein). These electrons have different origins: the can be precipitated from the solar wind (eventually after a journey within the magnetosphere) along the magnetic field lines. They can be due to the photoionisation by the solar energetic flux (EUV/XUV). They can also be secondary electrons due to the impact of the previous primary ones with the thermosphere. The Boltzmann equation accounts for all the sources and describes how a precipitated electron flux degrades its energy by collisions with the atmospheric neutral species. The main inputs are the electron impact cross sections, the neutral atmosphere density and temperature, the EUV solar flux, and the spectrum of the precipitated flux. The unknown of the Boltzmann equation is the electron stationary flux $[cm^{-2}eV^{-1}sr^{-1}s^{-1}]$ at all altitudes, energies and pitch angle. From this flux, different parameters can be deduced. The upward flux escaping the atmosphere is simply the upward stationary flux at the upper altitude. The different ions and excited states productions, and the emission rates are direct by-products of the equation.
The code solving this equation has been carried to different planets, such as the Earth [5], Titan [3] , Venus [2], Mars ([1] where it was used to asses the discovery of the Mars aurorae, and in [6] to predict the presence of intense blue auroras at Mars. In , [4], it allowed to model the Mars atmospheric escape). This series of codes written in FORTRAN is called "the Trans* family".
This series of applications resulted in different codes that evolve independently. An improvement on one of them is not automatically carried to the others. However, Europlanet aims at building new tools to make comparative planetology easier. In this aim, we started building a new version of the code that is independent of the planet and with a user friendly interface.

2. Description

The physics has been described in different articles and will not be rewritten here (see for example [4]). The code starts with the making of two main files. NEUTRAL contains all the parameters describing the neutral atmosphere in which one will make the transport calculation. ELEC contains the parameters describing the electron precipitation characteristics and the ambient electron parameters, density and temperature. In particular, NEUTRAL indicates to the other codes which species have to be considered. These two files can be constructed by hand or using a pre-code called Stationo. The next step is to compute the photoelectron production. The previous versions of the code used the solar fluxes proposed by [9] or alternately the models from [7] or [8] (ref). These models had the great disadvantage of a truly bad discretization of the spectrum (37 or 39 lines). The new code uses the solar flux proposed by Woods et al., 2009 for a minimum solar activity (F10.7 = 68). For other activity levels, we use the same linear interpolation than between the min and max solar spectra proposed by [9]. The exact parameters will be published in a subsequent refereed

article.
The cross section files have been fully re-worked to allow the computation of any excited neutral or ionized state production (including doubly charged ions) of any gaseous species amongst $N_2, O_2, O, H, He, CH_4, H_2O, CO_2, CO$. Any other specie can be very easily added.
The next step is to compute the differential cross sections for the electron impact with the neutral gas. These electrons are either precipitated or photo produced. Here again, the code has been rewritten so that the code makes the computation only on the species indicated in the file NEUTRAL and on any excited neutral or ionized state.
Finally, the transport code itself solves the excitation, dissociation, ions and electron productions. It reads the results of the two preceding codes and solves the Boltzmann transport equation independently of the species.
This organization obliged us to add new modules to compute the emissions of the considered species independently. This is made through a new series of subroutine, one per species that gather all the codes developed for all the different planets studied before. The full new module is called Planetary-emissions.

3. Next steps

This is an ongoing work. In the case of the Earth, the magnetic mirroring makes it so that the electron transport code is sufficient to compute most of the emissions. This is hardly the case in many other configurations. A proton transport code has been developed but still need to be rewritten so that it too becomes independent of the planet. Only then will we be able to address most of the planetary configurations. The resulting code already results in several tens of thousands of Fortran lines. In order to make it useable for the Planetary research community, we need to work on a user friendly interface. These are the two next steps

Acknowledgements

We thank the European contract EUROPLANET Horizon 2020 research and innovation programme under Grant Agreement No. 654208, Task 4, package 7: VA1-PSWD (Planetary Space Weather and Diary)

References

[1] Bertaux, J.L., Leblanc, F., Witasse, O., Quemerais, E., Lilensten, J., Stern, S. A., Sandel, B., and Korablev, O., Discovery of Aurora on Mars, Nature, 435, p 790-794, 2005, doi 10.1038

[2] Gronoff, G., Lilensten, J., Simon, C., M. Barthelémy, and Leblanc, F., Modelling the Venusian airglow, Astronomy and Astrophysics, vol. 482, 1015 - 1029, 2008

[3] Lilensten, J., Witasse, O., Simon, C., Soldi-Lose, H., Dutuit, O., Thissen O. and Alcaraz, C., Prediction of a N_2^{++} layer in the upper atmosphere of Titan, Geoph. Res. Letters, L3203, 32, 2005

[4] Lilensten, J., Simon Wedlund, C., Barthelémy, M., et al.: Dications and thermal ions in planetary atmospheric escape, Icarus, Vol. 222, pp 169, 2013

[5] Lilensten, J., Bommier, V., Barthelémy, M., Bernard, D., Lamy, H., Moen, J., Johnsen, M. G., Løvhaug, U. P.and Pitout, F., The thermospheric auroral red line polarisation: comparison between theory and observations , J. Space Weather Space Clim., 5, A26, DOI: 10.1051/swsc/2015027, 2015

[6] Lilensten, J., Bernard, D., Barthelémy, M., Gronoff, G., Simon Wedlund, C., and Opitz, A., Prediction of blue, red and green aurorae at Mars, Planetary and Space Science, 2015

[7] Richards, P. G.; Fennelly, J. A.; Torr, D. G., EUVAC: a solar EUV flux model for aeronomic calculations, Journal of Geophysical Research (ISSN 0148-0227), vol 99, no. A5, p. 8981-8992

[8] Tobiska, W. Kent; Bouwer, S. Dave, New developments in SOLAR2000 for space research and operations, Advances in Space Research, Volume 37, Issue 2, p. 347-358

[9] Torr, M. R.; Torr, D. G., Ionization frequencies for solar cycle 21 - Revised, Journal of Geophysical Research (ISSN 0148-0227), vol. 90, July 1, 1985, p. 6675-6678

EPSC Abstracts
Vol. 11, EPSC2017-178-2, 2017
European Planetary Science Congress 2017

Testing space weather connections in the solar system

B. Grison (1), J. Souček (1), V. Krupař (1), D. Píša (1), O. Santolík (1), U. Taubenschuss (1) and F. Němec (2)
(1) Institute of Atmospheric Physics CAS, Prague, Czech Republic , (2) Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic. (grison@ufa.cas.cz / Fax: +420 272762528)

Abstract

This study aims at testing and validating tools for prediction of the impact of solar events in the vicinity of inner and outer solar system planets using in-situ spacecraft data (primarily MESSENGER, STEREO and ACE, but also VEX and Cassini), remote Jovian observations (Hubble telescope, Nançay decametric array), existing catalogues (HELCATS and [2]) and the tested propagating models (the ICME radial propagation tool of the CDPP and the 1-D MHD code propagation model presented in [1]). We achieved our results using AMDA and VESPA web tools.
We first present the results concerning ICME propagation between various bodies of the inner solar system, starting from Mercury. Then we investigate the prediction facilities to two outer planets, Saturn and Jupiter.

1. ICME propagation: testing the CDPP propagation tool

The CDPP propagation tool is publicly available online (URL: http://propagationtool.cdpp.eu). Running the propagation tool for each of the 61 suitable events in the catalogue of ICME observations at Mercury by the NASA spacecraft MESSENGER [2], we could identify the ICMEs that probably hit another object of the solar system. The objects are spacecraft orbiting around planets (MEX at Mars, VEX at Venus) or at 1 AU (ACE, Stereo A and B). The necessary inputs for the propagation tool (in addition to the start point, MESSENGER in the present case) are: radial velocity (default value 500 km/s), wideness of the CME at the Sun (default value 45 deg) and the end point (VEX, MEX, ACE, Stereo A and B). The catalogue entries can be summarized as following:

- Time coverage: from 2011-05-19 to 2014-09-02
- Number of Records: 143
- Number of Pairs: 45 (Stereo-A:11, Stereo-B:6, Earth:4, Venus:16, Mars:8)

Detailed comparisons between observations and propagation tool predictions lead us to the following results. The propagation tool is accurate for impact prediction (84%) with a time accuracy of about 10 hours. We also propose to slightly modify the default parameters of the propagation tool by increasing the default radial propagating velocity by 50 km/s (550 instead of 500 km/s). We also note that the ICME propagation velocity decreases with increasing distance from the Sun (see Table 1).

Table 1: Mean ICME propagating velocity and standard deviations, between MESSENGER and target (observations).

Target	V_{prop} km/s	σ km/s
ALL	603	162
VENUS	639	169
1 AU	584	160

In addition to corresponding statistics, we also present the case study of an ICME that is observed at Mercury by MESSENGER, then at Venus by VEX and at L1 by ACE.

We finally simulate the evolution of the Dst index with ICME observations at ACE, Stereo A and Stereo B locations. This allows predicting not only ICME impacts, but also the corresponding potential geomagnetic effects.

2. Event predictions at the outer planets

2.1. Saturn

The 1-D MHD numerical code ([1]) permits to propagate interplanetary magnetic field (IMF) and solar wind properties inside the heliosphere. Inputs are in situ observations of these parameters (solar wind density, velocity, dynamic pressure, IMF tangential component). This model has been previously tested at

Jupiter with comparisons to Galileo data [1]. The most important observational constraint is the angle between the target, the observation point and the sun (Θ, Galileo-Earth-Sun angle in [1], Cassini-Stereo-Sun angle in our study). The lower Θ is, the better the predictions are.

We collect measurements of the solar wind velocity (Cassini/MIMI instrument), electron plasma density (Cassini/RPWS) and three components of the magnetic field (Cassini/MAG). The solar wind velocity and density measurements time intervals overlap is very short and occur for large Θ. Thus the plasma dynamic pressure cannot be derived from measurements. The time coverage of the plasma density is irregular while the solar wind velocity measurements occur mainly during the last part of Cassini's cruise to Saturn, so still far from the planet. We thus present only short time intervals of comparisons between plasma density observations and predictions.
Cassini/MAG data provide a continuous coverage of the IMF tangential component (B_t). B_t is also predicted by the model [1]. Figure 1 presents a 5 days window of both predicted and observed values of B_t. We present in our study a comparison of the B_t prediction accuracy of the model in function of Θ.

We emphasize here that the model predictions and the Cassini/MAG data used for this study are publicly available on the AMDA tool of the CDPP.

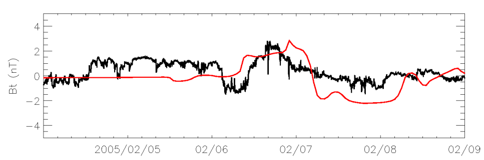

Figure 1: Example of comparison between observations (black line, Cassini/MAG measurements) and 1-D MHD simulations (red line) of the tangential component of the magnetic field.

2.2. Jupiter

There has been a large gap in in-situ data at Jupiter since the end of the Galileo mission and the recent arrival of JUNO. We thus propose to include remote observations for testing MHD propagation model [1]. Applying the propagation tool to all ICME events observed by Stereo-A and Stereo-B in the HELCATS catalogue, there are potentially 149 ICMEs that impacted the Jovian magnetosphere during the 2007-2014 period (see Table 2).

The Hubble images of Jovian aurorae and the radio emissions from the auroral regions observed at the Nançay radiostation are available through the VESPA web service. The last part of our study concerns a potential correlation of the 149 dates of predicted ICME impacts with an intensification of the remotely observed auroral activity.

Table 2: Number of predicted Jupiter-ICME encounters based on the HELCATS catalogue and the CDPP propagation tool.

Observatory	Total events	Impact
Stereo-A	550	73
Stereo-B	512	76

Acknowledgements

This work has been carried out with the support from the Europlanet 2020 research infrastructure. Europlanet 2020 RI has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 654208. We acknowledge the CDPP for their support. We thank G. B. Hospodarsky (University of Iowa) for the Cassini/RPWS density estimates and the team of M. E. Hill (JHU/APL) for the list of the averaged solar wind speeds obtained by the Cassini/MIMI instrument.

References

[1] Tao, C., R. Kataoka, H. Fukunishi, Y. Takahashi, and T. Yokoyama (2005), Magnetic field variations in the Jovian magnetotail induced by solar wind dynamic pressure enhancements, J. Geophys. Res., 110, A11208, doi:10.1029/2004JA010959.

[2] Winslow, R. M., N. Lugaz, L. C. Philpott, N. A. Schwadron, C. J. Farrugia, B. J. Anderson, and C. W. Smith (2015), Interplanetary coronal mass ejections from MESSENGER orbital observations at Mercury, J. Geophys. Res. Space Physics, 120, 6101–6118, doi:10.1002/2015JA021200.

EPSC Abstracts
Vol. 11, EPSC2017-190-1, 2017
European Planetary Science Congress 2017

A Transplanet model of magnetosphere-ionosphere coupling at Earth, Mars, Jupiter, (Saturn and Venus)

M. Indurain (1), A. Goutenoir (1), M. Bouchemit (1), M. Gangloff (1), N. Jourdane (1), P.-L. Blelly (1), A. Marchaudon (1), N. André (1), and V. Génot (1)

(1) IRAP, CNRS-UPS, 9 avenue du colonel Roche, 31028 Toulouse, France (nicolas.andre@irap.omp.eu / Fax: +33-5-61-55-83-70)

Abstract

Under Horizon 2020, the Europlanet 2020 Research Infrastructure (EPN2020-RI, http://www.europlanet-2020-ri.eu) includes an entirely new Virtual Access Service, "Planetary Space Weather Services" (PSWS) that extends 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.
PSWS will provide at the end of 2017 12 services distributed over 4 different service domains – 1) Prediction, 2) Detection, 3) Modelling, 4) Alerts. These services include in particular a Transplanet model of magnetosphere-ionosphere coupling at Earth, Mars, and Jupiter that enables the users to make runs on request of the model, archive and/or connect the results of their simulation runs to various tools developed in the Virtual Observatory. The present paper will first describe the Transplanet model (at Earth, IPIM, Marchaudon & Blelly, 2015), and then present the system architecture developed by the Space Plasma Physics Data Center (http://www.cdpp.eu) in France in order to make the service operational (http://transplanet.irap.omp.eu).
Europlanet 2020 RI has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 654208.

References

Marchaudon, A., and P.-L. Blelly, A new 16-moment interhemispheric model of the ionosphere : IPIM, J. Geophys. Res., 120, doi:10.1002/2015JA021193, 2015.

EPSC Abstracts
Vol. 11, EPSC2017-191-1, 2017
European Planetary Science Congress 2017

An heliospheric propagation model for solar wind prediction at planets

A. Goutenoir (1), M. Bouchemit (1), E. Budnik (2), C. Tao (3), N. André (1), and V. Génot (1)

(1) IRAP, CNRS-UPS, 9 avenue du colonel Roche, 31028 Toulouse, France; (2) Noveltis, Ramonville Saint Agne, France; (3) National Institute of Information and Communications Technology, Tokyo, Japan (nicolas.andre@irap.omp.eu / Fax: +33-5-61-55-83-70)

Abstract

Under Horizon 2020, the Europlanet 2020 Research Infrastructure (EPN2020-RI, http://www.europlanet-2020-ri.eu) includes an entirely new Virtual Access Service, "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.

PSWS will provide at the end of 2017 12 services distributed over 4 different service domains – 1) Prediction, 2) Detection, 3) Modelling, 4) Alerts. **These services include in particular an heliospheric propagator for solar wind prediction at planets and probes that is based on a 1D magnetohydrodynamic propagation model originally developed by Tao et al. (2005)**. The service gives access to various propagated parameters including solar wind density, temperature, velocity, dynamic pressure, and tangential magnetic field. The present paper will first describe the solar wind propagation model, and then present the system architecture developed by the Space Plasma Physics Data Center (http://www.cdpp.eu) in France in order to make the service operational (http://heliopropa.irap.omp.eu).

Europlanet 2020 RI has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208.

References

Tao, C. et al., Magnetic field variations in the Jovian magnetotail induced by solar wind dynamic, Journal of Geophysical Research: Space Physics, 110, A11208, 10.1029/2004JA010959, 2005

EPSC Abstracts
Vol. 11, EPSC2017-195, 2017
European Planetary Science Congress 2017

Extensions of the CDPP/Propagation tool to the case of comets, giant planet auroral emissions, and catalogues of solar wind disturbances

N. André (1), V. Génot (1), A. Rouillard (1), M. Bouchemit (1), S. Caussarieu (2), L. Beigbeder (2), J.-P. Toniutti (2), D. Popescu (2)

(1) IRAP, CNRS-UPS, 9 avenue du colonel Roche, 31028 Toulouse, France; (2) GFI Informatique, Toulouse, France (nicolas.andre@irap.omp.eu / Fax: +33-5-61-55-83-70)

Abstract

Under Horizon 2020, the Europlanet 2020 Research Infrastructure (EPN2020-RI, http://www.europlanet-2020-ri.eu) includes an entirely new Virtual Access Service, "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.
PSWS will provide at the end of 2017 12 services distributed over 4 different service domains – 1) Prediction, 2) Detection, 3) Modelling, 4) Alerts. *GFI Informatique* has extended the Propagation Tool available at CDPP (http://propagationtool.cdpp.eu) to the case of comets, giant planet auroral emissions, and catalogues of solar wind disturbances. The service provides new plug-ins including selection of comets as targets, visualization of their trajectories, projection onto solar maps, projection onto J-maps (maps of solar wind outflows obtained from the Heliospheric Imagers onboard STEREO spacecraft, in which multiple elongation profiles along a constant position angle are stacked in time, building an image in which radially propagating transients form curved tracks in the J-map; it will enable the user to use catalogue of solar wind disturbances in order to identify those that have impacted the planetary environments.
Europlanet 2020 RI has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208.

EPSC Abstracts
Vol. 11, EPSC2017-196, 2017
European Planetary Science Congress 2017

Planetary SpaceWeather Services for the Europlanet 2020 Research Infrastructure

N. André (1), M. Grande (2), and the PSWS Team (3)

(1) IRAP, CNRS-UPS, 9 avenue du colonel Roche, 31028 Toulouse, France; (2) Aberysthwyth University, Aberysthwyth, United Kingdom; (3) http://planetaryspaceweather-europlanet.irap.omp.eu (nicolas.andre@irap.omp.eu / Fax: +33-5-61-55-83-70)

Abstract

Under Horizon 2020, the Europlanet 2020 Research Infrastructure (EPN2020-RI, http://www.europlanet-2020-ri.eu) includes an entirely new Virtual Access Service, "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.

PSWS will provide at the end of 2017 12 services distributed over 4 different service domains – 1) Prediction, 2) Detection, 3) Modelling, 4) Alerts. These services include **1.1) A 1D MHD solar wind prediction tool**, **1.2) Extensions of a Propagation Tool**, **1.3) A meteor showers prediction tool, 1.4) A cometary tail crossing prediction tool, 2.1) Detection of lunar impacts, 2.2) Detection of giant planet fireballs, 2.3) Detection of cometary tail events, 3.1) A Transplanet model of magnetosphere-ionosphere coupling, 3.2) A model of the Mars radiation environment, 3.3.) A model of giant planet magnetodisc, 3.4) A model of Jupiter's thermosphere, 4) A VO-event based alert system.** We will provide an overview of the project as an introduction to the session where all of them will be detailed.

The proposed Planetary Space Weather Services will be accessible to the research community, amateur astronomers as well as to industrial partners planning for space missions dedicated in particular to the following key planetary environments: Mars, in support of ESA's ExoMars missions; comets, building on the success of the ESA Rosetta mission; and outer planets, in preparation for the ESA JUpiter ICy moon Explorer (JUICE). These services will also be augmented by the future Solar Orbiter and BepiColombo observations. This new facility will not only have an impact on planetary space missions but will also allow the hardness of spacecraft and their components to be evaluated under variety of known conditions, particularly radiation conditions, extending their knownflight-worthiness for terrestrial applications.

Europlanet 2020 RI has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208.

EPSC Abstracts
Vol. 11, EPSC2017-263, 2017
European Planetary Science Congress 2017

Implementation of a Space Weather VOEvent service at IRAP in the frame of Europlanet H2020 PSWS

M. Gangloff(1), N. André(1), V. Génot(1) , Baptiste Cecconi(2), Pierre Le Sidaner(2), Myriam Bouchemit(1), Elena Budnik(1),Nathanaël Jourdane(1)

(1) IRAP, CNRS Université Paul Sabatier Toulouse, France

(2) Observatoire de Paris, France

(Michel.Gangloff@irap.omp.eu / Fax: +33-561-556701)

Abstract

Under Horizon 2020, the Europlanet Research Infrastructure includes PSWS (Planetary Space Weather Services), a set of new services that extend the concepts of space weather and space situation awareness to other planets of our solar system. One of these services is an Alert service associated in particular with an heliospheric propagator tool for solar wind predictions at planets, a meteor shower prediction tool, and a cometary tail crossing prediction tool. 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

This presentation will focus on the enhancements of the VOEvent standard necessary to take into account the needs of the Solar System community and Comet, a freely available and open source implementation of VTP used by PSWS for its Alert service. Comet is implemented by several partners of PSWS, including IRAP and Observatoire de Paris.

A use case will be presented for the heliospheric propagator tool based on extreme solar wind pressure pulses predicted at planets and probes from a 1D MHD model and real time observations of solar wind parameters.

Acknowledgements

Europlanet 2020 RI has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208.

EPSC Abstracts
Vol. 11, EPSC2017-504, 2017
European Planetary Science Congress 2017

Sunspot as the source of slow solar wind

B. Ryabov
Ventspils International Radio Astronomy Centre, Ventspils, Latvia (ryabov@latnet.lv / Fax: +371-63-628303)

Abstract

The coronal and microwave observations are analysed along with the Potential Field Source Surface (PFSS) model simulations of the coronal magnetic fields to verify that the isolated sunspot in the solar active region NOAA 8535 is the source of slow solar wind.

1. Introduction

The local plasma outflows at the periphery of some bipolar active regions (ARs) have proven to be the origin of slow solar wind [1]. Such outflows persist for days over the confined areas of one magnetic polarity with reduced coronal emission. The outflows occur along the quasi-separatrix layers (QSLs), where the magnetic connectivity is high.

This work presents the analyses of the reduced emission and the magnetic structure of the sunspot NOAA 8535. The aim is to test the analogy between the plasma outflows in the bipolar ARs and in this isolated sunspot.

2. Reduced emission

Two regions of the reduced soft X-ray emission near the sunspot overlap two open-field regions simulated with the PFSS model [2]. These depressed regions correspond to the location of relatively weak absorption in the He 10830Å line. This correspondence confirms the comparison made in [3].

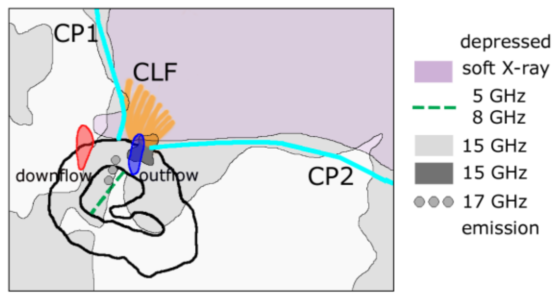

Figure 1: The schematic picture of the reduced emission and two coronal partings near the sunspot (the black thick contours are of the sunspot umbra and penumbra).

The maximum depression at 15 GHz in the north-west region of the sunspot penumbra corresponds to the location of the Doppler blue shifts in the EUV line OV 629 Å (Doppler velocities up to 52 km s^{-1} [4]).

3. Boundaries between open and closed field lines

[1] The areas, which underlie the depressed regions, are the unipolar areas with the footprints of coronal loops connected to the different regions of opposite magnetic polarity (so called coronal partings [5]). To reveal the preferential location for magnetic reconnection - the QSL [6] - the lines of the squashing factor Q > 10^8 are drawn. The northern QSL marks the western boundary between the open and closed field lines. Another extended QSL traces the south-west coronal parting and crosses the region of the Doppler blue shifts observed in the EUV line.

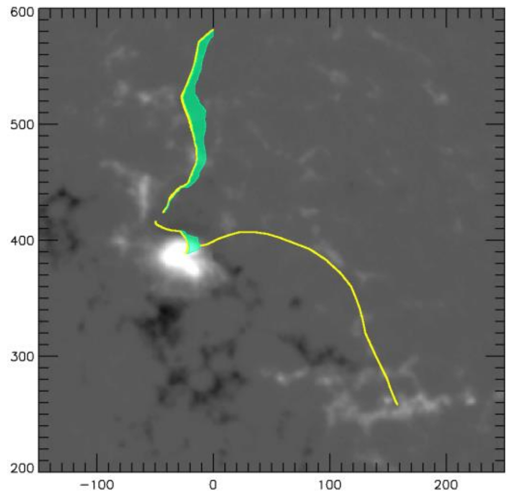

Figure 2: Calculated QSLs (yellow lines) and open-field regions (azure colour) overlaid on the SOHO MDI map of the Br magnetic component.

4. Summary and conclusions

The observational and topological features of the isolated sunspot NOAA 8535 are similar to those of the bipolar ARs with a coronal parting. The essential difference is that the sunspot magnetic fields in the region of the plasma outflow are stronger than the magnetic fields at the outer edges of the bipolar ARs by two orders of magnitude.

The simulated open field lines, which connect the sunspot with the heliospheric current sheet, give evidence of the long duration connectivity. Two-step mapping and the ballistic model [7] led to the solar wind speed of 370 – 400 km s^{-1}.

One might conclude that the isolated sunspot NOAA 8535 is associated with the source of slow solar wind. The maximum depression of 15 GHz emission in ordinary electromagnetic mode can indicate the location of the plasma outflow [2].

References

[1] Brooks, D.H.: Full-Sun observations for identifying the source of the slow solar wind, Nature Communications, 6:5947, 2015.

[2] Ryabov, B.I. and Shibasaki, K.: Depressed emission between magnetic arcades near a sunspot, Baltic Astronomy, Vol. 25, 225, 2016.

[3] Ryabov, B.I., Gary, D.E., Peterova, N.G., Shibasaki, K., and Topchilo, N.A.: Reduced coronal emission above large isolated sunspots, Solar Physics, Vol. 290, 21, 2015.

[4] Brosius, J.W. and Landi, E.: Properties of a sunspot plume observed with the Coronal Diagnostic Spectrometer aboard the Solar and Heliospheric Observatory, ApJ, Vol. 632, 1196, 2005.

[5] Nikulin, I.F. and Dumin, Y.V.: Coronal partings, Advances in Space Research, Vol. 57, 904, 2016.

[6] Titov, V.S.: Generalized squashing factors for covariant description of magnetic connectivity in the solar corona, ApJ, Vol. 660, 863, 2007.

[7] Neugebauer, M., Liewer, P.C., Smith, E.J., Skoug, R.M., and Zurbuchen, T.H.: Sources of the solar wind at solar activity maximum, Journal of Geophysical Research, Vol. 107, A12, 1488, 2002.

EPSC Abstracts
Vol. 11, EPSC2017-570, 2017
European Planetary Science Congress 2017

Interactive Tools to Access the HELCATS Catalogues

Alexis Rouillard (1,2), Illya Plotnikov (1,2), Rui Pinto (1,2), Vincent Génot (1,2), Myriam Bouchemit (1,2), and Jackie Davies (3)
(1) Institute of Research in Astrophysics and Planetology, Toulouse, France (arouillard@irap.omp.eu), (2) Université Paul Sabatier, Toulouse III, Toulouse, (3) RAL SPACE, Science Technology Facilities Council, Chilton, UK

The propagation tool is a web-based interface written in java that allows users to propagate Coronal Mass Ejections (CMEs), Corotating Interaction Regions (CIRs) and Solar Energetic Particles (SEPs) in the inner heliosphere. The tool displays unique datasets and catalogues through a 2-D visualisation of the trajectories of these heliospheric structures in relation to the orbital position of probes/planets and the pointing direction and extent of different imaging instruments. Summary plots of in-situ data or images of the solar corona and planetary aurorae stored at the CDPP, MEDOC and APIS databases, respectively, can be used to verify the presence of heliospheric structures at the estimated launch or impact times. A great novelty of the tool is the immediate visualisation of J-maps and the possibility to superpose on these maps the HELCATS CME and CIR catalogues.

EPSC Abstracts
Vol. 11, EPSC2017-612-2, 2017
European Planetary Science Congress 2017

Estimating the solar wind pressure at comet 67P from Rosetta magnetic field measurements

Z. Nemeth (1), **M. Dósa** (1), C. Goetz (2), H. Madanian, (3) A. Opitz (1), I. Richter (2), K. Szego(1) and A. Timar (1)
(1) Wigner Research Centre for Physics, Hungary, (2) TU Braunschweig, Germany, (3) University of Kansas, USA
(nemeth.zoltan@wigner.mta.hu)

Abstract

The solar wind pressure is an important parameter of planetary space weather, which plays a crucial role in the interaction of the solar wind with the planetary plasma environment. Unfortunately, it is not always possible to measure its value at every locations where it would be useful or needed. Spacecraft observing the internal dynamics of a planetary magnetosphere, for example, would benefit greatly from solar wind pressure data, but as the solar wind does not penetrate to their locations, direct measurements are impossible. It is well known that the maximum of the magnetic field in the pile-up region of a magnetosphere is proportional to the square root of the solar wind pressure. Recent investigation of Rosetta data revealed that the maximum of the magnetic field in the pile-up region can be approximated by magnetic field measurements performed in the inner regions of the cometary magnetosphere close to the boundary of the diamagnetic cavity. This relationship holds for several months spanning from June 2015 to January 2016. Here we investigate the possibility to use this relationship to determine a solar wind pressure proxy for this time interval using magnetic field data measured by the Rosetta Magnetometer. This pressure proxy would be useful not only for other Rosetta related studies, but could also serve as a new independent input database for space weather propagation to other locations in the Solar System.

1. Introduction

Solar wind pressure (together with a few internal properties) determines the shape and size of a magnetosphere. It influences most of the magnetospheric boundaries and currents, and many other magnetospheric phenomena. Thus most magnetospheric investigations would benefit from knowing the solar wind pressure. Spacecraft deep inside a magnetosphere or spacecraft without proper instruments however cannot measure it directly. Solar wind monitoring spacecraft are sometimes millions of kilometers away, in which case researchers have to rely on data propagated to their region of interest by solar wind propagation tools. In this paper we describe a method, which can be used to derive an in situ solar wind pressure proxy based on Rosetta magnetic field measurements for the location of comet 67P, for such times when Rosetta was deep inside the cometary magnetosphere.

2. Method

It is well-known that the magnetic pressure of the compressed magnetic field in a cometary induced magnetosphere balances the pressure of the incoming solar wind. Thus the maximum of the magnetic field magnitude in the pile-up region (B_0) closely follows the square root of the solar wind pressure. When the solar wind pressure increases for example, the induced magnetosphere is compressed until the growing magnetic pressure of the compressed field is once again able to withstand the pressure of the solar wind.

Thus $B_0^2/2\mu_0$ would be a good proxy for the solar wind pressure, provided that one can actually measure its value. However, to measure this maximum a spacecraft should always be there, where the field is most compressed, which is a very specific and swiftly changing spatial position inside the magnetosphere. Instead of such direct measurements, we have to rely on some known relationships, which connect B_0 with $B(r)$, the field amplitude actually measured at the position (r) of the spacecraft. Since the magnetosphere is a very complex and dynamic environment, it is not always possible to find such a relationship, especially a relationship accurate enough to be useful as a basis of a pressure proxy.

Recent investigations [5] revealed that there is a region deep inside the cometary magnetosphere, where a single process seem to dominate the dynamics of the field magnitude. This raises the hope that we can determine a $B_0(r,B(r))$ relationship there, accurate enough for our purpose. This region is the vicinity of the diamagnetic cavity [2,3,4]. Here the neutral drag model [1] dominates the physical processes, and the model is able to predict not only the size (r_{cs}) of the cavity, but the field magnitude as well, as a function of B_0 and r. This $B(B_0,r)$ relationship can be inverted, to get the desired B_0 values from the measurements. The resulting magnetic field based pressure proxy is far better in predicting the size of the diamagnetic cavity, for example, than the pressure values propagated from other spacecraft by solar wind propagation tools. We test the accuracy of this pressure proxy on other phenomena observed in the plasma environment of comet 67P, which are also expected to be sensitive to the variation of the solar wind pressure.

Figure 1 shows the magnetic field based pressure proxy for the time interval between June 2015 and January 2016, in which Rosetta was close enough to the diamagnetic cavity that one can use the solution of the neutral drag model to estimate B_0. The results are compared to the predictions of the mSWiM solar wind propagation tool [6]. The two curves are very similar, they agree as well as the accuracy of the Earth based prediction allows.

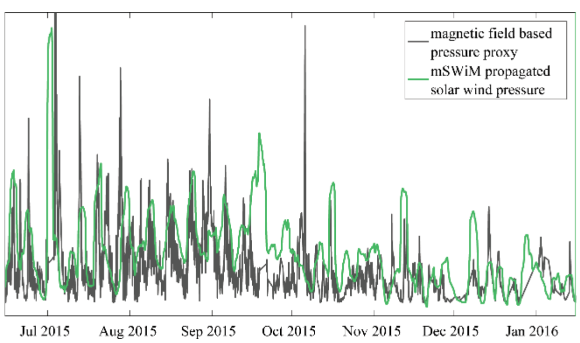

Figure 1: Pressure proxy derived from magnetic field measurements of the Rosetta Magnetometer (black); solar wind pressure propagated from Earth based spacecraft by the mSWiM propagation tool (green).

3. Summary and Conclusions

Magnetic field measurements performed near the diamagnetic cavity of comet 67P/Churyumov-Gerasimenko can be used to estimate the maximum of the magnetic field magnitude in the magnetic pile-up region, which in turn is a measure of the solar wind pressure acting on the outside of the cometary magnetosphere. Thus from the magnetic field measured deep inside the magnetosphere we can deduce the pressure of the solar wind around the comet. The pressure proxy derived by this method can be used in investigations of other solar wind pressure sensitive plasma phenomena of comet 67P. It also makes the Rosetta Magnetometer a solar wind pressure monitor, the data of which can be used as input for space weather predictions propagated to other locations in the Solar System.

Acknowledgements

Rosetta is an ESAmission with contributions from its member states and NASA. We thank the Rosetta Mission Team, SGS, and RMOC for their outstanding efforts in making this mission possible. The work of ZN was supported by the János Bolyai Research Scholarship of the Hungarian Academy of Sciences. The work on RPCMAG was financially supported by the German Ministerium für Wirtschaft und Energie and the Deutsches Zentrum für Luft- und Raumfahrt under contract 50QP 1401.We thank K.C. Hansen and B. Zieger for providing solar wind propagations from their Michigan SolarWind Model.

References

[1] Cravens T. E., 1986, in Battrick B., Rolfe E. J., Reinhard R., eds, ESA SP-250: ESLAB Symposium.

[2] Goetz C. et al., 2016, A&A, 588, A24.

[3] Goetz C. et al., 2016, MNRAS, 462, 459.

[4] Nemeth et al., 2016, MNRAS, 462, 415.

[5] Timar et al., 2017 submitted to MNRAS.

[6] Zieger, B. and K.C. Hansen 2008, J. Geophys. Res., DOI: 10.1029/2008JA013046.

EPSC Abstracts
Vol. 11, EPSC2017-631, 2017
European Planetary Science Congress 2017

Validity and reliability of space weather predictions at Venus, Mars and Comet 67P

A. Opitz (1), K. Szego (1), Z. Dalya (1), A. Timar (1), Z. Nemeth (1), M. Dosa (1), D. Vech (1,2) and N. Andre (3)
(1) Wigner RCP, Budapest, Hungary (opitz.andrea@wigner.mta.hu), (2) University of Michigan, USA, (3) IRAP, Toulouse, France

Abstract

Plasma processes at unmagnetized planets and comets strongly depend on the solar wind properties. Prediction of space weather conditions to these targets is necessary to interpret the observations inside such induced magnetospheres. In this paper we describe validation activities of planetary space weather services and define their reliability.

Introduction

The solar wind interaction with the ionosphere of unmagnetized planets and comets is highly important in defining their plasma environment. In order to study this interaction of the solar wind and the planetary plasma environment, ideally one would need measurements both in the solar wind and in the induced planetary magnetosphere the same time. When there is only one spacecraft around the planet or the comet, it cannot perform such simultaneous observations, thus the prediction of solar wind properties and solar events to the different planetary objects becomes important.

Space weather predictions

Space weather predictions to planets and comets are performed in different forms: remote or in-situ data as input, ballistic propagation method or MHD modeling to name a few. Background solar wind, coronal mass ejection (CME) and solar energetic particle predictions must be separated due to their different propagation characteristics.

The Planetary Space Weather Services (PSWS) in the scope of the EU H2020 Europlanet Research Infrastructure [1] aims to provide a comprehensive set of tools including an extended database in order to provide the planetary community easy access to these predictions. Before making them publicly available, extensive validation is performed. In this paper we describe the validation activites of the CDPP Propagation Tool and the CDPP AMDA database for their Venus, Mars and Comet 67P predictions, which is part of the PSWS project.

Validation of predictions

The solar wind predictions for Venus, Mars and Comet 67P can be validated by in-situ solar wind measurements onboard the planetary spacecraft Venus Express (VEX), Mars Express (MEX) and Rosetta while these are located in the undisturbed solar wind. We show how the prediction accuracy depends on the spatial separation of the solar and the planetary or cometary spacecraft.

The predicted arrival times of the interplanetary CME (ICME) signatures at our targets are also tested based on in-situ observations. Even if the planetary spacecraft performs measurements inside the induced magnetosphere during the ICME arrival, we can indirectly derive the timing and duration from its effects on the planetary plasma environment [2].

Reliability of predictions

The reliability of a given planetary space weather prediction depends on several factors: the quality and availability of the input solar wind data, the spatial separation of the observing spacecraft from the target, the limitations of the method with its assumptions, the current heliospheric space weather conditions and so forth. Based on these, we can define both theoretical and empirical reliability factors that can be added as a quality flag to the predicitions. For instance, the large spacecraft separation is a major issue during solar activity maximum, while the assumption of constant bulk velocity during radial propagation can be fine during quiet solar wind conditions without large gradients.

Acknowledgements

The authors acknowledge the entire PSWS (especially CDPP) team and the support from EU H2020 Europlanet-RI. We are grateful for data availability from VEX, MEX and several solar spacecraft. Additionally, we want to thank useful suggestions by our students: Vano L., Wirnhardt B., Tajkov Z., Becsy B., Hoffmann A., Novak M., and Zsoka S.

References

[1] Andre, N. et al.: Virtual Planetary Space Weather Services offered by the Europlanet H2020 Research Infrastructure, Planetary and Space Science, in press, 2017.

[2] Vech, D. et al.: Planetary space weather effects on the position of the bow shock and the ion composition boundary at Venus, J. Geophys. Res., vol. 120, p4613-4627, 2015.

EPSC Abstracts
Vol. 11, EPSC2017-635, 2017
European Planetary Science Congress 2017

Magnetic lasso: a new solar wind propagation method and its application concerning space weather at 67P/C-G

M.Dósa, A. Opitz, Z. Németh, K. Szegő
Wigner Research Centre for Physics, Budapest, Hungary (dosa.melinda@wigner.mta.hu)

Abstract

Concerning the increasing number of heliospheric space missions it is a key issue to foresee space weather conditions in the spacecraft's and the target object's neighborhood. Solar wind parameters are propagated to outer orbits by several ballistic and magnetohydrodynamic (MHD) methods. MHD models describe the underlying physical processes more realistic, but computations are time-demanding. Ballistic models are simple, computationally fast and need only input data. They work quite well closer to the Sun, where MHD effects have smaller amplitudes.

The ballistic model presented here is enhanced by adjusting for the target movement during the propagation time through the following method: First, a dataring is created around the Sun containing solar wind parameters for each Carrington longitude, based on ACE data. It is assumed that solar wind parameters from the same source are constant for one solar rotation.

The second step is the actual propagation where we are trying to find the magnetic field line connecting the target object with a certain longitude of the source surface at the Sun. The field line has to meet two criteria. First, there is a criteria for its shape: it has to meet the target object at the right place, second, it has to get to the right place at the right time. Both criteria depend on solar wind velocity. This search is carried out by a minimum variance analysis.

Once the proper magnetic field line is found, solar wind bulk velocity, density and magnetic field polarity is propagated assuming no change during travel time. The method was tested successfully during the Rosetta mission. While the spacecraft was investigating the close environment of the comet Churyumov-Gerasimenko it was necessary to know the properties of the ambient solar wind in order to evaluate data and account for the dynamic changes.

EPSC Abstracts
Vol. 11, EPSC2017-655, 2017
European Planetary Science Congress 2017

Modelling the radiation on the Martian surface

D. Matthiä (1), T. Berger (1)

(1) German Aerospace Center (DLR), Institute of Aerospace Medicine, Linder Höhe, 51147 Cologne, Germany (Daniel.Matthiae@dlr.de/ Fax: +49 2203 61970)

Abstract

Just as on Earth the radiation environment in the Martian atmosphere caused by cosmic radiation is most of the time dominated by galactic cosmic rays (GCR) and secondary particles created in interactions with constituents of the atmosphere. Due to the lack of magnetic shielding and a significantly lower atmospheric shielding, the radiation exposure on the Martian surface, however, is much higher than on Earth. The increased radiation level can be harmful to electronics and is of interest for the evaluation of the health risks of astronauts on future manned missions. A parameterized model calculating the radiation exposure from GCR on the Martian surface is developed within the "Planetary Space Weather Services" (PSWS) of the Europlanet 2020 Research Infrastructure (EPN2020-RI, http://www.europlanet-2020-ri.eu). The model is based on transport calculations of the primary GCR nuclei through the Martian atmosphere performed with GEANT4 and includes the backscattering of albedo particles from the regolith. Model results for the period between August 2012 and July 2016 are presented and compared to measurements of the Radiation Assessment Detector (RAD) onboard the Curiosity rover of the Mars Science Laboratory (MSL).

EPSC Abstracts
Vol. 11, EPSC2017-757-1, 2017
European Planetary Science Congress 2017

DeTeCt 3.0: A software tool to detect impacts of small objects in video observations of Jupiter obtained by amateur astronomers

J. Juaristi [jon.juraristic@ehu.eus] (1), M. Delcroix (2), **R. Hueso** (1) and A. Sánchez-Lavega (1)

(1) Dpto. Física Aplicada I, Escuela de Ingeniería de Bilbao, UPV/EHU, Bilbao, Spain, (2) Commission des Observations planétaires, Sociéte Astronomique de France, Paris, France.

Abstract

Impacts of small size objects (10-20 m in diameter) with Jupiter atmosphere result in luminous superbolides that can be observed from the Earth with small size telescopes. Impacts of this kind have been observed four times by amateur astronomers since July 2010. The probability of observing one of these events is very small. Amateur astronomers observe Jupiter using fast video cameras that record thousands of frames during a few minutes which combine into a single image that generally results in a high-resolution image. Flashes are brief, faint and often lost by image reconstruction software. We present major upgrades in a software tool DeTeCt initially developed by amateur astronomer Marc Delcroix and our current project to maximize the chances of detecting more of these impacts in Jupiter.

1. Introduction

The first fireball impact in Jupiter was observed by Anthony Wesley from Australia and Christopher Go from the Philippines in July of 2010 [1]. A second superbolide in Jupiter's atmosphere was observed from Japan in August of 2010 by three amateur astronomers (Masayuki Tachikawa, Kazuo Aoki and Masayuki Ichimaru) with telescope apertures in one case as small as 15 cm. A third fireball was observed in September of 2012 by Dan Petersen from Racine, Wisconsin visually observing Jupiter with a small telescope and resulting in an alert that reached to George Hall from Dallas, Texas who happened to have a video observation of the planet with the impact [2]. The last object that was detected to impact Jupiter was discovered by Gerrit Kernbauer and John McKeon observing the planet on March 16, 2016. All of these detections were produced by the visual examen of the video signal, sometimes as it was being recorded by in many other cases days after the video recording happened. Some of these events are so faint that they would be difficult to find visually and many amateur astronomers storage Terabytes of past video observations of Jupiter equivalent to dozens of days of observing time.

Figure 1: Image of the most intense Jupiter flash event recorded by George Hall in September 10, 2013. Background image from stacking all frames in the video sequence. The bright flash corresponds only to stacking the frames where the impact was visible in the video. Note the diffraction patterns around the punctual light source associated to the bright flash.

2. DeTeCt

DeTeCt is an open source Linux/Windows application developed by M. Delcroix that allows to search for impacts in Jupiter videos. The first versions of this software was developed and written by Luis Calderon from Spain as part of his Master in Space Science and Technology. An improved version was done by Marc Delcroix from France and has since then been regularly used by dozens of observers examining data equivalent to about 76 days of observations distributed unevenly over the last few years. The software runs from the line command and produces log files that can be used to examine the statistics of non detections when comparing with the fortuitous detections of impacts. It also produces detection images (see Figure 2). The detection algorithm is based on differential photometry on coregistered images of the video sequence. The software and its statistics can be accessed at:

http://www.astrosurf.com/planetessaf/doc/project_detect.shtml

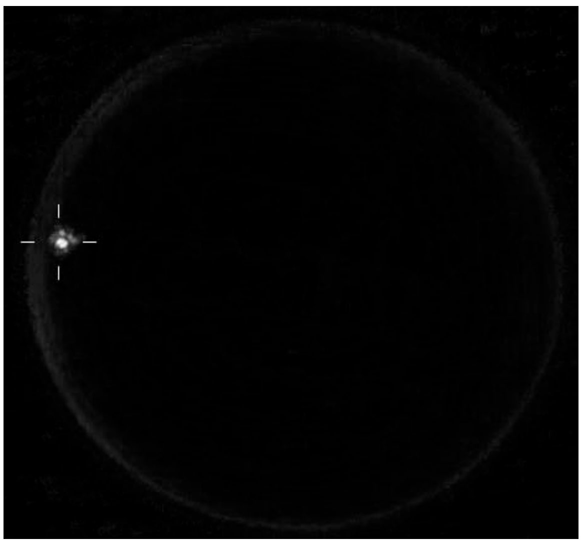

Figure 2: Detection image produced by DeTeCt3.0. Each video examined by the software produces an output in a text file and a detection image where the user can verify the existence and position of a possible impact. Example from the impact detected by George Hall.

DeTeCt3.0 is an open software for Windows that further develops DeTeCt and incorporates a Graphical User Interface, visualization options, improvements in the detection algorithm and outputs and further simplifications in the use of the software. Our goal with this project is to maximize the number of users that examine their video observations of Jupiter. Large impacts (objects larger than 20 m) could also be observed in Saturn and we encourage the use of the software in video observations of both planets.

The new version of the software was developed as part of the Europlanet-2020 RI Planetary and Space Weather Services (PSWS) and is integrated into the PVOL web service (also developed through Europlanet-2020 funds). DeTeCt3.0 is available at:

http://pvol2.ehu.eus/psws/jovian_impacts/

Both webpages will be coordinated so that statistics of impacts and information will appear in both websites.

3. Amateur-profesional collaboration

This work constitutes a novel research area where the large amount of data required to detect impacts in the planet is supplied by amateur astronomers and the analysis is done by software also produced by a collaboration between amateur and professionals. We expect that the largest frequency of Jupiter observations linked to the Juno mission and its call to amateur observers to participate in the mission through regular monitoring of the planet and the fact that Jupiter oppositions are moving from North hemisphere winter in the last few years to Spring in the current and next Jupiter opposition will result in better chances of finding new impacts in the planet.

Acknowledgements

This work has been developed in the framework of the Europlanet 2020 RI. Europlanet 2020 RI has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208. This work has also been supported by the Spanish MINECO project AYA2015-65041-P (MINECO/FEDER, UE), Grupos Gobierno Vasco IT-765-13 and UFI11/55 from UPV/EHU.

References

[1] Hueso et al.: First Earth-based detection of a Superbolide on Jupiter, The Astrophysical Journal Letters, Vol. 721, L129-L133, 2010.

[2] Hueso et al. Impact flux on Jupiter: From superbolides to large-scale collisions. A&A, 560, A55, (2013).

EPSC Abstracts
Vol. 11, EPSC2017-834-1, 2017
European Planetary Science Congress 2017

Capabilities of software "Vector-M" for a diagnostics of the ionosphere state from auroral emissions images and plasma characteristics from the different orbits as a part of the system of control of space weather

V. A. Avdyushev (1), **M. A. Banshchikova** (1), I. N. Chuvashov (1), A. K. Kuzmin (2)
(1) Tomsk State University, Russian Federation, (2) Space Research Institute, Russian Federation (mba-tomsk@mail.ru)

Abstract

In the paper are presented capabilities of software "Vector-M" for a diagnostics of the ionosphere state from auroral emissions images and plasma characteristics from the different orbits as a part of the system of control of space weather. The software "Vector-M" is developed by the celestial mechanics and astrometry department of Tomsk State University in collaboration with Space Research Institute (Moscow) and Central Aerological Observatory of Russian Federal Service for Hydrometeorology and Environmental Monitoring. The software "Vector-M" is intended for calculation of attendant geophysical and astronomical information for the centre of mass of the spacecraft and the space of observations in the experiment with auroral imager Aurovisor-VIS/MP in the orbit of the perspective Meteor-MP spacecraft.

1. Introduction

Online diagnostics of characteristics of the ionosphere (global and local) and their short term forecast subsystem are really fitted in the system of control of space weather parameters. Sources of data measurements of characteristics of the ionosphere consist of: the nets both of the ground radio, riometer, magnetometer instruments and optic imaging instruments located in polar north and south zones and in perspective on the different orbits of low-orbit and high-apogee spacecrafts and at the series of drone that are long time at the altitude more 15 km, and functioning of all these instruments needs to be synchronized. All information received from experiments should flow to data centre for processing, analysis, and visualization of global and local distributions of characteristics of the ionosphere. Significant contribution in this information will be bring direct small-scale data measurements of near-satellite plasma namely energetic characteristics of charge particles fluxes that precipitate to the ionosphere and go out from the ionosphere in 10 eV – 100 keV span, field aligned current along magnetic field lines base on small-scale gradients of magnetic and electric fields in ±5000 nT span, characteristics of VLF/ELF waves, and images of auroral emissions both small-scale visible (at perspective Meteor-MP and Probe spacecrafts and large-scale VUV auroral emissions [4] (in perspective Arctic-2 space project).

Energetic characteristic of charge particles can be compute from the auroral emissions intensity distributions in images both visible (at the night side of the ionosphere) [1, 5] and VUV (at the night and sunlit side of the ionosphere). Energy flux and mean energy of electrons and protons distributions are based for definition of altitude integrated Hall and Pedersen conductance distribution, and local N_e concentration in maximum of E-region of the ionosphere can be compute too [2]. Knowledge of local distribution of these characteristics is necessary to research the reason of delay and the failure of signals of orbital navigation systems and their phase and amplitude scintillations in time crossing of region of precipitation charge particles, field aligned currents and auroral structures when geomagnetic conditions change [3].

Auroral imagers Aurovisor-VIS/MP at perspective spacecraft Meteor-MP consist of three parallel imaging monochromatic channels tuned to oxygen emission λ630,0 nm, emission of 1NG system of N_2^+ λ427,8 nm, and Doppler shifted hydrogen line H_β of Balmer series accordingly that provide capability for control of electrons and protons precipitation contributions in excitation of auroral emissions [3]. 30° field of view angle of each channel provides presence of magnetic field line projection in the images at according altitude of the emission. Axis of channels directed to nadir. Threshold response of every channel is <50 Rayleigh. The parallel monochromatic channels of auroral imager Laetitia tuned to emission λ630,0 nm and λ427,8 nm have field of view angle 30° too and similar threshold response. Direction of axis f.o.v. of channels of Laetitia depend on instantaneous position of Sun because axis (-Y) of Probe spacecraft see the Sun always. Simultaneous launch of Meteor-MP and Probe is expected to "create" the circle Sun synchronous orbits in near-by planes at different altitudes. Due to this quality there can be situations when both imagers will be "see" the same auroral structure from different position when spacecrafts will be cross the auroral oval. Stereoscopic observations and 2D images from different angle provide opportunity reconstruction 3D images of emissions and local N_e concentration accordingly [2].

2. Description of the software "Vector-M"

The purpose of "Vector-M" is calculation of the positions of the centre of mass of the spacecraft Meteor-MP, planning of geophysical experiments and also processing of geophysical data. The software is relevant for heights up to 60 R_E and for angles of inclination of the orbital plane both more and less than 90 degrees.

The software "Vector-M" is based on the high-precision numerical orbital model of the satellite. This model was developed by the staff of the celestial mechanics and astrometry department of Tomsk State University. The main tasks of the "Vector-M" are: 1) coordinate transformation, 2) tracing along the force lines of the geomagnetic field, 3) calculation of the conjugation matrices of images along the magnetic force lines, 4) calculation of the attendant geophysical and astronomical information for the centre of mass of the spacecraft Meteor-MP, 5) calculation of the forecast for specific situations of locations of several spacecrafts (in the different orbits) in space and over specific points on the Earth.

The initial data for the software "Vector-M" are: 1) spacecraft's initial orbital parameters, 2) geomagnetic field and atmosphere parameters, 3) the ephemeris of the Sun and Moon and the lunar phase angle, 4) the coordinates of the earth-based observation stations, 5) the orientation of the spacecraft data received on both the night and day sides of the orbit. The initial data of the auroral imager Aurovisor-VIS/MP and Laetitia are: the viewing angles of fields of the channels, the angles of optical axes of the channels with the construction axes of the spacecraft, the angles of input windows of the analyzer of charged particles.

The software "Vector-M" makes calculations of the positions of the centre of mass of the spacecrafts and its forecasting at specific times and time intervals by using the numerical model of the spacecraft motion. It is also possible to make calculations relative locations of the spacecrafts in space: 1) within certain values of the dipole latitude and MLT, 2) geographic and geomagnetic local time in the neighbourhood of magnetic force line and its footprint at the altitude of emission, 3) at the intersection of the concrete sectors of northern and southern auroral ovals, 4) at the flyby of the spacecraft over specific points on the Earth's surface (earth-based bright sources of light and points of location of the earth-based all-sky imagers and another diagnostic instruments), 5) on illumination (Sun, Moon).

References

[1] Ivanov V.E., Kozelov B.V.: Transport of electron and proton-hydrogen atom fluxes in the Earth atmosphere. Apatity: Print. KSC RAS, 2001. 260 p.

[2] Frey S., Frey H.U.: Auroral emission profiles extracted from three dimensional reconstructed arcs. Journ.Geophys.Res. 1996. Vol. 101. No. A10. pp. 23731-23741.

[3] Kuzmin A. K., Merzliy A. M., Banshchikova M. A., at all: Applied aspects of measurements of auroral emissions and characteristics of the polar ionosphere of Aurovisor-VIS/MP on the perspective spacecraft Meteor-MP. Trudy VNIIEM–2016, pp. 325-341., 2016. (in Russian)

[4] Mende S.B.: Observing the magnetosphere through global auroral imaging: 1. Observables. Journal Geophysical Research: Space Physics, v.121, issue 10, pp. 10623-10637, 2016

[5] Steel D.P., McEwen D.J.: Electron auroral excitation efficient and intensity ratios. Journ.Geophys.Res., v. 95, pp. 10321-10336, 1990.

EPSC Abstracts
Vol. 11, EPSC2017-847, 2017
European Planetary Science Congress 2017

Mercury Na exospheric emission related to solar disturbances.

S. Orsini (1), V. Mangano (1), **A. Milillo** (1), C. Plainaki (2), A. Mura (1), S. Massetti (1), J. Raines (3), E. De Angelis (1), R. Rispoli (1), F. Lazzarotto (1), A. Aronica (1)

(1) National Institute of Astrophysics/ Institute of Space Astrophysics and Planetology, Rome, Italy, (stefano.orsini@iaps.inaf.it) (2) Italian Space Agency, Rome, Italy, (3) Department of Atmospheric, Oceanic and Space Sciences, University of Michigan, Ann Arbor, USA

A first attempt to use Na exospheric emission at Mercury as a proxy of CME transit is presented, in a kind of planetary space weather. The link existing between the dayside exosphere Na pattern at Mercury and the solar wind-magnetosphere-surface interactions is investigated. This goal is pursued by analyzing the Na hourly average distributions, as observed by the ground-based THEMIS solar telescope during 10 selected periods between 2012 and 2013 (seeing <2”), when also data from MESSENGER were available. Very often a two-peak pattern of variable intensity is observed, symmetrically located at high latitudes in both hemispheres. Occasionally, the signal is instead diffused above the sub-solar region. We compare these different Na emission patterns with the time profiles of proton fluxes and magnetic field data, as measured in-situ by MESSENGER. Among these 10 cases, only in one occasion the Na signal is all the time diffused above the subsolar region, and only in this case the MESSENGER data indicate the occurrence of significant solar CME perturbations.

EPSC Abstracts
Vol. 11, EPSC2017-871, 2017
European Planetary Science Congress 2017

A software tool for the finding of potential cometary tail crossings

G. H. Jones (1,2)
(1) Mullard Space Science Laboratory, University College London, Holmbury St. Mary, Dorking, Surrey RH5 6NT, UK, (2) The Centre for Planetary Sciences at UCL/Birkbeck, Gower Street, London WC1E 6BT, UK (g.h.jones@ucl.ac.uk)

Abstract

As part of the Europlanet 2020 Research Infrastructure Planetary Space Weather Services (PSWS), University College London's Mullard Space Science Laboratory (MSSL) is developing software to allow the prediction of possible comet tails crossings. Comet's ion tails are produced when cometary gases are ionized and join the solar wind that flows almost radially outwards from the Sun. Spacecraft can cross these comet tails if they are both downstream of the comet's nucleus at the correct time, and that the solar wind speed is within a range that allows the cometary ions to arrive at the spacecraft when it is downstream. Several such instances of serendipitous comet tail crossings are known to have occurred [1,2,3]. The software allows spacecraft trajectories to be uploaded, and a database of all known comets is searched for periods when nuclei were upstream of the spacecraft path to allow solar wind within a reasonable velocity range to arrive at the spacecraft to allow detection and analysis. We shall give examples of the software in use, demonstrating its ability to "predict" known tail crossings.

References

[1] Jones G. H., Balogh A., Horbury T. S., Nature, 404, 574, 2000

[2] Gloeckler G., Allegrini F., Elliott H. A., McComas D. J., Schwadron N. A., Geiss J., von Steiger R., Jones G. H., ApJ, 604, L121, 2004.

[3] Neugebauer M., et al., ApJ, 667, 1262, 2007.

EPSC Abstracts
Vol. 11, EPSC2017-876, 2017
European Planetary Science Congress 2017

Estimating solar wind speeds from comet ion tail images

G. H. Jones (1,2), Y. Ramanjooloo (3)
(1) Mullard Space Science Laboratory, University College London, Holmbury St. Mary, Dorking, Surrey RH5 6NT, UK, (2) The Centre for Planetary Sciences at UCL/Birkbeck, Gower Street, London WC1E 6BT, UK (g.h.jones@ucl.ac.uk) , (3) University of Hawai'i, USA

Abstract

As part of the Europlanet 2020 Research Infrastructure Planetary Space Weather Services (PSWS), University College London's Mullard Space Science Laboratory (MSSL) is making available software to estimate the speed of the solar wind at comets by measuring the orientation of their ion tails. As ion tails are cometary ions flowing downstream of the comet carried by the solar wind, images of the tails can provide a great deal of information about the solar wind speed at the comet. Software has been developed that allows the user to trace the ion tail, and, using information on the comet's position and velocity at the time the image was taken, allows estimates to be made of the solar wind speed at the comet's location in the inner heliosphere. These estimates can complement more accurate but limited measurements of the solar wind by spacecraft. We describe the software, its use, and limitations. The latter includes complications that arise when the solar wind flow is not purely radial, and difficulties in the use of the software when the Earth is crossing the plane of the target comet's orbit.

EPSC Abstracts
Vol. 11, EPSC2017-899, 2017
European Planetary Science Congress 2017

Modelling Magnetodisc Response to Solar Wind Events

N. Achilleos (1), P. Guio (1), C. S. Arridge (2)
(1) Dept. of Physics / Centre for Planetary Sciences, UCL, London, UK; (2) Dept. of Physics, Lancaster University, Lancaster, UK

Abstract

Theoretical models play an important role in the Planetary Space Weather Services, due to their ability to predict the physical response of magnetospheric environments to compressions or rarefactions in the upstream solar wind flow. We illustrate this aspect by presenting results of some calculations done with the UCL Magnetodisc Model in both 'Jupiter' and 'Saturn' mode.

For each planet's space environment, we present model outputs showing the effect of compressions and rarefactions on the global magnetic field, plasma pressure and azimuthal current density. We quantify these effects by comparing these outputs to a nominal 'average state' model, reflecting more typical solar wind dynamic pressures. These are examples of the kind of model outputs we aim to make available through the PSWS framework.

Acknowledgements

The authors acknowledge very useful and important discussions and interaction with the Europlanet teams associated with the Planetary Space Weather Services (PSWS) and the Virtual European Solar and Planetary Access (VESPA).

EPSC Abstracts
Vol. 11, EPSC2017-948, 2017
European Planetary Science Congress 2017

EPSC
European Planetary Science Congress

Solar wind parameters near Mars and Venus obtained by Mars Express and Venus Express missions. Comparison with simulations and MAVEN data.

E. Knizhnikova (1), A. Fedorov (1), and S. Barabash (2)
(1) IRAP-UPS-CNRS, Toulouse, France, (Andrei.Fedorov@irap.omp.eu) , (2) IRF, Kiruna, Sweden

Abstract

We present ion moments data set obtained from the IMA mass-spectrometer that is a part of ASPERA plasma package. ASPERA experiments have been mounted onboard of ESA Mars Express and Venus express missions. Mars Express is still active and we have an excellent solar wind and planetary ions data set from 2007 up to now. Venus Express mission has been completed in 2014 and the ions moment data set covers 2006 - 2014 time interval. For space weather purposes we have selected a special data set corresponding to undisturbed solar wind observed in the vicinity of Mars and Venus. The resulting data are available in AMDA database (http://amda.cdpp.eu/) online. The present work shows the comparison of our data with the solar wind simulations, and with available MAVEN (NASA) data. We discuss also the pitfalls that user can meet during the data analysis.

EPSC Abstracts
Vol. 11, EPSC2017-949, 2017
European Planetary Science Congress 2017

Ion fluxes and ion distribution function moments in the Martian and Venusian magnetospheres for 2007 - 2017 time interval. The data of the ASPERA instrument onboard of Mars Express and Venus Express missions

A. Fedorov (1), E. Knizhnikova (1) and S. Barabash (2)
(1) IRAP-UPS-CNRS, Toulouse, France, (Andrei.Fedorov@irap.omp.eu) , (2) IRF, Kiruna, Sweden

Abstract

We present ion moments data set that have been obtained from the IMA mass-spectrometer which is a part of ASPERA plasma package. ASPERA experiments have been mounted onboard of ESA Mars Express and Venus express missions. Mars express is still active and we have an excellent solar with and planetary ions data set from 2007 up to now. Venus Express mission has been completed in 2014 and the ions moment data set covers 2006 - 2014 time interval. IMA is a sophisticate ion mass-spectrometer with almost omnidirectional field of view. It accumulates a 3D distribution function of H+, He++, He+, O+, and O2+ every 193s. Since Venus express and Mars Express are planetary focused, 3D stabilized mission, we can expect the ion flux from almost any direction in the spacecraft reference frame. The instrument field of view is partially obscured by the spacecraft and its solar panels. We have take into account all such circumstances during the moments calculation and the ion distribution function analysis. The presentation shows all aspects of IMA data processing, ion distribution function reconstruction, and moments calculations. The resulting data are available in AMDA database (http://amda.cdpp.eu/) online. The presentation shows examples of online data manipulation

EPSC Abstracts
Vol. 11, EPSC2017-967, 2017
European Planetary Science Congress 2017

ALFI – Automatic Lunar Flash Investigation

A. C. Cook (1)
(1) Department of Physics, Aberystwyth University, UK.

Abstract

Publically available lunar impact flash software is being written, under the Horizon 2020, Europlanet 2020 Research Infrastructure (EPN2020-RI), for the detection of short term temporal changes on both the night and day side of the Moon.

1. Introduction

Lunar impact flashes result when meteoroids strike the lunar surface, travelling at tens of kilometres per second. Just under a percent of the kinetic energy released, from gram to kilogram mass objects, is converted into light. This light is of sufficient flux to produce flashes brighter than magnitude 10 which can be detected by telescopes, equipped with light sensitive video cameras, back here on Earth [1].

The ALFI software being developed is not meant to replace the already highly successful, popular, and publically available LunarScan software [2] by Peter Gural, and made available by NASA's Marshall Space Flight Center. Nor to supercede the more sophistictaed, but not yet publically available, MIDAS software [3] by José M. Madiedo. However because ALFI uses different algorithms to the above, and has some design functionailty to work with non-tracking Dobsonian video imagery, and under lunar day side and terminator condtions, it can handle a greater diversity of lunar observational video.

2. Approach

ALFI utilizes a simple local point detector, looking for maxima within 3x3 portions of each video frame that lie N standard deviations above the neighboring 8 pixels in the spatial domain and above M standard deviations for the same pixel in the time domain. To cater for flashes of different spatial sizes, the algorithm is passed over smaller versions of images produced by averaging 2x2, 3x3, … pixels. Likewise in the time domain the algorithm works on time averages to cater for flashes of different duration.

When applied to the dayside and terminator areas of the Moon, a blurred edge mask will be used to prevent the software triggering false detections due to atmospheric seeing effects on contrasty crater rims.

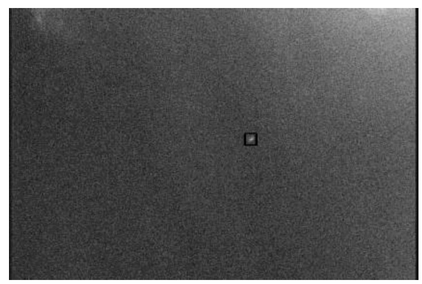

Figure 1. A lunar Leonid impact flash, captured by the author, from Alexandria, VA, USA at 00 :10 UT on 19th November2001 UT. Detected after running the video through the ALFI software.

3. Summary

At the time of writing, the ALFI software is undergoing development, and testing, but when complete will be made it publically available to both amateur and professional astronomers, towards the end of 2017, for detecting short term lunar changes.

Acknowledgements

This software development has been made possible by the Horizon 2020, Europlanet 2020 Research Infrastructure (EPN2020-RI, http://www.europlanet-2020-ri.eu).

References

[1] Cudnik. B., Lunar Meteoric Impacts and How to Observe Them, Springer, pp 240, 2010. **[2]** Suggs, R.M. *et al*. Icarus, 238, 23-36, 2014 **[3]** Madiedo J.M., *et al*., Advances in Astronomy, doi:10.1155/2010/167494, 2010.

EPSC Abstracts
Vol. 11, EPSC2017-1000, 2017
European Planetary Science Congress 2017

Mars Radiation Surface Model

N. Alzate (1), M. Grande (1) and D. Matthiae (2)
(1) Institute of Mathematics, Physics and Computer Science, Aberystwyth, Cymru, United Kingdom (naa19@aber.ac.uk)
(2) Institut fur Luft- und Raumfahrtmedizin (DLR Cologne), Germany

Abstract

Planetary Space Weather Services (PSWS) within the Europlanet H2020 Research Infrastructure have been developed following protocols and standards available in Astrophysical, Solar Physics and Planetary Science Virtual Observatories. Several VO-compliant functionalities have been implemented in various tools. The PSWS extends 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. One of the five toolkits developed as part of these services is a model dedicated to the Mars environment. This model has been developed at Aberystwyth University and the Institut fur Luft- und Raumfahrtmedizin (DLR Cologne) using modeled average conditions available from Planetocosmics. It is available for tracing propagation of solar events through the Solar System and modeling the response of the Mars environment. The results have been synthesized into look-up tables parameterized to variable solar wind conditions at Mars.

1. Introduction

The Planetocosmics application allows the computation of hadronic and electromagnetic interactions of cosmic rays with the Earth, Mars and Mercury environment [1]. It is an application of the Geant4 toolkit for the Monte-Carlo simulation of the passage of particles through matter [2]. The purpose of our work is to produce a PSWS tool for predicting Mars surface space weather conditions. The model consists of the following:

1) prediction of arrivals at the top of the Martian atmosphere for which two models are available, a 1-D MHD code which provides real time archive access to propagated solar wind parameters at Mars, initially developed by Chihiro Tao [3], and the WSA-Enlil, a widely available 2D hydrodynamic code developed at NOAA and available at the Community Coordinated Modelling Centre, which has been used for testing the accuracy of this model in predicting coronal mass ejection (CME) arrival at Venus [4];

2) propagation of energetic particles through the Martian atmosphere. This work has been done for an average atmosphere by DLR. Preliminary Geant4 [2] simulations of Martian atmospheric propagation have also been carried out at Aberystwyth. Tools for Geant4 simulation of atmospheric models are available at Planetocosmics (https://www.spenvis.oma.be/help/models/planetocosmics.html);

3) conversion to dose in silicon. The parameterized DLR radiation surface model calculates the dose rate in silicon on the surface of Mars caused by galactic cosmic radiation (GCR) and their variability due to solar activity. It consists of a combination of the DLR model for the primary GCR intensity [6], the particle transport (Geant4 Monte-Carlo) through the Martian atmosphere including backscatter from the regolith and a particle fluence to dose conversion procedure; and

4) web interface. The results will be mounted into a web interface provided by IRAP. Links to the two heliospheric propagation tools will be provided and an interface to pull up the appropriate atmospheric propagation curves from the derived lookup tables for energetic particles through the atmosphere to a specific location. Data will be available for archive in VESPA format.

2. Methods and Implementation

Planetocosmics (as implemented in SPENVIS) allows someone to calculate the flux of any type of primary and secondary particles at user defined altitudes (SPENVIS allows you to put up to five detectors) or the energy deposited by atmospheric cosmic ray showers in the atmosphere and soil. In addition, Planetocosmics output file contains information about the production of cosmogenic nuclides in the atmosphere.

In the SPENVIS interface to Planetocosmics, run parameters are defined through a series of input pages that the user can access on the main page of the model. The user can choose from a number of input pages and enter their preferred parameters. Once saved, a macro file can be generated. The user can then start a calculation, which will then bring up the results page. The Monte-Carlo simulation-based code can result in long execution times. The runs are therefore limited to five minutes.

The generated (ASCII) output file contains 1D (figure 1) and 2D histograms (figure 2). The former is presented as a 5-column table where each column represents the lower limit, upper limit, mean value, height and error of the histogram bins respectively. The latter, is displayed as a 6-column table where each column corresponds to the x lower limit, x upper limit, y lower limit, y upper limit, height and error of the histogram bins, respectively. The output for particle flux and the energy deposition analysis is shown as 1D histogram while the production of cosmogenic nuclides in the atmosphere is presented as a 2D histogram.

3. Results

Results carried out for a sample of 100 particles reaching a detector on Mars are as follows:

```
////////////////////////////////////////////////
IHistogram1D    /EDEP/ALTITUDE/1
////////////////////////////////////////////////
normalisation_factor :1.000000e+00
Title :    Deposited energy vs altitude [rad*cm2]
Name :  1
Entries :17531
Mean :  2.9765
Rms :    3.6974
Extra Entries :    126
Overflow :   0
Underflow : 126
xaxis_title :  altitude[km]
-2.491400e+00  8.989900e+01   2.976452e+00   3.567897e-06   4.799913e-08
////////////////////////////////////////////////
IHistogram1D    /EDEP/DEPTH/1
////////////////////////////////////////////////
normalisation_factor :1.000000e+00
Title :    Deposited energy vs depth [rad*cm2]
Name :  1
Entries :17531
Mean :  13.369
Rms :    4.1976
Extra Entries :    0
Overflow :   0
Underflow : 0
xaxis_title :  depth[g/cm2]
0.000000e+00   2.100000e+01   1.336882e+01   3.567897e-06   4.799913e-08
////////////////////////////////////////////////
```

Figure 1. Energy deposited by atmospheric cosmic rays. Output from a Plantecosmics run carried out for Mars through SPENVIS.

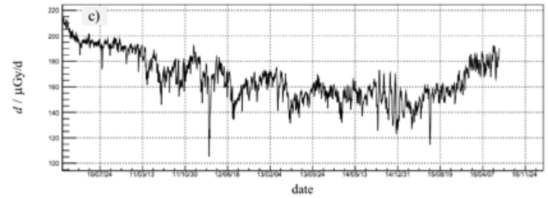

Figure 2. Predicted dose in silicon at the Martian Surface.

4. Summary and Conclusions

Planetary Space Weather Services (PSWS) tools have been developed within the Europlanet H2020 Research Infrastructure, which is strongly linked to the space weather services developed within the ESA's Space Situational Awareness Program (http://swe.ssa.esa.int/heliospheric-weather). The PSWS tools will have an impact on planetary space missions and on the hardness of spacecraft and their components to be evaluated under variety of known conditions, particularly radiation conditions.

Acknowledgements

Europlanet 2020 RI has received funding from the European Union's Horizon 2020 research and innovation program.

References

[1] Desorgher, L., Fluckiger, E., Gurtner, M. and Butikofer, R.: Atmocosmics: A geant4 code for computing the interaction of cosmic rays with the earth's atmosphere, International Journal of Modern Physics A, 20, pp. 6802-6804, 2005.

[2] Agostinelli, S. et al.: Geant4 – a simulation toolkit, Nuclear Instruments and Methods in Physics Research A, 506, pp. 250-303, 2003.

[3] Tao, C. et al.: Magnetic field variations in the Jovian magnetotail induced by solar wind dynamic, Journal of Geophysical Research: Space Physics, 110, A11208, 10.1029/2004JA010959, 2005.

[4] Guymer, G. E.: Observations of the Solar Wind Interaction with Venus using the ASPERA-4 Ion Mass Analyser and Magnetometers on board the Venus Express Spacecraft, Aberystwyth University, PhD Thesis, 2014.