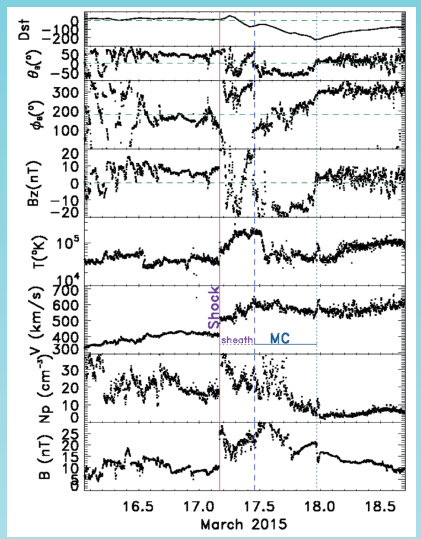
Earth, Planets and Space

Global Data Systems for the Study of Solar-Terrestrial Variability



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Earth, Planets and Space

Watanabe *et al. Earth, Planets and Space* (2017) 69:155
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PREFACE

Open Access

Special Issue "Global data systems for the study of solar-terrestrial variability"

Takashi Watanabe[1*], Toshihiko Iyemori[2], Kazuo Shiokawa[3], Jie Zhang[4], Shrikanth G. Kanekal[5] and Nozomu Nishitani[3]

This special issue includes selected papers presented in the "SCOSTEP–WDS Workshop on Global Data Activities for the Research of Solar-Terrestrial Variability," which was held at the National Institute of Information and Communications Technology (NICT), Tokyo, Japan, on September 28–30, 2015 (http://isds.nict.go.jp/scostep-wds.2015.org/). This workshop was promoted by the Scientific Committee on Solar-Terrestrial Physics (SCOSTEP) and the World Data System (WDS), both of which are Interdisciplinary Bodies of the International Council of Science (ICSU). The principal objective of the workshop was to stimulate interaction among data providers, data scientists, and data-oriented researchers participating in the SCOSTEP's current research program VarSITI (Variability of the Sun and Its Terrestrial Impact, http://www.varsiti.org/). The long-term preservation and provision of quality-assessed data and information will be common objectives for both SCOSTEP and WDS. The development of advanced data systems to enable scientists to perform multidisciplinary data analysis will be another common target. Data analysis of selected solar-terrestrial events was another important component of the workshop. The principal topics of the workshop were: (1) application of information technologies to data activities; (2) data systems for VarSITI; (3) data analysis of VarSITI Campaign Intervals and others; and (4) data-oriented collaborations between SCOSTEP and WDS. The total number of participants was 71 (53 Japanese and 18 foreign participants). In the workshop, 51 papers were presented (four keynote presentations, 21 papers on the data analysis of solar-terrestrial phenomena, and 26 technical papers on data systems).

For topic (1), the technical report by Ritchel et al. (2017) explores the use of a semantic web-based mashup of appropriate data and models to enable interdisciplinary usage of data and information. This approach will be important for the data-oriented study of space weather and solar–climate connections in which multidisciplinary data analysis is inevitable because the majority of data are not well documented and tend to be suitably structured for machine-based combination.

For topic (3), five papers are included in this issue. Among them, two papers discuss solar–interplanetary phenomena relating to the intense geomagnetic storm that initiated on March 17, 2015, widely known as the St. Patrick's Day Event. This geomagnetic storm was associated with a partial halo coronal mass ejection (CME) occurred on March 15, 2015, which was associated with a C9.1/1F flare (S22W25). This storm's minimum Dst reached − 228 nT (provisional) on March 18, and this was the first super geomagnetic storm of solar cycle 24. This event attracted considerable interest from the VarSITI community because the worldwide network of space weather agencies did not expect such a strong geomagnetic storm to be associated with the relatively minor solar flare (e.g., Kamide and Kusano 2015; Baker et al. 2016). As reported in this issue, Wu et al. (2016a, b), basing on detailed data analysis of solar and interplanetary observations, showed that the storm was caused by subsequent arrivals of an interplanetary shock sheath, carrying the southward interplanetary magnetic field (IMF), and a large magnetic cloud (MC) with a strongly southward IMF. Marubashi et al. (2016) fitted a flux-rope model to the temporal change of IMF near the Earth, and they concluded that the observations are most consistently explained by a toroidal flux rope with the torus plane nearly parallel to the ecliptic plane and that the observations are characterized by the peculiar location of near-Earth spacecraft, staying on the east-side flank of the flux-rope loop throughout its passage.

The second strong geomagnetic storm discussed in the workshop was that occurred on June 21–24, 2015, with

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the minimum Dst of − 204 nT (provisional). This event is known as the Summer Solstice 2015 Event and was the result of at least three prominent coronal CMEs and associated interplanetary shocks, which subsequently hit the Earth's magnetosphere (Baker et al. 2016). Cherniak and Zakharenkova (2017) analyzed data from ~ 5800 ground-based GNSS stations, observing GPS and GLONASS radio signals to study high-latitude ionospheric disturbances during the geomagnetic storm. From this case study, they demonstrated the advantage of such "multi-constellation measurements" to monitor high-latitude ionospheric irregularities.

Two papers on long-term data analysis of solar-terrestrial phenomena are also included in this issue. Watari (2017) discussed the weakness of solar-terrestrial activity in the rising-maximum phase of the current solar cycle (24). He showed that the low geomagnetic activity in this cycle is caused by the weak dawn-to-dusk solar wind electric field. It was also reported in this paper that the majority of the 17 geomagnetic storms with minimum Dst indices of less than − 100 nT that occurred in 2009–2015, including the previously mentioned strong geomagnetic storm in March 2015 and June 2015, were caused by relatively slow CMEs. Araki and Shinbori (2016) studied the local-time variation of the characteristics of storm sudden commencements (SSCs) based on the global geomagnetic database of 1953–2003. They concluded that the SC amplitude at 4–5 h local time of middle- and low-latitude stations most directly reflects the dynamic pressure effect of the solar wind. Based on this finding, they re-estimated the amplitude of the three largest SCs observed since 1868.

In summary, the data-analysis papers in this special issue provide us with current progress in the understanding of solar-terrestrial phenomena observed in the VarSITI interval and in the wider time span. These studies mainly depend on databases provided by research groups, data centers, and data networks. International collaboration of these data providers will be important to ensure long-term data management because the majority of data providers are operated under more or less unstable conditions. In addition, owing to the inherently multidisciplinary character of SCOSTEP-led research programs, collaboration with the informatic community is inevitable for effective data usage, such as introducing the advanced technology of data mining, data processing and data presentation. Further collaboration between SCOSTEP and WDS will be important in these aspects.

Finally, we wish to inform the SCOSTEP community of the sudden demise of Prof. Shi-Tsan Wu [Alabama University in Huntsville (Fig. 1)] on May 21, 2017, at the age of 83. He was internationally recognized for his works on the solar-terrestrial relationship, particularly for the pioneering works on numerical magnetohydrodynamic (MHD) modeling of CMEs. He had submitted a presentation on the data-driven MHD simulation of CMEs (e.g., Wu et al. 2016b), to be presented at the WDS Asia-Oceania Conference 2017 held in Kyoto, Japan, on September 27–29, 2017 (http://wdc2.kugi.kyoto-u.ac.jp/wds2017/), which was planned to be a follow-up of the SCOSTEP–WDS Workshop. His paper was presented at the conference by one of his colleagues. He will be sorrowfully missed by his friends and colleagues.

Fig. 1 Prof. Shi Tsan Wu (1933–2017)

Authors' contributions

All authors of this article served as guest editors for this special issue. TW prepared this preface with the agreement of the other authors. All authors read and approved the final manuscript.

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FULL PAPER Open Access

The first super geomagnetic storm of solar cycle 24: "The St. Patrick's day event (17 March 2015)"

Chin-Chun Wu*, Kan Liou, Ronald P. Lepping, Lynn Hutting, Simon Plunkett, Russ A. Howard and Dennis Socker

Earth, Planets and Space 2016, **68**:151 DOI:10.1186/s40623-016-0525-y
Received: 12 March 2016, Accepted: 18 August 2016, Published: 2 September 2016

Abstract

The first super geomagnetic storm (Dst < −200 nT) of solar cycle 24 occurred on "St. Patrick's day" (17 March 2015). Notably, it was a two-step storm. The source of the storm can be traced back to the solar event on 15 March 2015. At ~2:10 UT on that day, *SOHO*/*LASCO* C3 recorded a partial halo coronal mass ejection (CME), which was associated with a C9.1/1F flare (S22W25) and a series of type II/IV radio bursts. The initial propagation speed of this CME is estimated to be ~668 km/s. An interplanetary (IP) shock, likely driven by a magnetic cloud (MC), arrived at the *Wind* spacecraft at 03:59 UT on 17 March and caused a sudden storm commencement. The storm intensified during the Earth's crossing of the ICME/shock sheath and then recovered slightly after the interplanetary magnetic field (IMF) turned northward. The IMF started turning southward again due to a large MC field itself, which caused the second storm intensification, reaching a minimum value (Dst = −223 nT). It is found that the first step is caused by a southward IMF component in the sheath (between the upstream shock and the front of the MC), whereas the second step is associated with the passage of the MC. The CME that erupted on 15 March is the sole solar source of the MC. We also discuss the CME/storm event with detailed data from observations (*Wind* and *SOHO*) and our algorithm for predicting the intensity of a geomagnetic storm (Dst_{min}) from known IP parameter values. We found that choosing the correct Dst_{min} estimating formula for predicting the intensity of MC-associated geomagnetic storms is crucial for space weather predictions.

Keywords: Coronal mass ejection, Interplanetary shock, Super geomagnetic storm, Magnetic cloud

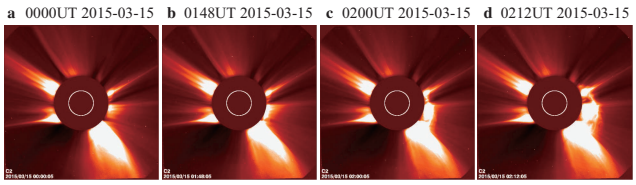

Figure 1

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FULL PAPER Open Access

The 17 March 2015 storm: the associated magnetic flux rope structure and the storm development

Katsuhide Marubashi*, Kyung-Suk Cho, Rok-Soon Kim, Sujin Kim, Sung-Hong Park and Hiromitsu Ishibashi

Earth, Planets and Space 2016, **68**:173 DOI:10.1186/s40623-016-0551-9
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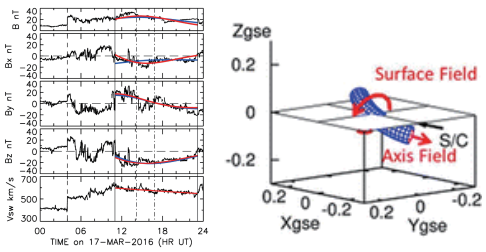
Abstract

The objective of this study is (1) to determine the magnetic cloud (MC) structure associated with the 17 March 2015 storm and (2) to gain an insight into how the storm developed responding to the solar wind conditions. First, we search MC geometries which can explain the observed solar wind magnetic fields by fitting to both cylindrical and toroidal flux rope models. Then, we examine how the resultant MC geometries can be connected to the solar source region to find out the most plausible model for the observed MC. We conclude that the observations are most consistently explained by a toroidal flux rope with the torus plane nearly parallel to the ecliptic plane. It is emphasized that the observations are characterized by the peculiar spacecraft crossing through the MC, in that the magnetic fields to be observed are southward throughout the passage. For understanding of the storm development, we first estimate the injection rate of the storm ring current from the observed *Dst* variation. Then, we derive an expression to calculate the estimated injection rate from the observed solar wind variations. The point of the method is to evaluate the injection rate by the convolution of the dawn-to-dusk electric field in the solar wind and a response function. By using the optimum response function thus determined, we obtain a modeled *Dst* variation from the solar wind data, which is in good agreement with the observed *Dst* variation. The agreement supports the validity of our method to derive an expression for the ring current injection rate as a function of the solar wind variation.

Keywords: Magnetic cloud, Coronal mass ejection, Flux rope, Solar wind, Solar wind magnetic field, Geomagnetic storm, Ring current, Injection rate, *Dst*



Graphical abstract

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LETTER Open Access

Relationship between solar wind dynamic pressure and amplitude of geomagnetic sudden commencement (SC)

Tohru Araki* and Atsuki Shinbori

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Abstract

The local time variation of geomagnetic sudden commencements (SCs) has not been taken into account in the Siscoe's linear relationship which connects the SC amplitude with the corresponding dynamic pressure variation of the solar wind. By considering the physical background of SC, we studied which local time is best to extract the information of the solar wind dynamic pressure and concluded that the SC amplitude at 4–5 h local time of middle- and low-latitude stations most directly reflects the dynamic pressure effect. This result is used to re-check the order of magnitude of the largest 3 SCs observed since 1868.

Keywords: Geomagnetic sudden commencement, Solar wind dynamic pressure, Local time variation, Siscoe's relationship, Largest sudden commencement

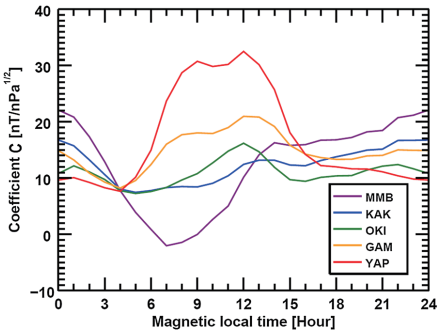

Figure 3

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LETTER Open Access

New advantages of the combined GPS and GLONASS observations for high-latitude ionospheric irregularities monitoring: case study of June 2015 geomagnetic storm

Iurii Cherniak* and Irina Zakharenkova

Earth, Planets and Space 2017, **69**:66 DOI:10.1186/s40623-017-0652-0
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Abstract

Monitoring, tracking and nowcasting of the ionospheric plasma density disturbances using dual-frequency measurements of the Global Positioning System (GPS) signals are effectively carried out during several decades. Recent rapid growth and modernization of the ground-based segment gives an opportunity to establish a great database consisting of more than 6000 stations worldwide which provide GPS signals measurements with an open access. Apart of the GPS signals, at least two-third of these stations receive simultaneously signals transmitted by another Global Navigation Satellite System (GNSS)—the Russian system GLONASS. Today, GLONASS signal measurements are mainly used in navigation and geodesy only and very rarely for ionosphere research. We present the first results demonstrating advantages of using several independent but compatible GNSS systems like GPS and GLONASS for improvement of the permanent monitoring of the high-latitude ionospheric irregularities. For the first time, the high-resolution two-dimensional maps of ROTI perturbation were made using not only GPS but also GLONASS measurements. We extend the use of the ROTI maps for analyzing ionospheric irregularities distribution. We demonstrate that the meridional slices of the ROTI maps can be effectively used to study the occurrence and temporal evolution of the ionospheric irregularities. The meridional slices of the geographical sectors with a high density of the GPS and GLONASS measurements can represent spatio-temporal dynamics of the intense ionospheric plasma density irregularities with very high resolution, and they can be effectively used for detailed study of the space weather drivers on the processes of the ionospheric irregularities generation, development and their lifetimes. Using a representative database of ~5800 ground-based GNSS stations located worldwide, we have investigated the occurrence of the high-latitude ionospheric plasma density irregularities during the geomagnetic storm of June 22–23, 2015.

Keywords: GPS, GLONASS, Plasma irregularities, ROTI, High-latitude ionosphere, Geomagnetic storm

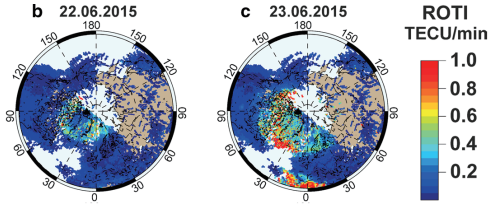

Figure 4

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LETTER Open Access

Geomagnetic storms of cycle 24 and their solar sources

Shinichi Watari

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Abstract

Solar activity of cycle 24 following the deep minimum between cycle 23 and cycle 24 is the weakest one since cycle 14 (1902–1913). Geomagnetic activity is also low in cycle 24. We show that this low geomagnetic activity is caused by the weak dawn-to-dusk solar wind electric field (E_{d-d}) and that the occurrence rate of E_{d-d} > 5 mV/m decreased in the interval from 2013 to 2014. We picked up seventeen geomagnetic storms with the minimum Dst index of less than −100 nT and identified their solar sources in cycle 24 (2009–2015). It is shown that the relatively slow coronal mass ejections contributed to the geomagnetic storms in cycle 24.

Keywords: Geomagnetic storm, Rising and maximum phases, Two peaks, Solar cycle 24, Coronal mass ejection, Coronal hole

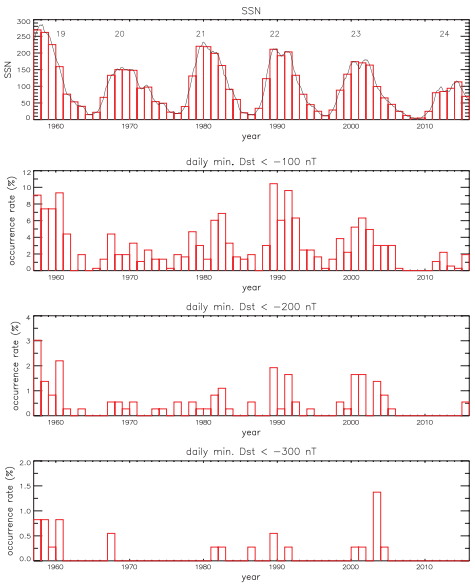

Figure 1

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TECHNICAL REPORT Open Access

Experiments using Semantic Web technologies to connect IUGONET, ESPAS and GFZ ISDC data portals

Bernd Ritschel*, Friederike Borchert, Gregor Kneitschel, Günther Neher, Susanne Schildbach, Toshihiko Iyemori, Yukinobu Koyama, Akiyo Yatagai, Tomoaki Hori, Mike Hapgood, Anna Belehaki, Ivan Galkin and Todd King

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Abstract

E-science on the Web plays an important role and offers the most advanced technology for the integration of data systems. It also makes available data for the research of more and more complex aspects of the system earth and beyond. The great number of e-science projects founded by the European Union (EU), university-driven Japanese efforts in the field of data services and institutional anchored developments for the enhancement of a sustainable data management in Germany are proof of the relevance and acceptance of e-science or cyberspace-based applications as a significant tool for successful scientific work. The collaboration activities related to near-earth space science data systems and first results in the field of information science between the EU-funded project ESPAS, the Japanese IUGONET project and the GFZ ISDC-based research and development activities are the focus of this paper. The main objective of the collaboration is the use of a Semantic Web approach for the mashup of the project related and so far inoperable data systems. Both the development and use of mapped and/or merged geo and space science controlled vocabularies and the connection of entities in ontology-based domain data model are addressed. The developed controlled vocabularies for the description of geo and space science data and related context information as well as the domain ontologies itself with their domain and cross-domain relationships will be published in Linked Open Data.

Keywords: E-science, Semantic Web, Linked Open Data, Data system, System mashup, Controlled vocabulary, Domain ontology, Terminological ontology

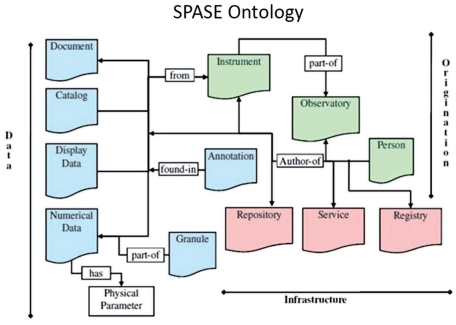

Figure 1

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5. The main text can have multiple free headings.
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7. References must follow the Springer Basic style.

Correspondence

If you have any questions, please contact editorial@earth-planets-space.com.

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