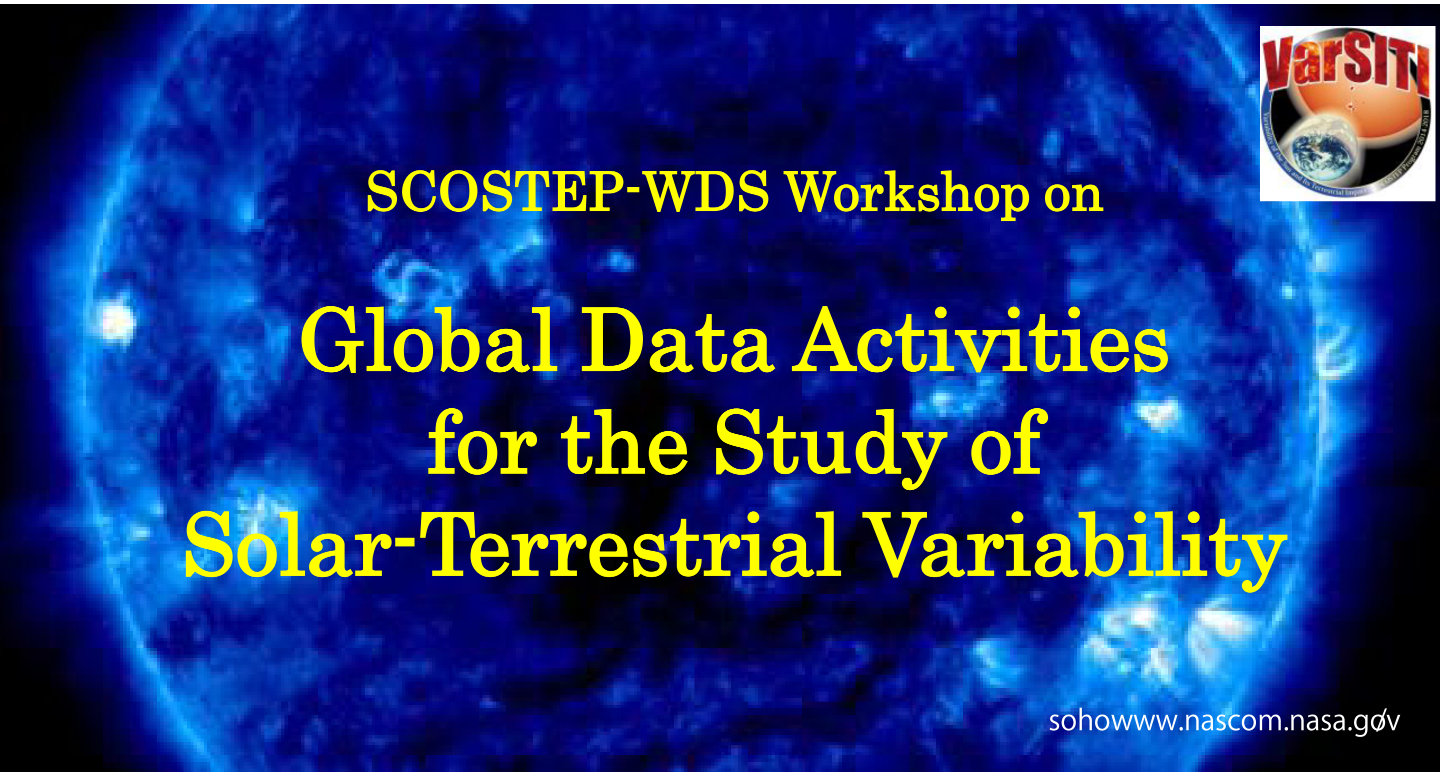
SCOSTEP
Scientific Committee on Solar-Terrestrial Physics

ICSU
WORLD DATA SYSTEM

VarSITI



SCOSTEP-WDS Workshop on

Global Data Activities for the Study of Solar-Terrestrial Variability

28 - 30 September 2015
National Institute of Information and Communications Technology
Tokyo, Japan

http://isds.nict.go.jp/scostep-wds.2015.org/

NiPR National Institute of Polar Research

STEL

NICT

SGEPSS Society of Geomagnetism and Earth, Planetary and Space Sciences

Program and Abstracts

SCOSTEP-WDS Workshop on Global Data Activities for the Study of Solar-Terrestrial Variability

28 - 30 September 2015

National Institute of Information and Communications Technology

Tokyo, Japan

Contents

Scope

This joint workshop of the Scientific Committee on Solar-Terrestrial Physics (SCOSTEP) and the ICSU World Data System (ICSU-WDS) on 'data' will be held on 28–30 September 2015 in Tokyo, Japan. The principal objective of the workshop is to stimulate interaction among data providers (WDS members, data centres, data networks, etc.), data scientists, and data-oriented researchers participating in SCOSTEP, which is the Interdisciplinary Body of ICSU promoting a series of international research programs on solar-terrestrial connection. Its current program VarSITI (Variability of the Sun and Its Terrestrial Impact, http://www.varsiti.org/) will strive for international collaboration in data analysis, modelling, and theory to understand how the solar variability affects the Earth's environment in a vast range of time scale, from seconds to billions of years. Long-term preservation and provision of quality-assessed data and information will be common objectives for SCOSTEP and WDS. Development of advanced data systems to enable scientists to perform multidisciplinary data-analysis will be another common target. This workshop will be a remarkable opportunity to initiate close collaboration between SCOSTEP and WDS to promote our data-oriented activities by introducing outcomes from the information technology. Data analysis of selected solar-terrestrial events will be an important component of the workshop also not only to develop the study of solar-terrestrial variability but also to establish a mutual feedback loop between "data users" and data providers. Principal topics of the workshop are:

(1) Application of information technologies to mutual data activities
(2) Data systems for VarSITI (data centres, data networks, data analysis systems, etc.)
(3) Data analysis (VarSITI Campaign Intervals and others)
(4) Data-oriented collaborations between SCOSTEP and WDS.

Scientific Organizing Committee

Sponsors and Organizing Committees

Principal Sponsors

Scientific Committee on Solar-Terrestrial Physics (SCOSTEP)
ICSU World Data System (ICSU-WDS)

Co-Sponsors

ICSU-WDS International Programme Office (WDS-IPO)
Solar-Terrestrial Environment Laboratory (STEL), Nagoya University
National Institute of Polar Research (NIPR)
National Institute of Information and Communications Technology (NICT)

Scientific Organizing Committee (* Chairs)

T. Watanabe*	ICSU WDS International Programme Office
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T. Iyemori	WDC for Geomagnetism, Kyoto, Kyoto University
N. Gopalswamy	Goddard Space Fright Center, NASA
V. Obridko	IZMIRAN, Russian Academy of Science
T. Nakamura	National Institute of Polar Research
Y. Miyoshi	Solar-Terrestrial Environment laboratory, Nagoya University

Local Organizing Committee (* Chairs)

K. Shiokawa	Solar-terrestrial Environment Laboratory, Nagoya University
N. Nishitani*	Solar-terrestrial Environment Laboratory, Nagoya University
M. Mokrane	WDS-International Programme Office
T. Watanabe*	WDS-International Programme Office
R. Edmunds	WDS-International Programme Office
Y. Murayama	National Institute of Information and Communications Technology
K. Murata	National Institute of Information and Communications Technology
S. Watari	National Institute of Information and Communications Technology
T. Nakamura*	National Institute of Polar Research
T. Iyemori	WDC for Geomagnetism, Kyoto, Kyoto University
Y. Ebihara	Research Institute for Sustainable Humanosphere, Kyoto University
S. Abe	International Center for Space Weather Science and Education, Kyushu University

General Structure of the Workshop*

<table>
<tr><th>Date (2015)</th><th colspan="2">AM</th><th colspan="2">PM</th><th>Evening</th></tr>
<tr><td>27 Sep. (SUN)</td><td colspan="2"></td><td colspan="2"></td><td>Registration
Icebreaker
16:00 - 19:00</td></tr>
<tr><td>28 Sep. (MON)</td><td>Registration
Poster posting
10:00 - 10:30</td><td>Opening Talks
10:30 - 12:30</td><td colspan="2">Session 1: Collaboration of WDS and SCOSTEP/VarSITI
14:00 - 17:30</td><td></td></tr>
<tr><td>29 Sep. (TUE)</td><td colspan="2">Session 2: Data Analyses of VarSITI and STE Events
10:00 - 12:20</td><td colspan="2">Session 2: Data Analyses of VarSITI and STE Events
13:30 - 17:30</td><td>Get-together Party
18:00 - 20:00</td></tr>
<tr><td>30 Sep. (WED)</td><td colspan="2">Session 3: Data-oriented Information Technology
09:30 - 12:35</td><td>Session 4: Activity Reports of Data Systems 13:30 - 15:45</td><td>Concluding Session
15:45 - 16:20</td><td></td></tr>
</table>

*Detailed programme is given in pp 8 - 11.

Important activities

Registration: 28 Sep. (16:00-19:00), 29-30 Sep. (10:00-)
Icebreaker: 27 Sep. (16:00-19:00 at NICT)
Site visit: 28 Sep. (12:20 – 14:00)
Demonstrations of data systems: 28 Sep. (12:20 – 14:00)
Poster viewing: 28 – 30 Sep.
Group photo:: 29 Sep. (12:20-12:30, at the Entrance Lobby of the NICT Main Building)
Get-together Party: 29 Sep. (18:00 – 20:00 at NICT)

Information on Icebreaker and Get-together Party

Icebreaker

When? 16:00 – 19:00 on 27 Sep. 2015
Where? NICT (4th floor of NICT Main Building)

This is a side event of the Workshop to invite participants to exchange information on your activities and discuss on the strategy of collaborations between SCOSTEP and WDS . All participants of the Workshop are invited. Wines, beers and right snacks will be served.

Get-together Party

When? 18:00 – 20:00 on 29 Sep. 2015
Where? In NICT (to be announced)
How much? 4000 JPY (Please pay in advance. We accept only cash of Japanese Yen)
How good? "Good meals" and excellent Japanese Sake!
How to book? Please book at the registration desk by the noon of 29 Sep.

Guide of Venue (The Head quarter of NICT)

1. Upon your arrival at NICT, please stop firstly at the "**Security Office**" and receive your ID card to enter. The card is only good for the day of issue. Your card should be returned to the office at your "final" leave on the day.

2. Go to the "**Main Building**", and use lifts or staircases to get to the "**International Conference Room**" located on the 4th floor. The plan of the floor is given in the opposite page.

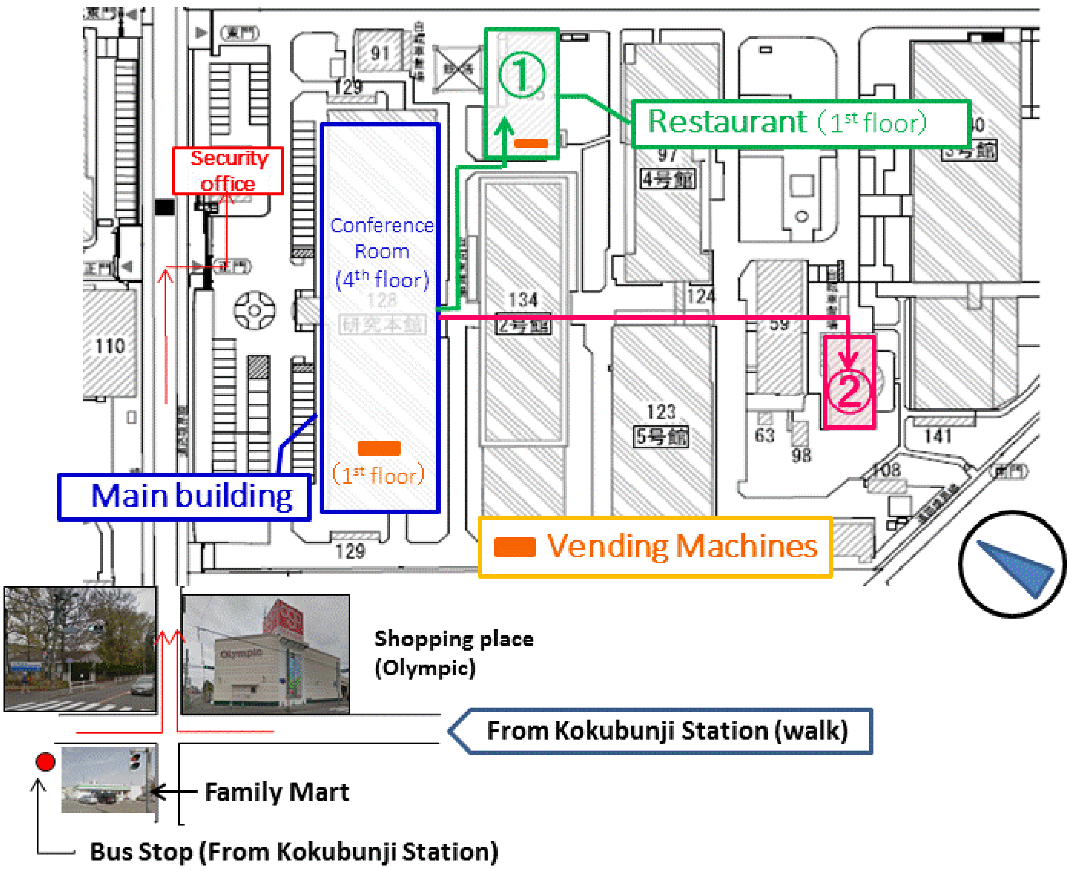
3. **Internet connection**: Please receive the instruction on the registration desk.

4. The restaurant for your lunch is located at ① on the map shown below.

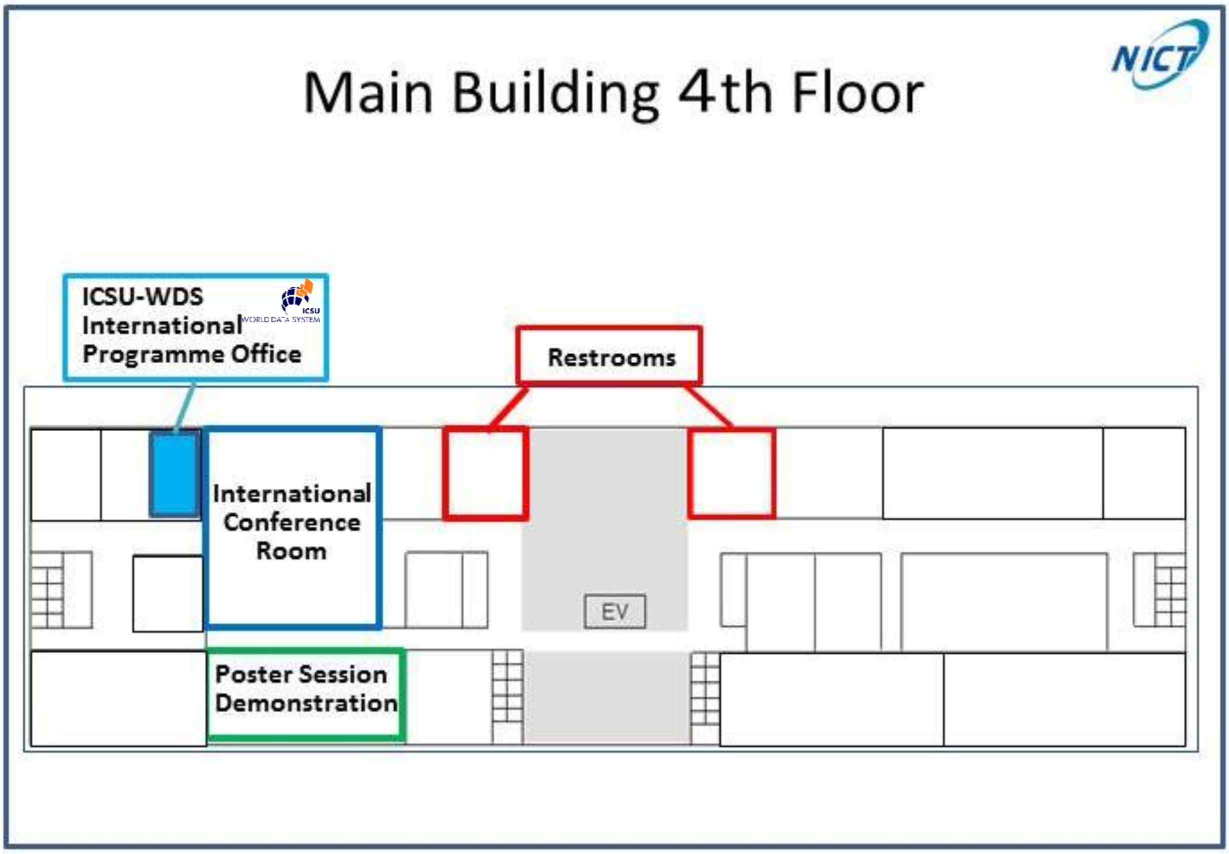
5. The "get together" party will be held at ② on 29 Sep (TUE).

6. Vending machines for beverages are available on the 1st floor of the Main Building.

7. Foods, daily necessaries, medicines, electronic instruments etc are available at a nearby shopping place (Olympic). Sandwiches and beverages are also available at Family Mart, a typical "convenience store" in Japan.



Plan of 4th Floor of the NICT Main Building



Remarks:

1. The room for Poster Session and Data-System Demonstrations (TV Conference Room) will be closed on 29 Sep. (TUE) from 10:00 to 12:00, due to an internal meeting of NICT.
2. Please keep quiet in the corridor because daily business works of NICT are going on.

Practical Information

Currency and Exchange

The unit of currency in Japan is the 'yen' (JPY), and is the only accepted currency in almost all shops and restaurants. Paper notes come in four denominations (10,000 yen, 5,000 yen, 2,000 yen, and 1,000 yen) and metal coins in six denominations (500 yen, 100 yen, 50 yen, 10 yen, 5 yen, and 1 yen). As of March 2015, the exchange rate is approximately 120 JPY = 1 USD. You can purchase Japanese yen at a reasonable rate in foreign exchanges at all international airports and on high streets, as well as within most major banks. Please ask our Supporting Stuff for details.

Consumption Tax

A consumption tax (value added tax) of 8% is added to the price of all goods purchased in Japan. Typically, this is included in the stated price, but may sometime be written within parentheses.

Traveler's Checks and Credit Cards

The use of traveler's checks is not popular in Japan and they are typically only accepted at airports, major banks, and large hotels. VISA, MasterCard, Diners Club, and American Express credit cards (and debit cards with a credit facility) are widely accepted at shops and restaurants in urban areas. Many ATMs in Japan do not accept foreign credit/debit cards for cash advances; however, money can be withdrawn from ATMs at the Japan Post Office and Seven-Eleven convenience stores. Overseas participants are strongly recommended to exchange currency into JPY upon your arrival at international airports in Japan, or to obtain yen in advance in their own country.

Electricity

Electricity is supplied at 100 volts, 50 Hz AC in eastern Japan, including the Tokyo area. The type of plague is the same one being used in U.S.A (A-type).

Shopping

A shopping center “OLYMPIC” is located near NICT where you can get foods, drinks, electronic items, daily-use stuff, etc. A “convenient store” FAMILY MART” selling sandwiches drinks, etc, is located near NICT also. There is a department-style shopping center (MARUI) is located inside the building of JR Kokubunji station.

SCOSTEP-WDS Workshop on 'Global Data Activities for the Study of Solar-Terrestrial Variability'

Dates: 28 - 30 September 2015
Place: National Institute of Information and Communications Technology (NICT), Tokyo
Web: http://isds.nict.go.jp/scostep-wds.2015.org/

27 Sep. (SUN)			
	16:00 -19:00	Registration, Poster posting, Icebreaker, etc. Place: NICT	
28 Sep. (MON)			
	10:00-10:30	Registration, Poster posting	
	10:30-10:40	Opening Remarks	SOC
0-1	10:40-11:00	Long-term Preservation of Solar terrestrial Data	N Gopalswamy*
0-2	11:00-11:20	ICSU World Data System: Trusted Data Services for Open Science	M Mokrane*
0-3	11:20-11:40	Activity of CODATA on Earth and Space Science Data Interoperability	A Rybkina*, and S Hodson
0-4	11:40-12:00	Variability of the Sun and Its Terrestrial Impact (VarSITI): SCOSTEP's scientific program in 2014-2018	K Shiokawa* and K Georgieva
	12:00-12:15	General Information on Workshop	LOC
	12:15-12:30	Information on Data-System Demonstrations and Site Visits	LOC, Exhibiters
	12:30-14:00	Lunch, Data-system Demonstrations, Poster Viewing, and Site Visits (Facilities of NICT, WDS-IPO)	
Session 1: Future Collaboration between SCOSTEP/VarSITI and WDS			
	14:00-14:10	Opening Address of Plenary Sessions	F Tomita*
	14:10-14:20	Scope of the session	T Iyemori*
	14:20-14:40	SCOSTEP–WDS collaboration to address VarSITI Data Challenges	K Shiokawa*
	14:40-15:40	Panel Discussion	
	15:40-16:00	Break	
	16:00-16:30	Panel Discussion and Conclusion	
	16:30-17:30	Short Presentations of Posters (3-min each)	
	17:30-18:30	Poster Viewing	
29 Sep. (TUE)			
Session 2: Data Analyses of VarSITI and STE Events			
	10:00-10:10	Scope of the Session	T. Watanabe*
2-1	10:10-10:30	ISEST Data Products and Campaign Study (Invited)	Jie Zhang*
2-2	10:30-10:50	Extreme space weather events as seen in the historical geomagnetic records of Colaba, India and their estimation of interplanetary conditions (Invited)	B. Veenadhari*, S Kumar, S Tulasiram, R Selvakumaran, S Mukherjee, R Singh, B D Kadam
2-3	10:50-11:05	Global solar activity in Cycle 24	K Shibasaki*
2-4	11:05-11:20	Geomagnetic storms of Cycle 24 and their solar sources	S Watari*, M Den, and Y Kubo
	11:20-11:30	Break	
2-5	11:30-11:50	Overview of solar-terrestrial environment between	S Abe*

		March and September, 2015	
2-6	11:50-12:05	The first super geomagnetic storm of solar cycle 24: "The St. Patrick day (17 March 2015)" event	C-C Wu*, K Liou, B Jackson, H-S Yu, L Hutting, R P Lepping, Simon Plunkett, R A Howard, and D Socker
2-7	12:05-12:20	Flux rope structures of the solar wind associated with two intense geomagnetic storms in 2015: the 17 March and the 22 June storms	K Marubashi*, K-S Cho, R-S Kim, S Kim, and S-H Park
	12:20-12:30	Group Photo at Entrance Lobby (GF)	
	12:30-13:30	Lunch, Poster Viewing	
2-8	13:30-13:45	Pileup accident hypothesis of magnetic storm on 2015 March 17	R Kataoka*, D Shiota, E Kilpua, and K Keika
2-9	13:45-14:05	Van Allen Probes Observation of prompt energization of electrons to ultra-relativistic energies during the 17 March 2015 IP shock (Invited)	S G Kanekal* and D N Baker
2-10	14:05-14:20	Recent geoeffective space weather events and technological system impacts	R J Redmon*, W F Denig, T M Loto'aniu, H J Singer, D C Wilkinson, D J Knipp, and L Kilcommons
2-11	14:20-14:35	Experiences of Forecasting the magnetic storms of march and June 2015 and analysis of the resulting ground effects in the UK	S J Reay *, L A Billingham, G S Kelly, and A W P Thomson
2-12	14:35-14:50	Upper atmosphere data in the polar region during the March 17-18 and June 22-24, 2015 geomagnetic storms	Y Tanaka*, A Kadokura, Y Ogawa, N Umemura, S Abe, Y Koyama, A Shinbori, M Yagi, S Ueno, and M Nose
	14:50-15:05	Break	
2-13	15:05-15:20	Energetic particle precipitations impacts on the mesosphere observed by the PANSY radar	T Nishiyama*, T Nakamura, K Sato, M Tsutsumi, T Sato, K Nishimura, Y Tanaka, Y Tomikawa and M Kohma
2-14	15:20-15:35	Multi-instrumental study of the ionospheric response to the 2015 St. Patrick's Day storm	E Astafyeva, I Zakharenkova* , and M Förster
2-15	15:35-15:50	Dynamics of ionospheric convection associated with low latitude aurora in Hokkaido during the March 2015 storm	N Nishitani*, T Hori, R Kataoka, Y Ebihara, K Shiokawa, Y Otsuka, and H Suzuki
2-16	15:50-16:05	Low-latitude red aurora observed in Japan during the St. Patrick's Day 2015 Event	K Shiokawa* and Y Otsuka
2.17	16:05-16:20	Wide energy electron precipitations and their impact on the middle atmosphere associated with the pulsating aurora	Y Miyoshi*, S Oyama, S Saito, E Turunen, S Kurita, A Kero, P T

			Verronen, R Kataoka, Y Ebihara, C Kletzing, G Reeves, O Santolik, M Clilverd, C Rodger, and F Tsuchiya
	16:20-17:30	Short Presentations, Discussions	
	18:00-20:00	Get-together Party (NICT)	
30 Sep. (WED)			
Session 3: Data-oriented Information Technology			
3-1	09:30-09:55	Open Data, Open Publication and Open Science Approach for Geo and Space Science Domain (Invited)	B Ritschel*, T Iyemori, G Neher, Ch Seelus, Y Koyama, Y Murayama, T King, S. Hughes, S. Fung, M Hapgood and A Belehaki
3-2	09:55-10:20	Data Citation Analysis Framework for Open Science Data (Invited)	K. Zettu*
3-3	10:20-11:05	Using A Virtual Observatory (VO) to Enable Multidisciplinary Data Analysis (Invited)	Shing F Fung*, Robert E McGuire, and Joseph B Gurman
	11:05-11:15	Break	
3-4	11:15-11:40	NOAA National Centers for Environmental Information Space Physics and Geomagnetism Activities: Historical perspective and future directions (Invited)	R J Redmon*, W F Denig, E A Kihn, A Chulliat and S McLean
3-5	11:40-12:05	Challenges in geomagnetic data processing for a better understanding of geomagnetic field evolution (Invited)	A Solovyev and A Rybkina*
3-6	12:05-12:20	IUGONET (Inter-university Upper atmosphere Global Observation NETwork) activities	T Nakamura*, Y Tanaka, N Umemura, S Abe, Y Koyama, A Shinbori, M Yagi, S UeNo, M Nose, and IUGONET project team
3-7	12:20-12:35	Application of SPEDAS to VarSITI Program -- Introduction of IUGONET?and ERG-SC Plugins	Y Tanaka*, Y Miyoshi, V Angelopoulos, A Shinbori, N Umemura, S Abe, Y Koyama, M Yagi, S UeNo, T Hori, Y Miyashita, K Keika, M Shoji, K Seki, T Segawa, and I Shinohara
	12:35-13:30	Lunch, Poster Viewing	
Session 4: Activity Reports of Data Systems of WDS and VarSITI			
4-1	13:30-13:55	Introduction to Chinese Meridian Project (Invited)	C Wang*
4-2	13:55-14:10	CSSDC promoted service also strengthened connection to Solar-Terrestrial Community through deep projects cooperation	Zou Ziming, Xiong Senlin*, and Ji Zhen

4-3	14:10-14:25	The World Data Centre (WDC) for Solar-Terrestrial Science (STS) of Australia	K Wang*, C Yuile, C Thomson, N Bukilic, R Marshall, M Terkildsen, and M Hyde
4-4	14:25-14:40	Recent activities of the World Data Centre for Geomagnetism (Edinburgh)	S J Reay*, T S Humphries, S Macmillan, S M Flower, P C Stevenson and E Clarke
	14:40-15:00	Break. Poster Removal	
4-5	15:00-15:15	The neutron monitor database (NMDB)	C Steigies*
4-6	15:15-15:30	Continued operation of Nobeyama Radioheliograph and its database	S Masuda* and the International Consortium for the Continued Operation of Nobeyama Radioheliograph (ICCON)
4-7	15:30-15:45	Recent activity of DOI-minting to solar-terrestrial physics data in Japan	M Nosé*, Y Koyama, T Iyemori, Y Murayama, T Kinoshita, M Kunitake, T Watanabe, M Nishioka, M Ishii, Y Tanaka, A Kadokura, and I Shinohara
	15:45-16:20	**Concluding Session**	

*Presenting author.

Posters		
P1	Development of the JavaFX-based iUgonet Data Analysis Software (JudasFX)	Y Koyama*, Y Sato, S Nakano, M Yagi, Y Tanaka, S Abe, M Nose, K Kurakawa, D Ikeda, N Umemura, A Shinbori, and S Ueno
P2	A geomagnetic event review from March to August, 2015 at Kakioka	M Sasaoka*, H Hirahara, N Mashiko and T Ohkawa
P3	Data publication of the Kakioka Magnetic Observatory	S Nagamachi, K Morinaga, N Mashiko and M Sasaoka*
P4	The necessity of "scientifically related" database in solar-terrestrial physics	M Ishii*, Y Kubo, T Nagatsuma, H Kato and S Watari
P5	New solar radio telescope of NICT	K Iwai*, Y Kubo, S Watari, H Ishibashi, and M Ishii
P6	Data standardization and distribution of NICT solar radio observation	Y Kubo*, K Iwai, H Ishibashi, and S Watari
P7	Variation of Solar Microwave Spectrum in the Last Half Century	M Shimojo*, K Iwai, A Asai, S Nozawa, T Minamidani and M Saito
P8	Development of solar flare prediction technique based on image processing of real-time solar magnetogram data	N Nishizuka*, Y Kubo, M Den, S Watari, and M Ishi
P9	Routine observations and data acquisition of the ionosphere at Syowa station Antarctica	T Nagatsuma*, H Ishibashi, T Kondo, H Kato, T Naoi, and M Nishioka
P10	Space environment data acquisition monitor (SEDA) onboard HIMAWARI-8 as a space weather monitoring platform	T Nagatsuma*, K Sakaguchi, and Y Kubo
P11	60-year database of cosmic-Ray neutron fluxes held by WDC for Cosmic Rays	T Watanabe*, M Hirahara, F Abe, and A Maeda
P12	Observation of the high-latitude ionospheric irregularities: methodology and service	Iu Cherniak* , I Zakharenkova, and A Krankowski
P13	Dynamics of the ionospheric irregularities during the St. Patrick's Day storm by ground-based GPS measurements	Iu Cherniak*, I Zakharenkova, and R Redmon
P14	Relationship between amplitude of geomagnetic sudden commencement(SC) and the corresponding dynamic pressure variation of the solar wind	T Araki* and A Shinbori
P15	Equatorial Plasma Bubbles Studies using Airglow and GPS Data	D J Shetti* and P T Patil

*Presenting author.

Several unnumbered posters will be exhibited also under the approval of LOC.

Extended Abstracts

[0-1]

LONG-TERM PRESERVATION OF SOLAR TERRESTRIAL DATA

N Gopalswamy*[1]**

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Email: nat.gopalswamy@nasa.gov

Humans are now capable of observing Earth to a significant fraction of the universe using a wide variety of techniques. For solar terrestrial physics, we observe the Sun and Earth and everything in between to understand the changing influence of the Sun and Earth on the terrestrial environment in which life thrives. In addition to observing the solar-terrestrial phenomena, scientists are involved in tapping into the natural archives, which have preserved the effect of cosmic rays and solar activity on the terrestrial environment. One of the best examples of long-term observations that have been well preserved is the record of sunspot number. The sunspot number has been extended to the pre-telescope era to understand the influence of the Sun as indicated by the variation of C-14 in tree rings and Be-10 in ice cores (Eddy, 1976).

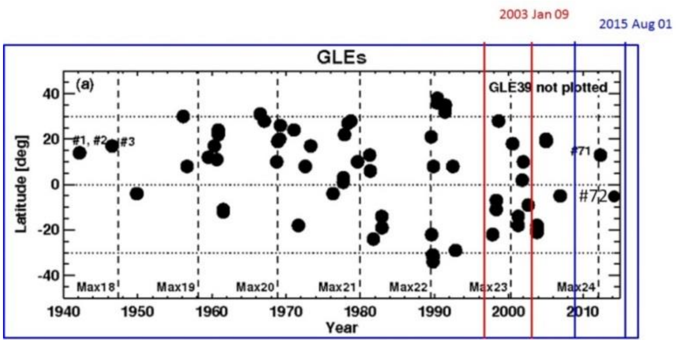

Figure 1. Latitudes of the 72 GLE source regions since 1942. The period between the first set of vertical lines (May 1996 to January 2009) in solar cycle 23 is compared with the corresponding epoch in cycle 24 (December 2008 to August 2015). One can see a clear dearth of GLE events in cycle 24. The approximate maximum phase of each solar cycle are marked by the vertical dashed line. (From Gopalswamy and Mäkelä, 2014).

I will emphasize that preservation of data helps future investigations on problems that are completely different from the original ones for which the data were acquired. A good example is the record of ground level enhancement (GLE) in solar energetic particle events. Figure 1 shows the latitudes GLE events since their discovery in 1942. GLEs were discovered almost three decades prior to the discovery of coronal mass ejections (CMEs), which are now thought to be responsible for accelerating GLE particles via MHD shocks. The dearth of GLEs in solar cycle 24 (there are only two events compared to 10 in cycle 23 over the corresponding epoch) is clear from Figure 1. The significance is realized when compared with all solar cycles since the 19^{th}.

ACKNOWLEDGEMENTS

Acknowledgements may be made to individuals or institutions, not previously mentioned, that have made a significant contribution to the intellectual content of the paper.

REFERENCES

Eddy, J. A. (1976) The Maunder minimum. *Science* 192, 1189
Gopalswamy, N., & Mäkelä, P. (2014) Latitudinal Connectivity of Ground Level Enhancement Events. *ASP Conf. Ser.* 484, 63

[0-2]

ICSU WORLD DATA SYSTEM: TRUSTED DATA SERVICES FOR OPEN SCIENCE

M Mokrane*

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Email: Mustapha.mokrane@icsu-wds.org

More than 50 years ago the International Council for Science (ICSU) initiated what can be retrospectively labelled as the first international initiative promoting open data for science, effectively setting the standard for what will become the Open Data movement. The International Geophysical Year (1957–1958) was an international multidisciplinary research programme inspired by the previous two International Polar Years. Its organizers agreed to implement the visionary principle that 'all observational data shall be available to scientists and scientific institutions in all countries.' because they felt that to realize the maximum benefit of the research, it was indispensable to have free exchange of data across international borders. Therefore, The World Data Centres and the Federation of Astronomical and Geophysical data analysis Services were established by the Council to manage data generated by IGY research and provide data services to the scientific community. These bodies fulfilled their mission over half a century, however, it became clear after the last International Polar Year (2007–2008) that they were not able to respond fully to modern data needs. They were thus disbanded by the General Assembly of the Council in 2008 and replaced by the World Data System (ICSU-WDS) in 2009.

Building on the legacy of its predecessor bodies, WDS continues to promote universal and equitable access to, and long-term stewardship of, quality-assured scientific data and data services, products, and information. In addition, WDS in its new incarnation covers a broader range of disciplines—extending from the natural to the social sciences, and humanities—and operates as a coordinated network. An essential mandate of WDS is to facilitate the scientific research endeavour by coordinating and engaging collaborations between trusted open scientific data services for the provision, use, and preservation of datasets, in particular those relevant to the research conducted under the ICSU umbrella. To fulfil its remit, WDS supports the establishment of 'communities of excellence' for scientific data management by certifying member organizations—holders and providers of data or data products—from wide-ranging fields using internationally recognized standards. WDS Members are then the building blocks of a searchable common infrastructure with which to form an open data system that is both interoperable and distributed.

WDS is faced with key challenges and its Scientific Committee decided to address these by advancing a number of strategic targets. For example to ensure that trusted data services are an integral part of research. It is essential that research projects consider their data needs and engage relevant data services from the early stages of the scientific planning. To achieve this target, appropriate bridges need to be actively established between the research programmes and the data communities. Another target is to strengthen disciplinary and multidisciplinary data services communities. It is necessary for these communities to reach a critical mass allowing them to sustain the services needed by the research communities they serve. On another front, WDS is working with research funders to make sure that research funding includes data planning and management activities. It is also crucial to improve trust in and quality of open scientific data services to ensure scientific integrity. The WDS certification procedure and the promotion of good practices such as publishing data are examples of activities in this area. To reach these targets will require WDS to effectively engage stakeholders beyond the data communities: the research community itself, science publishers, research funders, the private sector, and policy makers.

Data services need to respond to new mandates and requirements dictated by the Open Science paradigm. They need also to adapt to a rapidly changing research landscape. WDS is positioning itself as the premium global multidisciplinary network for quality-assessed scientific research data, and together with its partners, it is working at the forefront of these issues to facilitate this adaptation.

[0-4]

VARIABILITY OF THE SUN AND ITS TERRESTRIAL IMPACT (VARSITI): SCOSTEP'S SCIENTIFIC PROGRAM IN 2014-2018

K Shiokawa[1] and K Georgieva[2]*

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The solar activity was extremely low during the last solar minimum for an extended period, and the present maximum of sunspot cycle 24 is the lowest in the last 100 years. It is not clear what long-term solar activity variations we can expect in the future: whether this is just the end of the recent decades of high solar activity, or whether the Sun is entering a Maunder-type minimum. Moreover, it is not clear to what extend our present understanding of how the Sun influences the geospace - which is based on instrumental observations taken during only the period of high solar activity in the second part of the 20th century - will hold during periods of more moderate to low solar activity that may follow. And it is still more unclear how all this would affect global climate change, or how important becomes the penetration of various inputs from the Earth's lower atmosphere to the ionosphere and plasmasphere. In 2014-2018 the Scientific Committee On Solar-TErrestrial Physics (SCOSTEP) operates the scientific program "Variability of the Sun and Its Terrestrial Impact" (VarSITI) which will focus on the recent and expected future solar activity and its consequences for the Earth, for various time scales from the order of thousands years to milliseconds, and for various locations and their connections from the solar interior to the Earth's atmosphere. In order to elucidate these various Sun-Earth connections, we encourage much closer communications between solar scientists (solar interior, atmosphere, and heliosphere) and geospace scientists (magnetosphere, ionosphere, and atmosphere). Campaign observations/data analysis for particular intervals, VarSITI web pages (http://www.varsiti.org/), mailing lists, and newsletters, are developed for this purpose. Four scientific projects are carried out under the VarSITI program: (1) Solar Evolution and Extrema (SEE), (2) International Study of Earth-Affecting Solar Transients (ISEST/MiniMax24), (3) Specification and Prediction of the Coupled Inner-Magnetospheric Environment (SPeCIMEN), and (4) Role Of the Sun and the Middle atmosphere/thermosphere/ionosphere In Climate (ROSMIC). These four projects will be carried out in collaboration with relevant satellite and ground-based missions as well as modeling efforts to facilitate the implementation of the projects. We will also discuss the collaboration with other on-going international projects like the UN-based space weather activities, particularly for promoting VarSITI-related science in developing countries, and ICSU World Data System (ICSU-WDS).

[2-1]

ISEST DATA PRODUCTS AND CAMPAIGN STUDY

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The International Study of Earth-Affecting Solar Transients (ISEST) (ISEST/MiniMax) is one of the four projects of SCOSTEP's VarSITI program (2014-2018). The project coordinates international activity in observation, theory and modeling, and involves scientists from both developed and developing countries.The project is aimed at bringing together scientists from different countries to interact and establish collaboration links that can effectively address the physical mechanisms of the origin, propagation, and Earth impact of coronal mass ejections (CMEs) and other transient events. The ultimate goal is to develop the capability to predict the arrival of solar transients at Earth and their potential Space Weather consequences. I will present the progress of this project with a focus on (1) a jointed study on data collection and analysis, and (2) the campaign study within ISEST and the connection to VarSITI.

[2-2]

EXTREME SPACE WEATHER EVENTS AS SEEN IN THE HISTORICAL GEOMAGNETIC RECORDS OF COLABA, INDIA AND THEIR ESTIMATION OF INTERPLANETARY CONDITIONS

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Geomagnetic variations recorded at ground can well project the role of electromagnetic fields and currents in the ionosphere. Active regions in the sun give rise to flares, coronal mass ejections and several major solar energetic particle events of varying amplitudes and characteristics resulting in geomagnetic disturbances. Solar flares and Coronal Mass Ejections (CMEs) are the most prominent and violent manifestation of the solar activity. When the ejecta from solar flares and CMEs hit the Earth's magnetosphere, they often lead to intense magnetic storms. The geomagnetic data from Colaba Magnetic Observatory consisted of systematic hourly eye observations using Grubb’s magnetometer from 1847 to 1872 in continuation of the earlier series of observations at Colaba since 1841. The regular daily photographic records of the geomagnetic components are available since 1872 to 1905 from Colaba. The geomagnetic records from Colaba-Alibag observatories in India, contain historically the longest and continuous observations recorded on photographic paper since 1872 to the present day digital data using modern magnetometers. Data reduction and analysis techniques evolved at various stages of data processing. Some of the super intense space weather events are investigated using old preserved historical records of Colaba, India. The study of super intense storms after 1900 as recorded at Alibag Observatory will provide important insights into plausible interplanetary conditions for intense geomagnetic storms and probable frequency of their occurrence. Following the *Burton et al*. [1975], an empirical relationship is derived for estimation of interplanetary electric field (IEFy) from the variations of Dst index and ΔH at Colaba-Alibag observatories. The estimated IEFy values using Dst and ΔH_{ABG} variations agree well with the observed IEFy, calculated using ACE (Advanced Composition Explorer) satellite observations for intense geomagnetic storms in solar cycle 23. This study will provide the uniqueness of each event and provide important insights into possible interplanetary conditions for intense geomagnetic storms and probable frequency of their occurrence. The WDC Mumbai activities and data preserving, digitization process will be presented as a member of WDS.

REFERENCES

Burton R. K., R. L. McPherron, and C. T. Russell (1975), Empirical relationship between interplanetary conditions and Dst, *J. Geophys. Res*., 80, 4204.

[2-3]

GLOBAL SOLAR ACTIVITY IN CYCLE 24

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The solar activity cycle 24 has two peaks, the first one around 2012 and the second one around 2014. Activities of the first peak are mainly in the northern hemisphere and that of the second peak are in the southern hemisphere. We study these activities and high latitude activities using a butterfly diagram synthesized from daily radio images at 17 GHz observed by the Nobeyama Radioheliograph.

In the northern hemisphere, low latitude activity started to decline after the peak in 2012 but the decline slowed down after mid-2013. On the other hand, high latitude activity does not show any sign of increase after the minimum in 2012. These situations can be easily identified in a hysteresis curve (plot of high latitude average brightness vs low latitude average brightness). The data points in the curve continue to approach to the lower left corner, which means activity (both at high and low latitudes) is declining. Also, activity rhythm seems to be lost in the northern hemisphere.

On the other hand, southern hemisphere seems to keep activity rhythm and the current activity level is close to that of the cycle 23. Low latitude activity started to decline after the peak in 2014 and high latitude activity started to increase. The hysteresis curve after 2014 mimics that of the declining phase of the 23 cycle. EUV full disk images taken by AIA/SDO show that the south polar region is covered by well-developed coronal hole, but not the north pole yet.

Solar activity indices such as relative sunspot numbers and total microwave fluxes show that the cycle 24 is low activity. With the help of the radio butterfly diagram, we can see that activities in the northern and the southern hemisphere are quite different. The southern hemisphere seems to be keeping its activity level compared to the previous cycle but the activity in the northern hemisphere seems to be weakening and losing activity rhythm.

[2-4]

GEOMAGNETIC STORMS OF CYCLE 24 AND THEIR SOLAR SOURCES

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Maximum of cycle 24 occurred in April 2014 with the maximum sunspot number (SSN) of 116.4 according to 13-month smoothed monthly SSN from the WDC-SILSO, Royal Observatory of Belgium, Brussels. This value of the maximum SSN is low since cycle 14 (1902-1913). Geomagnetic activity of cycle 24 is also low reflecting this low solar activity. The St. Patrick's Day storm in March 2015 is only one storm of cycle 24 with Dst index less than -200 nT. We picked up geomagnetic storms with Dst index less than -100 nT and identified their solar sources. Fourteen storms are picked up as shown in Table 1. The Summer Solstice storm on July 2015 is the second largest storm of cycle 24. Main cause of the geomagnetic storms are coronal mass ejections (CMEs) because the analyzed period is rising and maximum phases of cycle 24. Relatively slow CMEs contributed to the geomagnetic storms according to our analysis. We will report on the geomagnetic storms of cycle 24 and their solar sources using several examples.

Table 1 Geomagnetic storms of cycle 24 with Dst index less than -100 nT

No.	Date	Min. Dst (nT)	Type	Solar Sources	Speed at 1AU (km/s)
1	2011/08/05 17:50 -2011/08/06 15:00	-115	SC	full halo CME	611
2	2011/09/26 12:35-2011/09/28 17:00	-118	SC	full halo CME	704
3	2011/10/24 18:31-2011/10/25 21:00	-147	SC	full halo CME	534
4	2012/03/08 11:03-2012/03/10 19:00	-131	SC	full halo CME	737
5	2012/04/23 03:20-2012/04/26 16:00	-108	SC	partial halo CME	720
6	2012/07/14 18:10-2012/07/17 12:00	-127	SC	full halo CME	667
7	2012/09/30 11:32/23:05-2012/10/01 16:00	-119	SC	full halo CMEs	410
8	2012/10/08 05:16-2012/10/09 24:00	-105	SC	partial halo CME	526
9	2012/11/12 23:12-2012/11/14 19:00	-108	SC	partial halo CME	467
10	2013/03/17 06:00-2013/03/18 12:00	-132	SC	full halo CME	725
11	2013/05/31 16:17-2013/06/02 21:00	-119	SC	coronal hole	774
12	2014/02/18 13:54-2014/02/19 23:00	-112	GC	partial halo CME	530
13	2015/03/17 04:45-2015/03/21 15:00	-223	SC	partial halo CME	683
14	2015/06/22 18:33-2015/06/24 12:00	-195	SC	full halo CME	742

SC means Sudden Commencement and GC means Gradual Commencement.

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We acknowledge SSN data for the WDC-SILSO, Dst indices for WDC-Geomagnetism, Kyoto, the geomagnetic storm catalog for Kakioka Magnetic Observatory, Japan Metrological Agency, and solar wind data for OMNI database, NASA Space Science Data Coordinated Archive. The CME catalog used in this study is generated and maintained at the CDAW Data Center by NASA and The Catholic University of America in cooperation with the Naval Research Laboratory. SOHO is a project of international cooperation between ESA and NASA.

[2-5]

OVERVIEW OF SOLAR-TERRESTRIAL ENVIRONMENT BETWEEN MARCH AND SEPTEMBER, 2015

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The space weather event report workshop promotes the overview and collaborative analysis of observation and simulation data to study the cause-effect activities of space weather environment between the Sun and the Earth for recent a half year. In this workshop, we will introduce the space weather environment report from March to September, 2015.

The sunspot number has decreased since the middle of 2014. From the 13month moving average of sunspot relative number of Sunspot Index and Long-term Solar Observations, the maximum definitive value of sunspot number is 116.4 at April 2015. In addition, latest definitive value is 101.9 at September 2014, and latest final predicted definitive value is 89.8 at January 2015. Cycle 24 seems to be the declining phase as both this prediction model and observation. We can see some over M-class flares from GOSE satellite X-ray flux observation data during this period. However, there were only two X-class flare, 11 March (X2.1) and 5 May (X2.7). We encountered concentrated flare occurrence at this March, and some long duration events at this June. In present, X-ray flare activity is settled in low. There are three high solar energetic particle events in June. In particular, a proton event with a full halo CME at 21 June has 1070 PFU. This is the fourth largest proton event in solar cycle 24. Except the above period, proton event activity is not so high.

There are two severe geomagnetic storms with Dst-index value less than -100 nT in latest a half year. Especially during 15-18 March 2015, we encountered a severe geomagnetic storm event called "St. Patrick's Day 2015 Event". A long duration C-class solar flare and related CMEs were occurred on 15 March. In the result, a severe geomagnetic storm (minimum Dst index was -228 nT) were observed during 16-18 March. It is the first and largest event reported over -200nT Dst index in solar cycle 24. However, no large solar energetic particle and related events were observed, and therefore, we could not forecast such a huge geomagnetic storm attacked to the Earth. For investigating the mechanism of this complex space weather event between Sun and Earth region, it is important to make cross-cutting studies with various kinds of data observed at various regions and methods. We will show some integrated analysis results of this severe geomagnetic storm event.

ACKNOWLEDGEMENTS

We thank to all the creators, archivers, and provider of various kind of space weather related data. We also thank to the IUGONET project providing the integrated data analysis software and metadata database for ground based upper atmosphere observations.

REFERENCES

STE Event Reports Workshop website: http://www2.nict.go.jp/aeri/swe/swx/ste/ste-e.html

[2-6]

THE FIRST SUPER GEOMAGNETIC STORM OF SOLAR CYCLE 24: "THE ST. PATRICK DAY (17 MARCH 2015)" EVENT

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The first super geomagnetic storm of solar cycle 24 occurred on the "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 March 15, 2015. At ~2:10 UT on that day, *SOHO/LASCO* C3 recorded a partial halo corona mass ejection (CME) which was associated with a C9.1/1F flare (S22W25) and a series of type II/IV radio bursts. The propagation speed of this CME is estimated to be ~668 km/s during 02:10 – 06:20 UT (Figure 1). An interplanetary (IP) shock, likely driven by the CME, arrived at the *Wind* spacecraft at 03:59 UT on 17 March (Figure 2). The arrival of the IP shock at the Earth may have caused a sudden storm commencement (SSC) at 04:45 UT on March 17. The storm intensified (Dst dropped to -80 nT at ~10:00 UT) during the crossing of the CME sheath. Later, the storm recovered slightly (Dst ~ -50 nT) after the IMF turned northward. At 11:01 UT, IMF started turning southward again due to the large magnetic cloud (MC) field itself and caused the second storm intensification, reaching Dst = - 228 nT on March 18. We conclude that the St. Patrick day event is a two-step storm. The first step is associated with the sheath, whereas the second step is associated with the MC. Here, we employ a numerical simulation using the global, three-dimensional (3D), time-dependent, magnetohydrodynamic (MHD) model (H3DMHD, Wu et al. 2007) to study the CME propagation from the Sun to the Earth. The H3DMHD model has been modified so that it can be driven by (solar wind) data at the inner boundary of the computational domain. In this study, we use time varying, 3D solar wind velocity and density reconstructed from STELab, Japan interplanetary scintillation (IPS) data by the University of California, San Diego, and magnetic field at the IPS inner boundary provided by CSSS model closed-loop propagation (Jackson et a., 2015). The simulation result matches well with the in situ solar wind plasma and field data at *Wind*, in terms of the peak values of the IP shock and its arrival time (Figure 3). The simulation not only helps us to identify the driver of the IP shock, but also demonstrates that the modified H3DMHD model is capable of realistic simulations of large solar event. In this presentation, we will discuss the CME/storm event with detailed data from observations (*Wind* and *SOHO*) and our numerical simulation.

***Key words**: Realistic 3D MHD simulation, coronal mass ejection, interplanetary shock, super geomagnetic storm

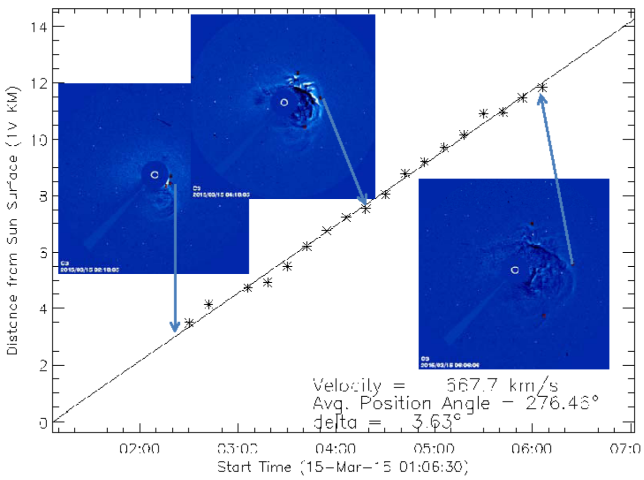

Figure 1. *SOHO/LASCO* C3 recorded a partial halo corona mass ejection (CME) during 02:10-0620UT on 15 March 2015. The propagation speed of this CME is estimated to be ~668 km/s during 02:10 – 06:20 UT.

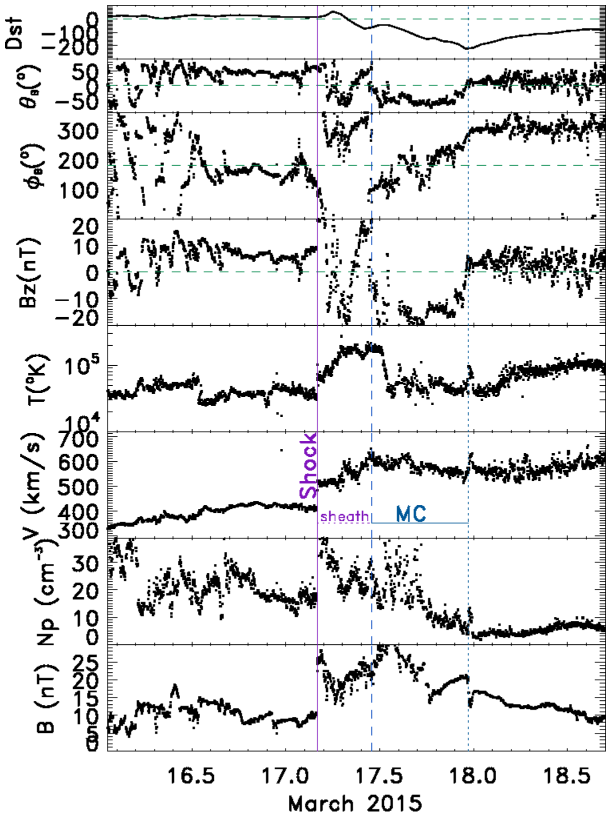

Figure 2: Geomagnetic activity index (Dst: top panel) and *Wind* observed in situ solar wind parameters (1^{st} - 7^{th} panels) during March 16-18, 2015. From Top to Bottom: Dst, latitude (θ_B) and longitude (ϕ_B) in GSE cords., Bz of the field in GSE, proton temperature (T), bulk speed (V), and number density (Np), magnetic field (B) in terms of magnitude. The blue horizontal line in the 3^{rd} panel represents the scheme's identification of the extent of this MC candidate [Lepping et al., 1990]. The purple-solid line and blue-dashed lines represent the IP shock and the front boundary of the MC.

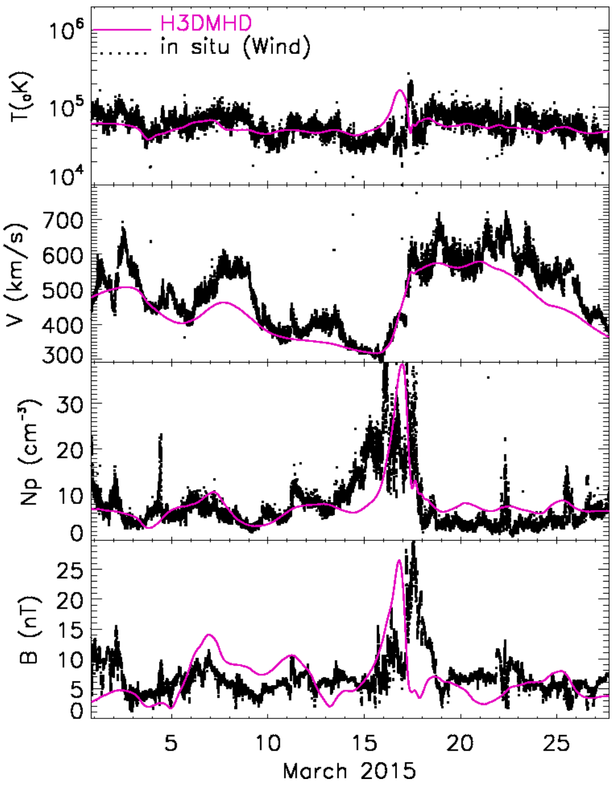

Figure 3: Observation (black-dotted curves observed by *Wind*) and simulation (pink-solid curved simulated by IPS-H3DMHD) of solar wind parameters during 01-27 March, 2015. From Top to Bottom: solar wind temperature (T), bulk speed (V), and number density (Np), magnetic field (B) in terms of magnitude.

[2-7]

FLUX ROPE STRUCTURES OF THE SOLAR WIND ASSOCIATED WITH TWO INTENSE GEOMAGNETIC STORMS IN 2015: THE 17 MARCH AND THE 22 JUNE STORMS

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We have analyzed the solar wind magnetic field structures associated with the two intense geomagnetic storms in 2015: the 17 March storm (minimum Dst = -223 nT, provisional) and the 22 June storm (minimum Dst = -195 nT, real-time). In both cases, flux rope structures are found in the solar wind data during the storm main phase. The flux rope analysis for the 17 March event yields two possible flux rope geometries, one cylinder model and one torus model. Of the two geometries, the result from the torus model well matches the observations of the solar source related to the storm, if it is assumed that the axis direction of the flux rope was parallel to the polarization inversion line (PIL) of the active region 12297 when erupted, and that it propagated through interplanetary space without change of the axis direction (See Marubashi et al. 2015). In case of the 22 June storm, the flux rope fitting provides two possible flux rope geometries from the torus model: one with left-handed chirality and the other with right-handed chirality; and no satisfactory result from the cylinder model. In this case however, we find that the photospheric magnetic field polarity change across the PIL in the solar source region is opposite to that suggested from the solar wind observation. Thus, the 22 June event is a very challenging case to our understanding of connection between the solar eruption and the interplanetary magnetic flux rope. It suggests three possibilities: (1) There is some uncertain effect in the process of the flux rope analysis; (2) The parallelism does not always hold true between the flux rope axis and the PIL; and (3) The solar source event may be different from that we assumed. We are still making an effort to find evidence for the third possibility, and expect reliable results from more detailed studies during this Data Analysis Workshop.

ACKNOWLEDGEMENTS

We thank the WIND/MFI and SWE teams for the solar wind data. We would like to acknowledge our thankfulness also to NSSDC, NASA/GSFC, for providing the WIND data through the CDAWeb.

REFERENCES

Marubashi, K., Akiyama, S., Yashiro, S., Gopalswamy, N., Cho, K.-S., and Park, Y.-D., (2015) Geometrical relationship between interplanetary flux ropes and their solar sources. *Solar Physics*, 290, pp 1371-1397 .

[2-8]

PILEUP ACCIDENT HYPOTHESIS OF MAGNETIC STORM ON 2015 MARCH 17

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We propose a "pileup accident" hypothesis, based on the solar wind data analysis and magnetohydrodynamics (MHD) modeling, to explain unexpectedly geoeffective solar wind structure which caused the largest magnetic storm so far during the solar cycle 24 on 17 March 2015: First, a fast coronal mass ejection with strong southward magnetic fields both in the sheath and in the ejecta was followed by a high-speed stream from a nearby coronal hole. This combination resulted in less adiabatic expansion than usual to keep the high speed, strong magnetic field, and high density within the coronal mass ejection. Second, preceding slow and high-density solar wind was piled up ahead of the coronal mass ejection just before the arrival at the Earth to further enhance its magnetic field and density. Finally, the enhanced solar wind speed, magnetic field, and density worked all together to drive the major magnetic storm.

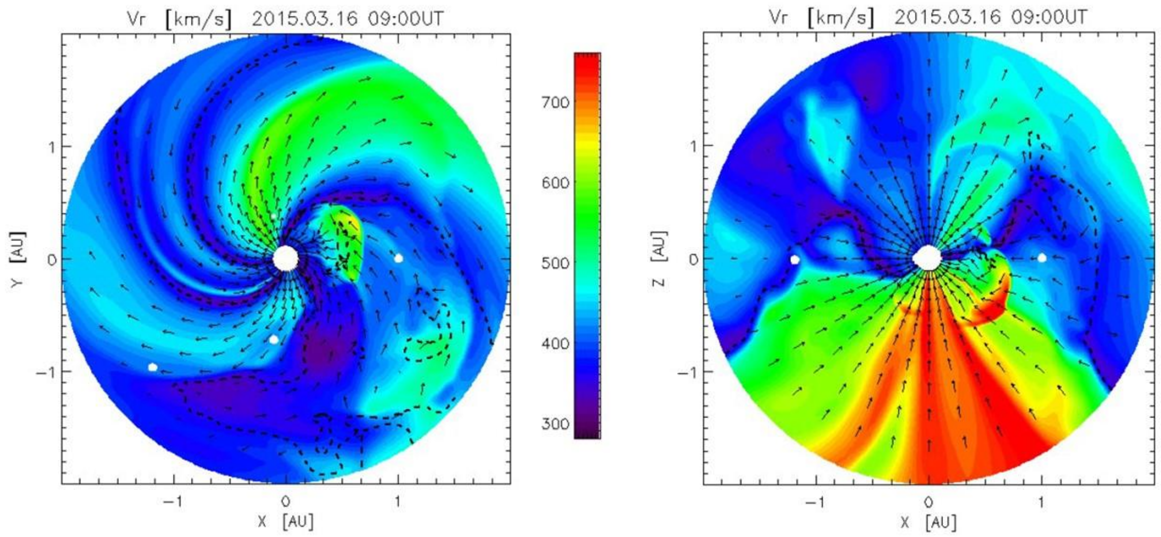

Figure 1. Solar wind speed (color) and magnetic field directions (arrows) as reproduced by the MHD simulation.

REFERENCES

Kataoka, R., D. Shiota, K. Emilia, and K. Keika (2015), Pileup accident hypothesis of magnetic storm on 2015 March 17, Geophys. Res. Lett, doi:10.1002/2015GL064816.

[2-9]

VAN ALLEN PROBES OBSERVATION OF PROMPT ENERGIZATION OF ELECTRONS TO ULTRA-RELATIVISTIC ENERGIES DURING THE 17 MARCH 2015 IP SHOCK

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On 17 March 2015, a strong interplanetary shock impacted the Earth's magnetosphere, which resulted in a super-geomagnetic storm with minimum Dst reaching below -200 nT. The radiation belts responded to the shock and subsequent coronal mass ejection both in a gradual and impulsive manner. While the gradual response led to a build-up of ultra-relativistic electron fluxes, which peaked over several days, the shock itself also resulted in rapid, almost instantaneous energization. Energetic particle instruments onboard Van Allen Probes observed this near instantaneous energization of electrons to ultra-relativistic energies, which were seen deep within the magnetosphere at L~3.3 injected as a result of the shock impact. We present electron measurements from the Relativistic Electron-Proton Telescope (REPT) and the Magnetic Electron Ion Spectrometer (MagEIS) onboard the Van Allen Probes mission. We discuss both the gradual development and the prompt energization of radiation belt electrons. Other aspects of this unique event include the so-called butterfly pitch angle distributions observed deep inside the magnetosphere. These kinds of pitch angle distributions are normally seen at high L shells and are attributed to drift shell splitting. The high-energy electron observations are complemented by the electric and magnetic field measurements from the **Electric and Magnetic Field Instrument Suite and Integrated Science (EMFISIS) instrument. In-situ measurements from the WIND and Themis are used to fully characterize the interplanetary shock properties.**

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[2-10]

RECENT GEOEFFECTIVE SPACE WEATHER EVENTS AND TECHNOLOGICAL SYSTEM IMPACTS

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We review the state of the space environment for three recent intense geoeffective storms using NOAA observations and model predictions. On February 27, 2014, the US Wide Area Augmentation System (WAAS) navigation service over eastern Alaska and northeastern continental US was degraded due to a strong ionospheric storm. Similarly, on March 17, the St. Patrick's Day geomagnetic storm commenced, resulting in the most intense storm of the solar cycle to date with mid-latitude auroral sightings, intense ionospheric irregularities and WAAS degradation. On June 22, a strong (G4) geomagnetic storm commenced following the impact of 3 coronal mass ejections (CMEs). Late on June 22, solar protons entered the polar regions along open magnetic field lines producing intense radio absorption. We summarize, compare and contrast the space environmental state for each of these events from the perspective of NOAA observations and model predictions. We do so by leveraging GOES and POES/MetOp observations of the space radiation environment, DMSP observations of precipitating particles and bulk plasma parameters, OVATION Prime predictions of the auroral energy input and the US Total Electron Content (USTEC) and D-Region Absorption Prediction (DRAP) modeled response of the ionosphere. We discuss impacts to technological systems as available.

[2-11]

EXPERIENCES OF FORECASTING THE MAGNETIC STORMS OF MARCH AND JUNE 2015 AND ANALYSIS OF THE RESULTING GROUND EFFECTS IN THE UK

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Since the 1990's the British Geological Survey (BGS) have issued a daily (Monday to Friday) three-day geomagnetic activity forecast. Recipients of this service have included the Met Office, as part of the UK's 'National Hazards Partnership' that provides government with data and analysis, and power companies concerned about geomagnetic induced currents (GIC).

The St. Patrick's Day storm of 17th March 2015 was the first magnetic storm since August 2005 with a daily *Ap* > 100. By this measure it could be considered to be the largest magnetic storm of solar cycle 24 (so far). The magnitude of the geomagnetic activity was surprising as the solar event signatures preceding it were not considered that remarkable. The magnetic storms of 21st – 24th June, caused by a series of Earth-directed coronal mass ejections, resulted in further significant geomagnetic activity. This time daily *Ap* reached a peak of 73 on the 23rd June 2015. In each case the magnetic storms reached a peak of G4 in the NOAA Space Weather scale for geomagnetic storms. Both these events are described from the viewpoint of BGS operational space weather forecasters.

In the UK BGS operate three magnetic observatories continuously recording the Earth's magnetic field. Additionally since 2013, BGS also monitor changes to the geo-electric field at all three observatories. These geomagnetic and geo-electric data are used to model and research the impact of GIC on the UK power grid. Observational and modeling results from both the March and June storms are presented and discussed.

[2-12]

UPPER ATMOSPHERE DATA IN THE POLAR REGION DURING THE MARCH 17-18 AND JUNE 22-24, 2015 GEOMAGNETIC STORMS

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The Japanese Antarctic Research Expedition (JARE) started on the occasion of the International Geophysical Year (IGY) and has performed various observations at Syowa Station and the surrounding areas. National Institute of Polar Research (NIPR) involves in a wide range of activities in the Antarctic research programs, especially through long-term monitoring observations and advanced researches of the Antarctic region. We, space and upper atmospheric sciences group, NIPR, have been conducting ground-based network observations in the Arctic region as well as the Antarctic region, with optical imagers, radars, and magnetometers. Such observational data are used to study the mechanisms of various auroral phenomena, solar wind-magnetosphere-ionosphere interaction, and coupling processes in the middle and upper atmosphere in the polar regions.

The space and upper atmospheric sciences group, NIPR, is a member of IUGONET (Inter-university Upper atmosphere Global Observation NETwork), which is a Japanese inter-university project that started in 2009 to build research infrastructure for the upper atmospheric studies, such as metadata database and data analysis software (Hayashi et al., 2013). As a part of the project activities, we converted most types of the upper atmospheric data at NIPR to CDF (Common Data Format) files and released them to the public via the internet. The converted files can be easily loaded, visualized, and analyzed with SPEDAS (Space Physics Environment Data Analysis Software), which was developed using IDL (Interactive Data Language) and includes a plug-in module provided by IUGONET.

We will show the upper atmospheric data obtained by auroral imagers, magnetometers, and ionospheric radars in the Arctic and Antarctic regions during the geomagnetic storms on March 17-18 and June 22-24, 2015. In addition, we will briefly introduce how easily these data can be visualized and analyzed with SPEDAS.

REFERENCE

Hayashi, H., Y. Koyama, T. Hori, Y. Tanaka, S. Abe, A. Shinbori, M. Kagitani, T. Kouno, D. Yoshida, S. UeNo, N. Kaneda, M. Yoneda, N. Umemura, H. Tadokoro, T. Motoba, and IUGONET project team (2013), Inter-university Upper Atmosphere Global Observation NETwork (IUGONET), Data Sci. J., 12, WDS179-WDS184.

[2-13]

ENERGETIC PARTICLE PRECIPITATIONS IMPACTS ON THE MESOSPHERE OBSERVED BY THE PANSY RADAR

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Polar Mesosphere Winter Echo (PMWE) is known as back scatter echo from 55 to 85 km in the mesosphere, and it has been observed by MST and IS radar in polar region during winter. Due to the lack of free electrons as scatterer in the dark mesosphere during winter, it is suggested that PMWE requires strong ionization of neutral atmosphere associated with Energetic Particles Precipitations (EPPs) during Solar Proton Events [Kirkwood et al., 2002] or during geomagnetically disturbed periods [Nishiyama et al., 2015]. However, the detailed relationship between PMWE and ionization process triggered by EPPs has not been revealed yet, partly because the reported PMWE occurrence rate was quite low (2.9%) [Zeller et al., 2006].

The PANSY (Program of the Antarctic Syowa MST/IS) radar, which is the largest MST radar in Antarctica, observed many PMWE events since it has started mesosphere observations in June 2012. In this presentation, we would like to focus on occurrence characteristics of PMWE during two big geomagnetic storm events as St. Patrick's Day and the Summer Solstice 2015 Event. On 19 and 22 March corresponding to recovery phase of St. Patrick's Day Storm, strong PMWE was suddenly detected near 60 km altitudes by the PANSY radar. In order to estimate background electron density for PMWE altitudes, we established an application method of the PANSY radar as riometer using measured temporal variations of background noise level. As a result, strong Cosmic Noise Absorptions (CNA) of ~ 0.8 dB and 1.0 dB were detected at the same time as the intensifications of PMWE on 19 and 22 March, respectively. This strongly suggested that EPPs generated on the recovery phase of the storm triggered electron density enhancement at PMWE altitudes. It should be noted that this is the first simultaneous measurement of PMWE and CNA in the exact common volume during such a large magnetic storm by single MST radar. Moreover, we will report intensification of nighttime PMWE detected around 16 UT, which is equal to 19 LT at Syowa station, corresponding to onset of the Summer Solstice 2015 Event. Since PMWE observations are primarily confined to daytime because of relatively abundant free electrons in the illuminated mesosphere, this strong and long-lived nighttime PMWE implies that EPPs related to the storm caused the sporadic ionization sufficient for PMWE even in dark mesosphere.

REFERENCES

Kirkwood, S., V. Barabash, E. Belova, H. Nilsson, T. N. Rao, K. Stebel, A. Osepian, and P. B. Chilson (2002) Polar mesosphere winter echoes during solar proton events, *Adv. Polar Upper Atmos. Res.*, *16*, 111–125.

Nishiyama, T., K. Sato, T. Nakamura, M. Tsutsumi, T. Sato, M. Kohma, K. Nishimura, Y. Tomikawa, M. K. Ejiri, and T. T. Tsuda (2015) Height and time characteristics of seasonal and diurnal variations in PMWE based on 1 year observations by the PANSY radar (69.0◦S, 39.6◦E), *Geophys. Res. Lett.*, *42*, doi:10.1002/2015GL063349.

Zeller, O., M. Zecha, J. Bremer, R. Latteck, and W. Singer (2006) Mean characteristics of mesosphere winter echoes at mid- and high-latitudes, *J. Atmos. Sol. Terr. Phys.*, *68*, 1087–1104.

[2-14]

MULTI-INSTRUMENTAL STUDY OF THE IONOSPHERIC RESPONSE TO THE 2015 ST. PATRICK'S DAY STORM

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The geomagnetic storm of 17-18 March 2015 (the St. Patrick's Day 2015 storm) was the strongest one in the 24th solar cycle (minimum SYM-H value of -233 nT). In this study we: 1) analyze the ionospheric response on a global scale by making use of numerous ground-based and space-born instruments; 2) study the occurrence of the plasma density irregularities in the topside ionosphere. The instruments used are ground-based GPS-receivers as well as GPS-receivers onboard several Low-Earth-Orbit (LEO) satellites: the three Swarm satellites (A, B, C), TerraSAR-X, GRACE and Jason-2 satellites (Figure 1). We select multi-site chains of the ionospheric sounding stations at different longitudinal sectors and co-located GPS receivers for detailed study the ionospheric response in the F region and the ionospheric total electron content (TEC).

Our analysis revealed that the storm provoked quite complex ionospheric effects throughout the globe. At high-latitudes, negative storm signatures were recorded in all longitudinal regions. The negative storm phase was found to be strongest in the Asian sector, in particular in the northern hemisphere (NH), but developed globally on March 18 at the beginning of the recovery phase. At mid-latitudes, inverse hemispheric asymmetries occurred in different longitudinal regions: in the European-African sector, positive storm signatures were observed in the NH, whereas in the American sector, a large positive storm occurred in the southern hemisphere (SH), and the NH experienced a negative storm. At low-latitudes, data from multiple satellites revealed the strongest storm-time effects in the morning (~100-150% enhancement) and post-sunset (~80-100% enhancement) sectors in the topside ionosphere. These dramatic VTEC enhancements were observed at different UT, but around the same area of Eastern Pacific region.

We report the significant intensification of the topside (above 500 km) plasma density irregularities at the main and recovery phases of the geomagnetic storm. The most intense irregularities the two specific zones of: 1) the region of the auroral oval and main ionospheric trough at high latitudes of both hemispheres; 2) the low- and equatorial latitudes in the Atlantic and Pacific region. Main peculiarities of the observed ionospheric plasma density redistribution, interhemispheric differences and physical mechanisms are discussed in the paper.

[2-15]

DYNAMICS OF IONOSPHERIC CONVECTION ASSOCIATED WITH LOW LATITUDE AURORA IN HOKKAIDO DURING THE MARCH 2015 STORM

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The 2015 March storm (St. Patrick's Day storm), which occurred during 17-21 March 2015, is the largest one during Solar Cycle 24 for now. During the main phase of the storm (minimum Dst=-223 nT), optical instruments installed at Rikubetsu, Hokkaido, Japan (geomagnetic altitude: 36.5 degs) registered auroral emissions during 15 to 19 UT (corresponding to 00 to 04 LT) on March 17. In addition, both the SuperDARN Hokkaido East and West radars succeeded in obtaining unprecedented set of high-time-resolution (1 to 2 mins) ionospheric convection data associated with the low latitude aurora up to below 50 degs geomagnetic latitude. It is found that the initial stage of the low latitude aurora appearance (before 1630 UT) was associated with equatorward convective flow, and later there was sheared flow structure, consisting of westward flow (about 500 m/s) equatorward of eastward flow (about 1000 m/s), with the equatorward boundary of auroral emission embedded in the westward flow region. Details of the data analysis results and their interpretation will be presented. Preliminary report on the NLC event in Japan at 17-18 UT on June 20, just before the June 2015 storm event, will also be presented.

[2-16]

LOW-LATITUDE RED AURORA OBSERVED IN JAPAN DURING THE ST. PATRICK’S DAY 2015 EVENT

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We report an event of low-latitude red aurora observed in the northern part of Japan associated with the St.Pattick’s day storm in 2015. A large geomagnetic storm took place on March 17-18, 2015 with the minimum Dst index of ~-223nT. The low latitude red aurora was observed in the northern sky of Rikubetsu, Japan (43.5N, 143.8E, dipole magnetic latitude = 35N), at 15-19UT (00-04LT) on March 17, 2015 with a maximum intensity of ~0.5 kR at a wavelength of 630.0nm. The red aurora was observed both by a meridican-scanning filter-tilting photometer and an all-sky monochromatic cooled-CCD camera. Green line emission at a wavelength of 557.7 nm was not observed during this event. The aurora appeared during the recovery phase of the geomagnetic storm; the Dst index started to increase at 00 UT on March 17. These features suggest that the observed red aurora is a Stable Auroral Red (SAR) arc which is caused by interaction of high-energy ring-current particles with cold electrons in the plasmasphere. An airglow temperature photometer at Rikubetsu also observed a weak enhancement of 427.8-nm emission at the zenith at 00-0LT with a maximum intensity of 12 R. This suggest precipitation of energetic neutral atoms to low latitudes during the recovery phase of the storm.

[2-17]

WIDE ENERGY ELECTRON PRECIPITATIONS AND THEIR IMPACT ON THE ATMOSPHERE DURING THE PULSATING AURORA

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Pulsating aurora is caused by intermittent precipitation of electrons with energies of tens of keV; the energy spectrum of the precipitating electrons is formed as a result of chorus wave particle interactions. From theory, it is expected that not only tens keV electrons but also sub-relativistic/relativistic electrons will precipitate simultaneously into the polar ionosphere because the resonance energy increases when the chorus waves propagate to higher latitudes. We analyzed a pulsating aurora event in November 2012 using several ground-based observational data from EISCAT radar, riometer, sub-ionospheric radio wave receivers, and also the Van Allen Probes satellite. The electron density profile obtained from the EISCAT Tromsø VHF radar identifies enhancements at >68 km altitudes. The electron energy spectrum derived from a Markov Chain Monte Carlo (MCMC) method indicates wide energy electron precipitation spanning from 10 - 200 keV, suggesting precipitation of this population from the outer belt. The riometer and network of sub-ionospheric radio wave observations also show energetic electron precipitation coinciding with the electron density enhancements starting at 68 km altitude. During this period, the footprint of the Van Allen Probe-A satellite was very close to Tromsø, and the satellite observed rising tone emissions of lower-band chorus (LBC) waves near the equatorial plane. Using the satellite-observed LBC and trapped electrons as an initial experimentally determined condition, we conducted a computer simulation of the wave-particle interactions. The simulation showed simultaneous precipitation of electrons at both tens of keV and a few hundred keV (Miyoshi et al., 2015). This result is consistent with the energy spectrum estimated with the MCMC method. This result revealed that electrons with a wide energy range spanning those of the plasma sheet to the outer belt simultaneously precipitate into the polar ionosphere in association with the pulsating aurora. Using the Sodankylä Ion and Neutral Chemistry (SIC) model which includes a detailed description of middle atmospheric/lower ionospheric chemistry, we also discuss the possible impacts of wide-energy electron precipitation on atmospheric composition, e.g., ozone.

REFERENCE

Miyoshi, Y, et al., Energetic electron precipitation associated with pulsating aurora: EISCAT and Van Allen
Probes observations, J. Geophys. Res., 120, doi:10.1002/2014JA020690, 2015

[3-1]

OPEN DATA, OPEN PUBLICATION AND OPEN SCIENCE APPROACH FOR GEO AND SPACE SCIENCE DOMAIN

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Geo and Space sciences thus far have been very successful even often an open and cross-domain approach did not play an essential role. But this situation is changing rapidly. The research focus is shifting into more complex non-linear and multi-domain specified phenomena, such as climate change or space environment, which only can be understood step by step using a holistic concept. So, what is necessary for a successful cross-domain and holistic approach in geo and space sciences? Research and science in general becomes more and more dependent from a fundus of multi-domain data sources. The buzzword phrase Big Data is reflecting this development. But Big Data also addresses the real exponential growing of data and information produced by measurements or simulations. The concept of Open Data or in particular the open access to scientific data is addressing the free and open availability of -at least publicly founded and generated- data. The open availability of data covers the free use, reuse and redistribution of data which have been established with the formation of World Data Centers already more than 50 years ago. So we should not forget, the basis for open data is the responsibility of the individual scientist up until the big science institutions and organizations for a sustainable management of data. Other challenges are finding or discovering and collecting the appropriate data, and preferably all of them or at least the majority of the right data. Therefore a network of individual or even better institutional catalog-based at least domain-specific data servers is necessary. In times of the WWW or nowadays Semantic Web, context enriched and mashed-up open data catalogs pointing to the appropriate data sources, step-by-step will help to overcome these obstacles. Further on, the Semantic Web provides an interoperable and universal format for data and metadata, the Resource Description Formation (RDF), which inherently enables a domain and cross-domain mashup, realized in the Linked Open Data project.

Scientific work and appropriate papers in the geo and space domain often are based on data, physical models and previous publications, which again have been dependent on data, models and publications. So in order to guarantee a high quality of scientific work, the complete verification process of the results is necessary. This is not a new discovery, but in times of Big Data a real challenge. So, what do we need for a complete verification of presented results? Yes, especially we need all the original data which has been used. But it is also necessary to get complete information about the context of the research objectives and the resulting constraints in the preparation of the raw data. Further on we need knowledge about the methods and the appropriate processing software, which have been used to generate the results. The Open Data approach enriched by the Open Publication idea is providing the concept for sustainable and verifiable scientific work. Open Publication of course stands for the free availability of scientific papers. But furthermore it focuses on mechanisms and methods within the realm of scientific publications for referencing and providing the underlying data, methods and software. Such reference mechanism are the use of Digital Object Identifier (DOI) or Uniform Resource Identifier (URI) within the Semantic Web, in our case for geo and space science data, but also methods and code. Nowadays, more and more open and private publishers are demanding such kind of references in preparation of the publishing process. In addition, references to well documented earth and space science data are available via an increasing amount of data publications. This approach serves both, the institutional geo and space science data centers and the scientists which are looking for data. The data centers increase their awareness and importance, whereas the scientists, will find the right and already DOI-referenced data in the appropriate data journals.

The Open Data and Open Publication approach finally opens out in the concept of Open Science. Open Science emphasizes an open sharing of knowledge of all kinds, based on a transparent multi-disciplinary and cross-domain scientific work. But Open Science is not just an idea, it also stands for a variety of projects which following the rules of Open Science, such as open methodology, open source, open data, open access, open peer review and open educational resources. Open Science also demands a new culture of scientific collaboration based on social media, and shared cloud technology for data storage and computing. But we should not forget, the WWW is not a one way road. As more data, methods and software for science research become freely available at the Internet, as more chances for a commercial or even destructive use of scientific data are opened. Already now, the giant search engine provider, such as Google or Microsoft and others are collecting, storing and analyzing all data which is available at the net. The usage of Deep Learning (DL) for the detection of semantical coherence of data for e.g. natural language processing or the creation of personalized on time and on location predictions, using neuronal networks and artificial intelligence methods should not be reserved for them but also used within Open Science for the creation of new scientific knowledge. Open Science does not mean just to dump our scientific data, information and knowledge into the Web. Far from it, we are still responsible for a sustainable handling of our data for the benefit of humankind.

The usage of the principles of Open Science is demonstrated on the scientific and software engineering activities for the mashup of the Japanese IUGONET, European Union ESPAS and GFZ ISDC related data server covering different geo and space science domains.

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REFERENCES

Conference presentation
Ritschel, B., Seelus, C., Neher, G., Iyemori, T., Koyama, Y., Murayama, Y., King, T., Hughes, J., Fung, S., Galkin, I., Hapgood, M., Belehaki, A., (2015) Open Science via the Mashup of Heterogenous Data Server and Systems in the Geo and Space Science Domain, 12th Annual Meeting Asia Oceania Geosciences Society 2015, Singapore, Singapore.

Ritschel, B., Seelus, C., Neher, G., Iyemori, T., Koyama, Y., Murayama, Y., King, T., Hughes, J., Fung, S., Galkin, I., Hapgood, M., Belehaki, A., (2015) Experiments for the mashup of heterogenous data systems using semantic web concepts, 26th IUGG General Assembly 2015, Praha, Czech Republic.

Ritschel, B., Seelus, C., Neher, G., Iyemori, T., Koyama, Y., Murayama, Y., King, T., Hughes, J., Fung, S., Galkin, I., Hapgood, M., Belehaki, A., (2015) Semantic Web based Mashup of Data Systems for Open Data and Open Science, Japan Geoscience Union Meeting 2015, Tokyo, Japan.

Ritschel, B., Seelus, C., Neher, G., Iyemori, T., Koyama, Y., Murayama, Y., King, T., Hughes, J., Fung, S., Galkin, I., Hapgood, M., Belehaki, A., (2015) Opportunities for the Mashup of Heterogenous Data Server via Semantic Web Technology, European Geosciences Union General Assembly 2015, Vienna, Austria.

Ritschel, B., Seelus, C., Neher, G., Iyemori, T., Koyama, Y., Murayama, Y., King, T., Hughes, J., Fung, S., Galkin, I., Hapgood, M., Belehaki, A., (2015) Mashup of Geo and Space Science Data Provided via Relational Databases in the Semantic Web, American Geophysical Union Fall Meeting 2014, San Francisco, U.S.A.

[3-2]

DATA CITATION ANALYSIS FRAMEWORK FOR OPEN SCIENCE DATA

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Recent trend of open data encourages to publish and reuse science data across the networked data repositories. Data citation is the practices of providing a citation to data in the same way as a bibliographic reference to published articles (CODATA-ICSTI, 2013). Through data citation links are formed between articles and DOI-assigned data sets in repositories. The articles cite related data sets properly, and also the data sets provide citations of all articles related to the data set. As the result, the 'web of data citation' is being formed in emerging repositories like Pangaea, ICPSR and others.

Data citation is expected to create new ways of making research data actionable for reuse. Researchers can validate a conclusion of an article through the reanalysis of cited data. Moreover, the catalogue of cited data will encourage interdisciplinary collaboration and open up new user base for the data. In order to facilitate those benefits, it is the key to locate and discover appropriate data for reuse by analyzing the web of data citation. This talk introduces our research work on data citation mining for usage analysis of open science data.

Data citation mining process starts at collecting the citation metadata from the data repositories. It is done automatically by software programs which we developed in this work, extracting lists of citing articles for each data set through the standard API (OAI-PMH) or directly from the web pages. The collected metadata are uniformly formatted to create a "data citation graph", where a citation is represented by a directed link from an article node to a data node. More than 128,000 citations have been collected from Pangaea, ICPSR, ESDS, ADA, DRYAD, DataCite and others. Figure 1 shows examples of the data citation graphs.

The analysis process discovers following characteristics of data usage from the citation graph. The most intuitive one is the data linked by a large number of articles, which we call a reputable data here. The popularity is measured by number of citation links, while it can be further detailed by classifying the citing articles by subjects and/or authors. We found another type which is a cluster of datasets co-cited by a single or a very few articles, or a data collection community (Figure 1 (a)). A typical example can be seen in Pangaea, where each community corresponds to a research project collecting a lot of data. Those data are considered to be collected intentionally for a specific subject, thus the center article provides the index to many data sets. The community is more coherent if the fewer data are cited by those articles outside the community (independent), as well as the data are similar with each other in the community (consistent). In contrast, a cluster of articles citing a single or a small number of data sets with similar subjects can be called a data sharing community. For example, in Figure 1 (b), the center data, National Social Science Survey and its similarities, are shared by groups of articles related to 'working', 'inequality' and 'attitude' issues. In fact, the web of data citation is a composite of both kinds of communities. Moreover, a hub article can be found as an article citing many reputed data. For example, in Figure 1 (c), the hub article in the center, Australian Broadcasting Cooperation (Audience Research), cites radio survey data at different locations (Brisbane radio, Melbourne radio, Sydney radio, etc.), each of which is also cited by the local report articles. The hub article is considered to play a role of a catalogue of data sets from multiple communities.

A data can be characterized by the citing articles differently from its content. That is called a referential context of the data. For example, in Figure 1 (d), the population data and the income data can also be referred to as health insurance-related data through the citing articles, while those data originally have nothing to do with it. The referential context give a different viewpoint to the data, thus facilitate 'repurposing' of the data. A more common reference can be discovered by clustering the citing articles, which represents typical usage of that kind of data.

This talk introduces and demonstrates data citation mining for usage analysis of open science data with some analysis results. To the best of our knowledge, it is the first attempt of large scale and practical data citation analysis. This benefits both data repositories and researchers with improved discoverability of cited data, as well as increasing incentives to put more data citations. The data citation mining will enhance the analysis to more comprehensive networks of research relationships between scientific data, documents, authors and funding sources.

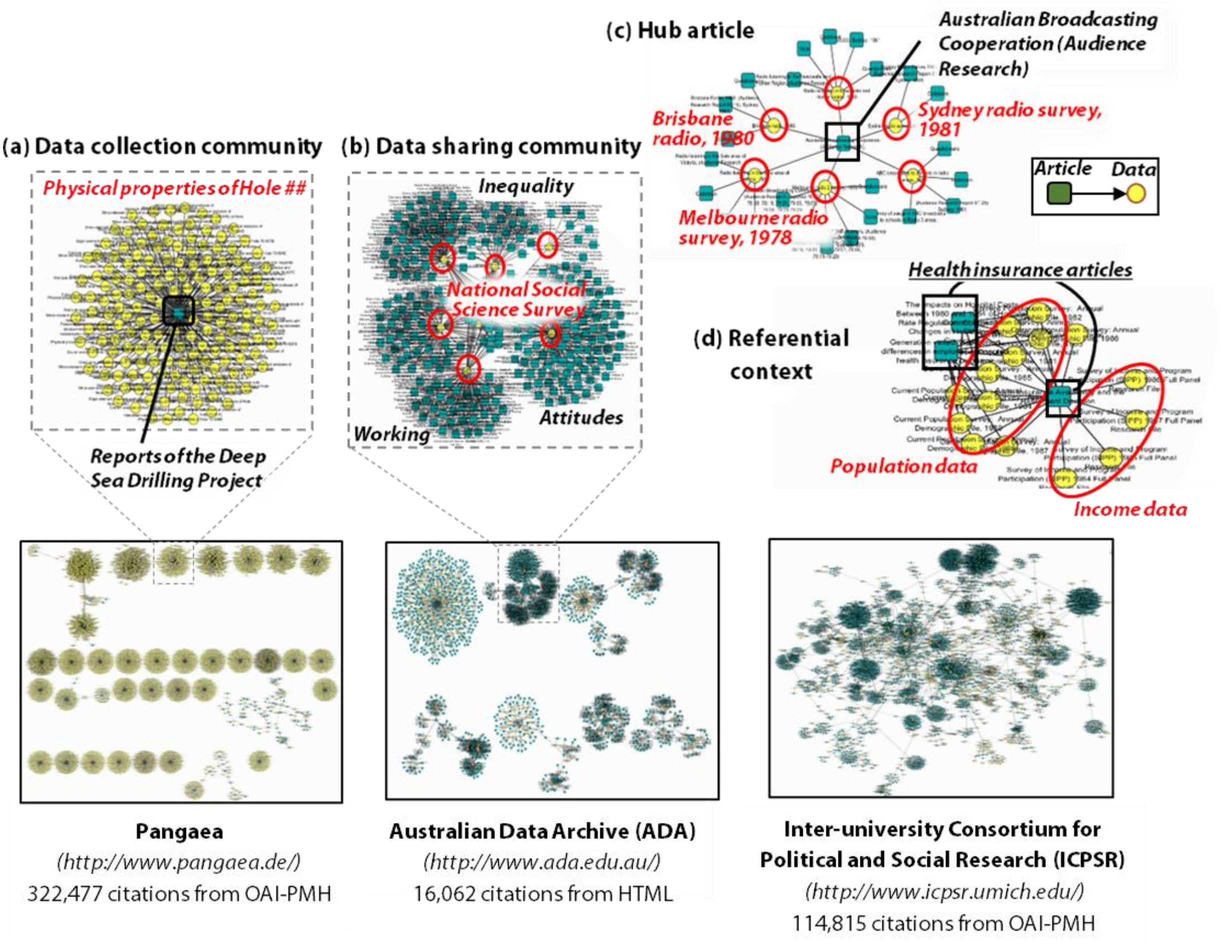

Figure 1: Examples of data citation mining

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REFERENCES

CODATA-ICSTI Task Group on Data Citation Standards and Practices (2013) Out of Cite, Out of Mind: The Current State of Practice, Policy, and Technology for the Citation of Data. Data Science Journal 12, CIDCR1–CIDCR75.

[3-3]

USING A VIRTUAL OBSERVATORY (VO) TO ENABLE MULTIDISCIPLINARY DATA ANALYSIS

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There have been numerous spacecraft launched since the beginning of Space Age to study the sun, the heliosphere, geospace and planetary environment. Many satellites are currently operating, covering different spatial and temporal domains. While individual missions have typically been developed to achieve different mission or science objectives, when taken together they effectively form an extended sensor that can be used to observe processes in the solar system as an integrated system. The fleet of operating NASA spacecraft has been referred to as the *Heliophysics System Observatory* (HSO). While space missions have finite time spans, if stored and maintained appropriately their data can remain available, accessible and usable continuously. The data from different missions can then be used in investigations even after the missions have ended. In support of distributing widely the data obtained from NASA's heliophysics missions, the *Space Physics Data Facility* (*SPDF*) and the *Solar Data Analysis Center* (*SDAC*), both at the NASA Goddard Space Flight Center, have been successful in archiving (storing, documenting and maintaining) and providing access to the mission data. As heliophysics research provides the foundation for the understanding of space weather, there is an increasing need to analyze coordinated, cross-disciplinary datasets that cut across different heliophysics domains. To extend the existing NASA heliophysics data services to better support the needs for cross-disciplinary investigations, we will explore the concept of a virtual observatory (based on the existing NASA VxO infrastructure) and examine how it could enable access to all heliophysics-relevant data obtained by NASA and non-NASA missions and ground stations.

[3-4]

NOAA NATIONAL CENTERS FOR ENVIRONMENTAL INFORMATION SPACE PHYSICS AND GEOMAGNETISM ACTIVITIES: HISTORICAL PERSPECTIVE AND FUTURE DIRECTIONS

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The NOAA Solar Geophysics Branch and Earth and Space Magnetism Team within the Center for Coasts, Oceans and Geophysics of the US National Centers for Environmental Information (NCEI) are dedicated to the observation and characterization of the natural environment from Sun to Earth. NCEI’s environmental data sets from ground to orbital platforms are vast in both space and time, with worldwide contributions of solar imagery, geomagnetic and ionospheric measurements and interpretations dating long before the 1957/1958 International Geophysical Year (IGY). With technological advancements, continuous operational measurements of the near earth space environment have trended towards the use of fully instrumented space based assets. Space platform measurements in NOAA’s current archive provide (non-inclusively) irradiance measurements of the solar disk and plasma and magnetic properties of the equatorial radiation belt charged particle environment sensed by the Geosynchronous Operational Environmental Satellites (GOES), similar plasma properties and upper atmosphere energy inputs sensed by the low earth Polar Orbiting Environmental Satellites (POES) and European Meteorological Operational (MetOp) and Defense Meteorological Satellite Program (DMSP; multi-institution collaboration) satellites. NOAA’s strong observational continuity continues with two flagship programs: the Deep Space Climate Observatory (DSCOVR) (launched February 2015) which will provide NOAA with a new operational solar wind monitoring capability and GOES-R (first launch 2016) which will advance our GEO radiation environment monitoring. The aggregated expertise within NCEI provides a powerful arsenal supporting many key, internationally valuable activities. These include leadership roles in the development of the standard International Geomagnetic Reference Field (IGRF), the World Magnetic Model and its Extension (WMM and EMM), the new Satellite Anomaly Initiative, NOAA’s foray into the Big Data arena, and numerous contributions to the operations and research communities. We present on NOAA’s past, present and future space physics and geomagnetism activities.

[3-5]

CHALLENGES IN GEOMAGNETIC DATA PROCESSING FOR A BETTER UNDERSTANDING OF GEOMAGNETIC FIELD EVOLUTION

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Geomagnetic studies require accurate and precise measurements of the Earth's magnetic field carried out from ground and space. It implies a wide range of measures starting from locating specific sites for establishment of non-magnetic pavilions with geomagnetic equipment to sophisticated data processing to produce high-quality geomagnetic data products as well as data mining applications to reveal hidden patterns in geomagnetic records. Herein we focus on several specific issues dealing with geomagnetic data handling and processing and give an overview of recent achievements in the fields of:

1. Advanced approach to storing and handling continuously transmitted data for geomagnetic field monitoring;
2. Automated realtime recognition of anthropogenic disturbances in observatory and satellite data based on fuzzy logic;
3. Operational correction of geomagnetic variations and production of quasi-definitive data;
4. Coordination and combined processing of sattelite and on-ground observations;
5. New data mining techniques for studying geomagnetic secular variation using on-ground observations;
6. New approach to data visualization.

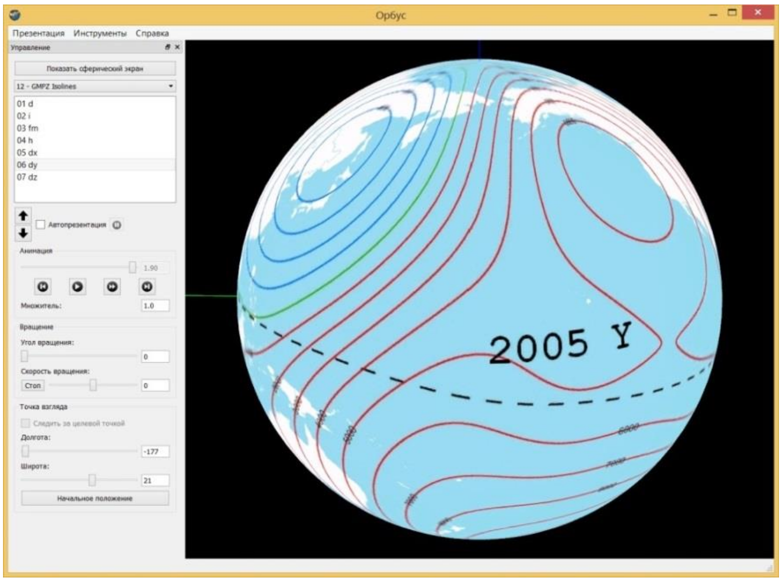

Fig.1 Example of the visualization of the Magnetic Field
using ORBUS software (component Y, year 2005).

Along with fundamental studies high-quality geomagnetic data are crucial in several industry sectors. In this paper we elucidate challenges in oil and gas industry strongly influenced by a proper separation of internal and external field contributions in geomagnetic recordings. Supported by Grant No. 14.607.21.0058 of the Ministry of Education and Science of Russia.

REFERENCES

Gvishiani, A., Lukianova, R., Soloviev, A., Khokhlov, A. (2014) Survey of Geomagnetic Observations Made in the Northern Sector of Russia and New Methods for Analysing Them. *Surveys in Geophysics* 35 (5), 1123-1154, doi: 10.1007/s10712-014-9297-8

Gvishiani, A.D., Lukianova, R. Yu. (2015) Geoinformatics and observations of the Earth’s magnetic field: The Russian segment. *Izvestiya, Physics of the Solid Earth* 51(2), 157-175

Krasnoperov, R.I., Sidorov, R.V., Soloviev, A.A. (2015) Modern Geodetic Methods for High-Accuracy Survey Coordination on the Example of Magnetic Exploration. *Geomagnetism and Aeronomy* 55 (4), 547-554, doi: 10.1134/S0016793215040076

Rybkina, A.I., Bobkov, A.E., Nikiforov, O.V., Pyatygina, O.O. (2015) Hardware and software system for visualization of geophysical data on a spherical screen. *Scientific visualization*, 7 (2), 38-49

Sidorov, R.V., Soloviev, A.A., Bogoutdinov, Sh. R. (2012) Application of the SP Algorithm to the INTERMAGNET Magnetograms of the Disturbed Geomagnetic Field. *Izvestiya, Physics of the Solid Earth* 48(5), 410–414

Soloviev A., Bogoutdinov, S., Gvishiani, A., Kulchinskiy, R., Zlotnicki, J. (2013) Mathematical Tools for Geomagnetic Data Monitoring and the INTERMAGNET Russian Segment. *Data Science Journal* 12, WDS114-WDS119 doi:10.2481/dsj.WDS-019

Soloviev, A., Chulliat, A., Bogoutdinov, S., Gvishiani, A., Agayan, S., Peltier, A., Heumez, B. (2012) Automated recognition of spikes in 1 Hz data recorded at the Easter Island magnetic observatory. *Earth Planets Space* 64 (9), 743-752 doi:10.5047/eps.2012.03.004

Soloviev, A.A., Agayan, S.M., Gvishiani, A.D., Bogoutdinov, Sh.R., Chulliat, A. (2012) Recognition of Disturbances with Specified Morphology in Time Series: Part 2. Spikes on 1-s Magnetograms. *Izvestiya, Physics of the Solid Earth* 48(5), 395-409.

[3-7]

APPLICATION OF SPEDAS TO VARSITI PROGRAM -- INTRODUCTION OF IUGONET AND ERG PLUG-INS --

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Variability of the Sun and Its Terrestrial Impact (VarSITI) program aims at understanding the current extremely low solar activity and its influence on the Earth. The VarSITI is organized by four projects as follows: SEE (Solar evolution and Extrema), MiniMax24/ISEST (International Study of Earth-affecting Solar Transients), SPeCIMEN (Specification and Prediction of the Coupled Inner-Magnetospheric Environment), and ROSMIC (Role Of the Sun and the Middle atmosphere/thermosphere/ionosphere In Climate). In particular, SPeCIMEN and ROSMIC require a comprehensive analysis of various data obtained by satellite and/or ground-based observations from multiple regions, such as solar surface, heliosphere, magnetosphere, ionosphere, and atmosphere. Thus, it is important to develop data analysis tools that enable researchers to analyze various types of data in an integrated fashion. We introduce SPEDAS (Space Physics Environment Data Analysis Software) for such an integrated analysis tool.

SPEDAS is an open-source data analysis software developed by the THEMIS Science Support Team and other contributors using IDL (Interactive Data Language). SPEDAS evolved from analysis software developed for the THEMIS mission (Angelopoulos, 2008), which was formerly called TDAS (THEMIS Data Analysis Software). SPEDAS has some useful features:

- It can download data files from remote web servers via the internet, regardless of the location and format of the files.
- Many useful routines for time series analysis are available.
- A GUI (graphical user interface) is available to those new to IDL and SPEDAS.
- It can be used with or without IDL license.
- It supports plug-in modules for multiple projects, such as THEMIS, GOES, WIND, ERG, and IUGONET.

IUGONET (Inter-university Upper atmosphere Global Observation NETwork) project is an inter-university project, which started in 2009 by five Japanese institutes and universities (Tohoku University, Nagoya University, Kyoto University, Kyushu University, and the National Institute of Polar Research) to build a research infrastructure for interdisciplinary study (Hayashi et al., 2013). IUGONET has provided a plug-in module for SPEDAS, which includes many routines to load ground-based observational data from various types of instruments, such as solar telescope, solar radio telescope, ionosphere radars (e.g., SuperDARN radars, EISCAT radar, ionosondes), atmosphere radars (e.g., MU radar, Equatorial Atmosphere Radar), imagers, magnetometers, and so on.

ERG(Exploration in energization and Radiation in Geospace) is a geospace exploration project that consists of the satellite program, ground-based observations, and modeling/simulation studies (Miyoshi et al., 2012). More than 100 researchers and 20 universities/instituted in Japan join this project. The development of the satellite is now going and the satellite will be launched in 2016. The data from the ground-based observation teams (SuperDARN, Magnetometer, VLF data, Imager, Riometer, Standard Radio Waves) is now going their activities. These data are opened to the public via the ERG Science Center. The science center develops SPEDAS plug-in for ERG in cooperation with IUGONET.

We will present our activities how IUGONET and ERG-SC develops their mission-oriented plug-ins and how SPEDAS is useful for scientific research and capacity building in the VarSITI program.

REFERENCE

Angelopoulos, V. (2008), The THEMIS mission, Space Sci. Rev., 141, 5-34, doi:10.1007/s11214-008-9336-1.

Miyoshi, Y.,et al. , The Energization and Radiation in Geospace (ERG) Project, in Dynamics of the Earth's Radiation Belts and Inner Magnetosphere, Geophys. Monogr. Ser., vol 199, edited by D.Summers, I.R. Mann,D.N.Baker,and M.Schulz, pp.103-116, AGU, Washington, D.C. doi:10.1029/2012BK001304, 2012.

Hayashi, H., Y. Koyama, T. Hori, Y. Tanaka, S. Abe, A. Shinbori, M. Kagitani, T. Kouno, D. Yoshida, S. UeNo, N. Kaneda, M. Yoneda, N. Umemura, H. Tadokoro, T. Motoba, and IUGONET project team (2013), Inter-university Upper Atmosphere Global Observation NETwork (IUGONET), Data Sci. J., 12, WDS179-WDS184.

[4-1]

INTRODUCTION TO CHINESE MERIDIAN PROJECT

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To develop an understanding of near-Earth space's response to solar activities and the coupling among different layers in geospace, China has initiated a ground base program to monitor China's geospace environment. Called the Meridian Space Weather Monitoring Project (or Chinese Meridian Project), the effort consists of a chain of 15 ground-based observatories located roughly along 120°E longitude and 30°N latitude. Each observatory is equipped with multiple instruments to measure key parameters such as the baseline and time-varying geomagnetic field, as well as the middle and upper atmosphere and ionosphere from about 20 to 1000 kilometers. This project started collecting data in 2012. We will give a brief overview about the Meridian Project, especially its data related activities.

ACKNOWLEDGEMENTS

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REFERENCES

Wang, C. (2010), New Chains of Space Weather Monitoring Stations in China, Space Weather, 8, S08001, doi:10.1029/2010SW000603.

Wang C. (2014), Recent advances in Chinese Meridian Project. Chin. J. Space Sci., 2014, 34(5): 535-543, doi:10.11728/cjss2014.05.535

[4-2]

CSSDC PROMOTED SERVICE ALSO STRENGTHENED CONNECTION TO SOLAR-TERRESTRIAL COMMUNITY THROUGH DEEP PROJECTS COOPERATION

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Through the extensive and deep projects cooperation with Solar-Terrestrial community, Chinese Space Science Data Centre (CSSDC) contacted and served the research community not only in supplying qualified scientific data and data analysis tools or computation models service, but also in providing data process and manage software and data standards service. In recent decades, China approved and executed a number of space exploration projects including Double Star Program (DSP) and Meridian Space Weather Monitor Project. All the raw data material from instruments firstly should be correctly converted and well formatted, organized to scientific data, then open to public and keep permanent usable. In those programs, CSSDC mainly in charge of raw data conversion, scientific data validation, distribution, archiving and data standards construction on accounting of its (CSSDC) role in space science data reduction, management, sharing and keeping data permanent safety. With the help of the experiences in programs, CSSDC established an operation model in data process and mange procedures, which consists of data production, collection, quality assurance, storage standardization, classification, labeling, archiving and distribution. We present the main procedures in this model, then describe the metadata specifications and data organization frame we constructed and adopted. By the way, we got lots of meaningful advice from the researchers in the above standards construction. The model together with standards and organization frame ensured our data being high quality, normalized and easy understanding. Furthermore, to expand our serve aspects, CSSDC designed a data distribution portal–Solar-Terrestrial and Astronomy Research Network (STAR-Network), which fulfilled functions of data acquisition, storage, analysis, model computation and simulation tools operation by using of cloud storage and computation resources. There’s no doubt this portal assisted scientists a lot in their research, though much more data, tools and models need to integrate into this portal. In the future satellite plan “Solar wind Magnetosphere Ionosphere Link Explorer” (SMILE), CSSDC would be in charge of the whole data process and manage procedures. In this way, CSSDC could contact and serve scientists community well and would prompt more research achievements.

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REFERENCES

Tong J.Z., & Zou Z.M. (2011) Virtual Space Science Observatory: An e-Science Implementation in Space Science. *E-Science Technology & Application*, pp 60-68

Zheng Y., & Zou Z.M. (2009) Research on the Planetary Data System (PDS). *E-Science Technology & Application*, pp 43-49

Zou Z.M., & Gao W.J. (2013) Design and Implementation of Space Weather Quantitative Forecasting System. *Science & Technology Review*, 31(10), 18-23.

Jiang X., & Zou Z.M (2013) Virtual Observatory Technology in HXMT Mission. *E-Science Technology & Application*, 4(6), 41-47.

Zhong J., & Zou Z.M. (2014) The algorithm of density visualization of magnetic flux lines based on geo-magnetic dipole field. *Progress in Geophysics*, 29(5), 2614-2619.

Wang C. (2010) New Chains of Space Weather Monitoring Stations in China. *Space weather*, Vol.8, S08001

[4-3]

THE WORLD DATA CENTRE (WDC) FOR SOLAR-TERRESTRIAL SCIENCE (STS) OF AUSTRALIA

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In 2014 the former IPS Radio and Space Services was restructured into Space Weather Services (SWS) and Space Weather Networks (SWN). The World Data Centre (WDC) for Solar-Terrestrial Science (STS) is a part of and operated by the Australian Bureau of Meteorology's SWS. The WDC for STS operates in Sydney, New South Wales, Australia.

The Australian Bureau of Meteorology's SWS is the Australian national space weather agency. It was established in 1947 and originally called the Ionospheric Prediction Services (IPS). It operates the Australian Space Forecast Centre (ASFC), and is a Regional Warning Centre (RWC) for space weather under International Space Environment Service (ISES). Around 1998 IPS was invited to host a World Data Centre based on its existing data holdings. In 2008, the World Data Centre system was reformed and a new ICSU World Data System (WDS) was established in 2009. The SWS (IPS) remains a member of ICSU WDS.

The SWS WDC for STS has an extensive collection of solar-terrestrial physics data obtained from field instruments in Antarctica, islands surrounding Australia, mainland of Australia and New Zealand, the oldest data being ionospheric recordings dating back to the 1930s. Archived datasets include raw and clean ionogram data, scaled hourly ionospheric data, monthly ionospheric medians of foF2 and M(3000)F2 data, magnetometer data, riometer data, cosmic ray data, solar images, solar radio spectrograph data, solar radio flux data, ionospheric scintillation data, imaging riometer data and FEDSAT data. Those data collected in the Australasian and Antarctic region flow into the SWS WDC at Sydney, mostly in near real time. These data provide a basis for developing space weather reports for Australasia and Antarctica. The majority of the archived data are available to domestic and international clients online.

In addition to the data obtained by SWS in the Australasian area and Antarctica, the WDC for STS also archives data from other countries and organisations, such as China, Germany, Japan, Pakistan, NGDC of NOAA, Physical Oceanography Distributed Active Archive Centre (PODAAC), Jet Propulsion Laboratory (JPL) of NASA, and SuperDARN. Most of these archived data are available by request.

The SWS adopt and implement an open data policy. The main points of the policy include:

- Preliminary SWS data will be released in real time or as soon as practicable.
- Where the data are not verified for quality, there must be a warning associated with the data.
- Data are provided in a standard format if one exists or in an easily accessible format. The format and general information about the dataset are to be available on the SWS website.
- SWS WDC is operated for the benefit of the domestic and international scientific community.
- SWS WDC provides data to scientists in any country free of charge, on an exchange basis, or at the cost of copying and sending the requested data.

Data sharing is the practice of making data used for scholarly research available to other investigators. In the past decades, SWS has established data sharing relationships with a few peer organizations. SWS have exchanged scaled ionospheric data with the China Research Institute of Radiowave Propagation (CRIRP) for over 30 years. SWS have been providing space weather data to the Space Physics Interactive Data Resource (SPIDR) since its establishment. Since 2014, SWS have also provided cosmic ray data to the Neutron Monitor Database (NMDB) with python scripts. The NMDB is located in the Kiel University, Germany.

This presentation will introduce the SWS, the datasets of solar-terrestrial physics archived within the WDC for STS, the open data policy and data sharing.

[4-4]

RECENT ACTIVITIES OF THE WORLD DATA CENTRE FOR GEOMAGNETISM (EDINBURGH)

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For almost 50 years the World Data Centre for Geomagnetism (Edinburgh) has been a custodian of geomagnetic data. In particular, over recent years the scope of the data holdings has been increased, quality control measures introduced and better interfaces to make the data more accessible to users are being developed.

The WDC hold geomagnetic time-series data from around 280 observatories worldwide at a number of time resolutions along with various magnetic survey, model, and geomagnetic activity indices. These data are of value to various scientific communities. Commonly the spatial and temporal coverage of geomagnetic observatory data are valuable for geomagnetic field modelling and contribute to models such as the International Geomagnetic Reference Field (Thébault *et al.*, 2015) and the World Magnetic Model (Chulliat *et al.*, 2015). More recently long-time series of geomagnetic data at a higher-cadence (one-minute means) have been useful in the space weather community, for example in extreme event analysis to estimate likely maxima in geomagnetic activity levels (Thomson *et al*., 2011). Furthermore recent efforts to digitise historic data and magnetograms may help scientists to re-analysis the largest geomagnetic storms of the past such as the 1859 'Carrington Event' (Humphries *et al.*, 2015).

The World Data Centre accepts definitive observatory data from all operating observatories who submit their data. The primary aim is to provide a repository of data that is freely accessible to all. That said, good quality science requires good quality data and to that end various quality control checks are applied to on all new data received. Work has also been carried out to assess and improve the quality of our long-standing datasets.

Recent activities have focused on the development of an improved user interface in the form of a new Data Portal for geomagnetic observatory data (http://www.wdc.bgs.ac.uk/dataportal/). This sits atop a RESTful web service which should allow other users or data platforms to integrate the data in the WDC more directly into their applications. This and other activities will be presented. We would welcome feedback from the community on these efforts.

REFERENCES

Chulliat, A., Macmillan, S., Alken, P., Beggan, C., Nair, M., Hamilton, B., Woods, A., Ridley, V., Maus, S., Thomson, A. (2015) The US/UK World Magnetic Model for 2015-2020. BGS and NOAA report, 112pp.

Humphries, T., Clarke, E., Williamson, J., Reay, S.J., Dawson, E., McIntyre, B.M., McIntosh, R.P., Nash, G.V., Thomson, A. (2015) An online digital archive of magnetograms from 1846 to 1987. Poster presented at: *IUGG 26th General Assembly*, Prague, Czech Republic. http://nora.nerc.ac.uk/511248/

Thébault, E., Finlay, C.C., Beggan, C.D., Alken, P., Aubert, J., Barrois, O., Bertrand, F., Bondar, T., Boness, A., Brocco, L., Canet, E., Chambodut, A., Chulliat, A., Coïsson, P., Civet, F., Du, A., Fournier, A., Fratter, I., Gillet, N., Hamilton, B., Hamoudi, M., Hulot, G., Jager, T., Korte, M., Kuang, W., Lalanne, X., Langlais, B., Léger, J-M., Lesur, V., Lowes, F.J., Macmillan, S., Mandea, M., Manoj, C., Maus, S., Olsen, N., Petrov, V., Ridley, V., Rother, M., Sabaka, T.J., Saturnino, D., Schachtschneider, R., Sirol, O., Tangborn, A., Thomson, A., Tøffner-Clausen, L., Vigneron, P., Wardinski, I., Zvereva, T. (2015) International Geomagnetic Reference Field: the 12th generation. *Earth, Planets and Space*, 67 (79). doi:10.1186/s40623-015-0228-9

Thomson, A.W.P., Dawson, E.B., Reay, S.J. (2011) Quantifying extreme behaviour in geomagnetic activity. *Space Weather* (9), S10001. Doi: 10.1029/2011SW000696

[4-5]

THE NEUTRON MONITOR DATABASE (NMDB)

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Since the International Geophysical Year (IGY) in 1957-58 cosmic rays are routinely measured by many ground-based Neutron Monitors (NM) around the world. The World Data Center for Cosmic Rays (WDCCR) was established as a part of this activity and is providing a database of cosmic-ray neutron observations in unified formats. However, that standard data comprises only of one hour averages, whereas most NM stations have been enhanced at the end of the 20th century to provide data in one minute resolution or even better. This data was only available on the web-sites of the institutes operating the station, and every station invented their own data format for the high-resolution measurements. There were some efforts to collect data from several stations, to make this data available on FTP servers, however none of these efforts could provide real-time data for all stations. In 2008 and 2009 an EU FP7 project (NMDB: real-time database for high-resolution Neutron Monitor measurements, http://nmdb.eu) was funded by the European Commission, and a new database was set up by several Neutron Monitor stations in Europe and Asia to store high-resolution data and to provide access to the data in real-time (i.e. less than five minute delay). By storing the measurements in a database, a standard format for the high-resolution measurements is enforced. This database is complementary to the WDCCR, as it does not (yet) provide all historical data, but the creation of this effort has spurred a new collaboration between Neutron Monitor scientists worldwide, (new) stations have gone online (again), new projects are building on the results of NMDB (SEPSever, HESPERIA), new users outside of the Cosmic Ray community are starting to use NM data for new applications like soil moisture measurements using Cosmic Rays. These applications are facilitated by the easy access to the data with the http://nest.nmdb.eu interface that offers access to all NMDB data for all users.

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[4-6]

CONTINUED OPERATION OF NOBEYAMA RADIOHELIOGRAPH AND ITS DATABASE

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Nobeyama Radioheliograph is a radio interferometer specially designed to observe the full disk of the Sun at 17 and 34 GHz. Eighty-four antennas with a diameter of 80 cm were installed along a T-shape baseline (North - South: 250 m, East - West: 500 m). The spatial resolution is about 10 arcseconds and 5 arcseconds in 17 GHz and 34 GHz, respectively. The time resolution of NoRH is typically 1 second and 0.1 second for the event mode. NoRH continuously observes the full sun for about eight hours (22:45 - 6:30 UT) every day. The system has been quite stable and NoRH data are available in the period more than 99 % out of the total possible operational window.

The National Astronomical Observatory of Japan (NAOJ) has successfully operated NoRH during these two decades. From April 2015, the Solar-Terrestrial Environment Laboratory, Nagoya University started the operation of NoRH as a representative of the International Consortium for the Continued Operation of Nobeyama Raidoheliograph (ICCON; http://hinode.stelab.nagoya-u.ac.jp/ICCON/). The current ICCON representatives are N. Gopalswamy (NASA), Y. Yan (NAOC), K. S. Cho (KASI), M. Ishii (NICT), K. Shibasaki (Nagoya University) and S. Masuda (Nagoya University).

NoRH data are automatically transferred from the observational site (Nobeyama) to Solar Data Analysis System (SDAS; http://hinode.nao.ac.jp/SDAS/index_e.shtml) of NAOJ at Mitaka, and then all of them are automatically mirrored to Hinode Science Center at Nagoya (http://hinode.stelab.nagoya-u.ac.jp/index.shtml.en). Any researcher registered in either system can access all of the NoRH data. The software for the data analysis is supplied as a part of the solarsoft (IDL-based software system mainly maintained by Lockheed Martin Solar and Astrophysics Laboratory) and distributed via internet.

[4-7]

RECENT ACTIVITY OF DOI-MINTNG TO SOLAR-TERRESTRIAL PHYSYCS DATA IN JAPAN

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Recent electronic journals are published with DOI (digital object identifier) such as doi:10.1029/2012SW000785. DOI is a persistent name that is resolved into URL, where readers can obtain digital objects of the journal articles; for example, abstract, figures, and pdf files. The DOI system was launched around 2000 and becomes popular these days so that DOI is ordinarily indicated in references and citations.

The next development of the DOI system is to extend it to observational data. It makes possible for researchers to cite the data used in a scientific publication, which is called “data citation”. Data citation provides the following benefits:

- Readers can more easily locate the data used in the paper, obtain necessary information of the data (i.e., metadata), and validate the findings of the paper.
- Readers can also easily discover datasets which are relevant to their interests but has not been noticed.
- Data contributors can gain professional recognition and rewards for their published data in the same way as for traditional publications.
- Data centers can measure the impact of individual datasets and receive proper credit of their work.

Recognizing the importance of data citation, World Data Centers (WDCs) in Japan including WDC for Geomagnetism (Kyoto University) and WDC for Ionosphere and Space Weather (National Institute of Information and Communications Technology) started discussion to mint DOI to their own database in August 2013. The discussion finds that Japan Link Center (JaLC) is a proper agency to register DOI-URL mapping, because JaLC aims at public information services to promote science and technology in Japan and it handles scientific and academic metadata and content from holders nationwide, including national institutes and universities. We also develop a web-based system to register metadata with JaLC and to create landing pages of data, to which DOIs are mapped. The system can handle version of the landing pages when the data are updated. JaLC starts a 1-year pilot program to mint DOI to the database from October 2014. We have been participating in the program, resulting in a DOI for the mesospheric wind velocity data observed with MF radar at Poker Flat, Alaska (doi:10.17591/55838dbd6c0ad). This is the first place of the DOI-minting to scientific data in Japan. This DOI is even cited in a paper by Kinoshita et al. (2015), providing the first example of data citation in Japan.

We will present results of the pilot program and discuss future perspective for DOI-minting to solar-terrestrial physics data in Japan.

REFERENCE

Kinoshita, T., Y. Murayama, and S. Kawamura (2015), Tidal modulations of mesospheric gravity wave kinetic energy observed with MF radar at Poker Flat Research Range, Alaska, *J. Geophys. Res. Atmos.*, 120, 6379-6390, doi:10.1002/2014JD022647.

[P1]

DEVELOPMENT OF THE JAVAFX-BASED IUGONET DATA ANALYSIS SOFTWARE (JUDASFX)

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By Open Access Jounals and Institutional Repositories, many citizens become accessible to research papers. Then it is becoming accessible to research data from papers via research data DOI. After reaching research data from papers, data visualization and analysis software is necessary. In the Inter-university Upper atmosphere Global Observation NETwork (IUGONET) project members have been developing iUgonet Data Analysis Software (UDAS) for domain researchers. Basically, the software needed commercial license and it was difficult to use for the researcher of the next field, data scientist, and citizens. To solve this issue, we started to develop the free data visualization and analysis software for upper atmospheric research data. The software is,

- 100% Free Software: Business licenses are not required. Only Java Runtime Environment (JRE) is necessary for executing the software. The JRE is freely distributed, and it is probably installed in your computer already.
- Windows, Mac OS X, Linux, and Solaris are supported: "Write once, run anywhere" is the key feature of Java Platform. The JudasFX is written in Java, so it runs on multiple operating systems because Java Virtual Machine in JRE absorbs differences of operating systems.
- Java Web Start is supported: Java Web Start is a framework allows users to start application software for the Java Platform directly from the Internet using a web browser. The key benefit is seamless version updating for globally distributed applications.
- GUI & CLI are supported: Graphical User Interface (GUI) as well as Jython*1 Command- line Interface (CLI) are supported.
- Output on high-quality figure is supported: High-quality figure for papers can be output.
- IUGONET metadata database cooperation is supported: It can access to the IUGONET metadata database via the Internet. The obtained metadata is interpreted mechanically, and is used for visualization and analysis.

We will present current status of the software development and discuss future perspective.

*1 Jython is a Python implementation by Java. Python is a de facto standard programming language for data centric science.

[P2]

A GEOMAGNETIC EVENT REVIEW FROM MARCH TO AUGUST, 2015 AT KAKIOKA

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Geomagnetic observation results at Kakioka are reviewed from March to August, 2015. Geomagnetic field activities are reported mainly for the following events;

(a) March 17-21, 2015 moderate severe geomagnetic storm (St. Patrick's Day 2015 Event): The 15 March halo coronal mass ejection (CME) associated with both a filament eruption and C9.1 flare

A Sudden Storm Commencement (SSC) was observed with the H component amplitude of 43 nT at 0445UTC on 17 March due to effects from the 15 March halo CME. Geomagnetic storm started with initial and main phases around 06UTC on 17 March. The geomagnetic disturbance progressed gradually during the storm period and the storm amplitude resulted in an increase: the H component amplitude of 237 nT is ranked as the 2nd in the solar cycle 24.

(b) June 21-24, 2015 moderate severe geomagnetic storm (Summer Solstice 2015 Event): A full-halo CME associated with an M2 flare on 21 June

Arrivals of small interplanetary shock waves that preceded the storm were observed at 1643UTC on 21 and at 0544UTC on 22 June, respectively. These shocks were associated with a partial-halo CME caused by a filament eruption on 18 and 19 June. And another shock from the 21 June CME associated with a double peak M2 flare was observed at 1833UTC on 22 June as SSC which the H component amplitude of 104 nT is ranked as the 1st in the solar cycle 24. Geomagnetic storm started with initial and main phases around 19UTC on 22 June. The geomagnetic disturbance progressed rapidly during the storm period and continued until 24 June: the H component amplitude of 279 nT is ranked as the 1st in the solar cycle 24.

[P3]

DATA PUBLICATION OF THE KAKIOKA MAGNETIC OBSERVATORY

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The Kakioka Magnetic Observatory (KMO) has published the geomagnetic field data, the geoelectric field data and the geomagnetic events catalogue on our web site (http://www.kakioka-jma.go.jp/en/index.html). Recently, we are making 1-minute and 7.5-second geomagnetic data digitized from analog magnetograms (Mashiko et.al, 2013). So far, these data from 1956 to 1975 at KAK have been published. And the digitized data from 1980 to 1984 at MMB and KNY will be published in this year. Table 1 shows the data and the period which can be offered. The data are updated routinely whose end time is not described .

Table 1: The list of the data which are available on the KMO web site

Geomagnetic data						
	1-hour	1-minute	1-minute*	7.5-sec*	1-sec	0.1-sec
KAK	1913-	1976-	1956-1975	1956-1975	1993-	1997-
MMB	1958-	1985-			1997-	1997-
KNY	1958-	1985-			1996-	1996-
CBI	1973-	1989-			1993-	
Geoelectric field						
KAK	1962-	1987-			2000-	1997-
MMB	1962-	1987-			2000-	1997-
KNY	1962-	1987-			2001-	1996-
Atmospheric Electric field						
KAK	1962-	2006-				
MMB	1962-2010	1987-2010				

Geomagnetic Event Catalogue								
	Magnetic Storm	Telluric Storm	Si & SSC	Bay	sfe	Pi	Pc	K-index
KAK	1924-	1999-	1924-	1999-	1999-	1999-2011	1997-2011	1932-
MMB	1957-	1999-	1957-	1999-	1999-	1999-	1997-	1956-
KNY	1958-	2001-	1958-	1999-	1999-	1999-2011	1996-2011	1958-

* The data digitized from magnetograms

REFERENCE

Mashiko, N., Yamamoto, T., Akutagawa, M., and Minamoto, Y. (2013) Digitization of bromide paper records to extract one-minute geomagnetic data. *Data Science Journal 12*, WDS254-WDS257.

[P4]

THE NECESSITY OF “SCIENTIFICALLY RELATED” DATABASE IN SOLAR-TERRESTRIAL PHYSICS

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“Space Weather” is the electro-magnetic condition on the vicinity of the Earth which affects to social infrastructure, e.g., radio propagation, satellite operation and electric facilities. Recently, the social necessity of space weather information is increasing. The ICAO prepares to use space weather information in civil aviation. This paper presents the present status of space weather monitoring and forecasting including domestic and international activities.

The space weather phenomena is a serious of several events which relates to each other in different regions, e.g., sun, interplanetary, magnetosphere and ionosphere.

The observations of space weather has a long history. The sunspot number on the solar disk has been observed for more than four hundred years, and even in ionosphere used by a kind of radar, the observing period exceeds half century. The geomagnetic observation on the ground is also the same situation. However, these sets of database are not considered to connect each other with scientific knowledge.

On March 2015, we had one of the biggest space weather phenomena named “St. Patrick’s event.” It was an extraordinary case that the flare as a source of this event is much smaller than usual and all of space weather forecasters in the world missed their forecasts. If we have such a “scientifically related” database, we could have found any similar events and considered the possibility that the small flare made a large magnetic storm. In addition, the database must contribute to research of solar-terrestrial physics.

One of the difficulties to build such databases is to make them relate to each other. Sometimes we cannot find any counter phenomena, or possible multi-phenomena. Space weather forecast report will help to solve this issue.

[P5]

NEW SOLAR RADIO TELESCOPE OF NICT

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The solar corona contains many eruptive phenomena such as flares and coronal mass ejections (CMEs) that are caused by the interactions between the coronal magnetic field and plasma. Non-thermal electrons accelerated in the coronal eruptive phenomena emit radio waves. As a result, many types of solar radio bursts are observed (McLean & Labrum 1985 and references therein). The radio emission propagates faster than the particles. Hence, the monitoring observation of the solar radio bursts is one of the efficient tools to forecast the space weather environment.

National Institute of Information and Communications Technology (NICT) have been observed the solar radio burst since 1980's at Hiraiso. The current solar radio observation instruments named HiRAS have been used to monitor the solar radio burst for more than 20 years. Recently, we developed a new solar radio telescope to improve the observation quality and achieve the better space weather forecasting. The new telescope was constructed in the Yamagawa radio observation facility of NICT at Kagoshima prefecture. This telescope has an 8m parabola dish. The feed system of this telescope consists of two wideband log-periodic antennas. These two antennas are tuned for different frequency bands and the entire observation frequency band of this telescope is between 0.07 GHz and 9.0 GHz. The apparent diameter of the Sun is about 0.5 degree. The higher band of the feed system is de-focused to cover the entire solar disc on the field of view. The received signal is divided in the receiver system and fed to the digital fast Fourier transform (FFT) spectrometers made of the field-programmable gate array (FPGA). We developed two types of digital spectrometers. The one has 2 GHz bandwidth and 4098 FFT points. The other one has 1 GHz bandwidth and 32768 FFT points. These spectrometers have no dead time and spectra are accumulated inside the FPGA processors. The accumulated spectra are recorded every 8ms. The observation system has a total of 10 digital spectrometers. Hence, the entire system can simultaneously observe the right and left handed circular polarizations of the solar radio emission between 0.07 and 9.0 GHz with 8ms time resolution. This wide observation frequency band is very efficient to capture the various types of solar radio bursts. In admission, the high time resolution of this instrument has significant benefit to detect the various fine spectral structures of the radio bursts that are thought to be generated by the micro processes of the corona.

REFERENCES

Kondo, T., Isobe, T., Igi, S., Watari, S., & Tokumaru, M. (1994) The New Solar Radio Observation System At Hiraiso, Review of the Communications Research Laboratory, 40, 85

McLean, D.J., & Labrum, N.R.: 1985, Solar Radiophysics, Cambridge University Press, Cambridge.

[P6]

DATA STANDARDIZATION AND DISTRIBUTION OF NICT SOLAR RADIO OBSERVATION

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After the first observation of solar radio dynamic spectra by Wild and McCready (1950), a large number of solar radio spectrographs have been developed and they have observed solar radio bursts. In late 80's to early 90's, Communications Research Laboratory, predecessor of National Institute of Information and Communications Technology (NICT), started solar radio dynamic spectrum observation at Hiraiso, which is widely known as HiRAS (Kondo et.al., 1994). The HiRAS had the widest observation frequency range in the world at that time. However, the time went through twenty years from the development of the HiRAS system, the system has been decrepit. Because of this, a new solar radio spectrograph has been developed at Yamagawa radio observation facilities, NICT since 2013.

The HiRAS data are widely quoted in space weather forecasting as well as scientific research. However, as the raw data format is not standard format such as FITS (Flexible Image Transport System), treatment of the data is somewhat difficult and inconvenient. This situation is unfavorable to spread the use of the data. In order that many researchers can use our data, we have converted the non-standard original format data to the standard FITS format, which is the most popular in astronomy community.

The raw data format of the YAMAGAWA solar radio spectrograph is VDIF (VLBI Data Interchange Format), which is developed in VLBI community, because the spectrograph of the system is developed in VLBI community. The VDIF data is popular in VLBI community, but not popular in astronomy community. This is also unfavorable situation in order that astronomers use the data of new solar radio spectrograph. Therefore, the VDIF data should be converted to FITS format. As the data convert procedure is included in the new system, final outputs of the system are FITS data.

Since NICT is one of the members of World Data Center (WDC for Ionosphere and Space weather), we are considering that the standardized solar radio observation data, especially data obtained by new system, will be distributed from the WDC for Ionosphere and Space weather.

REFERENCES

Kondo, T., Isobe, T., Igi, S., Watari, S., & Tokumaru, M. (1994) The New Solar Radio Observation System At Hiraiso, Review of the Communications Research Laboratory, 40, 85

Wild, J.P., & McCready, L.L. (1950) Observations of the Spectrum of High-Intensity Solar Radiation at Metre Wavelengths. I. The Apparatus and Spectral Types of Solar Burst Observed, Australian Journal of Scientific Research A, 3, 387

[P7]

VARIATION OF SOLAR MICROWAVE SPECTRUM IN THE LAST HALF CENTURY

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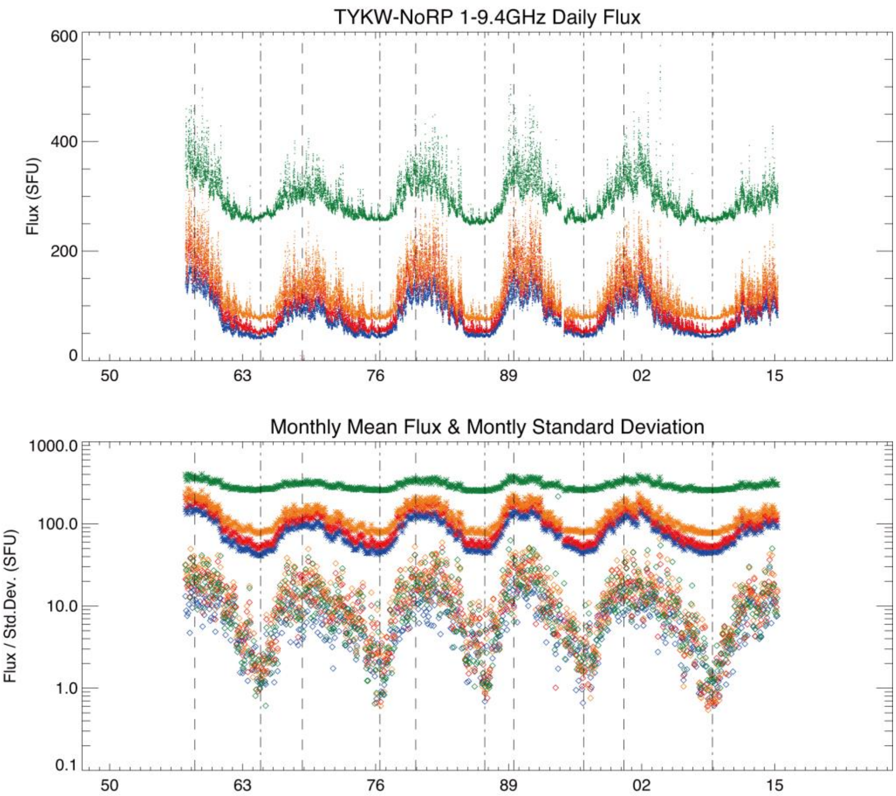
The total solar fluxes at 1, 2, 3.75 and 9.4 GHz have been observed continuously from 1957 to 1994 at Toyokawa, from 1994 at Nobeyama, Japan. We examined the multi-frequencies and long-term dataset, and found that monthly standard deviation of total solar flux in microwave can indicate an actual minimum state of solar activity rather than sunspot number. Therefore, we define ”radio solar minimums” from the value. Comparing the microwave spectrums of the radio solar minimums of Cycle 20∼24, we found that they match within 7 %. It shows that the average atmospheric structure above transition region in quiet sun didn’t vary during the half a century, and suggest that the energy input for atmospheric heating from sub-photosphere to corona didn’t change in quiet sun though the strength of solar cycles variation changed significantly.



The variation of the total solar flux in microwave. Upper panel: The daily total solar fluxes at 1 (Blue), 2 (Red), 3.75 (Orange) and 9.4 (Green) GHz. Middle Panel: The monthly mean flux (Asterisks) and monthly standard deviation (diamonds) of each frequency.

[P8]

DEVELOPMENT OF SOLAR FLARE PREDICTION TECHNIQUE BASED ON IMAGE PROCESSING OF REAL-TIME SOLAR MAGNETOGRAM DATA

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Many flare prediction techniques currently used are based on the statistics of white light sunspot observations in the past. It is generally known that bigger and more complex sunspots tend to produce larger flares in higher possibility. Recent solar satellite observations have enabled the real-time steady observations of magnetogram, i.e. direct observations of magnetic field in the sunspots, and also gave us a chance to predict flares by measuring the amount of stored energy in the sunspot and capturing the appearance of trigger features around there. Now we are developing a new method to predict flares based on the data of the magnetogram images taken by HMI telescope on board SDO satellite of NASA, by coupling with the image processing techniques. At first, from the magnetogram data, we detect the sunspot region, where the flare occurrence is highly expected. Secondly, we calculate the characteristic values: physical parameters, like the sunspot area, the magnetic field strength and the share angle of the horizontal magnetic field along the polarity inversion line, and image parameters characterizing the sunspots, like colors and shapes. We have been preparing a series of database of these physical and image characteristic values, from which we statistically investigate the status of the sunspot just before the flare occurrence and try to find what are most important values for flare prediction. Finally, this system will be developed to the one for the real-time operation, which automatically detects the active region, measures the characteristic values, and estimates the amount of stored energy and the risk of flare occurrence.

[P9]

ROUTINE OBSREVATIONS AND DATA ACQUISITION OF THE IONOSPHERE AT SYOWA STATION, ANTARCTICA

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The Earth's ionosphere is one of the important area for short-wave telecommunications and broadcasting. The conditions of the ionosphere varies depending on activities of space weather. Arctic and Antarctic regions are the gateway of electromagnetic and mechanical energy transfer between the magnetosphere and the ionosphere. National Institute of Information and Communications Technology (NICT), which is responsible for Japanese space weather forecast, has been operating routine ionospheric observations over Japan for more than 50 years as monitoring of space weather and radio-wave propagation. Also, NICT has been operating routine observations and data acquisition of the ionosphere at Syowa station in Antarctica from the early stages of Japanese Antarctic Research Expedition (JARE). These more than 50 years of ionospheric data enables us to study daily, seasonal, solar-cycle dependent, and long-term variations of ionosphere.

Currently, we operate three types of ionospheric observations. The first one is the vertical observation of the ionosphere (ionosonde). This observation enables us to estimate height-profile of ionospheric electron density. The second one is the measurement of GNSS-TEC and GNSS scintillations using three GNSS receivers. The density fluctuations caused by the electrons and ions precipitation from the magnetosphere produces scintillations of GNSS signal. The third one is the observation of LF standard time and frequency signal along the course of the Antarctic research expedition icebreaker, "Shirase", from Japan to Antarctica and back. This observation is for comparison with calculation results based on a new field strength prediction method developed by NICT for long distance propagation of LF waves. The data is transferred using Wide-area Observation Network Monitoring (WONM) system (Nagatsuma et al., 2014).

In this presentation, we will introduce our ionospheric observation at Syowa station, Antarctica, and current status of our observations at Syowa station.

ACKNOWLEDGEMENTS

Ionospheric observation at Syowa Station is based on the consignment study from the Ministry of Internal Affairs and Communications.

REFERENCES

Nagatsuma, T., Murata, K.T., Yamamoto, K., Tsugawa, T., Kitauchi, H., Kondo, T., Ishibashi, H., Nishioka, M., & Okada, M. (2014), Operation of a data acquisition, transfer, and storage system for the global space-weather observation network, *Data Science Journal*, 13, PDA51-PDA56, http://dx.doi.org/10.2481/dsj.IFPDA-09.

[P10]

SPACE ENVIRONMENT DATA ACQUISITION MONITOR (SEDA) ONBOARD HIMAWARI-8 AS A SPACE WEATHER MONITORING PLATFORM

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New Japanese meteorological satellite, Himawari-8, was successfully launched on October 7, 2014. Space environment data acquisition monitor (SEDA) is on board Himawari-8, as one of the housekeeping information for satellite operation. SEDA consists two sensors. One is proton sensor, which has 8 separate diode detectors. The energy range of the proton detectors are from 20 MeV to 100 MeV. The other is electron sensor, which measures internal charging currents caused by energetic electrons. There are eight sensor plates arranged in a stack and each plate responds to a different energy range. As a result, energetic electrons whose energy range between 0.2 to 4.5 MeV can be measured by the electron sensors. The time resolution of each sensors is 10 sec. The field of view of SEDA is eastward. Thus, the specification of SEDA is suitable for monitoring the energetic electrons and protons above Japanese meridian of geostationary orbit. Further, combination of SEDA with other geostationary satellite data, such as GOES, DRTS, enables us to monitor wide area of space environment along geostationary orbit.

Himawari-8/SEDA has been operating since November 3, 2014. Based on the agreement between Japan Meteorological Agency (JMA) and NICT, JMA is providing Himawari/SEDA data in near-real time since January 21. 2015. JMA also ask us to archive and distribute SEDA data to the public. Thus, we have tried to check the quality of SEDA data. We are now developing online database for archiving and providing Himawari-8/SEDA. The current status of Himawari-8/SEDA observation will be introduced in our presentation.

[P11]

60-YEAR DATABASE OF COSMIC-RAY NEUTRON FLUXES HELD BY WDC FOR COSMIC RAYS

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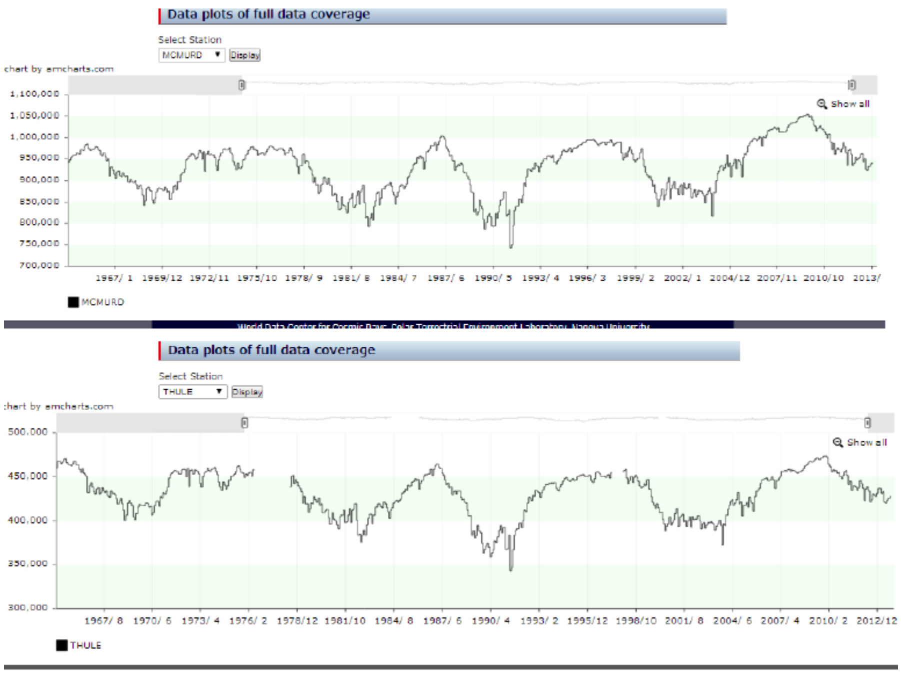
The World Data center (WDC) for Cosmic Rays was established in 1957 in RIKEN, Tokyo, as a C2 center of the ICSU WDC. This WDC has been moved to the Solar-Terrestrial Environment Laboratory, Nagoya University in 1991. The principal data held by the WDC are pressure-corrected and scale-adjusted one-hour counts of cosmic-ray neutron data which are provided by ground-based stations (about 50 at present) distributed in a wide range of the longitude and the latitude. Quality controlled data are opened through the Web page given below. This database will be useful for studies of variations of cosmic-lay flux with time scales ranging from hours to years. A long-term trend of the time variations of cosmic-ray flux in current 60 years is discussed. Beside of well-known 11-year variations of the flux, in the opposite sense of the sunspot cycle, a general increasing trend can be seen since the Cycle 23.

http://center.stelab.nagoya-u.ac.jp/WDCCR/.



Examples of on-line plots of monthly values at McMurd (upper) and Thule (lower).

[P12]

OBSERVATION OF THE HIGH-LATITUDE IONOSPHERIC IRREGULARITIES: METHODOLOGY AND SERVICE

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Observation and analysis of the ionospheric irregularities at the high latitudes using GPS measurements represent very actual task for both scientific point of view and Global Navigation Satellite Systems (GNSS) applications, as the occurrence of the ionospheric irregularities can impact a variety of communication and navigation systems. In this work we describe methodology and service for continuous generation of high-resolution maps of the ionospheric irregularities. To observe the high-latitude ionospheric irregularities, data collected from three ground-based GPS networks of the Northern Hemisphere are processed and analyzed (Fig. 1a). Here we used GPS-based parameters ROT (rate of total electron content (TEC) change) and ROTI (index of ROT) to study the occurrence of TEC fluctuations [Pi et al. 1997].
For representation of the high-latitude irregularities spatial evolutions and estimation of their linkage with the Earth's magnetosphere (due to strong connections between the Earth's magnetic field and the ionosphere) we analyze the diurnal ROTI polar maps. Here, ROTI behavior is represented as a function of a magnetic local time (MLT) and corrected magnetic latitude (MLAT) for a specific day. Resulted polar map is a daily map with the grid of $2° \times 2°$ spatial and 00-24 MLT time frames. Maps show binned and averaged ROTI data within the magnetic latitude range of $50°$ - $90°$.

The ROTI maps allow us to estimate the overall fluctuation activity and auroral oval evolutions, in general, the ROTI values are corresponded to the probability of the GPS signals phase fluctuations. We analyze the dependence of the GPS-detected ionospheric irregularities on the auroral activity indices, such as Dst index, the auroral electrojet (AE) and the planetary geomagnetic Kp indices. We demonstrate that the occurrence and magnitude of TEC fluctuations, measured using GNSS networks, increase dramatically during space weather events. The irregularities oval expands considerably equatorward with simultaneous increase of the TEC fluctuation intensity (Fig. 1b-c).

The indices and maps, based on TEC changes, can be effective and very perspective indicator of the presence of irregularities in the high-latitude and midlatitude ionosphere. We expect the high potential of the proposed products; however, it is the just tool and great work should be done on data processing, statistical analysis, comparative or/and joint investigations with other ionosphere-magnetosphere measurements.

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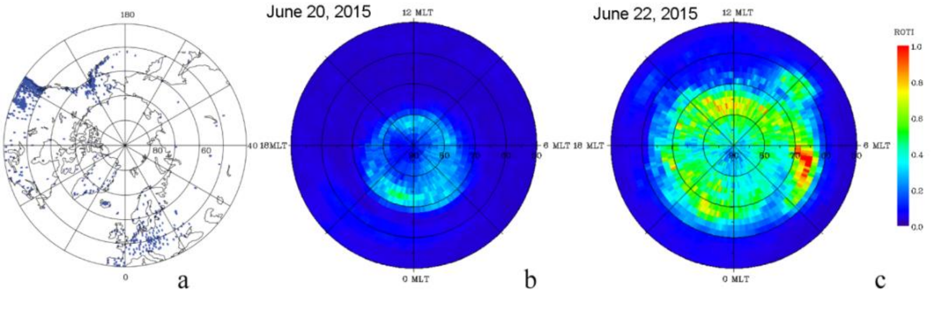

Figure 1. Map with geographical location of the processed GNSS stations (a), ROTI maps for quiet (b) and disturbed (c) geomagnetic conditions.

REFERENCES

Pi, X., A. J. Mannucci, U. J. Lindqwister, and C. M. Ho (1997), Monitoring of global ionospheric irregularities using the worldwide GPS network, Geophys. Res. Lett., 24, 2283−2286, doi:10.1029/97GL02273.

[P13]

DYNAMICS OF THE IONOSPHERIC IRREGULARITIES DURING THE ST. PATRICK'S DAY STORM BY GROUND-BASED GPS MEASUREMENTS

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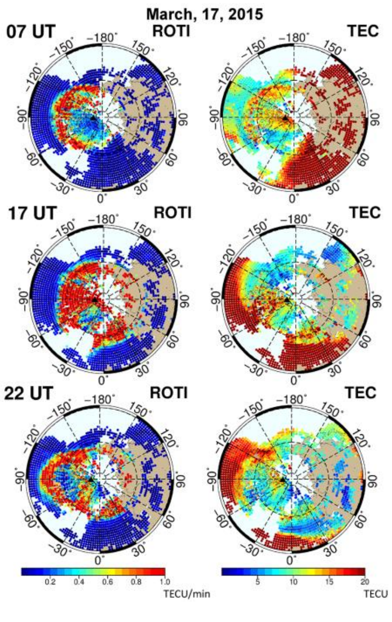
We report first results on the study of the high-latitude ionospheric irregularities observed in worldwide GPS data during the St. Patrick's Day geomagnetic storm [Cherniak et al, 2015]. Multi-site GPS observations from more than 2500 ground-based GPS stations were used to analyze the dynamics of the ionospheric irregularities in the Northern and Southern Hemispheres. We conclude that current fast-growing networks of GPS receivers can provide much more information about the ionospheric irregularities than it was possible for the past super-storms in the years 2003-2004. Few types of the GPS data processing were implemented to analyze the dynamics of the high-latitude ionospheric irregularities produced by the St. Patrick's Day geomagnetic storm. It was constructed the diurnal and hourly Rate of TEC (ROTI) maps, hourly TEC maps as well as derived a high-resolution ROT variability for selected GPS station chains. The diurnal and hourly ROTI maps are constructed for both Northern and Southern Hemispheres. The most intense ionospheric irregularities lasted for more than 24 hours starting at 07 UT of March 17. The period of the most intense irregularities occurrence was strongly correlated with changes in the auroral Hemispheric Power index and it was associated with processes related to enhanced auroral particle precipitation. We find hemispheric asymmetries in the intensity and spatial structure of the ionospheric irregularities, this asymmetry can be related to the IMF orientation, which can lead to a hemispheric asymmetry in the Region 1 FACs. Over North America the ionospheric irregularities zone expanded equatorward below ~45°N geographic latitude. Additionally, the strong mid- and high-latitude GPS phase irregularities in the auroral oval were found. Formation and further evolution of storm enhanced density and a polar tongue of ionization structures caused the storm-induced plasma density gradients and the appearance of the strong GPS phase irregularities at the mid- and high-latitudes of the Northern Hemisphere (See Fig. 1).

Significant increases in the intensity of irregularities within the polar cap were observed in both hemispheres associated with the formation and evolution of a polar tongue of ionization and polar cap patches. Further studies of the high-latitude ionosphere response to the St. Patrick's Day storm with the use of satellite and ground-based observations will be valuable for understanding processes within the ionosphere-magnetosphere system during geomagnetic storms.



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REFERENCES

Cherniak Iu, Zakharenkova I., Redmon R. Dynamics of the high-latitude ionospheric irregularities during the March 17, 2015 St. Patrick's Day storm: Ground-based GPS measurements, Submitted to Space Weather, 2015.

Figure 1. The GPS ROTI and GPS TEC maps over the Northern Hemisphere for selected moments of time on March 17, 201

[P14]

RELATIONSHIP BETWEEN AMPLITUDE OF GEOMAGNETIC SUDDEN COMMENCEMENT (SC) AND THE CORRESPONDING DYNAMIC PRESSURE VARIATION OF THE SOLAR WIND

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Araki [2014] confirmed that SC occurred on March 24, 1940 was largest since 1868. The amplitude is 310nT at Alibag and more than 273nT at Kakioka. Using the experimental relationship between SC amplitude ｄH and dynamic pressure Pd associated with interplanetary shock (IPS) [Siscoe et al. ; 1968], ｄH = Aｄ(Pd^0.5） where A is proportionality constant, the corresponding Pd increase was estimated as 400-500nPa.

When the magnetosphere is compressed by IPS, field aligned currents (FACs) and ionospheric currents (ICs) are induced in addition to the primary magnetopause current (MPC). The SC amplitude is determined as the magnetic field produced by these currents. Although it shows a clear LT variation, it is not taken into account in the Siscoe' s relationship.

The calculation of geomagnetic fields due to the FAC and IC [Araki et al. , 2009] show that the resultant field becomes almost zero around 6h LT. Thus the SC amplitude around 6h LT expresses the geomagnetic field caused by MPC which is directly connected with dynamic pressure of the solar wind.

REFERENCES

Araki, T., S. Tsunomura and T. Kikuchi、Local time variation of the amplitude of geomagnetic sudden commencements (SC) and SC-associated polar cap potential. Earth Planets Space, 61, e13–e16, 2009

Araki, T, Historically largest geomagnetic sudden commencement (SC) since 1868. Earth, Planets and Space, 66,164, 2014.

Siscoe GL, Formisano V, Lazarus AJ (1968) Relation between geomagnetic sudden impulses and solar wind pressure changes: an experimental investigation. J Geophys Res 73:4869–4874.

[P15]

EQUATORIAL PLASMA BUBBLES STUDIES USING AIRGLOW AND GPS DATA

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Simultaneous observations of OI630 nm and TEC were carried out using a CCD based All-Sky Imaging system, Photometer and GPS system at low latitude station Kolhapur (16.8˚N, 74.2˚E) to study the day-to-day variability in the occurrence of Equatorial Spread F (ESF) or Equatorial Plasma Bubble (EPB). GPS data of Bangalore (13.020N, 77.570E) IGS stations were analyzed for the period 2002-2013 to investigate response of Total Electron Content (TEC) and occurrences rate of EPBs in quiet and disturbed conditions. In the present data analysis work we have also discussed the trends in the occurrences of EPBs with solar activity in descending phase of solar cycle 23 and ascending phase of solar cycle 24.

BANGALORE-GPS DATA

Year	Total days	Total EPBs	% EPBs	Disturbed days	EPBs days	% EPBs	Quiet days	Total EPBs	% EPBs
2002	316	142	44.9367089	52	14	26.92307692	113	60	53.09735
2003	364	129	35.4395604	60	10	16.66666667	120	58	48.33333
2004	365	98	26.8493151	59	12	20.33898305	120	40	33.33333
2005	362	72	19.8895028	60	12	20	120	34	28.33333
2006	361	50	13.8504155	59	5	8.474576271	116	21	18.10345
2007	365	57	15.6164384	60	8	13.33333333	120	23	19.16667
2008	337	40	11.8694362	56	3	5.357142857	109	16	14.6789
2009	358	24	6.70391062	59	5	8.474576271	120	13	10.83333
2010	356	88	24.7191011	60	11	18.33333333	115	36	31.30435
2011	363	163	44.9035813	60	13	21.66666667	119	63	52.94118
2012	365	173	47.3972603	60	15	25	120	64	53.33333
2013	317	139	43.8485804	49	16	32.65306122	108	56	51.85185
Total	4229	1175	27.7843462	694	124	17.86743516	1400	484	34.57143

- **Total days (2002-2013) = 4383**
- **Available data = 4229 i.e 96.48%**
- **% EPBs= 27.78%**
- **% EPBs in disturbed days= 17.86%**
- **% EPBs in Quiet days= 34.57%**

Table 1: Bangalore GPS data Analysis for the period 2002 to 2013 to study the occurrence rate of EPBs