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Space Weather of the Heliosphere: Processes and Forecasts

Edited by

Claire Foullon

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SPACE WEATHER OF THE HELIOSPHERE:
PROCESSES AND FORECASTS

IAU SYMPOSIUM 335

COVER ILLUSTRATION: TWO SEASONS IN THE CYCLE OF THE SUN

This is an enlarged part of the symposium poster, showing two seasons in the activity cycle of the Sun to represent the changes in space weather, against the backdrop of the Exeter cathedral.

The underlying inspiration for the poster logo comes from both the symposium topic, space weather, where the Sun is center-stage, and the conference location in Devon, UK. Since the rise of seaside resorts with the arrival of the railways in the 19th century, Devon's economy has been heavily reliant on tourism. The sunburst logo design is inspired by vintage British touristic posters, and is reminiscent of 19th century Art Deco sunburst. The two-season logo is reminiscent of a 1922 London Underground Museum Poster by British artist Albert E. Fruin.

The solar images in the poster are based on two events, respectively in period of high solar activity (2002 January 4 blasting Coronal Mass Ejection (CME), right forefront) and low solar activity (2010 July 11 solar eclipse, left background). The 'blasting CME' image is from the 'Best Of SOHO' image gallery courtesy of SOHO/EIT and SOHO/LASCO consortium (SOHO is a project of international cooperation between ESA and NASA). In this composite image, the solar disk from an EIT image in EUV light (304Å) was enlarged and superimposed on a LASCO C2 coronagraph image. The low-activity Sun is a composite of coronal images courtesy of NASA SDO/AIA and from the ESA 'Space in Images' gallery courtesy Institut d'Astrophysique de Paris (CNRS & UPMC), S. Koutchmy/J. Mouette. In this composite, the solar disk is made of SDO/AIA combined images at three wavelengths in the EUV (211, 193, 171Å) taken at about the same time as a reconstructed white-light image of the extended corona taken from the ground, in Atoll Hao, French Polynesia.

The landscape of the Exeter Cathedral in the poster is based on a photograph by Guy Edwards.

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**SPACE WEATHER OF THE
HELIOSPHERE:
PROCESSES AND FORECASTS**

**PROCEEDINGS OF THE 335th SYMPOSIUM
OF THE INTERNATIONAL ASTRONOMICAL
UNION HELD AT UNIVERSITY OF EXETER,
UNITED KINGDOM
JULY 17–21, 2017**

Edited by

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Table of Contents

Preface	xii
The Organizing Committee.....	xiv
Welcome Address by the Organizing Committee.....	xvi
Conference Photograph	xvii
Participants	xviii

Part 1. Solar Drivers and Activity Levels

Statistical Analysis of Individual Solar Active Regions	3
<i>G. Kromyda & L. Vlahos</i>	
Magnetic Activity Discrepancies of Solar-Type Stars Revealed by <i>Kepler</i> Light Curves	7
<i>H. He, H. Wang, Y. Yan & D. Yun</i>	
Variation of Quiet Sun Radiation during Solar Cycles 23 and 24	11
<i>M. Aroori, G. Yellaiah & K. C. Reddy</i>	
Temperature of Source Regions of ³ He-Rich Impulsive Solar Energetic Particle Events	14
<i>N.-H. Chen, R. Bučík & R.-S. Kim</i>	
Spatial Inhomogeneity in Solar Faculae	17
<i>A. Elek, N. Gyenge, M. B. Korsós & R. Erdélyi</i>	
Magnetic Helicity as a Predictor of the Solar Cycle	20
<i>G. Hawkes & M. A. Berger</i>	
Simulating the Dynamics of Coronal Plasma Condensations	23
<i>P. Kohutova & E. Verwichte</i>	
Alignment as an Indicator of Changes to Modal Structure within the Roberts Flow	26
<i>D. Miller</i>	
Hard X-Ray Emission of Solar Flares Measured by Lomonosov Space Mission ..	29
<i>I. N. Myagkova, A. V. Bogomolov, V. V. Bogomolov, S. I. Svertilov, S. Yu. Bobrovnikov, I. V. Yashin, M. I. Panasyuk, V. V. Kalegaev, V. L. Petrov & S. S. Shishkova</i>	
On the Dynamics of the Largest Active Region of the Solar Cycle 24	32
<i>R. Sarkar, N. Srivastava & S. K. Dhara</i>	
Excitation and Evolution of Transverse Loop Oscillations by Coronal Rain.	36
<i>E. Verwichte, P. Kohutova, P. Antolin, G. Rowlands & T. Neukirch</i>	

Part 2. Solar Wind and Heliosphere

Gamma-Ray Solar flares and In Situ Particle Acceleration	43
<i>A. Struminsky</i>	

The Relationship between Long-Duration Gamma-Ray Flares and Solar Cosmic Rays	49
<i>H. S. Hudson</i>	
Acceleration of Solar Wind Particles Passing through the 3D Heliospheric Current Sheet	54
<i>V. V. Zharkova</i>	
Pursuing Forecasts of the Behavior and Arrival of Coronal Mass Ejections through Modeling and Observations	58
<i>H. Cremades</i>	
Geomagnetic Consequences of Interacting CMEs of June 13-14, 2012	65
<i>N. Srivastava, Z. Mirtoshev & W. Mishra</i>	
Effects of ICMEs on High Energetic Particles as Observed by the Global Muon Detector Network (GMDN)	69
<i>A. Dal Lago, C. R. Braga, R. R. S. de Mendonca, M. Rockenbach, E. Echer, N. J. Schuch, K. Munakata, C. Kato, T. Kuwabara, M. Kozai, H. K. Al Jassar, M. M. Sharma, M. Tokumaru, M. Duldig, J. Humble, P. Evenson & I. Sabbah</i>	
Re-Acceleration of Energetic Particles in Large-Scale Heliospheric Magnetic Cavities	75
<i>O. V. Khabarova, O. E. Malandraki, G. P. Zank, G. Li, J. A. le Roux & G. M. Webb</i>	
Structure of the Power Spectral Density of Galactic Cosmic Ray Variation during 1953-2016	82
<i>P. Väisänen, I. Usoskin & K. Mursula</i>	
Testing Models of the Fast Solar Wind using Spectroscopic and In Situ Observations	87
<i>A. Fludra & E. Landi</i>	
Electron Acceleration in Collapsing Magnetic Traps during the Solar Flare on July 19, 2012: Observations and Models	90
<i>P. A. Gritsyk & B. V. Somov</i>	
A Behavioural Model of the Solar Magnetic Cycle	94
<i>M. Munroe</i>	
The Aging Solar Wind: a Break in Wind Evolution at Older Ages?	98
<i>D. Ó. Fionnagáin & A. A. Vidotto</i>	

Part 3. Impact of Solar wind, Structures and Radiation on Magnetospheres

Comparison and Time Evolution of the Geomagnetic Cutoff at the ISS Position: Internal vs External Earth's Magnetic Field Models	105
<i>M. J. Boschini, S. D. Torre, M. Gervasi, D. Grandi, G. La Vacca, S. Pensotti, P. G. Rancoita, D. Rozza & M. Tacconi</i>	
How does the Sun Influence the Magnetospheres of Jupiter and Saturn?	109
<i>C. M. Jackman & C. S. Arridge</i>	
The Response of the Martian Atmosphere to Space Weather	114
<i>D. A. Brain</i>	

Geomagnetopause Position and Shape Dependence on Solar Wind Plasma and IMF Parameters: Analytic Model Comparison with Observations and 3-D MHD runs	121
<i>M. I. Verigin, G. A. Kotova & V. V. Bezrukikh</i>	
Analysis of Magnetic Field Variations Produced by Equatorial Electro-Jets	125
<i>E. López, F. Aldás & A. Yoshikawa</i>	
Statistical Analysis of Extreme Electron Fluxes in the Radiation Belts	128
<i>V. Lanabere & S. Dasso</i>	
Four-Spacecraft Magnetic Curvature Analysis on Kelvin-Helmholtz Waves in MHD Simulations	132
<i>R. Kieokaew, C. Foullon & B. Lavraud</i>	
Space Observations to Determine the Location of Locally Vertical Geomagnetic Field	135
<i>S. Lepidi, D. Di Mauro, R. Tozzi, L. Cafarella, P. De Michelis & M. Marzocchetti</i>	
Determining the Polar Cusp Longitudinal Location from Pc5 Geomagnetic Field Measurements at a Pair of High Latitude Stations	139
<i>S. Lepidi, P. Francia, L. Cafarella, D. Di Mauro & M. Marzocchetti</i>	
CCMC Modeling of Magnetic Reconnection in Electron Diffusion Region Events	142
<i>P. H. Reiff, J. M. Webster, A. G. Daou, A. Marshall, S. Y. Sazykin, L. Rastaetter, D. T. Welling, D. DeZeeuw, M. M. Kuznetsova, A. Glocer & C. T. Russell</i>	

Part 4. Impact of Solar wind, Structures and Radiation on Ionospheres, Atmospheres

Thermospheric Dynamics in Quiet and Disturbed Conditions	151
<i>A. Bounhir, Z. Benkhaldoun, J. J. Makela, M. Kaab, B. Harding, D. J. Fisher, A. Lagheryeb, M. Khalifa, K. Elbouyahyaoui, M. Lazrek & A. Daassou</i>	
Variability of the Vertical Total Electron Content, from GPS data, during 2 to 8 November 2015, Using Oukaimeden and Rabat Stations in Morocco	159
<i>K. El bouyahyaoui, A. Bounhir, Z. Benkhaldoun, R. Fleury, C. Amory-Mazaudier & M. Kaab</i>	
Particle-In-Cell Modeling of CubeSat Interaction with Ionospheric Plasma	162
<i>N. Imtiaz & R. Marchand</i>	
Possible Influence of the Solar Eclipse on the Global Geomagnetic Field	167
<i>J.-H. Kim & H.-Y. Chang</i>	
About Factors of Solar Radiation Affecting the Ionosphere	171
<i>A. V. Rakhlin, O. A. Sheiner, F. I. Vybornov & A. V. Pershin</i>	

Part 5. Long-term Trends and Predictions for Space Weather

Predicting a Solar Cycle Before its Onset Using a Flux Transport Dynamo Model	177
<i>A. Rai Choudhuri</i>	

Towards Estimating the Solar Meridional Flow and Predicting the 11-yr Cycle Using Advanced Variational Data Assimilation Techniques	183
<i>C. P. Hung, A. S. Brun, A. Fournier, L. Jouve, O. Talagrand & M. Zakari</i>	
Reconstruction of the Filament Properties, Based on Centenarian Daily Observations of the Sun in H_{α} Line	187
<i>K. A. Tlatova, V. Vasil'eva & A. Tlatov</i>	
Space Weather in the Heliosphere	191
<i>C. T. Russell</i>	
Principal Component Analysis of Geomagnetic Activity: New Information on Solar Wind	197
<i>K. Mursula & L. Holappa</i>	
Predicting the Loci of Solar Eruptions	201
<i>N. Gyenge & R. Erdélyi</i>	
Sunspots Areas and Heliographic Positions on the Drawings Made by Galileo Galilei in 1612	205
<i>M. V. Vokhmyanin & N. V. Zolotova</i>	
Regularities of the IMF Sector Structure in the Last 170 Years	208
<i>M. V. Vokhmyanin, N. V. Zolotova & D. I. Ponyavin</i>	
Reinforcing a Double Dynamo Model with Solar-Terrestrial Activity in the Past Three Millennia	211
<i>V. V. Zharkova, S. J. Shepherd, E. Popova & S. I. Zharkov</i>	
 Part 6. Challenges and Strategic Plans for Earth and the Heliosphere	
Challenges and Strategic Research Plans for Earth and Heliosphere: Research Infrastructures, Projects and Initiatives	219
<i>I. Mann, K. Kauristi, R. Bamford, I. McCrea, J. Moen, K. Oksavik, M. Yamauchi, M. J. Gullikstad & E. Turunen</i>	
Defining and Characterising Heliospheric Weather and Climate	226
<i>M. Messerotti</i>	
Monitor and Prediction of Near-Earth Radiation Environment in the Frame of Space Monitoring Data Center at Moscow State University	232
<i>I. N. Myagkova, V. V. Kalegaev, M. I. Panasyuk, Y. S. Shugai, S. A. Dolenko, S. Yu. Bobrovnikov, V. O. Barinova, M. D. Nguyen, V. R. Shiroky, V. E. Ereemeev, A. V. Bogomolov, O. G. Barinov, N. A. Vlasova & N. V. Kusnetsov</i>	
The Mexican Early Warning System for Space Weather	236
<i>V. De la Luz, J. A. González-Esparza, M. Sergeeva, P. Corona-Romero, J. Mejía-Ambríz & L. X. González</i>	

Part 7. Forecasting Models

Numerical Short-Term Solar Activity Forecasting	243
<i>H. Wang, Y. Yan, H. He, X. Huang, X. Dai, X. Zhu, Z. Du, H. Zhao & Y. Yan</i>	
Sandpile Models and Solar Flares: Eigenfunction Decomposition for Data Assimilation	250
<i>A. Strugarek, A. S. Brun, P. Charbonneau & N. Vilmer</i>	
The Role of Empirical Space-Weather Models (in a World of Physics-Based Numerical Simulations)	254
<i>M. J. Owens, P. Riley & T. Horbury</i>	
A New Technique to Provide Realistic Input to CME Forecasting Models	258
<i>N. Gopalswamy, S. Akiyama, S. Yashiro & H. Xie</i>	
Prospects for Modeling and Forecasting SEP Events with ENLIL and SEPMOD	263
<i>J. G. Luhmann, M. L. Mays, D. Odstrcil, Y. Li, H. Bain, C. O. Lee, C. M. S. Cohen, R. A. Mewaldt, R. A. Leske & Y. Futaana</i>	
Application of Test Particle Simulations to Solar Energetic Particle Forecasting	268
<i>S. Dalla, B. Swalwell, M. Battarbee, M. S. Marsh, T. Laitinen & S. J. Proctor</i>	
High Speed Solar Wind Forecast Model from the Solar Surface to 1AU Using Global 3D MHD Simulation	272
<i>M. Den, T. Tanaka, Y. Kubo & S. Watari</i>	
The HelMod Monte Carlo Model for the Propagation of Cosmic Rays in Heliosphere	276
<i>M. J. Boschini, S. D. Torre, M. Gervasi, D. Grandi, G. La Vacca, S. Pensotti, P. G. Rancoita, D. Rozza & M. Tacconi</i>	
The Space Weather through a Multidisciplinary Scientific Approach	280
<i>Z. Benkhaldoun, M. Khalifa, A. Bounhir, N. Vilmer, K. El bouyahyaoui, M. Kaab, A. Lagheryeb & A. Daassou</i>	
Physics-Based Modeling Activity from the Solar Surface to the Earth's Atmosphere Including Magnetosphere and Ionosphere at NICT	284
<i>M. Ishii, M. Den, H. Jin, Y. Kubo, Y. Kubota, A. Nakamizo, H. Shinagawa, D. Shiota, T. Tanaka, C. Tao, S. Watari & T. Yokoyama</i>	
Numerical Effects on Wave Propagation in Atmospheric Models	288
<i>D. J. Griffin & J. Thuburn</i>	
Comparison of Predictive Efficiency of Topological Descriptors and SHARP in Solar Flares Forecasting	291
<i>I. Knyazeva, F. Urtiev & N. Makarenko</i>	
On the Evolution of Pre-Flare Patterns of a 3-Dimensional Model of AR 11429	294
<i>M. B. Korsós, S. Poedts, N. Gyenge, M. K. Georgoulis, S. Yu, S. K. Bisoi, Y. Yan, M. S. Ruderman & R. Erdélyi</i>	
Forecasting Solar Energetic Particle Fluence with Multi-Spacecraft Observations	298
<i>T. Laitinen, S. Dalla, M. Battarbee & M. S. Marsh</i>	

Prediction of Ground Level Enhancements	301
<i>M. Núñez, P. J. Reyes-Santiago & O. E. Malandraki</i>	
A Probabilistic Approach to the Drag-Based Model.	304
<i>G. Napoletano, R. Forte, D. Del Moro, E. Pietropaolo, L. Giovannelli & F. Berrilli</i>	
PFSS-Based Solar Wind Forecast and the Radius of the Source-Surface	307
<i>L. Nikolić</i>	
Solar Flare Prediction Using Machine Learning with Multiwavelength Observations	310
<i>N. Nishizuka, K. Sugiura, Y. Kubo, M. Den, S.-i. Watari & M. Ishii</i>	
AMR-MHD Simulation of CME Propagation in Solar Wind Generated on Split Dodecahedron Grid	314
<i>T. Ogawa, M. Den, T. Tanaka & K. Yamashita</i>	
Ground-Based Observations of Powerful Solar Flares Precursors	318
<i>S. S. Snegirev, O. A. Sheiner & A. S. Smirnova</i>	
Solar Radio Emission as a Prediction Technique for Coronal Mass Ejections' Detection.	321
<i>V. M. Fridman & O. A. Sheiner</i>	
Forecasting Solar Energetic Particle Events and Associated False Alarms	324
<i>B. Swalwell, S. Dalla & R. Walsh</i>	
METU Data Driven Forecast Models: From the Window of Space Weather IAU Symposium 335.	328
<i>Y. Tulunay & E. Tulunay</i>	

Part 8. Space Weather Monitoring, Instrumentation, Data and Services

The MOTH II Doppler-Magnetographs and Data Calibration Pipeline	335
<i>R. Forte, S. M. Jefferies, F. Berrilli, D. Del Moro, B. Fleck, L. Giovannelli, N. Murphy, E. Pietropaolo & W. Rodgers</i>	
The Inner Coronagraph on Board ADITYA-L1 and Automatic Detection of CMEs	340
<i>D. Banerjee, R. Patel, V. Pant & ADITYA team</i>	
Data Handling and Assimilation for Solar Event Prediction	344
<i>P. C. Martens & R. A. Angryk</i>	
SWERTO: a Regional Space Weather Service.	348
<i>F. Berrilli, M. Casolino, D. Del Moro, R. Forte, L. Giovannelli, M. Martucci, M. Mergé, G. Napoletano, L. Narici, E. Pietropaolo, G. Pucacco, A. Rizzo, S. Scardigli & R. Sparvoli</i>	
The Ionosphere Prediction Service	352
<i>C. Albanese, F. Rodriguez, R. Ronchini, S. Di Rollo, F. Berrilli, A. Cristaldi, D. Del Moro, R. Forte, G. De Franceschi, C. Cesaroni, L. Spogli, V. Romano, M. Aquino, S. V. Veetil, O. Kalden, M. Hutchinson & E. Guyader</i>	

The Belgian Space Weather Observatory in Dourbes	355
<i>D. Sapundjiev, T. G. W. Verhulst, S. M. Stankov & J. C. Jodogne</i>	
The Coronal Solar Magnetism Observatory	359
<i>M. J. Thompson, S. Tomczyk, S. E. Gibson, S. W. McIntosh & E. Landi</i>	
The Forecast of Space Weather According to Ground-Based Observatories	362
<i>A. Tlatov</i>	
The High-Energy Particle Detector (HEPD) on Board the CSES Mission	365
<i>V. Vitale, for the CSES/HEPD collaboration</i>	
Author index	368
Parallel Education Program	372

Preface

The Sun is an active and variable star. Instabilities and non-stationary processes connected to the solar magnetic field and its evolutionary mechanisms modify its radiative and particle output on different time scales, from seconds to the evolutionary scale of the star. Solar activity affects interplanetary space and planetary environments. The physical state of space associated with short-term solar activity is called space weather, while long-term activity of our star determines space climate. The multi-disciplinary IAU Symposium 335 on 'Space Weather of the Heliosphere: Processes and Forecasts' was held at the University of Exeter, UK in July 17-21 2017. It linked various aspects of research in solar, heliospheric and planetary physics, emphasizing cross-disciplinary developments.

The ability to understand, monitor and forecast the space weather is of paramount importance to our high-technology society. Sudden changes in space weather, due to eruptive events on the Sun such as coronal mass ejections (CMEs) and solar flares, can impact the technology we rely on every day. In June 2015 the World Meteorological Organisation (WMO) endorsed space weather activities. In addition, in October 2015 the United States President's Office of Science and Technology Policy released the U.S.'s comprehensive Strategy and Action Plan for space weather, titled 'Space Weather: Understanding Potential Impacts and Building Resilience'. This release was a major step in the USA's determination to address civil societal issues related to all aspects of space weather. Also released that year was a lengthy international road map document by C. Schrijver et al. titled 'Understanding space weather to shield society: A global road map for 2015-2025 commissioned by COSPAR and the ILWS'. Thus, the Symposium subject was timely and strongly linked to our modern society's technological and economical developments. Moreover, the human exploration vision and ongoing efforts to send manned missions into space are putting increasing demands for space weather predictability beyond our Earth's environment. The effects of interplanetary space weather on planets or moons in our Solar System, as well as the space weather experienced by comets and asteroids, are enriching and stretching our understandings. Our scientific community has the responsibility to use its knowledge to support tackling societal problems; one of the roles that the community can play is to identify the research questions that have to be answered in order to improve forecasts.

The IAU Symposium 335 had received the support from 5 out of 9 Divisions across IAU, including the Coordinating Division E Sun and Heliosphere. It was one of the 9 approved by the IAU Executive Committee in May 2016. The symposium brought together scientific experts from various pertinent disciplines to the meeting from all over the world around the topic of Space Weather. We would like to emphasize the strongly international character of the symposium and that it was the first IAU symposium organised on this topic. We welcomed 185 participants from 30 different countries and 21 accompanying persons, exhibitors or public lecturer. Thanks to IAU and 14 cosponsors listed on page *xxi* of these Proceedings, we supported 47 scientists from around the world to attend and present their work. Particular noteworthy was the relatively high (36.8%) proportion of women attendees, one of the highest ever encountered at a major international meeting in our field.

The overall scientific program involved a total of 204 abstracts. Of those presented abstracts, 122 were posters and 82 were in the oral program. The oral program consisted of 26 invited talks by leaders in the field and 56 oral contributed presentations. 10 chairs led the sessions and provided lively question and answer sessions. The scientific program consisted of 8 sessions, scheduled over 4.5 days. Each session topic was explored by 2 to 4

invited talks, contributed talks and poster sessions. All oral presentations were plenary, except for the last theme where we had a common plenary and a split in 2 round tables. Thanks to the rich representation and optimal (scientific, regional, gender) diversity of the SOC, balance was respected in the selection of the 26 invited speakers and the general scientific program. The symposium therefore gave a balanced international overview of the general advances in space weather, focusing on the key topics of solar drivers and activity levels (session 1); Solar wind and heliosphere (2); Impact of solar wind, structures and radiation on and within terrestrial and planetary environments (3 and 4); Long-term trends and predictions for space weather (5); Challenges and strategy plans for Earth and the heliosphere (6); Forecasting models (7); Space weather monitoring, instrumentation, data and services (8). This volume contains a representative sample of 83 reviewed papers from all sessions whilst respecting the order of the scientific program.

Besides the main sessions, the oral program included a town hall session and round-table discussions, plenary summaries, and a few opening and closing talks. In the last few years, we have seen transformations of the UK political landscape, all in response to space weather being on the national risk register (e.g. the Met Office centre). The Symposium opened with a Welcome Introduction by M. Hapgood, chair of the Space Environment Impact Expert Group (SEIEG) that advises the Cabinet Office on Space Weather. Space weather is increasingly recognised as an international challenge faced by several communities. In Session 6, the United Nations Expert Group on Space Weather led a town hall session on 'Strategy for Developing an International Framework for Space Weather Services (2018-2030)'. On the last day, Session 8 included two parallel round tables RT1 'Data Handling and Assimilation' and RT2 'Relationships with the 'civil' society', with the findings summarized in the plenary by invited speakers. The ability to understand, monitor and forecast the space weather of the Earth and the heliosphere is of paramount importance for our high-technology dependent society and for the current rapid developments in our knowledge and exploration (robotic and human) of the Solar System. Space weather is not just important at Earth and this symposium brought a vast range of expertise together, discussing the activity and winds of other Suns and the effects on planets and other objects of the solar system such as Pluto.

To foster the excitement of younger colleagues in presenting their work, two competitions took place. A poster competition was organised with judges assigned among the senior participants; the poster winners were: in joint fourth, R. Chiba and V. Pant; in joint second, N. Hussain and M. Korsos; and in first place, S. Mahajan. An independent committee drawn from the SOC singled out K. Tlatova for her research, oral presentation and overall performance, and nominated her for a IAGA Young Scientist Award. Congratulations to all of them.

Special thanks are expressed to all SOC members for their help in organising the sessions. The editors take this opportunity to thank the following reviewers, for their valuable assistance in improving the papers: Z. Benkhaldoun, F. Berrilli, N.B. Crosby, S. Dalla, S. Dasso, B. Fleck, C. Foullon, I. Hannah, C. Jackman, D. Knipp, J. Luhmann, O.E. Malandraki, M. Owens, P. Reiff, K. Shiokawa, N. Srivastava, M. Thompson, I. Usoskin, E. Verwichte, J. Wang and D. Webb. The international services that address space weather disaster risks require a rapid dissemination of current research. May the IAU 335 Symposium and these companion Proceedings covering interdisciplinary topics and attracting a variety of interested parties become a crucial reference at this moment to help the international space weather community prosper.

*Claire Foullon and Olga E. Malandraki,
Exeter, UK and Athens, Greece, January 15, 2018*

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Welcome Address by the Organizing Committee

Dear Colleague,

The University of Exeter is proud to host the IAU Symposium 335 on Space Weather of the Heliosphere: Processes and Forecasts. It is a pleasure to report that 193 participants from 31 different countries are expected to attend the event, sharing progress in all key topics of the scientific program.

Space weather is increasingly recognised as an international challenge faced by several communities. The ability to understand, monitor and forecast the space weather of the Earth and the heliosphere is of paramount importance for our high-technology society and for the current rapid developments in knowledge and exploration within our Solar System. This 5-day Symposium aims to further our understanding of space weather by linking various aspects of research in solar, heliospheric and planetary physics, and by putting particular emphasis on cross-disciplinary developments, merging different communities, learning from interplanetary comparisons and discussing some of the most current challenges at the international level via various forums, including invited and contributed talks and posters, but also a Town Hall and two Round Tables.

Exeter, UK, offers world-leading expertise in weather research and forecasting, and is rapidly expanding its efforts in space weather. Thus Exeter provides an ideal combination of communities to host the Symposium. What is most special about the history of space weather for our conference is that ‘the first recorded impact of space weather on civilisation ’ can be placed here, in the South West (when the former Great Western Railway (GWR) company was operating): on 18th of October 1841, the 10.5 PM train between Starcross and Exeter, had been delayed by 16 minutes, on the account of a very intense magnetic disturbance, at a time when telegraphs were means of communication to give clearance for railway switching (Cade 2013). Scientific excursions and local exhibitions are planned throughout the week, and will reveal all local treasures and facilities surrounding us.

The heart of the city offers a wealth of history, interesting architecture, cafés, pubs and restaurants for spending the evenings. Situated in the heart of Devon, Exeter is the perfect base to explore the South West of England, a scenery part of the world we hope our social activities will help you to discover.

As modern society becomes increasingly dependent on ground- and space-based technology, it also becomes increasingly vulnerable to the effects of space weather. Not only is it important for the public to better understand space weather but it is also an area of astronomy and space physics that inspires the public with beautiful phenomena such as auroras. We will promote our field of astronomy and space weather science, by giving you the opportunity to engage about space weather with our local young people (students), teachers and the general public in an active parallel education/public outreach program.

We thank you all for your dedication and your participation.

Best wishes on behalf of the Local and Scientific Organising Committees,

Dr Claire Foullon, Chair of IAUS335 LOC & SOC

Exeter, 9 July 2017

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