W O R L D M E T E O R O L O G I C A L O R G A N I Z A T I O N

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COMMISSION FOR BASIC SYSTEMS
&
COMMISSION FOR AERONAUTICAL METEOROLOGY

INTER-PROGRAMME COORDINATION TEAM ON SPACE WEATHER

FOURTH SESSION

GENEVA, 25-28 NOVEMBER 2013

FINAL REPORT

EXECUTIVE SUMMARY

The fourth session of ICTSW was held in Geneva from 25 to 28 November 2013. Among its main outcomes the session has:

- Reviewed the draft ICAO Standard and Recommended Practices (SARP) for space weather information support to international air navigation and the related CONOPS;
- Approved the ROB (Belgium) Sunspot product for inclusion into the Product Portal;
- Recommended the evolution of the Product Portal to a new “Product Access Guide”;
- Agreed on guidelines for harmonizing severe space weather warnings;
- Noted and supported the development of the GTEX format for GNSS slant TEC data;
- Noted and welcomed the planned CMA format for FY-3C GNOS radio-occultation data;
- Recommended NICT (Japan) to become a WIS DCPC for space weather information;
- Noted and encouraged the WIS demonstration actions involving four products;
- Noted the inventory and categorization of space-based space weather observing capabilities in OSCAR and took action to review the measurements-instruments links;
- Exchanged views on the current plans and strategic goals of members for space weather, discussed the global need for coordination of operational space weather activities and agreed that a proposal for a “Space Weather Watch” should be prepared in response to the request from the 16th WMO Congress;
- Stressed the need to advocate the long term continuation and expansion of essential space weather observation infrastructure and to seek support from WMO Members to the space weather coordination activities undertaken within WMO.

Participants in the ICTSW-4 meeting in Geneva. From left to right: Henrik Lundstedt, David Jackson, Bruno Zolezi, Nicole Vilmer, Neil Mitchison, Vyacheslav Burov, Jan Janssens, Alain Hilgers, Iwona Stanislawska, Mamoru Ishii, Larisa Trichtchenko, Mangala Sharma, Norbert Jakowski, Terry Onsager, Kichang Yoon, Lee-Anne McKinnell, Raul Romero, Hyesook Lee, Margit Haberreiter, Kirsti Kauristie, Daniele Biron, Jérôme Lafeuille, Xiaoxin Zhang.

FINAL REPORT

1. OPENING OF THE MEETING

The fourth session of the Inter-programme Coordination Team on Space Weather (ICTSW) opened on 25 November 2013 at 9:00. On behalf of the Secretary-general of WMO, Jérôme Lafeuille welcomed the participants for their first face-to-face meeting held in WMO premises, and proposed that this session be chaired by Dr Terrance Onsager.

The Chairman introduced the participants (See Annex 1), recalled the objectives of the session and presented the draft agenda, which was approved (See Annex 2). The working documents were on line (http://www.wmo.int/pages/prog/sat/meetings/ICTSW-4.php).

2. UPDATE ON WMO

J. Lafeuille introduced the participants to WMO, its high-level objectives, priorities, main programmes, and organizational structure. He recalled that the sixteenth WMO Congress (Cg-16) had expressed the need for "a coordinated effort by WMO Members to address the observing and service requirements to protect against the global hazards of space weather" and had recognized space weather as one of the four main areas of activities of the WMO Space Programme.

It was confirmed that although space weather was addressed within the WMO Space Programme, the scope of activities was not limited to outer space but was expected to encompass ground-based observations and user impacts.

3. ICTSW CO-CHAIRS' REPORT

The Chairman presented the report from the two Co-chairs, giving the broad picture of ICTSW activities since its establishment and underlining that all the aspects of the ICTSW Terms of Reference had been addressed and substantial achievements reached, while much more was still planned.

The meeting acknowledged that the activities described in the Terms of Reference were useful and should be tackled to the extent possible; however, the team should plan its tasks in accordance with its resources. It was recommended to focus the effort on ensuring a tangible improvement of space weather services.

It was also highlighted that the mandate to provide operational space weather services in any country was expected to be part of a governmental response to societal needs. It was thus essential to communicate at the governmental level on space weather impacts and on the benefits of space weather services.

- *Recommendation 4.1: All Members involved in ICTSW to communicate at the governmental level on space weather impacts and on the benefits of space weather services*.

4. STATEMENT OF GUIDANCE ON SPACE WEATHER OBSERVATIONS

The Chairman recalled the Rolling Review of Requirements (RRR) process and the established practice to draft and keep under review a "Statement of Guidance" (SOG) that intended to: (i) summarize the status of observing networks, (ii) analyze the gaps and (iii) provided guidance for evolution and improvement of the observing networks. It was agreed in principle to prepare an update of the Space Weather SOG every two years.

The Chairman recalled the recommendations of the SOG. The team stressed the need to ensure availability of ground-based and space-based observations as recommended in the SOG. The need "*to maintain the continuity of satellite-based solar, solar wind and other space weather measurements*" was recognized in a resolution of the Executive Council (EC-65, June 2013). There is a lack of a mechanism to address space agencies beyond the Earth Observation community. The ICTSW should take the opportunity of the COSPAR Space Weather Roadmap to communicate its assessment of observation needs. As concerns ground-based observations, the team acknowledged that there is a lack of integration and data sharing, which prevents an optimal use of current networks.

ICTSW-4 approved in principle the comprehensive statement prepared by David Jackson and others about radiation dose rate and thermosphere measurements, subject to finalization. It was noted that the radiation dose rate is not precisely defined in OSCAR.

- *Action 4.1: All ICTSW members to review and check that the actual contents of the SOG are current (check any gap or risk that was overlooked or that has emerged in the meantime) and report to the co-chairs and the Secretariat (jlafeuille@wmo.int). (30 June 2014)*

- *Action 4.2: In particular, all ICTSW members to check and report if the observations they are aware of at the national level are fully reflected in the proposed addition to the SOG regarding radiation dose rate, thermospheric wind and density. (30 June 2014)*

- *Action 4.3: David Jackson, Terry Onsager, Jérôme Lafeuille to condense the text in Doc. 4.2 Appendix, with a view of its inclusion in the SOG update. (31 July 2014)*

- *Action 4.4: David Jackson to propose a more precise definition of the Radiation Dose Rate, specifying which part of the energy spectrum is considered. (31 January 2014)*

- *Action 4.5: Kirsti Kauristie to draft a 2-page summary of the Statement of Guidance for communication to COSPAR as a contribution to the Space Weather Roadmap. (28 February 2014)*

- *Recommendation 4.2: To advocate the importance of space and ground-based observations, as documented in the SOG; this advocacy effort should be directed towards the current operators of space- or ground-based observing capabilities as well as towards potential new operators.*

5. SPACE WEATHER SERVICES TO AVIATION

5.1 Review process of ICAO documents by ICTSW

The Chairman recalled the previous iterations on the draft "Concept of Operations for Space Weather Information in Support of International Air Navigation" (CONOPS) produced by the International Civil Aviation Organization (ICAO). A number of comments had been made on the previous version (2. 2) of the CONOPS and it had been suggested to establish an ad-hoc team to work with ICAO in order to solve the points of concern. This ad-hoc team, led by Andy Wells from the United Kingdom, was invited to submit comments by email in July 2013. Many comments have been submitted by the team, represented by T. Onsager, and a number of them have been taken into account in the revised draft version (2.3). An opportunity is given to provide further comments on this version 2.3 until December 6.

He also recalled that ICAO had produced a draft document on "Space Weather Impacts on International Air Navigation", which provided a fair overview of space weather impacts, and was now developing draft "Standards and Recommended Practices" (SARP), which should

be given high attention by ICTSW.

Raúl Romero (ICAO) explained that, unlike the SARP, the CONOPS is intended to be a guiding document that will evolve together with technological improvements and the development of requirements. The ICTSW acknowledged that draft version 2.3 of the CONOPS was improved with respect to the previous version although some ambiguities and inconsistencies remained. The ICTSW considered the current draft version as a basis for discussion that, subject to further improvement, could provide useful guidance for the evolution of space weather services to aviation. Bearing in mind that a number of comments made on the previous version had been disregarded by the editors of the document, and noting that the CONOPS was less critical than the SARP, the ICTSW concluded that the most efficient way to assist ICAO on this subject was to focus the comments only on factual corrections and on the main points of concern.

- *Action 4.6: All ICTSW members to provide Terry Onsager and Jérôme Lafeuille with comments on the CONOPS Draft Version 2.3. (Due date: 4 December 2013)*

- *Action 4.7**:** T. Onsager and J. Lafeuille to consolidate the ICTSW comments and provide the ICAO Secretariat and Andy Wells with the formal response from WMO on the CONOPS Draft V. 2.3. (Due date: 6 December 2013)*
  [Note: Action completed on 6 December].

5.2 ICAO requirements for space weather information

Raúl Romero (ICAO) presented the proposed SARPs for space weather services to aviation, which call for the designation of “Space Weather Centres”. The Space Weather Centres would be in charge of delivering space weather information relevant to air navigation in alphanumerical and/or digital form; the draft SARPs include a template for the alphanumerical information to be provided in future. R. Romero stressed the importance of decisions to be made by the conjoint WMO-ICAO Met Divisional meeting in July 2014 to endorse the SARPs. Such a conjoint meeting only convenes every 10 to 12 years. The SARPs will be included in an amendment to Annex 3– *Meteorological Service for International Air Navigation* of the ICAO Convention that will be submitted to the ICAO Council for adoption in February/March 2016, for intended applicability in November 2016. It would be helpful to have the formal comments from WMO in advance of the next meeting of the International Airways Volcano Watch Operations Group (IAVWOPSG).

ICTSW-4 noted that the proposed draft was a very good basis for possible initial SARPs. It suggested however that the template should include indication of the typical/potential impact of the events on user systems. It was also suggested that the information should not be limited to the observed situation but also indicate the anticipated situation (nowcast or forecast), to the extent it is predictable. It was clarified that when a Member applies to serve as a Space Weather Centre it shall specify which functions it commits to provide, over which area of responsibility (e.g. global, or only in a certain region). Additionally it was clarified that it is a prerogative of each State, if wished, to apply a cost recovery scheme for the provision of the services. As concerns possible liability it was noted that no centre can be held liable for an inaccurate forecast or observation, but the centres should be able to give evidence that they follow the “rules of the art”, for example through a certified quality management system. The ICTSW members were invited to review the draft SARP and to provide further comments off-line.

- *Action 4.8: All ICTSW members to review the draft SARPs contained in ICTSW-4/Doc. 5.2 Rev1 and provide comments to T. Onsager and J. Lafeuille. (10 January 2014)*

- *Action 4.9: T. Onsager and J. Lafeuille to consolidate the comments from ICTSW on the draft SARPs. (17 January 2014)*

- *Action 4.10: J. Lafeuille to provide ICAO Secretariat (R. Romero) with the WMO comments on the draft SARPs, after finalization. (24 January 2014)*

5.3 Organization of space weather services to aviation

The ICTSW recognized the importance of providing guidance to ICAO States regarding the network organization and functions of future Space Weather Centres, preferably in advance of the IAVWOPSG meeting in February 2014. Questions to be addressed are for instance: Shall all centres perform the same functions or is there any operational advantage in specializing them? Is there an operational need for centres in particular geographic areas (e.g. high and low latitudes, etc)? What is the minimum/maximum number of centres required to ensure the most efficient service? Such issues require discussions among ICTSW members.

- *Action 4.11: Terry Onsager to schedule in January 2014 two ICTSW teleconferences on the network organization and functions of space weather centres for ICAO. (15 January 2014)*

6. SPACE WEATHER PRODUCT PORTAL

6.1 New WMO portal, concept and procedures

Nils Hettich presented the prototype of the Product Access Guide (PAG) which is proposed to replace and enhance the current Space Weather Product Portal. The PAG will offer more flexibility than the current product portal through the use of multiple search keys (e.g. by category of product, by region, by data source, by application), and should have more visibility since it will be a common portal with other, meteorological or environmental, products, though with a strong initial focus on products derived from satellite data. ICTSW-4 welcomed the new PAG concept and approved in principle the migration of the Space Weather Product Portal to the PAG once operational.

- *Action 4.12**:** All ICTSW Members to review the prototype PAG (http://wmo-sat.info/product-access-guide/) and forward comments on the layout and overall functionality. (10 January 2014)*

The meeting recalled the purpose of the portal which is three-fold:

- Provide a showcase to demonstrate selected, quality-controlled, mature products for potential users,
- Foster harmonization of product specifications and of related documentation and quality standards, thereby contributing to ensure maturity of products transferred from research to operations,
- Provide training and near-real time information to meteorologists who intend to become involved in space weather and in the provision of such products to end users.

In order to gain more visibility for the Space Weather Product Portal it was recommended to include “Space weather” among the topics searchable from the WMO home page.
[Note: This is done. When typing “Space weather” in the search box at the bottom of the left-hand menu several links relevant to space weather are displayed, starting with the Space Weather Product Portal.]

6.2 New candidate products

Jan Jansens presented the two candidate products that came out of the call for proposals to all ICTSW Members, both products being proposed by Belgium: (i) Sunspot Index and Long-Term Solar Observations (SILSO) sunspot cycle information page, and (ii) a K-Index hourly estimate. ICTSW-4 welcomed these proposals and commended Belgium for the

comprehensive description which was fully compliant with the portal requirements. The team approved the inclusion of the SILSO product. It also expressed interest for the proposed K-index product but raised the need of agreeing to a general approach for such regional/local geomagnetic products, with a view to define common specifications.

- *Action 4.13: Jan Janssens and Nils Hettich to coordinate to implement the sunspot cycle in the Space Weather Product Portal. (31 December 2013)*
  [Note: Action was completed on 7 December].

- *Action 4.14: J. Janssens and Larisa Trichtchenko to lead a discussion to define guidelines for the specifications of regional geomagnetic disturbance products to ensure that future regional geomagnetic products on the portal are comparable. (28 February 2014)*

6.3 Candidate training material

Xiaoxin Zhang presented a whole list of links to online space weather training material that could be considered for posting on the portal. The team welcomed this list whilst noting that it was not mature enough for inclusion in the PAG. The list would first need to be reviewed/approved, but also organized (how shall this be structured: by topics, or associated with particular products or product collections?).

The publication of references to training material was considered as a first step in a broader training strategy which still needs to be defined (See item 12). The ad-hoc team established on this subject should provide guidance on how to take advantage of the portal for training material.

- *Action 4.15: The training strategy team, including Hyesook Lee, Mamoru Ishii, Nicole Vilmer, Xiaoxin Zhang, to select the training material references to be included in the Space Weather Product Portal and recommend how it should be organized in the portal (e.g. according to which topic categories). (31 August 2014)*

7. WARNING FOR EXTREME SPACE WEATHER EVENTS

Following discussions by ICTSW-3, a Panel session on extreme space weather event warning was held during the NOAA Space Weather Week in Boulder in April 2013. The outcomes of this session were captured in a presentation at the 10th European Space Weather Week (ESWW10) in November 2013 by Terry Onsager, Mangala Sharma and Jérôme Lafeuille. An increasing number of countries are now addressing space weather hazards in their national risk management approach at the governmental level (Note: the word “Hazard” relates here to probability and severity of a hazardous event, while “Risk” addresses the impact, resulting from the hazard combined with the exposure and vulnerability of people and/or infrastructures). At ESWW10, several civil contingency agencies recommended to rely on national meteorological services to communicate space weather alerts. It was pointed out that extreme events in the space weather climatology (Superstorms) are useful references for resilient system design but are very infrequent by definition; the scope of space weather event warning should be extended more generally tp the warning of any severe space weather events, i.e. particular events with potentially hazardous consequences without being restricted to centennial extremes only. The panel session showed that several space weather warning centres have individually a valuable experience in severe event warning but there is a lack of coordination, harmonization and exchange of experience among centres. A number of actions were thus suggested to improve coordination and develop best practices to deal with severe space weather event warnings. These are summarized in the recommendation below and in a new action which replaces former Action 3.25.

- *Recommendation 4.3 : ICTSW should work along the following lines in support of severe space weather event warning:*

    1. *Encourage all countries to include space weather risk into their national multi-hazard warning schemes;*
    2. *Identify/select proper indices (R, S, G, DIX, W,…) to characterize the severity of the events, and define levels above which specific procedures should be activated;*
    3. *Establish a real-time communication mechanism among warning centres to share urgent technical and informal information, cross-verify forecasts, keep each other informed of the press/media accounts about extreme events (taking into account the need to be efficient in an emergency context); exercise such communication mechanisms under test conditions;*
    4. *Develop a "manual of best practices" to deal with severe/extreme events; in particular, the manual should define a standard set of products in concise formats including for instance a risk index in a space weather hazard scale;*
    5. *Conduct post-event analyses and statistics to refine the capabilities and to document the reliability of the warnings issued.*

- *Action 4.16: David Jackson, Mauro Messerotti, Mike Terkildsen, Terry Onsager, Vyacheslav Burov and Xiaoxin Zhang to evaluate, improve, and expand as necessary the set of global and local Space Weather scales in order to ensure efficient and standardized information communication to the users in severe event situations. (30 November 2014)*

8. DATA AND PRODUCT EXCHANGE ISSUES

8.1 Overview and critical issues

One of the main goals of ICTSW is to facilitate data exchange in taking advantage of the WMO Information System (WIS) when relevant. This includes identifying and promoting appropriate data formats and metadata standards, facilitating data discovery, retrieval, storage and long-term preservation, and near-real time data exchange.

8.2 Formats and standards

Various formats can be used in the WIS context, either Table Driven Code Forms (TDCF) such as BUFR and GRIB2 with supporting documentation maintained by WMO, or other internationally recognized formats such as NetCDf which are less compact but self documented. NetCDF is increasingly used by research users, it is noted however that for NetCDF like for BUFR or GRIB a specific implementation needs to be defined for each new data type. It is therefore important to ensure that the NetCDF implementation is supported by an identified community involving users and providers.

<u>BUFR and GRIB</u>
Mike Terkildsen reported on ongoing developments regarding the use of WMO Table Driven Code Forms BUFR and GRIB2 for space weather data. First of all a proposal has been submitted –and supported by ICTSW already – to encode space weather gridded data in GRIB2, which is designed for data defined on a regular grid, such as a model output. Furthermore, the pilot products prepared for distribution over the WIS will be encoded in BUFR, which is extensively used by the NWP community (e.g. for satellite data or ground observations) with the advantage of being compact and easily compressed. In his presentation, M. Terkildsen recommended the following actions:

- Identify those space weather data and parameters the community would most benefit from under a standardised data exchange through the WIS

- Identify the most suitable format for representation of the selected parameters, in light of existing coding proposals.
- Formulate a proposal to update the relevant WMO code tables for space weather data not covered by existing proposals.

The meeting considered that the discussion on the use of TDCF should best take place after completion of the WIS demonstration actions (See 8.4). Noting that meteorological satellite imagery products are often coded in BUFR rather than GRIB, there were doubts about whether GRIB was the most appropriate for coding the various observation data described in the GRIB coding proposal (IPETDRC-III/Doc.2-3_12). This should be investigated further.

GTEX format

Mamoru Ishii presented the ongoing effort to define the GNSS TEC data exchange format (GTEX), an extension of the widely used RINEX format. GTEX could be used in addition to IONEX to exchange TEC slant data without including commercially or strategically sensitive data, thereby respecting the constraints of the data providers.
ICTSW-4 understood that the GTEX format is under discussion by the Radiocommunications Study Group 3 of the International Telecommunications Union (ITU-R SG3). Iwona Stanislawska presented additional background information on RINEX, IONEX, and ISO and other standards applicable to ionospheric data.

- *Recommendation 4.4: The ICTSW recommends the finalization of the GTEX format by ITU and ultimately its use for the exchange of TEC slant data.*

- *Action 4.17: M. Ishii and J. Lafeuille to investigate whether the RINEX format is currently used on the WMO GTS or WIS for Integrated Water Vapour observations from ground-based GNSS receivers and, if necessary, will recommend to the WMO CBS that the RINEX format – and GTEX once finalized - be recognized for data exchange in the WIS. (28 February 2014)*

- *Recommendation 4.5: The ICTSW should express a recommendation on the use of BUFR and GRIB for space weather data in the light of the pilot activities when completed.*

FY-3C GNOS Format

Xiaoxin Zhang introduced the radio-occultation data format that is planned to be used for level 2 data from the GNSS Occultation Sounder (GNOS) operated aboard the newly launched Feng-Yun 3C spacecraft (FY-3C). ICTSW welcomed the GNOS format description, noting that this format was consistent with corresponding formats for Formosat-3/COSMIC. The question was raised whether CMA was also providing GNOS RO data in BUFR format for the NWP community.

- *Action 4.18: Xiaoxin Zhang shall investigate whether GNOS RO data will also be used in BUFR format by CMA in addition to the proposed GNOS RO format and report to ICTSW. (15 January 2014)*

Format issue by IROWG

At the last international workshop of the International Radio-occultation Working Group (IROWG), the space weather sub-group gave an action to T. Onsager and Bill Schreiner (UCAR) to investigate the format to be recommended for COSMIC-2 Radio-occultation data exchange for operational use for ionospheric applications, taking advantage, if technically relevant, of the formats used by NWP users for the near-real time exchange of radio-occultation data (bending angles or refractivity). COSMIC data are currently being sent in NetCDF to the United States Air Force. The ICTSW should clarify whether the NWP and space weather communities are interested in the same data content and, if relevant, whether common formats would be technically suitable and helpful.

- *Action 4.19: T. Onsager, in coordination with Bill Schreiner, to provide a sample of Formosat-3/COSMIC-1 and Formosat-7/COSMIC-2 data formats for comparison with the data formats used by the NWP community (15 February 2014).*

8.3 Update on the WMO Information System (WIS)

Steve Foreman provided an update on the WIS, whereas eight Global Information System Centres (GISC) were already operational, and 123 Data Collection or Production Centres (DCPC) and 223 National Centres (NC) had been nominated. He described the main functions of the WIS and, as an example of use beyond the meteorological community, he mentioned that the Global Disaster Alert and Coordination System (GDACS) sponsored by the European Commission Joint Research Centre (JRC) and the United Nations was disseminating alerts through the WIS. S. Foreman emphasized that metadata records are crucial to enable data discovery and to control the information flow within the WIS. Based on the ISO 19115 metadata standard, the WIS core metadata profile identifies some elements of ISO 19115 as mandatory and specifies how these elements should be used. A planned update of the WIS core metadata profile will be compatible with ISO 19225-2. As regards data such as solar, interplanetary or magnetospheric observations, which are not geo-located, S. Foreman suggested to describe them in the WIS metadata as "non geographic" and to include the spatial location information in the free text abstract field. The alternative solution, which is to amend the core metadata profile to include a non Earth-based reference system, could be misleading for many users.

S. Foreman then explained the procedure by which a centre could apply to become a NC or a DCPC. For a regional space weather warning centre it is fully appropriate (though not an obligation) to consider becoming a DCPC to make its data and products internationally accessible through the WIS. There are basically three steps: (i) the application has to be submitted by the Permanent Representative (PR) of the country[1]; (ii) the technical relevance and the ability to contribute to a WMO programme at the required standard are evaluated by an expert body; (iii) the compliance with WIS technical specifications (including for instance the provision of compliant metadata records and data samples, the commitment to a service level agreement, the successful completion of functionality testing, and successful pre-operation with a GISC) has to be documented and evaluated by a WIS expert team.

Application of NICT as a DCPC

The ICTSW noted the letter of application of the National Institute of Information and Communications Technology (NICT) to become a DCPC, and the letter of the PR of Japan nominating NICT. NICT is operating as the Space Weather Information Centre in Japan and contributes to the International Space Environment Service (ISES) as a Regional Warning Centre (RWC). M. Ishii gave an overview of NICT operational space weather activities. The current status and activity of NICT, as reflected on its website (http://swc.nict.go.jp/contents/index_e.php) and through its regular operation as a RWC of ISES, is widely acknowledged in the space weather community. The ICTSW acknowledged that NICT has the capability to provide space weather products to the international community.

- *Recommendation 4.6: ICTSW, as the CBS expert body on the subject matter, unanimously supports the application of NICT as a DCPC for space weather.*

- *Recommendation 4.7: All space weather regional warning centres are encouraged to register as a DCPC in the WIS.*

[1] There are also provisions for international organizations to become a DCPC, for example like the European Centre for Medium Range Weather Forecast (ECMWF), EUMETSAT, or the European Space Agency (ESA), who have signed Working Arrangements with WMO.

8.4 WIS demonstration actions

Presentations by M. Terkildsen and by M. Ishii introduced the "WIS pilot project", which aims to demonstrate, and document requirements for, the exchange of space weather data through the WIS by establishing the operational exchange of a small number of simple space weather products. Through this process, requirements and procedures will be documented such as data format requirements, required metadata standards, software requirements, certification requirements on Regional Warning Centres (RWCs), and the requirements and process of registering space weather data with WMO (e.g. code table updates).

The four products selected as pilots are:
- Solar flare probability (forecast only)
- Solar flaring activity level (forecast and observation)
- Geomagnetic activity level - daily average Ap index (forecast and observation)
- Geomagnetic activity level - maximum 3-hourly Kp index over 24 hours (forecast and observation)

ICTSW-4 confirmed the selection of 4 pilot products proposed for WIS. The meeting appreciated the action taken respectively by the Bureau of Meteorology (BOM) to perform the BUFR encoding, and by NICT to produce the corresponding metadata in view of their registration into the WIS.

- *Recommendation 4.8: NICT, BOM to pursue the WIS demonstration actions on the four selected products and their BUFR encoding with a view of distributing these products through the WIS.*

- *Recommendation 4.9: In the light of the WIS pilot project, ICTSW should further discuss whether there is a need and/or advantages to migrate products from current ISES codes to e.g. BUFR.*

9. SPACE WEATHER OBSERVING CAPABILITIES

9.1 Surface-based observations

Larisa Trichtchenko provided a sketch inventory of space-based observing capabilities in four categories: (i) Solar observatories providing measurements of e.g. sunspot number, F10.7, radio bursts or solar magnetic field; (ii) Ionospheric stations including ionosondes and riometers (TEC measurements from GNSS ground-based receivers can be added as well if considered as a surface-based observations); (iii) Geomagnetic observatories including the Intermagnet network and other stations; and (iv) Cosmic ray neutron monitors. This information (contained in Appendices A, B, C and D of Doc. 9.1) was found a very valuable starting point to refine the assessment of observing capabilities and update if necessary the Statement of Guidance. Ms Trichtchenko called upon the participation of ICTSW members in their respective areas of expertise to complete the list of ground-based observations; she invited the ICTSW to propose a procedure for evaluating the importance of different measurements (possibly similar to the procedure for evaluating the relevance of including a new product in the Space Weather Product Portal); she invited the ICTSW to refine the observation requirements, to outline the gaps in ground-based data provision and to update accordingly the recommendations in the Statement of Guidance. The team supported this approach, though also acknowledged that observing requirements were already captured in OSCAR. Noting that some observation networks are well documented on line, the team recommended to point to these online information sources (See for instance the European neutron monitor database www.nmdb.eu).

- *Action 4.20: All ICTSW members to review the Appendices to Doc 9.1, complete as appropriate the list of ground-based observation networks, update the links to relevant information sources and inform Larisa Trichtchenko (30 June 2014).*

9.2 Outcome of the IROWG workshop

The report from the space weather sub-group of the IROWG workshop[2] addresses many points of interest to the ICTSW (COSMIC-2 programme risks, GNSS-RO format harmonization, international workshop on ionospheric applications, linkage with ICTSW). As concerns observation planning the IROWG encouraged missions flying GNSSRO sensors to incorporate a complete set of ionospheric measurements including measurements of ionospheric scintillation (high rate data scintillation measurements on all available line of sight TEC measurements) and, wherever possible, to reduce data latencies to less than 30 minutes.

9.3 Introduction to OSCAR/(Requirements and Space capabilities)

Nils Hettich introduced the team to OSAR, an online tool designed to include three main modules: (i) a repository of observation requirements; (ii) a structured inventory of space-based capabilities; (iii) an inventory of surface-based capabilities, which is still being developed. The space-based capabilities module (www.wmo.int/oscar/space) contains references and characteristics of more than 800 instruments among which 267 space weather instruments (without counting the GNSS sensors that are used in several application fields). A unique feature of OSCAR is the association between the instruments and the variables they can measure, which results of an expert assessment of the technical features of the particular instruments. Most of the contents of OSCAR are related to Earth Observation and have been validated by EO expert. The space weather capabilities have not yet been validated by ICTSW and, therefore, the association between space weather instruments and variables in OSCAR is still considered as tentative.

In his presentation J. Lafeuille explained that prior to finalizing the classification and assessment of space-based instruments for space weather it would be helpful to clarify a few issues regarding the requirements and the variables, as proposed in Doc. 9.3(1):

- simplify the list of “layers” and “coverage” delineating vertical and horizontal areas where requirements are applicable;
- review and correct if necessary the definition and units of some variables, or add an explanation when the usual understanding differs from the rigorous definition;
- review the list of variables (which should be independent physical quantities characterizing the environment in a technology-free manner) noting that a number of variables had to be added by the Secretariat (in particular as concerns radiative and particle fluxes) in order to satisfy a basic rule that the same variable cannot have different physical dimensions.

He highlighted the following issues that had emerged when linking instruments with variables:

- Several of the initial ionospheric variables look like derived quantities (e.g. derived from electron density) and are not technology-free (e.g. assumed from ionosondes);
- The initial solar imagery variables have been defined for specific spectral bands, hence a need to define a different variable for every single band, which artificially leads to a large number of variables and no technology-free rationale to require one band rather than another;
- The Vector magnetic field could be renamed Geomagnetic field or Earth magnetic field to avoid confusion with the Solar and Interplanetary magnetic fields;
- There is a major ambiguity about particle flux variables (electrons, protons, heavy ions) as these variables are not defined as directional, though their units imply a directional dimension; the actual measurements are often directional and highly dependent on

[2] OPAC-IROWG workshop, Graz, 5-11 September 2013.

the direction (which is not always explicitly indicated) but it is not clear whether the required information is a uni-directional, multi-directional, or direction-integrated flux;
- For both radiative and particle fluxes, it should be clarified whether only the spectrum or the spectrally integrated flux, or both, are required;

- *Action 4.21: ICTSW members shall review the proposed typology of "layers" and "coverage" included in Doc. 9.3(1) and provide comments to the WMO Secretariat (30 April 2014)*

9.4 Instrument categorization/evaluation review

J. Lafeuille further explained that the 267 space weather instruments belonging to 5 main types (solar monitors, solar wind and cosmic radiation monitor, magnetosphere/ ionosphere sounders, aurora imagers and platform environment monitors) had been sorted into about 120 performance classes within these types in order to enable associating each class with a list of potential measurements. This link between instruments and variables is the starting point for generating a raw gap analysis for each of the variables, with the timelines of available or planned satellite missions relevant to this variable. OSCAR also supports the review of broad "capabilities" (to be understood here as a range of instrument classes that have the capability to meet certain observing requirements of WMO), which is a pragmatic way to focus the gap analysis on certain sets of instruments of particular interest for WMO without entering into the single details of each variable. There is also a filter function enabling to select e.g. only operational missions from CGMS members. He stressed that only a tentative association between instruments and variables had been entered as yet, in order to provide a basis to be refined by ICTSW (e.g. it can be refined taking advantage of a possible ranking of instrument relevance in 5 levels).

In a breakout session, the team was invited to review the relevance of the assessments entered in OSCAR in focusing on the top ten variables or instruments for particular subjects. The feedback from the breakout sessions revealed that the team must first familiarize with the considerable amount of information contained in OSCAR and its overall functionality before being able to provide general guidance and deliver a comprehensive assessment.

The breakout groups provided feedback on the definition of the variables:
- the ionospheric subgroup suggested new variables for aurora (Aurora light, Aurora zone precipitation) and TEC (Vertical TEC, Slant TEC), proposed renaming the Vector magnetic field "Magnetic field", and acknowledged that some variables (foEs, foF2, hmF2, h'P) could be derived from electron density, which is a fundamental physical quantity; as a consequence the team should consider converting the requirements for these variables into requirements on electron density;
- the solar energetic particles group discussed replacing e.g. "electron flux" by "directional electron flux" although wondering whether the required quantity was a directional or integrated flux; it also wondered whether the user simply required "Particle flux density" or the more detailed "Particle flux density energy spectra", and in the latter case what is the required spectral resolution; the group also noted that "nuclei" were included in "heavy ions" and considered that the only neutrons to be observed were cosmic ray neutrons.

Some preliminary corrections to the satellite instrument categorization were suggested by the three groups. These suggestions need to be further refined off line. There were suggestions to focus on operational instruments, and other suggestions to include more research instruments.

- *Recommendation 4.10: The list of variables should be reviewed with the aim to have independent, technology-free quantities with consistent definitions and units.*

- *Action 4.22: Alain Hilgers will lead a further review of the instrument categorization in OSCAR and of the association between instrument classes and variables, and will suggest modifications as necessary for consideration by the WMO Secretariat (J. Lafeuille). (31 March 2014)*

- *Recommendation 4.11: ICTSW recommends to put emphasis in OSCAR on operational observation capabilities, for instance taking advantage of the filter function (R&D or Operational agencies) and/or of the "Capability review" function which allows assessing the gaps with respect to a pre-defined reference constellation.*

9.5 Impact on the Statement of Guidance

Once the evaluation of observing capabilities in OSCAR will be reviewed ad validated, the "Gap Analysis" and "Capability Review" functionalities will be available to inform, and update if necessary, the Statement of Guidance.

10. STRATEGIC PLAN FOR SPACE WEATHER

10.1 National/regional strategic plans for space weather

Presentations were given on national activities and plans, highlights of which are reported below (See the presentations for more details).

- Brazil space weather enterprise (input provided off-line)

The Brazilian space weather enterprise is a coordinated effort hosted by the National Institute for Space Science (INPE) under the Embrace Space Weather Program coordination spanning from basic research to operational services to emergency response. The Embrace/INPE program aims to monitor the various environments from the Sun to the Earth, including ground effects. Monitoring products for neutral and ionized atmospheres covering most of South America are currently available with 10-minute latency. Magnetic measurements over the East coast of South America are performed in real time every minute and regional geomagnetic indices are provided on the web. The Embrace/INPE program engages in international partnerships to provide satellite link support and or ground based coverage to the other regional Warning centres. The future plans include embracing data acquired from other environments (Sun and Interplanetary Medium) and setting up a Data Processing Center to perform space weather modelling to allow space weather forecasts.

- US space weather enterprise

The U.S. space weather enterprise is a coordinated, multi-agency effort that covers the full spectrum of activities from basic research to operational services to emergency response. The agency activities are organized through the National Space Weather Program (NSWP), with the goal of achieving "*an active, synergistic, interagency system to provide timely, accurate, and reliable space weather warnings, observations, specifications, and forecasts*" (www.nswp.gov). Space weather has been designated by the U.S. Subcommittee on Disaster Reduction (www.sdr.gov) as one of six Grand Challenges for Disaster Reduction. The WMO has an essential role in facilitating the global availability and coordination of data and services required to advance space weather capabilities.

- China's national plan for space weather

The overall objective of the strategy plan for space weather operation in China is to establish a service-driven, forecast-cored and monitoring-based space weather operation system which provides different users with timely, accurate and reliable products and services. The system with international leading standard and specification on space weather operation is

operated in the National Center for Space Weather (NCSW) as a national agency with the goal of enhancing the capability of space weather disaster prevention and warning, forecasting and services characterized by multi-level and multi-sector international and domestic collaboration.
NCSW is considering to launch a small space weather satellite on sun-synchronous dawn-dusk orbit, as well as an equatorial satellite to monitor the South-Atlantic anomaly.

- ESA SSA Space Weather Element

The European Space Agency activities related to Space Weather address on one hand the effects of space weather on space systems and associated ground infrastructures and on the other hand the development, on behalf of its member states, of a relevant infrastructure to provide Space Weather related services. The first aspect is taken care of by the technical directorate of the Agency which is running a R&D programme to develop the relevant technologies. The infrastructure for Space Weather services is developed by the Space Situational Awareness programme initiated in 2009 which already led to the establishment of several Space Weather Centres in Europe coordinated by the Space Weather Coordination Centre operated by the Royal Observatory of Belgium. In the coming years this network of centres will be consolidated and new services and observation means will be deployed.

- Space weather services to the government emergency operations centre in Canada

The Canadian Space Weather Forecast Centre (CSWFC) is operated by Natural Resources Canada. Developed originally in 1970s to help magnetic surveyors it now covers a wide range of phenomena from geomagnetic storms and effects on ground infrastructure to parameters of satellite environment at geostationary orbit. CSWFC services include short-term and long-term forecasts of geomagnetic activity at different locations over Canada, and real-time services for ground infrastructure.

- NICT space weather centre activities in Japan

NICT has mid-term plan for research and is now at the third of its five-year plan. Currently the two main development targets in space weather forecasting are: (i) improved forecasting of ionospheric disturbances for precise satellite positioning, and (2) improved forecasting of electromagnetic condition in radiation belt for safe geostationary satellite operations. This project combines observations, model development and simulation to provide high-precision space weather information. In addition house-keeping data from Japanese meteorological satellite are now available for space environment monitoring, through a fruitful cooperation with JMA.

- United Kingdom national plan for space weather

Space weather has been on the UK National Risk Assessment since 2011. The Met Office 'own' the space weather risk, and are responsible for providing operational space weather alerts and forecasts on a 24/7 basis. The Met Office and the Cabinet Office (responsible for UK civil contingencies) are working on an overarching plan for the governmental response to severe space weather and its impacts. When a severe event is anticipated, Met Office advice and forecasts will be input to the Science Advisory Group for Emergencies, consisting of experts on space weather and its impacts, who provide a single authoritative source of science advice to decision makers. A senior Government level crisis response committee would be convened if necessary. Co-ordination of research and operational applications is detailed in the Space Weather strategy. Co-ordination with international partners is important in all areas (emergency response, operational services and research).

- Korean national preparedness plan for space weather

In accordance with the Radio ACT of Korea, the Radio Research Agency (RRA) has been delivering space weather services to the public since 1966. The Korean Space Weather Center (KSWC) of RRA, an ISES RWC, delivers 1 to 3-day forecasts, warnings & alerts, conducts R&D activities on analysis and modelling, and runs observation facilities including

e.g. GIC monitoring systems. KSWC is in charge of the "Space Weather Disaster Manual" and the "Guide on Space Weather Disasters" to assist the Korean government to minimize the impact of severe space weather. Both the manual and the guide were developed in 2012 and are kept under review by KSWC.

In accordance with the revised Weather Act of Korea, the Korea Meteorological Administration (KMA) has been delivering space weather service to the public since 2012. KMA space weather service targets the support to satellite operations, support to aviation, and ionospheric dynamics. KMA proceeds with three major focusing respectively on space weather observation, prediction modeling and service delivery.

- Prospects for space weather activities in Russian Federation

The Institute of Applied Geophysics (IAG) acts as both monitoring centre of the heliogeophysical environment over Russia and RWC of ISES (www.space-weather.ru). IAG provides for a continuous real-time data flow to the central data bank from a number of sources such as: Electro geostationary spacecraft, ground based or space based ionosondes, magnetic observatories, and GPS/GLONASS receivers. Routine operations include a new original Median Model of the Ionosphere (SIMP), geoeffective solar proton fluxes nowcasting, the Radiowaves Propagation Conditions estimation (3 MHz - 30 MHz) and other services. IAG plans to take an active part in the support to transpolar aviation routes as all of them pass across Russian airspace.

- Swedish space weather strategy

The Swedish Space Weather Center (SRC) at the Swedish Institute of Space Physics (IRF) hosts RWC-Sweden of ISES. It carries out research on solar storms based on SDO HMI data, consequences and forecasts. Operational forecast services are given of geomagnetic indices, geomagnetic variation, and GIC, based on real-time ACE solar wind data. IRF has also operational magnetometers, ionosondes, riometers and all-sky-cameras for space weather monitoring. Main users are the Swedish National Grid, Swedish Civil Contingencies Agency (MSB) and Swedish Armed Forces. After the Boulder workshop in 2010 on managing critical disasters, MSB has taken a leading role in coordinating the efforts to mitigate the space weather effects and contacting stakeholders. Solar storms were identified in a national risk and capability assessment. Solar storm and space weather scenarios are developed and analysed. The Armed Forces and MSB support the participation of the Swedish National Space Board in SSA of ESA. The Permanent Representative of Sweden with WMO has delegated to IRF the participation in ICTSW.

- Space weather monitoring in Pakistan

Pakistan's National Space Weather Plan has been endorsed in the Space Vision 2040 by the Government of Pakistan. SUPARCO, being Pakistan's national space agency, has the mandate to carry out space science research and strive to develop infrastructure and facilities. SUPARCO has ground-based observatories for round the clock monitoring of the ionosphere and the geomagnetic field as well as sudden ionospheric disturbances. As a result, related products are routinely generated and timely disseminated to our users. In the prospect of future space weather monitoring and forecasting, new hardware is being procured and efforts for establishment of a new space weather monitoring centre are underway. They will further enhance Pakistan's capabilities to come at par with ISES RWCs.

- Space weather services and research in Finland

In Finland space weather activities are conducted in the Universities of Helsinki, Oulu (incl. Geophysical Observatory in Sodankylä) and Turku and in the Finnish Meteorological Institute (FMI). Finnish research groups have developed several prototypes for space weather services with the European Union 7th Framework Programme (EU FP7) funding. The goal for the coming years is to bring these assets to full-scale operational use both in the ESA SSA-programme and in the 24/7 monitoring service for natural hazards maintained by FMI. New openings to support space weather research in the long run are the EISCAT_3D project of an advanced incoherent scatter radar system and the global Vlasiator

simulation code for kinetic modelling of the near-Earth plasma environment.

- Near-term plans for research and applications in space weather in Poland

Space weather strategy is led and implemented by the Heliogeophysical Prediction Service Laboratory of Space Research Centre of the Polish Academy of Sciences (PAS). The Centre hosts the ISES RWC-Poland. The Laboratory carries out research e.g. on interpretation of Solar X-Ray observations and forecasts solar storms consequences for near-Earth environment. Ionosond data are used to prepare the maps of ionospheric characteristics and GPS/Galileo navigation information. Both type of data are used in operational forecast services. SRC operates a range of monitoring instruments (magnetometers, ionosonds, riometers, GPS and Galileo receivers) in Poland and at Arctic Svalbard station. The aim is to provide services required by our users, which include Military Telecommunication Services, Electro-Energetic Companies, Government Centre for Security, Defence, etc. The main thrust of the space weather strategy is on international partnership through participation in ISES and ESA Space Situation Awareness Program.

- Space weather related projects in Italy

Two European projects related with Space Weather were introduced: the Digital Upper Atmosphere Server (DIAS) and the Near Earth Space Data Infrastructure for e-Science platform (ESPAS). The DIAS system (http://www.iono.noa.gr/Dias) operates since 2006 and the basic products that are delivered are real-time and historical ionograms, frequency plots and maps of the ionosphere on the foF2, M(3000)F2, MUF and bottom side electron density, as well as long term and short term forecasting up to 24 hours ahead. The aim of the ESPAS platform (http://www.espas-fp7.eu) is to integrate heterogeneous data from the earth's thermosphere, ionosphere, plasmasphere and magnetosphere. ESPAS supports the systematic exploration of multipoint measurements from the near-Earth space through homogenized access to multi-instrument data.

- Solar-terrestrial physics and space weather activities in France

Research activities in solar-terrestrial physics and space weather are conducted in several laboratories and coordinated by a National Program of CNRS/INSU (http://pnst.obspm.fr). One aim of the program is to develop research for space weather applications. A strategic plan for these activities is currently under discussion and several prospective meetings will be held in France in 2014. Activities and data holdings are described in the following web site: http://pnst.obspm.fr/Meteo_espace/Page_web_meteo_espace_France_v3.html .
It contains a list of regular observations of the sun at optical and radio wavelengths (ground-based and space-based); a list of web sites with data (and models) for high energy particles in the earth’s environment: earth radiation belts and observations from neutron monitors (some of them in real-time); measurements of the earth’s magnetic field; a list of web pages with data products (solar irradiance, geomagnetic indices, semi-empirical model of the thermosphere, and survey of radiation doses for civil aviation).

- Space weather activities in Germany

Being aware that space weather may have strong impact on key infrastructures and human activities on Earth and in space, Germany supports a broad spectrum of related scientific and technical developments and monitoring activities. Considering the increasing societal dependence of the society on modern communication and navigation systems, Germany is preparing the establishment of an “Ionospheric Monitoring and Prediction Centre” (IMPC) to provide scientific and operational data service support to national needs and for integration in international activities in coordination with organizations such as ESA and NOAA. Germany is also establishing the national “German Space Situational Awareness Centre” (GSSAC).

10.2 Global needs to be addressed in a strategic plan for space weather

In light of these reports the team acknowledged that a global cooperation framework was needed to facilitate and supplement the individual national space weather plans. Global

cooperation would be highly beneficial in particular in the following areas:

- To organize and facilitate the sharing of data from existing observation and analysis sources;
- To ensure the continuity of these sources through long-term coordinated planning and interoperability;
- To build resilience of current space weather monitoring and warning systems through interoperability and back-up arrangements among space weather centres;
- To develop and promote best practices, for instance in extreme event warning, or in product specifications, thus assisting each other in capacity building;
- To raise the profile of space weather activities through international recognition.

It was felt that WMO provided a suitable framework to address all these topics.

In addition, X. Zhang submitted Document 10.2(4) on the physical interaction between space weather and Earth's meteorology and climate, based on a basic research project of the Chinese Ministry of Science and Technology. The document mentioned issues such as the impact of solar UV and solar energetic particles on stratospheric photo-chemical processes, the potential effect of cosmic rays on cloud formation[3], and potential effect of geomagnetic storms on the Earth's angular momentum. The document concluded that further research was needed on these topics. There was no time to discuss the document.

10.3 International initiatives and potential partnerships for space weather

David Jackson presented an overview of international initiatives and potential partnerships with WMO in space weather. A large number of international, regional and national organisations are active in, or interested in, space weather. It is important to review their activities, to ensure synergy or complementarity with WMO ICTSW activities, and to plan how WMO can contribute to a co-ordinated set of activities which will benefit users of space weather services and warnings. It was proposed to categorize organizations into:

- Research-based: COSPAR[4], SCOSTEP[5], International unions (e.g. URSI[6], IAU[7], EGU[8], AGU[9], ICSU[10], etc), ISWI[11], Agency programmes (e.g. ILWS[12]).
- Operations-based: ISES, CGMS[13], ESA/SSA[14], EMS[15]
- Other which may focus on specific technologies (ICG[16], IGS[17]), applications (ICAO[18]/IAVWOPSG[19], ITU[20]), or regions (Asia-Oceania SW Alliance)
- COPUOS[21] provides a cross-cutting, high-level, policy forum where members can raise awareness, seek international support and promote coordination on issues related to long-term sustainability of outer space activities including space weather.

[3] The effect of cosmic rays on cloud formation is a matter of controversy in the scientific community
[4] COSPAR : Committee on Space Research of ICSU
[5] SCOSTEP : Scientific Committee on Solar-Terrestrial Physics of ICSU
[6] URSI : Union Radio-Scientifique Internationale, member of ICSU
[7] IAU : International Astronomical Union, member of ICSU
[8] EGU: European Geosciences Union
[9] AGU : American Geophysical Union
[10] ICSU : International Council for Science
[11] ISWI : International Space Weather Initiative
[12] ILWS : International Living With a Star program
[13] CGMS : Coordination Group for Meteorological Satellites
[14] ESA/SSA : Space Situation Awareness programme of the European Space Agency
[15] EMS : European Meteorological Society
[16] ICG : International Committee on GNSS
[17] IGS : International GNSS Service
[18] ICAO: International Civil Aviation Organization
[19] IAVWOPSG : International Airways Volcano Watch Operations Group
[20] ITU : International Telecommunications Union
[21] COPUOS: United Nations Committee on the Peaceful Uses of Outer Space

D. Jackson highlighted that besides current or planned activities of these international organizations there remained a number of gaps. For instance there is a need to improve data exchange and delivery, to detail the definition of space weather services, to consolidate and ensure consistency of observation requirements, to pull research into operations, to improve modelling and analysis, and to incorporate space weather in education programmes. A strategy should be developed to ensure long-term observations, involving CGMS, COPUOS, COSPAR and ESA/SSA. Common practices and procedures could be further developed in collaboration within the ISES and WMO framework to ensure that space weather warnings are issued in a coordinated fashion and integrated, when relevant, with existing warning procedures; linkages with national Civil Contingencies services need to be developed. An international policy for space weather should be defined, with COPUOS playing an "end to end" role, COSPAR having special focus on research (and research to operations) and WMO contributing to setting the future direction of operational activities. The ICTSW should plan dialogue among ICTSW and potential partners in space weather services in order to address these issues.

The following actions and recommendations were agreed:

- *Recommendation 4.12: Continue and update the review of international initiatives and potential partnerships contained in Appendices to Doc. 10.3.*

- *Recommendation 4.13: Utilize the new Space Weather agenda item to promote awareness and coordination of data needs within COPUOS.*

- *Recommendation 4.14**:** Research to operations. Engage research organisations to ensure their research activities are extended to research to operations activities. An example would be to lobby for extension of ISWI to make new ISWI observations suitable for operational use.*

- *Recommendation 4.15: CGMS should engage in space weather activities:*
    - *to promote a strategy to ensure the long-term continuity of space weather observations, in coordination with WMO and other international organizations;*
    - *to coordinate the acquisition and availability of space weather observations made by meteorological satellites;*
    - *to jointly define with ICTSW a strategy to improve the collection, availability, and uses of satellite anomaly information;*
    - *to express its requirements for space weather products and services to satellite operators and to provide feedback on the value of available products.*

The team noted that CGMS had taken steps to respond to this recommendation at its 41st meeting (Tsukuba, Japan, 8-12 July 2013). The following points of contacts have been nominated by CGMS to jointly define, with ICTSW, a strategy to collect satellite anomaly information:

- CMA: ZHANG Xiaoxin (xxzhang@cma.gov.cn)and Dr.GUO Jianguang cn; guojg@cma.gov.cn
- EUMETSAT: Mike WILLIAMS (mike.williams@eumetsat.int)
- KMA: Inchul SHIN (icshin@korea.kr)
- NASA: Elsayed R. Talaat (elsayed.r.talaat@nasa.gov)
- WMO: Jérôme LAFEUILLE (jlafeuille@wmo.int)
- The other CGMS agencies (CNES, CNSA, ESA, IMD, JAXA, JMA, NOAA, ROSCOSMOS, ROSHYDROMET) did not provide any point of contact.

Furthermore, CGMS has set up an ad-hoc team to frame its future role in Space weather. Draft Terms of Reference for CGMS Space Weather activities are in Doc. 10.3 Add 2.

- *Recommendation 4.16: The focus of space weather educational activities (mainly organised by ISWI and SCOSTEP) should be extended from research to operational activities. This may include: producing training materials on WMO ICTSW website (See Action 4.15 above); expanding the scope of SCOSTEP and other workshops to include research to operations; WMO, ISES or CGMS running operational space weather workshops.*

10.4 Proposed WMO Strategy for Space Weather

J. Lafeuille expressed the view that the remarkable achievements of the ICTSW in its few years of existence have demonstrated its usefulness, and that the increasing participation of Members in ICTSW was very promising. He emphasized however that a number of subjects were emerging, which needed attention. A real breakthrough in terms of services to the society would thus require even broader and more active engagement of WMO Members, supported by more Secretariat resources. This would be more likely to happen if WMO Members agreed on a programme for space weather, with an agreed strategy and roadmap, guided by a shared vision. J. Lafeuille recalled the request from the 16th WMO Congress *"to develop near-term and far-term action plans, including education and training, and work with the WMO Regional Associations to implement a coordinated strategy for space weather*". This request was expanding an earlier request from the WMO Executive Council (EC-60) "*to develop plans for WMO activities in space weather identifying objectives, activities, resources, deliverables and expected outcomes, in close cooperation with ISES and the relevant bodies of COPUOS, CAO, IMO and ITU.*" J. Lafeuille therefore invited the team to look beyond its current Terms of Reference and suggested to develop a proposal for a "Space Weather Watch" that would be submitted for approval by WMO Members at the next Congress in order to meet the current and future challenges of space weather

The Director of the WMO Observing and Information Systems Department, Dr Wenjian Zhang, reinforced this view. He explained that WMO was committed to respond to important global challenges in particular in the area of climate monitoring and services and of hydro-meteorological disaster risk reduction. A formal framework such as a Space Weather Watch programme or project would give more visibility and would enable WMO Members to assign a proper priority level to space weather activities. He advised to submit an outline of such a proposal to the 66th Executive Council (June 2014) and, subject to approval by the Council, a full proposal to the 17th Congress (May 2015).

In the light of the presentations and discussions of items 10.1, 10.2 and 10.3, the team confirmed that WMO was well positioned to play a major role in space weather, within the broader international community in order to advance space weather services for the benefit of all Members. A Space Weather Watch proposal should be developed to expand the current objectives of ICTSW; it would build on the progress already demonstrated by ICTSW and formalize the scope of future WMO's activities in space weather. The Space Weather Watch proposal should describe the needs, communicate on the benefits of this coordinated activity, consider the partnership opportunities with other international organizations, and support the engagement of WMO through appropriate structure and governance mechanisms. The proposal should present a vision, consider the current activities of the Members as building blocks, and analyze the activities to be performed, the associated resources and expected benefits. It was felt that a common vision helps all Members to develop their own plans in a consistent and complementary fashion.

Key activities would include:

- Organizing data sharing/management from existing sources (including policy issues, protocols, formats, metadata, infrastructures)
- Ensuring long-term continuity of observations (including inventory and assessment of ground-based and space-based observations, interoperability issues, long-term planning)
- Strengthening preparedness and coordinating the response to extreme events (including best practices, back-up arrangements, warning scales and verification)

- Implementing operational services to key users such as the aviation sector
- Improving and expanding communication to new users
- Securing more resources to space weather coordination and development

- *Action 4.23: The ICTSW co-chairs to coordinate the preparation of an outline of a Space Weather Watch (SWW) proposal, providing a reasonable description of the planned SWW proposal, in advance of EC-66 in May 2014. (28 February 2014)*

11. WMO-ISES MEMORANDUM OF UNDERSTANDING

The draft Memorandum of Understanding between WMO and ISES was presented. The team welcomed the principle of formalizing the essential connection between ISES and the space weather activities of WMO and agreed that the proposed MoU would meet this objective, provided that the status of ISES was eligible to such an agreement. If this was not the case, a working arrangement with a similar scope should be established in the appropriate legal form (e.g. exchange of letters).

- *Action 4.24: T. Onsager (as ICTSW Co-chair and ISES Director) and J. Lafeuille to clarify with the WMO and NOAA legal counsels whether ISES is eligible for a MoU or a working arrangement should be concluded in an equivalent form, and proceed towards the signature of this MoU or other arrangement by WMO and ISES. (30 April 2014)*

12. TRAINING AND OUTREACH MATTERS

12.1 Training and outreach strategy

Training strategy

The need to support training is unanimously acknowledged but there is still a need to clarify what the target audiences are (e.g., potential or new end-users, users in developing countries, decision makers, or meteorologists expected to assist in the delivery of space weather products) and what practical training modalities should be used (workshop, distance learning, face-to-face sessions) and outline the programme and the related written or video training material that should be gathered or developed. A small team will be set up to draft such a training strategy.

Training activities should preferably be conducted in partnership with e.g. the WMO-CGMS Virtual Laboratory (VLab) network, the Committee on Space Research (COSPAR) who has signed with WMO a Memorandum of Understanding for training, and/or the United Nations Office for Outer Space Affairs (OOSA) and its International Space Weather Initiative (ISWI) or the International Living With a Star (ILWS) program.

The strategy should also consider the relevance of including some basic concepts of space weather into the training standards and guidelines for professional meteorologists, as defined by WMO Publication 1083 " Manual on the Implementation of Education and Training Standards in Meteorology and Hydrology" [Replacing WMO Publication N° 258].

- *Recommendation 4.17: ICTSW should define a training strategy identifying the target audiences, the intended focus (subjects and training goals), the key partnership opportunities to be exploited such as VLab and COSPAR, and including a plan to develop training material, or select existing training material.*

- *Action 4.25: The training strategy team, including Xiaoxin Zhang, Mamoru Ishii, Nicole Vilmer, Hyesook Lee, will propose a training approach for discussion at ICTSW-5. (31 October 2014)*

Review of draft CIMO Guide

Document 12(2) provides draft extracts of the new Guide on Meteorological Instruments and Methods of Observation (CIMO Guide) for review by ICTSW members. The extracts are from Chapter 3 (Instruments), Chapter 4 (Programmes) and Chapter 5 (Products).

- *Action 4.26: ICTSW members to review the material contained in Doc. 12(2) in their respective areas of expertise and report any correction or addition needed. (28 February 2014)*

13. ICTSW WORK PLAN FOR 2014-2015

The actions of previous ICTSW meetings were reviewed. Many actions were noted as completed, or superseded by new actions discussed under previous agenda items. The remaining actions were replaced by the new actions indicated below. As a consequence, all previous actions were closed.

- *Action 4.27: Xiaoxin Zhang, Matt Francis, Martin Zurn (designated by Neil Mitchison), Norbert Jakowski shall liaise with the Space Weather subgroup of the IROWG (Point of contact: Anthony Mannucci, NASA/JPL) for the preparation the workshop on atmosphere and ionosphere applications planned with the 2014 COSMIC/Formosat Data Users Workshop in Boulder (See background in Doc. 9.2). (28 February 2014)*

- *Action 4.28: The ICTSW co-chairs to set up a task team in charge of developing a plan to address space agencies and space weather service-providing agencies at the proper level for programmatic issues regarding the long-term continuity of essential space weather satellite observations (including future L1 missions, missions to other heliospheric locations, coronagraph measurements, and heliospheric imaging), advocating for both space-based and ground-based, including both long-term continuity and immediate availability. (31 January 2014)*

- *Recommendation 4.18: T. Onsager, in the context of ISES, and J. Lafeuille, at the WMO Executive Council, should encourage full participation of ISES members in ICTSW (e.g. India, Austria, …)*

- *Recommendation 4.19: All members contributing to the Space Weather Product Portal to maintain consistency of their web pages with the ICTSW agreed standards.*

- *Action 4.29: T. Onsager, M. Ishii to contact IPET-MDRD to determine schedule for updates to the WMO metadata profile and make sure that space weather considerations are addressed in a satisfactory manner, noting that ICTSW was invited to contribute to revise the metadata profile. (15 January 2014)*

- *Action 4.30: Xiaoxin Zhang, Mamoru Ishii and T.Tsugawa, Mike Terkildsen, David Jackson, Hyesook Lee, to investigate the modalities of ground-based GNSS network data exchange for NWP (as discussed at the NAEDEX-APSDEU meetings) and for ionospheric monitoring (as discussed within e.g. IGS), and evaluate if the data from the GNSS sites used for NWP could also be made available (or already are available) for space weather applications. (31 August 2014)*

- *Action 4.31: All ICTSW members to investigate possibilities of their organization providing a seconded expert to WMO to support space weather and ICTSW activities, and/or financial resources to a WMO trust fund for these activities. (31 March 2014)*

- *Action 4.32: WMO to send a letter to all WMO Members involved in ICTSW encouraging them to second staff to support the work ICTSW and thus leverage the benefits of ICTSW activities. (31 January 2014)*

It was agreed that the work plan would be updated with the outcome of ICTSW-4.

- *Action 4.33: X. Zhang, T. Onsager and J. Lafeuille to update the ICTSW work plan for 2014-2015 by 31 January 2014.*

14. REVIEW OUTCOME OF DISCUSSIONS ON PREVIOUS ITEMS

The outcome of discussions was addressed through the action review under item 13.

The list of all actions and recommendations is included as Annex 3 to this report.

15. ANY OTHER BUSINESS

No other business was raised.

16. CONCLUSIONS

The next regular meeting of ICTSW should be held towards the end of 2014. In addition, the team was pleased to accept an offer from the Russian Federation to host an extraordinary meeting of ICTSW as a joint session with ISES during the time frame of the COSPAR scientific assembly in Moscow (2-10 August 2014).

- *Action 4.34: V. Burov, X. Zhang, T. Onsager and J. Lafeuille to coordinate the preparation and invitation for the next ICTSW meetings (20 February 2014).*

The Chairman thanked the participants for their active contribution and closed the meeting.

ICTSW-4 AGENDA

1. **OPENING OF THE MEETING**

2. **UPDATE ON WMO**

3. **ICTSW CO-CHAIRS' REPORT**

4. **STATEMENT OF GUIDANCE ON SPACE WEATHER OBSERVATIONS**

5. **SPACE WEATHER SERVICES TO AVIATION**
   - **5.1 Review process of ICAO documents by ICTSW**
   - **5.2 ICAO requirements for space weather information**
   - **5.3 Organization of space weather services to aviation**

6. **SPACE WEATHER PRODUCT PORTAL**
   - **6.1 New WMO portal, concept and procedures**
   - **6.2 New candidate products**
   - **6.3 Candidate training material**

7. **WARNING FOR EXTREME SPACE WEATHER EVENTS**

8. **DATA AND PRODUCT EXCHANGE ISSUES**
   - **8.1 Overview and critical issues**
   - **8.2 Formats and standards**
   - **8.3 Update on the WMO Information System (WIS)**
   - **8.4 WIS demonstration actions**

9. **SPACE WEATHER OBSERVATION CAPABILITIES**
   - **9.1 Surface-based observations**
   - **9.2 Outcome of the IROWG workshop**
   - **9.3 Introduction to OSCAR/Space capabilities**
   - **9.4 Instrument categorization/evaluation review**
   - **9.5 Impact on the Statement of Guidance**

10. **STRATEGIC PLAN FOR SPACE WEATHER**
    - **10.1 National/regional strategic plans for space weather**
    - **10.2 Global needs to be addressed in a strategic plan for space weather**
    - **10.3 International initiatives and potential partnerships for space weather**
    - **10.4 Proposed WMO Strategy for Space Weather**

11. **WMO-ISES MEMORANDUM OF UNDERSTANDING**

12. **TRAINING AND OUTREACH MATTERS**

13. **ICTSW WORK PLAN FOR 2014-2015**

14. **REVIEW OUTCOME OF DISCUSSIONS ON PREVIOUS ITEMS**

15. **ANY OTHER BUSINESS**

16. **CONCLUSIONS**

ICTSW-4 List of Participants

Participants in Geneva

BELGIUM	Jan Janssens
CANADA	Larisa Trichtchenko
CHINA	Zhang Xiaoxin
ESA	Alain Hilgers
EUROPEAN COMMISSION	Neil Mitchison
FINLAND	Kirsti Kauristie
FRANCE	Nicole Vilmer
GERMANY	Norbert Jakowski
ICAO	Raul Romero
ISES	Terrance Onsager,
ITALY	Daniele Biron
ITALY	Bruno Zolesi
JAPAN	Mamoru Ishii
POLAND	Iwona Stanislawska
REPUBLIC OF KOREA	Ki-Chang Yoon
REPUBLIC OF KOREA	Hyesook Lee
RUSSIAN FEDERATION	Vyacheslav A. Burov
SWEDEN	Henrik Lundstedt
SOUTH AFRICA	Lee-Anne McKinnell
SWITZERLAND	Margit Haberreiter
UNITED KINGDOM	David Jackson
UNITED STATES OF AMERICA	Terrance Onsager (Chairman)
UNITED STATES OF AMERICA	Mangala Sharma, Ph. D
WMO	Wenjian Zhang
WMO	Jérôme Lafeuille
WMO	Steve Foreman
WMO	Nils Hettich

Remote participants

AUSTRALIA	Mike Terkildsen
BRAZIL	Clezio Marcos De Nardin
PAKISTAN	Muhammad Ayyaz Ameen

LIST OF ACTIONS AND RECOMMENDATIONS FROM ICTSW-4

- *Recommendation 4.1: All Members involved in ICTSW to communicate at the governmental level on space weather impacts and on the benefits of space weather services*.

- *Action 4.1: All ICTSW members to review and check that the actual contents of the SOG are current (check any gap or risk that was overlooked or that has emerged in the meantime) and report to the co-chairs and the Secretariat (jlafeuille@wmo.int). (30 June 2014)*

- *Action 4.2: In particular, all ICTSW members to check and report if the observations they are aware of at the national level are fully reflected in the proposed addition to the SOG regarding radiation dose rate, thermospheric wind and density. (30 June 2014)*

- *Action 4.3: David Jackson, Terry Onsager, Jérôme Lafeuille to condense the text in Doc. 4.2 Appendix, with a view of its inclusion in the SOG update (31 July 2014).*

- *Action 4.4: David Jackson to propose a more precise definition of the Radiation Dose Rate, specifying which part of the energy spectrum is considered. (31 January 2014)*

- *Action 4.5: K. Kauristie to draft a 2-page summary of the Statement of Guidance for communication to COSPAR as a contribution to the Space Weather Roadmap (28 February 2014)*

- *Recommendation 4.2: To advocate the importance of space and ground-based observations, as documented in the SOG; this advocacy effort should be directed towards the current operators of space- or ground-based observing capabilities as well as towards potential new operators.*

- *Action 4.6: All ICTSW members to provide Terry Onsager and Jérôme Lafeuille with comments on the CONOPS Draft Version 2.3. (Due date: 4 December 2013)*

- *Action 4.7: T. Onsager and J. Lafeuille to consolidate the ICTSW comments and provide the ICAO Secretariat and Andy Wells with the formal response from WMO on the CONOPS Draft V. 2.3. (Due date: 6 December 2013)*
  [Note: Action completed on 6 December].

- *Action 4.8: All ICTSW members to review the draft SARPs contained in ICTSW-4/Doc. 5.2 Rev1 and provide comments to T. Onsager and J. Lafeuille. (10 January 2014)*

- *Action 4.9: T. Onsager and J. Lafeuille to consolidate the comments from ICTSW on the draft SARPs. (17 January 2014)*

- *Action 4.10: J. Lafeuille to provide ICAO Secretariat (R. Romero) with the WMO comments on the draft SARPs, after finalization. (24 January 2014)*

- *Action 4.11: Terry Onsager to schedule in January 2014 two ICTSW teleconferences on the network organization and functions of space weather centres for ICAO. (15 January 2014)*

- *Action 4.12: All ICTSW Members to review the prototype PAG (http://wmo-sat.info/product-access-guide/) and forward comments on the layout and overall functionality. (10 January 2014)*

- *Action 4.13: Jan Janssens and Nils Hettich to coordinate to implement the sunspot cycle in the Space Weather Product Portal. (31 December 2013)*
  [Note: Action was completed on 7 December].

- *Action 4.14: J. Janssens and Larisa Trichtchenko to lead a discussion to define guidelines for the specifications of regional geomagnetic disturbance products to ensure that future regional geomagnetic products on the portal are comparable. (28 February 2014)*

- *Action 4.15: The training strategy team, including Hyesook Lee, Mamoru Ishii, Nicole Vilmer, Xiaoxin Zhang, to select the training material references to be included in the Space Weather Product Portal and recommend how it should be organized in the portal (e.g. according to which topic categories). (31 August 2014)*

- *Recommendation 4.3 : ICTSW should work along the following lines in support of severe space weather event warning:*

    6. *Encourage all countries to include space weather risk into their national multi-hazard warning schemes;*
    7. *Identify/select proper indices (R, S, G, DIX, W,…) to characterize the severity of the events, and define levels above which specific procedures should be activated;*
    8. *Establish a real-time communication mechanism among warning centres to share urgent technical and informal information, cross-verify forecasts, keep each other informed of the press/media accounts about extreme events (taking into account the need to be efficient in an emergency context); exercise such communication mechanisms under test conditions;*
    9. *Develop a "manual of best practices" to deal with severe/extreme events; in particular, the manual should define a standard set of products in concise formats including for instance a risk index in a space weather hazard scale;*
    10. *Conduct post-event analyses and statistics to refine the capabilities and to document the reliability of the warnings issued.*

- *Action 4.16: David Jackson, Mauro Messerotti, Mike Terkildsen, Terry Onsager, Vyacheslav Burov and Xiaoxin Zhang to evaluate, improve, and expand as necessary the set of global and local Space Weather scales in order to ensure efficient and standardized information communication to the users in severe event situations. (30 November 2014)*

- *Recommendation 4.4: The ICTSW recommends the finalization of the GTEX format by ITU and ultimately its use for the exchange of TEC slant data.*

- *Action 4.17: M. Ishii and J. Lafeuille to investigate whether the RINEX format is currently used on the WMO GTS or WIS for Integrated Water Vapour observations from ground-based GNSS receivers and, if necessary, will recommend to the WMO CBS that the RINEX format – and GTEX once finalized - be recognized for data exchange in the WIS. (28 February 2014)*

- *Recommendation 4.5: The ICTSW should express a recommendation on the use of BUFR and GRIB for space weather data in the light of the pilot activities when completed.*

- *Action 4.18: Xiaoxin Zhang shall investigate whether GNOS RO data will also be used in BUFR format by CMA in addition to the proposed GNOS RO format and report to ICTSW (15 January 2014)*

- *Action 4.19: T. Onsager, in coordination with Bill Schreiner, to provide a sample of Formosat-3/COSMIC-1 and Formosat-7/COSMIC-2 data formats for comparison with the data formats used by the NWP community (15 February 2014).*

- *Recommendation 4.6: ICTSW, as the CBS expert body on the subject matter, unanimously supports the application of NICT as a DCPC for space weather.*

- *Recommendation 4.7: All space weather regional warning centres are encouraged to register as a DCPC in the WIS.*

- *Recommendation 4.8: NICT, BOM to pursue the WIS demonstration actions on the four selected products and their BUFR encoding with a view of distributing these products through the WIS.*

- *Recommendation 4.9: In the light of the WIS pilot project, ICTSW should further discuss whether there is a need and/or advantages to migrate products from current ISES codes to e.g. BUFR.*

- *Action 4.20: All ICTSW members to review the Appendices to Doc 9.1, complete as appropriate the list of ground-based observation networks, update the links to relevant information sources and inform Larisa Trichtchenko (30 June 2014).*

- *Action 4.21: ICTSW members shall review the proposed typology of "layers" and "coverage" included in Doc. 9.3(1) and provide comments to the WMO Secretariat (30 April 2014)*

- *Recommendation 4.10: The list of variables should be reviewed with the aim to have independent, technology-free quantities with consistent definitions and units (31 March 2014)*

- *Action 4.22: Alain Hilgers will lead a further review of the instrument categorization in OSCAR and of the association between instrument classes and variables, and will suggest modifications as necessary for consideration by the WMO Secretariat (J. Lafeuille). (31 March 2014)*

- *Recommendation 4.11: ICTSW recommends to put emphasis in OSCAR on operational observation capabilities, for instance taking advantage of the filter function (R&D or Operational agencies) and/or of the "Capability review" function which allows assessing the gaps with respect to a pre-defined reference constellation.*

- *Recommendation 4.12: Continue and update the review of international initiatives and potential partnerships contained in Appendices to Doc. 10.3.*

- *Recommendation 4.13: Utilize the new Space Weather agenda item to promote awareness and coordination of data needs within COPUOS.*

- *Recommendation 4.14**:** Research to operations. Engage research organisations to ensure their research activities are extended to research to operations activities. An example would be to lobby for extension of ISWI to make new ISWI observations suitable for operational use.*

- *Recommendation 4.15: CGMS should engage in space weather activities:*
    - *to promote a strategy to ensure the long-term continuity of space weather observations, in coordination with WMO and other international organizations;*
    - *to coordinate the acquisition and availability of space weather observations made by meteorological satellites;*

- *to jointly define with ICTSW a strategy to improve the collection, availability, and uses of satellite anomaly information;*
- *to express its requirements for space weather products and services to satellite operators and to provide feedback on the value of available products.*

- *Recommendation 4.16: The focus of space weather educational activities (mainly organised by ISWI and SCOSTEP) should be extended from research to operational activities. This may include: producing training materials on WMO ICTSW website (See Action 4.15 above); expanding the scope of SCOSTEP and other workshops to include research to operations; WMO, ISES or CGMS running operational space weather workshops.*

- *Action 4.23: The ICTSW co-chairs to coordinate the preparation of an outline of a Space Weather Watch (SWW) proposal, providing a reasonable description of the planned SWW proposal, in advance of EC-66 in May 2014. (28 February 2014)*

- *Action 4.24: T. Onsager (as ICTSW Co-chair and ISES Director) and J. Lafeuille to clarify with the WMO and NOAA legal counsels whether ISES is eligible for a MoU or a working arrangement should be concluded in an equivalent form, and proceed towards the signature of this MoU or other arrangement by WMO and ISES. (30 April 2014)*

- *Recommendation 4.17: ICTSW should define a training strategy identifying the target audiences, the intended focus (subjects and training goals), the key partnership opportunities to be exploited such as VLab and COSPAR, and including a plan to develop training material, or select existing training material.*

- *Action 4.25: The training strategy team, including Xiaoxin Zhang, Mamoru Ishii, Nicole Vilmer, Hyesook Lee, will propose a training approach for discussion at ICTSW-5. (31 October 2014)*

- *Action 4.26: ICTSW members to review the material contained in Doc. 12(2) in their respective areas of expertise and report any correction or addition needed. (28 February 2014)*

- *Action 4.27: Xiaoxin Zhang, Matt Francis, Martin Zurn (designated by Neil Mitchison), Norbert Jakowski shall liaise with the Space Weather subgroup of the IROWG (Point of contact: Anthony Mannucci, NASA/JPL) for the preparation the workshop on atmosphere and ionosphere applications planned with the 2014 COSMIC/Formosat Data Users Workshop in Boulder (See background in Doc. 9.2).*

- *Action 4.28: The ICTSW co-chairs to set up a task team in charge of developing a plan to address space agencies and space weather service-providing agencies at the proper level for programmatic issues regarding the long-term continuity of essential space weather satellite observations (including future L1 missions, missions to other heliospheric locations, coronagraph measurements, and heliospheric imaging), advocating for both space-based and ground-based, including both long-term continuity and immediate availability. (31 January 2014)*

- *Recommendation 4.18: T. Onsager, in the context of ISES, and J. Lafeuille, at the WMO Executive Council, should encourage full participation of ISES members in ICTSW (e.g. India, Austria, …)*

- *Recommendation 4.19: All members contributing to the Space Weather Product Portal to maintain consistency of their web pages with the ICTSW agreed standards.*

- *Action 4.29: T. Onsager, M. Ishii to contact IPET-MDRD to determine schedule for updates to the WMO metadata profile and make sure that space weather considerations are addressed in a satisfactory manner, noting that ICTSW was invited to contribute to revise the metadata profile. (15 January 2014)*

- *Action 4.30: Xiaoxin Zhang, Mamoru Ishii and T.Tsugawa, Mike Terkildsen, David Jackson, Hyesook Lee, to investigate the modalities of ground-based GNSS network data exchange for NWP (as discussed at the NAEDEX-APSDEU meetings) and for ionospheric monitoring (as discussed within e.g. IGS), and evaluate if the data from the GNSS sites used for NWP could also be made available (or already are available) for space weather applications. (31 August 2014)*

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