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 Aeronautical Meteorology
Commission for Basic Systems/Open Programme Area Group on Data-Processing and Forecasting System

Inter-Programme Team on Space Weather Information, Systems and Services

FIRST SESSION

GENEVA, SWITZERLAND

21-23 JUNE 2017

FINAL REPORT

WMO General Regulations

Regulation 42

Recommendations of working groups shall have no status within the Organization until they have been approved by the responsible constituent body. In the case of joint working groups the recommendations must be concurred with by the presidents of the constituent bodies concerned before being submitted to the designated constituent body.

Regulation 43

In the case of a recommendation made by a working group between sessions of the responsible constituent body, either in a session of a working group or by correspondence, the president of the body may, as an exceptional measure, approve the recommendation of behalf of the constituent body when the matter is, in his opinion, urgent and does not appear to imply new obligations for Members. He may then submit this recommendation for adoption by the Executive Council or to the President of the Organization for action in accordance with Regulation 9(5).

EXECUTIVE SUMMARY

The first session of the Inter-Programme Team on Space Weather Information, Systems and Services (IPT-SWeISS-1) was held from 21 to 23 June 2017 in Geneva.

The meeting reviewed the IPT-SWeISS Terms of Reference and IPT-SWeISS Work Plan for the period 2017-2018. The meeting also reviewed the status of actions extracted from the Four-Year-Plan.

It was decided to establish three task teams under IPT-SWeISS; TT-SYS (Task Team on Space Weather Basic Systems), TT-SCI (Task Team on Space Weather Science), and TT-APP (Task Team on Space Weather Applications).

It was also decided to establish an ad hoc Task Team on Aviation (TT-AVI), *inter alia,* to assist WMO in conducting, at the request of ICAO, of site assessments and audits of prospective space weather information providers with a concept of operations for space weather that would enable an operational global space weather information service for aviation in the 2018 timeframe.

It was agreed that the action items extracted should be discussed in each TT and finalized by September 30, 2017 with respective ToR. Each TT will work through regular teleconference monthly basis and email correspondence in accordance with ToR and action item respectively. The progress will be shared with members.

The meeting delivered a follow-up discussion on a Vision of the space-based components of the WMO Integrated Global Observing System (WIGOS) in 2040 (WIGOS/Vision 2040).

The meeting also discussed the progress of developments of the space module of the Observing System Capability and Analysis and Review tool (OSCAR/Space), and its long-term maintenance that should facilitate its use in support of future gap analysis studies in the space-based Space Weather observation.

http://www.wmo.int/pages/prog/sat/meetings/IPT-SWeISS-1/IPT-SWeISS-1.html

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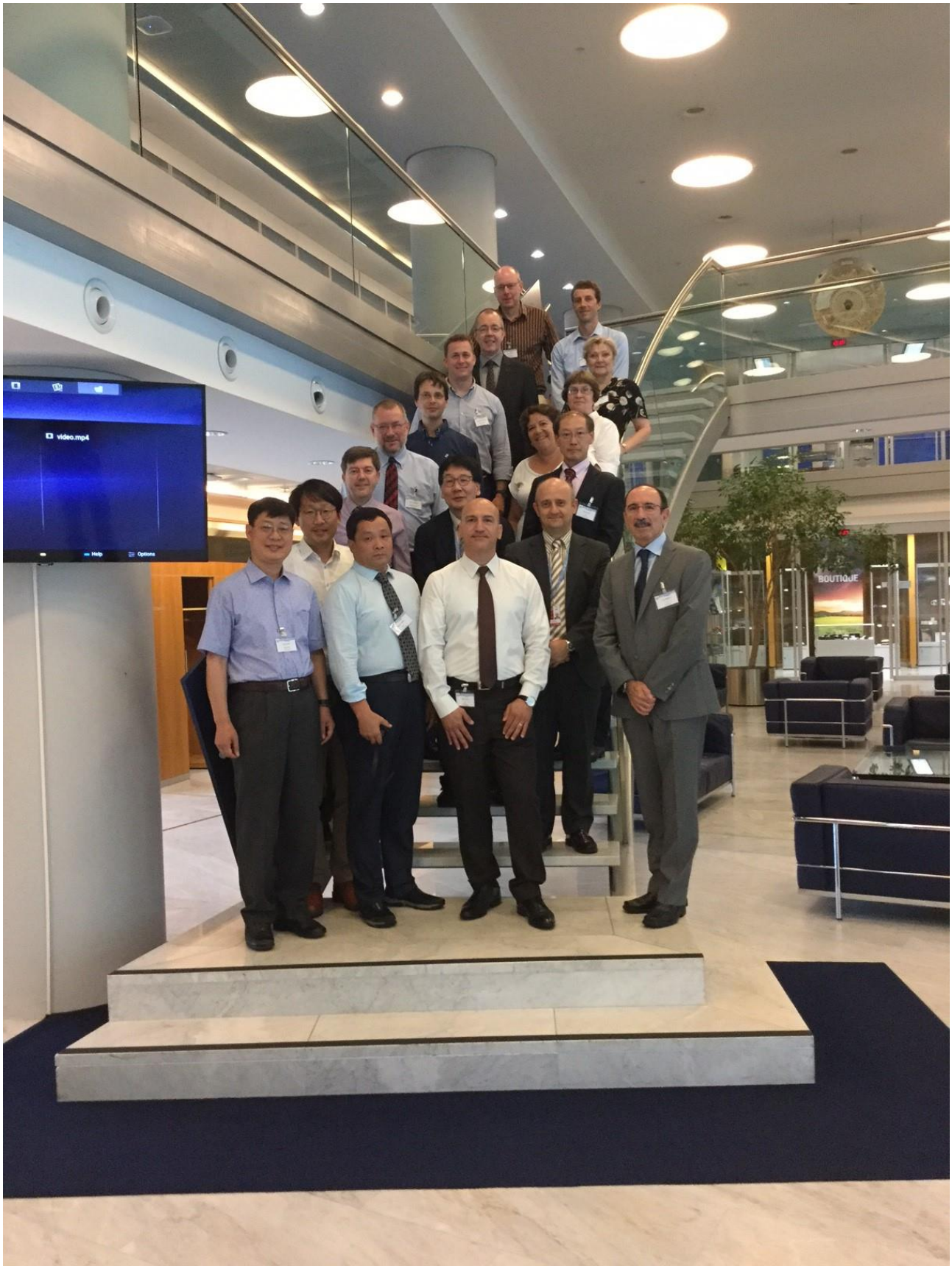

IPT-SWeISS-1 participants:
From left to right (back to front): David Jackson, Michael Terkildsen, Juha-Pekka Luntama, Iwona Stanislawska, Robert Rutledge, Larisa Trichtchenko, Jens Berdermann, Nicole Vilmer, David Frank, Mamoru Ishii, Mark Gibbs, Toshiyuki Kurino, Jiyoung Kim, Fernando Belda, Jangsuk Choi, XiaoXin Zhang, Daniele Biron, Raul Romero (Not on this picture: Margit Haberreiter).

FINAL REPORT

1. OPENING OF THE MEETING

1.1. Welcome and Introduction of participants

The session opened at 9.00 on Wednesday 21 June in Press Room in WMO Headquarters, Geneva, Switzerland. The meeting was chaired by Xiaoxin Zhang (CMA, China) and Robert Rutledge (NOAA, USA).

The Director of Observing and Information Systems Department, Fernando Belda, welcomed the participants (See **Annex 1**) and provided opening remarks on behalf of the Secretary-General. In his opening remarks, he stressed that there is an increasing societal demand for space weather services as a result of growing dependence on technologies impacted by space weather: 1) air navigation on polar routes exposed to space weather events; 2) fleets of satellites used operationally for telecommunication, broadcasting, observation, or positioning; 3) use of satellite-based navigation and timing signals that are affected by ionospheric disturbances; 4) electric power grids that are exposed to geomagnetically induced currents with potentially disastrous cascading effects.

Fernando Belda recalled the participants that the former WMO initiative for Space weather, the Inter-Programme Coordination Team on Space Weather (ICTSW), commenced its activities in 2010 under the auspices of CBS and CAeM. As of April 2016 it involves experts from twenty-six WMO Members, and several UN and international organizations. This role, played by WMO through ICTSW, has been acknowledged and encouraged by various international partners. However, a number of challenges are still in front of us. Further mobilization of experts, sustained engagement of WMO Members to operate observing systems and share data, and continued support by the Secretariat, would be required in order to achieve a breakthrough in the capability of WMO Members to provide and benefit from space weather services. A way forward to address these challenges is detailed in the present FOUR-YEAR PLAN FOR WMO ACTIVITIES RELATED TO SPACE WEATHER 2016-2019, as agreed by the sixty-eighth session of WMO Executive Council (EC-68) in June 2016 for the next four years.

The IPT-SWeISS Co- Chair, Xiaoxin Zhang (CMA, China) and Robert Rutledge (NOAA, USA) welcomed the participants.

1.2. Adoption of the agenda and working arrangements

The members agreed with the meeting agenda (See **Annex 2**).

1.3. IPT-SWeISS Terms of Reference

The members reviewed the Terms of Reference (See **Annex 3**) of IPT-SWeISS, which was decided by CBS-16 in November 2016.

2. STATUS REPORT FROM THE MEMBERS

2.1. Report from Argentina

Sergio DASSO, Servicio Meteorológico Nacional reported the status on Space Weather activities and operative capabilities in Argentina remotely. Argentina is taking the first steps in the direction of creating its own RWC, from 2014. There is a strong link between University of Buenos Aires (UBA) and Argentine National Weather Service (Servicio Meteorológico Nacional, SMN), developing several activities on R2O and operative Space Weather. Other national institutions have capabilities and are working also in the direction of R2O in Space Weather. The presentation included a discussion on the operations of several institutions in Argentina, including Servicio Meteorológico Nacional (SMN), national space agency (CONAE), Antarctic institute (IAA), Science council of Argentina (CONICET), Universidad de Buenos Aires (UBA), and Universidad Nacional de Tucumán (UNT).

2.2. Report from Australia

Michael TERKILDSEN, Bureau of Meteorology reported the state of space weather activities in Australia. Space weather service provision in Australia is the responsibility of the national meteorological service, the Australian Bureau of Meteorology. This section was formerly known as the Ionospheric Prediction Service (IPS). The Bureau's Space Weather Service (SWS) operates the Australian Space Forecast Centre (ASFC), supported by an extensive network of ground-based space weather monitoring equipment. SWS maintains a strong customer focus, serving a broad range of stakeholders including aviation, power networks, defence, emergency services, HF and precision GNSS users. SWS is actively engaged in international coordination and communication activities through organisations and programs such as ICAO, WMO, UN-COPUOUS, and ISES.

2.3. Report from Canada

Larisa TRICHTCHENKO, Canadian Space Weather Forecast Centre of Natural Resources Canada reported the state of space weather activities in Canada. “Space Weather” is a term that embraces a mix of phenomena, ranging from activity on the Sun, changes in the interplanetary electromagnetic field and particle population and their geophysical consequences. In addition to being a scientifically challenging problem, space weather can damage or disrupt space-borne, airborne and ground-based technology systems, and has large negative impacts on critical technological infrastructure, such as energy infrastructure, communication and navigation. Space weather impacts depend on the location on Earth thus, due to the location of Canada at high latitudes, its technology infrastructure is exposed to more intense and more frequent space weather effects. To mitigate the risks requires space weather now-casting and forecasting. The Canadian Space Weather Forecast Centre (CSWFC) is operated by Natural Resources Canada. Developed originally in late 1960s to help magnetic surveyors, its services now cover a wide range of phenomena from geomagnetic storms and effects on ground infrastructure to parameters of ionosphere and satellite environment. The Centre provides a wide range of services to Canadian Government, critical infrastructure operators and general public, for example:

- Forecasts of geomagnetic disturbances and space weather events distributed through on-line system and as dedicated messages to several organisations.

  The Forecast system is a semi-automatic operating 24/7 and is updated each 15 min. All forecast products are available on web site, our primary mode of product dissemination. The operational back-up systems exist in several different locations for robustness.
- Real-time geomagnetic and other space weather data.

- On-line simulations to provide dedicated information to affected industries

2.4. Report from China

XiaoXin ZHANG , National Center for Space Weather of CMA reported the state of space weather activities in China in associated with the space weather observation, forecast and services. The observing facilities of space weather operation in CMA were then discussed including the spaced-based payloads onboard the FENGYUN meteorological satellites, ground-based instruments for monitoring the solar, upper atmospheric and ionospheric activities, as well as the GPS/MET network. Forecast requirements, product category, platform, and public and special services were also demonstrated. New capabilities for space weather on CMA's satellites are planned focused on upper atmospheric, ionospheric, auroral, and solar imaging. Observed data and products from space weather operation in CMA are available for global and regional cooperation.

2.5. Report from France

Nicole VILMER, LESIA-Paris Observatory reported the state of space weather activities in France.

2.6. Report from Germany

Jens BERDERMANN, Space Weather Information Systems and Services at the German Aerospace Center reported the state of space weather activities in Germany. The German Aerospace Center operates a space weather service with special focus on monitoring and forecasting ionospheric conditions to support GNSS applications. The highly dynamic ionosphere has a strong effect on the performance of radio systems used in space based communication, navigation and remote sensing. Moreover, ionospheric disturbances caused by space weather effects may degrade the accuracy, reliability and availability of Global Navigation Satellite Systems (GNSS), such as GPS and the future civilian European system Galileo. DLR addresses the need for nowcasts and forecasts of the ionosphere with the Ionosphere Monitoring and Prediction Center (IMPC). Being the successor of the well-established Space Weather Application Center – Ionosphere (SWACI), IMPC provides considerably improved ionosphere weather information and forecasts. The IMPC, as a permanent ionospheric weather service, is using ground and space based GNSS data from extended geodetic networks such as IGS and satellite missions such as GRACE, respectively. The long term experience of DLR in respect to reception, archiving and use of remote sensing data in operational mode is used within the IMPC.

2.7. Report from Indonesia

Clara YATINI, LAPAN reported the state of space weather activities in Indonesia remotely. LAPAN is an Indonesian government institution which is responsible in conducting space activities under the Space Law of the Republic of Indonesia, with one of its main tasks to provide space weather services. The Space Science Center has been appointed to conduct research and development related to space science and its applications. Information and forecast of space weather services have been conducted by this center since 2008 and it was started by weekly space weather information which delivered to the user/stakeholder by facsimile. To serve the

space weather community in Indonesia who use the technology susceptible to interference from space weather, LAPAN needs to enhance the space weather information services that were previously done weekly to daily basis. This activity is called Space Weather Information and Forecast Services (SWIFtS). SWIFtS are the activities of space weather information and forecast services for the Indonesian region conducted by the Centre for Space Science. SWIFtS formed in March 2015 with the aim of providing daily information and prediction of space weather for the space weather community in Indonesia, especially for the HF radio communication users, Indonesian satellite operators, and geological surveyors as well, and has sufficient capability in space weather issues. Another aim is to contribute to the international space weather community related to the sharing of research, data, and services results of space weather with other space agencies whose are involved in the field of space weather.

2.8. Report from Italy

Daniele BIRON, IAF reported the state of space weather activities in Italy. Italy has not yet established a National Entity for the provision of Space Weather information. Having the responsibility to represent Italy within WMO, in October 2012 IAF joined the WMO Space Weather initiative group: Inter-programme Coordination Team on Space Weather (ICTSW). Together with IAF representative, the PR of Italy in 2012 indicated also for the ICTSW membership the Istituto Nazionale di Astrofisica and the Istituto Nazionale di Geofisica e Vulcanologia. Since the beginning, IAF promoted a multidisciplinary and multiagency approach to the topic, with possibly public-private effort, in order to reach in the coming years a proper approach towards the needs of air navigation safety. IAF in October 2014 organized a conference for the Semester of Italian Presidency of the Council of European Union on future perspectives of Remotely Piloted Aircraft Systems (RPAS), Single European Sky Air Traffic Management Research (SESAR) and Space Weather. At the moment there is no governmental endorsement of Space Weather risk; IAF has a plan for the coming years, and is proactive in discussing it nationally, taking advantage of international relations.

2.9. Report from Japan

Mamoru ISHI, NICT reported the state of space weather activities in Japan. As one of the ISES/RWC, NICT provides operational space weather (SWx) forecast information every day including weekends and holidays. The main users of the information are satellite operators, radio communication, broadcast and satellite positioning operators, etc. NICT provides the SWx information via email and web. The number of email registration is about 10,000 and web access number is about 160,000 a month.

NICT has been undertaking ionospheric observations in Japan and Antarctica since the IGY at five stations located in Wakkanai, Kokubunji, Yamagawa, Okinawa, and Syowa. NICT has been one of the ground stations of the Real-Time Solar Wind network (RTSWnet) since 1997 and has been tracking two satellites, ACE and STEREO, which retrieve real-time information on solar winds and images on the basis of international cooperation. NICT will contribute to data reception from DSCOVR satellite, which was launched in 2015. Concerning solar observation, NICT has a long history of measuring solar radio waves at the Hiraiso observatory since 1952. In 2014, NICT built a new solar radio telescope in Yamagawa observatory and started solar observation. As a research project mainly studying the dynamics and characteristics of plasma bubbles and geospace

disturbances related to radiation belt dynamics, NICT has network observations of the ionosphere in Southeast Asia, a ground-based magnetometer network in the Siberian region, and an HF radar in Alaska in cooperation with universities and academic institutes.

NICT has been developing the model and simulation code of ionosphere and magnetosphere to improve the precision of space weather forecast. NICT is providing some information with empirical models and developing numerical models. NICT created several empirical models to satisfy current user needs Such models can provide practical information in near real time. NICT has developed a Kalman filter based on a multivariate autoregressive model to predict relativistic electron flux at geostationary orbit [Sakaguchi et al., 2013].

NICT has been developing two types of magnetospheric models: 1) A global magnetospheric MHD simulation for understanding the physical processed of space weather [Tanaka, 1995]; and 2) A fast real-time 3-D MHD magnetospheric simulator used from 2004 to 2012 [Den et al., 2006]. The next-generation of the real-time simulation system is now under development. Plasma bubbles are known to affect satellite positioning, and it is still difficult to forecast their occurrence numerically. NICT is now developing an empirical model of the occurrence of plasma bubbles using a neural net. At present, NICT can provide the TEC distribution on the vicinity of Japan every hour, and provide a forecast 24 hours in advance. The behaviour of the lower atmosphere also influences ionospheric and thermospheric variations. NICT's Ground-to-Topside Model of Atmosphere and Ionosphere for Aeronomy (GAIA) [Jin et al., 2011] is being developed to solve ionosphere-thermosphere, including electrodynamics, in a self-consistent manner.

The Asia-Oceania space weather alliance (AOSWA) established on 2010 for information exchange among SWx organizations in the region. Now the number of members is 27 from 13 countries. NICT works for secretary of AOSWA. Face-to-face meetings are held every one and half years and the last one is hosted by RRA, Korea on October 2016. NICT succeeded to get a budget on the Grant-in-Aid for Scientific Research on Innovative Areas on 2015, MWXT, Japan named "Project for Solar-Terrestrial Environment Prediction" (PSTEP). One of the goal of PSTEP is to build a system to provide a useful information for users with frequent communications and establish Japanese original hazardous map for preparedness against SWx extreme events. As an issue to be raised on the members of IPT-SWeISS, we point out activities related on SWx in ITU-R SG3. Study Group 3 works for radio propagation and there are many recommendation documents related on SWx. Some of them are already obsolete. As experts of SWx research and operation we need to update these documents.

2.10.1. Report from Korea (1)

Jiyoung KIM, KMA reported the state of space weather activities in Korea. Recent advances and future plan of the KMA's space weather service and R&D program were presented. The aims of the KMA's space weather service are safe operation of meteorological satellites and provide of space weather information concerned with civil aviation and ionospheric disturbances. KMA has developed a cosmic radiation dose model (KREAM, Korean Radiation Exposure Assessment Model for aviation route dose) as a research to operation (R2O) program with KASI (Korea Astronomy and Space Science Institute). The model performance on radiation dose estimation was validated with a number of aircraft measurements and compared with existing models such as CARI-6 and NAIRAS. Good agreement of the model estimation with aircraft-based measurement data (Liulin-6K) was found. The KREAM model output is going to be experimentally opened via the

KMA/NMSC's webpage. The model will be verified with other measurement data (e.g., ARMAS) and compared with existing models to evaluate the SPE and GCR contribution on the total radiation dose. The evaluation results will be used for the model improvement. The first Korean space weather mission, KSEM (Korean Space Weather Monitor) on-board Geo-KOMPSAT-2A (GK2A) is in the final stage of flight model development and will be integrated into satellite by the end of August 2017. KSEM is designed to continuously monitor the space weather during 10 years of the GK2A mission. The suite of KSEM instruments consists of the medium energy Particle Detector (PD), Magnetometer (MG), and satellite charging monitor (CM). PD is inherited the design from the THEMIS SST. The SOSMAG from ESA is hosted to monitor the Earth's magnetic field, as part of the space weather package on-board GK-2A. CM measures the satellite internal charging. KMA will continue the space weather mission for GEO and has a plan to newly establish the space weather program for LEO.

2.10.2. Report from Korea (2)

Jangsuk CHOI, KSWC of RRA reported the state of space weather activities in Korea. The Korean Space Weather Center (KSWC) of the National Radio Research Agency (RRA) is a government agency which is the official source of space weather information for Korean Government and the primary action agency of emergency measure to severe space weather condition as the Regional Warning Center of the International Space Environment Service (ISES). KSWC's main role is providing alerts, watches, and forecasts in order to minimize the space weather impacts on both of public and commercial sectors of satellites, aviation, communications, navigations, power grids, etc. KSWC is also in charge of monitoring the space weather condition and conducting research and development for its main role of space weather operation in Korea.

Recently, KSWC are focusing on increasing the accuracy estimation of space weather forecasting results. The forecasting accuracy will be calculated based on the probability statistical method so that the results can be compared numerically. Regarding the cosmic radiation dose, we are gathering the actual measured data of radiation dose using the instrument by cooperation with the domestic airlines. Based on the measurement, we are going to verify the reliability of SAFE system which was developed by KSWC to provide the cosmic radiation dose information with the airplane cabin crew and public users.

2.11. Report from the Netherlands

Gijsbertus VAN DEN OORD, Royal Netherlands Meteorological Institute (KNMI) reported the state of space weather activities in the Netherlands remotely. The Royal Netherlands Meteorological Institute (KNMI) was assigned the task of national space weather information provider in 2015. The service will become operational in 2018, well before the next solar cycle, and will consist of two front offices (military and civilian) and a joint back office in which universities, technological institutes, government agencies, industry and SMEs participate. KNMI is working with the so-called vital sectors (energy, water management, telecommunications, financial sector, main ports (aviation and harbors)) to identify space weather related risks. Where possible adaptation measures are identified, otherwise risk mitigation is achieved via warnings, provided by KNMI, and adjustments of Business Continuity Management Procedures.

In 2016 the Netherlands joined the ESA Space Situational Awareness program that aims at developing a European space weather warning infrastructure. Together with the Solar Terrestrial Center of Excellence (STCE) in Brussels a Space Weather Introductory Course (SWIC) has been developed. An overview was provided of the observing capabilities that are being developed and of the research programs that have been initiated to identify/monitor space weather effects on infrastructures and to improve forecasts. Space weather is a relatively new subject in the Netherlands and because of its size and geolocation space weather services will be relatively small. Focus will be on 1) the effects on critical infrastructures, 2) collaboration with neighboring services within Europe and 3) development of capabilities within the WMO Information System.

2.12. Report from New Zealand

Craig RODGER, University of Otago reported the state of space weather activities in New Zealand remotely.

2.13. Report from Poland

Iwona Stanislawska, Space Research Centre Polish Academy of Sciences reported the state of space weather activities in Poland. The Space Research Centre of the Polish Academy of Sciences performs its duty as space weather science developer; pure and applied, near-space and Earth monitoring and space instrumentation provider for domestic and international users.
The Heliogeophysical Prediction Service Laboratory of Space Research Centre is part of the global International Space Environment Service (ISES) working as the Regional Warning Centre *RWC Warsaw* (http://rwc.cbk.waw.pl/). The Laboratory serves as space weather data and prediction/forecast provider. It exchanges data with other Warning Centres, and receives large amounts of data from national observatories and institutions in different countries. Data from Polish observatories are also collected. A special daily bulletin (URSIGRAM Warsaw) is published and broadcast to ISES members.
The Ionospheric Despatch Centre in Europe's web service (http://rwc.cbk. waw.pl/idce) provides online access to a database of the ionospheric characteristics for all sites. Other ionospheric and plasmasperic parameters and maps described in continuous now-casting of limited areas are also available. It is active within the SSA Space Weather Expert Service Centers. Data from the LOFAR interferometer, designed to track signals from space and their use in the diagnosis of ionospheric scintillation is currently tested. The Space Research Centre provides forecasts of high-frequency radio signal intensity to governmental and commercial communications units on the own prepared software packages. It provides a database of operational, data-driven models and can produce messages and files tailored to user requirements.
The laboratory responds to all requests for information about space weather phenomena. Information is disseminated in seminars and lectures aimed at our partners and media.

2.14. Report from Switzerland

Margit HABERREITER, PMOD/WRC reported the state of space weather activities in Switzerland.

2.15. Report from UK

David JACKSON and Mark GIBBS, Met Office reported the state of space weather activities in UK. The Met Office Space Weather Operations Centre (MOSWOC) has been operational on a 24/7 basis since April 2014. Services are made available free at the point of use for UK government, critical national infrastructure providers and members of the public. Forecasters are issued twice daily by email and on webpages, focusing on geomagnetic storms, solar flares, high energy electron events and solar radiation storms. Recent accomplishments include developments in the use of observations (magnetometers, DSCOVR data), and operational model developments (including development of an Enlil ensemble prediction system). Verification of operational forecasts is very important and we have recently introduced verification of our geomagnetic storm and solar flare forecasts based on NWP methods. The report outlined a range of planned future improvements in the solar and heliosphere domain (including upgrading our Enlil background solar wind forecasts, and, eventually, introducing Enlil data assimilation) and in the near Earth domain (including implementing models of the aurora, ionospheric scintillation and the global magnetosphere), in the upcoming years. The main achievements the Met Office would like to see from IPT-SWeISS are improved coordination of space weather alerts, especially during severe events, and development of improved space weather scales in response to customer needs. It is very important that IPS-SWeISS sets standards for operational space weather services, including forecaster competency, consistent verification methods, and good practice in Research to Operations.

2.16. Report from US

Robert David RUTLEDGE, NOAA Space Weather Prediction Center reported the state of space weather activities in US. Space weather continues to receive strong support within the US and within the National Weather Service. Execution of the National Space Weather Strategy, corresponding Action Plan (October 2015), and Executive Order 13744 – *Coordinating Efforts to Prepare the Nation for Space Weather Events* (Oct 2016) continues. Additionally, Senate Bill 141 - Space Weather Research and Forecasting Act - passed the Senate in May 2017. A necessary companion bill in the House has yet to be taken up. Additionally, mitigation of the space weather risk to the bulk power system continues with the Federal Energy Regulatory Commission TPL-007-1: Transmission System Planned Performance for Geomagnetic Disturbance Events issuance in September 2016. TPL-007-1 will require full analysis of the Extra High Voltage (EHV) system against a benchmark geomagnetic storm and will require both operational and physical mitigation.

The US continues to sustain its key space-based observations. The Deep Space Climate Observatory (DSCOVR) became the operational solar wind monitor, replacing the Advanced Composition Explorer (ACE), in July 2016. Additionally, GOES-16 was launched in November 2016 and on-orbit checkout continues of its space weather sensors. The replacement of DSCOVR in situ solar wind monitoring and coronagraph imaging from the L1 Lagrange point is still in the planning phases, with a tentative launch date in the 2022 timeframe.

Space weather modeling and service improvements continue to be strongly supported as well. The geospace model, in partnership with the University of Michigan, became operational in September 2016. Progress continues in the Whole Atmosphere Model domain as well, with initial versions expected yet in 2017. Induced electric field specification and forecasting has seen great progress as well, with operational products of induced electric field for the contiguous US expected in 2018.

2.17. Report from ESA

Juha-Pekka LUNTAMA, reported the state of space weather activities in ESA, covering the current status of the ESA's SSA Space Weather Network, the current service capabilities and the next steps for transitioning it into a Space Weather System, and addressing ESA's plans for implementing a space based SWE monitoring system including the mission to L5 and considerations for international collaboration for maintaining space weather observation capability in a sustainable way.

Networking of European Space Weather capabilities has reached a major milestone in spring 2017, when new capabilities from ESA's Space Weather (SWE) Network consisting of the SSA SWE Coordination Centre (SSCC) and the five Expert Service Centres (Solar Weather, Heliospheric Weather, Space Radiation, Ionospheric Weather and Geomagnetic Conditions) have been deployed and made available to the end users. This deployment brings the total number of space weather products from the network to over 115 and the services available to the end users to 17. These achievements together with the mandate and funding given by the ESA Member States to the ESA's SSA Programme in the Ministerial Council in December 2016 are putting the Programme in an excellent position to start transitioning the SWE Networks towards the SSA Space Weather System. The strategic objectives for the Space Weather System development for 2017-2019 have been defined as:

- Reinforce and mature SWE System Elements
- Reduce dependence on non-European systems
- Begin transition towards an operational system

The means to achieve these objectives will include verification and validation of the products and services from the system, enhancement of services to key user domains, establishment of a robust R2O process, consolidation of the interfaces to ground based SWE measurements and development of operational European space based SWE measurement capability. As part of this work, ESA will continue the development of a space weather monitoring mission to L5.

2.18. Report from ISES

Terry ONSAGER, ISES Chair reported the state of space weather activities in ISES remotely.

2.19. Report from CGMS Task Team on Space Weather

Elsayed TALAAT, Co-Chair of CGMS Task Team on Space Weather reported the state of space weather activities in CGMS remotely.

2.20. Report from COSPAR

Jean-Louis Fellous, COSPAR Executive Director reported the state of Space Weather Capacity Building Programme produced by COSPAR remotely. A COSPAR Capacity Building Workshop on Space Weather was held in Kamchatka, Russia, in August 2016, organized by the Institute of Cosmo-physical Research and Radio waves Propagation (IKIR). The workshop was co-sponsored by WMO in the framework of the Memorandum of Understanding signed by COSPAR and WMO in 2012 and renewed in 2015. The COSPAR Capacity Building programme for 2017 and 2018 may include a new workshop on Space Weather, proposed by the Brazilian Institute for Space Research (INPE) in São Jose dos Campos. Co-sponsorship by WMO is recommended.

2.21. Report from WMO

Toshiyuki Kurino, WMO Secretariat reported the WMO's initiative for space weather. In May 2015, the World Meteorological Congress (Cg-17) agreed that WMO should undertake international coordination of operational space weather monitoring and forecasting with a view to support the protection of life, property and critical infrastructures and the impacted economic activities in an optimized overall effort. In June 2016, the Executive Council (EC-68) approved the Four-year Plan for WMO activities related to Space Weather in 2016-2019, and requested CAeM and CBS to establish Inter-Programme Team on Space Weather Information, System and Services (IPT-SWeISS) who will pursue the work and achievement of the former expert team on Space Weather, the Interprogramme Coordination Team on Space Weather (ICTSW) with 21 WMO Member Countries and 4 associate members from UN and Intergovernmental Organization.

3. IPT-SWeISS WORKING PLAN FOR 2017-19

The IPT-SWeISS Work Plan for 2017-19 (see **Annex 4**), which was described in the four-year plan, was reviewed and approved**.**

4. IPT-SWeISS WORKING STRUCTURE

The members were invited to discuss about the working structure for IPT-SWeISS with the list of action items (see **Annex 5**) broken down from the IPT-SWeISS Work Plan for 2017-19. For carrying out the action items, it was approved to establish the following three task teams under IPT-SWeISS; TT-SYS (Task Team on Space Weather Basic Systems), TT-SCI (Task Team on Space Weather Science), and TT-APP (Task Team on Space Weather Applications):

TT-SYS: Space weather basic systems, including issues related to observation techniques and networks, data management and exchange, data centres, and space climatology

TT-SCI: Space weather science, including issues related to modelling, model evaluation and verification, interaction with climate, and transition from research to operations;

TT-APP: Space weather applications, including requirements evaluation, the delivery of services, capacity building and user interaction

It was agreed that the action items should be discussed in each TT and finalized by September 30, 2017 with respective ToR. Then each TT will work through regular teleconference monthly basis and email correspondence in accordance with ToR and action item respectively. The progress will be shared with members.

5. COOPERATION WITH ICAO

Raul ROMERO, ICAO Secretariat reported the plan of International Civil Aviation Organization (ICAO) for establishing global framework for the operational global space weather information service for aviation. The ICAO Meteorology Panel (METP) has brought forward a concept of operations for space weather that would enable an operational global space weather information service for aviation in the 2018 timeframe, and provided a guidance on the space weather

information provider designation process. One of the key components in the realization of an operational, global space weather information service for aviation before the end of 2018 is the conducting, by WMO at ICAO's request, of site assessments and audits of prospective space weather information providers.

IPT-SWeISS members agreed with the establishment of an ad hoc Task Team on Aviation (TT-AVI) with its terms of reference (see **Annex 6**), *inter alia,* to assist WMO in the conducting of site assessments and audits at the request of ICAO.

6. RADIO FREQUENCY COORDINATION FOR SPACE WEATHER OBSERVATION

David THOMAS, WMO Secretariat reported the status of preparation of WMO Steering Group on Radio Frequency Coordination (SG-RFC) for the agenda of the World Radio Communications Conference 2019 (WRC-19).

David FRANK, NOAA, WMO SG-RFC Co-Chair reported the spectrum issues relating to space weather operations. WMO supports retention of both of the preliminary agenda items on the WRC-23 Agenda, related to EESS (active) around 45 MHz and to space weather sensors, ensuring that the RF-based space weather sensors providing operational data are protected from interference

Joaquin GONZALEZ, EUMETSAT, CGMS WG-I Co-Chair, report the frequency management related matters of mutual interest and concern to the meteorological satellite community remotely. All of them are related to WRC-19 agenda items

David JACKSON reported WMO observing requirements and Radio Frequencies used for space weather observation of Ionosphere and Solar, space weather RF spectrum protection by the survey of technical specifications.

It was agreed that the report on the usage of radio frequencies for space weather will be submitted from IPT-SWeISS to the WMO Steering Group on Radio Frequency Coordination (SG-RFC) for the further development of the WMO document into a form suitable for presentation to the International Telecommunication Union (ITU).

7. SPACE WEATHER IN WIGOS VISION 2040 (VISION/SPACE AND VISION/SURFACE)

Toshiyuki Kurino, WMO Secretariat reported the plan for drafting the Vision for WIGOS in 2040. WMO regularly reviews its Vision of future global observing systems to support weather, climate and related environmental applications. Currently, a "Vision for WIGOS in 2040" is in preparation, with the aim of submitting it for approval to the 18th World Meteorological Congress in 2019. The document is structured in three parts: An overarching "Vision for WIGOS in 2040" providing scope, context and background for the Vision, supplemented by two annexes, Annex I: "Vision for the WIGOS space-based component in 2040", and Annex II: "Vision for the WIGOS Surface-based component in 2040". Preliminary drafts of all three components have been developed, and these are included below for information. The plan is to further develop and integrate the three elements in consultation with a broad group of stakeholders, and to present a solid draft of an integrated "Vision" document for discussion at the 7th Session of the Inter-commission Coordination Group on WIGOS (ICG-WIGOS) in early 2018.

IPT-SWeISS members are invited to review the Vision for updating surface-based and space-based observation for space weather.

8. OSCAR/SPACE FOR SPACE WEATHER

Toshiyuki Kurino, WMO Secretariat reported the proposed maintenance and upgrade scheme of satellite information in the WMO Observing System Capability Analysis and Review Tool (OSCAR).

The OSCAR (oscar.wmo.int) is comprised of the following components:

- **OSCAR/Requirements**, which is the repository of technology free observational user requirements recorded quantitatively for the WMO Application Areas. www.wmo-sat.info/oscar/observingrequirements . See document no. 7.1.1, and its Appendix 5 which provides a summary description of OSCAR/Requirements.
- **OSCAR/Surface**, which records WIGOS metadata (i.e. description of the observing platforms and their instruments allowing to derive the surface-based observing systems capabilities). This new component developed in partnership with MeteoSwiss was deployed operationally in May 2016, and now replaces WMO No. 9, Volume A. oscar.wmo.int/surface/. See document No. 7.2(2) for details.
- **OSCAR/Space**, which includes an inventory of satellite instruments, missions and programmes, and an assessment of the variables that the instruments have the potential to measure, is the subject of this document. oscar.wmo.int/space.

Through Decision 16 (CBS-16), the Commission for Basic Systems decided to assign responsibility within CBS for the technical development of OSCAR.

In September 2016, the new version of the OSCAR/Space was released. It offers now (i) factual information on satellites and instruments, and (ii) instrument assessments and "gap analyses". In addition, the frequency plans of meteorological and some associated satellites and space-based space weather observation instruments are included as well. It was reviewed in CGMS-45 in June 2017, and CGMS Members and Observers are asked to support the WMO effort to maintain and update OSCAR/Space v2.

To achieve a sufficient maintenance and support for OSCAR/Space with keeping the database updated with information of sufficiently high quality, WMO would like to strengthen the cooperation with CGMS members and observers from other space agencies through newly established support groups, the OSCAR/Space Support Team (O/SST) and the OSCAR/Space Science and Technical Advisory team (O/SSAT), to ensure the sustainability of OSCAR/Space in the years to come. This scheme will lay the foundation of cooperation with CGMS for sustaining the OSCAR/Space updating process through provision of information on their satellite programmes by making use of the provided templates.

IPT-SWeISS members are invited to contribute to O/SSAT for reviewing the space weather

9. UPDATING THE WMO BASELINE DOCUMENT "STATEMENT OF GUIDANCE FOR SPACE WEATHER OBSERVATION"

Larisa TRICHTCHENKO reported the updated version of Statement of Guidance has been drafted by the consortium of ICTSW members. According to their particular domain of expertise, i.e., Solar, Solar wind/ and Heliosphere (including energetic particles in the interplanetary space), Energetic Particles in near-Earth environment (including surface-based neutron flux and

measurements at aviation altitudes), Ionosphere, Thermosphere, Geomagnetic Field (surface-based and in near-Earth space). It was then consolidated to fit the same template.

8. ANY OTHER BUSINESS

9. SUMMARY OF ACTIONS AND CONCLUSION

The list of actions and other major conclusions was reviewed and adopted. The main outcome of the meeting will be reported to the CBS by the OPAG DPFS Chair.

10. CLOSING OF THE MEETIONG

The meeting was closed at 15h30 on Friday 23 June2017.

Annex 1

LIST OF PARTICIPANTS

Co-Chairs
XiaoXin ZHANG (CMA, China) – Co-Chair (CAeM)
Robert David RUTLEDGE (NOAA, USA) – Co-Chair (CBS)

Members
Sergio DASSO (Argentina) – remote participation
Michael TERKILDSEN (Australia)
Larisa TRICHTCHENKO (Canada)
Nicole VILMER (France)
Jens BERDERMANN (Germany)
Clara YATINI (Indonesia) - remote participation
Daniele BIRON (Italy)
Mamoru ISHII (Japan)
Jiyoung KIM (KMA, Korea)
Jangsuk CHOI (KSWC, Korea)
Gijsbertus VAN DEN OORD (Netherland) – remote participation
Craig RODGER (New Zealand) - remote participation
Iwona STANISLAWSKA (Poland)
Margit HABERREITER (Switzerland)
David JACKSON (UK)
Mark GIBBS (UK)

UN and Intergovernmental Organization (Associate Members)
ESA: Juha-Pekka LUNTAMA
ICAO: Raul ROMERO
ISES: Terry ONSAGER - remote participation
CGMS TT-SWx: Elsayed TALAAT

Invited Experts
NOAA: David FRANK
EUMETSAT: Joaquin GONZALEZ - remote participation
COSPAR: Jean-Louis Fellous- remote participation

WMO Secretariat
Dimitar IVANOV, Aeronautical Meteorology Division, Weather and Disaster Risk Reduction Services Department
David THOMAS, Information and Telecommunication System Division, Observation and Information System Department
Toshiyuki KURINO, Space-based Observing System Division, Observation and Information System Department

Annex 2

IPT-SWeISS-1 AGENDA

1. OPENING OF THE MEETING

1.1 Welcome
1.2 Introduction of participants
1.3 Approval of agenda and working arrangements
1.4 IPT-SWeISS Terms of Reference
1.5 Election of Rapporteur

2. STATUS REPORT FROM THE MEMBERS

3. IPT-SWeISS WORKING PLAN FOR 2017-19

4. IPT-SWeISS WORKING STRUCTURE

5. COOPERATION WITH ICAO

6. RADIO-FREQUENCY COORDINATION FOR SPACE WEATHER OBSERVATION

7. SPACE WEATHER IN WIGOS 2040 (VISION/SPACE AND VISION/SURFACE)

8. OSCAR/SPACE AND OSCAR/SURFACE DATABASE FOR SPACE WEATHER

9. UPDATING A BASELINE DOCUMENT "STATEMENT OF GUIDANCE FOR SPACE WEATHER OBSERVATION"

10. COLLABORATION WITH INTERNATIONAL ORGANIZATION ON SPACE WEATHER

11. OUTREACH ACTIVITIES ON SPACE WEATHER

12. ANY OTHER BUSINESS

13. SUMMARY OF ACTIONS/RECOMMENDATIONS AND DECISIONS

14. NEXT MEETING

15. CLOSING OF THE MEETING

Annex 3

IPT-SWeISS TERMS OF REFERENCE

(Approved by CBS-16 in November 2016)

Scope

The responsibility of the Inter-Programme Team on Space Weather Information, Systems and Services (IPT-SWeISS) is to coordinate space weather activities within the WMO Programmes, to maintain linkage with the constituent bodies and their relevant subsidiary groups, to maintain linkage with partner organizations, and to provide guidance to WMO Members. IPT-SWeISS is established under the Commission for Basic Systems (CBS) and the Commission for Aeronautical Meteorology (CAeM) which will provide joint oversight in consultation with each other via their presidents.

Main tasks

(a) Integration of Space Weather observations, through review of space- and surface-based observation requirements, harmonization of space-based sensor specifications, monitoring plans for Space Weather observations;

(b) Standardization and enhancement of Space Weather data exchange and delivery through the WMO Information System (WIS);

(c) Coordinating the development of SPW best practices for end-products and services, including, for example, quality assurance guidelines and emergency warning procedures, in collaboration with aviation and other major application sectors;

(d) Encouraging the dialogue between the research and operational space weather communities;

(e) Organization of capacity-building, training and outreach activities towards WMO Members and Space Weather potential users;

(f) Provision of guidance to WMO Members and Programmes on Space Weather matters, and conduct appropriate actions as requested by CBS and CAeM;

(g) Oversee the development and review of OSCAR so that it meets the needs of WIGOS for information concerning user space weather observing system capabilities

Composition

IPT-SWeISS will be composed of members nominated by the relevant technical commissions, selected WMO Members and points of contacts nominated by the regional associations and associate members including representatives of ISES and other partners or major user applications.

IPT-SWeISS members shall cover the various fields of expertise necessary to address space weather matters within WMO and will contribute to the relevant expert teams or other groups of WMO technical commissions including: Commission for Basic Systems (CBS)[1]

[1] Such as the Inter-Programme Expert Teams on Observing System Design and Evolution (IPET-OSDE), on WIGOS Framework Implementation (IPET-WIFI), on Codes Maintenance (IPET-CM), on Data Representation Development (IPET-DD), or the Steering group on Radio-Frequency Coordination (SG-RFC).

Annex 4

IPT-SWeISS WORKING PLAN FOR 2017-19

(extracted from the four-year plan for WMO activities related to space weather 2016 – 2019)

3.1 Reviewing user requirements for space weather products and services, and priorities for coordinated responses
3.2 Developing best practices for products and services
3.3 Training and capacity-building, for new service providers and user uptake
3.4 Coordinating ground- and space-based space weather observations
3.5 Promoting and facilitating data management, standardization and exchange
3.6 Evaluating space weather analysis and forecasting methods, promoting transition of mature research models to operations and synergy with climate/weather modelling
3.7 Coordinating the actions and ensuring a science-based, authoritative communication on operational space weather related activities in the United Nations system and beyond

Tasks	Priority	Time frame	Deliverable	Cooperation with ISES
TT-SYS (Task Team on Space Weather Basic Systems)				
Update the space weather observation requirements and the Statement of Guidance for space weather observation as part of the WMO RRR process	First	2016/2017	Requirements in OSCAR and updated SOG	
List the key ground-based measurements to be performed on a routine operational basis, with required observation cycles	First	2017	Initial list and specification of measurements	
List the space weather observatories performing the required measurements above (analogue to Vol. A)	First	2017	List of observatories	
Develop observation metadata characterizing the measurements above	First	2017/2018	WIGOS metadata	
Update the assessment of space-based capabilities for space weather observation in OSCAR/space as a support to gap analysis	First	2017	OSCAR/Space update including gap analysis	

Dialogue with space agencies (including major agencies such as NASA, and international satellite coordination bodies such as CGMS) and relevant authorities, on actions needed to fill the gaps in space-based observation	First	2017	Gap analysis communicated to major stakeholders in space observation	
Prepare initial addition to the WIGOS Manual	First	2018	Draft update of WIGOS Manual	
Expand observing capabilities, communication infrastructure and procedures in order to fill the gaps in observation and improve data availability	Lower	>2019	Reduction of gaps	
Expand the lists of measurements and observatories	Lower	>2019	Updated lists	
Harmonize sensor specifications for energetic particle measurements and best practices for intercalibration and intercomparison of measurements	Lower	2018	Specification guidelines, Intercomparison procedures	
Agree on quality standards for ground-based space weather observations (existing standards, or new provisions for inclusion into CIMO Guide if relevant)	Lower	>2019	Observation quality standards	
Identify list of essential data and products to be considered for routine exchange on the WIS, characterize them with appropriate discovery metadata, register and make them available in the WIS (with IPET-MDRD)	First	2016/2017	Set of space weather data and products discoverable and globally available, in near real-time in WIS	
Register space weather service centres as Data Collection or Production Centre (DCPC) or National Centres (NC) in the	First	2016/2017	Additional space weather service centres designated as DCPC or NC	

WIS (with IPET-WISC)				
Investigate the applicability and advantages of new formats, including e.g. RINEX/GTEX, for exchange of space weather data and products	Lower	2017	Recommended format implementation	
Investigate the applicability and advantages of new protocols, such as the Common Alert Protocol (CAP)	Lower	2018	Recommended protocol	
TT-SCI (Task Team on Space Weather Science)				
Share lessons-learned in the usage of space weather models in daily forecasting activities	First	2017	Handbook for good practices in space weather forecasting	
Define skill scores and other verification techniques to assess the potential value of existing research models for user-oriented services	First	2018	Objective evaluation of existing models	
Workshops on space weather impacts on Essential Climate Variables	Lower	2017	Improved understanding of space weather– climate linkages	
Evaluate the benefit of whole atmosphere models (from the surface to the top of the thermosphere) used in conjunction with other space weather models	Lower	2018	Impact evaluation of whole atmosphere models	
Workshop on data-assimilation capabilities for Sun-Earth system models to improve forecast skill	Lower	2019	Guidelines for utilization of available data in numerical prediction models	
TT-APP (Task Team on Space Weather Applications)				
Establish real-time coordination and consultation mechanisms among warning centres for extreme events	First	2016/2017	Consultation procedure for extreme events	
Review the existing global and regional space weather event scales and	First	2017	Community agreed space weather event scales	

develop an international, community agreed, scale or set of scales to characterize the severity of space weather events with a view to facilitate emergency procedures and verification activities				
Collaborate with CGMS to review the procedure for recording spacecraft anomalies attributed to space environment, including the archiving and utilization of this data	Lower	2016/2017	Agreed procedure spacecraft anomaly data	
Develop best practices for space weather warning centres during extreme events, in collaboration with DRR programme	Lower	2018	Guide on extreme space weather events	
Develop best practices for space weather warning centres during extreme events, in collaboration with DRR programme	Lower	2018	Guide on extreme space weather events	
Analyse requirements for space weather services regarding radio-propagation in collaboration with ITU-R/SG-3 and ICG	Lower	2018	Statement to ITU-R/SG-3, roadmap for development of such services	
Select existing training material and make it available on line through the Space Weather Product Portal	First	2016/2017	Training material on the Space Weather Product Portal	
Identify target audiences, including NMHS meteorologists who wish to establish space weather service delivery within their organization, and training objectives	First	2017	Schedule of training programme to support NMHS interest	
Conduct training sessions in coordination with the VLab and partner organizations, provide tutorial tools.	First	2018	Completed training programme, feedback for training improvements	
Develop new educational material, in	Lower	>2019	Region-specific resources for	

different languages and with content structured for different regional needs			space weather service improvement	
Contribute to user information events to raise awareness of space weather impacts and of potential benefit of using space weather services	Lower	2018	Co-sponsored events	
ATT-AVI (Ad-hoc Task Team on Space Weather for Aviation)				
Support to WMO AeMP representation on the relevant ICAO working groups to review the feasibility of the draft requirements of ICAO for space weather services to aviation, and advise ICAO on the corresponding draft Standard And Recommended Practices (SARP)	First	2016	ICAO requirement analysis ICAO SARP review	
Support to WMO AeMP representation on the relevant ICAO working groups to define the role, number, and required capabilities of future global and regional centres for the provision of space weather services to aviation	First	2016/2017	Roles, capabilities and target number of space weather service centres for ICAO	
WMO Secretariat				
Keep COPUOS informed of the WMO plan for space weather and of the challenges requiring mobilization of effort beyond the WMO community	First	Annual	Reports	
Report at the annual space weather workshops organized in the USA, in Europe, and in Asia	First	Annual	Presentations, or panel sessions	
Identify cases demonstrating the benefit of space weather activities coordinated by WMO	First	2017 - 2019	Report on case studies	
Provide the WMO Congress (Cg-18) with a draft plan for space weather	First	2019	Draft plan	

activities beyond 2019 (e.g. within a Space Weather Watch programme)				
Coordinate with COSPAR on the interaction between this plan and the COSPAR roadmap implementation	Lower	Annual	Feedback	
Address regional implementation of space weather services at Regional Association meetings or associated Technical Conferences	Lower	RA meetings	Presentation at RA meeting or Technical Conference	

Annex 5

Actions for IPT-SWeISS-1

1. Actions from IPT-SWeISS-1

1.1. Actions to IPT-SWeISS members

Reference	Action content	Actionee	Due date	Status
AII.A01	WMO Secretariat (Toshiyuki KURINO) to confirm members' intentions for their contribution to TTs and provide draft list of membership to TT-SYS, TT-SCI, TT-APP, TT-AVI leaders	WMO	July 14, 2017	Open
AII.A02	TT-SYS, TT-SCI, TT-APP, TT-AVI leaders coordinate the list, and agree with the membership	TTs leaders	Jul. 31, 2017	Open
AII.A03	TT-SYS, TT-SCI, TT-APP to produce draft ToR and agree ToR in IPT-SWeISS members	TT-SYS, TT-SCI, TT-APP	Sep. 30, 2017	Open
AII.A04	IPT-SWeISS members agree with ToR for TT-AVI	IPT-SWeISS members	Jun. 23, 2017	Closed
AII.A05	IPT-SWeISS members to provide comprehensive details of technical and operational characteristics for Radio Frequency-based Space Weather Sensors to David Jackson	IPT-SWeISS members	Aug. 17, 2017	Open
AII.A06	IPT-SWeISS members to provide comments on draft "Statement of Guidance for Space Weather Observations" to Larisa Trichtchenko	IPT-SWeISS members	Sep. 01, 2017	Open
AII.A07	TT-SYS leader (Larisa Trichtchenko) finalize "Statement of Guidance for Space Weather Observations"	TT-SYS leader	Oct. 30, 2017	Open
AII.A08	IPT-SWeISS members to provide inputs to draft Vision for WIGOS in 2040	IPT-SWeISS members	Jul. 31, 2017	Open
AII.A09	IPT-SWeISS members to review and update the space based observation of Space Weather to be recorded in OSCAR/Space.	IPT-SWeISS members	periodicall y	Open
AII.A10	IPT-SWeISS members to nominate point of contact for participation in the newly established OSCAR/Space Science and Technical Advisory Team.	IPT-SWeISS members	Jul. 31, 2017	Closed IPT-SWeISS nominated Larisa Trichtchrnko

1.2. Actions to IPT-SWeISS Task Teams

Reference	Action content	Due date	Status
TT-SYS.A01	Update the space weather observation requirements - drafting template for ground base Space Weather observation to be included in OSCAR/Surface	2017	Open
TT-SYS.A02	Update the Statement of Guidance for space weather observation as part of the WMO RRR process	October 2017	Open
TT-SYS.A03	List the key ground-based measurements to be performed on a routine operational basis, with required observation cycles	2017	Open
TT-SYS.A04	List the space weather observatories performing the required measurements above (analogue to Vol. A)	2017	Open
TT-SYS.A05	Develop observation metadata characterizing the measurements above	2018	Open
TT-SYS.A06	Dialogue with space agencies (including major agencies such as NASA, and international satellite coordination bodies such as CGMS) and relevant authorities, on actions needed to fill the gaps in space-based observation	2017	Open
TT-SYS.A07	Prepare initial addition to the WIGOS Manual	2018	Open
TT-SYS.A08	Expand observing capabilities, communication infrastructure and procedures in order to fill the gaps in observation and improve data availability	>2019	Open
TT-SYS.A09	Expand the lists of measurements and observatories	>2019	Open
TT-SYS.A10	Harmonize sensor specifications for energetic particle measurements and best practices for intercalibration and intercomparison of measurements	2018	Open
TT-SYS.A11	Agree on quality standards for ground-based space weather observations (existing standards, or new provisions for inclusion into CIMO Guide if relevant)	>2019	Open
TT-SYS.A12	Provide information needed on radio spectrum-reliant sensor systems and operations in order to support work within the ITU-R to ensure radio frequency protection for space weather observations	2017-2019	Open
TT-SYS.A13	Identify list of essential data and products to be considered for routine exchange on the WIS, characterize them with appropriate discovery metadata, register and make them available in the WIS (with IPET-MDRD)	2017	Open
TT-SYS.A14	Encouragement to register space weather service centres as Data Collection or Production	2017-2019	Open

	Centre (DCPC) or National Centres (NC) in the WIS (with IPET-WISC)		
TT-SYS.A15	Investigate the applicability and advantages of new formats, including e.g. RINEX/GTEX, for exchange of space weather data and products	2017	Open
TT-SYS.A16	Investigate the applicability and advantages of new protocols, such as the Common Alert Protocol (CAP)	2018	Open
TT-SCI.A01	Share lessons-learned in the usage of space weather models in daily forecasting activities	2017	Open
TT-SCI.A02	Define skill scores and other verification techniques to assess the potential value of existing research models for user-oriented services	2018	Open
TT-SCI.A03	Workshops on space weather impacts on Essential Climate Variables	ESSW in 2018	Open
TT-SCI.A04	Evaluate the benefit of whole atmosphere models (from the surface to the top of the thermosphere) used in conjunction with other space weather models	Space Weather Workshop in April 2018	Open
TT-SCI.A05	Workshop on data-assimilation capabilities for Sun-Earth system models to improve forecast skill	2019	Open
TT-APP.A01	Establish real-time coordination and consultation mechanisms among warning centres for extreme events	2018	Open
TT-APP.A02	Review the existing global and regional space weather event scales and develop an international, community agreed, scale or set of scales to characterize the severity of space weather events with a view to facilitate emergency procedures and verification activities	2017-19	Open
TT-APP.A03	Collaborate with CGMS to review the procedure for recording spacecraft anomalies attributed to space environment, including the archiving and utilization of this data	2017-18	Open
TT-APP.A04	Develop best practices for space weather warning centres during extreme events, in collaboration with DRR programme	2017-19	Open
TT-APP.A05	Develop best practices for space weather warning centres during extreme events, in collaboration with DRR programme	2017-19	Open
TT-APP.A06	Analyse requirements for space weather services regarding radio-propagation in collaboration with ITU-R/SG-3 and ICG	2017-19	Open
TT-APP.A07	Select existing training material and make it available on line through the Space Weather Product Portal	2017-19	Open

TT-APP.A08	Identify target audiences, including NMHS meteorologists who wish to establish space weather service delivery within their organization, and training objectives	2017-18	Open
TT-APP.A09	Conduct training sessions in coordination with the VLab and partner organizations, provide tutorial tools.	2018-19	Open
TT-APP.A10	Develop new educational material, in different languages and with content structured for different regional needs	2018-19	Open
TT-APP.A11	Contribute to user information events to raise awareness of space weather impacts and of potential benefit of using space weather services	2018 (annual)	Open
TT-AVI.A01	Support to WMO AeMP representation on the relevant ICAO working groups to review the feasibility of the draft requirements of ICAO for space weather services to aviation, and advise ICAO on the corresponding draft Standard And Recommended Practices (SARP)	2016/2017	Closed
TT-AVI.A02	Support to WMO AeMP representation on the relevant ICAO working groups to define the role, number, and required capabilities of future global and regional centres for the provision of space weather services to aviation	2016/2017	Closed
TT-AVI.A03	Develop DRAFT audit procedures and reporting templates (in coordination with ET-CAC)	Aug. 2017	Open
TT-AVI.A04	Develop DRAFT working methodology and schedule for conducting audits	Aug. 2017	Open
TT-AVI.A05	Conduct (virtual) TT-AVI coordination sessions (in coordination with ET-CAC as necessary)	Aug. and Sept. 2017	Open
TT-AVI.A06	Develop FINAL audit procedures and reporting templates (in coordination with ET-CAC)	Sept. 2017	Open
TT-AVI.A07	Develop FINAL working methodology and schedule for conducting audits	Sept. 2017	Open
TT-AVI.A08	Conduct (pre-audit) SWXC capabilities review (based on information received through ICAO)	Sept. 2017	Open
TT-AVI.A09	Prepare SKELETON audit reports: 1) abridged (open) and 2) full (restricted)	Sept. 2017	Open
TT-AVI.A10	Collaborate (in person or virtual) with ET-CAC at their meeting in Darmstadt (18-20 Oct. 2017)	Oct. 2017	Open
TT-AVI.A11	Conduct on-site assessments and audits of prospective SWXC	Oct. 2017 to Feb. 2018	Open
TT-AVI.A12	Prepare DRAFT audit reports: 1) abridged (open) and 2) full (restricted)	Oct. 2017 to Feb. 2018	Open
TT-AVI.A13	Conduct (virtual) TT-AVI post-audit debriefs to share experiences and lessons learned	Oct. 2017 to Feb. 2018	Open
TT-AVI.A14	Prepare FINAL audit reports: 1) abridged (open) and 2) full (restricted)	Oct. 2017 to Feb. 2018	Open
TT-AVI.A15	Update working methodology and schedule, if necessary, taking into account post-audit	Oct. 2017 to Feb. 2018	Open

	debriefs and/or other developments		
TT-AVI.A16	Assist WMO report findings to ICAO	Feb. and Mar. 2018	Open
WMO.A01	Keep COPUOS informed of the WMO plan for space weather and of the challenges requiring mobilization of effort beyond the WMO community	2017-2019 (annual)	Open
WMO.A02	Report at the annual space weather workshops organized in the USA, in Europe, and in Asia	2017-2019 (annual)	Open
WMO.A03	Identify cases demonstrating the benefit of space weather activities coordinated by WMO	2017-2019	Open
WMO.A04	Provide the WMO Congress (Cg-18) with a draft plan for space weather activities beyond 2019 (e.g. within a Space Weather Watch programme)	2019	Open
WMO.A05	Coordinate with COSPAR on the interaction between this plan and the COSPAR roadmap implementation	2017-2019 (annual)	Open
WMO.A06	Address regional implementation of space weather services at Regional Association meetings or associated Technical Conferences	2019	Open

Annex 6

Inter-Programme Team on Space Weather Information Systems and Services (IPT-SWeISS)
Ad-hoc Task Team on Space Weather for Aviation (TT-AVI)
Terms of Reference (DRAFT)

Objective

The objective of the Task Team on Space Weather for Aviation (TT-AVI) shall be to facilitate the establishment and maintenance, by the International Civil Aviation Organization (ICAO) in coordination with the World Meteorological Organization (WMO), of an operational global space weather information service for international air navigation.

Activities

The activities of the TT-AVI shall include, as a minimum:

i) review of the aeronautical requirements for space weather information services, as defined in the Standards and Recommended Practices (SARPs) of ICAO Annex 3/WMO-No. 49, Technical Regulations, Volume II – *Meteorological Service for International Air Navigation,* to ensure a common understanding amongst team members;

ii) assistance to WMO in the conducting of site assessments and audits of prospective space weather information providers for aviation (by WMO at the request of ICAO), including associated audit procedures and schedule, and the consequential reporting of the WMO findings to ICAO;

iii) (if requested) advice to ICAO, through WMO, on the current and foreseen capabilities of prospective space weather information providers for aviation, including in the context of the optimal number of global and/or regional centres; and

iv) assistance to ICAO, through WMO, in the development of space weather-related guidance material and other capacity development/outreach necessary to support implementation.

Reporting

TT-AVI shall be an ad-hoc task team of the Inter-Programme Team on Space Weather Information Systems and Services (IPT-SWeISS) under the Commission for Basic Systems (CBS) and Commission for Aeronautical Meteorology (CAeM).

TT-AVI shall report to IPT-SWeISS on a routine basis through its designated rapporteur (see *Composition*).

IPT-SWeISS shall be responsible for determining the continued need for TT-AVI.

Coordination

The TT-AVI shall ensure necessary coordination with, as a minimum and as necessary:

- IPT-SWeISS and its other task teams;
- Expert teams of WMO technical commissions; and
- Working groups of the ICAO Meteorology Panel (METP.

Working methodology

TT-AVI shall establish and maintain a work programme, comprising deliverables with deadlines, to support the efficient and effective progress of work. The TT-AVI work programme shall be reviewed and, as necessary, updated by the task team at least annually.

TT-AVI shall work, to the greatest extent, through electronic correspondence and virtual meetings, thereby minimizing or preventing the need for physical meetings.

Composition

The TT-AVI shall comprise up to six (6) members of IPT-SWeISS. Where necessary, one or more advisor may assist each member of TT-AVI.

TT-AVI shall establish, from amongst its membership, a rapporteur responsible for reporting to IPT-SWeISS on a routine basis (see *Reporting*).

ICAO shall be an *ex-officio* member of TT-AVI.