CGMS

CGMS-35, WMO-WP-02
Prepared by WMO
Agenda Item: B.4
Discussed in Plenary

POTENTIAL WMO ACTIVITIES REGARDING SPACE WEATHER

WMO-WP-02 addresses the relevance of Space Weather observations for WMO activities and the potential role of WMO in that area. It underlines the critical importance of Space Weather events for CGMS satellites, the contribution of CGMS satellites to Space Weather observations, and the possible impact of Space Weather phenomena on climate variables and on a number of human activities.

Space Weather is not within the current mandate of WMO, but several WMO Members have suggested that WMO could support global cooperation in this area. Given the very limited resources that could be devoted to such a new activity within WMO, it would be focussed on some precise topics such as observation requirements, instrument information and data exchange.

CGMS satellite operators are invited to express their views on whether they would see a benefit in WMO involvement in Space Weather, its potential scope, as well as on the specific role of CGMS in this respect.

POTENTIAL WMO ACTIVITIES REGARDING SPACE WEATHER

1 INTRODUCTION

Space Weather encompasses the conditions and processes occurring in space, including on the sun, in the magnetosphere, ionosphere and thermosphere, which have the potential to affect the near-Earth environment. Space Weather processes can include changes in the interplanetary magnetic field, solar wind, coronal mass ejections from the Sun, and disturbances in the Earth's magnetic field.

Space Weather can affect the performance and reliability of space-borne and ground-based technological systems and can endanger human life or health. The effects of Space Weather can range from damage to satellites arising from charged particles to disruption of power grids on Earth during geomagnetic storms.

Space Weather monitoring, study and applications are more and more important with the increasing use of space technique in day-to-day life for telecommunications, observation and navigation, and further with the prospect of planetary exploration.

While anomalies from solar events are regularly on the agenda of CGMS meetings, and all CGMS Satellite Operators have a permanent action to report on this point, WMO does not present any requirement for this area, which is not within its mandate and current scope of activity.

However, in January 2007, the seventh Consultative Meeting on High-level Policy on Satellite Matters (CM-7) discussed the importance of Space Weather and noted that several space agencies were already involved in Space Weather in response to national mandates including energy, aviation and spacecrafts although there was not an identified intergovernmental body with responsibility for Space Weather. Thus, it "*requested the WMO Space Programme to consider the appropriate scope and breadth for Space Weather within the WMO Space Programme*". It further suggested appointing a consultant and establishing an ad-hoc group to elaborate recommendations on this particular matter. In May 2007, the Fifteenth WMO Congress (Cg-XV) " *encouraged the WMO SP to consider activities in the area of Space Weather, since it had a direct impact on meteorological satellite operations."*

2 RELEVANCE OF SPACE WEATHER OBSERVATIONS TO WMO

There are several aspects by which Space Weather can be relevant to WMO activities.

(a) Satellites contributing to the Global Observing System (GOS) are directly affected by Space Weather events such as:
- Differential charging and discharge, Single Event Upsets causing anomalies or damage to onboard computers and instrumentation;
- Total Dose aging effect on electronic hardware and on solar panel efficiency;
- Increased spacecraft drag requiring additional manoeuvres;
- Magnetic disturbances on orientation systems;
- Interference on communications.

(b) Climate variables can be affected by Space Weather, and namely:
- Total Solar Irradiance;
- Stratospheric heating;
- Ionization and ozone processes.

(c) Although Space Weather events are not meteorological phenomena, they are combining with meteorological/climate factors to affect human activities, health and life, namely:
- Aircraft navigation and safety is increasingly affected by Space Weather on polar routes;
- Telecommunications reliability is affected by atmosphere and Space Weather;
- Electric power distribution is affected by thunderstorms and geomagnetic storms;
- Space Weather has an impact on health for astronauts and airline crew and passengers;
- The possible impact of Space Weather on vegetation is being investigated.

(d) Meteorological observations and Space Weather observations do share some infrastructure:
- Space Weather information can be retrieved from Radio-Occultation sounders;
- Dedicated Space Weather in-situ sensors are regularly carried on meteorological satellites. (See Table below)

(e) Meteorological services can provide experience and support for Space Weather activities.
- Space Weather forecasting is still at a very early stage while atmospheric weather forecasting is a well established discipline; it has thus been suggested that Space Weather might benefit from the experience of atmospheric weather forecasting.
- Actually, in several WMO Members, including China, Denmark, Finland, Russian Federation, and the USA, Space Weather belongs to the mandate of the NMHSs.

In summary, while Space Weather is not directly within the mandate of WMO, there might be a benefit for WMO Members if WMO could support some coordination in this area, building on the experience, infrastructure, services and cooperation practices that have been implemented for WMO programmes. A parallel can be drawn e.g. with WMO's activity in support of tsunami warning, since tsunami are not meteorological events either, but WMO does play a valuable role in this respect thanks to its assets in terms of infrastructure, services and operational experience.

SPACE WEATHER INSTRUMENTS ON CURRENT/PLANNED GOS SATELLITES
(Not exhaustive)

Agency	Satellite	Sensor	Remark
NASA	UARS	PEM (AXIS)	X-Rays
NASA	UARS	PEM (HEPS)	High-energy particles
NASA	UARS	PEM (MEPS)	Low-energy particles
NASA	UARS	PEM (VMAG)	Magnetic field
Roshydromet	Meteor-3M	KGI-4C	High-energy electrons & protons
Roshydromet	Meteor-3M	MSGI-MKA	Low-energy electrons % protons
Roshydromet	Meteor-M	GGAK-M	Radiation and magnetic sensors
Roshydromet	Elektro-L	GGKAK-E (HMS)	Radiation and magnetic sensors
NOAA	POES	SEM (TED)	Total Energy Detector
NOAA	POES	SEM (MEPED)	Medium Energy Proton-Electron Detector
NOAA	GOES	SEM (Magnetometer)	Magnetometer
NOAA	GOES	SEM (EPS)	Energetic Particle Sensor
NOAA	GOES	SEM (HEPAD)	High-Energy Proton & Alpha Detector
NOAA	GOES	SEM (XRS)	X-Ray Sensor
NOAA	GOES	SXI	Solar X-ray Imager
NOAA	GOES	SEISS	Space Environment In-Situ Suite
NOAA	GOES	SUV	Solar UV Imager
NOAA	GOES	EXIS	Extreme UV and Irradiance Sensors
NOAA	NPOESS	SESS	Auroral characteristics, geomagnetic field, electron density profile, total electron content
NOAA	NPOESS	GPSOS	GPS Occultation Sensor
CMA	FY-1	SEM	High-energy protons, electrons, heavy particles
CMA	FY-2		Idem + solar X-ray monitor
CMA	FY-3		Idem + solar X-ray monitor
CMA	FY-4		Idem + solar X-ray imager
EUMETSAT	Metop	GRAS	GNSS Receiver Atmospheric Sounding

3 PRELIMINARY CONTACTS AND CURRENT ACTIVITIES OF WMO MEMBERS

3.1 Exploratory contacts with WMO Members

Given the heavily loaded work plan of the WMO SP Secretariat for 2007, it was not possible to organize a Task Force in first instance as recommended by CM-7. As a first step, the Secretariat took advantage of planned meetings to hold bilateral discussions with the three CM Members having the strongest interest and involvement in the matter: China, Russian Federation and the USA. A meeting was held with CMA in Beijing on 15 April and with ROSHYDROMET and ROSCOSMOS in Moscow on 25 April. A meeting is planned on 12 November with the Space Environment Centre of NOAA/National Weather Service in Boulder, Colorado.

In China, the National Center for Space Weather (NCSW) was established in 2002 and this new role was assigned to the National Satellite Meteorology Centre (NSMC) of the China Meteorological Administration (CMA). NCSW is exploiting data from a network of ground-based GPS receivers as well as from Space Weather sensors aboard current (FY-1D, FY-2C) meteorological satellite series. There are plans for additional ground-based measurements and new sensors aboard future (FY-3, FY-4)

satellite series. NCSW is issuing warnings as well as daily, weekly, monthly and yearly reports.

The Russian Federation has more than two decades of experience in observations and studies of Space Weather events. The Institute of Applied Geophysics (IAG) of the Russian Federal Service for Hydrometeorology and Environmental Monitoring (ROSHYDROMET) plays a central role as the National Space Weather forecast centre and as a European regional warning centre, with the support of a number of Institutes of the Russian Academy of Sciences, Universities and Agencies. Space Weather sensors are regularly flown aboard Russian meteorological satellites.

In the USA, the Space Environment Center (SEC) is the national warning centre for disturbances in the space environment that can affect people and equipment. Within the National Oceanic and Atmospheric Administration (NOAA), SEC, located in Boulder, Colorado, is one of the National Weather Service's (NWS) National Centers for Environmental Prediction (NCEP). SEC conducts research to understand the space environment, and performs critical Space Weather operations, jointly staffed by NOAA and the U.S. Air Force, to provide forecasts and warnings of solar and geomagnetic activity to users in government, industry, the private sector, and the public.

3.2 International cooperation on Space Weather

At the regional level, in Europe, a cooperation framework was set up from 2002 to 2007 under the aegis of the European Union and named “COST Action 724” in order to develop the basis for monitoring, modelling and predicting Space Weather. It involved 27 organizations from 23 different European countries with a strong participation of the European Space Agency.

At the global level, some coordination started in 1928 already with the initiation of regular forecasts of radio conditions by the International Union of Radio Science (URSI). Cooperation was enhanced during the International Geophysical Year in 1957-1958 with the establishment of a calendar of “world days“ for coordinated observations and with the setting up of a series of Regional Warning Centres (RWC) and a World Warning Agency. These initiatives were then combined and renamed in 1962 the International Space Environment Service (ISES).

ISES is now one of the permanent services of the International Council of Scientific Unions (ICSU) with affiliation to URSI, the International Union for Geodesy and Geophysics (IUGG), and the International Astronomical Union (IAU). ISES presently involves 12 RWCs located in Australia, Belgium, Canada, China, Czech Republic, France, India, Japan, Poland, Russian Federation, Sweden, the United States of America and is considering new RWCs in South Africa and Brazil. The SEC in Boulder plays a special role as "World Warning Agency", acting as a hub for data exchange and forecasts.

At present, Space Weather is not addressed by any United Nations’ organization. The main coordinating body seems to be the ISES mentioned above, which works in relation with IAU, ICSU, IUGG and URSI. On 15 June 2007, the President and the Secretary-General of WMO received a letter from ISES which expressed a clear wish to cooperate with WMO and to assist WMO in defining an activity in the area of

Space Weather. This letter suggests that Space Weather activities could benefit from enhanced operational and scientific international cooperation through WMO and that such a WMO involvement could be defined in consultation with the relevant organizations.

4 POTENTIAL ROLE OF WMO ON SPACE WEATHER

WMO is considering the possibility of an activity in the area of Space Weather if it responds to an identified need, falls within WMO's capabilities, and benefits WMO Members without duplicating any existing activity. Preliminary contacts with CMA, Roshydromet and NOAA encouraged further investigation. The recent letter from the International Space Environment Service (ISES) to the President and Secretary-General of WMO also invited WMO to explore the issue.

The Expert Team on Satellite Systems (ET-SAT) acknowledged that Space Weather phenomena had a considerable impact on spacecraft and discussed the relevance and feasibility of an involvement of WMO in that area. It was acknowledged that Space Weather was a complex matter which deals with a very wide range of astronomical and magnetic phenomena that meteorologists are not familiar with. Moreover, it did not lie within the mandate of WMO, although for many WMO Members it is part of their mandate as a NMHS. This suggests that the potential role of WMO could be a support role rather than a leading role.

Given the uncertainty about the level of resources available within WMO to support such activity, ET-SAT suggested that a potential involvement of WMO should be focused on particular aspects such as:

- Harmonizing the specifications of Space Weather instruments aboard GOS satellites;
- Harmonizing data and products to ensure that they are comparable;
- Facilitating data exchange e.g. through the WIS;
- Supporting exchange of experience between the NWP and the Space Weather communities.

This should be refined in coordination with ISES and other relevant organizations, such as IAU, ICSU, IUGG and URSI, in order to best capture the expectations of the Space Weather community.

5 CONCLUSIONS

CGMS satellite operators are invited to express their views on the possible initiation of a WMO activity in the area of Space Weather, considering in particular the potential benefit of enhancing the existing international arrangements to support technical cooperation, and taking into account the specific role of CGMS in this respect.