



ICAO

IMPLEMENTATION OF ANNEX 3 SPACE WEATHER REQUIREMENTS IN THE AFI REGION

Frequently Asked Questions (FAQs)

First Edition

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FREQUENTLY ASKED QUESTIONS (FAQs) ON SPACE WEATHER	
PART A: INTRODUCTION TO SPACE WEATHER	
1.	<p>Q: What does the term "Space Weather" refer to?</p> <p>A: All conditions and events on the Sun, in the solar wind, in near-Earth space and in our upper atmosphere</p>
2.	<p>Q: In what format should the space weather advisory information be disseminated?</p> <p>A: IWXXM GML format</p>
3.	<p>Q: What are some of the risks or effects of space weather?</p> <p>A: - Damage to long-distance natural gas and oil pipelines - Interruption of radio communications on earth and in space - Radiation exposure for astronauts and passengers on high altitude aircrafts - Impacts on Navigation Applications and Systems</p>
4.	<p>Q: How long does a coronal mass ejection (CME) take from the Sun to reach the Earth?</p> <p>A: Between 1-4 days</p>
5.	<p>Q: What affects radio propagation by absorbing the radio waves?</p> <p>A: X-ray bursts</p>
6.	<p>Q: Aurora occurs at:</p> <p>A: High-latitudes frequently and mid-latitudes infrequently</p>
7.	<p>Q: Which space weather conditions mostly affect HF communication to and from aircrafts?</p> <p>A: X-ray flares</p>
8.	<p>Q: What are the most important space weather effects?</p> <p>A: - Communication damage (HF and Satellite) - Navigation failures - Satellite damage - Space radiation to space/air travel</p>
9.	<p>Q: By when should the States be required to implement the Annex 3 amendment relating to space weather?</p> <p>A: By November 2022</p>
PART B: THE SCIENCE OF SPACE WEATHER	
1.	<p>Q: Are there any space weather incidents that can be referenced?</p> <p>A: An example of such a space weather impact is the large geomagnetic storm of October 2003, when it was reported that the vertical navigation guidance from the US Wide Area Augmentation System (WAAS) was unavailable for approximately 30 hours. Solar radio bursts can also affect the availability of WAAS, for example, the largest recorded burst in December 2006 caused a loss of vertical guidance for 15 minutes.</p>

	<p>The UK Royal Academy of Engineering report estimated that during a solar superstorm the avionic risk could increase by as much as 1 200 times compared to the background risk level.</p>
2.	<p>Q: Who used to provide Space Weather to aviation in the past? MET Service providers or other institutions?</p> <p>A: Space Weather has only recently been identified as a risk to aviation, and regulations on how to access the information put in place by ICAO. Space Weather Centres have therefore been the go to place for space weather information, however, now a designated centre is required to be used.</p>
3.	<p>Q: Is there a link between weather phenomena in the lower troposphere and space weather, for example between thunderstorms and solar winds?</p> <p>A: No. Space weather and terrestrial weather are produced by entirely different mechanisms.</p>
4.	<p>Q: You used images from 2013 and 2004 in your presentation. Can you show us images of recent space weather events?</p> <p>A: We are emerging from the quiet phase of solar activity right now. The last real storms were in 2017. Events from 2017 will not look significantly different than 2013.</p>
5.	<p>Q: Space weather Prediction and forecasting are some of the activities of SANSA. What is the difference between the two?</p> <p>A: Forecasting is a subset of the science of prediction. A prediction of unseen data might use any means to provide the prediction. A forecast uses analysis of time series data to make a prediction.</p>
6.	<p>Q: The solar event that occurred in October, affected South Africa and the Indian ocean but did not affect much the northern hemisphere. Could you please explain why?</p> <p>A: October is autumn in the northern hemisphere, and spring in the southern hemisphere. The sub-solar point in October is in the south, so solar events will tend to be stronger in the southern hemisphere. Time of day is also a factor in the location of a radio blackout.</p>
7.	<p>Q: Does a solar flare affect the whole atmosphere or just a part of it?</p> <p>A: The radio blackout caused by a solar flare affects the upper atmosphere, which impacts the transmission of radio waves.</p>
8.	<p>Q: During the implementation phase, will space weather messages be developed and broadcast by dedicated centres or will all States be broadcasting the same messages?</p> <p>A: During implementation, space weather messages will be developed and broadcast by designated centres. Only designated centres can broadcast messages. The messages have been designed and coordination is such that the message should be consistent and deliver the same information irrespective of which centre issued the message.</p>
9.	<p>Q: Does SANSA forecast and predict for the entire region including East Africa?</p> <p>A: There are instrument monitors available in some parts of the African Region. SANSA is</p>

	<p>open to collaborating with as many African States as possible to ensure denser coverage for our space weather monitoring purpose. SANSa has implemented an African Instrumentation Network project in order to expand instruments on the continent to allow for more operational predictions as well as an expansion of modelling capability. So, yes it is intended that East Africa will be covered.</p>
10.	<p>Q: What does the 11 years solar circle of the sun really mean, does it mean that there is a specific period in the circle where the sun's activities increase and decrease? What is the typical fluctuations in activities during the given 11 year circle?</p> <p>A: During the 11-year solar cycle, there is a time when the Sun is more active, that is more active regions on the Sun. And there is a time when the Sun is less active, little to no active regions on the Sun at all. The cycle goes from minimum to maximum and back to minimum again to complete a cycle. During solar maximum, we can have as many as 250 sunspot number also known as active regions. Then, we have higher probabilities of observing solar flares. During solar minimum, we can spend more than 2 months without observing any solar flares, that is zero sunspot numbers.</p>
11.	<p>Q: What are the consequences of a solar flare on air traffic? Does this phenomenon disrupt/affect air traffic?</p> <p>A: A loss of HF communication due to a radio blackout will have the greatest effect on air traffic as well as on the sunlit side of Earth. High latitude flights may need to be diverted in order to remain in communication with the ground. All flights will need to adjust communication plans and schedules to accommodate the impact on HF communication.</p>
12.	<p>Q: Why do we speak of aurora borealis instead of another name such as aurora equatorial?</p> <p>A: Aurora are caused by high energy particles trapped in the Earth's magnetosphere from the North and South poles. These energetic particles interact with the atmosphere at high latitudes where the magnetic field lines are open to space. Aurora do not occur at low latitudes because of the shielding of the Earth's magnetic field.</p>
13.	<p>Q: Do States directly disseminate the space weather advisory messages received from SWXCs like SANSa or do they prepare their own messages based on information received from SWXC just like we prepare SIGMET when we receive information like Volcanic Ash/Tropical Cyclone?</p> <p>A: The idea is that States will be able to directly disseminate the space weather advisory messages received from SWXCs, however, we are open to assisting States to disseminate in the most efficient way possible.</p>
14.	<p>Q: Is there a centre responsible for broadcasting solar flare messages for an area?</p> <p>A: For the AFI Region, the South African National Space Agency has been designated as the Regional Space Weather Centre to provide space weather information when there are solar flares that may affect activities, technologies, or even humans. Other Regions also have their own designated Space Weather Centres.</p>
15.	<p>Q: Is there a relationship between the sun's rotation speed and the frequency and intensity of solar eruptions?</p> <p>A: No, the rotation speed of the Sun does not vary with solar activity.</p>

16.	<p>Q: Does the SANSa Regional Space Weather Centre have all the technical means to monitor and identify the impacts of solar anomalies on air navigation in the whole AFI Region (on GNSS or HF, SATCOM)?</p> <p>A: Yes, SANSa has the technical means and expertise to provide space weather information in the GNSS and HF domains. In addition, SANSa is continually expanding and improving its capabilities to ensure that we keep up to date with what is required for aviation. SATCOM impacts are currently on hold due to a lack of scientific information, however, when ICAO gives the go ahead SANSa will then investigate these impacts as well. SANSa has committed to be ready by Nov 2022 to provide the required information needed for aviation over the AFI region and we are well on the way to have everything in place.</p>
17.	<p>Q: In terms of monitoring these studies, can a satellite provide reliable information in relation to a device that is submerged taking into account its spatial position?</p> <p>A: An instrument on the ground cannot measure x-rays because the atmosphere absorbs them. A coronagraph on the ground cannot measure CMEs due to scattered light in the atmosphere.</p>
18.	<p>Q: Can you summarise what exactly happens during the 11-year solar cycle? What are the frequencies and statistics if possible, on solar flares?</p> <p>A: Magnetic structures emerge on the surface of the Sun. At the beginning of the solar cycle, these active regions appear at mid-latitudes. Each active region persists for a few months before diffusing. As the solar cycle progresses, more regions appear closer to the equator. The time between one solar minimum and another is eleven years on average. An extreme radio blackout R5 might happen once per decade. An R4 blackout might happen once per year. A summary of the statistics is available here: https://www.swpc.noaa.gov/noaa-scales-explanation</p>
19.	<p>Q: What are the main laws that Govern the motions of solar flares after their emission?</p> <p>A: The motion of CMEs and photons are the normal laws of plasma physics. We know a lot about magnetic fields and particle motion.</p>
20.	<p>Q: Can global warming on earth be explained by solar flares?</p> <p>A: No. Although the change at Xray and extreme ultraviolet wavelengths during a flare is large (factor of thousands), a flare is a short term event. The total energy in these short wavelengths is a tiny fraction of the light we get from the Sun. 99% of the solar irradiance is in the visible and infra-red ranges, and they are extremely stable. The total solar irradiance changes by about 0.1% over the solar cycle, and any changes over longer time scales are so small that they are difficult to detect at all. Climate change has skyrocketed in the last few decades while the output of the Sun has remained constant.</p>
21.	<p>Q: Is there any known relation between the solar activities and global warming?</p> <p>A: There is probably very little relation between changes on the Sun and changes in climate. Over the last 100 years, the Sun has changed by less than 1%, but the concentration of CO₂ in the atmosphere has gone up by 100%.</p>

22.	<p>Q: What promotes solar flares and what are its consequences on the earth and in space weather. What mechanisms are available to predict it?</p> <p>A: The Sun’s 11-year activity cycle has quiet periods and more active times. During the active part of the cycle, there are many more active regions on the Sun and the chances of flares are much higher. As was shown in Dr. Mpho’s overview, eruptions on the Sun can damage satellites, change the properties of the upper atmosphere (causing disruption in communication), induce electric currents in the ground (causing failures of the power grid), and many more. It is difficult to predict flares in advance. We can observe active regions and some configurations are more likely to erupt. Space Weather forecasters undergo long periods of training and compile information from many sources to make their forecasts.</p>
23.	<p>Q: What motivated ICAO to choose South Africa to host a space weather centre? Is its geographical position near the South Pole?</p> <p>A: South Africa applied to be a candidate State due to its extensive existing capability in space weather operations, and space weather research. South Africa participated in an extensive audit that was requested by ICAO and implemented by WMO. This audit required a demonstration of capability, infrastructure and unique positioning against set guidelines provided by ICAO. South Africa passed this audit and was then designated as a regional centre to serve Africa.</p>
24.	<p>Q: If we are in the corona, what are the effects of solar flares on aircraft and electronic communication systems?</p> <p>A: The Earth is far away from the solar corona. Solar flares can change the ionization state of the ionosphere, changing the radio propagation pathways. HF communication between aircraft and the ground are disrupted by solar flares.</p>
25.	<p>Q: The practical impacts to communication and radar in the ATC context are very well appreciated operationally. Is there any noted impact of space weather to time synchronisation since ATC systems are synchronized with GPS clock systems? Aircraft estimates, separations would be impacted and therefore safety.</p> <p>A: Time synchronization should not be an issue in the ATC context.</p>
<p>PART C: ICAO ANNEX 3 SPACE WEATHER REQUIREMENTS</p>	
1.	<p>Q: Can you please enlighten us on the date of November 2022 for the implementation of Annex 3 requirements on space weather? There is a confusion at my level regarding the dates.</p> <p>A: The current date for implementation of the requirements on space weather information is 7 November 2022. This date may be reviewed by the ICAO council depending on other factors, such as the impact of COVID-19 on the aviation sector. However, South Africa has been told to aim for this November 2022 date.</p>
2.	<p>Q: What is the TTAAii of space weather advisory messages?</p> <p>A: TBC</p>
3.	<p>Q: Apart from the five space weather centres, can more States be allowed to set new centres?</p>

	<p>A: The decision on designated States, and additional States will be with the ICAO Council. However, other African States that would like to be involved in Space Weather Information provision could collaborate with South Africa.</p>
4.	<p>Q: I have a concern about the responsibilities of Annex 3, Chapter 3, Section 3.8 on space weather. Since the requirements of Chapter 3.8 concern global and regional centres, in the process of transposing the Annex into national regulations, is it a requirement for States that are not regional centres to consider this chapter?</p> <p>A:TBC</p>
5.	<p>Q: HF is a family of frequencies where in AFI we have Johannesburg, Nairobi and Brazzaville as the coordinators of the frequencies. Even though HF is long range but it has limitations- reason why the 3 points were made as boosters for each other. Why was South Africa made the sole HF monitor? I think we should follow the existing ICAO family frequency charts to be effective.</p> <p>A: South Africa is monitoring the impacts of Space Weather on HF Communication, which is different from the work of the coordinators of these frequencies. SANSA would like to work with the coordinators of HF frequencies for the aviation sector as Space Weather is a significant concern. SANSA can provide the impacts on HF that would require a change in communications planning. So, we believe that SANSA can aid and assist and collaborate with these centres.</p>
6.	<p>Q: Since space weather is not related to earth weather, is there a separation?</p> <p>A: Space weather events are more likely during the active phase of the solar cycle. The solar cycle lasts about 11 years. Terrestrial weather is primarily governed by the annual cycle of the Earth's orbit.</p>
7.	<p>Q: In the implementation of space meteorology according to Annex 3, what could be the impact of space weather requirements on the workload of weather forecasters and watchmen?</p> <p>A: We are planning and coordinating to ensure that the impact on the workload of weather forecasters is a minimum. The forecasting of space weather will be done at SANSA by Space Weather Forecasters and the information disseminated in an easy to integrate format that will be discussed and prepared in coordination with our Met colleagues.</p>
8.	<p>Q: How will SANSA be connected to the MET Services in order to provide information on space weather to the pilots? Will the information be available in the GTS?</p> <p>A: This is still a work in progress however SANSA is working with the South African Weather Services (SAWS) to ensure that existing dissemination protocols are utilised to avoid duplication and to make the receipt of information easy for the pilots.</p>
9.	<p>Q: Will SANSA charge for the provision of Space Weather to the air operators? If yes, how will it be done, considering that MET Services already charges air operators for the service provision?</p> <p>A: Yes, there will be a charge which will be based on cost recovery. The principles behind the cost will be governed by ICAO who are currently developing a cost recovery model for space weather information. There will be 2 tiers of charges – the 1st will be a minimum tier governed by ICAO for the compliance with Annex 3, and the 2nd will be for</p>

	<p>added value services such as training and additional information. The mechanisms are being worked out with due consideration to current charges and to ensuring consistency between centres.</p>
10.	<p>Q: Will the collaboration with SANSA in the implementation of space weather lead to capacity building for the other associated African centres or the Centres themselves at the level of their respective Contracting States?</p> <p>A: Yes, SANSA is keen to be involved in capacity building initiatives throughout Africa.</p>
11.	<p>Q: What's will be the role of national space weather centers in the flow of advisories from SANSA?</p> <p>A: This will depend on the national centers' capabilities and resources. There will be opportunities for other centers to host equipment and be data providers as well as to collaborate in the research and model improvements. SANSA is willing to collaborate with other centers.</p>
12.	<p>Q: What is the responsibility of the Regional OPMET Databanks (RODBs) Pretoria and Dakar in complying to the Annex 3 requirements on space weather?</p> <p>A: They will be involved in the disseminating of the space weather advisories.</p>
13.	<p>Q: What was ICAO's rationale for creating more global centres as compared to regional space weather centres? How will this arrangement work in the context of SANSA and Africa as whole?</p> <p>A: ICAO's original intention was for only 2 Global Centres and 4 Regional Centres. However the ICAO Council changed this decision at the time of designation. South Africa is still designated as a Regional Centre and as such we will represent Africa in the context of Space Weather Information provision. The role of Regional Centres is currently being discussed within ICAO, and we expect that there will be more clarification on this in the near future.</p>
14.	<p>Q: We often receive TEST SWX advisories from different SWXCs on our AFTN platform and we respond by an acknowledgment of receipt. Is there a standard format that we should follow?</p> <p>A: An acknowledgment of receipt is all that is required for now. SANSA can assist if interpretation or implementation is required.</p>
15.	<p>Q: Will SANSA implement the 24/7 SPWX products and services to AFI region by November 2022 given the acute ground station networks in the AFI region?</p> <p>A: Yes, SANSA plans to implement the 24/7 SWX products and services to the AFI region by November 2022. Within the next year we will roll out more ground stations to increase the network of operational data, and we will commission new products. The forecasting will be done with a mixture of ground and space based data, models, and expertise.</p>
16.	<p>Q: Does the SANSA centre work like the Volcanic Ash Advisory Centre (VAAC) in Toulouse? If yes, will the ASECNA CVMs be the only centres to relay this information?</p> <p>A: No, although space weather information provision is modelled somewhat on that of the VAAC, SANSA operates somewhat differently. It is anticipated that the information will be disseminated via the RODBs and not the CVMs.</p>
17.	<p>Q: Regarding the Total Electron Content (TEC), please provide more details about this parameter and its impact on communication systems.</p>

	<p>A: The TEC parameter is important for the monitoring of communication and navigation systems as it tells us by how much the atmosphere has been impacted by space weather. This in turn allows us to estimate the level of inaccuracy that can be expected in the applications. The product we use is called a TEC Map which allows us to see the characteristics across an entire region. We then compare this to normal conditions and together with other parameters can then provide impact information.</p>
18.	<p>Q: With regards to monitoring and measuring radiation exposure on the flight path, is it possible to have a measuring equipment that can be fitted on aircraft to measure the phenomena during the flight? (e.g. something like AMDAR data collection)?</p> <p>A: Yes, it is possible, and having this equipment does assist us as it provides in-situ data that is extremely valuable. However, it is not a requirement to have measuring equipment on the aircraft.</p>
19.	<p>Q: Will ICAO involve aircraft operators in issuing and sending AIRS when pilots encounter space weather phenomena?</p> <p>A: We believe that this is the intention.</p>
20.	<p>Q: Will information on space weather will be included on en-route MET flight documentation that States obtain from SADIS for States that use SADIS FTP?</p> <p>A: This has not been discussed yet, however, we believe that this is possible.</p>
21.	<p>Q: What is the course of action for a CVM or CMP that has received a notice from a SWXC?</p> <p>A: The course of action will depend on the information contained in the notice, and the impacted domain. Regulations will need to be devised to provide a course of action depending on the notice. It is recommended that training be given in this regard.</p>
22.	<p>Q: On the AFTN/AMHS link, introduction of space weather requirements will significantly change the procedures and therefore will there be training to ensure the quality of data exchange?</p> <p>A: Yes, the intention is for SANSa to develop training material in collaboration with aviation training schools on space weather information, interpretation and requirements. In fact, SANSa is already certified as an aviation training school by the South African Civil Aviation Authority (SACAA) and already provides some training courses in magnetic technology.</p>