



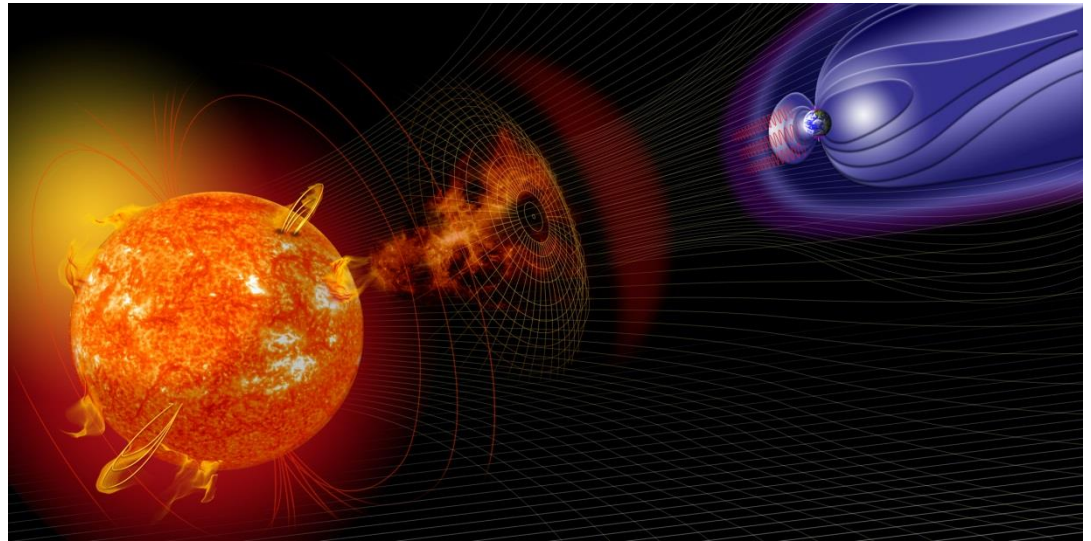
OPERATIONAL SPACE WEATHER PRACTICES AS A SERVICE TO SOCIETY IN SOUTH AFRICA

*Rendani Nndanganeni , Mpho Tshisaphungo , Lee-Anne McKinnell and Tshimangadzo Matamba
South African National Space Agency (SANSa)*

WHAT IS SPACE WEATHER?

Space Weather refers to **conditions on the Sun** and in the solar wind, magnetosphere, ionosphere, and thermosphere that can **influence the performance and reliability** of space-borne and ground-based **technological systems**.

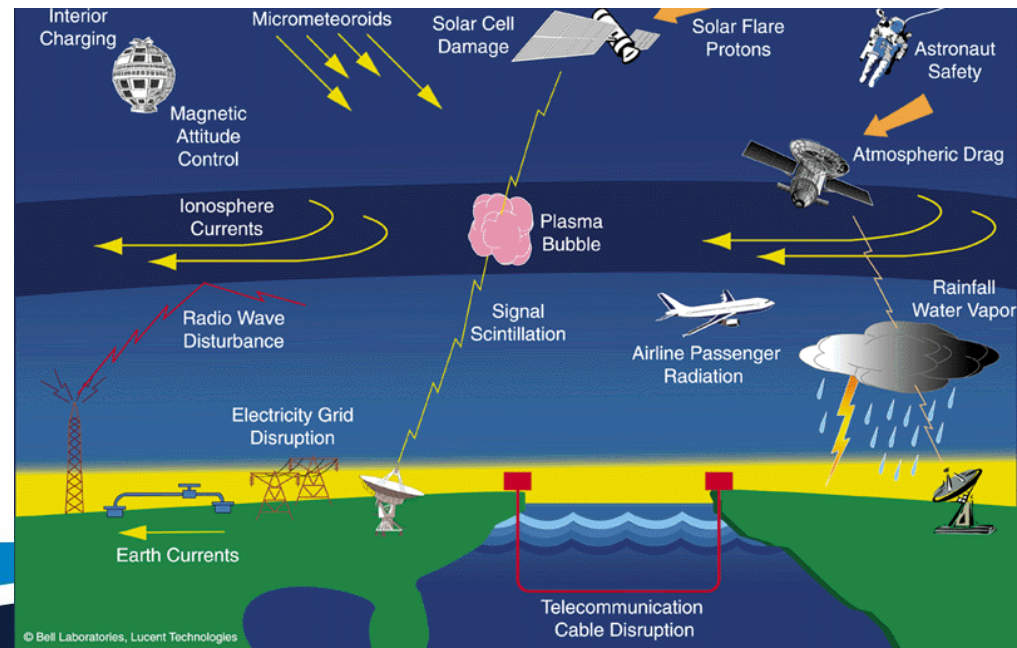
Space weather is a consequence of the behaviour of the sun, the nature of Earth's magnetic field and atmosphere, and our location in the solar system.

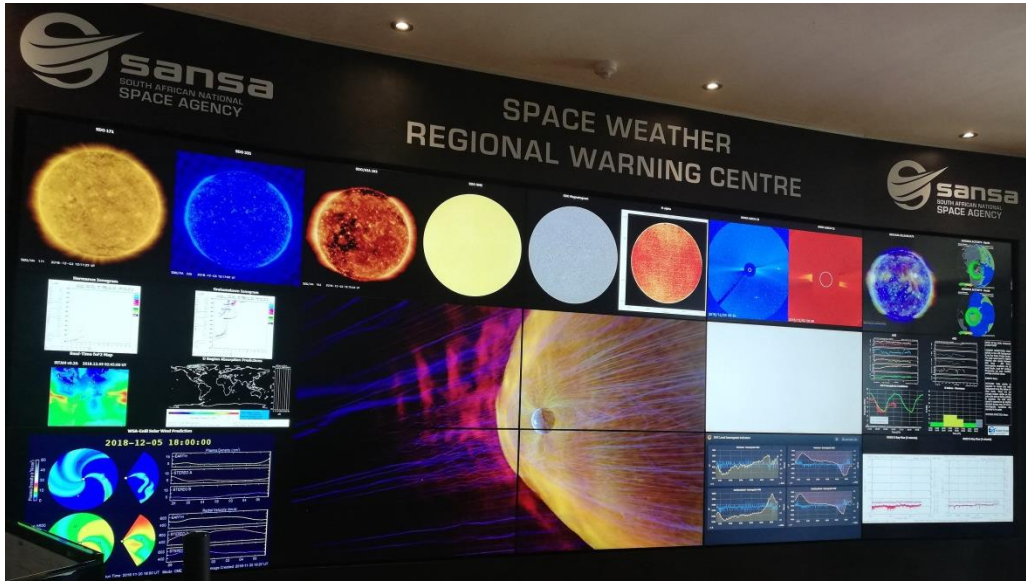


WHY IS SPACE WEATHER IMPORTANT?

- Technology continues to play an ever-increasing role in our society and the potential for space weather to impact our daily lives is also growing.
- Technological infrastructure, including the power grid, GPS and satellites used for communication and navigation, are vulnerable to space weather effects caused by the Sun's variability.

Space weather awareness is on the rise nationally and globally.



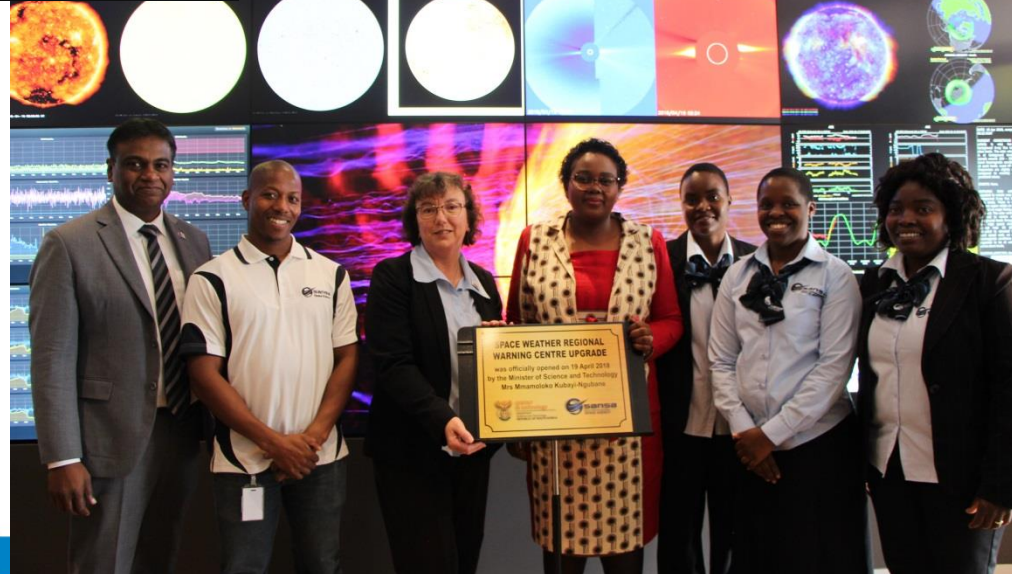


Space Weather Centre
launched in December
2010

Re-launched after
upgrade in April 2018

*SANSA – South African National
Space Agency is the implementing
agency for space related activities
in South Africa*

*Space Weather falls under the
Space Science Programme of
SANSA*



SPACE WEATHER CENTER ACTIVITIES

SW Forecast
HF predictions
Warning/Alert
Bulletins

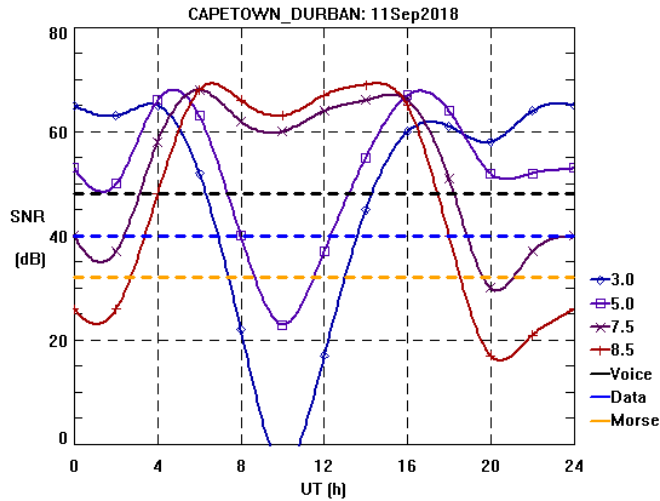
Space weather
research
Model
developments

Expansion
and usage of
data network

Weekly tours
Information days
Training

- Provide forecasts, alerts and warnings to government, defence and the public
- Delivery of training courses to users
- Provision of space weather information
- Provision of applicable tools to assist users
- Building capacity through internships, bursaries etc
- Developing additional products/services in collaboration with research group
- Global partnerships to enhance space weather access (ISES)
- Past focus has been on HF Communication impacts

HF frequency predictions



Space Weather Website

Daily Space Weather
bulletins

Space Weather Warnings

From: SANSa Space Weather Centre
To: Mpho Tshisaphungo
From: SANSa Space Weather Centre
To: Mpho Tshisaphungo
Cc:

Space Weather Bulletin

11 Sept 2018, composed at 08:38 SAST

WARNING/ALERT;

Active geomagnetic storm is in progress with maximum Hermanus K index of 4 observed. This is due to coronal hole high speed stream. A possibility of unstable HF communication is expected during the cause of today. Geomagnetic conditions are expected to return to normal conditions by tomorrow, 12 September.

SYSTEMS THAT MAY BE AFFECTED;

HF Communications.

Prepared by M. Tshisaphungo

Space Weather Monitoring Products & Services



Space Weather Monitoring Products & Services

Constant Monitoring of Space Weather

24/7 On-call System

Alert and Warning System

Interpretation of data to obtain useful
information

Space Weather Training and needs
analysis

CHANNELS FOR DISTRIBUTION OF SPACE WEATHER INFORMATION

- Website: <http://spaceweather.sansa.org.za>
- Bulletins
- Warnings
- Predictions
- Media

VIA

Emails, sms

Website posting

Press releases



The screenshot shows the SANSa website interface. At the top right is the SANSa logo. Below it is a navigation menu with links for Home, Products and Services, Space Weather Information, Contact Us, and Clients. The main content area features a welcome message and a paragraph describing the agency's role as a regional warning center. To the right, there is a 'Current Conditions' section with a table of data for 2014-04-06 06:33:00 UT. Below that is a 'Space Weather Bulletin' section with a date and a summary of solar activity. At the bottom right, there is a 'Twitter' section. A large image of Earth from space is visible in the lower-left portion of the screenshot.

sansa
SOUTH AFRICAN NATIONAL
SPACE AGENCY

Home Products and Services Space Weather Information Contact Us Clients

Welcome to Space Weather at SANSa

SANSa Space Science is host to the only Space Weather Regional Warning Centre in Africa which operates as part of the International Space Environment Service (ISES). The Space Weather Centre provides an important service to the nation by monitoring the sun and its activity to provide information, early warnings and forecasts on space weather conditions. The space weather products and services are required primarily for communication and navigation systems, in the defence, aeronautics, navigation and communication sectors.

Current Conditions	
2014-04-06 06:33:00 UT	
Sunspot number:	172
Solar wind speed:	401.0 km/s
IMF Bz:	4.3 nT
Dst Index:	-1 nT
Hermanus K-index:	0

Space Weather Bulletin

04 April 2014
Several C-class X-ray solar flares have been detected during the past 24 hours. Solar activity is moderate with background X-ray flux at upper B-class levels. Geomagnetic conditions are at unsettled levels. Local HF working frequencies are highly elevated compared to monthly average predicted values.

Twitter



SECTORS

Defence (safety and security)

Energy (protection of assets)

Aviation (safety of life)

Maritime (oceans protection)



- Operational requirements
- Legislative requirements Dependencies
- User needs
- Training and knowledge sharing
- Awareness (public, decision-makers, leaders, operators)

Space Weather Impacts on Aviation

SANSA Policy Brief

April 2016



Executive Summary

This policy brief addresses the need to raise awareness of the impacts caused by space weather on the aviation sector. The main recommendation put forward is that South Africa should align itself with international standards for the provision and access to space weather information in order to meet the International Civil Aviation Organisation (ICAO) recommendations by 2017, and to protect the vulnerable areas within the aviation sector. An additional seven recommendations are included which would assist South Africa in developing capabilities, strategies and action plans around space weather and its impact on the aviation sector in South Africa.

Space weather refers to the conditions in space; on the Sun and in the solar wind, magnetosphere, ionosphere, and thermosphere that can influence the performance and reliability of space-borne and ground-based technological systems. Continuous monitoring of the space environment allows for early warning, forecasting and prediction of space weather events that could lead to technological and infrastructure failure. Due to the increasingly interconnected and interdependent technological systems of modern society space weather can negatively impact numerous sectors, leading to a cascade of operational failures. Research has shown that the defence, communications, navigation, aviation, and energy sectors are most vulnerable to space weather effects. The South African National Space Agency (SANSA) operates the Space Weather Regional Warning Centre for Africa, under the International Space Environment Service (ISES), which aims to coordinate global space weather activities. The SANSA Space Weather Centre was established in 2010 with the mandate to (i) develop space weather capabilities within South Africa, (ii) improve the understanding and awareness of space weather within Africa, and (iii) provide a space weather operational service to government, industry and the public. It is important to note that space weather is a global phenomenon with regional impact.

Ground based support and aircraft are vulnerable to space weather impacts, primarily in four key areas: communication, navigation, aircraft avionics and radiation exposure. ICAO has recognised the need for the adoption of procedures related to mitigating space weather impacts. During the 2014 Montreal Meeting of the ICAO Meteorology Division a recommendation was passed for




Economic Impact of Space Weather

SANSA Policy Brief

April 2017




Executive Summary

This policy brief addresses the need to raise awareness of the economic impacts that can arise from space weather events and the national risk that space weather presents to South Africa. The main recommendation put forward is that South Africa should identify extreme space weather events as a potential risk to the economy and critical infrastructure, and therefore appropriate recognition, understanding and capability development is required in order to ensure adequate preparedness. Nine recommendations are included which would assist South Africa in developing capabilities, strategies, action and mitigation plans in order to manage the national risk presented by the space environment.

Due to the increasingly interconnected and interdependent technological systems of modern society space weather can negatively impact numerous sectors, leading to a cascade of operational failures. Research has shown that the defence, communications, navigation, aviation, and energy sectors are most vulnerable to space weather effects. Research has also shown that space weather is a global phenomenon with regional impact. The South African National Space Agency (SANSA) operates the Space Weather Regional Warning Centre for Africa, under the International Space Environment Service (ISES), which aims to coordinate global space weather activities. The SANSA Space Weather Centre was established in 2010 with the mandate to (i) develop space weather capabilities within South Africa, (ii) improve the understanding and awareness of space weather within Africa, and (iii) provide a space weather operational service to government, industry and the public.

The field of space weather is growing rapidly, with new discoveries and continuous developments in forecasting and prediction capabilities which improve almost daily. There are still many unknowns and a rigorous assessment of the economic impact resulting from a severe solar storm is a work in progress. Some analysis has been done on the impacts resulting from Geomagnetically Induced Currents (GICs), however, to a large extent the evidence is still anecdotal. This policy brief describes the possible economic impacts, and presents likely scenarios as well as discussion points around the risk that South Africa may be exposed to from space weather.




	<p>REPUBLIC OF SOUTH AFRICA</p> <p>CIVIL AVIATION AUTHORITY</p>	<p>CAA Private Bag x73 Halfway House 1685</p>
<p>Tel: (011) 545-1000 Fax: (011) 545-1465 E-Mail: mail@caa.co.za</p>	<p>AERONAUTICAL INFORMATION CIRCULAR</p>	<p>A/C Series X xxx/2017 [Effective Date]</p>

SPACE WEATHER IMPACTS ON AVIATION

1. Purpose

To provide an awareness of the potential impacts that space weather events can have on various aspects of concern to the South African aviation community. To work towards a common understanding of the compliance requirements recommended by the International Civil Aviation Organisation (ICAO) concerning the provision of space weather information to the aviation industry.

2. Background

- Space weather refers to the conditions on the Sun, in the solar wind, magnetosphere, ionosphere and thermosphere that can influence the performance and reliability of space – borne and ground based technological systems.
- The impact from space weather events are known to affect the areas of communications, navigation, radiation exposure, and avionics within the aviation sector.
- South African National Space Agency (SANSA), as the custodian of the only regional warning centre for space weather in Africa, can provide space weather related information, training and key impact factors that may be of concern to the aviation community.
- To ensure that accurate and relevant space weather information is provided, SANSA needs to understand how the aviation sector operates as well as their user requirement specifications. To achieve this aim, SANSA has embarked together with ATNS, on a research project to investigate the impacts of space weather within the aviation sector.
- The aviation industry has indicated a requirement to be educated on the potential impact of space weather to their operations.

ATNS/HO/C/15/01 Page 1 of 3 20 October 2017

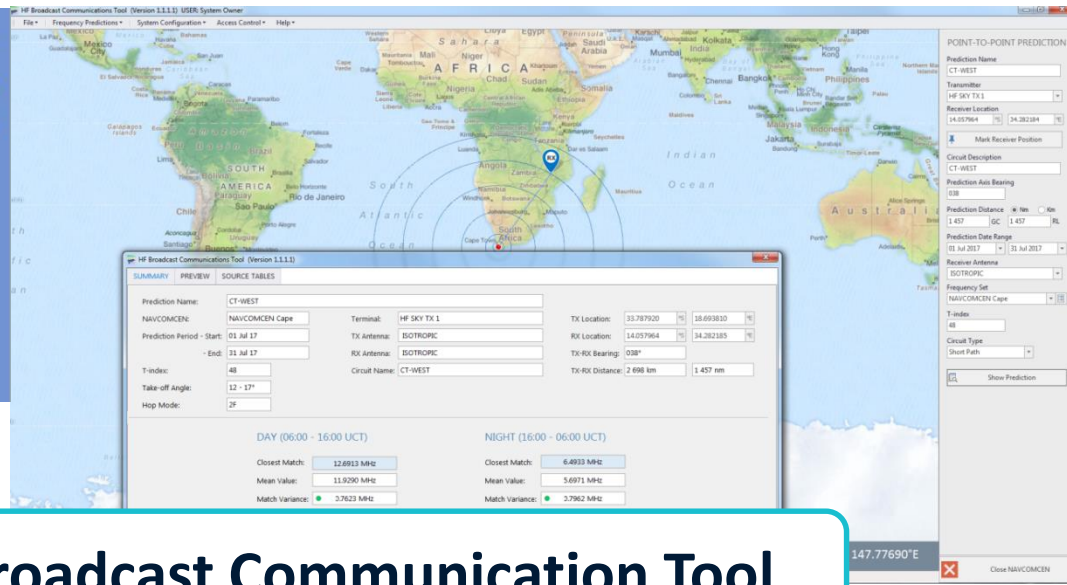
INDUSTRY PARTNERSHIP: SPECIAL PRODUCTS



South African Navy
HF Broadcast Communications Tool

NAVCOMCEN Cape

NAVCOMCEN Durban

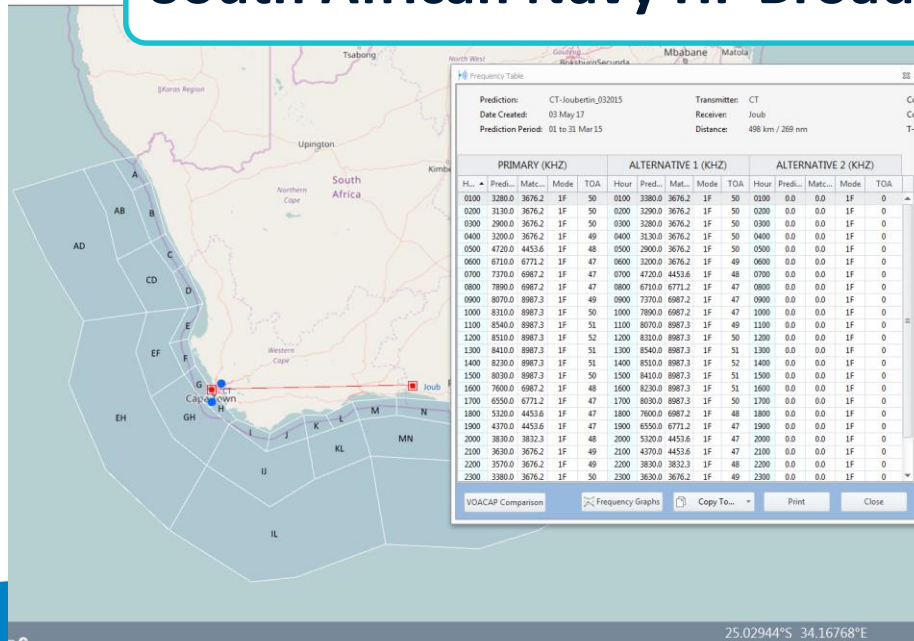
HF Broadcast Communications Tool (Version 1.11.1) - ISEK System Console

Prediction Name: CT-WEST
 NAVCOMCEN: NAVCOMCEN Cape
 Terminal: HF SKY TX 1
 TX Location: 31.787920 °N 18.693820 °E
 TX Antenna: ISOTROPIC
 RX Location: 14.025964 °N 34.282185 °E
 RX Antenna: ISOTROPIC
 TX-RX Bearing: 038°
 Circuit Name: CT-WEST
 TX-RX Distance: 2 698 km 1 457 nm

Closest Match: 12.6913 MHz
 Mean Value: 11.9200 MHz
 Match Variance: 3.7623 MHz

Closest Match: 6.4933 MHz
 Mean Value: 5.6971 MHz
 Match Variance: 3.7962 MHz

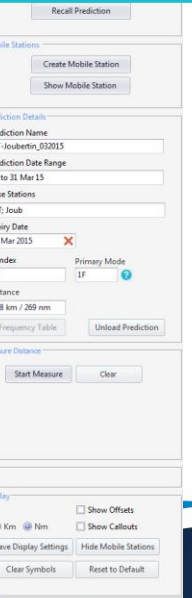
South African Navy HF Broadcast Communication Tool



Frequency Table

Prediction: CT-Joubertin_032015
 Date Created: 03 May 17
 Prediction Period: 01 to 31 Mar 15
 Transmitter: CT
 Receiver: Joub
 Distance: 498 km / 269 nm

PRIMARY (KHZ)				ALTERNATIVE 1 (KHZ)				ALTERNATIVE 2 (KHZ)							
H.	Pred.	Mat.	Mode	TOA	Hour	Pred.	Mat.	Mode	TOA	Hour	Pred.	Mat.	Mode	TOA	
0100	3280.0	3676.2	1F	50	0100	3380.0	3676.2	1F	50	0100	0100	0.0	0.0	1F	0
0200	3130.0	3676.2	1F	50	0200	3290.0	3676.2	1F	50	0200	0.0	0.0	0.0	1F	0
0300	2900.0	3676.2	1F	50	0300	3280.0	3676.2	1F	50	0300	0.0	0.0	0.0	1F	0
0400	3200.0	3676.2	1F	49	0400	3130.0	3676.2	1F	50	0400	0.0	0.0	0.0	1F	0
0500	4720.0	4453.6	1F	48	0500	2900.0	3676.2	1F	50	0500	0.0	0.0	0.0	1F	0
0600	6710.0	6771.2	1F	47	0600	3200.0	3676.2	1F	49	0600	0.0	0.0	0.0	1F	0
0700	7370.0	6987.2	1F	47	0700	4720.0	4453.6	1F	48	0700	0.0	0.0	0.0	1F	0
0800	7890.0	6987.2	1F	47	0800	6710.0	6771.2	1F	47	0800	0.0	0.0	0.0	1F	0
0900	8070.0	8987.3	1F	49	0900	7370.0	6987.2	1F	47	0900	0.0	0.0	0.0	1F	0
1000	8310.0	8987.3	1F	50	1000	7890.0	6987.2	1F	47	1000	0.0	0.0	0.0	1F	0
1100	8540.0	8987.3	1F	51	1100	8070.0	8987.3	1F	49	1100	0.0	0.0	0.0	1F	0
1200	8510.0	8987.3	1F	52	1200	8310.0	8987.3	1F	50	1200	0.0	0.0	0.0	1F	0
1300	8410.0	8987.3	1F	51	1300	8540.0	8987.3	1F	51	1300	0.0	0.0	0.0	1F	0
1400	8230.0	8987.3	1F	51	1400	8510.0	8987.3	1F	52	1400	0.0	0.0	0.0	1F	0
1500	8030.0	8987.3	1F	50	1500	8410.0	8987.3	1F	51	1500	0.0	0.0	0.0	1F	0
1600	7600.0	6987.2	1F	48	1600	8230.0	8987.3	1F	51	1600	0.0	0.0	0.0	1F	0
1700	6550.0	6771.2	1F	47	1700	8030.0	8987.3	1F	50	1700	0.0	0.0	0.0	1F	0
1800	5320.0	4453.6	1F	47	1800	7600.0	6987.2	1F	48	1800	0.0	0.0	0.0	1F	0
1900	4370.0	4453.6	1F	47	1900	6550.0	6771.2	1F	47	1900	0.0	0.0	0.0	1F	0
2000	3830.0	3832.3	1F	48	2000	5320.0	4453.6	1F	47	2000	0.0	0.0	0.0	1F	0
2100	3630.0	3676.2	1F	49	2100	4370.0	4453.6	1F	47	2100	0.0	0.0	0.0	1F	0
2200	3570.0	3676.2	1F	49	2200	3830.0	3832.3	1F	48	2200	0.0	0.0	0.0	1F	0
2300	3380.0	3676.2	1F	50	2300	3630.0	3676.2	1F	49	2300	0.0	0.0	0.0	1F	0



Recall Prediction

Mobile Stations

Create Mobile Station
 Show Mobile Station
 Hide Mobile Station

Prediction Details

Prediction Name: CT-Joubertin_032015
 Prediction Date Range: 01 to 31 Mar 15
 Base Stations: CT: Joub
 Expiry Date: 31 Mar 2015
 T-index: 52
 Primary Mode: 1F
 Distance: 498 km / 269 nm
 Measure Distance



National Communications Tool

Starting...

Copyright © 2017

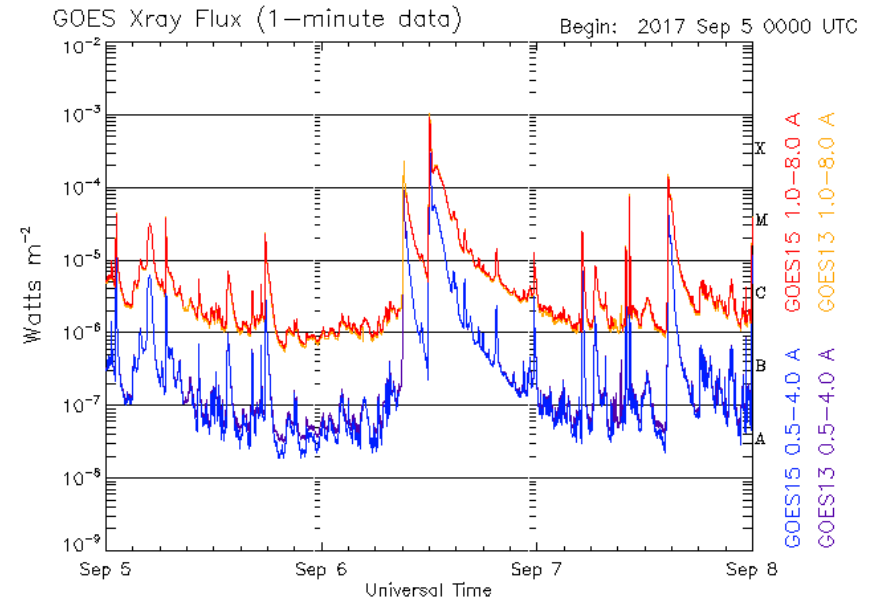


Example of impact on Technology: Communications

Example of X9.3 –class solar flare observed on the 6th September 2017 at ~ 12:04 UT. This is ~15:04 local time. The example shows strong radio blackout over Europe, Africa and the Atlantic Ocean.

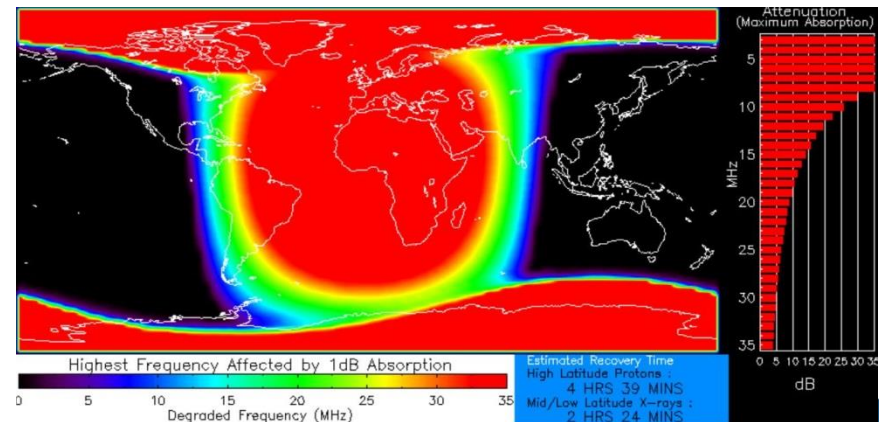
D-region absorption (D-RAP)

The D-region of ionosphere has largest effect on highest frequency (HF) Comms and low frequency (LF) navigation systems. The map indicates an area of the ionospheric D-region absorption during a solar flare event as well as the estimated recovery time.



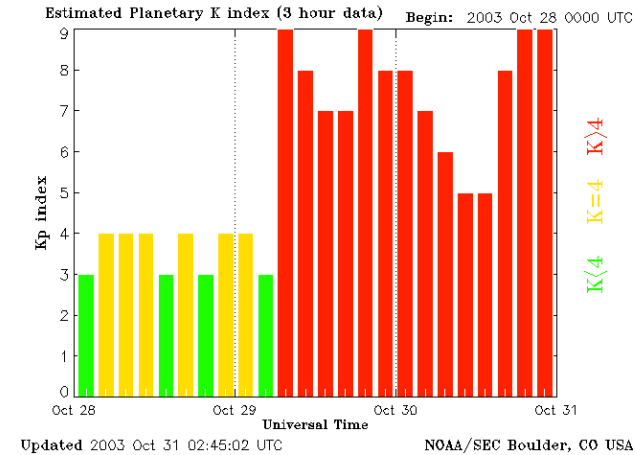
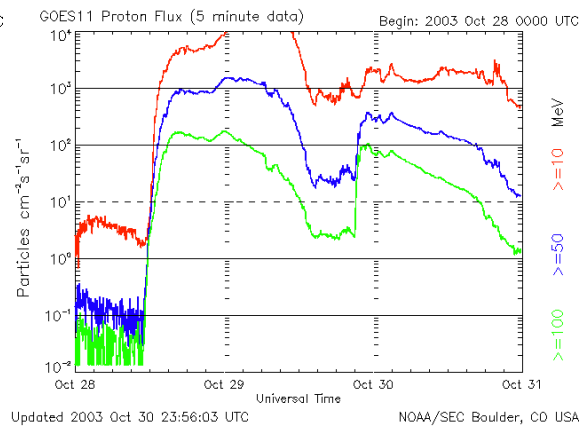
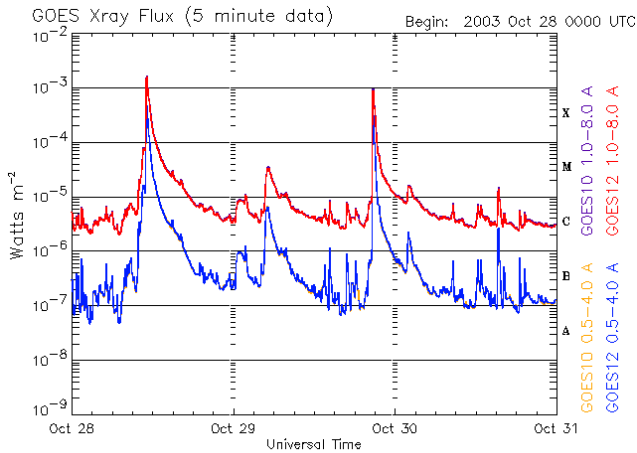
Updated 2017 Sep 7 23:59:12 UTC

NOAA/SWPC Boulder, CO USA



Strong X-ray flux
Product Valid At : 2017-09-06 12:04 UTC

Minor Proton Flux
NOAA/SWPC Boulder, CO USA

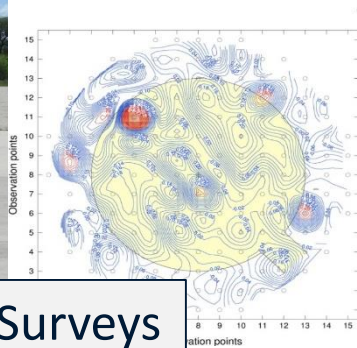


ESKOM, Matimba &
Ruacana,
(Photos CT Gaunt)



- Transformer replacement cost: ~\$10 - 13 million
- Transformer replacement time: 12 - 18 months
- 29 October 2003 (Halloween storm), ESKOM 15X 400 KV transformers failed within a year

SERVICES DEVELOPED FROM SPACE KNOW-HOW



Compass Base Surveys

Space
Weather
Aviation



AVIATION RELATED SERVICES FOR SUSTAINABLE DEVELOPMENT



Landing
Compass
Calibration

Training and
Skills
Development



Space Weather Information for Aviation

- Space weather phenomenon relevant to the whole flight route has been added to the general information to be provided to operators and flight crew members.
- Space weather information shall be provided as part of the flight documentation.
- **South Africa, through SANSa, has received designation as a Regional Centre for Space Weather Information Provision from the International Civil Aviation Organisation (ICAO)**
- Space weather advisory information will include one or more of the following effects:
 - a) high frequency (HF) radio communications;
 - b) Satellite communications
 - c) GNSS-based navigation and surveillance; and
 - d) radiation exposure at flight levels;

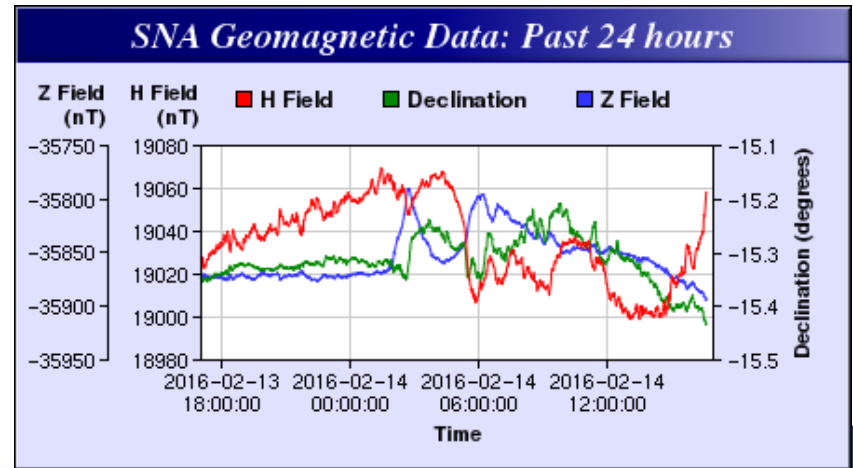
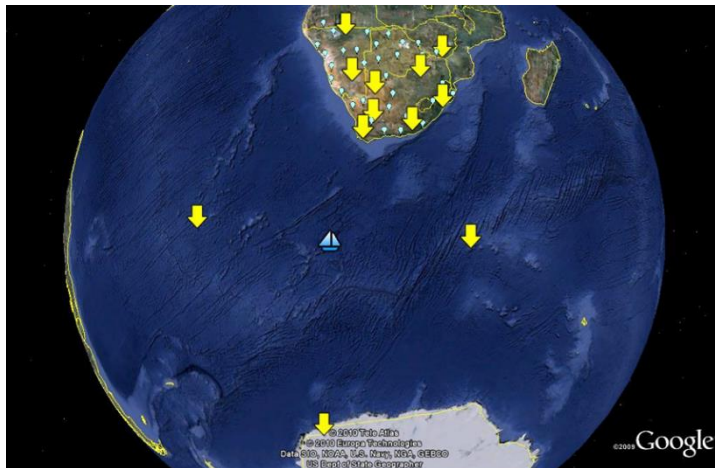
**IMPLEMENTATION IS SET
FOR BETWEEN MAR 2019
(Global) & Nov 2022
(Regional)**



Measuring space from the ground in support of space weather research and applications

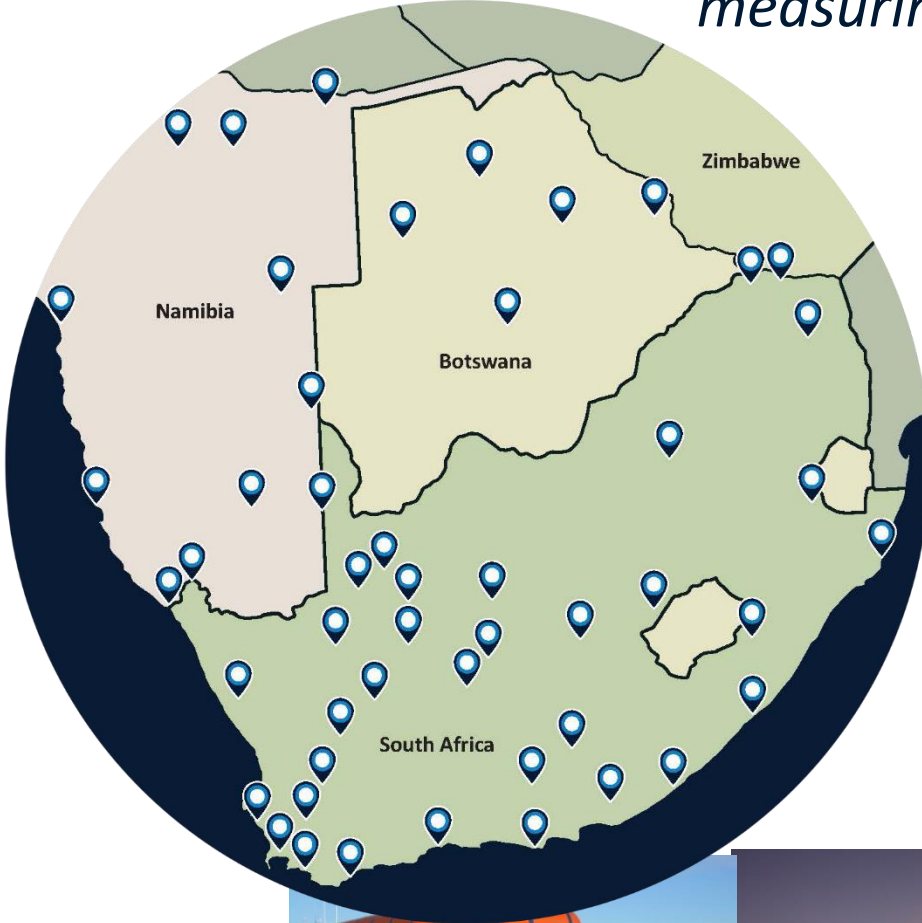
SANSA operates an extensive geophysical instrumentation network across Southern Africa, Antarctica and the Atlantic Islands

This is complimented with available satellite data



INFRASTRUCTURE

measuring space from the ground



TRAINING AND KNOWLEDGE SHARING

- HF
Propagation
Prediction
Training



- Space
Weather
Course for
Industry

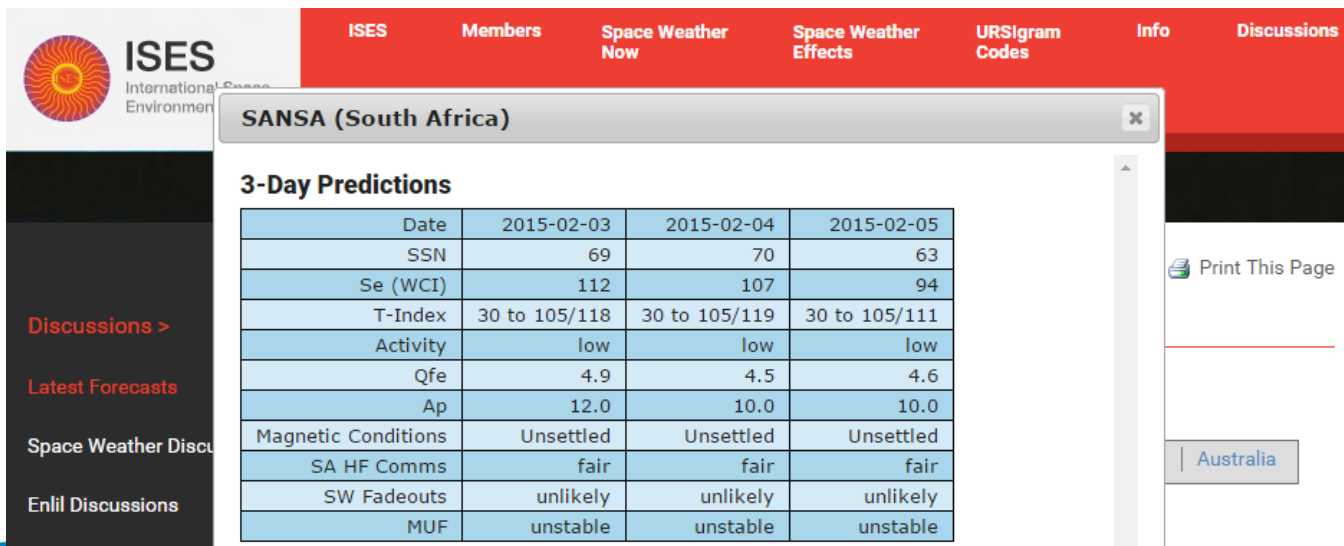


CONCLUSION



Focus areas include:

- Expand on products and services
- Expansion of Regional Space Weather Models
- Establish Forecast Verification Methods
- Space weather data networks
- Aviation Sector Focus to meet ICAO requirements



ISES International Space Environment Centre

ISES Members Space Weather Now Space Weather Effects URSIgram Codes Info Discussions

SANSa (South Africa)

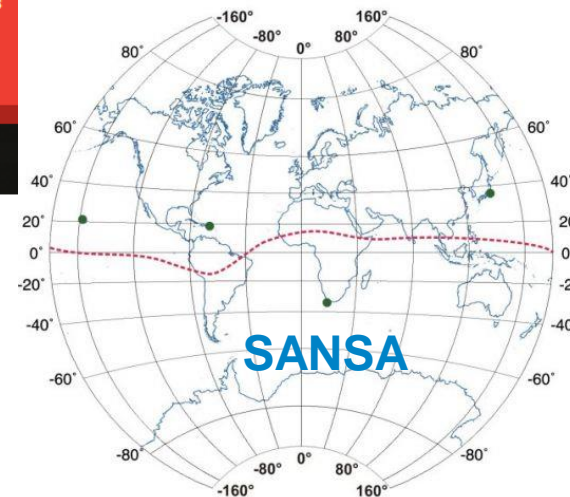
3-Day Predictions

Date	2015-02-03	2015-02-04	2015-02-05
SSN	69	70	63
Se (WCI)	112	107	94
T-Index	30 to 105/118	30 to 105/119	30 to 105/111
Activity	low	low	low
Qfe	4.9	4.5	4.6
Ap	12.0	10.0	10.0
Magnetic Conditions	Unsettled	Unsettled	Unsettled
SA HF Comms	fair	fair	fair
SW Fadeouts	unlikely	unlikely	unlikely
MUF	unstable	unstable	unstable

Print This Page

Australia

Dst Index



INTERNATIONAL BENEFIT FOR SW OPERATIONAL REQUIREMENTS

Benefits of working together:

Forecaster exchange for skills development

Sharing ideas for outreach activities around Space Weather

Forecast verification comparisons

Providing data to international databases (INTERMAGNET, DIDBASE)

Access to industry and industry requirements

Participation in international research and operational projects





Thank you

<http://www.sansa.org.za>

<http://spaceweather.sansa.org.za>

<http://research.sansa.org.za>