SANSA Infrastructure and opportunities

Pierre Cilliers, PhD, PrEng

Regional Workshop on GNSS and Space Weather, Rabat, Marocco

12 May 2022


sansa
SOUTH AFRICAN NATIONAL
SPACE AGENCY
Overview
SANSA History
Infrastructure
SW Products
Opportunities

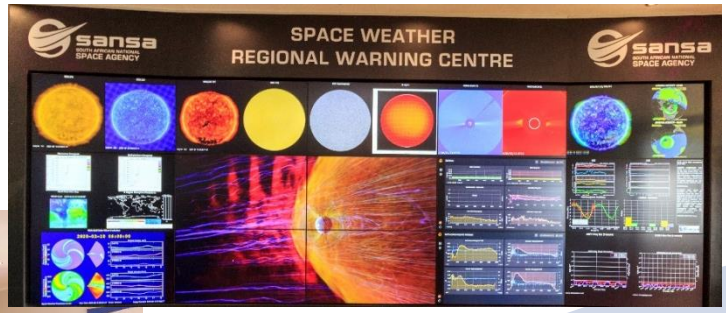
Legislative Mandate (SANSA Act of 2008)

"...provide for the promotion and use of space and co-operation in space-related activities, foster research in space science, advance scientific engineering through human capital, support the creation of an environment conducive to industrial development in space technologies within the framework of national government policy..."

Hermanus Magnetic Observatory to South African National Space Agency

Date	Status
1932	A magnetic observatory established at the University of Cape Town in response to International Commission for the Polar Year 1932-1933
1937	Magnetic Observatory placed under Trigonometrical Survey Office, Department of Lands
1941	Magnetic Observatory relocated to Hermanus to escape the disturbing effects of the electric railway system in Cape Town
1969	The Hermanus Magnetic Observatory (HMO) incorporated into the Council for Scientific and Industrial Research (CSIR)
2001	HMO declared a National Facility and transferred to the National Research Foundation (NRF)
2007	Regional Space Weather Warning Centre for Africa established at HMO
2011	HMO migrates to the South African National Space Agency (SANSA)

Space Weather Status



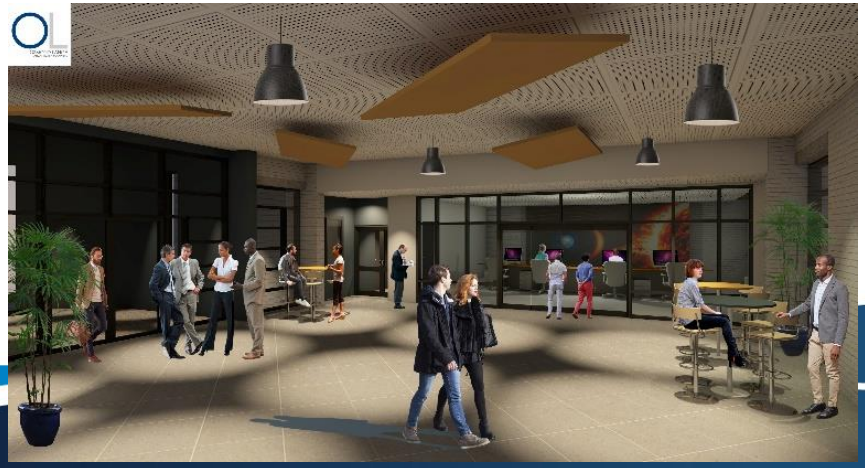
2022 Towards 24/7 Operational Space Weather Centre

2018 Space Weather Regional Warning Centre Upgrade

2010 Regional Space Weather Warning Centre for Africa

2007 Member of ISES (Space Weather Community)

virtual 3D tour of the Space Weather Centre
https://www.youtube.com/watch?v=eICp6XEWoVo



Regional Space Weather Warning Centre for Africa

SANSA Space Science, Hermanus

24/7 Operational Space Weather Warning Centre

24/7 Operational Space Weather Warning Centre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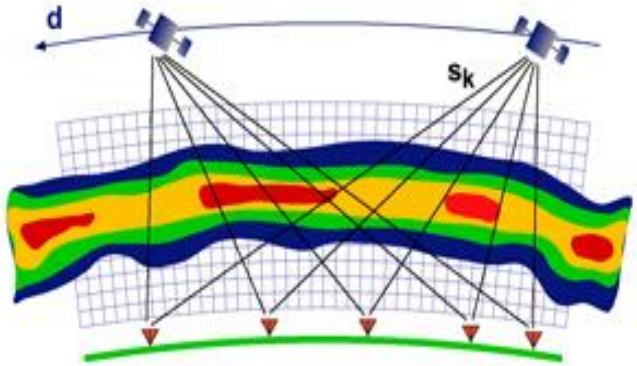
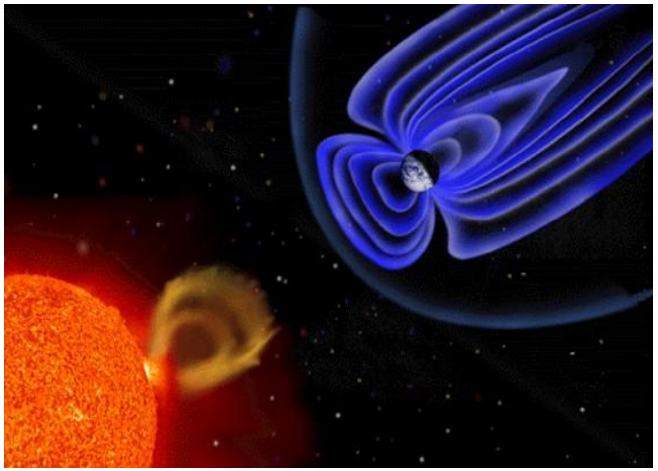
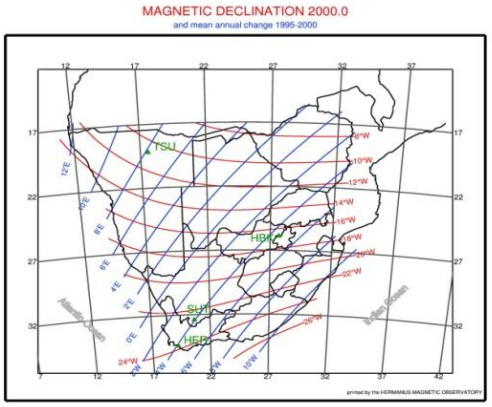
Infrastructure

RESEARCH AND APPLICATIONS

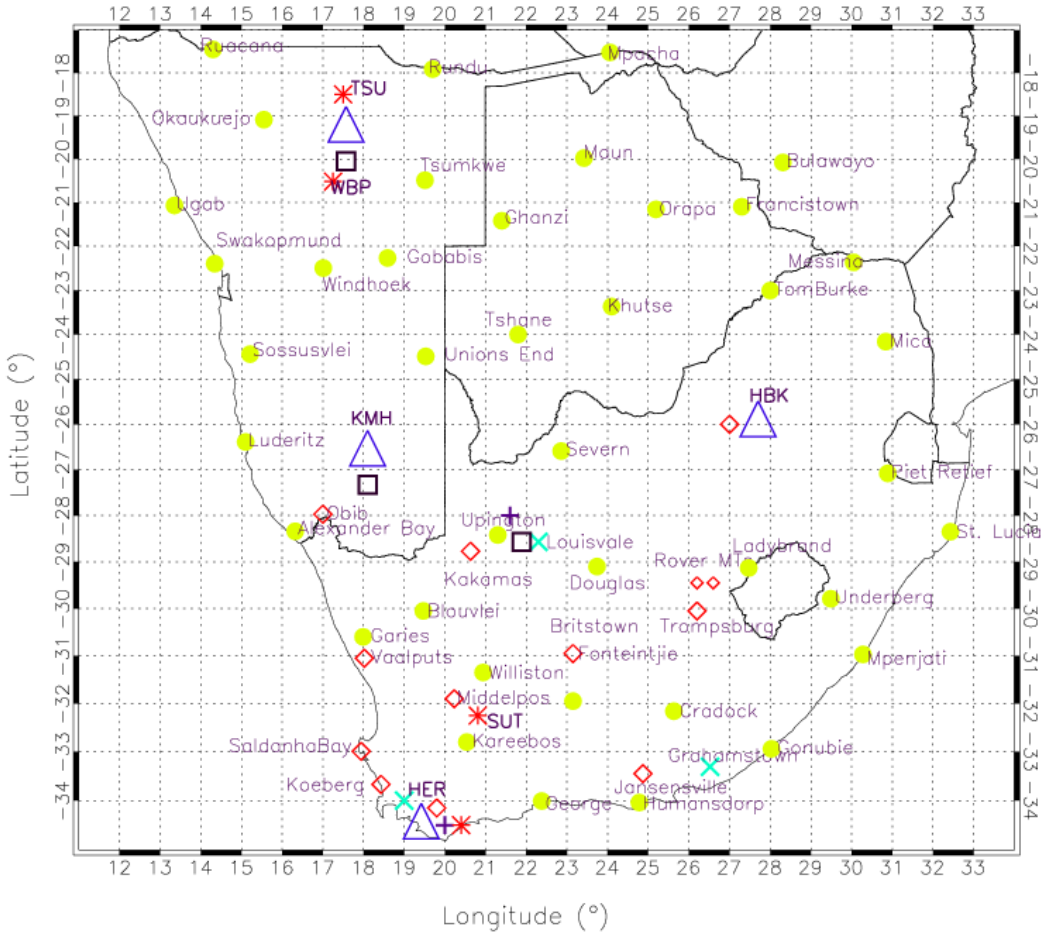
- Geomagnetic Research
- Ionospheric Research and Characterisation
- Waves and Space Plasmas
- Space Weather Prediction (Solar, Ionospheric, Geomagnetic)







SANSA INSTRUMENTATION NETWORK IN SOUTHERN AFRICA



- **80+ years of operations**
- **Approx. 80 instruments**
- **20 individual sites**
- **6 – 10TB of data per year**

MT stations

GPS

Doppler radar

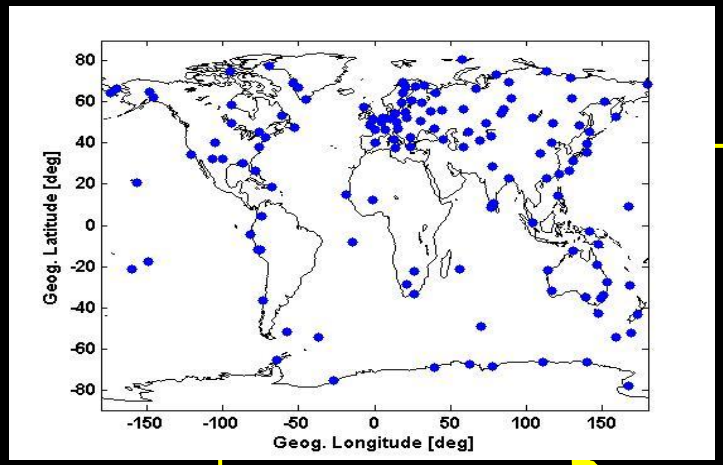
Magnetic Observatories

Secular Variation Stations

PLASMON stations

Ionosonde

South African Ionosonde Network



2000 – 2020

(22.4ºS, 30.9ºE) Madimbo

2000 – 2019

Louisvale (28.5ºS,21.2ºE)

1973 – 2022

2008-2022

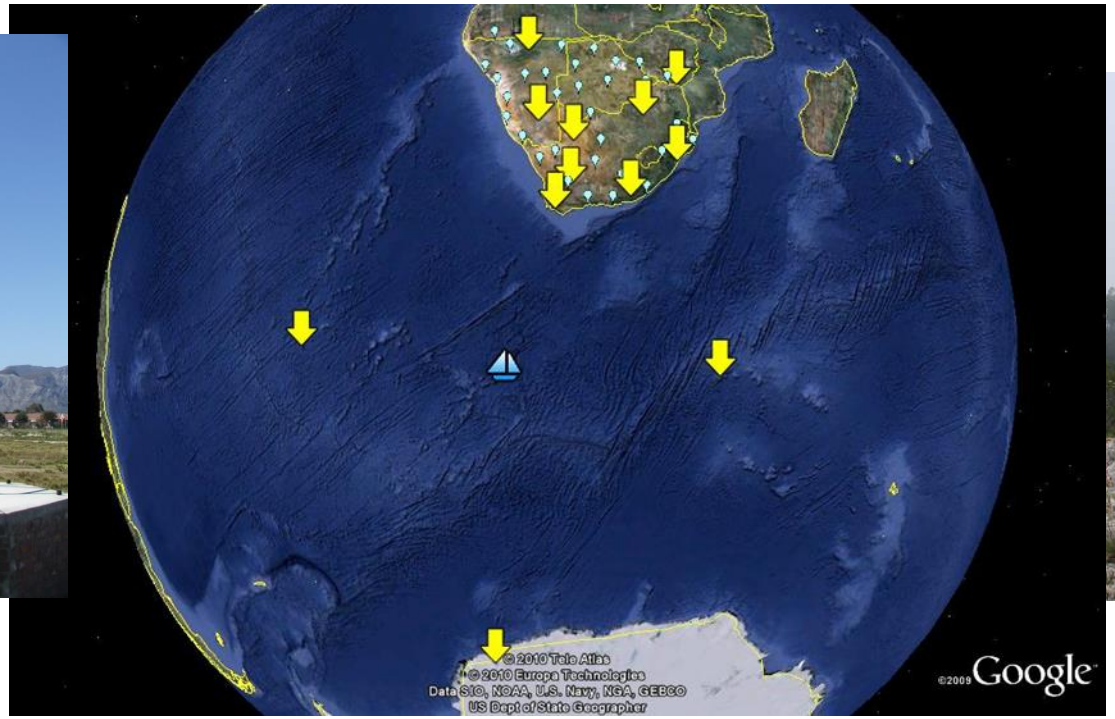
Grahamstown (33.3ºS, 26.5ºE)

Hermanus (34.4ºS, 19.2ºE)

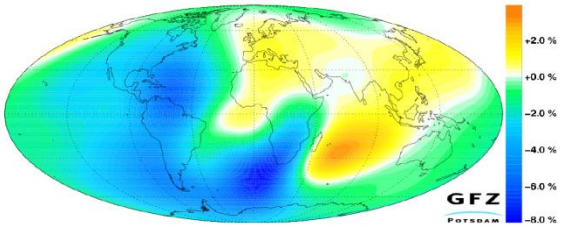
SA Ionosonde network

- The South African Ionosonde Network consists of 4 ionosonde stations located at Grahamstown (Eastern Cape, 33.3°S, 26.5°E), Louisvale (Northern Cape, 28.5°S, 21.2°E), Madimbo (Limpopo, 22.4°S, 30.9°E) and Hermanus (Western Cape, 34.4°S, 19.2°E).
- All 4 ionosondes are Digisondes produced by the University of Massachusetts, Lowell Center for Atmospheric Research (UMLCAR). The three older Digisondes (Grahamstown, Madimbo and Louisvale) are DPS-4 models,
- Grahamstown Digisonde operating since 1996, and Madimbo and Louisvale from 2000 to 2019 and 2020 respectively.
- Grahamstown station had a Barry Research Chirpsounder operated prior to the installation of the DPS-4 and so there is a database of ionospheric data for Grahamstown going back to 1973.
- The Hermanus ionosonde is a new model DPS-4D digisonde whose installation was completed in July 2008 and is the first DPS-4D operational in the field throughout the world.

RESEARCH PLATFORMS



Geographic Advantage

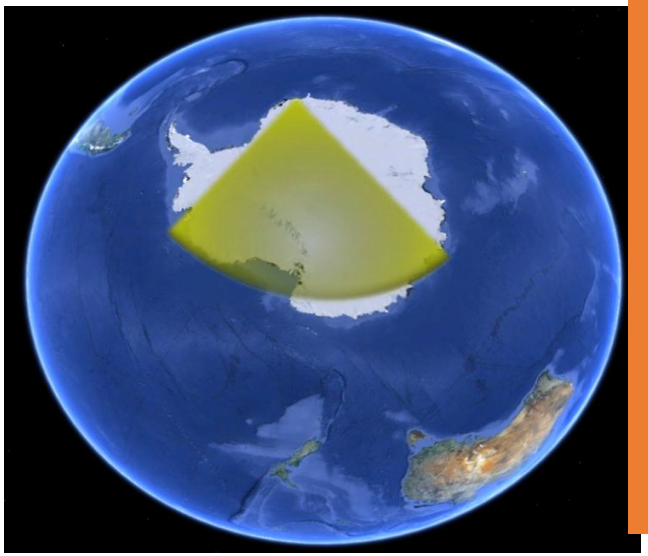


Wide Observational Network

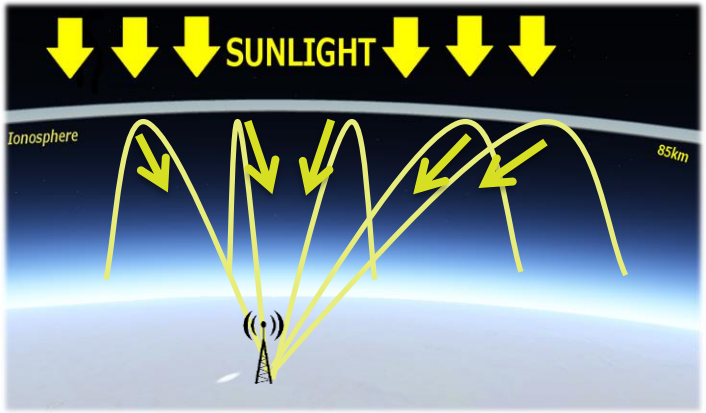
Global Data Distribution & Access – example:

- INTERMAGNET
- SuperDARN

SuperDARN HF Radar



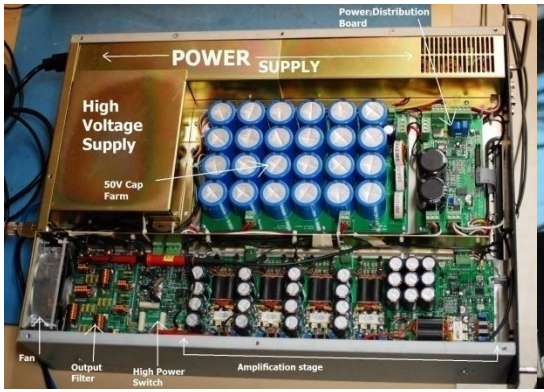
SANSA & UKZN Collaborative project supported by SANAP

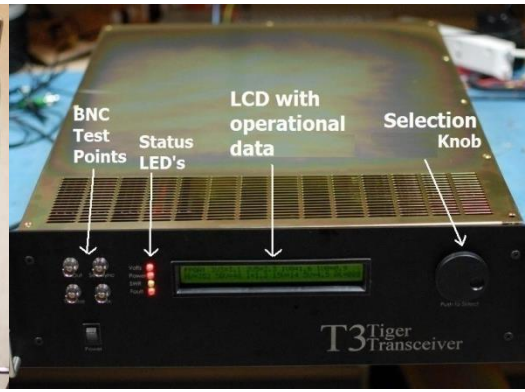


Field of view of SANAE radar.

HF signals are reflected off the ionosphere back to antenna. Echos used to determine plasma convection.

Main radar antenna array in Antarctic.





New FPGA based digital electronic unit to drive each antenna and receive return signals.

Infrastructure

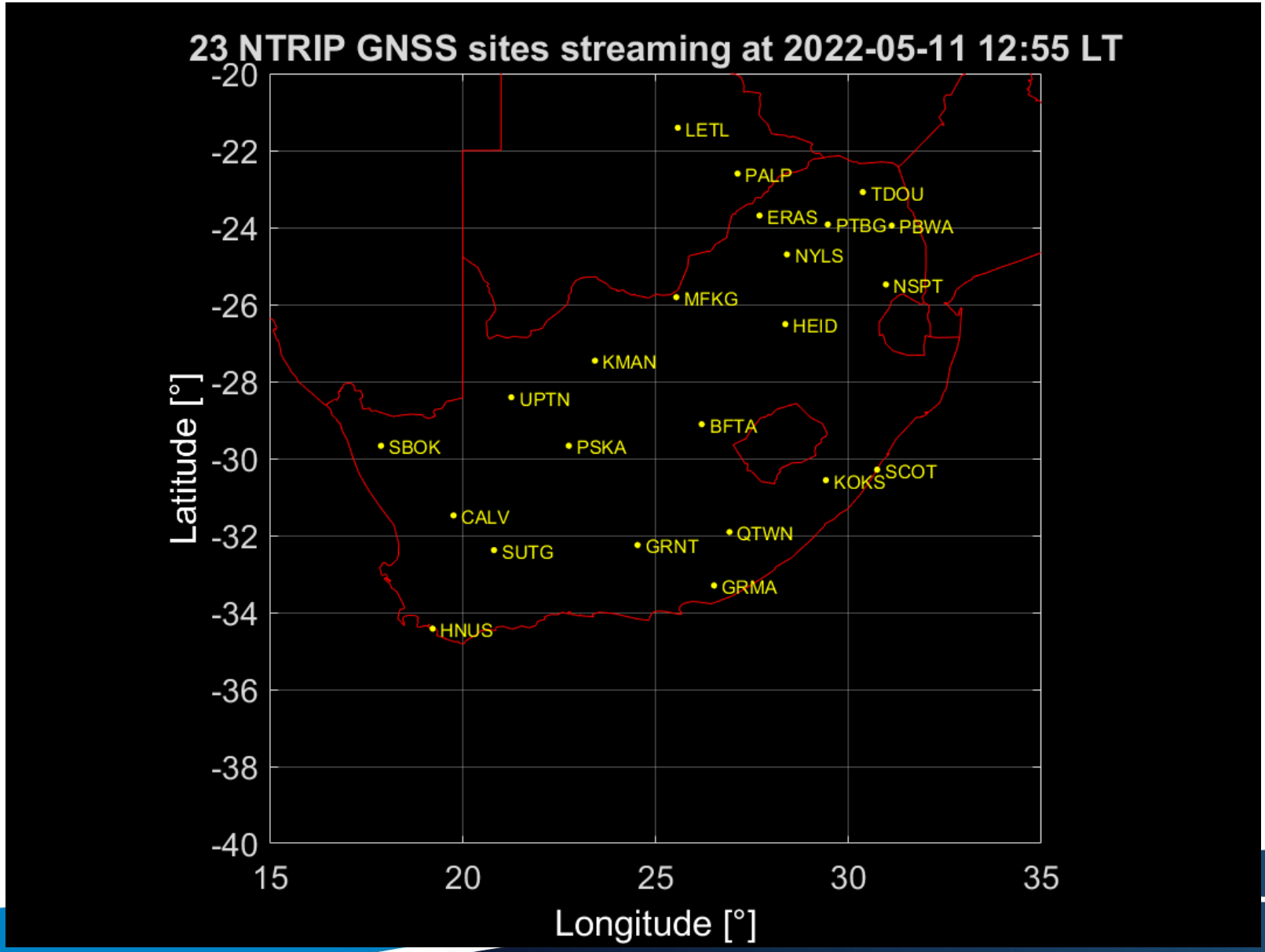
Location	Geodetic		CGM	Instruments
	Lon	Lat	Lat	
Hermanus	19.22°E	34.42°S	42.59°S	Magnetometers (Lemi, Overhauser, Pulsation, Fluxgate, DI Flux), Scintillation and TEC monitors (SBAS, Novatel), Neutron Monitor, World Wide Lightning Location Network (WWLLN), HF Beacon Receiver, HF Doppler, Ionosonde (Digisonde DSP4), E-Callisto Solar Spectrometer
SANAE-IV, Antarctica	2.84°W	71.67°S	61.85°S	SuperDARN HF Radar, Magnetometers(Overhauser, Pulsation, Rock, Fluxgate, DTU), Riometers wide-angle(30, 51.4 MHz), beamforming(38.2 MHz), GNSS Receivers(Geodetic(Trimble), Scintillation and TEC monitors(Novatel GSV4004B, Septentrio PolaRsX PRO, 4tuNe SDR), VLF(AWESOME, UltraMSK, DVRAS, Whistler Detector), Ozone monitor, Neutron Monitor

Location	Geodetic		CGM	Instruments
	Lon	Lat	Lat	
Gough Island	9.88°W	40.34°S	43.01°S	Scintillation and Total Electron Content (TEC) monitors (Novatel), Dual Frequency GPS Receiver (Trimble)
Marion Island	37.86°E	46.87°S	52.04°S	Magnetometers (LEMI), Scintillation and TEC monitor (Novatel), VLF(DVRAS, UltraMSK, Whistler Detector), Tidal Gauge, WWLLN, Dual Frequency GPS Receiver, Seismometer
Tsumeb, Namibia	17.60°E	19.20°S	31.11°S	Fluxgate magnetometer, Total Field magnetometer
Keetmanshoop, Namibia	18.10°E	26.50°S	36.69°S	Fluxgate magnetometer, Total Field magnetometer
Hartebeesthoek	27.7°E	25.9°S	35.98°S	Fluxgate magnetometer, Total Field magnetometer,
Waterberg, Namibia	17.25°	20.52°S	31.50°S	Pulsation magnetometer
Sutherland	20.66°E	32.39°S	41.19°S	Pulsation magnetometer, FPI, E-Callisto Solar Spectrometer, GNSS Receiver

TRIGNET: SOUTH AFRICAN GNSS NETWORK

http://www.trignet.co.za/map/sensormap.aspx

TRIGNET REAL-TIME (NTRIP) STATIONS

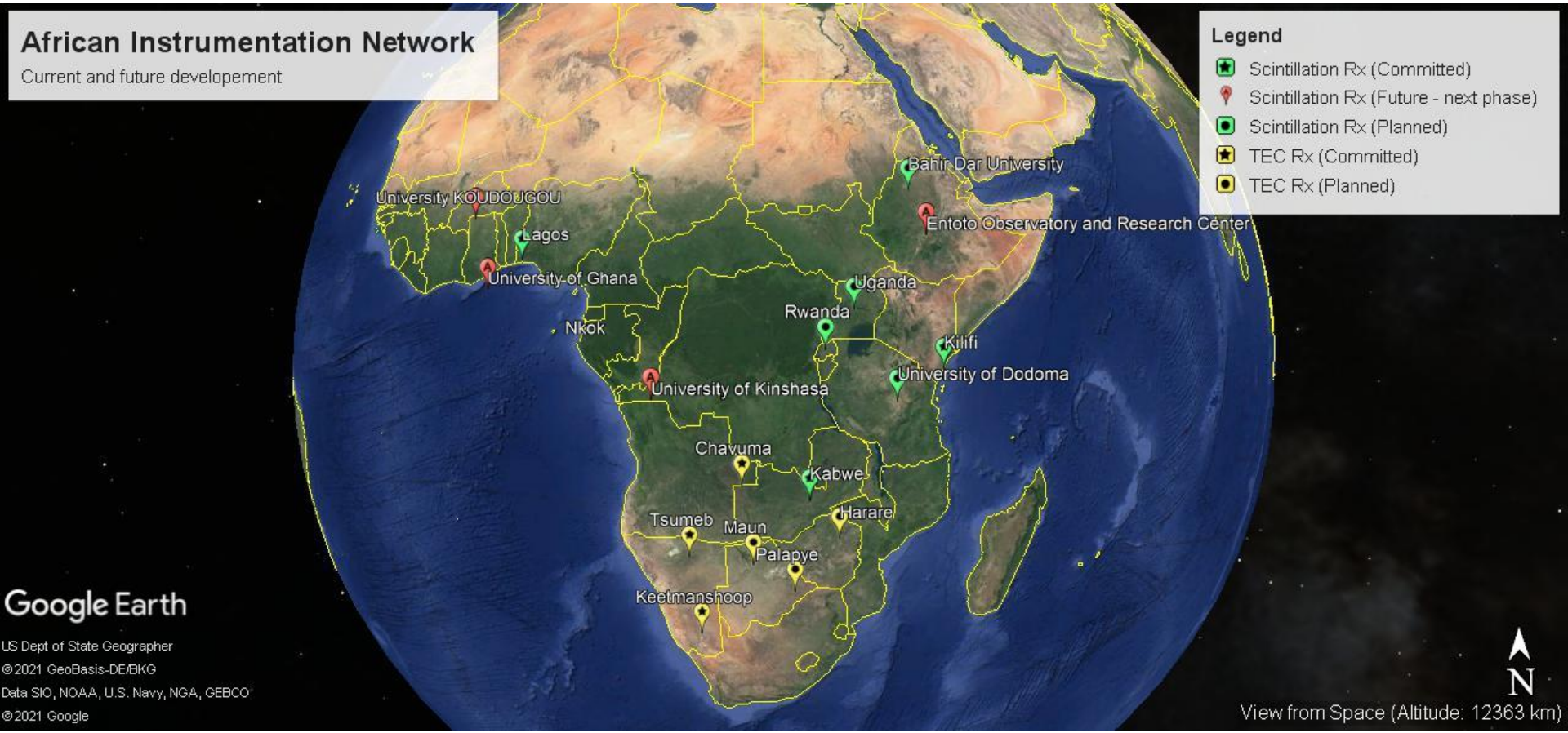


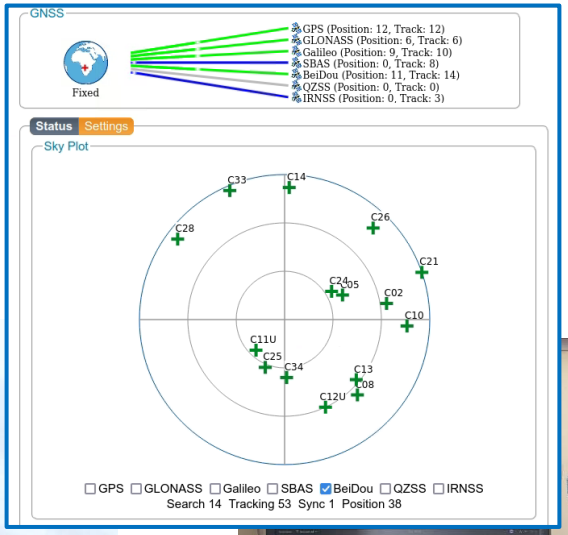
NEW GNSS EQUIPMENT

Source: www.septentrio.com

- 8 New Septentrio PolaRx5S receivers by 2022!
- State-of-the-art Ionospheric Monitoring GNSS Receivers
  - Multi-frequency
  - Multi-constellation
  - High precision geodetic choke ring antennas
  - Real-time output
  - Remote control
- TEC and Scintillation data products

New GNSS Instrumentation





Kwame Nkrumah University (KNU), Kabwe, Zambia

Resource Centre in Chavuma, Zambia

New GNSS Instrumentation: Gabon

SANSA had discussions in Feb 2022 with Dr Aboubakar Ndjoungui, Deputy General Manager of AGEOS (AfriGEOSS), about deployment of a GNSS receiver at the AGEOS headquarters in Libreville, Gabon.

AGEOS is an African Implementattion of the Global Earth Observation System of Systems
www.ageos.ga

SANDIMS Sites Instruments Search Data About Us LOGIN

SANDIMS **is the repository of all Geomagnetic, Ionospheric and Magnetospheric data gathered from SANSA Space Science's instrumentation network.**

Instrumentation Network

Instruments in the network are grouped into the above three classes, and further sub-classed by **Instrument Type**, each of which is represented by one or more **Instrument Models**. Specific instruments so classified are the **Field Instruments** of the network, which extends throughout **South Africa** and **Namibia**, as well as **Gough** and **Marion** islands in the southern oceans and the **SANAE IV** research base in Antarctica. The SANDIMS Metadata Model includes GPS location, manufacturer and Principal Investigator information, as well as technical parameters of the instruments (most importantly sampling interval) and their antennae. Metadata associated with a data bundle may be exported and shared using NASA's DIF v10.0 interchange format.

Search and Download Facility

The metadata are searchable by instrument site, type and sampling interval. Datasets are archived per Field Instrument, File Type and Processing Level and may be filtered by date ranges. Data selected for download is compressed and bundled and made available via an FTP site with a temporary login.

Data Access

The data is free for academic research purposes, subject to users registering on this website. Commercial use of the data requires a contract, which can be arranged by contacting the Data Acquisition Practitioner at SANSA Space Science.

science & technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

https://sandims.sansa.org.za/

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The metadata are searchable by instrument site, type and sampling interval. Datasets are archived per Field Instrument, File Type and Processing Level and may be filtered by date ranges. Data selected for download is compressed and bundled and made available via an FTP site with a temporary login.

- **Data Access**

The data is free for academic research purposes, subject to users registering on this website..

SANDIMS Sites

Hermanus

Type	Model	Version	Commissioning Date
Ionospheric Instruments			
GPS Ionospheric TEC and Scintillation Monitor	GSV4004B	1.77	2010-06-18
High Frequency Beacon	IC 728	None	2008-09-01
High Frequency Doppler	High Frequency Doppler	None	2010-05-25
Ionosonde Digital	Digisonde DPS-4D	None	2008-07-04

SANSA Instrument Network

Instrument Class: Ionospheric Instruments — INFO

Instrument Type: GPS Ionospheric TEC and Scintillation Monitor — INFO

Instrument Model: GSV4004B — INFO

Field Instrument: GSV4004B-1 [Hermanus] — INFO

sandims
SOUTH AFRICAN NATIONAL GEOPHYSICAL DATA AND INSTRUMENTATION MANAGEMENT SYSTEM

SANDIMS Sites

Instrument Class: Ionospheric Instruments

Click on any of the site markers on the map to see detailed information regarding a specific site and the available instrumentation for the site.

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SANDIMS Sites

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Search by Site

Hermanus

GPS Ionospheric TEC and Scintillation ..

1.00 second interval

Start Date
2019-03-15

End Date
2019-03-15

Available data: 2010-06-18 - 2019-04-15

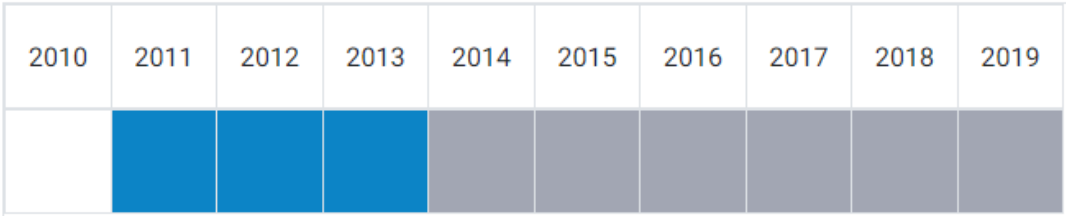
SUBMIT

Temporal Coverage

The graphs below represent the temporal coverage of the data for the selected Instrument Type. Note that ar
representing the availability of data for that file type. The key below indicates the colour coding of temporal b
a new graph, spanning the same time interval at a new resolution. When you reach the resolution of the temp
file may be displayed above. Please note that **quicklooks are not provided for all data file types** generated by
be displayed as quicklooks.

Instrument not commissioned	No data available	Data available

Key



HERGST1 - GST daily ISM files

View Cart

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SANDIMS Sites Instruments Search Data About Us 0 Kate

Instrument	Site	Samp Int (s)	ProcLevel	Timeslot	Duration (s)	Filename	Size (kB)	Select
Lemi 25 daily files								✓
3-Axis Fluxgate Magnetometer (1s) - HERL251	Hermanus	1.00	Raw	2019-04-02 00:00:00	86400	HERL251-20190402	4,471	✓
3-Axis Fluxgate Magnetometer (1s) - HERL251	Hermanus	1.00	Raw	2019-04-03 00:00:00	86400	HERL251-20190403	4,471	✓
3-Axis Fluxgate Magnetometer (1s) - HERL251	Hermanus	1.00	Raw	2019-04-04 00:00:00	86400	HERL251-20190404	4,471	✓
3-Axis Fluxgate Magnetometer (1s) - HERL251	Hermanus	1.00	Raw	2019-04-05 00:00:00	86400	HERL251-20190405	4,471	✓
				Dataset Size:	17.47MB	*Bundle Size:	17.47MB	ADD TO CART

*Note that files are compressed, so downloads will be significantly smaller than the Bundle Size

- This data bundle has been added to your Data Cart.

VIEW CART

Space Weather Products

SPACE WEATHER DATA AND MODELS

Space weather monitoring, forecasting and predictions.

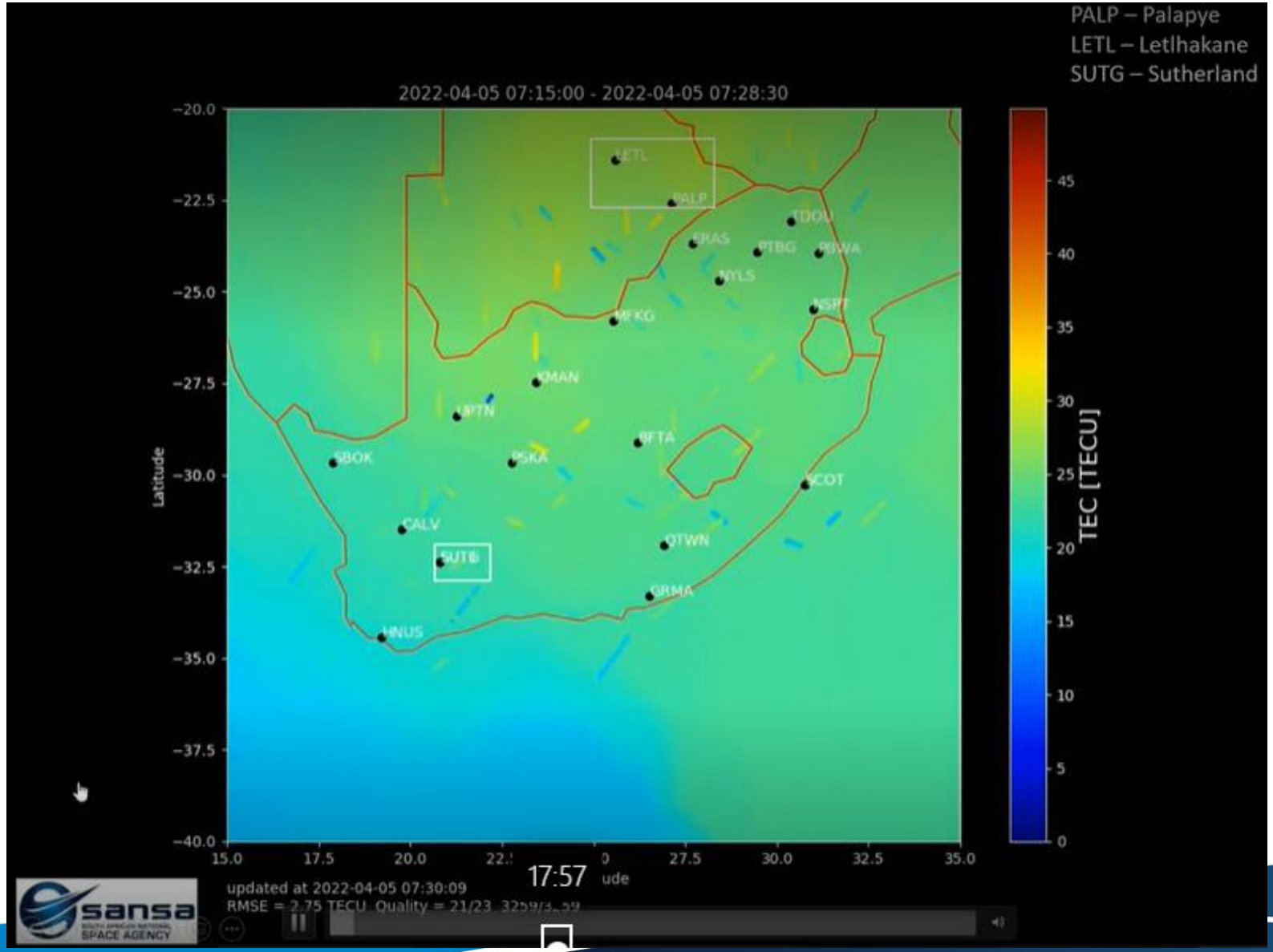
Disseminate SW information to clients and public via website, emails, sms and fax

Space weather analysis and verifications of forecasts and predictions

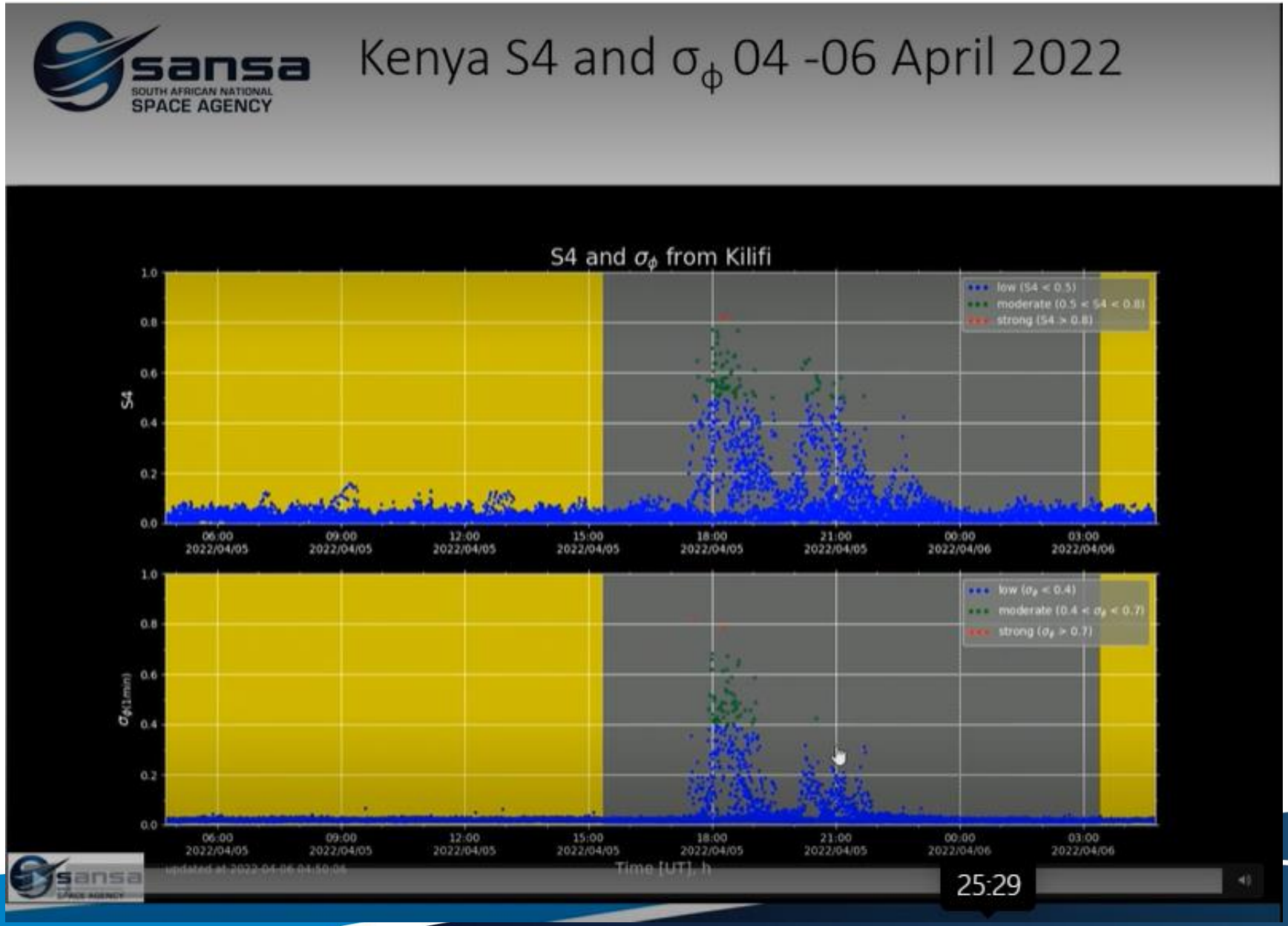
- Data from Satellite instrumentation: to measure the main source of space weather conditions as well as the impacts
- Data from Ground-based instrumentation : to measure the magnitude of the impact of space weather

SPACE WEATHER CENTRE

Real-time TEC mapping

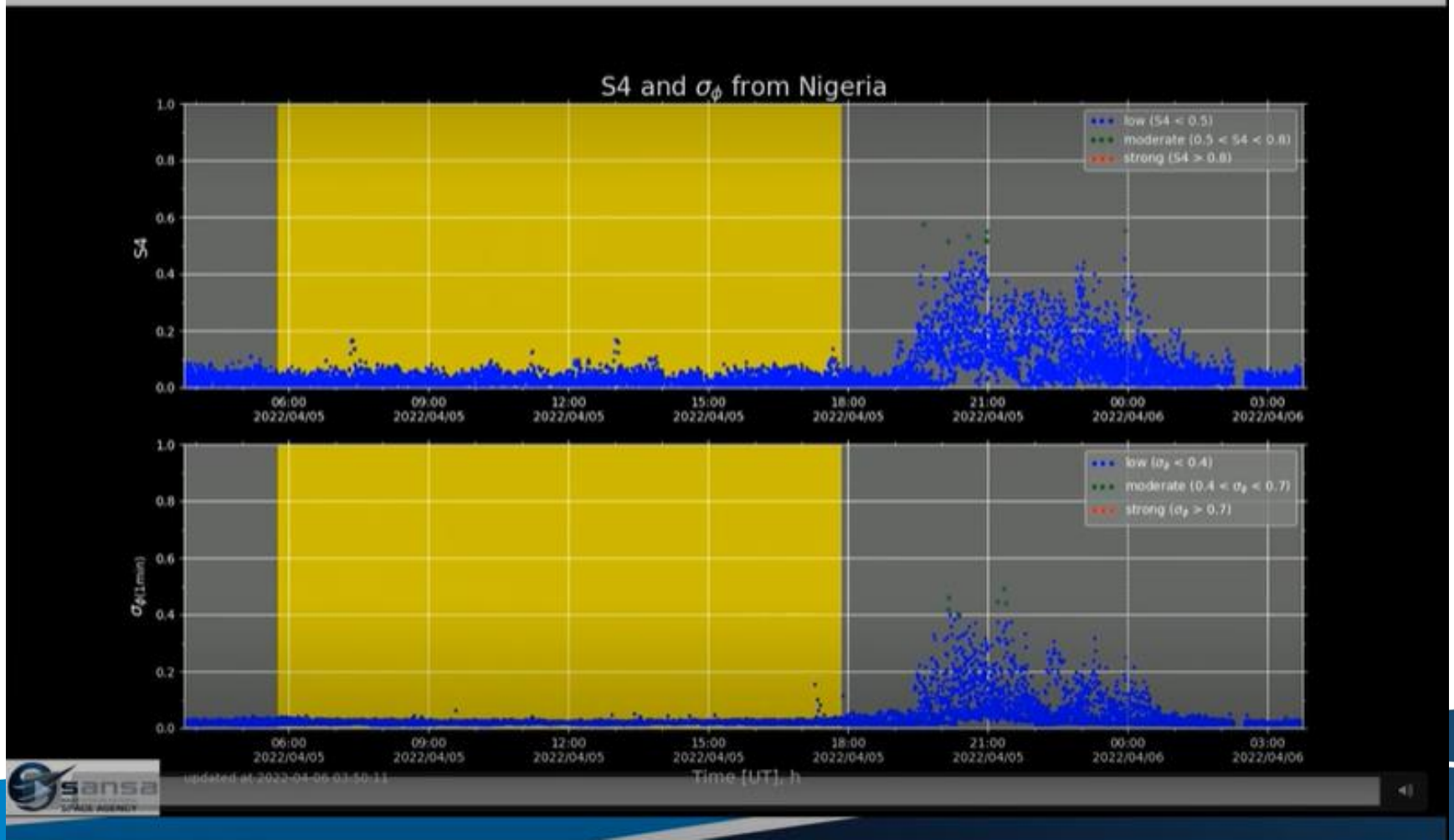


Real-time Ionospheric Scintillation Monitoring



Real-time Ionospheric Scintillation Monitoring

Nigeria S4 and σ_ϕ 04 -06 April 2022



Space Weather Models

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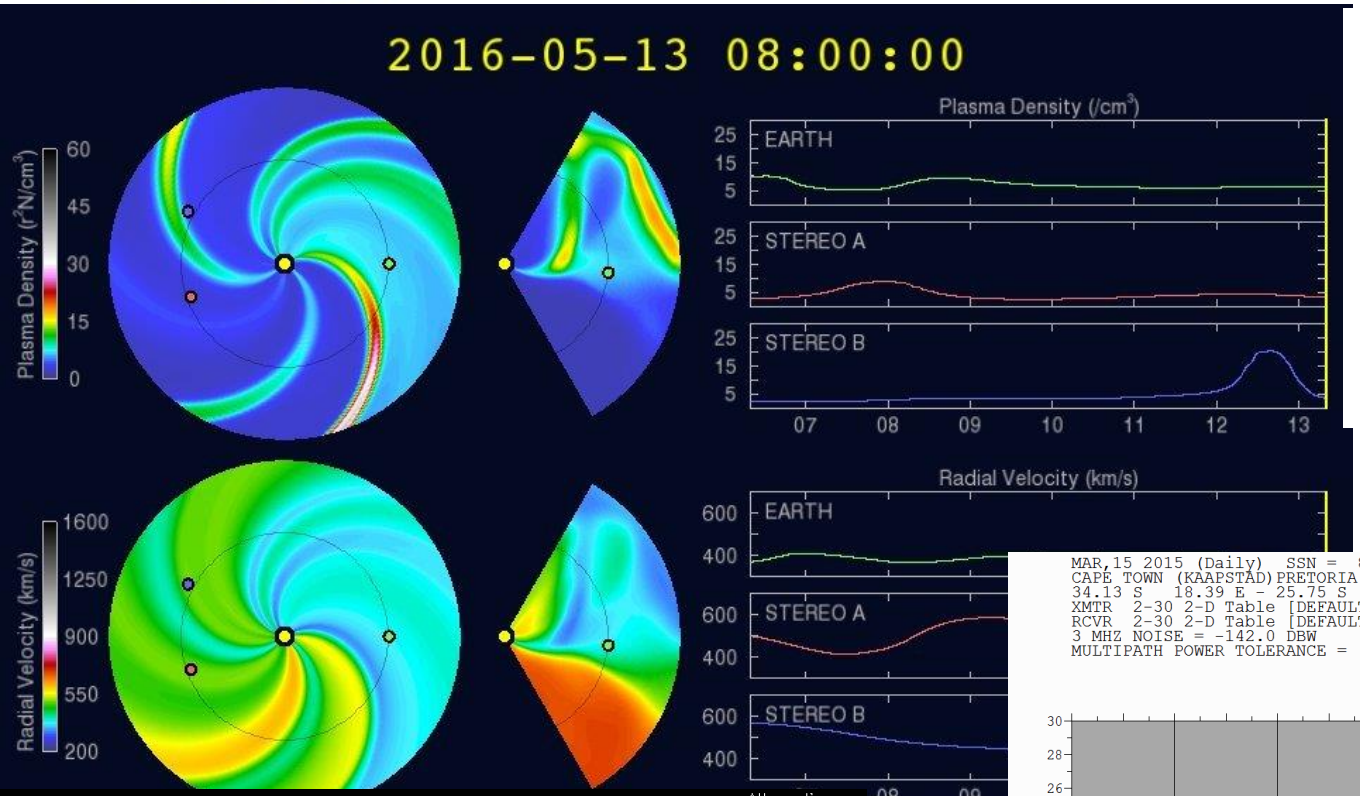

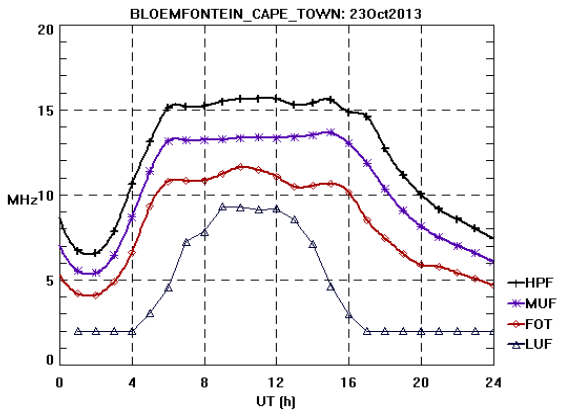


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MAR,15 2015 (Daily)   SSN =  83.      Qeff= 4.7      Minimum Angle  0.10 deg
CAPE TOWN (KAAPSTAD)PRETORIA              AZIMUTHS          N. MI.       KM
34.13 S   18.39 E - 25.75 S   28.17 E     47.87  222.97      714.8    1323.7
XMTR  2-30 2-D Table [DEFAULT\CONST17.VOA  ] Az=  0.0 OFFaz= 47.9 500.000kW
RCVR  2-30 2-D Table [DEFAULT\SWWHIP.VOA   ] Az=  0.0 OFFaz=223.0
3 MHZ NOISE = -142.0 DBW     REQ. REL = .80    REQ. SNR = 48.0 DB
MULTIPATH POWER TOLERANCE =  3.0 DB   MULTIPATH DELAY TOLERANCE =  0.100 MS
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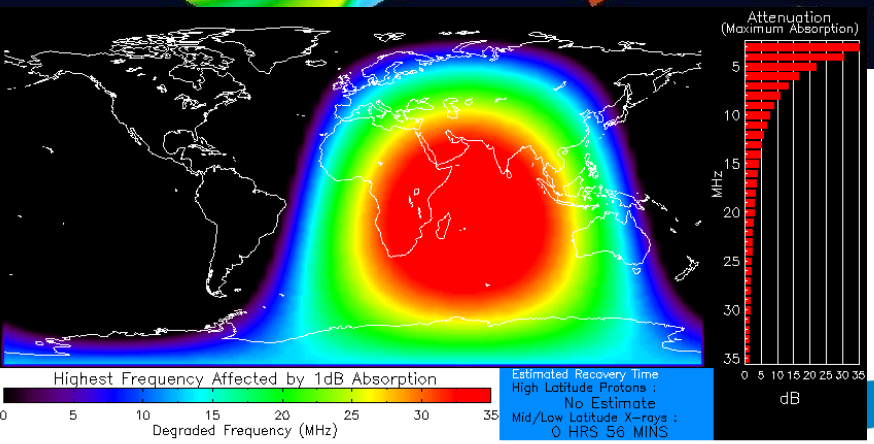

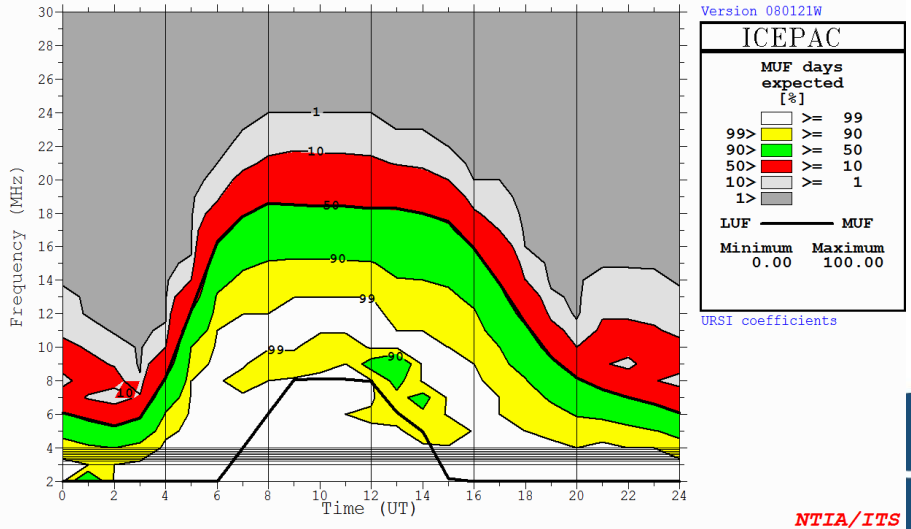

Moderate X-ray flux

Normal Proton Background

NTIA/ITS

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SOUTH AFRICAN NATIONAL SPACE AGENCY

Space Weather Daily Bulletin

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Daily Forecast

DATE: 14 Mar 2022, composed at 08:58 SAST

CURRENT CONDITIONS: Solar activity is low with the background X-ray flux at B-class levels. Several C-class flares were observed over the past 48 hours, with the largest being a C5.1 flare at 13/03:20 UT. There are five sunspot regions visible on the solar disk (AR2960, AR2965, AR2967, AR2968 and a new unnumbered region) with simple magnetic configurations. Solar wind speed is slightly elevated above background levels with speed ranging between 430-500 km/s due to the effects of the coronal mass ejection (CME) arrival at 13/10:14 UT. No Earth-directed CMEs have been observed in the available imagery over the past 24 hours. Geomagnetic conditions are at unsettled to active levels, with a G1/Minor (Kp 5) storm observed at 13/15:00-18:00 UT interval, and a G2/Moderate storm (Kp 6) at 13/12:00-15:00 UT and at 13/21:00-00:00 UT. The local HF working frequencies are near monthly predicted values.

EVENTS: G1/Minor (Kp 5) and G2/Moderate storms observed in the past 24 hours.

OUTLOOK: Solar activity is expected to be low to moderate with the background X-ray flux at B-class levels. There are five sunspot regions visible on the solar disk with simple magnetic configurations. There is a high chance of C-class flaring and a slight chance of isolated M-class flaring expected. The solar wind speed is expected to remain slightly elevated above background levels due to the effects of the CME. Geomagnetic conditions are expected to be unsettled to active, with a slight chance of a G1/Minor storm as the effects of the CME gradually eases.

SYSTEMS AFFECTED: HF Communications and GNSS Navigation

Current Conditions

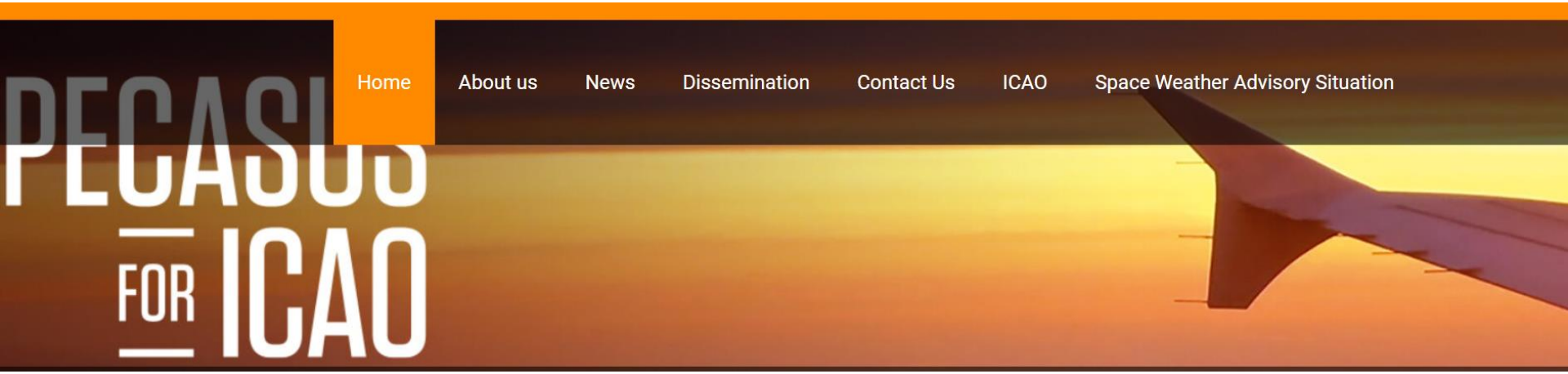
2022-03-14 07:52

Solar wind speed:	420.1 km/s
IMF Bz:	22.4 nT
Hermanus T-index:	84
Hermanus K-index:	0
Hermanus hmF2:	256.410 km
Hermanus foF2:	8.300 MHz
Dst Index:	-39 nT
Dcx Index:	-54.6 nT

Space Weather Bulletin

14 March 2022
Solar activity is low with the background X-ray flux at B-class levels. Several C-class flares were observed over the past 48 hours, with the largest being a C5.1 flare at 13/03:20 UT. There are five sunspot regions visible on the solar disk (AR2960, AR2965, AR2967, AR2968 and

PECASUS



The PECASUS consortium is one of four global centers providing space weather advisories according to ICAO regulations. These advisories are sent to airliners using the existing aeronautical fixed network for international aviation.
https://pecasus.eu/

https://pecasus.eu/

ICAO - Summary of Annex 3 Amendments

→ Space weather phenomenon relevant to the whole flight route has been added to the information to be provided to operators and flight crew members.

→ Space weather information shall be provided as part of the flight documentation.

→ 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;



Opportunities

Applications for GNSS Data

1. Surveying – acting as a reference station for differential GPS surveying of landmarks
2. Geodesy – providing a means to track continental drift
3. Total Electron Content (TEC) – Ionospheric measurements and generation of TEC maps
4. Electron Density Profiles – Derived from TEC measurements combined with ionospheric tomography
5. Ionospheric Scintillation – Derivation of the Rate of Change of TEC index from TEC measurements
6. Precipitable Water Vapour (PWV) – used in Terrestrial Weather prediction and climate studies
7. Avionics – support for Air Traffic Navigation through estimation of navigation errors near airports

Opportunities

1. Fostering collaboration with other African institutions
2. Instrumentation provided by SANSA to serve as a proof of concept for home-grown / self-funded instrumentation networks with support and training from SANSA to maintain.
3. African students can apply to visit SANSA for collaborative research through the SCOSTEP visiting scholar program. We host 1 or 2 young researchers most years.
4. African students can also come to us if they have their own funding.
5. We can do joint projects that use the data from our new African instrumentation network
6. Promoting and possibly developing a Space Science curriculum with university partners

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