



# OPERATIONAL SPACE WEATHER PROGRAMME IN KENYA:

Space Weather Monitoring and Prediction Using GNSS Receiver Data and  
Magnetometer Data

United Nations/Finland Workshop on the Applications of GNSS

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- ❑ Research grants to Kenyan Universities
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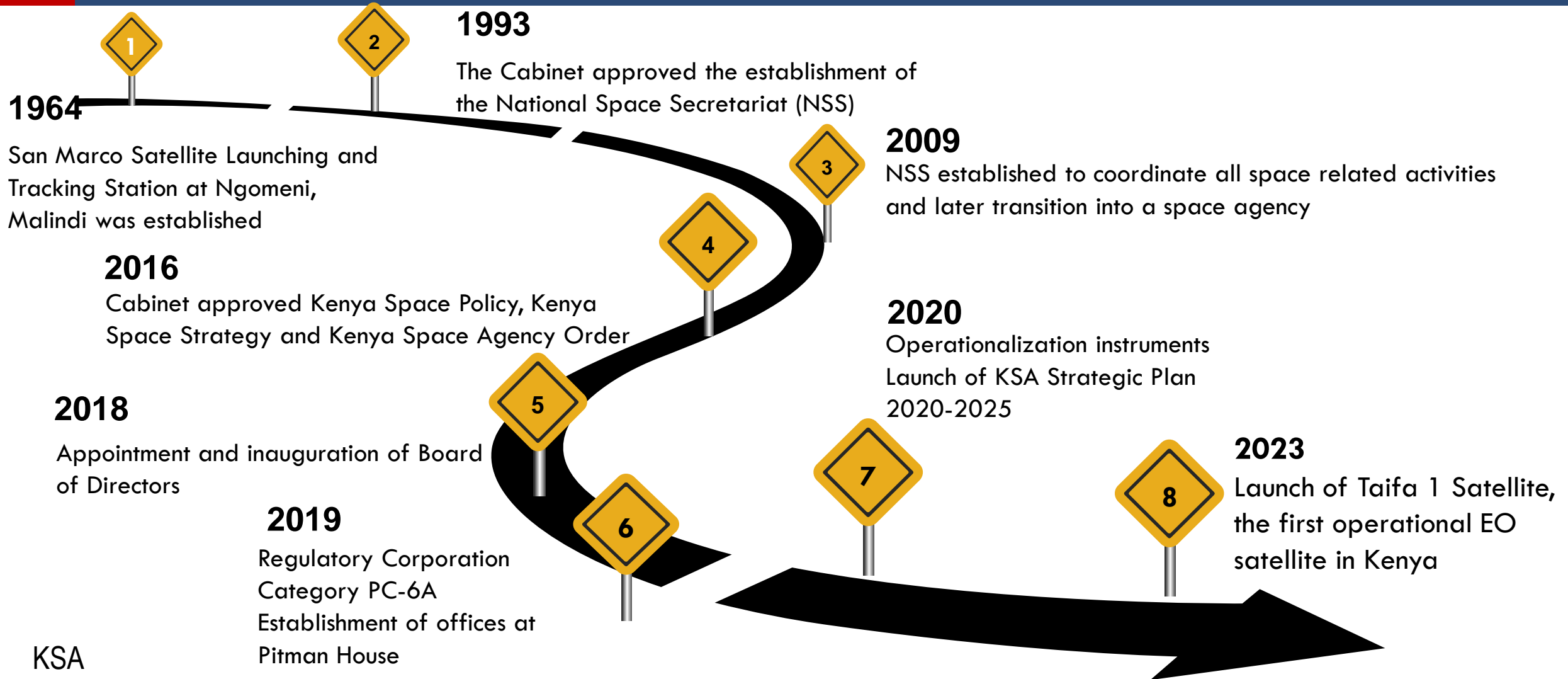


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# Our History

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# Introduction

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## What is space weather?

- A dynamic and ever-changing phenomenon in the GeoSpace environment, including the Sun, interplanetary medium, and magnetosphere-ionosphere-thermosphere system that can have a significant impact on our planet.

## Why is space weather monitoring and predicting important?

- Space weather impacts can range from minor disruptions of communication systems to large-scale geomagnetic storms that can damage satellites and power grids resulting in social economic losses hence the need for monitoring and predicting of space weather.

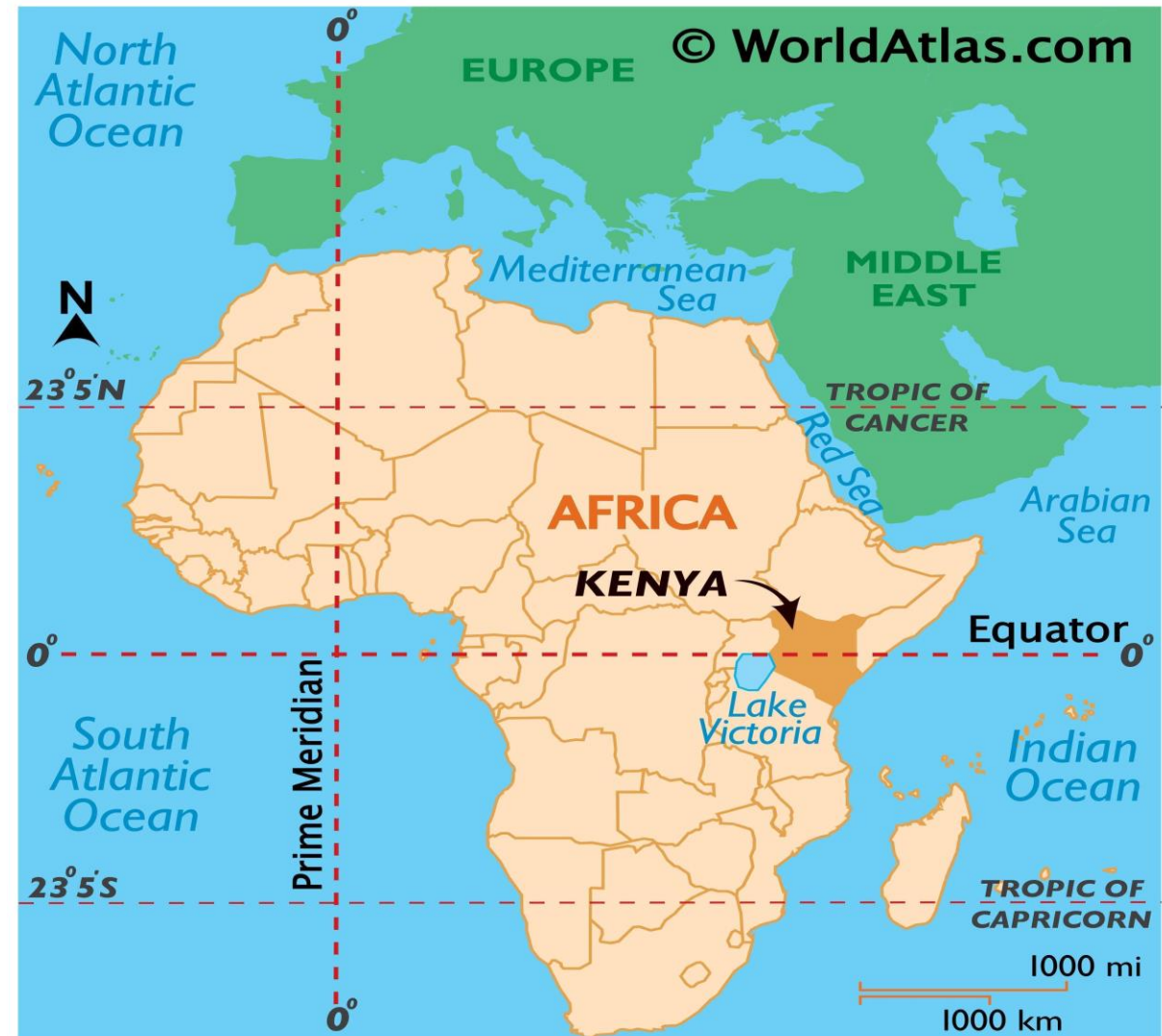




# The Impact of Space Weather in Kenya

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- ❑ Kenya's location in the low latitude region makes it particularly vulnerable to space weather effects
- ❑ **Operational Space Weather** entails a monitoring network to provide real-time data and predictions for:
  - ❑ Aviation Safety
  - ❑ Navigation Systems
  - ❑ Satellite Operations
  - ❑ Power Grid management
  - ❑ Pipelines
  - ❑ Radio communications
  - ❑ Surveying

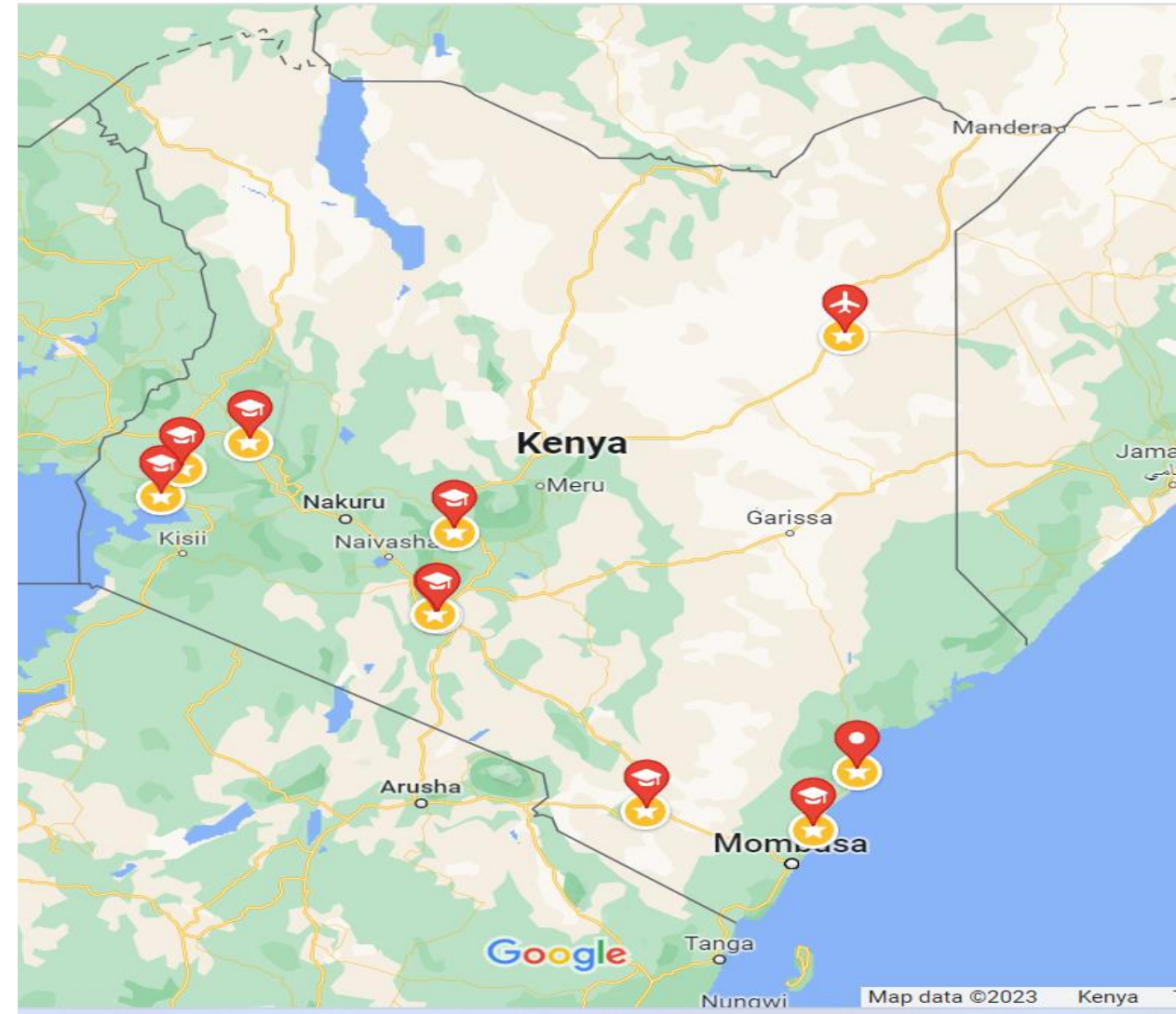




# Space Weather Sensor network in Kenya

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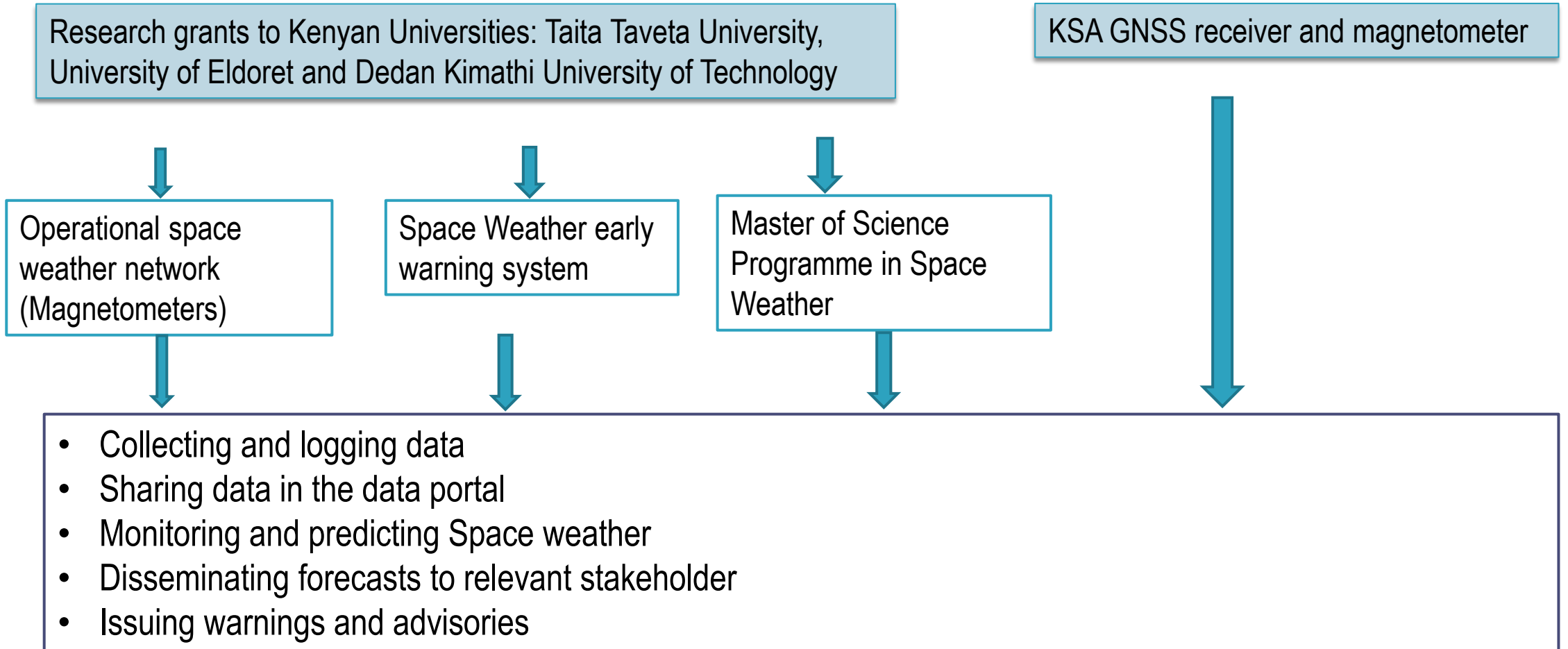
- ❑ **Existing Sensors**
  - ❑ Pwani University (Scint, Mag)
  - ❑ Maseno University (Mag)
  - ❑ Technical University of Kenya (Mag)
  - ❑ Masinde Muliro University of Science and Technology (Mag)
- ❑ **OSW Research Grant**
  - ❑ Taita Taveta University (Mag)
  - ❑ University of Eldoret (Mag)
  - ❑ Dedan Kimathi University (Mag)
- ❑ **Kenya Space Agency**
  - ❑ Nairobi (Scint)
  - ❑ Wajir Airport (Mag)
- ❑ **NORISK Proposed**
  - ❑ Malindi Space Centre (Ionosonde, Mag)





# Overview of the Operational Space Weather Programme

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# Research Grants to Kenyan Universities

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## 1. The Space Weather monitoring network

- The Kenya Space Agency awarded a consortium of three universities a research grant on Operational Space Weather with the purpose of:
  - ▣ Catalyzing homegrown research and innovation in Space Science and Technology
  - ▣ Promoting capacity building and establishing linkages between academia and industry
- The consortium is establishing a space weather monitoring network with nodes at Eldoret, Nyeri, and Voi with a view of expanding the network towards the crest of the geomagnetic equator ( $-15^{\circ}$  geomagnetic latitude)
- Currently, the network is collecting data from magnetometers
- The data will be used to monitor and predict space weather events such as geomagnetic storms



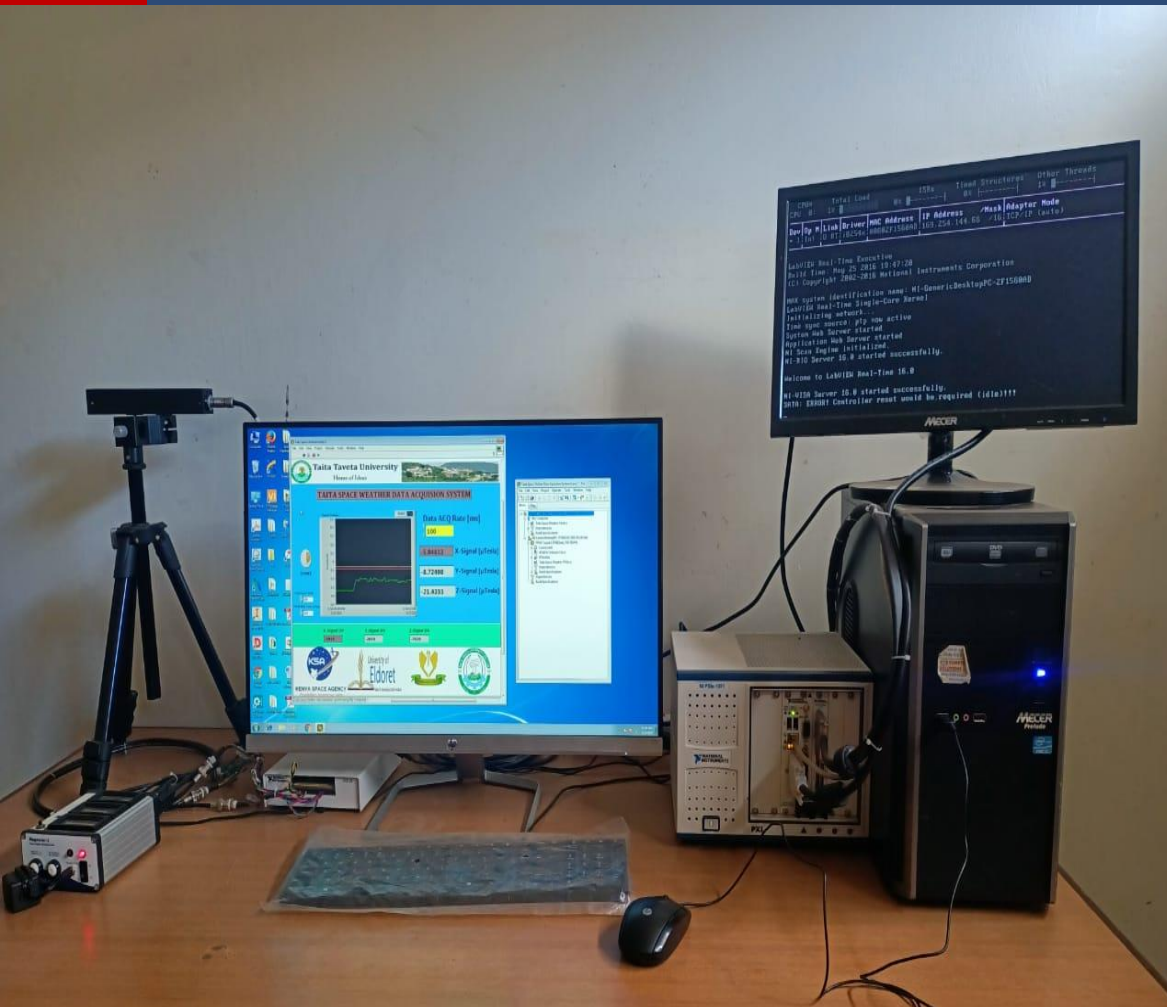


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# Project Set-up

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Taita Space Weather Host.vi

File Edit View Project Operate Tools Window Help

**Taita Taveta University**  
Home of Ideas

**TAITA SPACE WEATHER DATA ACQUISITION SYSTEM**

Signal [Voltage] Plot 0

Amplitude

**Data ACQ Rate [ms]**  
100

**-5.8197 X-Signal [ $\mu$ Tesla]**

**-8.78601 Y-Signal [ $\mu$ Tesla]**

**-31.4148 Z-Signal [ $\mu$ Tesla]**

START

Conversion Factor  
100

FPGA Wait Time (mSec)  
100

11:41:22.209 PM 3/22/2022

11:41:27.209 PM 3/22/2022

**X-Signal DV**  
-1907

**Y-Signal DV**  
-2879

**Z-Signal DV**  
-10294

**KENYA SPACE AGENCY** *Possibilities beyond our skies*

**University of Eldoret** *Flame of knowledge and innovation*

**TAITA TAVETA UNIVERSITY COLLEGE**

Taita Space Wather Data Aquisition System.lvproj/My Computer



# Research Grants to Kenyan Universities Cont..

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## 2. The Space Weather early warning system

- The consortium is also developing a space weather early warning system
- The system will provide alerts to relevant stakeholders about impending space weather events
- This information can be used to protect critical infrastructure and mitigate the impact of space weather events



# Research grants to Kenyan Universities Cont..

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## 3. The Master of Science Programme in Space Weather

- The consortium has developed a Master of Science programme in Space Weather
  - ▣ The MSc in Space Weather Engineering at Taita Taveta University
- The Programme will train the next generation of space weather scientists in Kenya in the following specialties:
  - ▣ Space weather observation
  - ▣ Space weather instrumentation
  - ▣ Space weather early warning systems
- This will help to address the national gap for specialists in space weather



# KSA's GNSS Receiver

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- KSA installed a PolaRx5S ionospheric monitoring GNSS receiver in Nairobi  
Lat:  $-1.29^{\circ}$  - Lon:  $36.8^{\circ}$
- The GNSS receiver data can be accessed through:  
[http://eswua.ingv.it/ewphp/daily\\_data\\_gnss.php?st=nai0p](http://eswua.ingv.it/ewphp/daily_data_gnss.php?st=nai0p)

Not secure | eswua.ingv.it/ewphp/daily\_data\_gnss.php?st=nai0p

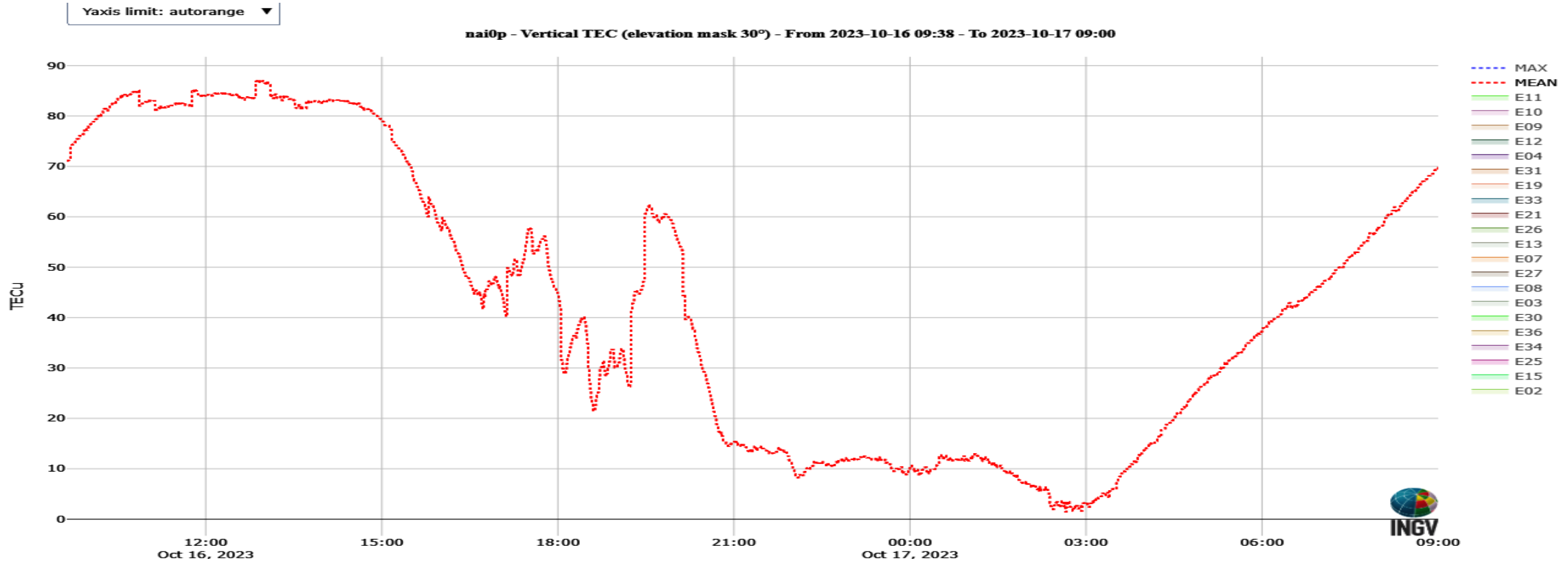
SELECT STATION:  DATA AVAILABILITY TIME RANGE (MAX 1 MONTH): 2023/10/15 16:49 - 2023/10/15 19:49

STATION CODE - LOCATION		STATION AREA:	STATION STATUS
nai0p - Nairobi		AFRICA	ACTIVE
STATION INSTRUMENT		LAT: $-1.29^{\circ}$ - LON: $36.8^{\circ}$	LAST DATA RECEIVED
Septentrio PolaRx5S			4 minutes ago
HOST	DATA OWNER		





# Sample Data from KSA's GNSS Receiver

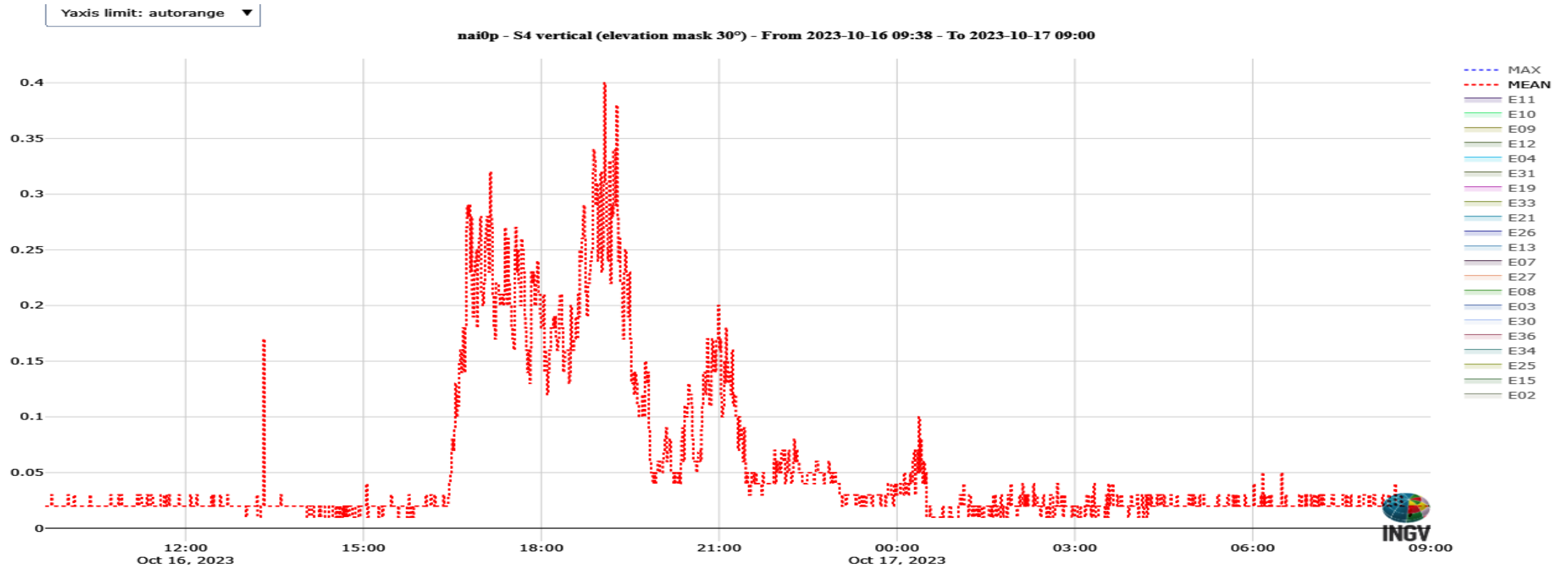


The above graph shows vertical TEC over a 24 hours period from 09:38 16/10/2023 to 09:00 17/10/2023. Peak TEC is observed between 09 and 15 UTC (12 to 18 LT). This can be attributed to increased solar radiation during the daytime, resulting in increased ionization of the atmosphere and/or EIA.



# Sample Data from KSA's GNSS Receiver cont...

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The above graph shows scintillation index over a 24 hours period from 09:38 16/10/2023 to 09:00 17/10/2023. A peak in scintillation is observed between 17 and 20 UTC (20 to 23 LT). This can be attributed to Post-sunset enhancement (PSE) or Equatorial plasma bubbles (EPBs).



# KSA's Spectramag-3 Magnetometer

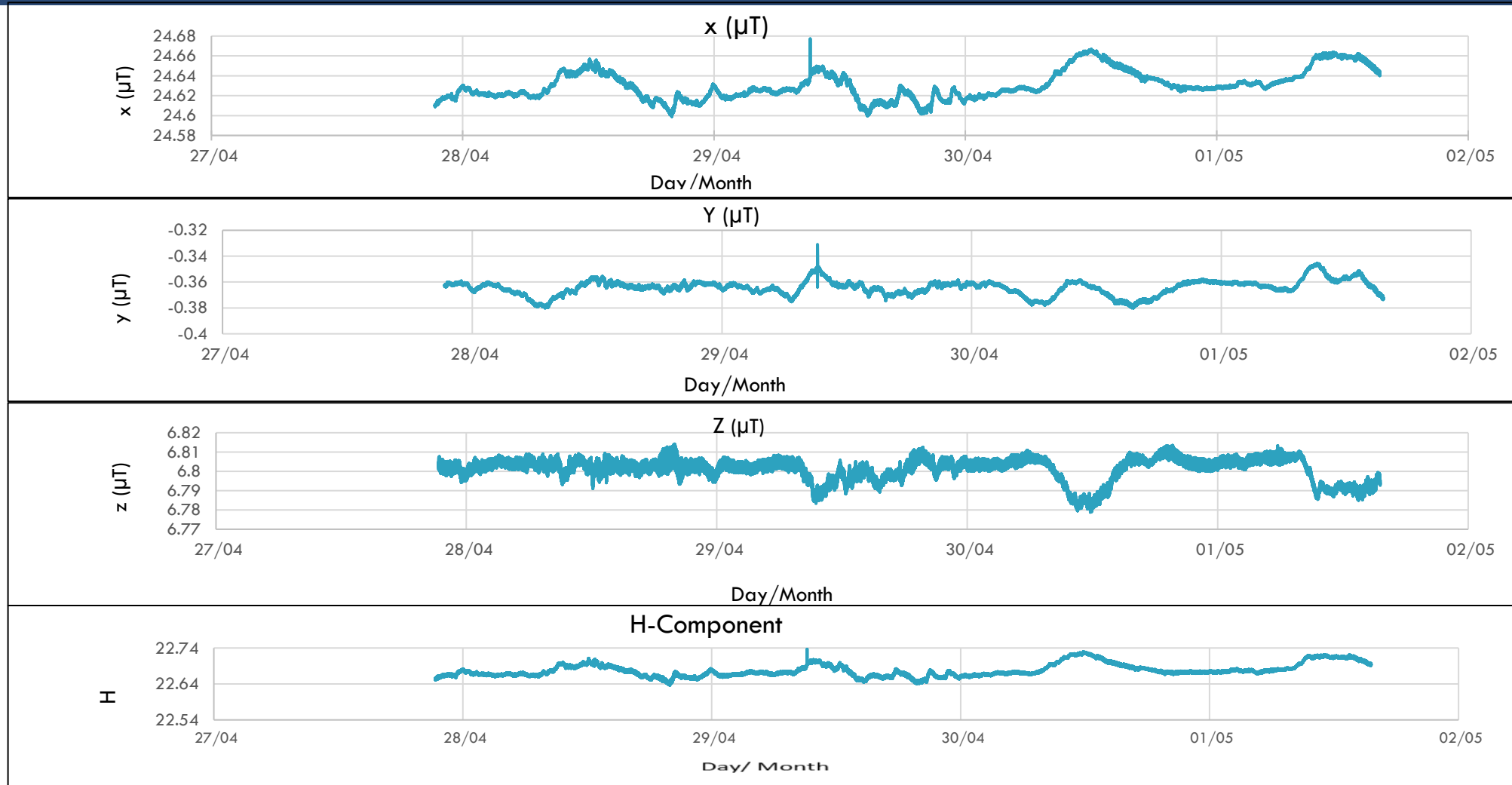
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- KSA installed a Magnetometer station in Wajir Airport (Spectramag-3 magnetometer) Lat:  $-1.73^{\circ}$  - Lon:  $40.08^{\circ}$
- The data collected by the magnetometer is hosted by the Agency and will soon be availed in the Agency's website and data portal





# Sample Magnetometer Data from Wajir Station

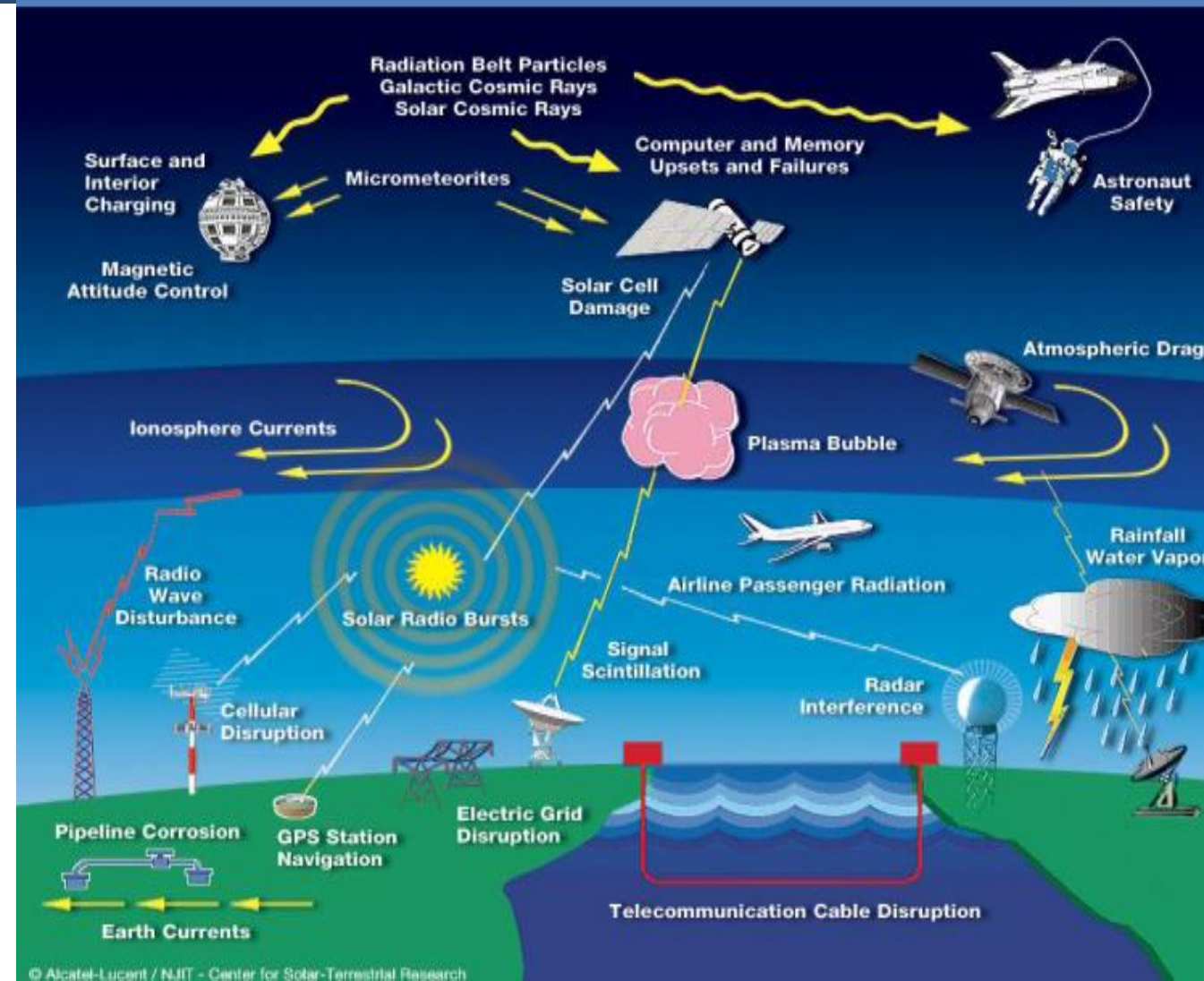


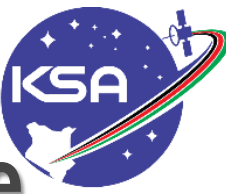




# Predicting Space Weather Events

- The KSA intends to use data from GNSS receiver and magnetometers to predict the likelihood of space weather events such as solar flares and geomagnetic storms.
- This information will be disseminated to relevant stakeholders
- Stakeholders can use this information to protect critical infrastructure and mitigate the impact of space weather events





# Benefits of the Operational Space Weather Programme

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- Benefits of the Operational Space Weather Programme include:
  - ▣ Improved space weather monitoring and prediction
  - ▣ Reduced risk to critical infrastructure
  - ▣ Enhanced disaster preparedness
  - ▣ Increased knowledge of space weather
  - ▣ Training of skilled workforce in space weather

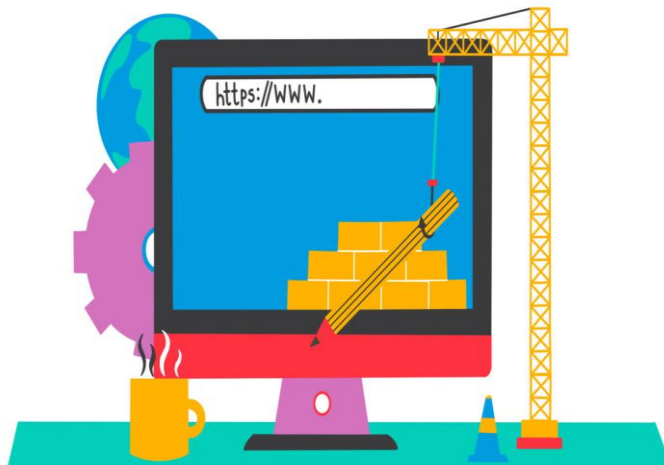


# Disseminating space weather information

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- The KSA intends to disseminate space weather information through a variety of channels

The KSA website



Email alerts



Direct communication with stakeholders





# Capacity Building

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- KSA supports capacity building workshops on GNSS and Space Weather. Workshops that have been supported by the Agency include:
  - ▣ The East African Global Navigation Satellite System and Space Weather workshop on 13-17 May 2019
  - ▣ East African GNSS and Space Weather capacity building workshop on 21-25 June 2021
  - ▣ ICTP African capacity building workshop on Space Weather Effects on GNSS on 3-14 October 2022
  - ▣ East African capacity building workshop on Space Weather and low latitude ionosphere on 3-12 October 2023
- KSA will host the 2024 International Reference Ionosphere Capacity Building Workshop





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# Conclusion

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- The Operational Space Weather Programme is an important step in ensuring that Kenya is prepared for the challenges of space weather
- The next steps of the Programme involve:
  - ▣ Completion of deployment of sensors for the space weather monitoring network
  - ▣ Collaboration with the consortium of universities in developing a space weather prediction model
  - ▣ Engagement of stakeholders to develop mitigation strategies and contingency plans for space weather events



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# Acknowledgement

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The Agency would like to acknowledge the following organizations for their support of the Operational Space Weather Programme:

- The Government of Kenya
- Taita Taveta University
- University of Eldoret
- Dedan Kimathi University of Technology
- Pwani University
- National Institute of Geophysics and Volcanology (INGV)
- Italian Space Agency (ASI)



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Thank  
you for  
Listening



Comments/  
Questions?