Space Weather: South Africa's abilities and capabilities

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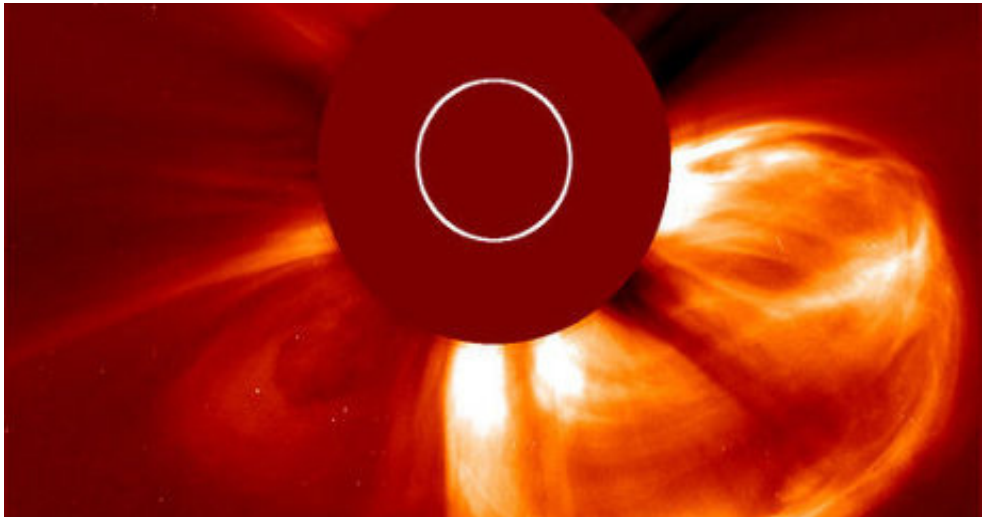
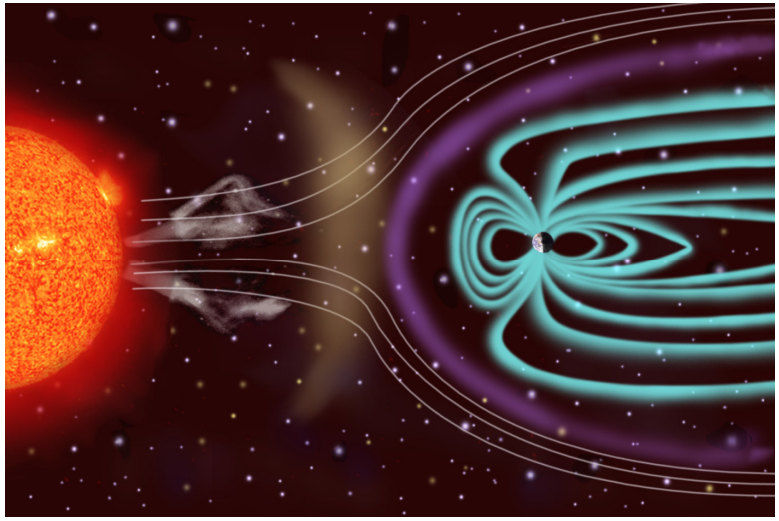
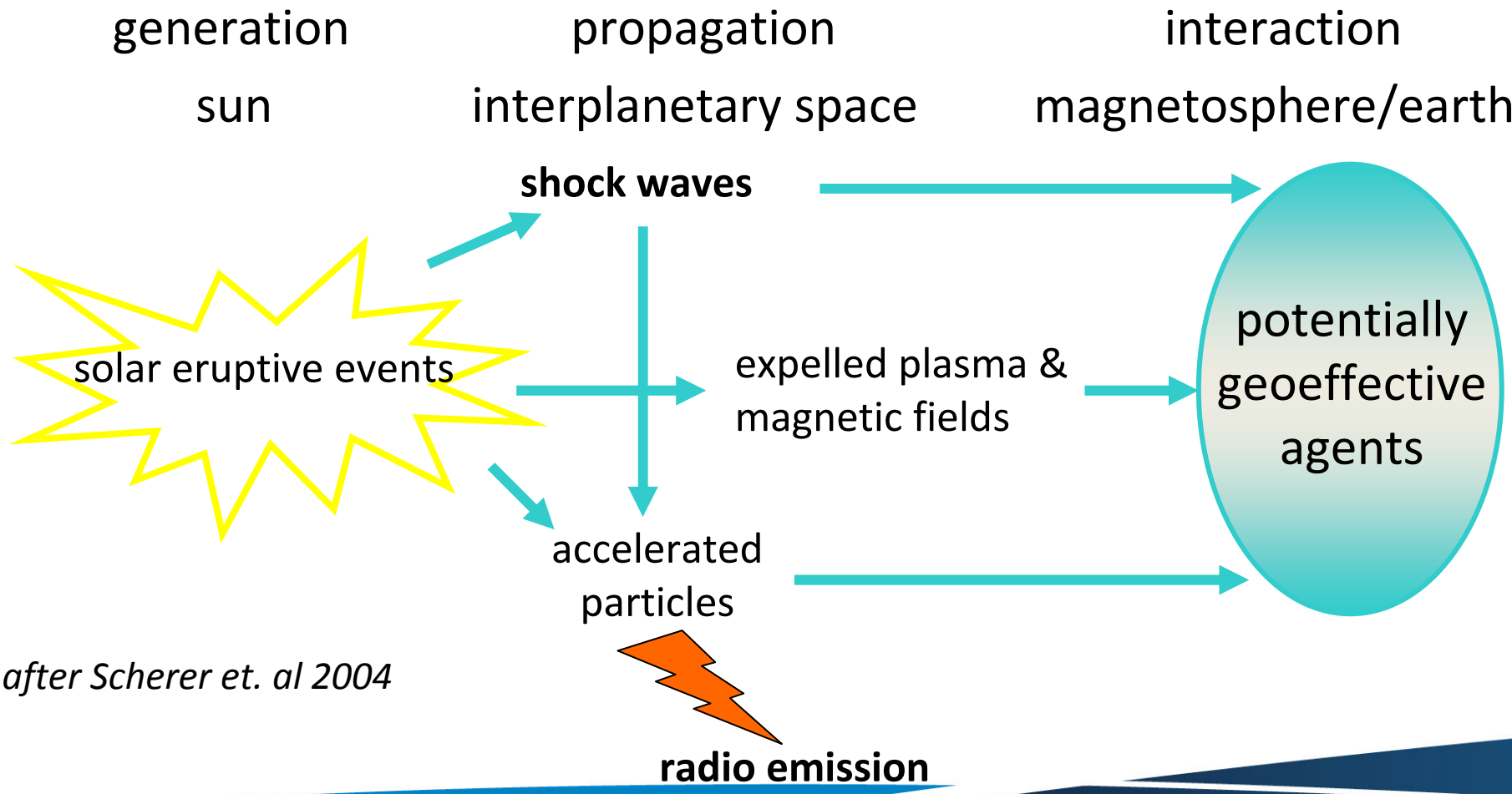
Space Weather

- Conditions on the Sun and in space that affect the Earth and its technological systems.
- Eruptive events from the Sun (e.g. solar flares and coronal mass ejections (CMEs)) are the main drivers of space weather.





Space Weather Elements



after Scherer et. al 2004

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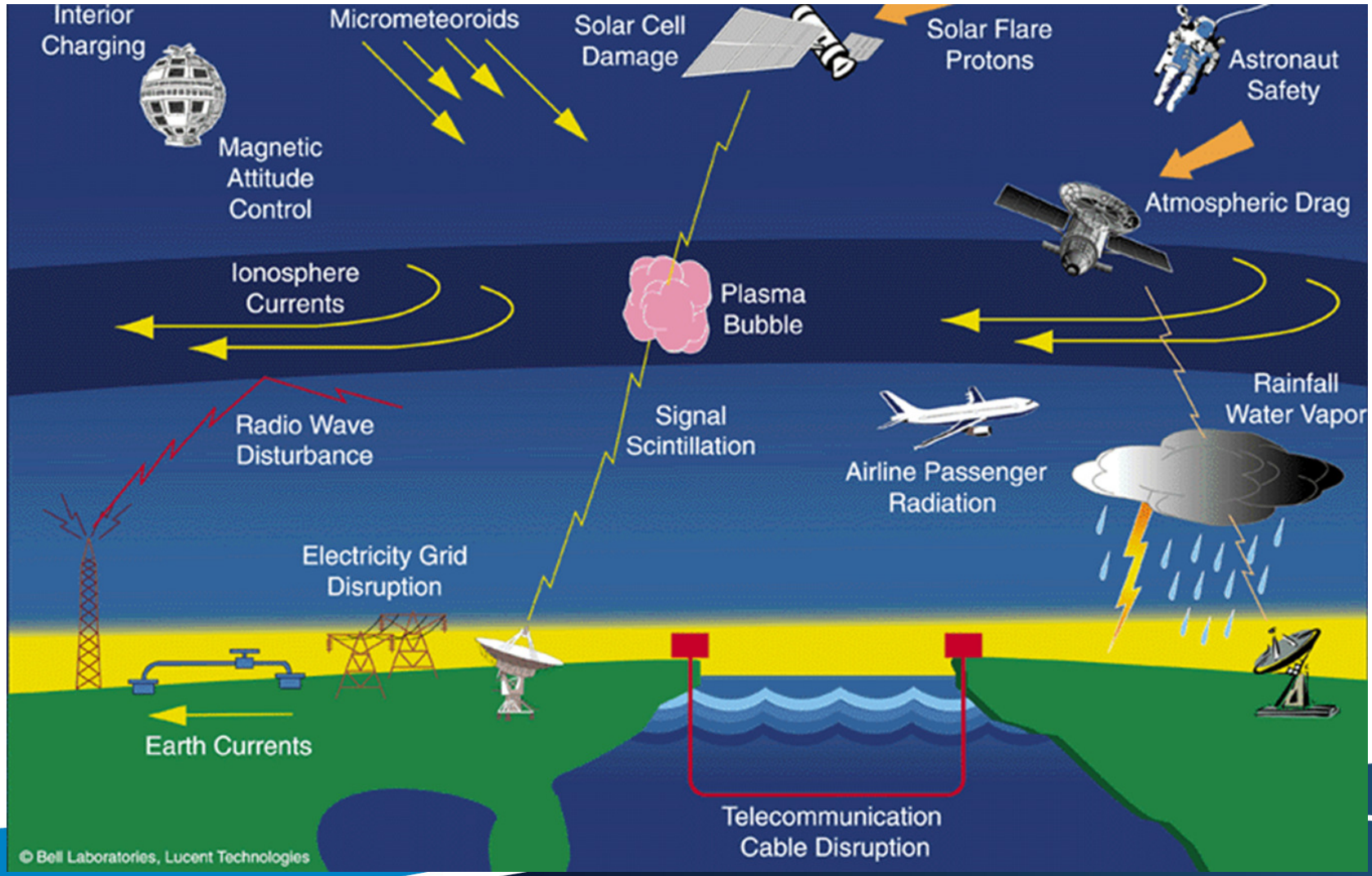
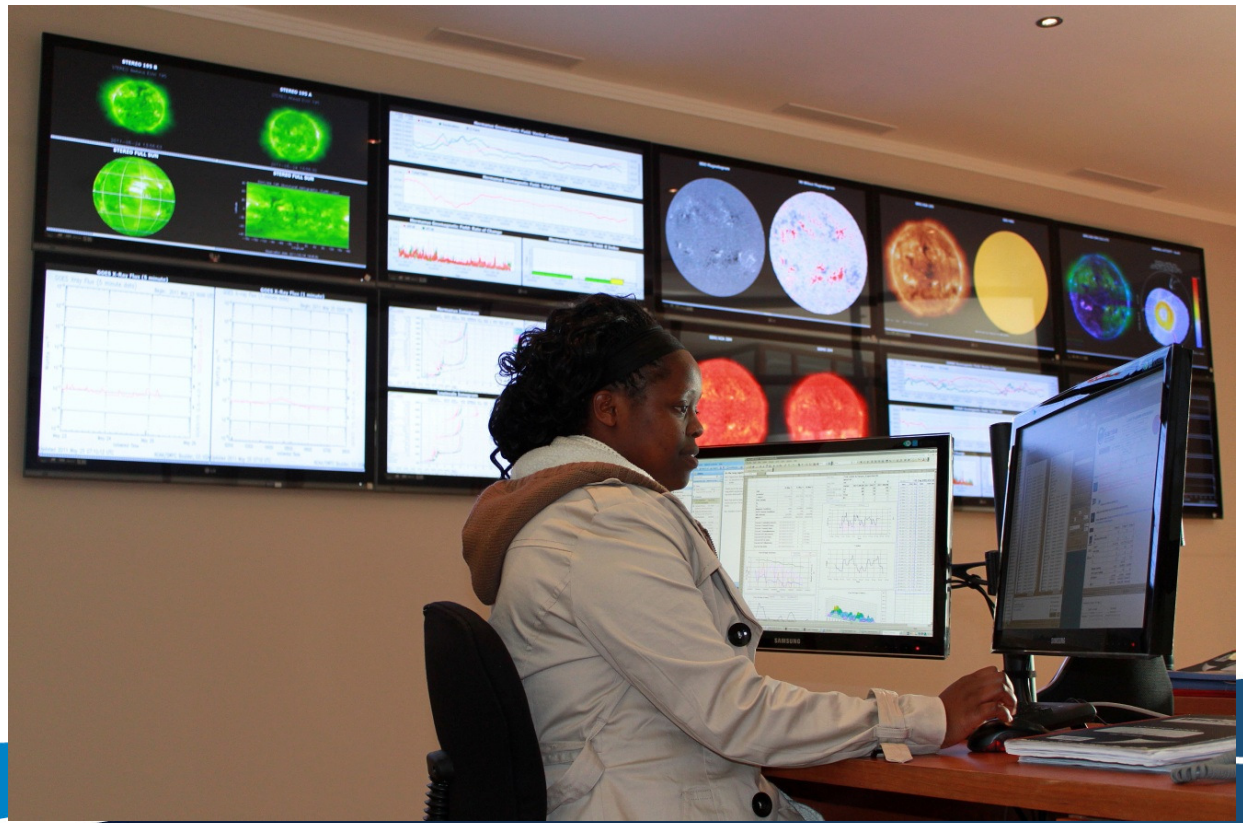
Space Weather Effects on Technology



Regional Space Weather Warning Centre For Africa at SANSA

- Part of the International Space Environmental Service (ISES)
- Provides important service to the nation by providing information, early warnings and forecasts on space weather conditions:
  - Products and services used mainly by defence, aeronautics, navigation and communication sectors

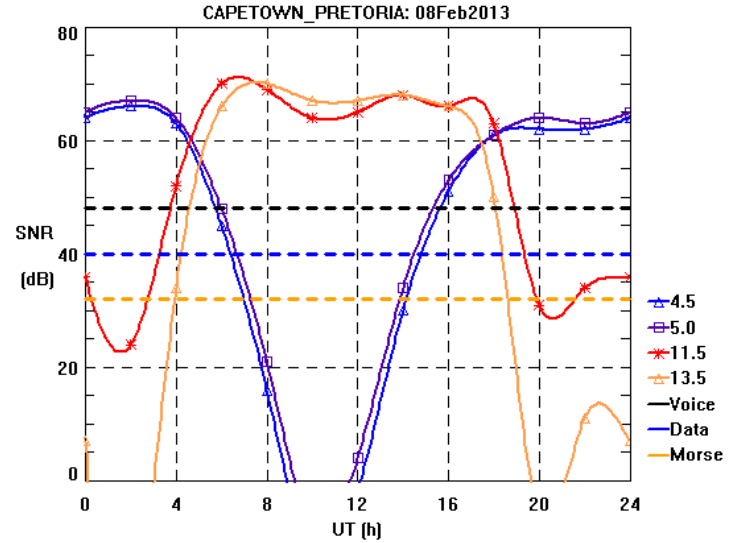


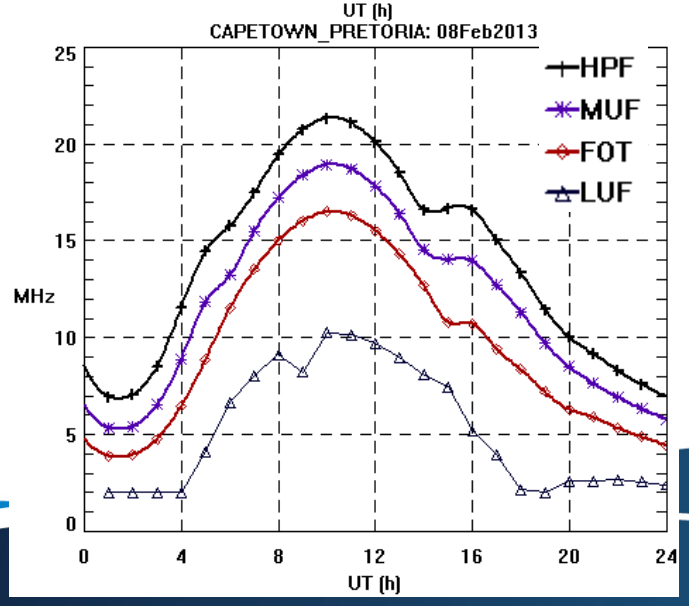
Space Weather Centre Products: Example

	08-Feb-13	09-Feb-13	10-Feb-13
SSN	45	37	37
Solar Index (WCI for preds)Se*	52	50	48
T-Index**	30 to 105/60	30 to 105/53	30 to 105/46
Solar Activity	moderate	low to moderate	moderate
Q_{fe}	4.1	5.3	6.1
A_p	8.0	12.0	15.0
Magnetic Conditions	Quiet to Unsettled	Unsettled	Unsettled to Active
SA HF Comms Conditions	fair	fair	fair
SW Fadeouts	unlikely	unlikely	unlikely
MUFs***	unstable	unstable	unstable

Current T-Index(Hermanus) -	2013/02/07 11:00SAST	is	58.8
Current T-Index(G/Town) -	2013/02/07 11:00SAST	is	56
Current T-Index(L/Vale) -	2013/02/07 08:00SAST	is	50
Current T-Index(Madimbo)-	2012/07/31 22:30SAST	is	N/A
Current foF2 (Hermanus) -	2013/02/07 09:00UT	is	8.050 MHz
Current foF2 (G/Town) -	2013/02/07 09:00UT	is	8.163 MHz
Current foF2 (L/vale) -	2013/02/07 06:00UT	is	6.262 MHz
Current foF2 (Madimbo) -	2012/07/31 20:30UT	is	N/A MHz
Current Ap-Index -	2013/02/07 11:14SAST	is	3

Green border - OK, Yellow border - beware, Red border - problems for HF comms.





Impact on Economy
Examples

- Solar and geomagnetic storms prediction and reporting:
  - allows for rescheduling of satellite launches
  - reduces cost of doing costly magnetic surveys during disturbed periods
  - minimise unnecessary call-outs for apparent (temporary) problems with Satellite TV, Microwave links, Internet service
- GPS total electron content (TEC) and scintillation status reports permits mitigation of navigation errors in applications such as European Geostationary Navigation Overlay System (EGNOS)
- Radio propagation prediction optimises the efficiency of long distance communication using High Frequency (HF) radio.

Impact on Economy: Power Systems

- Space weather centre will provide critical information that could be used to mitigate space weather effects on our power system:
  - Prediction of geomagnetic storm impacts permits power system reconfiguration to minimise transformer failures during a space weather storm,
  - Reporting of geomagnetic storm status assists power companies to better manage power cuts and power redistribution during space weather storms,
  - Modeling of the distribution of impacts on power systems allows better localization of costly mitigation measures such as system hardening and series capacitors,
  - Prediction of radiation storms allows for mitigation of space weather impact on communication and control systems used in power management.

History: Magnetic Observatory

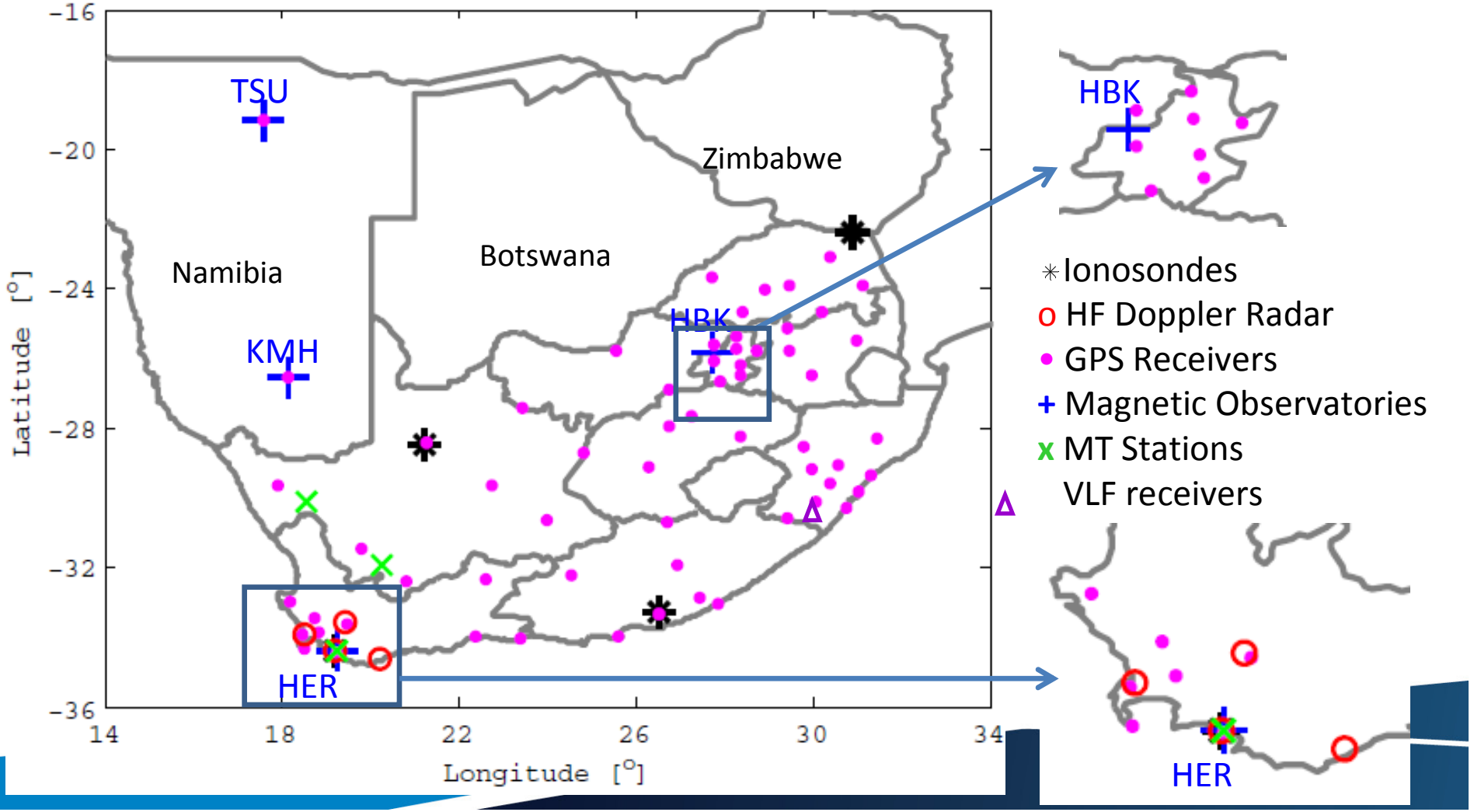
Year	Event
1932	Prof Ogg at UCT established a magnetic observatory (in response to International Commission for the Polar Year)
1937	Magnetic Observatory placed under Trigonometrical Survey Office, Department of Lands
1941	Magnetic Observatory relocated to Hermanus (to escape the disturbing effects of the electric railway system)
1969	Magnetic Observatory incorporated into the CSIR
1987	Some of HMO's services commercialised as a result of CSIR commercialisation
2001	HMO declared a National Facility and transferred to the NRF
2011	HMO migrates to the South African National Space Agency (SANSA)

- Geomagnetic data used as input for global disturbance storm time (Dst) index
  - Major magnetic activity index that is widely used in the space science community
  - HERMANUS one of only four stations used

Available Infrastructure

- Proven track record of measuring space from the ground:
  - Outer space:
    - Neutron Monitor
  - Magnetosphere:
    - Superconducting Quantum Interference Device (SQUID), Magnetometers, Magnetotelluric (MT) stations, Lightning Detectors
  - Ionosphere:
    - GPS receivers (dual frequency and scintillation), Ionosondes, High Frequency (HF) Doppler Radar, HF Radar and VLF receivers
  - Lower Atmosphere:
    - Radio Ionospheric Opacity Meter (Riometer) and Lidar

Distribution of Instruments: Southern Africa



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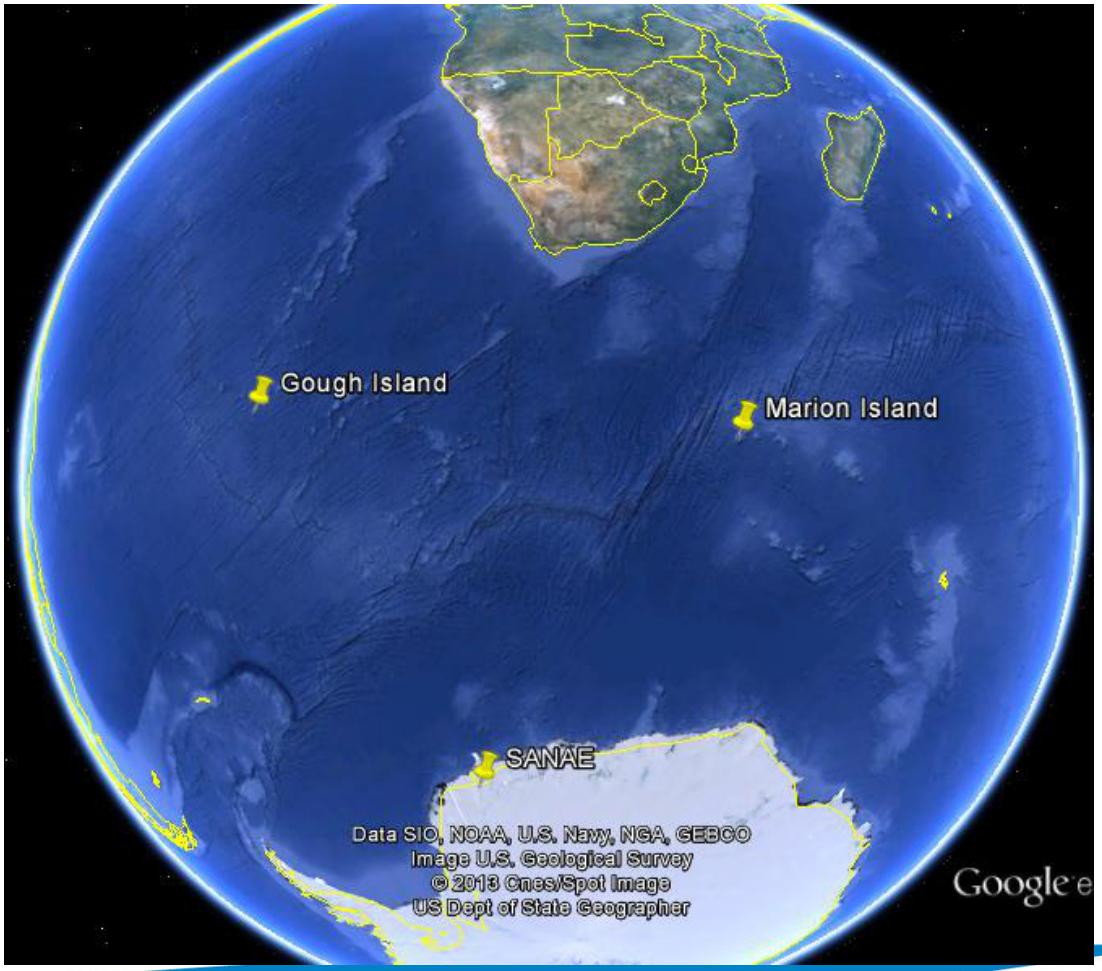
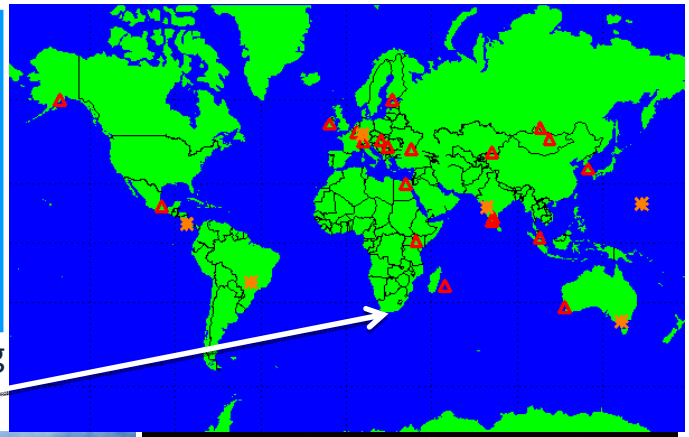
Distribution of Instruments: Remote Areas



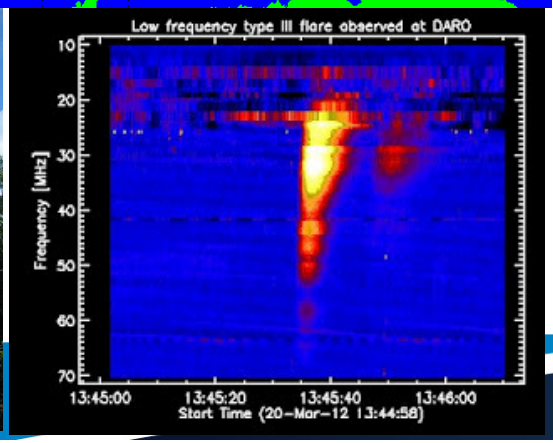
Infrastructure Expansions in Progress

8 MT stations, 3 GPS receivers, 1 HF Doppler system and 1 Spectrometer receiver for e-Callisto network, 1 Solar Telescope

Compound **A**stronomical **L**ow-cost **L**ow frequency Instrument for **S**pectroscopy and **T**ransportable **O**bservatory



e-Callisto station coming soon in Hermanus



MT Station

Conductivity profiles obtained with MT units

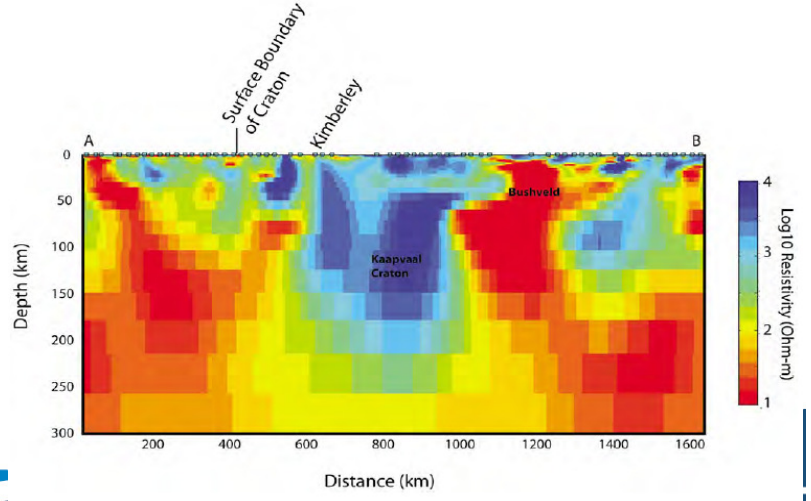
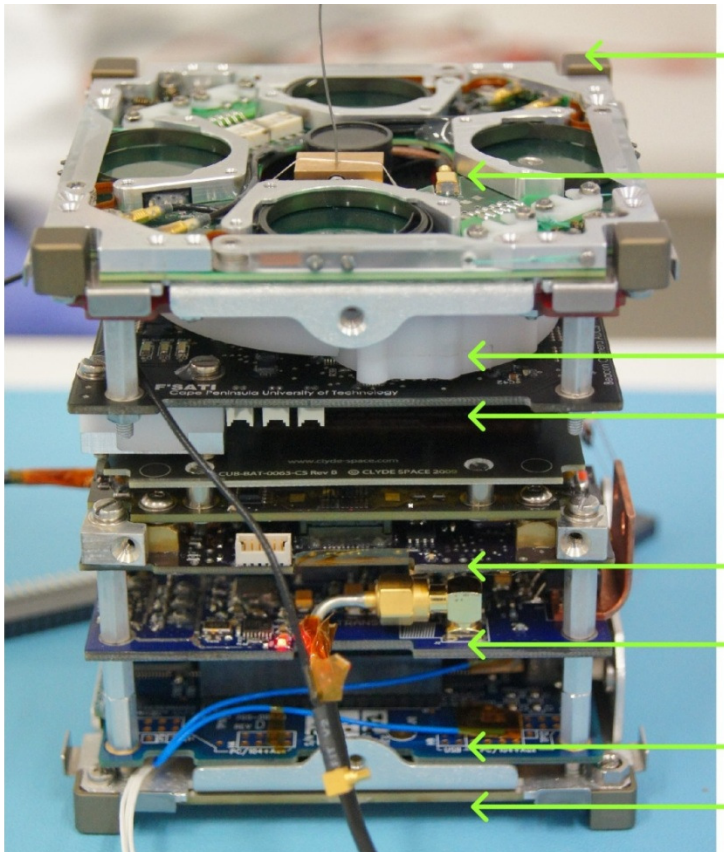


Figure 3. An isotropic inversion model of the main SAMTEX profile across the Kaapvaal craton and surrounding terranes. Points A and B are as shown in Figure 1. Labeled are the resistive root of the Kaapvaal craton and the highly conductive mantle beneath the Bushveld Complex.

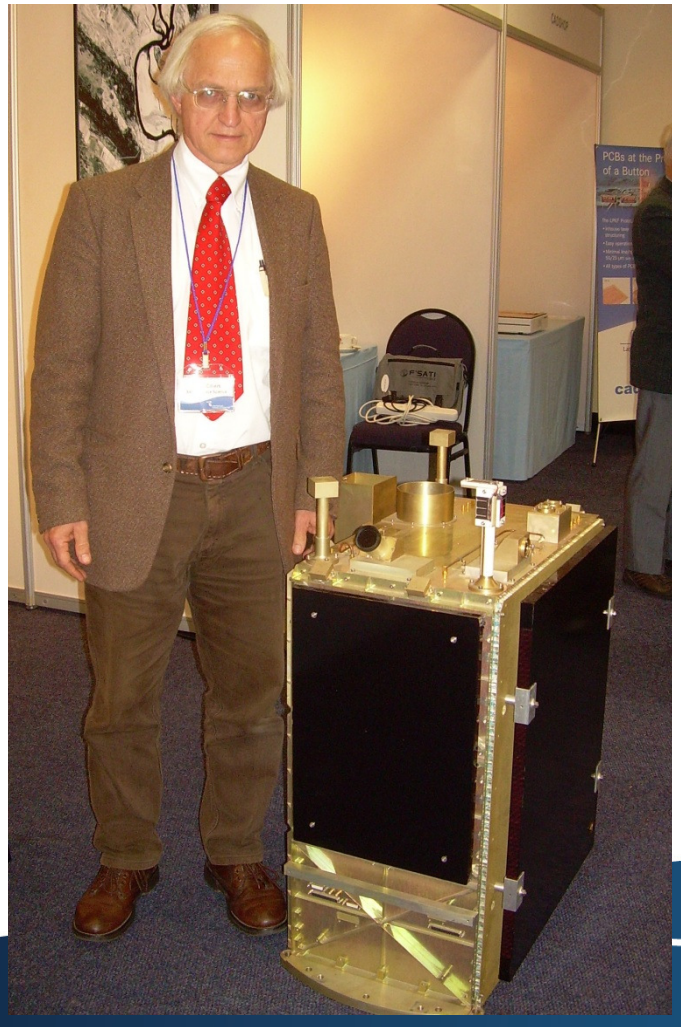
Nanosatellite Mission: ZACUBE-1



- Specifications
  - 10x10x10 cm, 1.3 kg
- Designed and built by postgrad students at Cape Peninsula University of Technology in partnership with SANSA and University of Stellenbosch
- Has an HF Beacon to calibrate the HF Radar (SuperDARN) at SANAE
- Launched by Russia early April 2013

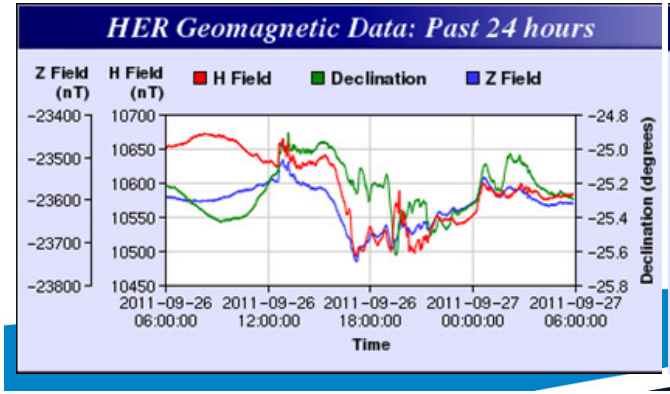
Microsatellite Missions: IBSA

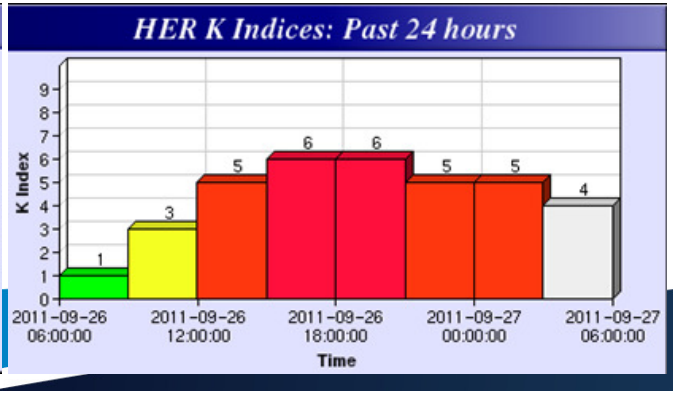
- Decision by Science and Technology Ministers of India, Brazil and South Africa (IBSA) in Oct 2009 for joint satellite development
- IBSA -1: Space weather satellite; IBSA-2: Earth Observations
- IBSA-1 mission:
  - South Atlantic Magnetic Anomaly
  - Observations of Magnetic Field
  - Plasma parameters
  - Energetic particles
  - Electron precipitation
  - Beacons for tropospheric scintillation and attenuation
  - Ionospheric research
  - Aurora camera
- Contribution of each country:
  - India: Launch
  - Brazil: Primary instruments
  - South Africa: Satellite bus and secondary instruments

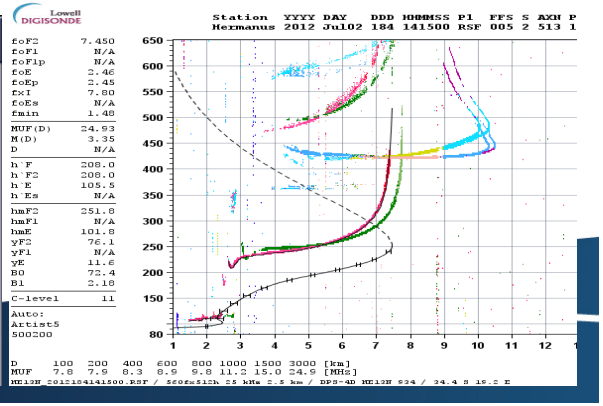


Space Weather Measurements

- Quality ensured data
  - Measurements used in developing global and national models
- Several of our data is used in real-time to monitor space weather
  - K index from local magnetometer stations (HER, SANAE)
  - Ionosonde measurements
- Several of our data contribute to the global community for space weather modeling
  - Ionospheric Predictions Service (IPS, Australia)
  - Space Environment Centre (USA)
  - Ionospheric models (e.g. International Reference Ionosphere (IRI))

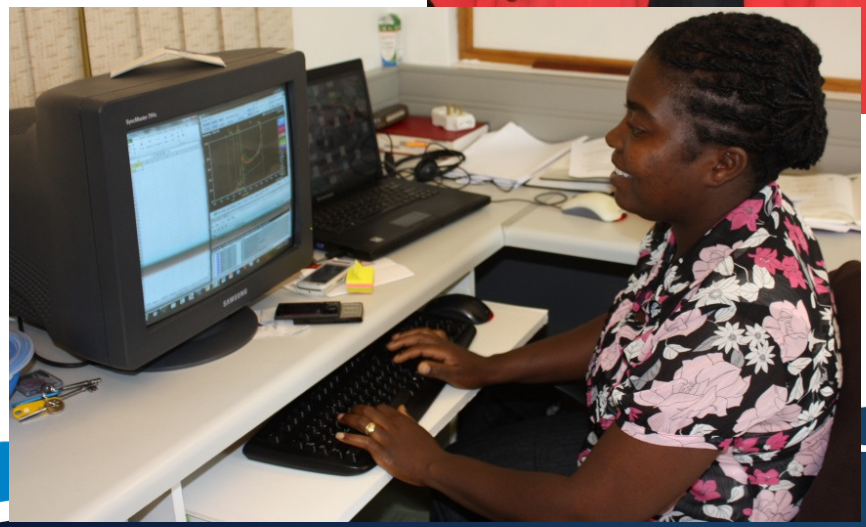






Skills Development: Students

- Contributing to skills development in South Africa and Africa:
  - Postgraduate student supervision
  - University courses in space physics
  - Annual summer and winter schools



Skills Development: Africa

- Workshops in space weather for African scientists
  - International Reference Ionosphere (IRI) workshop, 10-14 Oct 2011
  - Ionospheric Monitoring: Africa, 24-25 Jan 2013
  - International Space Weather Initiative (ISWI)/Scientific Committee on Solar-Terrestrial Physcis (SCOSTEP) School on Space Science, 31 Aug – 09 Sep 2013
  - Scintillation Network Decision Aid (SCINDA), 31 Aug – 09 Sep 2013
- Collaborate on scientific projects
  - Integrating data from several countries with space weather capabilities for space modeling
  - Cote d'Ivor, Ethiopia, Kenya, Madagascar, Namibia, Nigeria, Rwanda, Uganda and Zambia

International Collaborations

- Supply data to global and national community for space weather purposes:
  - World Data Centre (WDC) System
  - INTERMAGNET
  - Global Digital Ionogram Database (DiDBase)
  - Space Physics Interactive Data Resource (SPIDR)
  - e-CALLISTO network
  - South African National Defence Force (SANDF)
  - Scintillation Network Decision Aid (SCINDA)
- Collaborate on space weather projects:
  - Geomagnetically Induced Currents (GIC)
    - Canada, Finland, Kenya, Namibia, Sweden and USA
  - Satellite based Aircraft Landing Augmentation system (EGNOS)
    - SANSA Space Operations, ESA
  - Improvements of ionospheric storm time models
    - USA, Europe, International Telegraphic Union (ITU)

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