Space Science Research, Training and other Related Activities at SANSA: Opportunities for Africans

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Research Physicist: SANSA Space Science

Outline

SANSA History

SANSA Mandate and structure

SANSA Activities & instruments

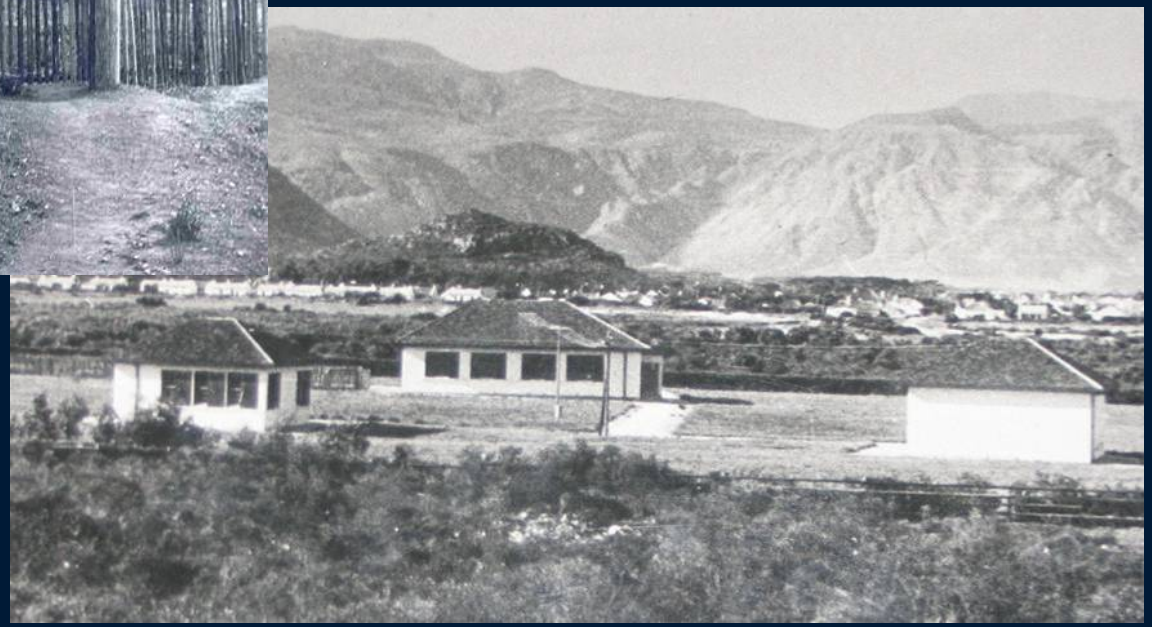
SANSA Opportunities for Africans

SANSA History

2nd International Polar Year (1932-33)

First magnetic observatory in South Africa established on UCT campus – moved to Hermanus in 1941.

Buildings on UCT campus which housed the fist magnetic observatory instruments.



The HMO's first buildings on the outskirts of Hermanus in 1941

HMO to SANSA Space Science

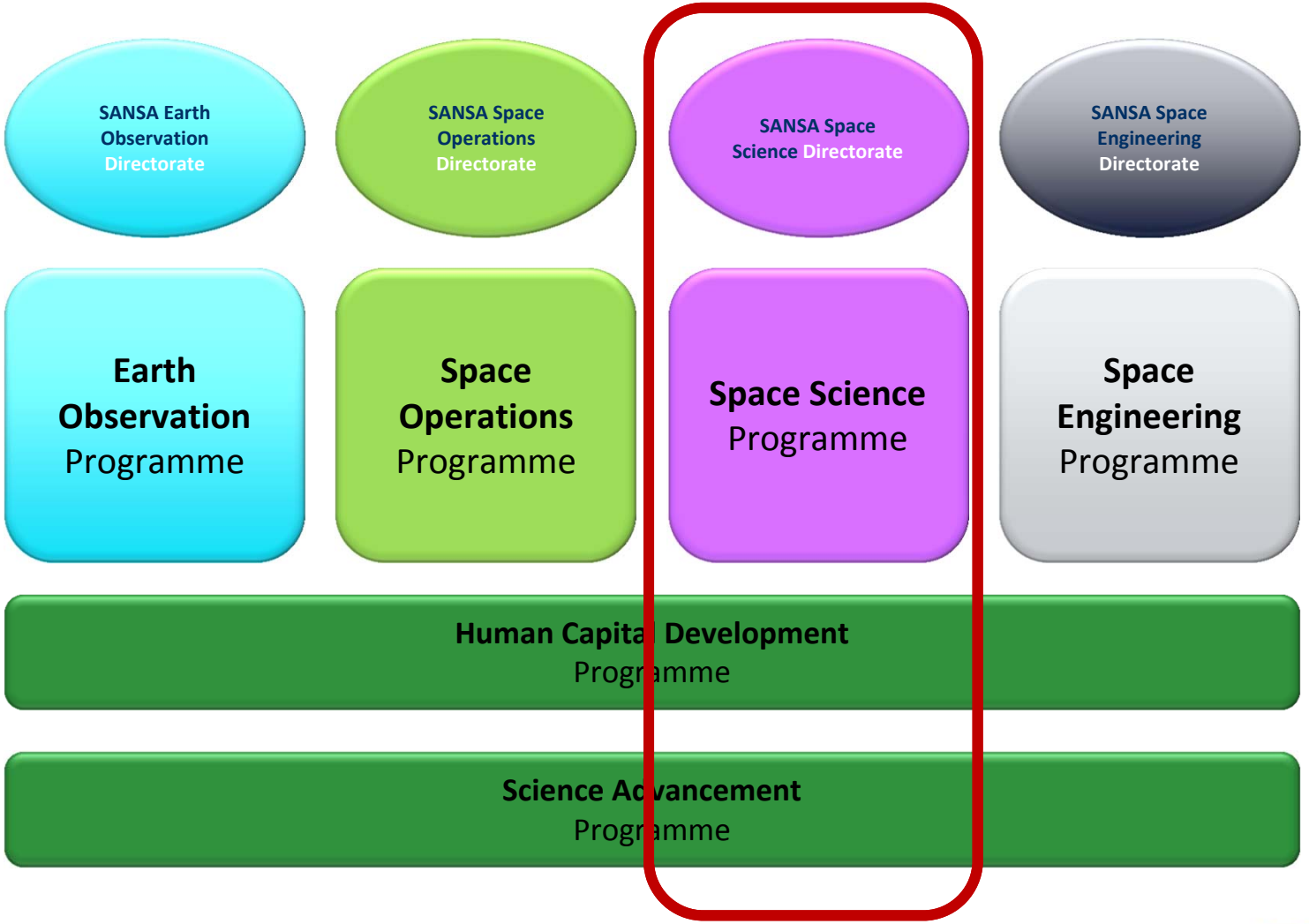
Year	Event
1932	Prof Ogg at UCT established a magnetic observatory (in response to International Commission for the Polar Year)
1937	Magnetic Observatory placed under Trigonometrical Survey Office, Department of Lands
1941	Magnetic Observatory relocated to Hermanus (to escape the disturbing effects of 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
2002	HMO mandate expanded to include student training
2011	HMO migrates to the South African National Space Agency (SANSA)

SANSA Mandate & Structure

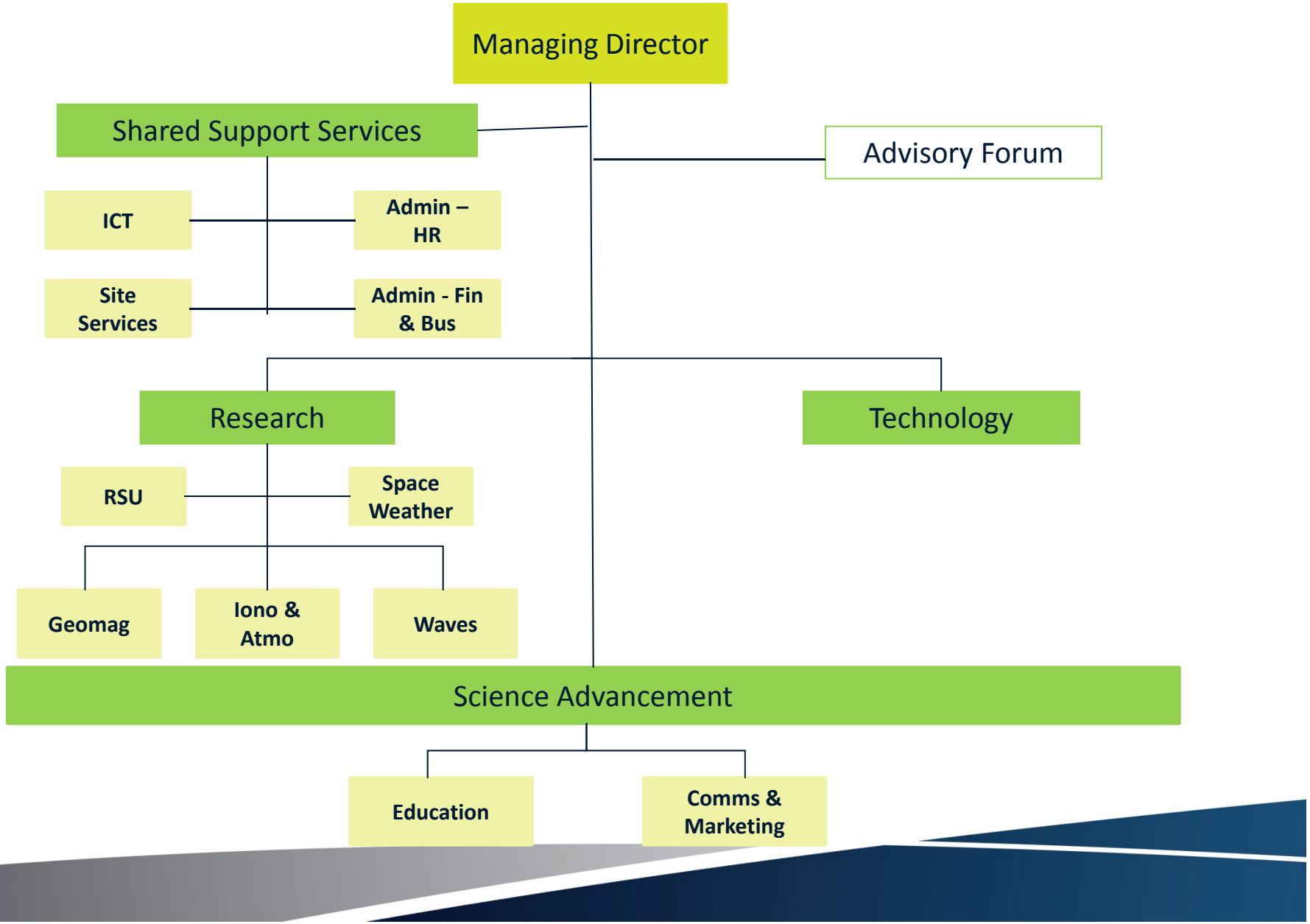
Legislative Mandate (SANSA Act)

"...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..."

STRATEGIC PROGRAMMES



SPACE SCIENCE STRUCTURE



SANSA SPACE SCIENCE Hermanus

The Space Science Directorate of SANSA is part of the worldwide network of magnetic observatories and is responsible for research infrastructure and data used to monitor the near Earth space environment. The scope of activities include fundamental and applied space physics research, post-graduate student training, science advancement, Space Weather and the provision of geomagnetic field related services on a commercial basis.

SANSA SPACE SCIENCE

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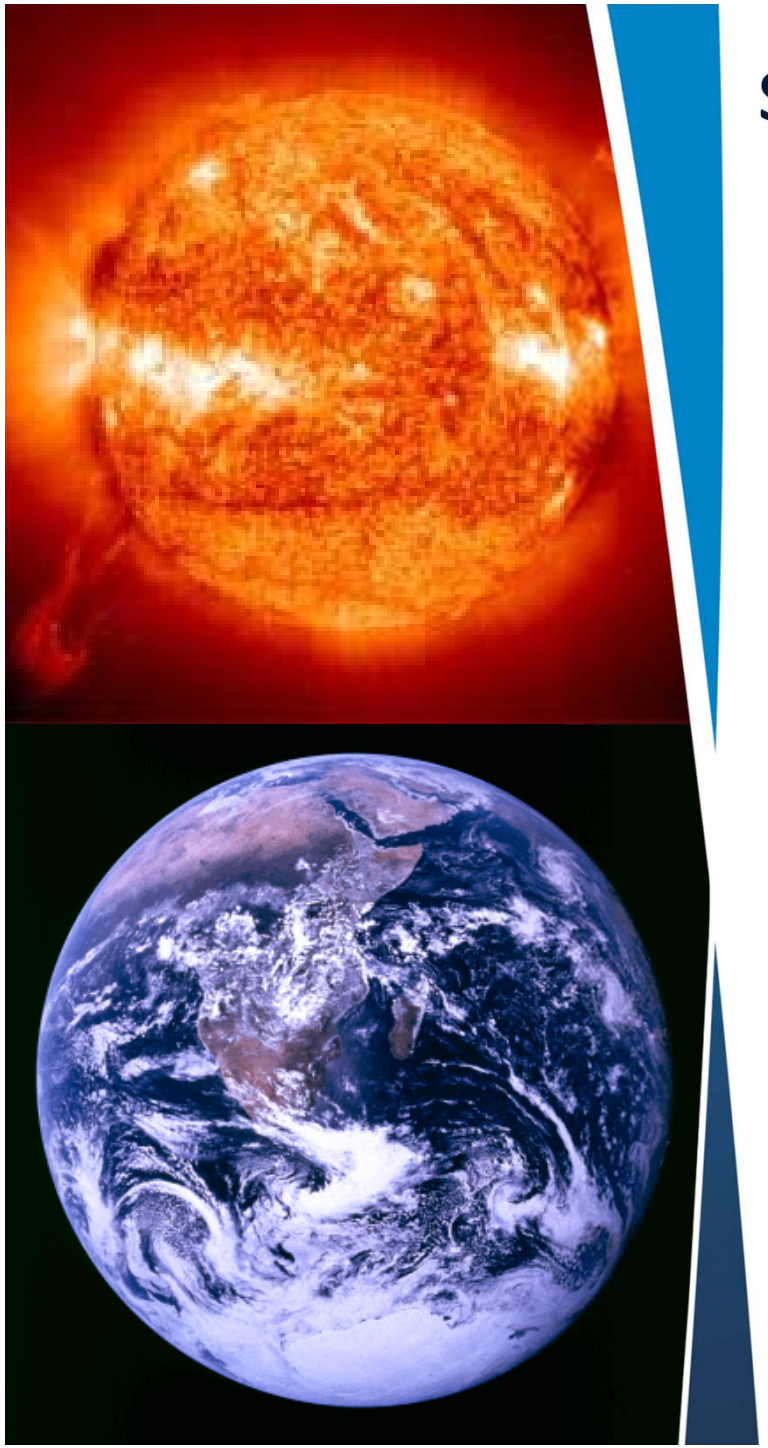


SANSA SPACE SCIENCE PROGRAMME

SANSA Space Science Mandate

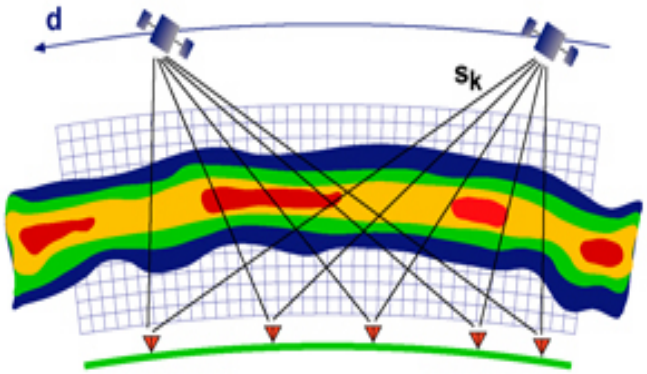
- Knowledge creation
- Knowledge utilization – applied science services e.g. space weather services
- Knowledge distribution – publications & other research outputs
- Knowledge impartation - student & personnel training (transferable skills)

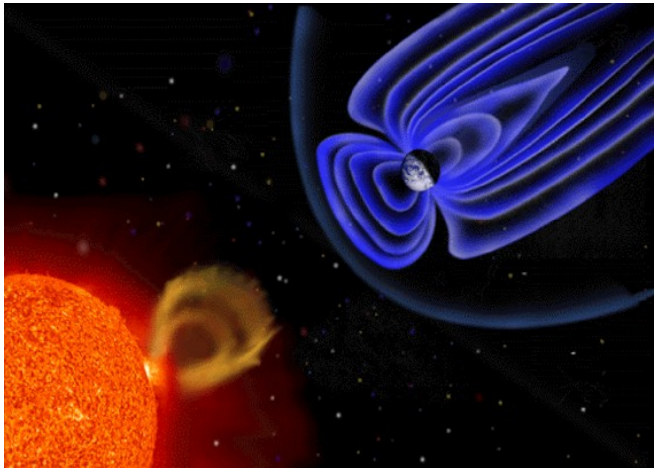
sansa
SOUTH AFRICAN NATIONAL
SPACE AGENCY

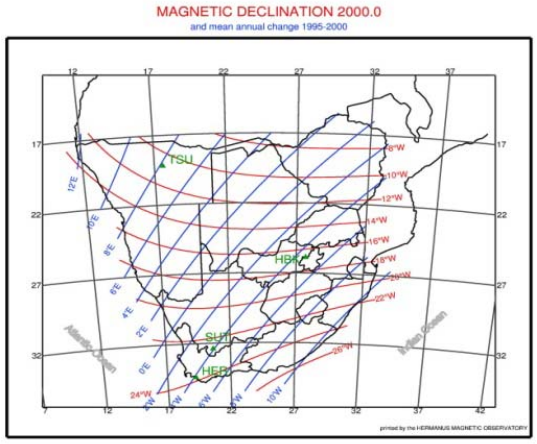
Activities & Instruments

SCIENCE RESEARCH & APPLICATIONS

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

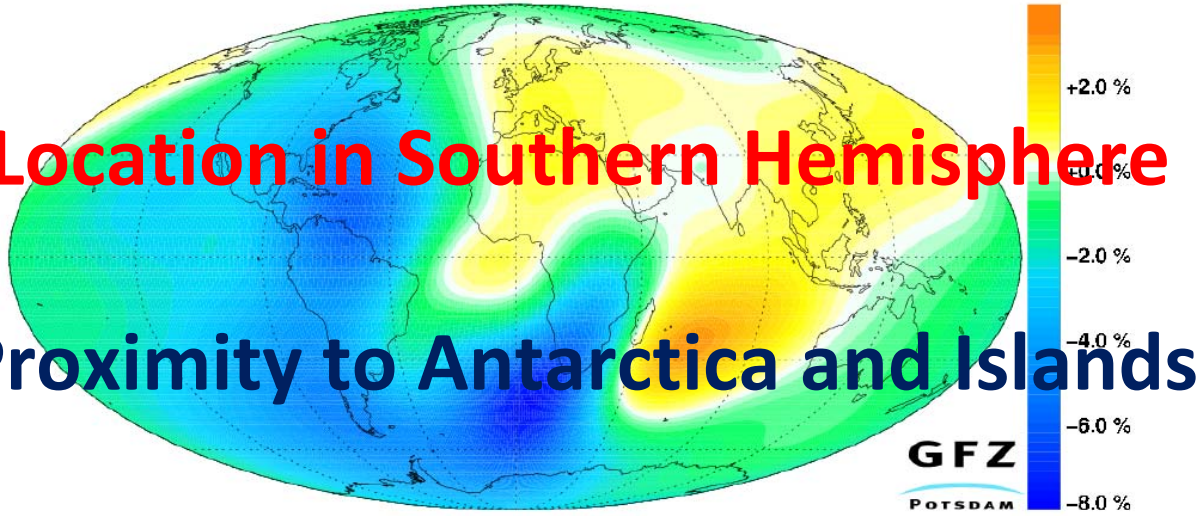






EARTH-SPACE SCIENCE IN A GEOGRAPHICALLY ADVANTAGEOUS REGION

South Atlantic Anomaly

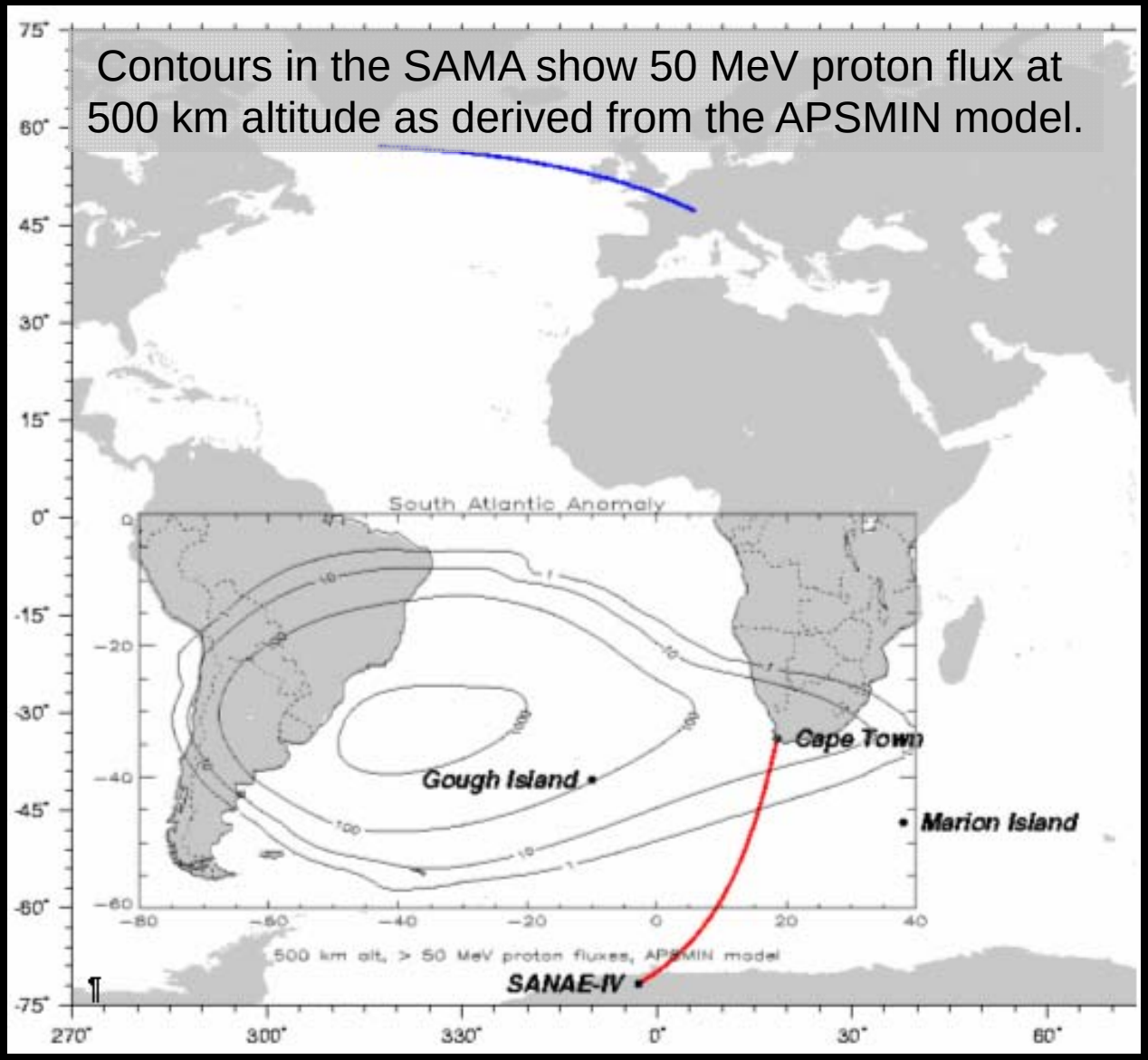


Location in Southern Hemisphere

Proximity to Antarctica and Islands

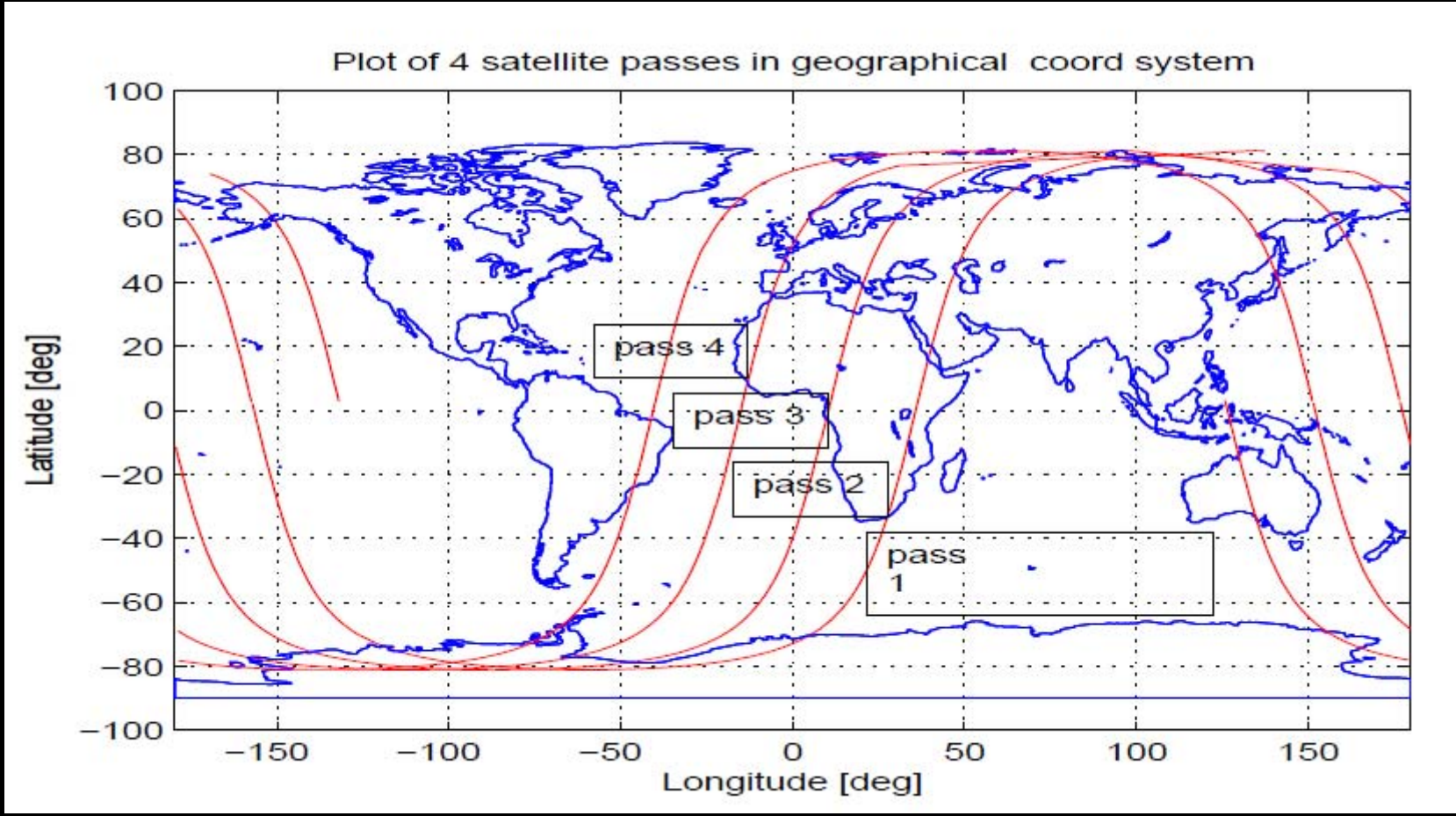
On the African continent

South Atlantic Magnetic Anomaly (SAMA)



South Atlantic Magnetic Anomaly (SAMA)

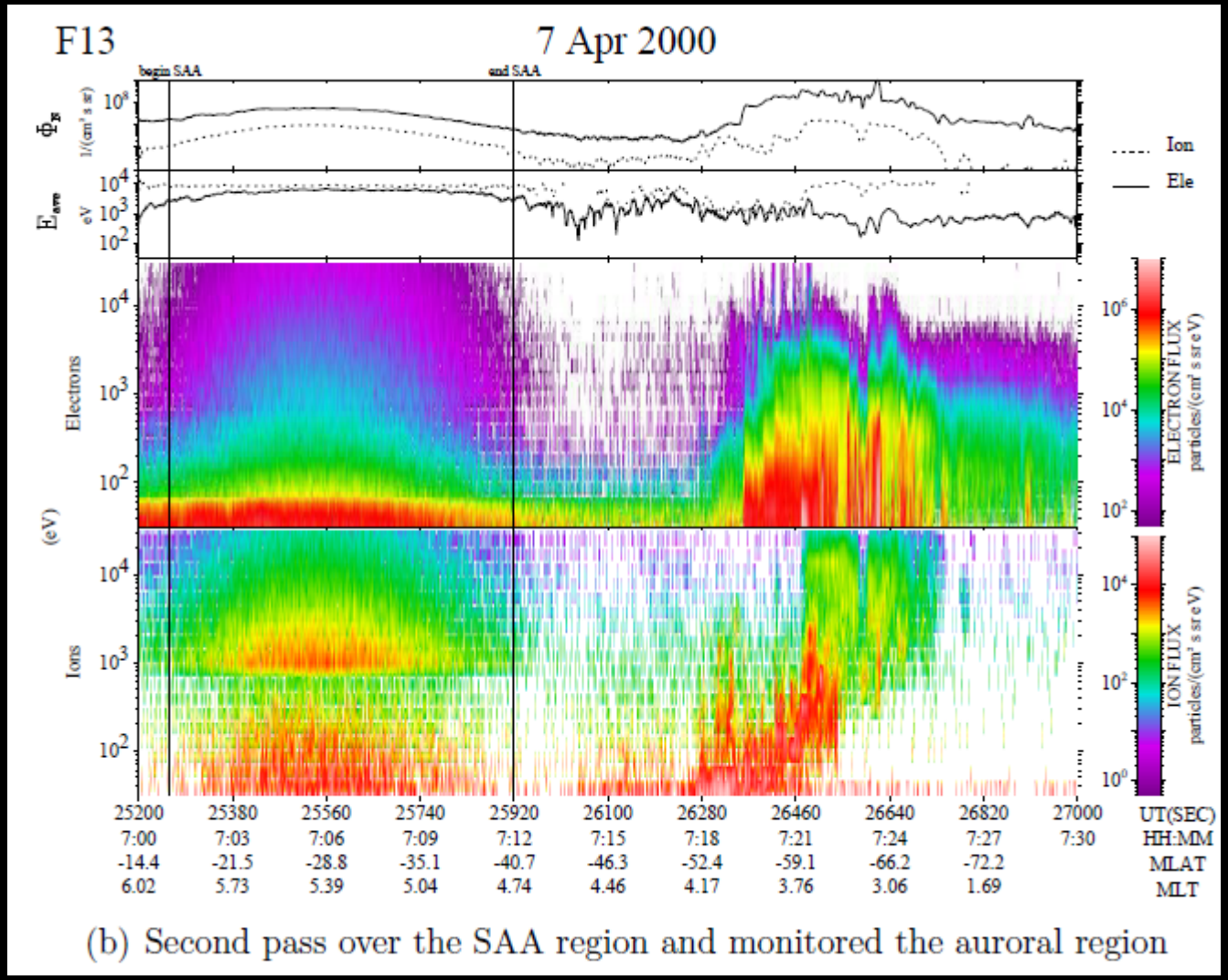
Particle precipitation over the South Atlantic Anomaly



Patrick Sibanda MSc Dissertation 2006

South Atlantic Magnetic Anomaly (SAMA)

Particle precipitation over the South Atlantic Anomaly



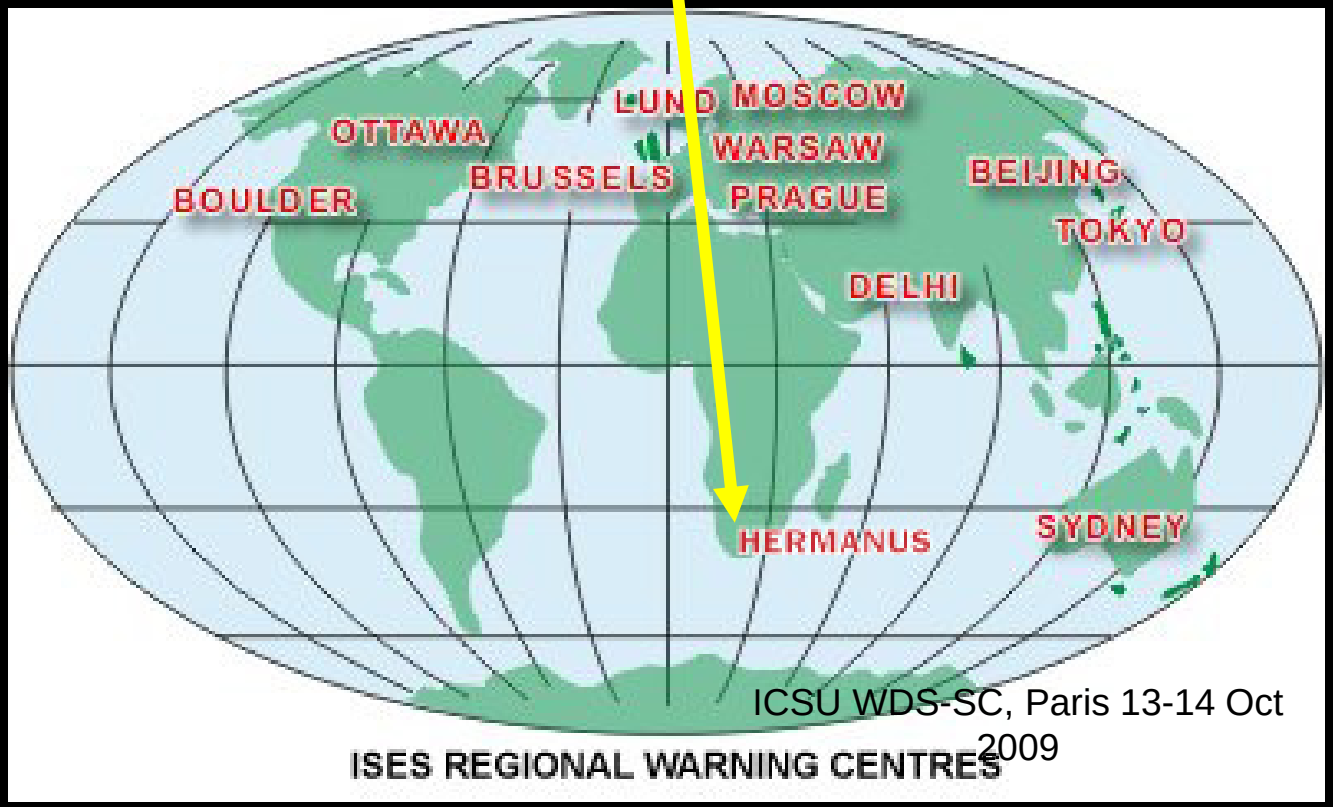
(b) Second pass over the SAA region and monitored the auroral region

Patrick Sibanda MSc Dissertation 2006

SANSA Space Weather Centre

International Space Environment Service (ISES)

Regional Warning Center (RWC) for Africa

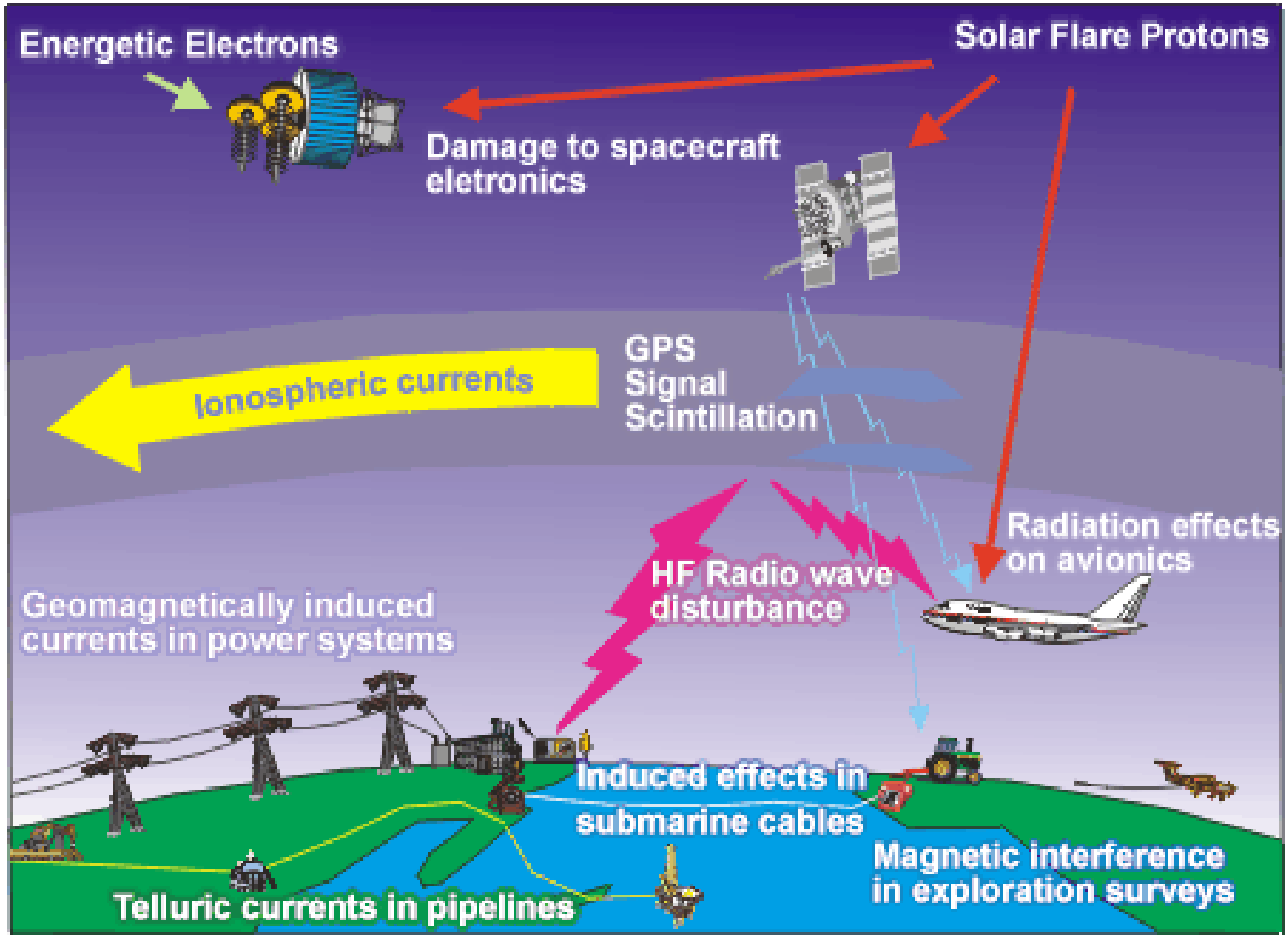


ICSU WDS-SC, Paris 13-14 Oct 2009

Hermanus RWC Established June 2007

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

SPACE WEATHER EFFECTS ON TECHNOLOGY



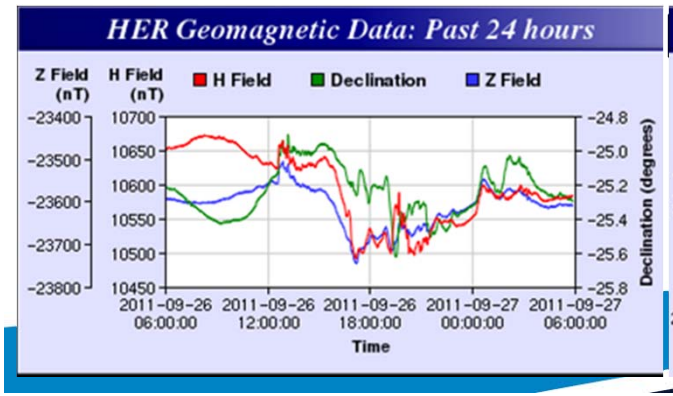
http://www.spaceweather.gc.ca/tech/se-eng.php

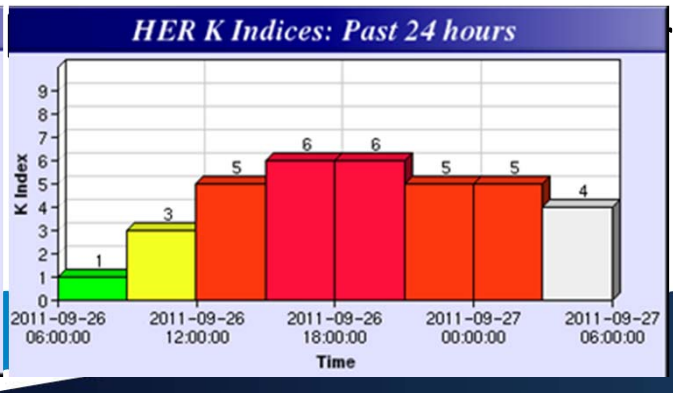
REGIONAL SPACE WEATHER WARNING CENTRE FOR AFRICA AT SANSA

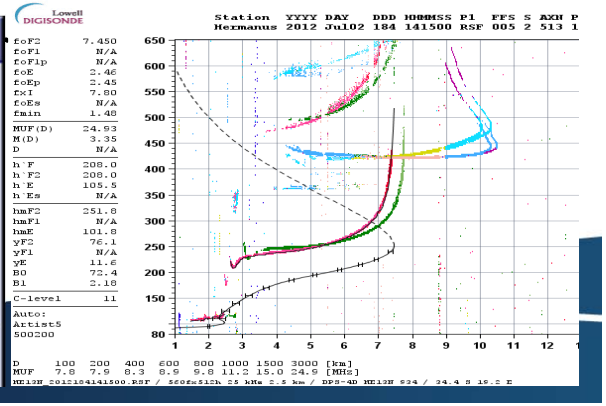
- Part of the International Space Environmental Service (ISES)
- Provides important service to the nation by providing information, early warnings and forecasts on space weather conditions
- Products and services used mainly by defence, aeronautics, navigation and communication sectors

SPACE WEATHER MEASUREMENTS

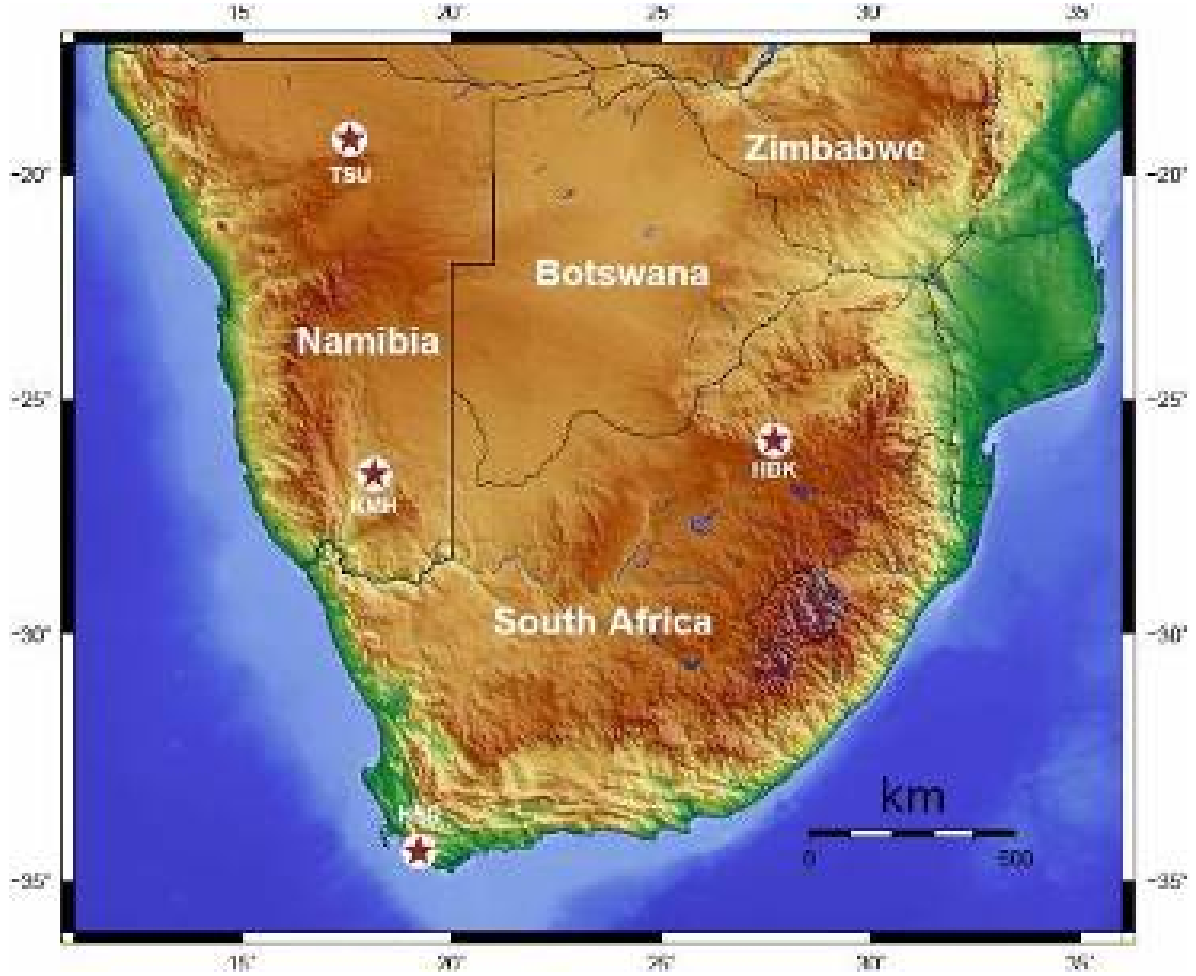
- Quality ensured data
  - Measurements used in developing global and national models
- Several of our data is used in real-time to monitor space weather
  - K index from local magnetometer stations (HER, SANAE)
  - Ionosonde measurements
- Several of our data contribute to the global community for space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





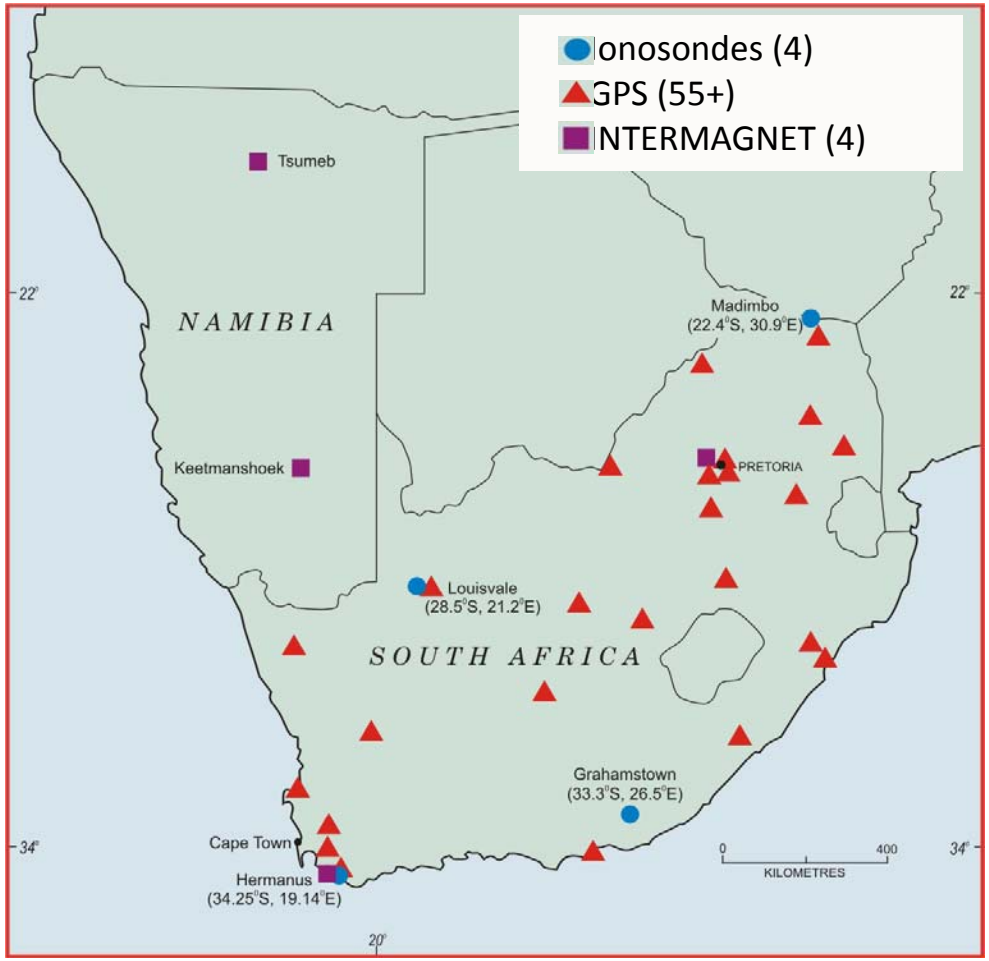


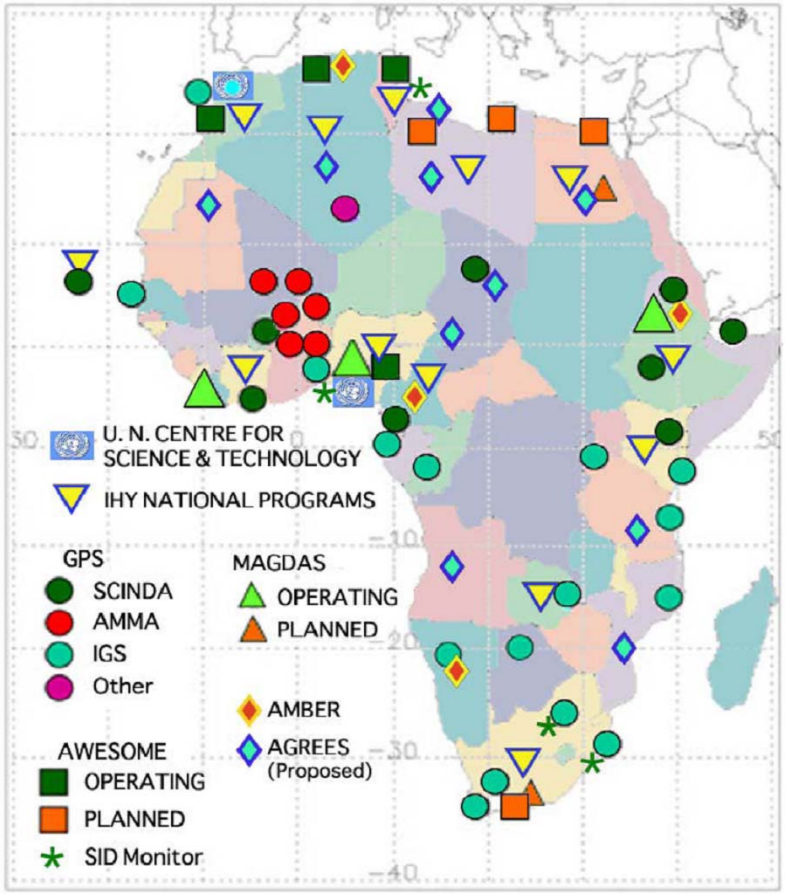
INTERMAGNET MAGNETOMETERS MANAGED BY SANSA SPACE SCIENCE



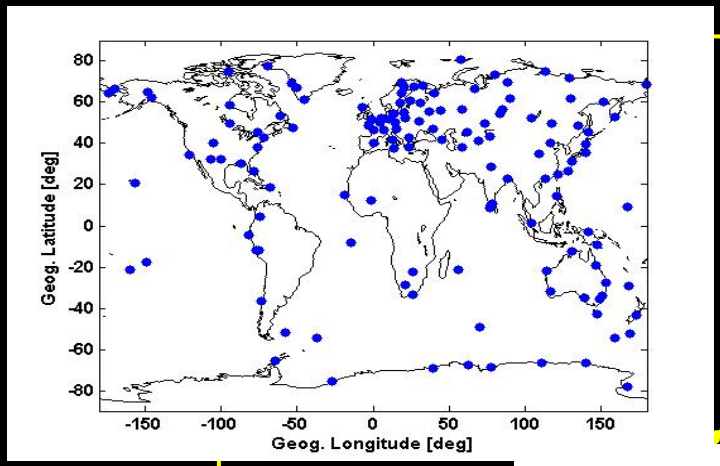
http://www.intermagnet.org/data-donnee/dataplot-eng.php

SPACE WEATHER INSTRUMENTATION IN SOUTHERN AFRICA





South African Ionosonde Network



2000 – 2009

(22.4°S, 30.9°E) Madimbo

2000 – 2009

Louisvale (28.5°S,21.2°E)

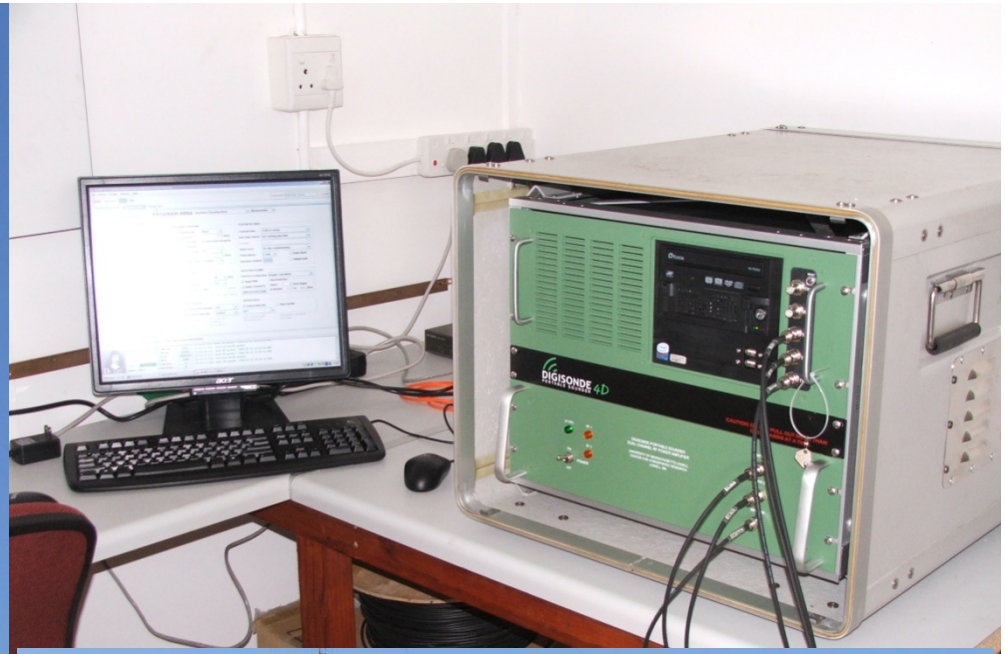
1973 – 2009
N(h) profiles from 1996

Installed June 2008

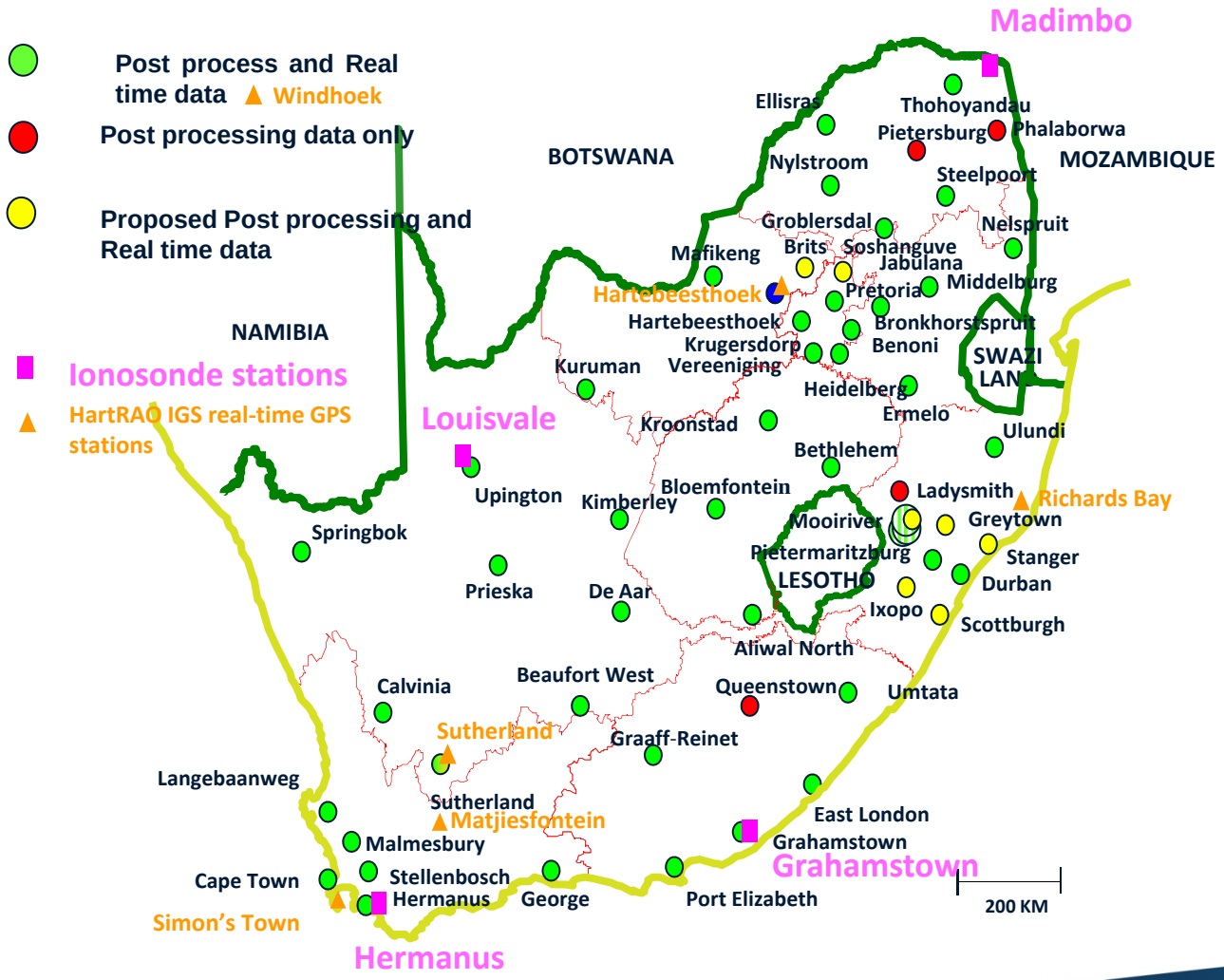
Grahamstown (33.3°S, 26.5°E)

Hermanus (34.4°S, 19.2°E)

HERMANUS IONOSONDE

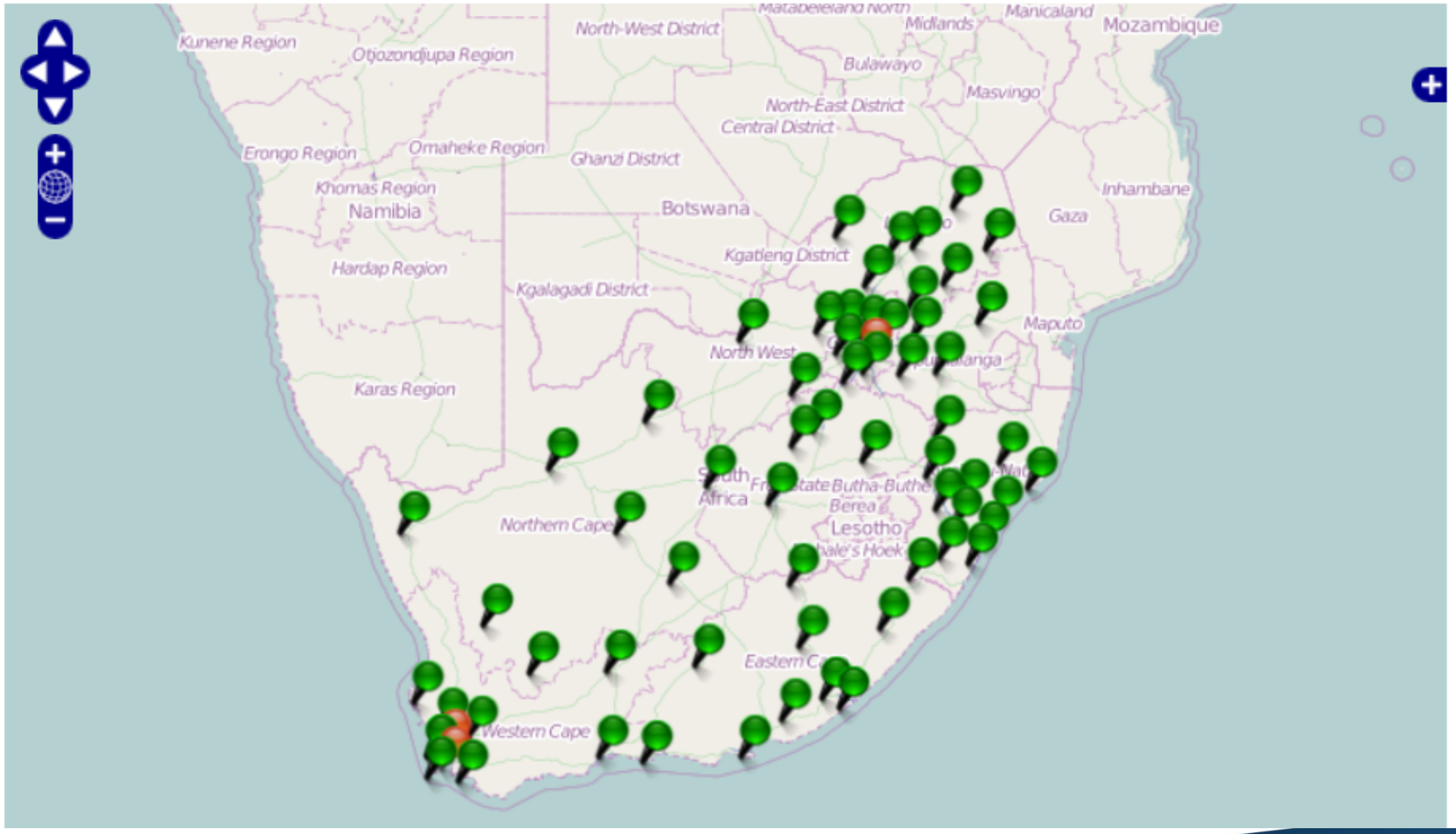


RSA GPS AND IONOSONDE NETWORK (SEP 2008)



TRIGNET GPS NETWORK (JUN 2014)

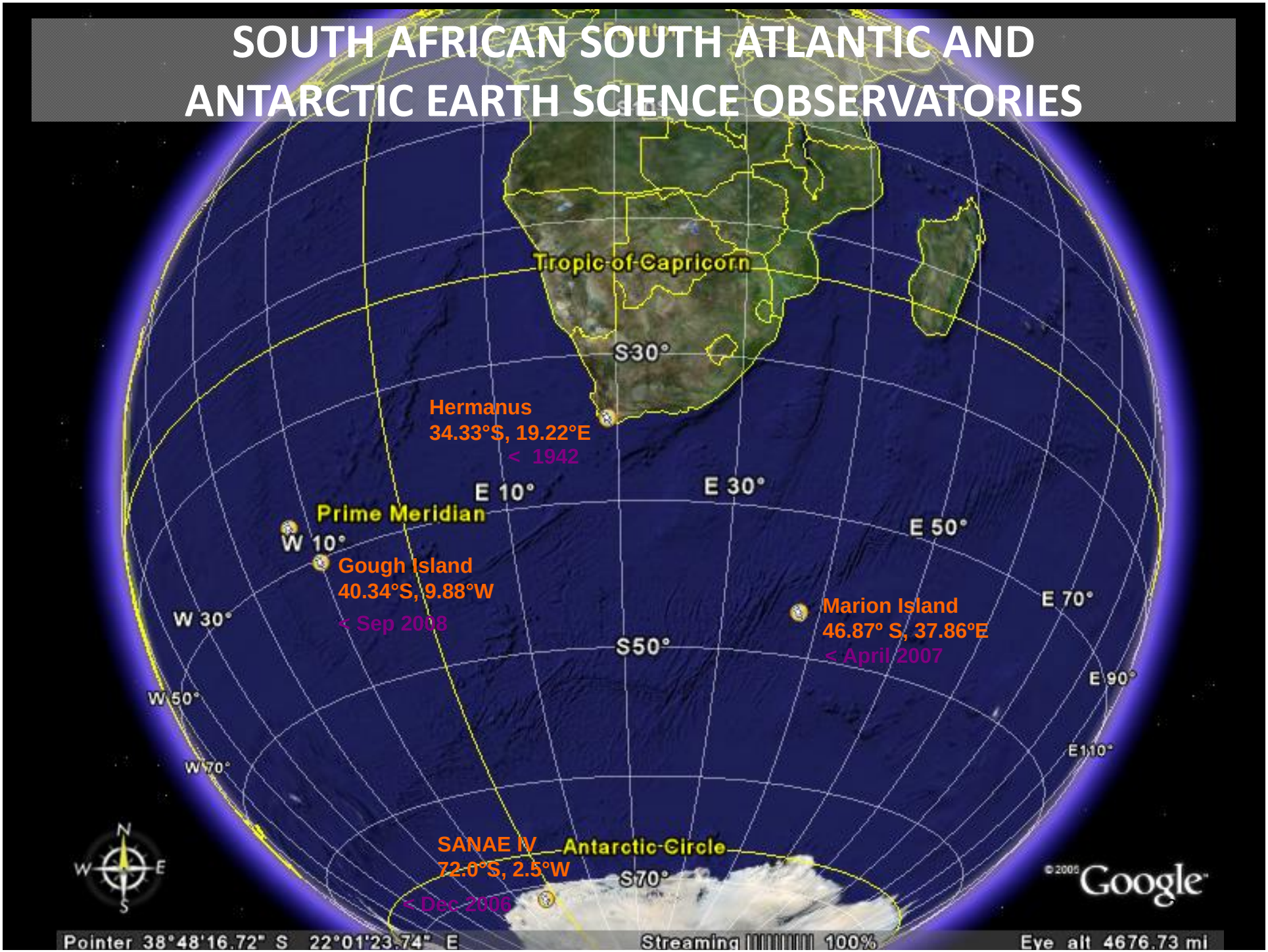
Sensor Map

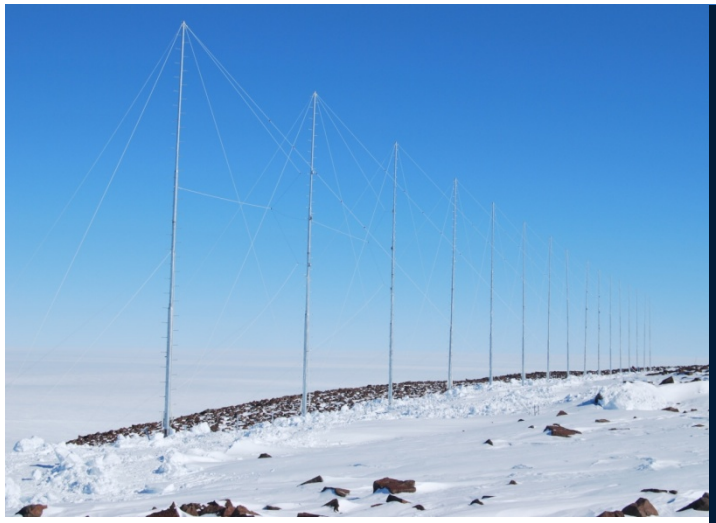


66 sensors:

ANTH
BENI
BETH
BFTA
BISO
BRIT
BRNK
BWES
CALV
Cosmic
CPNT
CTWN
DEAR
DRBA
ELDA
EMLO
ERAS
GDAL
GEOA
GREY
GRHM
GRNT
HEID
HNUS
IXOP
KLEY
KMAN
KOKS
KRUG

SOUTH AFRICAN SOUTH ATLANTIC AND ANTARCTIC EARTH SCIENCE OBSERVATORIES





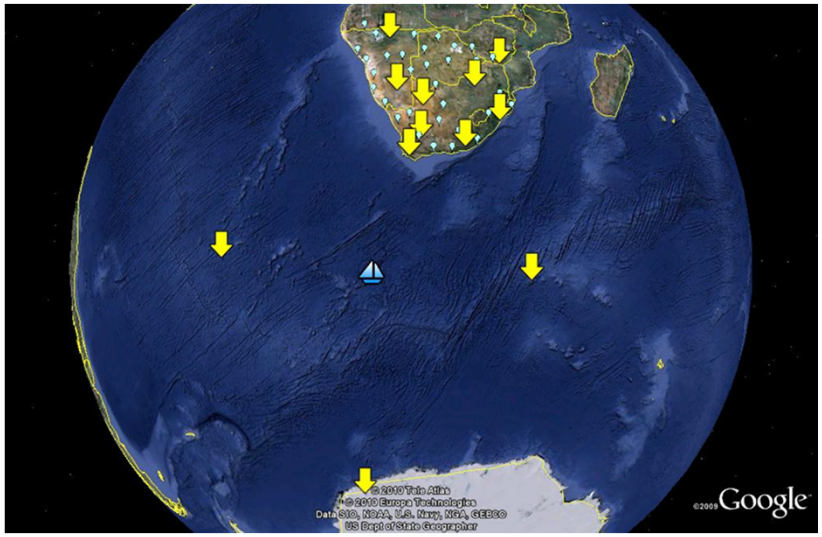
Geophysical Laboratory Providing the data to investigate space

- Ionosondes
- GPS receivers (dual frequency & scintillation)
- VLF receivers
- Doppler Radar
- Magnetometers (variation & pulsation)
- Riometer
- MT Stations
- Radar (Aurora and Mid Latitude)
- Lidar
- Lightning detectors
- Neutron Monitor

ANTARCTIC AND ISLANDS RESEARCH

- SANSA is part of the South African National Antarctic Programme (SANAP)
- Conducts several on-going space science and space weather related research projects in Antarctica, Marion Island and Gough Island.
- SANSA sends 3 overwintering engineers per year
- 5 months technical training in Hermanus + 1 month survival training in Cape Town
- Engineers spend 14 months in Antarctica and Marion Island
- Space science students have a high chance of doing a relief voyage to Antarctica for 3 months

GEOPHYSICAL LABORATORY PROVIDING DATA TO INVESTIGATE SPACE



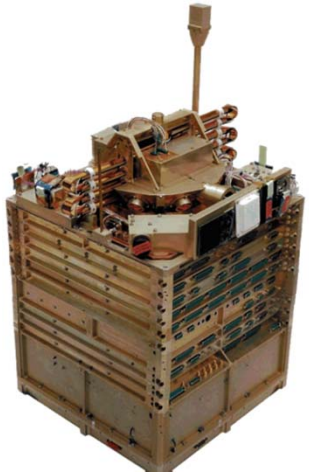
Global Data Distribution & Access – example:

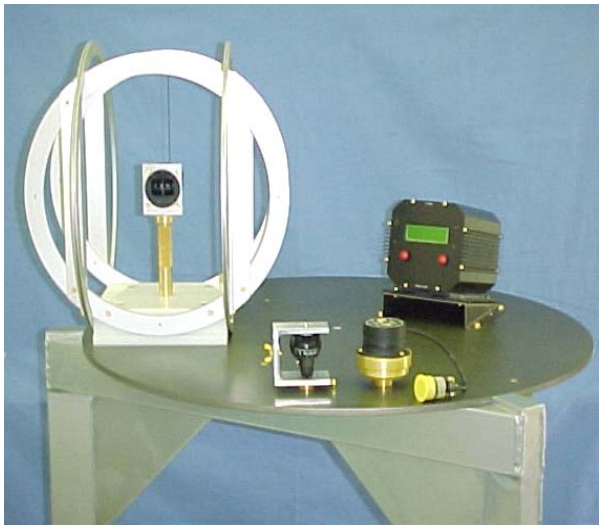
- ISES
- INTERMAGNET
- SuperDARN
- DIDBase

APPLIED SCIENCE & TECHNOLOGY (AST)

AST utilises our knowledge of geomagnetism and our unique facilities, located in a magnetically clean environment, to provide quality controlled services to clients in the defense and aerospace industries.

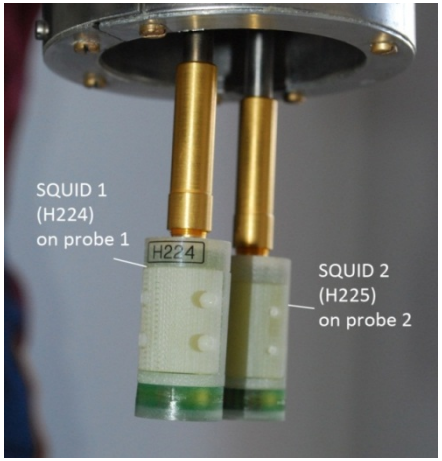
- Magnetic navigation support to SAAF and civilian aviation
- Magnetometer technology support services
- Application of signal processing techniques
- Low cost sensor integration





HMO designed and built test bench for the evaluation of aircraft compasses

SUPERCONDUCTIVITY AND SPACE SCIENCE



SQUID – Superconducting Quantum Interference Device

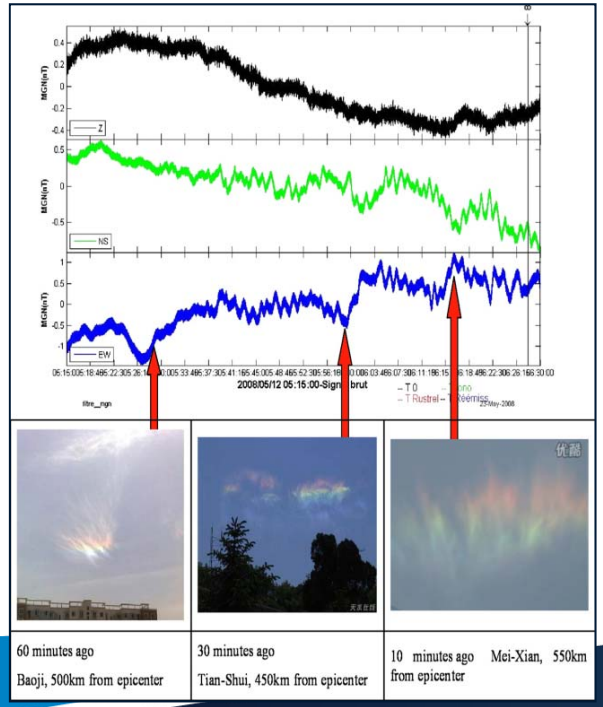
HTS (High Temperature) SQUID recently installed at SANSA in Hermanus:

- can operate without shielding
- high dynamic range
- sensitivity ±100 fT, noise 30 fT/√Hz
- cooled with liquid N to 77 K (-196 °C)

Partners at LSBB, France
LTS (Low Temperature) SQUID:

- require high shielding
- high sensitivity ±1 fT
- noise 3 fT/√Hz
- cooled with liquid He to 4 K

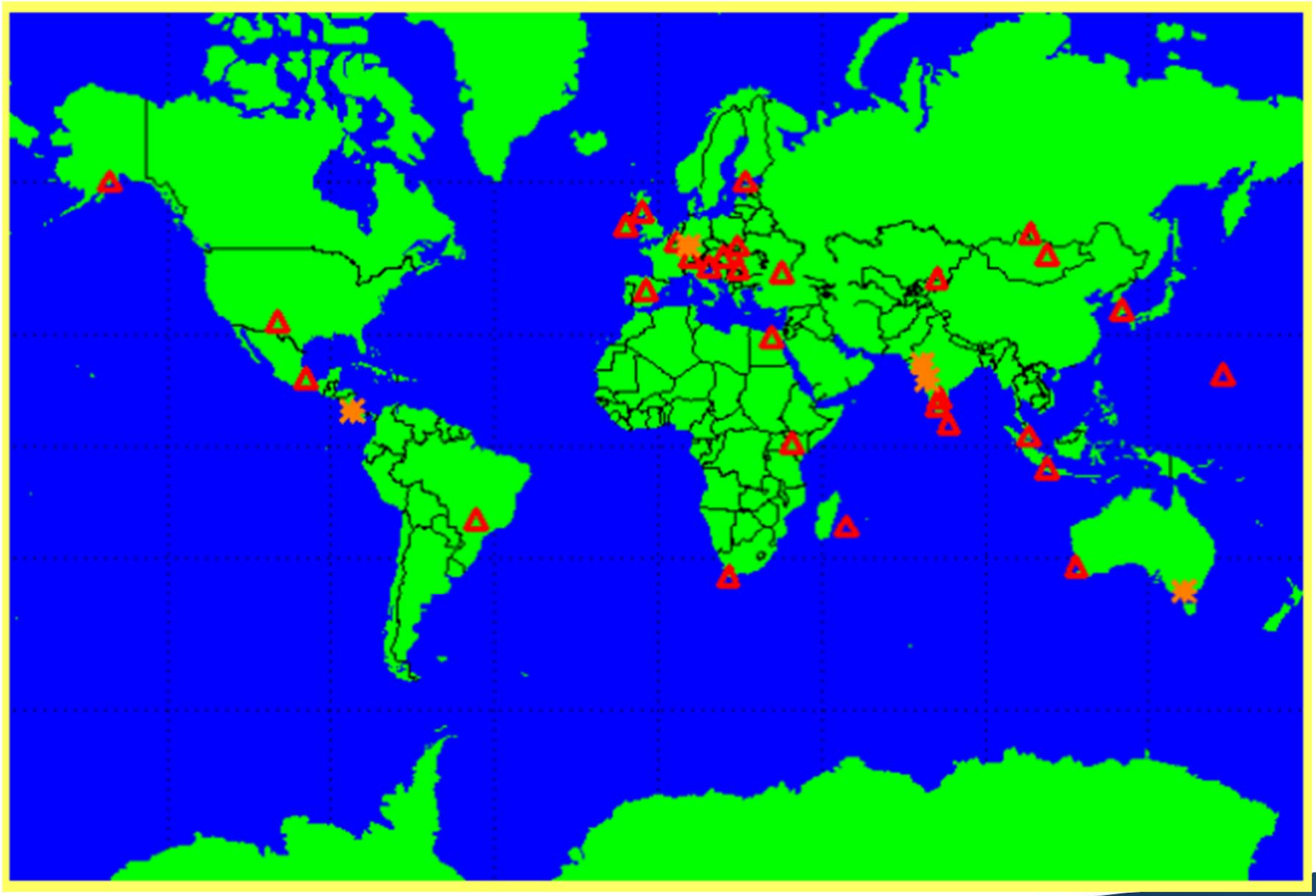
Magnetic data strongly correlated to ionospheric disturbances above epicentre of 2008 earthquake in China



Future: global network of SQUID sensors:

- Establish use of SQUIDs as observatory instruments
- Investigate correlation between seismic and SQUID data
- Early warning systems for detection of earthquakes & adverse space weather

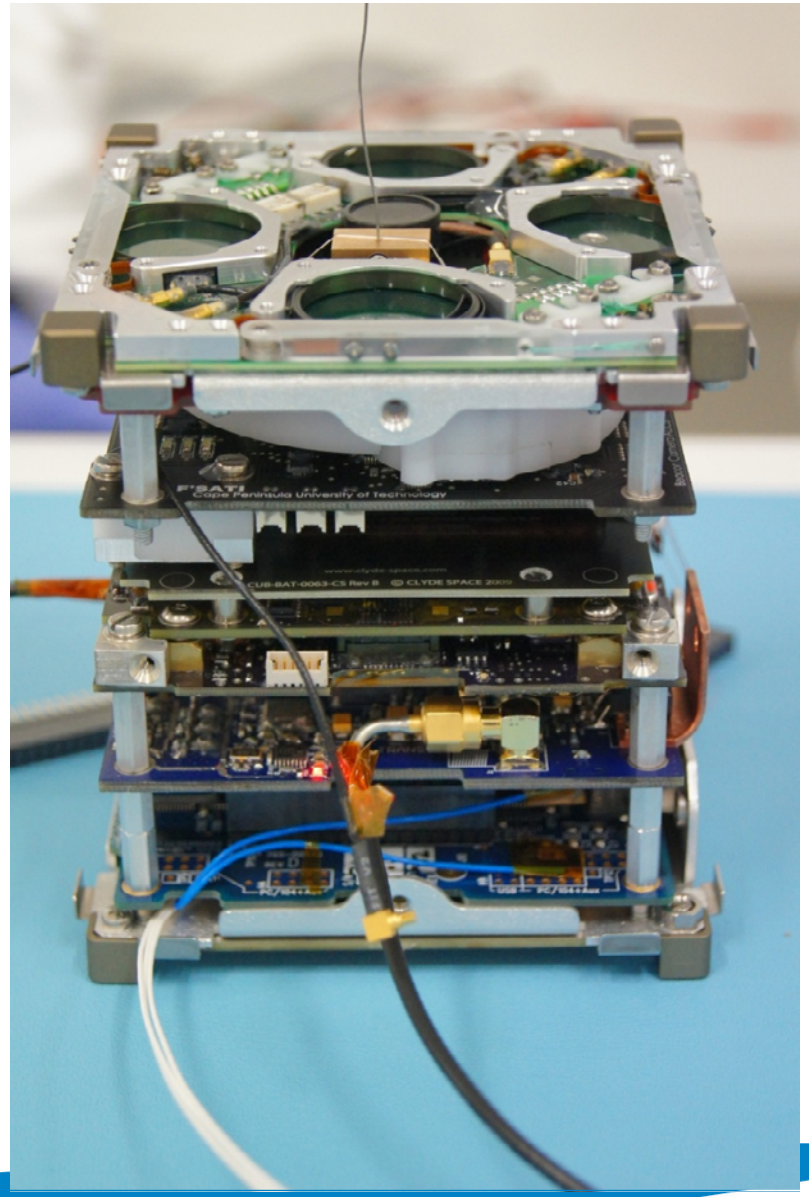
E-CALLISTO SOLAR RADIO NOISE SPECTROMETER NETWORK



E-CALLISTO SOLAR RADIO NOISE SPECTROMETER NETWORK

Log-Periodic CALLISTO antenna at
SANSA Space Science in Hermanus, South Africa

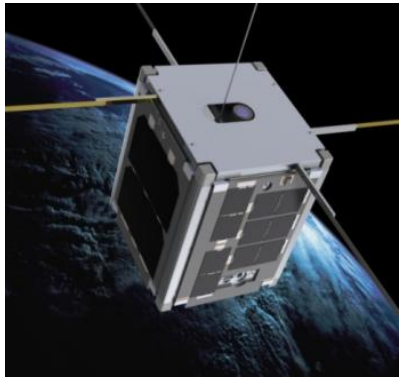
SCIENTIFIC PAYLOADS FOR CUBESATS



CPUT F'Sati Project 1 U Cube includes SANSA 14 MHz HF Beacon

Opportunities for other designs and contributions to CubeSAT payloads

SCIENTIFIC PAYLOADS FOR CUBESATS



http://www.cput.ac.za/blogs/fsati/zacube-1/

- Built by CPUT students in collaboration with SUN and SANSA,
- Launched at 09:10 on 2003-11-21 from Yasny Launch Base in Russia, on top of a Dnepr rocket into Low Earth Orbit at 630 km altitude.
- First telemetry communicated to CPUT ions at 23:00 on 2003-11-21 on S-band.
- HF beacon at 14.1 MHz to be activated in December 2013. Report contacts to spacesci-info@sansa.org.za

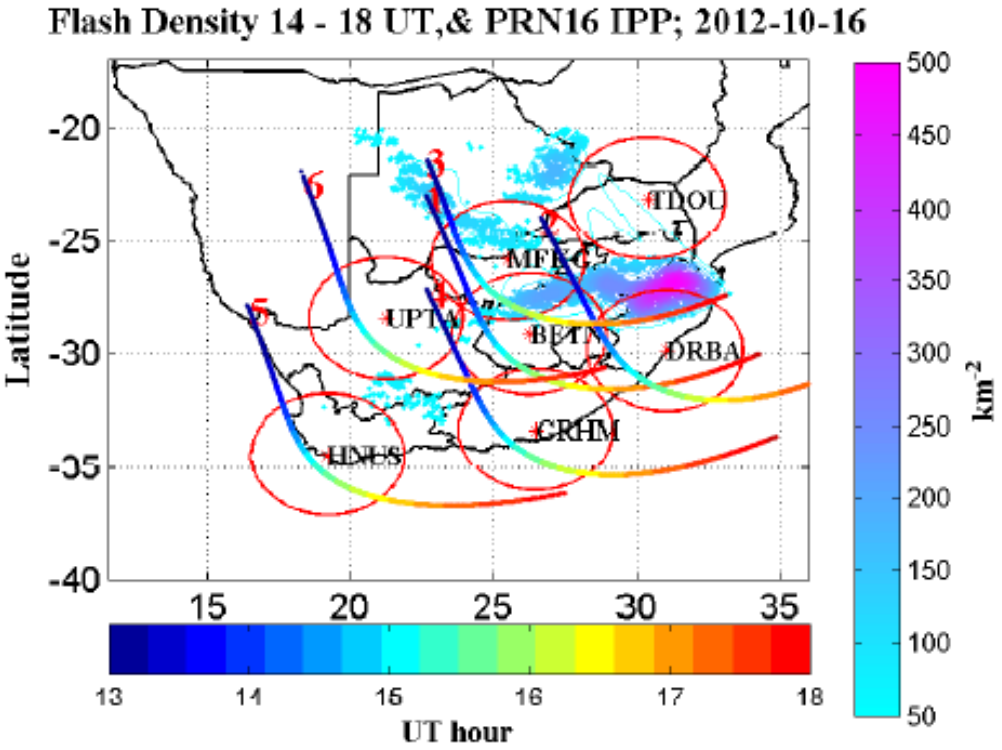
SCIENTIFIC PAYLOADS FOR CUBESATS

- First 3 elements of 7 element L-array HF Direction Finding (DF) receiver for estimation of the angle of arrival of the HF Beacon on TshepisoSat (ZACUBE-1)

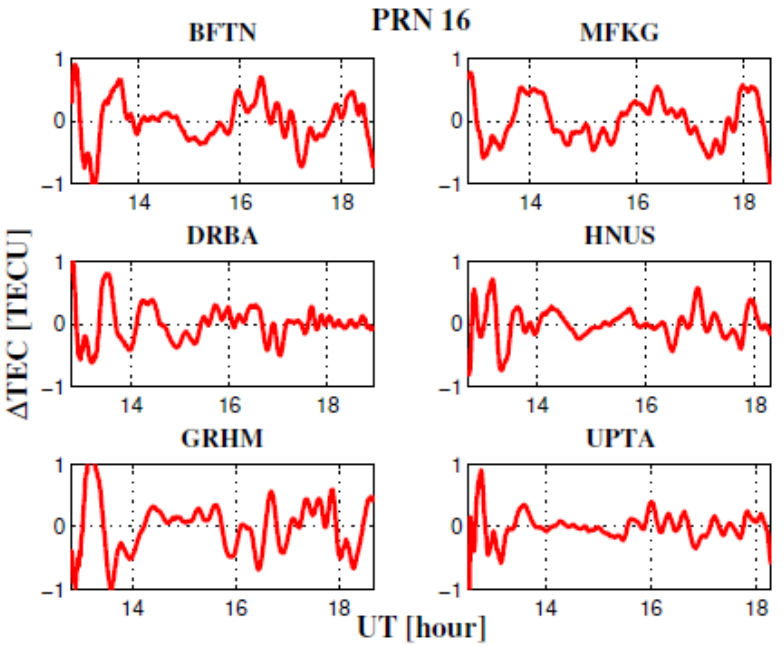
LIGHTNING & TEC RESEARCH

- SANSA is a member of the World Wide Lightning Location Network (WWLLN) and is host to one of its instruments for detecting lightning.
- The objective of the lightning research at SANSA is among others to investigate the link between tropospheric weather, of which lightning is a well-documented phenomenon and changes in the ionospheric total electron content.
- South Africa is well –positioned for such research, since high lightning density regularly occurs in the Eastern and Northern parts of the country.
- Results obtained to date show that variations of up to 1 TECU occur with respect to the background TEC subsequent to intense lightning density.

LIGHTNING & TEC RESEARCH



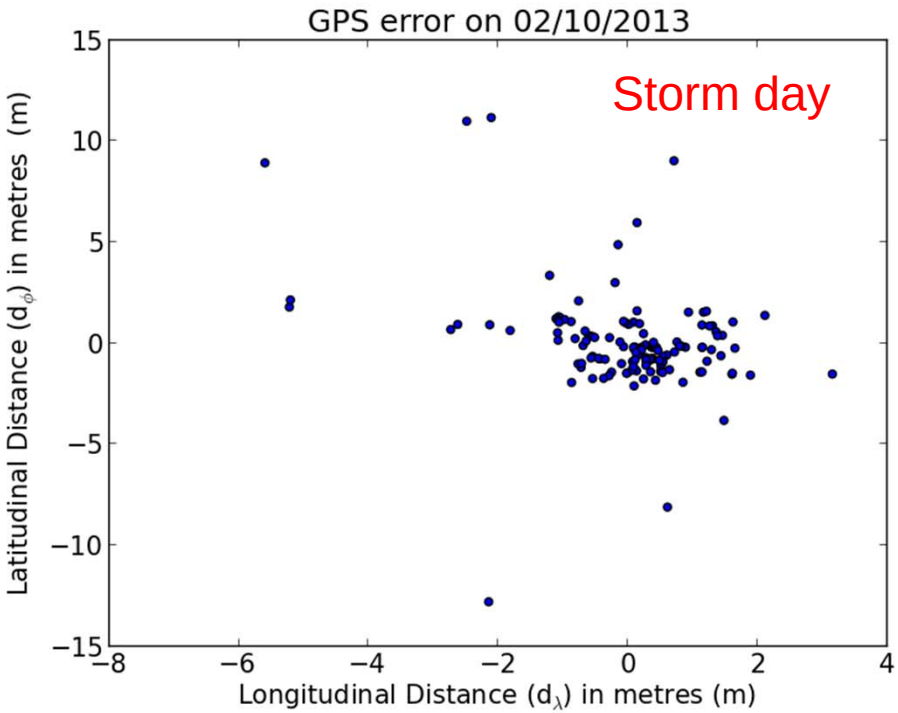
Flash density and GPS IPP coded by time of day

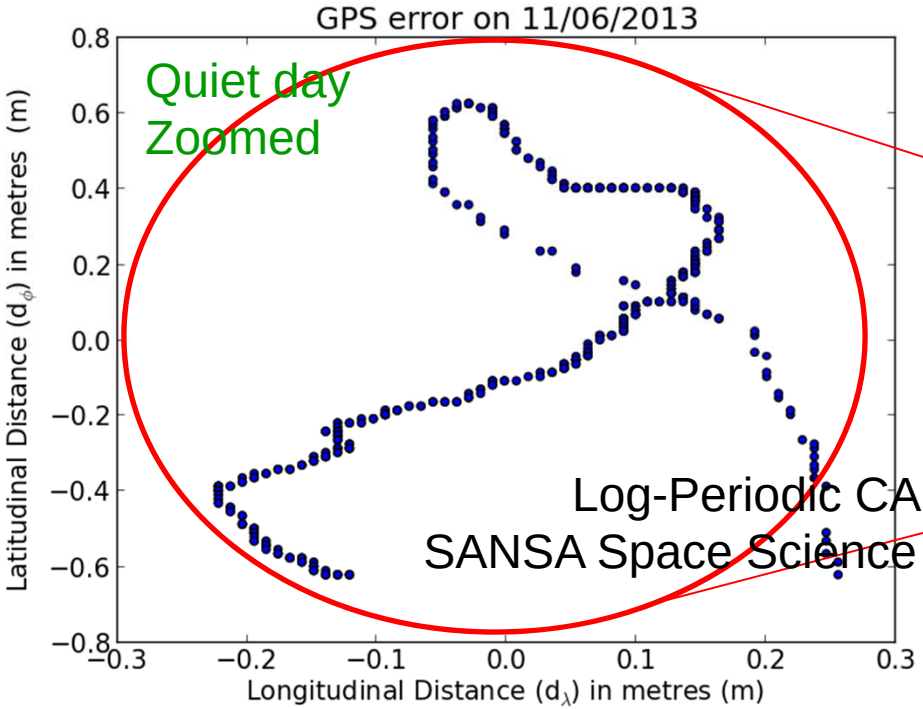


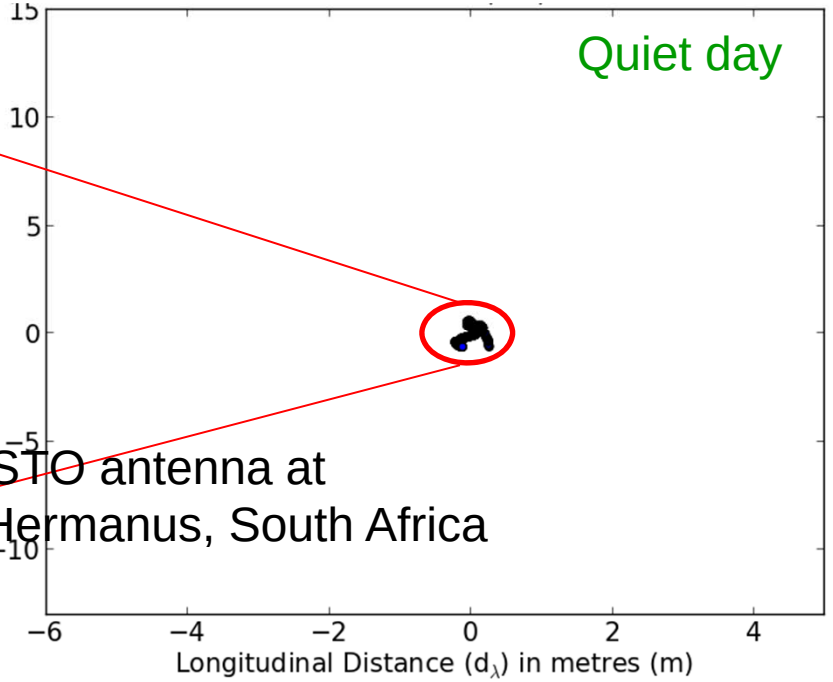
TEC perturbations noted on PRN 16 slant TEC over selected GPS receivers

GPS ERRORS DUE TO IONOSPHERIC SCINTILLATION

Single frequency handheld GPS receiver



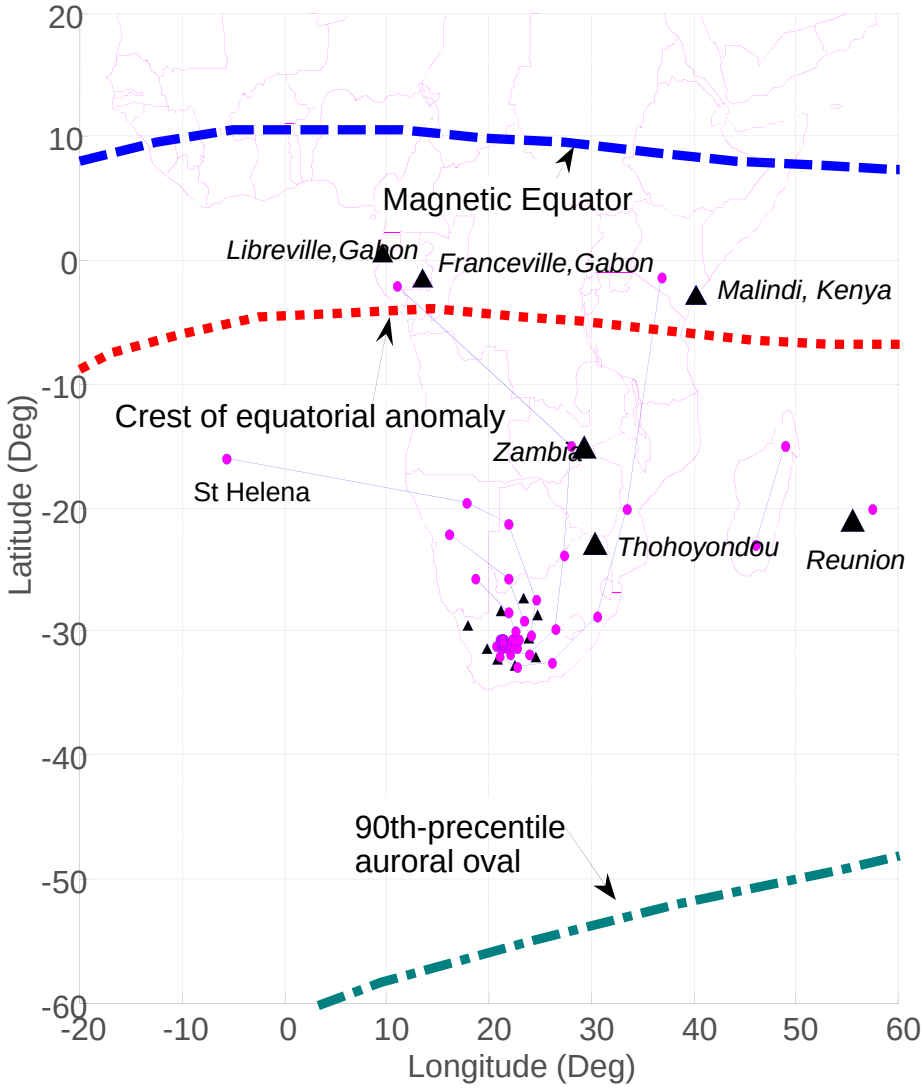




Log-Periodic CALLISTO antenna at SANSA Space Science in Hermanus, South Africa

SKA IONOSPHERIC STUDY

- TEC variability
- foF2-TEC correlation
- Spread-F occurrence



SKA hub (Northern Cape),

International Partners:

Namibia, Botswana, Mozambique, Madagascar, Mauritius, Kenya, Gabon, St Helena.

SKILLS DEVELOPMENT: STUDENTS

- Contributing to skills development in South Africa and Africa:
  - Postgraduate student supervision
  - University courses at UCT and CPUT 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
  - International Workshop on GIC modelling and measurement 1-2 April 2014
- 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, Zambia and Egypt

SKILLS DEVELOPMENT: AFRICA

- International Workshop on GIC modelling and measurement
  1-2 April 2014 at University of Cape Town
- Participants from UK, Italy, Spain, Australia, Ethiopia, Kenya, Madagascar, Namibia, Nigeria, Rwanda, Uganda and Zambia

VISITING SCIENTISTS FROM AFRICA

Other visitors:

Paul Baki (Uganda)
Endawoke Yizengaw (Ethiopia)
Baylie Damtie (Ethiopia)
Chigo Ngwira (Zambia)
Kola Adewale (Nigeria)
Elijah Oyeyemi (Nigeria)
Gizaw Mengistu (Ethiopia)
… and hopefully many more
In future!

Prof Babatunde Rabiu from National Space Research and Development Agency Nigeria

DATA CONTRIBUTION FOR INTERNATIONAL SPACE SCIENCE COMMUNITY

- SANSA Supplies 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)

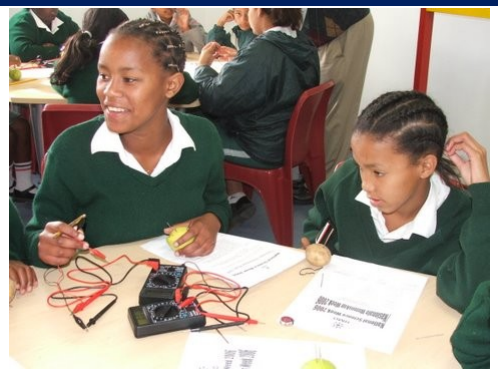
INTERNATIONAL COLLABORATIONS

- Collaborate on space weather projects:
  - Geomagnetically Induced Currents (GIC)

    Canada, Finland, Kenya, Namibia, Sweden and USA
- Satellite based Aircraft Landing Augmentation system (EGNOS)
  - Scintillation monitoring & modelling
  - SANSA Space Operations, ESA
- Improvements of ionospheric storm time models
  - USA, Europe, International Telegraphic Union (ITU)

SCIENCE ADVANCEMENT

- Science Center
- School Visits
- Educator Training
- Public Awareness



STUDENT TRAINING (HCD)

Postgraduate student supervision
Summer & Winter Schools
Honours projects & Supervision
University courses in Space Physics
Internship & Volunteer programs

STUDENT TRAINING (HCD)

Africa needs people in the Science Technology Engineering Mathematics (STEM) sector to:

- Grow the knowledge economy
- Solve the many different problems of our countries
- To create an environment that is sustainable

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Opportunities for Africans

STUDIES AT SANSA

- SANSA is not a degree-granting institution.
- Researchers at SANSA act as supervisors and co-supervisors
- Some researchers at SANSA have honorary appointments at local and African universities.
- Students must be admitted to one of the universities in South Africa with Space Science programmes
- Limited bursaries are available for postgraduate studies
- SANSA Appoints interns
- SANSA Welcomes African visiting scientists

UNIVERSITIES AND PROGRAMMES TO WHICH SANSA SPACE SCIENCE IS AFFILIATED

- ✓ National Astrophysics and Space Science Programme (NASSP) at University of Cape Town (UCT)
- ✓ UCT Space Studies Programme
- ✓ North West University (NWU)
- ✓ University of KwaZulu Natal (UKZN)
- ✓ Rhodes University
- ✓ Cape Peninsula University of Technology (CPUT)
- ✓ University of the Witwatersrand (WITS)
- ✓ University of Pretoria (UP)
- ✓ University of the Western Cape (UWC)

SANSA also has collaborative agreements with Universities in Ethiopia, Nigeria, Zambia, Uganda, Namibia, Cote d'Ivor …

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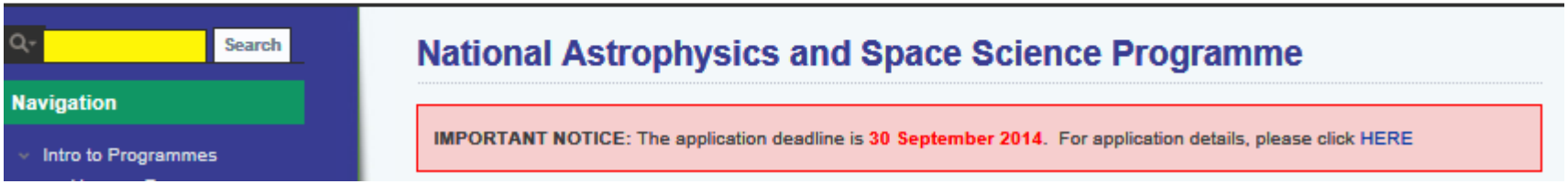
NASSP

National Astrophysics and Space Science Programme

http://www.star.ac.za/



Researchers from around the region have joined forces to create a cooperative, combined graduate programme, hosted at the University of Cape Town where South African students and students from around Africa and the rest of the World can study under the guidance of some of South Africa's leading scientists.

Honours in Astrophysics and Space Science

Masters in Astrophysics and Space Science

PhD in Astrophysics and Space Science

NASSP Space Science students from African Countries

NASSP Masters students (2003-2013)					
Student Name	Entrance year	Country	Gender	Status of degree	Graduation Year
Oyapo Chimidza	2006 SANSA	Botswana	Male	completed	2008
Debu, Desalegn	2010 UKZN	Ethiopia	Male	current	current
Ayane, Getinet	2012 North West	Ethiopia	Male	completed	2014
Mezgebe, Nigussie	2012 SANSA	Ethiopia	Male	completed	2013
Alamirew, Netsanet	2012 SANSA UCT	Ethiopia	Male	current	curent
Afful, Michael	2011 SANSA	Ghanaian	Male	completed	current
Joel Botai	2004 RU	Kenya	Male	completed	2005
Daniel Okoh	2008 SANSA	Nigeria	Male	completed	2009
Oronsaye, Samuel Iyen Jeffery	2011 SANSA	Nigeria	Male	completed	2013
Pheneas Nkundabakura	2006 UFS	Rwanda	Male	completed	2007
Jean Uwamahoro	2007 SANSA	Rwanda	Male	completed	2009
Kudoda, Ayman	UKZN	Sudan	Male	current	current
Edward Jurua	2004 UFS	Uganda	Male	completed	2005
Baluku Kisandi	2005 UKZN	Uganda	Male	completed	2007
John Haburulema	2006 SANSA	Uganda	Male	completed	2008
Bosco Oruru	2007 UFS	Uganda	Male	completed	2008
Nicholas Ssessanga	2009 SANSA	Uganda	Male	completed	2011
Amabayo, Emirant	2010 SANSA	Uganda	Male	completed	2012
Athieno, Racheal	2010 SANSA	Uganda	Female	completed	2012
Agaba, Doreen	2011 SANSA	Uganda	Female	completed	2012
Daniel Opolot	2008 UWC	Uganda	Male	completed	2009
Naluminsa, Elizabeth	2012 SAAO	Uganda	Female	completed	2014

NASSP Space Science students from African Countries

NASSP Masters students (2003-2013)					
Student Name	Entrance year	Country	Gender	Status of degree	Graduation Year
Webby Miyoba	2004 UKZN	Zambia	Male	completed	2007
Patrick Sibanda	2005 SANSA	Zambia	Male	completed	2007
Fred-Joe Nambala	2007 SANSA	Zambia	Male	completed	2009
Chigomezyo Ngwira	2008 SANSA	Zambia	Male	completed	2009
Namumba, Brenda	2013 UKZN	Zambia	Female	current	current
Phiri, Temwani	2011 SANSA	Zambia	Male	completed	2013
Masimba Paradza	2007 RU	Zimbabwe	Male	completed	2008
Courage Mudzingwa	2008 SANSA	Zimbabwe	Male	completed	2009

MPHIL IN SPACE STUDIES AT UCT

- A research-based degree with a coursework component that provides a broad foundational knowledge of the space arena and space applications.
- Research topics will be chosen in alignment with identified research needs in the national and continental space programmes. There is the possibility to upgrade the masters thesis to a doctoral (PhD) thesis.

http://www.humanities.uct.ac.za/mphil-specialising-space-studies-0#sthash.n0O9DDH6.dpuf

MPHIL IN SPACE STUDIES AT UCT

All participants will be required to complete a foundational core lecture component which comprises the following modules:

Space Mission Analysis and Design - which focuses on the definition, development and operation of space systems.

Space Applications for Sustainable Development - which focuses on practical applications of space technology for societal benefit, with emphasis on addressing African problems.

Space and Society - which focuses on the commercial, security, cooperation, policy and regulatory aspects of outer space activities.

Special Topics in Space Technology - which focuses on a highly specialised or cutting-edge topic in space technology.

SKILLS THAT ARE EMPLOYED BY SANSA

- Physics
- Engineering (particularly RF and Electronics)
- Mathematics
- Computer Science
- IT and Software Development
- Remote Sensing
- Statistics

Opportunities are advertised on our website www.sansa.org.za

SECTORS THAT EMPLOY SANSA SCIENTISTS

-- Telecommunications

-- Navigation

-- Power stations, nuclear, alternative sources of energy

-- Aviation (calibration, tracking systems)

-- Defence sector (communications and navigation)

-- Banking, actuarial science, investment houses

-- Space sector

COMMITMENT TO CAPACITY BUILDING IN AFRICA

9 September 2009, SANSA Space Science MD,
Dr Lee-Anne McKinnell

Award: African Union Women in Science Award for Basic Science, Technology and Innovation in the Southern African Region.

Citation: “for the contribution made to science in Africa, particularly in the area of capacity building”

AFRICAN STUDENTS AT SANSA

Dr Stefan Lotz (MSc, PhD Rhodes), Dr Lee-Anne McKinnell (SANSA MD), Dr Jean Uwamahoro (MSc, PhD, Rhodes)
2012 Graduation at Rhodes University

AFRICAN STUDENTS AT SANSA

John-Bosco Habarulema (Uganda)

MSc (Rhodes) 2008,
PhD (Rhodes) 2012

2014 award:
Sunanda and Santimay Basu 2014 AGU International Early Career award for making outstanding contributions to research in Sun-Earth systems Science that further the understanding of both plasma physical processes and their application to the benefit of society.

CHIGO NGWIRA (ZAMBIA)

20 January 2010, Chigo Ngwira at SANAE, Antarctica

Degrees obtained while at SANSA: MSc & PhD (Rhodes University)

Award: AGU Science Solution Award (Dec 2014)

Citation: recognition of *"significant contributions in the application and use of the Earth and space sciences to solve societal problems."*

AFRICAN STUDENTS AT SANSA

Patrick Sibanda (Zambia)

MSc (Rhodes) 2006,
PhD (Rhodes) 2010

Daniel Okoh (Nigeria)

MSc (Rhodes) 2009

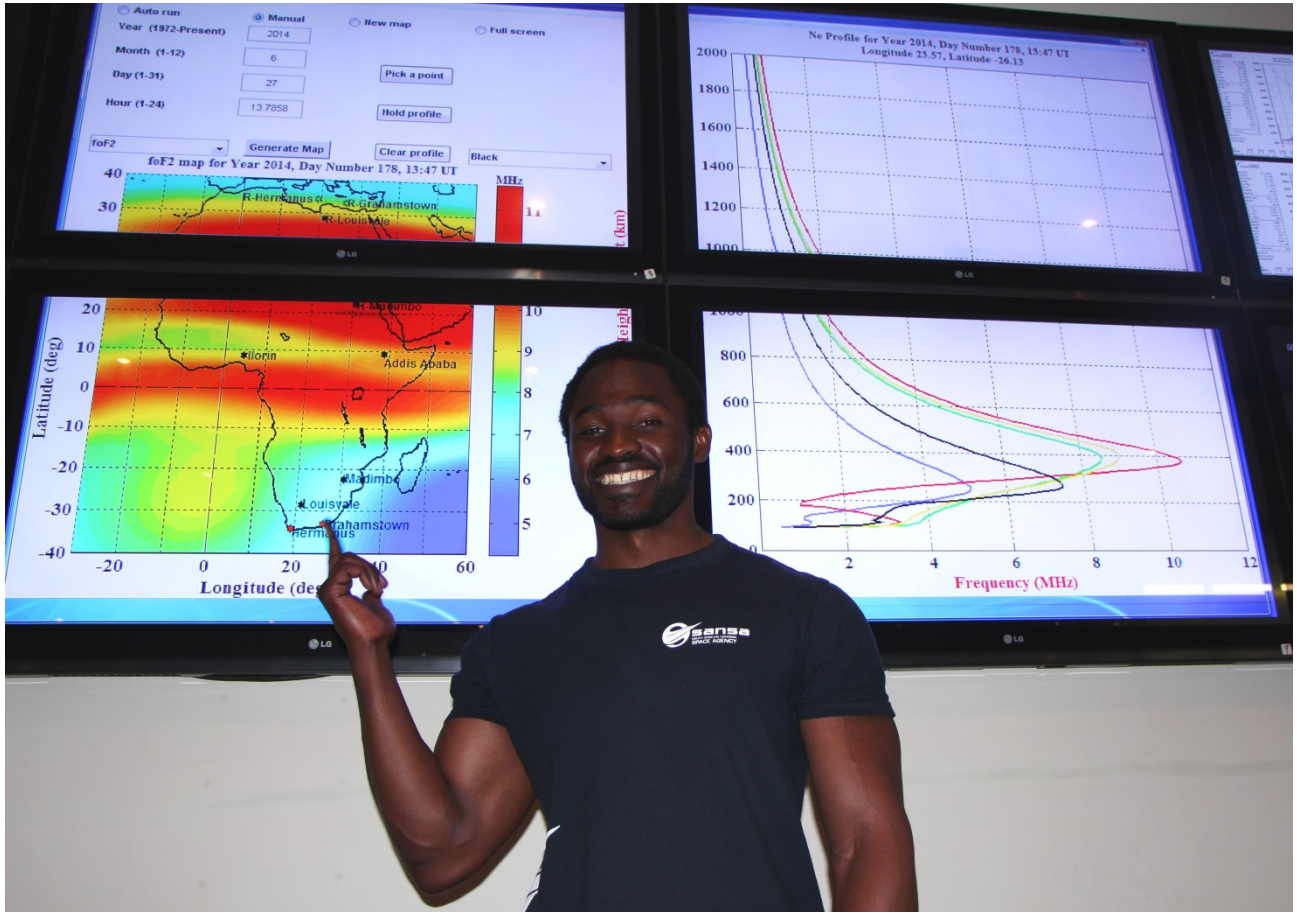
Other visitors from Nigeria: Elijah Oyeyemi(PhD), Chijioke Nwosa (Hons), Kola Adewale (Visiting Scientist), Babatunde Rabiu (visiting scientist)

ELECTDOM MATANDIROTYA (ZIMBABWE)

Degrees obtained while at SANSA: Mtech

Currently working on Dtech (CPUT) on Geomagnetically Induced Currents.

AFRICAN STUDENTS AT SANSA



MSc (Rhodes, 2011), PhD (Rhodes,2013)

AFRICAN STUDENTS AT SANSA

Netsanet Alamirew (Ethiopia)

Mphil UCT,
Research on Space Weather modelling for GICs

Courage Mudzingwa (Zimbabwe)

MSc Rhodes,
Research on HF Radio propagation

AFRICAN STUDENTS AT SANSA

Fenni Shidhika (Namibia)

MTech (CPUT)
Research on HF DF algorithms for CubeSat

Doreen Agaba (Uganda)

Mphil (UCT, 2011) on raytracing for HF beacon, Currently PhD UCT

Emirant Amabayo (Uganda)

MSc (Rhodes, 2011)

AFRICAN STUDENTS AT SANSA

Malan Ahoua (Cote d'Ivor, PhD)

Flavien Minko (Cameroen)

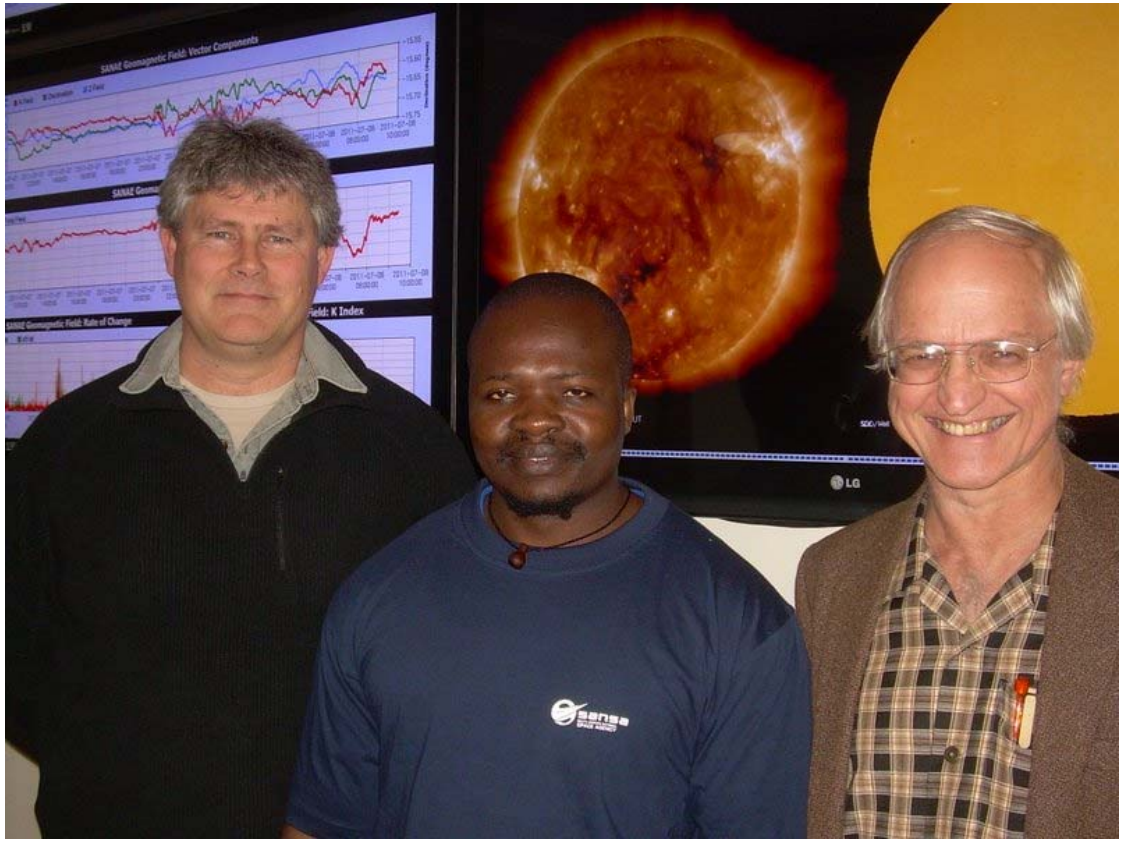
African students who worked as interns at SANSA

Flavien Minko (Cameroen) **Sandiso Mbane (South Africa)**

African students who worked as interns at SANSA

Sandiso Mbane (South Africa) & Flavien Minko (Cameroen) members of the team building the new HF Digital Radar for SANAE

African students who did research at SANSA



Ben Opperman (SANSA), Joseph Olwendo (Kenya) Pierre Cilliers (SANSA)

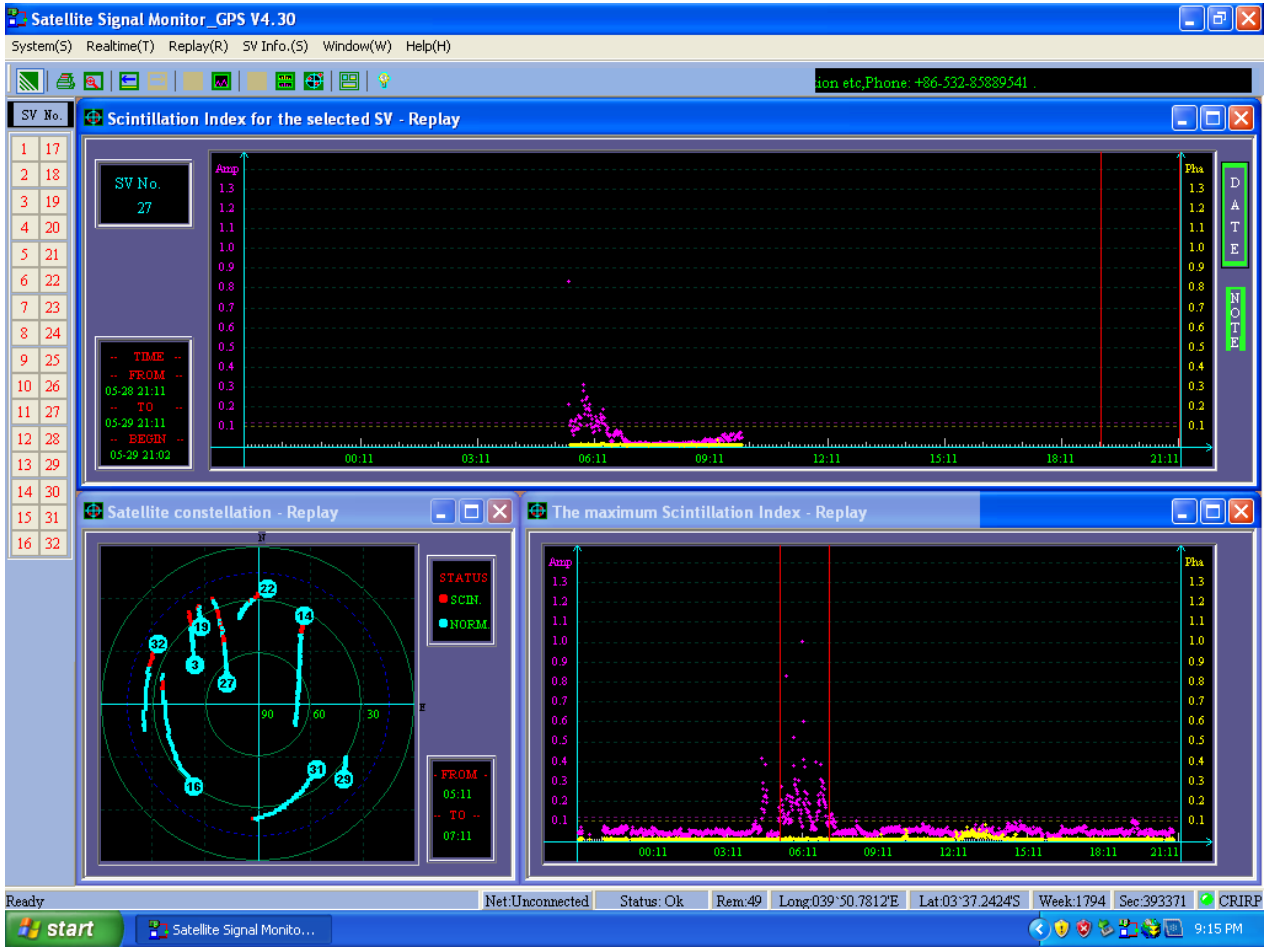
SANSA AFRICAN STUDENTS ACTIVITIES

Scintillation receiver at University of Nairobi, Kenya.

Joseph Olwendo ,
Prof Paul Baki from Technical University of Kenya

Other students from Kenya who have visited SANSA Space Science:
Adero Owuor(MSc),
Beryl Atieno(Undergraduate Final Year project).

SANSA AFRICAN STUDENTS OUTPUT



Satellite System monitoring software developed by Joseph Olwendo at Pwani,Kenya


RVCA
VA

Acknowledgements

- Organisers and sponsors of the African School of Space Science
- Colleagues at SANSA who have contributed materials for this presentation
- Students and African colleagues who have visited SANSA who have made contributions for this presentation

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