EASY SCIENCE

Taking a Look at the BLUE PLANET

Earth Observation from Space

Space science is a rapidly emerging field in South Africa. The government is establishing the South African Space Agency and our own unique micro satellite, SumbandilaSAT will be launched soon. This satellite will take pictures of Southern Africa to help with research, planning and management in areas such as agriculture, the fishing industry, water resources, urban planning, and losses caused by disasters such as fires and oil spills.

What is space science?

A broad definition of space science is any scientific field that studies events in space or space flight. This normally includes anything from about 80 km and higher – outside of Earth's atmosphere.

How do we observe Earth from space?

Earth observation satellites can study the atmosphere (meteorological observation), or the sea, land, and even oceanic winds.

A typical Earth observation satellite is made up of the following:

Observation instrument

The observation instrument acts as a camera and is one of the most important parts of the satellite. It takes 'pictures' (observation data) and sends these back to a data-recording and telemetry unit. Telemetry allows you to measure the Earth from far away (remotely) and report the information.

Telemetry subsystem

This subsystem sends the data it observes as well as information about units onboard the satellite to the ground station.

Command subsystem

A command subsystem almost works like your brain! It sends commands to the rest of the units on the satellite.

Data storage subsystem

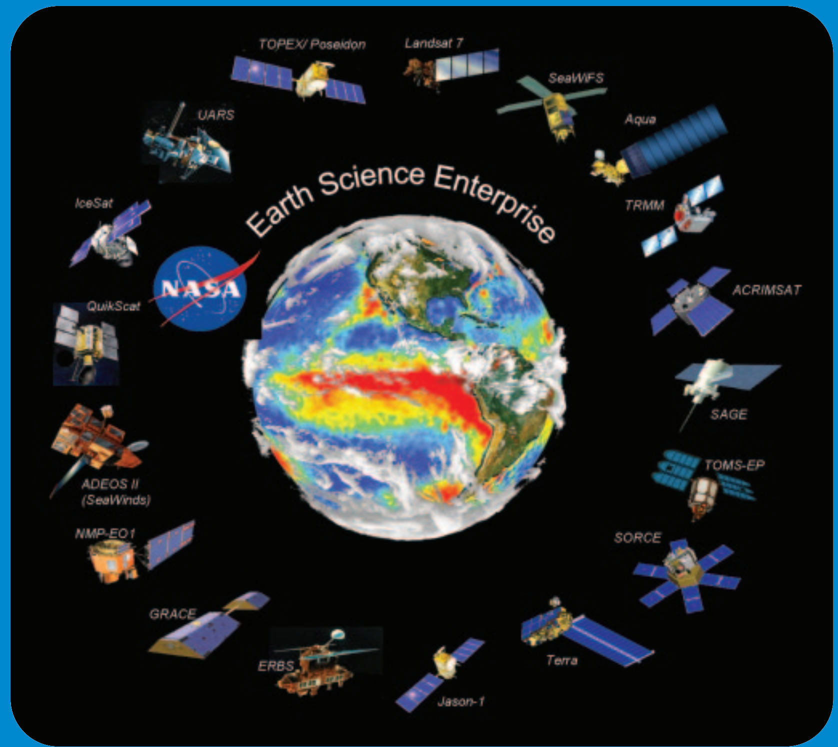
The data storage subsystem stores the image and housekeeping data of onboard subsystems for a certain amount of time.

Navigation subsystem

This system produces the information about the satellite's position in space.

Attitude control subsystem

This tells the ground station that monitors the satellite what the satellite's direction is compared to that of Earth. The satellite's cameras and imager normally point towards specific targets (e.g. the sea or land) with its solar panels facing the Sun.



Different satellites used by NASA

Propulsion subsystem

A propulsion subsystem gives the necessary power to change the flight path (orbit) and attitude of the satellite.

Power subsystem

A power subsystem works like the heart of the satellite in that it supplies the electric power necessary for operation.

Thermal control subsystem

This subsystem keeps the temperatures of onboard units within set ranges so that the satellite works properly.

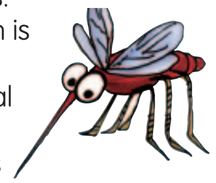
Processing subsystem

This controls the entire satellite operations.

How does space technology benefit us?

Through satellite technology, we can get important data about human activities. We can also analyse the Earth as a global system of natural processes that are all connected. The information from analysing the satellite data increases our Earth science knowledge and helps decision-makers to address challenges.

A great advantage of space-based observation is that it can cover a large geographical area.



Typical uses for satellite data include agricultural monitoring, predicting where possible human health problems may arise (for example, changes in rainfall has an effect on the spreading of ticks and mosquitoes) and security (disaster management), land-use change (e.g. if the soil is being eroded by human activities), solid-earth hazards (e.g. earthquakes, tsunamis), climate and weather changes, and water resources.

These things may affect and influence the way we live, work and even survive on Earth!

Some challenges are:

- **Changing ice sheets and sea level**
  Will the major ice sheets, such as those of Greenland or the West Antarctic, collapse? If they do – how quickly will it happen and how fast will the sea level rise?
- **Large-scale and persistent shifts in rainfall and water availability**
  Will we have more droughts in specific places? How will this affect wildfires and will a decrease in snowfalls change the way we store water?
- **Air pollution across continents**
  How will continuing economic development affect the production of air pollutants, and how will these pollutants move across oceans and continents?
- **Shifts in ecosystem structure and function in response to climate change**
  How will coastal and ocean ecosystems respond to changes in the climate, particularly those systems with a lot of human activity, such as fishing? If temperature and rainfall changes, what will the impacts be on animal migration patterns?
- **Human health and climate change**
  Will previously rare diseases become common? How will mosquito-borne viruses spread with changes in rainfall and drought? Will we be able to predict the outbreak of certain diseases, such as bird flu?
- **Extreme events, including severe storms, heat waves, earthquakes, and volcanic eruptions**
  Will tropical cyclones and heat waves become more frequent and more intense?

Left: TerraSAR X stripmap, multidate intensity composite over the Swartland.

Right: TerraSAR X stripmap, multidate coherence composite illustrating structural differences between newly planted wheat (left) and recently germinated rye (right).

What are the limitations of Earth observation?

Satellite orbits are mostly higher than 500 km, which lead to lower resolution (i.e. detail that is not as fine as what it would be in an aircraft taking a photo at 10 km above the ground – in the same way you will see much more detail on the leaf of a plant by standing next to it, than the person sitting in an aircraft or the satellite that is outside of Earth's atmosphere).

Other drawbacks include high cost of satellite observation, and limitations in instrument sensitivity and the number of species that can be measured.

This is why scientists often combine space and ground-based measurements when trying to understand earth systems.

Satellite dishes at the CSIR-run space ground station. at Hartebeesthoek.

What about 'spy' satellites?

To a certain extent, the technology used in Earth observation satellites can monitor the activities of humans, for example building roads. Communication satellites could be used to monitor radio and microwave-based telecommunications.

However, some 'spy' satellites gather data that could be used to monitor cloud cover or the rate of desertification and land degradation. In fact, in the USA the space agency NASA works with a number of partners, including their Department of Homeland Security.

Research, satellites and computer models can give data that can respond to any threat to the USA's infrastructure. Although satellites are traditionally used for mapping and disaster relief, they can also be used for law enforcement or border security. Some people see this as an intrusion of their privacy.

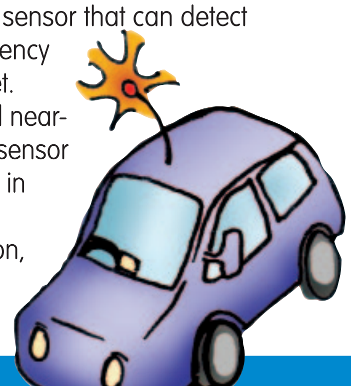
EasyScience is produced by the South African Agency for Science and Technology Advancement (SAASTA), an operational unit of the National Research Foundation. SAASTA's mission is to promote the public understanding, appreciation and engagement with science and technology among all South Africans. Visit the website: www.saasta.ac.za for more information.

Links to military, optics, GIS, communication

Earth observation from space is closely linked to military applications. For example, the global positioning system (GPS) started out as a military navigation system but quickly found its way into non-military applications – from ocean and land navigation to personal navigation by civilians (look around you to see how many cars on the road have a GPS on the dashboard!).

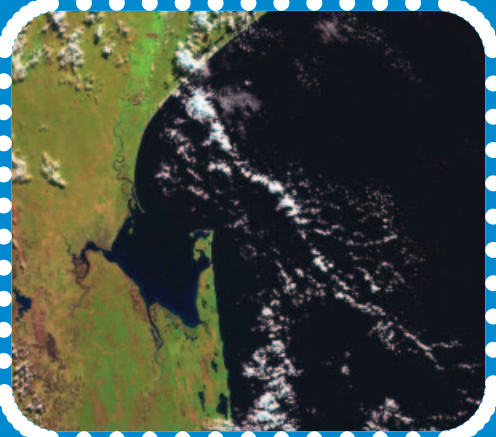
Remote sensing uses instruments that often rely on very high quality optics (the behaviour of electromagnetic light). The optics is used with a sensor that can detect radiation at some specified frequency such as infrared, visible or ultraviolet.

For example, the advanced visible and near-infrared radiometer (AVNIR) is an optical sensor used for observing land and coastal zones in visible and near-infrared regions. The data from AVNIR tell us more about desertification, the destruction rate of tropical forests and pollution of coastal zones.



Data from AVNIR and other sensors on Earth observing satellites are often included in a geographical information system (GIS). Satellite data are collected at different spatial (happening in space), spectral (a range of electromagnetic radiation in certain wavelengths) and temporal (relating to time) resolutions for agricultural applications and crop measurement. Data from this can give information about irrigated landscape mapping or soil conditions. This data can be used in a GIS where different layers of information can be stored. A researcher can then access these layers of information to find out if a certain soil type – given a certain amount of water at a certain time of the year – produces more or less crops than another area that received water at a different time of the year.

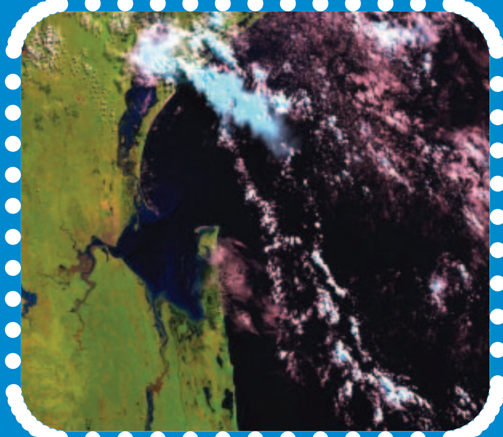
Most satellites have some form of communications link to transfer the data to a control or ground station on Earth. Earth observation satellites use a radio link to transfer data. Future satellites may use laser links, resulting in more data that will enable higher data rates, i.e. more data passed on in a shorter time.



Maputo Bay (Mozambique) with the Limpopo River estuary.

Left: Landsat 7 image from 5 July 1999.

Right: The same area on 3 April 2000 with heavy inundations (rising waters overflowing normally dry land) due to cyclone Eline that hit the coast in February 2000.



Research and development in space science and its applications

Billions of dollars have been invested in the development of space science projects. Apart from the USA, many countries are involved in space research, including Russia, China, Japan, India, Pakistan, Australia, South Africa, Nigeria and Brazil.

New developments in space research will lead to satellites that are able to measure:

- solar and Earth radiation
- soil moisture and freeze-thaw for weather and water cycle processes
- ice sheet height changes for climate change
- make-up of land surface for agricultural and mineral classification
- atmospheric gas columns for air quality forecasts.

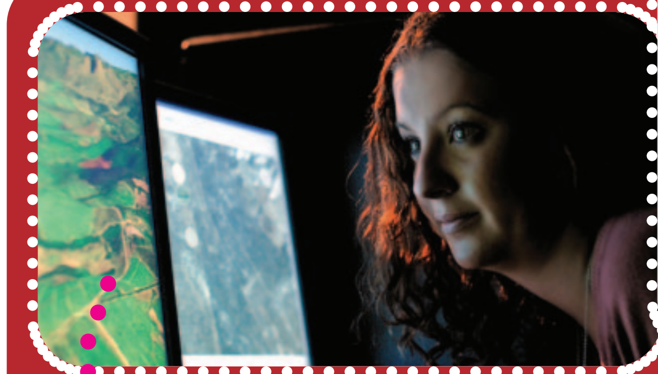
Global security

Country legislations around occupying space

Several countries, notably Australia, USA, Sweden, Russia, Canada, UK and Israel, have space legislation to guide and regulate their space activities. South Africa is developing a Space Agency, and has recently drafted a Space Agency Bill, which commits to research and development in space science.

Space science careers

Space science is very broad and includes a number of fields that seem unrelated. Careers include space geodesy (determining the position of geographical points, the shape and size of Earth), aeronautics, orbital dynamics, satellite technology, oceanography, land management, mapping, forestry, agriculture and GIS. All of these can be split into fields of specialisation. Anybody with post-school training in mathematics, physics, electronics, engineering, geology, geophysics, geography, computer science, statistics or nearly any subject, will be able to pursue a career in space science.



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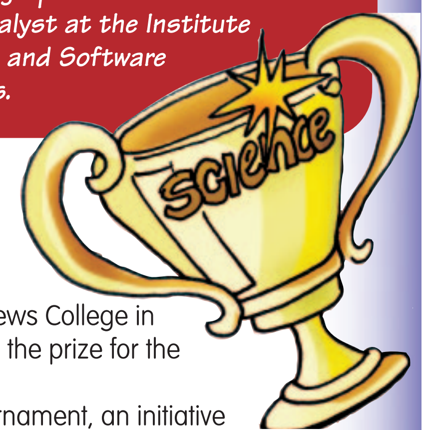
Eastern Cape learners take top honours in national debates tournament



At a glittering awards function in Pretoria, three learners from the Eastern Cape beat stiff competition to win the finals of a national debates tournament.

Over the last weekend in September, the top debating teams from North West Province, the Eastern Cape, Gauteng, Free State, Mpumalanga, Limpopo and KwaZulu-Natal faced each other in an eloquent battle of wits. In the final round the members of the Eastern Cape team, Andrew de Blocq, Anade Situma, and Ndzwayiba Makabongwe trumped worthy opponents Rebone Matabane, Sizwe Moagi, and Kgwerano Mpamonyane of the Limpopo team.

Andrew de Blocq of St Andrews College in Grahamstown also received the prize for the best overall speaker.

The national debates tournament, an initiative of the SAASTA in partnership with the South African Schools Debating Board gives learners an opportunity to develop and fine-tune their skills in scientific research, critical thinking and information literacy, as well as their ability to work as a team to present logical, clear arguments.

The Deputy Minister of Science and Technology, Derek Hanekom, in his keynote address highlighted the insight and understanding the young learners displayed regarding issues of environmental concern and the fact that poverty marches along with problems such as pollution of natural resources like water.

"It is up to us and future generations to find smart ways and smart actions to solve these problems," he told the audience. "Our challenge is to find the right formula to offer all the people of the world a decent, sustainable lifestyle. It is therefore imperative that we understand life systems so that we know how to protect our natural resources."

Deputy Minister of Science and Technology, Derek Hanekom, with the winning team of the SAASTA national school debates competition. The Eastern Cape learners are Ndzwayiba Makabongwe, Anade Situma and Andrew de Blocq.