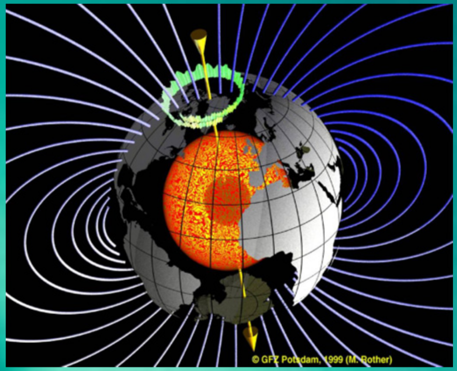
Mission objectives

Planet Earth is subject to a constant bombardment by high-energy particles from sun and space. Fortunately, the geomagnetic field acts as a protective shield against this dangerous radiation. Measurements of the past decades reveal that the geomagnetic field is decaying. The strongest decrease is observed in the South Atlantic with a rate of 12% over a time period of 30 years. Spacecraft crossing this area suffer more technical malfunctions here than elsewhere. Crew members of the international space station (ISS) receive their highest radiation dose when moving over this region. These hazards require a close monitoring of the unpredictable future evolution of the geomagnetic field – a task that can be accomplished best by low-orbiting satellites like the Swarm mission.

The high resolution magnetic readings will also be processed for the mapping of magnetized rocks and sediments. The resulting magnetic image of the Earth's crust may be used for the detection of magnetic minerals and ore deposits.

Apart from the magnetic field, the Swarm satellites will survey the partly ionized and conductive upper atmosphere. The electron density variations at these altitudes may cause radio wave scintillations as well as distortions or disruptions of GPS navigation signals. Swarm may contribute substantially to the improvement of navigation data by monitoring these variations closely. Furthermore, scientists expect contributions to space weather predictions, estimation of cosmic radiation hazards, and disturbances caused by geomagnetic storms.

Another great challenge for the Swarm mission is the determination of the electrical conductivity of the Earth's mantle from magnetic field measurements. Natural fluctuations of the geomagnetic field induce electrical currents in Earth's mantle. These currents are stronger for high conductivity compared to low conductivity, inducing in turn larger secondary magnetic fields. Thus the Swarm mission is able to contribute to the understanding of Earth's deep interior with the determination of the hitherto little-known mantle conductivity.



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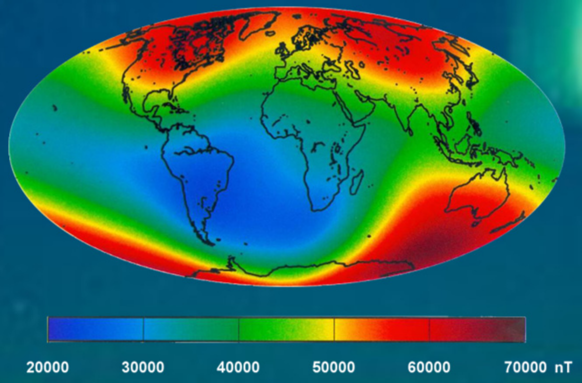
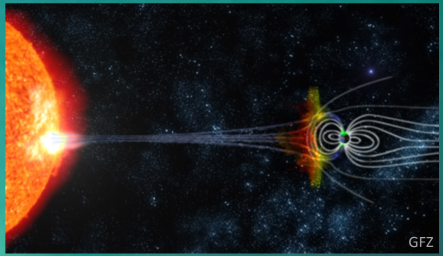
Earth's magnetic field

The magnetic field measured at satellite altitude originates from internal and external sources. The main internal part (95%) is generated by the geodynamo in the liquid core of the Earth. Due to the great heat in the Earth's core and the fast rotation of the Earth, heat convection evolves in spirals parallel to the Earth's rotation axis. These spiralled convection flows induce the geomagnetic field. While Earth's magnetic field features multiple poles at the core-mantle boundary, it resembles the shape of a dipole field at the surface, as known from a bar magnet. The position of its magnetic north and south pole is detectable with a compass. On average the geomagnetic field reverses twice in a million years. This process of pole reversal takes place in the geodynamo and lasts for several thousand years. The latest pole reversal occurred 780.000 years ago. Therefore it is possible that another reversal is imminent.



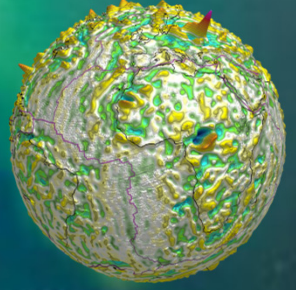
Distribution of the geomagtic field strength on the Earth's surface. The intensity is greatest above North America, Siberia and between Antartica and Australia. The established conception of a dipole (north pole – south pole) fails to explain the zone of weak intensity in the South Atlantic.

The external part of the magnetic field is generated by electric currents in the Earth's magnetosphere and ionosphere. These magnetospheric currents are constantly driven by interaction of the solar wind with the geomagnetic field. The solar wind is a stream of charged particles ejected from the sun into space. It compresses the geomagnetic field on the dayside, facing sunward. On the nightside, a magnetic tail stretches for millions of kilometres into space. The magnetosphere contains a gas of charged particles, a so-called plasma. These particles originate partly from the Earth's atmosphere and partly from the solar wind. Plasma moves preferentially along magnetic field lines. On striking the atmosphere in the polar regions, some of these particles excite aurora. The magnetic signals of related ionospheric currents can be observed clearly in satellite measurements.



GFZ

A further part of the magnetic field stems from magnetized rocks and sediments of the lithosphere (crust). During volcanic eruptions the cooling lava stores the direction of the geomagnetic field. The smallest part of the geomagnetic field is generated by large-scale ocean currents that move conductive saltwater across the magnetic field, causing charge separation which in turn drives electric currents.



View onto the Earth: magnetic rocks clearly emerge with yellow-red being positive and green-blue being negative magnetic field values. Strikingly discernible on the northern hemisphere is the Kursk magnetic field anomaly (red peak). It can be related to the corresponding iron-ore deposit in Russia.

The best ever survey of the geomagnetic field from space

A new generation of satellites will be launched 2012 to probe the Earth‘s magnetic field with high precision and resolution. Swarm is one of the Earth observation missions in ESA’s Living Planet Programme. The main mission aim is the best ever survey of the geomagnetic field and its temporal evolution, in order to improve our knowledge of the Earth’s interior and near-Earth space.

The Swarm concept consists of a constellation of three satellites in three different polar orbits between 300 and 530 km of altitude. During their constellation flight, high-precision instruments measure the direction, intensity, and temporal variations of the magnetic field. In combination, they will provide the necessary observations that are required to model the various sources of the geomagnetic field. Additionally, the satellites will provide the electric field vector, plasma density, electron and ion temperature, air density and wind, and the spacecraft velocities and positions with unprecedented accuracy.

ESA

ESA's magnetic field mission Swarm,
European Space Agency (ESA)
http://www.esa.int/esaLP/LPswarm.html

Swarm Project Office Germany

The Swarm Project Office in Germany was initiated to coordinate the scientific and technical use of the mission results by German companies and research institutions. In support of this activity, funding lines and programmes are initiated and coordinated. The Project Office also provides information about the Swarm mission and raises public awareness.

c/o Helmholtz Centre Potsdam
GFZ German Research Centre for Geosciences
Telegrafenberg, D-14473 Potsdam, Germany

http://www.swarm-projektbuero.de

The Swarm Project Office at GFZ is sponsored by the Federal Republic of Germany, Initiator: the Space Agency of the German Aerospace Center through funds of the German Federal Ministry of Economics and Technology, following a decision of the German Federal Parliament (grant code 50EE0916).

status : Nov. 2012
picture credits: geomagnetic field strength, lithospheric field, solar wind: GFZ; aurora: Jouni Jussila, Finland.

Technical details

number of satellites:	3 (identical)
launch:	March/April 2013 from Plesetsk Cosmodrome (Russia)
carrier system:	Rockot
mission duration:	4 years
satellite mass:	~500 kg each
orbit type:	circular, polar

orbit constellation:		
altitude	Sat. A,B:	460-300 km
	Sat. C:	530 km
inclination	Sat. A,B:	87.3°
	Sat. C:	88.0°
separation	Sat. A-B:	1.4° geogr. longitude

scientific payload:
- scalar magnetometer (measures the magnetic field strength)
- vector magnetometer (measures the magnetic field components along three directions)
- electric field and plasma instrument (measures the plasma temperatures and density, and the electric field vector)
- three star cameras (measure the orientation in space)
- GNSS-receivers (GPS for positioning and time stamping)
- accelerometer (measures the air drag of the satellite)
- laser retro reflector (for precise orbit determination)

prime contractor:
EADS Astrium, Friedrichshafen, Germany

satellite operation:
- management: ESOC (Darmstadt, Germany)
- data transmission stations: Kiruna (Sweden) and Svalbard (Norway)
- data processing and distribution: ESRIN (Frascati, Italy)

mission contributions to research areas:
- geomagnetic field
- ionosphere, thermosphere
- space weather
- geodesy, geosciences

EADS Astrium

SWARM

Satellite trio on voyage through the Earth‘s magnetic field