RAS/BGA Specialist Discussion, 9 Oct. 2009, London

The Geomagnetic Field: Preparing for the Swarm Multi-Satellite Mission

Schedule

Morning session: Convenor Malcolm Dunlop

10.30 Introduction – Richard Holme
10.35 The Swarm Magnetic Mission, Roger Haagmans, ESA
11.00 Achievements in Characterising Ionospheric and Magnetospheric Fields, Hermann Lühr, GFZ Potsdam.
11.30 Modelling the recent geomagnetic field using satellite and ground magnetic observations – lessons learned from Ørsted and CHAMP and prospects for SWARM, Nils Olsen, DTU Space, Copenhagen.
12.00 Opportunities for the joint analysis of Swarm and SuperDARN measurements of ionospheric electric fields, Adrian Grocott, University of Leicester
12.15 Modelling the ionospheric current system with General Circulation Models: Strengths and Limitations, Tim Spain, UCL.
12.30 Can we use space magnetometer data in operational ionospheric models? Mike Hapgood, RAL

Lunch, 13.00-14.00

Afternoon session: Convenor Richard Holme

14.00 Swarm Ground Segment & Data Products, Gernot Plank, ESA/ESTEC.
14.30 Cluster- highlights and case for extension, Andrew Fazakerley, UCL.
15.00 Discussion session: Organising and optimising UK participation in the Swarm mission.

Close and tea, 15.30

Swarm: ESA's Magnetic Field Mission

Roger Haagmans, Gernot Plank
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Swarm is the fifth Earth Explorer mission in the European Space Agency's Living Planet Programme. The objective of Swarm is to provide the best ever survey of the geomagnetic field and its temporal evolution. The mission shall deliver data that allow access to new insights into the Earth system by improving our understanding of the Earth's interior and climate. The mission is nominally scheduled for launch in 2011. After release from a single launcher, a side-by-side flying slowly decaying lower pair of satellites will be released at an initial altitude of about 490 km together with a third satellite that will be lifted to 530 km to complete the Swarm constellation. High-precision and high-resolution measurements of the strength, direction and variation of the magnetic field, complemented by precise navigation, accelerometer and electric field measurements, will provide the observations that are required to separate and model various sources of the geomagnetic field and near-Earth current systems.
The presentation will focus on mission aspects and the current project status of Swarm.

Achievements in Characterising Ionospheric and Magnetospheric Fields

Hermann Lühr[1], Claudia Stolle[1], Stefan Maus[2]

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2. Cooperative Inst. for Research in Environm. Sci., University of Colorado, Boulder, CO

The recent magnetic field missions have brought about an enormous progress in the understanding of near-Earth external field structures and the description of their sources. Based on observations from Ørsted, CHAMP and SAC-C a rather comprehensive picture of their temporal-spatial variability could be achieved.

More and more evidence has been presented for the significance of currents at F region altitudes where ion-neutral collisions are less important. These currents are driven predominantly by plasma processes. Among others, gravity and pressure gradient forces are acting on the charged particles. In particular, plasma irregularities like plasma bubbles cause detectable magnetic signatures. These F region currents are shown to flow also on the night side, and they cause magnetic fields of order 5 nT. At low latitudes the effect of the F-region dynamo could be verified experimentally. This wind-driven generator sets up meridional current systems which peak around noon and sunset.

It is now possible to separate the magnetic effects from the ring current and the magnetospheric tail currents could. With that it became evident that the quiet time strength of the ring current is much weaker than previously thought. Magnetospheric missions could provide space-truth for that.

An appropriate method would be to model all the currents self-consistently and predict the magnetic field corrections. The constellation mission Swarm is equipped for providing observational input for such an approach.

Modeling the recent geomagnetic field using satellite and ground magnetic observations – lessons learned from Ørsted and CHAMP and prospects for SWARM

Nils Olsen, DTU Space, Copenhagen

Magnetic field observations measured on ground or in space is the superposition of contributions from a variety of sources in the Earth's environment (e.g. ionospheric and magnetospheric currents) and its interior (e.g. the fluid core, crust, and currents induced in the mantle and crust by the time-variations of the external fields). The separation of these various sources is a major scientific challenge.

In this talk I will report on recent achievements in modeling the Earth’s magnetic field using observatory and satellite data. Analysis of data from the present satellites Ørsted and CHAMP allows determining small-scale structure of the core field changes (globally up to, say, spherical harmonic degree n=15) and of the lithospheric field (up to, say, n=60).

The upcoming /Swarm/ satellite constellation mission will make it possible to improve this, especially regarding the lithospheric field.
Results from an analysis of data from a simulated full-mission indicate that the lithospheric field up to n=150 can be resolved.

Opportunities for the joint analysis of Swarm and SuperDARN measurements of ionospheric electric fields

A. Grocott, M.P. Freeman, M. Lester, S.E. Milan, T.K. Yeoman, University of Leicester

A key objective of the Swarm mission is to characterise the Earth's external magnetic field, arising from complex electromagnetic processes in the solar wind-magnetosphere-ionosphere system. To facilitate this, the Swarm satellites will each carry both magnetic and electric field instruments, the latter enabling the ionospheric electric field to be probed at ~1 km spatial resolution and 0.1 second temporal resolution over a signal range of +/- 200 mV/m (equivalent to a convection velocity range of about +/- 4 km/s). A complementary dataset that will prove highly valuable in calibrating, validating, and interpreting measurements from Swarm is provided by the Super Dual Auroral Radar Network (SuperDARN), which provides mesoscale observations of the ionospheric electric field at up to 15 km spatial resolution and as good as 3 second temporal resolution, and global-scale maps with a cadence of up to once every minute. Thus SuperDARN can help to: (1) validate electric field variations over the lower part of the spatial and temporal frequency spectrum, including on the spacecraft separation scale of 150 km, (2) separate spatial and temporal components, and (3) provide a large-scale context for the high-frequency fluctuations. We present an overview of the SuperDARN facility, and show examples of the joint ground- and space-based analyses which can be achieved.

Modelling the ionospheric current system with General Circulation Models: Strengths and Limitations.

Tim Spain, Anasuya Aruliah and Alan Aylward, UCL

Traditionally most studies of the ionospheric current system have concentrated predominantly on the physics of the charged components of the ionosphere with the neutral atmosphere largely ignored or provided by a statistical model such as MSIS. General Circulation Models (GCMs) of the upper atmosphere allow simultaneous feedback between the neutral atmosphere and the charged ionosphere. This feedback includes the Joule heating of the thermosphere by the ionosphere and changes in ionospheric composition due to changes in ionization and recombination rates. GCMs also provide high temporal resolution in the neutral atmosphere for studying of the response of the atmosphere to short-lived events such as Solar flares and other geomagnetic storm events. The global aspect of a GCM also allows the provision of model data that is self-consistent throughout the domain of the model. This combination of features is advantageous to many studies involving the ionosphere. Herein we will present in detail these advantages, but also the limitations of GCMs, with an emphasis on studying currents in the ionosphere, using as examples UCL-CTIP and CMAT2 models, which are the UCL current- and next-generation upper and middle atmosphere GCMs.

Can we use space magnetometer data in operational ionospheric models?

Mike Hapgood, RAL

The development of operational ionospheric models is a topic of scientific importance because of ever-growing range of practical applications that require knowledge on the recent and current state of the ionosphere. These range far beyond the traditional, but still important, area of HF communications to include many space and navigational systems. As a result ionospheric issues are a major element in the space situational awareness programmes now developing in Europe and the US. Experience suggests that operational models should include a diverse range of data inputs, subject only to the requirement for adequate execution speed. This increases the constraints on the models and thus improves their ability to reflect physical reality. This talk will explore how space magnetometer data might be used to constrain future models alongside familiar ionospheric measurements such as GPS total electron content and ionosonde data. It will outline some of the relevant physics and suggest what scientific research is needed to enable the use of magnetometer data in ionospheric applications.

Swarm Ground Segment & Data Products

Gernot Plank[1], Rune Floberghagen[2]

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Cluster – highlights and case for extension

Andrew Fazakerley, UCL

The ESA Cluster mission comprises four spacecraft flying in formation launched into an initially polar 4x19.6 Re Earth orbit. The orbit allows the spacecraft to visit many important regions of the magnetosphere and near-Earth environment. As the mission has progressed, the orbit has evolved due to gravitational perturbations, enabling Cluster to visit new regions of the magnetosphere, opening up further opportunities for science investigations. Together with SOHO, Cluster forms one of the Cornerstone missions of the ESA Horizon 2000 programme. Cluster began operations in February 2001 and ESA have just granted approval for an extension of operations to 2012. This talk will illustrate a few of the recent Cluster highlights, and summarise the case for the new extended mission which is anticipated to overlap with SWARM operations. Cluster's inner magnetospheric measurements will complement and support analysis of the "external field" observations of SWARM.

POSTERS

A comparison of neutral wind measurements from CHAMP and ground-based Fabry-Perot Interferometers with the Coupled Thermosphere Ionosphere Plasmasphere (CTIP) model.
A.L.Aruliah, M.Foerster, T.C.Spain, A.D.Aylward, UCL.

Miniaturised particle sensors suitable for future space weather missions
D.O.Kataria, Anasuya Aruliah, Bob Bentley, Alan Smith, Robert Bedington, UCL.

Using Satellite Geomagnetism to Study Ocean Flow
James Hawe[1], Richard Holme[1] and Robert Tyler[2], [1]University of Liverpool and [2]APL, University of Washington

Magnetic Field Modelling at BGS and Readiness for Utilising Swarm Data
Susan Macmillan, Brian Hamilton, Ciaran Beggan and Alan Thomson, BGS

Ground-based geomagnetic data collection and dissemination which will support Swarm Susan Macmillan, Sarah Reay and Chris Turbitt, BGS

Global scale-invariant dissipation in collisionless plasma turbulence
Khurom Kiyani and Malcolm Dunlop, RAL

Magnetization Models Derived From High Resolution Satellite Lithospheric Anomaly Fields
Kathy Whaler (University of Edinburgh) and Mike Purucker (NASA GSFC)

Towards the modelling of high latitude magnetic fields from satellite data
Gemma Kelly[1], Richard Holme[1] and Alan Thomson[2] [1]University of Liverpool, [2]BGS

Comparisons of eight years magnetic field data from Cluster with Tsyganenko models and the spatial distributions of Ring Current
Qinghe Zhang[1,2], M. W. Dunlop[2], R. Holme[1], and E. E. Woodfield[3]
[1] University of Liverpool, [2] Rutherford Appleton Laboratory,[3] University of Lancaster.

Magnetic Field Forecasting using Virtual Observatories, core flow modelling and Ensemble Kalman Filtering
Ciarán Beggan[1,2], Kathy Whaler[1] and Susan Macmillan[2], [1]University of Edinburgh, [2]BGS

Reconstruction of bandwidth-limited data on a sphere using Slepian functions: applications to crustal modelling
Ciarán Beggan[1,2] and Frederik Simons[3], [1]University of Edinburgh, [2] BGS, [3] Princeton University

Jovimagnetic Secular Variation
Victoria Ridley and Richard Holme, University of Liverpool