Highlights from AGU's Virtual Session on New Magnetic Field Satellites

In conjunction with the 2002 Spring Meeting (28–31 May), AGU hosted a virtual session on the analysis of satellite magnetic field observations from the low-earth orbiting Ørsted, CHAMP, and SAC-C mini-constellation. Some 27 authors and co-authors from 9 countries presented talks at an AGU session without leaving their office or home. The purpose of the virtual session was to facilitate interactions among the far-flung community working in the areas of geomagnetism and space physics. Our Web page (www.dsri.dk/multimagsatellites) hosted visits from researchers representing 29 countries. More than 100 important questions, answers, and comments were received during the course of two online sessions, each two hours long, occuring on 28–29 May. In addition to highlighting some of the exciting new science taking place, we, as the conveners, felt that the wider membership would want to know the ingredients for the successful electronic interaction that we conducted.

Process

AGU's first online session occurred during the prior (2001) Spring Meeting on the topic of "Integrated Models of Earth Structure and Evolution," drawing from a breadth of Earth science disciplines (e.g., seismology, geodynamics, mineral physics). Session conveners invited contributions from twenty-one scientists; twenty uploaded presentations.

Challenges from last year were used as guidance for the success of this year's online session. For example, in 2001, each "virtual presentation" was submitted as a single document in PDF format, which were all posted as links on AGU's Web server. This created a variety of challenges: many authors were not familiar with the PDF format; download times were excessively long for some of the larger presentations; the format of presentations was non-uniform in style and size (ranging from a couple of figures with captions to full publication preprints); and the general "feel" of the session was far from interactive.

Following a suggestion in October 2001 from H. McCreadie and M. Purucker to hold an all-electronic meeting, the CHAMP, Ørsted, and SAC-C projects agreed to provide a coordinated data set. In December 2001, the conveners chose data sets, and a Web page outlining the session concept was constructed at the Danish Space Research Institute (DSRI). The community was alerted to the session via e-mail with a link included to the Web page. A presentation template was chosen that was based on the HTML markup language and JPEG graphics. Although this template was not required, only one participant utilized a different template. The session was advertised by e-mail, and through advertisements that appeared in *Eos* in January and April. Throughout January and February, the data sets were made available via the Web site. Abstracts were submitted and posted on the site on 15 March. At this point, the authors were provided with the template for their presentations. In May, the authors submitted their presentations, which went live on 20 May at the DSRI Web site. Links to papers and seed questions to authors were prepared on the AGU Web site, which went live on 23 May. Two online sessions, each two hours long, occurred on 28 and 29 May. In June, the discussions were appended to the individual papers and a CD with papers (100Mb) and data (300Mb) was prepared for distribution to the authors.

The Satellites

The ongoing Ørsted, CHAMP, and Ørsted-2 experiment onboard SAC-C measure the absolute and vector geomagnetic fields in conjunction with high-accuracy star cameras and GPS receivers. All three satellites utilize a boom-mounted CSC triaxial fluxgate magnetometer for vector measurements. Absolute measurements of the field are provided by Overhauser magnetometers on CHAMP and Ørsted, and by a helium magnetometer on SAC-C. The satellites are in near-polar orbits, with CHAMP being the closest to polar, with an inclination of 87.3°. CHAMP is also at the lowest altitude (400+ km), while SAC-C and Ørsted are in the 600–800 km altitude range. SAC-C is fixed in local time at 10:30/22:30, while Ørsted and CHAMP move through all local times. As a consequence, the satellites perform a dance in the heavens, with many possible permutations.

Because the three missions were designed individually, carried different instrument configurations, were subject to differing calibration approaches, and do not operate together or utilize common ground-control systems, they are not a true constellation. However, they do provide a test bed from which to assess the strengths and limitations of constellations. In addition, CHAMP and SAC-C are still undergoing calibration and data are subject to significant change. In fact, one of the outcomes of the virtual session was to point to areas where calibration concerns still exist. In addition, high-precision star camera fixes are not available from the Ørsted-2 experiment on SAC-C.

Data Selection

The conveners, led by S. Vennerstrøm, selected time intervals between May and October 2001 when observations were available from at least two, and usually all three satellites. A total of 19 days were selected for study, including quiet days, days of steady northward interplanetary magnetic field (IMF), active days with slowly rotating IMF of significant magnitude, and a single storm (16–19 August, 2001) period. Times during which two satellites were in approximately the same orbit plane (local time), as well as periods in which all three satellites were in different planes were also selected. A major part of the selected periods were quiet days, suitable for investigations of the core and crustal fields. These data sets, however, are also interesting from a space physics point of view, for studies of the Equatorial Electrojet (EEJ) and high-latitude polar cap and cusp currents during northward IMF. The data sets were complemented by the addition of descriptive models and indices to each observation.

Session Science Highlights

Over the past 150 years, the axial dipole component of the Earth's magnetic field has decayed by nearly 10%. That is ten times faster than if the dynamo that generates the field were switched off completely. The current decay rate reflects the presence of growing flux patches of reversed polarity in the outer core, which, if continued, could result in a magnetic reversal. Geographically, the decay is largely due to changes in the field in the South Atlantic region, where the expanding and deepening South Atlantic anomaly has serious implications for low-Earth orbit satellite operations. Magnetic models developed during sessions such as these can be used to verify and follow these trends.

One of the strengths of the virtual session was the ability to apply different methods to evaluate identical data sets. Presentations were welcomed on external current systems, the main field, induction, and crustal fields. About half of the 14 presentations described studies of external sources, mostly at high latitudes.

T. Moretto et al. inferred high-latitude ionospheric currents in the northern (winter) and southern (summer) hemispheres by combining simultaneous scalar field observations from all three satellites. Field-aligned currents were studied in four presentations: A method for the automatic determination of the position and strength of field-aligned current sheets was presented by M. Connors. F. Christiansen and V. Papitashvili evaluated the forecast capabilities of their "Field-Aligned Currents Experimental Model" by comparing model maps with the magnetic observations for various space weather conditions, while S. Vennerstrøm et al. investigated the validity of the infinite sheet assumption when modeling field-aligned currents. A.M. Stampe et al. elaborated on the question "are quiet days really geomagnetically quiet?" and concluded that data selection with criteria that are typically used for field modeling may not be sufficient to avoid high-latitude external field contributions.

The magnetic signature of the Equatorial Electrojet (EEJ) was investigated in two papers: G. Jadhav et al. fit a parametric model to the scalar data (after subtraction of a field model) to obtain parameters that describe

the EEJ, while H. McCreadie applied a filtering technique. The necessity of good models of the main, crustal, and magnetospheric fields for the extraction of the EEJ signal was one of the conclusions of these studies.

A remarkable agreement between simultaneous magnetic observations from different satellites, even during moderately disturbed conditions (only a few nT difference), was found by M. Purucker during close encounters of the spacecraft.

N. Olsen et al. utilized simultaneous data from all satellites to determine a new geomagnetic field model. Significant improvements compared to previous models were obtained; for instance, by using only shadowed data (with the Sun below the horizon) at high latitudes.

Studies of small-scale crustal fields in Antarctica and Argentina, respectively, were presented by A. DeSantis et al. and M. Ghidella et al. B. Langlais also investigated the lithospheric field at polar latitudes from magnetic data of the various satellites.

An overall conclusion was that the presence of ionospheric and magnetospheric signatures is one of the limitations of present crustal maps, especially in the polar areas. Since improved field models are required for a better extraction of external field signatures, the need for a close collaboration of scientists and synergistic research beyond the usual division into "external" and "internal" investigations is necessary, in order to utilize the improved data accuracy that the present, high-precision magnetic satellites provide.

Success Factors

The virtual session was judged a success, for which we identified at least three reasons. First, we had a unique data set that was available only on our Web site. Second, the conveners were pro-active, and both seeded the talks with questions and provided questions during the online session. And finally, we had a well-defined but international community for whom travel can sometimes be difficult, but who were anxious to participate. This year's move to HTML format with JPEG graphics was viewed as a significant improvement for authors and viewers. Future online sessions will also benefit from the use of guidelines or templates for presentations, as used this year.

Several areas for improvement were also noted. The two most common were (1) the ability to know who else is on the AGU discussion forum at a given moment, and (2) the AGU discussion forum should allow at least authors the ability to easily post additional figures.

The individual talks and discussion, and the satellite data sets, remain available at www.dsri.dk/multimagsatellites and are available on CD by request at the e-mail address below.

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