Results from the magnetic mapping payload onboard SAC-C

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Introduction

The 8 m long boom containing the magnetic mapping payload on SAC-C was extended on 23 Jaunary 2001, two months after launch. The payload contains three instruments: 1) a scalar helium magnetometer (E. Smith, JPL-NASA PI) for absolute measurement of the intensity of the magnetic field, 2) a compact spherical coil triaxial fluxgate magnetometer (F. Primdahl, DTU PI) for the measurement of the vector components of the magnetic field, and 3) a low magnetic noise star camera (J. Jorgenson, DTU PI) to provide orientation information to the vector magnetometer.

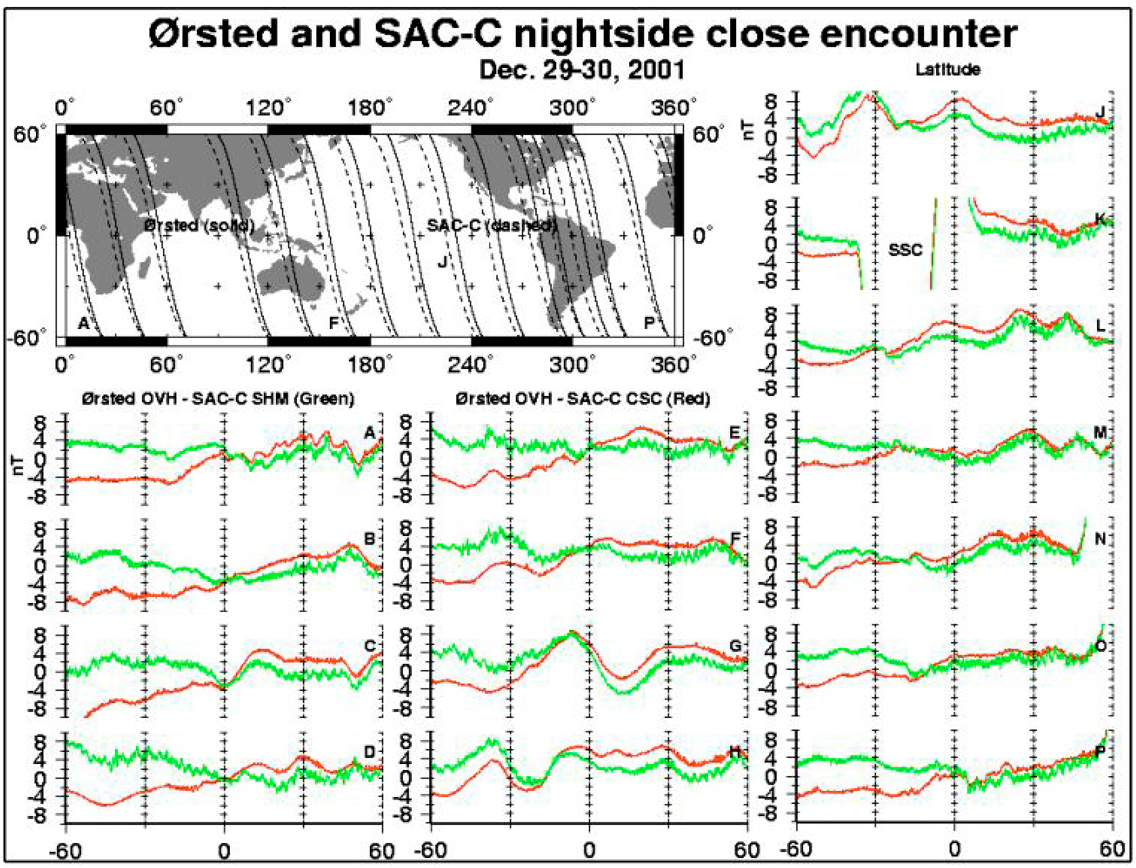

Figure 1: SAC-C intercalibration

The absolute magnetometer is located at the end of the boom, the vector magnetometer and star camera are located about 1 m from the end. The star camera has given no information during the course of the mission, possibly because of a cabling problem on the boom. As a consequence, magnetic field measurements from SAC-C are restricted to the 1 Hz values from the absolute magnetometer, and partially oriented values at 20 Hz from the vector magnetometer.

Calibration and Intercalibration

Although the absolute magnetometer onboard SAC-C should be accurate to within about 1 nT, there may be contaminating spacecraft fields of a few nT, especially on a spacecraft as complex and with as many instruments as SAC-C. Because spacecraft fields are well-characterized, and small, on the dedicated CHAMP and Oersted satellites, we compared the absolute magnetometers onboard these satellites during their close encounters with SAC-C, when the satellites were in similar orbits. Such configurations occur every six monthes or so, as the three satellites perform a dance in the heavens, with many possible permutations. The premise is that during close encounters, the external magnetic fields seen by the two satellites will be similar. One such close encounter, between SAC-C and Oersted, occurred on 29 December 2001. The results, after removal of the earth's main magnetic field, are shown in Figure 1. As a consequence of this close encounter, and three other such encounters between May of 2001 and October of 2002, a correction of between 0.5 and 1.5 nT was applied to the absolute magnetometer measurements to empirically correct for SAC-C spacecraft fields.

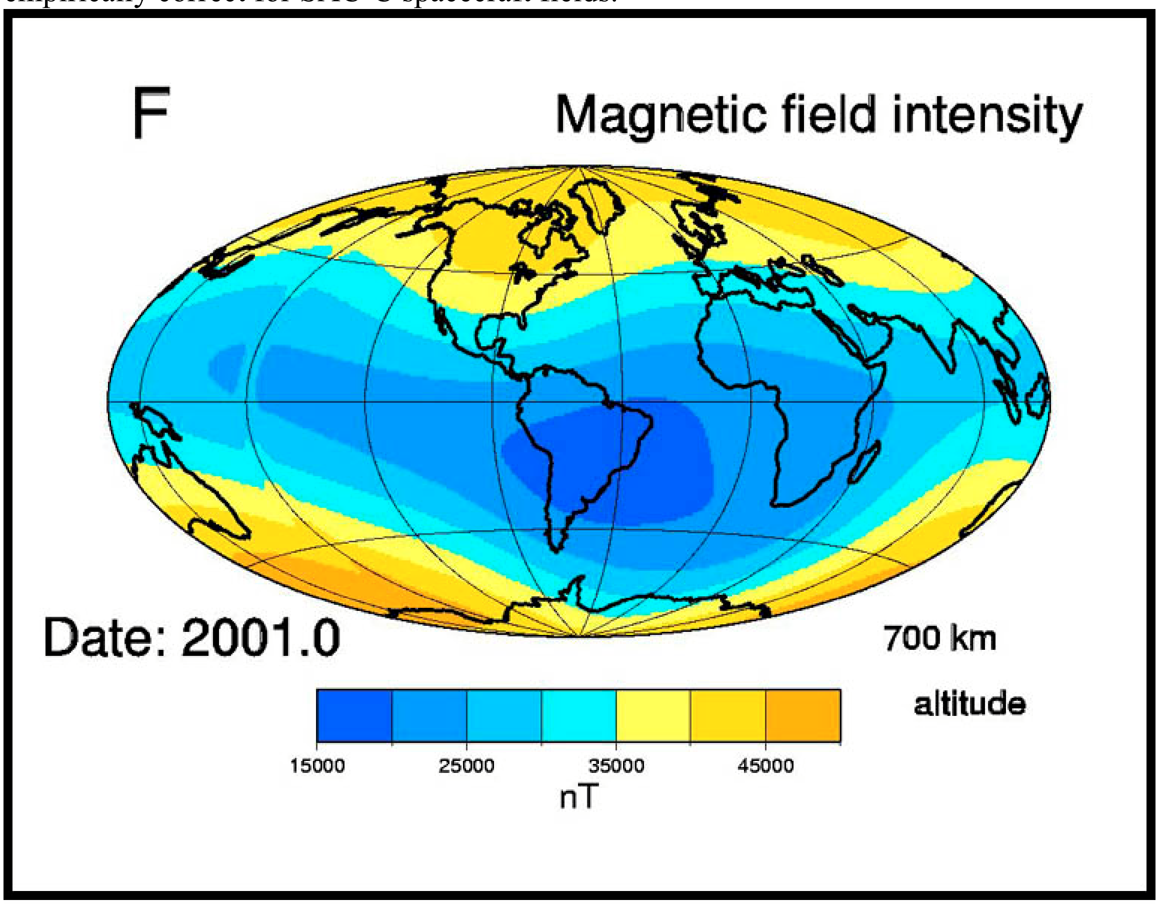

Figure 2: Magnetic field at beginning of SAC-C mission

Data Sets

Magnetic field data from SAC-C using the preflight calibration of the vector magnetometer are available at www.dsri.dk/multimagsatellites. These data, and the data from CHAMP and Oersted for the same time period, are described in Purucker et al. (2002). Calibrated values will be available from the Oersted data center (web.dmi.dk/fsweb/projects/oersted/homepage.html) in Denmark.

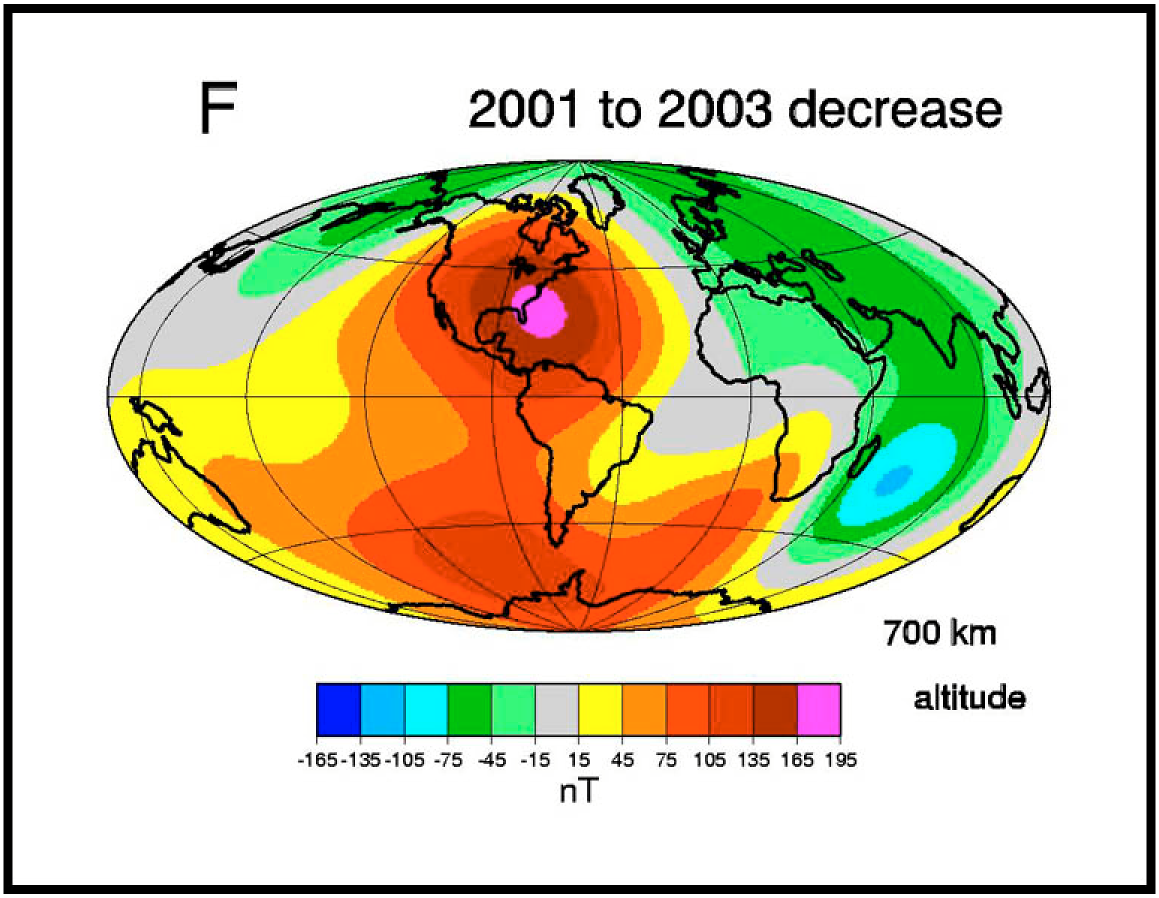

Figure 3: Magnetic field changes since SAC-C launch

Results

The earth's magnetic field is constantly changing. On the continents we monitor this secular change with magnetic observatories, such as the Argentine observatory at Trelew. Global magnetic secular variation is our only direct measure of motion in the fluid outer core of the earth. Monitoring the earth's magnetic field is currently almost impossible to do over the oceans, and so satellites such as SAC-C are our best source of information on magnetic changes over the oceans. Prior to SAC-C, mapping of secular variation of the magnetic field from satellites had been performed only by NASA's POGO missions from 1967-1971, and to some degree by the Magsat mission of 1979-1980. Figure 2 shows the total magnetic field at the beginning of SAC-C's magnetic mapping mission, in January of 2001. Note that the lowest field values are centered over Argentina and the surrounding South Atlantic. This feature, called the ‘South Atlantic anomaly’ has been a hazard for orbiting spacecraft since the dawn of the space age because of the increased radiation hazards in this region at low-earth orbit.

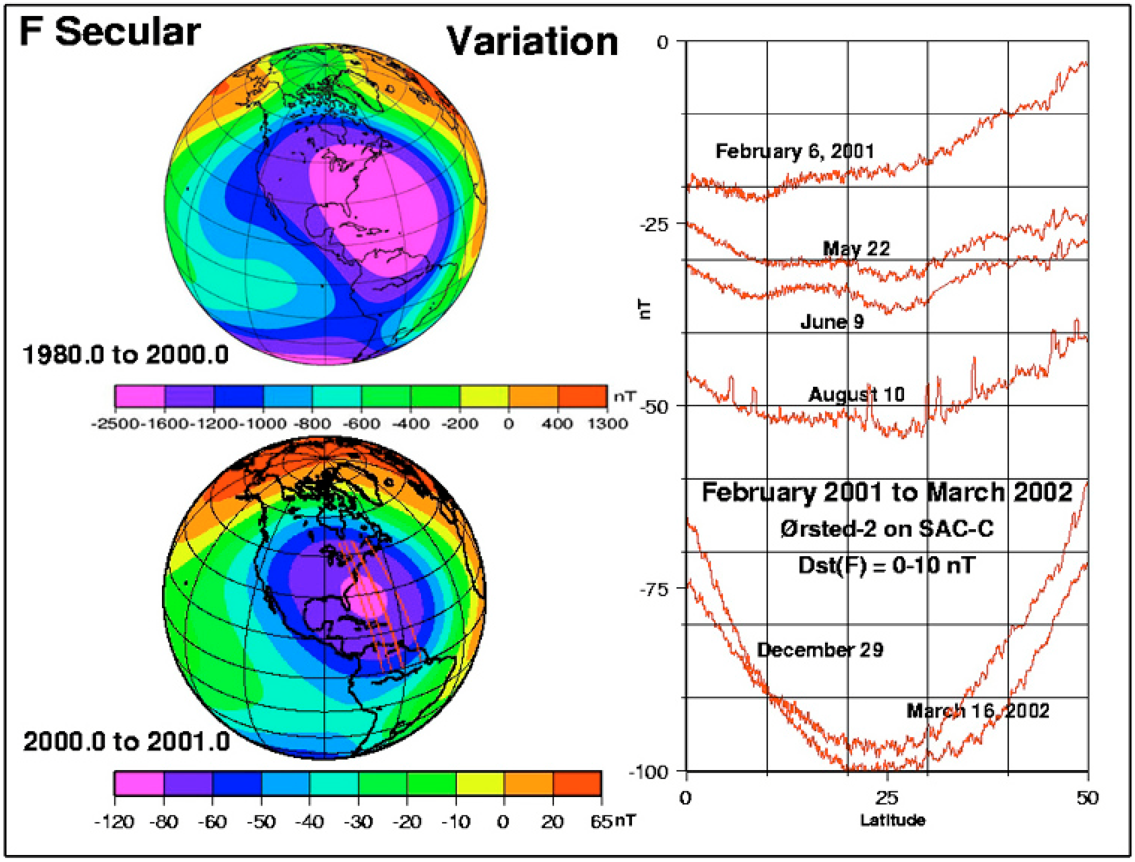

Figure 4: Details of magnetic field decrease from SAC-C

One of the purposes of the magnetic mapping package on SAC-C was to better define this region, and to map its changes. In the two years beginning with the start of the mission, this region has expanded both to the north and south, as shown in Figure 3.

This expansion of the South Atlantic anomaly has not been uniform, and the decrease in the magnetic field along the flanks of the anomaly has been significant since 1980, amounting to some 5% of the total field, as shown in Figure 4. SAC-C profiles (locations shown in red in the lower left corner of the figure) illustrate the continuation of the decrease along the flanks of the South Atlantic anomaly for the 13 month period beginning in February of 2001.

Another use of SAC-C has been to provide a real-time measure, and correction, of the field associated with the magnetospheric ring current (Olsen et al., 2002). This field is very dynamic, and most previous attempts to correct for this field relied on the Dst index. SAC-C improves our ability to forecast this field by more than a factor of two.

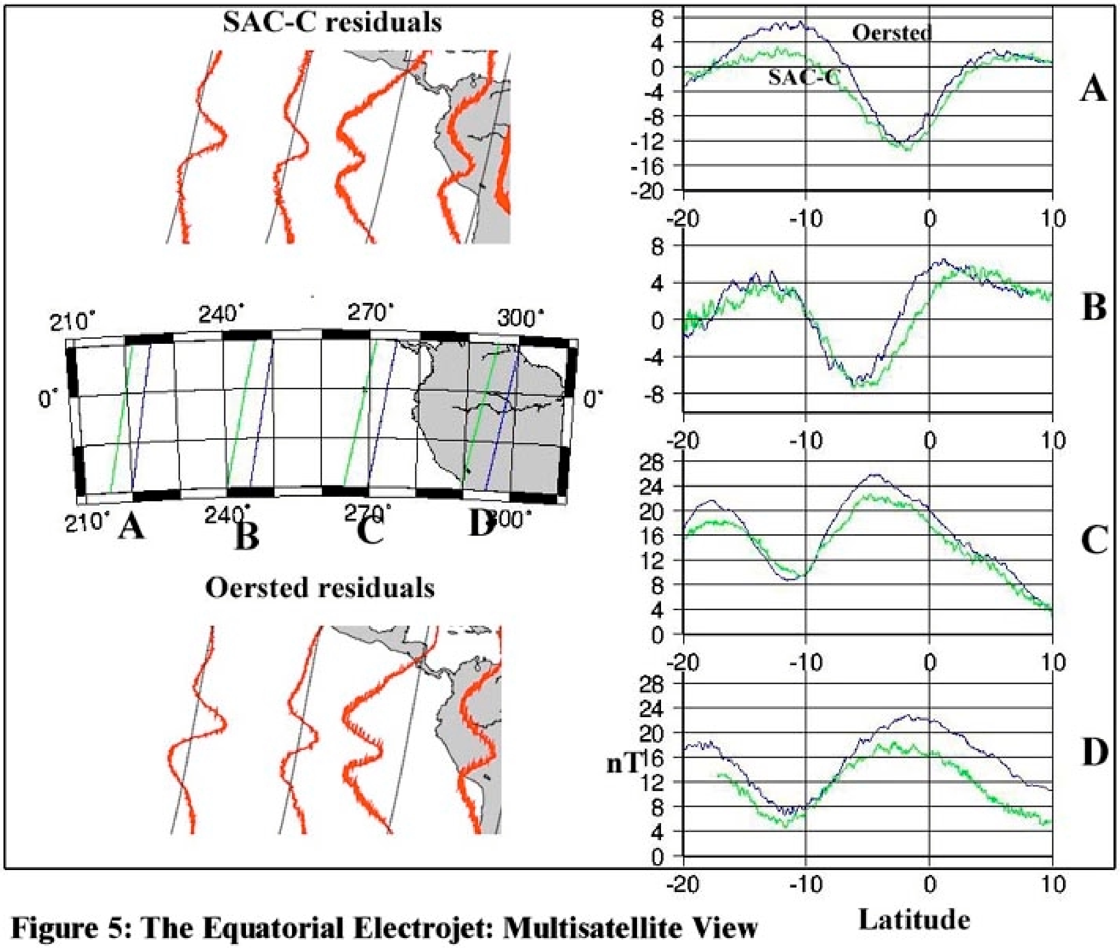

Figure 5: The Equatorial Electrojet: Multisatellite View

A close encounter of the Oersted and SAC-C satellites occurred in late December of 2001 and early January of 2002. These close encounters provide a way to separate temporal and spatial field variability of the magnetic field. Figure 5 shows the close encounter on December 28th when the satellites are following one another within 5 minutes. The altitudes of the satellites are typically within 100 km, at about 700 km altitude. This is a disturbed period, with Kp values up to 4 and Dst values as large as 50 nT. Focusing on the signature of the equatorial electrojet in the Oersted and SAC-C close encounter, we can see that the two satellites are seeing almost identical features. The strength and center of the electrojet in these four passes, labeled A through D, are almost indistinguishable. Larger differences are apparent in the steepness of the electrojet flanks (in pass B, for example), and in the maximum intensity on the flanks (especially the north flank of D and the south flank of A). The origin of these differences is discussed in Purucker (2002).

References

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