

SCAR Fellowship Report 2007/2008

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Institution visited

Thayer School of Engineering, Dartmouth College, Hanover - NH, USA.
Host: Prof. Simon G. Shepherd

Dates

March 2008 – June 2008 (4 months visit)

Work towards scientific objectives of the fellowship: Interhemispheric comparisons of abrupt solar wind dynamic pressure variations on the polar ionosphere.

The physical context of the proposal concerns the interaction of the solar wind with the magnetic field of the Earth and, in particular, the effects of abrupt variations of the solar wind dynamic pressure on the Earth's magnetosphere and ionosphere. In this framework, SuperDARN (Super Dual Auroral Radar Network, <http://superdarn.jhuapl.edu>) is one of the most important international collaborations, which consists of 20 HF radar (13 in the Northern Hemisphere and 7 in the Southern Hemisphere at present), that work simultaneously and continuously providing convection maps of the ionospheric plasma drift velocity every two minutes, over the whole polar regions. From SuperDARN maps of the patterns of the polar cap potential can be easily inferred, which is very important for deriving information about the conductance and electric field distributions over the polar caps. The objectives of the proposal were to build a database of solar wind pressure pulses and to look at the ground effects in both Hemispheres, mainly by means of SuperDARN data. Previous results by Coco et al. (2005) [1] have shown that, under the same conditions, pressure pulses alone are able to significantly alter the plasma density and the presence of plasma irregularities, with possible serious consequences on HF radio wave propagation, scintillation of radio waves, and therefore GPS signals accuracy.

During the stay at Thayer School, we built a database of about 400 pressure pulses (both increases and decreases of the pressure) occurred from 1998 until 2004. For each event we collected plasma and magnetic field data from ACE spacecraft, magnetic field data from 5 equatorial

ground-based magnetometers and data from all the available SuperDARN data in both Hemispheres, in 1-hour windows centred at the pulses time. An analysis on the radar echo percentage variation throughout the events has been performed, grouping the events in classes of “Quiet” and “Disturbed” with respect to the pre-existent geomagnetic conditions. The results are in agreement with the work of Coco et al. (2005) [1] for what concerns the Northern Hemisphere, and are extended to the Southern Hemisphere thanks to the larger database that we have built: a sudden increase of the solar wind pressure causes a fast compression of the magnetospheric cavity which, in turn, favours an increase of the particle precipitation within the polar regions and a prompt increase of the echo activity.

Milestones and deliverables

The collaboration with Prof. Shepherd at Thayer School has been very effective and allowed to fulfill the most important part of the work described in the proposal. A large database of pressure pulses has been established and refined, “ad hoc” analysis software has been developed and tested (mainly using the Interactive Data Language – IDL), and preliminary promising results have been obtained. These results have been presented at the SCAR/IASC IPY Open Science Conference, held in St. Petersburg in July 2008, and in a SuperDARN technical workshop held in Irkutsk, Russia, in August 2008.

Additional work conducted

A particular promising pressure pulse event has been studied in the detail, evidencing the ionospheric effects of magnetic reconnection tailward of the Northern cusp. For the first time the role of the solar wind pressure in favoring reconnection has been shown for the case of northward-oriented interplanetary magnetic field. This study, though standing aside the main stream of the proposal research, has been very fruitful and led to an important publication (Coco et al, 2008 [2]).

What SCAR funds were allocated?

€7,000/\$10,000 were awarded to the fellow.

How were the SCAR funds spent?

Funds has been spent mainly for covering accomodation and life expenses during a 4 months stay in U.S.A, and the round trip flights from/to Italy. Other minor expenses concern health insurance, VISA fees and an external hard disk for data storage.

Future work plans

Starting from the encouraging preliminary results, much work is still to do for understanding the dynamics of the energy transfer between the solar wind and the ionosphere during pressure

pulse events. First of all, the effects of the abrupt decreases of the pressure on the radar echoes are still not clear: we are trying to better characterize the timing of the ground effects making use of ground-based magnetometer data in order to clean the statistics. A following step of the analysis will be the investigation of the behaviour of the cross polar cap potential during pressure pulse events, because this quantity is directly related to the energy transferred in the ionosphere from the magnetosphere.

Talks and seminars

1. I. Coco, Seminar: “Ionospheric Effects of Abrupt Variations of the Solar Wind Dynamic Pressure” - Dept. of Physics and Astronomy, Dartmouth College - Hanover, NH, USA, April 22th, 2008.
2. I. Coco, S. G. Shepherd, E. Amata, M. F. Marcucci, Talk: “Effects of Abrupt Variations of the Solar Wind Dynamic Pressure on the High-Latitude Ionosphere”, SCAR/IASC IPY Open Science Conference, St. Petersburg, July 8–11th, 2008.
3. I. Coco, E. Amata, M. F. Marcucci, D. Ambrosino, J.-P. Villain, C. Hanuise, S. G. Shepherd, Talk: “Effects of Abrupt Variations of the Solar Wind Dynamic Pressure on the High-Latitude Ionosphere”, “SuperDARN as a powerful instrument for space science research: Principles, technique, results”, Irkutsk (Russia), August 26th – 29th, 2008.

Publications

1. Coco, I., E. Amata, M. F. Marcucci, M. De Laurentis, J.-P. Villain, C. Hanuise, and M. Candidi Effects on SuperDARN HF radar echoes of sudden impulses of solar wind dynamic pressure, *Ann. Geophys.*, **23**, 1771–1783, 2005.
2. Coco, I., E. Amata, M. F. Marcucci, J.-P. Villain, and C. Hanuise, The effects of an interplanetary shock on the high-latitude ionospheric convection during a IMF \mathbf{B}_y – dominated period: a case study, *Ann. Geophys.*, **26**, 2937–2951, 2008.