Istituto Nazionale di Geofisica e Vulcanologia, Italy

Low frequency geomagnetic field fluctuations in Antarctica: comparison between two polar cap stations

L. Santarelli, L. Cafarella, S. Lepidi, P. Palangio

EGU06-A-03706

INTRODUCTION

We present a statistical analysis of low frequency (~0.5-5 mHz, periods ~3-30 min) geomagnetic field fluctuations at the Antarctic stations Mario Zucchelli Station (TNB, formerly Terra Nova Bay) and Scott Base (SBA), which are located at the same geomagnetic latitude but with 1-hr difference in MLT (Table 1). The two stations are usually in the polar cap, at the footprint of open geomagnetic field lines, but around local geomagnetic noon they approach the polar cusp.

This study focuses on the coherence and phase difference between the fluctuations at the two stations. The analysis is based on 1-min values of the horizontal H component measured during the entire years 2001-2002. The coherence and phase difference have been computed for each 2-hours interval with a step-size of 1 hour.

Station TNB is run by INGV; data from SBA are provided by INTERMAGNET CD-ROMs. Interplanetary magnetic field (IMF) and solar wind (SW) data from ACE spacecraft have been downloaded from OMNI database. Interplanetary data have been delayed by 1 hour to take into account the average SW transit time from ACE to Earth.

Station	Geographic Coord.	Corr. Geom. Coord.	MLT NN (UT)
TNB	74.7S 164.1E	80.0S 306.9E	20:11
SBA	77.8S 166.8E	79.9S 326.3E	19:01

Table 1. *Geographic coordinates, IGRF02 corrected geomagnetic coordinates and times in UT of the geomagnetic local noon for the two stations.*

COHERENCE ANALYSIS

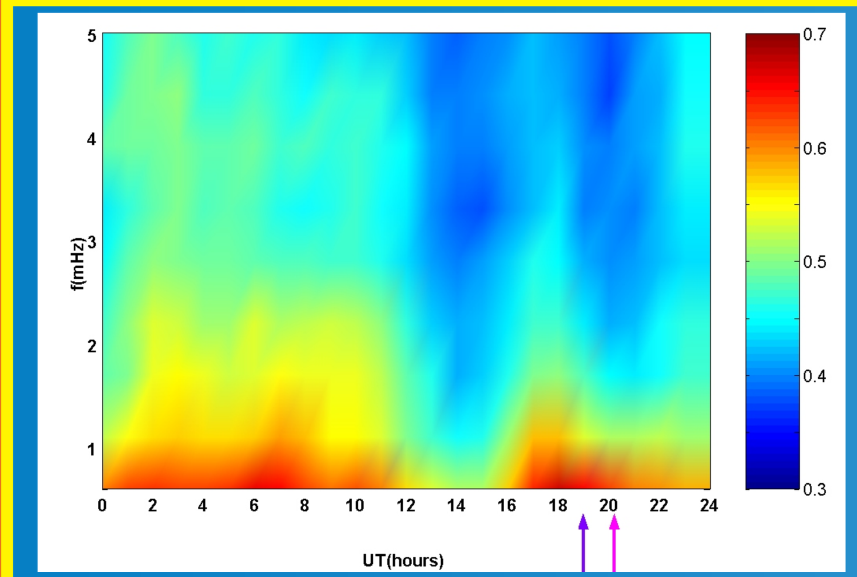

Figure 1. *Daily distribution of the average coherence between fluctuations at TNB and SBA for the whole 2-years interval. Pink and violet arrows in all the plots indicate local geomagnetic noon at TNB and SBA, respectively.*

The occurrence of coherent fluctuations maximizes in the hours before and around local geomagnetic midnight at the two stations, i.e. when they are located within the polar cap, and just before local noon. The coherence generally decreases for increasing frequency, and this decrease is more steep around noon.

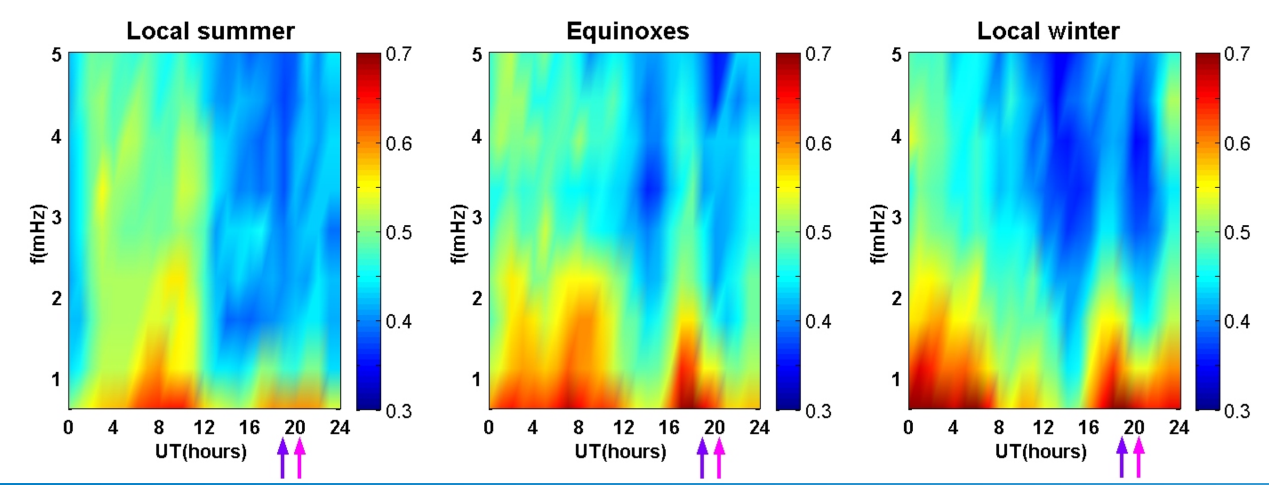

Figure 2. *Daily distribution of the average coherence between fluctuations at TNB and SBA separately for the three Lloyd seasons (local summer = nov-dec-jan-feb; equinoxes = mar-apr-sep-oct; local winter = may-jun-jul-aug).*

The coherence is lower during local summer and this feature is more evident in the hours around geomagnetic noon, when the stations approach the polar cusp.

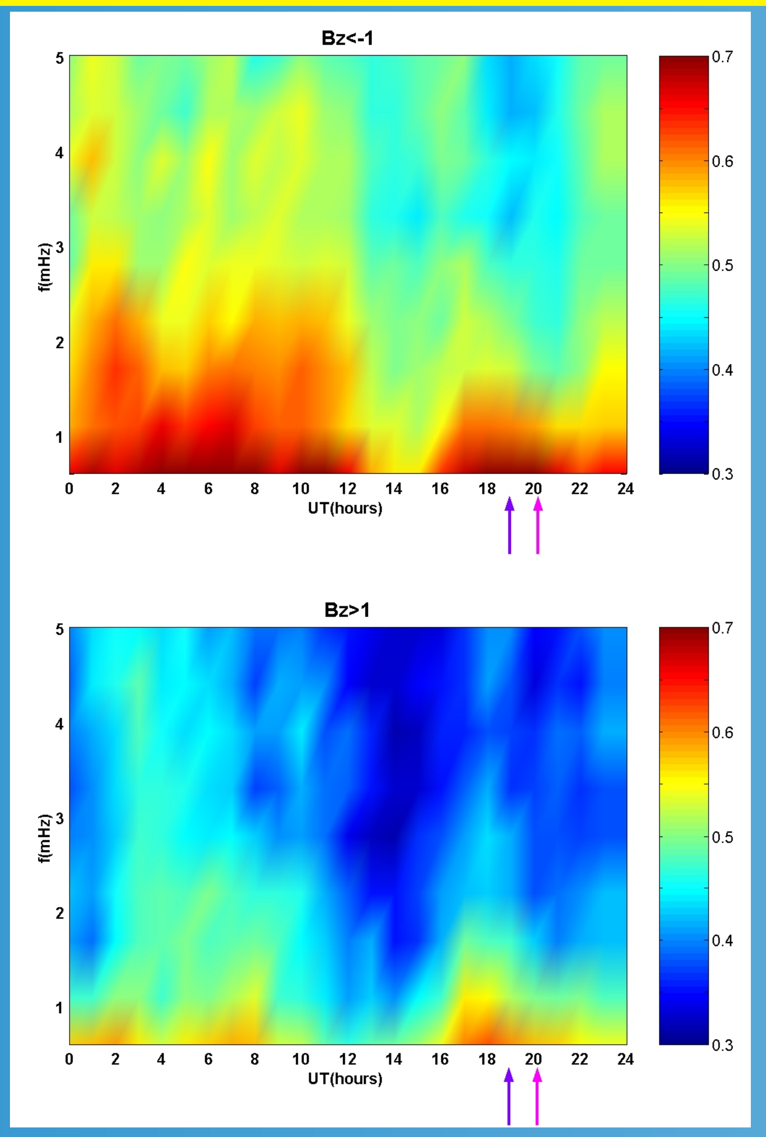

Figure 3. *Daily distribution of the average coherence for Bz<-1nT and Bz>1nT, where Bz is the north-south component of the IMF.*

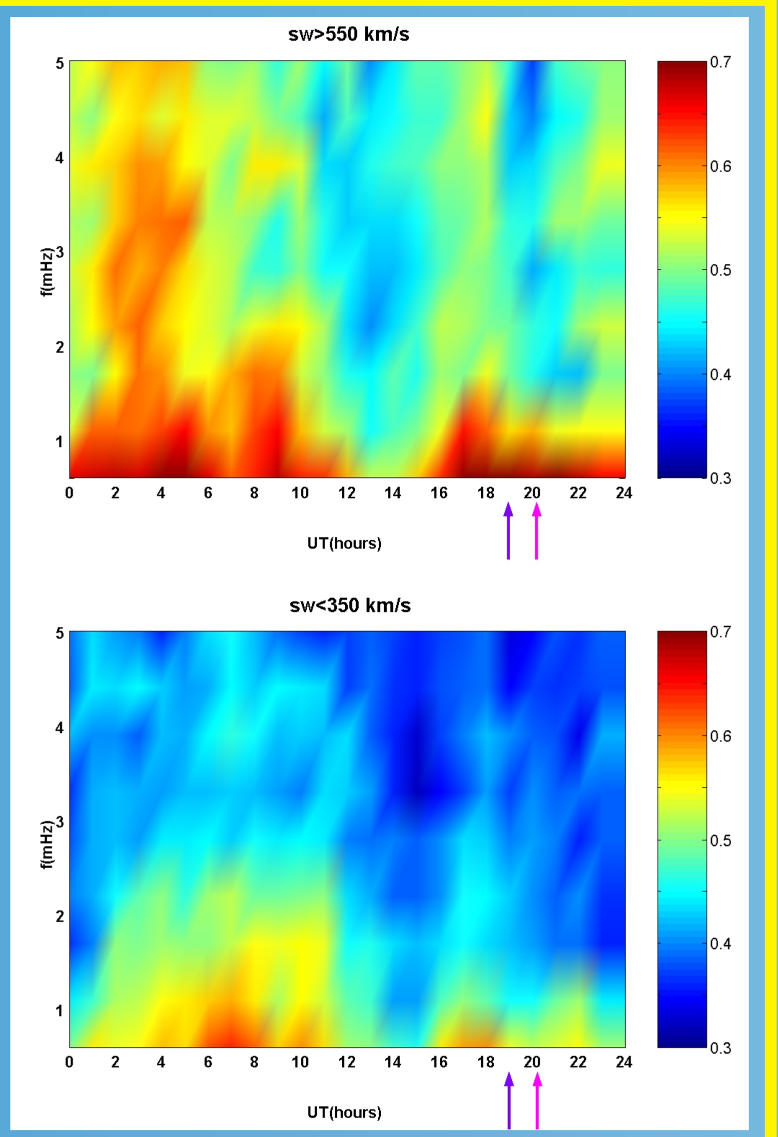

Figure 4. *Daily distribution of the average coherence for Vsw<350km/s and Vsw>550km/s, Vsw being the SW speed.*

The occurrence of coherent fluctuations is higher, during the whole day, when the IMF is southward, i.e. for open magnetospheric conditions. In particular, for Bz<-1 nT, in the hours before and around local magnetic midnight, the average coherence exceeds 0.6 for frequencies up to ~2mHz, and even for higher frequencies is around 0.5; this result can be related to the occurrence of geomagnetic storms.

The occurrence of coherent fluctuations is higher, during the whole day, when the SW speed is high. In particular, for Vsw>550km/s, in the hours before local magnetic midnight the average coherence reaches 0.6 in the whole analyzed frequency range.

PHASE DIFFERENCE ANALYSIS

The phase difference analysis has been conducted only for coherent fluctuations, i.e. when the coherence exceeds 0.6.

Since the two stations are at the same geomagnetic latitude, the phase difference indicates an azimuthal propagation: it is positive (negative) for SBA (TNB) leading, i.e. for signals propagating westward (eastward).

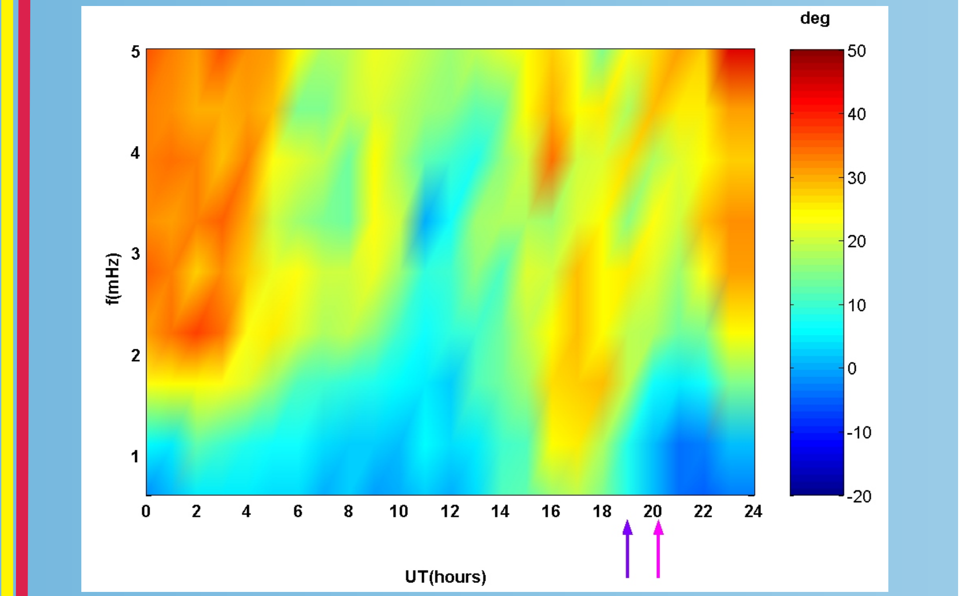

Figure 5. *Daily distribution of the average phase difference between the two stations for the whole two-years interval.*

During the day the phase difference shows four reversals: ~8UT, 14UT, 19UT and 22UT. In particular around noon, for f<~2.5mHz, it reverses from positive to negative, indicating a longitudinal propagation away from the subsolar point. Conversely, the reversal around 8 UT for f>2mHz, indicates a longitudinal propagation away from midnight.

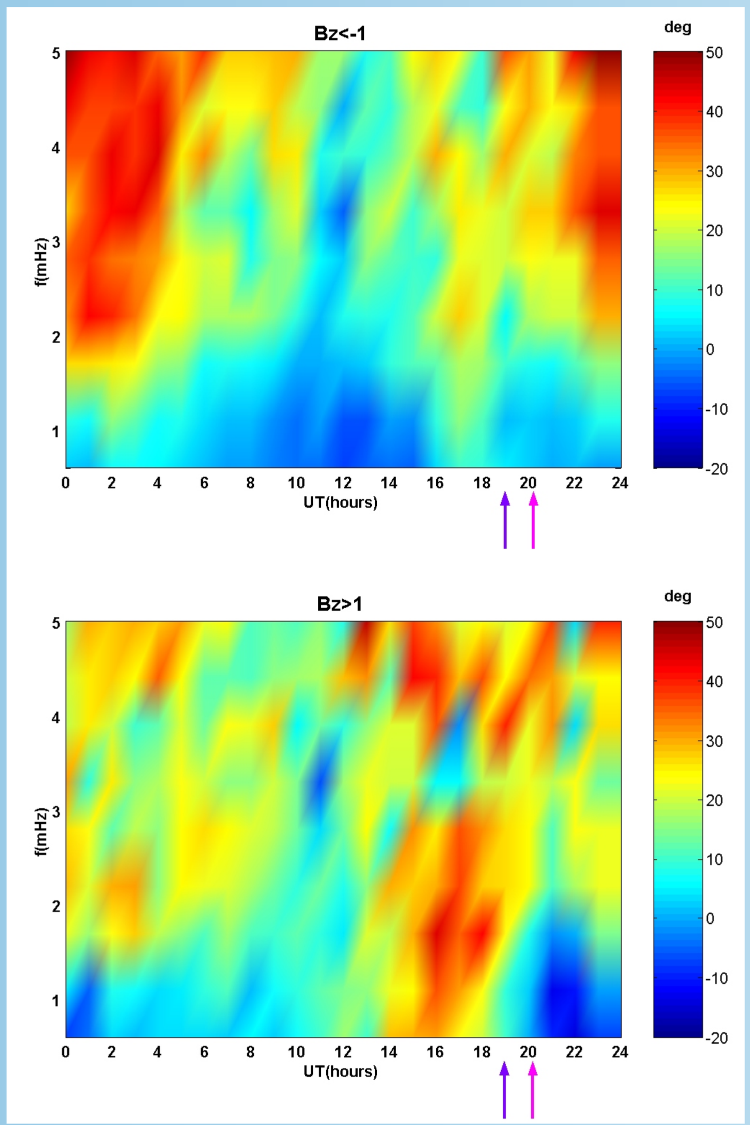

Figure 6. *Daily distribution of the average phase difference between the two stations for Bz<-1nT and Bz>1nT.*

The phase reversals around local geomagnetic noon and midnight are more evident for closed (Bz>1nT) and open (B<-1nT) magnetospheric conditions, respectively.

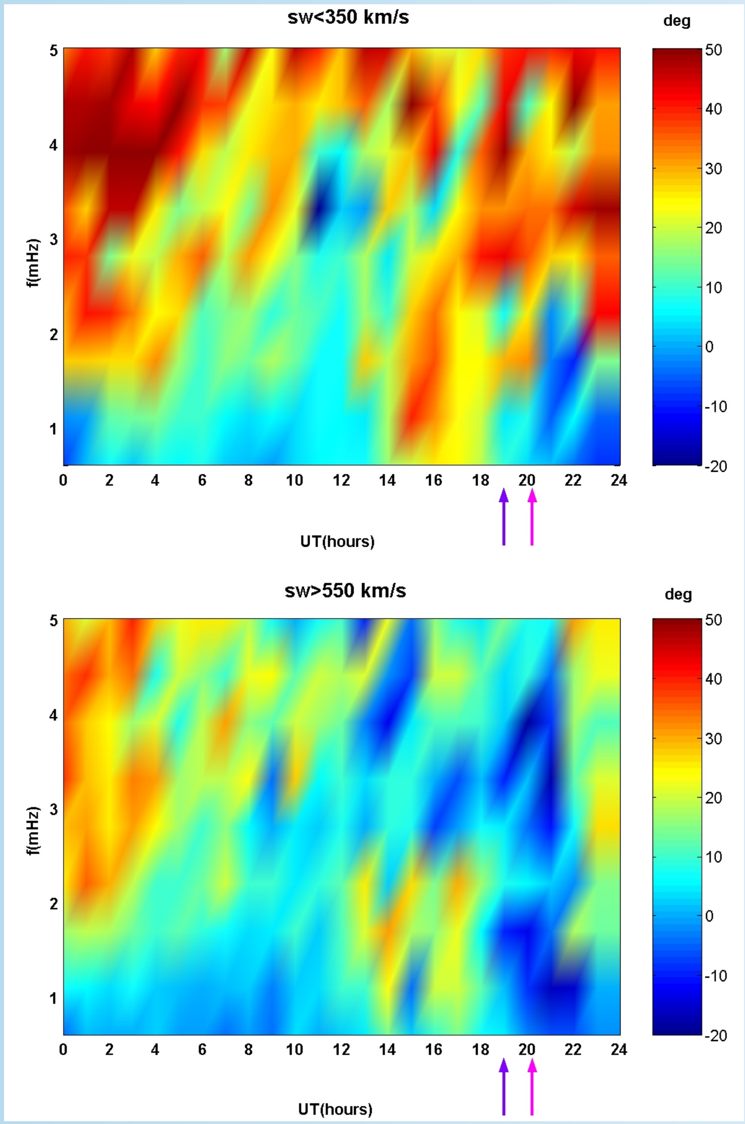

Figure 7. *Daily distribution of the average phase difference for Vsw<350km/s and Vsw>550km/s.*

The phase reversal around local noon, at f<2.5mHz, is more evident for low SW speed; however for high SW speed this reversal appears also at higher frequencies (4-5 mHz).

SINGLE EVENT ANALYSIS

We select a single event characterized by fluctuations coherent between the two stations and with a clear phase difference reversal around local geomagnetic noon. It occurs on Feb. 2, 2001, in a time interval characterized by very quiet magnetospheric conditions (Kp<=1+), low SW speed (Vsw<400 km/s) and northward IMF.

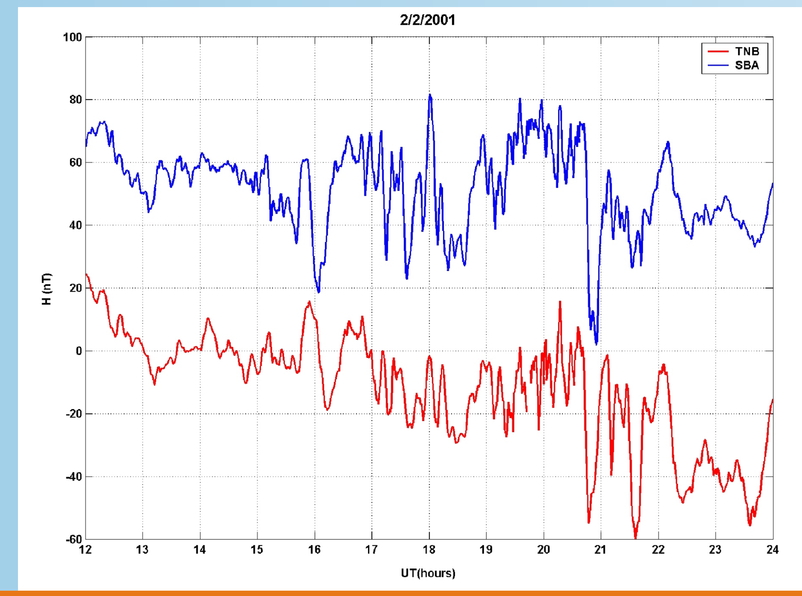

Figure 8. *Variations of the geomagnetic field H component at the two stations between 12 and 24 UT on Feb. 2, 2001.*

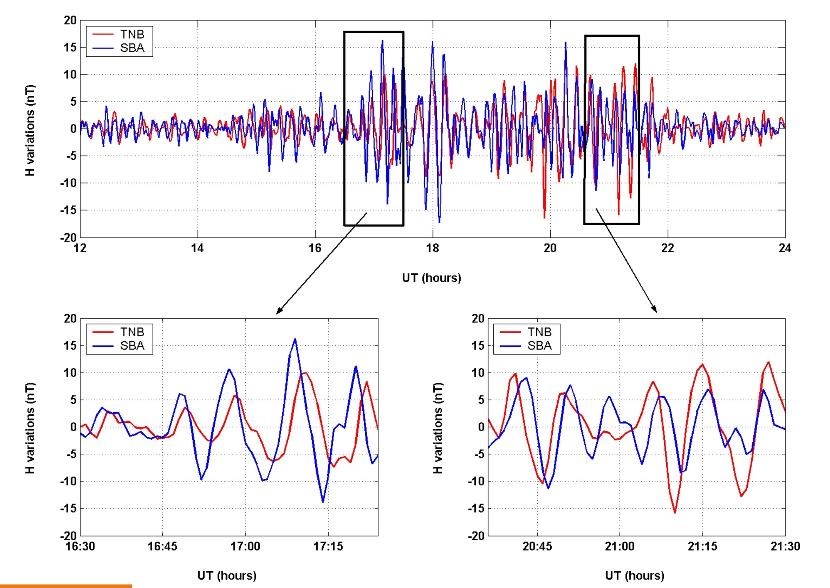

Figure 9. *Filtered data (~1-5 mHz) at the two stations.*

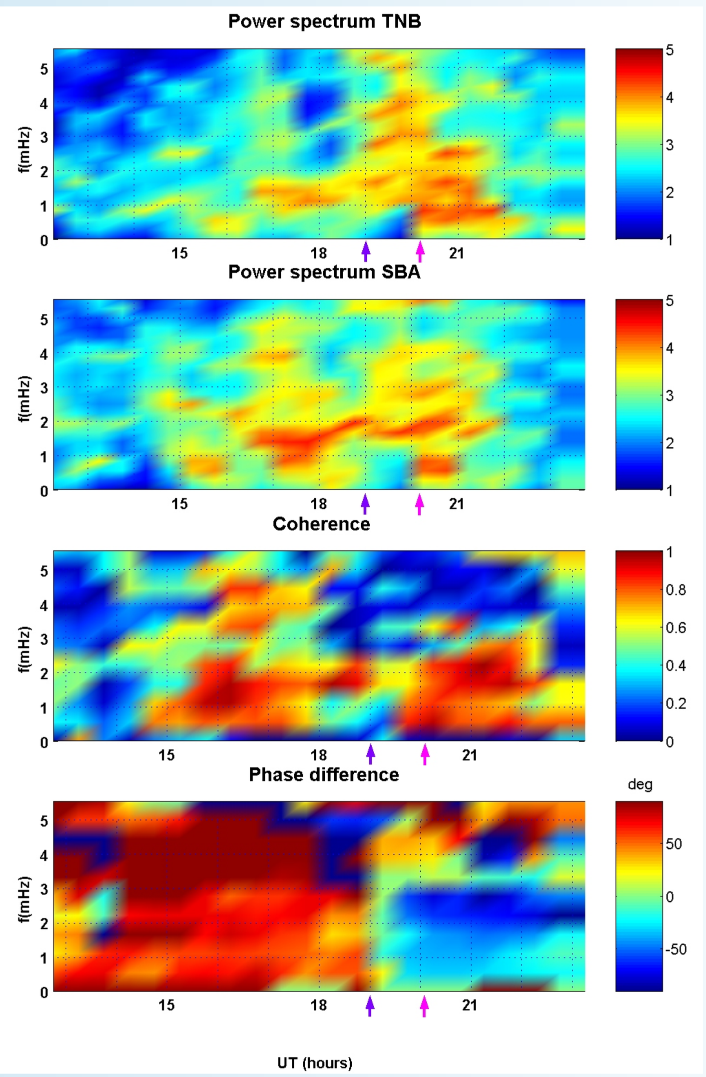

Figure 10. *From top: Power spectra at TNB and SBA, coherence and phase difference between the two stations.*

At both stations there is a sustained wave activity between 16 and 22 UT. In the first hours the fluctuation amplitude is greater at SBA, while after 20 UT it is greater at TNB, indicating an increasing amplitude approaching noon.

The fluctuations are highly coherent between the two stations, and the phase difference reverses from positive to negative around 19 UT, indicating an azimuthal propagation away from noon. Consistently, fig. 9 shows that around 17 UT (before noon) SBA is leading with respect to TNB, while around 21 UT (after noon) TNB is leading with respect to SBA.

SUMMARY. We statistically analyze the coherence and phase difference between low frequency geomagnetic fluctuations at two cap latitude stations at the same geomagnetic latitude, with 1-hour longitudinal displacement.

Coherent fluctuations are mostly detected in the hours around local geomagnetic midnight and noon, and the coherence is higher during southward IMF and high SW speed conditions.

In the nighttime hours, the phase difference for coherent fluctuations with f~2-5 mHz reverses, indicating a propagation direction away from midnight; this reversal is more clear for open magnetospheric conditions, suggesting a relation with substorm activity. The phase difference for f~1-3mHz also reverses around local geomagnetic noon. This reversal, more clear for closed magnetospheric conditions, for high SW speed appears also at higher frequencies (~4-5mHz), indicating a propagation direction away from the subsolar point, as expected for a generation mechanism such as the Kelvin-Helmholtz instability on the magnetopause.

We also analyze a single fluctuation event, occurring during quiet magnetospheric conditions, which shows a clear example of waves propagating away from the local geomagnetic noon.

Acknowledgements *The research activity at TNB is supported by Italian PNRA (Programma Nazionale di Ricerche in Antartide). The authors thank the Institute of Geological & Nuclear Sciences Limited (NEW ZEALAND) that operates the INTERMAGNET observatory SBA.*

Contact: *Dr. Lucia Santarelli*
Istituto Nazionale di Geofisica e Vulcanologia, Castello Cinquecentesco 67100 L'Aquila, Italy.
E-mail: santarelli@ingv.it