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Inter-hemispheric comparisons of geospace environment in the polar regions — A proposed cooperative research program between China and Norway

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Abstract The Chinese Zhongshan Station in Antarctica and the stations in Svalbard (Auroral station at Longyearbyen and NP station at Ny-Ùlesund) are closely magnetic conjugate. All of them are equipped similar measurement instruments dealing with upper atmospheric physics. Therefore, there is a good reason to conduct a cooperative research program between China and Norway to do the inter-hemispheric comparisons of geospace environment in the polar regions. It will make significant contribution to further understanding of the coupled magnetosphere-ionsphere system. The scientific aims of the cooperative project are: to experimentally verify the modeled complicated conjugate relationship between Zhongshan Station in the Antarctic and Svalbard in the Arctic. To derive knowledge from the conjugate characteristics of auroral formations, ionospheric features and space plasma waves in the polar regions, which in turn will lead to better understanding of the solar wind-magnetosphere-ionosphere coupling processes. The proposed research contents, research methods and experimental techniques are discussed, and the manners of the cooperative research are suggested in the paper.

Key words geospace, comparison, cusp, Zhongshan Station, Svalbard.

1 Introduction

Geospace deals with the Earth's middle and upper atmosphere, thermosphere/ionosphere and magnetosphere. This "geospace environment" is of great scientific and practical interest, particularly as it is often subject to disturbances. A blast wave from the sun can compress the magnetosphere surrounding the earth and trigger a geomagnetic storm. This often disrupts radio communications and spacecraft systems, and sometimes affects electrical power line systems.

Inter-hemispheric comparisons of geospace environment in the polar regions will give us useful information on the acceleration mechanism of auroral particles, the generation and propagation mechanisms of plasma waves in the magnetosphere, and to get better understanding of responses of the geospace environment to variation in solar irradiance, solar wind and interplanetary magnetic field.

Table 1. Coordinates of the observational sites

Site	Geographic		Corr. Geomagnetic		MLTMN/UT	L
	Lat.	Long.	Lat.	Long.		
Zhongshan	-69.37	76.38	-74.55	96.48	22:13	14.0
Ny-Ùlesund	78.92	11.95	76.19	111.25	20:52	
Longyearbyen	78.20	15.82	75.25	112.08	20:48	15.4

In Fig.1 the Antarctic continent is projected along the Earth's magnetic field lines to the Arctic. It can be seen that the conjugate point of Zhongshan Station is near Svalbard. Table 1 gives the geographic and corrected geomagnetic coordinates of Zhongshan Station in Antarctica and the stations in Svalbard (Auroral station at Longyearbyen and NP station at Ny-Ùlesund). It is shown from Table 1 that the Chinese Zhongshan Station and the stations in Svalbard are closely magnetic conjugate. All of them are situated under the ionospheric projection of the high latitude magnetospheric cusp region, an ideal location for monitoring solar wind, magnetopause and outer magnetospheric phenomena from the ground.

Table 2 lists the instrumentation at those stations. It is clear that all of them are equipped with variety of similar measurement instruments dealing with upper atmospheric physics. Therefore, there is a good reason to conduct a cooperative research program between China and Norway to do the inter-hemispheric comparisons of geospace environment in the polar regions. It will make significant contribution to further understanding of the coupled magnetosphere-ionosphere system. In this paper we give the scientific background first, then describe the scientific goals and research contents, followed by the manners of the cooperative research program.

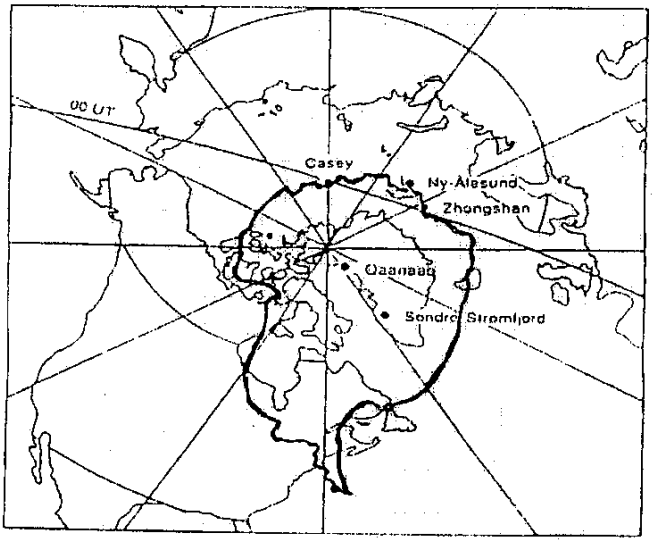

Fig.1. Projection of Antarctica along the magnetic-field lines on to the northern hemisphere. This figure clearly illustrates the possibilities for carrying out magnetic conjugate observations between Zhongshan Station in Antarctica and stations in Svalbard, Arctic.

Table 2. Ground based instrumentation on the observational sites

Site	Zhongshan	Ny-Ùlesund	Longyearbean
Digisonde	X		
All-Sky Camera		X	X
Auroral TV	X	X	X
Scan. Photometer	X	X	X
Magnetometer	X	X	X
Micropusation	X	X	
ELF/VLF Emission	X	X	
Imaging Riometer	X	X	X
Scin. Receivers	X	X	
IS Radar			X

2 Scientific background

Conjugate observation of auroral phenomena was initiated in the IGY period by using Campbell Island-Farewell, Alaska station pair at $L = 4$ (DeWitt 1962). A large number of scientific papers on the geomagnetic conjugacy of auroras, geomagnetic substorms, cosmic noise absorption (CNA) in the ionosphere, ULF and VLF emissions and other relevant phenomena were published based on the observations at the southern auroral zone in Antarctica and the northern auroral zone over Europe and America. An excellent overall review and summary of the conjugate studies was given by Prof. Takesi Nagata (1987).

The polar cap is a region where the magnetic field lines are open to connect with the interplanetary magnetic field. The term" inter-hemispheric comparisons "is used because phenomena in opposite polar caps with open field lines are not conjugate. However, the term" magnetic conjugacy "sometimes loosely used to describe phenomena in opposite hemisphere at locations that would be conjugate if the Earth 's main field were the only magnetic field. Because of logistics difficulties conjugate studies at very high latitudes, including the magnetospheric cusp and polar cap regions, have not been extensively pursued over the years.

In recent years conjugate studies attracts more people and became one of the main topics in the solar-terrestrial studies (Maclennan *et al*. 1998; Walker 1998). There are three main factors. The deployment of AGOs (Automatic Geophysical Observations) in Antarctica provides researchers with a much-improved set of instrumentation and locations to study high latitude geophysical phenomena. The SuperDARN chain of HF radars has been developed. There is now a conjugate pair of bistatic radars, which could determine conjugate convection velocity vectors. And a network of imaging riometers has been installed in polar cap regions. All these lead to new opportunities for conjugate phenomena studies.

Imaging riometers at Zhongshan Station in Antarctica and Ny-Ùlesund and Danmarkhavn in Arctic were used to examine conjugate feature of ionospheric absorption (Nishino *et al*. 1998, 1999, 2000; Yamagishi *et al*. 1998, 2000). Yamagishi *et al*. (1998) point out that if the invariant latitudes are not too high ($< 77°$) and the magnetic local time are away from the noon and midnight the geomagnetic conjugate point can be calculated using Tsyganenko model. Fig.2 shows daily drift motion of the conjugate point of Zhongshan Station for equinox and solstices from Yamagishi *et al*. (1998). The conjugate point of Zhongshan Station is calculated by using Tsyganenko 1996 model under $B_y = B_z = 0$ conditions. The solid squares in the figure denote the field of view of imaging riometers. The radius of the drift motion is much larger (about 3 times)

for polar cup conjugate points as compared to auroral zone conjugate points. Huang *et al** *compared magnetometer's data between Zhongshan Station and Tromsö-Svalbard chain and a selection of Greenland stations for four auroral substorm nights. It is shown that the conjugate point of* Zhongshan does drift from one substorm to another, and appear to move around west of Svalbard and the radius of drift motions less than the model calculated one.

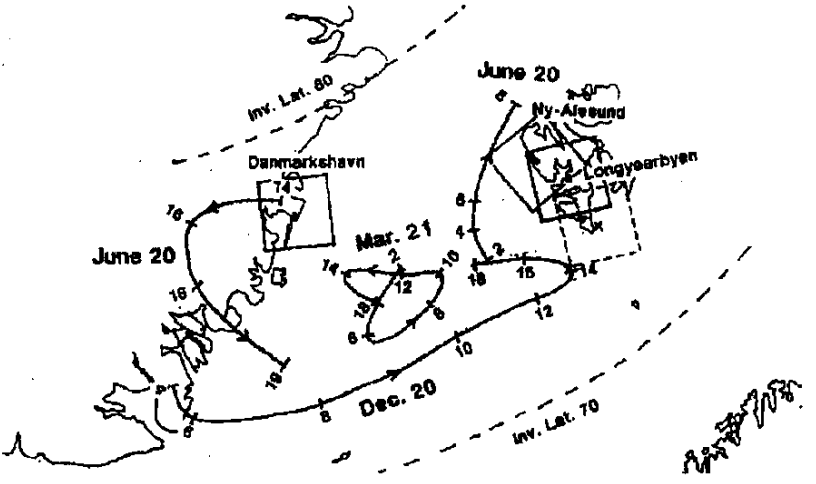

Fig.2. Daily drift motion of the conjugate point of Zhongshan Station for equinox and solstices from Yamagishi *et al*. (1998). The conjugate point of Zhongshan Stations is calculated by using Tsyganenko 1996 model under $B_y = B_z = 0$ conditions. The solid squares in the figure denote the field of view of imaging riometers.

3 Scientific goals and research contents

The Scientific goals of the proposed program are:

To experimentally verify the modeled complicated conjugate relationship between Zhongshan Station in the Antarctic and Svalbard in the Arctic.

To take knowledge of the conjugate characteristics about auroral formations, ionospheric features, and space plasma waves in the polar regions, so as to get better understanding of the solar wind-magnetosphere-ionosphere coupling processes.

To build up a polar ionospheric model.

The proposed research contents are listed in follows:

(1) Investigate the conjugate relationship between Zhongshan Station in the Antarctic and Svalbard in the Arctic.

Using geomagnetic field observations at Zhongshan Station and from the IMAGE magnetometer network, it will be studied the diurnal and seasonal variations of the conjugate location of Zhongshan Station, the dependence of the conjugate relationship on interplanetary magnetic field

* Huang DH (2000): Interhemispheric comparisons of high-latitude phenomena. Cand. Scient. Thesis., Department of Physics, University of Tromsö.

(IMF), geomagnetic activity and so on.

(2) Conjugate observations and inter-hemispheric studies on auroral phenomena and energetic particles precipitation.

Using the conjugate observations of optical auroral monitor instruments and imaging riometers at both sites, especially the observations of post-noon aurora and auroral substorms at cusp latitude, the auroral formation mechanism and its dependence on solar wind and IMF conditions will be studied.

(3) Conjugate observations and inter-hemispheric comparisons on characteristics of high latitude ionosphere.

Using the imaging riometers, ionosonde observations and HF radars at both sites, the magnetic controlling processes on polar ionosphere and its inter-hemispheric asymmetry will be studied. And the researches on the conjugate characteristics of the cusp dynamics will be carried out.

(4) Conjugate observations and inter-hemispheric studies on space plasma waves.

Using the induction magnetometer observations at both sites, it will be studied the conjugate characteristics of magnetic pulsations, such as Pc3, Pc5, Pi2 and so on, and the characteristics of their magnetospheric source regions and propagation.

(5) Collaborative studies on polar ionospheric modeling

Using the high resolution and multi-parameters observations of EISCAT Svalbard Radar, the SuperDARN observations at the two polar regions, and some other observations carried out at Zhongshan and Svalbard, the polar ionospheric structure and dynamic processes will be studied. And a polar ionospheric model will be built up and improved.

4 Manners of the cooperative research program

The Polar Research Institute of China, University of Tromsö, University of Oslo, and University Courses in Svalbard (UNIS) will jointly participate in the cooperative research program. Manners of the cooperative research are:

(1) Coordinated observations at the conjugate sites and data exchange. To make measurement schedule for coordinate observations at the conjugate sites, and to plan campaign periods by consulting the International Geophysical Calendar and Dark Moon Day and covering solstices and equinox.

(2) Developing or purchasing advanced instruments, to install them at the conjugate sites. The existing digisonde DPS-4 at Zhongshan Station will be upgrade. Three monochromic all sky CCD TV camera will be developed and installed there.

(3) To conduct several common research topics

-by exchanging visiting scientists

-by contacting with each other through internet

- by co-educating graduate students

(4) To hold China-Norway joint symposiums on polar upper atmospheric physics.

5 Summary

The Chinese Zhongshan Station in Antarctica and the stations in Svalbard are closely mag-

netic conjugate. All of them are equipped with similar instrumentation dealing with upper atmospheric physics. Therefore we propose a cooperative research program to do the inter-hemispheric comparisons of geospace environment. This proposed program has a high scientific meaning and more realistic.

We strongly believe that further progress will depend on thorough planning, coordination and cooperation, the realization of the cooperative program will make a significant contribution to further understanding our geospace environment.

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