



China Sets up One of the World's Most Powerful Ground-based Systems for Space Weather Monitoring

By XIN Ling (Staff Reporter)

The Meridian Space Weather Monitoring Project (or the Chinese Meridian Project) is the first major scientific infrastructure China has ever built in the field of space science to understand and predict near-Earth space environment variations. It started construction in early 2008 and became fully operational in October 2012. In this issue of *BCAS*, we will present you with the latest development and major scientific facts of this remarkable project.

Fifteen stations, 38 observing sites and 94 instruments: after 58 months of construction, the world's most extensive and integrated ground-based system for geospace weather monitoring passed national acceptance check in Beijing on October 23 (Figure 1) to officially start data collection and scientific research. For a group of scientists

from the National Space Science Center (NSSC), the Chinese Academy of Sciences who have led through the project, the day brought them not only a relief, a joy, but the pride for having been a part of this unprecedented endeavor, and building it into "a role model for the concerted construction of scientific facilities" as the acceptance report reads.

Figure 1. At NSSC on October 23, 2012, officials and scientists formally started the operation of the Chinese Meridian Project by pushing buttons on the project's sand table in front of them. Among them were CAS Vice President YIN Hejun (sixth from right), project manager and NSSC director WU Ji (first from right).



The Chinese Meridian Project: Significance and Uniqueness

By connecting the existing 15 ground-based stations located roughly along the 120°E longitude and 30°N latitude in the country, the Chinese Meridian Project has set up two chains to detect the geospace environment above the Chinese territory. One extends from the northernmost city of Mohe to the southernmost province of Hainan, the other from the Tibetan Plateau in the west to the coastal Shanghai in east China, boasting the most extensive ground-based system of its kind in the world.

Meanwhile, the stations are equipped with a total of 94 state-of-the-art observational instruments, including magnetometers, all-sky imagers, ionosondes, radars and sounding rockets. These devices are capable of catching

space disturbances over a large vertical span, from about 20 kilometers above the ground to more than a dozen Earth radiuses' distance away in space. Therefore, the project is also the world's most technically integrated ground-based system for space weather monitoring.

What has made China more proud is that many of the instruments were developed by its own scientists and engineers, including, among others, a world-class incoherent scattering radar in Yunnan Province (Figure 2), a HF coherent scattering radar in Antarctica (Figure 3), an all-day and all-weather monitoring MST radar near Beijing, as well as a meteorological rocket (Figure 4) and a sounding rocket (Figure 5) lifting off from south China in 2010 and 2011, respectively.

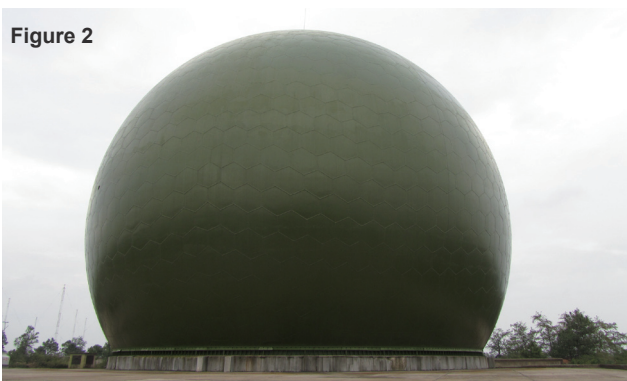


Figure 2

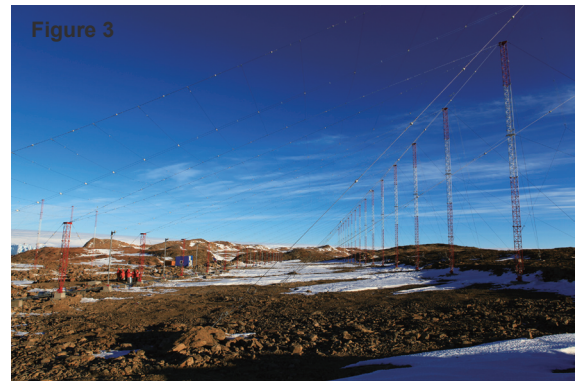


Figure 3



Figure 4



Figure 5

Figure 2. The incoherent scattering radar in Qijing City, south China's Yunnan Province, developed by the Institute of Radio Wave Propagation under the China Electronics Technology Group Cooperation. As the first incoherent scattering radar in China and the most powerful of its kind across Asia, it is capable of measuring physical parameters of the upper atmosphere such as the electron density, electron temperature, ion temperature, ion composition and the movement velocity of plasmas, as well as dozens of indirectly measured parameters.

Figure 3. The high frequency scattering radar at China's Zhongshan Station in Antarctica. Developed by the Polar Research Institute of China, the radar is mainly used to detect the ionospheric convection and the formation and evolution of plasma irregularities in polar regions.

Figure 4. The first meteorological rocket of the Meridian Project lifted off from Hainan before daybreak on June 3, 2010.

Figure 5. The first sounding rocket of the Meridian Project was successfully launched on May 7, 2011 in Hainan.



Prof. WANG Chi, chief engineer of the Chinese Meridian Project, NSSC deputy director and head of the State Key Laboratory of Space Weather.

But anyway, why does China need such a project? According to Prof. WANG Chi, NSSC's deputy director and chief engineer of the project, with the increase of human activities in space, we are using more and more space-based instruments such as spacecraft and satellites. Many countries have launched navigational and communications satellites to facilitate people's lives. However, adverse space weathers near these satellites may lead to severe operating errors or even destroy them. So the timely and accurate prediction of space weather plays a vital role in space exploration.

As China's space exploration develops rapidly in recent years, the launch of satellites is also booming in this nation. In 2011, China sent up a total of 20 satellites, ranking the second in the world only next to Russia. In its Twelfth Five-year Plan, China will have more than 100 satellite emissions on its agenda, over 20 on average for each year between 2011 and 2015. The plan is extremely challenging, and the Meridian Project will play a key role in backing up each mission with reliable space weather predictions.

The project's two chains enable scientists not only to monitor the weather high above the Chinese territory, but

with the Earth's rotation, to scan the geospace environment of the entire globe. "Via the Meridian Project, we aim at understanding the space weather variations above China and how they are related to global-scale changes," noted WEI Fengsi, a senior professor of space physics and one of the initiators of the project.

Why is the project such a success? "Challenges came from not only massive technical difficulties, but more importantly, the management of such a huge cross-institutional collaboration as the Meridian Project," Prof. WANG confessed.

The Meridian Project is a consortium of as many as 12 different institutions under seven ministries, namely the Chinese Academy of Sciences (the leader), the Ministry of Education, the Ministry of Industry and Information Technology, the China Earthquake Administration, the State Oceanic Administration, the China Meteorological Administration, etc. These institutions are administratively independent, each with their own way of operation, Prof. WANG told *BCAS*.

For instance, the Beijing Station comprises NSSC's lidar facility in Yanqing County, the MST radar of the CAS Institute of Atmospheric Physics at Xianghe Observatory, the geomagnetic observatory run by the CAS Institute of Geology and Geophysics near the Ming Tombs, the ionospheric high-frequency Doppler receivers at Peking University, and the Sanhe-based ionosondes run by the Institute of Radio Wave Propagation under the China Electronics Technology Group Cooperation, etc (Fig. 6).

To invent a "common language" for the consortium, Ms. ZHANG Xiaoxi, a chief coordinator of the project, spent more than three months with her colleagues to compile a 60-page manual which details the project's implementation norms, including working and testing procedures, technical standards as well as organizational and management modes. "The 'common language' proved to be a key to pushing

Figure 6. The Beijing Station of the Meridian Project has a total of 10 observing sites under it.





Figure 7. Some other instruments applied by the Meridian Project: **(top left)** the very high frequency radar array built by NSCC in Hainan, mainly for the monitoring of ionospheric variations; **(top right)** a radar facility built by the National Astronomical Observatories in Miyun County, suburban Beijing to detect interplanetary scintillations and measure the velocity of solar winds; **(bottom left)** a magnetic fluxgate theodolite; **(bottom right)** the digital ionosonde (**digisonde**) installed in northernmost China's Mohe City by the Institute of Geology and Geophysics, Chinese Academy of Science.

forward our project,” Ms. ZHANG concluded.

Led by a common scientific goal and a unique management solution, scientists and engineers from different institutions overcame numerous problems to fulfill their task with high efficiency in more than four years' time. The project is hailed by

the national acceptance report as “a role model for the concerted construction of scientific facilities in China”. This makes the highest honor for all participants, who have taken devotion and tolerance as their motto. After all, such a feat might be improbable for many other countries in the world.

Achievements By Far

The Meridian Project is made up of three systems: a space weather monitoring system, a data and communications system, and a research and forecast system.

For Chinese scientists, the project offered a golden opportunity, for the first time in history, to obtain massive first-hand data for space weather studies.

XU Jiyao from NSCC is a professor in middle and upper atmospheric physics. Before the Meridian Project was launched, most of his researches were conducted in the office using data obtained by foreign colleagues. During the construction of the project, his group was in charge of installing optical observation instruments (such as all-sky imagers) at Beijing (Figure 8) and Hainan stations. With these instruments,

they acquired plenty of fresh data and published their findings in a famous journal even before the construction was finished.

“Field work, as tough as it is, taught me a lot — things that you can't learn in a lab. Thanks to large scientific projects like the Meridian Project and the new instruments developed by domestic colleagues, China's middle and upper atmospheric physics has been prospering over the last ten years. Hopefully, before long, we'll be able to join the top nations in this field,” XU was excited.

By August 2012, the project had collected nearly 1.1TB data describing 64 key parameters in the geospace environment. In November, “we receive about 1,000 data files every day. The daily dataflow stands at 1GB,” said ZHONG



Figure 8. The all-sky imager installed by Prof. XU Jiyao and his colleagues from NSSC in Xinglong County, Hebei Province near Beijing.

Dingkun, chief designer of the data services subsystem.

At the project's data center based at NSSC, ZHONG was explaining the various curves and visual images on computer screens. He told the *BCAS* reporter that the data are verified, calibrated and uploaded in time by various observing sites, and are processed at the Beijing headquarters before they finally enter the database. ZHONG and his coworkers are also responsible for forwarding these data to the forecasting services platform, where authorized users can download the data they need.

"Now most of the data are available by default access," he added.

With funding from the National Natural Science Foundation of China, the Ministry of Science and Technology and the State Key Laboratory of Space Weather under NSSC, data analysis will be a major task for scientists during the project's operation, Prof. WANG stressed.

In fact, over 100 scientific papers have already been published under the Meridian Project. For instance, through joint observation, Chinese scientists monitored the Earth's response to solar storms from higher to lower latitude areas for the first time.

They also observed the coupling of disturbances between different layers in geospace. During several magnetic storms above the Mohe Station, they discovered that a decrease in the electron density of the ionosphere always happens before a decrease in density of the plasma sphere. This provided a new insight into the magnetosphere-ionosphere coupling. In 2011, soon after the tsunami hit Japan, the Beijing and Shenzhen stations reported a link between the earthquake and ionospheric disturbances.

Many of these studies would have been impossible without the extensiveness and technical integrity of the Meridian Project, the chief engineer emphasized.

To guarantee the project's stable operation and to plan for its future development, a "National Space Weather Science Center" will soon be established at NSSC. According to Prof. WANG, the center will comprise all member institutions of the Meridian Project. It will be responsible for raising and allocating operational funds, making annual work plans, and implementing effective management over all the stations.

The International Meridian Project: In Action

The Meridian Project will be collecting data for at least a decade after it started operation in October 2012. Meanwhile, scientists at NSSC have drawn more ambitious blueprints for its development.

On one hand, they are promoting another two ground-based monitoring chains in China, along the 100°E longitude and 40°N latitude respectively, as was revealed by NSSC director Prof. WU Ji in October. The new chains will notably improve the observational accuracy and be able to capture both the spatial and temporal variations of space weather. This proposal has been listed in China's Mid- and Long-term Development Plans for Major Scientific Infrastructures.

On the other hand, the Chinese will pilot an International Meridian Project by inviting countries along the 120°E and 60°W longitudes to join for a global-scale monitoring of the geospace environment (Figure 9). By far, the suggestion has

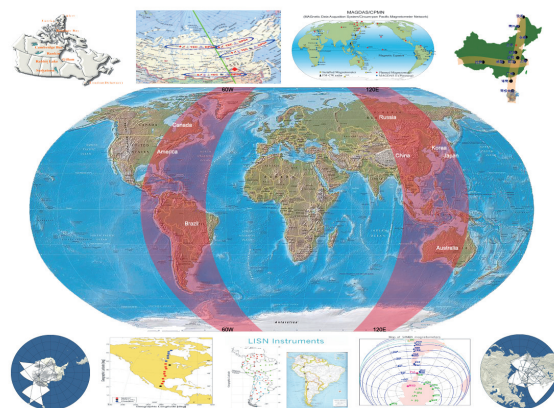


Figure 9. Scheme of the International Meridian Project proposed by China: Linking observing sites in Russia, China, Korea, Japan and Australia in the eastern hemisphere, and those in Canada, the US and Brazil in the western hemisphere to form a circular-shaped network for global space weather monitoring.



On September 6, 2010, NSSC director general WU Ji (left) and INPE director Gilberto Câmara signed a cooperation agreement in Beijing to jointly promote the International Meridian Project and carry out collaborations in space weather research.

been warmly applauded by scientists from Russia, Canada, the United States and Brazil.

The United States have shown great interests in the program, by exemplifying it as a major cooperation event in the Decadal Strategy for Solar and Space Physics issued last August by the US National Research Council. Also, the Haystack Observatory at MIT has inked an agreement with NSSC on joint ionospheric observation, and has proposed to host the second seminar on the International Meridian Project in 2013, Prof. WANG revealed.

The collaboration between NSSC and the Brazilian National Institute for Space Research (INPE) has also scored substantial progresses, according to Dr. Francisco Carlos from INPE who has been visiting NSSC for almost a year.

“The INPE has a long experience in monitoring and analyzing the ionosphere and upper-atmosphere at certain scientifically important regions over the Brazilian territory, and it has its own space weather monitoring program, so the INPE was invited by the NSSC to be a partner in the International Meridian Project,” Dr. Carlos told *BCAS*.

“According to an NSSC-INPE agreement, the NSSC will install some important ground-based equipment for space weather measurements in Brazil. In addition, the NSSC is proposing to establish a joint center at the INPE's

headquarters, near Sao Paulo, to facilitate the installation and operation of those equipment and to encourage more cooperation opportunities between the two,” he specified.

“The joint center will also be responsible for promoting the International Meridian Project in the western hemisphere,” Prof. WANG added.

The International Meridian Project has been included by the United Nations Office for Outer Space Affairs in its International Space Weather Initiative (ISWI), Prof. WANG said.



The First Seminar on the International Meridian Project was convened in February 2011 in Sanya, Hainan Province. More than 60 officials and experts from China, the United States, Canada, Russia, Australia, Brazil and the United Nations attended the seminar.



Space Science in China: Chances and Challenges

The Meridian Project has greatly boosted the ground-based observation ability in China. With the nation's increasingly intense and sophisticated space missions, its space science is facing big chances as well as challenges.

In infrastructure, despite the successful construction of the Meridian Project, the best way to understand our sky is via the observations in space itself, Prof. WANG emphasized. Of the 70 or so satellites ever launched by China to orbit the Earth, none is dedicated for space science.

Fortunately, Prof. WANG and his coworkers have already made the first step toward that goal. Several years ago, they started working on a satellite program called the "Magnetosphere Ionosphere Thermosphere Coupling Small Satellite Constellation Exploration Program" (MIT), which is mainly designed to detect the acceleration of particles when they ascend from one space region to another as well as its impacts upon the space environment. The MIT program has been going on smoothly and is now in the payload and orbit design phase.

Except for strengthening space-based observation, China may have two more priorities for developing its space science, Prof. WANG said. One is to encourage scientists to do innovative research, and the other is to enhance the strategic design at government levels to help the science better serve national and civil needs.

The lack of a strategic design at the governmental level, he pointed out, is the biggest handicap for the discipline's development. By far, China has not appointed or established any special agency to take charge of its space programs. For instance, the construction of the Meridian Project was funded by the National Development and Reform Commission, while its research activities will be largely supported by the National Natural Science Foundation of China, the Ministry of Science and the Chinese Academy of Sciences.

"China needs its own NASA", he hoped. With such an agency, China will be able to carry out long-term planning of its space strategy, and to provide sustaining support to the scientific community and the whole society as well.

From Prof. WANG's gleaming eyes and determined face, we can see a promising future of China's space science with the efforts of NSSC scientists.

Important Statistics of the Chinese Meridian Project (As of November 2012)

Total Cost: About **300** million yuan
(including **167** million from government investment)

Construction Period: **58** Months
(January 5, 2008 – October 23, 2012)

Number of Monitoring Stations: **15**

Number of Observing Sites: **38**

Longitudinal Span: **4,000**km

Latitudinal Span: **3,500**km

Number of Instruments: **94**

Number of Data Centers: **8**

Data Collected: **1.1** TB

Data Distributed: **2.6** TB

Types of Physical Parameters Obtained: **64**

Number of Participant Institutions: **12**
(Under 7 ministries or departments)

Number of Staff for Operation: Around **300**

Expected to Run: **11** Years or more