International Civil Aviation Organization

EIGHTEENTH MEETING OF THE METEOROLOGY SUB-GROUP (MET SG/18) OF APANPIRG

ICAO Regional Sub-Office, Beijing, China
18 – 21 August 2014

Agenda Item 7: Research, development and implementation issues in the MET field

7.9 Other

THE CHINA SPACE WEATHER SERVICES FOR CIVIL AVIATION

(Presented by China)

SUMMARY

This paper presents information on the operational space weather forecast and tailored service provided by China in support of international air navigation and some suggestions on future development of space weather service. Action by the meeting is in paragraph 3.

1. Introduction

1.1 Space weather events are a known risk to aviation. China fully recognizes the needs of providing information for international air navigation and supports the proposed structure consisting of global centres and regional centres presented by WMO.

1.2 The National Centre for Space Weather (NCSW) was established in 2002 by China Meteorological Administration (CMA) and began to provide space weather operational service in 2004. In support of ICAO's initiative, since Jun.1 2012, the routine space weather products based on domestic and international data using the NOAA scales (Radio blackouts, Solar radiation storm, and Geomagnetic storm) have been provided to aviation industry via the Aviation Meteorological Centre of CAAC.

2. Discussion

2.1 The global and local effects of space weather on aviation

2.1.1 Space weather phenomenon spans a wide range of temporal and spatial scales. The geomagnetic storm may last several days, while the solar flare only lasts for tens of minutes. The geomagnetic disturbance could extend from high–latitude region to low-latitude region, while ionospheric scintillation primarily occurs at equatorial and high-latitude regions.

2.1.2 The space weather impacts on aviation focus on two principal areas: radio frequency communications and radiation levels. The airlines need reliable HF and satellite communications, and GNSS signals. The ionosphere is the key part to radio frequency communications for aviation. The lower HF frequencies need the ionosphere to reflect the signal back earthward. For satellite

communications, the higher satellite frequencies that must pass through the ionosphere may suffer loss of power or frequency stability. The D-region absorption caused by solar flare could disrupt the HF propagation and ionospheric storm is capable of affecting the HF. These are global scale phenomena. There is also local disturbance in the ionosphere, such as high total electron content (TEC) and high electron density gradients, rapid fluctuations in the signal strength and phase (scintillation), which could affect the propagation of SATCOM and GNSS signals. The effects of radiation on humans and avionics are also need to be considered. The causes are due to slowly varying galactic cosmic ray background and solar radiation storms which are global scales.

2.2 The China operational space weather business system

2.2.1 CMA/NCSW is the nation's official source of space weather forecasts. Based the operational space weather observation system, CMA/NCSW could give real-time observations and reliable forecasts for those space weather phenomena which pose potential risk to the international aircraft flight operations.

2.2.2 CMA/NCSW has preliminary developed a complete business system which are designed similar to an architecture commonly seen at a meteorological service, covering monitoring, forecasting, and services, along with some R&D activities and could provide the reliable real-time space weather data from the sun to the earth.

2.2.3 Monitoring: an operational space weather monitoring system has been built based on the existing meteorological observing systems, aiming at the enhancement of a seamless atmosphere-space monitoring capability（see Figure 1）.

1) Global: the FY satellites have become the ideal platform for space weather observations and the necessary back-up of GOES satellites. From FY-1C, every meteorological satellite has carried the space environment detectors. FY-2 geo-synchronous satellites are used to measure solar X-ray and energetic particles. FY-3 sun-synchronous satellites are mainly used to monitor impacts of high-energy particles on spacecraft. For the next generational satellites, FY-3 will have aurora and ionosphere capabilities, and FY-4 will provide the solar imaging and geomagnetic field observations.

2) Regional: the country-wide network of ground-based observations has been built to conduct systematic investigations on the solar photosphere, chromosphere, magnetic field and radio, the ionospheric electron density profile, scintillation and D-region absorption, and the wind and temperature of upper atmosphere. And the geomagnetic observatories are on the way. In order to monitor ionospheric phenomena, 6 ionosonde stations with 1 mobile ionosphere sounder, 4 scintillation stations, and 4 riometer stations have been established in 2012. And more than 800 GPS/MET stations in CMA/NCSW are available for routine TEC map product. In near future (by 2015), the number of GPS stations will increase to about 2500 stations. A network of ionospheric scintillation monitor has also been established in south of China. Besides, as the member of the “Median Space Weather Monitoring Project” (or Chinese Meridian Project), CMA/NCSW could get access to the data from a 120°E median chain of stations which consist of magnetometers, ionosondes, incoherent scatter radars, high-frequency backscatter radars, mesosphere-stratosphere-troposphere radars, meteor radars, lidar (light detection and ranging), Fabry-Perot interferometers (FPI), and aurora spectrographs.

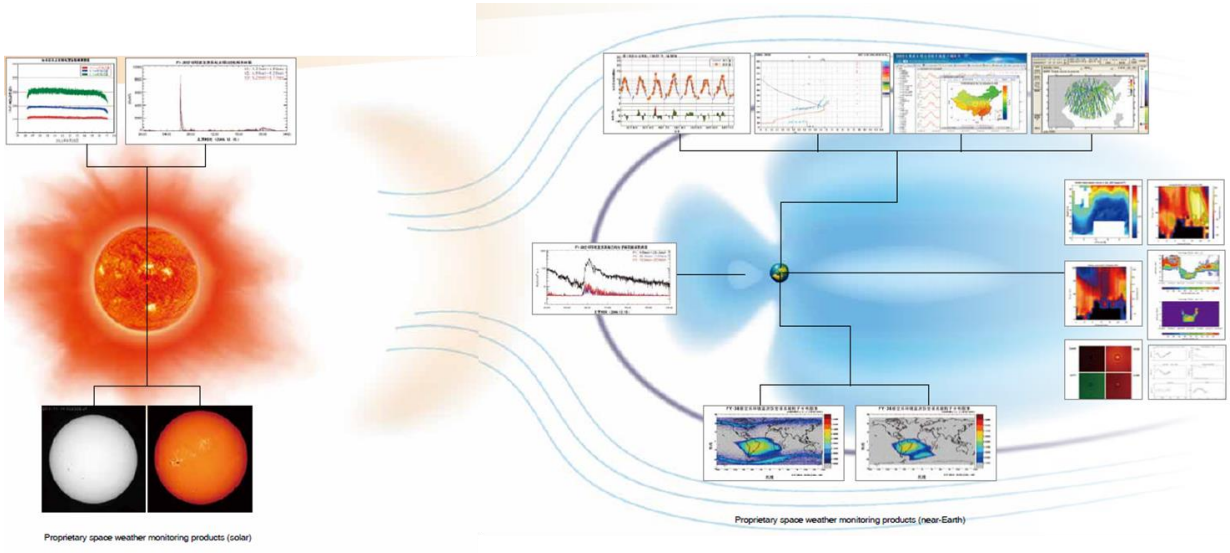

Figure 1 The space-based and ground-based space weather monitor data

2.2.4 Forecasting and Services: Based on the international and domestic data, the CMA/NCSW could describe and forecast the state of the environment from the sun to the earth, such as the solar and geomagnetic activity, the likelihood of solar flares, solar proton events and magnetic storm, the ionospheric weather. CMA/NCSW currently delivers daily, monthly, and annual monitoring and forecasting products and services to users through hard-copy bulletins, internet, phone, SMS, e-mail, public media, etc. CMA also provides special services for important customers, including Shenzhou, ChangE, Beidou missions and State Grid, etc. On Jun.1 2013, the space weather channel of the www.weather.com.cn has been online. The website provides space weather information for the public.

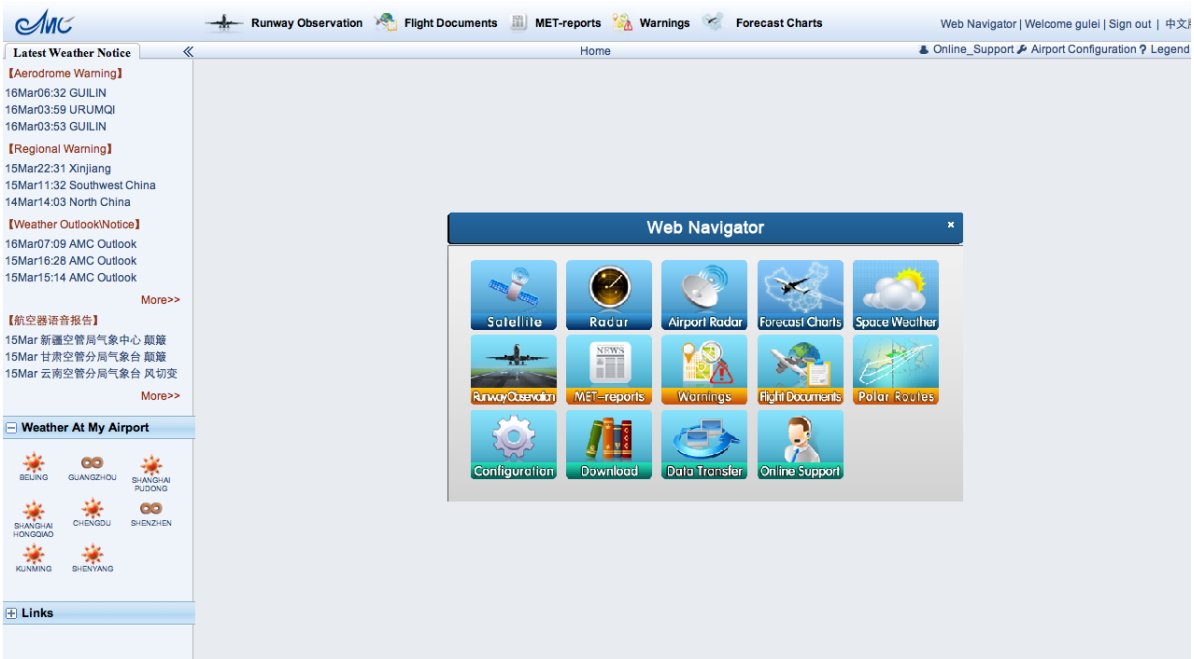

Figure 2 Aviation meteorological service platform of CAAC
(http://www.amsc.net.cn/ENG/Flash/Index.aspx#

2.3 CMA/NCSW is also the co-chair of the WMO Inter-programme Coordination Team on Space Weather of (ICTSW) which has conducted collaborative actions with the ICAO on the specification of space weather services to global aviation.

2.4 Under a cooperative agreement between CMA/ NCSW and CAAC/AMC, that the terms of reference are to investigate the request of aviation for space weather, develop the relative technology, and promote the service of space weather for aviation. Some space weather products have been integrated into aviation weather products and issued routinely via aviation meteorological service platform of CAAC (see Figure 2). A more detailed list of CMA/NCSW products and services for aviation is provided in the appendix to this paper. Furthermore, CMA/NCSW is developing new means to provide space weather services with the operational use of space weather global observations from the FY Satellites, as well as the growing number of country-wide network of regional ground-based observations. China is thus well positioned provide the space weather information in support of international civil aviation.

2.5 Comments on future development of space weather service

2.5.1 China generally support the inclusion of space weather service under Annex 3 to support and satisfy the requirements of the international aviation, and to provide users with the accurate and effective space weather products and services which will increase the sustainability of the global system. We believe that a three or more global centre framework with mutual backup will have more advantages considering geographical coverage of space-based observations augmented by ground-based observations and specific characteristics for data assimilation, model simulation and validation than that for two global centre framework, and will have a higher chance of meeting the aviation user requirements for space weather.

2.5.2 We suggest that the standards and technical specifications of space weather products and services to international aviation should be developed and approved, and the selection criteria for global space weather centres should be defined.

2.5.3 We also suggest that the number of global space weather centres with mutual backup and augmented by regional centres to ensure smooth coordination between the global and regional levels should be quantified.

3. Action by the Meeting

3.1 The meeting is invited to:

a) note the information contained in this paper; and

b) discuss any relevant matters as appropriate.

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APPENDIX

CMA/NCSW SPACE WEATHER

PRODUCTS AND SERVICES FOR AVIATION

A.1 Space Weather Regular Products

Items	Products	Description
1	Summary of previous 24 hours	a) the solar activity of last 24 hours, latest space weather condition and solar eruptive events b) the evolution of geomagnetic field, the geomagnetic storm and its process; c) the space radiation environment condition, the disturbance and its source; d) the ionosphere process and its latest condition.
2	Short term forecast of solar 10.7cm radio flux	Forecasting the solar 10.7cm radio flux in the coming 24, 48 and 72 hours
3	Short term forecast of Ap index	Forecasting the Ap index in the coming 24, 48 and 72 hours
4	Short term forecast of the probability of M class solar flare	Forecasting the probability of M class solar flare in the coming 24, 48 and 72 hours
	Short term forecast of the probability of X class solar flare	Forecasting the probability of X class solar flare in the coming 24, 48 and 72 hours
5	Short term forecast of the probability of solar proton event	Forecasting the probability of solar proton event in the coming 24, 48 and 72 hours
6	Short term forecast of the probability of minor geomagnetic storm	Forecasting the probability of minor geomagnetic storm in the coming 24, 48 and 72 hours
	Short term forecast of the probability of major geomagnetic storm	Forecasting the probability of major geomagnetic storm in the coming 24, 48 and 72 hours
7	Space weather development forecast	a) Issue the space weather condition in coming 72 hours; b) forecast the space weather event and its process; provide manipulation
8	Ionosphere TEC nowcast	The latest condition of TEC map over China

A.2 **Aviation Space Weather Index**.

The RSG scales from NOAA Space Weather Prediction Centre (NOAA/SWPC) have been widely adopted by aviation to describe space weather information. Following the NOAA space weather scales, CMA/NCSW provides aviation space weather indexes (see Figure 1) including geomagnetic storms, solar radiation storms, and radio backouts based on international and domestic data (eg. Fengyun satellites data). CMA/NCSW also issues space weather alert and forecast based on the scales.

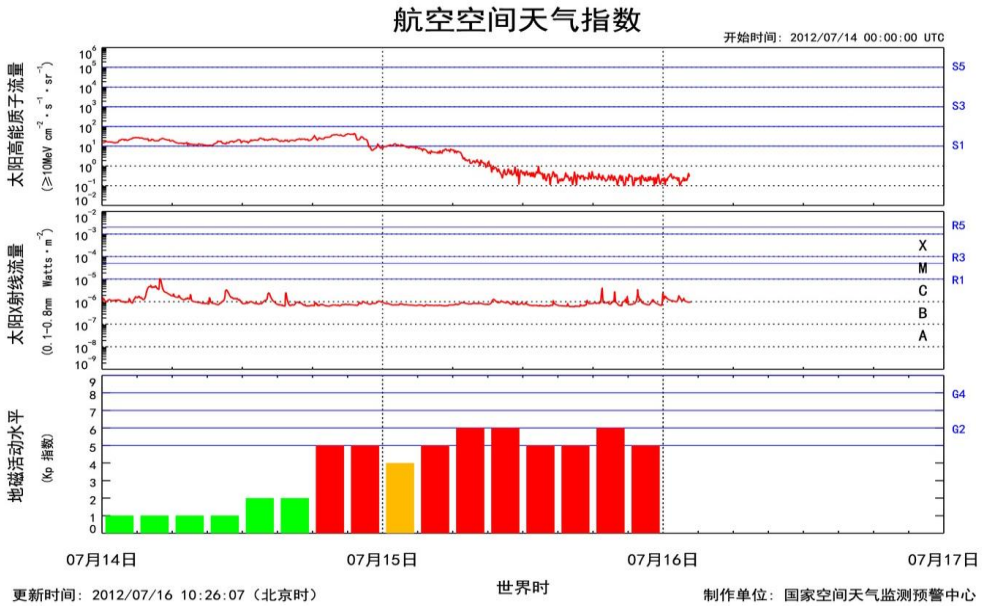

Figure 1 The space weather index for aviation based on the NOAA/SWPC scales

A.3 Ionospheric Optimum Frequency for Aviation.

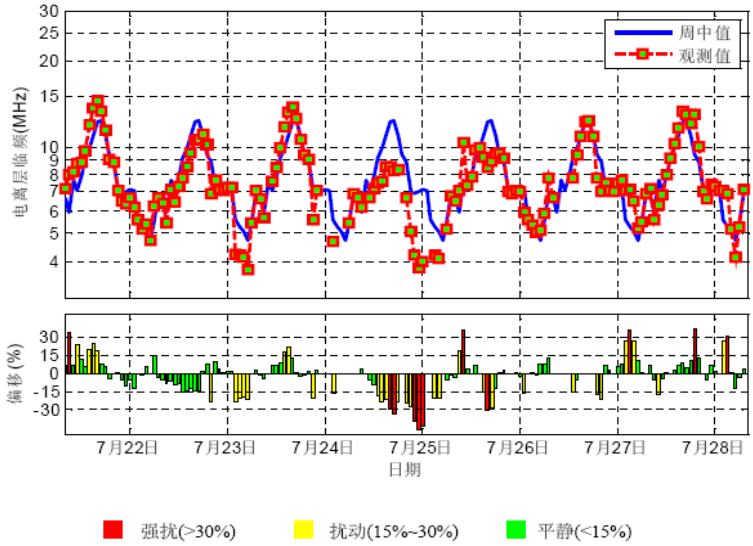

图 5 地区电离层天气（临频）变化
（北京时间 07 月 21 日 8 时－07 月 28 日 8 时）

Figure 2 Variation of Ionospheric weather(foF2)

The ionosonde data could be used for finding the optimum operation frequencies for broadcasts or point-to-point communications in the high communications in the high frequency range. Using ionosonde observations from Xiamen, Kezhou, Nanning and Xi'an stations in CMA, the product of variation of ionospheric critical frequency (foF2) has been developed (see Figure 2). Based on the requirement analysis for aviation, CMA/NCSW would develop specific product for optimum frequency selection.

A.4 Ionospheric Scintillations Service.

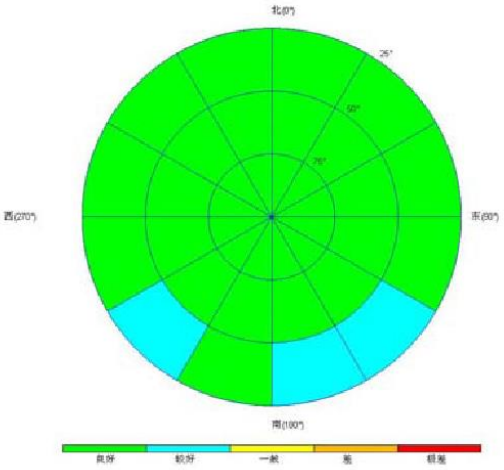

图 1、2010 年 10 月 10 日
广州上空不同天区星地通信质量统计图

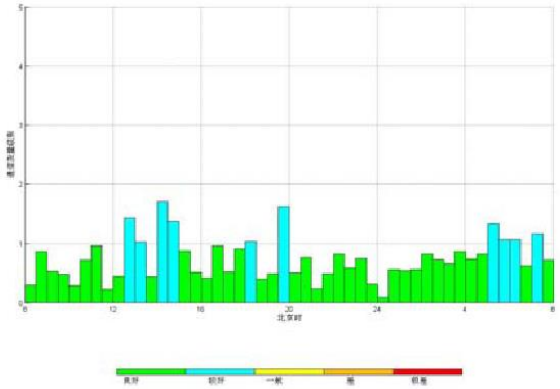

图 2、2010 年 10 月 10 日
广州每日随北京时变化的星地通信质量统计图

Figure 3 Satellite communication quality for Guangzhou 2010 Asian Games

The solar-induced drifting ionospheric electron-density irregularities may lead to the scintillation of trans-ionospheric GNSS signals. Scintillations not only degrade signal quality but also cause loss-of-lock, posing a major threat to GNSS-based applications demanding high levels of accuracy, availability and integrity. Using ionospheric scintillation data of both GPS and FY-2D satellites, the services of ionospheric scintillation monitoring product in South China have been provided to Guangzhou 2010 Asian Games and Shenzhen 2011 Universal Games (see Figure 3).

A.5 Radiation Dose for Aviation.

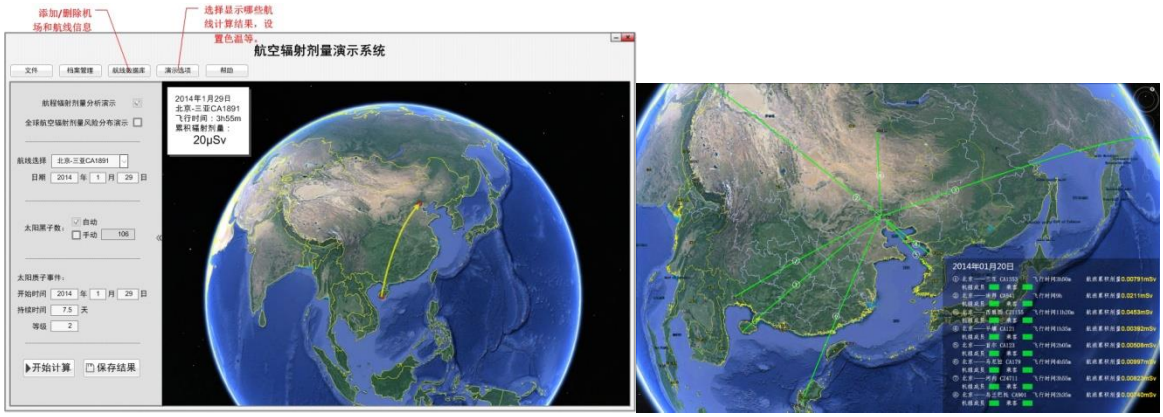

Figure 4 The demo system for aviation radiation dose

It is well known that radiation increases with altitude and latitude. Especially in the polar and high-latitude regions, solar radiation storms can further increase the radiation exposure to passengers and crew in aircraft. A radiation dose calculation system is being developed to provide the radiation exposure quantity related to biological risk – effective dose rate (uSv) and accumulated dose expected along a flight path (see Figure 4).

A.6 Total Electron Content (TEC) Map over China

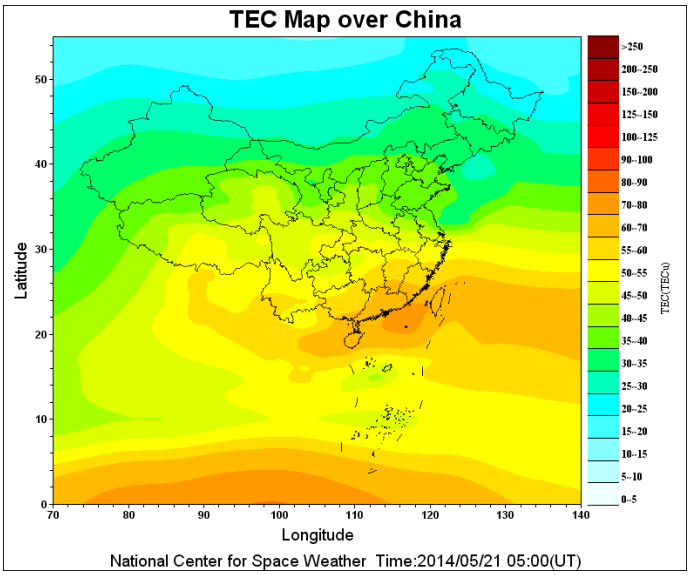

Figure 5 The TEC Map over china

This near real-time vertical TEC map is produced at CMA by using more than 800 GPS stations data over china (see Figure 5). Note that TEC values outside of the china come from the IRI ionospheric model and should be treated with caution. This ionospheric product could give the information of the signal delay for single and dual frequency GPS applications.

A.7 HF Maritime Communications Demo System in China

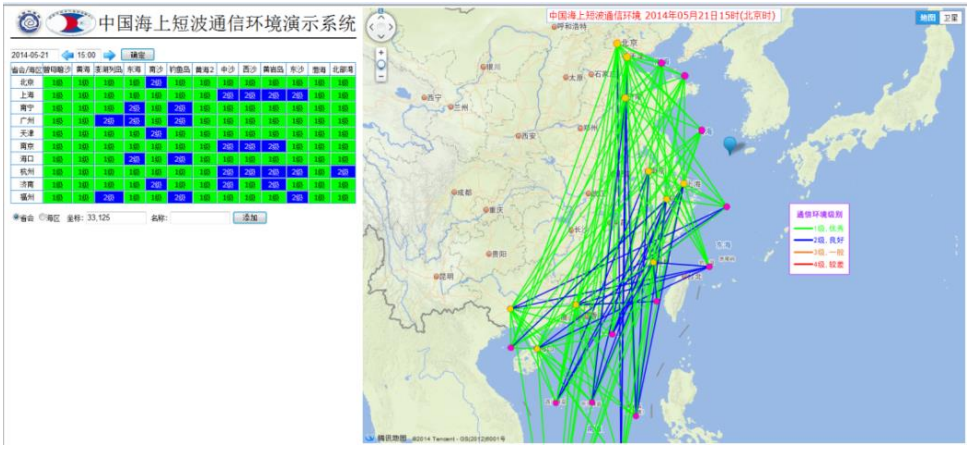

Figure 6 The demo system for HF maritime communications

This system can grade the communication quality of the HF links between the cities on land and typical locations on coastal marine areas (see Figure 6). The quality of each link is divided into 4 grades according to the link midpoint ionospheric status. The results of all links are given as a form, including the grades, link distance, midpoint positions. The results can be updated every half an hour.

— END —