

New Development with Upper Air Sounding in China

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1. Upper air sounding network distribution in China

There are 120 upper air-sounding stations in China (except for Hong Kong and Taiwan district), with average interval 200-300 km, which is a relatively dense country in upper air sounding network. There are 87 stations participating global data exchange. The sounding observation is at 00 and 12 UTC, and there are 26 stations operating at 18 UTC for only wind measurements. In order to meet the weather service requirements of Beijing 2008 Olympic games, 10 sounding stations in Beijing and its circumjacent areas were added in the sounding observations at 06 and 08 UTC from July to September.



There are 7 GCOS GUAN stations in China, as well as 7 mobile GPS sounding system and L-band radar sounding system in Fujian, Anhui and Yunnan province.

2. Sounding technology

2.1 Sounding and wind measurement

In China, there are two systems in upper air sounding operation. One is the secondary windfinding radar system-digital electronic radiosonde; the other is GPS radiosonde. The radar system occupies most of upper air stations.

2.1.1 In the past five years, CMA implemented an “Upper air sounding system replacement program” to deploy L band (1675MHz) electronic radiosonde and windfinding radar sounding system as a new sounding system, to replay the old system (Tape 59-701 Mechanical Radiosonde and Secondary Windfinding Radar). 80 stations have been deployed the L band sounding system by the end of 2005.



L band secondary windfinding radar

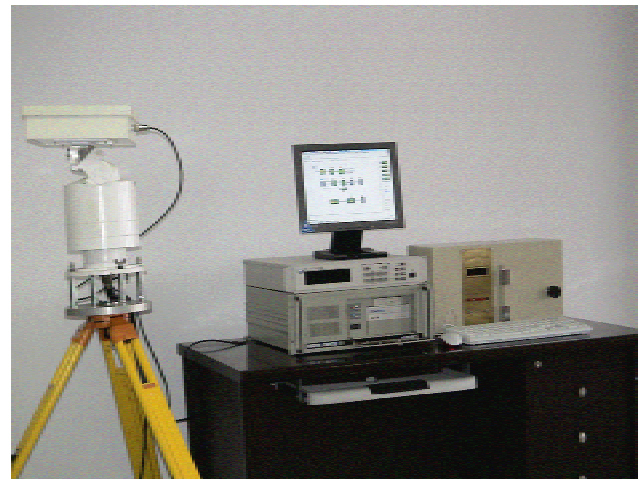
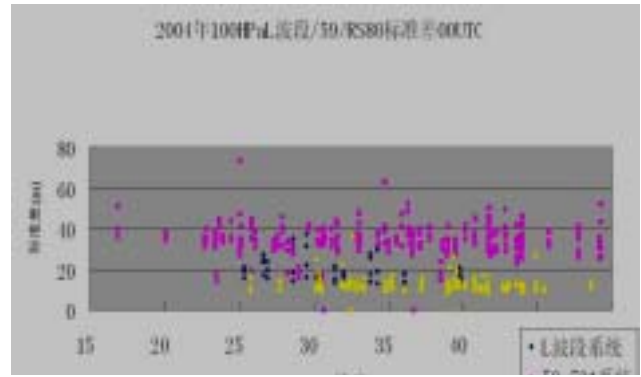
The measuring accuracy of L band system meet fully the requirement of 《Guide to Meteorological Instrumentation and Methods of Observation》 by WMO. After putting in use, upper air sounding precision and data quality in China have been increased obviously. Through the evaluation made by European center for numerical forecast, detection precision of L-band sounding system is corresponding to that of RS80 sounding system of

Vaisala, and has caught up with international level in the middle of 1990s, and the observation automatic degree has also clearly increased.

2.1.2 30 stations have completed P band second wind measurement radar-electronic sounding system as transitional system until next replacement program.

2.1.3 10 stations (include 7 GCOS GUAN stations) have used GPS sounding system. From 1 Jan 2006, 1500g balloons have been launched and detection height has reached 5hPa in all of GUAN.

2.1.4 2 stations (Beijing and Naqu) will deploy ozone sounding system in 2007.



GPS Upper sounding system

2.2 Main technical specifications of the sounding system

2.2.1 L band sounding system

L band sounding system is composed of L band secondary windfinding radar; type GTS digital electronic radiosonde and ground check set.

A. L band secondary windfinding radar

Main property and characteristics of L band radar:

- Operating frequency: 1675±6 MHz
- Pulse peak: ≥15kW
- Lobe width: vertical lobe ≤6°, horizontal lobe ≤6°
- Action distance: max. 200km; min: ≤100m
- Range precision: slant range error is no more than 20m (RMS)
- Angular measurement range: Azimuth angle 0~360°,
Pitch angle -6°~+92°
- Angular measurement precision: Azimuth angle (>6°) ≤0.08°(RMS)
Pitch angle (>6°) ≤0.08°(RMS)
- Operating condition: continuous operating time: 8 hours; still normally operating at strong gale

L band radar has the following characteristics:

- Operating frequency is high, which is favorable to lessen the antenna size and reduce

antenna weight.

- Pulse peak power is small (15 kW). Compared to equivalent radar, save power, which is a strongpoint of second radar.
- Pulse width and lobe width are both narrow. Thus range precision and angular measurement precision are relatively high.

B. Digital electronic radiosonde

The type GTS digital electronic radiosonde is a high accuracy and good quality, which developed in 1998 by Shanghai Changwang Meteorological Science and Technology Company. To combine with L band secondary windfinding radar, temperature, pressure, relative humidity and wind have been observed in different height from ground to 30 km. This radiosonde is composed of temperature sensor, humidity sensor, intelligent converter (including pressure sensor), transmitter and battery. Fully electronic sensor and sub-carrier wave binary system digital coding remote have good anti-jamming of same frequency.

Temperature sensor has used clubbed thermistor, with high reflectivity cover, which can reduce short wave radiation; In the software processing, the temperature error caused by long wave radiation has been corrected.

Humidity sensor has applied macromolecule thermistor. Avoiding direct radiation and refractive radiation on the hygistor has been considered in order to reduce the error caused by radiation.

Pressure sensor has used **silicon** and its structure is 2 lengthways resistors and 2 transverse resistors set in the silicon, thus 4 resistors have connected into electronic bridge. There is a vacuum chamber at the back of the bridge, when the atmosphere pressure has changed, the resistance of the 4 resistors will be changed. At the manufactory, temperature-pressure correction of each sensor has been made and temperature compensation has been done all over full scale, thus pressure error caused by temperature change can be reduced.

Main technical specifications are as followed::

Measurement scale

- Temperature: 50°C ~ -90°C
- Humidity: 0% ~ 100%RH
- Pressure: 1060hPa ~ 5hPa

Measurement range

- Temperature: 40°C ~ -80°C
Standard uncertainty $\leq 0.3^{\circ}\text{C}$
- Humidity: 15% ~ 95%RH
Standard uncertainty $\leq \pm 5\% \text{RH}$ (Temperature is above -25°C)
 $\leq \pm 10\% \text{RH}$ (Temperature is under -25°C)

- Pressure: 1050hPa~10hPa
Standard uncertainty: $\leq 2\text{hPa}$ (Pressure is above 500hPa)
 $\leq 1\text{hPa}$ (Pressure is under 500hPa)
- Central frequency of carrier wave f_0 : 1675 MHz \pm 3 MHz
- Transmit power: $P \geq 400\text{mW}$
- Modulation mode: amplitude modulation
- Transmission speed: 1200 Baud
- Sampling period: $t \leq 1.5\text{s}$
- Battery adopted Mg-CuCl water-activated batteries, voltage: $\pm 13.5\text{V} \sim \pm 12.5\text{V}$, operating time: 100 min.

2.2.2 GPS sounding system

The GPS sounding system is composed of ground receiving and processing system; GPS radiosonde and ground check set.

Main technical specifications are as followed:

A. GPS radiosonde

- Detection range
Distance: 0~200km
Height: 0~36km
- Temperature range: $-90^\circ\text{C} \sim 50^\circ\text{C}$
Accuracy
Repeatability in calibration $\leq 0.2^\circ\text{C}$
Reproducibility in sounding $\leq 0.3^\circ\text{C}$ (under 25 km);
 $\leq 0.5^\circ\text{C}$ (above 25 km)
- Humidity range: 0~100%RH
Accuracy
Repeatability in calibration $\leq 3\%RH$
Reproducibility in sounding $\leq 3\%RH$ (under troposphere)
 $\leq 10\%RH$ (above troposphere)
- Pressure range: 5~1050hPa
Accuracy
Repeatability in calibration $\leq 0.8\text{hPa}$
Total uncertainty in sounding $\leq 2\text{hPa}$ (Ground to 500hPa)
 $\leq 1\text{hPa}$ (500-5hPa)
- Wind direction error $\leq 3^\circ$
- Wind velocity error $\leq 0.3\text{ m/s}$
- Positioning error (differential): horizontal $\leq 10\text{m}$; vertical $\leq 16\text{m}$
- Operating frequency: 403~406MHz
- Belt width: $\leq 200\text{kHz}$
- Transmit power: $\geq 200 \sim 350\text{ mW}$
- Data speed: 1200 baud
- Modulation mode: FM

- Supplying time: >2 hours
- Repeatability: <450 g

B. Ground receiver system

- Antenna gain: $\geq 10\text{dB}$
- Receiver frequency: 400~460MHz
- Sensitivity: $\leq -120\text{dBm}$ (The ratio of signal to noise is 12 hours)
- Consumed power of ground receiver system: $\leq 600\text{W}$
- Continuous operating time: $\geq 24\text{ hr}$

3. Research and development system of upper air sounding in CMA

CMA has attached importance to research and develop upper air sounding system and set up a whole technique development system to offer strong supports for the progress of upper air sounding system. This system consists of development plan, function specification, model development, test assessment, technique identification, station tryout and final design, etc.

Development plan Based on the requirements of meteorological forecast and service, development program and plan of upper air sounding system made by CMA have represented technique system and production requirements.

Function specification Based on the development program requirements of upper air sounding system, function specification of each system made by CMA has specified technique indices and become the basis of developing model for the manufactory.

Model development The manufactory develop model on the basis of function specifications.

Test assessment CMA has a special atmosphere comprehensive observation test base to carry out kinds of observation system assessment test. The assessment test of upper air sounding system model from the manufactories has been organized by CMA and carried out in the test base. The contents include: technique indices of the model, dynamic assessment in running status, observation comparison and software test etc. After passed the test assessment, evaluate whether the system has met the requirements of function specification and technique demand in contract.

Technique identification The model passed the assessment test will be made for technique identification by CMA, identifying the model can meet the requirements of technique level.

Station tryout The model passed the assessment test will be arranged to tryout in a few stations, assessing whether the model can meet operation requirements.

Final design As for some models tried out in the stations for a period, the production

design will be decided by CMA to identify the technique property, reliability and the economic cost of the model to meet the operation requirements.

Generally, it takes 2-3 years for a new instrument from production to operation. Some need more. For example, Chinese L band sounding system, technique system and structure had been made certain in 1995. Function specification had developed in 1996. Model development had been done in 1997. Test had been carried out in 1998. The model had been tried out in Beijing sounding station in 2000. Large numbers of instruments had been produced in 2001 and 80 sounding stations had been completed in 2005.

Also, GSP radiosonde system, wind profiler and other sounding systems are carried out according to the above specification, thus can make sure the stable operation of sounding system.

4. Quality control system of sounding operation in China

In order to guarantee observation quality, CMA has set up a complete quality control system, including instrument quality supervision, detection operation criterion, operation monitoring and data quality control etc.

Instrument quality supervision can guarantee the quality of instrument and the measurement precision met the detection requirements. Before using in the station, the radiosonde has to pass for the quality examination made by the staff from CMA. As for the radiosonde used in station, CMA also needs some periodic comparison test to check and assess the stability and reliability of radiosonde.

Detection operation criterion CMA had established upper air observation operation flow and criterion, and regulated that observer must be according to uniform working process to develop observation, and each operational step has its clear requirement. Critic assessment should be done as each detection height, blast frequency of the balloon and fault frequency, and some other operational quality indices. Checking each detection data is to guarantee the accuracy of the detection data.

Operation monitoring CMA has established real time monitoring system. Each sounding station has been monitored in operational conditions and operation quality, thus CMA can hold the working status and operation quality of each sounding system. If malfunction is found, it should supervise the observers or technicians from the manufactory in time to maintain in the spot in time.

Data quality control CMA has established a set of strict data quality control system. At first, primary quality control has been made at the station. One is to use major and minor working regulation, which is that after the major staff has completed the sounding work; the minor should take charge if there is mistake in the working. If there is, it should be corrected in time; the other is data check regulation. When the observation completed, the special checking staff should look through the working flow and data information. If there

is mistake, it should send corrected information to CMA to guarantee the accuracy of exchange with global data. Secondly, National centre of atmosphere observation technology, CMA do analysis and assessment termly on sounding data at each station. As for some stations existing quality problem, it should look for the problem and solve it, thus make sure the accuracy of the sounding data.

5. Development plan in the next step

Upper air sounding is not only satisfied with weather forecast, but met the requirements step by step of climate prediction and climate change research, which has become a global issue. The first workshop of GCOS sounding held in Boulder, USA in Nov. 2005 had completed the technique report “Climate requirements in upper air observation”; In addition, the second workshop meeting held in Seattle, USA in May, 2006, based on the climate observation requirements, suggests that global sounding stations should carry out classified construction and operation, mainly strengthen construction of global reference sounding stations, generally increase detection precision and at the same time reinforce the amalgamation of sounding with satellite, GPS and other remote sensing measurements.

CMA has begun to develop operation technique system innovation, on the basis of weather and climate requirements, innovation and development of new generation upper air sounding system has clearly increased detection precision and space-time density. The emphases in the next five years are as followed:

5.1 Make great efforts to develop high quality radiosonde

Although the electronic radiosonde in use has obviously been improved compared to mechanical ones, the stability and accuracy should further be increased to meet the requirements of climate observation. On the aspect of temperature sensor, it should use bead sense organ and make the precision increased from 0.3°C to 0.2°C. Furthermore, radiation-proof cover should use metal to reduce the long wave and short wave error. Humidity sensor should use capacitive sensor instead of current resistance sensor and the measurement precision should increase from 10% to 5% and further to increase its stability. Pressure sensor should increase measurement range from 1060hPa~10hPa to 5hPa to meet the requirements of GCOS sounding observation.

5.2 Do rapid construction on GPS sounding system

With the prefect of GPS application technique and decrease of production cost, GPS technique has applied comprehensively in upper air sounding observation. In the next five years, CMA will make the construction of GPS sounding system fast and has planed to construct GPS sounding system in about 40 stations and launched GPS radiosonde. At the same time, technique alteration will be made at 80 L-band radiosonde stations and forming integrated upper air sounding system, simultaneously, having GPS and radar wind measurements function.

5.3 Strengthen construction of GCOS GUAN stations

China has 7 GCOS sounding stations (except for Kowloon station in Hongkong), there into; the altitude of Nachu in Tibet Autonomous Region is the highest (4300 m). The altitude of Yichang in Hubei province is the lowest. Launching 1600g balloons, its detection height reached 5hPa from 1 Jan 2006. Most indices have be up to basic requirements of GUAN. CMA is strengthening detection capability of these GCOS sounding station, including taking precedence of high accuracy GPS radiosonde to reach objective requirements of GUAN as soon as possible. This year and the next, ozone sounding system will be constructed in Beijing and Nachu to develop ozone sounding. At the same time, GPS water vapor observation system and wind profiler system will also be developed in the sounding stations to strengthen amalgamation of sounding system with other remote sensing and create conditions for setting up global reference upper air stations in China.

5.4 Setting up mobile sounding system

In order to meet the requirements of meso- and small scale disaster weather and emergency disaster warning system, it should set up mobile sounding system in super-city, main river area and few sounding stations area to carry out flexibility and dense observation. Thus, the upper air network in China will be formed based on the fixed sounding stations, which is complemented by moving sounding stations.