

Weather Real-time Reporting System Based on Intelligent Network

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ABSTRACT

Real-time weather information has been in urgent needs all the time, especially in the summer when server convection weather occurs frequently. Real-time weather warning based on real data from real observation is intuitive and easier to be believed and alert than qualitative weather forecast warning. In many severe weather events of the world more lives and properties could be saved if there were Weather Real-time Reporting System. Combined with intelligent meteorological sensor, Internet of Things and Mobile Internet, weather real-time reporting system with multi-factors and high space-time resolution was established. Weather Real-time Reporting System contains real-time observation system, information collection and transmission system and the location based weather information publishing system, in which real-time observation system includes national benchmark weather stations, provincial regional automatic weather stations, weather station based on Internet of things and mobile internet meteorological observation. Each observation elements and value transmission and traceability system were described in detail. Weather Real-time Reporting System is a major development and leap in meteorological service for providing real-time weather information at any location.

Keywords --- Weather Real-time Reporting System, automatic observation, Internet of Things, mobile phone internet, Location Based System

0 INTRODUCTION

Weather Real-time Reporting System(abbr.**WRS**) refers to current weather real-time observation, real-time transmission, real-time release and real-time queryable. Real-time weather information has been the people's urgent needs, especially in the summer when server convection weather occurs frequently. Driving on the road to see dark clouds ahead, not knowing whether rain or not on road front, and if so, what the amount of precipitation is. If there is GIS location based real-time weather information system with high space resolution, drivers could query real-time weather conditions on his route so as to decide whether he should go home or move on. It is very important. The heaviest rainfall in 61 years fell on the Chinese capital city of Beijing on July 21, 2012. Rainfall over Beijing averaged 215 millimeters (8.5 inches), and reached 460 millimeters (18 inches) in the city's Fangshan District, 79 people dead^[1]. Even the meteorological department issued several heavy rainfall early warning information, some still braved the rain and went out, and lost their lives on the way. If there is real-time weather information available and queryable, one would never go out if he found the precipitation is close to 500 millimeters (almost 20 inches) in the place he wanted to go. Due to the weather forecast warning information is the concept of qualitative, not quantitative data, sometimes let to suspect, and not enough attention given. But the information from **WRS** is real data based on real observation, so the warning information is intuitive and easy to believe and alert. Warnings from WRS sometimes arouse more attention and seriously taken than early warning from weather forecast. In many severe weather events of the world, more lives could be saved if

there were Weather Real-time Reporting System for real-time weather information release and query.

In fact, many occasions require real-time weather information. For example, in a weather caused flight delay, passengers want to know the destination airport real-time visibility and weather phenomena actual conditions to see if it is suitable for plane landed. On scorching summer, ladies want to know real-time solar irradiance and ultraviolet intensity outside in her location in order to take appropriate sun protection. For outdoor sportsman should be aware of real time weather of the local space and change on the route, so as to adjust the travel time and route. Many outdoor sportsmen died in a flash flood or at low temperature, primary causes are not aware of real time change in the weather.

Therefore, location based real-time weather information is on enormous demand. In this paper, using intelligent meteorological sensor, combined with Internet of Things and Mobile Internet, weather real-time reporting system with multi-factor and high space-time resolution was established which could truly achieve location based real-time observation, real-time transmission, real-time release and real-time queryable.

1 Overview of WRS

1.1 Present development of live weather situation

China Meteorological Administration(abbr.**CMA**) and some provincial meteorological bureau, have already started real-time weather information publishing business. For example, National Meteorological Center of CMA in her website provide the whole China hourly temperature, precipitation, wind direction, wind speed, as shown in figure 1 [2],also hourly real time observation data of lightning, short-time strong rainfall, strong wind and hail, as shown in figure 2 [2].

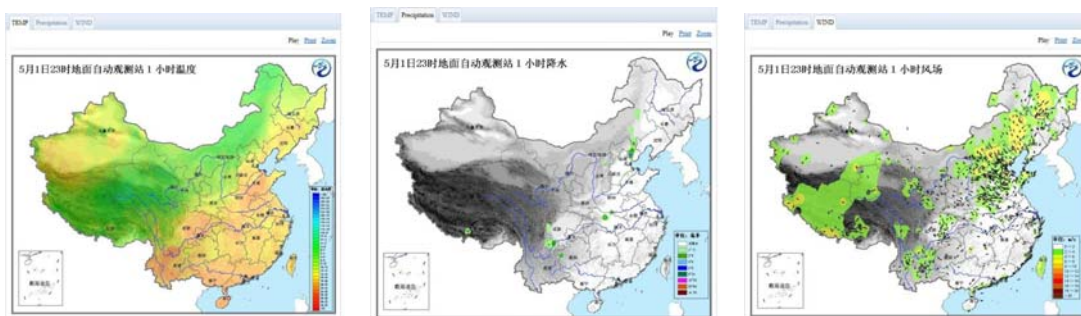


Fig 1.China hourly temperature, precipitation, wind direction, wind speed

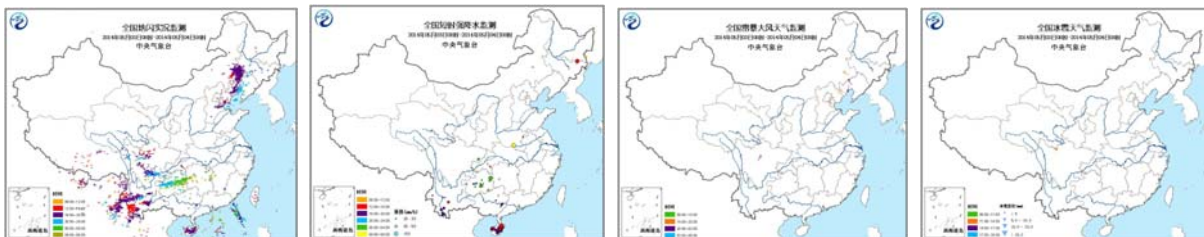


Fig 2. China hourly lightning, short-time strong rainfall, strong wind and hail

China Weather Web(<http://www.weather.com.cn/>) from first-tier to third-tier city hourly live weather

conditions, such as providing Beijing air temperature, relative humidity, precipitation and wind speed hourly observation data, which from one of the national benchmark weather stations located in the south of Beijing, as shown in figure 3 [3].



Fig 3.Beijing hourly temperature, relative humidity ,precipitation, wind direction, wind speed

Some provincial meteorological observatory website also provides some of the local actual live weather information. Such as Guangzhou China meteorological administration give hourly air temperature, relative humidity, rainfall and wind speed value of Guangzhou city, also including hourly live real weather images about four direction of Guangzhou city, as shown in figure 4 [4].



Guangzhou live weather images(E,N,W,S)

hourly tem, humi, rain,wind

Fig 4.Guangzhou hourly live weather condition

(four direction images , temperature ,relative humidity ,precipitation, wind direction, wind speed)

Weather real-time reporting systems described above greatly satisfy the needs. However, as the limitation of observation system, current WRS's time resolution only per hour, minimum spatial resolution only about 50km×50 km, meteorological elements limited to traditional basic such as temperature, precipitation, wind ,etc, which still can't meet the demand. People need WRS with higher spatial and temporal resolution (time per minute, space 100 m×100 m), also include visibility, weather phenomena, atmospheric pollution composition the better. In this paper, elaborate WRS with multi-factor and high space-time resolution was established by using intelligent meteorological sensor and combing with Internet of Things and Mobile Internet.

1.2 Structure and characteristics of WRS

WRS is mainly divided into the real-time observation system, information collection and transmission system and the location based information release system, as shown in figure 5.

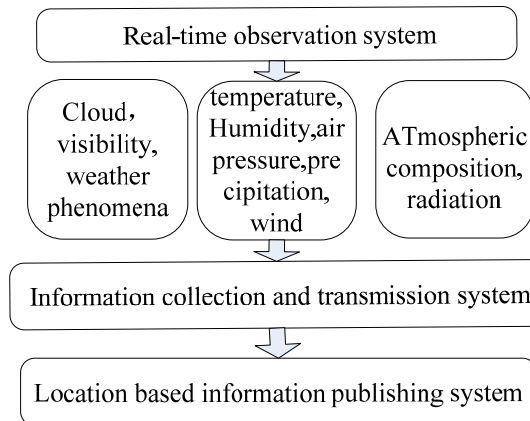


Fig 5. Structure of WRS

Real-time observation system is the core of WRS. In order to realize high space-time resolution observation, real-time observation system is mainly divided into four parts, that are the national benchmark weather stations, provincial regional automatic weather stations, weather station based on Internet of things and mobile internet meteorological observation. Observation elements includes cloud, visibility, weather phenomena, temperature, humidity, precipitation, air pressure, wind direction, wind speed, solar radiation, atmospheric composition and other factors. Information collection and transmission system includes meteorological data field acquisition, data transmission based on China meteorological administration backbone network combined with the mobile network. Location based meteorological information publishing system provide real-time weather information based on mobile communication network and satellite positioning system combined with GIS.

The main characteristics of WRS are:

- (1) **Authenticity.** WRS information quotes real observation stations true data, so warning alert from WRS is more reliable than the weather forecast. Therefore, weather warning alert combined from WRS and weather forecast could ensure the safety of more lives and properties.
- (2) **Timeliness.** Information published by WRS is real time. All the observation data will be transmitted to WRS immediately.
- (3) **Precision.** By application of Internet of Things and Mobile Internet, WRS spatial resolution may up to 100 m×100 m, about hundreds of thousands of times higher than weather forecast 50 km×50 km spatial resolution.

2. Observation of WRS

2.1 Observation network structure of WRS

It is difficult to get high quality observation data and to achieve a high space-time resolution as well. So observation system of WRS can be divided into four levels, which are national automatic

meteorological station network, provincial regional automatic weather stations, weather station based on Internet of things and mobile internet meteorological observation, as shown in figure 6.

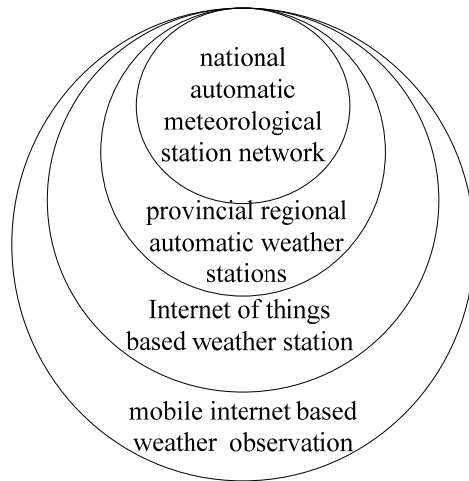


Fig 6. Observation network structure of WRS

The first level provides accurate weather minute data using professional cyc-calibrated equipment in national observation network, including temperature, humidity, precipitation, pressure, wind direction, wind speed, cloud height, cloud form, cloud cover, visibility and weather phenomenon and so on. Space resolution is about 100km×100km.

The second level is provincial regional automatic weather stations network, which spatial resolution may be 25 km× 25 km.

The third level is meteorological Internet of Things intelligent sensors which geographically dispersed and become full-function through the ZigBee network node design. Some of China provincial meteorological Administration has built local meteorological Internet of Things to improve ability of comprehensive meteorological disaster monitoring and early warning service which pace resolution is about 5km×5km.

The fourth level is from mobile phone internet based on GPS location. Street View from Google Earth implies abundant weather information, unfortunately not real-time (allegedly soon).Some Android or iphone OS applications like MoWeather share real-time current location weather pictures uploaded by users. With professional image recognition algorithm and data assimilation techniques, weather information could be extracted from these pictures. Due to tremendous users, real-time weather information in any location could be achieved by collecting all pictures information. This space resolution may even going so far as to100m×100m.

2.2 Observation elements of WRS

2.2.1 Clouds, visibility and weather phenomenon

Clouds, visibility and weather phenomenon used to observed four times a day by manual. Due to the personnel quality is uneven, the observation quality and reliability is difficult to guarantee. With the development of the intelligent sensors, automatic observation of clouds, visibility and weather phenomenon has become possible^[6-8].

Weather phenomenon classification in China consistent with international standards, which is 34

kinds of weather phenomenon ^[9].By analyzing data from three international popular weather phenomenon observation instruments (OWI-430, VPF-730 , PWS-100 and JY-2C/T)imported by Meteorological Observation Center of CMA, and comparing the same period manual records, the results show that weather phenomenon observation instruments have good result in capturing the precipitation and visibility obstacle phenomena^[8].

In order to obtain high spatial resolution of weather phenomenon, it may not be enough just rely on weather phenomenon observation station from official meteorological department. With the development of mobile Internet, mobile smartphone represented by IPHONE got widespread application among people. Many smart phone weather Apps (e.g.*MoWeather* international, *MojiWeather* in China) allow netizen upload real-time street view pictures. Through these pictures, most weather phenomenon closely associated with human living can be automatic identified. Images shown bellow in figure 7 were uploaded by mobile phone netizens, these images revealed some street real-time weather imaging about one district in Beijing, China.

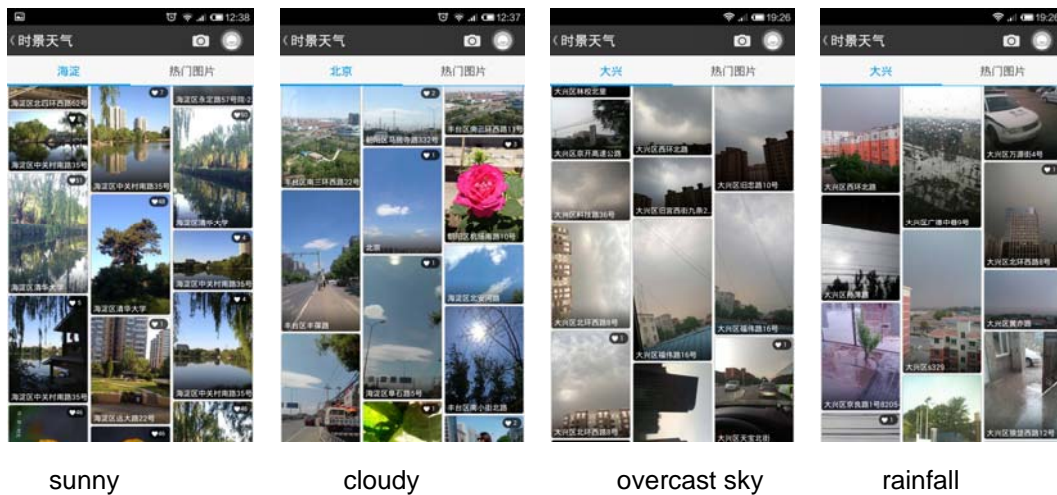


Fig. 7 Some street real-time weather imaging about one district in Beijing, China

Using street real-time weather images to determine the real-time weather phenomenon, you need an outdoor weather phenomena recognition algorithm extracting from street view images.

Paper[10]extracted features of power spectrum slope, contrast, noise, saturation from outdoor images to identify the multi—classification of weather situations with Support Vector Machine(SVM). It can recognize more than 75%rainy weather and about 85% sunny, overcast, foggy weather^[10].

Paper[11]acquired weather-related parameters using the degradation model of image and to identify the weather phenomenon. The relationship between weather phenomena and the line spread function is conducted by analyzing the variation of the line spread function. This method have a certain discrimination effect for the sunny, mist, haze, rain, dust storms and other weather phenomena^[11].

Paper[12]proposed a modified calculating method of dichromatic mode to identify low visibility weather phenomena via revising the atmospheric scattering direction, improving the calculating method of vector angles and adding humidity parameter information. This method is excellent in identifying various kinds of low visibility weather phenomena, such as fog, haze, dust blowing, dust floating, and sand storm. whose total identification rates are 73.2%,90.5% respectively^[12].

2.2.2 Other basic meteorological elements observation

Other observation elements of WRS include temperature, humidity, air pressure, wind direction, wind speed, radiation, etc. Radiation covers sun radiation and earth radiation, which is divided into global radiation, direct radiation, reflected radiation, diffuse radiation, ultraviolet radiation, atmospheric long wave radiation, the earth long-wave radiation, photosynthetic radiation, spectral radiation and so on^[13]. Ultraviolet radiation is closely related to People's Daily lives. After intense ultraviolet radiation will cause skin vasodilation and appears erythema. So the real-time observation and report of the ultraviolet radiation help people to take the corresponding protective measures.

With increased air pollution in China, the atmospheric PM2.5 fine particles real-time observation data publishing is beneficial to people master the latest real-time atmospheric pollution and take the corresponding protective measures. On the basis of established sandstorm station network, China meteorological administration set up atmospheric composition observation network in some key and typical region, in which aerosol, greenhouse gases, chemical reaction gas, atmospheric ozone and acid rain could be observed^[14].

Internet of things technology can be used to improve the spatial and temporal resolution of observation system. Automatic weather station based on Internet of Things distribute in reasonable, effective layout according to the terrain, uses wireless sensor node real-time acquisition of various meteorological elements, transmits data through the wireless network based on the ZigBee agreement. With Internet of things, a large scale, low power consumption, self-organization automatic meteorological observation system can be achieved, which is beneficial to automatic meteorological observation in more remote areas^[15].

2.3 Value transmission and traceability system of WRS

Meteorological metrology is the basic business and services for meteorological observation, reliable quantity transmission and traceability is the premise and guarantee for meteorological observation. Value transmission and traceability process of WRS is shown in figure 8^[16].

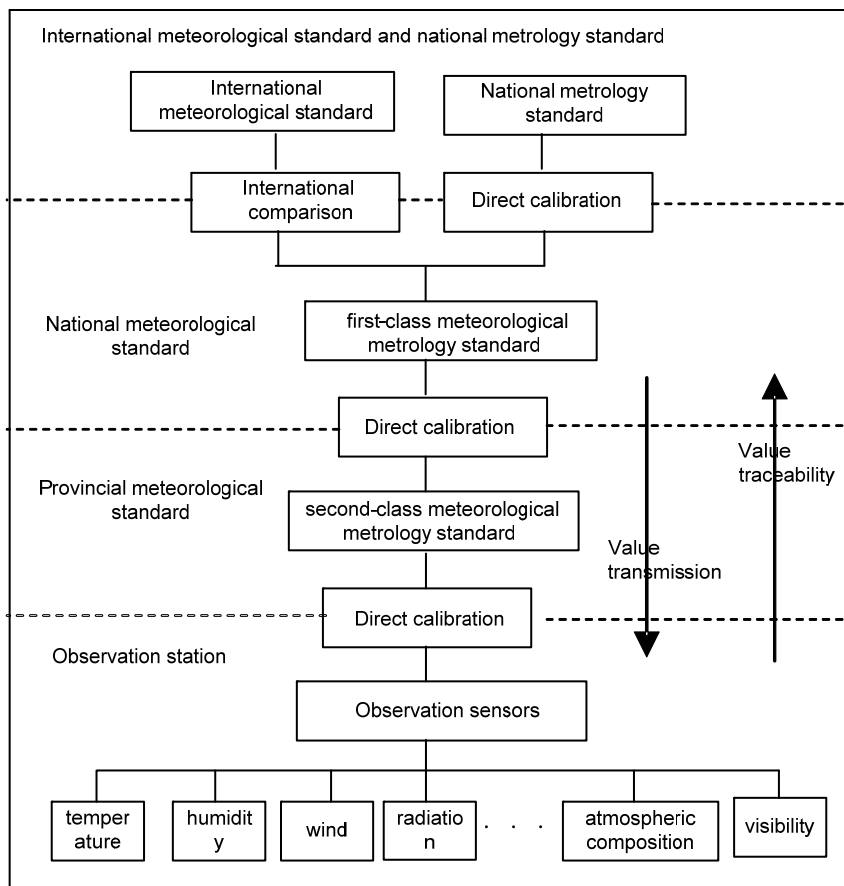


Fig. 8 Value transmission and traceability process of WRS

China national meteorological metrology station keeps each professional meteorological measurement highest national standard, including temperature, humidity, precipitation, air pressure, air velocity, sun and earth radiation, in which standard uncertainty of air pressure, air velocity and the sun and the earth radiation are $(12\text{ppm}+1\text{Pa})$, 0.1% and 0.1% respectively. Calibration for clouds, visibility, weather phenomena and atmospheric composition is under construction.

Considering the continuity of observation data, performance testing of WRS observation instrument is basically under field calibration. The main difference between laboratory calibration and field calibration is that field calibration cannot take whole range test. According to the using condition and environment condition, single point or a few points would be tested on field calibration to check if the performance of the meteorological instrument meets the technical requirements or not. Regularly field calibration is essential way to find measurement error change of meteorological sensors. Mobile field calibration system is shown in figure 9, which can take on-site calibration of air pressure, humidity, temperature, wind direction, wind speed, precipitation, evaporation, sunshine, solar radiation and so on.



Fig 9 Mobile field meteorological calibration system

As for the field calibration of visibility and weather phenomenon, here is no standard method. National observation data could be considered as the origin standard, then make external divergent calibration for meteorological sensors based on Internet of Things and Mobile Internet to ensure their measurement accuracy.

3. Location Based Real-time Meteorological Reporting and Inquiry Service

WRS is one of a kind of **Location-Based Services(LBS)**. From Wikipedia, LBS are a general class of computer program-level services that use location data to control features. As such LBS is an information service and has a number of uses in social networking today as an entertainment service, which is accessible with mobile devices through the mobile network and which uses information on the geographical position of the mobile device. This has become more and more important with the expansion of the smartphone and tablet markets as well^[17].LBS need GPS chip. With the popularity of large number of smart phones, GPS chip became a fundamental configuration, and nearly every Iphone and Android phones assembled with GPS chip.

LBS are used in a variety of contexts, such as health, GPS navigation, etc. WRS is one of a kind of

LBS. This service can be used to identify the location of a person or thing, customers can take advantage of the current location to provide or using real-time weather information. Like GPS navigation client can query the city real-time congestion or smooth route, WRS users can get any real-time weather information at anywhere.

Meteorological department is to build meteorological information service based on "Location Cloud" . " Location Cloud " will integrate multilayer GPS based weather platform into one open shared center, in which users could submit different weather service demand through smartphone and service center would feedback at any time in order to meet the needs of different types. The idea of interaction will be blended into "Location Cloud" meteorological service. For WRS users not only can query any position real-time weather information, also may upload real-time weather conditions on your location to help others.

4. Conclusion

In this paper, using intelligent meteorological sensor, combined with Internet of Things and Mobile Internet, weather real-time reporting system with multi-factor and high space-time resolution was established which could truly achieve location based real-time observation, real-time transmission, real-time publishing. The main characteristics of WRS are authenticity, timeliness and precision. WRS spatial resolution may up to 100 m×100 m. Weather warning alert combined from WRS and weather forecast be able to ensure the safety of more lives and properties.

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