Weather monitoring and forecasting services for provincial highways and railways in China

by Yan Mingliang¹, Yuan Chengsong¹ and Pan Xinmin²

Introduction

Along with the rapid increases in volumes of traffic, safety has become an increasing challenge. Severe weather is one of the main causes of traffic accidents. At the beginning of 2008, persistent snow and frost in southern China led to severe traffic disruption, as well as an increased number of accidents. Low visibility on expressways induces the tailgating of scores, even hundreds, of cars. Similarly, highway and railway traffic is frequently affected by rainstorm and flooding events, as well as rain-induced geological hazards such as debris flows. Railways in western China are often affected by gales and sand- and duststorms. At Hundred-Li Fetch near Hami in Xinjiang, gales can induce train derailments. Many water navigation channels in China are also frequently affected each year by severe weather such as heavy fog, gales and rainstorms with water damage to goods, ship collisions and even capsizing.

In the past decade, China has experienced record growth in the construction of air, land and water navigational infrastructure. All levels of government, as well as weather and traffic departments, have paid increasing attention to traffic weather. On 27 July 2005, the China Meteorological Administration and the Ministry of Communications signed a Memorandum for Joint Development of Highway Traffic Weather Forecasting Work, in order to issue joint national expressway traffic weather forecasts. This action was the start of a nationwide traffic weather forecasting service.

Traffic weather monitoring system

Traffic weather monitoring network and stations

Traffic weather monitoring must include the monitoring of highway surfaces, low-visibility weather conditions, water temperature and a number of other factors. All this information must be transmitted in real- or near-real time. The automatic meteorological monitoring stations covering expressways and water transportation routes need to include real-time monitoring of visibility, traffic surface, temperature, humidity, wind direction, wind speed and precipitation and, at the same time, meet the technical requirements of traffic engineering equipment.

Traffic weather monitoring networks consist mainly of four parts: a weather data acquisition module; a weather data processing module; an information monitoring module; and a weather service information module.

---

¹ Jiangsu institute of Meteorological Science, Nanjing 210008
² Xinjiang Meteorological Administration
Expressway traffic weather monitoring system

The weather monitoring network system constructed by the Nanjing Institute of Transportation Meteorology on the Shanghai-Nanjing Expressway is one of the most advanced highway traffic weather monitoring systems in China.

It acquires field weather information through 26 automatic meteorological monitoring stations and two highway surface-temperature monitoring stations along the expressway. Monitoring data are transmitted to the receiving centre by means of wireless communication and imported into the server database of the Meteorological Administration and expressway command centre. Real-time weather monitoring information, weather disaster warning and forecasting information are then synchronously saved in a server database and displayed at the terminal workstations of Shanghai-Nanjing Expressway management and weather departments. Such information can meanwhile be issued and displayed at various information terminals (information boards, monitoring terminals, etc.) of the expressway. During the second half of 2006, the forecasting centre introduced video monitoring and information sharing along 101 highways from the Shanghai-Nanjing Expressway Command Centre. This information has enabled weather observers and forecasters to directly monitor the weather and road conditions along highway segments.

All the management and safety data from the traffic weather monitoring stations and the forecasting products are entered into a database for the management system, the traffic weather information issue system and a number of other systems. Monitoring the analysis and application of data in real-time and displaying the data on the same or different screens by time, station and/or weather conditions in the form of tables, charts and GIS maps respectively (Figure 1) has also been a substantial advance. It is also possible to set up a colour warning and/or sound alarm for visibility at each station and then display this information (by means of a GIS) for traffic management departments and public users (Figure 3).

Railway gale monitoring system

The foundation engineering (single station for wind monitoring) for the Lanzhou-Xinjiang railway line in the Xinjiang autonomous region and the network engineering on the northern Xinjiang and southern Xinjiang lines were completed and installed between 1998 and April 2000. Since 1998, this system has been both upgraded and expanded.

It includes digital wind-monitoring instrumentation and optical cable communication and computer network techniques. Other features are a high degree of automation, simple and convenient operation, easy commands, a clear display, friendly
interface, stable performance and minimal maintenance.

At present, the Xinjiang railway gale monitoring and alarm system consists of 50 wind monitoring points (small stations), 32 cross stations (bus stations), one data-processing centre (main station of dispatching centre of railway administration), three database servers (electronic computation centre of the railway administration), one operation monitoring server (technical support centre) and many computers (customer service terminals). The system operates continuously 24 hours a day and includes a real-time alarm function.

### Traffic weather forecasting technology

Weather also has a significant influence on the main lines of communication, particularly given the relatively small areal extent and short duration of many events. Warnings in advance of high-impact weather events has improved by increasing the spatial density of monitoring equipment, the frequency of data uploading, combining monitoring data with that of a new generation of radar monitoring products and other automatic weather stations, and using the output results of meso-scale numerical prediction models. Technological development over the past two years has shown that the warning service has, indeed, reduced traffic accidents and produced other economic and social benefits.

### Qinghai–Tibet railway

The Chinese Qinghai–Tibet railway is a high-altitude railway that connects Xining to Lhasa. Its total length is 1 956 km.

Construction of the 815 km section between Xining and Golmud was completed in 1984. The 1 142 km section between Golmud and Lhasa was inaugurated on 1 July 2006.

The Tanggula Pass at 5 072 m above sea level is the world’s highest rail track. The 1 338-m Fenghuoshan tunnel is the highest rail tunnel in the world, at 4 905 m above sea level. At 4 264 m above sea level, the 3 345-m Yangbajing tunnel is the longest tunnel on the line.

More than 960 km—more than 80 per cent of the Golmud-Lhasa section—is at an altitude of more than 4 000 m. There are 675 bridges, totalling 159.88 km, and some 550 km of the railway are laid on permafrost.

### Forecasting of patchy heavy fog

The influences on, and damage to, traffic of low visibility and heavy fog are well known. Patchy, heavy fog and local “fog masses” are the focus of current highway traffic weather research. The accumulated monitoring data show that the formation and dissipation of heavy fog are not a process which develops slowly, but a weather phenomenon with relatively obvious evolution [1]. Setting up automatic weather monitoring stations along expressways will facilitate this much-needed area of research.

Some judgments on the forecasting of heavy fog can be made according to the determination of weather type, conditions at both the surface and high altitude, analysis of the movement of the cloud system, analysis of the temperature inversion layer and advection as per the sounding curve, combined with the information provided by monitoring stations along highways [4].

Through analysis of the monitoring data and the visibility atlas acquired...
over the previous four years, ranges for speed limits (50-200 m) and road closures (<50 m) have been established. Before the appearance of main-body heavy fog, an advanced oscillation usually occurs. This oscillation exists for a short time, and even though the visibility value is not particularly low, it serves as a prelude to sudden heavy fog and, therefore, has forecasting value.

The monitoring, warning and forecasting system of low visibility due to heavy fog are much improved by combining conventional meteorological observations with monitoring results transmitted and displayed by automatic monitoring stations with concrete place, time and numerical values measured along highway segments. This entire system integrates synoptic forecasting methods and numerical forecasting products, including the characteristics of heavy fog appearing along the Shanghai-Nanjing Expressway. It presents the forecasting flow, transmits the forecasting results to the highway command department and then evaluates the monitoring and forecasting results according to the road administration report.

Techniques for gale forecasting along railway lines

Through research on gale formation mechanisms and various forecasting methods, an hour-by-hour forecast system with a forecasting time of 12 hours for representative stations in 15 km and 50 km stretches along the railway line has been established. For hazardous gales (> grade 8) as a research and analysis object, typical gales in different seasons from 2006 to 2007 were studied. Based on analysis of the numerical forecasting model and measurements along railway stations points, a model forecasting equation was established. By correcting errors in the model forecasting equation, weather conditions in the 1-12 hour range were made possible. An hour-by-hour wind trend for the following 1-12 hour interval is output twice daily.

Traffic weather service

By combining a traffic weather monitoring system, an interface protocol and access authorization, various types of weather monitoring information and forecasting service information can be displayed along expressways. Among the information products provided, a series of other weather forecasting service products is available for users. These products have served as an interface for the system and will therefore improve future weather traffic services.

“e-route weather net” (http://www.167.com) is a professional traffic weather service Website. It integrates national and provincial traffic weather monitoring, forecasting information and traffic weather research results, traffic weather disasters and assessments of all of these. Through sharing the scientific and technological resources of traffic weather, this Website provides high-quality services for users from the traffic sector and also provides a platform for communication on traffic weather for regional and even national weather departments.

Traffic weather service products combine long-, middle- and short-time forecasting and include special-line forecasting, station-point forecasting, subdivided forecasting, regional forecasting, warning, important weather forecasting, actual situations and holiday forecasting.

Conclusion

Traffic weather research and implementation are a new subject in the weather system spectrum due to the significant impact on traffic safety of increased traffic and severe weather conditions.

Severe weather conditions, including low visibility due to heavy fog, high and low temperatures of road surfaces, heavy rain and snow, sand- and duststorms, heavy wind and icing on road surfaces are the main causes of traffic accidents. Constructing an applicable and pertinent traffic weather monitoring network system is the basis and
precondition for developing traffic weather work.

The forecasting and warning of severe weather conditions on main communication lines depend on both the judgment of the overall synoptic situation and weather type and on monitoring and numerical forecasting products.

References


