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Application of Quantitative Rainfall Nowcast to Hydrological Predictions in Hong Kong

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Abstract:

In Hong Kong, flooding occurs when rainfall is so high that natural or engineered drainage fails to drain away the surface runoff. Such heavy rain-induced floods are usually fairly transient in most parts of Hong Kong and the warnings of such hazards have been covered by the rainstorm warning system operated by the Hong Kong Observatory. However, it could take considerably longer time (usually of the order of a couple of hours) for the rainwater to accumulate and to drain away in the plain of the northern New Territories, where the catchment basin is relatively large and the natural slope is gentle. The resulting floods may therefore last up to a few hours, resulting in serious damages or even casualties. For example, the persistent torrential rain and squally thunderstorms throughout the period 5-12 June 2001 caused a series of severe flooding events, incurred widespread damages to the territory. Altogether, there were 262 reports of flooding and the New Territories was worst hit, with over 800 millimetres of rainfall recorded at Fanling during the period. Flood waters almost rose to the roofs of two-storey village houses. Two stone bridges in Pat Heung and Kam Tin were damaged by torrents. Of the many villagers stranded, 26 people were rescued by helicopters and 113 people by firemen in dinghies. Thirteen of them were injured. Some 17 hectares of fish ponds and 227 hectares of farmland belonging to 1,200 households were inundated, costing about eight million Hong Kong dollars.

To mitigate the disasters resulting from such serious inundates peculiar to the "flood plain", the Observatory issues the Special Announcement on Flooding in the Northern New Territories (SAFNNT) when heavy rain affects this area and flooding is expected to occur. The issuance criterion is mainly based on a rainfall rate threshold chosen by the Drainage Services Department and its value had been set close to the rainfall intensity criterion in the Red Rainstorm Warning, viz. 50 mm/h. It was reviewed recently to a higher value taking into account the improvement in the drainage system. During the last 10 years (1998-2007), the SAFNNT was issued 50 times, out of which 27 cases were not accompanied by rainstorm warning at Red or higher level. This indicated that about half of the flood-prone rainstorm events in Hong Kong were indeed localized in nature and a flood plain-specific alert independent of the rainstorm warning, which generally applies to widespread rainstorm situations, was proven necessary. The SAFNNT is intended to prompt the public to take precautionary measures against flooding and to alert farmers, fish farm operators, engineers, contractors and others who are likely to suffer losses from flooding. The announcement also alerts the relevant government departments and organizations to take appropriate actions, such as opening of temporary shelters, search and rescue operations, closure of schools in affected or vulnerable areas and relief work.

The successful operation of a weather warning service relies primarily on continuous weather watch. In Hong Kong, rainstorm related severe weathers were monitored uninterruptedly using both surface observation and remote-sensing networks, including automatic weather stations, raingauges, Doppler weather radars and lightning sensors. To aid the forecasters in their warning decision making process, e.g. providing advance alerts with sufficient lead time and clear delineation of impact area and severity, tailored forecasting tools are indispensable. However, severe weathers such as rainstorms are often volatile and chaotic in nature, with a wide spectrum of life span ranging from tens of minutes to several hours, as well as a large spatial variability down to the kilometre scale. To make accurate and reliable prediction of them, even with a very short lead time, is a notorious challenge that forecasters have faced up to for many years. Considering the constraints inherent to weather prediction science and the characteristics and impacts of the typical rainstorms in Hong Kong, the Observatory has adopted nowcasting (i.e. prediction of imminent weather several hours ahead) as the appropriate strategy and successfully developed an automated system called SWIRLS (Short-range Warning of Intense Rainstorms in Localized Systems) to meet the longstanding challenge. SWIRLS is radar-based, high spatial resolution, fast updating and tailor-made for the prediction of detailed rainfall distribution over Hong Kong up to 6 hours ahead. In essence, it converts radar signal power into rainfall intensity using a dynamic correlation function, calibrated in real-time based on raingauge data. To make a very-short range forecast on the movement of the radar-rainfall, SWIRLS firstly derives the motion vectors by a technique called TREC (Tracking of Radar Echo by Correlation). Next, SWIRLS carries out a time integration out to 6 hours by extrapolating the radar-rainfall field according to the TREC motion vectors in 6-minute time steps. At each time step, radar-rainfall is accumulated at each grid cell to generate the 1- to 6-hour forecast rainfall distributions over Hong Kong. The nowcasting data are applied to all the rainstorm related warnings in Hong Kong and are shared among partners, including the Drainage Services Department and the Geotechnical Engineering Office.

In this presentation, SWIRLS will be introduced and the underlying key concepts explained. Various applications of the SWIRLS rainfall nowcast data will be presented, with emphasis on flood forecasting in relation to the SAFNNT. The limitations inherent to radar-based nowcasting and the various error sources in the resulting flood forecast will be highlighted. Finally, the ways forward will also be discussed.