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Strategies of Nowcasting and Forecasting Rainstorms in Hong Kong

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Strategies of Nowcasting and Forecasting Rainstorms in Hong Kong

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1. Introduction

While nowcasting systems and mesoscale NWP models are striving to come to terms with volatile mesoscale weather systems such as rainstorms, forecasters still have to face the day-to-day challenge of issuing timely warnings. Recognizing such operational reality, forecasting system developers in Hong Kong have made a conscious effort in the past few years to come up with purposely designed tools for forecasters to lean on in their time of need.

The effort and rationale behind the three-prong approaches adopted operationally are presented in Sections 2, 3 and 4. A discussion on current problems and future possibilities is given in Section 5.

2. Translating Technical Jargons into One Meaningful Message

The first approach is to translate all nowcasting guidance and numerical prognoses into instantly digestible information that can be directly associated with decision-making criteria. This is particularly relevant for severe weather events such as rainstorms for which the available forecast lead time is often very short and the critical piece of information has to be extracted from the mosaic of analyses and prognoses.

From the Observatory's nowcasting system SWIRLS (Short-range Warning of Intense Rainstorms in Localized Systems), tailor-made rainfall distribution maps are generated for the next three hours based on 6-minute updated radar images and 5-minute updated surface raingauge data. For example, the forecast accumulated rainfall maps for the coming hour (Fig. 1) and the coming two hours gives forecasters a useful objective reference in operating the local rainstorm warning system. It has also been found that the forecast rainfall amount in the next three hours, in conjunction with the running 21-hour total, is a surprisingly effective tool for assessing the need for issuing landslip warnings.

Similarly, a recent attempt is to convert forecast gridded information and fields from the Observatory's experimental non-hydrostatic model, Advanced Regional Prediction System (ARPS), into a display of weather elements planted onto the locations of the automatic weather stations (AWS) (Fig. 2). Forecasters, who are used to monitoring local weather situation through the AWS data display, can then readily bridge over from what they observe at the moment to what they will probably see in the not-too-distant future. One side effect from this effort is that as things pan out, forecasters can also have a better feel for the reliability of the results by constantly comparing with the actual and verifying in a subconscious manner.

In spite of the inherent limitations in forecast accuracy, the net results from such relatively crude mimicking attempts have nonetheless proven to be functional and useful.

3. Towards an Ensemble Picture

The second approach is to collate quantitative precipitation forecast (QPF) information from all available sources into one integrated display for forecasters' reference. While undoubtedly useful for assimilating information quickly, the idea is primarily to create some kind of ensemble picture from which forecasters can implicitly assign confidence levels to their forecasts and make appropriate plans for warning strategies.

From the Observatory's operational model ORSM (Operational Regional Spectral Model), forecast results from successive model runs are retrieved and QPF information extracted to isolate areas of significant rain. The analyzed results are presented in the form of "rain index" giving the probabilities of rain occurrence over pre-defined threshold values (Fig. 3). Given that sufficiently accurate deterministic QPF is still out of reach, an intelligent probabilistic evaluation can nonetheless be very helpful for users or clients reliant on risk assessment to mitigate the impact of severe weather.

4. Forming One Coherent Picture

The third approach is to relate actual observations, nowcasting guidance and NWP outputs into one coherent picture as far as possible. Starting from the current situation as depicted by real-time observations from local networks, nowcasting applications can cover for the NWP blind spot in the first few hours and NWP information can in turn extend the validity range of nowcasting projections.

A good example of this idea at work is the "SWIRLS-ORSM Combined Warning Panel Display" (Fig. 4) immensely popular with forecasters at the Observatory. First of all, it contains an element of actual rainfall information as measured every 5 minutes by the dense network of local raingauges, giving forecasters a constant point of reference as to how close the "ground truth" is from the rainstorm warning criteria. Projection of local rainfall amount into the next hour, broken into intervals of 6 minutes, is then obtained by merging SWIRLS radar-based QPF information with the raingauge running total. Forecasters can then assess how critical the rainfall situation is and decide on the most appropriate rainstorm warning strategy. And from the ORSM heavy rain/thunderstorms guidance shown in the lower panel, forecasters can also evaluate how persistent the inclement weather is likely to be and activate the corresponding response measures among various government agencies and emergency units.

5. Review of Experience and Looking Ahead

From the experience gained through the development effort in mesoscale weather forecasting at the Observatory in recent years, it becomes increasingly obvious that no matter how sophisticated the nowcasting tools are or how advanced the NWP model is, any operational forecasting systems that stand the tests will have to achieve the following design targets.

First of all, the prognostic information will need to be presented in the "working language" of forecasters and in a format resembling as close as possible the monitoring display regularly used by forecasters. Some would suggest that this amounts to pampering to the forecasters' indulgence. But we have to recognize that in mesoscale weather forecasting, RMS errors verified over the seasons do not mean a lot to the forecasters who have to issue the warnings there and then. In such situations, a tool that would allow the forecasters to readily check against the actual observations and to get a feel of how the various systems are performing in real time would be something of immense value.

Secondly, seemingly outdated or more obscure prognostic information should not be discarded too readily. In recognizing that we can never be too exact in our severe weather forecast, collating such information through an ensemble approach may help to generate probability assessment that would prove helpful to decision-makers, including, of course, the forecasters who may otherwise be unaware of any growing risks of heavy rain strikes.

Thirdly, seemingly unrelated analyzed and prognostic information from different source types can still be meaningfully assembled into one coherent picture. For forecasters who are used to synoptic analyses at set time intervals, how to deal with information measured at asynoptic hours or valid at intermediate hours is still something of a challenge. A forecasting system that will readily help the forecasters to bridge over from the present to the near future would undoubtedly have a positive impact on forecast formulation and warning strategies.

In the coming years, the volume of analyzed and prognostic information available to the forecasters will only grow and grow. Forecasters are in danger of being overwhelmed by a deluge of data. Forecasting systems enabling skilful merging of information will ultimately become established as a kind of basic practice in mesoscale weather forecasting for forecasters' continuous monitoring of the rapidly evolving weather situation, complementing the conventional synoptic analyses that are mostly useful for tracking weather systems on the larger scales.

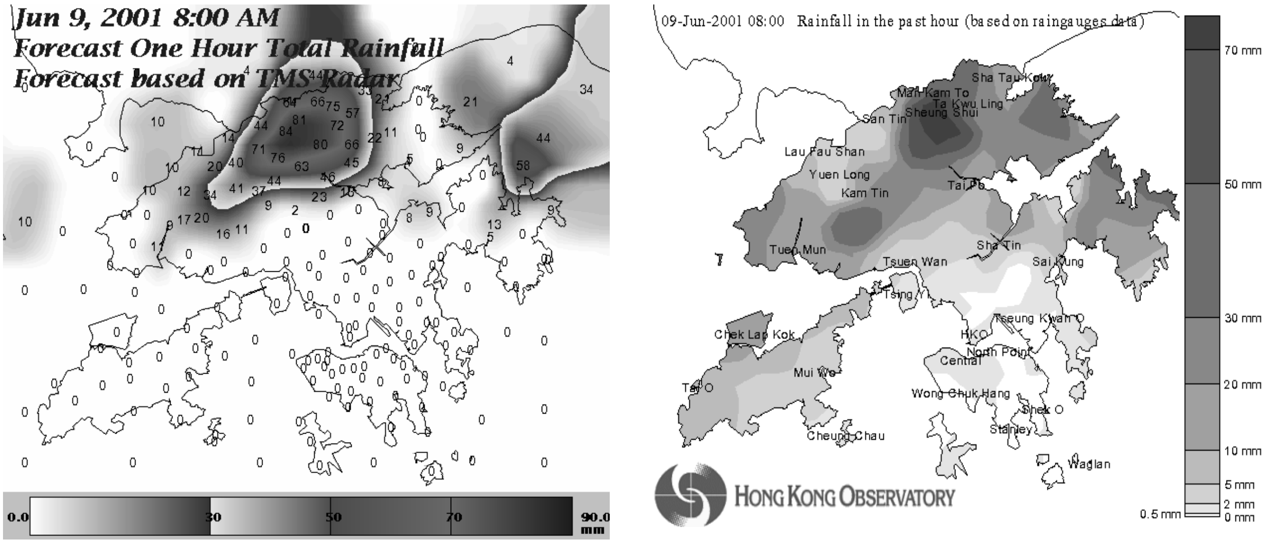

Fig. 1 SWIRLS one-hour rainfall forecast ending at 8 am on 9 June 2001 (left) as compared with the actual rainfall distribution map valid at the same time (right).

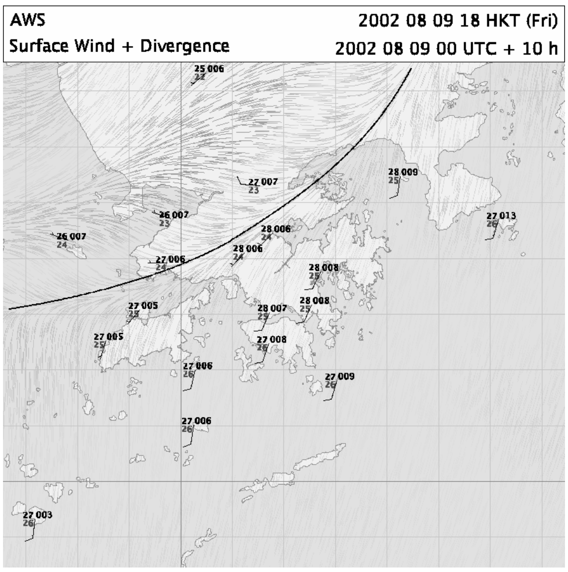

Fig. 2 ARPS forecast meteorological conditions at the locations of the automatic weather stations valid for 6 pm on 9 Aug 2002.

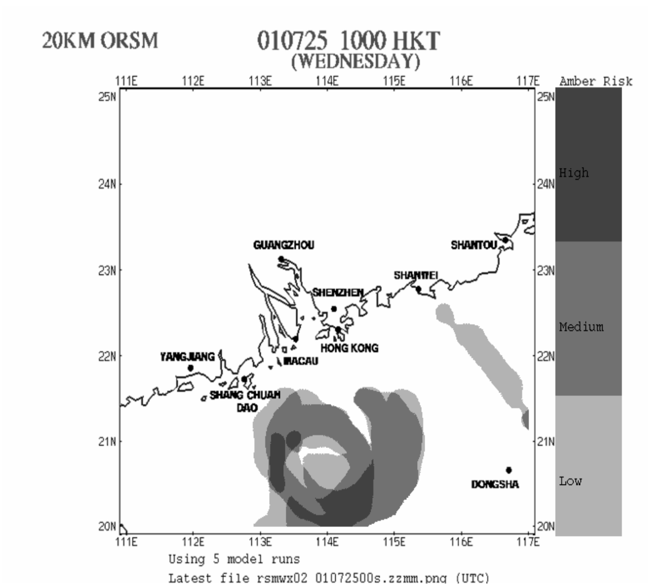

Fig. 3 ORSM rain index for a tropical cyclone case on 25 July 2001. "Amber" refers to a threshold rainfall of 30mm in an hour.

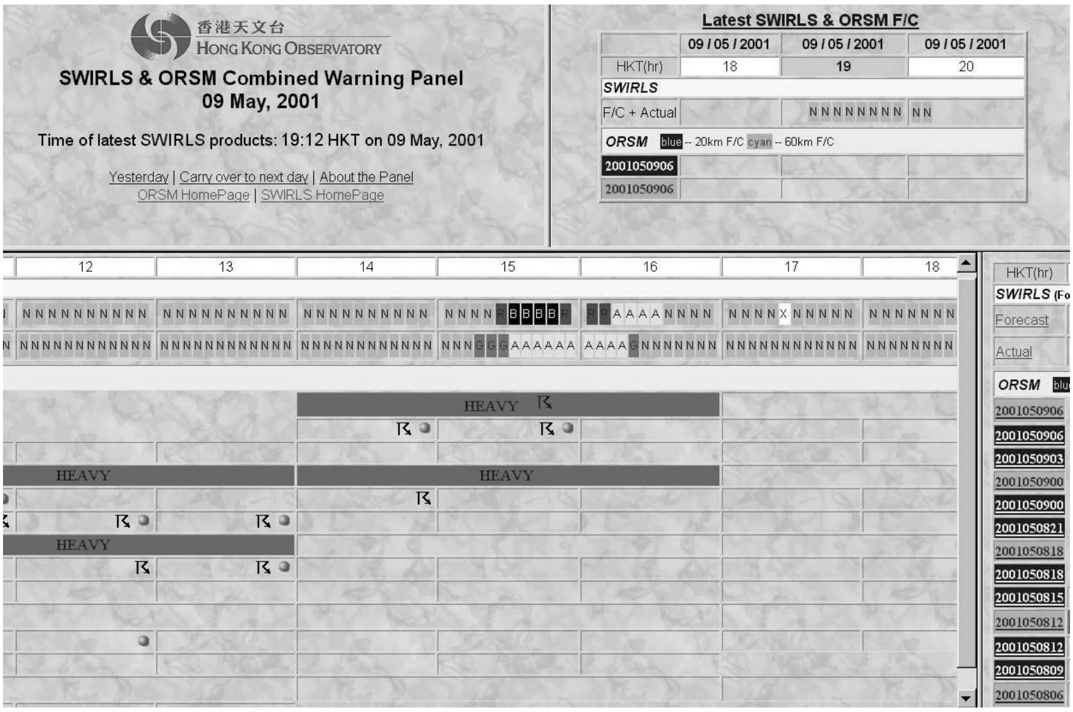

Fig. 4 **SWIRLS-ORSM Combined Warning Panel is an integration of current, nowcasting and NWP information.**