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HONG KONG OBSERVATORY

Reprint 419

Use of Web-based Display of NWP Products at the Hong Kong Observatory

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Seventh ECMWF Workshop on
Meteorological Operational Systems,
Reading, United Kingdom, 15-19 November 1999

USE OF WEB-BASED DISPLAY OF NWP PRODUCTS AT THE HONG KONG OBSERVATORY

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Summary: The paper presents the web-based display of NWP products developed in the past two years as well as the application of meso-scale model output in the automated generation of local weather forecasts for forecasters' reference.

1. Introduction

The Hong Kong Observatory began the use of global NWP outputs from ECMWF, UKMetO and JMA for weather forecasting since the mid eighties. Regional-scale models adapted from JMA were implemented and tuned for the application in Hong Kong since the late eighties. With the advance in computer and data communication technology, more and more NWP outputs are now available to the forecasters. For example, in the early days, only 24hr plots of a few levels in the vertical up to T+48 at 5.0 degree resolution were available. Nowadays, 1.25 degree resolution data up to 8 days ahead at standard levels from JMA global model are available. In order for the forecasters to benefit from the increased volume of NWP information, emphasis has been put on the development of user-friendly display systems as well as development of useful products to aid interpretation.

2. Web-based display system

In the early days, NWP outputs were provided to the forecasters in hardcopy form. Displays on UNIX workstation were developed in the late eighties. As the UNIX machines were relatively expensive, these displays were available to a limited number of users at the Observatory, namely the duty forecasters in the Central Forecasting Office only. Several display menu applications were developed using platform independent X-window libraries on UNIX workstations. Forecasters can select various meteorological elements from different models for still picture display or animation of time sequence of forecast products. They had the advantage of large and clear display as the graphics could be readily configured to utilize the whole screen area.

With the proliferation of personal computers in our organization in the past few years, there is a demand for access of NWP products by professional staff at their office PC's. Taking the advantage of the maturity of web server and browser software, the Observatory began implementation of a web-based display for regional NWP products in the past two years. Such implementation gradually expanded to cover displays of observational data and global NWP products, and is about to replace the UNIX-based display system.

Though the screen size of user-end PC monitors are generally small for the display of a large image, users need no more than a web browser to view the pre-generated figures or animation sequence on their PCs. The web-based system has the advantage of being convenient to use. Development of new products generally take less time, allowing quick turn around time for the development/testing/modification cycle. Experimentation of products and improvement of products incorporating user feedback can take place at a quicker pace than before. As a result, we can see rapid development of products, meeting better user needs. Also, such a system has the advantage of having products ready for dissemination to customers via Internet. The list of products on the web-based display system is given in Table 1. Examples of products like forecast weather map and overlay of weather type forecast by 60-km Regional Spectral Model (RSM) on the IR satellite imagery are shown in Figures 1 and 2 respectively. RSM (NPD/JMA, 1997; WMO, 1998) is the current operational regional model at the Observatory.

3. Automated Forecast Generation

Forecasters nowadays find themselves in a situation where they have more and more observational data as well as NWP products to assimilate on the one hand, and greater demand by the public or customers, on the other hand, for more accurate and precise forecasts/warnings as well as more frequent updates. This is translated into heavier workload for forecasters. In order to ease the workload of the forecasters, we try to build some intelligence into the post-processing of the RSM output and generate objective local weather forecast in text form. The forecast covers 24 hours in respect of wind, temperature, relative humidity, state-of-sky, visibility and precipitation up to two days ahead. Typically, model output variables at the grid point over Hong Kong and the neighboring 8 grids (60km grid) are used to derive the forecast. Kalman filtered results will also be used, if appropriate. Details of the algorithm are contained in Lam & Chow (1999). Forecast categories are given in

Table 2. Such automated forecast helps the forecaster extract the most relevant information at a quick glance. Over the past few months, the algorithm has been fine-tuned. The performance of the automated forecasts was found to trail closely to that of subjective forecasts under an objective verification scheme.

4. 20-km RSM

The Observatory has installed a new computer, CRAY SV1, in summer 1999 with 16 CPU's and an aggregate peak performance of 19.2 GFLOPs. With the new machine, it is planned to implement the RSM with 60km nesting into 20km in the vicinity of Hong Kong and complete the forecast calculation before events actually happen. The schematic flow diagram for the analysis forecast system is given in Figure 3. Besides conventional data, the RSM ingests digital cloud data from the GMS (Lam, 1999i) as well as incorporates locally generated rainfall analysis based on rain gauge and radar data to improve short-term rainfall forecasts through a physical initialization process (Lam, 1999ii). The model is run over the inner domain every 3 hours to take advantage of the frequent rainfall information.

With frequent model runs, we have developed simultaneous displays of the same kind of product from consecutive runs to facilitate comparison. Figure 4 shows a sample product of surface prognoses with rainfall. All the frames are synchronized to be for the same valid time from the past 4 consecutive runs and they can be displayed in loops. Other useful products are the time traces of temperature, relative humidity and hourly rainfall for past consecutive runs for easy reference. Figure 5 is an example of hourly forecast rainfall superimposed on the actual values. Automated forecast algorithm is also applied to the 20-km RSM output to generate local weather forecast product as shown in Figure 6. Moreover, warnings for thunderstorm and heavy rain situations (Black, Red and Amber Rainstorm Signal corresponding to 70mm, 50mm and 30mm per hour respectively) will be generated automatically when threshold criteria are met in the neighboring 25 grid points. One can also invoke a spatial plot showing which grid points are being affected (Figure 7).

5. Conclusion

In this paper, we have shown our efforts, through the use of a web-based display system and automated forecast generation, to help forecasters efficiently interpret NWP output. Future directions include expansion to 3-D visualization of NWP output. We also plan to extend the automated forecast algorithm to global model

output to generate local forecasts for short and medium ranges and to develop some objective means to provide the forecasters with an optimal forecast, combining and utilizing output and forecasts from various NWP models.

References

Lam C.C. and C.K. Chow, 1999: RSM automated weather forecast (Version 1.1). Internal document of the Hong Kong Observatory.

Lam C.C., 1999i: Use of satellite data in the Regional Spectral Model. Internal document of the Hong Kong Observatory.

Lam C.C., 1999ii: Performance of 20-km Regional Spectral Model with the incorporation of physical initialization : Case illustration by the rainstorm of 9 June 1998. Internal document of the Hong Kong Observatory.

NPD/JMA, 1997: Outline of the operational numerical weather prediction at the Japan Meteorological Agency. Appendix to progress report on numerical weather prediction, pp.48-63.

WMO, 1998: WWW technical progress report on the global data-processing system for 1998, pp.101-109.

Models	Products
20-km RSM	Hourly interval animation for synchronous composite display from past 4 model runs with following products: (a) Surface rainfall with MSLP (b) Surface temperature (c) Relative humidity (RH)and wind on 925, 850, 700 and 500 hPa (d) Divergence and wind on 200 hPa (e) Weather map
	Automated forecast with rainstorm warning for past 4 model runs with display of distribution of "alarm points" within 25 grid-point warning area around Hong Kong
	Vertical profile, time cross-section and time series of meteorological elements at grid point of HK for several past model runs
60-km RSM	3-hourly interval animations with following products (a) Surface rainfall with MSLP (b) Surface temperature (c) Relative humidity (RH)and wind on 925, 850, 700 and 500 hPa (d) Divergence and wind on 200 hPa (e) Weather map (f) Satellite IR imageries overlaid with surface rainfall
	2-day automated forecast
	Vertical profile, time cross-section and time series of meteorological elements at grid point of HK
	Daily maximum and minimum temperature, rainfall and RH forecast in tabular form
JMA GSM	12-hour accumulated rainfall with MSLP on surface level Surface wind and temperature Surface pressure change Surface temperature change
	925 hPa RH and wind
	850 hPa wind, vorticity and temperature 850 hPa RH and wind
	700 hPa wind, RH and temperature
	500 hPa wind and streamline 500 hPa geopotential height 500 hPa RH and wind
	200 hPa wind and divergence
ECMWF	Surface pressure Surface pressure change
	850 hPa wind, vorticity and temperature
	500 hPa geopotential height
	200 wind and divergence
UKMetO	Surface pressure Surface pressure change
	850 hPa wind, vorticity and temperature
	700 hPa RH and temperature
	500 hPa wind

Table 1 List of NWP graphical products available on the web-based system

Forecast elements	Categories
Wind	Direction : 16 compass points Force : light winds or Beaufort scale 2-12
State of sky	Fine
	Mainly fine
	Sunny periods
	Bight periods
	Cloudy
	Overcast
Precipitation	Nil
	Light rain/light showers
	Rain/showers (moderate)
	Heavy rain/heavy showers
Reduced visibility	Fog
	Mist
	Haze
Temperature	Minimum temperature over 24 hours
	Maximum temperature over 24 hours
Relative humidity	Range of relative humidity over 24 hours (in percentage)

Table 2 Categories in the automated weather forecast.

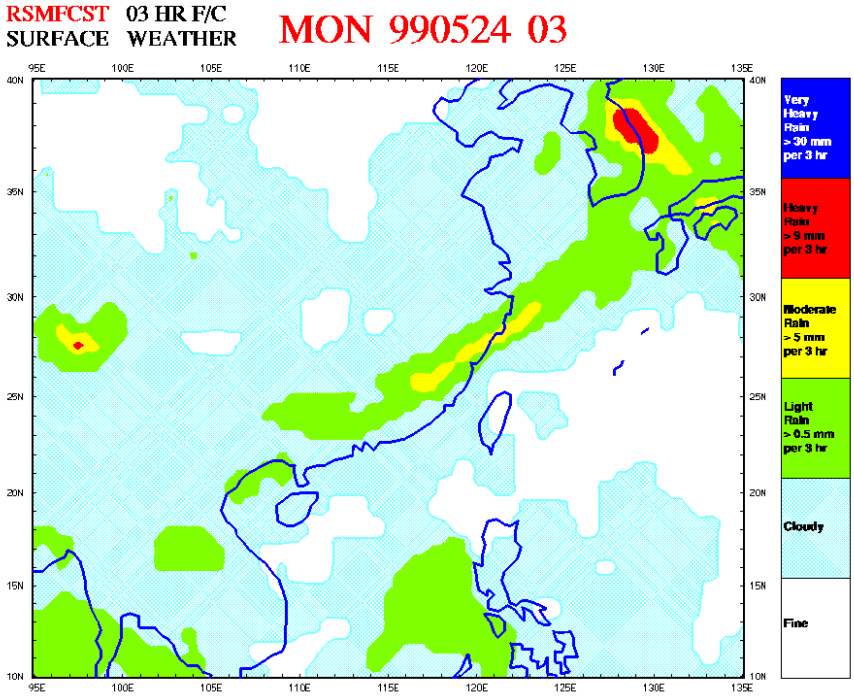

Figure 1 Weather map generated from 60-km RSM forecasts of cloud cover and rainfall.

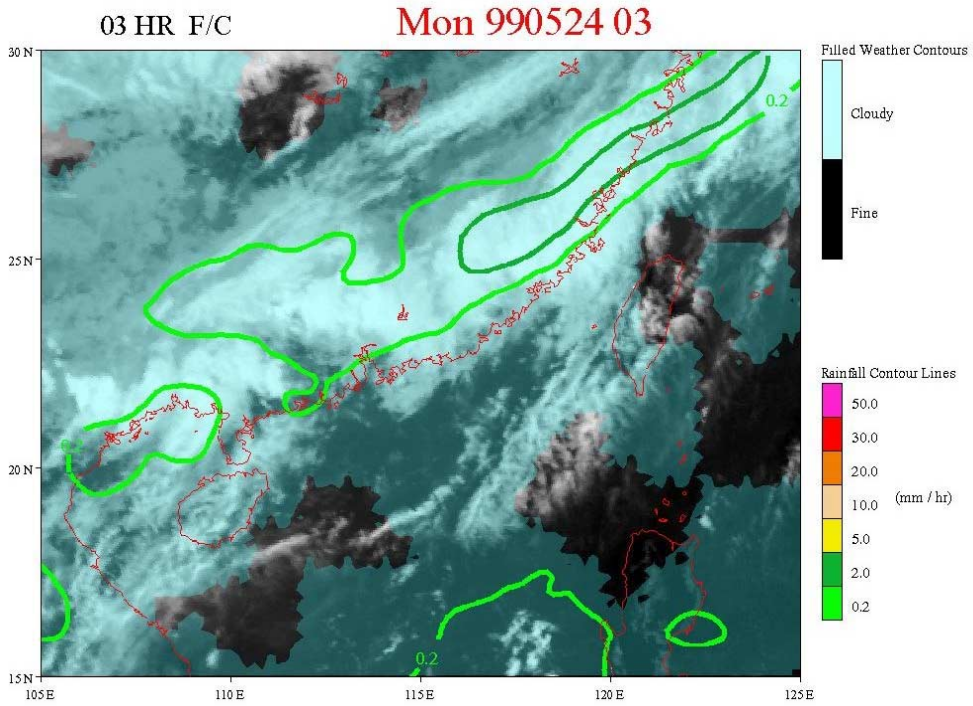

Figure 2 Model predicted weather types and rainfall overlaid with the IR satellite imagery captured by GMS of JMA.

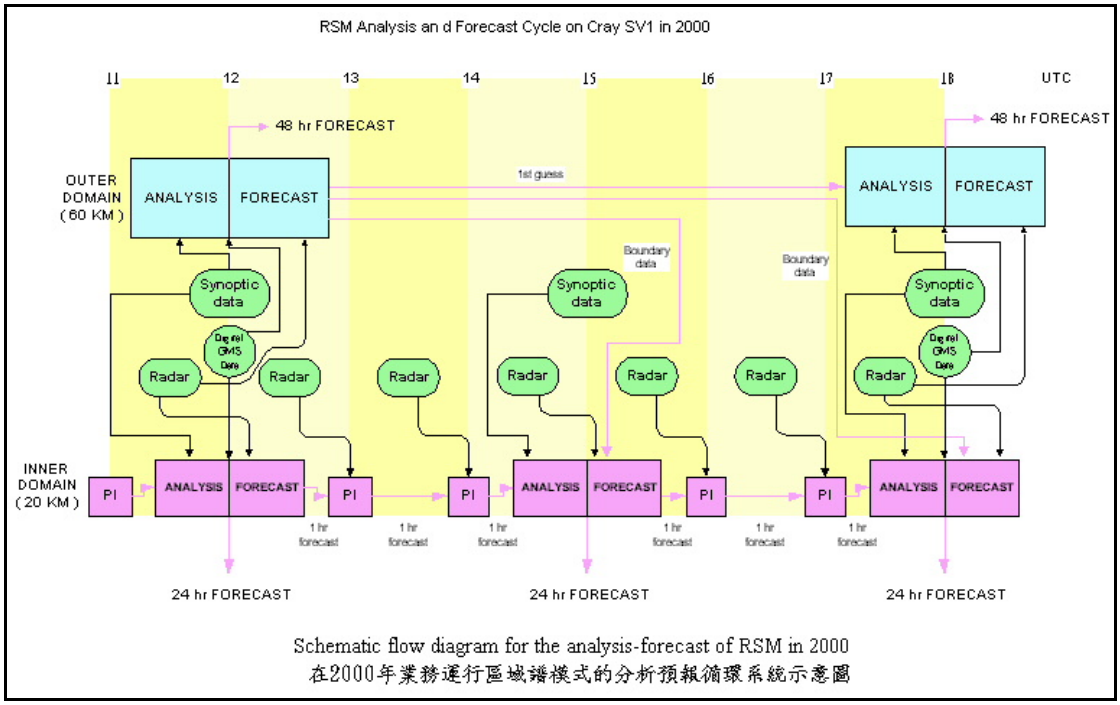

Figure 3 Schematic flow diagram for the analysis forecast cycle of 20-km RSM.

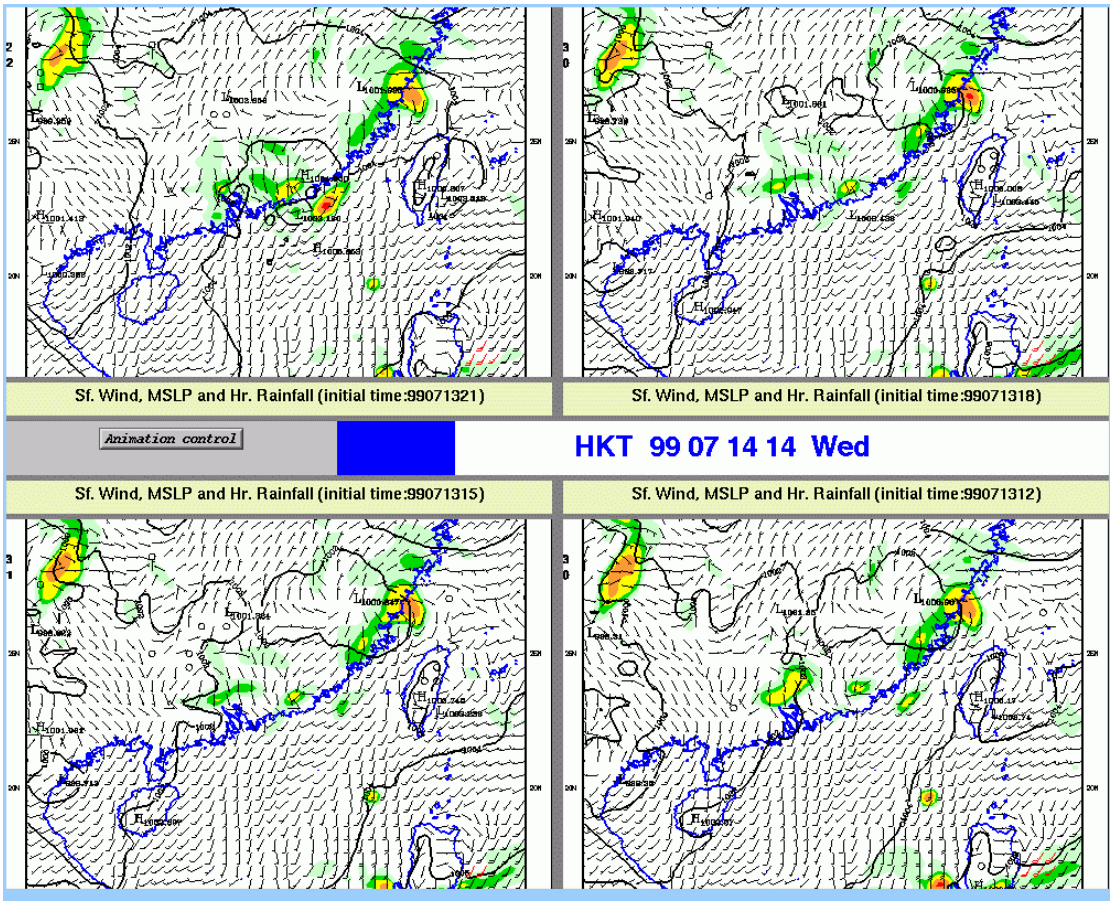

Figure 4 Display of mean-sea-level pressure and hourly rainfall forecast generated by consecutive runs of 20-km RSM on the web-based system.

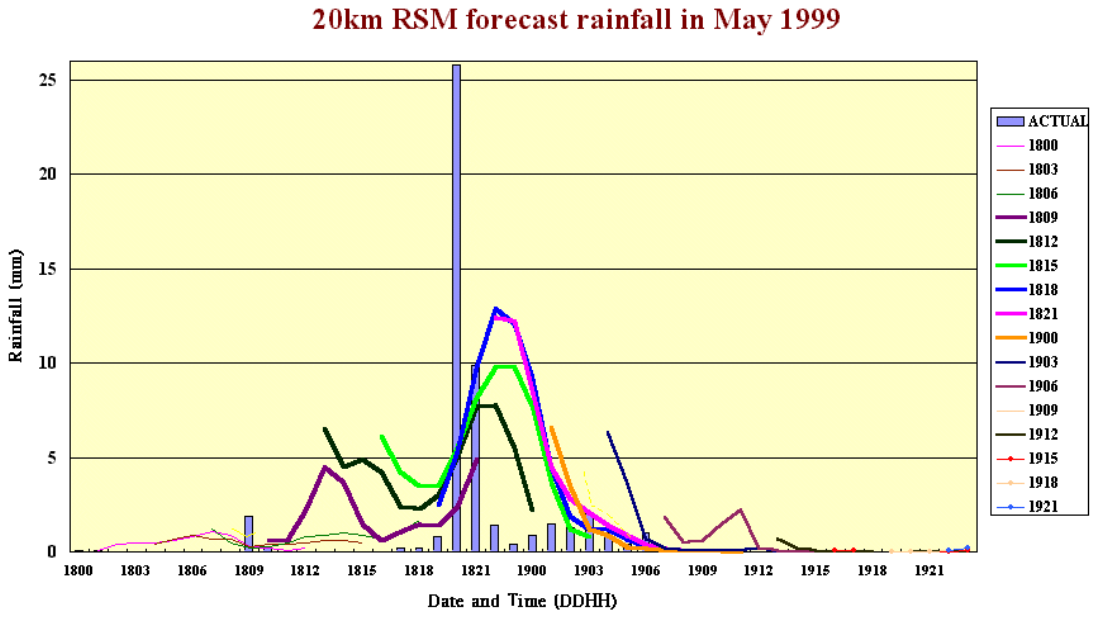

Figure 5 Hourly rainfall forecasts from 20 km-RSM runs with different initial times compared with the actual rainfall recorded at the Observatory.

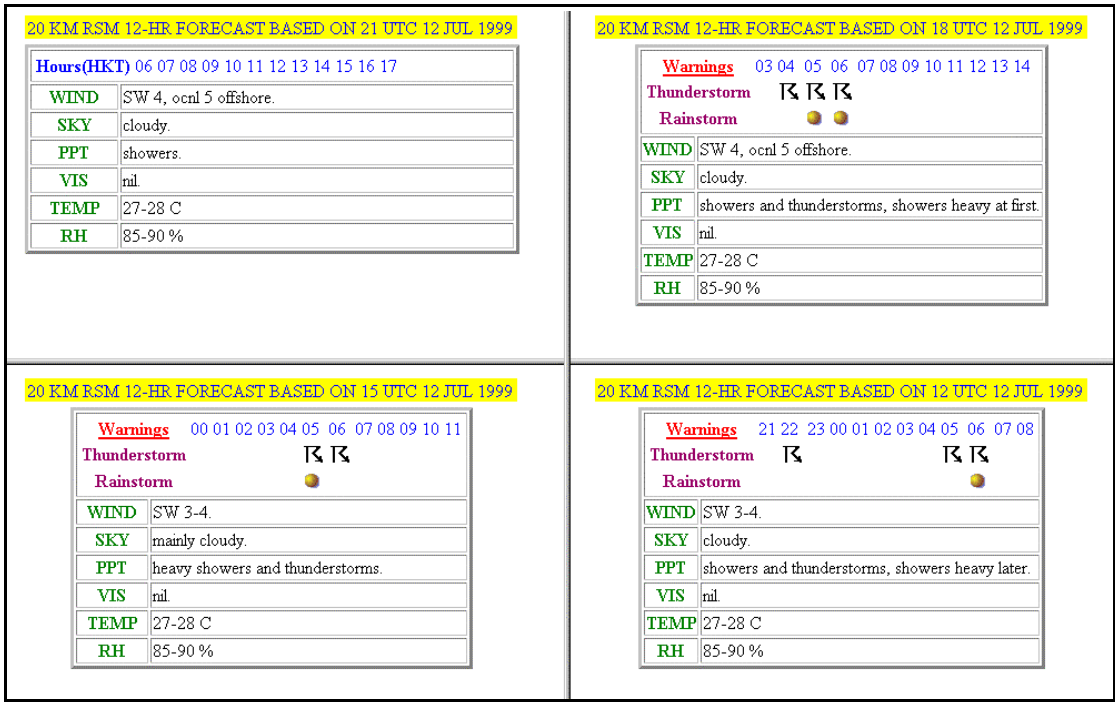

Figure 6 Display of the automated weather forecasts and warnings generated from consecutive runs of 20-km RSM on the web-based system.

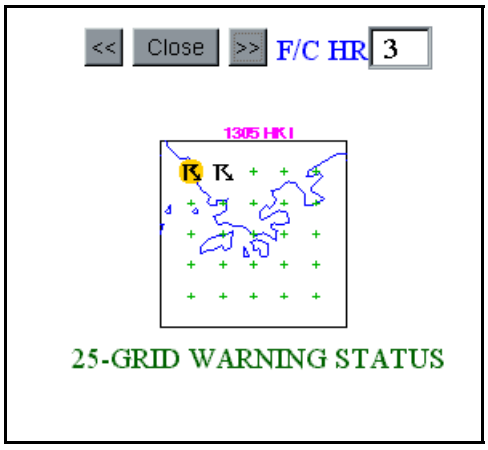

Figure 7 Display of the spatial plot of automated warning for thunderstorms and rainstorms over 25 grid points in the vicinity of Hong Kong on the web-based system.