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Long-range Forecasting for Hong Kong with Ensembles from a Regional Model – Some Preliminary Results

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Long-range Forecasting for Hong Kong with Ensembles from a Regional Model – Some Preliminary Results

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The usefulness of regional models nested into global climate models for long-range forecasting of total rainfall has recently been studied by a number of researchers (Hong and Leetma 1999, Cocke and Larow 2000, Fennessy and Shukla 2000). However, these studies pertain mainly to the United States.

This paper presents preliminary results of experiments using such a nested regional model by the Hong Kong Observatory to give long-range rainfall forecasts for Hong Kong. As Hong Kong lies in the East Asian monsoon region, these experiments should provide insight into the performance of the model in a climate regime different from that of the United States.

Rainfall forecasts were made for May and June of 1998 to 2001 using ensembles derived from the regional model. May and June were selected because they are the months in which the rainy season in Hong Kong begins, and the period 1998 to 2001 was used because these are the years for which data from the global model for forcing the regional model are available. These forecasts represent the first in a series of similar experiments.

The regional model used is similar to that utilized by Hong and Leetma (1999) in their long-range forecasting study. It is based on National Centres for Environmental Prediction's (NCEP) regional spectral model (RSM). Detailed descriptions of the regional model can be found in Juang et al. (1997) as well as Hong and Leetma (1999) and are omitted here. A special feature of NCEP's regional model is that its forecasts are cast as spectrally resolved perturbations superimposed on the global field. Further, this regional model has the same physics and parameterizations as the Global Spectral Model (GSM) into which it is nested (see Roads et al 2000 for a description of the GSM).

Errors due to lateral boundaries as well as to differences in global and regional model climatologies are thus reduced, making the regional model attractive for long-range forecasts.

The regional model was successfully ported from the Scripps Institute of Oceanography to an IBM F-50 at the Hong Kong Observatory towards the end of 2001. It is configured to run on an inner domain of 49 x 50 grid points centred on Hong Kong (Fig. 1a). The horizontal resolution of this inner domain is 15 km, with 18 levels in the vertical. There are 21 x 14 grids in the outer domain (Fig. 1b). The effective resolution is T62 and there are again 18 levels in the vertical. Details of the adaptation and operation are given in Hui et al. (2001).

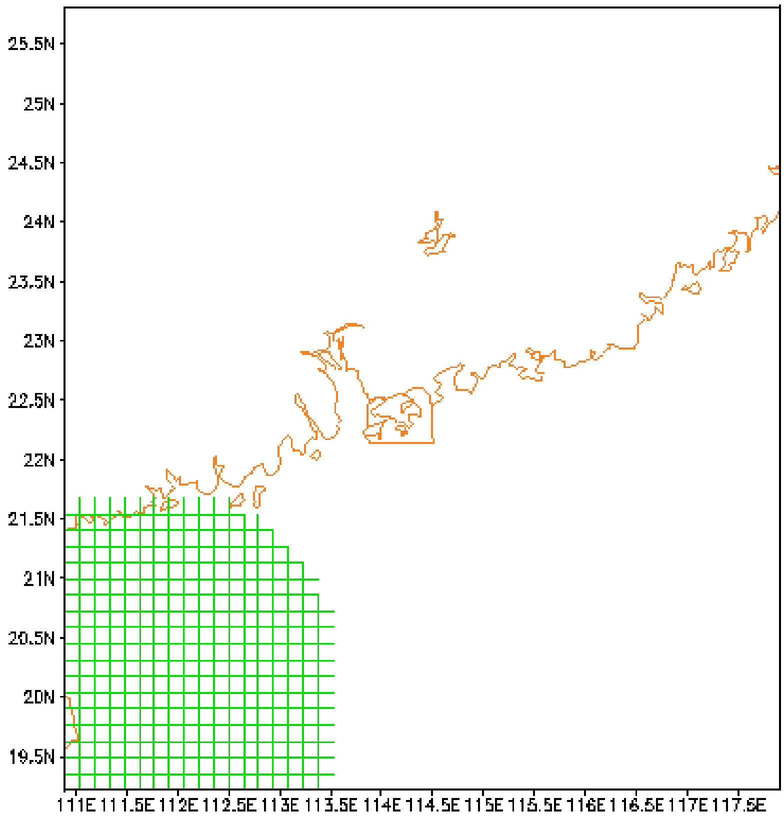

Fig 1a. The inner domain of the regional climate model.

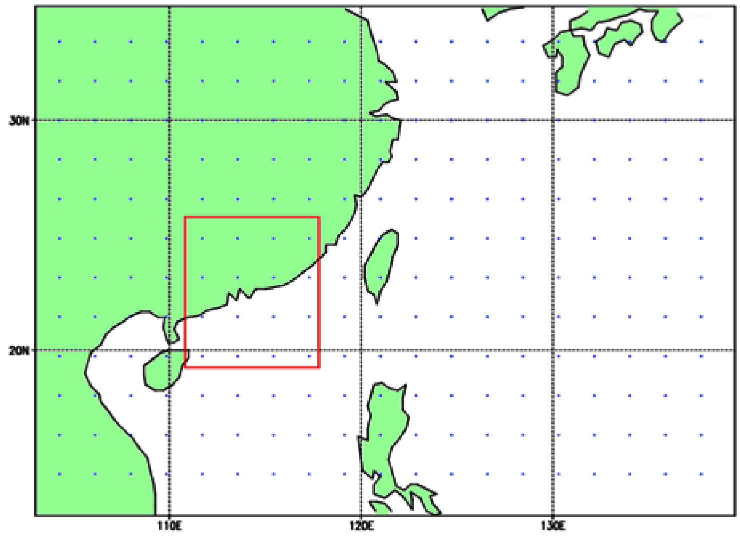

Fig 1b. The outer domain of the regional climate model.

In the present study, the ensemble members for May and June 1998 to 2001 were generated by integrating forward for up to 12 weeks from April of the corresponding year to give one-month lead forecasts for May and two-month lead forecasts for June. Integrations were made a week apart, as the global forecasts are available to the Hong Kong Observatory at that frequency. The start dates of each ensemble member are shown in Table 1.

Table 1. List of model runs for constructing the May and June 1998 to 2001 ensembles. 19980404 denotes 4 April 1998, 19980411 denotes 11 April 1998 etc.

Year	Forecast month	Model run
1998	May, June	19980404, 19980411, 19980418, 19980425
1999	May, June	19990403, 19990410, 19990417, 19990424
2000	May, June	20000401, 20000408, 20000415, 20000422, 20000429
2001	May, June	20010407, 20010414, 20010421, 20010428

Table 2a to 2d below shows respectively the May and June forecast rainfall for 1998 to 2001 against the observed rainfall, both parameters being expressed in mm/day. It can be seen that for 1998, the observed rainfall in May and June are well forecast by the ensemble means. For May, the ensemble mean gave a good deterministic forecast from the individual forecasts. For both months, the ensemble mean outperformed all the individual members except the model run with initial date of 19980418.

For 1999, the ensemble mean as well as all the individual ensemble members over predicted for both May and June. The year 2000 again sees the ensemble mean over-predicting the actual rainfall for the two months, especially for June. May 2001 was correctly predicted by the ensemble mean whose value was the closest to the actual rainfall than the individual members. June 2001 was under predicted by the ensemble mean and none of the ensemble members was able to forecast the observed 36.1 mm/day rainfall.

Table 2. Ensemble rainfall forecasts for Hong Kong for May and June 1998 to 2001.

(a) May and June *1998*

Model run	Rainfall forecast (mm/day)	
	May	June
19980404	3.9	30.6
19980411	17.2	36.5
19980418	8	26.8
19980425	3.6	18.6
Ensemble mean	8.2	28.1
Observed rainfall	10.8	27.2

(b) May and June *1999*

Model run	Rainfall forecast (mm/day)	
	May	June
19990403	21.1	33.4
19990410	18.6	20.5
19990417	16.4	25.2
19990424	15.5	43.7
Ensemble mean	17.9	30.7
Observed rainfall	5.7	6.6

(c) May and June *2000*

Model run	Rainfall forecast (mm/day)	
	May	June
20000401	8.6	29.3
20000408	15.5	36.0
20000415	18.7	31.3
20000422	7.3	27.2
20000429	4.6	38.8
Ensemble mean	10.9	32.5
Observed rainfall	6.7	14.8

(d) May and June *2001*

Model run	Rainfall forecast (mm/day)	
	May	June
20010407	4.2	15.1
20010414	3.6	26.5
20010421	8.2	15.4
20010428	4.8	19.5
Ensemble mean	5.2	19.1
Observed rainfall	5.2	36.1

To assess the overall skill of the ensemble forecasts, the ensemble means are converted into the two categories 'normal and above' and 'below normal' for the calculation of the scaled Kupier scores, one of the scores suggested in WMO (2000) for evaluating the skill of long-range forecasts. Normal is defined as the rainfall within ±½ standard deviation of the climatological mean. For May this is 7 mm/day to 13.4 mm/day (10.2 mm/day ±3.2 mm/day), and for June this is 9.2 mm/day to 15.8 mm/day (12.5 mm/day ±3.3 mm/day).

Table 3. Contingency table for ensemble rainfall forecasts

(a) May

		Observed	
		Normal & above	Below
Forecast	Normal & above	1	2
	Below	0	1

(b) June

		Observed	
		Normal & above	Below
Forecast	Normal & above	3	1
	Below	0	0

Table 3a and 3b shows the contingency tables summarizing ensemble performance. The scaled Kupier scores for May and June are 0.67 and 0.5 respectively. Thus, the ensemble shows skill for May or one-month lead forecasts, and lesser skill for June or 2-month lead forecasts. However these are early results based on a limited number of experiments. More experiments are being conducted for model performance to be further evaluated against Hong Kong's as well as regional rainfall.

The tendency for the model to over predict summer rainfall was also noted by Hong and Leetma (1999) in their study for the United States. They suggest that removing model bias would improve the accuracy of the forecasts. Work in this direction is in progress with the view to producing anomaly forecasts as well.

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