

# 試驗性香港月預報 Experimental Monthly Forecast for Hong Kong

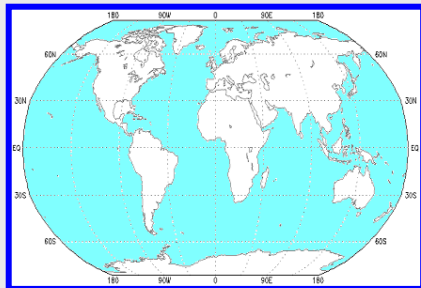
珠三角氣候變化及氣候預報工作坊  
Workshop on Climate Change and Climate  
Prediction in the Pearl River Delta Region  
15-16 Dec 2008

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香港天文台  
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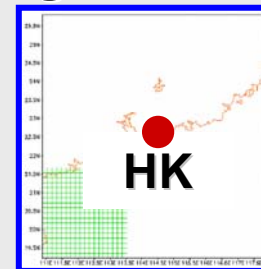
# 背景資料 Background

- 2001 – 從ECPC引進一個15公里區域模式作季度預報  
Adapted a 15 km regional model from ECPC for seasonal forecasting
- 2006 – 從ECPC引進一套「全球—區域」模式  
Adapted a suite of global-regional model from ECPC
  - 全球模式 global model – 200 km (28層 levels)
  - 區域模式 regional model – 15 km
- 以NCEP/NCAR再分析數據為初始條件  
Initialised by NCEP/NCAR re-analysis data

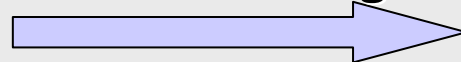
全球模式  
global model



15km 區域模式  
regional model

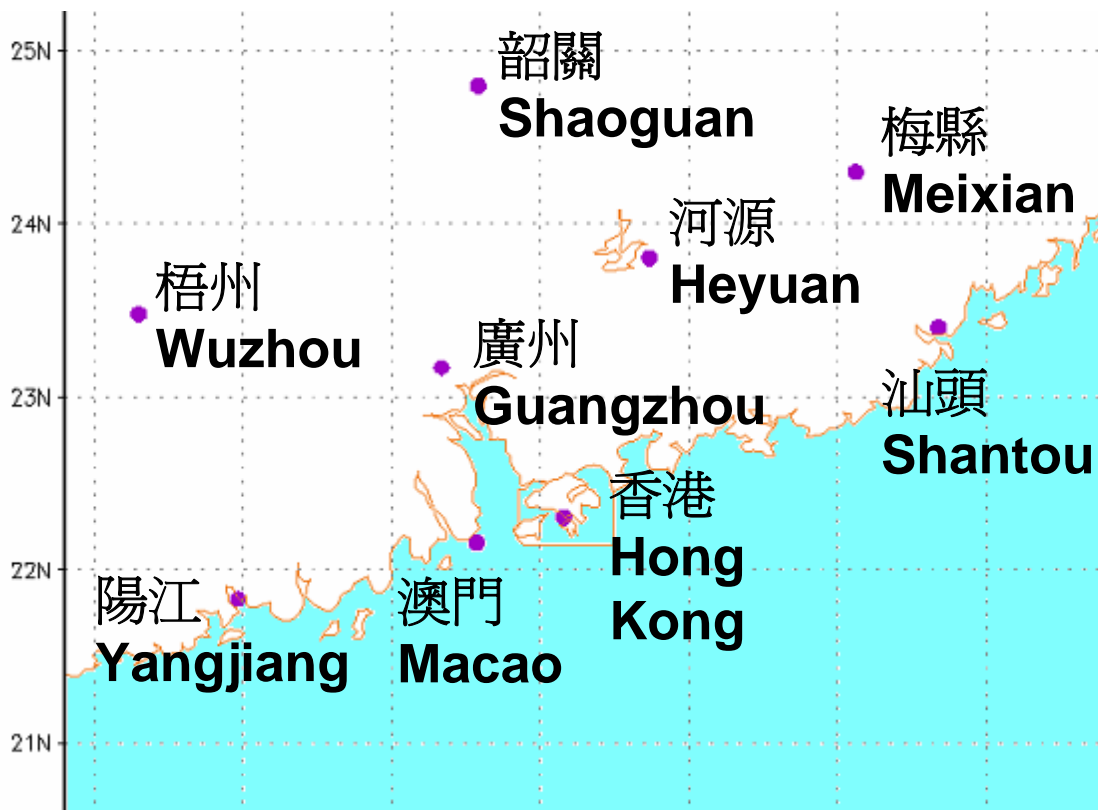


降尺度  
Downscaling



# 預報驗證用數據

## Station Data for Forecast Verification



數據來源 Data source :

中國氣象科學數據共享服務網 China Meteorological Data Sharing Service System

澳門地球物理暨氣象局 Macao Meteorological and Geophysical Bureau

廣東省氣象局 Guangdong Meteorological Bureau

## To Evaluate Forecasting Skill

**Scaled Hanssen and Kuipers score**

$$K_s = (\text{命中率} - \text{誤報率} + 1) / 2$$

$$K_s = (\text{hit rate} - \text{false alarm rate} + 1) / 2$$

**Ks 介乎 0 至 1 之間**

**Ks ranges between 0 and 1**

**等級定義 Definition of tercile category :**

**偏高 / 偏多 : 實況(預測) > 氣候平均 + 方差 / 2**

**偏低 / 偏少 : 實況(預測) < 氣候平均 - 方差 / 2**

**正常 : 其餘情況**

**Above normal : observation (forecast) > climatological normal + standard deviation/2**

**Below normal : observation (forecast) < climatological normal - standard deviation/2**

**Near normal : Otherwise**

# 15公里模式的季度預報技巧

## Seasonal Forecasting Skill of the 15 km Model

	預報偏少雨 Forecasting below-normal rainfall Ks	預報正常雨量 Forecasting near-normal rainfall Ks	預報偏多雨 Forecasting above-normal rainfall Ks
春季(3-5月) Spring (MAM)	<b>0.52</b>	<b>0.49</b>	<b>0.52</b>
夏季(6-8月) Summer (JJA)	<b>0.52</b>	<b>0.48</b>	<b>0.59</b>
秋季(9-11月) Autumn (SON)	<b>0.47</b>	<b>0.50</b>	<b>0.49</b>
冬季(12-2月) Winter (DJF)	<b>0.46</b>	<b>0.43</b>	<b>0.59</b>

# 15公里模式的季度預報技巧

## Seasonal Forecasting Skill of the 15 km Model

	預報偏低溫 Forecasting below-normal temperature Ks	預報正常氣溫 Forecasting near-normal temperature Ks	預報偏高溫 Forecasting above-normal temperature Ks
春季(3-5月) Spring (MAM)	<b>0.55</b>	<b>0.50</b>	<b>0.63</b>
夏季(6-8月) Summer (JJA)	<b>0.58</b>	<b>0.48</b>	<b>0.54</b>
秋季(9-11月) Autumn (SON)	<b>0.59</b>	<b>0.50</b>	<b>0.53</b>
冬季(12-2月) Winter (DJF)	<b>0.60</b>	<b>0.51</b>	<b>0.60</b>

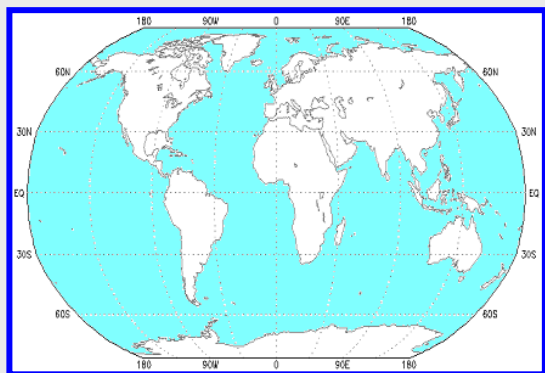
# 15公里模式高估雨量

## Over-forecast of Rainfall by the 15km Model

- 香港夏季平均雨量(1971-2000)  $\approx$  1200毫米
- 模式平均輸出(1971-2000)  $\approx$  3300毫米
  
- Average of summer rainfall in HK (1971-2000)  $\approx$  1200mm
- Average of model output (1971-2000)  $\approx$  3300mm

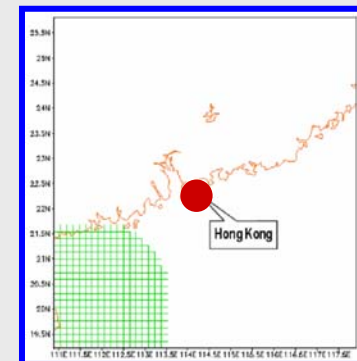
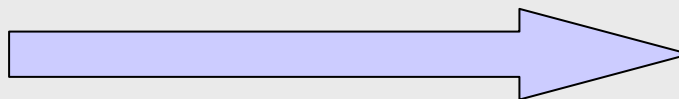
# 降尺度 實驗

## Downscaling Experiment

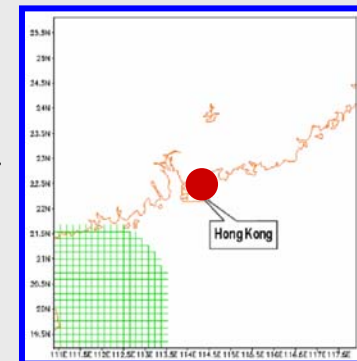
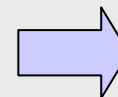
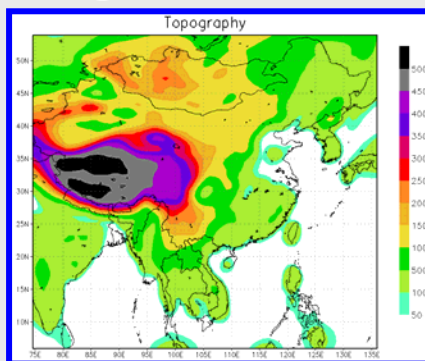
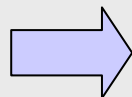
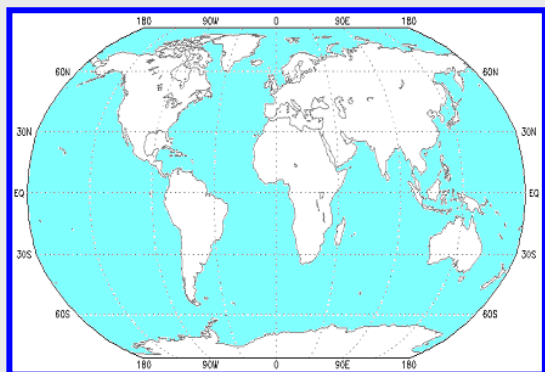


全球模式  
global model

配置 Setup (1)



15 km 區域模式  
regional model



配置 Setup (2)



# 模式預測與實況 (1997年2月雨量)

## Forecast Vs Observation (rainfall of Feb 1997)

	實況 Obs. (mm)	60 km	15 km (1)	15 km (2)
香港 Hong Kong	<b>112</b>	<b>98</b>	<b>352</b>	<b>390</b>
澳門 Macao	<b>159</b>	<b>91</b>	<b>374</b>	<b>435</b>
韶關 Shaoguan	<b>97</b>	<b>179</b>	<b>429</b>	<b>387</b>
梅縣 Mexian	<b>93</b>	<b>152</b>	<b>487</b>	<b>202</b>
梧州 Wuzhou	<b>89</b>	<b>147</b>	<b>355</b>	<b>179</b>
廣州 Guangzhou	<b>106</b>	<b>136</b>	<b>785</b>	<b>491</b>
河源 Heyuan	<b>104</b>	<b>152</b>	<b>664</b>	<b>287</b>
汕頭 Shantou	<b>116</b>	<b>95</b>	<b>501</b>	<b>175</b>
陽江 Yangjiang	<b>168</b>	<b>132</b>	<b>236</b>	<b>260</b>

# 預報技巧的比較

## Comparison of Forecasting Skill

	預報偏少雨 Forecasting below-normal rainfall Ks		預報正常雨量 Forecasting near-normal rainfall Ks		預報偏多雨 Forecasting above-normal rainfall Ks	
	15 km	60 km	15 km	60 km	15 km	60 km
MAM	0.52	0.68	0.49	0.57	0.52	0.61
JJA	0.52	0.50	0.48	0.47	0.59	0.43
SON	0.47	0.52	0.50	0.51	0.49	0.50
DJF	0.46	0.52	0.43	0.38	0.59	0.59

# 預報技巧的比較

## Comparison of Forecasting Skill

	預報偏低溫 Forecasting below-normal temperature Ks		預報正常氣溫 Forecasting near-normal temperature Ks		預報偏高溫 Forecasting above-normal temperature Ks	
	15 km	60 km	15 km	60 km	15 km	60 km
MAM	0.55	0.62	0.50	0.57	0.63	0.67
JJA	0.58	0.54	0.48	0.56	0.54	0.54
SON	0.59	0.73	0.50	0.50	0.53	0.64
DJF	0.60	0.53	0.51	0.50	0.60	0.61

# 預測香港的月平均溫度及總雨量

## Forecasting monthly mean temperature and total rainfall of Hong Kong

- 以天文台的實況驗證60公里模式的預測
- **Verify the 60km model forecast against HKO obs.**
- 驗證時段 verification period : 1997-2006
- **Mean Squared Skill Score (MSSS)**

$$MSSS = 1 - \frac{MSE}{MSE_c}$$

$$MSE = \frac{1}{N} \sum_{i=1}^N (F_i - O_i)^2$$

F : 預測 forecast  
O: 實況 obs.

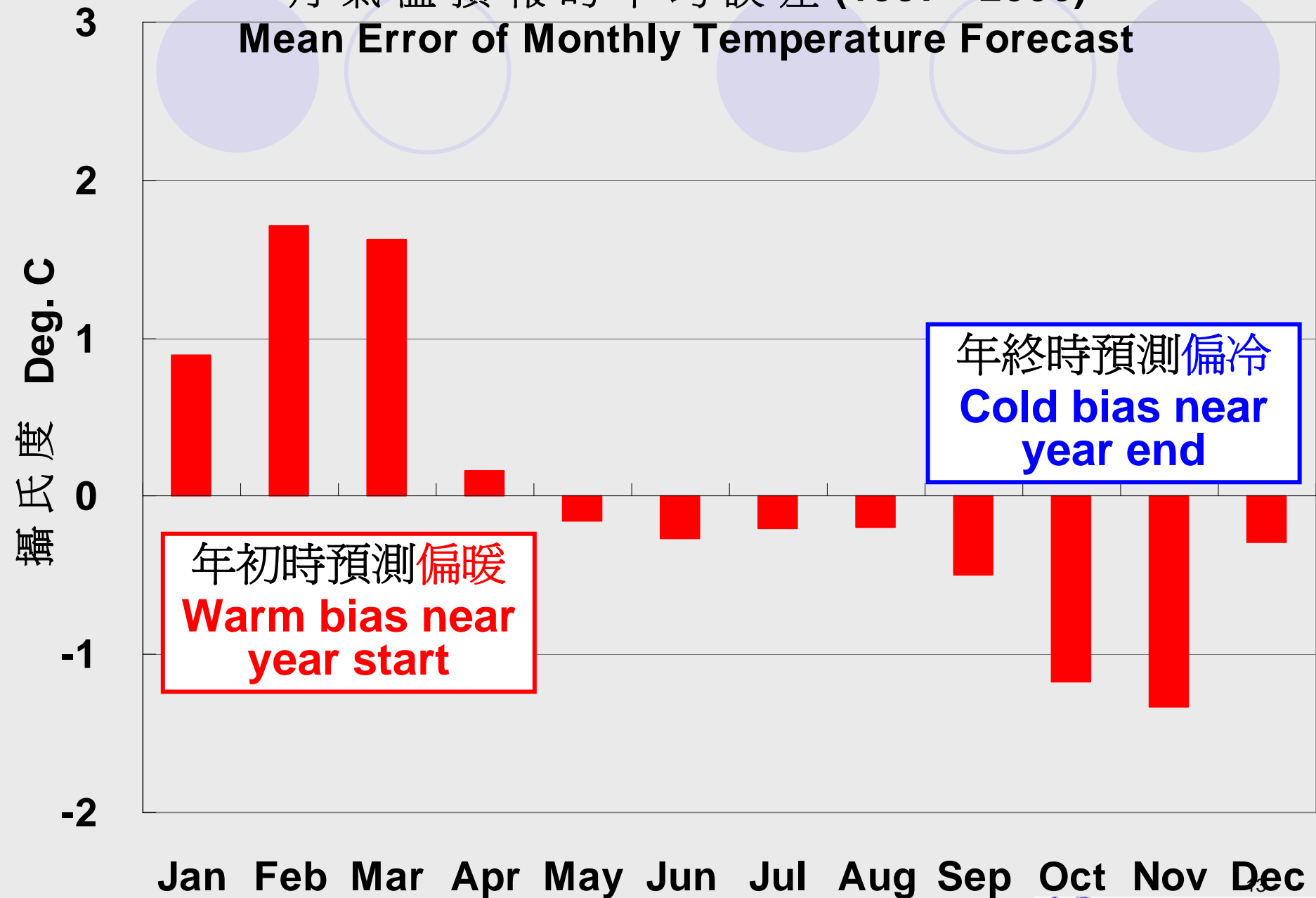
$MSE_c$  : 以氣候平均作預測  
forecast by climatology

**MSSS = 1 : 完美 Perfect !**

**MSSS < 0 : 沒有技巧 no skill**

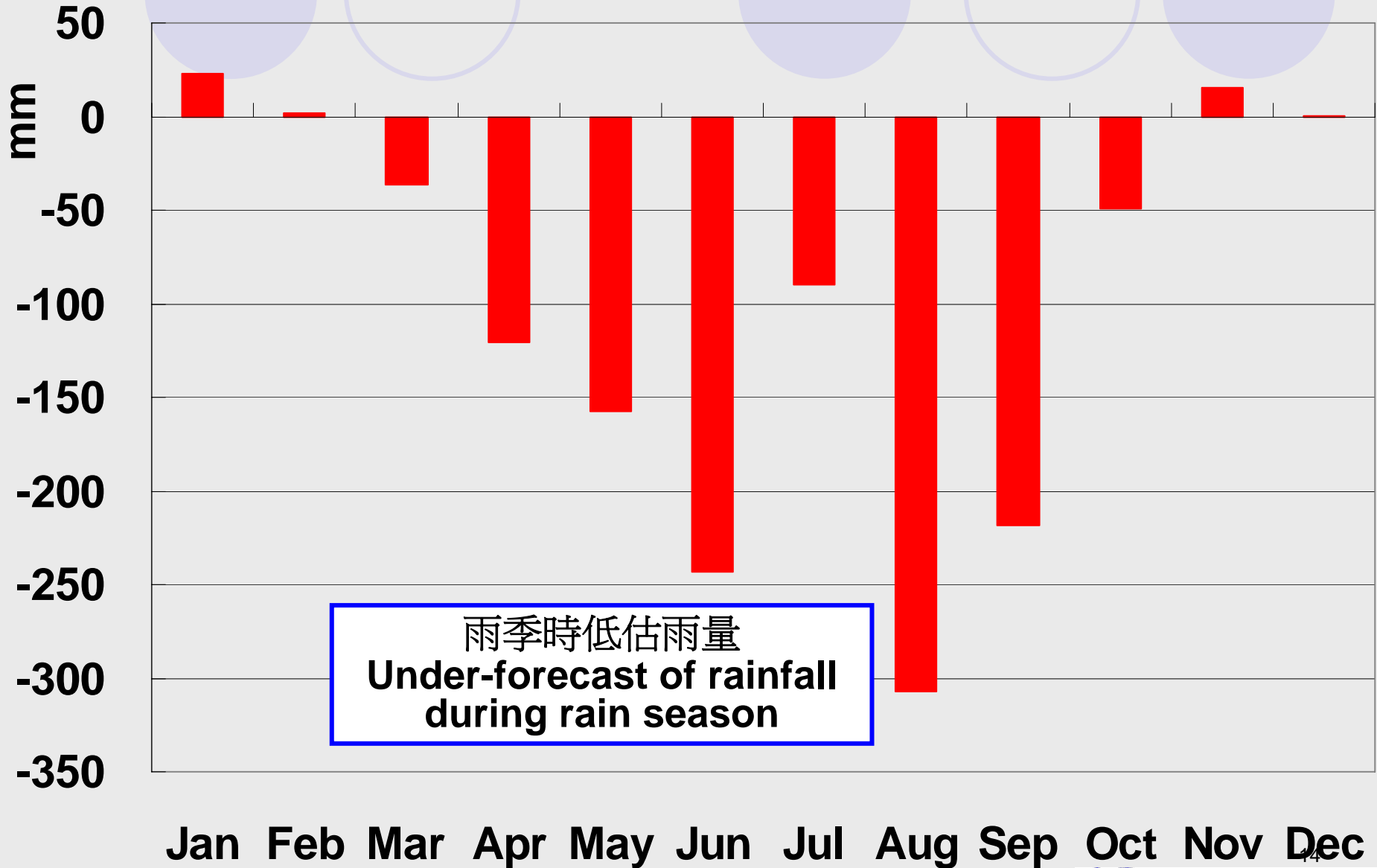
# 月氣溫預報的平均誤差 (1997 - 2006)

## Mean Error of Monthly Temperature Forecast



# 月雨量預報的平均誤差 (1997 - 2006)

## Mean Error of Monthly Rainfall Forecast



# 去掉系統性偏差

## To Remove Systematic Bias

- 線性迴歸法 Linear regression
- 交叉驗證 Cross validation

1	2	..	K-1	K	K+1	..	..	..	N
---	---	----	-----	---	-----	----	----	----	---

以第1至第K-1年及第K+1至第N年的數據建立迴歸方程，然後預測第K年的實況

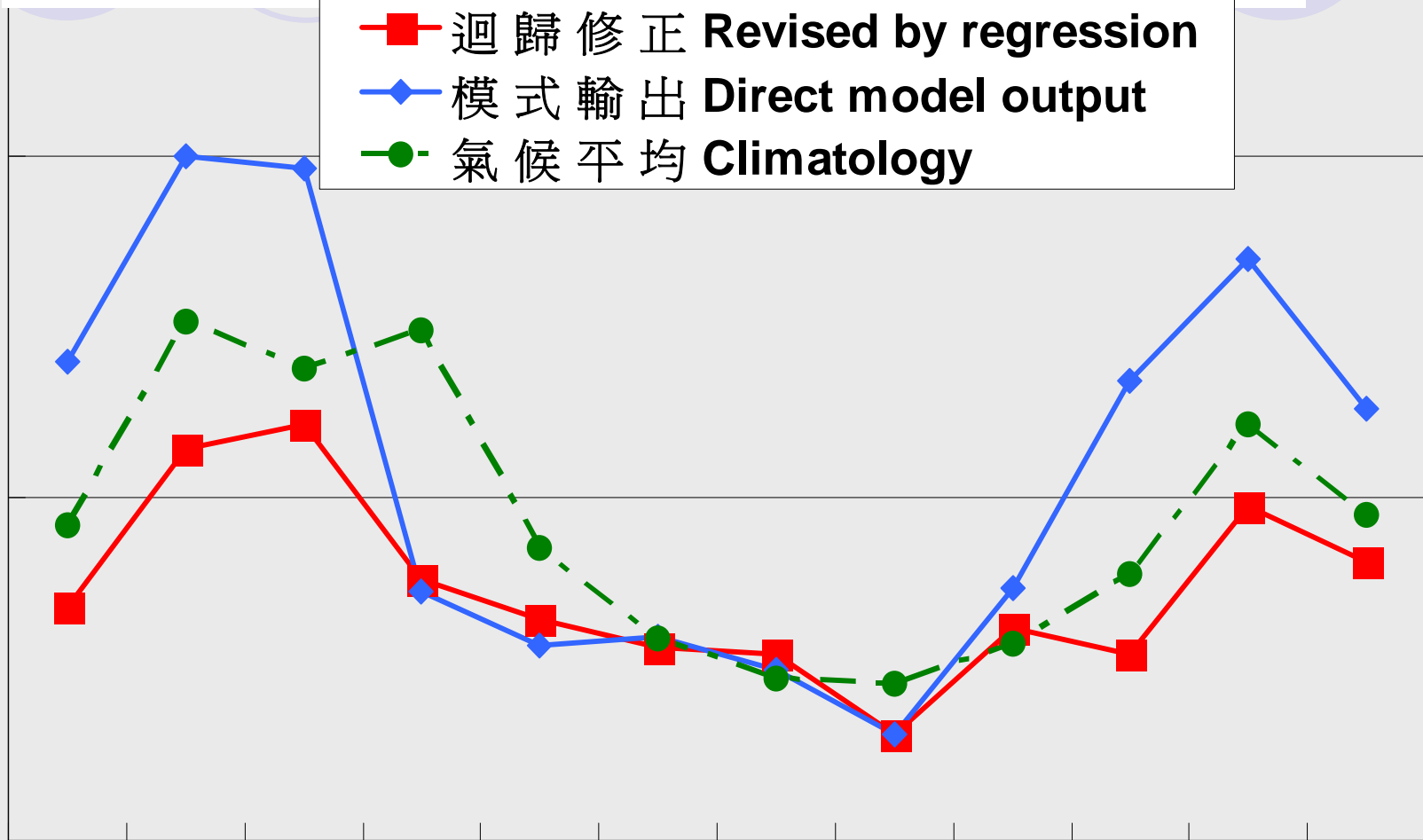
**Construct a regression equation using observed data of years 1 to K-1 and K+1 to N, and forecast for year K using that equation.**

# 月氣溫預報的誤差平方根 (1997-2006) Root Mean Squared Error of Monthly Temperature Forecast

攝氏度 Deg. C

3  
2  
1  
0

- 迴歸修正 Revised by regression
- ◆ 模式輸出 Direct model output
- 氣候平均 Climatology



Jan

Mar

May

Jul

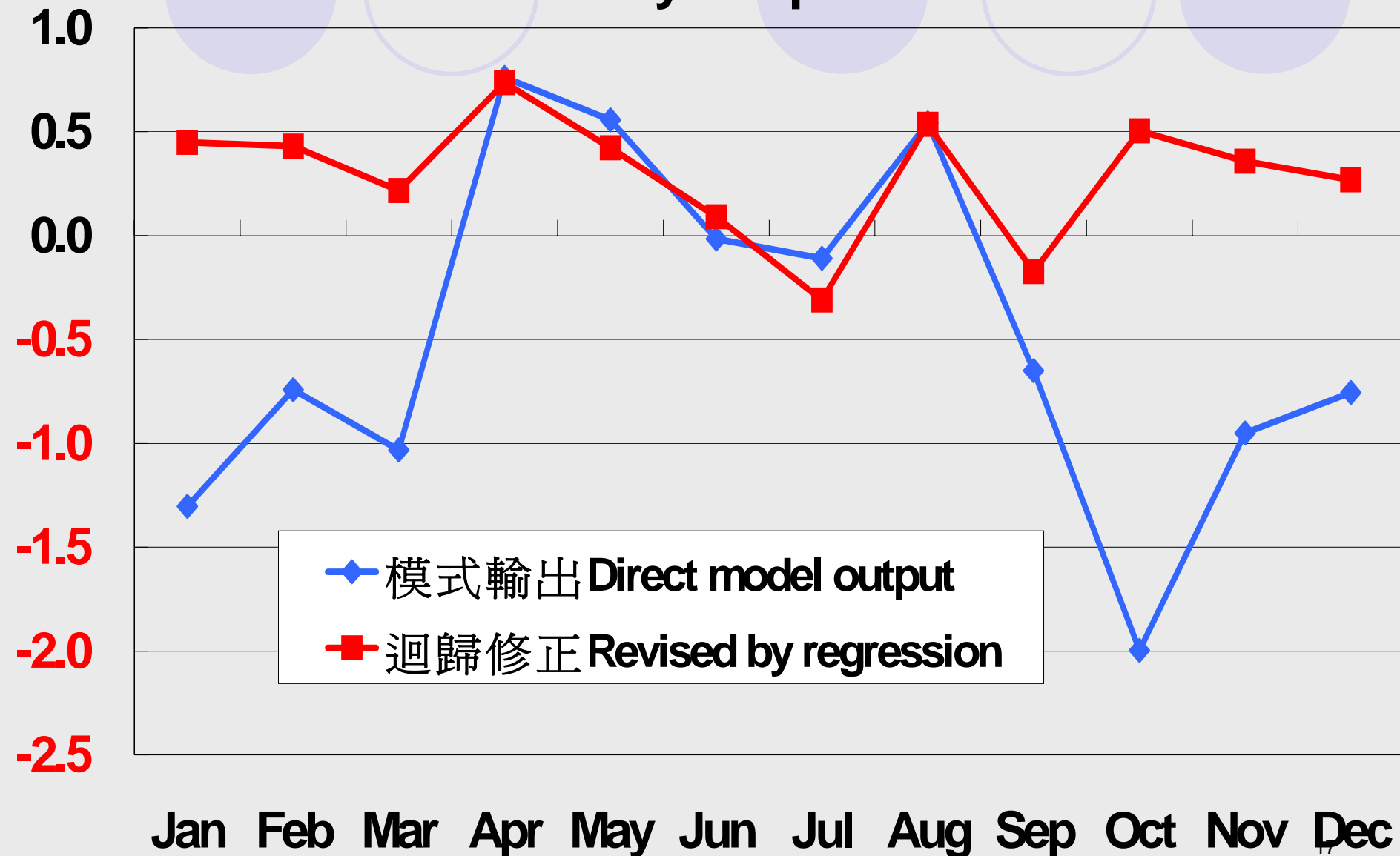
Sep

Nov



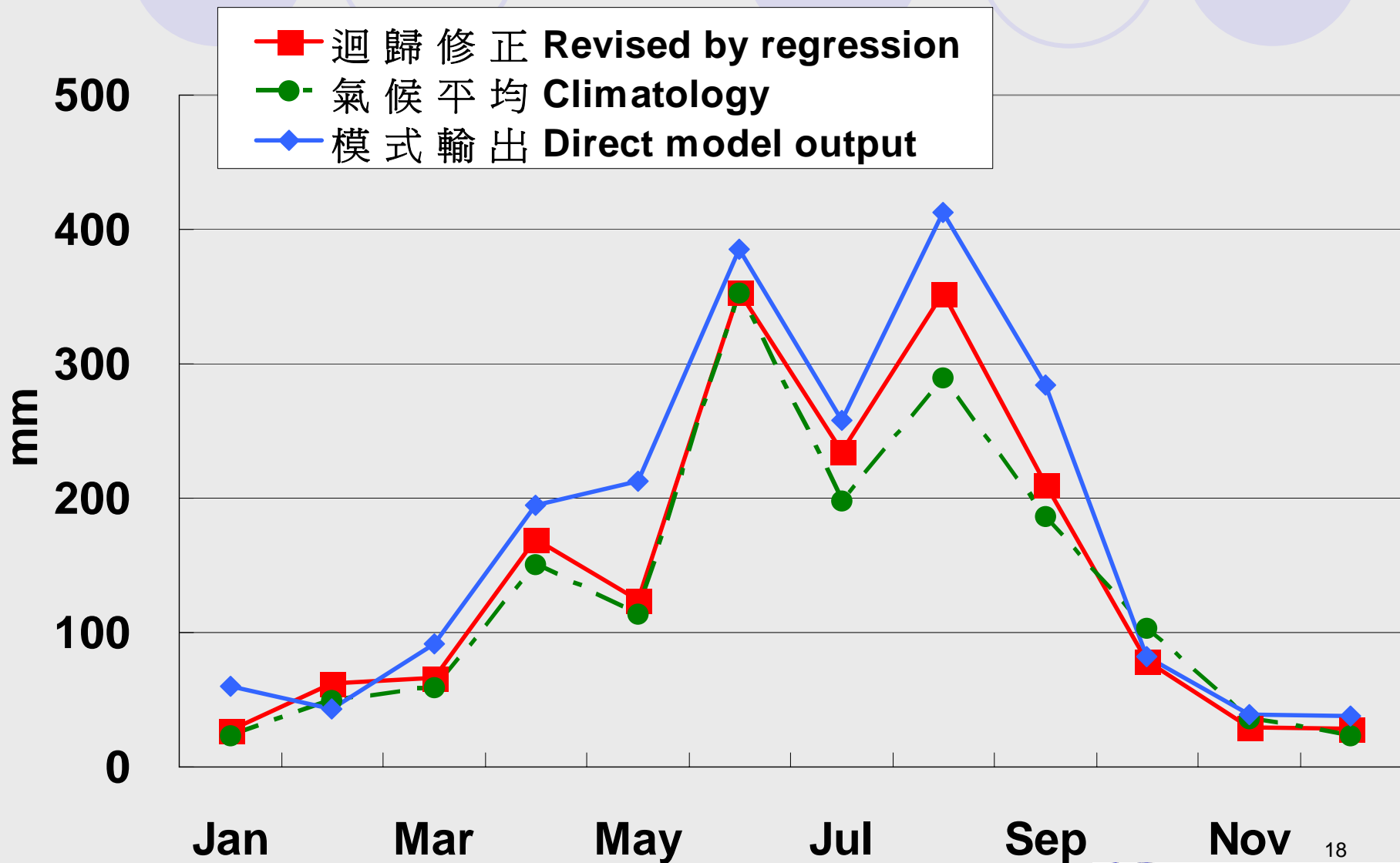
# 月氣溫預報的 MSSS (1997 - 2006)

## MSSS of Monthly Temperature Forecast



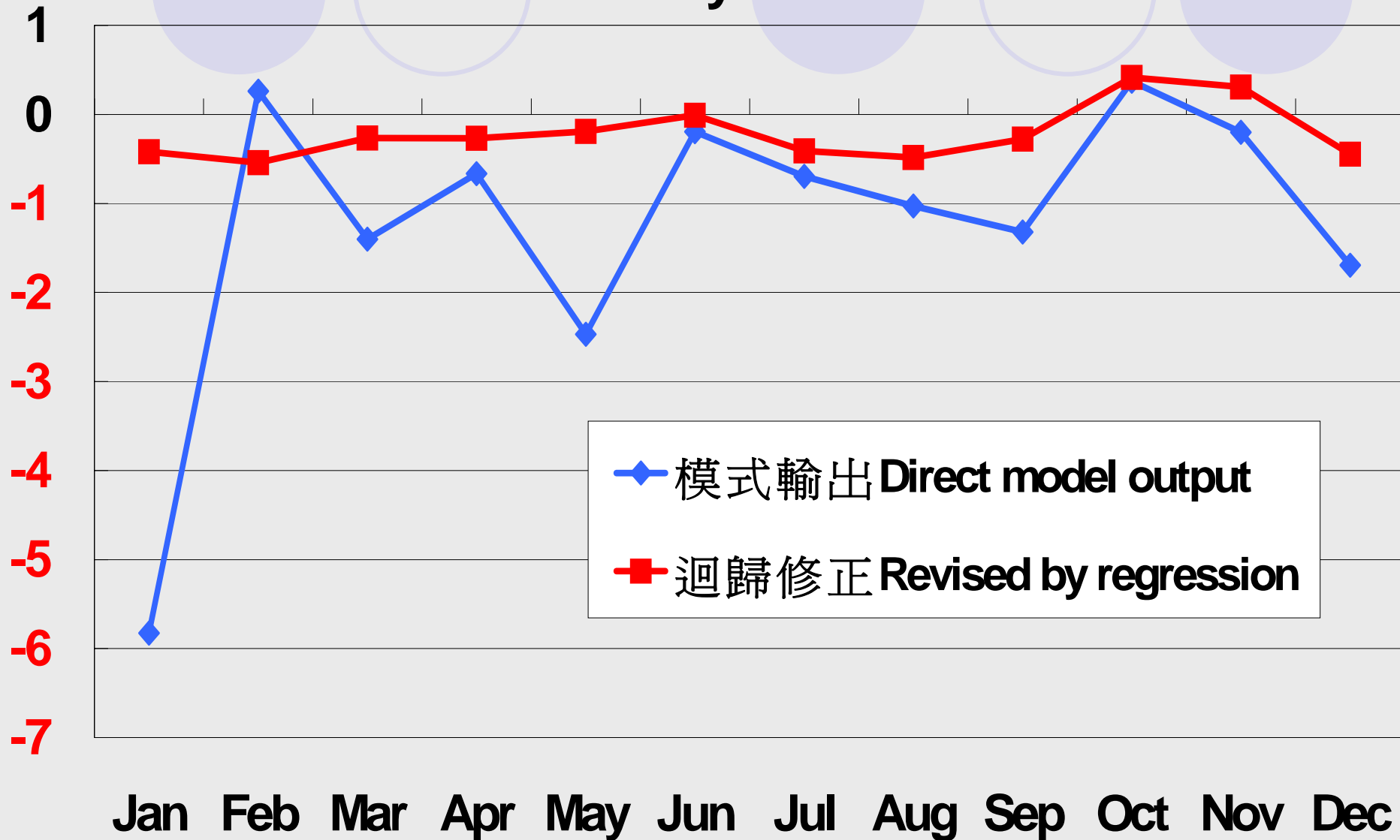
# 月雨量預報的誤差平方根 (1997 - 2006)

## Root Mean Squared Error of Monthly Rainfall Forecast



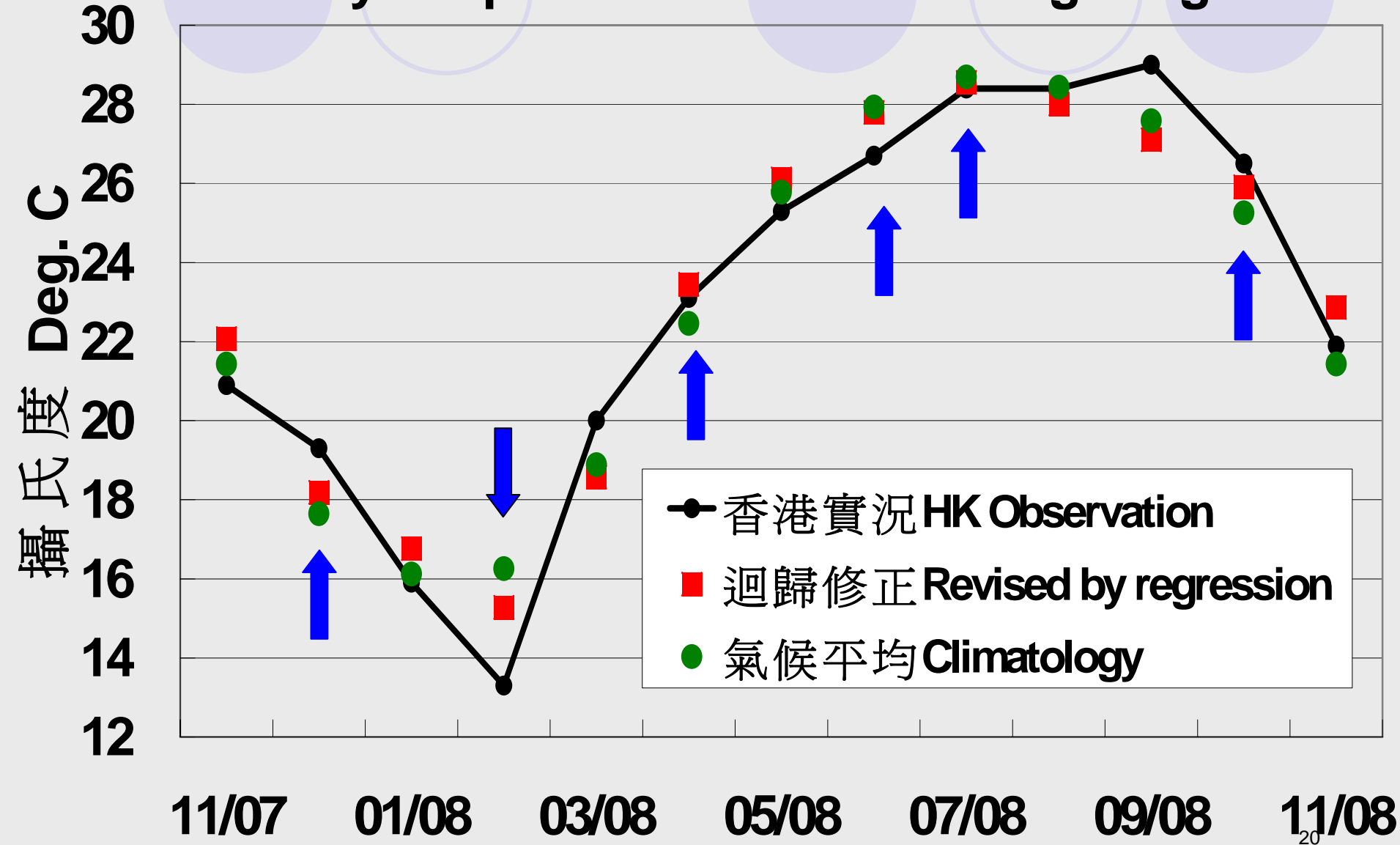
# 月雨量預報的 MSSS (1997 - 2006)

## MSSS of Monthly Rainfall Forecast



# 香港月氣溫預報

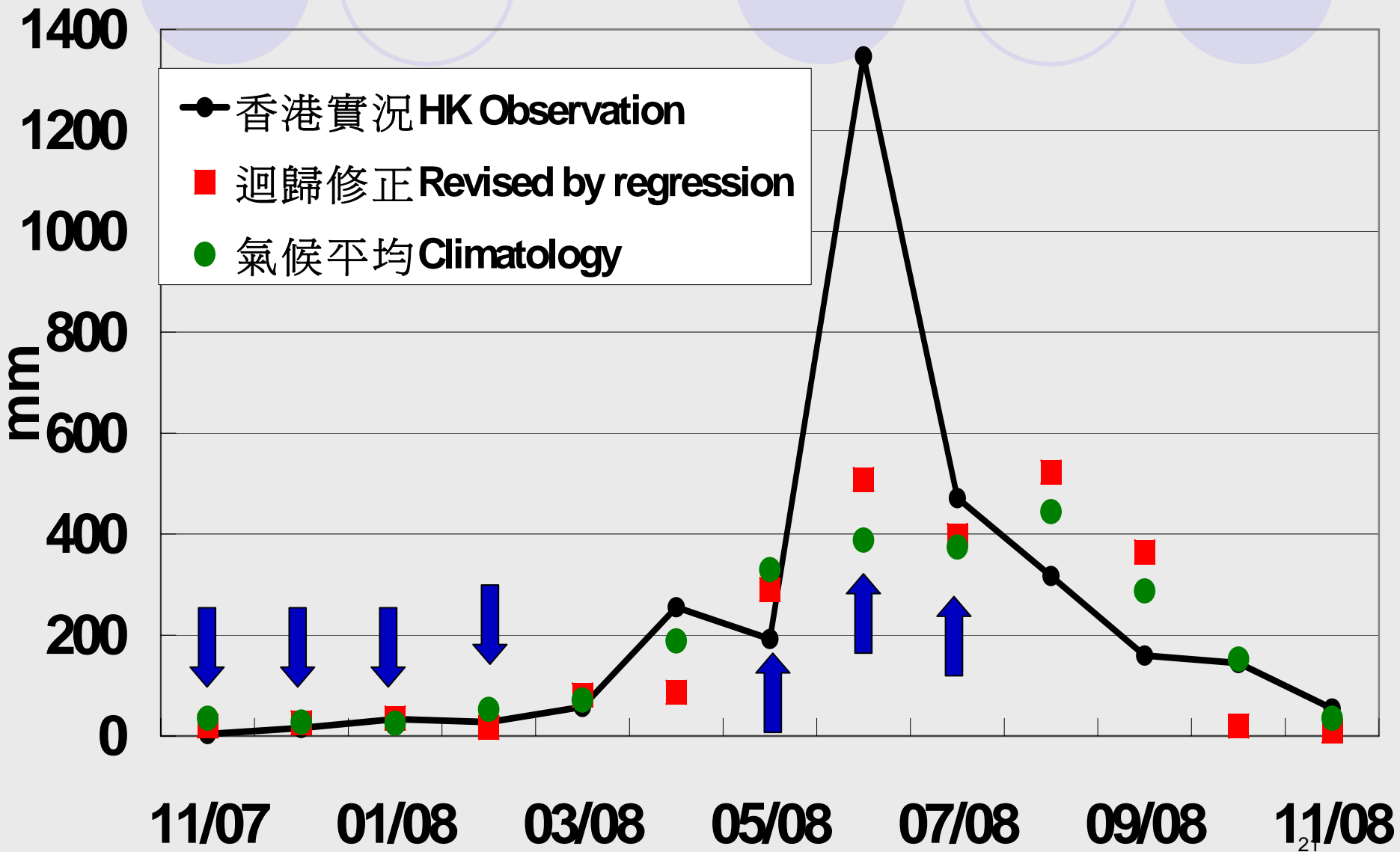
## Monthly Temperature Forecast for Hong Kong



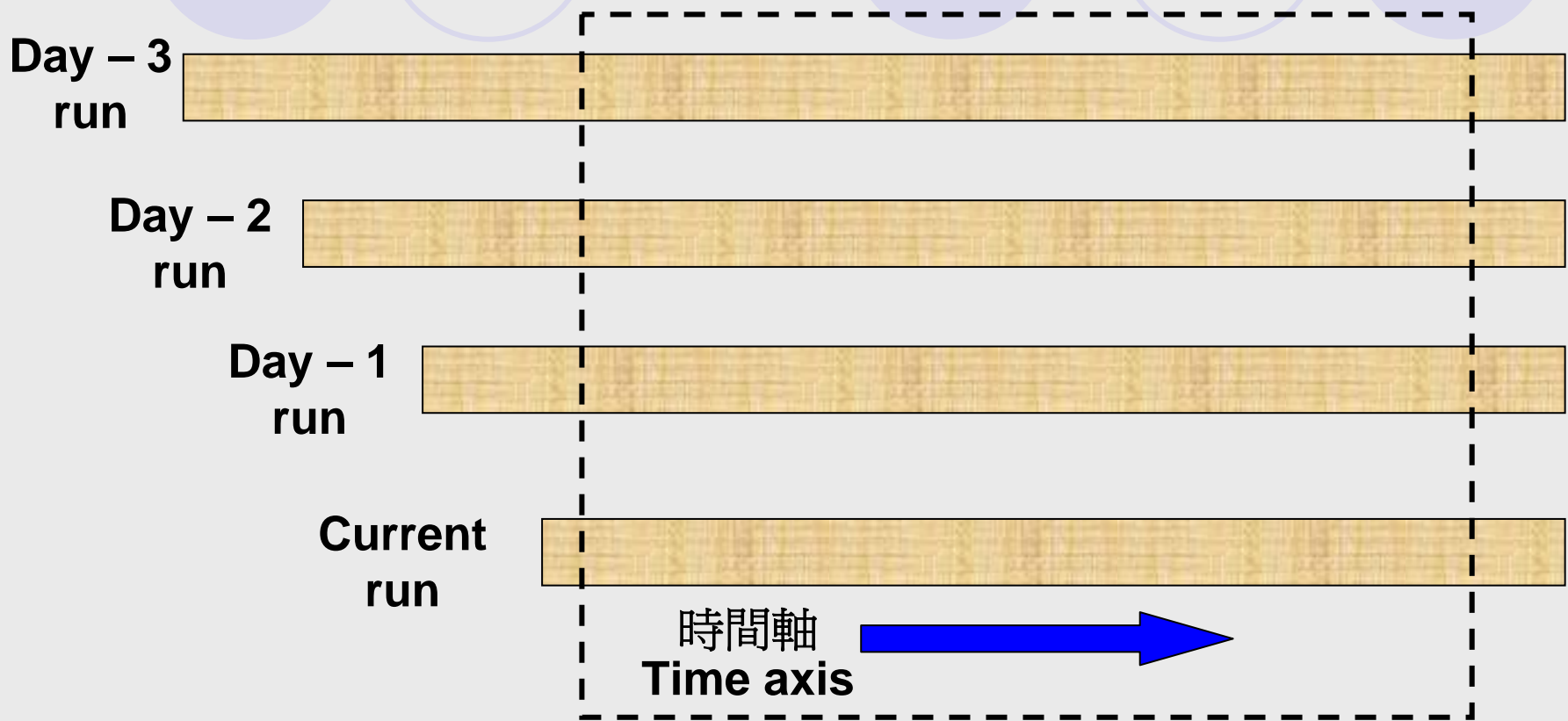
- 香港實況 HK Observation
- 迴歸修正 Revised by regression
- 氣候平均 Climatology

# 香港月雨量預報

## Monthly Rainfall Forecast for Hong Kong



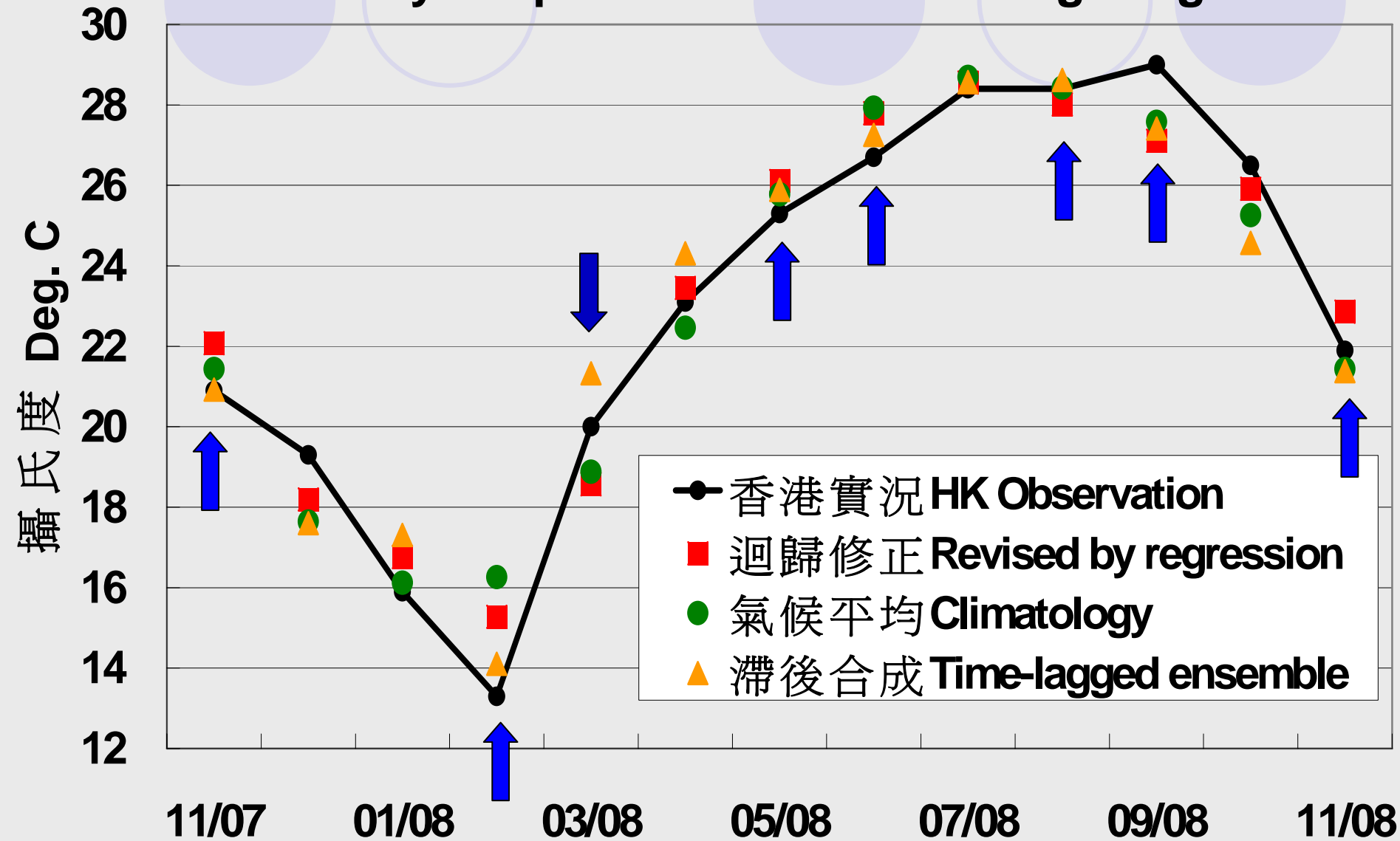
# 時間滯後合成預報 (Time-lagged ensemble forecast)



把相同時效預報平均  
Average the common  
portion

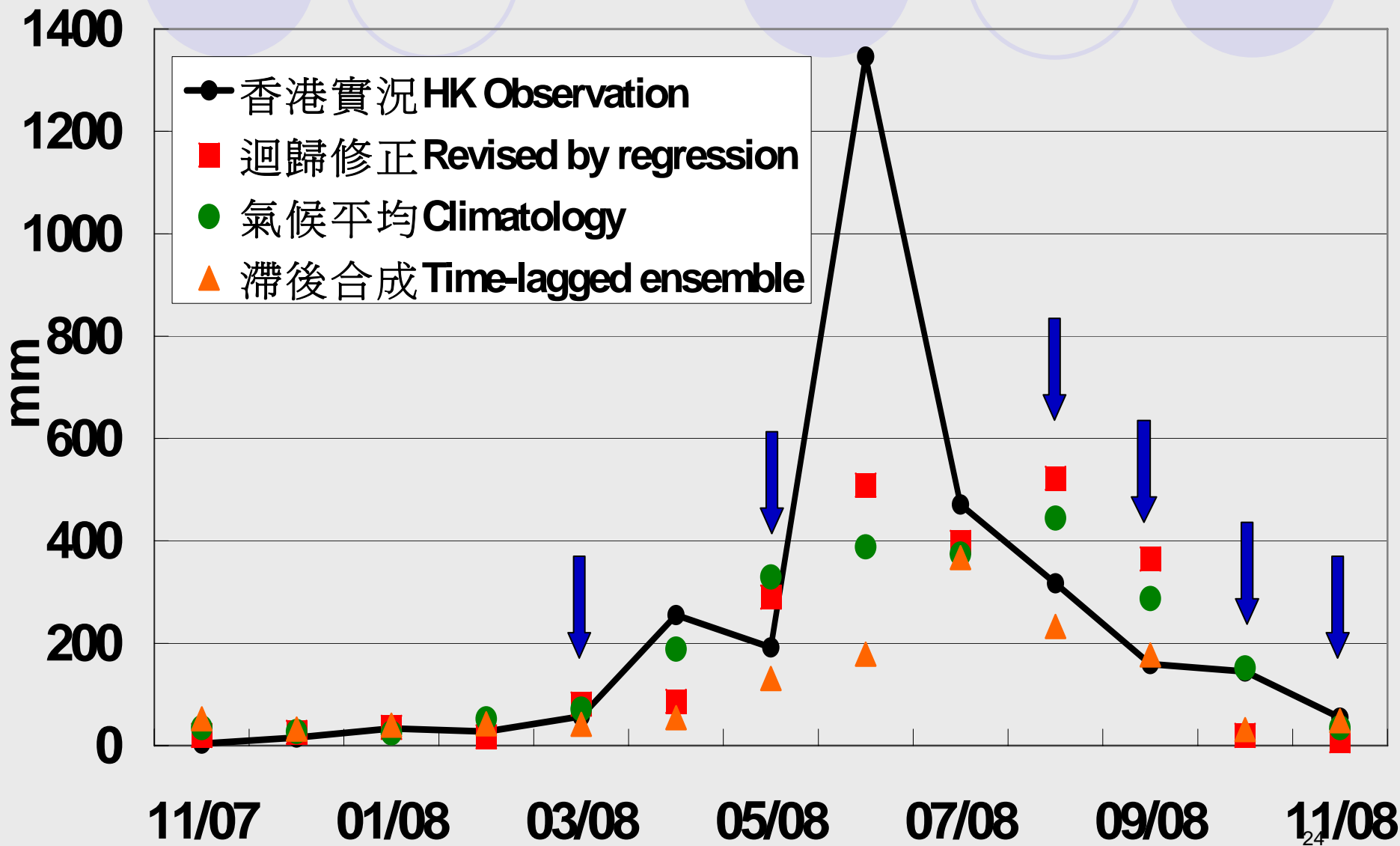
# 香港月氣溫預報

## Monthly Temperature Forecast for Hong Kong



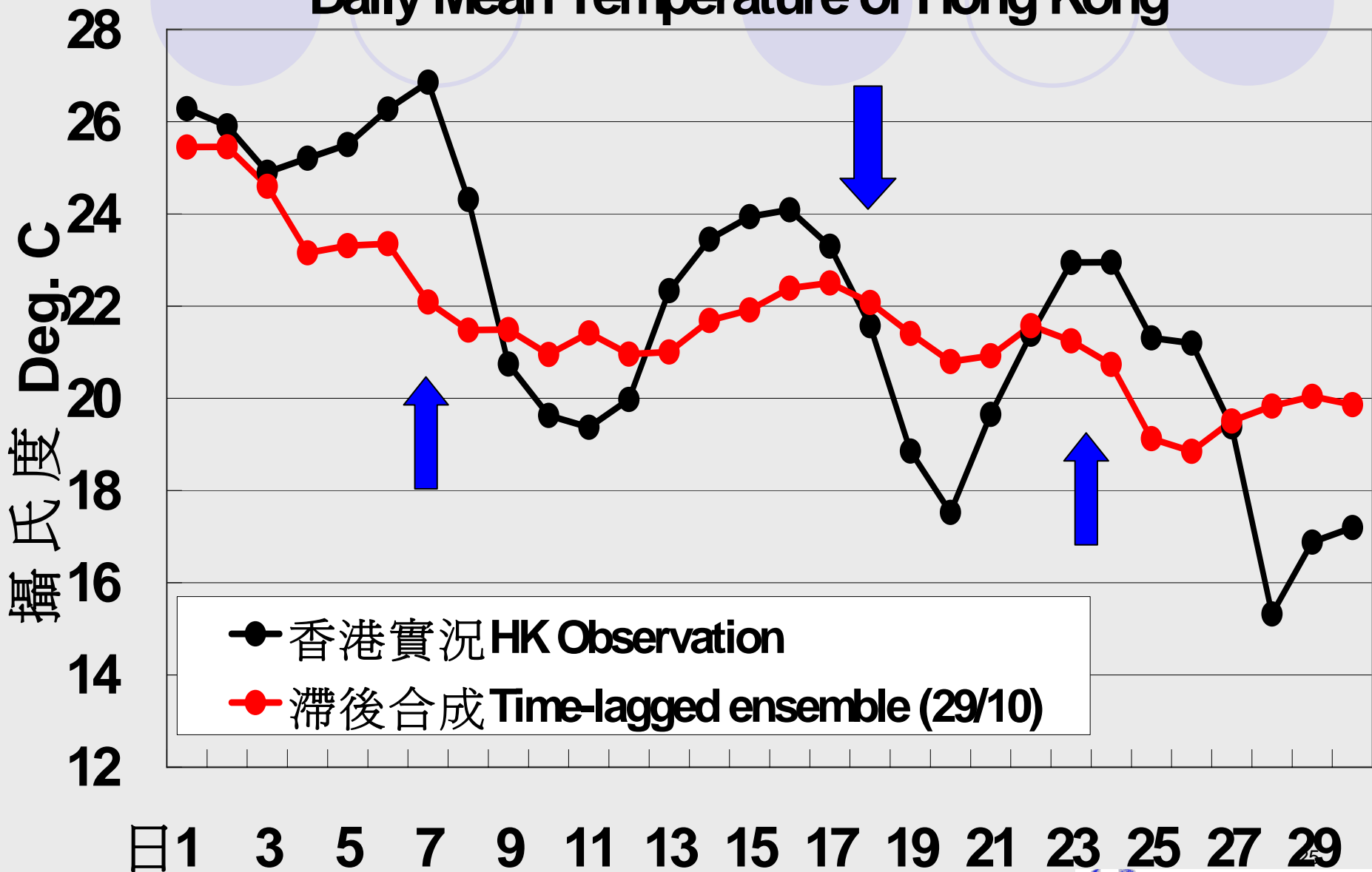
# 香港月雨量預報

## Monthly Rainfall Forecast for Hong Kong





# 香港日平均氣溫 (Nov 2008) Daily Mean Temperature of Hong Kong



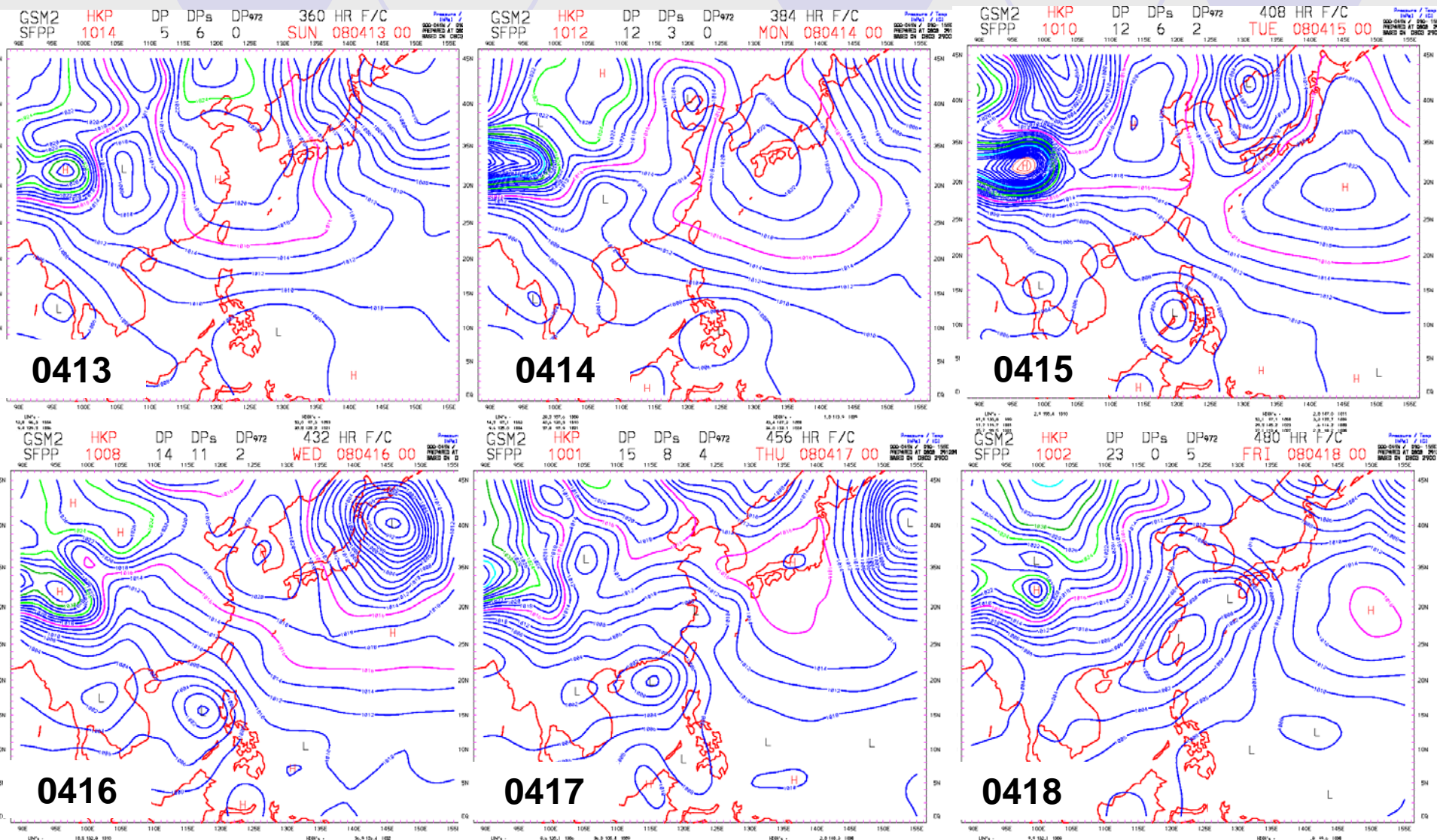
# 颱風浣熊 (Apr 2008)

## Typhoon Neoguri



# 初始時間為 2008 0329 00 UTC 的預報

## Forecast initialised at 2008 0329 00 UTC



## Monthly Forecast for Hong Kong

- 香港月氣溫、雨量的定量預報
  - 寒潮襲港的時間
  - 天氣系統之演化
  - 進入南海的熱帶氣旋數量和時間
- 
- **Quantitative forecast of monthly temperature and rainfall**
  - **Timing of cold surges**
  - **Evolution of weather systems**
  - **Number and timing of tropical cyclones entering the South China Sea**



# Thank you

*Acknowledgement: The HKO would like to thank*

- 1. ECPC for providing the suite of global-regional climate model, initial data, and its technical support and advices on the operation of the model suite;*
- 2. NOAA for providing the initial conditions to run the model suite.*

# Some Statistics of HKO Rainfall

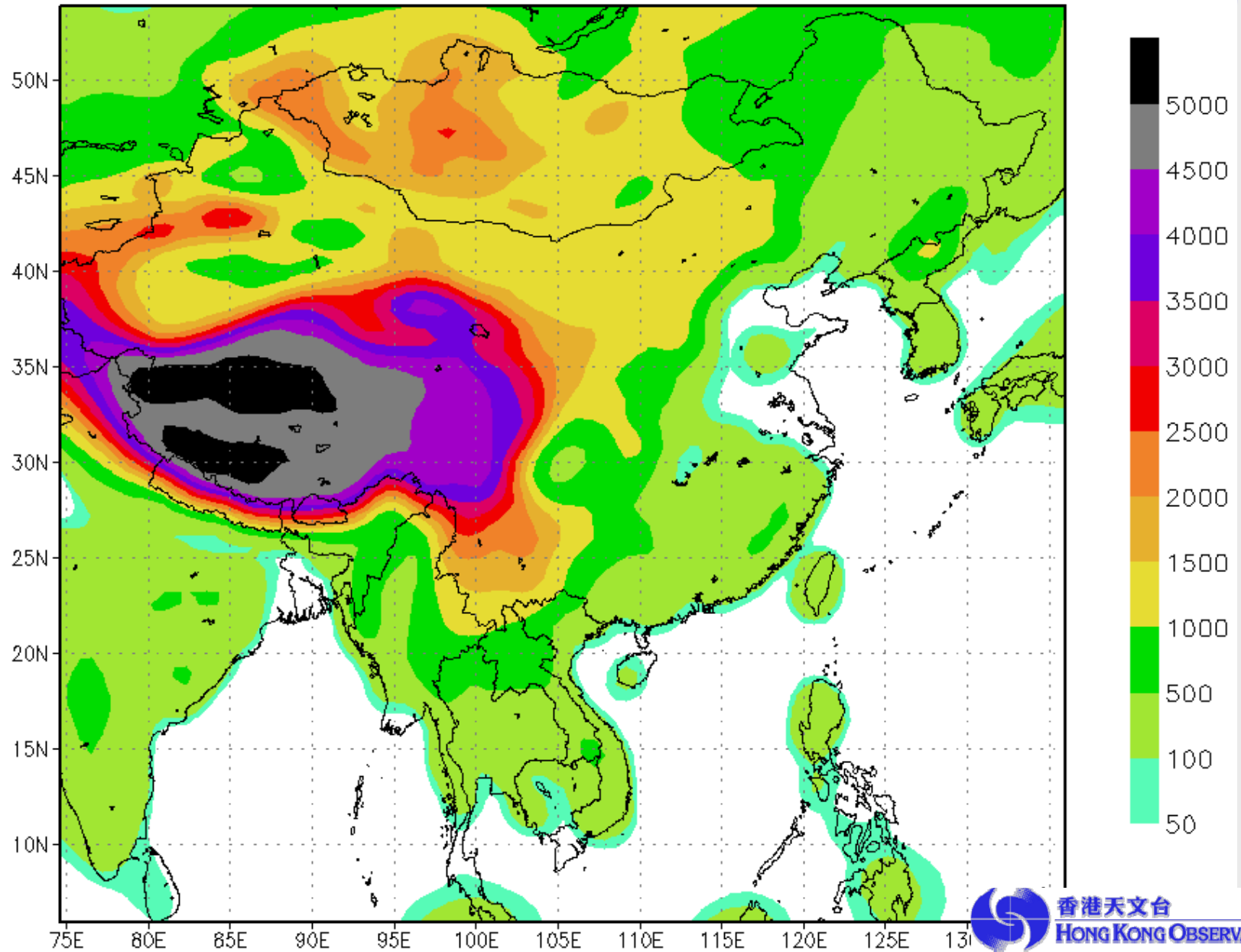
	1971-2000		1961-2007	
	Mean	S.D.	Min	Max
Jan	25	22	0	101
Feb	52	69	0	241
Mar	71	89	1	428
Apr	188	126	6	548
May	330	199	6	772
Jun	388	183	106	1084
Jul	374	223	77	1147
Aug	445	275	85	1090
Sep	288	155	24	798
Oct	152	175	0	718
Nov	35	40	0	145
Dec	35	53	0	207

# Some Statistics of HKO Temperature

	<b>Mean (71-00)</b>	<b>S.D. (71-00)</b>	<b>Min (61-07)</b>	<b>Max (61-07)</b>
<b>Jan</b>	<b>16.1</b>	<b>1.1</b>	<b>13.7</b>	<b>17.9</b>
<b>Feb</b>	<b>16.3</b>	<b>1.5</b>	<b>11.7</b>	<b>19.5</b>
<b>Mar</b>	<b>18.9</b>	<b>1.2</b>	<b>15.8</b>	<b>21.5</b>
<b>Apr</b>	<b>22.5</b>	<b>1.3</b>	<b>20.4</b>	<b>24.8</b>
<b>May</b>	<b>25.8</b>	<b>0.9</b>	<b>24.4</b>	<b>28.2</b>
<b>Jun</b>	<b>27.9</b>	<b>0.6</b>	<b>26.9</b>	<b>28.9</b>
<b>Jul</b>	<b>28.7</b>	<b>0.4</b>	<b>27.9</b>	<b>29.7</b>
<b>Aug</b>	<b>28.4</b>	<b>0.6</b>	<b>27.4</b>	<b>29.5</b>
<b>Sep</b>	<b>27.6</b>	<b>0.5</b>	<b>26.4</b>	<b>29.0</b>
<b>Oct</b>	<b>25.3</b>	<b>0.6</b>	<b>24.0</b>	<b>26.4</b>
<b>Nov</b>	<b>21.4</b>	<b>1.0</b>	<b>19.1</b>	<b>23.3</b>
<b>Dec</b>	<b>17.8</b>	<b>1.1</b>	<b>14.5</b>	<b>21.3</b>

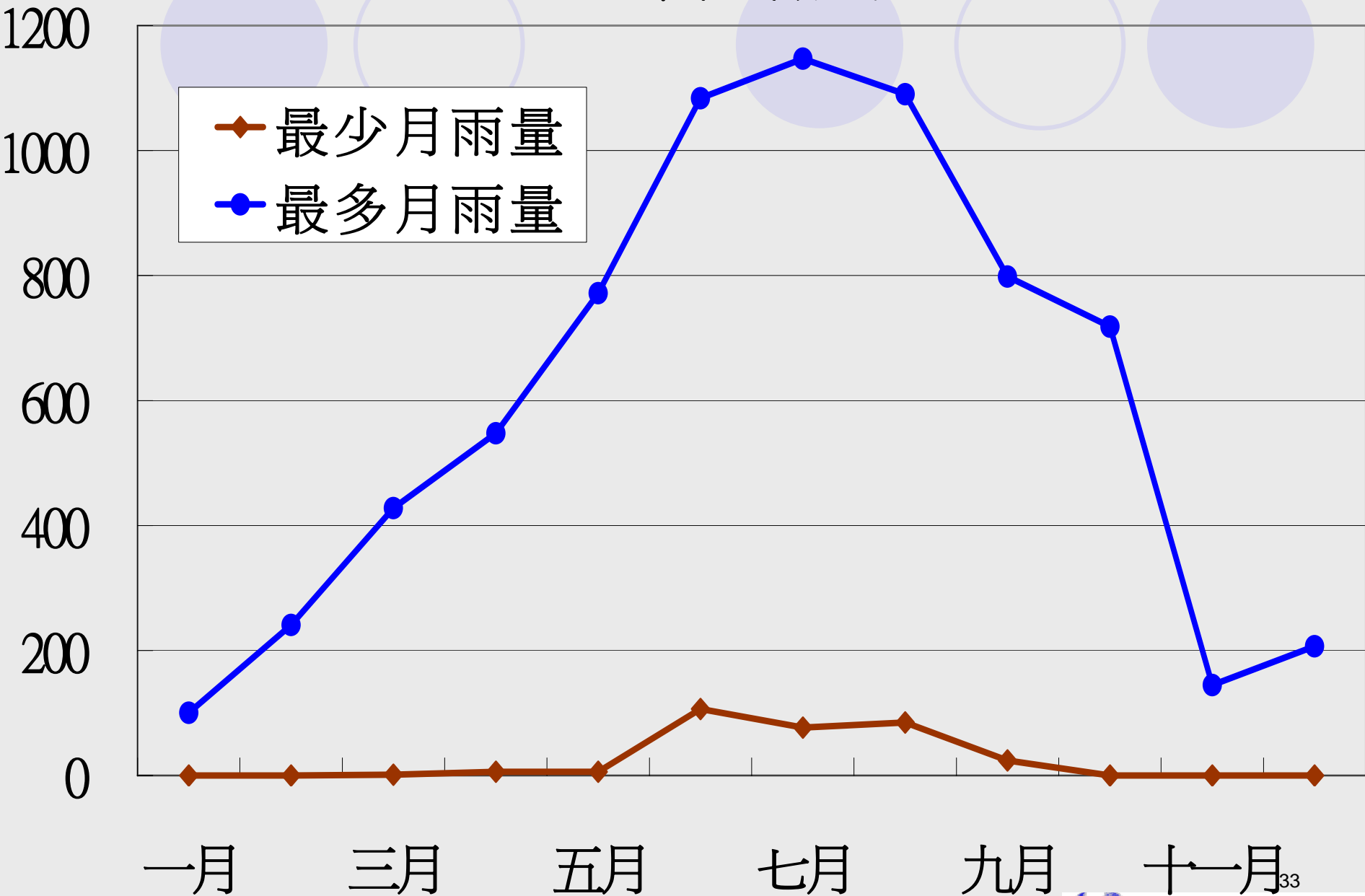
# Domain of the 60-km Regional Model

## Topography





# 1961 - 2007 年極端月雨量



# 1961-2007 年極端月平均氣溫

