Objective verification of weather forecast in Hong Kong

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Introduction

- **Hong Kong Observatory (HKO) - an official meteorological institution responsible for the provision of weather forecasts and warnings in Hong Kong**
- **Forecasts: 24-36 hr , 7-day**
- **Warnings: Rainstorm and thunderstorm, Landslip and flooding, High winds from tropical cyclones and strong monsoon, Cold and very hot, Fire danger**


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Introduction

- **Accuracy of weather forecasts is one of the key indicators of the performance of HKO.**
- **HKO verification scheme developed, procedures standardized, computerized and automated**

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Content

- **Essential features of the HKO verification scheme**
- **Compare the accuracy of weather forecasts with that of persistence forecasts**
- **Compare the verification scores with subjective ratings given by the public in the opinion survey conducted twice daily by independent consultant**

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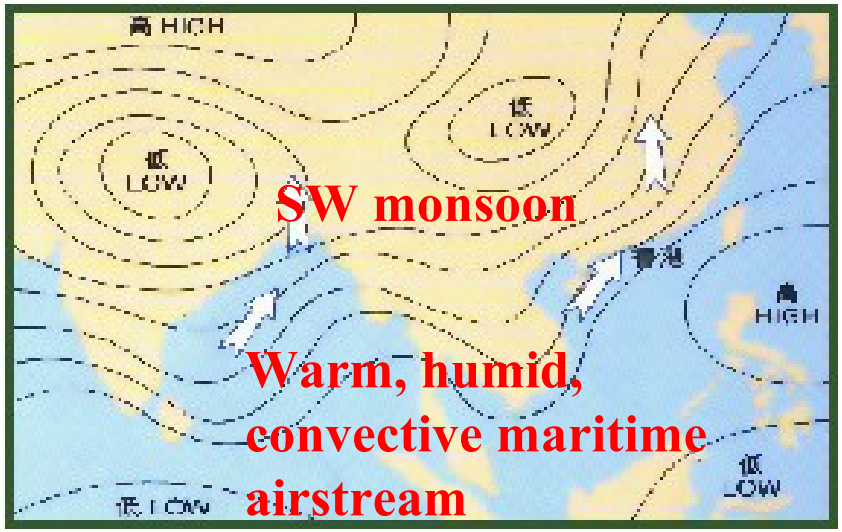
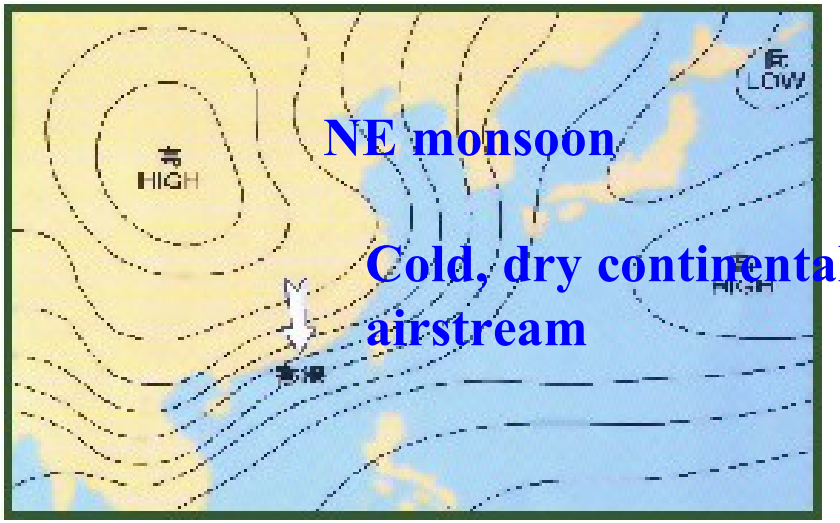
Climate of Hong Kong





- **Hong Kong situated in East Asian Monsoon Region**
- **Distinct seasonal characteristic: warm, wet summer with heavy rainfall and tropical cyclones; cold, dry winter with sudden fall in temperature**

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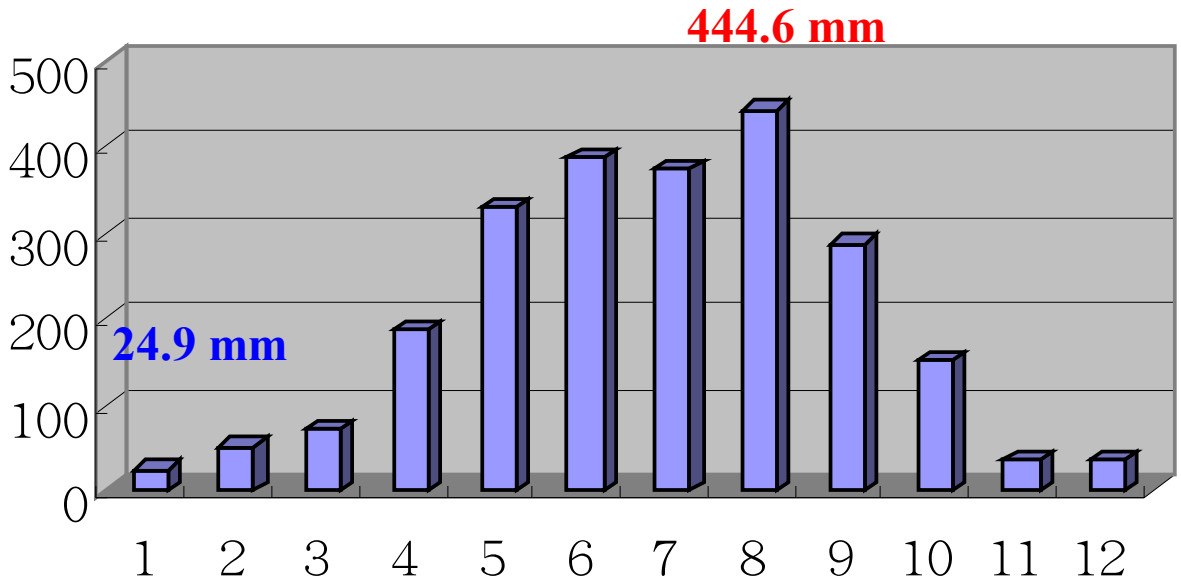
Climate of Hong Kong



1971-2000 30-yr normal rainfall in Hong Kong

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HKO verification scheme

- **24-36 hours weather forecast**
- **Weather forecast based on model guidance (ECMWF, JMA, HKO meso-scale model) and forecaster's experience**
- **Target for the general public: simple, easily understand and user-oriented, tailor-made**
- **A score was given for each forecast based on the accuracy of the six weather elements: wind, state of sky, precipitation, visibility, maximum temperature and minimum temperature**

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HKO verification scheme

$$S = \sum_{i=1}^{6} W_i S_i \qquad \sum_{i=1}^{6} W_i = 1$$

where S is the final score of a forecast,

S_i the element score for the i^{th} weather element

W_i the corresponding weighting.

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HKO verification scheme

- Different weightings (in %) assigned to different weather elements at different time of the year according to climatology and the relative importance of the elements in the eye of the public

	Wind	State of sky	Precipitation	Visibility	Max temperature	Min temperature
January	15	15	20	0	20	30
February	10	10	20	10	20	30
March	5	5	30	30	15	15
April	5	5	40	30	10	10
May	10	10	60	0	10	10
June	20	10	60	0	5	5
July	20	15	60	0	3	2
August	20	15	60	0	3	2
September	20	20	50	0	5	5
October	20	20	30	0	15	15
November	20	20	20	0	15	25
December	15	20	20	0	15	30

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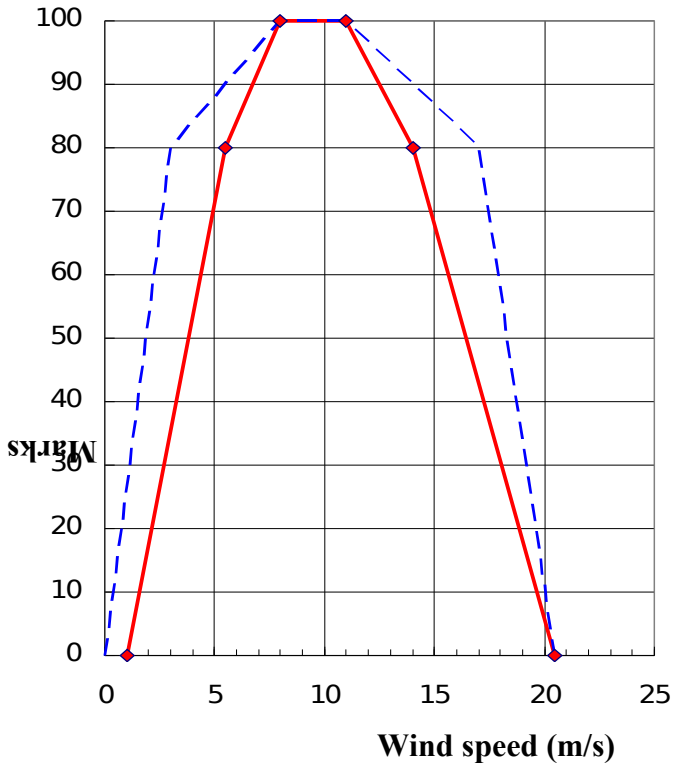
Wind

Wind category	Averaged hourly mean wind speed (in m/s)
Moderate	0-8
Moderate to fresh	5.5-9.5
Fresh	8-11
Fresh to strong	9.5-14.0
Strong	11-17
Strong to gale	14.0-20.5
Gale	17 onwards

Wind speed is forecast in Beaufort scale

Give credit to "close" forecast



Marking scheme for fresh wind (solid line). Dotted line is used if the actual wind is not belonged to the fresh category when the forecast is issued

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State of sky

- **Divided into sunshine duration and cloud amount**

Category	Sunshine duration (in %)	Mean cloud amount (in oktas)
Overcast	0	7.6-8
Cloudy	0-5	6.1-7.5
Bright	5.1-10	6.1-7.5
Mainly fine	10.1-50	0-6
Fine/sunny/clear	50.1	0-6

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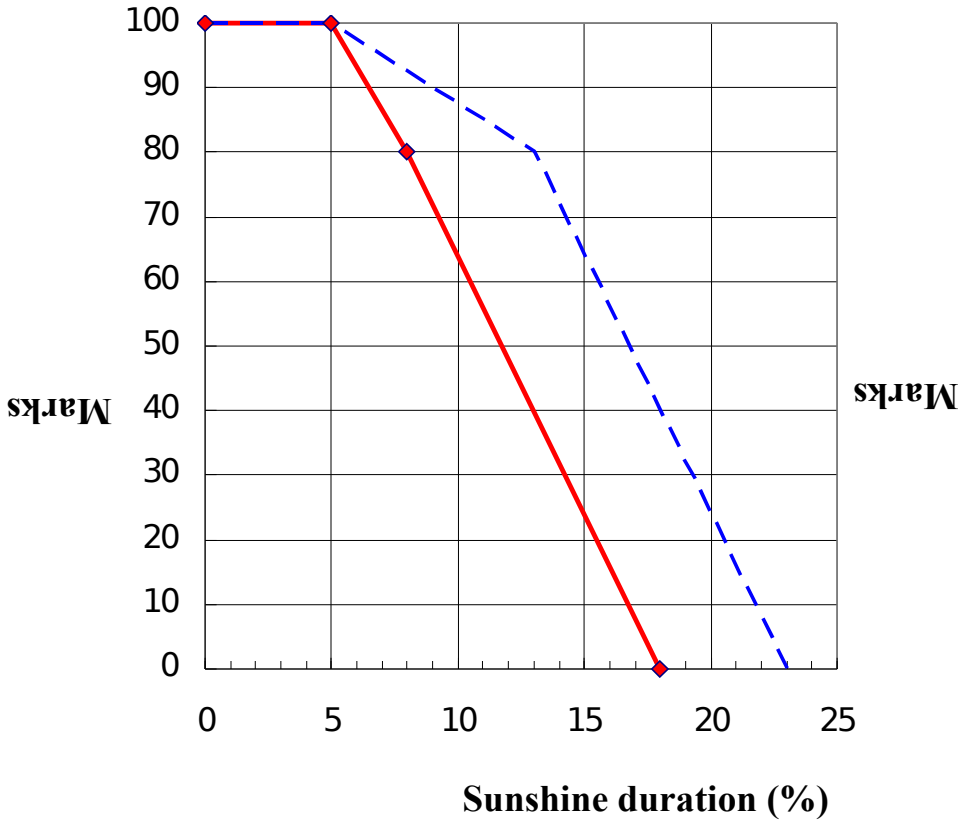
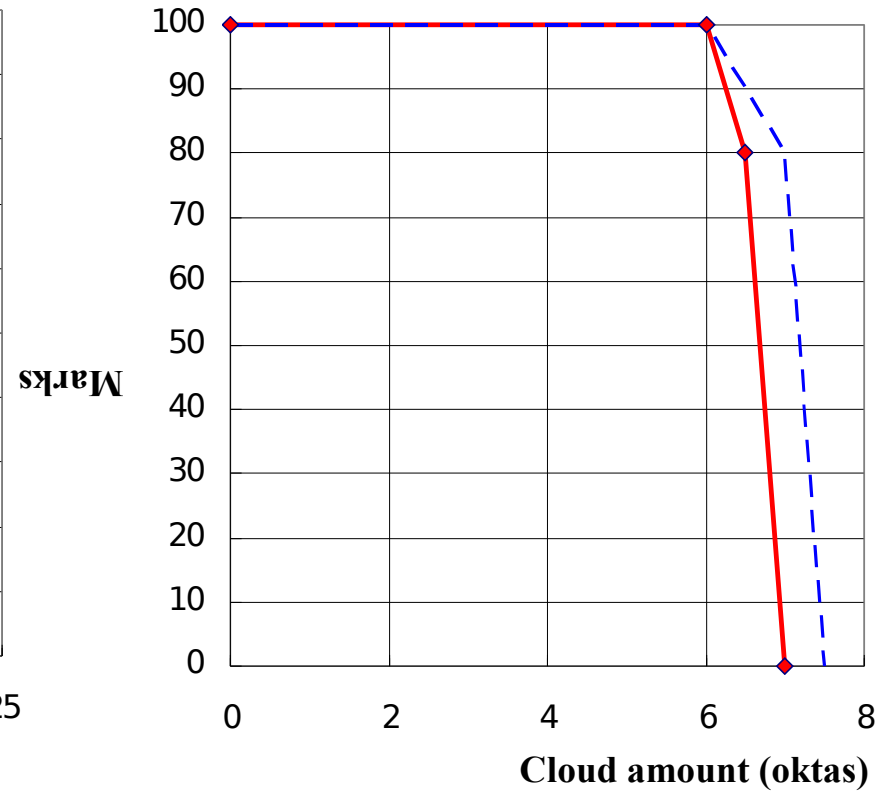
State of sky



Marking scheme of sunshine duration for the category of cloudy



Marking scheme of cloud amount for the category of fine/sunny/clear

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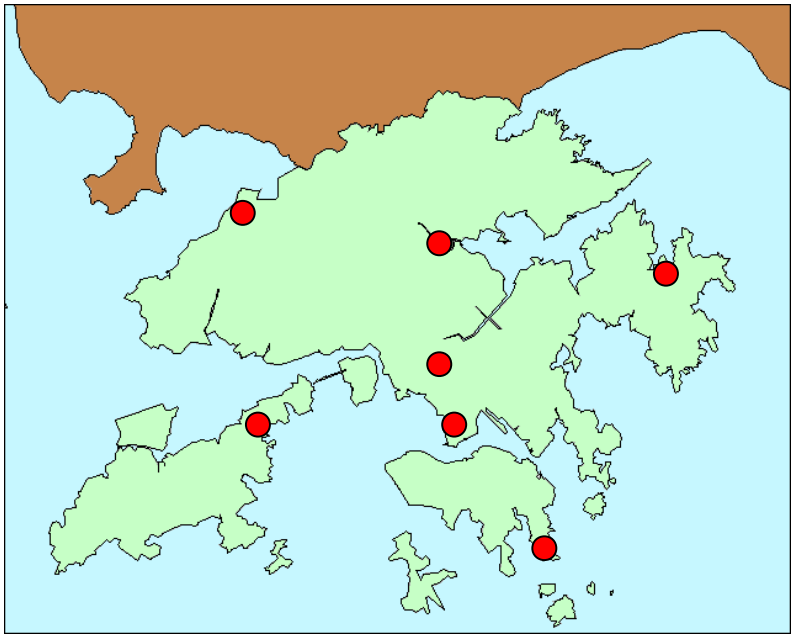
Precipitation

Category	24-hour rainfall amount (mm)
No rainfall	Nil
Light	0 < Rainfall < = 5
Moderate	5 < Rainfall < = 25
Heavy	25 < Rainfall



• If the forecast period with rain is less than or more than 24 hours, the figures would be modified in proportion to the length of the period

• The average of readings from 7 raingauges is taken as the actual

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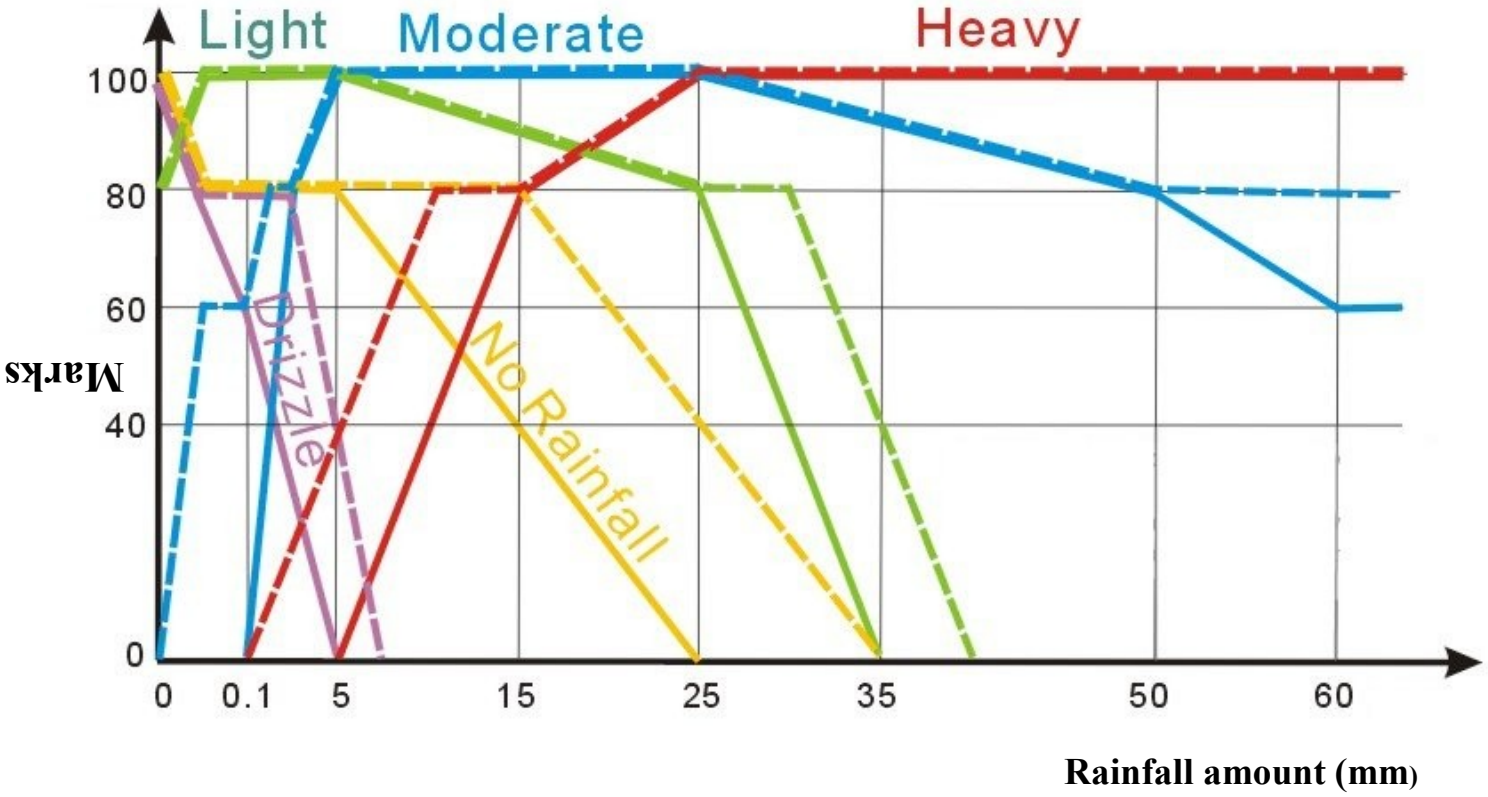
Precipitation



Marking scheme of precipitation

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Precipitation

- **An additional score (positive or negative) for thunderstorm forecast would be added to give the total score for precipitation**

Forecast thunderstorm	Thunderstorm reported	Score
Yes	Yes	+20
Yes	No	-5
No	Yes	-5
No	No	0

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Visibility

- **Visibility forecast are given in categories**

Category	Fog	Mist	Haze	Low visibility
Visibility (in m)	< = 1000	1000 < Visibility < 5000	Visibility < 5000	Visibility < 5000

- **The lowest hourly visibility readings in three observing stations is taken for verification**

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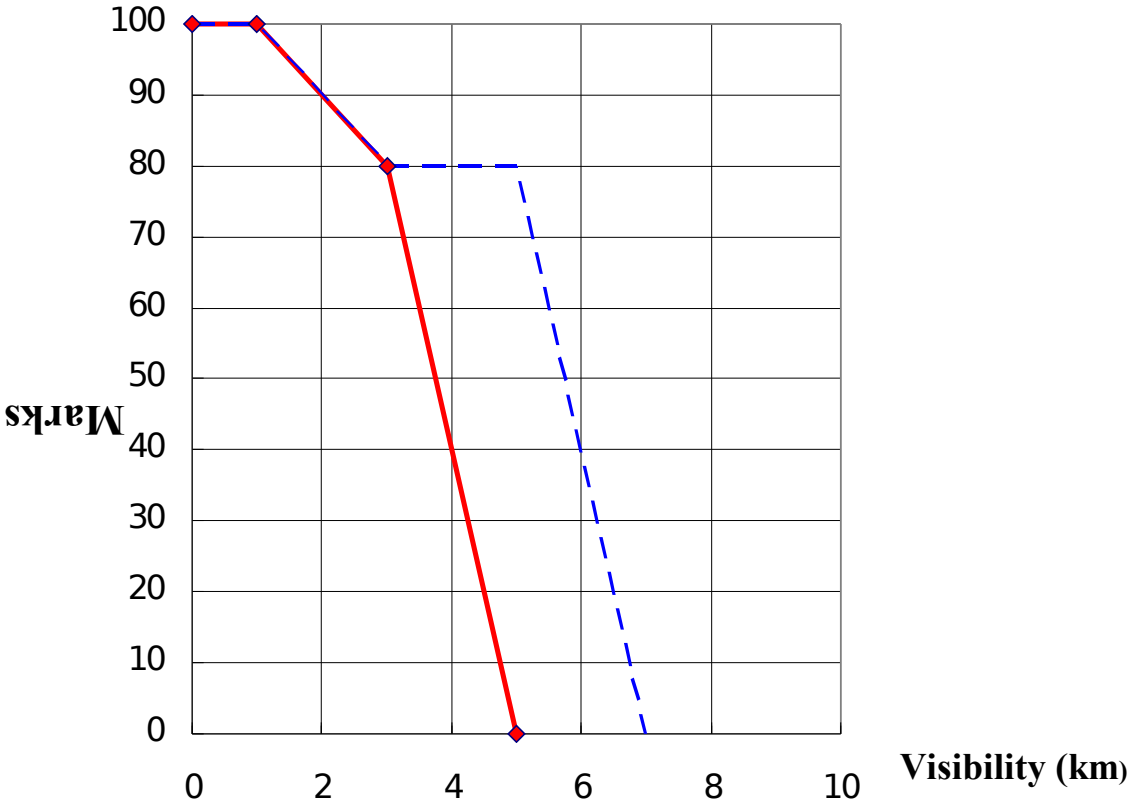
Visibility



Marking scheme for visibility category of fog

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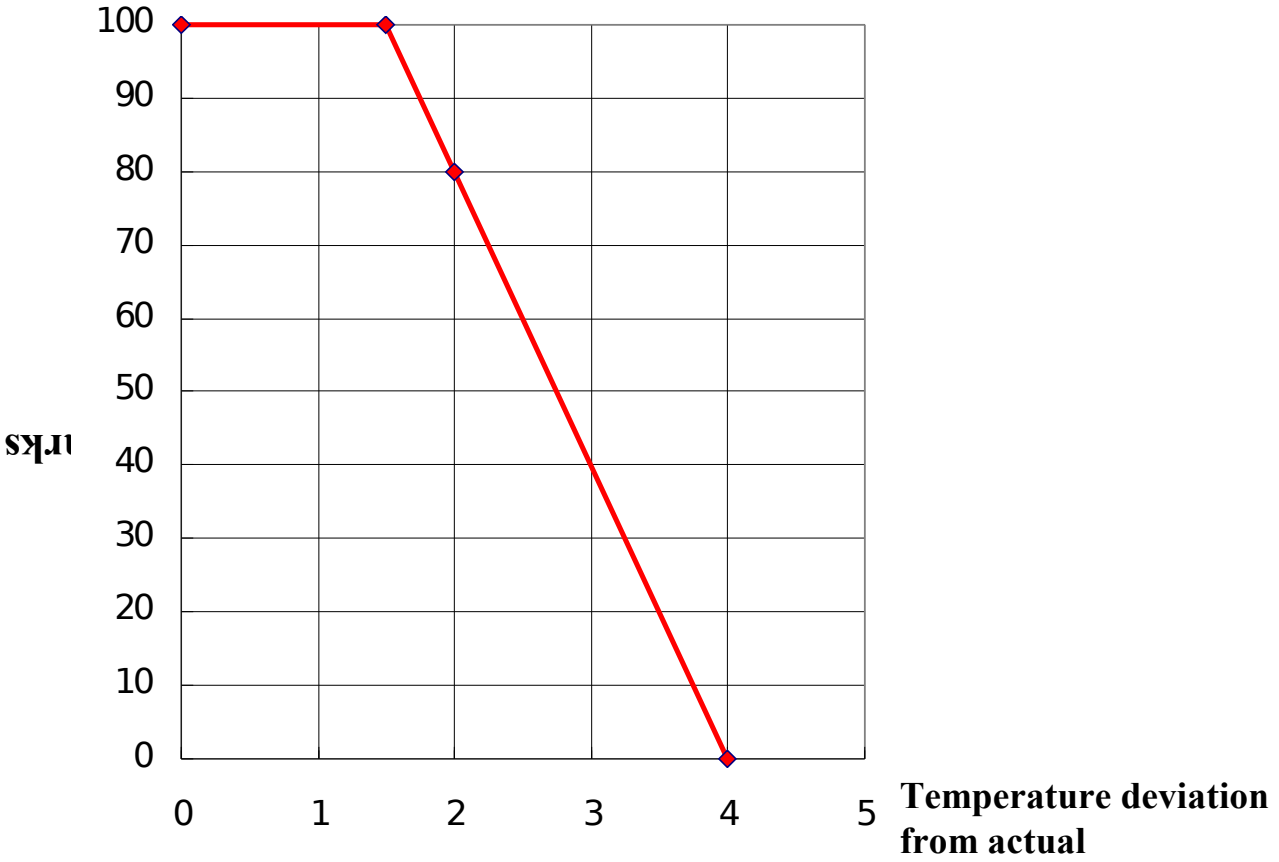
Maximum and minimum temperature



Marking scheme for max/min temperature

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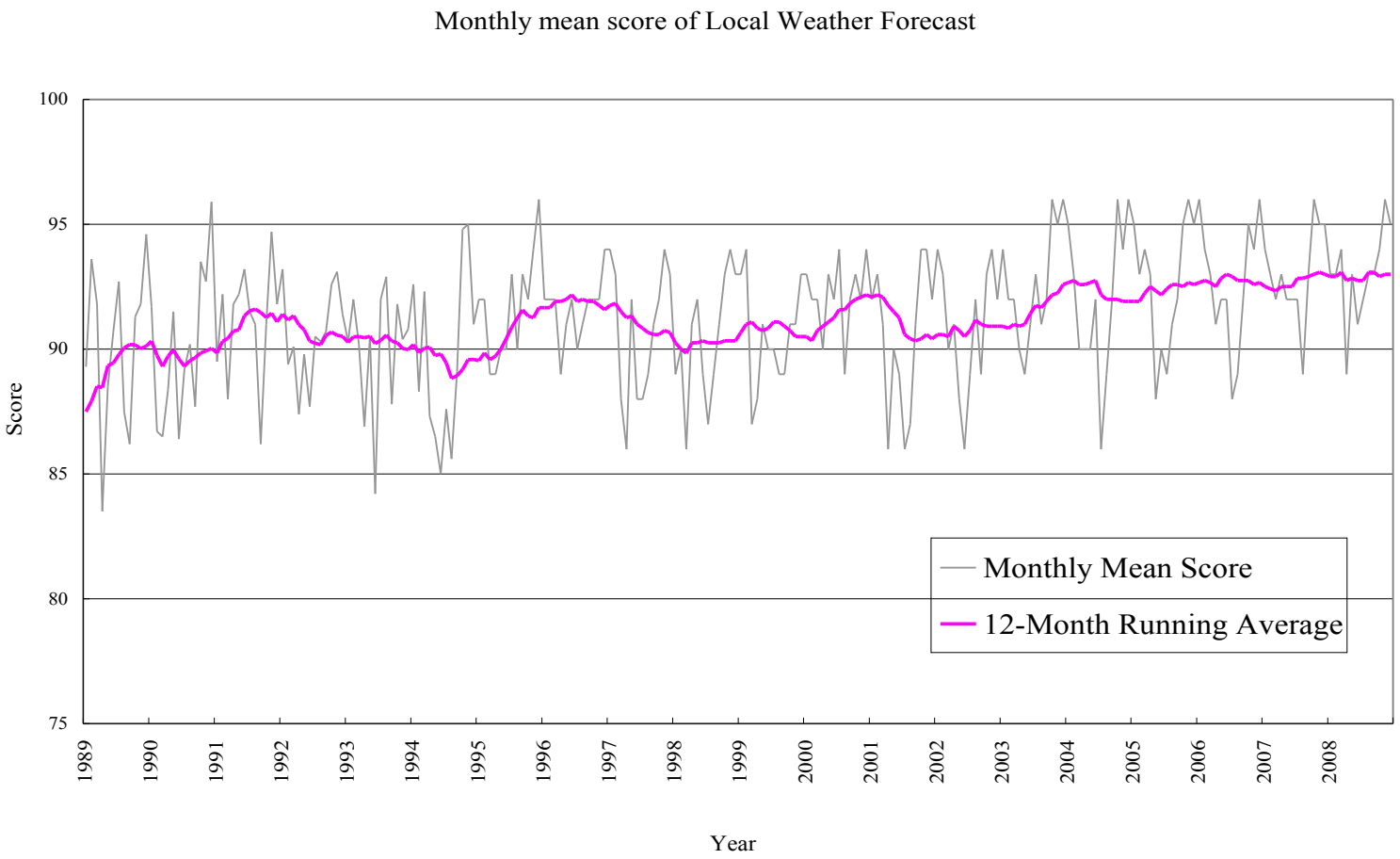
Trend of verification scores



- **The score was in general on the rising trend in line with scientific advancement in weather observations, remote sensing technology, NWP and weather forecasting skills**

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Seasonal pattern of verification scores

Month	Mean score (1989-2008)
January	92.6
February	92.0
March	90.4
April	89.1
May	90.5
June	89.6
July	90.0
August	89.8
September	90.5
October	93.4
November	93.6
December	93.8

- Score pattern generally in line with higher forecasting skill of numerical models for synoptic scale systems than meso-scale system
- The lower scores in spring and summer months may reflect the difficulty in forecasting meso-scale systems like rainstorm and fog/mist
- The higher scores in winter months may reveal the better skill in capturing the variation in the surge of synoptic scale northeast monsoon

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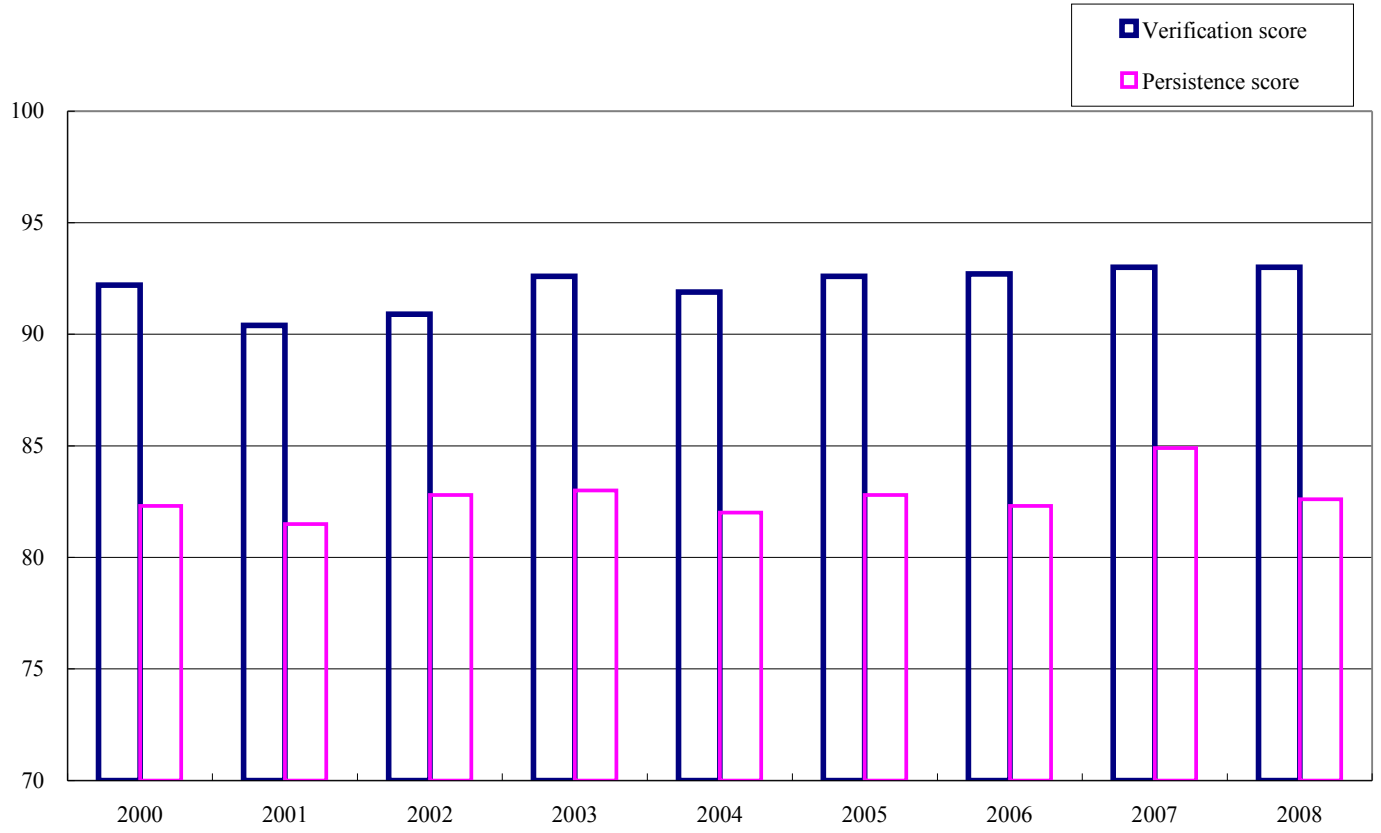
Comparison of verification scores with persistence score



- **The verification score is generally 10 marks better than the persistence scores indicating weather forecaster/models has skill in predicting weather changes.**

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Comparison between verification scores and public's subjective ratings

- **Subjective ratings given by the public at the time of survey depends greatly on the public's past memory and impression on forecast accuracy**
- **Lagged correlations between the subjective ratings and the rolling average verification scores of preceding 1, 3, 6, 12, 36 and 48 months respectively for 1992-2008**
- **Two-tailed t-test to test the statistical significance of the correlations**
- **Build a stepwise regression model of using verification score to predict the subjective ratings**

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Comparison between verification scores and public's subjective ratings

	Correlation coefficient	Statistical significant at 5% level?
1 month	0.386	Yes
3 months	0.418	Yes
6 months	0.406	Yes
12 months	0.441	Yes
24 months	0.407	Yes
36 months	0.382	Yes
48 months	0.444	Yes

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Comparison between verification scores and public's subjective ratings

- **Using stepwise regression, equation obtained is:**

$$y = 0.314\ x_3 + 0.806\ x_{48} - 25.656$$

with multiple correlation coefficient equal to 0.51, statistically significant at 5% level. x_3 denotes the 3-month (short-term) and x_{48} the 48-month (long-term) rolling averages respectively

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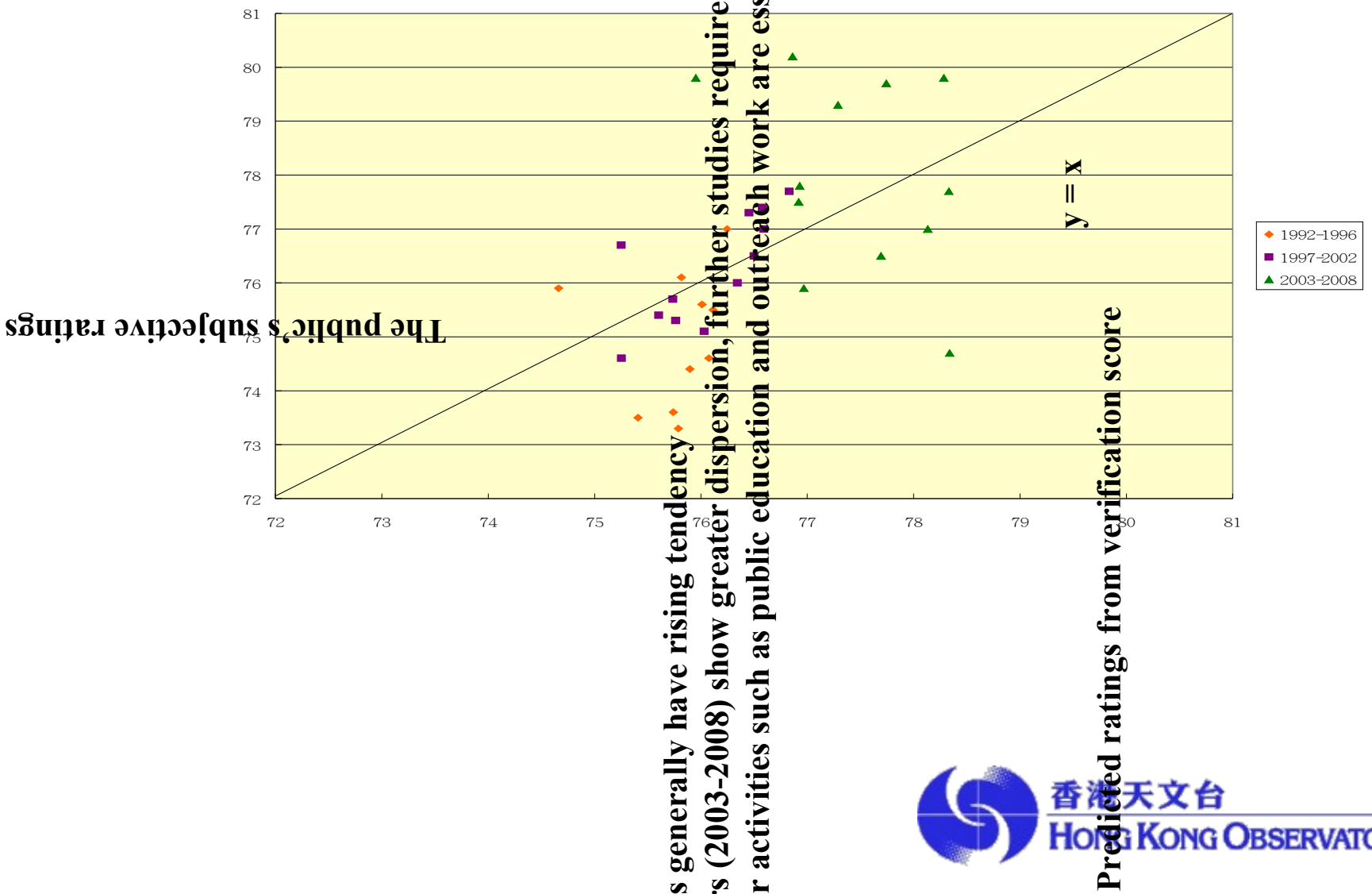
Comparison between verification scores and public's subjective ratings



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Thank you

State of sky

- **For periods of non-zero available sunshine, the state of sky score is given by the arithmetic mean of the scores on sunshine duration and cloud amount**
- **Otherwise, the state of sky score is given by the cloud amount alone**
- **Final state of sky score is the weighted mean of the scores of the two periods according to their respective length**