

**ABOUT THE EVENT**  
 The workshop will include both tutorial sessions and a scientific presentation session. A list of talks and posters on recent research on verification methods, with particular emphasis on high impact weather and use-focused verification. The tutorial sessions will cover basic verification concepts, verification of categorical, continuous, probabilistic (including ensemble) and seasonal weather forecasts, as well as spatial forecast verification and relevance. Hands-on laboratory sessions, whereby participants will use the methodology on real case studies, are an integral part of the tutorials. Participants will be invited to bring their own datasets and verification procedures for these laboratory sessions.

**FURTHER INFORMATION**  
 The scientific workshop will include keynote addresses as well as contributed presentations on new verification techniques and issues related to the practice of forecast verification. Subjects will cover verification of high impact weather, ensemble probability forecasts, spatial verification, seasonal and climate projection verification, propagation of uncertainty, use issues, communicating verification to decision makers, and verification tools.

**ORGANISING COMMITTEE**  
 Pierluigi Belli (FMI, Finland)  
 Barbara Brown (NOAA, USA)  
 Barbara Casati (Durham, Canada)  
 Stephen Chen (BOM, Australia)  
 Dr. Jukka Järvi (University of Jyväskylä, Finland)  
 Glenn Chaffin (ECMWF, UK)  
 Markku Miettinen (Met Office, UK)  
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# Verification of daily minimum and maximum temperatures in Hong Kong

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# Outline

- **Introduction**
- **Objectives**
- **Data and Methodology**
- **Results**
- **Summary**
- **Conclusion**

# Introduction

- **Hong Kong Observatory (HKO) uses ECMWF global model forecast as a daily reference forecast for maximum and minimum temperatures for Hong Kong**
- **The model data is available twice daily at 00Z and 12Z and the forecast is up to 10 days ahead**
- **The Direct Model Output (DMO) data are subjected to post-processing automatically at HKO using Kalman Filter (KAL) and regression (REG)**

# Objectives

- **To compare the performance of the three different forecasts: DMO, KAL and REG in predicting min/max temperature in Hong Kong**
- **To find out which forecast is better in predicting min or max temperature**
- **To see whether there is a trend in the skill of the model**

# Data

- **Five years (2004-2008) ECMWF DMO, KAL and REG day 1, forecast data issued at 12Z at a grid point near Hong Kong**
- **Five years (2004-2008) observed daily minimum and maximum temperature data at the Hong Kong Observatory Headquarters**



**Observed data**

**Forecast data**

# Methodology

- **R software was used for scatter plots and compute the following scores:**

**Direction of error**

$$\text{linear bias} = ME = \frac{1}{n} \sum_{i=1}^n (y_i - x_i) = \bar{Y} - \bar{X}$$

**Accuracy of error**

$$MSE = \frac{1}{n} \sum_{i=1}^n (y_i - x_i)^2$$

**Skill score**

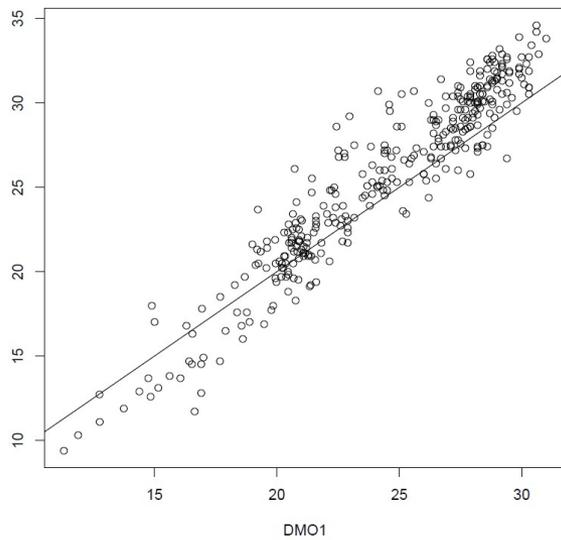
$$SS_{MSE} = \frac{MSE - MSE_{ref}}{MSE_{perf} - MSE_{ref}} = 1 - \frac{MSE}{MSE_{ref}}$$

# Results

## Maximum temperature 2004

### DMO1 vs Obs

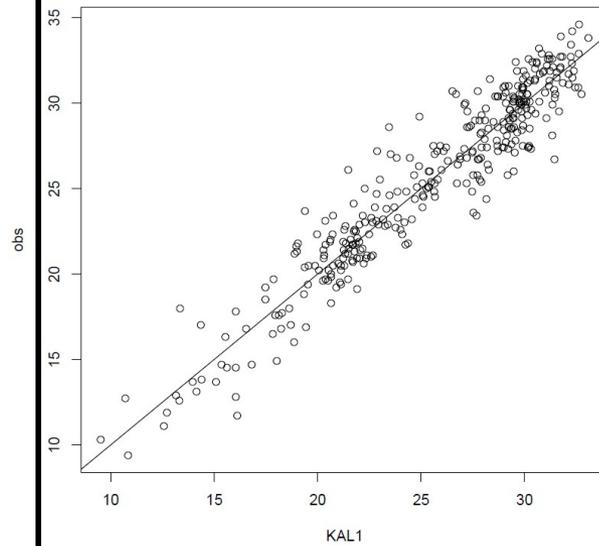
hkte2004.max.10d



**Bias=-1.2**  
**Under-forecast**

### KAL1 vs Obs

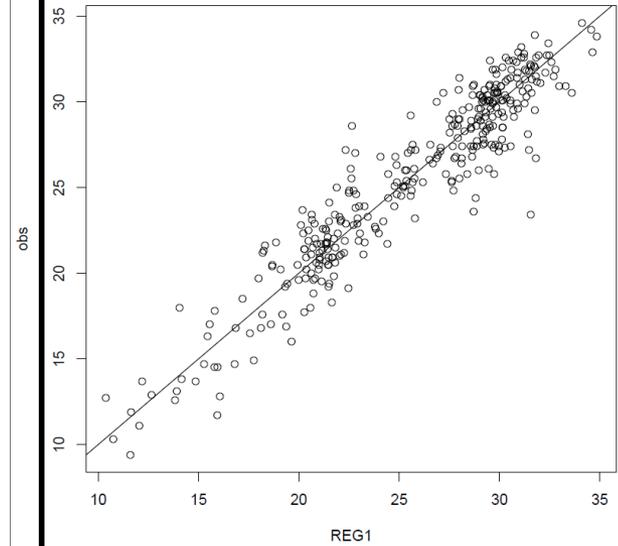
hkte2004.max.10d



**Bias=-0.06**  
**Under-forecast**

### REG vs obs

hkte2004.max.10d



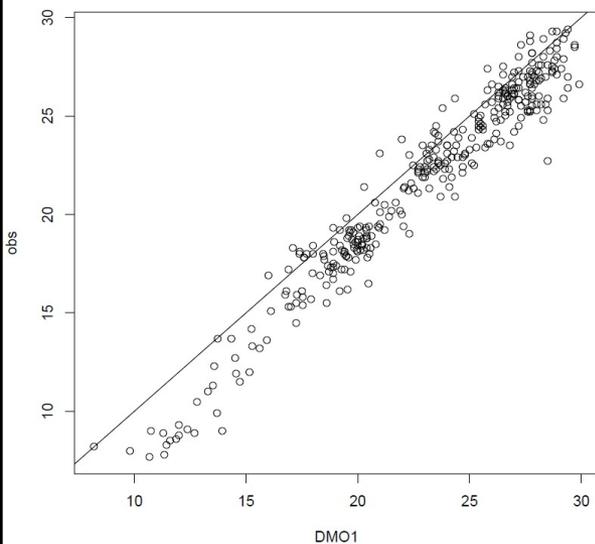
**Bias=0.01**  
**Over-forecast**

# Results Continued ...

## Minimum temperature 2004

### DMO1 vs Obs

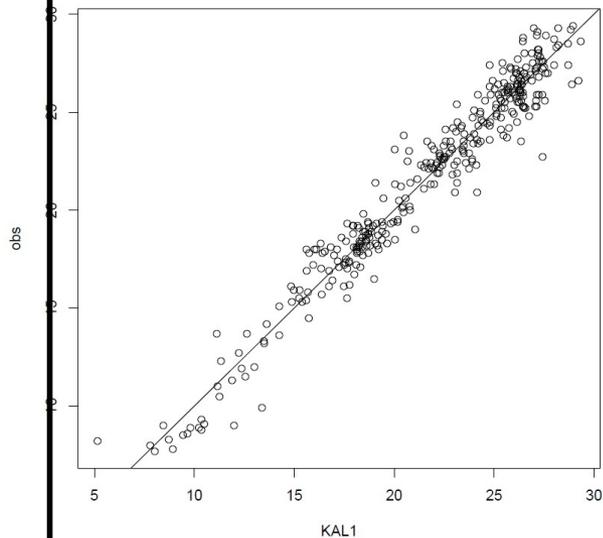
hkte2004.min.10d



**Bias=1.24**  
**Over-forecast**

### KAL1 vs Obs

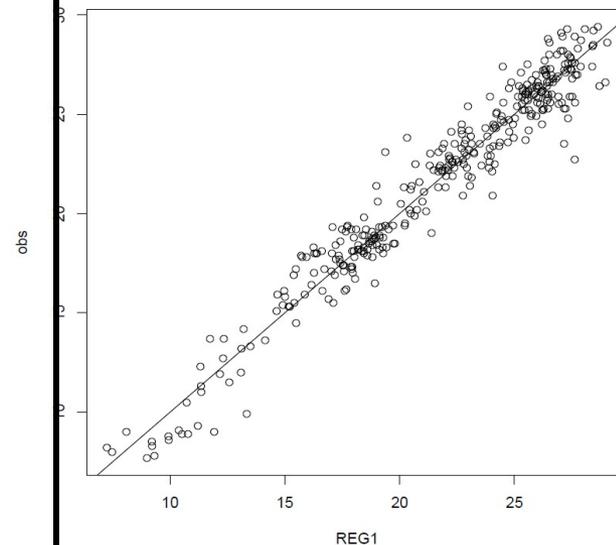
hkte2004.min.10d



**Bias=-0.02**  
**Under-forecast**

### REG vs obs

hkte2004.min.10d



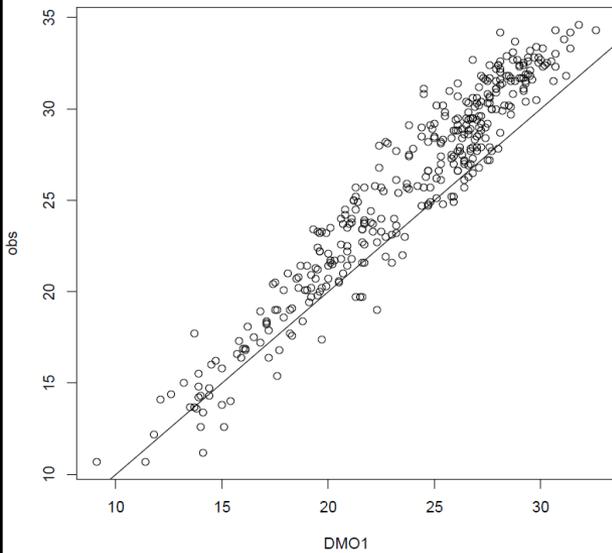
**Bias=-0.05**  
**Under-forecast**

# Results Continued ...

## Maximum temperature 2008

### DMO1 vs Obs

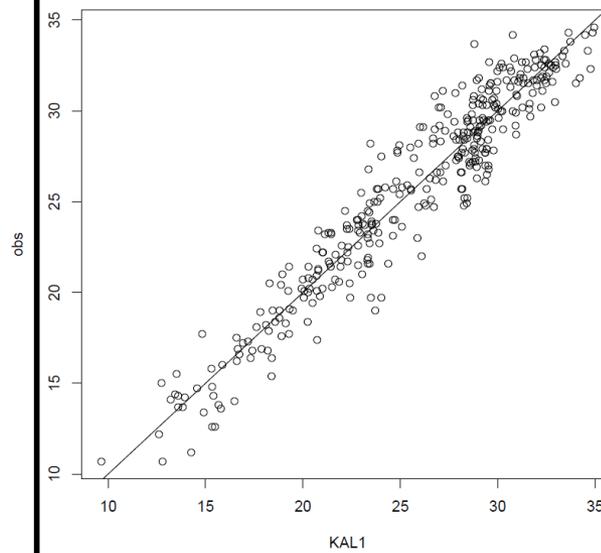
hkte2008.max.10d



**Bias=-1.98**  
**Under-forecast**

### KAL1 vs Obs

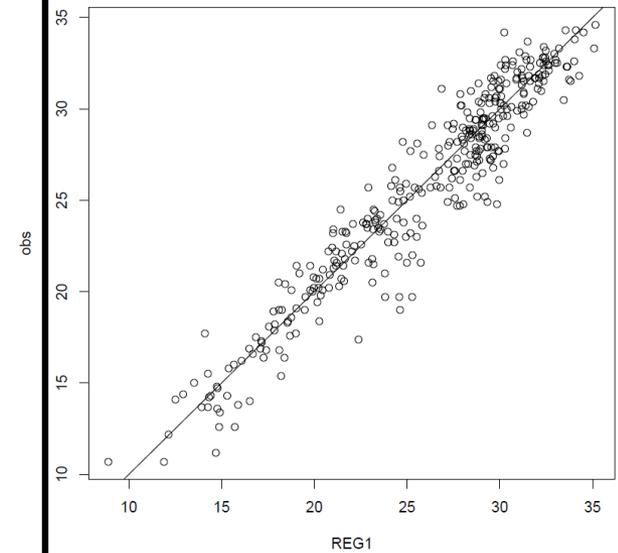
hkte2008.max.10d



**Bias=-0.04**  
**Under-forecast**

### REG vs obs

hkte2008.max.10d



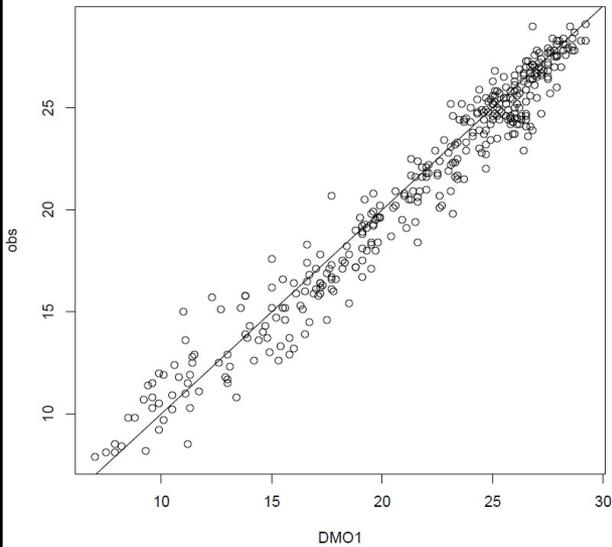
**Bias=0.18**  
**Over-forecast**

# Results Continued ...

## Minimum temperature 2008

### DMO1 vs Obs

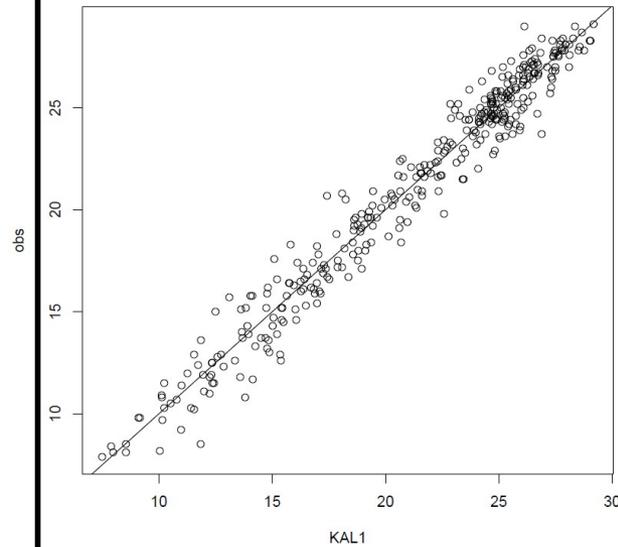
hkte2008.min.10d



**Bias=0.39**  
**Over-forecast**

### KAL1 vs Obs

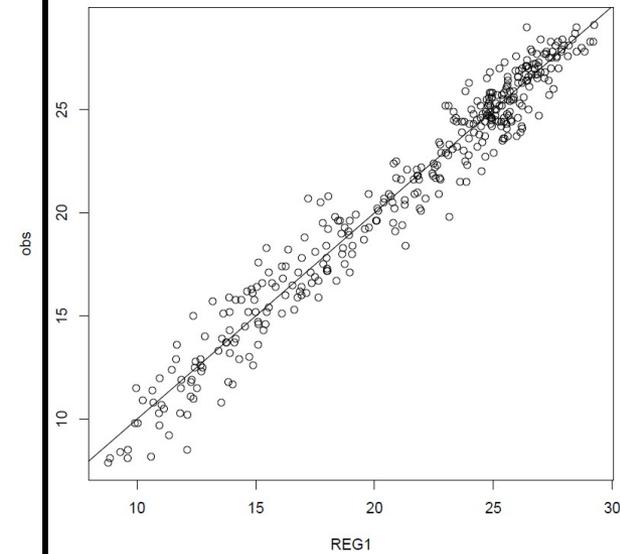
hkte2008.min.10d



**Bias=0.02**  
**Over-forecast**

### REG vs obs

hkte2008.min.10d



**Bias=0.09**  
**Over-forecast**

# Results Continued ...

**2004\_Max**

	<b>MSE</b>	<b>MSERef</b>	<b>SS</b>
<b>DMO1</b>	<b>4,8</b>	<b>3,7</b>	<b>-0,2973</b>
<b>KAL1</b>	<b>2.6</b>	<b>3,7</b>	<b>0.2778</b>
<b>REG1</b>	<b>3.0</b>	<b>3,7</b>	<b>0.1892</b>

**2008\_Max**

	<b>MSE</b>	<b>MSERef</b>	<b>SS</b>
<b>DMO1</b>	<b>6,7</b>	<b>4,3</b>	<b>-0,5581</b>
<b>KAL1</b>	<b>2,5</b>	<b>4,3</b>	<b>0,4186</b>
<b>REG1</b>	<b>2,6</b>	<b>4,3</b>	<b>0,3953</b>

**2004\_Min**

	<b>MSE</b>	<b>MSERef</b>	<b>SS</b>
<b>DMO1</b>	<b>2.7</b>	<b>2,3</b>	<b>-0,1739</b>
<b>KAL1</b>	<b>1,2</b>	<b>2,3</b>	<b>0,4783</b>
<b>REG1</b>	<b>1,3</b>	<b>2,3</b>	<b>0,4348</b>

**2008\_Min**

	<b>MSE</b>	<b>MSERef</b>	<b>SS</b>
<b>DMO1</b>	<b>1.5</b>	<b>2,3</b>	<b>0.3478</b>
<b>KAL1</b>	<b>1.1</b>	<b>2,3</b>	<b>0.5000</b>
<b>REG1</b>	<b>1.2</b>	<b>2,3</b>	<b>0.4783</b>

# Summary

- **Maximum temperatures**

- An increase in MSE for DMO1 from 2004 to 2008, contributing to the decrease in skill.
- There was an improvement on MSE for Kalman Filter and Regression from 2004 to 2008, resulted in increase in skill.
- Post processing resulted in improved skills scores as compared to DMO1.
- DMO1 under-forecasts maximum temperatures.
- KAL1 and REG1 correct the scores.

- **Minimum temperatures**

- There is an decrease in MSE for DMO1, and improvement in skill scores.
- There was an improvement on MSE for Kalman Filter and Regression from 2004 to 2008, resulted in increase in skill.
- Post processing resulted in improved skills scores even though the model forecast (DMO1) was good.

# Conclusion

- DMO1(model) under-forecast maximum temperature, but over-forecast minimum temperature.
- DMO1 is more skillful when forecasting minimum as compared to maximum temperatures.
- Model post-processing correct forecast scores.
- Kalman filter is a better forecast tool as compared to regression.
- Kalman filter forecasts are easily comparable to observations.
- More studies are required to draw conclusion.

**Thank you**