

# Evaluation of Delta Forecasting MQO v5.1 for London

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Portugal

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# airTEXT forecasting system for London



MAYOR OF LONDON



Free air pollution, UV, pollen and temperature forecasts for Greater London

**Currently providing free air quality alerts to more than 10 000 subscribers**

# airTEXT forecasting system for London

**airTEXT**  
Free air pollution forecasts

www.airtext.info

Daily Health Bulletin for Islington  
Wednesday 25th July 2012

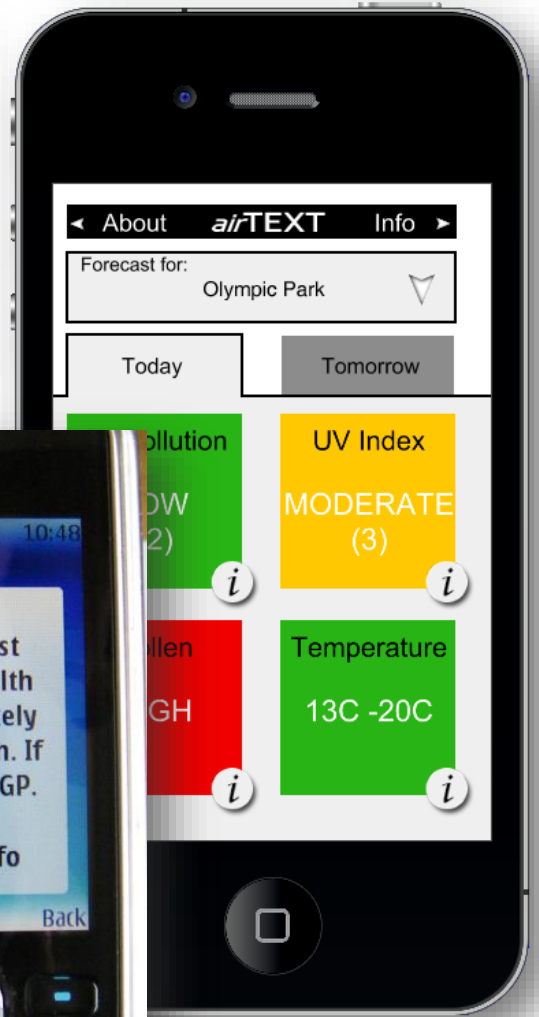
+5 Recommend this on Google

RSS, iPhone, Android icons

<b>Air pollution</b>	<b>UV Index</b>
<b>MODERATE</b>	<b>7 (HIGH)</b>
<b>Action may be required.</b> Health effects are unlikely to require action. If unwell, contact GP.	<b>Protection required.</b> Seek shade during midday hours, cover up and wear sunscreen.
<small>This is a daily air pollution forecast and may be LOW, MODERATE, HIGH or VERY HIGH.</small>	<small>This is a forecast of maximum hourly cloud-adjusted solar UV index over a 24-hr period. 1 to 2 is LOW, 3 to 5 is MODERATE, 6 to 7 is HIGH or 8+ is VERY HIGH</small>

<b>Pollen</b>	<b>Temperature</b>
<b>LOW</b>	<b>Max. Day 29°C/84°F</b>
<small>This is a daily grass pollen forecast and may be LOW, MODERATE, HIGH or VERY HIGH.</small>	<b>Min. Night 17°C/62°F</b>
	<small>These are the minimum and maximum hourly temperatures predicted over a 24-hour period.</small>

Forecasts supported by funding from defra (www.defra.gov.uk) and EU FP7 PASODOBLE (www.myair-eu.org)



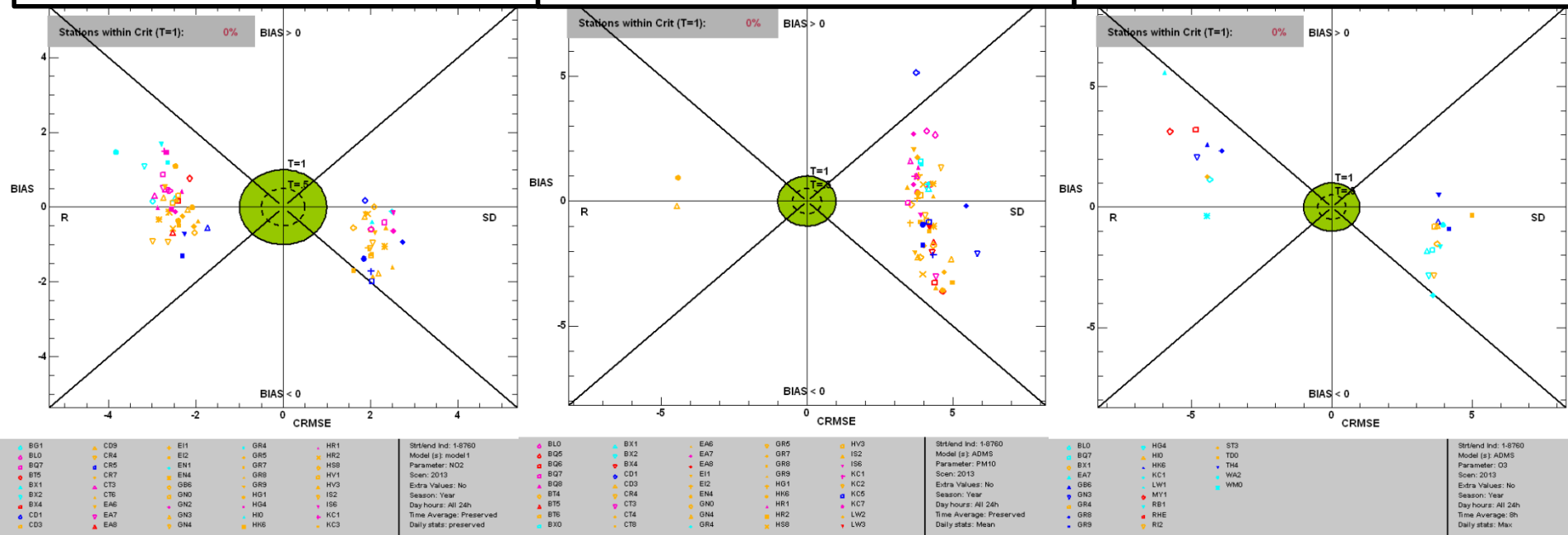
# Model performance (DELTA version 3.6)

- How well is *airTEXT* performing according to DELTA 3.6, using the 2013 dataset?

## NO<sub>2</sub> (1-hour daily maximum)

## PM<sub>10</sub> (24-hour daily average)

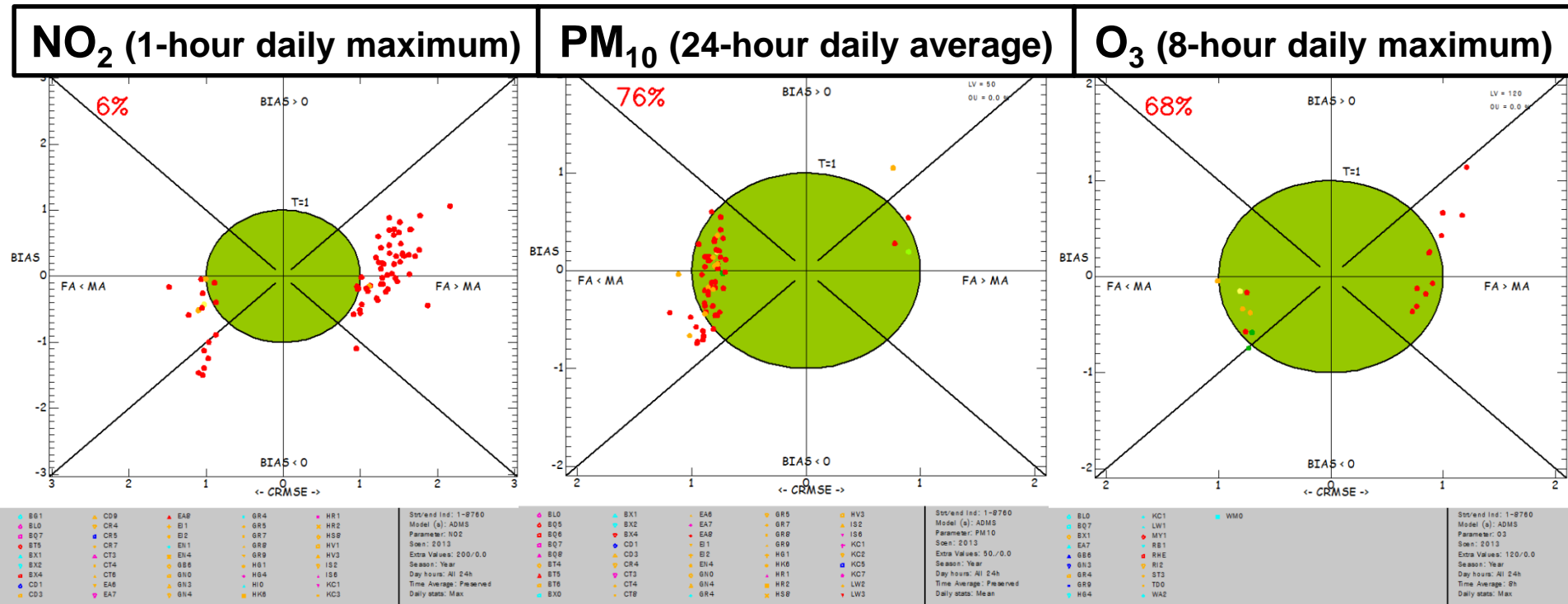
## O<sub>3</sub> (8-hour daily maximum)



- Terribly!!!

# Model performance (DELTA version 5.1)

- How well is *airTEXT* performing according to DELTA 5.1, using the 2013 dataset?

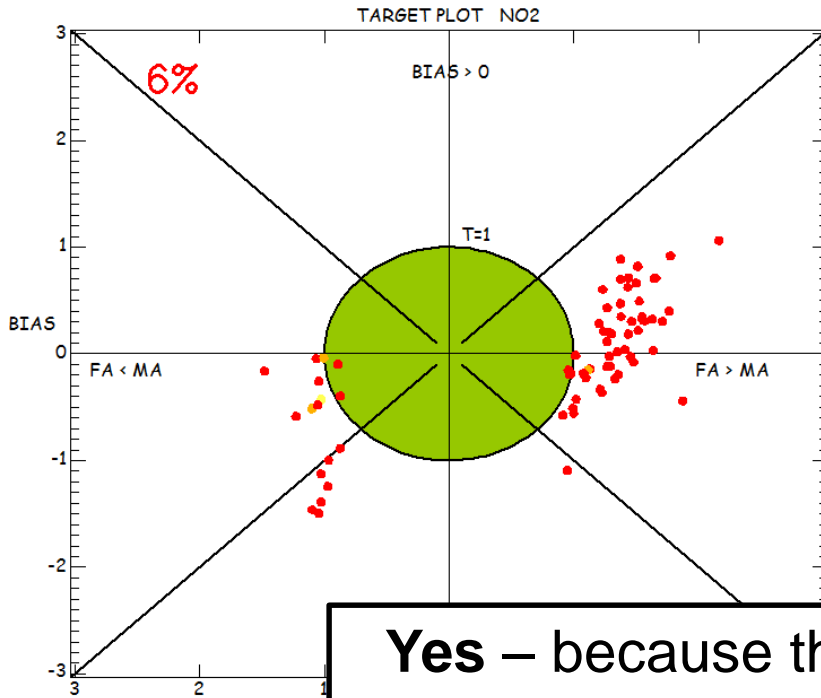


- Much better for version 5.1, but still not very well for the hourly objective: **NO<sub>2</sub> MAXIMUM DAILY VALUE**

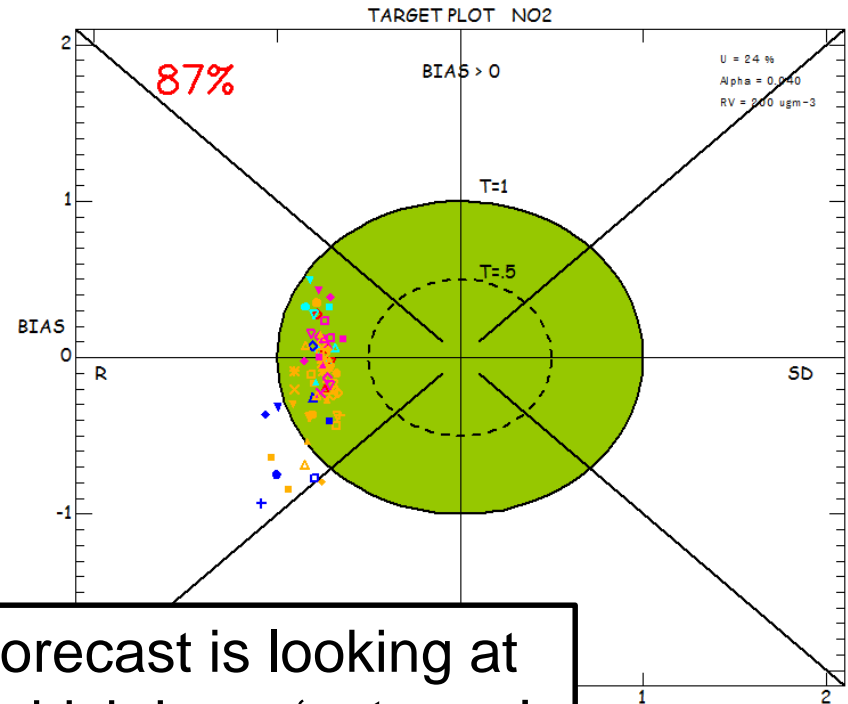
# Model performance (DELTA version 5.1)

- Does this poor performance make sense when the model performs well in the standard Target plot (same dataset)?

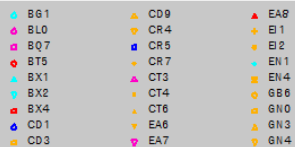
## NO<sub>2</sub> – Forecasting target



## NO<sub>2</sub> – Standard target



**Yes** – because the forecast is looking at the maximum daily, which is an ‘extreme’ statistic, compared to the hourly values analysed in the standard target



Strt/end Ind: 1-8760  
Model (s): ADMS  
Parameter: NO2  
Soen: 2013  
Extra Values: No  
Season: Year  
Day hours: All 24h  
Time Average: Preserved  
Daily stats: preserved

## Specific issues:

# Forecasts for more than one day ahead

- Target for forecasting applications is related to the forecast being as good as a persistence model:

$$\text{Target} = \frac{\sqrt{\frac{1}{N} \sum_{i=1}^N (M_i - O_i)^2}}{\sqrt{\frac{1}{N} \sum_{i=1}^N (O_{i-1} - O_i)^2}}$$

where N is the number of observations,  $M_i$  is the modelled value and  $O_i$  is the observed value.

- This works when you have made a forecast for today (Day 1, say) and you are comparing to measured data from yesterday (Day 0).



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- This works when you have made a forecast for today (Day 1, say) and you are comparing to measured data from yesterday (Day 0).
- Quite often, on Day 1, you also want to forecast for tomorrow, and the next day (Day 2 and Day 3). **You still only have the observation from Day 0.**
- The current Delta formulation:

$$\text{Target}_{\text{forecast\_ji}} = \frac{\sqrt{\frac{1}{N} \sum_{i=1}^N (M_{ji} - O_i)^2}}{\sqrt{\frac{1}{N} \sum_{i=1}^N (O_{i-1} - O_i)^2}} \text{ with } \_j = i - n, \dots, i$$

for Day 3 compares makes a comparison to the observations from Day 2. But on Day 1, you don't have the observations on Day 2 – only those from Day 0.

## Specific issues:

# Forecasts for more than one day ahead

- Suggestion: replace the proposed formulation with:

$$\text{Target}_{\text{forecast}_j} = \frac{\sqrt{\frac{1}{N} \sum_{i=1}^N (M_i - O_i)^2}}{\sqrt{\frac{1}{N} \sum_{i=1}^N (O_{i-j} - O_i)^2}}$$

where N is the number of observations,  $M_i$  is the modelled value, j is the forecast day and  $O_i$  is the observed value.

## Specific issues:

# Is the forecasting target formulation robust?

- Take:

$$\text{Target} = \frac{\sqrt{\frac{1}{N} \sum_{i=1}^N (M_i - O_i)^2}}{\sqrt{\frac{1}{N} \sum_{i=1}^N (O_{i-1} - O_i)^2}}$$

where  $N$  is the number of observations,  $M_i$  is the modelled value and  $O_i$  is the observed value.

- If you had a period where the levels of pollution remained the same on a **day by day basis** (either constant, or varying diurnally), then

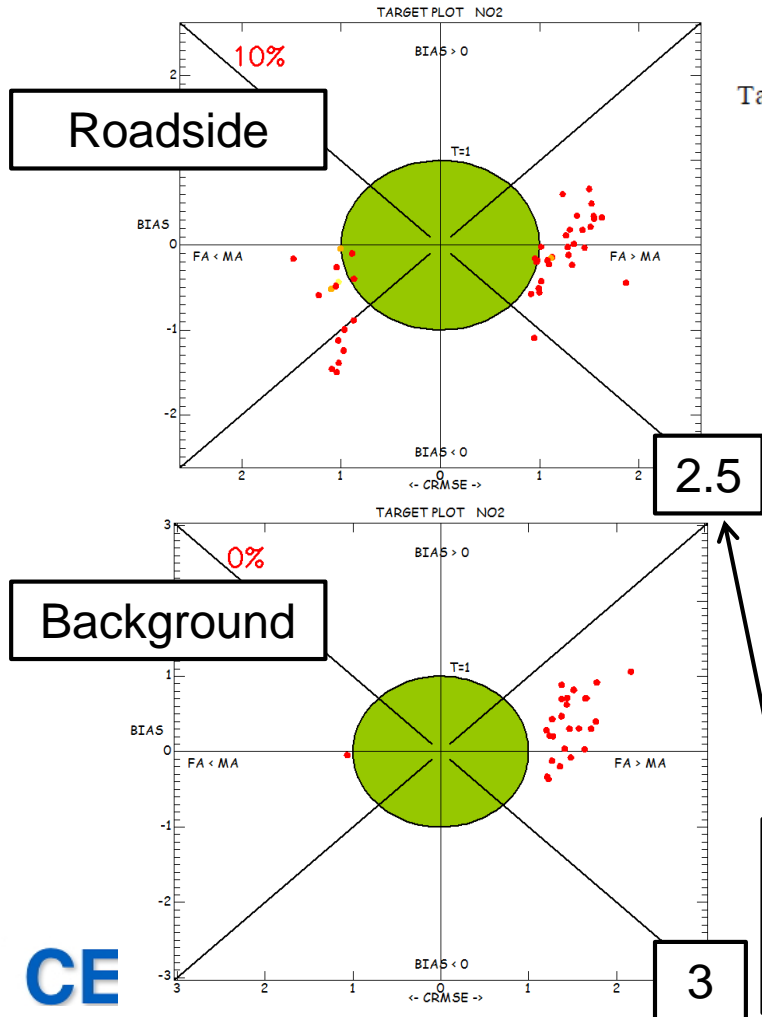
$$\frac{1}{N} \sum_{i=1}^N (O_{i-1} - O_i)^2 = 0$$

so the target  $\rightarrow$  infinity

# Specific issues:

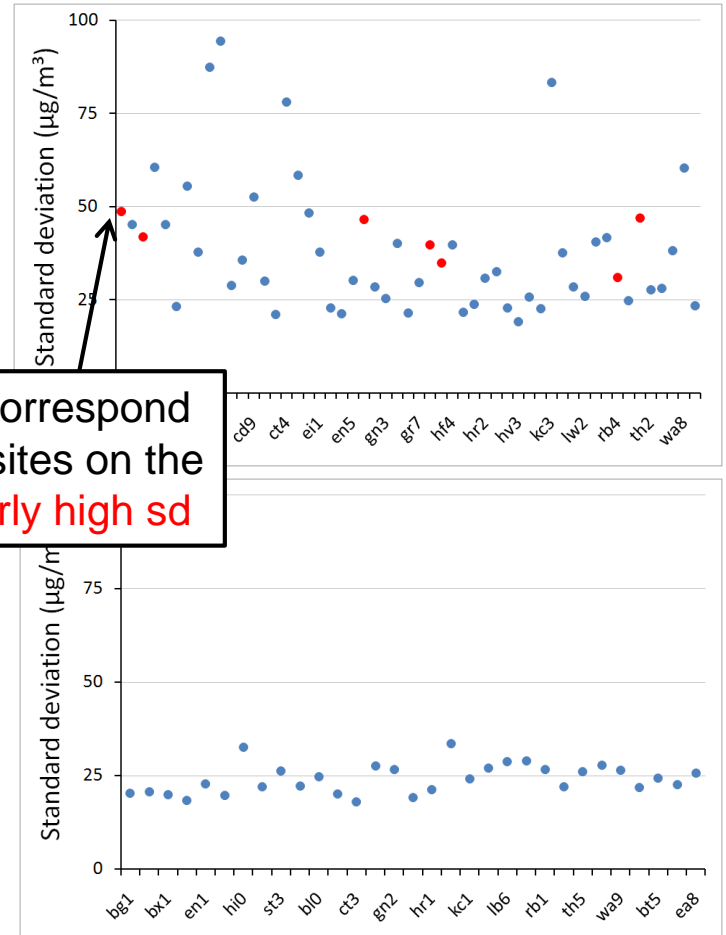
## Is the forecasting target formulation robust?

- This means that at background sites, it is more difficult to get within the target than at roadside sites, because the **standard deviation (sd)** of the **observations (looking at daily maximum NO<sub>2</sub>)** is lower.



$$\text{Target} = \frac{\sqrt{\frac{1}{N} \sum_{i=1}^N (M_i - O_i)^2}}{\sqrt{\frac{1}{N} \sum_{i=1}^N (O_{i-1} - O_i)^2}}$$

Sites in **red** correspond to the 7 best sites on the Target i.e. **fairly high sd**



Note different scale

## Specific issues:

# Is the forecasting target formulation robust?

- This means that at background sites, it is more difficult to get within the target than at roadside sites, because **the standard deviation (sd) of the observations (looking at daily maximum NO<sub>2</sub>)** is lower.
- Is it robust for the Target formulation to be independent on the sd of the observations?

$$\text{Target} = \frac{\sqrt{\frac{1}{N} \sum_{i=1}^N (M_i - O_i)^2}}{\sqrt{\frac{1}{N} \sum_{i=1}^N (O_{i-1} - O_i)^2}}$$

- The formulation for the standard Target plot includes the sd:

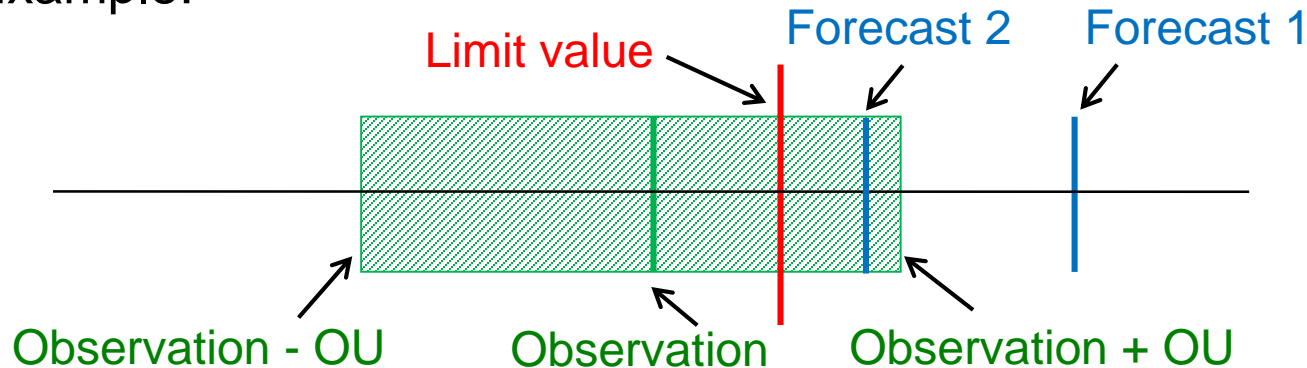
$$MQO = \frac{RMSE}{2RMS_U} = \frac{1}{2} \frac{\sqrt{\sum (O_i - M_i)^2}}{\sqrt{\sum U_i^2}} \leq 1$$

$$RMS_U = k u_r^{RV} \sqrt{(1-\alpha)(\bar{O}^2 - \sigma_0^2) + \alpha * RV^2}$$

- Persistence is a better option at background sites than at kerbside sites – are we happy with this to be part of the formulation?

## Specific issues: Uncertainty

- It is difficult to take into account uncertainty when considering alerts
- Example:



**Observation < Limit value BUT Observation + OU > Limit value**

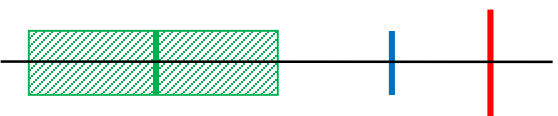
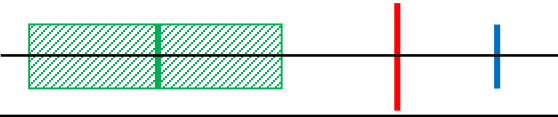
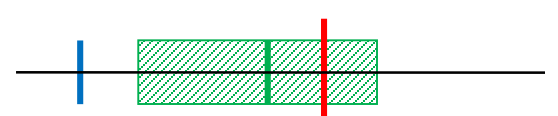



i.e. it is *possible* there should have been an alert

*Proposed Delta method gives*

- *Forecast 1 as a False Alert*
- *Forecast 2 as a Correct Alert*

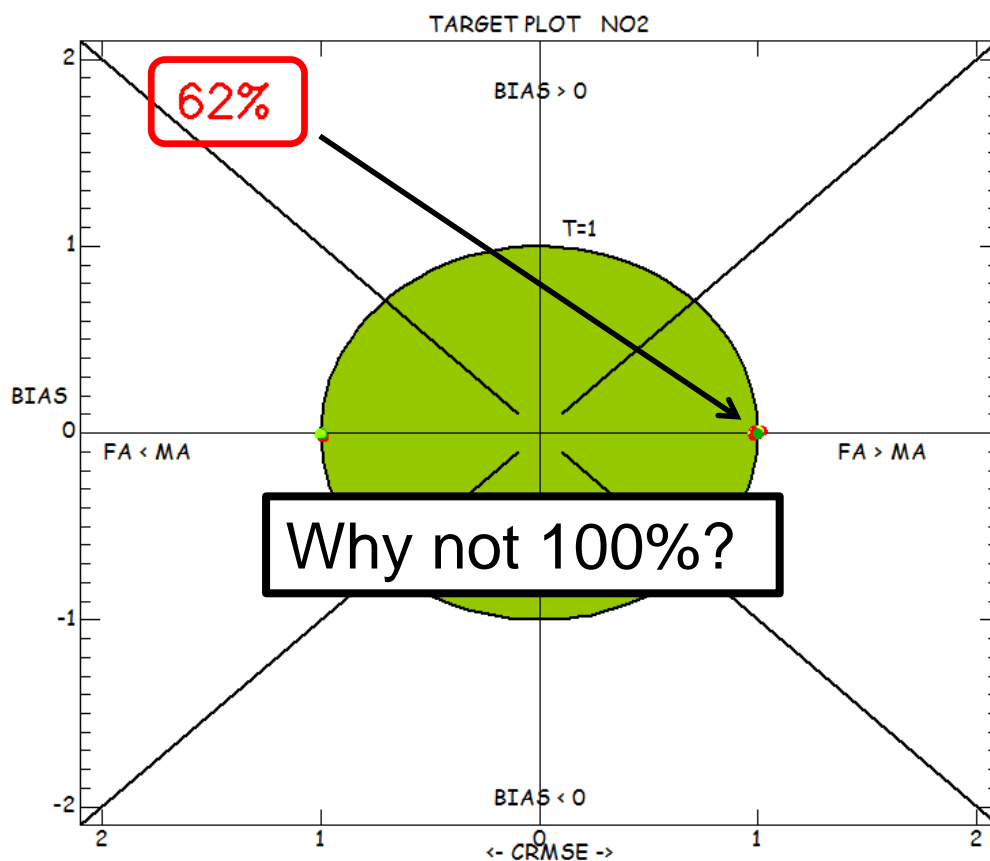
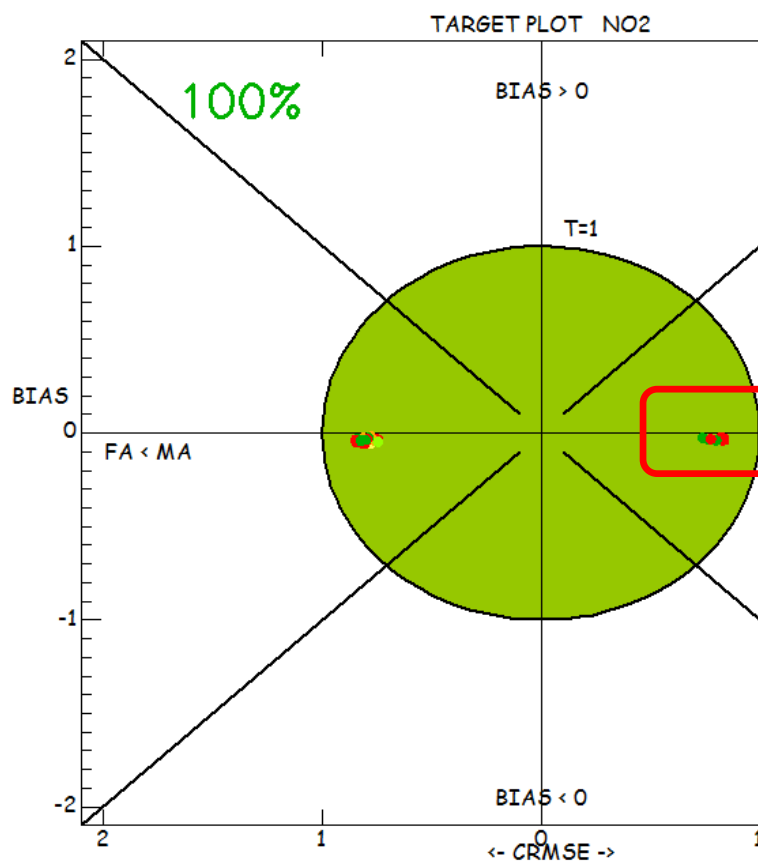
We would say this is incorrect because the methodology is taking into account biases, when it should be just looking at alerts

# Specific issues: Uncertainty – an alternative method?

Example case	Obs in relation to LV?	Obs alert?	Mod in relation to LV?	Mod alert?	Status
	$O_+ < LV$	No	$M < LV$	No	GA-
	$O_+ < LV$	No	$M > LV$	Yes	FA
	$O_- < LV$ & $O_+ > LV$	A: Yes (conservative) B: No (cautious) C: Same as model	$M < LV$	No	MA GA- GA-
	$O_- < LV$ & $O_+ > LV$	A: Yes (conservative) B: No (cautious) C: Same as model	$M > LV$	Yes	GA+ FA GA+
	$O_- > LV$	Yes	$M < LV$	No	MA
	$O_- > LV$	Yes	$M > LV$	Yes	GA+

# Specific issues: Accuracy of the persistence plots

- Persistence plot for NO<sub>2</sub>

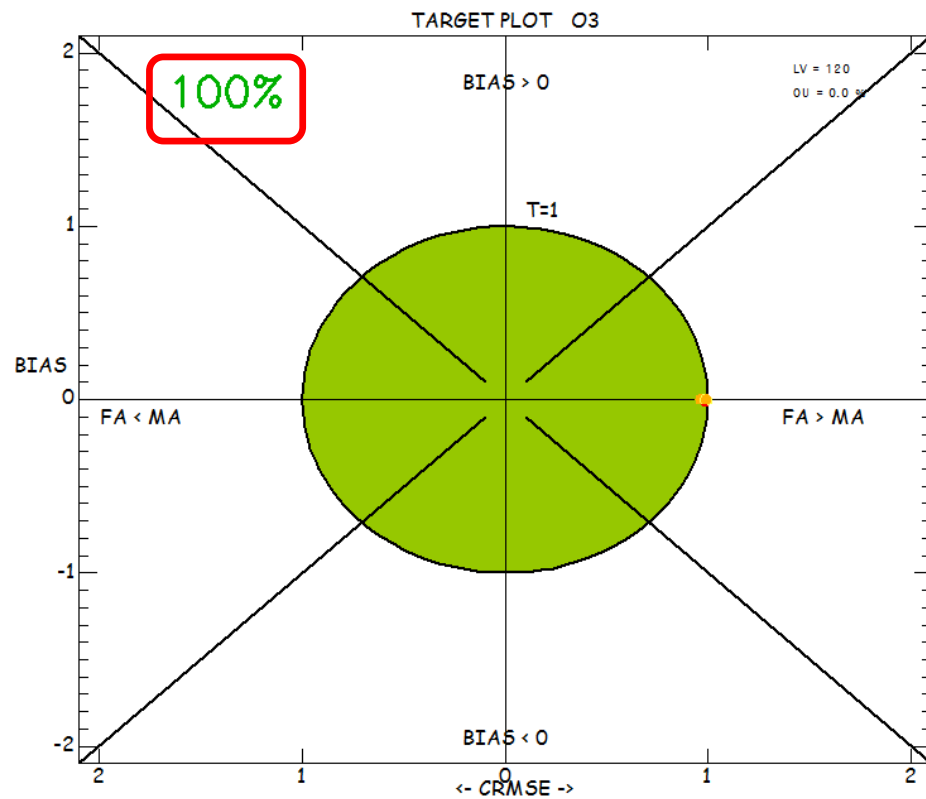
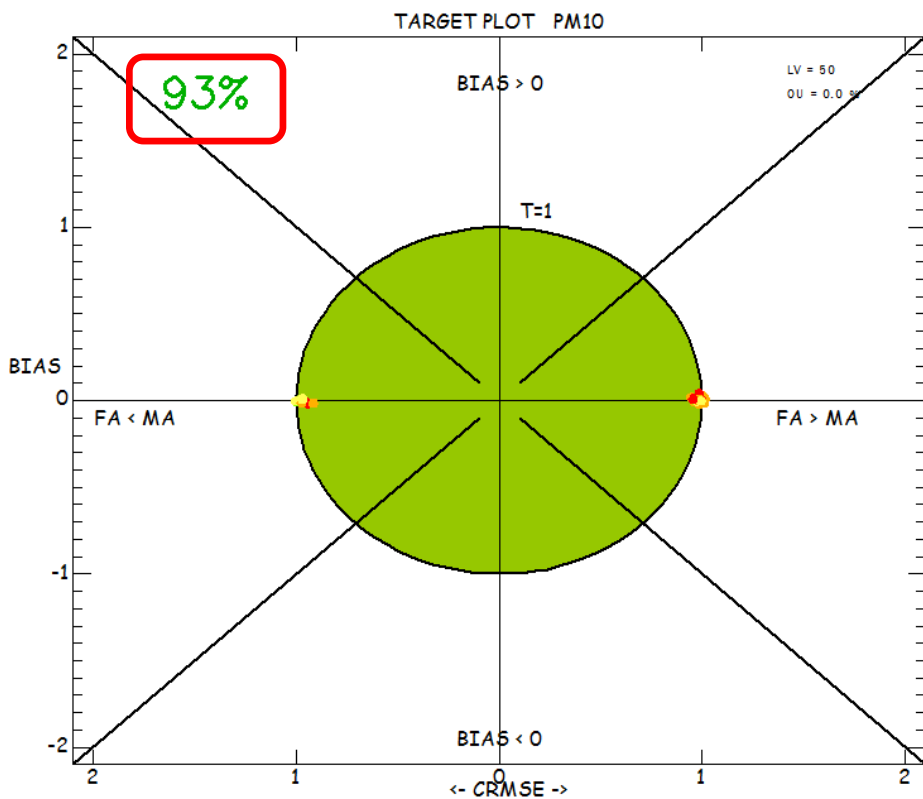


CD1	GN4	IS6	RB4	WM6	CD1	GN4	IS6	RB4	WM6	Strt/end Ind: 1-8760 Model (s): PERS Parameter: NO2 Year: 2013 Extra Values: 200/0.0 Season: Year Day hours: All 24h Time Average: Preserved Daily stats: Max
CD3	GR7	KC3	RHE	CD3	GR7	KC3	RHE	CD3	GR7	
CD9	GR8	KC4	RI1	CD9	GR8	KC4	RI1	CD9	GR8	
CR5	GR9	KC5	SK5	CR5	GR9	KC5	SK5	CR5	GR9	
CT6	HG1	LW1	ST6	CT6	HG1	LW1	ST6	CT6	HG1	
EA6	HK6	LW4	TK8	EA6	HK6	LW4	TK8	EA6	HK6	
EI1	HR2	ME1	WA7	EI1	HR2	ME1	WA7	EI1	HR2	
EI2	HS8	MY1	WA8	EI2	HS8	MY1	WA8	EI2	HS8	
GB6	IS2	RB1	WA9	GB6	IS2	RB1	WA9	GB6	IS2	



# Specific issues: Accuracy of the persistence plots

- Persistence plots for  $PM_{10}$  &  $O_3$



BL0	BX1	EA6	GR9	KC1
BQ5	BX2	EA7	HG1	KC2
BQ6	BX4	EA8	HK6	KC5
BQ7	CD1	BI2	HR1	KC7
BQ8	CD3	EN4	HR2	LW2
BT4	CR4	GR4	HS8	LW3
BT5	CT3	GR5	HV3	LW4
BT6	CT4	GR7	IS2	ME2
BX0	CT8	GR8	IS6	MY1

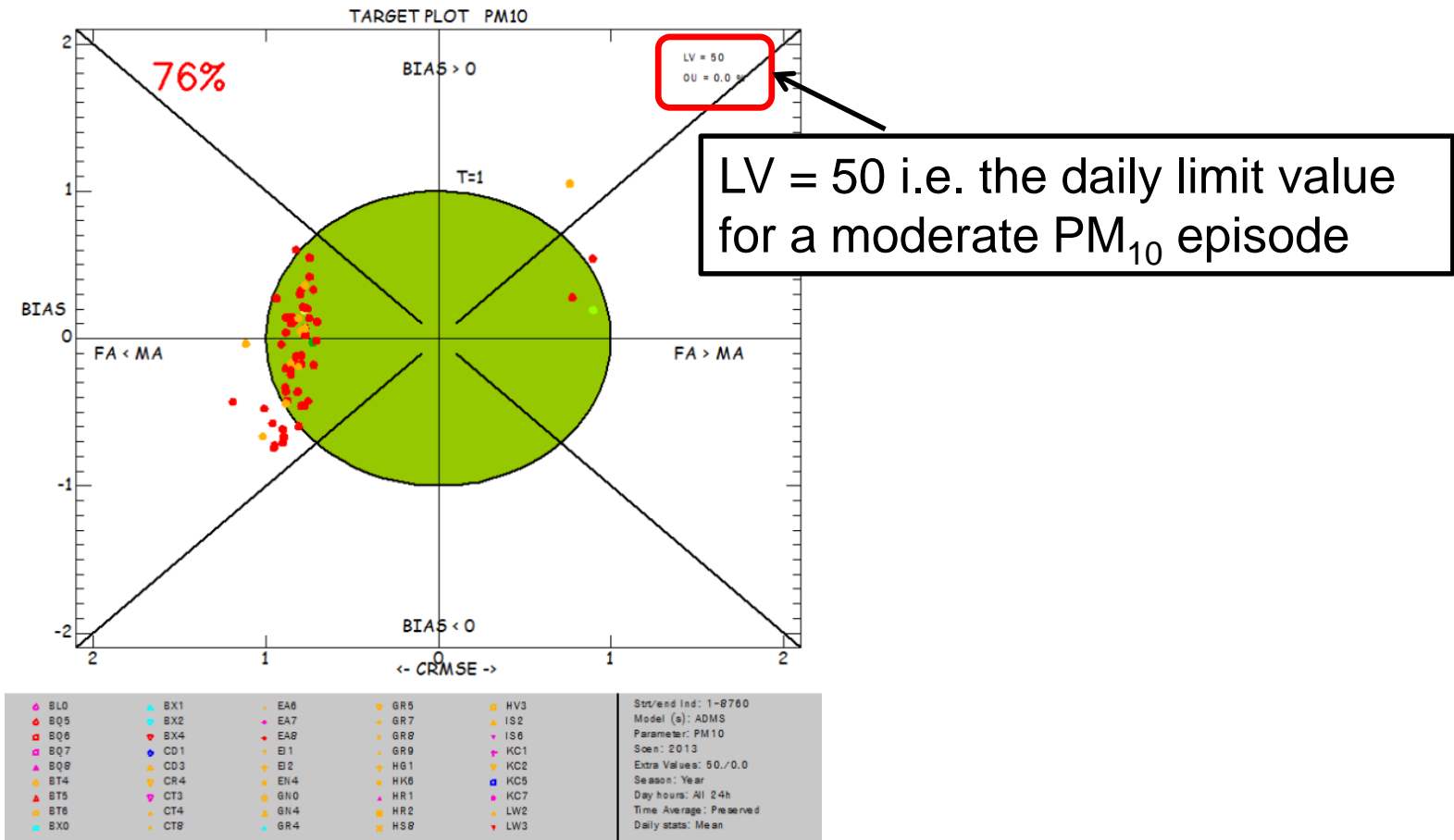
Strt/end Ind: 1-8760  
 Model (s): PERS  
 Parameter:  $PM_{10}$   
 Scen: 2013  
 Extra Values: 50./0.0  
 Season: Year  
 Day hours: All 24h  
 Time Average: Preserved  
 Daily stats: Mean

BQ7
EA7
GR4
HG4
KC1
RB1
RI2
TD0
WA2

Strt/end Ind: 1-8760  
 Model (s): PERS  
 Parameter:  $O_3$   
 Scen: 2013  
 Extra Values: 120./0.0  
 Season: Year  
 Day hours: All 24h  
 Time Average: 8h  
 Daily stats: Max

# Specific issues: Different alarm thresholds

- Forecast target diagram colouring and x-axis variation relate to a specific alert threshold:



## Specific issues: Different alarm thresholds

- Forecast target diagram colouring and x-axis variation relate to a specific alert threshold
- Usually there are a series of thresholds, eg Daily Air Quality Index (DAQI):

### Boundaries Between Index Points for Each Pollutant

Use the tabs below to view the bandings for each pollutant.

Ozone Nitrogen Dioxide Sulphur Dioxide PM2.5 Particles **PM10 Particles**

#### PM<sub>10</sub> Particles

Based on the daily mean concentration for historical data, latest 24 hour running mean for the current day.

Index Band	1	2	3	4	5	6	7	8	9	10
	Low	Low	Low	Moderate	Moderate	Moderate	High	High	High	Very High
µg/m <sup>3</sup>	0-16	17-33	34-50	51-58	59-66	67-75	76-83	84-91	92-100	101 or more

## Specific issues:

### Different alarm thresholds

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- Forecast target diagram colouring and x-axis variation relate to a specific alert threshold
- Usually there are a series of thresholds, eg Daily Air Quality Index (DAQI)
- Is there a way for the tool to calculate the target relating to all thresholds at the same time, rather than having to re-run for each pollutant and each threshold?

# Suggestions & minor issues

- Regarding suggestions for the Summary Performance Report:
  - For Alert thresholds, show
    - Probability of Detection
    - False Alarm Ratio
  - To assess performance against indices
    - Show % correct indices
    - Show % index values within  $\pm 1$  observed
- 'GA', 'GA+' & 'GA-' are not defined in the document
- The Forecast Target plot has a key that is now redundant
- Is there a way to output the actual statistics eg details of number of modelled & observed alerts, missed alerts, false alerts?
- The 'click and display site information' feature doesn't seem to be working on the Forecast Target plot
- Some of the Target plots have information in the top right hand corner, and some don't.

# Summary

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- London forecasting system performance is better with using Delta 5.1 compared to 3.6
- The Target formulation for forecasting may need further development, specifically with respect to:
  - Forecasts for more than one day ahead
  - Assessment of different types of station
  - Allowing for uncertainty in the alert thresholds
  - Accuracy of the persistence plots
- Various other suggestions and minor issues include:
  - POD, FAR and index performance in the Summary statistics
  - Improvements to the documentation
  - Click and display information not working on Target plot
  - Redundant key on Target plot
  - Inconsistency of key on Target plot
  - Output Alert statistics