Evaluation of local and regional air quality forecasts for London

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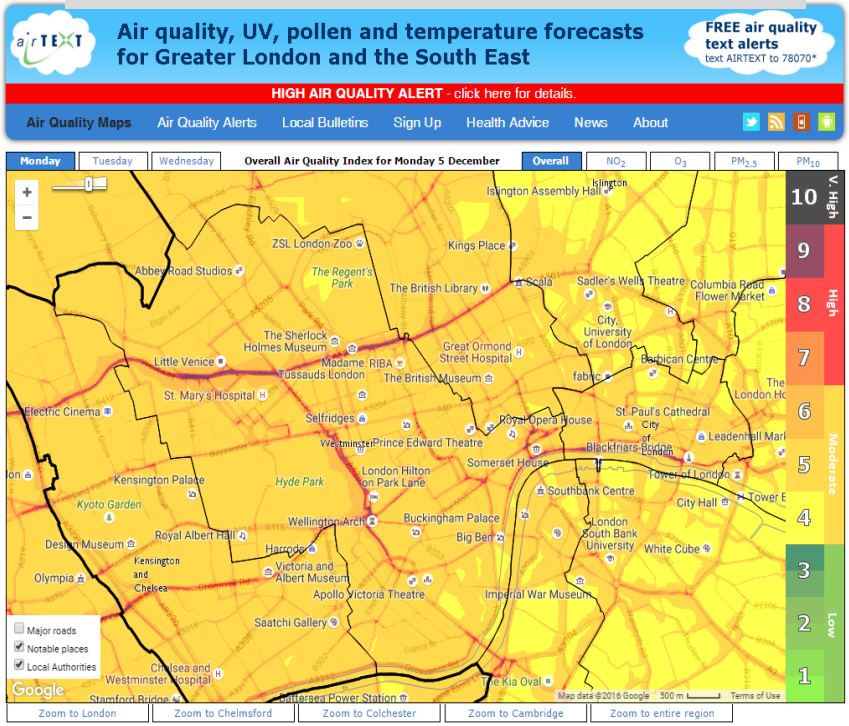
CERC
Cambridge Environmental Research Consultants
Environmental Software and Services

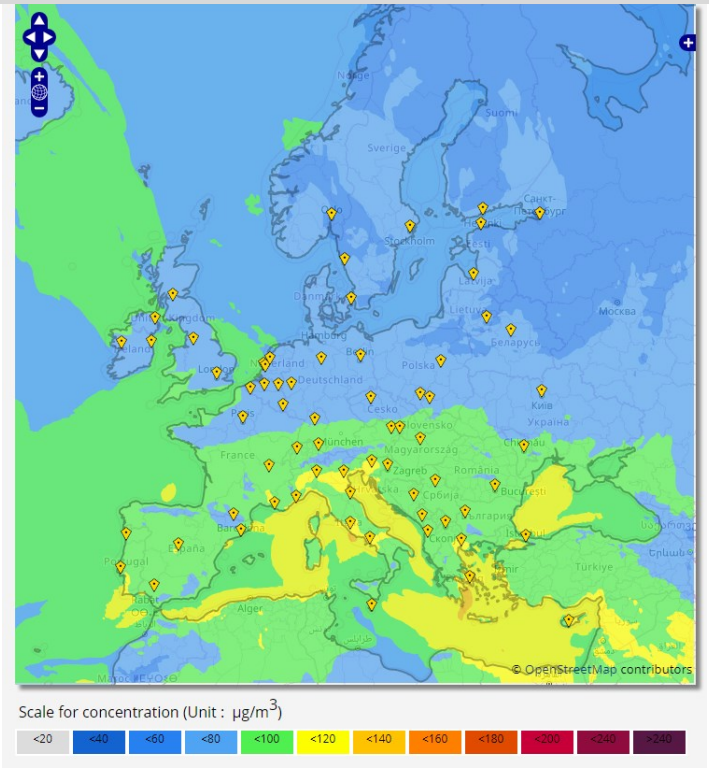
Motivation

- Air quality forecasting is an important application of pollution dispersion models
- *air*TEXT is a local air quality forecasting service that models local air pollution dispersion using CERC's ADMS-Urban model
- How does *air*TEXT compare with other available forecasts for London?

*air*TEXT: local air quality forecast



CAMS: regional air quality forecast



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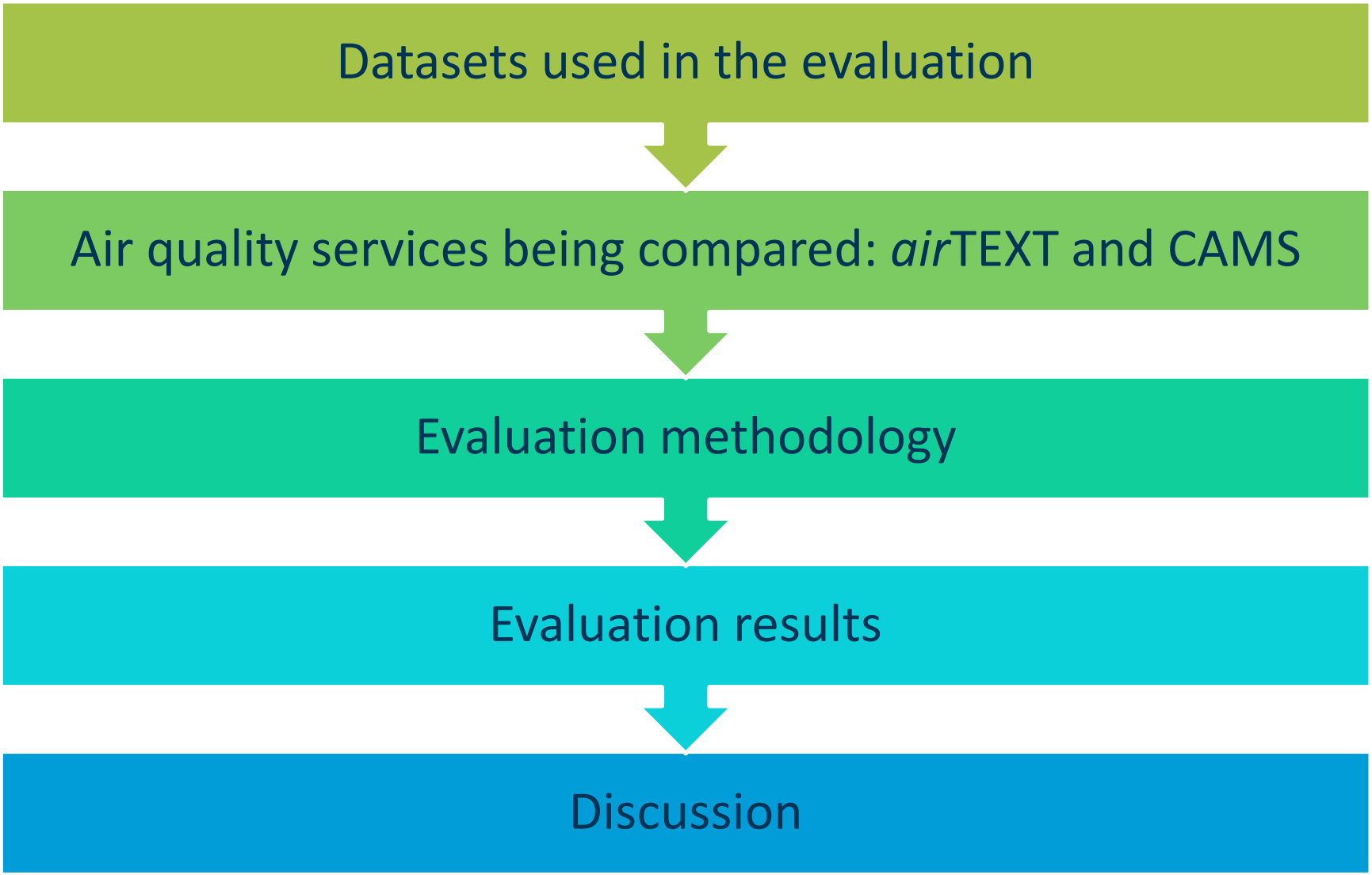
Overview of presentation



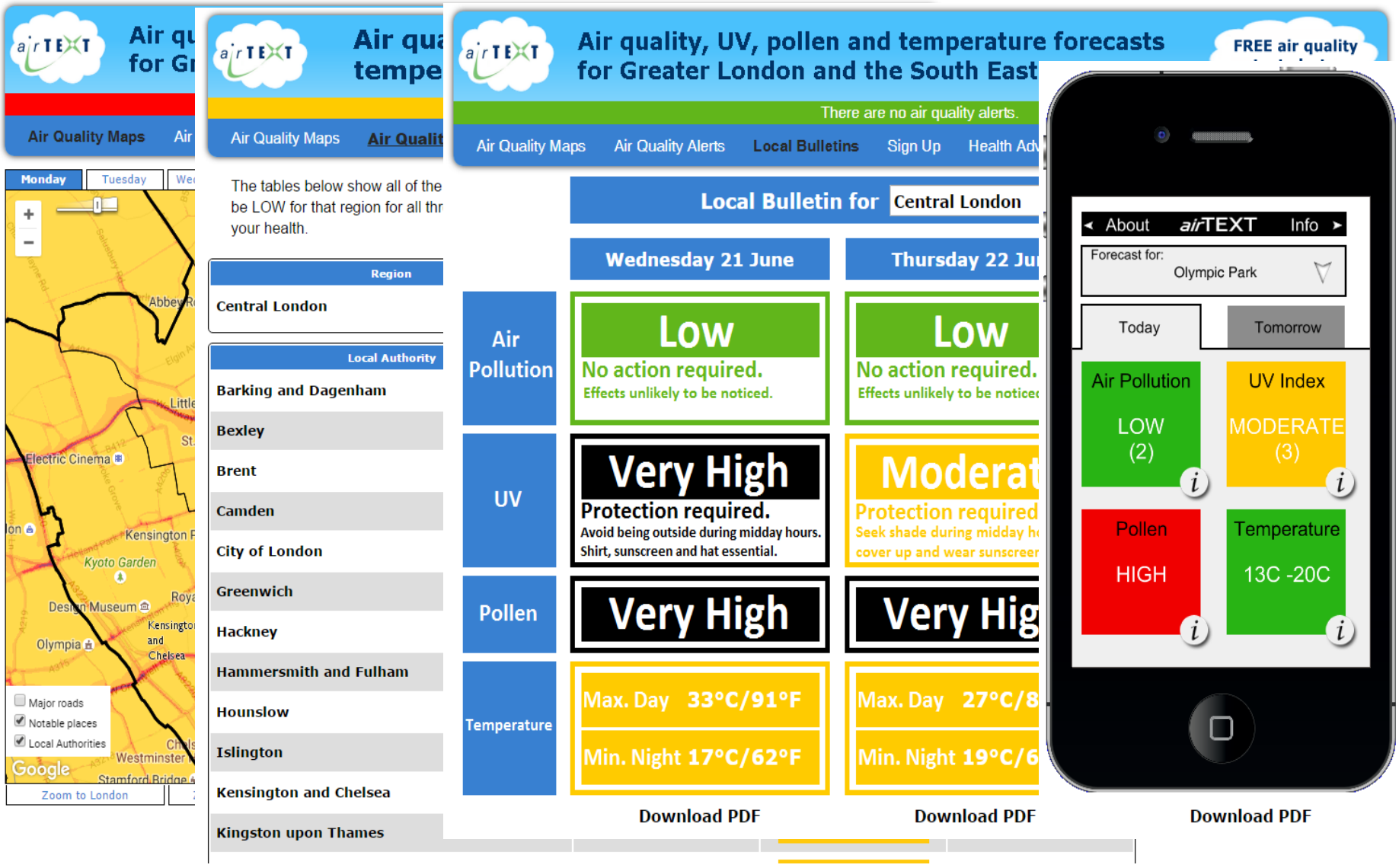
Datasets for Evaluation

- Three forecasting datasets have been evaluated during this exercise:
  - street-scale *air*TEXT forecast;
  - 'raw' CAMS forecast; and
  - 'adjusted' CAMS forecast
- Five months: February 2017 – July 2017
- Measured data from the London Air Quality Network

Number of measurement sites used in the evaluation exercise, by pollutant and site type

Site type	NO_2	O_3	PM_{10}	$PM_{2.5}$
Roadside	29	8	32	10
Suburban, urban background & industrial	21	8	19	6
Total	60	16	51	16

The London *air*TEXT Service



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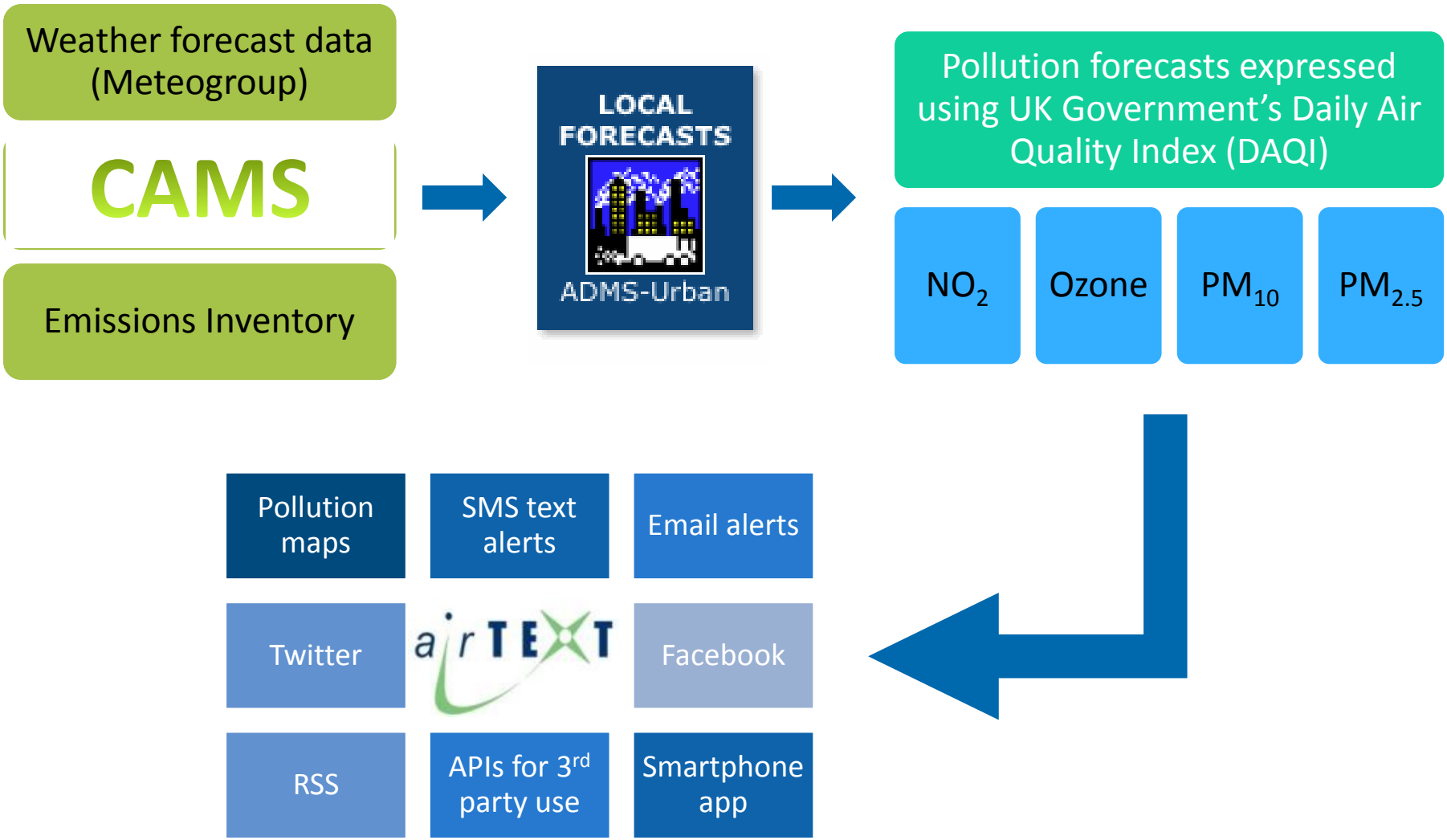
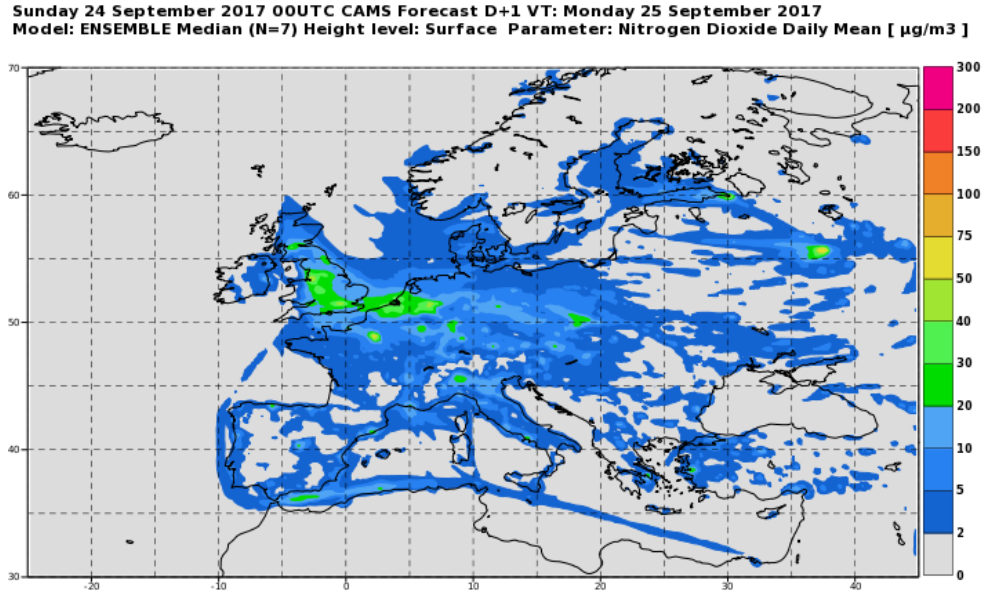


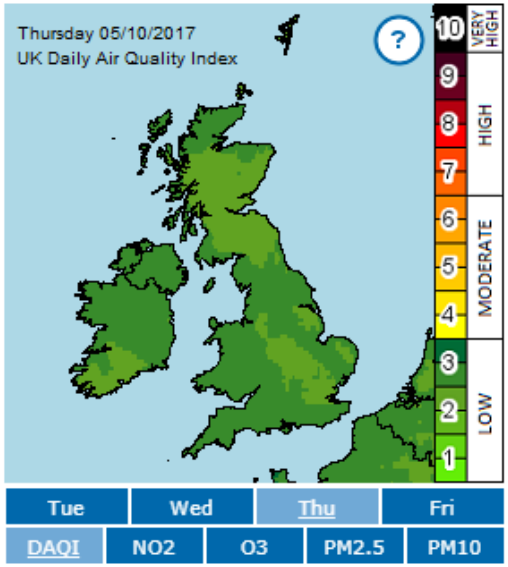
CAMS Regional Air Quality Forecast

- Hourly 96-hour forecasts of pollutants including NO_2, NO, O_3, PM_{10}, and $PM_{2.5}$ at 0.1° resolution on a domain covering all of Europe
- Regional-scale forecast derived from an ensemble of models that use varying degrees of data assimilation (in-situ and satellite)
- CAMS (adjusted) provides the “background” pollution levels for airTEXT

The CAMS forecast domain covers all of Europe



CAMS forecast for the UK displayed on the CERC website



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Adjustments to CAMS Forecast for airTEXT

Pollutant	'adjusted' CAMS concentration = $A_0 + A_1$ x 'raw' CAMS concentration	
	A_0 (µg/m³)	A_1 (-)
NO_2	1.40	0.77
O_3	0.22	0.89
PM_{10}	1.80	1.20
$PM_{2.5}$	3.70	1.20

- Model evaluation at rural monitoring sites for the south-east of England shows that the 'raw' CAMS ensemble model forecast includes some bias.
- Use regression analyses using historical datasets to calculate factors for linearly adjusting the 'raw' CAMS forecast to give an 'adjusted' CAMS dataset
- For south-east England,:
  - the 'raw' CAMS NO_2 and O_3 forecasts appear to be over-predicting by ~ 30% and ~ 12% respectively
  - the 'raw' CAMS particulate forecasts are under-predicting by ~ 17%.

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Evaluation Methodology

Model Evaluation Toolkit

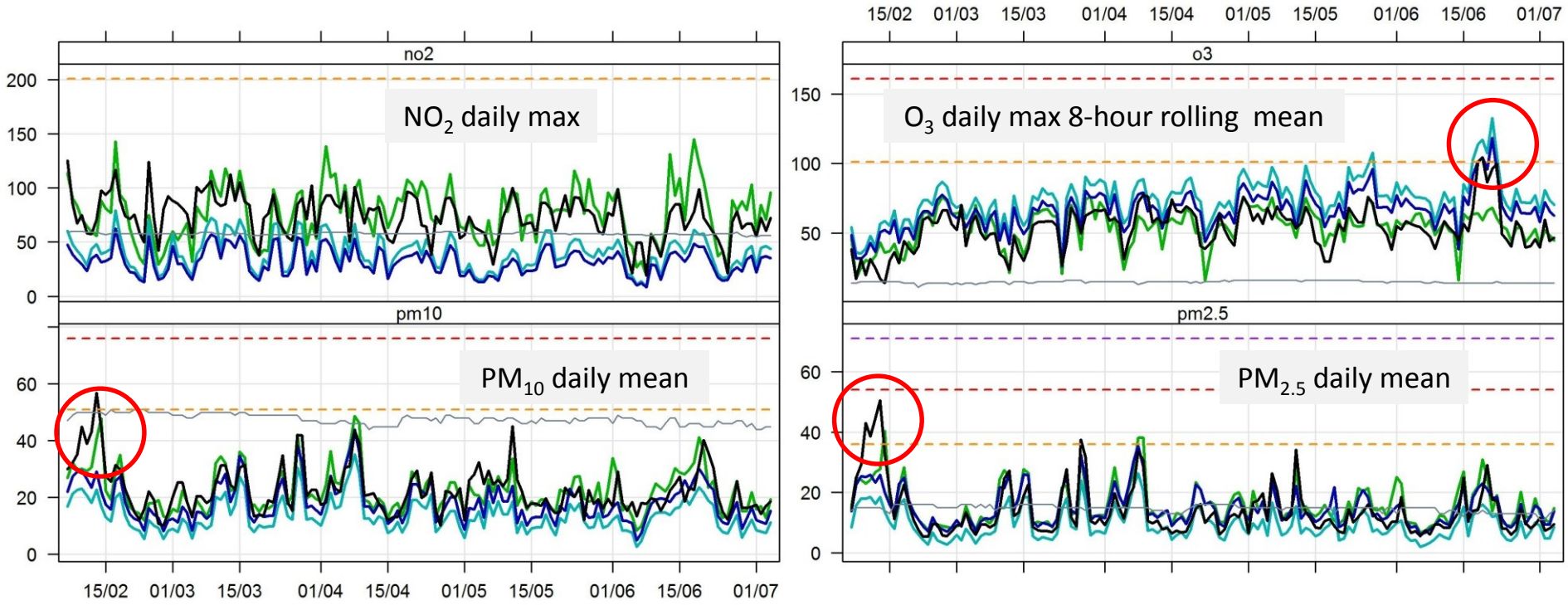
- Originally developed by CERC under FP7 PASODOBLE
- Free tool, open source
- Uses Openair tools
- Download from http://www.cerc.co.uk/modelevaluationtoolkit
- Evaluates both concentration and alert accuracy

DELTA Tool

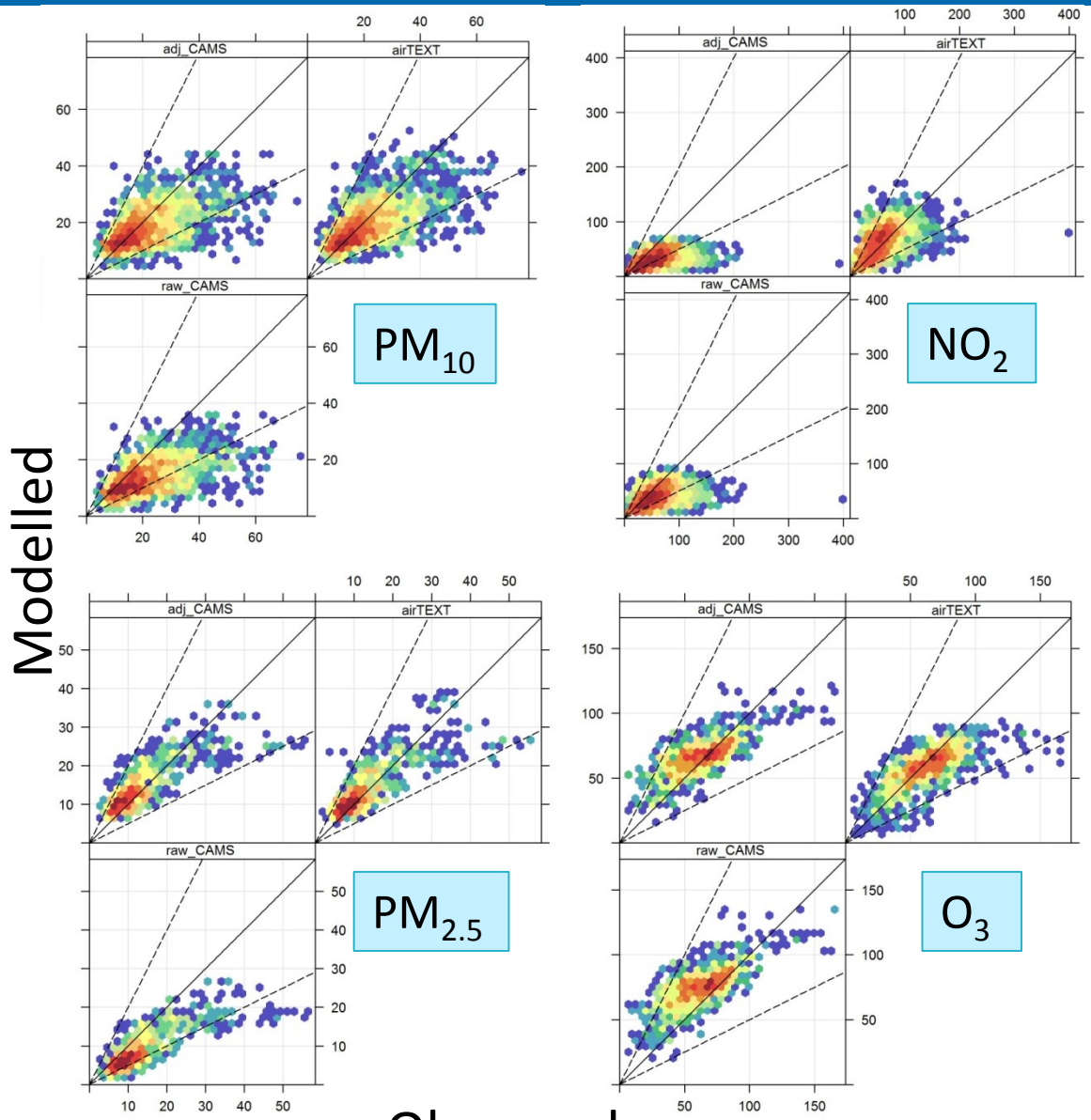
- Developed by JRC as part of the FAIRMODE initiative
- Download from http://fairmode.jrc.ec.europa.eu/downloads.html
- Forecast mode currently in development
- Accounts for observation uncertainty

Evaluation Results: Concentration (Toolkit)

Time series of daily concentration averaged over **all** monitoring sites (DAQI statistics)



Evaluation Results: Concentration (Toolkit)



Scatter plots of modelled vs observed daily statistics for **non-roadside sites only**

Pollutant	Statistic
NO_2	Daily max 1-hour
O_3	Daily maximum of 8-hour rolling average
PM_{10}	Daily average
$PM_{2.5}$	Daily average

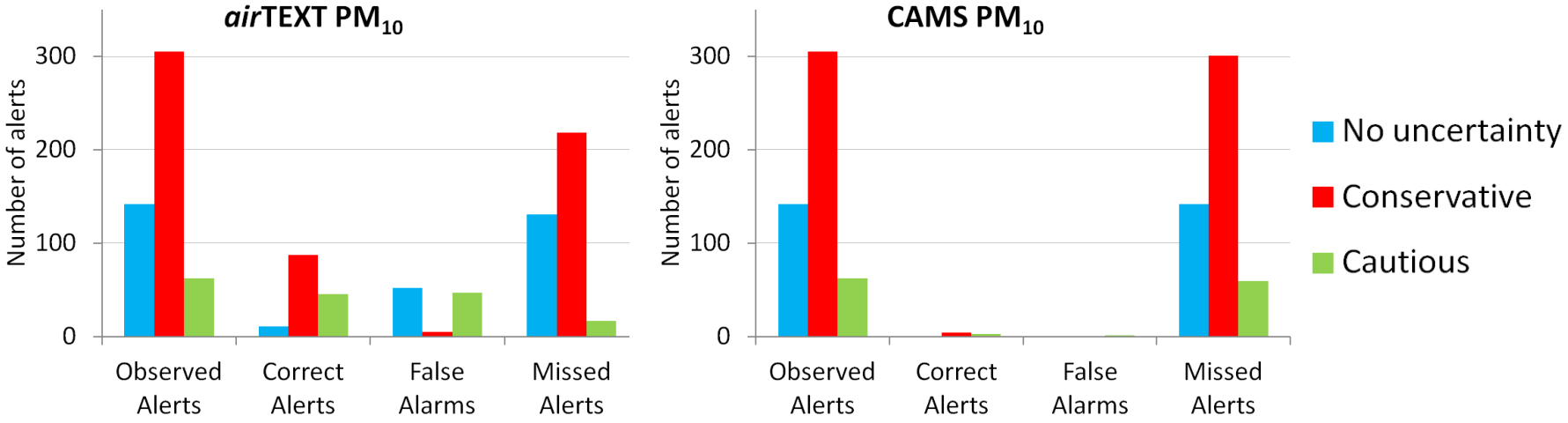
Evaluation Results: Concentration (Toolkit)

Pollutant (daily statistic)	Sites	Average concentration				Model evaluation statistics								
		Obs. (µg/m³)	Modelled (µg/m³)			FAC2			NMSE			R		
			airTEXT	'raw' CAMS	'adjusted' CAMS	airTEXT	'raw' CAMS	'adjusted' CAMS	airTEXT	'raw' CAMS	'adjusted' CAMS	airTEXT	'raw' CAMS	'adjusted' CAMS
NO_2 (max 1-hour)	non-road	56.3	61.7	39.6	31.9	0.85	0.78	0.65	0.23	0.46	0.74	0.54	0.43	0.43
	all	73.6	77.3	39.8	32.1	0.87	0.56	0.45	0.20	0.82	1.23	0.63	0.38	0.38
O_3 (max 8-hour rolling)	non-road	62.4	58.1	75.0	66.9	0.95	0.93	0.95	0.08	0.08	0.06	0.69	0.73	0.73
	all	53.5	54.1	74.6	66.7	0.92	0.79	0.85	0.09	0.19	0.13	0.69	0.62	0.62
PM_{10} (average)	non-road	21.3	19.3	13.7	18.2	0.92	0.76	0.89	0.19	0.48	0.24	0.63	0.56	0.56
	all	22.8	22.5	13.7	18.3	0.93	0.71	0.89	0.16	0.52	0.24	0.62	0.59	0.59
$PM_{2.5}$ (average)	non-road	13.9	14.4	9.3	14.9	0.97	0.83	0.96	0.14	0.40	0.14	0.80	0.80	0.80
	all	13.9	16.0	9.3	14.9	0.92	0.82	0.93	0.17	0.41	0.15	0.77	0.80	0.80

Evaluation Results: Alerts (DELTA)

DELTA Tool accounts for observation uncertainty

- 'conservative' approach: if accounting for measurement uncertainty results in the possibility of a threshold exceedance, then assume that an exceedance did occur
- 'cautious' approach: if there is the possibility that an exceedance did not occur, then assume that it did not occur

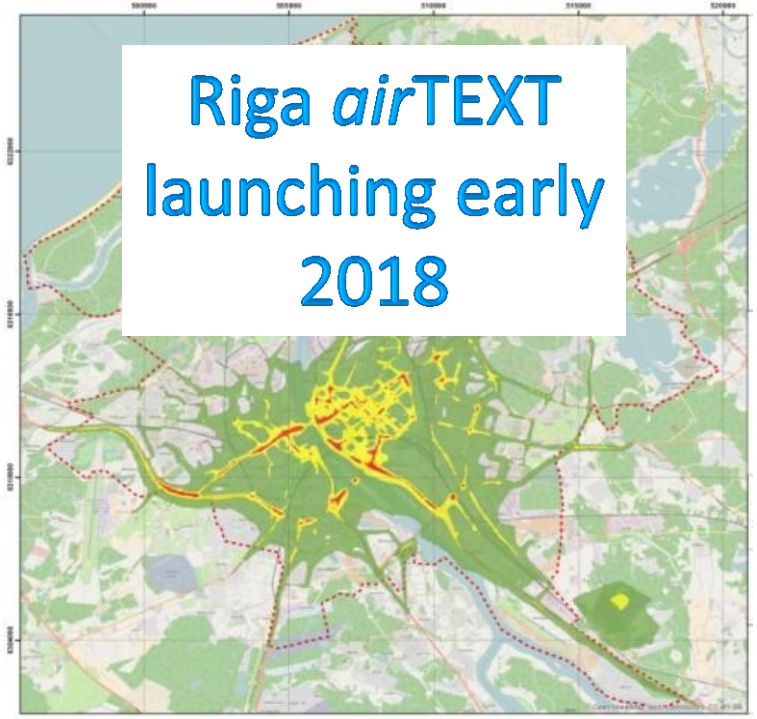


Number of observed, correct, false and missed PM_{10} moderate alerts for *air*TEXT and CAMS with ('Conservative' & 'Cautious') and without ('No uncertainty') accounting for measurement uncertainty; data for all sites presented.

Discussion

- No major air pollution episodes occurred during this period in the south-east of England
- In this evaluation, *air*TEXT performs better than the regional-scale CAMS forecasts for all pollutants considered
- NO_2: Main source in urban areas is traffic – need to model roads at high resolution to capture steep gradients
- O_3: Solely a secondary pollutant, strongly influenced by local CAMS. Mixed picture – generally *air*TEXT better, due to local titration (CAMS tends to overpredict), but *air*TEXT missed June episode caused by local ozone generation in very hot weather
- PM_{10}: Again regional component is significant. CAMS underestimates, but adjustment leads to good *air*TEXT prediction.
- $PM_{2.5}$: influenced both by long-range transport and local emissions sources. The 'raw' CAMS forecasts are lower than measured values, but the current 'adjusted' CAMS forecast is a slight over-prediction, which leads to a small over-prediction of *air*TEXT
- Alerts: one particulate concentration episode at the beginning of the evaluation period. CAMS missed the episode leading to an under-prediction by *air*TEXT, although the local forecast predicted some elevated PM_{10} values

*air*TEXT Service Evolution: Expansion e.g. Riga



Ministry of Environmental Protection and Regional Development of the Republic of Latvia

Thank you for listening