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Developing high-resolution surface analyses from bias corrected home AWS data

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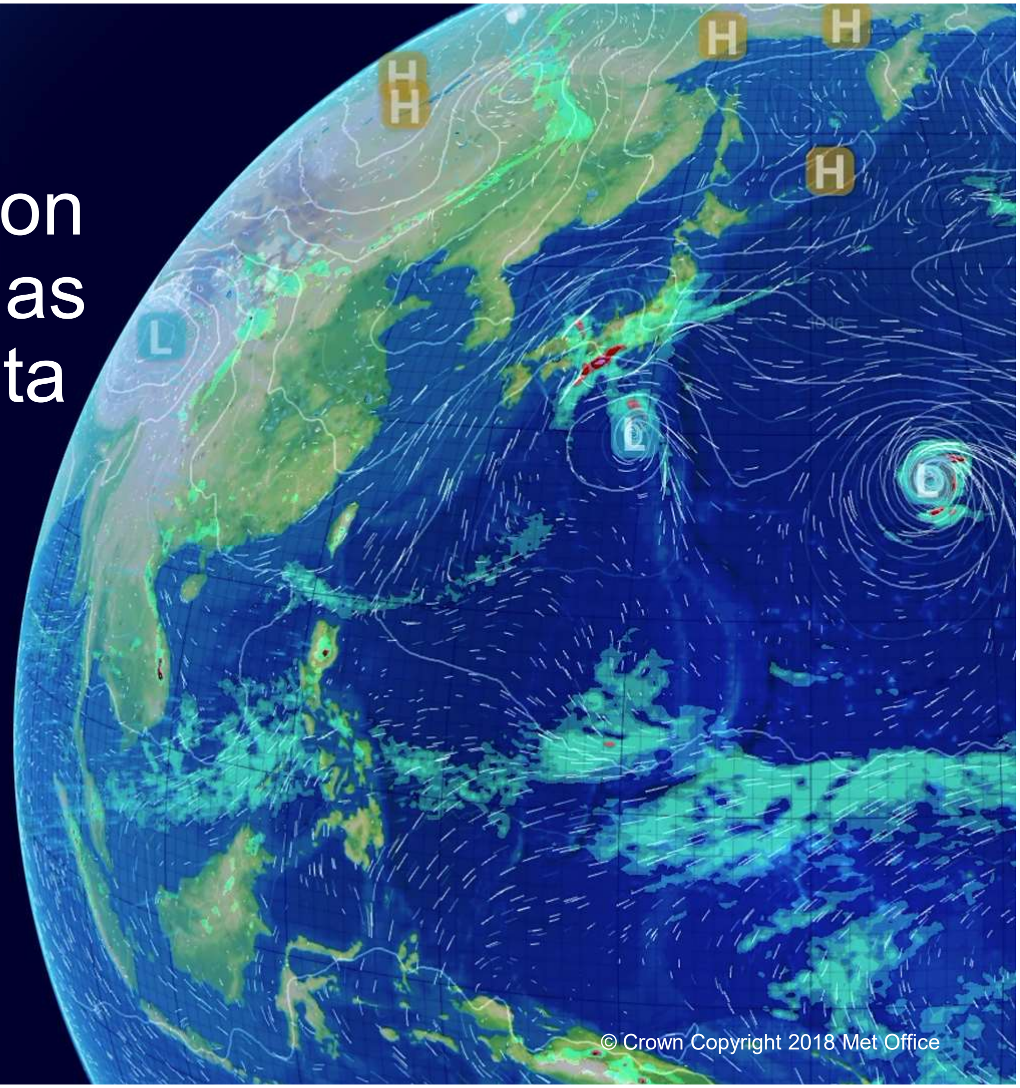

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Outline

- WOW overview
- WOW bias correction
- Case study
- Summary and future work

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WOW overview

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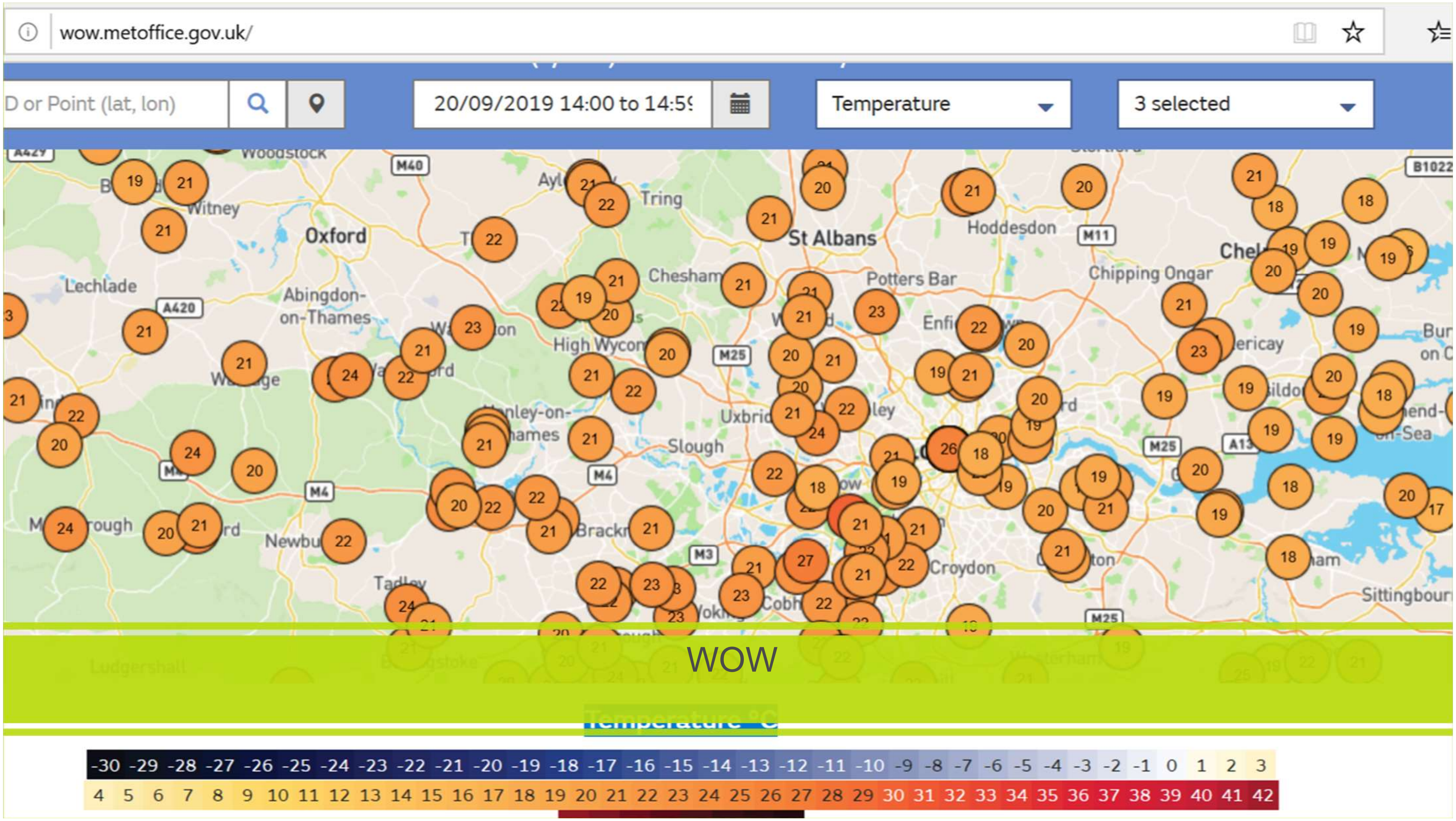
WOW

- In 2011 the Met Office launched the Weather Observations Website (WOW; wow.metoffice.gov.uk), a platform for the collection and archival of 'home' Automatic Weather Station (AWS) data.
- The word 'home' is used to highlight that data come mainly from privately owned stations that are not part of the Met Office's official surface observing network.
- At the time of writing, over 1,000 sites are registered on the WOW website within the UK. Furthermore, collaboration with other National Meteorological Services has resulted in the addition of many sites in other countries including the Netherlands, Belgium and Australia.

WOW


wow.metoffice.gov.uk/
D or Point (lat, lon)
20/09/2019 14:00 to 14:5
Temperature
3 selected
Oxford
St Albans
Tring
Witney
Hoddesdon
Lechlade
Abingdon-on-Thames
Chesham
Potters Bar
Chipping Ongar
High Wycom
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Uxbrid
Croydon
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4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42

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WOW photographs

- The WOW website supports both automated upload of AWS data and user-input of manual and/or qualitative reports, or text-based impact reports and photographs during severe weather events.

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WOW bias correction

- During 2016 and 2017, an automated technique for the bias correction of home AWS data was developed.
- Biases are estimated by comparison with data from neighbouring stations in the Met Office's official observing network.
- The bias correction methodology requires no prior knowledge of the data quality at each home AWS site, or of the AWS situation and exposure.
- It can therefore be applied to data from any home AWS site, provided that there is an official surface network (or some other reference) against which to make comparisons.

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WOW surface analysis

- Surface analyses are generated by interpolation of the bias-corrected WOW data, and a subset of the Met Office official station data (~80 stations that send data to the Met Office headquarters in real-time), onto a 4 km Cartesian grid.

- Given that there are many more stations in the WOW network than in the official observing network, the resulting analyses have the potential to provide a more detailed picture of mesoscale weather phenomena, which could be of benefit to nowcasting operations (i.e. short-term forecasts up to 6 hours ahead).

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Forecaster trial

- During summer 2018, WOW surface analyses were supplied to Met Office forecasters as part of a trial suite of new nowcasting products.
- The overriding aim of the trial was to improve the locational accuracy and timeliness of severe weather warnings, especially in severe thunderstorm events.

WOW bias correction

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WOW Bias Correction – 3 steps

- Correction of the home AWS data is a three-step process, comprising:
- 1) filtering to remove lower quality data (e.g. unrealistic or unphysical values, very noisy data),
- 2) bias-correction of the remaining data by comparison with neighbouring Met Office stations over a 72-hour period ending near analysis time,
- 3) final checking of the bias-corrected data by re-comparison with the Met Office station data.

WOW Bias Correction 1st step: filtering

- The filtering stage uses pre-defined thresholds for each parameter.
- Where a parameter value exceeds a threshold, data from the given station and given parameter are not included in the analysis.
- For example, in the case of temperature, data are excluded when one or more values over the 72-hour comparison period falls outside of current UK record temperature extremes.

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WOW Bias Correction 1st step: filtering

- Noisy data are identified by looking for many occurrences of step changes greater than a predetermined threshold value.

- Unusually frequent occurrences of large step changes are often associated with non-standard AWS siting (e.g. sheltering of the wind vane by obstacles upstream), sensor degradation or malfunction, or very low output resolution.

- A small number of large step changes are permitted, since large step changes may occasionally be genuine (and could, for example, be associated with some of the severe weather events of interest).

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Bias Correction 2nd step: SYNOP comparison

- The bias correction methodology is parameter dependent, but always relies on comparison with hourly SYNOP data from neighbouring Met Office surface stations. The SYNOP data are considered to be the reference (WMO data standards, station metadata well-documented).

- The home AWS bias is assumed to be equal to the difference between the SYNOP measurement and the home AWS measurement

- Strictly, this is a relative bias, because the SYNOP measurements are themselves subject to uncertainty in certain circumstances. However, the SYNOP bias should normally be small compared to the home AWS bias.

Bias Correction 2nd step: comparison period

- A 72-hour period is used for comparison because this greatly exceeds the typical lifetime of the mesoscale weather phenomena that the analyses are designed to capture.
- These mesoscale phenomena may result in transient differences between the home AWS and neighbouring SYNOP values that are not representative of the longer-term home AWS bias
- Use of a 72-hour comparison period ensures that these transient differences do not impact substantially on the calculated mean biases.

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WOW Bias Correction algorithm

- The bias-correction algorithm runs every 30-minutes.

- The latest results (i.e. a set of corrections) are then applied to current home AWS data every 10 minutes, from which the gridded analyses are generated ~15 minutes behind real time.

- A key feature of the methodology is that, whilst mean biases are removed, the home AWS data are otherwise unconstrained, so that they can reflect local, short-term variability in conditions at analysis time, even if this results in large instantaneous differences between the home AWS and neighbouring SYNOP station parameter values.

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WOW Bias Correction – one weakness

- One weakness is that the technique assumes conditions over the past 72-hours to be similar to those at analysis time. Where this is not the case, the analyses are likely to contain residual biases.

- An example is a situation with two or three sunny, calm days, followed by cloudy, windy conditions at analysis time.

- Afternoon warm biases are likely to be overestimated at analysis time in this situation because the magnitude of warm biases in many radiation shields depends strongly on the global radiation and wind speed, with biases increasing with increasing radiation and decreasing wind speed (e.g. Hubbard et al., 2001; Lin et al., 2001; Erell et al., 2005).

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WOW Bias Correction – variables and stats

- Bias-correction techniques have so far been developed for temperature, dew-point temperature, mean sea level pressure (MSLP), wind speed, and wind direction.

	Temperature	*Dew-point temperature*	*Wind speed and direction*	*MSLP*
Mean number of WOW sites contributing to analysis	547	425	216	197
Mean percentage of WOW sites contributing to analysis, out of all WOW sites providing data at analysis time	66.4	52.7	33.3	42.2
Number of official Met Office stations recording each parameter in the UK	260	260	170	130

WOW case study

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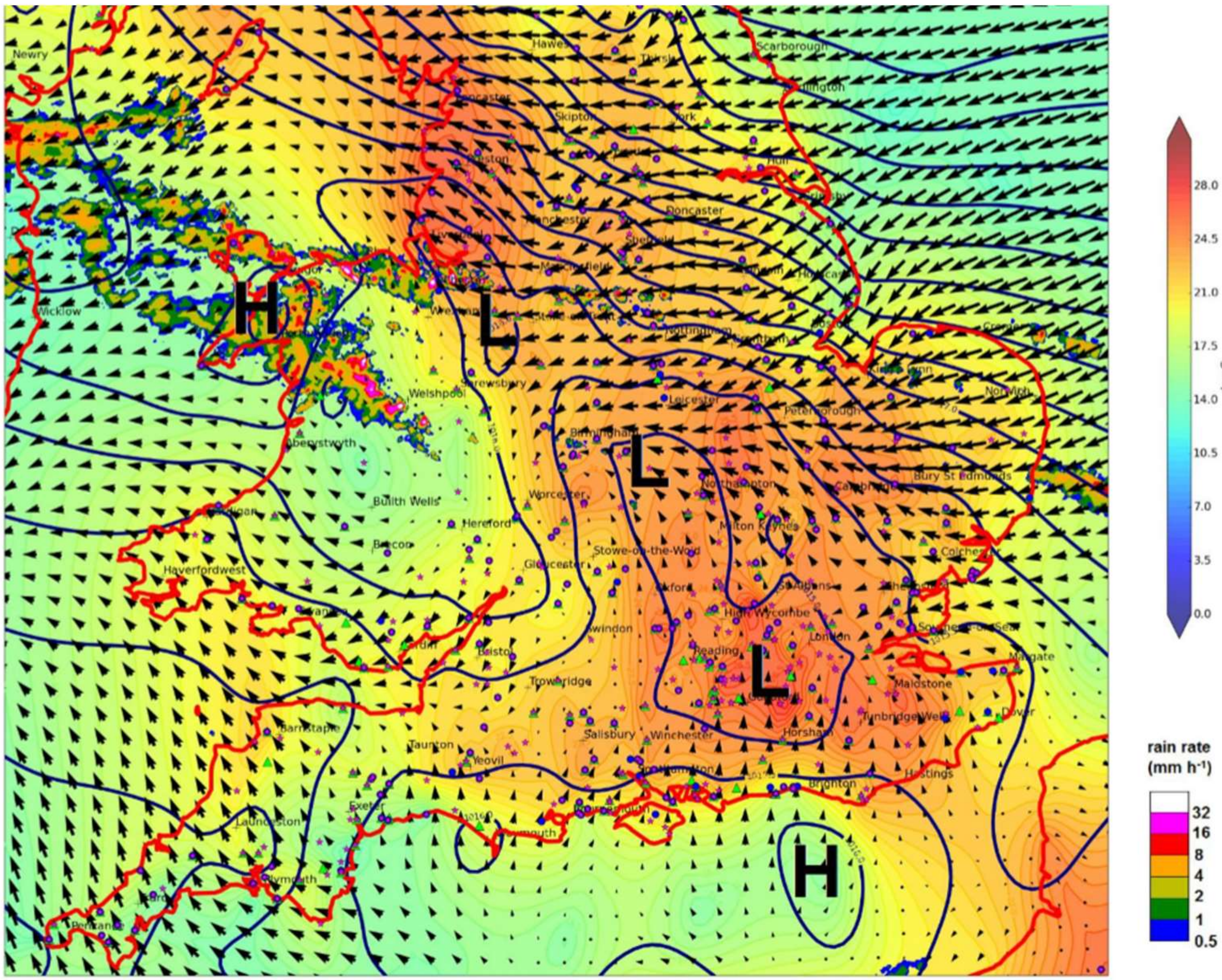
Case study – 27th May 2018

- During the afternoon of 27 May, a cluster of severe thunderstorms produced flash flooding in the Birmingham area.

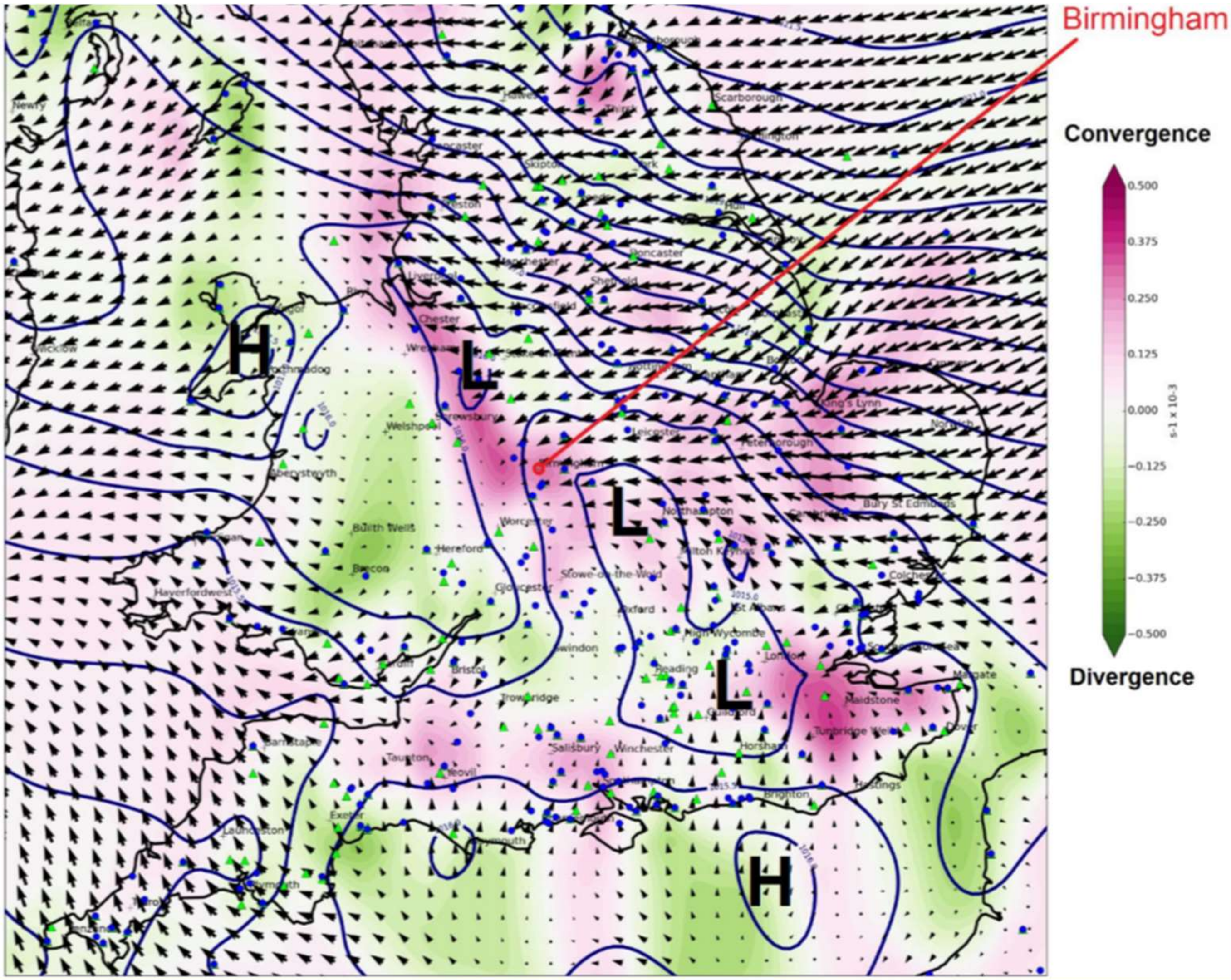
- Clusters of elevated convection had already moved north across this region during the morning.

- The analyses capture a prominent convergence zone (purple shading) extending from southeast England through the Midlands and into northwest England. Towards its northwest end, this convergence zone was collocated with a zone of strong temperature gradients



WOW surface analysis at **1400** UTC 27 May 2018 showing surface temperatures (shading), wind vectors (arrows) and MSLP (dark blue contours, contour interval 0.5 hPa) with composite radar rainfall rate overlaid.

Blue circles, green triangles and magenta stars show locations of WOW sites contributing wind, pressure and temperature obs to the analysis.



WOW surface analysis at **1400** UTC 27 May 2018 showing surface wind vectors (arrows), MSLP (contours) and horizontal divergence.

Blue circles and green triangles show locations of WOW sites contributing wind and pressure observations, respectively, to the analysis.

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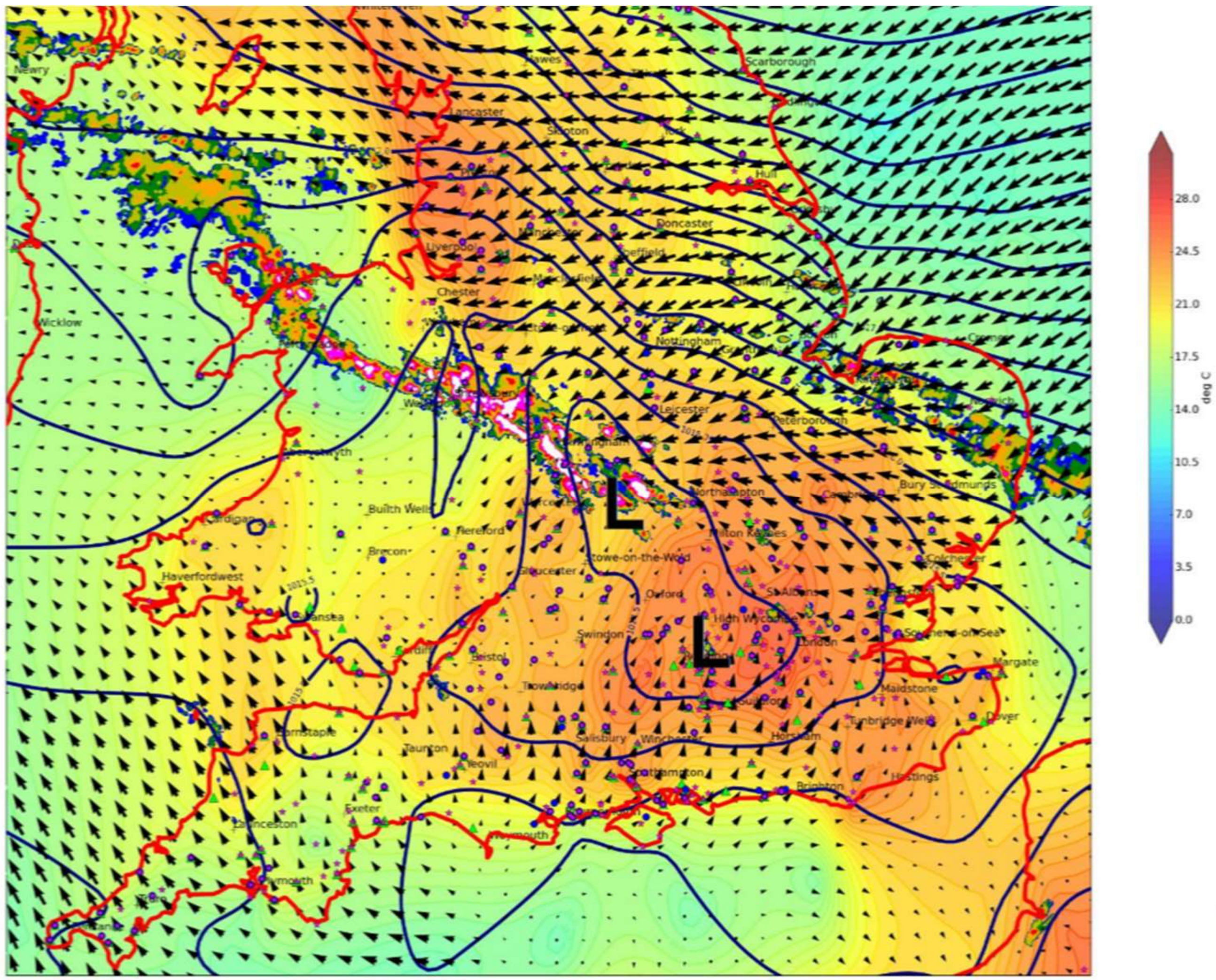
Case study – 27th May 2018

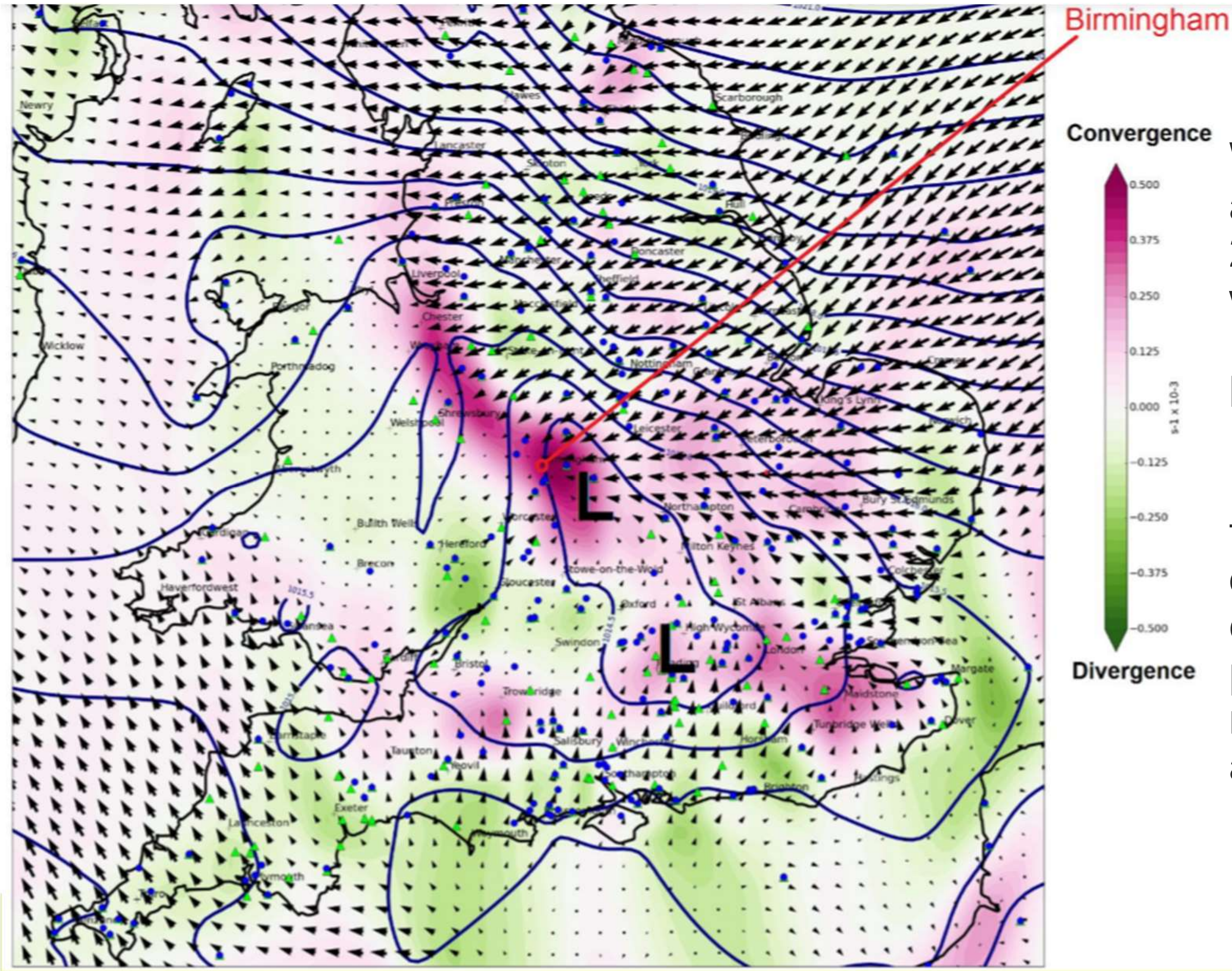
- By 1500 UTC, intense thunderstorms had begun to develop over the Birmingham area as temperatures continued to warm diurnally along the residual outflow boundary.

- The movement of individual cells was to the northwest i.e. parallel to the outflow boundary. Consequently, as new cells continued to develop and move along the boundary, torrential rainfall occurred over the same areas, producing exceptionally large rainfall totals and flash flooding.

- The surface analyses correctly identified the region at greatest risk of intense convection (i.e. the convergence zone) at least two hours ahead of time.



WOW surface analysis at **1600** UTC 27 May 2018 showing surface temperatures (shading), wind vectors (arrows) and MSLP (dark blue contours, contour interval 0.5 hPa) with composite radar rainfall rate overlaid.



WOW surface analysis at **1600** UTC 27 May 2018 showing surface wind vectors (arrows), MSLP (contours) and horizontal divergence.

Blue circles and green triangles show locations of WOW sites contributing wind and pressure observations, respectively, to the analysis.

Case study – 27th May 2018

- The convergence zone was in fact evident in analyses as early as 0900 – 1000 UTC (not shown), so the lead time may have been even greater, though it was not initially clear that the feature would persist into the afternoon.

- An amber warning was issued at the time that cells began to develop along the convergence zone.

- NWP model output had a strong signal for intense afternoon convection on this day, but the location and extent of convection was very variable in different models and different runs of each model.

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Case study – 27th May 2018

- The surface analyses therefore helped to pinpoint the most likely location of afternoon thunderstorms with useful lead time in a situation with otherwise low confidence.

- The analyses helped to highlight the elevated risk of flash flooding at an early stage in developments since they revealed, when used with radar data, the boundary-parallel movement of the initial cells.

- Movement of cells along a preexisting boundary has been shown to be an important mechanism for prolonging the duration of intense rainfall in many previous flash flood events (e.g. Burt, 2005); early operational recognition of the mechanism is critical for timely flash flood warnings.

Summary and future work

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Summary and future work

- Early results suggest that the WOW analyses have been beneficial to forecasters during the trial period, particularly during severe thunderstorm events.

- This demonstrates the potential usefulness of non-official observations data in the operational environment, provided that suitable data filtering and bias-correction techniques are applied before the data are used.

- The WOW analyses will continue to be made available to forecasters beyond the summer 2018 trial period. Further refinements are likely to be made to processing algorithms, and more parameters will be included.

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Thank you for listening. Questions?