EWGLAM/SRNWP - Helsinki, 8-11 Oct 2012

The UK Met Office Nowcasting Demonstration Project

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Introduction - NDP

- Aim: Develop a NWP nowcasting system to produce more accurate and timely forecasts of severe and high impact weather, focusing especially on flood risk

Data Assimilation/analysis vital for these short period forecasts of 0-6 hours

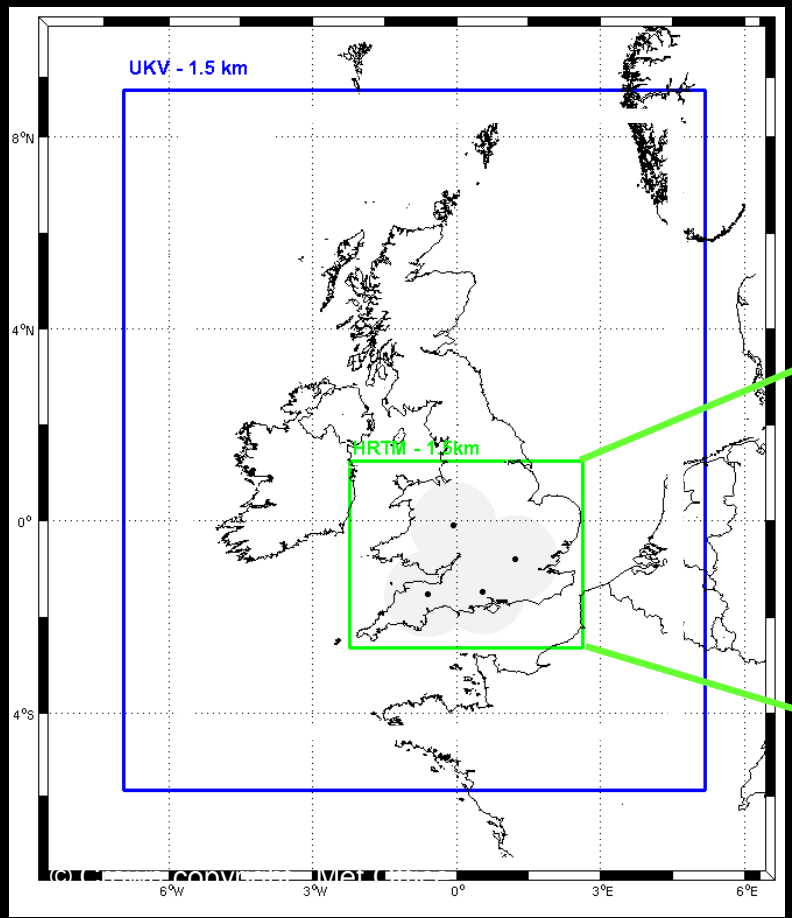
- Rapid update cycling is needed: Hourly cycling – Hourly analysis and forecasts every hour to T+6/12 hours
- 4D-Var to assimilate latest high resolution sub-hourly obs (e.g. Radar Doppler winds)
- Prompt delivery time (obs timeliness and P6/7)

Introduction - NDP

- The NDP system started running in real-time with forecasts to T+6 hours from March 2012 on IBM P6 (until Sept 2012)
- The real-time running on IBM P7 (operational support) began in July 2012 with extended forecasts to T+12 hours
- Use London 2012 Olympics to perform a real-time demonstration
- Evaluate extreme flood events over period of May, June and July 2012

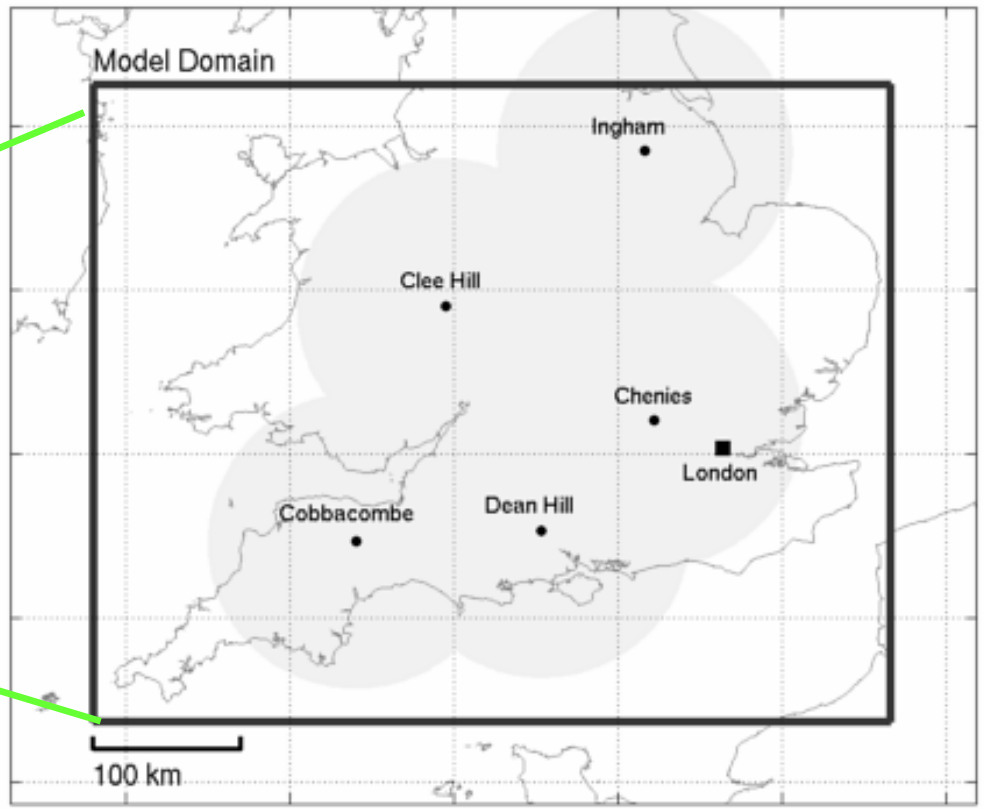
Configuration of the NDP (Sept 12, IBM P7)

Model	UM Resolution	DA method	DA time window	Cycling	Forecast Length/Freq
NDP (Southern UK)	1.5 km (360x288x70)	4D-Var (3km)	1 hr	1 hr	T+12 (every hr)
UKV (UK)	1.5 km (744x928x70)	3D-Var (3km)	3 hr	3 hr	T+36 (every 3h)

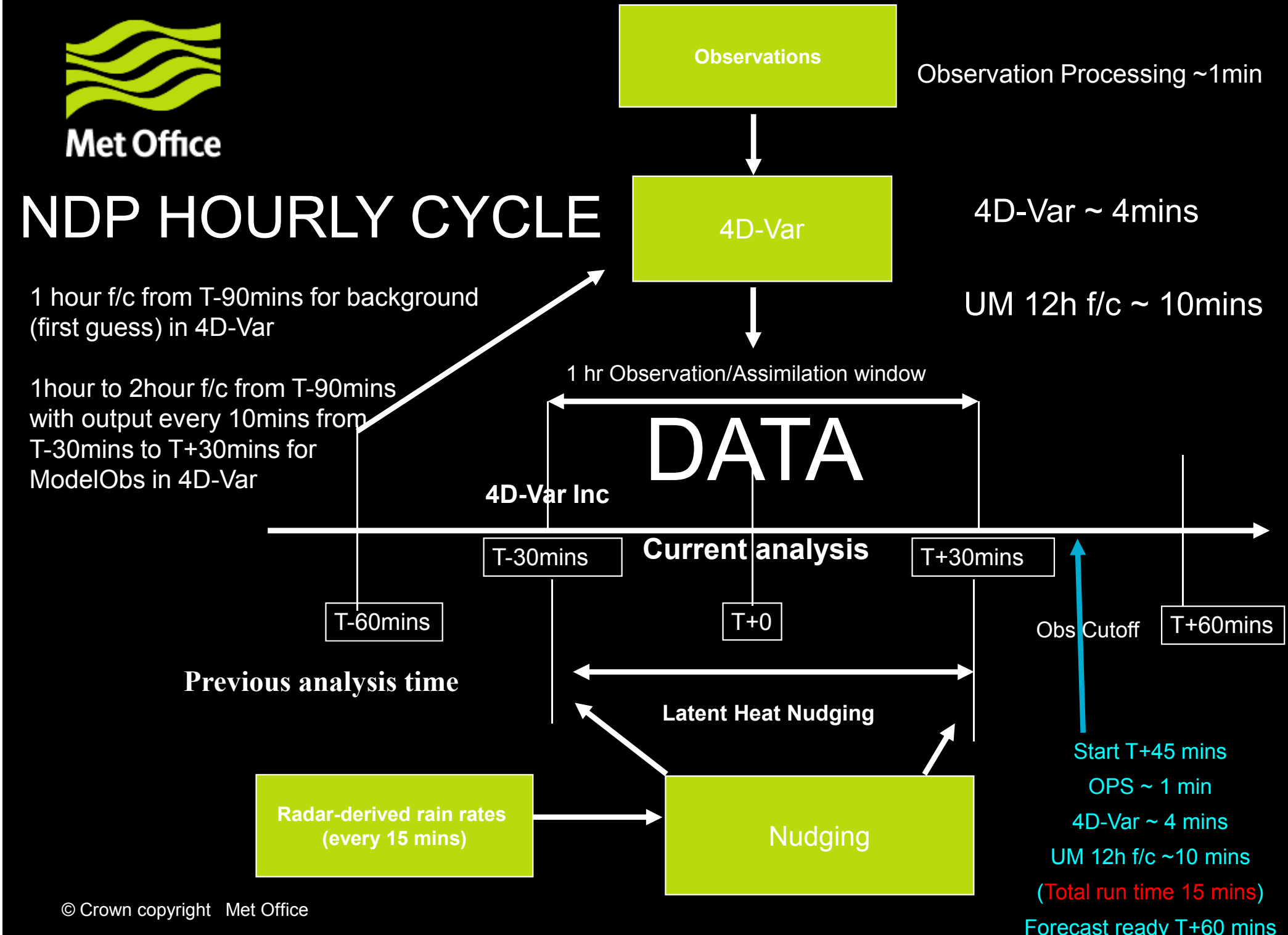


NDP

Nested in UKV. LBCs refreshed every 3 hours with 30 mins update interval



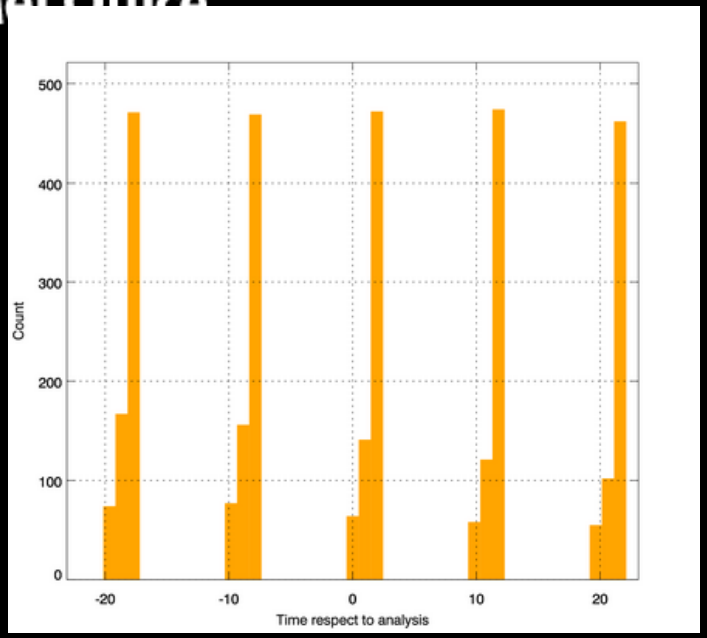
NDP HOURLY CYCLE



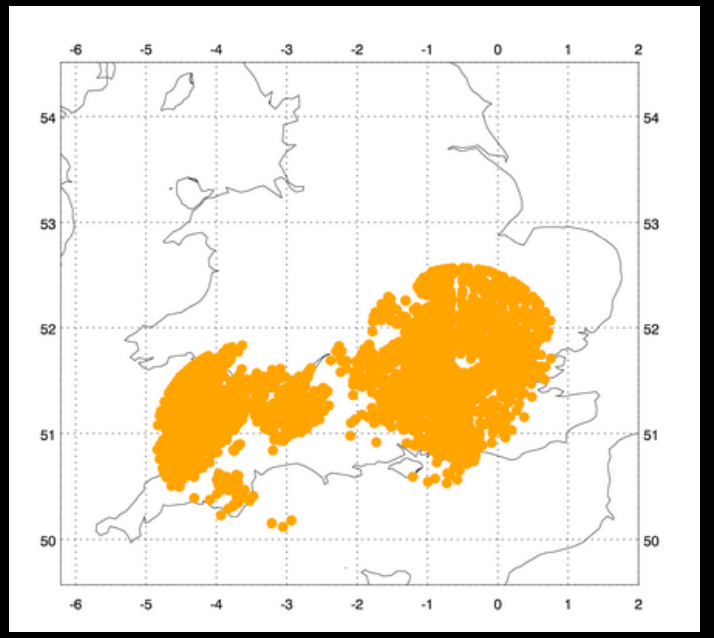
Use of Observations in NDP

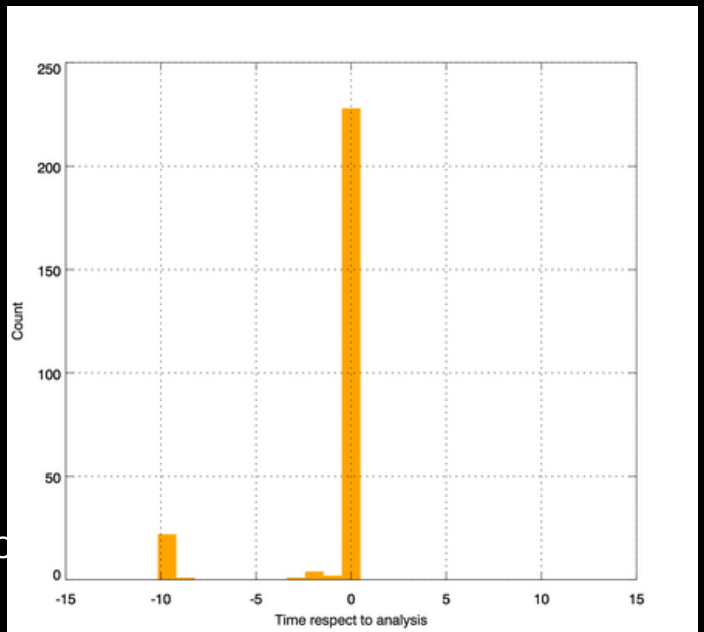
- 4D-Var assimilation of sub-hourly and hourly observations at each cycle [T-30mins to T+30mins], using
  - Doppler radial winds from 5 radars, every 10 mins
  - winds from 4 wind profilers every 15 mins
  - MSG SEVIRI satellite radiances: channel 5, channel 6 & window channels (sea only) every 15 mins
  - hourly cloud obs (satellite and surface reports)
  - hourly MSG AMVs
  - hourly aircraft temperature & wind
  - hourly surface temperature, relative humidity, wind & pressure from SYNOP and Open Road
- Latent Heat Nudging using radar-derived surface rain rates every 15 minutes

Doppler Radial winds and Surface Obs - 12UTC run 07 May 2012

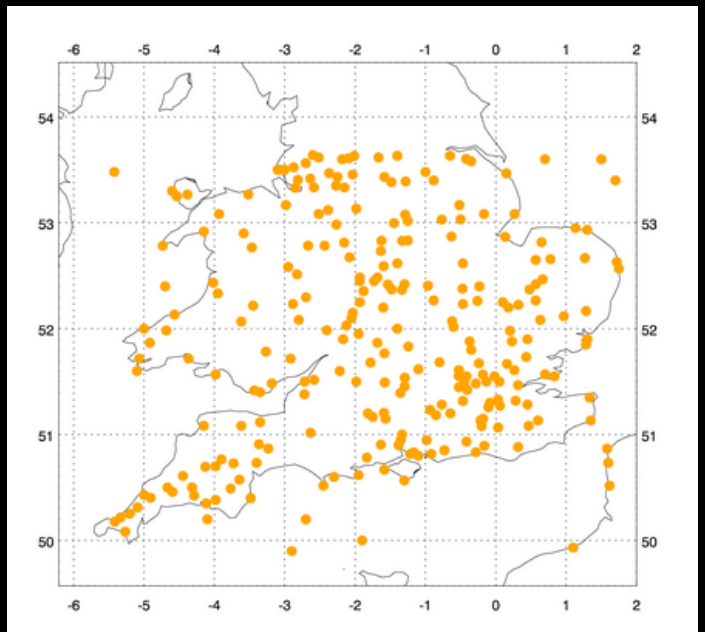


Doppler winds every 10 mins





Hourly surface obs (SYNOP+Open Road)

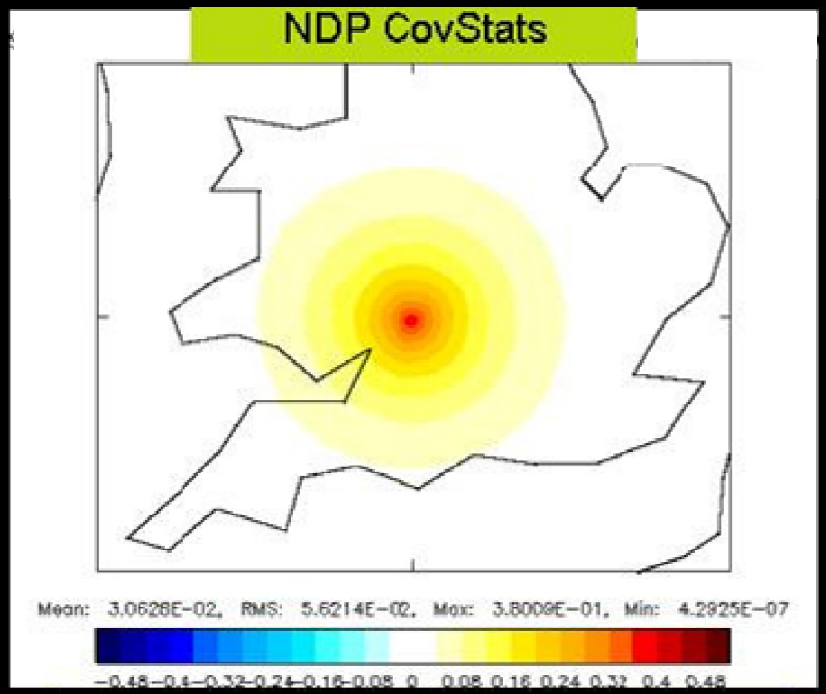


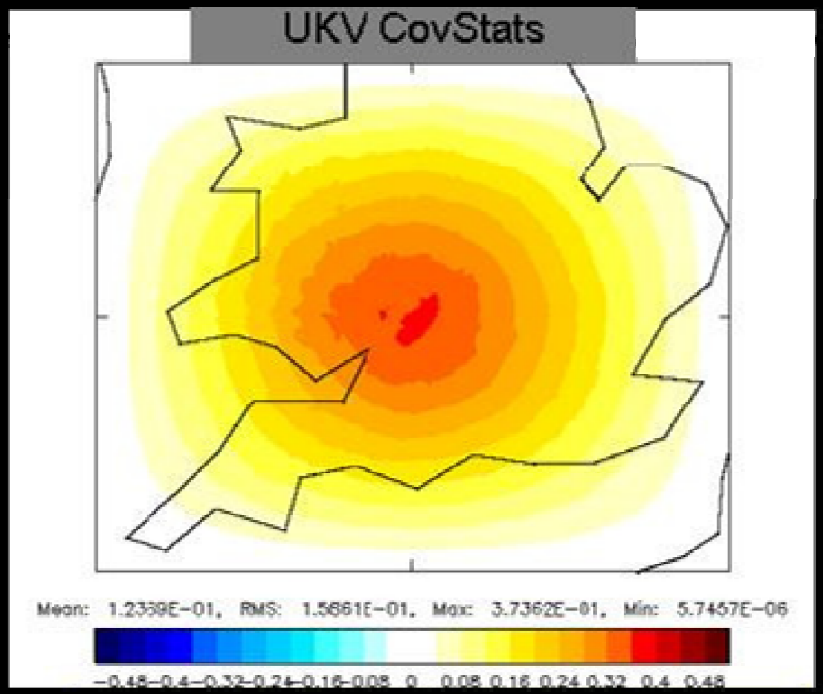
Background error covariances: Met Office covariance model for LAMs uses a SOAR function to model horizontal correlations

NDP length scales derived directly from 6 & 3 hour forecast differences and vary with vertical mode: 60 - 10 km for stream function / velocity potential & between 30 km - 2 km for unbalanced pressure / humidity

UKV length scales derived from 24 & 12 hour forecast differences at radiosonde locations: 180 km for streamfunction, 130 km for velocity potential / unbalanced pressure & 90 km for humidity

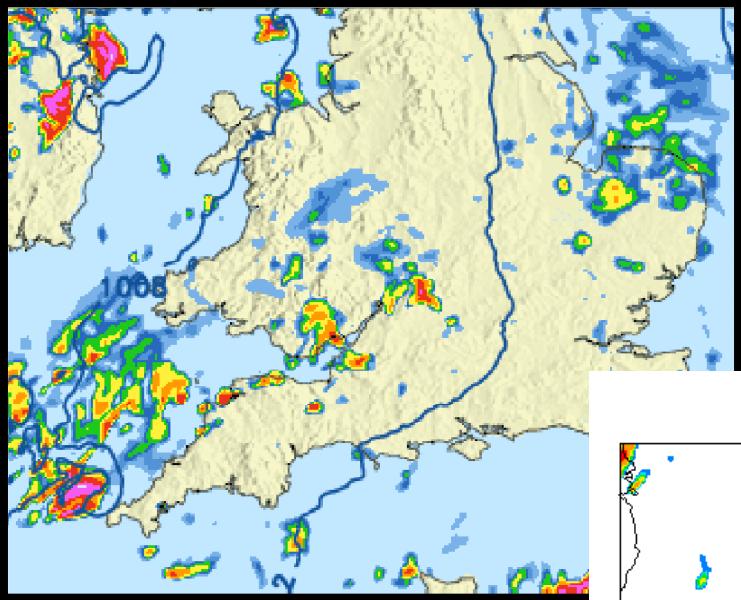
Spreading observations in space: assimilating a pseudo 2K temperature innovation with 1K error at 850hPa





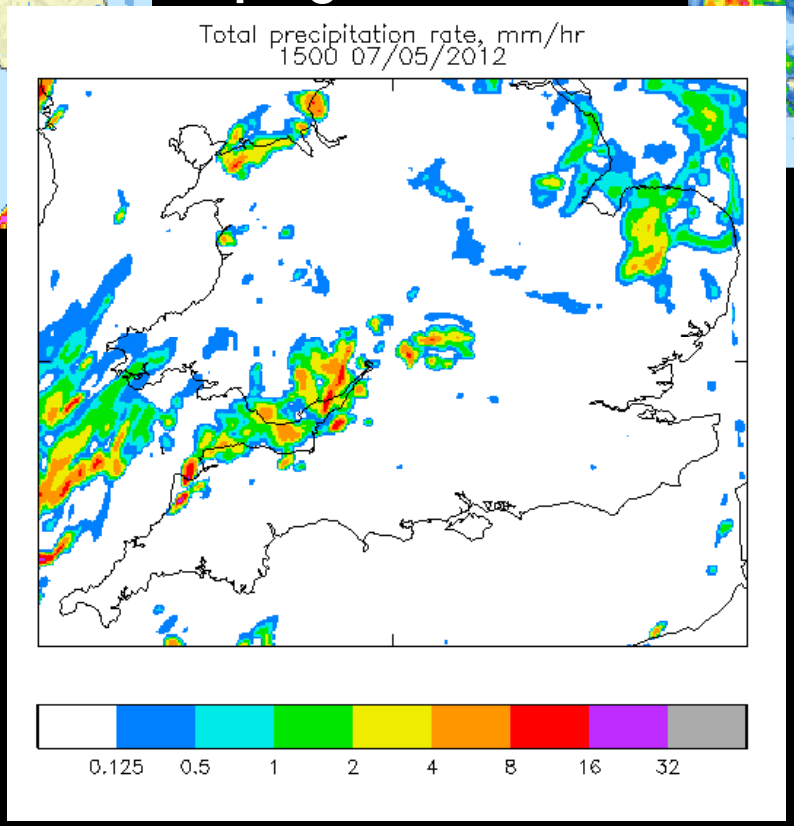
Oxfordshire tornado, 7th May 2012: comparison of analyses for 15UTC

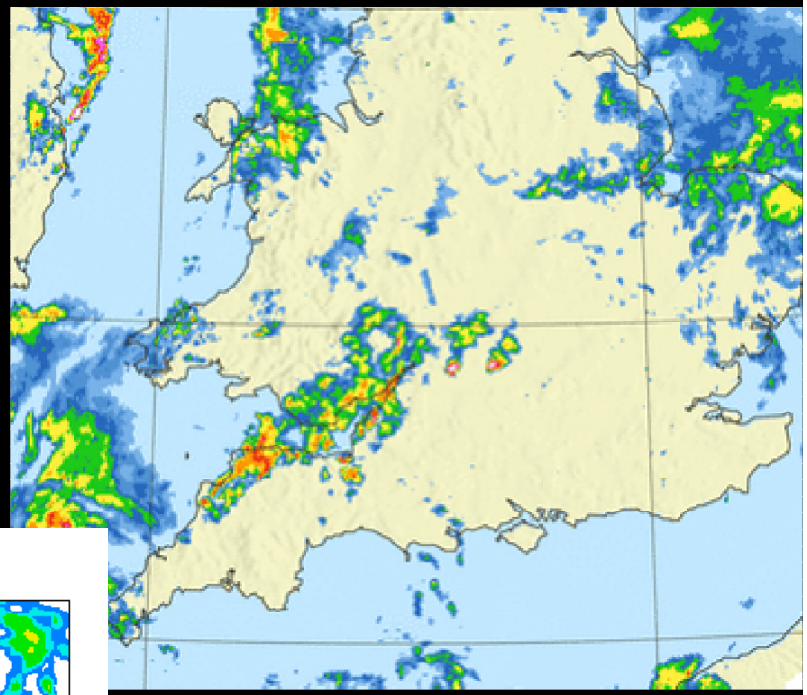
Met Office



15UTC UKV T+0

15UTC NDP T+0





15UTC radar composite

UKV T+6/T+0
Indication of location

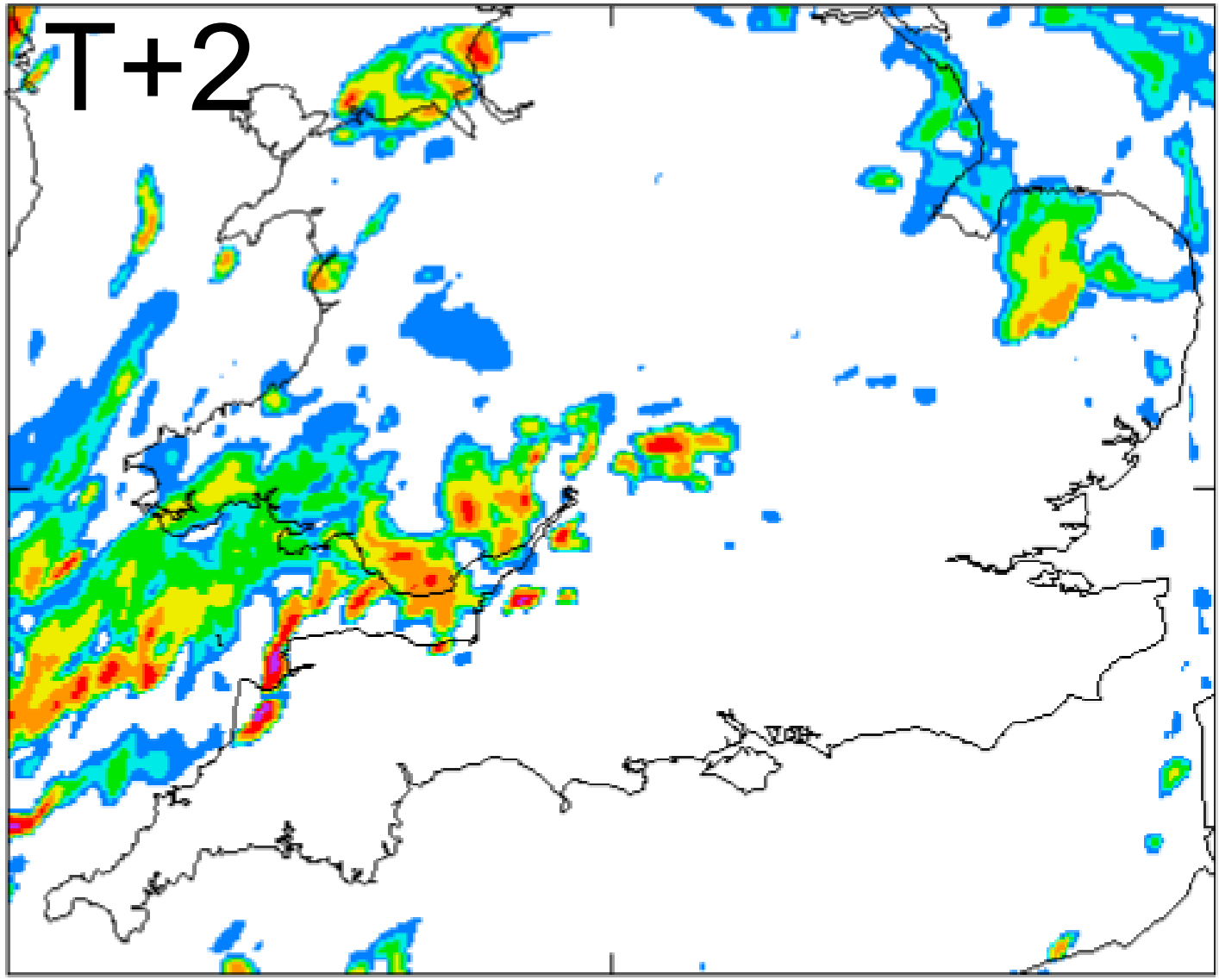
Oxfordshire tornado, 7th May 2012

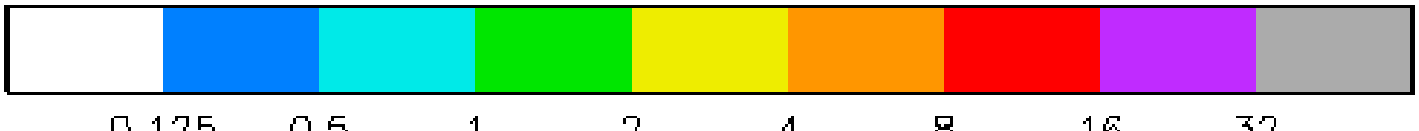
Met Office

NDP

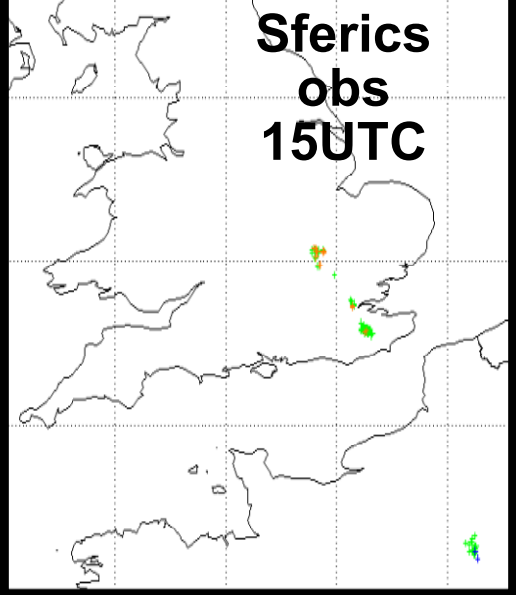
All NDP forecasts from 12UTC onwards had a good forecast of the location of the storms at 15UTC - skill improves with time

Valid at 15UTC





(London-Leicester) Line Convection: 28th May 2012
Animation: NDP 10UTC run (using UKV 03Z LBC)



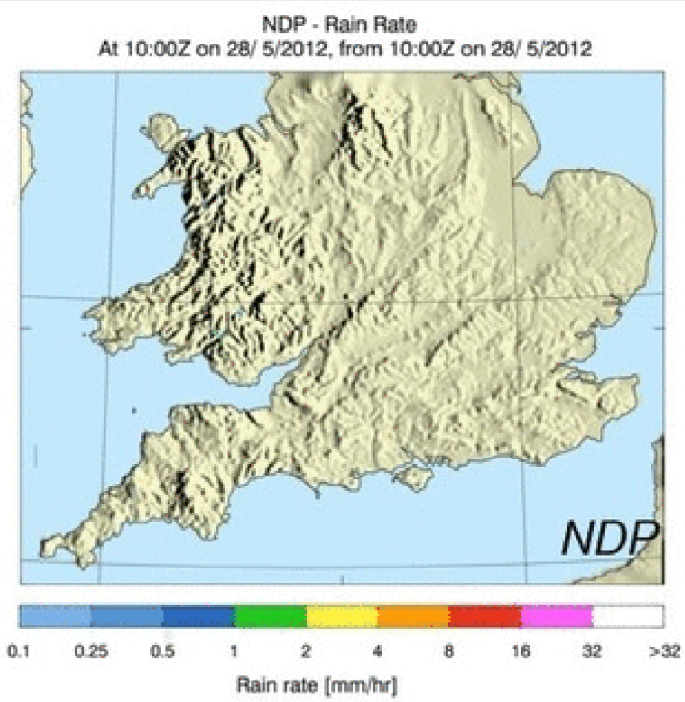
Thunderstorms not present at analysis times

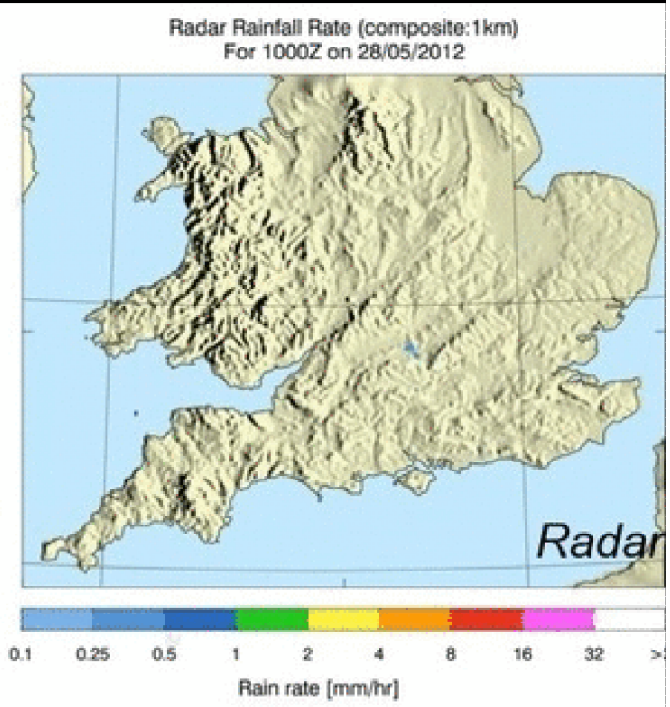
(1) UKPP failed to predict storms: neither extrapolation nor UK4 had them

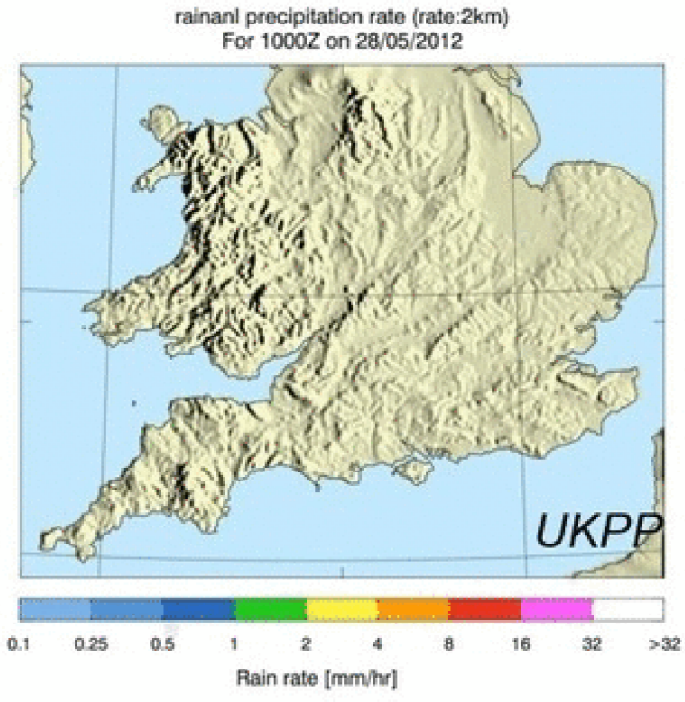
(2) UKV developed isolated storms too far east

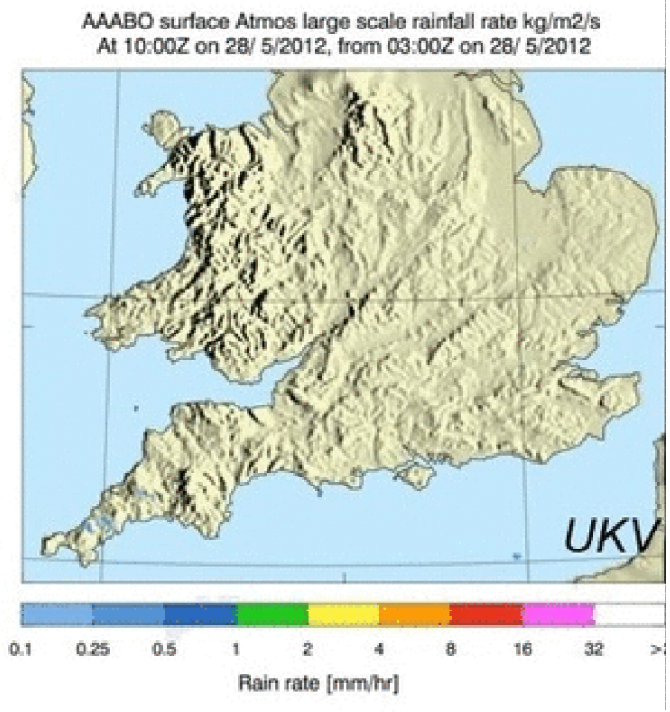
(3) NDP had a good forecast of the thunderstorms

UKPP(STEPS) - current nowcasting system:
Merged advection of actual radar rainrate and UK4 forecasts



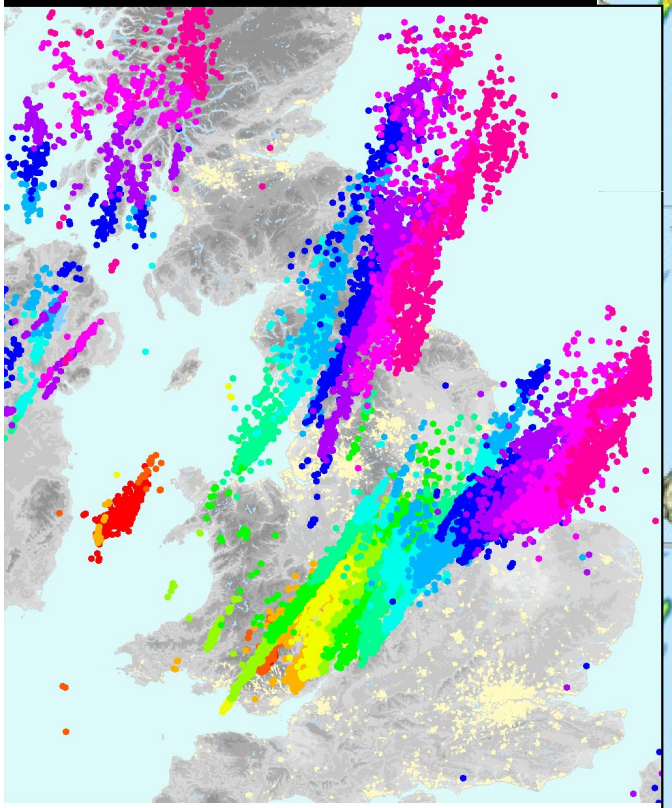






Thunderstorms & flooding June 28th 2012: NDP forecasts for 09UTC (UKV 3Z LBC)

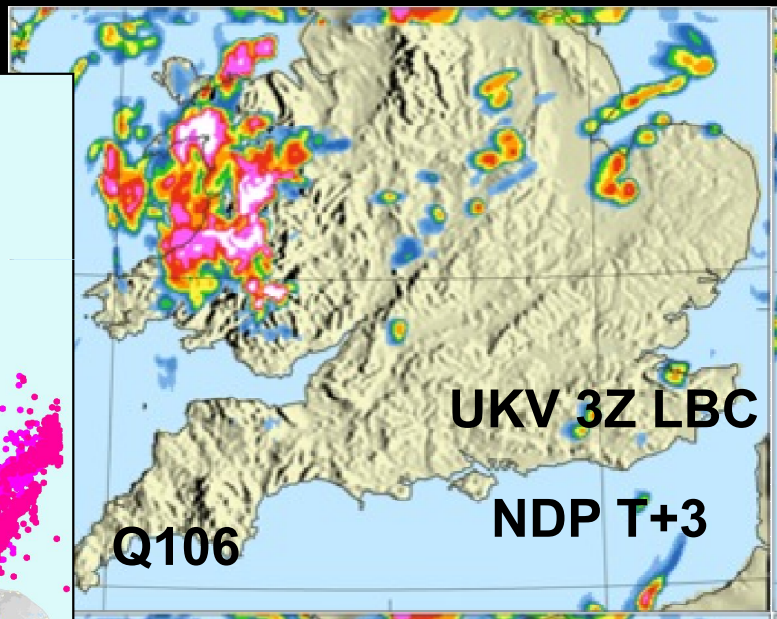
Met Office

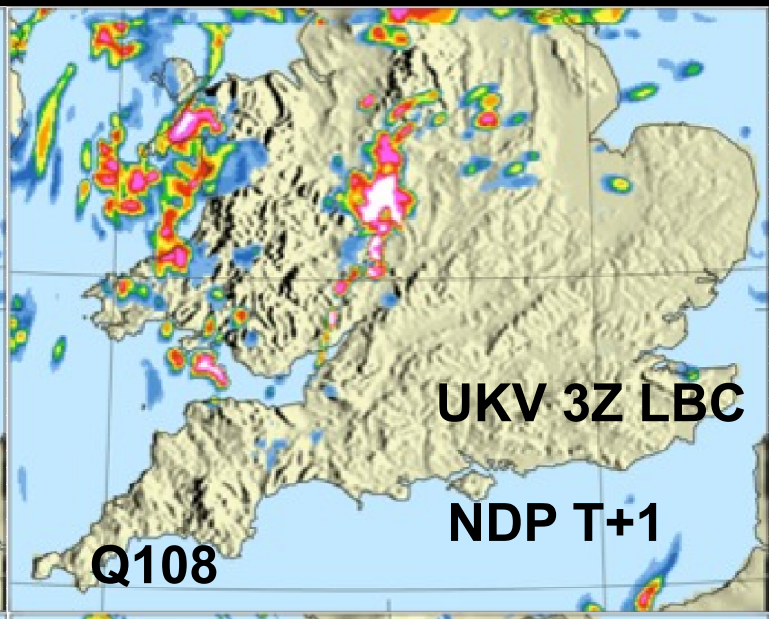


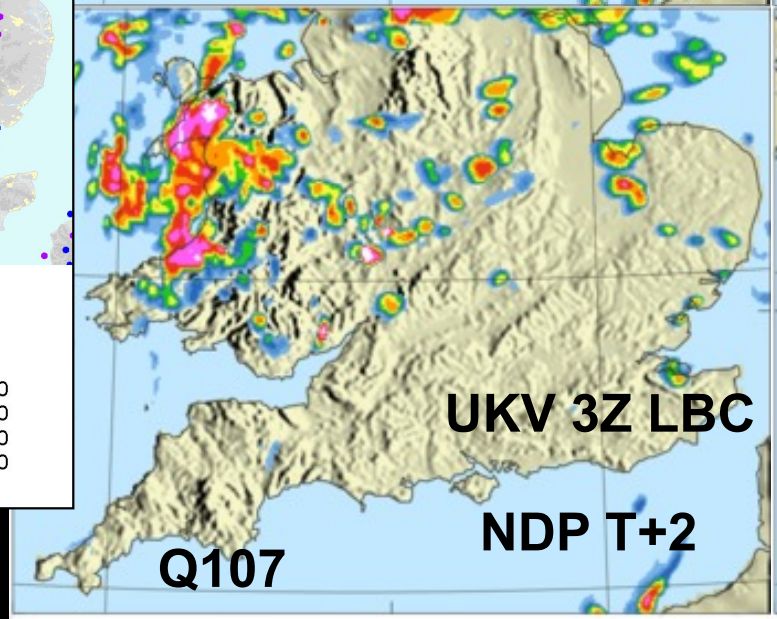
Lightning strikes 28th June 2012

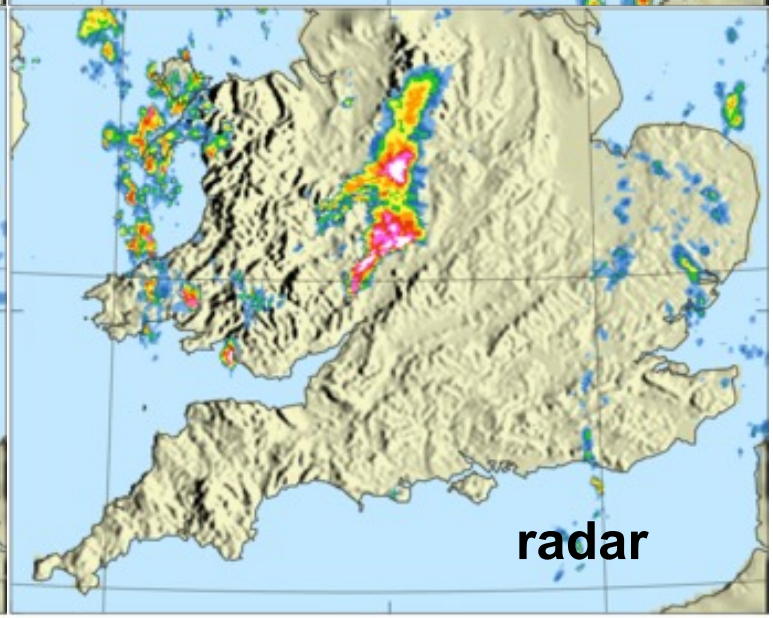
Lightning strike times

- 05:00 to 06:00
- 06:00 to 07:00
- 07:00 to 08:00
- 08:00 to 09:00
- 09:00 to 10:00
- 10:00 to 11:00
- 11:00 to 12:00
- 12:00 to 13:00
- 13:00 to 14:00
- 14:00 to 15:00
- 15:00 to 16:00
- 16:00 to 17:00
- 17:00 to 18:00



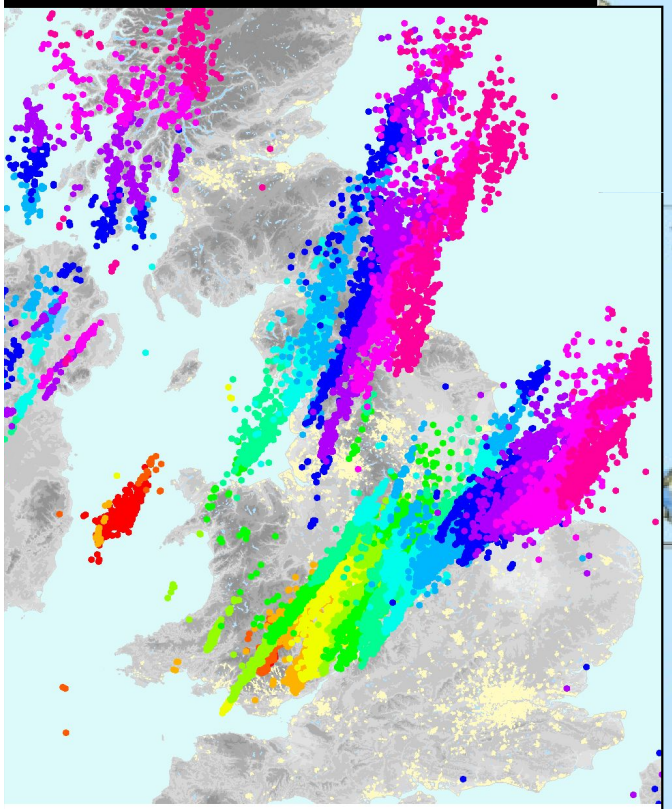






Thunderstorms & flooding June 28th 2012: NDP forecasts for 12UTC

Met Office



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05:00 to 06:00	10:00 to 11:00	14:00 to 15:00
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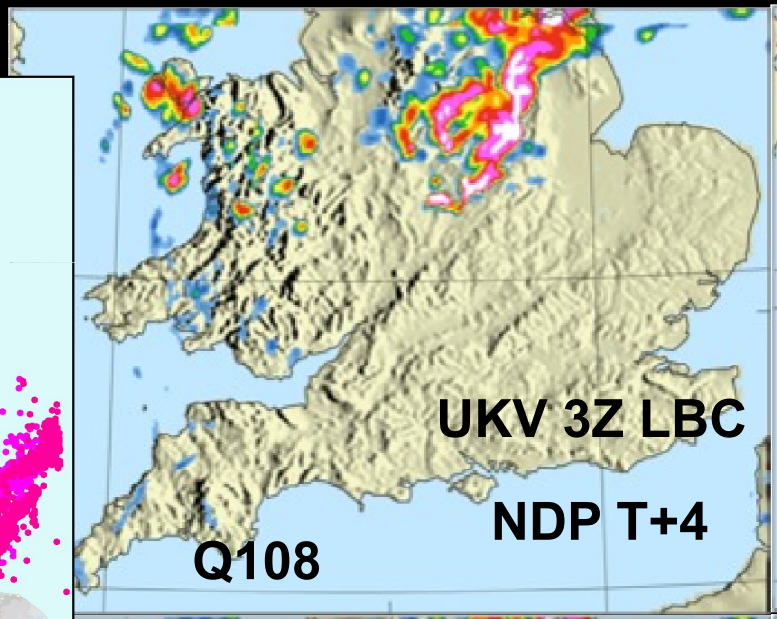
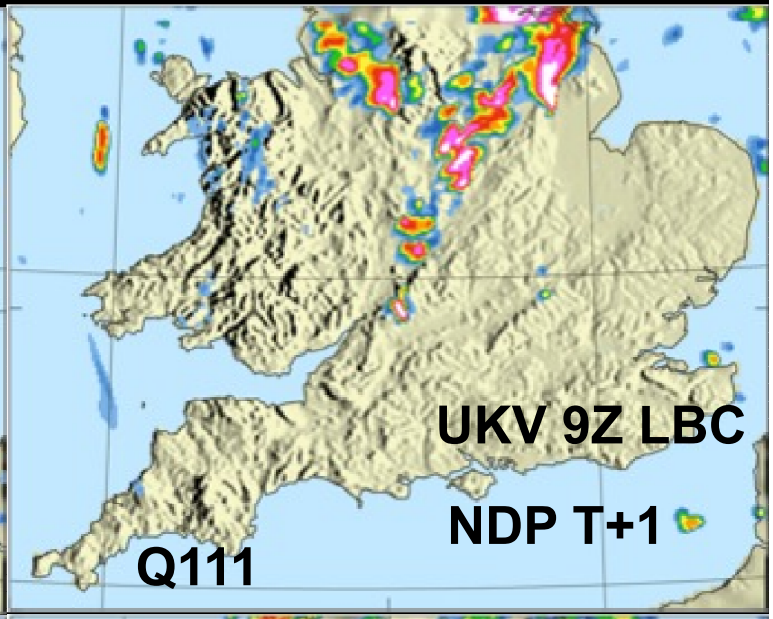
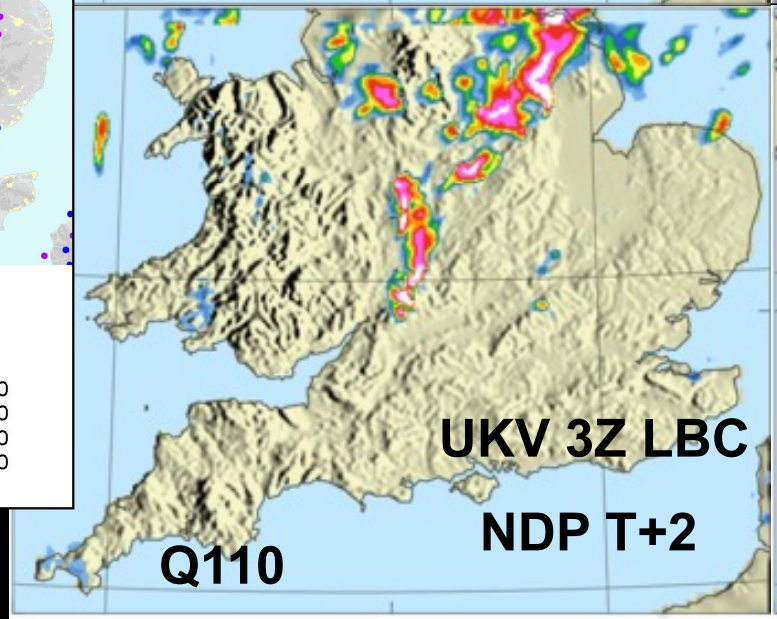
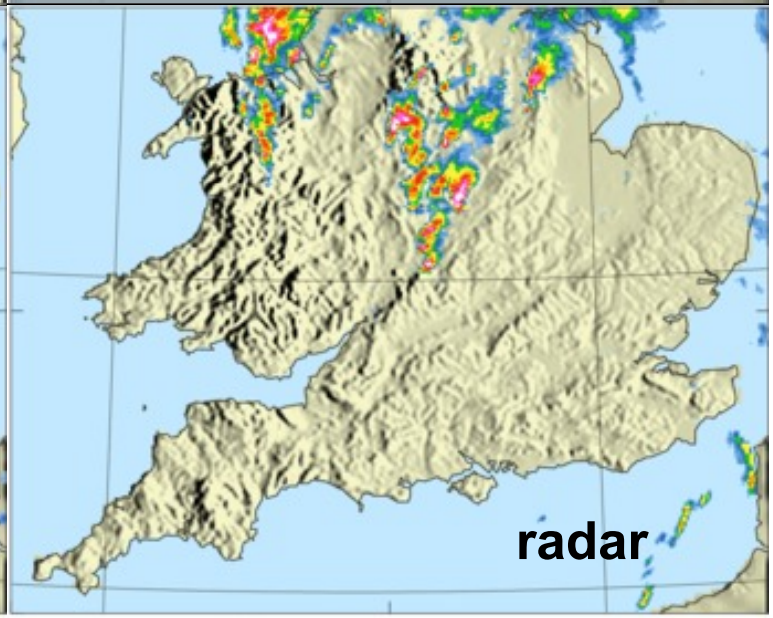
09:00 to 10:00		







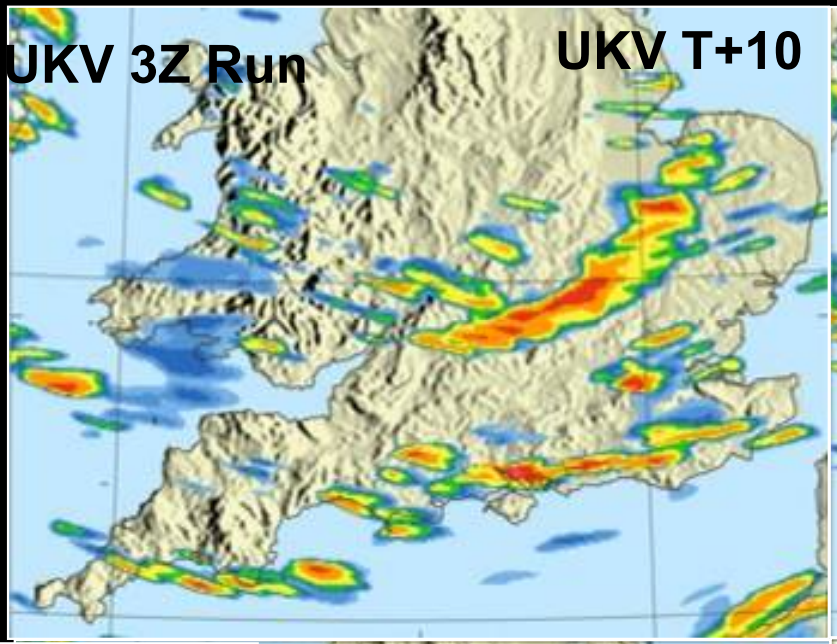


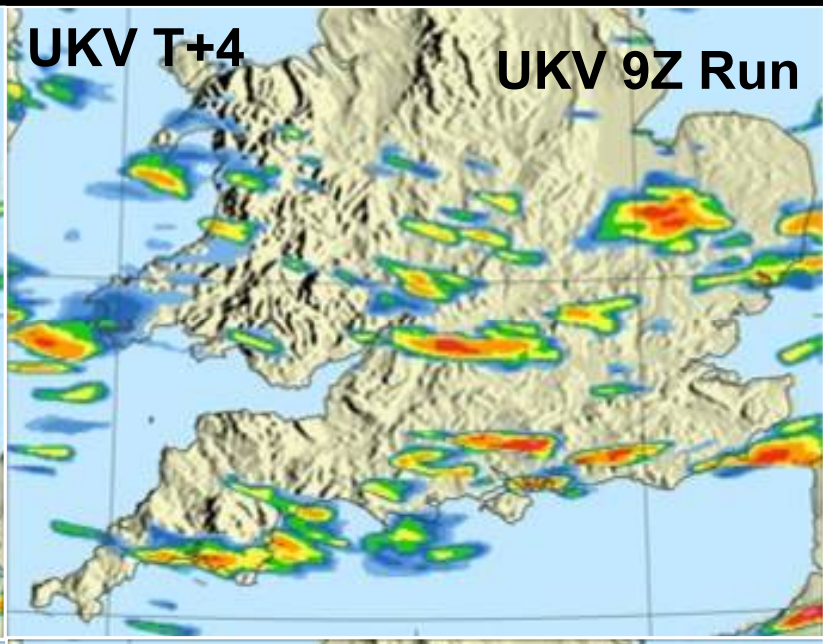
Flash Flooding along South Coast, July 11th 2012, Hourly Accumulations, 13UTC

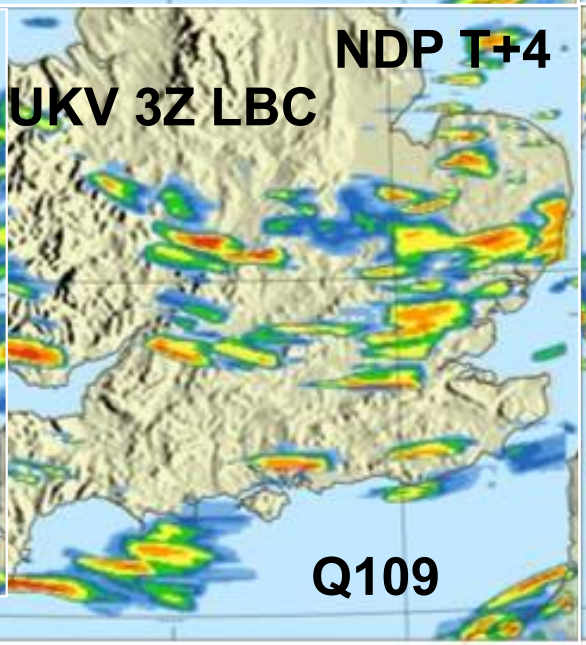
Met Office

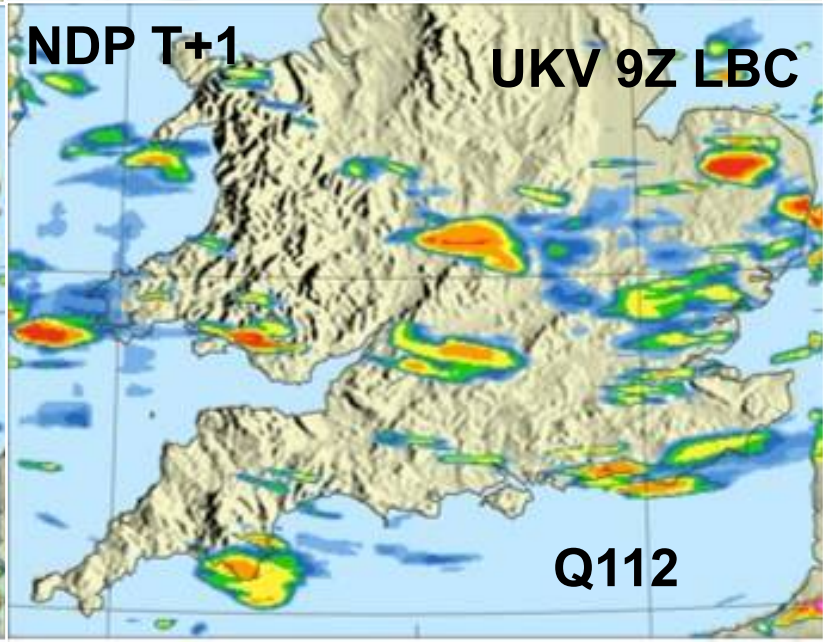
UKV T+10 is best match to radar

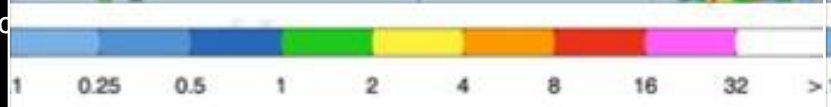
Later UKV & NDP appear to break up the rain band











FSS – NDP/ UKV / UKVPP – Same validity time, based on NDP delivery time

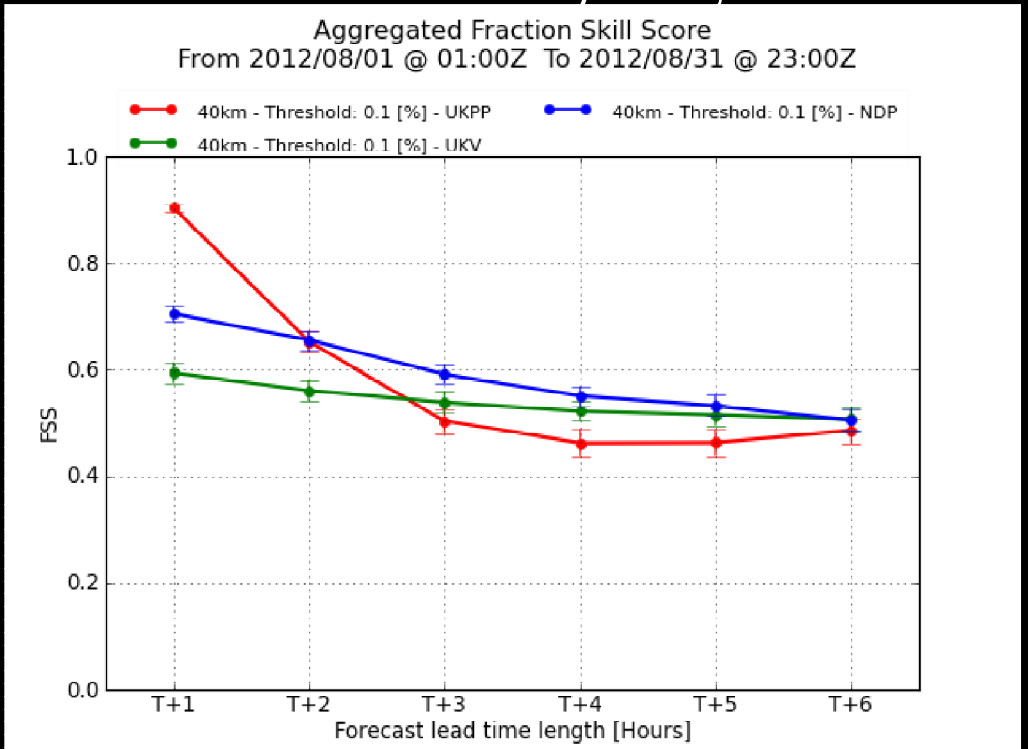
NDP P6
P6 UKV LBC - 6hrly
10% - 40 km square

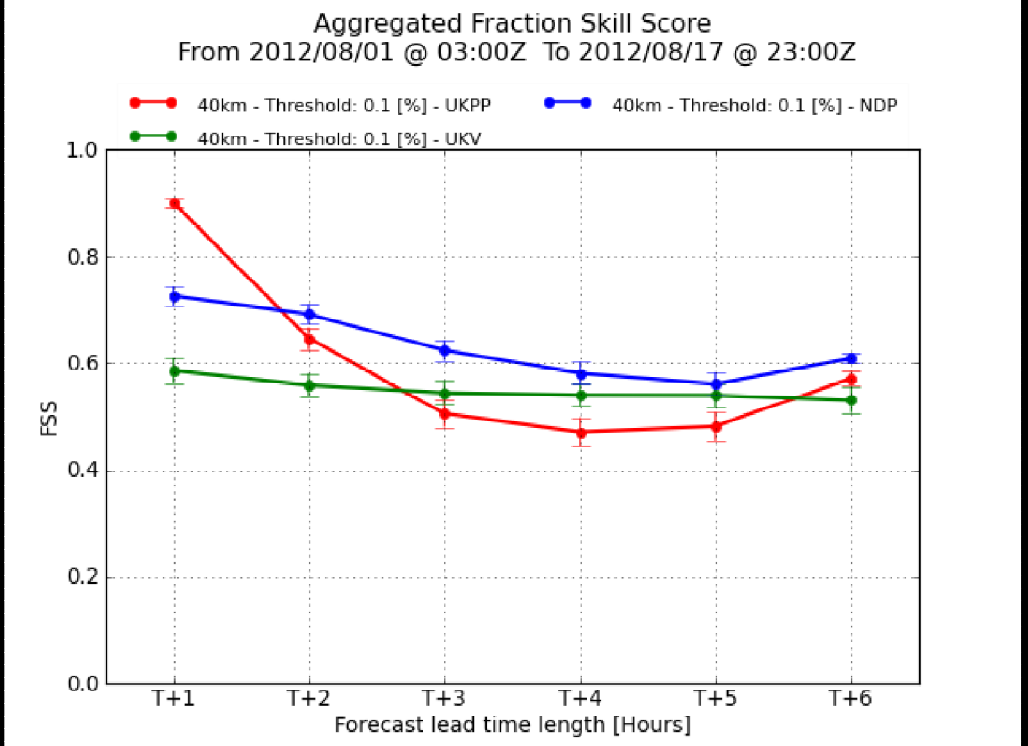
UKVLBC 03 09 15 21

NDP P7
P7 UKV LBC 3hrly
10% - 40 km square

UKVLBC 03 06 09 12

15 18 21 00





Match NDP forecast run with the latest UKV forecast available (UKV has a longer f/c lead time)

UKVPP -
Extrapolation of radar + UKV

UKVPP

NDP

UKV

NDP benefited from more upto date LBCs from UKV

Summary - NDP

- A high resolution (1.5km) NWP nowcasting system has been developed and run in real-time over the southern UK for demonstration during London 2012
- It assimilates sub-hourly Doppler radial winds, wind profiler, (GPS) & MSG SEVIRI data using hourly cycling 4D-Var
- The system currently produces a 12 hour forecast every hour by 30mins after the end of the observation window
- Forecasts were sometimes significantly better than the 6 hourly UKV, but substantial challenges remain
- FSS beats the STEPS (current Lagrangian extrapolation-based Nowcasting system)
- Form the basis for the Met Office next generation operational UK NWP nowcasting system

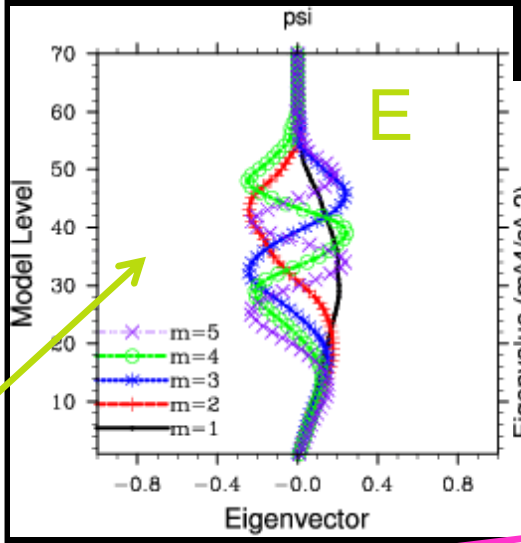
Thank you for your listening!

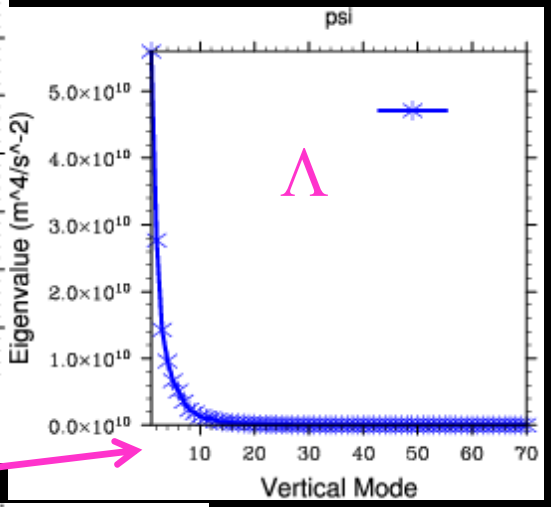
See http://www.metoffice.gov.uk/research/news

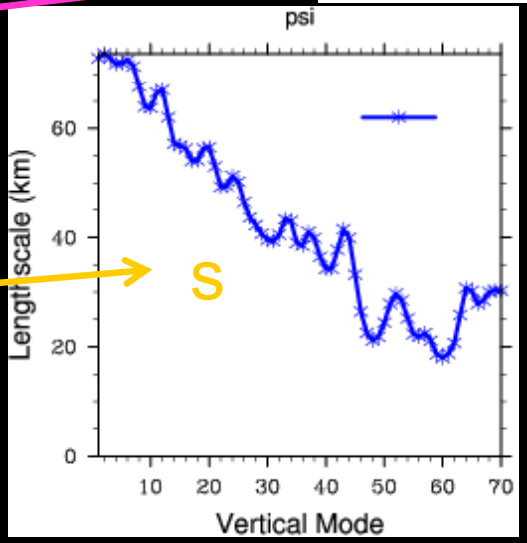
Questions?

Background error covariances

	Covariance model for LAMs	
1	$\mathbf{x}'$	$u', v', \theta', \rho', p', q'$
2	Parameter transform $\mathbf{v}_p = \mathbf{T}_p \mathbf{x}'$	ψ', χ', p'_u, r' $p'_u = p'_h - \mathbf{F} f(\psi)$
3	Vertical transform $\mathbf{T}_v$	auto covariances only $\mathbf{B}_v(i,j) = \mathbf{E}\Lambda\mathbf{E}^T$ $\mathbf{v}_p(i,j,k) \rightarrow \mathbf{v}_v(i,j,m)$
4	Horizontal transform $\mathbf{T}_h$	$\mathbf{B}_h(r) = \mathbf{B}_h(0)\left(1+\frac{r}{s}\right)e^{-r/s}$





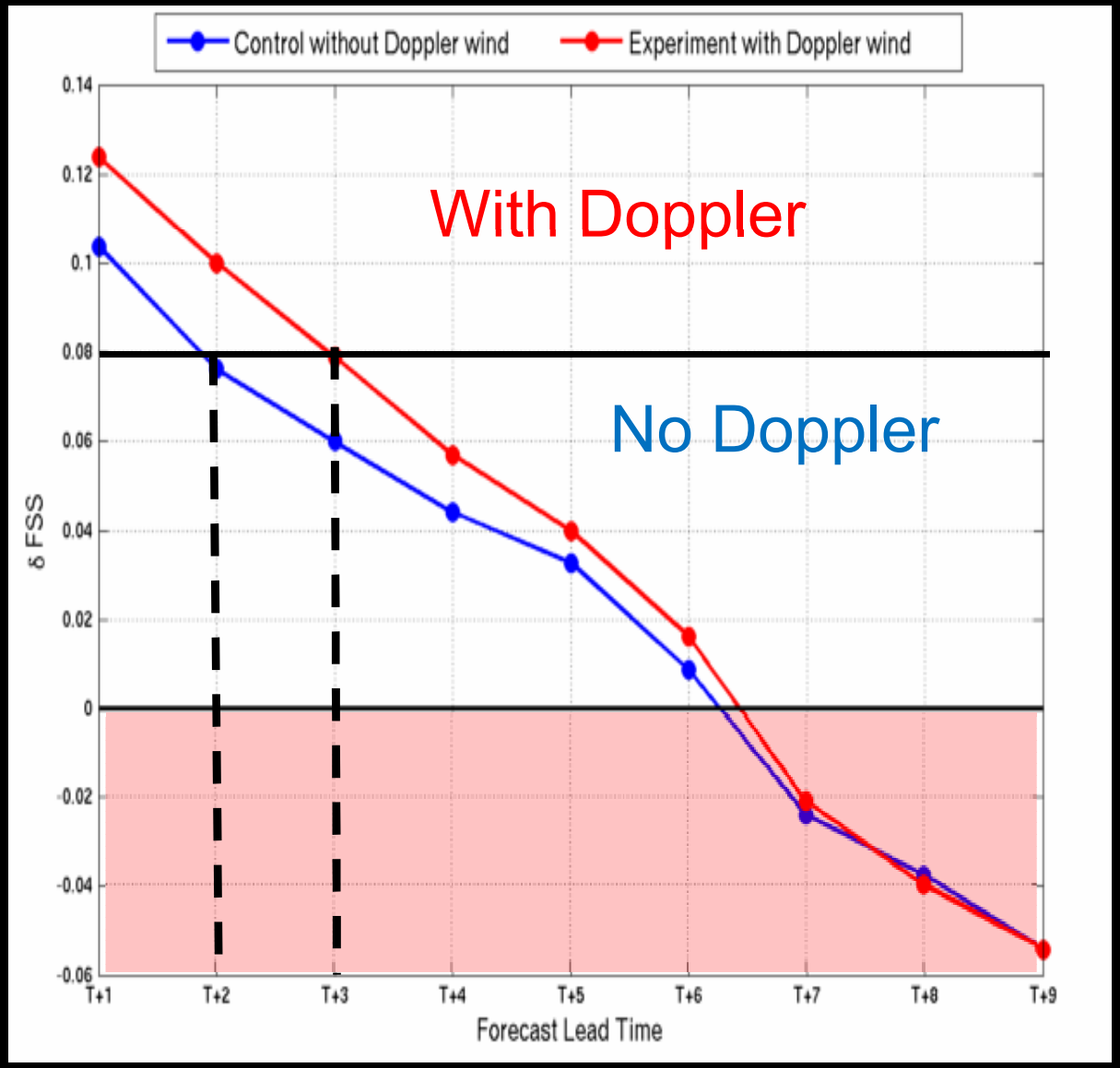


NDP

Impact of Doppler Radial Winds in 3D-Var

Fractions Skill Score (FSS) for > 0.2mm hourly accumulations at a scale of 55km

Forecast skill is improved for rain accumulations (~ 1-hour gain)



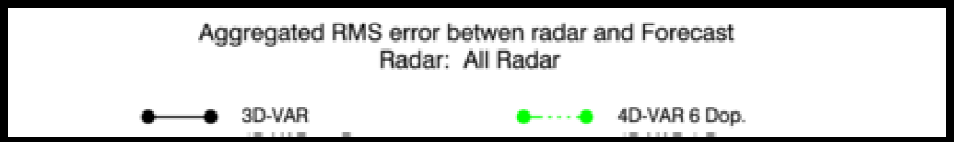
Forecast Lead Time

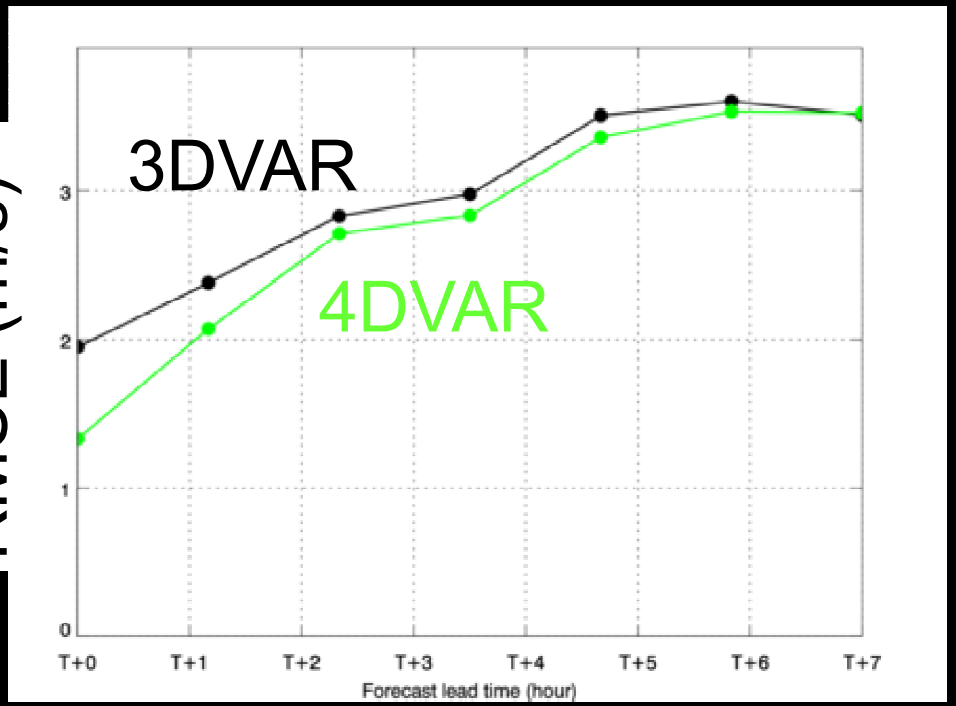
Impact of assimilating sub-hourly Doppler radial winds in 4D-Var on rms error

Verification against Doppler Radial Winds

4D-Var with 10 mins Doppler winds

3D-Var with hourly Doppler winds





T+0 Forecast range T+7

rms error aggregated for 2 cases of 16 and 23 cycles respectively