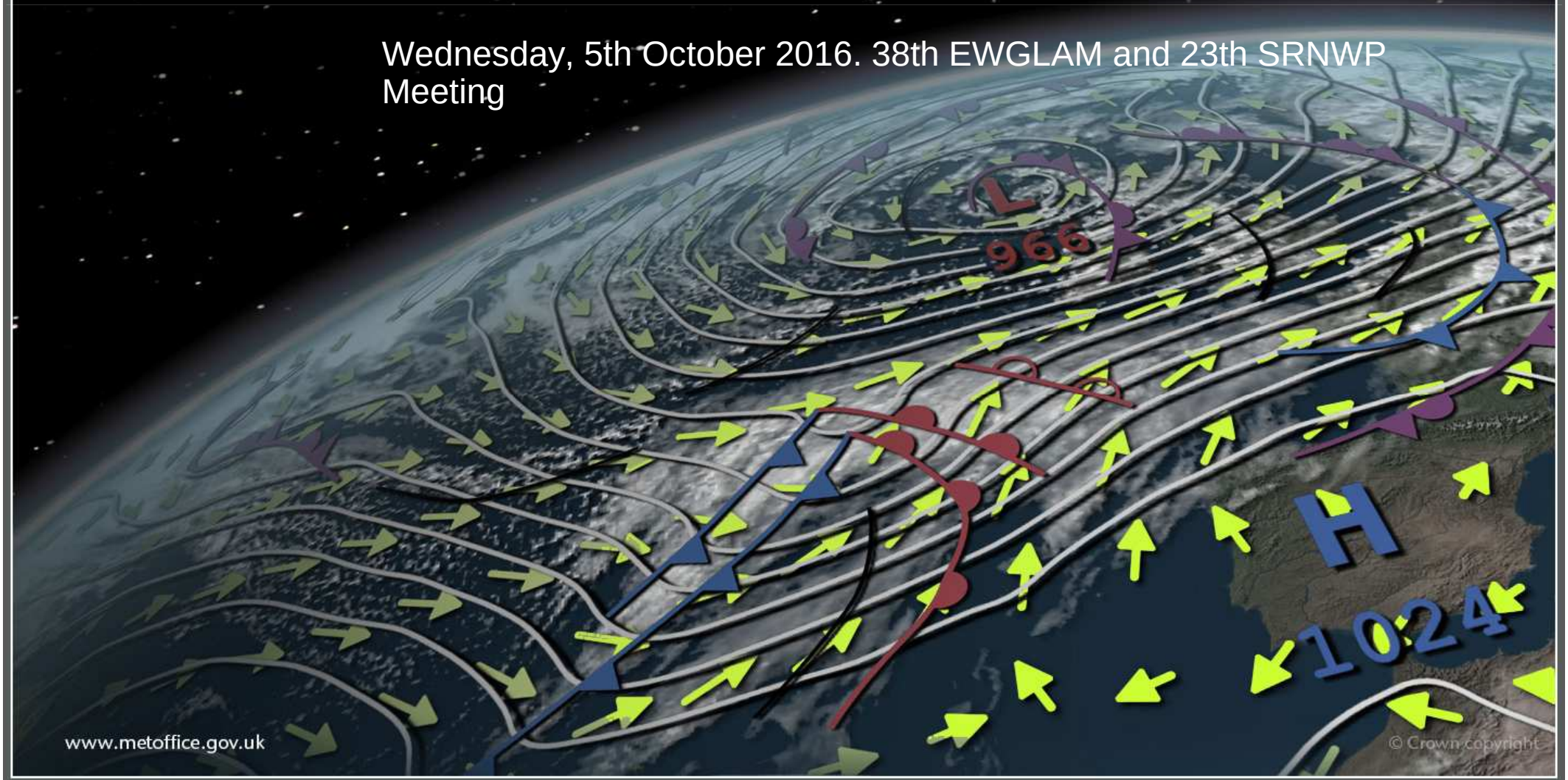
Comparison of Fractional skill score and new HiRA verification

Historical trends and Experience in parallel trials

Clive Wilson, Marion Mittermaier, Lesley Allison

Wednesday, 5th October 2016. 38th EWGLAM and 23th SRNWP Meeting



Contents

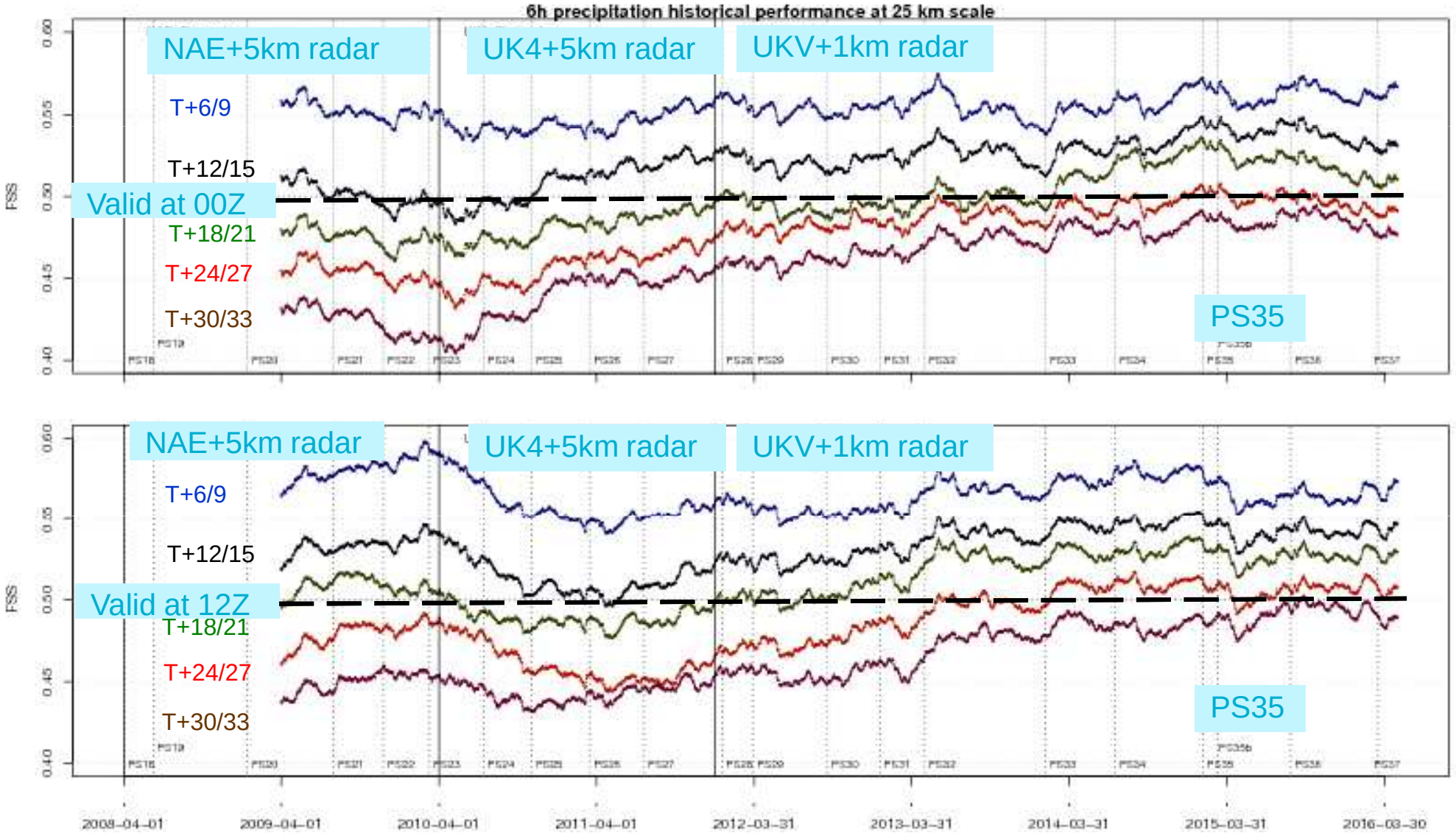
- Historical record of Fractional skill score
- Basics of High resolution Assessment (HiRA)
  - Single Ob – neighbourhood forecast
- Effect of neighbourhood size
- Comparisons – regular operational monitoring
  - UKV & MOGREPS-UK
  - UKV & Global cf conventional verification
- Use in parallel trial PS38
  - Summer precipitation cf Fractional skill score
- Conclusions

Historical data

- NAE (12 km), UK4 and UKV (1.5 km) models spanning the period **from April 2008**.
- During this period either 5 km or 1 km (or both) radar rainfall fields were used for verification.
- Series have a 365-day running mean applied.
- Times of day are kept separate to consider the **diurnal cycle**.
- Lead times up to t+36h are considered.
- 6h precipitation are considered.
- Radar data has been of variable quality across the UK during the last decade through the radar renewal project. Hence the use of percentile thresholds (here the 90^{th} or 95^{th}) to avoid as much of any biases that may be introduced by the radar as possible. (can't be fully eliminated)

From Mittermaier, in prep.

Precipitation:Fractional skill score @25km - historical



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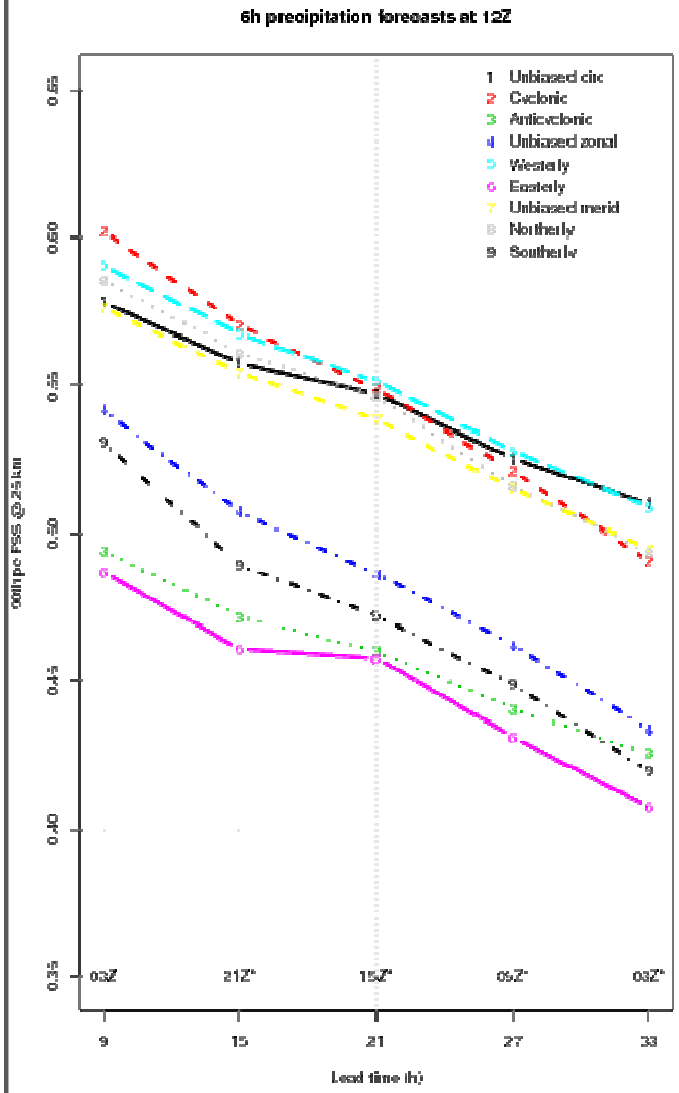
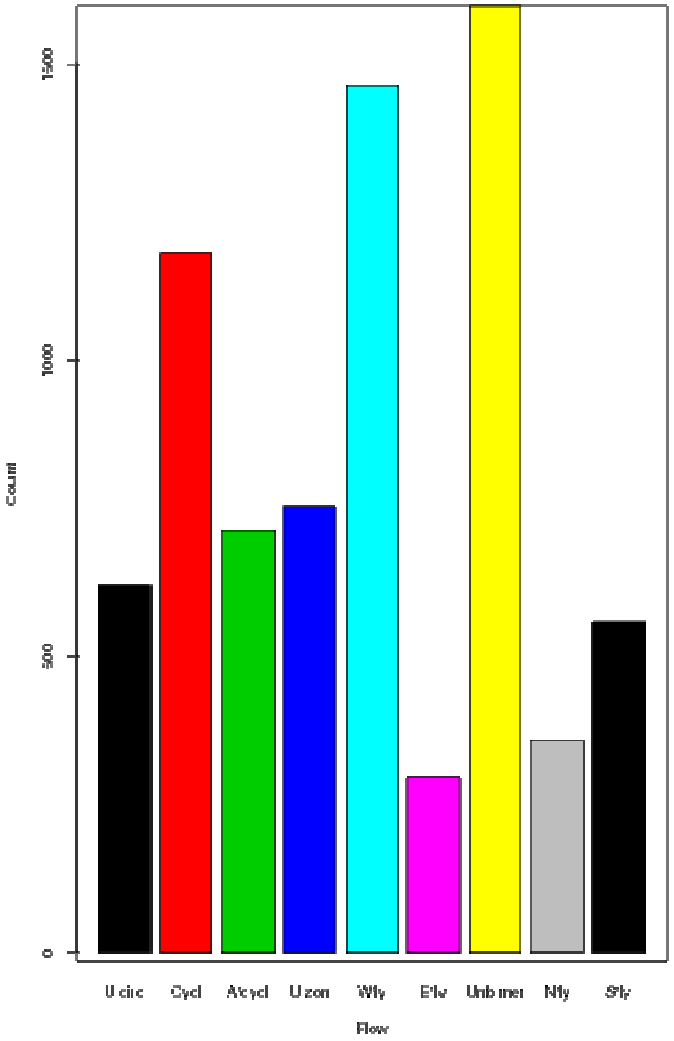
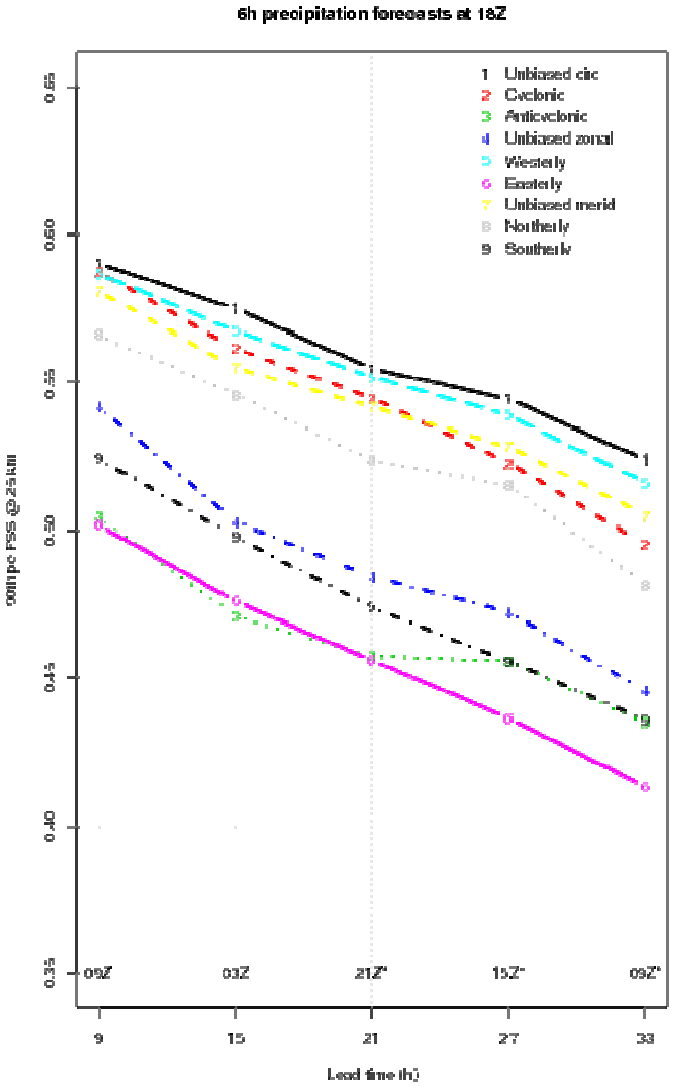
Weather regime stratification







From Mittermaier, in prep.

The “regional” effect

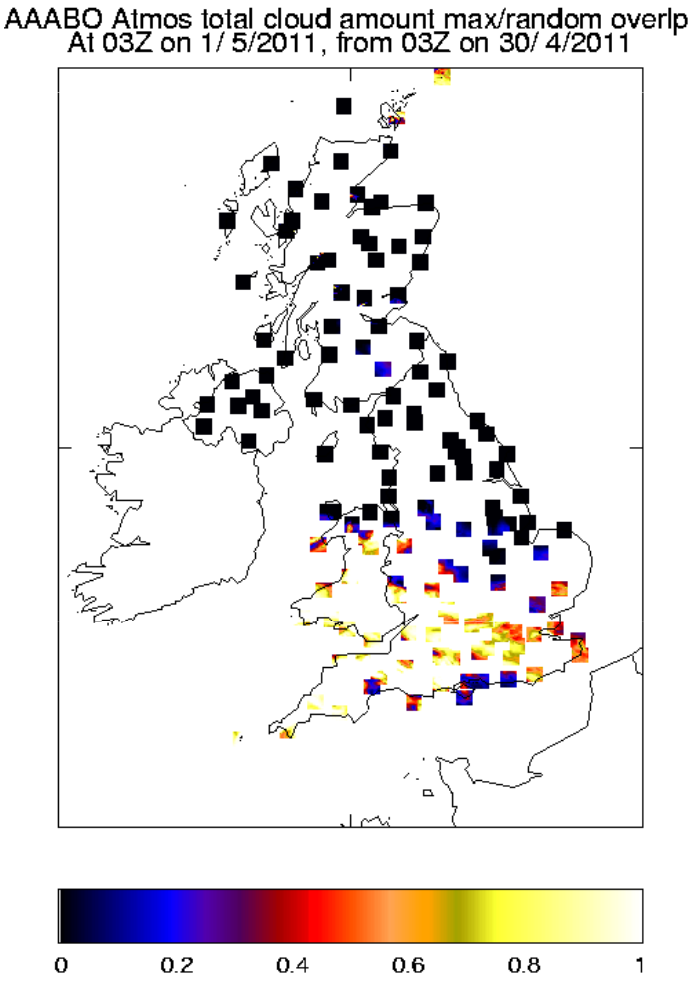
- Scores higher than @5km (not shown)
  - “useful” skill if FSS>0.5
- Improving trend with model upgrades
  - Though detrimental PS35
- Differences due time of day

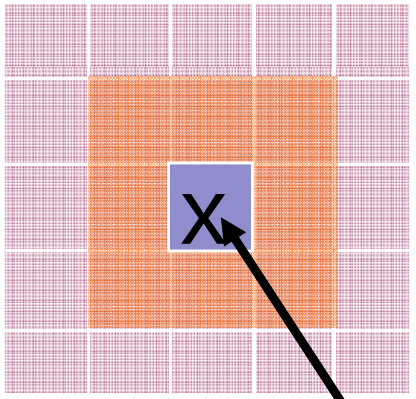
- Change in score with lead time not necessarily linear
- Strong variation in precipitation forecast skill with flow type

Spatial sampling

- Make use of spatial verification methods which compare **single observations** to a **forecast neighbourhood around the observation location**. → **SO-NF**

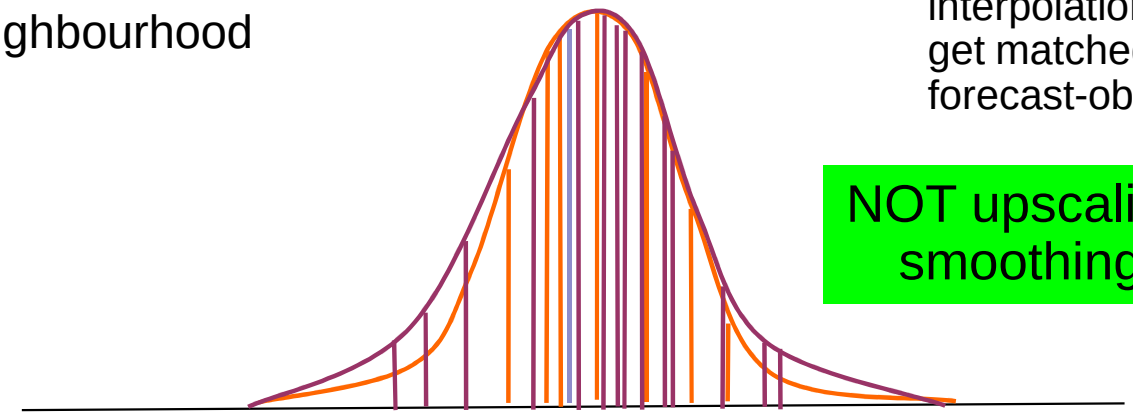
17 x 17





Observation

Forecast neighbourhood



Represents a **fundamental departure from our current verification system strategy** where the emphasis is on extracting the nearest GP or bilinear interpolation to get matched forecast-ob pair.

NOT upscaling/ smoothing!

Only ~130 1.5 km grid points in >500 000 domain used to assess entire forecast!
Note the variability in the neighbourhoods.

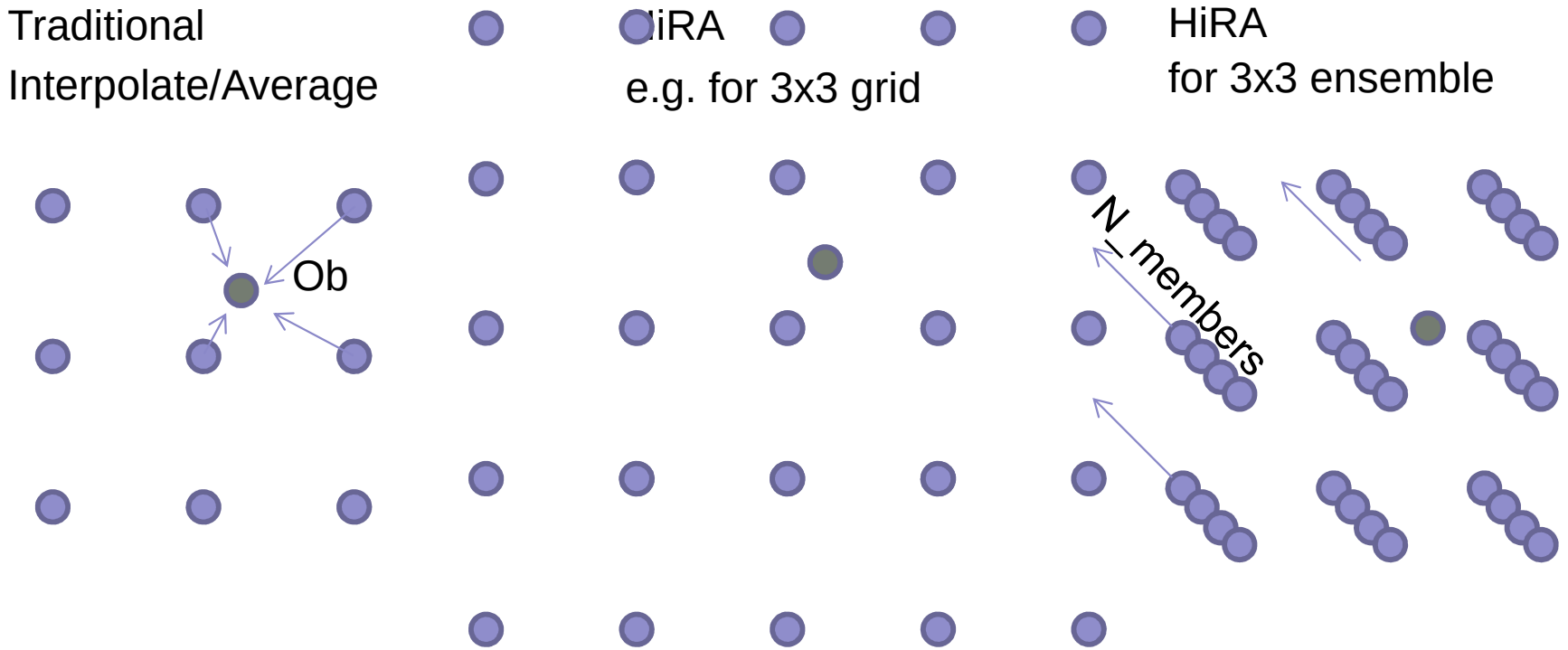
High Resolution Assessment framework*

- How to **consistently demonstrate skill** in increasingly higher-resolution models?
- Subjective assessment indicates skill, but the numbers don't always say this.
- Rapid error growth, timing errors, misplaced detail, double penalty effect.
- **single-observation-neighbourhood-forecast** approach (SO-NF).
- Verifying at observing sites is **relevant to the user.**

*Mittermaier M.P., 2014: A Strategy for Verifying Near-Convection-Resolving Model Forecasts at Observing Sites. Wea. Forecasting, 29, 185–204.

SO-NF

- Verifying against observations



Repeat for multiple neighbourhood sizes.

Create 3 scores from this data – Brier Score, RPS and CRPS (and associated skill scores)

High Resolution Assessment (HiRA) framework

@ grid scale

- Use standard synoptic observations and a range of neighbourhood sizes
- Use 24h persisted observations as reference
- The method needs to be able to compare:
  - Deterministic vs deterministic (different resolutions, and test vs control of the same resolution) ✓✓
  - Deterministic vs EPS ✓
  - EPS vs EPS
- Test whether differences are statistically significant (Wilcoxon signed rank test)
- Grid scale calculated for reference → NOT main focus.

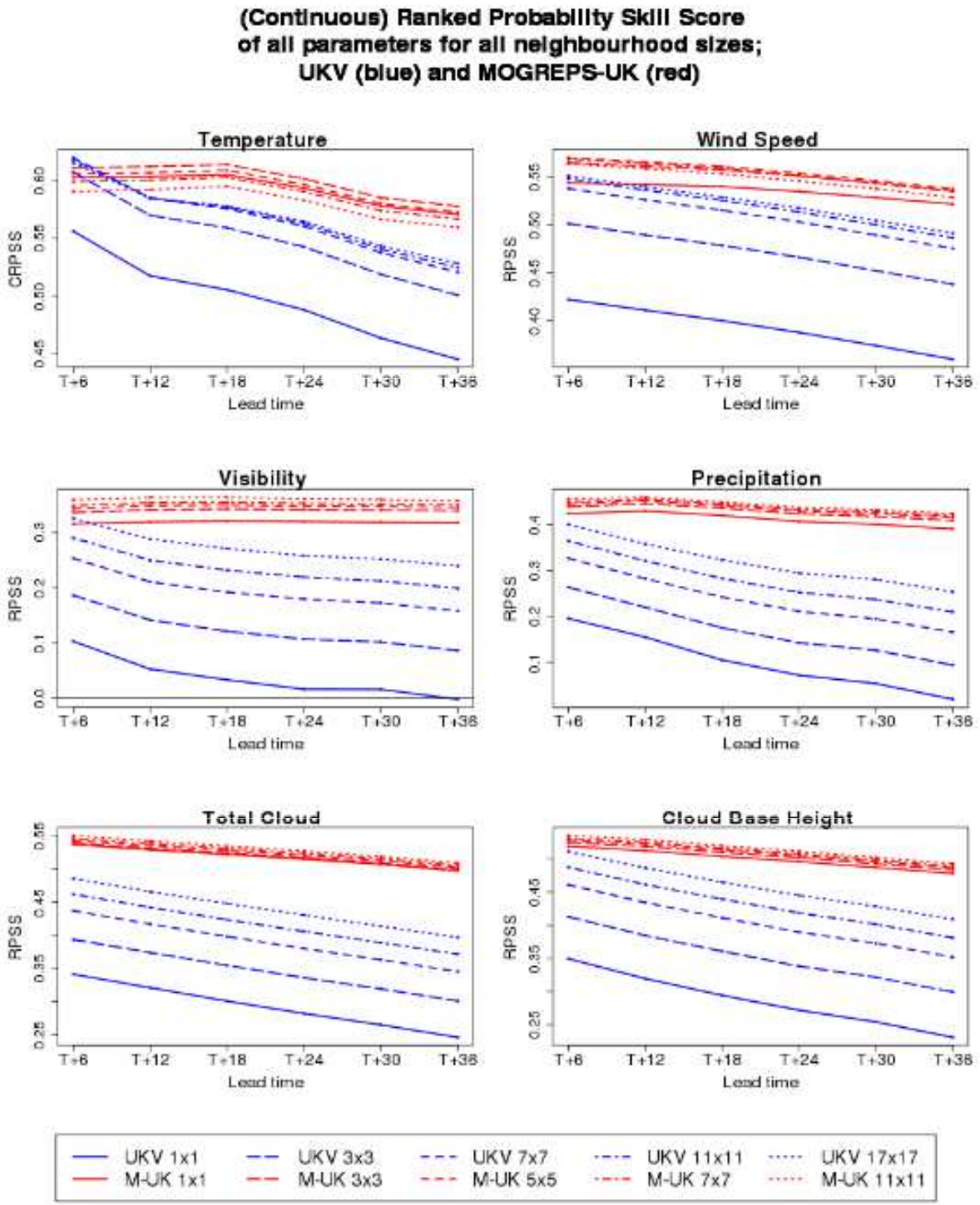
Variable	Old	New
Temp	RMSESS →	MAE
Vector wind (wind speed)	RMSVESS →	MAE
Cloud cover	ETS →	PC
CBH	ETS →	PC
Visibility	ETS →	PC
1h precip	ETS →	PC

RMS(V)ESS = Root Mean Square (Vector) Error Skill Score
ETS = Equitable Threat Score
BSS = Brier Skill Score
RPSS = Ranked Probability Skill Score
CRPSS = Continuous Ranked Probability Skill Score
MAE = Mean Absolute Error
PC = Proportion Correct

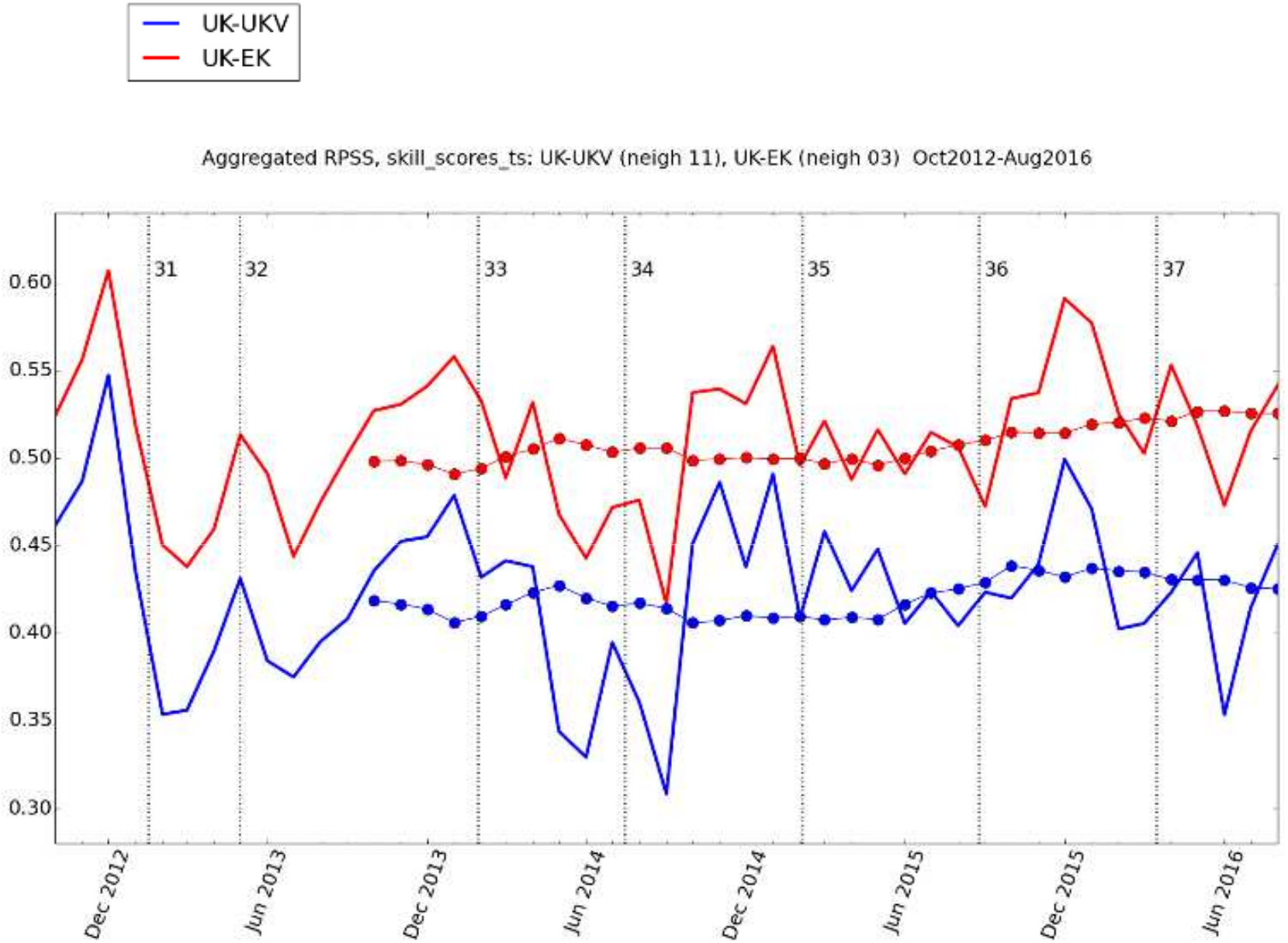
Mittermaier 2014, WAF.

Increasing neighbour hood size

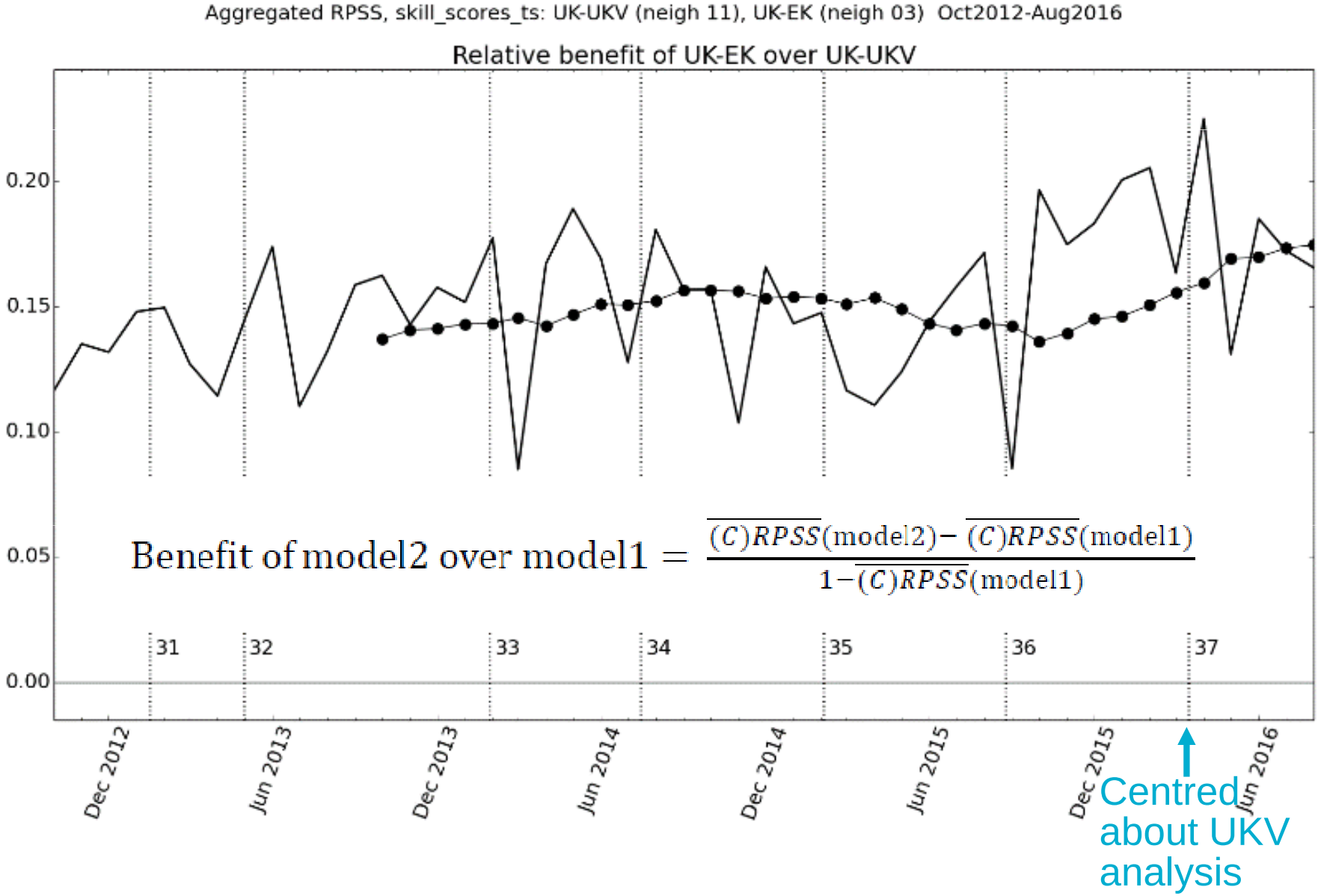
More effective for UKV than MOGREPS-UK



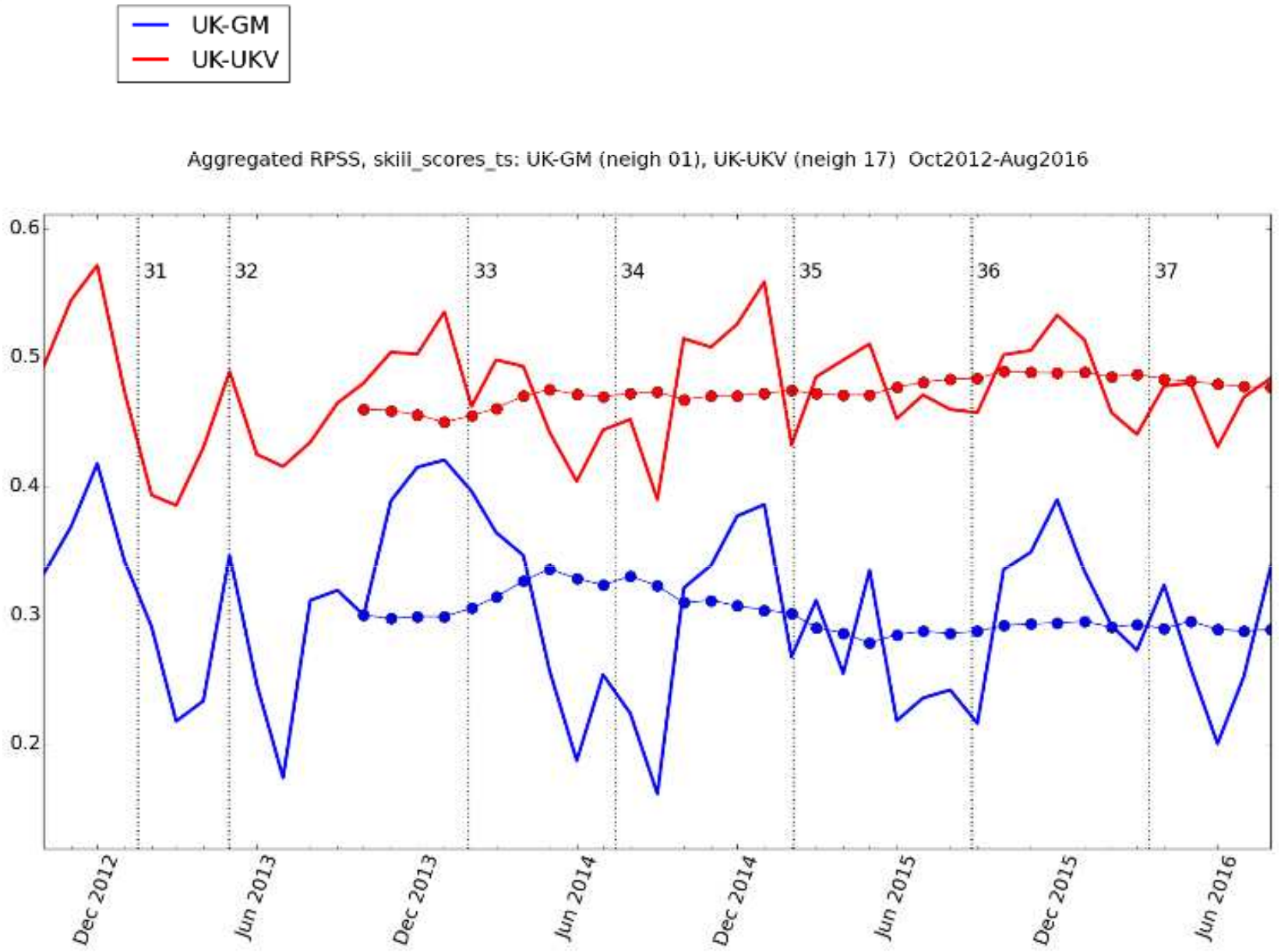
Monthly median index
MOGREPS-UK, UKV
“equal pseudo-ensemble 11x11, 12x9”



Relative benefit MOGREPS-UK, UKV – “equal pseudo-ensemble”

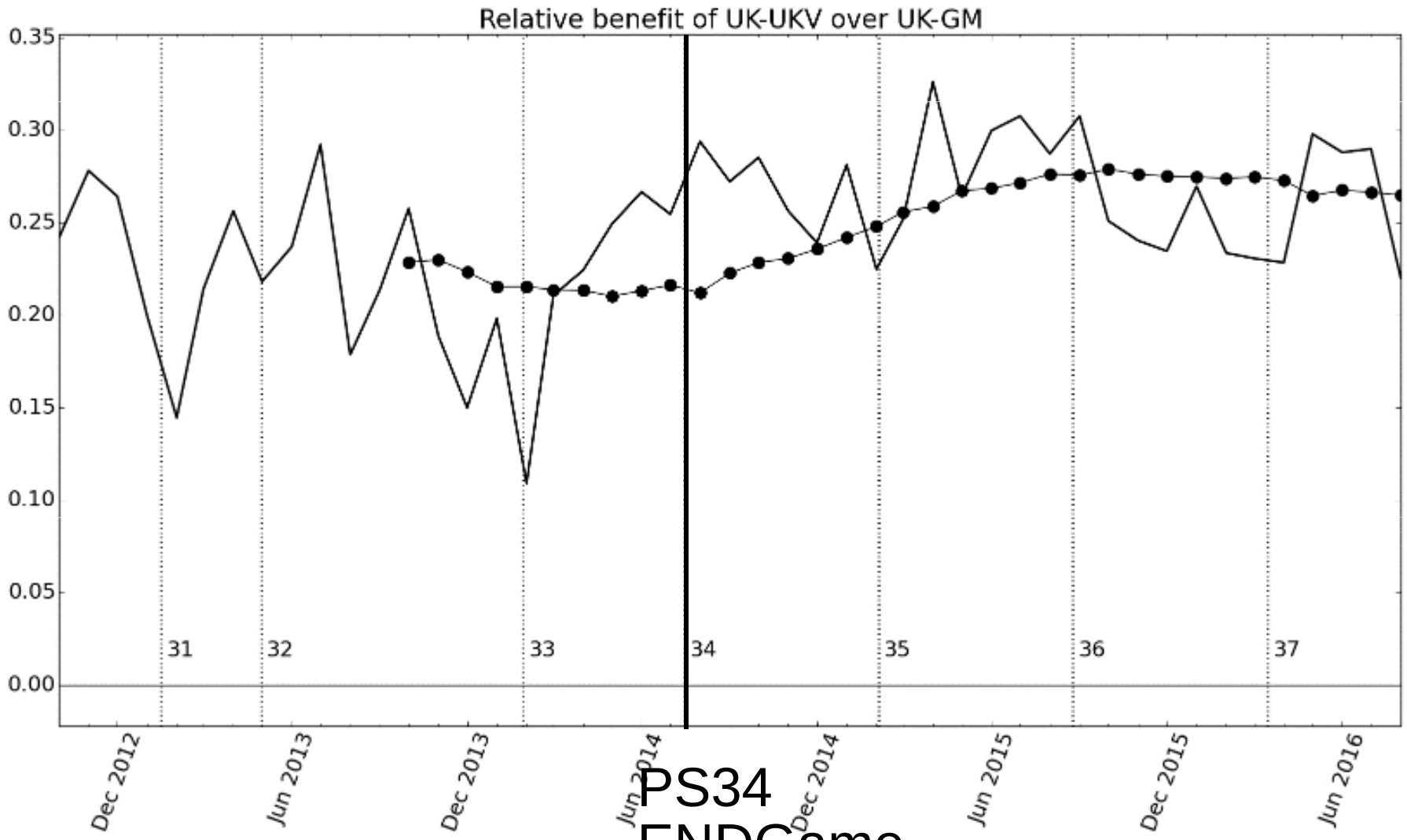


Relative benefit UKV over Global



$$\text{Benefit of model2 over model1} = \frac{\overline{(C)RPSS}(\text{model2}) - \overline{(C)RPSS}(\text{model1})}{1 - \overline{(C)RPSS}(\text{model1})}$$

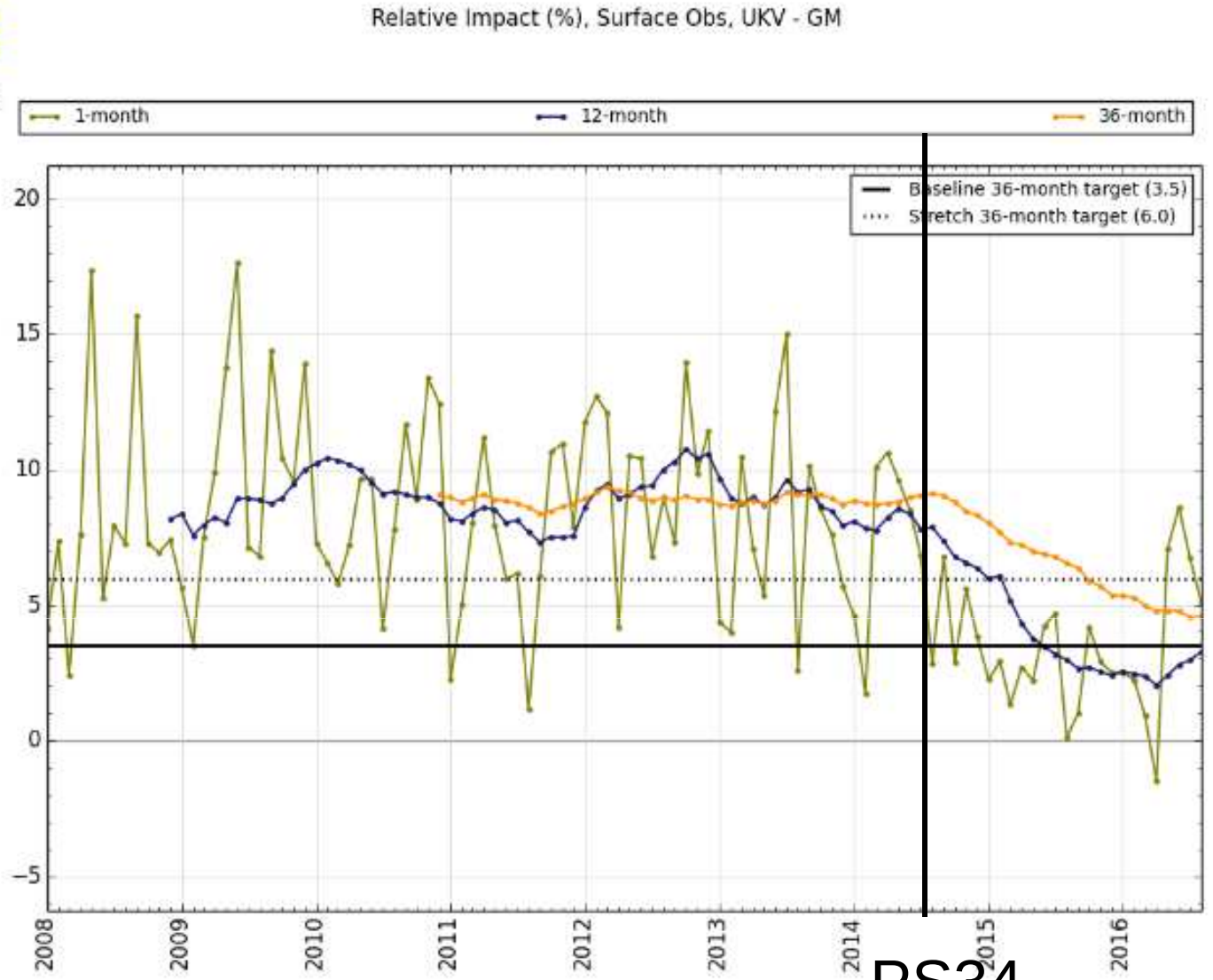
Relative benefit UKV over Global



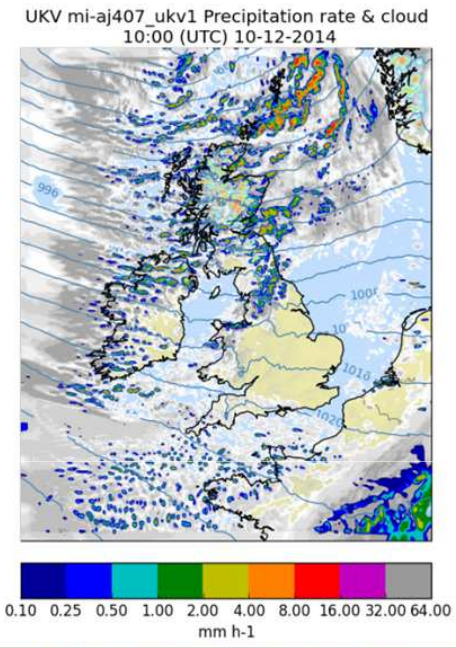
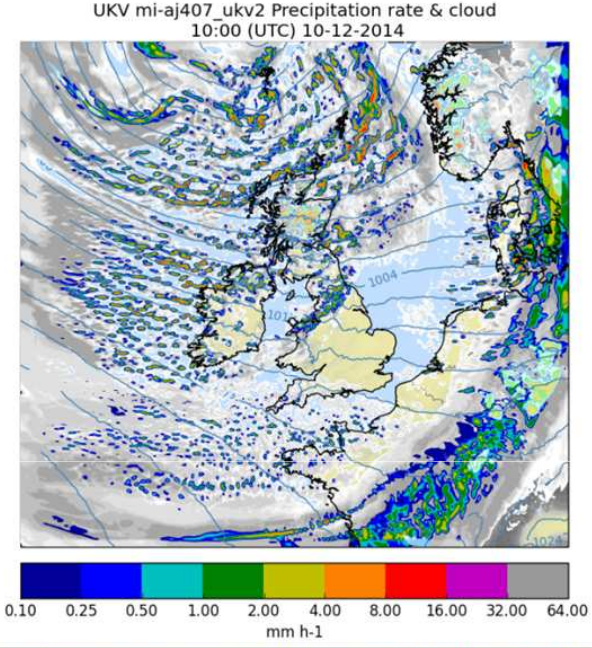
PS34
ENDGame

Old index- standard GP→Ob, RMSE, ETS skill scores

PS34 – ENDGame, GA6 physics, 17km



PS38 :extended domain
Improved Spin-up of Convection – 10/12/14

Operational UKV1	Extended Domain UKV2
	

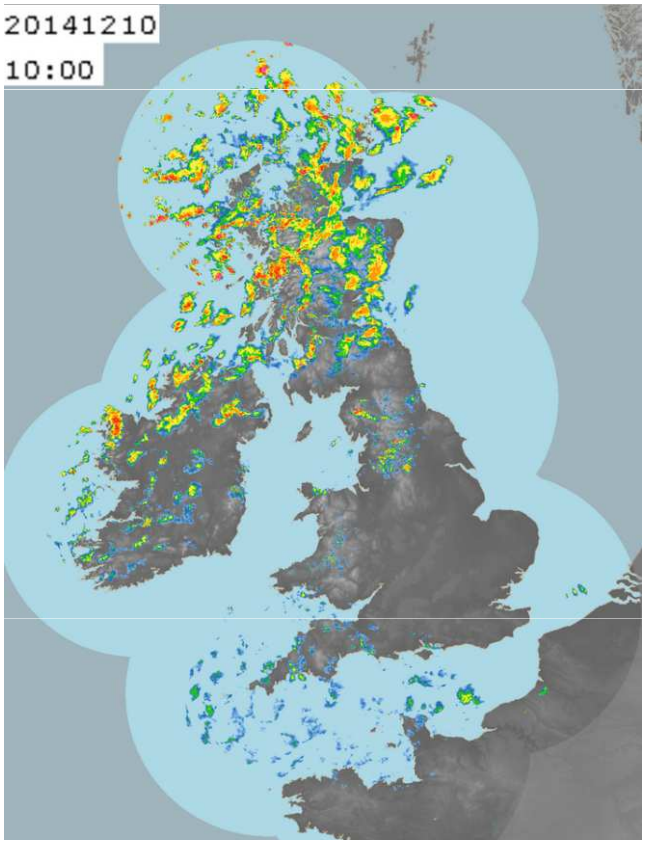
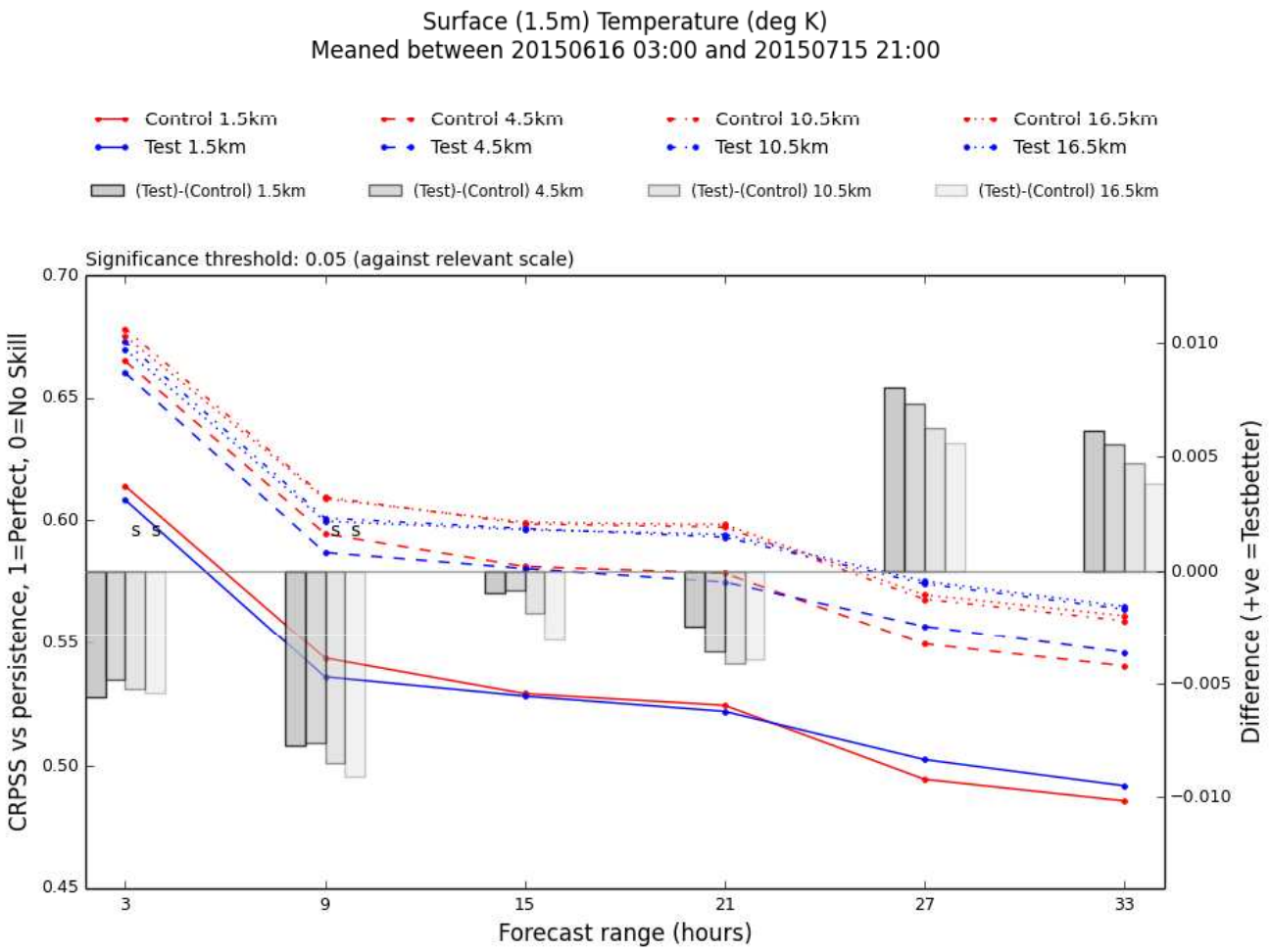


Figure 1 Comparsion showing improved representation of showery regime to the west of Ireland. Both models have cloudy boundary conditions in the west from which convection develops. UKV2 provides a better product for the UK given that the convection has more time to develop within it.

Parallel trials
1.5m temperature CRPSS
1-2% worse early forecast range

HiRA Summer

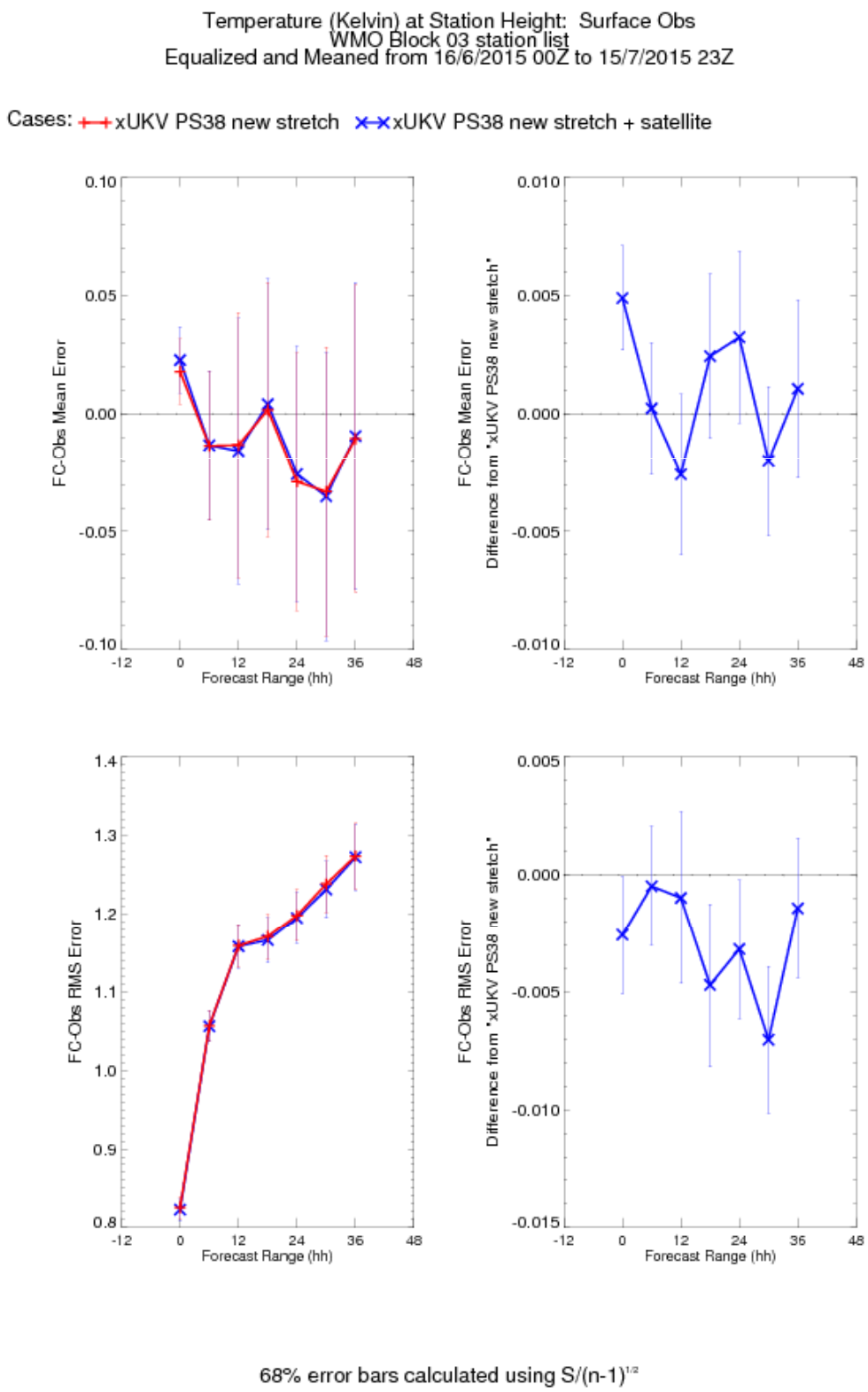
up is good



Standard bias and RMSE

PS38 package slight advantage ~ -0.4%

Summer

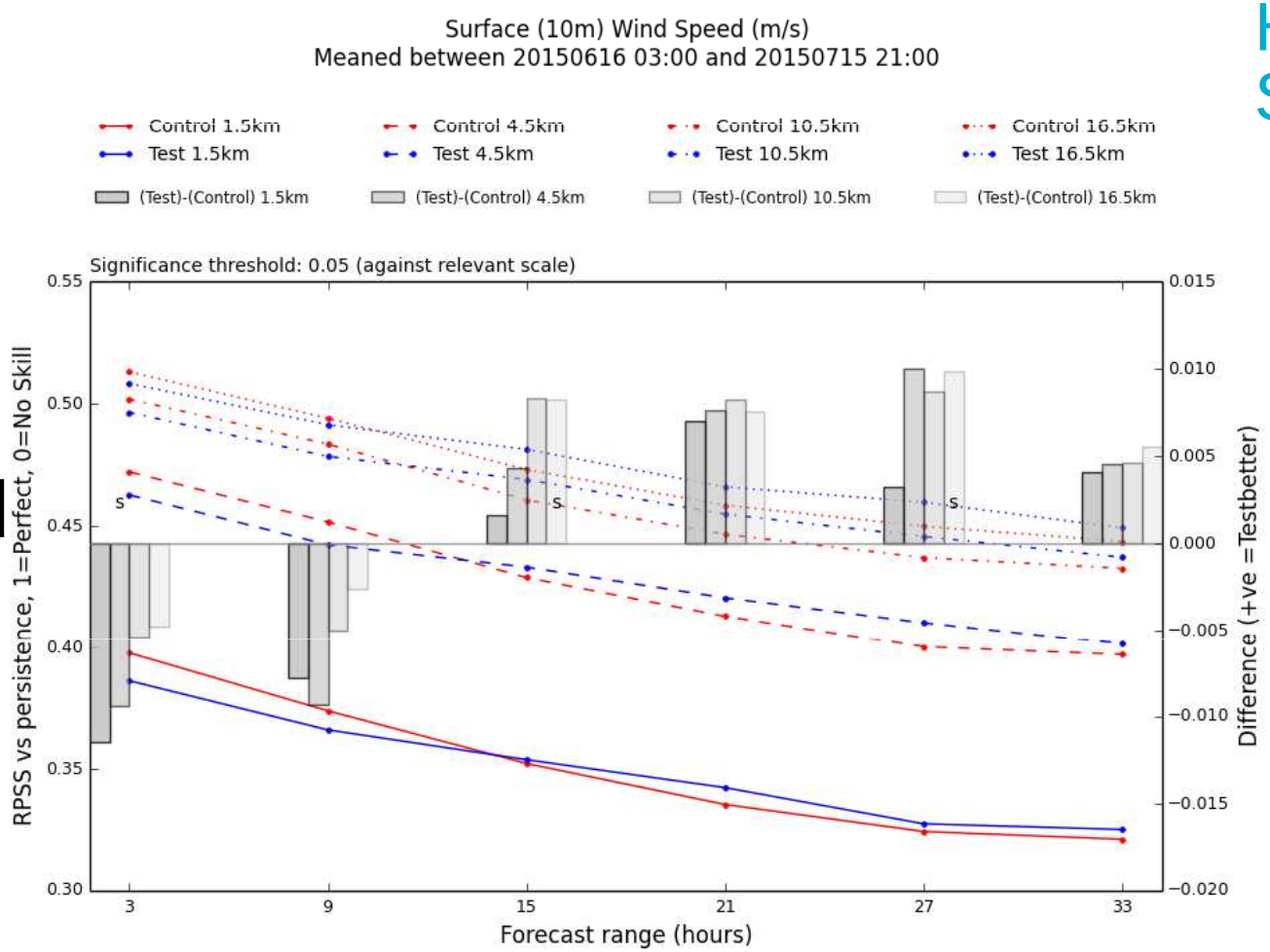


10m wind RPSS

2.5% worse early forecast range

HiRA Summer

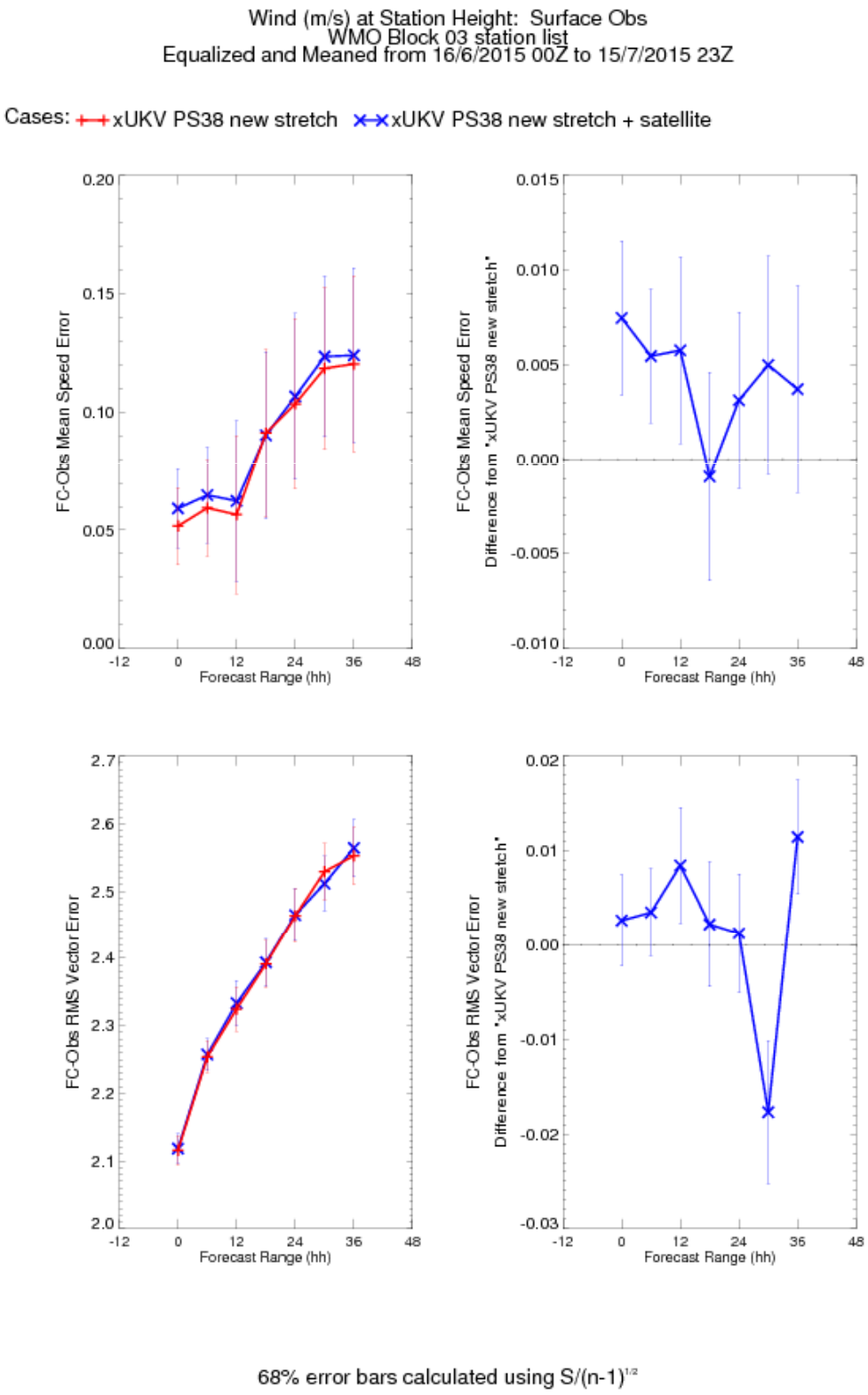
up is good



Standard speed bias and RMSVE

PS38 package slight detriment ~ +0.4%

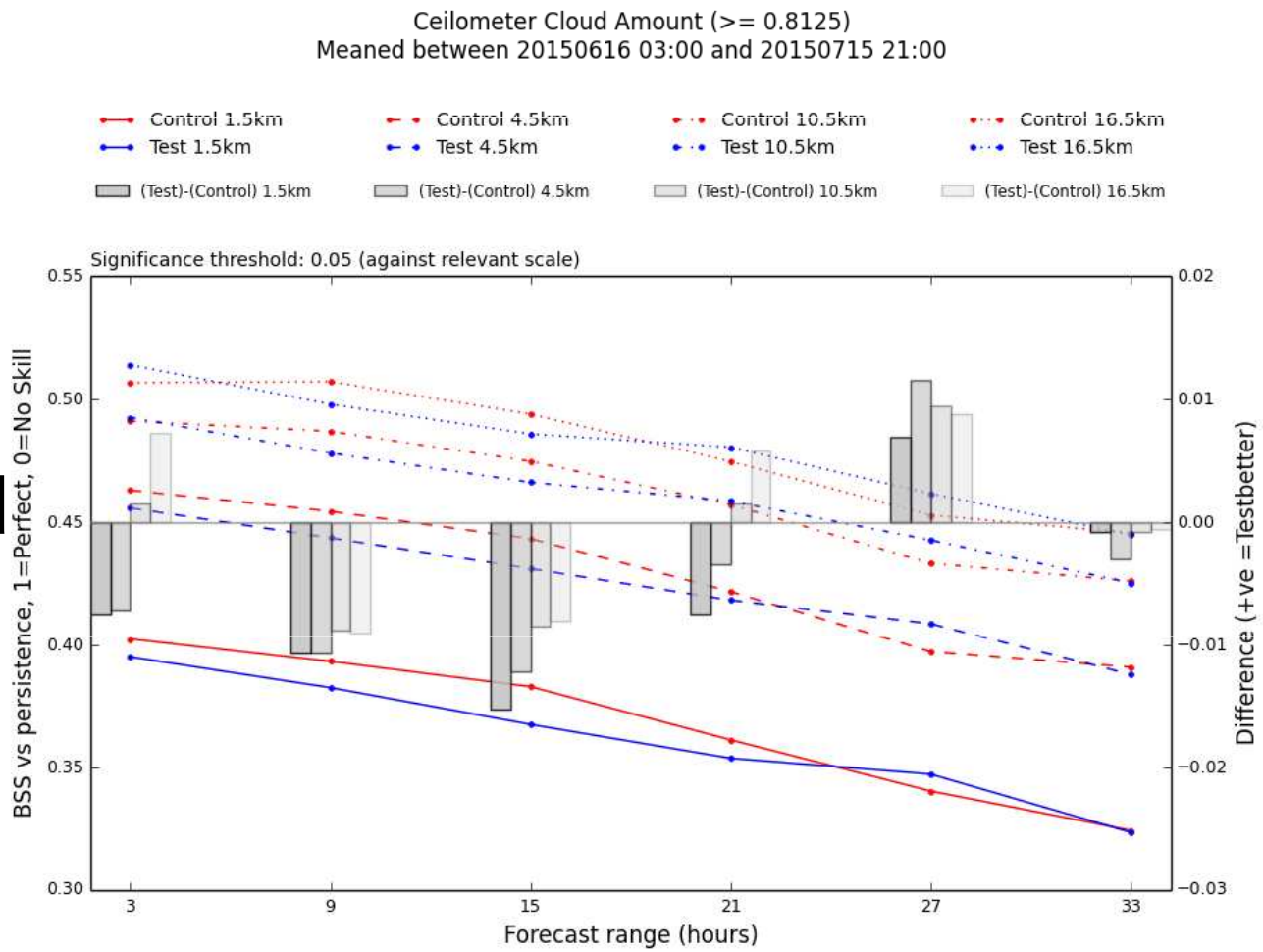
Summer



Cloud amount >=0.8125

HiRA Summer

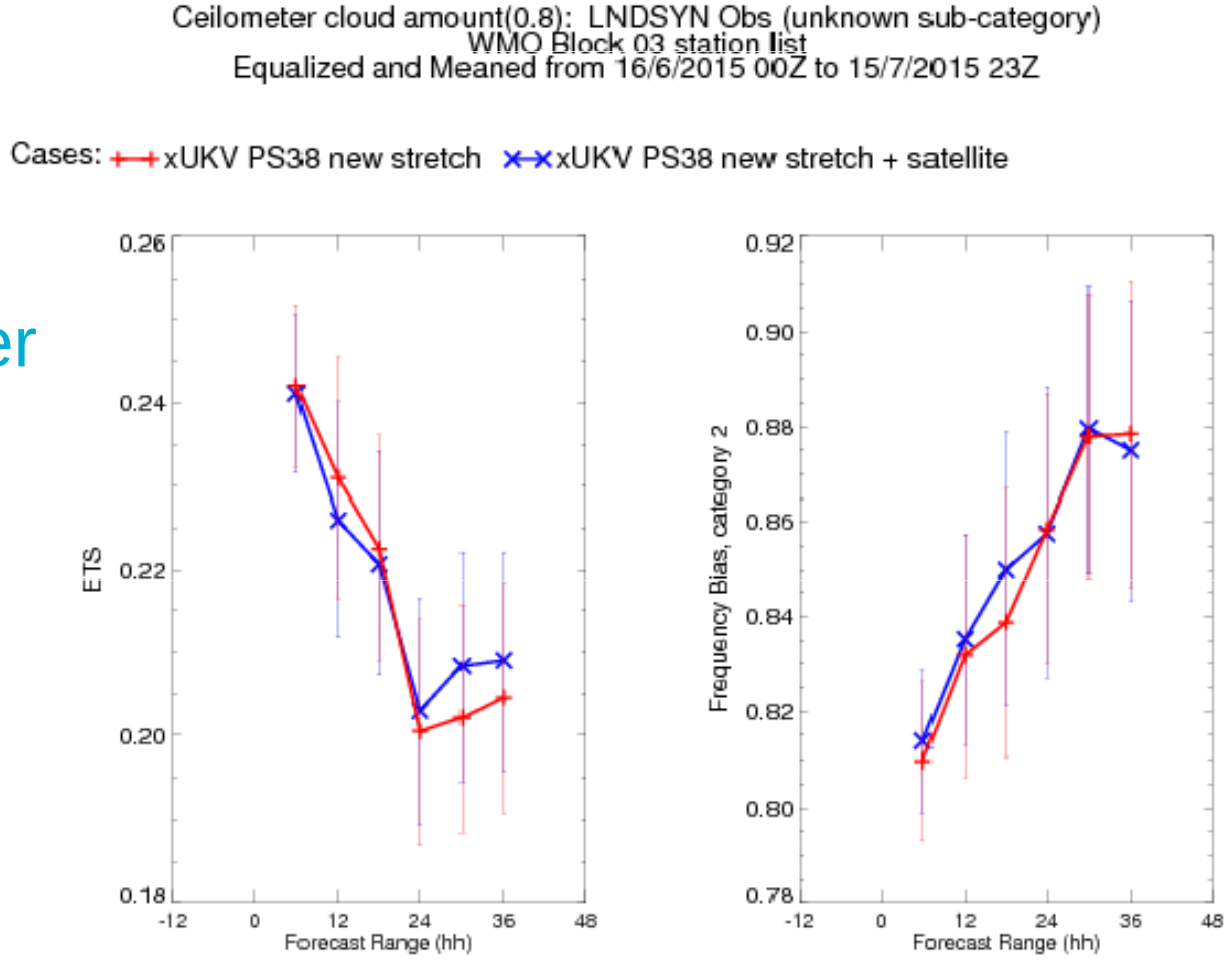
up is good



Cloud amount ≥0.8, Standard ETS and frequency bias

PS38 package slight detriment to T+18, better T+24 onwards

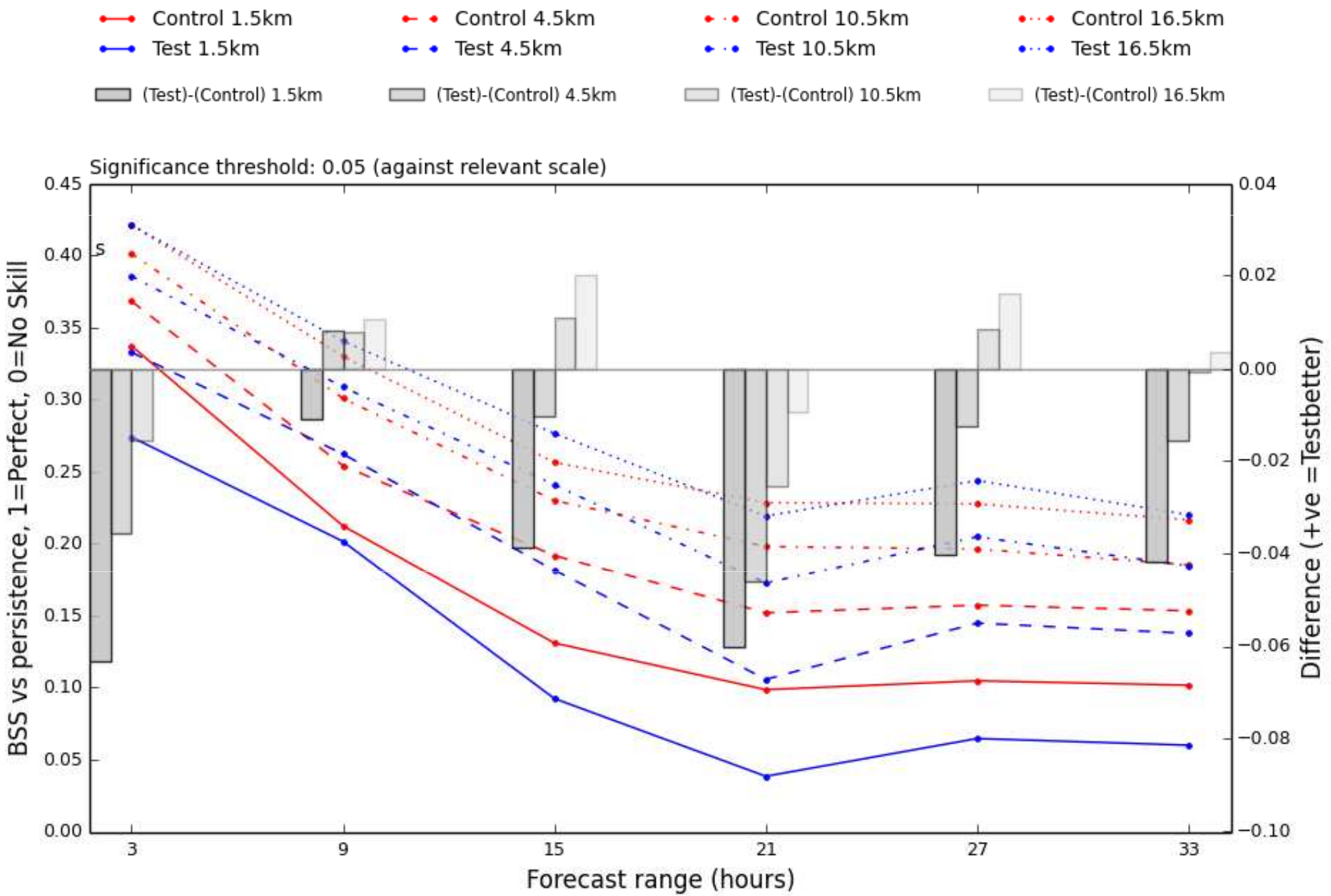
Summer



Summer

1hr Precipitation Accumulation (mm) (>= 1mm)
Meaned between 20150618 03:00 and 20150715 21:00

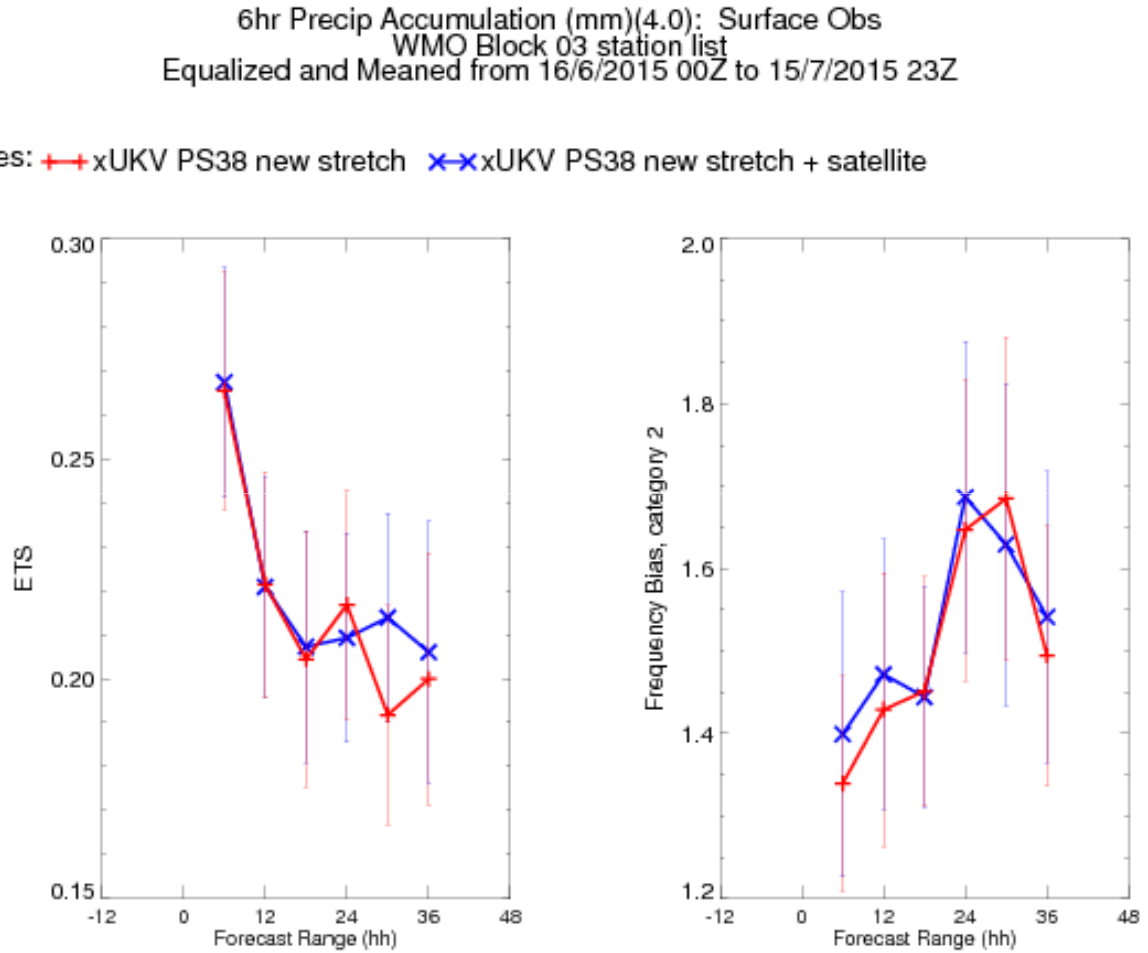
HiRA



PPN ≥4mm/6h Standard ETS and frequency bias

PS38 package ETS neutral to T+18; slight detriment to bias to T+24, different impact to HiRA

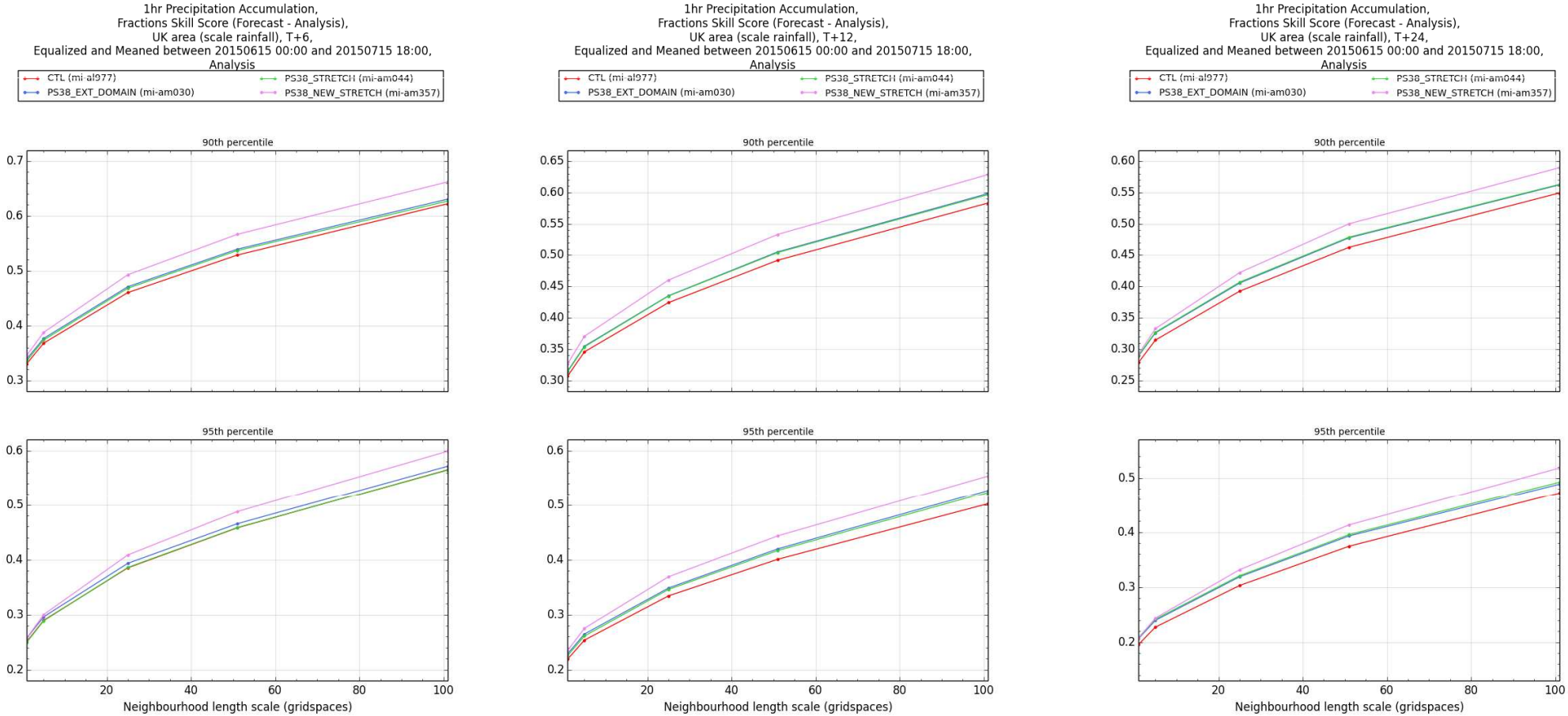
Summer



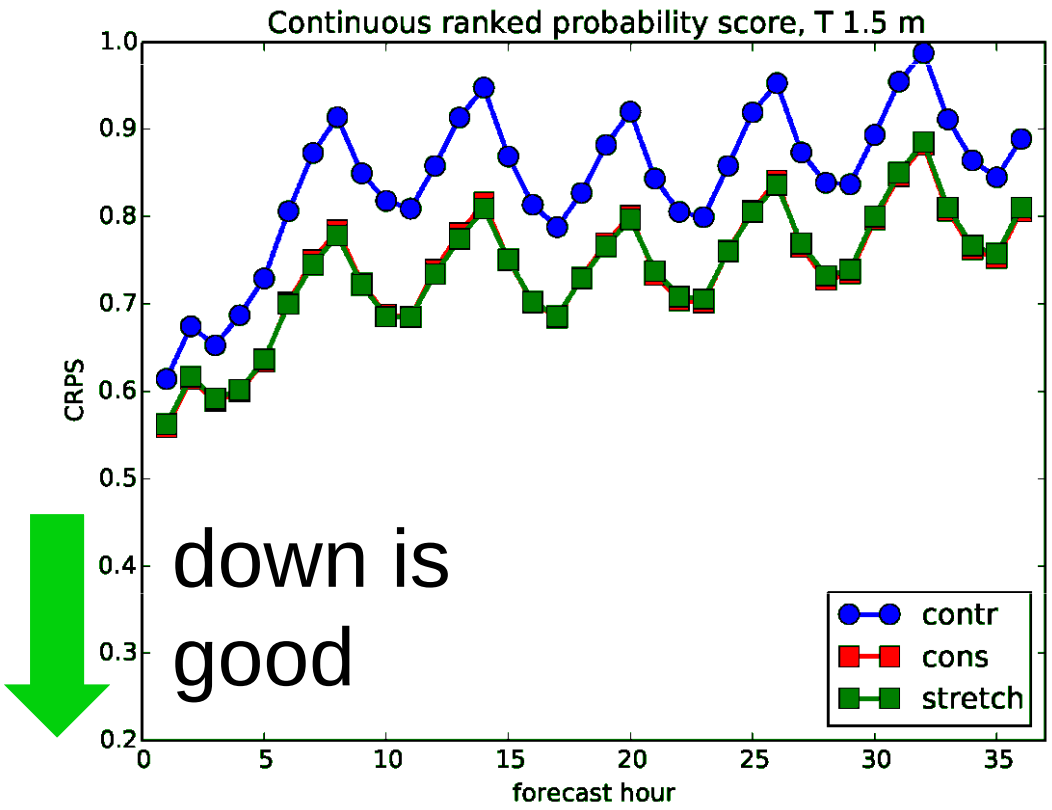
1 hr Ppn Accumulation FSS: T+6, T+12, T+24

Disagrees with HiRA

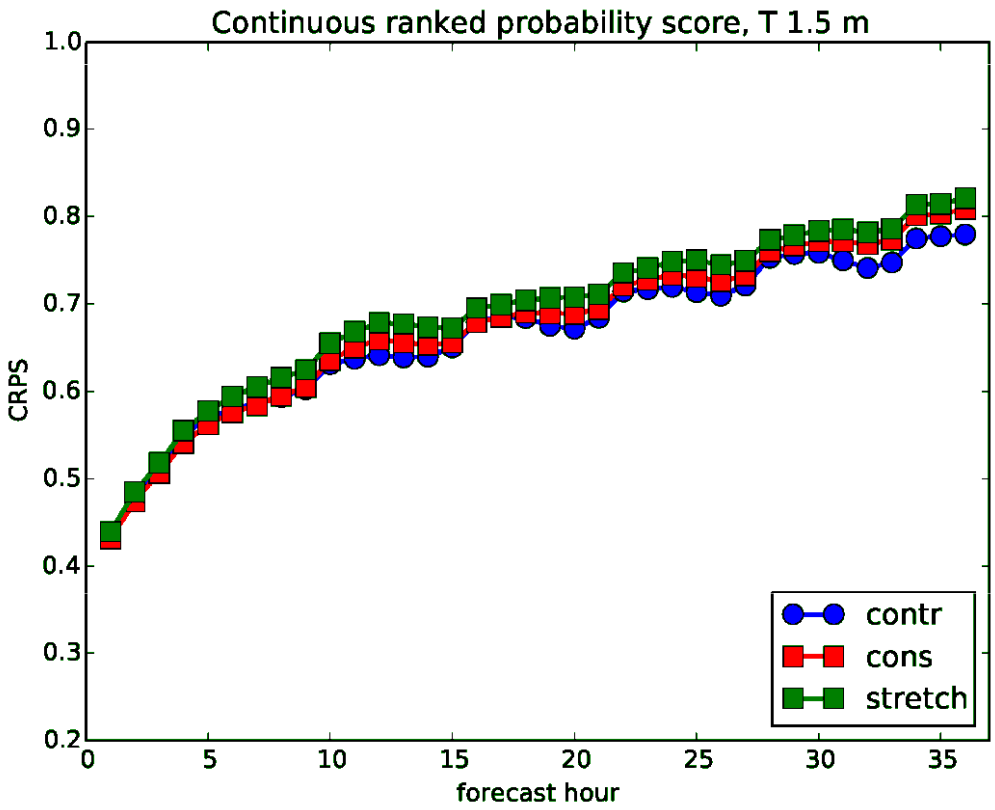
Summer



MOGREPS-UK
CRPS 1.5m temperature

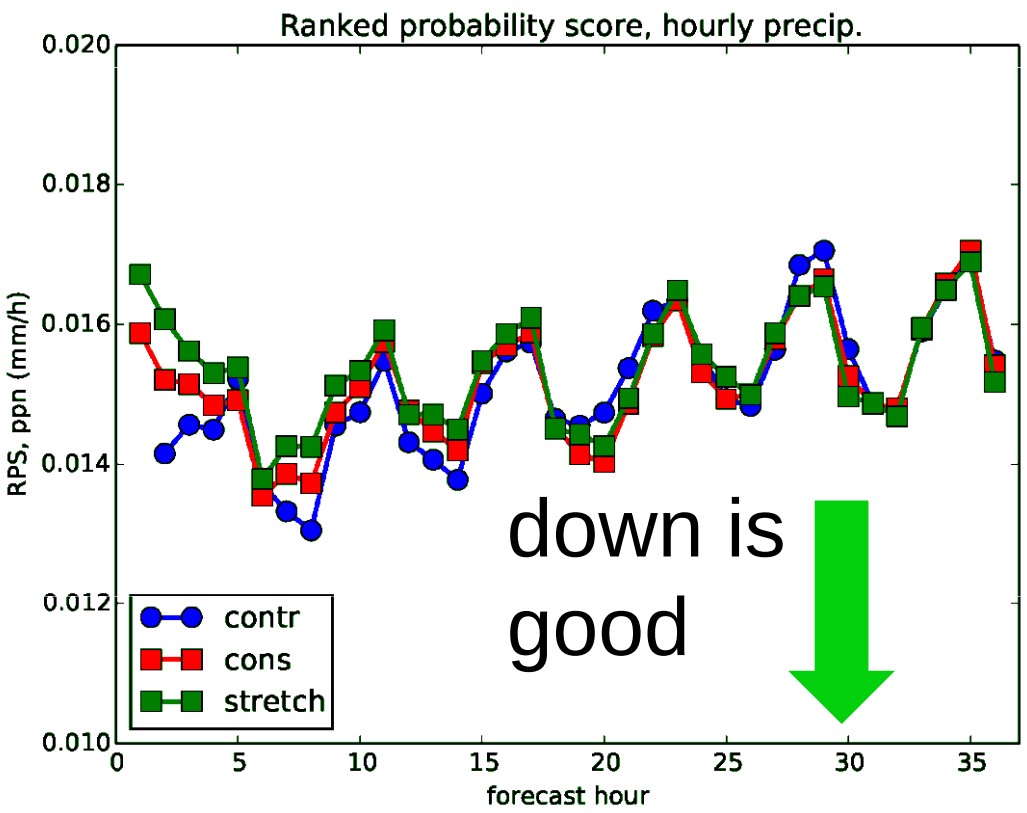


Summer

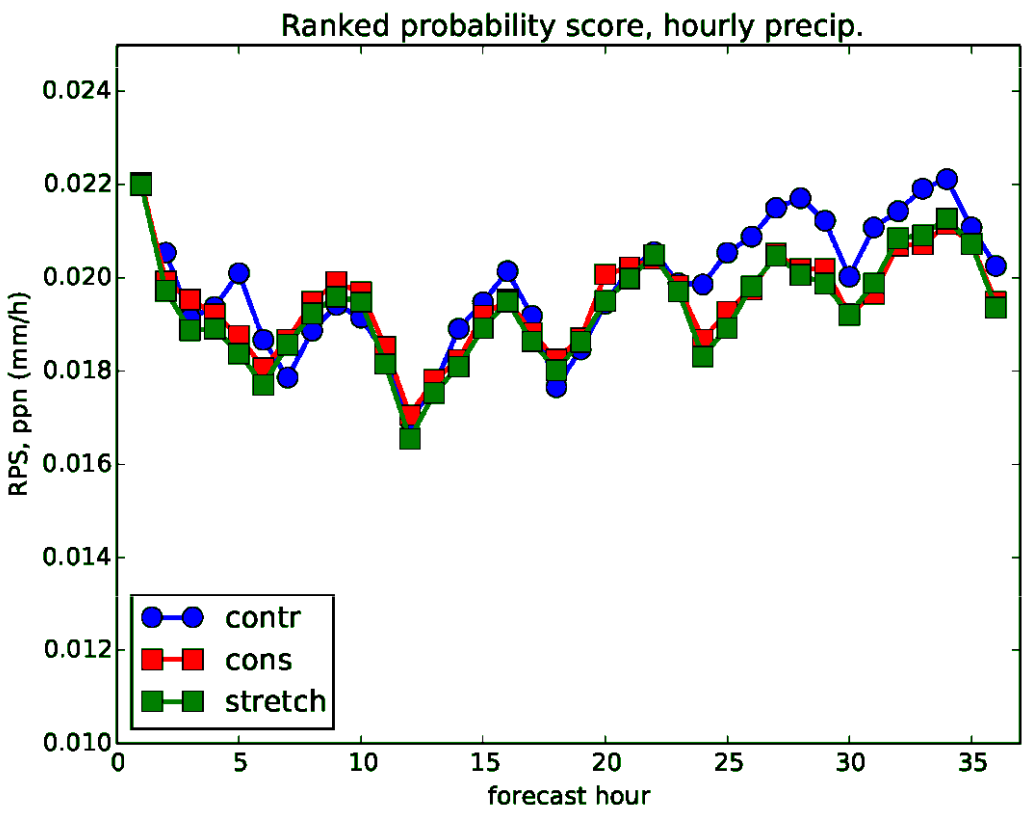


Winter

MOGREPS-UK
RPS precipitation (hourly)



Summer



Winter

Conclusions

- FSS monitor long term trends
- HiRA
  - Unified approach deterministic/ensemble
  - Show ensemble benefit
  - Show high resolution benefit (convective scale)
- Parallel trials use:
  - Some discrepancies with conventional GP-Ob
  - Summer (convective) disagreement with FSS
    - HiRA – smaller scale verification

Met Office

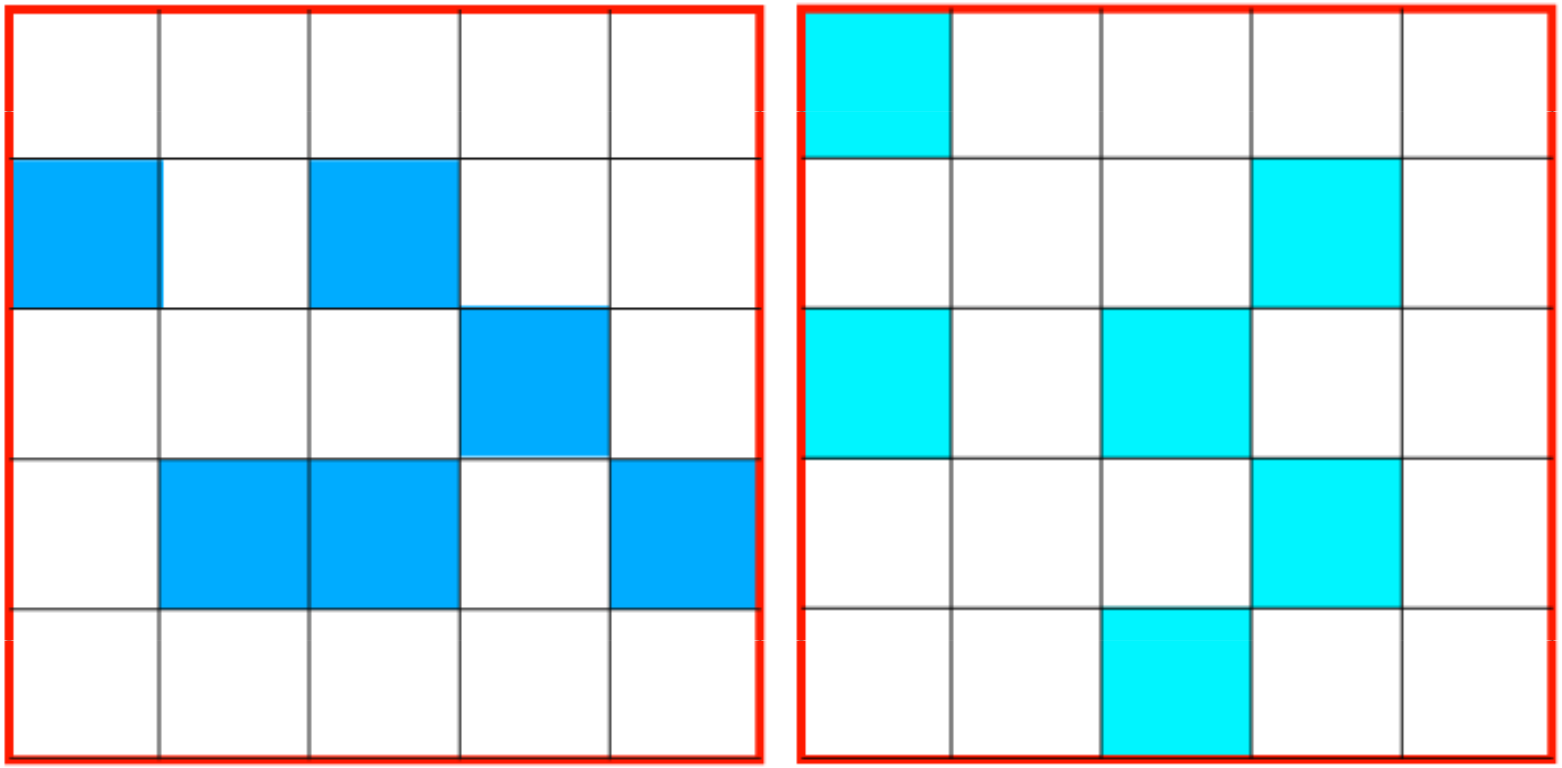
Grazie
Questions?

Extra slides

Compare fractional coverage over different sized areas

observed

forecast



Fraction = 6/25 = 0.24

Fraction = 6/25 = 0.24

Threshold exceeded where squares are blue

Courtesy of Nigel Roberts

The Fractions Skill Score (FSS) for comparing fractions with fractions

Roberts and Lean (2008), Roberts (2008), Mittermaier and Roberts (2010)

Mean square error for the fractions – variation on the Brier score

$$\underset{\text{(Fractions Brier Score)}}{\text{FBS}} = \frac{1}{N}\sum_{j=1}^{N}(p_j - o_j)^2$$

$0 \leqslant p_j \leqslant 1$ forecast fractions

$0 \leqslant o_j \leqslant 1$ radar fractions

N number of points

Skill score for fractions/probabilities - Fractions Skill Score (FSS)

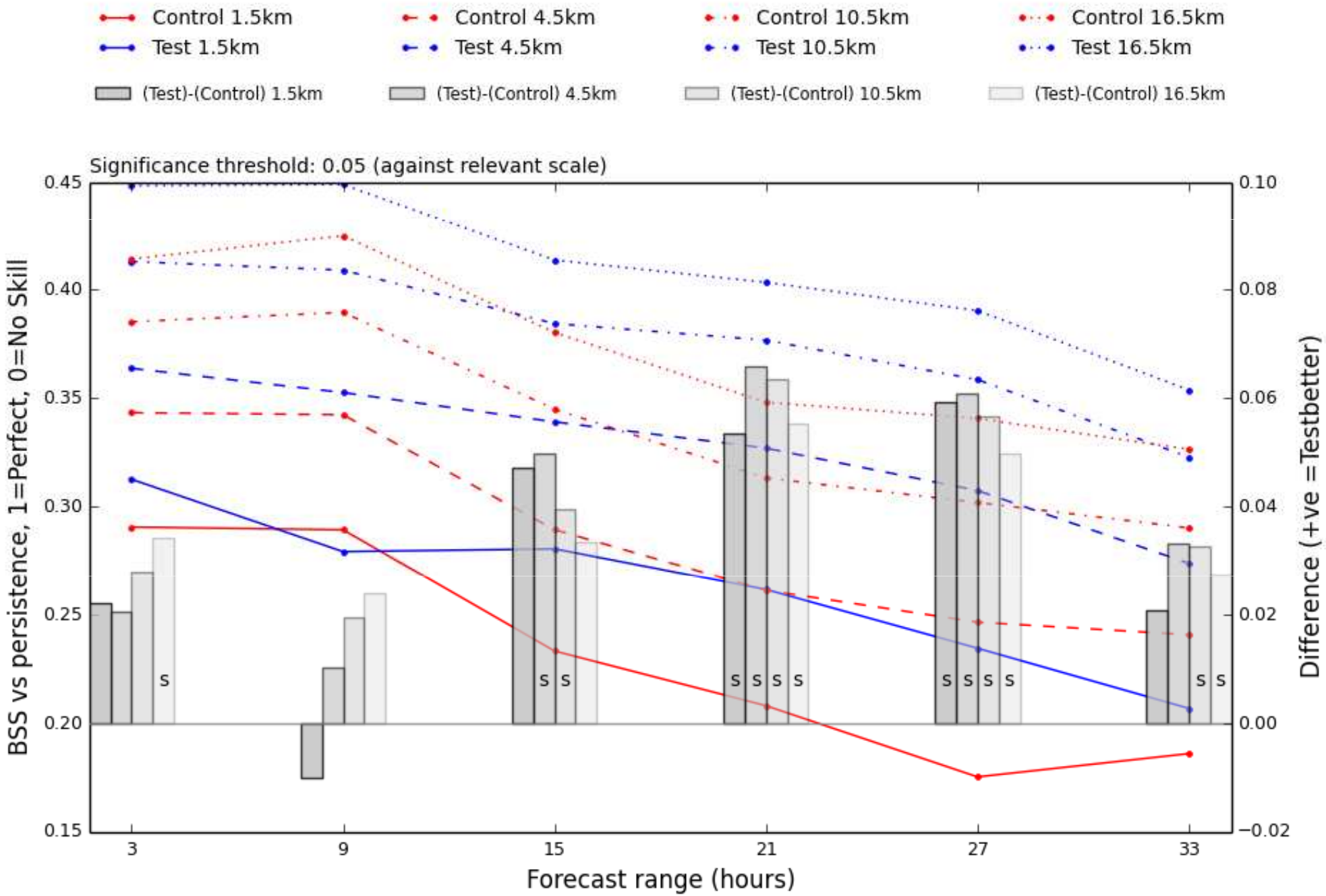
$$\text{FSS} = 1 - \frac{\text{FBS}}{\frac{1}{N}\left[\sum_{j=1}^{N}(p_j)^2 + \sum_{j=1}^{N}(o_j)^2\right]}$$

Courtesy of Nigel Roberts

Winter

1hr Precipitation Accumulation (mm) (>= 1mm)
Meaned between 20150112 03:00 and 20150305 21:00

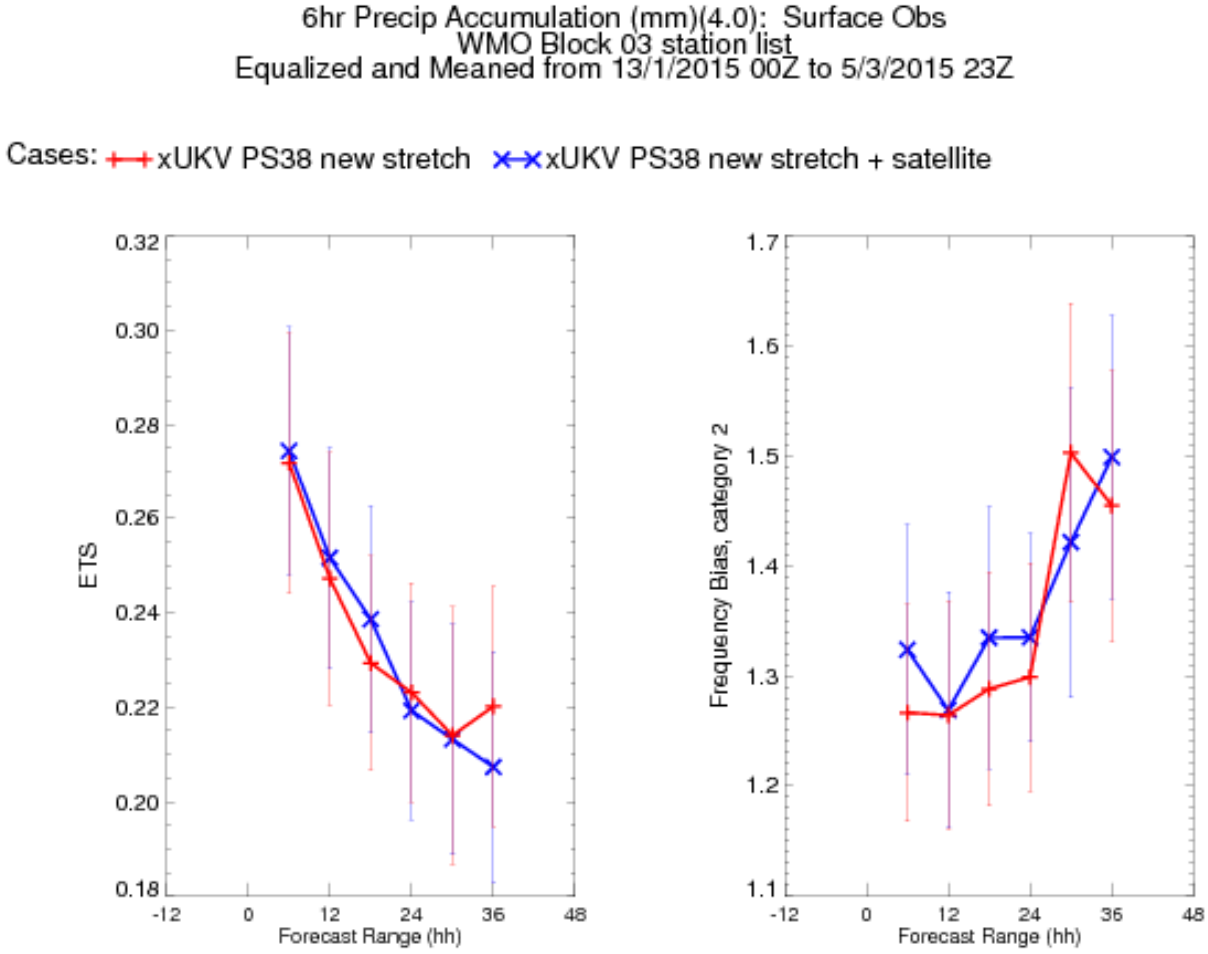
HiRA



PPN ≥4mm/6h Standard ETS and frequency bias

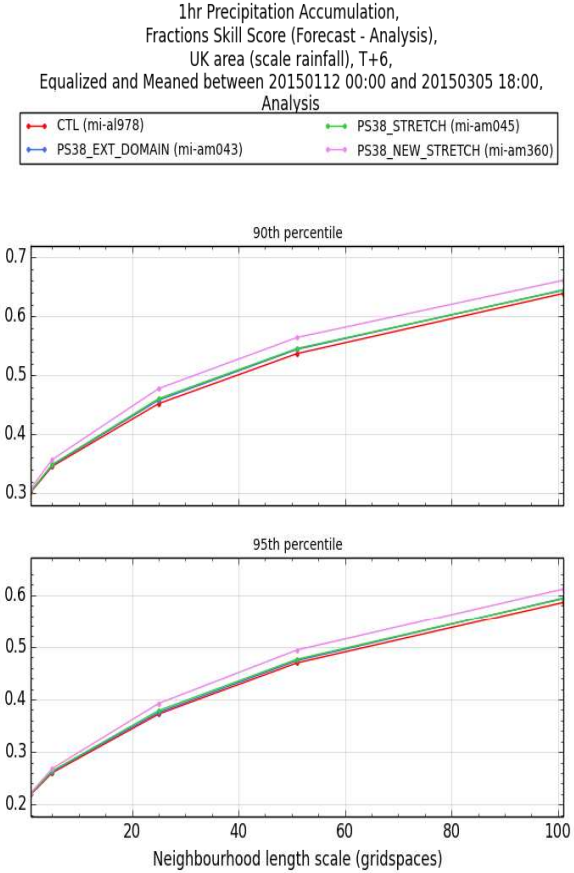
PS38 package ETS better to T+18; slight detriment to bias to T+24, similar impact to HiRA to T+18

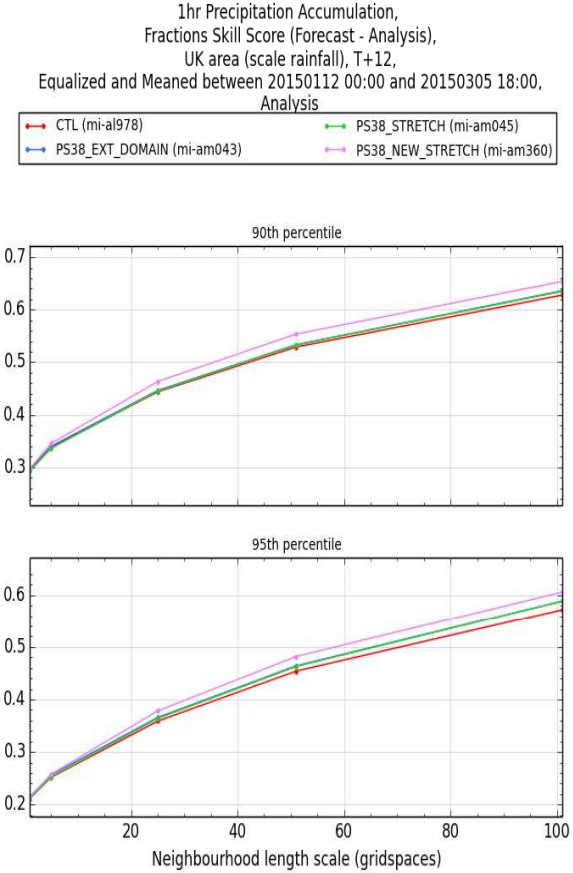
Winter

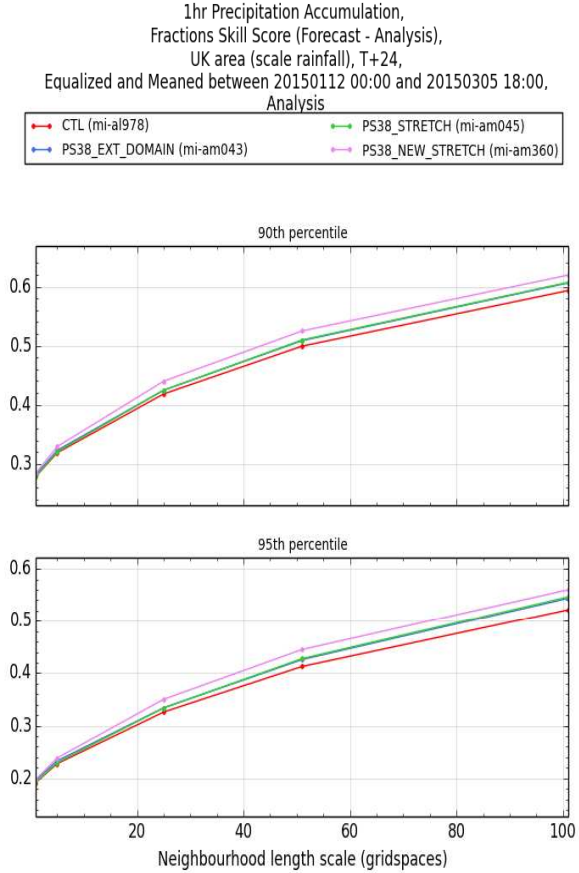


1 hr Ppn Accumulation FSS: T+6, T+12, T+24

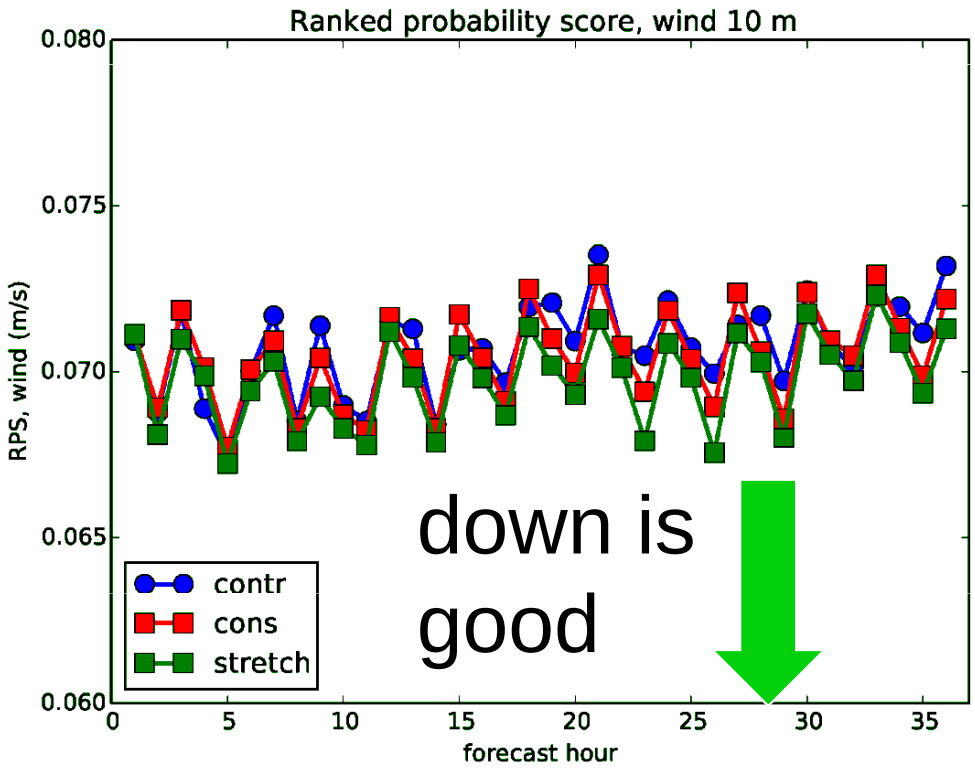
Winter

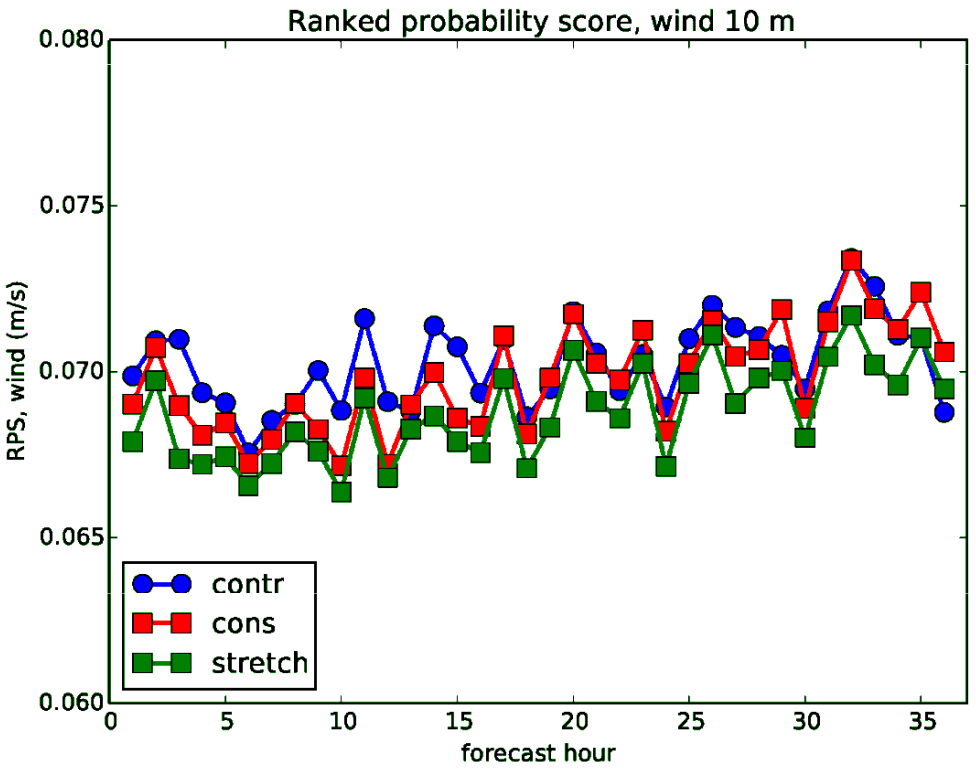






MOGREPS-UK
RPS 10m wind speed





Summer

Winter