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Insights into behaviour of long term trends of the fractional skill score

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Outline

FSS time series: can we actually understand what effect each operational upgrade had?

Refactoring: introducing the Lead Time Potential (LTP) alongside the Skilful Spatial Scale (SSS)

Stratification: performance as a function of flow types

Conclusions

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FSS time series

365-day running mean since the 1.5 km UKV became operational in 2011.

Operational suite block-mean analysis of the same scores.

Based on 95th percentile threshold exceedance of hourly precipitation accumulations.

The FSS, based on percentile thresholds, measures the degree of agreement in the spatial pattern of the forecast, *not the intensity.* i.e. has the forecast become a better or worse match in terms of the distribution and structure of precipitation elements.

[This analysis is based on taking the mean of individual scores.]

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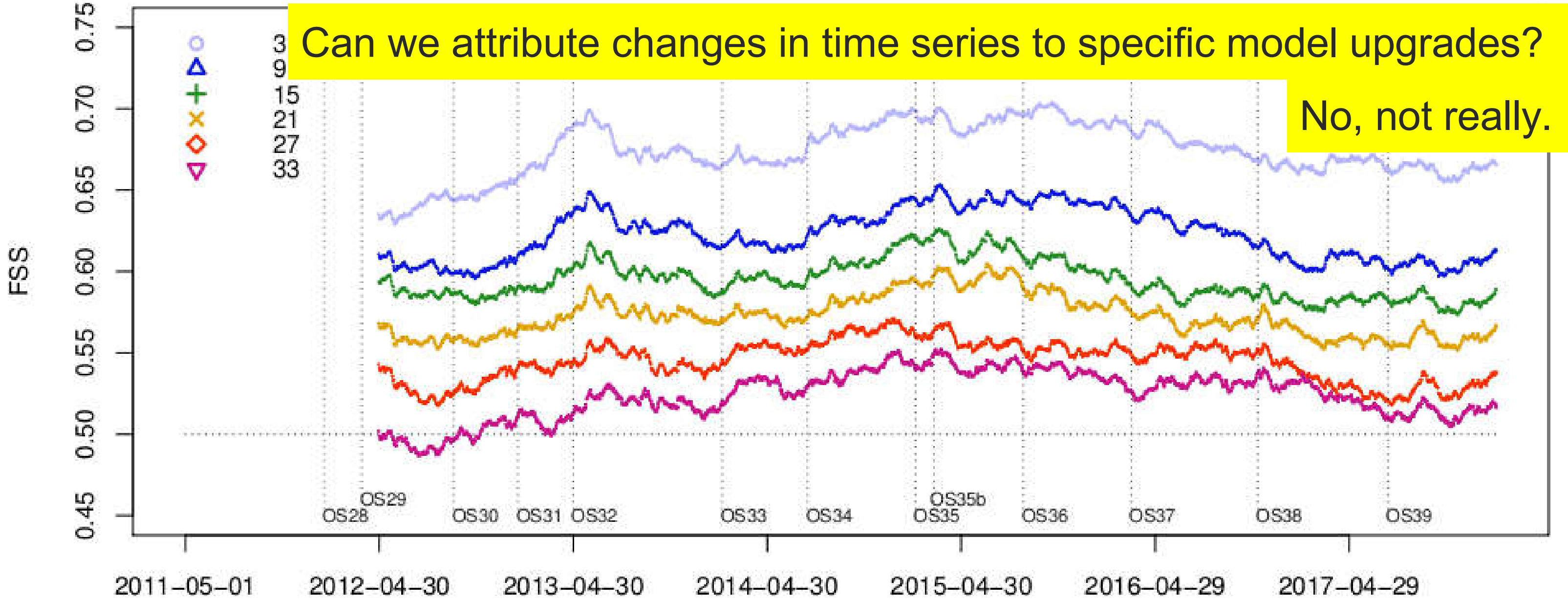
Continuous time series of model performance



Skill decreases with increasing lead time

Hourly precipitation scores for the 101 km neighbourhood as a 365-day running mean for a selection of lead times valid @ 12Z
Operational model upgrades are indicated by vertical dotted lines.
Changes can affect skill in a highly non-linear way.

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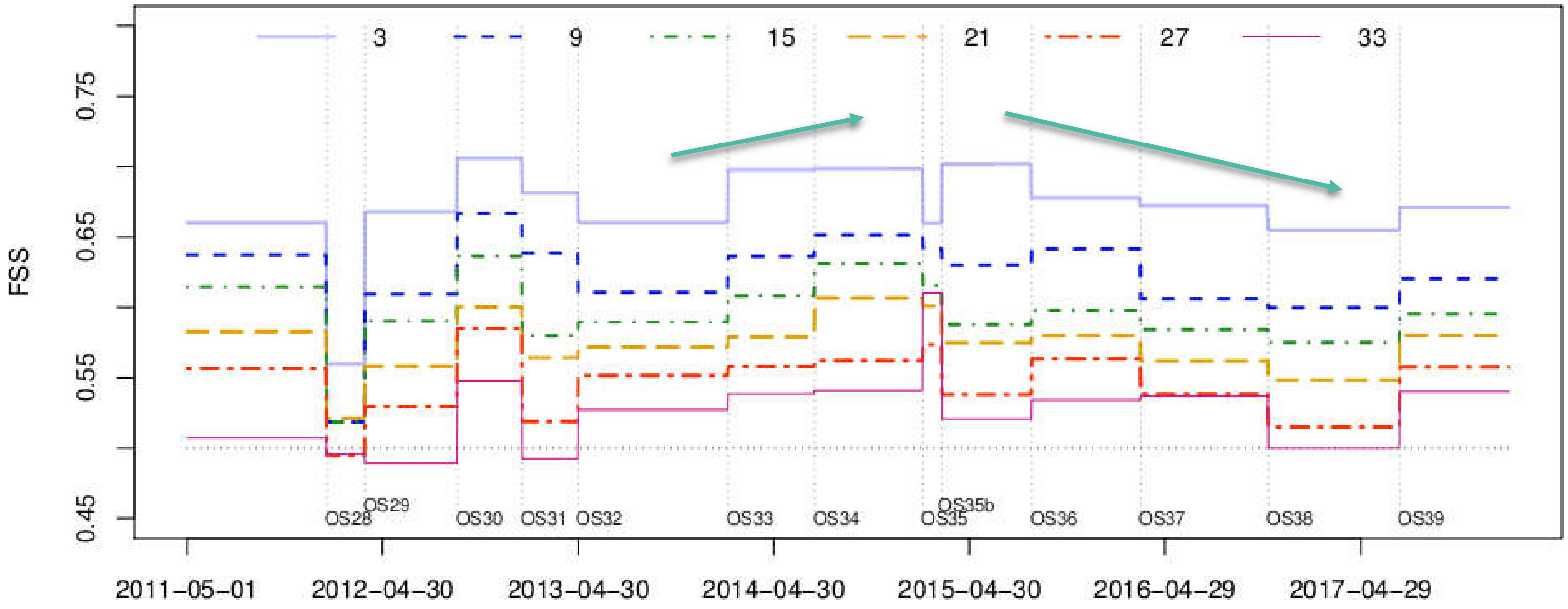
Block mean analysis



Analysing each operational suite as a block shows that the skill from OS to OS (block) can vary quite a bit.

Consecutive upgrades with positive or negative effects become clearer.

The non-linear impact (of model changes) as function of lead time is also more apparent.

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Refactoring the FSS

In space: skilful spatial scale (SSS)

In time: lead time potential → lead time where the FSS drops below 0.5 for the first time in a given 36h forecast integration (run)

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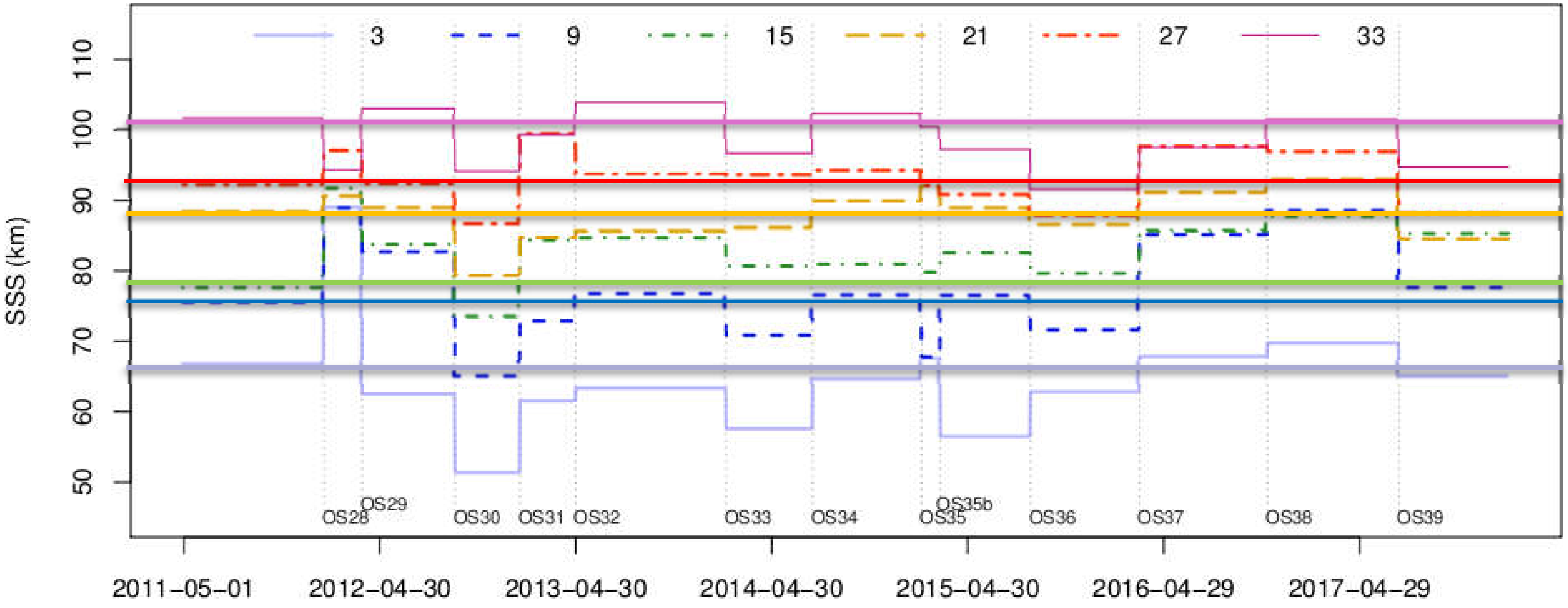
Average Skilful Spatial Scale

Refactoring the FSS can reveal other attributes of the forecast

Defined on the neighbourhood size where the

FSS >= 0.5 + *f*/2

where *f* is the observed frequency of occurrence at a given threshold for that forecast period.



The SSS has stayed relatively constant in the past 7 years, with considerable variation between operational models. Overall the average skilful spatial scale has decreased (good) for some, but not all, lead times.

Lead Time Potential @ 25 km

Consider each forecast integration/run and track the hour where

FSS <= *X*

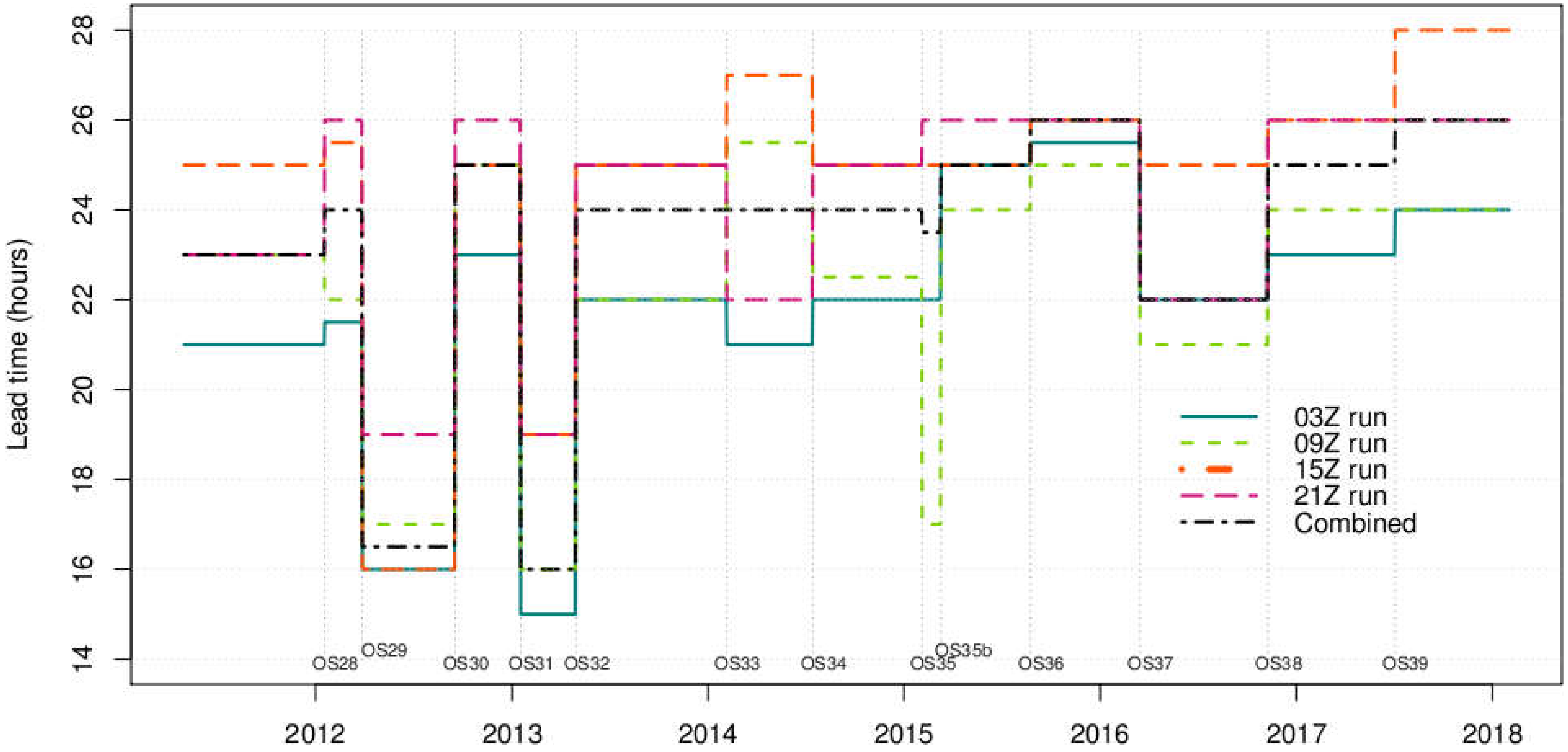
(set here to 0.5)

Consider 4 main initialisations separately.

Relatively noisy.

Surprisingly large differences between initialisation times.

General upward trend with the skilful time horizon for hourly forecasts increasing by 2-3h.



Forecast skill is maintained longer into the forecast integration.

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Stratification by weather regimes

What about the effect of skewed sampling of weather type on block averages or running means?

Performance is weather-regime dependent with some scenarios more predictable (though elements of the forecast may not reflect this).

Use regime classification to stratify scores and compute regime-dependent average FSS.

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Regime climatology

Decider is regime-based forecasting product which also classifies the high-resolution global analysis 4 times a day into one of 30 regimes.

This is too many to use. Reduce these by grouping into flow types.

	D/J/F	J/F/M	F/M/A	M/A/M	A/M/J	M/J/J	J/J/A	J/A/S	A/S/O	S/O/N	O/N/D	N/D/J	Mean occurrenc	Regime Descriptions (UK)
Regime 1	1.8%	1.9%	3.1%	5.1%	8.3%	12.1%	14.5%	12.8%	8.4%	4.1%	2.6%	2.0%	6.4%	Unbiased NWly
Regime 2	2.3%	2.6%	3.4%	5.0%	7.0%	8.9%	9.7%	9.2%	7.5%	5.5%	3.8%	2.8%	5.6%	Cyclonic SWly, returning Pm airmass
Regime 3	1.9%	1.9%	2.7%	4.3%	6.5%	8.9%	10.0%	9.4%	7.1%	4.7%	3.3%	2.3%	5.3%	Anticyclonic SWly, ridge over N France
Regime 4	2.2%	2.4%	3.1%	4.4%	5.7%	6.9%	7.6%	7.8%	6.7%	5.2%	3.6%	2.7%	4.9%	Unbiased Wly
Regime 5	2.4%	2.3%	3.0%	4.3%	5.8%	7.3%	8.0%	7.9%	6.4%	4.6%	3.3%	2.7%	4.8%	Unbiased Sly, high over Scandinavia
Regime 6	2.7%	3.0%	4.1%	5.3%	6.5%	6.7%	7.0%	6.5%	5.8%	4.4%	3.4%	2.8%	4.9%	Anticyclonic, Azores high ext.
Regime 7	2.1%	2.6%	3.5%	5.4%	7.4%	8.4%	8.5%	6.9%	5.5%	3.6%	2.8%	2.2%	4.9%	Cyclonic SWly, low WNW of Ireland
Regime 8	2.7%	2.6%	3.3%	4.4%	5.4%	6.0%	6.7%	6.7%	5.9%	4.6%	3.7%	3.1%	4.6%	Cyclonic Wly, low near Shetland
Regime 9	1.9%	2.3%	3.6%	5.6%	6.5%	6.3%	5.4%	5.5%	5.4%	5.0%	3.5%	2.6%	4.5%	Anticyclonic N-NEly, high near Iceland
Regime 10	2.9%	3.2%	4.1%	4.8%	5.6%	5.2%	5.1%	4.8%	4.5%	4.4%	3.7%	3.4%	4.3%	Anticyclonic W-SWly, slight Azores ridge
Regime 11	2.1%	2.4%	3.5%	4.8%	5.1%	4.6%	4.0%	3.8%	4.0%	3.6%	3.2%	2.4%	3.6%	Cyclonic, low centred over southern UK
Regime 12	4.0%	3.9%	3.7%	3.4%	3.0%	2.4%	2.2%	3.0%	4.1%	4.8%	4.6%	4.2%	3.6%	Anticyclonic Sly, high over Poland
Regime 13	4.0%	3.8%	4.2%	4.1%	3.8%	2.8%	2.2%	2.2%	2.6%	3.8%	4.3%	4.4%	3.5%	Anticyclonic NWly, high SW of Ireland
Regime 14	3.8%	3.6%	3.6%	3.1%	2.4%	1.7%	1.6%	2.1%	2.9%	3.8%	4.1%	4.1%	3.1%	Cyclonic N-NWly, low near S Sweden
Regime 15	4.9%	4.5%	3.8%	3.0%	2.1%	1.4%	1.2%	1.2%	2.3%	3.1%	4.3%	4.6%	3.0%	Unbiased SWly, very windy NW Britain
Regime 16	2.6%	3.2%	3.5%	3.4%	2.7%	1.9%	1.4%	1.8%	2.7%	3.4%	3.2%	2.7%	2.7%	Anticyclonic S-SEly, high E of Denmark
Regime 17	4.4%	4.0%	3.1%	2.2%	1.3%	0.8%	0.4%	1.0%	2.2%	3.3%	4.0%	4.3%	2.6%	Anticyclonic E-SEly high over Denmark
Regime 18	5.3%	5.0%	4.0%	2.6%	1.2%	0.6%	0.3%	0.4%	1.1%	2.3%	3.8%	4.8%	2.6%	Anticyclonic SWly, high over N France
Regime 19	3.8%	3.8%	3.5%	2.7%	1.7%	0.9%	0.6%	0.8%	1.8%	3.1%	3.8%	4.1%	2.6%	Unbiased Nly, low E of Denmark
Regime 20	4.5%	4.5%	3.7%	2.6%	1.5%	0.8%	0.4%	0.9%	1.8%	2.8%	3.5%	4.1%	2.6%	Cyclonic Wly, intense low near Iceland
Regime 21	3.8%	3.5%	2.9%	2.3%	1.7%	1.3%	0.9%	1.3%	2.1%	3.1%	3.6%	3.8%	2.5%	Cyclonic SWly, deep low S of Iceland
Regime 22	3.4%	3.5%	3.3%	2.8%	2.0%	1.1%	0.7%	0.9%	1.6%	2.3%	2.8%	3.2%	2.3%	Cyclonic Sly, low W of Ireland
Regime 23	4.9%	5.0%	4.0%	2.7%	1.3%	0.6%	0.2%	0.3%	0.8%	1.8%	2.9%	4.2%	2.4%	Unbiased Wly, windy in N
Regime 24	3.3%	3.3%	2.8%	2.0%	1.1%	0.5%	0.5%	0.7%	1.4%	2.3%	2.9%	3.2%	2.0%	Cyclonic Nly, low in N Sea
Regime 25	4.2%	3.9%	3.1%	1.8%	1.1%	0.5%	0.3%	0.5%	1.1%	2.2%	2.9%	3.7%	2.1%	Anticyclonic Nly, high centre Irish Sea
Regime 26	3.6%	3.4%	2.8%	1.9%	0.9%	0.3%	0.2%	0.6%	1.3%	2.3%	3.0%	3.5%	2.0%	Cyclonic NWly, low near Norway, windy
Regime 27	4.0%	3.8%	2.6%	1.4%	0.5%	0.3%	0.1%	0.2%	0.8%	1.8%	2.8%	3.7%	1.8%	Anticyclonic Ely, high in Norwegian Sea
Regime 28	3.6%	3.8%	3.2%	2.0%	0.8%	0.3%	0.1%	0.2%	0.6%	1.2%	2.1%	2.8%	1.7%	Cyclonic SEly, low SW of UK
Regime 29	3.6%	3.3%	2.8%	1.5%	0.8%	0.3%	0.2%	0.3%	0.6%	1.2%	2.2%	2.9%	1.6%	Cyclonic S-SWly, deep low W of Ireland
Regime 30	3.2%	2.9%	2.0%	1.1%	0.5%	0.3%	0.2%	0.4%	0.9%	1.7%	2.4%	3.0%	1.5%	Cyclonic W-SWly, deep low SE of Iceland

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Reducing the 30 regimes into flow types

Flow type	*Regimes*	
Unbiased (circulation)	1, 4, 5, 10, 15, 16, 23	Lows/highs centred on UK
Cyclonic	2, 7, 8, 11, 14, 19, 20, 21, 22, 24, 26, 28, 29, 30	
Anticyclonic	3, 6, 9, 12, 13, 17, 18, 25, 27	
Unbiased (zonal)	5, 6, 9, 11, 12, 14, 19, 24, 25	All meridional regimes
Westerly	1, 2, 3, 4, 7, 8, 10, 13, 15, 18, 20, 21, 22, 23, 26, 29, 30	
Easterly	16, 17, 27, 28	
Unbiased (meridional)	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 15, 18, 20, 21, 23, 25, 26, 27, 30	All zonal regimes
Northerly	13, 14, 19, 24	
Southerly	5, 12, 16, 17, 22, 28, 29	

30 regimes are grouped three different ways, each grouping trying to differentiate between the “biased” and “unbiased” (middle) state. E.g. northerly, southerly, no meridional component.

This is done to tease out the purest signal for each flow type.

Flow types groupings are not mutually exclusive.

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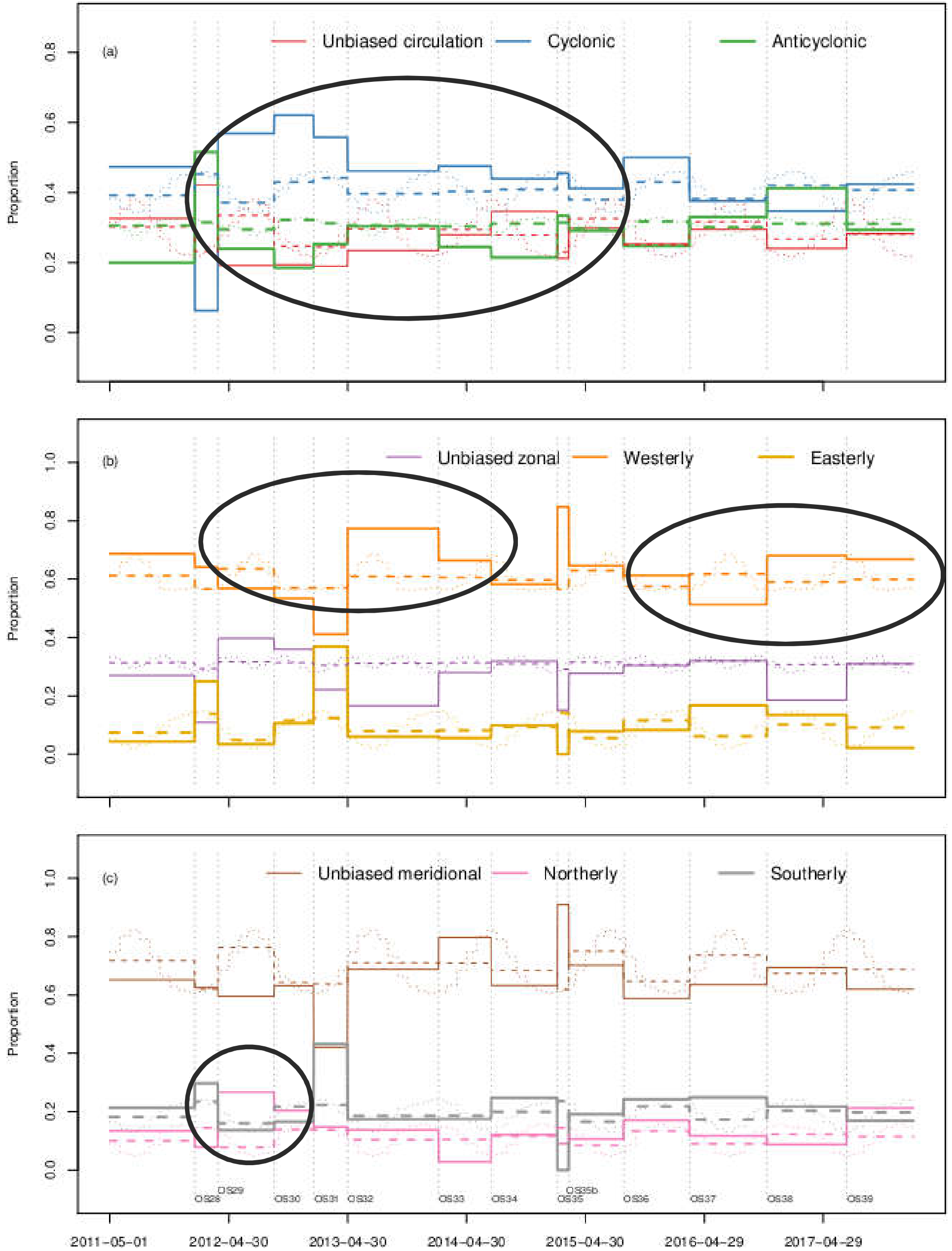
Frequency of occurrence

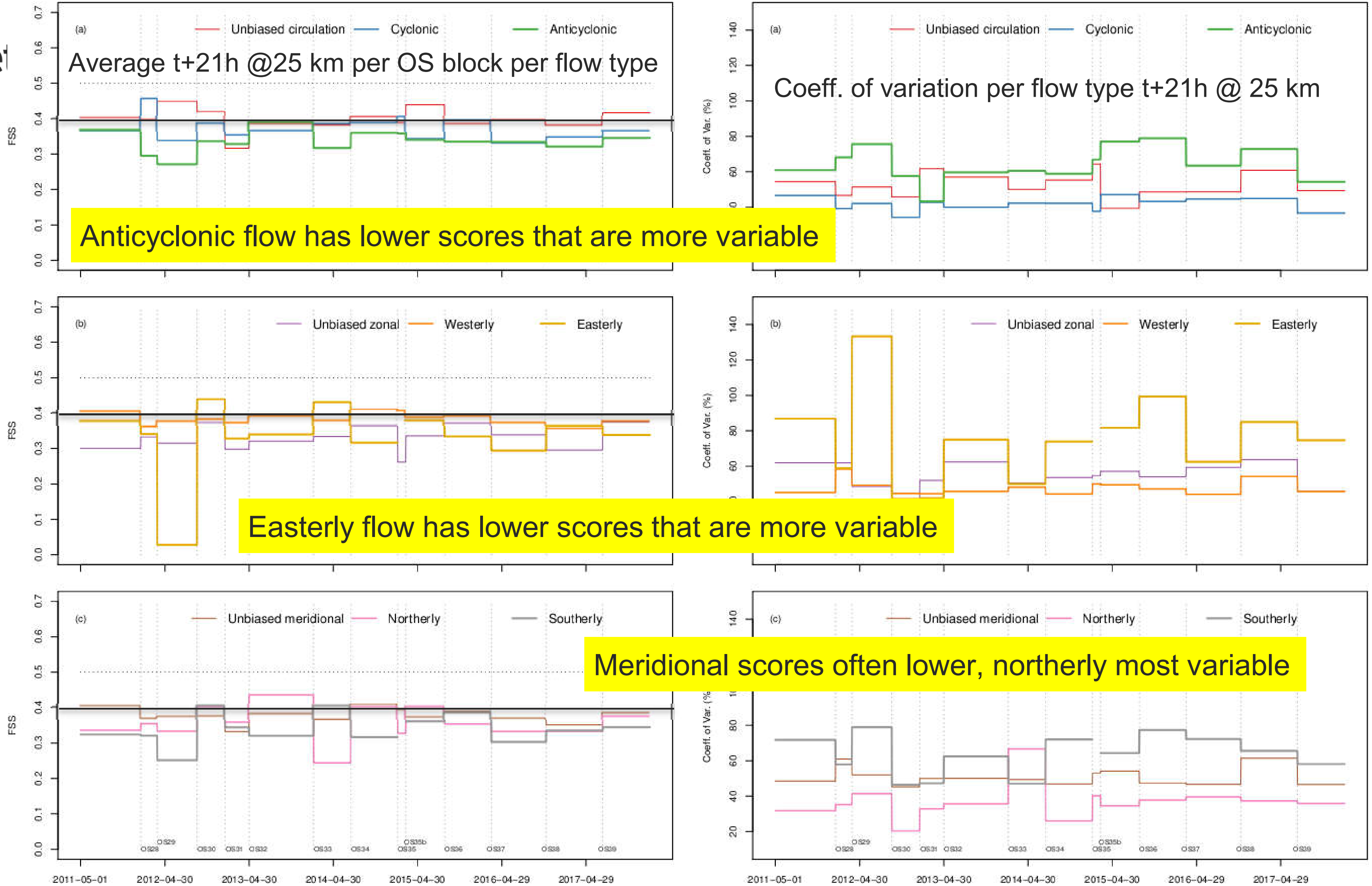
Where blocks dominated by a specific flow type?

00Z analyses were analysed for the observed flow type for each of the flow types (solid lines), compared to the long-term monthly climatological average occurrence (dotted lines) and the climatological average for the OS block.

There is evidence that persistent weather patterns dominated multiple successive OS blocks: e.g. cyclonic and westerly patterns. There is evidence that an easterly pattern dominated for OS37 and a northerly for OS 29.



FSS characteristics



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Comparing intensities

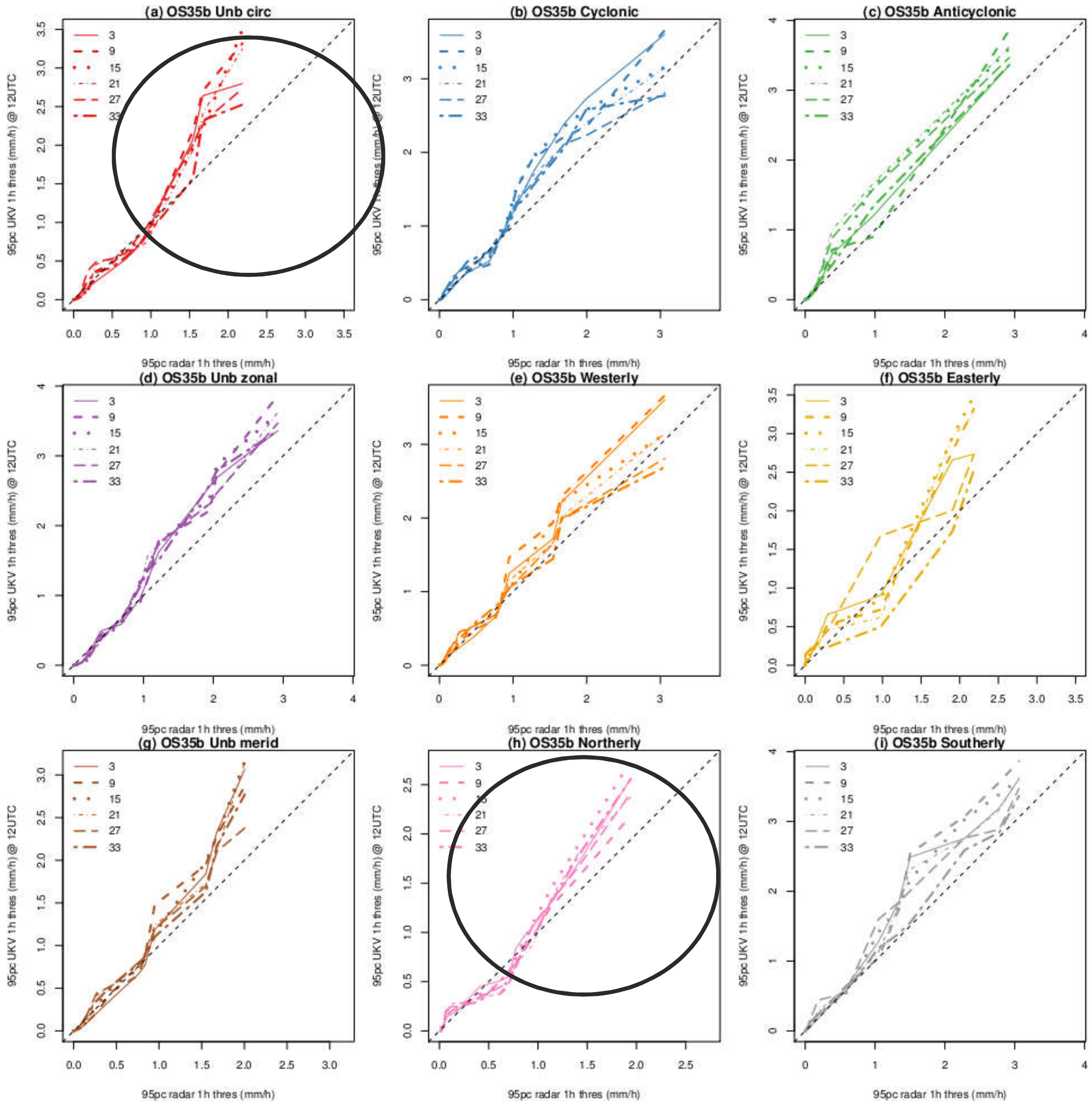
Consider the physical values associated with the 95th percentile thresholds.

Compare by weather regime type and lead time for different OS using quantile-quantile plots.

Larger biases for larger values (if there was no bias values would lie along diagonal).

Model upgrades affect this quite strongly, for the better (or worse).

Affect can be flow dependent. E.g. OS27 to OS35b northerly better but, for the same two OS unbiased circ (a) worse.



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Conclusions

Simple time series (running means) are not necessarily helpful in diagnosing impact of individual model upgrades.

Block averages can help but signals may still be masked by whether a particular flow type dominated, and whether the performance by flow type is one where we know skill is lower.

Refactoring the FSS into SSS and LTP provides somewhat different perspectives on how model upgrades may be affecting the evolution and perception of the forecast.

Northerly and easterly, as well as anticyclonic flows are associated with lower skill. These are also “dry” flows, though the northerly flow in the winter are associated with snow showers which can be problematic.

Forecasts are relatively unbiased for lower thresholds but the “tail” of the hourly distribution is affected strongly by model changes from OS to OS.

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