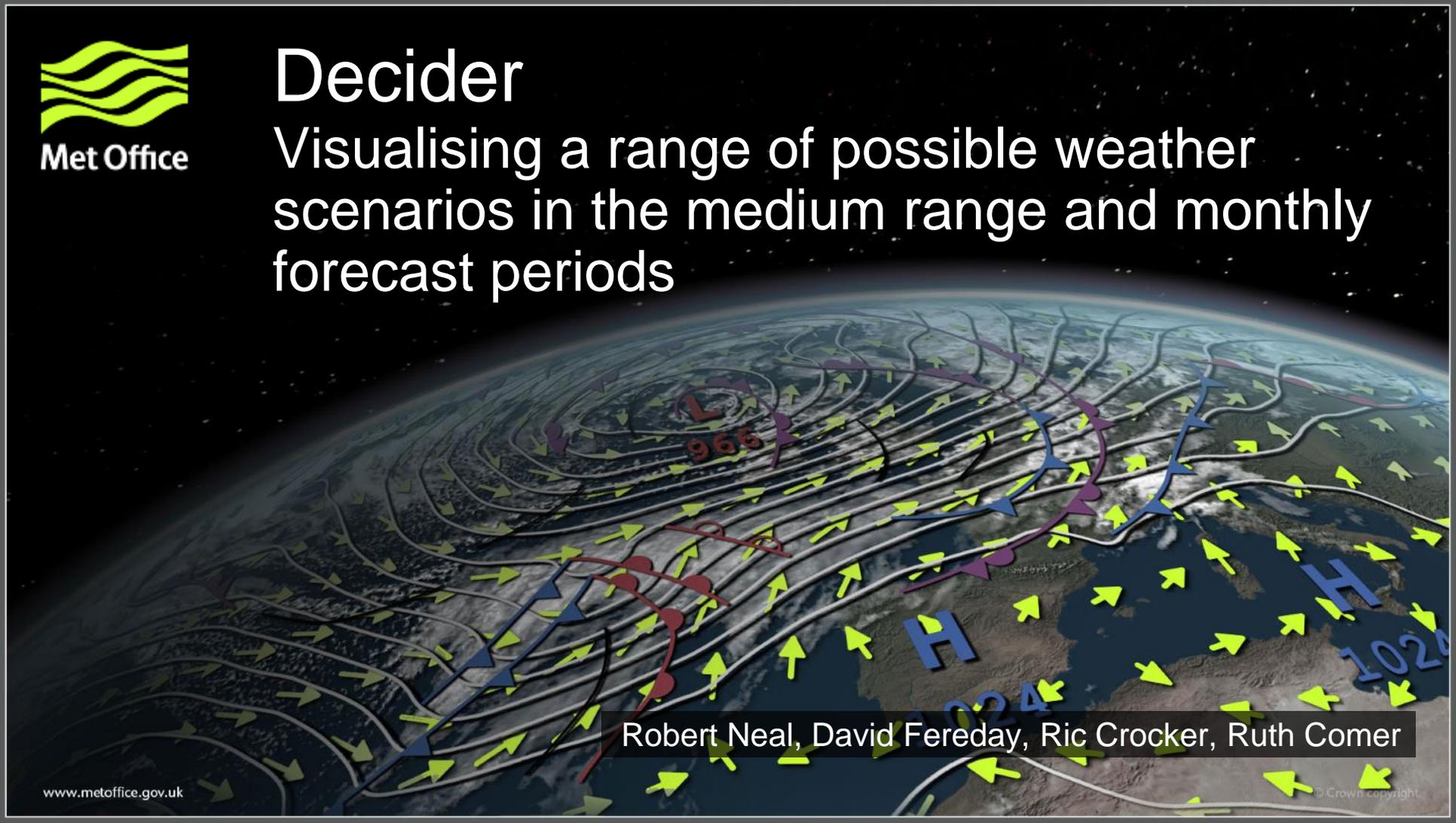


# Decider

Visualising a range of possible weather scenarios in the medium range and monthly forecast periods



Robert Neal, David Fereday, Ric Crocker, Ruth Comer

# Contents

1. Introduction to Decider
2. Quantifying and communicating forecast uncertainty
3. Summary

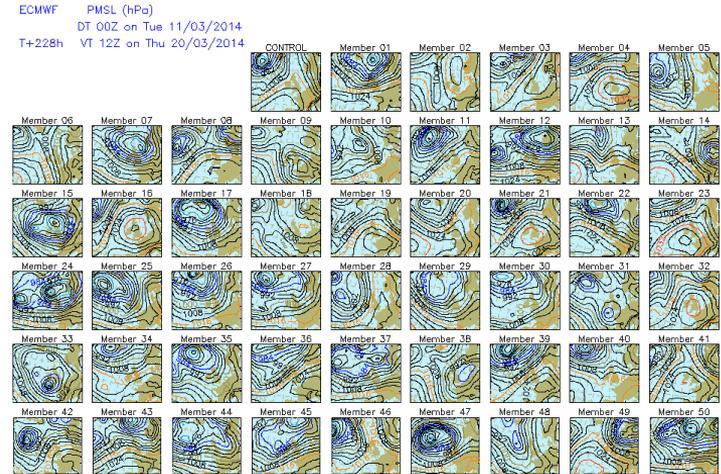


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# Introduction to Decider

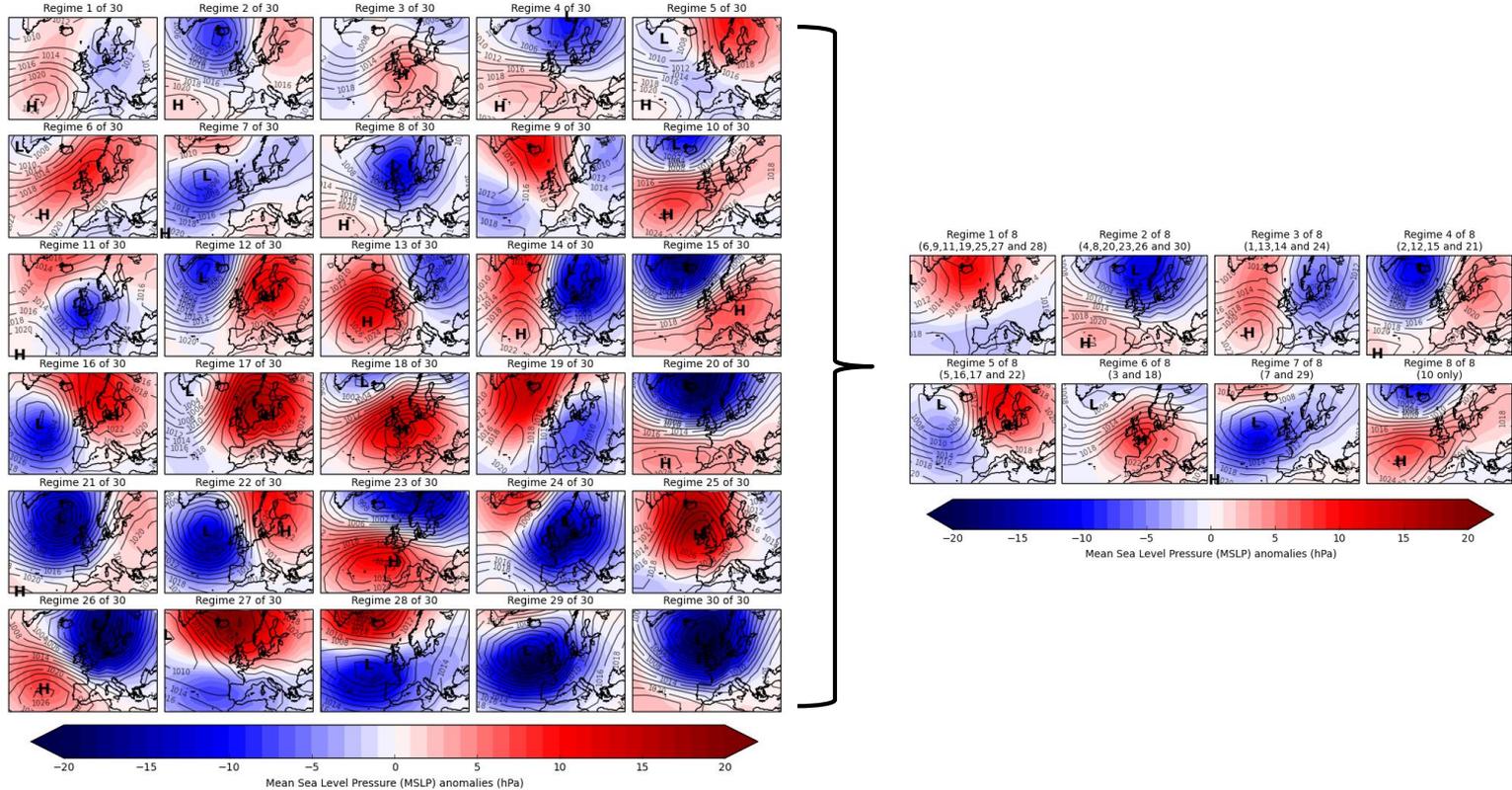
# Decider

- Decider is a weather regime forecast tool
- Recently updated to use a set of 30 and 8 objectively derived regimes
- Ensemble members are assigned to the closest matching regime definition, providing a probabilistic insight into the most likely weather regimes
- Summarises key aspects from the large volumes of data ensembles provide
- Once regime characteristics are understood (in terms of their climatology or impacts) it then becomes relatively easy to interpret forecast output and describe likely consequences



# 30 and 8 objectively derived regimes

The 30 regimes were derived by k-means clustering of daily MSLP (anomalies) using the EMULATE MSLP observation data set (1850 – 2003). The 8 regimes were derived by combining highly correlating combinations of the set of 30.

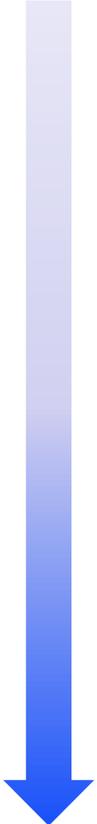




# Regime occurrences (1850 to 2014)

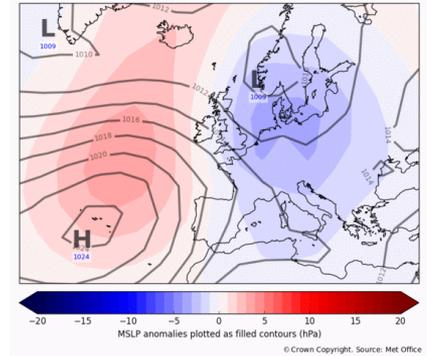
Historic classifications updated to 2014 using ERA-Interim

Increasing intensity in MSLP anomalies

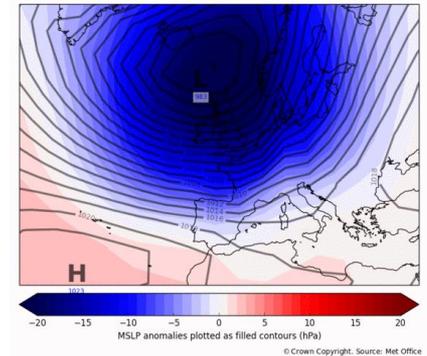


	D/J/J	J/F/M	F/M/A	M/A/M	A/M/J	M/J/J	J/J/A	J/A/S	A/S/O	S/O/N	O/N/D	N/D/J	Mean occurrence
Regime 1	1.9%	1.9%	3.1%	5.2%	8.4%	12.1%	14.6%	12.9%	8.5%	4.2%	2.7%	2.0%	6.5%
Regime 2	2.3%	2.5%	3.4%	5.0%	7.0%	8.9%	9.7%	9.2%	7.5%	5.5%	3.8%	2.8%	5.7%
Regime 3	1.9%	1.9%	2.7%	4.3%	6.5%	8.9%	10.0%	9.4%	7.1%	4.8%	3.3%	2.3%	5.3%
Regime 4	2.3%	2.4%	3.1%	4.4%	5.7%	7.0%	7.6%	7.9%	6.8%	5.3%	3.6%	2.7%	4.9%
Regime 5	2.5%	2.4%	3.1%	4.3%	5.9%	7.3%	8.0%	7.8%	6.3%	4.6%	3.4%	2.7%	4.9%
Regime 6	2.8%	3.1%	4.1%	5.3%	6.5%	6.8%	7.1%	6.6%	5.8%	4.3%	3.3%	2.8%	4.9%
Regime 7	2.1%	2.6%	3.6%	5.4%	7.3%	8.4%	8.4%	6.8%	5.4%	3.6%	2.8%	2.2%	4.9%
Regime 8	2.7%	2.6%	3.4%	4.4%	5.4%	6.0%	6.7%	6.7%	6.0%	4.7%	3.8%	3.1%	4.6%
Regime 9	1.9%	2.3%	3.6%	5.7%	6.5%	6.3%	5.4%	5.6%	5.5%	5.0%	3.5%	2.6%	4.5%
Regime 10	2.9%	3.1%	4.1%	4.8%	5.6%	5.2%	5.0%	4.7%	4.5%	4.4%	3.7%	3.4%	4.3%
Regime 11	2.1%	2.5%	3.5%	4.9%	5.1%	4.7%	4.0%	3.8%	4.0%	3.6%	3.2%	2.5%	3.7%
Regime 12	4.0%	3.9%	3.7%	3.4%	3.0%	2.4%	2.2%	2.9%	4.0%	4.7%	4.6%	4.2%	3.6%
Regime 13	4.0%	3.8%	4.1%	4.0%	3.7%	2.8%	2.2%	2.1%	2.6%	3.8%	4.3%	4.5%	3.5%
Regime 14	3.8%	3.6%	3.6%	3.1%	2.4%	1.7%	1.5%	2.1%	2.9%	3.8%	4.1%	4.0%	3.1%
Regime 15	4.9%	4.5%	3.9%	3.0%	2.1%	1.4%	1.1%	1.2%	2.3%	3.1%	4.3%	4.5%	3.0%
Regime 16	2.6%	3.3%	3.6%	3.4%	2.7%	1.9%	1.4%	1.8%	2.7%	3.4%	3.1%	2.7%	2.7%
Regime 17	4.5%	4.0%	3.0%	2.2%	1.3%	0.8%	0.4%	1.0%	2.1%	3.3%	4.0%	4.3%	2.6%
Regime 18	5.2%	5.0%	4.0%	2.5%	1.2%	0.6%	0.3%	0.4%	1.1%	2.3%	3.7%	4.7%	2.6%
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%
Regime 20	4.5%	4.4%	3.6%	2.6%	1.5%	0.8%	0.4%	0.9%	1.8%	2.8%	3.5%	4.0%	2.6%
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%
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%
Regime 23	4.8%	5.0%	4.0%	2.7%	1.3%	0.5%	0.2%	0.3%	0.8%	1.7%	2.7%	4.0%	2.3%
Regime 24	3.2%	3.3%	2.8%	2.0%	1.1%	0.5%	0.4%	0.7%	1.4%	2.3%	2.9%	3.2%	2.0%
Regime 25	4.1%	3.9%	3.1%	1.8%	1.0%	0.5%	0.3%	0.5%	1.1%	2.2%	2.9%	3.7%	2.1%
Regime 26	3.5%	3.3%	2.7%	1.9%	0.9%	0.3%	0.2%	0.5%	1.3%	2.3%	3.0%	3.4%	1.9%
Regime 27	4.0%	3.9%	2.6%	1.4%	0.5%	0.2%	0.1%	0.2%	0.8%	1.8%	2.8%	3.7%	1.8%
Regime 28	3.7%	3.9%	3.2%	1.9%	0.7%	0.3%	0.1%	0.2%	0.7%	1.3%	2.2%	2.8%	1.7%
Regime 29	3.7%	3.3%	2.8%	1.5%	0.8%	0.3%	0.2%	0.3%	0.6%	1.2%	2.2%	2.9%	1.6%
Regime 30	3.1%	2.9%	2.0%	1.1%	0.5%	0.2%	0.2%	0.3%	0.9%	1.7%	2.4%	3.0%	1.5%

Regime 1



Regime 30





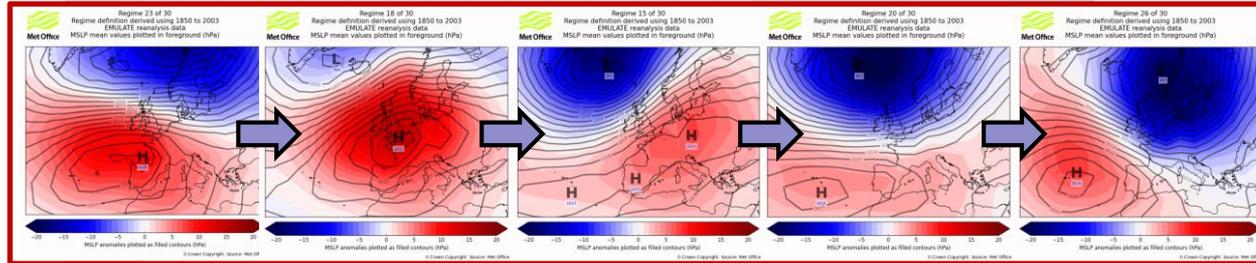
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# Quantifying and communicating forecast uncertainty

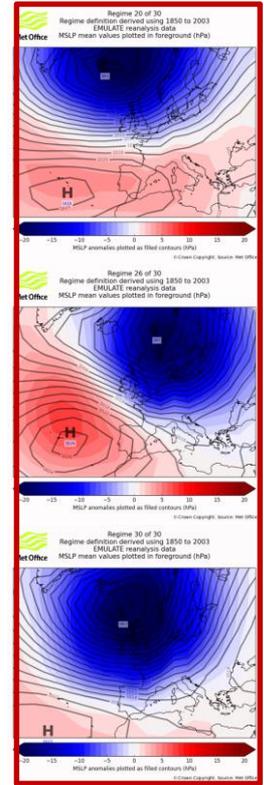
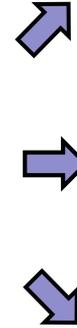
# Forecast summary table

## ECMWF medium range forecast (30 regimes)

	Thu 1 Jan	Fri 2 Jan	Sat 3 Jan	Sun 4 Jan	Mon 5 Jan	Tue 6 Jan	Wed 7 Jan	Thu 8 Jan	Fri 9 Jan	Sat 10 Jan	Sun 11 Jan	Mon 12 Jan	Tue 13 Jan	Wed 14 Jan	Thu 15 Jan	Regime Descriptions (UK)	Historic Occurrence D/J/F
Regime 1												2			4	Unbiased NWly	1.9%
Regime 2										2			2			Cyclonic W-SWly, returning Pm airmass	2.3%



Regime 13																Anticyclonic Nwly, high SW of Ireland	4.0%															
Regime 14												4	4	2		Cyclonic N-NWly, low near S Sweden	3.8%															
Regime 15				2		61	29						2	6	4	10	2	Unbiased SWly, very windy NW Britain	4.8%													
Regime 16																Unbiased S-SEly, high E of Denmark	2.6%															
Regime 17					2											Anticyclonic E-SEly high over Denmark	4.5%															
Regime 18						68	73	6	2	2			2	4	2	6	2	Anticyclonic SWly, high over N France	5.2%													
Regime 19																Cyclonic Nly, low E of Denmark	3.8%															
Regime 20								12		49	47	25	12	10	18	22	22	14	Cyclonic Wly, intense low near Iceland	4.5%												
Regime 21										10		2	4	2	10	8	2		Cyclonic S-SWly, deep low S of Iceland	3.8%												
Regime 22																	2		Cyclonic Sly, low W of Ireland	3.4%												
Regime 23	100	100	100					2	6				4	14	10	10	4	6	10	18	Unbiased Wly, windy in N	4.8%										
Regime 24																				6	2	6	4						Cyclonic Nly, low in N Sea	3.2%		
Regime 25																														Anticyclonic Nly, high centre Irish Sea	4.1%	
Regime 26														10		39	63	41		20	16	18	27						Cyclonic NWly, low near Norway, windy	3.5%		
Regime 27																														Anticyclonic Ely, high in Norwegian Sea	4.0%	
Regime 28																														Cyclonic SEly, low SW of UK	3.7%	
Regime 29																								2						2	Cyclonic S-SWly, deep low W of Ireland	3.7%
Regime 30										8	31	18	12	18	33	22	14														Cyclonic SWly, deep low SE of Iceland	3.1%
Total Members	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51																	

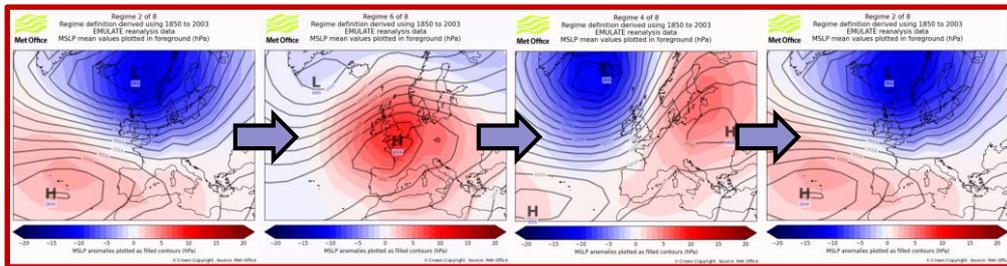


# Forecast summary table

## ECMWF medium range forecast (8 regimes)

	Thu 1 Jan	Fri 2 Jan	Sat 3 Jan	Sun 4 Jan	Mon 5 Jan	Tue 6 Jan	Wed 7 Jan	Thu 8 Jan	Fri 9 Jan	Sat 10 Jan	Sun 11 Jan	Mon 12 Jan	Tue 13 Jan	Wed 14 Jan	Thu 15 Jan	Regime Descriptions (UK)	Historic Occurrence D/J/F
<b>Regime 1</b>																Blocked	22.4%
<b>Regime 2</b>	100	100	100		2	18	57	92	98	98	62	78	69	67	Cyclonic Wly	20.9%	
<b>Regime 3</b>				2						2	10	8	10	4	18	Unbiased NWly	12.8%
<b>Regime 4</b>					24	67	41	4	2	2	6	8	20	18	8	Unbiased SWly	15.0%
<b>Regime 5</b>					2									2		Anticyclonic SEly	12.9%
<b>Regime 6</b>				98	73	16	2	2			2	4	2	6	2	Anticyclonic SWly	7.1%
<b>Regime 7</b>												2			4	Cyclonic SWly	5.8%
<b>Regime 8</b>								2	2					2	2	Anticyclonic Wly	2.9%
<b>Total Members</b>	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	---	---

Probabilities are derived by aggregating up probabilities from the 30 regimes, depending on which of the 8 regimes they are mapped to.





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# Forecast summary table

## ECMWF monthly forecast (8 regimes)

	Period 1					Period 2					Period 3					Period 4					Period 5					Regime Descriptions (UK)	Historic Occurrence D/J/F							
	Thu 1 Jan	Fri 2 Jan	Sat 3 Jan	Sun 4 Jan	Mon 5 Jan	Tue 6 Jan	Wed 7 Jan	Thu 8 Jan	Fri 9 Jan	Sat 10 Jan	Sun 11 Jan	Mon 12 Jan	Tue 13 Jan	Wed 14 Jan	Thu 15 Jan	Fri 16 Jan	Sat 17 Jan	Sun 18 Jan	Mon 19 Jan	Tue 20 Jan	Wed 21 Jan	Thu 22 Jan	Fri 23 Jan	Sat 24 Jan	Sun 25 Jan	Mon 26 Jan	Tue 27 Jan	Wed 28 Jan	Thu 29 Jan	Fri 30 Jan	Sat 31 Jan	Sun 1 Feb		
Regime 1															6	4	6	10	6	6	2	2	8	6	10	12	14	14	16	14	14	Blocked	22.4%	
Regime 2	100	100	100		2	18	55	92	96	96	82	78	71	69	65	59	47	39	45	37	35	27	43	51	49	47	35	37	39	29	31	43	Cyclonic Wly	20.9%
Regime 3				2						2	10	8	10	4	18	14	24	27	14	24	18	14	8	2	10	14	18	16	16	16	18	18	Unbiased NWly	12.8%
Regime 4					24	65	43	4	2	2	6	8	18	18	8	10	10	10	16	16	16	27	20	22	14	10	12	16	12	10	18	6	Unbiased SWly	15.0%
Regime 5					4									2	2	6	2	4	6	10	8	8	14	10	12	6	6	4	2	6	2	6	Anticyclonic SEly	12.9%
Regime 6				66	71	18	2	2				2	4	2	6	2	2	6	8	2	8	8	8	2	8	10	6	8	6	8	6	12	Anticyclonic SWly	7.1%
Regime 7												2			4	4	4	4	2	2	6	6	2	4		2	4	4	6	10	10		Cyclonic SWly	5.8%
Regime 8								2	2					2	2		4	4		4	4	8	4	2	2	2	8	2	6	6	2	2	Anticyclonic Wly	2.9%
Total Members	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	---	---

	Period 1 Mon 5 Jan 2015 to Fri 9 Jan 2015	Period 2 Sat 10 Jan 2015 to Wed 14 Jan 2015	Period 3 Thu 15 Jan 2015 to Mon 19 Jan 2015	Period 4 Tue 20 Jan 2015 to Sat 24 Jan 2015	Period 5 Sun 25 Jan 2015 to Thu 29 Jan 2015	Regime Descriptions (UK)	Historic Occurrence D/J/F
Regime 1			5%	5%	11%	Blocked	22.4%
Regime 2	53%	79%	51%	39%	42%	Cyclonic Wly	20.9%
Regime 3		7%	19%	13%	15%	Unbiased NWly	12.8%
Regime 4	27%	10%	11%	20%	13%	Unbiased SWly	15.0%
Regime 5	1%	0%	4%	10%	6%	Anticyclonic SEly	12.9%
Regime 6	18%	3%	4%	5%	7%	Anticyclonic SWly	7.1%
Regime 7		0%	4%	4%	3%	Cyclonic SWly	5.8%
Regime 8	1%	0%	2%	4%	4%	Anticyclonic Wly	2.9%
Total Members	255	255	255	255	255	---	---



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# Most likely forecast scenarios ECMWF monthly forecast (8 regimes)

Table valid for Period 3: 15<sup>th</sup> to 19<sup>th</sup> January 2015

- Provides a visual look at the most likely weather regimes on each day or period
- Regime definitions remain static throughout the year, but climatologies vary
- Ensemble mean maps for each cluster are also available for the medium range output

	1. Regime 2 (51%)	2. Regime 3 (19%)	3. Regime 4 (11%)
Regime definition	<p>Regime 2 of 8 Regime definition derived using 1850 to 2003 EMULATE reanalysis data MSLP mean values plotted in foreground (hPa)</p> <p>MSLP anomalies plotted as filled contours (hPa)</p>	<p>Regime 3 of 8 Regime definition derived using 1850 to 2003 EMULATE reanalysis data MSLP mean values plotted in foreground (hPa)</p> <p>MSLP anomalies plotted as filled contours (hPa)</p>	<p>Regime 4 of 8 Regime definition derived using 1850 to 2003 EMULATE reanalysis data MSLP mean values plotted in foreground (hPa)</p> <p>MSLP anomalies plotted as filled contours (hPa)</p>
Regime climatology ERA-Interim	<p>Regime 2 of 8 ERA-I climatology (1979 to 2014) Dec/Jan/Feb PMSL (hPa), 2m temperature anomalies (degC) and daily precipitation (mm)</p> <p>Daily precipitation plotted as filled contours (mm/day)</p>	<p>Regime 3 of 8 ERA-I climatology (1979 to 2014) Dec/Jan/Feb PMSL (hPa), 2m temperature anomalies (degC) and daily precipitation (mm)</p> <p>Daily precipitation plotted as filled contours (mm/day)</p>	<p>Regime 4 of 8 ERA-I climatology (1979 to 2014) Dec/Jan/Feb PMSL (hPa), 2m temperature anomalies (degC) and daily precipitation (mm)</p> <p>Daily precipitation plotted as filled contours (mm/day)</p>



# Circulation bias probability indicators ECMWF medium range forecast (30 regimes)

## Circulation bias indicators over UK (30 regimes)

Regimes have been classified for this region according to three circulation characteristics.

### 1) Probabilistic pressure index over UK (30 regimes)

	Thu 1 Jan	Fri 2 Jan	Sat 3 Jan	Sun 4 Jan	Mon 5 Jan	Tue 6 Jan	Wed 7 Jan	Thu 8 Jan	Fri 9 Jan	Sat 10 Jan	Sun 11 Jan	Mon 12 Jan	Tue 13 Jan	Wed 14 Jan	Thu 15 Jan
Pressure Index	100%	100%	100%	100%	78%	67%	67%	89%	84%	86%	88%	84%	80%	71%	67%

- RED** Anticyclonic conditions most likely
- GREEN** Unbiased conditions most likely
- BLUE** Cyclonic conditions most likely
- WHITE** Equal likelihood of two or three of the above tendencies occurring

### 2) Probabilistic zonal index over UK (30 regimes)

	Thu 1 Jan	Fri 2 Jan	Sat 3 Jan	Sun 4 Jan	Mon 5 Jan	Tue 6 Jan	Wed 7 Jan	Thu 8 Jan	Fri 9 Jan	Sat 10 Jan	Sun 11 Jan	Mon 12 Jan	Tue 13 Jan	Wed 14 Jan	Thu 15 Jan
Zonal Index	100%	100%	100%	100%	94%	94%	98%	98%	100%	100%	90%	94%	88%	96%	86%

- RED** Easterly conditions most likely
- GREEN** Both westerly and easterly conditions unlikely
- BLUE** Westerly conditions most likely
- WHITE** Equal likelihood of two or three of the above tendencies occurring

### 3) Probabilistic meridional index over UK (30 regimes)

	Thu 1 Jan	Fri 2 Jan	Sat 3 Jan	Sun 4 Jan	Mon 5 Jan	Tue 6 Jan	Wed 7 Jan	Thu 8 Jan	Fri 9 Jan	Sat 10 Jan	Sun 11 Jan	Mon 12 Jan	Tue 13 Jan	Wed 14 Jan	Thu 15 Jan
Meridional Index	100%	100%	100%	98%	94%	94%	98%	98%	100%	98%	90%	92%	86%	94%	82%

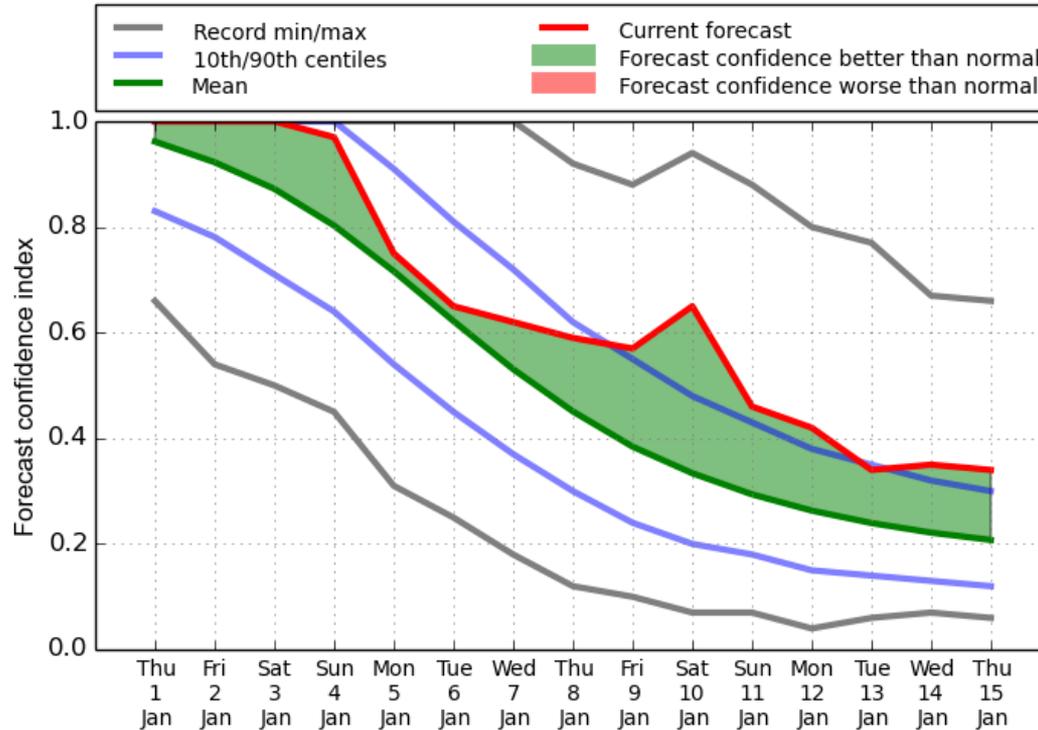
- RED** Southerly conditions most likely
- GREEN** Both northerly and southerly conditions unlikely
- BLUE** Northerly conditions most likely
- WHITE** Equal likelihood of two or three of the above tendencies occurring

Transitioning from anticyclonic to cyclonic conditions

High confidence of remaining westerly

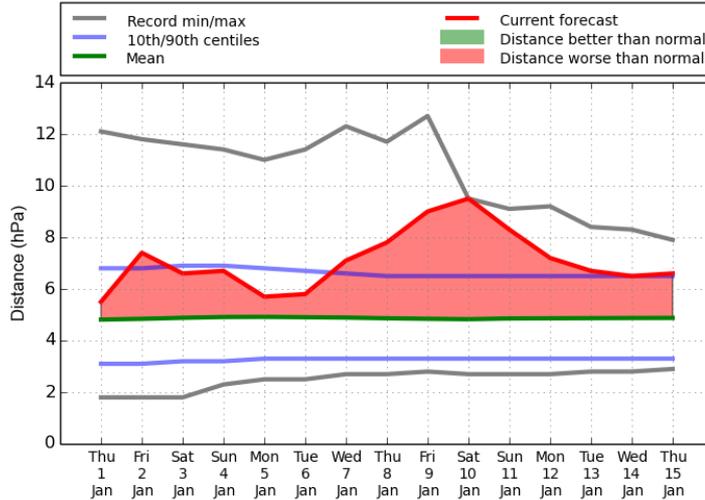
No major northerly or southerly incursions likely

# Quantifying forecast uncertainty ECMWF medium range forecast (30 regimes)

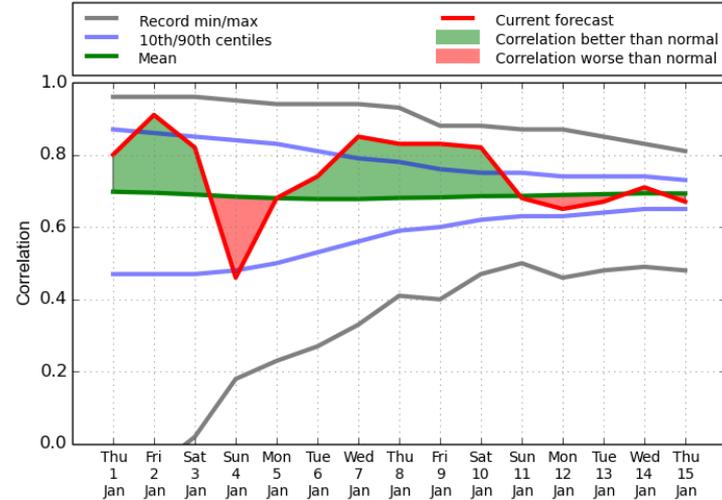


- Provides an objective interpretation of forecast confidence
- Index = 0; No forecast confidence with ensemble members equally distributed amongst all regimes
- Index = 1; Perfect forecast confidence with all ensemble members assigned to the same regime0

# How good is the match between members and regimes? ECMWF medium range forecast (30 regimes)



**Distance** is the measure used to assign ensemble members to regimes. It looks at whether features (lows and highs) in the ensemble members are as intense as their idealised regime would suggest.



**Correlation** looks at whether features (low and highs) in the ensemble members are in the same place as their idealised regime.



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# Verification

ECMWF 15 day forecasts between 1 January 2010 and 31 December 2014

Right: Annual forecast biases for the 8 regimes

Little forecast bias

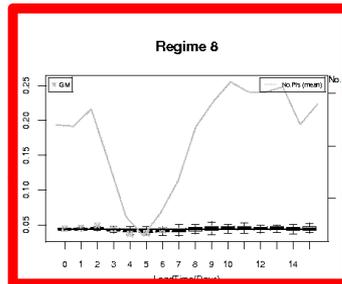
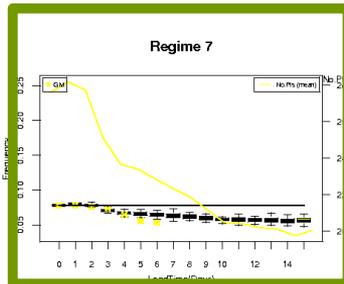
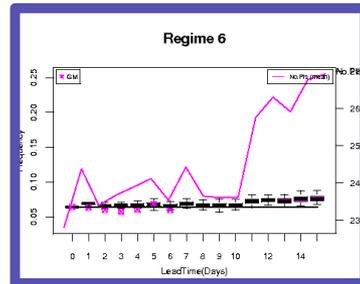
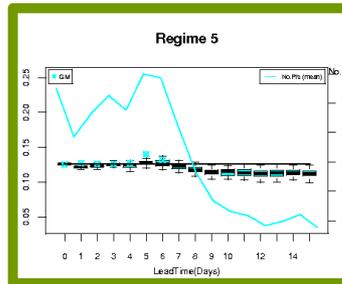
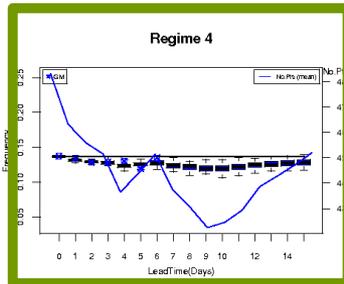
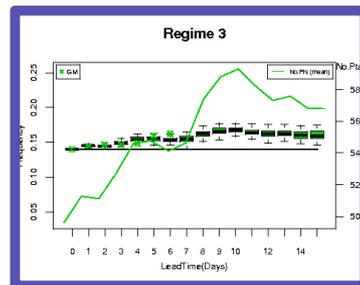
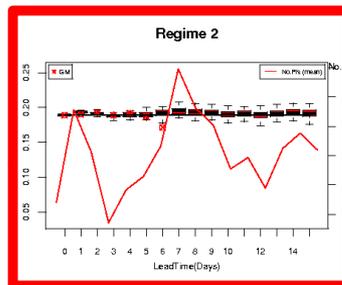
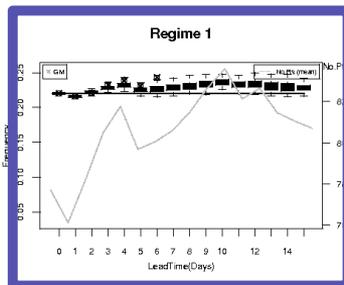
Over-forecasting at longer lead times

Under-forecasting at longer lead times

Better forecast skill in winter than summer.

Tendency for biases to be amplified in summer...

...with the exception of regime 2 which under-forecasts in winter and over-forecasts in summer.





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# Summary



# Summary

- **Decider summarises large volumes of data from ensembles**
  - Visualises the most likely forecast scenarios
  - Quantifies forecast uncertainty
  - Understanding regime characteristics helps interpret forecast output
  
- **Many weather regime applications**
  - Coastal flooding
  - Flow from Iceland into UK airspace
  - Energy demand and supply
  - The number of applications are potentially endless!
  
- **Ongoing research**
  - Regime persistence
  - Regime transitions
  - Developing new applications
  - Verification

