



Met Office
Hadley Centre

The use of synoptic regime classifications in medium- and extended-range ensemble forecasting

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Ensemble Forecasting

- Run many forecasts from a given starting time, each with slightly modified initial conditions
- Gradual divergence of solutions with increasing forecast time
- Gives probabilistic estimates for different outcomes, based on the spread and distribution of the resulting scenarios

The Problem

- Ensemble forecasts can be difficult to interpret -
 - Very large amount of information generated (especially for probabilistic forecasts)
 - Ensemble mean (deterministic outcome) can be stated, but its usefulness open to debate
 - Methods for reducing complexity by grouping outputs (e.g. Clustering) are difficult to optimize

Synoptic Type Classification – Benefits

- Regional day-to-day weather characteristics are closely related to the prevailing synoptic-scale circulation patterns
- Consecutive synoptic patterns which follow similar spatial development paths form a “Synoptic Regime” (typically lasting from a few days up to a fortnight or more)
- Weather can be considered to be a subordinate function of synoptic regime type (*a philosophical statement*)
- Therefore, classifying synoptic type is an essential task for describing regional weather
- Synoptic types have coherent small-scale structure embedded within their characteristic large-scale pattern (e.g. patterns of orographically-enhanced rainfall) - downscaling
- Can also help in summarizing synoptic type developments seen in forecasts – the subject of this talk

Synoptic Regimes over Europe

- Require an optimal set of synoptic types which characterize typical European circulation patterns
- Fully objective methods (e.g. Cluster Analysis, PCA) are limited in their ability to pull out meaningful and characteristic synoptic structures, especially with regards to infrequent but significant types
- Finding an optimal set of patterns may be strictly non-computable and requires synoptic experience and understanding
- The best currently available system is the subjective Grosswetterlagen (GWL) method of Baur et al. (1944), Hess and Brezowsky (1952-1977), and since updated by the German Weather Service
- GWL patterns are meaningful synoptic regime types, extending to cover most of Europe and N.E. Atlantic while focused on Central Europe
- Manual daily classification since 1881 – noting that each optimally chosen GWL event must last at least 3 days, ie. a regime.

The 29 European Grosswetterlagen

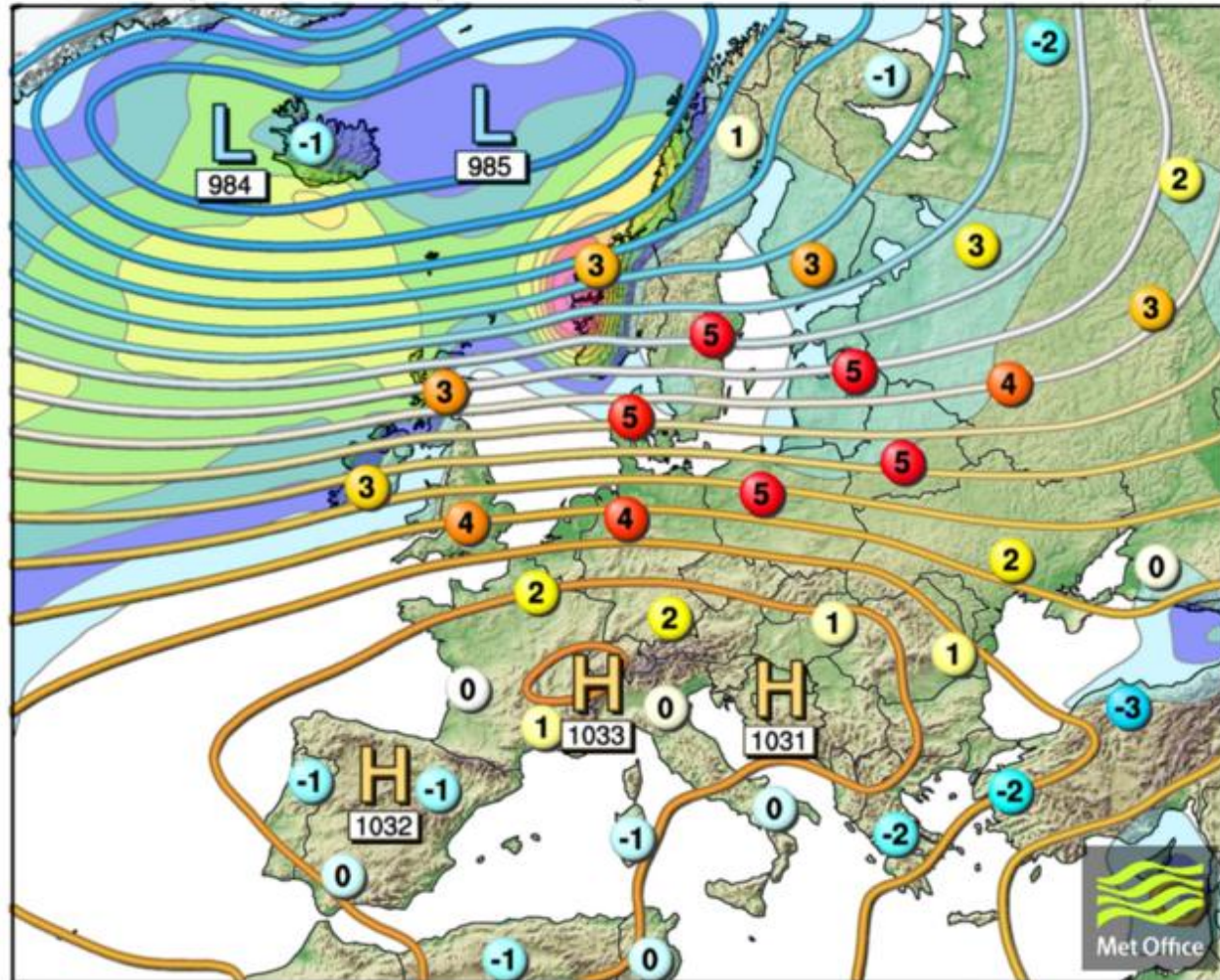
GWL	Definition	GWL	Definition
01 WA	Anticyclonic Westerly	16 HB	High over the British Isles
02 WZ	Cyclonic Westerly	17 TRM	Trough over Central Europe
03 WS	South-Shifted Westerly	18 NEA	Anticyclonic North-Easterly
04 WW	Maritime Westerly (Block E. Europe)	19 NEZ	Cyclonic North-Easterly
05 SWA	Anticyclonic South-Westerly	20 HFA	Scandinavian High, Ridge C. Europe
06 SWZ	Cyclonic South-Westerly	21 HFZ	Scandinavian High, Trough C. Europe
07 NWA	Anticyclonic North-Westerly	22 HNFA	High Scandinavia – Iceland, Ridge C. Europe
08 NWZ	Cyclonic North-Westerly	23 HNFZ	High Scandinavia – Iceland, Trough C. Europe
09 HM	High over Central Europe	24 SEA	Anticyclonic South-Easterly
10 BM	Zonal Ridge across Central Europe	25 SEZ	Cyclonic South-Easterly
11 TM	Low over Central Europe	26 SA	Anticyclonic Southerly
12 NA	Anticyclonic Northerly	27 SZ	Cyclonic Southerly
13 NZ	Cyclonic Northerly	28 TB	Low over the British Isles
14 HNA	Icelandic High, Ridge C. Europe	29 TRW	Trough over Western Europe
15 HNZ	Icelandic High, Trough C. Europe		

GWL Example (January) – No. 1, WA

Westerly, anticyclonic over C Europe

MSLP, Precipitation and 2m-Temperature Anomaly

WA, Mid January



Objective-Grosswetterlagen Composites

ECMWF ERA-40, 1957-2002

0 1 2 3 4 5 6 7 8 9 10 11 12 Precipitation (mm/day)

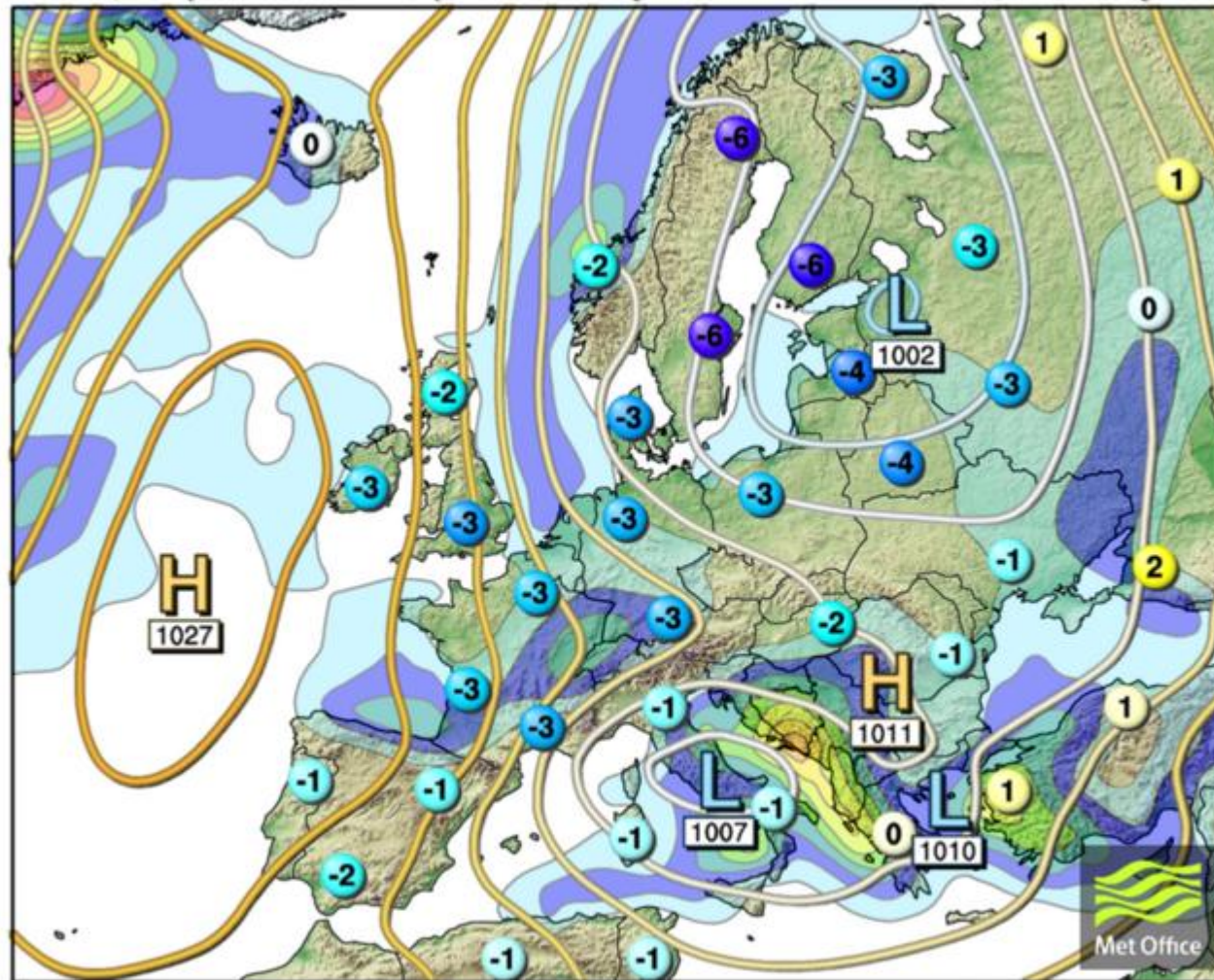
0 1 2 3 4 5 6 7 8 9 10 11 12

GWL Example (January) – No. 13, NZ

Northerly, cyclonic over C Europe

MSLP, Precipitation and 2m-Temperature Anomaly

NZ, Mid January



Objective-Grosswetterlagen Composites

ECMWF ERA-40, 1957-2002

0 1 2 3 4 5 6 7 8 9 10 11 12 Precipitation (mm/day)



GWL Example (January) – No. 23, HNFZ

Blocking High Finland-Iceland, cyclonic over C Europe

MSLP, Precipitation and 2m-Temperature Anomaly

HNFZ, Mid January



Objective-Grosswetterlagen Composites

ECMWF ERA-40, 1957-2002

0 1 2 3 4 5 6 7 8 9 10 11 12 Precipitation (mm/day)

0 1 2 3 4 5 6 7 8 9 10 11 12

Objectively classified Grosswetterlagen

- Objective method of classifying synoptic patterns according to the GWL set is required for operational forecasting use
- James' (2007) method correlates filtered daily MSLP and Z500 patterns with seasonally-adjusted climatological patterns for each GWL based on ERA40, taking the best GWL match for the day in question

James, P.M. (2007) An objective classification for Hess and Brezowsky Grosswetterlagen over Europe. *Theor. Appl. Climatol.*, **88**, 17-42.

- Subsequent temporal filtering algorithm applied to convert to sequences of GWL regimes, each lasting at least 3 days
- Objective-GWL catalogues based on re-analyses created back to 1948 (NCEP, ERA) and earlier to 1850 (Emulate MSLP)
- Generally works very well from a synoptic meteorologist's perspective
- Large-scale pattern characteristics are more coherent than for the original subjective Hess and Brezowsky GWL catalogue

Objective-GWLs in Ensemble Forecasts

- Run objective-GWL algorithm on each ensemble member
- Yields a set of N catalogues of GWL regime sequences
- Determine likelihood of various synoptic types

Added value :

- Indicates probable dates for major changes of regime
- Forms the basis for a meaningful synoptic clustering of possible outcomes
- Shows the specific influence of synoptic-scale circulation anomalies in the forecast
- **Communicates the ensemble outcomes in a very effective way to synoptic meteorologists**

Example

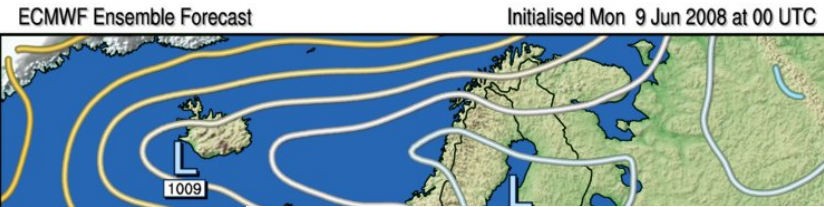
- ECMWF 15-day forecast from 00 UTC on 9th June 2008
- Table shows GWL frequency breakdown for the ensemble members for each day
- Most probable GWLs are highlighted visually – easy to grasp essential developments
- Gradual increase in spread of solutions with forecast day

GWL	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Description
	Jun	Jun	Jun	Jun	Jun	Jun	Jun	Jun	Jun	Jun	Jun	Jun	Jun	Jun	Jun	
WA											2	6	6	8	9	Anticyclonic Westerly
WZ										2	5	7	9	10	4	Cyclonic Westerly
WS					2	12	21	24	23	15	12	6	4	4	5	South-Shifted Cyclonic Westerly
WW											1	1	1			Maritime Westerly (Block E. Europe)
SWA								1	1	3	3	3	2	1	2	Anticyclonic South-Westerly
SWZ							3	5	5	7	4	3	1	1		Cyclonic South-Westerly
NWA	51	51	9	2											1	Anticyclonic North-Westerly
NWZ			3	3	3	1					1	4	4	5	5	Cyclonic North-Westerly
HM										1	3	4	5	4	3	High over Central Europe
BM											1	1	2	2	3	Zonal Ridge across Central Europe
TM								4	4	4	4	1	1			Low over Central Europe
NA												1	1	2	3	Anticyclonic Northerly
NZ			39	39	39	31	12	3	2	2	2	3	3	2	2	Cyclonic Northerly
HNA																Icelandic High, Ridge C. Europe
HNZ				2	2	2	3	3	3	3	1					Icelandic High, Trough C. Europe
HB												1	1	1	2	High over the British Isles
TRM				5	5	5	6	3	4	4	3	4	5	7	8	Trough over Central Europe
NEA											2	2	2	3	1	Anticyclonic North-Easterly
NEZ																Cyclonic North-Easterly
HFA															1	Scandinavian High, Ridge C. Europe
HFZ																Scandinavian High, Trough C. Europe
HNFA																High Norway-Iceland, Ridge C. Eur.
HNFZ								1	1	1						High Norway-Iceland, Trough C. Eur.
SEA																Anticyclonic South-Easterly
SEZ																Cyclonic South-Easterly
SA																Anticyclonic Southerly
SZ																Cyclonic Southerly
TB							2	3	4	4	3	1	1	1	1	Low over the British Isles
TRW							4	4	4	5	4	3	3		1	Trough over Western Europe

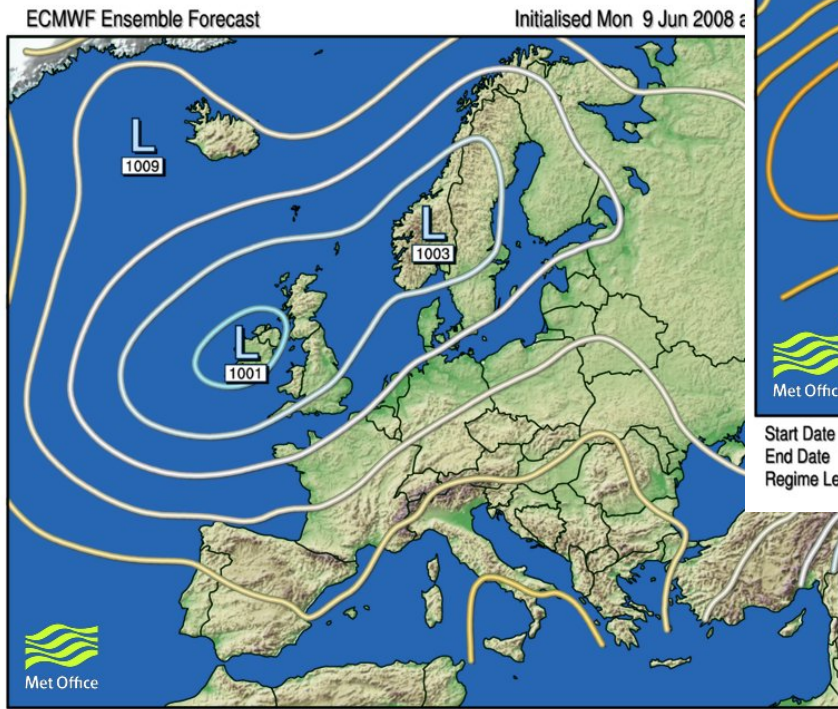
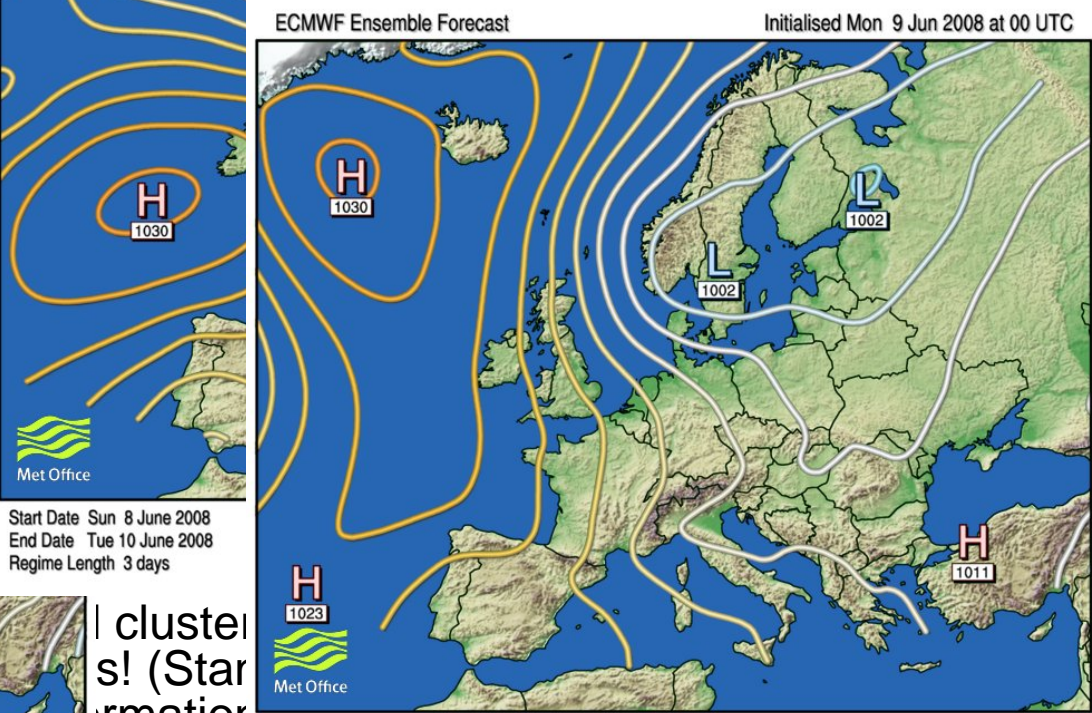
GWL Regime Clustering

- Summarize the GWL breakdown of the ensembles by clustering
- Most probable GWL sequence
- Next most probable (after re-assignment to Cluster 1) is assigned to Cluster 2 etc.

Cluster Set	9 Jun	10 Jun	11 Jun	12 Jun	13 Jun	14 Jun



Cluster 1) is



Start Date Sun 15 June 2008
End Date Wed 18 June 2008
Regime Length 4 days
Cluster 2
Regime Mean MSLP (hPa)
Objective-Grosswetterlage SWZ

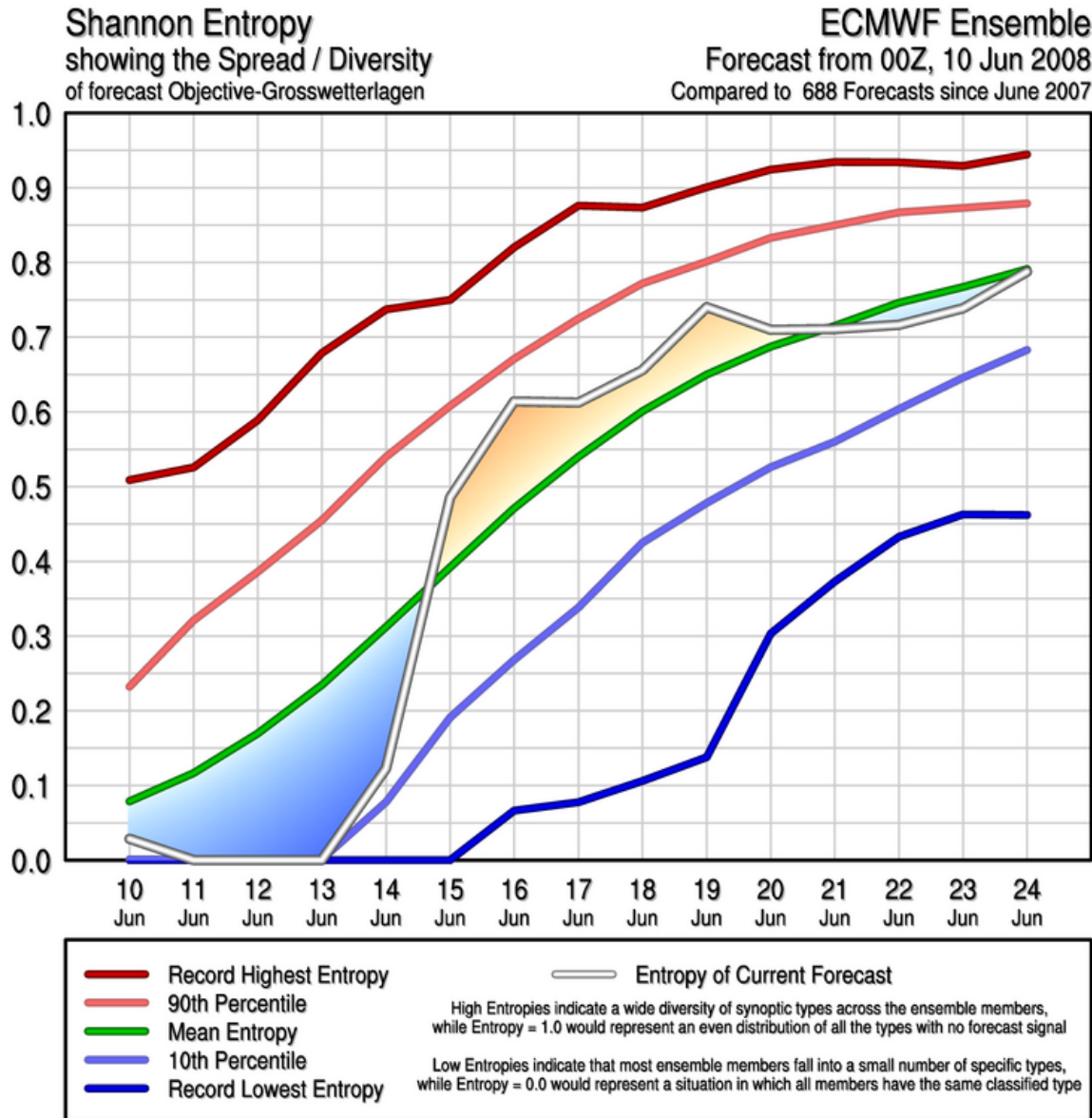
Start Date Sun 8 June 2008
End Date Tue 10 June 2008
Regime Length 3 days

Start Date Wed 11 June 2008
End Date Sat 14 June 2008
Regime Length 4 days
Cluster 1
Regime Mean MSLP (hPa)
Objective-Grosswetterlage NZ

clusters!
(Start information)
maps are
in question

Ensemble Spread of GWLs

- Measure spread of GWLs in ensembles using Shannon Entropy
- 0 = All members have same GWL
- 1 = Max possible spread of solutions (GWLs equally likely)



GWL applications at Met Office

- 15-day ECMWF / MOGREPS / NCEP-GFS ensembles (every 12 hours)
- 30-day ECMWF Monthly Outlook ensemble (once a week)
- GloSea 6-month forecast for seasonal forecasting (once a month)

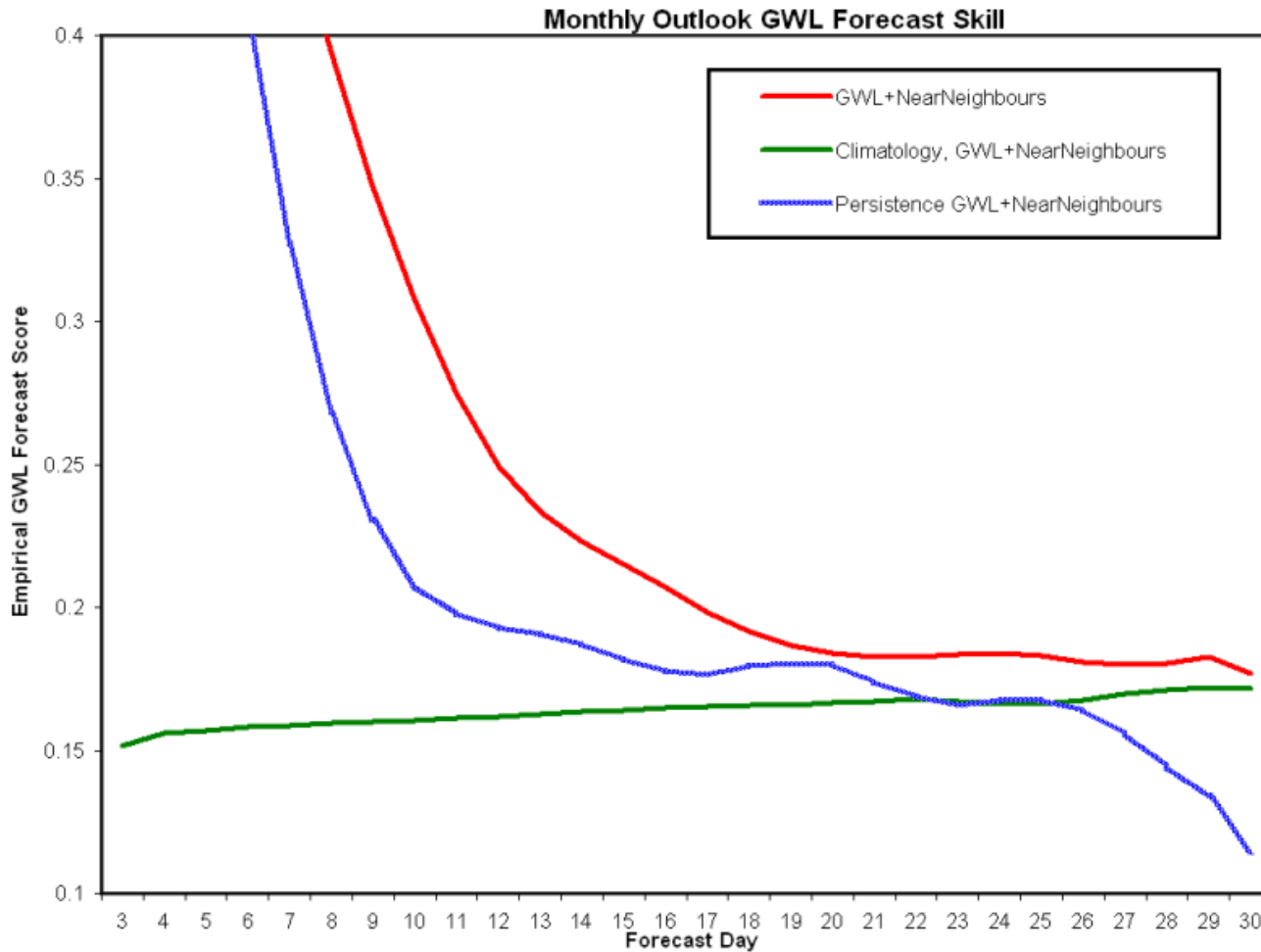
- Climate Model Development, compare statistics between models
- DePreSys decadal forecasting
- UKCIP regional climate scenarios

- Historical re-analyses and gridded MSLP data (ERA40, NCEP)
- Objective-GWL daily catalogue, 1850 to present available here:
<http://www.cost733.org/GWL/ObjGWL.html>

GWL forecast verification (preliminary)

- GWL method applied to 115 ECMWF 30-day forecasts each week since March 2006 - verify against Objective-GWL catalogue
- Rigorous verification methods need to be developed (e.g. Heidke Skill Scores for multi-category forecasts)
- Empirical first-order verification on the forecast GWL distribution across the ensemble members has been made using following daily scores:
 - 2 points when GWL correct
 - 1 point when a near-neighbour GWL predicted (subjectively, each GWL has 5 near-neighbours – defined in a matrix)
 - 0 points when GWL wholly incorrect (23 out of 29 GWLs, resp.)
 - Compare points totals to those gained by persistence of initial GWL and by using the Hindcast ensembles to estimate a climatological score

GWL forecast verification (preliminary)



- Residual skill out to at least 4 weeks, beating persistence and climatology
- Not yet enough forecasts to prove significance

Alternative Classification Methods

- Useful to apply such methods to other parts of the globe or to focus on specific regions
- A 26-type scheme based on the objective Lamb Weather Type method (improved and updated) is also being tested.
- Method has 8 flow directions and 3 vorticity classes (anticyclonic, unbiased and cyclonic), based on daily MSLP only
- Type nomenclature easy to understand
- Similar temporal filtering methods to GWL applied
 - yields “Lamb Synoptic Regimes (LSR)”, each lasting at least 3 days
- Scheme can be placed anywhere on the globe, except in tropics
- Further LSR-derivatives, with less classes, can be envisaged for a more compact output table

Summary

- Synoptic regime classification methods, such as European Grosswetterlagen, are being applied routinely to several ensemble forecasting systems over a wide range of timescales
- The output has the potential to be highly beneficial for the interpretation of ensemble forecasts
 - Indicates probable dates for major changes of regime
 - Forms the basis for a meaningful synoptic clustering of possible outcomes
 - Shows the specific influence of synoptic-scale circulation anomalies in the forecast
 - Above all it communicates the ensemble outcomes in a very effective way to synoptic meteorologists