Summarizing ensemble forecast scenarios using an objective classification of European synoptic patterns

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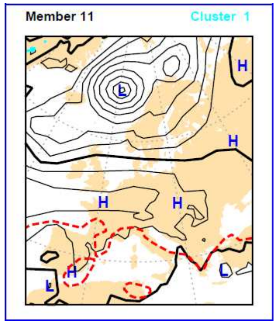
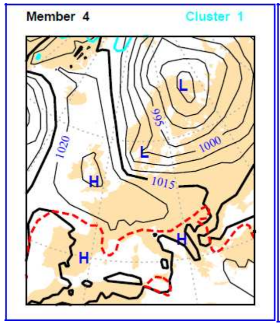
Medium-range ensemble forecasting

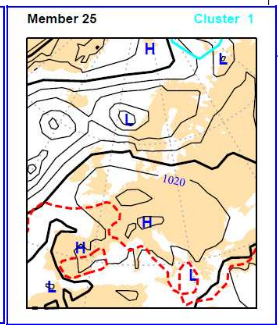
- ➔ Forecasters need to assimilate ensemble outputs efficiently and quickly
  - ➔ Most likely and primary alternative synoptic developments
  - ➔ Impacts of these developments on regional weather
  - ➔ Highlight times of potential major changes in synoptic regime

- ➔ Automatic prefiltering of large, complex ensemble datasets essential
- ➔ Clustering techniques important but are currently inadequate
  - ➔ Standard clusters typically fail to separate constrasting synoptic types over Europe (often most members in just one or two clusters)
  - ➔ ECMWF new-clusters are a major improvement
    - ➔ But clustering determined by large-scale Atlantic-dominated patterns
    - ➔ Synoptic patterns over European land mass still poorly separated

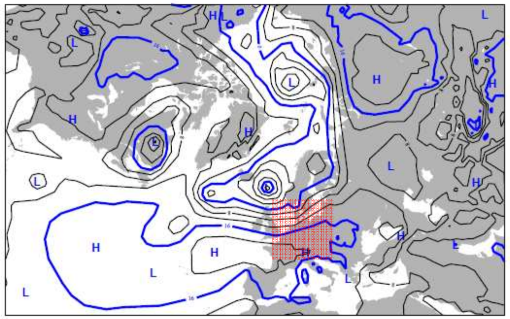
- Variations between clusters more noticeable over nearby N. Atlantic
- Relatively little variation over central European landmass (westerly flow, cyclonic over Scandinavia)
- Clusters do not reveal potential variations in synoptic types over central or western Europe adequately
- e.g. some individual members:



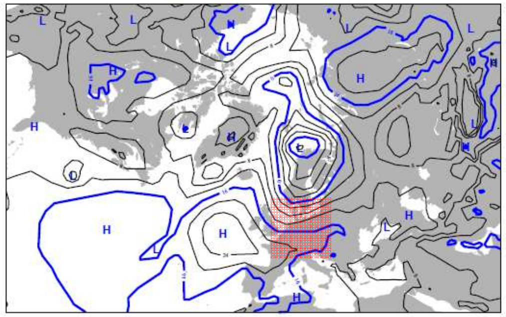




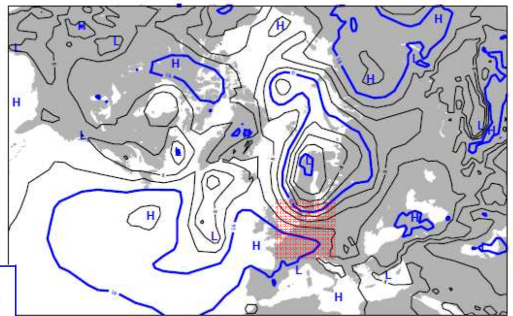
forecast t+168 VT:Thursday 15 September 2011 00UTC
Cluster: 1(of 5), population: 13, repres. member: 36



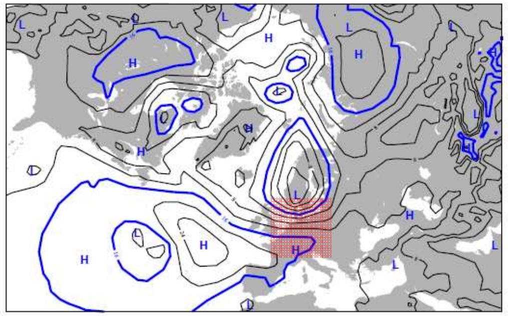
forecast t+168 VT:Thursday 15 September 2011 00UTC
Cluster: 3(of 5), population: 12, repres. member: 26



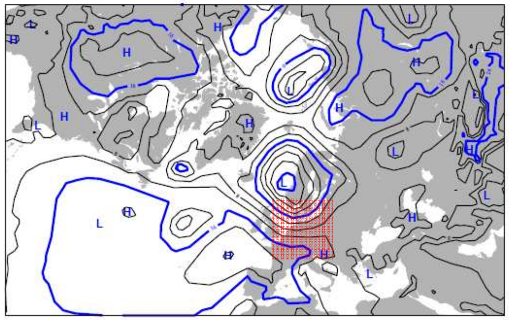
forecast t+168 VT:Thursday 15 September 2011 00UTC
Cluster: 2(of 5), population: 12, repres. member: 38



forecast t+168 VT:Thursday 15 September 2011 00UTC
Cluster: 4(of 5), population: 8, repres. member: 9



forecast t+168 VT:Thursday 15 September 2011 00UTC
Cluster: 5(of 5), population: 6, repres. member: 3



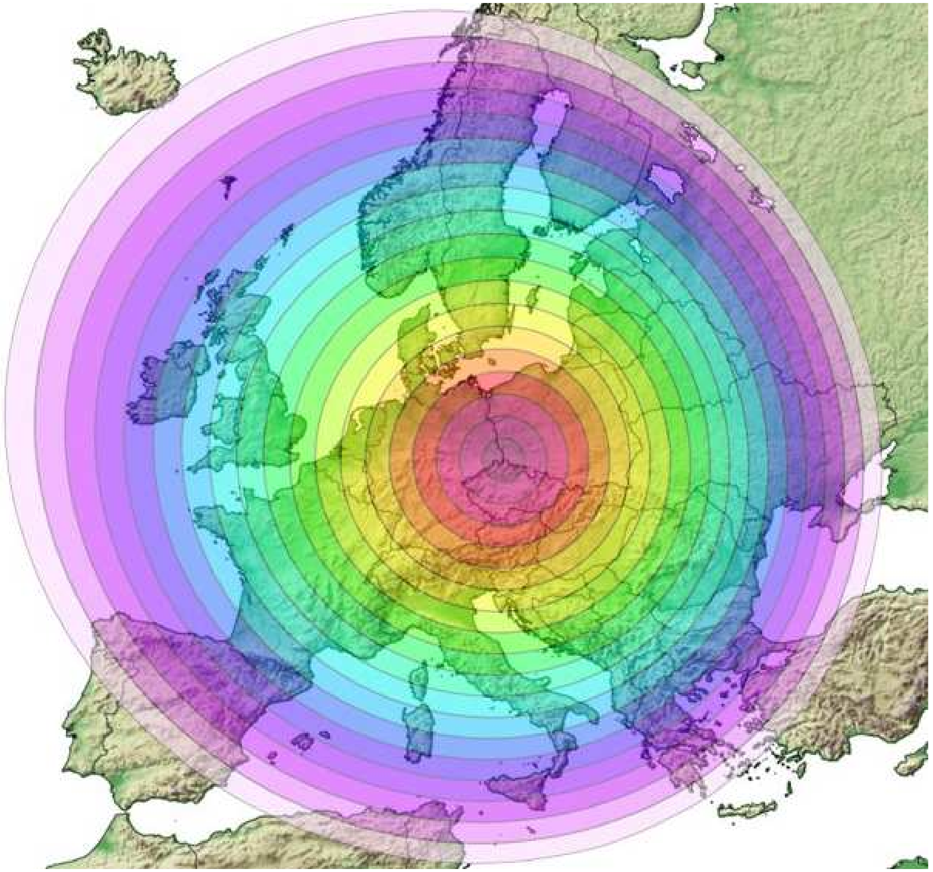
ECMWF new clusters example (08.09.2011, T+168h for 15.09.2011, 5 clusters)

The Grosswetterlagen Approach

- Grosswetterlagen (GWL) are a well-known set of European synoptic types
  - Developed originally by Baur, Hess and Brezowsky in the 1940s
  - Maintained at DWD and PIK-Potsdam up to present day
  - 29 diverse synoptic types, very useful and meaningful for describing large-scale flow and subsequent effect on regional weather (downscaling)
- GWL classification is undertaken manually (DWD, Potsdam)
  - Danger of inhomogeneity
  - Hard to apply routinely to forecast model output
- Objective GWL classification method developed to address this

SynopVis Grosswetterlagen: A new GWL system

- Classification of daily 12 UTC fields based on pattern correlations
  - Use MSLP, 500 hPa-Geopotential and 500-1000 hPa-Thickness
  - 29 GWL base patterns (Winter and Summer composites with sinusoidal weightings centred on 15th January and 15th July)
  - Correlation region relatively tightly weighted around central Europe
  - Subsequent temporal filter so that each GWL sequence lasts at least 2 or 3 days (latter as in Hess-Brezowsky)



SynopVis Grosswetterlagen (SVG) Products

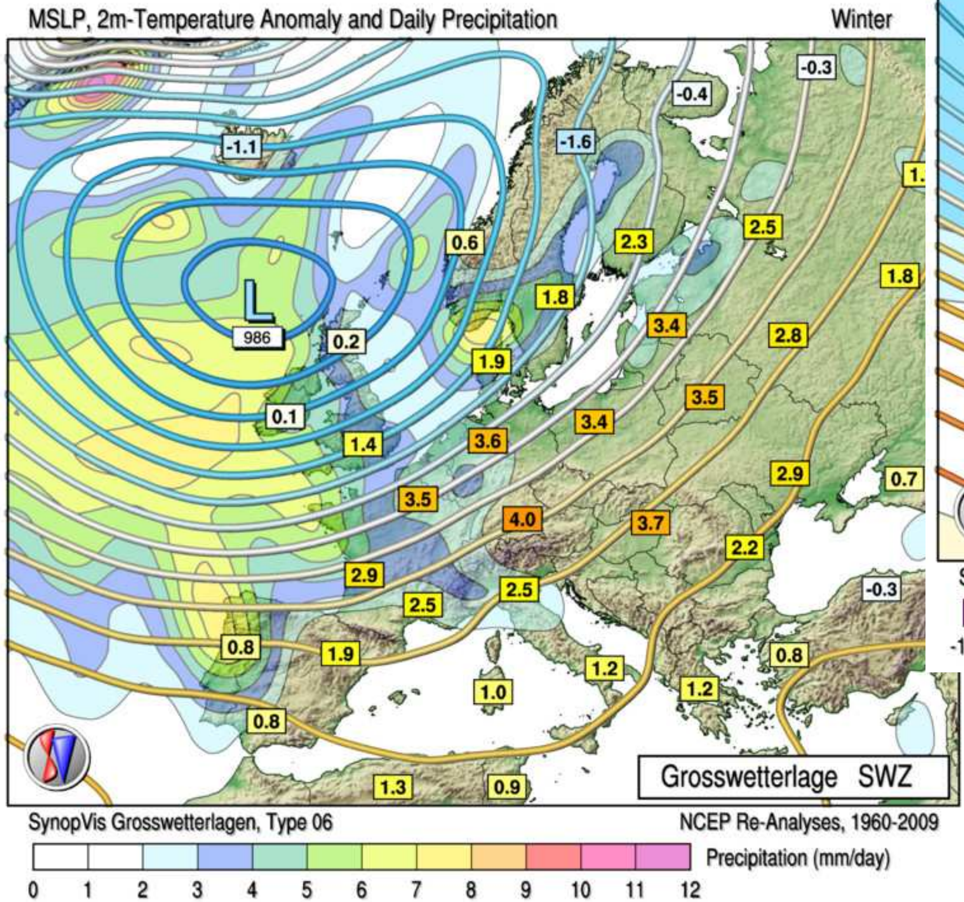
- Standard SVG classification output based on „20th-Century Reanalysis, v.2“
  - Complete daily catalogue from 1871-2008
  - Extended to present day using NCEP-Reanalyses
  - Very useful for synoptic climatological applications

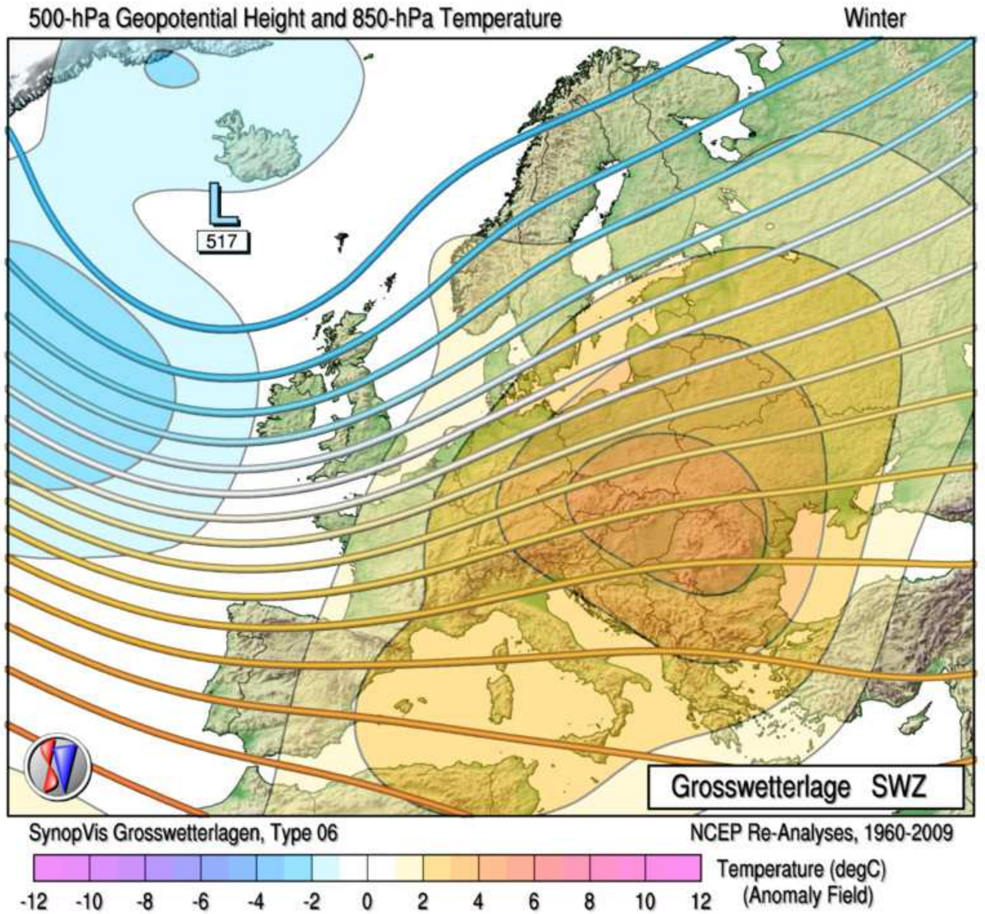
- Statistical analyses (frequencies, record sequence lengths, transition matrix etc.) have been created
- Climatological composite maps of each type at different times of the year
- Detailed type descriptions

SVG Climate Composite Example

Deutscher Wetterdienst
DWD

South-Westerly, cyclonic, SWZ

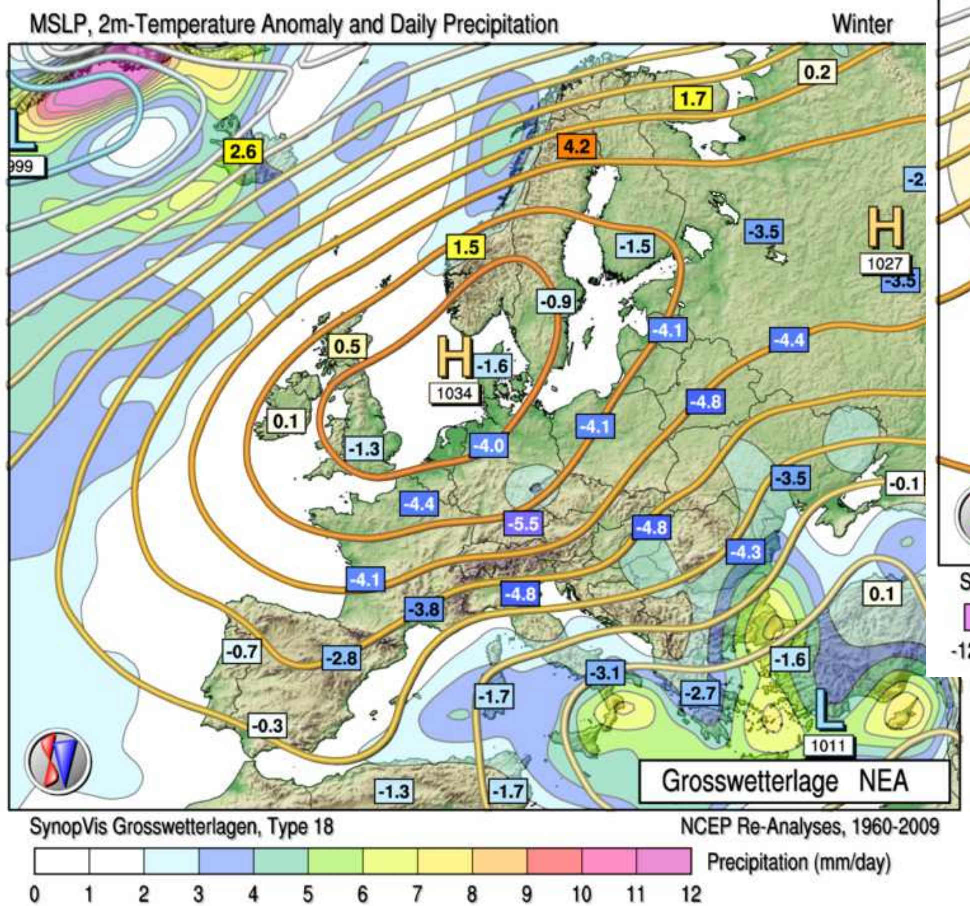


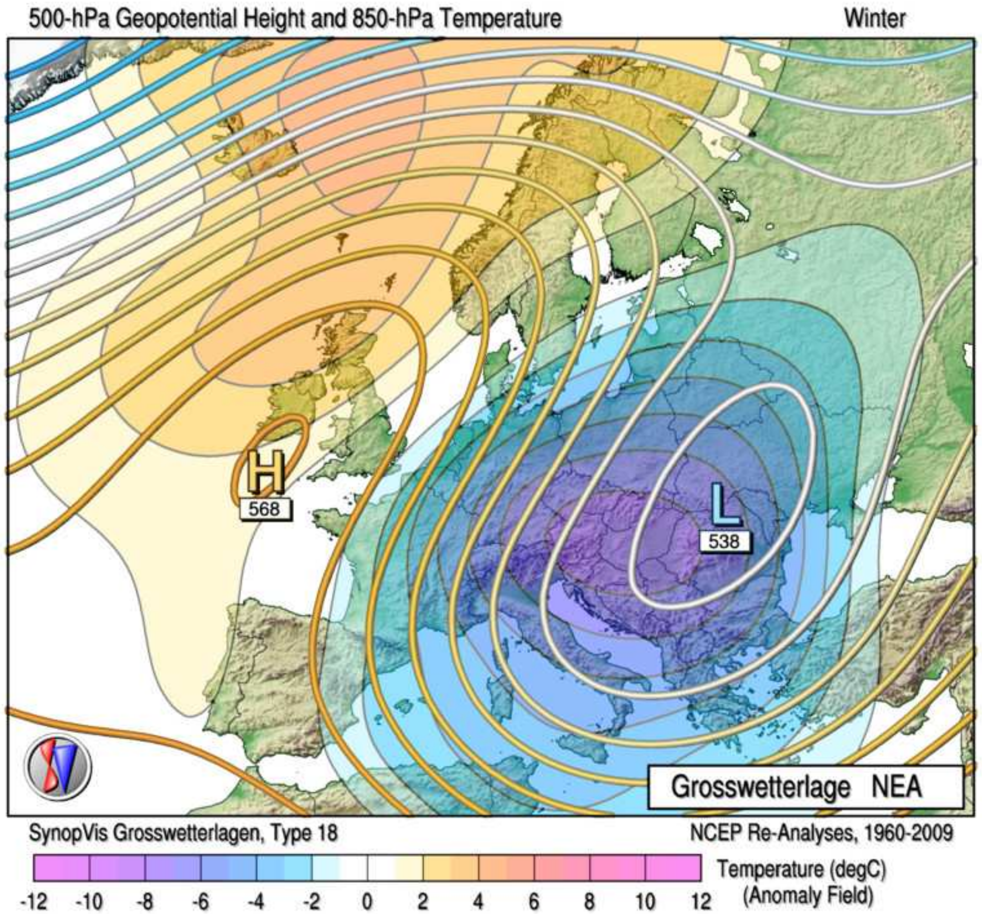


SVG Climate Composite Example

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

North-Easterly, anticyclonic, NEA

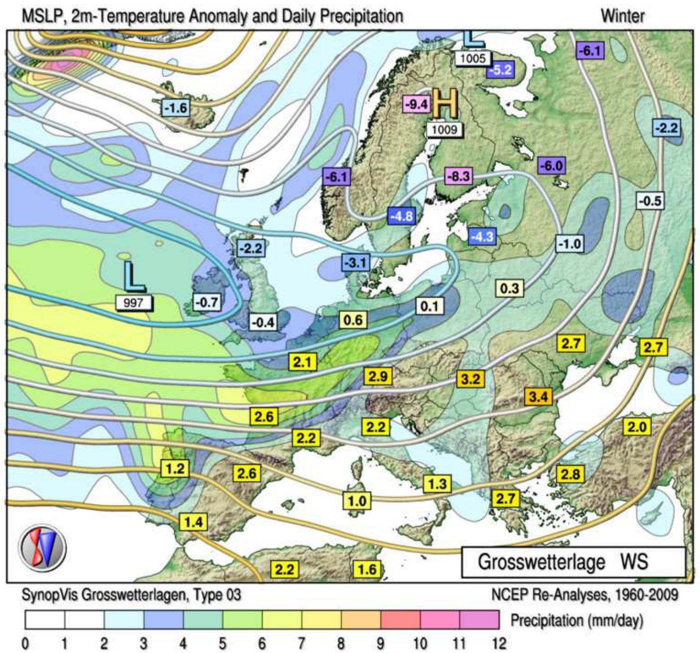


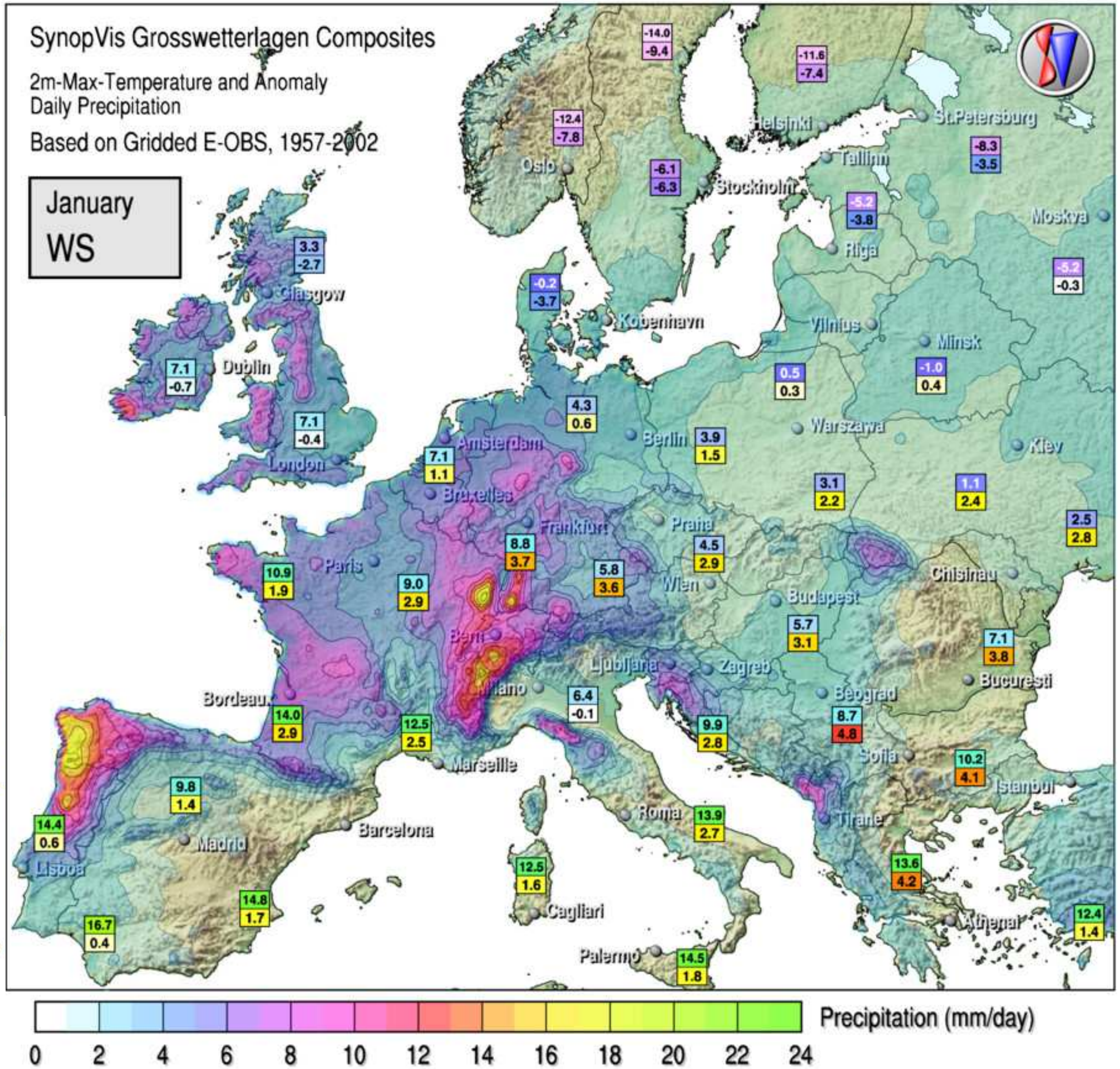


HD-Composites using Ensembles E-OBS Data

South-Shifted Westerly, WS

- ➔ Note fine local detail embedded within large-scale type (e.g. orographic rainfall)





SVG Catalogue Example, 2010

SynopVis Grosswetterlagen 2010

***** Hess-Brezowsky Format *****

Based on pattern correlations with MSLP, 500-1000 hPa Thickness and Z500 [NCEP Reanalyses]

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Jan	HNFZ		HNZ			HNFZ					HFZ				WW			HFZ			HFA			NEA			NWZ			TRM	
Feb	TRM	WS			HFZ			HNFZ			NEZ				TB						WS			TB							
Mar	NWZ			NA			HB				NZ			NWA			WA			SWZ				SZ			WZ			TRW	
Apr	TRW			WW			BM			NEA			NEZ			NWA			NWZ				WA						WZ		
May	WZ	TM							HNZ			TM				Ü	NA			NEA			NWA			WS					NEZ
Jun	NEZ		HNA			TB					HNZ				HB			NZ			NA						BM				
Jul	WW				BM			SWA				SZ					WW			TRW			NEZ			TRM				WZ	
Aug	WZ	TRM							WZ			TM					WS			SWZ				WZ				NZ			NA
Sep	NA		HNA			SEA			WW					WZ			NWZ			SWZ				TM			HFZ				
Oct	SZ					SA			Ü	HNA				NZ			TRM			NWZ			TRM			SWA				TRW	
Nov	TRW	WZ			NWZ			TB			WZ					HFZ				HNFZ			NZ				HNFZ				
Dec	HNFZ		WZ			HNZ			NA					NZ			TB						TM			Ü	SEA			NWA	
Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

SVG-Frequency Table 1871-2011

SynopVis Grosswetterlagen

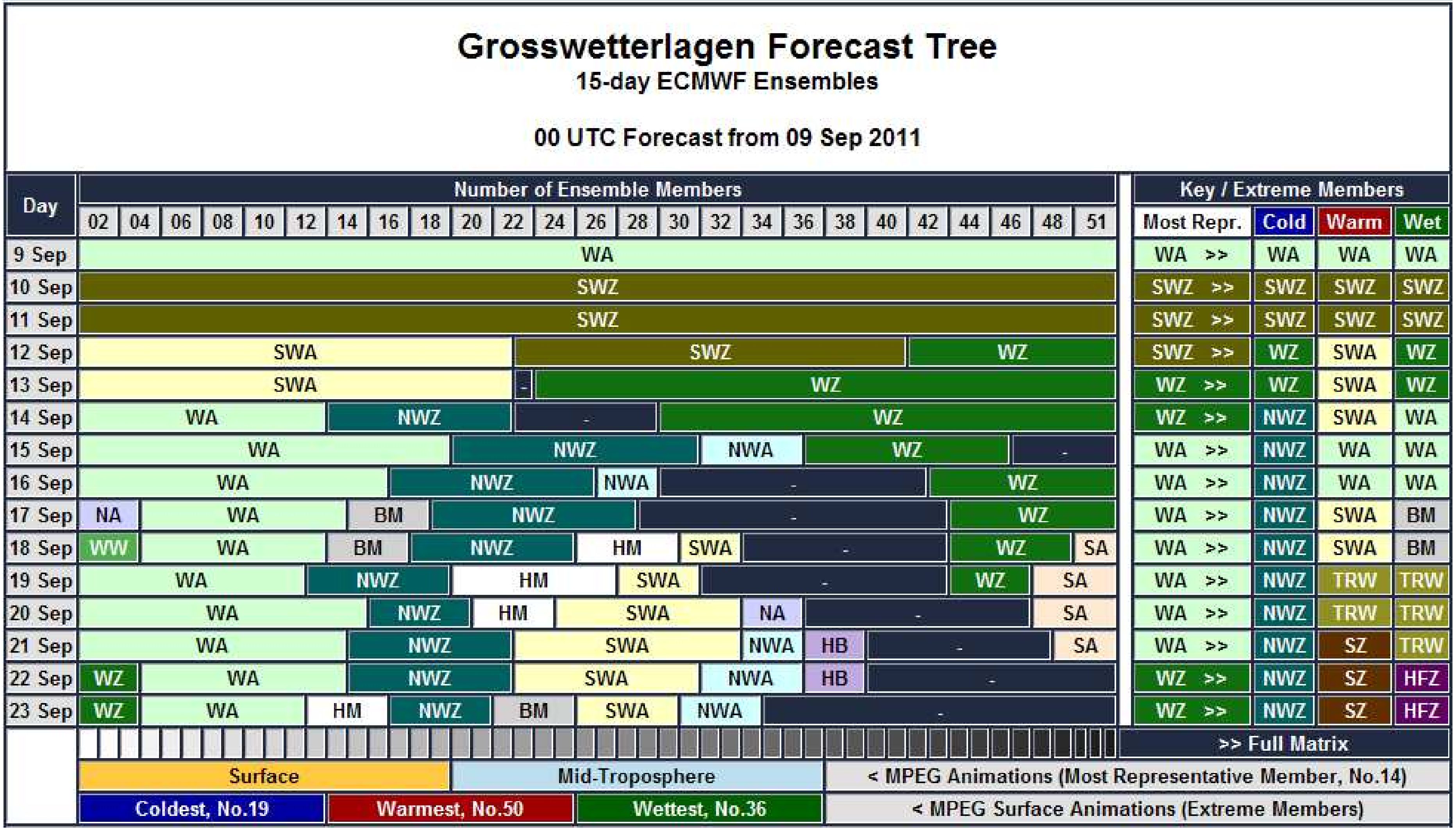
Monthly Frequencies (%), 1871-2011

GWL	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Description
WA	8.4	8.2	7.2	3.9	2.9	5.6	5.3	6.9	8.5	7.4	6.3	7.3	6.5	*Anticyclonic Westerly*
WZ	6.6	4.4	4.4	4.4	2.8	6.3	9.7	10.2	8.1	6.2	6.7	7.0	6.4	*Cyclonic Westerly*
WS	1.4	2.2	2.1	1.2	0.9	1.7	4.4	2.7	1.2	1.5	1.1	2.1	1.9	*South-Shifted Cyclonic Westerly*
WW	6.1	5.2	4.7	3.9	3.3	4.7	6.4	6.3	3.5	2.4	4.6	6.0	4.8	*Maritime Westerly (Block E.Europe)*
SWA	6.1	4.1	3.8	2.6	3.2	5.0	4.2	4.9	7.0	6.3	5.2	5.4	4.8	*Anticyclonic South-Westerly*
SWZ	6.6	5.3	4.5	2.9	4.3	4.5	5.3	6.2	4.4	5.8	5.1	5.3	5.0	*Cyclonic South-Westerly*
NWA	5.5	5.0	4.1	2.5	1.8	2.6	3.1	3.7	5.4	4.6	5.1	5.5	4.1	*Anticyclonic North-Westerly*
NWZ	6.4	5.2	5.0	3.0	1.7	4.6	7.6	5.9	4.2	4.8	5.7	5.6	5.0	*Cyclonic North-Westerly*
HM	4.4	3.8	2.8	2.1	1.4	2.3	2.2	2.8	3.5	2.6	2.2	4.1	2.9	*High over Central Europe*
BM	3.8	2.8	3.7	3.7	3.4	3.5	3.6	4.4	4.3	4.2	3.8	4.5	3.8	*Zonal Ridge across Central Europe*
TM	1.2	1.8	2.1	3.5	5.2	3.5	1.5	1.4	1.7	1.9	2.8	1.7	2.4	*Low over Central Europe*
NA	1.8	2.9	2.4	1.5	2.1	4.3	4.9	3.1	2.4	1.6	1.7	1.8	2.6	*Anticyclonic Northerly*
NZ	2.1	2.9	2.5	3.1	2.8	3.6	2.6	3.0	2.5	1.7	3.5	2.8	2.8	*Cyclonic Northerly*
HNA	2.2	2.2	2.4	3.1	3.7	2.6	2.3	2.1	2.9	2.6	1.9	2.6	2.6	*Icelandic High, Ridge C.Europe*
HNZ	1.0	1.6	1.8	1.6	3.2	3.0	1.2	2.0	1.6	1.9	1.5	1.5	1.8	*Icelandic High, Trough C.Europe*
HB	2.8	2.9	2.9	2.9	1.8	2.6	2.6	2.0	3.6	2.5	3.3	2.8	2.7	*High over the British Isles*
TRM	1.6	1.5	2.2	4.3	2.1	4.3	6.3	5.3	2.9	2.7	3.1	2.6	3.2	*Trough over Central Europe*
NEA	2.0	2.7	1.9	1.6	2.6	1.9	1.5	2.4	1.9	1.1	0.9	2.1	1.9	*Anticyclonic North-Easterly*
NEZ	2.2	3.1	2.4	4.8	3.8	5.0	4.5	2.6	2.9	1.5	1.9	2.1	3.1	*Cyclonic North-Easterly*
HFA	3.9	4.0	3.6	1.6	2.7	2.2	3.2	3.2	2.1	2.9	2.6	1.6	2.8	*Scandinavian High, Ridge C.Europe*
HFZ	3.5	3.6	4.0	5.1	5.3	4.7	4.0	2.7	2.6	2.6	2.6	3.2	3.7	*Scandinavian High, Trough C.Europe*
HNFA	1.7	1.2	1.7	1.9	2.8	2.0	0.4	0.9	1.0	1.4	1.0	1.5	1.5	*High Norway-Iceland, Ridge C.Eur.*
HNFZ	1.5	2.3	3.5	6.7	6.1	2.5	1.6	1.6	1.5	2.1	2.3	1.1	2.7	*High Norway-Iceland, Trough C.Eur.*
SEA	3.3	5.0	4.7	4.7	4.2	2.5	1.3	1.5	3.6	4.2	3.6	2.9	3.5	*Anticyclonic South-Easterly*
SEZ	1.6	2.8	3.9	5.9	5.3	1.7	1.0	1.5	2.7	3.4	2.6	2.7	2.9	*Cyclonic South-Easterly*
SA	3.2	3.0	3.4	2.1	3.2	2.5	1.6	2.8	4.9	4.7	2.8	3.0	3.1	*Anticyclonic Southerly*
SZ	3.4	3.6	3.6	5.1	6.5	2.8	2.8	2.6	2.8	5.3	4.5	3.5	3.9	*Cyclonic Southerly*
TB	2.2	3.8	4.8	4.9	4.4	2.5	1.4	1.3	1.5	4.0	4.6	3.0	3.2	*Low over the British Isles*
TRW	2.3	1.5	3.1	4.4	5.5	3.8	3.3	4.0	4.5	5.5	5.8	3.5	3.9	*Trough over Western Europe*
Ü	1.5	1.5	0.9	0.8	1.0	0.9	0.1	0.0	0.1	0.6	1.1	1.2	0.8	*Transitional Period*

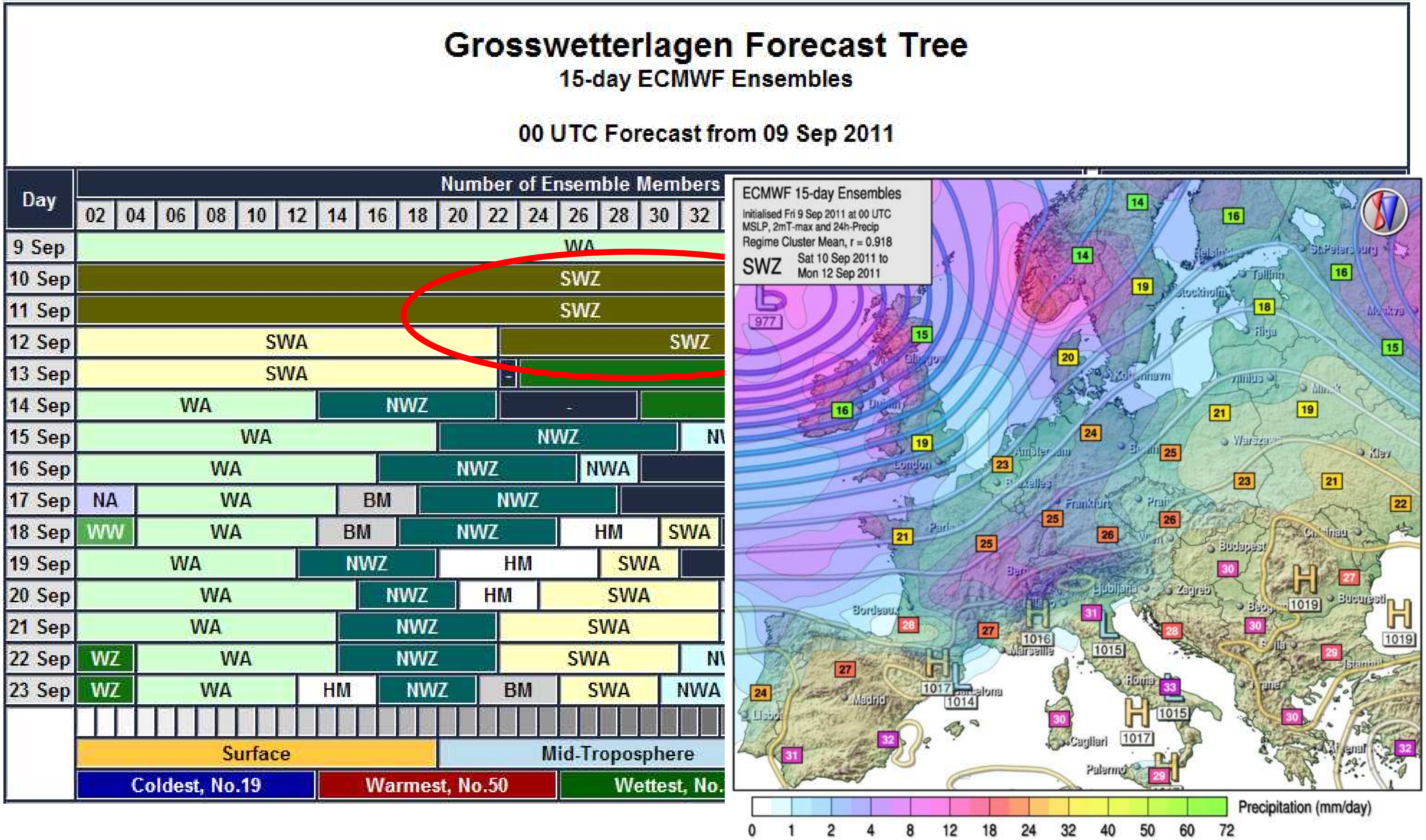
Application of GWLs to 15-day ensembles

- ECMWF EPS15 has 51 ensemble members
  - Runs twice a day, from 00 UTC and 12 UTC analyses
  - Classify daily sequences of each member with SVG method
  - Display GWL statistics in a tree-like structure…

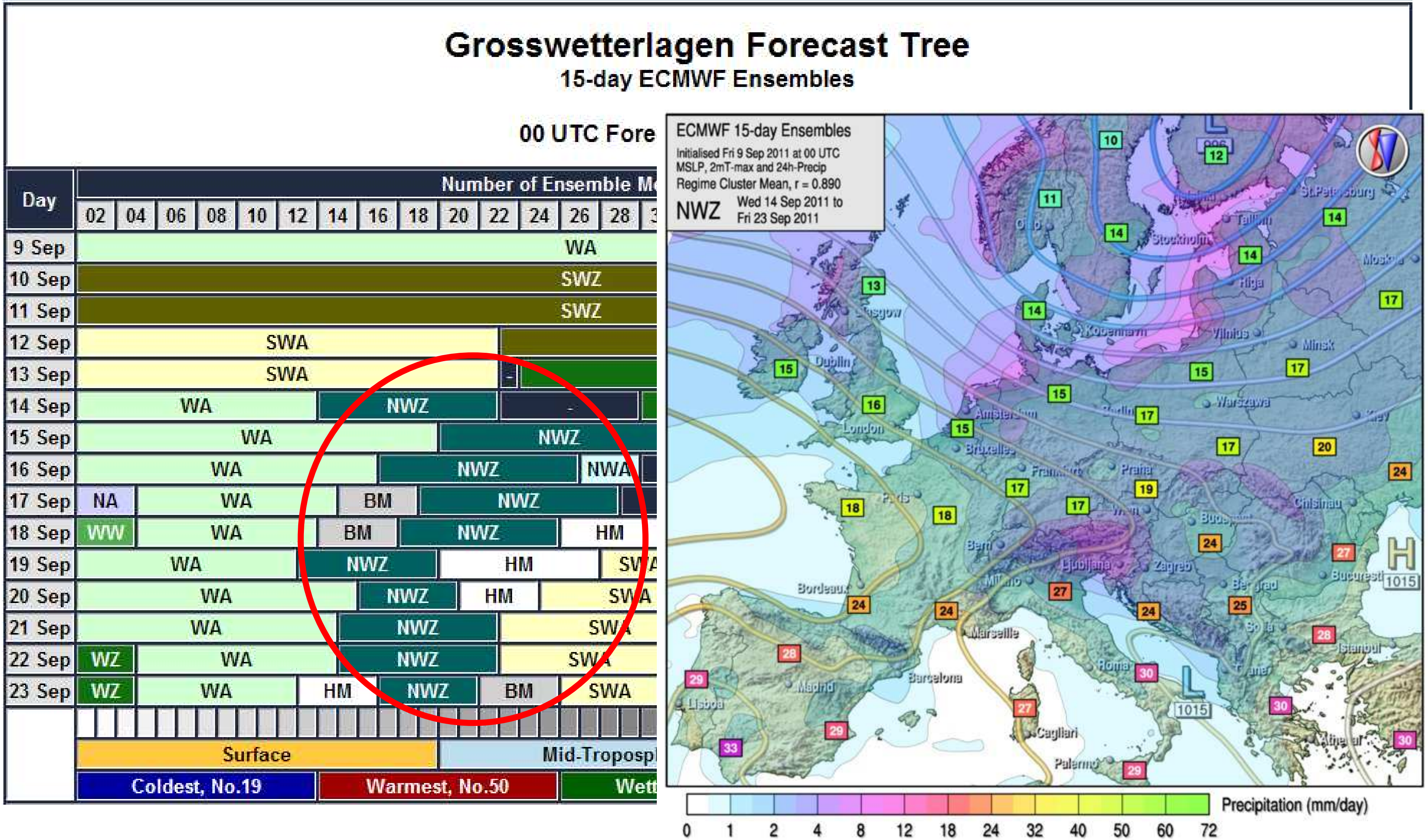
GWL EPS15 Forecast, 9th Sept 2011, 00 UTC



Clickable GWL-Cluster-Means within tree



Clickable GWL-Cluster-Means within tree



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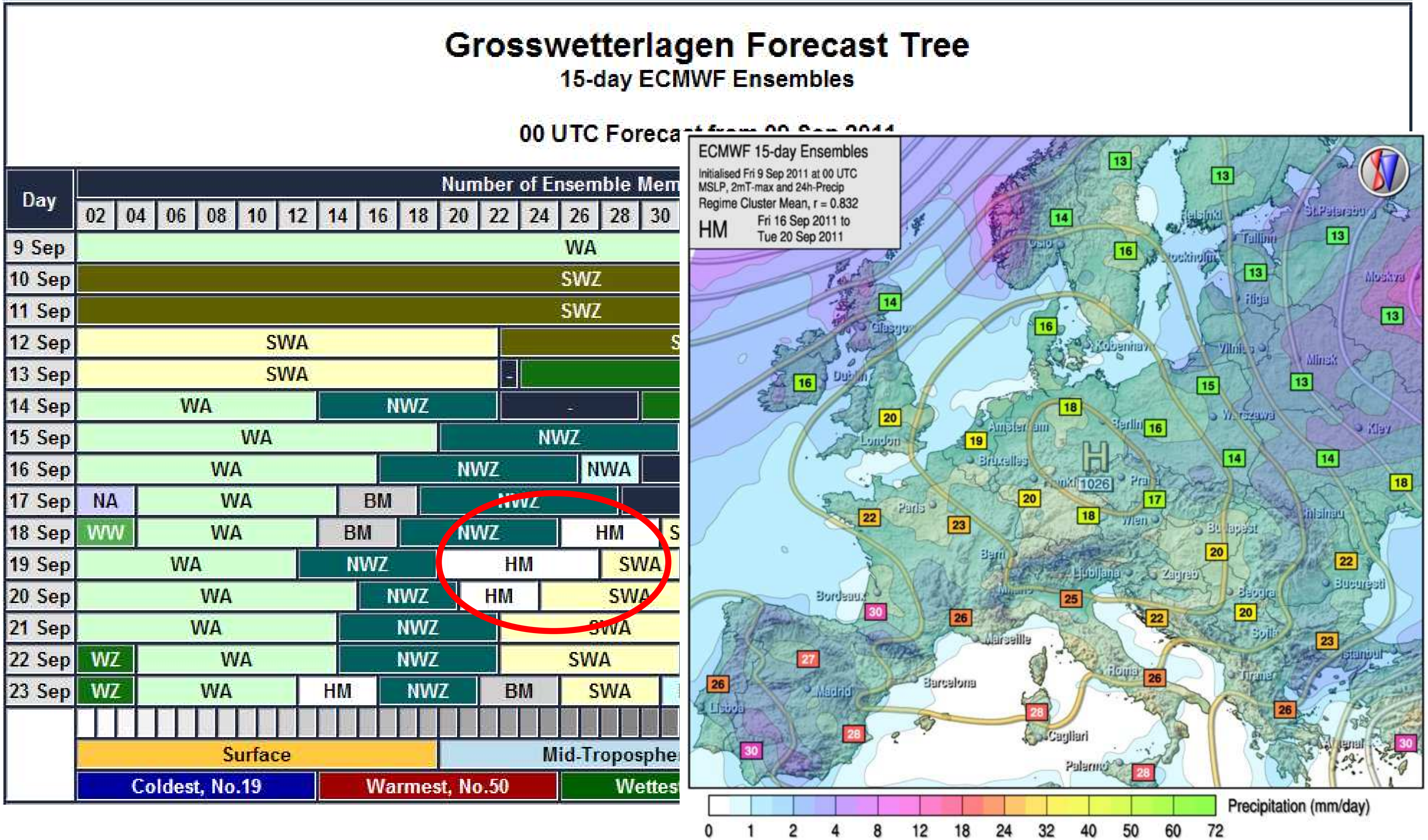
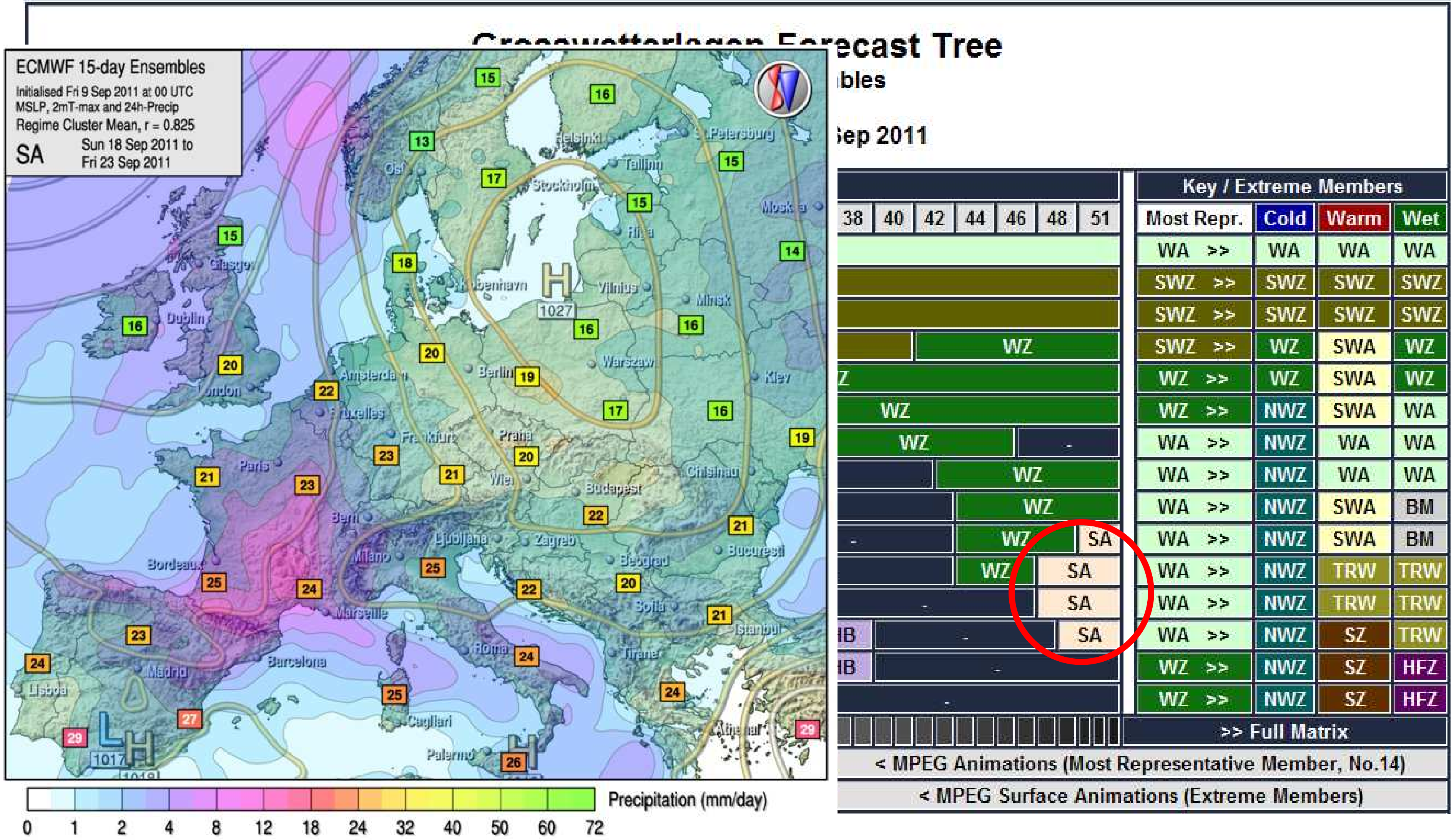
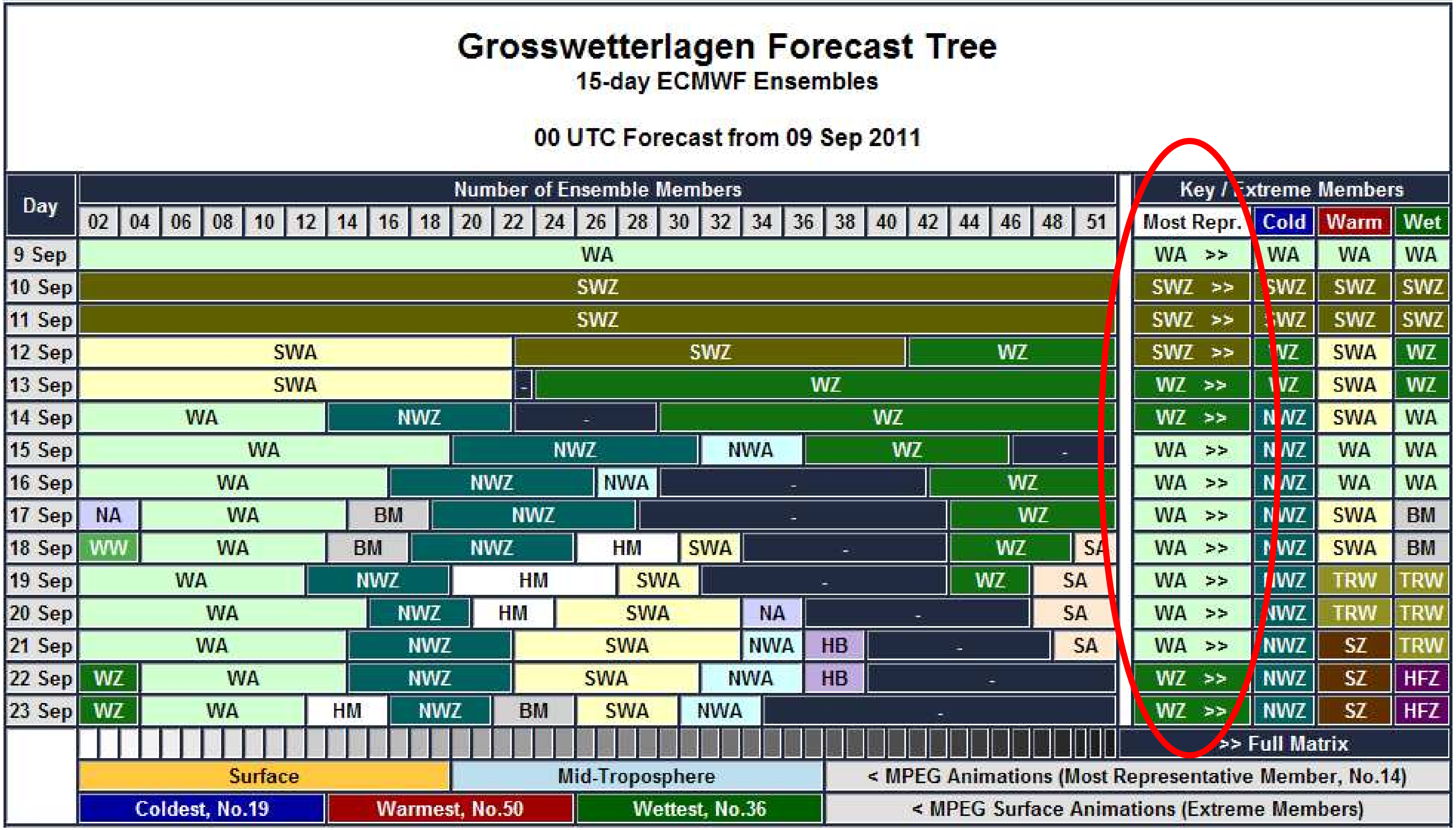


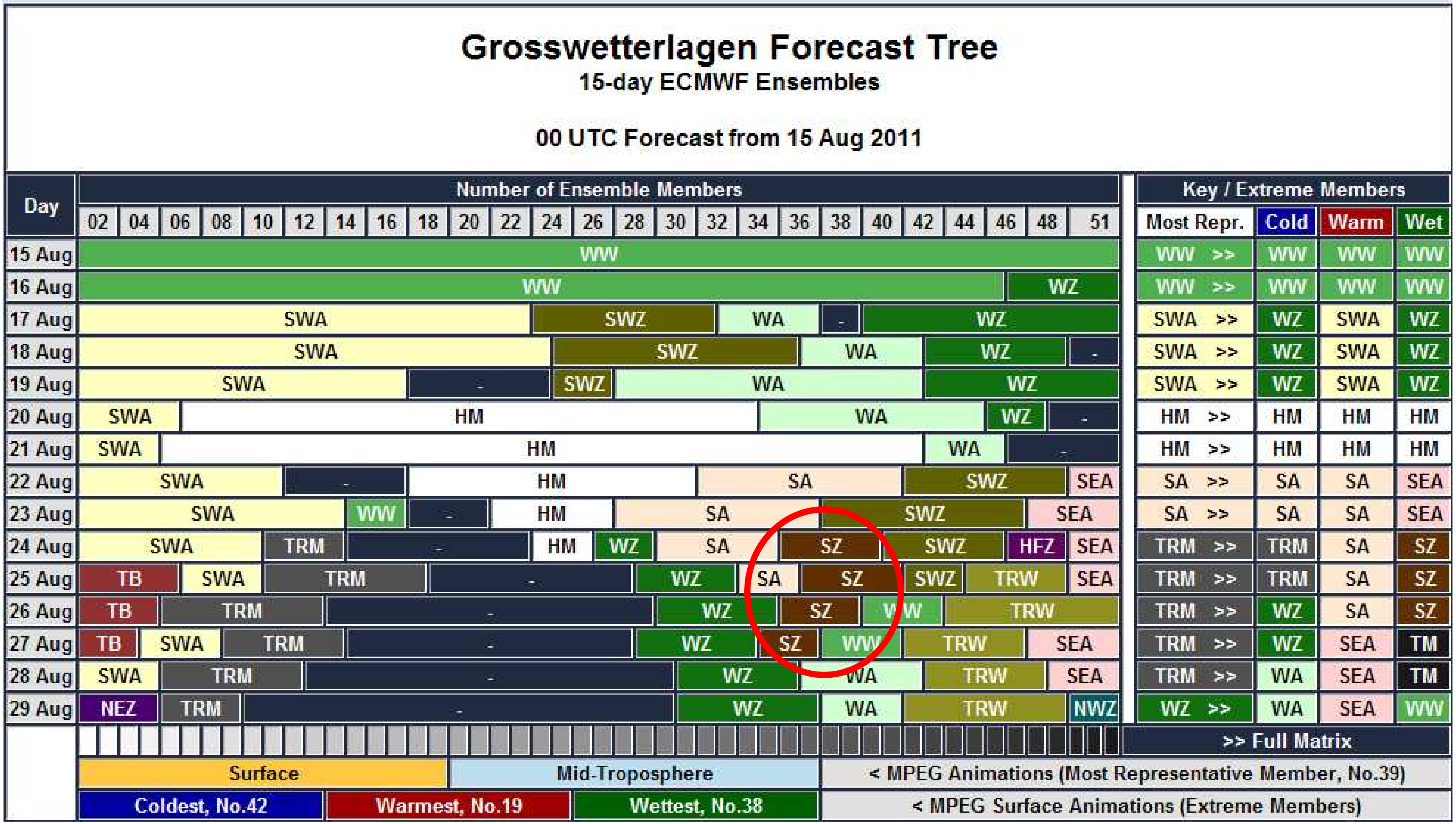
Clickable GWL-Cluster-Means within tree



GWL-Statistics provide very useful method of selecting most representative individual member



Exceptional late summer heatwave over Bavaria, 21-26 August (>35 degC in Munich, 26th Aug, with Föhn, GWL type SZ, rare in summer)



Summary

➔ A new clustering method for 15-day ensemble forecasts has been developed

- ➔ Based on objectively classified European Grosswetterlagen *
- ➔ Runs twice a day at DWD using ECMWF EPS15
- ➔ GWL probabilities displayed in an easily-readable tree-like structure
- ➔ Very useful for operational medium-range forecasters
  - ➔ Rapid visual assimilation of primary synoptic aspects of forecasts
  - ➔ Free of artificial constraints in respect to pre-specified forecast periods
  - ➔ Alternative synoptic developments in forecast easy to understand
  - ➔ Impacts of these developments on regional weather clarified using advanced graphical display of respective GWL-cluster-means

* Other classification methods, other regions of the globe can be envisaged