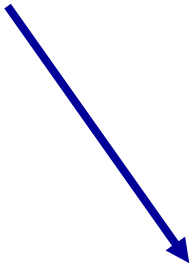
Forecast Product Development



web-based

Tim Hewson

(tim.hewson@ecmwf.int)

(Thanks to Cihan Sahin, Ervin Zsoter,

Sylvie Lamy-Thepaut, Paul Dando, Helen Titley)

Contents

- **1. Pseudo-Imagery products**
  - WV and IR

Operational

- **2. New 'Climatological Context' (EFI) products**
  - Based around hindcasts
  - M-climate (model climate) data is key
  - Severe weather focus, but other uses too

Operational

- **3. 'Synoptic-Feature' products**
  - Cyclone tracking and objective fronts
  - Conveys information using the language of forecasters

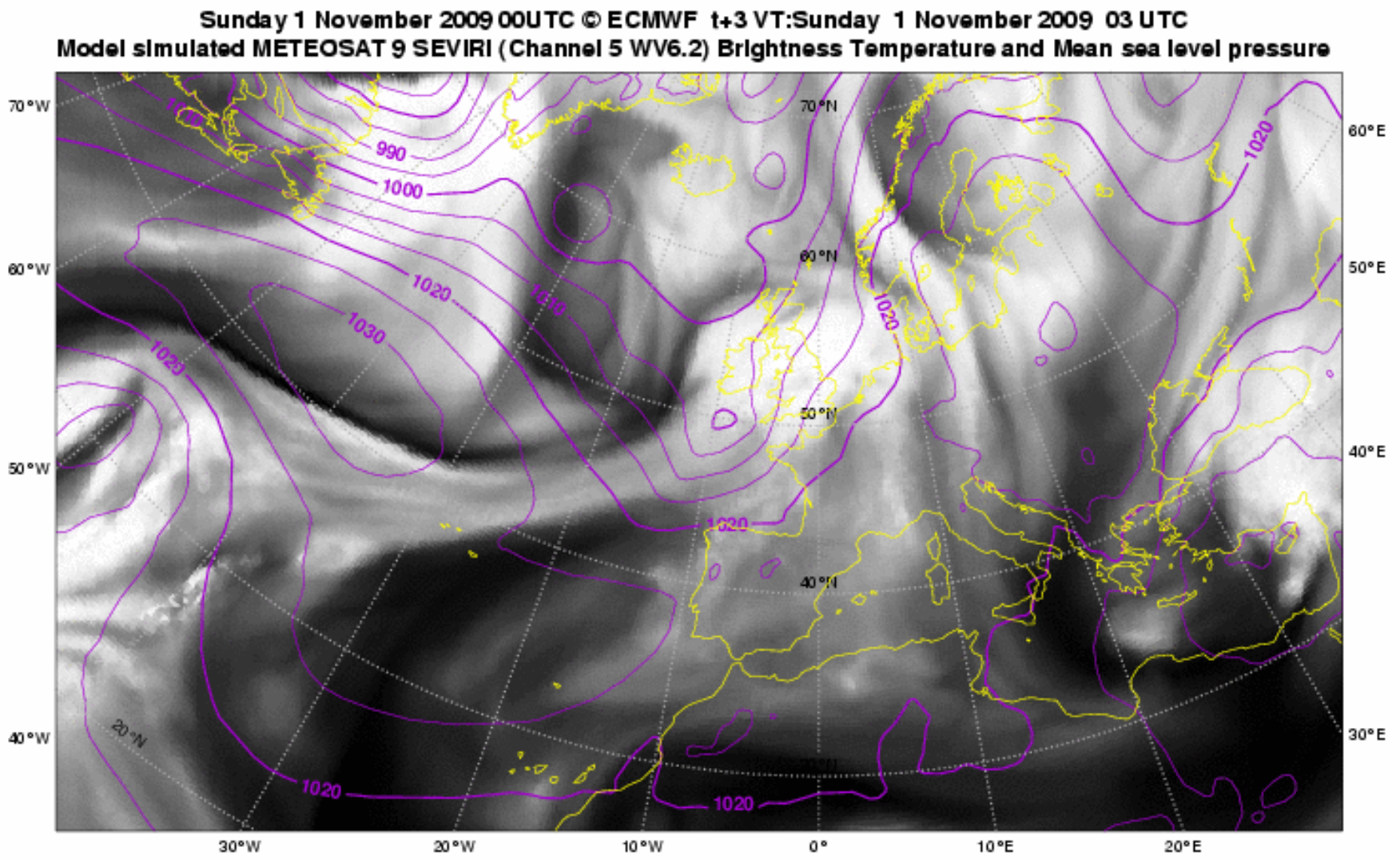
In real-time test mode -regularly evolving

- **4. Recent Example – to illustrate use of the above**
- **5. Future work: 'Representative members'**

1. Pseudo-Imagery products

- **Generated for the deterministic run**
- **Model level data is processed using the fast 'RTTOV' radiative transfer algorithm (as used in data assimilation at ECMWF)**
- **Enables pseudo-imagery for different geostationary satellites to be created**
- **Products are provided for IR and WV channels, for several regions**
- **Data interval varies (due to space constraints), but is deliberately 3-hourly on day 1 – very useful for monitoring short term model evolution**

Example 1



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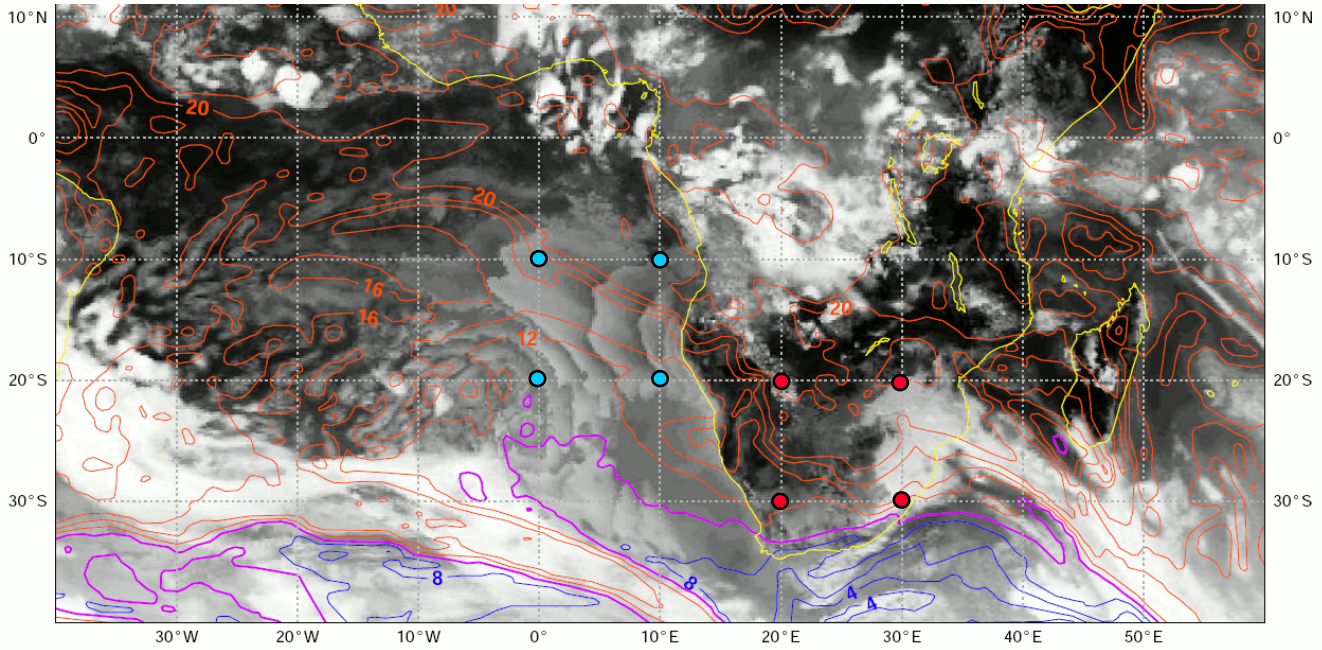
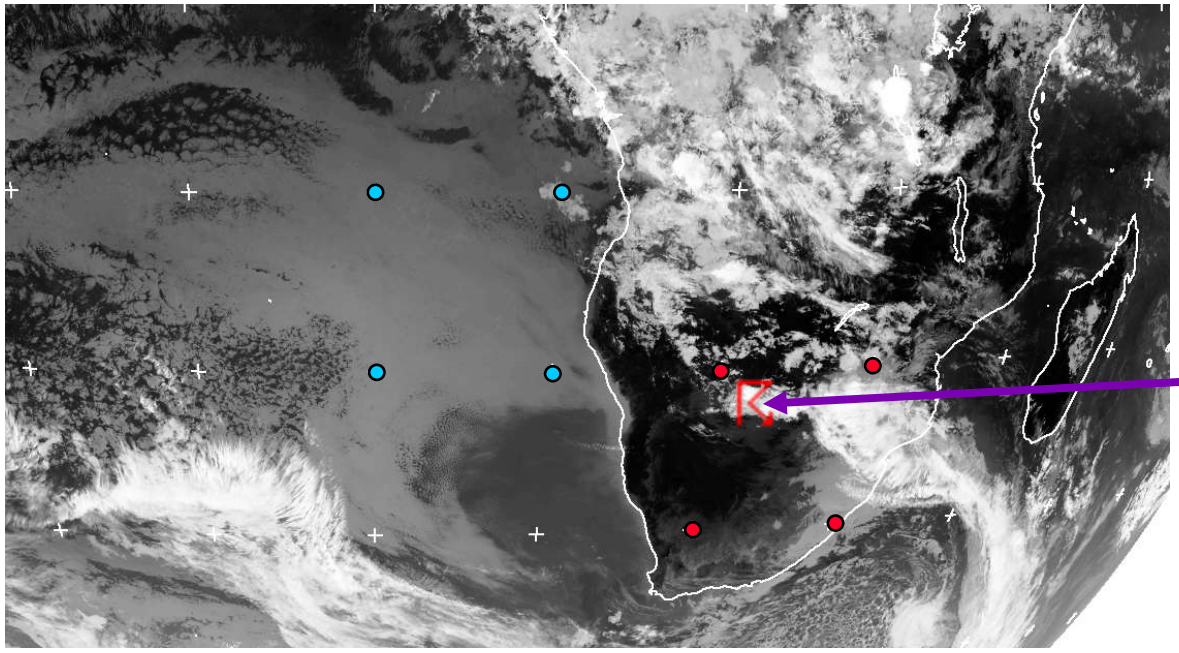
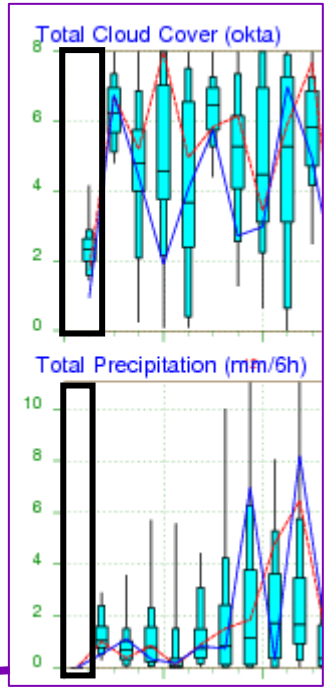
Example 2







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Some uses

- Gives impression of weather evolution in a format familiar to forecasters
- Inclusion of 850mb theta-w, as an air mass tracer, indicates both airmass boundaries and which cloud features are frontal
- Direct correspondance with real imagery facilitates direct comparison, and diagnosis of some model errors in real time (aided by 3-hourly interval)
- For cyclonic developments the connection with upper levels can often be clearly seen via the WV channel
  - Mismatches with real imagery can then provide early warning of cyclogenesis problems
- For convective outbreaks the short term evolution can be closely monitored and evaluated
  - Diurnal cycle problems will be highlighted
- New products thus provide assistance for severe weather prediction

2. New 'Climatological Context' (EFI) products

Recap – what does the EFI ('Extreme Forecast Index') measure?...

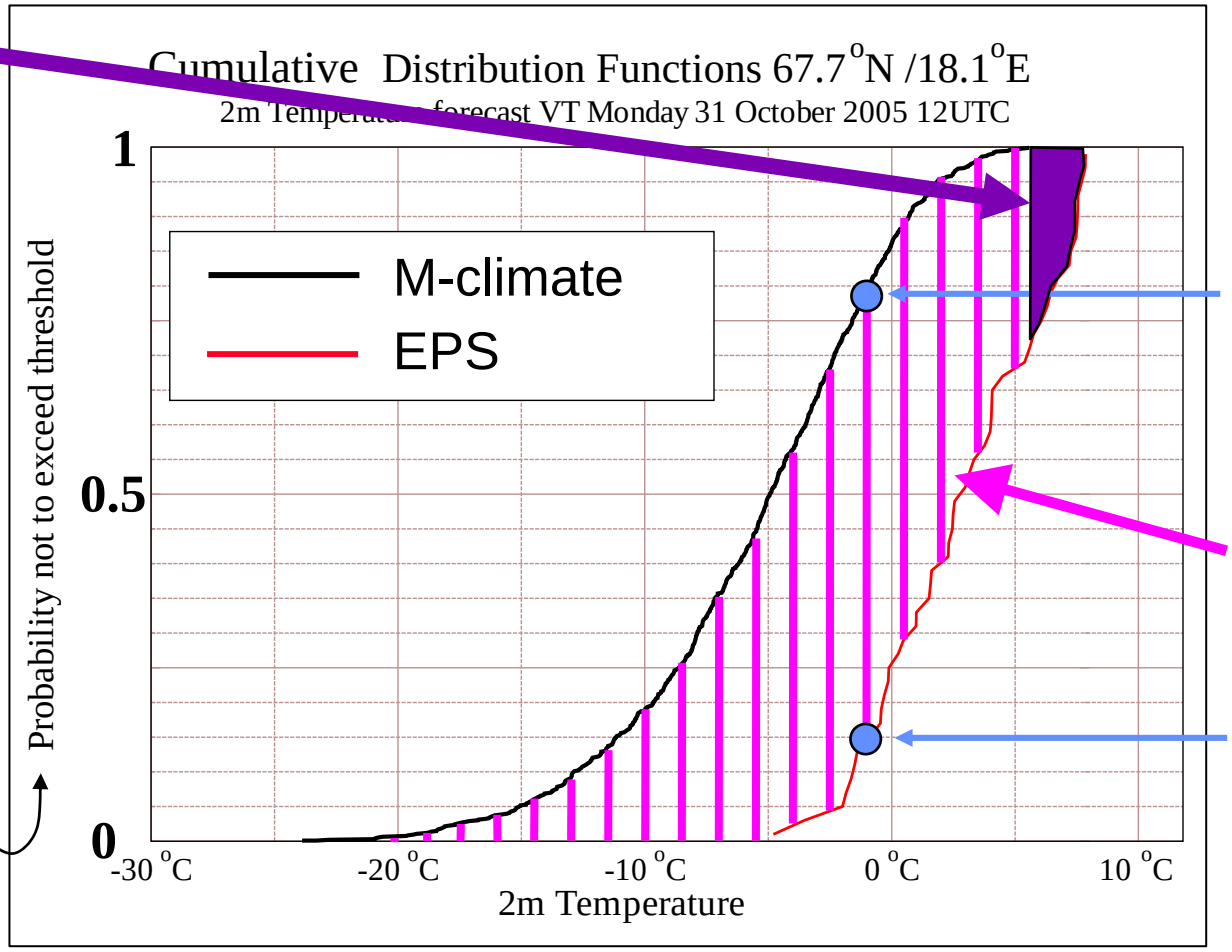
- **It is a measure, for a given weather parameter, of the difference in CDF (cumulative distribution function) between the M-climate, for a given date, and the EPS forecast.**
- **The M-climate is always based on the same model version as the forecast (via extensive hindcasts).**
- **CDFs are simple – they are a scatterplot of rank (y) against value (x) – with lines joining consecutive points**

$$EFI_{AD} = \frac{2}{\pi}\int_0^1 \left(\frac{p - F_f(p)}{\sqrt{p(1-p)}}\right) dp$$

Represented by pink lines below

More weight to extremes of M-climate

EFI takes no direct account of any EPS members beyond M-climate max



(rank/n) =

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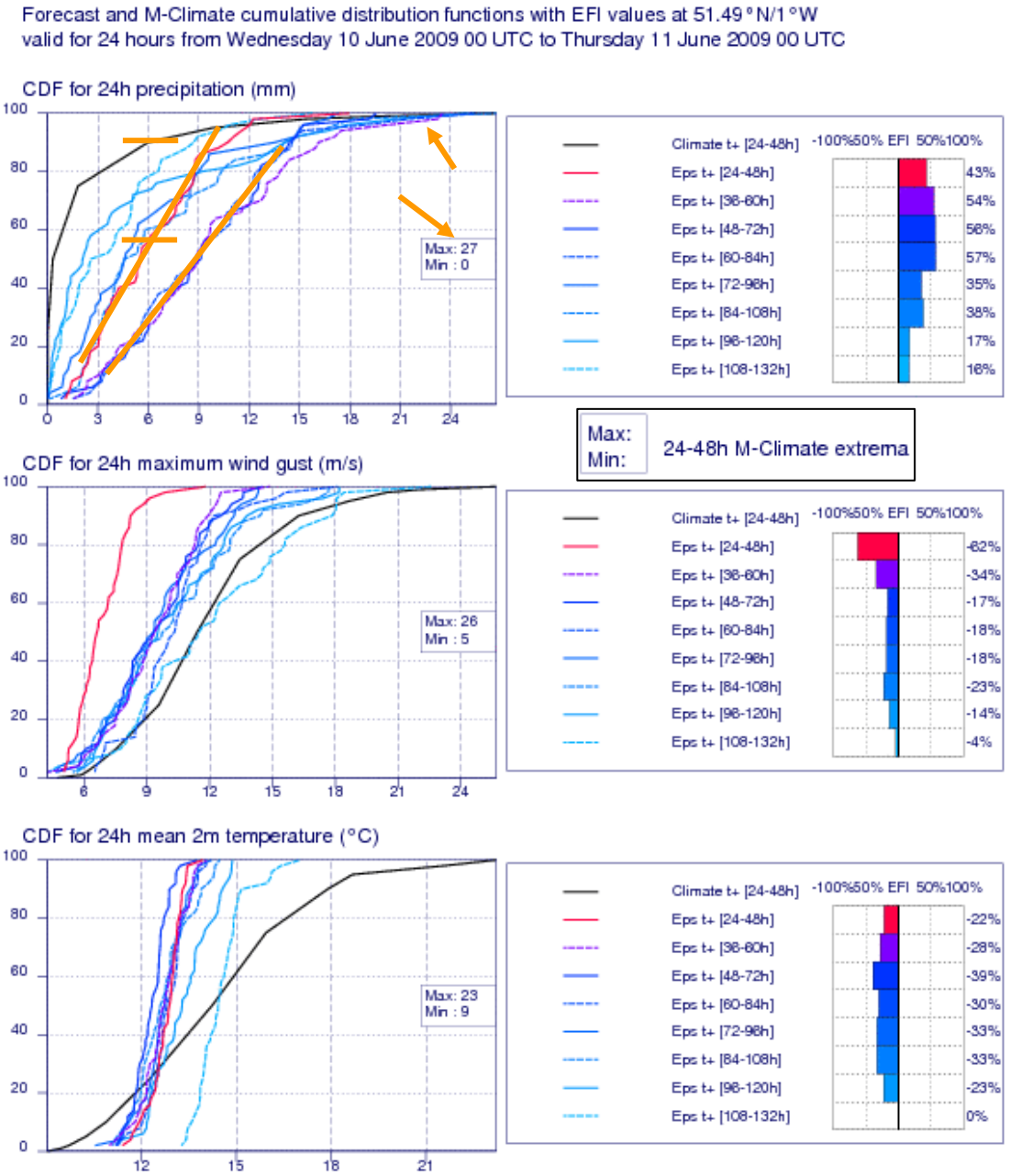
EFI distributions

- **So we can account for the 'purple zone' by providing a facility to display CDF graphs - anywhere in the world**
- **Additional benefits:**
  - **Sight of the model climate for the user, and its extremes**
  - **Sight of the full CDF for the user (within M-climate range too)**
  - **Capability to intercompare recent runs' handling, of both everyday and extreme events**
  - **This moves towards providing return-period-type information**
    - **As many aspects of infrastructure are based on this, should be very helpful for early warning provision**
    - **As the M-climate consists of 450 realisations, the M-climate extrema correspond, approximately, to 15-year return periods (for month-long time windows)**

Example: Reading on one day in June 2009

- 55% probability of >6mm
- 10% probability of >6mm on an average June day
- The 15-year return period 24h rainfall for ~June is 27mm (M-climate). In older forecasts there had been a small risk of exceeding 21mm, but not in the latest forecast (red)
- Steeper CDF slope on more recent forecasts signifies increasing confidence
- Downside – if parameter values are directly referenced, model biases are not accounted for



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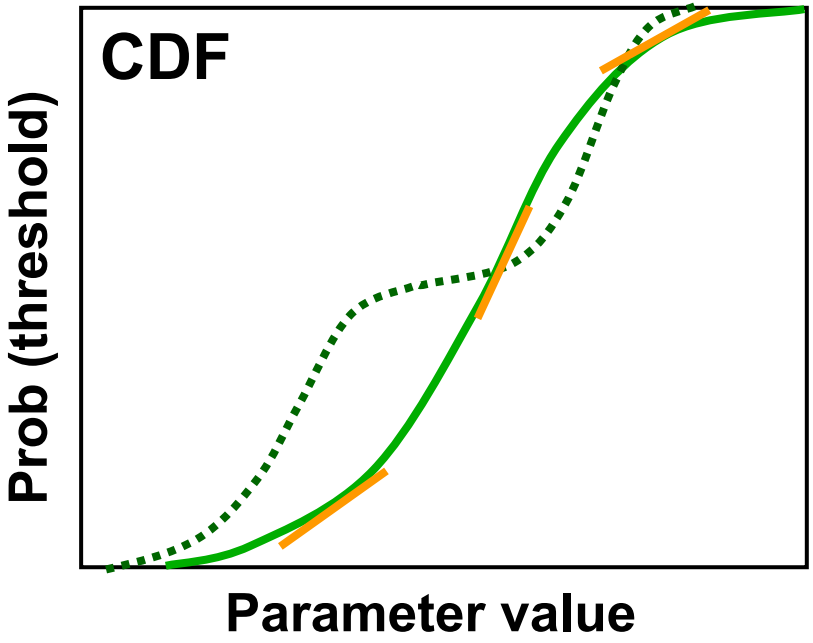
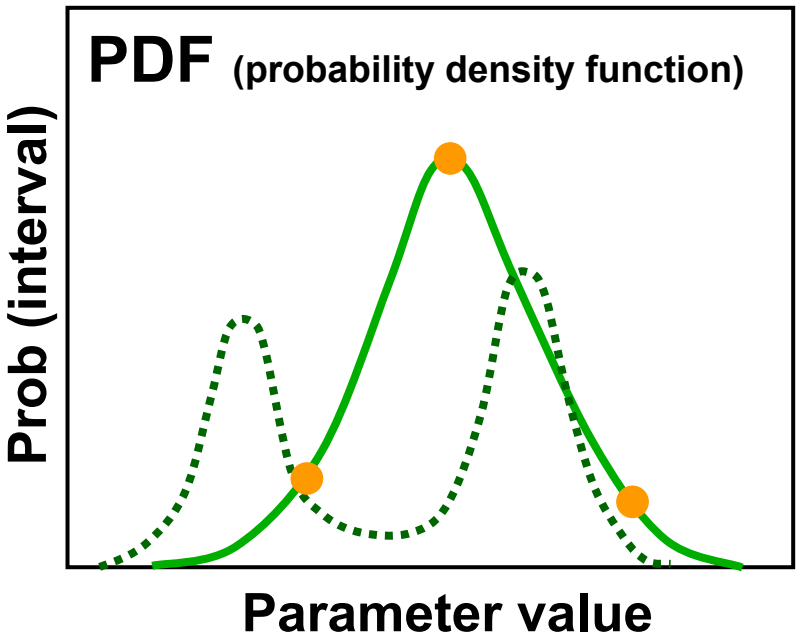
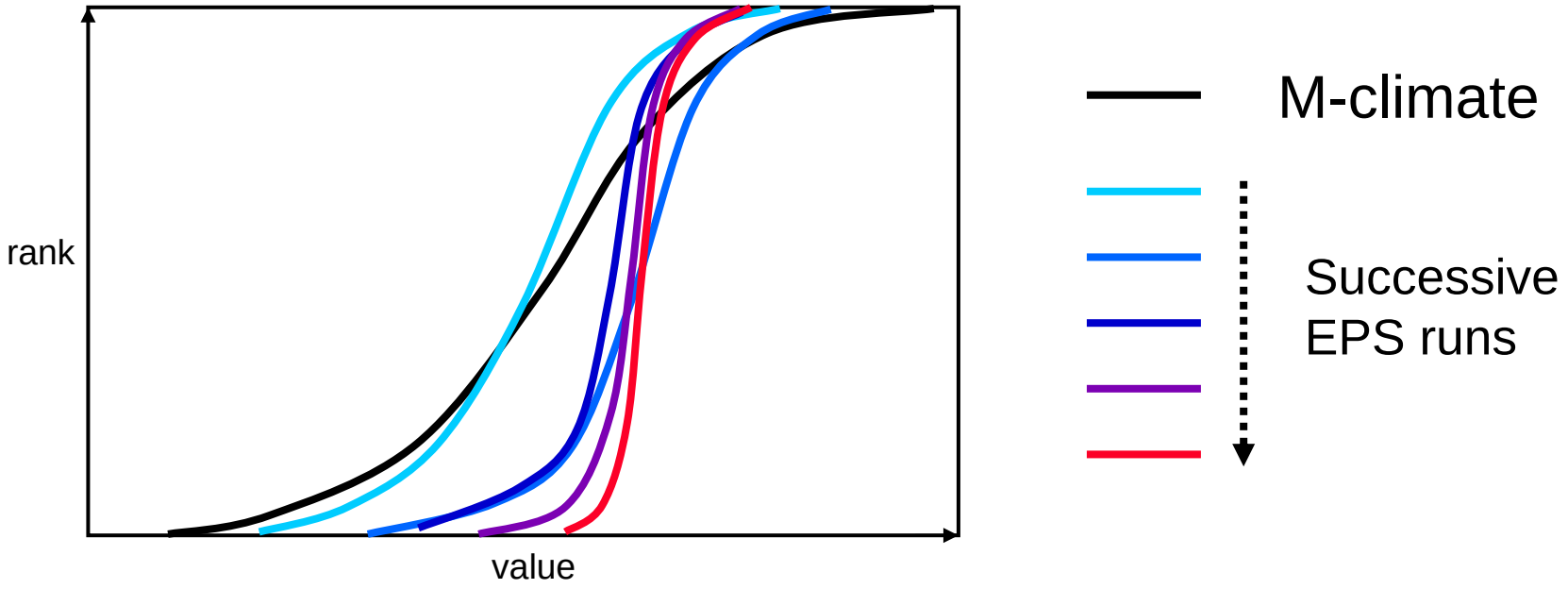
How do CDFs and PDFs relate ?





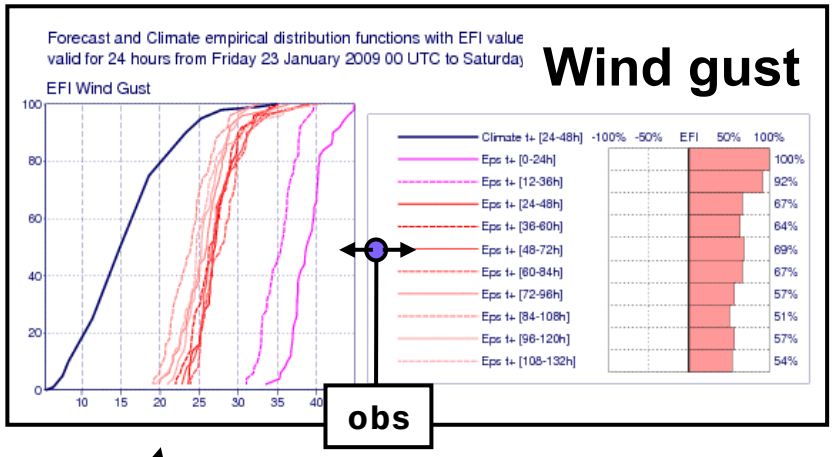
- The PDF (y-axis) value equals the slope of the CDF
- Steeper CDF = narrower PDF = higher confidence
- A step in the CDF means a bimodal PDF

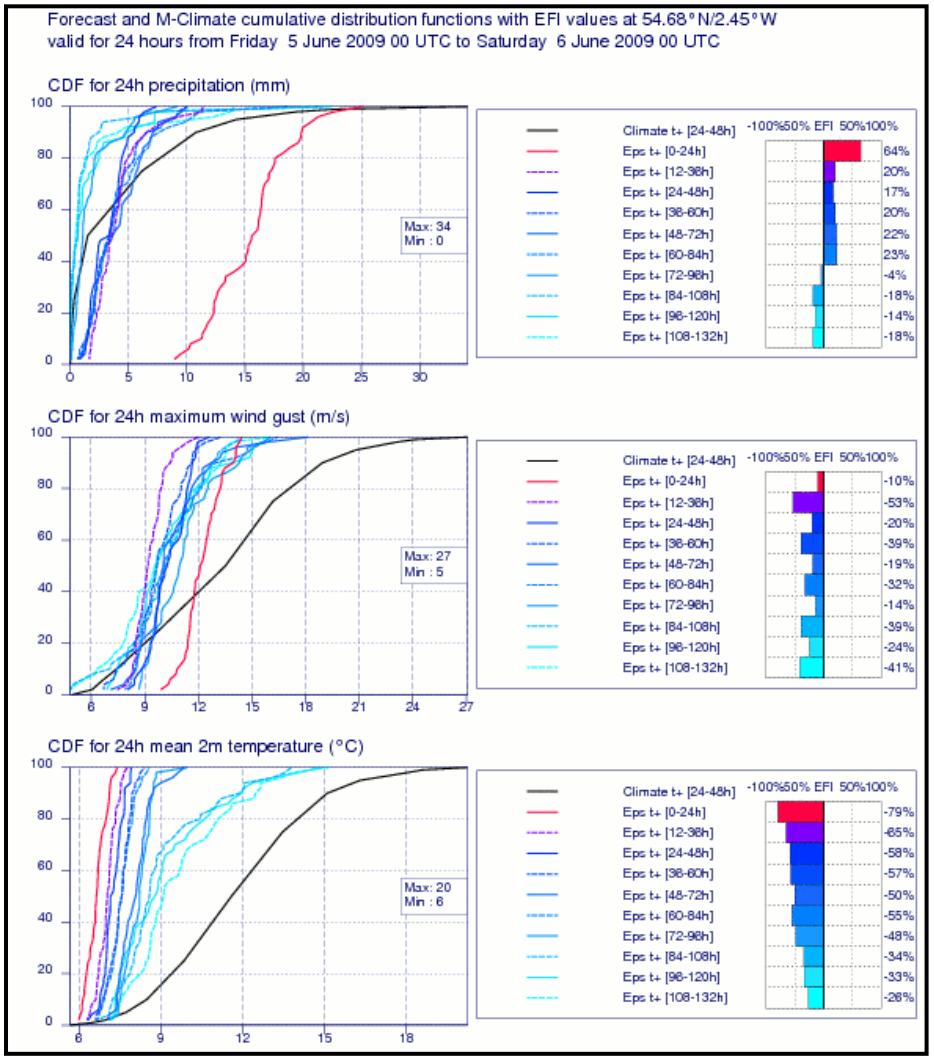
How ‘should’ CDFs behave in successive EPS runs?



- **At long leads CDF may be similar to the M-climate**
- **Lateral variations in CDF position between successive runs should, mostly, become less (with time)**
- **CDF slope will tend to increase (with time), implying higher confidence**

But there are Counter Examples:





- **Windstorm 'Klaus' – Jan 2009 – Atlantic point. Model problem?**
- **N England rain – June '09 - low prob alternative became likely at short range. If rare this is OK.**

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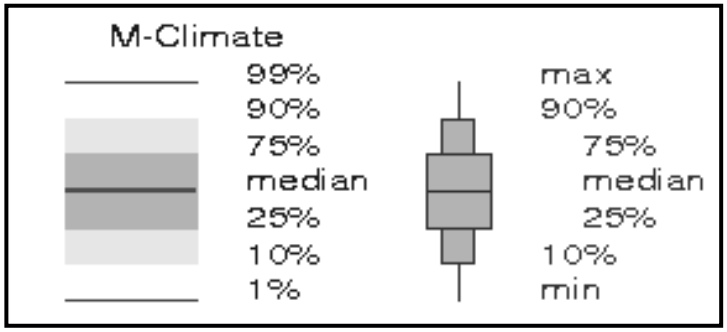
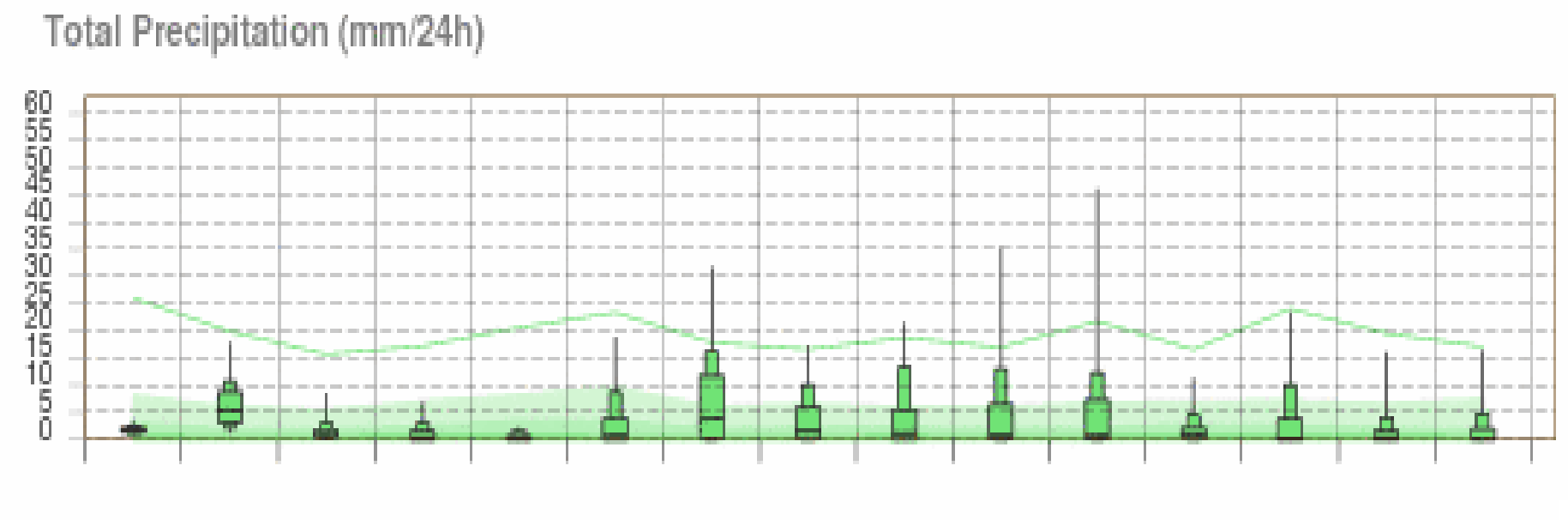
Other complementary products

- **EPSgrams with M-climate**





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Notes on M-Climate

- **M-climate is based on 5 EPS member hindcasts, from a Thursday 00Z data time over 18 years, for +/-2 weeks relative to validity date. It is a function of lead time as well as date (and of course location!).**
- **Model drift and sampling issues can thus introduce trends and noise into the M-climate that do not reflect the 'true climate'**
  - **Note that one also sees some noise in long period real climates (e.g. the Central England Temperature series)**
- **Sampling can also adversely affect the more extreme percentiles at shorter leads:**
  - **One particular extreme (Thursday) event in hindcasts could conceivably be captured by all 5 members on day 1: 5/450 ≈ 99th percentile**
  - **This will never happen at day 10**
- **Much testing went into M-climate design. Some compromises were inevitable.**

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Home > Products > Forecasts > Medium range forecast > Ensemble Prediction System > Global EFI all para

Show guide

Global EFI all parameters (Interactive chart)

This chart is ...
Clickable

Forecast base time
Tue 9 Jun 2009 00UTC

Day
1
2
3
4
5

Area
Global
Europe
North America
South America
Asia
Africa
Australia

Interactive point
- 10 days
- 15 days
- 10 days wave
- 15 days with clim
- efi distribution

Your Room
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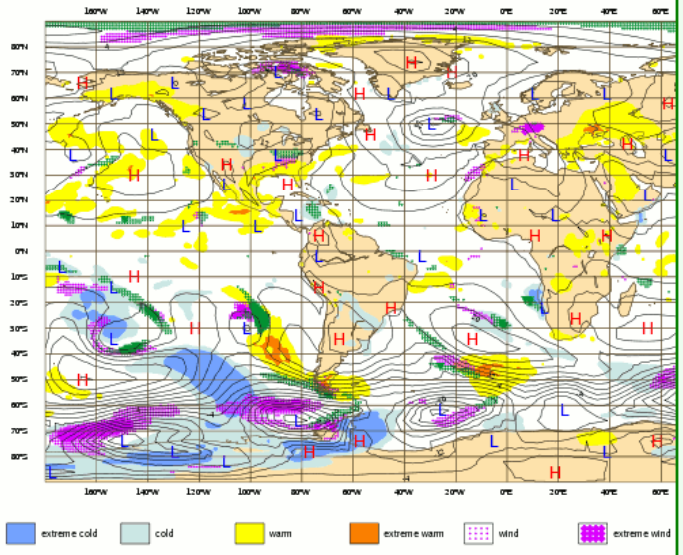
PDF
Postscript

Anomalous weather predicted by EPS: Tuesday 09 June 2009 at 00 UTC
1000 hPa Z ensemble mean (Thursday 11 June 2009 at 12 UTC)
and EFI values for Total precipitation,maximum 10m wind gust and mean 2m t
valid for 24hours from Thursday 11 June 2009 at 00 UTC to Friday 12 June 2009



09-06-2009

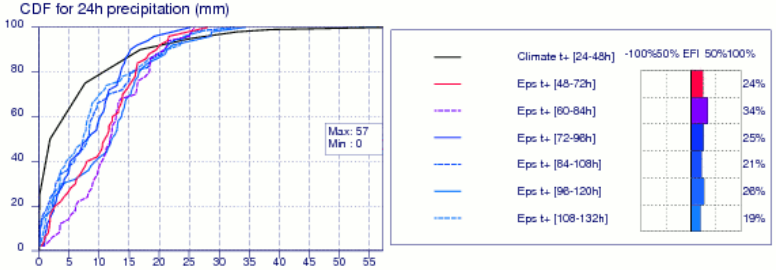
Latitude: 47.7
Longitude: 9.52
Make

Download ...
PDF
Postscript

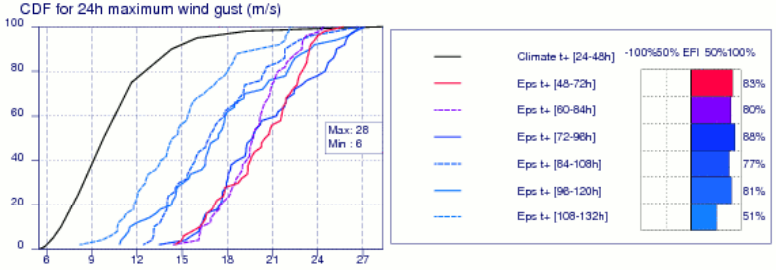
Recent clicks ...
47.7/9.52 (efi)
51.71/-1.01 (efi)
51.49/-1 (15c)
51.49/-1 (efi)
41.53/-47.88 (efi)
41.53/-47.88 (efi)
41.53/-47.88 (efi)
52.14/-1.2 (efi)
29.51/-25.63 (efi)
51.71/-1.01 (efi)
51.71/-1.01 (15c)
51.71/-1.01 (10)

Forecast and M-Climate cumulative distribution functions with EFI values at 47.7°N/9.52°E
valid for 24 hours from Thursday 11 June 2009 00 UTC to Friday 12 June 2009 00 UTC

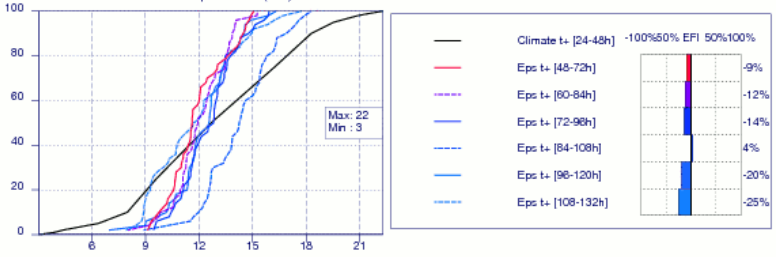
CDF for 24h precipitation (mm)



CDF for 24h maximum wind gust (m/s)



CDF for 24h mean 2m temperature (°C)



Max:
Min:
24-48h M-Climate extrema

M-Climate: this stands for "Model Climate". It is a function of lead time, date (+/- ~15 days), and model version. It is derived by rerunning a 5 member ensemble, over the last 18 years, once a week (450 realisations). M-Climate is always from the same model version as the displayed EPS data. On this page only the 24-48h lead M-Climate is displayed.

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Close Minimise Re-align

Interactive web Page

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Features of the New Web Interface

- **A user-focussed step change from past ECMWF web technology:**
  - **Interactivity – clickable points**
  - **Minimiseable moveable windows within windows!**
  - **‘Recent clicks’; past history facility on screen**
  - **One-stop shop for anomalous weather prediction (combining EFI, meteograms, waves, temporal evolution of forecasts)**
  - **Covers whole globe**
  - **pdf/postscript facility retained**

- **Can be called the ‘Clickable EFI’**

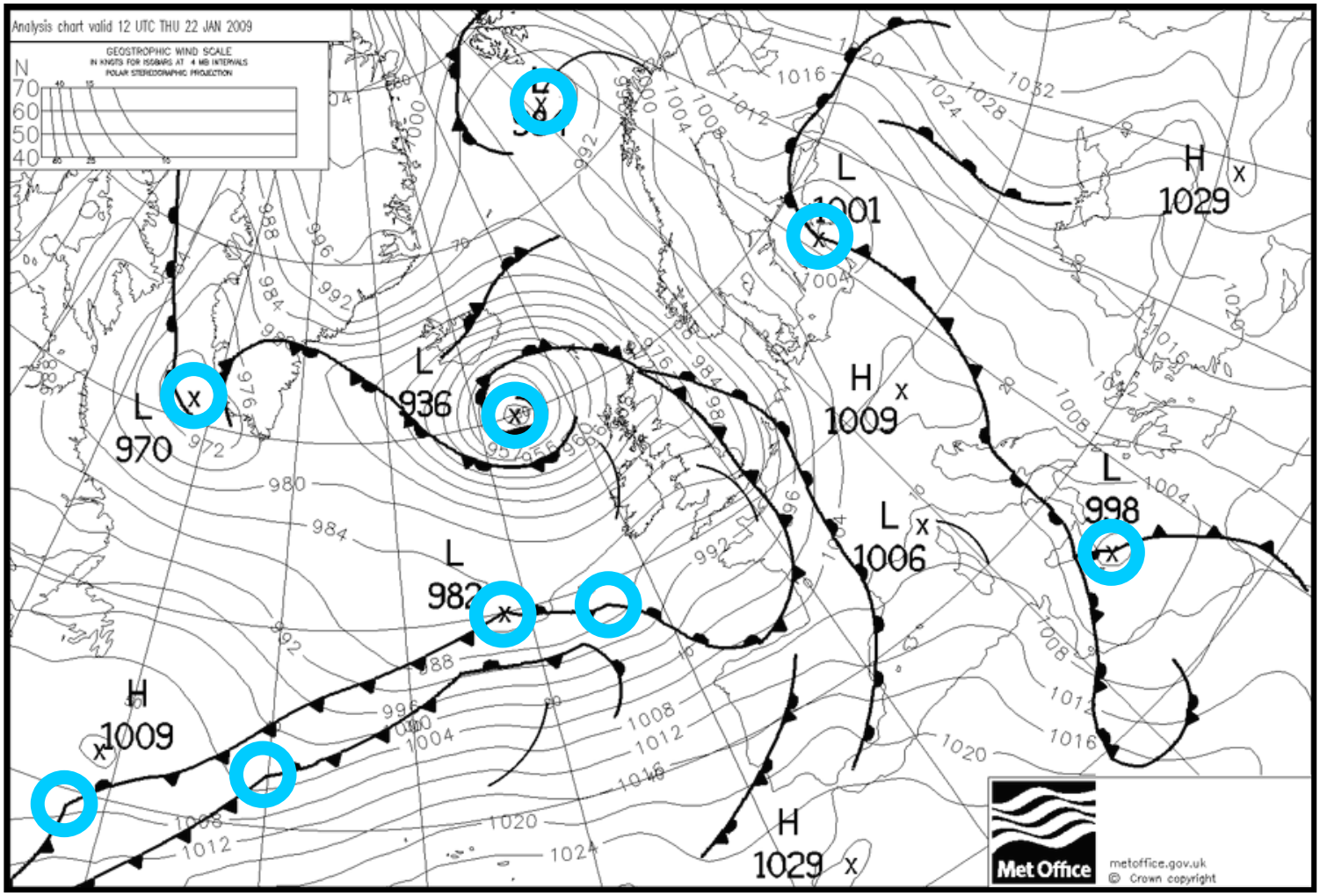
3. New 'Synoptic-Feature' products

- **Principle**
  - Forecasters make daily use of feature identification (e.g. fronts, troughs, frontal waves, lows, hurricanes,…), due primarily to the connection between features and adverse (or extreme) weather
  - Nowadays feature identification is based largely on model output
  - Why not therefore automate the identification of those features in that model output ?
  - Code now exists
- **Benefits**
  - Time-saving, especially when applied to an EPS (without automation feature identification in EPS output is not possible)
  - Provides a way of intercomparing EPS members using the 'language of forecasters'
  - Features, that the model can recognise, sometimes correlate with severe weather that the model can't explicitly represent

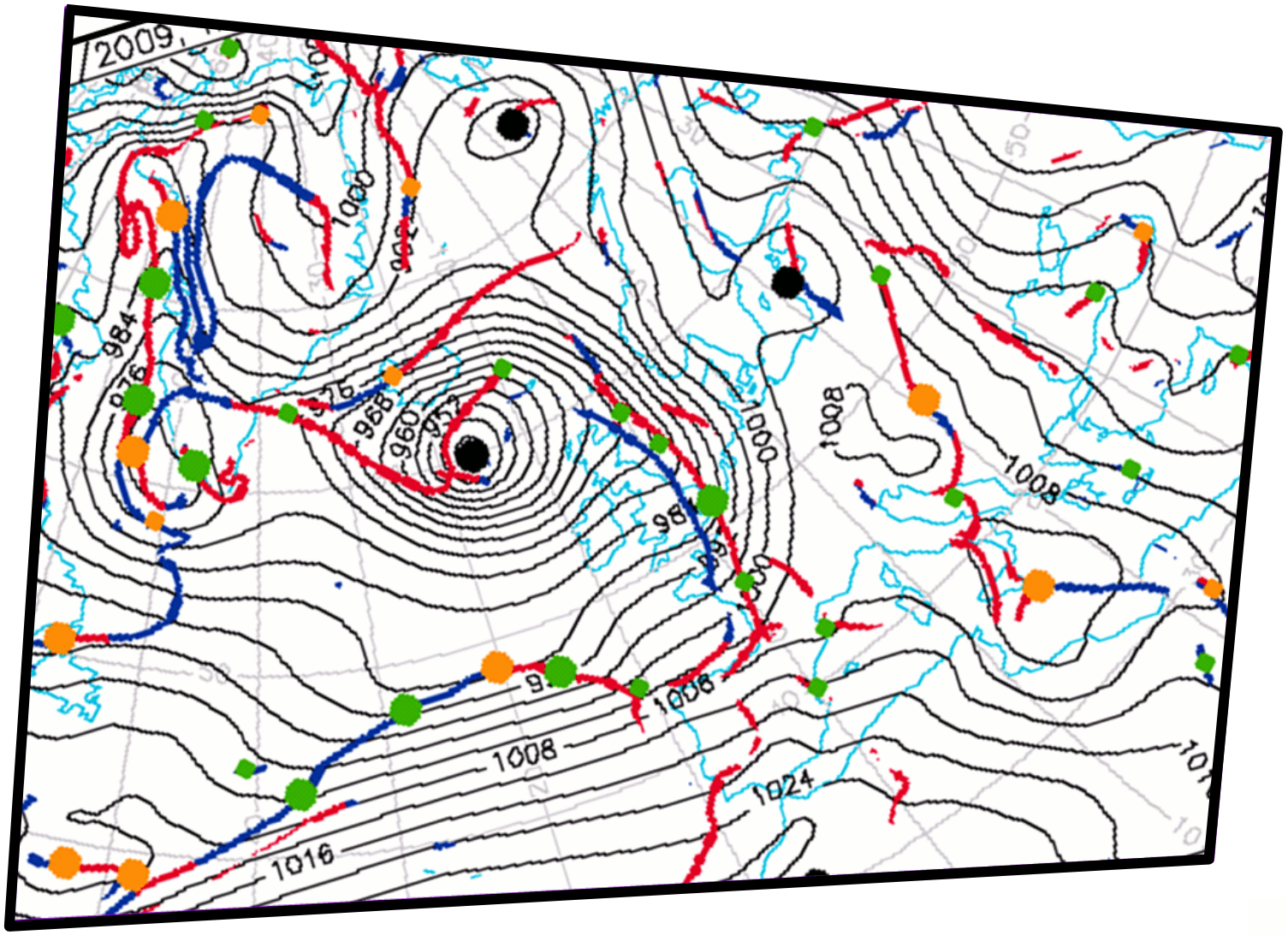
3.1 An extreme weather example

- **Windstorm Klaus that hit France and Spain in January 2009**

12UTC 22nd January 2009, 30-48 hours before windstorm Klaus peaked over land



ECMWF Control Run T+0, with objective features



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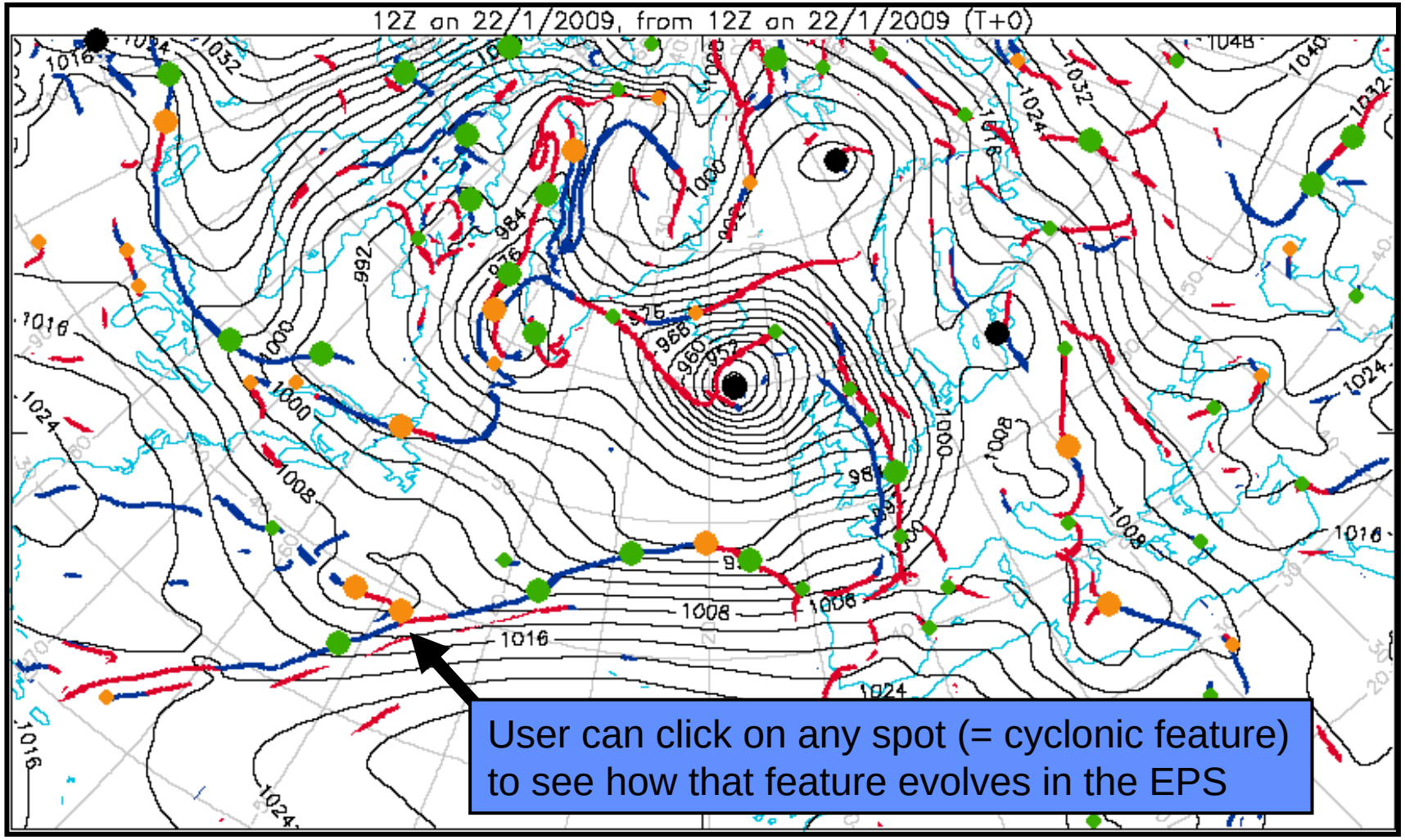
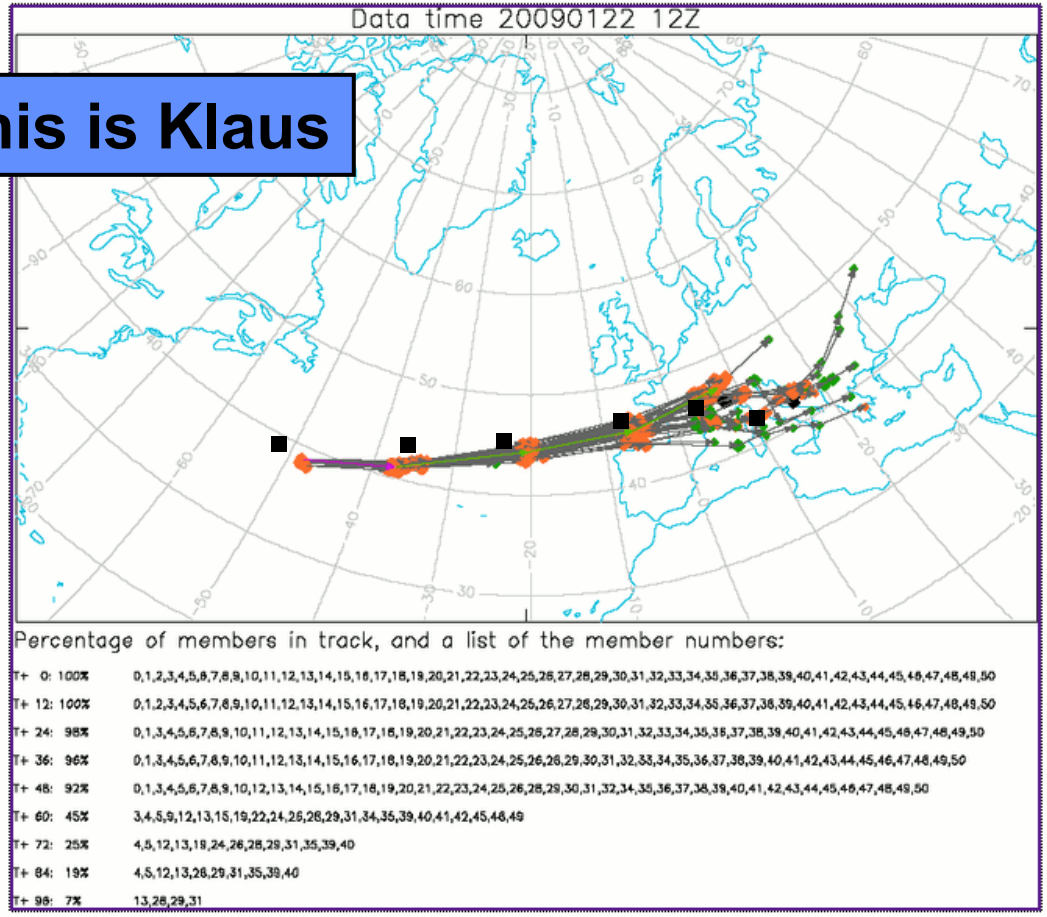
Standard, larger view



This is Klaus



Percentage of members in track, and a list of the member numbers:

T+ 0: 100% 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50

T+ 12: 100% 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50

T+ 24: 98% 0,1,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50

T+ 36: 96% 0,1,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50

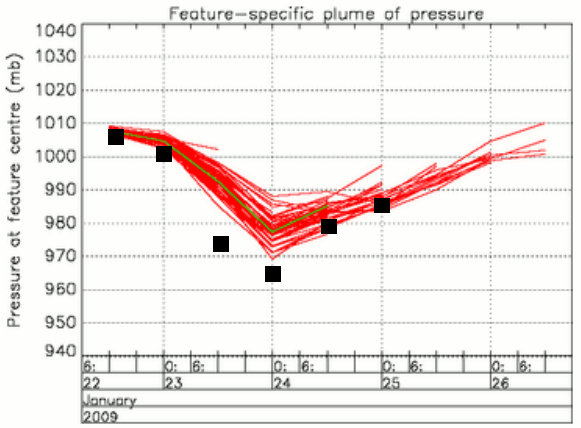
T+ 48: 92% 0,1,3,4,5,6,7,8,9,10,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,28,29,30,31,32,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50

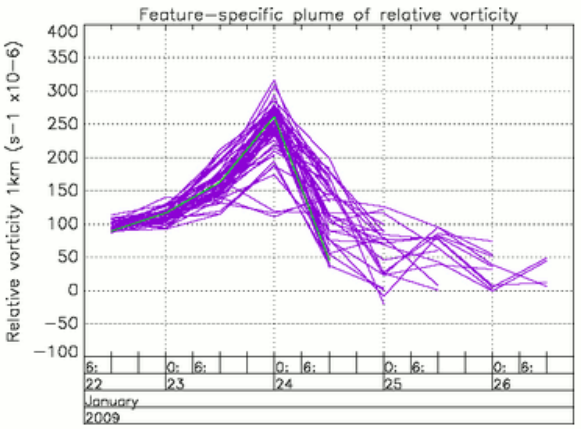
T+ 60: 45% 3,4,5,9,12,13,15,19,22,24,25,26,29,31,34,35,39,40,41,42,45,46,49

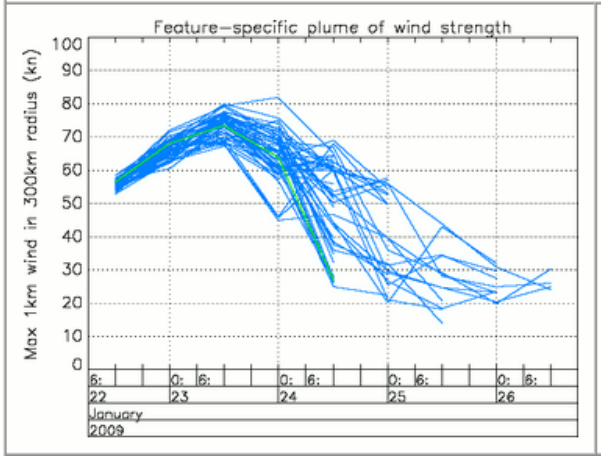
T+ 72: 25% 4,5,12,13,19,24,26,28,29,31,35,39,40

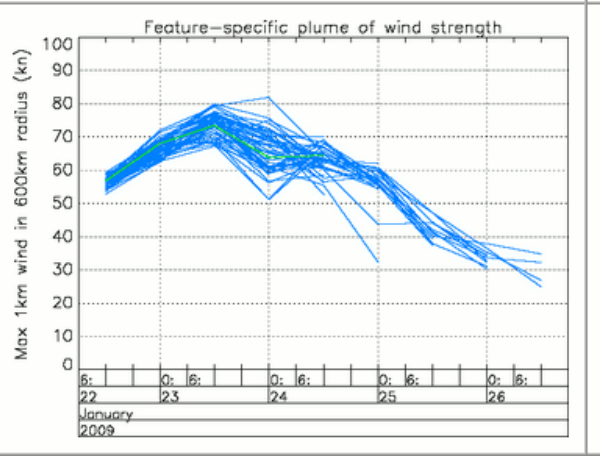
T+ 84: 19% 4,5,12,13,26,29,31,35,39,40

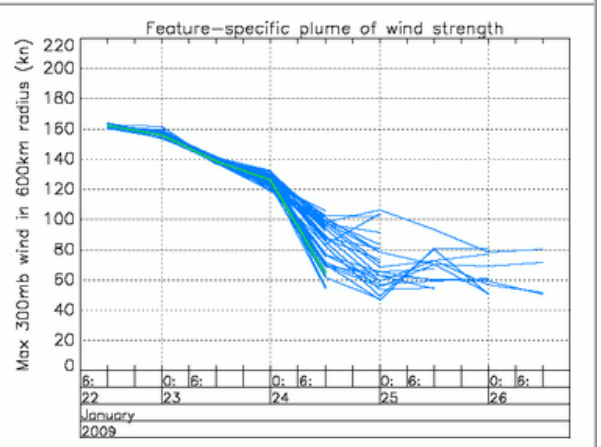
T+ 96: 7% 13,28,29,31







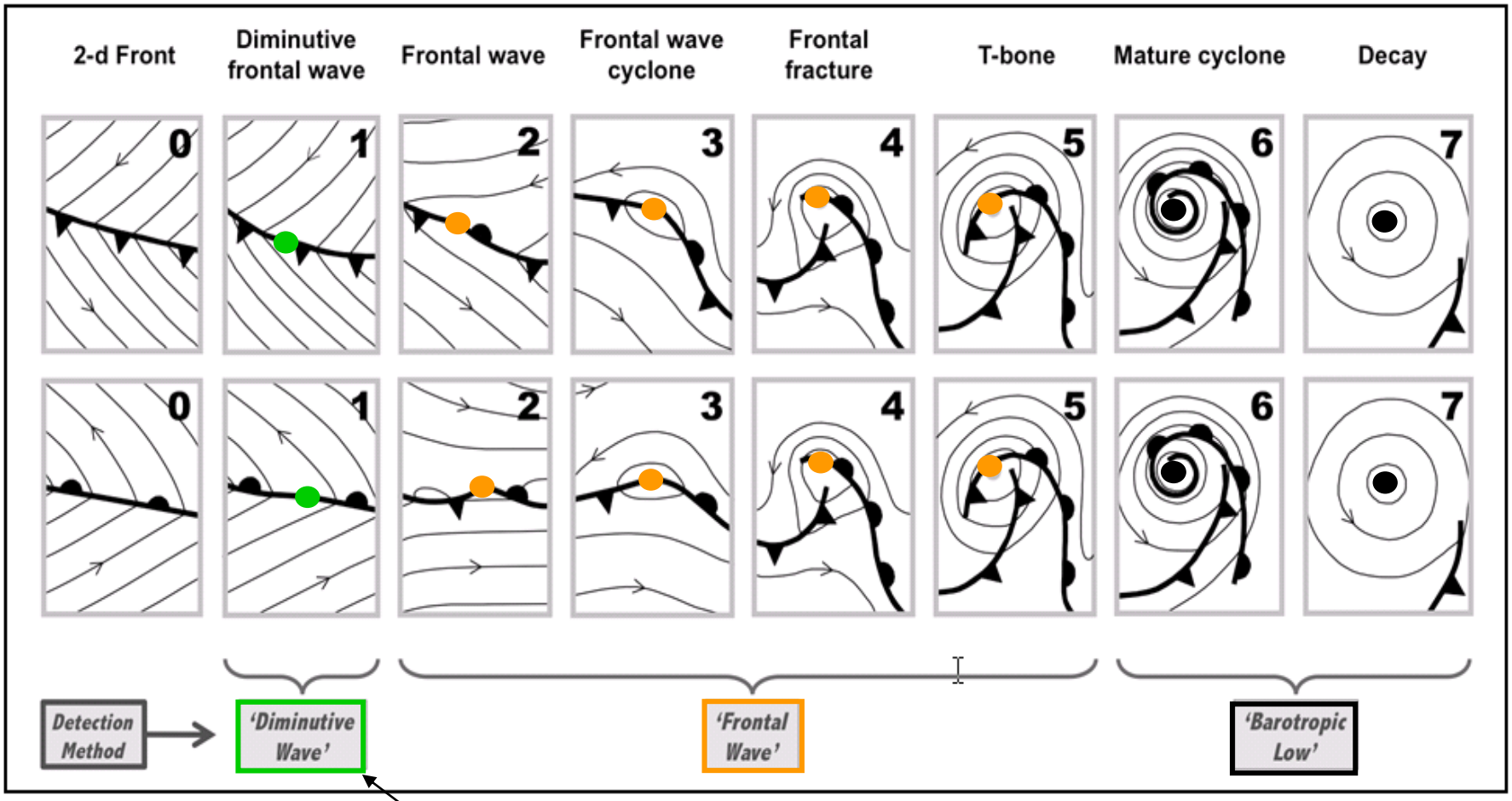




3.2 Methodology

- **Rationale**
- **Identification**
- **Tracking**

Rationale: Extratropical Feature Tracking is broadly based on a revised 'Cyclone Life-Cycle' conceptual model:



See Hewson, J. Atmos. Sci., Jan 2009

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Rationale - History

- **Diagnostic techniques were developed to automatically identify each of the displayed cyclone types (spots).**
- **Though the conceptual model provided a useful conceptual framework, no related constraints were imposed on the *behaviour* of any particular cyclonic feature – i.e. they don't have to follow this evolution, and indeed most don't.**
- **Aim was for output to closely resemble synoptic charts, both for features themselves, and their tracks. Special emphasis was placed on severe weather aspects, e.g. successful tracking of cyclonic windstorms.**
- **Another aim was to trial products in operational environments and demonstrate them at various international venues (was trialled at the Met Office, and used in T-PARC – a N Pacific field campaign).**
- **The above lead to considerable forecaster input. Much post-event adaptation and tuning of algorithms resulted.**
- **System now used operationally at the Met Office (on MOGREPS)**

Identification of cyclonic features

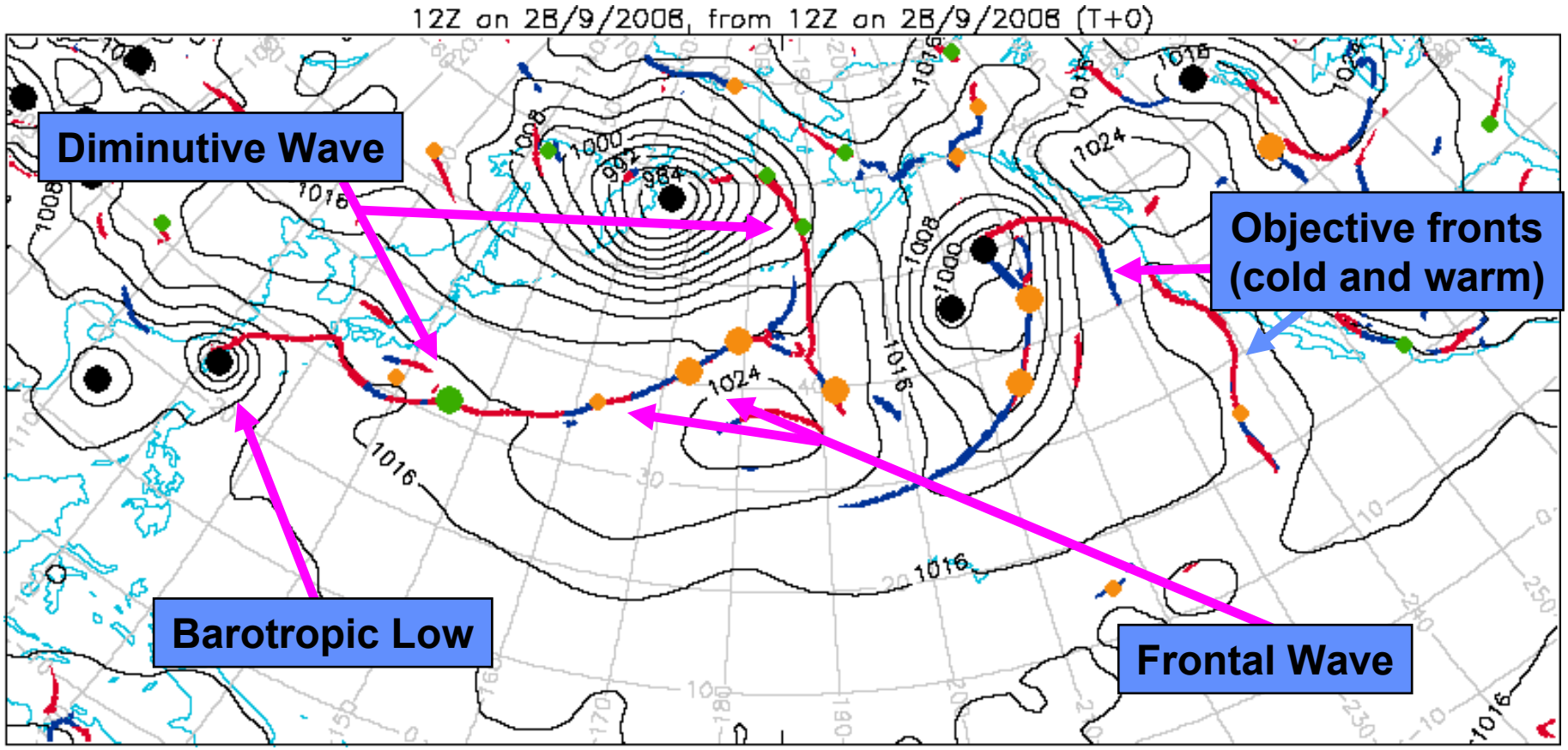
- **This is much more challenging in the extra-tropics than in the tropics!**
- **Firstly, Objective Front positions are identified - along the warm air boundaries of large theta-w gradient regions, 1km above the earth's surface**

See Hewson, Meteorol Appl., 1998

- **Frontal waves and Diminutive waves are then identified on the Objective Fronts, being pinpointed using a low level vorticity partition**
- **Barotropic lows are detected separately, as low pressure centres (where there is no frontal wave)**

- **There is a minimum permissible feature separation of ~300km**

Snapshot – N Pacific domain – showing features



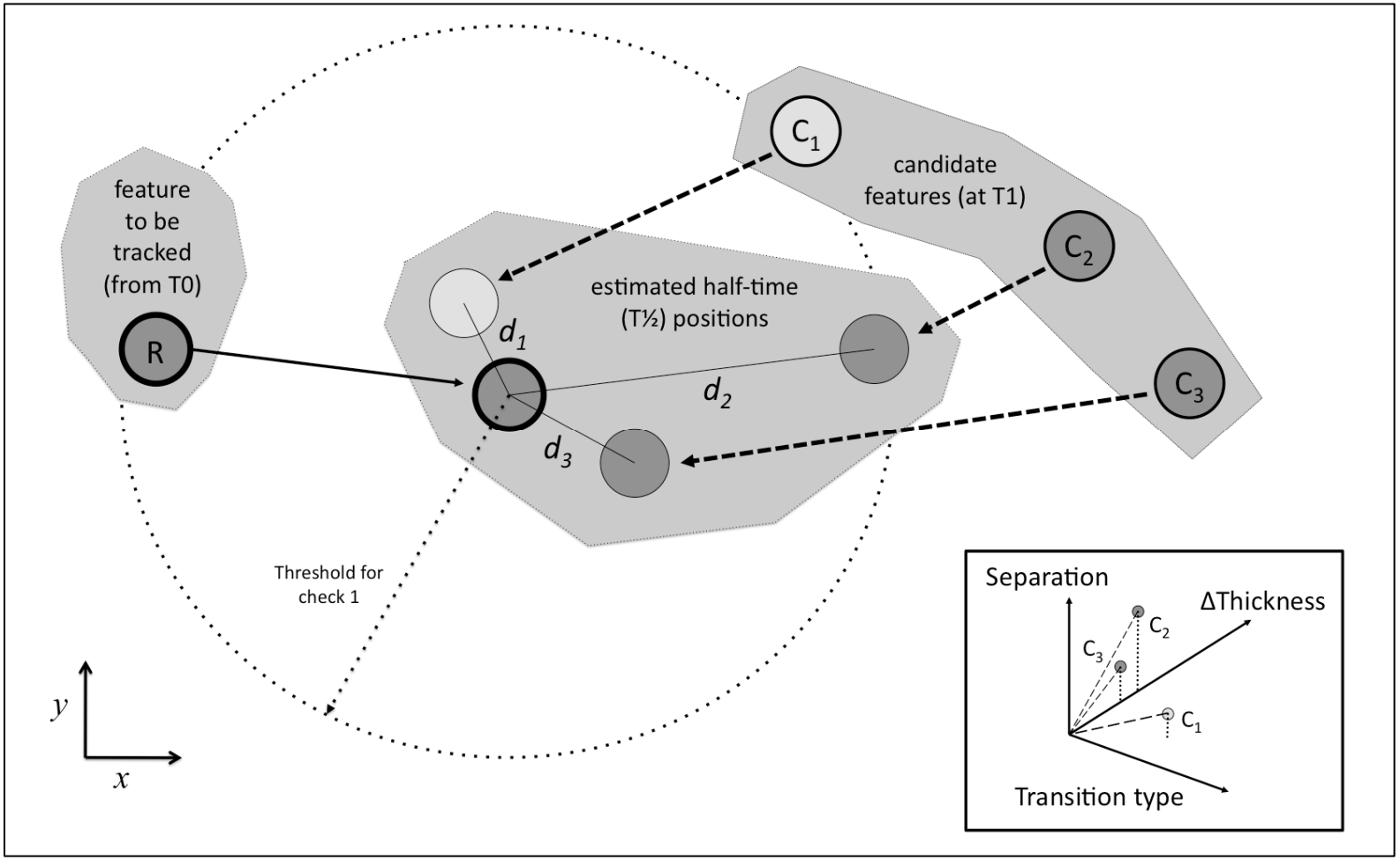
Tracking of cyclonic features

- **A sophisticated tracking scheme was required, due to:**
  - **The high resolution of input data (~50km)**
  - **The high feature density**
  - **The operational need to minimise computation time; hence 12h frame interval used**

- **'Feature association' is performed between successive time frames to generate sets of tracks in all EPS members – an iterative process dependant on three factors:**
  - **Feature positions (estimated using previous movement and 500mb wind)**
  - **Feature type transition probability**
  - **1000-500mb thickness change at the feature point**

Hewson and Titley, submitted to Meteorol. Appl., May 2009

Tracking – the association process



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Tracking accuracy..

- **Tracking is an inexact science. Considerable effort has gone into developing the tracking, elevating feature association accuracy to ~98%. This is ~1 EPS member out of 50.**
- **Therefore on plume diagrams, it is best to not focus on the one or two outliers (which will stand out), but instead on the majority signal**
- **In strike probability plots the visual impact of occasional glitches is very minor (compared to the feature plumes)**

3.3 New Products

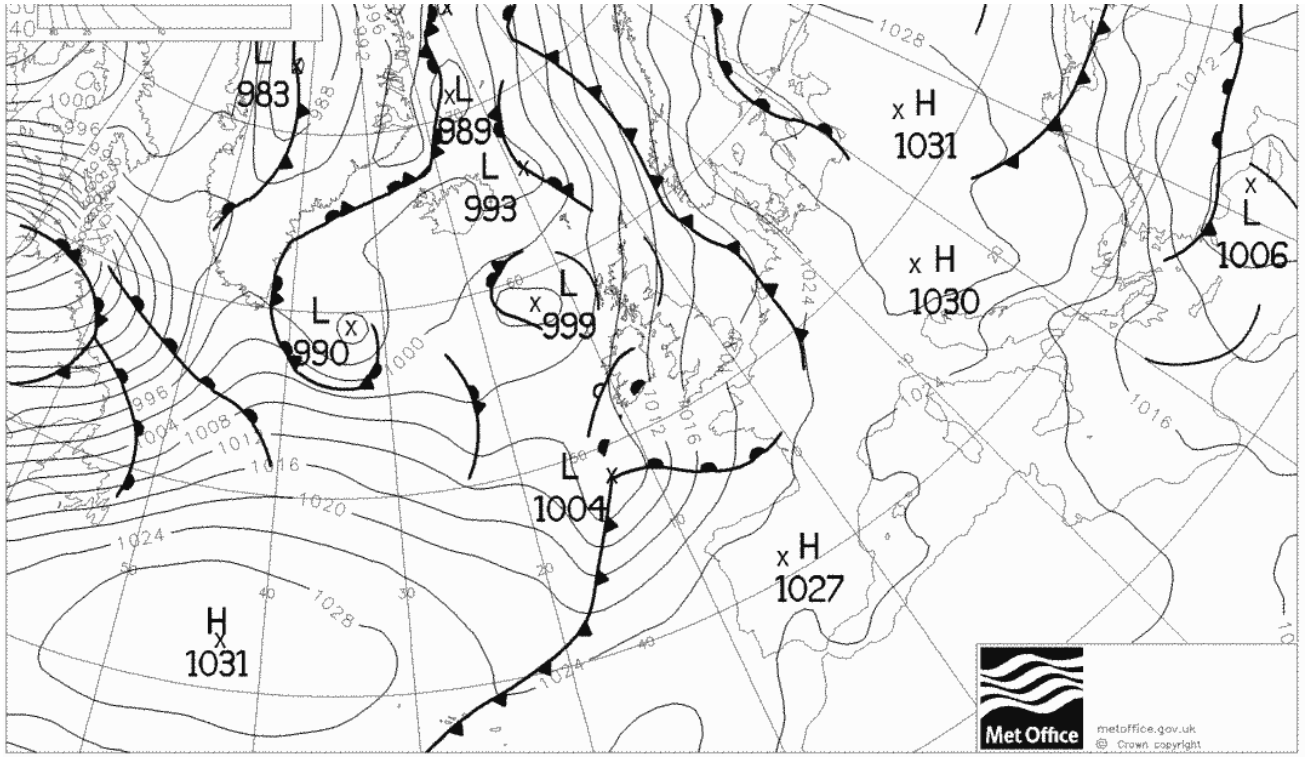
- **Synoptic chart-type products (single member animations, several postage stamp formats)**
- **Spaghetti fronts animation**
- **A 'Cyclonic feature equivalent' to the spaghetti fronts**
- **Feature plume diagrams (clickable interface)**
- **Multi-feature strike probabilities (for 3 intensity thresholds)**

  - **Live web demonstration to illustrate**

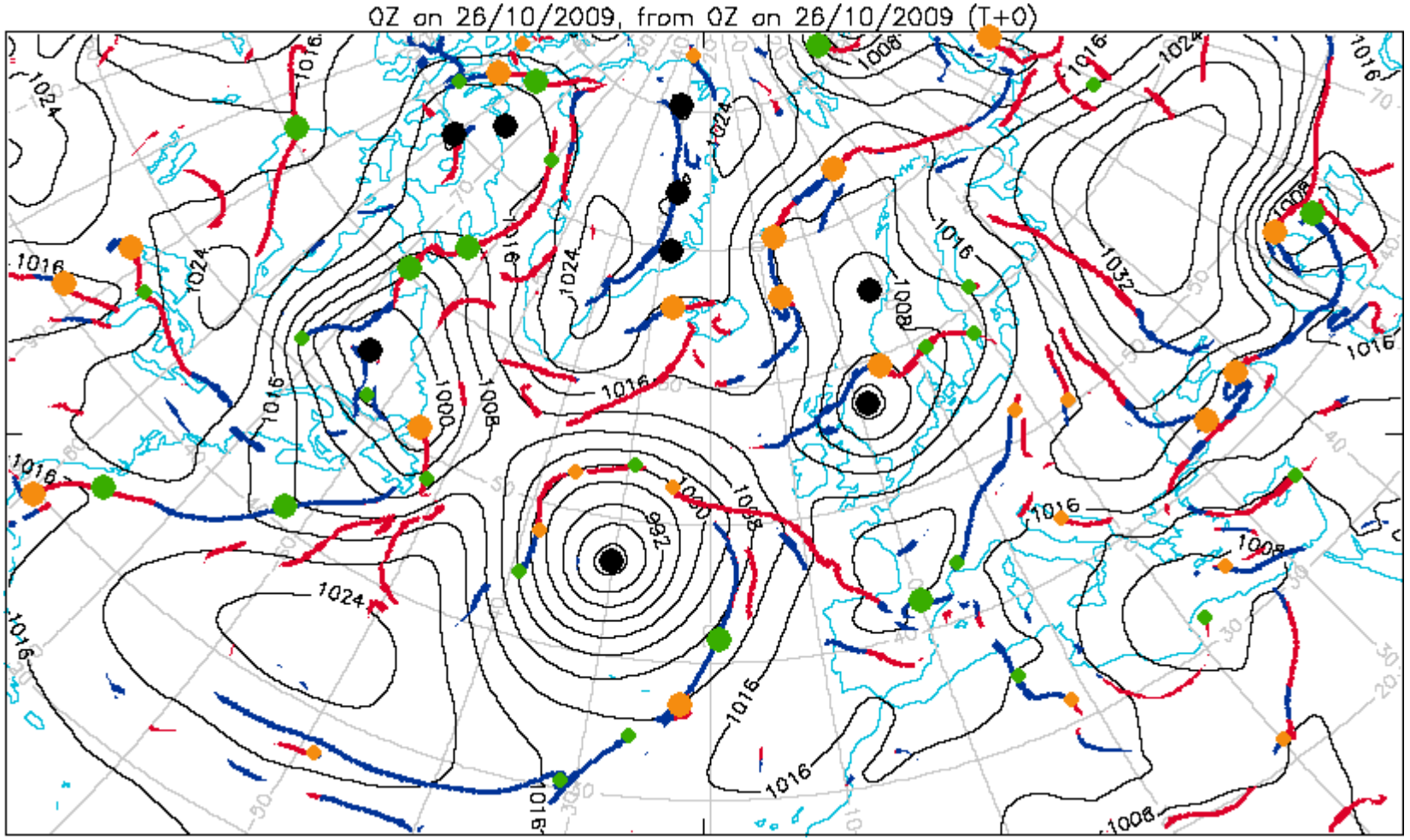
- **Generic name: 'Cyclone Database' products**

4. Recent Example

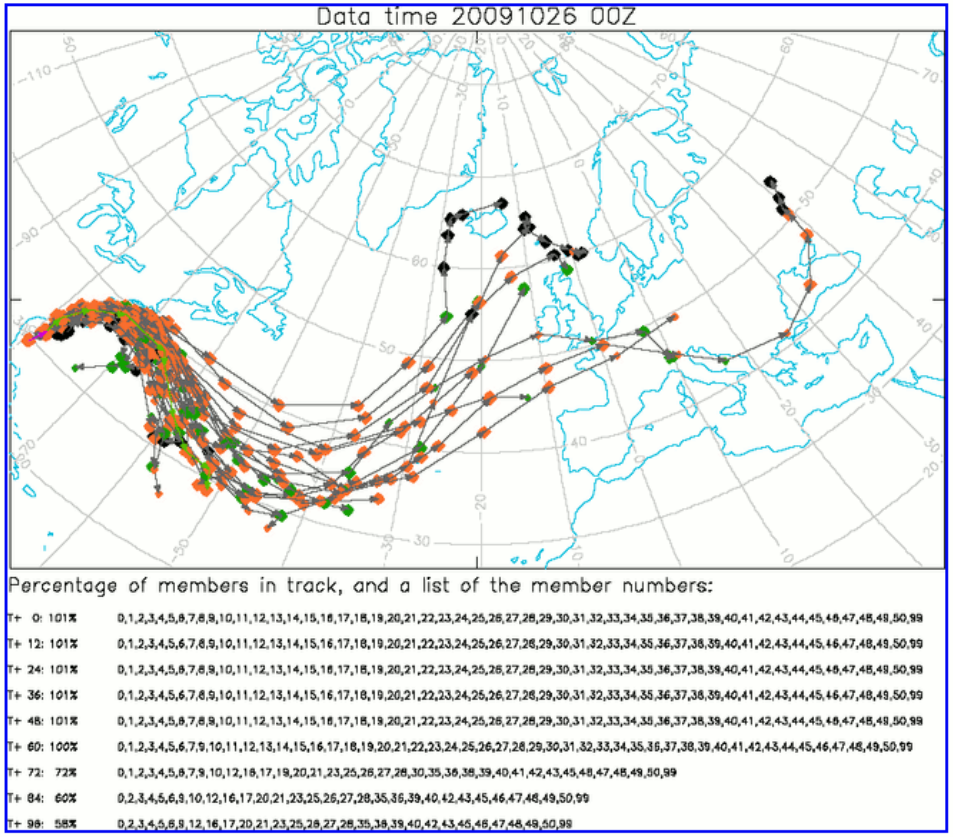
- **Flooding in E Scotland, on Sunday 1st November**
- **Considerable forecast uncertainty – in winds too**
- **Related to developing frontal wave**

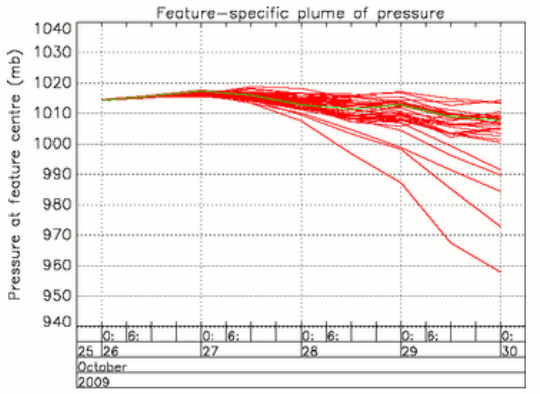


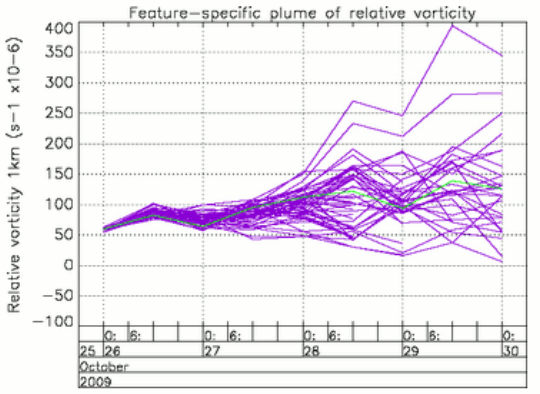
Automated Synoptic Chart Sequence - Analyses

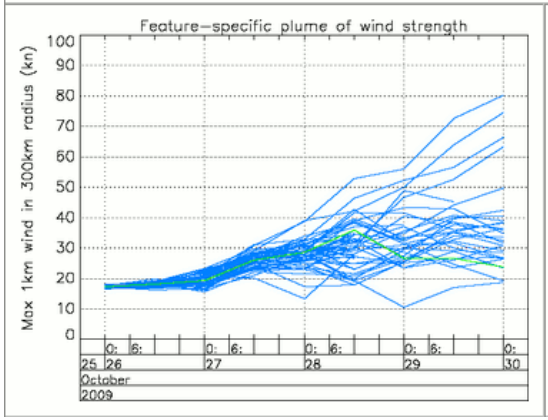


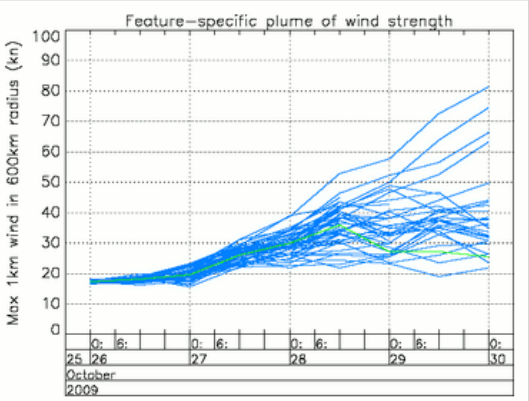
ECMWF

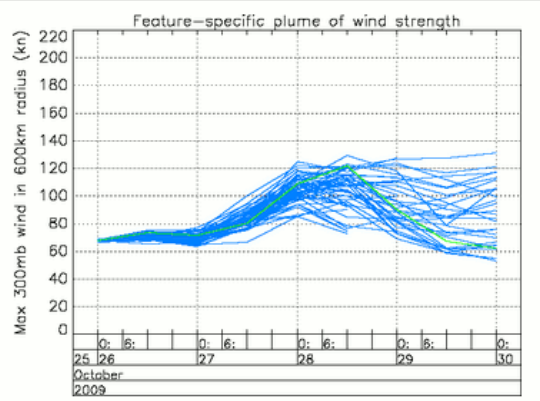

Data time 20091026 00Z
Percentage of members in track, and a list of the member numbers:
T+ 0: 101% 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,99
T+ 12: 101% 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,99
T+ 24: 101% 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,99
T+ 36: 101% 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,99
T+ 48: 101% 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,99
T+ 60: 100% 0,1,2,3,4,5,6,7,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,99
T+ 72: 72% 0,1,2,3,4,5,6,7,9,10,12,16,17,19,20,21,23,25,26,27,28,30,35,36,38,39,40,41,42,43,45,46,47,48,49,50,99
T+ 84: 60% 0,2,3,4,5,6,9,10,12,16,17,20,21,23,25,26,27,28,35,36,39,40,42,43,45,46,47,48,49,50,99
T+ 96: 58% 0,2,3,4,5,6,9,12,16,17,20,21,23,25,26,27,28,35,38,39,40,42,43,45,46,47,48,49,50,99


Feature-specific plume of pressure
Pressure at feature centre (mb)
1040
1030
1020
1010
1000
990
980
970
960
950
940
0: 6:
25 26
27
28
29
30
October
2009

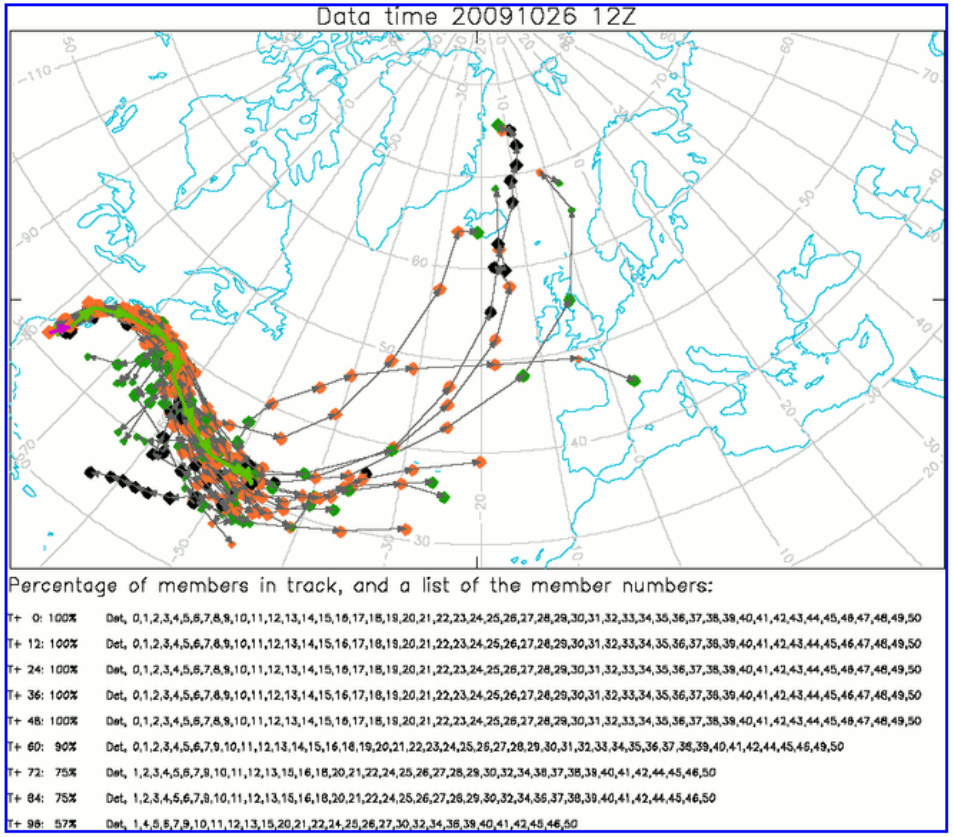

Feature-specific plume of relative vorticity
Relative vorticity 1km (s-1 x10-6)
400
350
300
250
200
150
100
50
0
-50
-100
0: 6:
25 26
27
28
29
30
October
2009

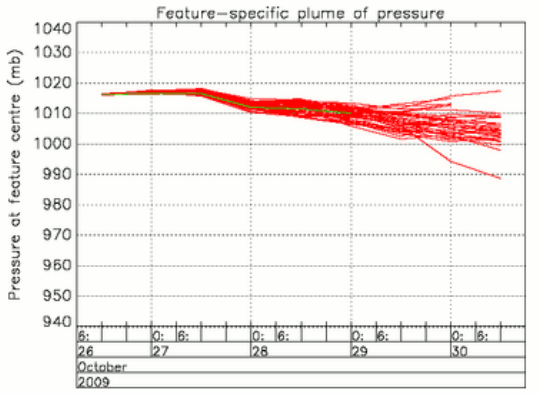

Feature-specific plume of wind strength
Max 1km wind in 300km radius (kn)
100
90
80
70
60
50
40
30
20
10
0
0: 6:
25 26
27
28
29
30
October
2009

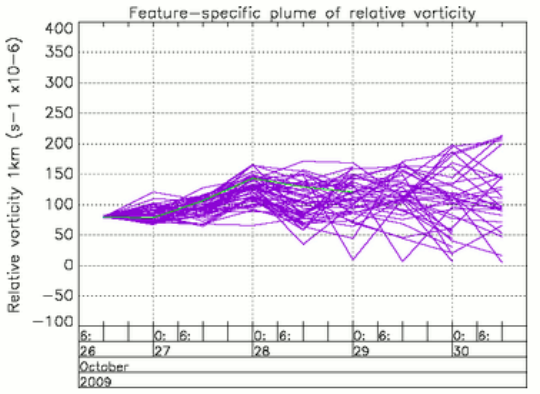

Feature-specific plume of wind strength
Max 1km wind in 600km radius (kn)
100
90
80
70
60
50
40
30
20
10
0
0: 6:
25 26
27
28
29
30
October
2009

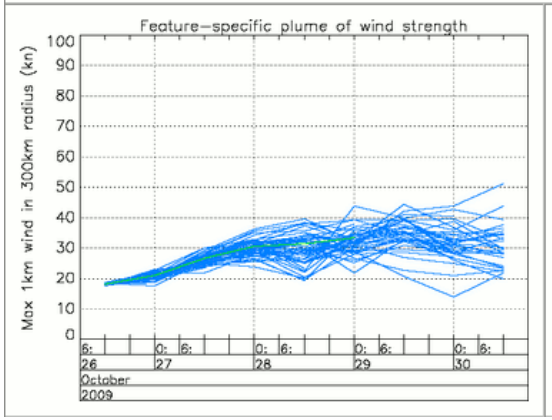

Feature-specific plume of wind strength
Max 300mb wind in 600km radius (kn)
220
200
180
160
140
120
100
80
60
40
20
0
0: 6:
25 26
27
28
29
30
October
2009

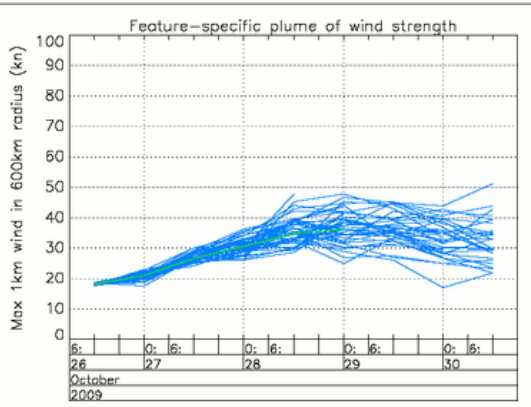
ECMWF

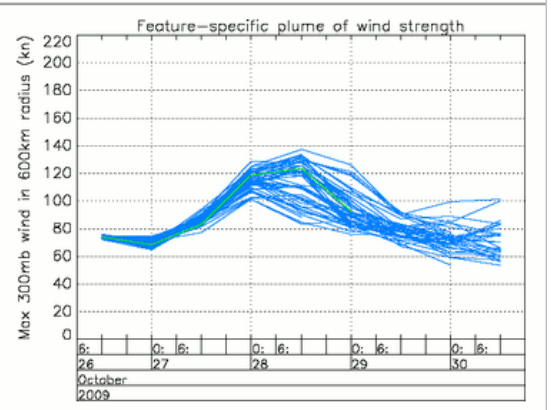

Data time 20091026 12Z
Percentage of members in track, and a list of the member numbers:
T+ 0: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 12: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 24: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 36: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 48: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 60: 90% Det, 0,1,2,3,4,5,6,7,9,10,11,12,13,14,15,16,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,44,45,46,49,50
T+ 72: 75% Det, 1,2,3,4,5,6,7,9,10,11,12,13,15,16,18,20,21,22,24,25,26,27,28,29,30,32,34,36,37,38,39,40,41,42,44,45,46,50
T+ 84: 75% Det, 1,2,3,4,5,6,7,9,10,11,12,13,15,16,18,20,21,22,24,25,26,27,28,29,30,32,34,36,37,38,39,40,41,42,44,45,46,50
T+ 96: 57% Det, 1,4,5,6,7,9,10,11,12,13,15,20,21,22,24,25,26,27,30,32,34,36,39,40,41,42,45,46,50


Feature-specific plume of pressure
Pressure at feature centre (mb)
1040
1030
1020
1010
1000
990
980
970
960
950
940
6: 0: 6: 0: 6: 0: 6: 0: 6:
26 27 28 29 30
October
2009

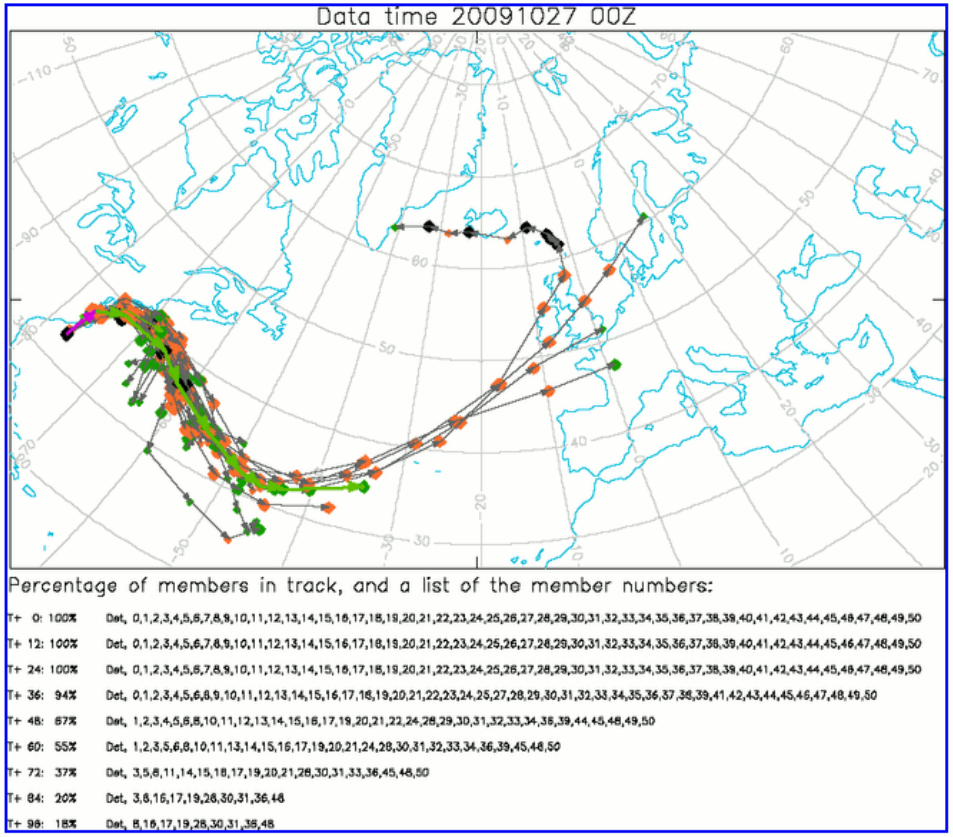

Feature-specific plume of relative vorticity
Relative vorticity 1km (s-1 x10-6)
400
350
300
250
200
150
100
50
0
-50
-100
6: 0: 6: 0: 6: 0: 6: 0: 6:
26 27 28 29 30
October
2009

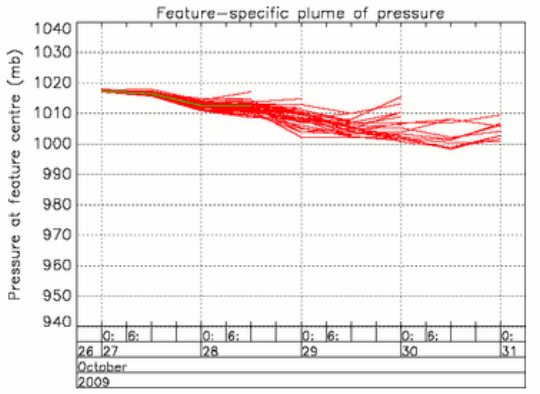

Feature-specific plume of wind strength
Max 1km wind in 300km radius (kn)
100
90
80
70
60
50
40
30
20
10
0
6: 0: 6: 0: 6: 0: 6: 0: 6:
26 27 28 29 30
October
2009

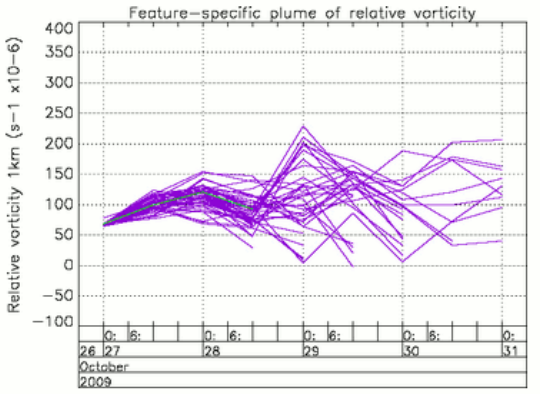

Feature-specific plume of wind strength
Max 1km wind in 600km radius (kn)
100
90
80
70
60
50
40
30
20
10
0
6: 0: 6: 0: 6: 0: 6: 0: 6:
26 27 28 29 30
October
2009

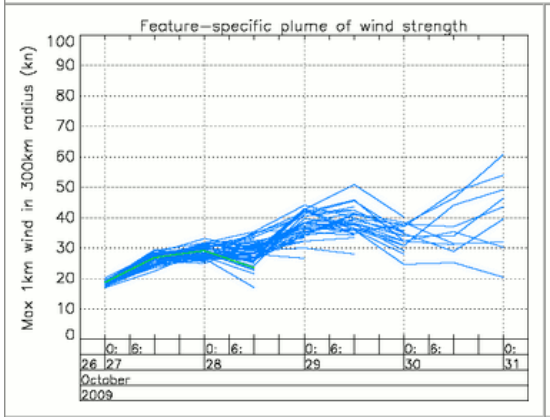

Feature-specific plume of wind strength
Max 300mb wind in 600km radius (kn)
220
200
180
160
140
120
100
80
60
40
20
0
6: 0: 6: 0: 6: 0: 6: 0: 6:
26 27 28 29 30
October
2009

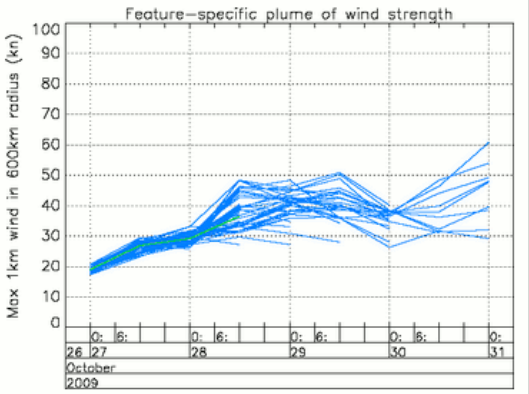
ECMWF

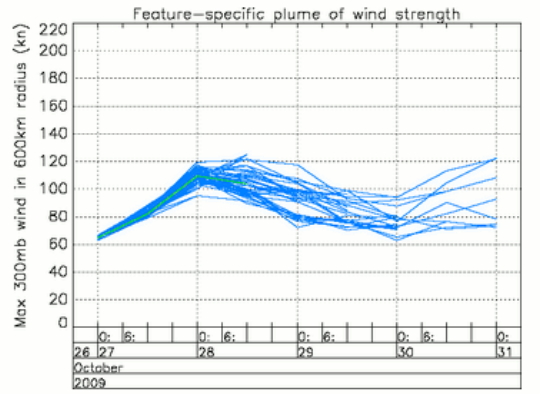

Data time 20091027 00Z
Percentage of members in track, and a list of the member numbers:
T+ 0: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 12: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 24: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 36: 94% Det, 0,1,2,3,4,5,6,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,27,28,29,30,31,32,33,34,35,36,37,38,39,41,42,43,44,45,46,47,48,49,50
T+ 48: 67% Det, 1,2,3,4,5,6,8,10,11,12,13,14,15,16,17,19,20,21,22,24,28,29,30,31,32,33,34,36,39,44,45,46,49,50
T+ 60: 55% Det, 1,2,3,5,6,8,10,11,13,14,15,16,17,19,20,21,24,28,30,31,32,33,34,36,39,45,46,50
T+ 72: 37% Det, 3,5,8,11,14,15,16,17,19,20,21,28,30,31,33,36,45,46,50
T+ 84: 20% Det, 3,8,16,17,19,28,30,31,36,46
T+ 96: 18% Det, 8,16,17,19,28,30,31,36,46


Feature-specific plume of pressure
Pressure at feature centre (mb)
1040
1030
1020
1010
1000
990
980
970
960
950
940
0: 6: 0: 6: 0: 6: 0: 6: 0:
26 27 28 29 30 31
October
2009

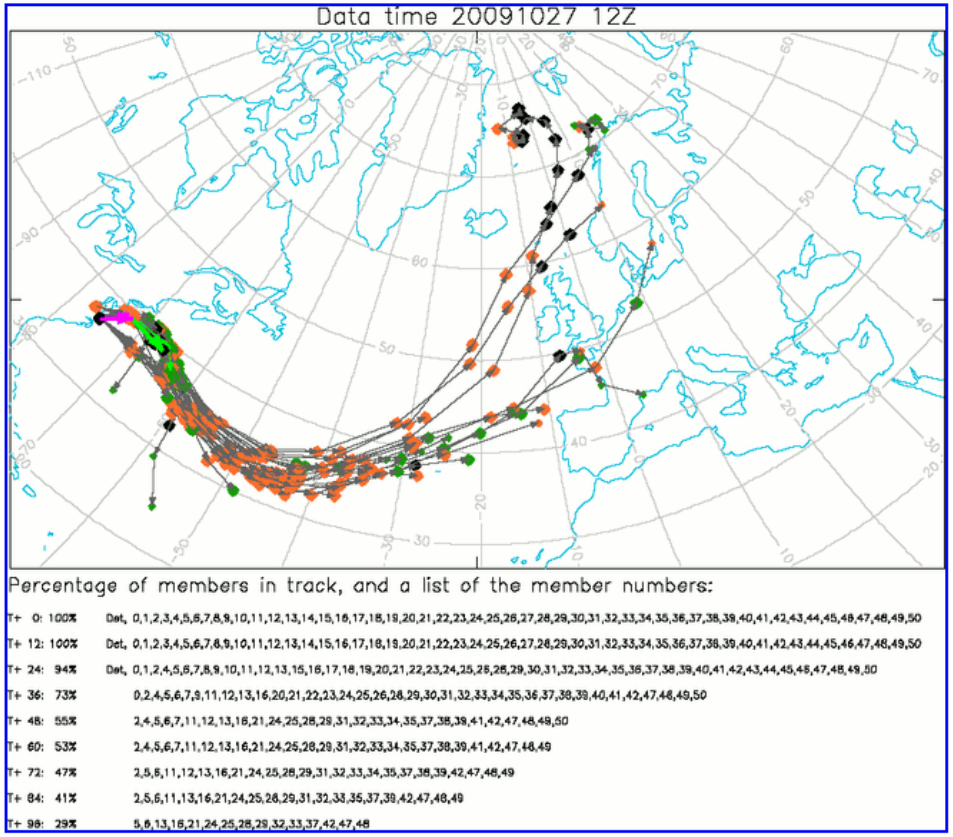

Feature-specific plume of relative vorticity
Relative vorticity 1km (s-1 x10-6)
400
350
300
250
200
150
100
50
0
-50
-100
0: 6: 0: 6: 0: 6: 0: 6: 0:
26 27 28 29 30 31
October
2009

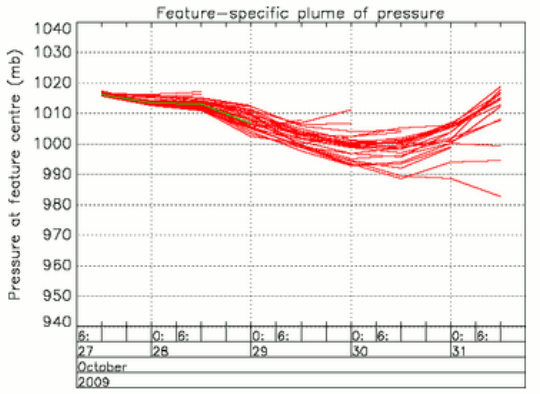

Feature-specific plume of wind strength
Max 1km wind in 300km radius (kn)
100
90
80
70
60
50
40
30
20
10
0
0: 6: 0: 6: 0: 6: 0: 6: 0:
26 27 28 29 30 31
October
2009

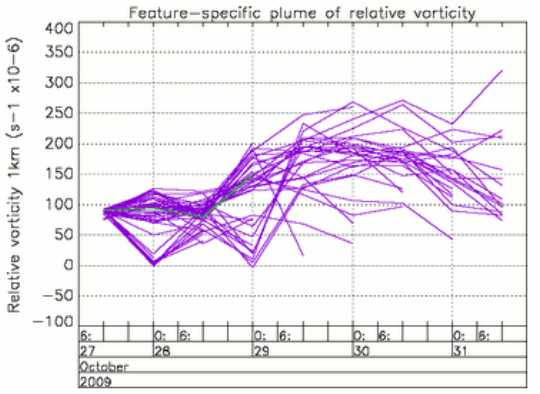

Feature-specific plume of wind strength
Max 1km wind in 600km radius (kn)
100
90
80
70
60
50
40
30
20
10
0
0: 6: 0: 6: 0: 6: 0: 6: 0:
26 27 28 29 30 31
October
2009

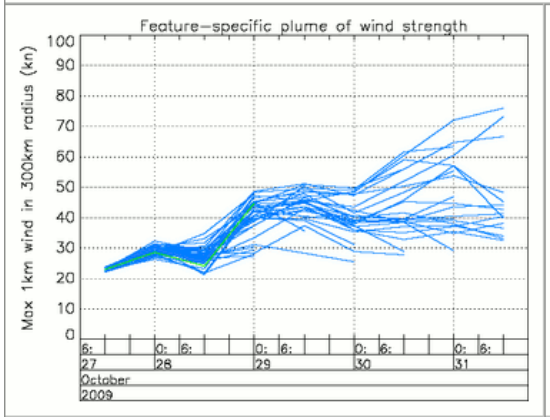

Feature-specific plume of wind strength
Max 300mb wind in 600km radius (kn)
220
200
180
160
140
120
100
80
60
40
20
0
0: 6: 0: 6: 0: 6: 0: 6: 0:
26 27 28 29 30 31
October
2009

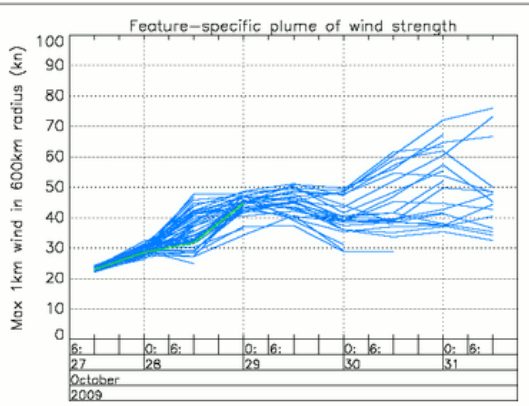
ECMWF

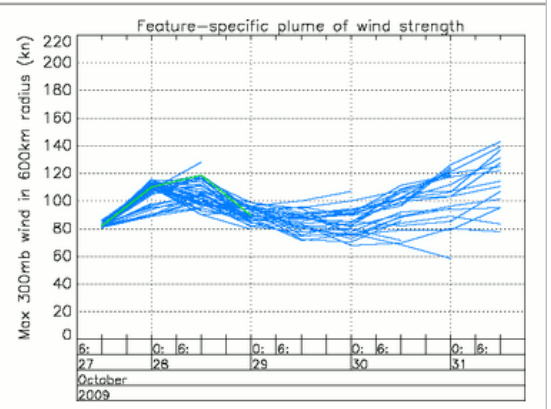

Data time 20091027 12Z
Percentage of members in track, and a list of the member numbers:
T+ 0: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 12: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 24: 94% Det, 0,1,2,4,5,6,7,8,9,10,11,12,13,15,16,17,18,19,20,21,22,23,24,25,25,26,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 36: 73% 0,2,4,5,6,7,9,11,12,13,16,20,21,22,23,24,25,26,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,47,48,49,50
T+ 48: 55% 2,4,5,6,7,11,12,13,16,21,24,25,28,29,31,32,33,34,35,37,38,39,41,42,47,48,49,50
T+ 60: 53% 2,4,5,6,7,11,12,13,16,21,24,25,28,29,31,32,33,34,35,37,38,39,41,42,47,48,49
T+ 72: 47% 2,5,6,11,12,13,16,21,24,25,28,29,31,32,33,34,35,37,38,39,42,47,48,49
T+ 84: 41% 2,5,6,11,13,16,21,24,25,28,29,31,32,33,35,37,39,42,47,48,49
T+ 96: 29% 5,6,13,16,21,24,25,28,29,32,33,37,42,47,48


Feature–specific plume of pressure
Pressure at feature centre (mb)
1040
1030
1020
1010
1000
990
980
970
960
950
940
6: 0: 6: 0: 6: 0: 6: 0: 6:
27 28 29 30 31
October
2009

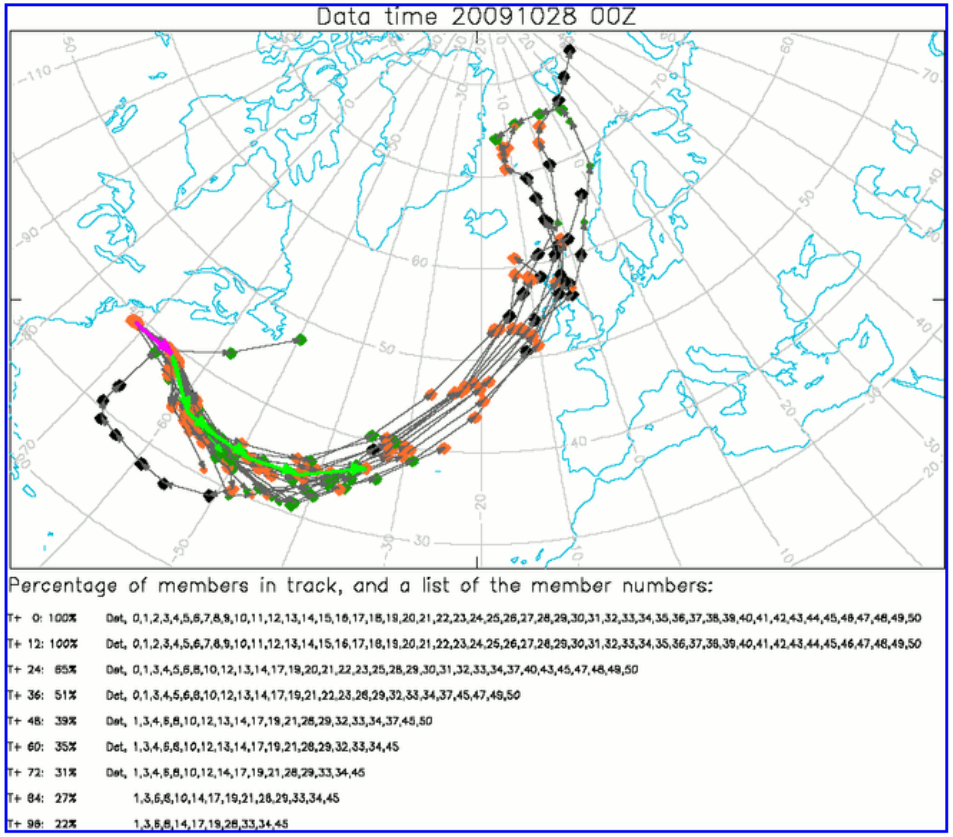

Feature–specific plume of relative vorticity
Relative vorticity 1km (s−1 x10−6)
400
350
300
250
200
150
100
50
0
−50
−100
6: 0: 6: 0: 6: 0: 6: 0: 6:
27 28 29 30 31
October
2009

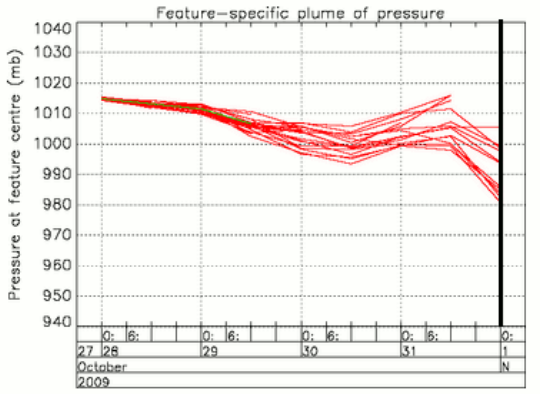

Feature–specific plume of wind strength
Max 1km wind in 300km radius (kn)
100
90
80
70
60
50
40
30
20
10
0
6: 0: 6: 0: 6: 0: 6: 0: 6:
27 28 29 30 31
October
2009

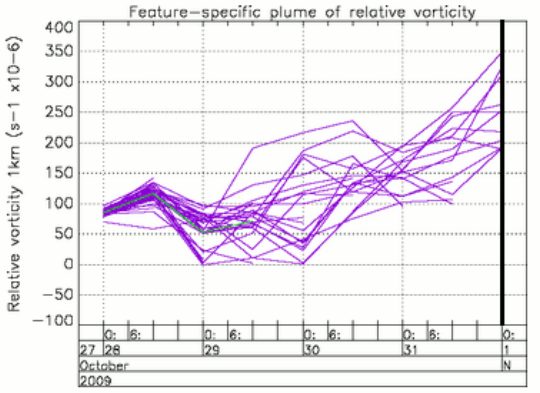

Feature–specific plume of wind strength
Max 1km wind in 600km radius (kn)
100
90
80
70
60
50
40
30
20
10
0
6: 0: 6: 0: 6: 0: 6: 0: 6:
27 28 29 30 31
October
2009

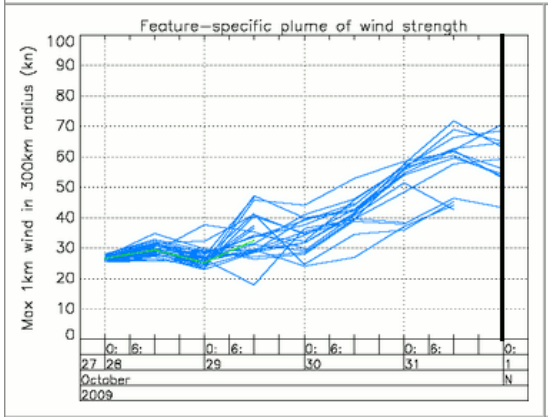

Feature–specific plume of wind strength
Max 300mb wind in 600km radius (kn)
220
200
180
160
140
120
100
80
60
40
20
0
6: 0: 6: 0: 6: 0: 6: 0: 6:
27 28 29 30 31
October
2009

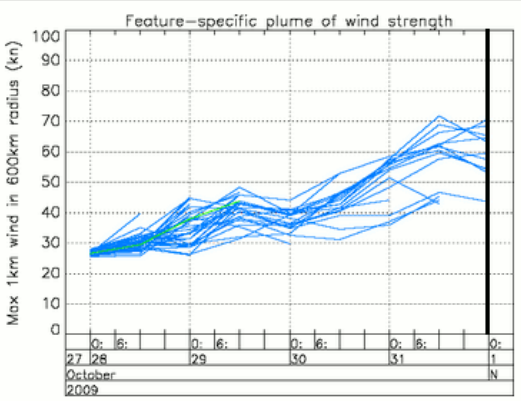
ECMWF

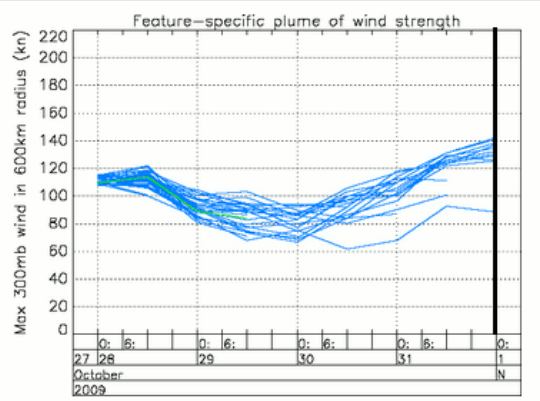

Data time 20091028 00Z
Percentage of members in track, and a list of the member numbers:
T+ 0: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 12: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 24: 65% Det, 0,1,3,4,5,6,8,10,12,13,14,17,19,20,21,22,23,25,28,29,30,31,32,33,34,37,40,43,45,47,48,49,50
T+ 36: 51% Det, 0,1,3,4,5,6,8,10,12,13,14,17,19,21,22,23,26,29,32,33,34,37,45,47,49,50
T+ 48: 39% Det, 1,3,4,6,8,10,12,13,14,17,19,21,28,29,32,33,34,37,45,50
T+ 60: 35% Det, 1,3,4,6,8,10,12,13,14,17,19,21,28,29,32,33,34,45
T+ 72: 31% Det, 1,3,4,6,8,10,12,14,17,19,21,28,29,33,34,45
T+ 84: 27% 1,3,6,8,10,14,17,19,21,28,29,33,34,45
T+ 96: 22% 1,3,6,8,14,17,19,28,33,34,45

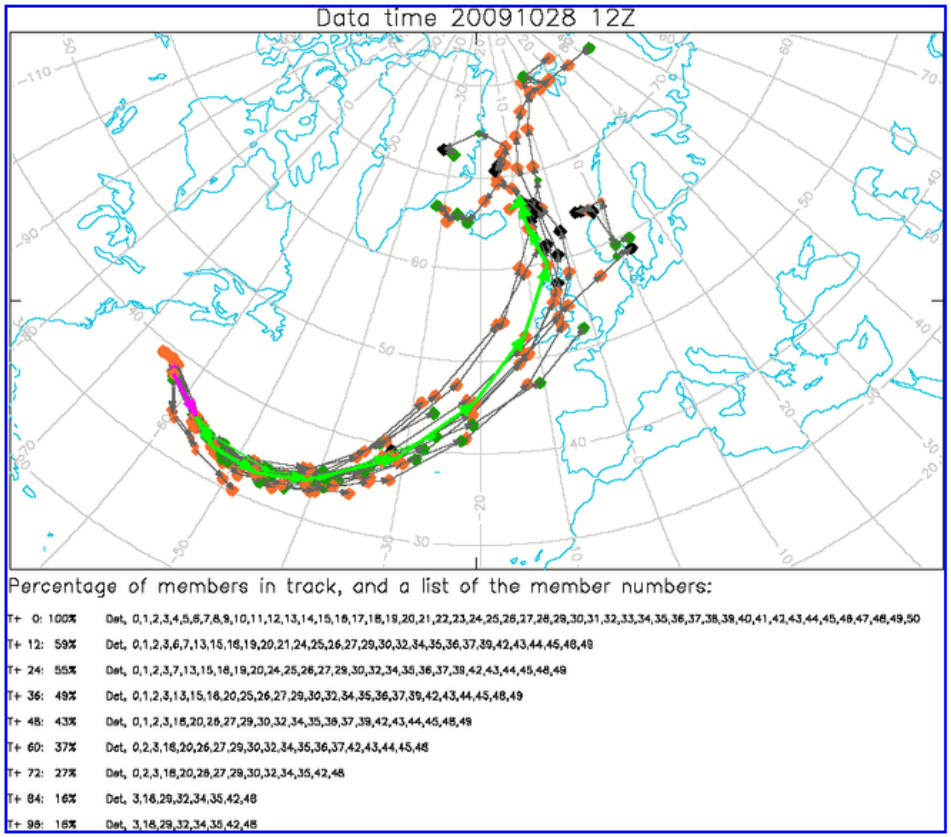

Feature-specific plume of pressure
Pressure at feature centre (mb)
1040
1030
1020
1010
1000
990
980
970
960
950
940
0: 6: 0: 6: 0: 6: 0: 6: 0:
27 28 29 30 31 1
October
2009
N

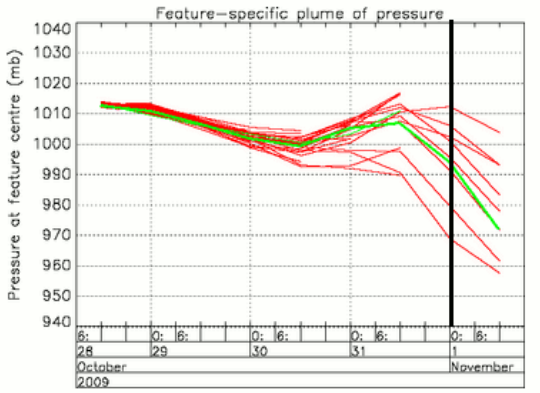

Feature-specific plume of relative vorticity
Relative vorticity 1km (s-1 x10-6)
400
350
300
250
200
150
100
50
0
-50
-100
0: 6: 0: 6: 0: 6: 0: 6: 0:
27 28 29 30 31 1
October
2009
N

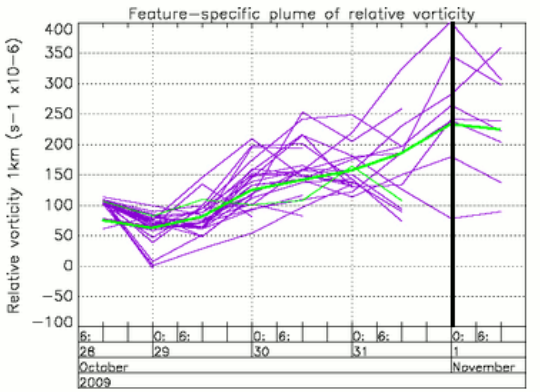

Feature-specific plume of wind strength
Max 1km wind in 300km radius (kn)
100
90
80
70
60
50
40
30
20
10
0
0: 6: 0: 6: 0: 6: 0: 6: 0:
27 28 29 30 31 1
October
2009
N

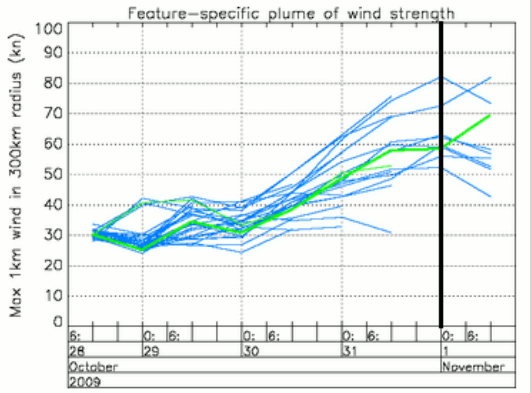

Feature-specific plume of wind strength
Max 1km wind in 600km radius (kn)
100
90
80
70
60
50
40
30
20
10
0
0: 6: 0: 6: 0: 6: 0: 6: 0:
27 28 29 30 31 1
October
2009
N

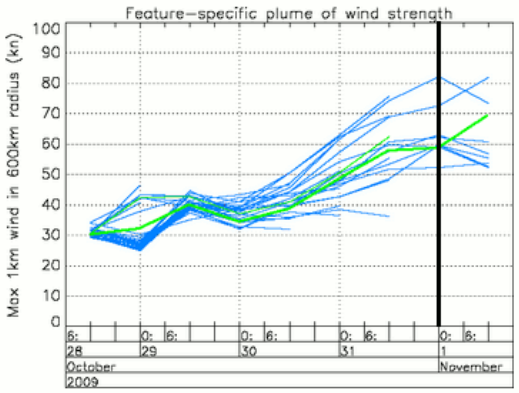

Feature-specific plume of wind strength
Max 300mb wind in 600km radius (kn)
220
200
180
160
140
120
100
80
60
40
20
0
0: 6: 0: 6: 0: 6: 0: 6: 0:
27 28 29 30 31 1
October
2009
N

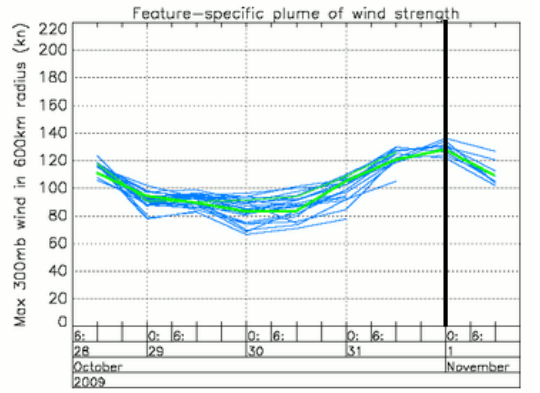

Data time 20091028 12Z
Percentage of members in track, and a list of the member numbers:
T+ 0: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 12: 59% Det, 0,1,2,3,6,7,13,15,16,19,20,21,24,25,26,27,29,30,32,34,35,36,37,39,42,43,44,45,46,48
T+ 24: 55% Det, 0,1,2,3,7,13,15,16,19,20,24,25,26,27,29,30,32,34,35,36,37,39,42,43,44,45,46,48
T+ 36: 49% Det, 0,1,2,3,13,15,16,20,25,26,27,29,30,32,34,35,36,37,39,42,43,44,45,46,49
T+ 48: 43% Det, 0,1,2,3,16,20,26,27,29,30,32,34,35,36,37,39,42,43,44,45,46,49
T+ 60: 37% Det, 0,2,3,16,20,26,27,29,30,32,34,35,36,37,42,43,44,45,46
T+ 72: 27% Det, 0,2,3,16,20,26,27,29,30,32,34,35,42,46
T+ 84: 16% Det, 3,16,29,32,34,35,42,46
T+ 96: 16% Det, 3,16,29,32,34,35,42,46

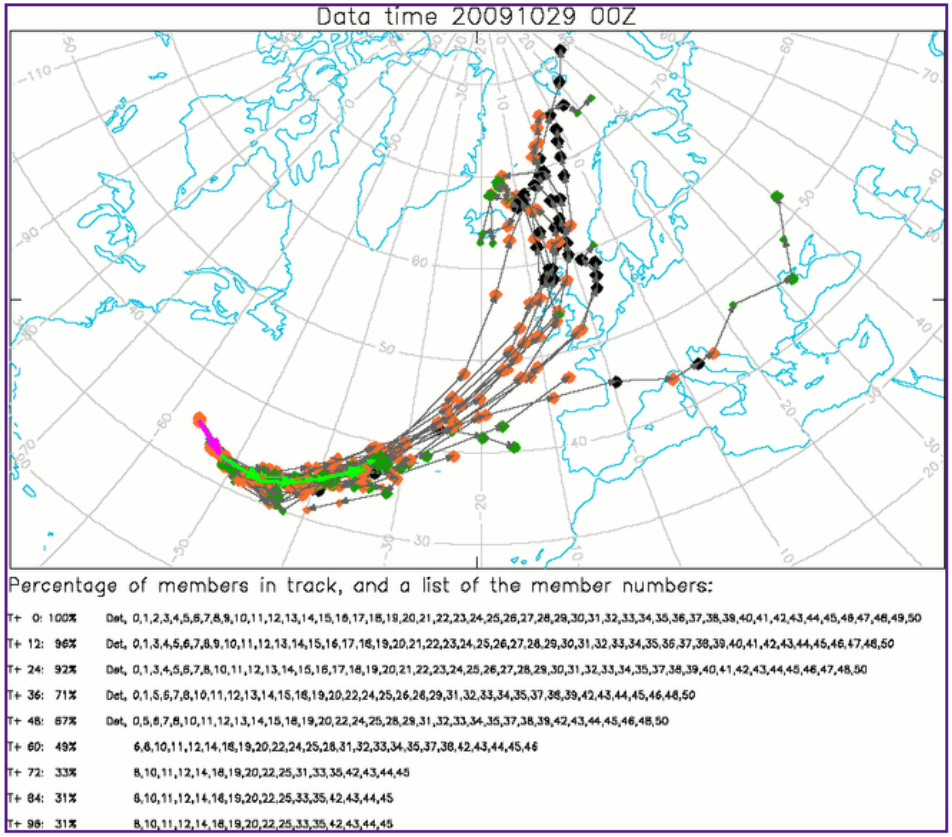

Feature-specific plume of pressure
Pressure at feature centre (mb)
October
November
2009

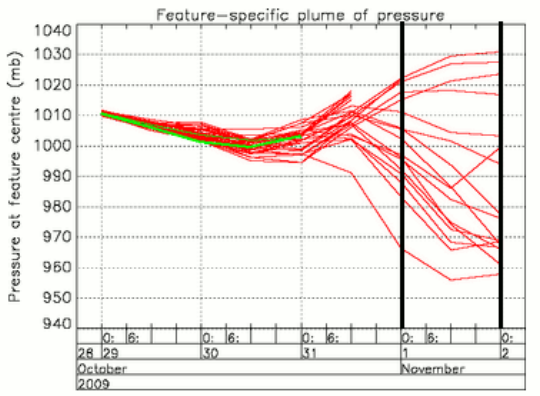

Feature-specific plume of relative vorticity
Relative vorticity 1km (s-1 x10-6)
October
November
2009

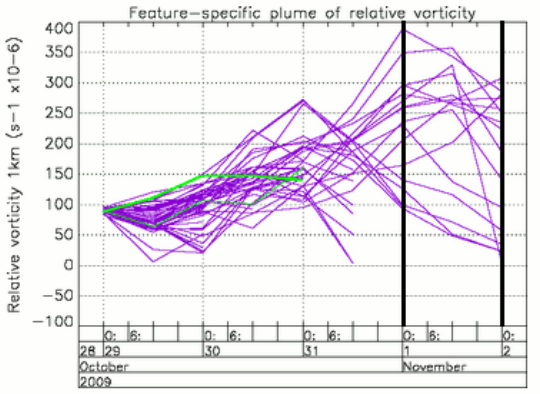

Feature-specific plume of wind strength
Max 1km wind in 300km radius (kn)
October
November
2009

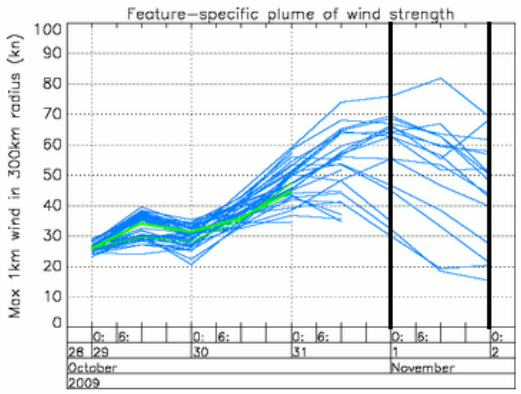

Feature-specific plume of wind strength
Max 1km wind in 600km radius (kn)
October
November
2009

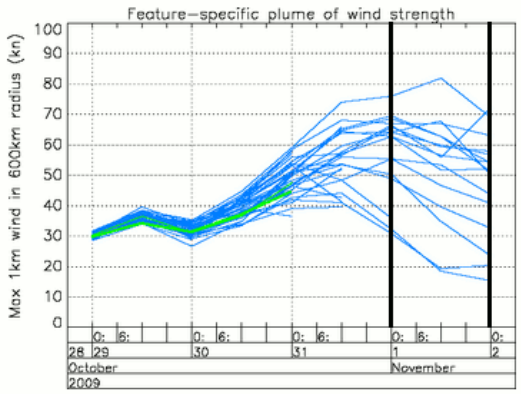

Feature-specific plume of wind strength
Max 300mb wind in 600km radius (kn)
October
November
2009

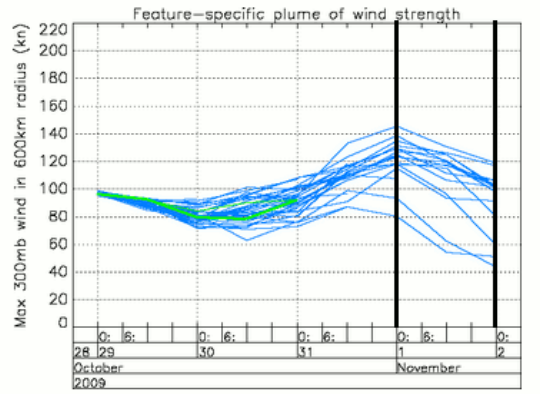

Data time 20091029 00Z
Percentage of members in track, and a list of the member numbers:
T+ 0: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 12: 96% Det, 0,1,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,50
T+ 24: 92% Det, 0,1,3,4,5,6,7,8,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,37,38,39,40,41,42,43,44,45,46,47,48,50
T+ 36: 71% Det, 0,1,5,6,7,8,10,11,12,13,14,15,16,19,20,22,24,25,26,28,29,31,32,33,34,35,37,38,39,42,43,44,45,46,48,50
T+ 48: 67% Det, 0,5,6,7,8,10,11,12,13,14,15,16,19,20,22,24,25,28,29,31,32,33,34,35,37,38,39,42,43,44,45,46,48,50
T+ 60: 49% 6,8,10,11,12,14,16,19,20,22,24,25,28,31,32,33,34,35,37,38,42,43,44,45,46
T+ 72: 33% 8,10,11,12,14,16,19,20,22,25,31,33,35,42,43,44,45
T+ 84: 31% 8,10,11,12,14,16,19,20,22,25,33,35,42,43,44,45
T+ 96: 31% 8,10,11,12,14,16,19,20,22,25,33,35,42,43,44,45

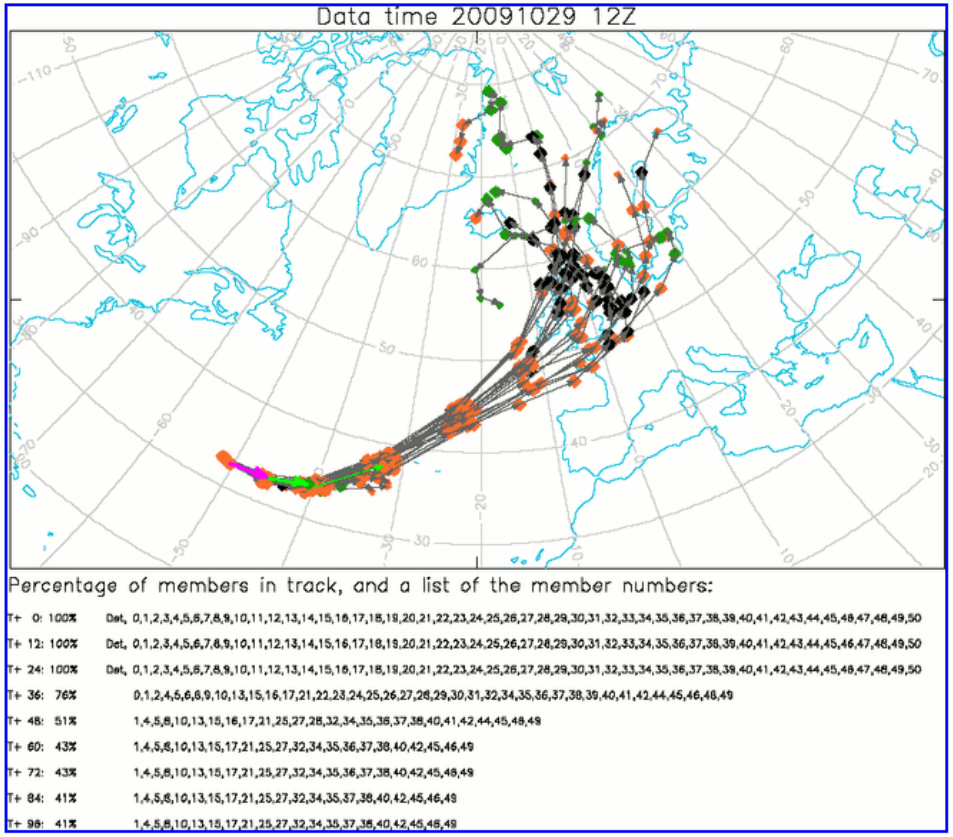

Feature-specific plume of pressure
Pressure at feature centre (mb)
October
November
2009

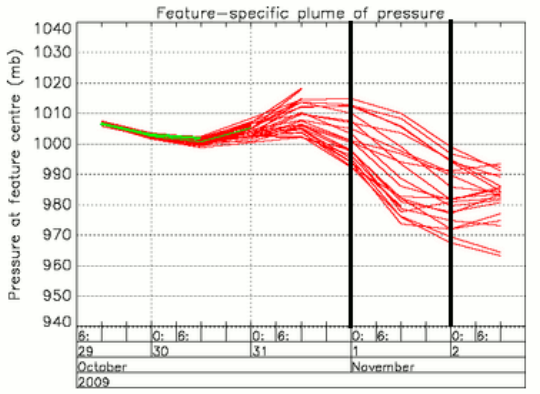

Feature-specific plume of relative vorticity
Relative vorticity 1km (s-1 x10-6)
October
November
2009

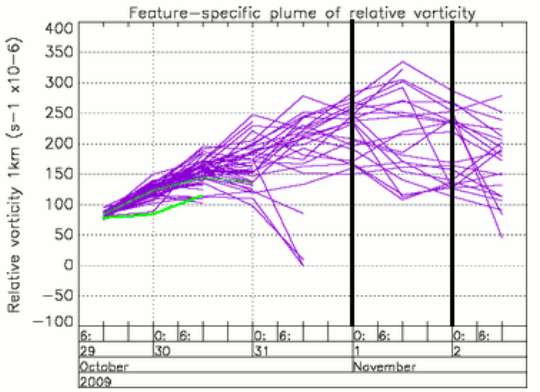

Feature-specific plume of wind strength
Max 1km wind in 300km radius (kn)
October
November
2009

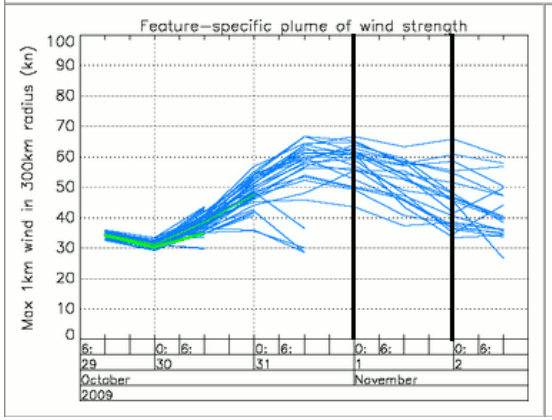

Feature-specific plume of wind strength
Max 1km wind in 600km radius (kn)
October
November
2009

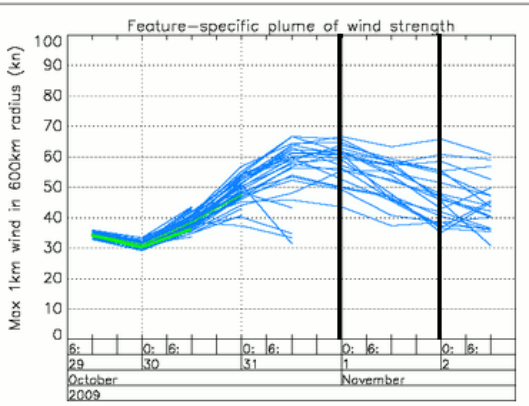

Feature-specific plume of wind strength
Max 300mb wind in 600km radius (kn)
October
November
2009

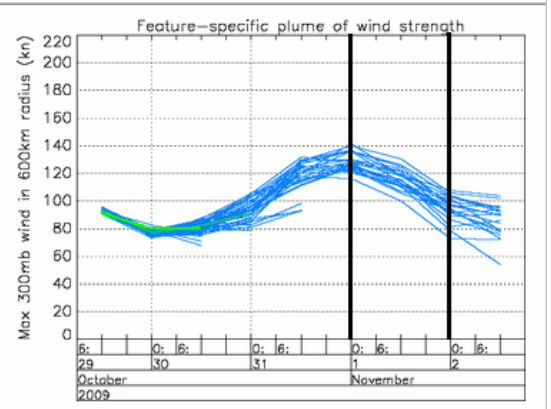

Data time 20091029 12Z
Percentage of members in track, and a list of the member numbers:
T+ 0: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 12: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 24: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 36: 76% 0,1,2,4,5,6,8,9,10,13,15,16,17,21,22,23,24,25,26,27,28,29,30,31,32,34,35,36,37,38,39,40,41,42,44,45,46,48,49
T+ 48: 51% 1,4,5,8,10,13,15,16,17,21,25,27,28,32,34,35,36,37,38,40,41,42,44,45,48,49
T+ 60: 43% 1,4,5,8,10,13,15,17,21,25,27,32,34,35,36,37,38,40,42,45,46,49
T+ 72: 43% 1,4,5,8,10,13,15,17,21,25,27,32,34,35,36,37,38,40,42,45,48,49
T+ 84: 41% 1,4,5,8,10,13,15,17,21,25,27,32,34,35,37,38,40,42,45,46,49
T+ 96: 41% 1,4,5,8,10,13,15,17,21,25,27,32,34,35,37,38,40,42,45,48,49


Feature-specific plume of pressure
Pressure at feature centre (mb)
1040
1030
1020
1010
1000
990
980
970
960
950
940
6: 0: 6: 0: 6: 0: 6: 0: 6:
29 30 31 1 2
October November
2009

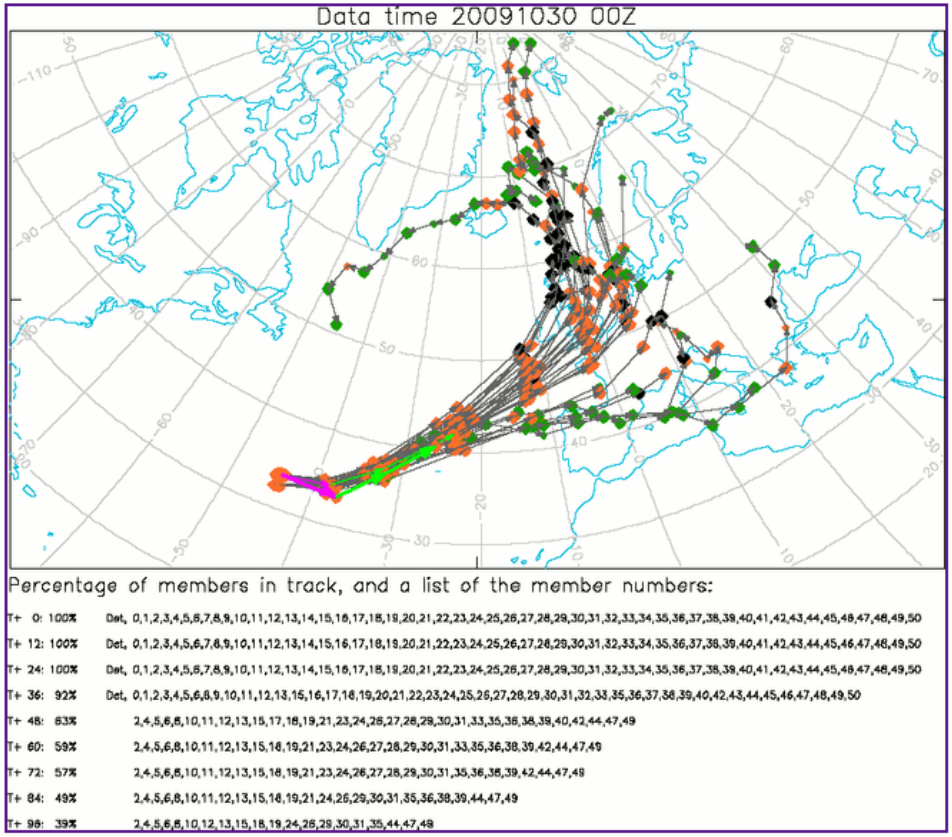

Feature-specific plume of relative vorticity
Relative vorticity 1km (s-1 x10-6)
400
350
300
250
200
150
100
50
0
-50
-100
6: 0: 6: 0: 6: 0: 6: 0: 6:
29 30 31 1 2
October November
2009

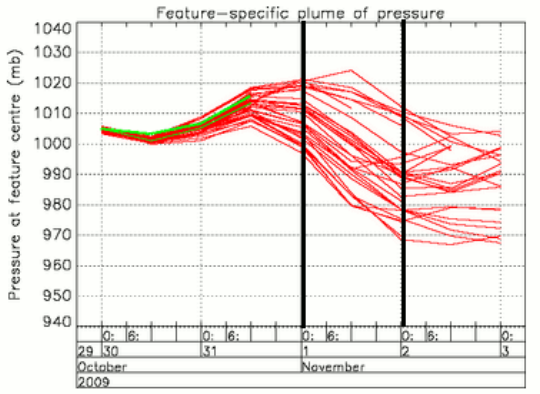

Feature-specific plume of wind strength
Max 1km wind in 300km radius (kn)
100
90
80
70
60
50
40
30
20
10
0
6: 0: 6: 0: 6: 0: 6: 0: 6:
29 30 31 1 2
October November
2009

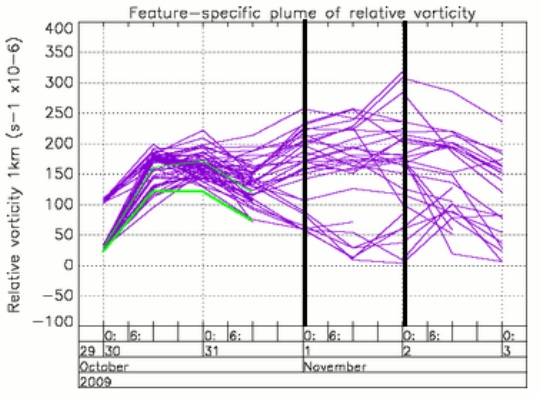

Feature-specific plume of wind strength
Max 1km wind in 600km radius (kn)
100
90
80
70
60
50
40
30
20
10
0
6: 0: 6: 0: 6: 0: 6: 0: 6:
29 30 31 1 2
October November
2009

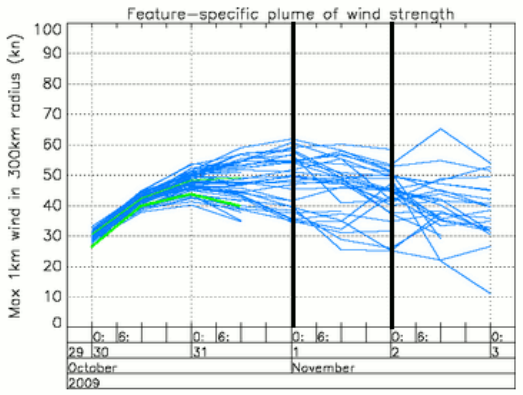

Feature-specific plume of wind strength
Max 300mb wind in 600km radius (kn)
220
200
180
160
140
120
100
80
60
40
20
0
6: 0: 6: 0: 6: 0: 6: 0: 6:
29 30 31 1 2
October November
2009

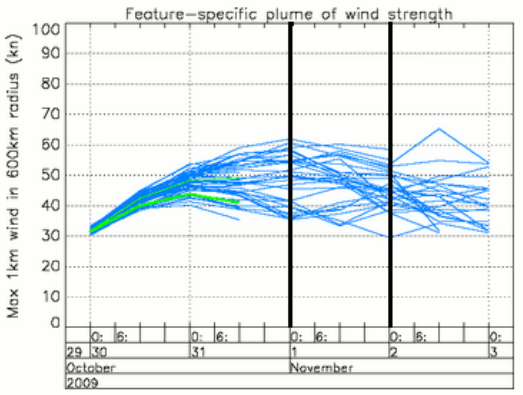
ECMWF

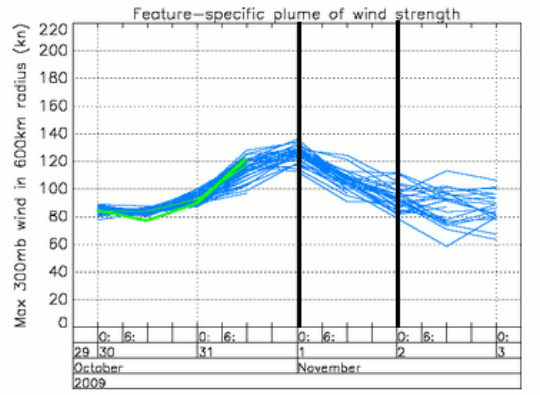

Data time 20091030 00Z
Percentage of members in track, and a list of the member numbers:
T+ 0: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 12: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 24: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 36: 92% Det, 0,1,2,3,4,5,6,8,9,10,11,12,13,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,35,36,37,38,39,40,42,43,44,45,46,47,48,49,50
T+ 48: 83% 2,4,5,6,8,10,11,12,13,15,17,18,19,21,23,24,26,27,28,29,30,31,33,35,36,38,39,40,42,44,47,49
T+ 60: 59% 2,4,5,6,8,10,11,12,13,15,16,19,21,23,24,26,27,28,29,30,31,33,35,36,38,39,42,44,47,49
T+ 72: 57% 2,4,5,6,8,10,11,12,13,15,16,19,21,23,24,26,27,28,29,30,31,35,36,38,39,42,44,47,49
T+ 84: 49% 2,4,5,6,8,10,11,12,13,15,16,19,21,24,26,29,30,31,35,36,38,39,44,47,49
T+ 96: 39% 2,4,5,6,8,10,12,13,15,18,19,24,26,29,30,31,35,44,47,49

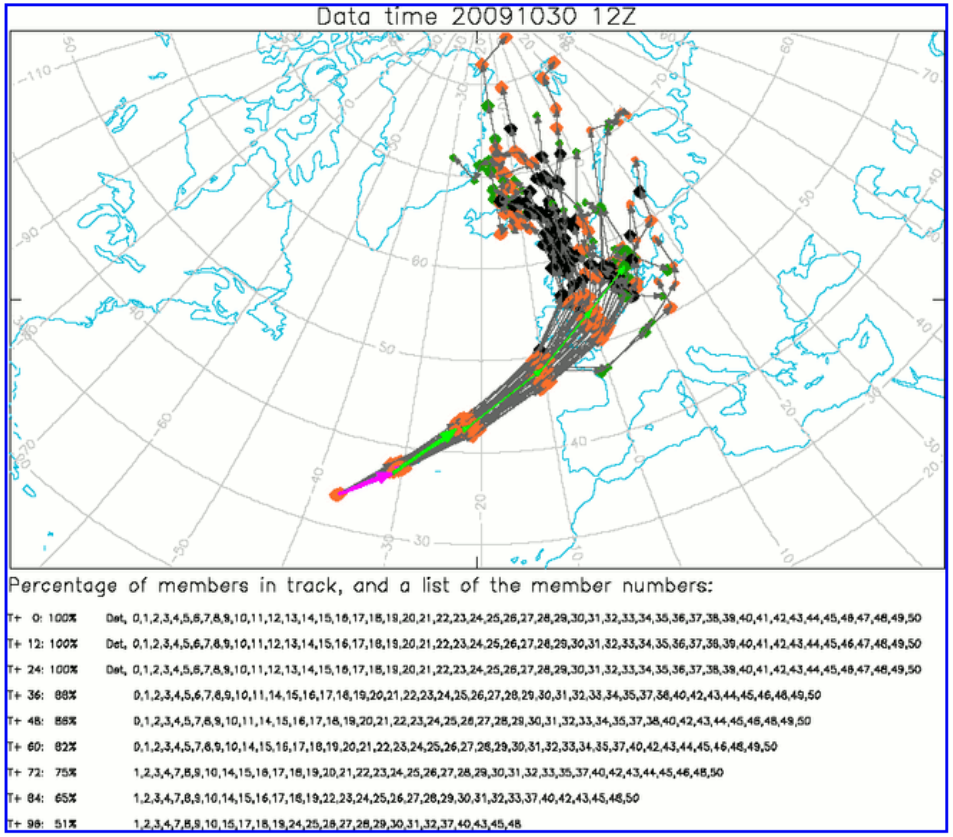

Feature-specific plume of pressure
Pressure at feature centre (mb)
October
November
2009

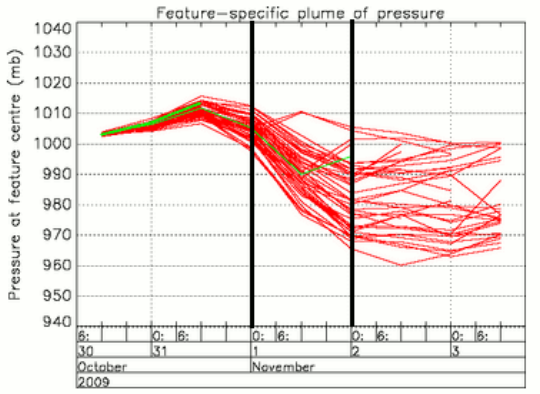

Feature-specific plume of relative vorticity
Relative vorticity 1km (s-1 x10-6)
October
November
2009

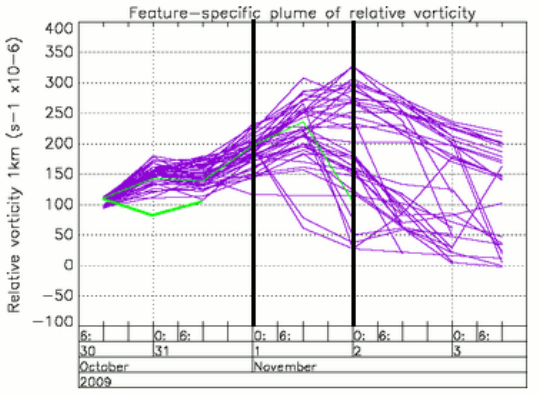

Feature-specific plume of wind strength
Max 1km wind in 300km radius (kn)
October
November
2009

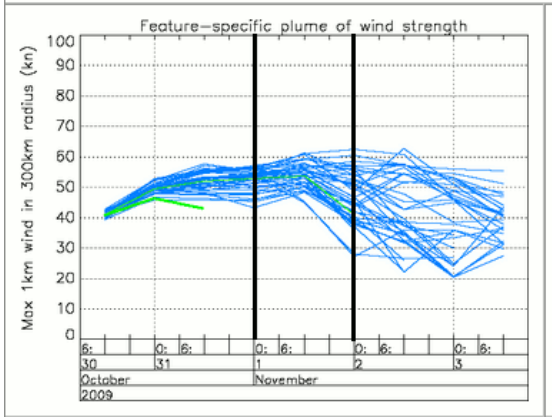

Feature-specific plume of wind strength
Max 1km wind in 600km radius (kn)
October
November
2009

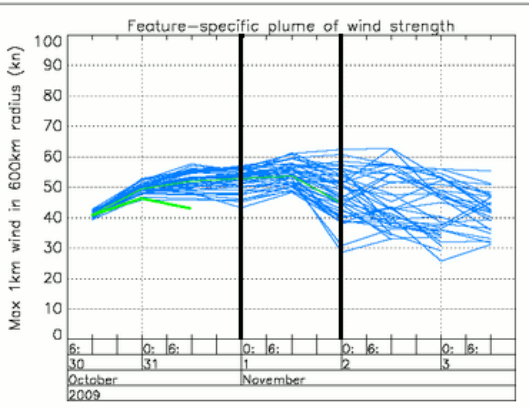

Feature-specific plume of wind strength
Max 300mb wind in 600km radius (kn)
October
November
2009

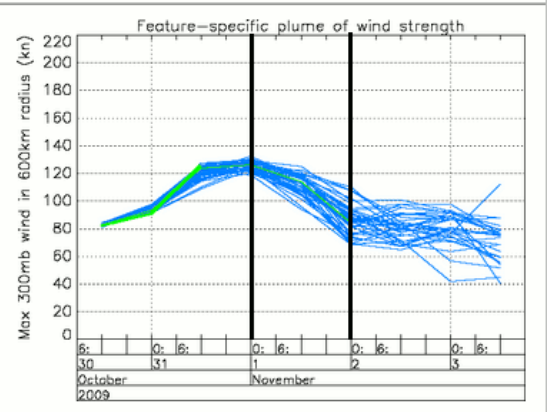

Data time 20091030 12Z
Percentage of members in track, and a list of the member numbers:
T+ 0: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 12: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 24: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 36: 88% 0,1,2,3,4,5,6,7,8,9,10,11,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,37,38,40,42,43,44,45,46,48,49,50
T+ 48: 86% 0,1,2,3,4,5,7,8,9,10,11,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,37,38,40,42,43,44,45,46,48,49,50
T+ 60: 82% 0,1,2,3,4,5,7,8,9,10,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,37,40,42,43,44,45,46,48,49,50
T+ 72: 75% 1,2,3,4,7,8,9,10,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,35,37,40,42,43,44,45,46,48,50
T+ 84: 65% 1,2,3,4,7,8,9,10,14,15,16,17,18,19,22,23,24,25,26,27,28,29,30,31,32,33,37,40,42,43,45,48,50
T+ 96: 51% 1,2,3,4,7,8,9,10,15,17,18,19,24,25,26,27,28,29,30,31,32,37,40,43,45,48


Feature-specific plume of pressure
Pressure at feature centre (mb)
1040
1030
1020
1010
1000
990
980
970
960
950
940
6: 0: 6: 0: 6: 0: 6: 0: 6:
30 31 1 2 3
October November
2009

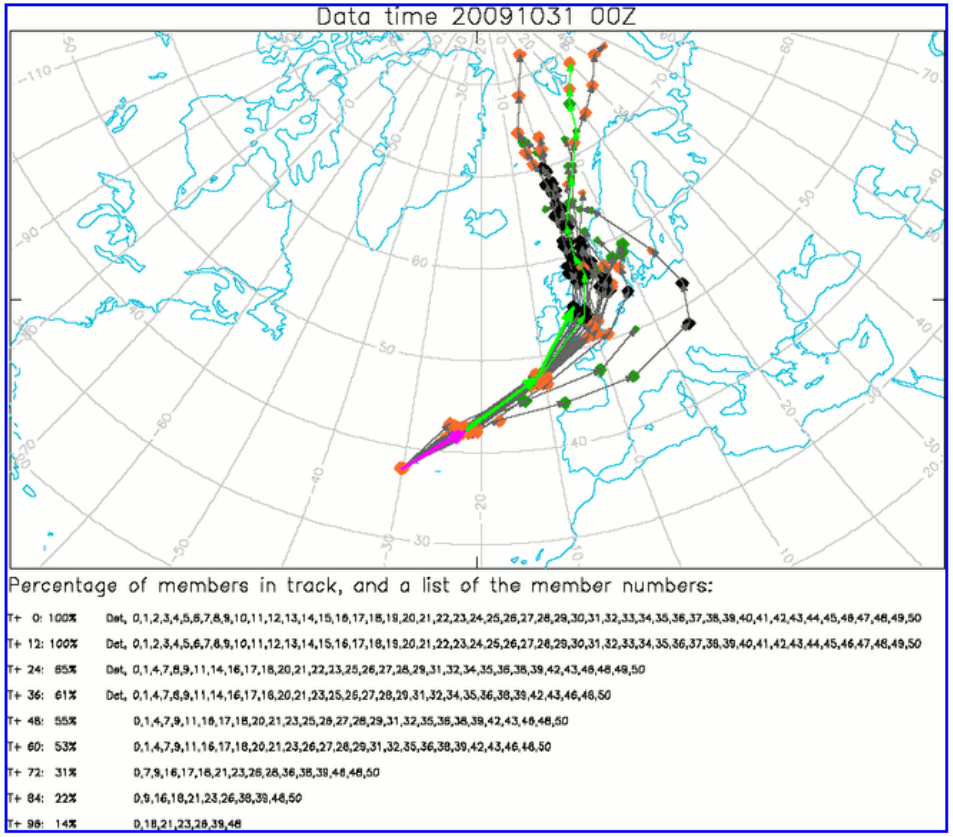

Feature-specific plume of relative vorticity
Relative vorticity 1km (s-1 x10-6)
400
350
300
250
200
150
100
50
0
-50
-100
6: 0: 6: 0: 6: 0: 6: 0: 6:
30 31 1 2 3
October November
2009

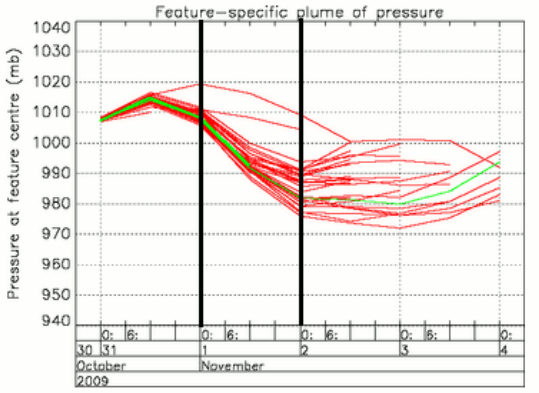

Feature-specific plume of wind strength
Max 1km wind in 300km radius (kn)
100
90
80
70
60
50
40
30
20
10
0
6: 0: 6: 0: 6: 0: 6: 0: 6:
30 31 1 2 3
October November
2009

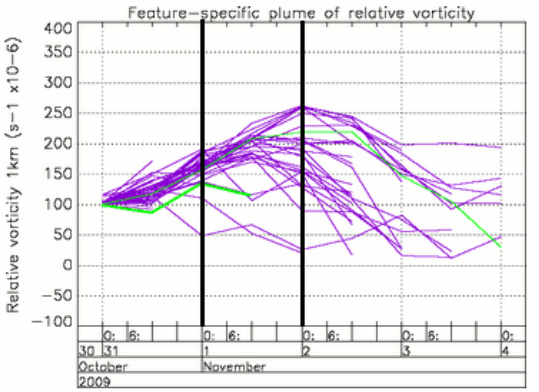

Feature-specific plume of wind strength
Max 1km wind in 600km radius (kn)
100
90
80
70
60
50
40
30
20
10
0
6: 0: 6: 0: 6: 0: 6: 0: 6:
30 31 1 2 3
October November
2009

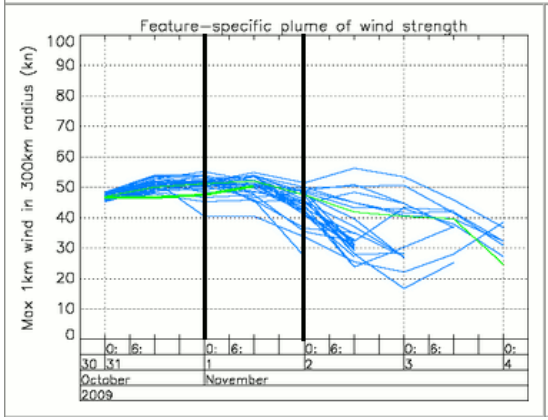

Feature-specific plume of wind strength
Max 300mb wind in 600km radius (kn)
220
200
180
160
140
120
100
80
60
40
20
0
6: 0: 6: 0: 6: 0: 6: 0: 6:
30 31 1 2 3
October November
2009

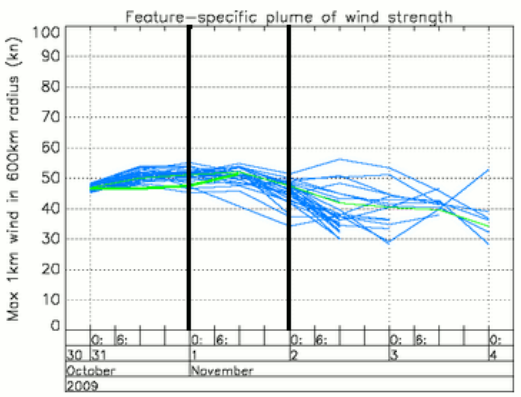
ECMWF

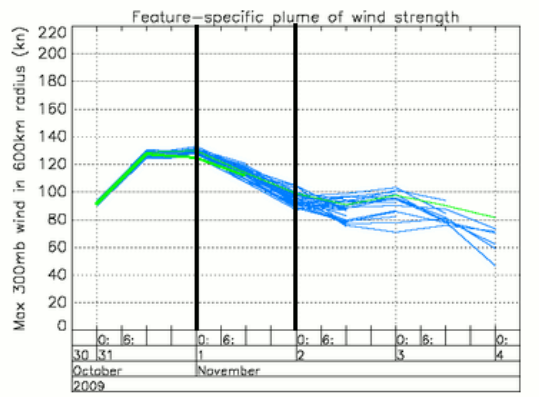

Data time 20091031 00Z
Percentage of members in track, and a list of the member numbers:
T+ 0: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 12: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 24: 65% Det, 0,1,4,7,8,9,11,14,16,17,18,20,21,22,23,25,26,27,28,29,31,32,34,35,36,38,39,42,43,46,48,49,50
T+ 36: 61% Det, 0,1,4,7,8,9,11,14,16,17,18,20,21,23,25,26,27,28,29,31,32,34,35,36,38,39,42,43,46,48,50
T+ 48: 55% 0,1,4,7,9,11,16,17,18,20,21,23,25,28,27,28,29,31,32,35,36,38,39,42,43,46,48,50
T+ 60: 53% 0,1,4,7,9,11,16,17,18,20,21,23,26,27,28,29,31,32,35,36,38,39,42,43,46,48,50
T+ 72: 31% 0,7,9,16,17,18,21,23,25,28,36,38,39,48,48,50
T+ 84: 22% 0,9,16,18,21,23,26,38,39,48,50
T+ 96: 14% 0,18,21,23,28,39,48

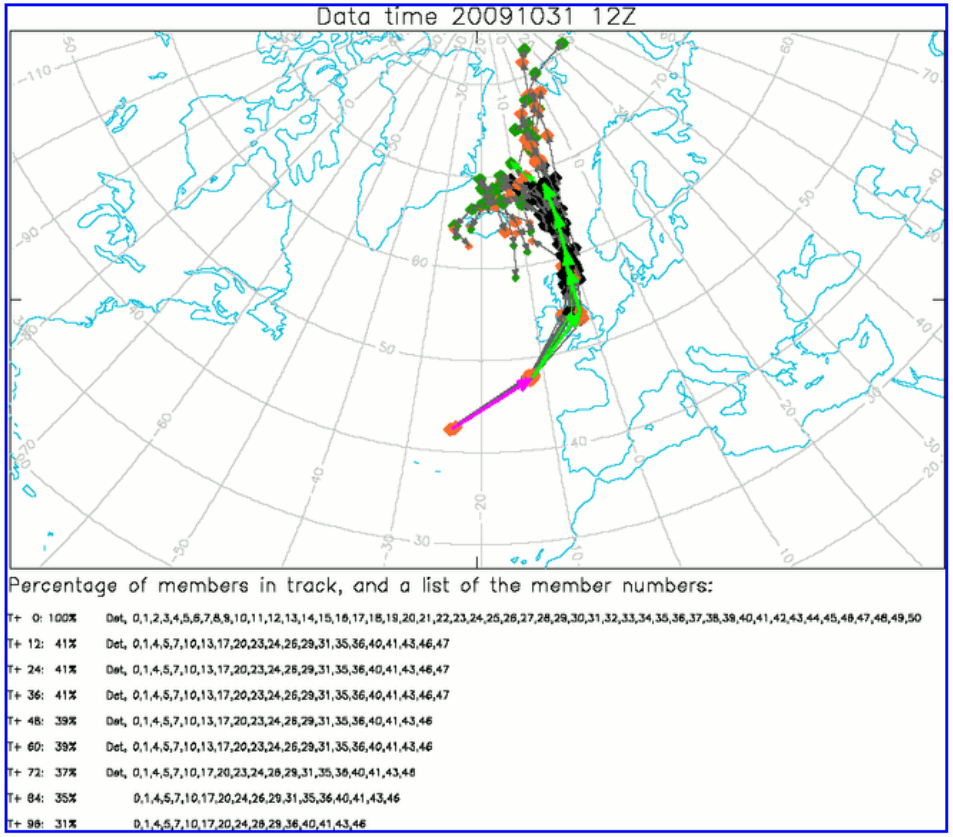

Feature-specific plume of pressure
Pressure at feature centre (mb)
October
November
2009

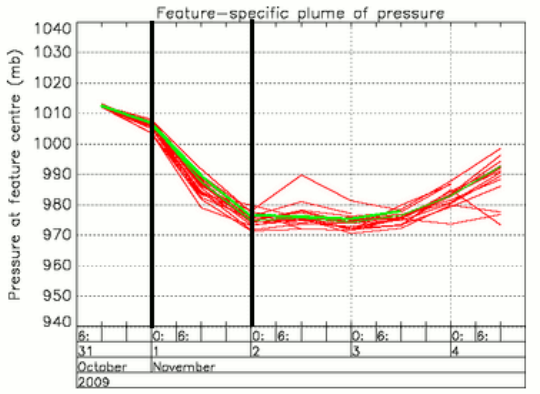

Feature-specific plume of relative vorticity
Relative vorticity 1km (s-1 x10-6)
October
November
2009

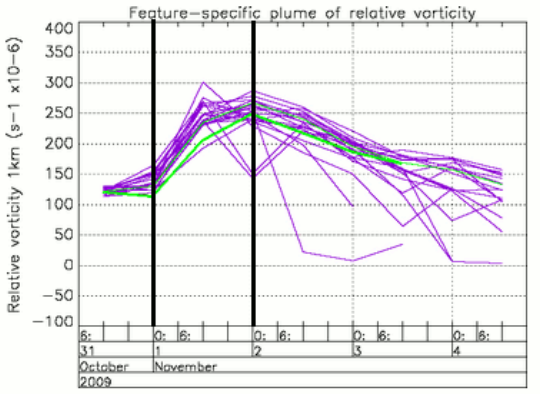

Feature-specific plume of wind strength
Max 1km wind in 300km radius (kn)
October
November
2009

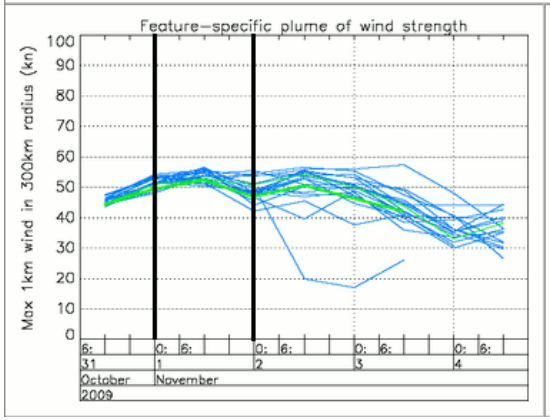

Feature-specific plume of wind strength
Max 1km wind in 600km radius (kn)
October
November
2009

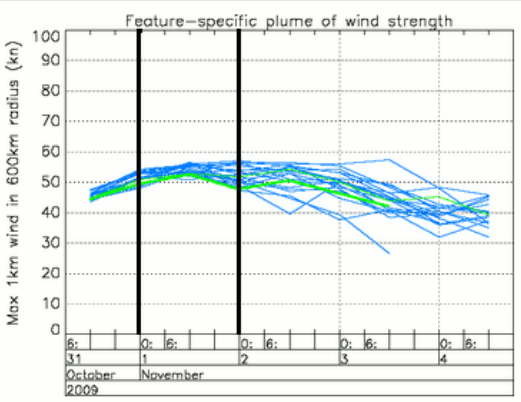

Feature-specific plume of wind strength
Max 300mb wind in 600km radius (kn)
October
November
2009

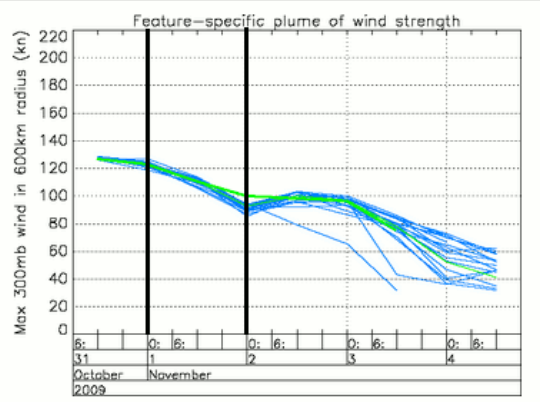

Data time 20091031 12Z
Percentage of members in track, and a list of the member numbers:
T+ 0: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 12: 41% Det, 0,1,4,5,7,10,13,17,20,23,24,25,29,31,35,36,40,41,43,46,47
T+ 24: 41% Det, 0,1,4,5,7,10,13,17,20,23,24,25,29,31,35,36,40,41,43,46,47
T+ 36: 41% Det, 0,1,4,5,7,10,13,17,20,23,24,25,29,31,35,36,40,41,43,46,47
T+ 48: 39% Det, 0,1,4,5,7,10,13,17,20,23,24,25,29,31,35,36,40,41,43,46
T+ 60: 39% Det, 0,1,4,5,7,10,13,17,20,23,24,25,29,31,35,36,40,41,43,46
T+ 72: 37% Det, 0,1,4,5,7,10,17,20,23,24,25,29,31,35,36,40,41,43,46
T+ 84: 35% 0,1,4,5,7,10,17,20,24,26,29,31,35,36,40,41,43,46
T+ 96: 31% 0,1,4,5,7,10,17,20,24,25,29,36,40,41,43,46


Feature-specific plume of pressure
Pressure at feature centre (mb)
1040
1030
1020
1010
1000
990
980
970
960
950
940
6: 0: 6: 0: 6: 0: 6: 0: 6:
31 1 2 3 4
October November
2009

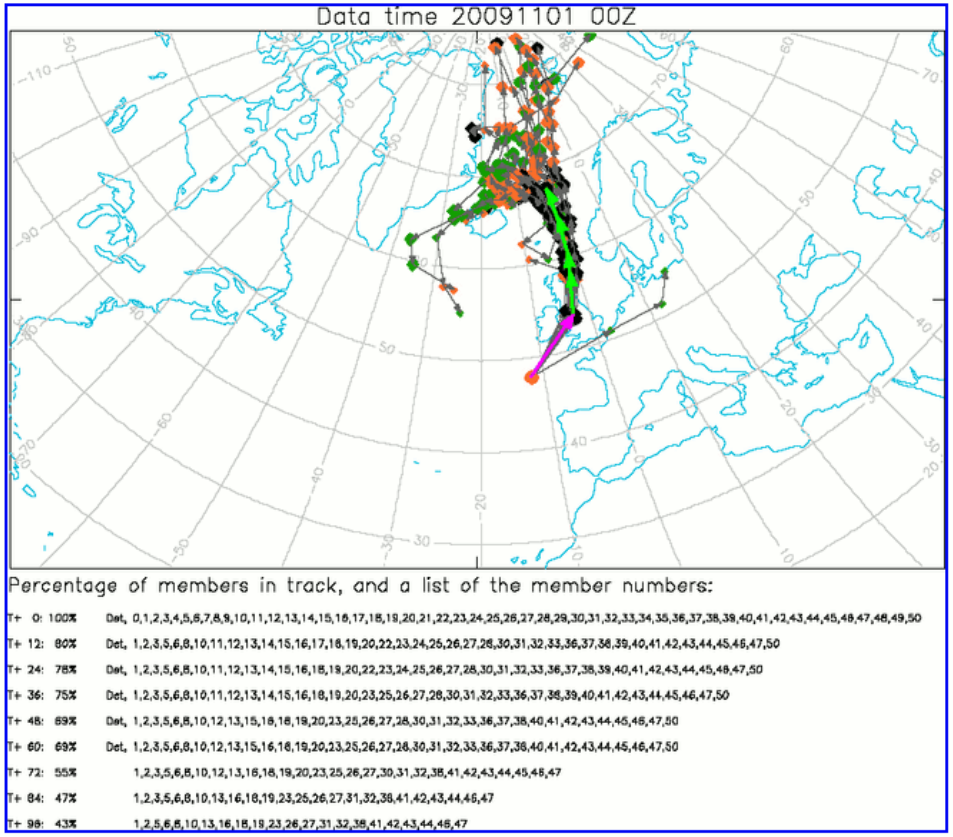

Feature-specific plume of relative vorticity
Relative vorticity 1km (s-1 x10-6)
400
350
300
250
200
150
100
50
0
-50
-100
6: 0: 6: 0: 6: 0: 6: 0: 6:
31 1 2 3 4
October November
2009


Feature-specific plume of wind strength
Max 1km wind in 300km radius (kn)
100
90
80
70
60
50
40
30
20
10
0
6: 0: 6: 0: 6: 0: 6: 0: 6:
31 1 2 3 4
October November
2009


Feature-specific plume of wind strength
Max 1km wind in 600km radius (kn)
100
90
80
70
60
50
40
30
20
10
0
6: 0: 6: 0: 6: 0: 6: 0: 6:
31 1 2 3 4
October November
2009


Feature-specific plume of wind strength
Max 300mb wind in 600km radius (kn)
220
200
180
160
140
120
100
80
60
40
20
0
6: 0: 6: 0: 6: 0: 6: 0: 6:
31 1 2 3 4
October November
2009

ECMWF



Percentage of members in track, and a list of the member numbers:

T+ 0: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50

T+ 12: 80% Det, 1,2,3,5,6,8,10,11,12,13,14,15,16,17,18,19,20,22,23,24,25,26,27,28,30,31,32,33,36,37,38,39,40,41,42,43,44,45,46,47,50

T+ 24: 78% Det, 1,2,3,5,6,8,10,11,12,13,14,15,16,18,19,20,22,23,24,25,26,27,28,30,31,32,33,36,37,38,39,40,41,42,43,44,45,46,47,50

T+ 36: 75% Det, 1,2,3,5,6,8,10,11,12,13,14,15,16,18,19,20,23,25,26,27,28,30,31,32,33,36,37,38,39,40,41,42,43,44,45,46,47,50

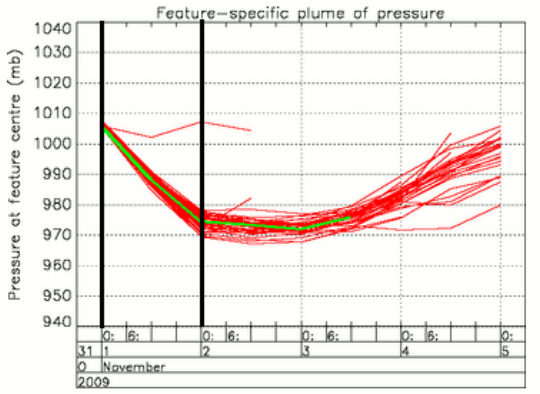
T+ 48: 69% Det, 1,2,3,5,6,8,10,12,13,15,16,18,19,20,23,25,26,27,28,30,31,32,33,36,37,38,40,41,42,43,44,45,46,47,50

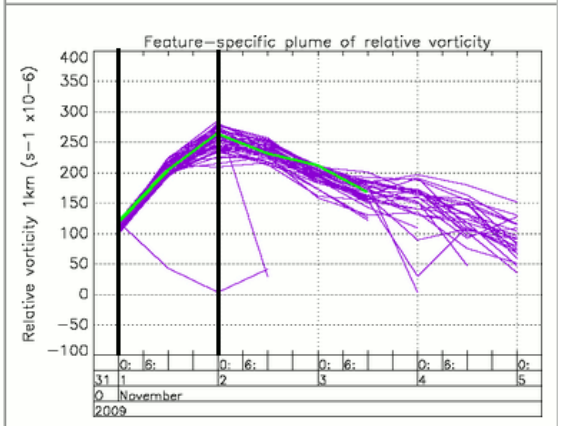
T+ 60: 69% Det, 1,2,3,5,6,8,10,12,13,15,16,18,19,20,23,25,26,27,28,30,31,32,33,36,37,38,40,41,42,43,44,45,46,47,50

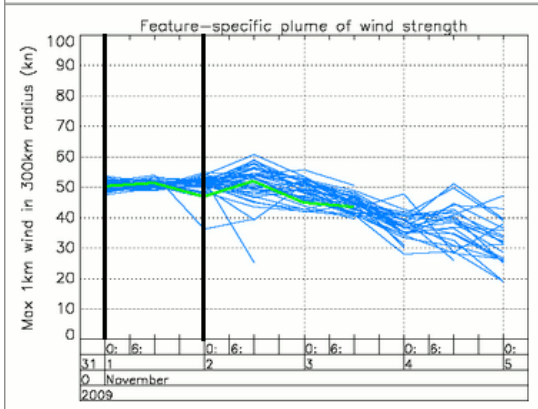
T+ 72: 55% 1,2,3,5,6,8,10,12,13,16,18,19,20,23,25,26,27,30,31,32,38,41,42,43,44,45,46,47

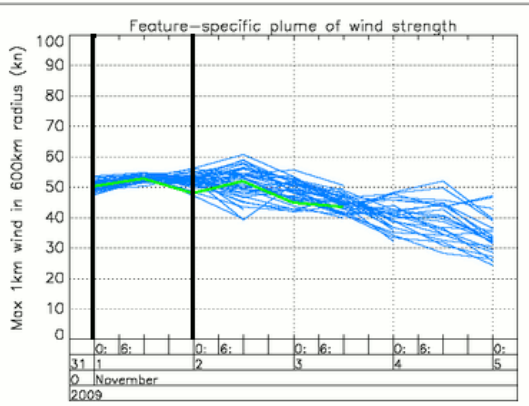
T+ 84: 47% 1,2,3,5,6,8,10,13,16,18,19,23,25,26,27,31,32,38,41,42,43,44,46,47

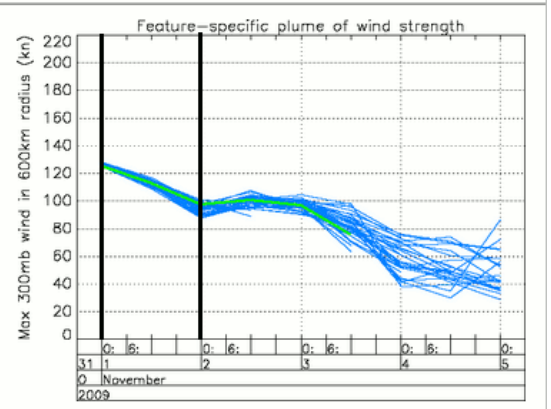
T+ 96: 43% 1,2,5,6,8,10,13,16,18,19,23,26,27,31,32,38,41,42,43,44,46,47



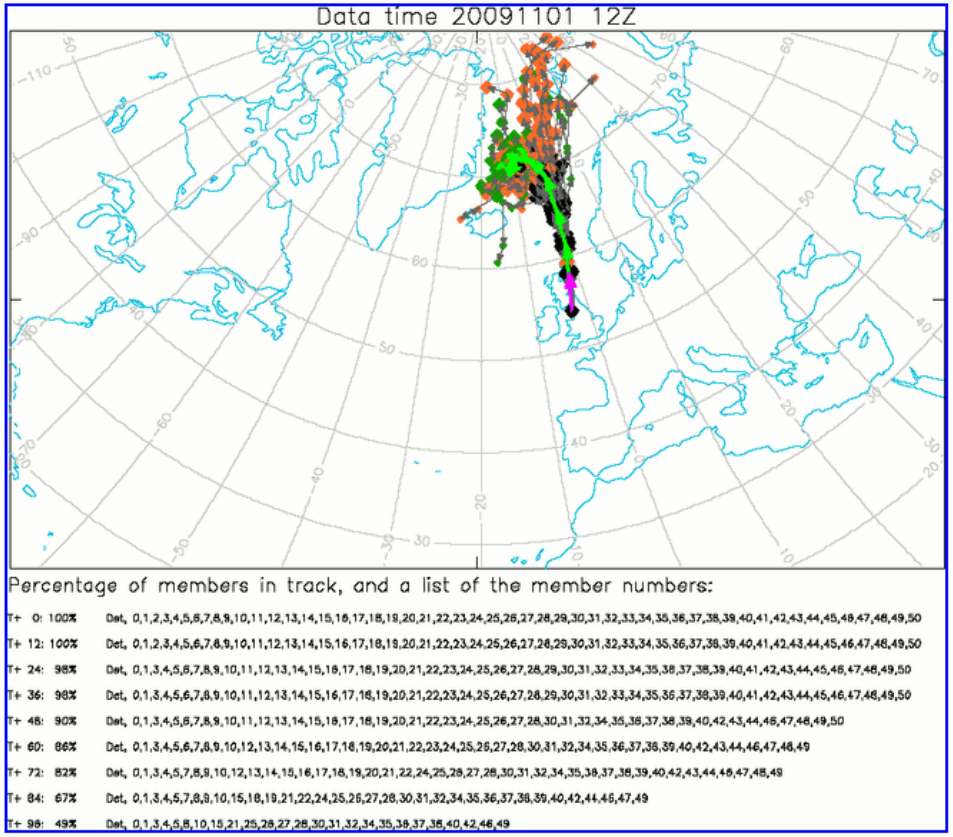


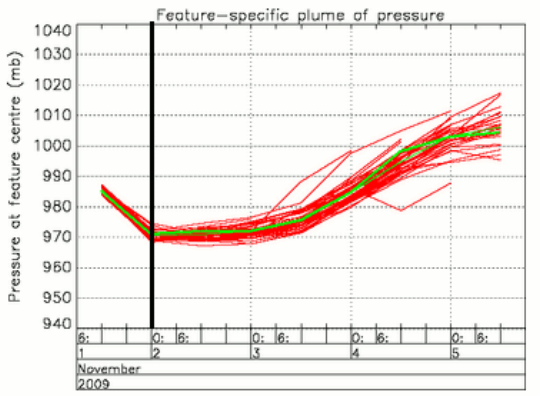


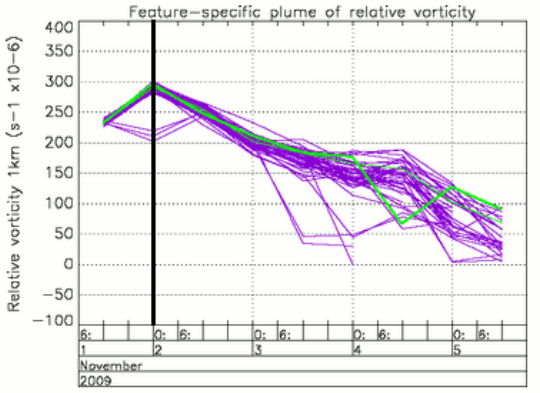


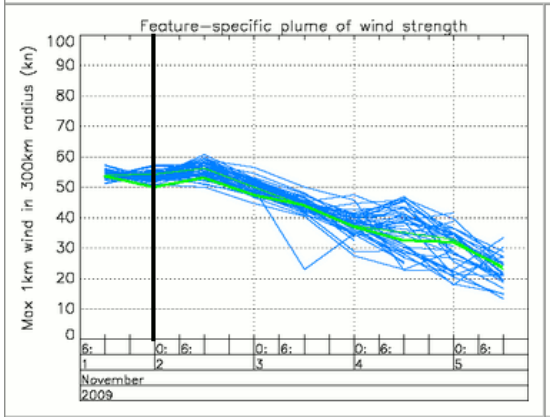


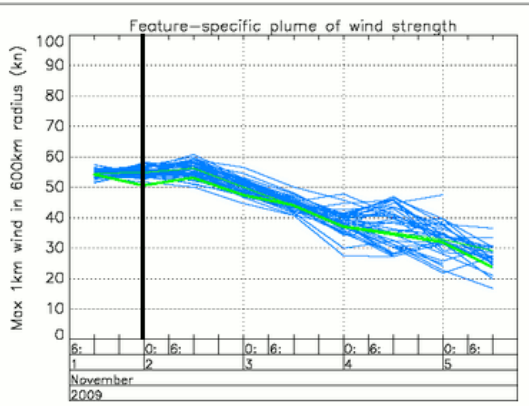
ECMWF

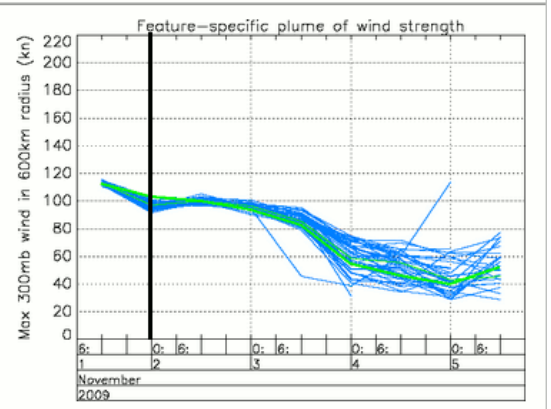

Data time 20091101 12Z
Percentage of members in track, and a list of the member numbers:
T+ 0: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 12: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 24: 98% Det, 0,1,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 36: 98% Det, 0,1,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 48: 90% Det, 0,1,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,30,31,32,34,35,36,37,38,39,40,42,43,44,46,47,48,49,50
T+ 60: 86% Det, 0,1,3,4,5,6,7,8,9,10,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,30,31,32,34,35,36,37,38,39,40,42,43,44,46,47,48,49
T+ 72: 82% Det, 0,1,3,4,5,7,8,9,10,12,13,14,15,16,17,18,19,20,21,22,24,25,26,27,28,30,31,32,34,35,38,37,38,39,40,42,43,44,46,47,48,49
T+ 84: 67% Det, 0,1,3,4,5,7,8,9,10,15,18,19,21,22,24,25,26,27,28,30,31,32,34,35,36,37,38,39,40,42,44,46,47,49
T+ 96: 49% Det, 0,1,3,4,5,8,10,15,21,25,26,27,28,30,31,32,34,35,38,37,38,40,42,46,49


Feature-specific plume of pressure
Pressure at feature centre (mb)
1040
1030
1020
1010
1000
990
980
970
960
950
940
6: 0: 6: 0: 6: 0: 6: 0: 6:
1 2 3 4 5
November
2009

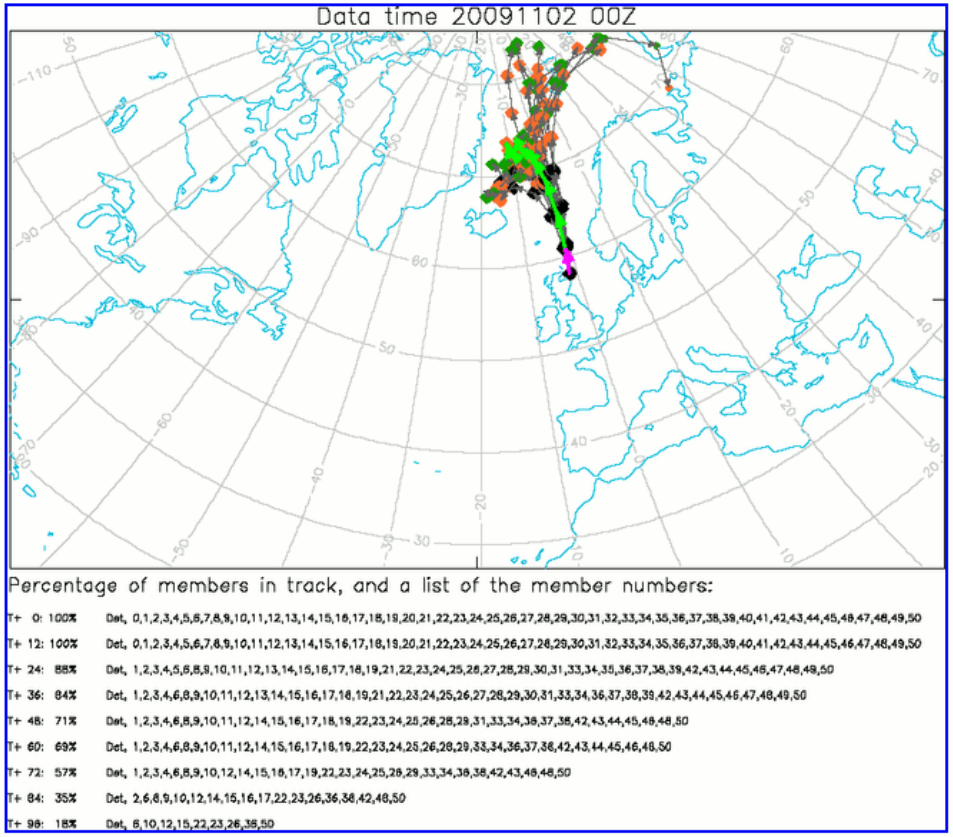

Feature-specific plume of relative vorticity
Relative vorticity 1km (s-1 x10-6)
400
350
300
250
200
150
100
50
0
-50
-100
6: 0: 6: 0: 6: 0: 6: 0: 6:
1 2 3 4 5
November
2009

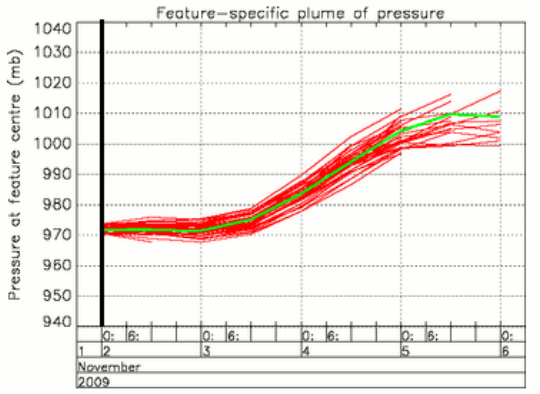

Feature-specific plume of wind strength
Max 1km wind in 300km radius (kn)
100
90
80
70
60
50
40
30
20
10
0
6: 0: 6: 0: 6: 0: 6: 0: 6:
1 2 3 4 5
November
2009

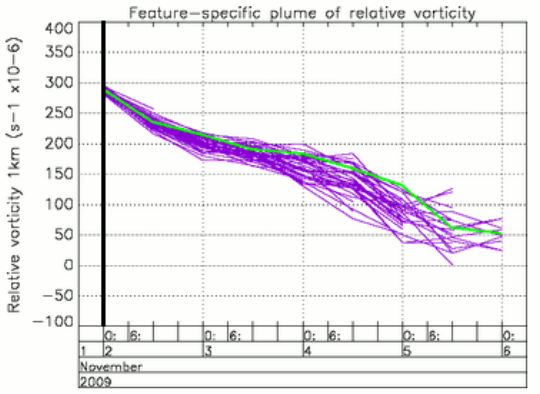

Feature-specific plume of wind strength
Max 1km wind in 600km radius (kn)
100
90
80
70
60
50
40
30
20
10
0
6: 0: 6: 0: 6: 0: 6: 0: 6:
1 2 3 4 5
November
2009

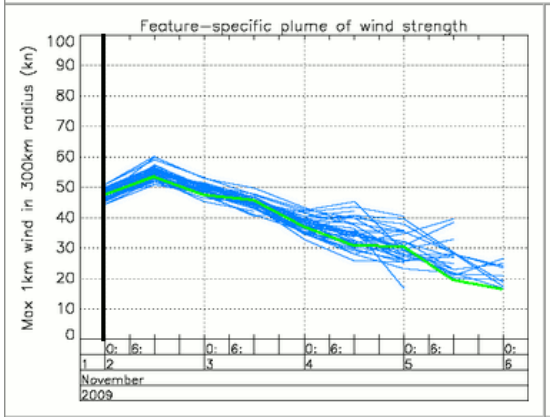

Feature-specific plume of wind strength
Max 300mb wind in 600km radius (kn)
220
200
180
160
140
120
100
80
60
40
20
0
6: 0: 6: 0: 6: 0: 6: 0: 6:
1 2 3 4 5
November
2009

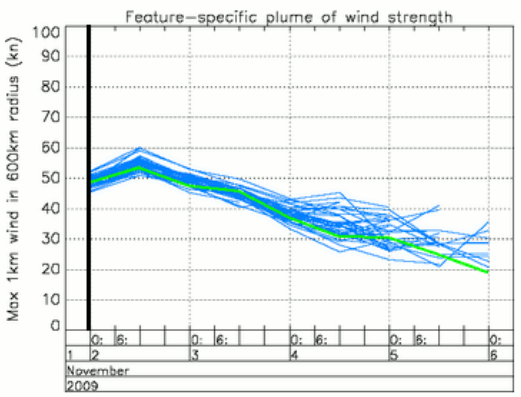
ECMWF

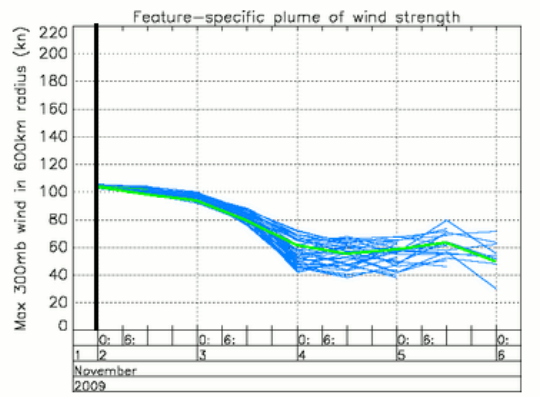

Data time 20091102 00Z
Percentage of members in track, and a list of the member numbers:
T+ 0: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 12: 100% Det, 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 24: 88% Det, 1,2,3,4,5,6,8,9,10,11,12,13,14,15,16,17,18,19,21,22,23,24,25,26,27,28,29,30,31,33,34,35,36,37,38,39,42,43,44,45,46,47,48,49,50
T+ 36: 84% Det, 1,2,3,4,6,8,9,10,11,12,13,14,15,16,17,18,19,21,22,23,24,25,26,27,28,29,30,31,33,34,36,37,38,39,42,43,44,45,46,47,48,49,50
T+ 48: 71% Det, 1,2,3,4,6,8,9,10,11,12,14,15,16,17,18,19,22,23,24,25,26,28,29,31,33,34,36,37,38,42,43,44,45,46,48,50
T+ 60: 69% Det, 1,2,3,4,6,8,9,10,11,12,14,15,16,17,18,19,22,23,24,25,26,28,29,33,34,36,37,38,42,43,44,45,46,48,50
T+ 72: 57% Det, 1,2,3,4,6,8,9,10,12,14,15,16,17,19,22,23,24,25,26,29,33,34,36,38,42,43,46,48,50
T+ 84: 35% Det, 2,6,8,9,10,12,14,15,16,17,22,23,26,36,38,42,48,50
T+ 96: 18% Det, 8,10,12,15,22,23,26,36,50


Feature-specific plume of pressure
Pressure at feature centre (mb)
November
2009


Feature-specific plume of relative vorticity
Relative vorticity 1km (s-1 x10-6)
November
2009

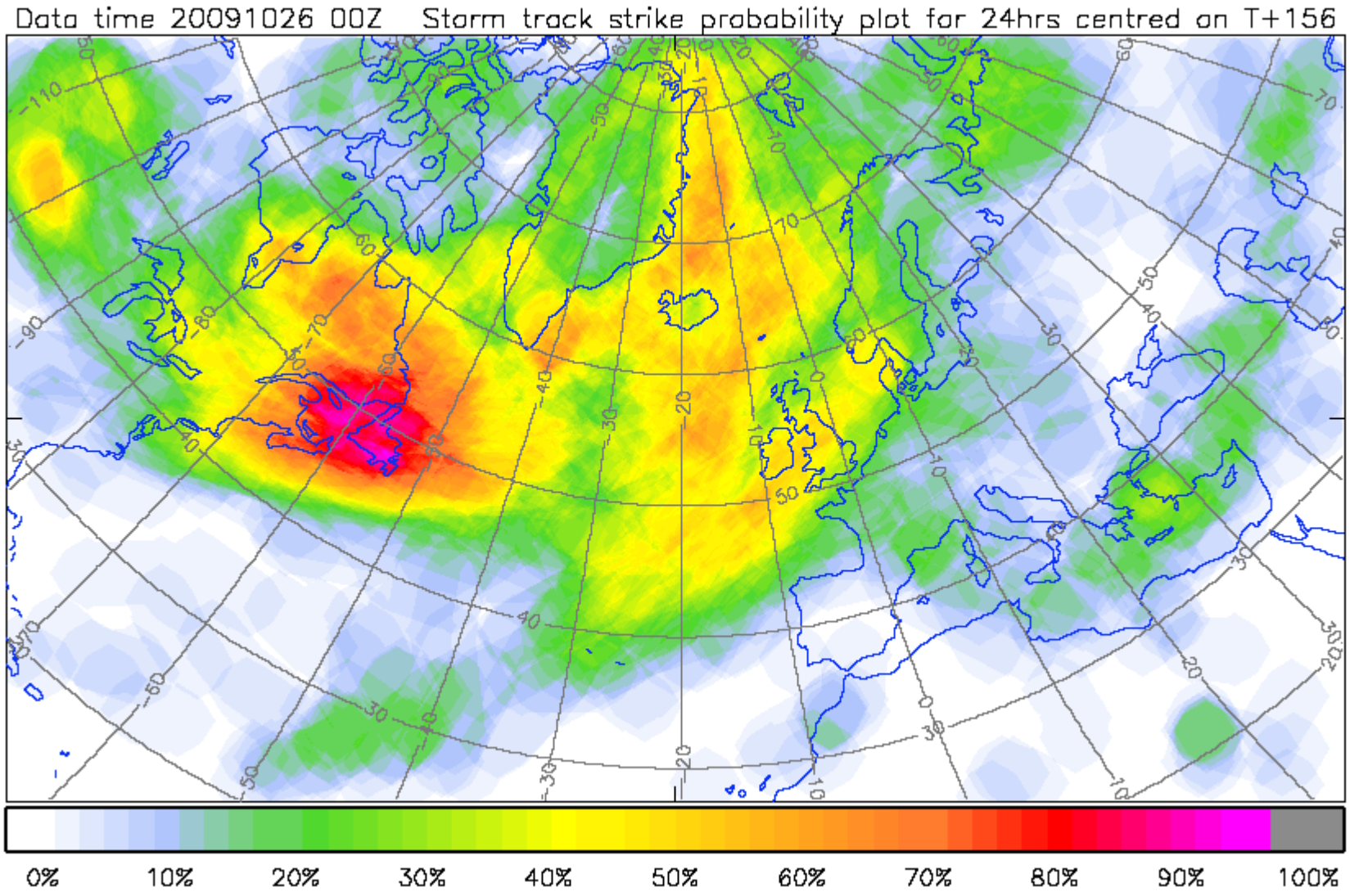

Feature-specific plume of wind strength
Max 1km wind in 300km radius (kn)
November
2009


Feature-specific plume of wind strength
Max 1km wind in 600km radius (kn)
November
2009


Feature-specific plume of wind strength
Max 300mb wind in 600km radius (kn)
November
2009

Strike Prob Animation – mid-range wind threshold

Reducing lead time – Fixed validity time (Sun 1st 12Z)



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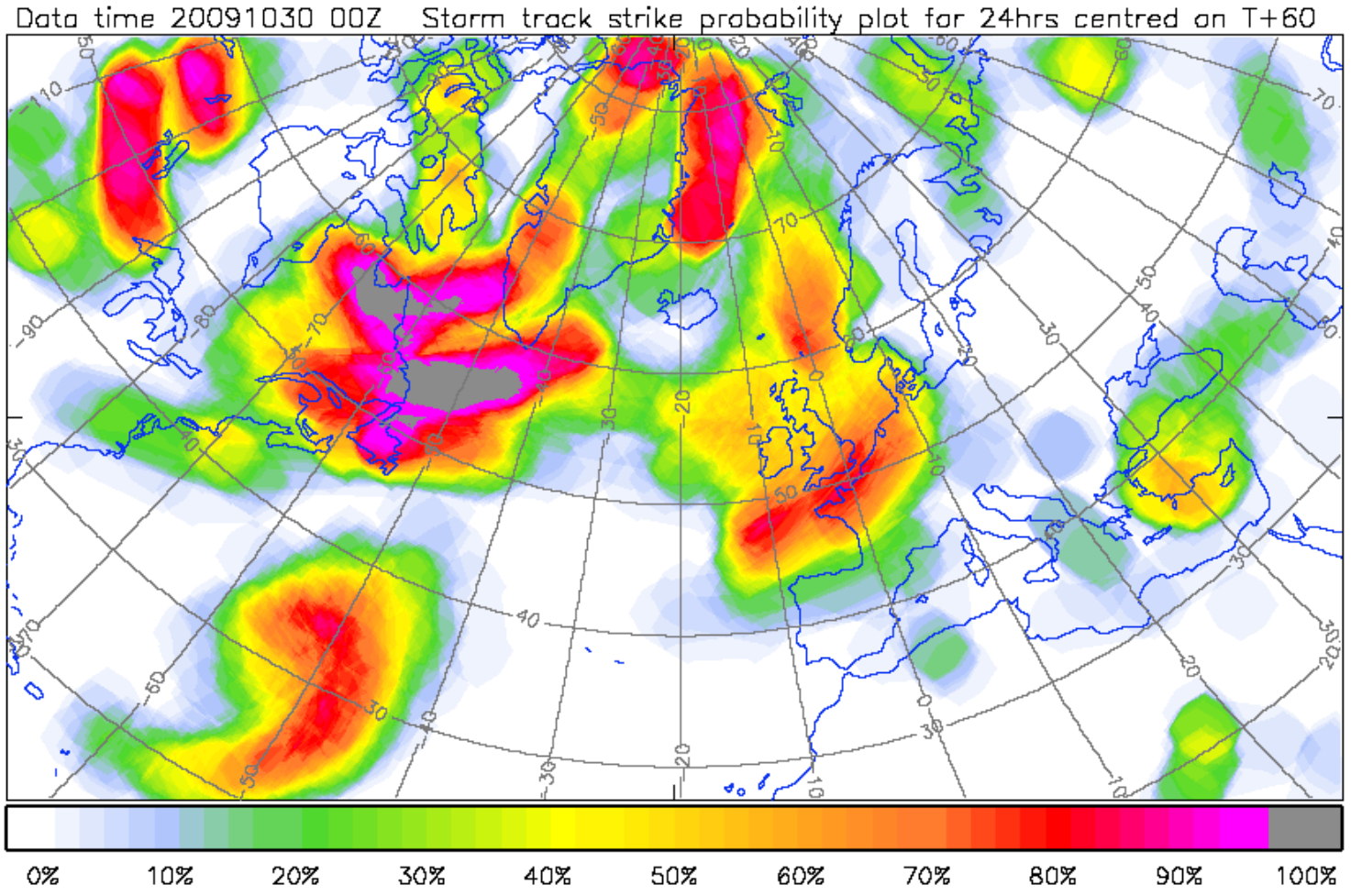
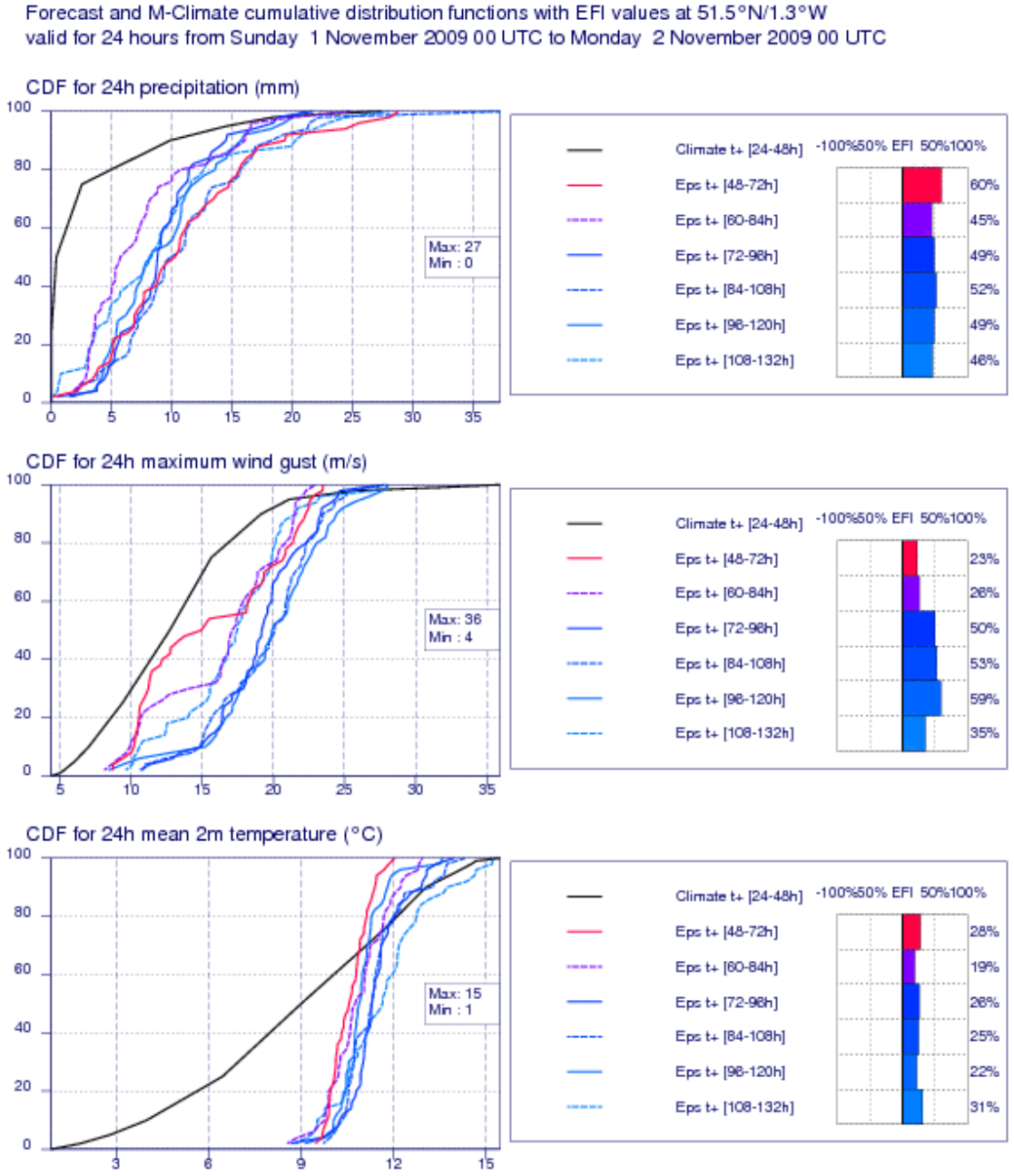
Now consider the 00Z 30th forecasts



- **Overall these were rather poor**

CDFs for Reading from DT 00Z 30th Oct for 1st Nov



- **Note reduction in wind gust, as wave track is more to the SE**
- **Also note the step in the wind CDF**
- **Denotes discretization of probabilities due to feature track**
- **Would not see this without CDFs – a clear benefit of providing these products…**

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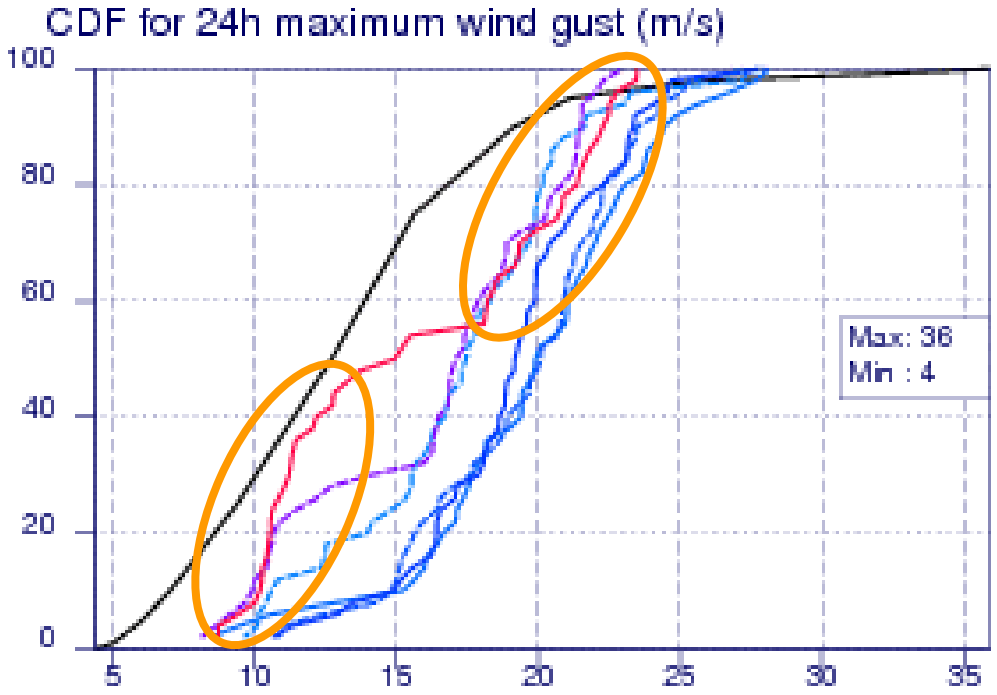
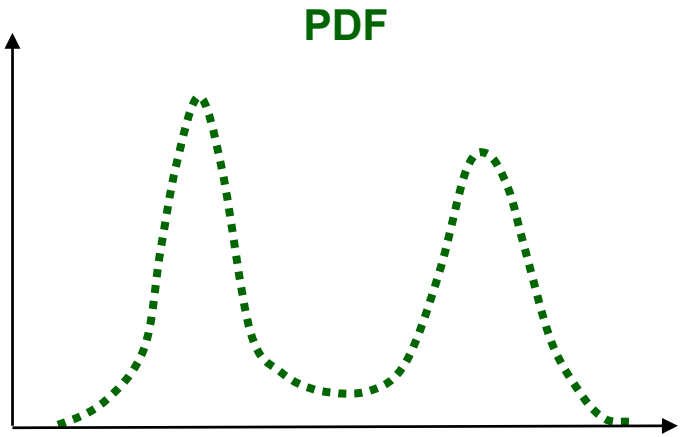


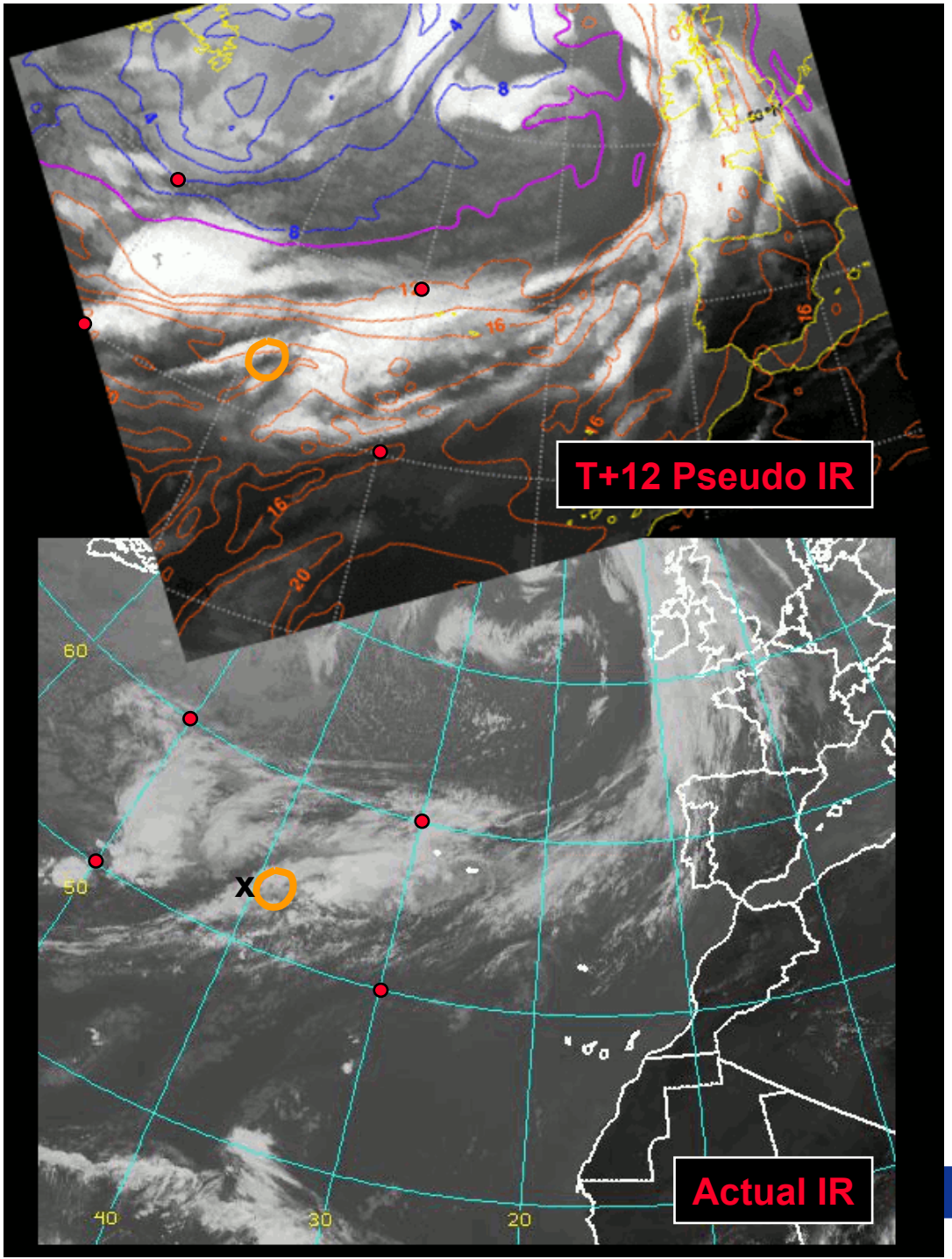


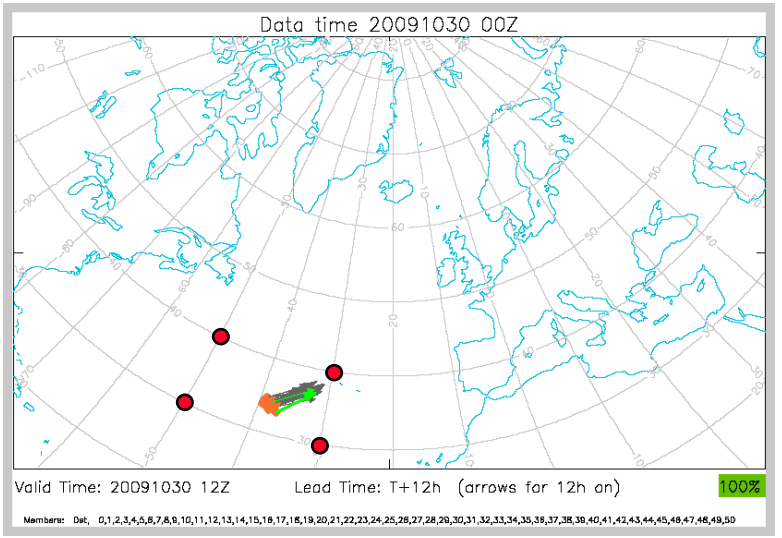
Forecast for Reading (from red curve):

“It will either be very windy” **(45% prob)**

“Or it won’t !” **(50% prob)**

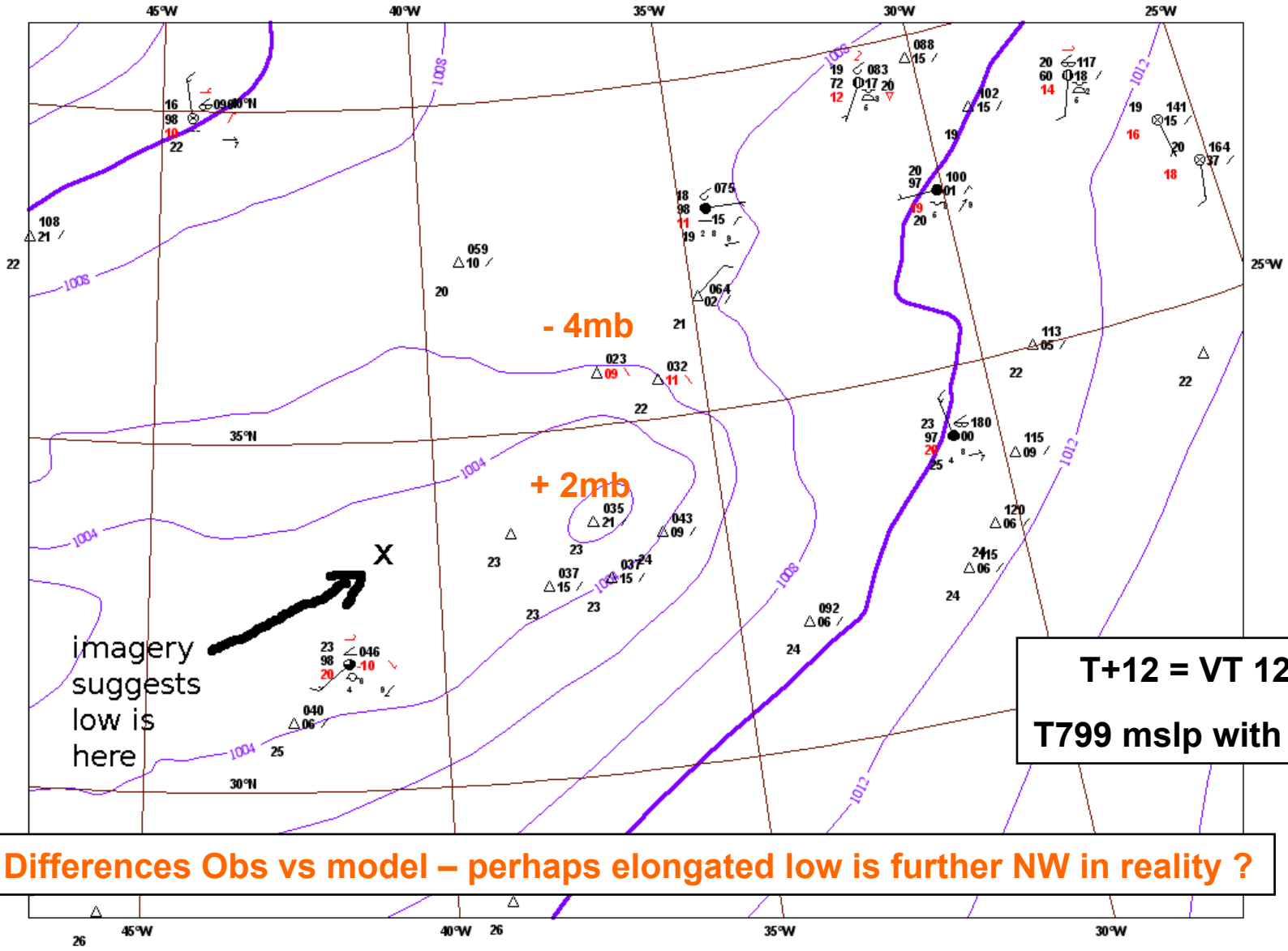
12Z Fri 30th Oct





- **Could forecast problems have been anticipated ?**
- **Use pseudo imagery, in conjunction with feature points**

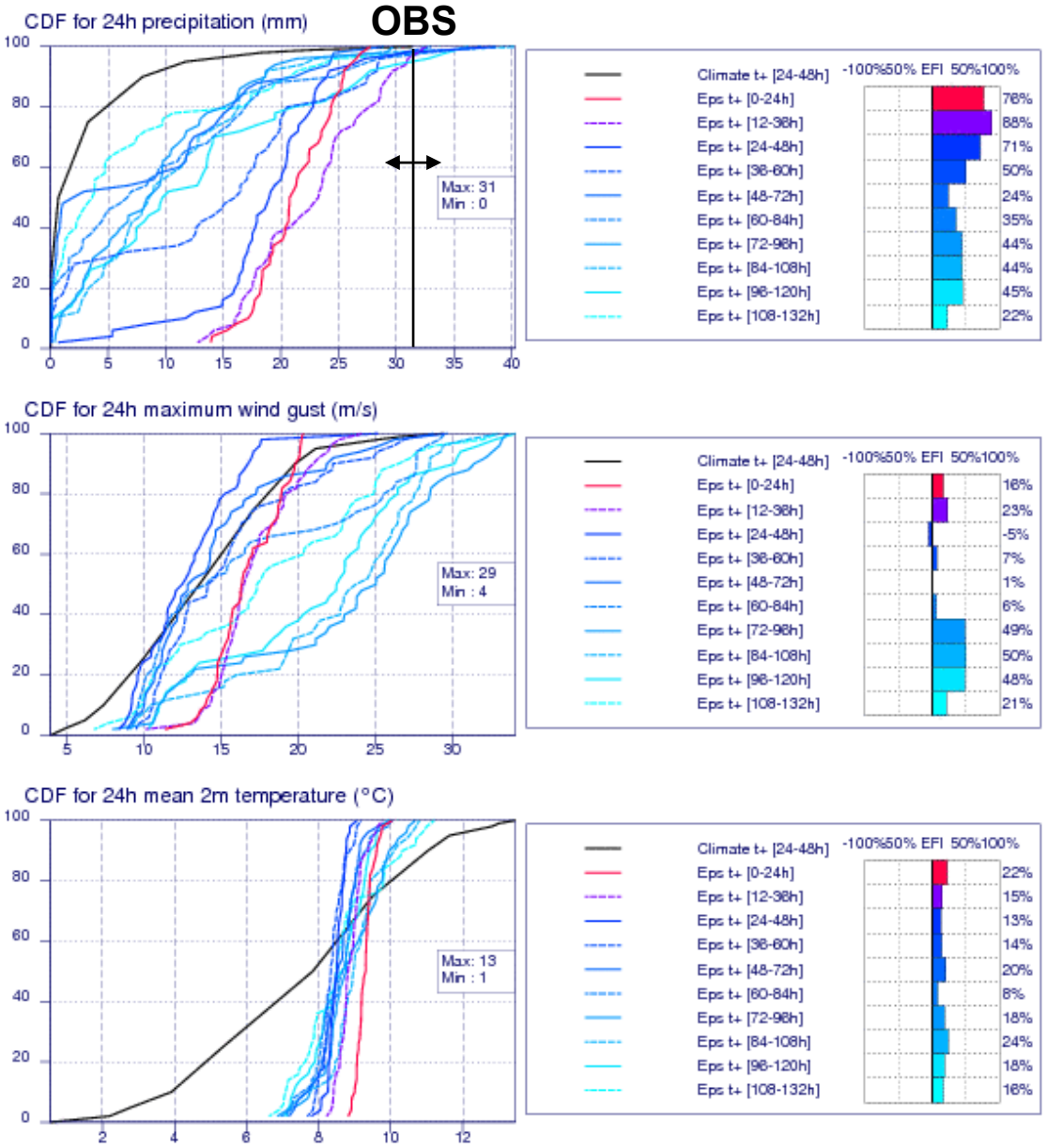
ECMWF



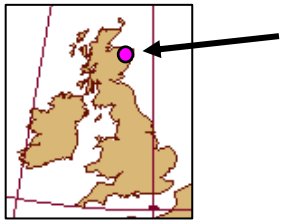
Differences Obs vs model – perhaps elongated low is further NW in reality ?

ECMWF

Forecast and M-Climate cumulative distribution functions with EFI values at 57.04°N/2.64°W
valid for 24 hours from Sunday 1 November 2009 00 UTC to Monday 2 November 2009 00 UTC



CDFs for Huntley, NE Scotland, where flooding reported



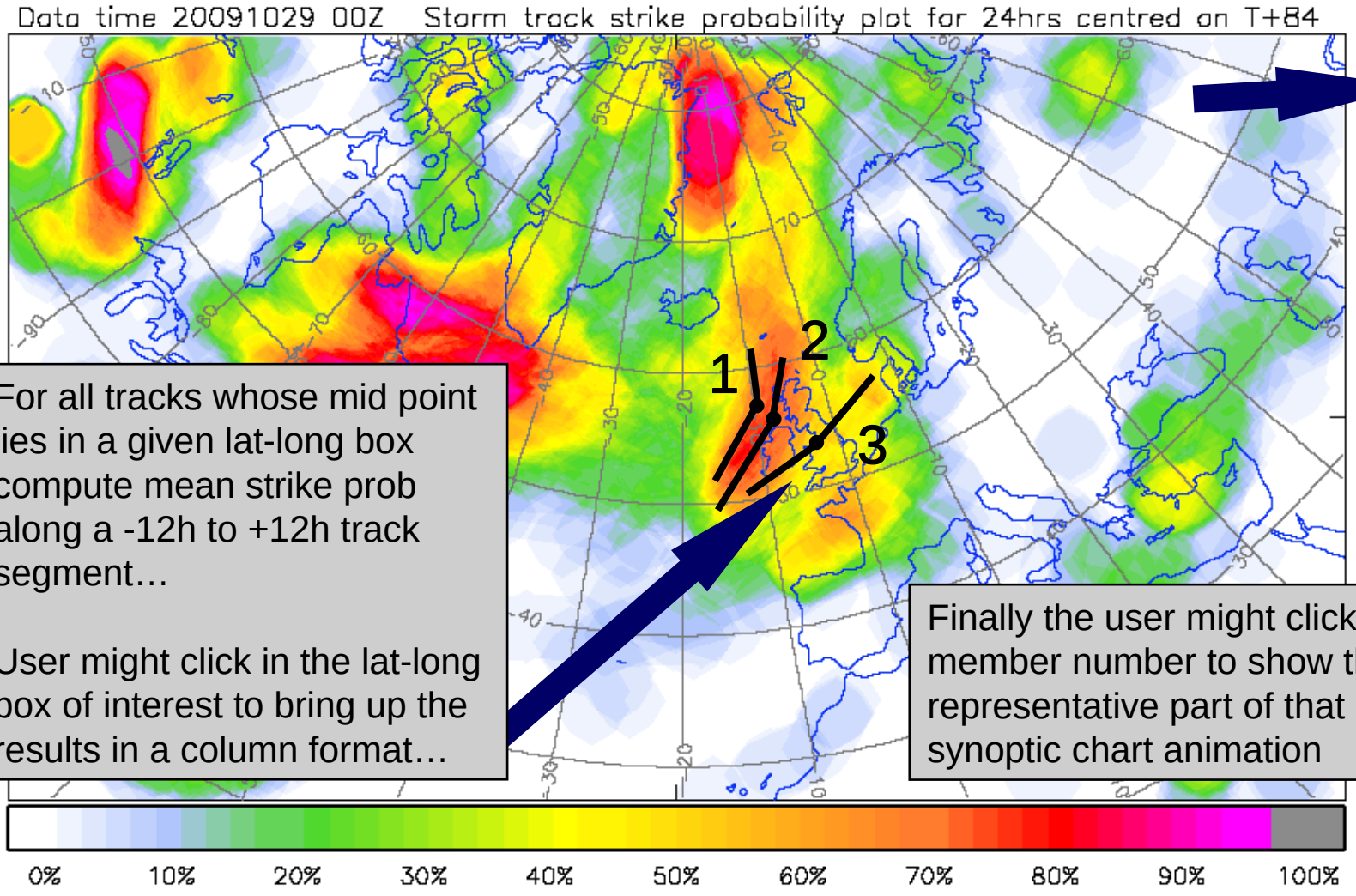
- **Shorter range forecasts**
- **Reasonable guide**
- **Note again steps in some CDFs –both wind and rainfall!**
- **Forecasting in these situations is a major challenge!**

ECMWF

5. Representative members – future work

- **By combining multi-feature strike probabilities with feature tracks from individual members there is scope to compute the representativeness, in a given sector of the chart, of a particular EPS member's handling of cyclonic feature(s)**
- **This can then be displayed as a numerical value, allowing the user to select a 'representative member', for that feature**
- **At this stage this is just a concept, which needs testing…**
- **Will illustrate with an example….**

Example – From Nov 1st Flood case



member score

2 : 83
1 : 70
3 : 55
…

For all tracks whose mid point lies in a given lat-long box compute mean strike prob along a -12h to +12h track segment…

User might click in the lat-long box of interest to bring up the results in a column format…

Finally the user might click on the member number to show the representative part of that member's synoptic chart animation

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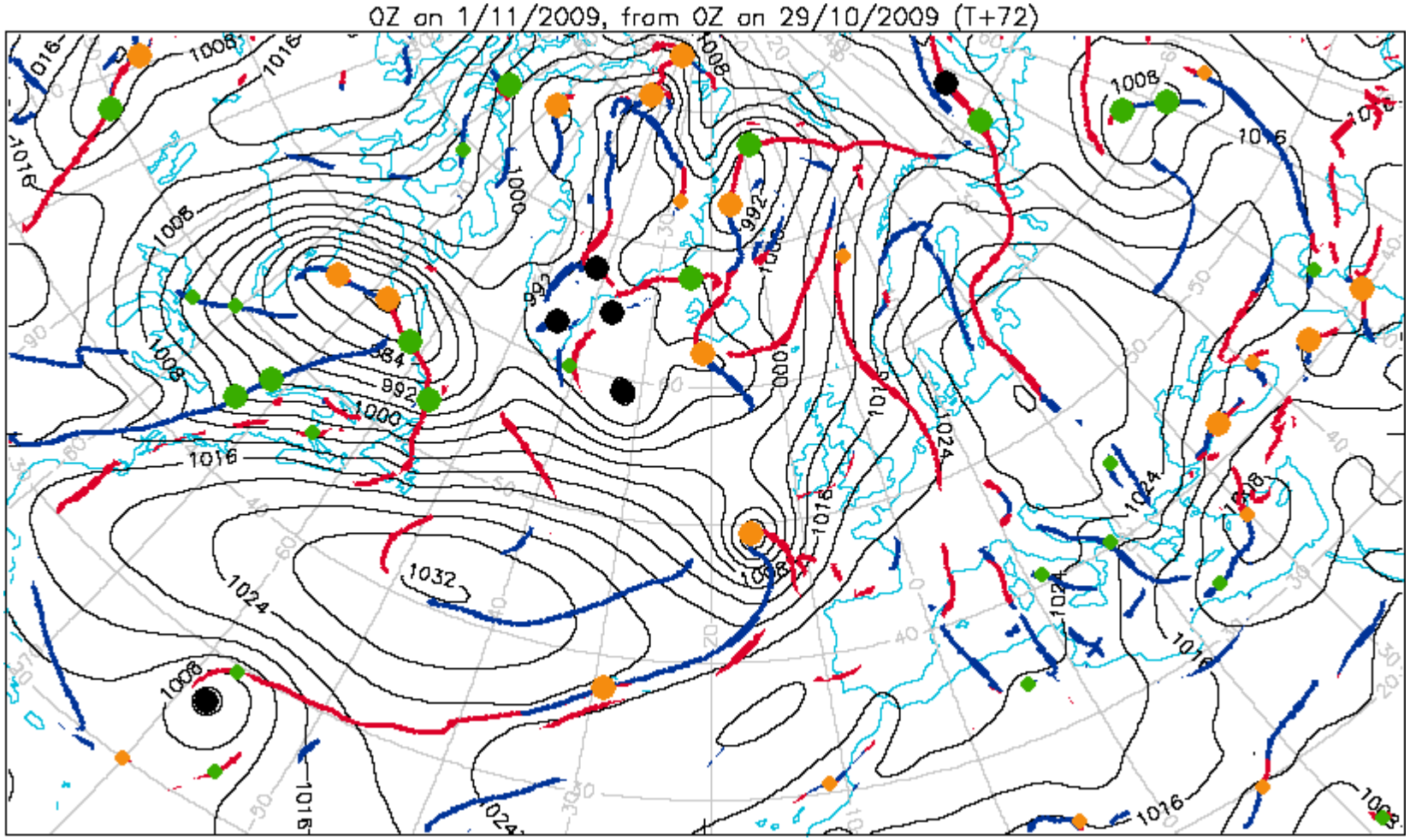
The ‘Representative member’



ECMWF

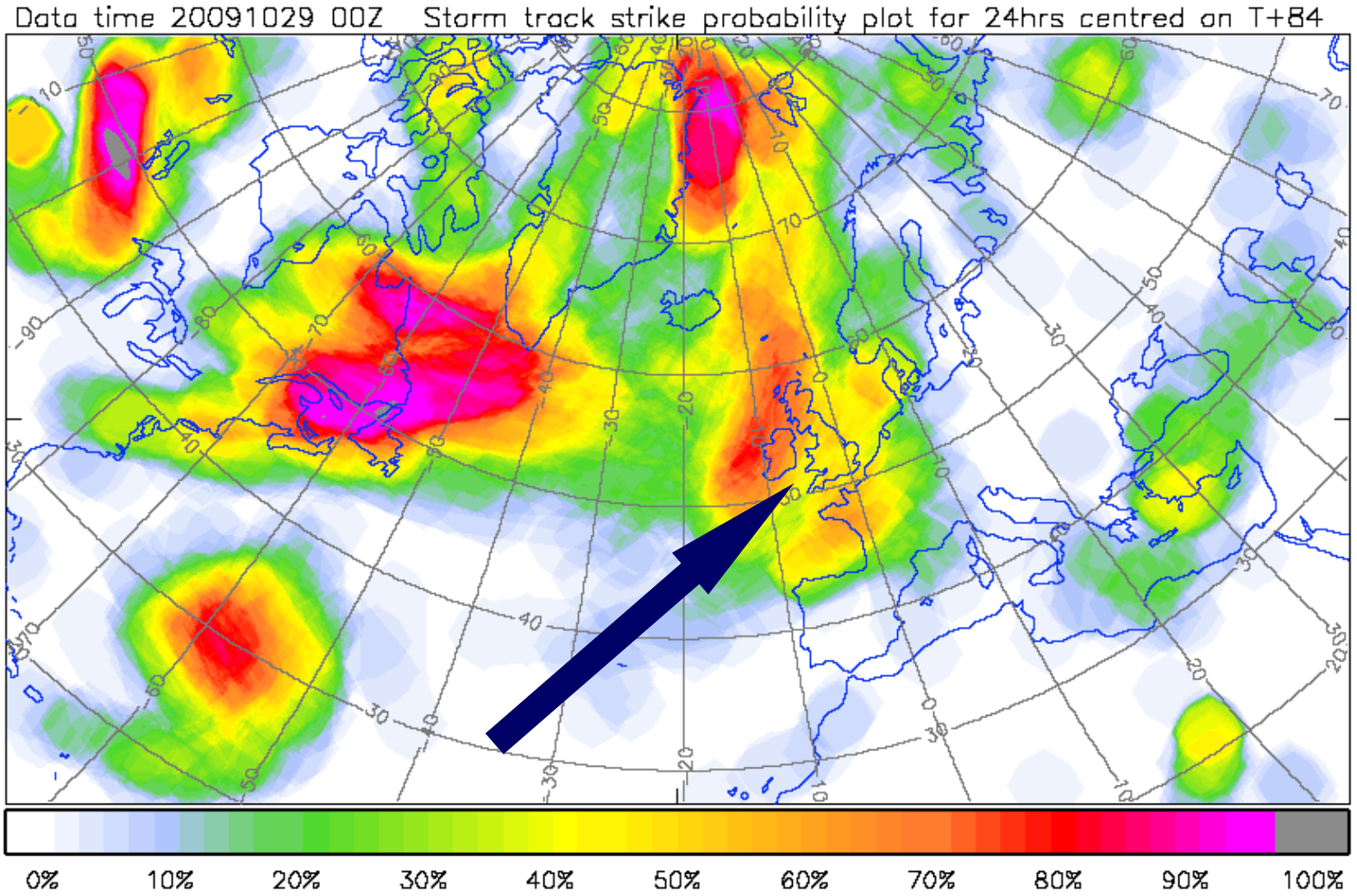
Coding this calculation

- Want to compute ‘mean strike prob’ along track
- Technically involves blending of two images, the ‘strike prob’ image and the ‘single track’ image
- Then need to compute ‘mean colour’ along track
- In PV-Wave such operations are straightforward…

Schematic of coding structure required

```
For a=1 to NoOfTracksInLatLongBox do
Begin
    TV(StrikeProbImage(LeadTime))
    A=TVRD(screen)
    Plot( TracksInBox[a,0:2,0:2], colour=1)
    B=TVRD(screen)
    Indices=(WHERE(B eq 1), count)
    C=A[Indices]
    Out2=(1/count)*C
    Out1=Member[a]
    Print, Out1, Out2 ;      (sort first)
End
```

Example – From Nov 1st Flood case



member	score
2	83
1	70
3	55
…	

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The Most Representative Member

- **Plotted values provide a semi-quantitative measure of 'representivity'**
- **For the feature of interest, in the region of interest, at the time of interest, at the threshold of interest, the highest scoring member can be considered the most representative within the EPS (provided representivity is > ~ 50%)**
- **Over many cases, if the EPS is 'reliable' in its handling of synoptic features, this approach to member selection should yield the lowest errors in feature tracks**
- **Feature track is CRITICAL for determining adverse weather (heaviest rain to N, strongest winds to S, snow to N in winter, etc)**
- **This methodology would thus be well-suited to the needs of operational forecasting (related interest/requests received from Finland and Germany)**
- **Deterministic run could easily be blended into the strike prob plot by applying weight, relative to an EPS member, as a function of lead time, but how much weight...?**

6. Summary and Outlook

- **ECMWF continues to introduce new products tailored to forecaster's needs, whilst at the same time exploiting new web technology**
- **More use is being made of hindcast data, to place forecasts in a 'climatological' context, following on from concepts underpinning the EFI**
- **EFI-related products are likely to be expanded – more variables, longer leads, more time windows…**
- **Resolution of the Pseudo imagery products should increase soon**
- **Synoptic-feature-based approach relates closely to forecasting practice, has great potential for expansion, and can also be used for verification that implicitly targets scenarios conducive to high impact weather**

See Hewson, 2009. ECMWF Newsletter (Autumn).

Access to Products

- **For the pseudo-imagery products go to:**

www.ecmwf.int/products/forecasts/d/charts/medium/deterministic/simulated/sim/

- **For the 'Clickable EFI' go to:**

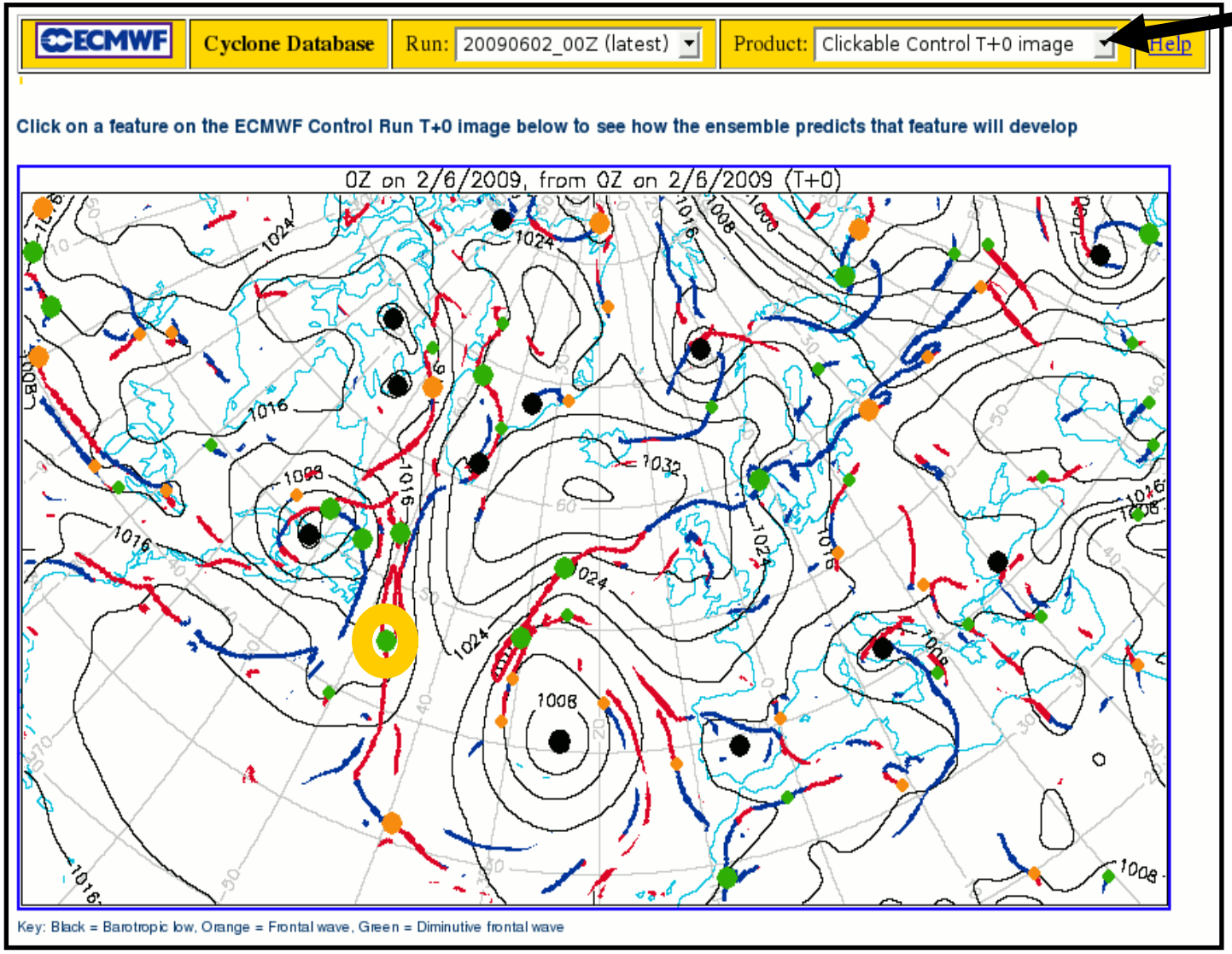
www.ecmwf.int/products/forecasts/d/charts/medium/eps/interactive/globalefi/

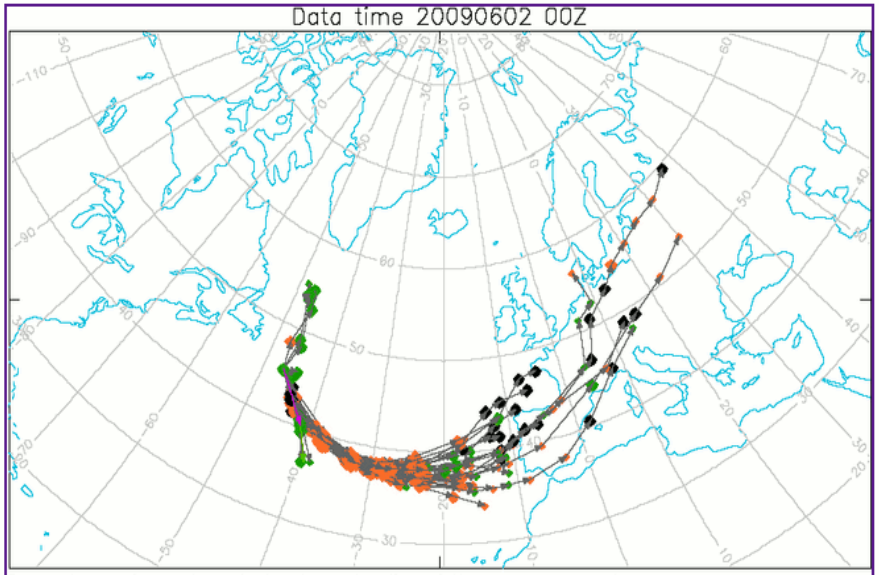
- **For the 'Cyclone Database' (temporary location) go to:**

nwmstest.ecmwf.int/products/forecasts/cdb/

Supplementary slides follow

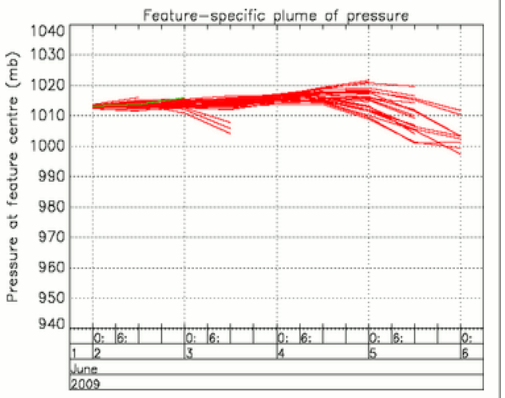
New Cyclone Database web interface:

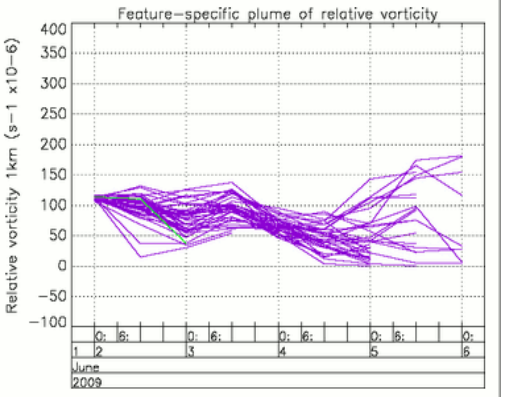


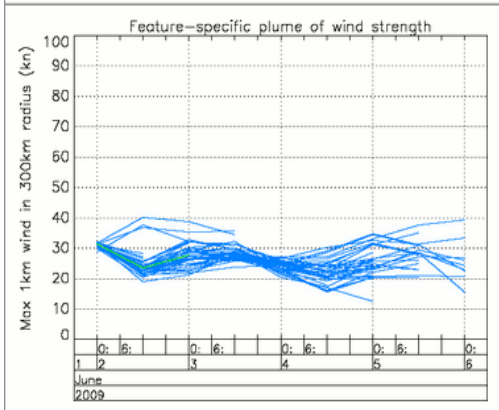


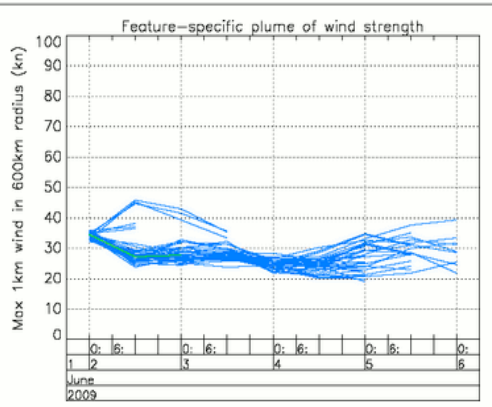
Percentage of members in track, and a list of the member numbers:

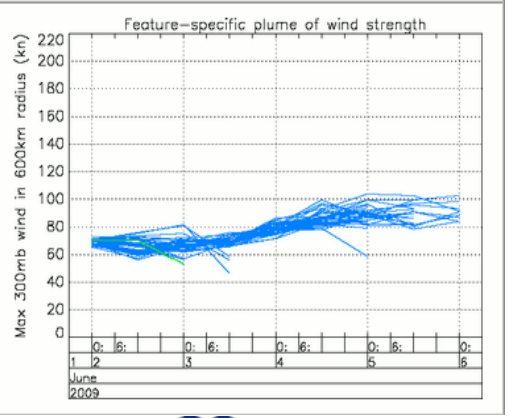
T+ 0:	100%	0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 12:	98%	0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
T+ 24:	86%	0,1,2,3,4,5,7,8,9,10,11,12,13,15,16,18,19,20,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,46,47,48
T+ 36:	78%	1,2,3,4,5,7,9,10,11,12,13,16,19,20,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,46,47,48
T+ 48:	72%	1,2,3,4,5,7,9,10,11,12,13,16,19,20,22,23,25,26,27,28,29,30,31,32,33,34,35,36,38,39,41,42,43,44,48,47,48
T+ 60:	72%	1,2,3,4,5,7,9,10,11,12,13,16,19,20,22,23,25,26,27,28,29,30,31,32,33,34,35,36,38,39,41,42,43,44,46,47,48
T+ 72:	66%	1,2,3,4,5,9,10,11,12,13,19,20,22,23,25,26,27,28,29,30,31,32,33,34,35,38,38,39,41,42,43,44,46,47
T+ 84:	37%	1,4,5,9,10,13,20,22,26,27,28,29,30,31,32,35,38,43,47
T+ 96:	17%	1,4,20,22,28,29,30,32,43



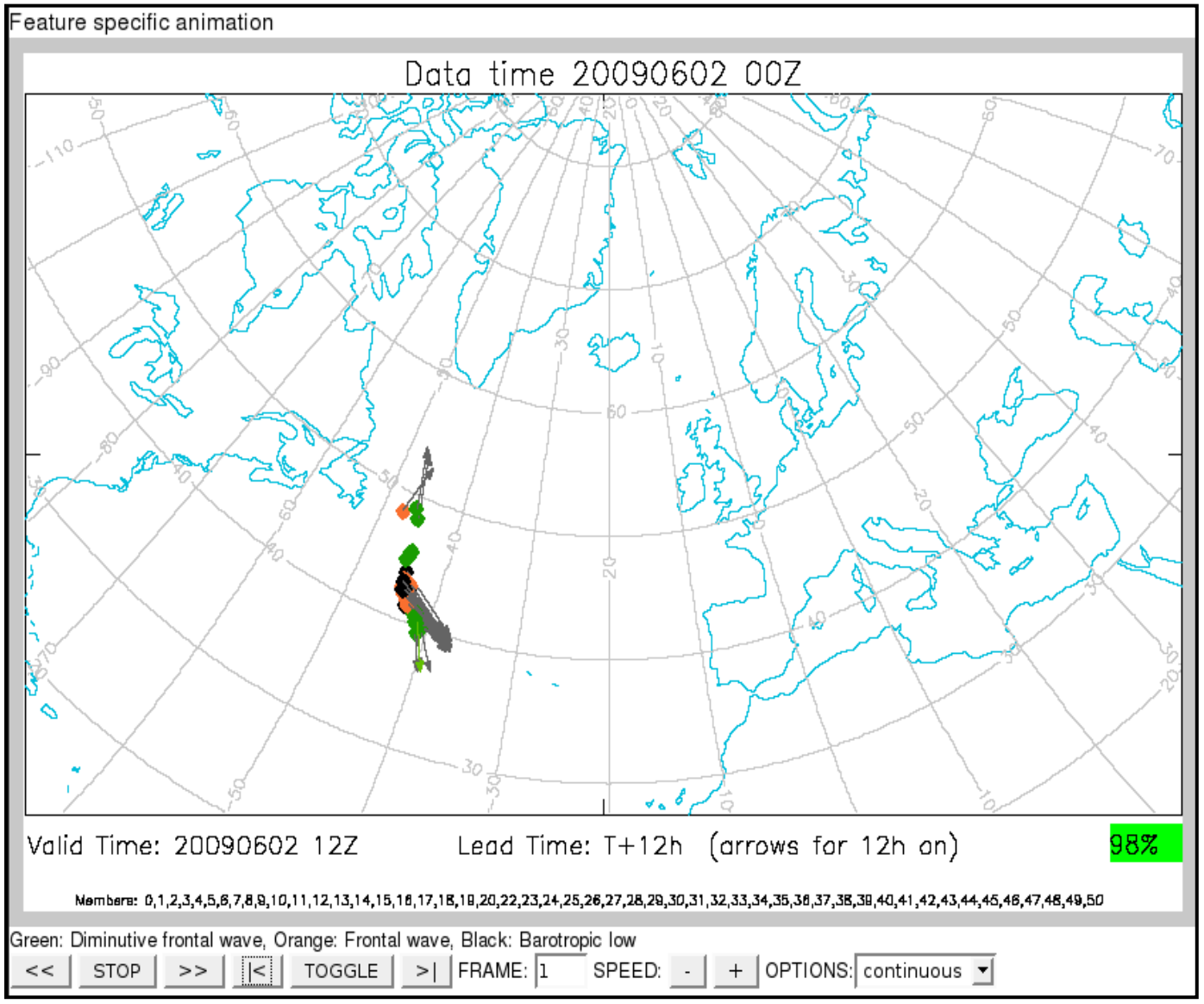


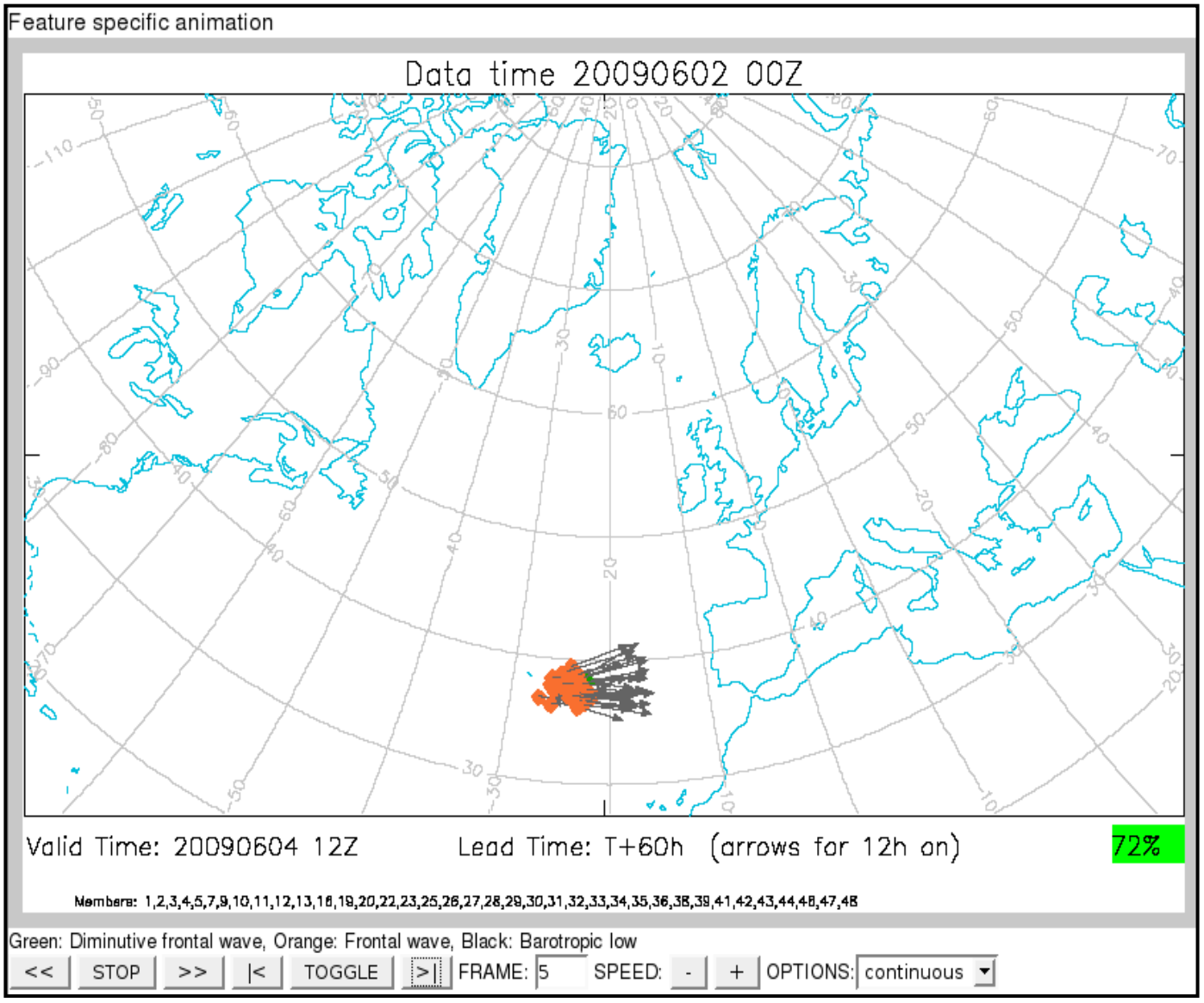




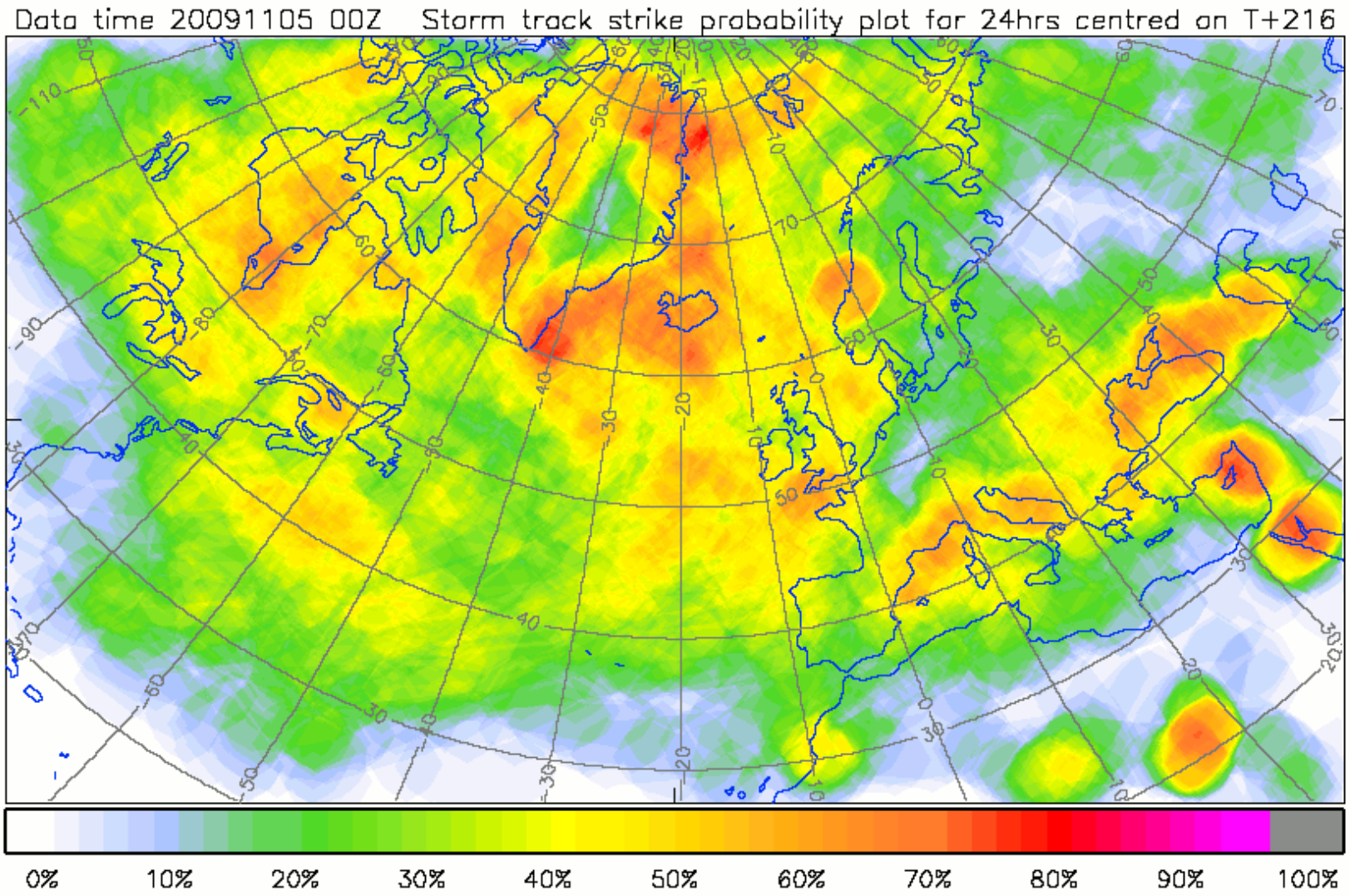


ECMWF


Feature specific animation
Data time 20090602 00Z
Valid Time: 20090602 12Z
Lead Time: T+12h (arrows for 12h on)
98%
Members: 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50
Green: Diminutive frontal wave, Orange: Frontal wave, Black: Barotropic low
<< STOP >> |< TOGGLE >| FRAME: 1 SPEED: - + OPTIONS: continuous


Feature specific animation
Data time 20090602 00Z
Valid Time: 20090604 12Z
Lead Time: T+60h (arrows for 12h on)
72%
Members: 1,2,3,4,5,7,9,10,11,12,13,16,18,20,22,23,25,26,27,28,29,30,31,32,33,34,35,36,38,39,41,42,43,44,46,47,48
Green: Diminutive frontal wave, Orange: Frontal wave, Black: Barotropic low
<< STOP >> |< TOGGLE >| FRAME: 5 SPEED: - + OPTIONS: continuous

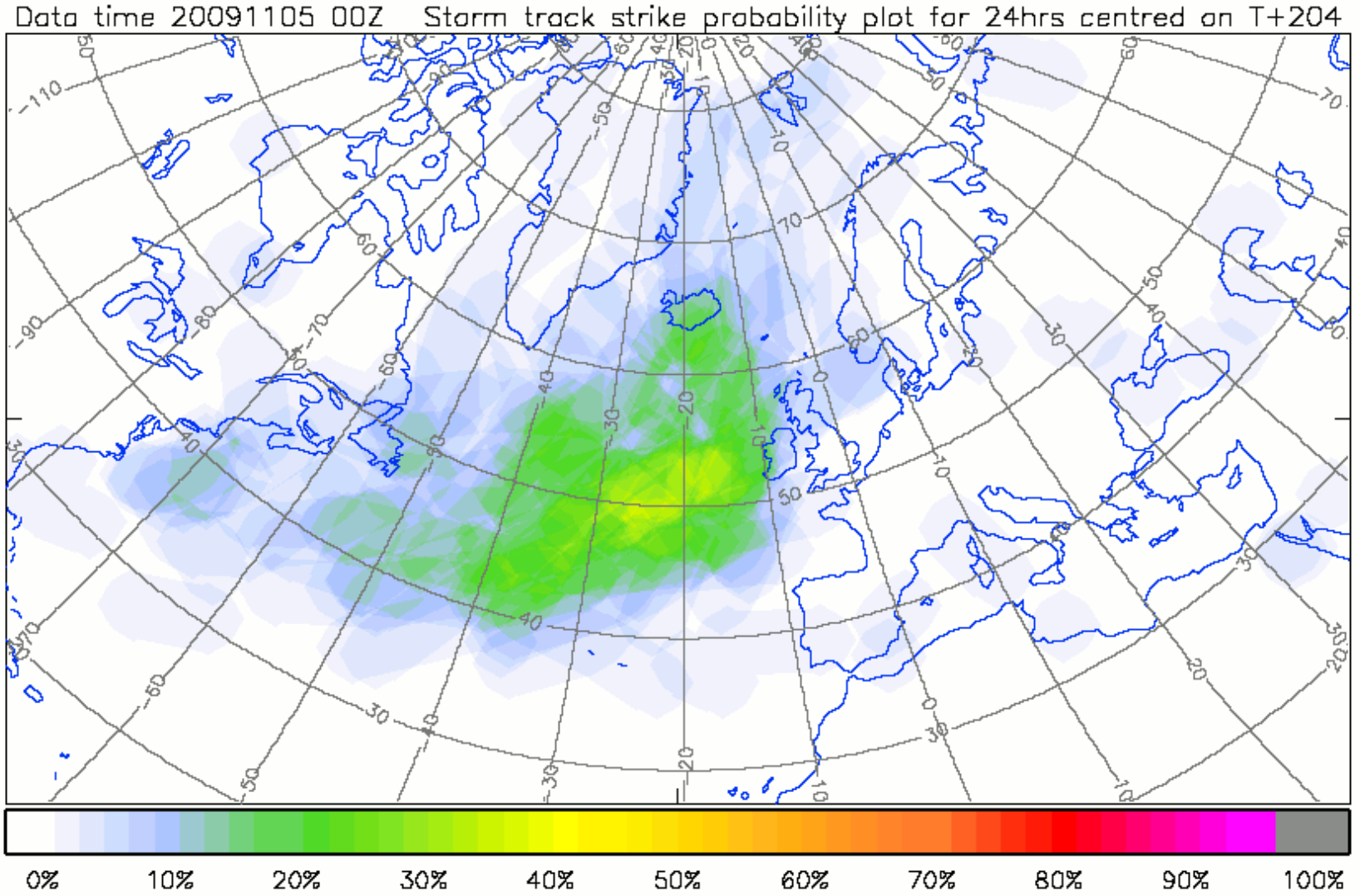
ECMWF | Cyclone Database | Run: 20091105_00Z (latest) | Product: Strike prob (all features) | Help



Maps show the number of members predicting a cyclonic feature tracking within 300km of each point in a 24-hour period.

<< | STOP | >> | |< | TOGGLE | >| Frame: 18 SPEED: - + OPTIONS: continuous

ECMWF | Cyclone Database | Run: 20091105_00Z (latest) | Product: Strike prob (1km wind >60kt) | Help



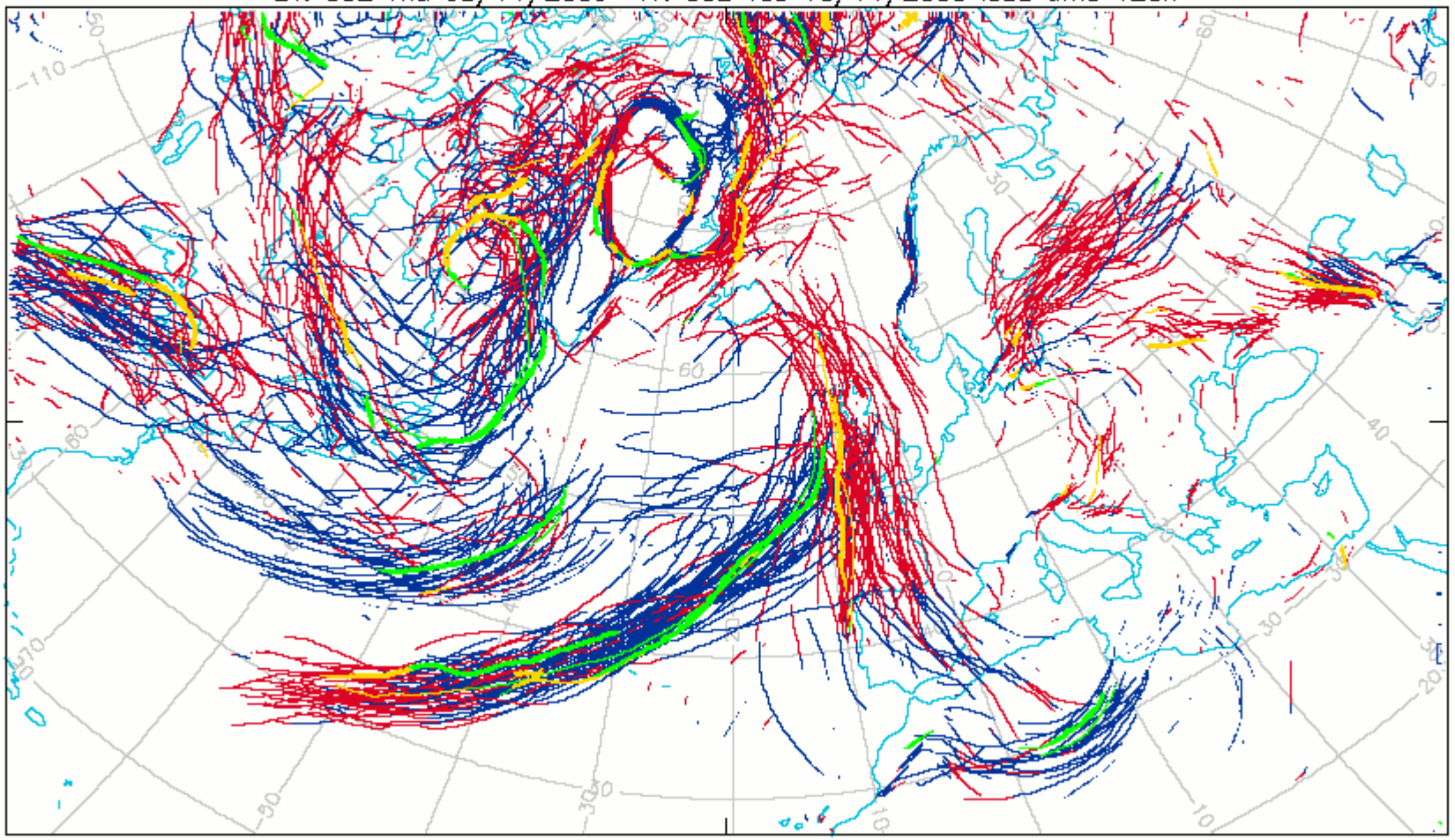
Maps show the probability of a cyclonic feature, with max 1km wind speed within 300km > 60 knots, tracking within 300km of each point in a 24-hour period.

<< | STOP | >> | |< | TOGGLE | >| Frame: 17 SPEED: - + OPTIONS: continuous

ECMWF | Cyclone Database | Run: 20091105_00Z (latest) | Product: Fronts Animation | Help

ECMWF spaghetti plot of fronts

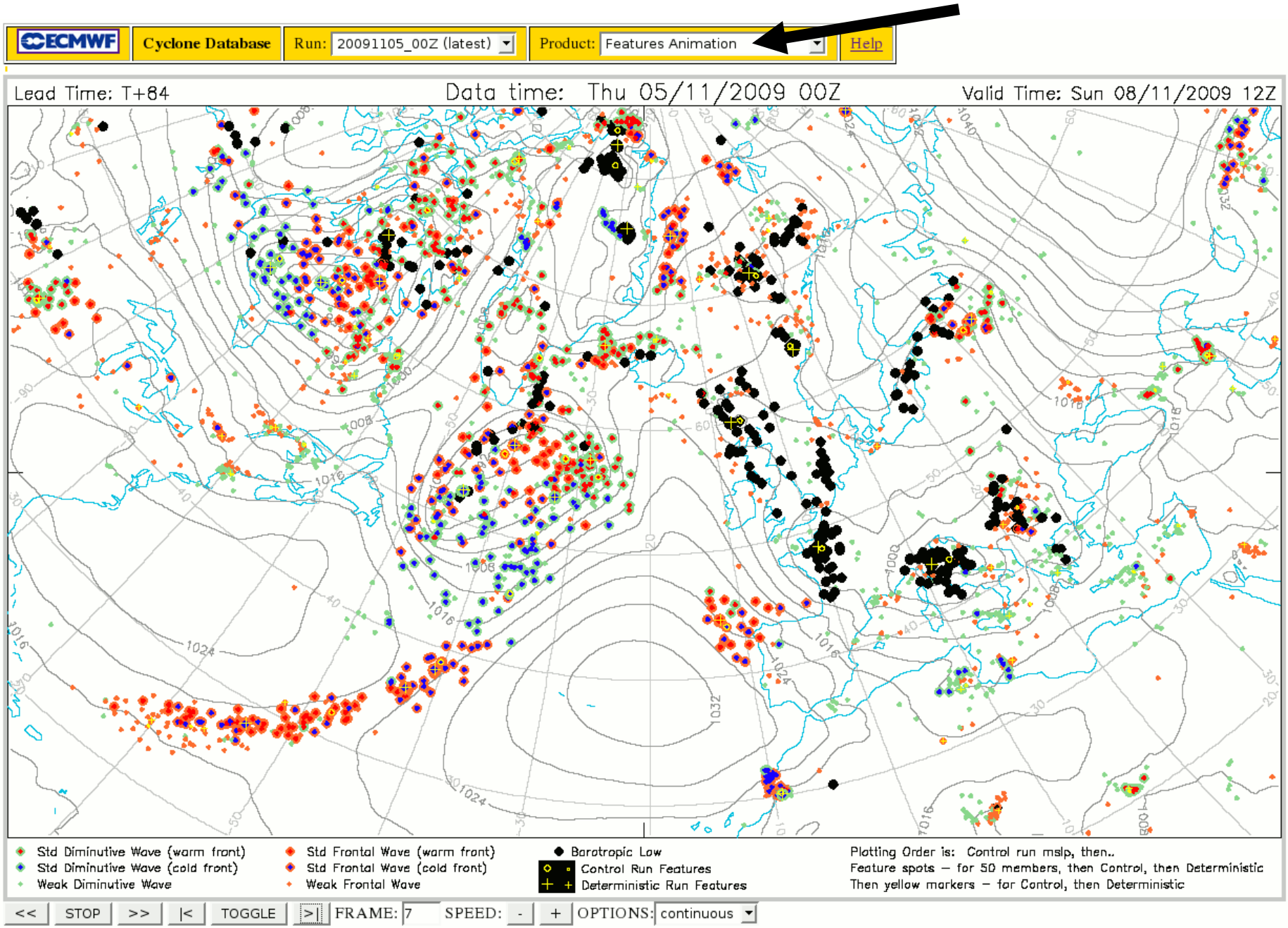
DT: 00Z Thu 05/11/2009 VT: 00Z Tue 10/11/2009 lead time 120h



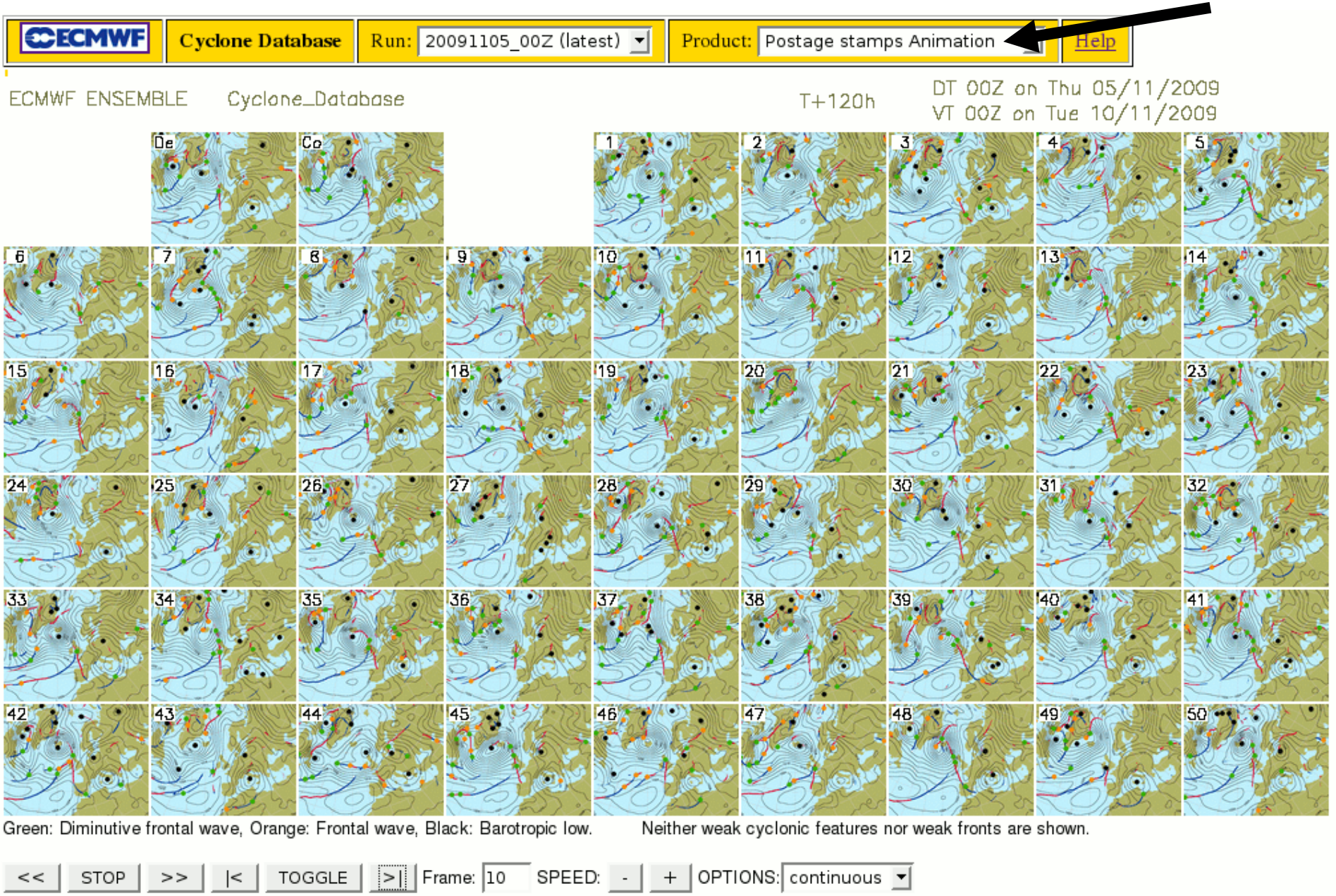
Blue=cold front, Red=warm front. Green/Gold=fronts in control (thin) & deterministic (thick). Weak fronts not shown.

<< | STOP | >> | |< | TOGGLE | >| | FRAME: 10 | SPEED: - + | OPTIONS: continuous

ECMWF


ECMWF
Cyclone Database
Run: 20091105_00Z (latest)
Product: Features Animation
Help
Lead Time: T+84
Data time: Thu 05/11/2009 00Z
Valid Time: Sun 08/11/2009 12Z
Std Diminutive Wave (warm front)
Std Diminutive Wave (cold front)
Weak Diminutive Wave
Std Frontal Wave (warm front)
Std Frontal Wave (cold front)
Weak Frontal Wave
Barotropic Low
Control Run Features
Deterministic Run Features
Plotting Order is: Control run mslp, then..
Feature spots – for 50 members, then Control, then Deterministic
Then yellow markers – for Control, then Deterministic
<< STOP >> |< TOGGLE >| FRAME: 7 SPEED: - + OPTIONS: continuous

ECMWF


ECMWF
Cyclone Database
Run: 20091105_00Z (latest)
Product: Postage stamps Animation
Help
ECMWF ENSEMBLE Cyclone_Database
T+120h
DT 00Z on Thu 05/11/2009
VT 00Z on Tue 10/11/2009
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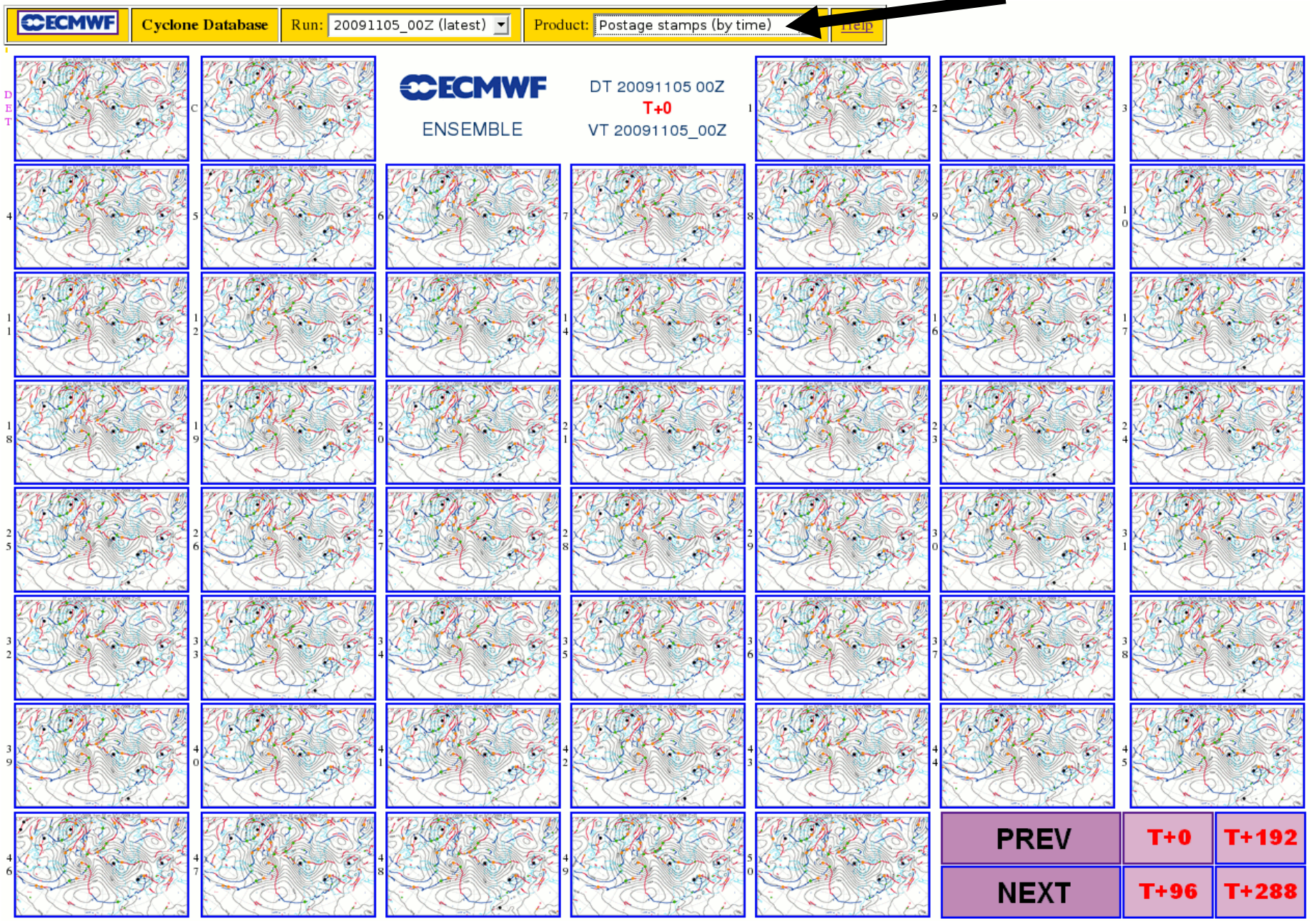
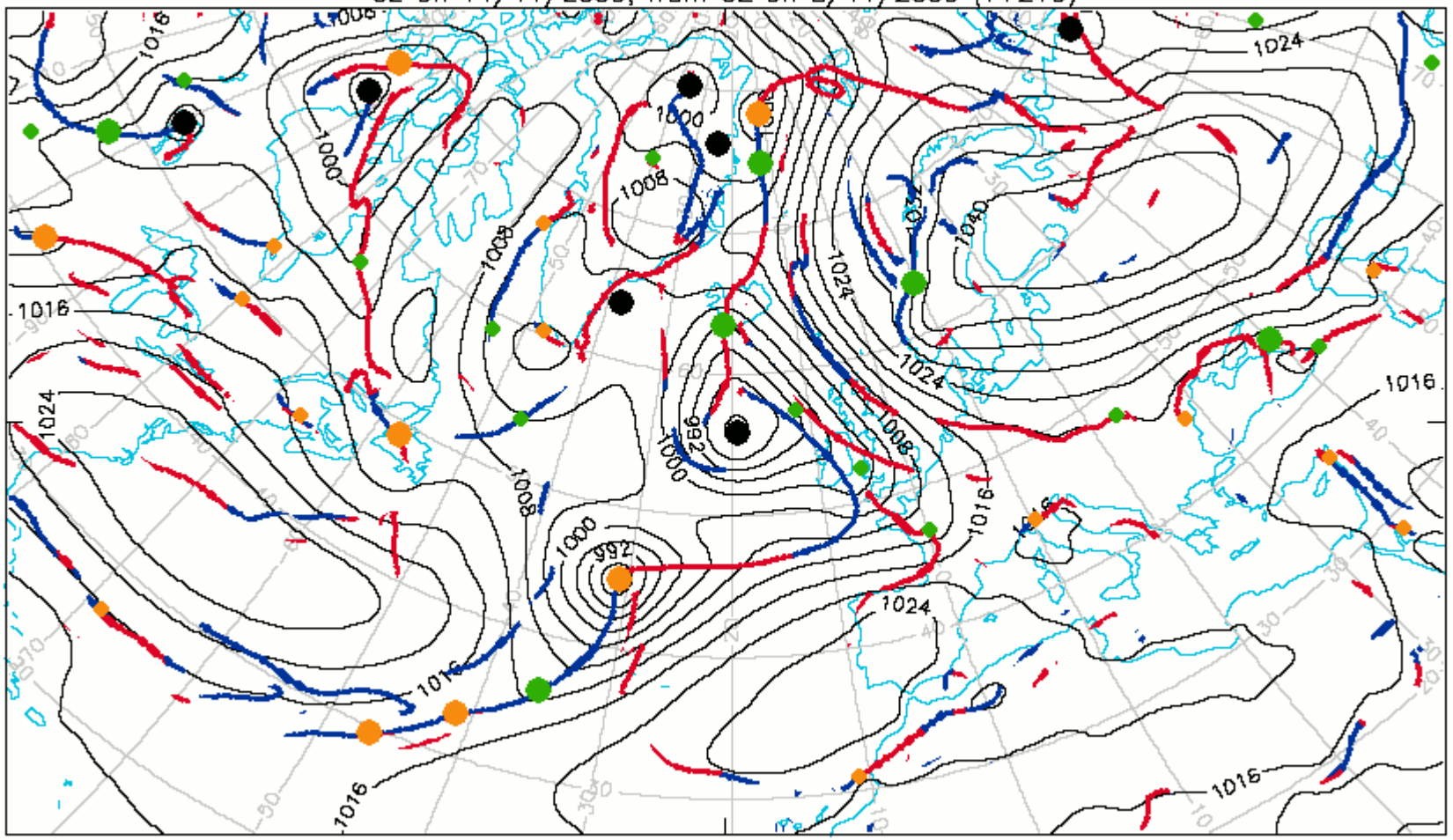
Green: Diminutive frontal wave, Orange: Frontal wave, Black: Barotropic low.
Neither weak cyclonic features nor weak fronts are shown.
<< STOP >> |< TOGGLE >| Frame: 10 SPEED: - + OPTIONS: continuous


ECMWF
Cyclone Database
Run: 20091105_00Z (latest)
Product: Postage stamps (by time)
Help
ECMWF
ENSEMBLE
DT 20091105 00Z
T+0
VT 20091105_00Z
DET
PREV
T+0
T+192
NEXT
T+96
T+288

ECMWF

ECMWF | Cyclone Database | Run: 20091105_00Z (latest) | Product: Animation of Deterministic | Help

ECMWF Deterministic animation



Green: Diminutive frontal wave, Orange: Frontal wave, Black: Barotropic low

<< | STOP | >> | |< | TOGGLE | >| | FRAME: 18 | SPEED: - + | OPTIONS: continuous

Strike Probabilities

- **Met Office strike probability verification suggests some skill in predicting intense storms in week 2 – e.g. :**

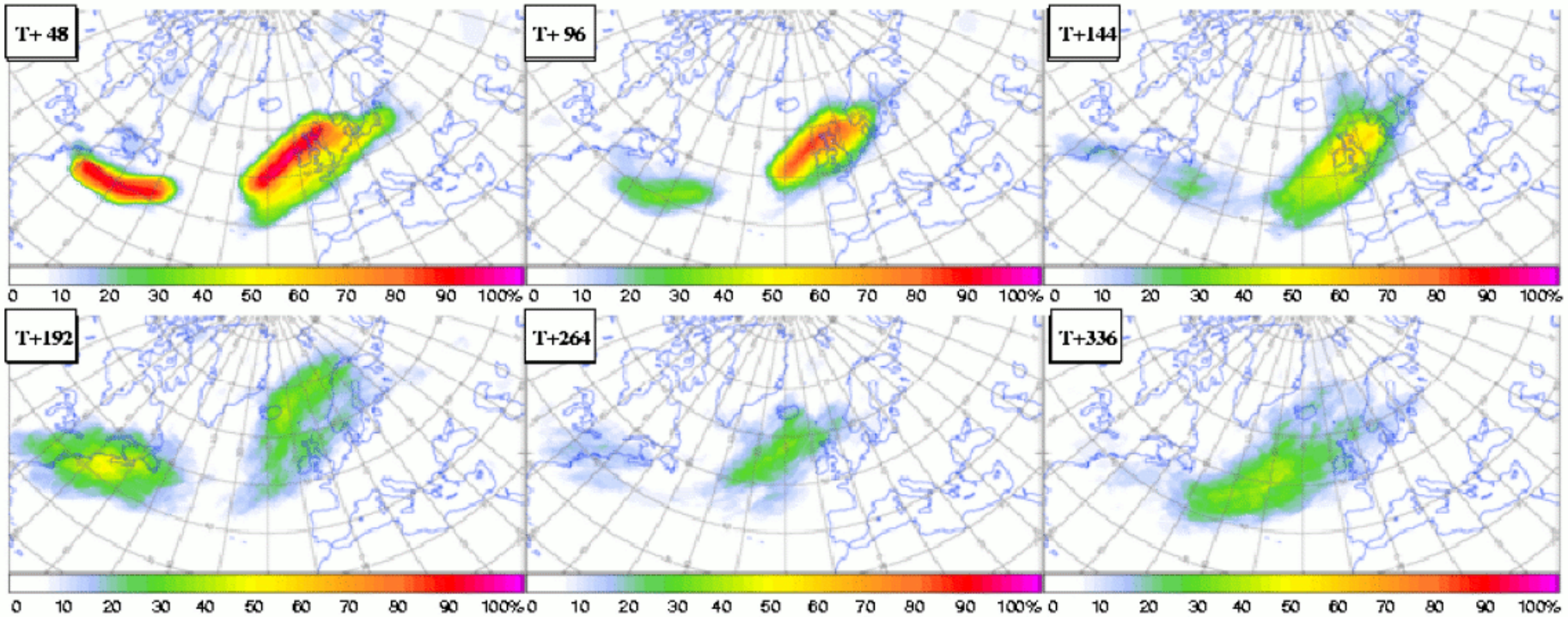
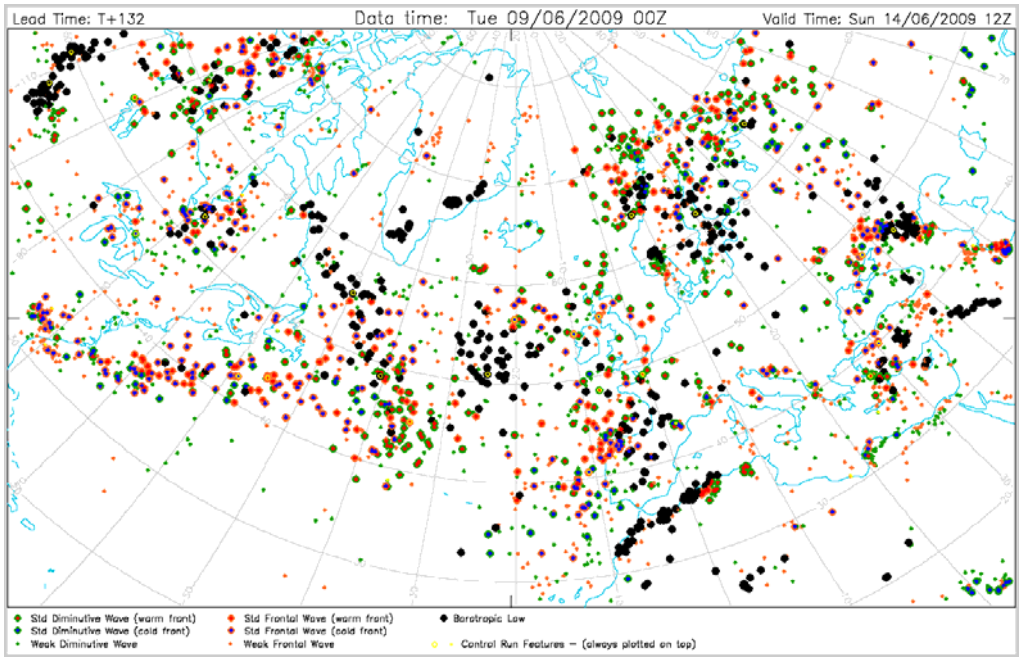


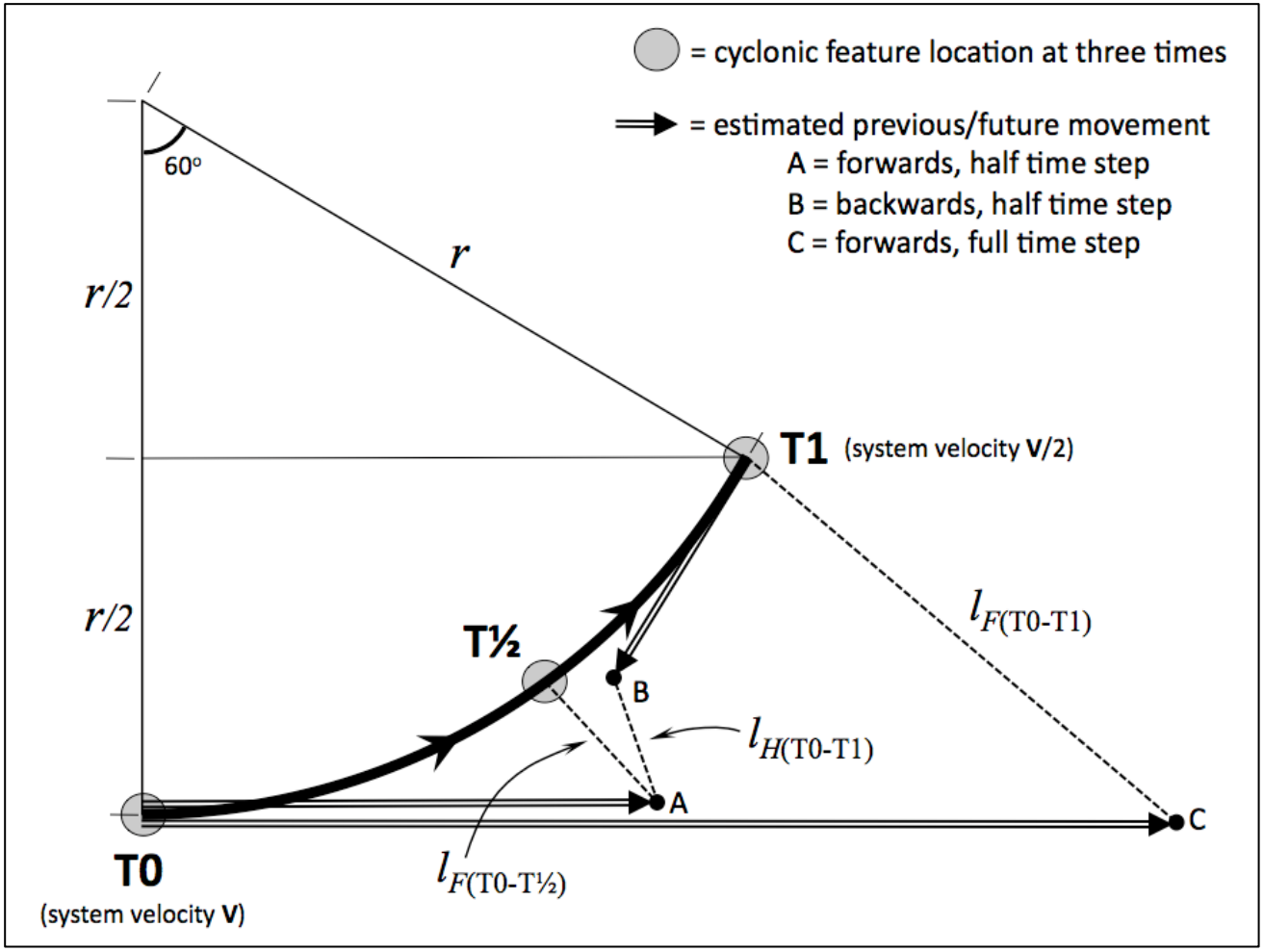
Figure 4.2.9: ECMWF EPS: Probability of a cyclonic feature with 1km winds > 60 knots tracking within 300km in a 24-hour period centred on VT 12Z 31/12/2006

A new name for the ‘feature spot’ chart?



‘Dalmatian chart’ ?

‘Half-time tracking’



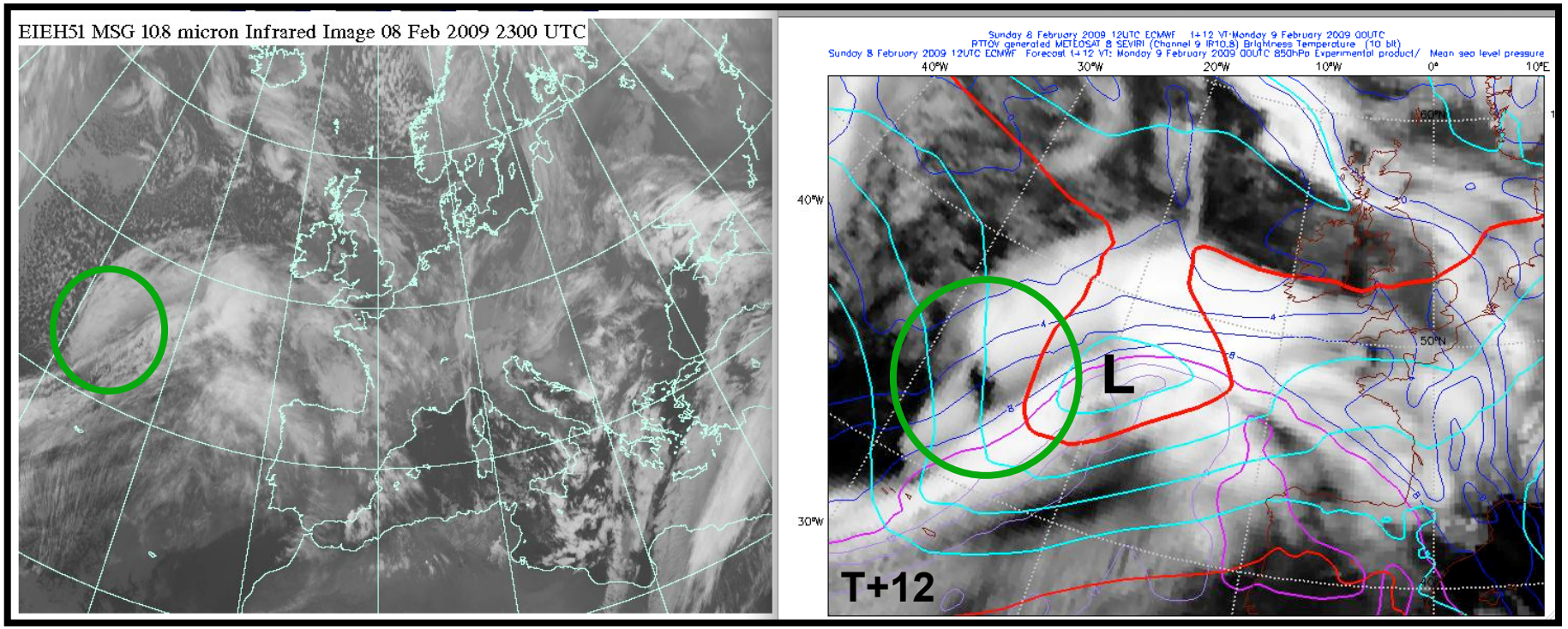
Tracking

- **'Half-time tracking' exhibits considerable benefits compared to most other previously used methods**

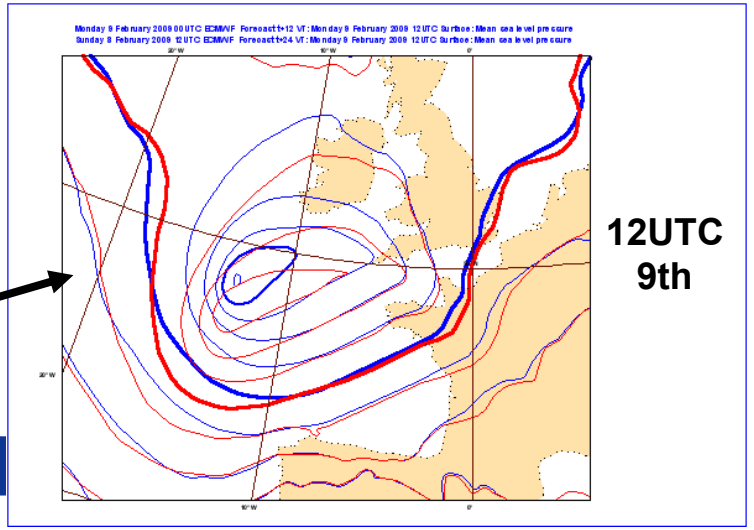
- **Feature-matching performed *across the ensemble* at time zero is used separately, to associate features for the 'plume diagrams'**

- **In each EPS run: 15 days, at 12h intervals, times 51 members gives ~85000 feature points to deal with (North Atlantic domain)!**

‘Quinten’ - 00UTC 9 Feb - e.g. of use of simulated IR product



- **Signs that model was going awry with track – break developing in cloud head (simulated), to SW O of low centre L, implying descent. No such signatures in real IR sequences – so low too far N in model.**
- **Simply illustrates that mismatch can allow model error to be inferred.**
- **Next run (red, at T+12) corrected this error (previous run in blue, at T+24).**



12UTC 9th