Forms show forecasts of 2m temperature, for a given day, at some central European location

There are 8 scenarios (A to H)

Successive columns show forecasts from 4.5, 4, 3.5 and 3 days out

For each scenario:

In the first box enter your forecast of 2m temperature (half degrees are allowed)

In the second box enter a confidence level for your forecast – high medium or low (H, M or L)

Put your name on the sheet (they can be returned!).

ECMWF

Forecast Jumpiness

Tim Hewson

Thanks to Ervin Zsoter, Ivan Tsonevsky and David Richardson

ECMWF

Motivation

- **ECMWF quite often receives feedback regarding unwanted / unexpected 'jumps' in the forecast**

- **Commonly these refer to the HRES, but sometimes also to the ENS**

- **To what extent is the feedback justified ?**

- **Are there ways in which a forecaster can deal more effectively with apparent jumps in the forecast ?**

ECMWF

Structure

- **Example**

- **Related research results**

- **Comments on short range 'instabilities'**

- **Summary**
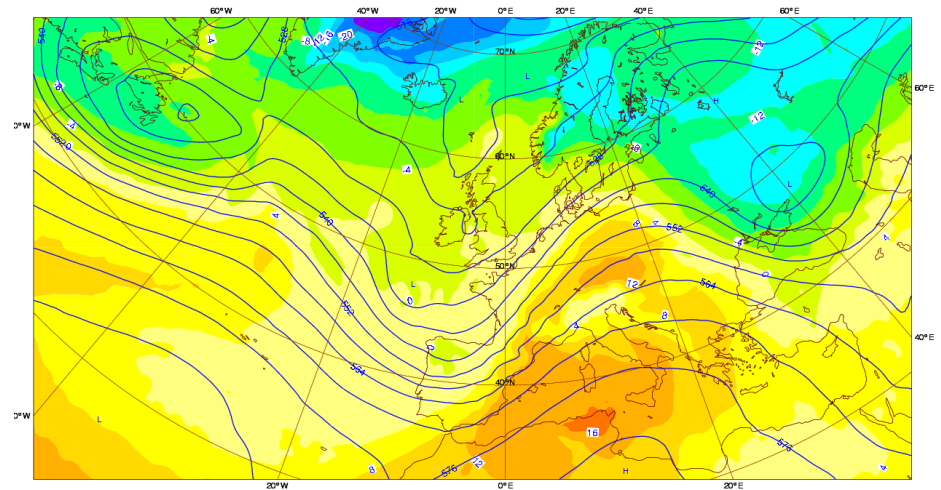
CCECMWF

An Example

- **Medium range forecasts for Belgrade**
  - Christmas Day, 2012

- **Jump in HRES and ENS, at the 5 to 6 day lead time**

ECMWF

VT: 25/12/2012 00UTC

Wednesday 19 December 2012 00UTC ©ECMWF Forecast t+144 VT: Tuesday 25 December 2012 00UTC
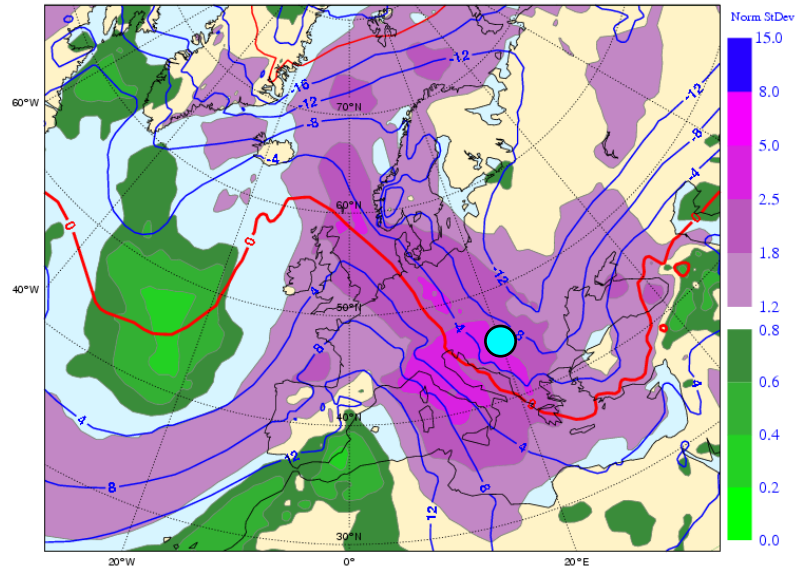850 hPa Temperature / 500 hPa Geopotential

Thursday 20 December 2012 00UTC ©ECMWF Forecast t+120 VT: Tuesday 25 December 2012 00UTC
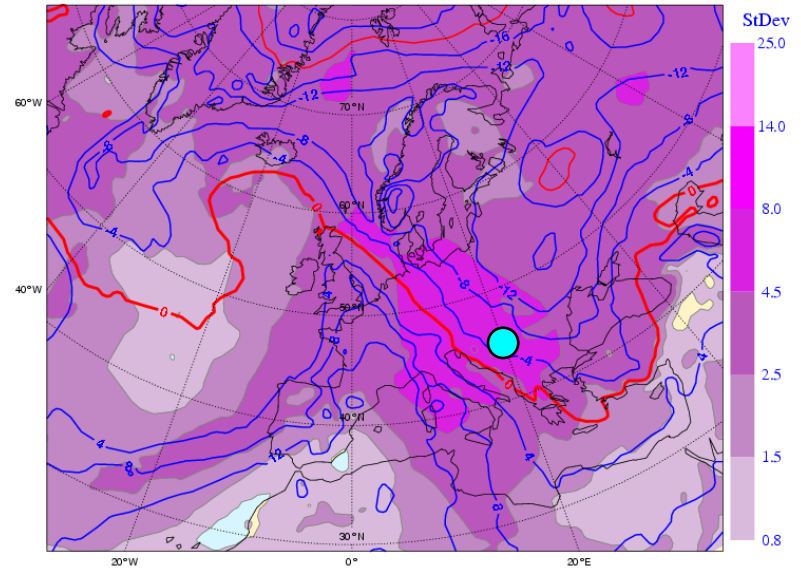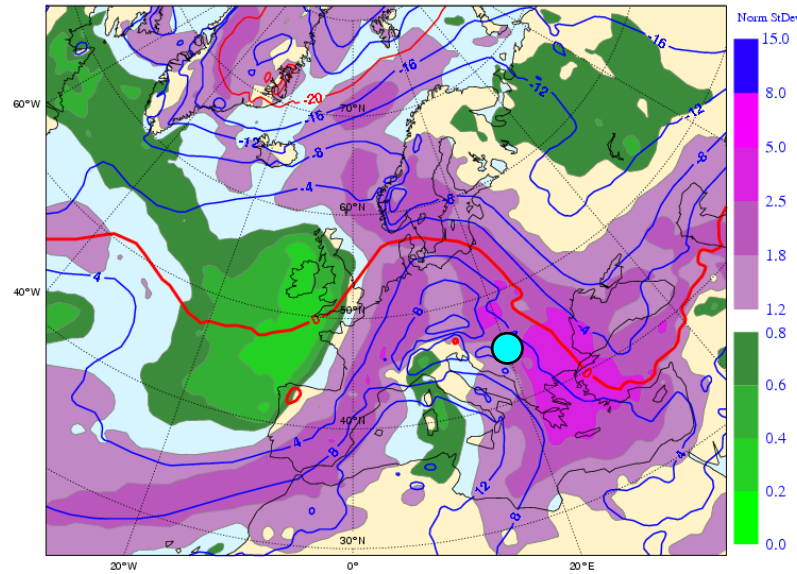850 hPa Temperature / 500 hPa Geopotential

ECMWF

ENS
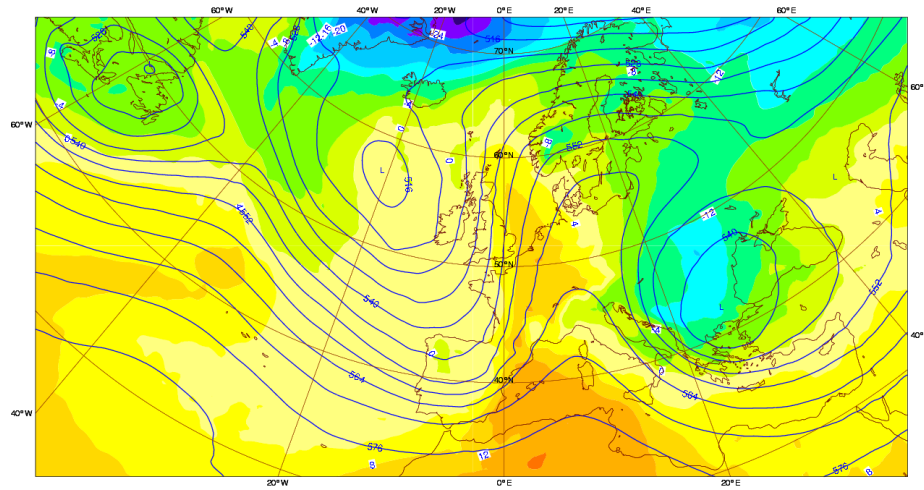
HRES

Tuesday 18 December 2012 00UTC ECMWF Forecast t+144 VT: Monday 24 December 2012 00UTC
850hPa Temperature Deterministic Forecast and Standard Deviation (shaded)

Thursday 20 December 2012 00UTC ECMWF Forecast t+120 VT: Tuesday 25 December 2012 00UTC
850hPa Temperature Ensemble Mean and Normalised Standard Deviation (shaded)

Thursday 20 December 2012 00UTC ECMWF Forecast t+120 VT: Tuesday 25 December 2012 00UTC
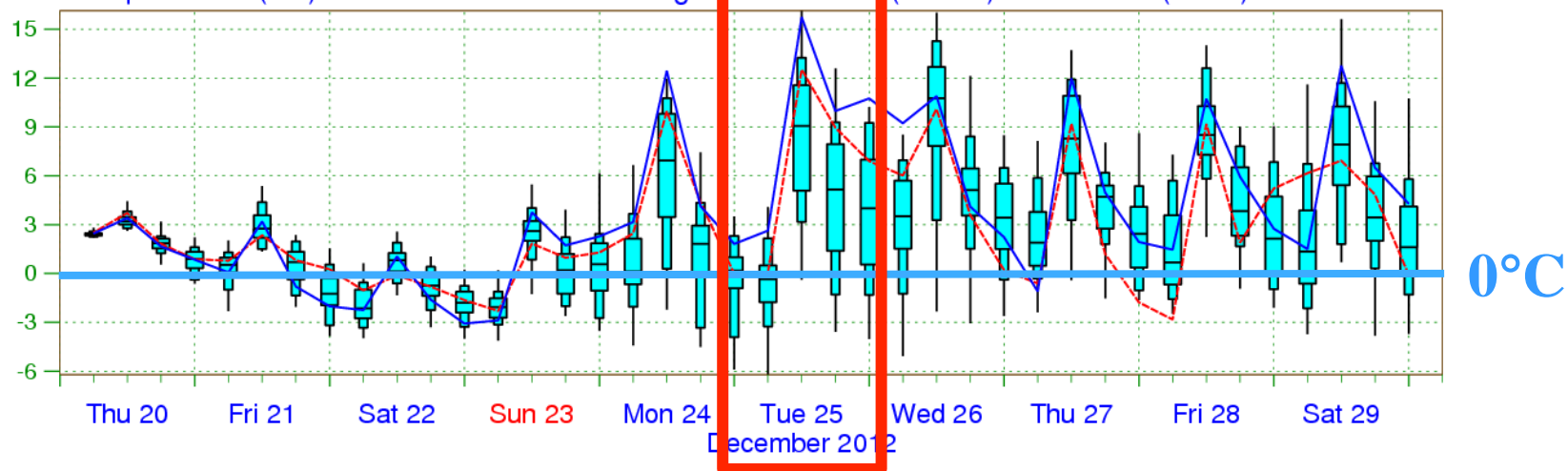850hPa Temperature Deterministic Forecast and Standard Deviation (shaded)

Forecast Jumpiness – Products Training Course - Jan/Feb 2015
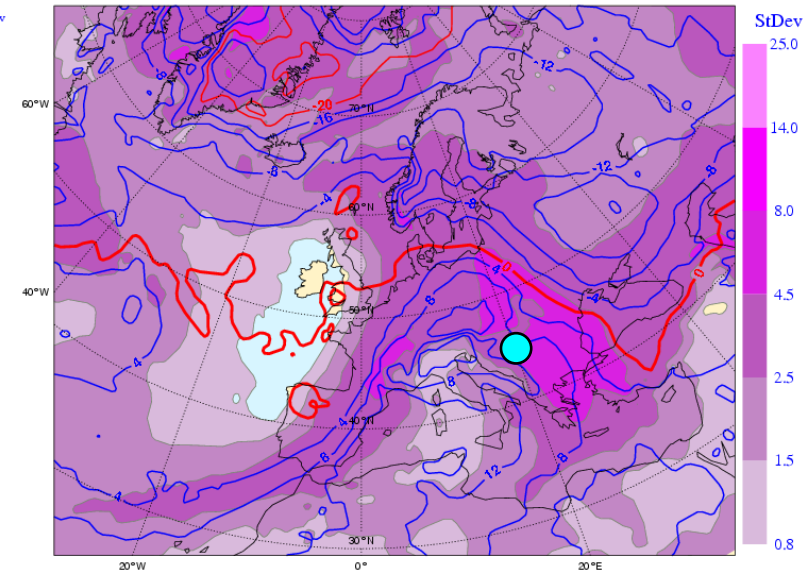
ECMWF

BELGRADE, SERBIA

2m Temperature (°C) reduced to the station height from 218 m (T1279) and 167 m (T639)
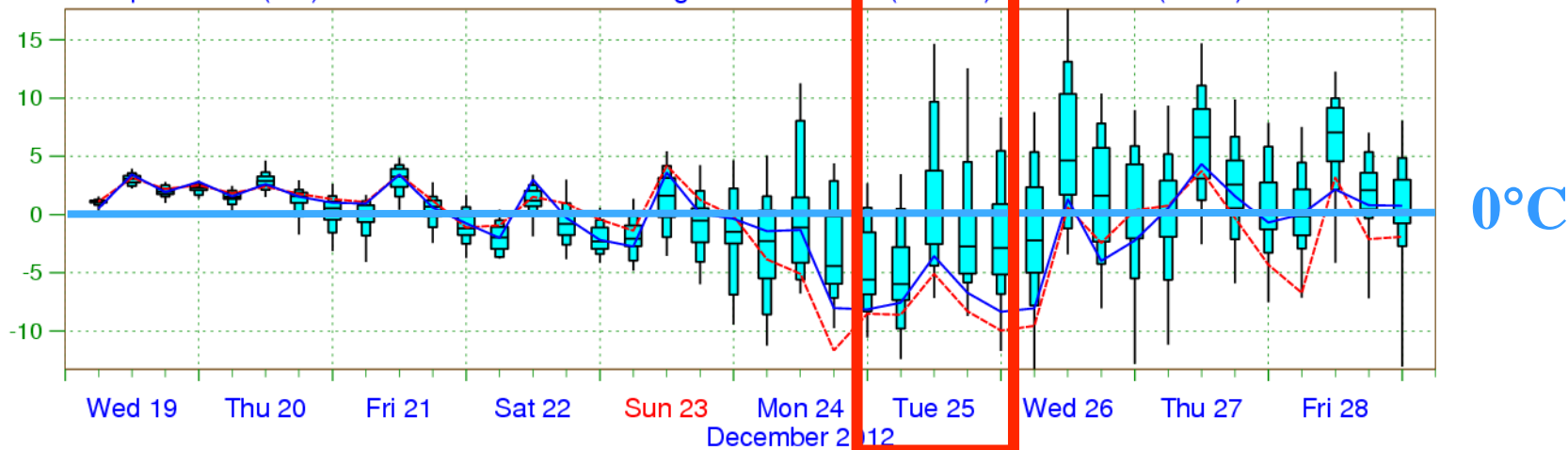
0°C

Wed 19   Thu 20   Fri 21   Sat 22   Sun 23   Mon 24   Tue 25   Wed 26   Thu 27   Fri 28

December 2012

2m Temperature (°C) reduced to the station height from 218 m (T1279) and 167 m (T639)

0°C

Thu 20   Fri 21   Sat 22   Sun 23   Mon 24   Tue 25   Wed 26   Thu 27   Fri 28   Sat 29

December 2012

ECMWF

ECMWF ENSEMBLE FORECASTS FOR: SERBIAMONTENEGR
DATE: 2012121900 BELGRADE LAT: 44.8 LONG: 20.5
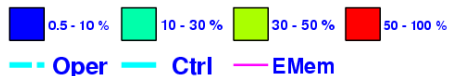
TEMPERATURE 850hPa - Probability for 1.0 deg intervals   Range: 40deg
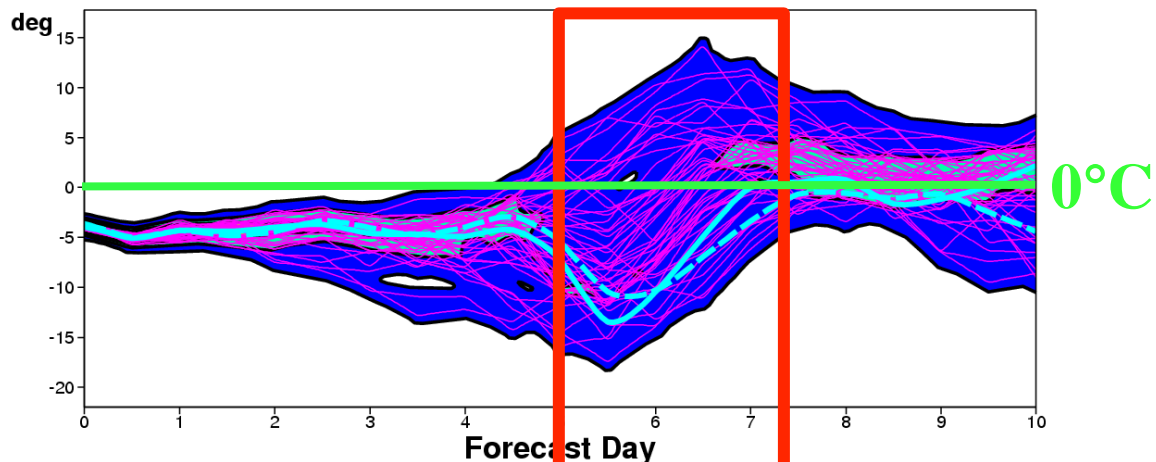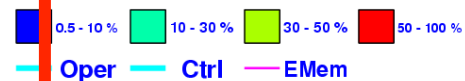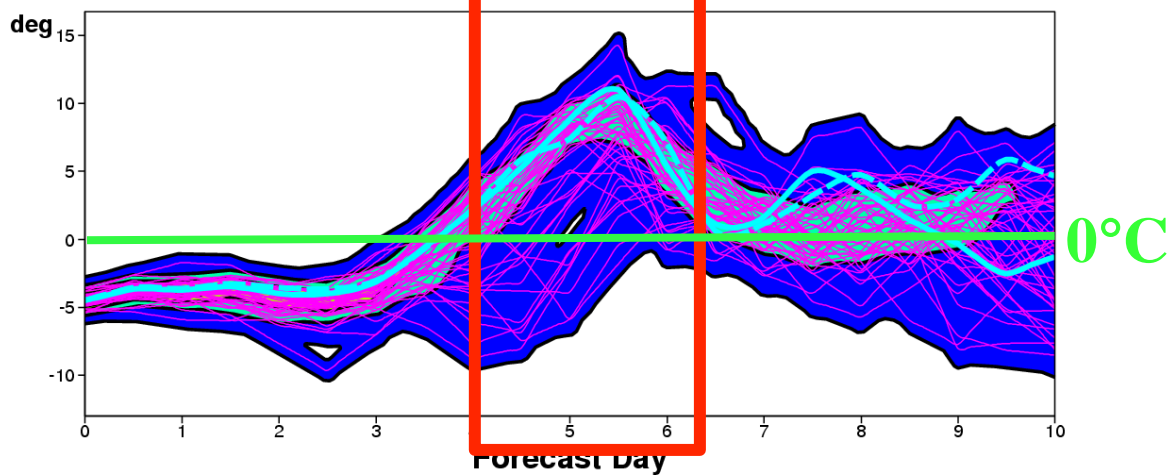
ECMWF ENSEMBLE FORECASTS FOR: SERBIAMONTENEGR
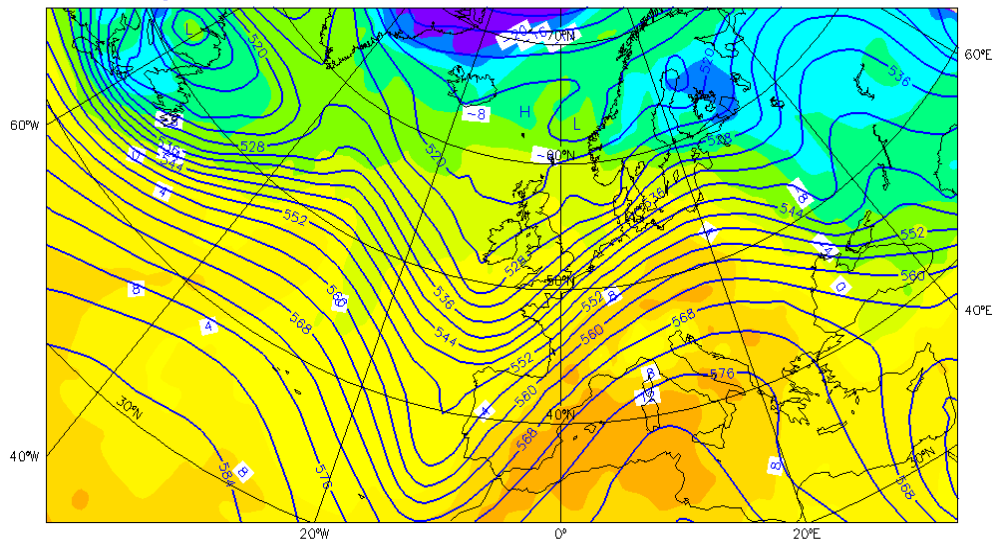DATE: 2012122000 BELGRADE LAT: 44.8 LONG: 20.5

TEMPERATURE 850hPa - Probability for 1.0 deg intervals   Range: 30deg

VT: 25/12/2012 00UTC

Tuesday 25 December 2012 00UTC ECMWF Forecast t+ 0 VT: Tuesday 25 December 2012 00UTC
500 hPa Height / 850 hPa Temperature

← **ANALYSIS**

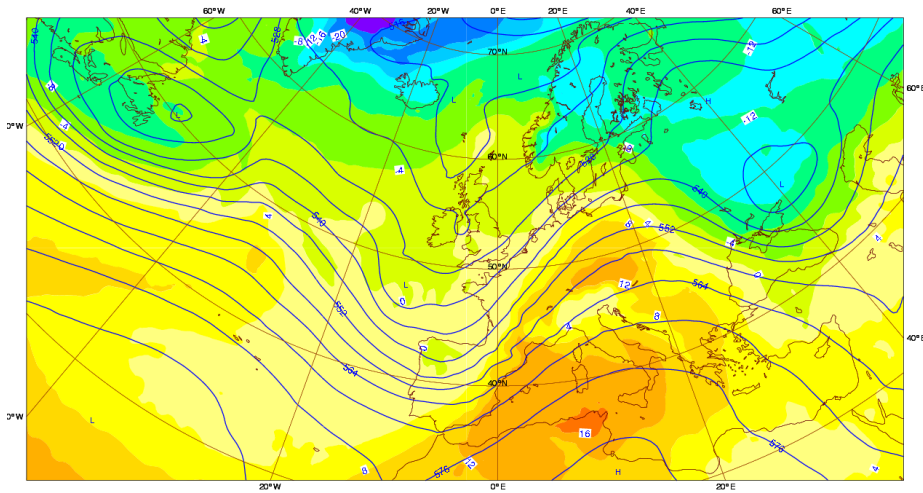Wednesday 19 December 2012 00UTC ©ECMWF Forecast t+144 VT: Tuesday 25 December 2012 00UTC
850 hPa Temperature / 500 hPa Geopotential

Thursday 20 December 2012 00UTC ©ECMWF Forecast t+120 VT: Tuesday 25 December 2012 00UTC
850 hPa Temperature / 500 hPa Geopotential

Forecast Jumpiness – Products Training Course - Jan/Feb 2015
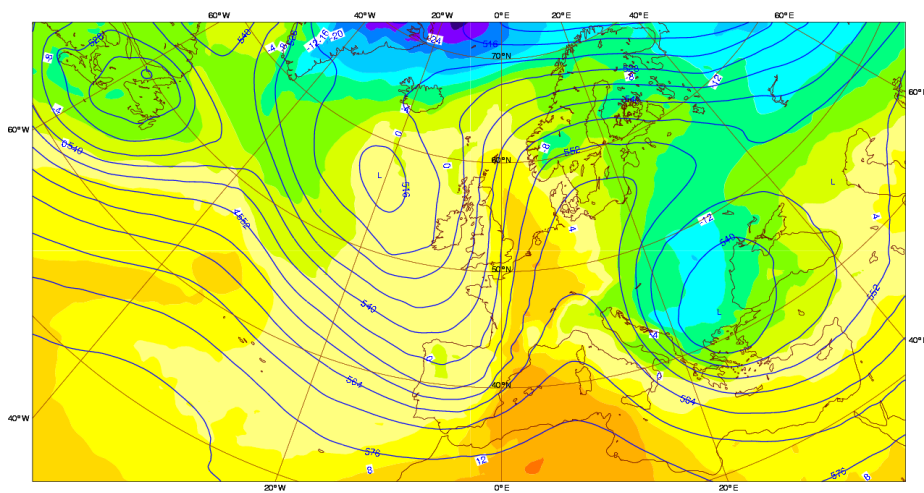
⊂⊂ECMWF

WMO id = 13272 Belgrade

500hPa geopotential
Anomaly correlation
Europe (lat 35.0 to 75.0, lon -12.5 to 42.5)
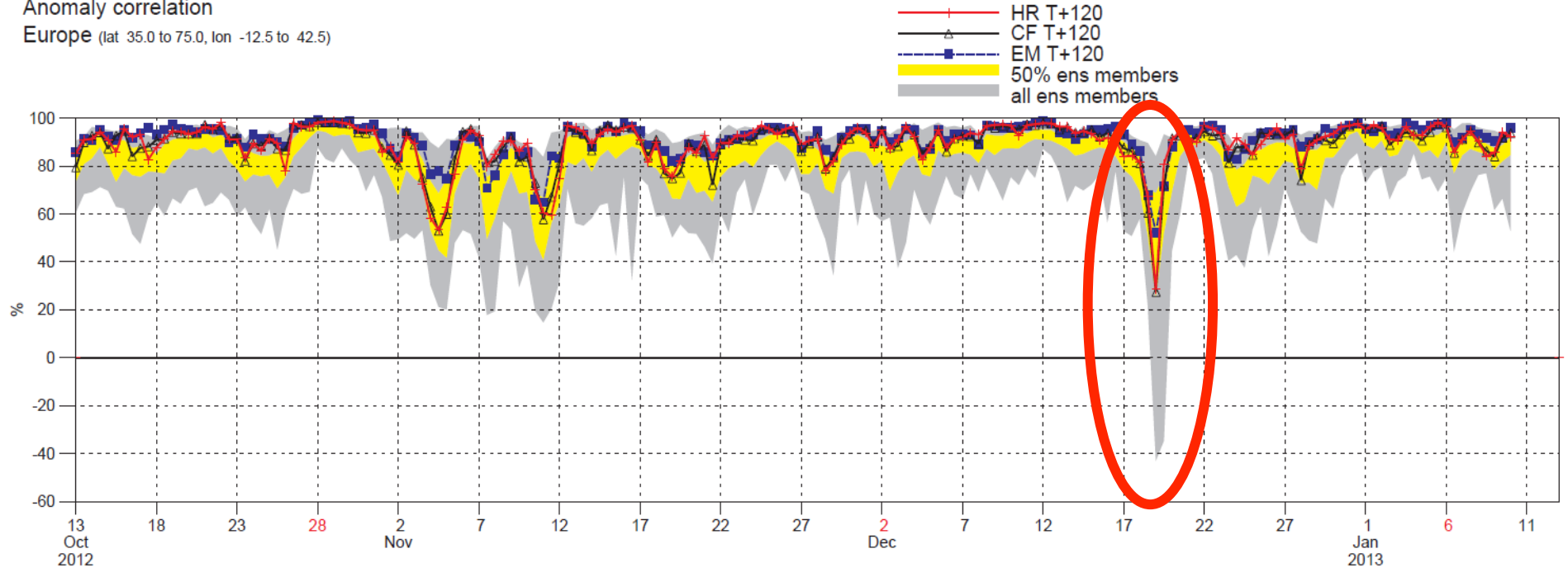
HR T+120
CF T+120
EM T+120
50% ens members
all ens members

500hPa geopotential
Anomaly correlation
Europe (lat 35.0 to 75.0, lon -12.5 to 42.5)
T+120

JMA
CMC
NCEP
UKMO
ECMWF

Forecast Jumping

ECMWF
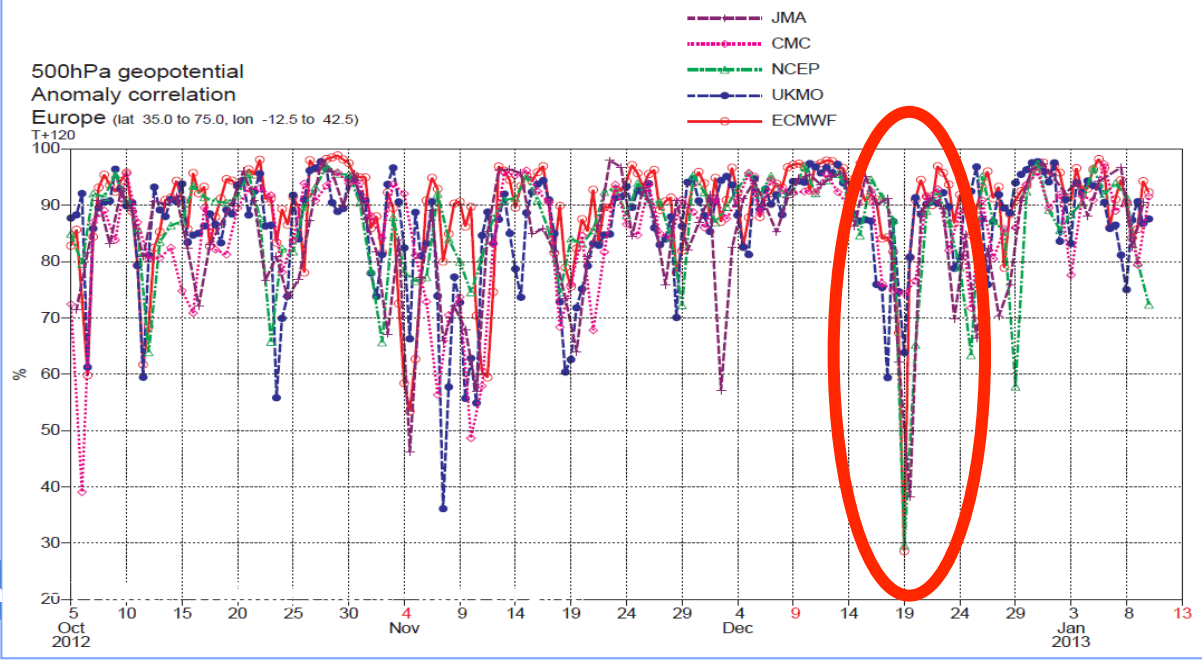
How *should* forecasts behave ?

● **Consider successive HRES forecast of a single parameter (eg temperature) for a given time for a given location…**
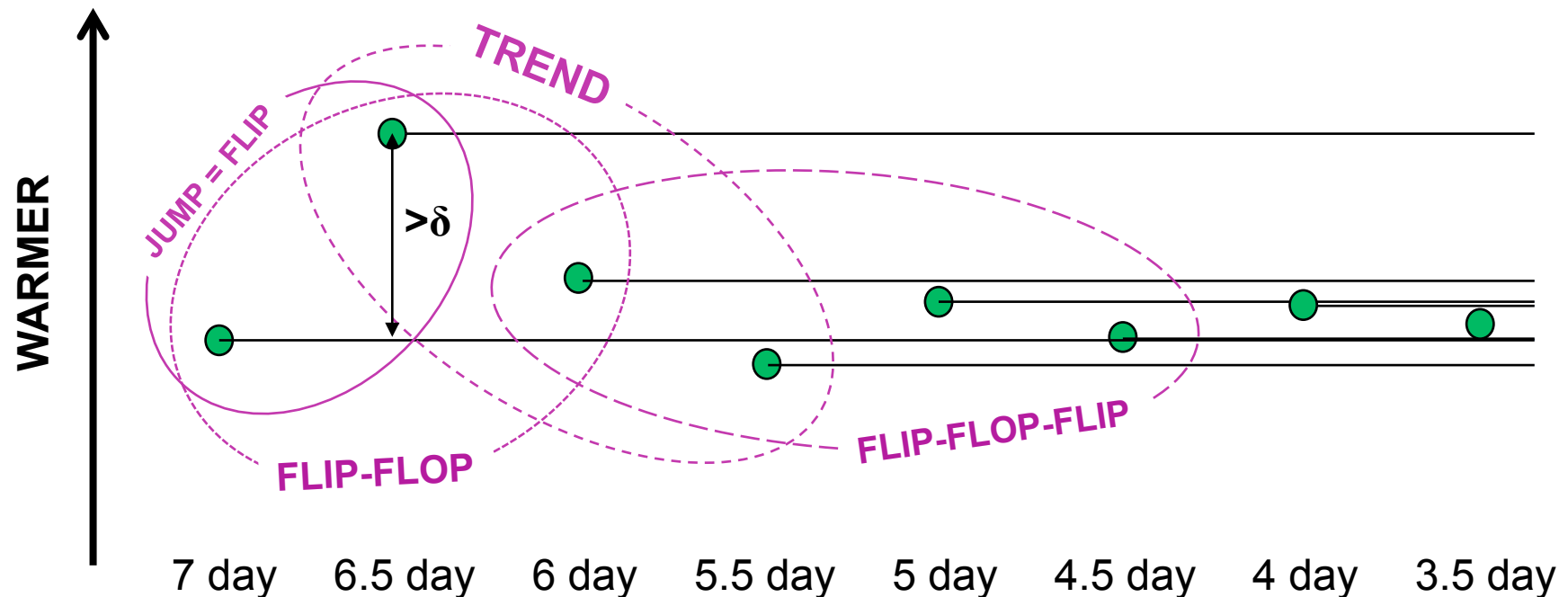
Dealing with jumps and trends...

● **At the most basic level, given three consecutive forecasts:**

- "Flip-flops" will happen half the time

- "Trends" will happen half the time

ECMWF

Whiteboard….

ECMWF

BOSTON

Cumulative Distribution Functions for snowfall at 42.4°/-71.3° VT: 27/01/2015 00UTC - 28/01/2015 00UTC

Legend:
- M-clim t+24-48
- ENS t+00-24
- ENS t+12-36
- ENS t+24-48
- ENS t+36-60
- ENS t+48-72
- ENS t+60-84
- ENS t+72-96
- ENS t+84-108
- ENS t+96-120
- ENS t+108-132
- ENS t+120-144
- ENS t+132-156
- ENS t+144-168
- ENS t+156-180

ECMWF

Cumulative Distribution Functions for snowfall at 40.6°/-74.2° VT: 27/01/2015 00UTC - 28/01/2015 00UTC
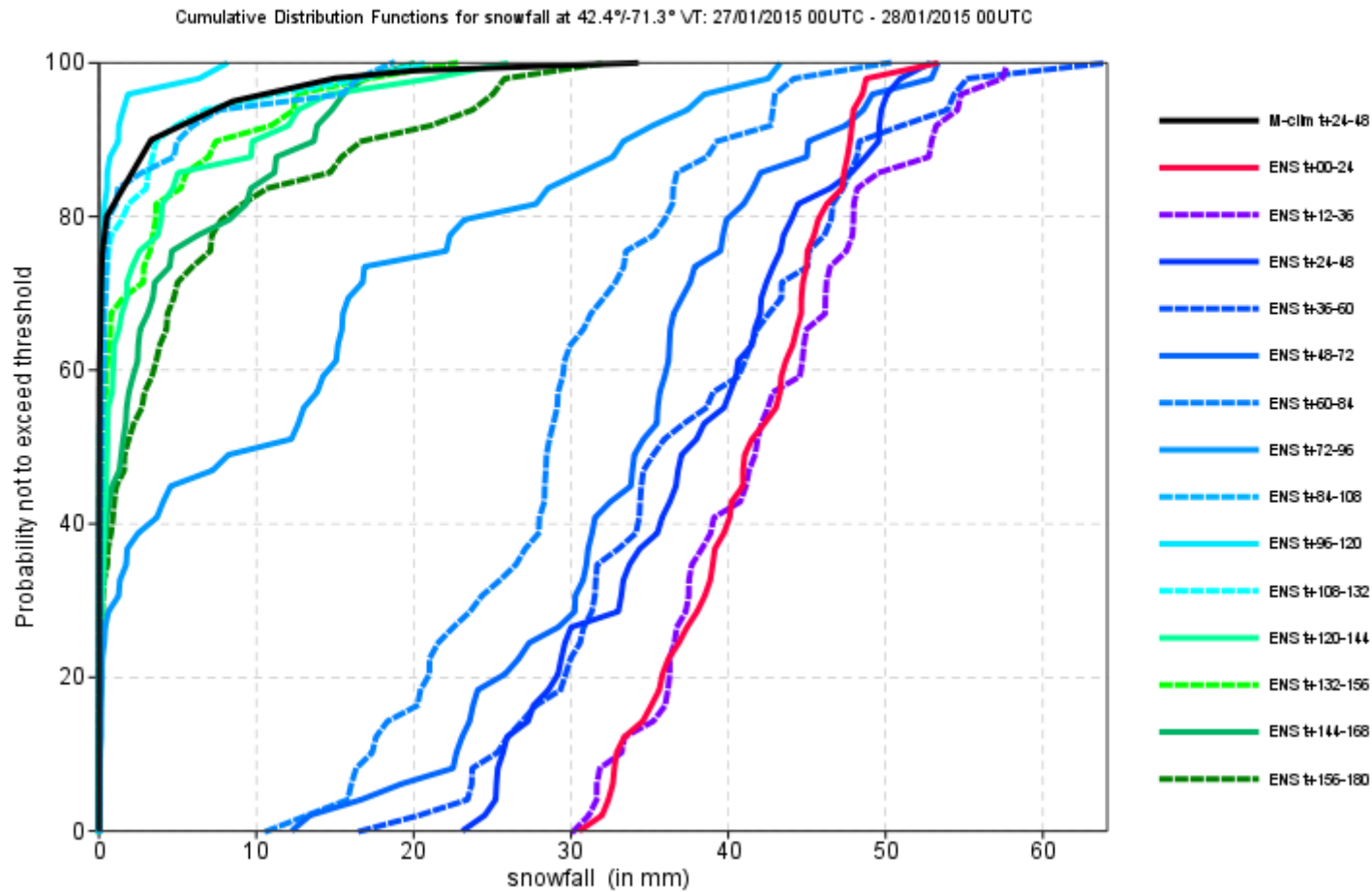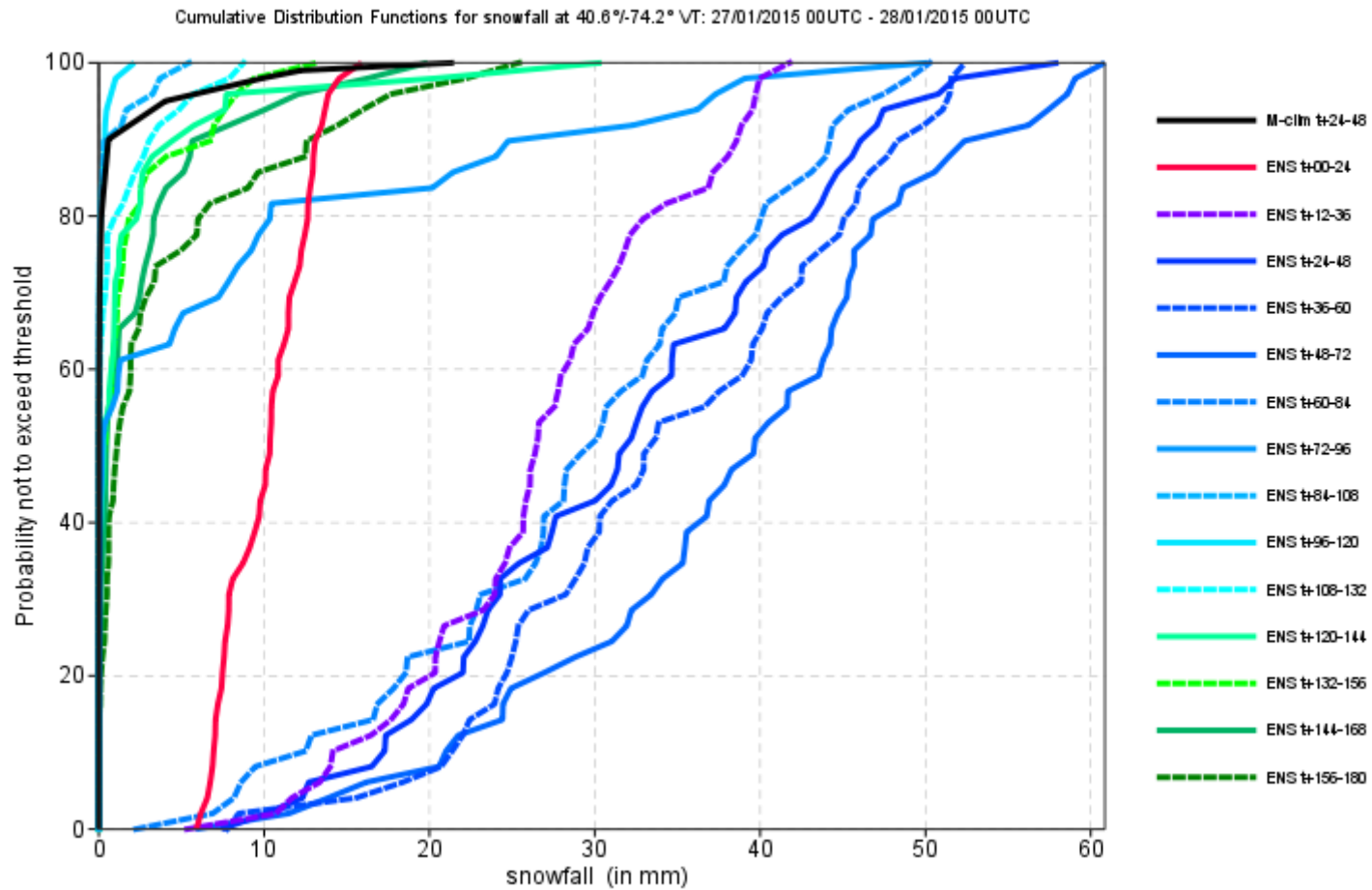
Dealing with jumps and trends...

- **At the most basic level, given three consecutive forecasts:**

    - **"Flip-flops" will happen half the time**

    - **"Trends" will happen half the time**

- **However we can classify jumpy behaviour to only be when the magnitude of jumps exceeds certain thresholds (making frequencies less)**

- **So what do we forecast, given a "jump" ?**

- **And what do we forecast, given a "trend" ?**

- **Is the forecast more likely to be right if there is a trend or if there is a jump ?**

- **How can the ensemble help ?**

ECMWF

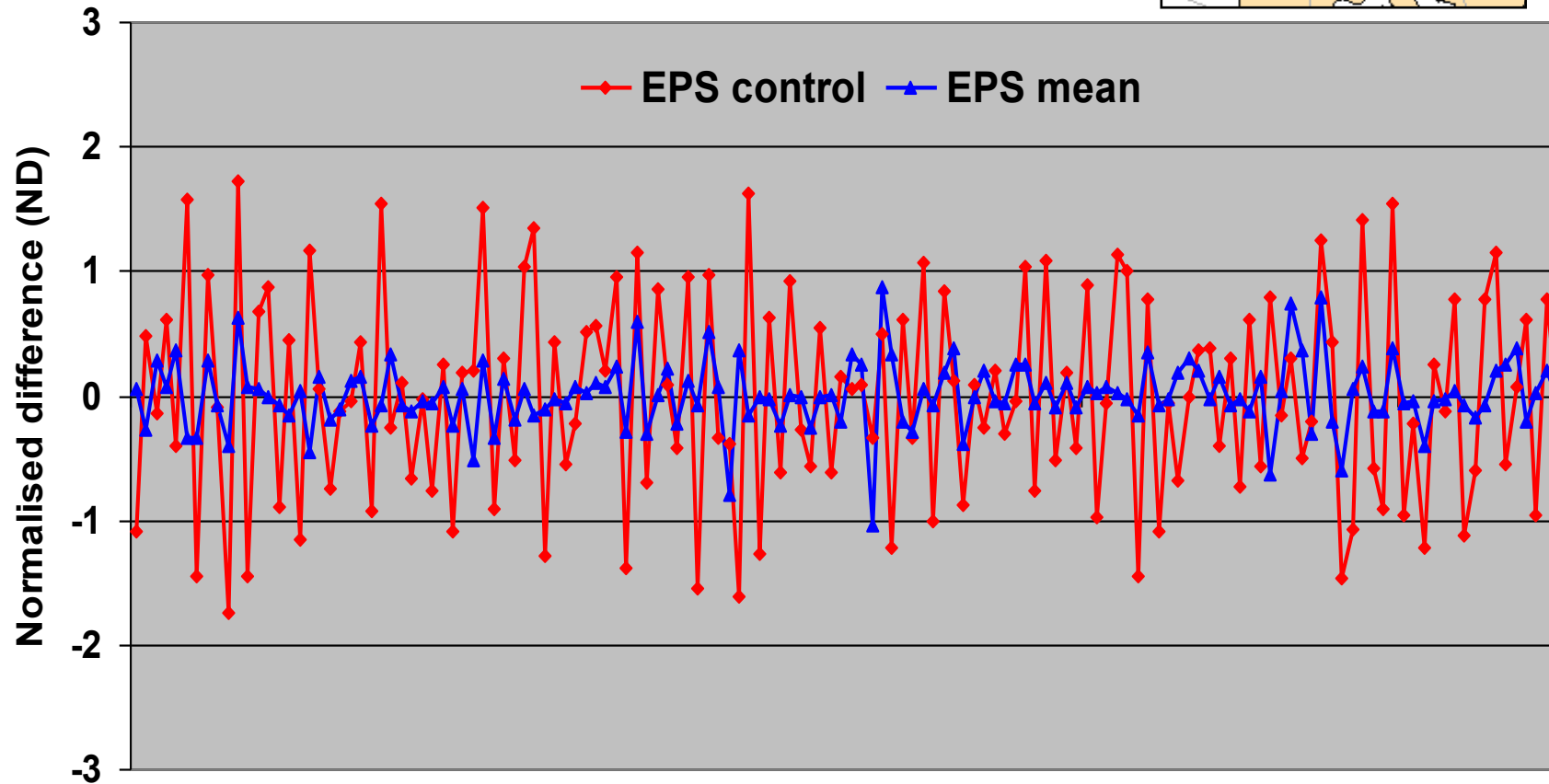# This topic has been studied in detail..

● **Some results from:**

- Zsoter, Buizza and Richardson, MWR 2009, "Jumpiness of the ECMWF and Met Office EPS Control and Ensemble-Mean Forecasts"

ECMWF

T+348 - T+360

500mb ht.   Area: [50N, 20W, 65N, 20E]
Period for plot : Jan/Feb 2008
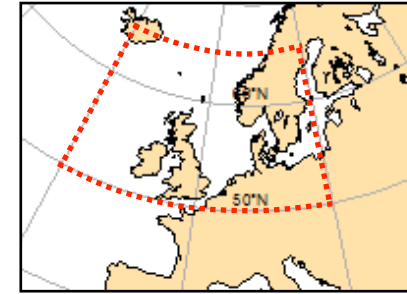
Differences between two consecutive forecasts, for the same validity times
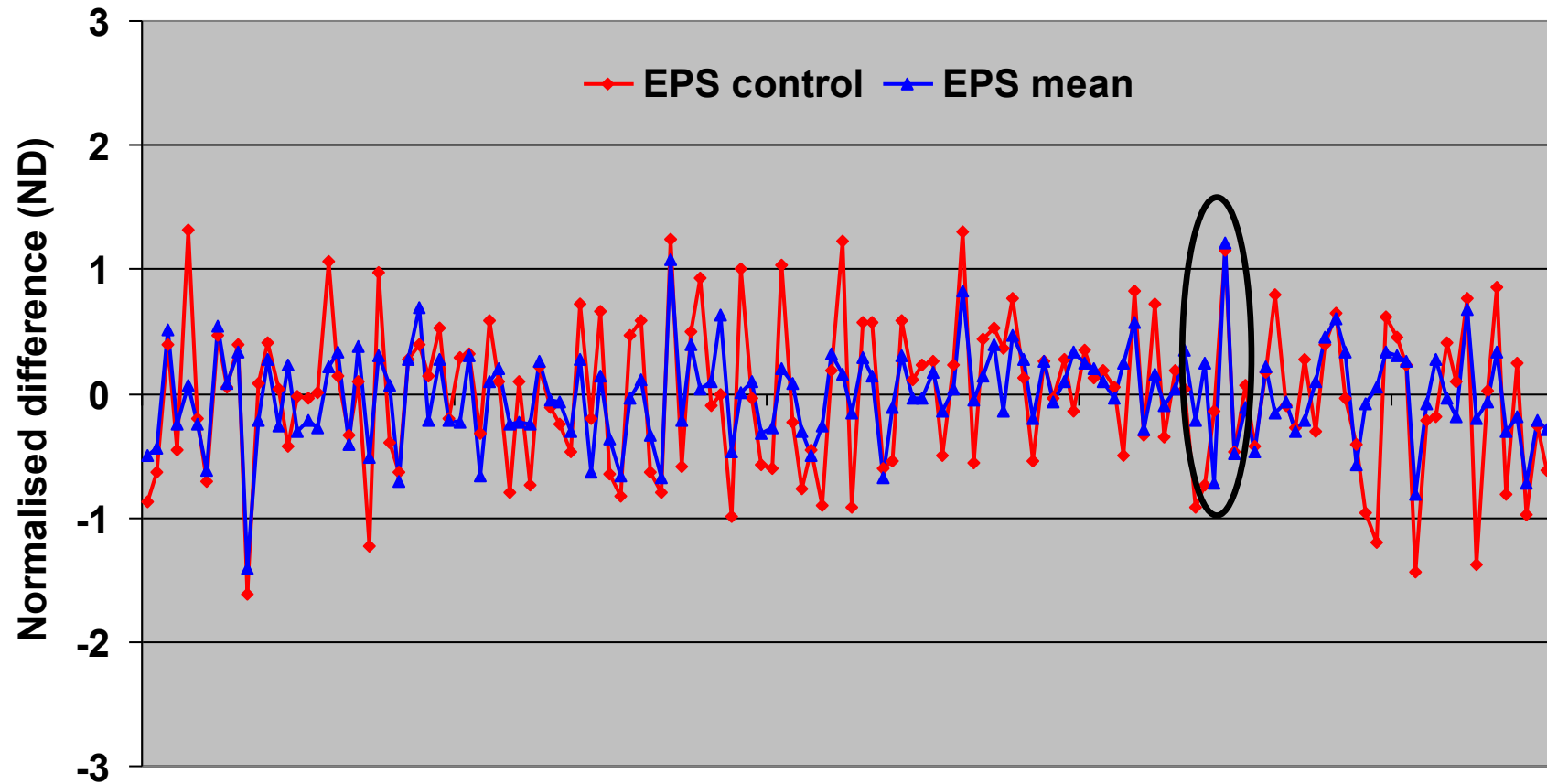
CCECMWF

T+156 - T+168

Differences between two consecutive forecasts, for the same validity times
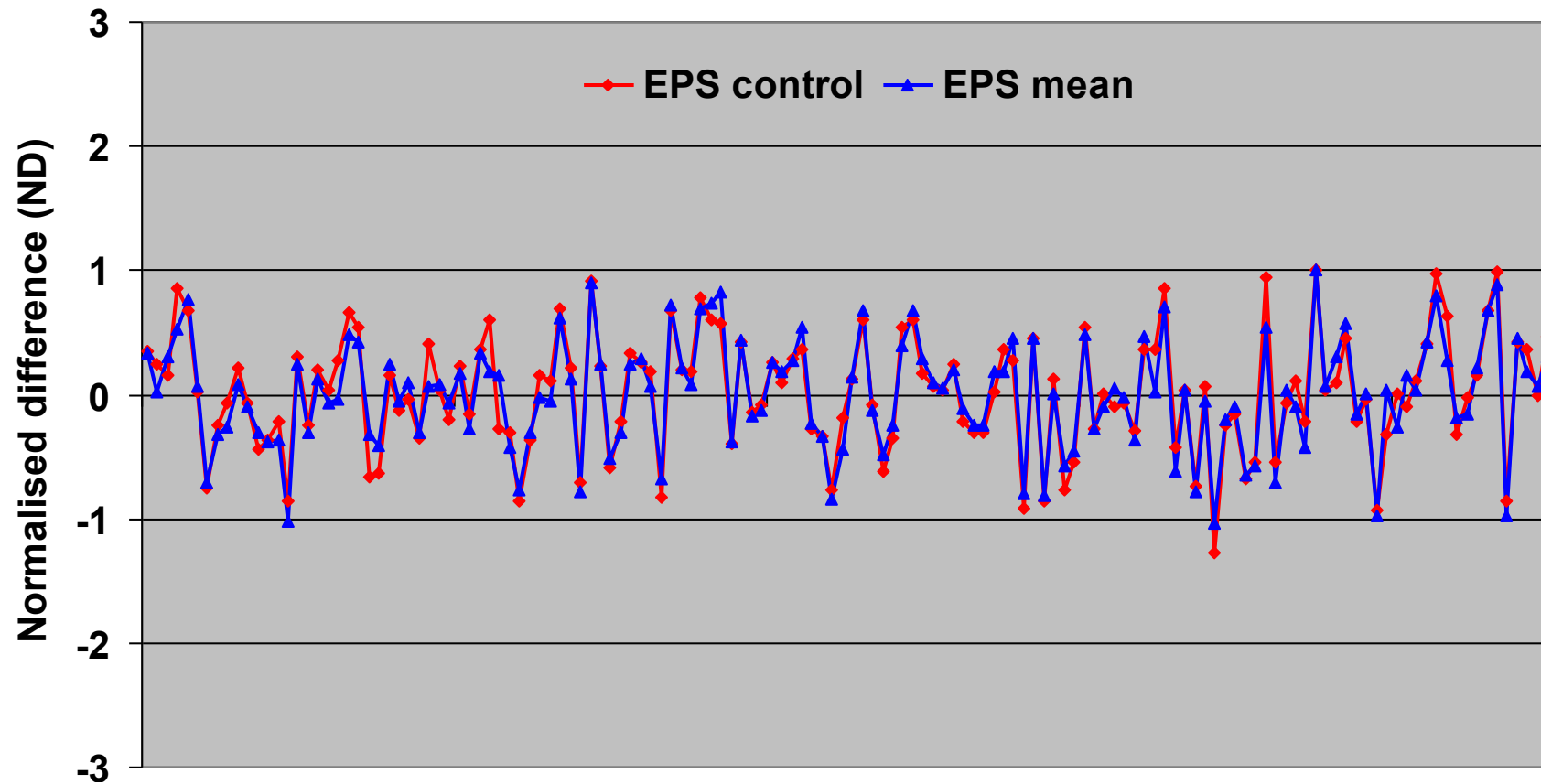
ECMWF

T+60 - T+72

Differences between two consecutive forecasts, for the same validity times

ECMWF

CASE STUDY – I
Permanent ridge

Forecasts verifying on **24 Oct 2007**
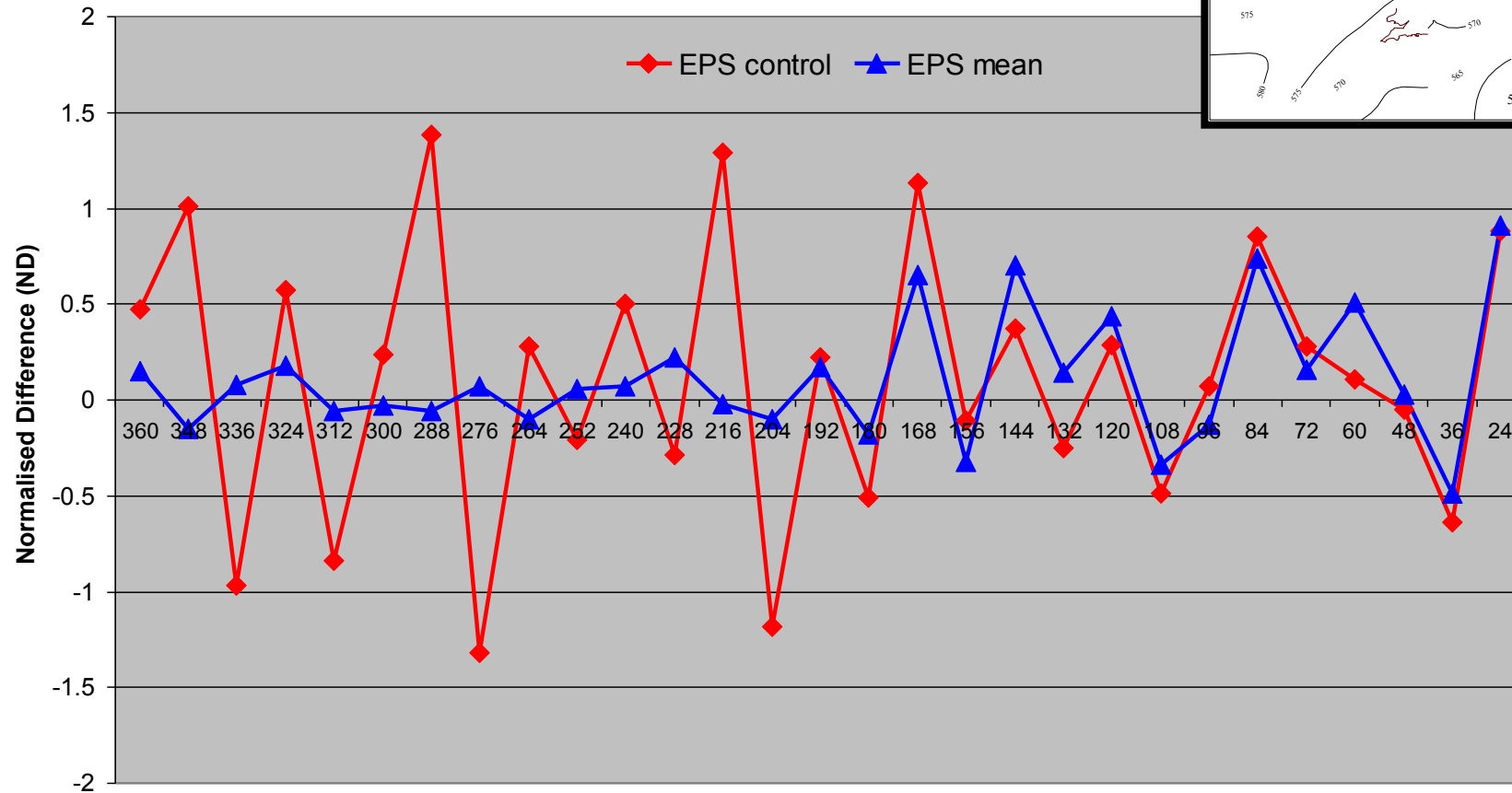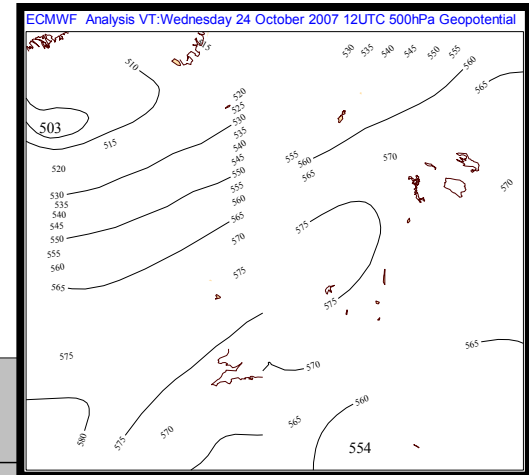
CASE STUDY – II
Intense low

Forecasts verifying on **9 Dec 2007**

ECMWF
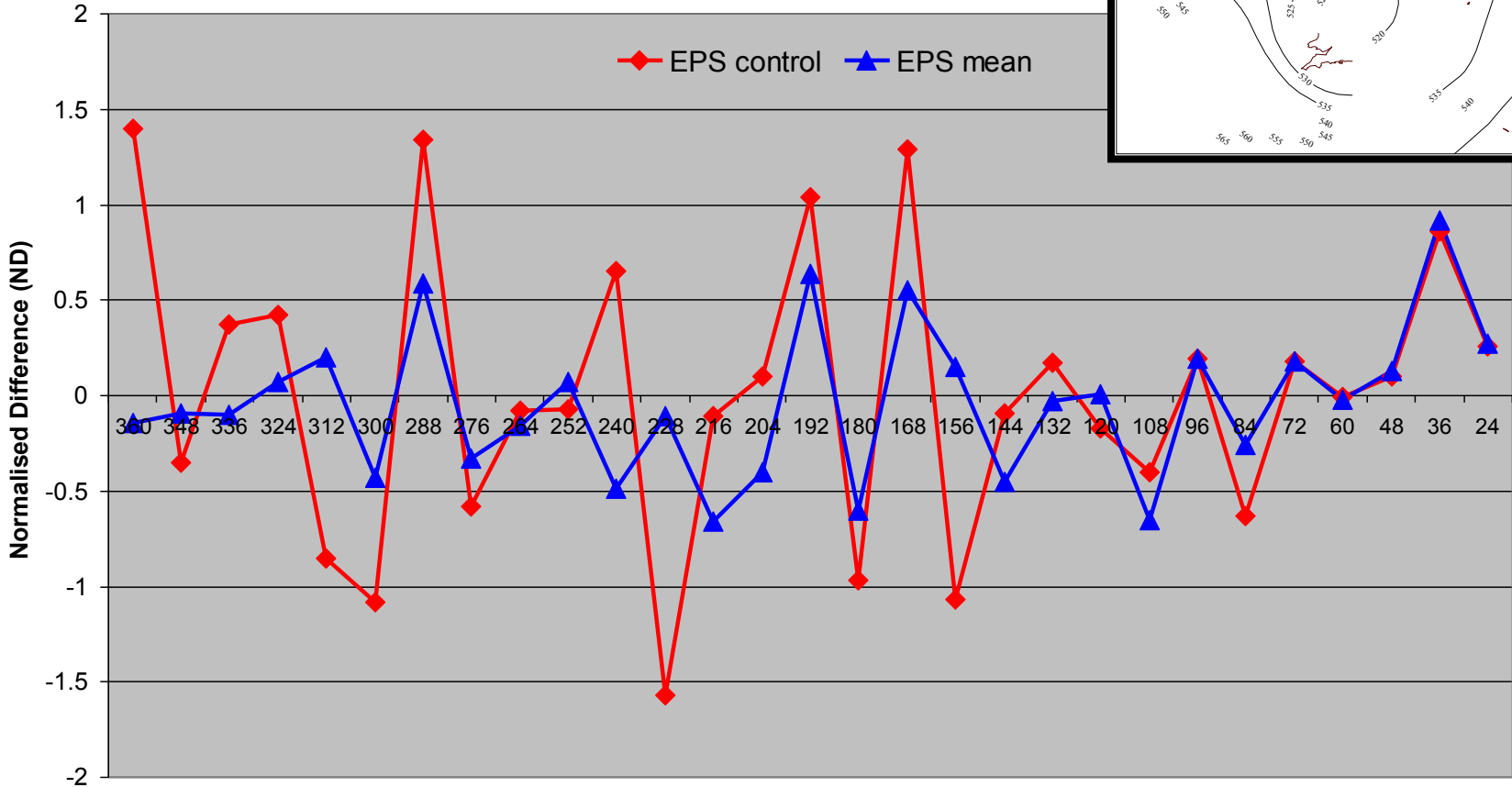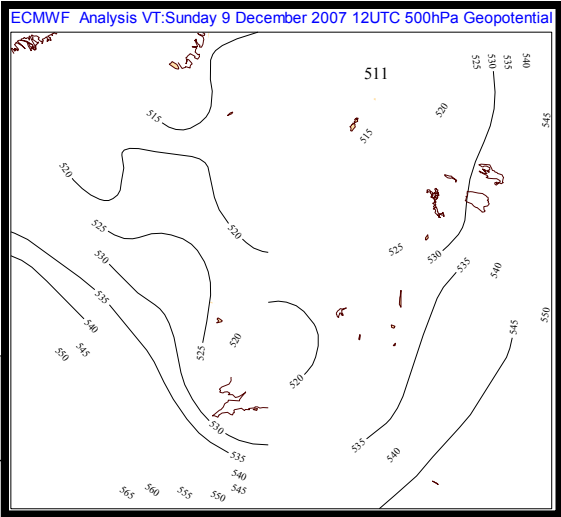
CASE STUDY – III

Very intense, fast moving cyclone

Forecasts verifying on **31 Jan 2008**
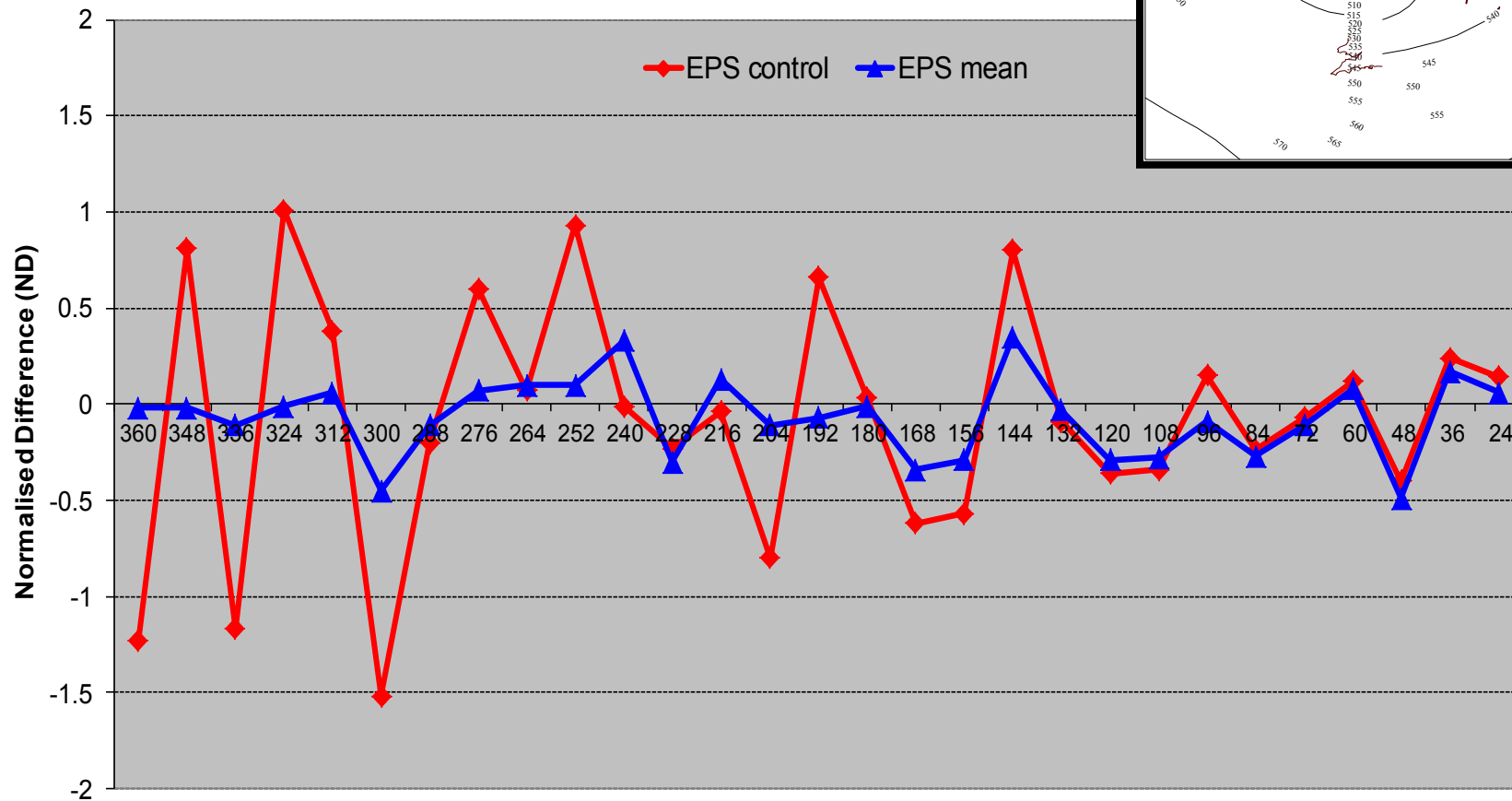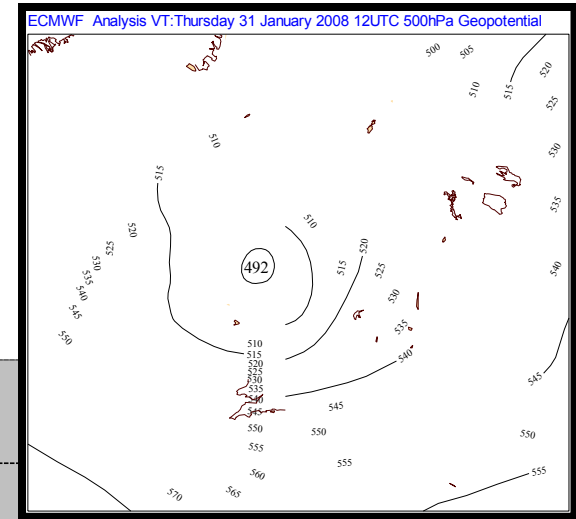
Lesson

- **Make more use of the Ensemble mean, rather than the Control (or HRES)**

- **Especially at longer lead times (say ≥ ~ 4 days)**

- **Forecasts will then be less jumpy**

- **Beware however that strong gradients are always weakened in the ensemble mean**

- **At short lead times the picture is more complicated..**

ECMWF

How often do the ENS mean and Control jump together?
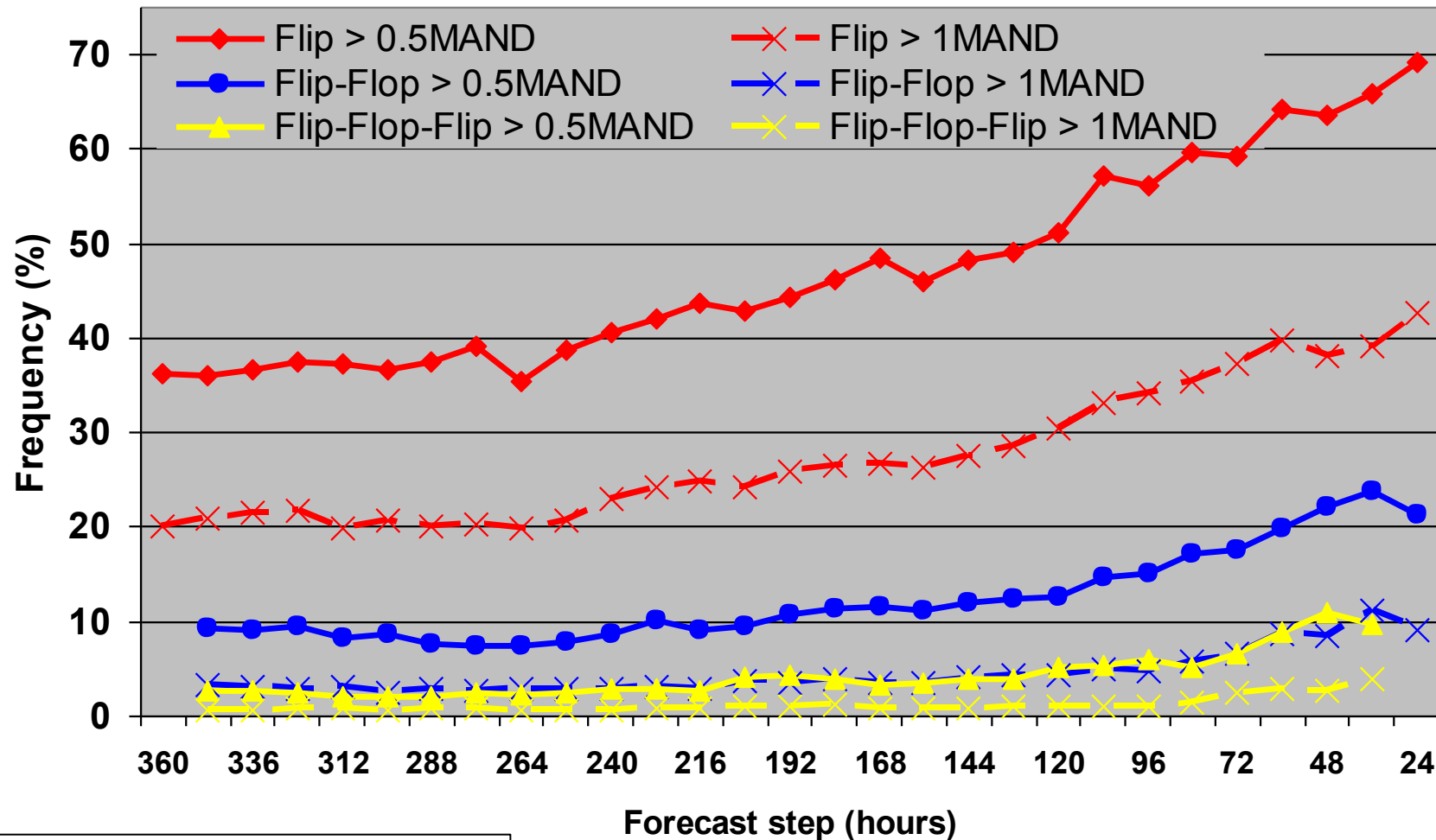
Period 2007+, NW Europe

CCECMWF

At short ranges...

- **ENS Mean and Control tend to "jump together" more often**

- **This makes the strategy of following the ENS mean, rather than Control or HRES, less beneficial**

- **Though it is probably still advantageous**

ECMWF

An explanation

- **The behaviour we see at both short and long ranges seems to be an inevitable (and necessary) consequence of ensemble design**

- **Perturbations, *positive and negative*, spread the ensemble forecasts either side of the Control early on, so any jumps in Control (and HRES) will likely be reflected in ENS also (at time zero ENS mean = Control)**

- **Later on in the forecast non-linearity becomes more important, and so the ENS members are less of a slave to the Control (and HRES), making the forecasting strategy of following the ENS mean (with the usual caveats) result in a less jumpy and more reliable forecast, on average**

ECMWF

Should we be more cautious about following a jumpy forecast ?

- **From a psychological and customer perspective, we don't want to give out forecasts that jump around**

- **But at the same time it is likely that in absolute terms forecasts that *don't* get adjusted whenever there is a jump will average out to be more accurate in the long term**

- **Remember that, strictly, flip-flops occur half the time!**

- **We have seen that we should not extrapolate a trend, but nor should we revert back if we see a jump**

- **This is a difficult area, affected by customer perception…**

- **So is there any evidence to say that jumpiness means forecasts are likely to be less accurate?**

ECMWF

Jumpiness/Spread relationship

Error statistics for Z500 for NW Europe

No-flip, 1, 2 and 3 consecutive flips
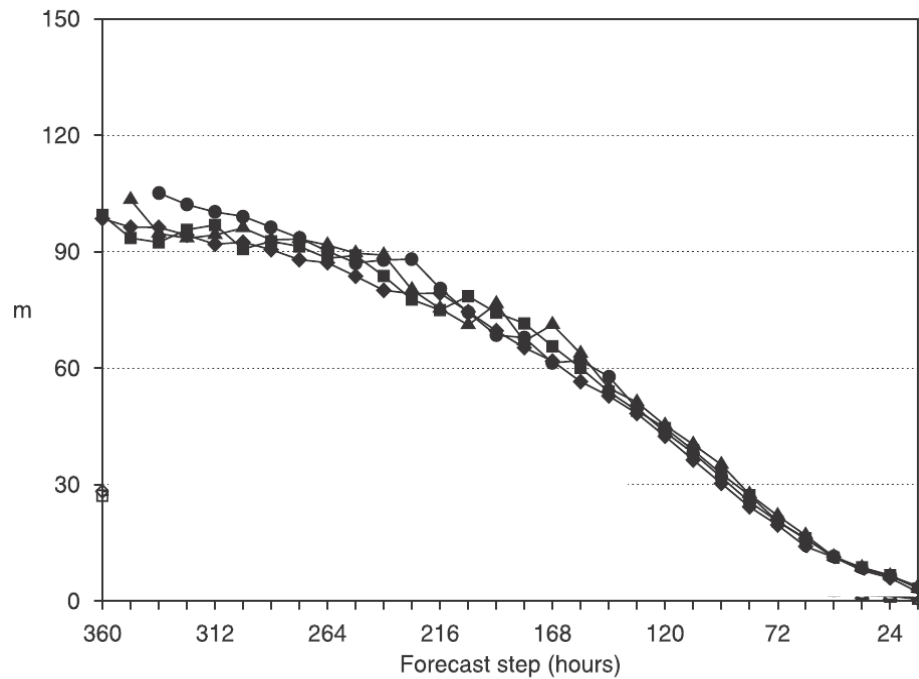
Small, medium-small, medium-large and large spread
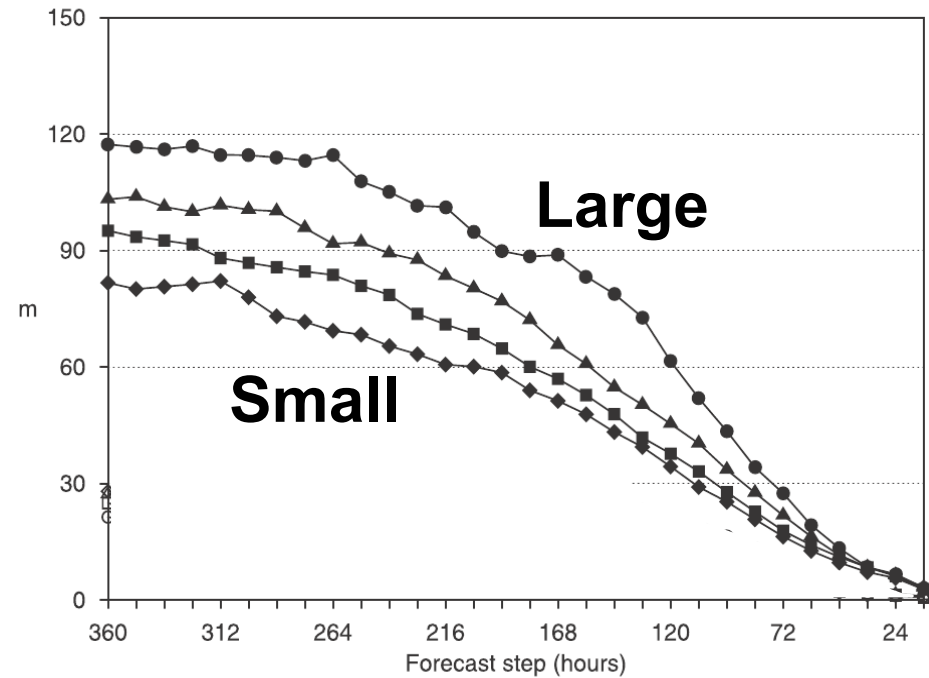
Errors

- **The average error of the ENS mean relates quite strongly to the absolute spread in the ensemble, as one would hope and expect. Larger spread implies larger errors, on average.**

- **However errors show only a very weak dependance on whether or not the ensemble mean forecast has been jumpy**

So is there any evidence to say that jumpiness means forecasts are likely to be less accurate?

No, not really

Think back to the exercise at the beginning – did you use the same strategy for the jumpy forecasts?

ECMWF

Dynamical sensitivities = extra jumpiness?

- **Should we expect more jumps in potential severe weather situations, at *short lead times*, because of 'dynamical sensitivity' ?**

- **By dynamical sensitivity we mean 'finely balanced' situations, where slight changes can have a big impact:**

  - **eg – precise phasing of upper and lower levels needed for explosive cyclogenesis**

  - **eg – high precipitation intensities can turn rain into (surprise) snow, due to cooling through melting**

- **Illustrate, briefly, with a windstorm example (Christian, St Jude: 28 October 2013)**

Further discussed in ECMWF Newsletter Spring 2014

ECMWF

Windstorm 'St Jude' / 'Christian'

MAX
GUSTS

m/s

🟢 15 - 20	🟡 20 - 25	🟠 25 - 30	🩷 30 - 35	🔴 35 - 40	🟣 40 - 45	🟪 45 - 50	⚫ 50 - 60

ECMWF
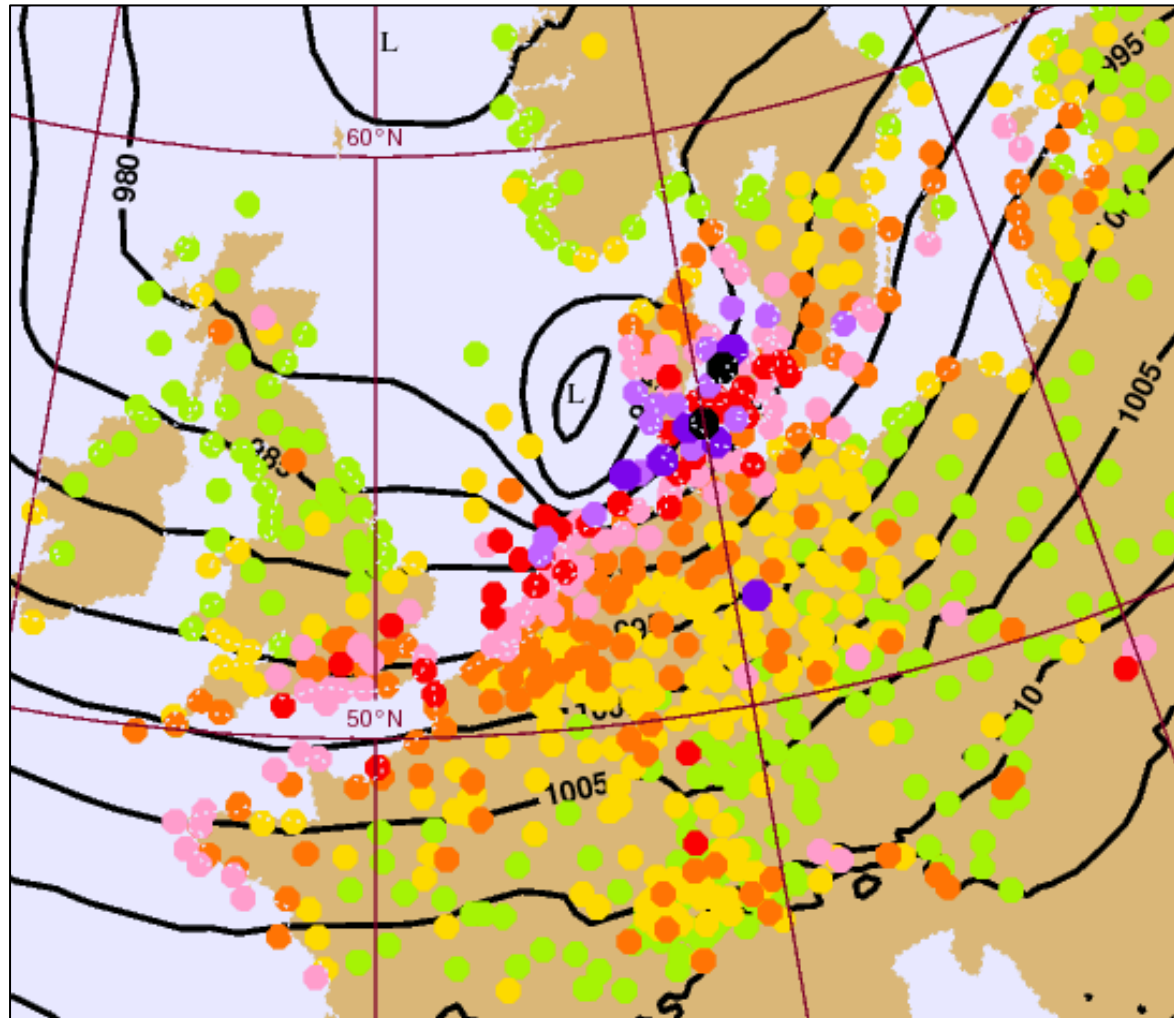
36h forecast for "Christian" – Valid 12UTC Oct 28th 2013
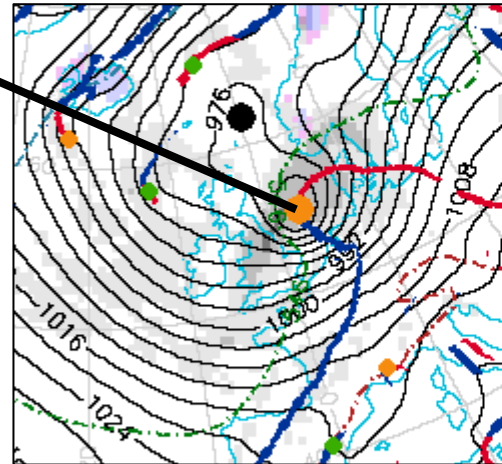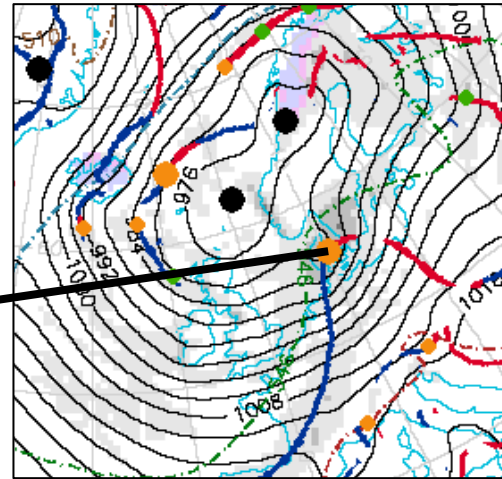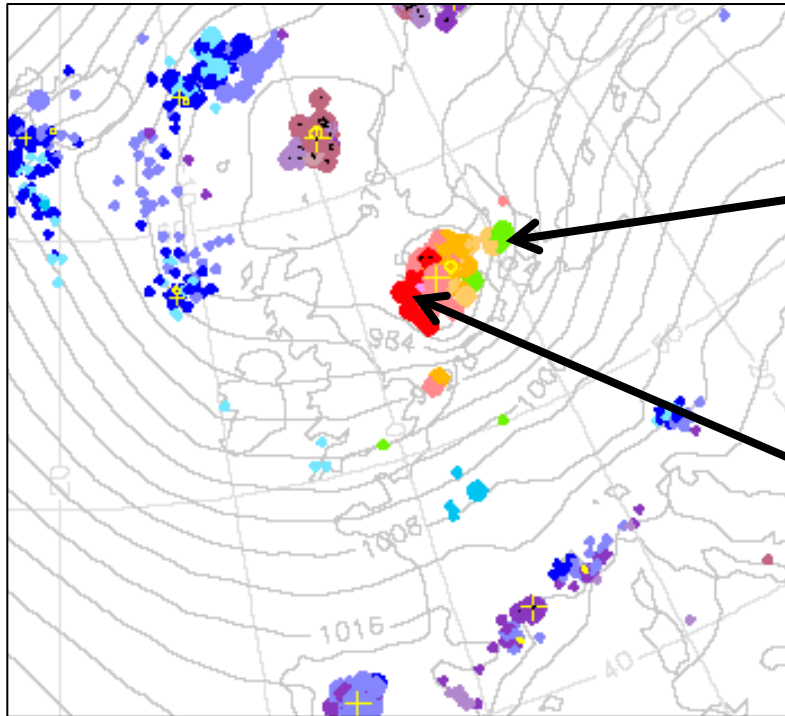
**Large spread
=
Large uncertainty**

**Is this OK at
short lead times ?**

ECMWF

How 'should' CDFs behave in successive ENS runs?
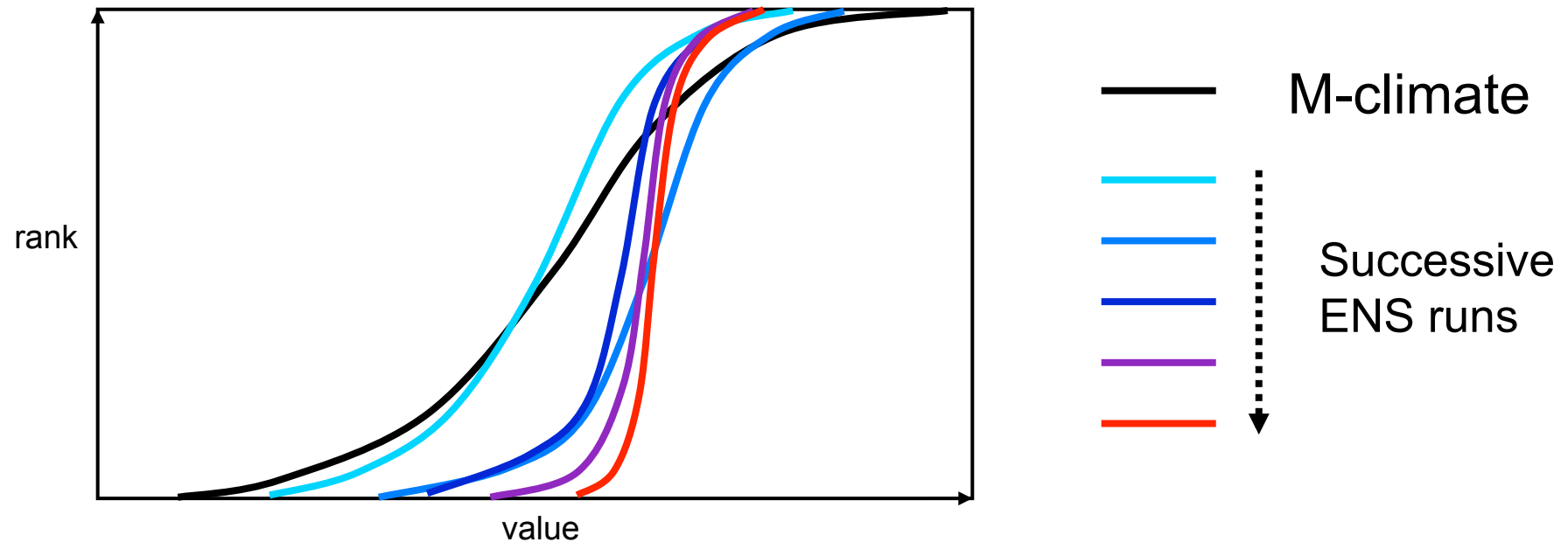
- **At long lead times forecast CDF may be similar to the M-climate.**

- **Lateral variations in CDF position between successive runs should, mostly, become less (with time).**

- **CDF will tend to become steeper (with time), implying higher confidence.**

ECMWF

Wind Gust CDFs - E England

OK!

Cumulative Distribution Functions for 10m wind gust at 52.11°/1.35° VT: 28/10/2013 00UTC - 29/10/2013 00UTC
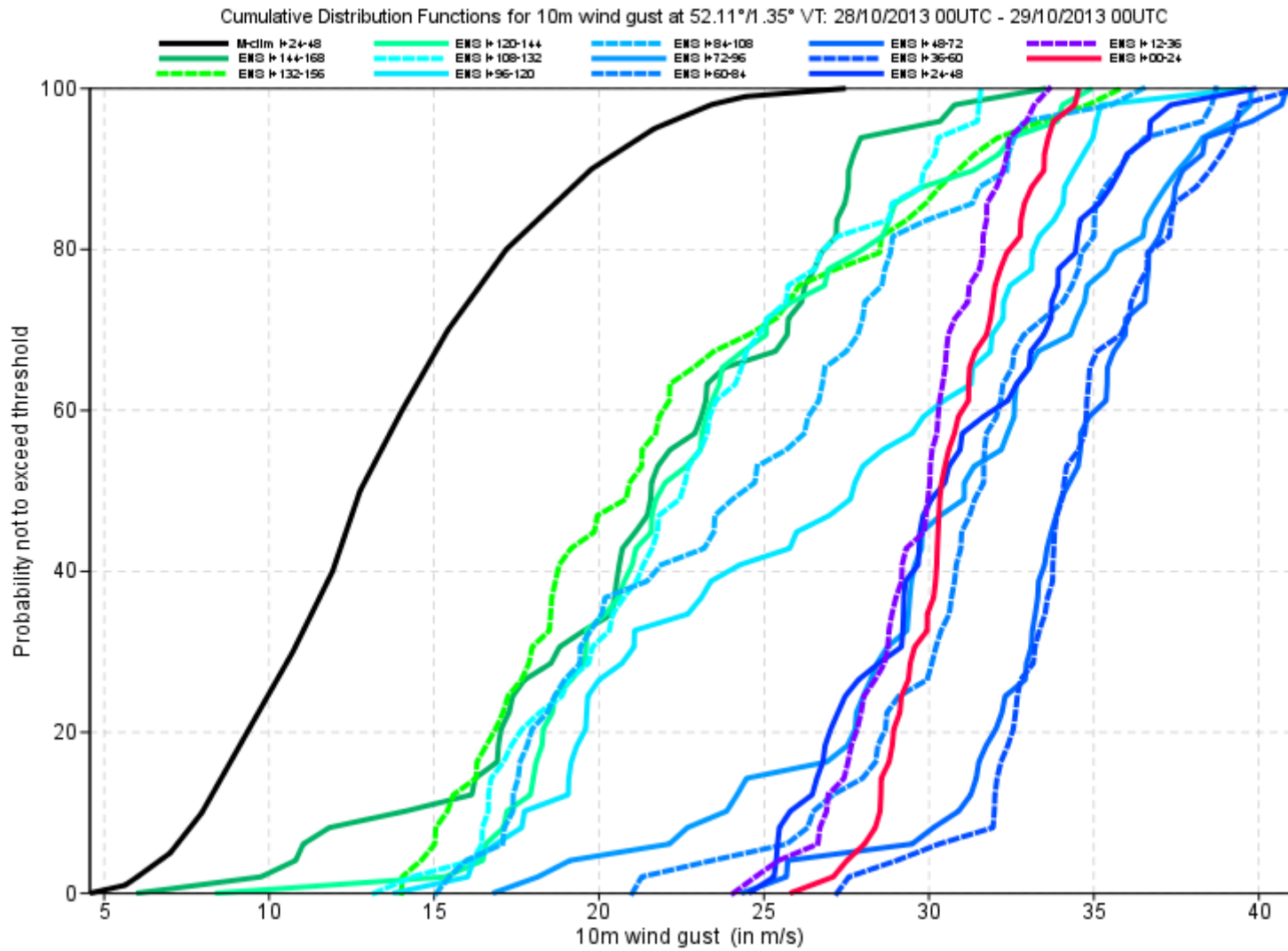
Wind Gust CDFs - Netherlands

Wind Gust CDFs - Denmark

Cumulative Distribution Functions for 10m wind gust at 54.94°/9.72° VT: 28/10/2013 00UTC - 29/10/2013 00UTC

Less confident
(so better)
But jump to next
forecast (red)
Still too big

ECMWF
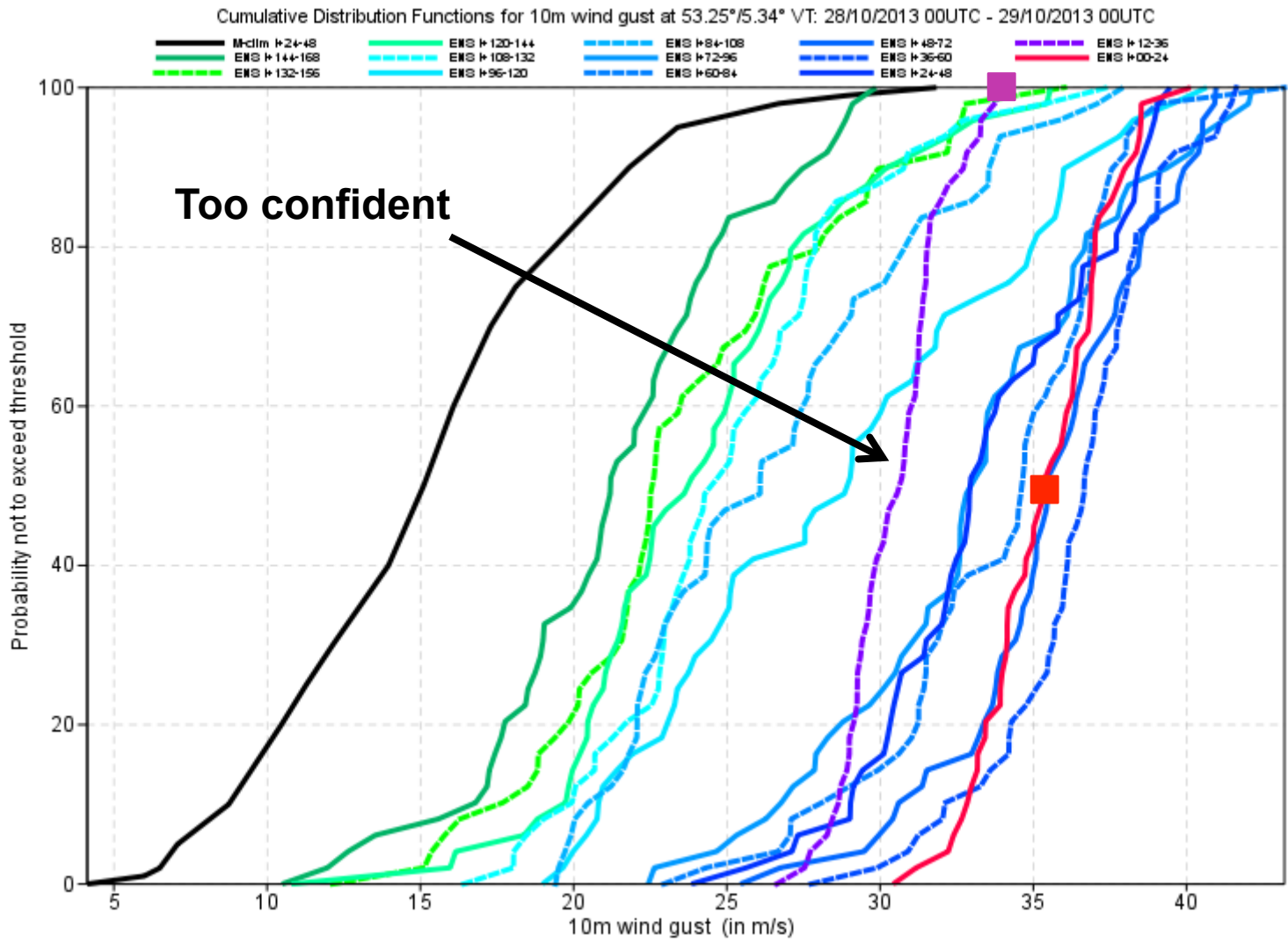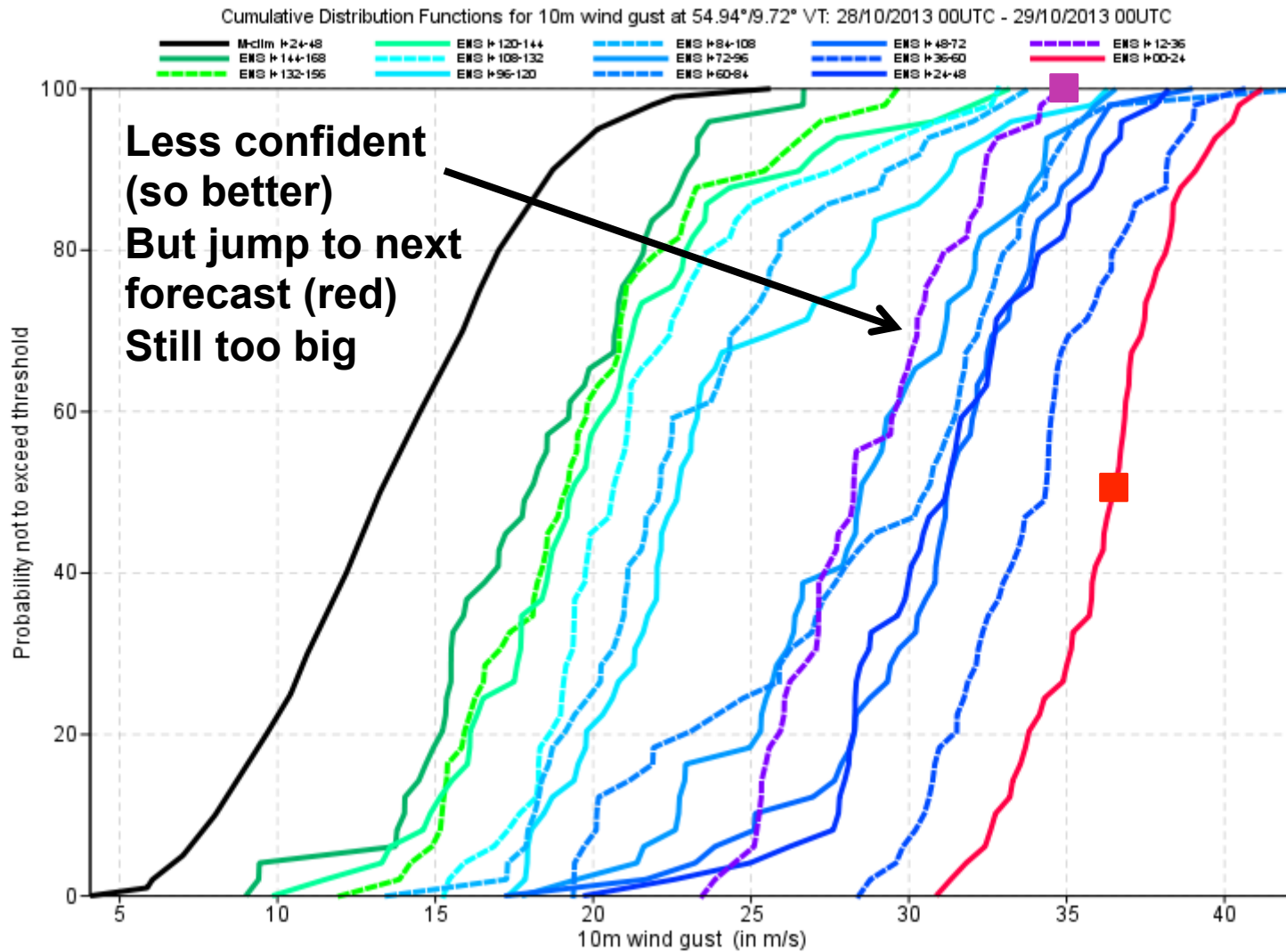
What can we learn?

- **Spread was high (eg from Dalmatian chart, but also other measures)**

  - **So this highlights uncertainty**

- **BUT, from the CDFs, it seems that for this case the spread was probably not great enough (using a simple metric of "median > extreme of previous forecast")**

- **The fine scale nature (sting jet?) and small lateral extent of the very strong winds was probably pushing the IFS to its limits!**

ECMWF

Conclusions

- **Jumpiness is not a good indicator of likely error, but spread is**

- **We have to expect some jumpiness, otherwise there would be something intrinsically wrong with the forecasting system**

- **There are however probably too many jumps, in general, which probably relates to a (slight) lack of spread in the ensemble system**

- **The fact that the ENS mean and Control (or HRES) jump together more at short ranges is very probably due to ensemble design**

- **Customer aversion to jumpy forecasts is a very difficult hurdle to overcome; however following the ensemble mean pattern, particularly at longer ranges, will help**

- **Dynamical sensitivity – related for example to strong jets - can unfortunately increase jumpy behaviour at short ranges in severe weather situations – beware!**

ECMWF

ECMWF

A note on assimilation...and forecast trends

- Before 4D-Var, or even 3D-Var, numerical models were less responsive, in general, to observations

- As a result they were sometimes playing catch up

- This made trends more likely, and jumps less likely (?)

- It also meant that there could actually be merit in extrapolating a trend

- Now that we have 4D-Var, and indeed EDA (ensemble of data assimilations), this is no longer the case

- One could even argue that the word 'trend' is inappropriate

- Phrases such as 'the forecasts are moving towards a less cyclonic outcome' are entirely inappropriate, because they implant 'trend extrapolation' into the mind of the customer

ECMWF

Recent and Future developments

- **Land surface analysis perturbations**

- **More use of EDA..**

- **Stochastic physics enhancements..**

- **Ocean coupling from day 0 (SSTs differ between runs)**

- **All designed to improve the quality of the ensemble**
    - **Should reduce jumpiness**

ECMWF

CASE STUDY – III

Very intense, fast moving cyclone

Forecasts verifying on **31 Jan 2008**

ECMWF Analysis VT:Thursday 31 January 2008 12UTC 500hPa Geopotential

ECMWF