Prediction of Hot and cold extremes

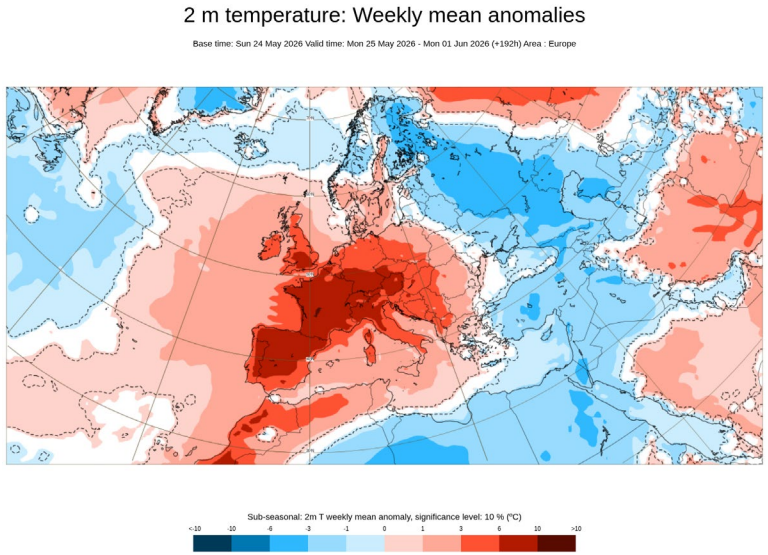
UEF 2026

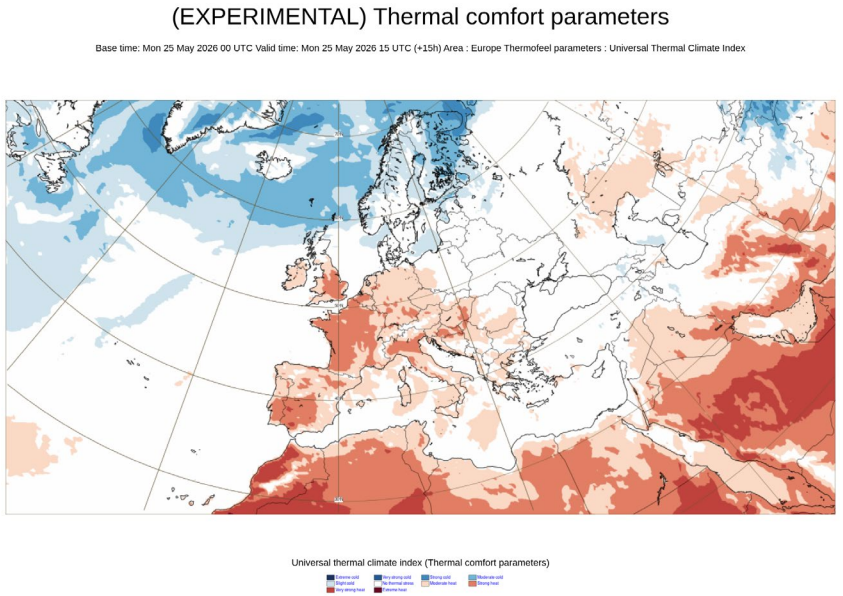
Linus Magnusson

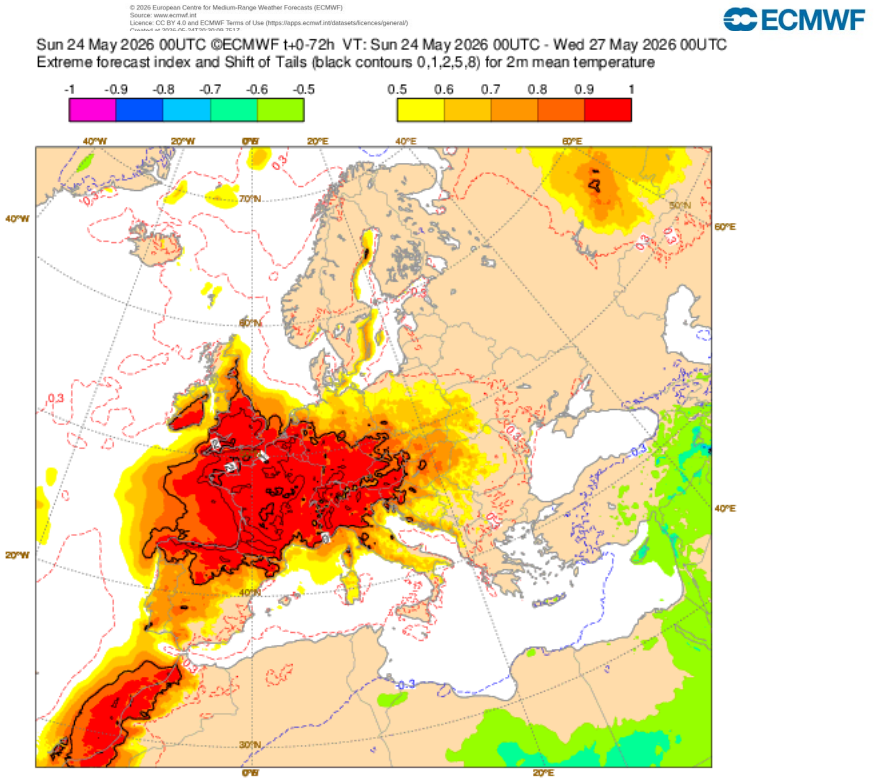
ECMWF

How to define an extreme temperature event?

- Length of the event
- Spatial extent
- Level of the extreme
  - Anomaly?
  - Percentile/return period/EFI?
  - Heat stress?





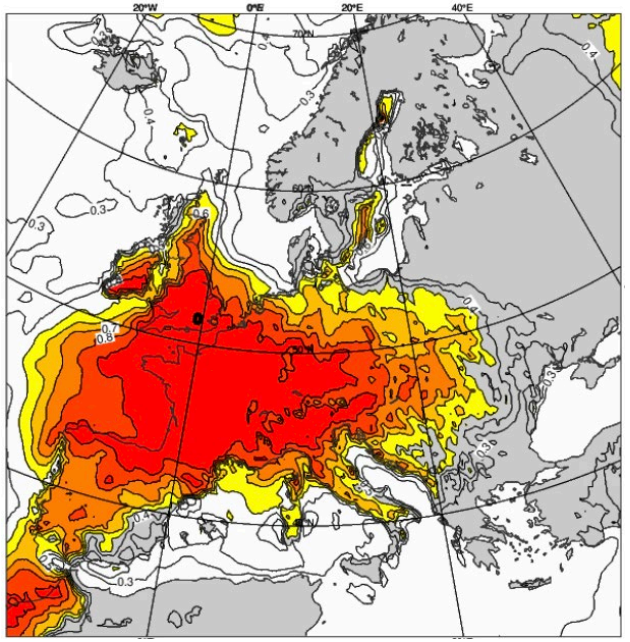


ECMWF

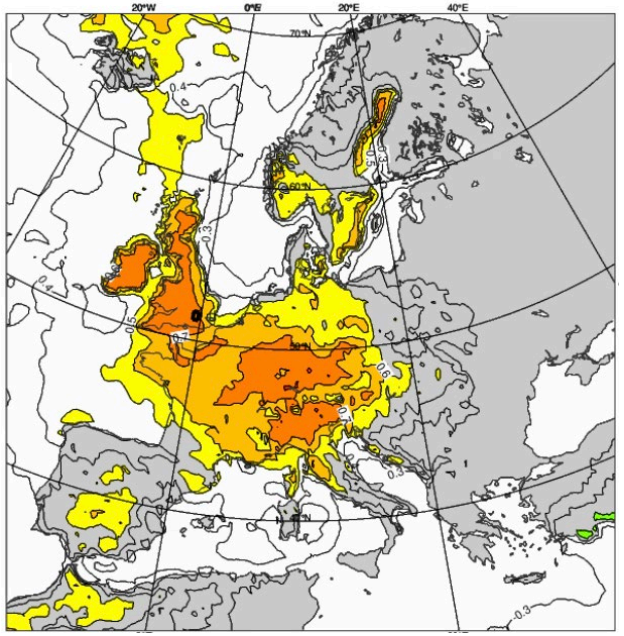
ECMWF

The recent heatwave:
Prediction of the 3-day mean temperature (24-26 May)

EFI from 24 May



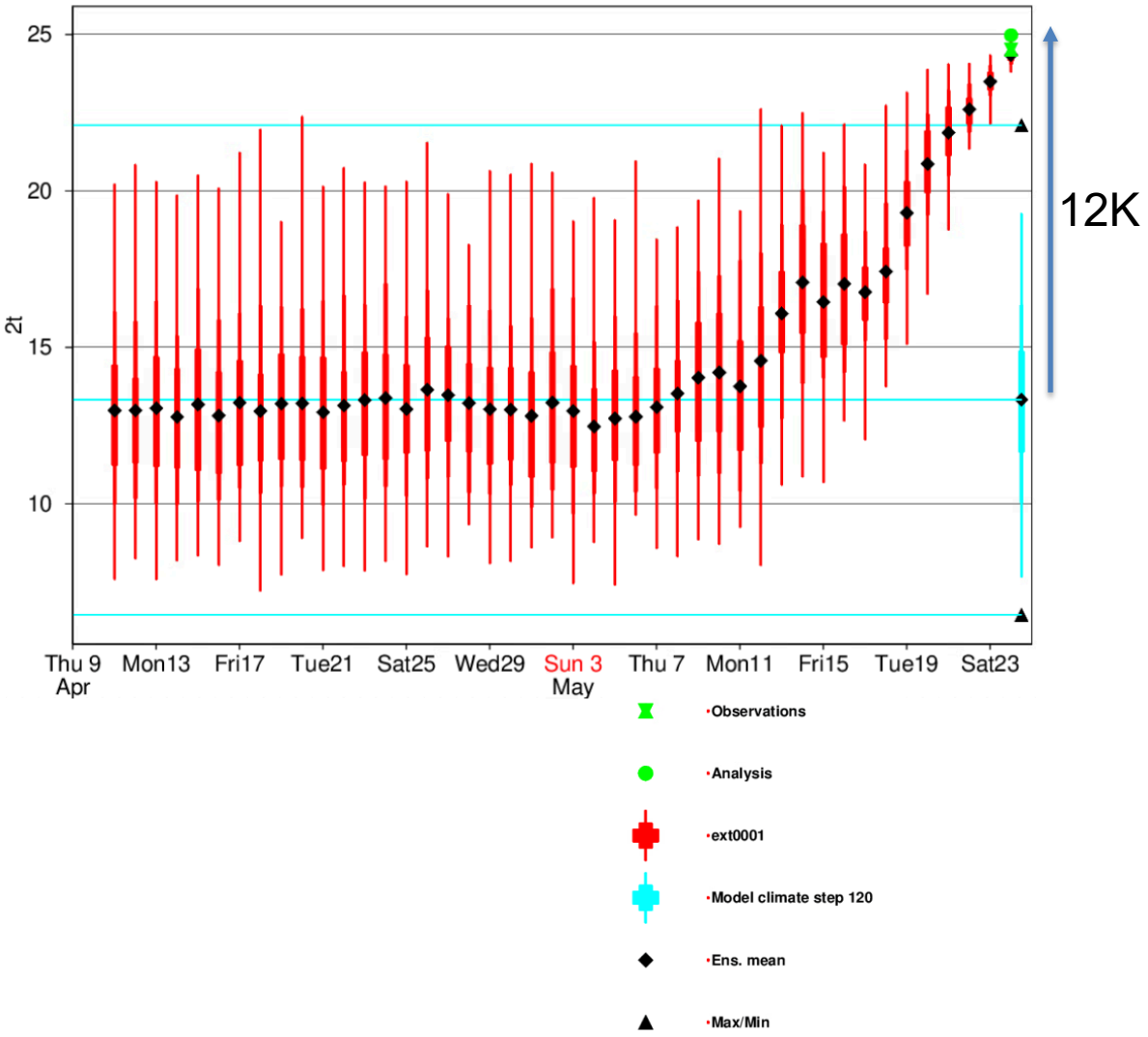
EFI from 18 May



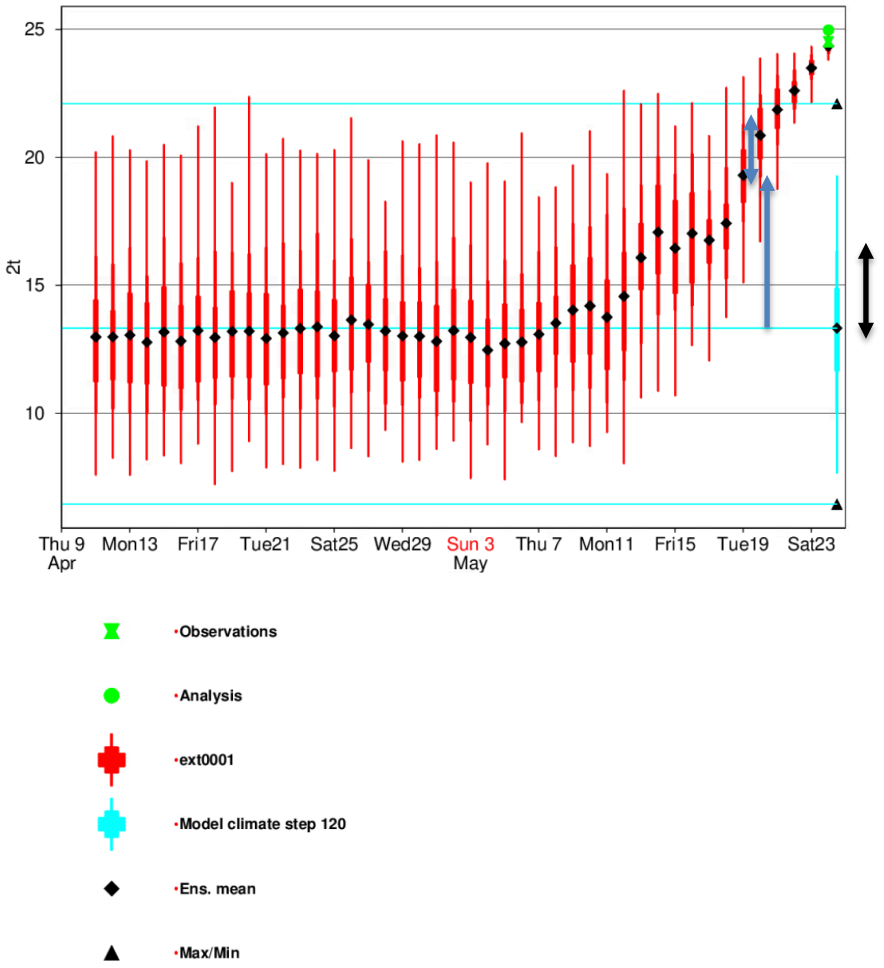
-0.9 -0.8 -0.7 -0.6 -0.5

0.5 0.6 0.7 0.8 0.9

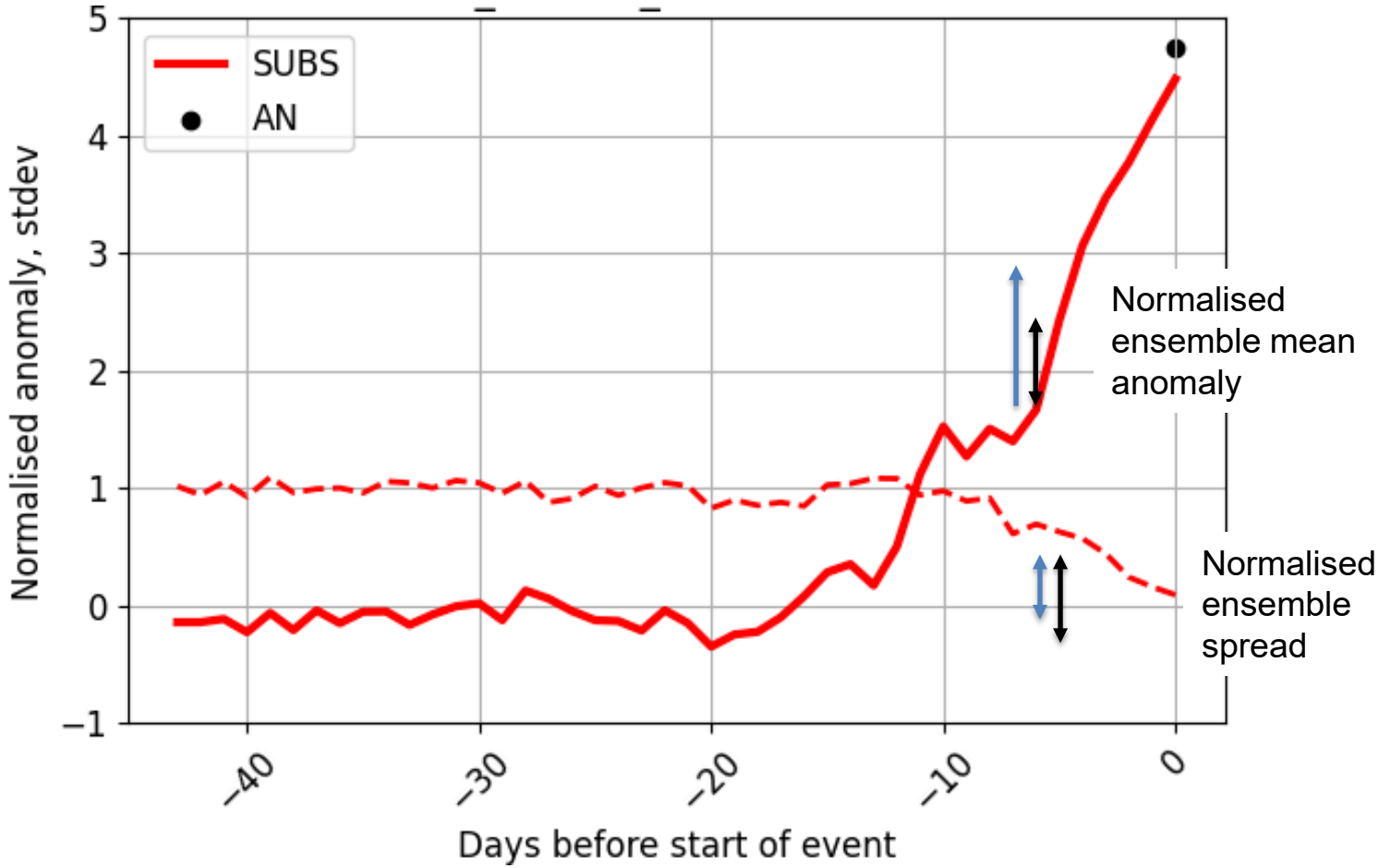
Evolution of the forecasts for London-Heathrow



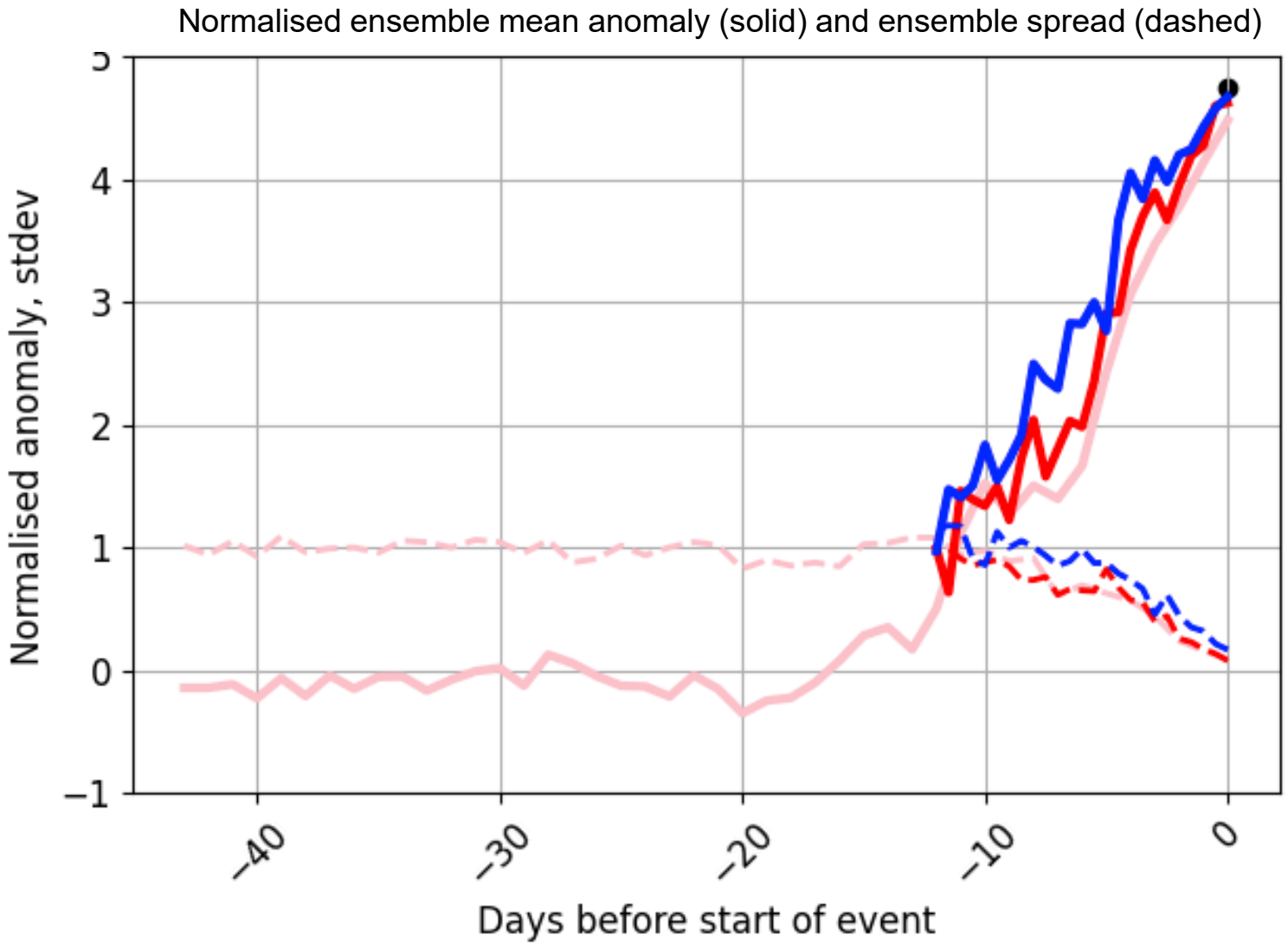
Summary plot of the evolution diagram



Normalised ensemble mean anomaly (solid) and ensemble spread (dashed)



Comparison between IFS and AIFS ensembles – recent heatwave

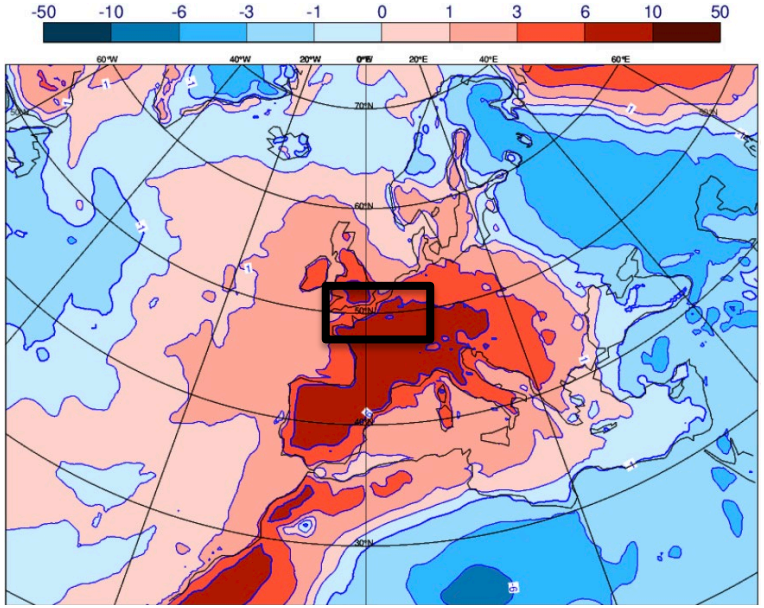


IFS-SUBS – pink
IFS-ENS – red
AIFS-ENS - blue

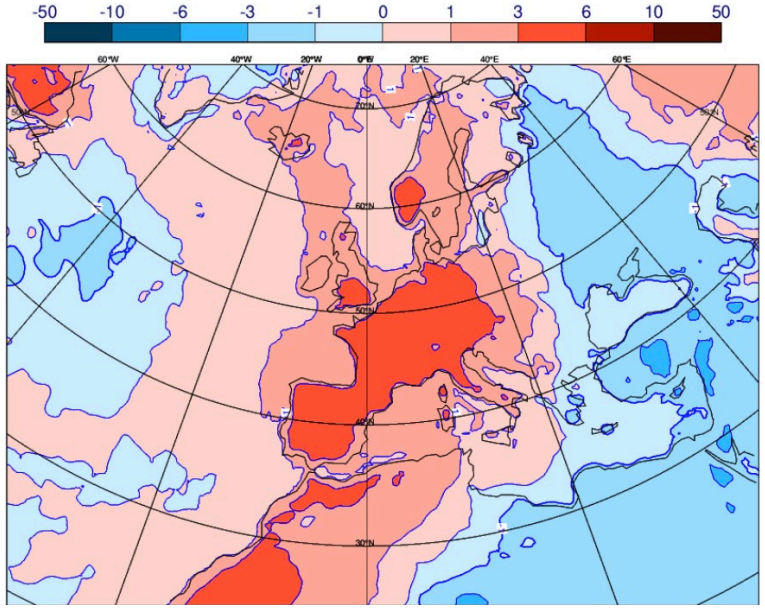
Sub-seasonal predictions

Weekly ensemble mean anomalies 25-31 May

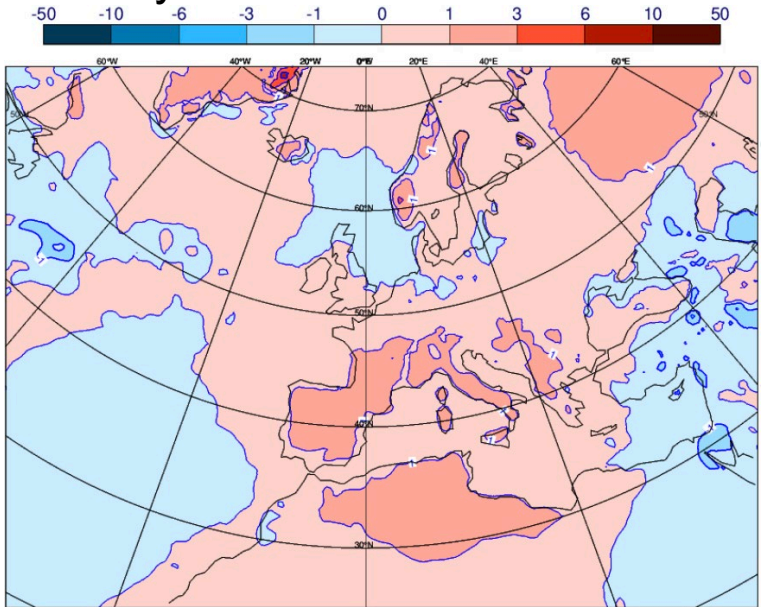
25 May



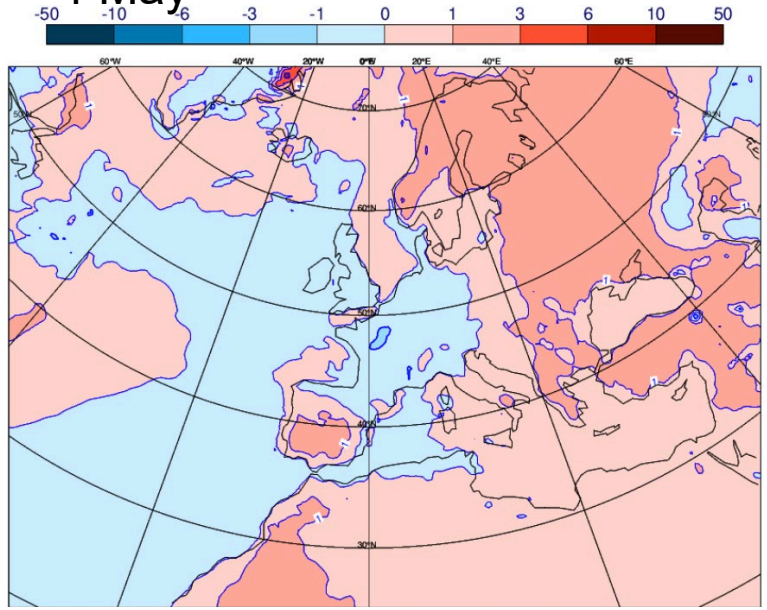
18 May



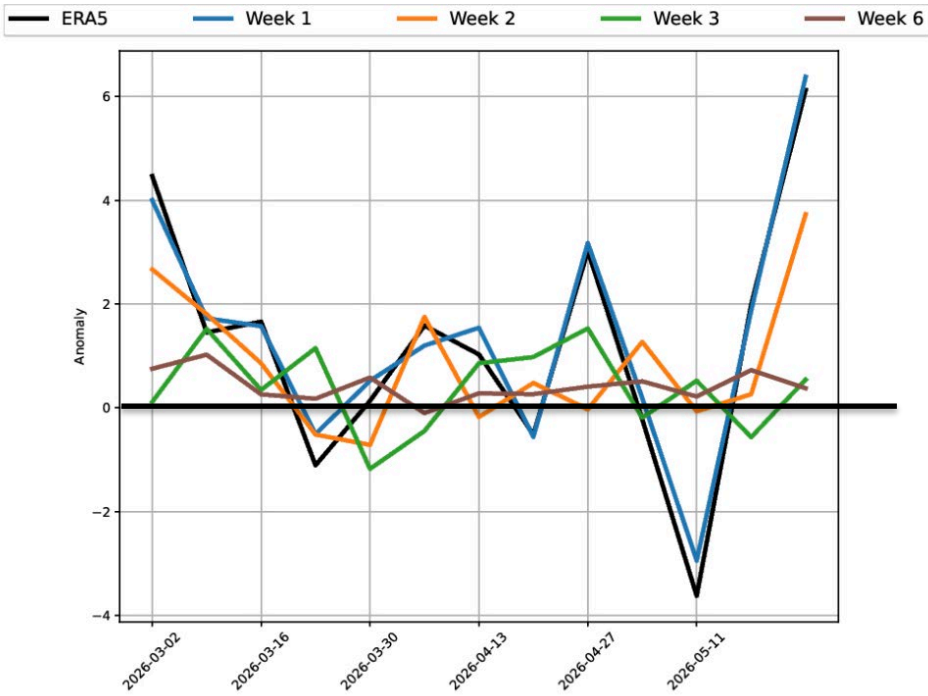
11 May



4 May



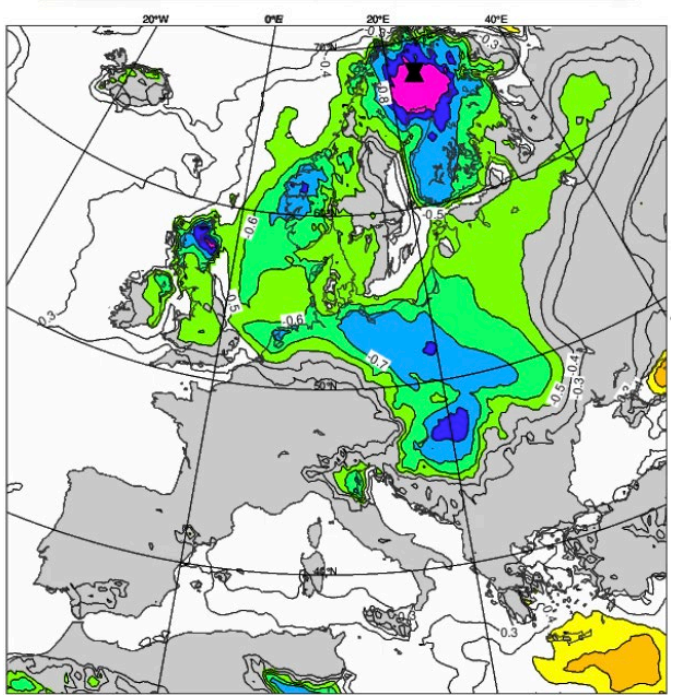
Weekly mean temperature in box over Western Europe



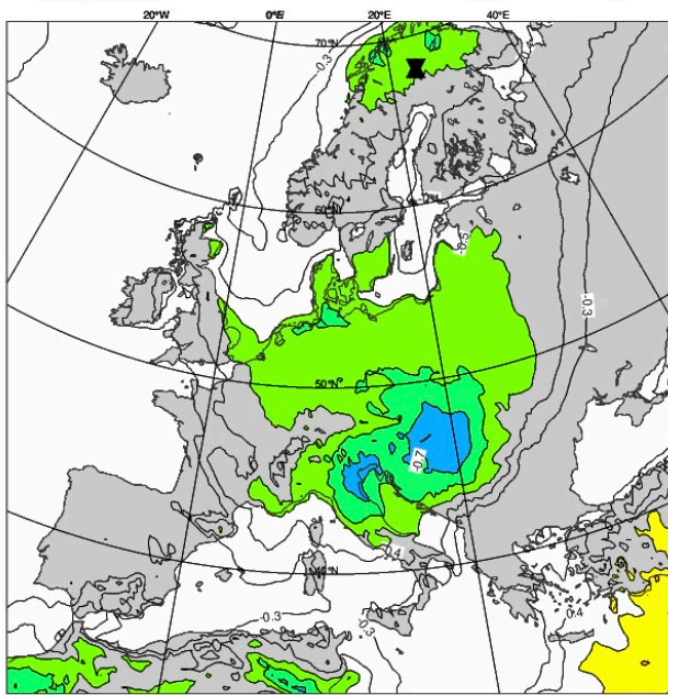
Annual correlations:
Week 2: 0.71
Week 3: 0.33
Week 4: -0.08

Cold Spell in northern Europe in January 2026 (8-10 January)

3-day EFI from 8 January

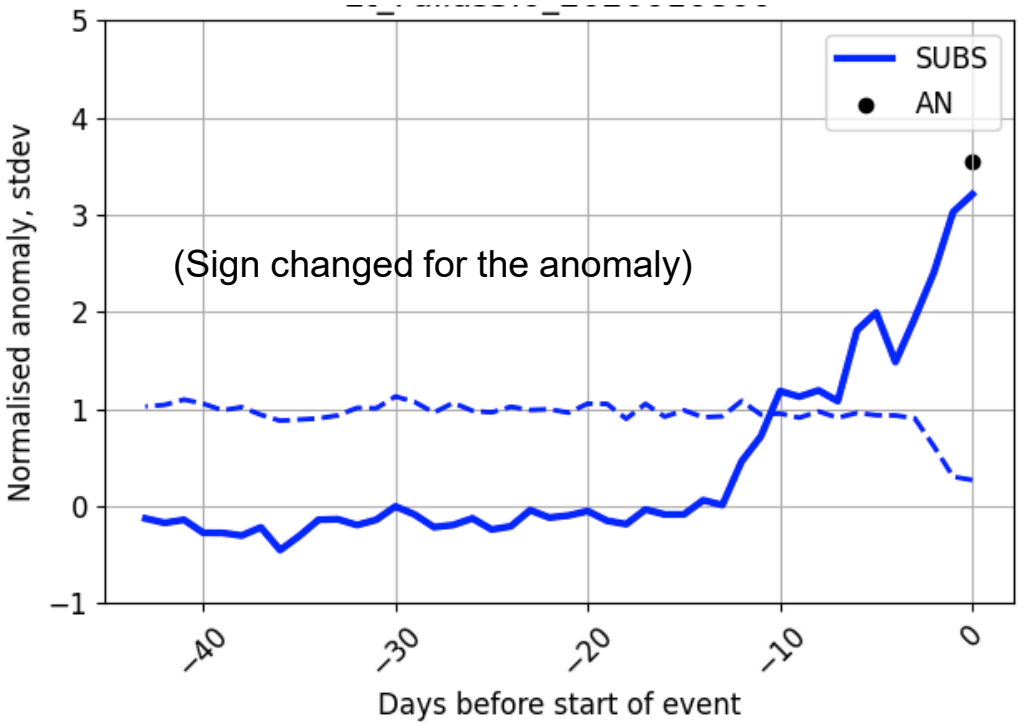


3-day EFI from 2 January



-0.9 -0.8 -0.7 -0.6 -0.5 0.5 0.6 0.7 0.8 0.9

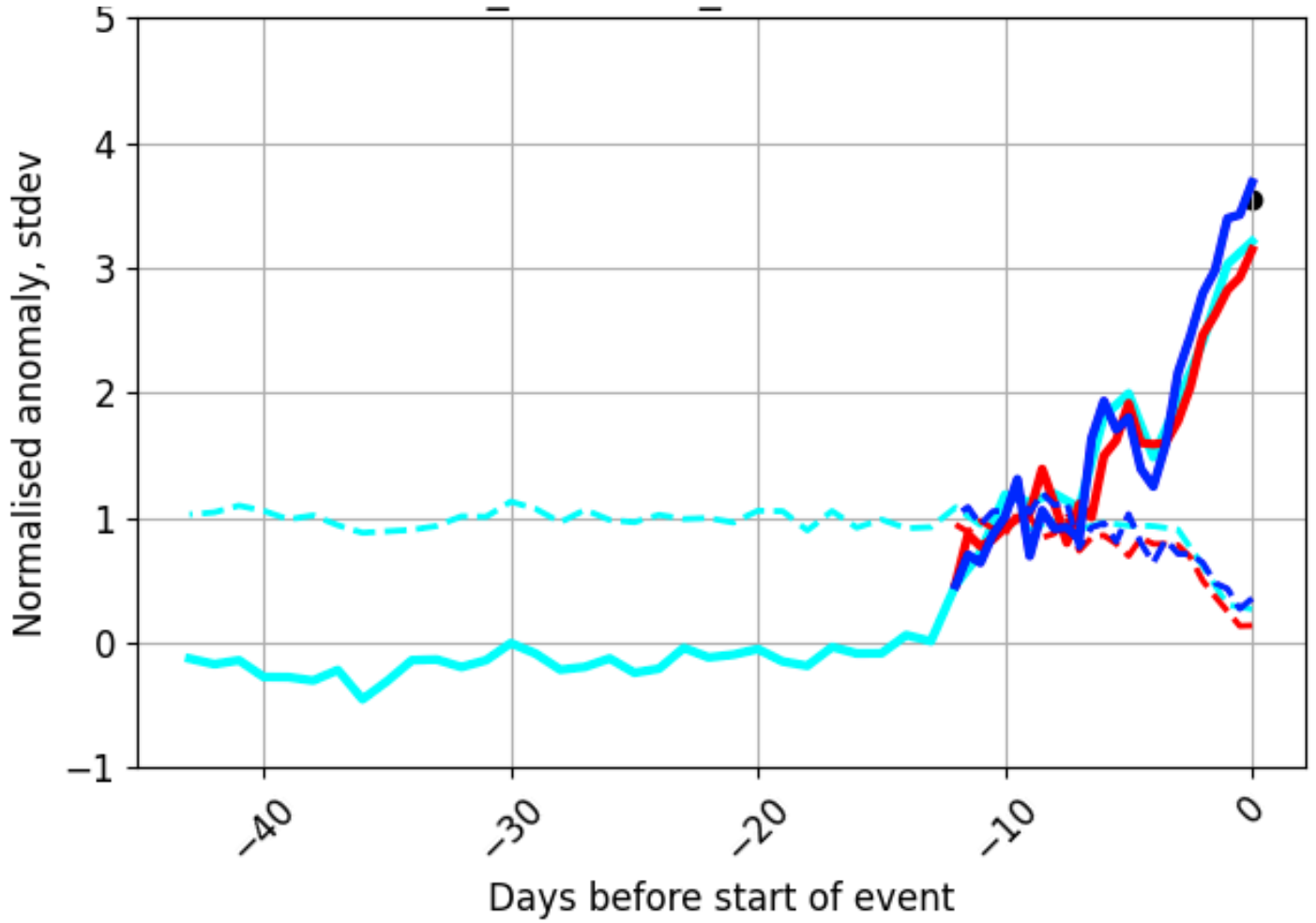
Normalised ensemble mean anomaly (solid) and ensemble spread (dashed) for point in northern Finland



3-day anomaly in the analysis of ~-15 degrees

Comparison between IFS and AIFS ensembles – cold spell

Normalised ensemble mean anomaly (solid) and ensemble spread (dashed)

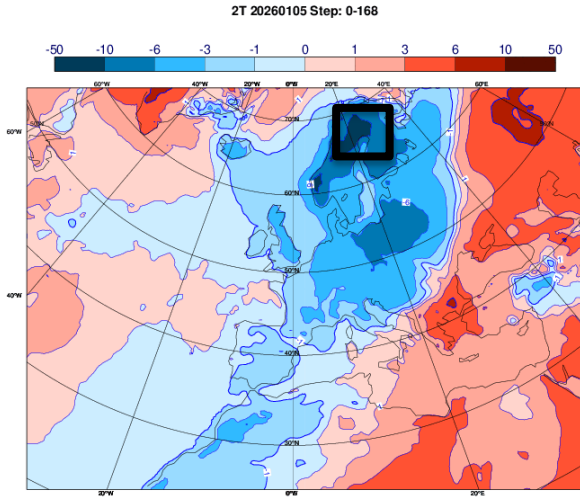


IFS-SUBS – cyan
IFS-ENS – red
AIFS-ENS - blue

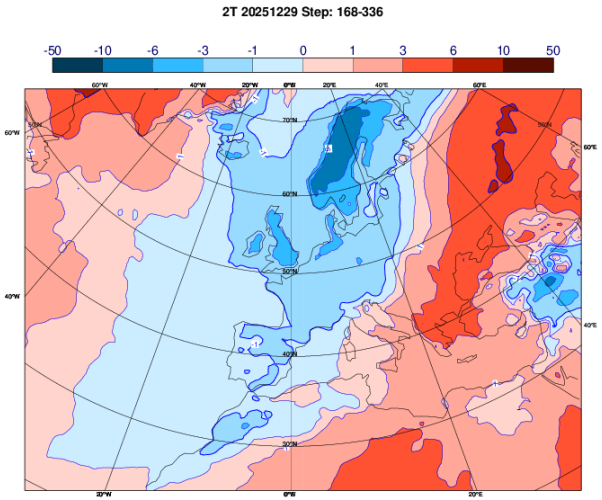
Sub-seasonal predictions:

Weekly ensemble mean anomalies 5-11 January

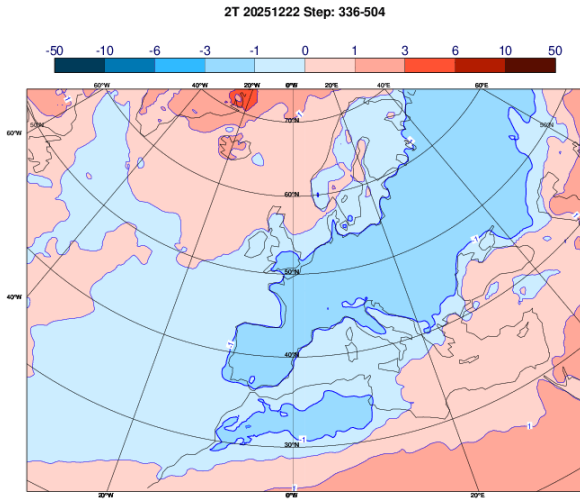
5 January



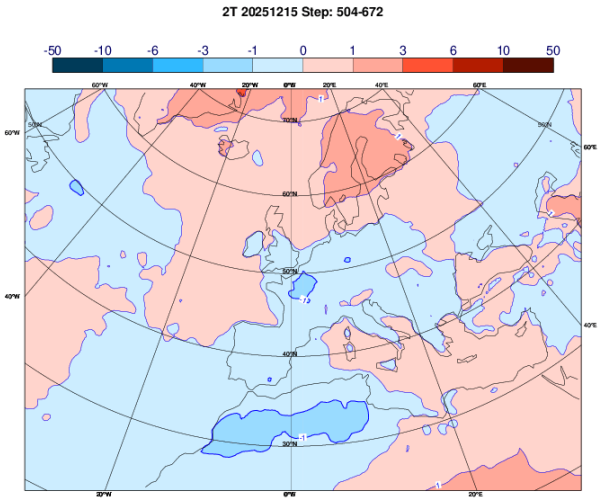
29 December



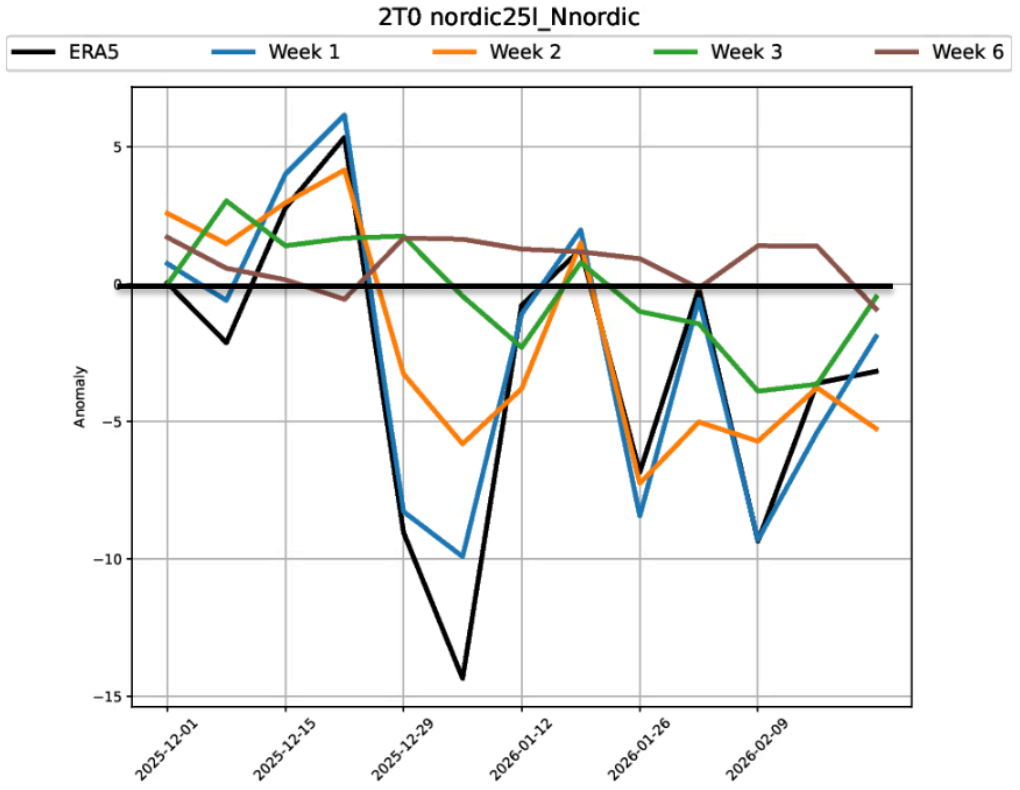
22 December



15 December



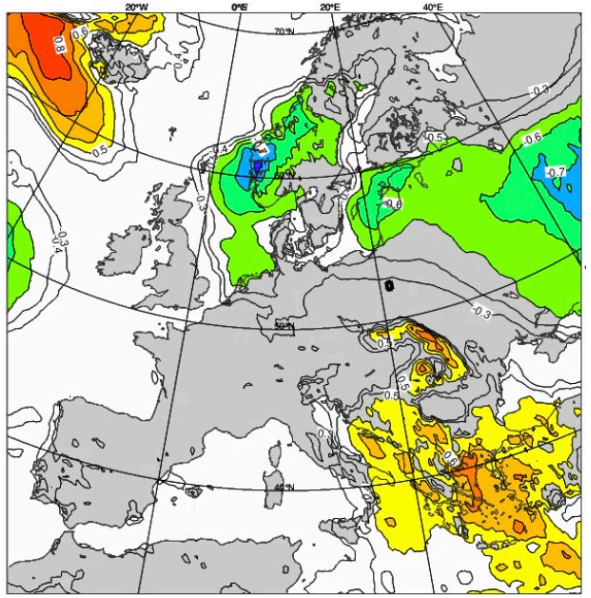
Weekly mean temperature in box over Northern Finland



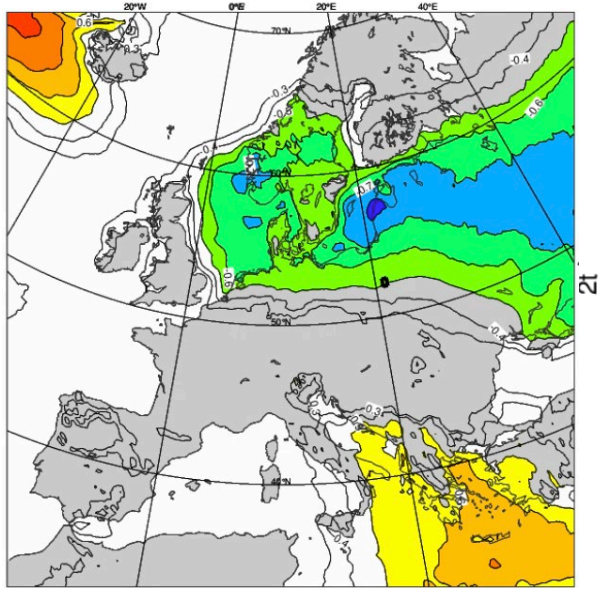
Annual correlations:
Week 2: 0.79
Week 3: 0.35
Week 4: -0.02

False alarm for cold spell in January 2026

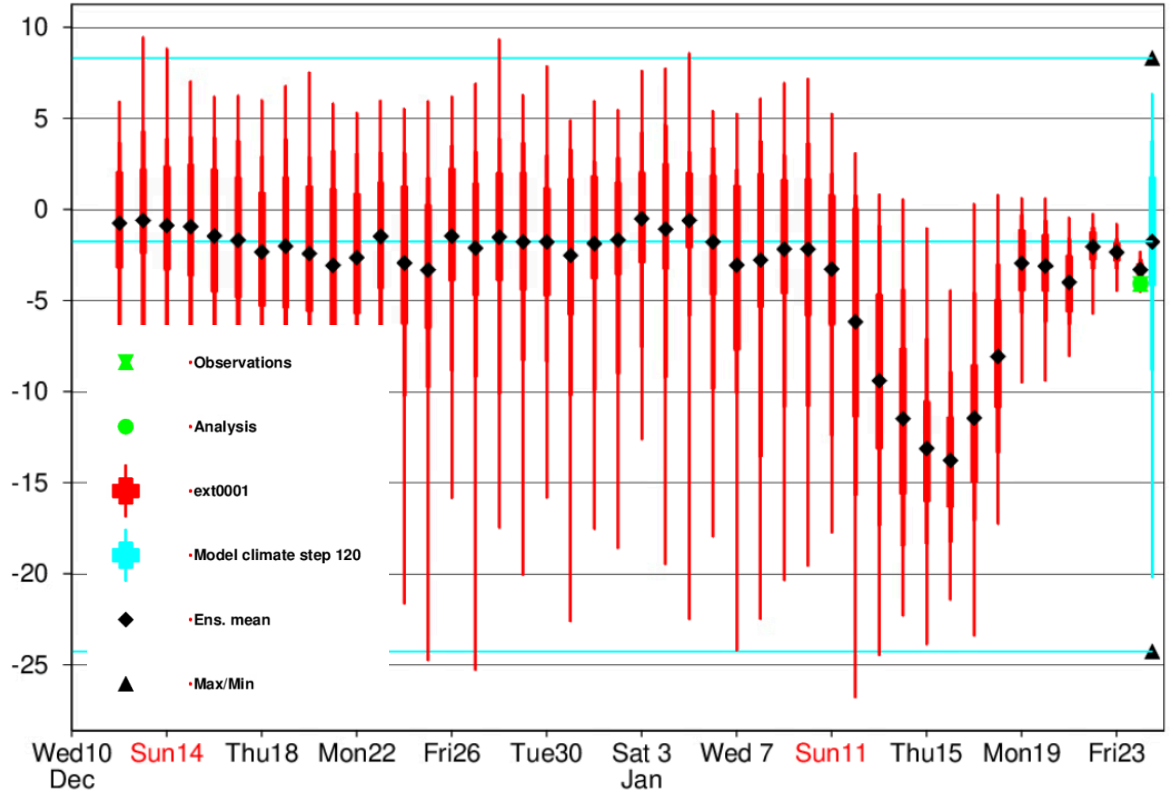
3-day EFI from 24 January



3-day EFI from 18 January



Evolution of forecast for Warzaw 24-26 January

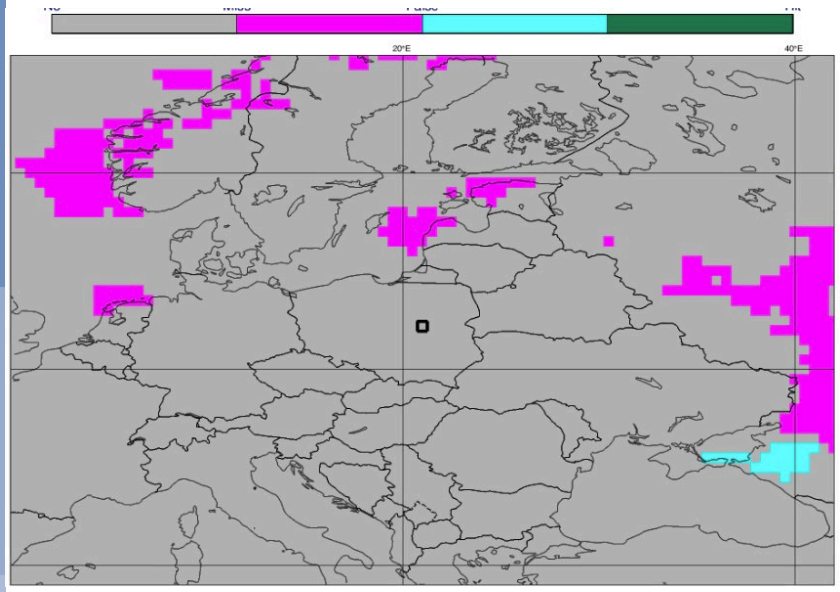


Spatial extension of the prediction of the high temperatures 24-26 January

Event defintion: Ensemble mean exceeding 90th percentile of the model climate

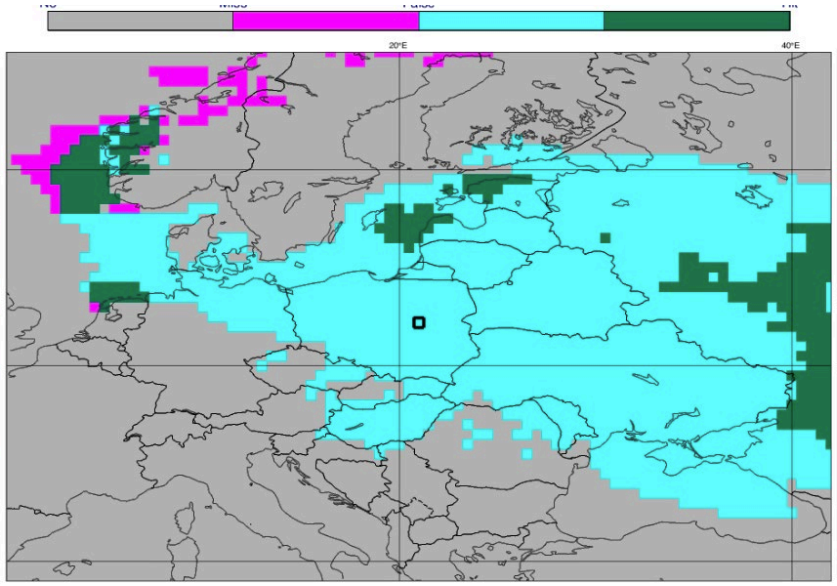
12 January

Miss False Hit



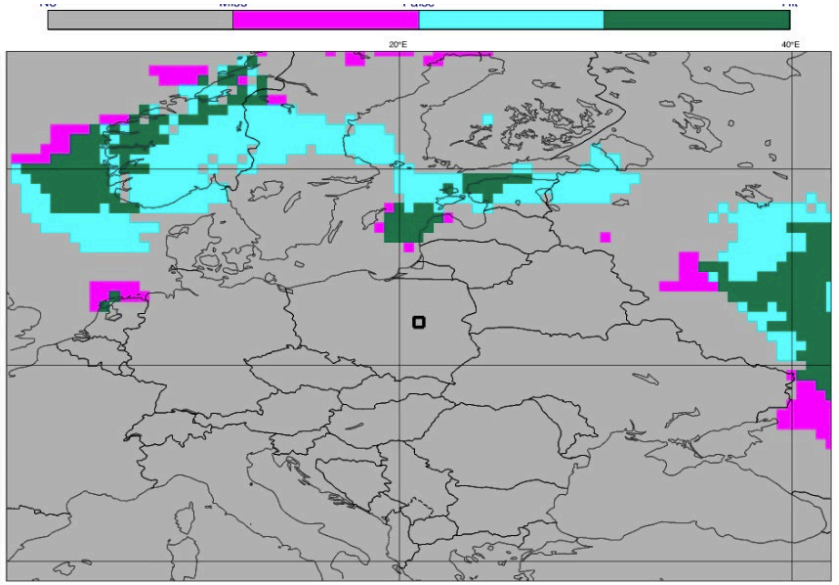
16 January

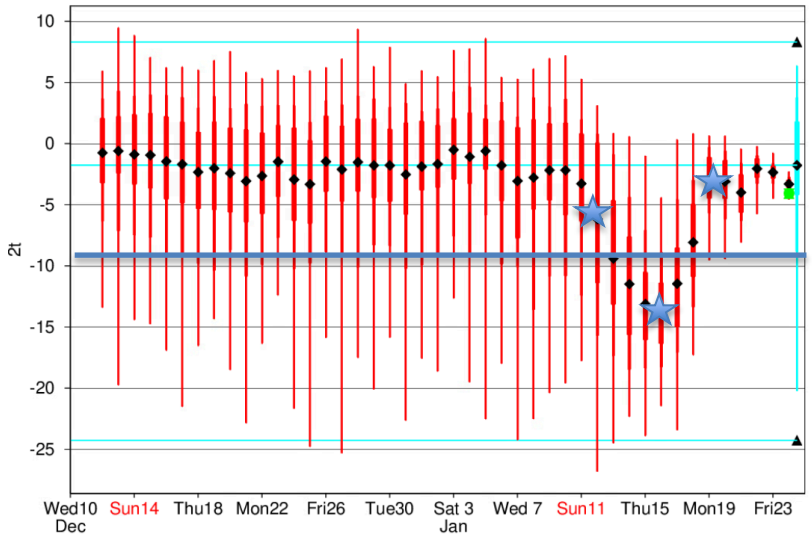
Miss False Hit



19 January

Miss False Hit



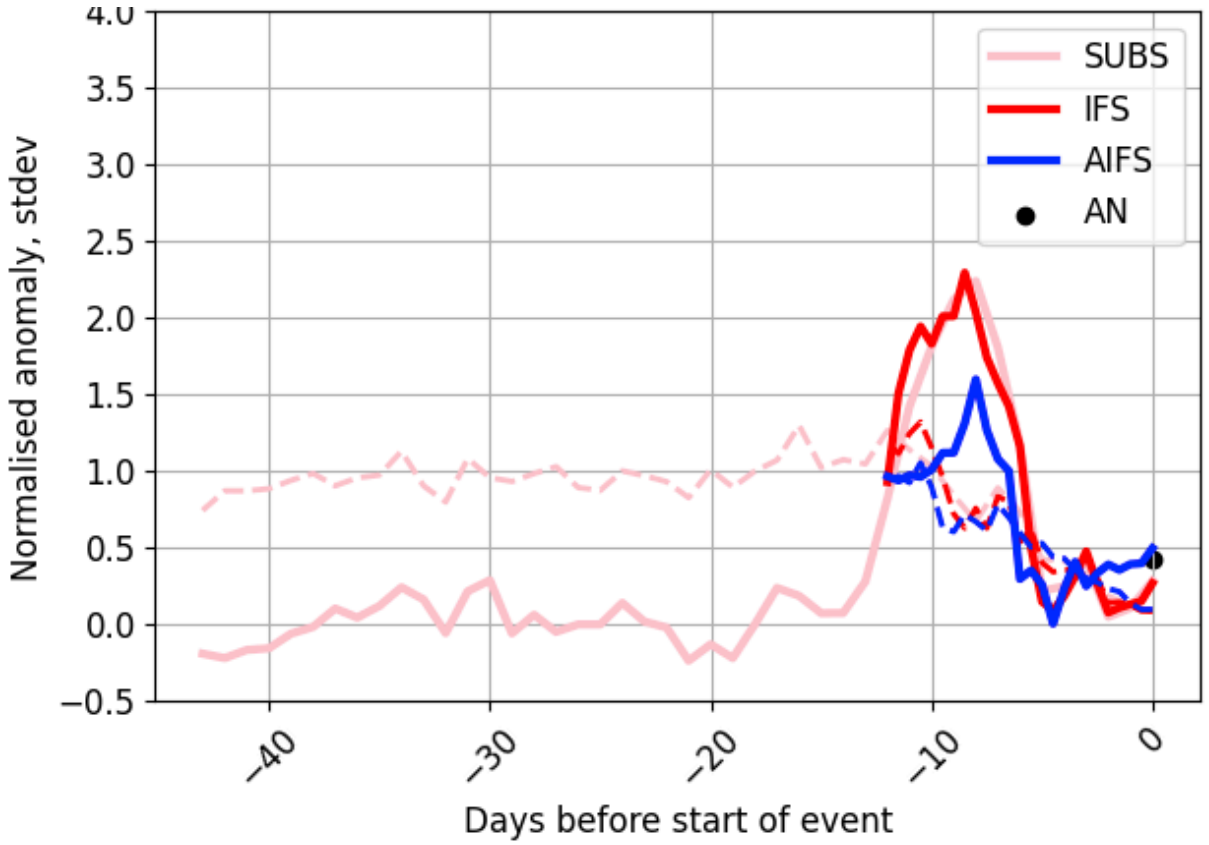


90th percentile

ECMWF

Comparison between IFS and AIFS ensembles – False alarm case

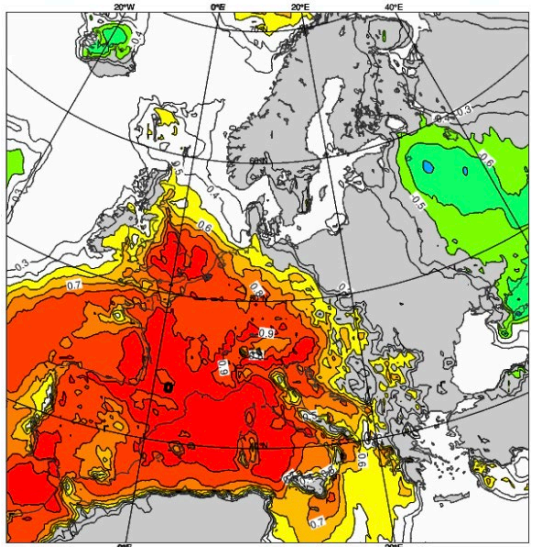
Normalised ensemble mean anomaly (solid) and ensemble spread (dashed)



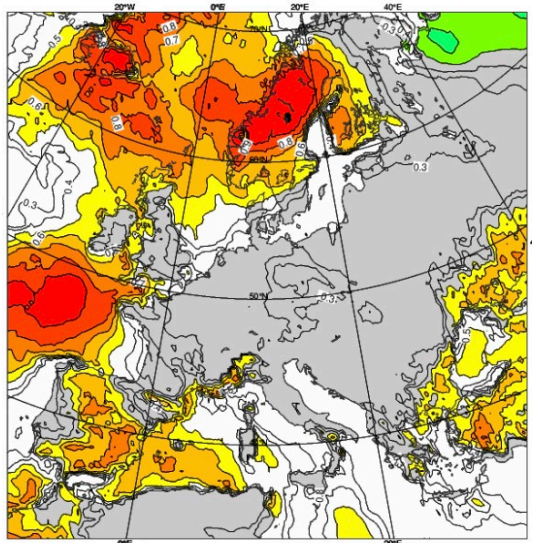
IFS-SUBS – pink
IFS-ENS – red
AIFS-ENS - blue

7 cases of extreme temperatures + 1 false alarm

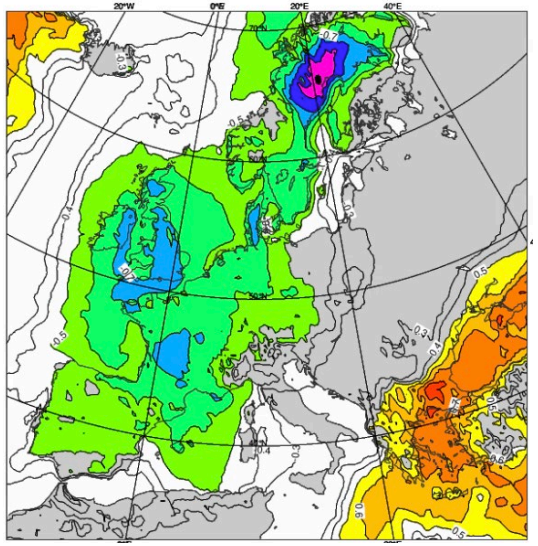
29 June – 1 July 2025



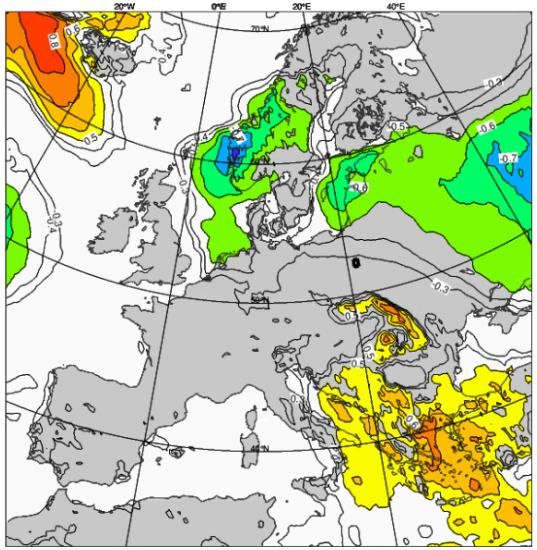
15-17 July 2025



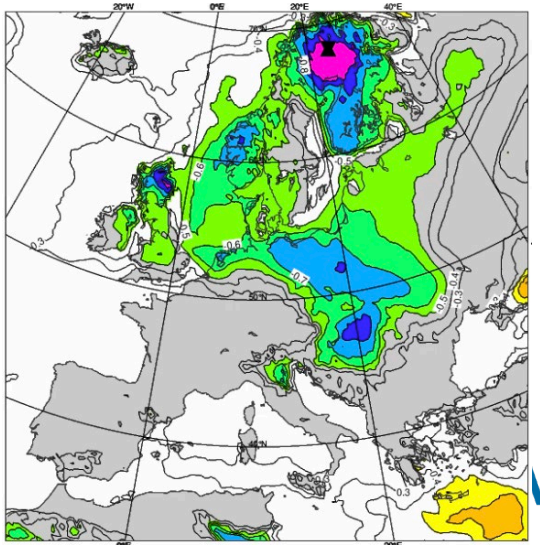
19-21 November 2025



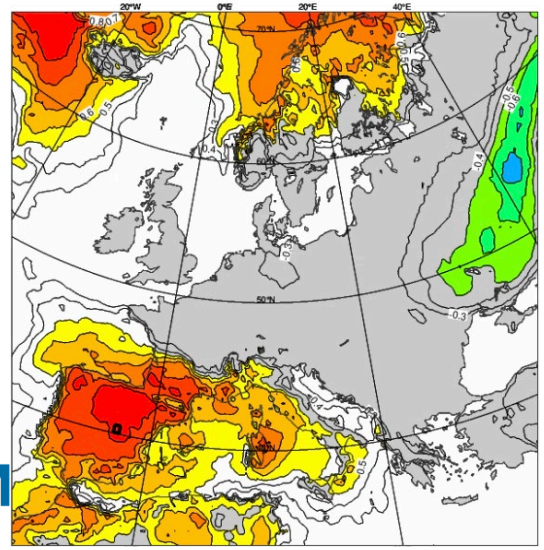
24-26 January 2026



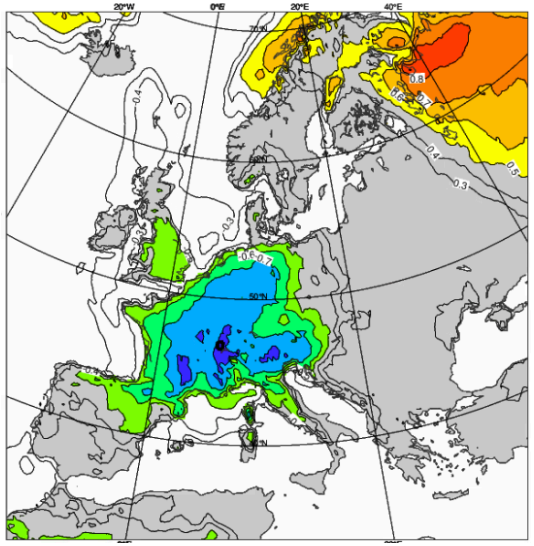
8-10 January 2026



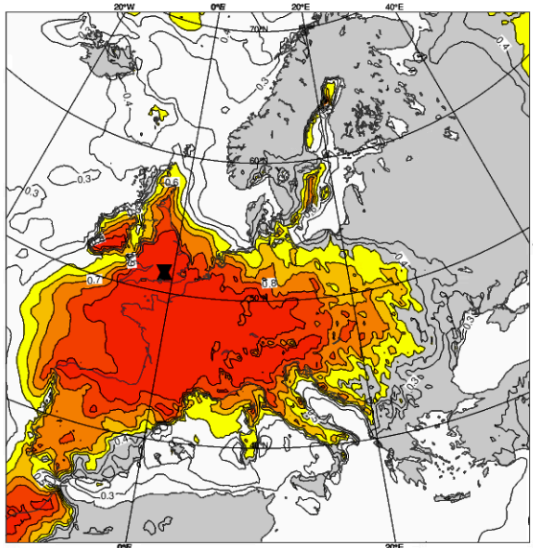
19-21 April 2026



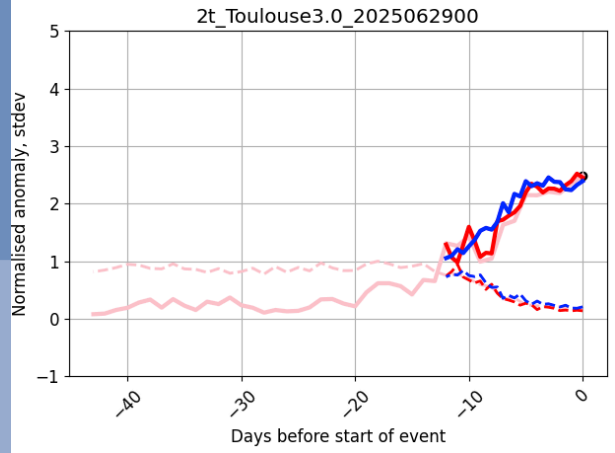
14-16 May 2026

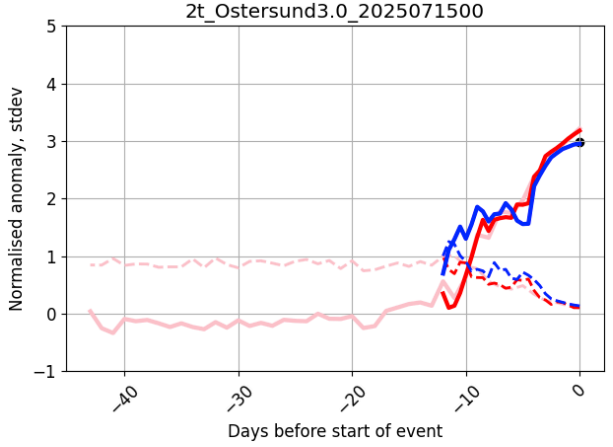


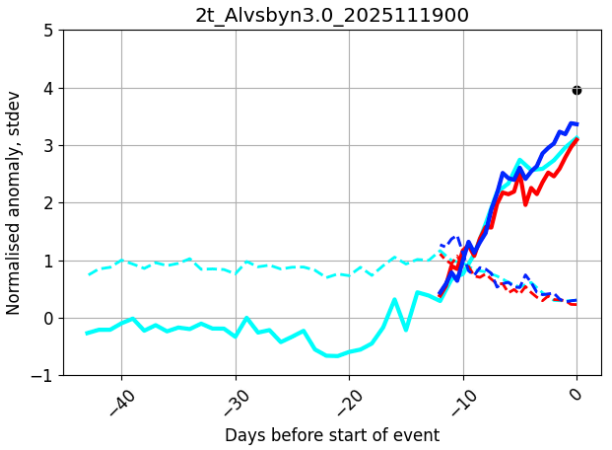
24-26 May 2026

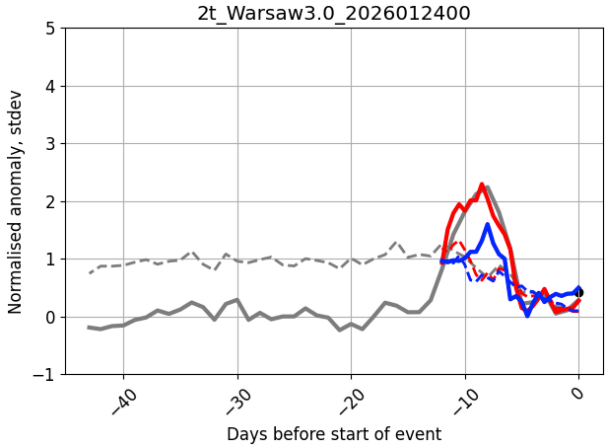


Comparison with AIFS-ENS

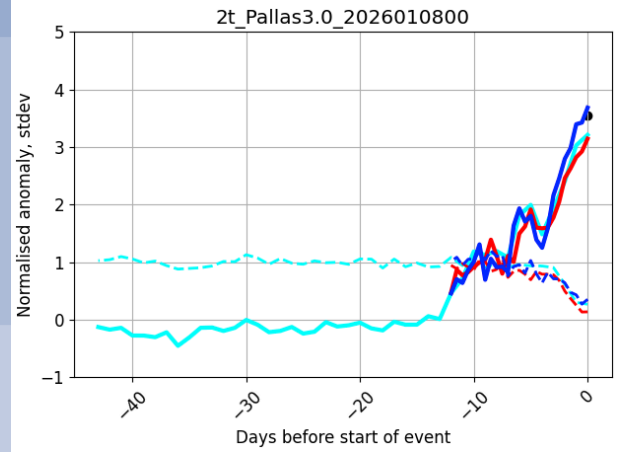


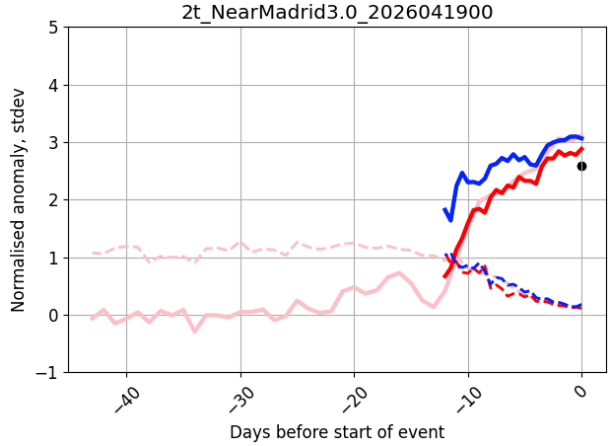


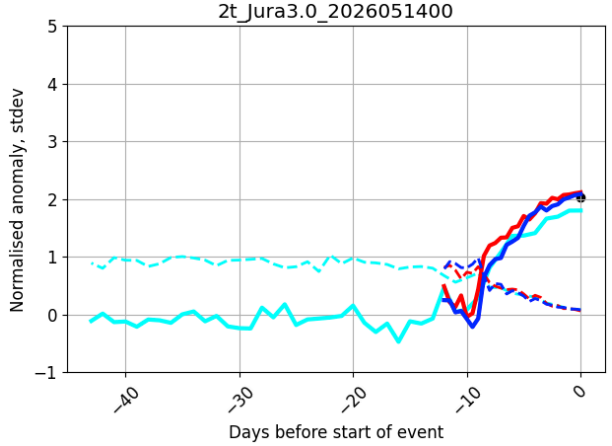


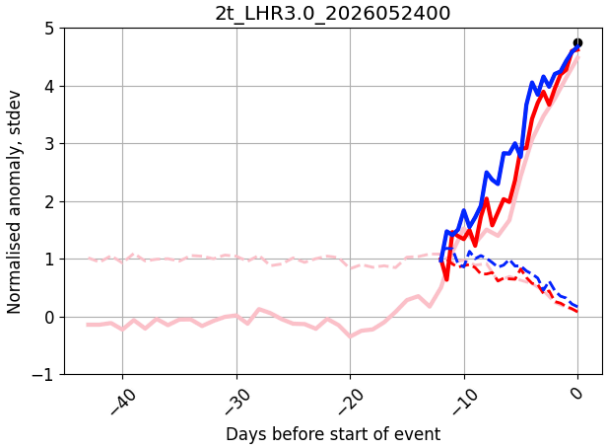


IFS-SUBS – pink/cyan/grey
IFS-ENS – red
AIFS-ENS - blue

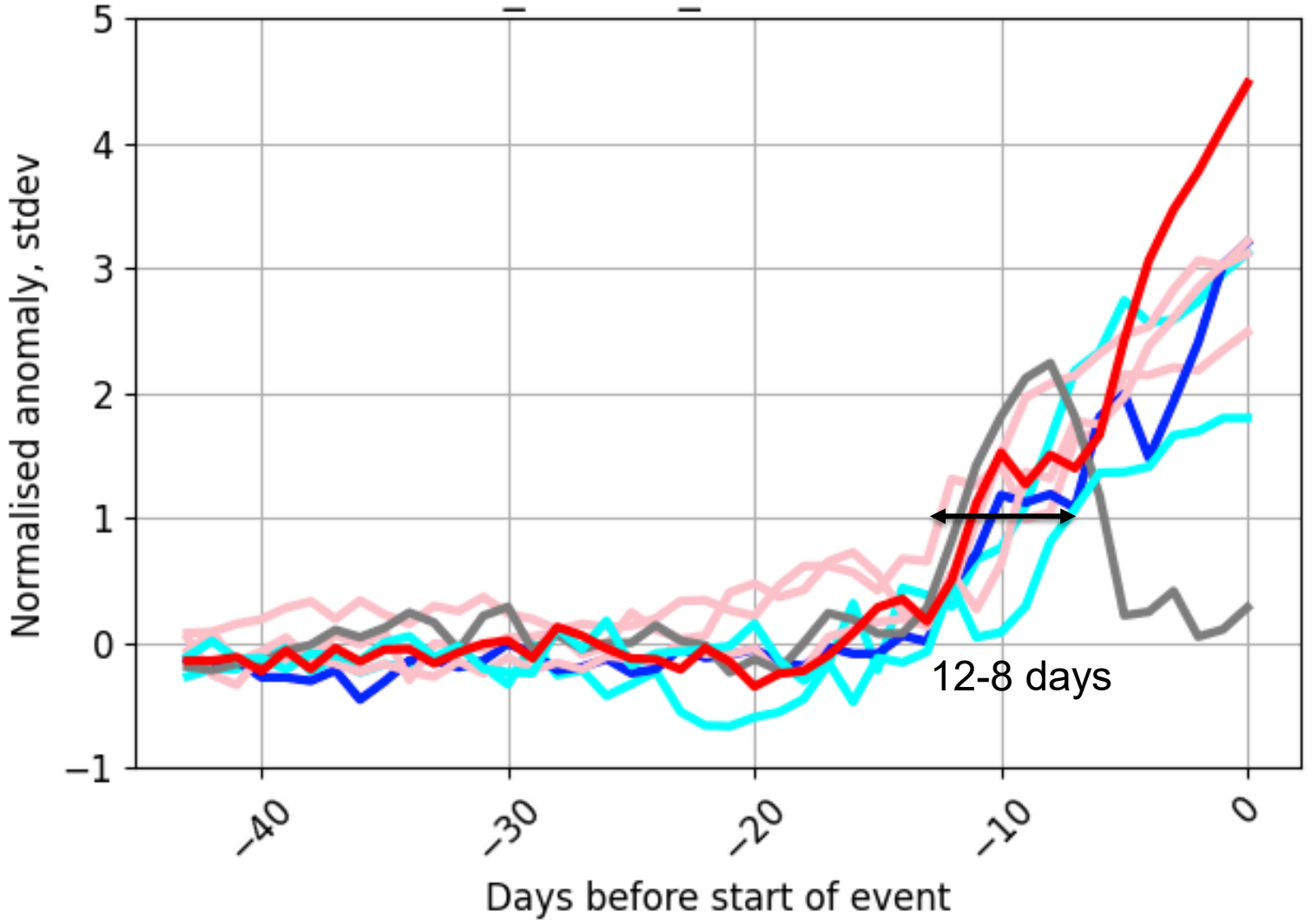








Summary of the events – normalised ensemble mean anomaly

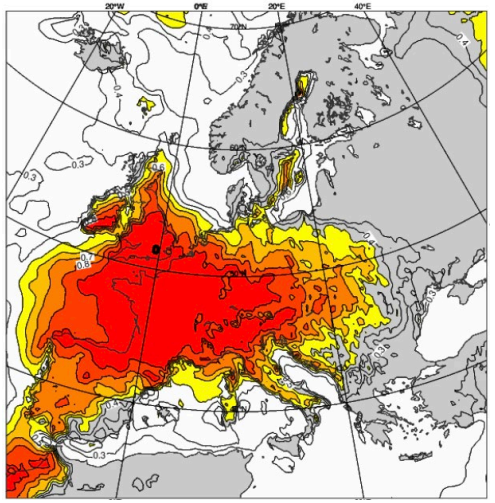


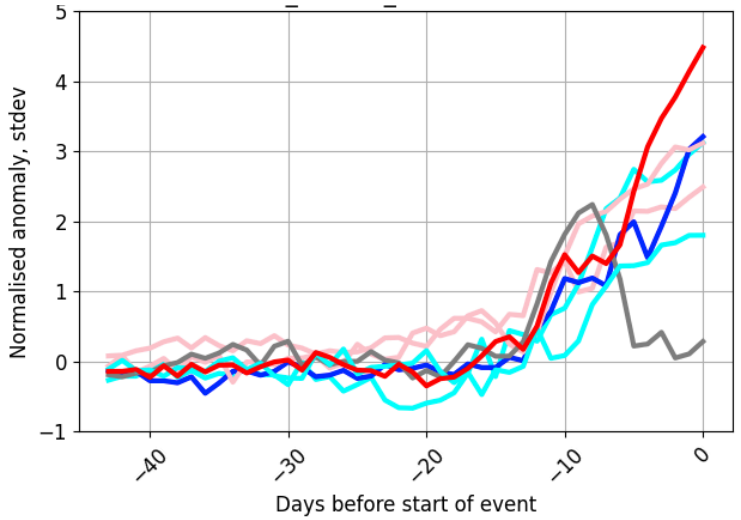
Heatwaves – red/pink
Cold spells – blue/pink
False alarm - grey

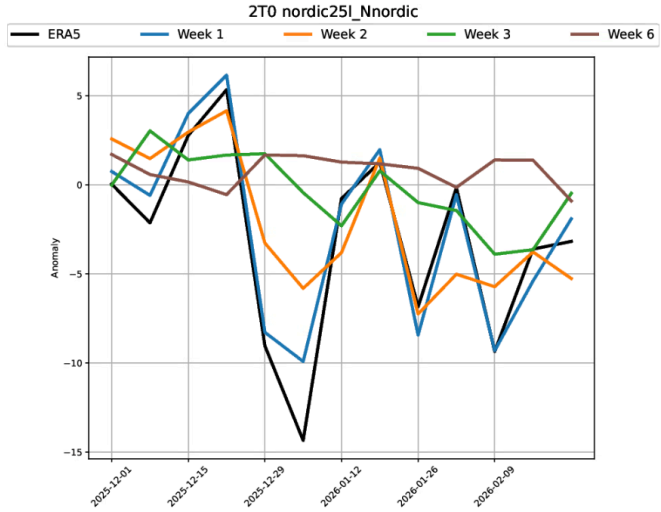
~84th percentile

(Sign changed for cold events)

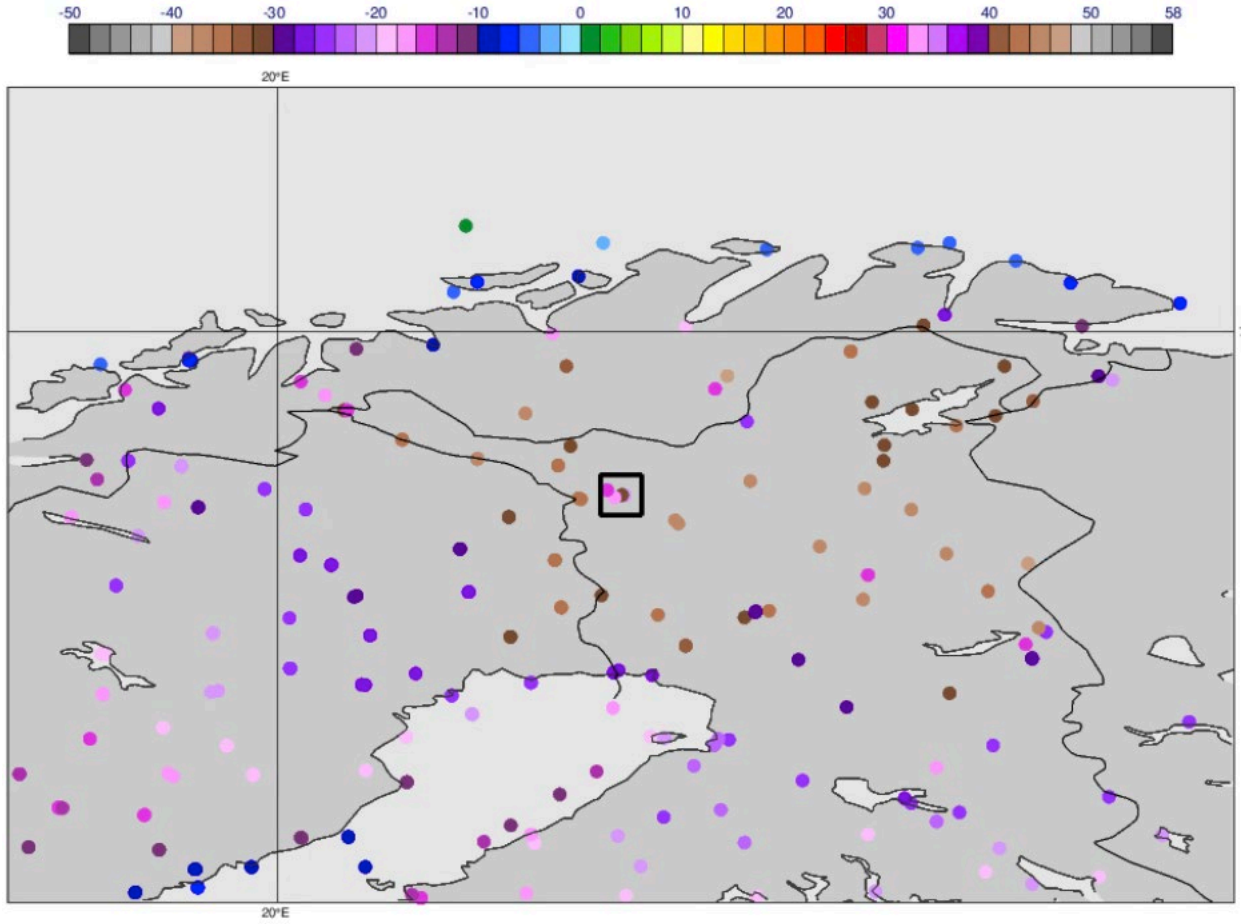
Summary

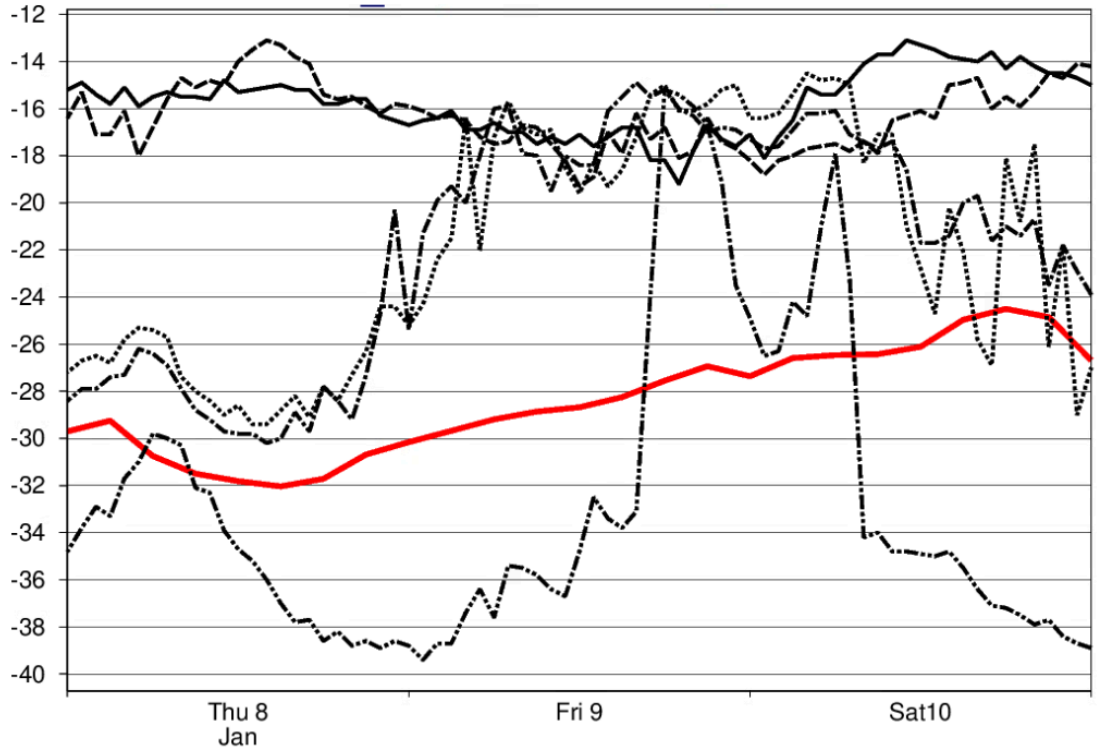



Normalised anomaly, stdev
Days before start of event


2T0 nordic25l_Nnordic
ERA5
Week 1
Week 2
Week 3
Week 6
Anomaly

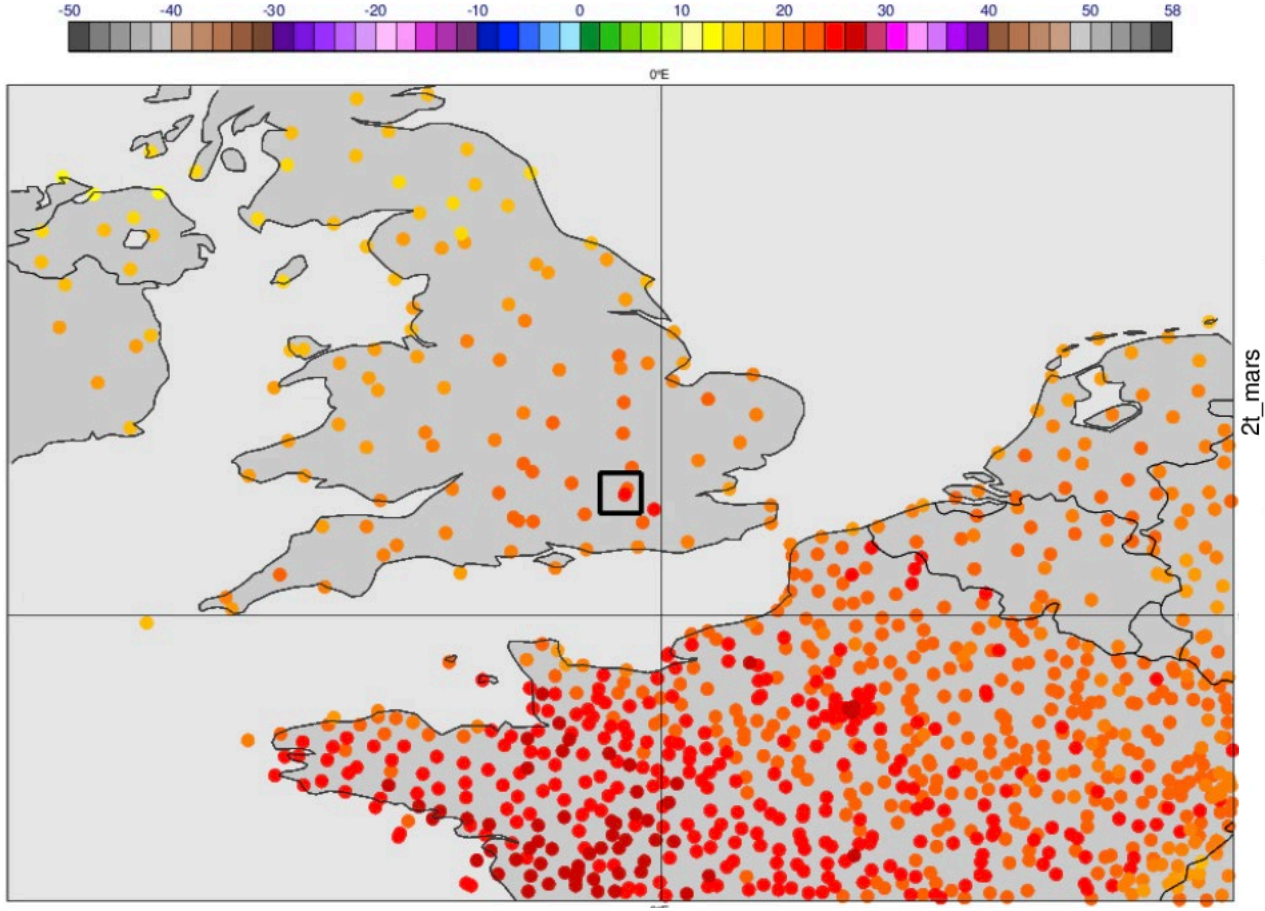
Spatial and temporal variability within the 3-day period 8 - 10 January 2026

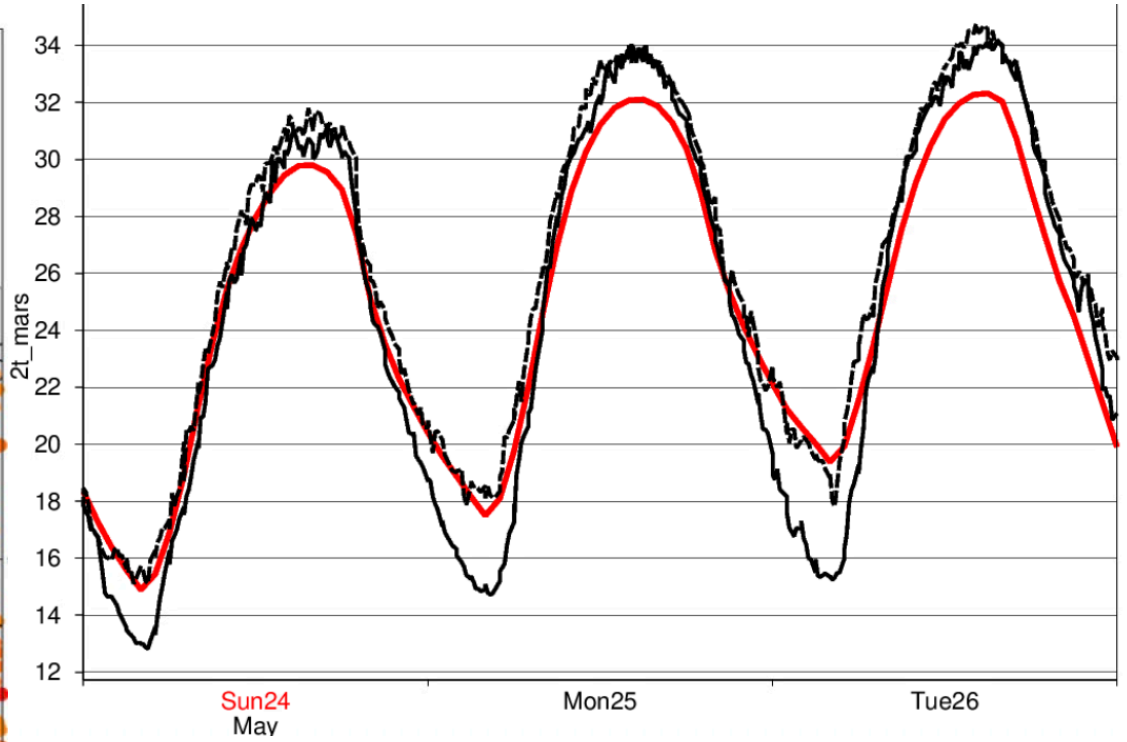




IFS control – red
Observation stations within 0.5 degrees - black

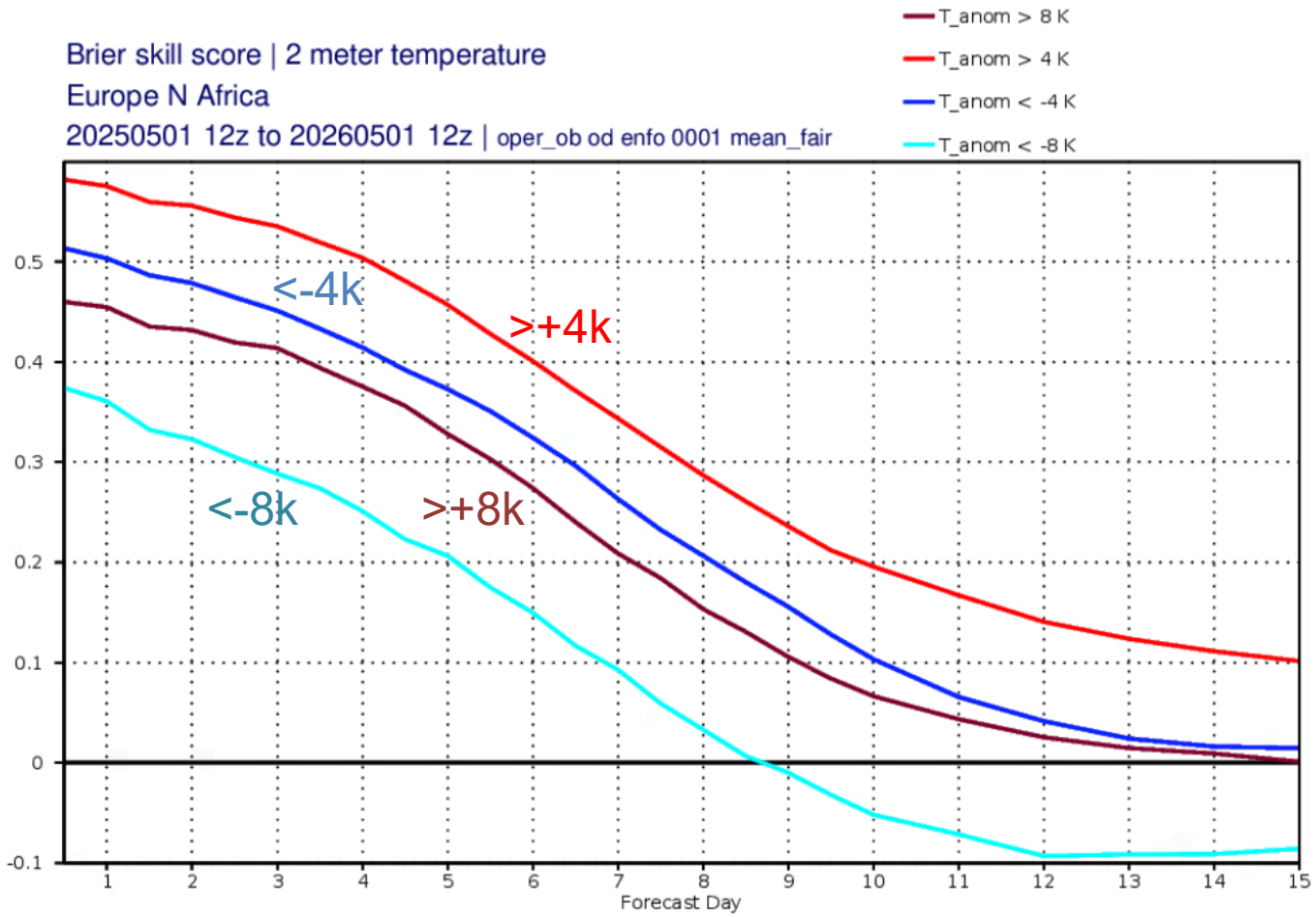
Spatial and temporal variability within the 3-day period 24 - 26 May 2026





IFS control – red
Observation stations within 0.5 degrees - black

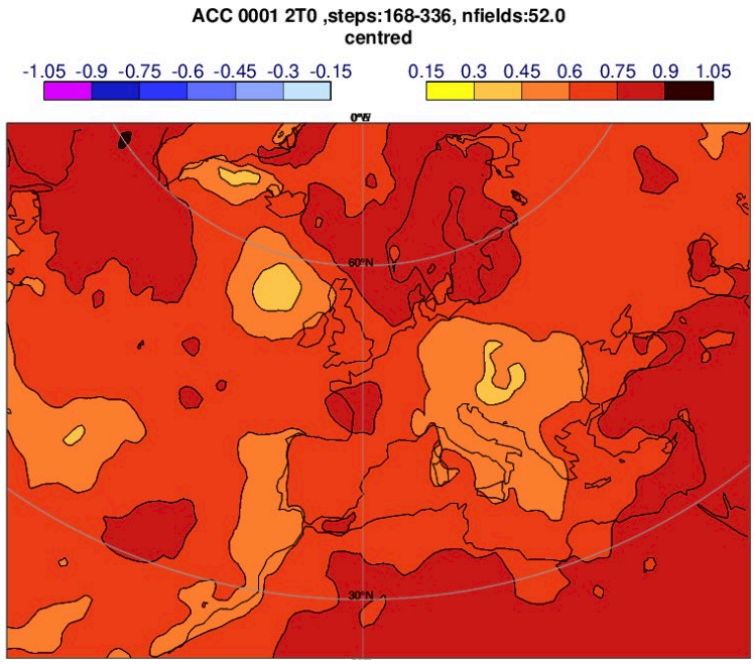
Verification of temperature extremes: Brier skill score over Europe May 2025 – May 2026



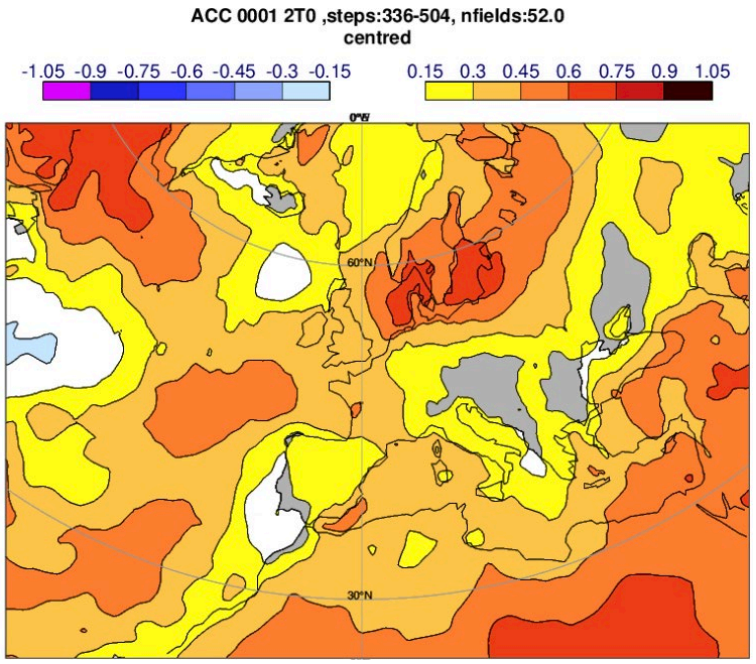
Instantanous temperatures against SYNOP

Anomaly correlation – weekly average of 2-metre temperature

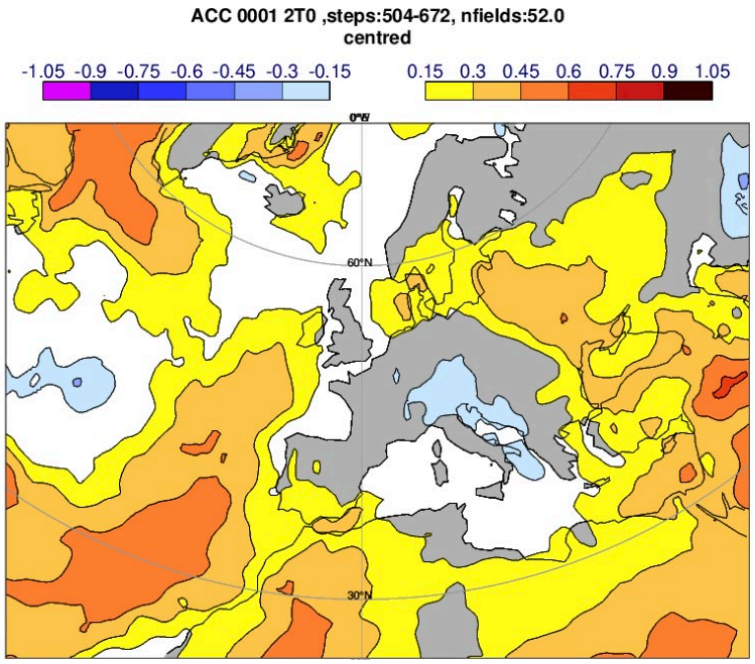
Week 2



Week 3



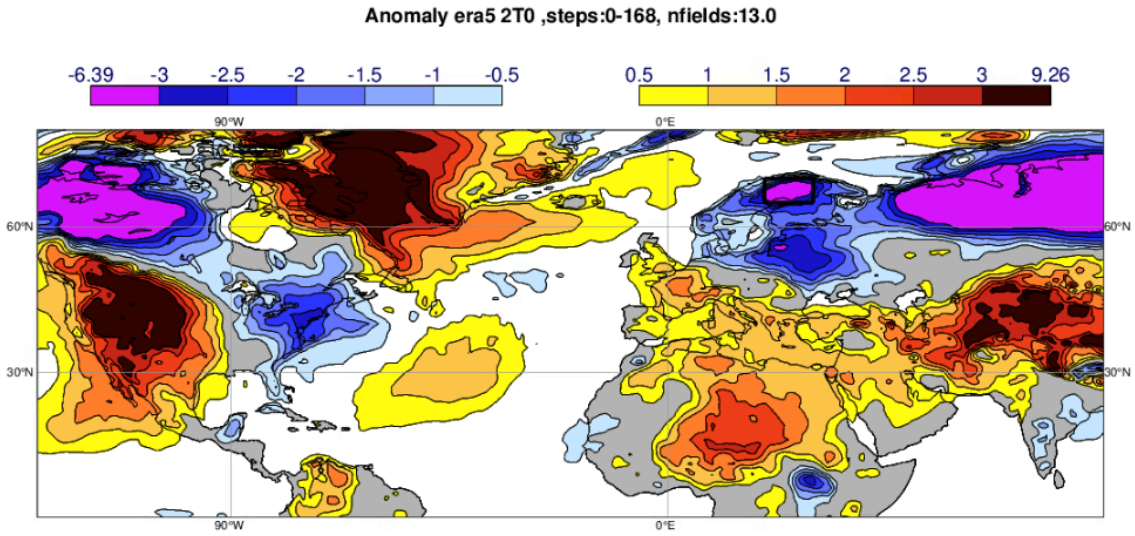
Week 4



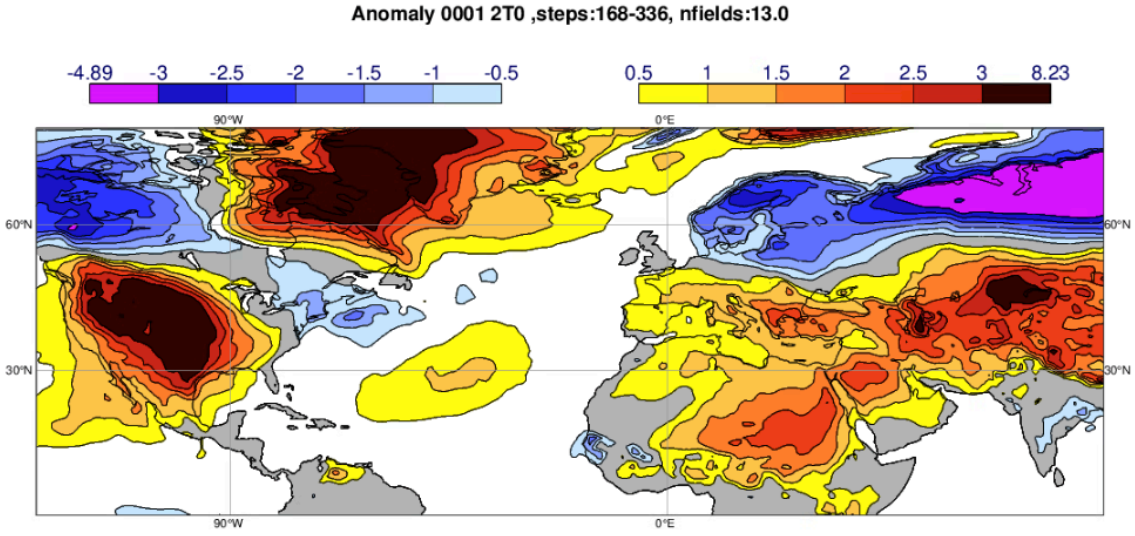
(centred defintion of ACC)

Composite of weekly mean 2-metre temperature mean anomaly for DJF 2025/26

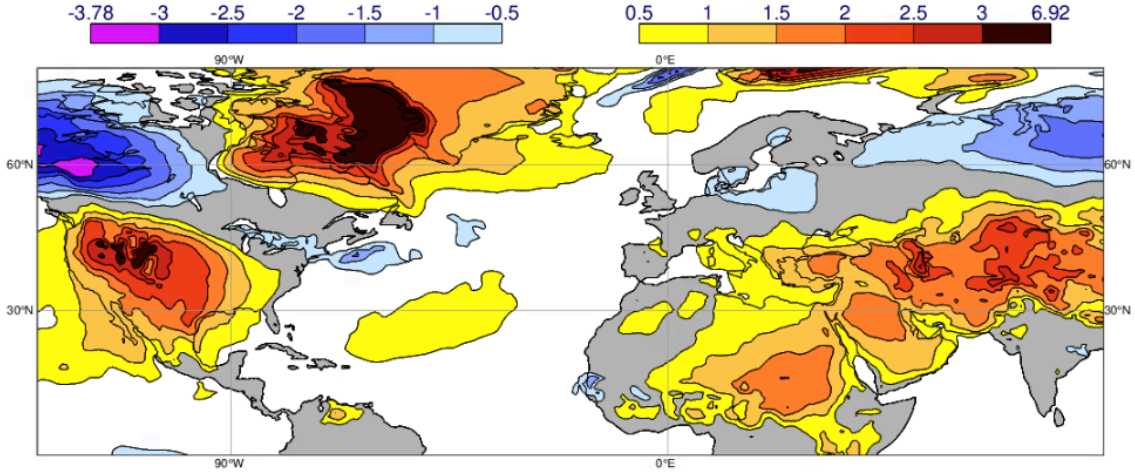
ERA5



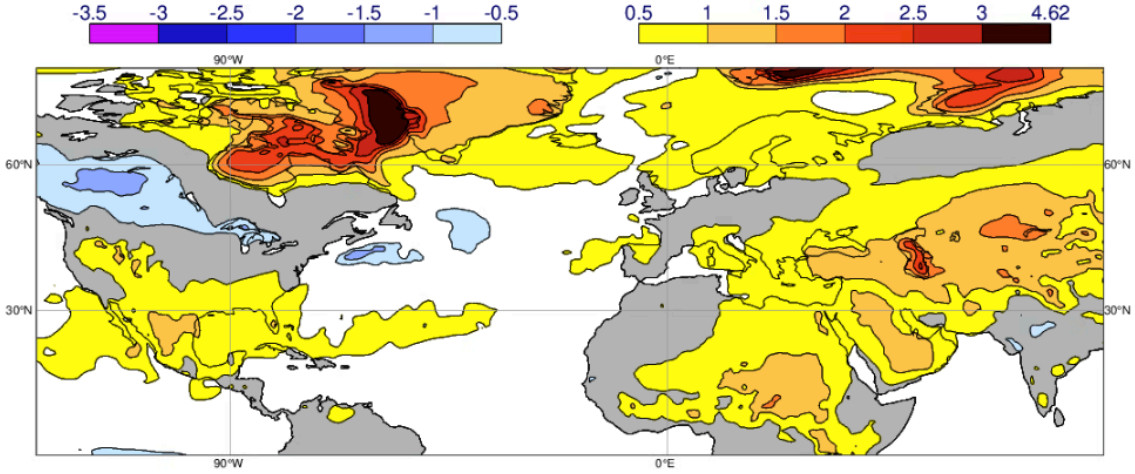
Week 2



Week 3



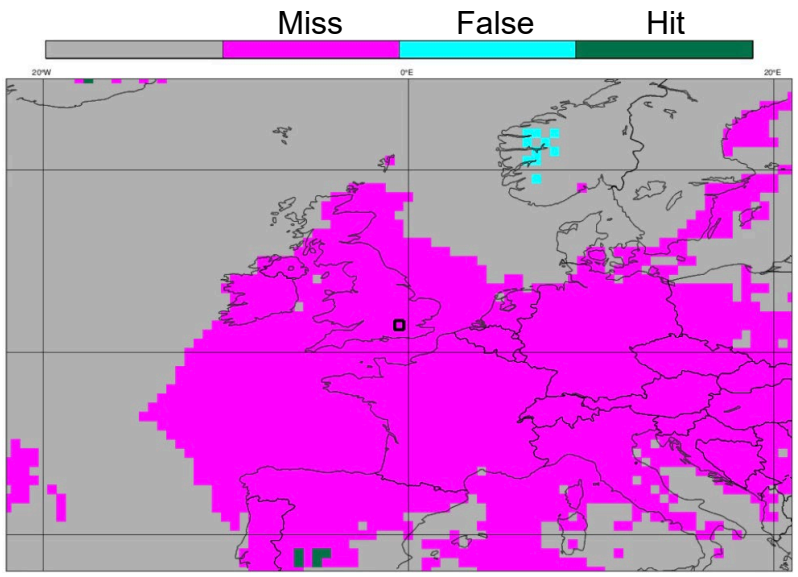
Week 6



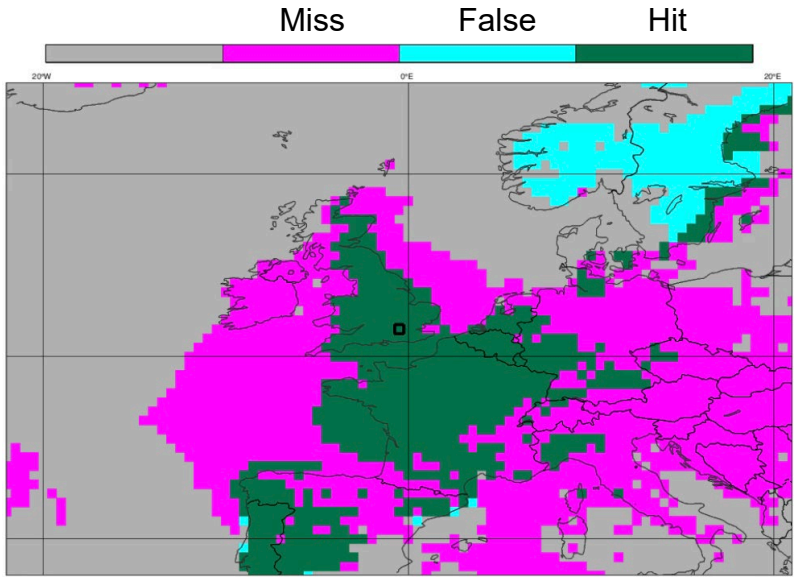
Spatial extension of the prediction of the high temperatures 24-26 May

Event defintion: Ensemble mean exceeding 90th percentile of the model climate

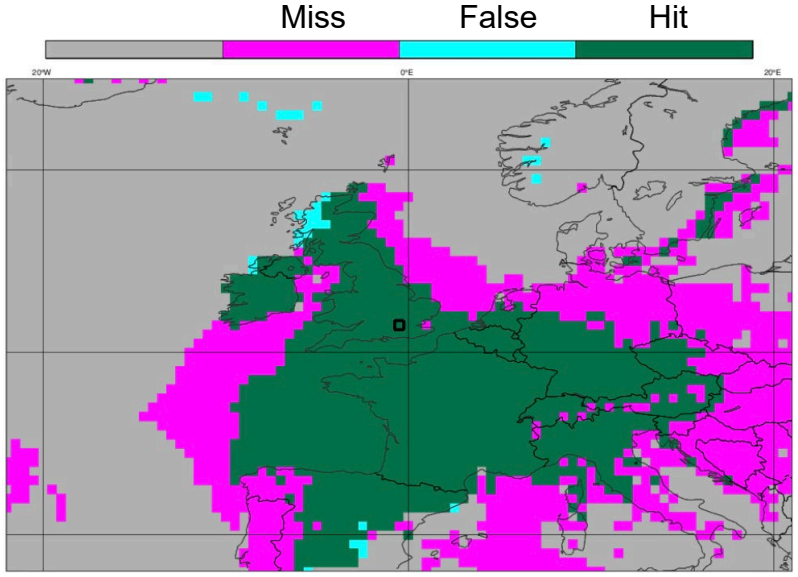
12 May

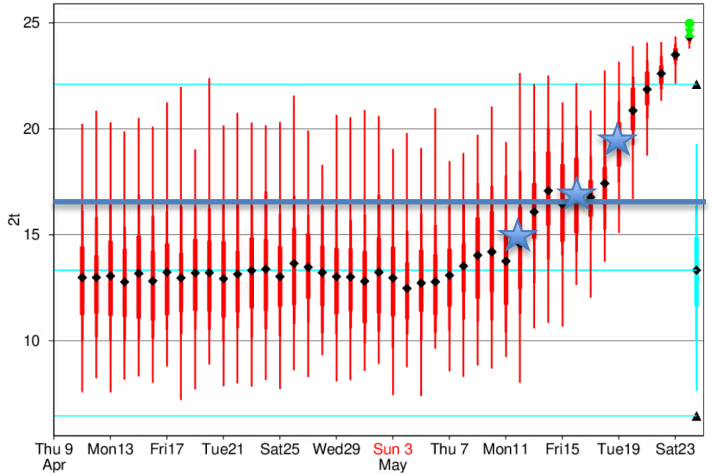


16 May

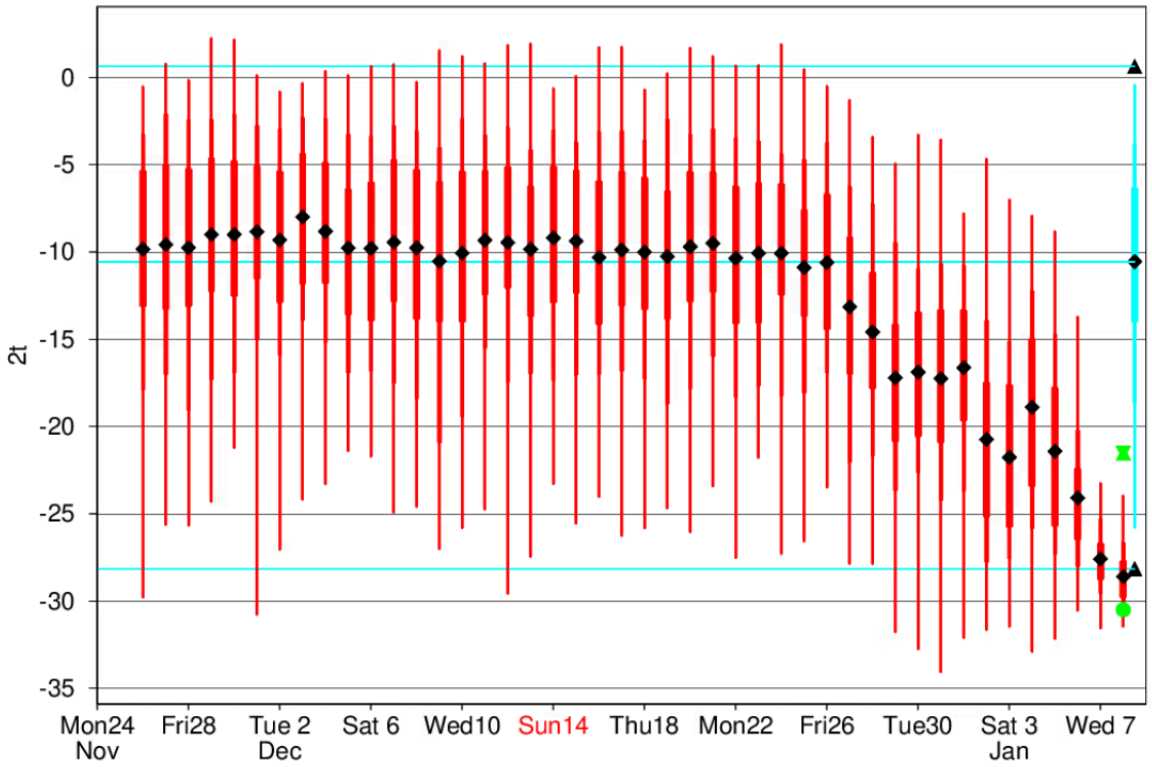


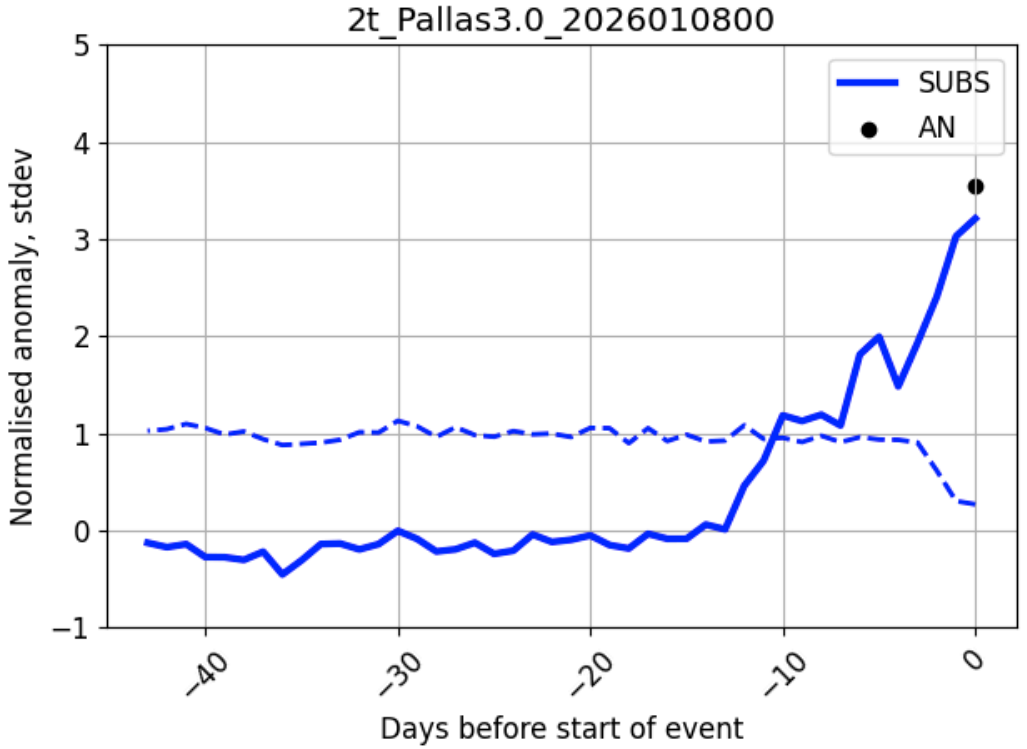
19 May





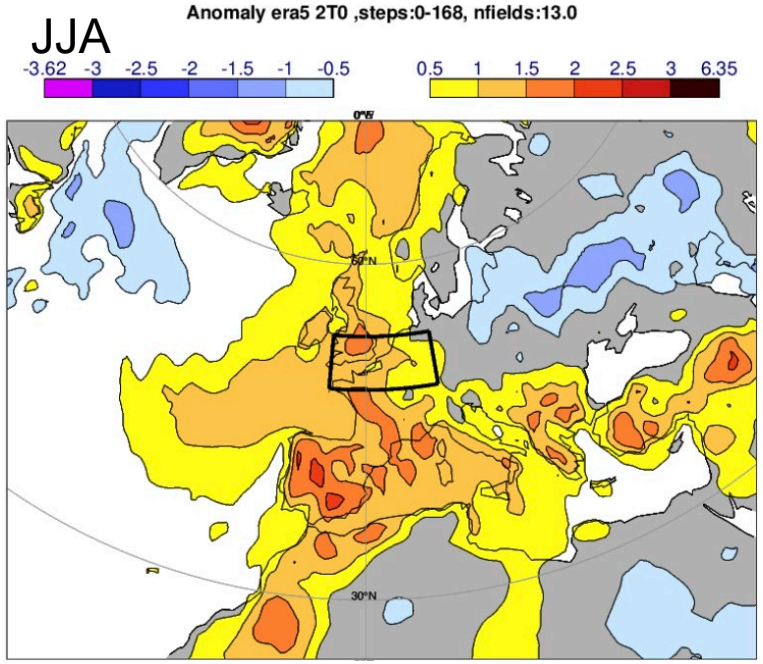
90th percentile


2t
0
-5
-10
-15
-20
-25
-30
-35
Mon24 Nov
Fri28
Tue 2 Dec
Sat 6
Wed10
Sun14
Thu18
Mon22
Fri26
Tue30
Sat 3 Jan
Wed 7

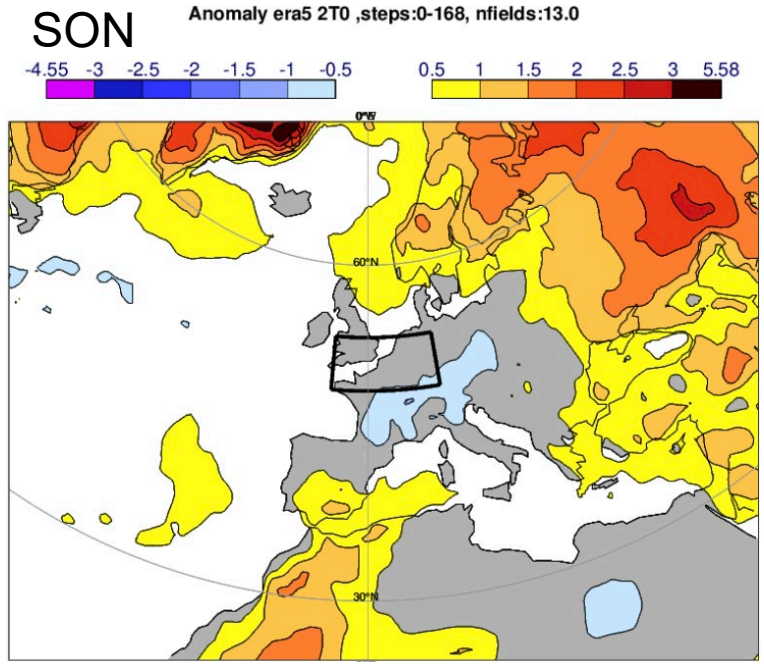

2t_Pallas3.0_2026010800
SUBS
AN
Normalised anomaly, stdev
5
4
3
2
1
0
−1
−40
−30
−20
−10
0
Days before start of event

Seasonal anomalies over the past year

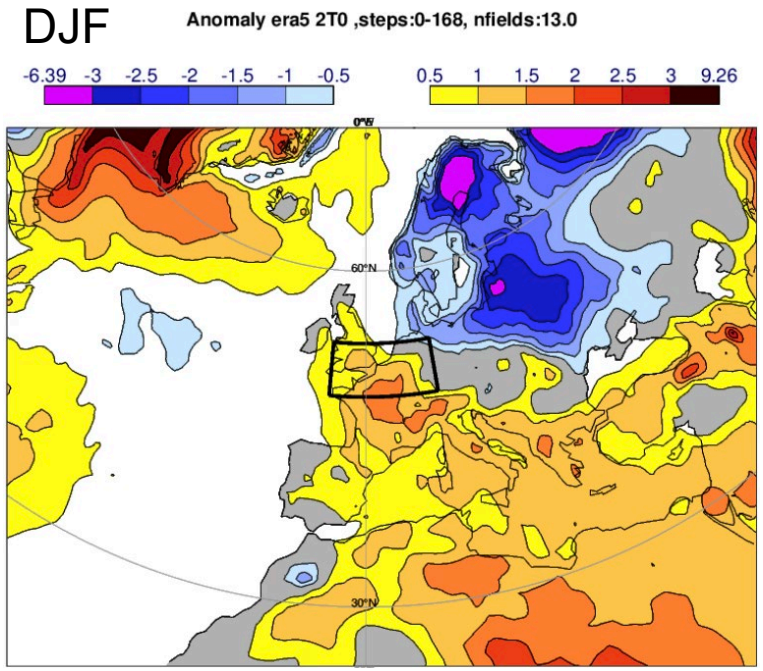
JJA



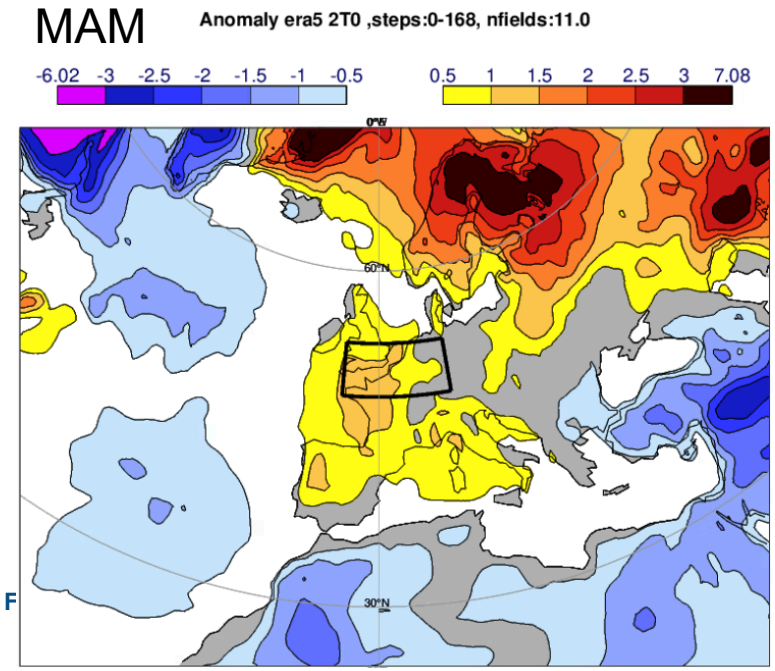
SON



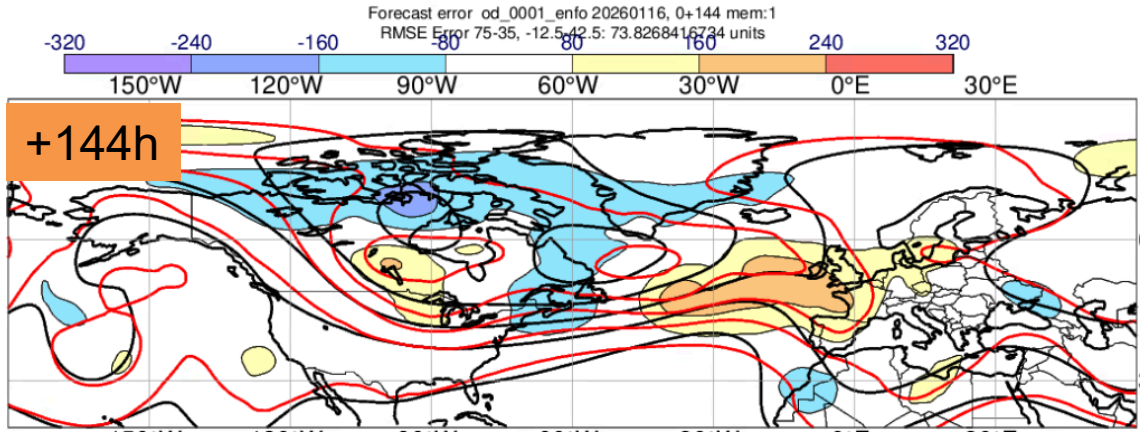
DJF

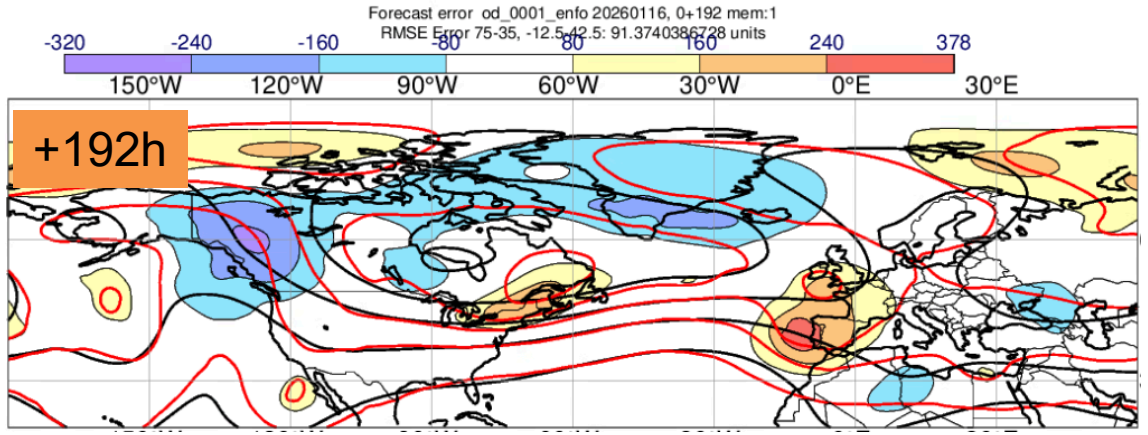


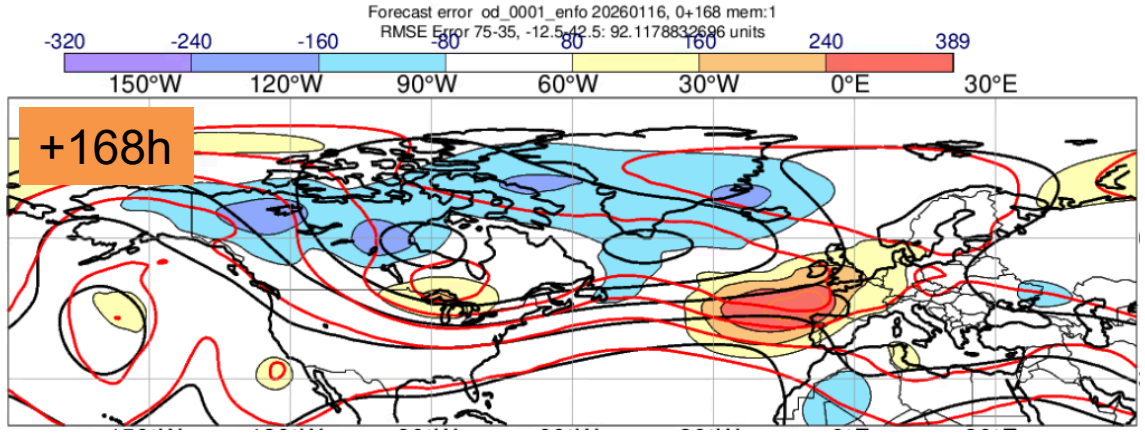
MAM

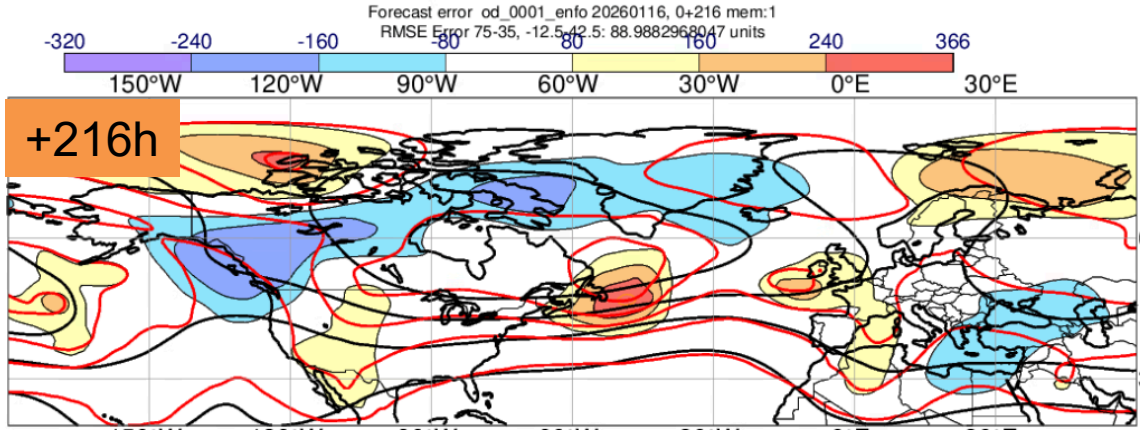


Z500 ensemble mean errors 16 January 00UTC

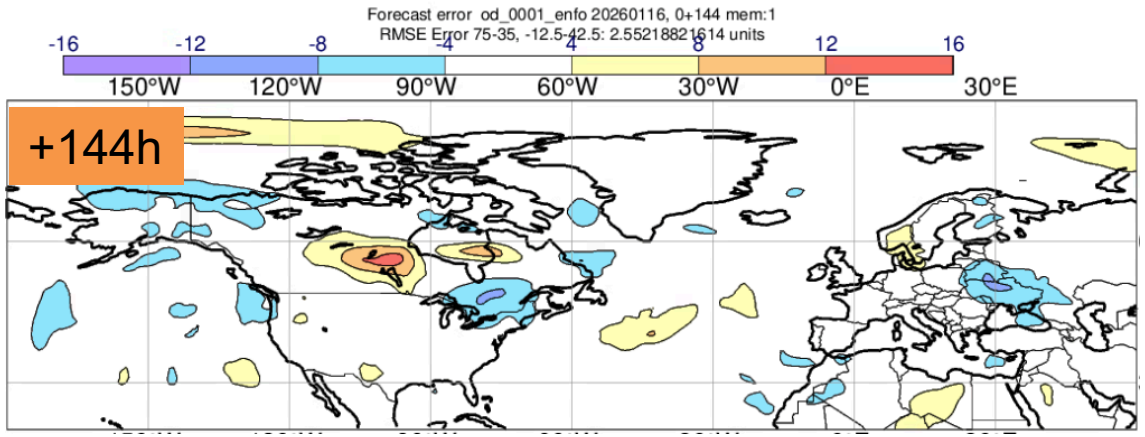


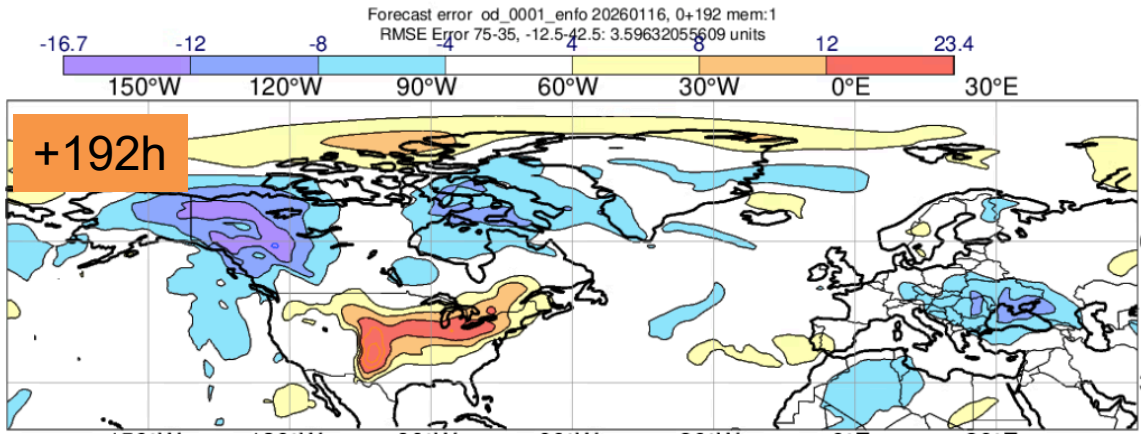


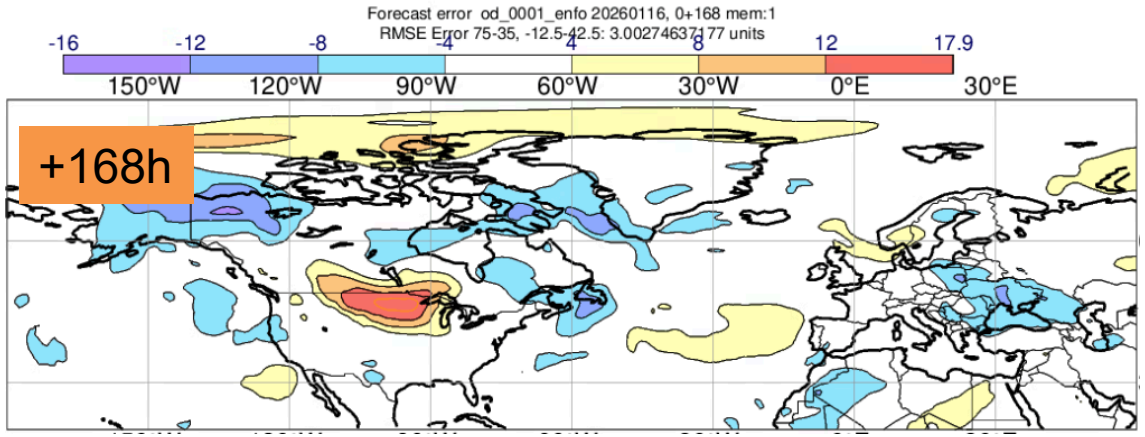


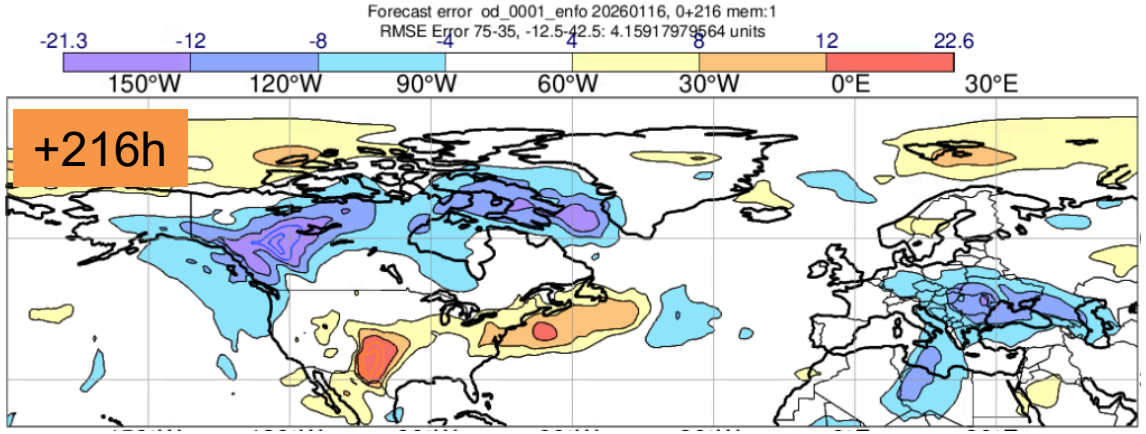


T850 ensemble mean error 16 January 00UTC









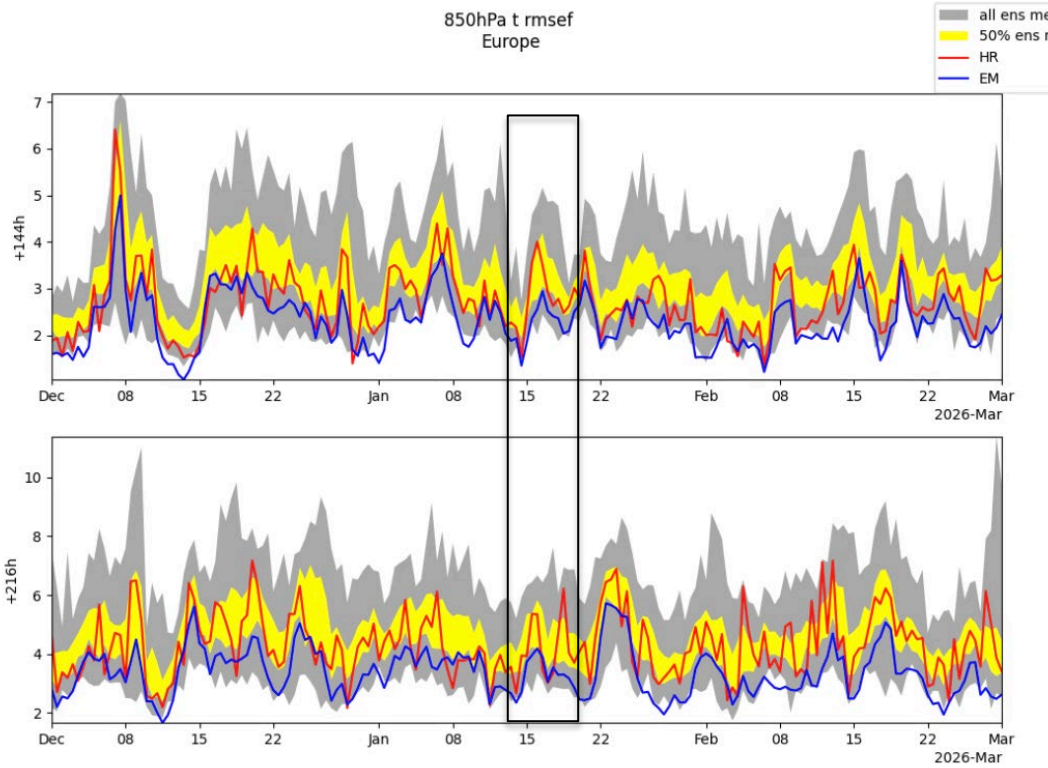
RMSE over Europe

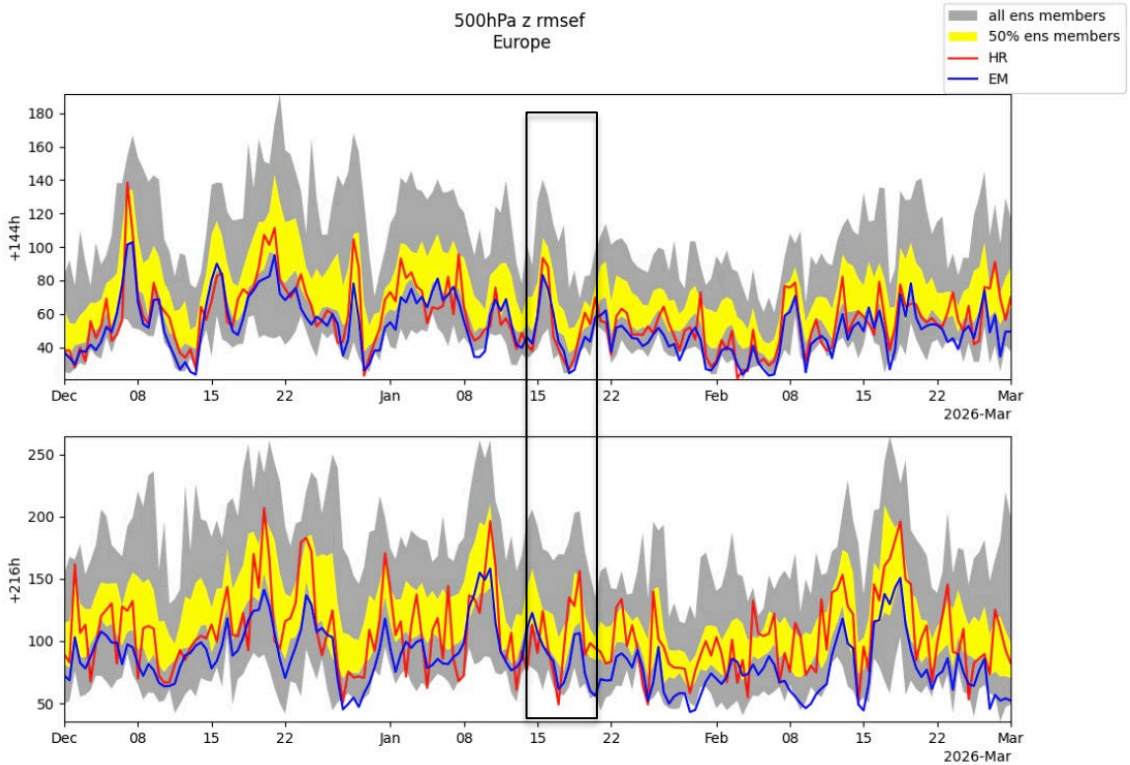
T850

z500

Day 6

Day 9

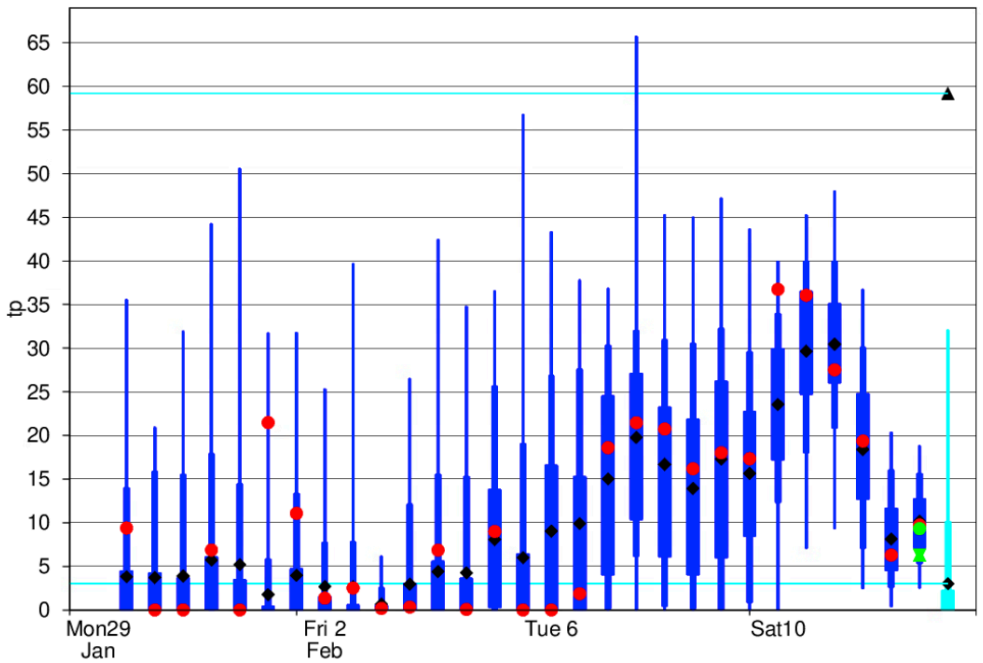


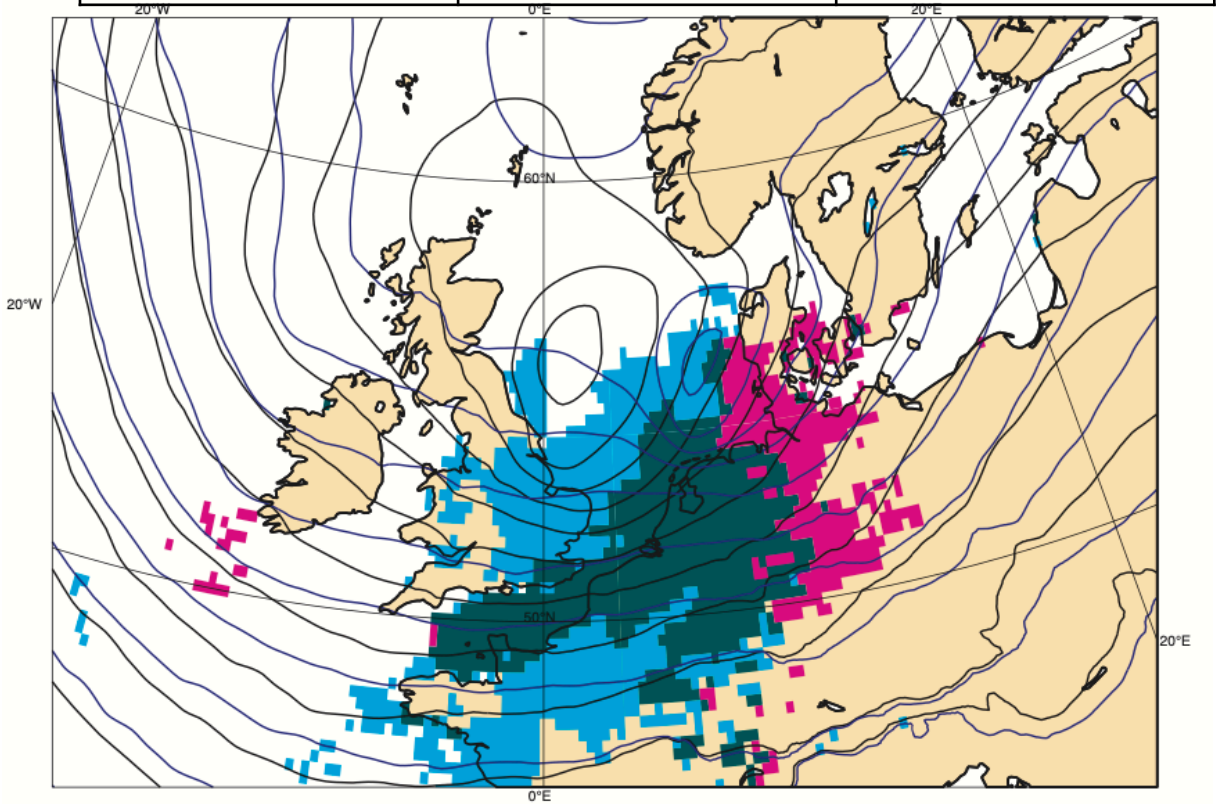


What is a false alarm?

- First, it requires a threshold for the event
- Requires to know the probability threshold considered if using an ensemble
- (For hits/misses the event to consider is based on the outcome)

	True in forecast	False in forecast
True in Obs	Hit	Miss
False in Obs	False alarm	No-event





(b) +60h wind speed over 98th percentile

Figure 9: Example of hits (green), misses (red) and false alarms (blue) for forecasts valid 28 October 2013 12z. The forecasts are verified against the own analysis.

Magnusson et al.,(2014, ECMWF Tech Memo 731)