ECMWF forecast performance

Thomas Haiden, Zied Ben Bouallegue, Martin Janousek

20190529 00Z, STEP=120

20190603 00Z
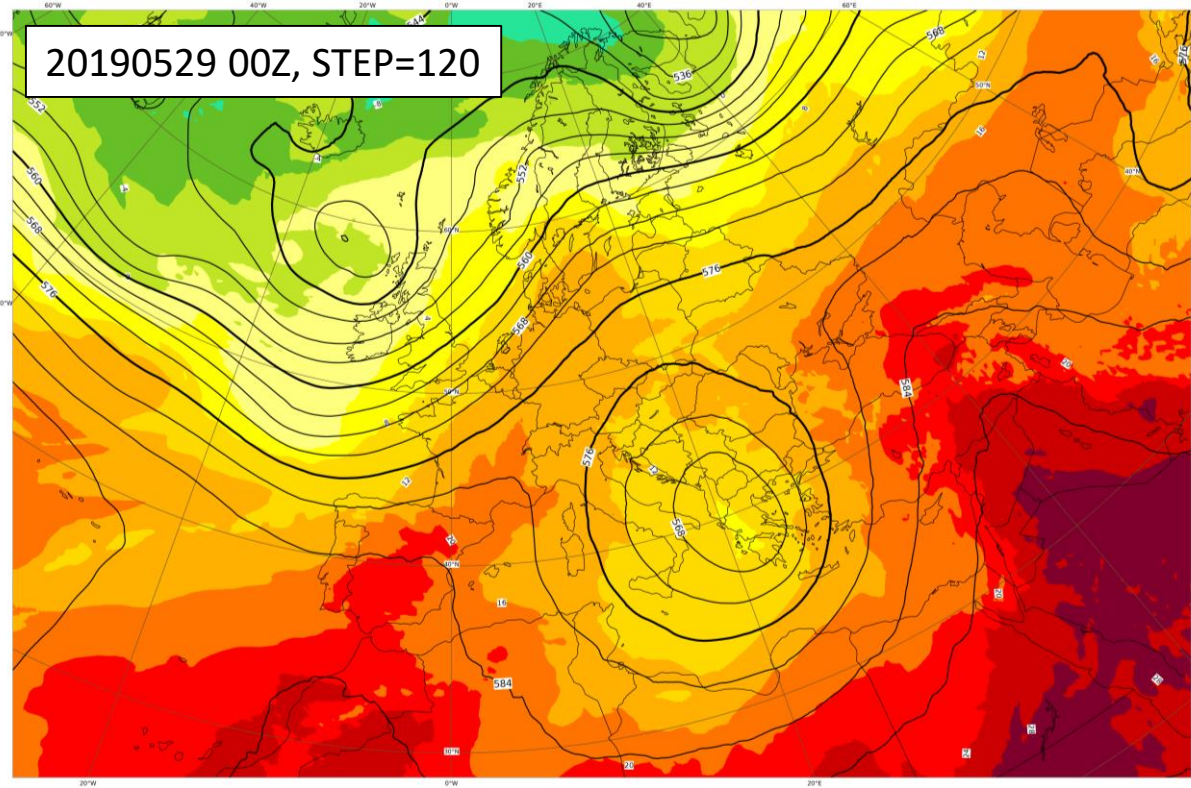
Day 5 forecast
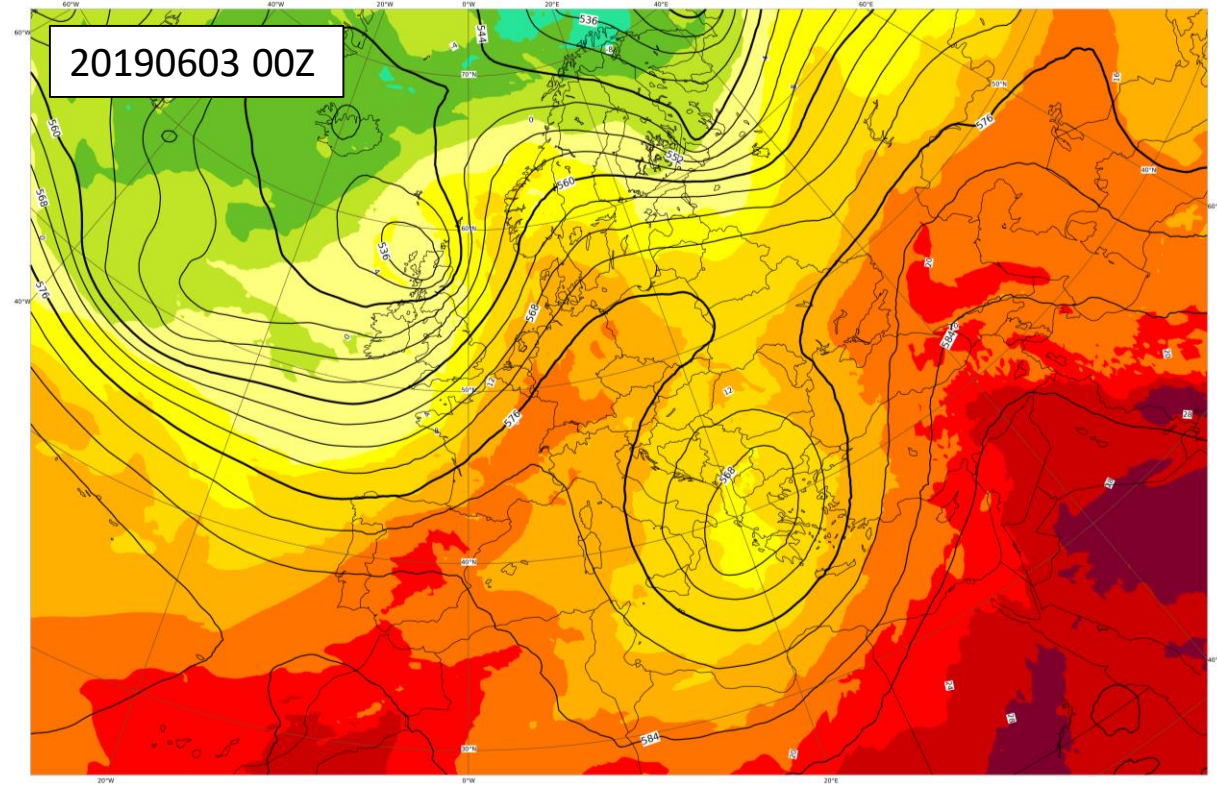
Verifying analysis

Overview

- Evolution of forecast skill

- Week 2 and ECMWF's strategy

- Lead time gains

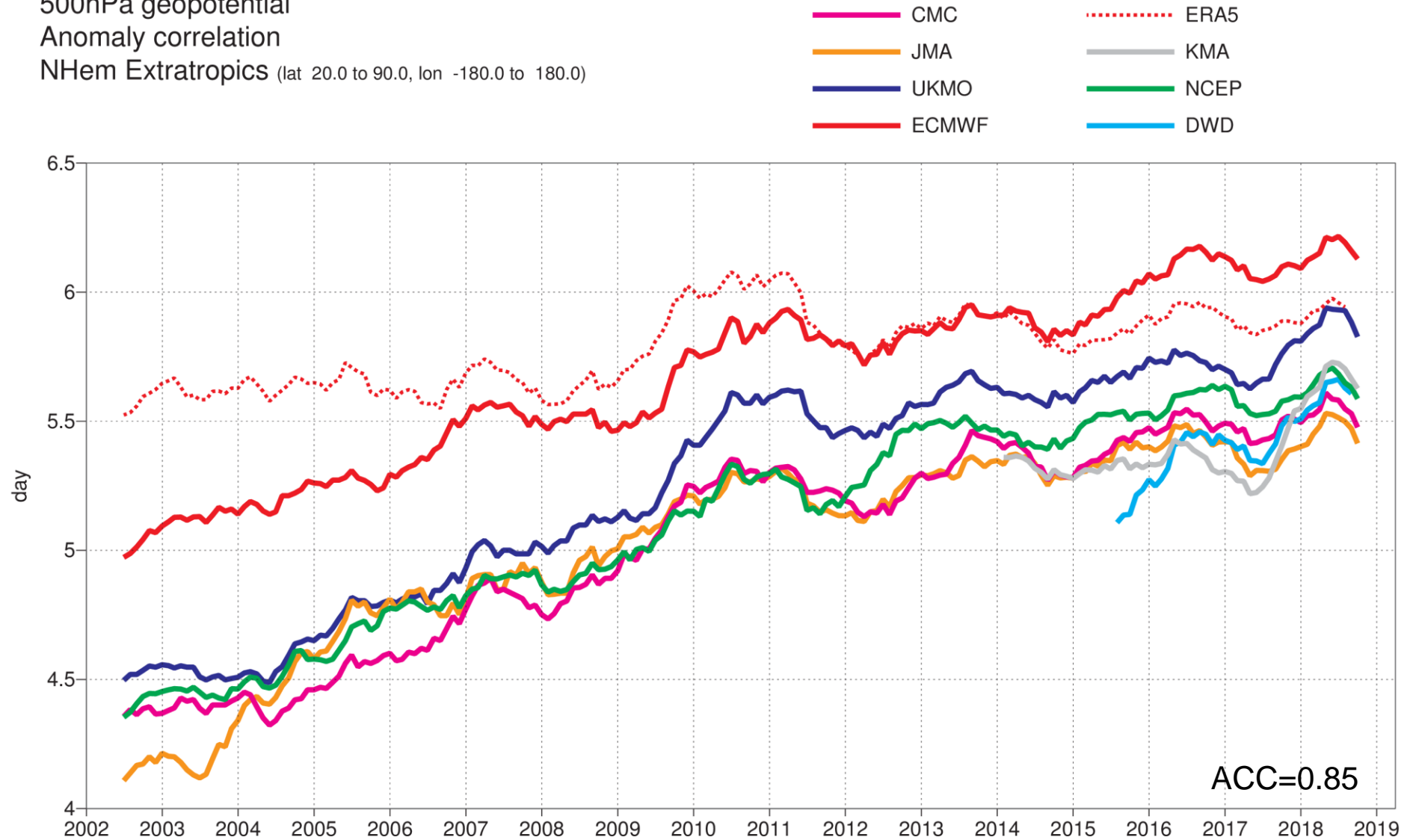- Observation uncertainty/representativeness

ECMWF

Evolution of forecast skill

Upper-air forecast skill HRES

500hPa geopotential
Anomaly correlation
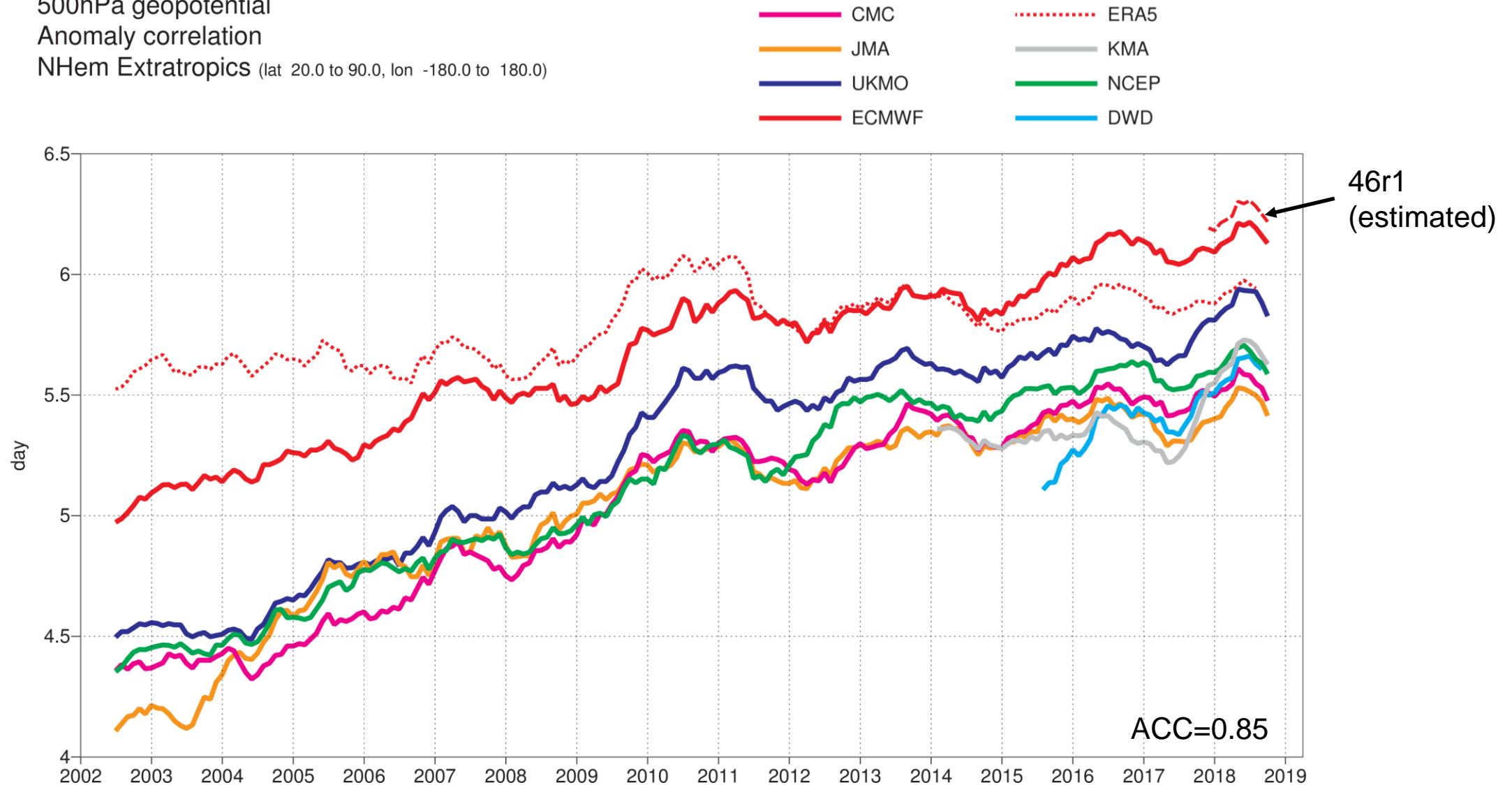NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)

Legend:
- CMC
- JMA
- UKMO
- ECMWF
- ERA5
- KMA
- NCEP
- DWD

ACC=0.85

Upper-air forecast skill HRES

500hPa geopotential
Anomaly correlation
NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)

CMC — ERA5 ·······
JMA — KMA —
UKMO — NCEP —
ECMWF — DWD —

46r1 (estimated)

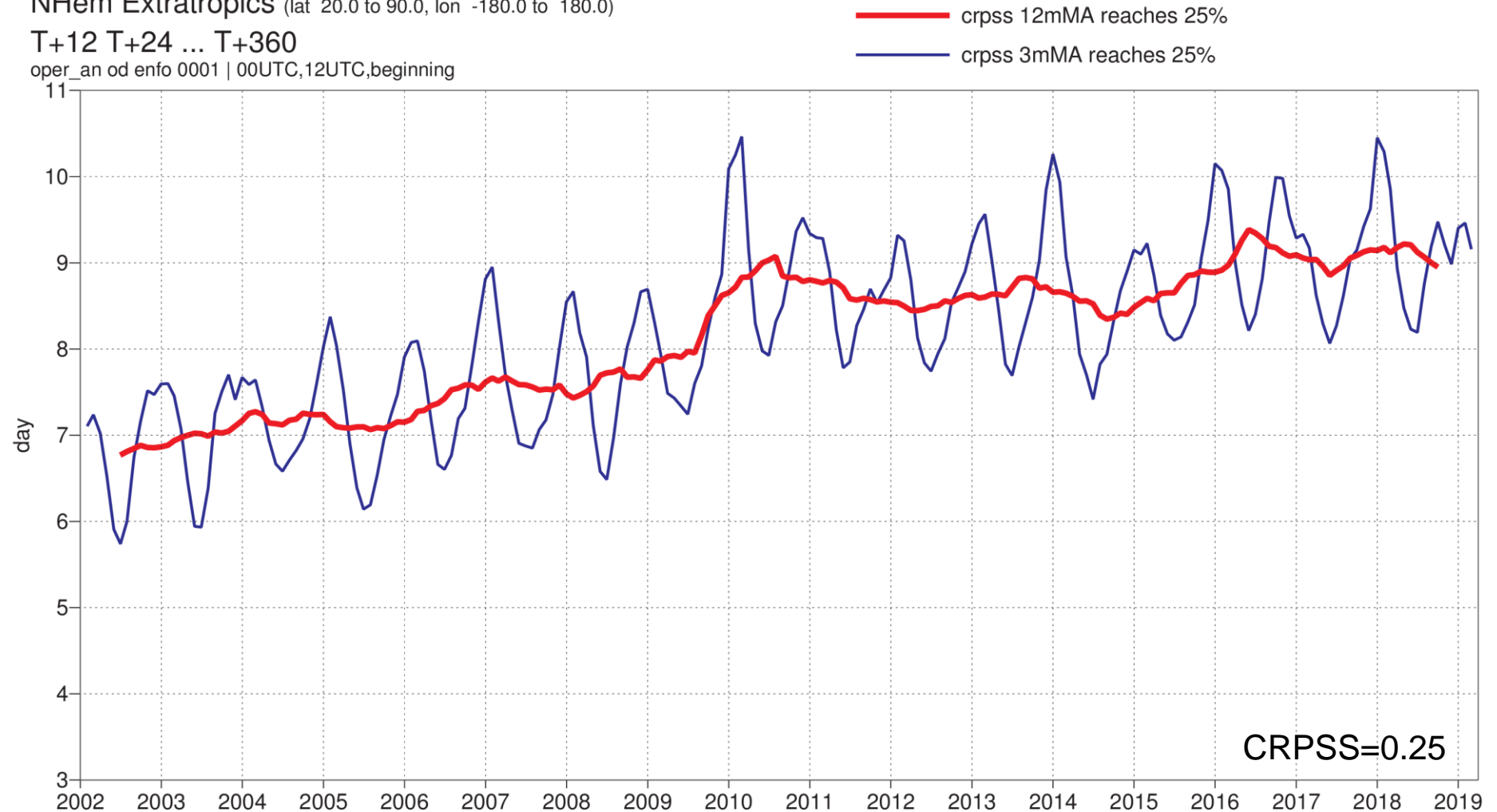ACC=0.85

Upper-air forecast skill ENS

850hPa temperature
Continuous ranked probability skill score
NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)
T+12 T+24 ... T+360
oper_an od enfo 0001 | 00UTC,12UTC,beginning

crpss 12mMA reaches 25%
crpss 3mMA reaches 25%

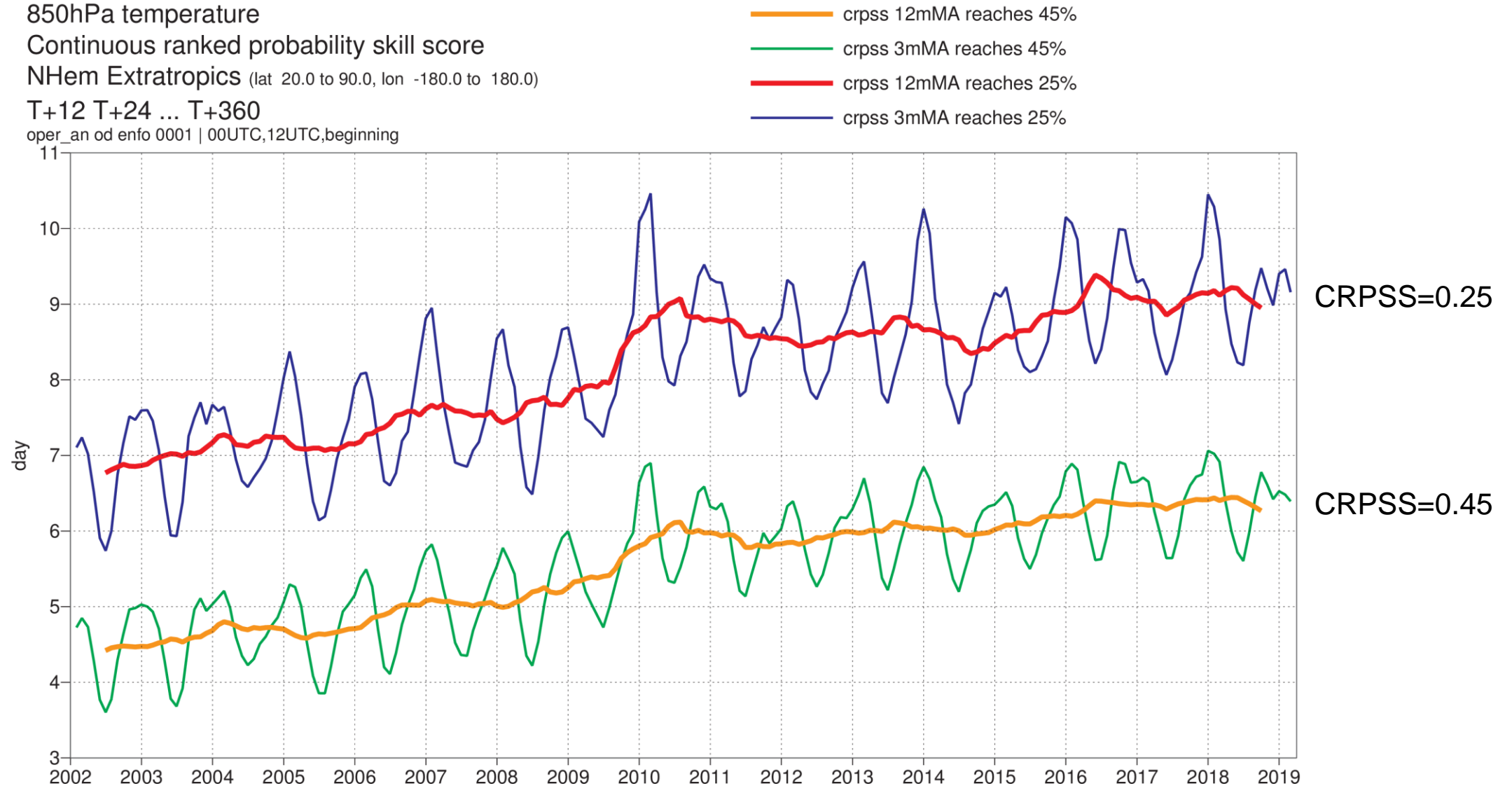CRPSS=0.25

Upper-air forecast skill ENS
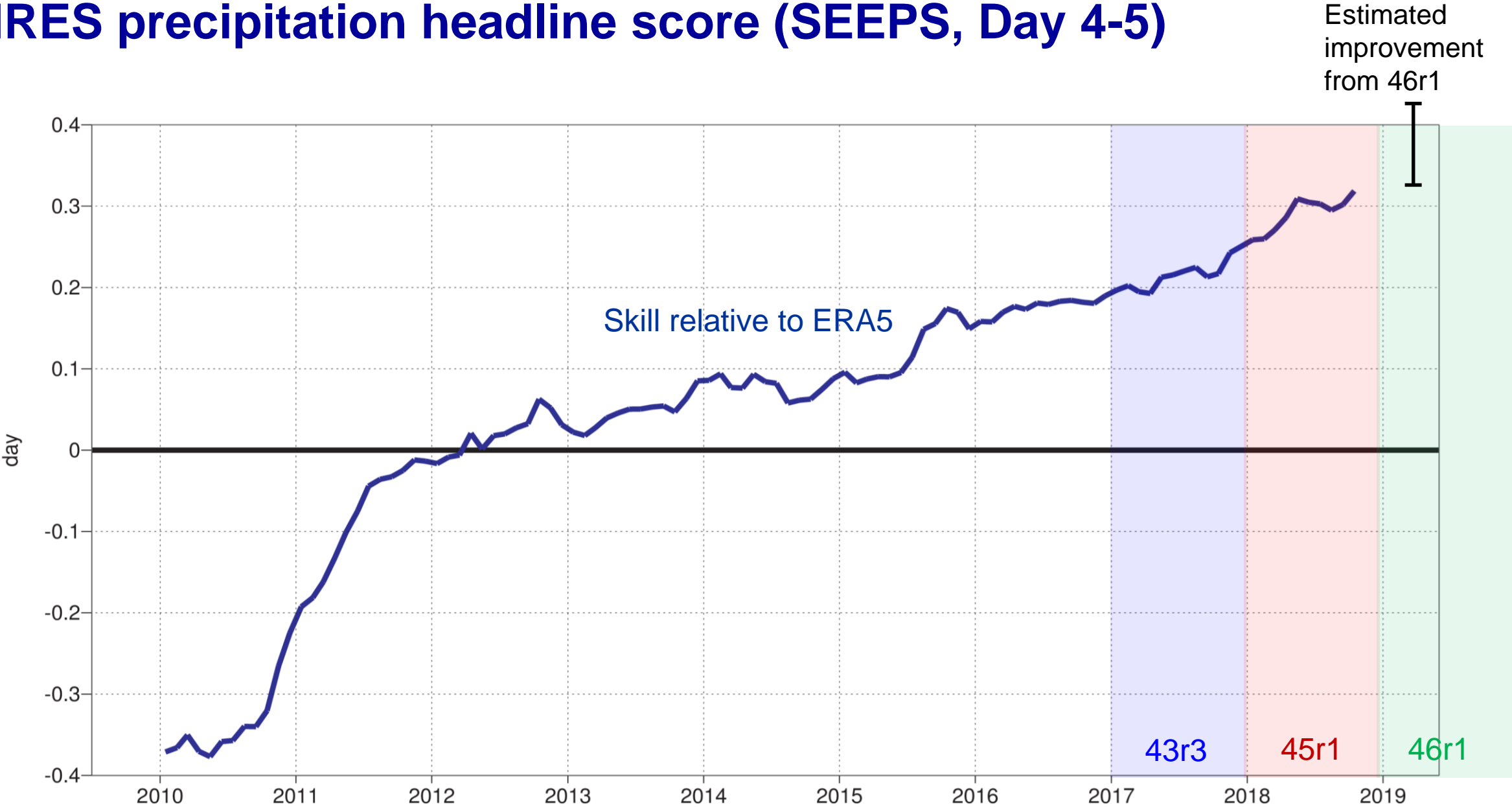

850hPa temperature
Continuous ranked probability skill score
NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)
T+12 T+24 ... T+360
oper_an od enfo 0001 | 00UTC,12UTC,beginning

Legend:
- crpss 12mMA reaches 45%
- crpss 3mMA reaches 45%
- crpss 12mMA reaches 25%
- crpss 3mMA reaches 25%

CRPSS=0.25
CRPSS=0.45

HRES precipitation headline score (SEEPS, Day 4-5)

Estimated improvement from 46r1

Skill relative to ERA5

43r3   45r1   46r1

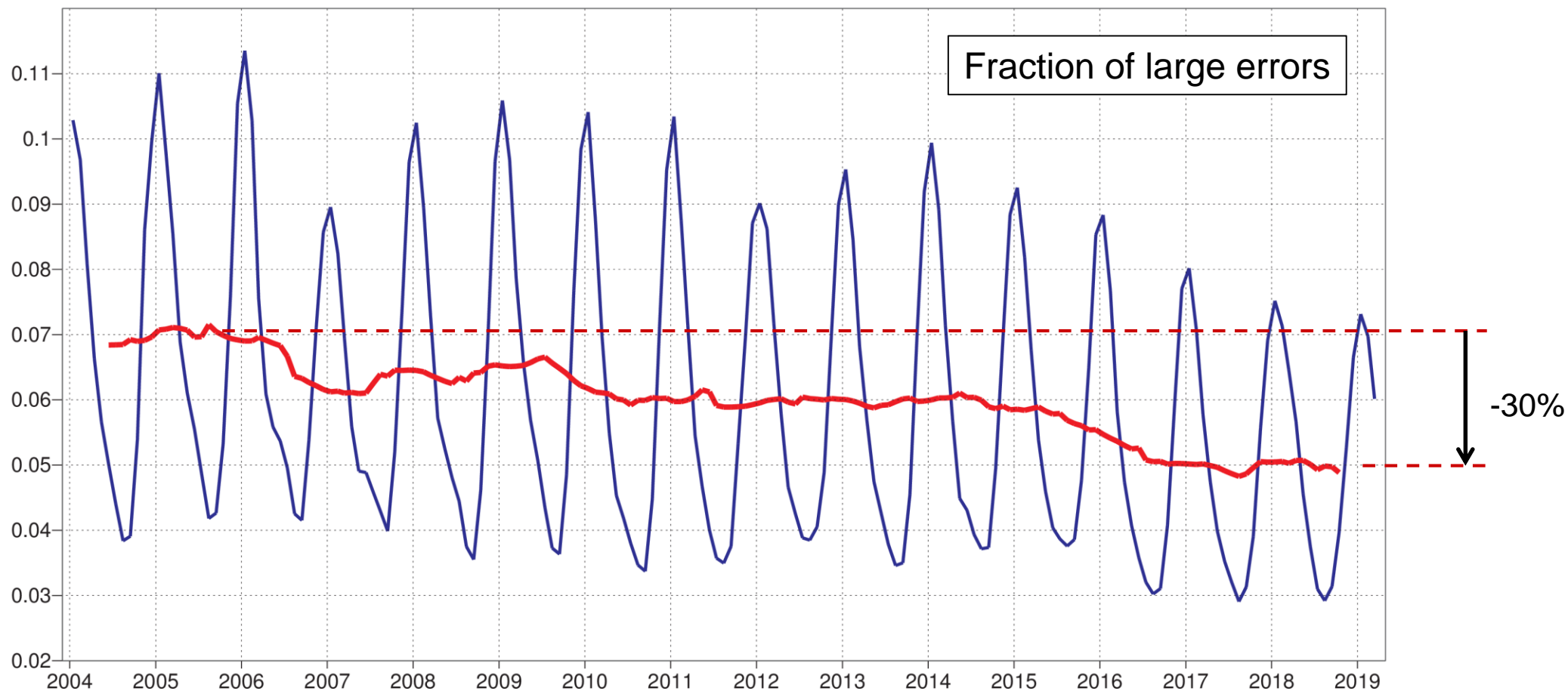# ENS 2m temperature headline score (Day 5)

2 meter temperature
Fraction of large CRPS value >5.0
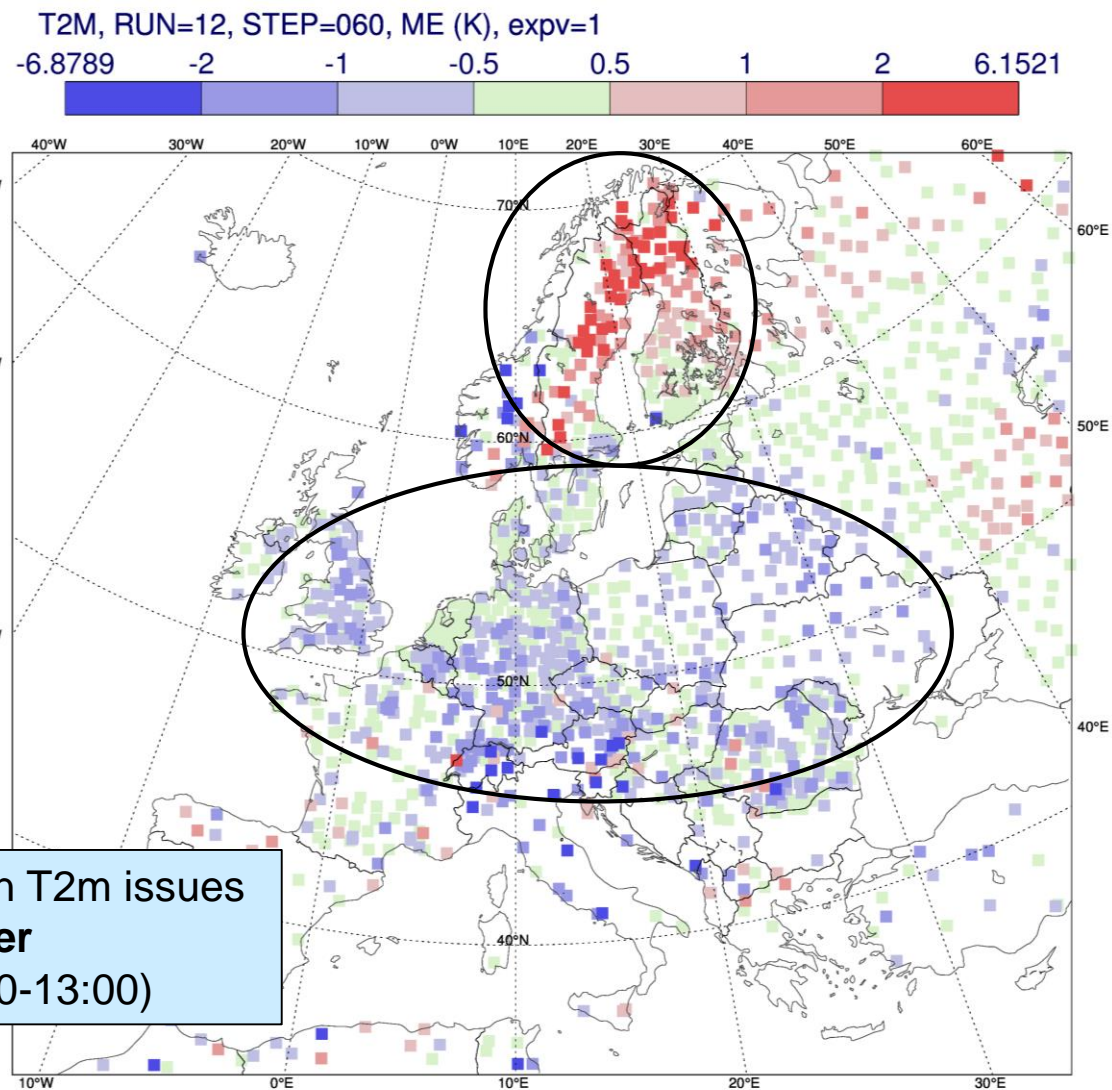Extratropics (lat -90 to -30.0 and 30.0 to 90, lon -180.0 to 180.0)
T+120
oper_ob od enfo 0001

Fraction of large errors

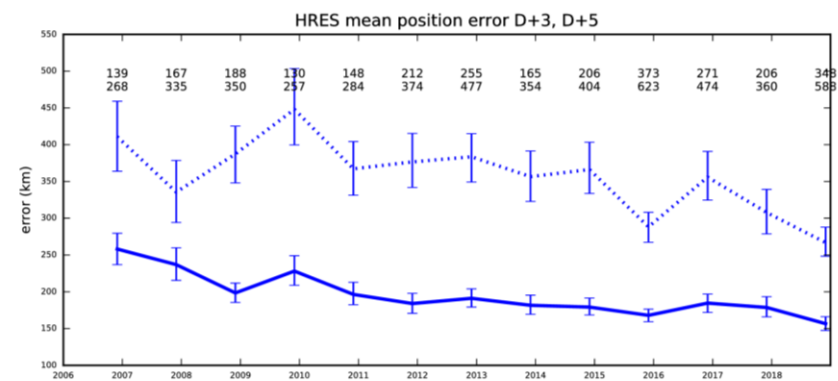-30%

T2m bias at 00 UTC

T2M, RUN=12, STEP=060, ME (K), expv=1

-6.0325 -2 -1 -0.5 0.5 1 2 7.4416

T2M, RUN=12, STEP=060, ME (K), expv=1

-6.8789 -2 -1 -0.5 0.5 1 2 6.1521
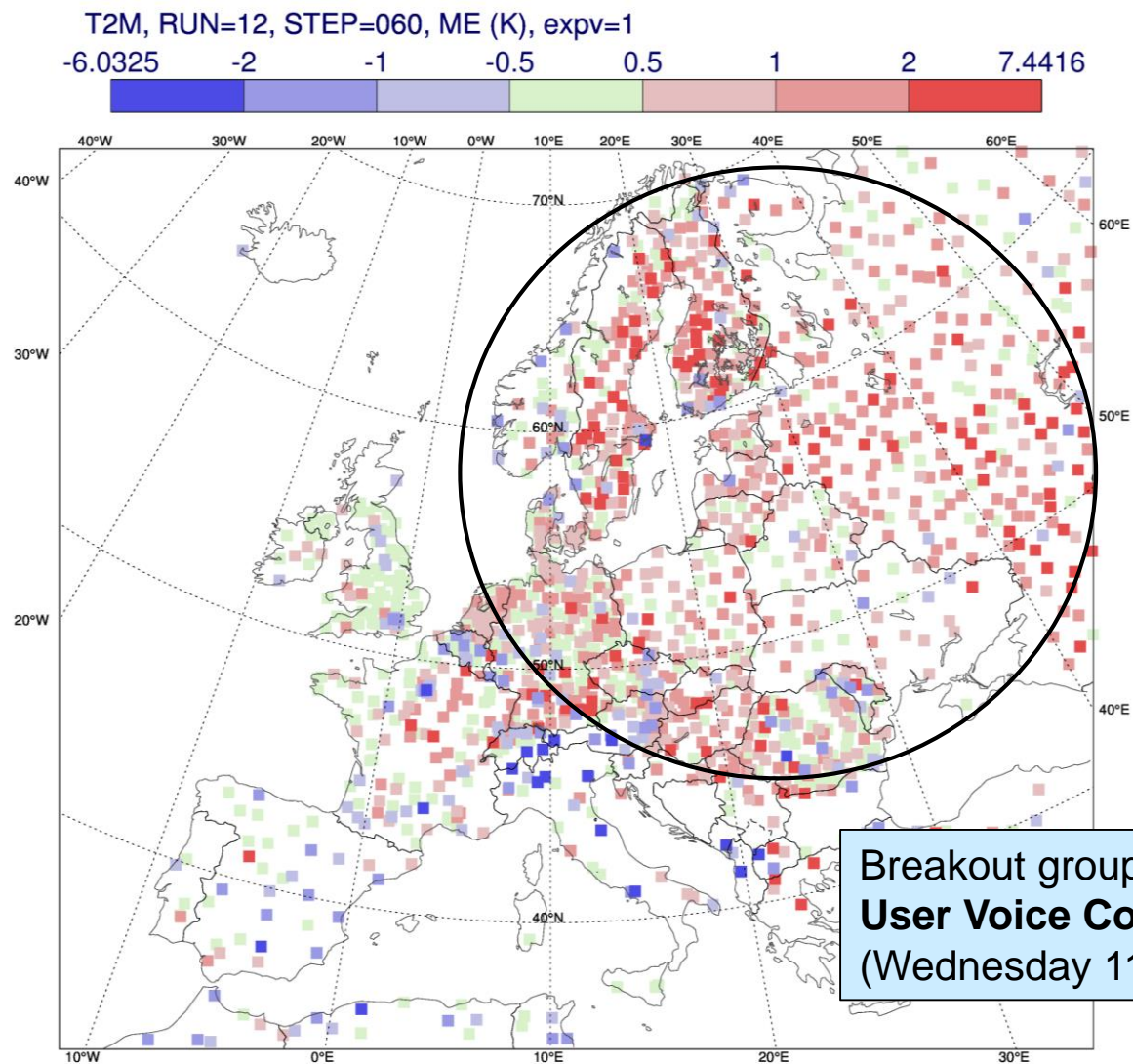
Breakout group on T2m issues
User Voice Corner
(Wednesday 11:30-13:00)

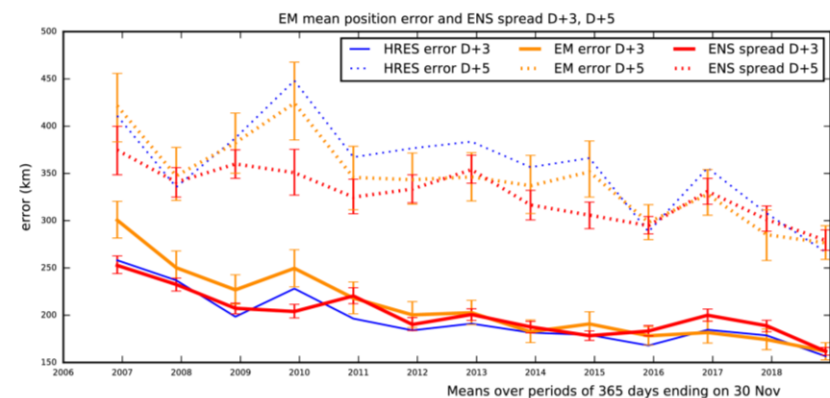JJA 2018

DJF 2018-19

High-impact weather

Tropical cyclones
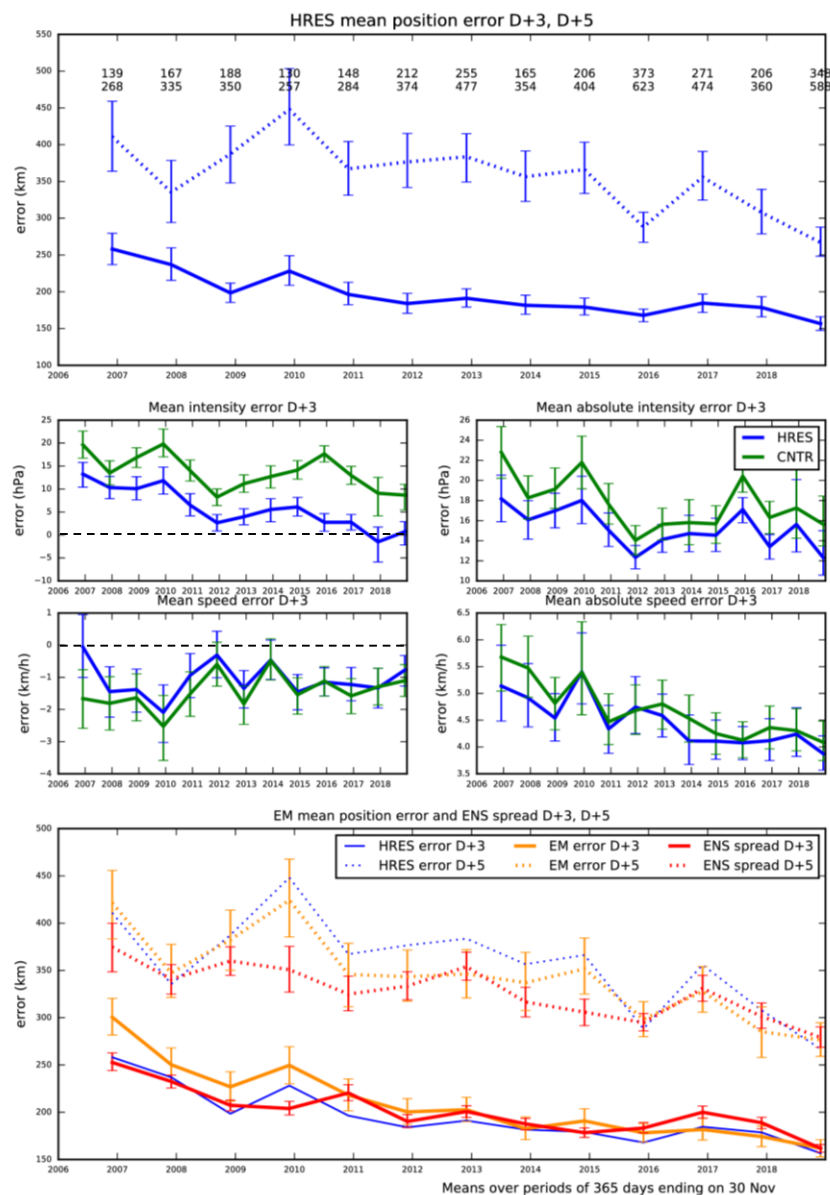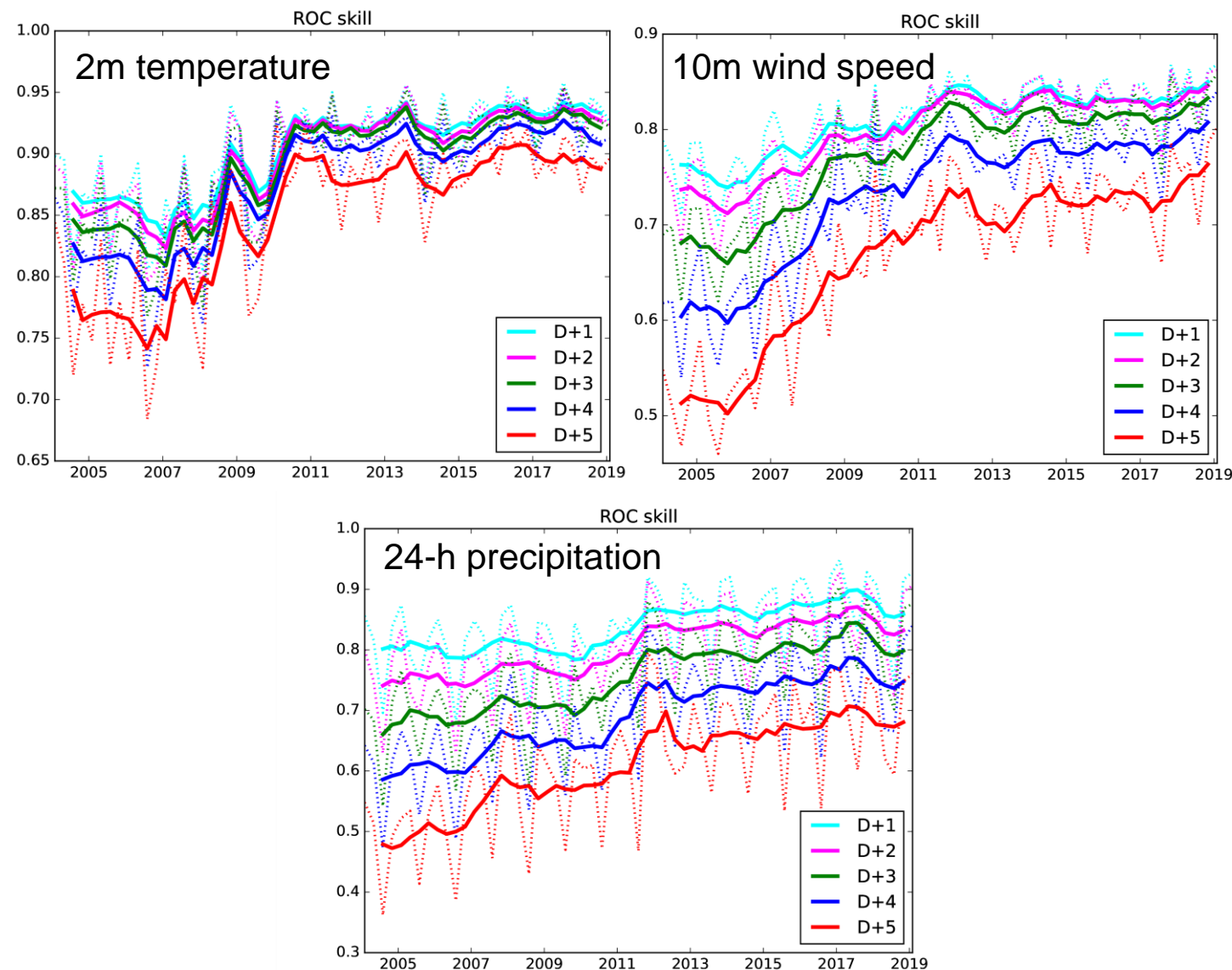

Position
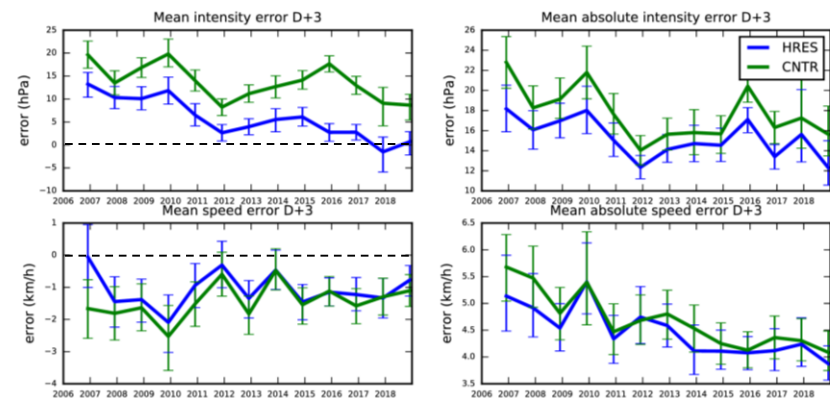
Intensity

Speed

Position
(spread/error)

High-impact weather

Tropical cyclones

Extreme forecast index (EFI)

More verification results: ECMWF webpage & Tech Memos
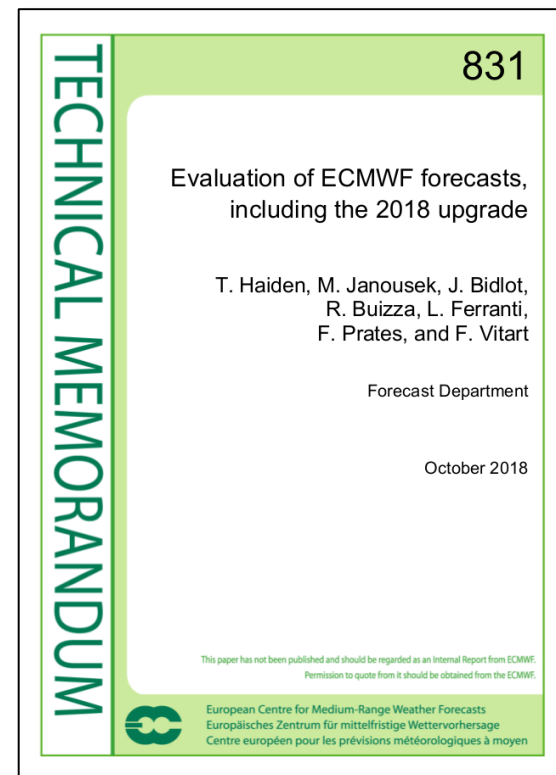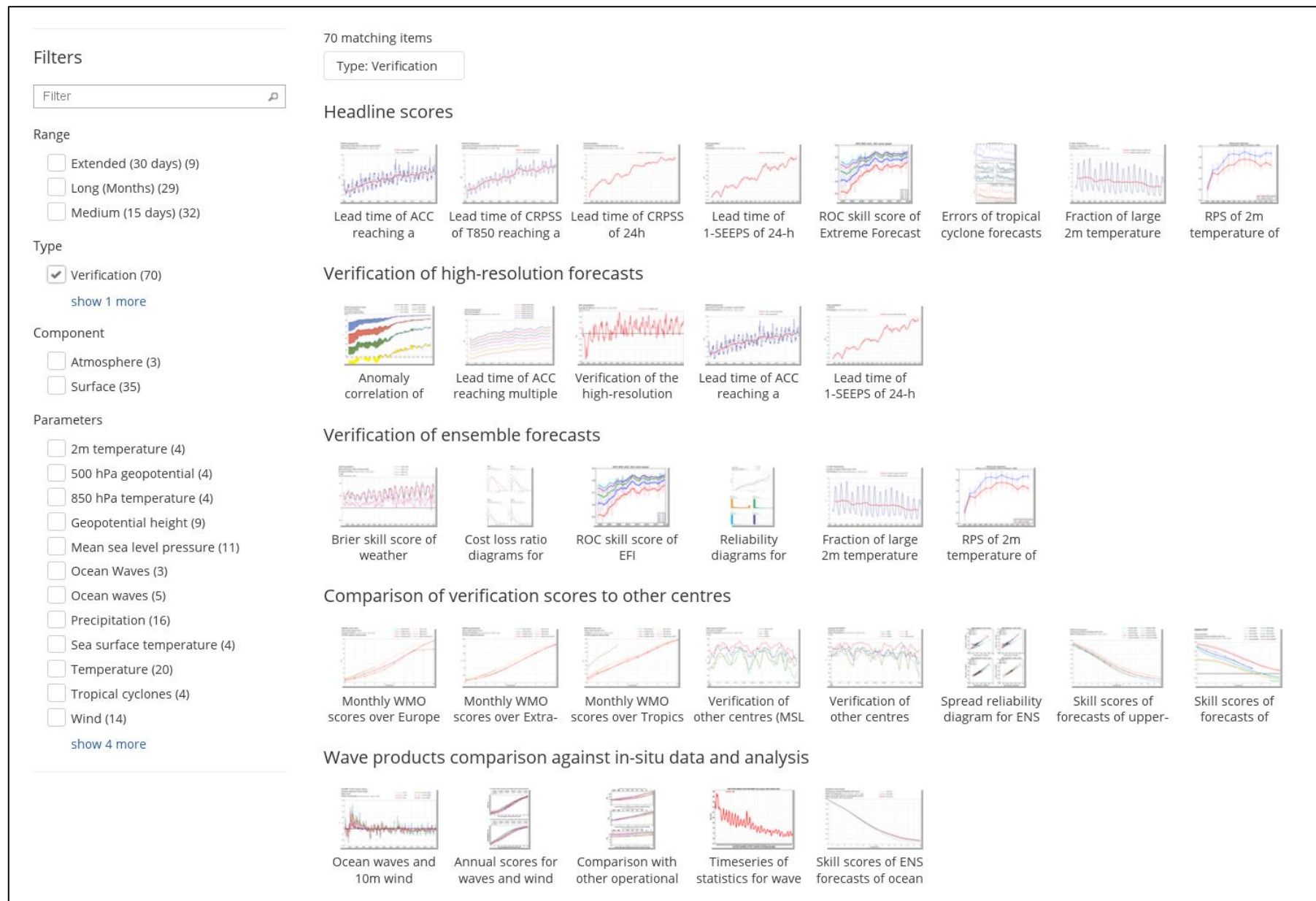
ECMWF 10-year strategy (2016-2025)

'.. provide economically and societally valuable forecasts of extreme wind speed and precipitation well into the 2nd week of the forecast, from the current range of just about 1 week.'

'.. extend the range of skilful predictions .. of heatwaves and cold spells to 3 weeks ahead on average, compared to about 2 weeks currently.'

Forecast skill for high 10m wind speeds (95th quantile)
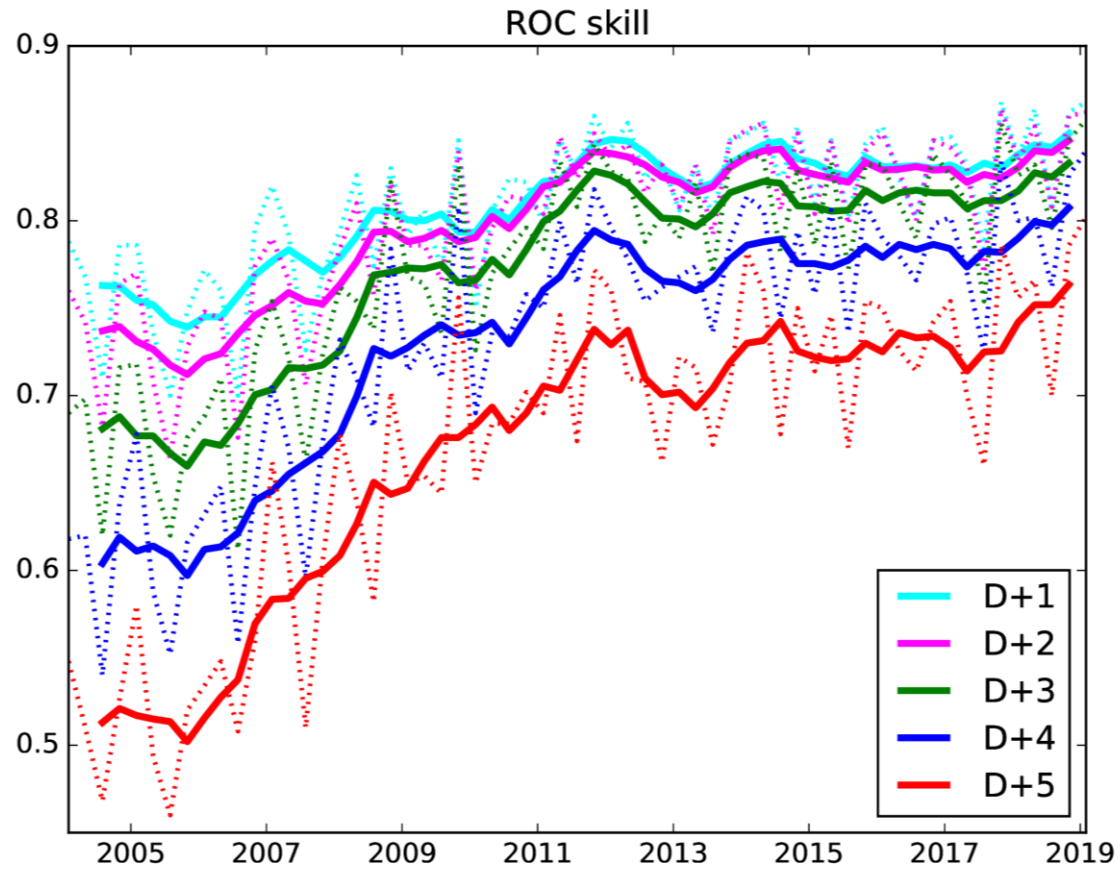
EFI ROC skill
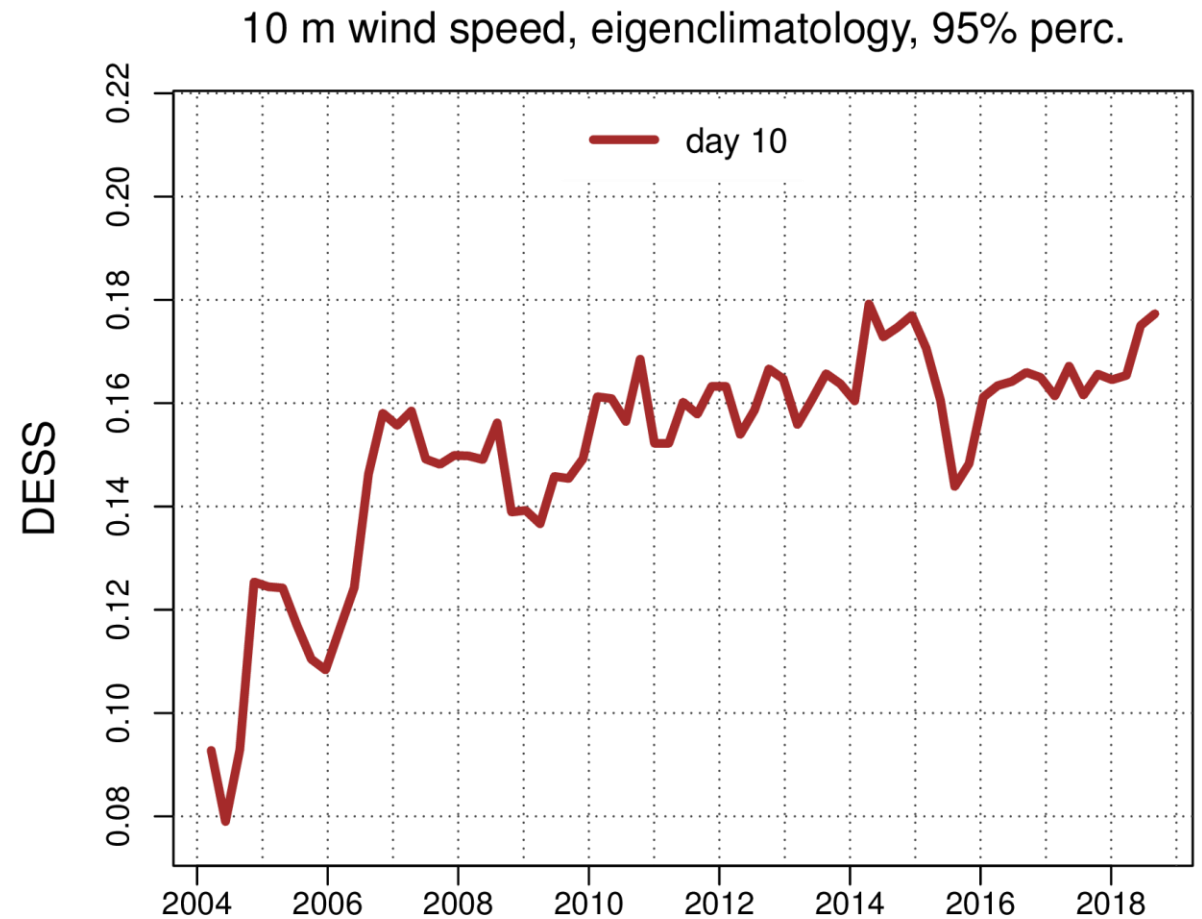
Diagonal elementary score

Ensemble forecasts of 10m wind speed (verification against SYNOP)

10m wind speed
Continuous ranked probability score
NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)
T+240
oper_ob od enfo 0001

00UTC,12UTC [running mean 730]
00UTC,12UTC [running mean 180]

Day 10

-6%

ENS 850hPa wind speed (verification against analysis)

850hPa wind speed
Continuous ranked probability score
NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)
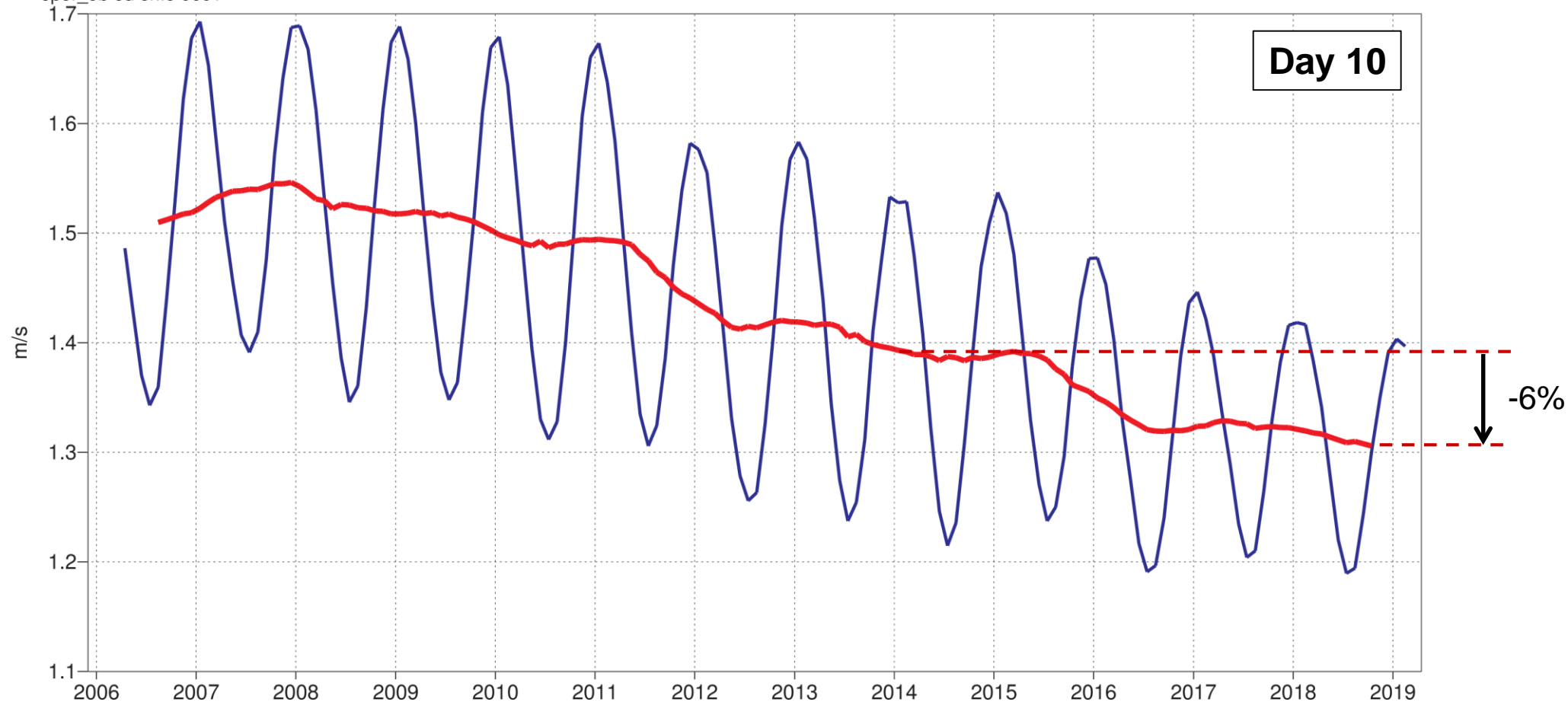T+240
oper_an od enfo 0001

Legend:
- 00UTC,12UTC [running mean 730] (red)
- 00UTC,12UTC [running mean 180] (blue)

Day 10

No change
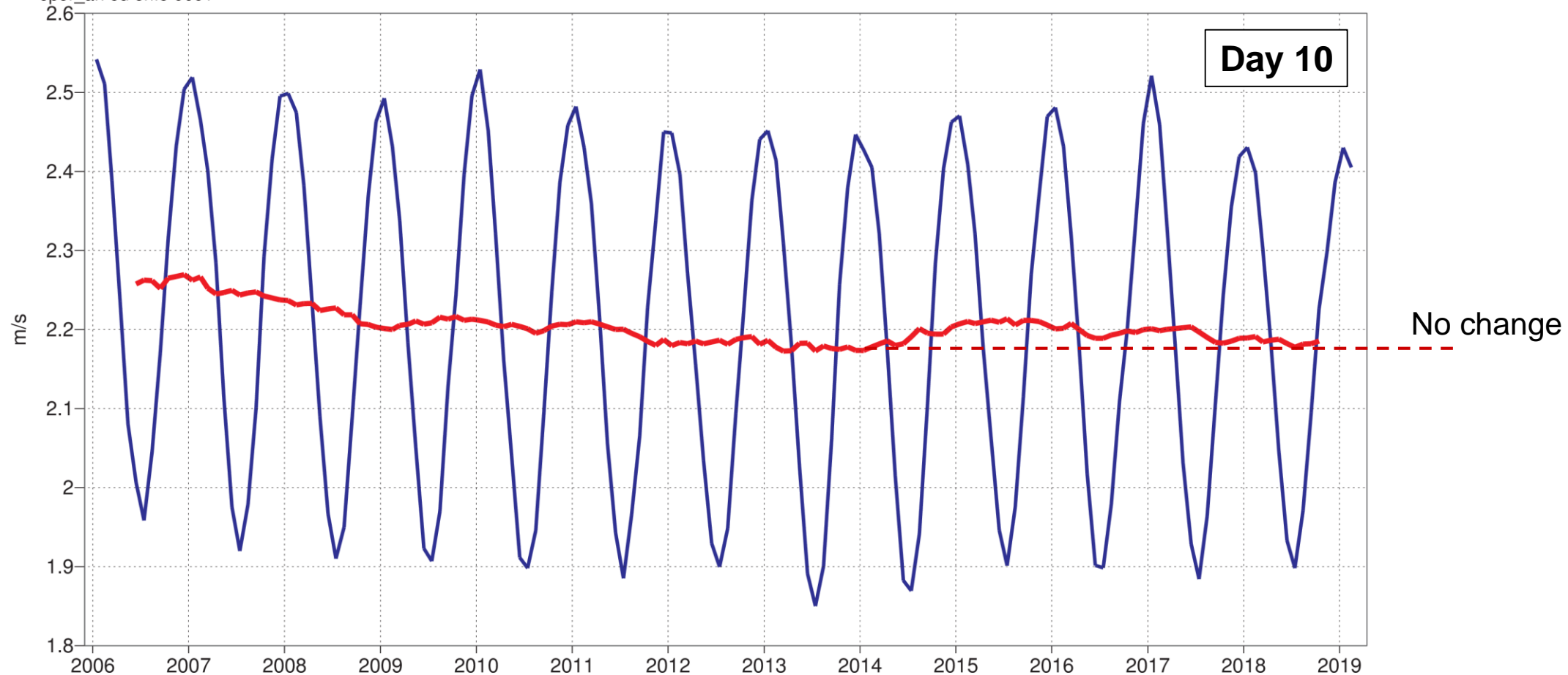
ENS 10m wind speed (verification against analysis)

850hPa wind speed
Continuous ranked probability score
NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)
Date: 20130416 00UTC to 20190415 12UTC
oper_an od enfo 0001 | Mean method: standard

Legend: 00UTC,12UTC (red), 00UTC,12UTC (blue)

Labels: 2013-2015, 2017-2019
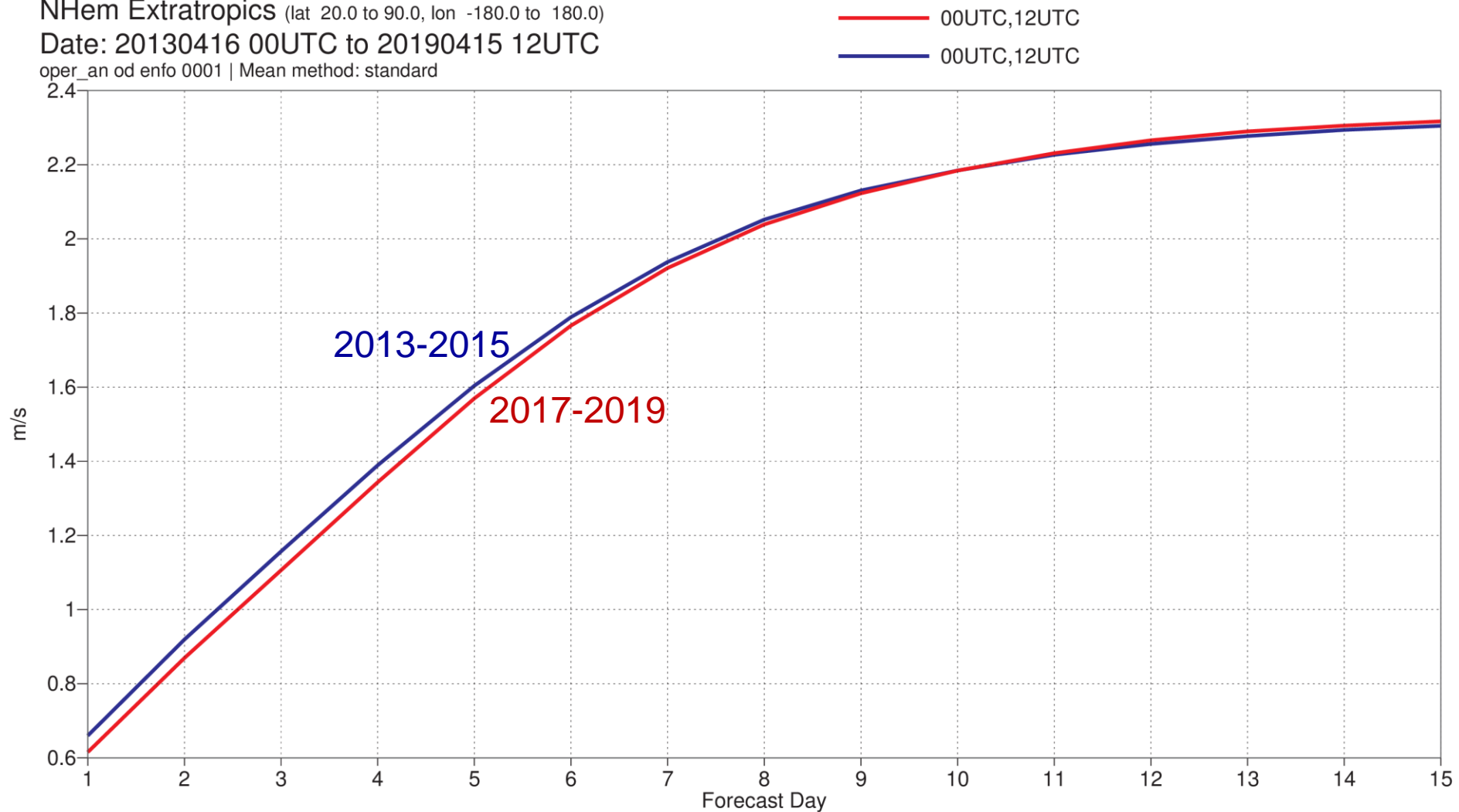
RMSE evolution (HRES) for upper-air variables at day 10

850hPa wind speed
NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)
T+240
oper_an od oper 0001

ACC evolution (HRES) for upper-air variables at day 10

Anomaly correlation
NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)
T+240
oper_an od oper 0001

Legend:
- MSLP
- FF850
- T850
- Z500

Geopotential
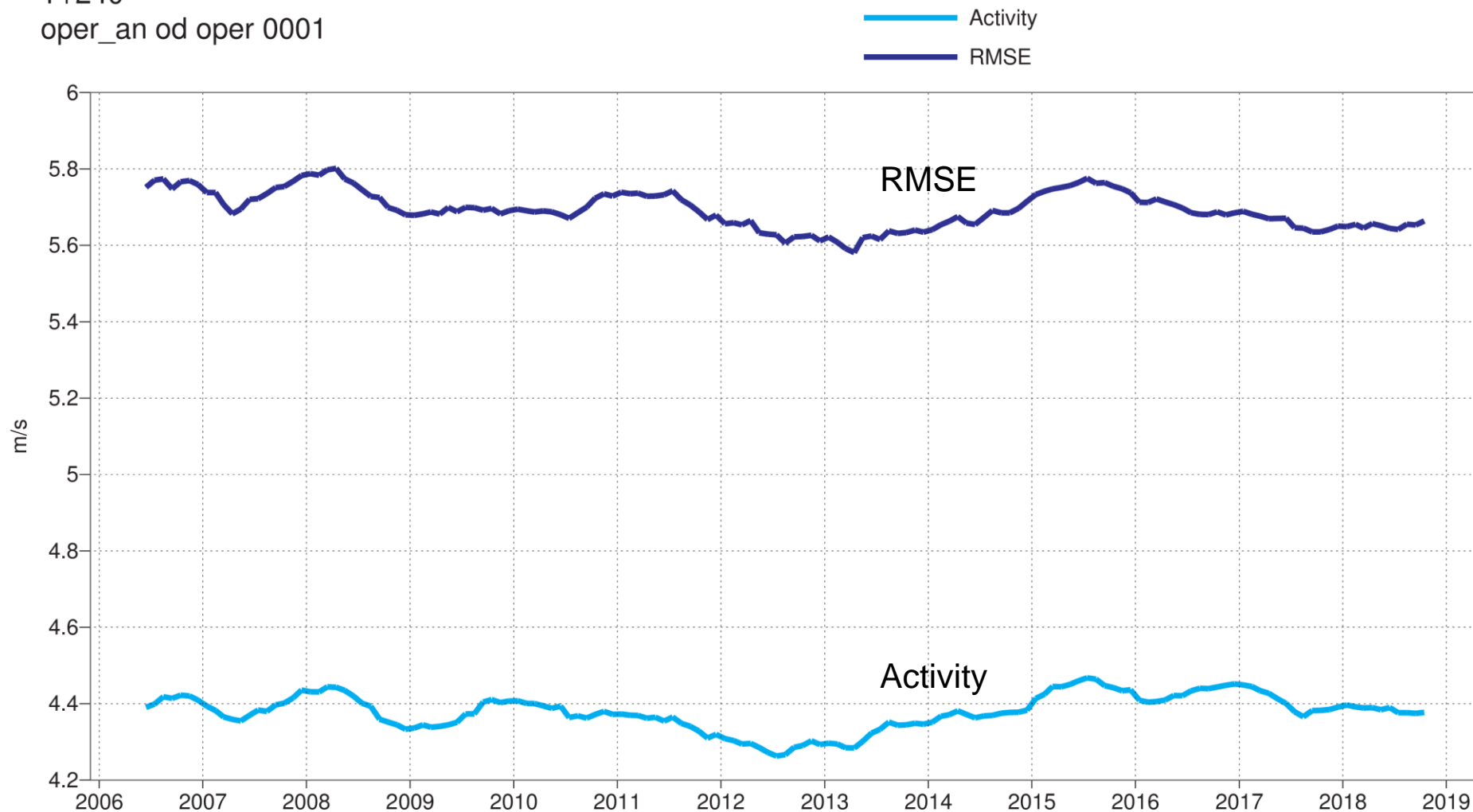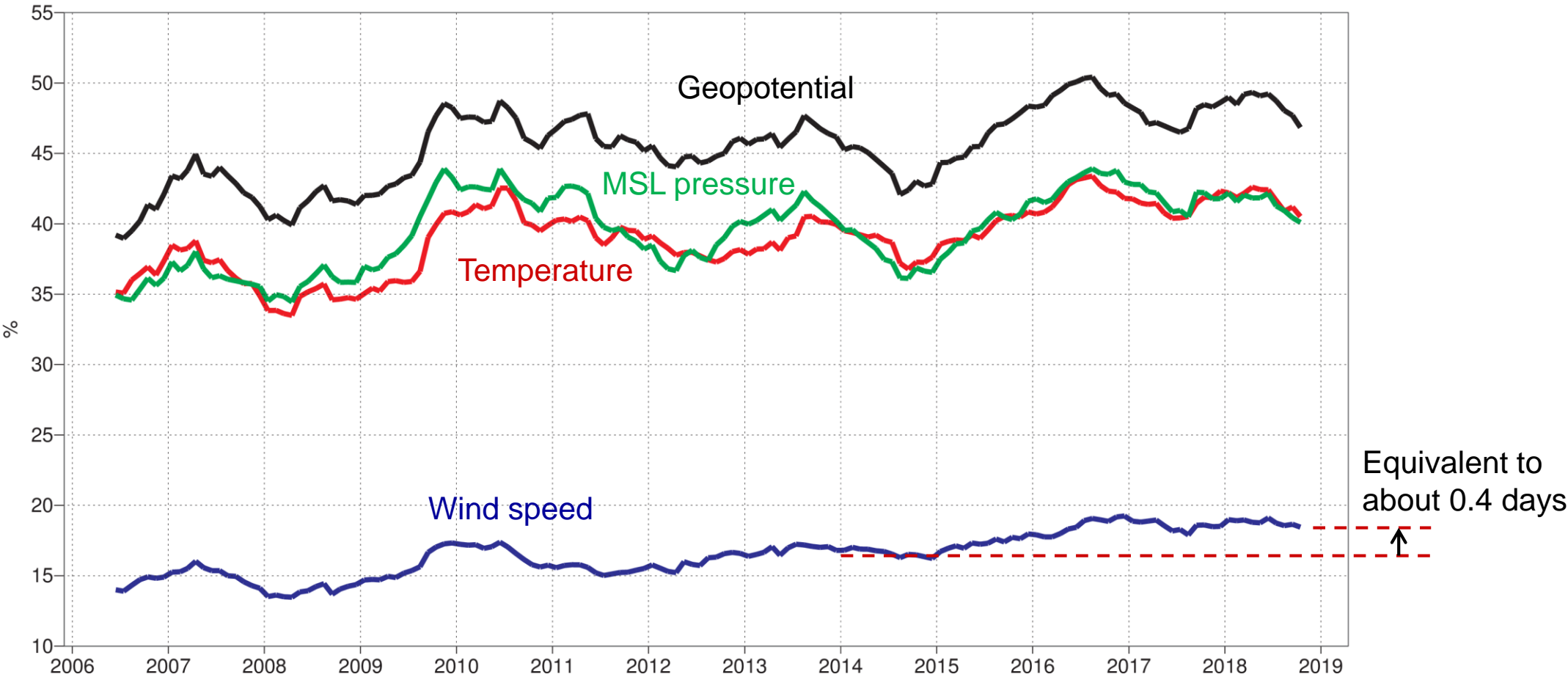MSL pressure
Temperature
Wind speed
Equivalent to about 0.4 days

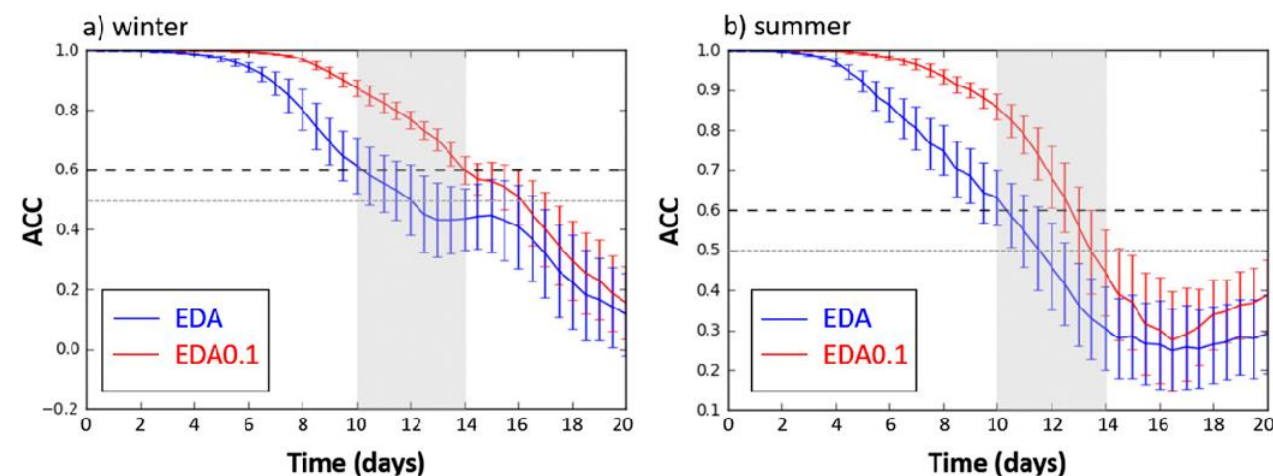# How much more lead-time can we gain at day 10?

FIG. 5. Anomaly correlation coefficient of 500-hPa heights averaged over the Northern Hemisphere midlatitudes (30°–60°N) for (a) the January 2016 case and (b) the July 2016 summer case. The blue line shows the ACC for all of the EDA members, and the red line shows the results for EDA0.1 members.

What Is the Predictability Limit of Midlatitude Weather?

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NOAA/Geophysical Fluid Dynamics Laboratory, Princeton, New Jersey

KERRY EMANUEL

Lorenz Center, Massachusetts Institute of Technology, Cambridge, Massachusetts

ABSTRACT

Understanding the predictability limit of day-to-day weather phenomena such as midlatitude winter storms and summer monsoonal rainstorms is crucial to numerical weather prediction (NWP). This predictability limit is studied using unprecedented high-resolution global models with ensemble experiments of the European Centre for Medium-Range Weather Forecasts (ECMWF; 9-km operational model) and identical-twin experiments of the U.S. Next-Generation Global Prediction System (NGGPS; 3km). Results suggest that the predictability limit for midlatitude weather may indeed exist and is intrinsic to the underlying dynamical system and instabilities even if the forecast model and the initial conditions are nearly perfect. Currently, a skillful forecast lead time of midlatitude instantaneous weather is around 10 days, which serves as the practical predictability limit. Reducing the current-day initial-condition uncertainty by an order of magnitude extends the deterministic forecast lead times of day-to-day weather by up to 5 days, with much less scope for improving prediction of small-scale phenomena like thunderstorms. Achieving this additional predictability limit can have enormous socioeconomic benefits but requires coordinated efforts by the entire community to design better numerical weather models, to improve observations, and to make better use of observations with advanced data assimilation and computing techniques.

1. Introduction

Weather forecasting has improved dramatically since the introduction of numerical weather prediction (NWP) nearly six decades ago (Bauer et al. 2015). This has been accomplished through ever-increasing computing power, improved models running at ever-increasing resolution with more accurate representation of atmospheric physical processes, and more sophisticated four-dimensional data assimilating algorithms that can better ingest ever-increasing volumes and quality of in situ and remotely acquired observations (WMO 2015). A widely used measure of global NWP forecast quality is the anomaly correlation coefficient (ACC) of 500-hPa geopotential height between the forecasts and observations. In practice, 60% is usually used as a threshold for measure of skillful synoptic-scale weather forecast. Examining the evolution of ACC (Fig. 1), useful deterministic forecasts by arguably the most advanced NWP model at the European Centre for Medium-Range Weather Forecasts (ECMWF) could at best be made up to around 10 days: this number was 7 days 30 years ago (Simmons and Hollingsworth 2002; Bauer et al. 2015).

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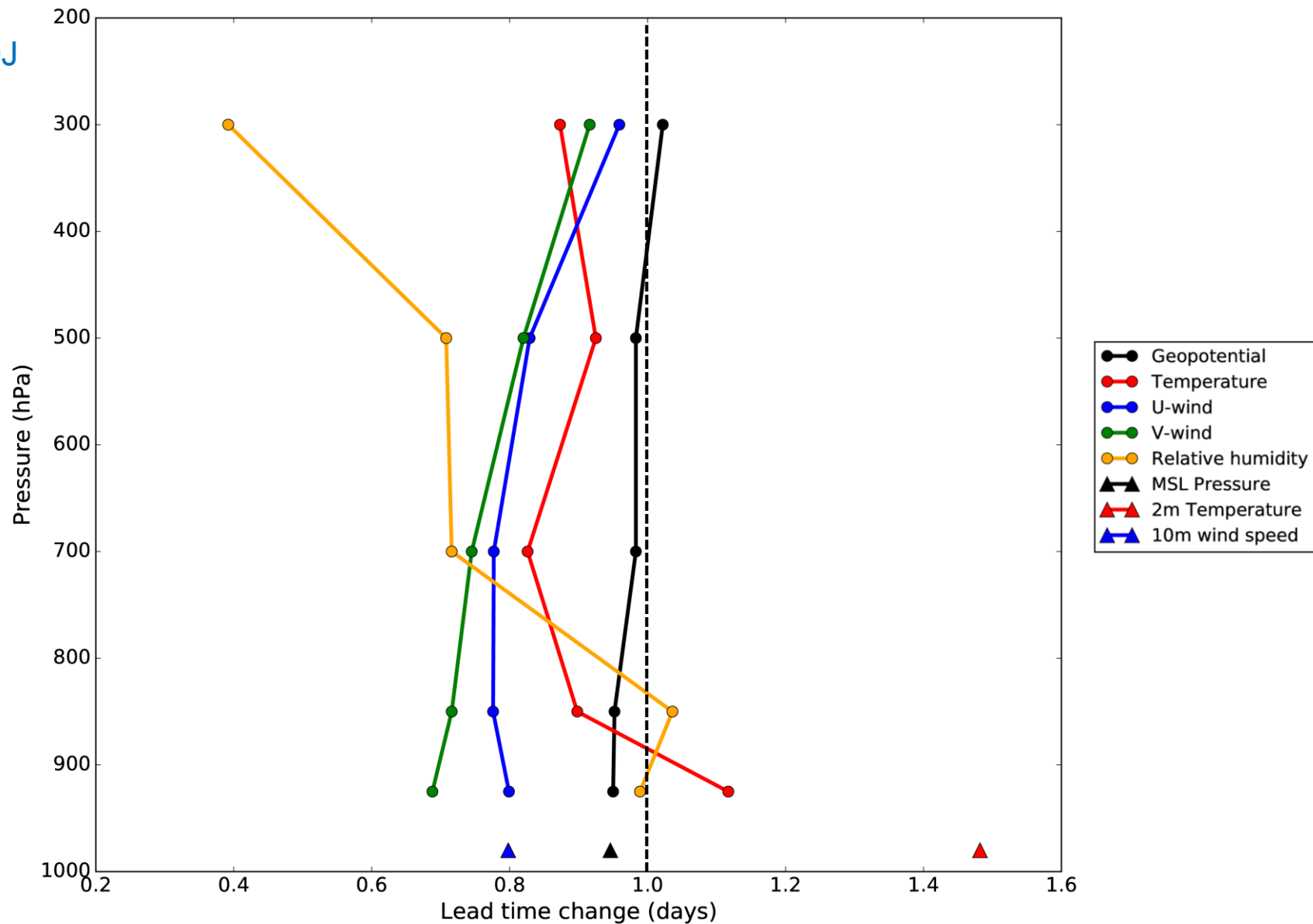
Lead time gains
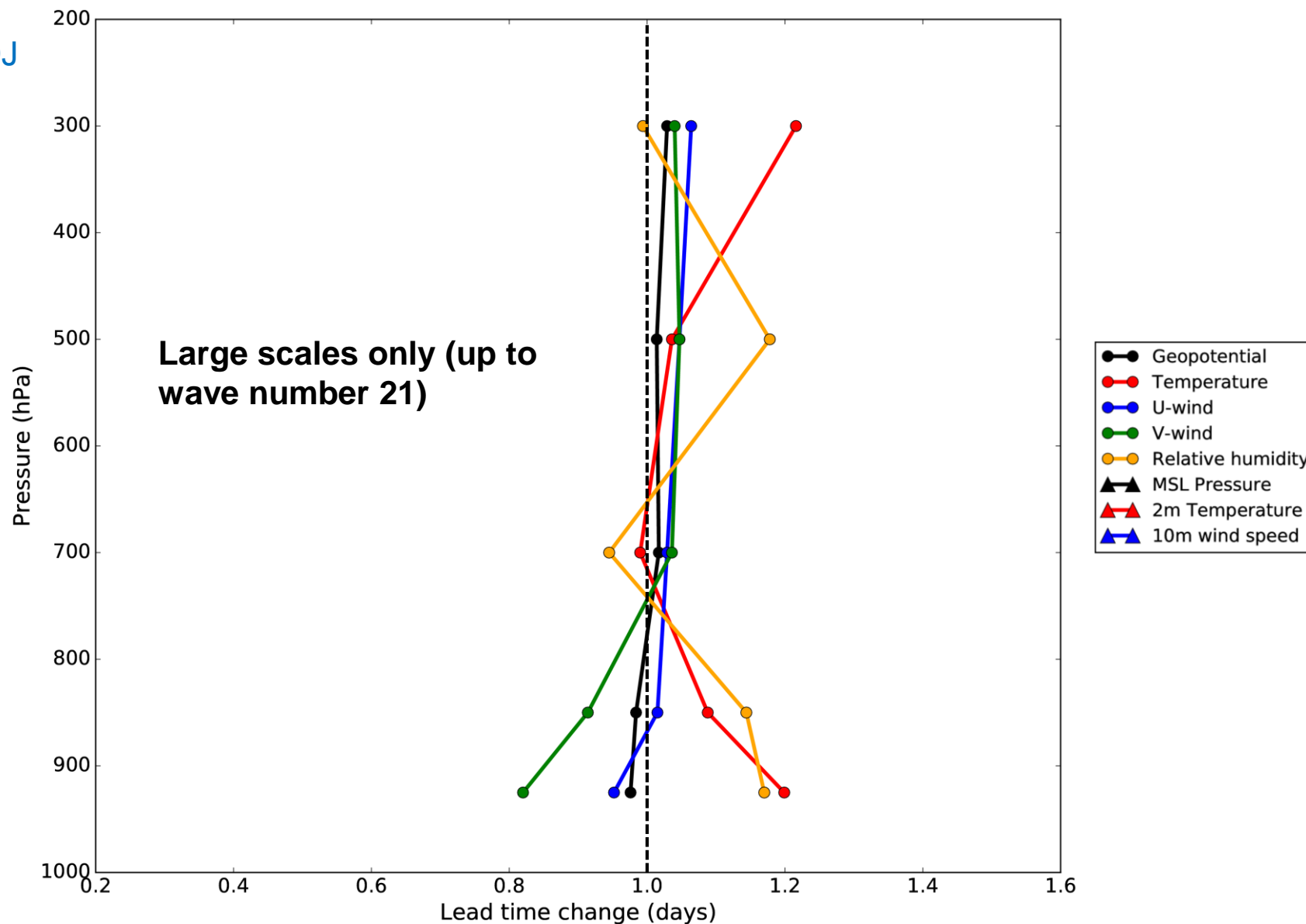
Evolution of upper-air forecast skill
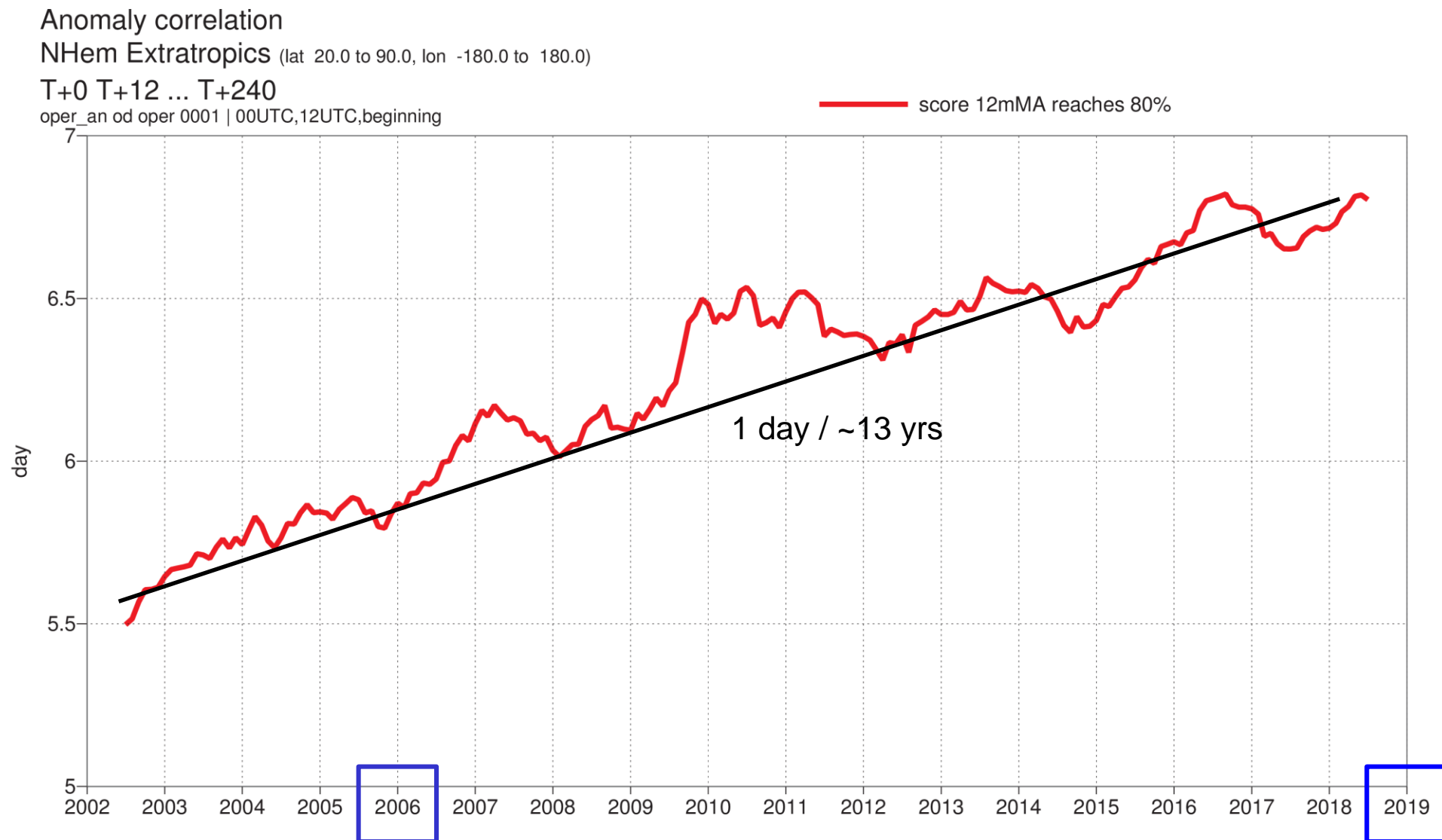
Vertical profiles of improvement 2006-2019

- Comparing periods NDJ 2005/06 and 2018/19
- Score=RMSE
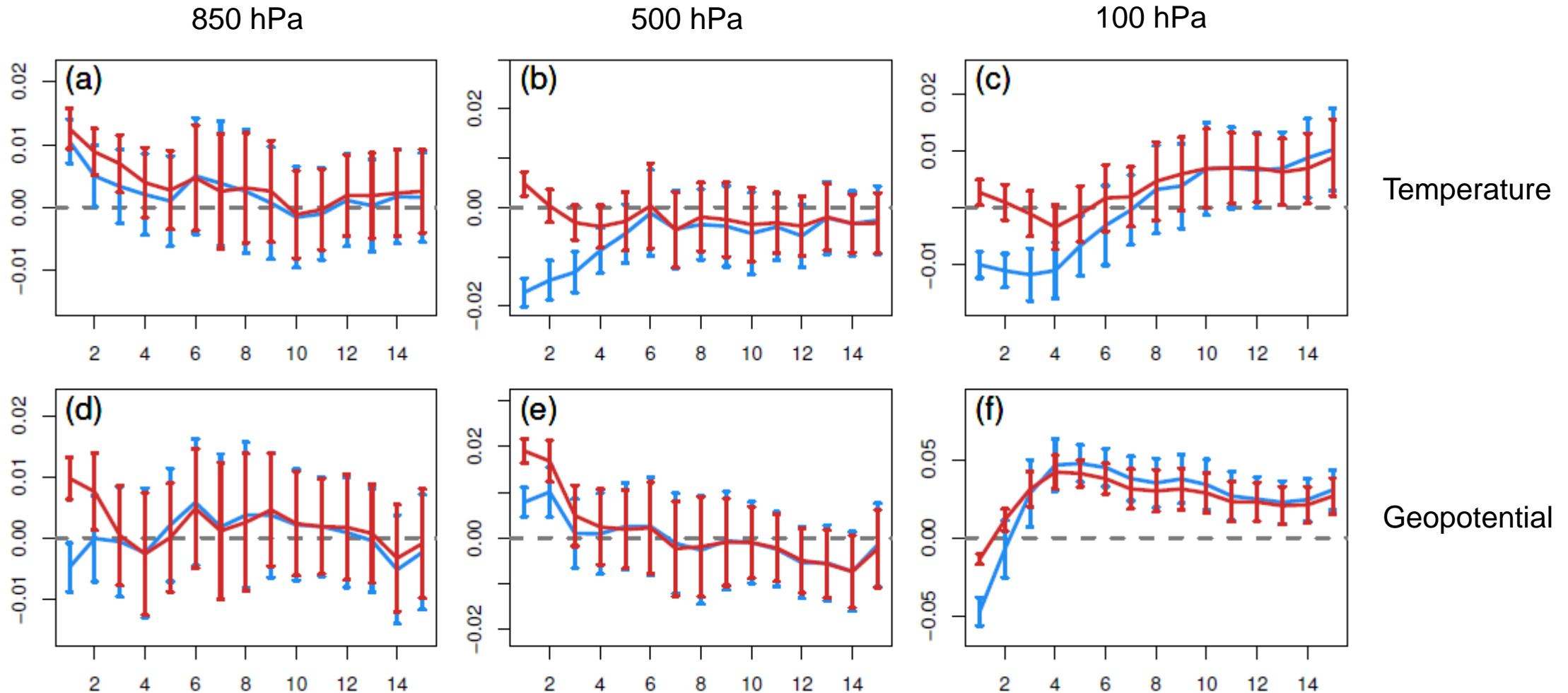- Verification against analysis

Vertical profiles of improvement 2006-2019

- Comparing periods NDJ 2005/06 and 2018/19
- Score=RMSE
- Verification against analysis

# Observation error and representativeness

Taking into account observation uncertainty

ENS performance of new model cycle (45r1) compared to previous (43r3)
Metric: normalized CRPS difference

Taking into account observation uncertainty: precipitation

- HDOBS: high-density observation network (precipitation data from Member and Co-operating States of ECMWF in addition to the European network of synoptic stations) ∼ 5000 observations/day. Jan., April, July, Oct. 2018.
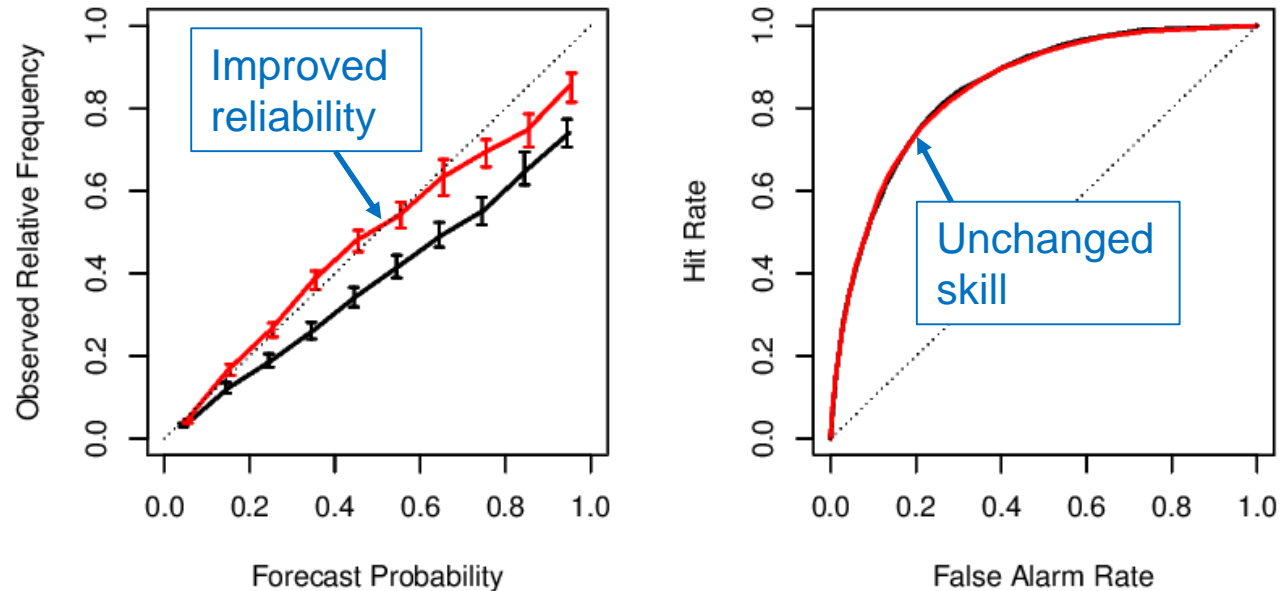

Example of HDOBS observations
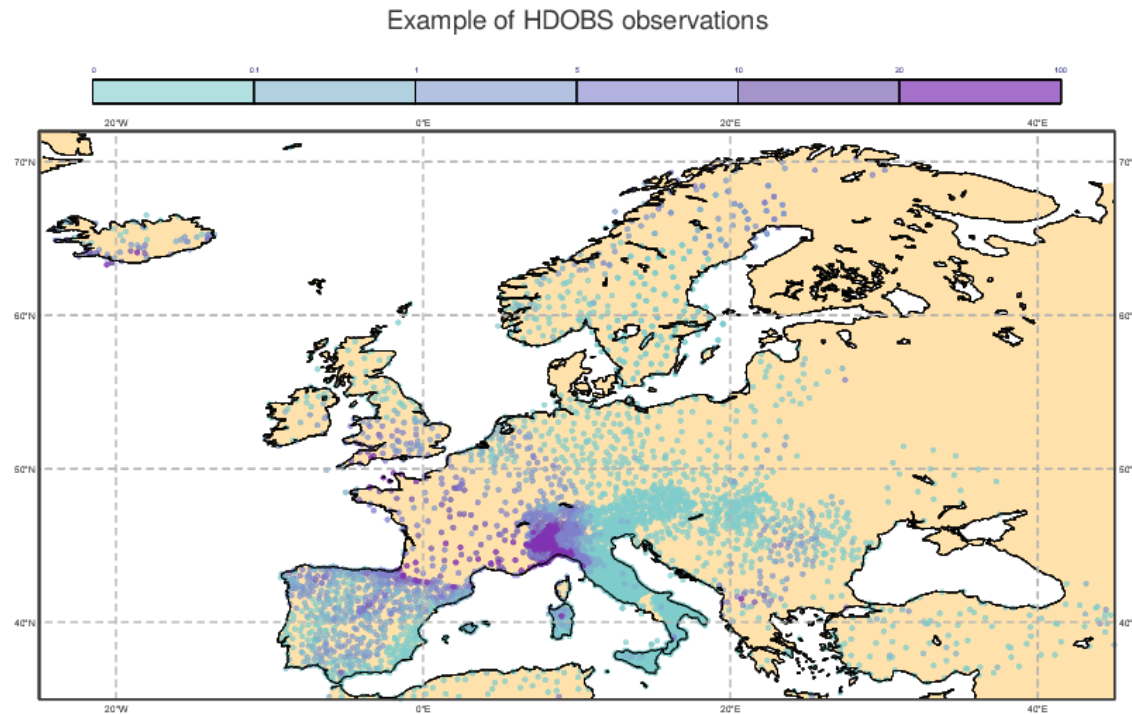
Observation uncertainty: precipitation

Brier Score for threshold 1mm/24h as a function of the forecast lead time, Summer 2018, **with** and **without** observation uncertainty:
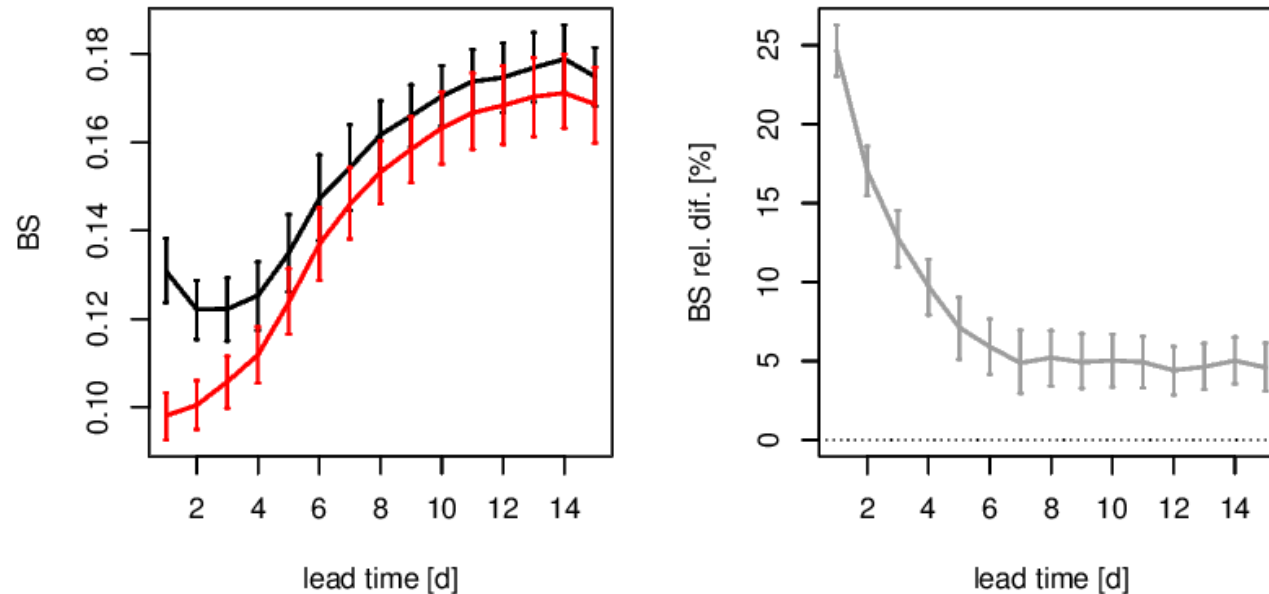
Observation uncertainty: precipitation

Reliability and ROC curves for event-threshold of 1mm/24h, day 5, Summer 2018, **with** and **without** observation uncertainty:

Summary

- Medium-range NWP (slowly) **further improving**, ECMWF and other centres

- **Lead-time gains** around **1 day/13 years** for large scales

- Translates into **substantial reduction of large errors**

- **Ambitious strategic goal:** skill in week 2 not easily improved

- **Observation uncertainty** resolves odd lead-time dependence of precip skill

ECMWF