Norwegian Meteorological Institute

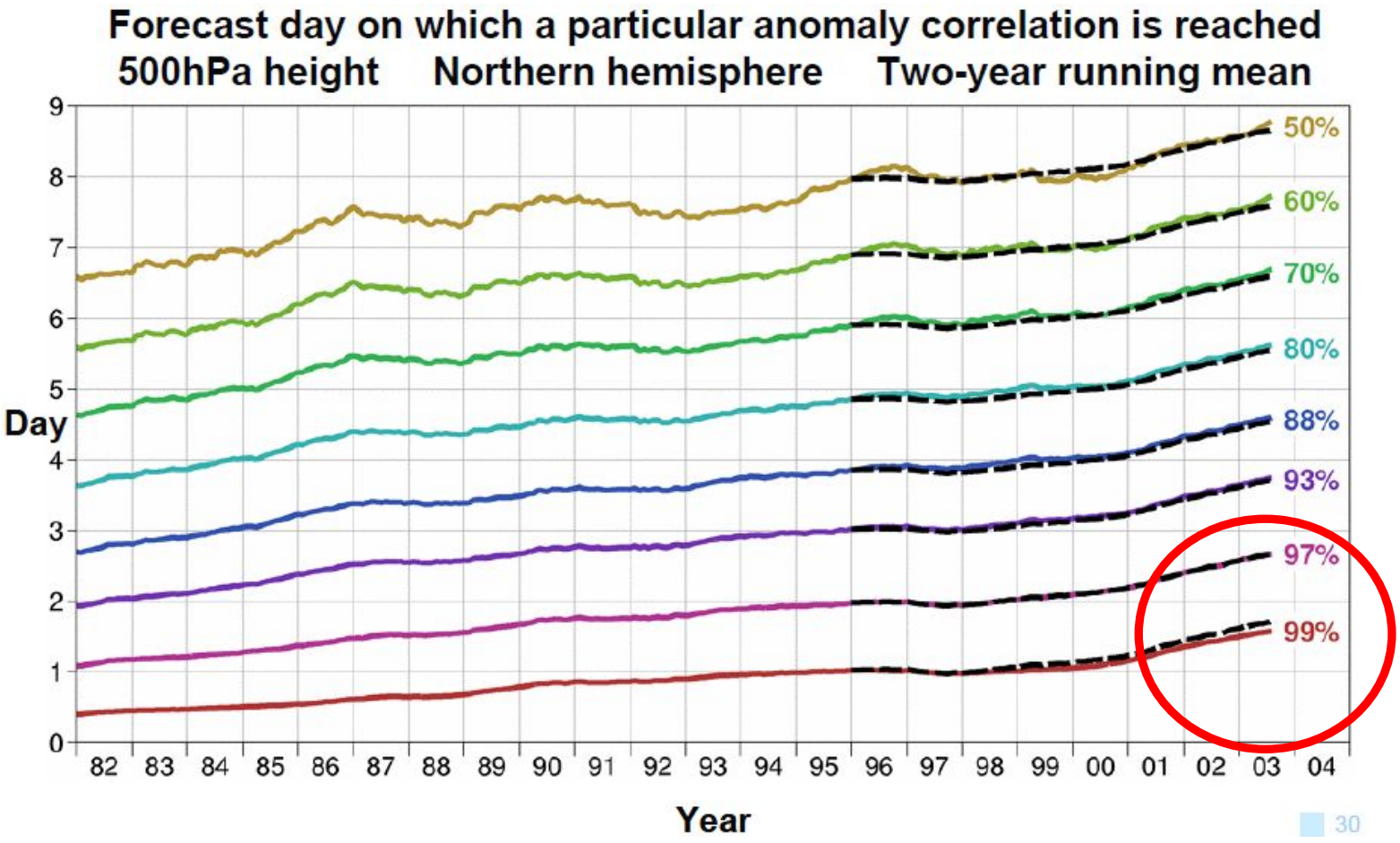
Very high-resolution, non-hydrostatic, short-range ensembles

Inger-Lise Frogner

ECMWF Annual Seminar 11 - 14 September 2017

High Resolution Limited Area Model Hirlam

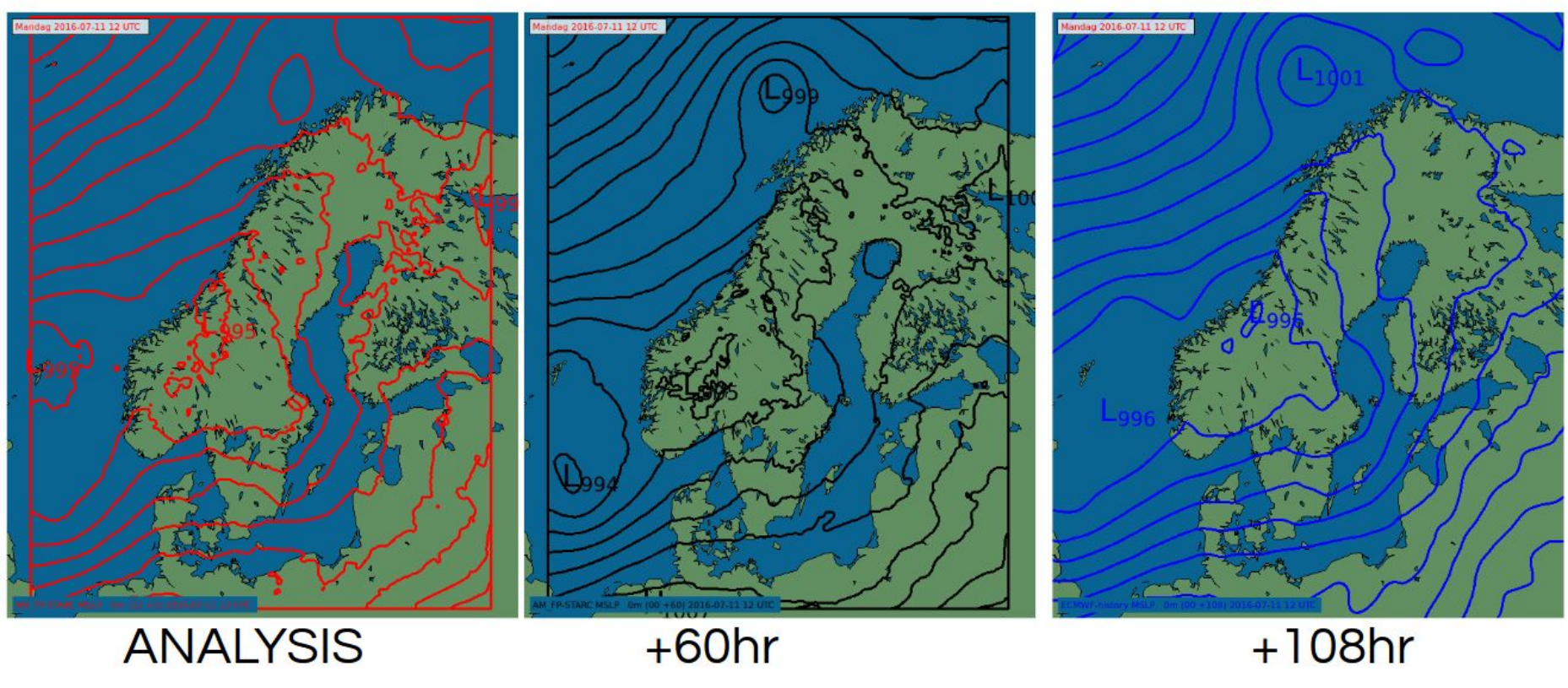
But: Deterministic forecasts first 2-3 days are nearly perfect !
- for z500



NWP quality for 500hPa geopotential heights

A. Simmons

A predictable situation?



MSLP

Courtesy Morten Køltzow, MET Norway

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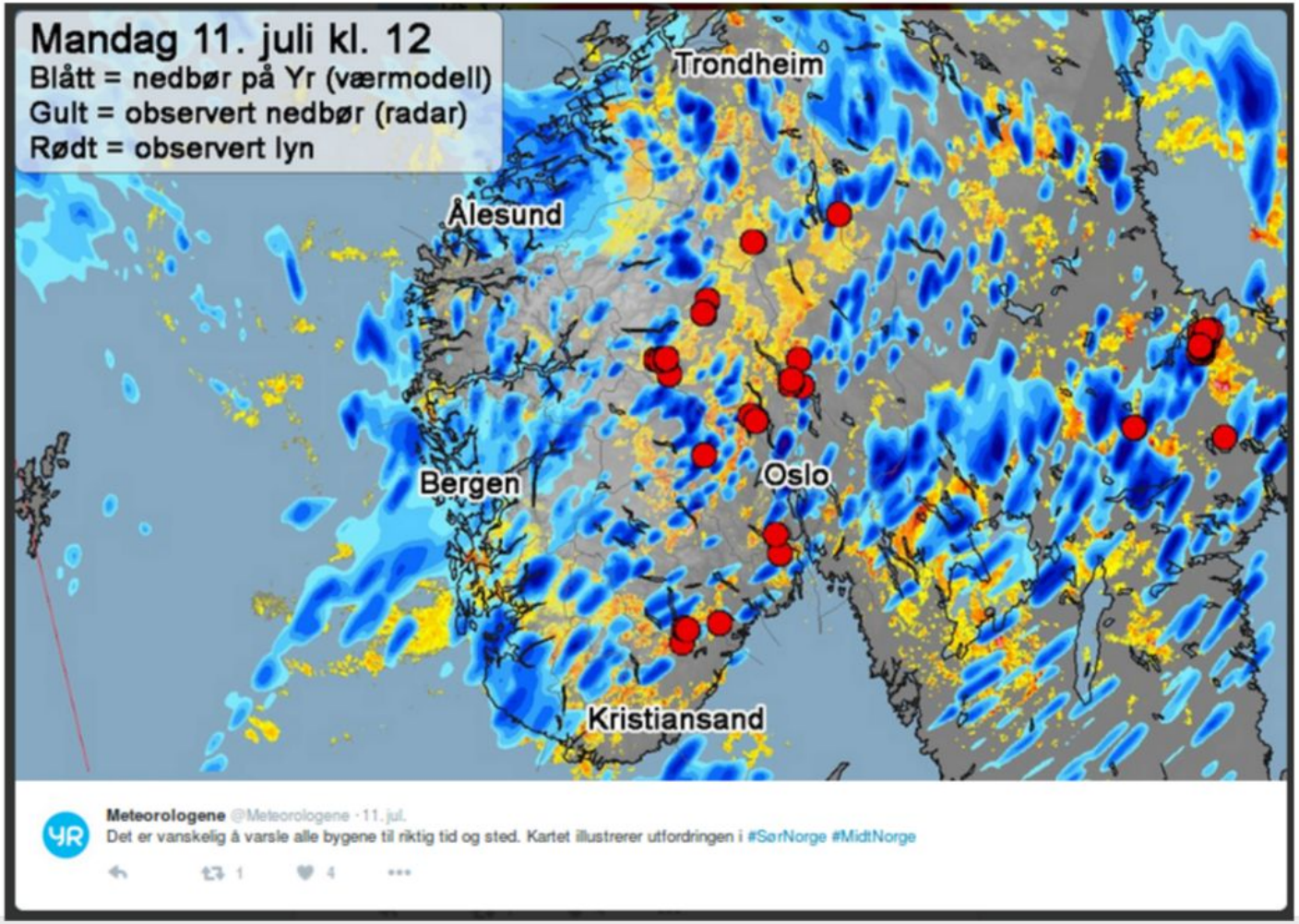
It depends on the scales you are interested in



"A tweet" with 1hr model precipitation in blue (+11hr), observed lightning in red, and radar reflectivity valid at the same time as the previous slide with MSLP

Courtesy Morten Køltzow, MET Norway

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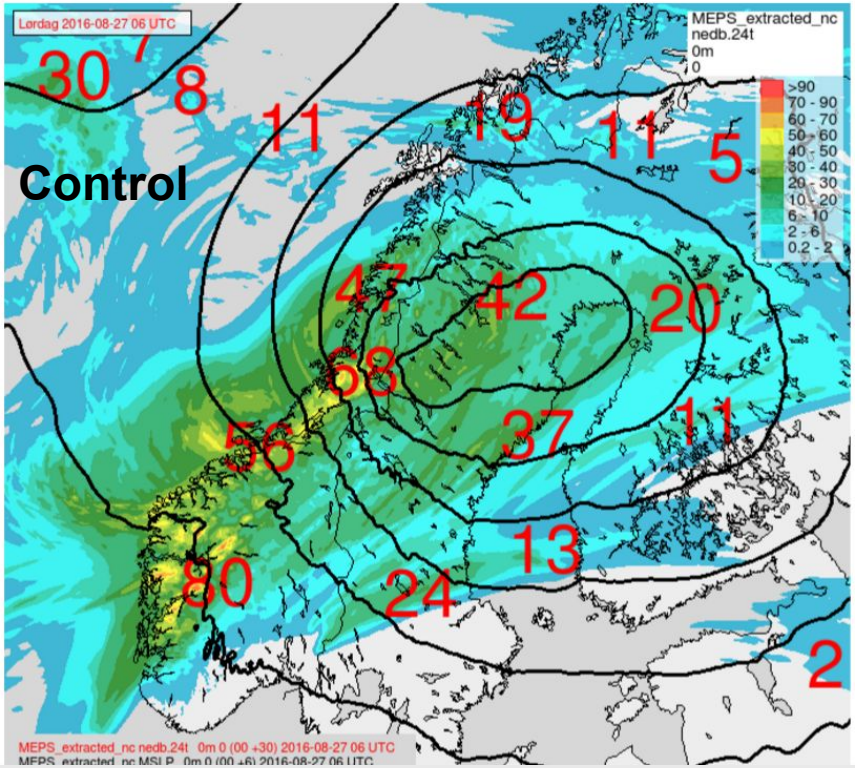
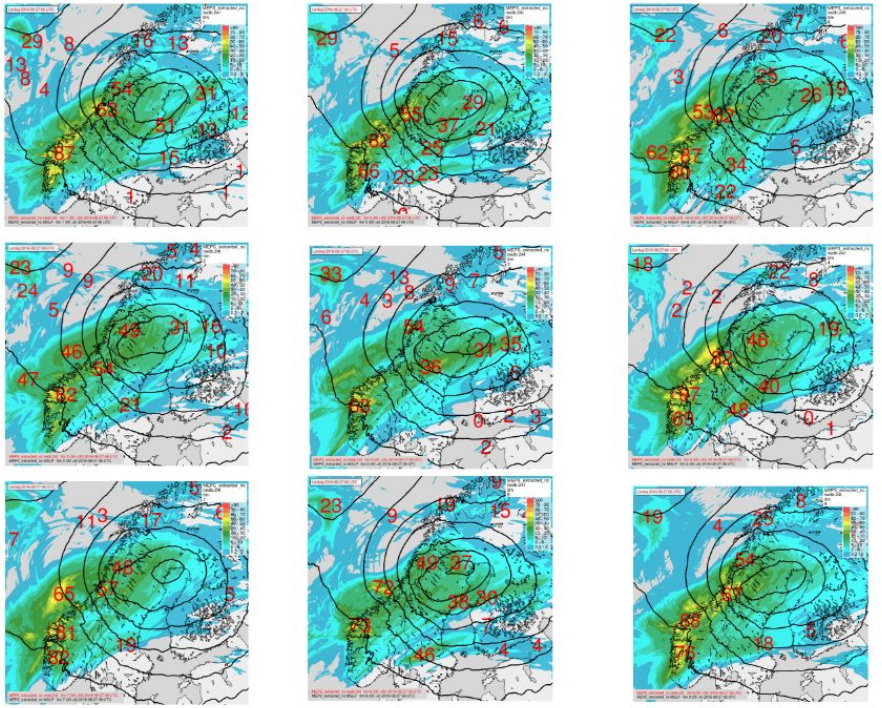
Synoptic scale agreement between MEPS (2.5km) members

24hr accumulated precipitation and MSLP 27.August 2016





Members 1 - 9

Courtesy Morten Køltzow, MET Norway

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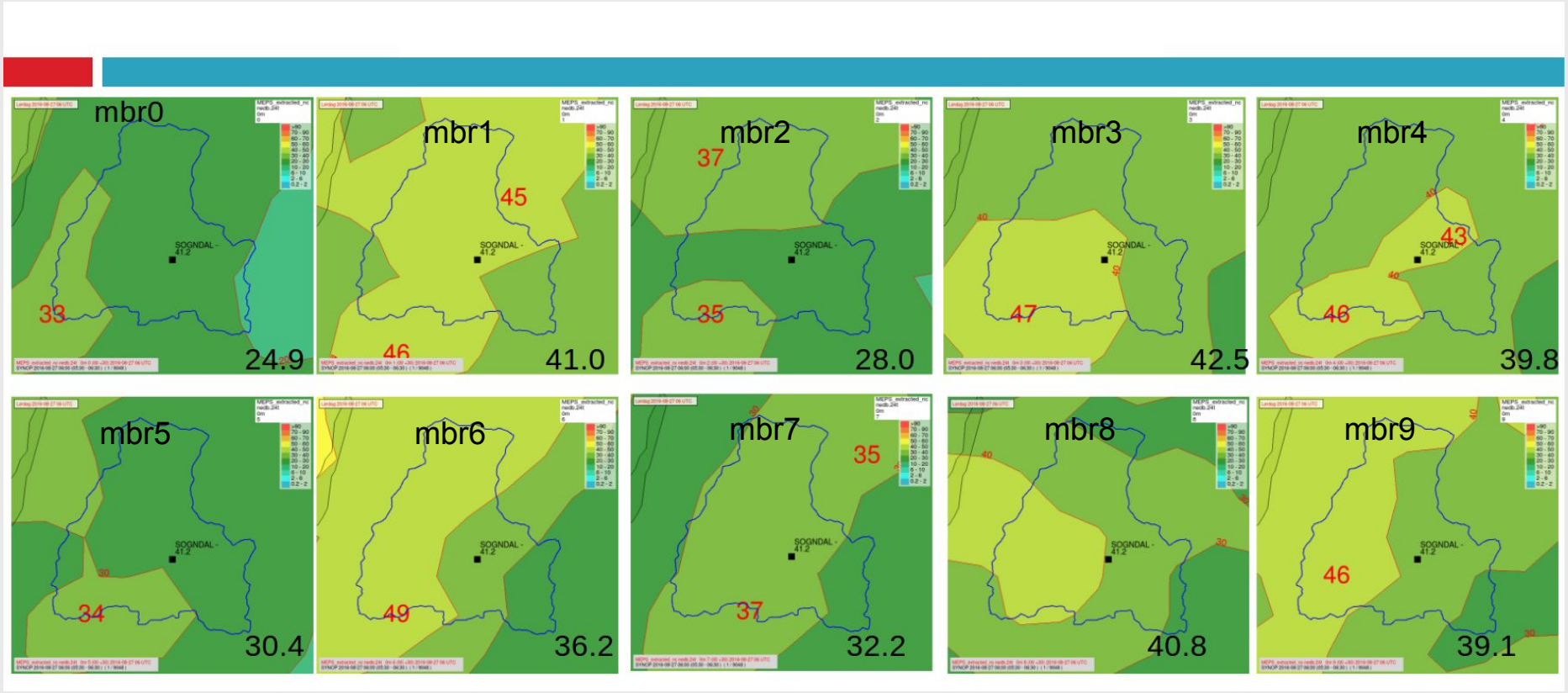
Zooming in on a catchment area

24h accumulated precipitation (+6h - +30h)



20-30 mm
30-40 mm
40-50 mm

Observed in Sogndal: 41.2 mm
Forecasted in Sogndal: 24.9mm (control) - 42.5mm (member 3)

Courtesy Morten Køltzow, MET Norway

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Very high-resolution, non-hydrostatic, short-range ensembles: Challenges

1. **Predictability as a function of scale**

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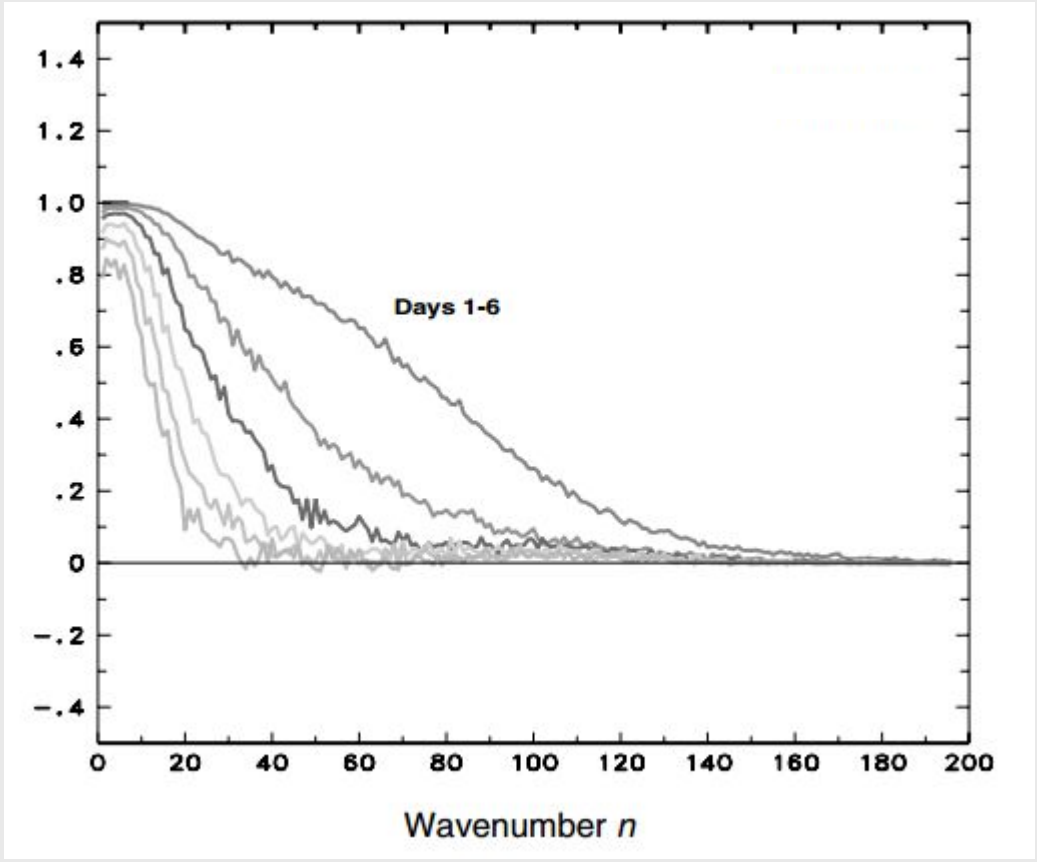
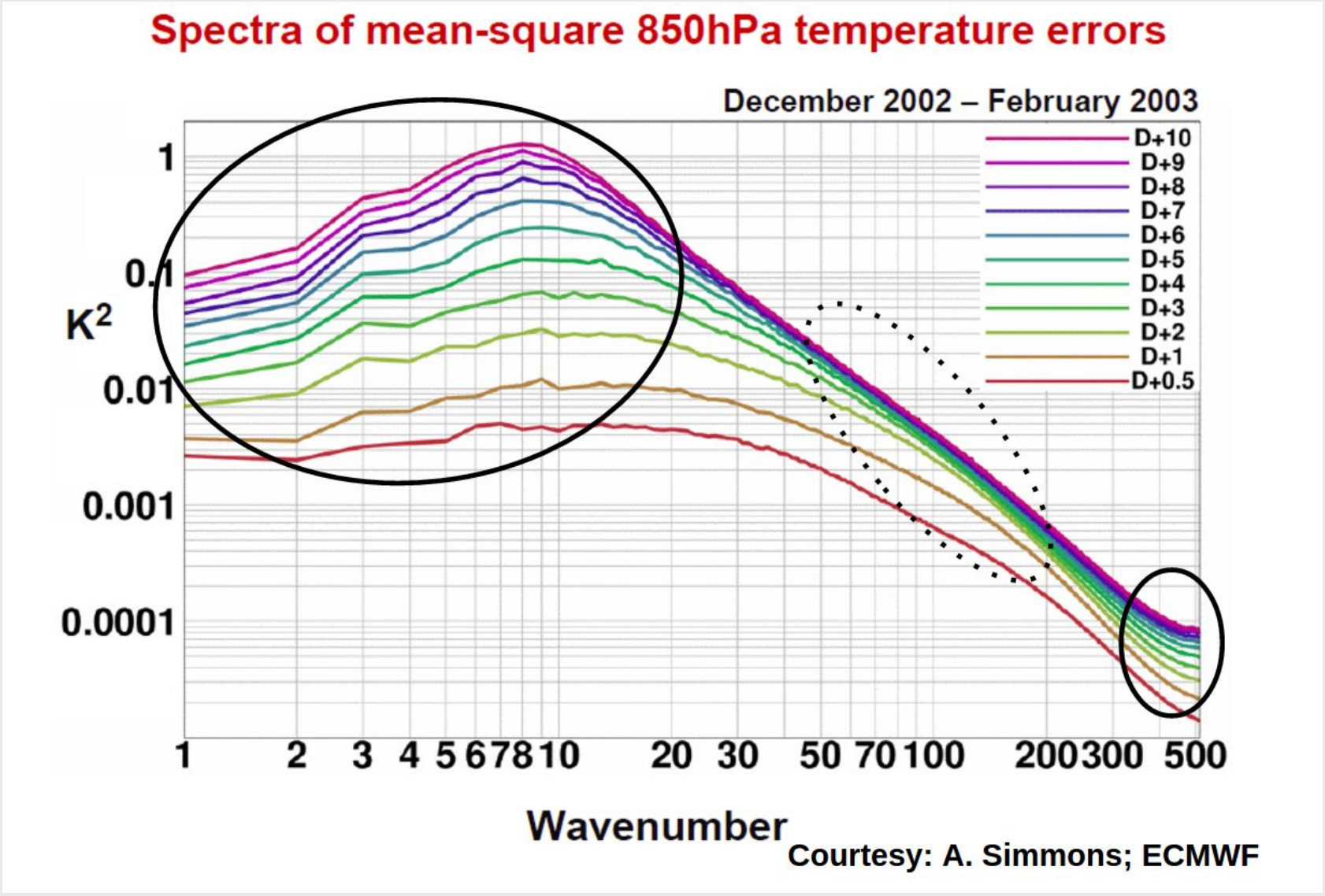
Classical predictability behaviour



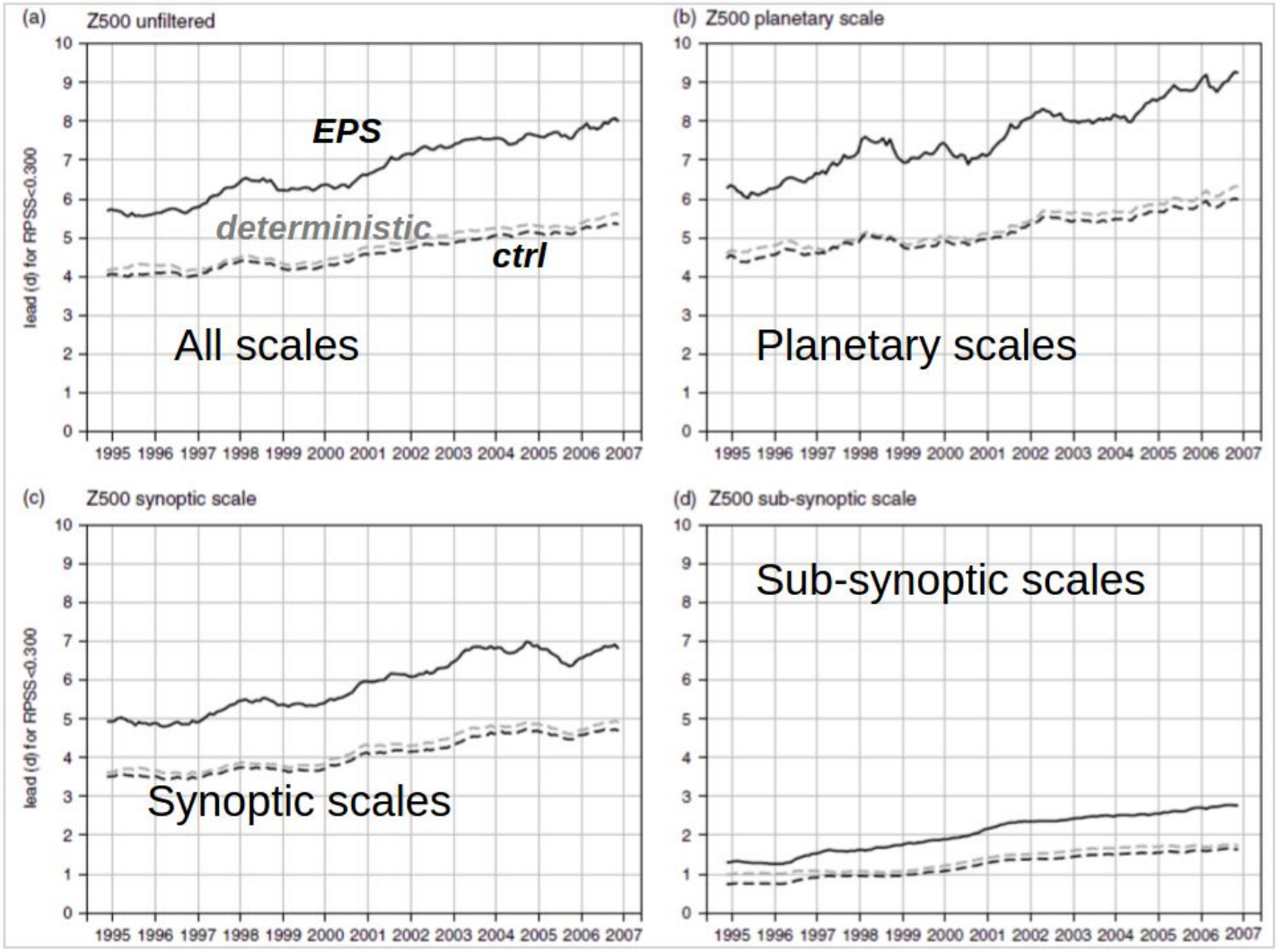
Boer (2003)

Norwegian Meteorological Institute

Predictability as a function of scale



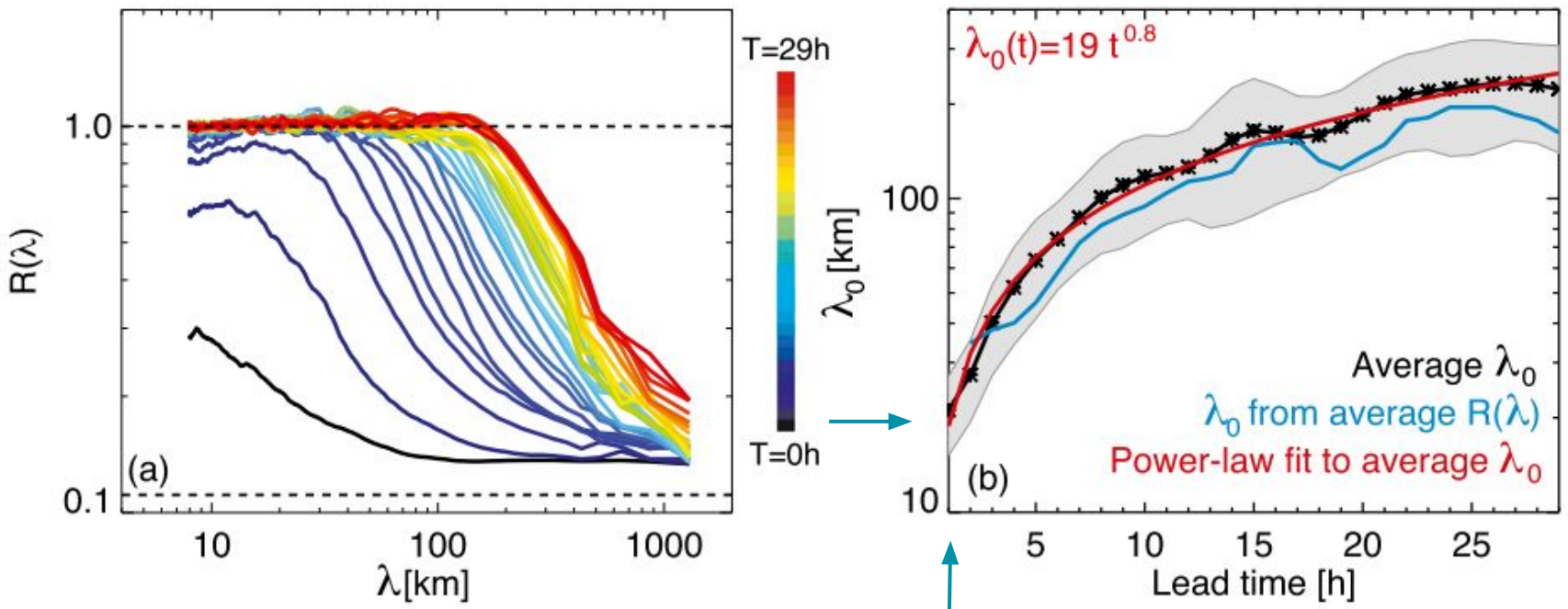
Forecast lead time when Rank Probability Skill Score (RPSS) for EC ENS of Z500 < 0.3 (1994-2007)



Jung, T. and Leutbecher, M. (2008)

Norwegian Meteorological Institute

Scale dependence of predictability for precipitation



Decorrelation scale between members: λ_0

Power ratio for the decorrelation scale: **R**. R reaching 1 = no predictability

Surcel, M., I. Zawadzki, and M.K. Yau, 2015

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Very high-resolution, non-hydrostatic, short-range ensembles: Challenges

1. Predictability as a function of scale
2. Constructing the ensemble

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An accurate analysis

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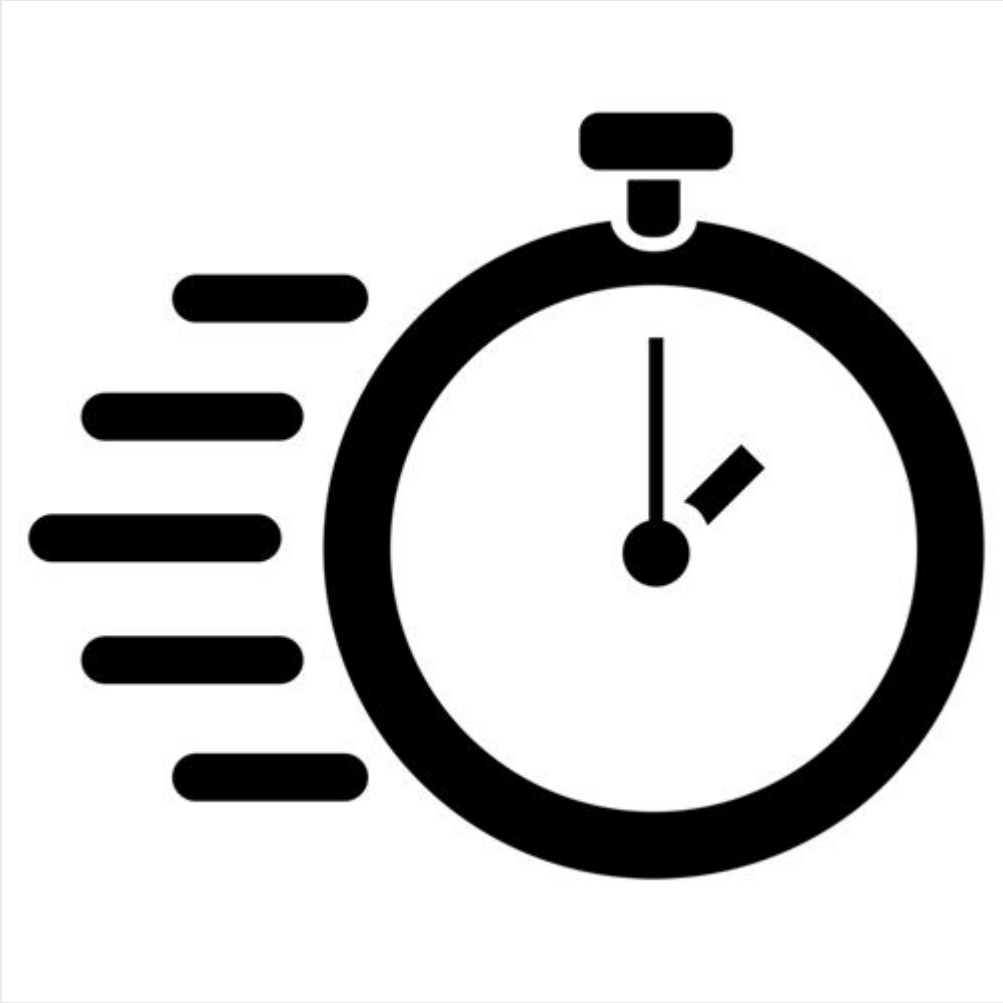
Computationally fast and frequently updated



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Short model spin-up

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Accounting for model error

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Accounting for surface uncertainties

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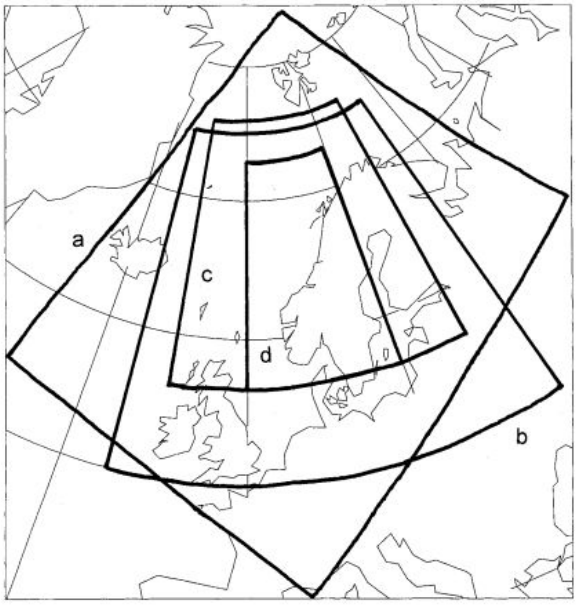
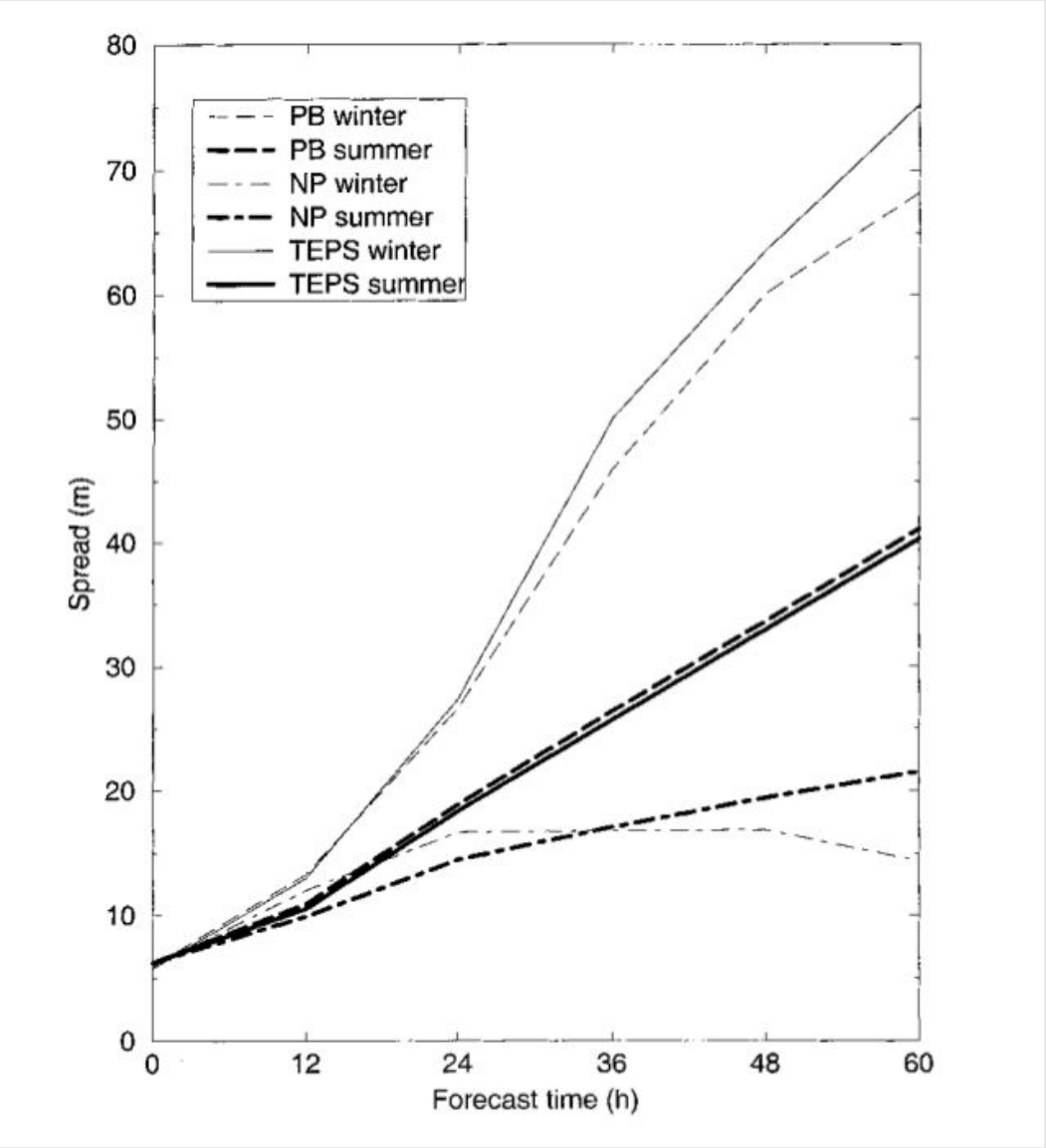
The lateral boundaries





_._._ No LBC pert.

_ _ _ LBC pert.

Summer
Winter

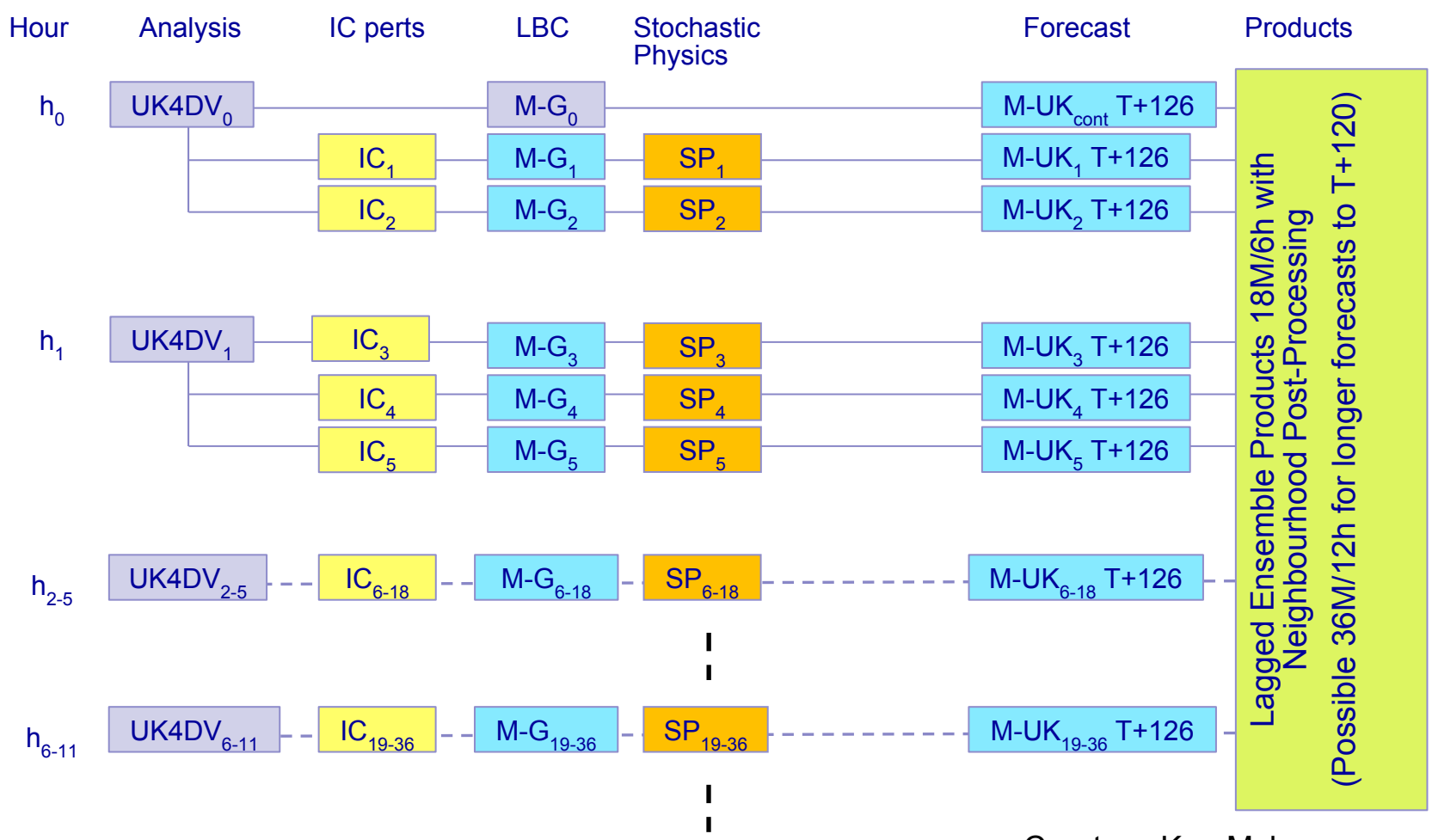
Frogner and Iversen, 2002

Cycling strategies

MOGREPS-UK Hourly-cycling Demo Suite

18M/6h MOGREPS-UK Nested in 18M MOGREPS-G

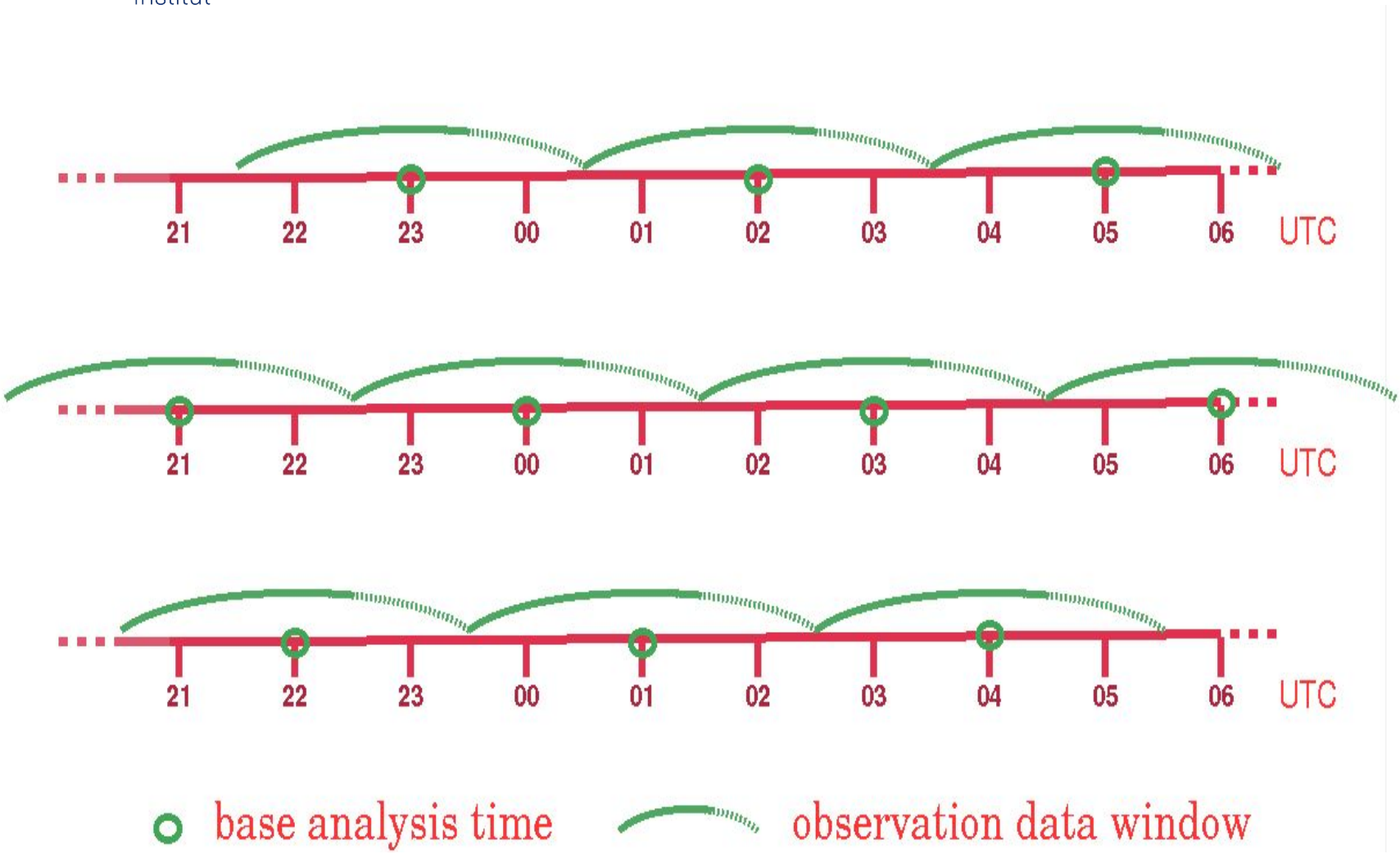
***Assumptions**: Each cycle takes LBCs and IC perts from latest available MOGREPS-G.*
Initial Demo Suite at 2.2km resolution to T+36
Operational-suite demo implementation at 1.5km resolution to T+120



Courtesy Ken Mylne

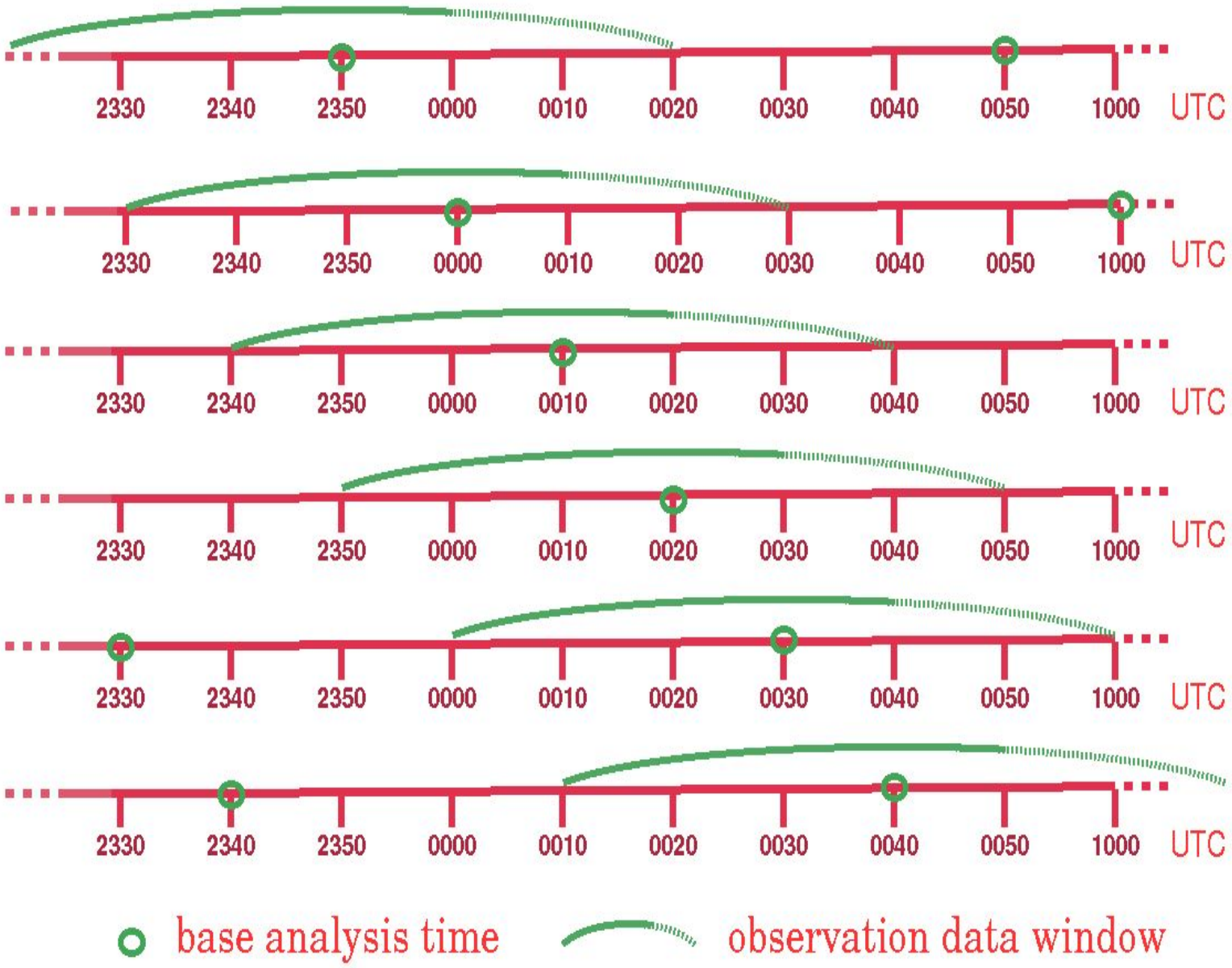
Danmarks Meteorologiske Institut

COMEPS - DMI



Courtesy Xiaohua Yang

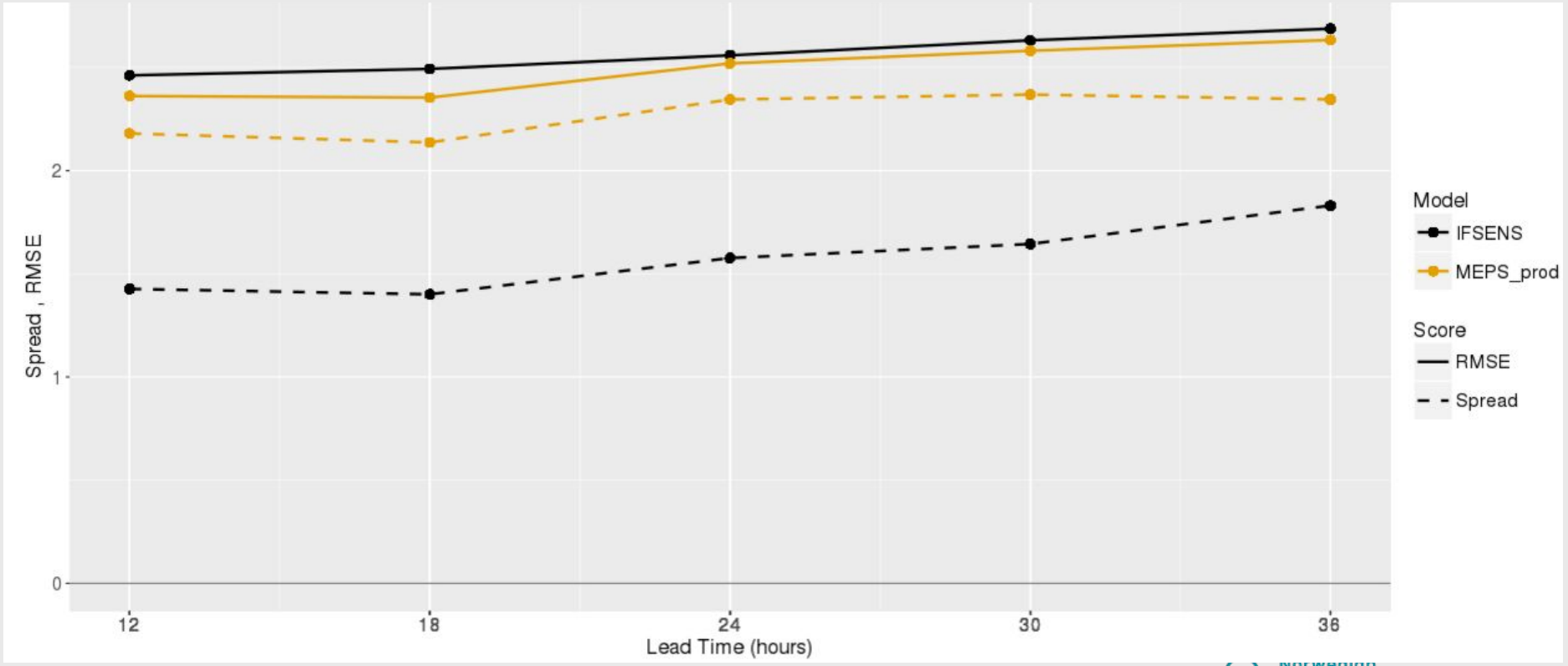
COMEPS - for Nowcasting



Courtesy Xiaohua Yang

How does high-resolution EPS (MEPS) score against EC ENS?

Spread and skill 12h accumulated precipitation July 2017



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Very high-resolution, non-hydrostatic, short-range ensembles: Challenges

1. Predictability as a function of scale
2. Constructing the ensemble
3. **Using the ensemble**

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Probabilistic forecasts

=

Better decisions, right?

15:00

10:00

Example based on a talk by A. Singleton (MET Norway)

fog

15:00

10:00

Deterministic forecast
12:00-13:00

fog

Mostly sunny. Risk of local fog, mainly along the coast.

10:00

Deterministic forecast
12:00-13:00

fog

"What does the probability forecast say?

10:00

Deterministic forecast
12:00-13:00

Probability of fog

20%

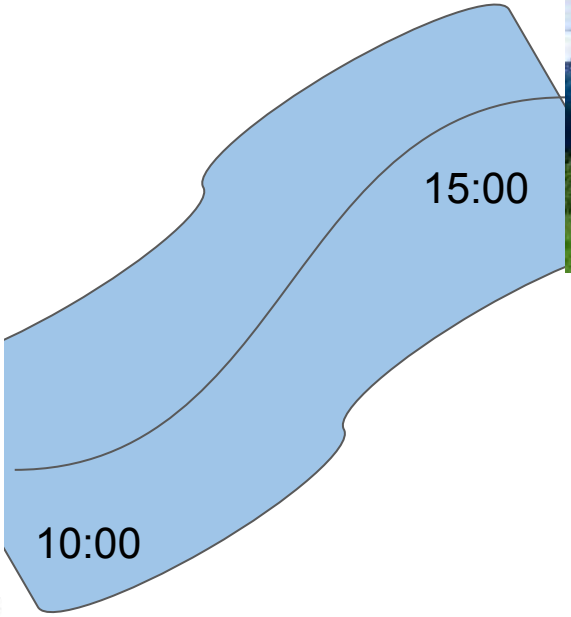
40%

60%

80%

100%

5 member ensemble



Probability of fog **10:00-11:00**: 20%

Probability of fog

20%

40%

60%

80%

100%

15:00

10:00

Probability of fog **11:00-12:00**: 20%

Probability of fog

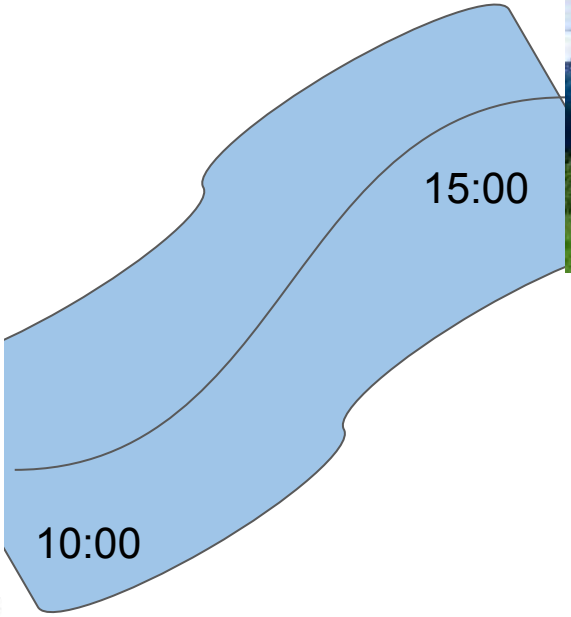
20%

40%

60%

80%

100%



Probability of fog **12:00-13:00**: 20%

Probability of fog

20%

40%

60%

80%

100%

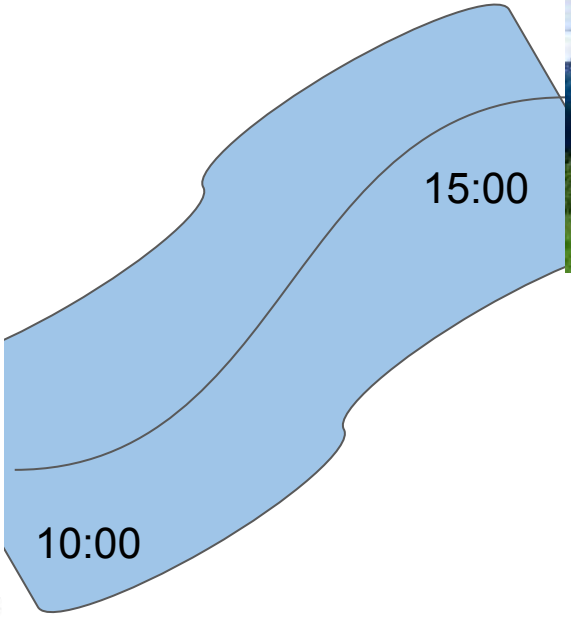
15:00

10:00

Probability of fog **13:00-14:00**: 20%

Probability of fog

- 20%
- 40%
- 60%
- 80%
- 100%



Probability of fog **14:00-15:00**: 20%

Probability of fog

- 20%
- 40%
- 60%
- 80%
- 100%

80% chance of no fog!

10:00

Probability of fog **14:00-15:00**: 20%

fog

5 member ensemble

15:00

10:00

Member 1: fog **11:00 -12:00**

fog

15:00

10:00

Member 2: fog **10:00 -11:00**

fog

15:00

10:00

Member 3: fog **14:00 -15:00**

fog

15:00

10:00

Member 4: fog **12:00 -13:00**

fog

15:00

10:00

Member 5: fog **13:00 -14:00**

Probability of fog

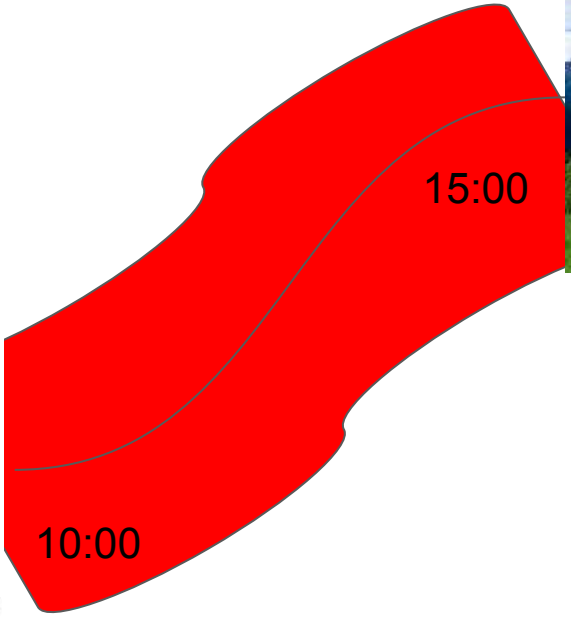
20%

40%

60%

80%

100%



Probability of fog during the trip: 100%

Probability of fog

20%

40%

60%

80%

100%

80% chance of no fog!

10:00

Probability of fog **14:00-15:00**: 20%

Probability of fog

20%

40%

60%

80%

100%

100% chance of fog!

10:00

Probability of fog **14:00-15:00**: 20%

Probabilistic forecasts

=

Better decisions, right?

Only if the probability directly refers to the decision

Good use of probabilistic forecasts

Courtesy: Andrew Singleton

Ensemble weather forecasts can provide useful guidance when making weather dependant decisions.

Good use of probabilistic forecasts

Courtesy: Andrew Singleton

Ensemble weather forecasts can provide useful guidance when making weather dependent decisions.

Uncertainty information gives the user an indication of how confident they can be in a forecast.

Good use of probabilistic forecasts

Courtesy: Andrew Singleton

Good use of probabilistic forecasts

Ensemble weather forecasts can provide useful guidance when making weather dependant decisions.

Uncertainty information gives the user an indication of how confident they can be in a forecast.

Probability information can be more complex as it requires an event definition, which may be unique to each individual user. The event definition may include

Courtesy: Andrew Singleton

Good use of probabilistic forecasts

Ensemble weather forecasts can provide useful guidance when making weather dependant decisions.

Uncertainty information gives the user an indication of how confident they can be in a forecast.

Probability information can be more complex as it requires an event definition, which may be unique to each individual user. The event definition may include

- a threshold
- a time window
- a spatial area
- any other conditions

Courtesy: Andrew Singleton

Good use of probabilistic forecasts

Ensemble weather forecasts can provide useful guidance when making weather dependant decisions.

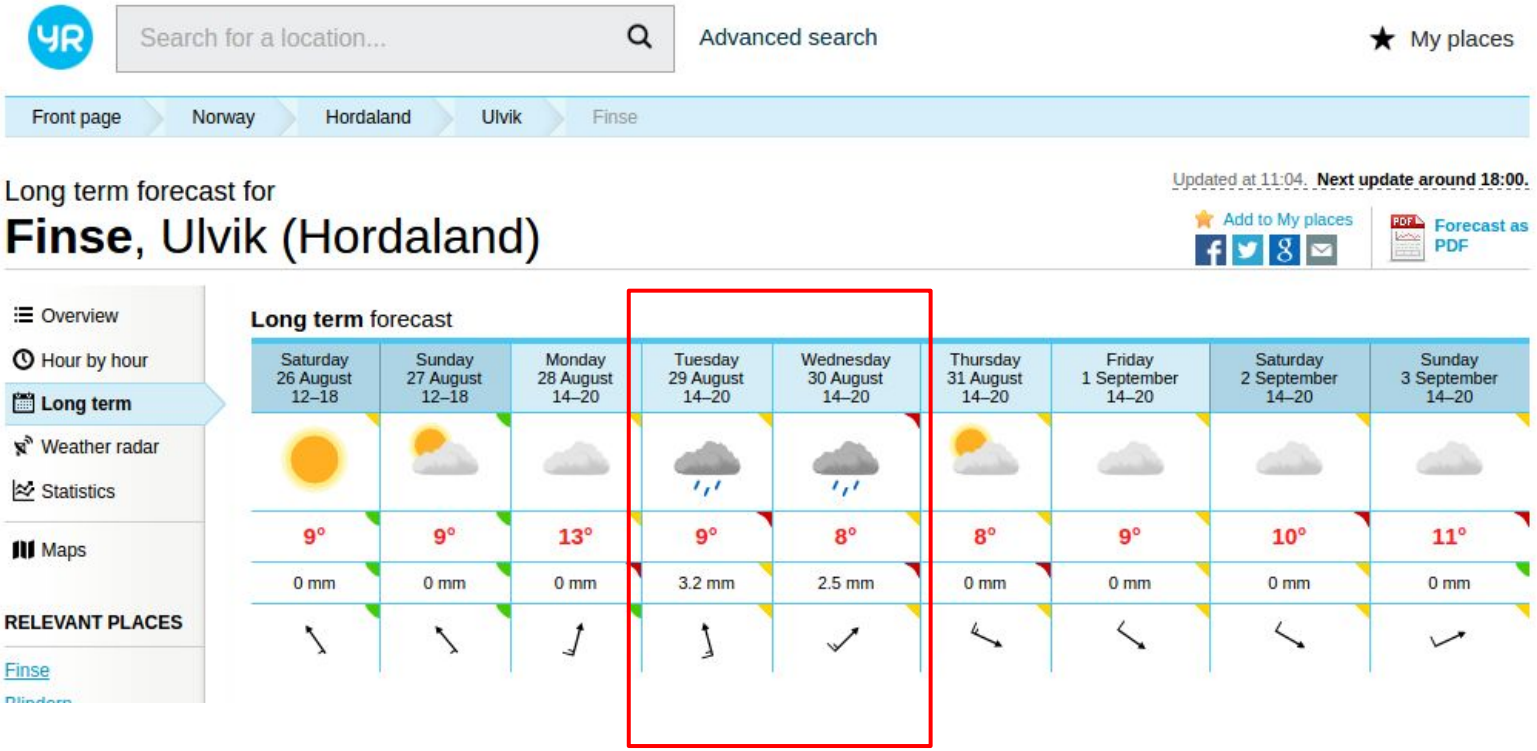
Uncertainty information gives the user an indication of how confident they can be in a forecast.

Probability information can be more complex as it requires an event definition, which may be unique to each individual user. The event definition may include

- a threshold
- a time window
- a spatial area
- any other conditions

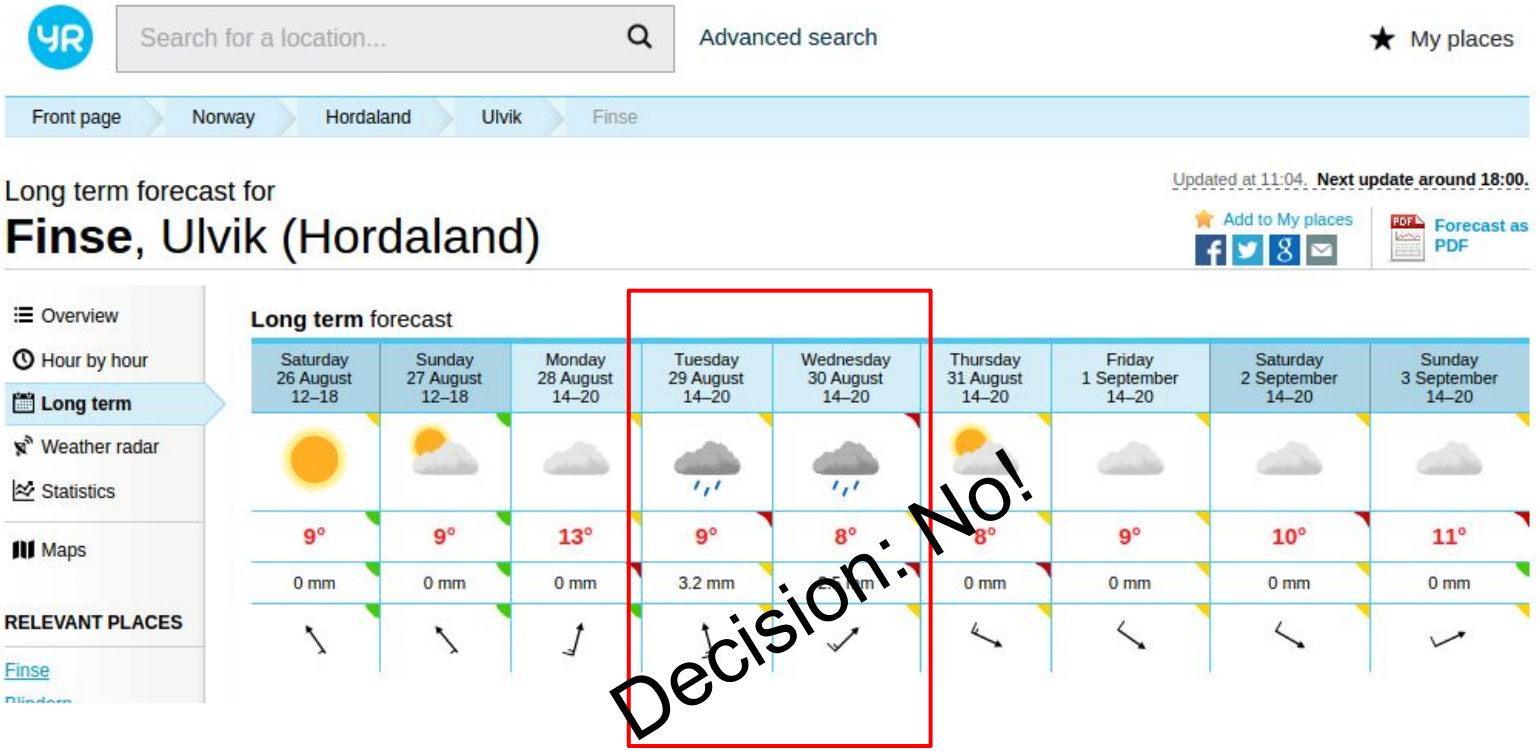
Good communication with users is therefore essential for ensemble forecasts to be used to their full capacity as a decision making tool.

Courtesy: Andrew Singleton



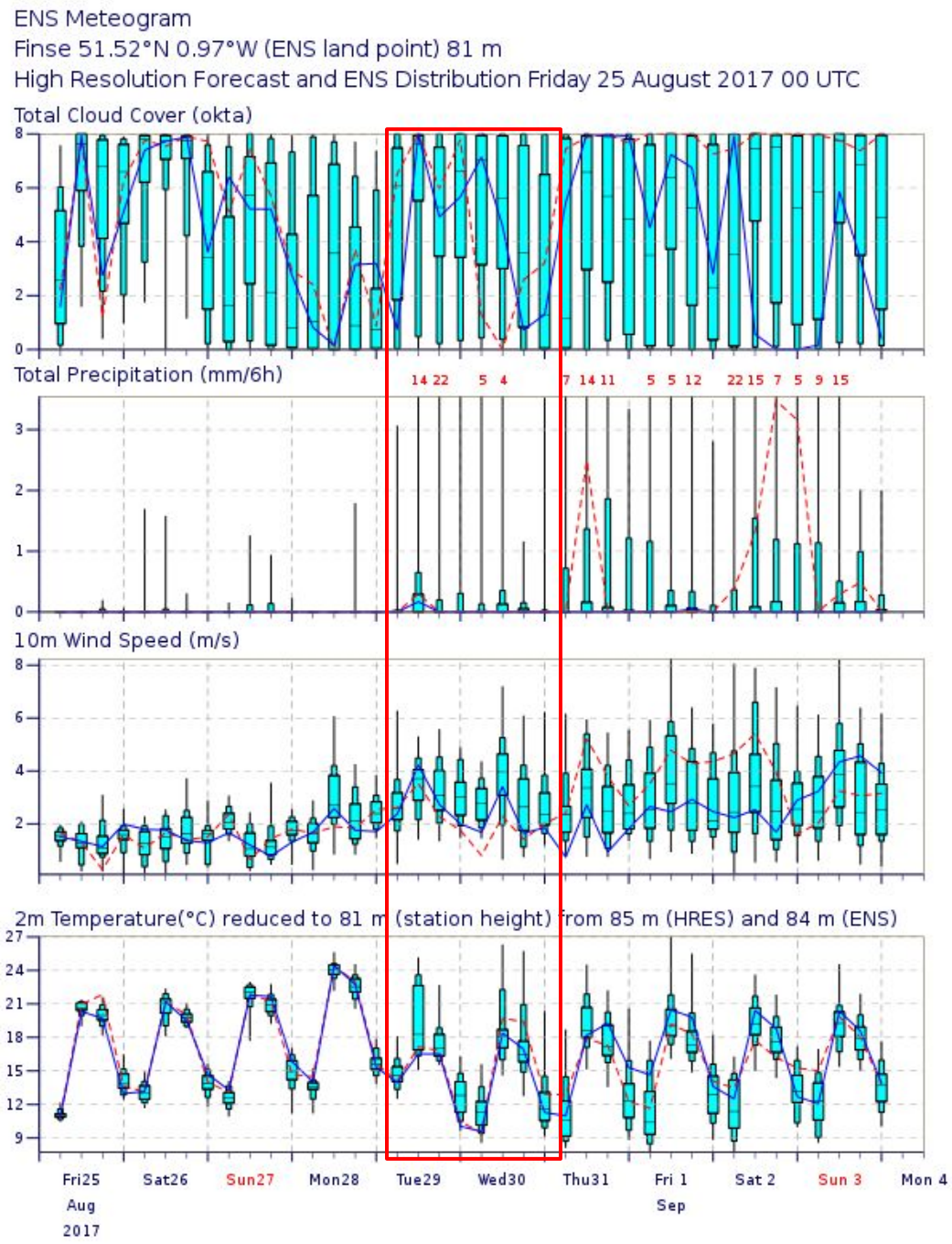
Forecast from yr.no - based on EC ENS

yr.no



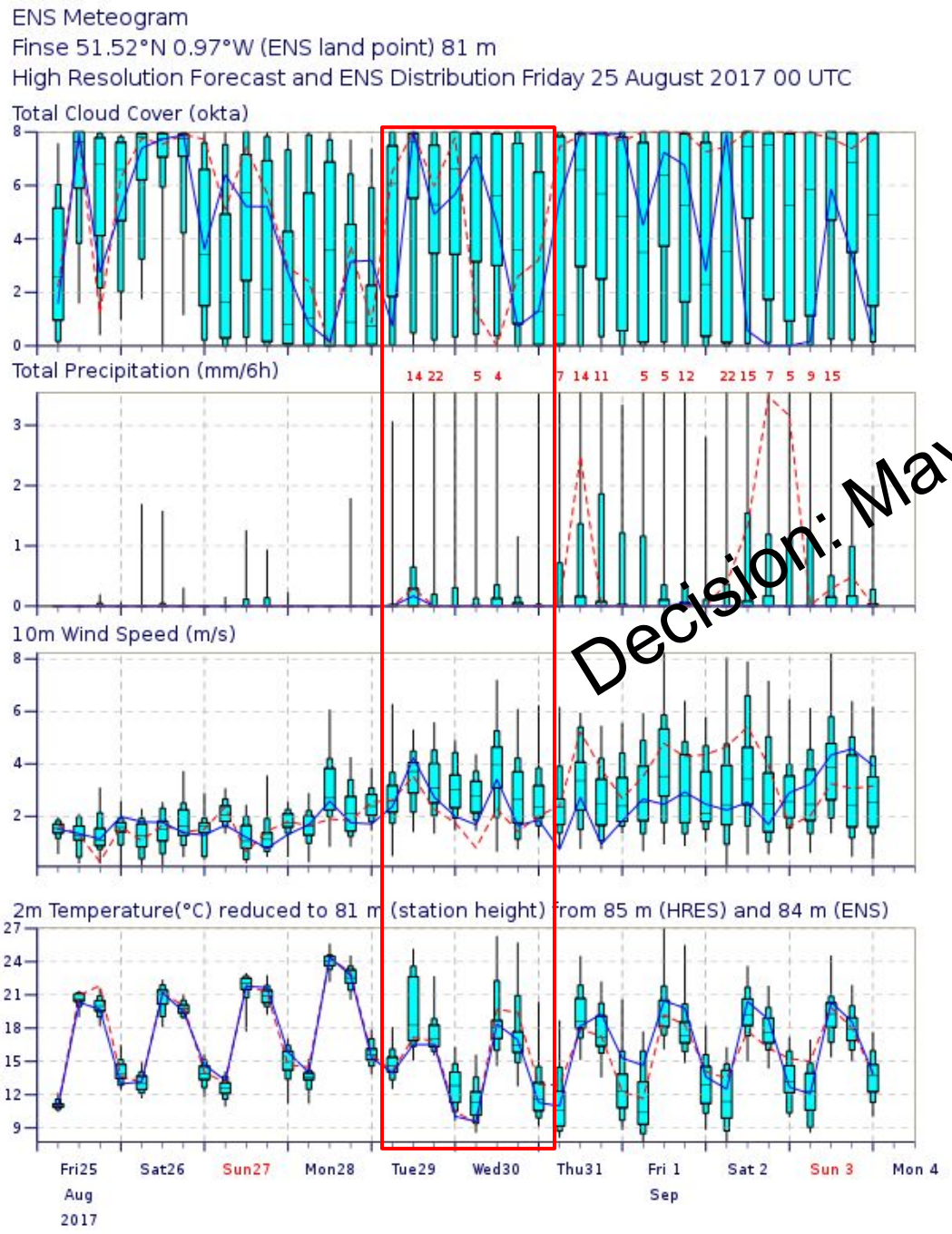
Forecast from yr.no - based on EC ENS

yr.no



Precipitation

ECMWF

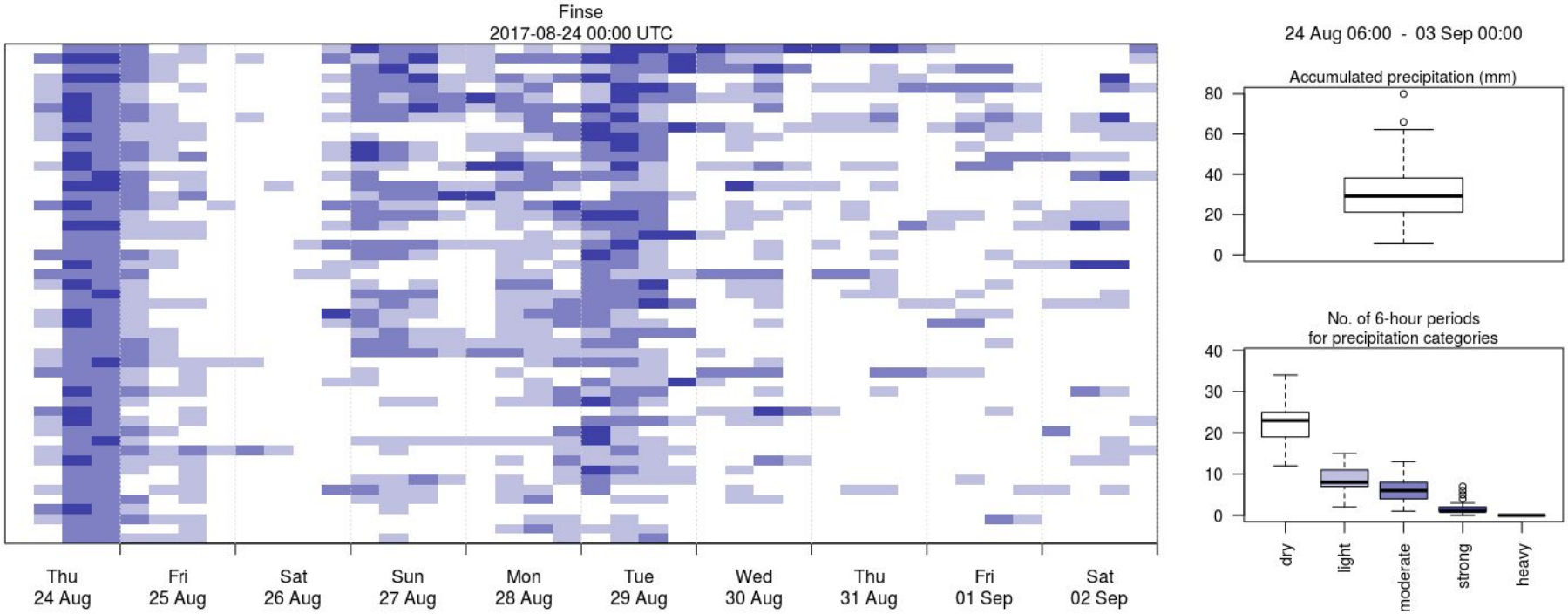


Decision: Maybe

Precipitation

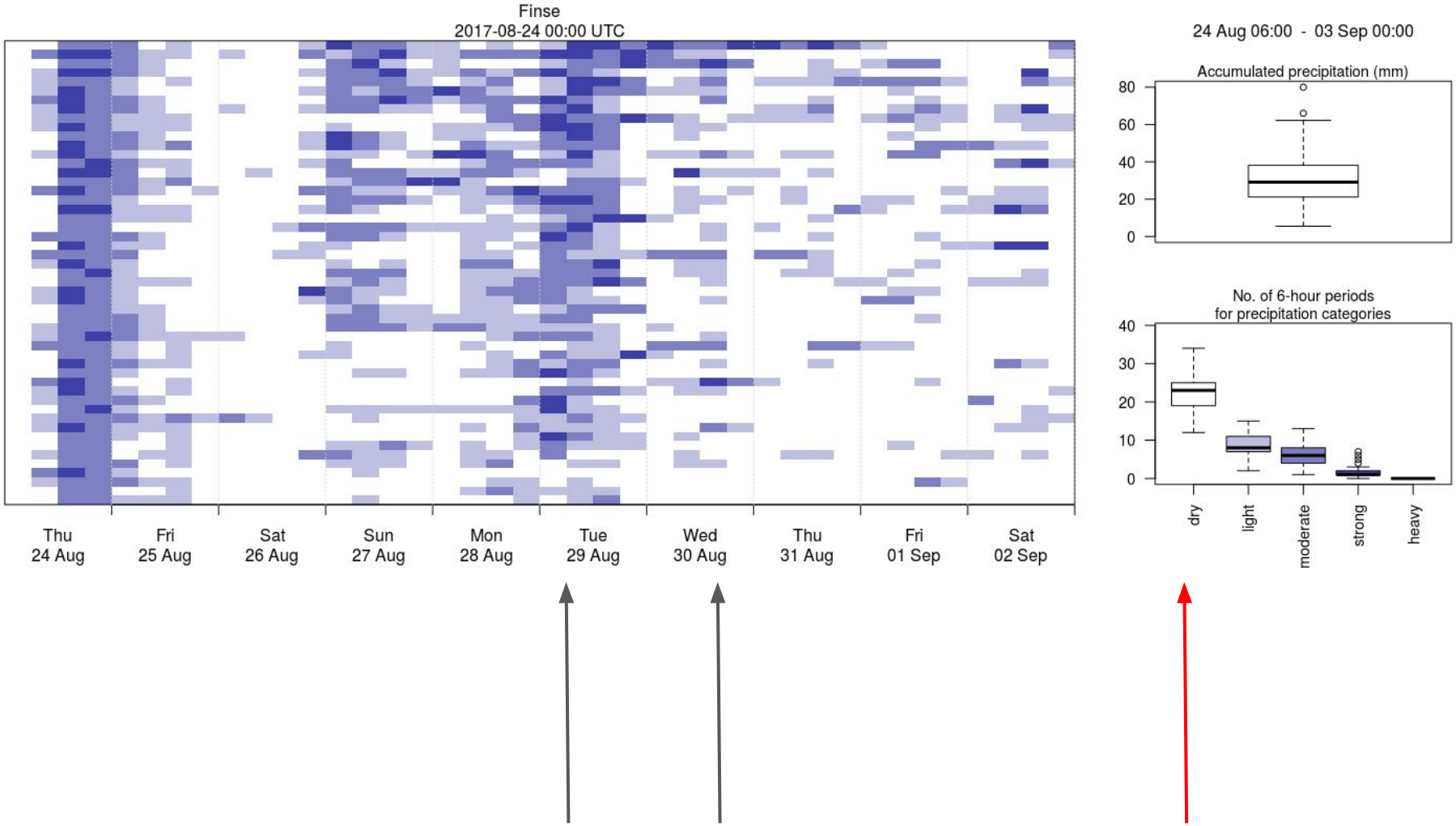
ECMWF

Precipitation meteogram with interactivity



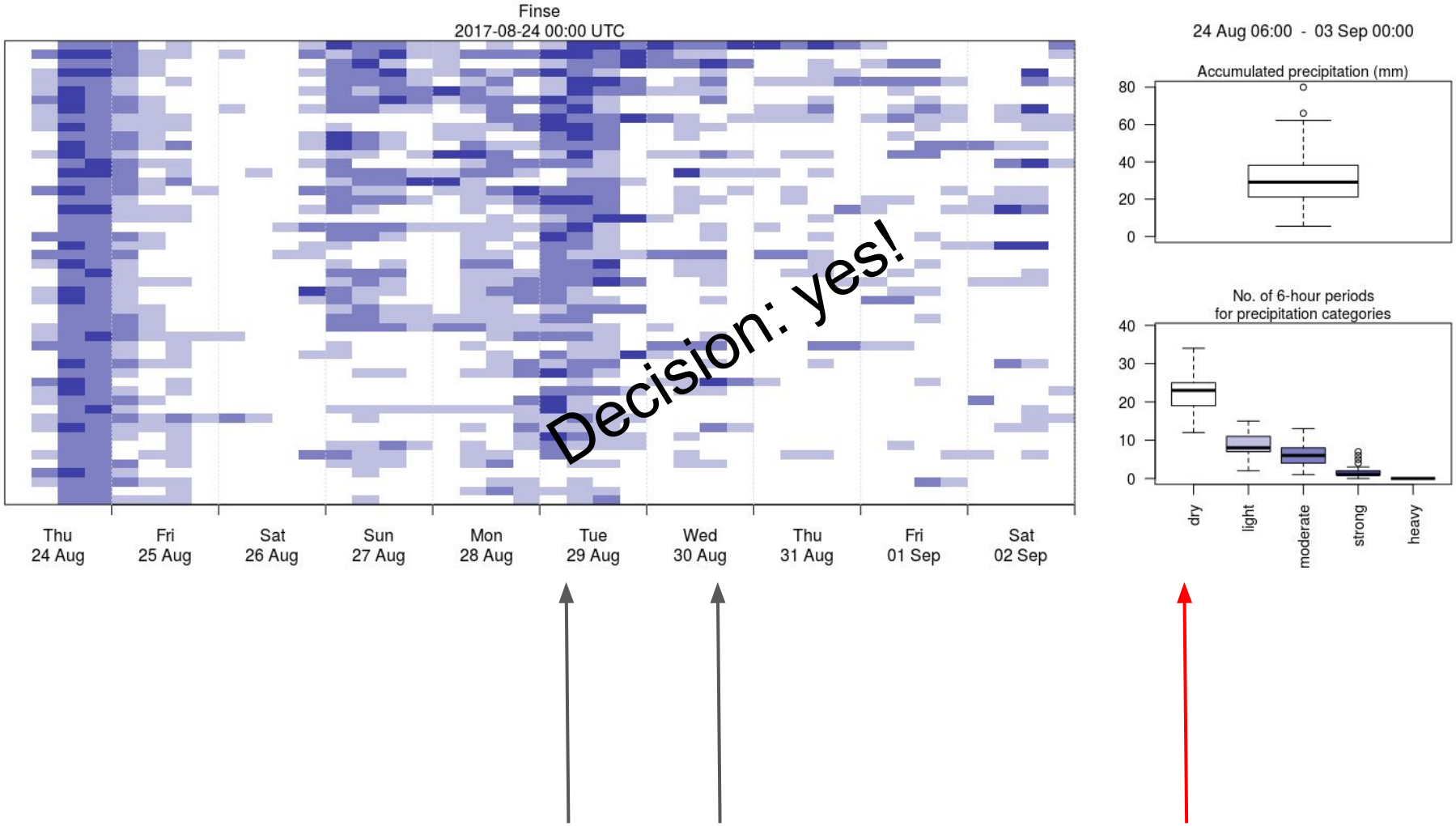
Courtesy John Bjørnar Bremnes, MET Norway

Precipitation meteogram with interactivity

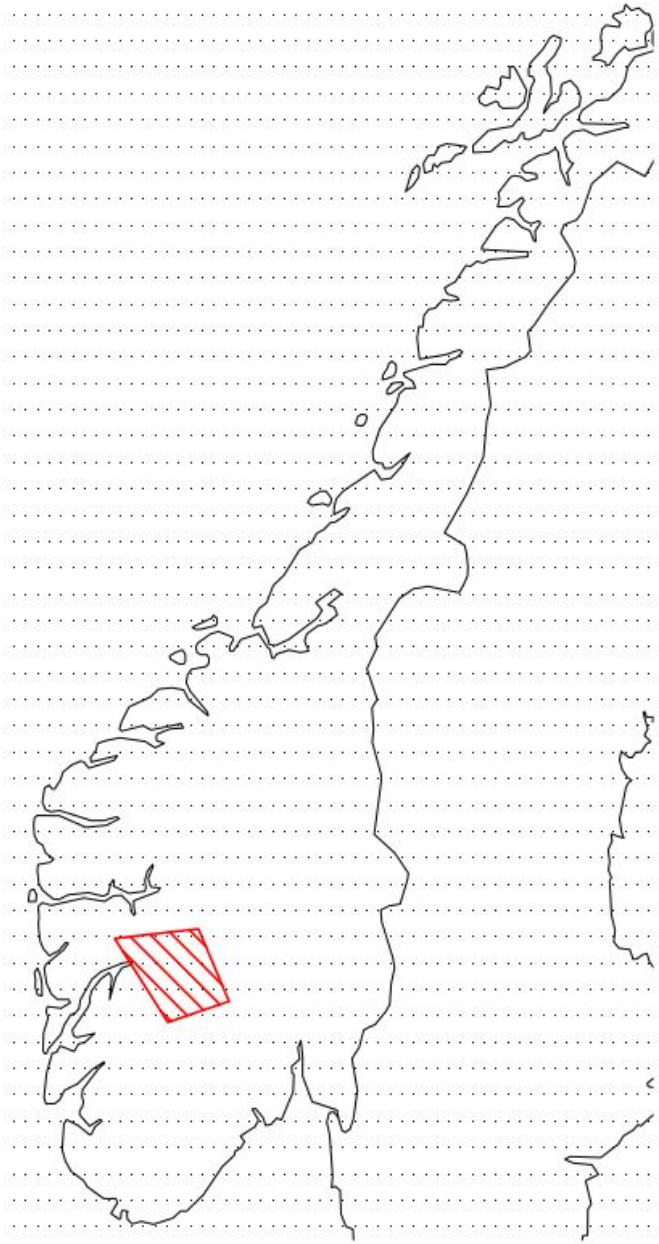


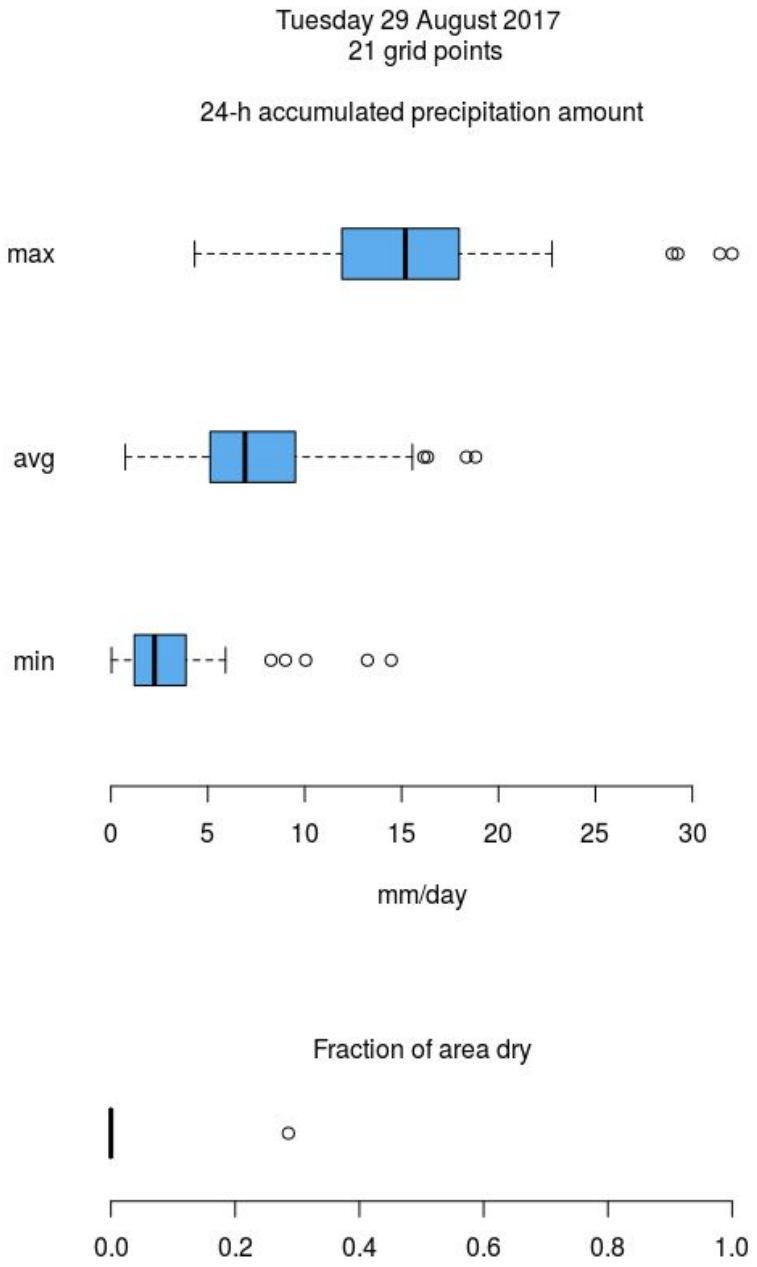
Courtesy John Bjørnar Bremnes, MET Norway

Precipitation meteogram with interactivity

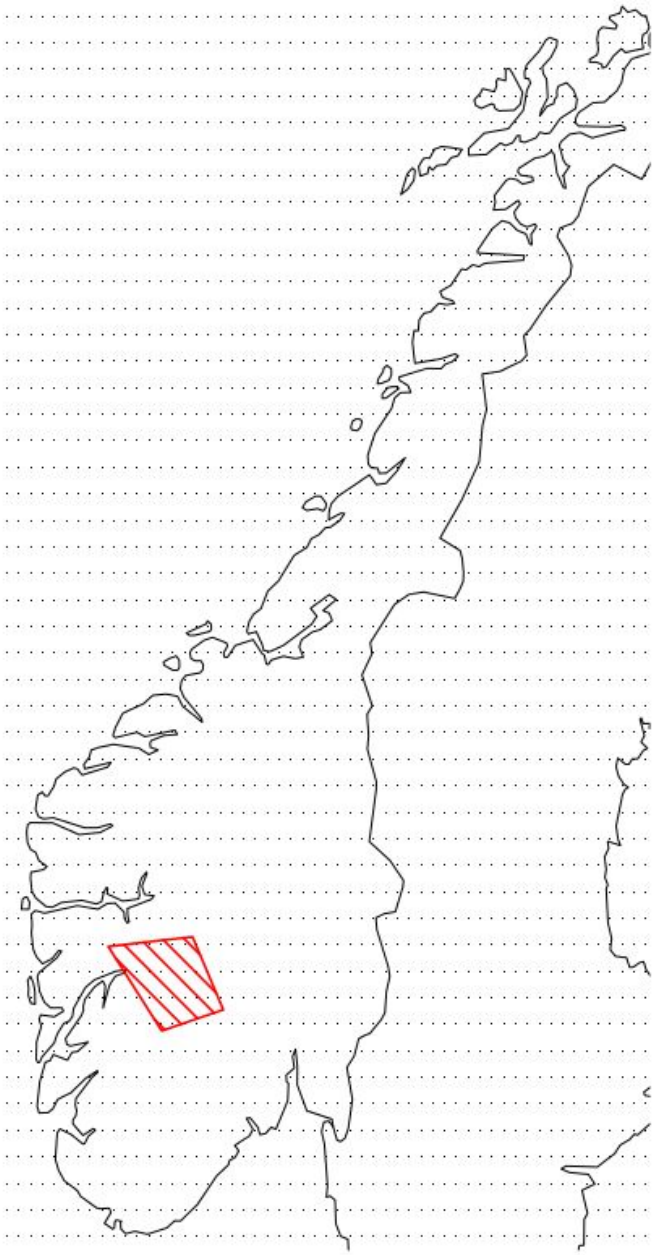


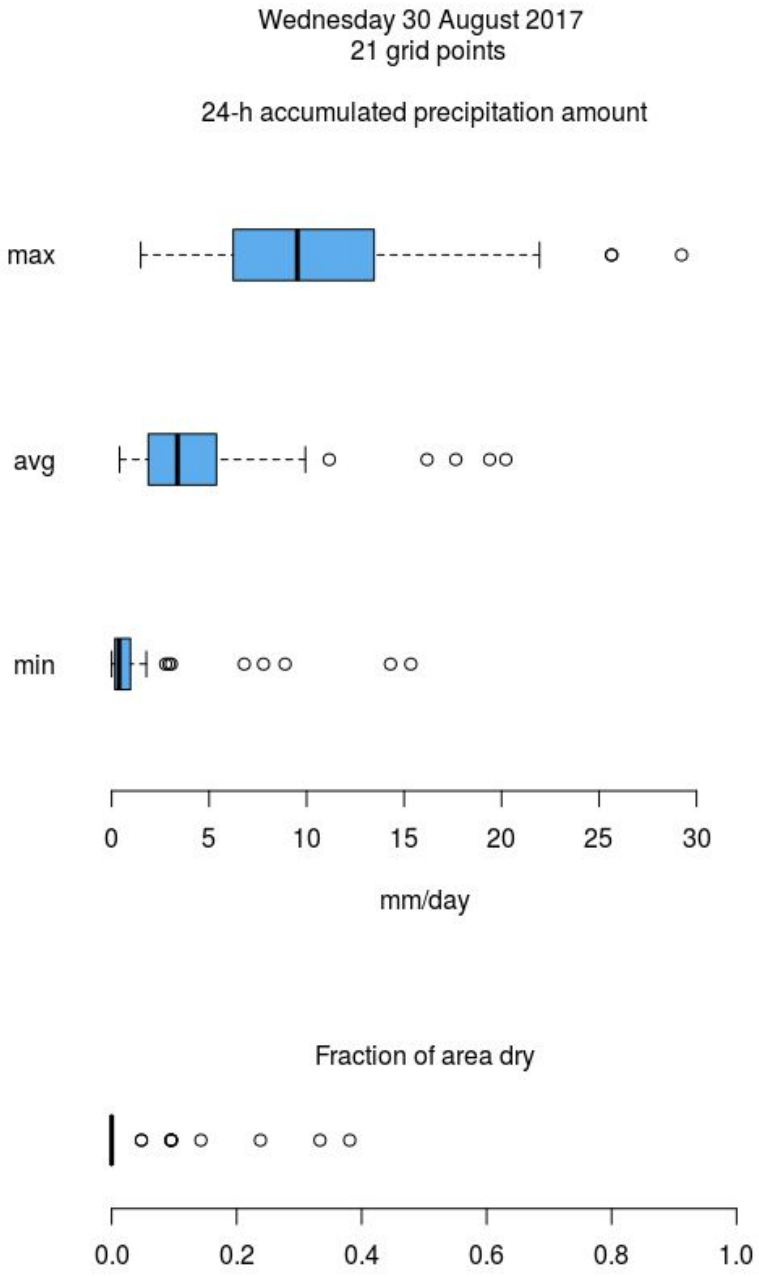
Courtesy John Bjørnar Bremnes, MET Norway





Courtesy John Bjørnar Bremnes, MET Norway





Courtesy John Bjørnar Bremnes, MET Norway

Very high-resolution, non-hydrostatic, short-range ensembles: Challenges

1. Predictability as a function of scale
2. Constructing the ensemble
3. Using the ensemble
4. **Even higher resolution?**

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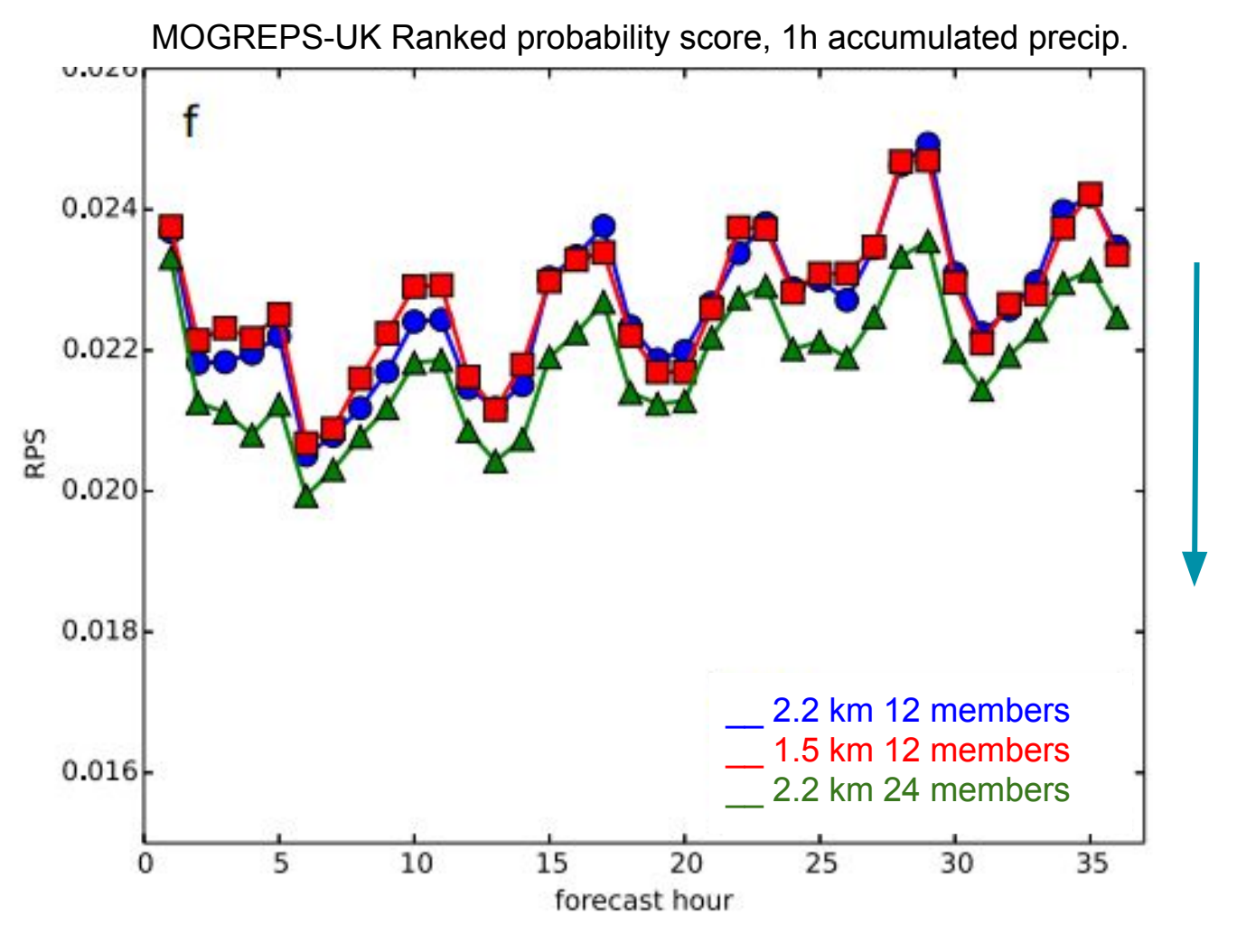
Higher resolution or more members?



MOGREPS- UK: Hagelin et al, 2017

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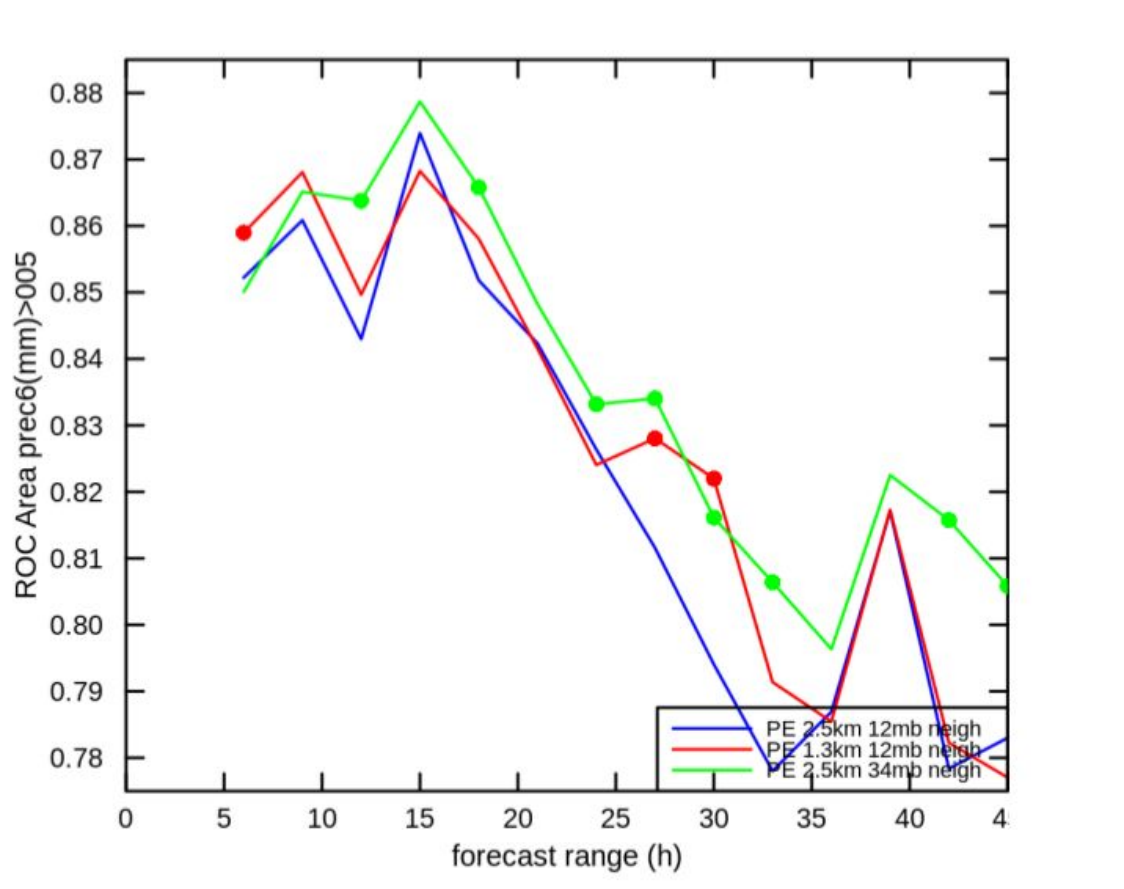
Higher resolution or more members?

Arome MF EPS Roc Area, 5mm/6h



___ 2.5 km 12 members
___ 1.3 km 12 members
___ 2.5 km 34 members

Raynaud and Bouttier, 2017

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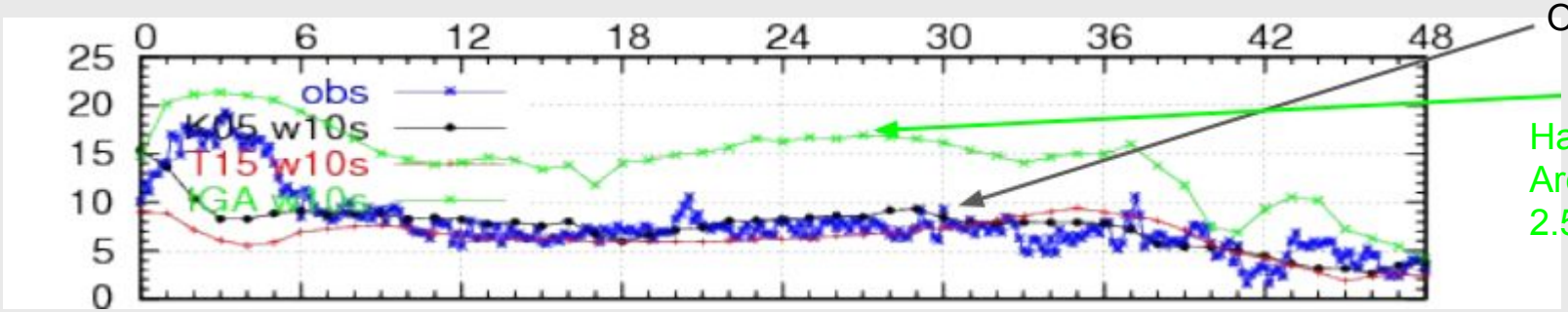
A case with apparent over-forecasting of wind in Greenland



Courtesy Xiaohua Yang, DMI

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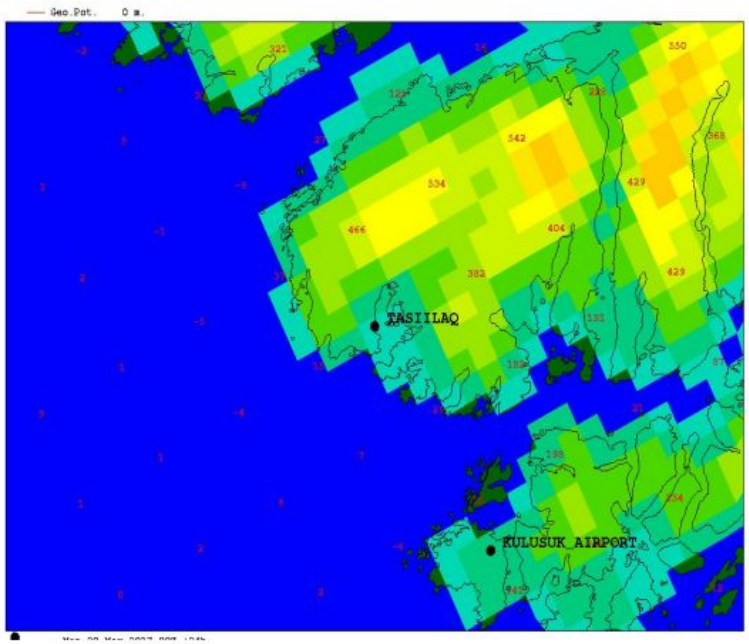
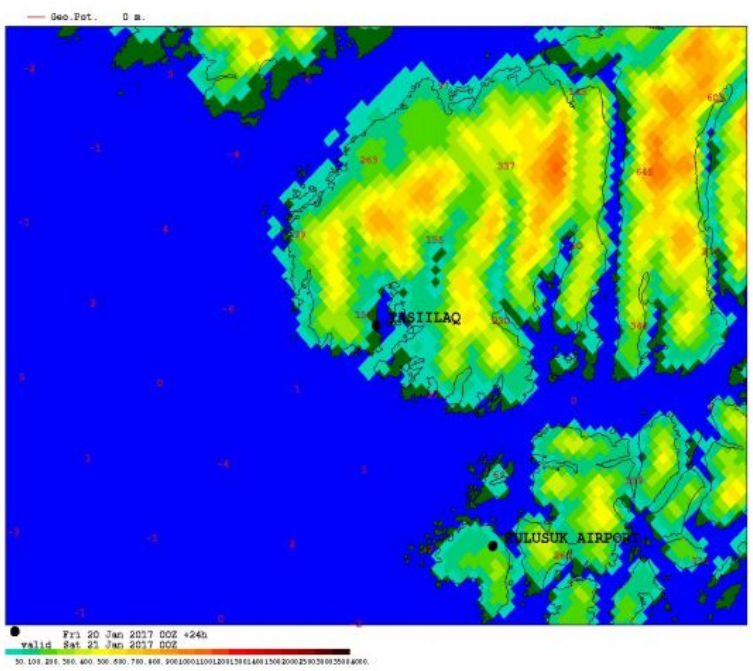
On 17/11 2016, while TASIILAQ wind measurement reads 6 m/s, it measured 15-22 m/s from the ship mast offshore the TASIILAQ harbour a few km away.

(Courtesy Ship Captain Eyðun Simonsen, M/V Arina Arctica)

2.5 km



750 m



Courtesy Xiaohua Yang, DMI

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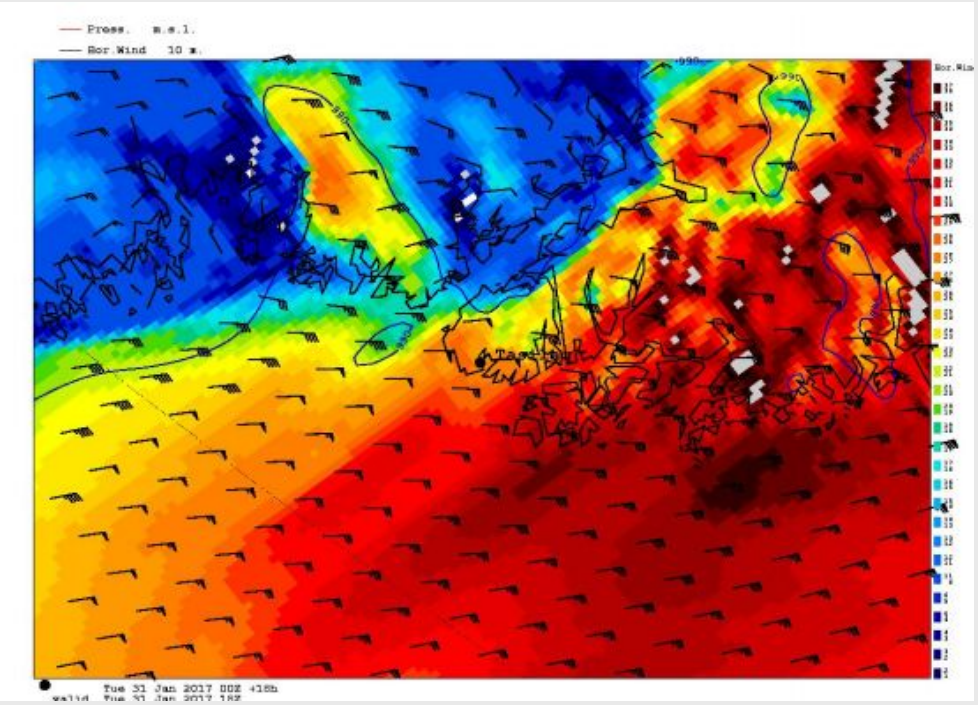

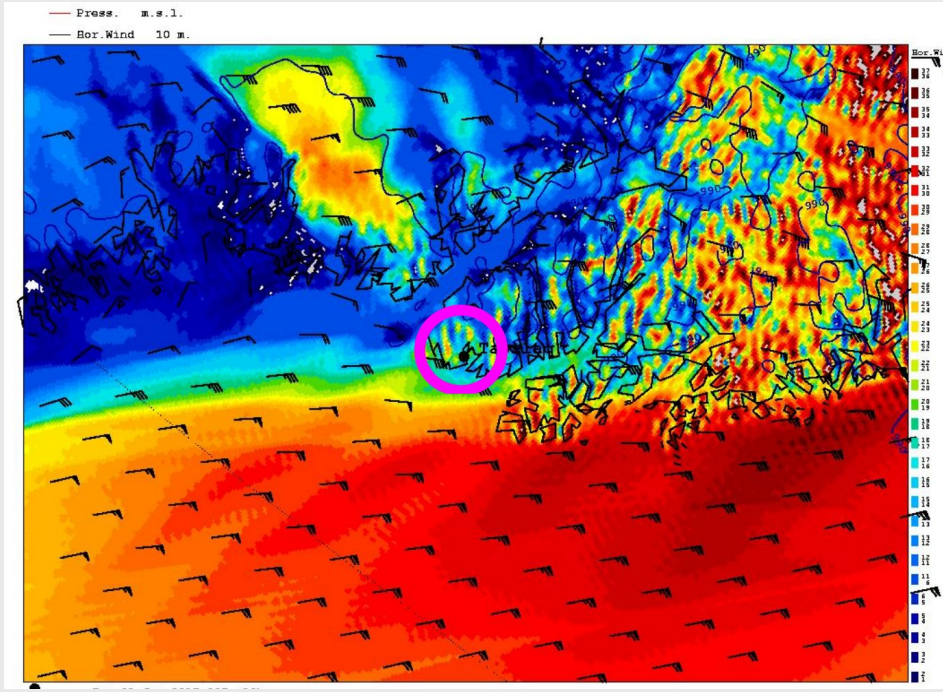

Courtesy Xiaohua Yang, DMI

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3. Using the ensemble
4. Even higher resolution?
5. **Post processing**

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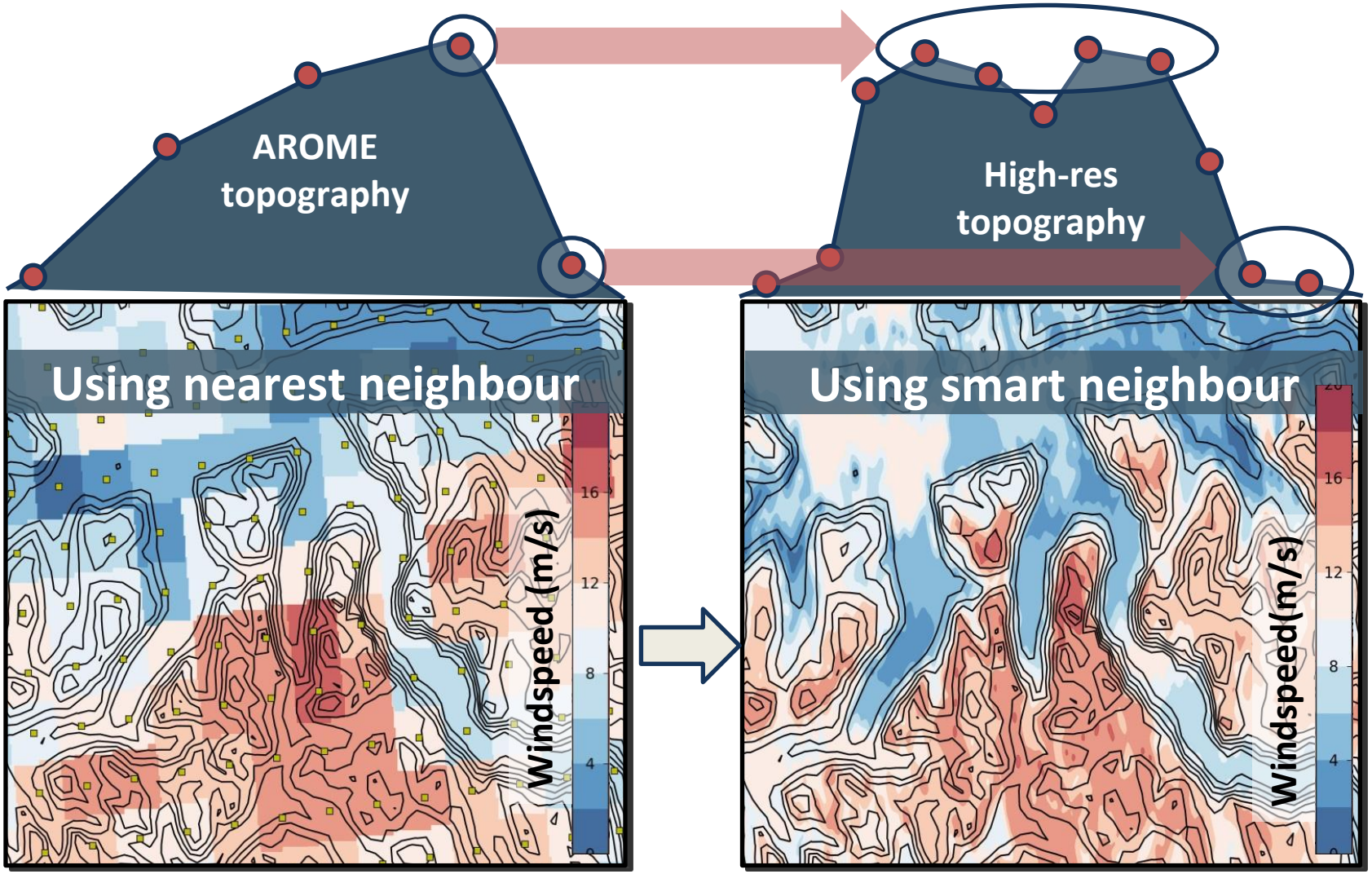
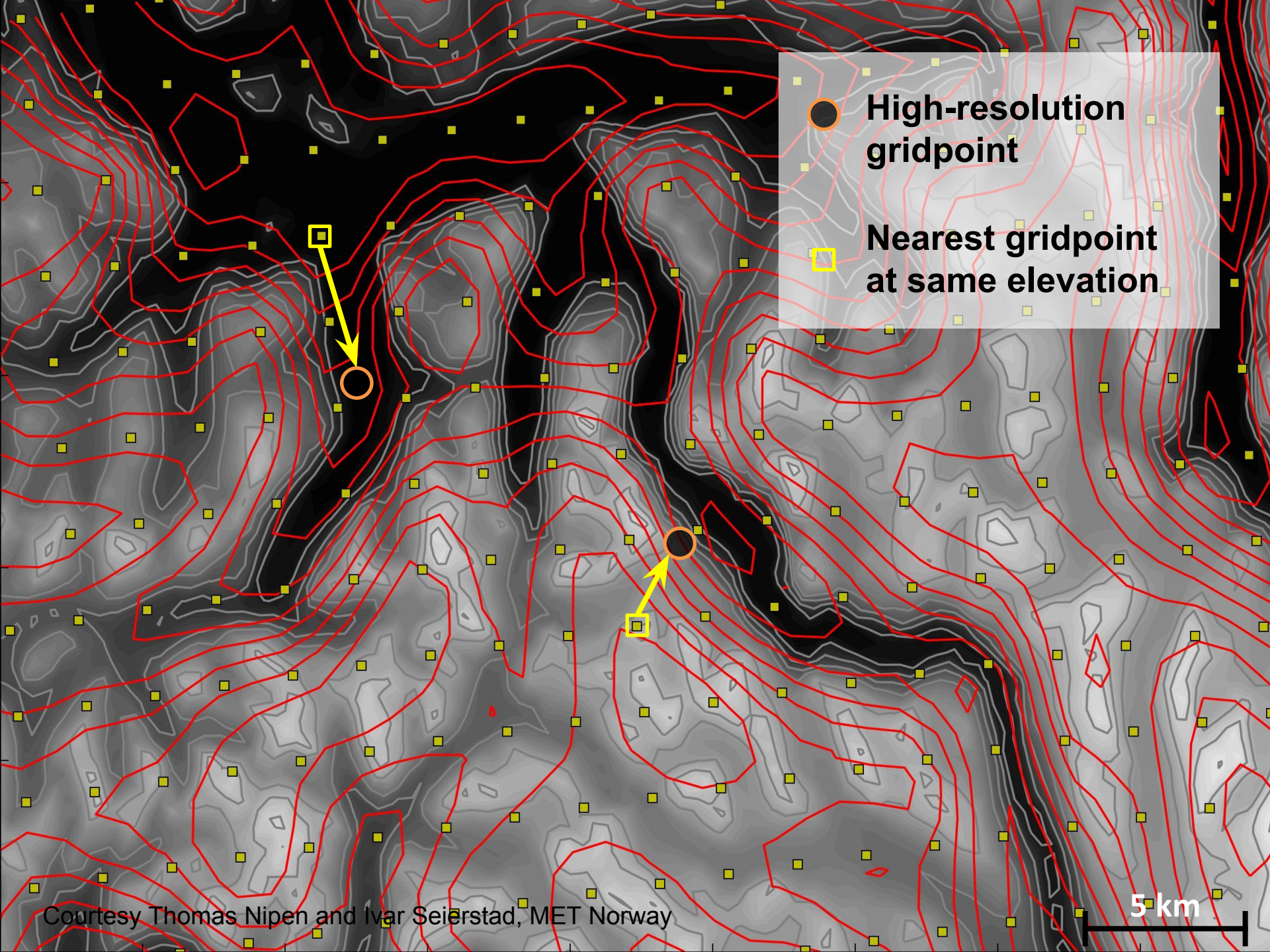
1: Smart neighbourhood

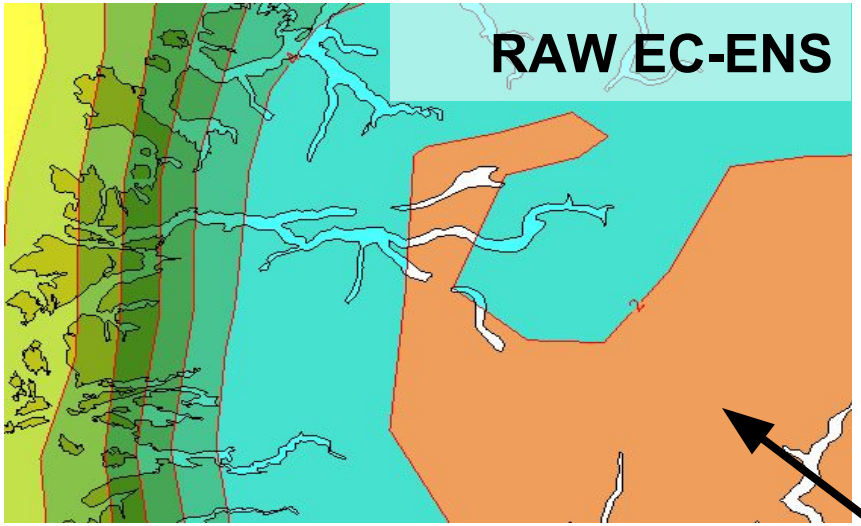
Method: Use nearest gridpoint at same elevation

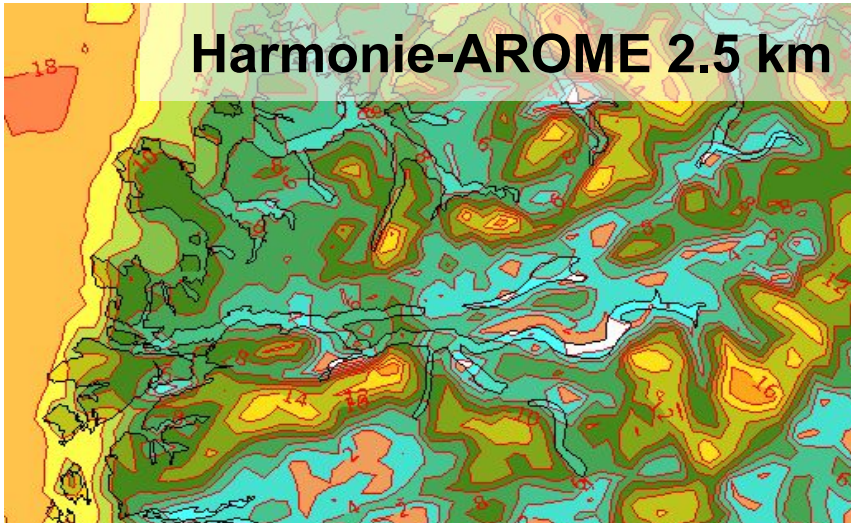


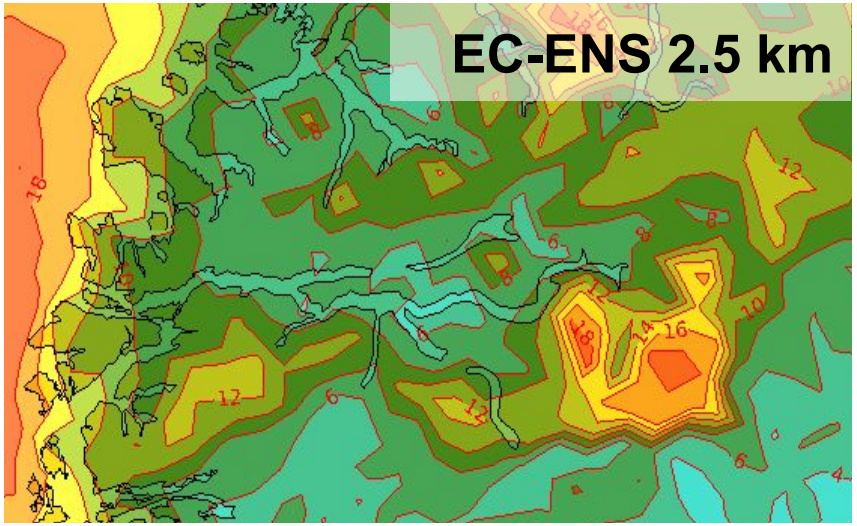
Courtesy Thomas Nipen and Ivar Seierstad, MET Norway


High-resolution gridpoint
Nearest gridpoint at same elevation
Courtesy Thomas Nipen and Ivar Seierstad, MET Norway
5 km

2: Downscaling using a high-resolution reference







Winds too weak in mountain areas

Method:

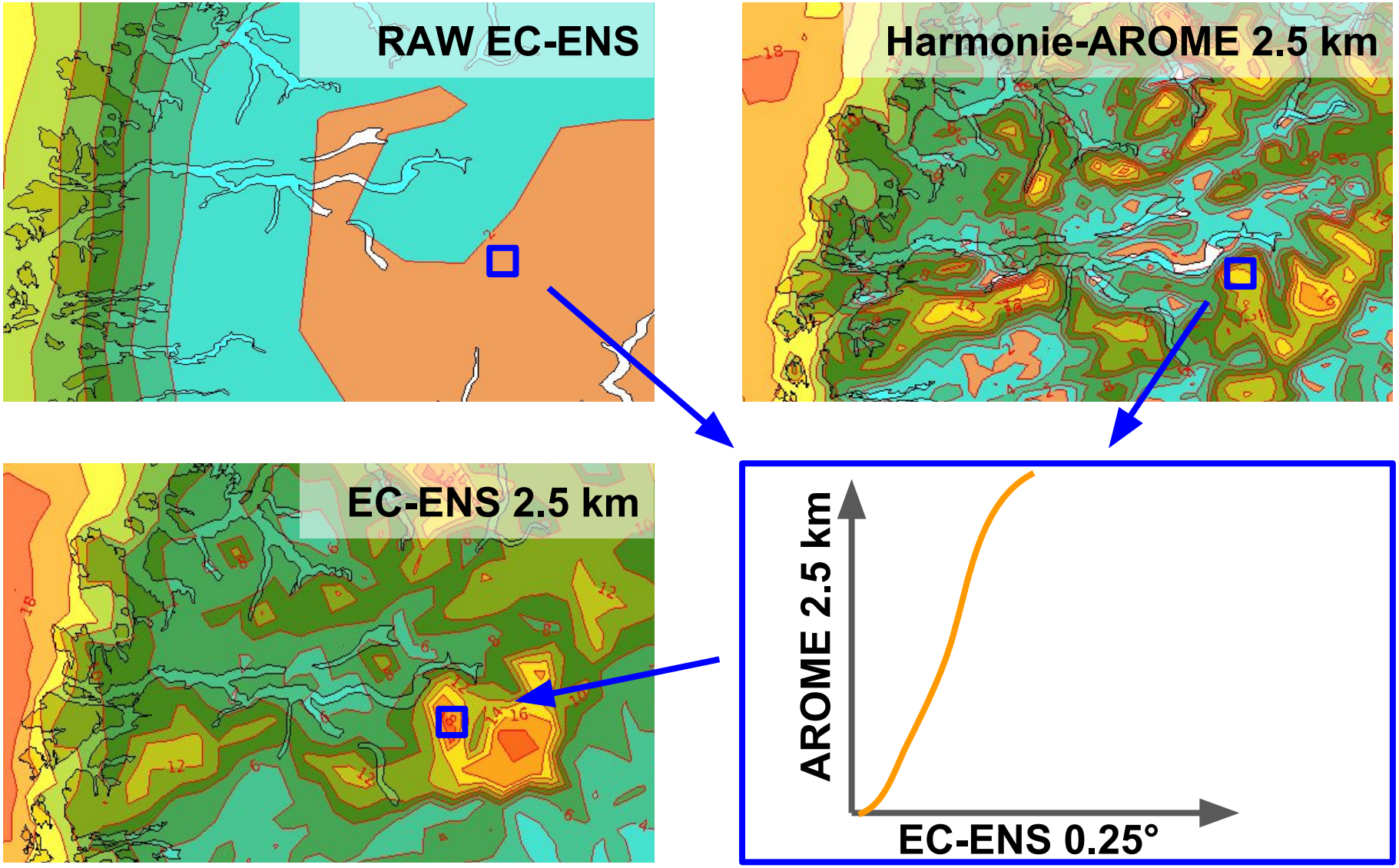
- Use historical AROME and EC
- Quantile mapping on each gridpoint

Results:

- Better forecast climatology

Courtesy Thomas Nipen and Ivar Seierstad, MET Norway

Downscaling using a high-resolution reference



Courtesy Thomas Nipen and Ivar Seierstad, MET Norway

Very high-resolution, non-hydrostatic, short-range ensembles

To summarize:
Ongoing work and open questions

Very high-resolution, non-hydrostatic, short-range ensembles

To summarize:
Ongoing work and open questions

- **Better error descriptions**
- **More members vs. higher resolution vs. size of area?**
- **How long forecasts are meaningful?**
- **Nowcasting**
- **Calibration and post processing**
- **Interactive use**

Very high-resolution, non-hydrostatic, short-range ensembles

To summarize:
Ongoing work and open questions

- **Better error descriptions**
- **More members vs. higher resolution vs. size of area?**
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- **Calibration and post processing**
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Thank you for your attention

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