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

Inger-Lise Frogner

ECMWF Annual Seminar 11 - 14 September 2017
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
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
Synoptic scale agreement between MEPS (2.5km) members

24hr accumulated precipitation and MSLP 27 August 2016

Control

Members 1 - 9

Courtesy Morten Køltzow, MET Norway
Zooming in on a catchment area

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

20-30 mm  Observed in Sogndal: 41.2 mm
30-40 mm  Forecasted in Sogndal: 24.9mm (control) - 42.5mm (member 3)
40-50 mm

Courtesy Morten Køltzow, MET Norway
Very high-resolution, non-hydrostatic, short-range ensembles: Challenges

1. Predictability as a function of scale
Classical predictability behaviour

Boer (2003)
Predictability as a function of scale

Spectra of mean-square 850hPa temperature errors

December 2002 – February 2003

$K^2$ vs Wavenumber

Courtesy: A. Simmons; ECMWF
Forecast lead time when Rank Probability Skill Score (RPSS) for EC ENS of Z500 < 0.3 (1994-2007)

Scale dependence of predictability for precipitation

Decorrelation scale between members: $\lambda_0$

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

Surcel, M., I. Zawadzki, and M.K. Yau, 2015
Very high-resolution, non-hydrostatic, short-range ensembles: Challenges

1. Predictability as a function of scale
2. Constructing the ensemble
An accurate analysis
Computationally fast and frequently updated
Short model spin-up
Accounting for model error
Accounting for surface uncertainties
The lateral boundaries

- - - No LBC pert.
- - - LBC pert.

**Summer**
Winter

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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*

<table>
<thead>
<tr>
<th>Hour</th>
<th>Analysis</th>
<th>IC perts</th>
<th>LBC</th>
<th>Stochastic Physics</th>
<th>Forecast</th>
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Lagged Ensemble Products 18M/6h with Neighbourhood Post-Processing (Possible 36M/12h for longer forecasts to T+120)

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Courtesy Ken Mylne
COMEPS - DMI

- base analysis time
- observation data window

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

Spread and skill 12h accumulated precipitation July 2017
Very high-resolution, non-hydrostatic, short-range ensembles: Challenges

1. Predictability as a function of scale
2. Constructing the ensemble
3. Using the ensemble
Probabilistic forecasts = Better decisions, right?
Example based on a talk by A. Singleton (MET Norway)
Deterministic forecast
12:00-13:00
Mostly sunny. Risk of local fog, mainly along the coast.

Deterministic forecast
12:00-13:00
“What does the probability forecast say?

Deterministic forecast
12:00-13:00
Probability of fog 10:00-11:00: 20%
Probability of fog 11:00-12:00: 20%
Probability of fog 12:00-13:00: 20%
Probability of fog 13:00-14:00: 20%
Probability of fog 14:00-15:00: 20%
Probability of fog 14:00-15:00: 20%

80% chance of no fog!
Member 1: fog 11:00 - 12:00

5 member ensemble
Member 2: fog 10:00 -11:00
Member 3: fog 14:00 - 15:00
Member 4: fog 12:00 -13:00
Member 5: fog 13:00 - 14:00
Probability of fog during the trip: 100%
80% chance of no fog!

Probability of fog

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

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

20%
40%
60%
80%
100%

100% chance of fog!

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

Good use of probabilistic forecasts

Courtesy: Andrew Singleton
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- a threshold
- a time window
- a spatial area
- any other conditions

Good use of probabilistic forecasts

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- 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
## Long term forecast for

**Finse, Ulvik (Hordaland)**

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Forecast from yr.no - based on EC ENS
Forecast from yr.no - based on EC ENS

Decision: No!
ENS Meteogram
Finse 51.52°N 0.97°W (ENS land point) 81 m
High Resolution Forecast and ENS Distribution Friday 25 August 2017 00 UTC

Total Cloud Cover (okta)

Total Precipitation (mm/h)

10m Wind Speed (m/s)

2m Temperature(°C) reduced to 81 m (station height) from 85 m (HRES) and 84 m (ENS)

Precipitation

ECMWF
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Decision: Maybe

Precipitation
Precipitation meteogram with interactivity

Finse
2017-08-24 00:00 UTC

24 Aug 06:00 - 03 Sep 00:00

Accumulated precipitation (mm)

No. of 6-hour periods for precipitation categories

Courtesy John Bjørnar Bremnes, MET Norway
Precipitation meteogram with interactivity
Precipitation meteogram with interactivity

Decision: yes!

Courtesy John Bjørnar Bremnes, MET Norway
Wednesday 30 August 2017
21 grid points

24-h accumulated precipitation amount

max

avg

min

mm/day

Fraction of area dry

 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?
Higher resolution or more members?

MOGREPS-UK: Hagelin et al, 2017

MOGREPS-UK Ranked probability score, 1h accumulated precip.
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
A case with apparent over-forecasting of wind in Greenland

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

(Courtesy Ship Captain Eyðun Simonsen, M/V Arina Arctica)
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?
5. Post processing
1: Smart neighbourhood

Method: Use nearest gridpoint at same elevation

Courtesy Thomas Nipen and Ivar Seierstad, MET Norway
2: Downscaling using a high-resolution reference

**Method:**
- Use historical AROME and EC
- Quantile mapping on each gridpoint

**Results:**
- Better forecast climatology

Winds too weak in mountain areas

Courtesy Thomas Nipen and Ivar Seierstad, MET Norway
Downscaling using a high-resolution reference

RAW EC-ENS

Harmonie-AROME 2.5 km

EC-ENS 2.5 km

AROME 2.5 km

EC-ENS 0.25°

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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Thank you for your attention


