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FINNISH METEOROLOGICAL INSTITUTE

(Energia)sään epävarmuuden mallintaminen

Modelling of (energy) weather uncertainty

Project: Improving the value of variable and uncertain power generation in energy systems (VaGe)

Funding: Academy of Finland, New Energy Programme, 2014 – 2018

ACADEMY OF FINLAND

Sami Niemelä, Karoliina Hämäläinen, Janne Kauhanen, Pirkka Ollinaho, Juha Kilpinen and Anders Lindfors

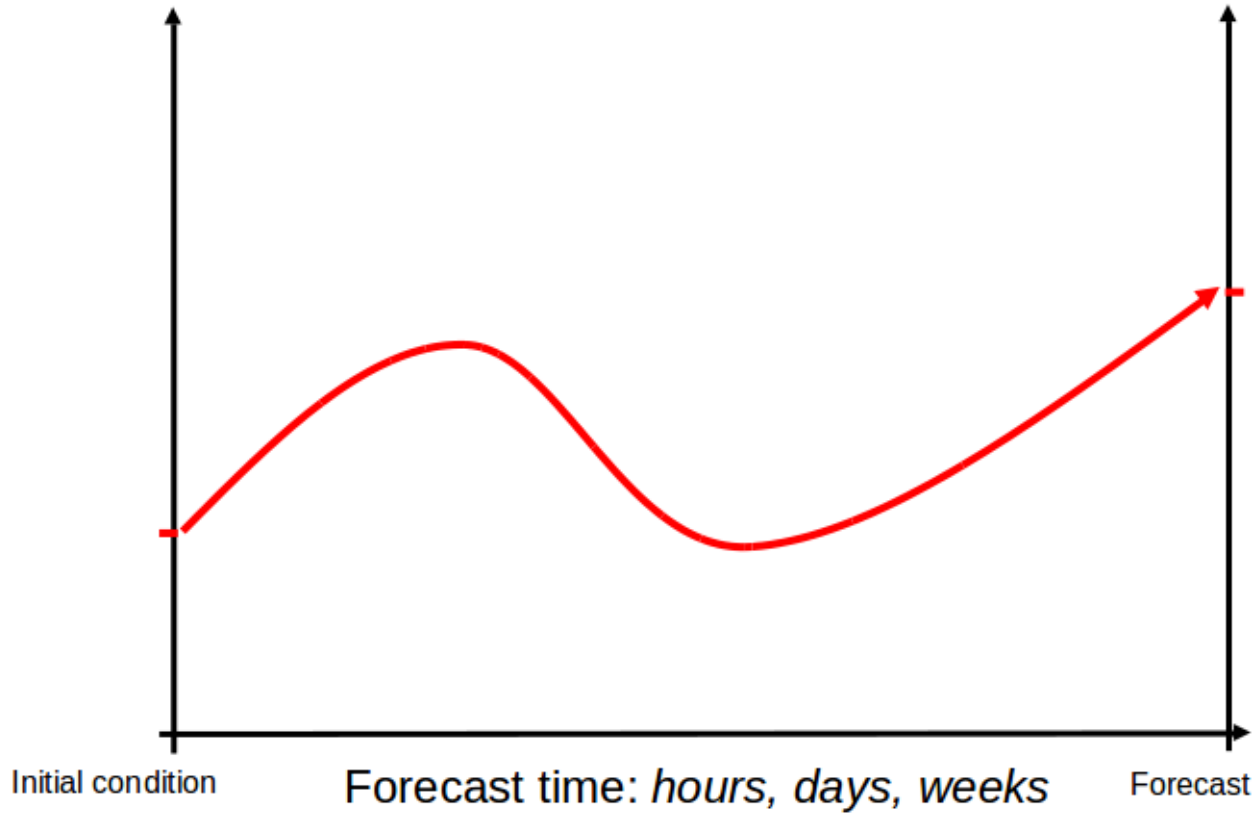
What is forecast uncertainty?

How to evaluate forecast uncertainty?

The concept of probabilistic weather forecasting

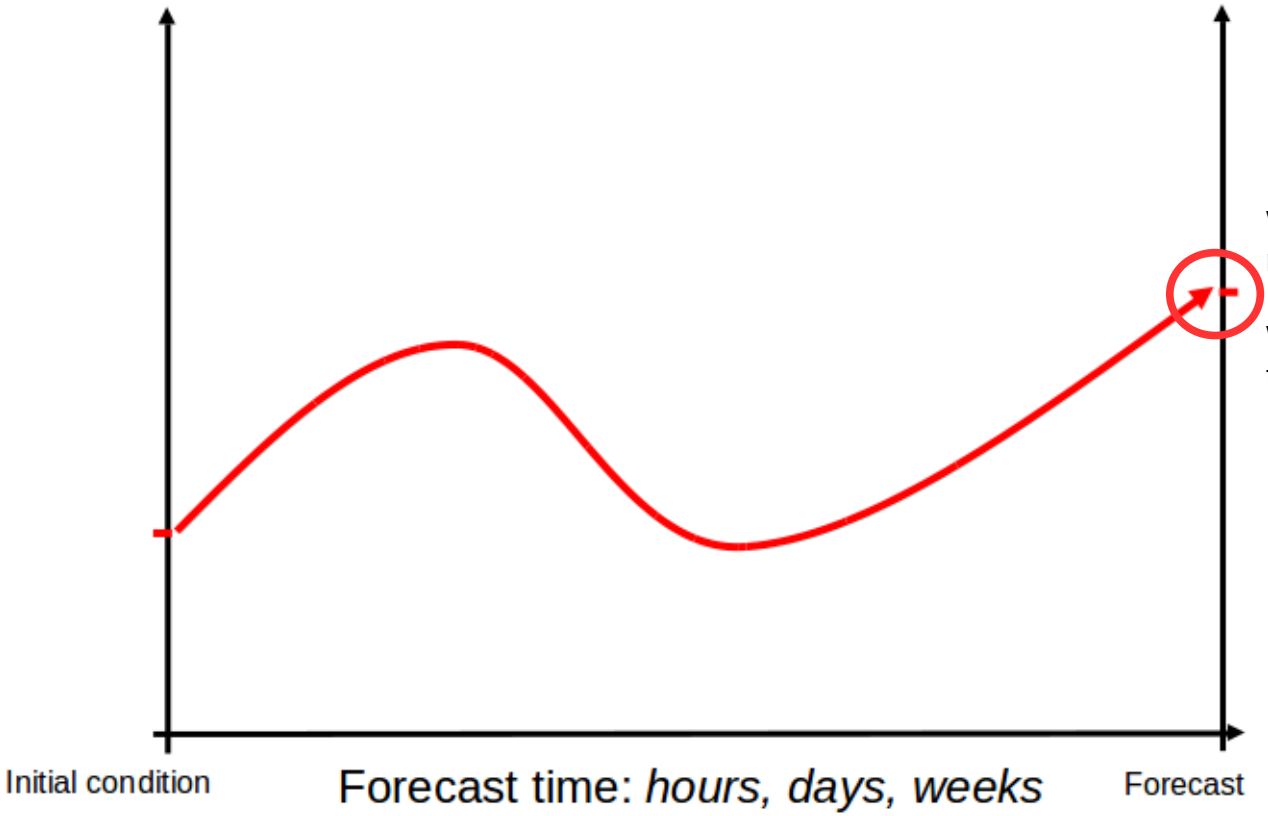
Probabilistic forecasting – concept

Deterministic forecast



Probabilistic forecasting – concept

Deterministic forecast



What is the uncertainty related to this forecast?

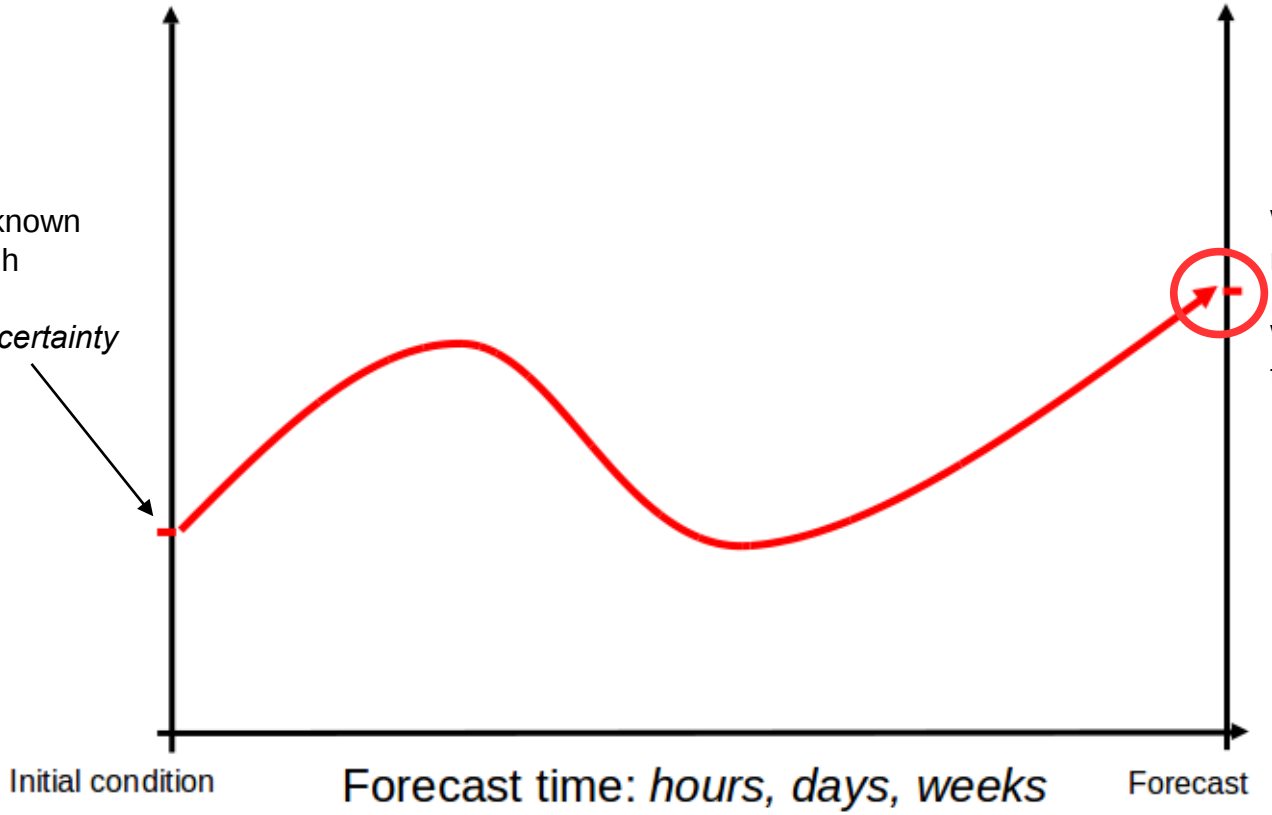
What are the ingredients of the forecast uncertainty?

Probabilistic forecasting – concept

Deterministic forecast

Current state of atmosphere not known accurately enough

→ *Initial state uncertainty*



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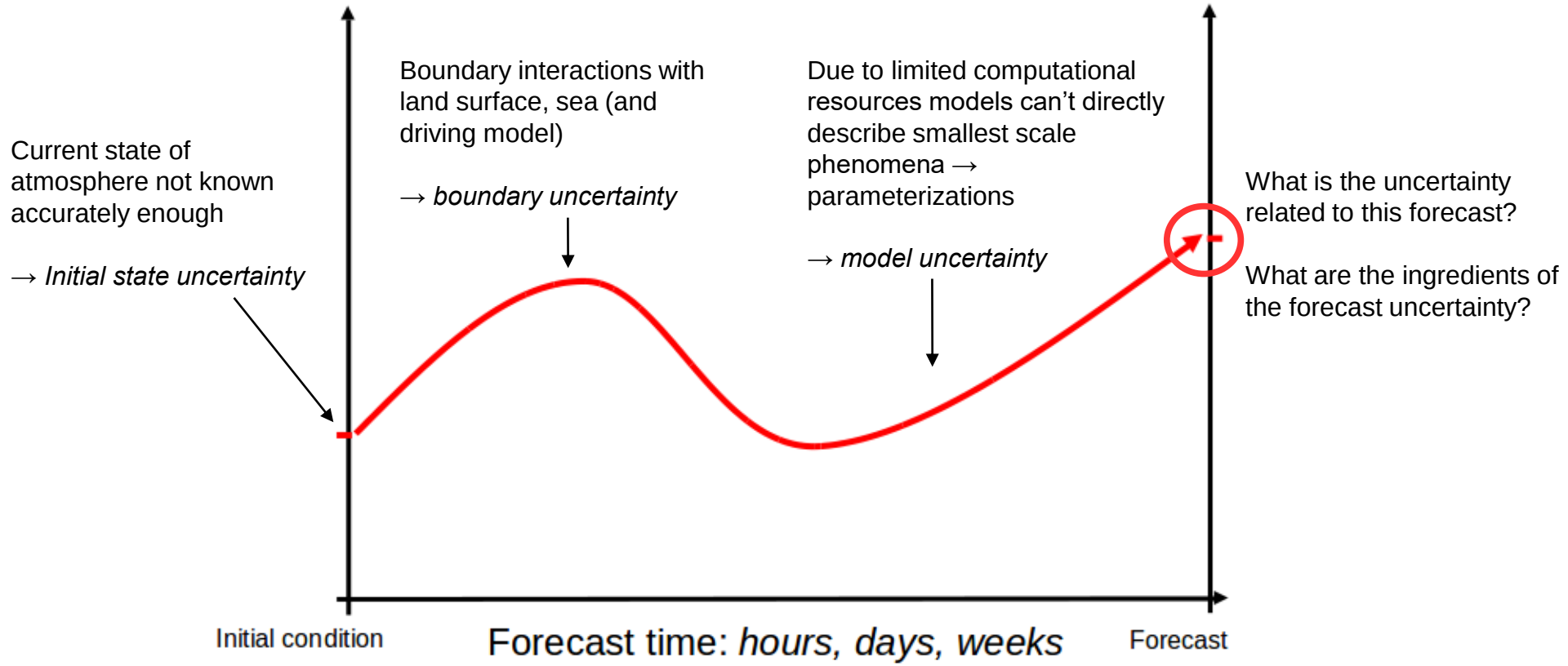
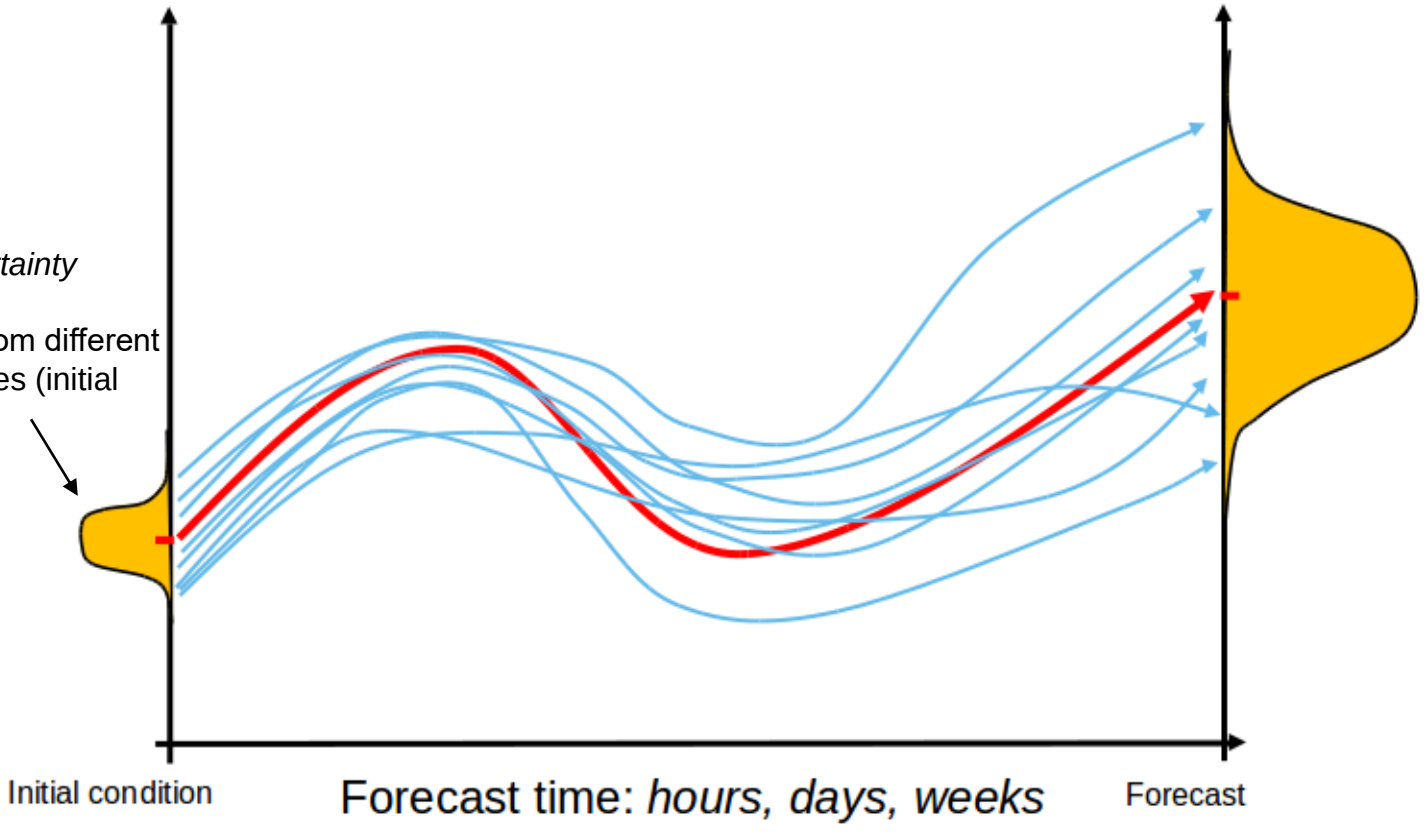


Probabilistic forecasting – concept

Ensemble forecast

Initial state uncertainty

→ Start model from different atmospheric states (initial perturbations)



Probabilistic forecasting – concept

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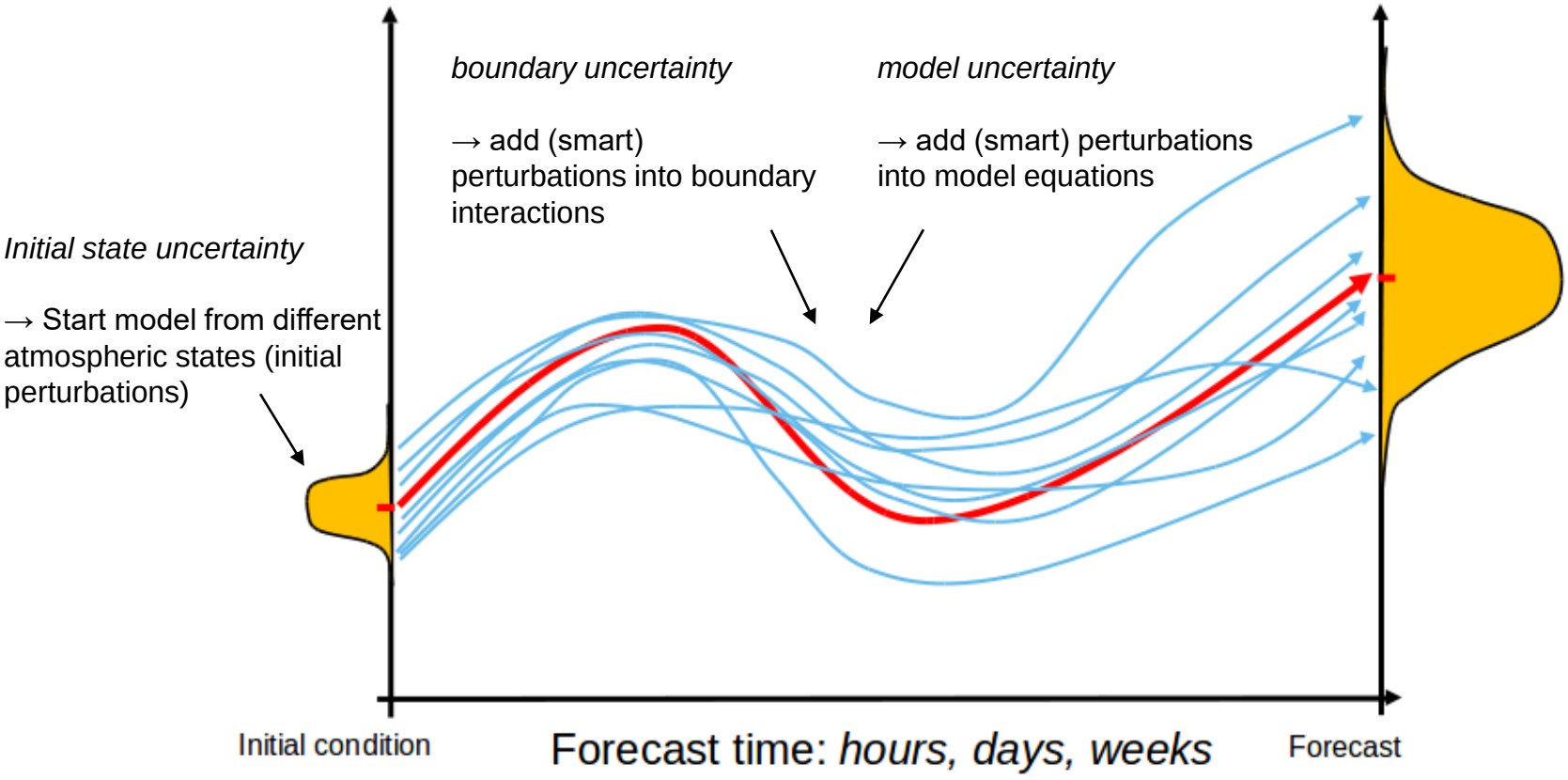

Probabilistic forecasting – concept

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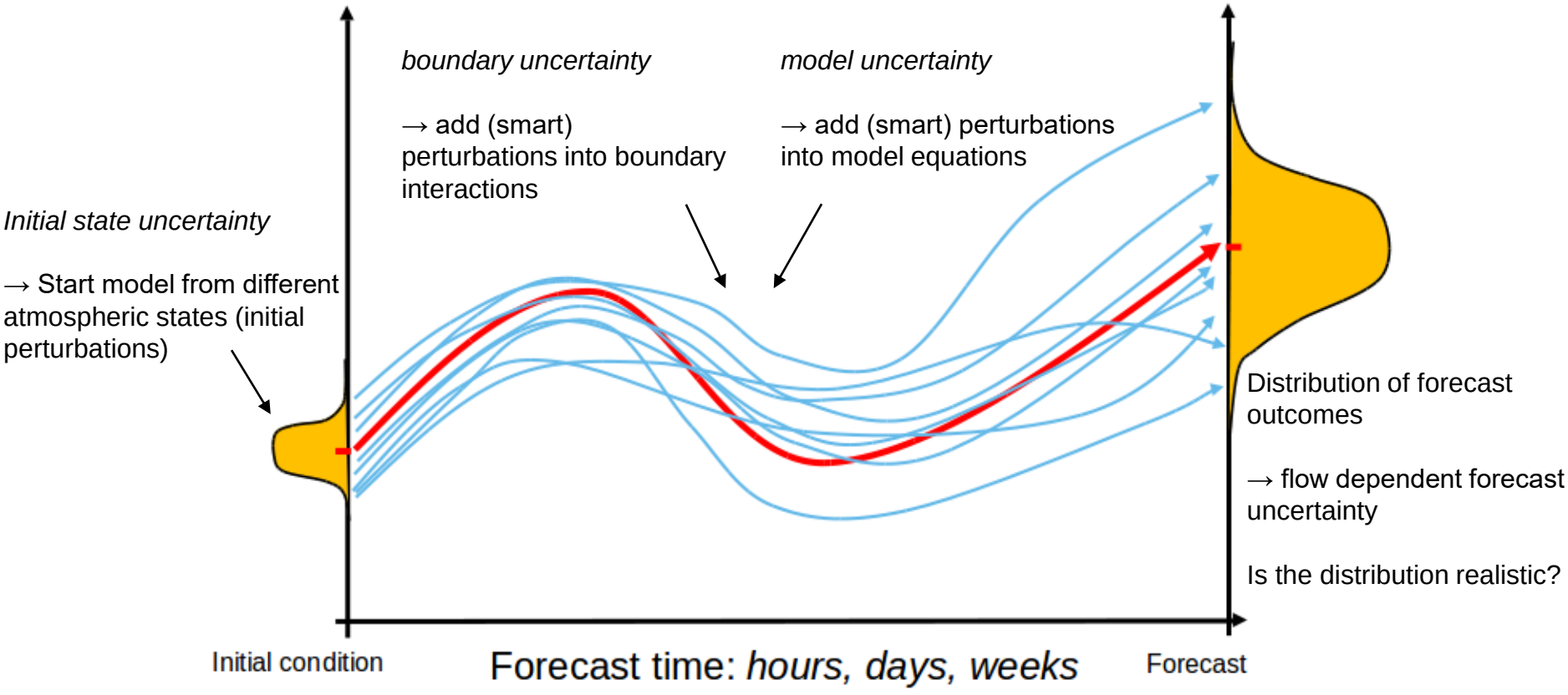

Probabilistic forecasting – concept

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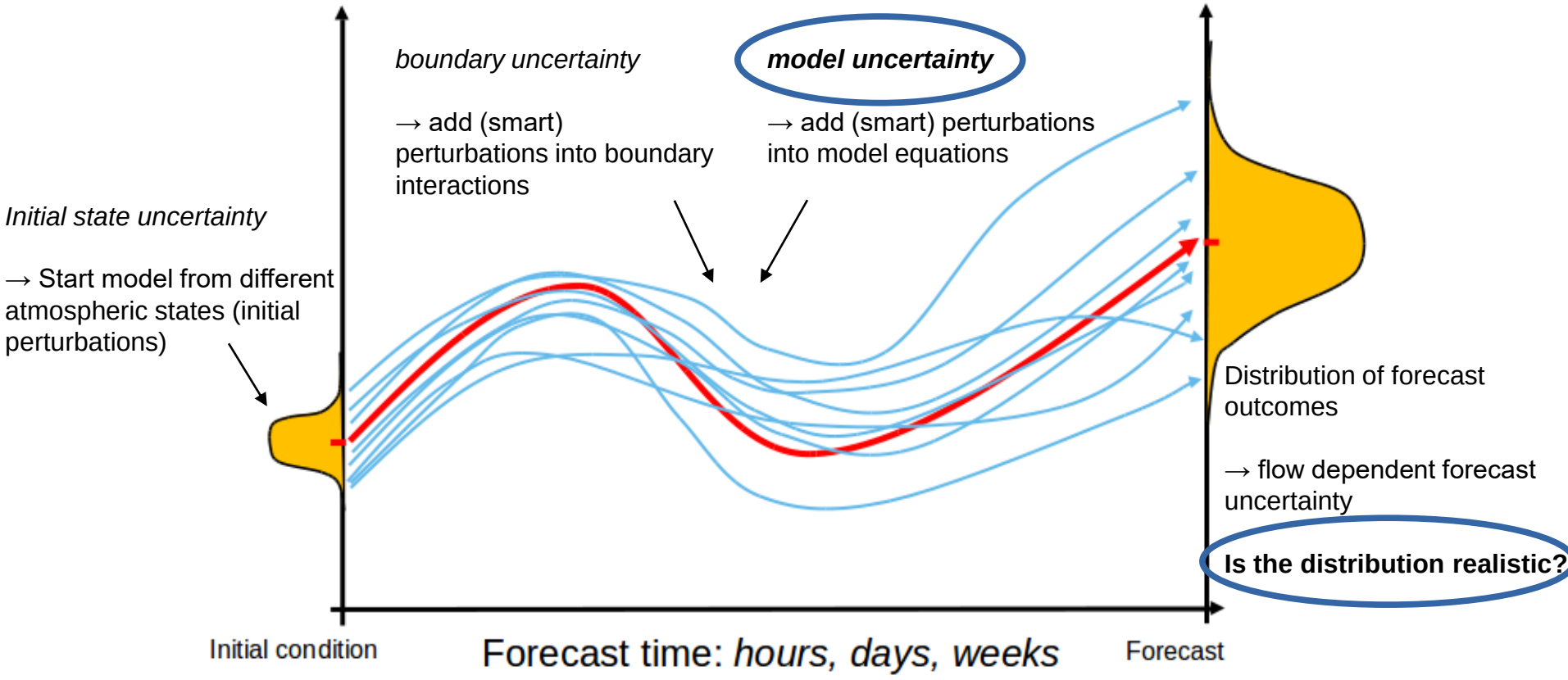
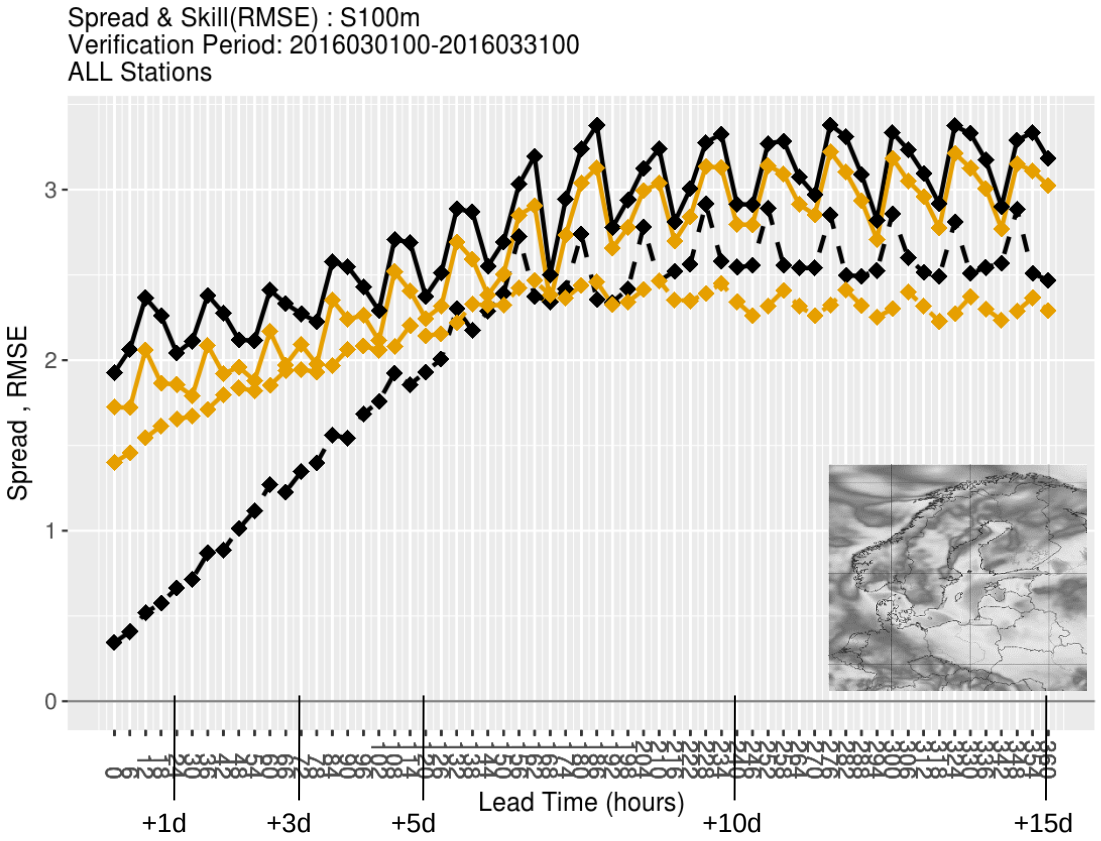


Is the uncertainty estimate realistic?

Statistical calibration of global ensemble forecast: ECMWF ENS

Statistical calibration of ensemble forecast



- Global ensemble (ECMWF)
  - 18km resolution
  - +15d forecast
  - 50+1 ensemble members
- Wind speed at 100m height
→ relevant for wind energy
- Calibration method: non-Gaussian regression
- Observations: Wind profiles from FMI's LIDAR network (5)
- Period: March 2016

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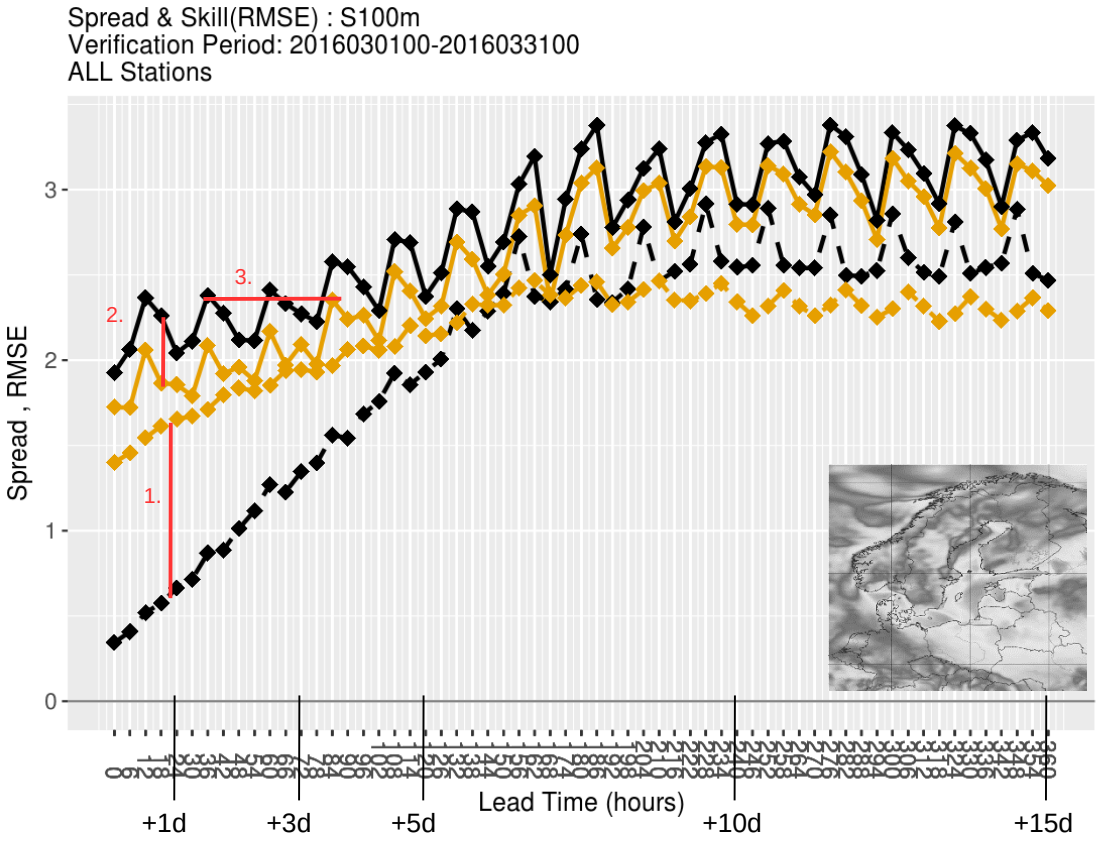
Statistical calibration of ensemble forecast



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1. Calibration increases and improves the spread during the first 5 days.

2. Calibration reduces RMS-error.

3. Calibration improves the predictability by 2 days (in this case).

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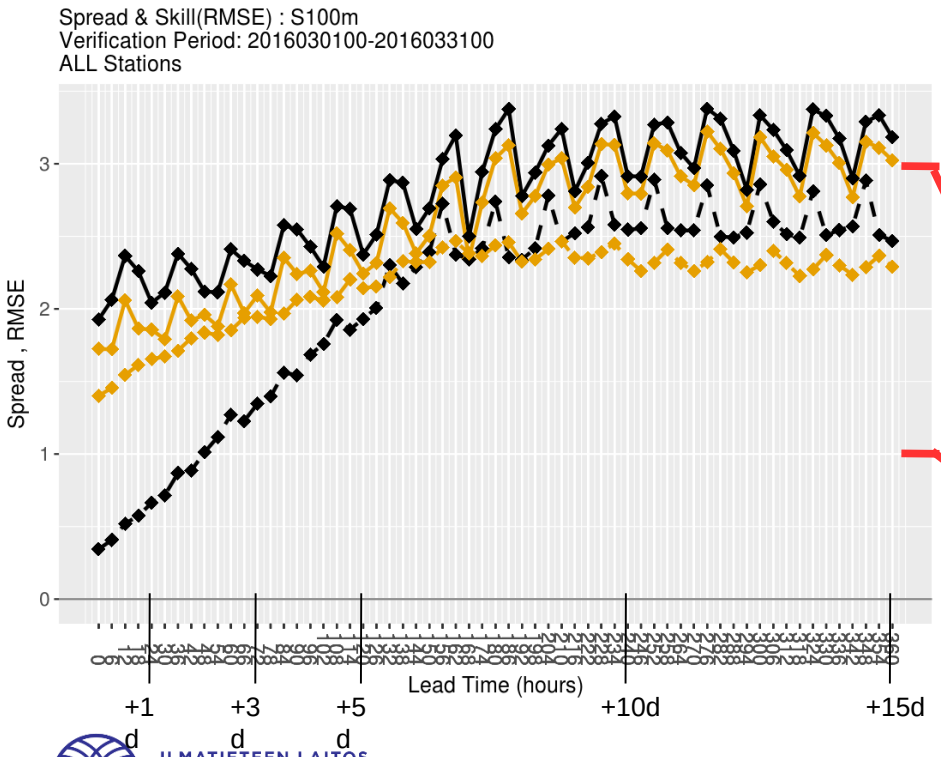
Statistical calibration of ensemble forecast

- Observations are critical in calibration

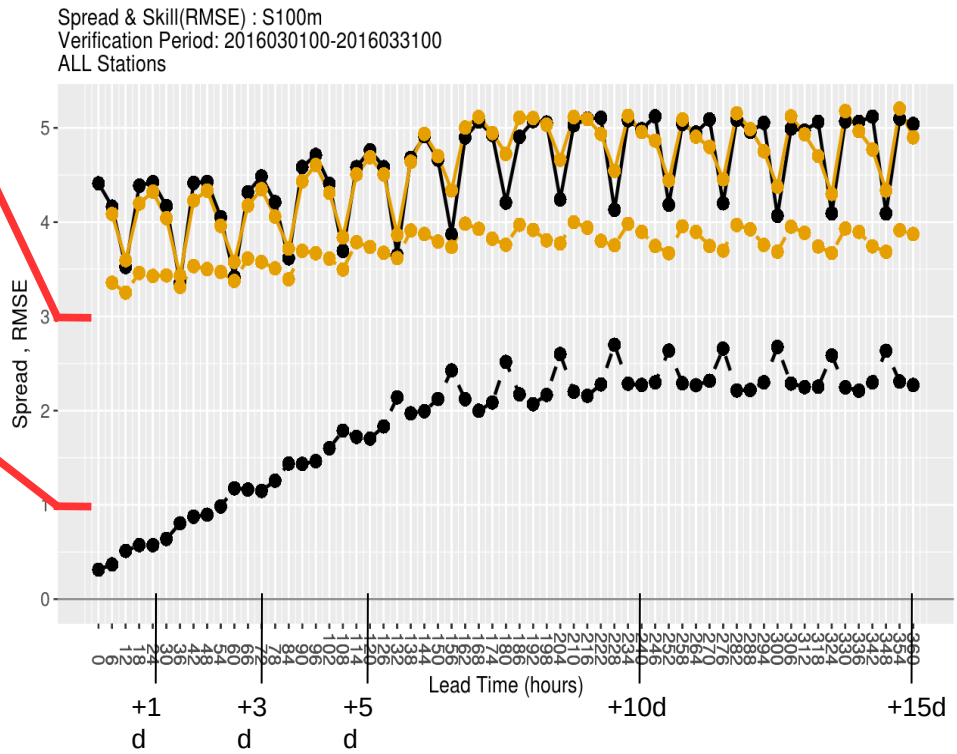
→wind speed observations at 100m are sparse

→Calibration test: LIDAR vs. RADAR

Wind speed obs from LIDAR



Wind speed obs from RADAR



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Hämäläinen et al., EMS annual meeting, Vol 18, 2018

Model uncertainty?

Stochastic physical parameterizations in high resolution ensemble prediction system: HarmonEPS

Stochastic physics: Stochastic Perturbation of Parameterisations Tendencies (SPPT)

Model equations

$$\frac{\partial \rho}{\partial t} = -(\nabla \cdot \rho \bar{\mathbf{V}})$$

$$\frac{\partial \bar{\mathbf{V}}}{\partial t} = -\bar{\mathbf{V}} \cdot \nabla \bar{\mathbf{V}} - \rho^{-1} \nabla p + \bar{\mathbf{g}} - 2\bar{\mathbf{\Omega}} \times \bar{\mathbf{V}} + \bar{\mathbf{F}}_{\mathbf{r}} + S_V$$

$$\frac{\partial \theta}{\partial t} = -\bar{\mathbf{V}} \cdot \nabla \theta + S_\theta$$

$$\frac{\partial q_n}{\partial t} = -\bar{\mathbf{V}} \cdot \nabla q_n + S_{q_n}$$

TKE = Adv. + Shear ± Buoy. ± sub-grid

Frogner et al., submitted to Wea. Forecasting , 2019

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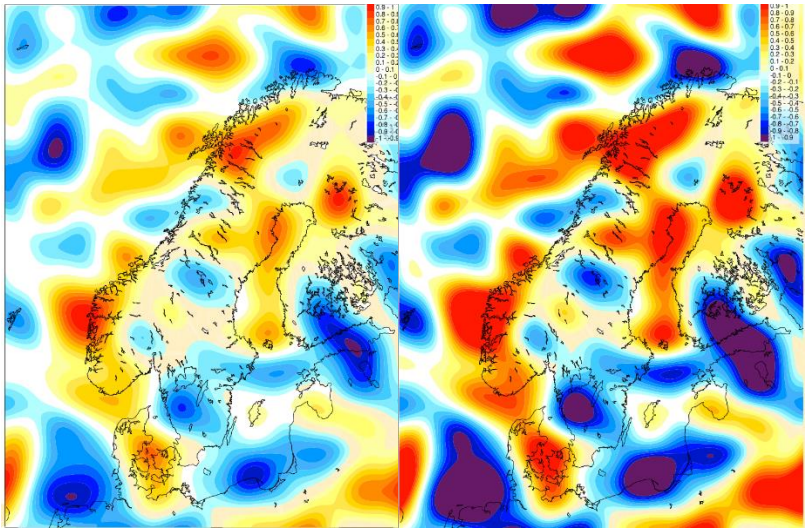
Stochastic perturbation patterns



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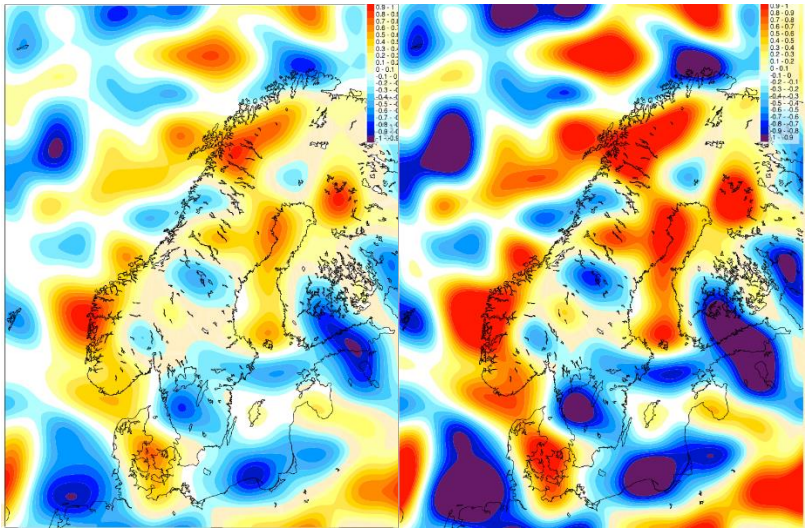
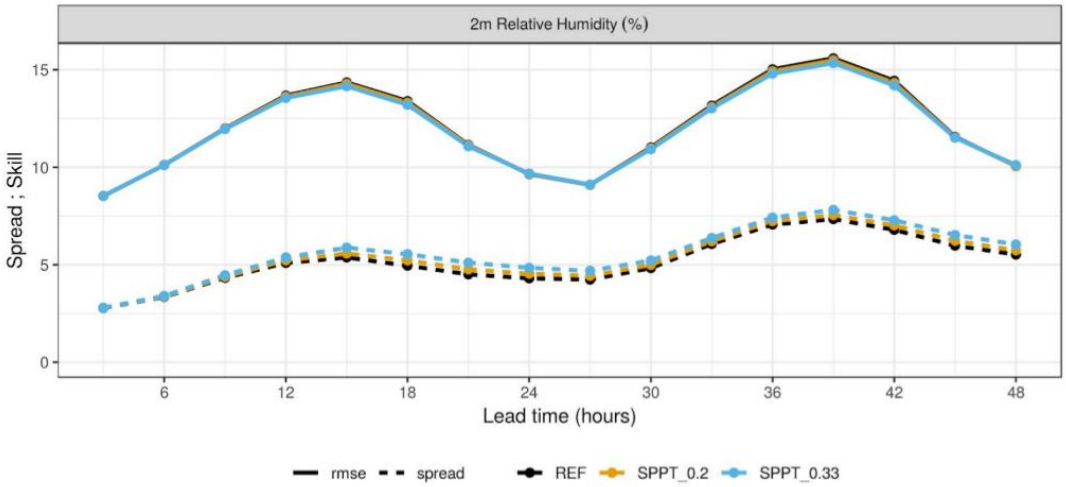


Forecast (relative humidity, May-June 2017)



SPPT has only marginal benefit! What to do?

1. SPPT perturbs total tendencies → combination of all sub-grid processes

2. More focused perturbations representing errors closer to their source could be more beneficial.

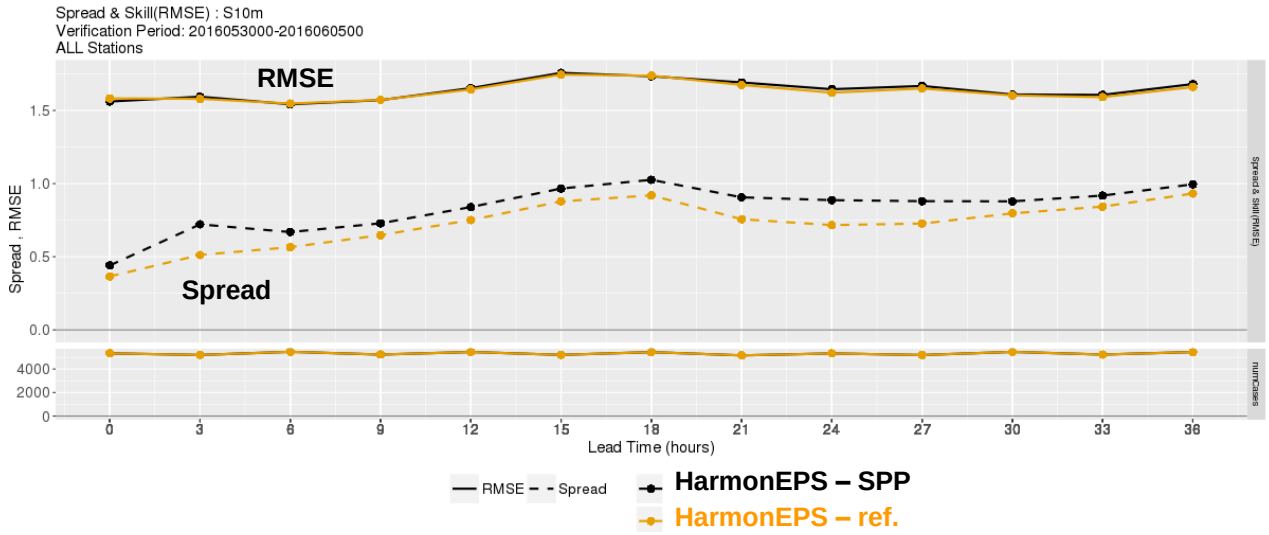
→ Stochastically Perturbed Parameterizations (SPP, *Ollinaho et al.; 2017*)

Frogner et al., submitted to Wea. Forecasting , 2019

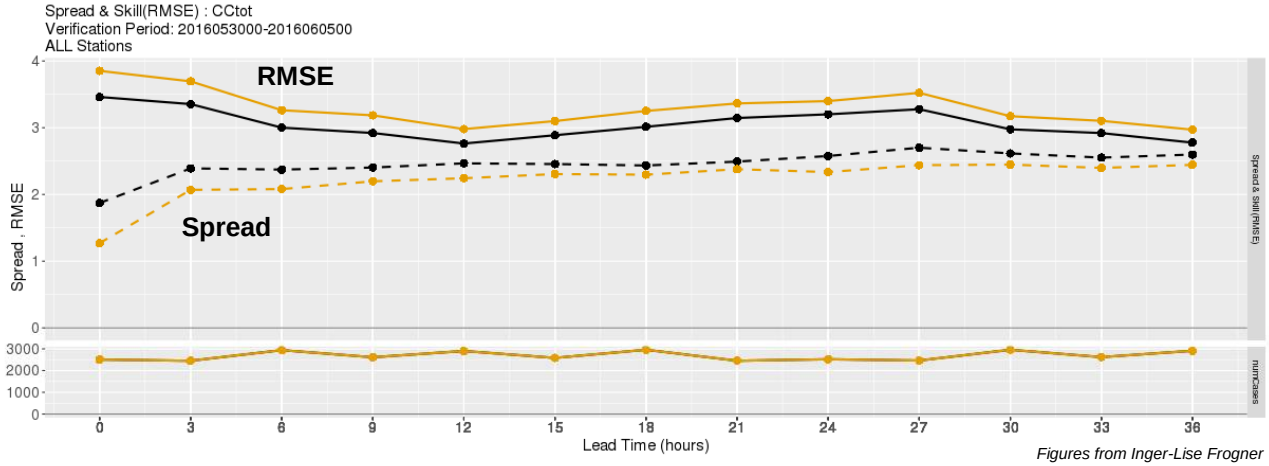
Stochastic physics: Stochastically Perturbed Parameterisations (SPP)

June 2016 (first results, small sample)

10m wind speed



Total cloudiness



Figures from Inger-Lise Frogner

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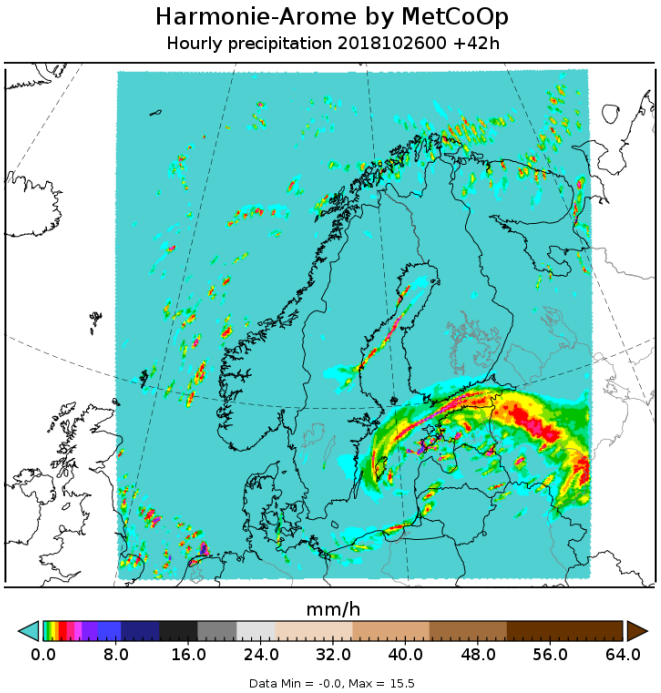
Where this development eventually end up?

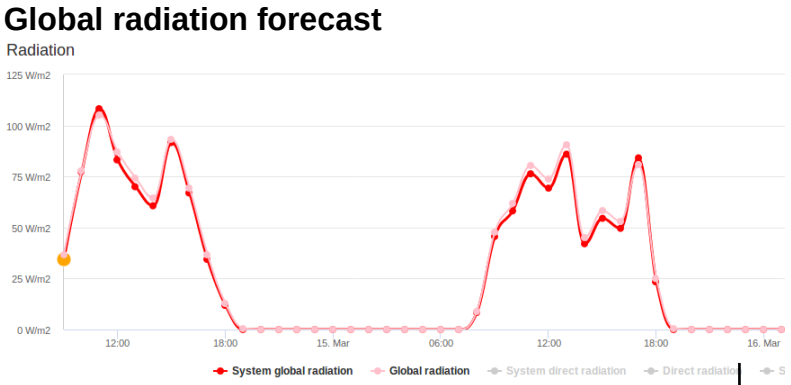
Joint Numerical Weather Prediction (NWP) production between Finland, Sweden and Norway: MetCoOp

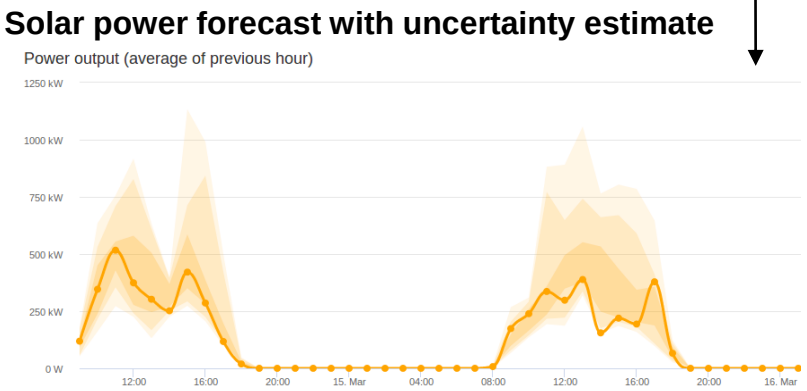
MetCoOp NWP production

- MetCoOp Ensemble Prediction System (MEPS), operational implementation of HarmonEPS.
- Scandinavian + Baltic Sea domain with 2.5km resolution
- 9 + 1 ensemble members
- Forecast 4 times/day: +66h (control), +54h (perturbed members).
- Data available from FMI Open Data interface.



FMI OPEN DATA





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