

# Should we use ECMWF-EPs initial and boundary condition perturbations for HarmonEPs?

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# Outline of talk

A comparison between the default HarmonEPS setup and a “random field perturbation” setup

- Describe random field perturbation setup
- Forecast examples and verification for 10-28 June 2012
- Open questions regarding the use of ECMWF-EPS as outer model for a nested HarmonEPS

# Random Field Perturbation\*

- Initial condition perturbation

$$z_m(0) = a_{\text{ctl}} + \alpha[r_1(0) - r_2(0)], \quad z_{m+1}(0) = a_{\text{ctl}} - \alpha[r_1(0) - r_2(0)]$$

- Lateral boundary condition perturbation

$$z_m(t) = x_{\text{ctl}}(t) + \alpha[r_1(t) - r_2(t)], \quad z_{m+1}(t) = x_{\text{ctl}}(t) - \alpha[r_1(t) - r_2(t)]$$

$a_{\text{ctl}}$  = analysis, control run

$x_{\text{ctl}}(t)$  = interpolated hi-res EC-field

$r_j(t)$  = interpolated hi-res EC-field from random date (similar time of year and same time of day as control);  $u, v, T, q, p_s$

$\alpha$  = scaling constant that determines perturbation magnitude

\*Magnusson et al., 2009: "Flow-dependent versus flow-independent initial perturbations for ensemble prediction"

# Default HarmonEPS perturbation

- Initial condition perturbation

$$z_m(0) = x_{ctl} + \alpha[x_m(0) - x_{ctl}(0)]$$

- Lateral boundary condition perturbation

$$z_m(t) = x_{ctl}(t) + \alpha[x_m(t) - x_{ctl}(t)]$$

$x_m(t)$  = member  $m$  of EC ensemble

$x_{ctl}(t)$  = control member of EC ensemble

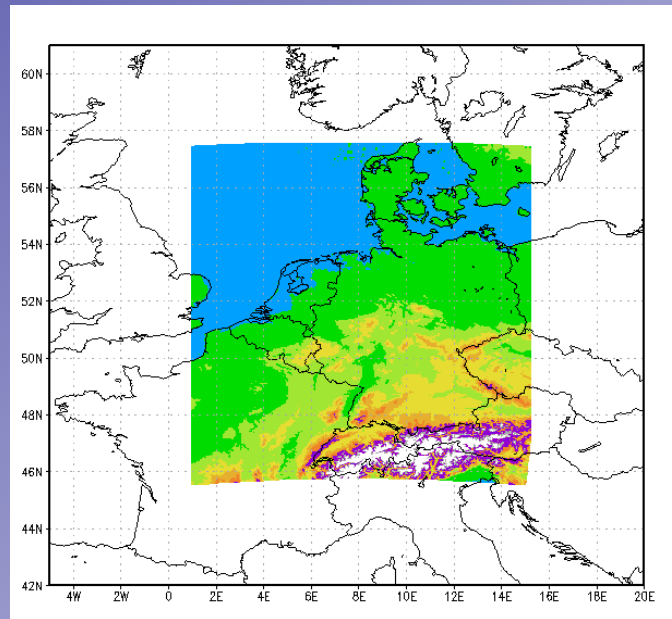
$\alpha = 1$  (scaling already done in EC ensemble)

# Scaling the perturbations

- Choose  $\alpha$  such that the total energy of the random field initial perturbations matches that of the default initial perturbations
- Total energy norm measures distance between two ensemble members
- **NB.** Lateral EC-EPS boundaries diverge from control run during forecast; random field boundaries are independent of control run and will not contribute (much) to ensemble spread

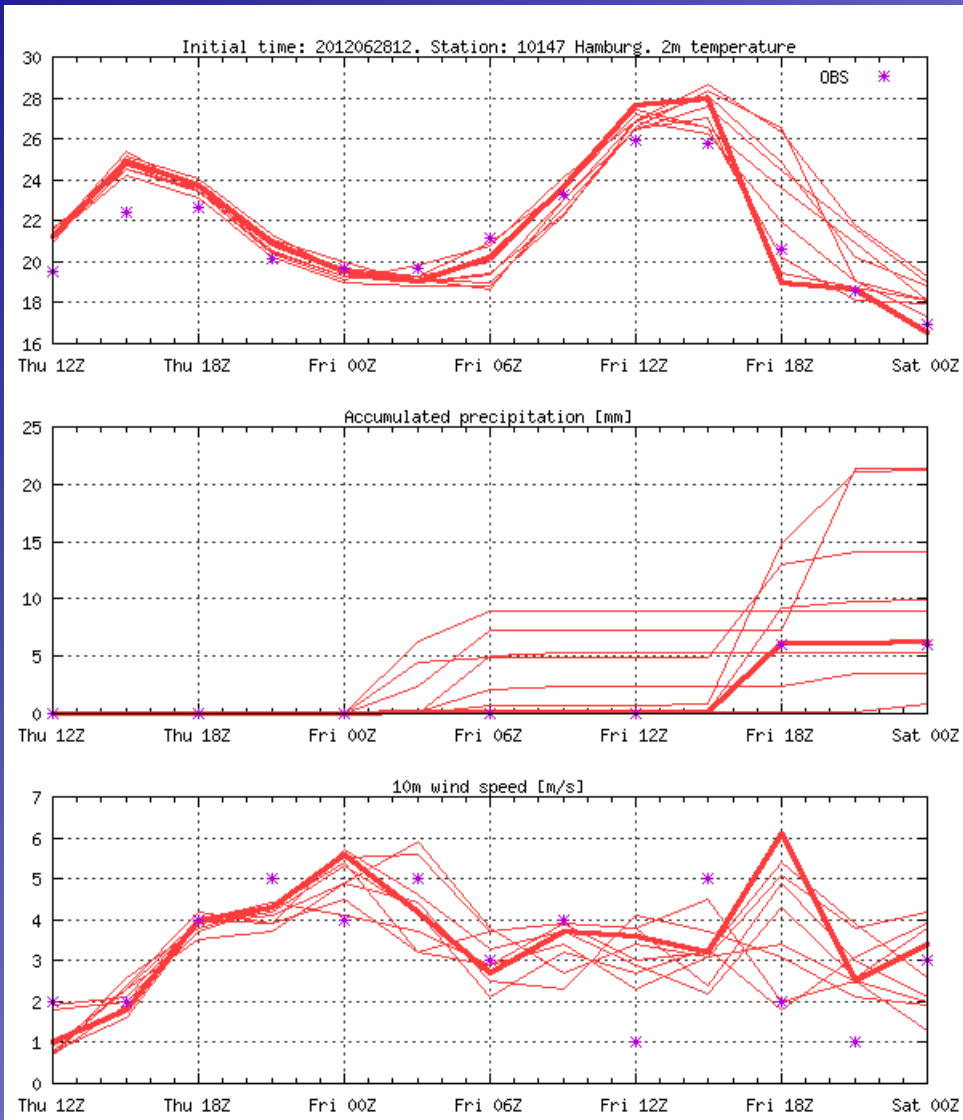
# HarmonEPS experiments

- Period: 10-28 June 2012 (when EC-EPS boundaries have been rerun and made available in MARS)
- Members: 1 control + 8 perturbed
- Model version: HarmonEPS-38h1.1 (AROME physics)
- Domain: HarmEPS\_1 (“Germany + surroundings” 2.5km × 2.5km, 450 × 540 grid points, 65 vertical levels)

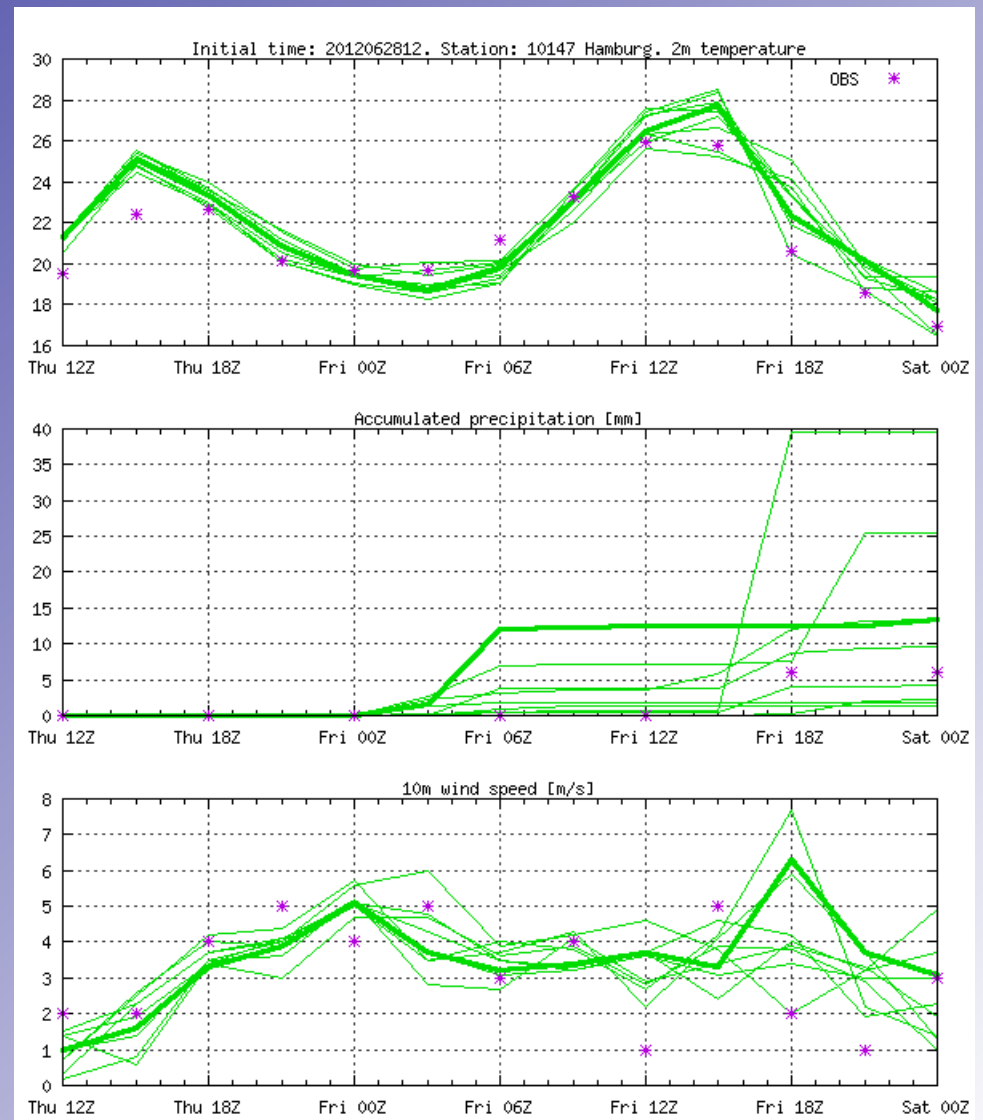


# Point forecast examples

## EC-EPS perturbations

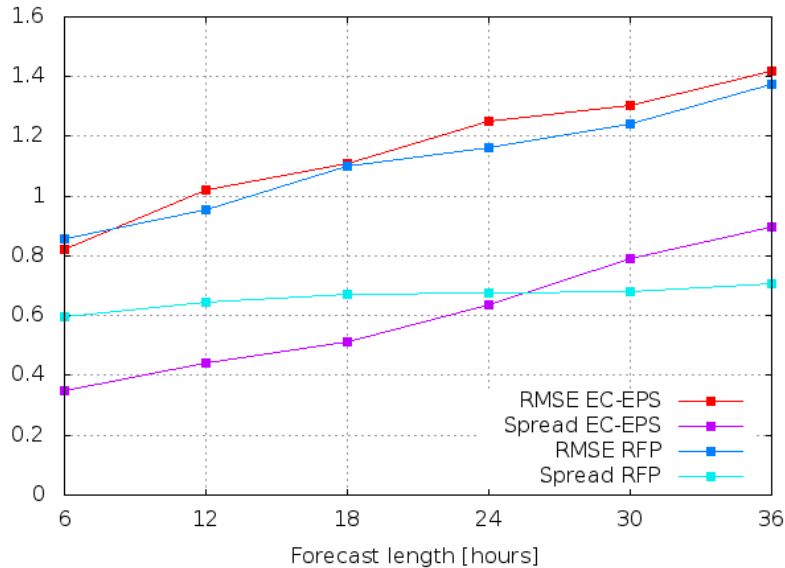


## Random field perturbations

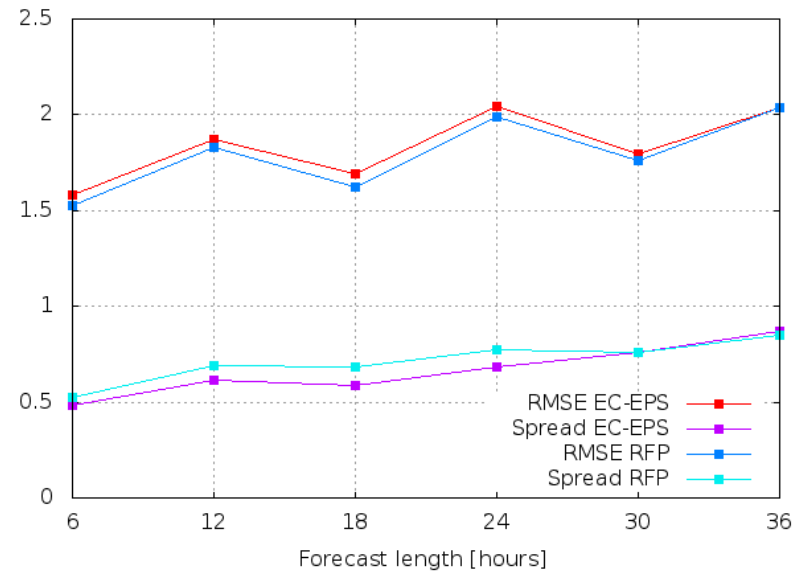


# Standard verification

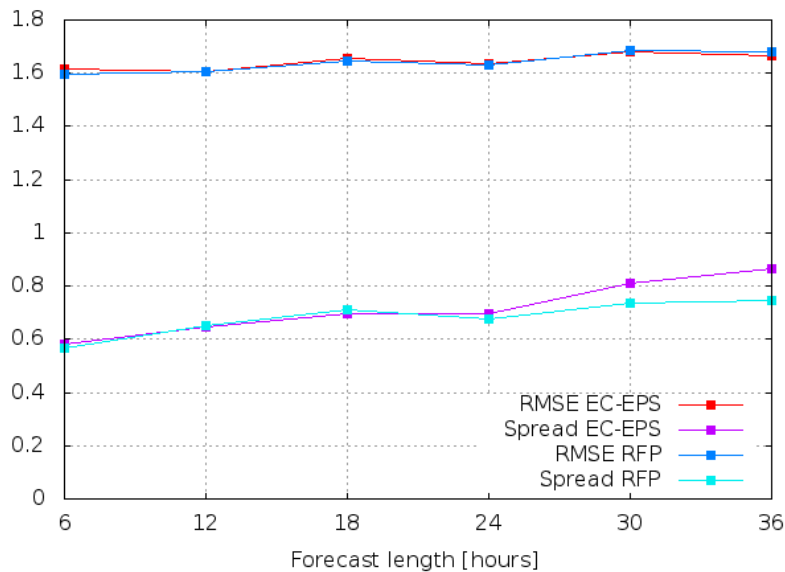
Spread/error, MSLP



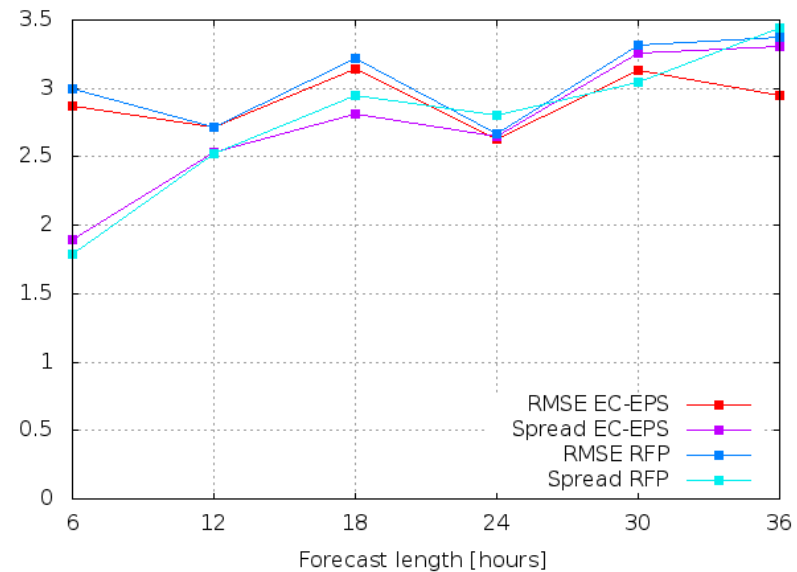
Spread/error, T2m



Spread/error, S10m

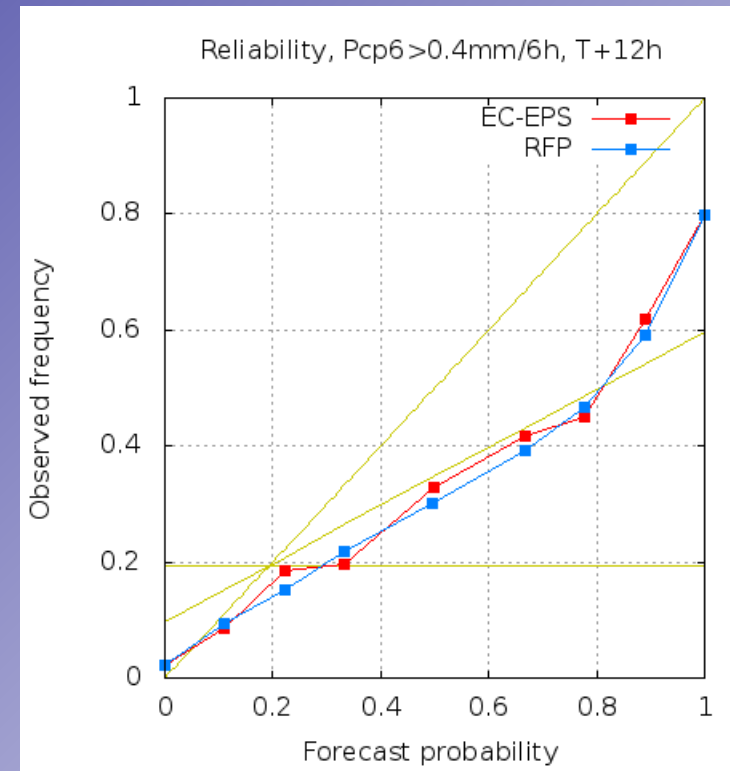
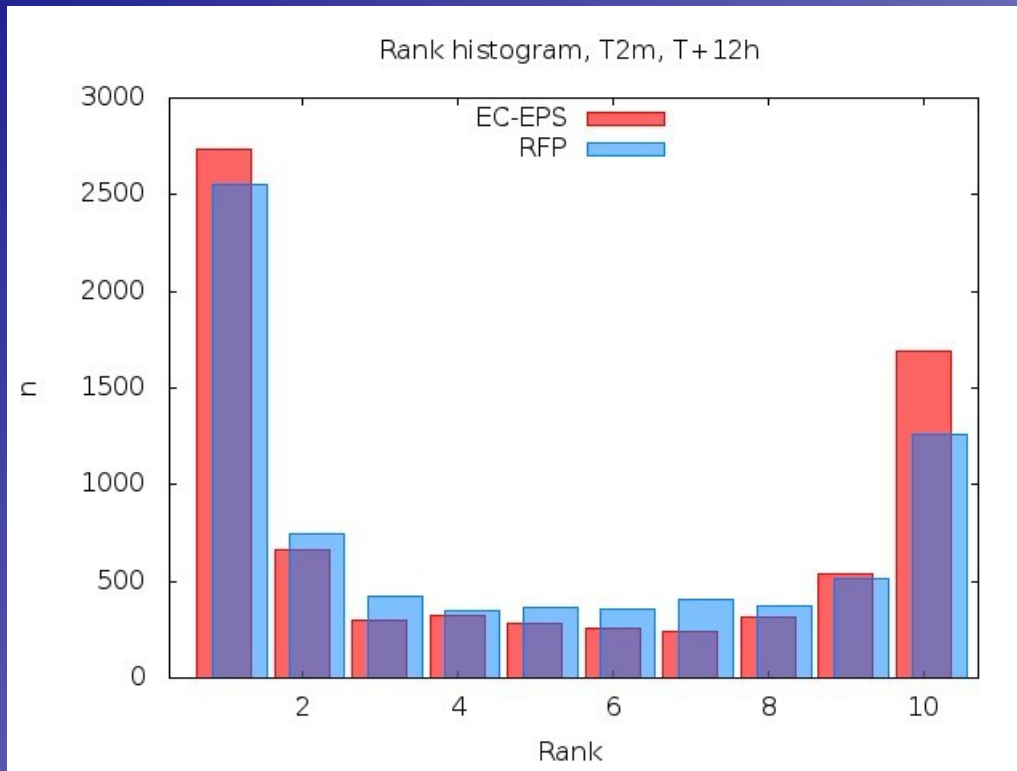


Spread/error, Pcp6

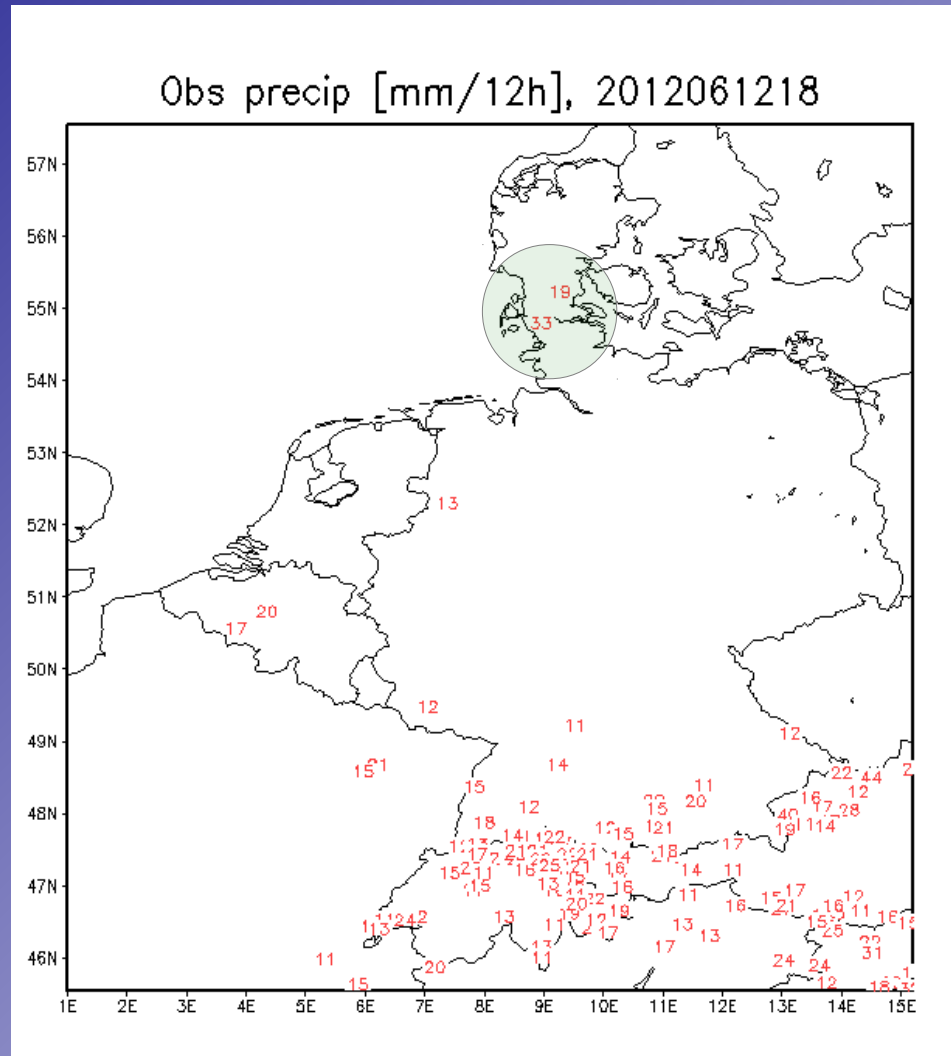




# Standard verification

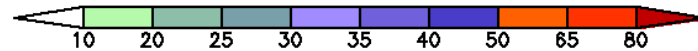
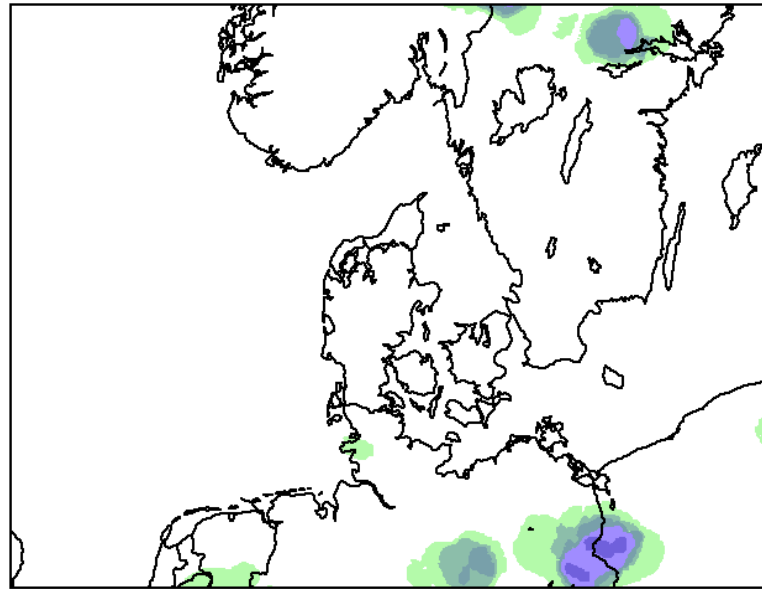


# Convective case

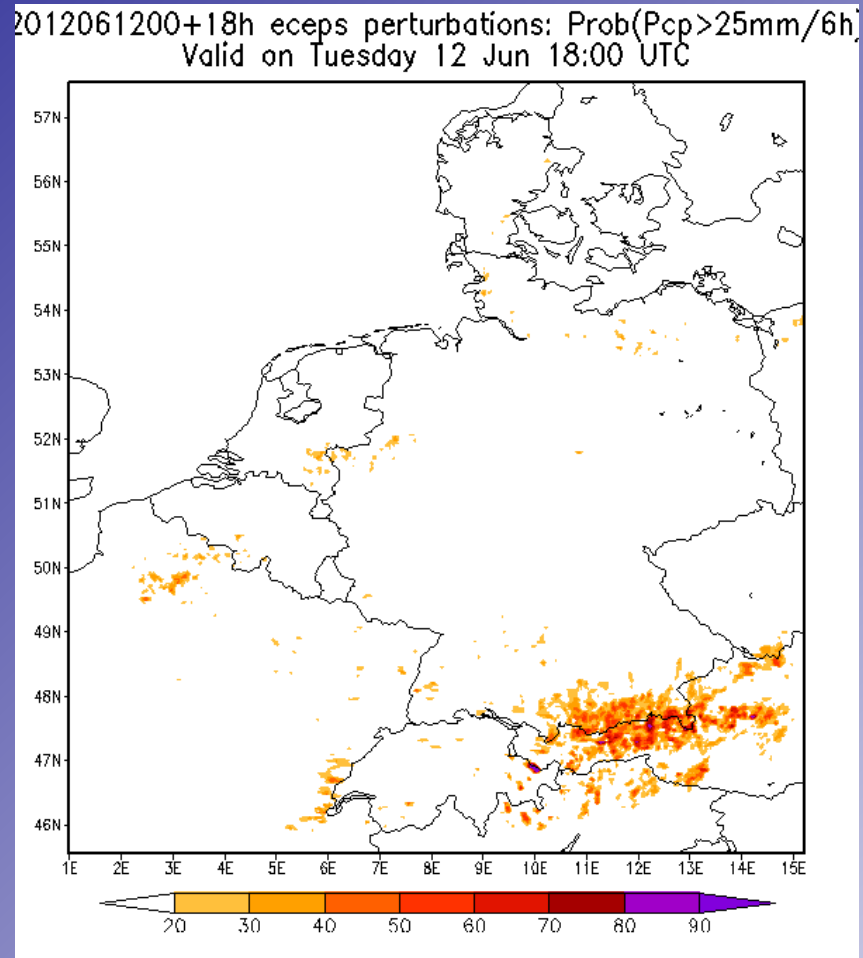


# DMI-EPS (HIRLAM) missed the event...

2012061200+018h: Prob(Pcp>24mm/6h)  
Valid on Tuesday 12 Jun 18:00 UTC



# HarmonEPS probabilities

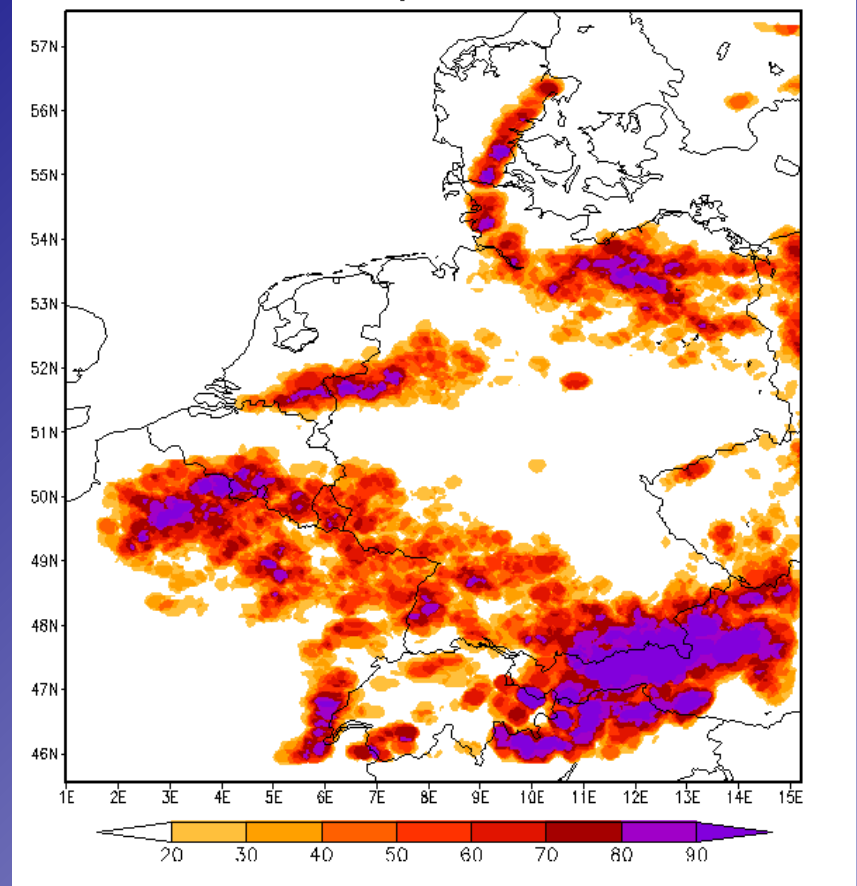


# HarmonEPS with upscaling (radius = 12.5km)

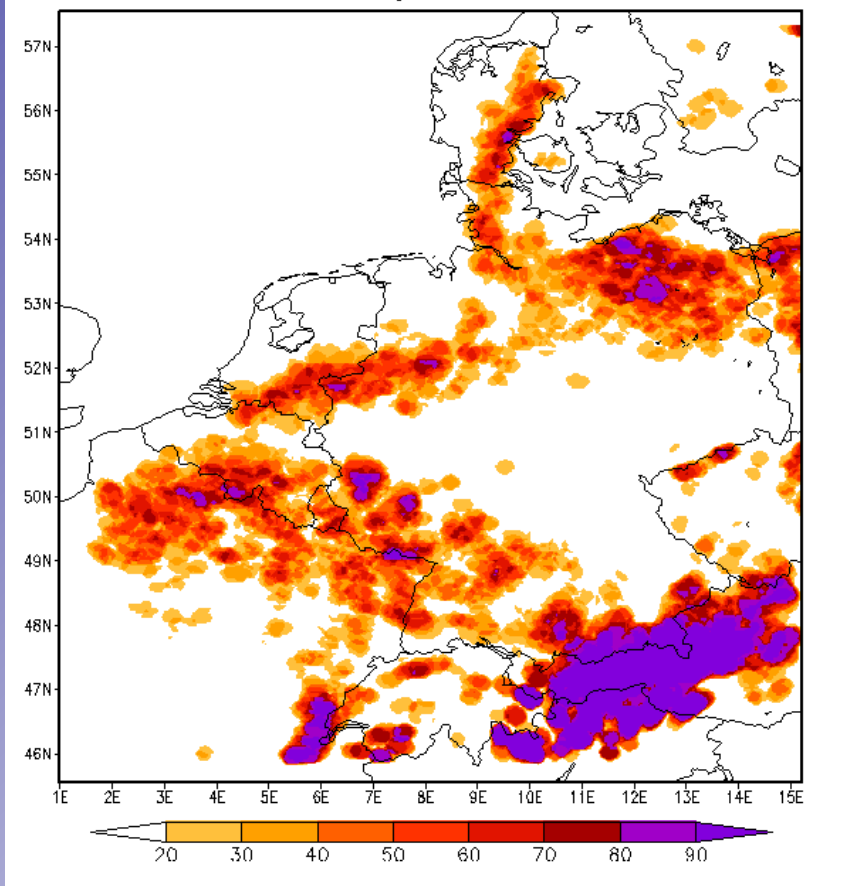
EC-EPS perturbations

Random field perturbations

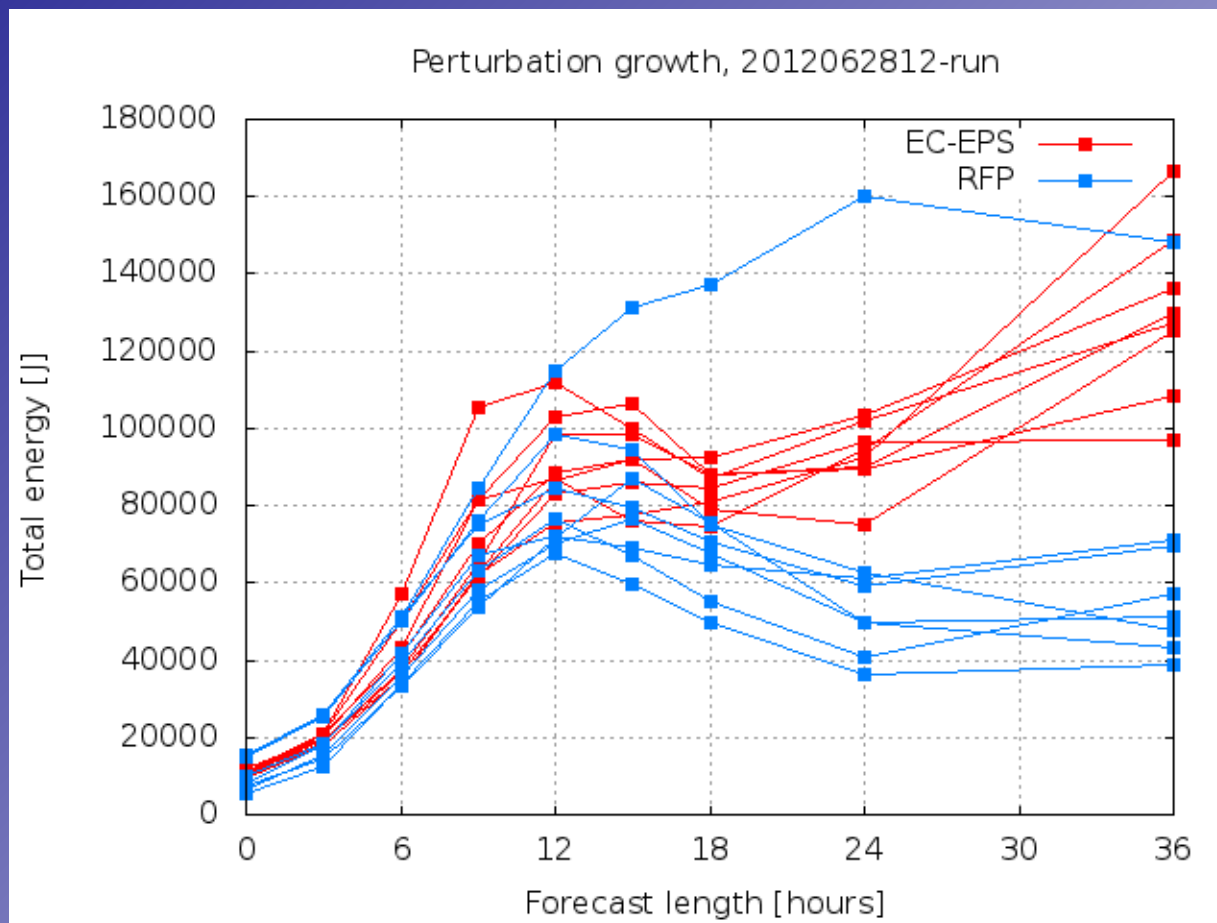
2012061200+18h eceps perturbations: Prob( $P_{cp} > 25\text{mm}/6\text{h}$ )  
Valid on Tuesday 12 Jun 18:00 UTC



2012061200+18h rfp perturbations: Prob( $P_{cp} > 25\text{mm}/6\text{h}$ )  
Valid on Tuesday 12 Jun 18:00 UTC



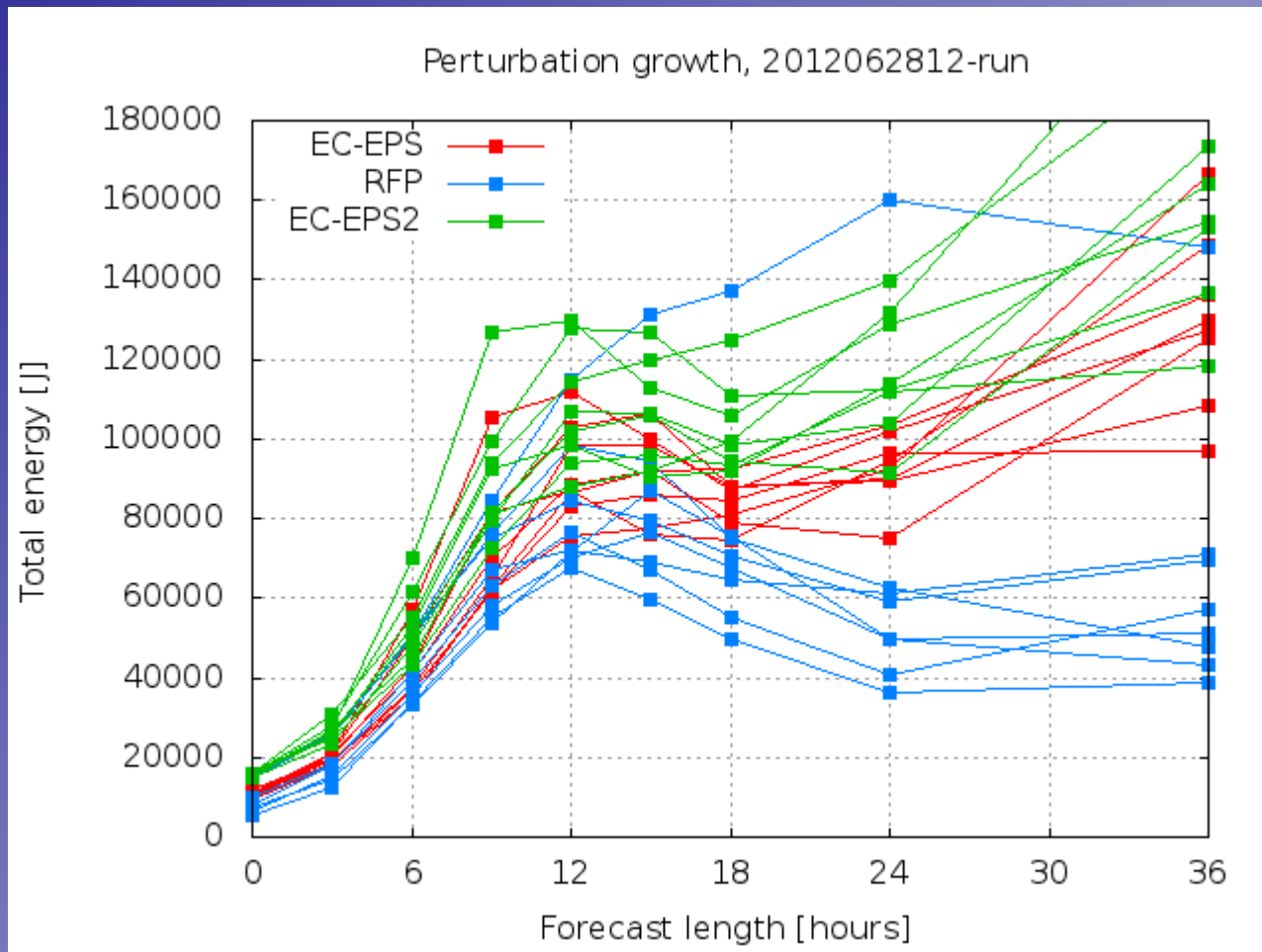
# Perturbation growth



# Summary

- Random field perturbations are not meant as an operational alternative
- But they perform as well as EC-EPS perturbations
  - Why?
- Ensemble forecasts are under-dispersive
  - Model perturbations are not included!
  - We could inflate IC and LBC perturbations
- Unclear how much lateral boundary conditions should be perturbed

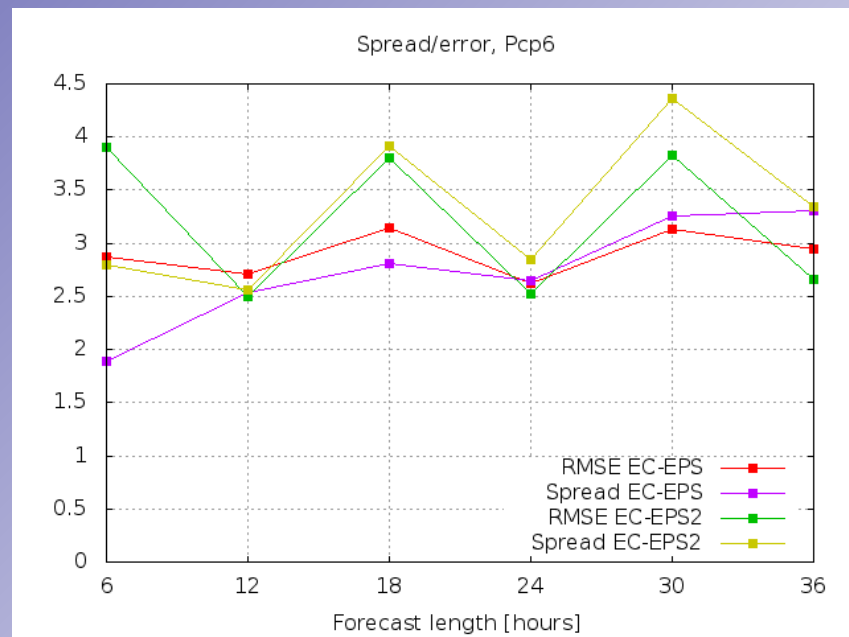
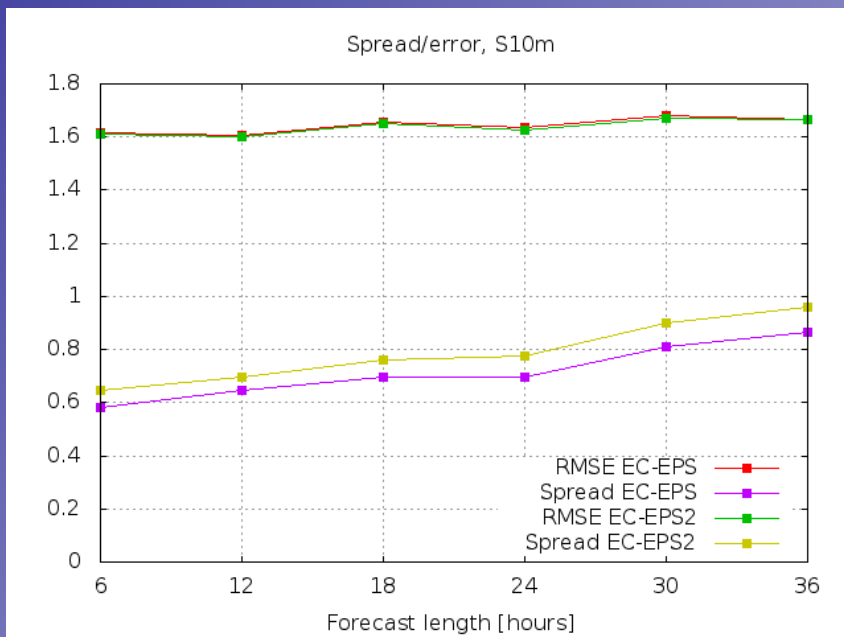
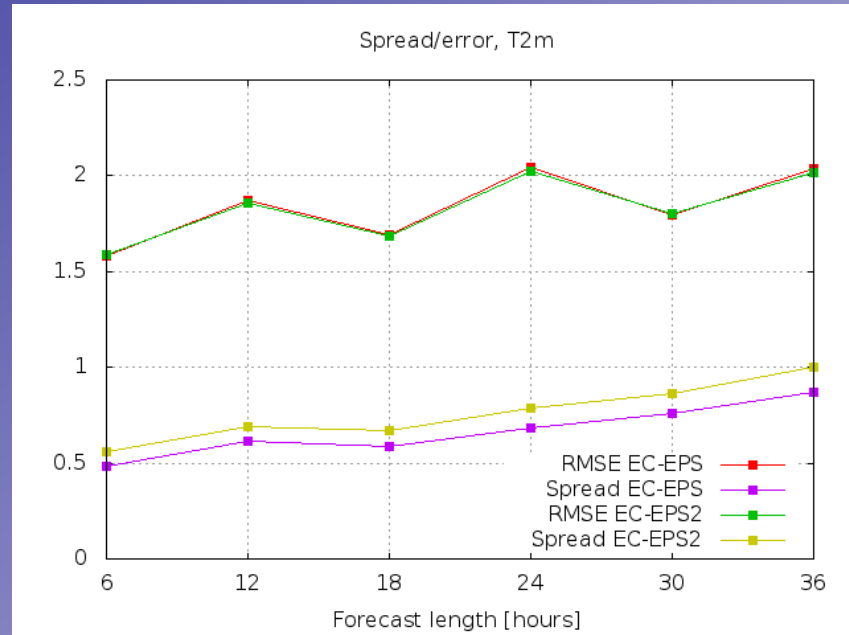
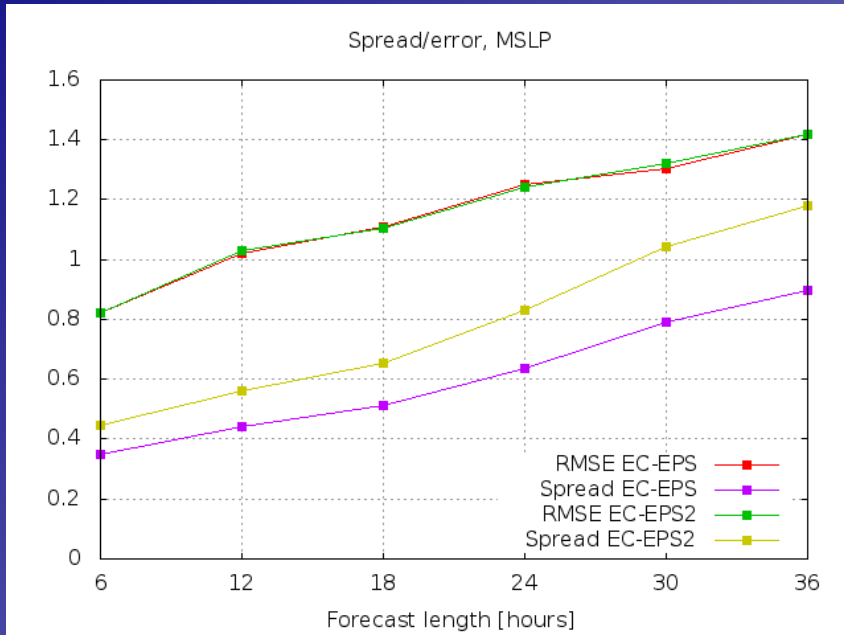
# Inflated initial and lateral boundary condition perturbations



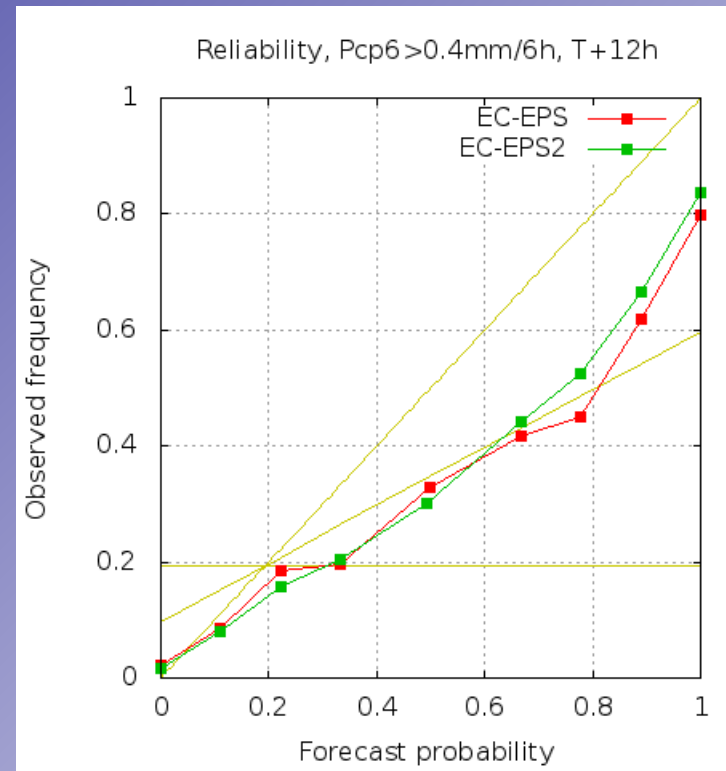
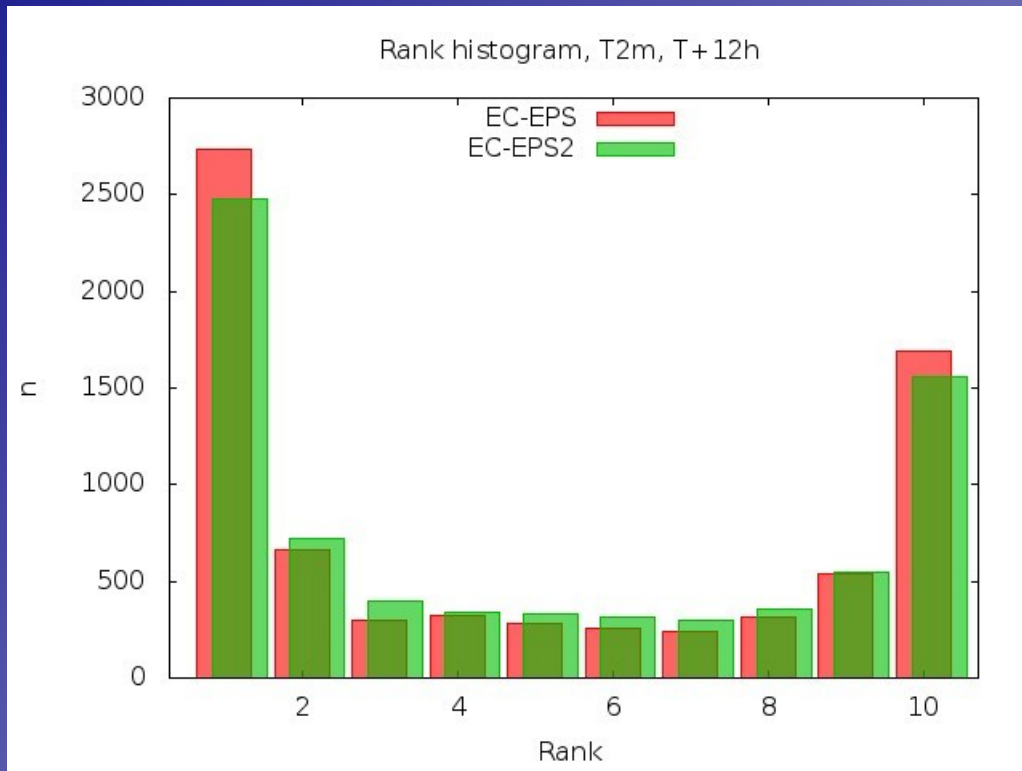
→ Probabilistic forecasts verify better!



# Standard verification



# Standard verification



# Should we use ECMWF-EPS initial and boundary condition perturbations for HarmonEPS?

- We can manage without ECMWF-EPS
- Continue development of improved initial condition perturbations
- More research needed for lateral boundary condition perturbations

A vibrant rainbow arches across a clear blue sky over a wet asphalt road. The road is lined with green trees and bushes. Several cars are visible on the road, including a dark car in the distance and a silver car in the foreground. The scene is captured from a low angle, looking down the road. The text "Thank you for your attention!" is overlaid in the center of the image in a bold, yellow font with a black outline.

**Thank you for your attention!**