Experiences with DMI's operational COMEPS* ensemble system

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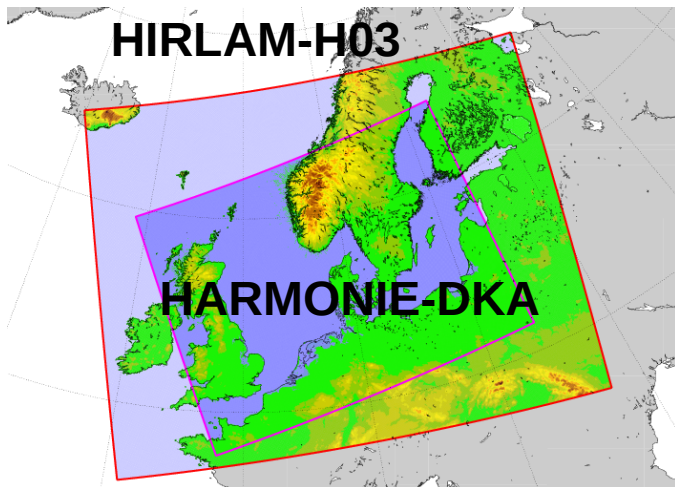
*Continuous mesocale ensemble prediction system

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Background

- [In-house] users wanted
  - High resolution
  - Large domain
  - Long forecasts
  - Many ensemble members
- We are constrained by
  - Computational resources

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Domains

COMEPS v1

COMEPS v2

- Big domain: 13 members
- Small domain: 12 members + big domain members interpolated to small domain grid

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Operational COMEPS

- Version 1 operationalized June 2017
  - Multi-model: HARMONIE-AROME + HIRLAM
- Version 2 operationalized May 2018
  - Only HARMONIE-AROME, HarmonEPS-40h1.1, 2.5km, 65 vert. levels
- Version 3 operational later 2019
  - One (big) domain: NEA
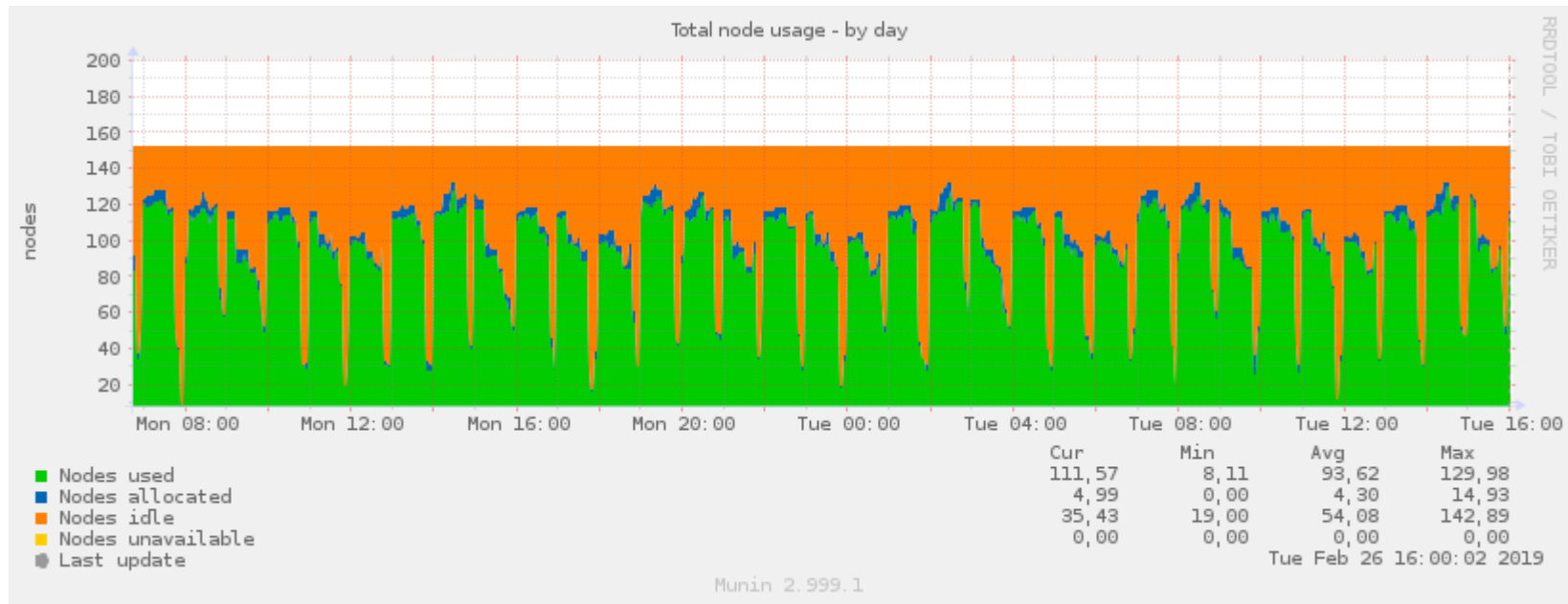 - HarmonEPS-40h1.1.1, 2.5km, 65 vert. levels

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HPC usage prior to COMEPS
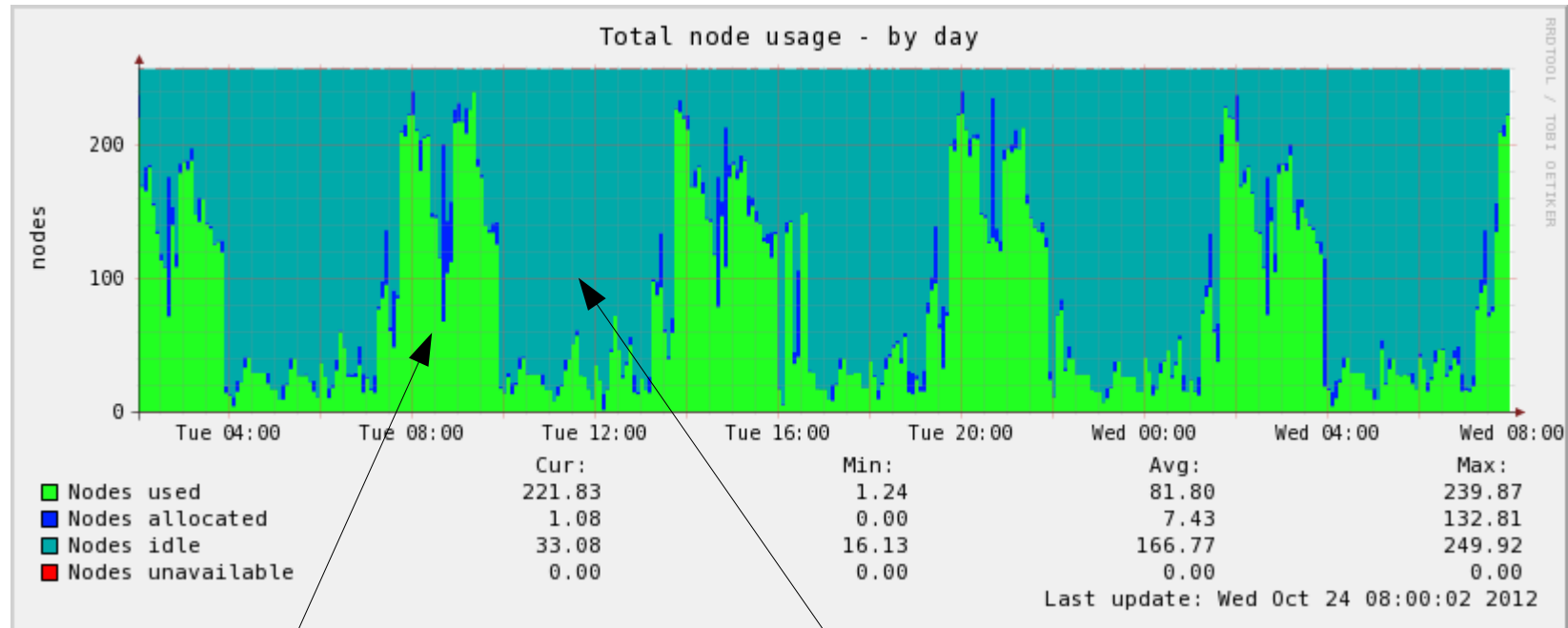
HPC used almost 100%
after main synoptic hours

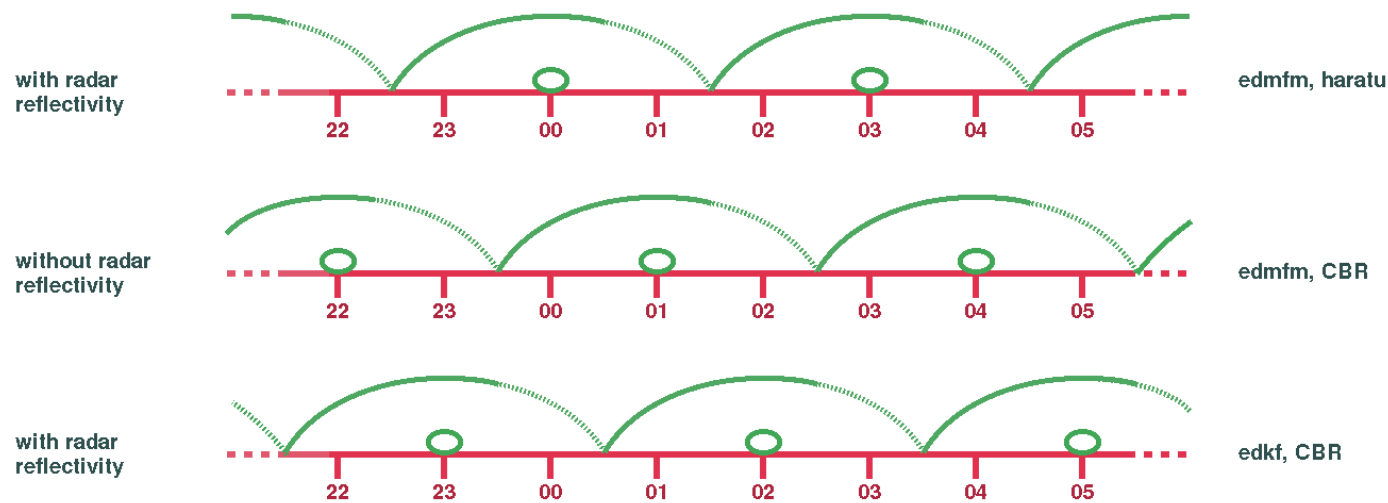HPC idle

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HPC usage with COMEPS v2

- Every hour we run two short control runs and four new perturbed COMEPS members

- COMEPS ensemble includes lagged members

- Every hour the four oldest perturbed members are replaced by the four new perturbed members

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Rapid update cycling for control runs

- For each domain, run three parallel, time-shifted HarmonEPS suites

- 3DVAR upper air assimilation (conventional observations plus AMSU-A, AMSU-B, MHS, AMV, MODE-S, ATMS, RO and radar reflectivity); surface assimilation

- Allow use of different observation types and physics configurations in the three suites

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Perturbations

- Initial conditions: SLAF/random field perturbations (IFS-HRES) + PertAna

- Lateral boundary conditions: SLAF/random field perturbations

- Stochastic perturbations of surface parameters (roughness, albedo, SST, soil temperature, soil moisture)

- Multi-physics (shallow convection, turbulence, OCND2, Z01D, LCRIT)

Postprocessed products
Probability maps, upscaled probabilities

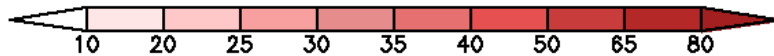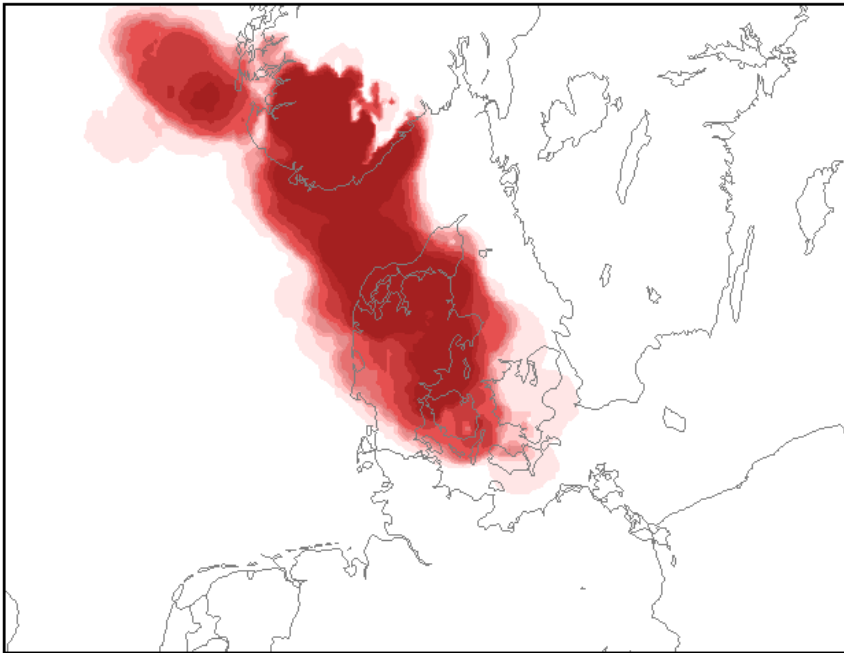2018102609+12h: Prob(Pcp>25mm/6h)
Valid on Friday 26 Oct 21:00 UTC
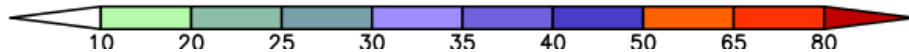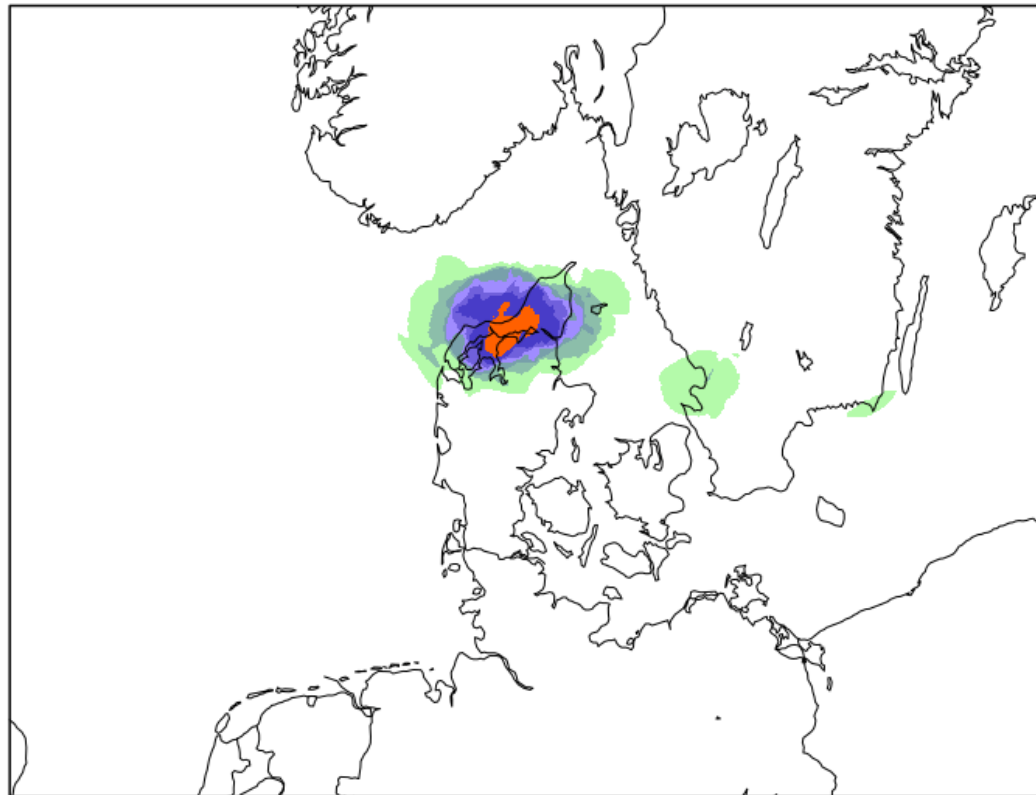
Probability of exceeding threshold somewhere in neighbourhood of grid point

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Postprocessed products
Probability maps

2012122212+027h: Prob(Snowstorm)
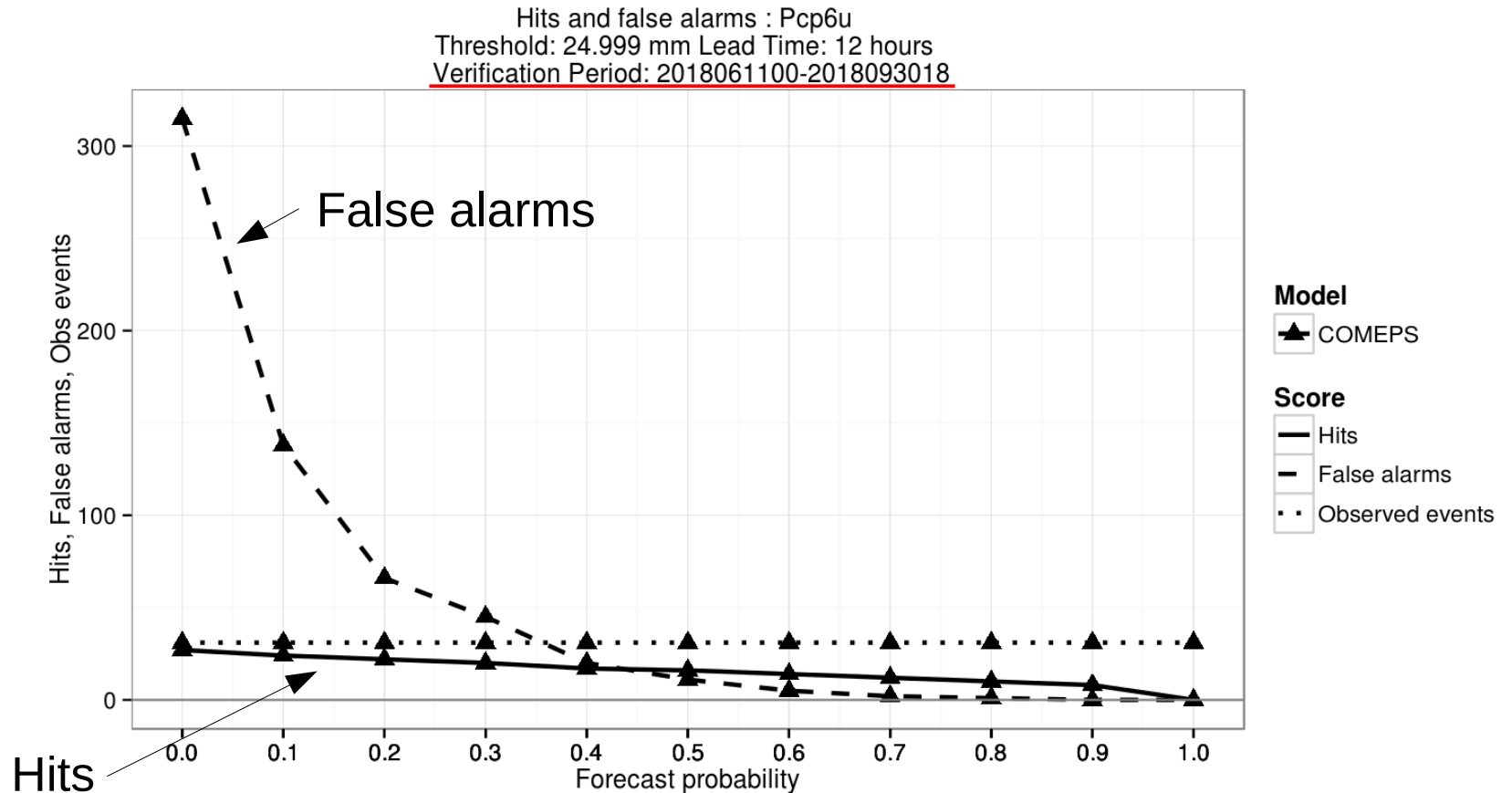Valid on Sunday 23 Dec 15:00 UTC

10 20 25 30 35 40 50 65 80

Joint probabilities of, e.g., exceeding thresholds for both wind speed and snowfall somewhere in neighbour-hood of grid point
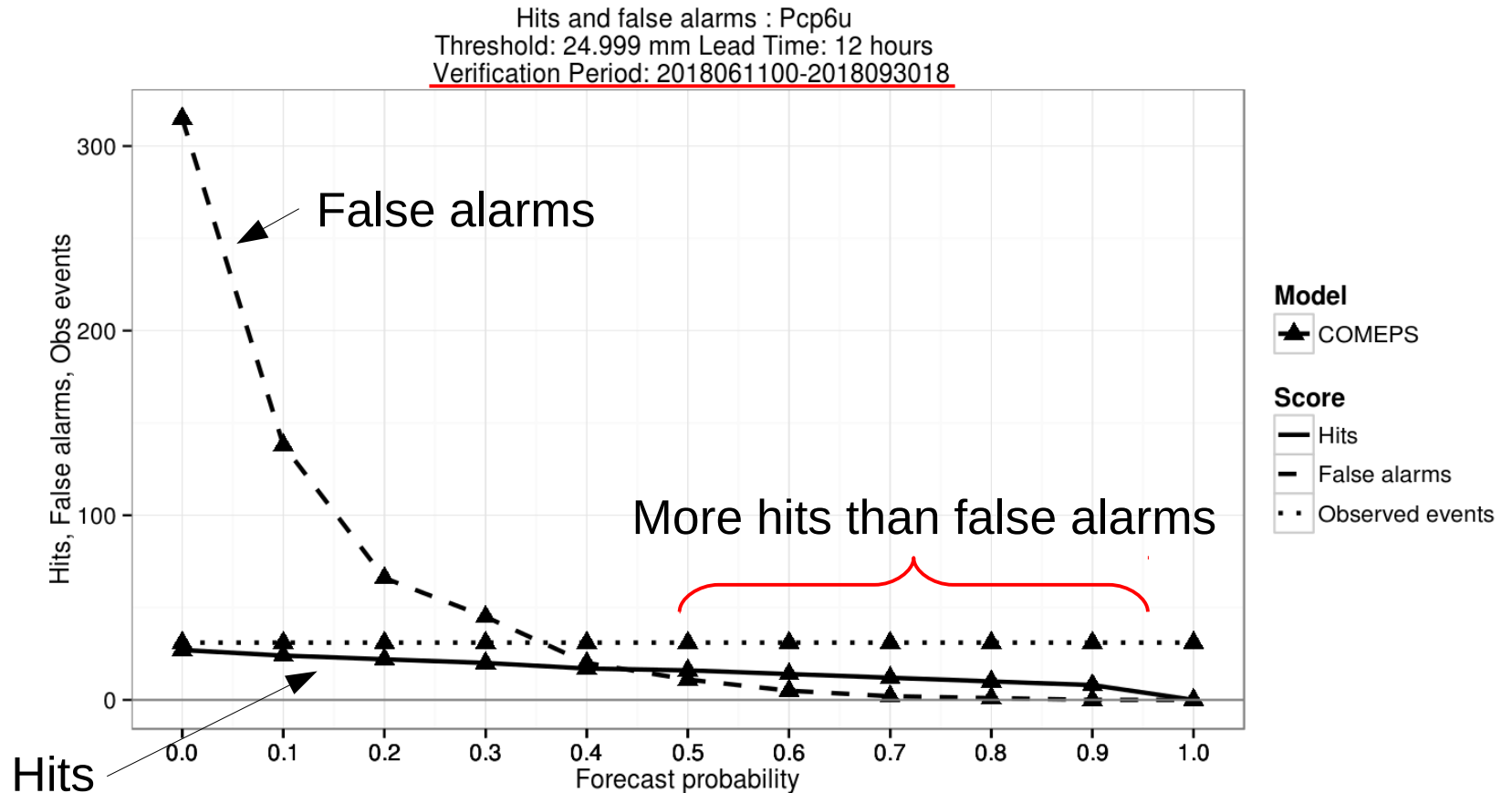
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Verification of upscaled probabilities

- Question from forecasters: "At what probability level do you recommend that we issue a warning?"

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Verification of upscaled probabilities prob(pcp≥25mm/6h)

Hits and false alarms : Pcp6u
Threshold: 24.999 mm Lead Time: 12 hours
Verification Period: 2018061100-2018093018

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- Question from forecasters: "At what probability level do you recommend that we issue a warning?"

- "Last summer you would have got more hits than false alarms if you had issued warnings [for pcp≥25mm/6h] when the upscaled probability was 50% or more!"

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Verification of upscaled probabilities

- Question from forecasters: "At what probability level do you recommend that we issue a warning?"

- "Last summer you would have got more hits than false alarms if you had issued warnings [for pcp≥25mm/6h] when the upscaled probability was 50% or more!"

- The optimal balance between hits, false alarms and misses must take into account costs and losses associated with false alarms and misses.
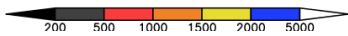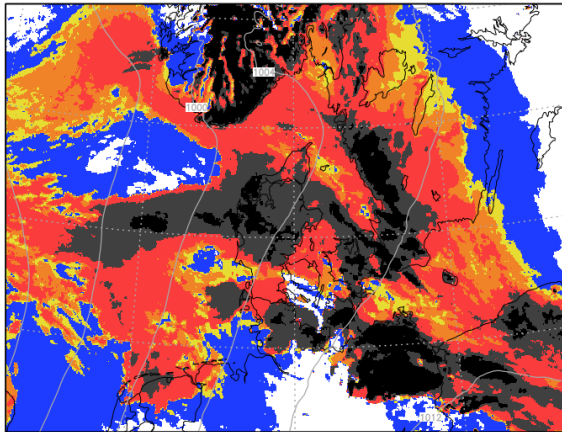
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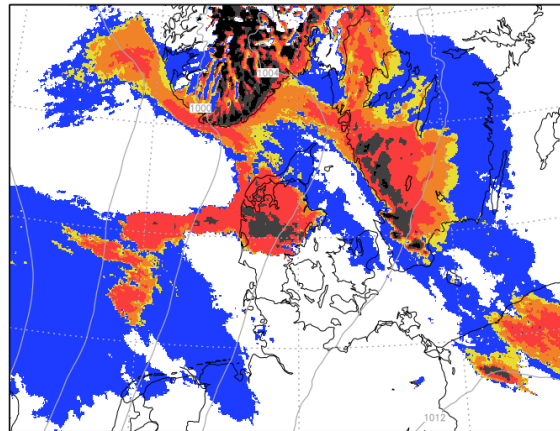# Postprocessed products
Percentile maps

Ceiling percentiles

10th percentile   median   90th percentile
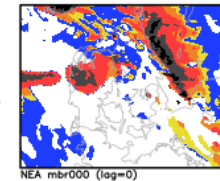
Postprocessed products
Postage stamp plots

2019030603+03h, ceiling [ft]
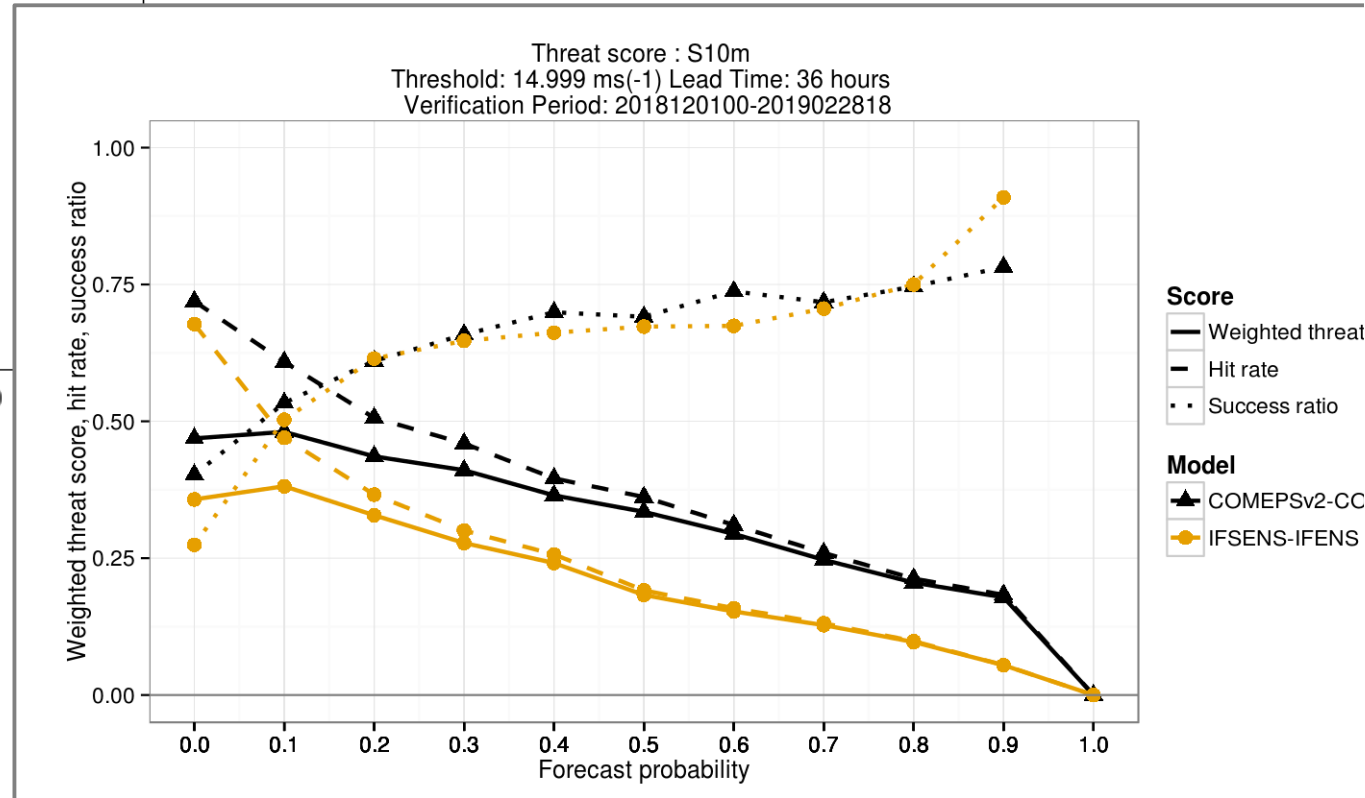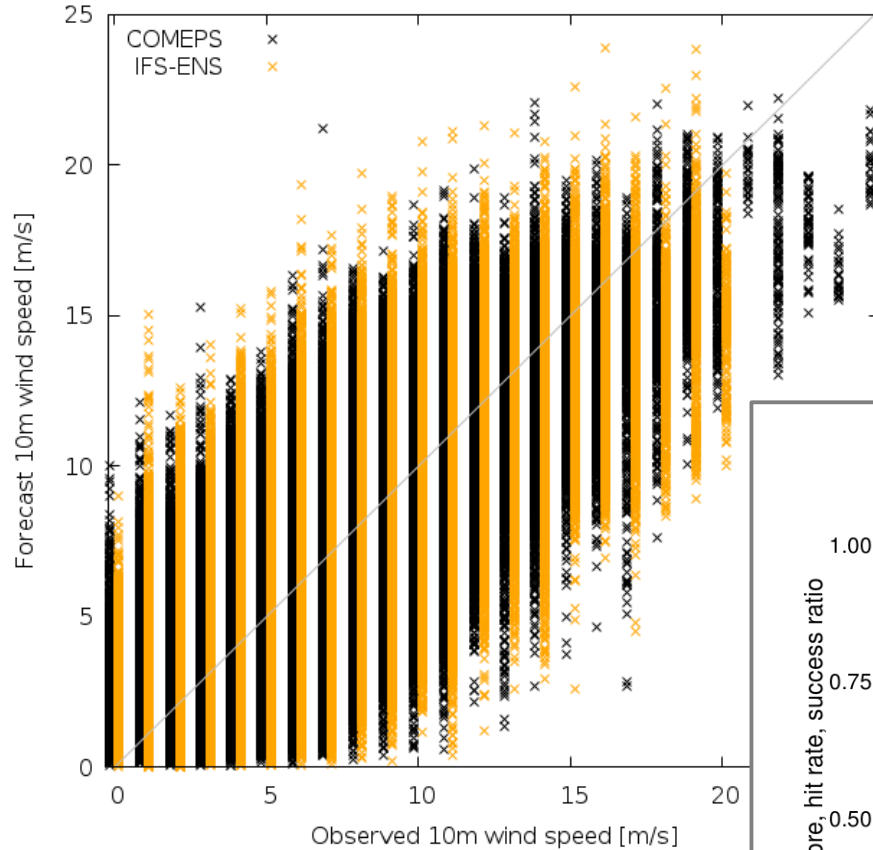Valid on Wednesday 6 Mar 06:00 UTC
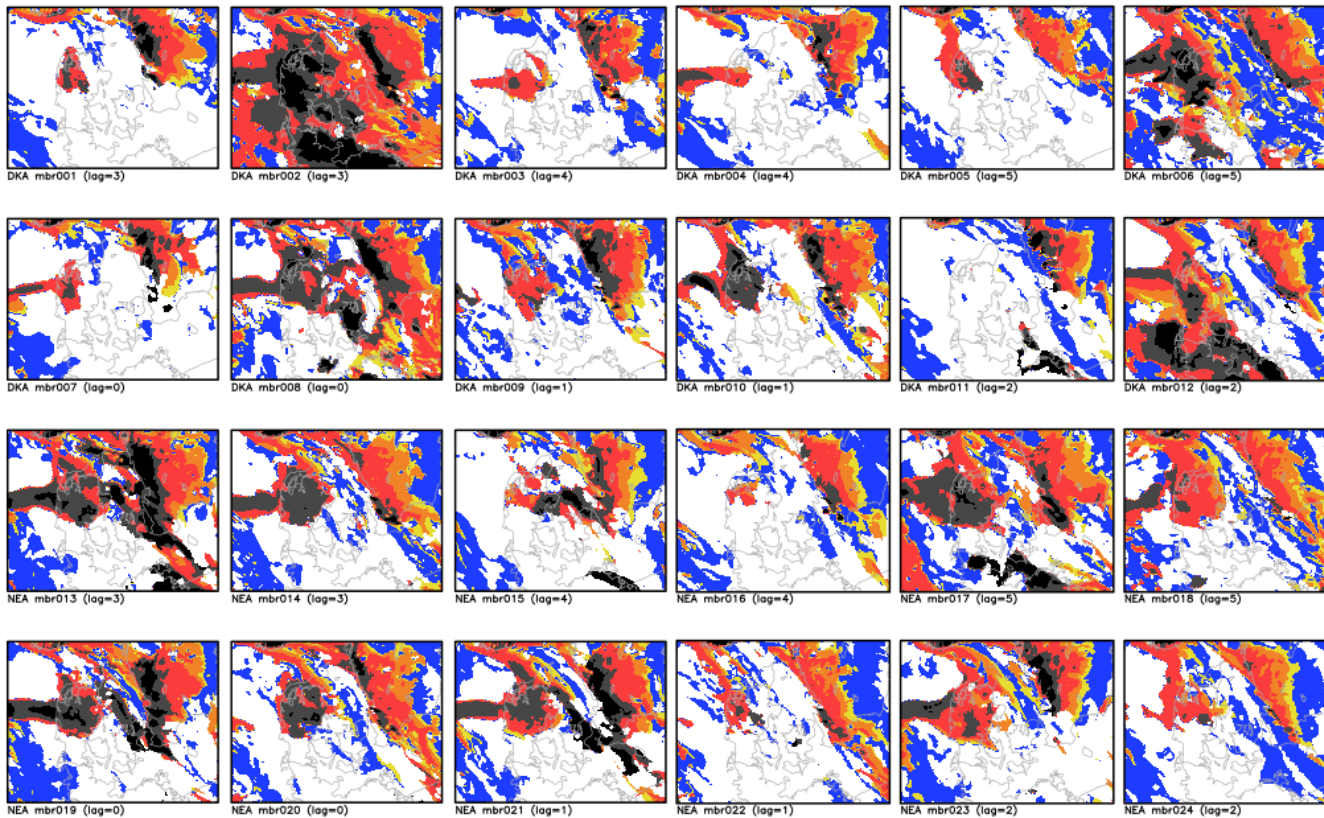
Verification of gale force wind
Comparison to IFS-ENS

36h forecasts, DJF 2018/19

Threat score : S10m
Threshold: 14.999 ms(-1) Lead Time: 36 hours
Verification Period: 2018120100-2019022818

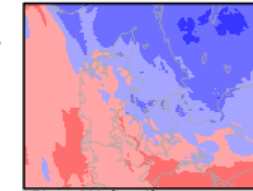# Planned upgrades

- HarmonEPS-40h1.1.1
- All members on big domain
- Humidity perturbations(?)
- Use of IFS-ENS perturbations(?)

DMI
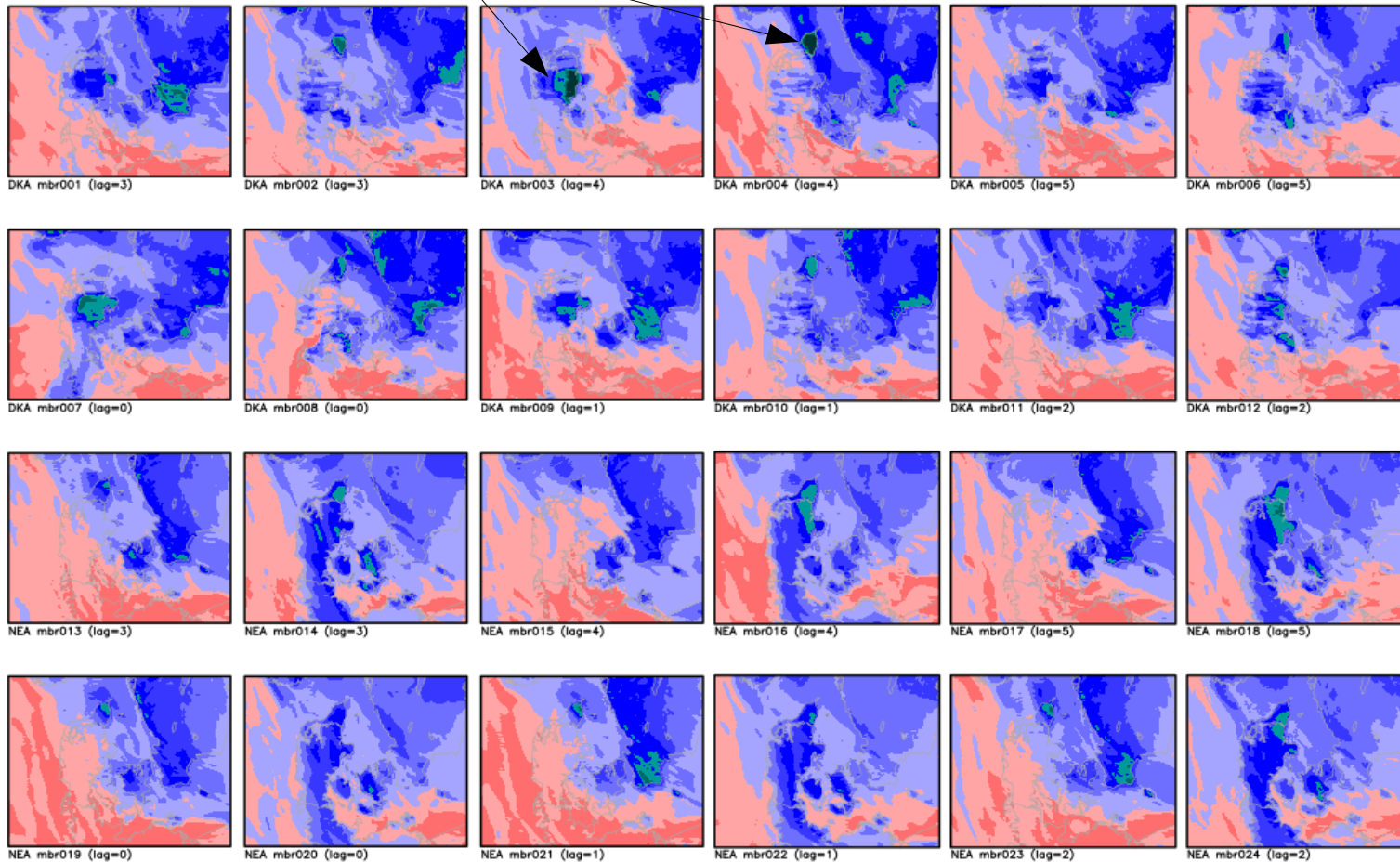Vejr, klima og hav

Dewpoint example

2019031909+3h, 2m dewpoint
Valid on Tuesday 19 Mar 12:00 UTC

−15 −12 −10 −8 −6 −4 −2 0 2 5 10 15 20

Unperturbed forecast

NEA mbr000 (lag=0)

**Extremely dry
(due to humidity perturbation?)**

DKA mbr001 (lag=3)   DKA mbr002 (lag=3)   DKA mbr003 (lag=4)   DKA mbr004 (lag=4)   DKA mbr005 (lag=5)   DKA mbr006 (lag=5)

DKA mbr007 (lag=0)   DKA mbr008 (lag=0)   DKA mbr009 (lag=1)   DKA mbr010 (lag=1)   DKA mbr011 (lag=2)   DKA mbr012 (lag=2)

NEA mbr013 (lag=3)   NEA mbr014 (lag=3)   NEA mbr015 (lag=4)   NEA mbr016 (lag=4)   NEA mbr017 (lag=5)   NEA mbr018 (lag=5)

NEA mbr019 (lag=0)   NEA mbr020 (lag=0)   NEA mbr021 (lag=1)   NEA mbr022 (lag=1)   NEA mbr023 (lag=2)   NEA mbr024 (lag=2)

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IFS-ENS perturbations

- SLAF initial condition perturbations are not mutually independent/orthogonal

- IFS-ENS perturbations are mutually orthogonal

- Describe perturbation orthonormality by the dimension spanned by the perturbations, i.e. the "ensemble dimension" (or "bred vector dimension"; Patil et al. 2001; Pazó et al. 2010), using a total energy norm
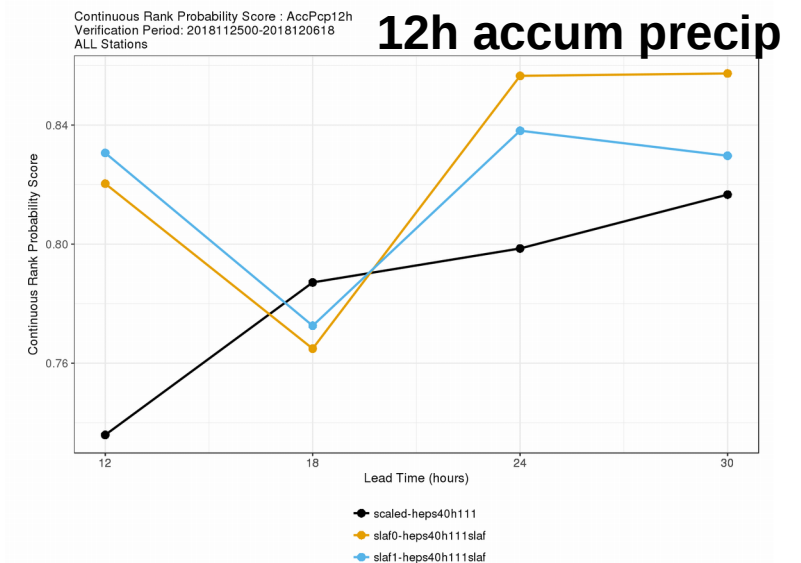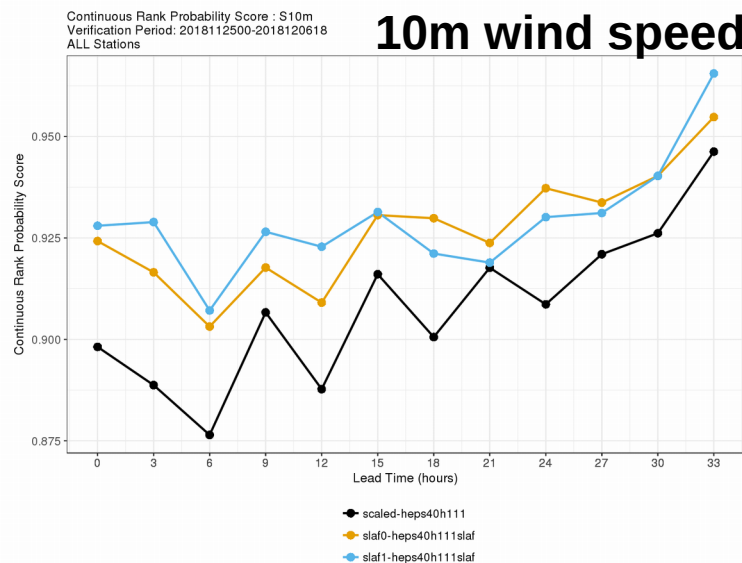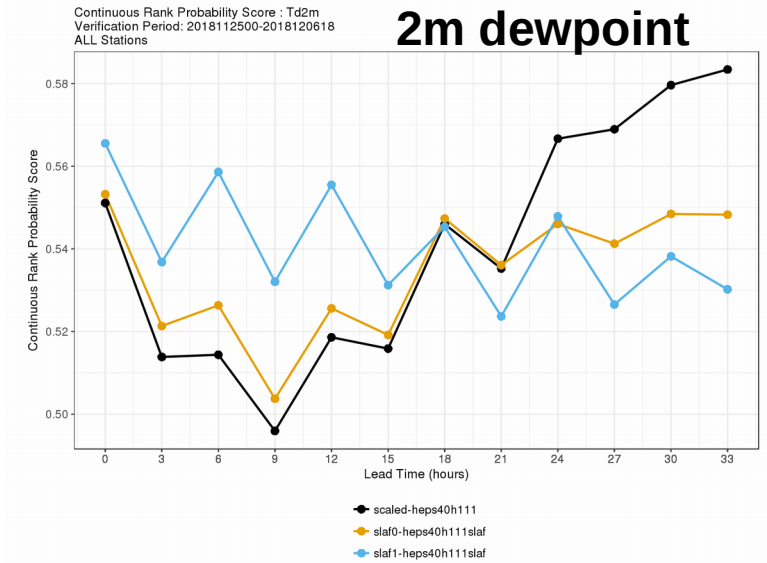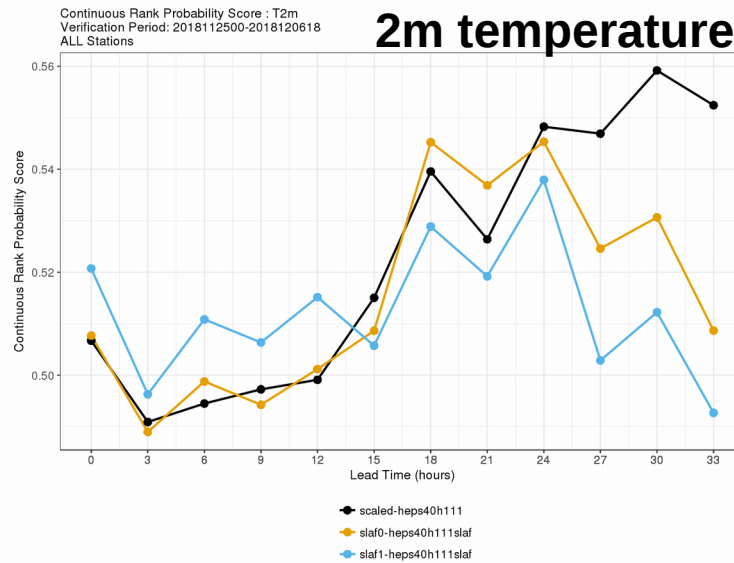
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Ensemble dimension
(at forecast initial time)

Ensemble dimension
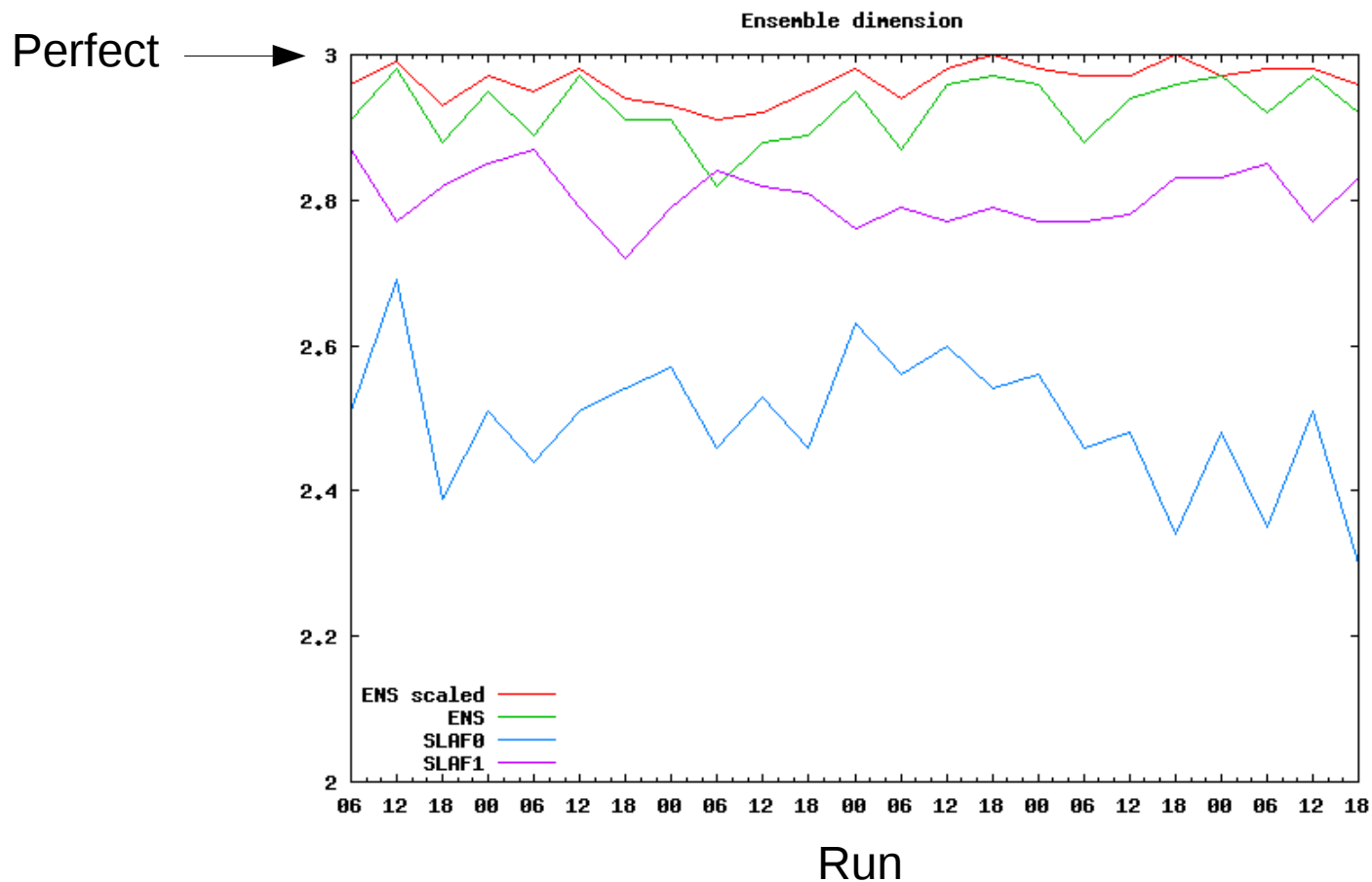
Continuous Ranked Probability Scores

Perturbations:
- **IFS-ENS**
- **SLAF0**
- **SLAF1**

IFS-ENS perturbations

- IFS-ENS perturbations span the phase space better than SLAF perturbations

- Skill (CRPS) is better for short lead times (less than ~12 hours) compared to SLAF method for the short period tested

- For longer lead times the benefits of IFS-ENS perturbations are not obvious

- More tests needed...

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Summary of experiences with COMEPS

- Meteorological performance is comparable to other mesoscale EPS's

- Hourly updates allow better utilization of HPC resources

- (Some) forecasters look at COMEPS when they make their forecasts

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Thank you for your attention!

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