GLAMEPS and HarmonEPS for Sochi Olympics

- and some plans for HarmonEPS

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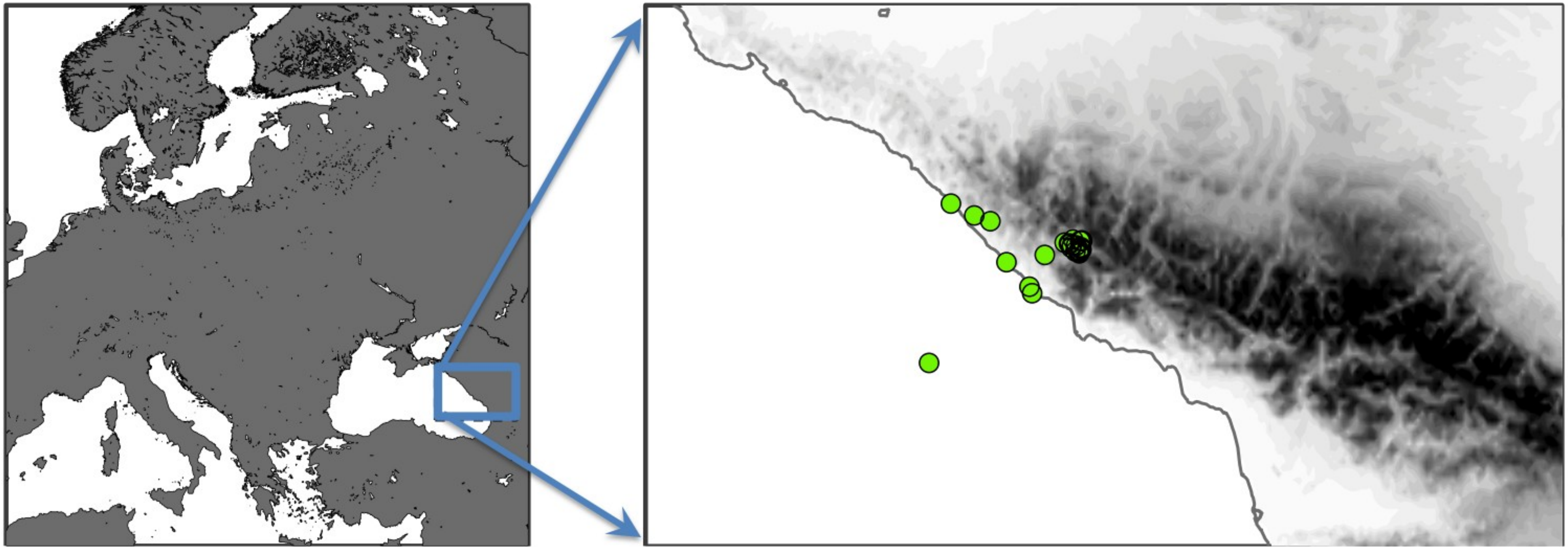
Kai Sattler, Andrew T. Singleton, Ole Vignes, Xiaohua Yang

GLAMEPS is a common project for operational EPS in the short-range in the HIRLAM and ALADIN SRNWP consortia

Offenbach 1 October 2014

Sochi Olympics: The FROST project
(Probabilistic part)
FROST=Forecast and Research in the Olympic Sochi Testbed

Goal:
- Regional meso-scale ensemble forecast products in winter complex terrain environment
- To deliver probabilistic forecasts in real time to Olympic weather forecasters and decision makers



HIRLAM involvement in FROST: (probabilistic part)

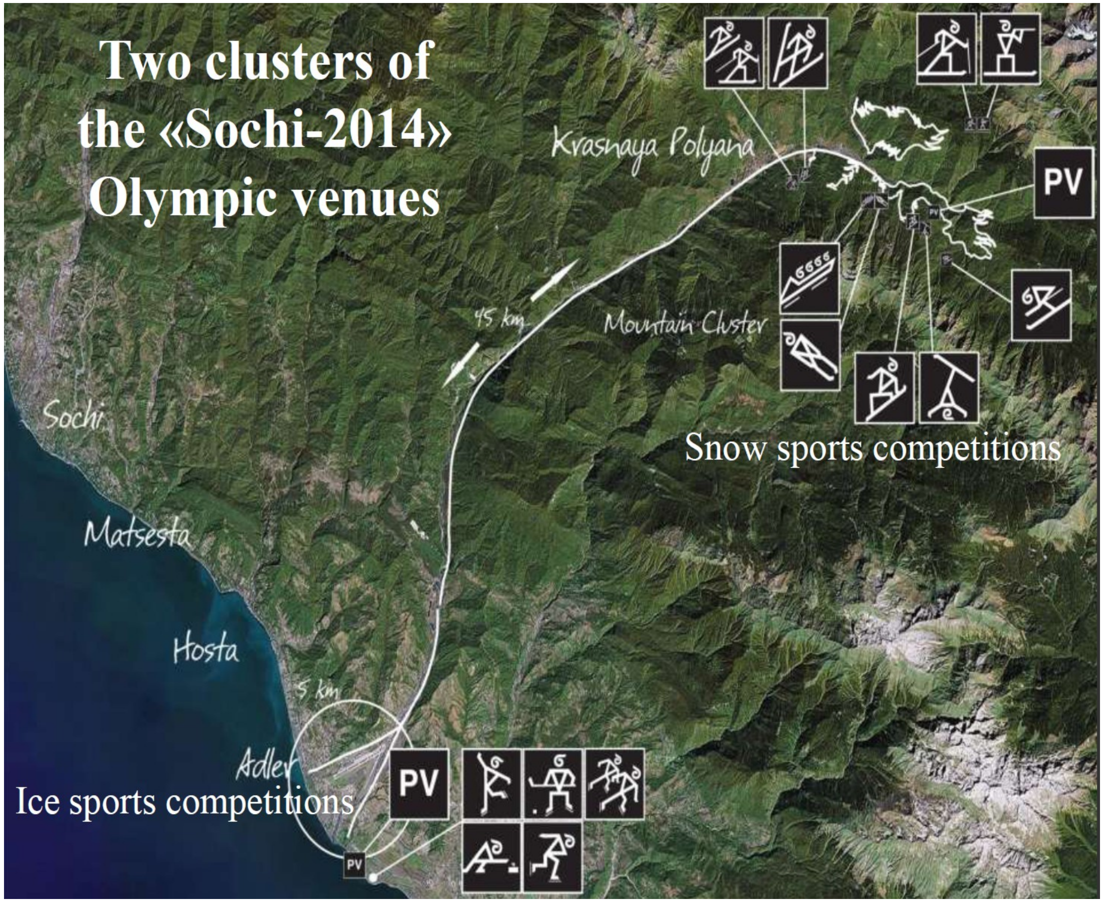
Three parts

- Raw GLAMEPSv1 – FDP
- Calibrated GLAMEPSv1 for venues – RDP
- HarmonEPS - RDP *but run in real time*

IFS ENS (ECMWF EPS) as baseline to compare against

Verification for 31 stations

OLYMPIC TEST PERIOD:
20140115 – 20140331



Introducing GLAMEPS (version 1):

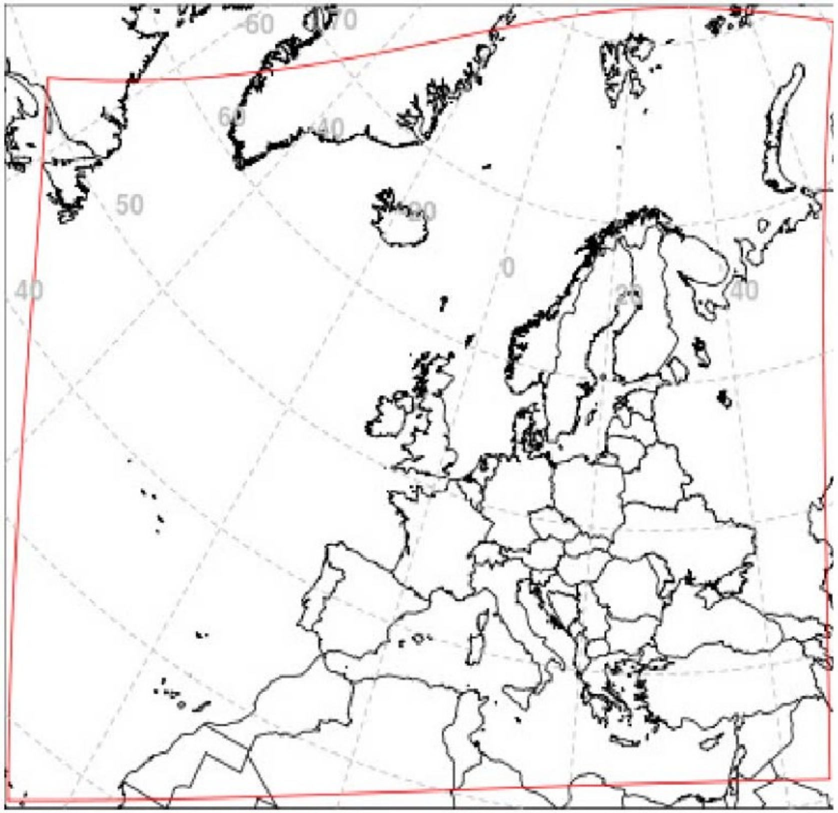
Multi-model, pan-European EPS

54 ensemble members;
4 sub-ensembles:
- Two HIRLAM ensembles with 3D-Var for controls
- One Alaro ensemble (downscaling)
- 14 members of IFS ENS
- One deterministic (IFS DET)

Nested in IFS ENS

- Forecast range: 54h
- 06 and 18 UTC (IFS 00 and 12 UTC)
- All members have surface assimilation cycles
- Stochastic physics in HIRLAM
- Perturbed surface observations
- ~11 km resolution

Runs as Time-Critical Facility at ECMWF,
Replaced by version 2: 26 September 2014



Black frame: Aladin domain
Red domain: Hirlam domain and common output domain

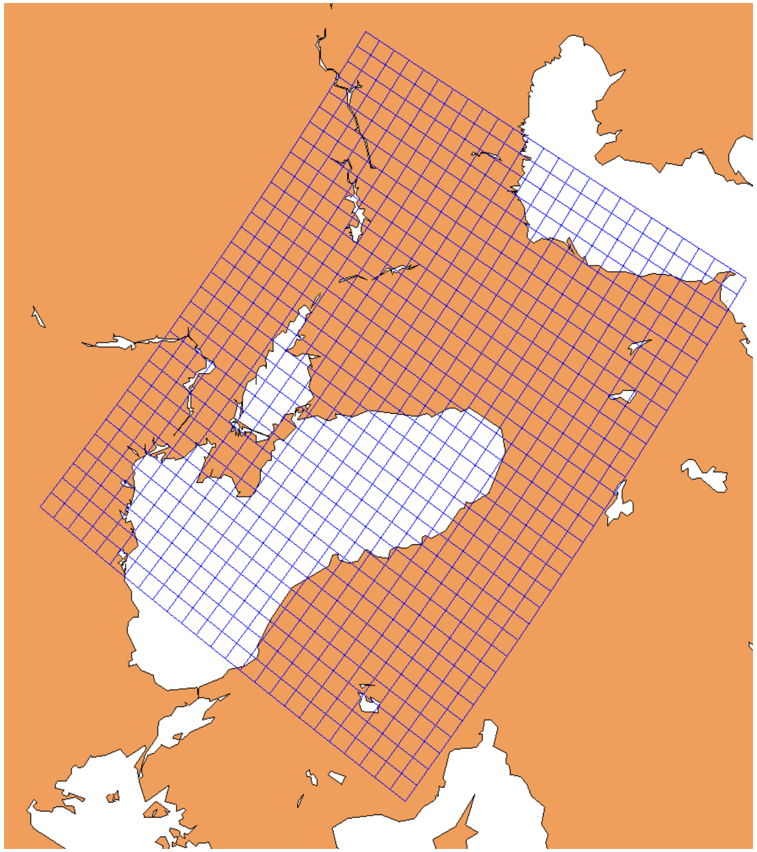
Introducing HarmonEPS for Sochi:

Single-model (Arome), regional EPS

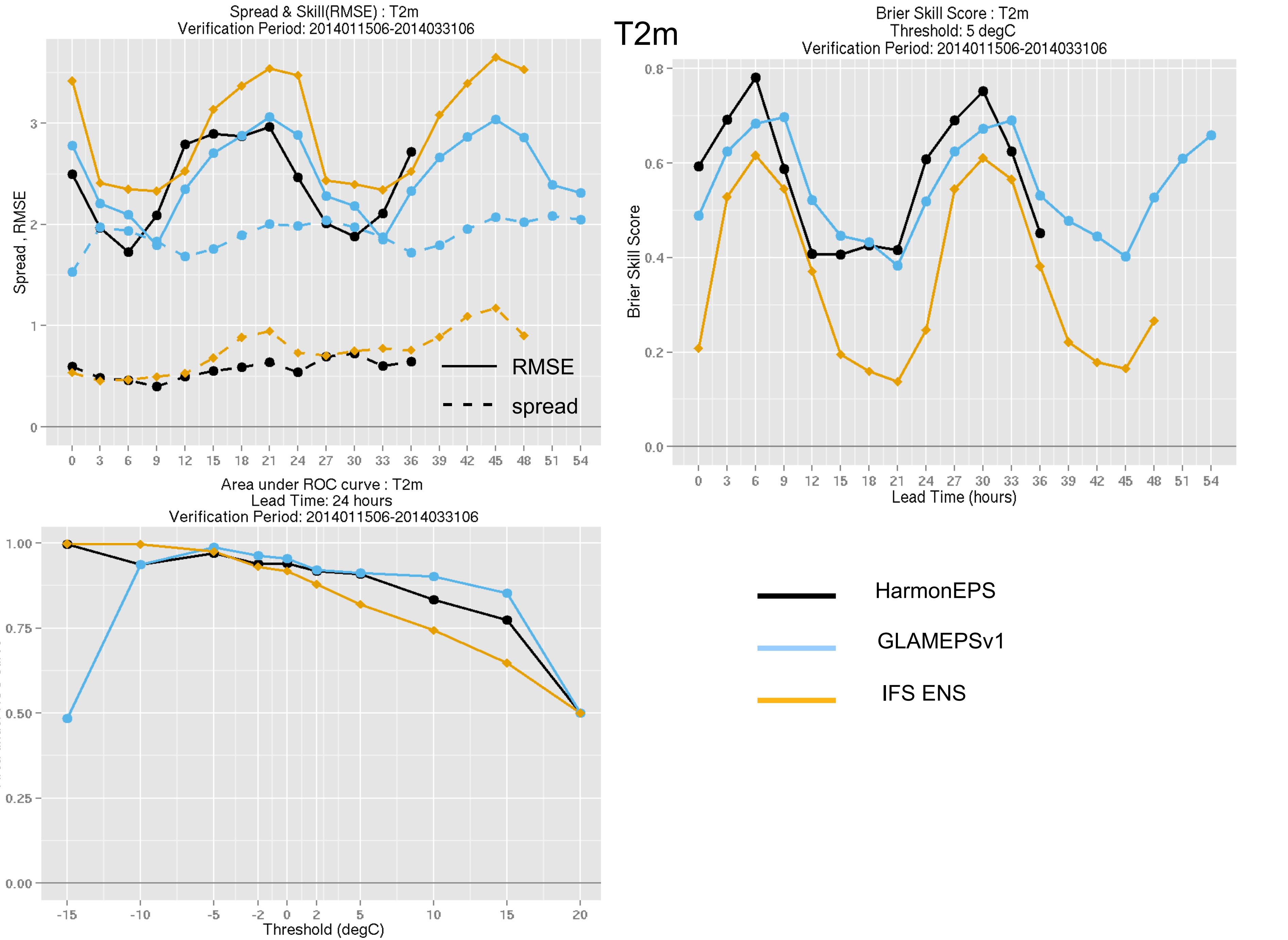
13 ensemble members
Full DA (3D-Var) and 6 hour cycling for the control

Nested in IFS ENS

- Forecast range: 36h
- 06 and 18 UTC (IFS 00 and 12 UTC)
- All members have surface assimilation cycles
- ~2.5 km resolution

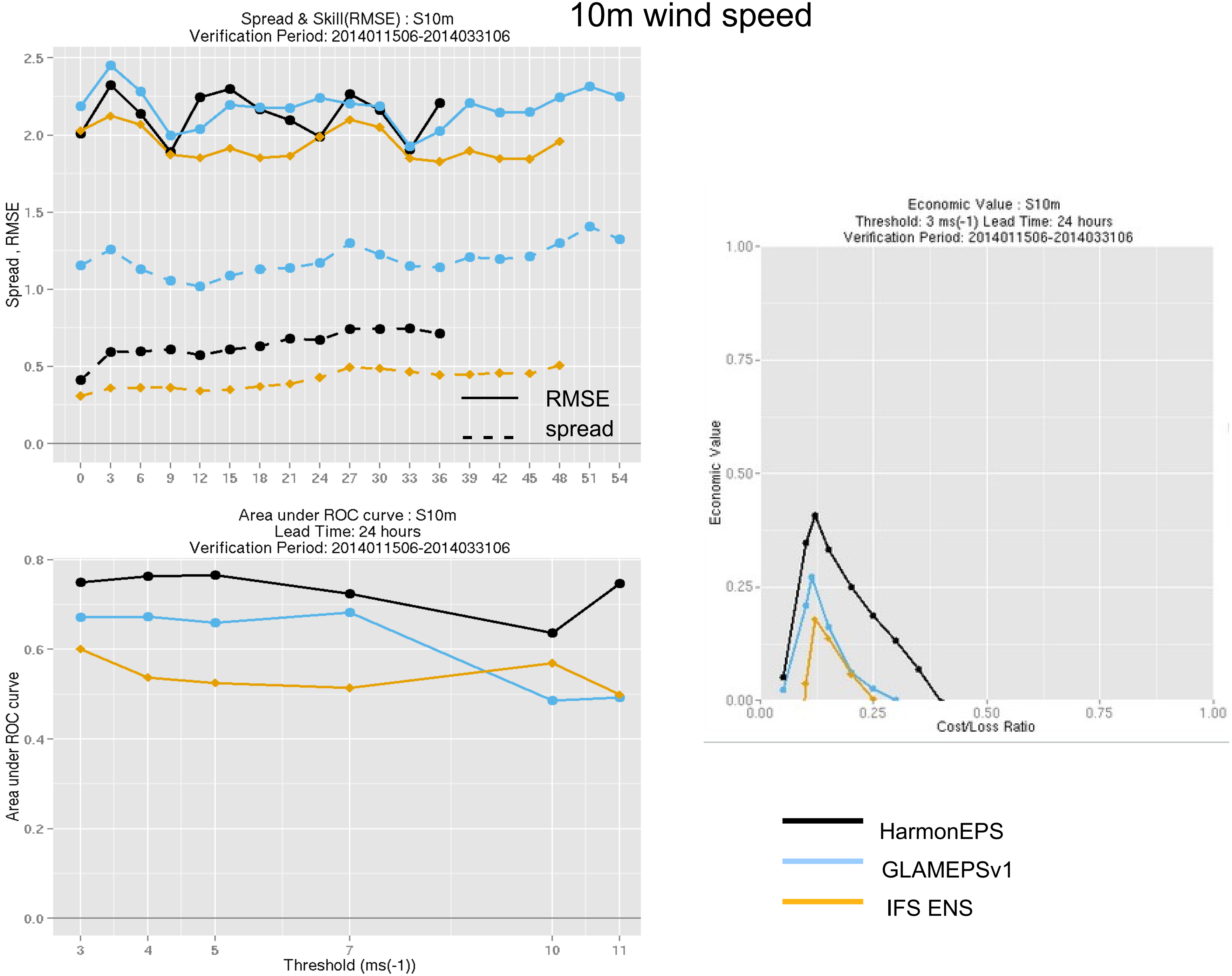


640 x 500 points

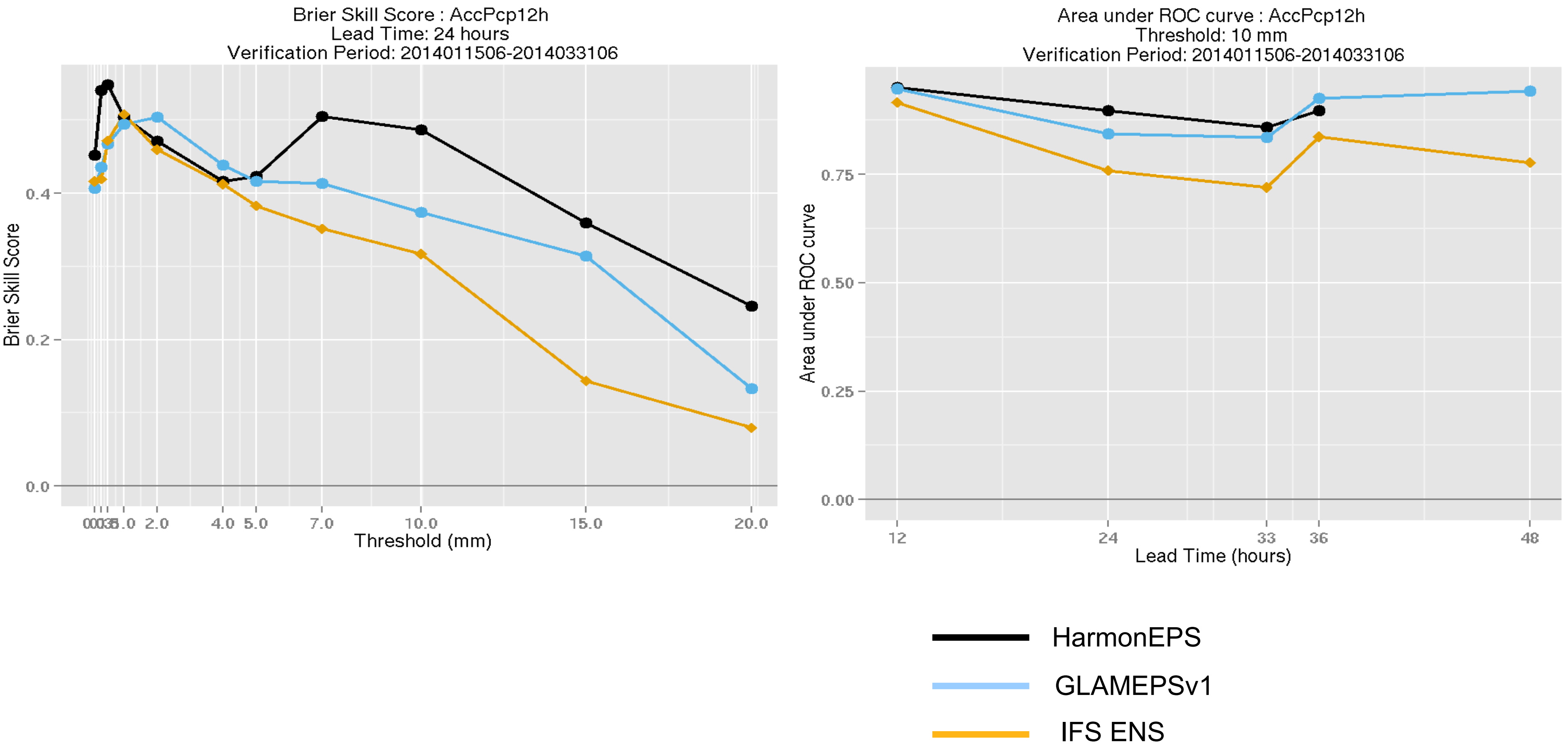


T2m
Spread & Skill(RMSE) : T2m
Verification Period: 2014011506-2014033106
Spread , RMSE
RMSE
spread
Brier Skill Score : T2m
Threshold: 5 degC
Verification Period: 2014011506-2014033106
Brier Skill Score
Lead Time (hours)
Area under ROC curve : T2m
Lead Time: 24 hours
Verification Period: 2014011506-2014033106
Threshold (degC)
HarmonEPS
GLAMEPSv1
IFS ENS

10m wind speed



12h accumulated precipitation



Calibrating GLAMEPSv1

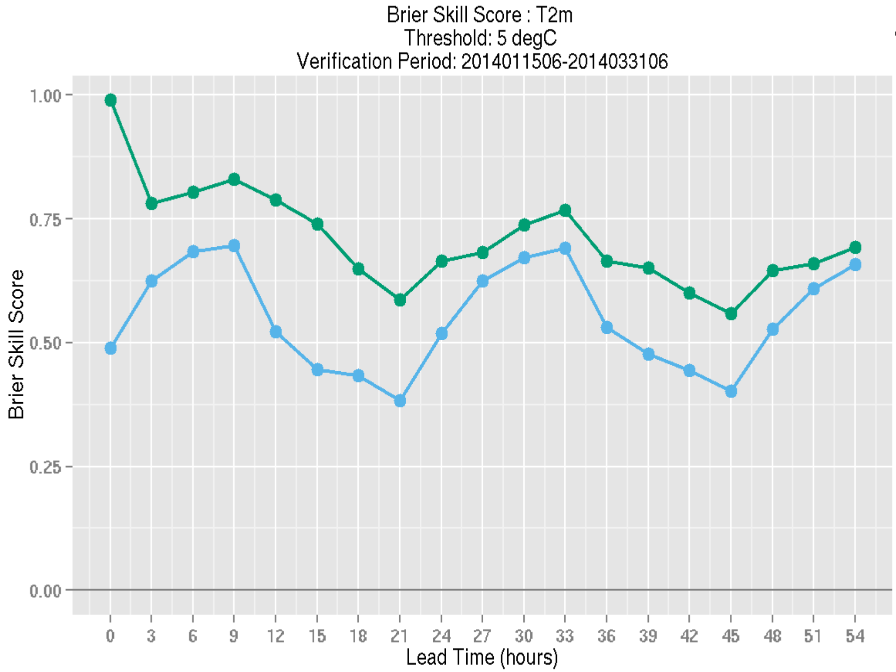
- Goal: Frequently updated forecasts (every hour)
- Probabilistic forecasts for 31 locations (venues)

Calibration method temperature:
Correct bias by weighting the bias from the last couple of days
Update with latest observation
Adjust ensemble spread to be in line with RMSE

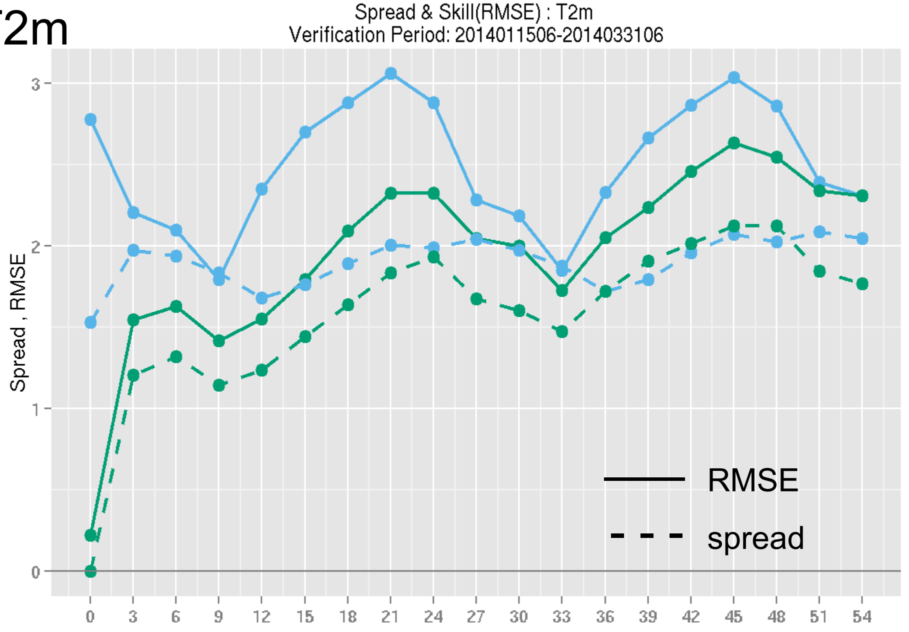
Calibration method wind:
Correct by scaling up or down

Calibration method precipitation:
Correct by scaling up or down

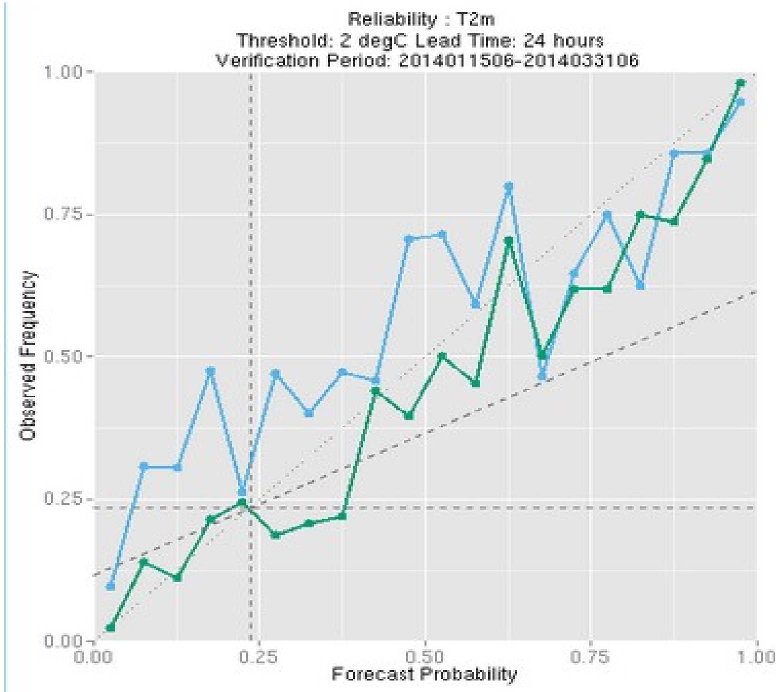
T2m



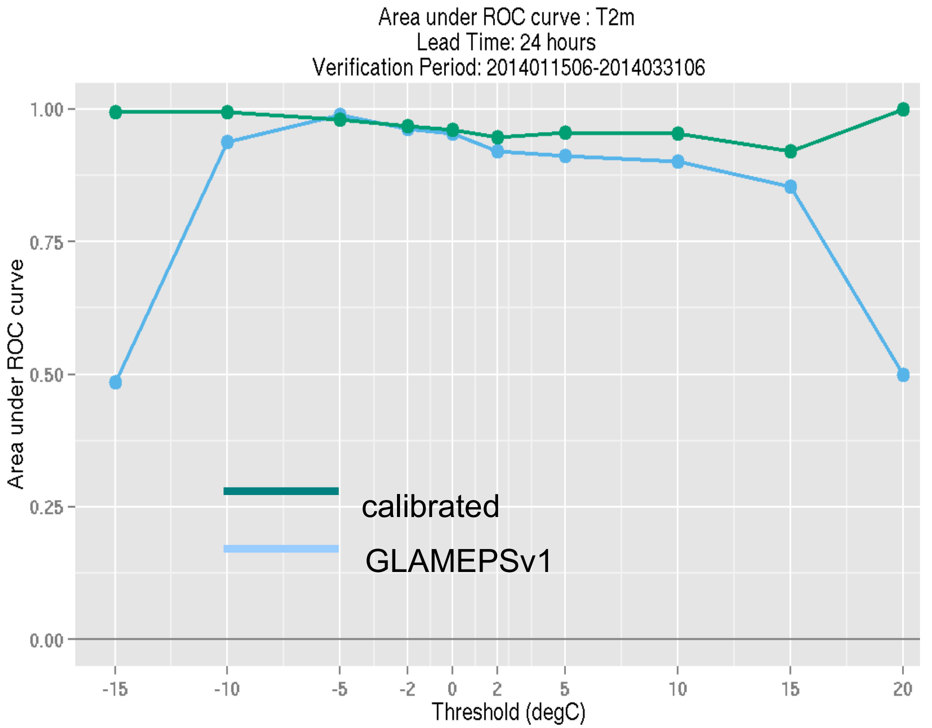
Brier Skill Score : T2m
Threshold: 5 degC
Verification Period: 2014011506-2014033106
Brier Skill Score
Lead Time (hours)



Spread & Skill(RMSE) : T2m
Verification Period: 2014011506-2014033106
Spread , RMSE
RMSE
spread

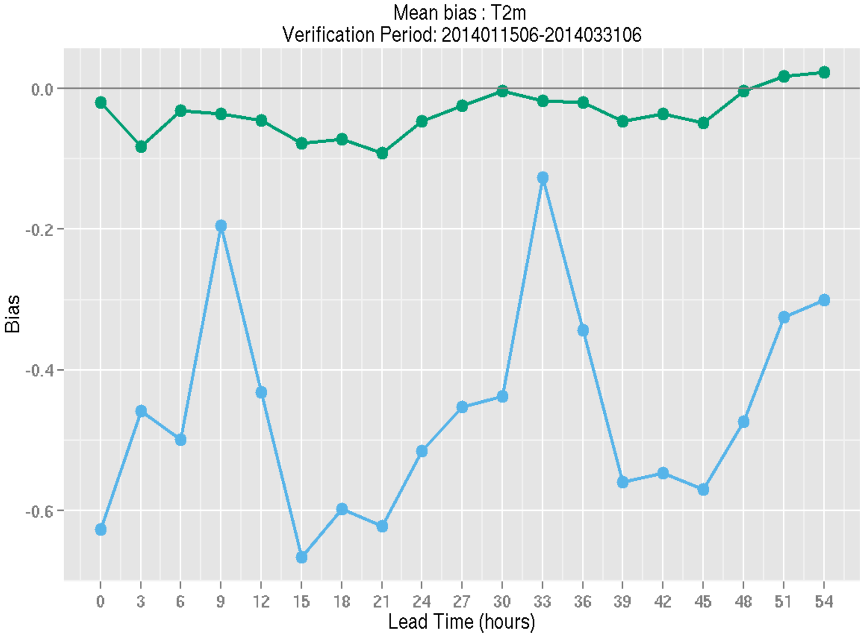


Reliability : T2m
Threshold: 2 degC Lead Time: 24 hours
Verification Period: 2014011506-2014033106
Observed Frequency
Forecast Probability

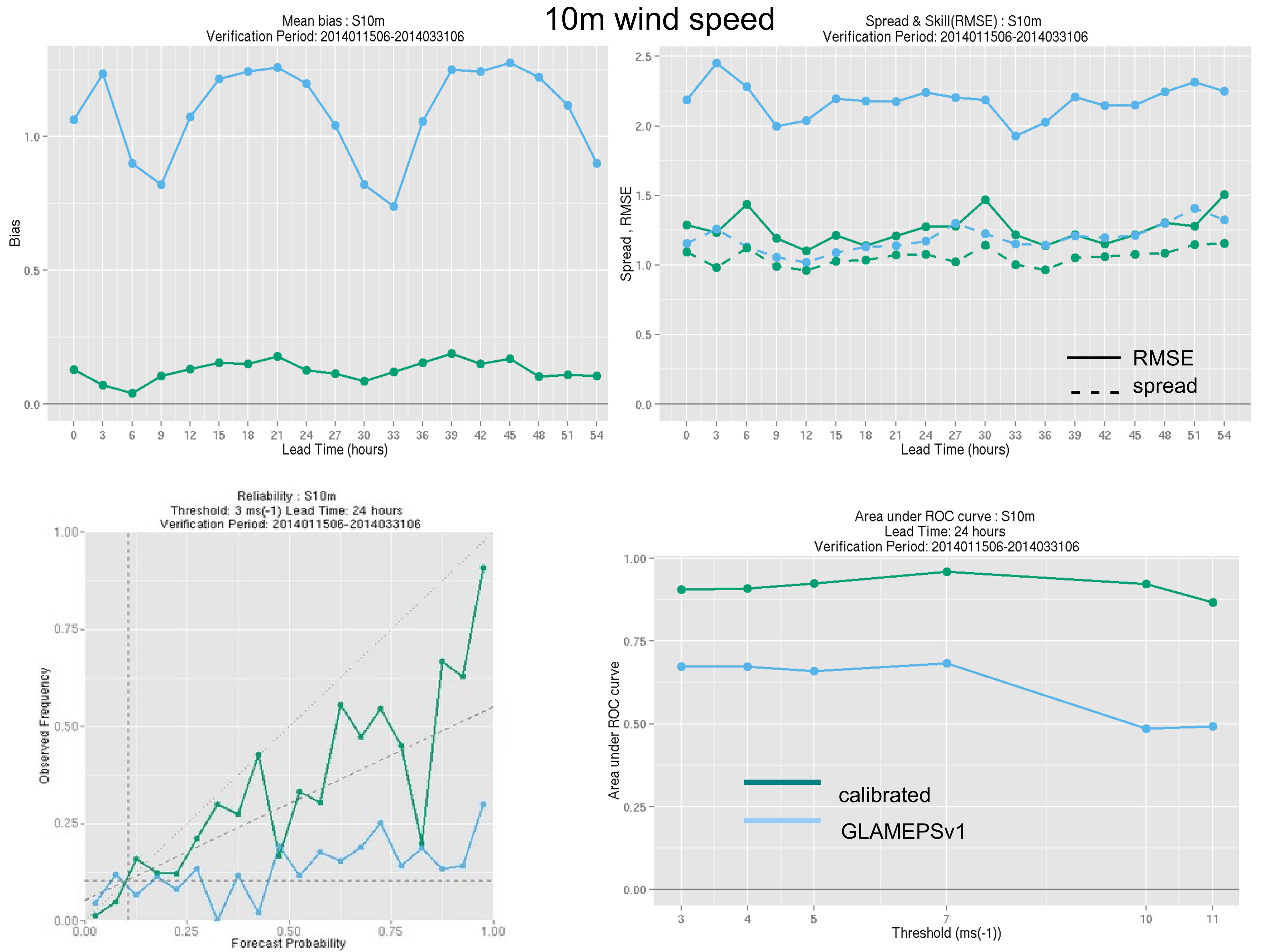


Area under ROC curve : T2m
Lead Time: 24 hours
Verification Period: 2014011506-2014033106
Area under ROC curve
Threshold (degC)
calibrated
GLAMEPSv1

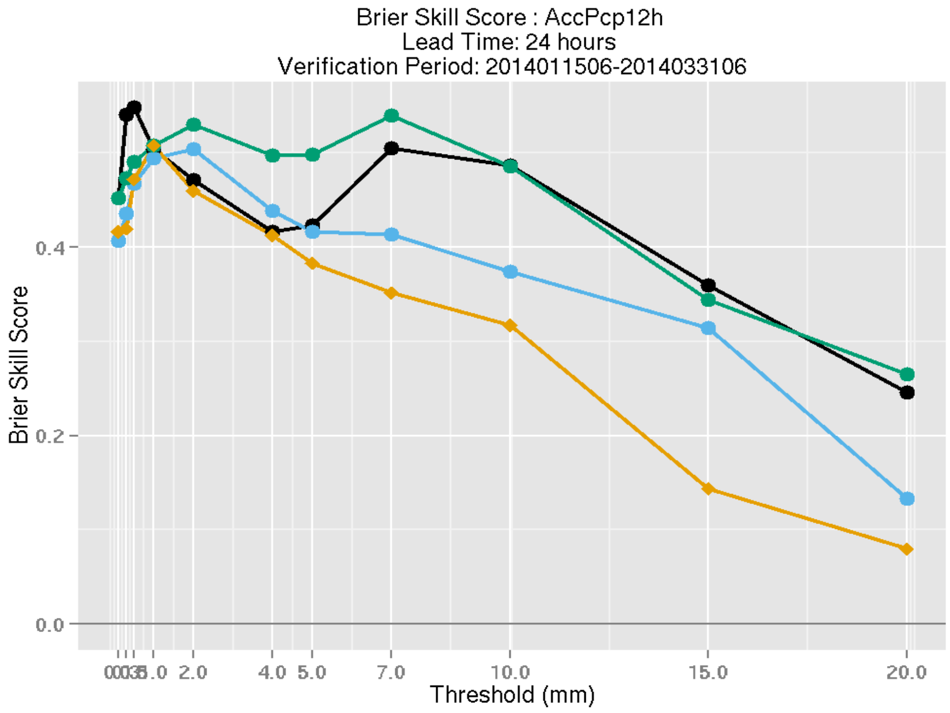
T2m



Mean bias : T2m
Verification Period: 2014011506-2014033106
0.0
-0.2
-0.4
-0.6
Bias
0 3 6 9 12 15 18 21 24 27 30 33 36 39 42 45 48 51 54
Lead Time (hours)


10m wind speed
Mean bias : S10m
Verification Period: 2014011506-2014033106
Bias
Lead Time (hours)
Spread & Skill(RMSE) : S10m
Verification Period: 2014011506-2014033106
Spread , RMSE
Lead Time (hours)
RMSE
spread
Reliability : S10m
Threshold: 3 ms(-1) Lead Time: 24 hours
Verification Period: 2014011506-2014033106
Observed Frequency
Forecast Probability
Area under ROC curve : S10m
Lead Time: 24 hours
Verification Period: 2014011506-2014033106
Area under ROC curve
Threshold (ms(-1))
calibrated
GLAMEPSv1

12h accumulated precipitation

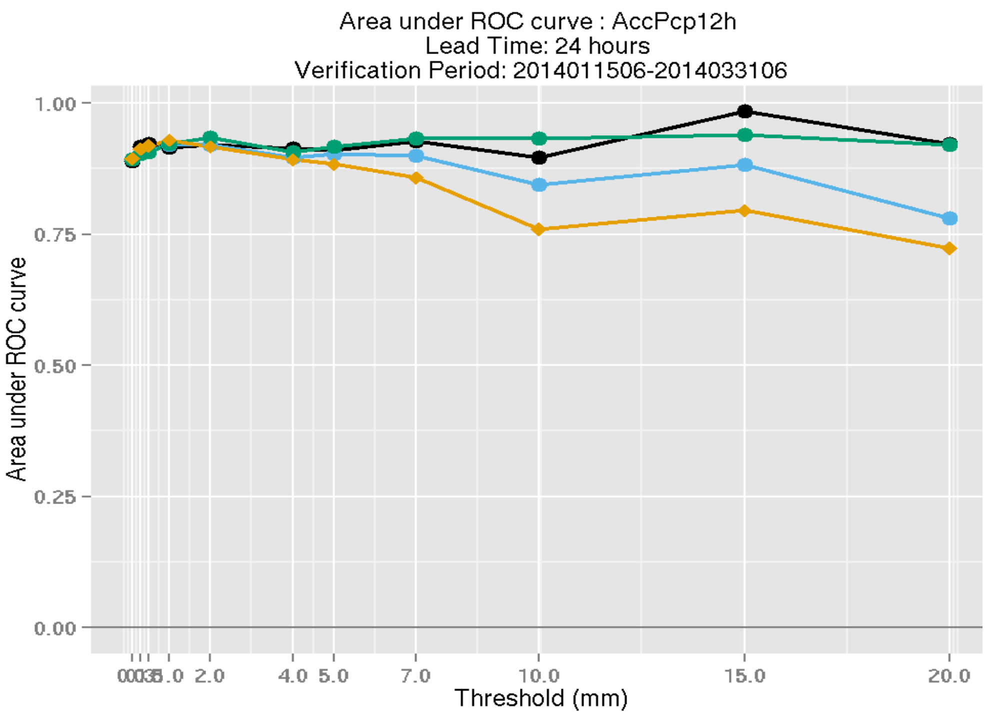


calibrated

GLAMEPSv1

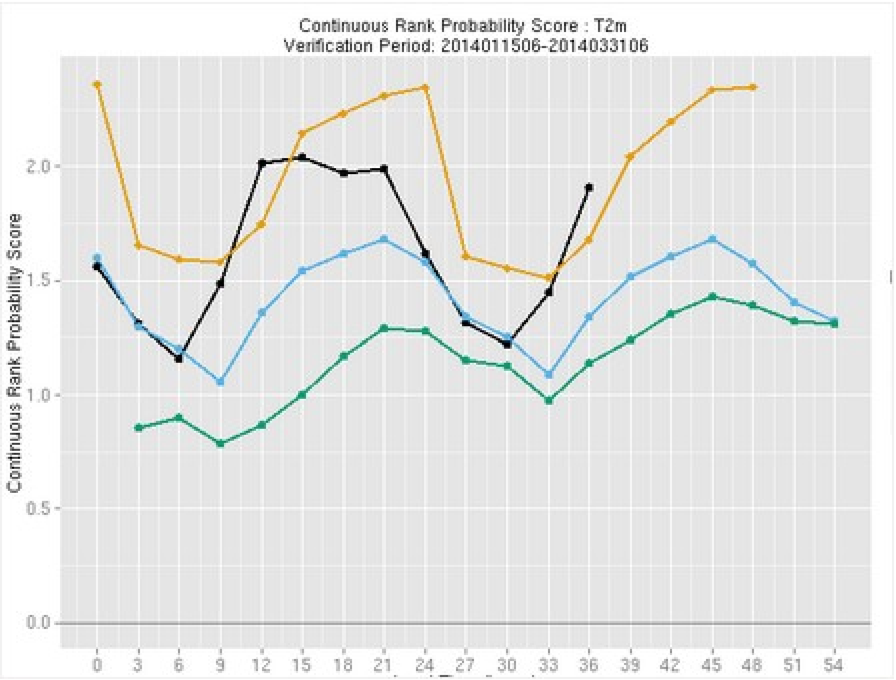
HarmonEPS

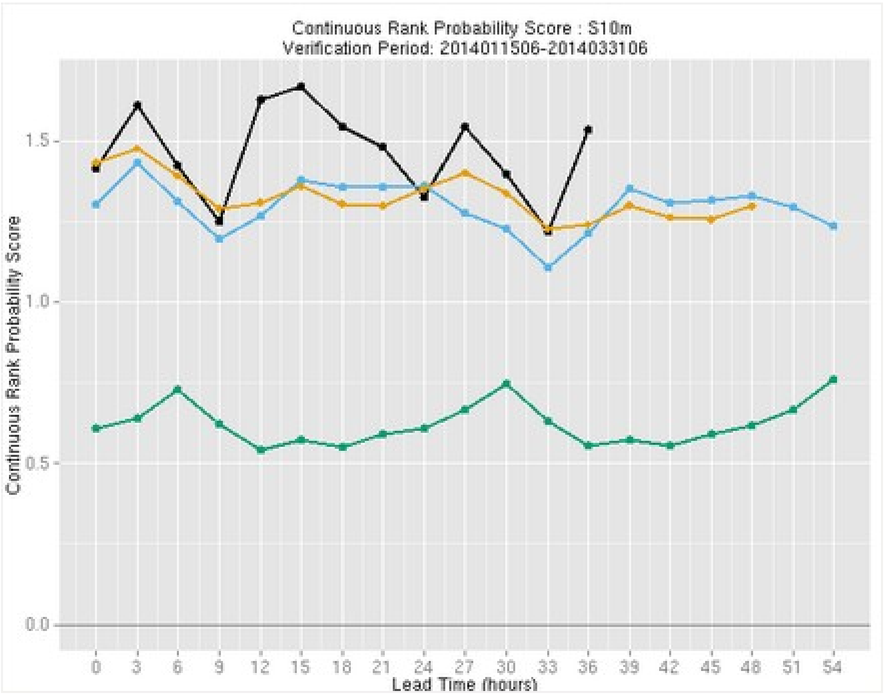
IFS ENS



Summarizing with CRPS

Perfect score: 0





calibrated

GLAMEPSv1

HarmonEPS

IFS ENS

Conclusions

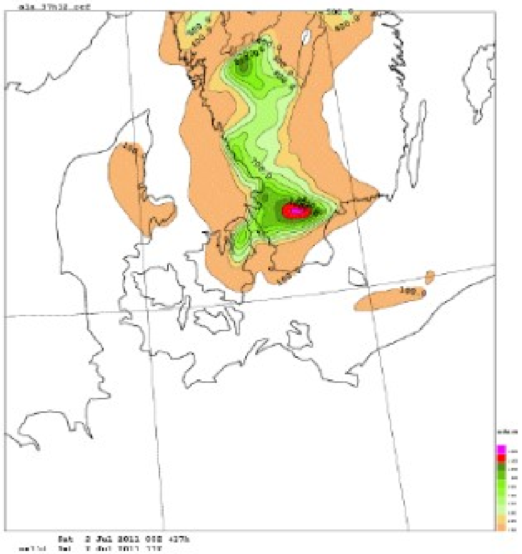
- GLAMEPS scores better than, or at the same level as, IFS ENS
- Calibration is effective in improving the scores for GLAMEPS
- First tests with HarmonEPS: performs reasonably well, even for the simple configuration used here

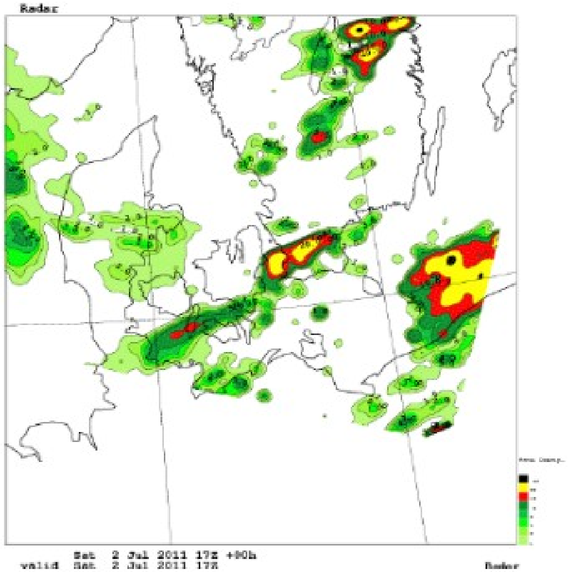
Short about ongoing work and plans: HarmonEPS

Cellular Automata Stochastic scheme

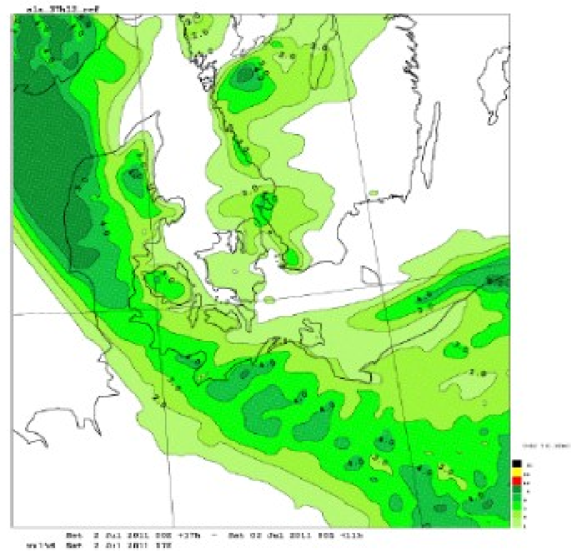
- A large contribution to model construction error uncertainty stems from the statistical representation of deep convection.
- We have studied the impact of a stochastic deep convection parameterization using cellular automata described in Bengtsson et al. (2013), as implemented in the high resolution ensemble prediction system HarmonEPS.
- The scheme use cellular automata within the deep convection param. It is two-way coupled in convection scheme, constrained by CAPE

CAPE (J/kg)

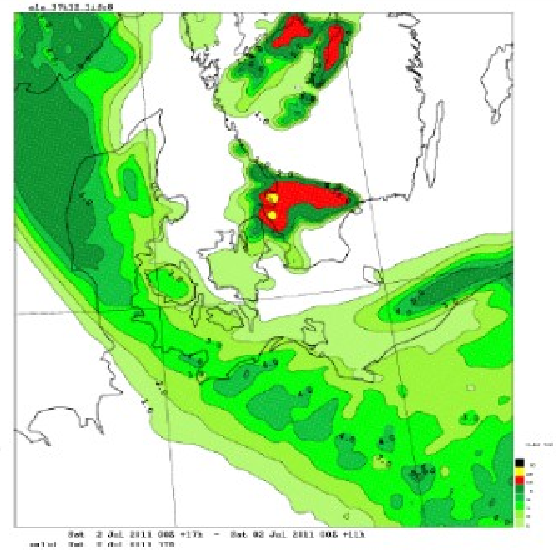




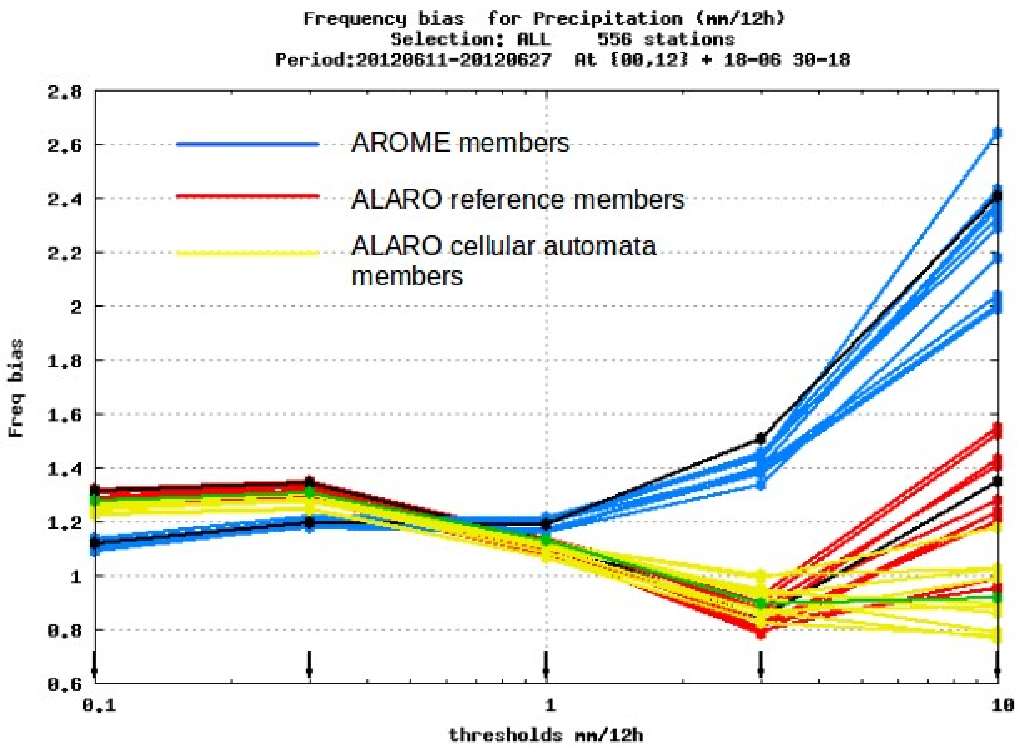
Radar



Reference model



With CA implementation



12 h precipitation

- The cellular automata scheme improves the frequency bias of 12 h acc. precip across all thresholds.
- Presently, the cellular automata scheme reduces the ensemble spread (not shown) due to the reduction of the overestimation of high amounts of precipitation.

Perturbing surface energy fluxes - a first experiment

A key weakness in EPS, particularly at the convection permitting scale, is under disperson of near surface parameters.

A method that perturbs the surface energy fluxes of heat and moisture is currently being tested in HarmonEPS

Surface fluxes in SURFEX

In SURFEX the surface is divided into tiles for ocean, inland water, nature and town. Turbulent fluxes for the nature tile are calculated using the classical bulk aerodynamic formulae:

$$H = \rho_a c_p C_H V_a (T_s - T_a) \tag{1}$$

$$E = \rho_a c_p C_H V_a (q_{sat}(T_s) - q_a) \tag{2}$$

where C_H is the exchange coefficient for heat and moisture:

$$C_H = C_{DN} F_h \tag{3}$$

$$F_h = \left[1 - \frac{15Ri}{1 + C_h\sqrt{|Ri|}}\right] \times \left[\frac{ln(z/z_0)}{ln(z/z_{0h})}\right] if Ri \leq 0 \tag{4}$$

$$F_h = \frac{1}{1 + 15Ri\sqrt{1 + 5Ri}} \times \left[\frac{ln(z/z_0)}{ln(z/z_{0h})}\right] if Ri > 0 \tag{5}$$

$$C_h = 15C_h^* C_{DN}(z/z_{0h})^{p_h} \times \left[\frac{ln(z/z_0)}{ln(z/z_{0h})}\right] \tag{6}$$

$$C_h^* = 3.2165 + 4.3431 \times \mu + 0.5360 \times \mu^2 - 0.0781 \times \mu^3 \tag{7}$$

$$p_h = 0.5802 - 0.1571 \times \mu + 0.0327 \times \mu^2 - 0.0026 \times \mu^3 \tag{8}$$

where μ is $ln(z_0/z_{0h})$ commonly referred to as kB^{-1} and in SURFEX has a fixed value of 2.3.

Perturbing surface energy fluxes - a first experiment

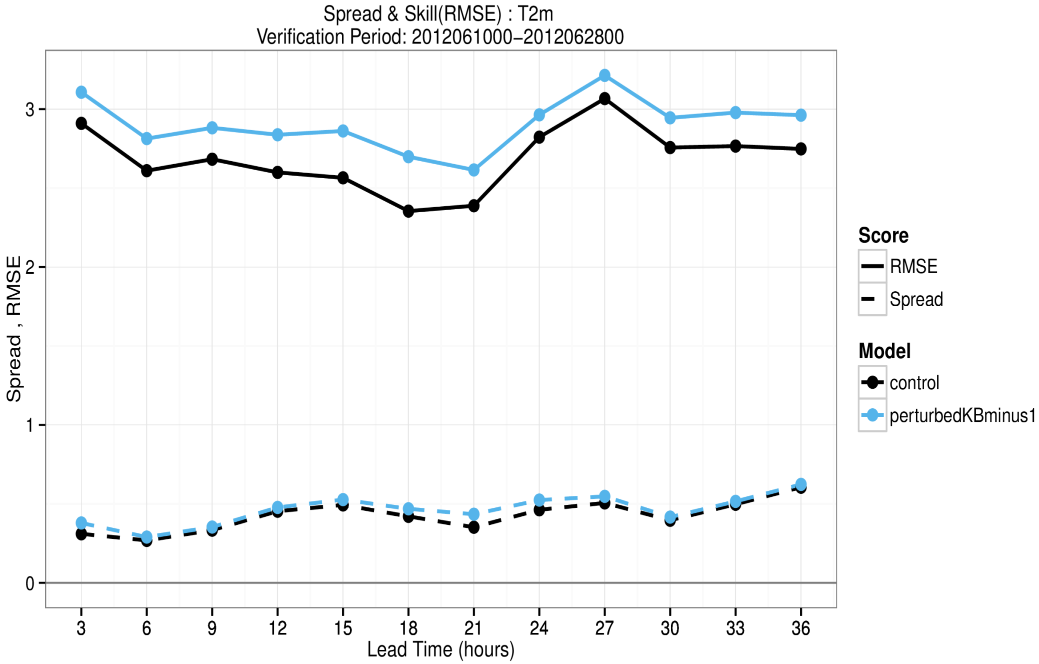
kB^{-1} clearly important in detemening magnitude and direction of turbulent fluxes of heat and moisture via the exchange coefficient C_H

Comprehensively studied over range of artificail and natural surfaces, with considerable range of values obtained. Often used kB^{-1} = 2.3

Here experimented with random values of kB^{-1} in HarmonEPS = [-2.3 , 4.6] (or Z0/ZH = [0.1 , 100])

Test of concept where the same perturbation is applied everywhere (on nature tiles)

Perturbing surface energy fluxes - a first experiment 19 days in summer 2012, 10 members Southern Norway



By randomly varying there is a worsening of scores. Likely due to the same perturbation applied to all vegetation types

Future work will focus on determining appropriate perturbations for different vegetations.

HarmonEPS: Perturbation strategies

Initial condition perturbations:

- Perturbations from IFS ENS
- EDA with 3D-Var
- LETKF

Lateral boundary perturbations:

- Perturbations from IFS ENS
- Difference between deterministic runs / SLAF

Model error

- Multi-physics (Arome and Alaro)
- SPPT
- physics parameter perturbations: learn from experiences LAEF
- stochastic perturbations in several (microphysics, cloud) parametrizations
- Introduce "stochastic physics" on process level, rather than multiplying the total physical tendencies
- Use Cellular Automata (CA)

Surface perturbations:

- Experiment with perturbations of surface parameters (e.g. soil moisture, albedo, snow, SST, LAI, vegetation fraction, roughhness length and soil temperature)
- surface physics: study perturbations in momentum, heat and moisture flux parameterizations

Thank you