Grand Limited Area Model Ensemble Prediction System

GLAMEPS and HarmonEPS:

LAM ensemble prediction systems under development.

Trond Iversen and Alex Deckmyn

and all co-workes

A common project for operational EPS in the short-range in the HIRLAM and ALADIN SRNWP consortia

SRNWP/EWGLAM Tallinn, Oct. 2011

The purpose of EPS

Since errors in initial data, boundary data, and prediction model grow and gradually destroy prediction accuracy,

a well calibrated EPS provides three elements of weather forecasts

1. The ”consensus” forecast: contains at any lead time all, and nothing more than, the predictable components;

2. Reliable forecast uncertainty of the ”consensus”;

3. Reliable probabilities of events relevant for individual users

   (with max possible forecast resolution,

   i.e. the sharpness of information matches the predictability ”of the day”).

The intention of GLAMEPS

- To provide member weather services operational probabilistic forecast for the next 2-3 days in a pan-European domain with grid-resolution 10-12km.
  - To be run as Time-Critical Facility at ECMWF

- The main success criterion is better forecast quality and potential value than operational ECMWF EPS.
  - Preliminary experiments have been successful
  - The multi-model approach is crucial

R&D for further improvements include:

- Multiple analyses for surface model
- Utilizing high-res deterministic EC forecast ats BC for control forecast
- Increase the number of Aladin ensemble members
- Use the entire set of EPS-members at BC
- Include ETKF or EDA in hybrid mode with 3DVar
- Include high-resolution, short-range, singular vectors for CAPE
- Statistical post-processing for bias- and variance-corrections and multi-model combination

The intention of HarmonEPS

- To provide to the member weather services a prototype probabilistic forecast system on non-hydrostatic, convection-permitting scales
  - Not pan-European
- To enable reliable predictions of probabilities for high-impact weather events which are confined in space and time by:
  - Meso-scale dynamical structures
  - Orographic and other fine-scaled surface forcing

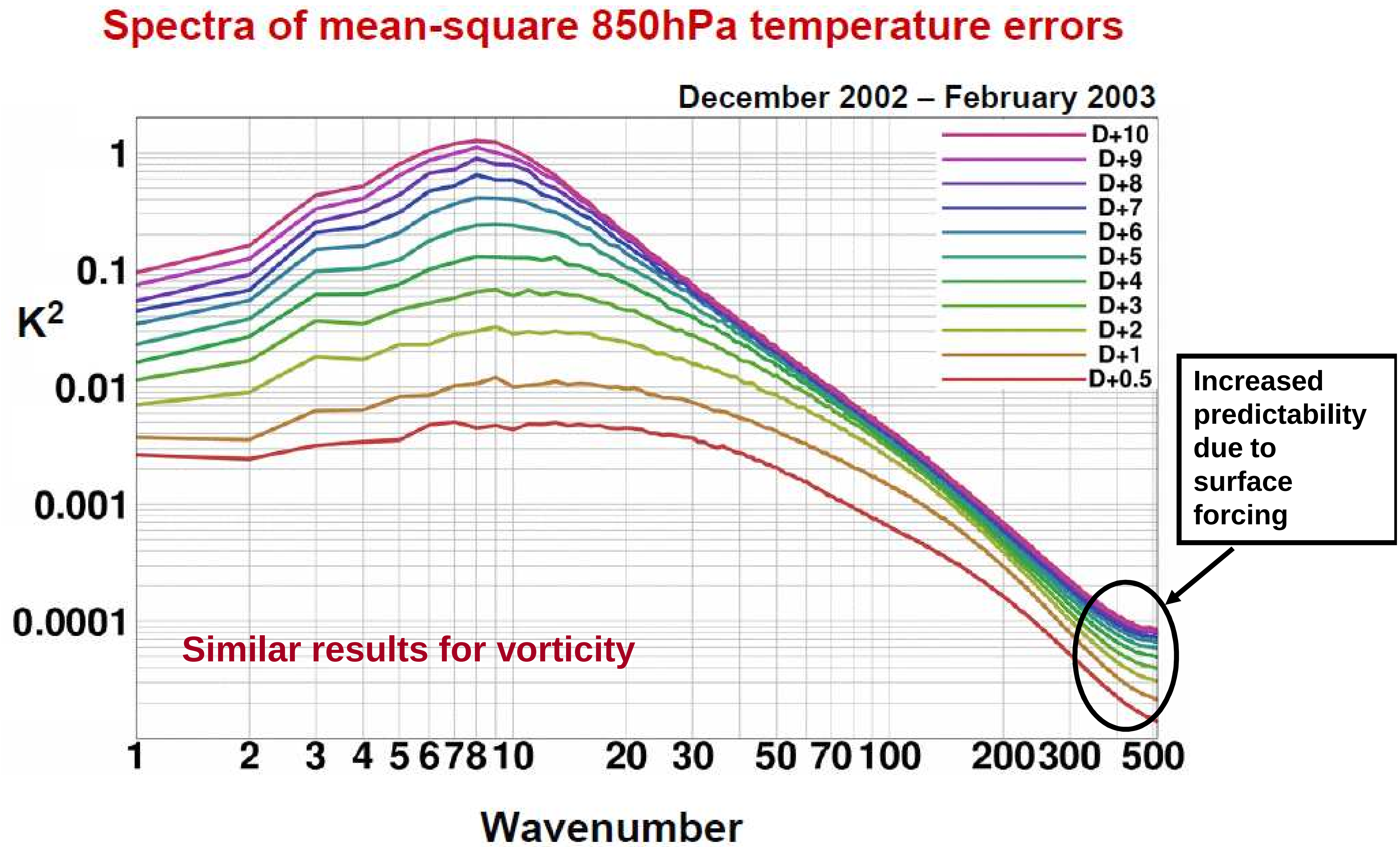
Challenge: high-impact weather

- **High-impact weather often involves a wide spectre of scales, for which:**
  - the larger ”synoptic” scales condition the potential of occurrence
  - the smaller embeded ”meso-”scales determine the structure of the extreme features

    (peak precip. and wind; fast temp. changes; etc.).

- **Key issue: to transform the predictability on the meso-scales into skilfull and valuable predictions**
  - the large growth rate and low saturation level of small scale errors is a limiting factor for predicting high-impact weather

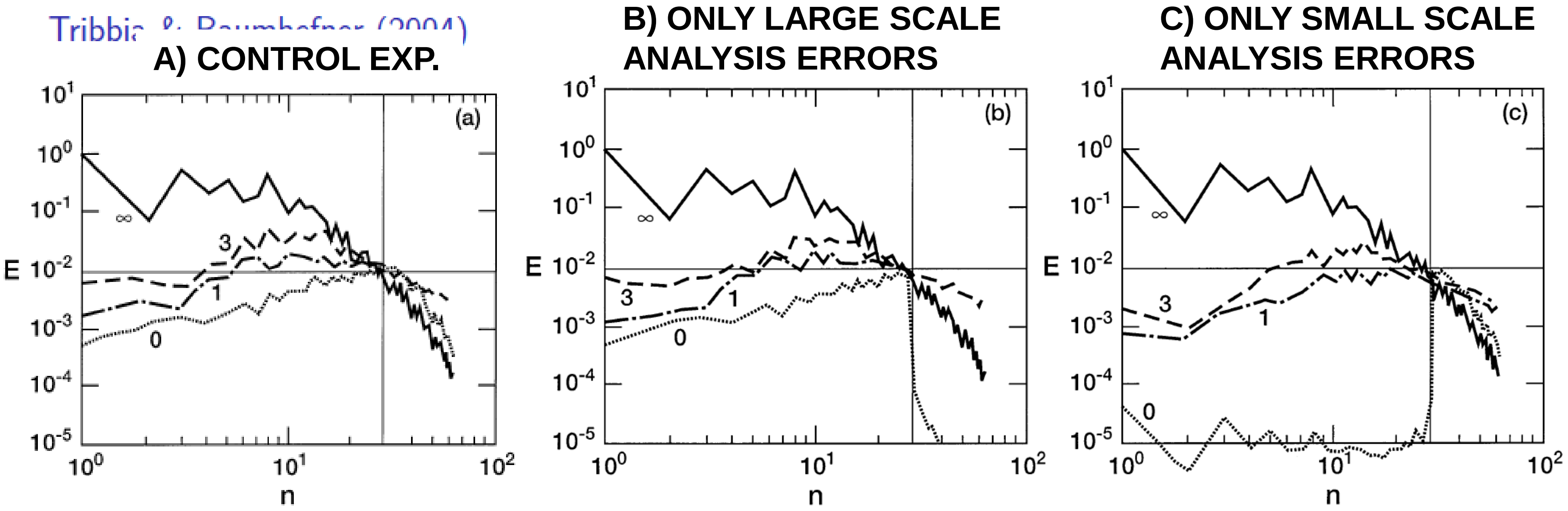
Predictability as a function of scale



Courtesy: A. Simmons; ECMWF

Upscale loss of predictability

Tribbia & Baumhefner (2004):
”Perfect-model” Predictability experiments with NCAR CCM3 AGCM



A) Errors grow simultaneously on all scales but saturate first on the smaller.

B**)** Small-scale initial errors (n>30) = 0 => no impact on forecasts after day 1.

C**)** Large-scale initial errors (n<30) =0 => ~1 day delay in error growth,
but only for the large scales

Challenge: high-impact weather

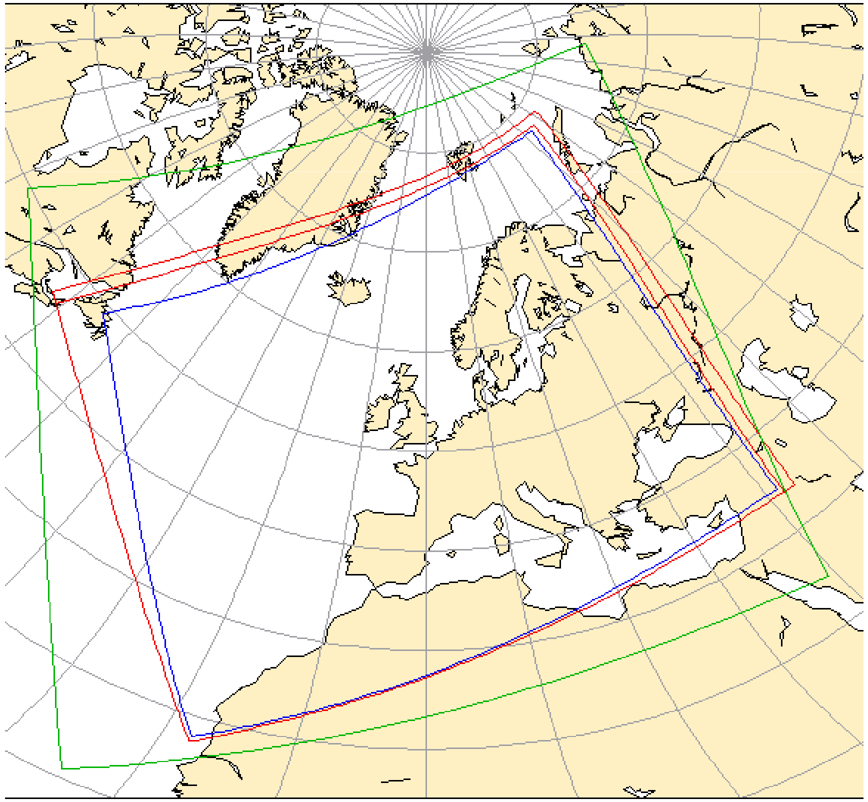
- Fast meso-scale error growth reaching saturation before ~1 day, imply that predicting extreme-weather requires
  - high spatial resolution with frequent updates (”RUC”)
  - very accurate and swiftly produced analyses
  - But: the large-scale flows that potentially embed high-impact weather can normally be predicted much longer

- Possible exception:
  - Extended-range predictability may occur for fine-scale surface forcing that interact with predictable large-scale flows. Leaves some hope for dynamical downscaling.

Tests with pre-operational GLAMEPS_v0 for the "synoptic" scales:

52 ensemble members; 13 per model .

EC EPS (12 + 1) + HirEPS_K (12+1)
+ HirEPS_S (12+1) + AladEPS (13) = 52



- ***~13km grid resolution***

(Aladin 509x416, 12.9km,L37);
(Hirlam 486x378, 0.115deg,L40)

- ***Forecast range: 42h***

- ***Multimodel approach:***

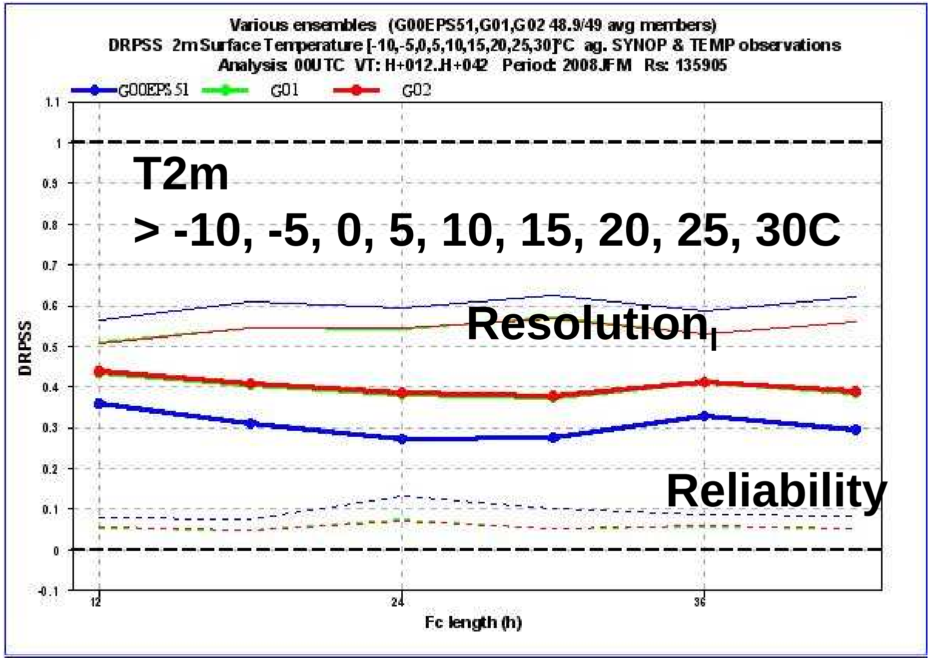
2 versions of Hirlam (different cloud / precipitation schemes
2 different LAMs (Aladin and Hirlam)
3 different analyses and control forcasts
(EC EPS_00, HirEPS_K_00, HirEPS_S_00)

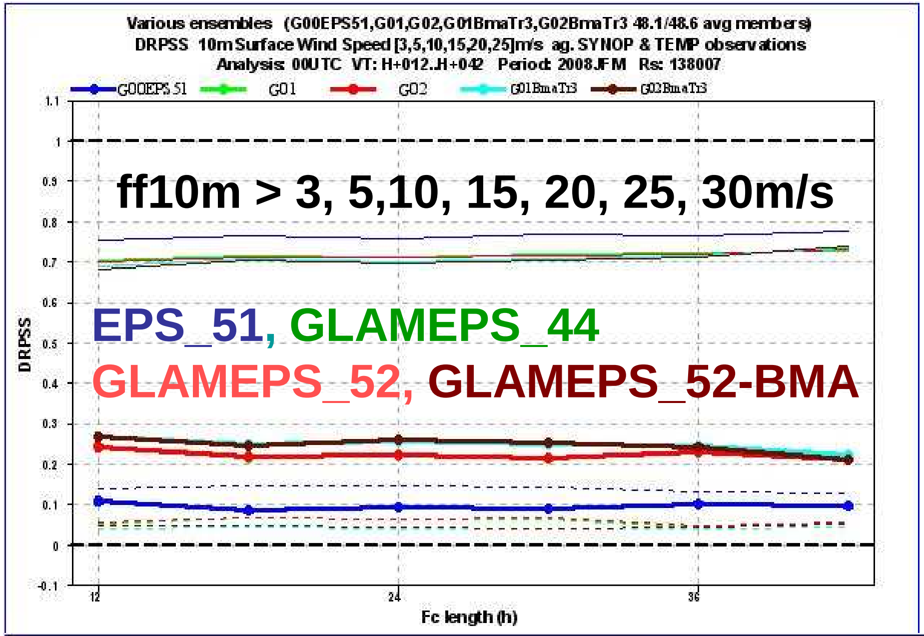
GLAMEPS

Descrete Ranked probability skill score – DRPSS

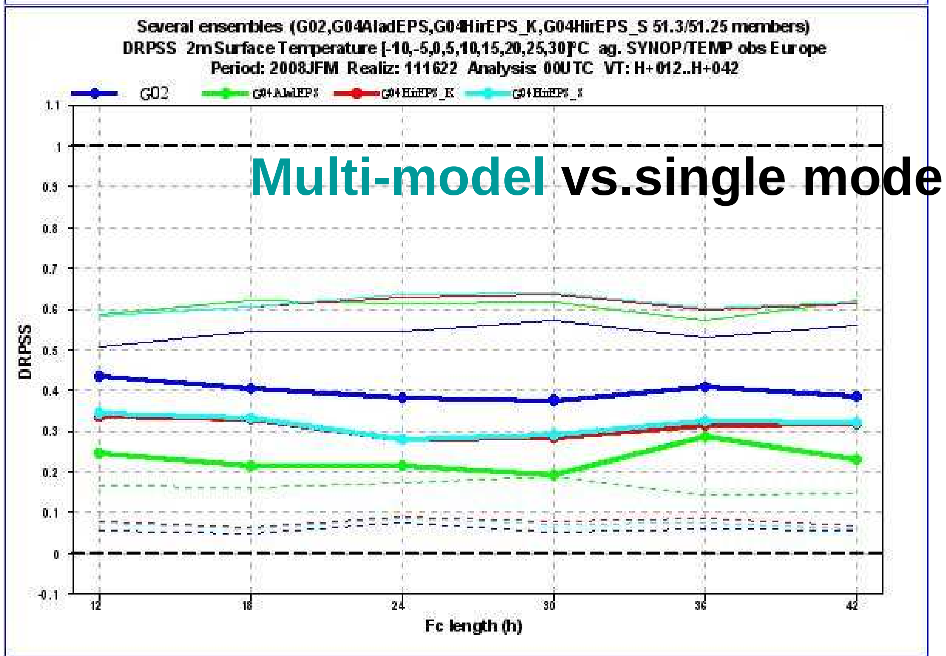
2008/0117 - 0308 (00, 12) Using T399L62 EuroTEPS, BEFORE EDA in ECEPS

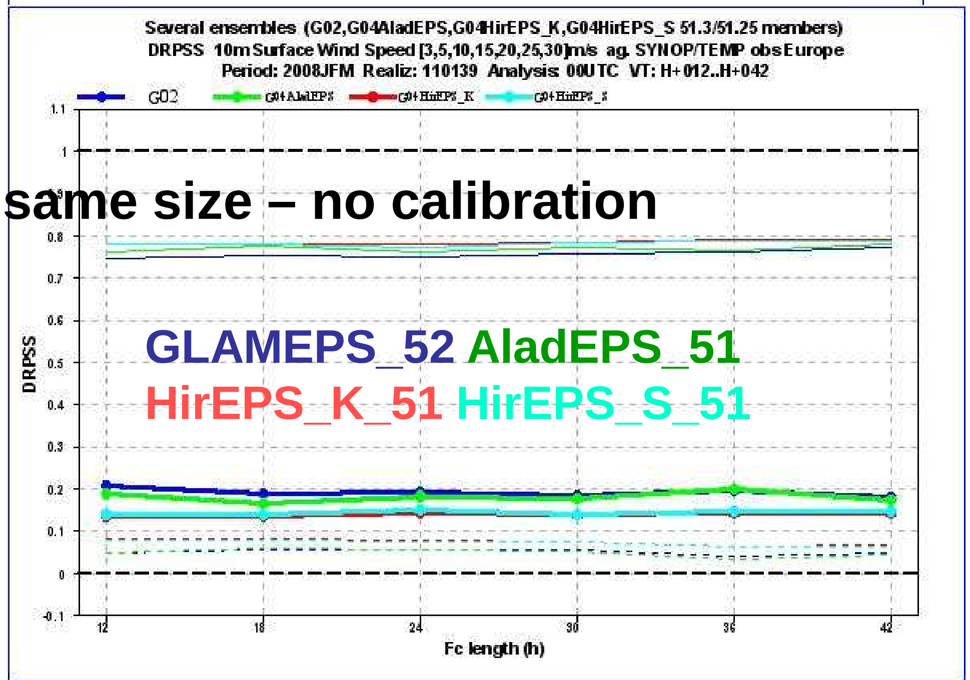
[DRPSS = 1 - Reliability - Resolution]





Multi-model vs.single model EPS of same size – no calibration

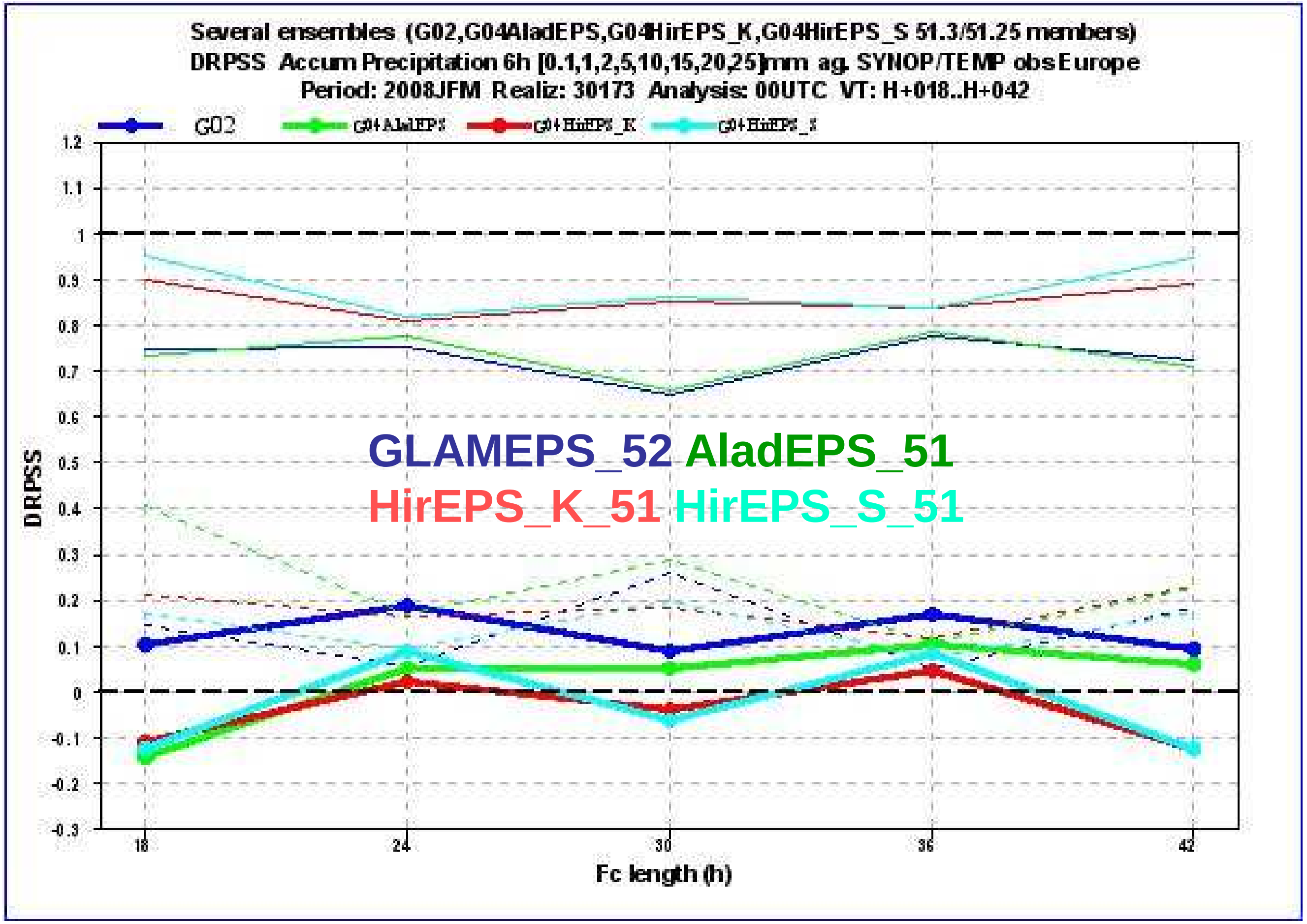




DRPSS 12-42h, 6h Precip

Multi-model vs.single model EPS of same size – no calibration

Pr6h > 0.1, 1, 2, 5, 10, 15, 20, 25, mm/6h

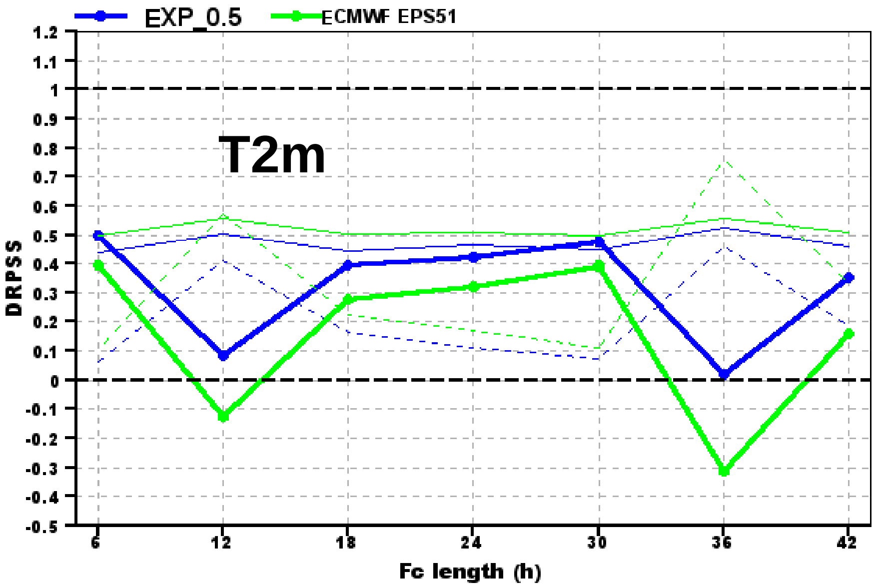


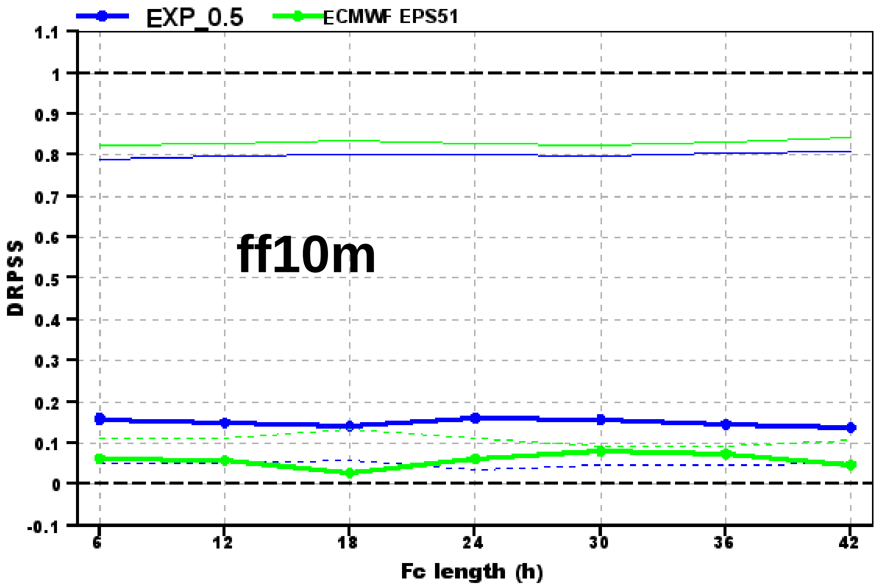
Pre-operational GLAMEPS.org

Aug-Sept-Oct 2010

Verification of 52-member GLAMEPS
compared with operational 51-member ECEPS T639L62 & EDA

DRPSS 12-42h

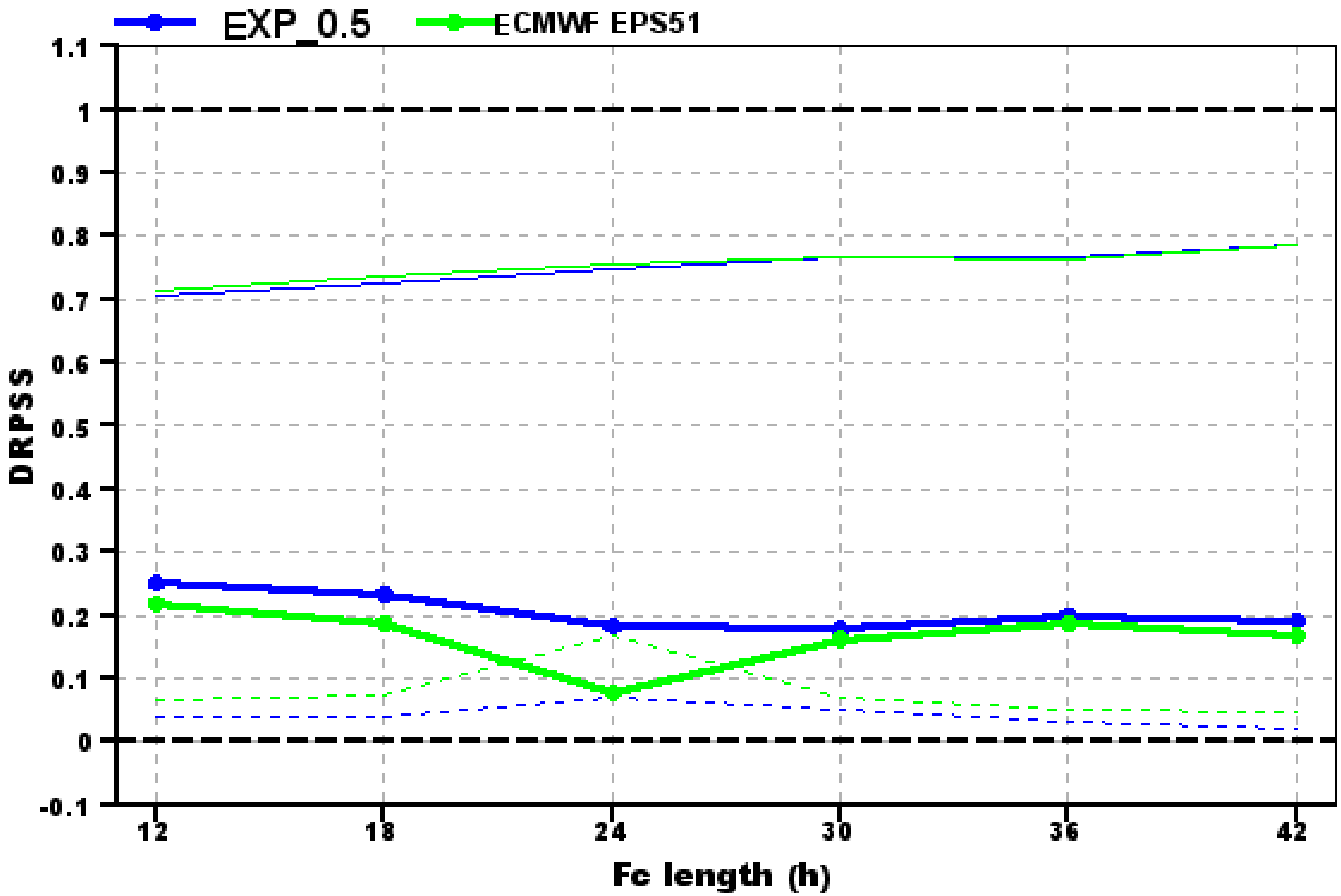




Verification GLAMEPS.org

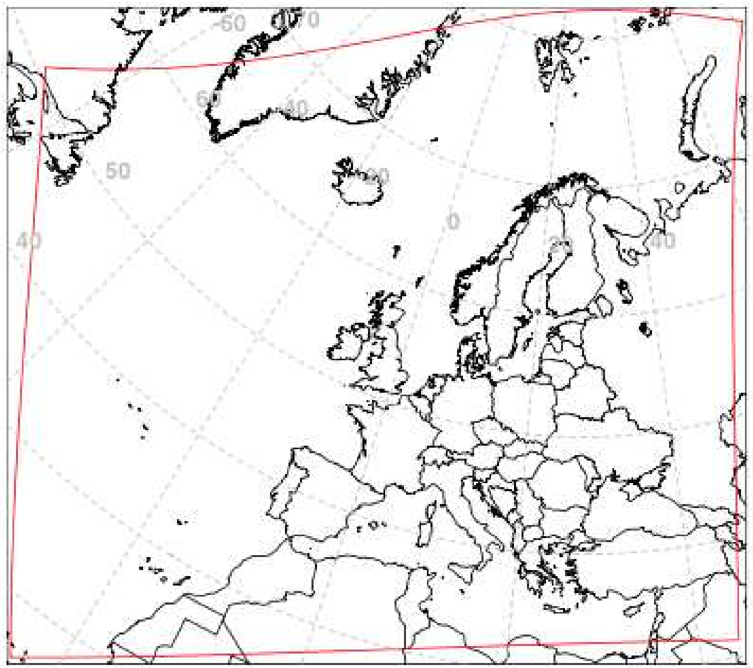
Aug-Sept-Oct 2010

DRPSS 12-42h, 6h Precip



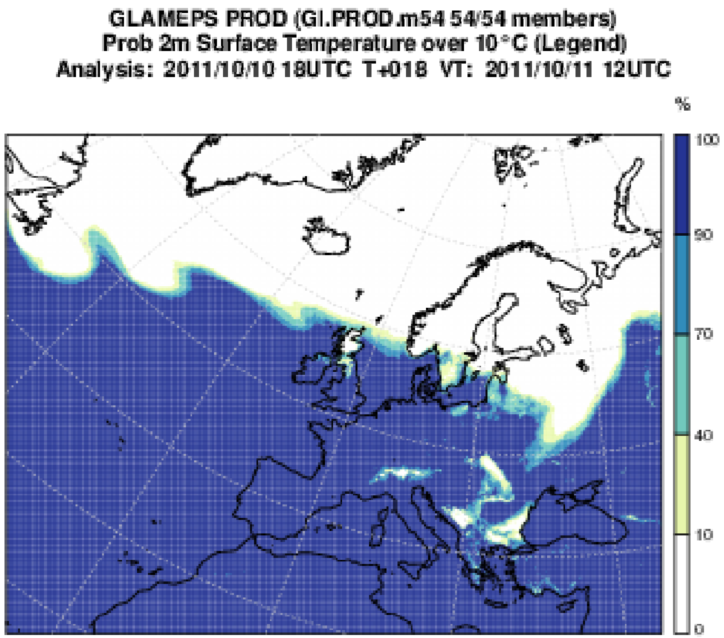
Summary on GLAMEPS_v0

- Improvement over operational EC EPS for the short range
- Multi-model better than single model EPS
  - Exceptions exist: systematic un-even model quality
  - Statistical post-processing is difficult for rare events
- An upgraded GLAMEPS is underway to operational – NEW domain:



GLAMEPS v1

- Running at 06 and 18h
- +54h



Experimental combination of GLAMEPS_v0 and LAEF

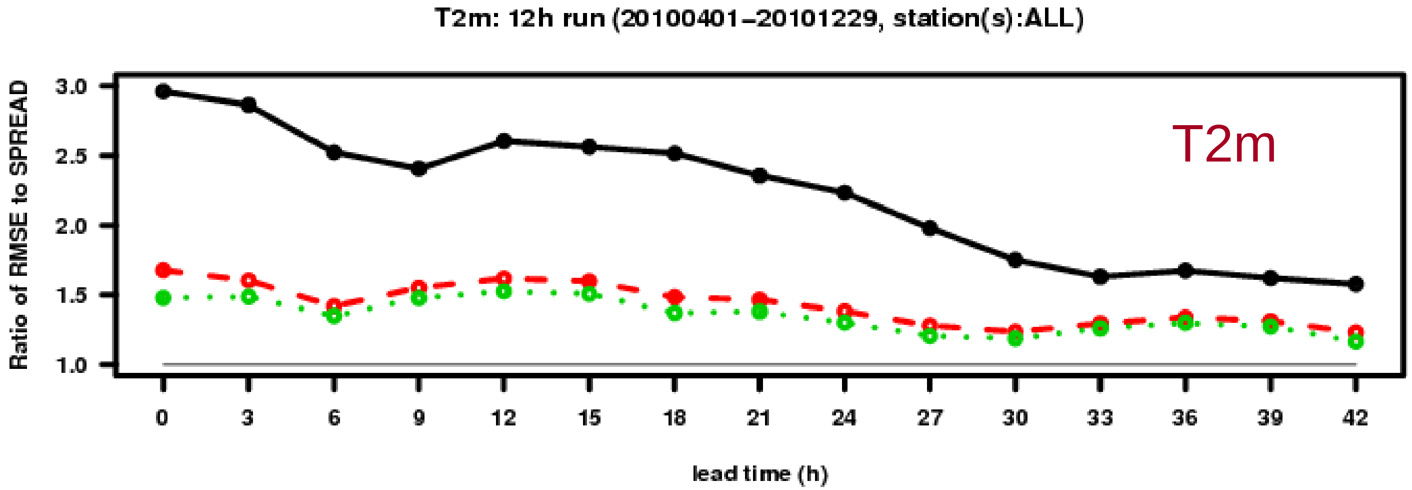
Geert Smet, KMI

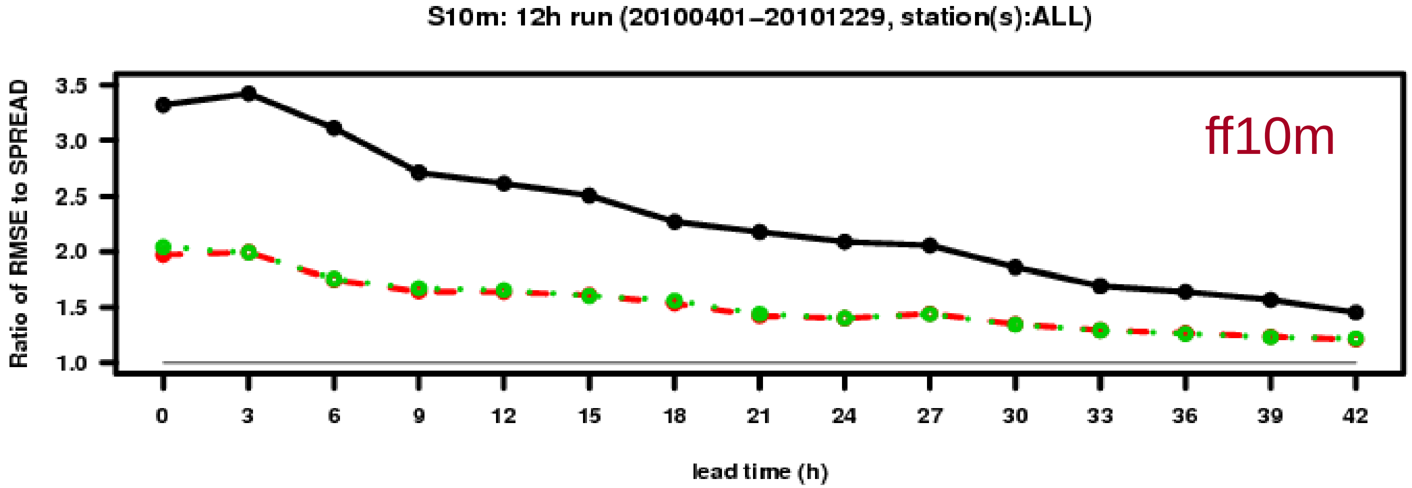
- We compare GLAMEPS and GLAMEPS-LAEF with ECEPS (EPS of ECMWF) over Belgium.
- Scores are averaged over 10 standard stations in Belgium.
- Verification period: 01/03/2010-29/12/2010 (forecast dates).
- Only T2m (2-meter temperature) and S10m (10-meter wind speed) for now.

Bias-correction

- Subtracting, for each forecast, the bias over the previous 28 days before any combination.
- The verification period of the bias corrected data is 01/04/2010-29/12/2010 (with observation data from 01/04/2010-31/12/2010).

Ratio of + 12h RMSE to RMS-spread of bias-corrected
ECEPS (black full line),
GLAMEPS (red dashed line) and
GLAMEPS-LAEF (green dotted line)



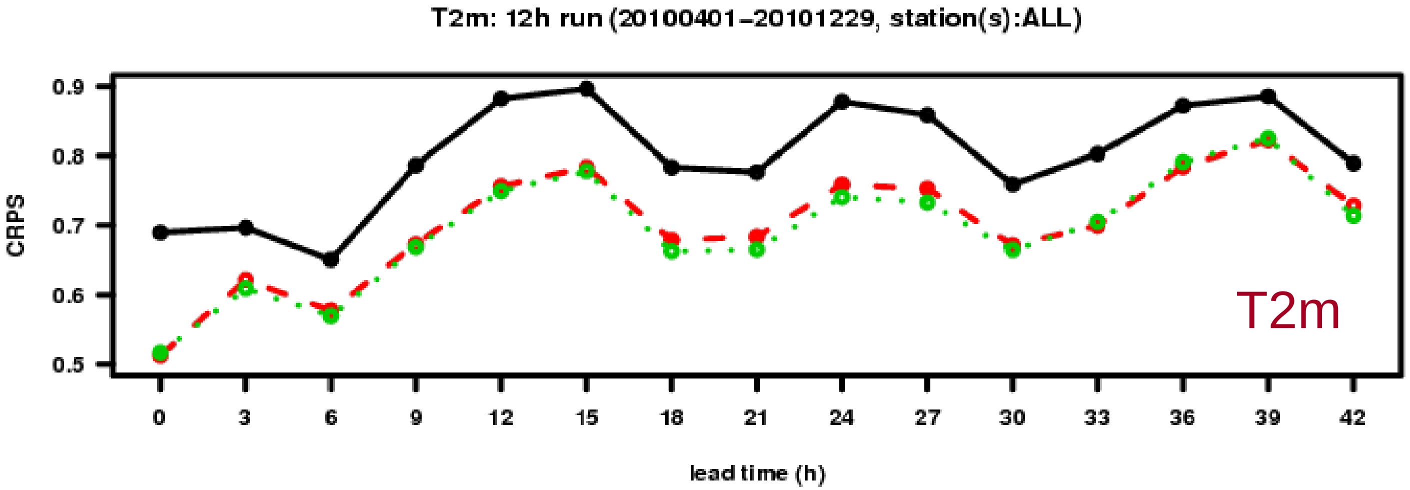


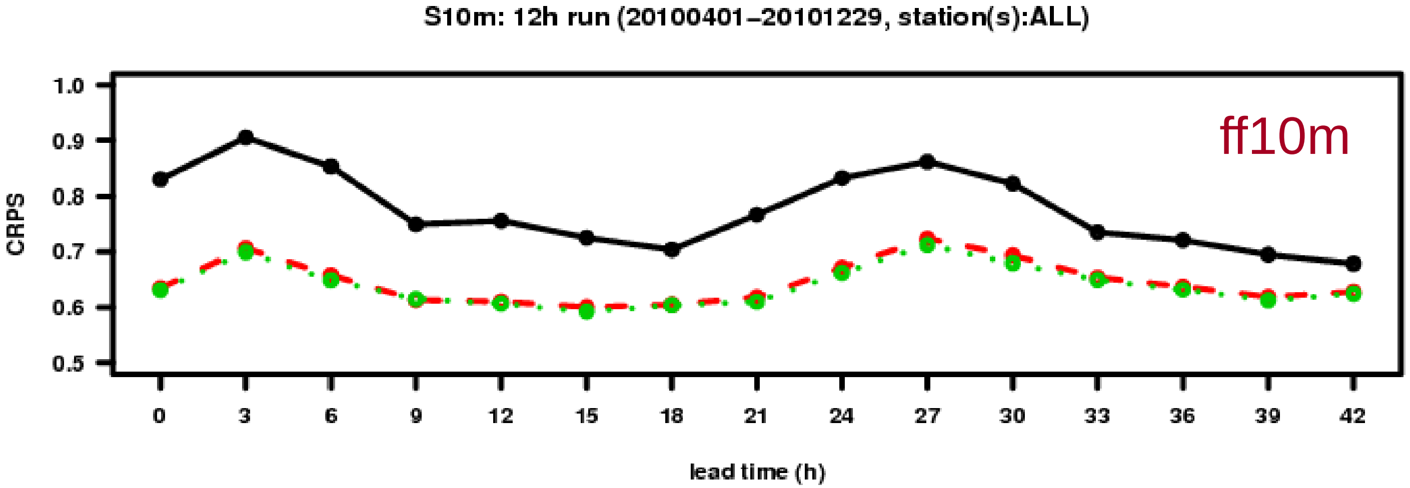
CRPS for bias-corrected +12h forecasts for:

ECEPS (black full line),

GLAMEPS (red dashed line) and

GLAMEPS-LAEF (green dotted line)

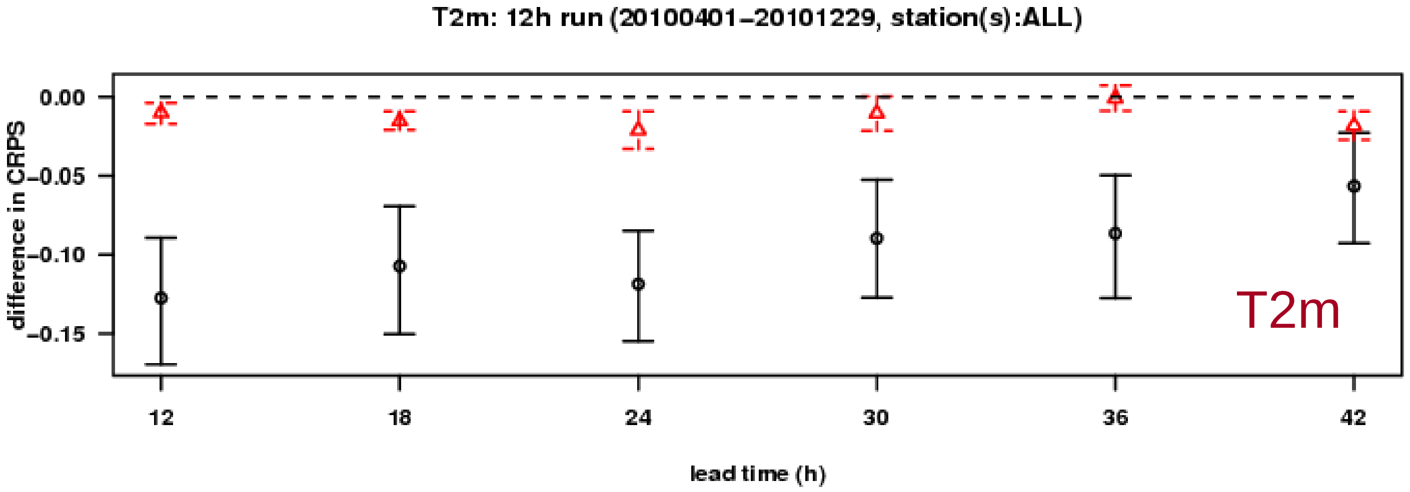


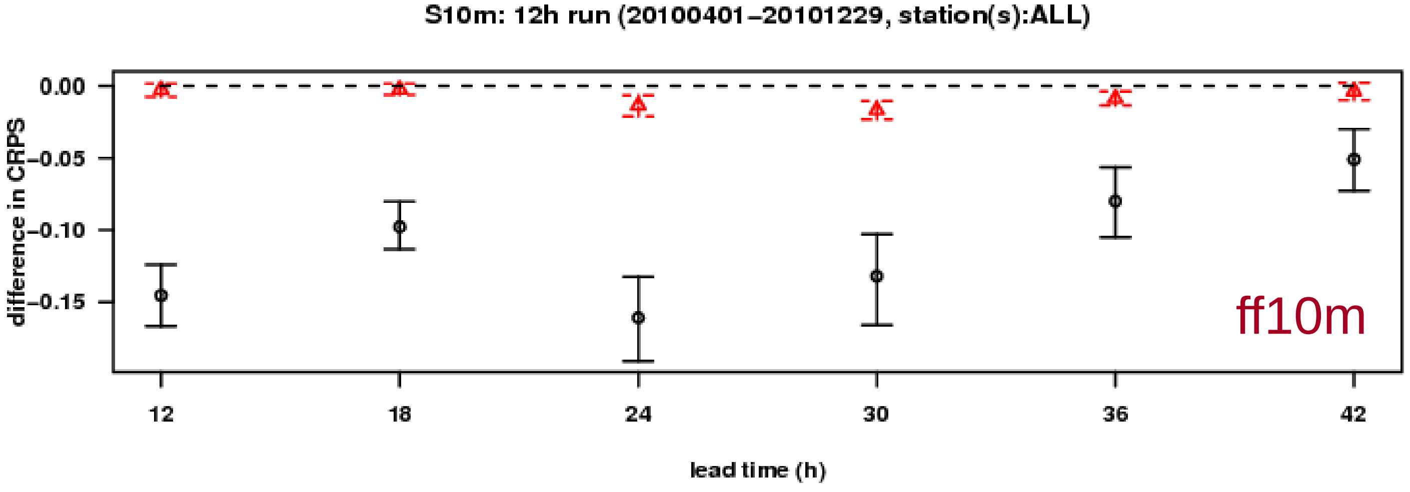


Confidence interval (bootstrap, 95%) for difference in CRPS for bias-corrected +12h forecasts, between:

GLAMEPS and ECEPS (black full line with circle) and

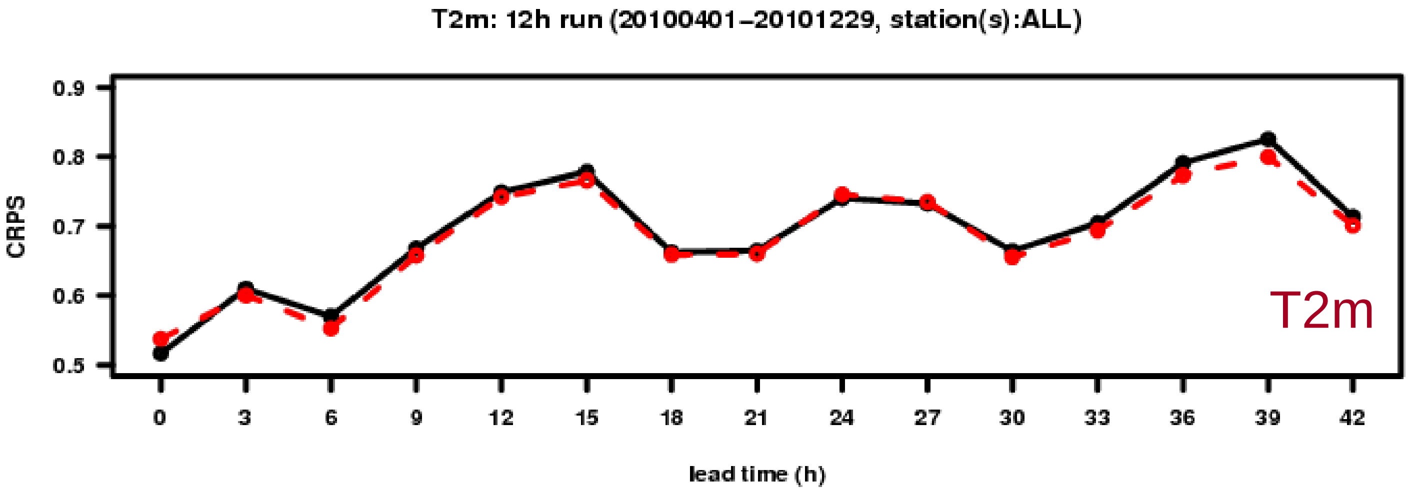
GLAMEPS-LAEF vs GLAMEPS (red dashed line with triangle)

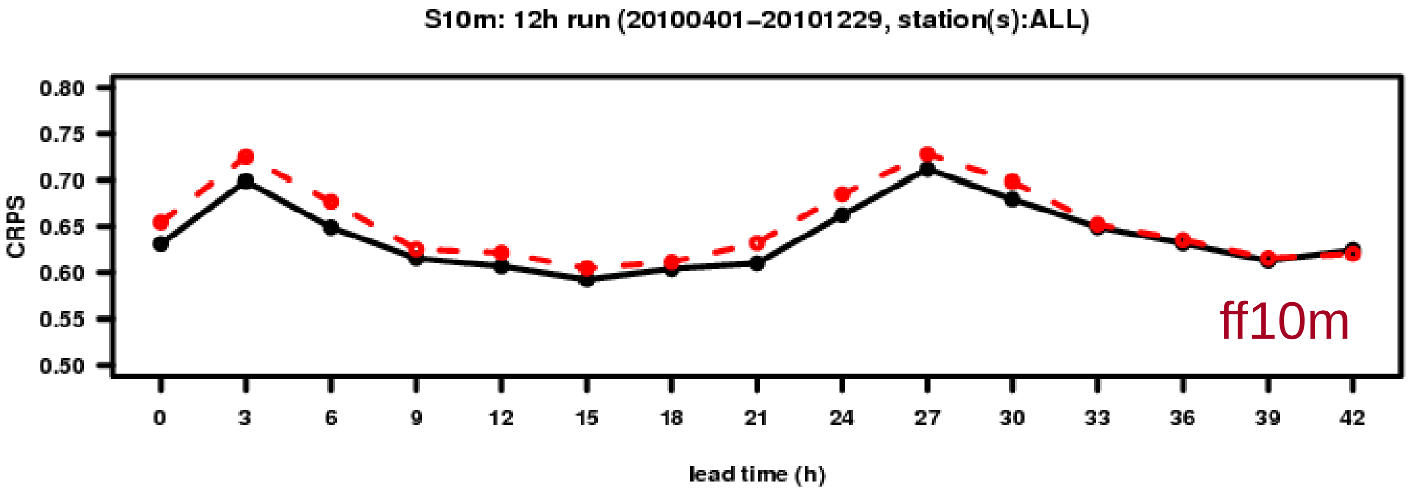




CRPS for bias-corrected +12h forecasts for:

GLAMEPS_LAEF (black full line), and
GLAMEPS-LAEF-ECEPS (red dashed line)





Conclusions

- GLAMEPS_v0 scores considerably better than ECEPS, both for T2m and ff10m.
- LAEF adds value to GLAMEPS_v0 for T2m and ff10m, but the additional value is much smaller than the improvement of GLAMEPS_v0 over ECEPS.
- Adding the remaining members of ECEPS to GLAMEPS-LAEF slightly improves the T2m scores, but slightly reduces the S10m scores.

Planning ”HarmonEPS”

- A convection-permitting EPS, ~2.5 km, sub-European
- Based on non-hydrostatic Harmonie
- LBC-data, intend to use increased resolution ECEPS (~16km) with single-step nesting
- Start with downscaling
- Multi-model approach:
  - Two physics packages possible
  - Later: Investigate combining with (UKMO) UM-EPS
- Step-wise develop
  - RUC with DA, and
  - finally hybrid DA and high-resolution observations

Thank You