Shaping GLAMEPS:

Grand Limited Area Model Ensemble Prediction System

Trond Iversen

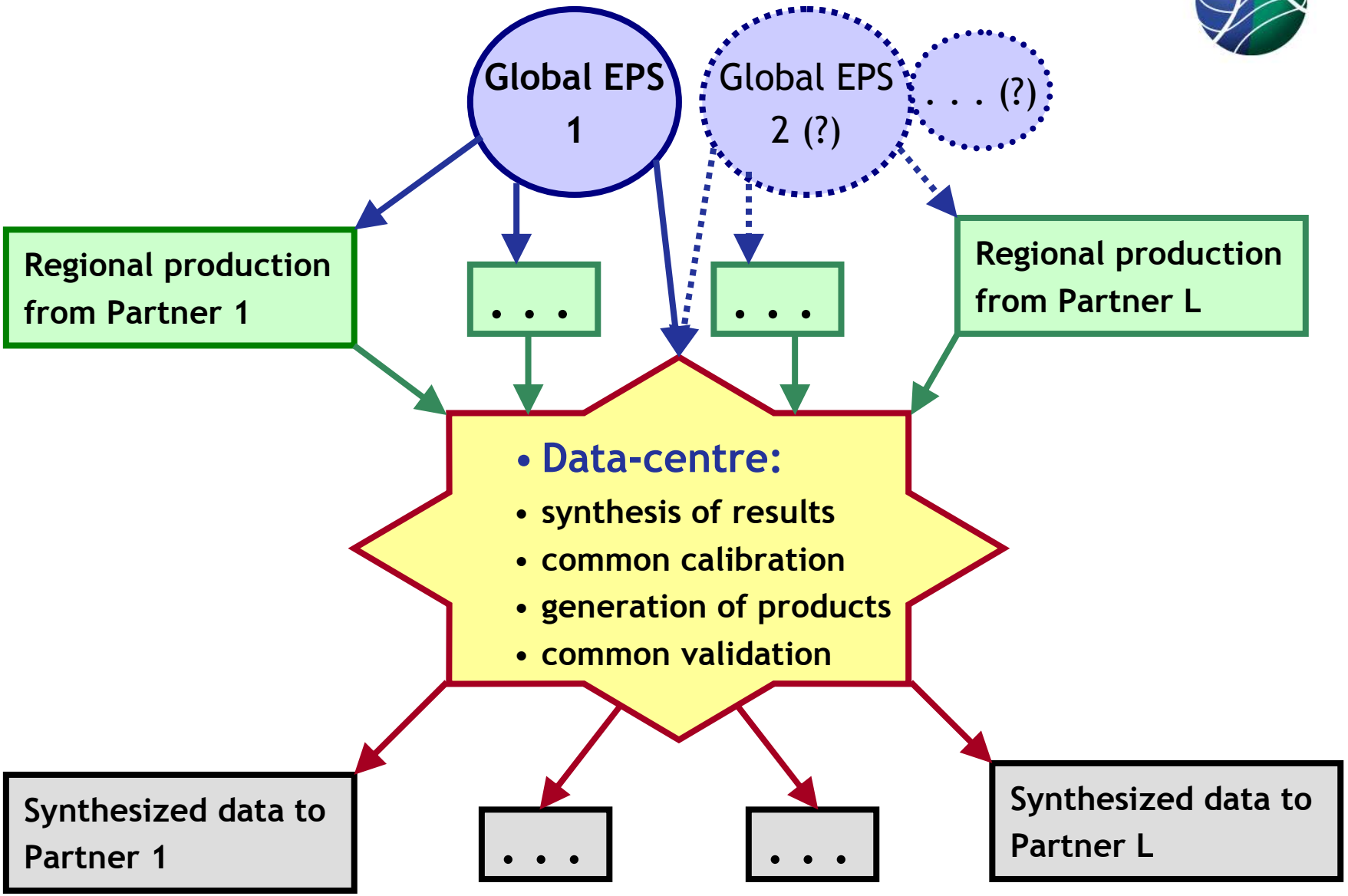
with major contributions from

Jan Barkmeijer, John Bjørnar Bremnes, Alex Deckmyn, Henrik Feddersen, Inger-Lise Frogner, Jose Antonio Garcia-Moya, Edit Hagel, Stjepan Ivatek-Sahdan, Richard Mladek, Carlos Santos, Kai Sattler, Roel Stappers, Sibbo Van der Veen, Martin Leutbecher (ECMWF) and others

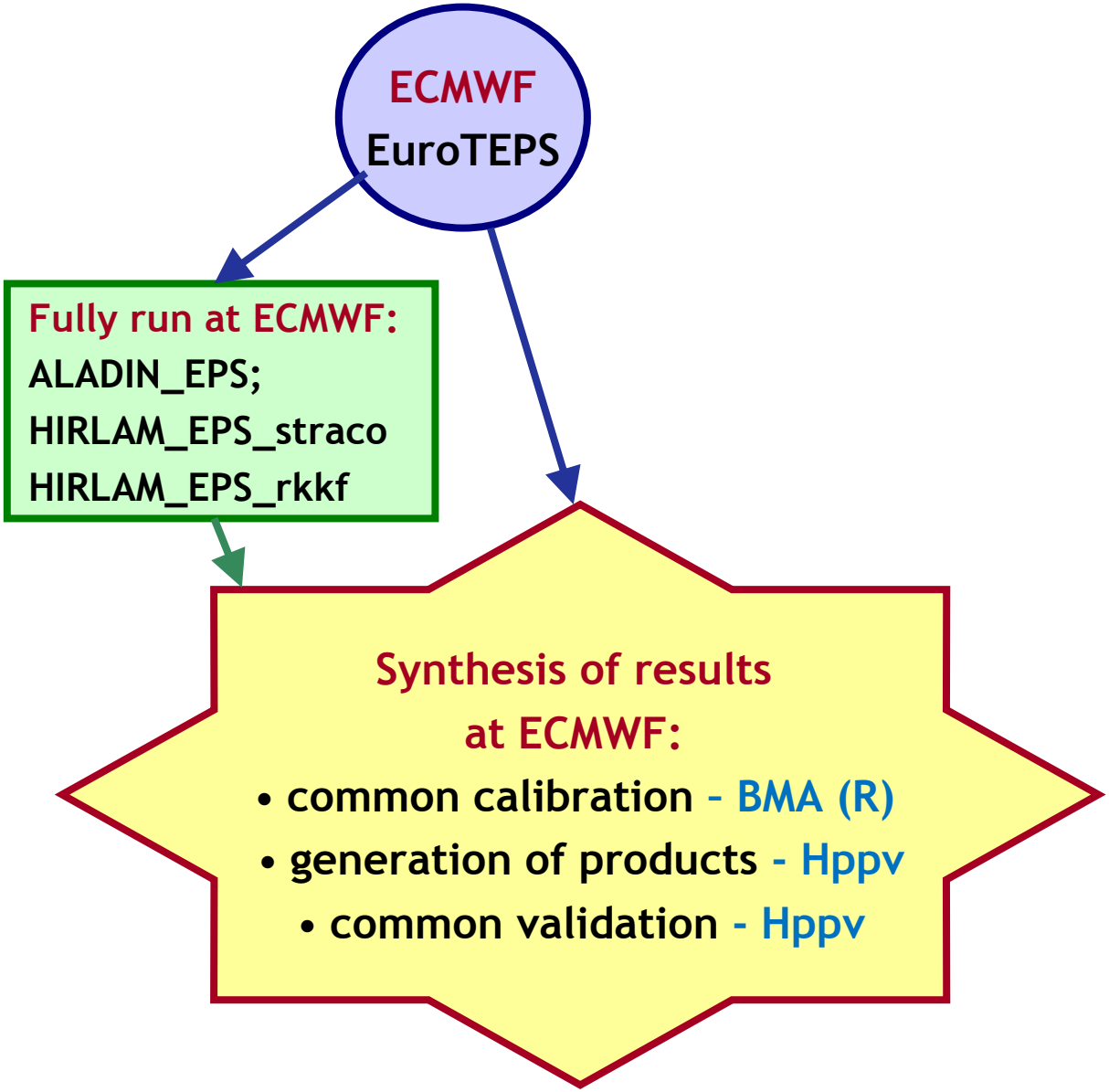
Ewglam, Madrid, October 2008

Norwegian Meteorological Institute met.no

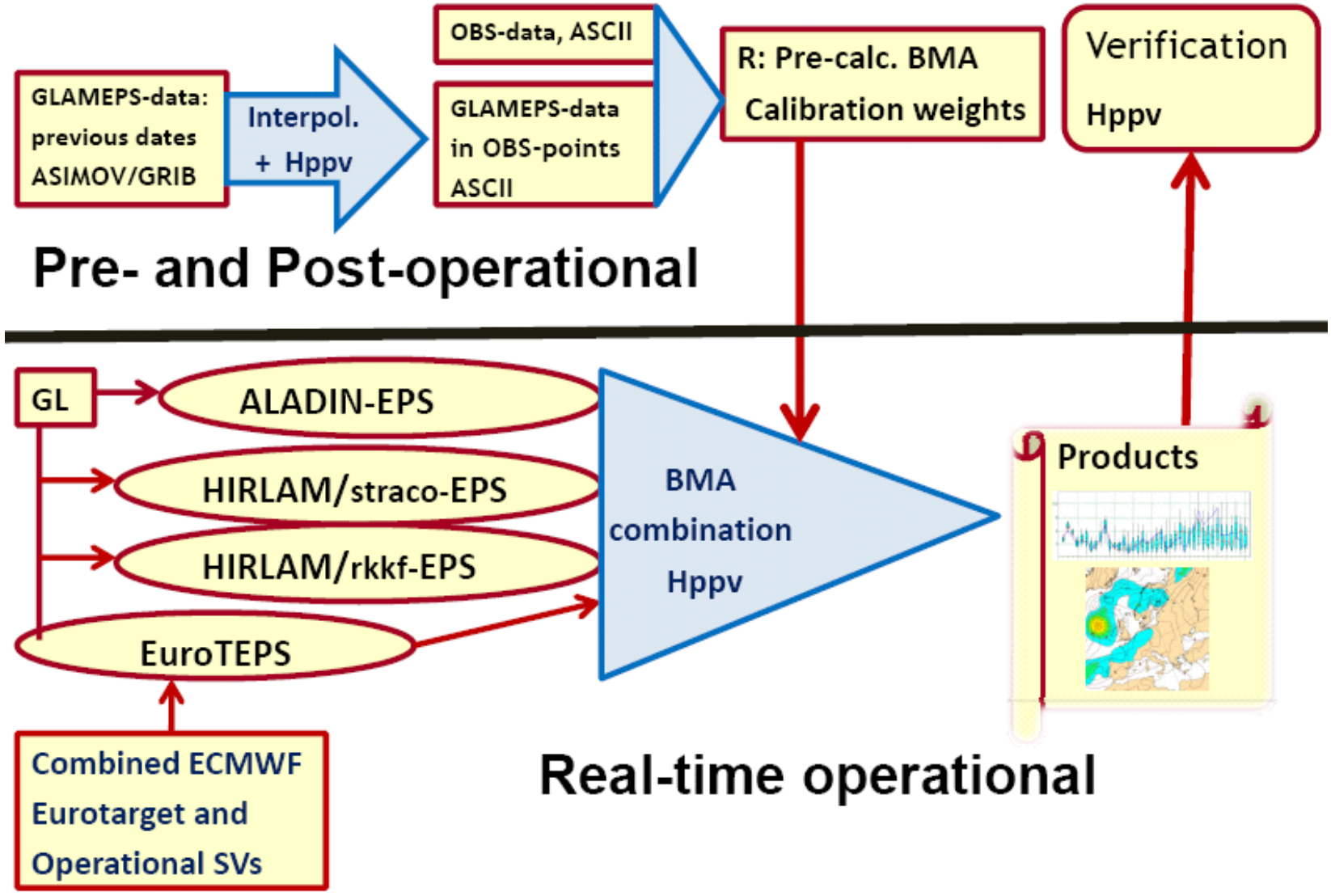
Operational Ideas for GLAMEPS



ECMWF Laboratory: GLAMEPS_v0



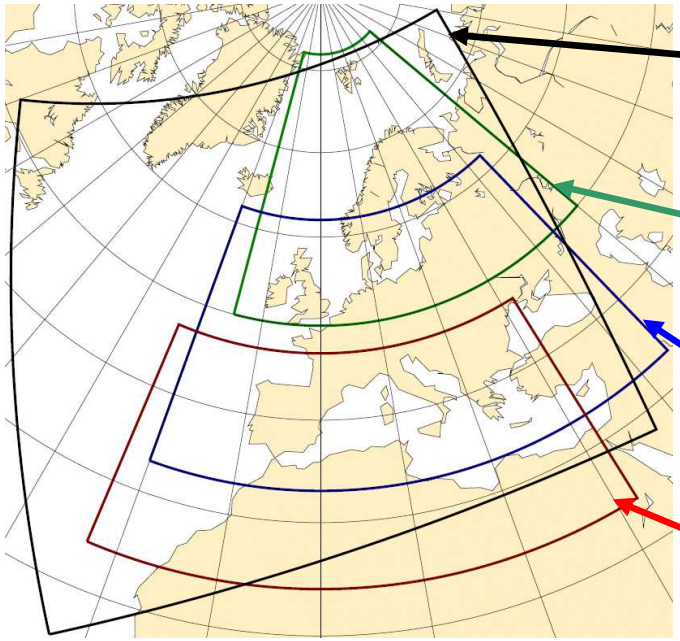
GLAMEPS_v0 production - flow chart



EuroTEPS

Method based on Leutebecher (2007):

- ECMWF IFS-code, cycle 32R3 (Nov. 07),
- Control run: operational T799L91, 4Dvar
- Ensemble members: T399L62, 72h forecasts
  - Define 30 TSVs; 3 target areas, 10 TSVs per target area;
  - TSVs orthogonal to ECMWF operational SVs and mutually orthogonalized
  - TSVs optimized over 0h - 24h, with resolution T159L62
  - Gaussian sampling of 2x(30 TSVs and 50 NH SVs) →20 members + control
  - 21-member EuroTEPS, 3-hourly output of data in model-levels.



GLAMEPS integration domain
(HIRLAM version)

Target area north
(82N,15W,50N,50E)

Target area central
(62N,20W,33N,44E)

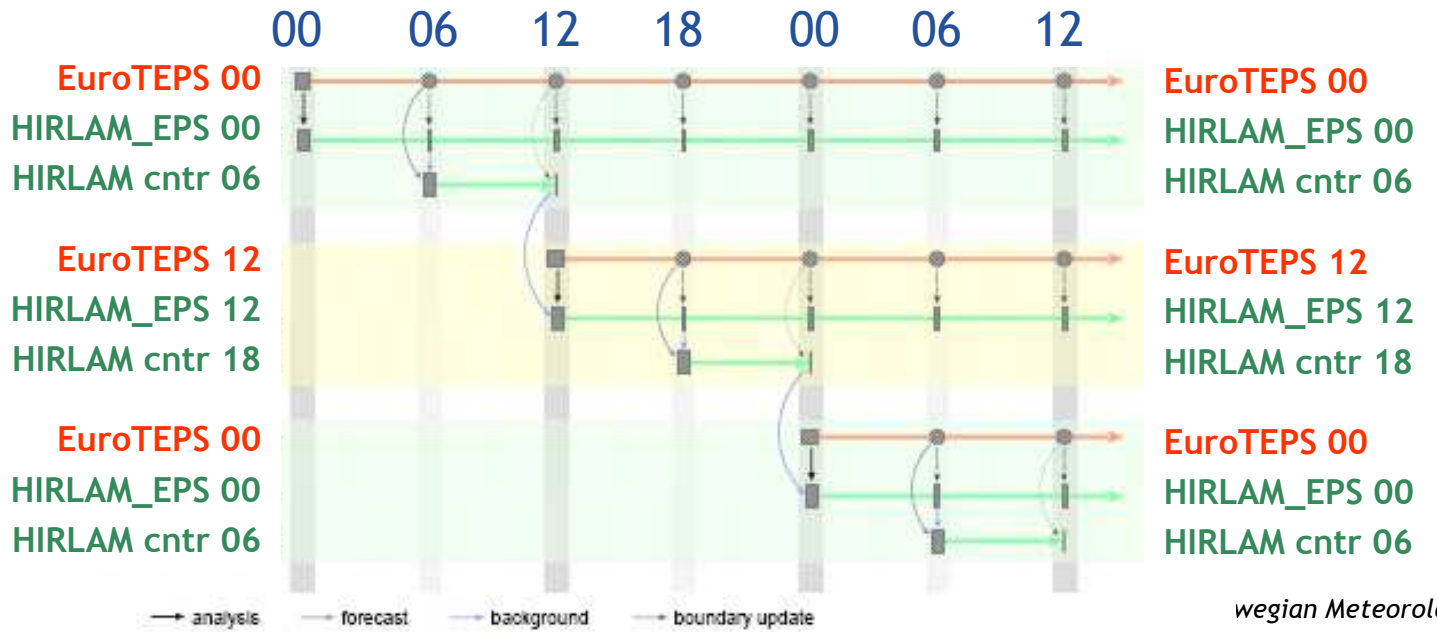
Target area south
(47N,23W,24N,32E)

HIRLAM_EPS

- HIRLAM 7.2, 0.2 degrees rotated lat-lon, 40 levels, 72h forecasts;
- Version S with STRACO cloud scheme;
- Version K with RKKF (Rasch-Kristjansson + Kain-Fritsch) cloud scheme;
    - 21 lateral boundaries and 20 initial perturbations from EuroTEPS;
    - Each HIRLAM version run with 6-hourly 3DVar data assimilation for control;
    - 21-member HIRLAM_EPS_S + 21-member HIRLAM_EPS_K,

HIRLAM - Cycling:

6h-DA for control, EPS-forecasts 00 and 12



ALADIN_EPS

- Cy31t1, 22km, 37 levels, 54h forecasts
- Can also be run with PEARP EPS from MeteoFrance;
    - 21 lateral boundaries and initial states from EuroTEPS;
    - Data fitted to ALADIN-grid by a separate GL-script;
    - Output in common rotated lat-lon by GL-script job;
- 21-member ALADIN_EPS, 3-hourly output

Combination and Calibration

- R-based package for BMA (Bayesian Model Averaging): Freeware.
  - Combination weights, PDF-parameters, bias corrections
  - *Pre-operational* over previous forecasts (at present: 3 days)
  - Presently under testing.

Products and Verification

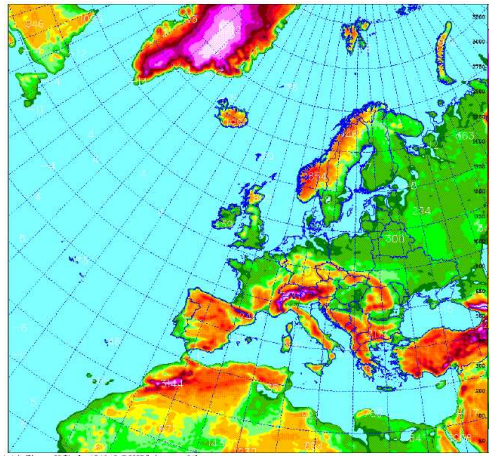
- MetView-based package Hppv, developed at AEMet (INM)
  - Batch for standard 3-hourly output products:
    - Real-time operational
    - Contribution to verification products
  - *Post-operational* synthesizing verification: same package (Hppv)
  - Presently under testing.

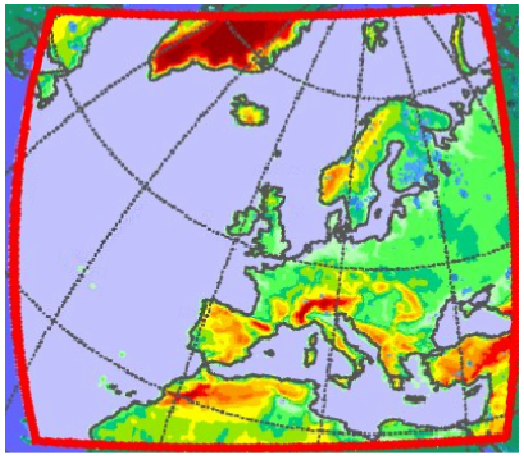
Present status

- *All tests performed in hindcast mode at ECMWF computers*
- *Present available dates (all run in hindcast mode)*
  - *12.08.07 - 25.08.07, 00 and 12 utc*
  - *[24.01.08 - 05.03.08, 00 and 12 utc is underway]*
- *Grid resolution*
  - *Now ~22km,* *[aim: ~11km or finer,]*
  - *37 and 40 levels;* *[aim: to be increased to 60 or higher]*
- *Forecast range*
  - 72h, for EuroTEPS and HIRLAM_eps; and 54h for ALADIN_eps
- *A common pan-European:*

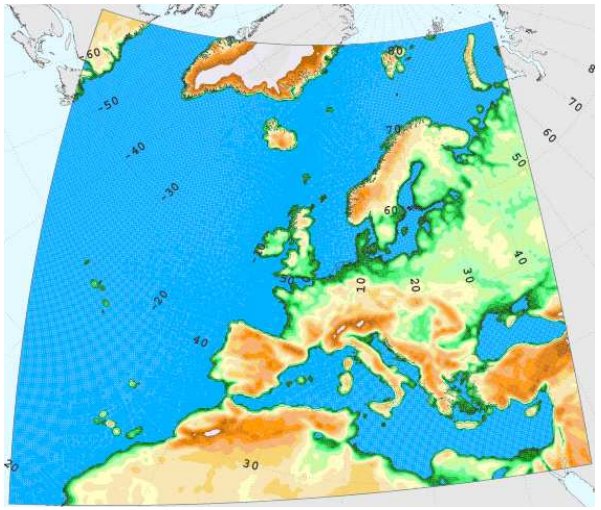
Integration - domain

ALADIN: 22km; 320 x 300 HIRLAM: 0.2deg.; 306 x 260





Product-domain



CHALLENGE: Resources

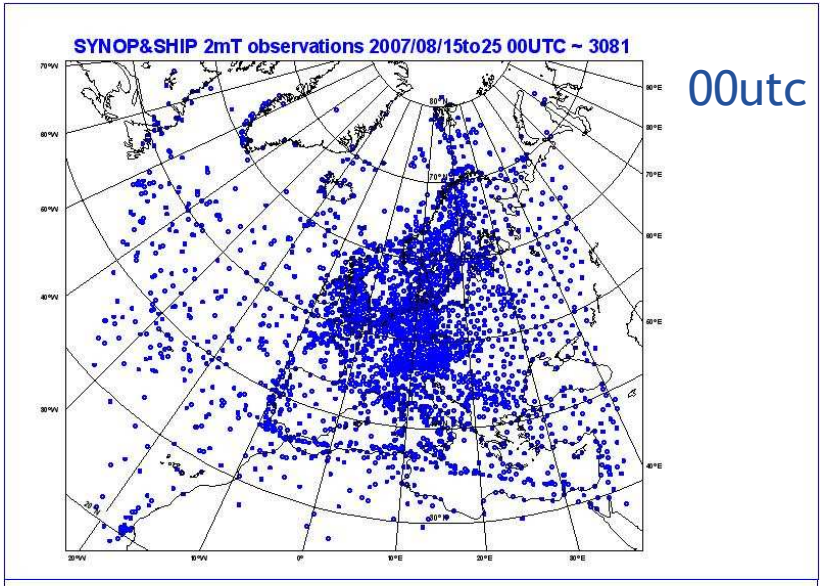
- **In Total when run at ECMWF: 7.1 Msbu per year**
  - plus calibration and combination (BMA)
  - and product generation and verification (Hppv)

- **Type 1 Experiments at ECMWF (GLAMEPS_v0)**
  Can we reach 11km resolution and 60 levels?
  - Issue for investigation the next 6 months:
    - Smaller ensemble (should match ECMWF's 51 members)?
    - Smaller integration domain and shorter lead time?
    - One or two target areas in EuroTEPS?
  - **Preliminary estimate: If we aim at:**
    - 11km, 60 levels, 13 member EuroTEPS, 13 member ALADIN_EPS, and 2x13 member HIRLAM_EPS; 36h forecasts:
    - EuroTEPS=0.85Msbu, HIRLAM_EPS=6.0Msbu, ALADIN_EPS=2.75Msbu
      - 9.6 Msbu - unchanged common integration domain
      - 7.1 Msbu - if integration domain is reduced to 275x258 grid-points in stead of 320x300 (HIRLAM)

    Optimistic prospect: New ECMWF hpc in 2009: IFS: 5X speed-up

Some Examples

Synops and Ships used for calibration and verification



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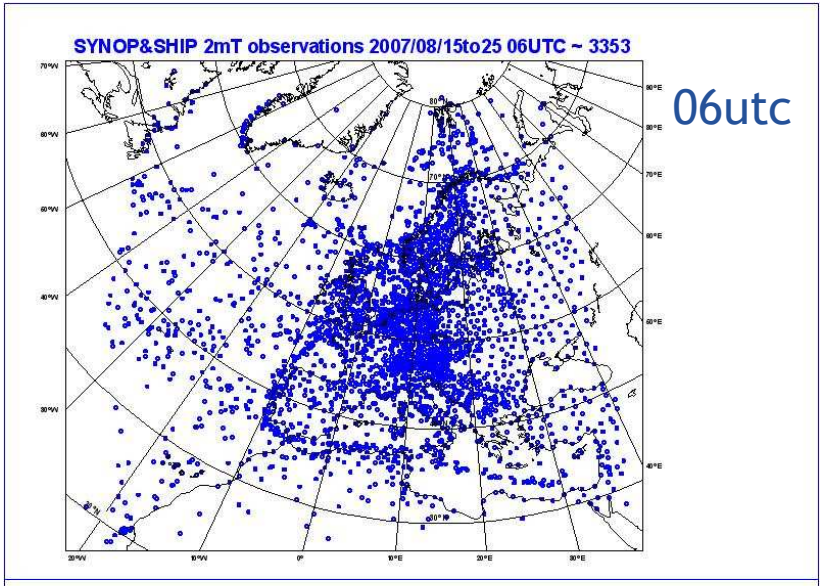

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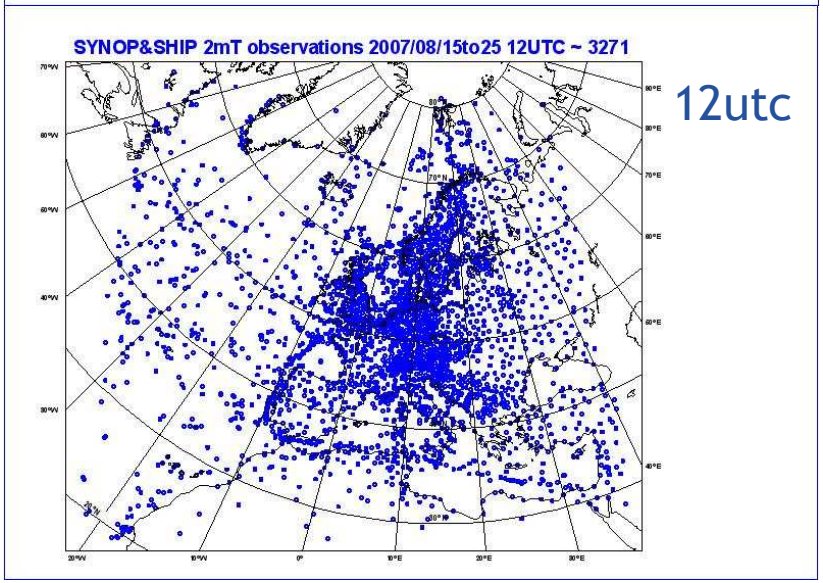

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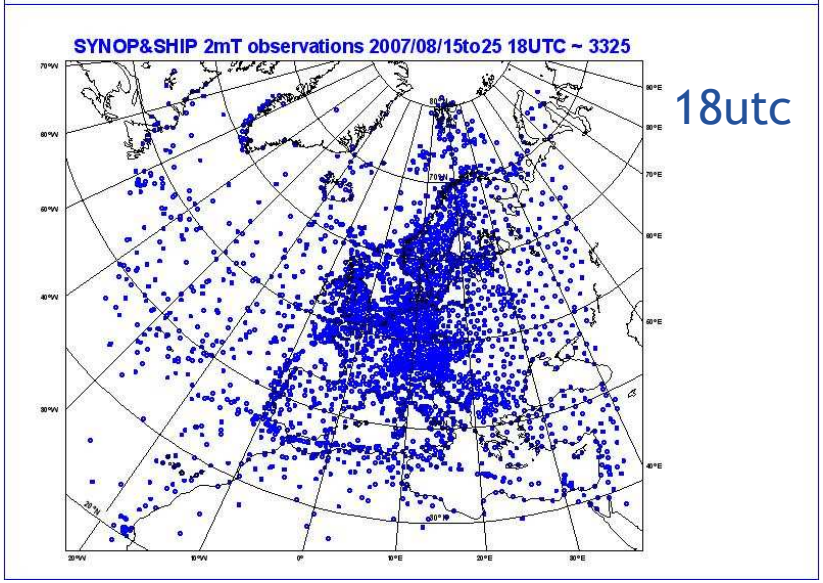


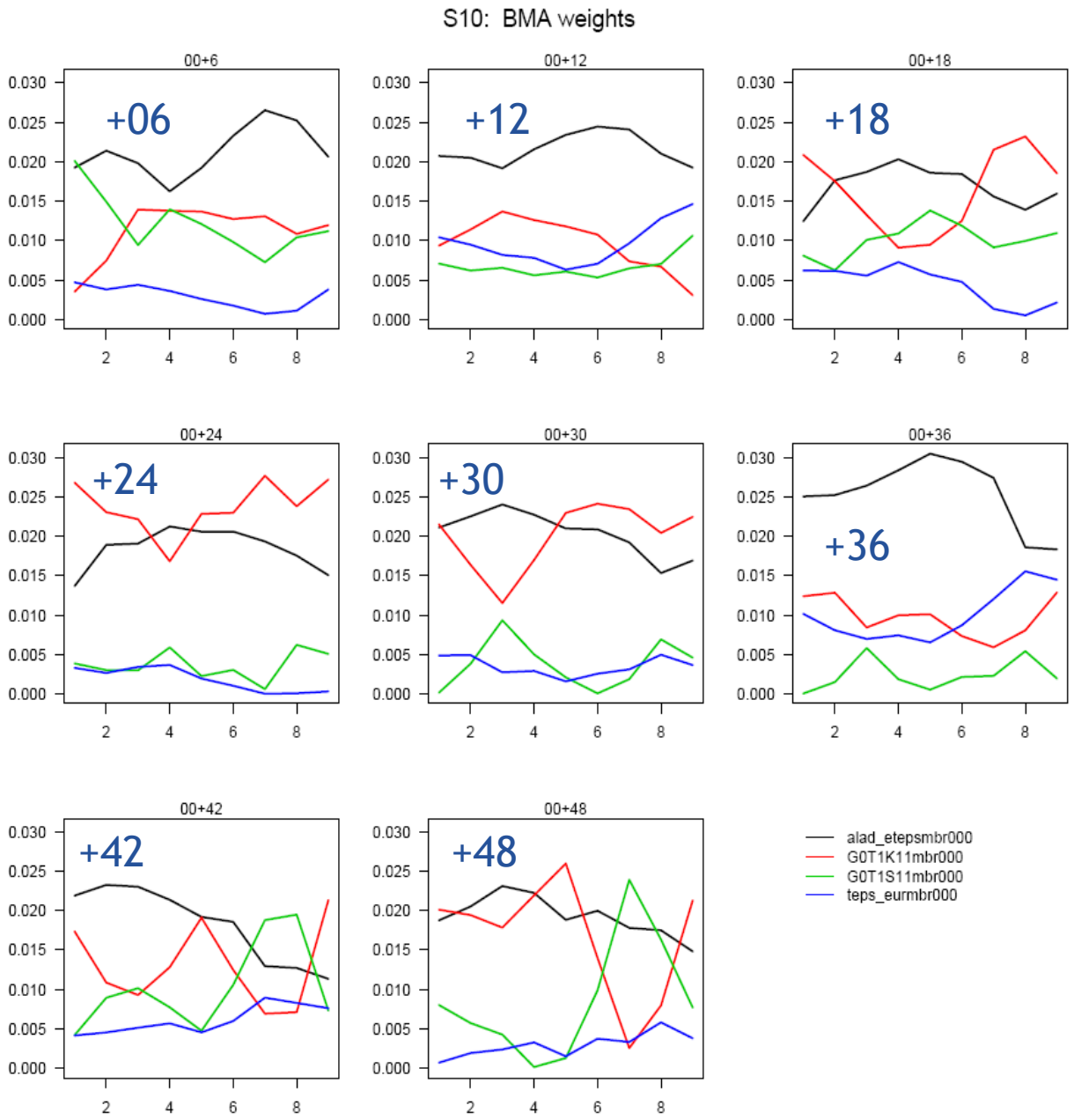
18utc

Some Examples

NB:

1. PRELIMINARY RESULTS
2. SMALL TEST SAMPLE (11 days)
3. SHORT LEARNING PERIOD FOR BMA (3 days)

Some Examples



BMA Weights, ff10m:

Day2 = 18. Aug.

Day8 = 25. Aug. 2007

3-day learning period

_____ALADIN_EPS

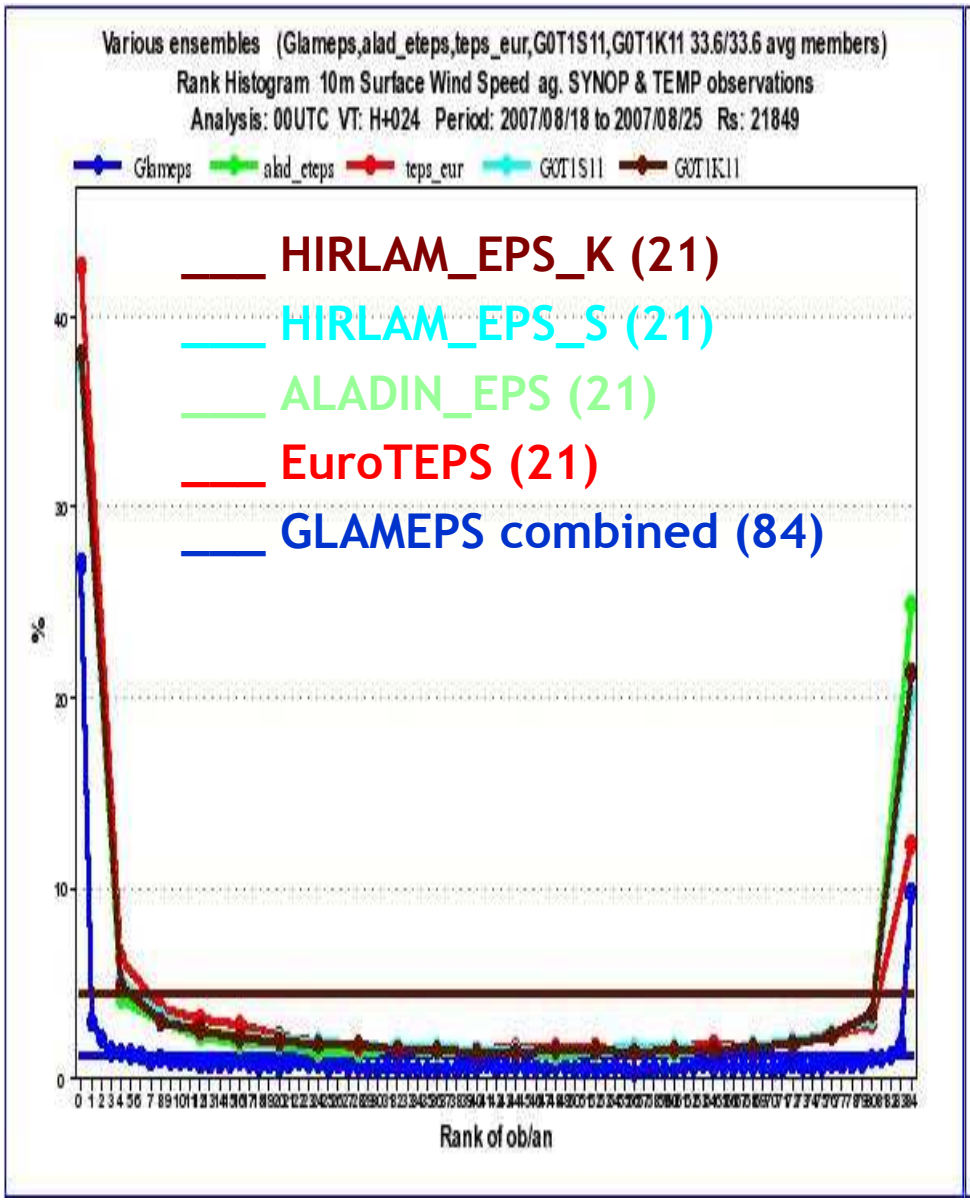
_____ HIRLAM_EPS_K

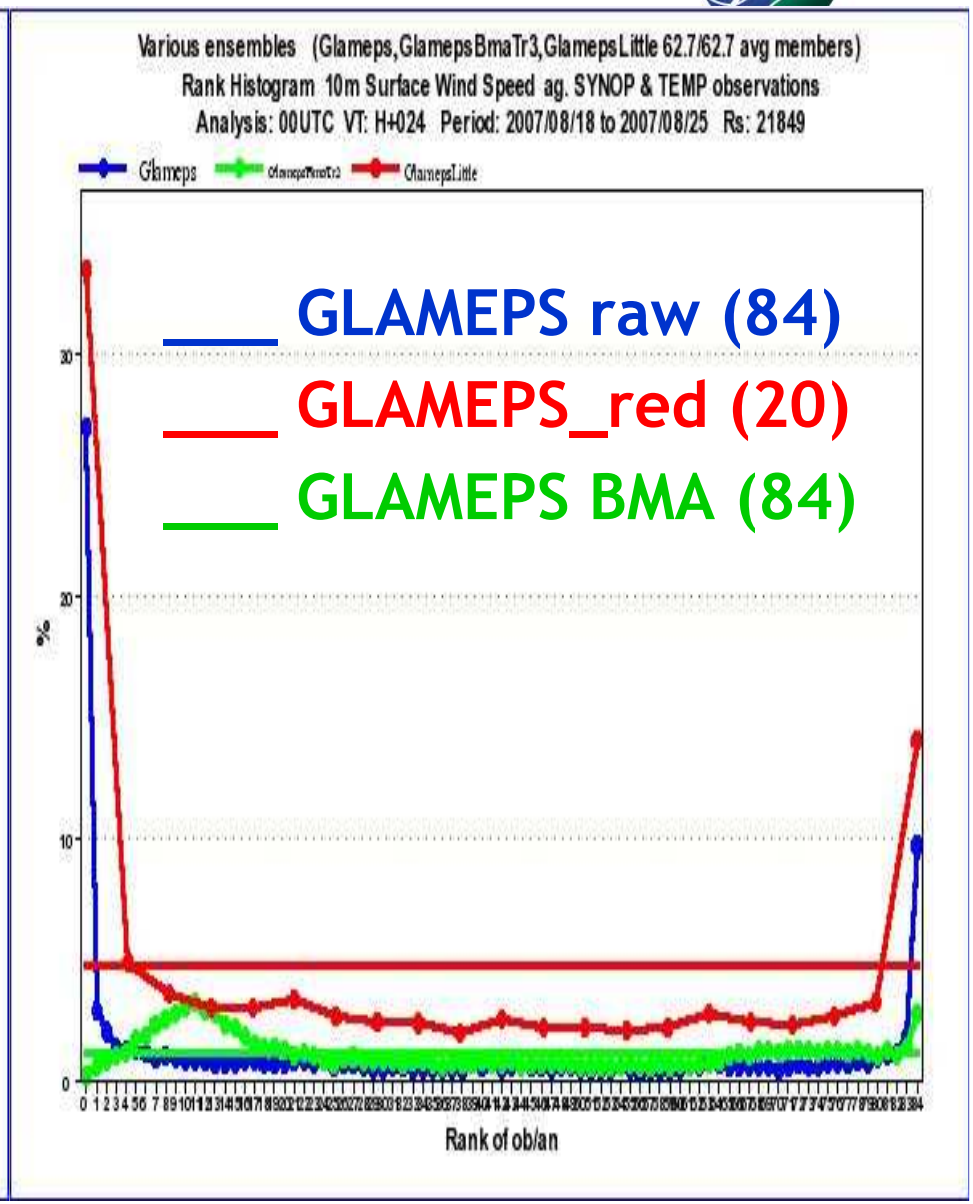
_____ HIRLAM_EPS_S

_____ EuroTEPS

Some Examples

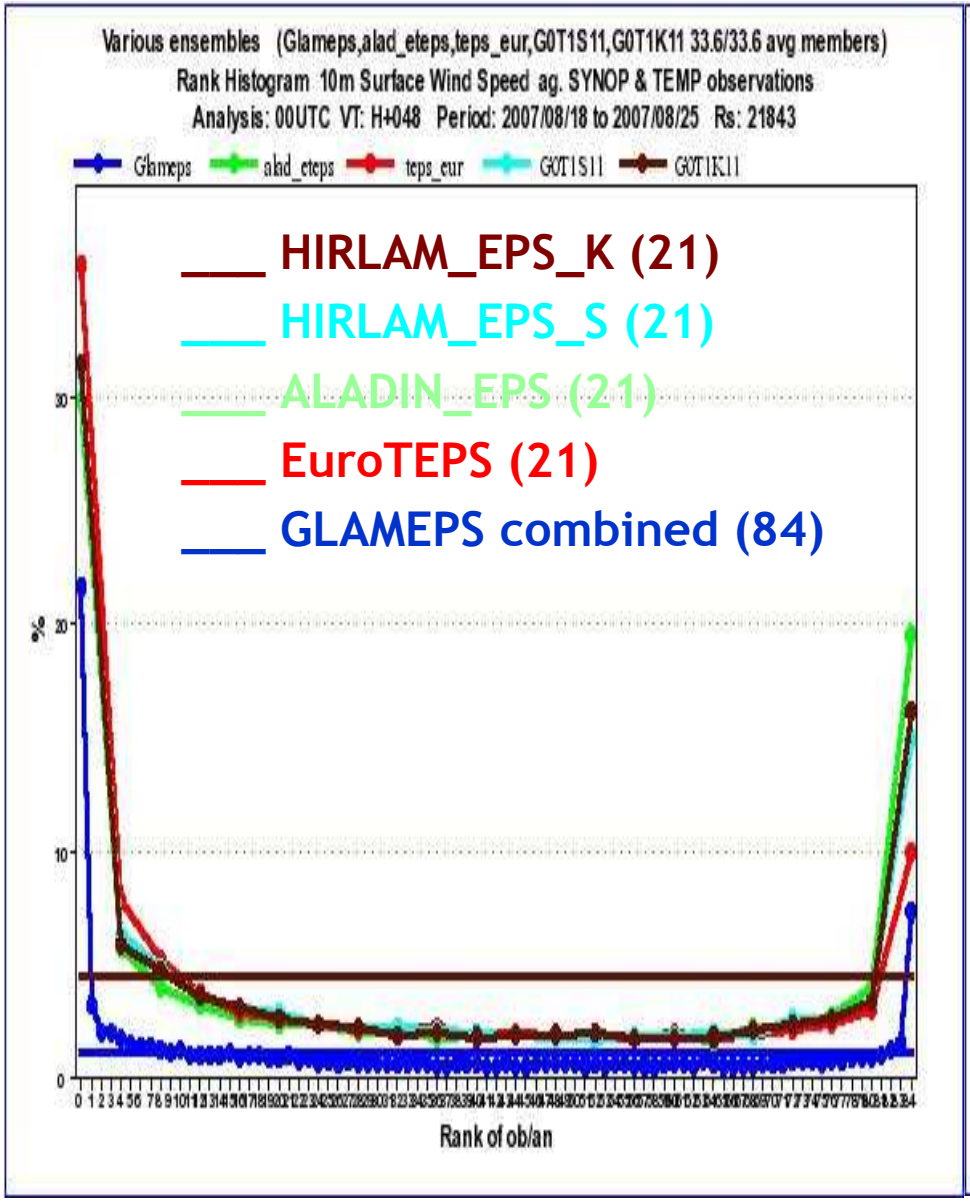
Rank Histograms, ff10m, +24h

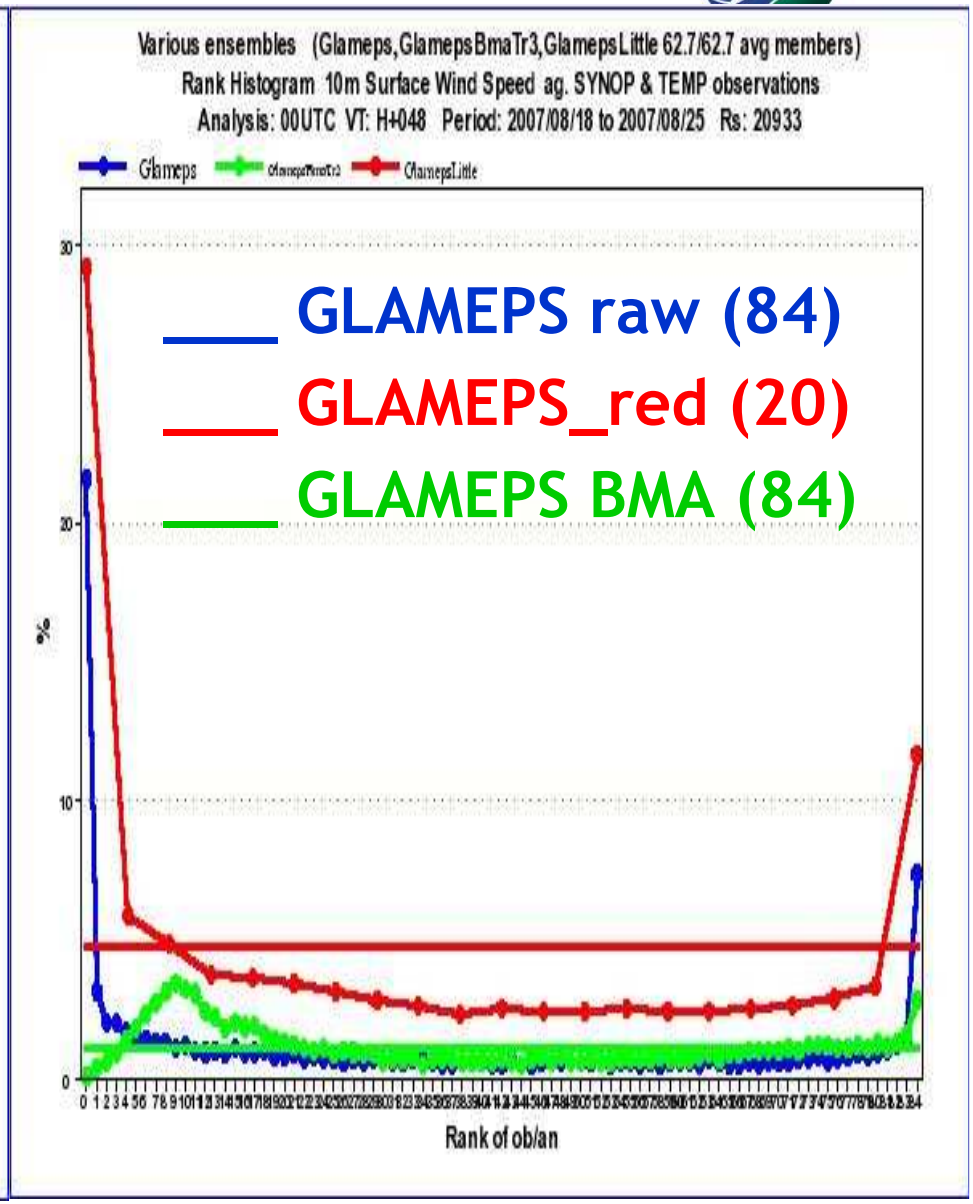




Some Examples

Rank Histograms, ff10m, +48h





Some Examples

Spread-Skill ff10m

___ HIRLAM_EPS_K (21)

___ HIRLAM_EPS_S (21)

___ ALADIN_EPS (21)

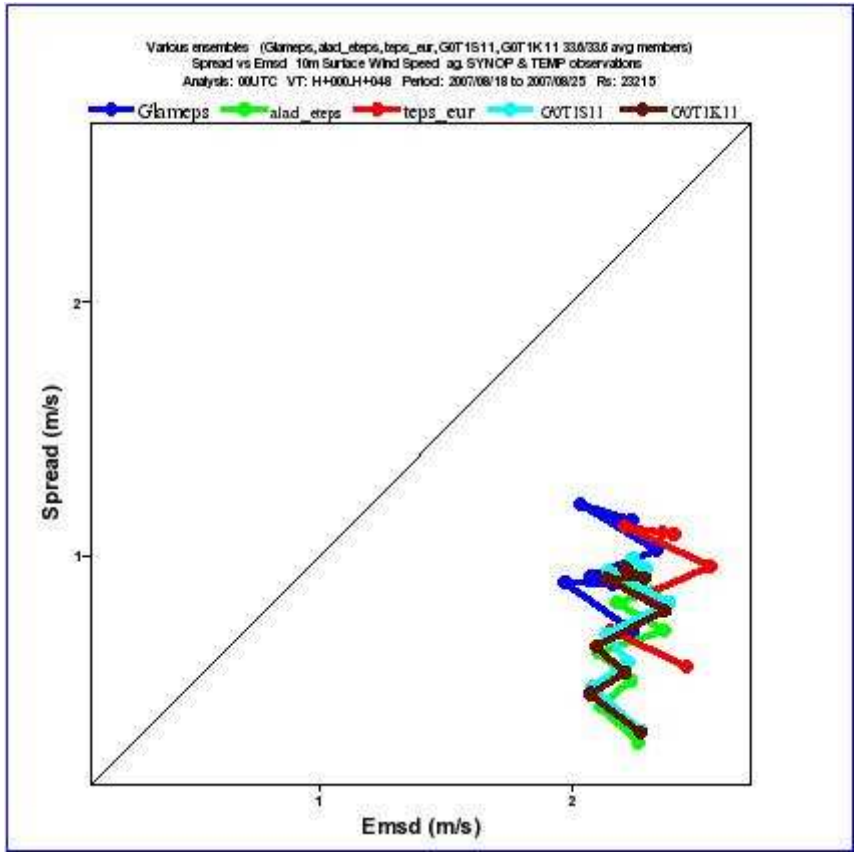
___ EuroTEPS (21)

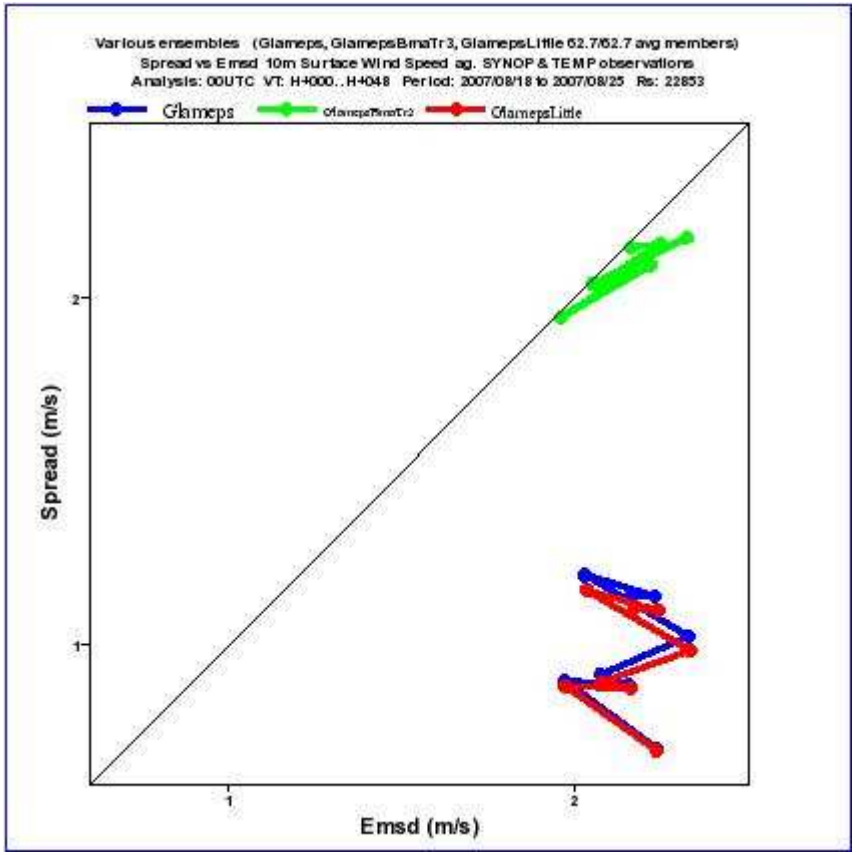
___ GLAMEPS combined (84)

___ GLAMEPS raw (84)

___ GLAMEPS_red (20)

___ GLAMEPS BMA (84)





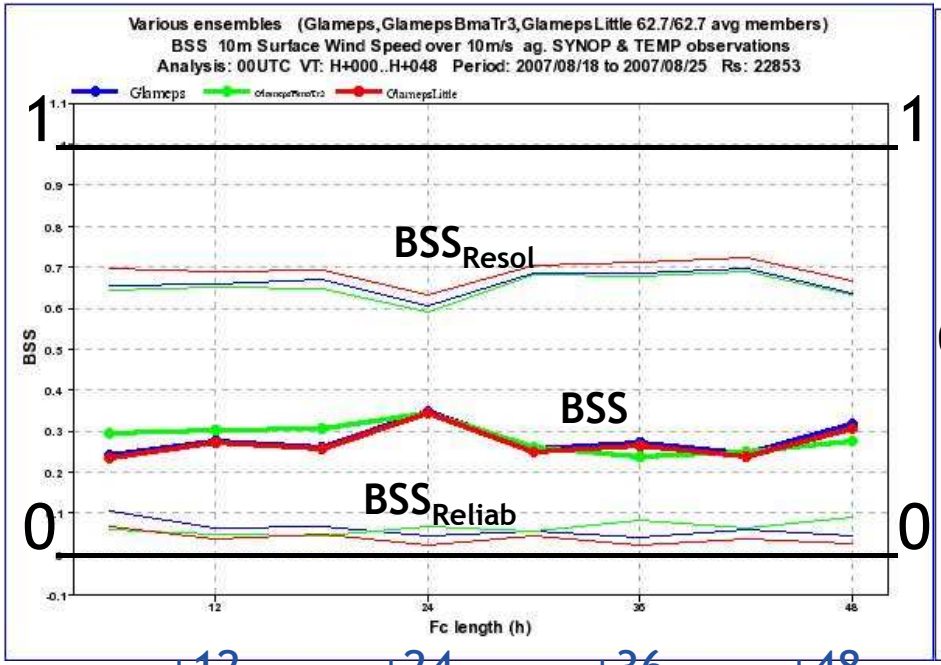
Some Examples

___ GLAMEPS raw (84) ___ GLAMEPS_red (20)

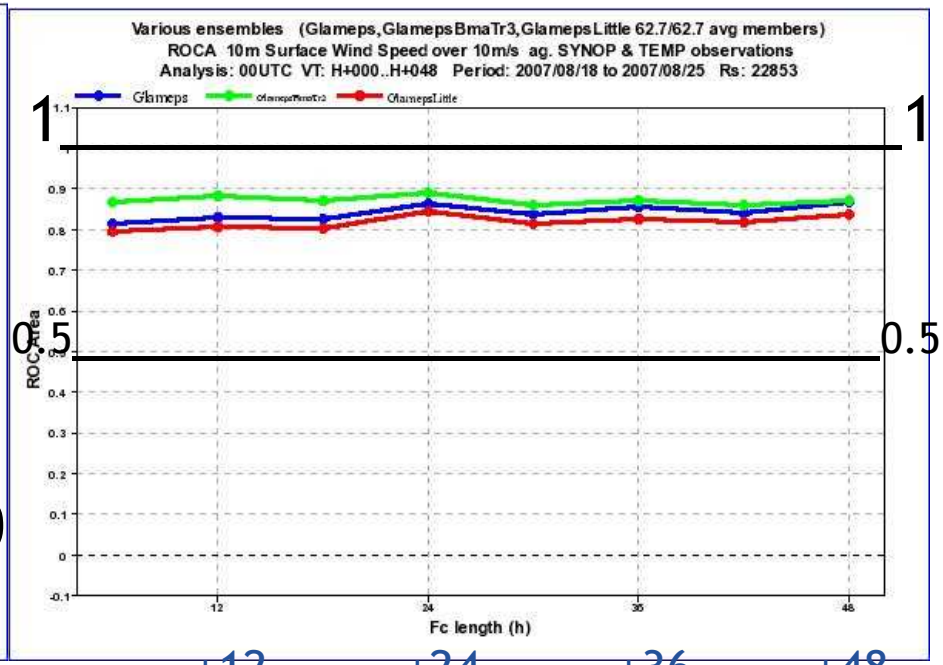
___ GLAMEPS BMA (84)

Brier Skill Score: ff10m > 10m/s

[BSS = 1 – BSS_{Reliab} - BSS_{Resol}]



Relative Operating Characteristics - Area: ff10m > 10m/s

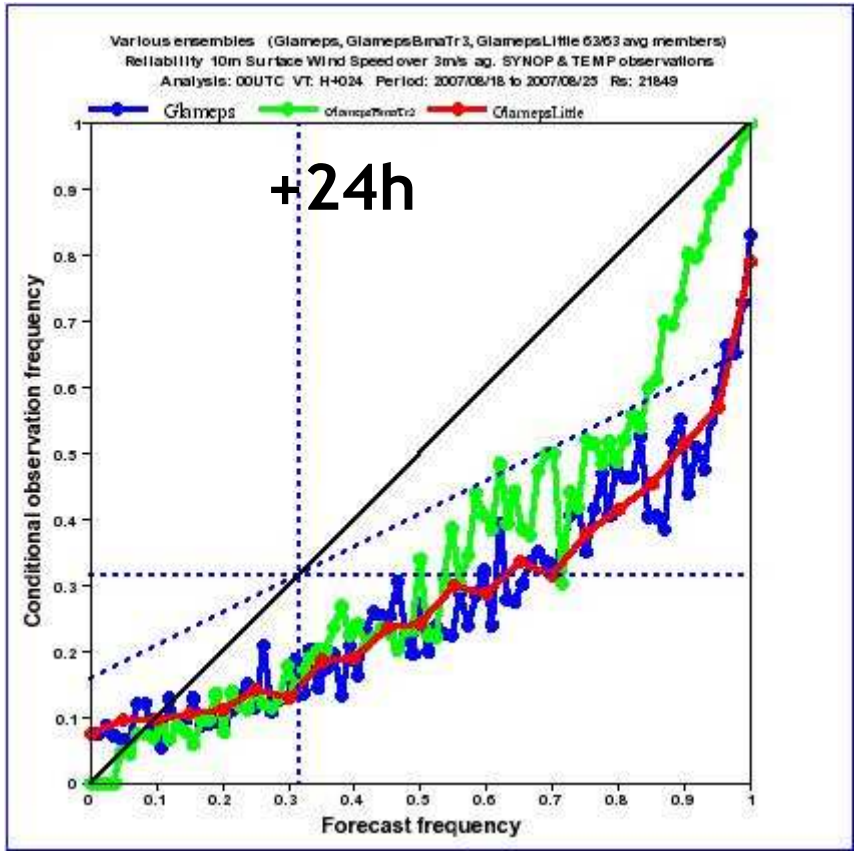


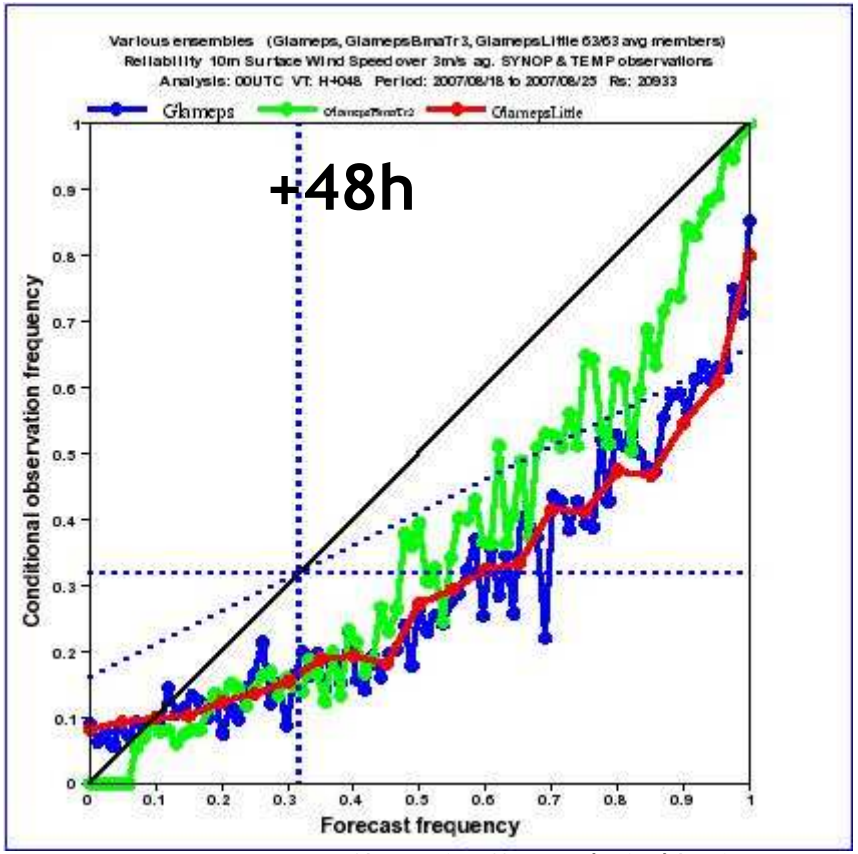
Some Examples

Reliability diagram: ff10m > 3m/s

___ GLAMEPS raw (84) ___ GLAMEPS_red (20)

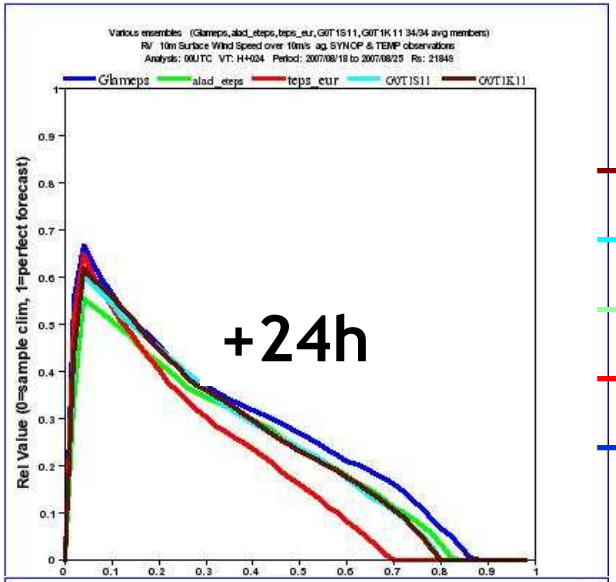
___ GLAMEPS BMA (84)

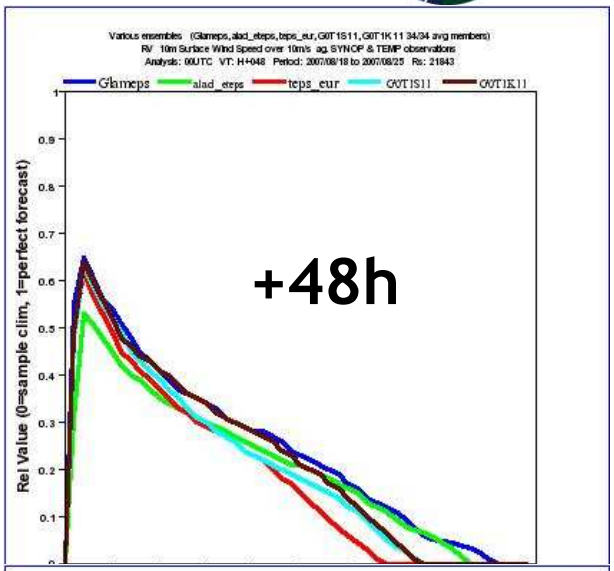




Some Examples

Relative Value as a function of cost/loss-ratio: ff10m > 10m/s





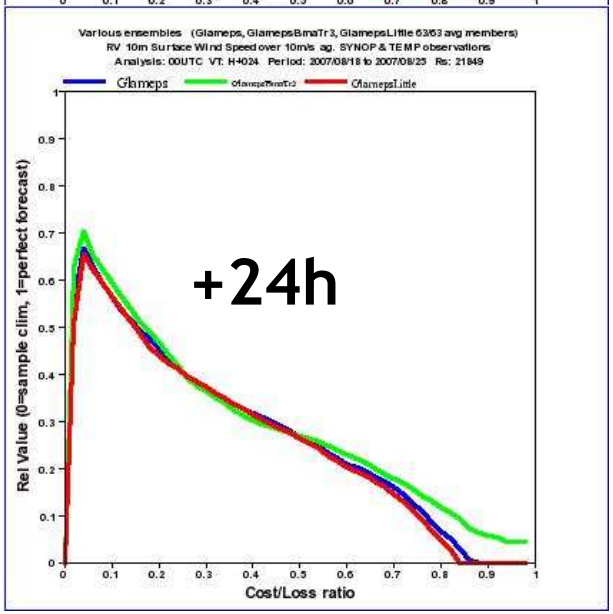
HIRLAM_EPS_K (21)

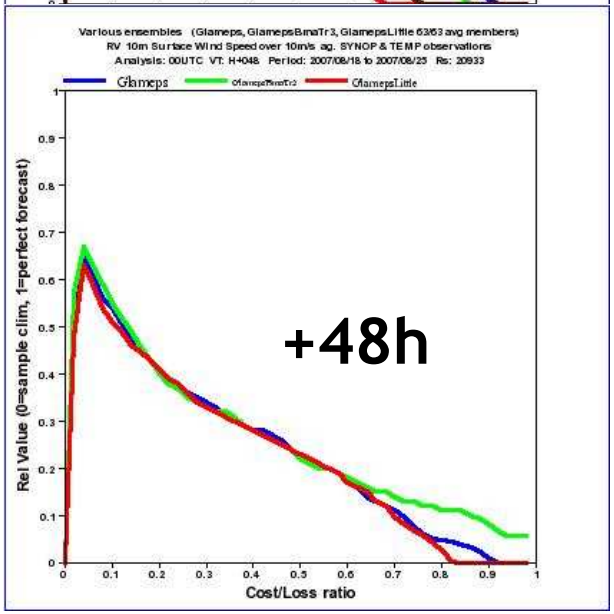
HIRLAM_EPS_S (21)

ALADIN_EPS (21)

EuroTEPS (21)

GLAMEPS combined (84)



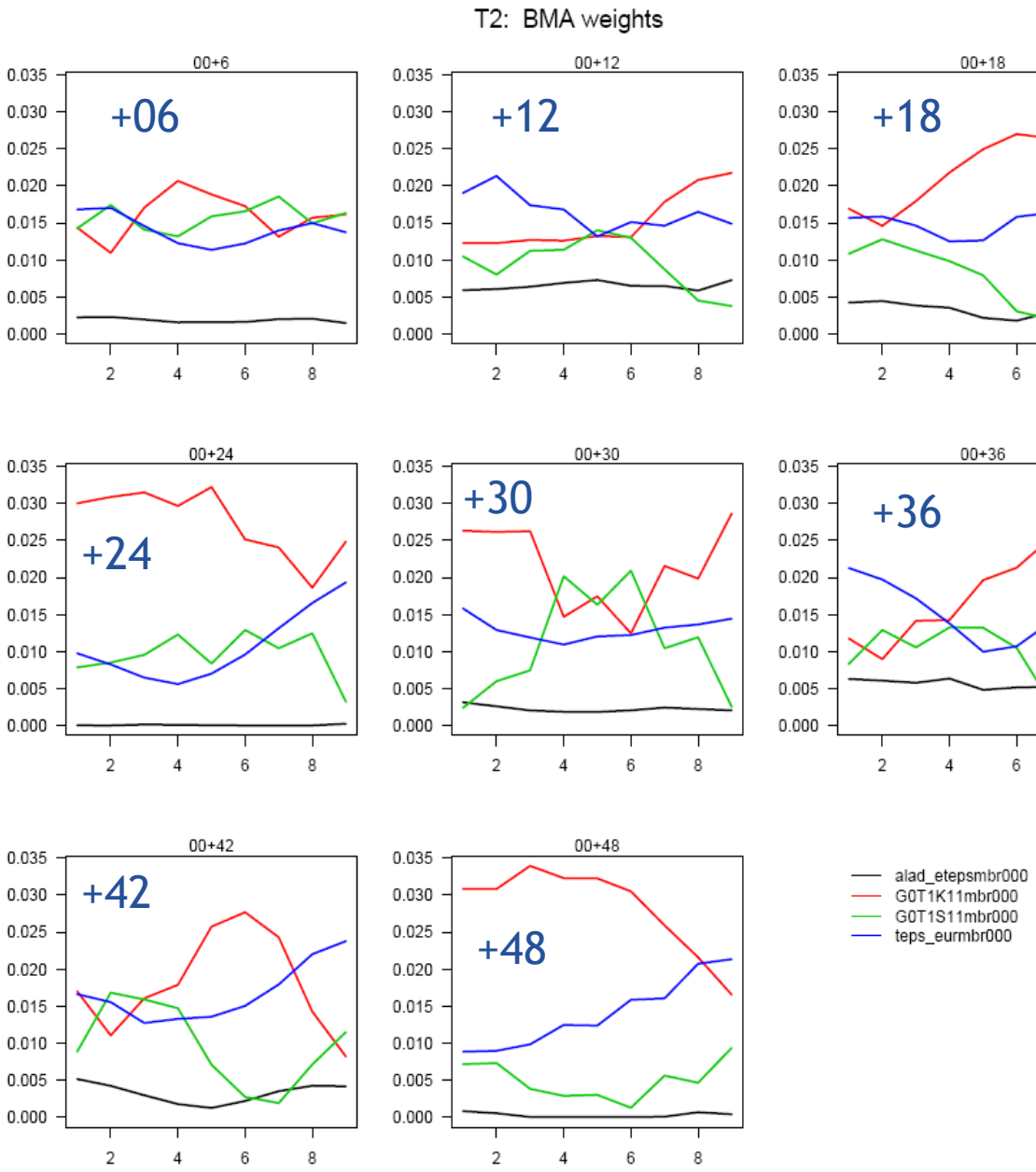


GLAMEPS raw (84)

GLAMEPS_red (20)

GLAMEPS BMA (84)

Some Examples



BMA Weights, T2m:

Day2 = 18. Aug.

Day8 = 25. Aug. 2007

3-day learning period

____ ALADIN_EPS

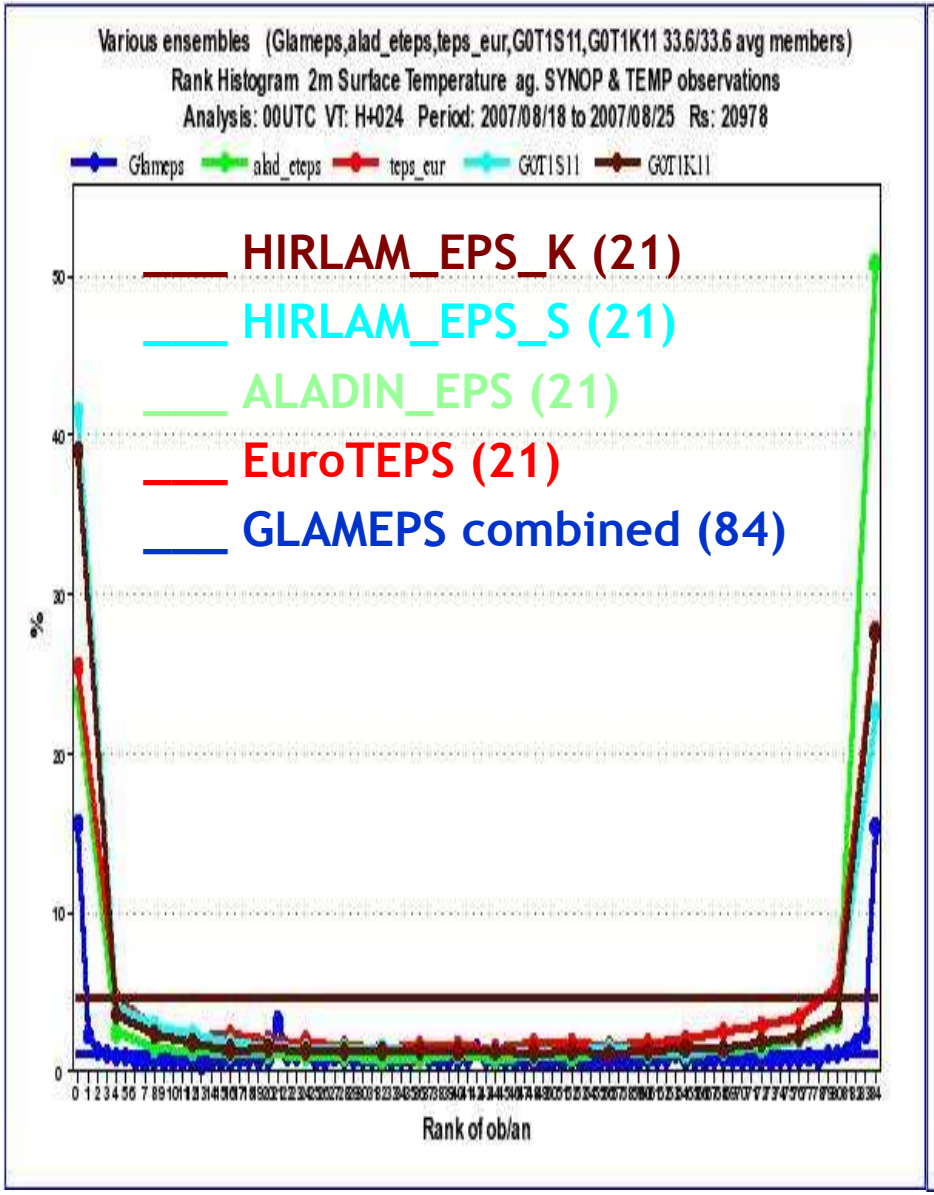
____ HIRLAM_EPS_K

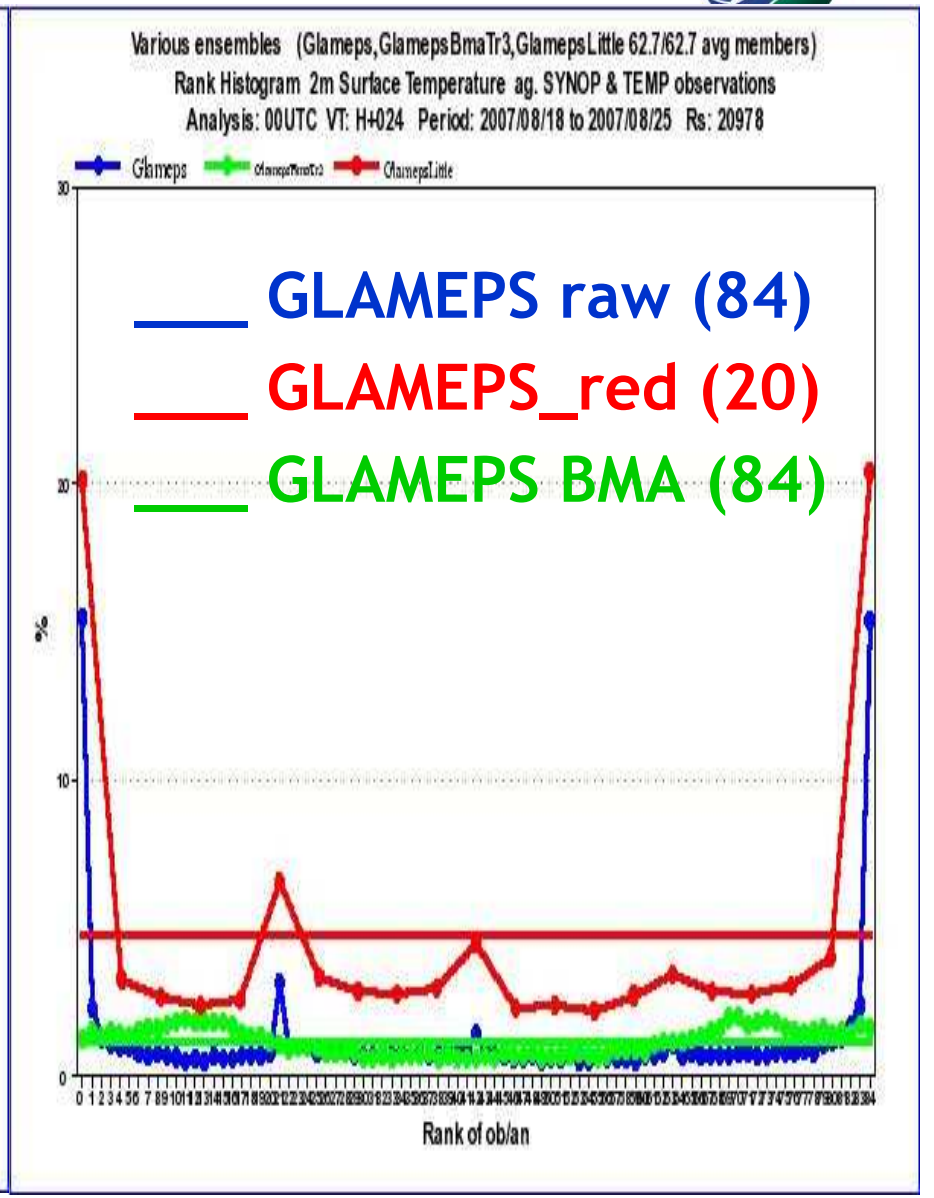
____ HIRLAM_EPS_S

____ EuroTEPS

Some Examples

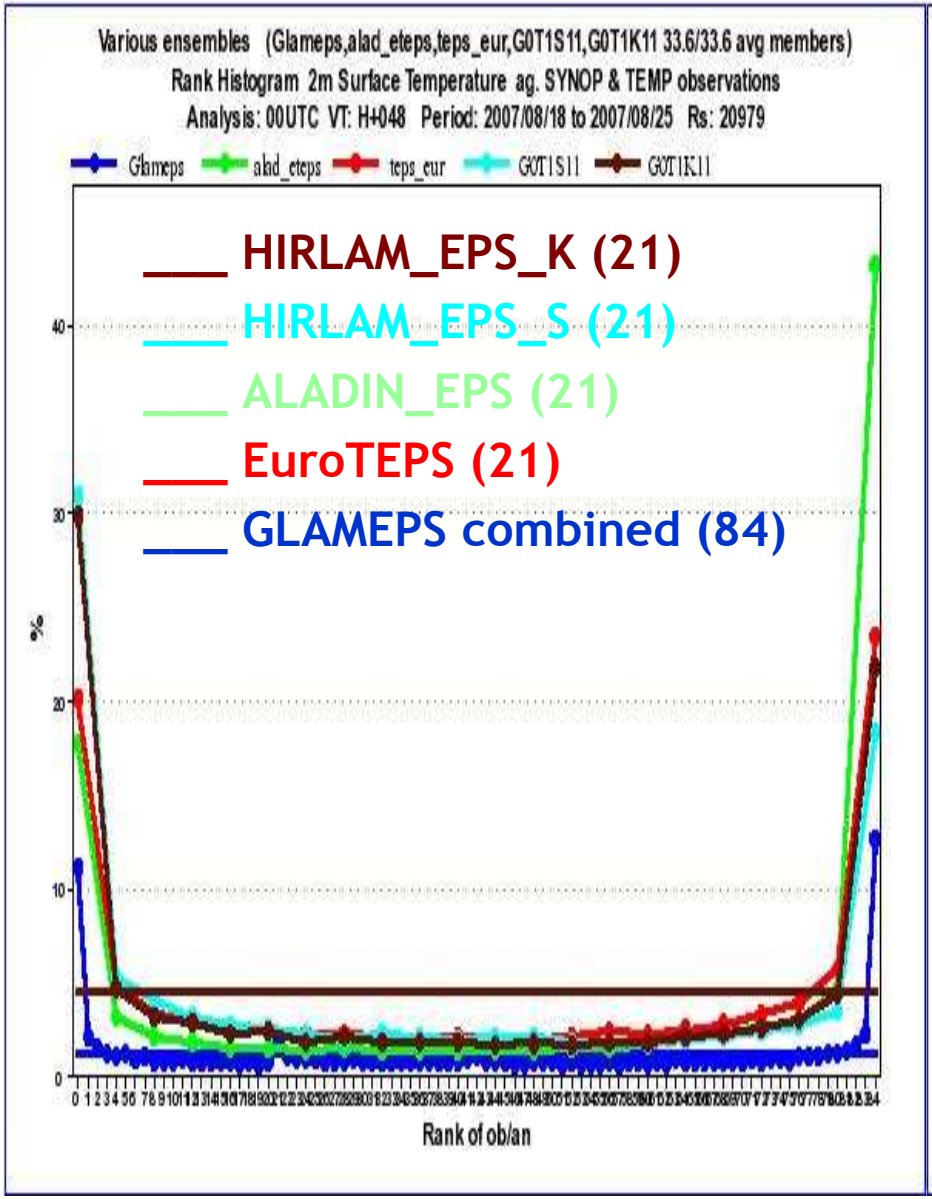
Rank Histograms, T2m, +24h

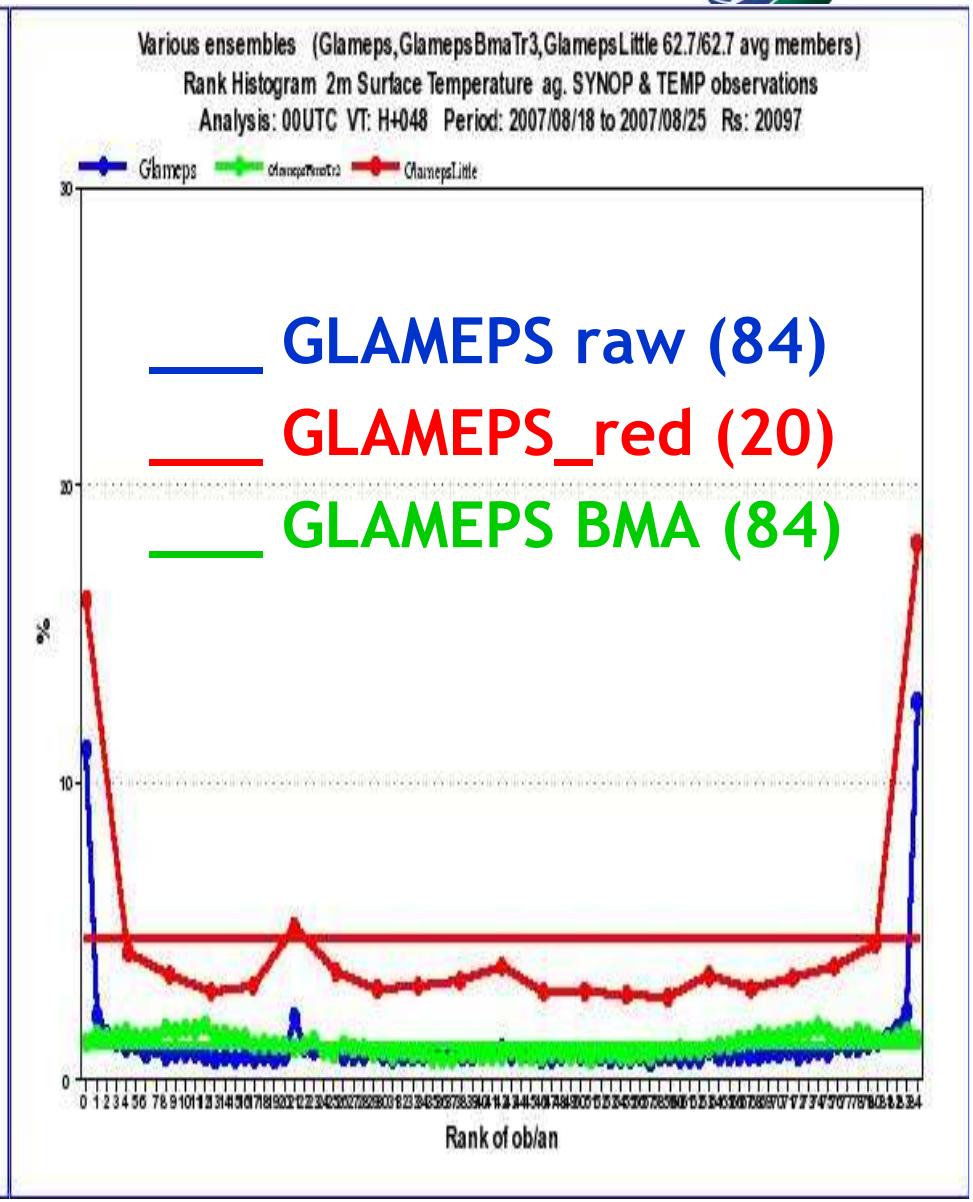




Some Examples

Rank Histograms, T2m, +48h





Some Examples

Spread-Skill T2m

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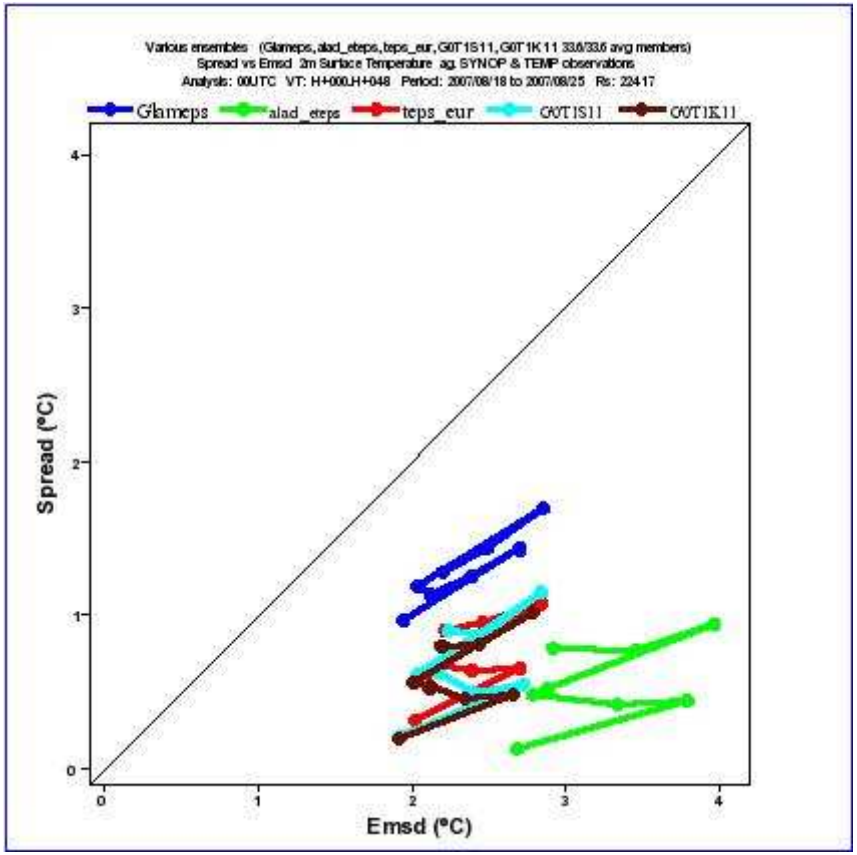
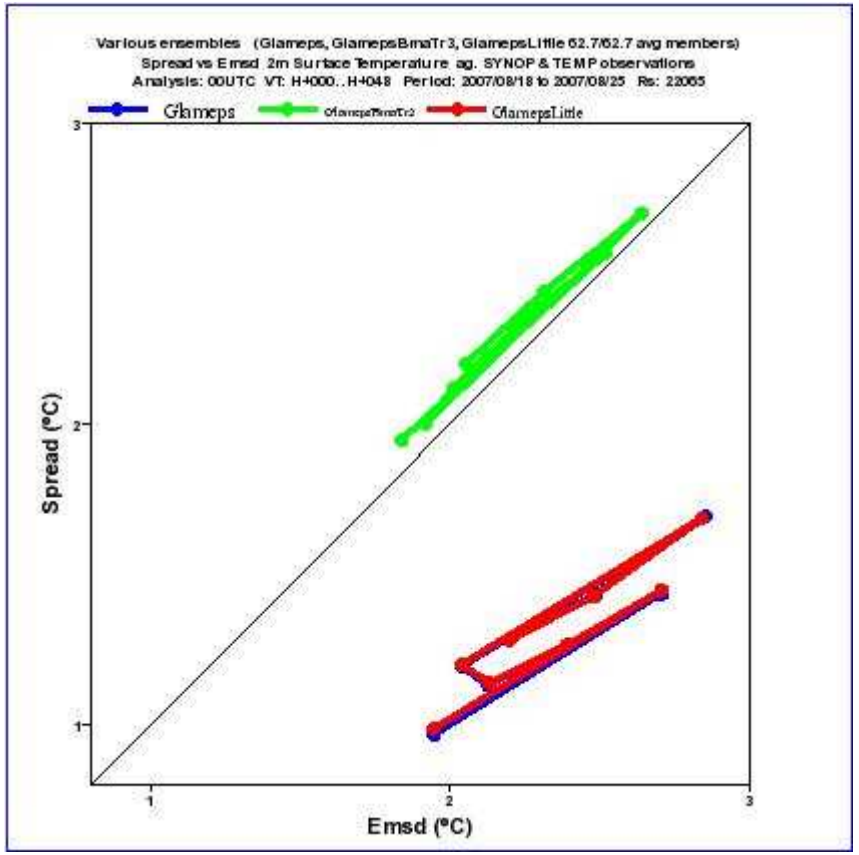




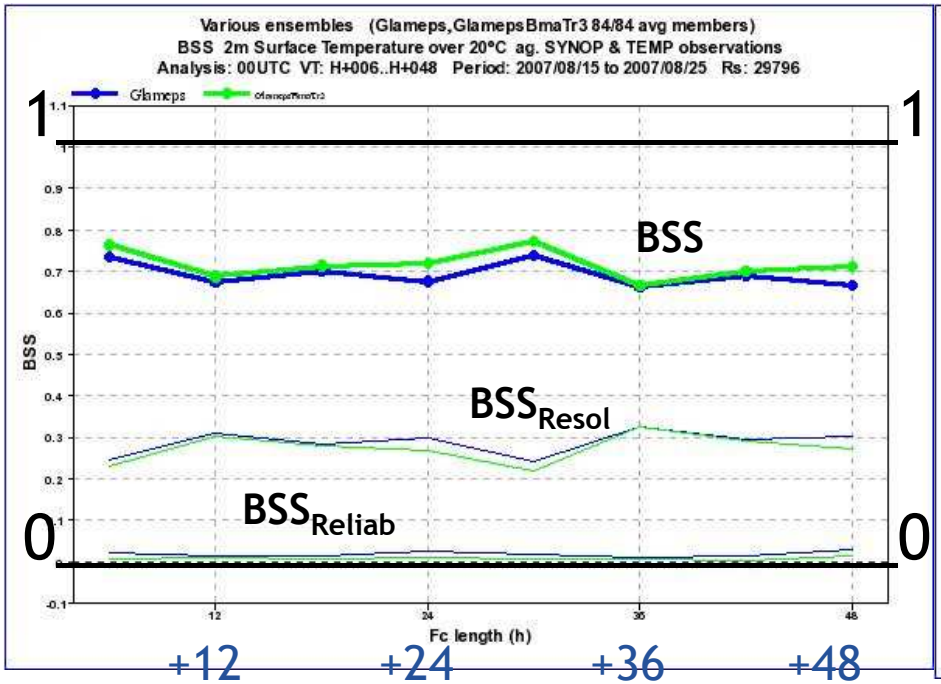
Some Examples

___ GLAMEPS raw (84) ___ GLAMEPS_red (20)

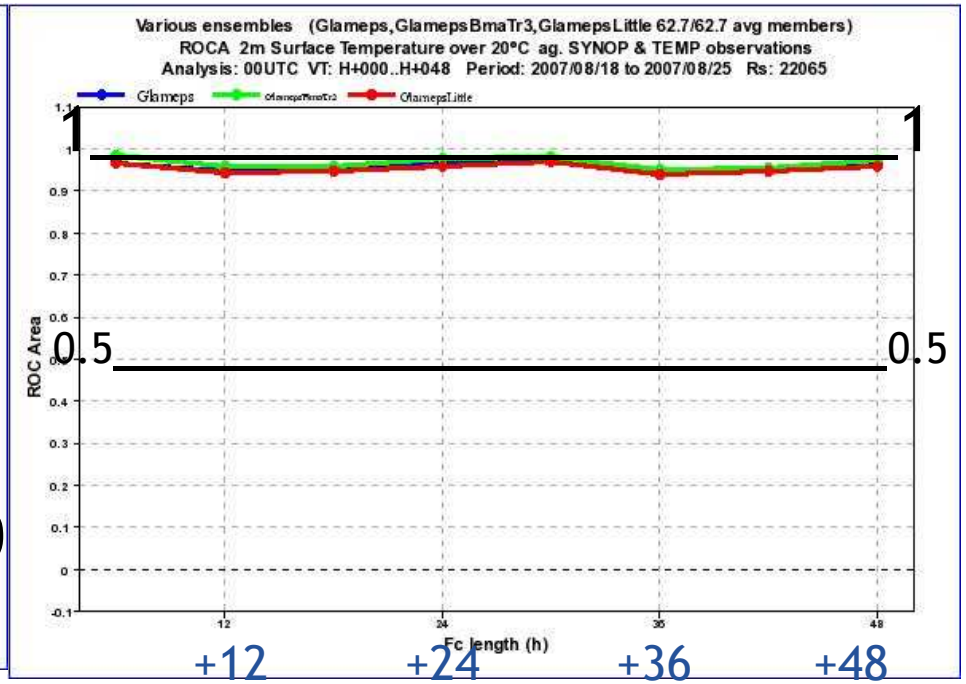
___ GLAMEPS BMA (84)

Brier Skill Score: T2m > 20°C

[BSS = 1 – BSS_{Reliab} - BSS_{Resol}]



Relative Operating Characteristics - Area: T2m > 20°C

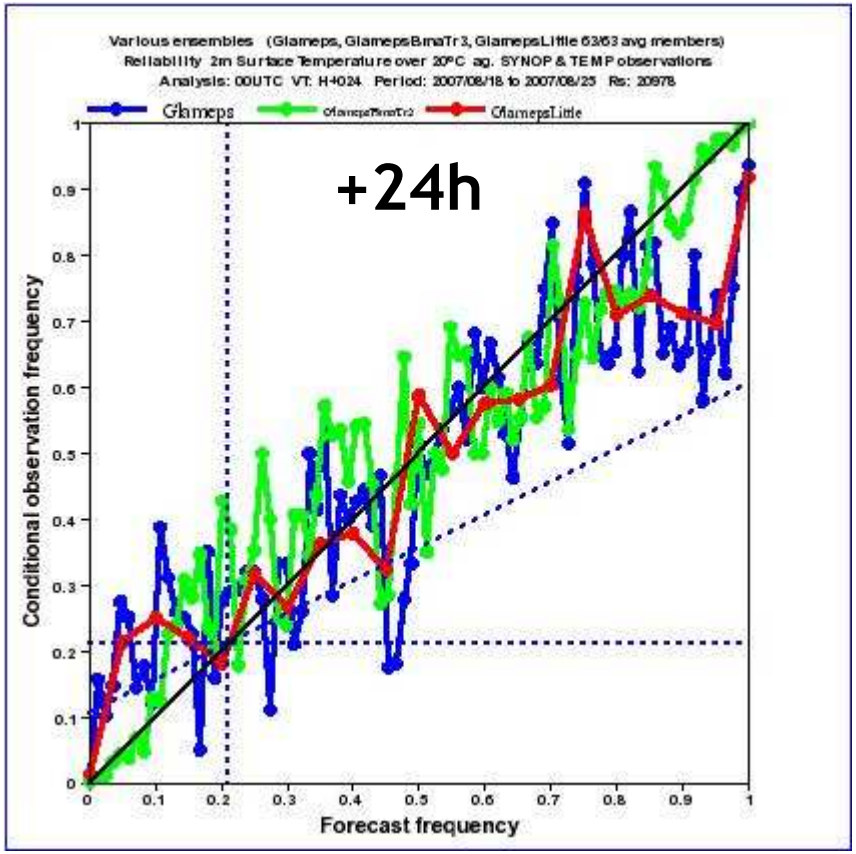


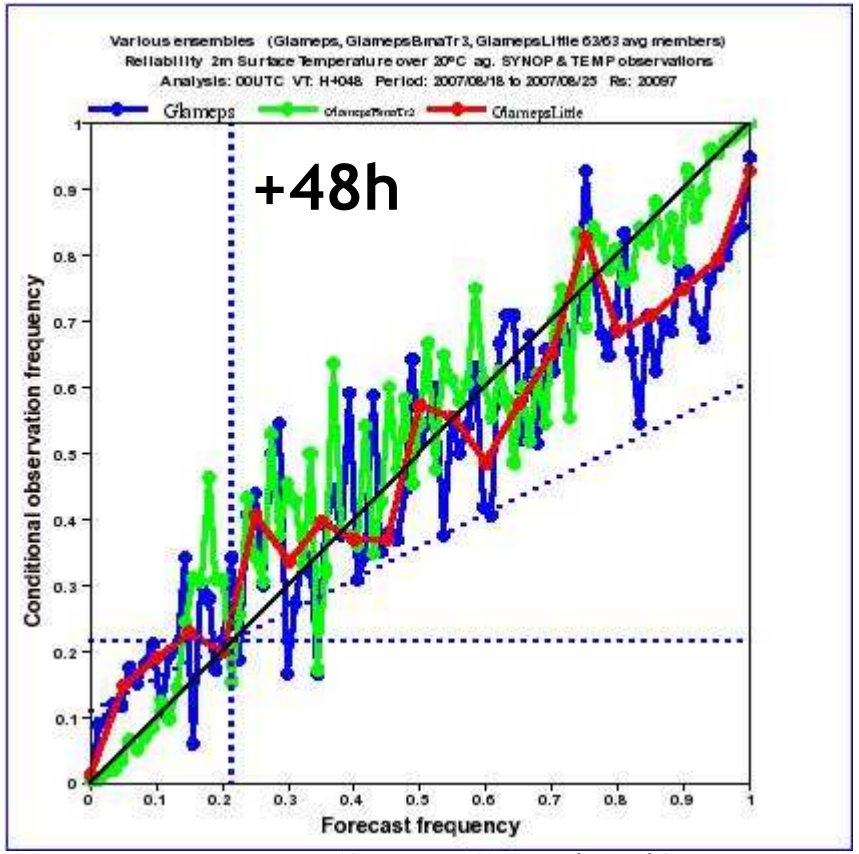
Some Examples

Reliability diagram: T2m > 20°C

___ GLAMEPS raw (84) ___ GLAMEPS_red (20)

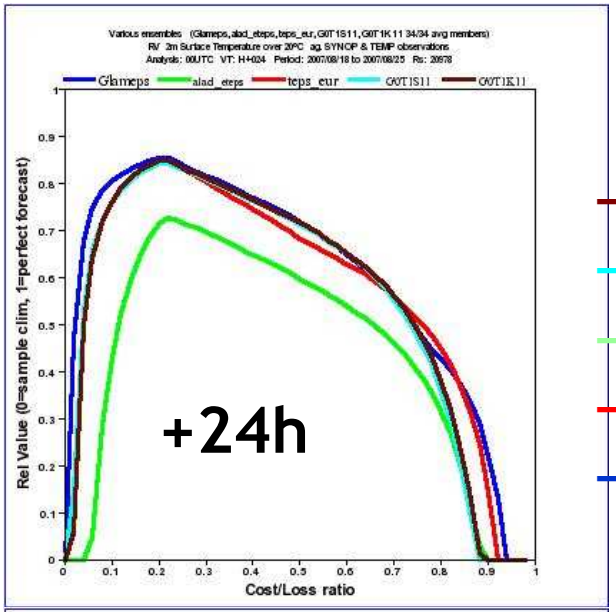
___ GLAMEPS BMA (84)

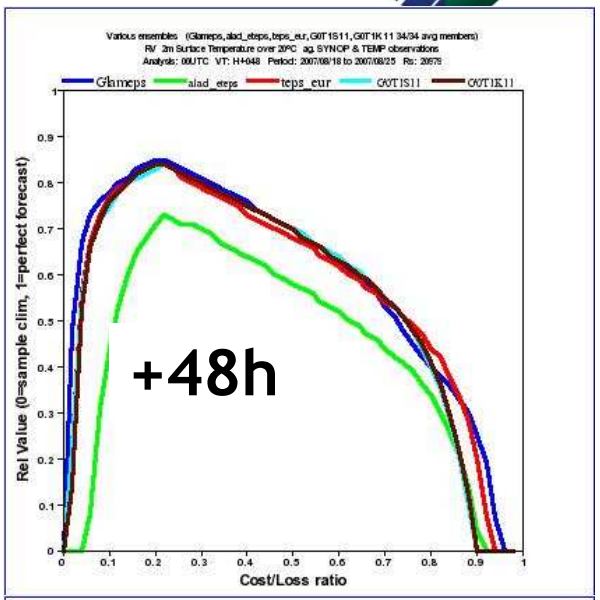




Some Examples

Relative Value as a function of cost/loss-ratio: T2m > 20°C





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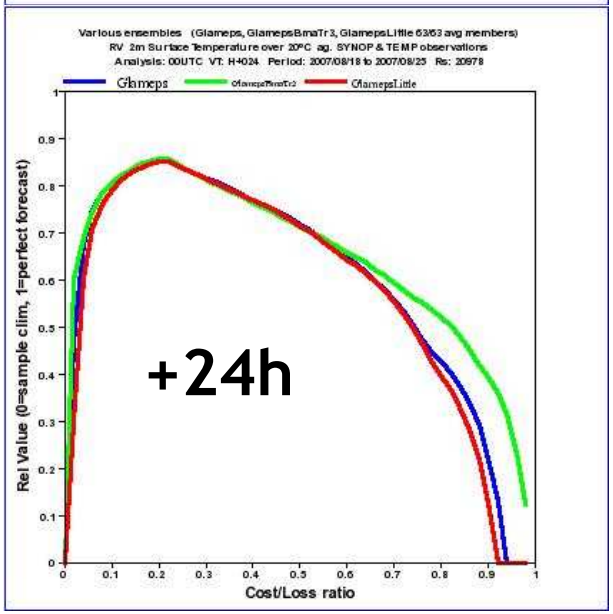
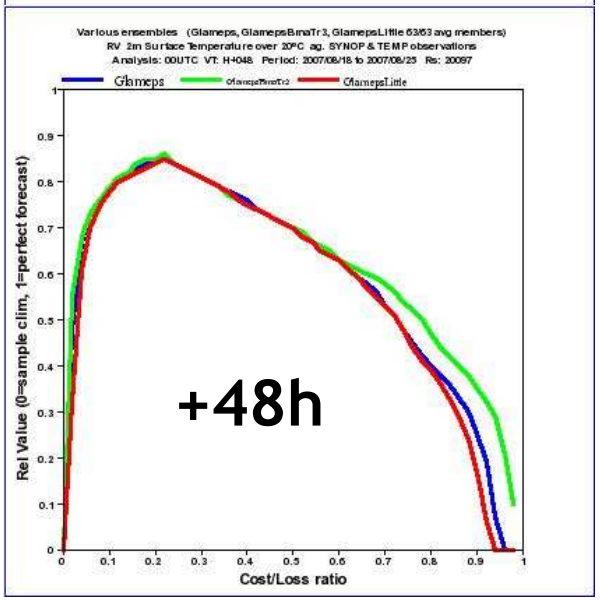
HIRLAM_EPS_S (21)

ALADIN_EPS (21)

EuroTEPS (21)

GLAMEPS combined (84)





GLAMEPS raw (84)

GLAMEPS BMA (84)

Other GLAMEPS developments
Type 2 Experiments

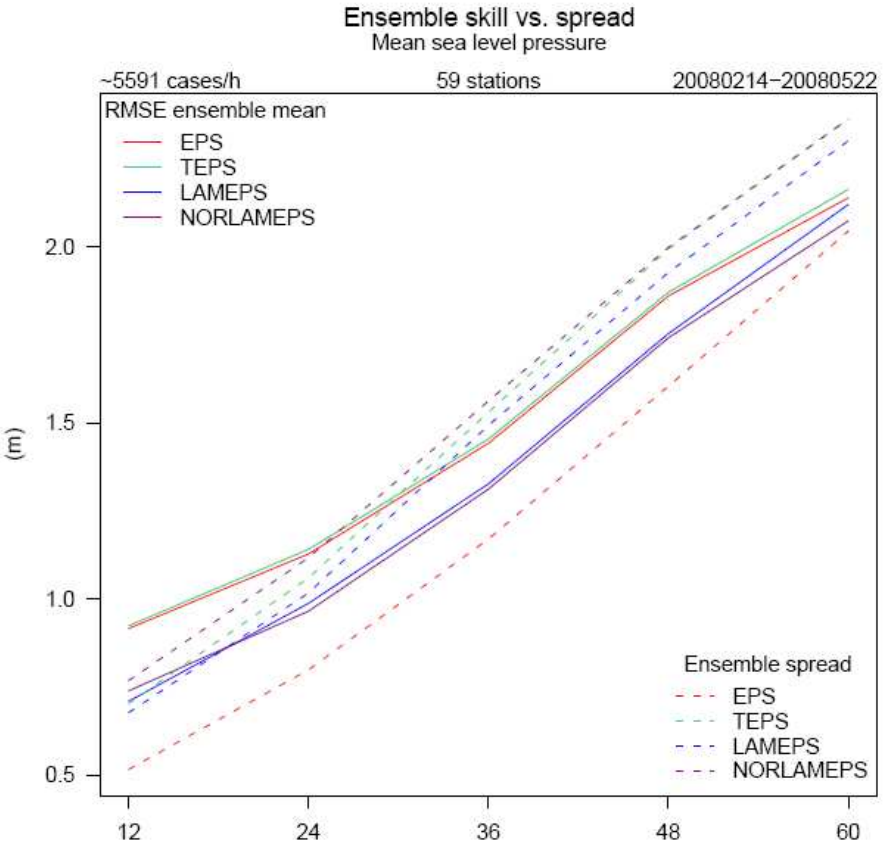
1. Physics perturbations
   - Stochastic Physics (H. Feddersen, J.A. Garcia-Moya)
   - Parameter variations (H. Feddersen)
   - Forcing SVs (J. Barkmeijer, R. Stappers)
   - Forcing Sensitivities (T. Iversen, J. Kristiansen)

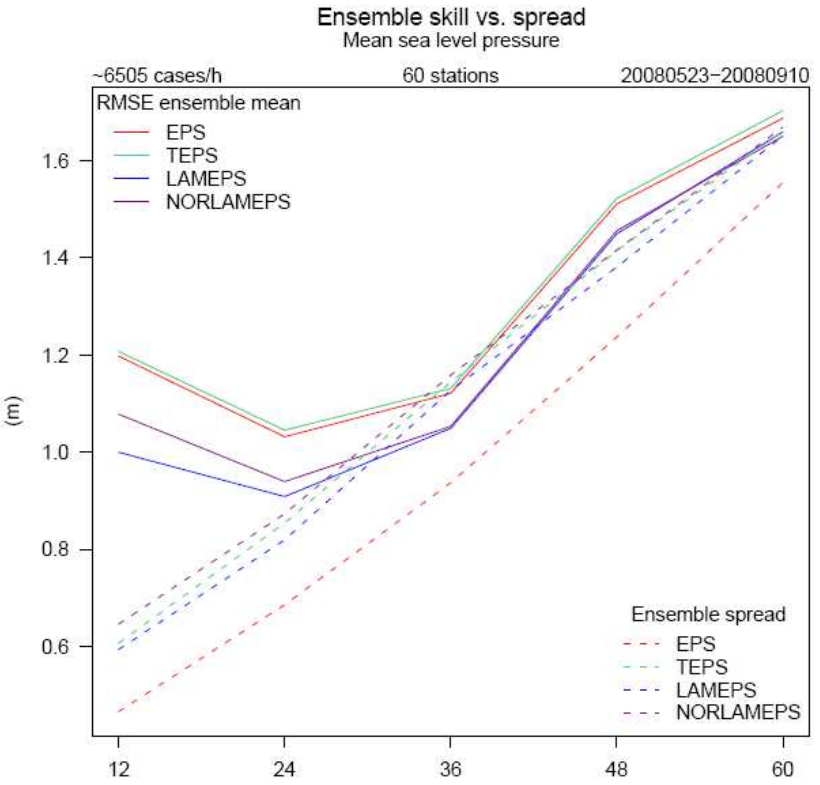
2. Alternative initial perturbations
   - Moist SVs and Hessian SVs in EuroTEPS (I.-L. Frogner)
   - Ensemble Transform Kalman Filtering (ETKF) (Å. Johansson)
   - LAM-specific SVs , alternative norm (TE, CAPE, Hessian)
     (J Barkmeijer, R. Stappers, S. van der Veen, E. Hagel, R. Mladek)
   - SLAF-techniques (J.A. Garcia-Moya)

Next: GLAMEPS_v1

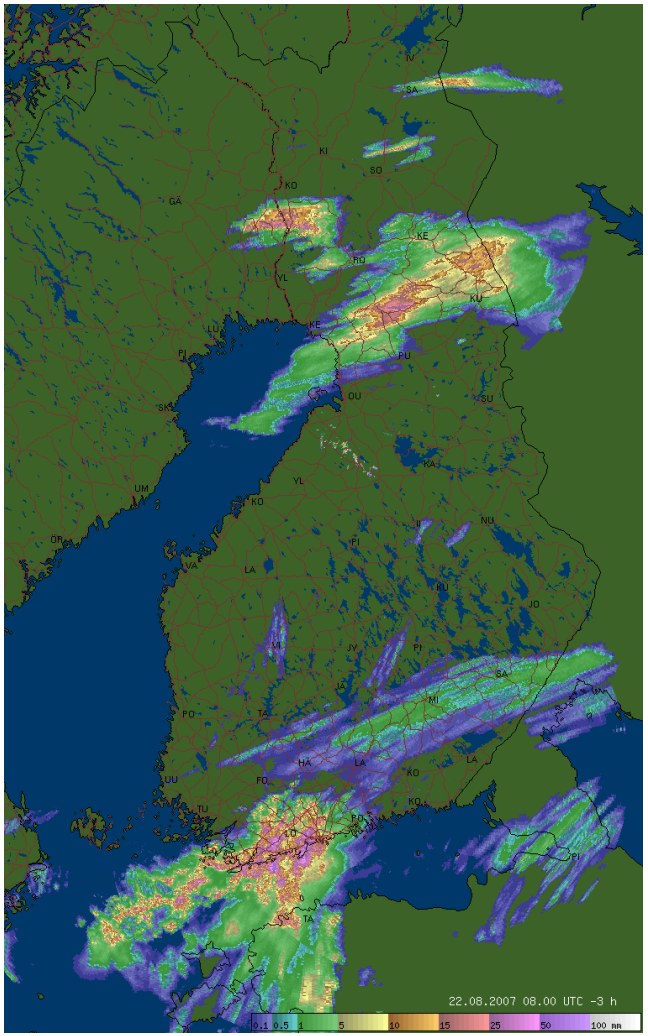
- **Still pre-operational, hindcast**
  - Some extensions to GLAMEPS_v0
    - Combination with LAM SVs, ETKF, Physics perturbations
  - Start experiments with decentralized production (1-3 nodes + ECMWF)

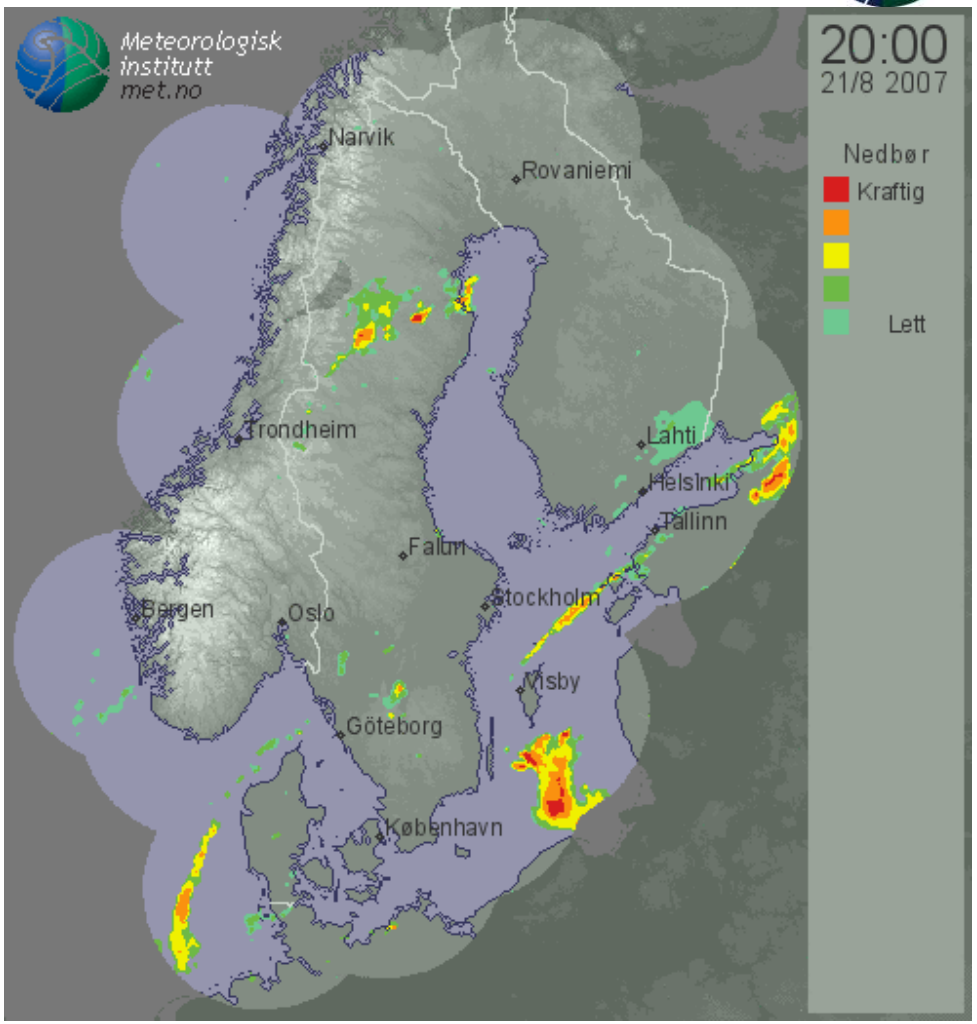

Thank You!


Ensemble skill vs. spread
Mean sea level pressure
~5591 cases/h
59 stations
20080214–20080522
RMSE ensemble mean
EPS
TEPS
LAMEPS
NORLAMEPS
Ensemble spread
EPS
TEPS
LAMEPS
NORLAMEPS
(m)
2.0
1.5
1.0
0.5
12
24
36
48
60


Ensemble skill vs. spread
Mean sea level pressure
~6505 cases/h
60 stations
20080523–20080910
RMSE ensemble mean
EPS
TEPS
LAMEPS
NORLAMEPS
Ensemble spread
EPS
TEPS
LAMEPS
NORLAMEPS
(m)
1.6
1.4
1.2
1.0
0.8
0.6
12
24
36
48
60

Problem-Case: Southern Finland, 22. Aug. 06-12

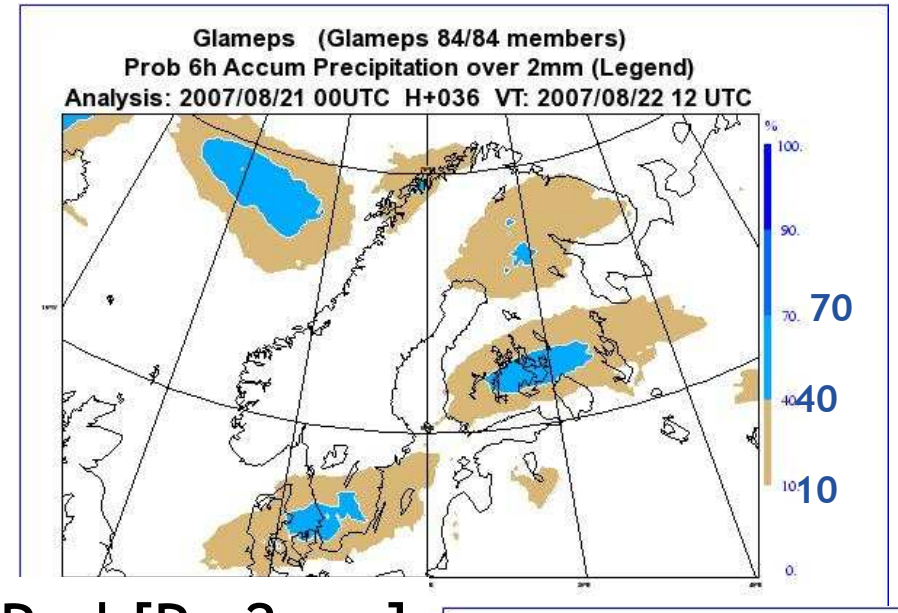




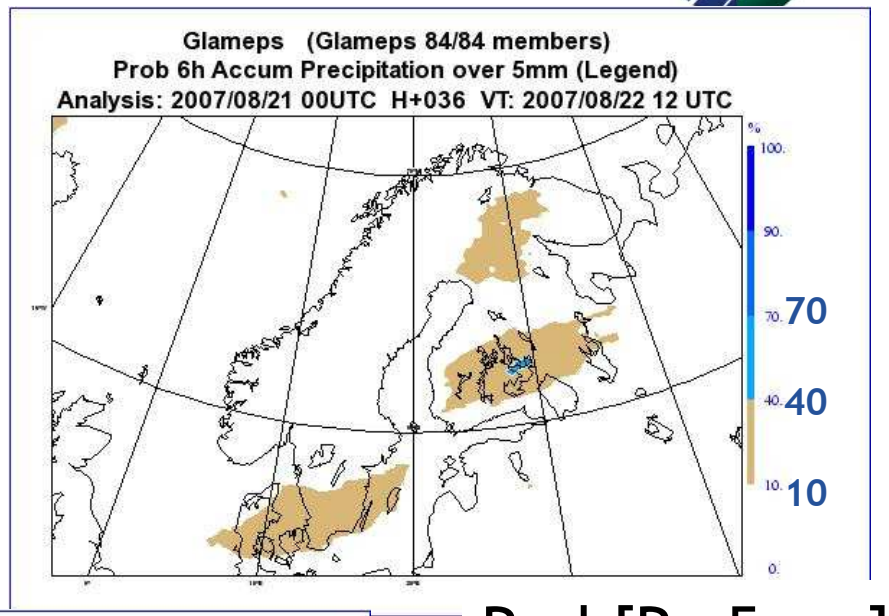
Cummulative Radar Echo

05-08 utc, 2007/08/22

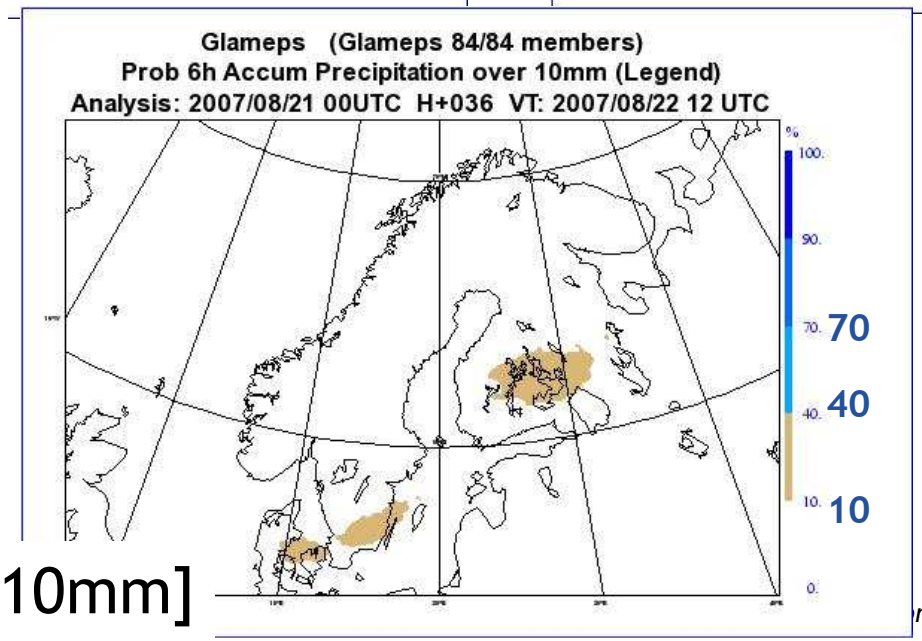
GLAMEPS Raw combination,
Acc. Precip.: 21.08.07 +30h - 36h



Prob[P_6>2mm]



Prob[P_6>5mm]



Prob[P_6>10mm]

ECMWF SBU consumption

- **EuroTEPS: ~2.7 Msbu per year**
  - 30 TSVs: ~600 sbu
  - 21-member, 72h TEPS: ~3000 sbu
  - Total ~3600 sbu per cycle, 730 cycles per year
- **HIRLAM_EPS: ~3.3 Msbu per year**
  - 21-members, 72h,12h cycles with 6h DA
  - Total ~2200 sbu per cycle, 1460 cycles per year
- **ALADIN_EPS: ~1.1 Msbu per year**
  - 21-members, 54h,12h cycles no DA:
  - ~1400 sbu per cycle, 730 cycles per year