15 April 2015, ASM, Helsingor, Denmark

Developments in Glameps and HarmonEPS

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A) Verification of GLAMEPS with and without additional perturbations from CAPE Singular Vectors in Hirlam-K and Hirlam–S.

(1 July – 31 August 2010):

6 UTC and 18 UTC runs

The GLAMEPS configuration

Hirlam_K	mbr000, mbr013 – mbr024	06 / 18
Hirlam_S	mbr000, mbr001 – mbr012	06 / 18
Aladin	mbr000, mbr025 – mbr036	06 / 18

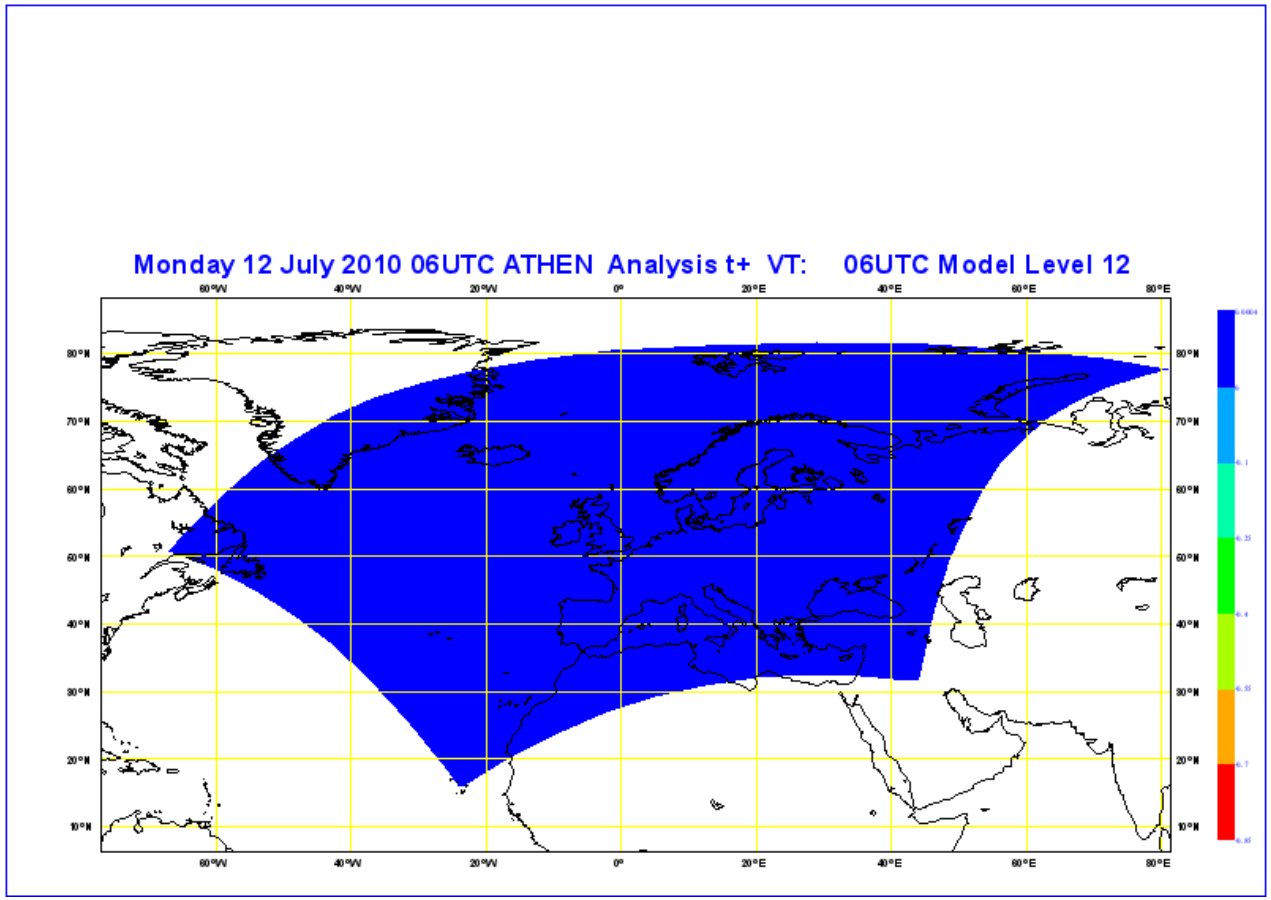
ECEPS mbr037 – mbr050
00 / 12

ECDET mbr000 00 / 12

Total number of members: 54

Resolution: 11.1 / 11.8 / 32 km

Glameps area



Singular vector computations

Analyses of control run were used; interpolation to ~ 48 km res.

Optimisation time: 12 h

CAPE

$$CAPE = g \int_{z_f}^{Z_n} \left(\frac{T_{v,parcel} - T_{v,env}}{T_{v,env}} \right) dz$$

Hirlam_S SV's for Hirlam_S

Hirlam_K SV's for Hirlam_K

#SV's : 14 use linear model of Hirlam

Perturbations for different members

-Gaussian symmetric

-u, v and T

-Perturbations are *added* to ECEPS perturbations

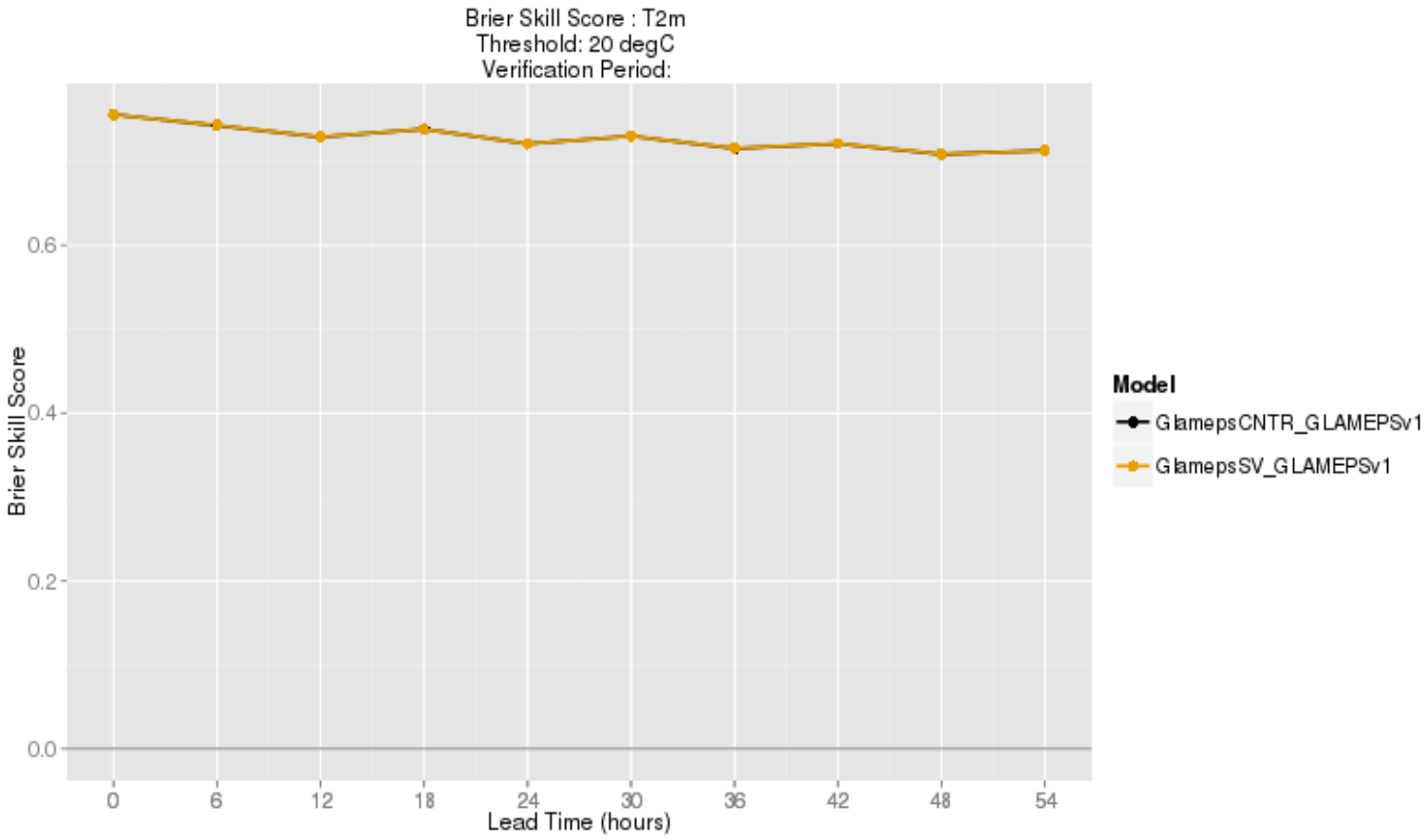
Verification of 5 model variables in the 2 Glameps experiments:

T2m
S10m
G10m
Pmsl
Pcp12h

Verification T2m

whole period, 6 and 18 UTC runs

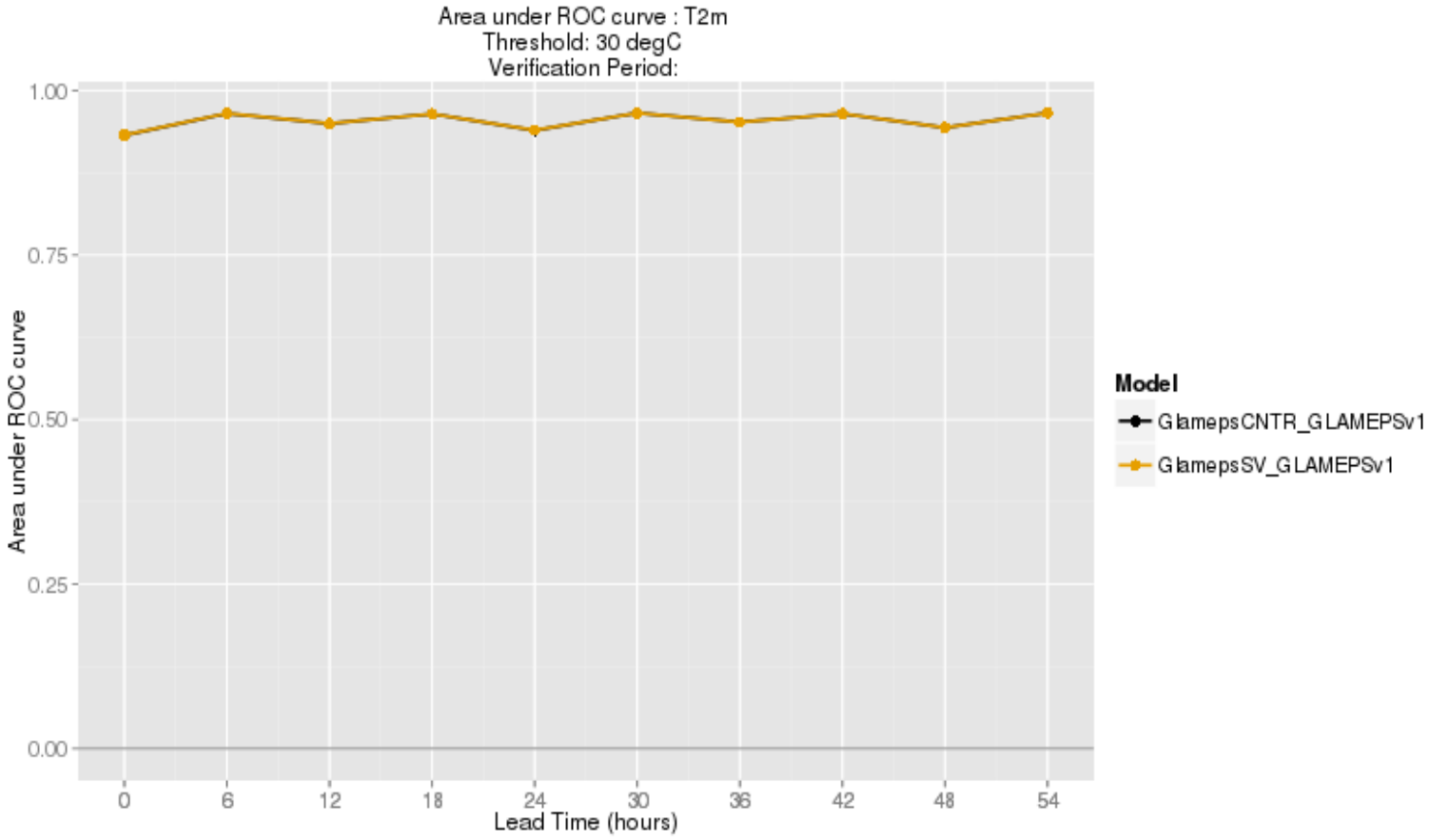
Neutral impact on Brier skill score



Verification T2m

whole period, 6 and 18 UTC runs

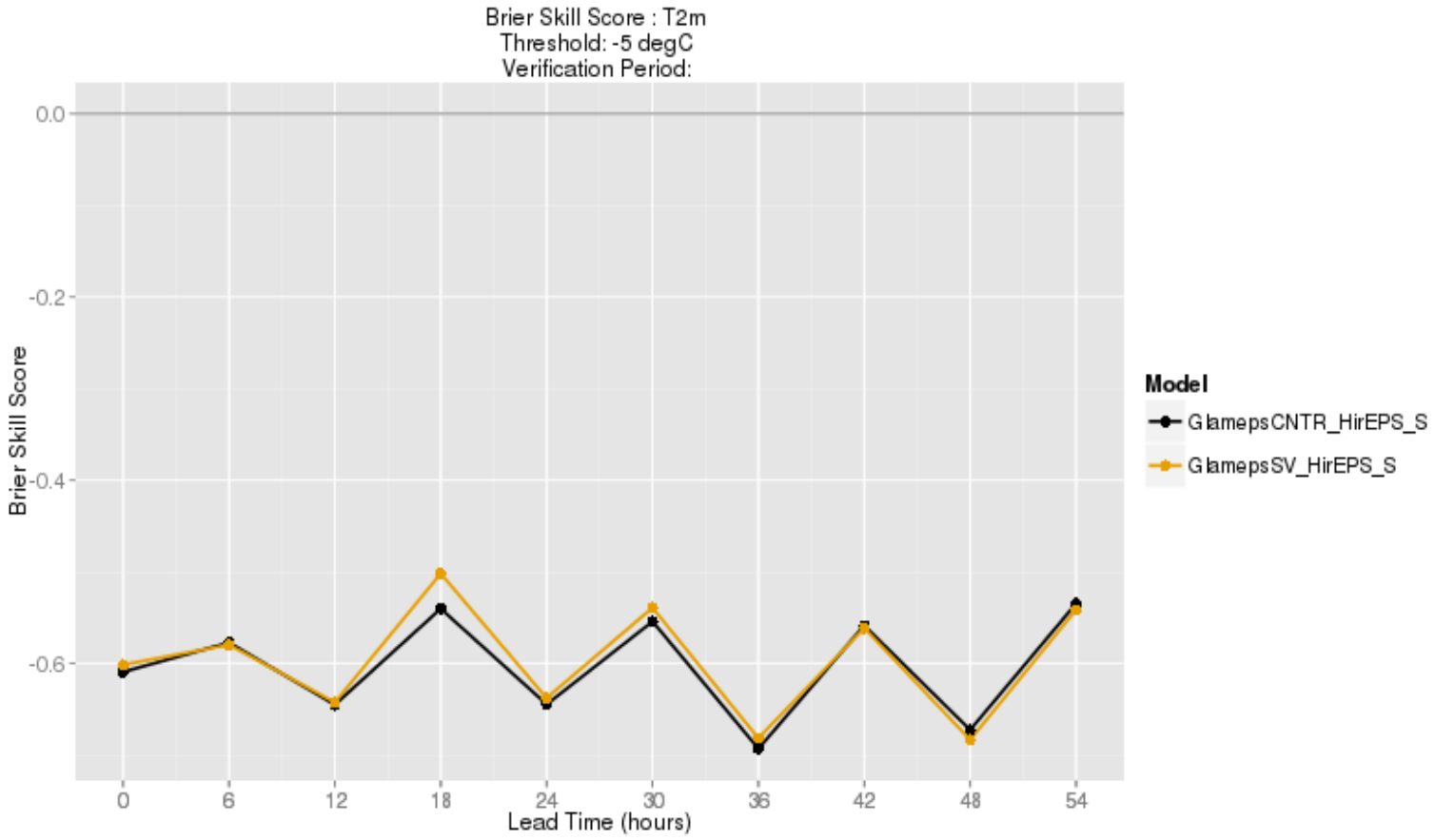
Neutral impact on ROC area



Verification T2m

whole period, 6 and 18 UTC runs

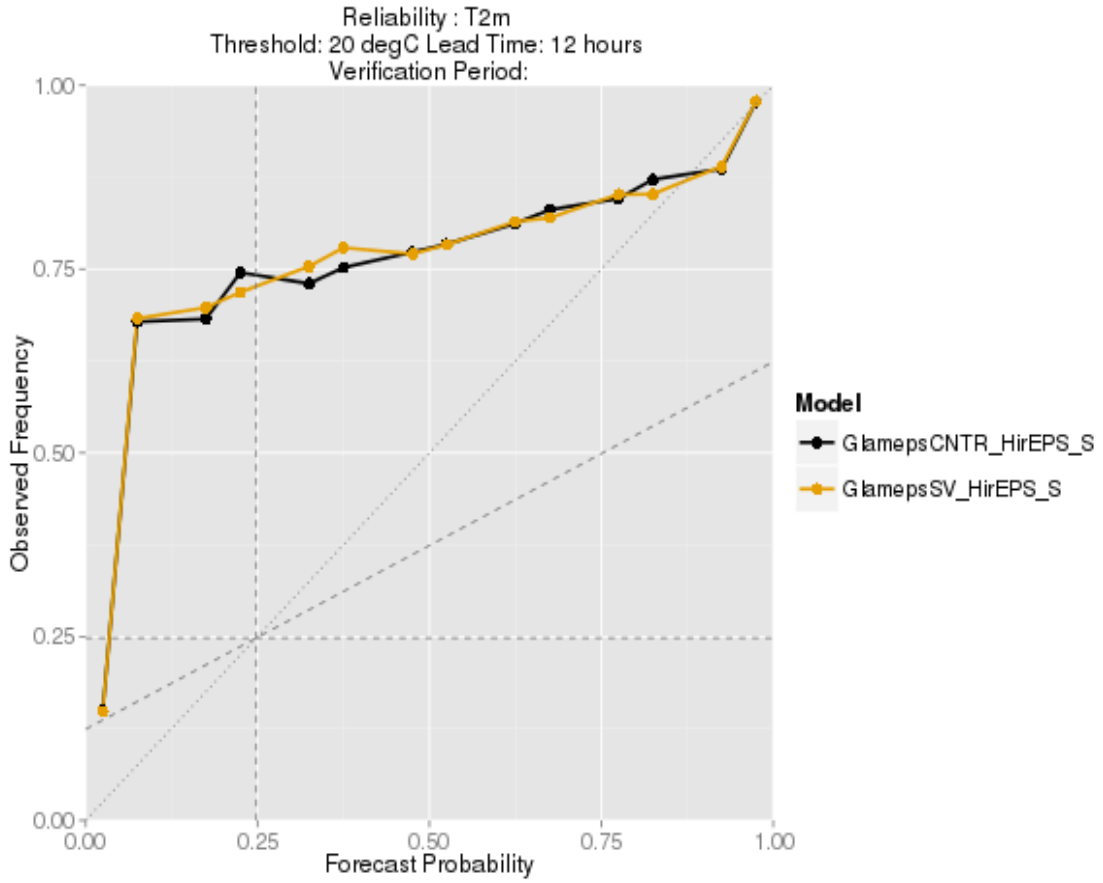
Brier skill score, -5 C, Hirlam Straco



Verification T2m

whole period, 6 and 18 UTC runs

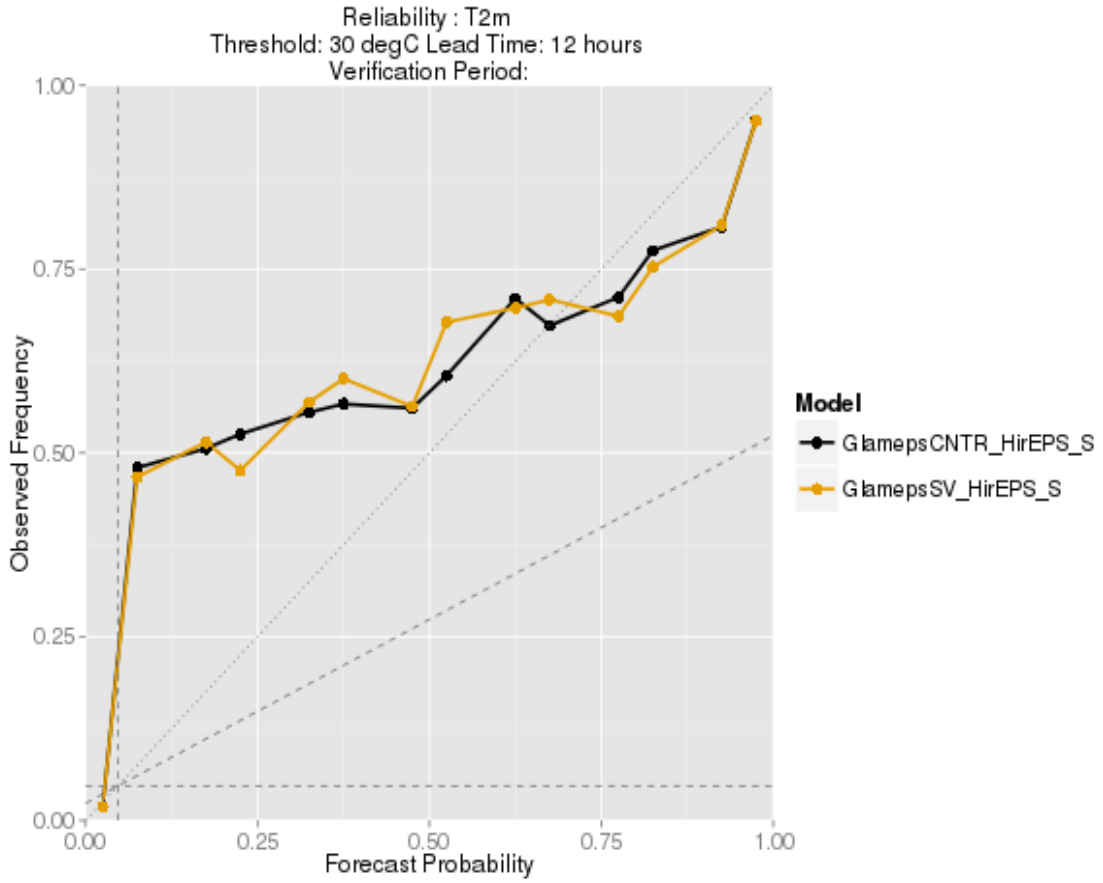
Reliability, 20 C, +12 h, Hirlam Straco



Verification T2m

whole period, 6 and 18 UTC runs

Reliability, 30 C, +12h, Hirlam Straco



Verification T2m

whole period, 6 and 18 UTC runs

scores show *neutral* or weak positive impact (ROC, BSS)

clearest impact at +18h

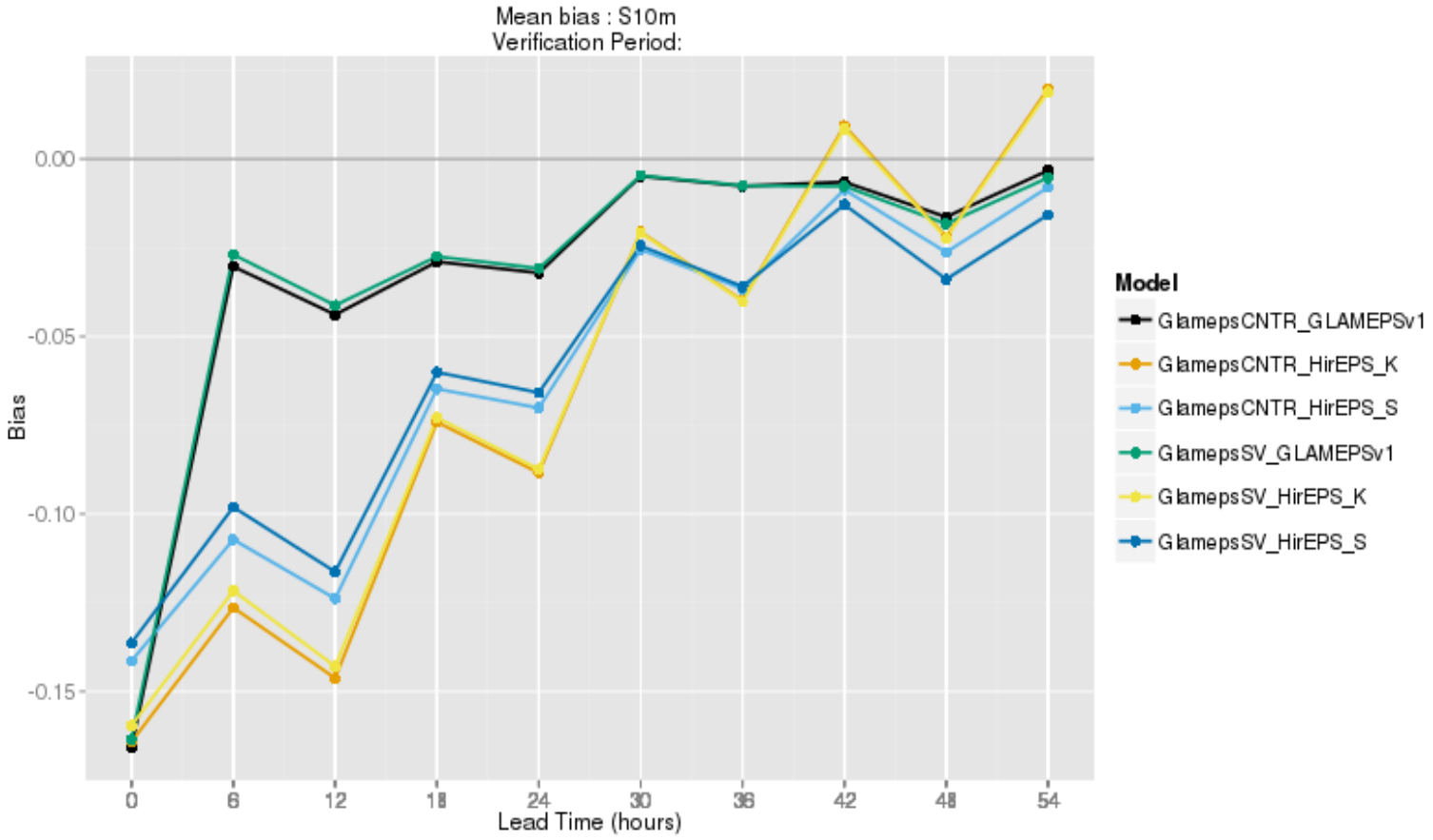
Straco shows stronger impact than *Kain-Fritsch*

Reliability not very sensitive to lead time

Verification S10m

whole period, 6 and 18 UTC runs

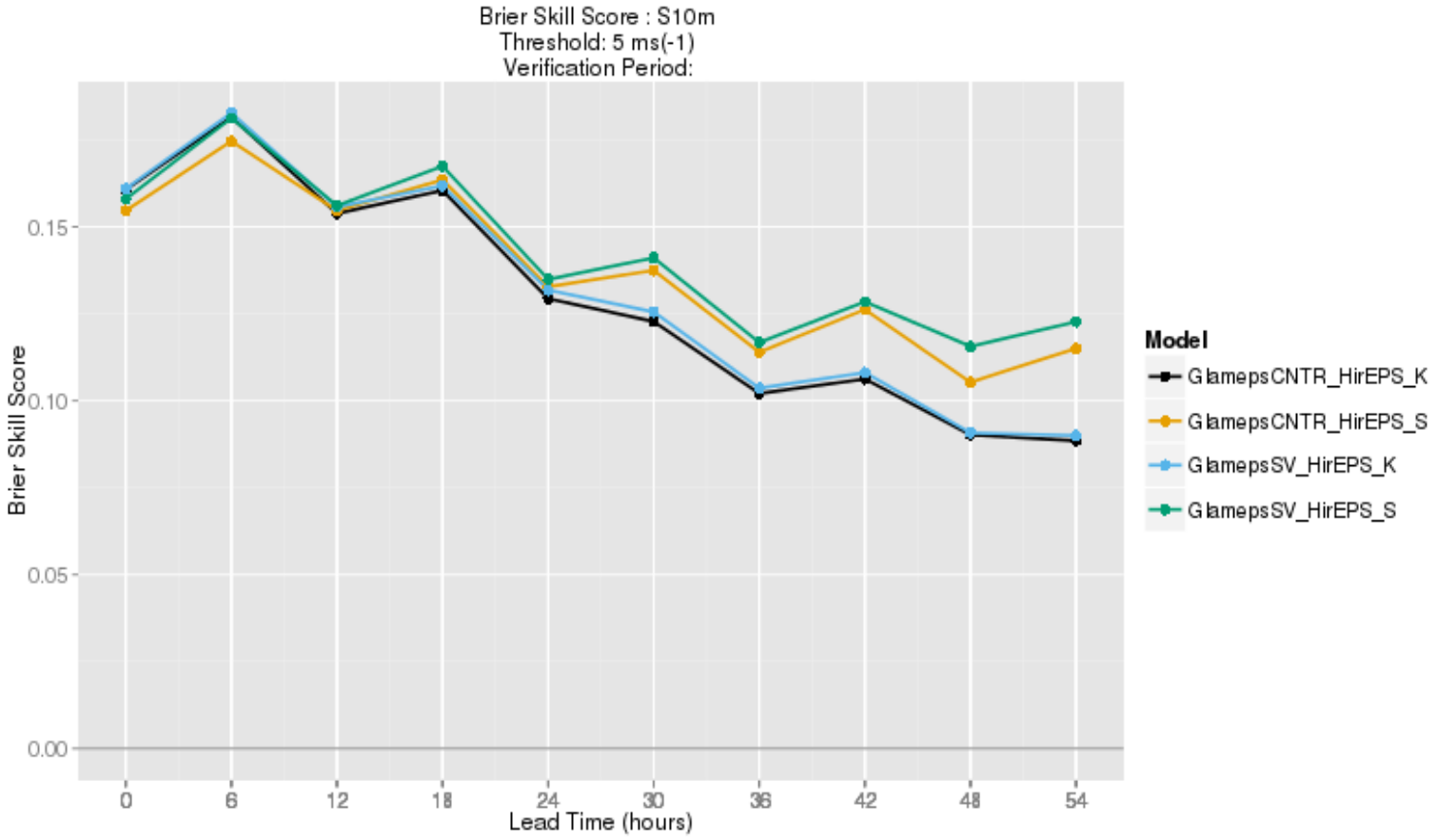
Bias, H-S and H-K, Glameps



Verification S10m

whole period, 6 and 18 UTC runs

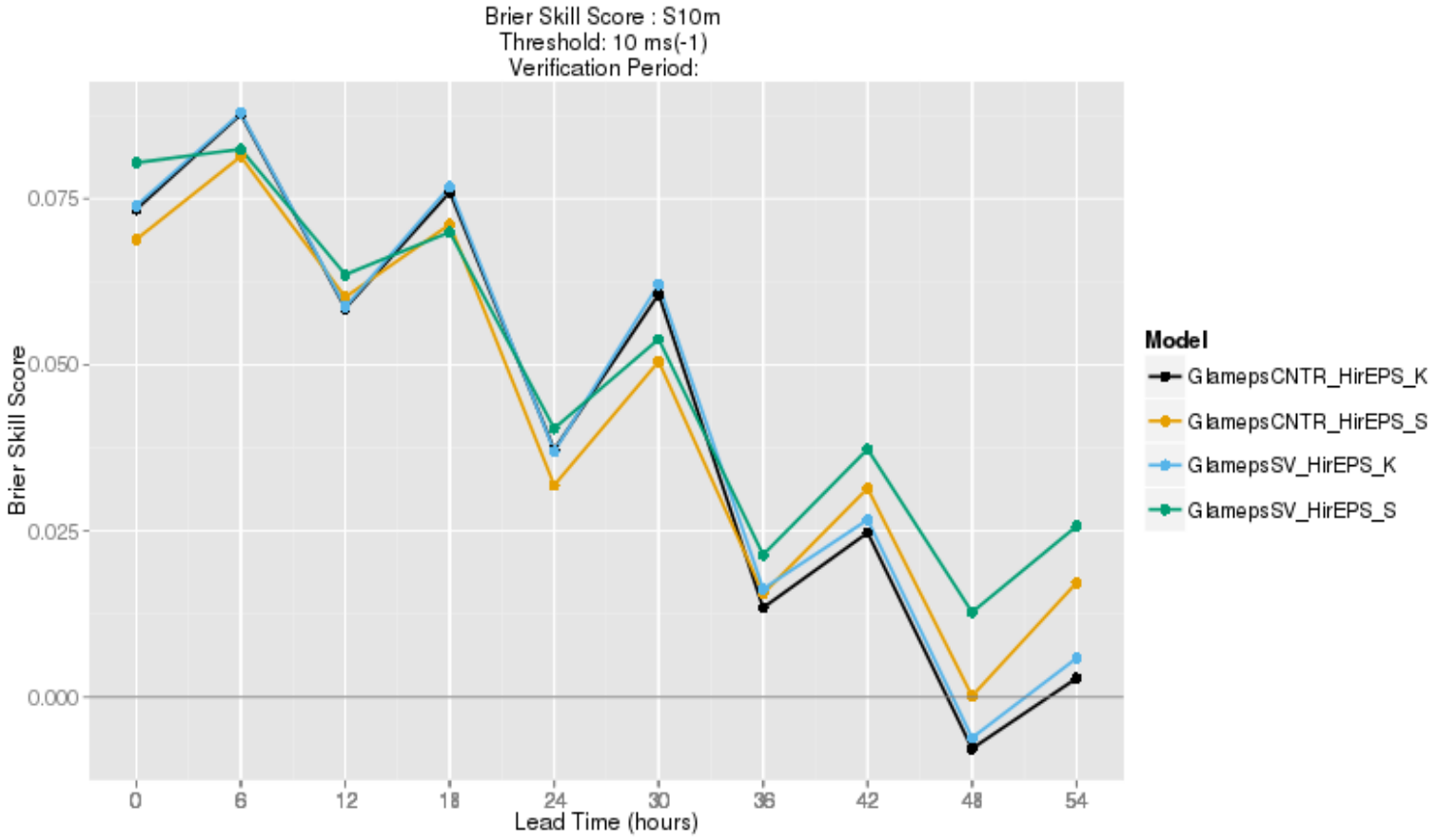
Brier skill score, 5 m/s, Hirlam-S and -K



Verification S10m

whole period, 6 and 18 UTC runs

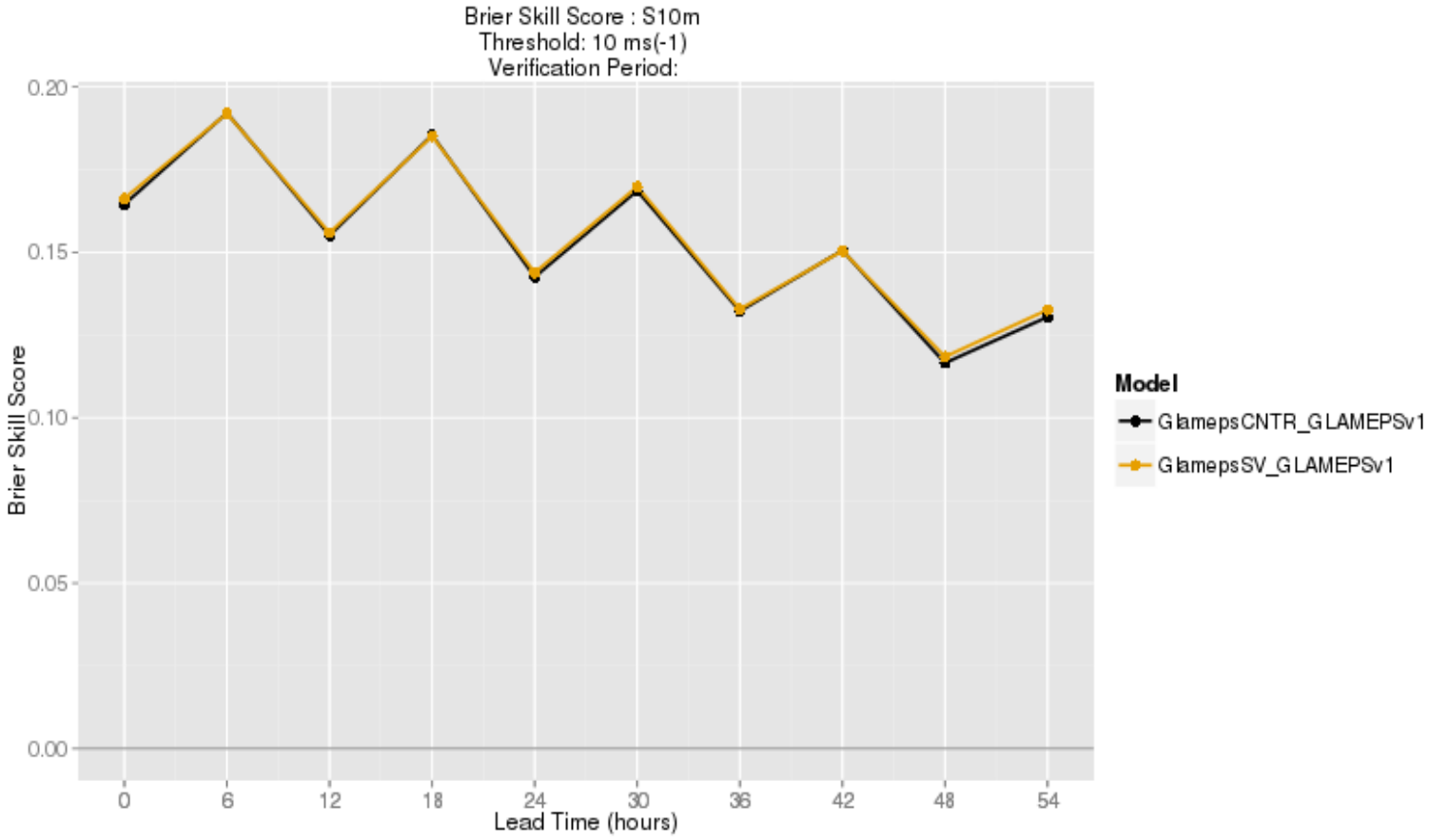
Brier skill score, 10 m/s, Hirlam-S and -K



Verification S10m

whole period, 6 and 18 UTC runs

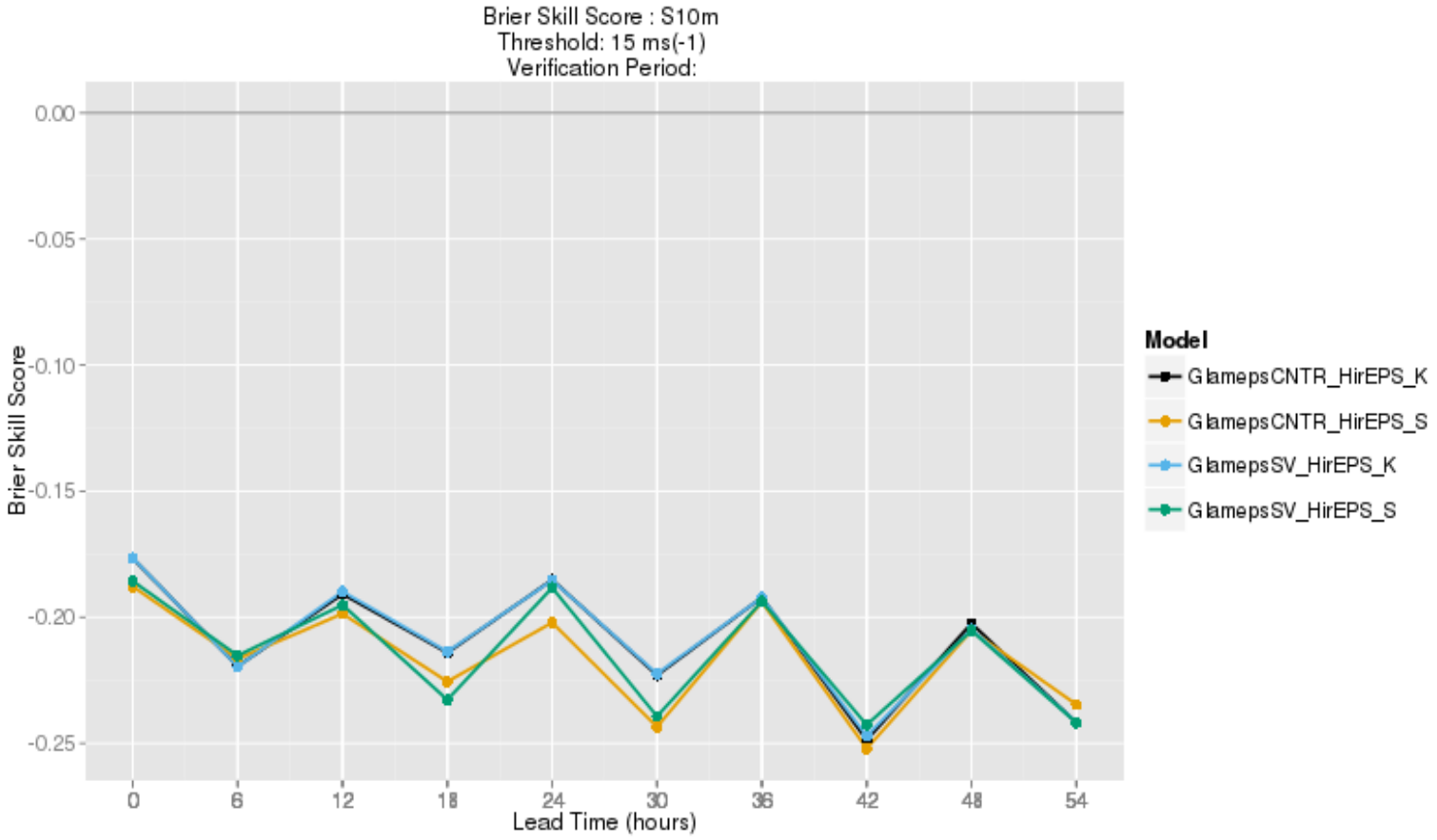
Brier skill score, 10 m/s, Glameps



Verification S10m

whole period, 6 and 18 UTC runs

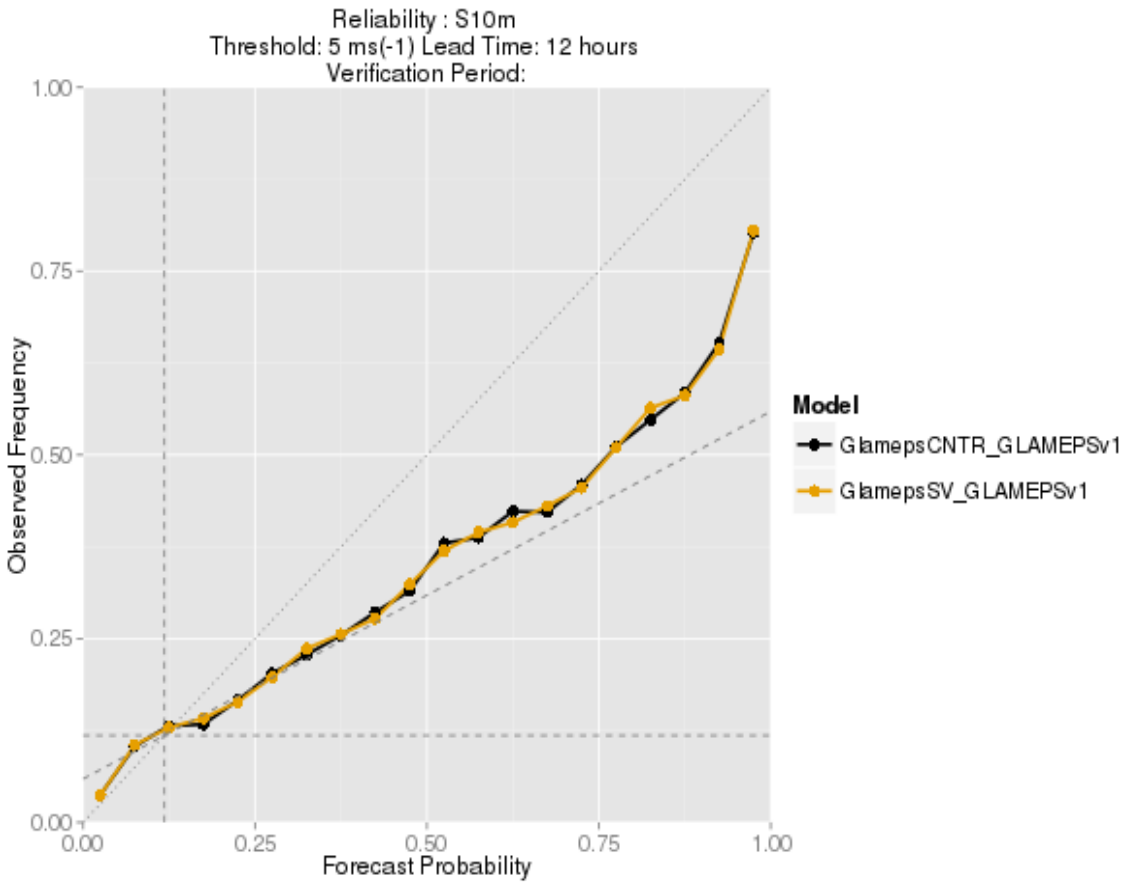
Brier skill score, 15 m/s, Hirlam-S and -K



Verification S10m

whole period, 6 and 18 UTC runs

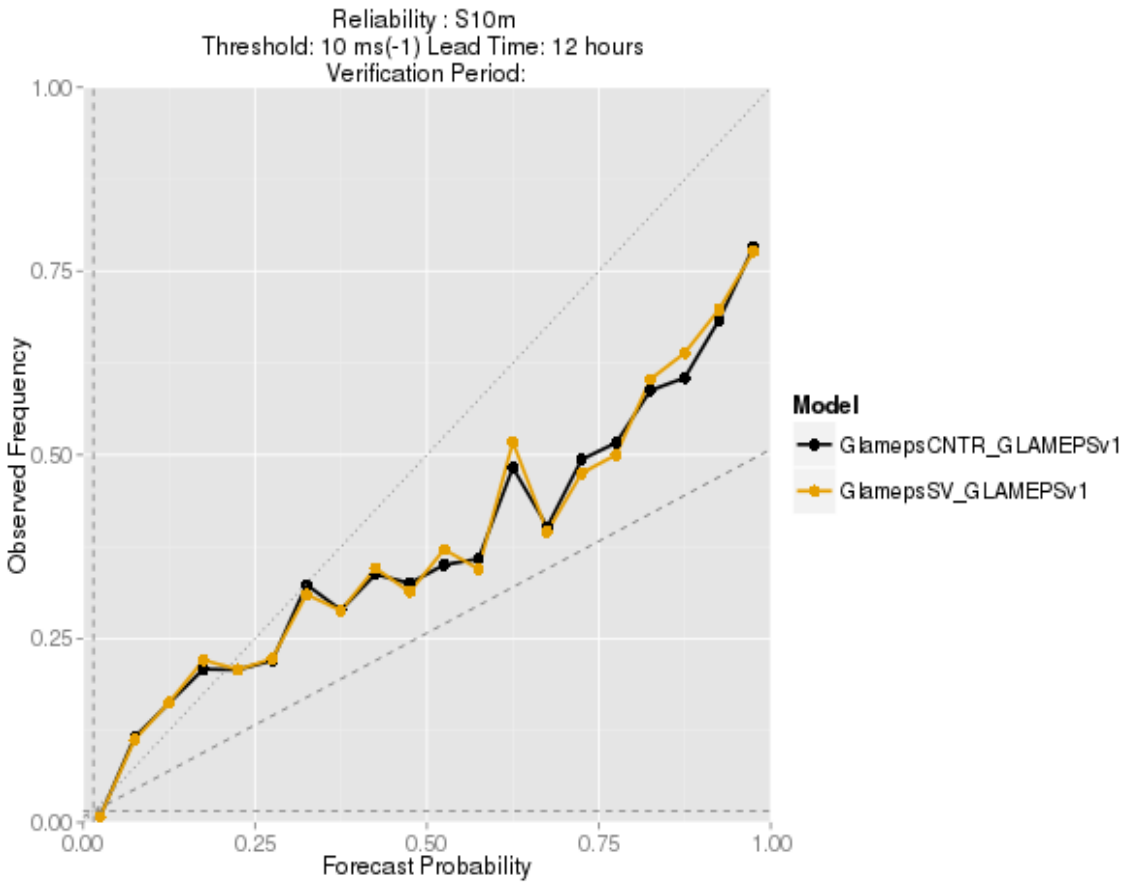
Reliability, 5 m/s, +12h, Glameps



Verification S10m

whole period, 6 and 18 UTC runs

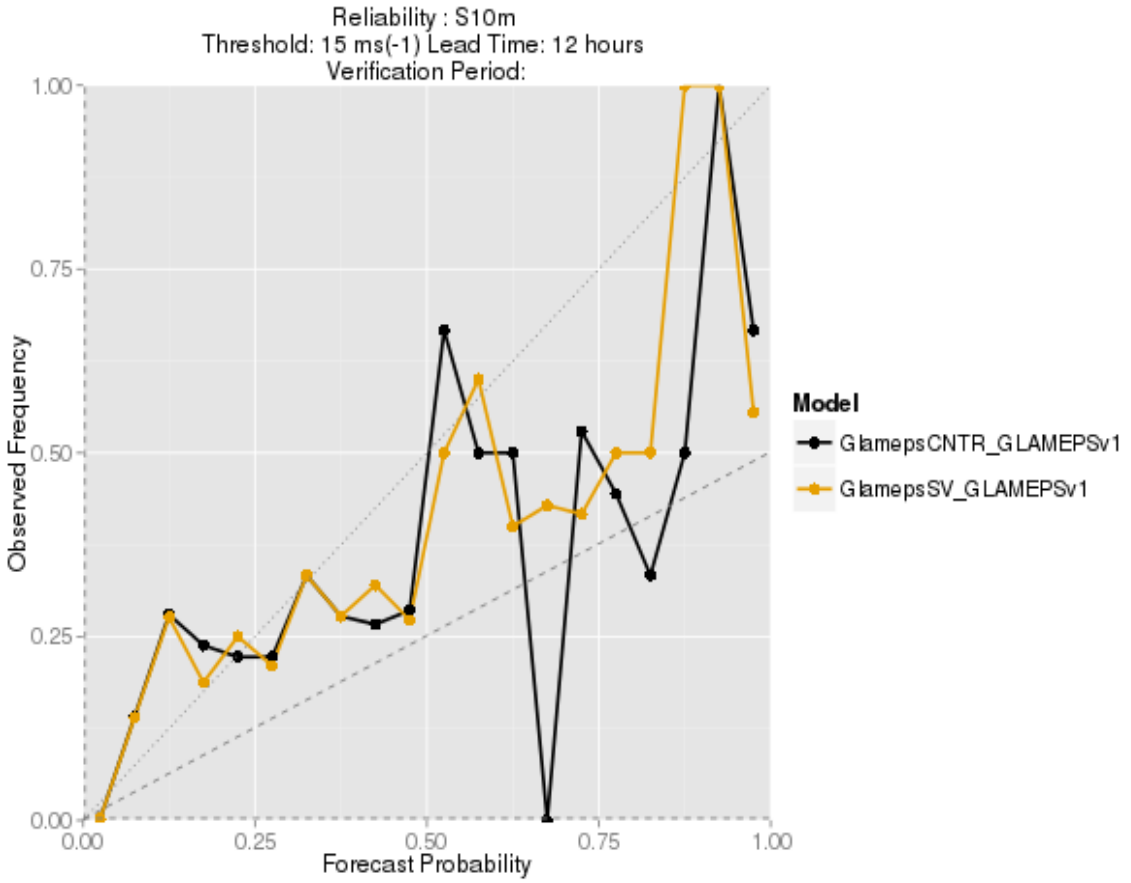
Reliability, 10 m/s, +12h, Glameps



Verification S10m

whole period, 6 and 18 UTC runs

Reliability, 15 m/s, +12h, Glameps



Verification results S10m

Bias improved,slightly worse after +42h

nearly always positive impact on BSS for all thresholds (quite small impact on Glameps as a whole)

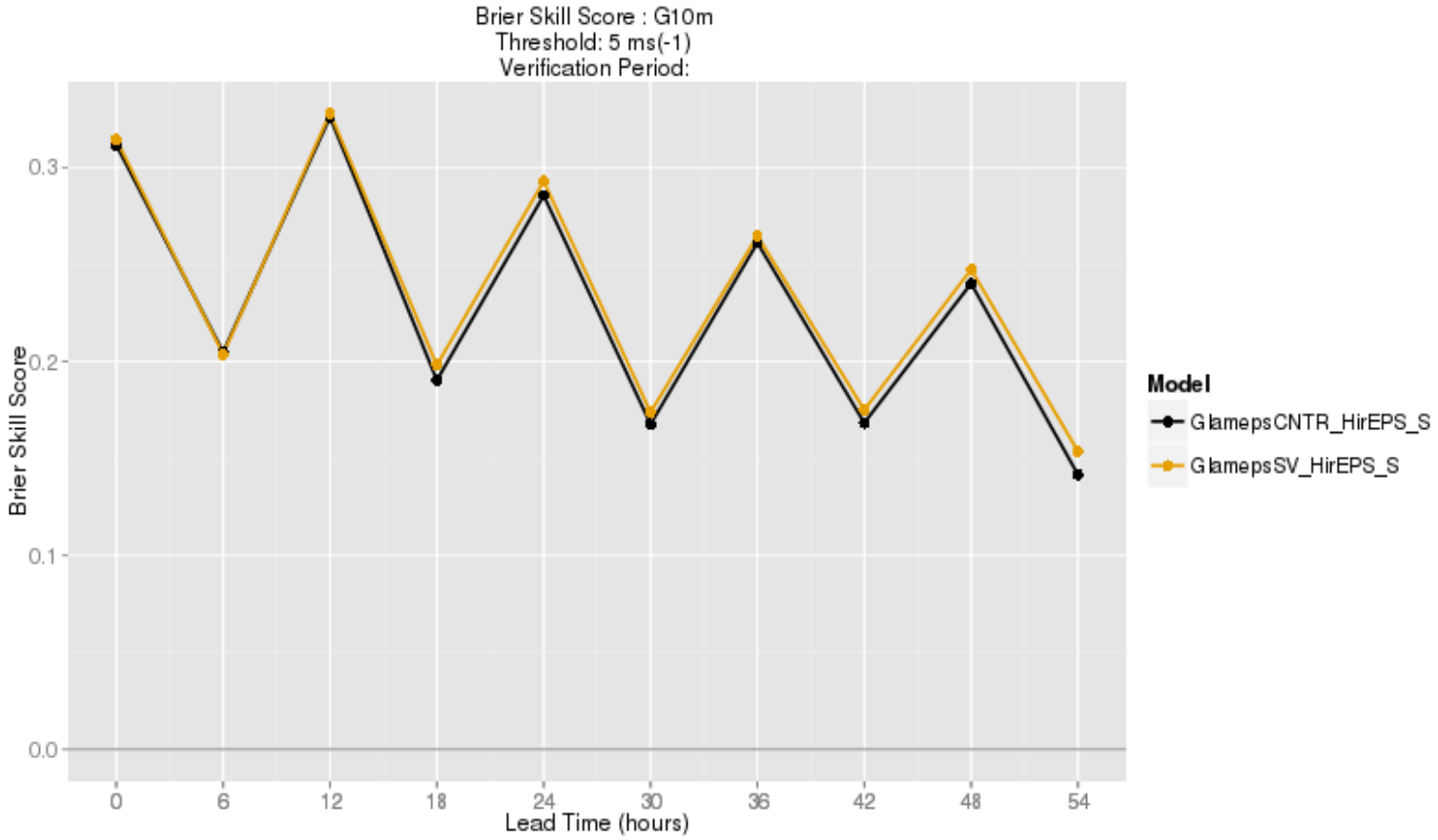
Reliability sometimes improved (e.g. 15 m/s and +12h)

no impact seen on ROC area (not shown)

Verification G10m

whole period, 6 and 18 UTC runs

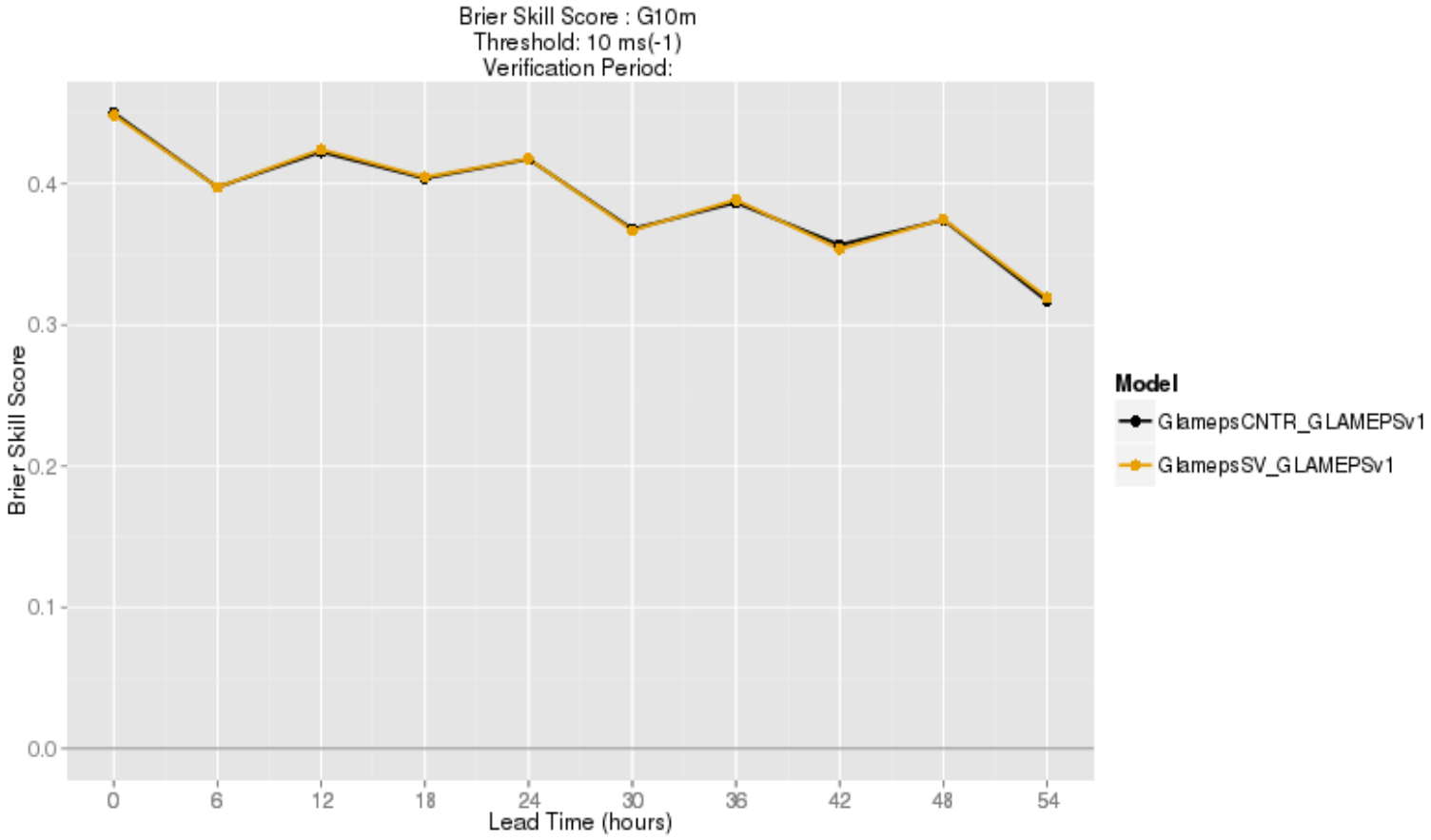
Brier skill score, 5 m/s, Hirlam-S



Verification G10m

whole period, 6 and 18 UTC runs

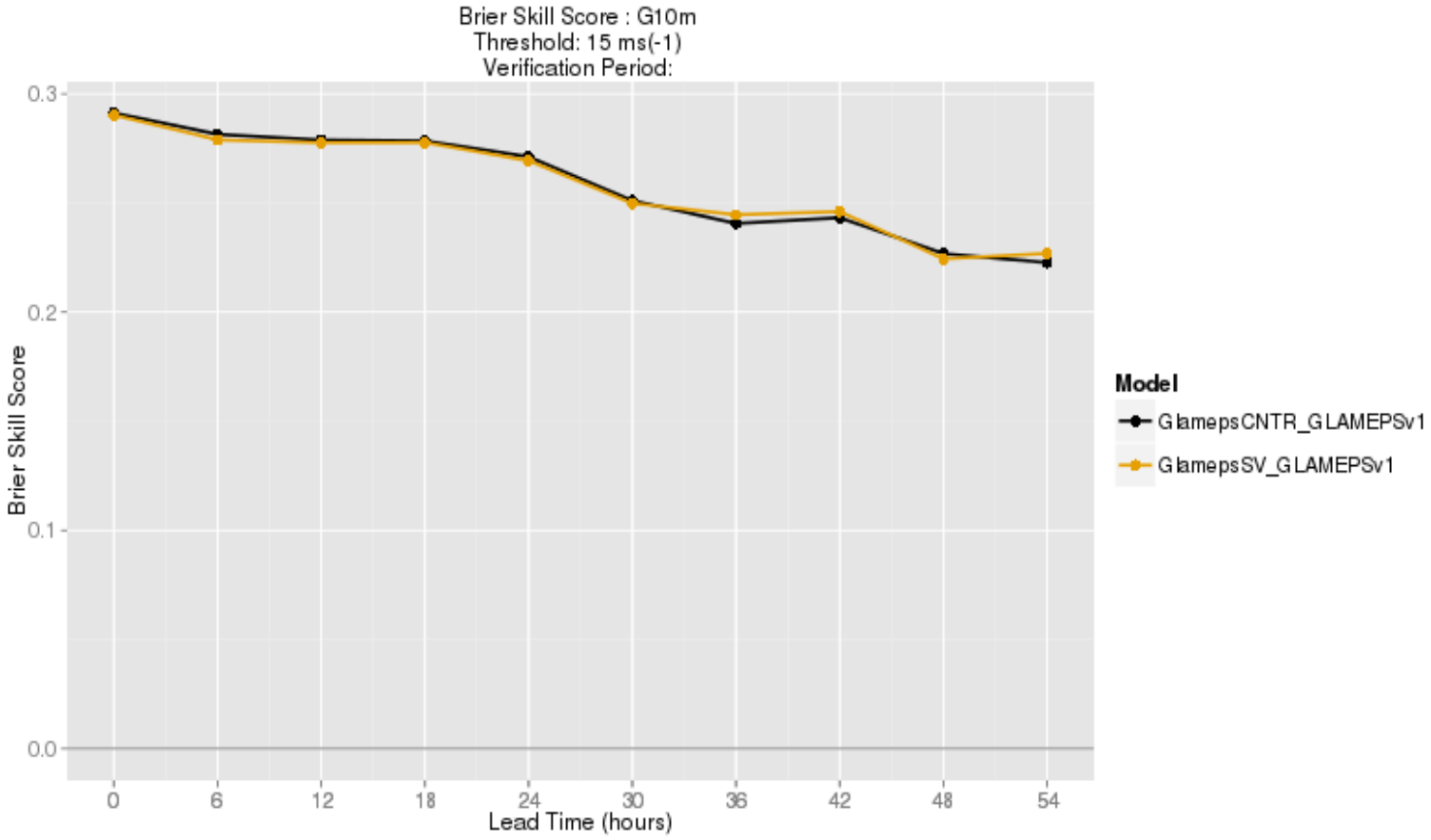
Brier skill score , 10 m/s, Glameps



Verification G10m

whole period, 6 and 18 UTC runs

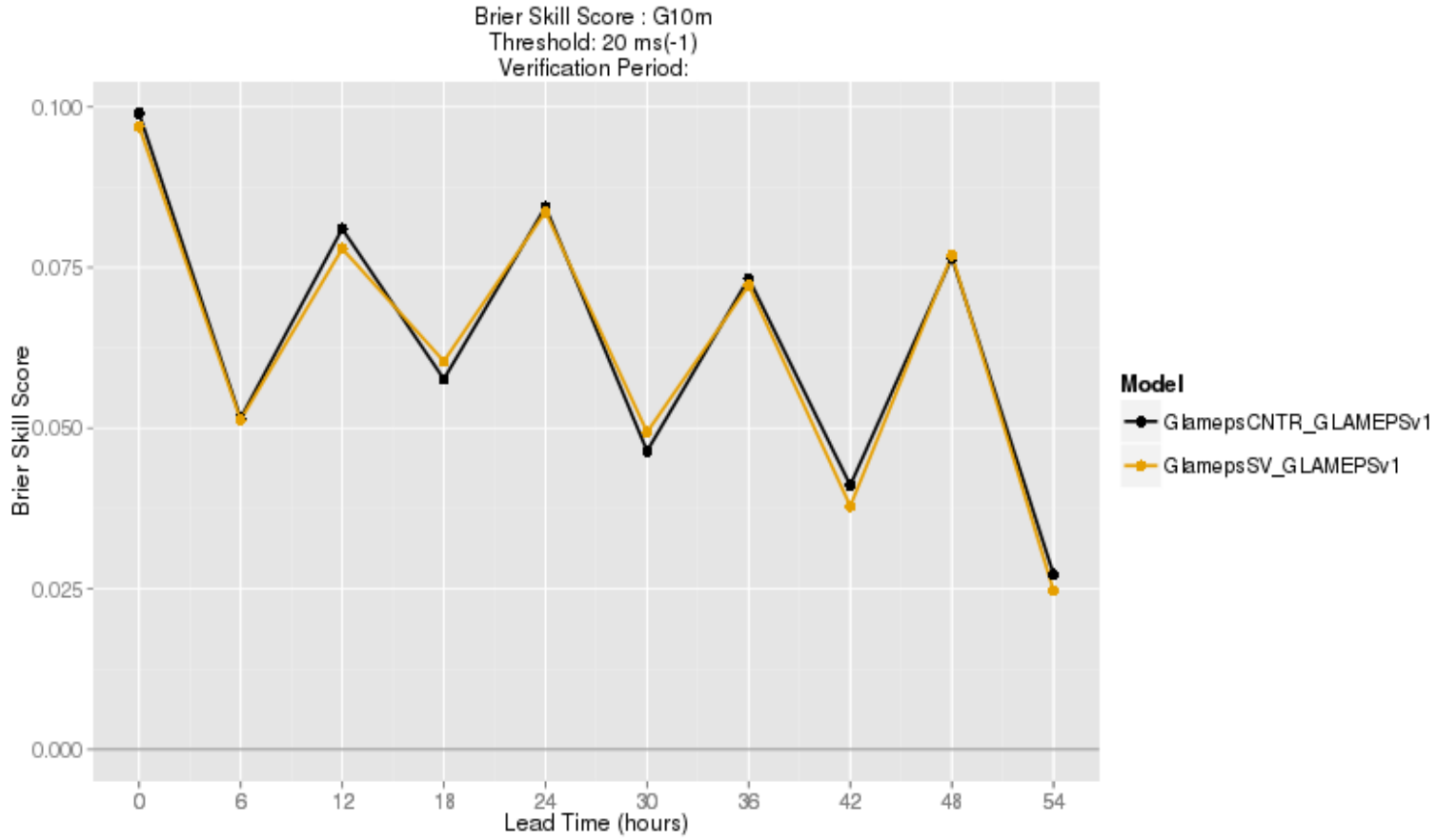
Brier skill score, 15 m/s, Glameps



Verification G10m

whole period, 6 and 18 UTC runs

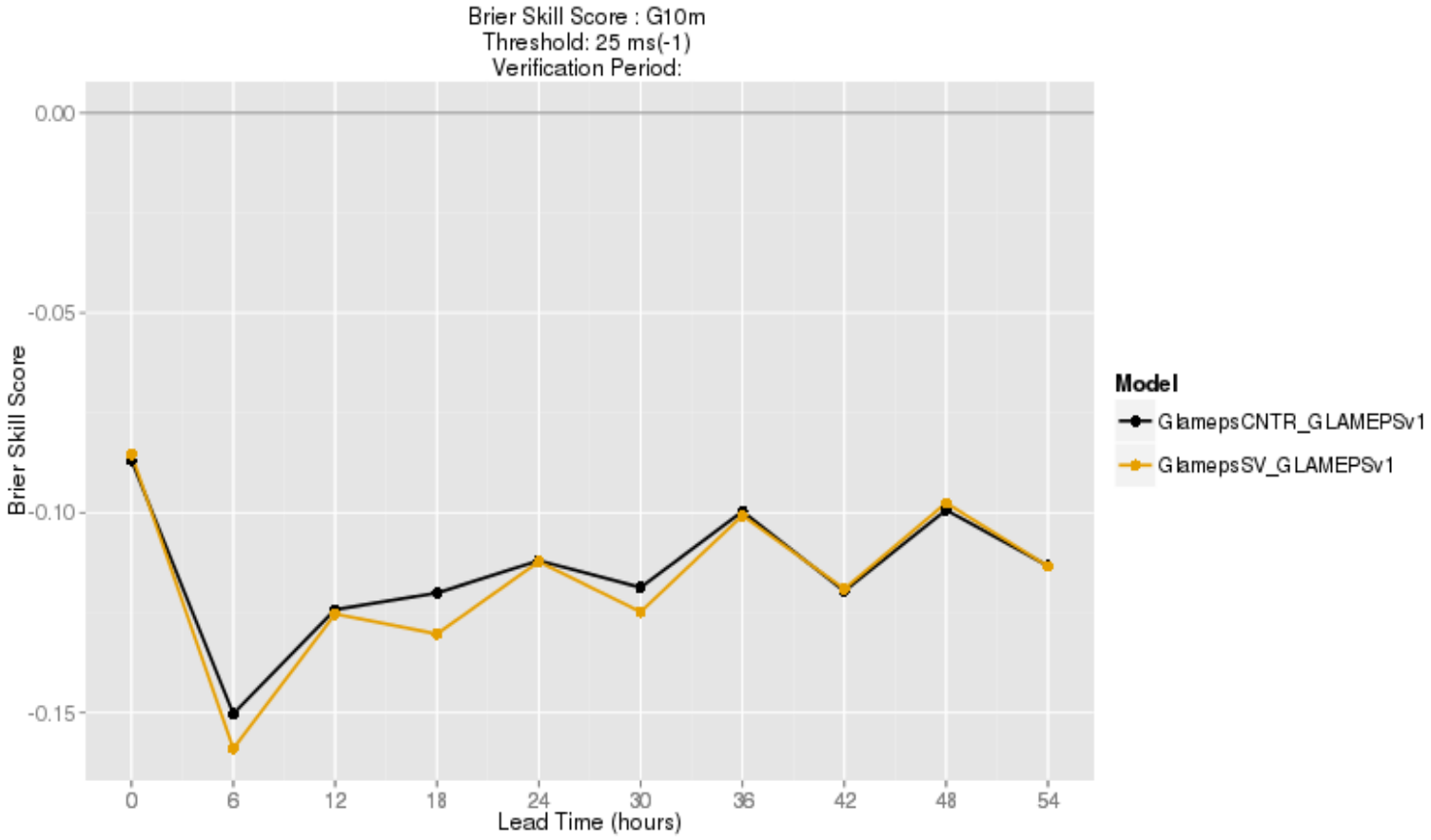
Brier skill score, 20 m/s, Glameps



Verification G10m

whole period, 6 and 18 UTC runs

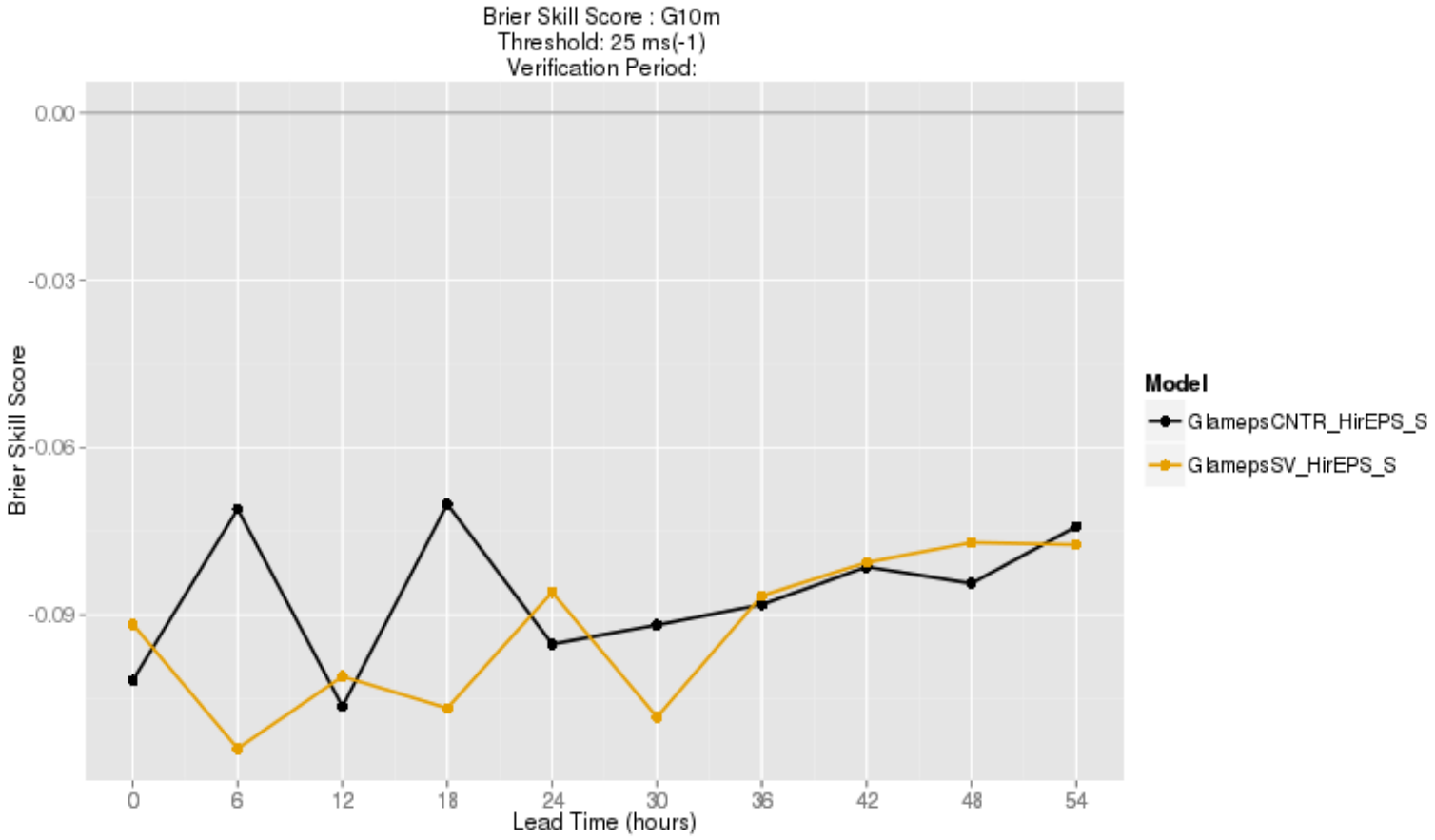
Brier skill score, 25 m/s, Glameps



Verification G10m

whole period, 6 and 18 UTC runs

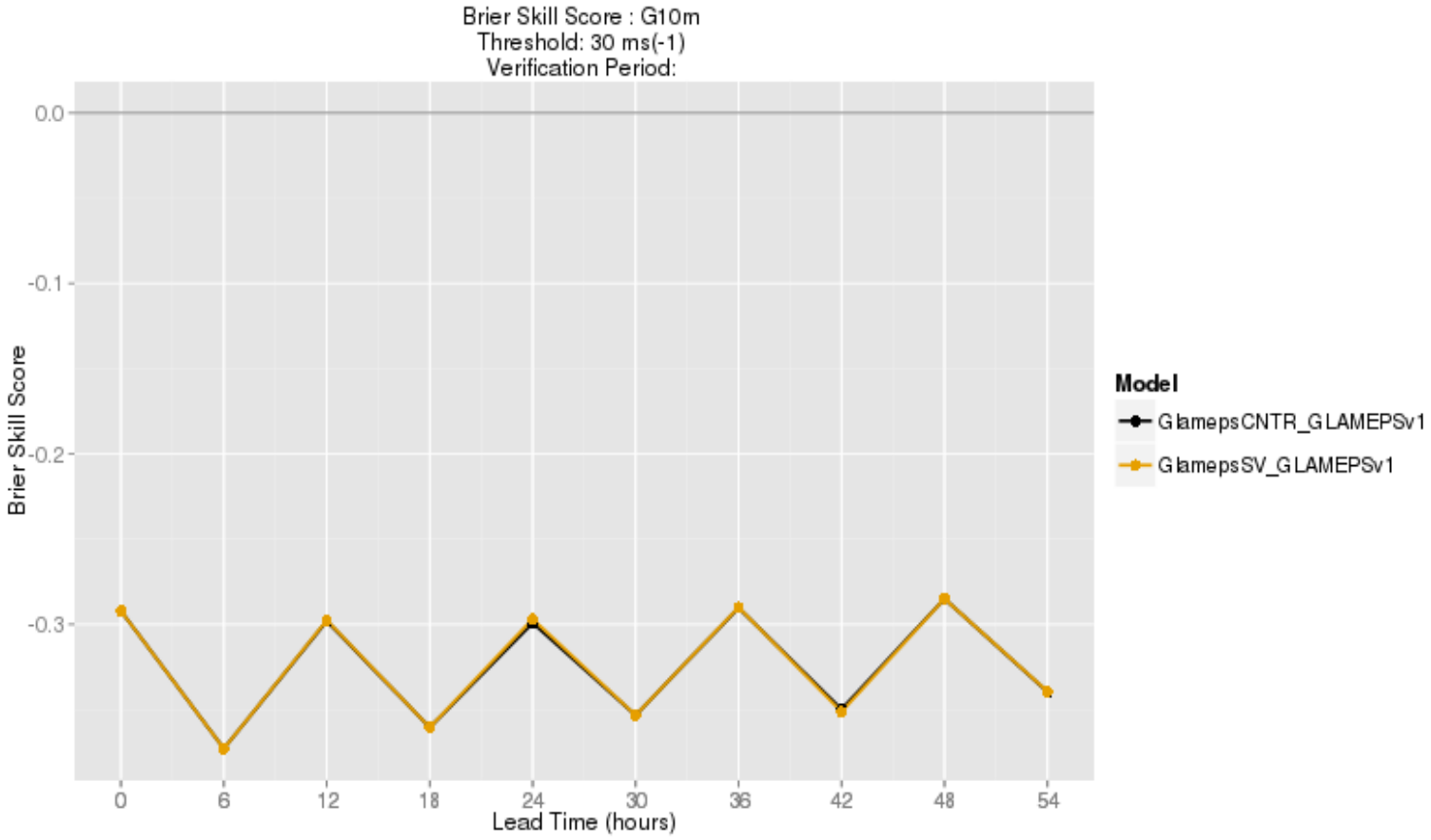
Brier skill score, 25 m/s, Hirlam-S



Verification G10m

whole period, 6 and 18 UTC runs

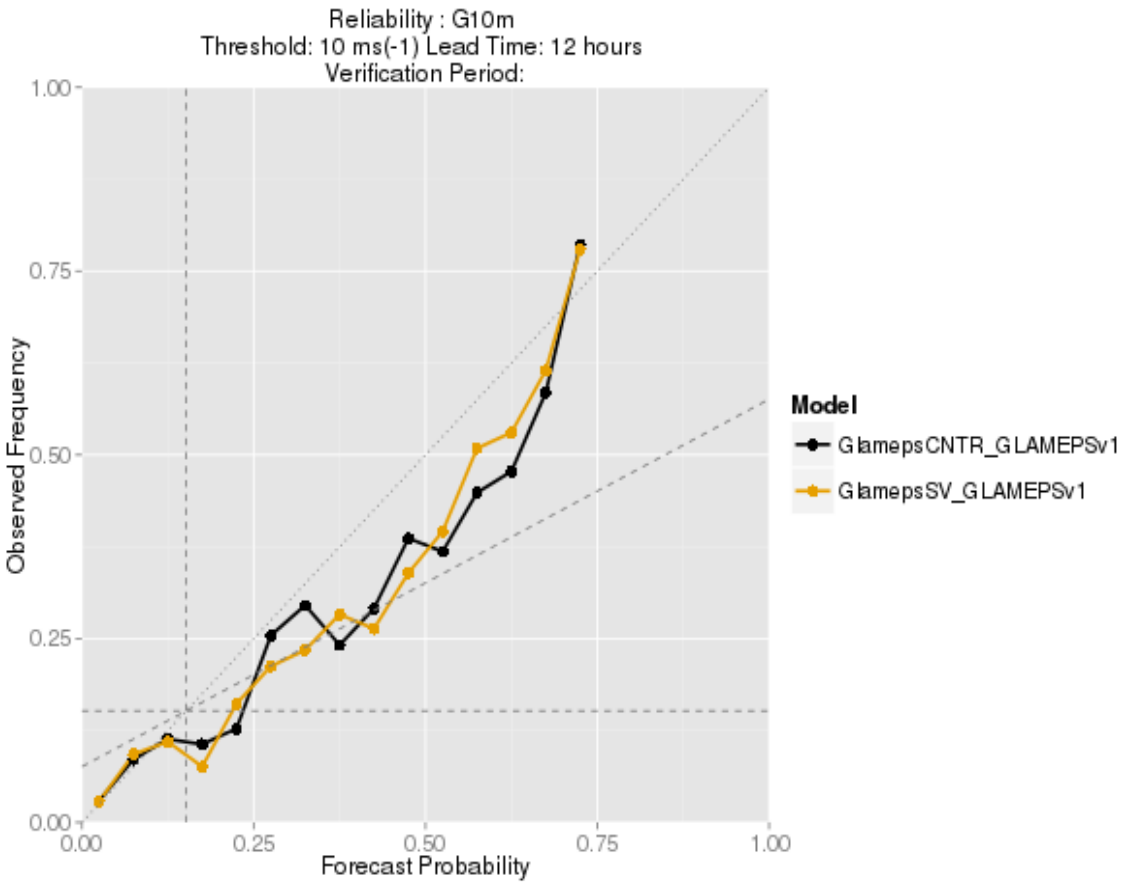
Brier skill score, 30 m/s, Glameps



Verification G10m

whole period, 6 and 18 UTC runs

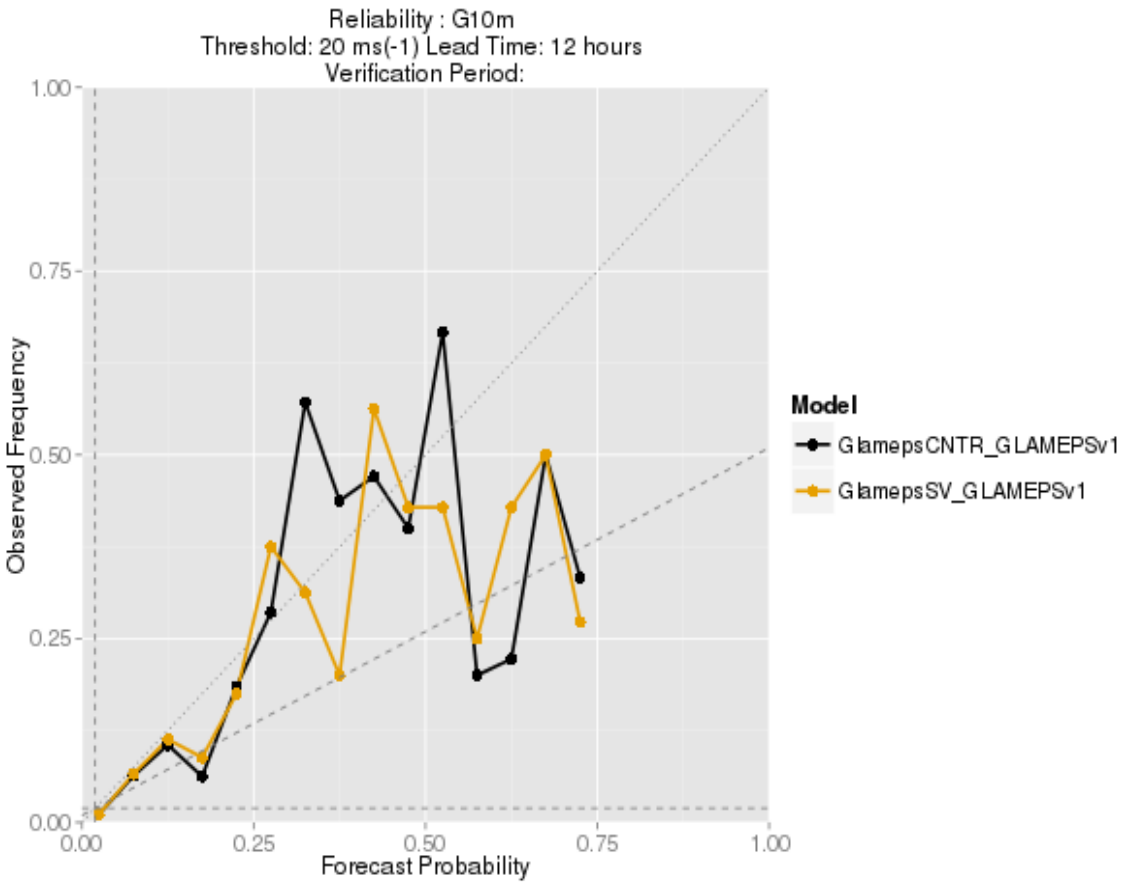
Reliability, 10 m/s, Glameps



Verification G10m

whole period, 6 and 18 UTC runs

Reliability, 20 m/s, Glameps



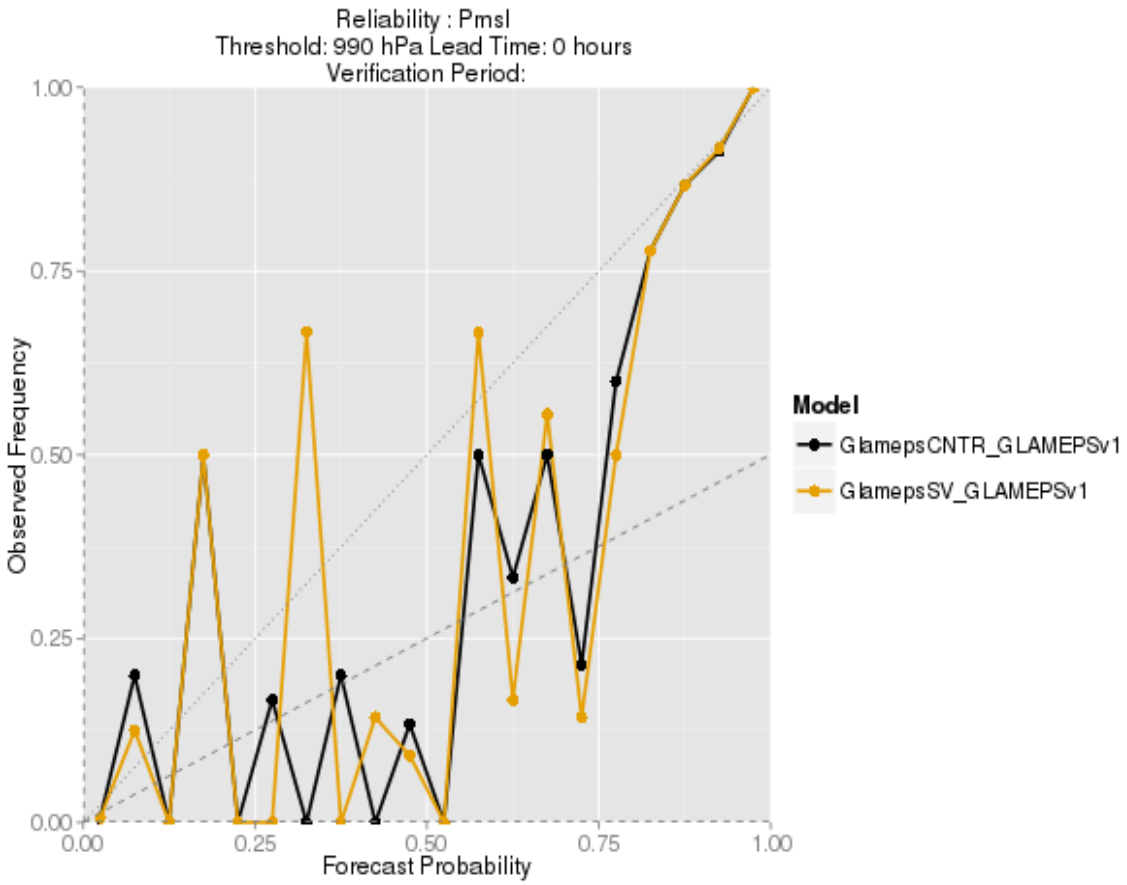
Verification G10m

Slight improvement BSS for weaker gusts,
clear deterioration for 25 m/s,
30 m/s neutral

Verification Pmsl

whole period, 6 and 18 UTC runs

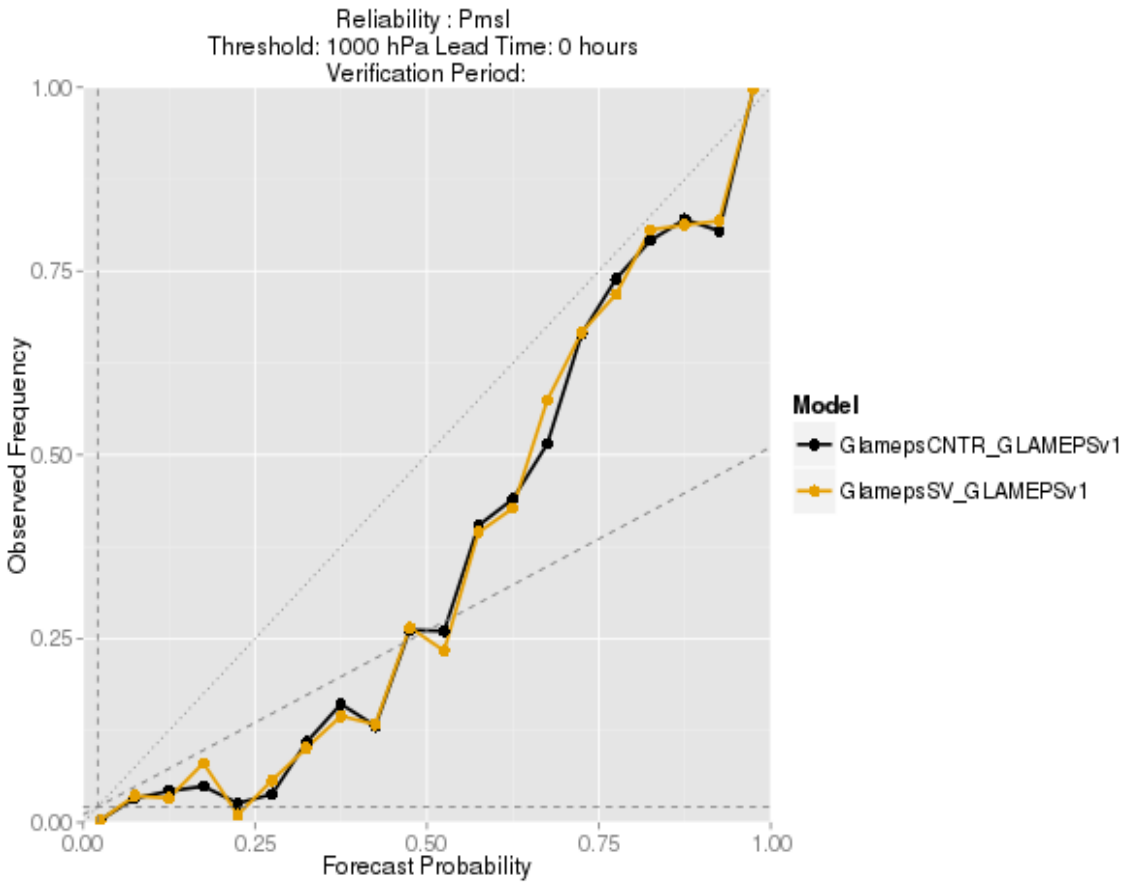
Reliability, +0h, 990 hPa, Glameps



Verification Pmsl

whole period, 6 and 18 UTC runs

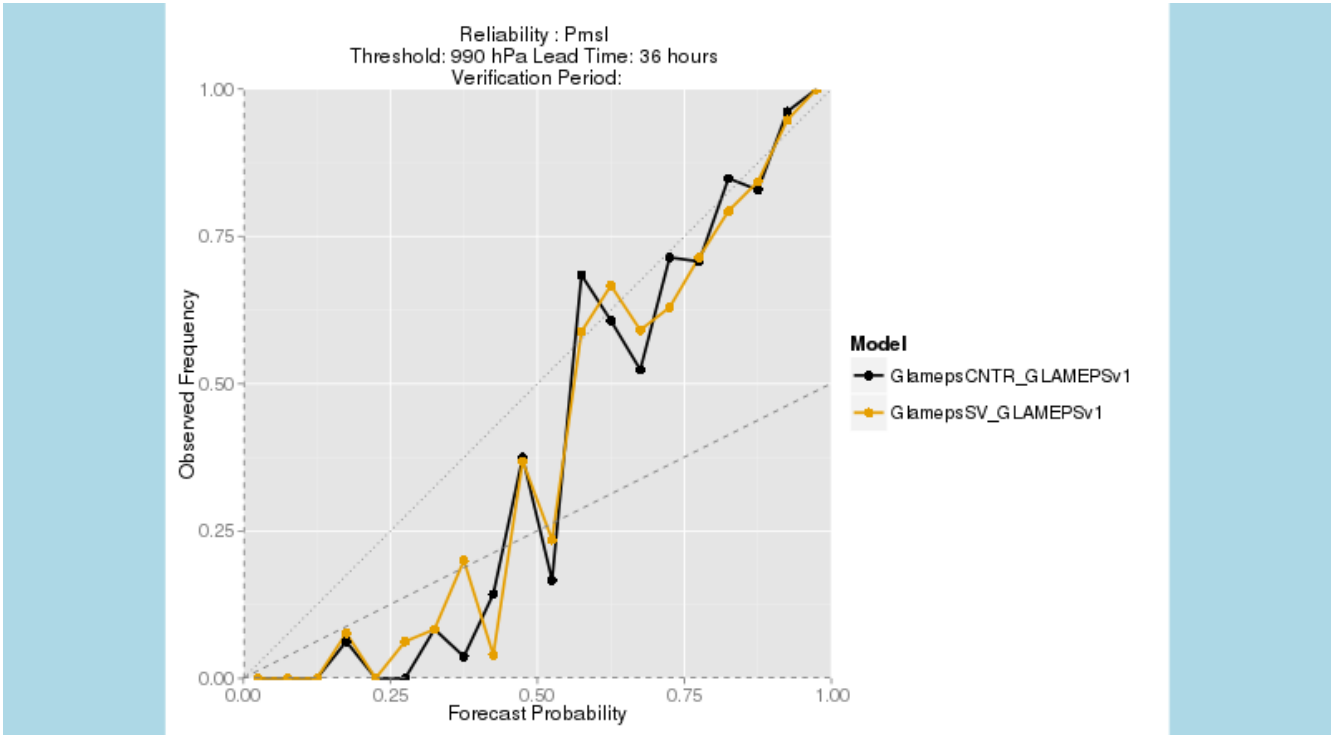
Reliability, 1000 hPa, +0h, Glameps



Verification Pmsl

whole period, 6 and 18 UTC runs

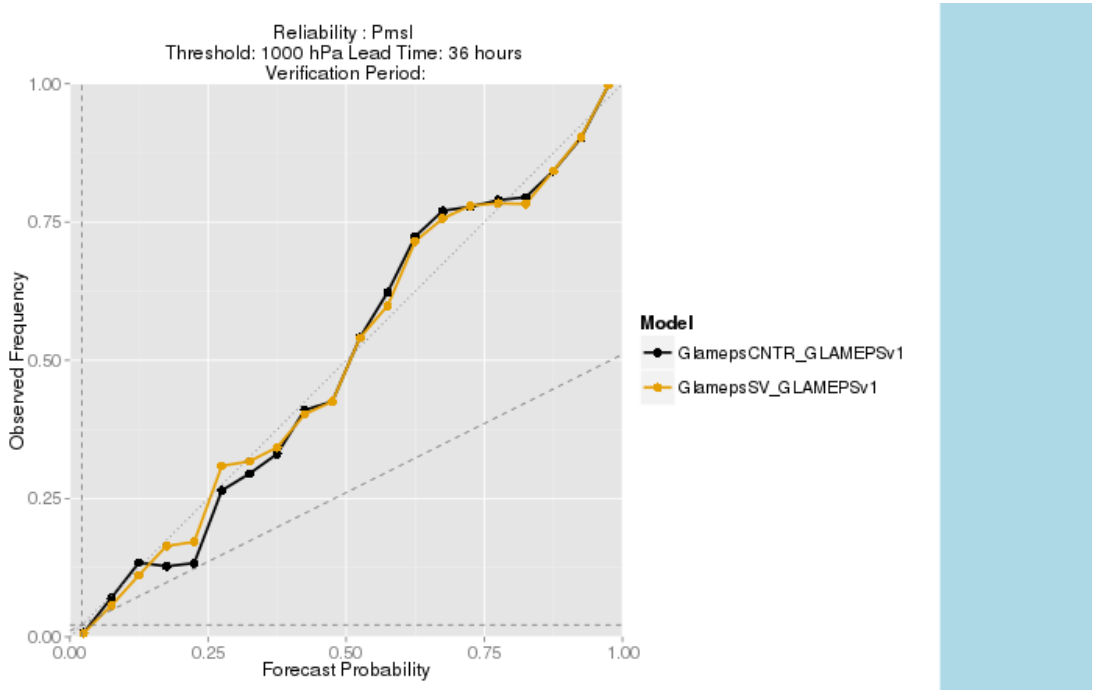
Reliability, 990 hPa, +36h, Glameps



Verification Pmsl

whole period, 6 and 18 UTC runs

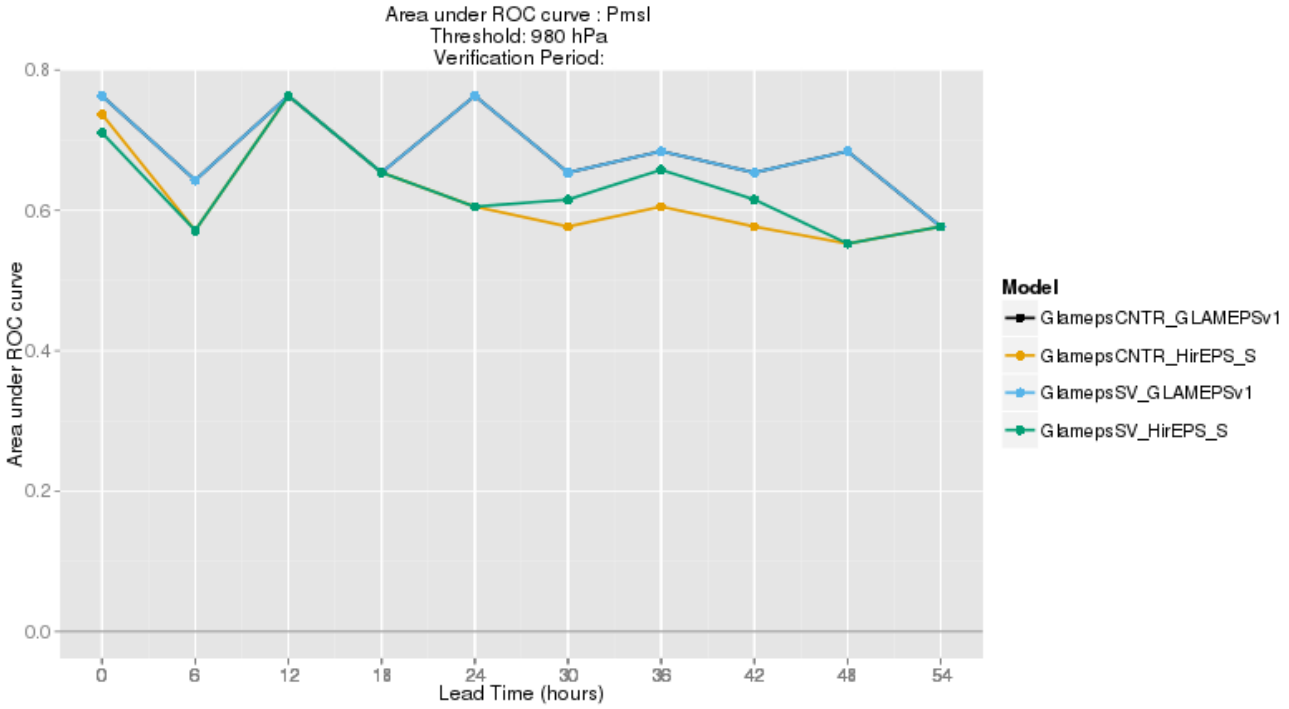
Reliability, 1000 hPa, +36h, Glameps



Verification Pmsl

whole period, 6 and 18 UTC runs

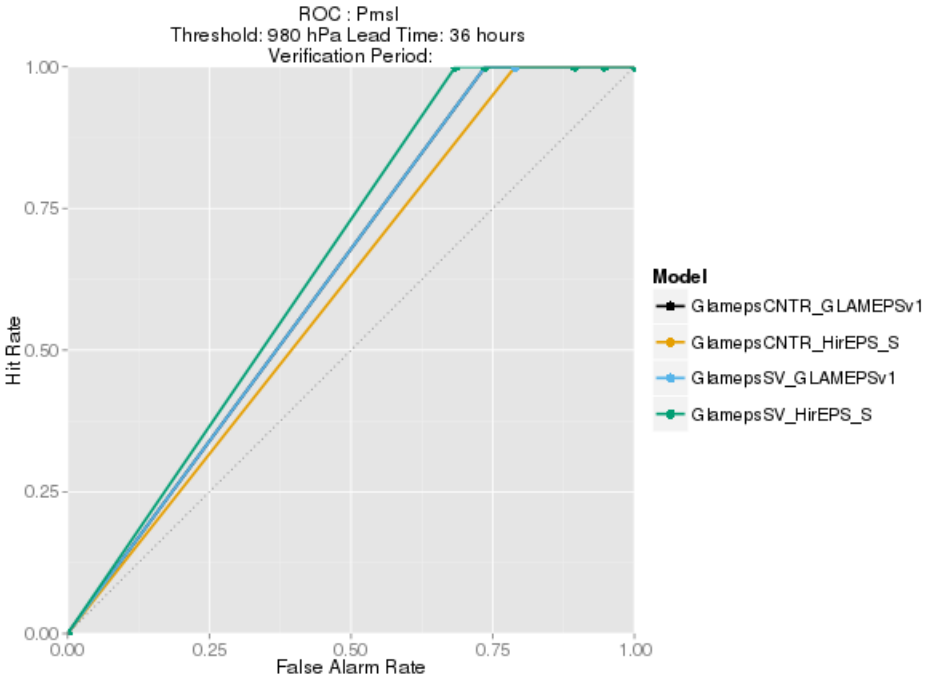
ROC area, 980 hPa, H-S,Glameps



Verification Pmsl

whole period, 6 and 18 UTC runs

ROC, 980 hPa, +36h, H-S, Glameps



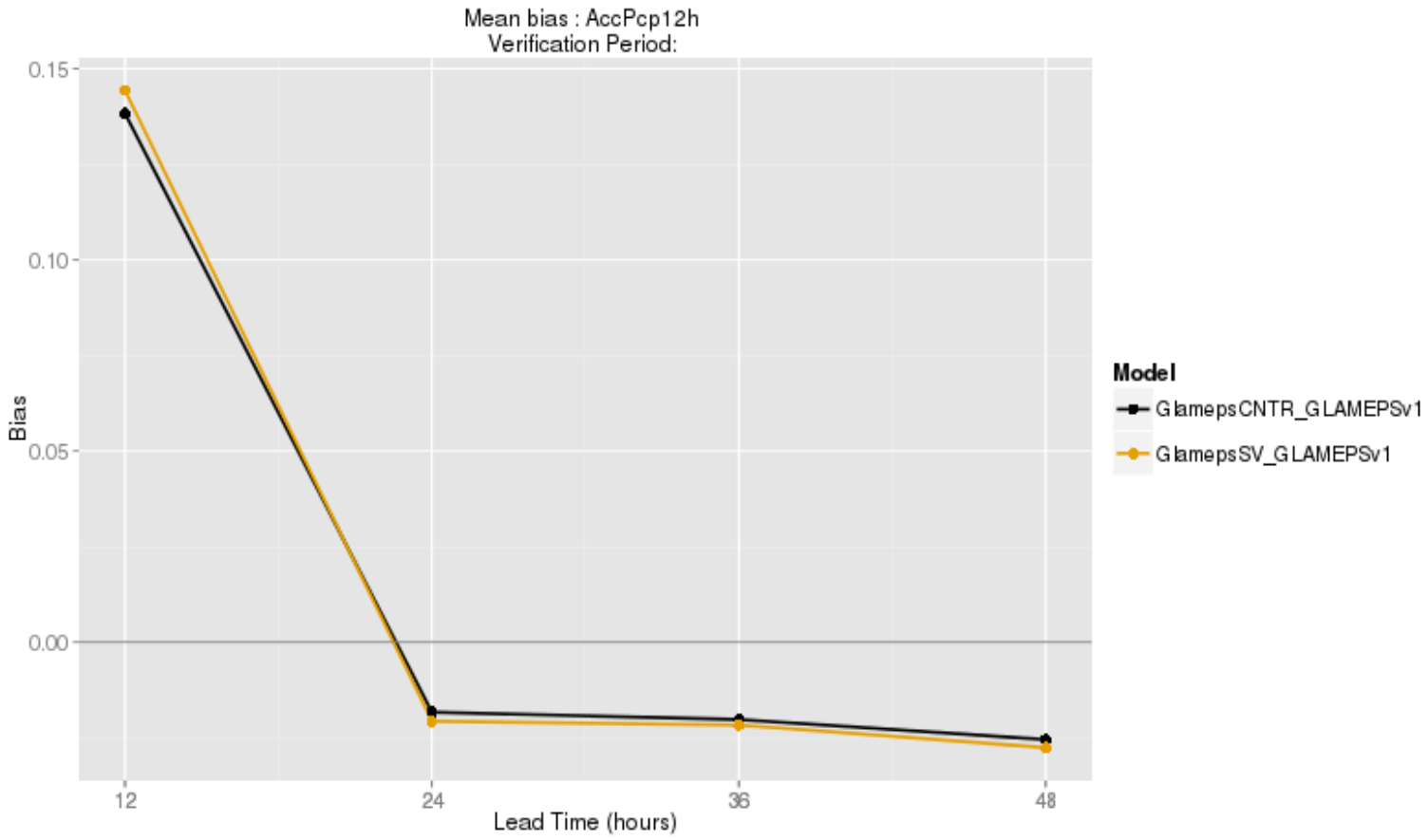
Verification Pmsl

neutral impact +0h, neutral to positive impact for Hirlam alone (+36h)

Verification Pcp12h

whole period, 6 and 18 UTC runs

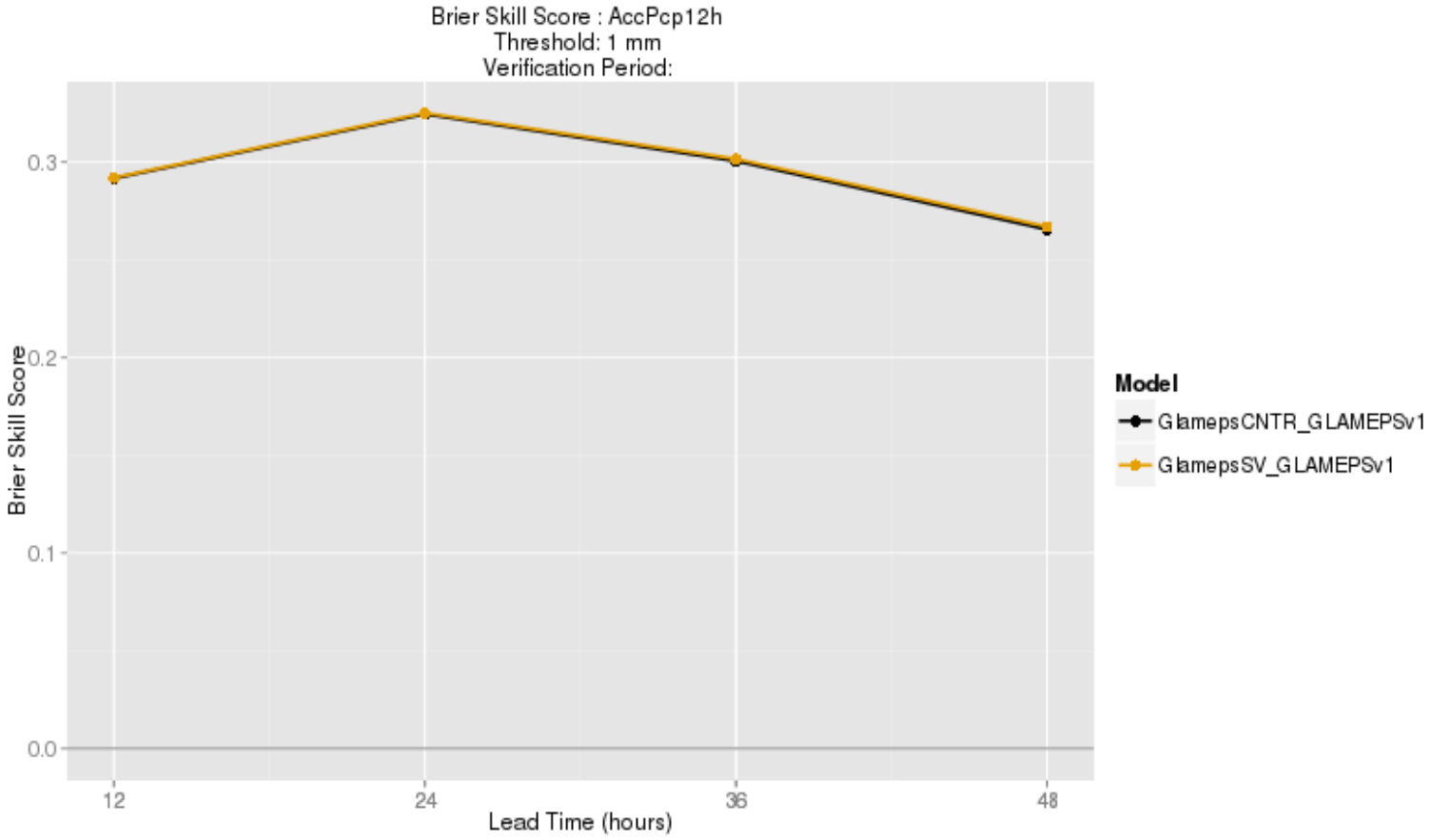
Mean bias, Glameps



Verification Pcp12h

whole period, 6 and 18 UTC runs

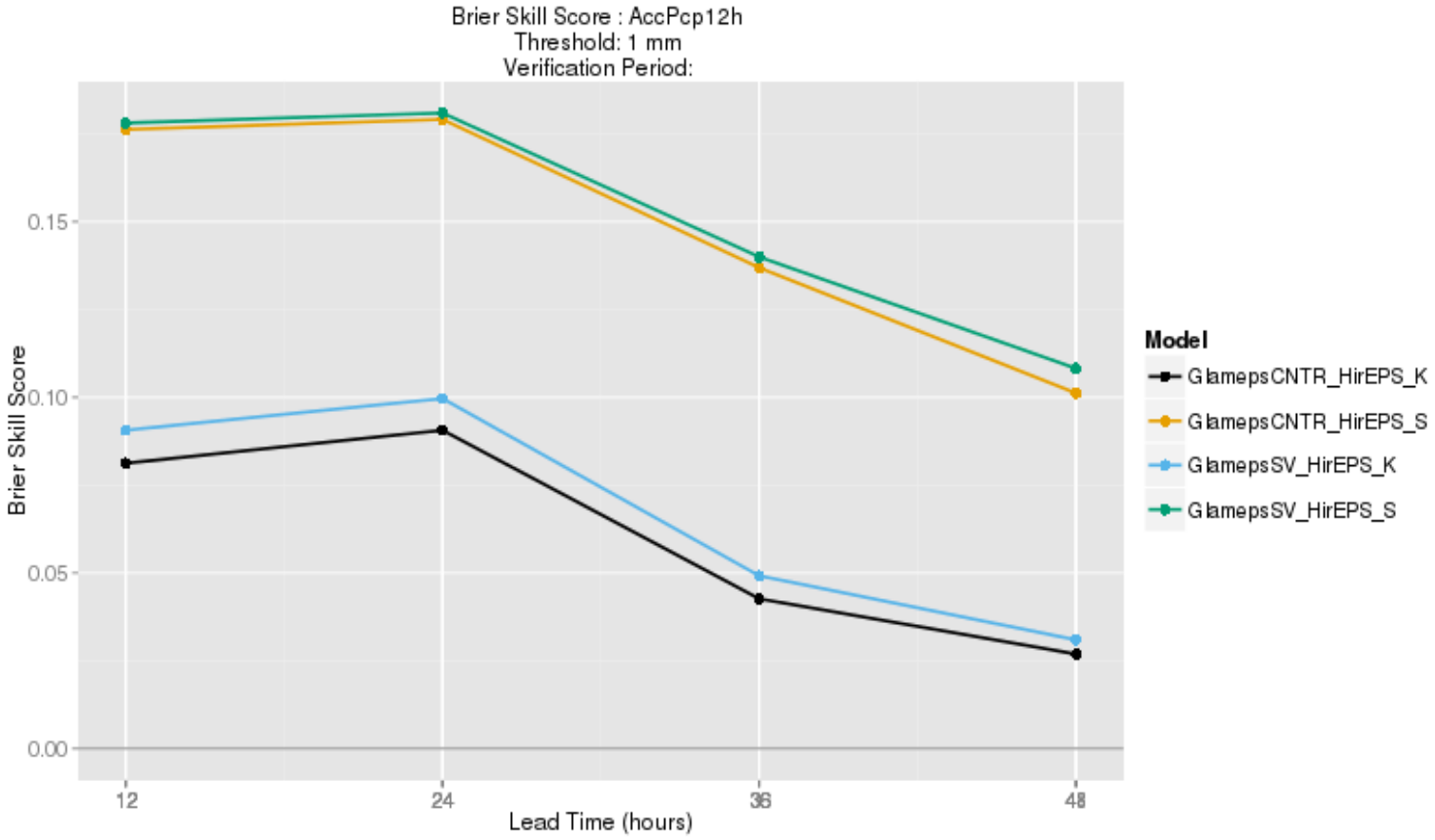
Brier skill score, 1 mm, Glameps



Verification Pcp12h

whole period, 6 and 18 UTC runs

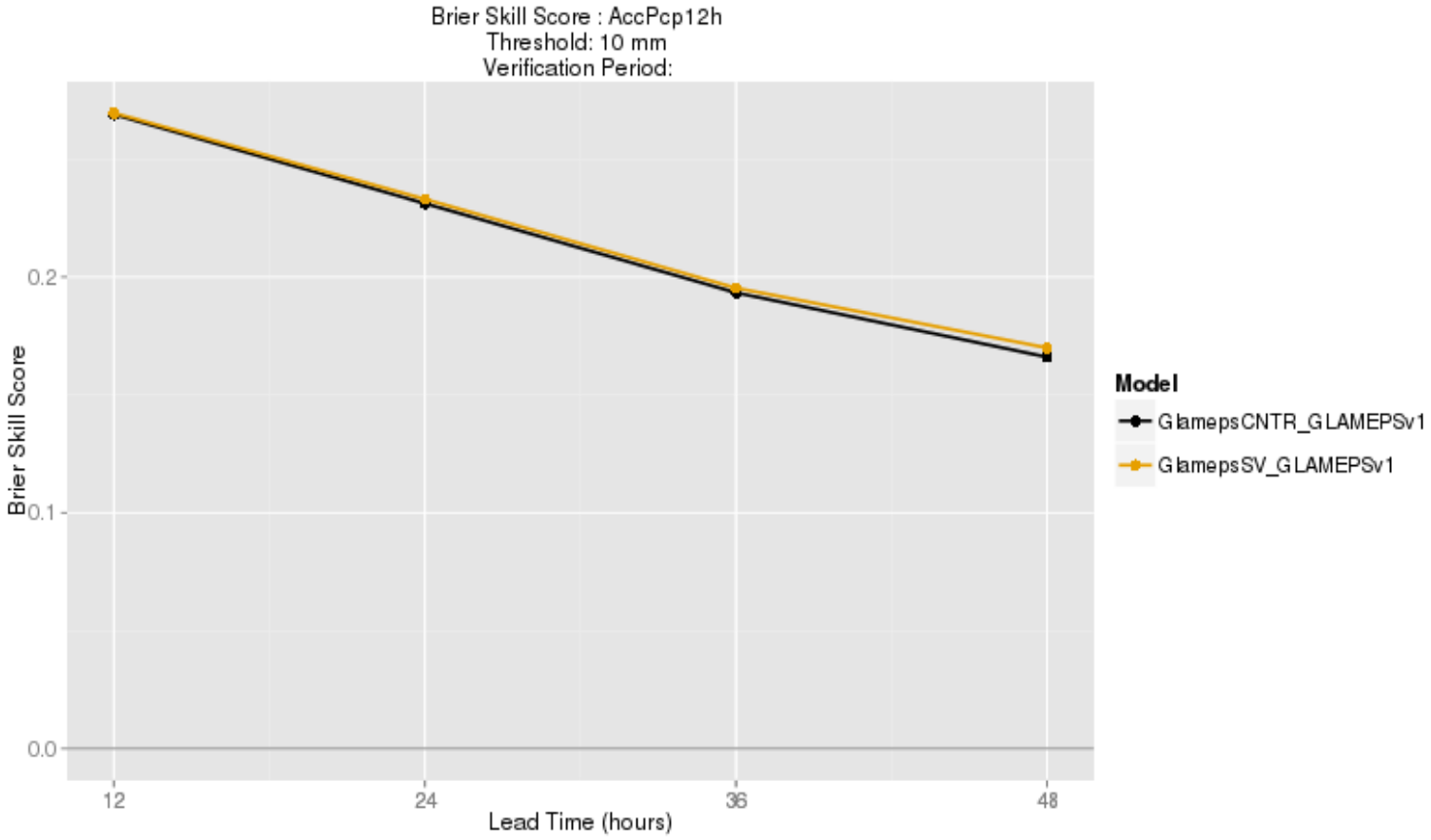
Brier skill score, 1mm, Hirlam-S and -K



Verification Pcp12h

whole period, 6 and 18 UTC runs

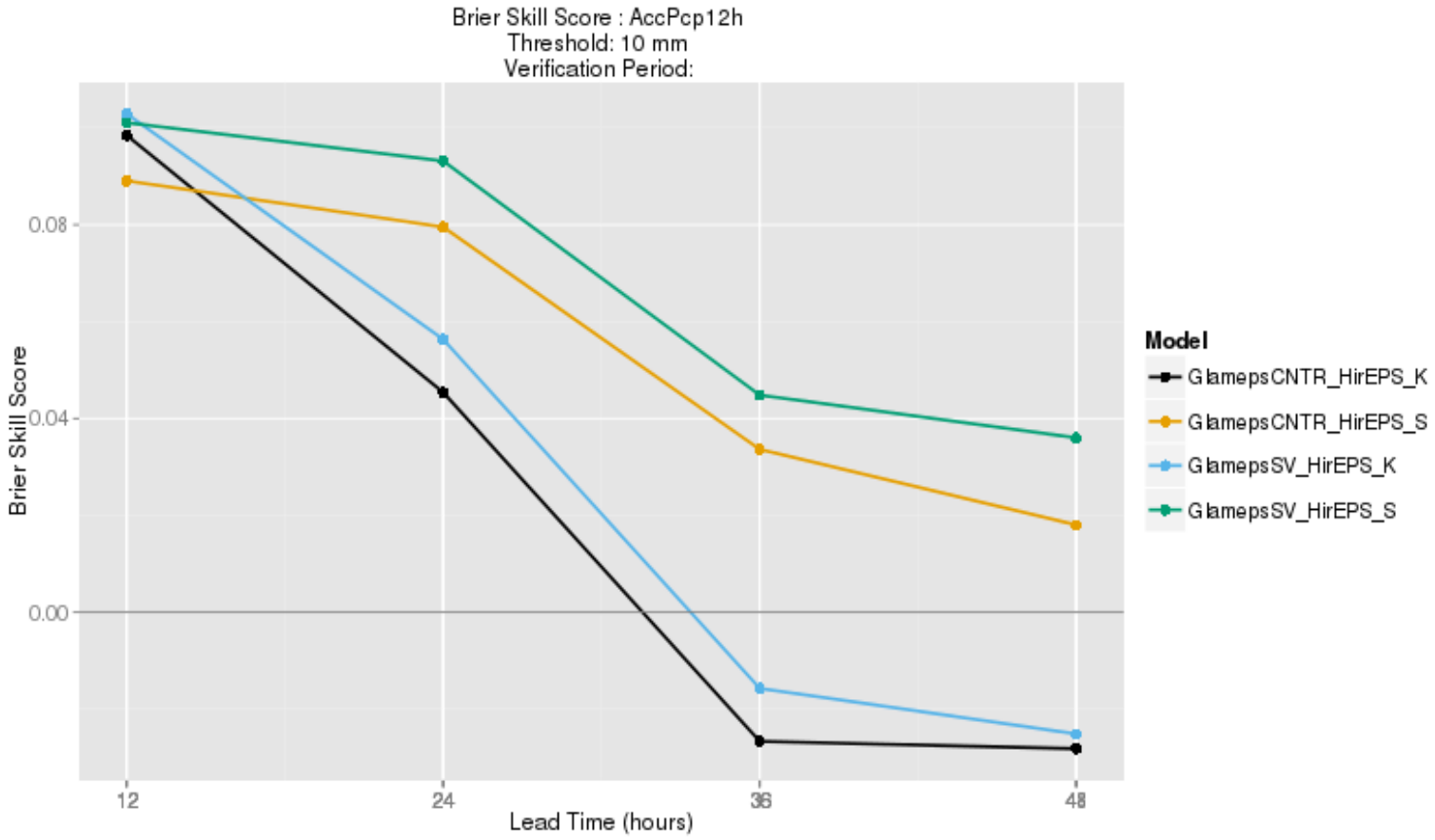
Brier skill score, 10 mm, Glameps



Verification Pcp12h

whole period, 6 and 18 UTC runs

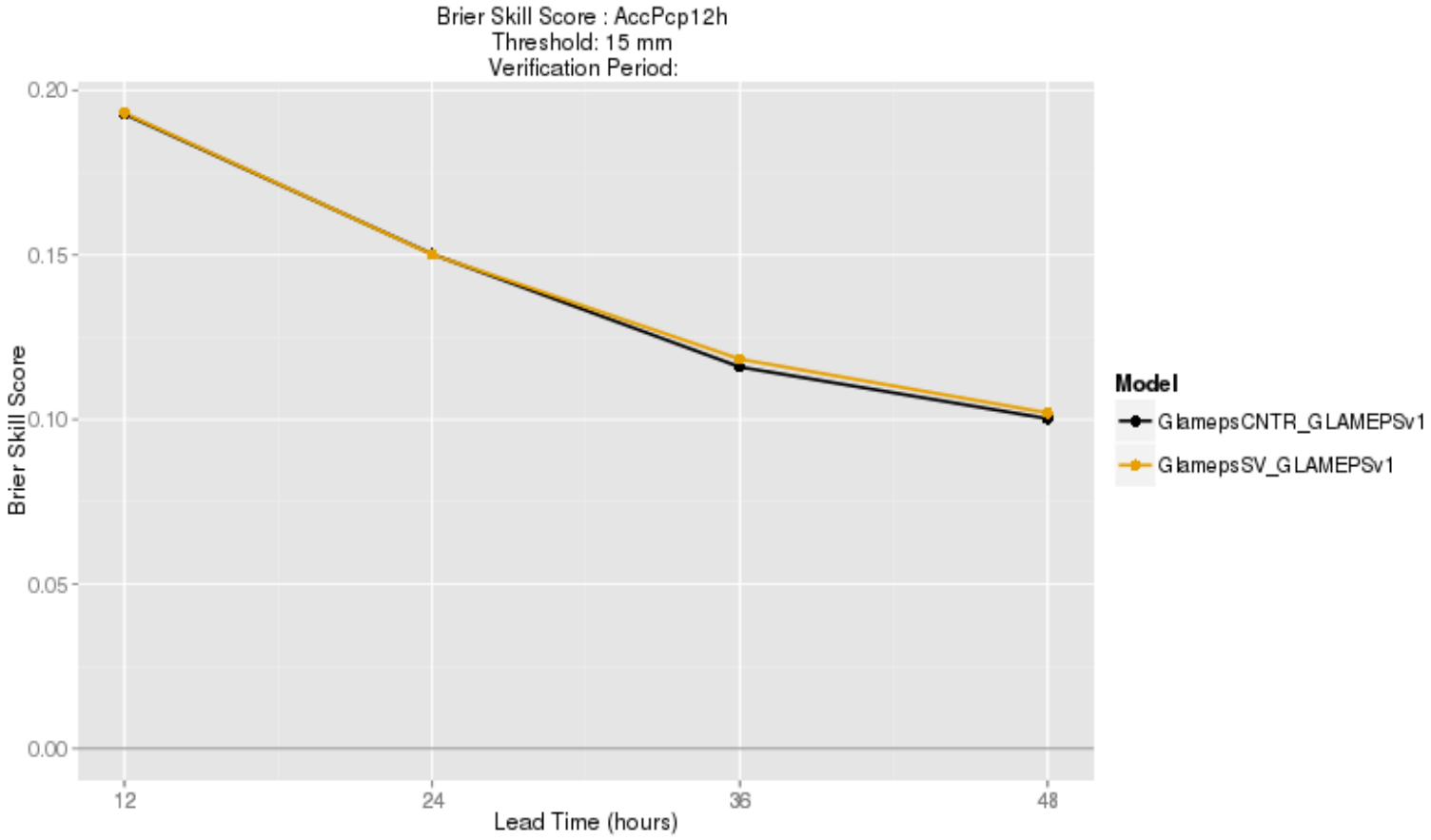
Brier skill score, 10 mm, Hirlam-S and -K



Verification Pcp12h

whole period, 6 and 18 UTC runs

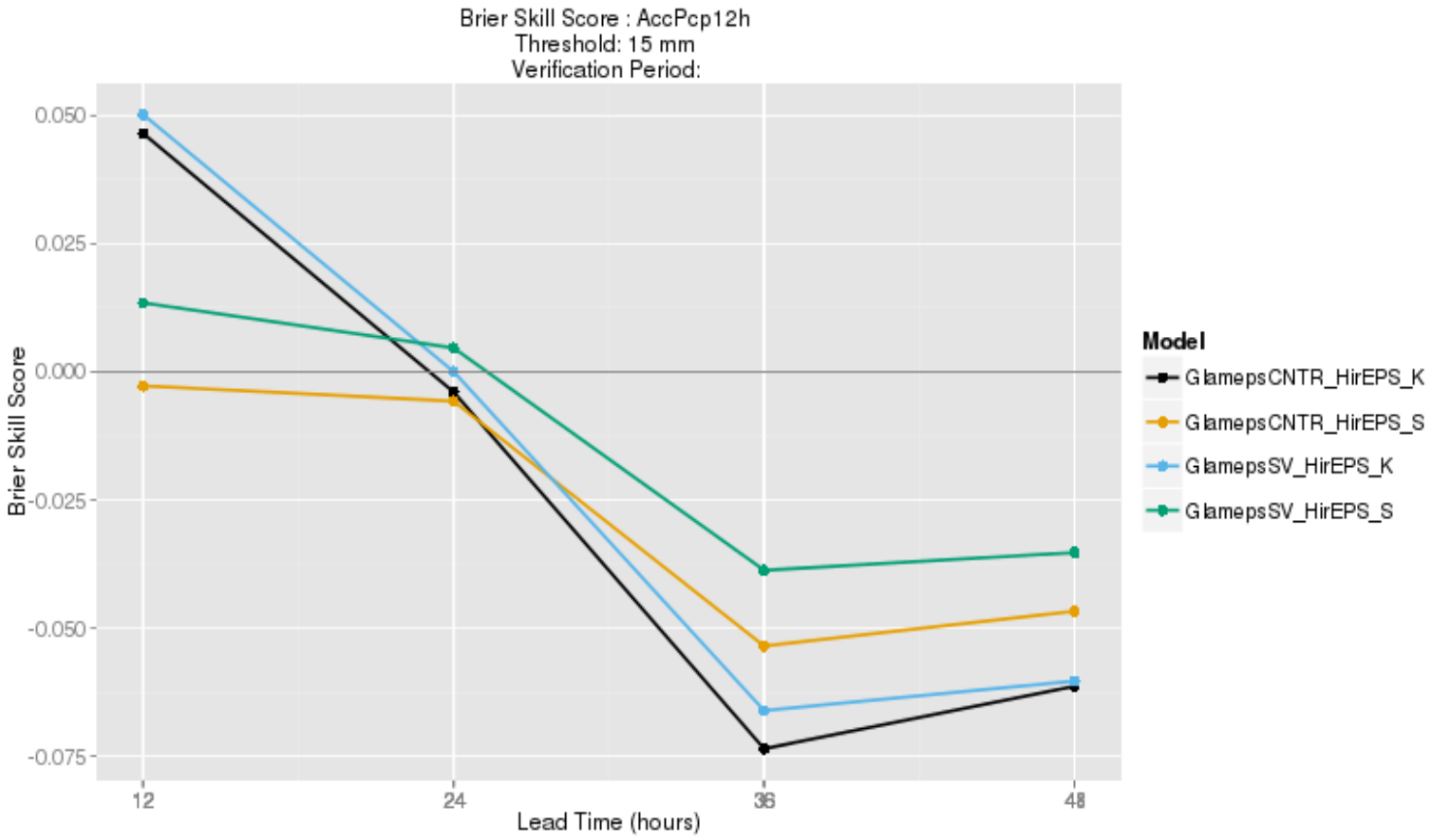
Brier skill score, 15 mm, Glameps



Verification Pcp12h

whole period, 6 and 18 UTC runs

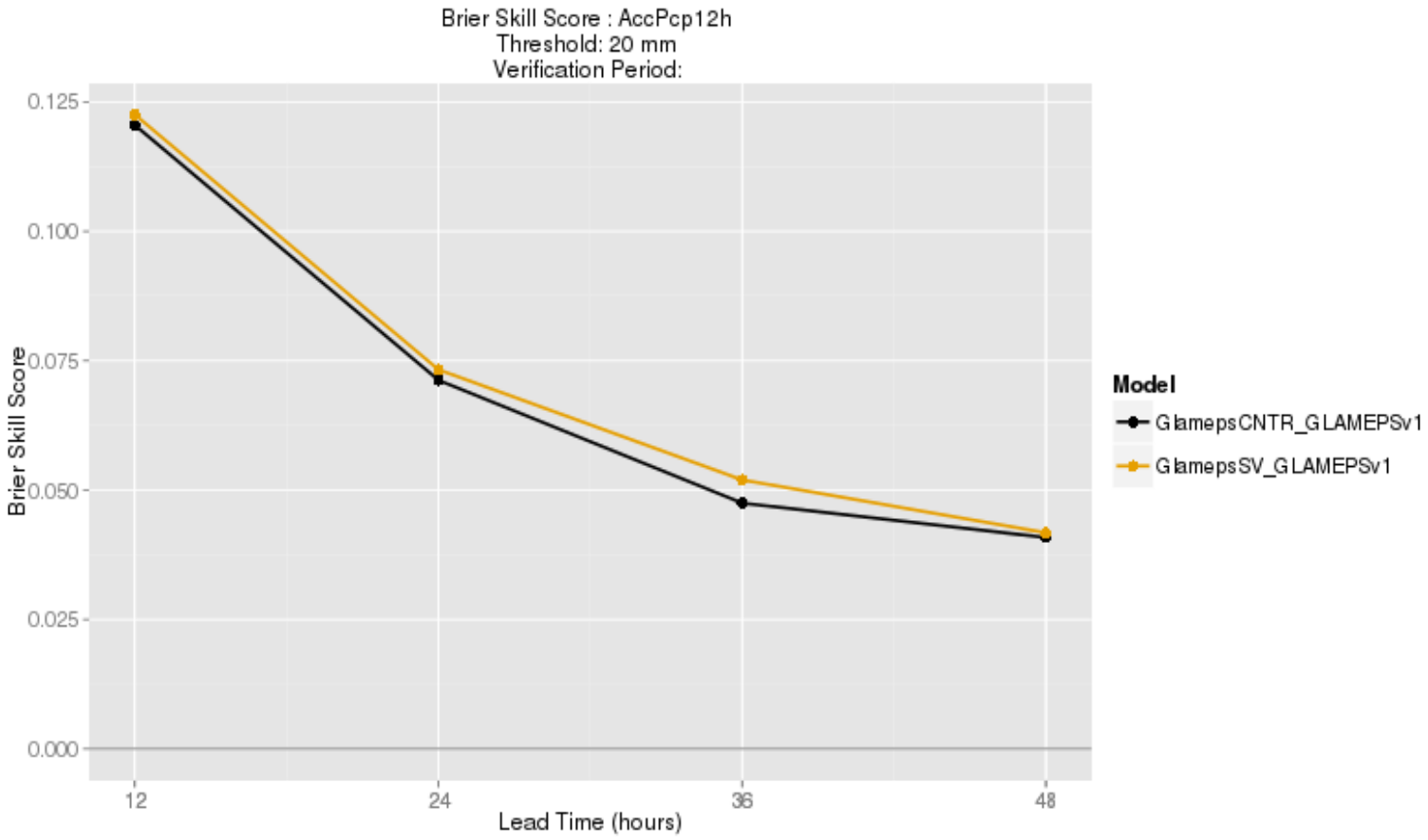
Brier skill score, 15 mm, Hirlam-S and -K



Verification Pcp12h

whole period, 6 and 18 UTC runs

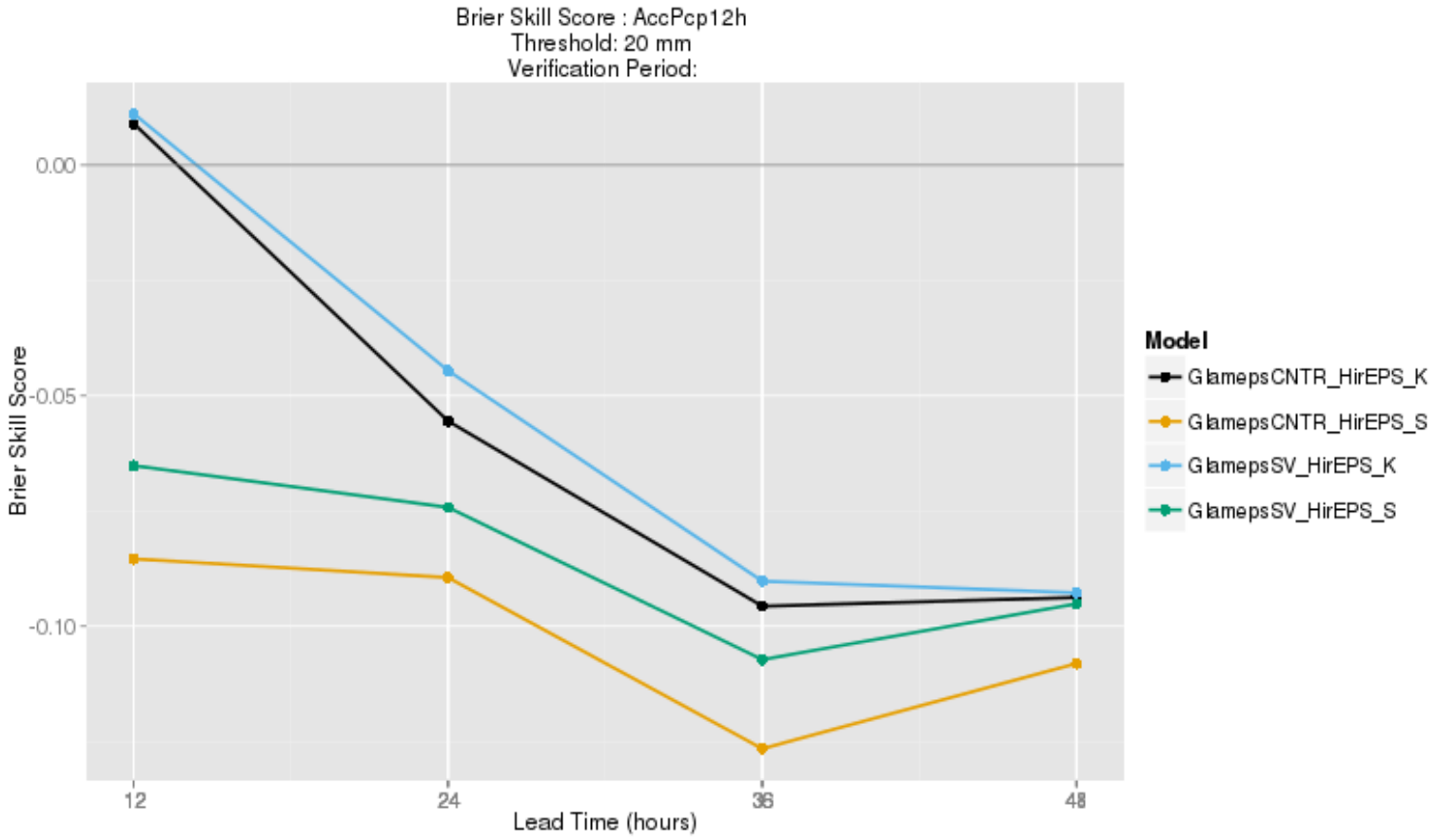
Brier skill score, 20 mm, Glameps



Verification Pcp12h

whole period, 6 and 18 UTC runs

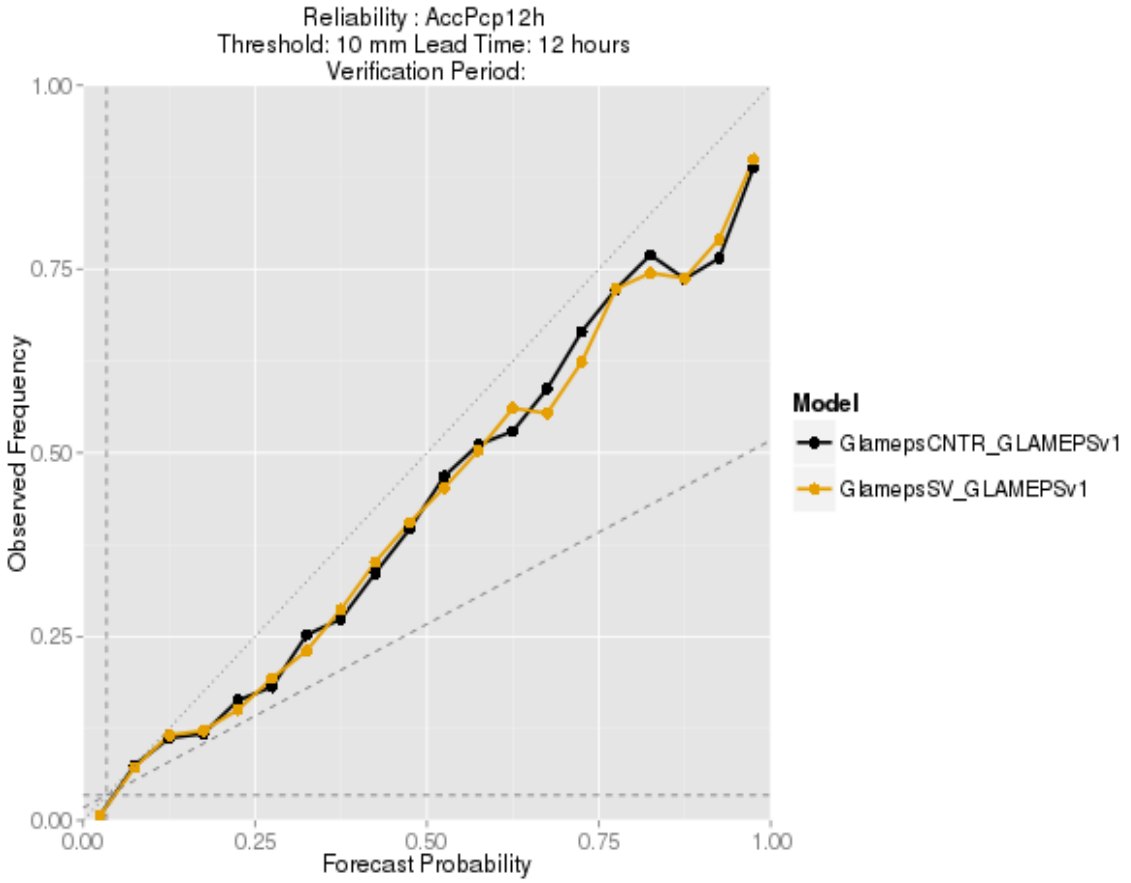
Brier skill score, 20 mm, Hirlam-S and -K



Verification Pcp12h

whole period, 6 and 18 UTC runs

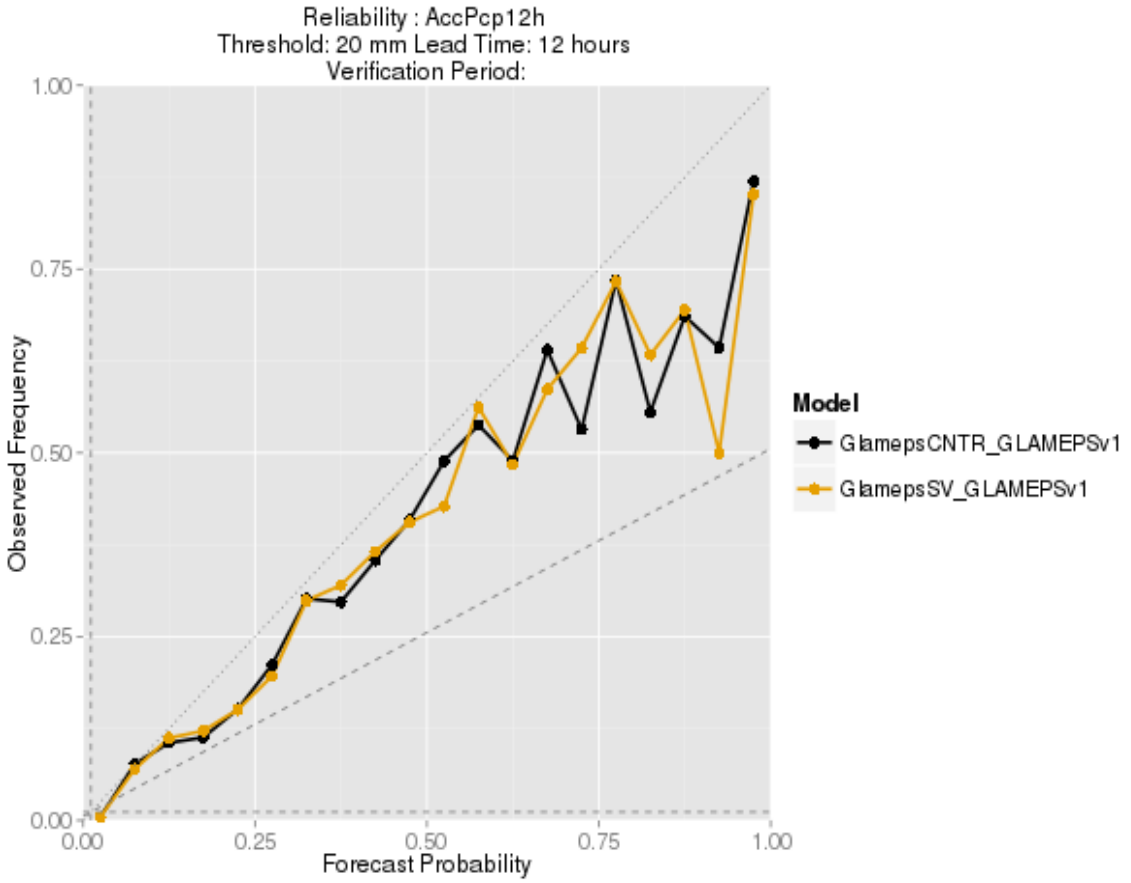
Reliability, 10 mm, +12h, Glameps



Verification Pcp12h

whole period, 6 and 18 UTC runs

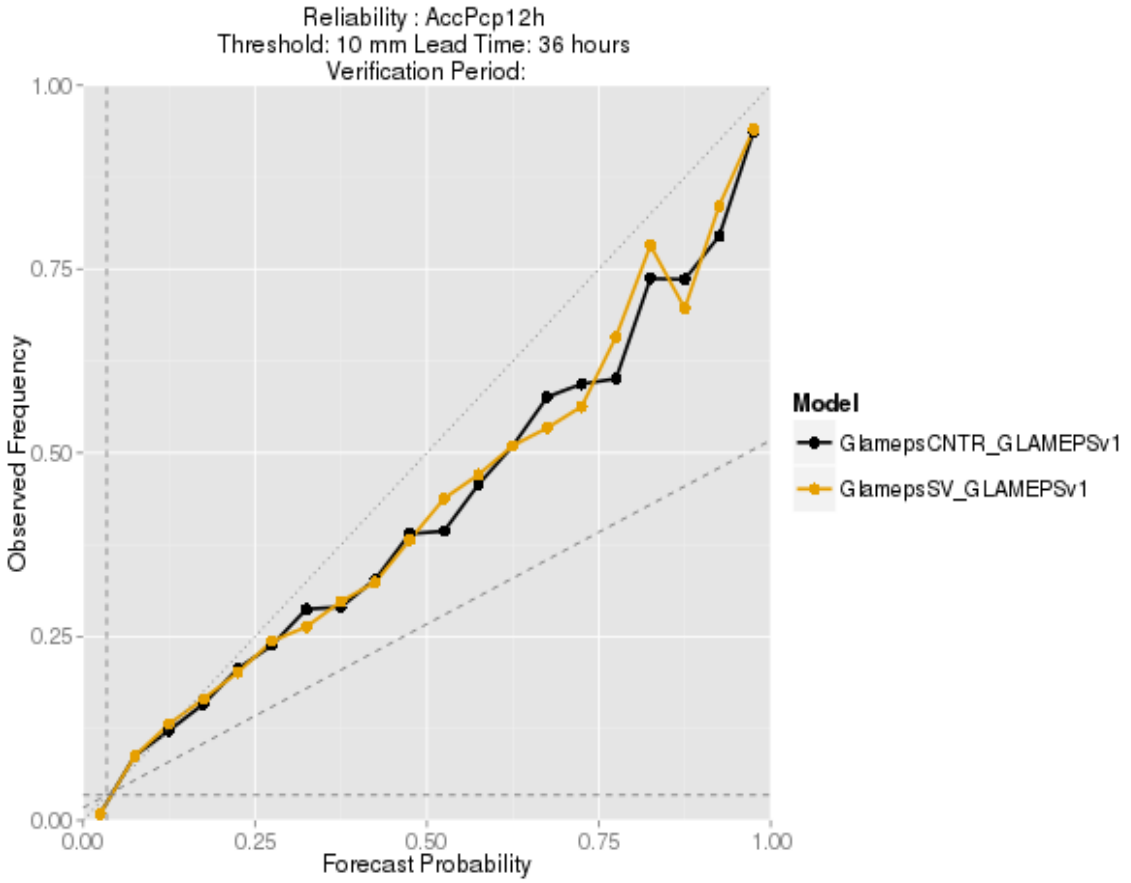
Reliability, 20 mm, +12h, Glameps



Verification Pcp12h

whole period, 6 and 18 UTC runs

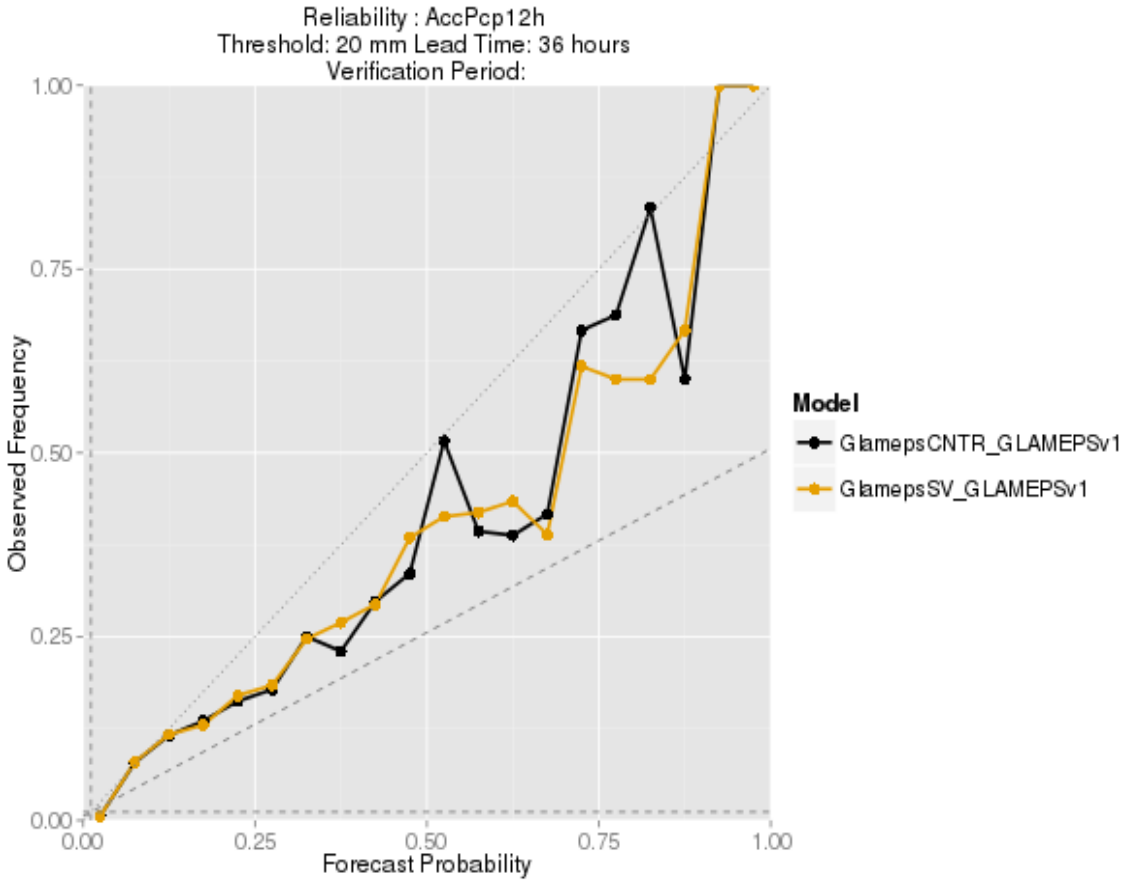
Reliability, 10 mm, +36h, Glameps



Verification Pcp12h

whole period, 6 and 18 UTC runs

Reliability, 20 mm, +36h, Glameps



Verification Pcp12h

Clear (modest) improvement BSS which is strongest for +36h and 20 mm threshold

Straco has stronger impact than Kain-Fritsch

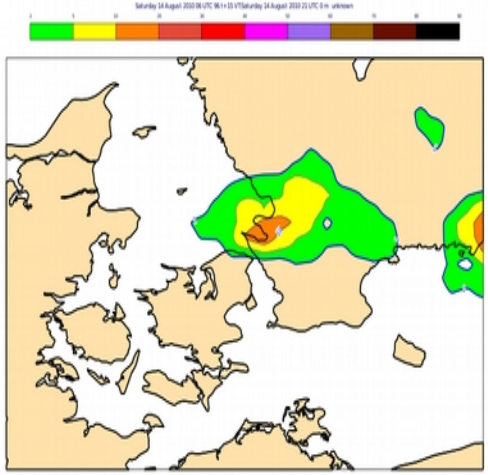
Case studies illustrating the effect of Singular Vector perturbations:

14 August 2010
17 August 2010
18 August 2010

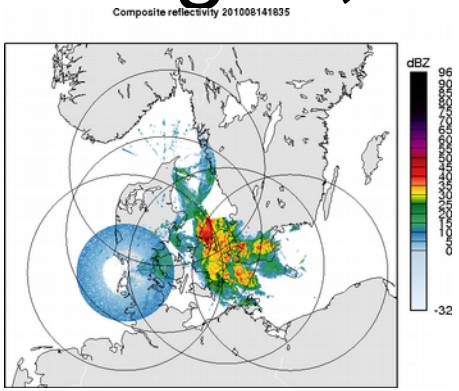
1. Area Copenhagen, August 14, 2010

18 – 21 UTC

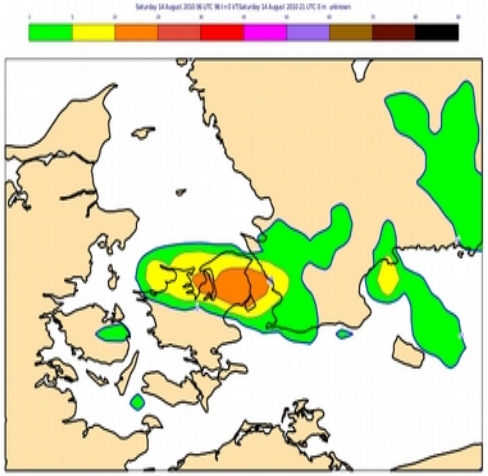
(06+15) – (06+12)



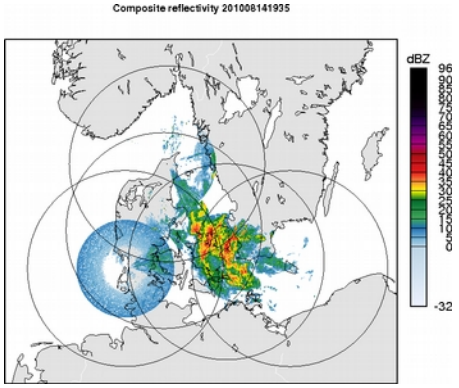
H



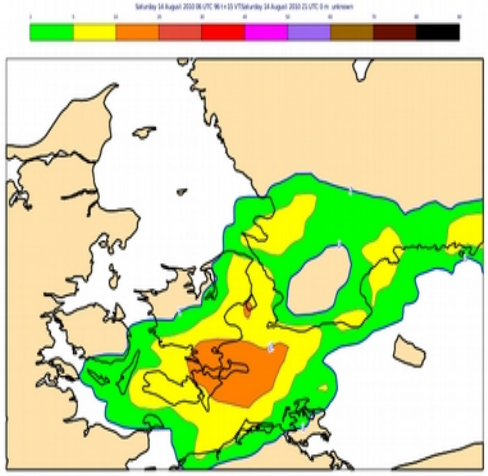
H



CNTR



SV



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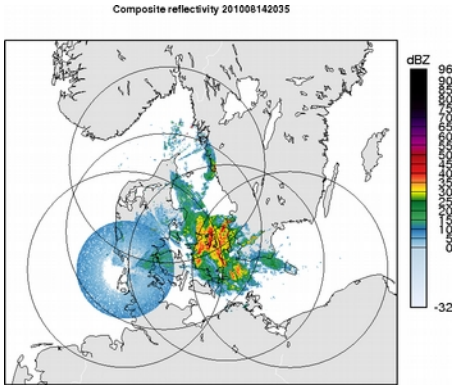

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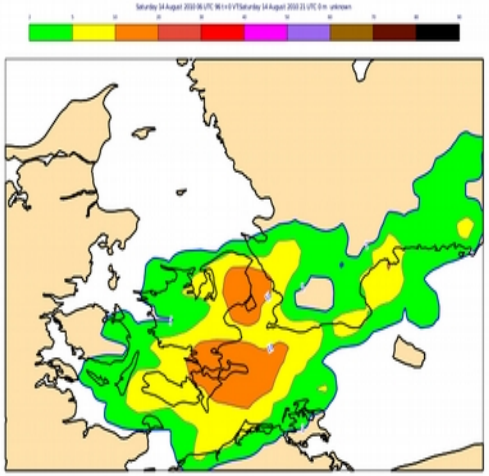
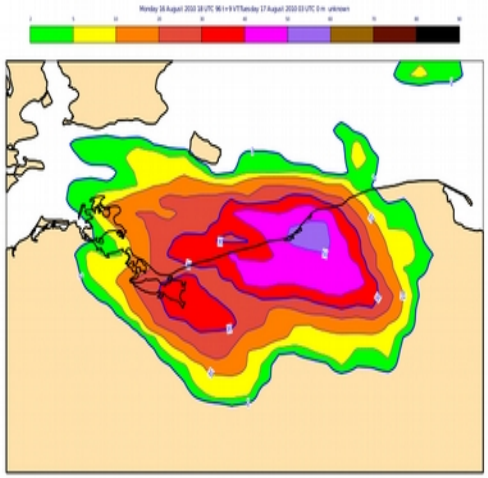


2. Bornholm, August 17, 2010

00 - 03 UTC

(18+09) – (18+06)



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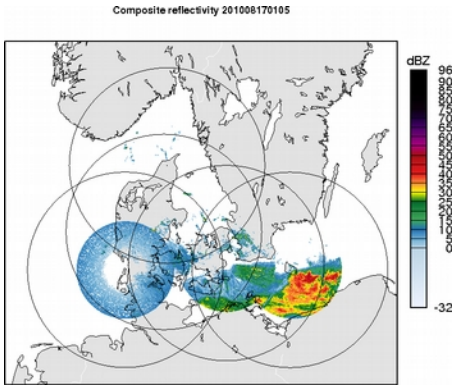
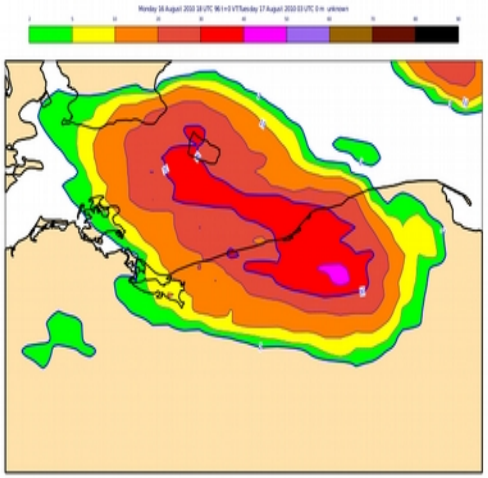
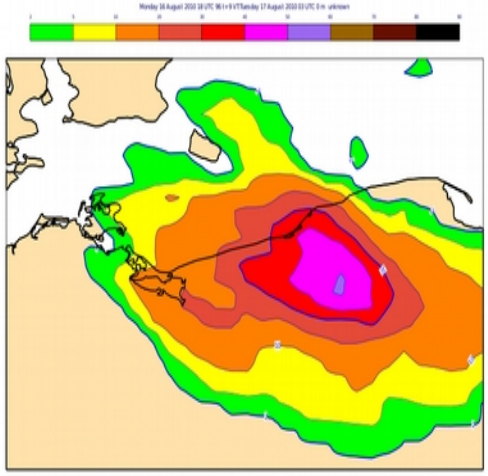


H



CNTR



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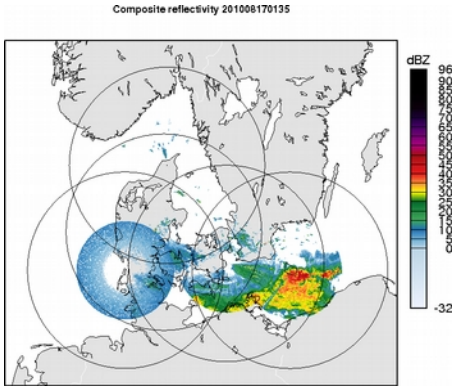
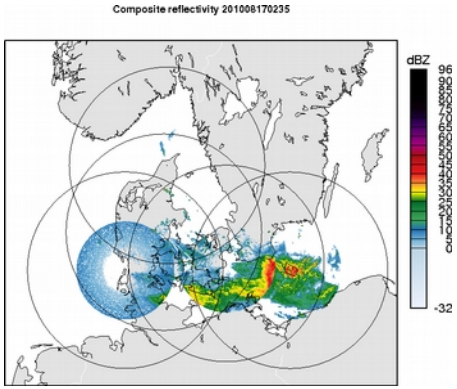
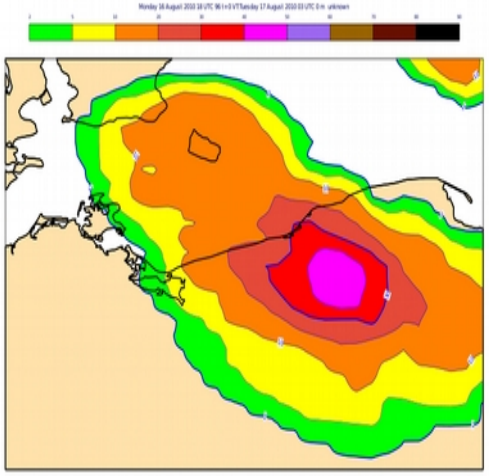




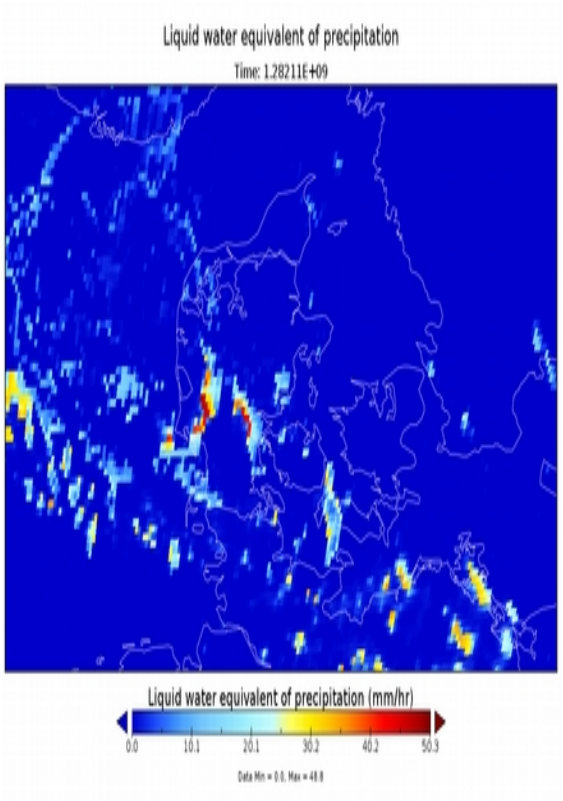
G

SV



3. Jutland, August 18, 2010

05 UTC 45 min



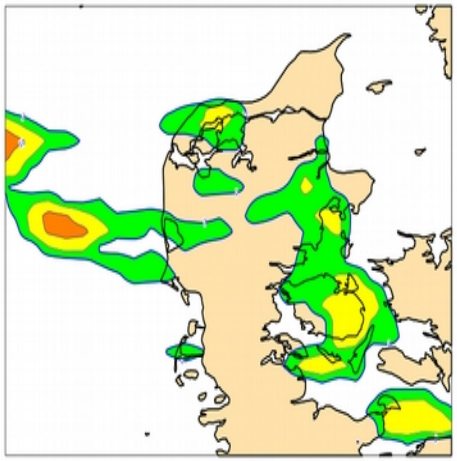
MSG precipitation

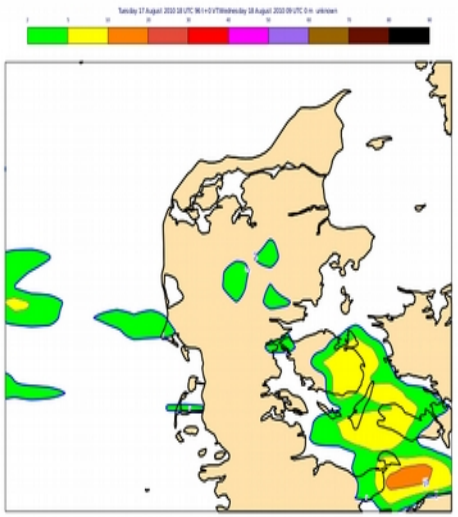
3. Jutland, August 18. 2010

06 - 09 UTC

(18+15) – (18+12)

06 UTC 00 min





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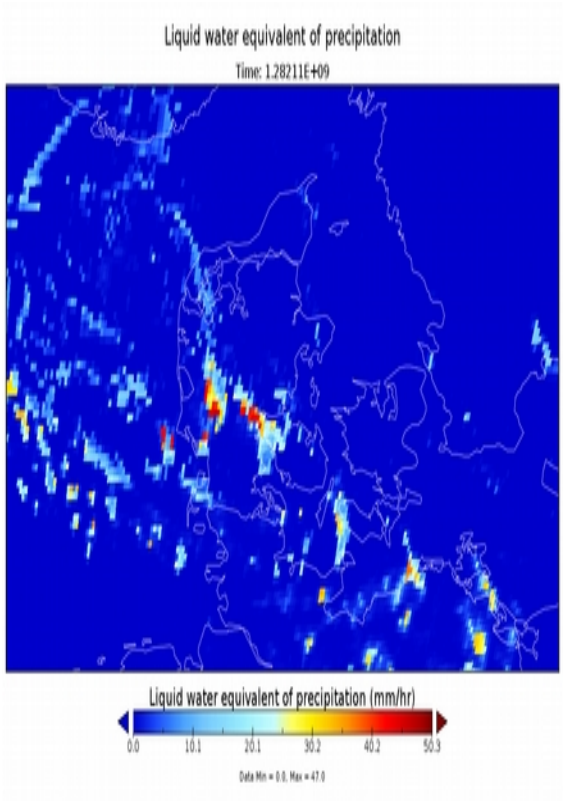
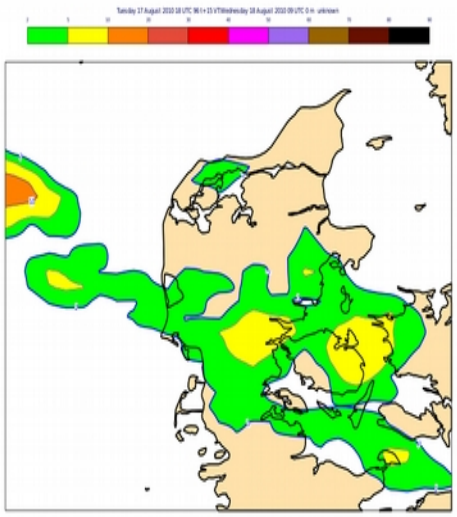


CNTR



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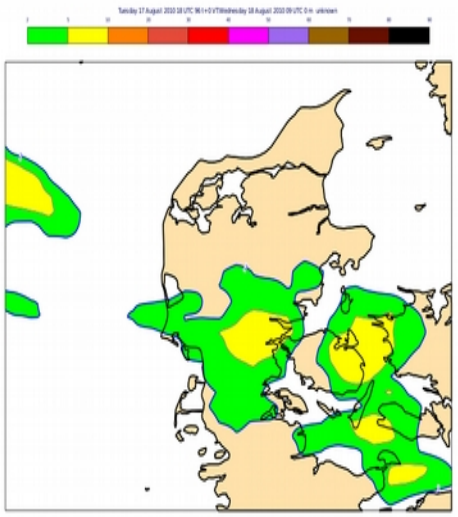


G

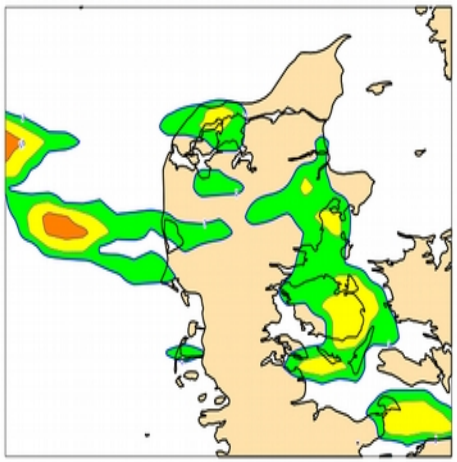
MSG precipitation

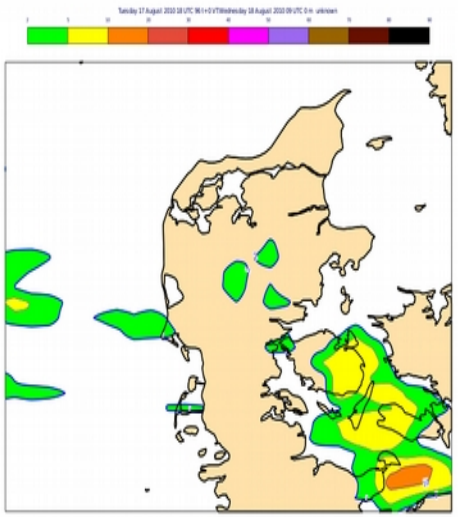
3. Jutland, August 18. 2010

06 - 09 UTC

(18+15) – (18+12)

06 UTC 15 min





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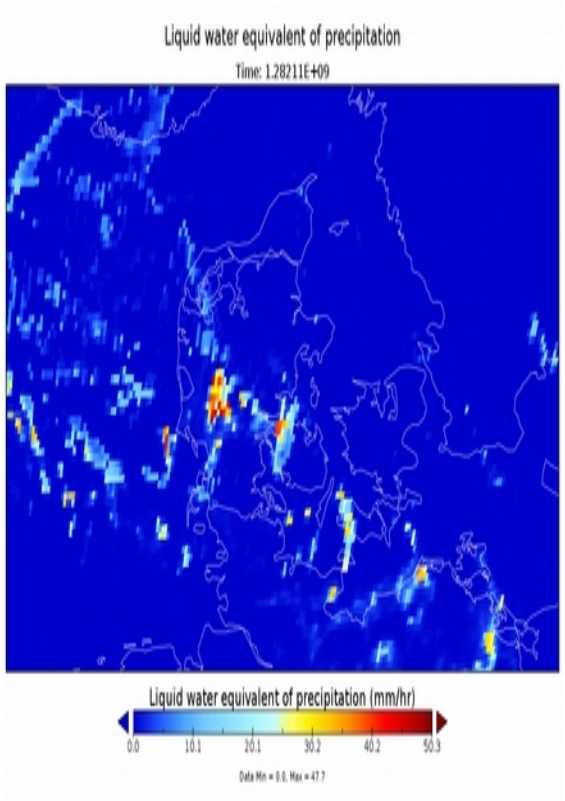
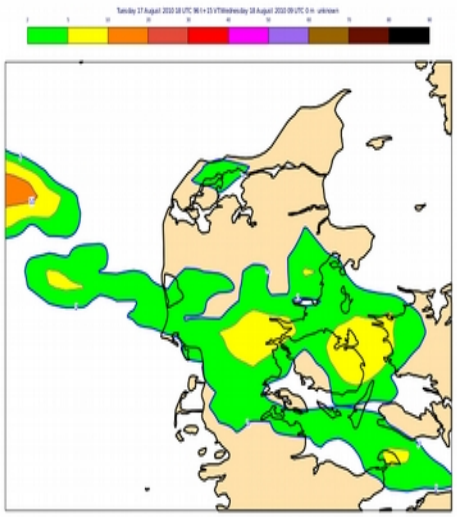


CNTR



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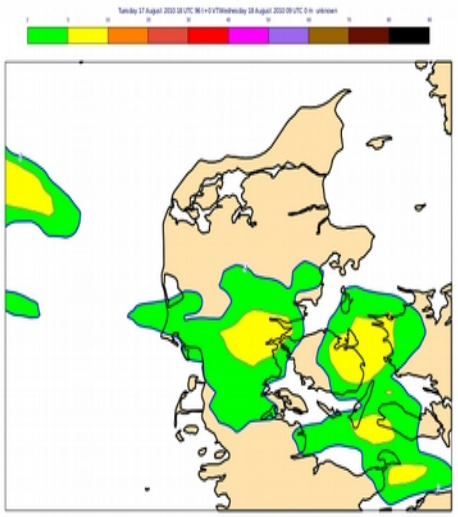


G

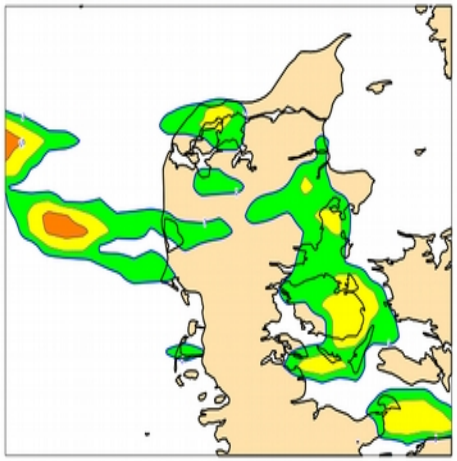
MSG precipitation

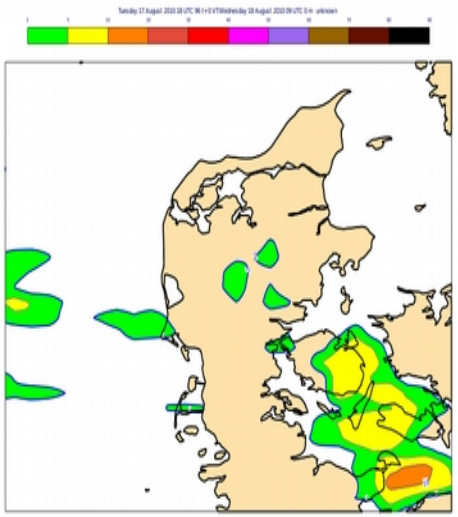
3. Jutland, August 18. 2010

06 - 09 UTC

(18+15) – (18+12)

06 UTC 30 min





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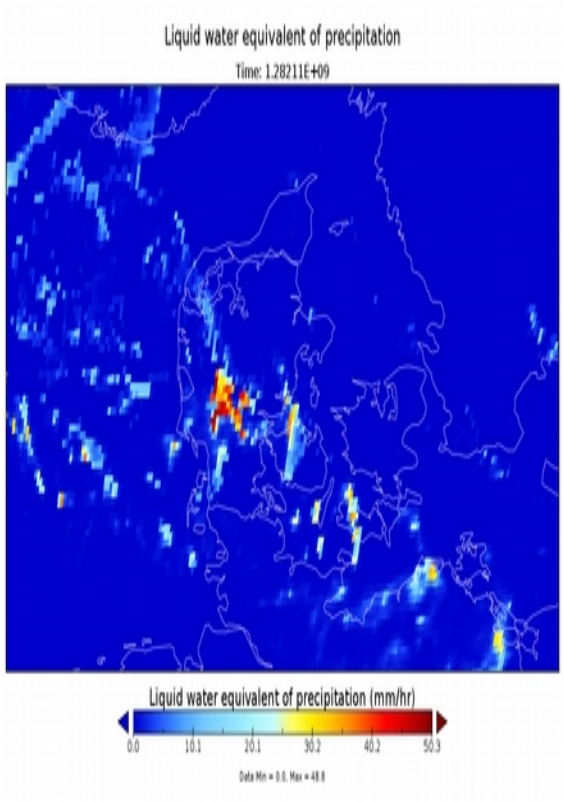
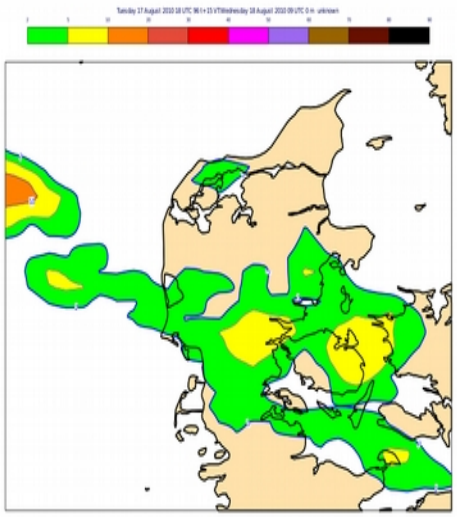
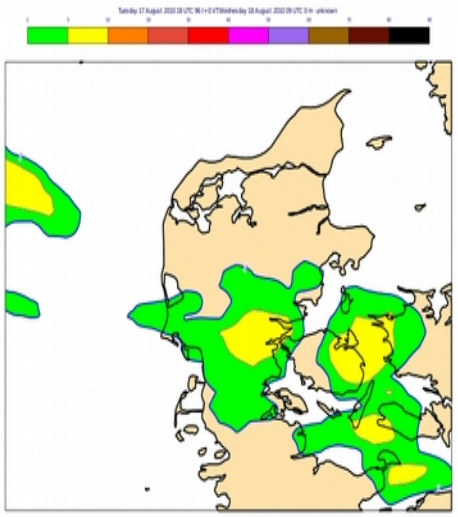


CNTR



SV



G

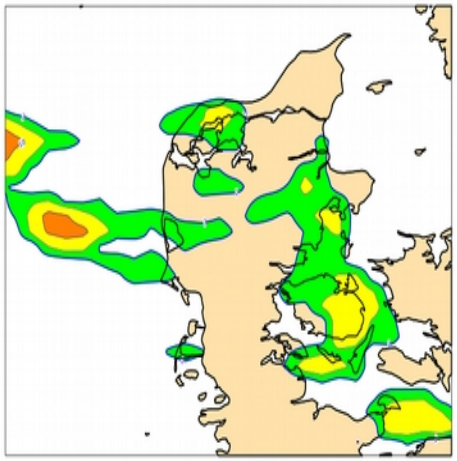
MSG precipitation

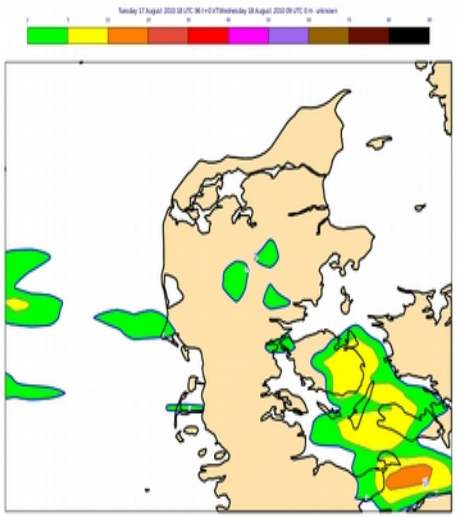
3. Jutland, August 18. 2010

06 - 09 UTC

(18+15) – (18+12)

06 UTC 45 min





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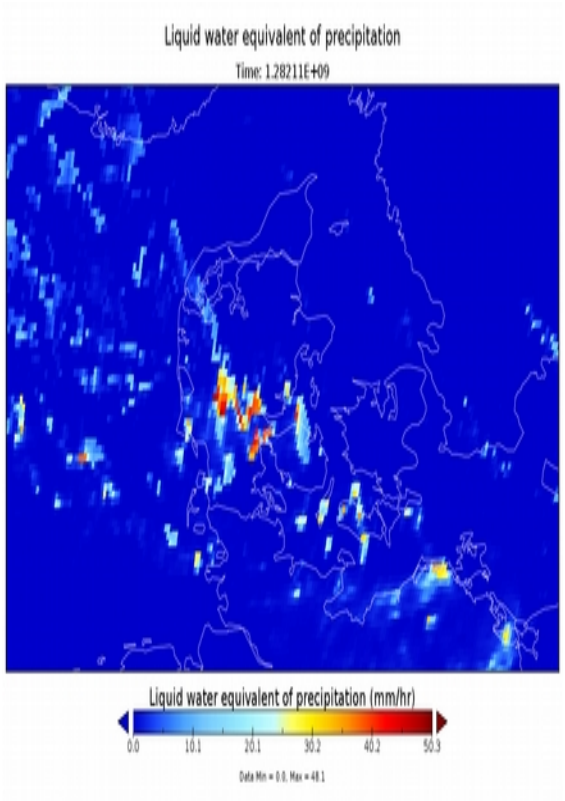
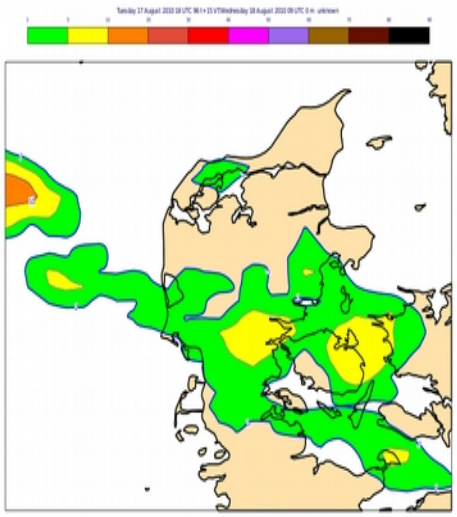


CNTR



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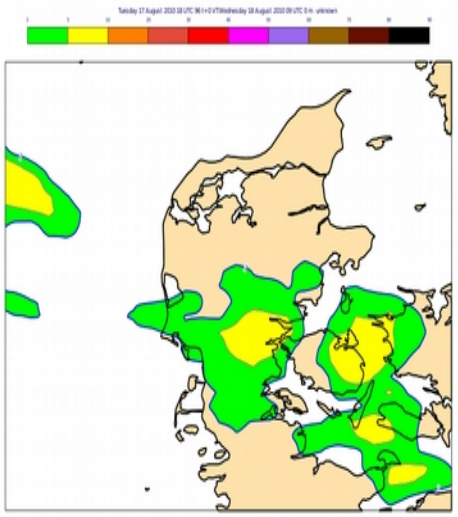


G

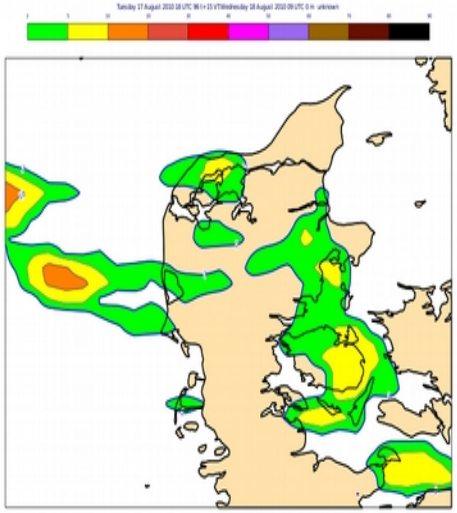
MSG precipitation

3. Jutland, August 18. 2010

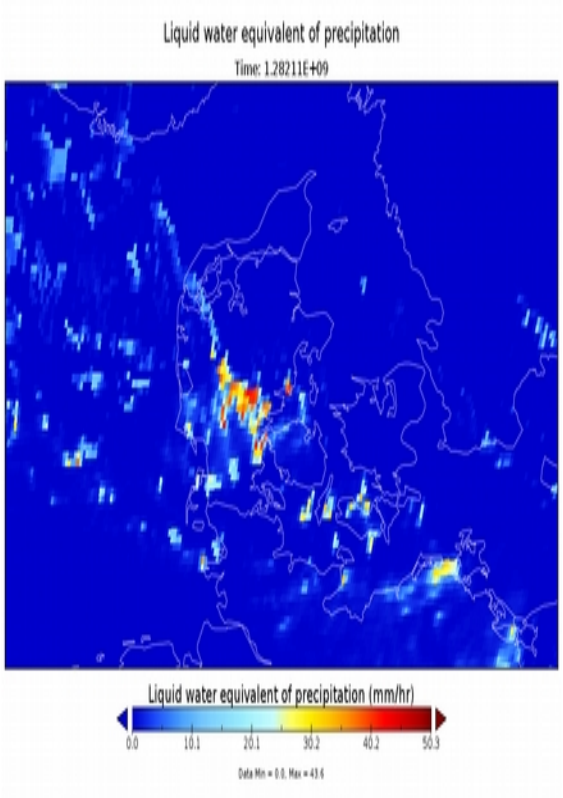
06 - 09 UTC

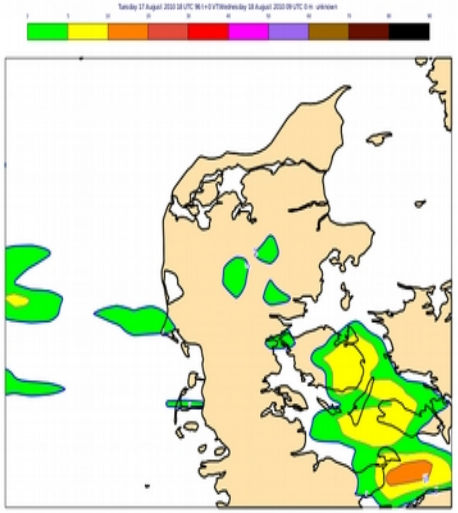
(18+15) – (18+12)

07 UTC 00 min

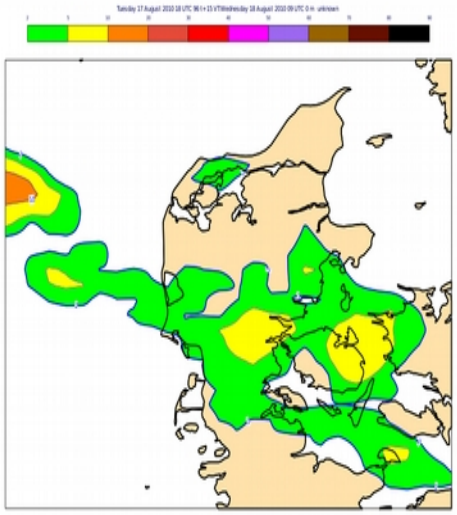


H





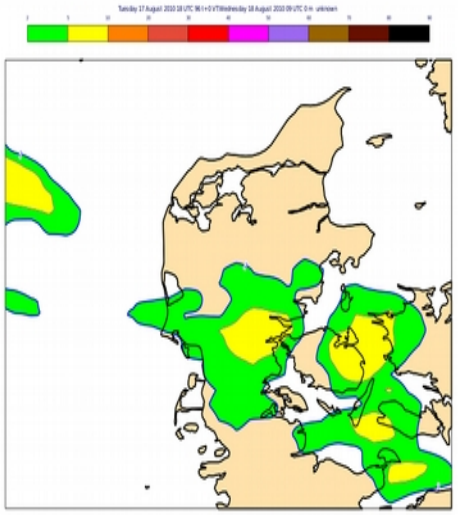
CNTR



G

MSG precipitation

SV

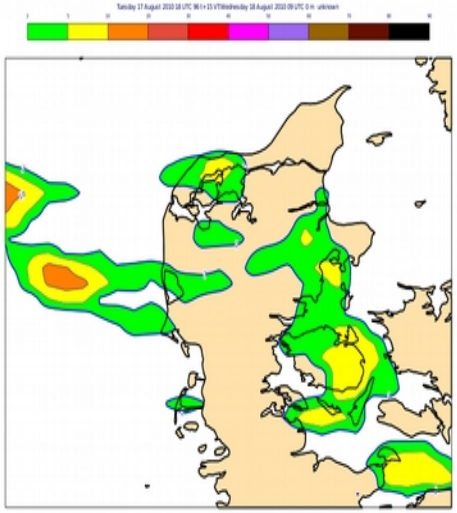


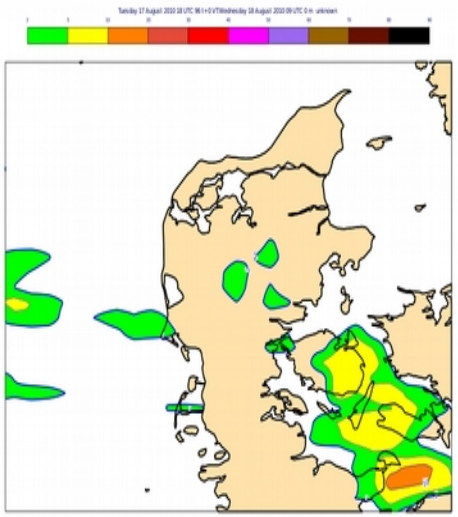
3. Jutland, August 18. 2010

06 - 09 UTC

(18+15) – (18+12)

07 UTC 15 min





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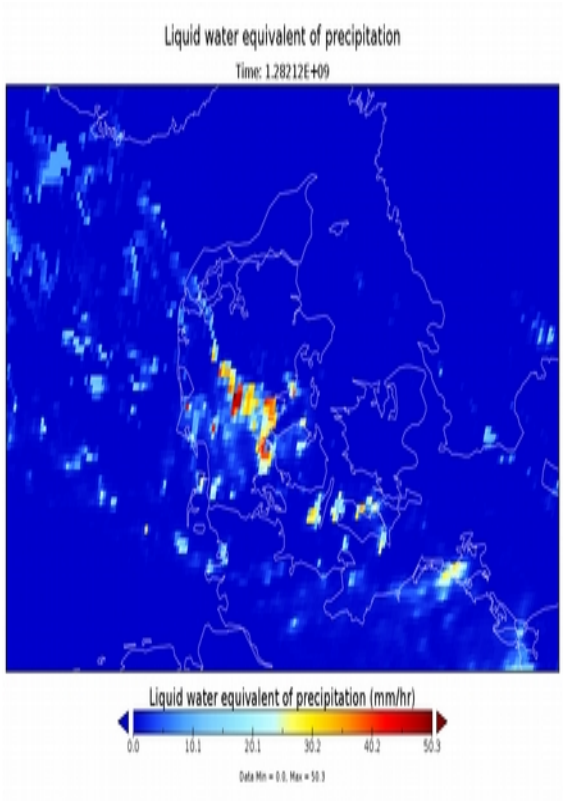
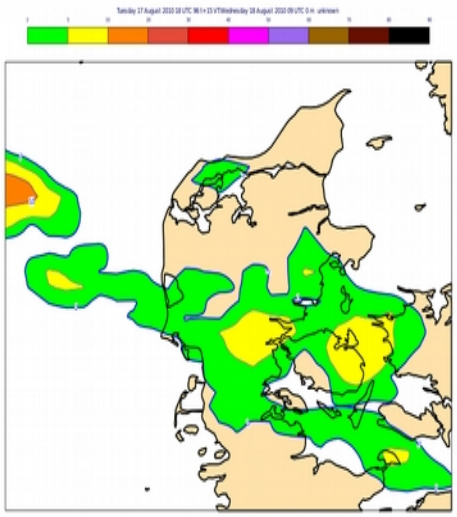


CNTR



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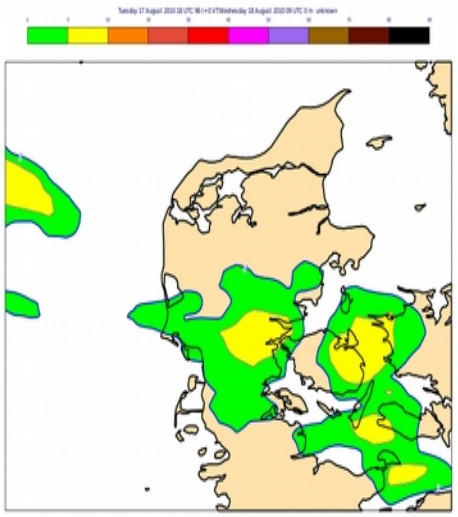


G

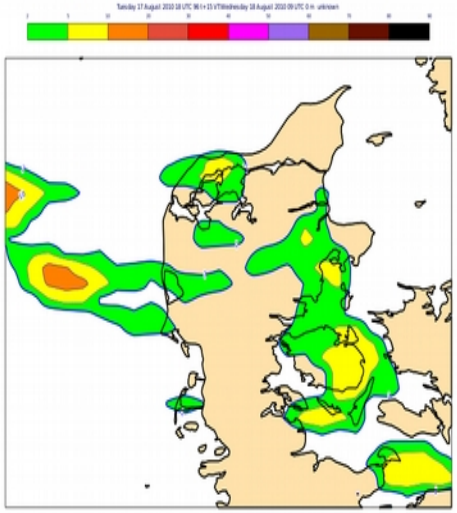
MSG precipitation

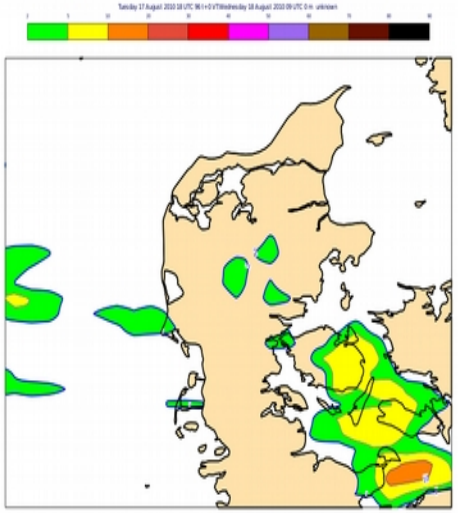
3. Jutland, August 18. 2010

06 - 09 UTC

(18+15) – (18+12)

07 UTC 30 min





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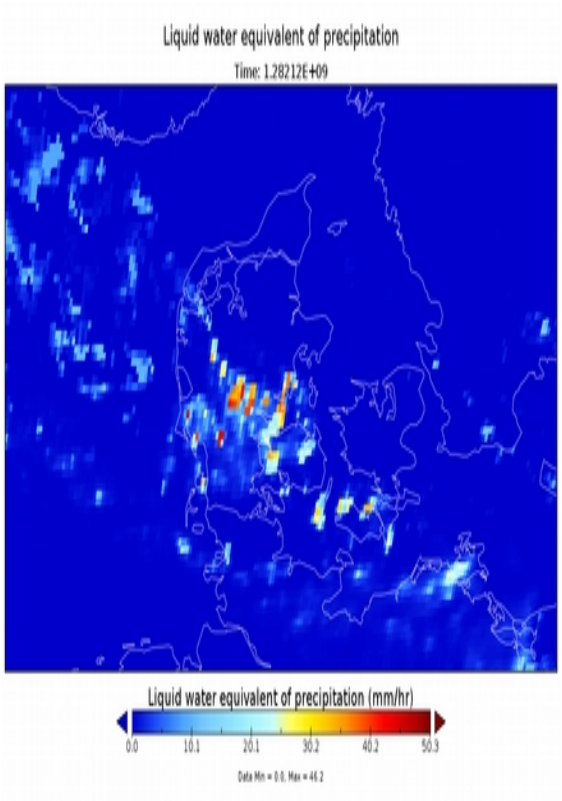
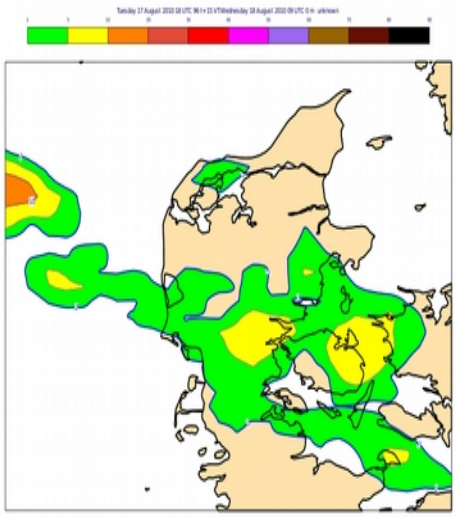


CNTR



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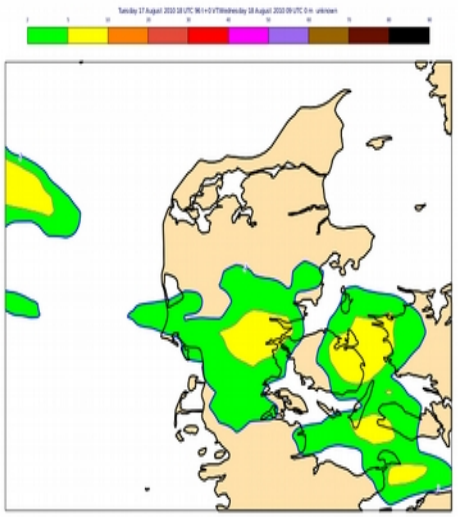


G

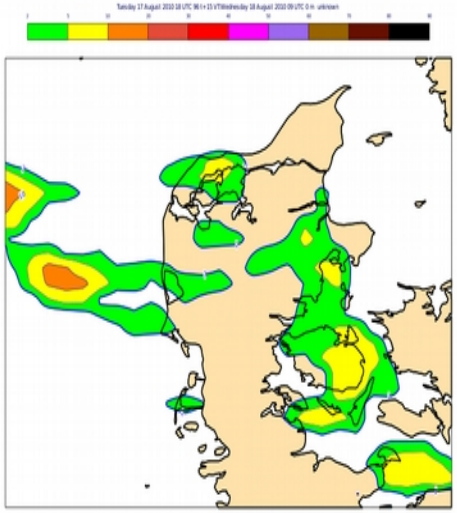
MSG precipitation

3. Jutland, August 18. 2010

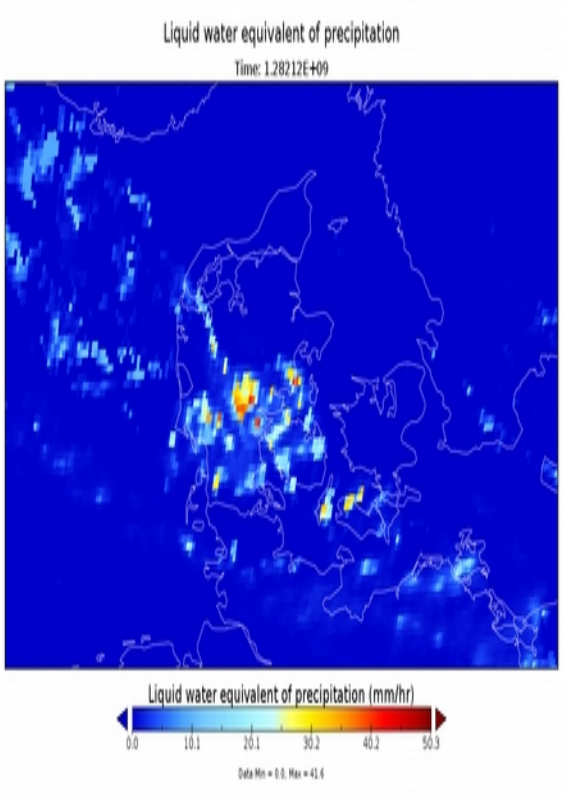
06 - 09 UTC

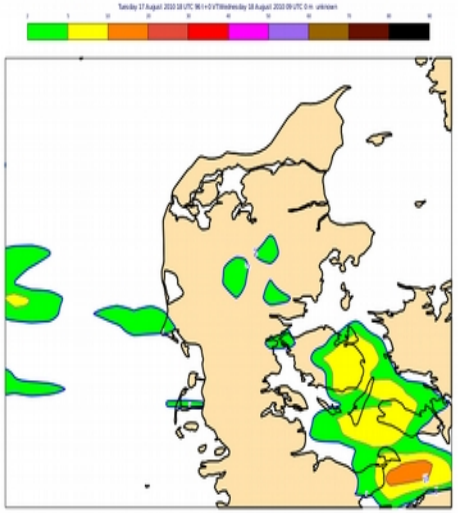
(18+15) – (18+12)

07 UTC 45 min

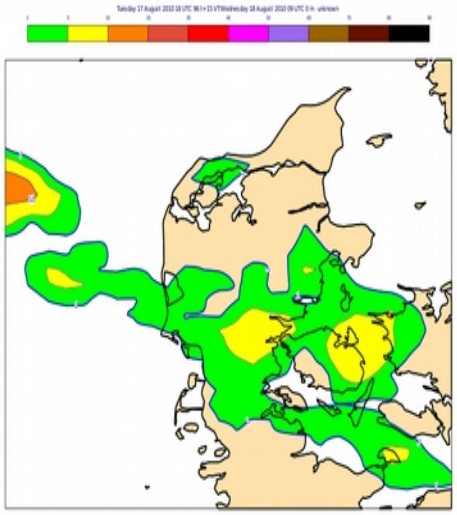


H





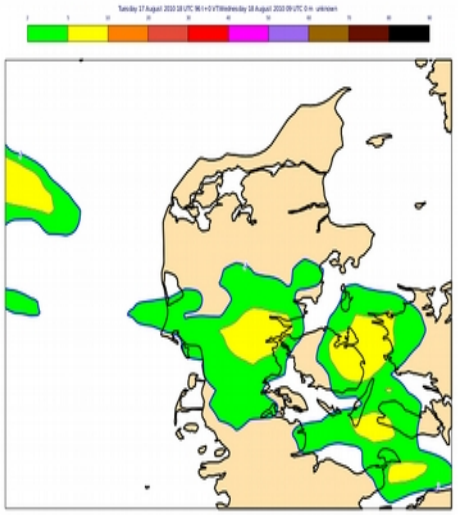
CNTR



G

MSG precipitation

SV

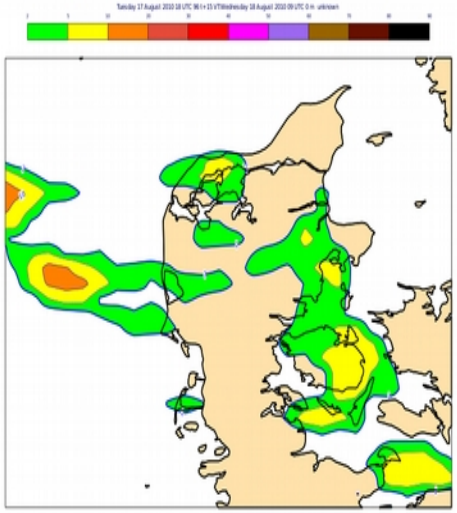


3. Jutland, August 18. 2010

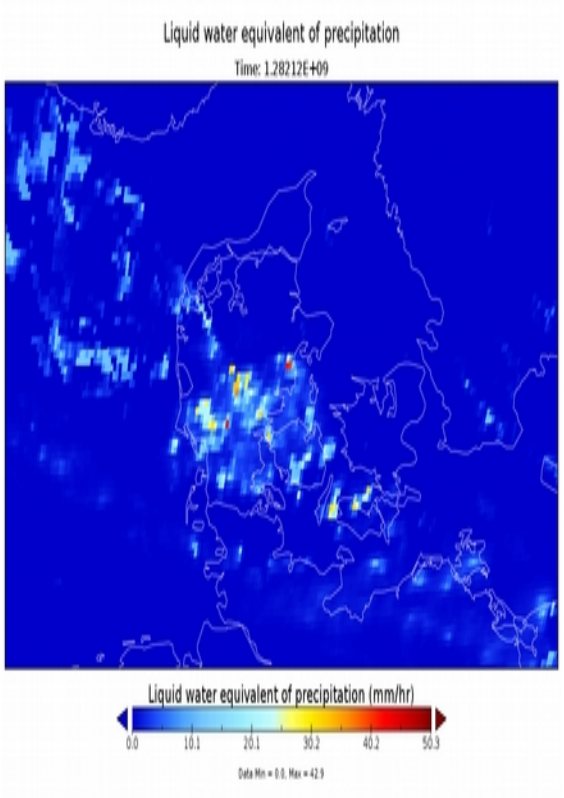
06 - 09 UTC

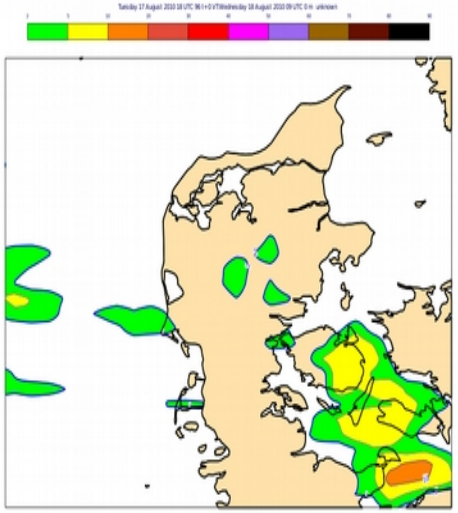
(18+15) – (18+12)

08 UTC 00 min

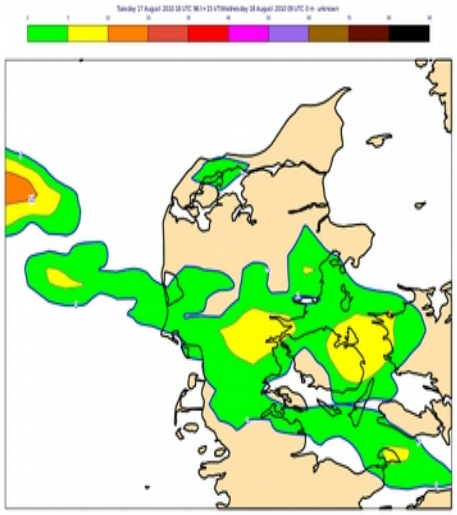


H





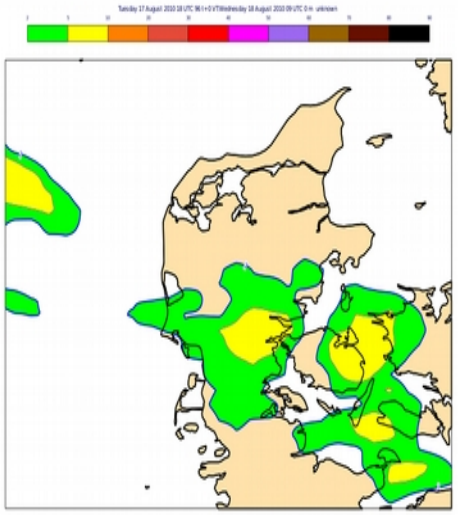
CNTR



G

MSG precipitation

SV

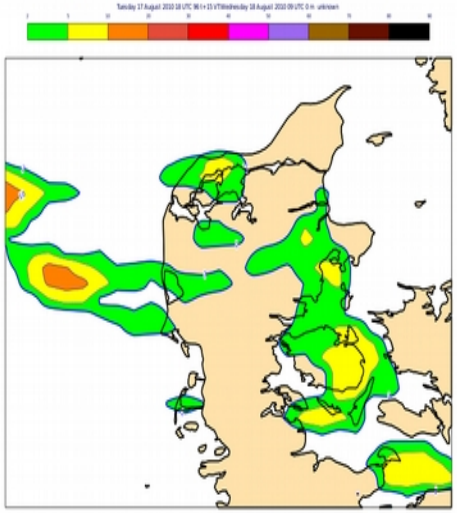


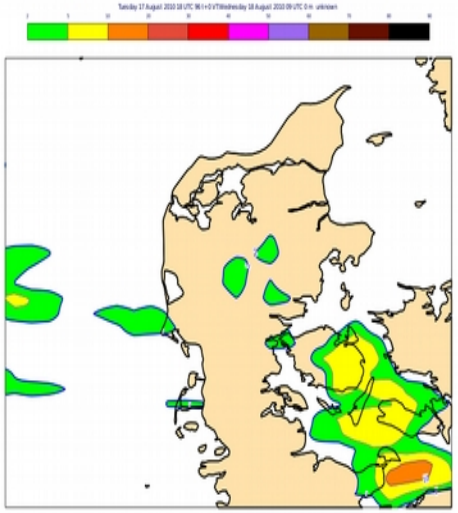
3. Jutland, August 18. 2010

06 - 09 UTC

(18+15) – (18+12)

08 UTC 15 min





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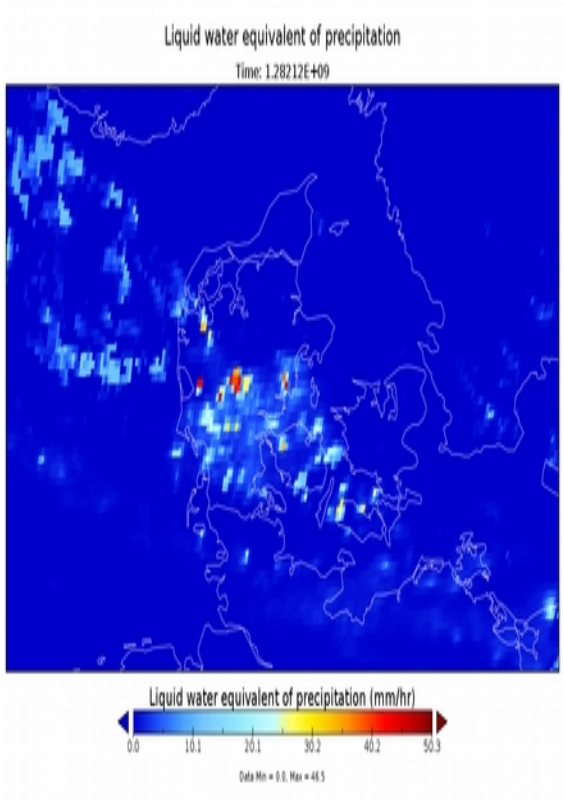
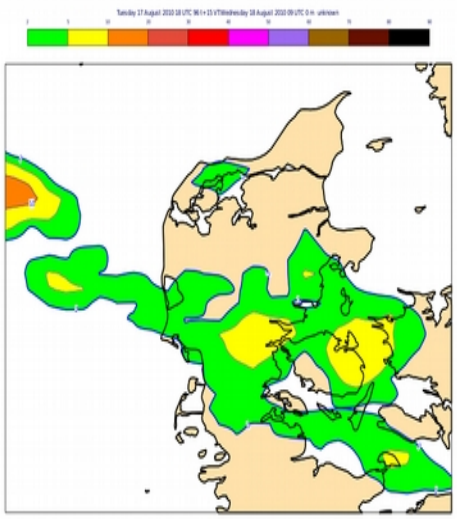


CNTR



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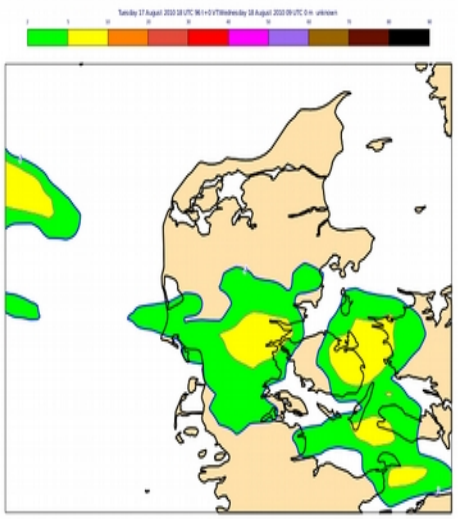


G

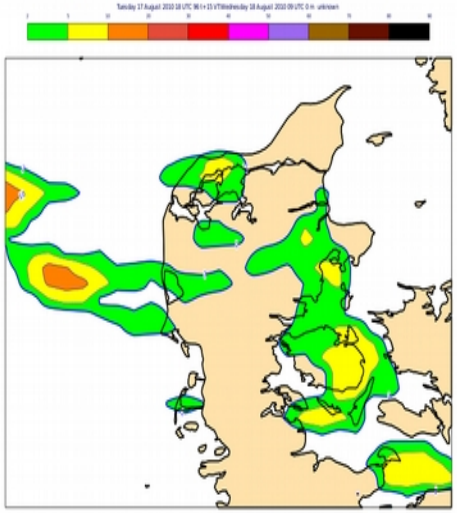
MSG precipitation

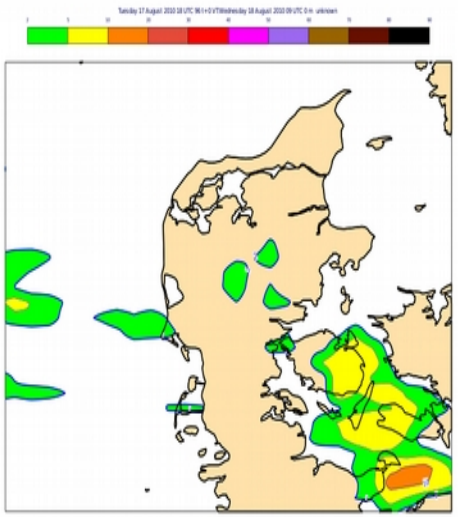
3. Jutland, August 18. 2010

06 - 09 UTC

(18+15) – (18+12)

08 UTC 30 min





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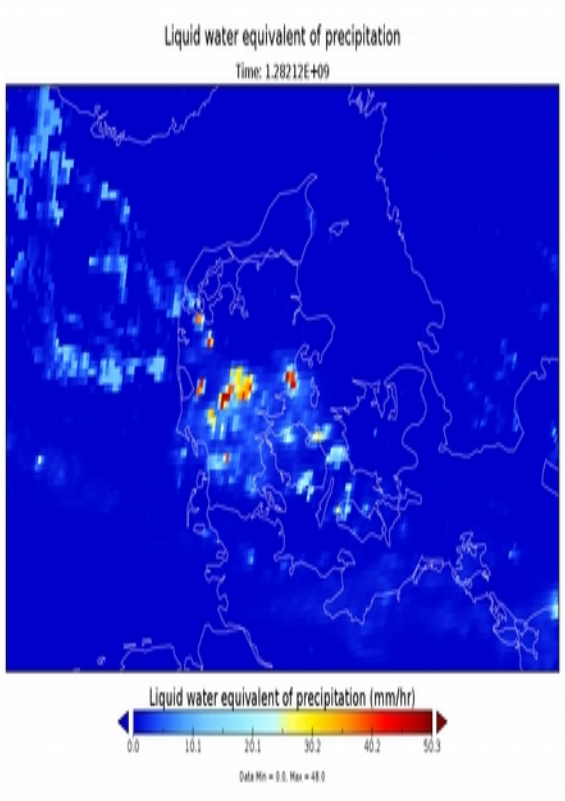
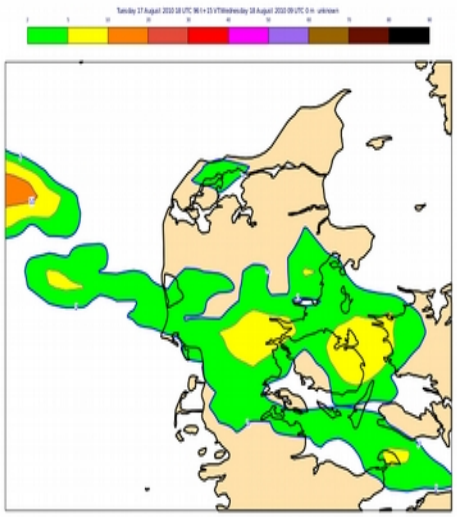


CNTR



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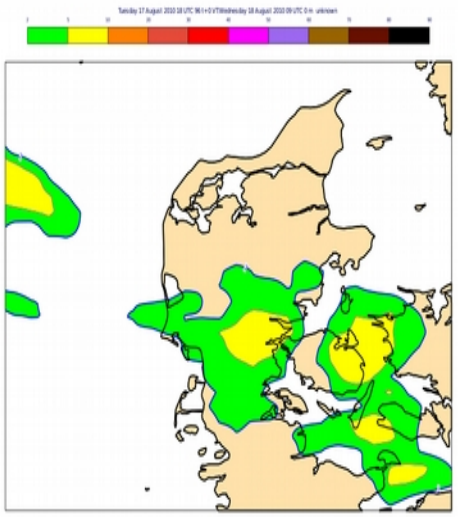


G

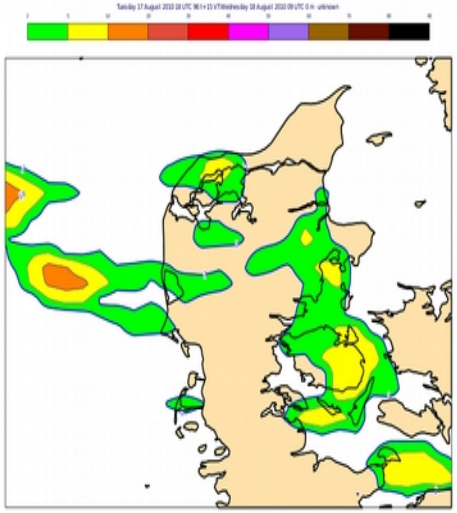
MSG precipitation

3. Jutland, August 18. 2010

06 - 09 UTC

(18+15) – (18+12)

08 UTC 45 min



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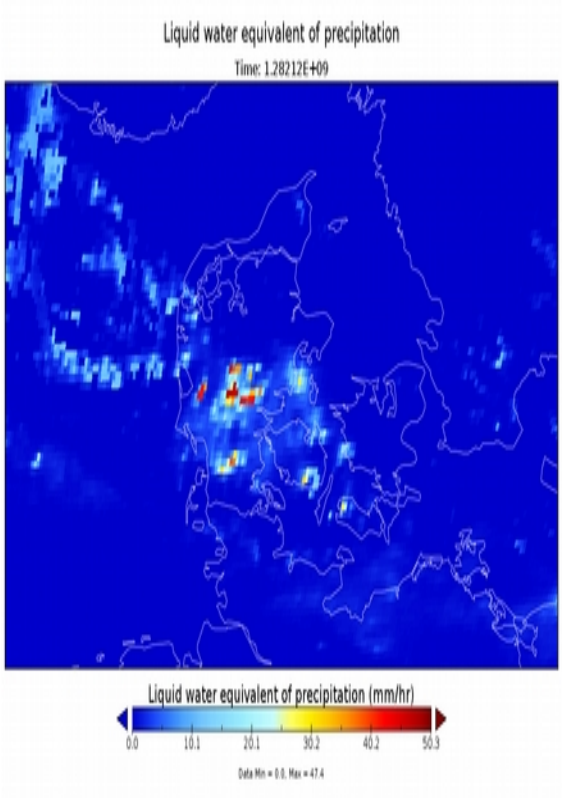

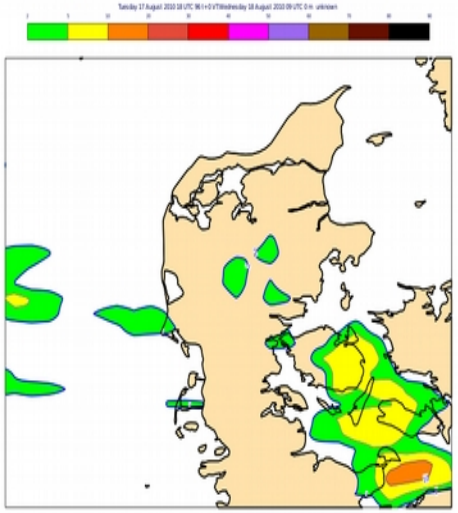

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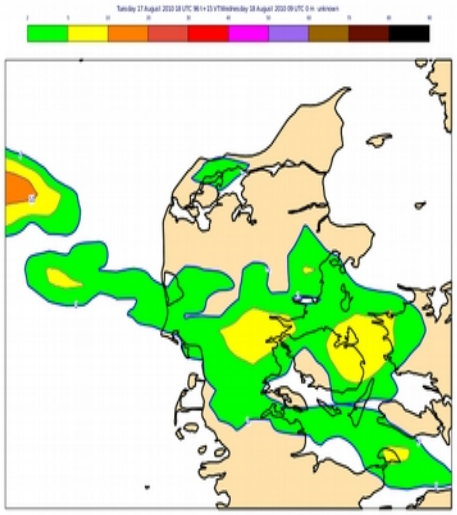
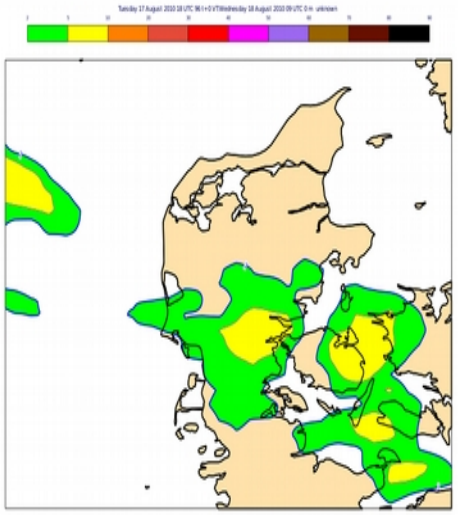


G

MSG precipitation

SV

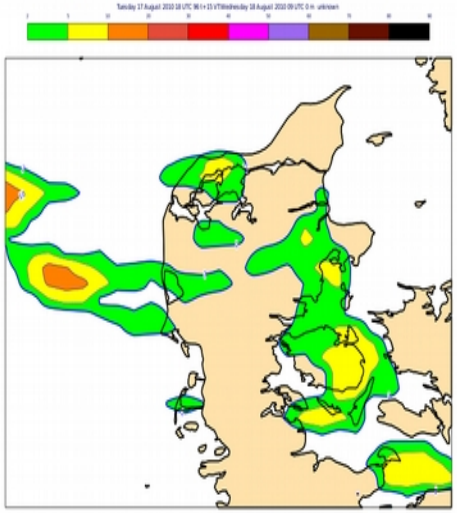


3. Jutland, August 18. 2010

06 - 09 UTC

(18+15) – (18+12)

09 UTC 00 min



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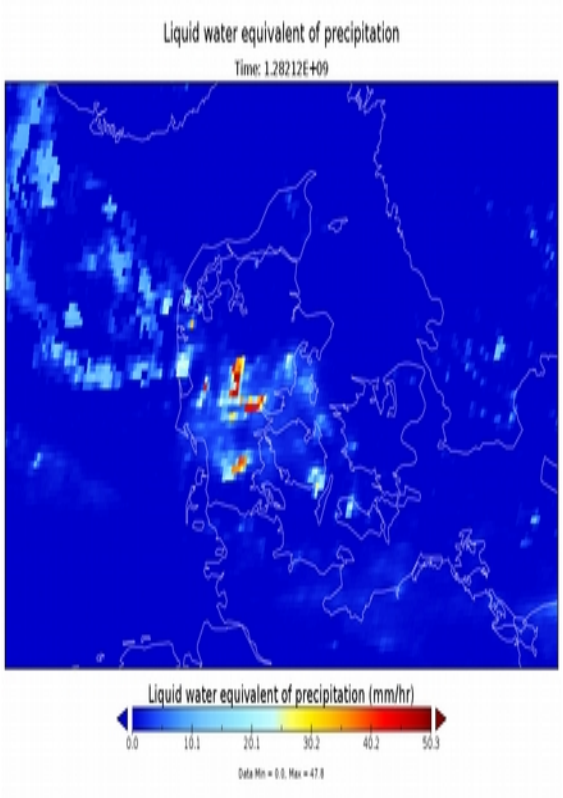

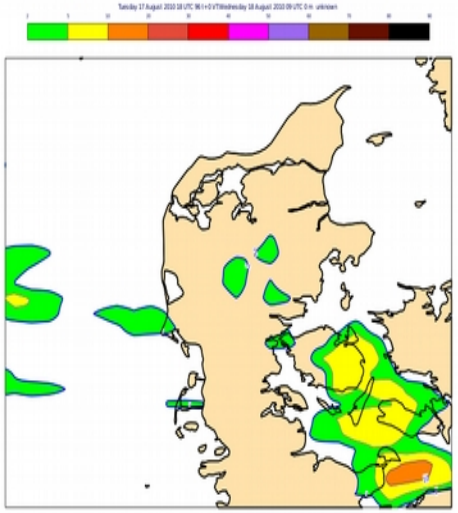

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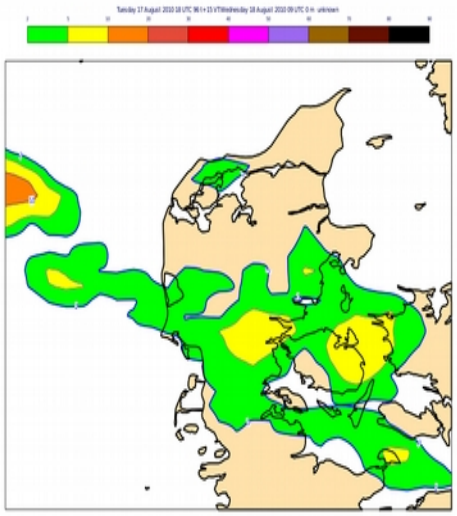
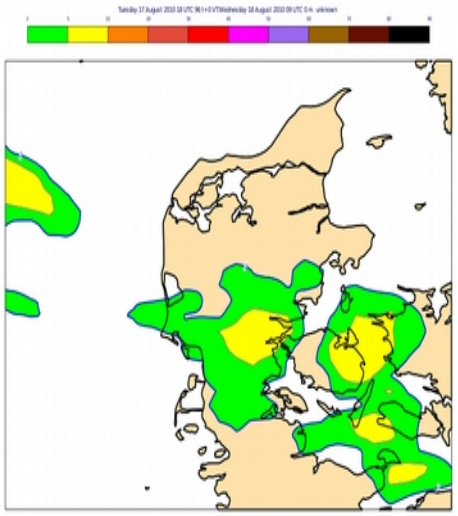


G

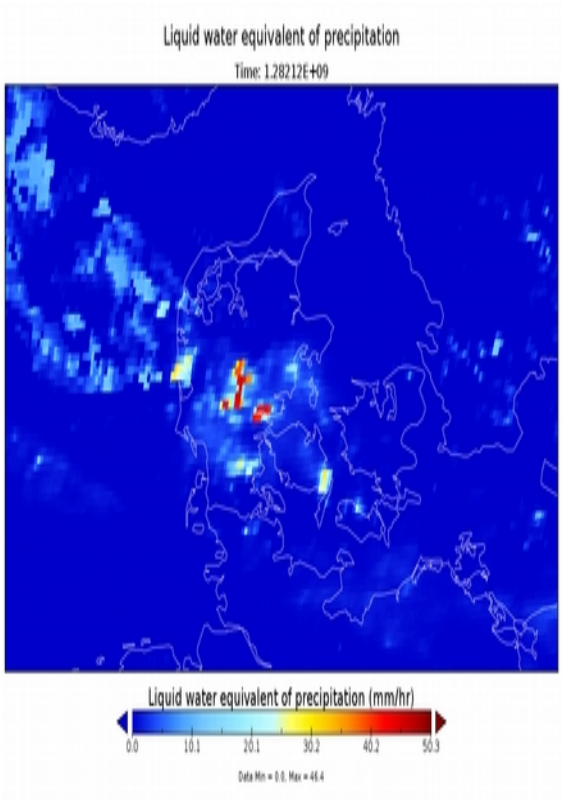
MSG precipitation

SV



3. Jutland, August 18, 2010

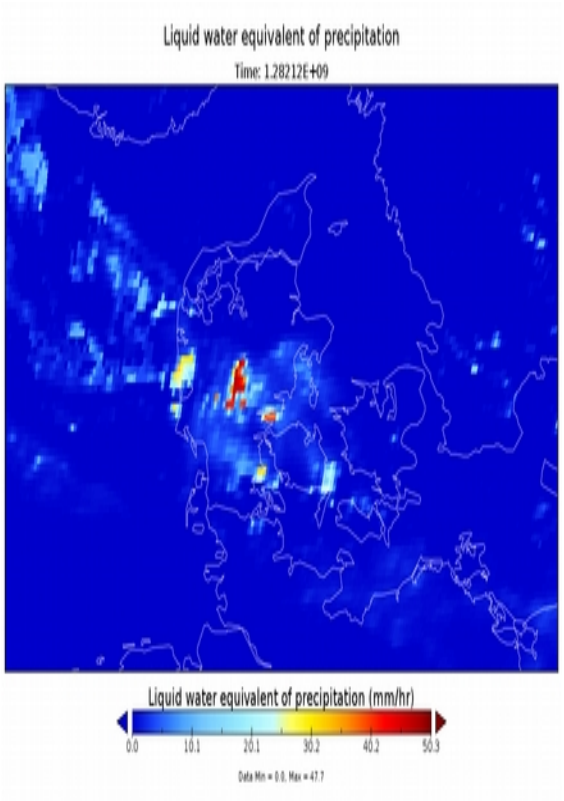
09 UTC 15 min



MSG precipitation

3. Jutland, August 18, 2010

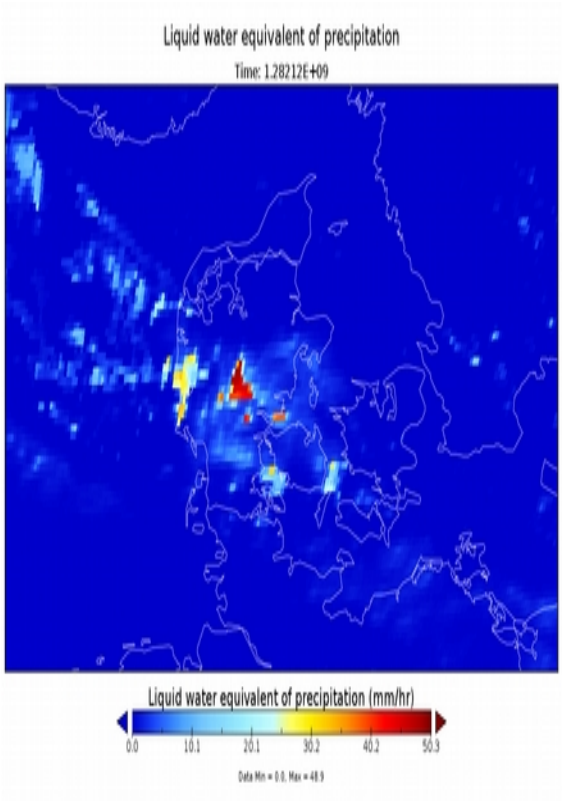
09 UTC 30 min



MSG precipitation

3. Jutland, August 18, 2010

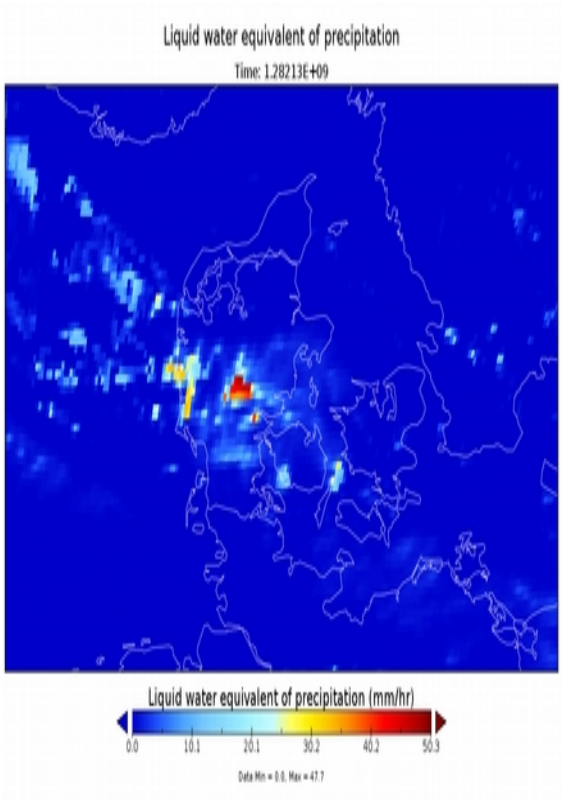
09 UTC 45 min



MSG precipitation

3. Jutland, August 18, 2010

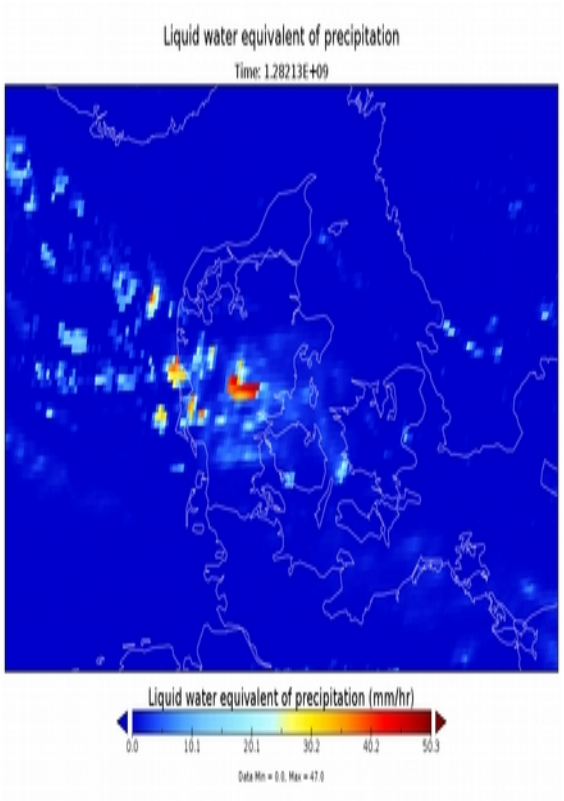
10 UTC 00 min



MSG precipitation

3. Jutland, August 18, 2010

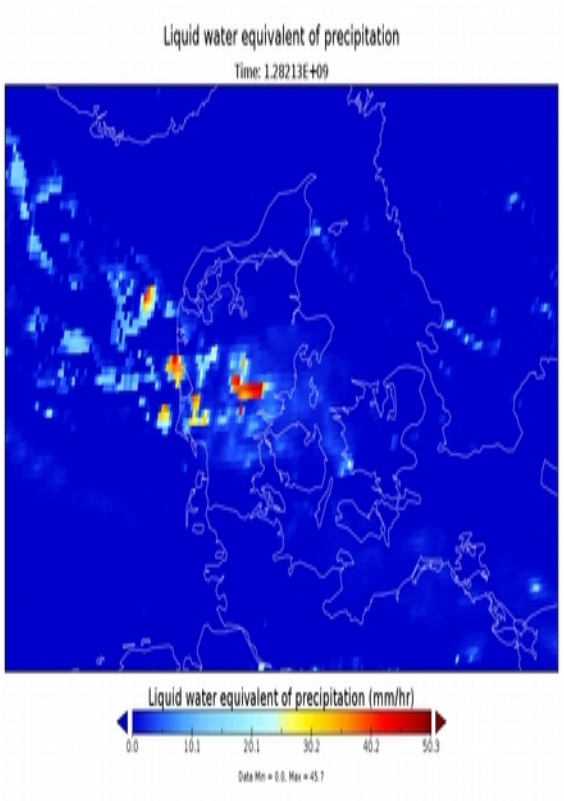
10 UTC 15 min



MSG precipitation

3. Jutland, August 18, 2010

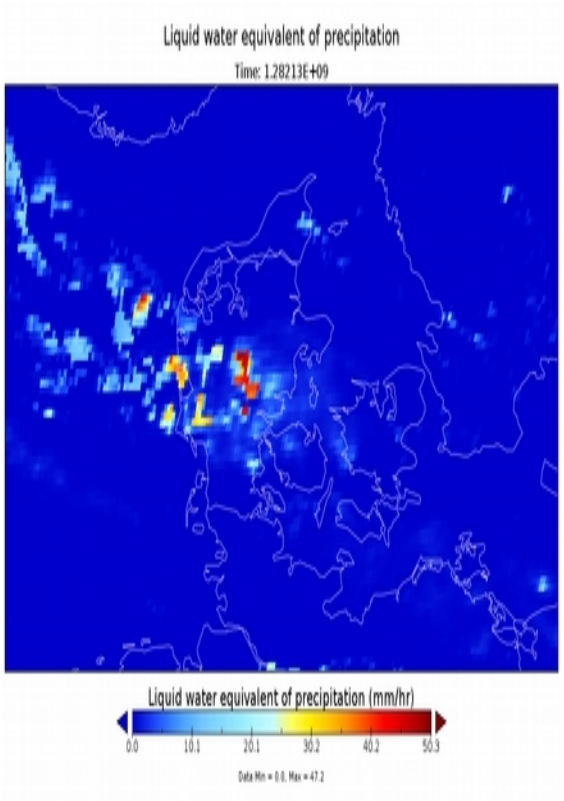
10 UTC 30 min



MSG precipitation

3. Jutland, August 18, 2010

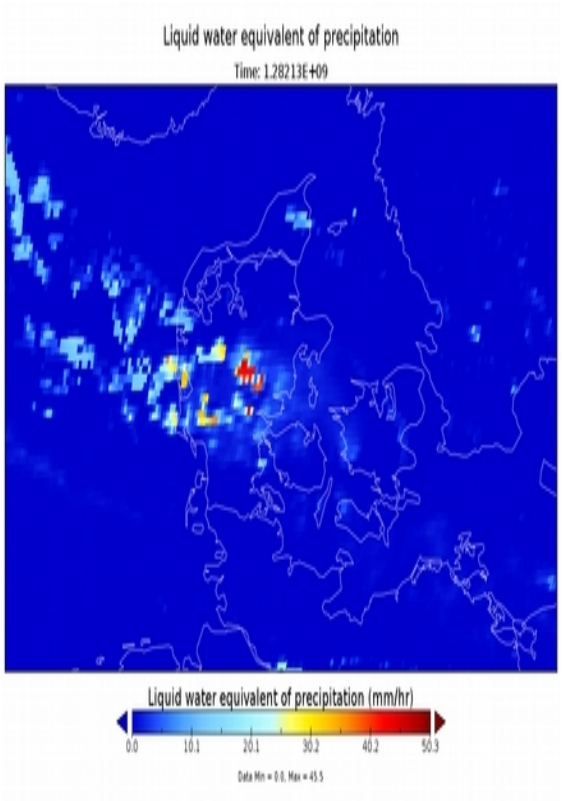
10 UTC 45 min



MSG precipitation

3. Jutland, August 18, 2010

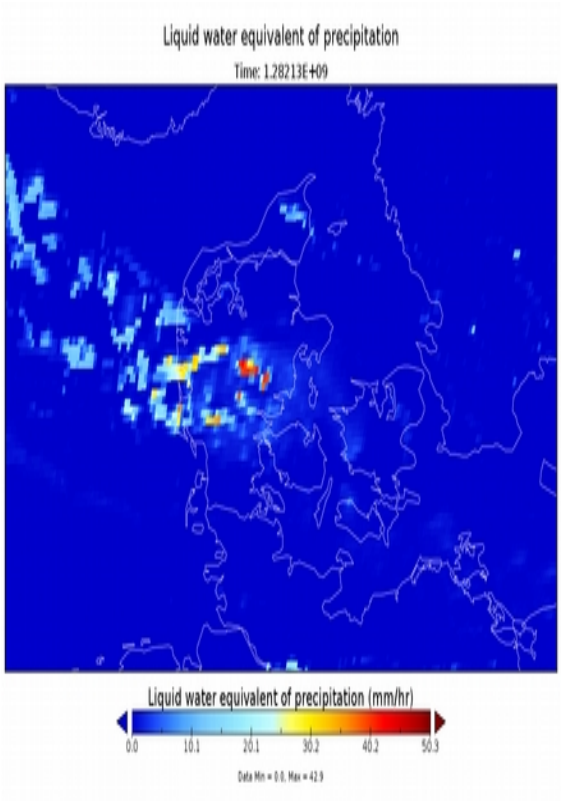
11 UTC 00 min



MSG precipitation

3. Jutland, August 18, 2010

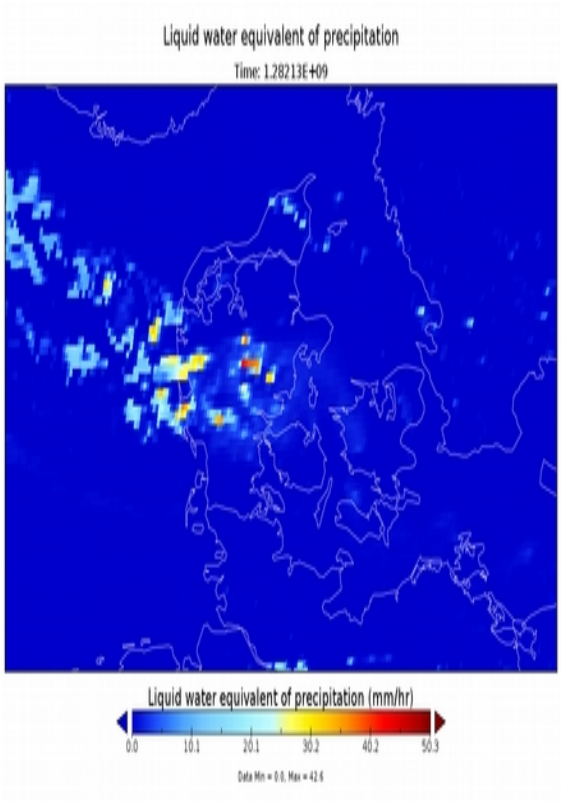
11 UTC 15 min



MSG precipitation

3. Jutland, August 18, 2010

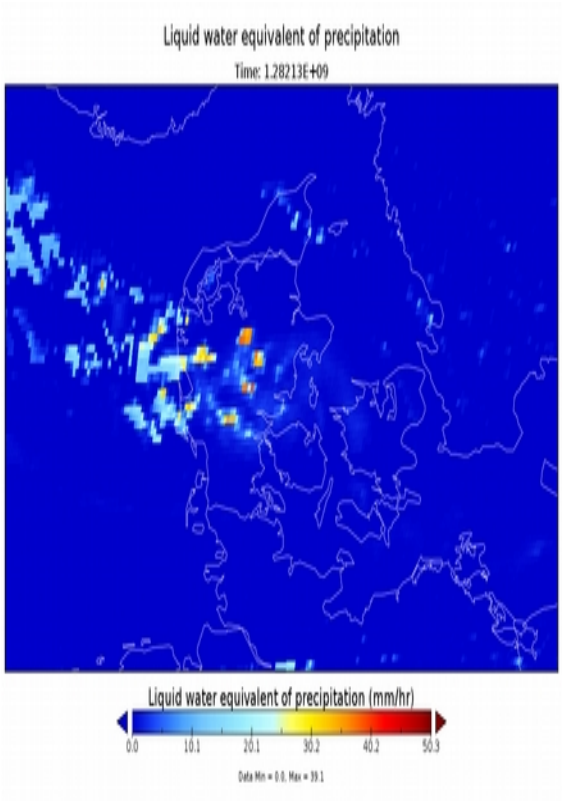
11 UTC 30 min



MSG precipitation

3. Jutland, August 18, 2010

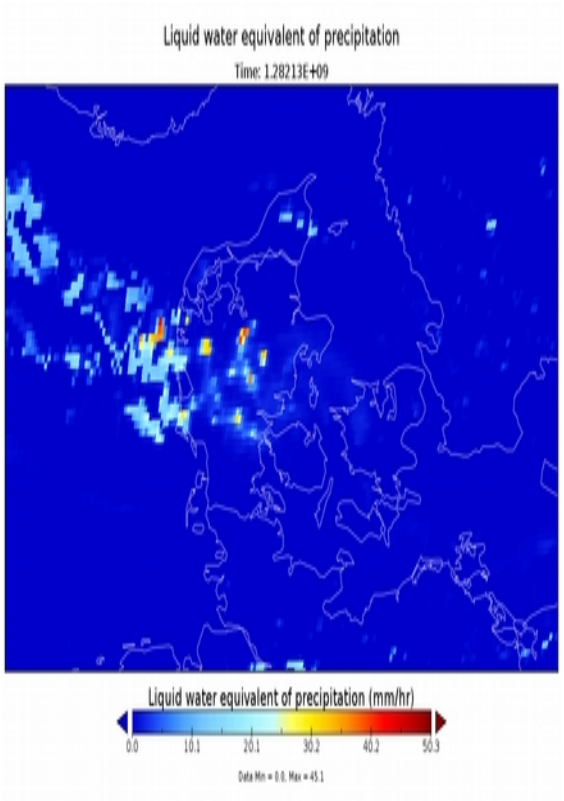
11 UTC 45 min



MSG precipitation

3. Jutland, August 18, 2010

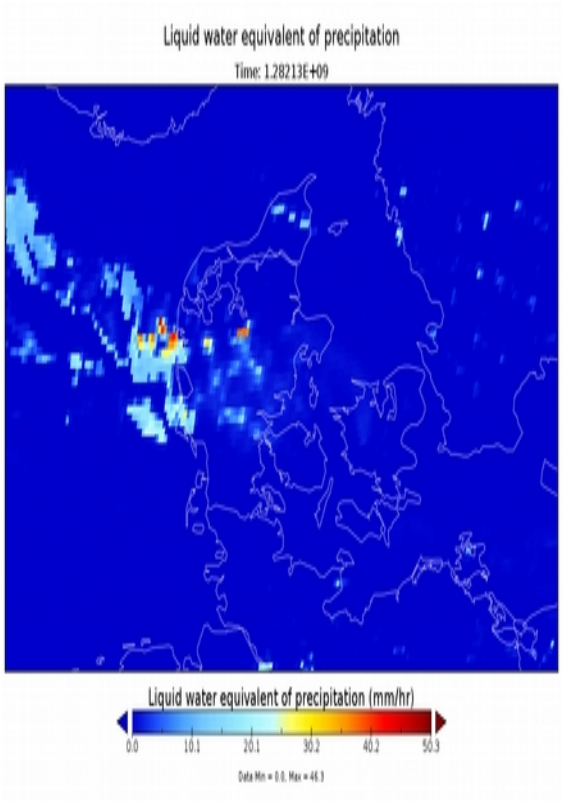
12 UTC 00 min



MSG precipitation

3. Jutland, August 18, 2010

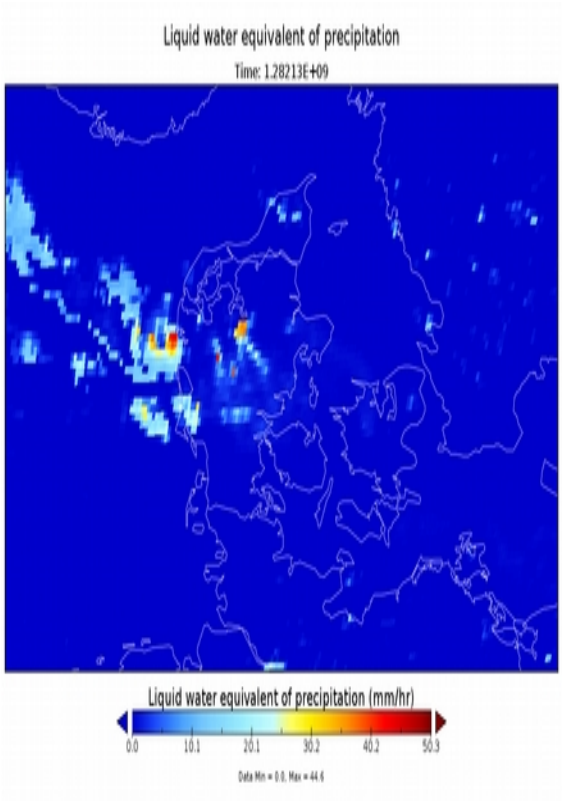
12 UTC 15 min



MSG precipitation

3. Jutland, August 18, 2010

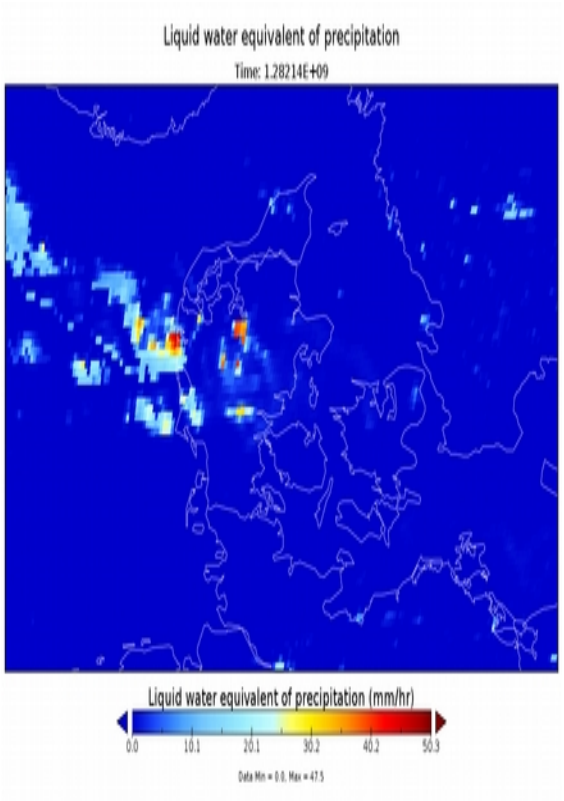
12 UTC 30 min



MSG precipitation

3. Jutland, August 18, 2010

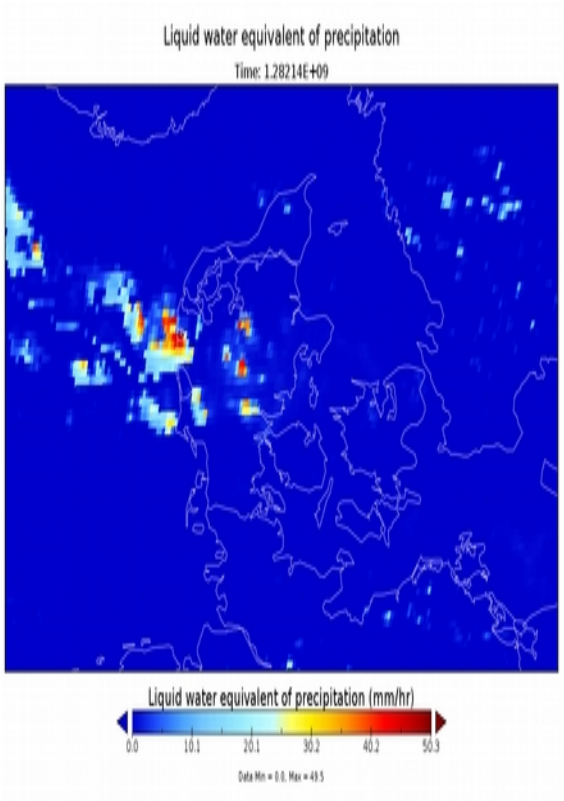
12 UTC 45 min



MSG precipitation

3. Jutland, August 18, 2010

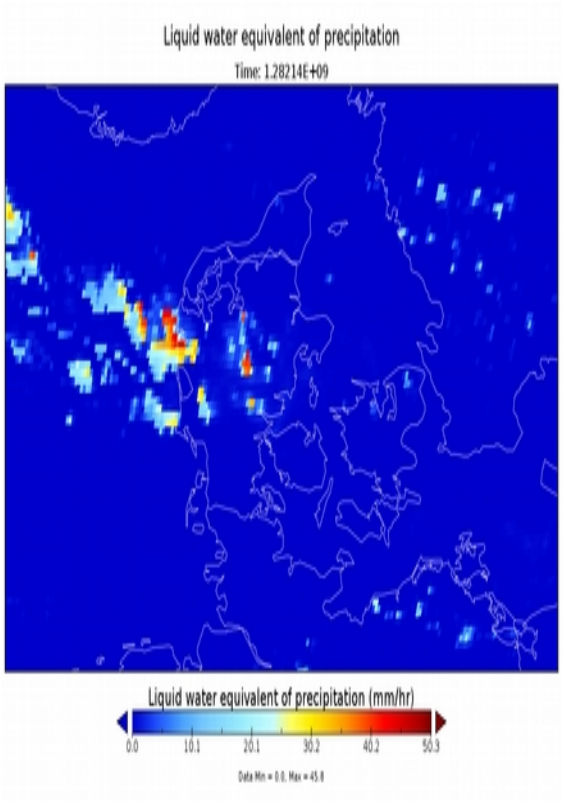
13 UTC 00 min



MSG precipitation

3. Jutland, August 18, 2010

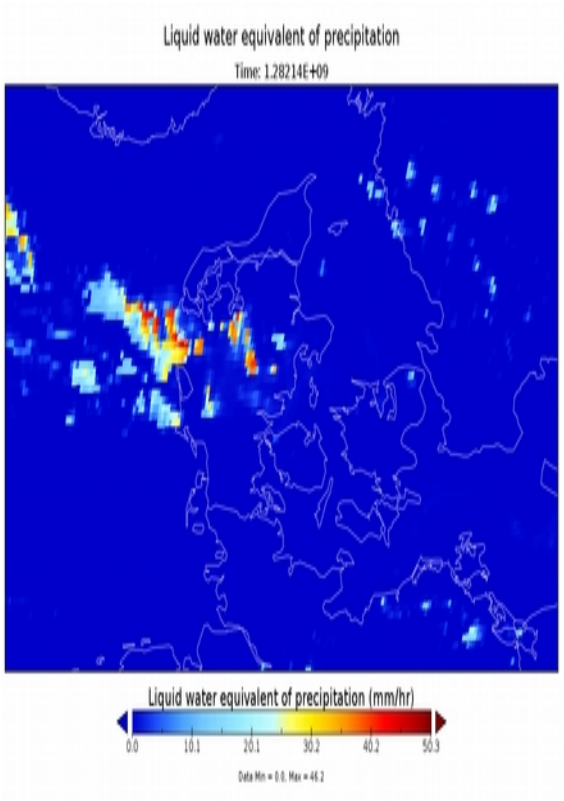
13 UTC 15 min



MSG precipitation

3. Jutland, August 18, 2010

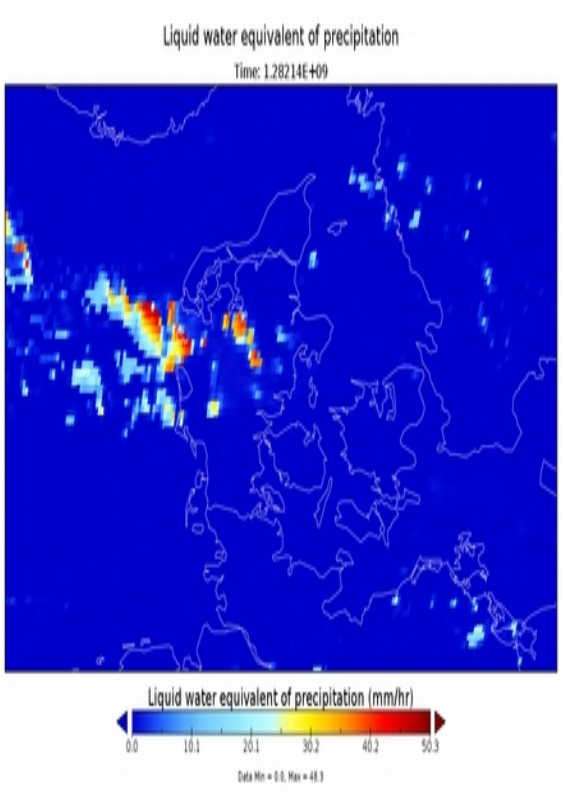
13 UTC 30 min



MSG precipitation

3. Jutland, August 18, 2010

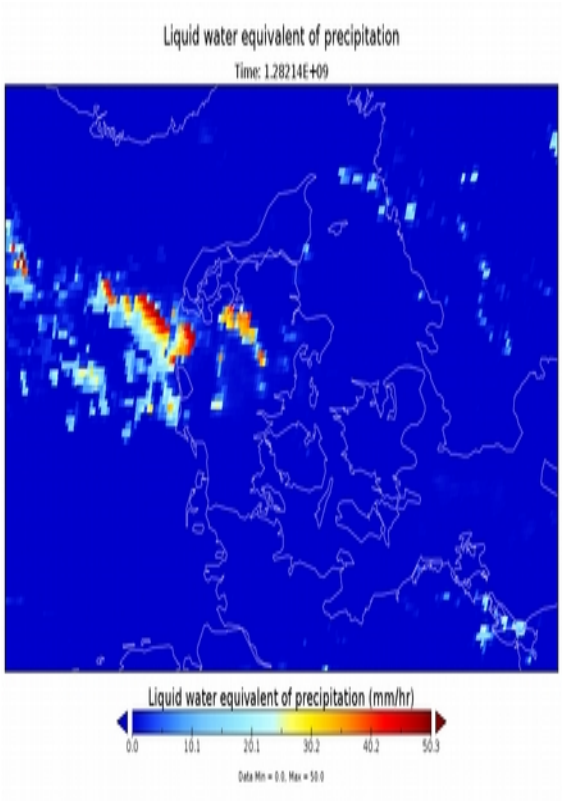
13 UTC 45 min



MSG precipitation

3. Jutland, August 18, 2010

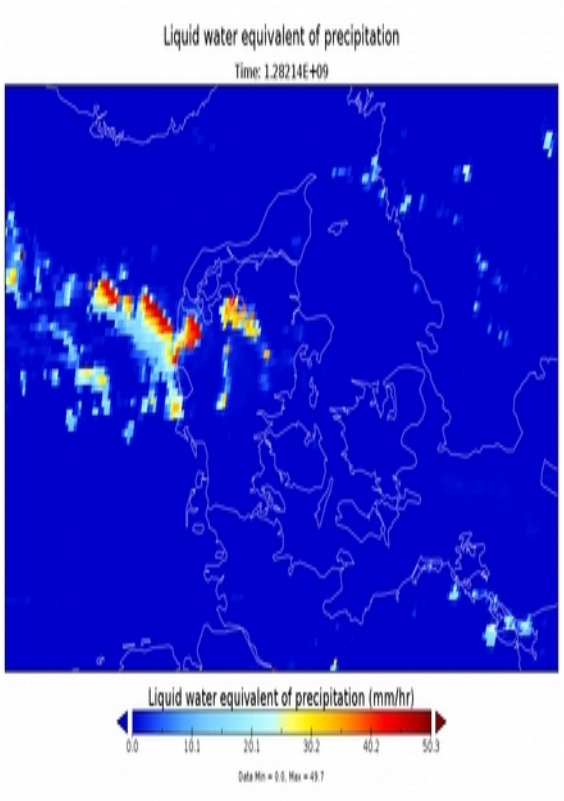
14 UTC 00 min



MSG precipitation

3. Jutland, August 18, 2010

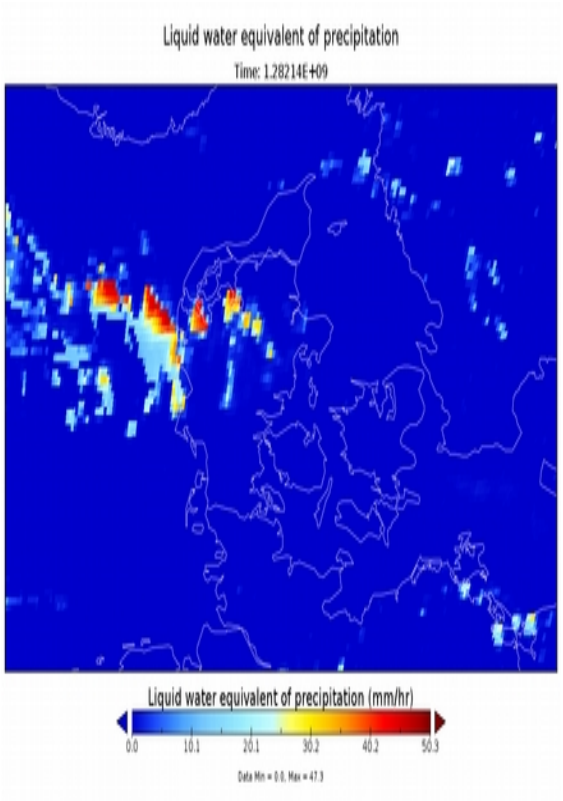
14 UTC 15 min



MSG precipitation

3. Jutland, August 18, 2010

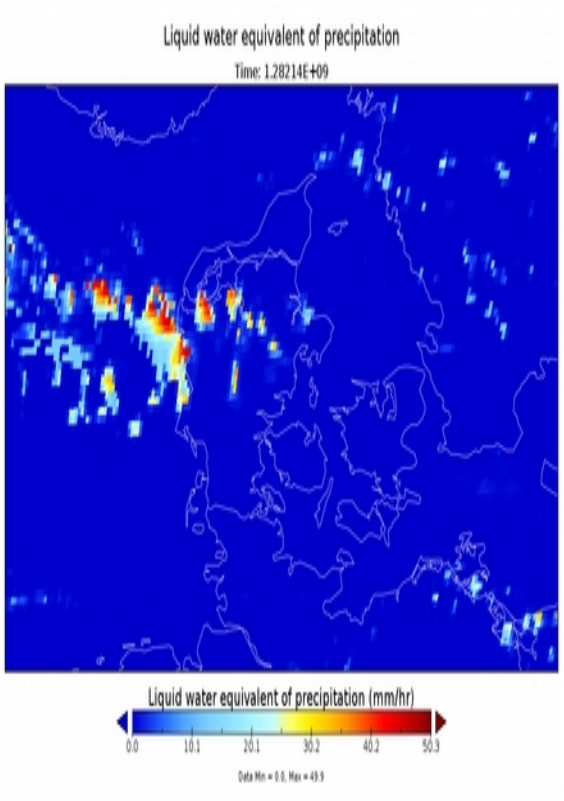
14 UTC 30 min



MSG precipitation

3. Jutland, August 18, 2010

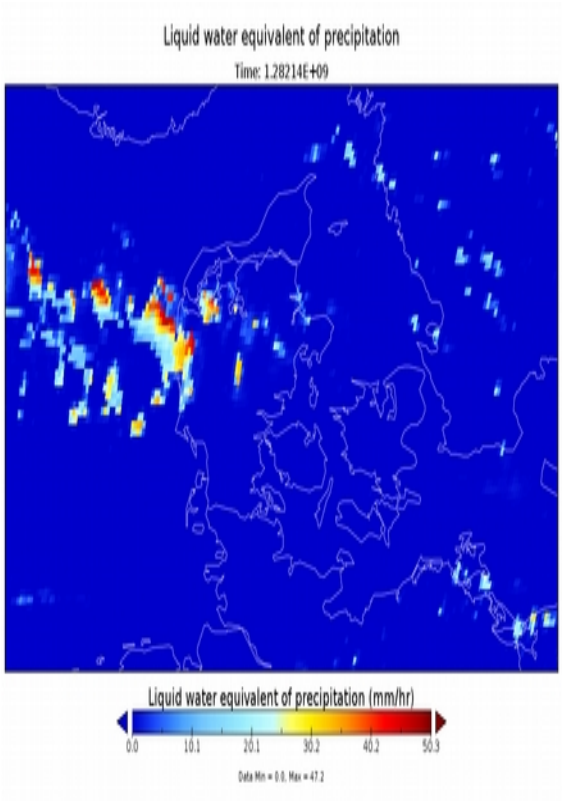
14 UTC 45 min



MSG precipitation

3. Jutland, August 18, 2010

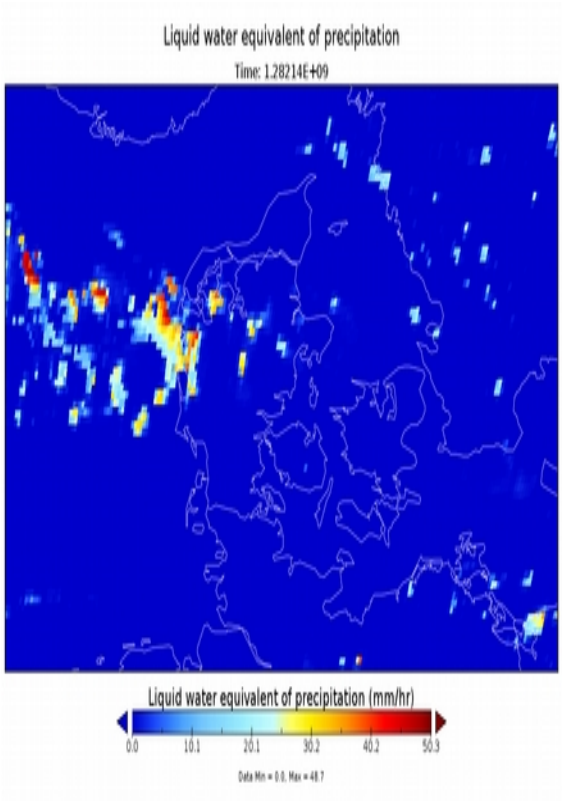
15 UTC 00 min



MSG precipitation

3. Jutland, August 18, 2010

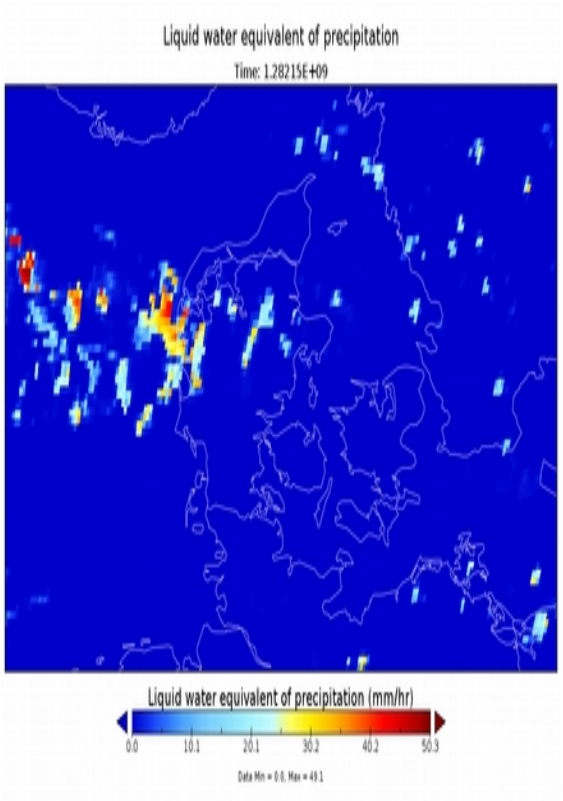
15 UTC 15 min



MSG precipitation

3. Jutland, August 18, 2010

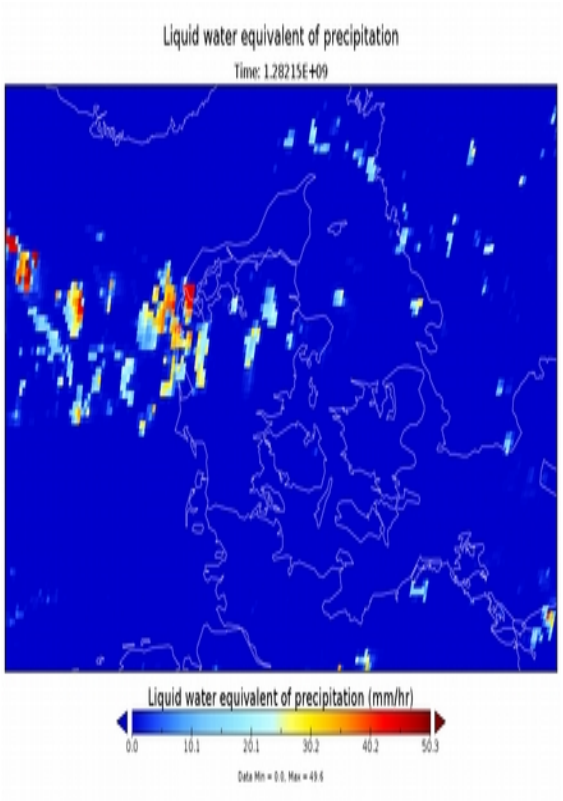
15 UTC 30 min



MSG precipitation

3. Jutland, August 18, 2010

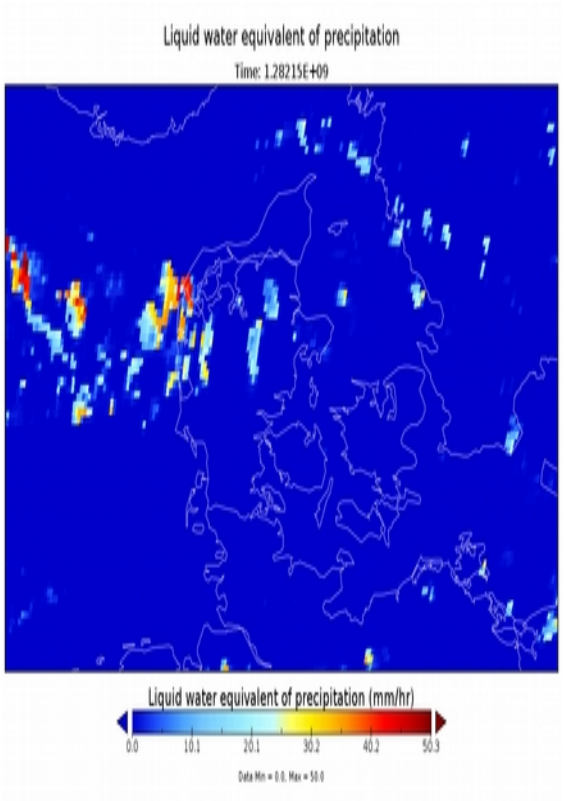
15 UTC 45 min



MSG precipitation

3. Jutland, August 18, 2010

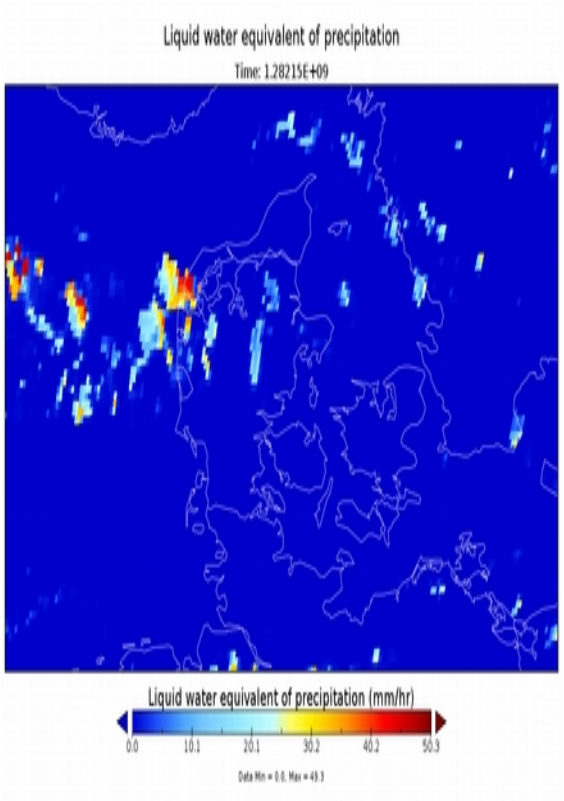
16 UTC 00 min



MSG precipitation

3. Jutland, August 18, 2010

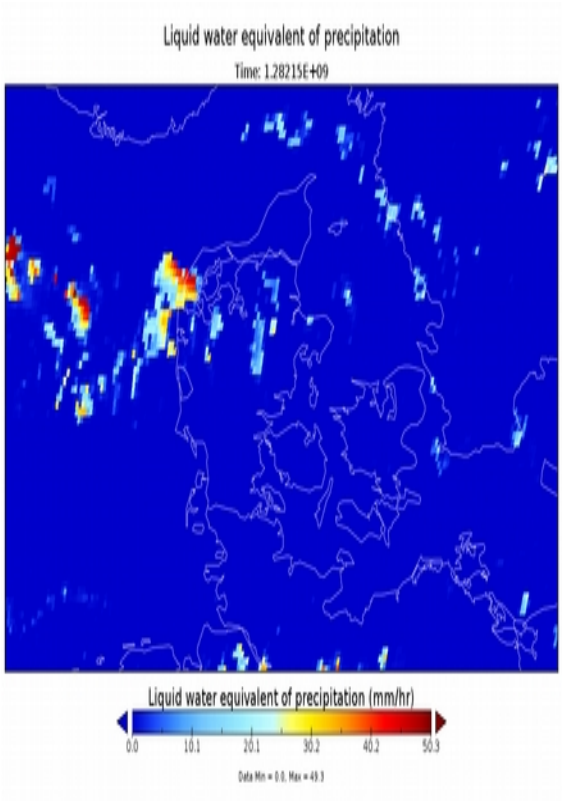
16 UTC 15 min



MSG precipitation

3. Jutland, August 18, 2010

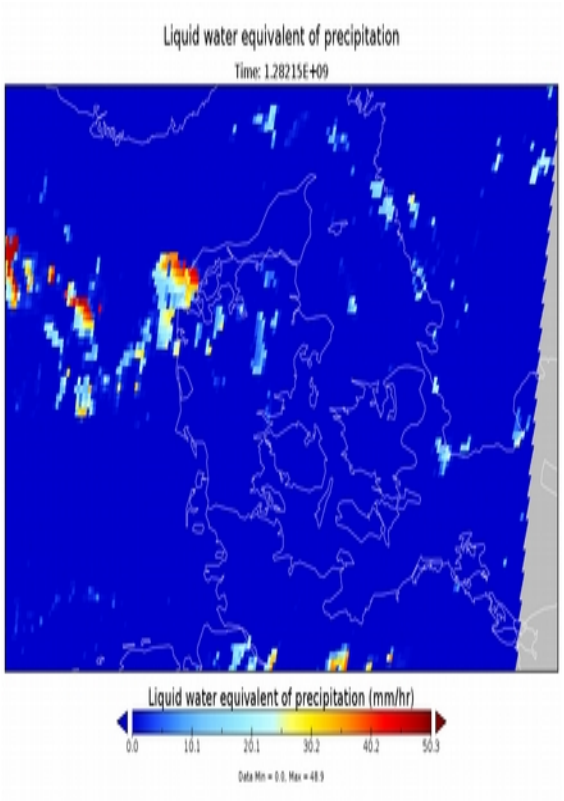
16 UTC 30 min



MSG precipitation

3. Jutland, August 18, 2010

16 UTC 45 min



MSG precipitation

Conclusions on impact of Singular Vectors (1):

1.Susceptibility of model variables:

T2m (least), G10, Pmsl, S10, Pcp12h (most)

2. *Hirlam Straco* is more strongly impacted than *Hirlam Kain-Fritsch*

Conclusions on impact of Singular Vectors (2):

T2m *neutral / very weak positive*

G10 *neutral /very weak positive*

(25 m/s negative...)

Pmsl *neutral / weak positive*

S10 *neutral / weak positive*

Pcp12h *clear positive impact for Hirlam, somewhat smaller but significant positive impact for Glameps (especially larger rainfall rates)*

very weak neg. impact mean bias

small improvement ROC

Conclusions on impact of Singular Vectors (3):

Positive verification results can be attributed to strong convection cases

B) Harmonie EPS

Experimental new developments :

- Humidity / cloud initialisation
- Humidity perturbations
- Stochastic perturbations in microphysics

-freezing probabilities

-thresholds for warm rain formation

Experiments with HarmonEPS

2 models: Arome and Alaro
Boundary perturbations from ECEPS

Members:
Alaro: 1, 2, 5, 6, 9, 10,13,14, 17, 18, 21
Arome: 0, 3, 4, 7, 8, 11, 12, 15, 16, 19, 20

Cycling frequency: 2 controls once every 3h
All other members run every 6 h

Forecast length: + 24h

3) experiments (January 2011):

1) Control ensemble

2) MSG cloud initialisation *and humidity perturbations*

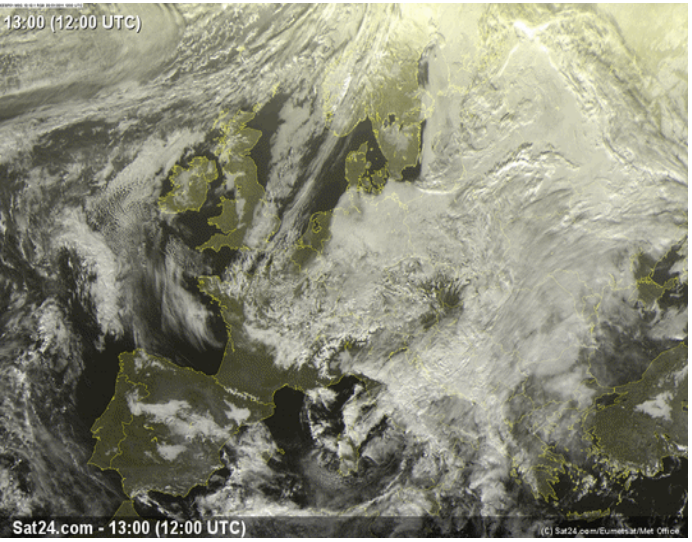
3) MSG cloud initialisation *without humidity perturbations*

* initial/boundary perturbations from EPS ECMWF

* domain: nlon=450 nlat=540

0-17 degr. E
45-58 degr.N

Example of initial clouds in different members (cntr. ens.)



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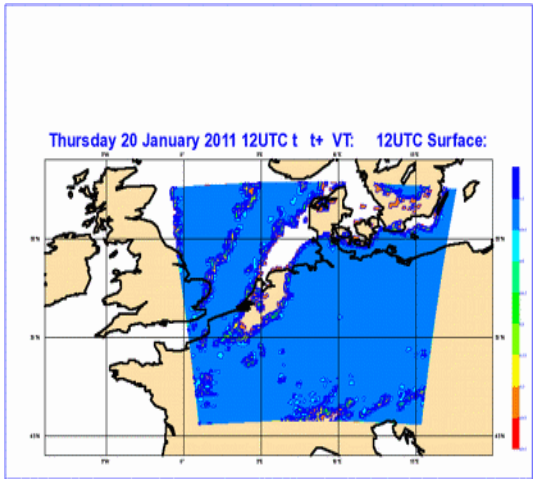
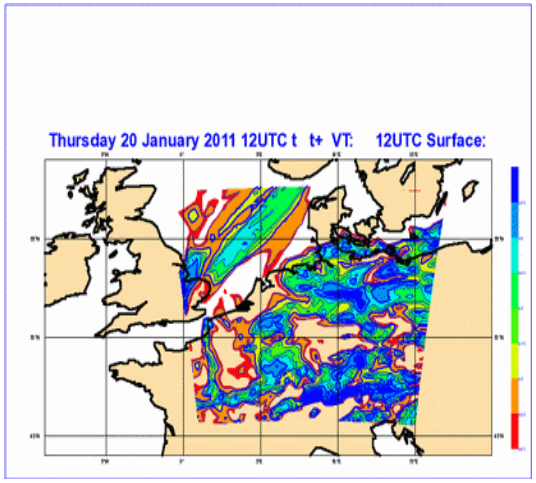


Mbr003



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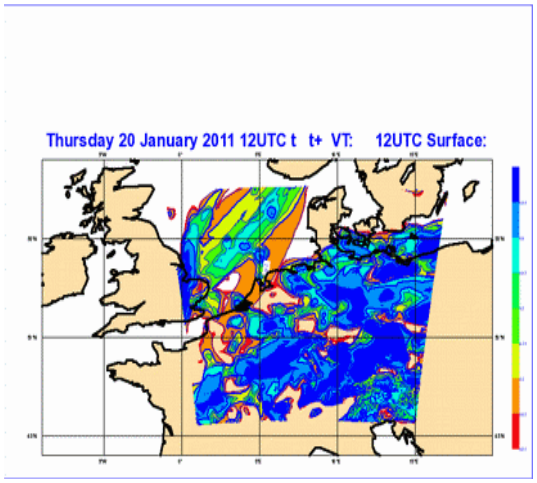
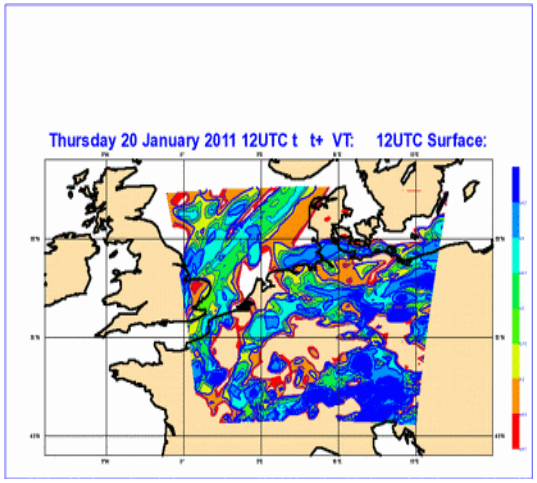
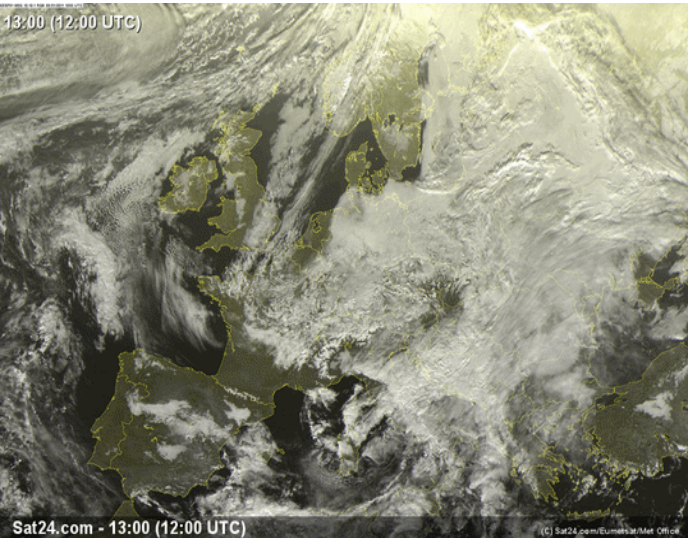




Example of initial clouds in different members (init+pert)



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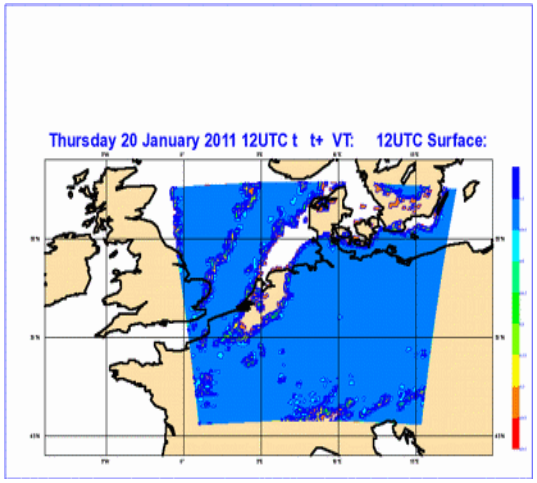

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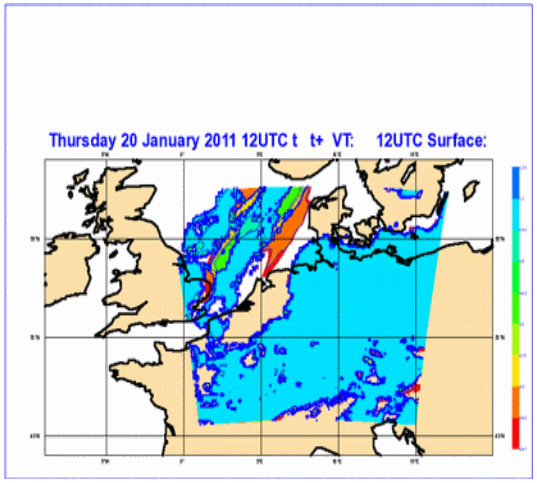

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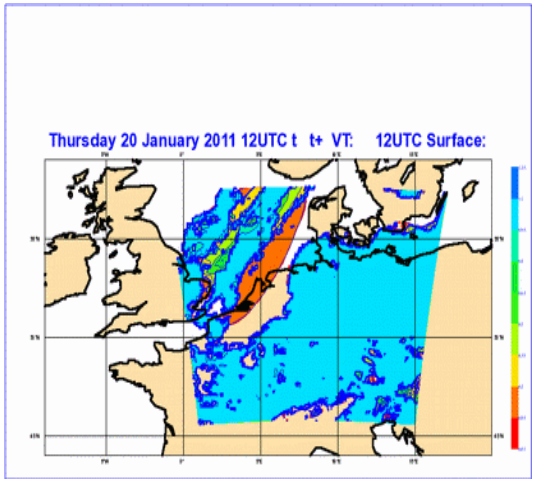
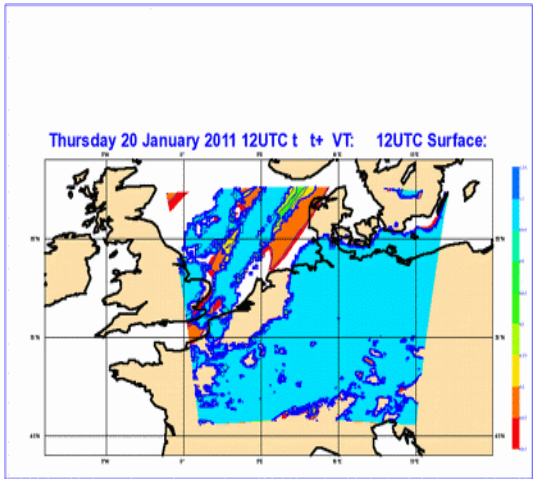
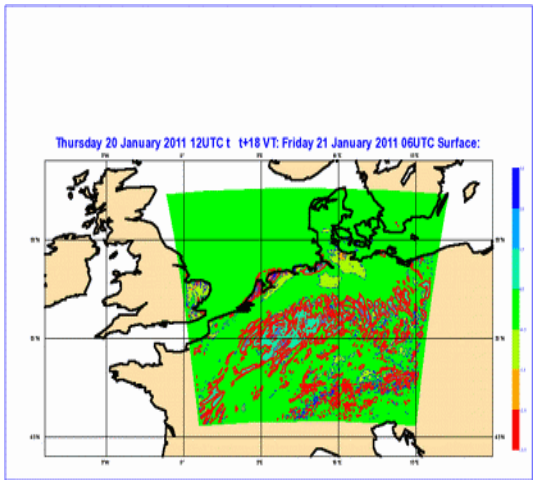




T2m differences with control of control ensemble (+ 18h)

Init + Pert



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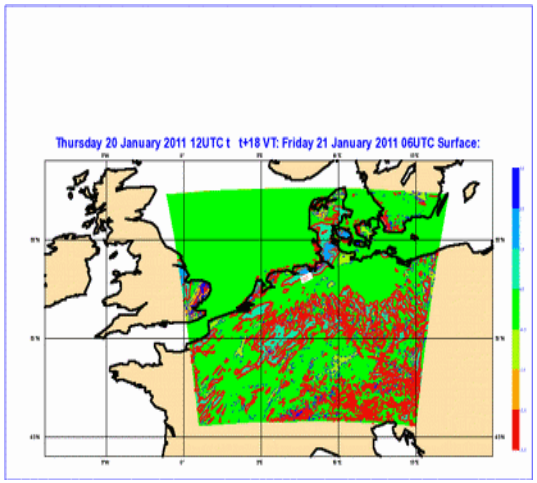

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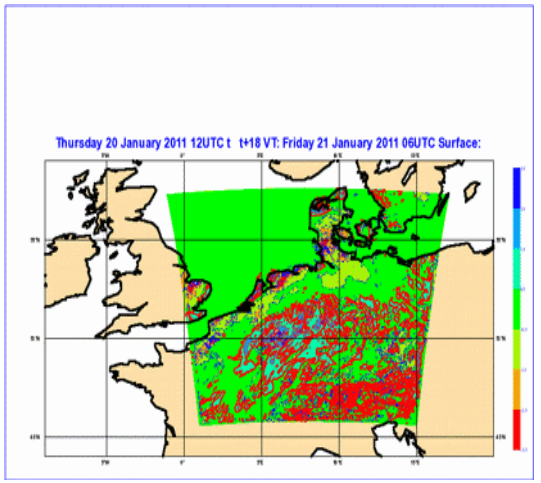

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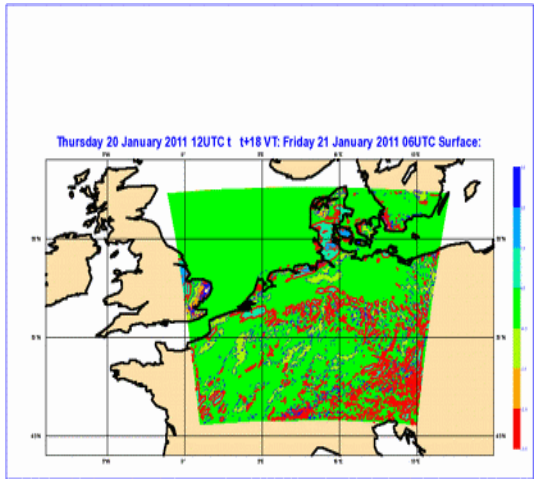
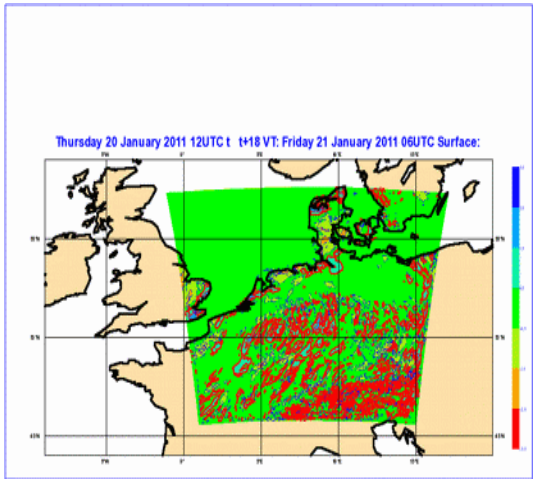
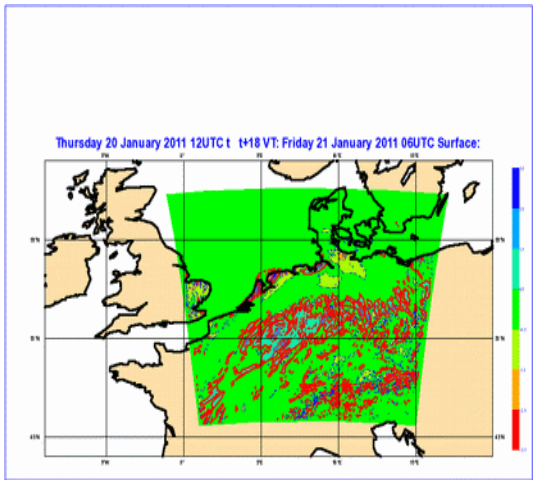
Control

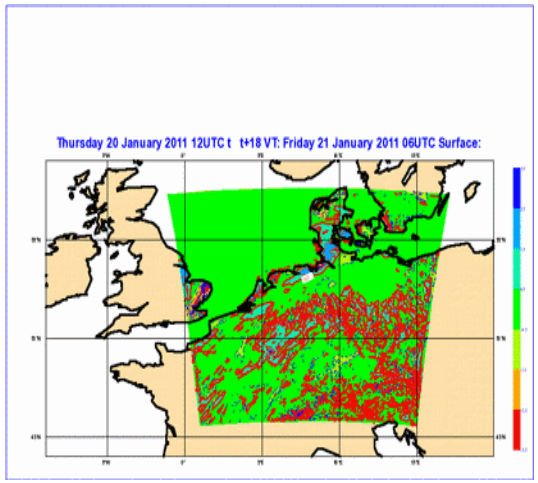


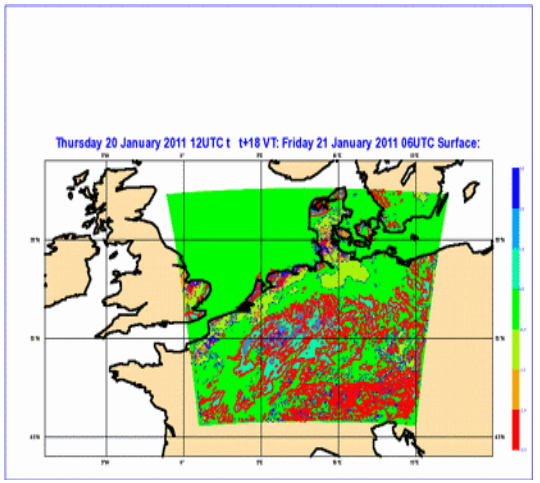


T2m differences with control of control ensemble (+ 18h)

Init + Pert





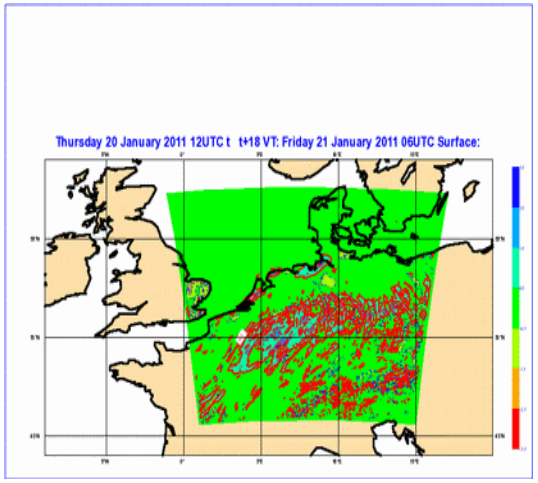


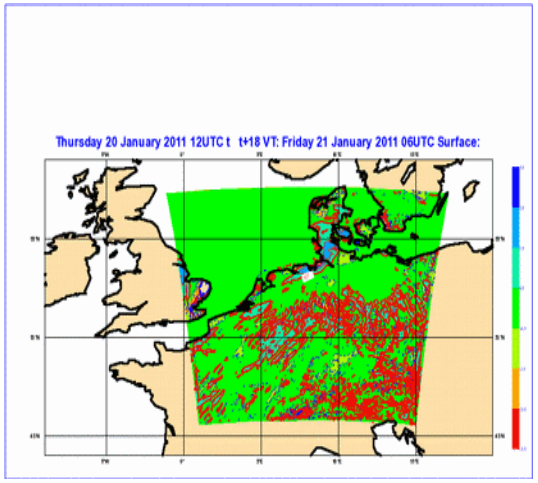
Mbr000

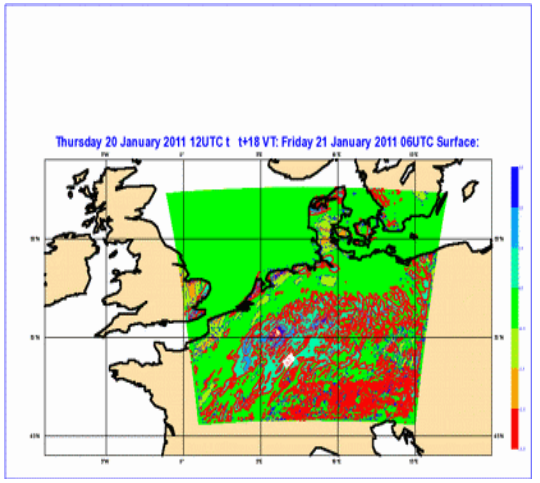
Mbr003

Mbr004

only Init







Some conclusions :

1) Initial spread in cloudiness appears quite large in control ensemble !

2) Cloud initialisation decreases this spread considerably *(also when stochastic perturbations are added!)*

3) Cloud initialisation creates additional fine scale structures in T2m differences with control of control ensemble (+18h fc); stochastic perturbations add even a little more

Summary:

1) Glameps

Singular Vectors in Hirlam have been shown to improve forecasts of strong convective precipitation *(without degrading other forecasts !)*

2) HarmonEPS

a) MSG cloud mask initialisation included

b) stochastic initial humidity perturbations included

c) plans for perturbing:
*autoconversion thresholds
*freezing of supercooled cloud water