



***Grand Limited Area Model Ensemble Prediction System***

***The GLAMEPS project for ensemble  
predictions for Europe:  
Current status and future plans***

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On behalf of the GLAMEPS team**

# *Outline*

- What is GLAMEPS?
- Current version (v.2)
- Future plans (v.3)
- Some recent verification results.
- GLAMEPS at RMI Belgium.

## *What is GLAMEPS?*

- A collaboration of the HIRLAM and ALADIN consortia.
- A multi-model limited area prediction system (LAM-EPS) over Europe.
- Different versions of ALARO and HIRLAM with lateral boundary conditions from ECMWF ensemble members (ENS).

# *What is GLAMEPS?*

## Downscaling of ECMWF ENS

- 52 ensemble members:
  - 26 Alaro (two different surface schemes),
  - 26 Hirlam (two different cloud physics).
- Runs at ECMWF as a time critical facility.
- Makes use of lagged members to have four forecasts per day.

# *GLAMEPS v2*

*operational since October 2013*

**Runs as time-critical facility at  
ECMWF**

**48 + 4 ensemble members**

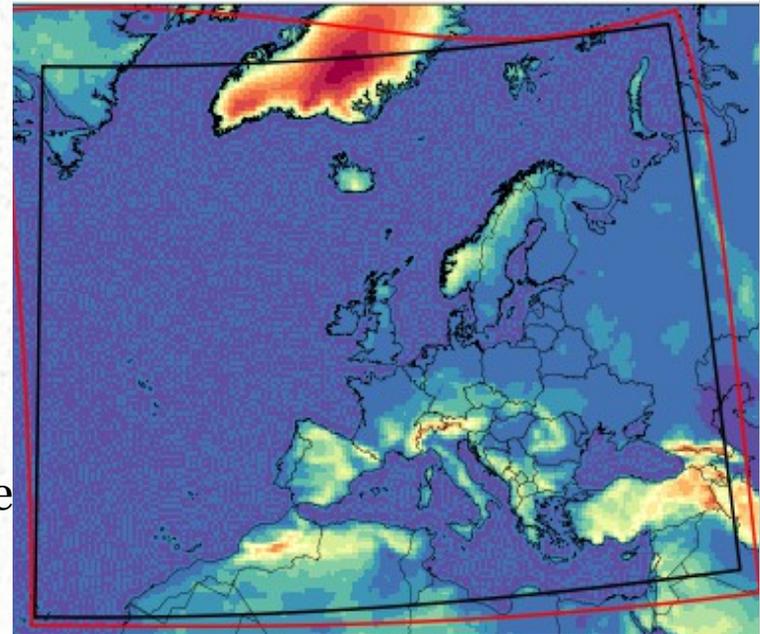
**Nested in ENS**

**Forecast range 54h, 4 times/day**

**~8km resolution**

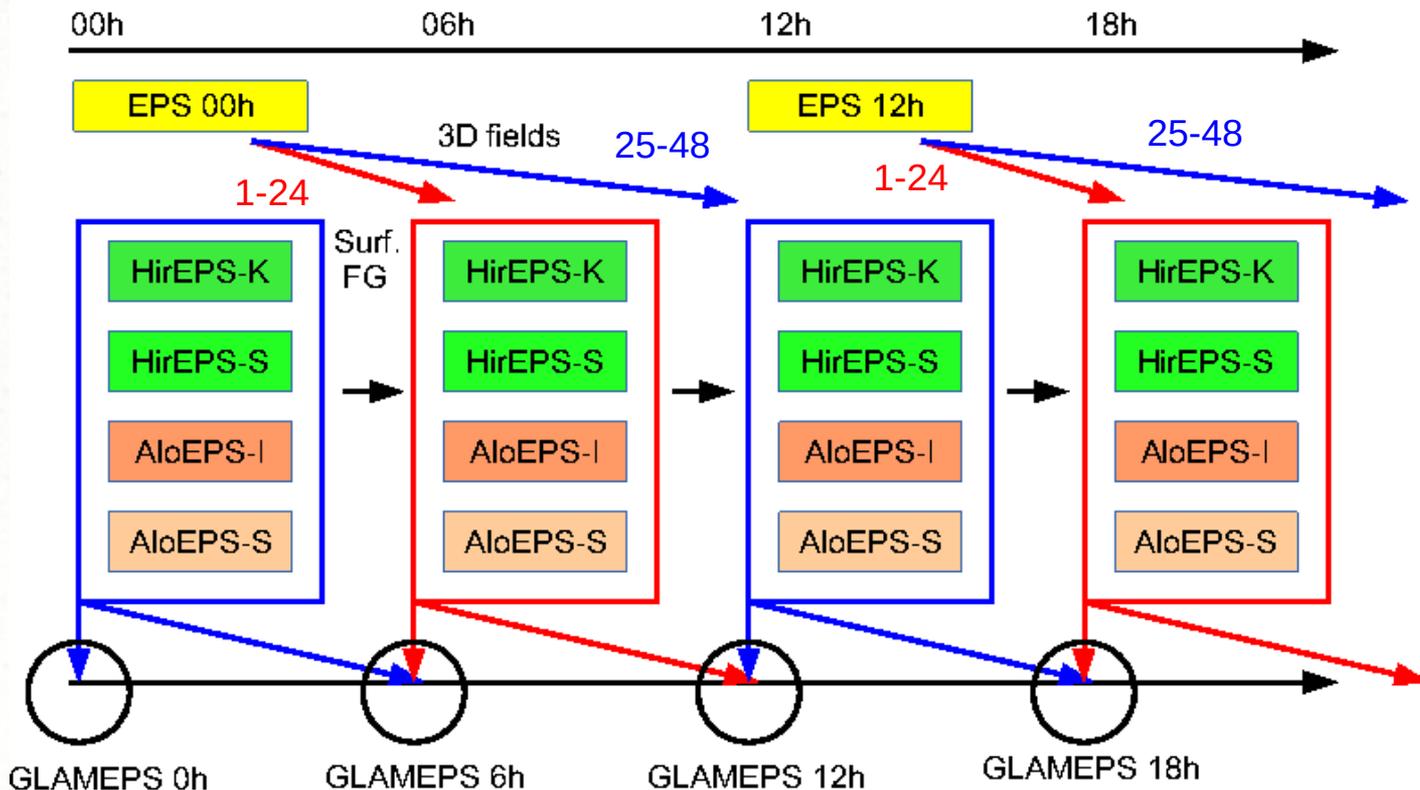
4 sub-ensembles:

- 2 HIRLAM ensembles with 3DVar for the control and stochastic physics + perturbed surface obs. in all members.
- 2 **ALARO** ensembles in downscaling mode.
- Half of the members are lagged.



# GLAMEPS v2

At every forecast time, 28 new members are combined with the 24 perturbed members from 6 hours earlier.



# Products:

– Website: <https://glameps.hirlam.org>

GLAMEPS - 3h acc. precip. at forecasted times Fig: All Favorites

[https://glameps.org/forecasted/index.html?choice\\_ind=0](https://glameps.org/forecasted/index.html?choice_ind=0)

../ forecasted

AccPcp3h ▾

Prob. type ⌵

upscaled  
raw

Threshold ⌵

prob. > 0.1 mm  
prob. > 0.3 mm  
prob. > 0.5 mm  
prob. > 1 mm  
prob. > 2 mm  
prob. > 4 mm  
prob. > 7 mm  
prob. > 10 mm  
prob. > 15 mm  
prob. > 20 mm

Resize ⌵ ⌵ ⌵

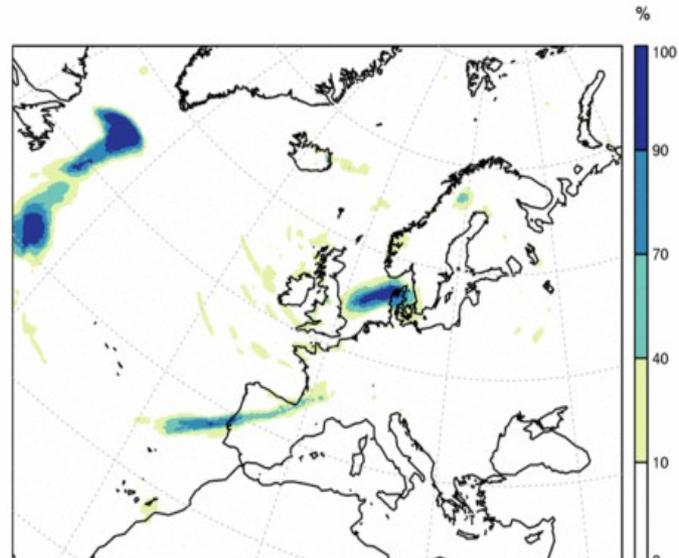
Download

png ▾

## GLAMEPS - 3h acc. precip. at forecasted times

Year Month Day Hour Fc length  
2013 10 28 06 006 ▾

GLAMEPS PROD (GI.PROD.m54 54/54 members)  
Upscaled Prob 3h Accumulated Rainfall over 4mm (Legend)  
Analysis: 2013/10/28 06UTC T+006 VT: 2013/10/28 12UTC



# GLAMEPS-o-GRAM

Available for a long list of locations.

Updated every 6 hours.

Available as .png from the GLAMEPS web site.

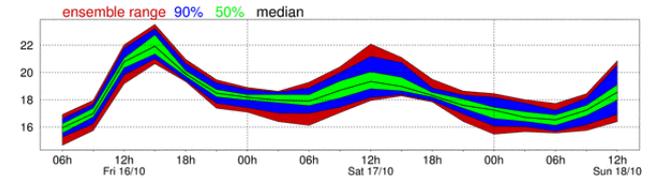
## GLAMEPS-o-GRAM

Lisboa-GC

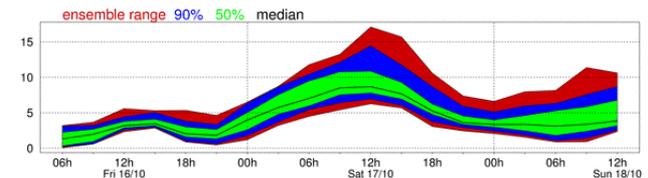
(lat=38.7667 lon=-9.1333 elev=123 SID=8536)

Forecast date: Friday 16 October 2015, 06h UTC

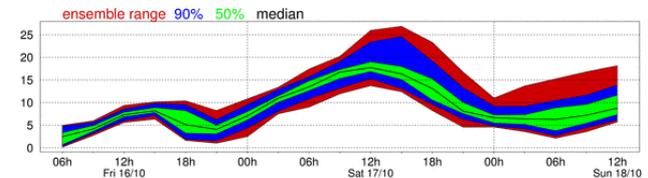
### 2m Temperature (uncalibrated)



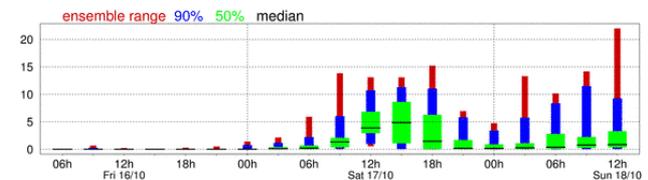
### 10m Wind (uncalibrated)



### 10m Wind Gusts



### 3h Precipitation



# *GLAMEPS v2*

## *status*

- Main contributor to ensemble spread is multi-model setup.
- Lagged members improve spread, but for many variables the effect is mainly at the beginning of the run.
- Spread of ALARO members is currently less than the HIRLAM members (downscaling with no extra perturbations added).

# *GLAMEPS v3*

*in preparation*

- Increase resolution to ~5km  
(domain size may have to be reduced a bit).
- Inflate initial perturbations to increase spread.
- Include CAPE Singular Vectors.
- ALARO: implement perturbations in horizontal diffusion.
- Improve the calibration method.
- Foreseen for spring 2016.

# Calibration

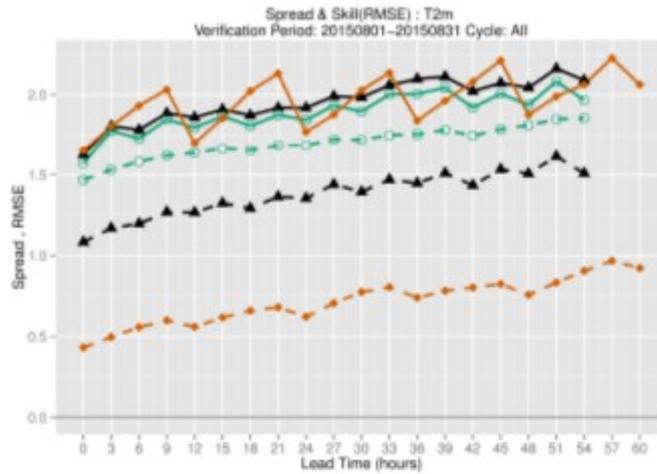
- **Extended Logistic Regression**

$$P(y < q_j | x) = \Lambda \left( \frac{g(q_j) - \beta x / \alpha}{1/\alpha} \right),$$

$$\Lambda(x) = \frac{e^x}{1 + e^x}$$

- Predictors: (square root of) **ensemble mean** and **grid point elevation**.
- Currently only T2m and S10m, trained over the whole domain (but separate per forecast time).
- A calibrated ensemble is sampled (pointwise) from the resulting probability distribution function for the fixed quantiles  $1 \dots N/(N+1)$ .
- In the future, it is planned to add other spatial dependencies.

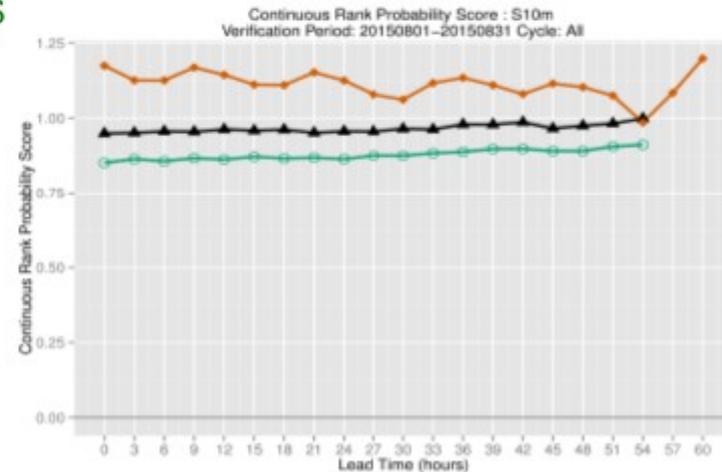
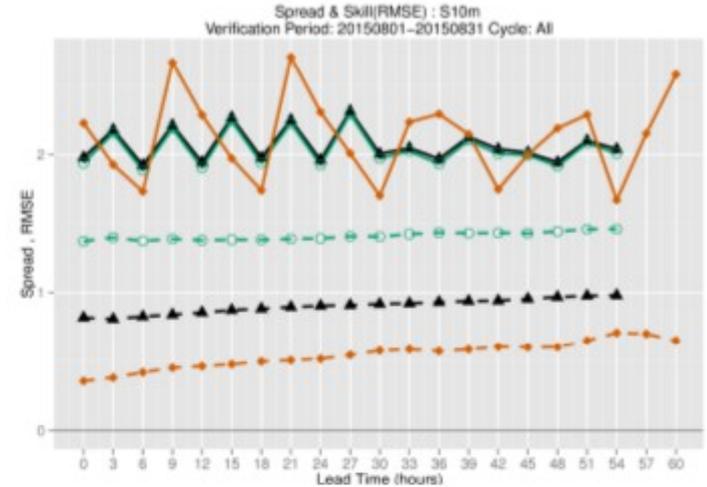
# Calibration Results



Spread/skill

— RMSE  
-- spread

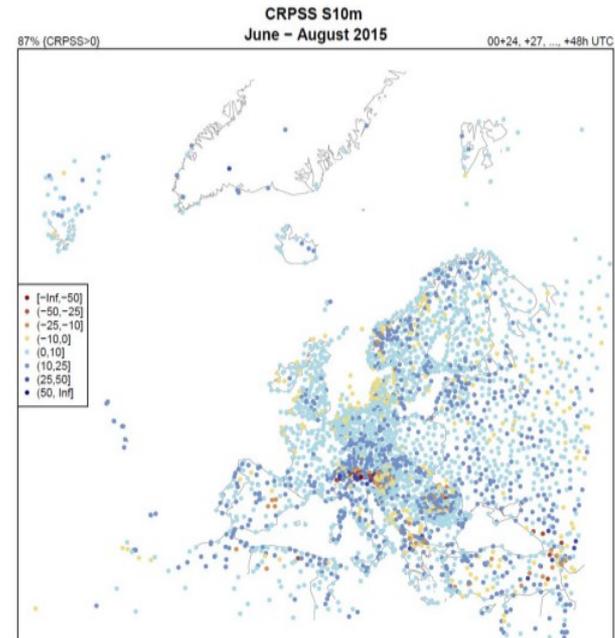
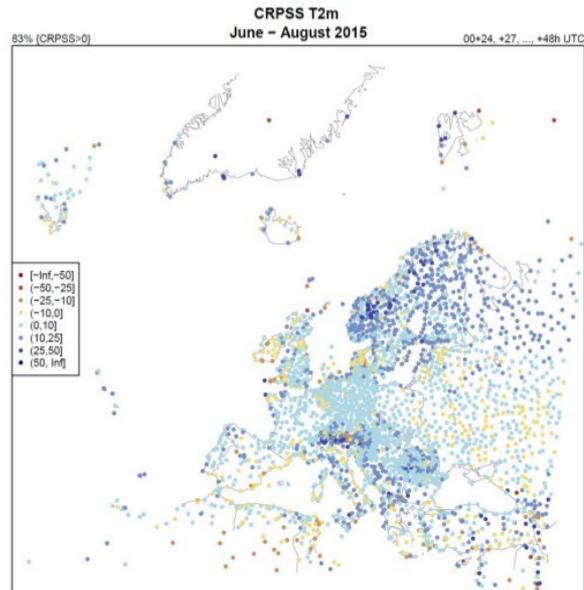
— GLAMEPS  
— calibrated GLAMEPS  
— ECEPS



CRPS



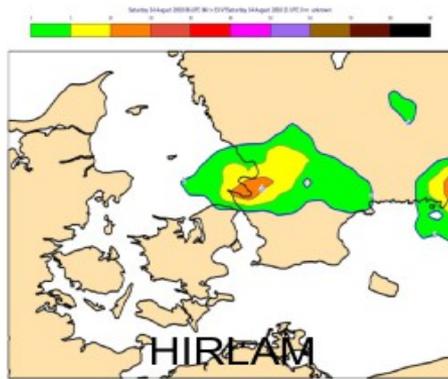
# Calibration Results



# CAPE singular vectors

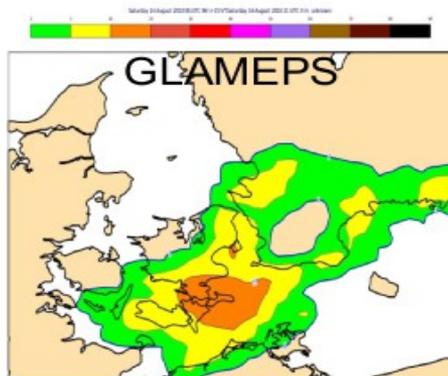
## Flooding Copenhagen, August 14, 2010

18 – 21 UTC

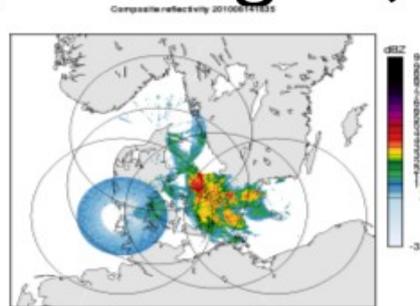


Probability exceeding 10mm between 18-21 UTC

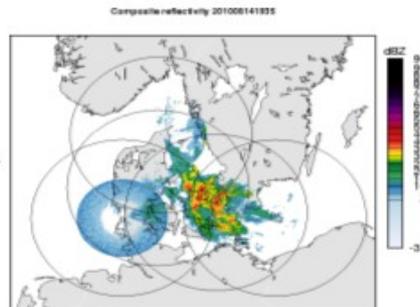
Default



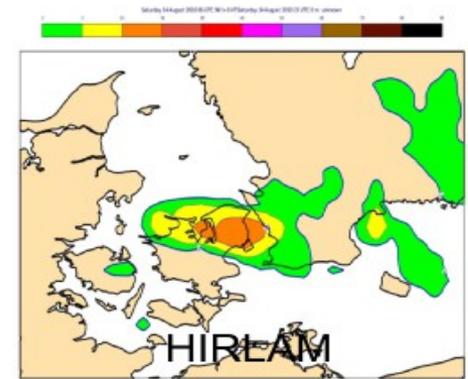
H



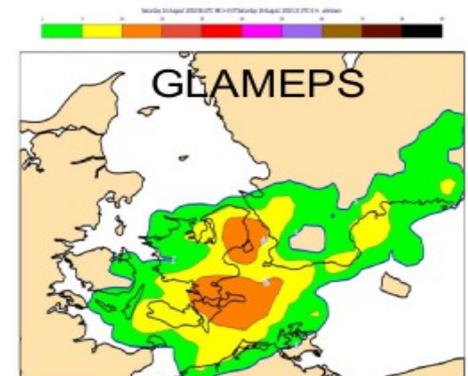
G



(06+15) – (06+12)

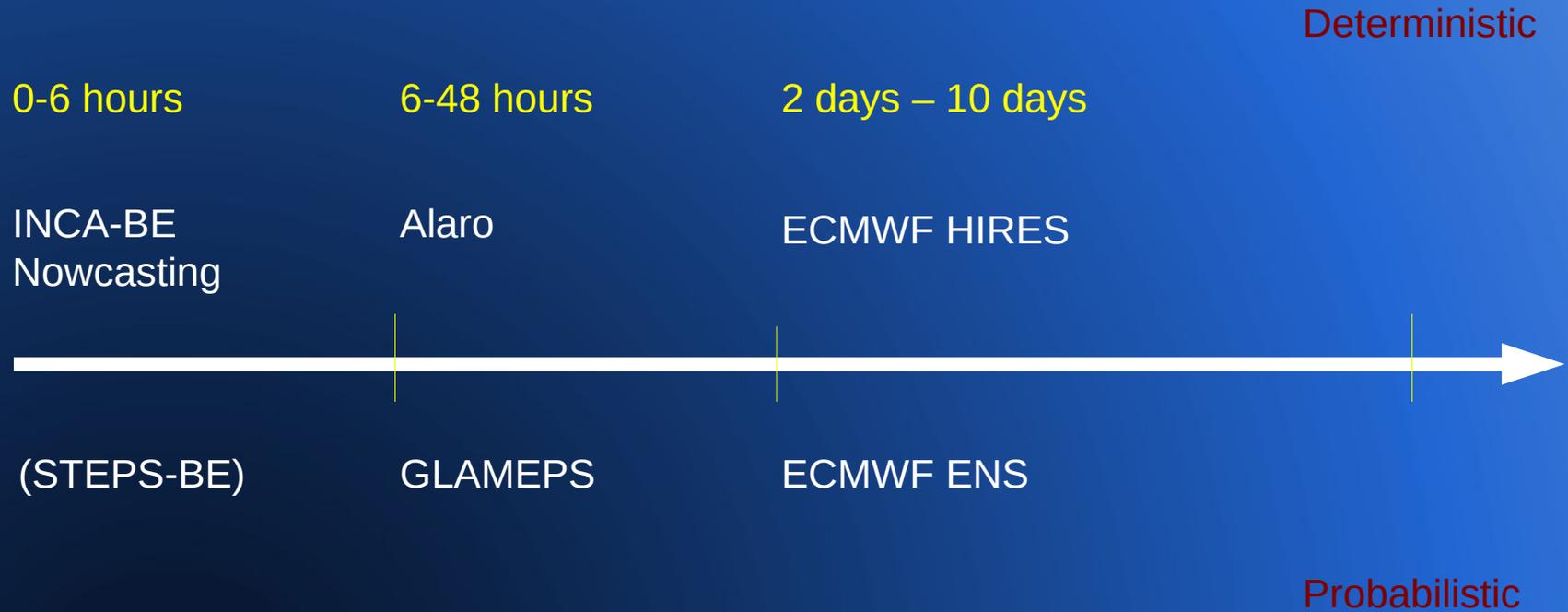


With CAPE-SV



# GLAMEPS at RMI Belgium

# Overview models



# GLAMEPS precipitation forecast for Belgian stations

precip > 1 mm »

GLAMEPS forecast of 23/02 06:00 UTC:

Estimated probability of exceeding threshold of 1 mm (green color: estimated probability < 10 %).

Stations / Forecast	23/02 12:00	23/02 18:00	24/02 00:00	24/02 06:00	24/02 12:00	24/02 18:00	25/02 00:00	25/02 06:00
Oostende-Airport					10 %			
Chievres	37 %	85 %			37 %	48 %		
Uccle	40 %	83 %			33 %	58 %		
Antwerpen-Deurne	23 %	69 %			23 %	29 %		
Florennes	88 %	92 %		10 %	67 %	79 %		
St.-Hubert	> 95 %	67 %	23 %	17 %	69 %	87 %	52 %	12 %
Bierset	88 %	67 %		10 %		67 %		
Kleine-Brogel	54 %	65 %		10 %	10 %	63 %		
Eisenborn	> 95 %	60 %	31 %	10 %	60 %	79 %	67 %	50 %
Gent-Industrie	13 %	69 %			27 %	17 %		

Click station names for detailed forecasts.

precip > 10 mm »

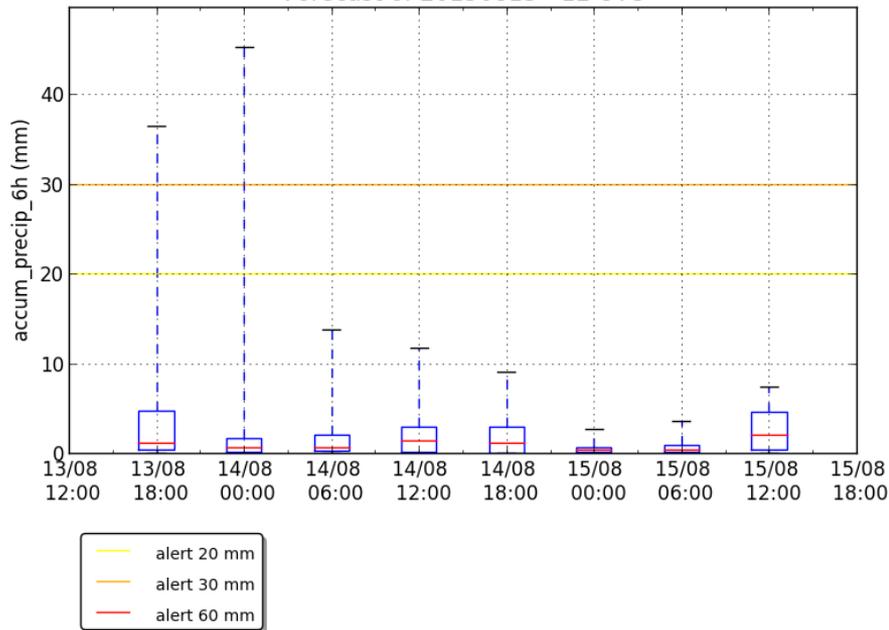
precip > 20 mm »

precip > 30 mm »

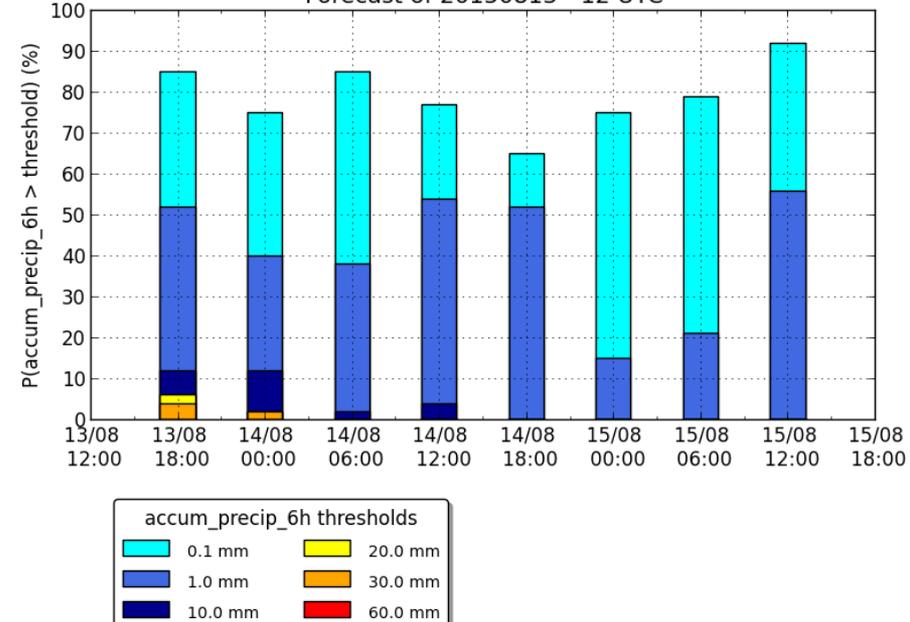
precip > 60 mm »

# Precipitation Forecasts

Forecast of 20150813 - 12 UTC

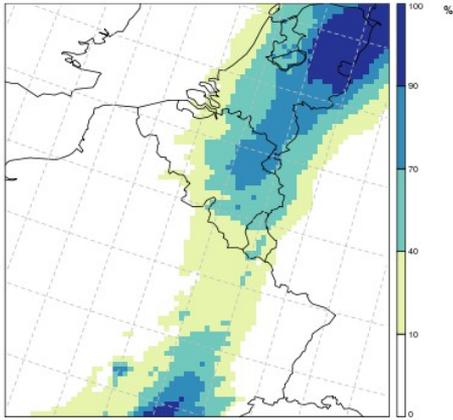


Forecast of 20150813 - 12 UTC

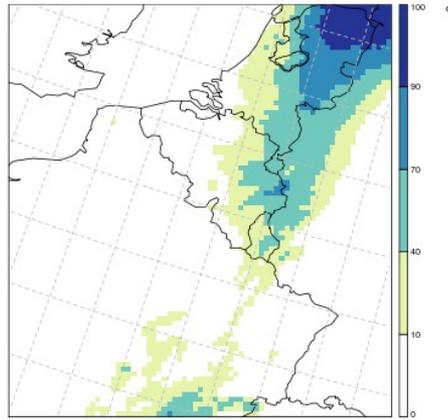


# GLAMEPS probability of precipitation

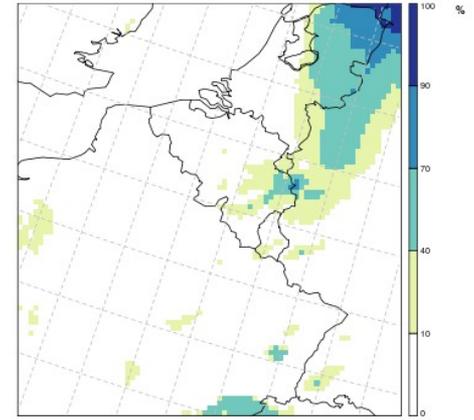
GLAMEPS Prob PCP3h over 1mm (Legend)  
Analysis: 2015/03/25 00UTC T+009 VT: 2015/03/25 09UTC



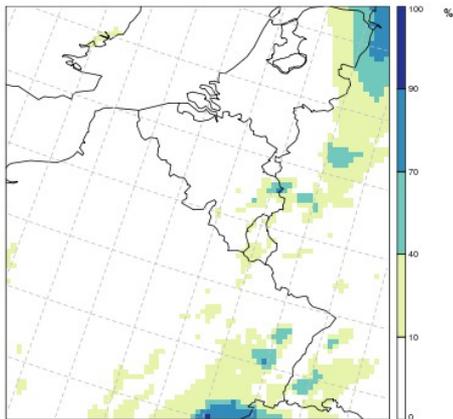
GLAMEPS Prob PCP3h over 1mm (Legend)  
Analysis: 2015/03/25 00UTC T+012 VT: 2015/03/25 12UTC



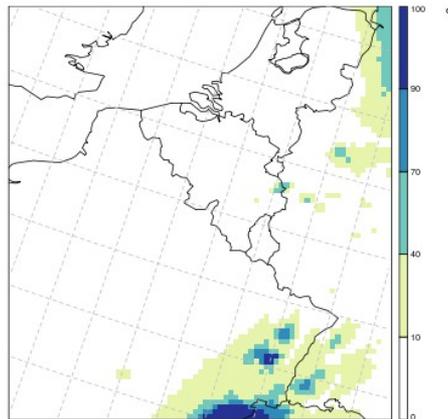
GLAMEPS Prob PCP3h over 1mm (Legend)  
Analysis: 2015/03/25 00UTC T+015 VT: 2015/03/25 15UTC



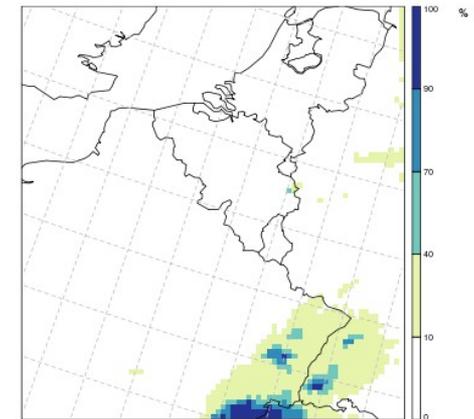
GLAMEPS Prob PCP3h over 1mm (Legend)  
Analysis: 2015/03/25 00UTC T+018 VT: 2015/03/25 18UTC



GLAMEPS Prob PCP3h over 1mm (Legend)  
Analysis: 2015/03/25 00UTC T+021 VT: 2015/03/25 21UTC



GLAMEPS Prob PCP3h over 1mm (Legend)  
Analysis: 2015/03/25 00UTC T+024 VT: 2015/03/26 00UTC



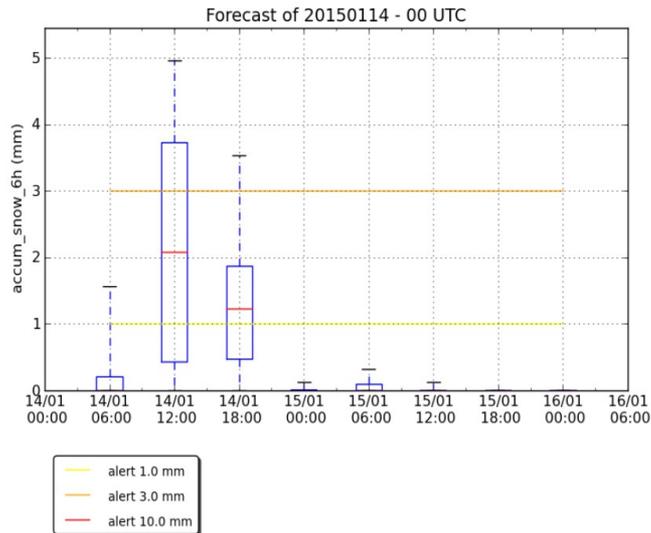
# GLAMEPS snow forecast

## ELSENBORN

Forecast of 6 hour accumulated snow

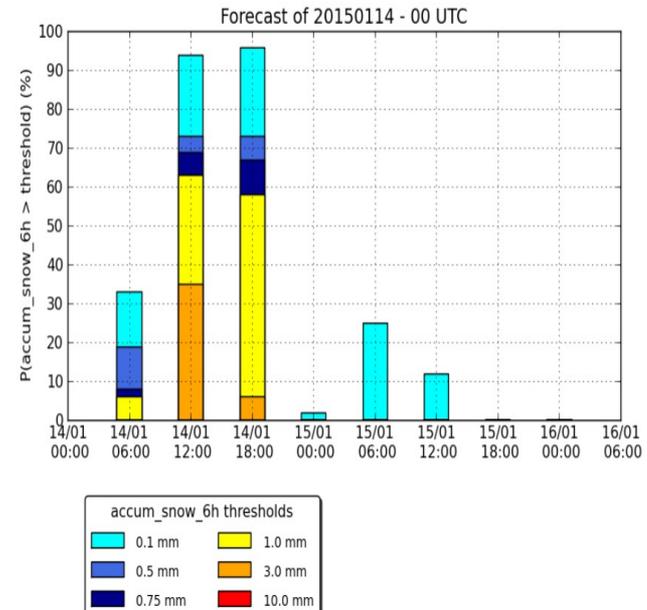
### Box and whisker plot

The box extends from the lower to upper quartile values of the forecast (P25% to P75%), with a red line at the median. The whiskers extend from the box to show the outliers (ensemble minimum and maximum).



### Probability plot

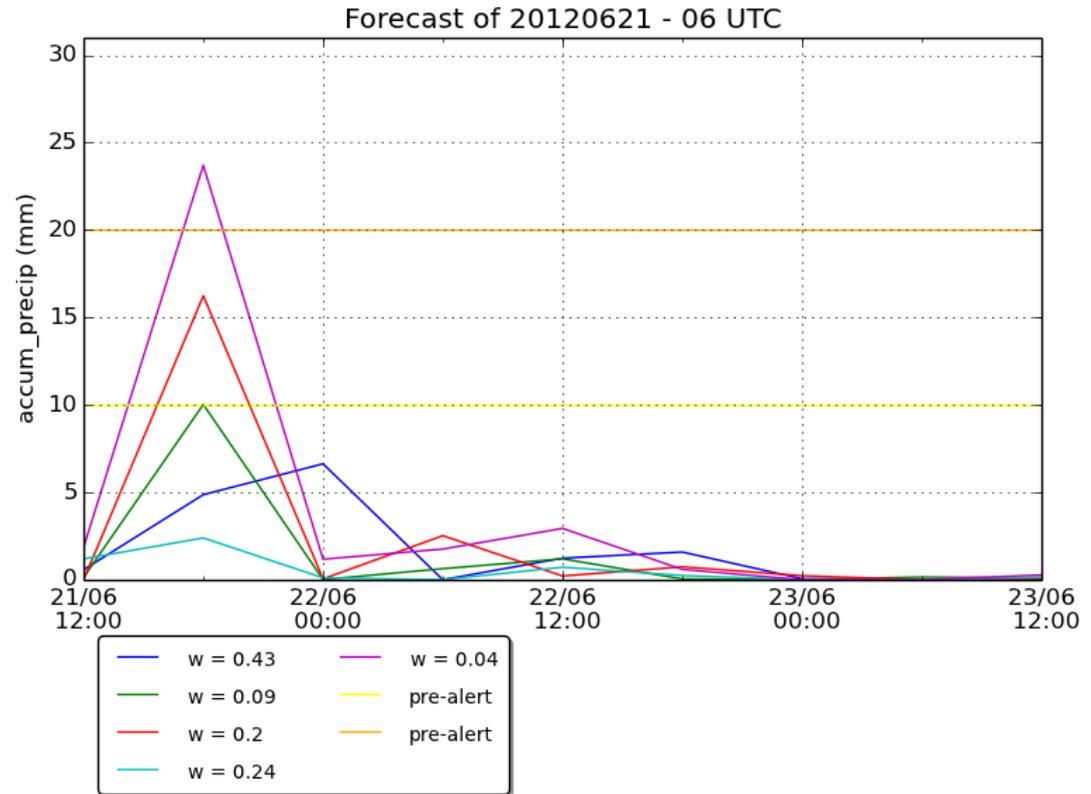
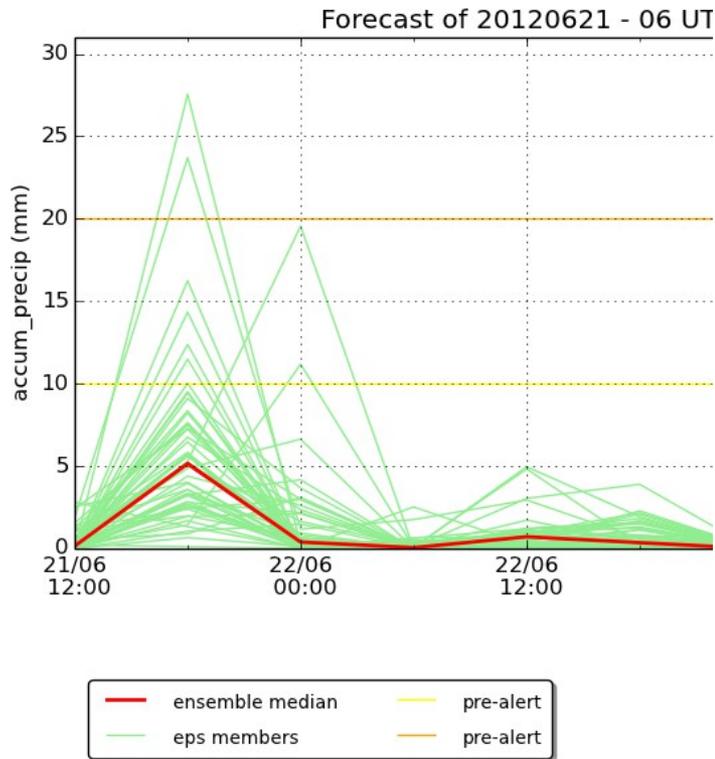
Probability of exceeding thresholds.



# Some GLAMEPS Users

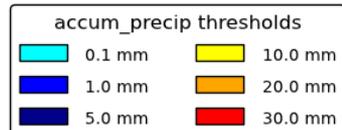
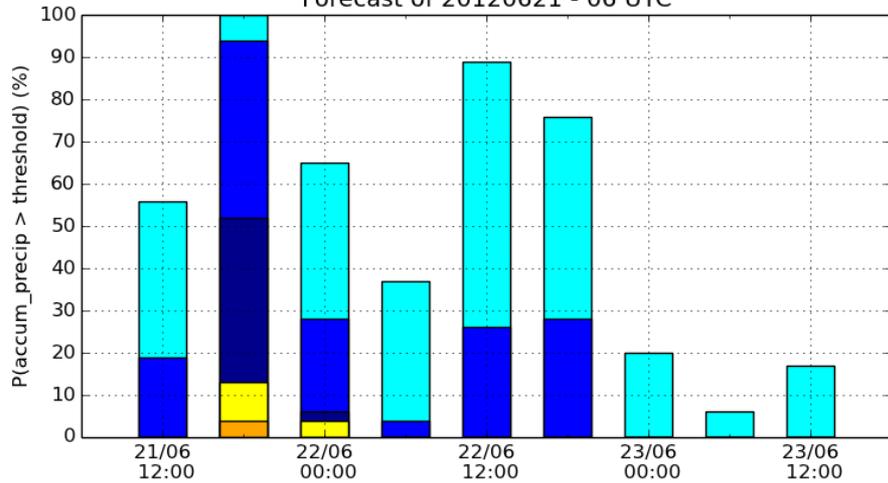
- Weather Office at RMI
- Vlaamse Milieumaatschappij (VMM) uses GLAMEPS for probabilistic hydrological forecasts for the first 2 days of their forecasts for river basins in Flanders.
  - [www.overstromingsvoorspeller.be](http://www.overstromingsvoorspeller.be)
- Other hydrological services also interested.
- Future users? : wind energy sector, ...

# Validation of clustering for VMM

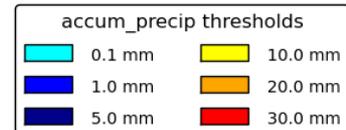
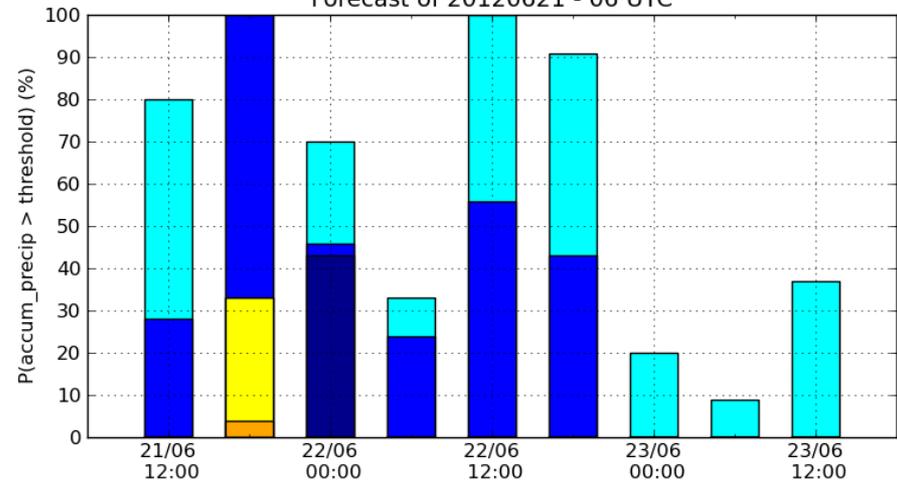


# Hierarchical clustering

Forecast of 20120621 - 06 UTC



Forecast of 20120621 - 06 UTC



# Temperature forecasts, summer

## Probability of hot temperatures

temperature > 25.0 C »

temperature > 30.0 C »

GLAMEPS forecast of 13/08 00:00 UTC:

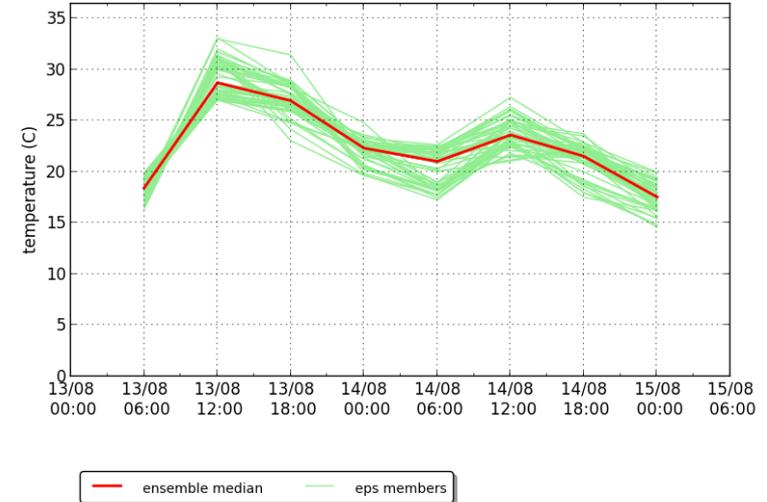
Estimated probability of exceeding threshold of 30.0 C (green color: estimated probability < 10 %).

Stations / Forecast	13/08 06:00	13/08 12:00	13/08 18:00	14/08 00:00	14/08 06:00	14/08 12:00	14/08 18:00	15/08 00:00
Costende-Airport								
Gent-Industrie								
Chievres		27 %						
Uccle		12 %						
Antwerpen-Deurne								
Florennes		37 %						
St.-Hubert		25 %						
Bierset		42 %						
Kleine-Brogel								
Eisenborn								

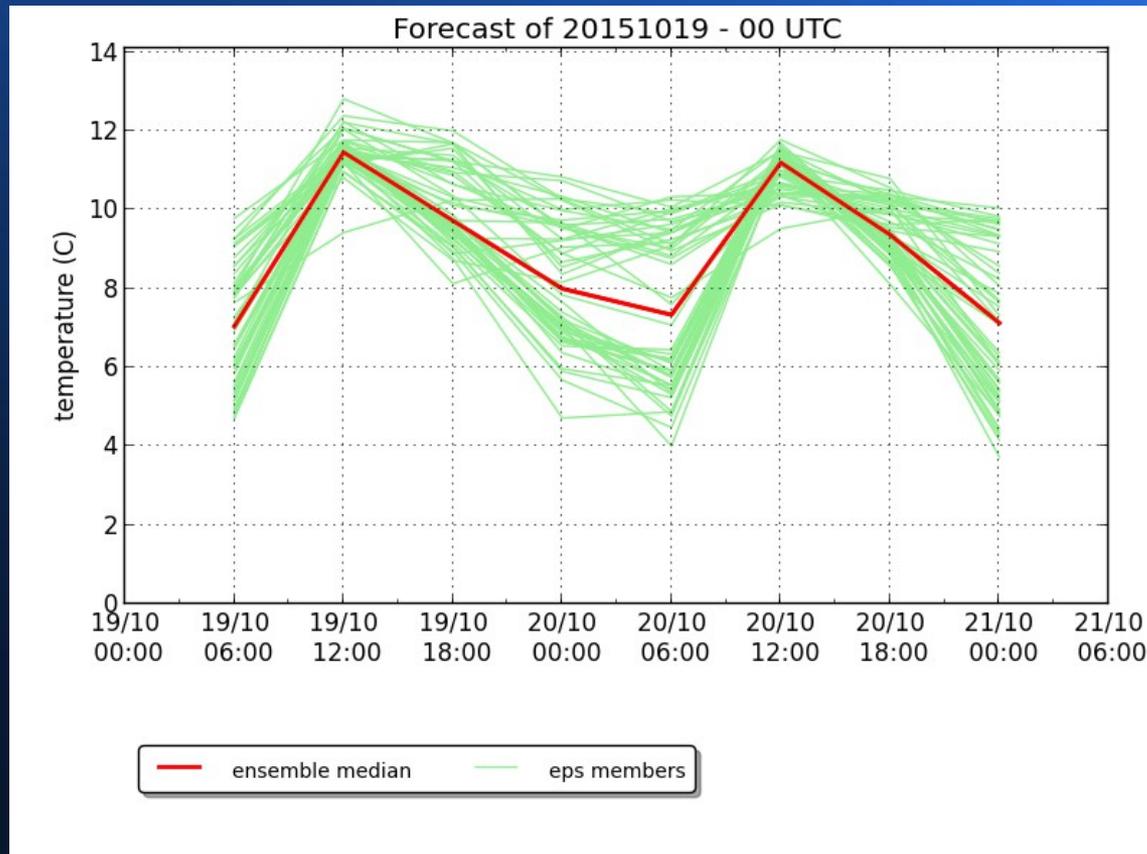
Click station names for detailed forecasts.

temperature > 35.0 C »

Forecast of 20150813 - 00 UTC



# Temperature forecasts, winter



Thank you for your attention.  
Questions?