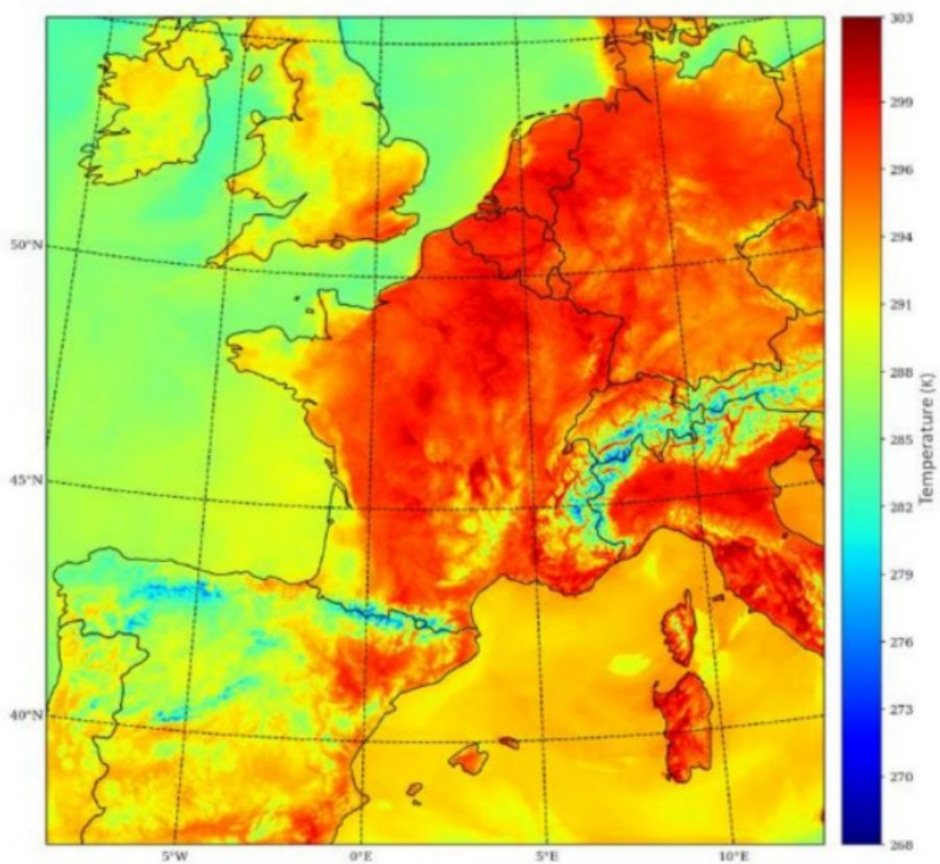
Data assimilation experiments of the SOFOG3D ground-based microwave radiometer network

Guillaume THOMAS, Pauline MARTINET, Pierre BROUSSEAU, Philippe CHAMBON

The AROME NWP model



Example of temperature field forecasted over the AROME domain

AROME-France

(Seity *et al*, 2011 : Brousseau *et al*, 2016)

- Non-hydrostatic operational NWP model since 2008

- Horizontal resolution : 1.3 km

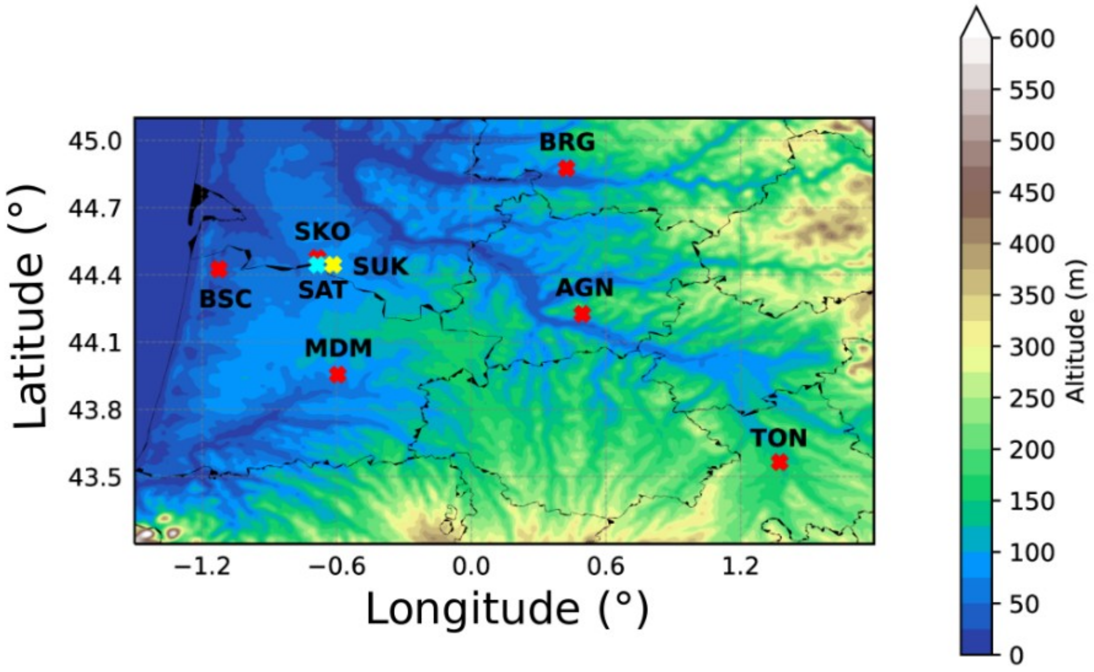
- 90 vertical levels (≈ 50 below 2 km of altitude)

- Three dimensional variational (3D-Var) data assimilation scheme in an hourly continuous cycle.

Nevertheless, fog forecasts remain challenging.

The SOFOG3D microwave radiometer (MWR) network

SOFOG3D : SOuth west FOGs 3D experiment for processes study (6 months campaign)



MWR network over the SOFOG3D domain.
(From Martinet et al, 2022 (submitted))

HATPRO MWR :

2 channels
(temperature and humidity)

Temperature profiles,

integrated water vapor

and

liquid water path

can be retrived from MWR measurements

Data assimilation experiment descriptions

As a first approach, only temperature profiles retrieved from MWR observations (altitude <2 km) which passed quality controls have been assimilated every hour.

REF

- 3D-Var
- Operational observing system (RS, weather radars, SYNOP,…).

ALLOBS

- 3D-Var
- Operational observing system (RS, weather radars, SYNOP,…).
- Complete MWR temperature profile (53 observations).

THIN

- 3D-Var
- Operational observing system (RS, weather radars, SYNOP,…).
- Thinned MWR temperature profile (3 observations).

Data assimilation experiment descriptions

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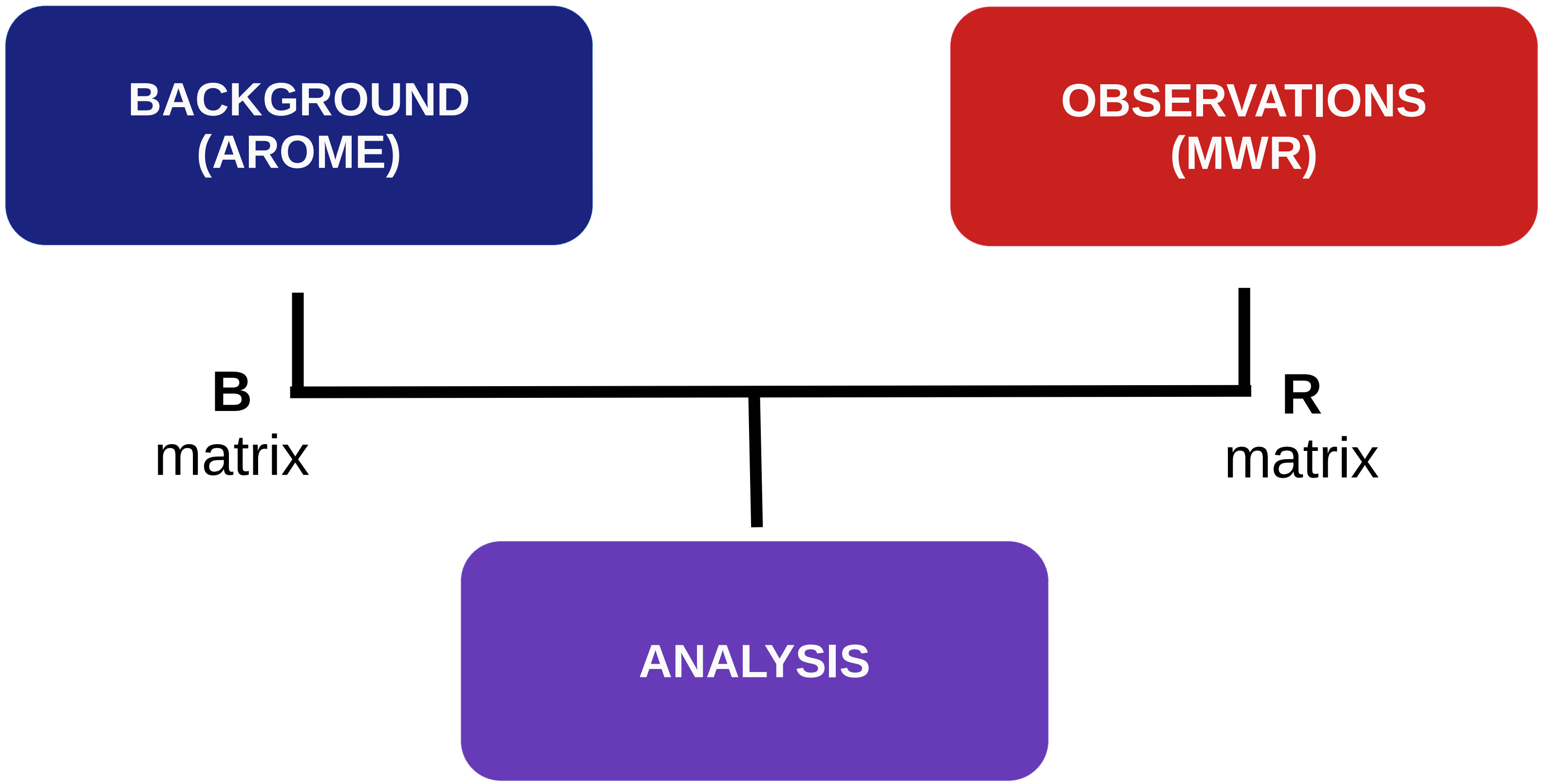
For these three experiments :

- A climatological **B** matrix
- A diagonal **R** matrix have been used for MWR temperature (same values then radiosounding temperature ones)

Departure statistics



Innovation (O-B) :
Observation – Background

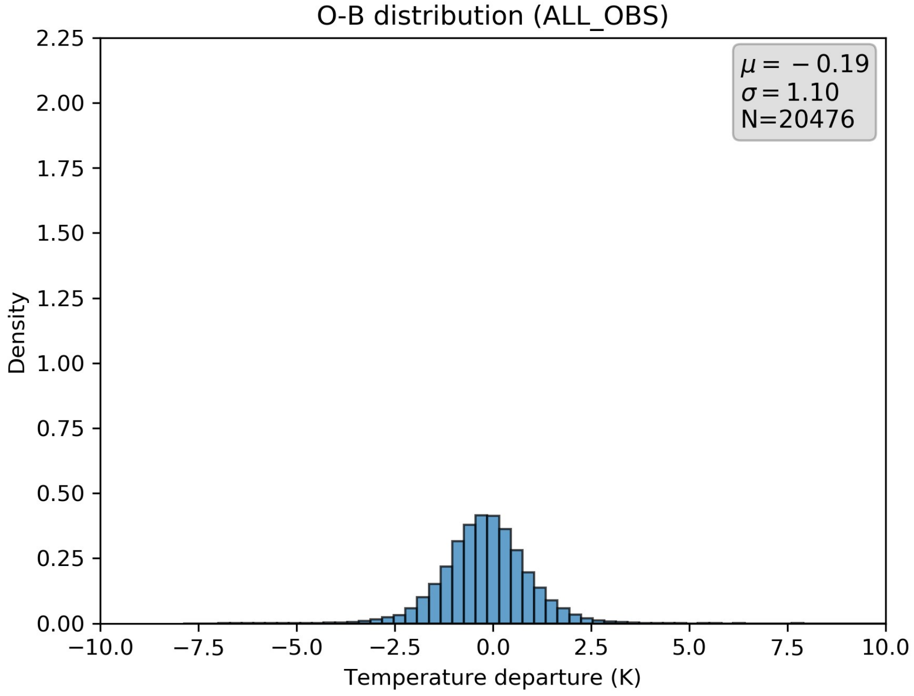
(Background = Short term forecast)

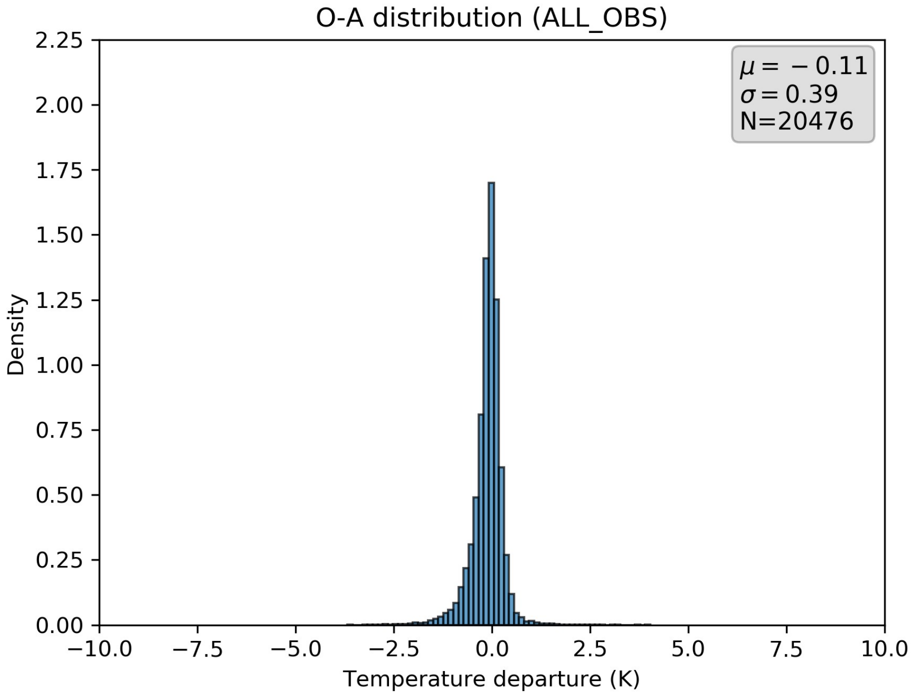
Analysis residual (O-A):
Observation – Analysis

(Analysis = New initial conditions)

Departure statistics : ALLOBS experiment

Statistics computed for a three month period (Decembre 2019 to February 2020).

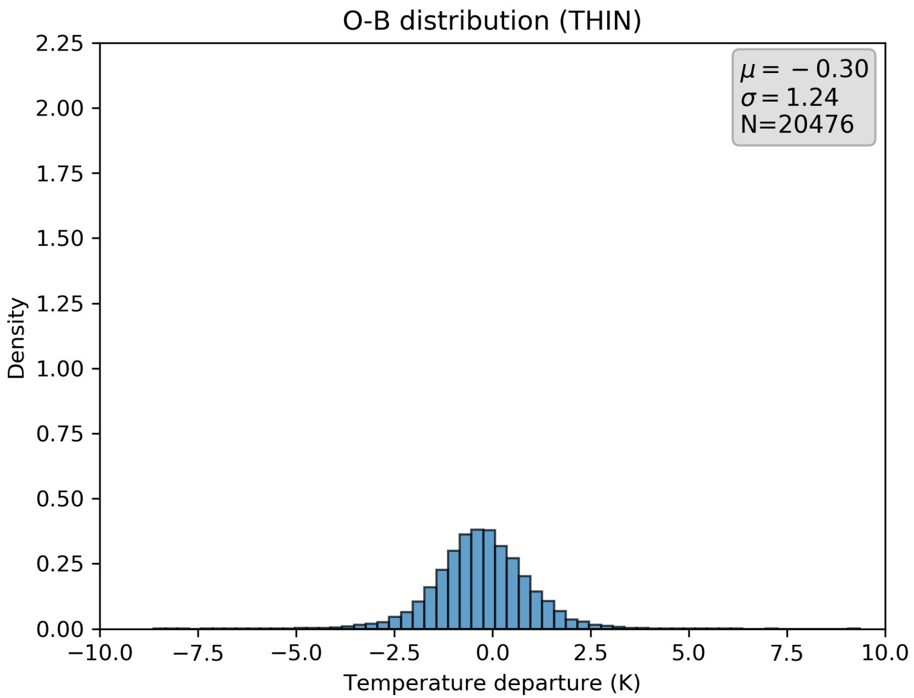


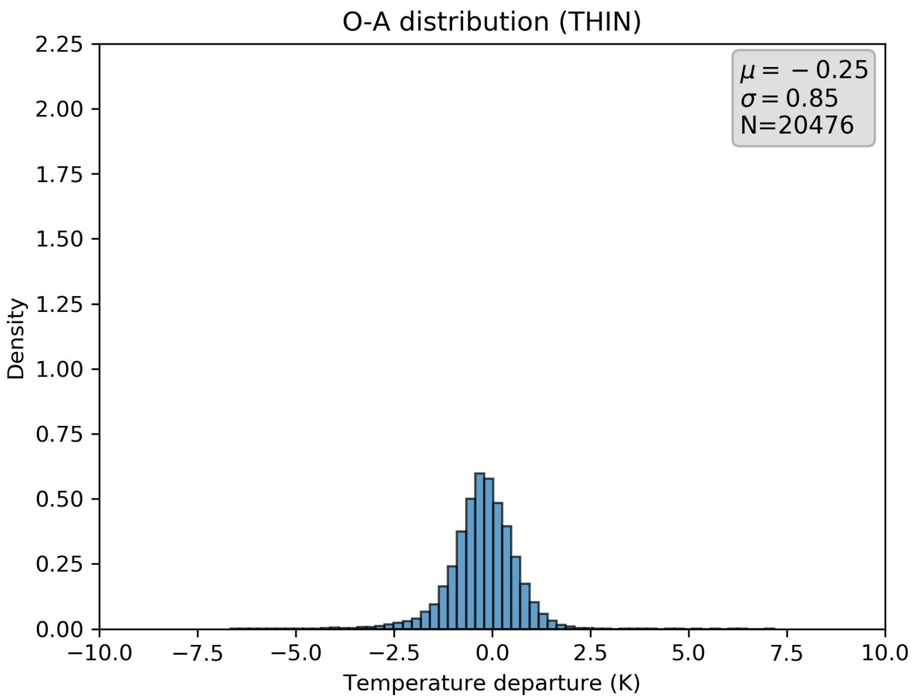


Bias reduced by ≈ 40 % and standard deviation is divided by ≈ 3.

Departure statistics : THIN experiment

Statistics computed for a three month period (Decembre 2019 to February 2020).





Bias reduced by ≈ 20 % and standard deviation by ≈ 30 %.

Departure statistics : THIN experiment

Statistics computed for a three month period (Decembre 2019 to February 2020).

Conclusions :

1 – MWR temperature data can be assimilated with the AROME 3D-Var.

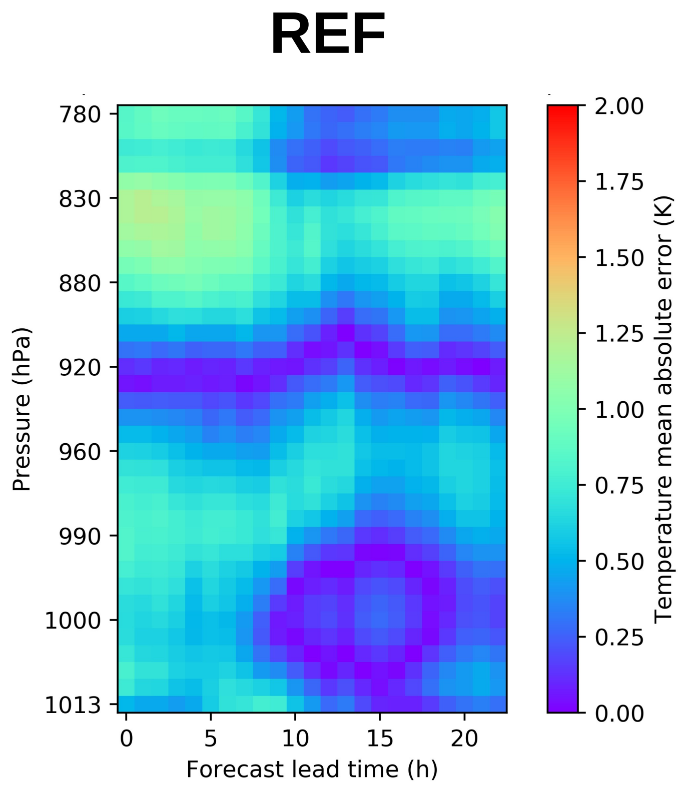
2 – ALLOBS presents a better improvement of departure statistics (due to the larger number of observations per profile).

Bias reduced by ≈ 20 % and standard deviation by ≈ 30 %.

Impact on temperature forecasts :

All MWR stations and all weather conditions (but precipitation).

Mean absolute error computed between forecasted temperatures (from 24h forecasts valid at 00 UTC) and non assimilated MWR temperature profiles.



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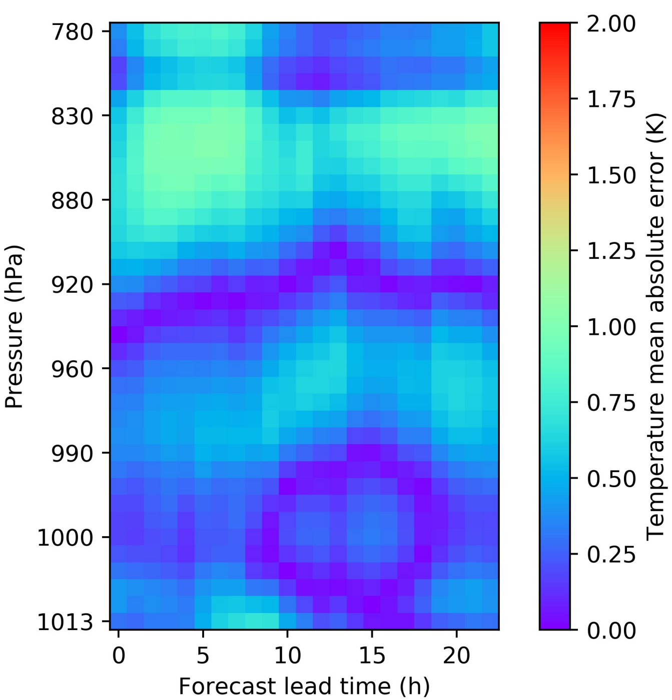
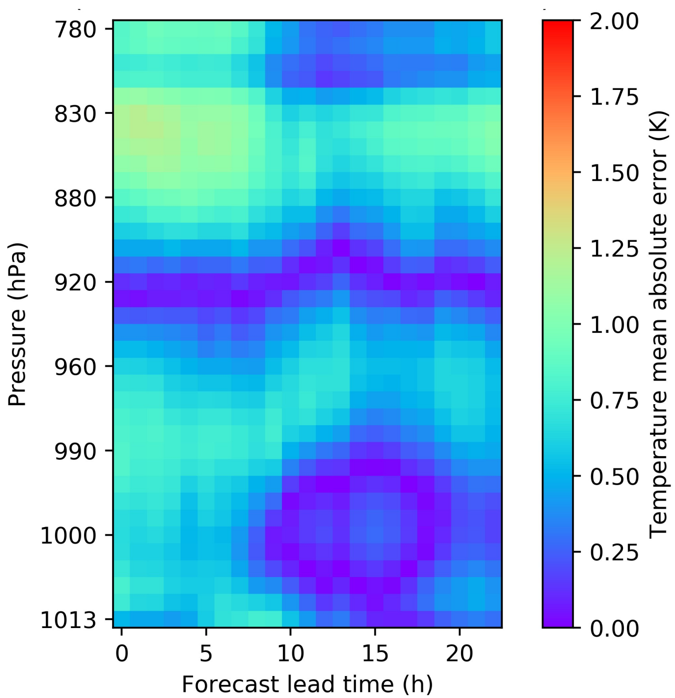
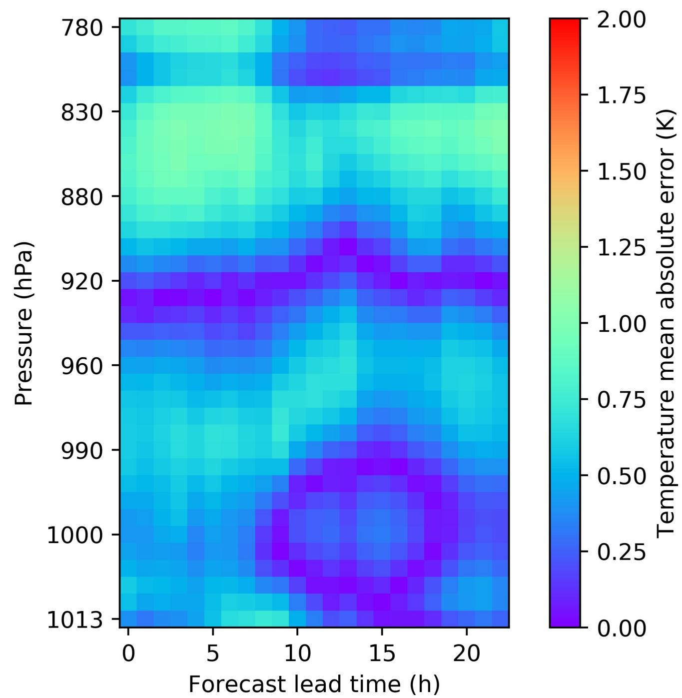
ALLOBS



REF



THIN



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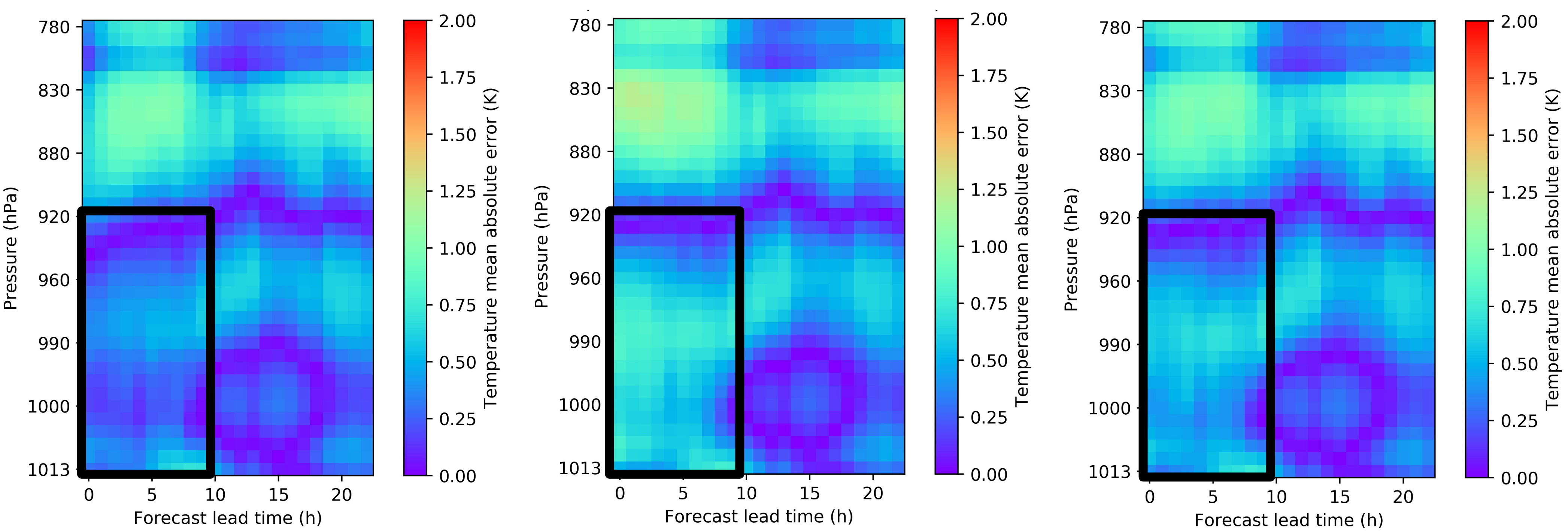
ALLOBS **REF** **THIN**

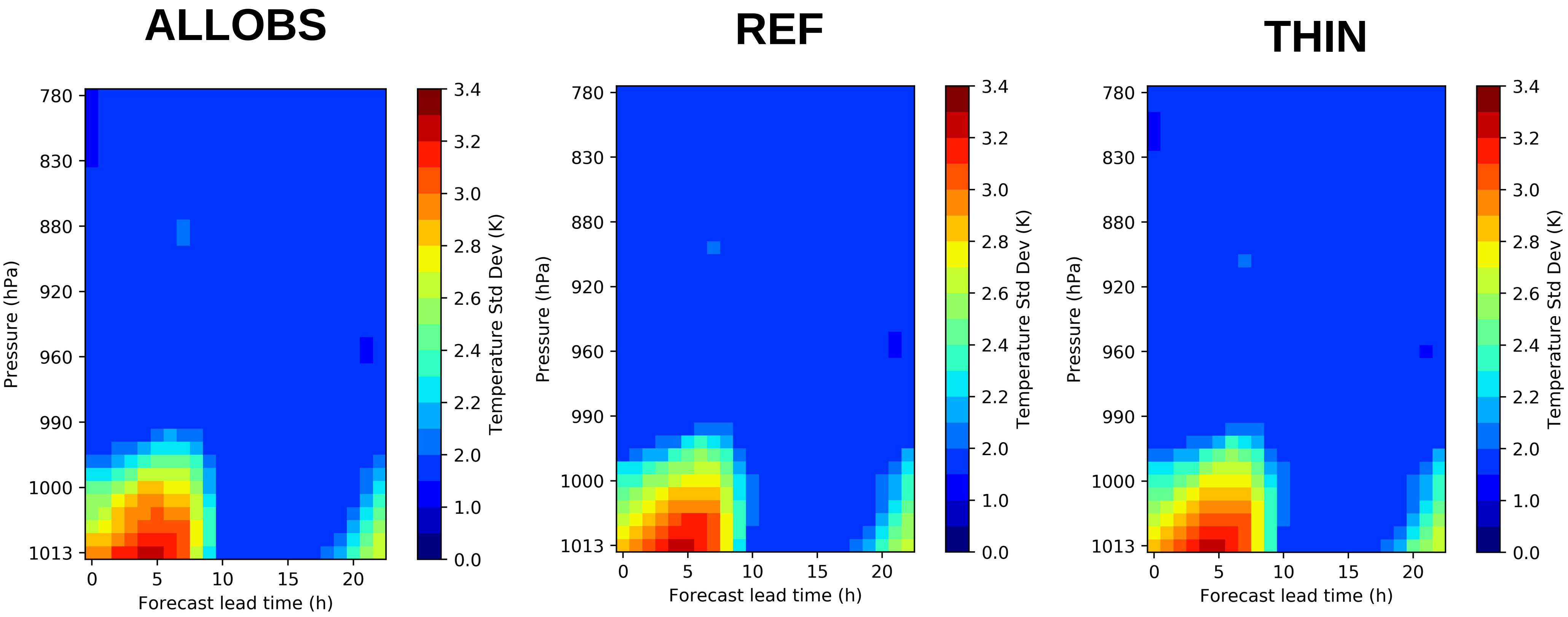


Mean absolute error reduction up to 50 % with **ALLOBS** and up to 30 % with **THIN.**

Impact on temperature forecasts :

All MWR stations and all weather conditions (but precipitation).

Standard deviation computed between forecasted temperatures (from 24h forecasts valid at 00 UTC) and non assimilated MWR temperature profiles.



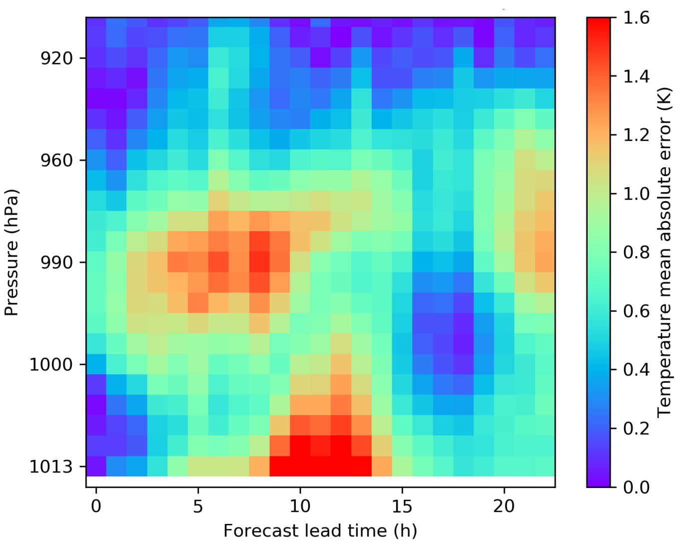
Associated standard deviations remain similar.

Impact on temperature forecasts :

At Agen for foggy days (57 observed and simulated).

Mean absolute error computed between forecasted temperatures (from 24h forecasts valid at 00 UTC) and non assimilated MWR temperature profiles.

ALLOBS



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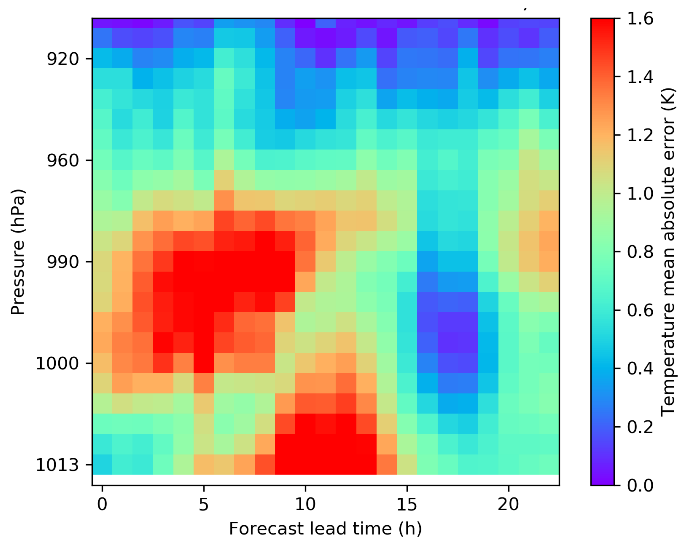
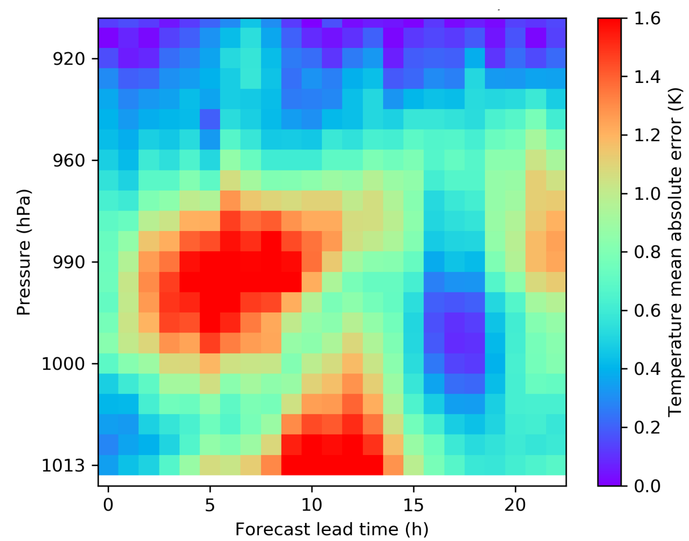


THIN



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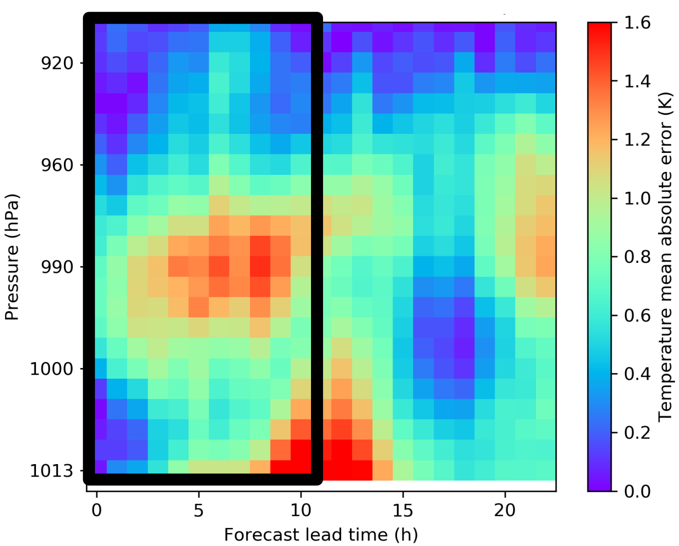

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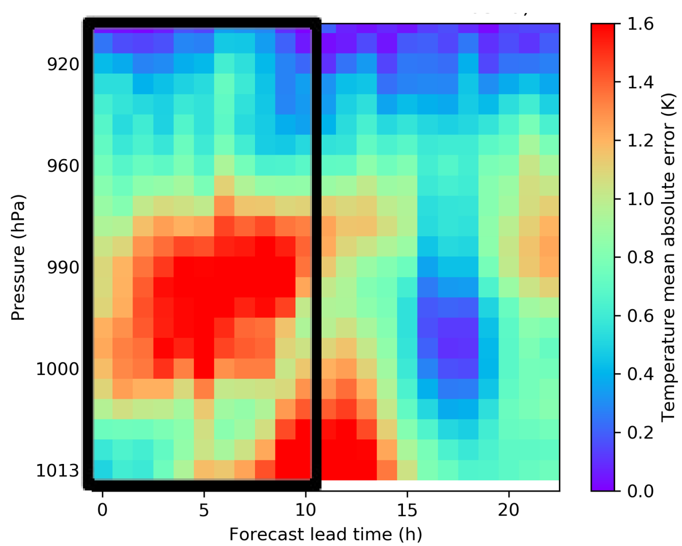

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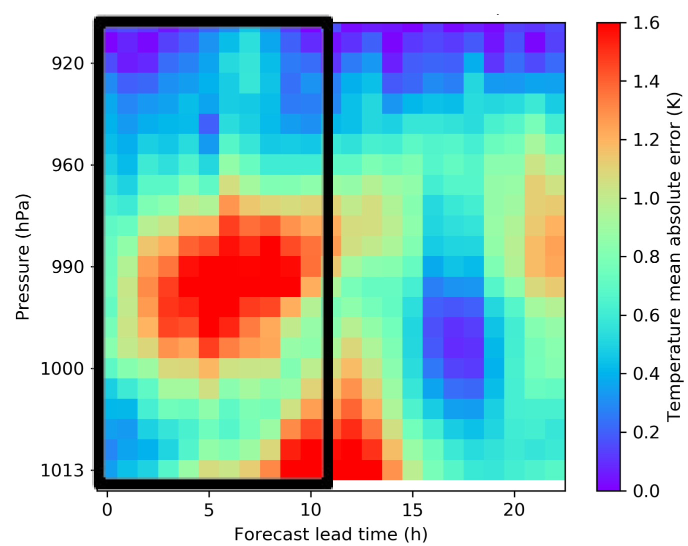

Up to 10 hours of forecasts, mean absolute error reduction up to 50 % with **ALLOBS** and up to 30 % with **THIN**.

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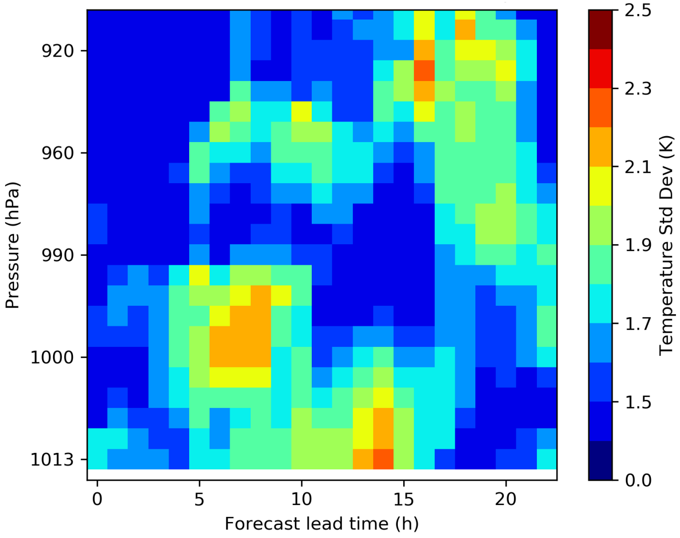

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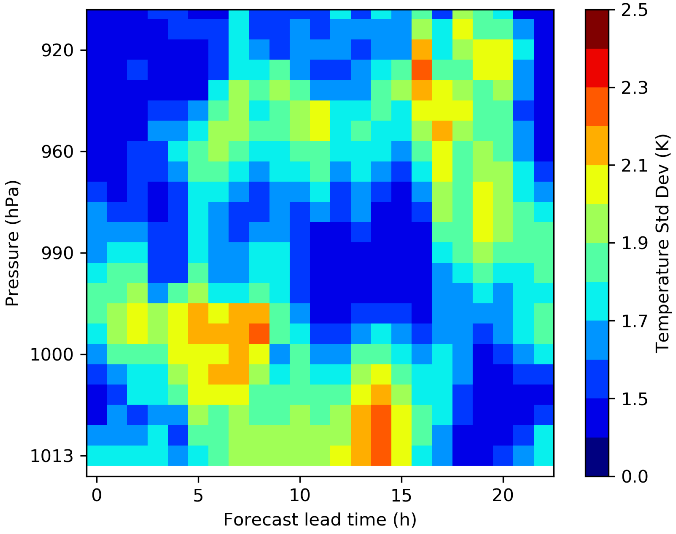

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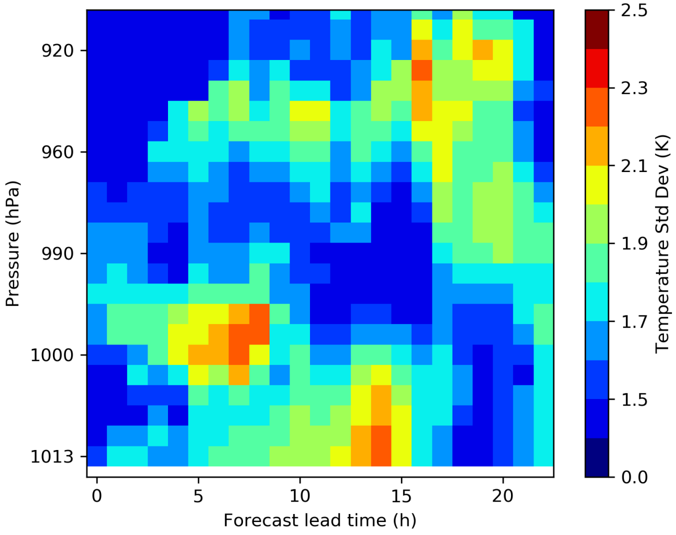

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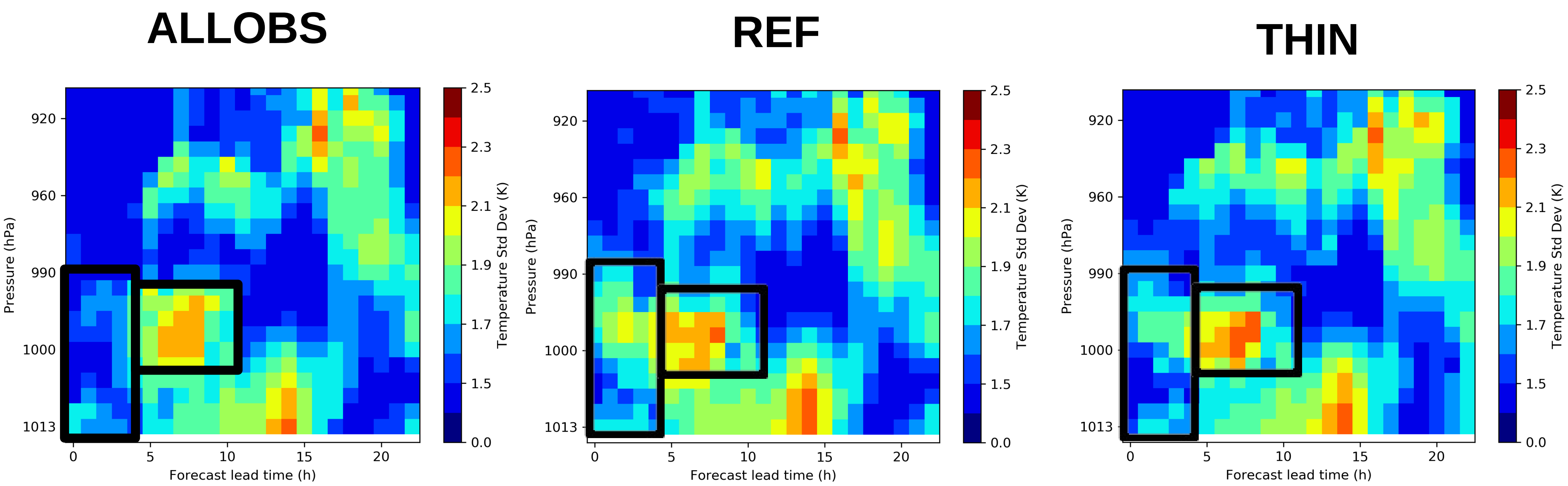
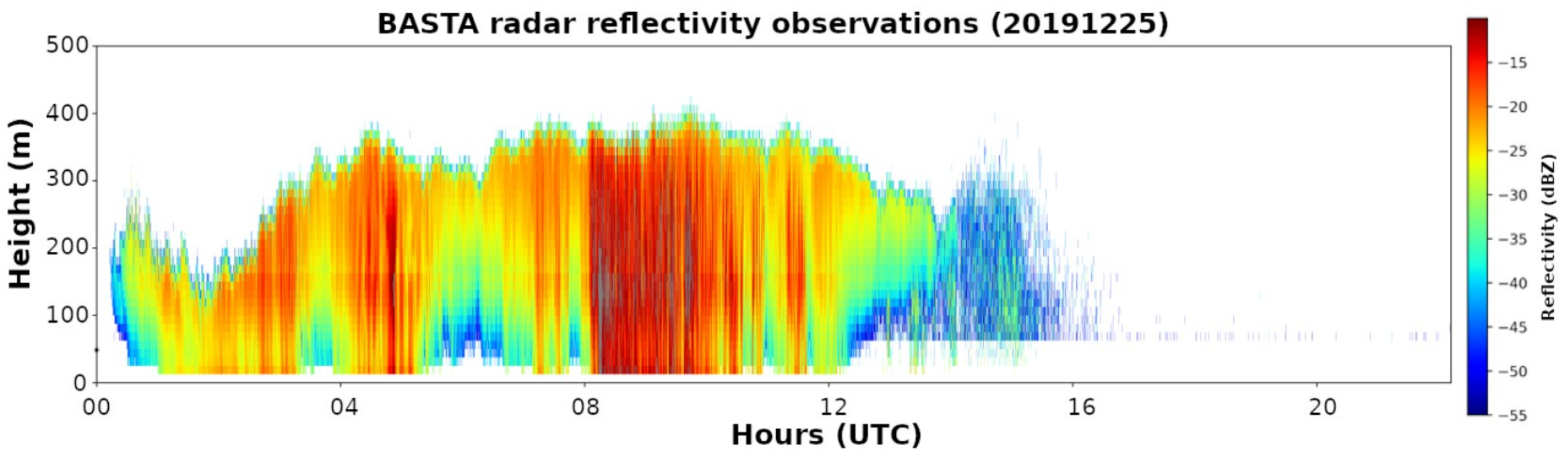


The most important impacts are situated between the ground and 200 m of height, for the first five hours of forecast.

Case study 1: a fog event at Charbonnières

On the 25th December 2019, a thick fog event was observed at the SOFOG3D super-site, similarly to a large domain of the South-West of France.



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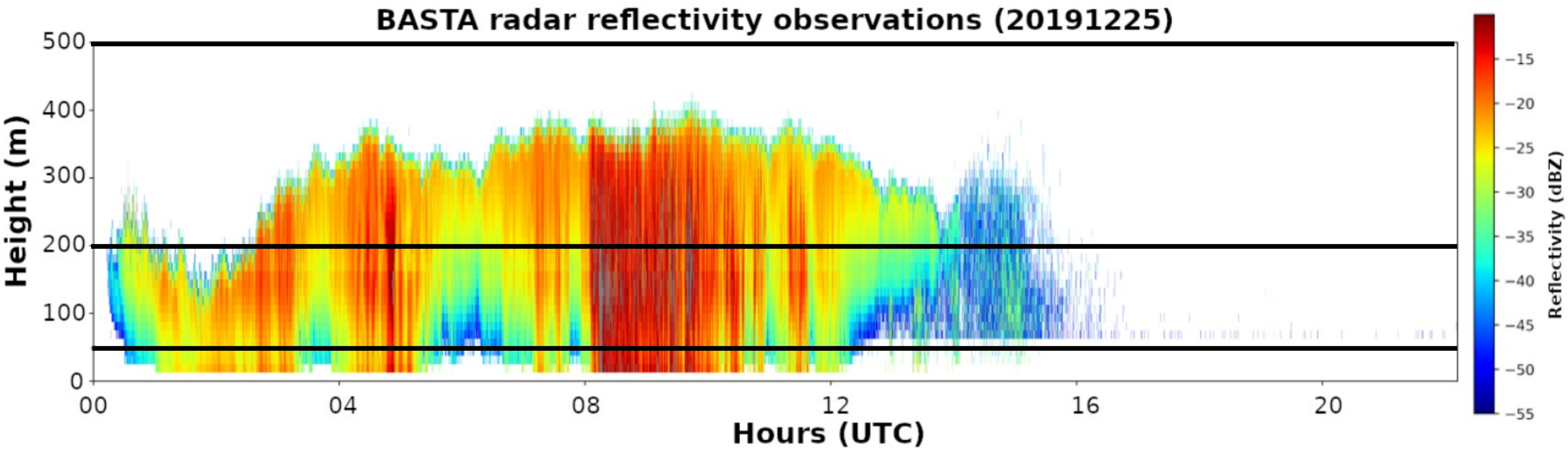
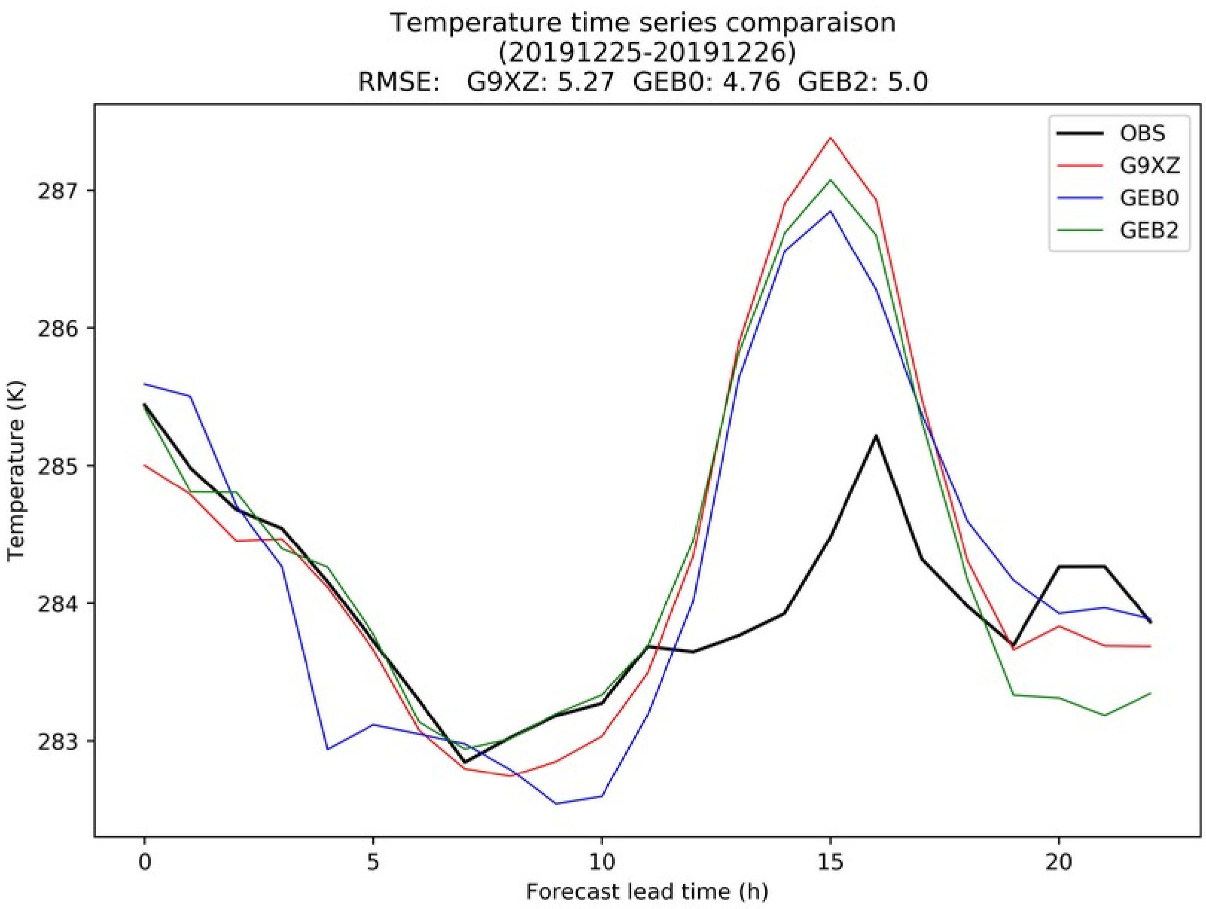


Case study 1: a fog event at Charbonnières

At 50m upon the ground



At the observed fog base

- At 00 UTC, **ALLOBS** is slightly warmer than **REF** and **THIN**, all being close to **OBS**.

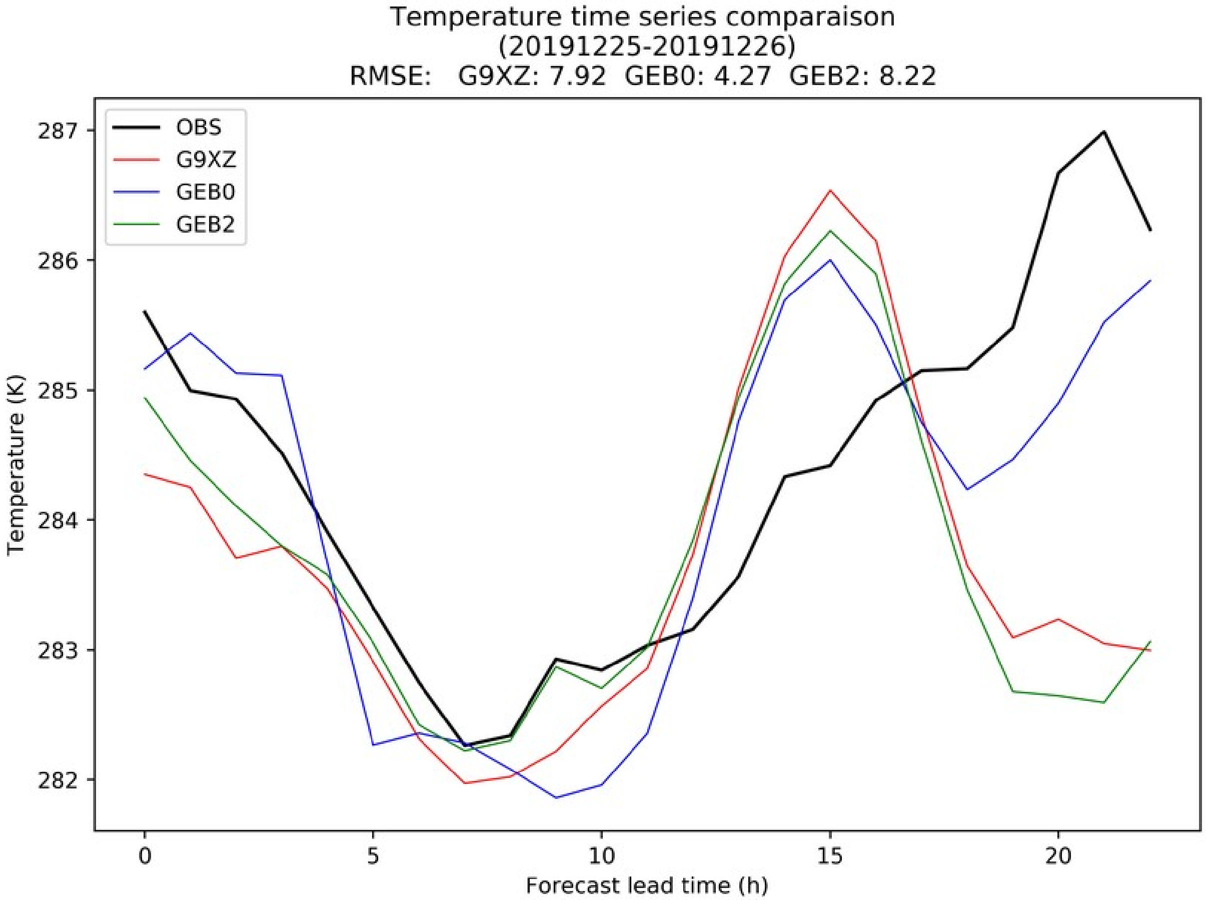
- Fog formation is delayed in **ALLOBS** forecasts, which globally lead to slightly colder temperatures until 12 UTC.

- After fog dissipation, the three forecasts are close each other.

- After 19 UTC, **ALLOBS** is closer to **OBS** and fog is not forecasted, contrary to **REF** and **THIN**.

Case study 1: a fog event at Charbonnières

At 200m upon the ground



<u>Within the observed fog :</u>

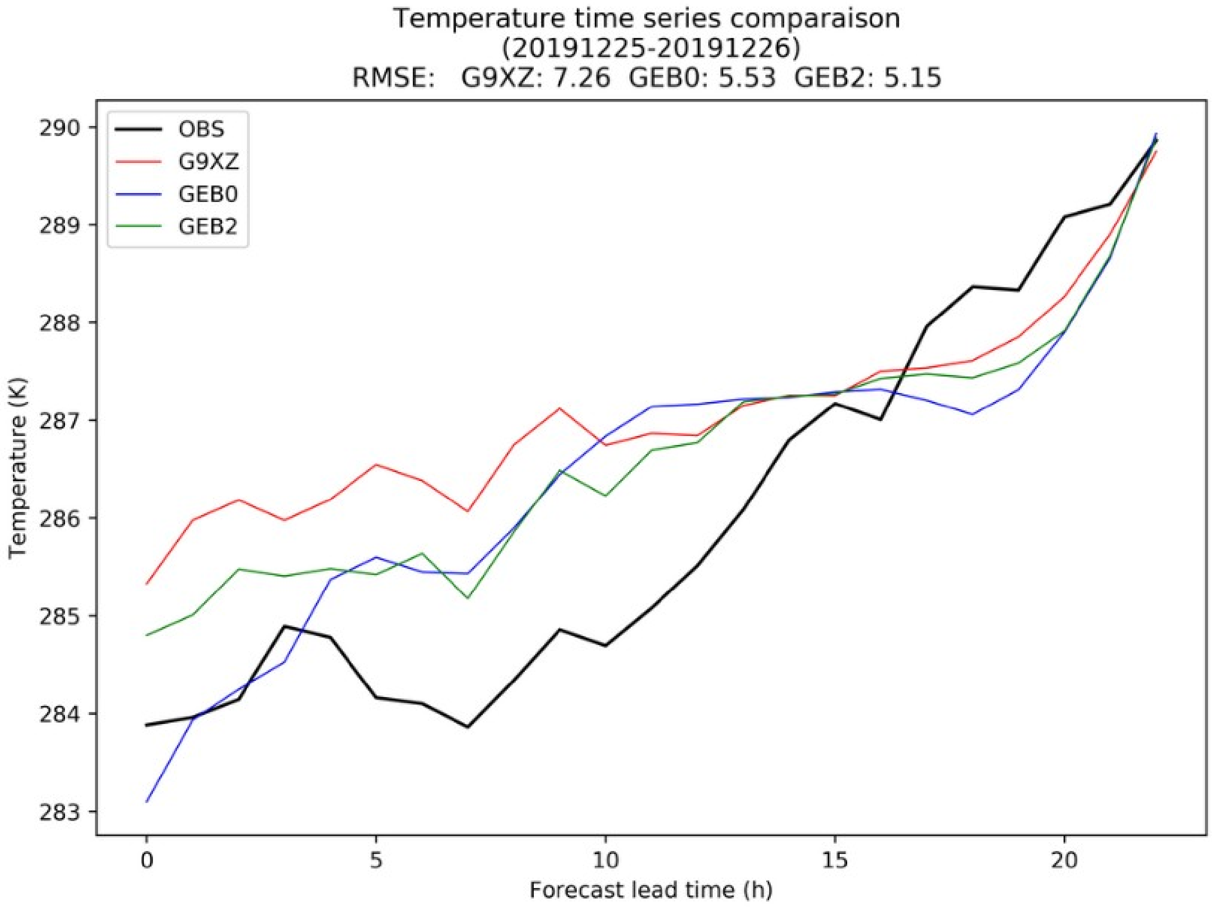
- At 00 UTC, **ALLOBS** is sligthly warmer than **THIN** and **REF**.

- Forecasts are close each other between 5 and 18 UTC.

- After 18 UTC, **REF** and **THIN** are cooling and lead to a fog formation. **ALLOBS** is closer to **OBS** (no fog forecasted).

Case study 1: a fog event at Charbonnières

At 500m upon the ground

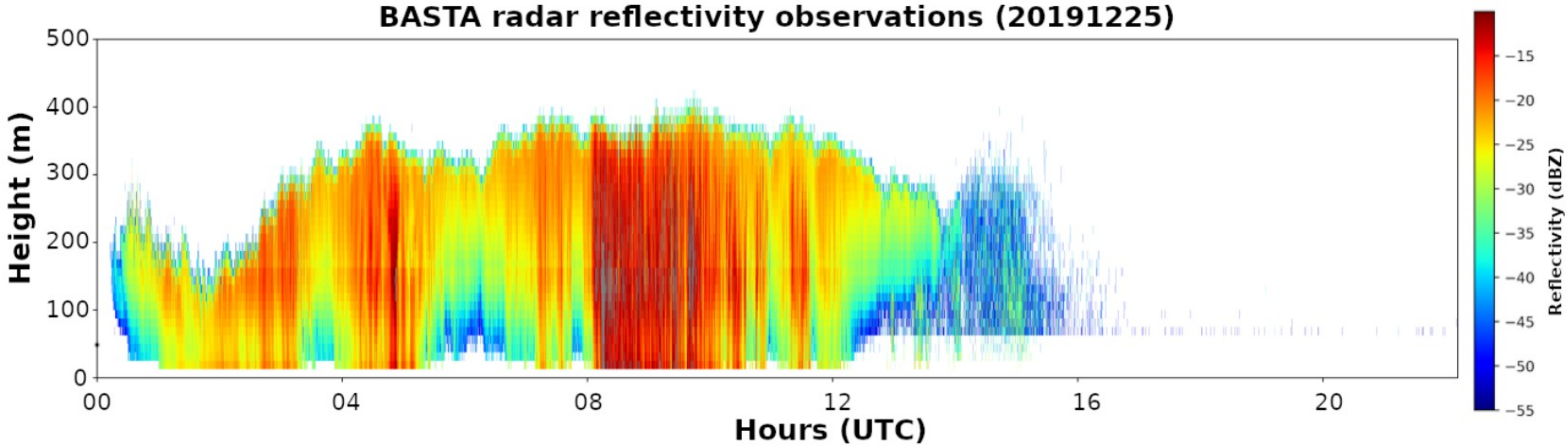


<u>Above the observed fog :</u>

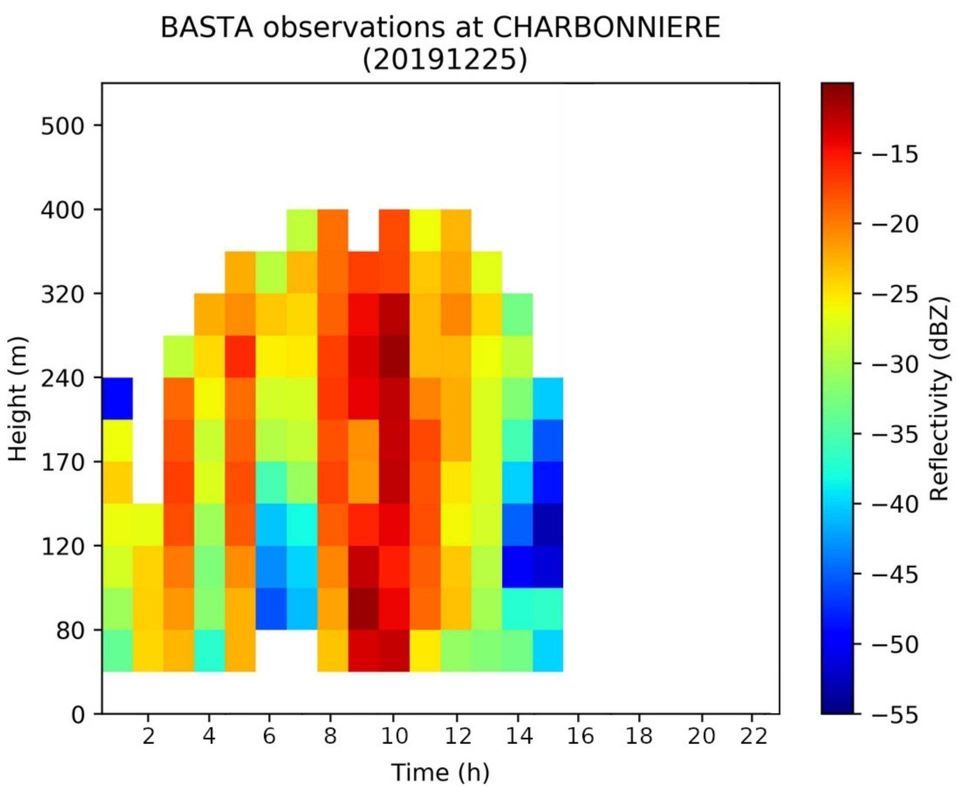
-At 00 UTC, **ALLOBS** is cooler (and closet to **OBS**) than **THIN**, being itself cooler than **REF**.

- Temperature forecasts improved in **ALLOBS** and **THIN** until 10 UTC. Afterwards, all forecast are close each other.

Case study 1: a fog event at Charbonnières



Interpolated BASTA observations upon the AROME vertical grid.



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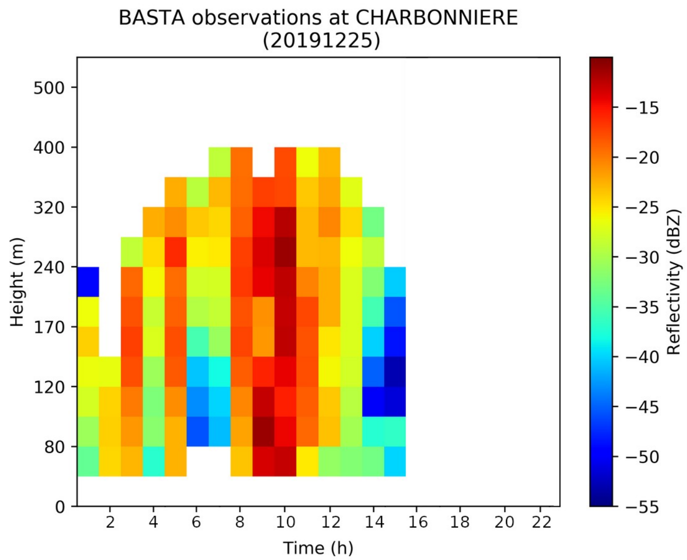
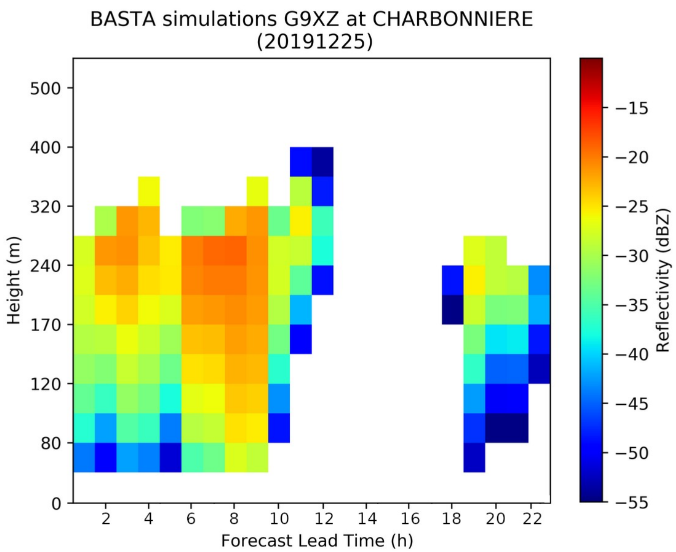
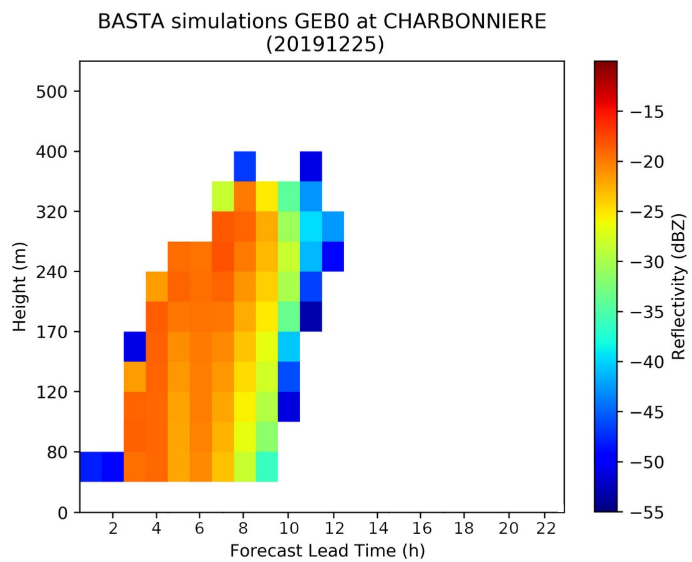


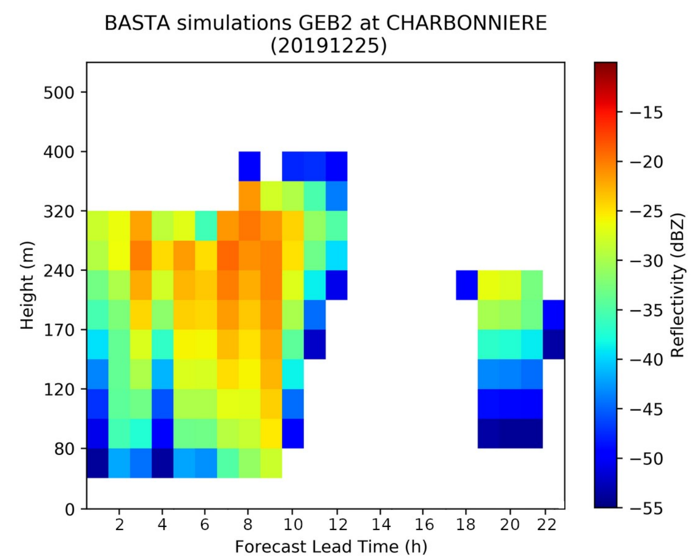
REF



ALLOBS

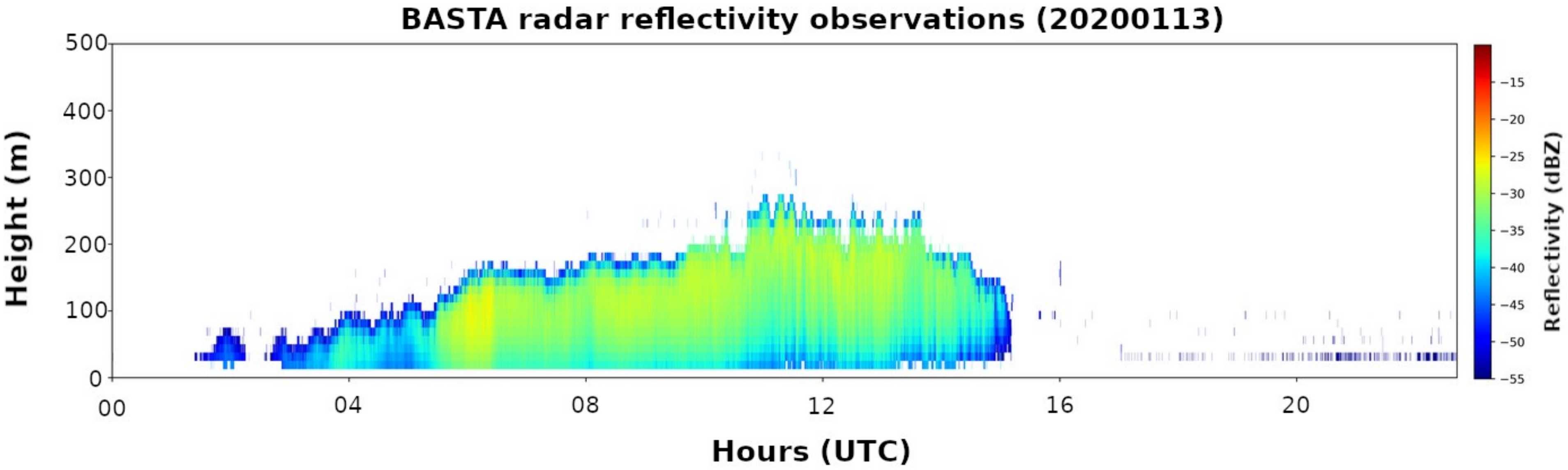


THIN



Case study 2: a non detection case at Agen

On the 13th of January, a fog event has been observed at Agen but not forecasted.



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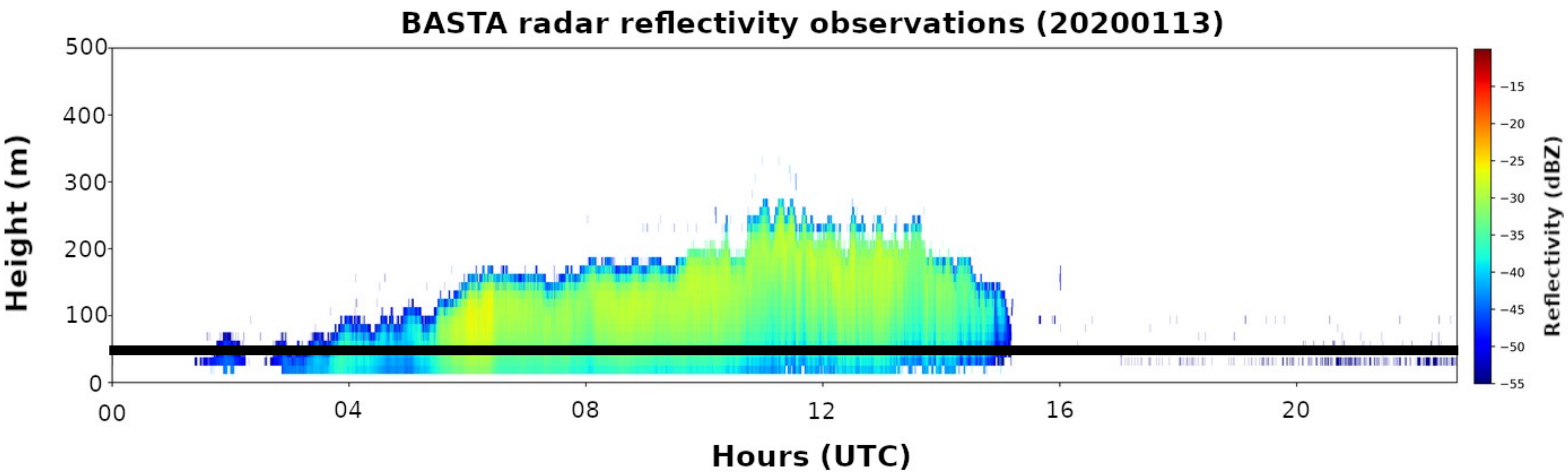

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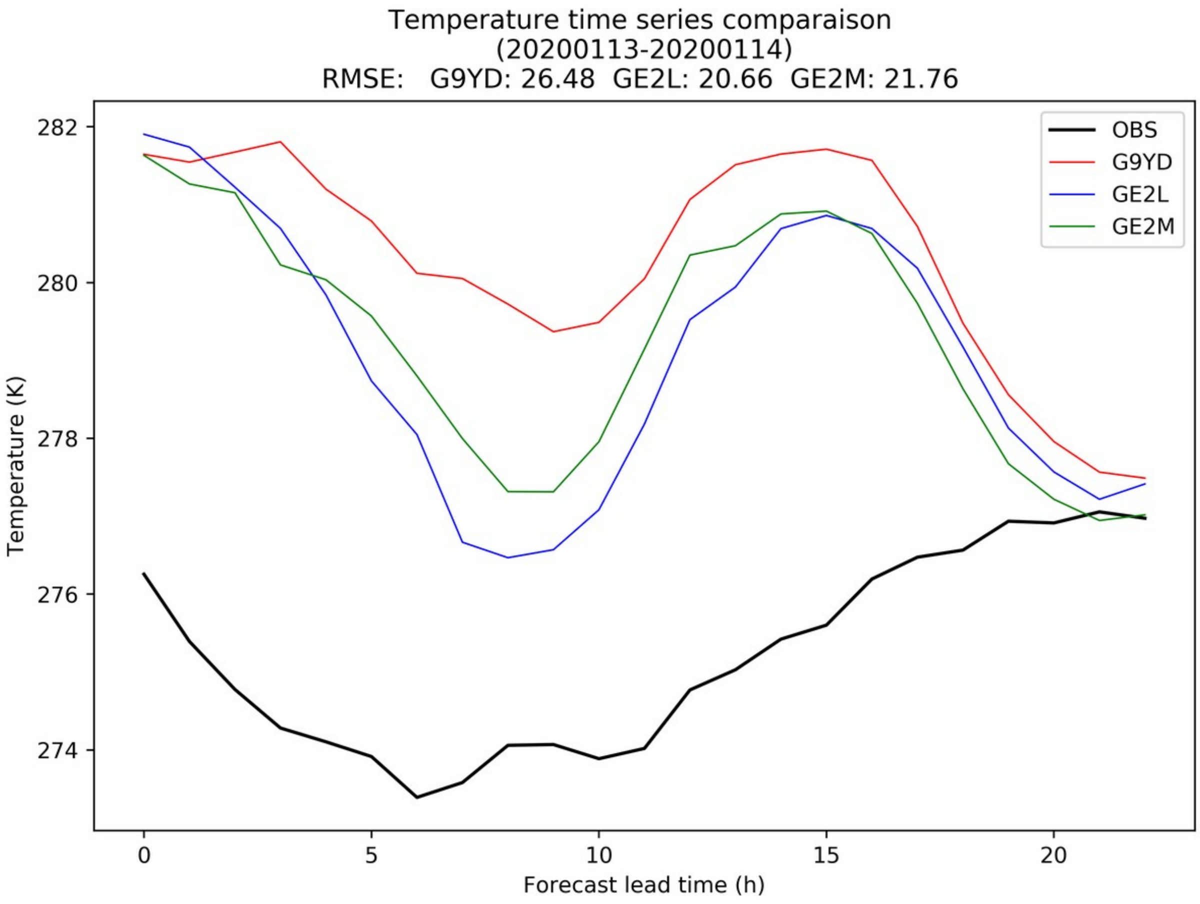

<u>At the fog base :</u>

- At 00 UTC, all the forecasts are close each other.

- After the first hours of forecast, **ALLOBS** and **THIN** start are cooler than **REF** and closer to **OBS**.

Case study 2: a non detection case at Agen

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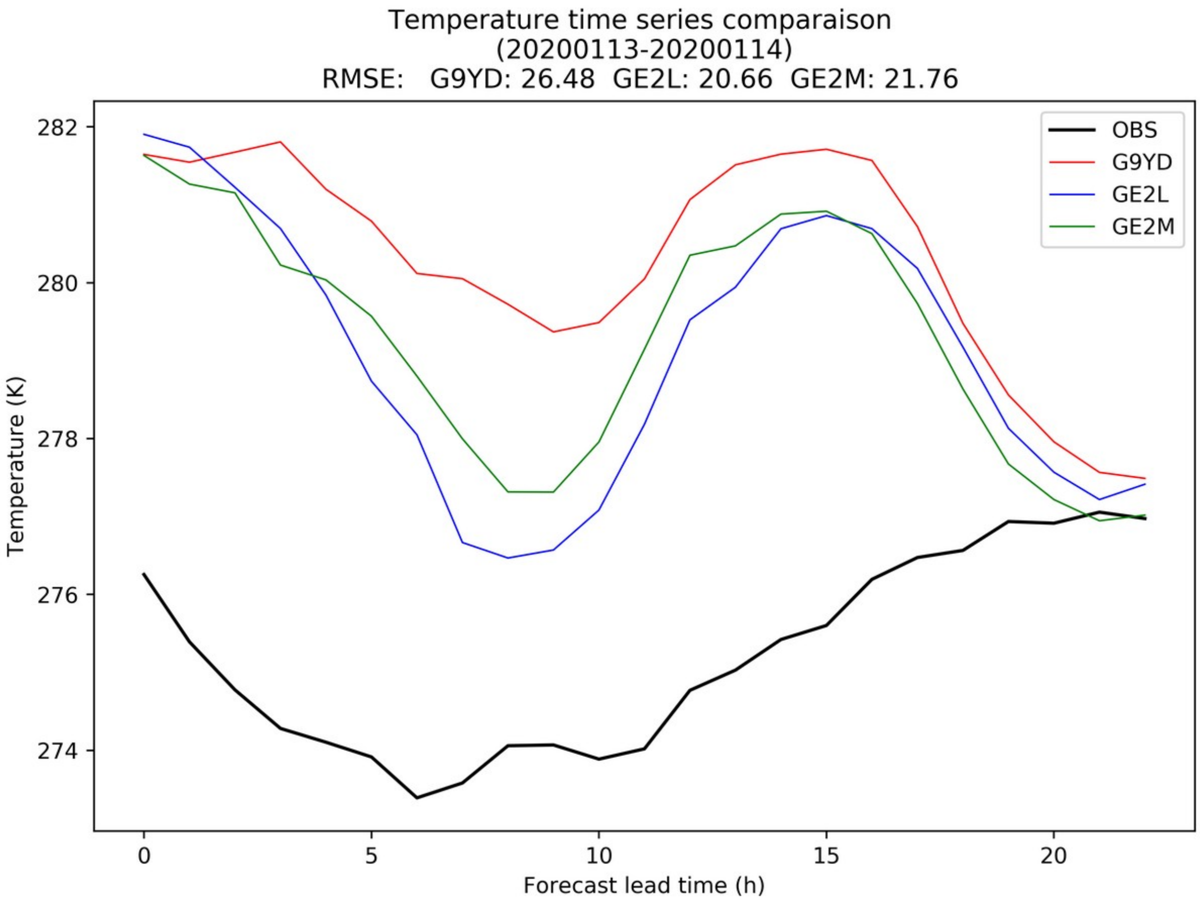

<u>At the fog base :</u>

- At 00 UTC, all the forecasts are close each other.

- After the first hours of forecast, **ALLOBS** and **THIN** start are cooler than **REF** and closer to **OBS**.

- Nevertheless, event if temperature forecasts are better, the air cooling was not sufficient to reach saturation (no fog forecasted in **ALLOBS** nor in **THIN**).

Conclusions and perspectives

- Temperature profiles retrieved from MWR observations can be assimilated.

- In comparaison with non assimilated MWR data, the assimilation of the retrieved temperature profiles improves the forecast up to 10 hours in average.

- However, a neutral statistical impact have been found on fog forecasts (with scores based on visibility).

- Consider a joint assimilation of temperature, humidity and LWP data retrieved from MWR.

- Tune the data assimilation experiments (diagnosed R matrix (and possibly a non-diagonal one), bias correction, …).