

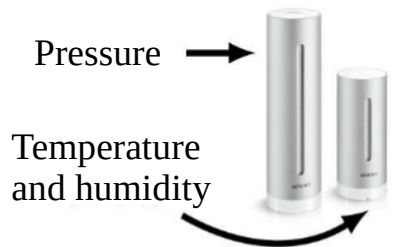
Added value of assimilating surface pressure observations from personal weather stations in AROME-France

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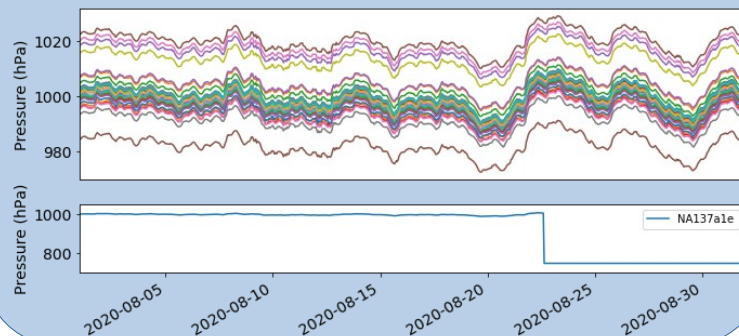
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Introduction : presentation of Netatmo weather stations (1/2)



- API available, allowing to download temperature, humidity, pressure, wind and rainfall

Time series of 30 pressure observations from Netatmo around Toulouse ; and an anormal one



Calibration
necessity

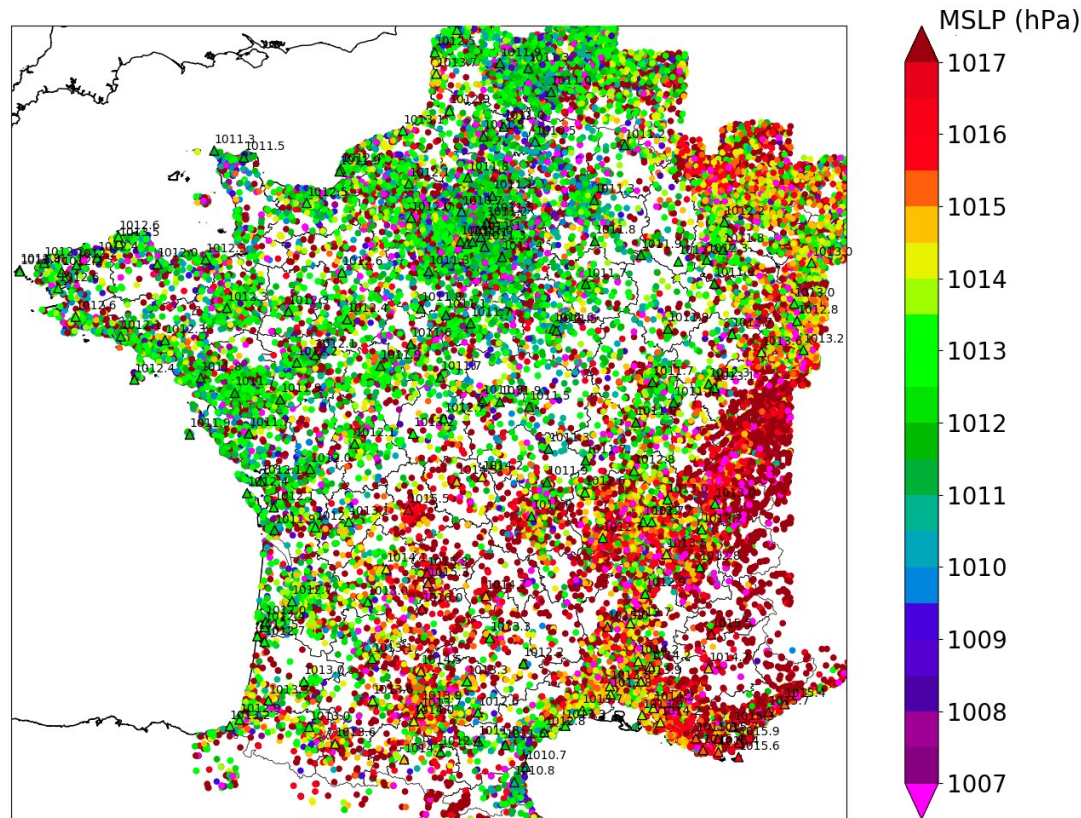
Quality control
necessity

Amount of surface
pressure observations
in France

Radome	Netatmo
188	44 978

↪ x240

Raw mean sea level pressure of Netatmo stations on the 12 of August 2020 at 20 UTC.



Introduction : presentation of Netatmo weather stations (2/2)

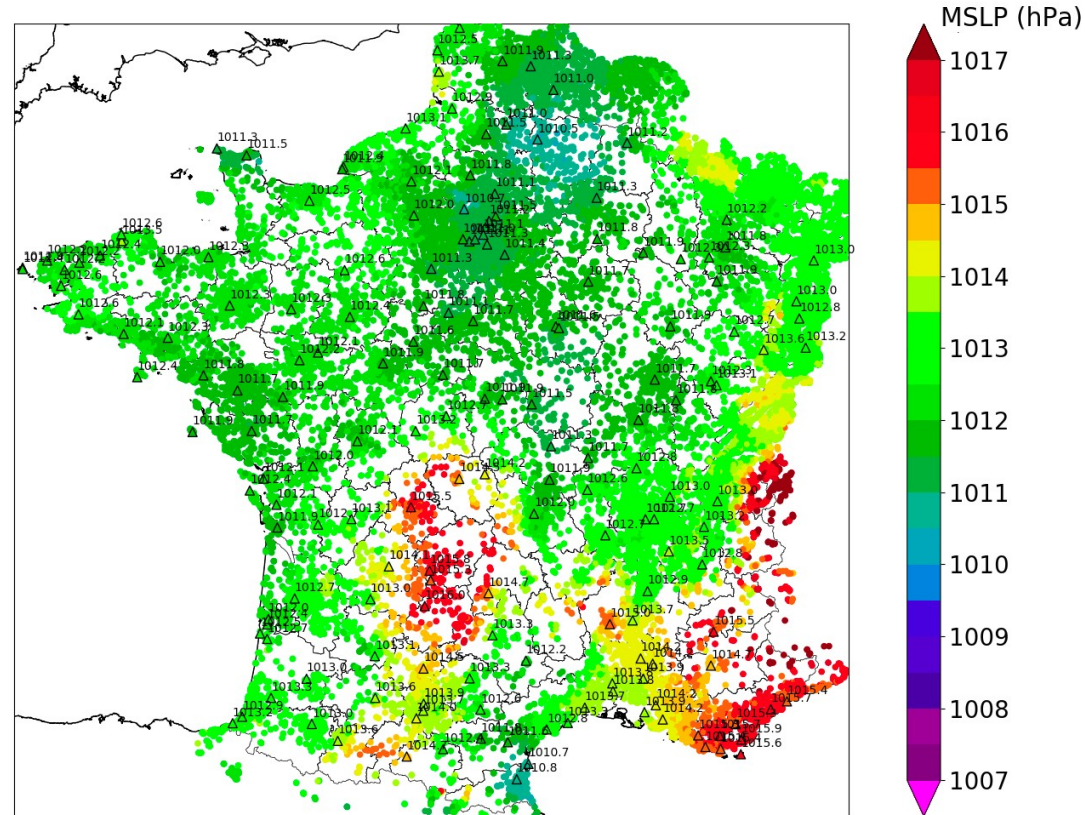
✓ Pressure observations from Netatmo weather stations with bias correction and quality control procedure are suitable to be used on process studies

Objective: Are there benefits to assimilate crowdsourced pressure in a convective-scale NWP system ?

Challenges :

- The assimilation of conventional observations in altitude depends on the model pressure ;
- Density of Netatmo network higher than the effective resolution of AROME (in the cities);
- Non-trivial bias correction on reliefs ;

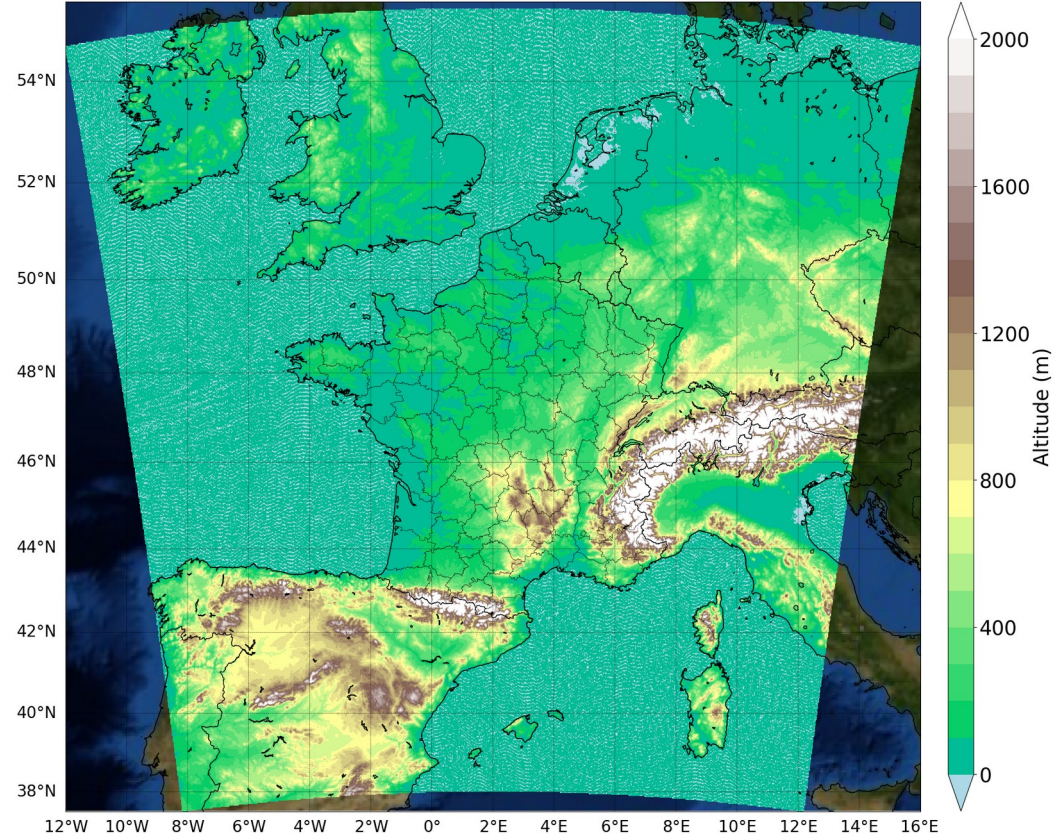
Mean sea level pressure of bias corrected and quality controlled Netatmo stations by **Mandement and Caumont (2020) method**



The AROME-France NWP system

Météo-France limited-area operational model

- Solves Euler fully compressible set of equations ;
- 1.3 km horizontal grid spacing (1536 x 1440 pts) ;
- 90 vertical levels from 5 m a.g.l. to 10 hPa ;
- Coupled to global ARPEGE model ;
- **3D Variational assimilation (1h cycle)**
- 13 prognostic variables :
 - ➔ two components of the horizontal wind (U and V), temperature, specific contents of water vapor, rain, snow, graupel, cloud droplets, ice crystals
 - ➔ turbulent kinetic energy
 - ➔ **hydrostatic pressure**, reduced non-hydrostatic pressure departure, reduced vertical divergence
- 8 forecasts per day up to 51h ;



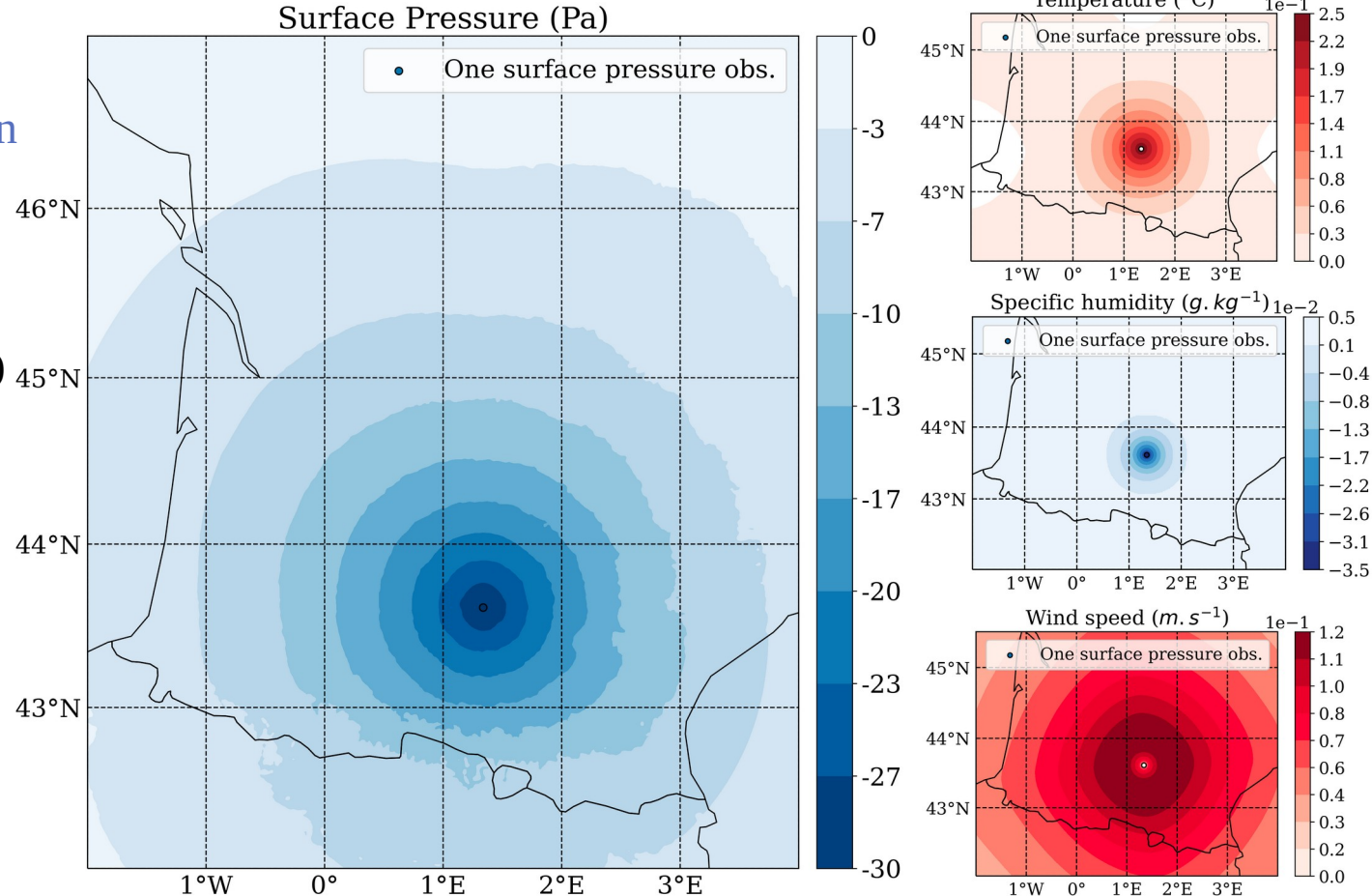
Orography of AROME-France domain

Assimilation in AROME 3D-Var

Assimilating one single bias corrected pressure observation (+0.3 hPa)

Analysis increment (analysis – background) of surface pressure, temperature, specific humidity and wind speed at first model level (5 m)

- AROME being in vertical pressure coordinate, it is usual to assimilate the geopotential (product of the station altitude and the gravitational constant at the altitude "station pressure") which is compared to the surface pressure thanks to an observation operator.



Diagnostics on Netatmo observation errors

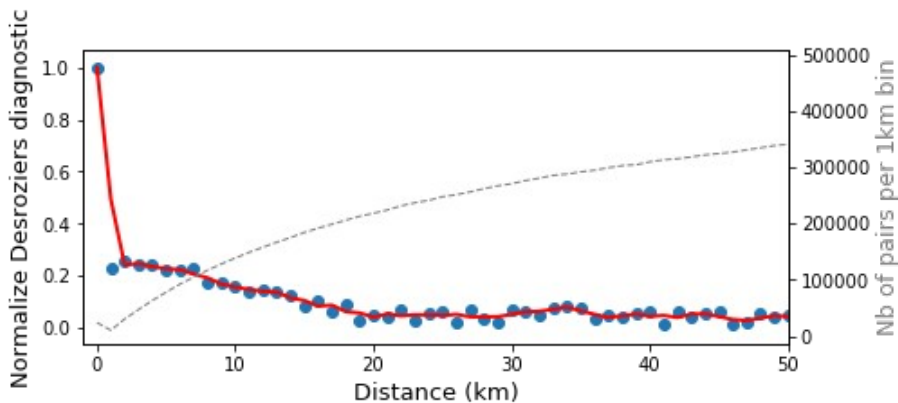
Experiment with
Netamo « XP » :
pre-processing
method

Bias correction	Supp. quality control	Thinning
1 month model correction	STD(obs - guess) <60 m ² .s ⁻²	1.3 km

Desroziers diagnostic allow us to estimate the error and the weight that should be given to the observation, in order to have an optimal use of it in the 3DVar cost function (Desroziers et al. 2005).

It is given by:

$$\sigma_o^2 = \overline{(obs - guess) \cdot (obs - analysis)}$$



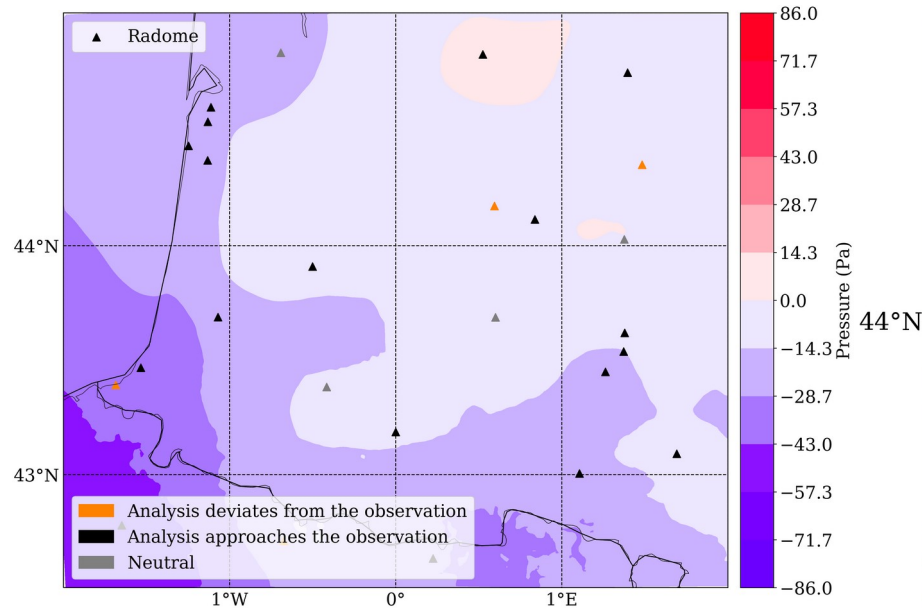
Spatial Desroziers diagnostic of pressure observations covariance error from Netatmo stations. Done on August 1, 2020 at 1 UTC. In grey, the number of pairs of equidistant stations (in 1 km bins); blue dots correspond to the mean of Desroziers' diagnostic; and red line the rolling average over 5 km.

	Prescribed	Estimated	
	All	Netatmo	SYNOP
σ_o (m ² .s ⁻²)	78	26	30

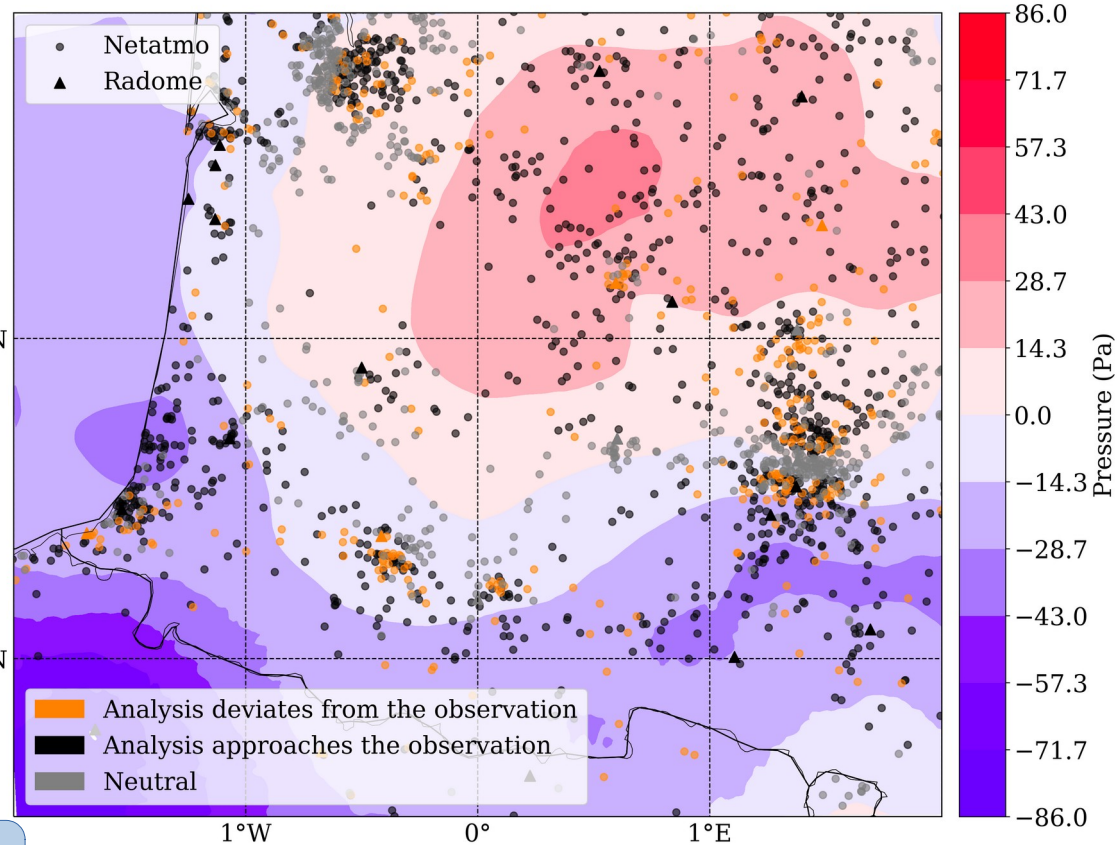
σ_o prescribed and estimated by
Desroziers diagnostic

- ✓ There is *no spatial correlation* of observation error (with a 1.3 km thinning);
- ✓ The weight given to Netatmo observation is underestimated, which is like conventional observations ;

Increment change when assimilating dense surface pressure observations



Surface pressure increment (analysis minus background), for OPER (left) and XP (with Netatmo, right).
 $|obs - analysis| > |obs - guess|$ in orange (and the opposite in black). Neutral is defined as ± 5 Pa of the increment.



- ✓ Small pressure increment added during calm conditions ;
- ✗ Large spatial size of the increment ;

Scores from the analysis and forecast during one month (August 2020)

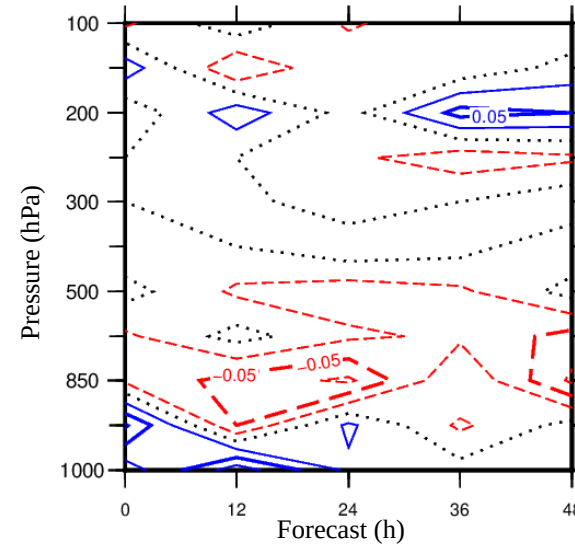
Analysis statistics with Netatmo :

Network	SYNOP Geop		SYNOP Hu2m	SYNOP u10m	SYNOP v10m
	All	France			
XP	-0.7 %	-2.6 %	-0.9 %	0 %	-1.9 %

Standard deviation of the departure between
SYNOP observation and guess. Difference between
XP and Oper.
If < 0 : improvement,
If > 0 : deterioration.

- ✓ The guess is getting closer to SYNOP observation with Netatmo : systematic improvement ;

Forecast statistics with Netatmo :



Temperature (°C)
RMSD between model
and radiosoundings at
different time steps of the
forecast (until 48 h) in
France ; difference
between OPER and XP ;
improvement in blue and
degradation in red

- ➔ Consistent signal thanks to the 25,000 Netatmo stations assimilated; but the results are not significant because of the small number of radiosoundings available

- ✓ Improvement during the first hours, on the ground ;
- ✗ Deterioration at the middle troposphere ;

Summary and future work

➤ *Summary:*

- ➔ A very large number of pressure observations from Netatmo can be used ;
- ➔ Simple method to assimilate them ("like SYNOP") with appropriate bias correction, quality control and thinning;
- ➔ Encouraging scores ;

➤ *Outlook:*

- ➔ Focus on how to allow AROME to take more advantage of the information from Netatmo observations :
 - decrease observation error ;
 - replace thinning by superobbing ;
 - Use of 3D-EnVar assimilation system ;
- ➔ Get significant result : longer experiment if necessary ;
- ➔ Use of a VarBC method for an operational approach ;

Thanks for your attention!