AROME-NWC

Overview, Results, Evolution and Perspectives

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Current nowcasting tools mostly use the extrapolation of observed data, either using radar reflectivity or satellite radiance. These tools can't be used for predictions beyond 1-2 hours, because they can't create or diminish cells, or take into account of orography for example. Progress in numerical modelling, together with increasing computational power, now enable us to contemplate using modelling at all forecasting ranges. AROME-NWC, which has been technically operational since March 2016, was designed to be used by forecasters for quick reaction in high-stakes events and as a means to improving our existing nowcasting tools.

This document is an overview after one year in operation. It is also a blueprint for the future evolution of the next and subsequent e-suites and avenues for a merger between extrapolation methods and numerical prediction.

AROME-NWC 2016 at a glance

AROME-NWC: " Configuration of AROME-NWC for nowcasting"

AROME-NWC is based on AROME-FR, the convective-scale and limited area system of METEO FRANCE: same domain, same physics and dynamics, same 3DVar data assimilation, same scale (1.3km), same ARPEGE coupler model...

Some adjustments were made to meet nowcasting needs : availability of data for very short range, and updates of latest observations - both within 30 minutes.

These constraints mean that a compromise must be made between the observation update and computational time. The assimilation window of AROME-NWC is thus narrower, hence uses fewer observations than in AROME-FR.

> ***AROME-NWC (cy41t1) at a glance:***
>
> **24 runs** (hourly atmospheric analysis)
>
> **Surface initialisation:** from a SURFEX AROME-FR forecast
>
> **Maximum forecast range:** +6h
>
> **Output:** 15min
>
> **Assimilation window:** [-10min;+10min[; cut-off+10min(against 1h30 for AROME-FR)
>
> **Output availability** from H+30min for the 6h forecast

AROME-NWC runs every hour based on an analysis from the last available AROME-FR forecast (the 'guess') and observations gathered between H-10min and H+10min. Every AROME-NWC run is not on the same footing as they are based on guesses of different ages . Robustness and assimilation performances led to making this choice.

- accumulated rainfall 15min (rain, snow, graupel)

Other fields are produced only for the calculation of some diagnostics : convection, fog, winter weather surface phenomena.

> ***AROME-NWC (cy41t1) at a glance:***
>
> *Every hour, 838 new AROME-NWC fields are produced:*
>
> *The AROME-NWC dashboard enables forecasters to be warned in case of any excess threshold of any field and to visualise relevant maps. These thresholds are set by Inter-regional Services.*
>
> *It enables visualisation of several available forecasts for a given hour.*
>
> *This site was tailored to meet forecasters' needs and expectations during the 2015 experiments.*

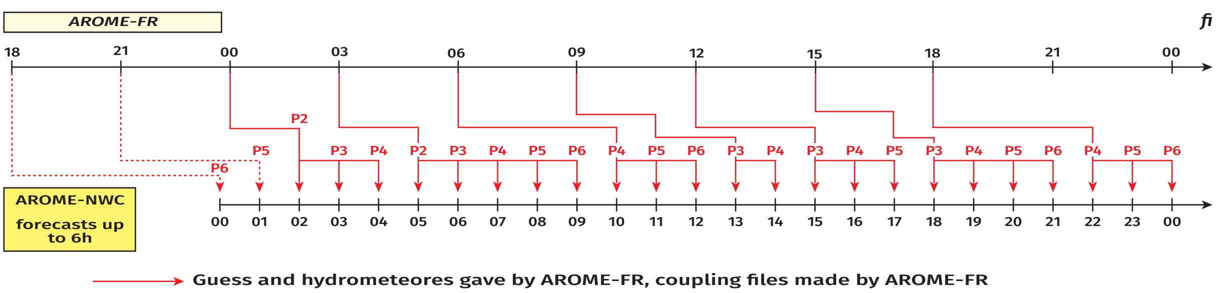


Figure 1: *Dependence of AROME-NWC to AROME-FR*

What are the results after one year?

Spring/Summer 2016 scores (source: Monitoring Report 118 & 119)

Sensible weather parameters (precipitation, mean wind speed, 10m gust, 2m temperature) are monitored. The goal is to check the added-value of AROME-NWC compared to AROME-FR which gave the background for the assimilation. We are thus in an operational context when comparing AROME-NWC to the available AROME-FR at the time and thus based on a less recent analysis.

Precipitation: better scores than for AROME-FR

For the hourly cumulative rainfall/precipitation (over 5mm/h), AROME-NWC reduces the overestimation made by AROME-FR. For the first hour, the reduction is too great but more accurate afterwards. It is worth noting that there is a decrease of false rate alarm and a slight increase of the detection rate. The false alarm rate is quite important in the morning while detection rates are low, leading to negative Heidke skill scores (HSS) but nevertheless better than those of AROME-FR. During the afternoon, there are fewer false alarm rates and detection rates are better; HSS are positive and again better than those of AROME-FR.

Wind: better score skill ,especially during the first hours

For gusts over 60km/h, AROME-NWC performs much better than AROME-FR during the first two hours, reducing under-estimations but still not enough. For these forecasts, AROME-NWC improves detection rates without being detrimental to false alarm rates. For other forecasts ranges, both models perform equally.

Similar to result for precipitation, HSS for AROME-NWC gust wind are better than those for AROME-FR.

For precipitation as well as for gust winds, HSS are monitored against forecasts of persistence initialized with available observations at the start of every AROME-NWC run.

This persistence gives good score skill for the first forecasts, and constitute a legitimate standard which numerical predictions will find difficult to beat.

A word about scores:

The success rate is the total number of good forecasts in relation to the total number of events.

HSS is equal to: success rate – reference success rate/1- reference success rate

HSS characterizes all good forecasts against a reference forecast (here the persistence).

It varies from $-\infty$ to 1, where 1 is the perfect score and 0 is the reference forecast score

Subjective evaluations

Subjective evaluations are carried out on selected meteorological events. The following elements are based on the 2015-2016 experiment and on the control of some recurring behaviours of the models.

2015 Lab test forecasts

Prior to being operational, the forecasting department carried out some forecasts during the autumn of 2015. They involved more than 40 forecasters from the main and regional forecasting departments. 10 events were thus studied in near operational conditions whereby convection, frontal rain, synoptic wind, maritime fog, gusts and snow were discussed.

The outcome is that AROME-NWC can be useful for forecast ranges under 2 h (the details about the first stages of an event…). The variability of the successive AROME-NWC runs together with the loss of observations from the assimilation of surface observations was upsetting to users and led to AROME-NWC behaving like AROME-FR.

Overview on the recurrent behaviour of models.

Since it became operational, AROME-NWC, like other models, is regularly monitored, with forecasters checking for recurring behaviour. The monitoring aims at pinpointing the erroneous and reproducible behaviours of numerical models. The latest published report deals with a dozen identified troublesome events over the period April-June 2016.

Most feedback is about difficulties encountered by AROME-NWC to readjust to observations (either late or no readjustment). For extreme cases, AROME-NWC fails to improve AROME-FR or even worsen AROME-FR forecasts.

Planned changes

- Specific defects of AROME-FR are transmitted to AROME-NWC
- Apart from the first few hours, AROME-NWC is found to be too close to AROME-FR
- The variability between AROME-NWC runs render its use difficult
- In some cases, difficulties encountered by AROME-NWC in readjusting to observations

In addition to AROME-FR improvements that will benefit AROME-NWC, other avenues are being explored:

Less weight given to observations? (next e-suite)

At the present time, observations are given more importance in the assimilation of AROME-NWC than in that of AROME-FR. Hence, AROME-NWC analyses are closer to observations than those of AROME-FR. To a numerical model, an analysis close to observations is no warranty of good predictions. As a matter of fact, during the assimilation, the closest post-processing has to be to observations, the furthest it may depart from its equilibrium which affects the first predictions of the model. To reduce the nudging coefficient leads to a reduction of the imbalance in the model fields due to the analysis stage, and hence, leads to better forecasts. This modification is currently in the process of validation to be implemented in the next e-suite.

Extension into the past of the observation extraction window

The current AROME-NWC assimilation window takes into account almost only radar and surface observations (essentially in precipitation areas covered by the French network). To increase the number of observed data over the domain and in all weather, it was suggested that the current window should be set to [-20mn;+10mn] so that SEVERI satellite observations, valid at H-15min (those at H being not available with a 10min cut-off), could be assimilated. However, this brought no improvement and will not be implemented in the next e-suite.

Use of a forecast initialised by IAU (Incremental Analysis Update)

For AROME-NWC, as for AROME-FR, hydro-meteor fields cannot be modified during the analysis phase as it takes some time to adjust to the new analysed fields (wind, temp, specific humidity and surface pressure). Therefore, reflectivity fields for the 15 or 30 minutes AROME-NWC forecasts may not be representative of the new state of the model.

The use of IAU, already implemented for AROME-FR, can shorten the adjustment time. IAU shall be used in a slightly different way in AROME-NWC (see boxed text)

Towards a cycled IAU initialised forecast

AROME-NWC is not run in cycle and does not use it own predictions for future predictions for lack of assimilated observations (too short cut-off). Consequently, the AROME-NWC run does not directly benefit from the previous AROME-NWC run modifications.

Cycling IAU in AROME-NWC aims at mixing information from two consecutive cycles in an innovative way, so that a maximum observations can gain control over analyses. Cycling IAU should also reduce the inter-run variability. First results are promising.

Data fusion extrapolation / numerical predictions

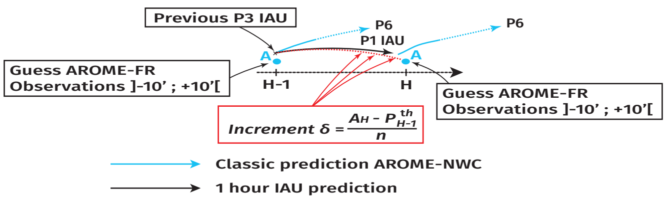
At nowcasting scale, AROME-NWC data are added to conventional ones retrieved from the extrapolation of observations. Thus, the extrapolation of observations and observed situations gets closer about the first hours of the forecast. AROME-NWC fields can remedy known defects of the extrapolation of observations (such as relief areas, no occurrence or disappearance of cells...)

Blending these very different data is an important line of work for the nowcasting department. The aim is to take the best of each method to have the most relevant information in the [0-3h] forecasts.

Several approaches have been investigated. The first method, based on predicted and extrapolated matching cells, was in the end discarded as too complex. The method, developed since June 2016, rests on a so-called "sequential aggregation of predictors" method. This method aims to blend two predictors (in our case the extrapolation of 2PIR and AROME-NWC) so as to get a compound close to, or better than, the best of any of them.

The end product is a weighted sum of numerical prediction fields and of extrapolations. The weights given to each predictor are adjusted in real time according to their recent behaviour in regard to observation.

A first merger version between extrapolation and numerical prediction of rainfall (with time step 5') has been produced since December 2016. It will be tested and improved during 2017. A fusion of reflectivities will also be implemented in 2017.



IAU at a glance

In AROME-FR, IAU is used to shift the first 1h prediction closer to the following run prediction by the addition by fraction of the (δ) analysis increment at each time-step.

For AROME-NWC, the idea is to take as a starting point of the prediction the result of a 1h prediction of the previous run, modified by IAU to get closer to the analysis of the run of the hour H.