The NWP systems at Météo-France

ARPEGE-ALADIN-AROME op. suites

CY42-op2, operational since December 5, 2017 :
ARPEGE-oper: Tl1198 with a stretching factor of 2.2 and 105 levels. First level at 10m. This gives a resolution of 7.5km over France. The time step is 360s. The 4DVAR operational suite uses 2 outer loops. The first one is 40 iterations at T149 C=1 with a time step of 1350s, the second one 40 iterations at T399 C=1 with a time step of 900s.
AROME-oper : 1.3km L90 (1440x1536x90 grid), with dt=50s, Hourly 3DVAR RUC, +48h forecasts, revised clouds optical properties, modified auto-conversion threshold, wind gusts tuning, new post processed domains...

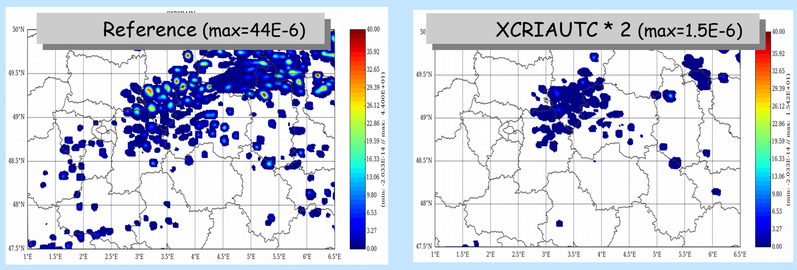
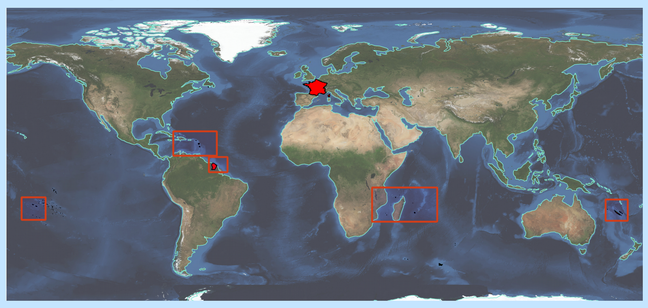


Figure 1: S070RAIN (2015-12-02 +02TU) with modified autoconversion threshold which prevents radar reflectivities assimilation to dry out the atmosphere

AROME Overseas

Characteristics: in operation since Feb. 11, 2016, upgrade in Dec. 2017

Figure 2: operational AROME overseas domains



Domains spread all along the Tropical belt (Fig.2), focused on the point of interests (2.5 millions inhabitants, 115000km2), with a 2.5km resolution, all the more important for small and rugged islands (cf. Fig. 3 for added value of Arome for heavy rain).
Downscaling from ECMWF HRES for atmosphere, ARPEGE for continental surfaces, Mercator-Ocean global model for Sea Surface Temperature.
Explicit deep-convection, ICE3 micro-physics, interactive coupling with a 1D ocean model, initial conditions from a previous run + IAU algorithm in order to reduce spin up.

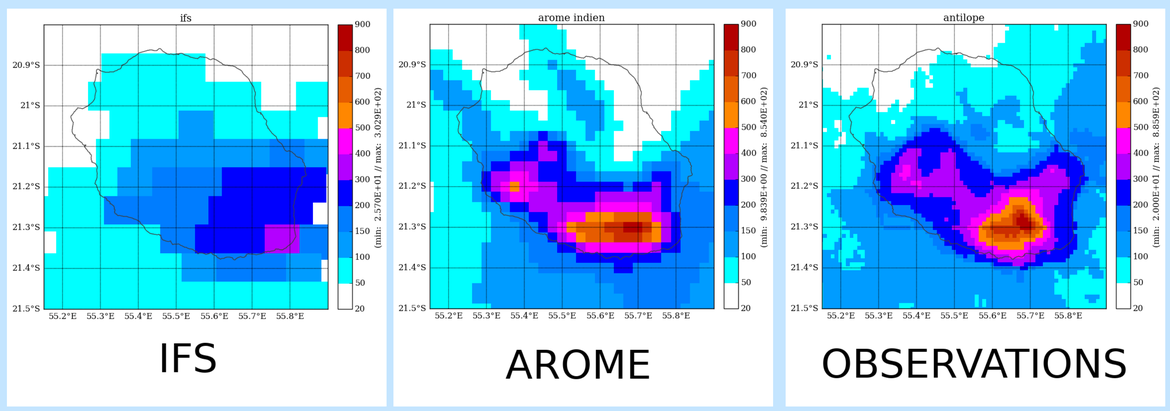


Figure 3 : 24h rainfall of Arome and IFS compared to observations (radar + rain-gauges). Period: 20180117 12Z -> 20180118 12Z ; runs issued on the 20180117 12Z

See also ALADIN-HIRLAM Newsletter n°10, Jan.2018, Forecasting the tropical cyclones IRMA and Maria with AROME-Antilles, G. Faure & C. Fischer

AROME-NWC: a high resolution model for nowcasting

See ALADIN-HIRLAM Newsletter n°9, Sep.2017, AROME for Nowcasting, N. Merlet et al

AROME-NWC general characteristics (operational since December 8, 2015)

- implemented in December 2015 and available to forecasters since March 2016
- 1 run every hour, up to 6 hour range, with outputs every 15 minutes
- 1,3 km resolution, 50 s time step, 90 levels
- 3D-VAR assimilation, with 10 minute cut-off time (window [-10 min, +10 min])
- guess from AROME-France, similar model with 30 minute cut-off time
- boundary conditions from the ARPEGE global model
- delivery 20 minutes after cut-off time
- designed mainly for surface condition forecasting (rainfall, snow, fog, gusts, humidity and cloudiness)

This very high rate of production makes a systematic use of the outputs difficult. Therefore a scoreboard helps the forecasters: for a selection of parameters, it shows different colours corresponding to different levels of warning and helps to look at the forecasts only when useful. For a given date, several forecasts started from different initial dates are available. Then the forecaster is able to look at different solutions given by the model for this given date, which can be seen as a "poor man ensemble forecast".

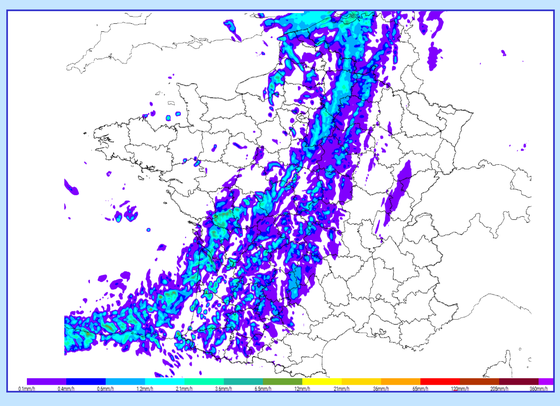
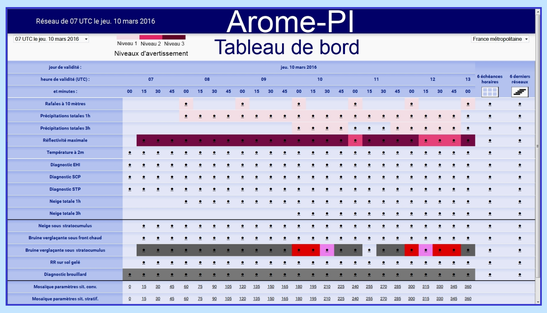


Figure 4: 5 hour forecast of the maximum reflectivity with AROME-PI for the 28th November 2015 at 00.15 UTC

Figure 5: The scoreboard proposed to the forecasters for a quick look at the most critical parameters of the current forecast



PEARP : MF short-range E.P.S.

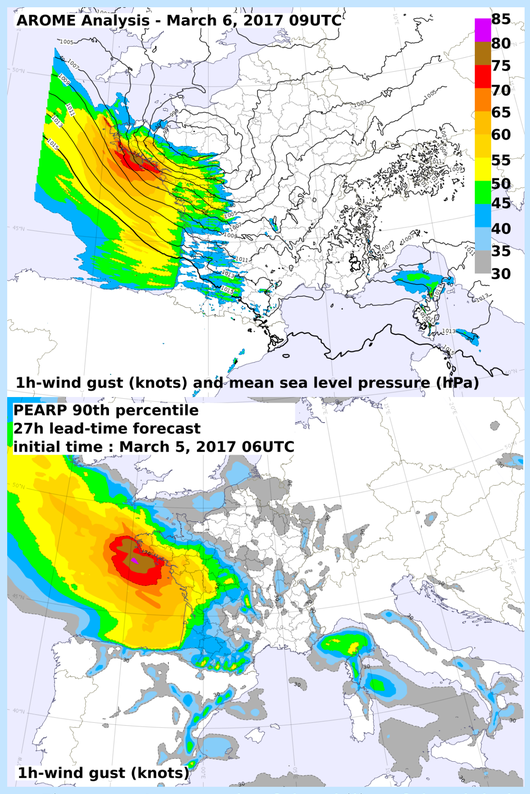


Figure 6 : An example of the ability of the global mesoscale hydrostatic ensemble system PEARP to capture an extreme storm event over France.

Implemented in MF since 2004

Global ensemble performing forecasts up to 4.5 days, running at 00(+48h), 06(+90h), 12 (+48h) & 18(+108h) UTC

Uses the operational global NWP model ARPEGE and benefits from its **variable horizontal resolution** (~10km over France, 60km on the opposite side of the globe)

35 members (including the control member)
* Perturbations to the initial conditions are computed by combining 25 background states and the mean from **MF Ensemble Data Assimilation** (**AEARP, Berre et al. 2007**) with **singular vectors**
* Model error is represented by a set of 10 different physical packages including that of operational ARPEGE model

Ref: Descamps L., Labadie C., Bazile E., Joly A., Arbogast P., Cébron P., 2014. PEARP, the Météo-France short-range ensemble prediction system, QJRMS

AROME-FRANCE Ensemble Prediction System

The configuration (operational production since October 2016):
Based on the deterministic AROME-France model with a 2.5km horizontal resolution (1.3km in AROME-France) and 90 vertical levels. Runs twice a day, at 09 and 21 UTC, to provide forecasts up to a 45h range.

AROME-EPS is a 12-member ensemble, designed in order to account for the main sources of uncertainty : **Perturbed Lateral Boundary Conditions (LBCs)** are provided by members from the lastest PEARP production, selected with a clustering technique; **Initial Conditions (ICs)** are build by adding to the AROME deterministic analysis the downscaled 3h forecast perturbations of the selected PEARP members; **Model error contributions** are represented with a stochastic physics approach using the SPPT scheme, that simulates the effect of random errors due to the physical parametrizations; **Random perturbations** are added to various parameters of the SURFEX surface scheme, including sea surface temperature, soil moisture and temperature.

Applications : choice of best model by human forecasters, decision aid for severe weather events (e.g. heavy precipitation, convection, gusts, winter conditions), probabilistic weather forecasts, forcing of flood models, air traffic management.

Recent research results : Use of ensemble data assimilation (EDA) for initial perturbations or cheaper alternative (to add small-scale random noise to the initial conditions) leads to large improvement over the simple downscaling from a larger-scale ensemble; - Comparison of ensemble resolution and size impacts indicates a larger impact of adding more members, especially as lead time (and uncertainty) increases.

Post-processing of ensemble outputs clearly needed to improve the value of EPS : The introduction of a tolerance in space and time when computing the precipitation probabilities improves the forecast scores, by filtering small-scale noise and increasing the apparent ensemble size; Object-based processing of quantitative precipitation forecasts may be useful to extract the signal at a larger, and more predictable, scale; The prediction of extreme weather events could benefit from an Extreme Forecast Index (EFI) calculation, even though the model climate is computed from a small operational archive.

Future works : Initial coupling to the AROME-EDA planned to become operational in 2018; New version of the clustering technique planned in 2018; Combination of lagged EPS productions with objective weighting; Work to be started on stochastic parameter perturbations.

See ALADIN-HIRLAM Newsletter n°8, Jan.2017, AROME-France convection-permitting EPS, F. Bouttier et al

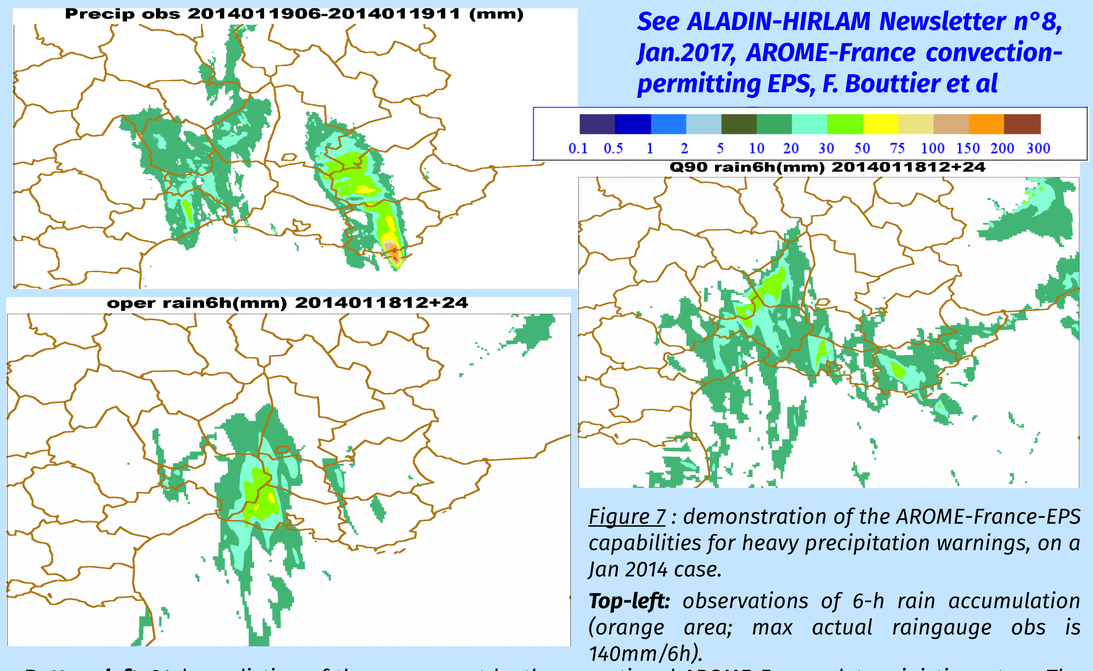


Figure 7 : demonstration of the AROME-France-EPS capabilities for heavy precipitation warnings, on a Jan 2014 case.

Top-left: *observations of 6-h rain accumulation (orange area; max actual raingauge obs is 140mm/6h).*

Bottom-left*: 24-h prediction of the same event by the operational AROME-France deterministic system. The heavy precipitation zone is misplaced.*

Right: *24-h AROME-France-EPS prediction of the 90% quantile of the rain PDF: underestimated intensity but risk of severe precipitation over Var much better indicated than in AROME-France and more consistent AROME-France-EPS forecasts in time.*

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