The NWP systems at Météo-France

MF global deterministic model : ARPEGE

CY42-op2, operational since December 5, 2017 :
Tl1198 with c=2.2 and 105 levels.
This gives a resolution of 7.5 km over France and 37 km at the antipode. The time step is 360s. The 4DVAR uses 2 outer loops. The first one is 40 iterations at T149 C=1 with a time step of 1350s, the second one is 40 iterations at T399 C=1 with a time step of 900s.

Next e-suite CY43t2-op1, to be operational beginning of 2019 :
Tl1798 with c=2.2 and 105 levels.
This gives a resolution of 5km over France and 25 km at the antipode. The time step is 240s. The 4DVAR uses 2 outer loops. The first one is 40 iterations at T224 C=1 with a time step of 1200s, the second one is 40 iterations at T499 C=1 with a time step of 720s. The main scientific evolutions are :
* Modification of the numerical diffusion to avoid a cold bias in the stratosphere,
* New version of the anti Grid Point Storm (GPS): with this new version there is less GPS in the Tl1798 than in the operational Tl1198,
* Use of version 8 of the external surface scheme SURFEX.

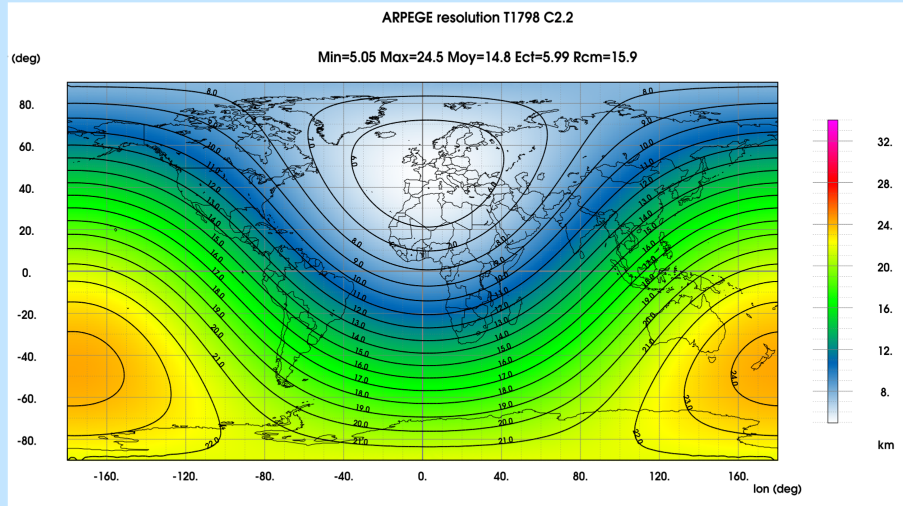


Figure 1: ARPEGE future resolution

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

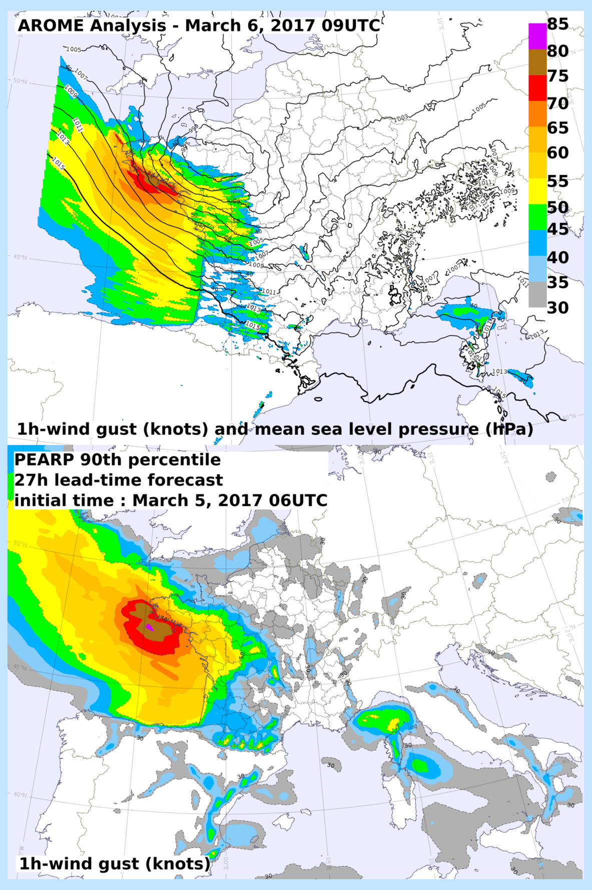


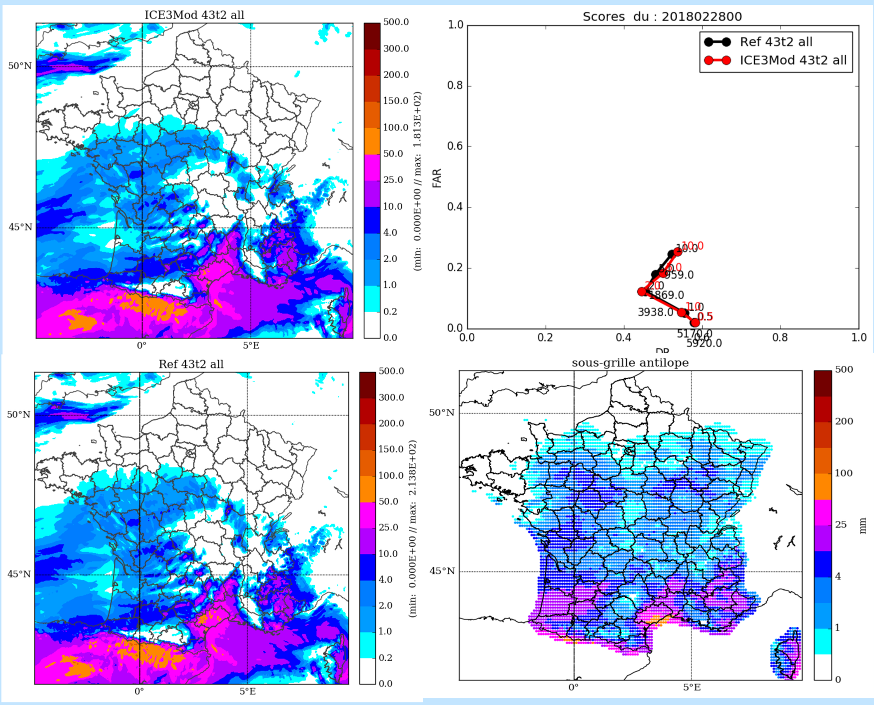
Figure 2 : An example of the ability of the global mesoscale hydrostatic ensemble system PEARP to capture an extreme storm event over France.

* **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 (ARPEGE EDA or AEARP)** with **singular vectors.**
  - Model error is represented by a set of 10 different physical packages including that of operational ARPEGE model.
* **New resolution for PEARP,** to be operational next winter : T1198 C=2.2 which gives a resolution around 7.5 kilometres over France and 37 kilometres at the antipode.

Ref: Descamps L. et al., 2014. PEARP, the Météo-France short-range ensemble prediction system, QJRMS

AROME-France deterministic model

CY42-op2, operational since December 5, 2017 :
AROME-France : 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…
CY43t2-op1, to be operational next winter :
AROME-France : New version of ICE3, MESCAN and T2m_Isba in surface analyses, visibility, surface precipitation type, …



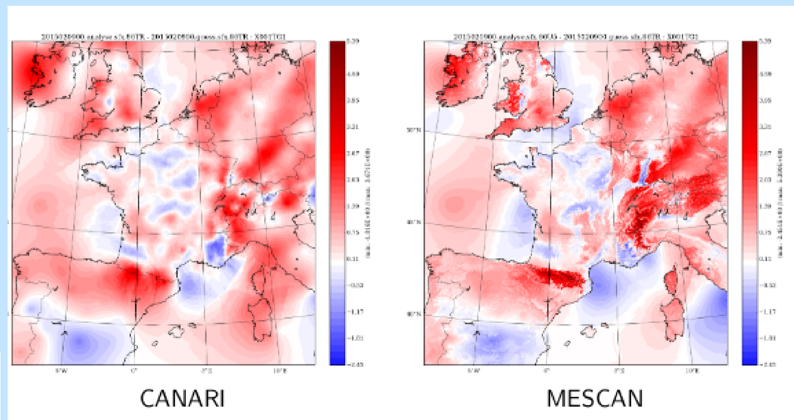


Figure 3: Surface temperature increment : impact of MESCAN structure functions in surface analyses

Figure 4: New version of ICE3 Microphysics (less time step sensitive, less graupels…)

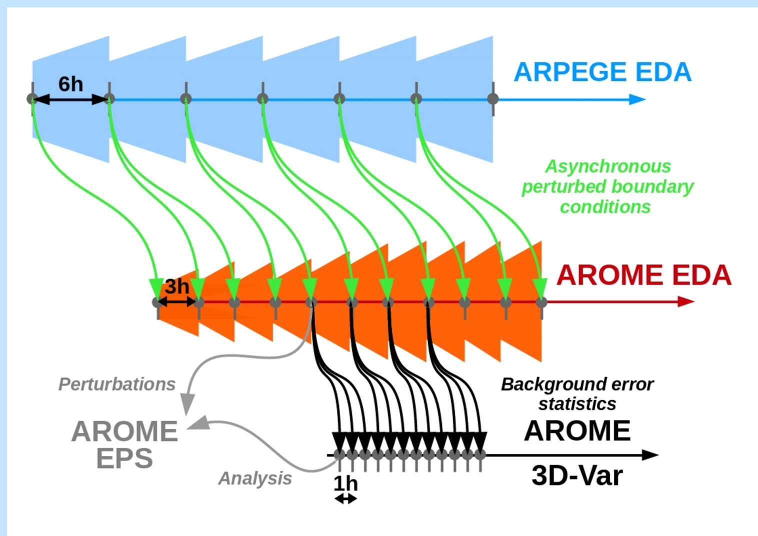
AROME-France Ensemble Data Assimilation

CY42-op3, operational since July 10th, 2018

The **AROME-France EDA** provides an ensemble of analyses and short-range forecasts to :
- initialize the **AROME-France Ensemble Prediction System**, in operations since July 2018
- provide flow-dependent background error variances to the AROME-France 3D-Var, proposed for the next e-suite at MF (2018-2019).

The implementation of the AROME-France EDA relies on 25 members of stochastic 3DVars that are performed at a reduced spatial resolution of 3.25 km to reduce the computational cost.

Figure 5: links between the global ensemble data assimilation (ARPEGE EDA), AROME-France Ensemble Data Assimilation (AROME-France EDA), AROME-France 3D-Var



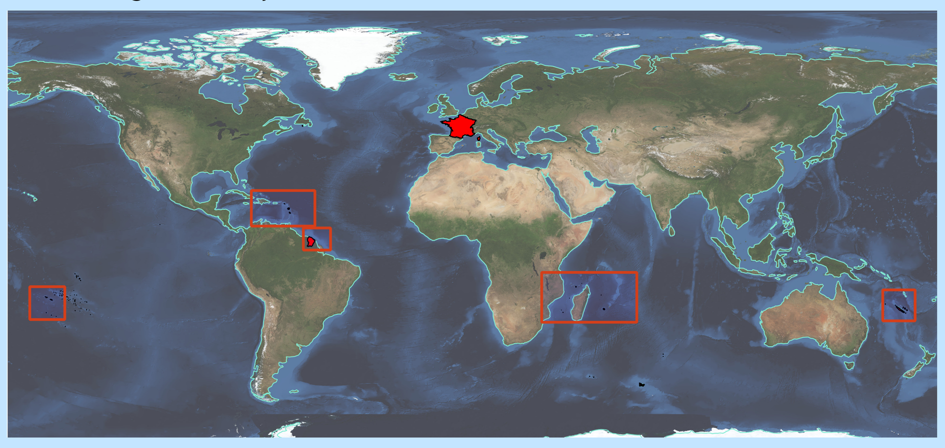
Ref: Raynaud, L. and F. Bouttier, 2016. Comparison of initial perturbation methods for ensemble prediction at convective scale, QJRMS

AROME Overseas

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

Domains spread all along the Tropical belt (Fig.6), with a 2.5km resolution, all the more important for small and rugged islands (cf. Fig. 7 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 6: operational AROME overseas domains



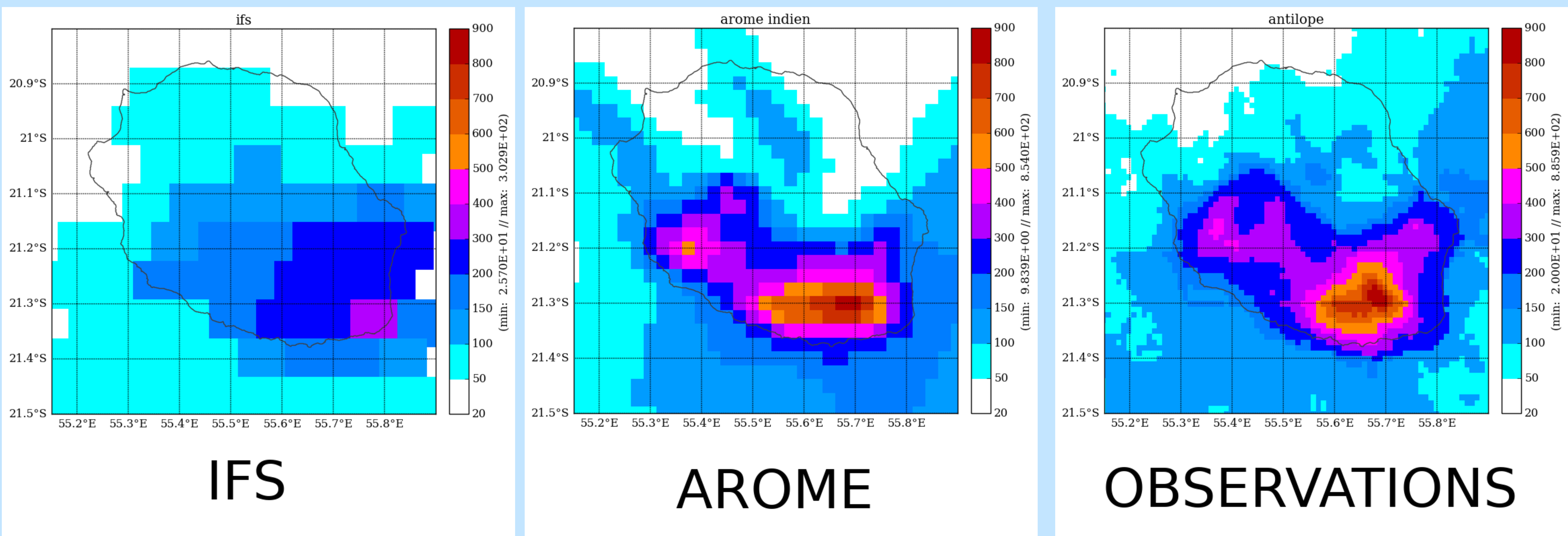


Figure 7 : 24h rainfall of Arome and IFS compared to observations (radar + rain-gauges). Period: 20180117 12Z -> 20180118 12Z ; runs issued on the 20180117 12Z

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: high resolution model for nowcasting

operational since December 8, 2015

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

AROME-France E.P.S.

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 at 03, 09, 15 and 21 UTC, to provide forecasts up to a 45/51h range.
AROME-France 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 (revised in 2018); **Initial Conditions (ICs)** are build by adding to the AROME deterministic analysis **perturbations from the AROME-France EDA**; **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 : Increase of the ensemble size to 16 members planned by the end of 2018; Combination of lagged EPS productions with objective weighting; Object-based processing to be extended to other variables (e.g., cloudiness, wind gusts); Investigation of deep learning methods to extract a relevant information from the ensemble; Work to be started on stochastic parameter perturbations. .

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

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