The NWP systems at Météo-France

26th ALADIN Wk & HIRLAM ASM 2016, Lisbon, 4-7 April 2016

ARPEGE-ALADIN-AROME suites

ARPEGE-oper in CY41t1-op1(operational since December 8, 2015) : T1198 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.

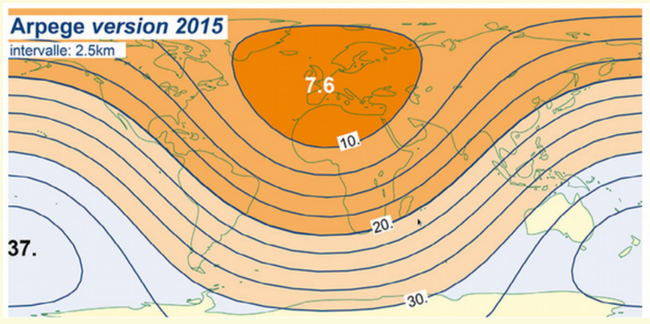


Figure 1 : Forecast resolution : T798C2.4L90 (~10km over France, 60km on the opposite side of the globe)

	Standard Height (km)	Aro90	Arp105	Ifs137
Surface boundary layer	0 - 0.15	**7**	**6**	6
Planetary boundary layer	0.15 - 1.5	**21**	**18**	18
Free troposphere	1.5 – 8.0	**38**	**26**	26
Tropopause	8.0 – 15.0	**16**	**24**	24
Stratosphere	15.0 – 50.0	**8**	**27**	51
Mesosphere	50.0 – 80.0+	**0**	**4**	12

Table 1 : Vertical resolutions of ARPEGE, AROME and IFS

ARPEGE E-suite in CY42_op1 (summer 2016) : main expected changes (still under evaluation) :
- Use of the externalized surface scheme SURFEX in ARPEGE
- New deep convection scheme PCMT (Prognostic Convection Microphysics and Transport)

Figure 2 : Surface temperature from ARPEGE-SURFEX

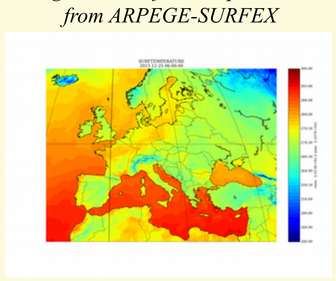


Figure 3 : Deep ground water from ARPEGE-SURFEX

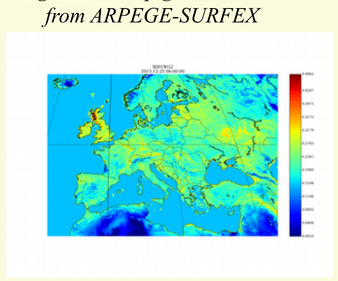
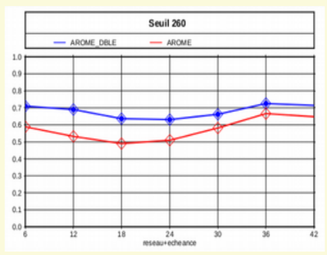


Figure 4 : ISP from AROME Brier skill score (Oct-Nov 2015) CY40_op/CY41T1_op



AROME-oper in CY41T1_op1 (Dec 2015) : 1.3km L90 (1440x1536x90 grid), with dt=50s :
- Include ORORAD (slopes, shadows) effects on SW radiation based on Senkova et al. (2007)
- Reduce radar data thinning from 15km to 8km (both reflectivities and Doppler winds)

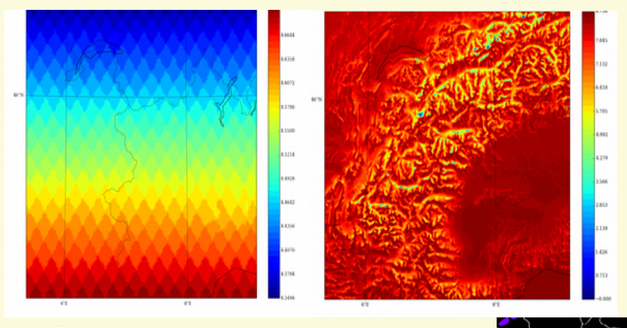
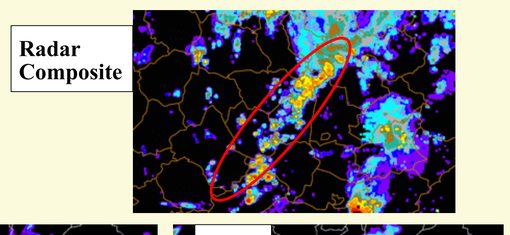


Figure 6 : Sunshine time duration over the French Alps on 2013/12/12 (left) : 40_op (values ranging from 8h21 to 8h42), (right) : 41T1_op (values from 0 to 8h42)

Figure 5 : 9h - Arome forecast valid for the 2014/09/19 at 09 TU: reflectivity field at 700 hPa for both Arome model images (bottom)



AROME-PI: a high resolution model for nowcasting

AROME-PI 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 25 minutes after cut-off time
- designed mainly for surface condition forecasting (rainfall, snow, fog, gusts, humidity and cloudiness)

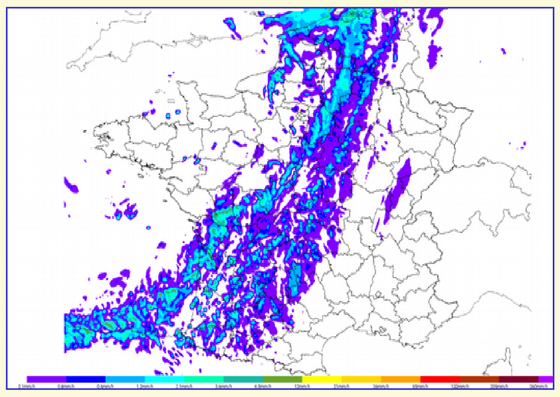


Figure 7: 5 hour forecast of the maximum reflectivity with AROME-PI for the 28th November 2015 at 00.15 UTC

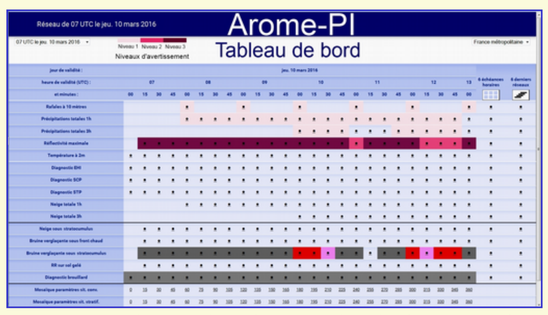
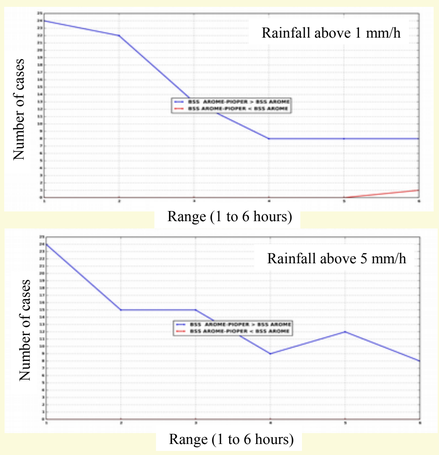


Figure 8: The scoreboard proposed to the forecasters for a quick look at the most critical parameters of the current forecast

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".

Figure9: From the 30th August 2015 to the 7th December 2015, the classical AROME-France with longer cut-off (from 15 minutes to 3 hours) and later time delivery (from 1 to 4 hours after initial time) has been compared to AROME-PI.
Based on the Brier Skill Score, the blue curve shows the number of cases when AROME-PI produces a significantly better rainfall forecast than AROME-France and the red curve when AROME-France produces a significantly better forecast than AROME-PI. Top figure for rainfall above 1 mm/h and bottom figure for rainfall above 5 mm/h.
One "case" corresponds to one given hour in the day. Therefore, there are 24 possible cases (00 UTC, 01 UTC, ... 23 UTC).
The impact of the most recent radar data is clearly positive on the forecast during spring 2015. The quality of the two models converges after 4 hour range.



AROME Overseas

Characteristics :
- Domains spread all along the Tropical belt (Fig.10)
  => more focused, than the Current ALADIN domains, on the point of interests : 2.5 millions inhabitants, 115 000 km2
- 2.5km resolution
  => all the more important for small and rugged islands (Fig. 11)
- total number of grid-points multiplied by 3 for a cost 30 times higher (with 60s time step).
- Explicit deep-convection, ICE3 micro-physics
- **In operation since February 11, 2016**

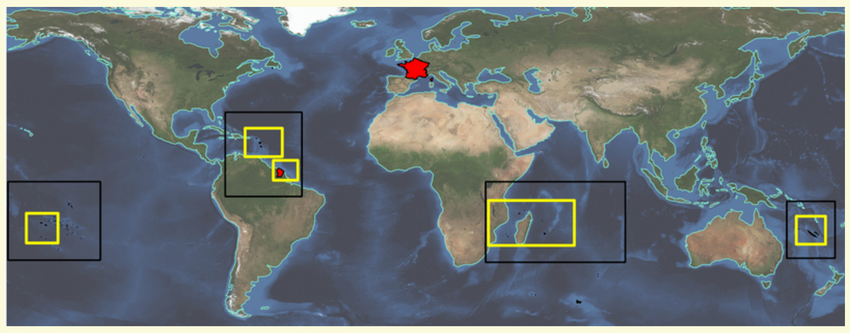
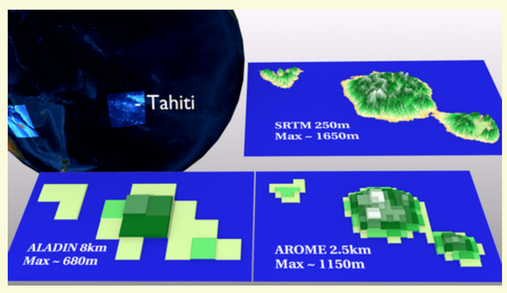


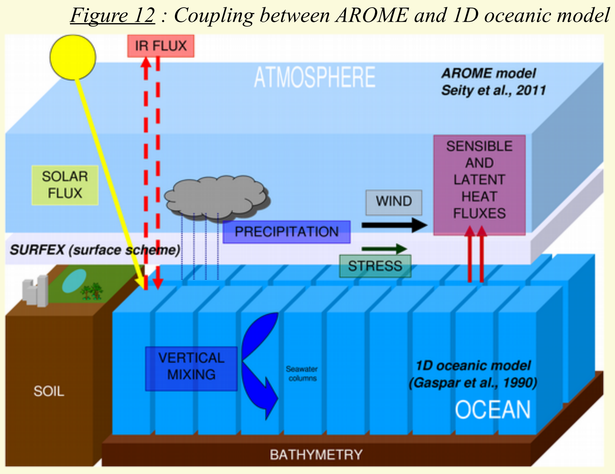
Figure 10 : AROME overseas domains (in yellow) and operational ALADIN domains (in black)

Figure 11 : Tahiti orography (in ALADIN and in AROME)



Specificities :
- **Ocean is preponderant**
- Many **tropical cyclones**
  => need for an ocean coupling
- First tests with 1D Ocean Model (Fig. 12)
  => promising results on Bejisa case (Fig. 13)

Figure 12 : Coupling between AROME and 1D oceanic model



Added value of AROME for heavy rain events

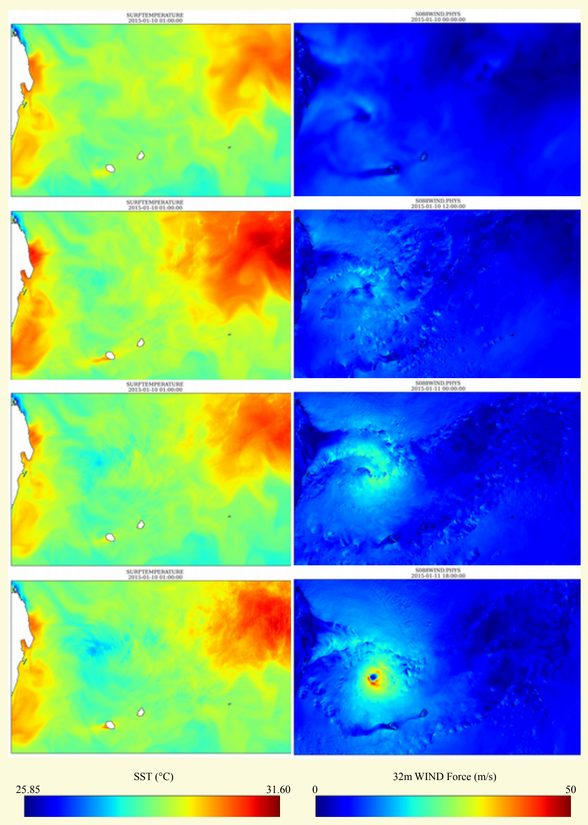


Figure 13 : AROME over Indian Ocean, Tropical Cyclone Bejisa, AROME +42h forecast based on 2013/12/31 0h run Initial ocean fields : Mercator-Ocean PSY4 model, 1/12°

AROME-FRANCE Ensemble Prediction System

The configuration (production will start in 2016):
- same model as the deterministic L90 AROME-France suite, except for the horizontal resolution (2.5km in the ensemble, 1.3km in AROME-France).
- 12 members at up to 45-h range.

Ensemble perturbations : clustered boundary conditions from the PEARP global ensemble, centered PEARP initial perturbations, SPPT stochastic model perturbations, comprehensive surface perturbations.

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:

Extensive validation using HyMeX SOP1 data shows that it not important to have consistent initial and lateral boundary perturbations => use of ensemble data assimilation (EDA) for initial perturbations or cheaper alternative (to add small-scale random noise to the initial conditions) with improvment over the simple downscaling from a larger-scale ensemble.

Surface perturbations improve the ensemble performance; explicit surface perturbations are necessary.

Spatial correlations of ensemble forecasts are highly sensitive to the correlations of surface perturbations, at low levels. The correlation sensitivity to SPPT correlation structures, or to correlations in the initial perturbations, seems to be negligible after a few hours.

The introduction of a **tolerance in space and time** when computing the precipitation probabilities, can be proven to improve the forecast scores, by filtering small-scale noise and increasing the apparent ensemble size.

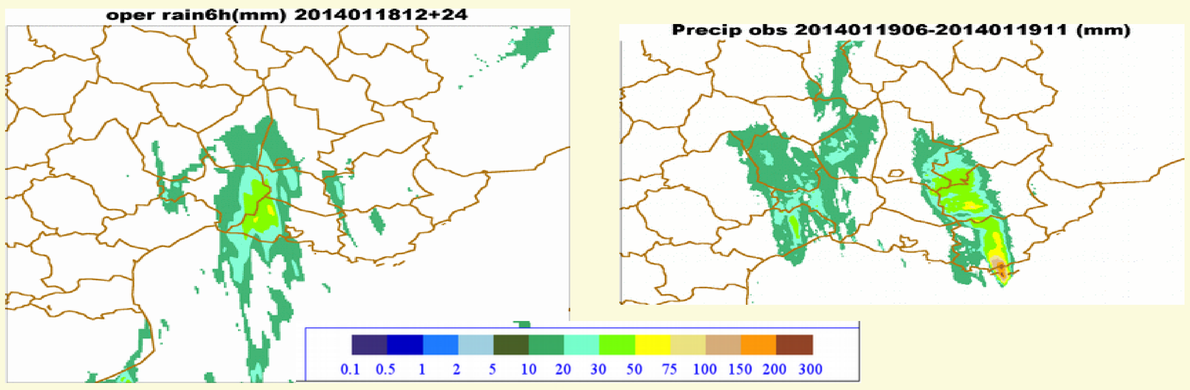


Figure 14 : demonstration of the AROME-France-EPS capabilities for heavy precipitation warnings, on a Jan 2014 case.
***Top right:** observations of 6-h rain accumulation (orange area; max actual raingauge obs is 140mm/6h).*
***Top left**:24-h prediction of the same event by the operational AROME-France deterministic system. The heavy precipitation zone is misplaced.*
***Bottom left:** 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.*