36th EWGLAM & 21st SRNWP meetings
Offenbach, 29 September – 2 October 2014

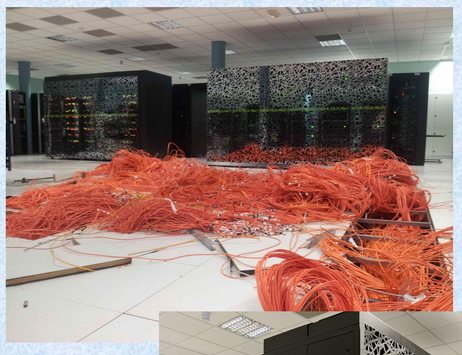
# THE NWP SYSTEMS AT METEO-FRANCE

with contributions from the CNRM/GMAP staff
Météo-France

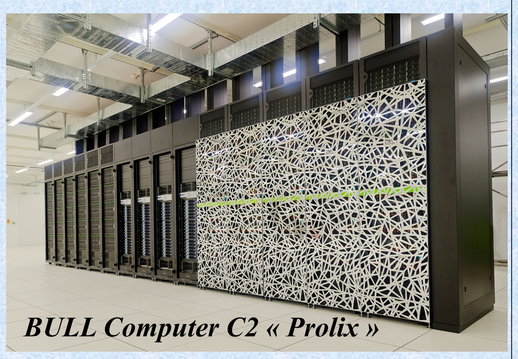
METEO FRANCE

cnrs

## New HPC at MF



*From NEC to BULL Computer C1 « Beaufix »*

*BULL Computer C2 « Prolix »*

**522 TFlops** peak performance
56 racks **bullx DLC**
1008 nodes
Fat Tree InfiniBand FDR
Lustre **2 Po, 69 GB/s**
Disks storage 209 TB

***Computer C1 (09/2013)***

**Operational & research platform since January 14, 2014**

Centre National de Calcul Météopole, Toulouse

**2,85 PFlops** peak performance
56+45 racks **bullx DLC**
1800 nodes
Fat Tree InfiniBand FDR
Lustre **3,57 Po, 138 GB/s**
Disks storage 400 TB

***Computer C3 (05/2016)***

Research

2014 2015 2016

Operational

Espace Clément Ader Montaudran

**513 TFlops** peak performance
55 racks **bullx DLC**
990 nodes
Fat Tree InfiniBand FDR
Lustre **1,53 Po, 46 GB/s**
Disks storage 135 TB

***Computer C2 (03/2014)***

**Operational & research platform since April 23, 2014**

**2,85 PFlops** peak performance
55+45 racks **bullx DLC**
1800 nodes
Fat Tree InfiniBand FDR
Lustre **2,55 Po, 92 GB/s**
Disks storage 135 TB

***Computer C4 (11/2015)***

## *ARPEGE-ALADIN-AROME experimental suite*

**CY40-op1 High Resolution ARPEGE-AROME configurations (switch to oper expected in the beginning of 2015) :**

• **ARPEGE** : T1198 with a stretching factor of 2.2 and 105 levels. First level at 10m (17m in present operational configuration). This gives a resolution of 7.5km over France. The proposed time step is 360s.
The 4DVAR experimental suite will use 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.

| | Standard Height (km) | Arp70 | **Arp105** | Ifs137 |
|---|---|---|---|---|
| Surface boundary layer | 0 - 0.15 | 3 | **6** | 6 |
| Planetary boundary layer | 0.15 - 1.5 | 11 | **18** | 18 |
| Free troposphere | 1.5 – 8.0 | 19 | **26** | 26 |
| Tropopause | 8.0 – 15.0 | 15 | **24** | 24 |
| Stratosphere | 15.0 – 50.0 | 19 | **27** | 51 |
| Mesophere | 50.0 – 80.0+ | 3 | **4** | 12 |

*Figure 1 : Vertical resolutions of ARPEGE oper, new and IFS*

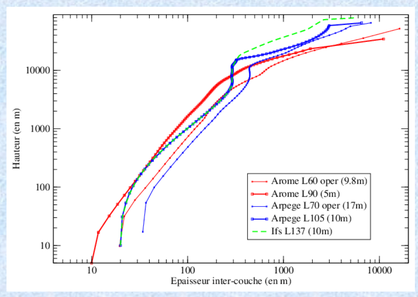



*Figure 2 : Layer thickness of AROME, ARPEGE and IFS*

• A new version of **AEARP** is also in test with 25 members, a resolution of T479 C=1 and a time step of 720s :

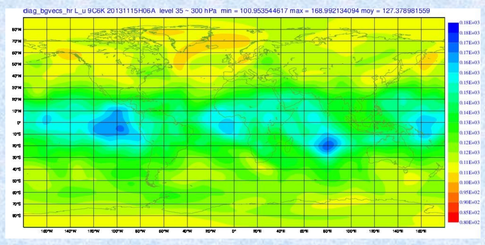


*Figure 3 : Wavelet B, 6 members, 4 day average, updated every 24h (operationnal)*

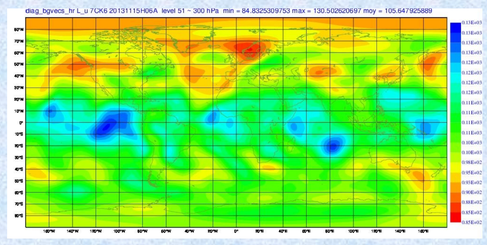


*Figure 4 : Wavelet B, 25 members, 1.5 day average, updated every 6h (experimental)*

•**AROME** :1,3km L90 (1440x1536x90 grid), with dt=45s ( PC iterative scheme used)
•Dynamics and physics modified choices (SLHD_new, COMAD, SBL scheme off)
•Data assimilation part (B calculation, 1 h cycle with Incremental Analyses Update)
•Improvements on convective cells realism (number, size, life time, intensity).
•also on scores : positive convective rainfall bias significantly reduced.

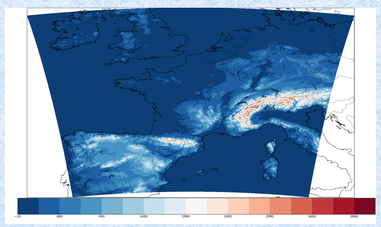


*Figure 5 : AROME 1,3km orography from GMTED 250m*

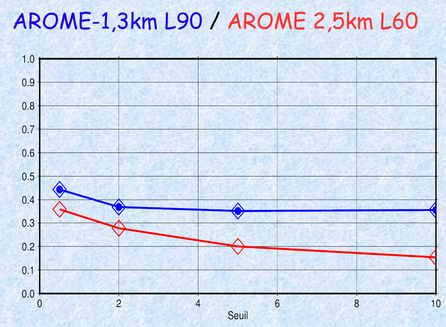



*Figure 6: Brier Skill Scores of 6h cumulated rainfalls with a neighbourhood of 20km, as a function of precipitation thresholds (>0,2>2,>5 and >10 mm/6h), for 18 TU. 31 forecasts starting at 3 TU in July 2013 used. Blue dots indicates statistically significant differences.*

## *AROME Ensemble Prediction system*

**The configuration :**

A high-resolution ensemble prediction system is being prepared for operational use (production will start in 2016).The model is the same as in the deterministic L90 AROME-France suite, except for the horizontal resolution (2.5km in the ensemble, 1.3km in AROME-France). There will be 12 members at up to 48-h range.

**Ensemble perturbations** come from: clustered boundary conditions from the PEARP global ensemble, centered PEARP initial perturbations, SPPT stochastic model perturbations, comprehensive surface perturbations. **Applications** being developed include: 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 (Sept-Nov 2012) proves that AROME-EPS beats PEARP and AROME-France for usual weather parameters, according to most measures of ensemble performance. HyMeX data allows verifying higher precipitation events than would be possible with routinely available observations.

**Economic Value** scores shows the relative value of AROME-EPS is best for higher precipitation thresholds.

**Surface perturbations** improve the ensemble performance; most of this improvement comes from perturbing soil moisture, soil temperature, and SST.

The **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.

**Intercomparison of AROME EPS with UK-MOGREPS and COSMO-DE-EPS** reveals these systems have similar performance for most weather parameters, and that combining these ensembles produces a **superensemble** that beats all contributors in the model overlap zones.

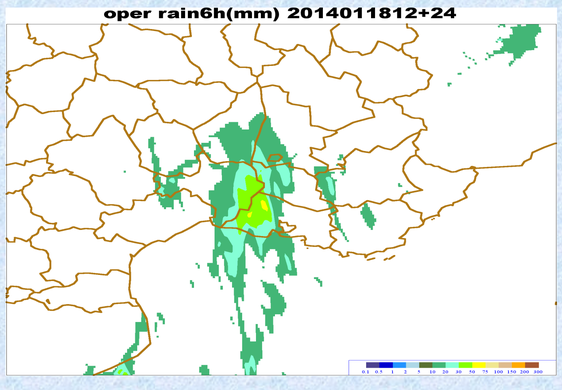



*Figure 7: demonstration of the AROME-EPS capabilities for heavy precipitation warnings, on a Jan 2014 case.*

***Top right:*** *observations of 6-h rain accumulation, which resulted in catastrophic flooding in the Var area (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 (it was better in previous and future forecasts).*

***Bottom left:*** *24-h AROME-EPS prediction of the 90% quantile of the rain PDF. Although the intensity is underestimated, the risk of severe precipitation over Var is much better indicated than in AROME-France. Besides, the AROME-EPS forecasts are more consistent in time, which may have helped the real-time forecasting decision process.*

## *Nowcasting activities at Météo-France*

**AROME-NWC :**

A new nowcasting configuration based on the meso-scale model AROME-FRANCE has been set up. The goal is to cover the nowcasting short time ranges 0-6 hour with an analysis using the most recent observations followed by a forecast. In spite of the short cut-off time (10 minutes) a majority of observations relevant for nowcasting are available, the radiosondings and gps obsevations are completely missing,but the impact on the overall system performance is small. The hourly forecasts are not cycled (Figure 8), that ensures less spin-up and a better resilience of the overall system. The system performs better compared to AROME-FRANCE mostly because the use of more recent observations (see Figure 9 for rain scores).

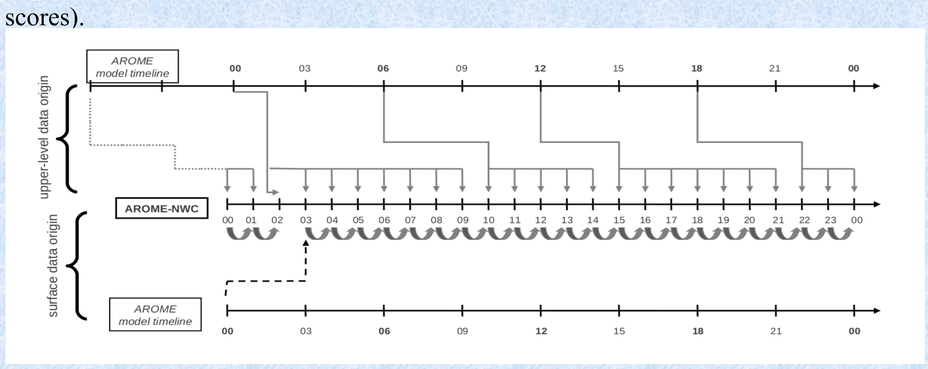



*Figure 8: Operational AROME-NWC system architecture*

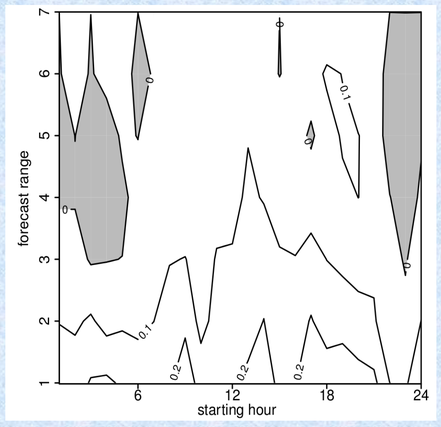



*Figure 9: Brier Skill Score for 1 hour rainfall accumulation, the difference between the AROME forecast and the AROME-NWC forecast as a function of the analysis time of the AROME-NWC forecasts (X-axis) and of the forecast range (Y-axis) is shown.*

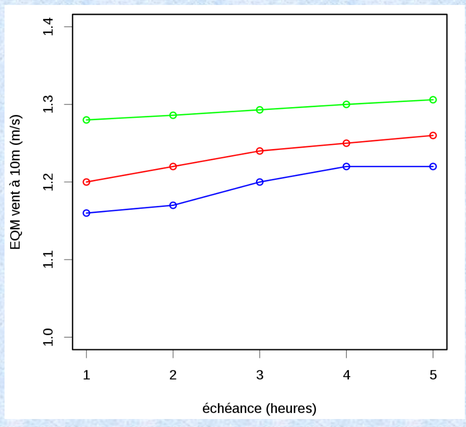



*Figure 10: RMSE of wind force for a) AROME-France (green) b) AROME-airport on the large domain at 2.5 km (red) and c) AROME-airport at 500m resolution. X-axis is the forecast range in hours.*

AROME-airport configuration :

A new configuration, AROME-airport has been set up. It is a 500m dynamical adaptation of AROME-NWC on strategic areas such as airports. If needed some dedicated observations can be included in the preceeding AROME-NWC analysis. The usefulness of such forecasts has been assessed during an observation campaign during which additional wind profilers were proven to have some impact (Figure 10).

**Conclusion :**

Nowcasting NWP configurations at Météo-France provide the best solution for lead times 2– 6 hour filling the gap between the observations extrapolations tools and the mesoscale system AROME-FRANCE. Those systems are basically the AROME-FRANCE configuration used with a very short cut-off, the increased forecast skills are mostly due to the use of more recent observations.