NWP Activities at the AEMET (Spain)

36th EWGLAM & 21th SRNWP Meetings, 29th Sep./2nd Oct. 2014 Offenbach, Germany

MINISTERIO DE AGRICULTURA, ALIMENTACIÓN Y MEDIO AMBIENTE

AEMet Agencia Estatal de Meteorología

HARMONIE/AROME SUITE

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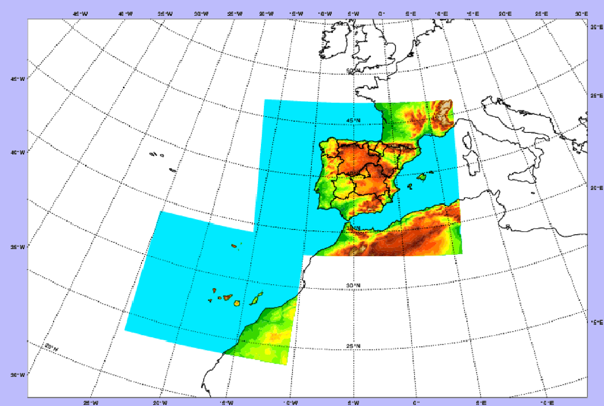
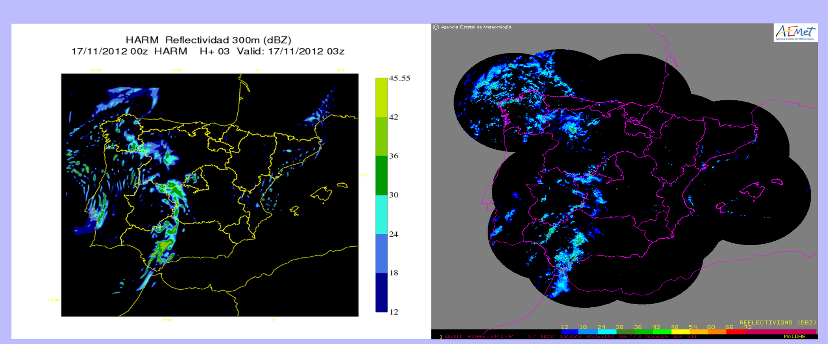
OPERATIONAL CONFIGURATION

- HARMONIE system in **AROME configuration** is run at ECMWF 4 times per day with a forecast length of 48 hours for 2 geographical domains (Iberia and Canary Islands).
- Model set up baed on Cycle 38h1.1 :
  - **2.5 km resolution 65 Levels**
  - ALADIN **NH dynamics**
  - **Blending with** ECMWF **H+6** forecasts to **initialize upper air fields**. This increase a little the spin up in the first 6 hours.
  - Only **analysis of surface fields**. This allows a short cut off time (1/2 hour) and an early delivery of the forecasts.
  - Boundaries: Direct nesting in ECMWF forecasts
  - Surface processes using **SURFEX** (ISBA tiling)
  - Unified **scheme shallow convection** (EDMFM)
  - **Explicit deep convection**
  - **ICE-3 microphysics** with 3 prognostic precipitation species



Operational domains at 2.5 km resolution

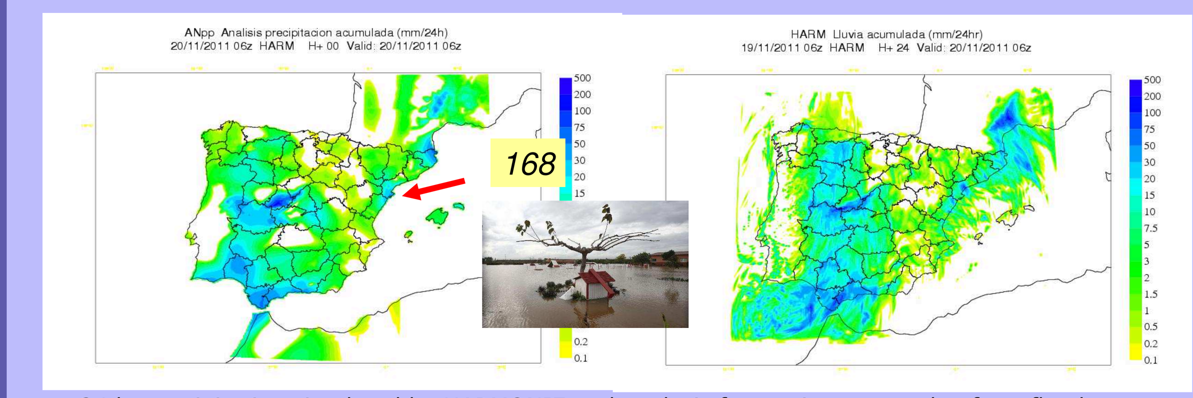


HARMONIE 2.5km — RADAR

Simulated reflectivities compared to RADAR observation in a case of clear dynamical forcing

RESULTS

- **Clear added value of HARMONIE/AROME** on **near surface variables** compared with models of larger scale (HIRLAM and ECMWF)
- **Improvement of wind forecasts** which have been successfully used for sailing forecasts.
- **Clear improvement of fog forecast** but with many false alarms. Work on progress to improve fog and low clouds in the model.
- **Significant improvement of precipitation forecasts** including spatial distribution and amount of precipitation but revealing uncertainty in the prediction of small scales suggesting the need of ensemble approaches.
- **Operational forecasters** and **other users** are **increasingly using the model**. Currently in the processes of migrating the applications and postprocesing from HIRLAM to HARMONIE

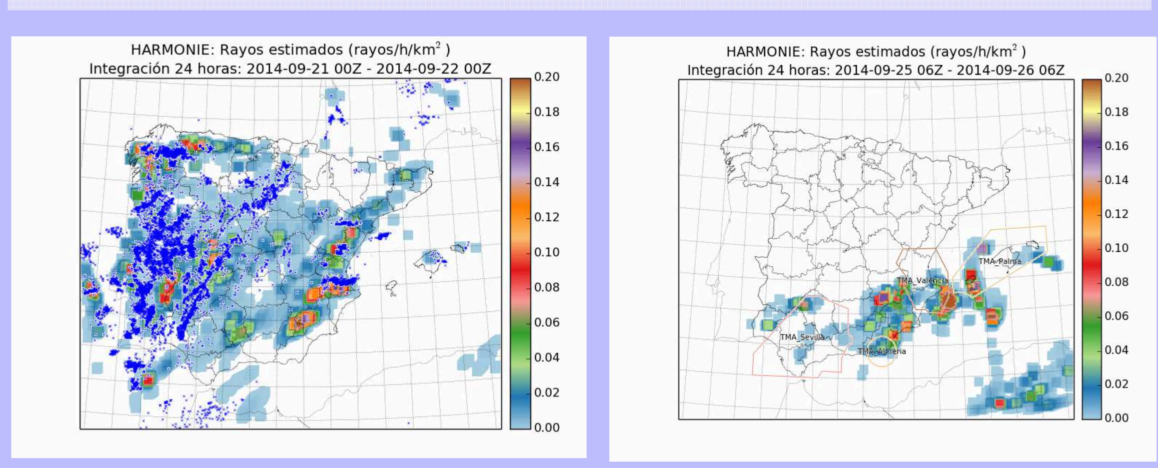


24 hr precipitation simulated by HARMONIE and analysis from rain gauges obs. for a flood event

LIGHTNING DIAGNOSTIC

J. A. Sousa (jsousac@aemet.es)

- **Lightning density** based on vertical integrated graupel following KNMI approach adapted to AEMET lightning network
- Performance depends very much on the representation of convection in the model but in general it is a good estimation of lightning activity
- A tool has been develop to generate warnings for aviation



Simulated lightning density in 24 hr compared to actual clou-earth discharges (blue crosses) — *Simulated lightning density and TMA warnings for different airports*

NH-DYNAMICS

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FINITE ELEMENTS IN THE NH-MODEL

Splines have been implemented successfully on IFS hydrostatic model by A. Untch and M. Hortal with linear and cubic B-splines using Galerkin method. All variables are kept at full levels, no staggering of variables is used.

In non-hydrostatic model there is a constraint between vertical operators (C1) which is very desirable to satisfy in order to reduce the Helmholtz equation to a single variable

B-splines space of functions is closed under derivation and integration.

We construct VFE operators based in their analytical properties

$$\frac{\partial}{\partial t} N_{ik} = (k-1)\left[\frac{N_{i,k-1}}{t_{i+k-1}-t_i} - \frac{N_{i+1,k-1}}{t_{i+k}-t_{i+1}}\right]$$

$$\int_0^t N_{ik} = \frac{t_{i+k}-t_i}{k} \sum_{i\leq s} N_{s,k+1}$$

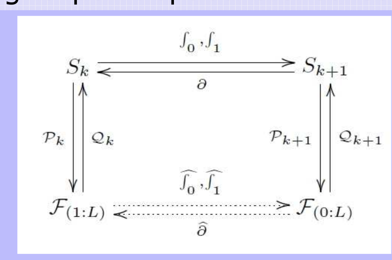
The vertical integral operators that appear in the semi-implicit nh-model are related by the C1-constraint that can be rewritten in a factorized form

$$\mathcal{G}^* f := \int_{\pi^*}^{\pi_s^*} f \frac{d\pi^*}{\pi^*}$$

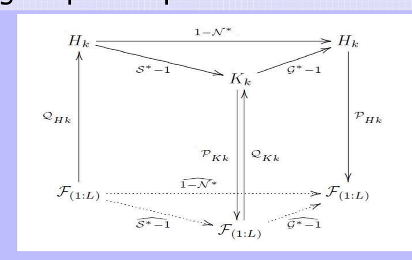
$$\mathcal{S}^* f := \frac{1}{\pi^*} \int_0^{\pi^*} f d\pi^*$$

$$\mathcal{N}^* f := \frac{1}{\pi_s^*} \int_0^{\pi_s^*} f d\pi^*$$

Invertibility between integral and derivatives in grid-point space is ensured



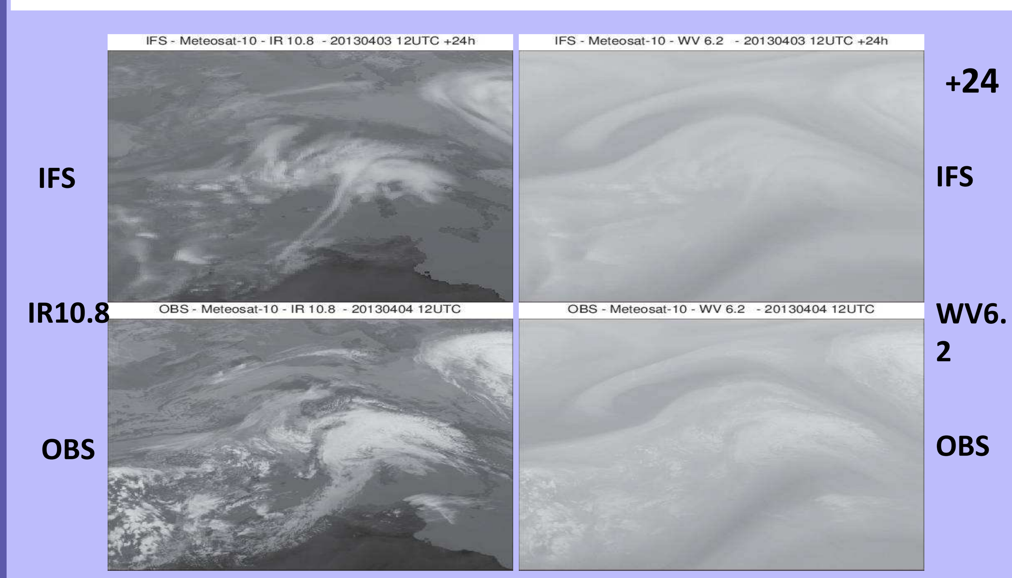
Given suitable basis functions factorization allow us to ensure **C1 constraint** in grid-point space



SYNTHETIC SATELLITE IMAGES

A. Carrascal (ahernandezc@aemet.es)

Model evaluation by objective comparison between synthetic and observed satellite images



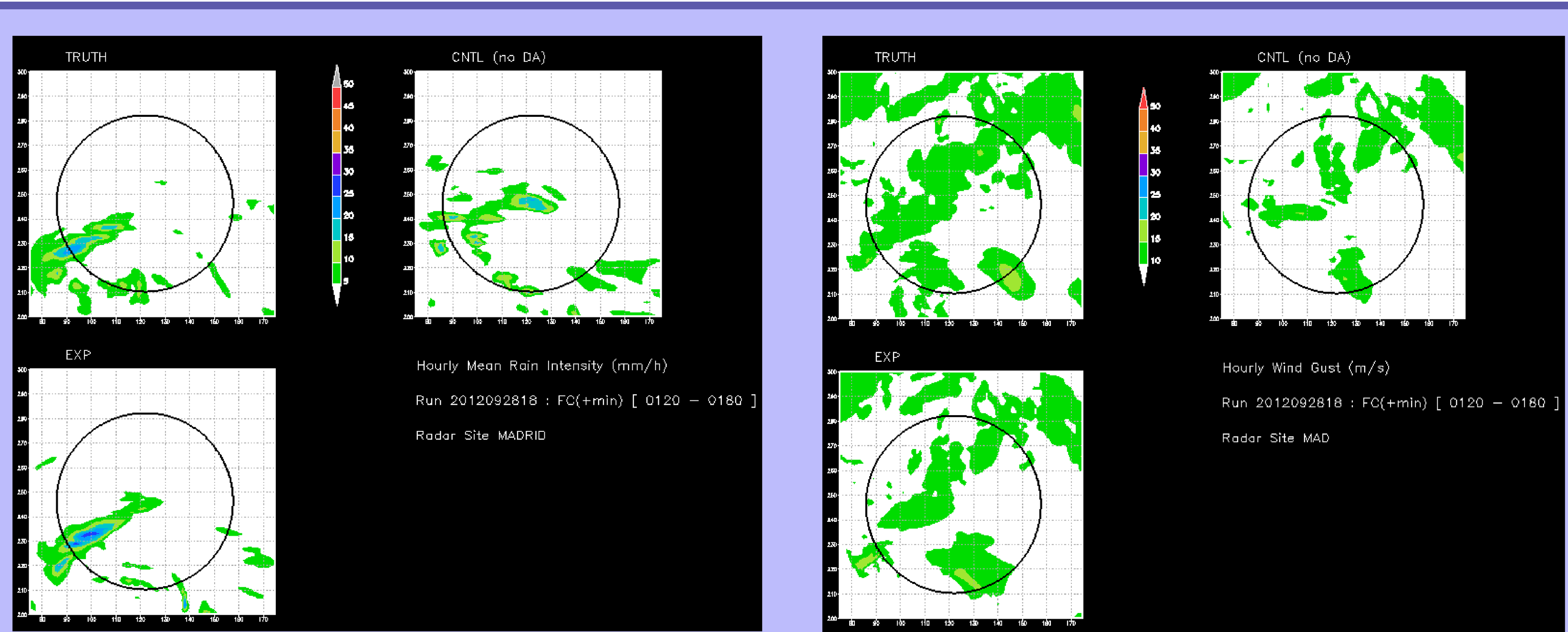
Synthetic satellite images from a IFS forecast at 2 spectral bands compared with MSG images

- Promising tool for operational weather forecasting, model development and model evaluation.
- Many scientific and technical challenges.
- Tests currently being done with IFS, although the final objective is to use HARMONIE synthetic images.

DATA ASIMILATION

A New Technique for Assimilation of High Density Observations in NWP Models at Convective Scales

Carlos Geijo (cgeijog@aemet.es)



It is today widely recognized that DA methods that have been inherited from NWP at coarse scales do not perform so well in scales of the order of 1 Km [1]. A method for assimilation of radar data in an operational convective scale NWP system based on the ideas of position error correction has been developed and is being validated and verified. The method is an implementation of the idea of Field Alignment presented in [2] and it is applicable whenever dense observations in space are available. It assimilates all scales in the data down to model resolution and avoids the need of data thinning. Other interesting features are that it incorporates from the outset flow-dependency and non-linearity.

In this application of the method, radar PPIs of reflectivity and radial Doppler winds are used to deform smoothly model fields of specific humidity, temperature and horizontal wind until they match patterns resolved in the radar images. The implementation meets difficulties related to issues like data void areas and disparity between radar and model geometry and to find satisfactory solutions requires some care. Also the question of imbalances in the initial state that may render the first hours of integration useless must be considered because the range of predictability of some local phenomena of interest in this study (i.e. heavy rain) is frequently restricted to a few hours.

Validation of the technique is being carried out in the framework of "twin experiments" (e.g. simulated observations) for some heavy rain episodes over Spain. The panels on the left show that the technique can indeed improve short-range forecasts (+3h) of precipitation (upper left panel) and wind gusts (upper right panel).

[1] Organizing Committee Summary of the 6th WMO DA Symposium, Maryland USA 7-11 October 2013. http://das6.umd.edu/docs/WMO6DA_Foreword.pdf

[2] Ravela S, Emmanul K, McLaughlin D, 2007: "Data Assimilation by Field Alignment" *Physica D*, 230, 12

ASSIMILATION OF GB GNSS ZTD OBSERVATIONS IN HARMONIE 2.5 KM

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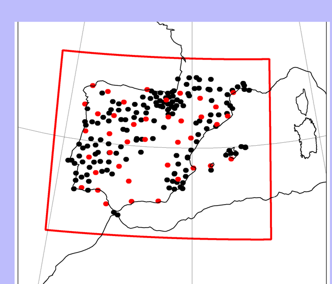
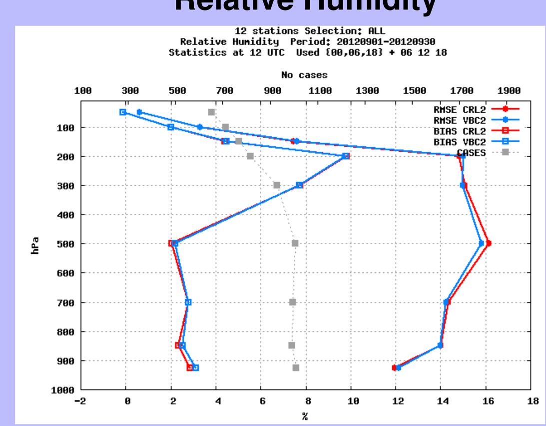
One month **parallel experiments with Cy38 Harmonie model assimilating gnss observations together** with **conventional** and **atovs** observations have been performed over the *Iberia domain* and with 2.5 km horizontal resolution and 65 vertical levels.
The period chosen has been september 2012 (Hymex :Convective systems over Spain)



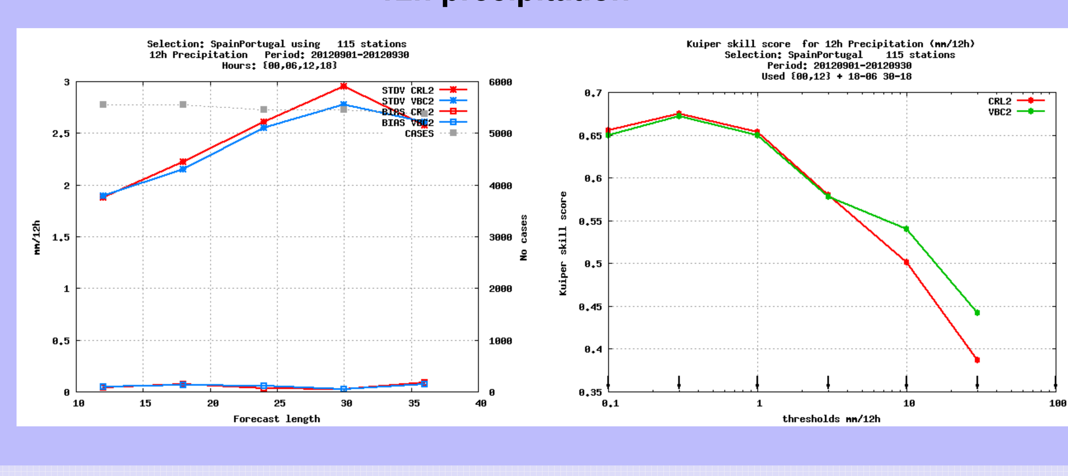
Model domain (red frame) and GNSS observations before (black dots) and after (red dots) thinning of data.

- One control run assimilating only conventional types of observations and one additional run with assimilation also of GNSS data in addition.
- The GNSS run has been optimized with respect to bias correction, error statistics and thinning distances.

Relative Humidity



12h precipitation



Conclusions & Future work

- Encouraging results from parallel experiments assimilating ZTD GNSS observations with VarBC scheme have been found.
Further studies of the results are being carried out. A scientific paper is being prepared.
- Other parallel studies assimilating gnss observations with a larger domain over the Iberian Peninsula are also being carried out.

SREPS AND γ-SREPS

C. Santos, A. Callado, P.Escribà and J.A. García-Moya (csantosb@aemet.es)

- **AEMET-SREPS** provides high performance probabilistic forecasts at synoptic-meso-α scale, giving added value to our deterministic HIRLAM suites and assessing predictability in the Short Range over-performing ECMWF EPS. Current research on the transition to meso-gamma scale: the future **AEMET-γ-SREPS**. Predictability issues at convective scale are not trivial. Research lines include:

1) Model error

Evaluating distinct methodologies at γ-scales dealing with model errors and uncertainties:

(1) Multi-model: HARMONIE + WRF (not yet)

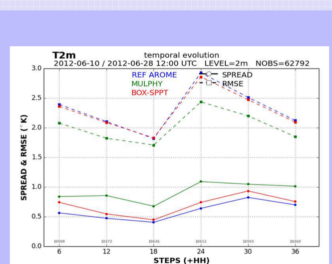
(2) **Multi-physics**: AROME + ALARO

(3)**SPPT** stochastic parameterization:

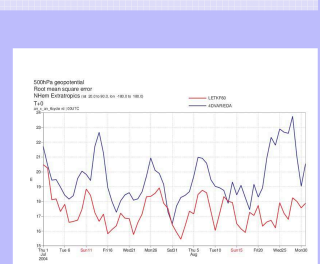
$$\frac{\partial X}{\partial t} = D_X + K_X + P_X + rP_X$$

random noise multiplying parameterization tendencies (Buizza et al. 1999).

SPPT implementation in HARMONIE.



(1)



(2)

2) Local Ensemble Transform Kalman Filter (**LETKF**, Hunt et al., 2007) P. Escribà: 6 months visit at ECMWF with M. Bonavita, assessing EDA, hybrid 4D-Var/EDA and the EnKF implemented at ECMWF. The figure shows Z500 RMSE analysis time series when only Surface Pressure is assimilated, with ECMWF IFS: LETKF performs better than 4DVAR /EDA, showing that LETKF can provide good ICs to HarmonieEPS

γ-SREPS

- Multimodel:
  - Harmonie
  - WRF
- Multiboundaries (Global Models+SLAF):
  - ECMWF
  - GSM from JMA (Japan Meteorological Agency)
  - GFS from NCEP
  - CMC from SMC (Canadian Weather Service)

γ-SREPS - Setup

- 36 hours forecast four times a day (00, 06, 12 & 18 UTC)
- Characteristics:
  - 2 models
  - 4*3 boundary conditions
  - [+2 latest ensembles (HH & HH-06)]
- 24 member ensemble every 06 hours
- Time-lagged Super-Ensemble of 48 members every 6 hours.
- 2.5 km horizontal resolution
- LETKF for ICs perturbations
- SPPT for model perturbations
- Focused on surface parameters (Precip, 2mT, 10mwind)

Road Map 2014-2015

- Setup Harmonie sub-EPS using ECMWF EPS as boundaries (June – October 2014)
- Global models and SLAF for boundaries and ICs (October - December 2014)
- Setup WRF sub-EPS using ECMWF EPS as boundaries (October - December 2014)
- Setup Harmonie sub-EPS and WRF sub-EPS using global models and SLAF for boundaries and ICs (January - Marck 2015)
- Implementation of SPPT in Harmonie (March - December 2014)
- First tests of LETKF in Harmonie and WRF (June - December 2014)
- Experiments with γ-SREPS v1 in cases of severe weather events (October 2014 – March 2015)
- Parallel test verifications (May – July 2015)
- Daily running of γ-SREPS v1 four times a day at ECMWF Cray computer (October 2015)

NEW High Performance Computer Facility

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A new supercomputer at least 40 times more powerful than current system will be installed in January 2015

- It will allow to replace HIRLAM by NH HARMONIE/AROME in operations.
  - Deterministic run of at least 2.5 km including RUC assimilation and increasing number of observations
- A small high resolution Ensemble Prediction System

The System will increase the computer capacity in March 2016 what will allow to implement the complete **γ-SREPS**