JOINT WMO TECHNICAL PROGRESS REPORT ON THE GLOBAL DATA PROCESSING AND FORECASTING SYSTEM AND NUMERICAL WEATHER PREDICTION RESEARCH ACTIVITIES FOR 2016

AEMET / SPAIN
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1. Summary of highlights

Operations and research has been based on the high-resolution convection-permitting model HARMONIE-AROME which is a configuration in the ALADIN-HIRLAM Shared System. The model is run at 2.5 km resolution in AEMET's supercomputer system. Over some coastal regions, simulations at 1 km resolution are produced. The HIRLAM model is still run in order to allow the transition of users to the new system.

In the area of predictability research has been focused on a convection-permitting multi-model multi-boundaries System, gSREPS, which is expected to enter in operations in 2018.

Downstream applications are the WAM wave model and the MOCAGE Chemistry Transport Model.

2. Equipment in use

The Bull Supercomputing System is extensively used. It includes 324 nodes and 7776 cores. The system is based on Intel Xeon 2697 V2 Ivy Bridge processors at 2.7 GHz with 64 GB DDR3 of memory per node for half of the nodes and 128 GB for the other half.

The archiving System started in operation in 2009 served by 4 Altix 350 (SGI) servers, a disk cabinet and an ADIC (QUANTUM) robot. From 2013, this System has been replaced by a cluster of nodes of EMS, and ISILON One FS.

The dust prediction model (NMMB/BSC-Dust) is run at the MareNostrum III supercomputer, where there is a reservation of 260 cores for the operational run. A backup run, at a reduced resolution, is daily performed at a dedicated server. Product dissemination is performed by the Barcelona Dust Forecast Center (BDFC) main server through the Center's website (https://dust.aemet.es), the GTS and EUMETCast. All computational resources are located at Barcelona Supercomputing Center (BSC) facilities. BSC is the AEMET partner in dust forecasting.

3. Data and Products from GTS in use

- SYNOP
- TEMP
- AMDAR, AIREP
- SHIP
- BUOY
- The satellite as BUFR ATOVS data are received from the EUMETCast dissemination. VAD and radial wind radar data, GPS Zenith Total Delay, are coming into the system from other data servers.

4. Forecasting system

AEMET is a partner in the international HIRLAM Programme, which has, as its main goal, the development of a Limited Area Model for its use in operational short and very short-range numerical weather prediction. As a result of the collaboration between HIRLAM and ALADIN consortia, a "ALADIN-HIRLAM Shared System" has been set and it is currently used operationally by many of the Meteorological Services belonging to the consortia.

On the other hand, Spain is a Member State of the ECMWF and uses their output products. They are received in real time from the dissemination system of the European These products include the deterministic forecasts up to 240 hours and the forecasts from the Ensemble Prediction System (EPS), both twice per day.

4.1 System run schedule and forecast ranges

HIRLAM model:

- 16 km resolution and 40 levels. Big domain over North Atlantic ocean and Mediterranean Sea. 3DVar analysis every 6 hours with two-hour cut-off time. The forecast lead time is 72 hours.
- 5 km resolution and 40 levels. Two domains over Iberian Peninsula-Balearic Islands and Canary Islands. 3DVar analysis every 6 hours with a forecast lead time of 36 hours.

HARMONIE-AROME model:

- 2.5 km resolution and 65 levels. Two domains over Iberian Peninsula-Balearic Islands and Canary Islands. 3DVar analysis every 3 hours with 1 hour 10 minutes cut-off time. The forecast lead time is 48 hours.
- 1 km resolution and 65 levels. Four domains in coastal areas three of them over Iberian Peninsula-Balearic Islands and one over Canary Islands, Integrations in dynamical adaptation mode twice per day with forecast lead time of 48 hours.

Both models used boundary conditions from the ECMWF-IFS model updated 4 times per day.

4.2 Medium range forecasting system (4-10 days)

Medium range forecasts are not produced in AEMET. ECMWF products are used instead.

4.2.1 Data assimilation, objective analysis and initialization

4.2.1.1 In operation
"[information on Data assimilation, objective analysis and initialization]"

4.2.1.2 Research performed in this field
"[Summary of research and development efforts in the area]"

4.2.2 Model

4.2.2.1 In operation
"[Model in operational use, *(resolution, number of levels, time range, hydrostatic?, physics used)*] "

4.2.2.2 Research performed in this field
"[Summary of research and development efforts in the area]"

4.2.3 Operationally available Numerical Weather Prediction Products

Several basic ECMWF products are available on the AEMET Internet web pages and additional ones on the McIDAS workstation. Others like diagnostic convective fields, predefined pseudo soundings of specific points, predefined vertical-cross sections, etc., are displayed on the Intranet system. All of them are obtained from 00 and 12 UTC runs. Maritime and aeronautical outputs are available in different platforms for operational purposes.

In some operational units, ECMWF products are used through ecCharts website application, especially for defence support.

4.2.4 Operational techniques for application of NWP products *(MOS, PPM, KF, Expert Systems, etc..)*

4.2.4.1 In operation
A database of gridded forecasts of sensible weather elements (BDDP) is fed with predictions from HIRLAM, HARMONIE and ECMWF models. From this database many end users products are generated. In principle, HIRLAM and HARMONE are used for the short range and ECMWF for longer ranges but backup procedures exists if some of the models are missing. For some of the parameters as the near surface temperature a post process is applied to remove the model bias.

4.2.4.2 Research performed in this field
The GFE (Graphical Forecast Editor) tool has been extensively tested although it has never been operational. It is able to generate automatic text products and graphics. With this tool, the forecaster can modify the model output before generating the end products.

4.2.5 Ensemble Prediction System (EPS)

4.2.5.1 In operation

"[Number of runs, initial state perturbation method, perturbation of physics?]" *(Describe also: time range, number of members and number of models used: their resolution, number of levels, main physics used, perturbation of physics, post-processing: calculation of indices, clustering)*

4.2.5.2 Research performed in this field

"[Summary of research and development efforts in the area]"

4.2.5.3 Operationally available EPS Products

"[brief description of variables which are outputs from the EPS"

4.3 Short-range forecasting system (0-72 hrs)

Two different systems are used: HIRLAM at 0.16 and 0.05 resolution, and HARMONIE/AROME at 2.5 km resolution up to 48 hours.

The HIRLAM analysis and forecast systems are described in the scientific documentation of HIRLAM-5. (see references). The main added value of HIRLAM compared with ECMWF is in near surface variables and especially in 2m temperature, wind and wind gust (Navascues et al, 2013). For precipitation, it complements ECMWF output helping to assess predictability of the weather systems. The three HIRLAM runs use the same version for each of the domains. In addition, the same dynamics and physics are used.

The HARMONIE/AROME is based on cycle 38 and it is close to the system described in Seity et al (2011). The verification shows a clear added value compared with HIRLAM and ECMWF forecasts, especially for near surface variables, precipitation and low level clouds.

4.3.1 Data assimilation, objective analysis and initialization

4.3.1.1 In operation

HARMONIE-AROME system uses a 3D-VAR analysis for upper-air including convectional observations, AIRCRAFT, ATOVS and GNS Zenith Total Delay. The analysis is updated every 3 hours with a cut-off time of 1 hour 10 minutes. No initialization is applied to the analysis fields. For the surface an Optimal Interpolation method is used including only convectional observations. The boundary conditions are provided by the ECMWF-IFS model updated every 6 hours with forecasts at 1 hour intervals.

4.3.1.2 Research performed in this field

- Optimal use of ATOVS data: Channels, Variational Bias Correction (VarBC), etc.
- Assimilation of GNSS Zenith Total Delay data (Sanchez Arriola, 2016). Tuning of the system, VarBC depending on the time of the day to take into account the availability of anchor observations.
- Radar assimilation with focus on using OPERA data.
- Use of the Field Alignment technique for correcting position errors in radar assimilation. Results are promising although the added value of the radar assimilation is lost after a few hours.
- Assimilation of Atmospheric Motion Vectors with focus on the use of the High Resolution Winds software provided by the Nowcasting SAF and to the use of the Cloud Products, which include new microphysics information.
- New techniques to ensure variational non-hydrostatic balances.

4.3.2 Model

4.3.2.1 In operation

Cycle 40h1.1 of the HARMONIE system is used. A general description of the model configuration can be found in Bengtsson et al. (2017) and in Seity et al. (2011). It is a Non-Hydrostatic, semi-Implicit spectral model without parameterized deep convection, using a unified approach for the turbulence-shallow convection processes (EDMFM scheme), ICE-3 microphysics and an externalized surface parameterization (SURFEX) based on ISBA for nature tiles. Two 2.5 km resolution domains with 65 vertical levels.

4.3.2.2 Research performed in this field

- Representation of low clouds and fog. Although the HARMONIE-AROME model improves significantly low clouds and fog predictions it tends to produce too many false alarms. Most efforts in the physics group have been devoted to understand and try to cure this problem.
- Representation of deep convection. Current version of the model tends to underestimate deep convection. The issue is under study but seems to be related with the interaction of different physical processes.
- Very Fine Resolution Modelling. In the context of an externally funded project, thorough testing has been carried out to define a configuration which is able to improve wind forecasts compared to the 2.5 resolution version of the model. The main modifications in order to fulfill stability and improve the wind forecast quality are IFS 0.1^o nesting, dynamical adaptation, the predictor-corrector time scheme, the reversion of HARATU update and activation of the Semi-Lagrangian horizontal diffusion (Lauritzen et al. 2011 and Vaná et al. 2008) for hydrometeors and spectral variables but temperature.

4.3.3 Operationally available NWP products

- Hourly output of model levels, postprocess levels, near surface variables and some surface variables at the different tessels and levels of the soil model.
- Fifteen minutes output for select variables as 2m temperature, precipitation, radiative fluxes and 10 m wind.
- Some new products are lightning density, hail diagnostic, precipitation type and visibility.

4.3.4 Operational techniques for application of NWP products

4.3.4.1 In operation

Advanced and specific HIRLAM and HARMONIE outputs are being used for aeronautical purposes: identification of turbulence, icing condition, mountain waves, etc., at flight levels. More sophisticated products will be obtained for mountain meteorology in the near future. Some NWP derived parameters and vertical profiles are obtained from model output to identify and forecast the most likely convection environments. Other end-user products are delivered automatically from the high resolution model at surface level to meet data requirements.

4.3.4.2 Research performed in this field

Many of the post-process products have been migrated from HIRLAM to HARMONIE. Also HARMONIE forecasts have started to replace HIRLAM forecasts in the Data Base of gridded forecast (BDDP) from which most end users products are generated.

4.3.5 Ensemble Prediction System AEMET-gSREPS

During 2016 the new multi-model multi-boundaries System (AEMET/gSREPS) was implemented and run on the ECMWF supercomputing facilities. Four LAMs (HARMONIE-AROME, HARMONIE-ALARO, WRF-ARW and NMMB) are integrated taking as initial and boundaries the global fields from five global models: ECMWF, Arpege from MeteoFrance, GFS (from NCEP), GSM (from JMA) and CMC (from Canada). Therefore, the number of ensemble members is 4x5=20.

4.3.5.1 Daily runs in 2016

The gSREPS System is running twice a day at 00 and 12h UTC up to 36 hours beginning in March 2016. The model resolution is around 2.5 km in the horizontal and 65 levels in the vertical. During the winter of 2017-2018 the gSREPS will be installed and run at AEMET supercomputing facilities in Madrid.

4.3.5.2 Research performed in this field

Work was done to correct bias (difference between mean values of the forecasts and the analyses in the verification areas), and to calibrate the system using different techniques. From a statistical point of view, results were encouraging for surface variables (including precipitation) but there was still an issue with extreme events.

4.3.5.3 Availability of gSREPS products

The AEMET-gSREPS provided two kinds of products. The deterministic products are averages of deterministic outputs of each of the members in the ensemble. They are made available every 1 hour for geopotential, temperature, specific humidity, wind and surface variables. The probabilistic products are obtained from the full set of the individual deterministic forecasts of the ensemble by estimating the probability of occurrence of a meteorological event, such as 6-hour accumulated precipitation higher than 1, 5, 10 and 20 mm; 10m mean wind higher than 10, 15 y 20 m/s; positive or negative variations higher than 2, 6 y 12 ºC of the 24 hours and tendency of the two meter temperature. Spread vs ensemble mean maps are available as well. In addition, there are snow outputs according to thresholds aimed to forecast adverse weather.

4.3.5.4 Additionally, and under the demand of some research projects, additional parameters related with renewable energies, like Global Horizontal Irradiation flux (GHI) and Direct Normal Irradiation flus (DNI), has been extracted from gSREPS and verified against available observations. Probabilistic products derived from these new parameters are under development.

4.3.6. Ensemble Prediction System GLAMEPS

AEMET is contributing to the development and testing of the Grand Limited Area Model Ensemble Prediction System (GLAMEPS) project developed within the HIRLAM and ALADIN Consortia. This system runs operationally (time critical facility) twice daily at ECMWF platforms. The system is a multi-model (two HIRLAM, one AROME, and for the rest a subset of ECMWF EPS is taken) and uses perturbations (ECMWF EPS is used as ICs and LBCs). It runs at 8 km with 40 vertical levels, over a domain that covers Europe, part of the North Atlantic Ocean, including Canary Islands. GLAMEPS data are transferred from ECMWF to AEMET and then conveniently post-processed. The configuration is operational since mid-September 2014.

4.3.6.1 Availability of GLAMEPS products

Probabilistic products: Two runs are available: 06 and 18 UTC. AEMET forecast offices are provided with a convenient set of probability maps, mainly for weather parameters (2mT, wind, precipitation), covering the required meteorological thresholds (more or less the same than for AEMET-SREPS) for short range warnings.

4.4 Nowcasting and Very Short-range Forecasting Systems (0-12 hrs)

No specific numerical model system is available to this purpose, but some HNR/CNN fields and parameters are used for linear extrapolation in the radar based cell convective identification modules. These applications work at national and regional levels. Other HIRLAM parameters are included into satellite applications for nowcasting, such as identification of convection and detection of icing conditions in real time.

HIRLAM wind fields are used for linear extrapolation when a cluster of lightning is identified and warning messages are sent automatically to aeronautical authorities.

HARMONIE graupel field outputs are used for a lightning probability forecasting product (McCaul et al, 2008).

4.4.1 Nowcasting system

4.4.1.1 In operation

"[information on processes in operational use, as appropriate related to 4.4]"

(Note: please also complete the CBS/PWS questionnaire on Nowcasting Systems and Services, 2014)

4.4.1.2 Research performed in this field

"[Summary of research and development efforts in the area]"

4.4.2 Models for Very Short-range Forecasting Systems

4.4.2.1 In operation

"[information on models in operational use, as appropriate related to 4.4]"

4.4.2.2 Research performed in this field

"[Summary of research and development efforts in the area]"

4.5 Specialized numerical predictions

HIRLAM outputs are used as inputs data by the following models:

- Wave models: A wave forecasting system developed by the Spanish holding of harbours (Puertos del Estado) is run by AEMET (Gomez and Carretero, 2005). This system is made-up by two main WAM based applications for the Atlantic Ocean and the Mediterranean Sea that provide boundary conditions to four nested applications: three based on the WAM model (Cantabrian coast, Gulf of Cadiz and Canary Islands) and the fourth on the WW3 model (Strait of Gibraltar). Both (WAM and WW3) are third generation well known models that solve the wave transport equation explicitly without any presumption on the shape of the wave spectrum. Furthermore, the WAM model incorporates a two-way nesting scheme that allows the definition of different grid resolutions in various sub-regions of the model domain. The system is driven with 10 m wind fields from the

HIRLAM ONR 0.16º and HIRLAM HNR 0.05º models and it is operated on a twice a day cycle with a 72 hour forecast length. The forecast results are verified on real time using the data from Puertos del Estado buoy network.

A new operational suite based on ECWAM and SWAN models is currently being developed at AEMET. At open waters, ECWAM (0.0417º) is forced by ECMWF global model winds and spectral boundary conditions (0.125º) providing hourly forecasts up to D+4 for a wide area which stretches from Biscay Gulf to Guinea Gulf in the Atlantic and from Gibraltar Strait to Corsica in the Mediterranean. In the Spanish coastal areas, a number of high resolution SWAN applications (1 km) will be nested and forced with HARMONIE winds to improve the predictions in the shallow water environment.

In the research field, AEMET is partner of the Iberian-Biscay-Irish Monitoring & Forecasting Centre of the Copernicus Marine Environment Monitoring Service (The Copernicus IBI-MFC).

- Trajectory model: FLEXTRA is a Lagrangian trajectory model, well known by the scientific community, which can be used to compute forward or back trajectories. It has nesting capabilities. It has been widely validated and the results can be found in the literature. FLEXTRA model is daily used, with HIRLAM ONR 0.16º fields as input, to calculate the analysed (from H+0 to H-96) and forecasted (from H+36 to H+0) back trajectories, in order to check the coherence of the observations of the Spanish EMEP/GAW air quality, the Brewer (ozone) and the Sun-photometer networks and as a help tool to understand the observed values of the parameters measured by the aforementioned networks.

- Chemical Transport Model: MOCAGE is the CTM used (Josse et al 2004). It has been developed and provided to AEMET by Météo-France. It is run operationally in AEMET for Air Quality and UV forecasting purposes and as an emergency tool in ACCIDENT mode. It allows nesting up to three additional domains to the global domain. The current configuration includes one global domain with 2º horizontal resolution and a second one with a 0.5º continental domain, covering most Europe and Atlantic area, nested to the 2º global domain are run daily up to H+24. A third domain nested to the continental domain covers the Iberian Peninsula with a spatial horizontal resolution of 0.1º in the chemical mode up to H+24 for Air Quality and UVI forecast. Besides, the accident mode can be run with different configurations by combining different domains: global, continental, Iberian area and the Canary Islands with different horizontal resolution ranging from 1º for the global domain to 0.05º for the smallest areas up to H+24 in order to calculate the evolution of an accidental nuclear or chemical release. AEMET calculates daily the evolution of a possible accidental release over every nuclear power site in operation in Spain. The global domain meteorological and surface forcings come from the ECMWF and MéteoFrance. The meteorological forcings for the continental and Iberian domain come from the HIRLAM ONR 0.16º and HIRLAM HNR 0.05º suites run operationally in AEMET. It is worth mentioning that the high-resolution emission inventory has been updated to TNO-MACCIII, which extends the covered period up to 2011 and updates or improves the spatial distribution proxies such as industry, wood combustion or population, even though the spatial resolution of the emission data remains without changes about 7 km (Kuenen et al 2014). In a few days (October 2017) a new version of the MOCAGE CTM model will be set up operationally and this will allow to start forecasting parameters related to aerosols (PM10 and PM2.5).

A dust prediction model (NMMB/BSC-Dust) is operationally run at a horizontal resolution of 0.1 x 0.1 degrees with 40 vertical sigma levels for a regional domain covering Northern Africa (north of equator), Middle East and Europe, which is the area of responsibility of the Barcelona Dust Forecast Center. There is a daily run at 12 UTC up to a 72-hour lead time. The resolution of the backup run is 0.33 x 0.33 degrees with 24 vertical levels. By the moment, there is not data assimilation: dust contents is initialised with the 24-hour forecast of the previous day. Initial meteorological conditions come from the NCEP global analysis at a 0.5º latitude x 0.5º longitude resolution and 6-hourly boundary meteorological conditions from the NCEP Global Forecast System at the same resolution.

The NMMB/BSC-Dust model solves the mass balance equation for dust taking into account the following processes:

- Dust generation and uplift by surface wind and turbulence.
- Horizontal and vertical advection (Janjic et al., 2009).
- Horizontal diffusion and vertical transport by turbulence and convection (Janjic et al., 2009).
- Dry deposition and gravitational settling (Zhang et al., 2001).
- Wet removal including in-cloud and below-cloud scavenging from convective and stratiform clouds (Betts, 1986; Betts and Miller, 1986; Janjic, 1994; Ferrier et al., 2002).

The operationally available products are:
- o Dust surface concentration (dust concentration at the lowest model level) in µg.m-3
- o Dust surface extinction at 550 nm (dust extinction at the lowest model level) in Mm-1
- o Dust load (columnar dust contents) in g.m-2
- o Dust optical depth at 550 nm
- o 3-hour accumulated dust dry deposition in mg.m-2
- o 3-hour accumulated dust wet deposition in mg.m-2

There is daily, monthly and annual verification based on AERONET retrievals of aerosol optical depth at 42 dust-prone stations.

There is a non-operational poor-man ensemble prediction system involving 12 models. The different members are interpolated to a common grid mesh of 0.5-degree resolution up to a lead-time of 72-hours. Products generated include mean and median to describe centrality and standard deviation and range of variation to describe spread. Involved variables are dust surface concentration and dust optical depth at 550 nm.

Ongoing research is mainly addressed to:
- o implementation of a Kalman-filter-based scheme to assimilate MODIS products
- o implementation of routine dynamical downscaling for specific dust-prone regions

4.5.1 Assimilation of specific data, analysis and initialization (where applicable)

4.5.1.1 In operation
"[information on the major data processing steps, where applicable]"

4.5.1.2 Research performed in this field
"[Summary of research and development efforts in the area]"

4.5.2 Specific Models (as appropriate related to 4.5)

4.5.2.1 In operation
"[information on models in operational use, as appropriate related to 4.5]"

4.5.2.2 Research performed in this field
"[Summary of research and development efforts in the area]"

4.5.3 Specific products operationally available

"[brief description of variables which are outputs from the model integration]"

4.5.4 Operational techniques for application of specialized numerical prediction products *(MOS, PPM, KF, Expert Systems, etc..)* (as appropriate related to 4.5)

4.5.4.1 In operation
"[brief description of automated (formalized) procedures in use for interpretation of specialized NP output]"

4.5.4.2 Research performed in this field
"[Summary of research and development efforts in the area]"

4.5.5 Probabilistic predictions (where applicable)

4.5.5.1 In operation
"[Number of runs, initial state perturbation method etc.]" *(Describe also: time range, number of members and number of models used: their resolution, main physics used etc.)*
4.5.5.2 Research performed in this field
"[Summary of research and development efforts in the area]"

4.5.5.3 Operationally available probabilistic prediction products
"[brief description of variables which are outputs from probabilistic prediction techniques]"

4.6 Extended range forecasts (ERF) *(10 days to 30 days)*

Not computed by AEMET. The ECMWF ERF System is used.

4.6.1 Models

4.6.1.1 In operation

"[information on Models and Ensemble System in operational use, as appropriate related to 4.6]"

4.6.1.2 Research performed in this field

"[Summary of research and development efforts in the area]"

4.6.2 Operationally available NWP model and EPS ERF **products**

"[brief description of variables which are outputs from the model integration]"

4.7 Long range forecasts (LRF) *(30 days up to two years)*

Apart from the application of different downscaling techniques to ECMWF seasonal forecasts already described in previous reports, most of the current activity is pointing to support the Mediterranean Outlook Forum (http://medcof.aemet.es) and to calibrate and combine different sources of seasonal information as a tool for operational activities. In addition, studies of predictability over Spain and the Mediterranean region are being developed in support of the operations.

4.7.1 In operation

"[Describe: Models, Coupled? (1 tier, 2 tiers), Ensemble Systems, Methodology and Products]"

4.7.2 Research performed in this field

"[Summary of research and development efforts in the area]"

4.7.3 Operationally available EPS LRF products

"[brief description of variables which are outputs from the model integration]"

5. Verification of prognostic products

5.1 Verification summary

HIRLAM, HARMONIE-AROME and ECMWF-IFS outputs are routinely verified against observations for different European and African observations. Standard scores are computed for all model parameters in the vertical and at surface using the available TEMP and SYNOP data. The common HARMONIE software Monitor is used for this purpose. For precipitation, also the observations from AIMET's climate observation network (around 4000 stations in Spain) are used.

The verification has been enlarged using METAR observations. This allows verifying new model variables such as visibility and cloud base and verify model output for aeronautical purposes.

A spatial verification method (SAL) for precipitation is also run using observations from the climatic network. This technique is able to compare models with different resolutions in a fair manner showing the added value of the convection permitting HARMONIE runs. The SAL technique has been extended to the verification of low cloud using the Nowcasting SAF data products (Cloud type). The technique is able to identify model deficiencies (in our case the overestimation of low clouds in certain areas) and it is sensitive enough to distinguish between different model configurations. The drawback is that it needs a significant effort to control the quality and representativeness of the data.

HARMONIE-AROME clearly improves forecast of near surface variables including precipitation and fog compared with HIRLAM and ECMWF-IFS. On the other hand error for upper air variables are slightly lower for the ECMWF mode.

5.2 Research performed in this field

Main efforts are devoted to spatial verification methods in the context of HARP package jointly developed by ALADIN and HIRLAM consortia, the use of more types of observations and the verification of the EPS systems.

6. Plans for the future *(next 4 years)*

6.1 Development of the GDPFS

The developments of the NWP system are carried out in the context of our participation in the HIRLAM Programme and the development of the ALADIN-HIRLAM Shared System.

6.1.1 Major changes in the operational DPFS which are expected in the short future

Further tunings in the ATOVs and GNNS data assimilation especially on the Canary Islands domain to take into account the more scarce data. Assimilation of q-AMDAR data. Operational implementation of the radar data assimilation. Try to reduce some model bias as is the deep convection underestimation.

6.1.2 Major changes in the operational DPFS, which are envisaged within the next 4 years

- Operational implementation of the convection permitting scale EPS
- Data assimilation of SEVIRI, IASI, AMVs, GNSS R, High-resolution drifting TEMP data, AIRCRAFT bias correction and probably MODES data, scatterometer data and all-sky radiances. The assimilation cycle frequency is expected to be 1 hour.
- Development of the HARMONIE-AROME system for the km and sub-km scale resolution.

6.2 Planned research Activities in NWP, Nowcasting, Long-range Forecasting and Specialized Numerical Predictions

Research on 4DVar assimilation and ensemble based methods will continue. On the other hand, the RUC assimilation and the convection-permitting EPS will allow to develop new nowcasting products. Most of our seasonal forecasting activities will be focused on the development of an operational framework to calibrate and combine different sources of seasonal information based on Bayesian methods.

6.2.1 Planned Research Activities in NWP

6.2.2 Planned Research Activities in Nowcasting

6.2.3 Planned Research Activities in Long-range Forecasting

6.2.4 Planned Research Activities in Specialized Numerical Predictions

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