Recent progress in operational Numerical Weather Prediction at Météo-France

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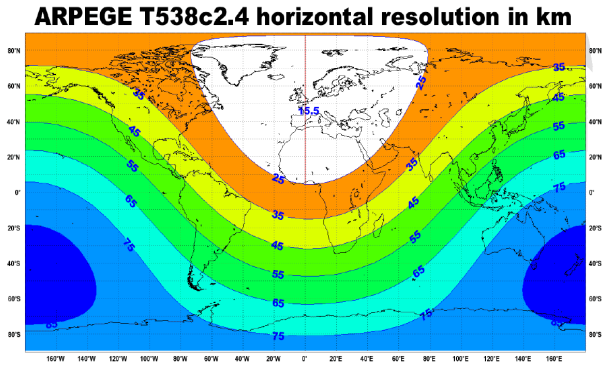
Météo-France runs a comprehensive global and regional numerical weather prediction (NWP) system. The atmospheric NWP is based on the global ARPEGE, regional ALADIN and AROME models, their data assimilation systems, and an ensemble prediction system. These components stem from international (essentially European) technical and scientific cooperations: the main partners are ECMWF (www.ecmwf.int), the ALADIN consortium (www.cnrm.meteo.fr/aladin/), the HIRLAM consortium (hirlam.org) and the Méso-NH group of CNRS and the Toulouse University (mesonh.aero.obs-mip.fr/mesonh/). Increasing priority is being given to the HIRLAM cooperation on convection-scale modelling, support to the ALARO project of the ALADIN consortium, and collaboration with ECMWF on non-hydrostatic modelling and NWP software management.
The resulting software is run operationally (pre-operationally, in the case of AROME), usually four times a day, on the Météo-France SX8 NEC supercomputer (used for production since Spring 2007). Additional details and updates can be found at www.cnrm.meteo.fr/gmap/.

The ARPEGE system

ARPEGE is a global, variable-resolution NWP model with a 4D-Var data assimilation. The major recent upgrade of ARPEGE is a substantial resolution increase (operational in early February 2008) and the activation of new satellite data. The new ARPEGE forecast resolution is T539L60C2.4 i.e. 15km horizontal resolution over Europe (90km over Southern Pacific); the vertical resolution has increased near the tropopause. This change (and other improvements) has substantially improved most objective forecast scores. Other changes include:



In the model and assimilation numerics:

- 4DVar increment horizontal resolution upgrade from T159 to T224
- use of vertical finite element discretisation (formulation similar to ECMWF's)
- use of a non-linear, omega multivariate balance equation in the background error covariance model
- calibration of background error covariances from an ensemble of assimilations (see below)
- variational bias correction of satellite radiances (documented elsewhere in this volume)

In the observation usage:

- assimilation of European GPS ZTD and radio-occultation GPS data from Cosmic, Champ and Grace
- assimilation of MetOp data (AMSU, MHS, HIRS, ASCAT) and ERS-2 data
- real-time monitoring of new instruments (IASI, AIRS)
- improvements to the IR radiance cloud detection scheme

In the model physics and surface assimilation:

- use of finer NESDIS SST product
- representation of soil ice melting in the soil assimilation algorithm
- revision of the evaporation of precipitation (to reduce spurious low-level divergence)
- new, efficient PDF-based algorithm to compute the sedimentation of resolved hydrometeors
- revision of the vertical diffusion in the free atmosphere

These changes have provided competitive forecast quality, particularly over Western Europe where the ARPEGE forecasts are preferred by forecasters over the IFS ones, approximately half of the time, yielding significant added value to the end forecast products.
Plans for the future include coupling 4DVar to an ensemble assimilation scheme (yielding flow-dependent background error variances, see below); assimilation of more satellite data, notably IASI and AIRS radiances,

and tropospheric microwave radiances over land and ice, thanks to a novel model of land surface emissivity (see contribution by Karbou et al in this volume); a strong increase in the horizontal density of assimilated satellite radiances; a revision to the model physics (vertical diffusion in stable boundary layers, prognostic TKE mixing, new shallow and deep subgrid convection schemes); in 2009, another upgrade will bring the ARPEGE horizontal resolution close to 10km over Europe.

The ALADIN system

The limited-area ALADIN model has inherited from most ARPEGE evolutions, except that the assimilation algorithms remains 3DVar (not 4DVar), and the horizontal resolution remains 9.5km. ALADIN-specific evolutions are:

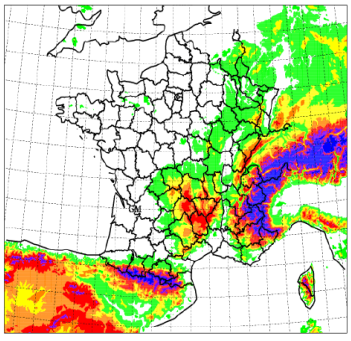
- the assimilation of low-level temperature, humidities and winds
- configuration of a new instance of the ALADIN model and data assimilation on the South-West Indian Ocean, to aid tropical cyclone forecasting in the area
- an improved dynamical initialization system (incremental digital filters)
- a revision of the observation weights in the 3DVar analysis

It is planned to implement new instances of ALADIN in tropical areas.
A new diagnostic version of the ALADIN 3DVar analysis system has been developed for nowcasting purposes; it draws well to the observations and has the potential to blend conventional, radar and satellite data as an aid to forecasters (e.g. for thunderstorm short-range forecast).

The AROME system

AROME is a non-hydrostatic, limited area model that inherits from the ARPEGE and ALADIN features, except for the physics (which are almost completely different and oriented towards convective scales), the NH dynamical core and special features in the data assimilation. Following intensive testing in 2007, several weaknesses of AROME have been identified and corrected, notably

- numerical performance improvements
- bug fixes in the low level physics and diagnostic computations
- a revision of the numerical diffusion
- implementation of a new subgrid shallow convection scheme (based on KFB and EDMF)
- ensemble-based model of background error covariances
- assimilation of radar data (doppler radial winds are slated for operations in 2008)



A recent AROME version improves upon ALADIN in most respects; AROME is due for operational implementation in October 2008 on a 2.5km-resolution grid that covers France and its surroundings. Preliminary tests with a 1-km resolution version of the model show encouraging performance. Current work focuses on improvements to surface assimilation, amtospheric physics tunings and the assimilation algorithm.

The ensemble systems

The Météo-France system uses an 11-member ensemble of ARPEGE 3-day forecasts at variable resolution (maximum is 24km over Europe), which serves as both a global and regional ensemble prediction system. The ARPEGE ensemble forecasts is supplied to the THORPEX/TIGGE international database since Nov 2007. A major upgrade of this system (January 2008) includes a better perturbation procedure (based on global singular and bred modes), which improves the ensemble outside the European area. Another upgrade is planned for 2008.
A ensemble assimilation system has been implemented, with six members of ARPEGE assimilations similar to the deterministic ARPEGE sytem, except that the assimilation algorithm is 3DVar (with FGAT) and the resolution are different (globally uniform at 134km); the dispersion is driven by random perturbations of the observations. An original technique is used to derive flow-dependent analysis error variances from the ensemble of assimilations, which may then be fed into the deterministic ARPEGE 4DVar assimilation (for flow dependent observation selection and structure function) and ARPEGE ensemble prediction (for better modelling of the analysis uncertainty). The ensemble assimilation has been shown to improve the ARPEGE forecasts, it started in preoperational mode in January 2008, with operational implementation foreseen in Spring 2008.