Working practices for the Management
of Operational Numerical Weather Prediction Software
in Météo-France

revised version by F. Bouttier on 10 February 2005

Motivation

Météo-France needs to maintain its NWP software at the best possible level of forecast quality, at any given time, with significant but limited staff resources. This process requires frequent importation of scientific improvements into the operational software, without ever compromising its competitiveness (forecast products must be as good as possible in the current state of science) and robustness (NWP production configurations should never crash or produce aberrant results). The software applications considered here are ARPEGE, ALADIN and AROME, as they are (or will be) used in Météo-France operations. AROME is in included in the list because it is being prepared for operational use ; AROME includes *de facto* a subset of the Méso-NH software. The existence of cooperations to develop these applications means that the working practices for updating the software need to be clarified, which is the aim of the present document.

This document has no official value with respect to legal or commercial property rights to the software, which will be clarified in separate documents.

Background information

ARPEGE has been developed in cooperation between Météo-France and ECMWF as part of the IFS/ARPEGE cooperation. The ARPEGE software shares large parts with the IFS, plus some components developed by Météo-France for its own use, e.g. ARPEGE/ALADIN physics, variable resolution, FA-file I/O. Access to the IFS parts is governed by ECMWF rules, in particular the National Meteorological Services of all ECMWF member states have free access to the IFS software.

ALADIN has been developed in cooperation between Météo-France and Meteorological Services of the ALADIN consortium. To use ALADIN requires access to most of the ARPEGE software, as well as additional ALADIN-specific components e.g. those related to the LAM geometry. A specific agreement between ECMWF and the ALADIN consortium grants access of the latter to all of the IFS and ARPEGE software, provided this access is not used to produce real-time global forecasts in non ECMWF member or associated States. ALADIN member institutes may grant access to the ALADIN software according to the rules of the current ALADIN Memorandum of Understanding, which clarifies among other things the research and commercial use.

AROME has been developed in cooperation between Météo-France, the Méso-NH community (whose main non-Météo-France member is the Laboratoire d'Aérologie), and the ALADIN consortium. AROME is based on the ALADIN software infrastructure and

contains large parts of the Méso-NH library; it requires the CNRM ISBA externalised surface scheme to run. To use AROME requires full access to the ALADIN software, to the relevant subset of the Méso-NH software, hereafter called the *common library* (some, but not all of Méso-NH physical parametrisations) and to the ISBA externalised software.

Pending a future simplification of the procedure, outside access to the AROME software currently requires the following authorization steps:

- access to ALADIN granted by any ALADIN member institute according to the ALADIN MoU,
- access to ISBA and the Méso-NH library, which requires a licence granted by the Méso-NH group.

Access to a piece of software implies the right to make a private copy, local modifications, and local installation. The right to modify the official, shared version requires further arrangements, at least because it requires special technical precautions and a strong involvement i.e. cost for all the parties involved.

Version management and merging arrangements

The keystone of a cooperative software development is the administration of versions, selection of imported components and resolution of conflicting requests for modification, a time-consuming process called « merging » or « phasing ». In the current organisation, the NWP software merging is performed as follows:

- internal Météo-France merges are made as « interim » IFS/ARPEGE/ALADIN versions, called « cycles », in the CNRM/GMAP group, approximately every 3 month, often involving ALADIN modifications and help of ALADIN visitors in GMAP. Similar interim cycles are made inside ECMWF.

- joint IFS/ARPEGE/ALADIN cycles are done by a bilateral library exchange procedure between CNRM/GMAP and ECMWF, always involving substantial permanent staff and ALADIN visitors in GMAP, and lasting 1 to 3 months (time needed to resolve all conflicts). The result is a common ECMWF/MF/ALADIN NWP library (a « full » cycle). This process is repeated every 6 to 12 months. ECMWF/MF coordination meetings are held around the time of each cycle to resolve outstanding conflicts, and for mutual information on scientific and technical plans.

- the Méso-NH library undergoes a similar procedure between the main involved groups, CNRM/GMME and Laboratoire d'Aérologie. News versions to incorporate scientific and technical developments, called MASDEVs, are prepared and validated by specialized staff before they are released to the community. This process is repeated about once a year. It applies to the externalised ISBA software as well.

Extension of the working arrangements to Méso-NH

Until it is qualified for operational use, AROME is vitally dependent on contributions from both ALADIN and Méso-NH groups. The interest of the ALADIN group is to get scientific expertise from the Méso-NH group to tune and improve the AROME physics, as well as scientific validation of AROME when it is used in turn by the mesoscale research scientific community for in-depth studies. The interest of the Méso-NH group is to get some operational validation of the Méso-NH physics, as well as new research tools such as data assimilation.

This requires explicit rules to ensure coordination in the evolution of the shared Méso-NH physics library. The intention is to add specific arrangements for this purpose:

- the Méso-NH physics software used in AROME will be separately modified in the ALADIN and Méso-NH groups, suitably coordinated by designated software managers inside each group, and then merged at least once a year, after due approval and validation on both sides. The result of this operation will be a new Méso-NH MASDEV and ARPEGE/ALADIN interim cycle, with an **identical** AROME physics library. The merging and validation work will be done by the AROME team in CNRM/GMAP and the Méso-NH software coordination staff in CNRM/GMME. Méso-NH/AROME coordination meetings will be regularly held in order to decide on the acceptance of modifications, to solve conflicts and for mutual information about future plans.

Consistency between the Méso-NH and AROME usage of the common library and continuing cooperation between the two communities, dictates that options that only work in one of the models are kept to a strict minimum and duly justified, must be clearly documented and apparent in the source code, and they must not degrade its readability. These rules shall be enforced on a case-by-case basis at the discretion of the Méso-NH and AROME software managers. If large, incompatible developments become desirable in the future, their detrimental effect on the Méso-NH/AROME cooperation will be taken into account in the decision to accept them or not.

It is stressed that modifications to the behaviour of Méso-NH shall be switchable so as not to jeopardize the scientific consistency of multi-year experimentation programmes. Users of Méso-NH and AROME will not unreasonably resist the use of demonstrably beneficial features introduced into the common library by the other party.

Procedures for the submission of modifications to the NWP software

There are three basic classes of non-trivial modifications of the software: (a) the introduction of extra options (usually for scientific testing), (b) technical software cleaning, and (c) voluntary alteration of the meteorological results. Decisions for acceptation or rejection are usually taken on an ad hoc basis by the software managers of each project listed above. The following provides some basic guidelines for clarification of this decision-making process.

(a) It is important to encourage scientific creativity and trying out **novel ideas.** This can

freely be done by anyone with access to a given piece of software, either on a private copy, or as a harmless and switchable option of the common software that does not modify the results, provided it does not cause more software management problems than can be handled by the available coordination staff. In other words, *it is the job of the person who suggests a new idea to make it suitable for incorporation into the common software*. In particular, it is not acceptable to compromise the integrity of NWP software, either by altering its meteorological behaviour, by degrading its performance, or by making the software too hard to read or to maintain for the other developers. These conditions apply to ARPEGE, ALADIN, AROME, ISBA and Méso-NH software.

(b) Another class of modifications is the so-called « cleaning », or more generally **modifications to the structure of the software** itself. For instance to make room for future new scientific or technical functionality, or for optimisation on a new computer architecture. Whatever the justification, it means that many software lines are modified, which will require enormous work for all users to re-train themselves on the new source code. In other words, *such modifications require a large effort to document the detailed nature of the change **before** they are actually done, and they have to be widely accepted by the user base*. Again, it is the job of the one who proposes the modification to convince the community, and to find the workforce to implement the change.

(c) The most important modifications are those who do **change the results of the NWP software**. By essence, all attempts to improve the NWP forecasts are of this kind. It does not matter whether or not the change was intended or not (e.g. when changing the numerics of a given scientific computation). It does not matter if the change was inspired by sophisticated scientific concepts. Such changes have the potential to degrade the NWP system if their submission does not follow these very strict rules:

1. The change must be based on sound and scientific reasoning, preferably as a publishable scientific material, or at least one that has been explained and understood by the members of the community who work in the same field.
2. If the change is going to involve a lot of coding, it is recommended to start by demonstrating its well-foundedness using a simple, but convincing, testbed.
3. The change shall be implemented in a by default inactive way into the NWP software, and its positive impact shall be demonstrated in a real-size framework, according to the working practices for the considered system:

    - In ARPEGE, the impact shall be demonstrated in OLIVE data assimilation experiments of at least two weeks in two different seasons, showing at least no degradation of the forecast scores (additional diagnostics may be required).
    - In ALADIN (i.e. in the ALADIN-France configuration), a non-degradation of the scores and of the subjective performance shall be demonstrated on at least two weeks of forecasts in two different seasons
    - In AROME, a non-degradation of the established test-cases shall be demonstrated
    - In Méso-NH, the established test cases shall be run by the person or team responsible for the change, and the results shall be validated by the Méso-NH community.

Finding the resources to achieve steps 1, 2 and 3 is the responsibility of the person who suggests the change. Modifications that have not passed these steps will be regarded as not having sufficient scientific foundation for inclusion into the common software - or more precisely, that their foundation is not sufficiently convincing to justify the expense and risk associated to the remaining steps:

4. The modified code will be scrutinized by the relevant software managers to check for compliance with established coding practices. This is important for subsequent understandability and maintenability of the software, and even scientifically sound modifications can be rejected if they do not comply.
5. The modification will then be merged into the common software library at the next release, pending resolution of possible conflicts with other contributions, and it will be tested in combination with the other simultaneous changes in order to check for possible incompatibilities.
6. The merged release will be placed under the administration of the relevant official software managers (GCO team of Météo-France).
7. For NWP software in operational production (ARPEGE and ALADIN currently), the new library will be tested as a real-time parallel suite (« chaîne en double ») for several weeks and its suitability will be decided by the operations department, the decision is taken in complete independence from the scientific community.

At each stage, the GMAP group will provide assistance within the limits of its own resources, the priorities being set according to the group's own R&D strategy as approved by the Météo-France management; the relevant aspects of the Méso-NH group R&D strategy are under the responsibility of the CNRM management.