

# Status of the Reference System<sup>1</sup>

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## 1 Recent HIRLAM releases

The current official version is the release 7.0, launched on May 2, 2006.

On September 27, 2006, HIRLAM 7.1 alpha1 was released. The release consists of several meteorologically significant new features,

- Introduction of the coming reference model domain with increased resolution. The geographic coverage will remain unchanged, but a resolution increase in both horizontal and vertical is planned, from the current grid mesh with 438x348 at 0.2 degree resolution and 40 levels, to 538x440 at 0.15 degree resolution and 60 levels;
- An upper air data assimilation based on incremental 4D-VAR with 6 h assimilation interval;
- An upgrade in CBR turbulence scheme with parameterization of moist processes, a tuned STRACO condensation scheme adding parameterization for cloud ice;
- A recoded physics parameterization package for CBR, STRACO and radiation schemes which is in phase with the "HIRLAM parameterization package" that was phased into the ALADIN/IFS;
- A statistical-balance structure function derived with NMC method replacing the one with analytical balance;
- A updated climate generation, version 7.1, which features parameters needed for mesoscale and subgrid scale orographic effects parameterization (MSO/SSO);
- Configuration to perform experiments on the new ECMWF computer platform HPCE.

In addition, preparation for several new components is still ongoing and the new features will be included in the forthcoming 7.1 alpha releases after some more tests:

- An upgrade in surface scheme with main focus on improved parameterization for snow and for forest. The code is already included in the reference repository but in form of a branch;
- Optional assimilation of MODIS wind vector and AMV wind data. The code has been delivered;
- Optional assimilation of surface relative humidity data. The code is available;
- Implementation of RTTOV 8 radiative transfer module and the algorithm to derive bias correction accordingly;
- First outcome of the HIRLAM-A code cleaning and system overhaul;
- Optional inclusion of climatological index field and Eady index to account for heterogeneity of background error structure function;
- Enhanced post-processing in forecast model to enable more direct diagnostic output such as visibility, gust wind, CAPE index, precipitation category, pseudo satellite image, max/min surface wind and temperature etc.
- Parameterization of MSO/SSO and radiation over sloping surface
- Assimilation of Ocean Sea Ice-SAF SST and ice data.
- Optional assimilation of Quikscat data.

Due to various delay the currently assembled 7.1 system is still an incomplete one compared to the targets for 7.1. Furthermore, not all individual components or the assembled system has been tested

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<sup>1</sup> An irregular update of this document is available on the HIRLAM system wiki page <https://hirlam.org/trac/wiki/ReferenceSystemStatus>

sufficiently. In the coming periods, emphasis of further evaluation and tuning will be on 4D-VAR and new surface scheme. Some delay of 7.1 is foreseen already now associated with these tasks. In addition, introduction of several new components, such as the assimilation for OSE-SAF and quikcat winds, is likely to be delayed. For the new surface scheme and parameterisation of MSO/SSO, there is still uncertainty about their entry into 7.1.

## 2 Planned HIRLAM system releases in the near future

It is estimated that several additional 7.1 alpha releases will be issued in the near future for introducing new components for 7.1. Upon completion of key components, 7.1 beta and rc (release candidate) will be issued prior to the official launch of Hirlam 7.1, which is now targeted for January/February 2007.

In October 2006, a 7.0.1 release will be made. 7.0.1 is a bug-fix release for the current official version (Hirlam 7.0) with no new features, with the exception that the default computation platform will be changed from ECMWF HPCD to HPCE.

## 3 Evaluation of the new components and 7.1alpha1

Extensive numerical experiments have been conducted to evaluate the key components for version 7.1. First the individual components are built separately on top of the official release 7.0, followed by parallel experiment to examine sensitivity of the new features. These tests indicate that,

- Resolution increase in horizontal and vertical, together with use of new statistical balance structure function representing background error characteristics, have positive impacts on most forecast parameters;
- 4D-VAR data assimilation, which are mostly conducted at the SMHI computer platform, shows consistently and significantly improvement in synoptic scores than that of 3D-VAR. The introduction of 4D-VAR with weak constraint on gravity wave also eliminates need for initialization;
- The new physics with moist CBR and tuned STRACO, shows largely positive impact on key verification parameters including precipitation. The impact is more clear in winter season.
- The new surface scheme improves forecast of surface temperature and humidity during melting season. The new scheme also improve description of diurnal cycle. On the other hand, there seems to be need for tuning for other seasons, for which an enlarged negative temperature bias has been observed.

Difficulties have been encountered during the evaluation phase of the new components. Besides the heavy needs for tuning of the new surface scheme:

- Several bugs have been identified with the climate generation, which causes problem to some of the HIRLAM operational domains, one of them being the new domain for RCR with 0.15 degree resolution and 60 levels. Existence of individual data holes for the input climate fields of surface temperature over water and ice tiles brings uncertainties to the results of numerical experiment.
- It was found lately from experiment at ECMWF IBM platforms that it is difficult to reproduce the significantly positive impact associated with 4D-VAR. Examination of computer platform dependency/equivalency thus become an urgent task.

In view of these findings, the first assembled release of 7.1 is named as alpha release instead of beta. The default model domain is kept as the original RCR one with 0.2 degree resolution and 40 levels, while the new surface scheme, is kept temporarily outside of the head version of the system repository. Instead, a code branch containing the new surface scheme is established with is kept in phase with the rest of head version.

A month-long data assimilation cycling run using the standard setup for 7.1alpha1 has been performed, and the results are presented in Figure 1, in which the averaged standard deviation and bias errors of the model forecasts for key forecast parameters for the period of March 2006 are shown, validating against EWGLAM station-list. Also shown in the plot is the equivalent run using current official release, 7.0. A general improvement in 7.1alpha1 for standard deviation error is seen for key parameters such as surface pressure and upper air parameters. Positive impact is also observed for bias in mean sea level pressure and surface relative humidity. The new system is also seen to be associated with a significantly reduced amount of precipitation for this month, which improves the score for low-precipitation class (not shown here). The improvement in 7.1 is attributed to 4D-VAR, use of statistical balance structure function and improved physics. Note the default version of 7.1alpha1 as run here does not include resolution change and the new surface scheme.

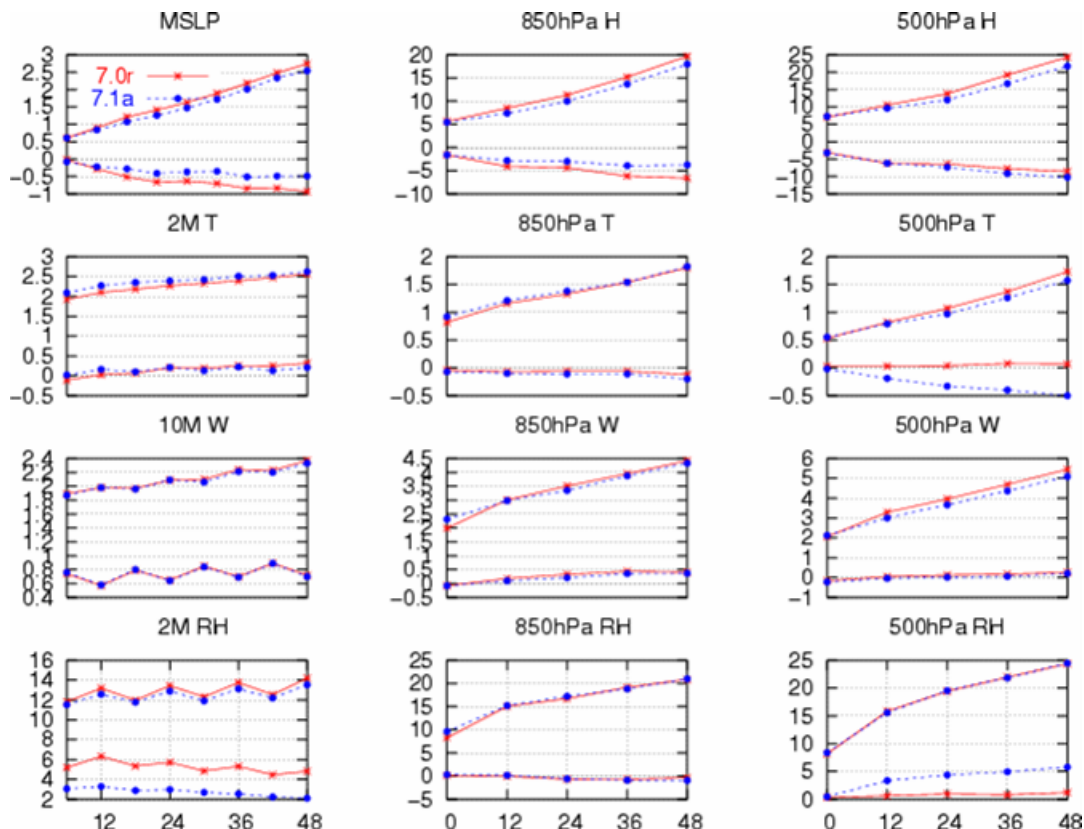


Figure 1 Observation verification for key forecast parameters with Hirlam 7.0 (in red) and with Hirlam 7.1alpha1 (in blue), for the period March 1 to 31, 2006, validation against EWGLAM station data. The upper curves are for averaged standard deviation errors and lower curves for bias errors. The main differences between the two systems are in data assimilation scheme (3D-VAR with analytical balance Sigma B in 7.0 and 4D-VAR with statistical balance Sigma B in 7.1, physics).

#### 4 Outstanding issues in the reference Hirlam system

- The forecast system continues to suffer problem of reproducibility of various degrees. For the forecast module, it has been identified that diagnostic procedure for mean sea level pressure and geopotential height does not reproduce results with MPI. Further, it has been found that evaluation tests on ECMWF HPC platform failed to reproduce the strongly significant positive impact by 4D-VAR, as has been observed on SMHI Linux-cluster platform.
- The current practice of model level output and initialization for physical quantities (such as cloud cover) needs improvement in order to ensure reproducibility at pure forecast re-start. Currently, not all required fields, such as 3D cloud cover, are saved to history files.

- The forecast model continue to suffer unexplained occasional crash on IBM HPC platform, which has been observed since 6.3.5. Recently this has also been observed at linux cluster platform. The reason for such crashes are unclear but they appear to be associate with MPI parallelization, since a simple change of domain decomposition, or a change of time step (either upward or downward) could make the run though.

## **5 Progress of the forecast quality with the operational Hirlam**

In the annual progress report about the HIRLAM system and operational implementation (Yang, 2006), the recent implementation of the HIRLAM system at operational centers has been reviewed. The report includes an illustration of the quality improvement of the HIRLAM system in the past years, through observation verification time series of the RCR forecasts for surface parameters. Significant quality improvements illustrated in those time series are seen to be closely associated with the system upgrades during June 2005 (version 6.4) and May 2006 (version 7.0).

## **6 Reference**

Xiaohua Yang, 2006, Progress Report of the Operational Hirlam, *Hirlam Newsletter*, 51. 70-77.