Re-forecast procedure in HIRLAM 7.0

Xiaohua Yang, DMI and Ole Vignes, met.no

Abstract

A re-forecast procedure has recently been implemented in the reference HIRLAM version 7.0[1]. The procedure involves remake of short range forecast every 6 hours with the purpose to improve description of the large scale flow in the background field and thereby to improve data assimilation. Such a re-forecast is initiated with a 'blended' model state combining large scale part of the (ECMWF) global analysis with smaller scales from the nested model (HIRLAM's) first guess, through application of the incremental digital filtering algorithm, IDFI. The implemented re-forecast procedure is similar to those used in the HIRLAM operational suites at DMI and met.no. In this note, we describe the implemented re-forecast procedure for HIRLAM 7.0.

1 Background

The HIRLAM forecast system comprises of two main components: a data assimilation module for deriving initial atmospheric condition (model state) from both observation and (model) background information, and a deterministic forecast model for prediction of future model state based on initial and lateral boundary conditions. Needless to say, the quality of the background information in a data assimilation cycling is of vital importance. Based on operational experiences at the HIRLAM member services and comparative monitoring of forecast results from HIRLAM and global models, it is argued that the quality of the background field can be improved significantly through a re-forecast procedure. Such a procedure seeks to 'blend' large scale features from the high quality (ECMWF) global analysis with HIRLAM's own high resolution, resolvable-scale features, thereby enhancing quality of the background field, especially in the description of large scale structures.

Over the past years, several alternative approaches for the above mentioned scale blending have been applied in HIRLAM's operational suites in member services, such as those in DMI, met.no and KNMI[2]. In DMI-HIRLAM, use of ECMWF analyses was initially introduced in 1999 via a re-assimilation procedure ('DMI1999') in which a direct blending of analyzed model states between ECMWF and hirlam model is made. This was then replaced by a re-forecast procedure ('DMI2004'), in connection with DMI's implementation of the current reference forecast model in its operational suite. With 'DMI2004', ECMWF analyses and HIRLAM first guesses are 'blended' via an incremental digital filtering scheme, IDFI (Yang, 2004). The operational implementation of re-forecasts at met.no ('metno2005') follows the same procedure (Vignes et al, 2005). At KNMI, similar blending of ECMWF and HIRLAM fields is done, although the filtering is made with a digital filtering launching scheme ('KNMI2005'), (Sander Tijm, personal communication). Finally, in November 2005, a newly developed incremental spatial filtering approach was introduced operationally in DMI-HIRLAM ('DMI2005'), in which HIRLAM's re-analysis is combined with ECMWF analysis through a more elaborate scale blending scheme (Yang et al, 2005).

For the first implementation of the re-forecast procedure in the reference HIRLAM 7.0, the above mentioned 'DMI2004'/'metno2005' approach has been adopted.

2 Scale mixing in the re-forecast procedure

The re-forecast is achieved by initiating a short range forecast using a blended initial model state, combing the key prognostic quantities from host analysis (ECMWF) with that of the first guess from the nested model, through an incremental digital filtering algorithm

$$\mathbf{X}_{ini} = \mathbf{X}_{fgs} + \overline{\mathbf{Y}_{ana}}^{DFI} - \overline{\mathbf{X}_{fgs}}^{DFI}, \quad (1)$$

[1] HIRLAM 7.0 was launched officially on May 2 2006

[2] A detailed description on the theoretical and practical aspects of the scale-blending methods can be found, e.g., in Yang (2005).

where $\mathbf{X}$ represents the model state from the nested model including P_s, U, V, T and Q, $\mathbf{Y}$ the model state from the host model. ini here denotes the initialized model state, ana the analysis, fgs the first guess (note that in HIRLAM, fgs is actually the modified one by surface analysis). Finally, DFI is the low-pass time filter.

With the current default configuration, a Dolph-window filter is applied twice, first after an adiabatic backward integration for 2 h. The filtered model state, which is nominally valid at -1 h from analysis time, is then re-started to integrate forward for 2 hours, this time with full physics. The second application of DFI results in a filtered model state valid at the original starting point. Figure 1 shows the amplitude response of the default DFI filter.

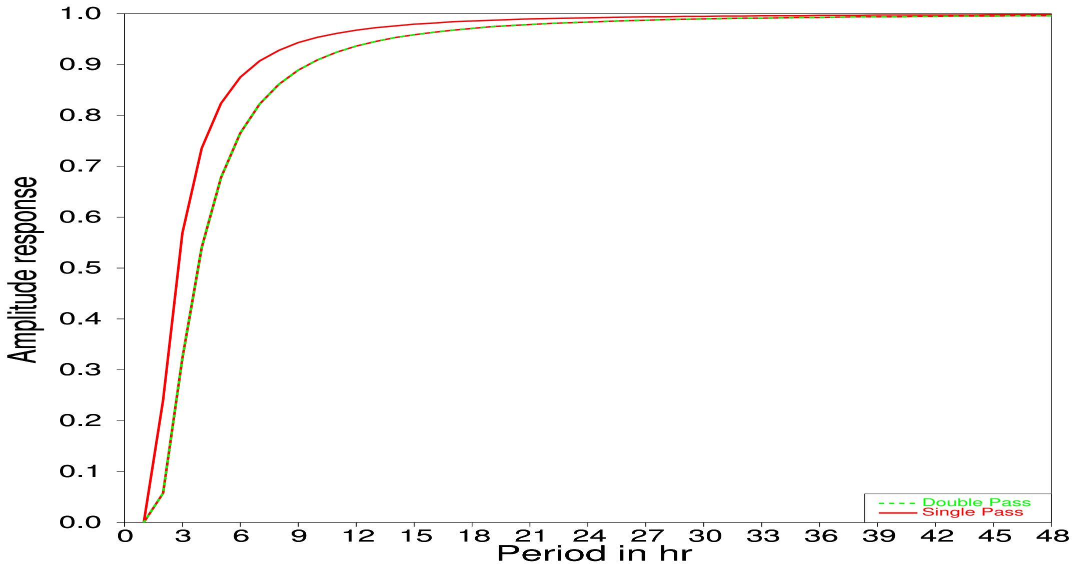

Figure 1: Filtering property of the DFI scheme as implemented in reference HIRLAM, represented by frequency response, as a function of period, for Dolph filter with a filter span of 2 hours, a cut-off period of 3 hours. Note the "cut-off period" here refers to the fact that energy is halfed for waves with that length-scale. (Original figure from Yang 2005, Figure 1)

With incremental DFI, the above procedure is applied separately to both the model state ana and fgs. After that, the difference of the filtered model states (initialization increment) is added to the original field fgs, thus the final initialized model state is a combination of the host model state, primarily in large scale, and the nested model state for 'remaining scales'[3].

3 HIRLAM data assimilation cycling with re-forecast

Figure 2 illustrate normal data flow in a assimilation cycle with HIRLAM 7.0. As is shown in the sketch, the introduction of re-forecast procedure requires an addition of short-range forecast, labled as "RE-FC" in red in Figure 2, following each regular cycle for long forecasts at synoptic time, (00, 06, 12 and 18 UTC). The step is done after reception of ECMWF global analysis, approximately 6 h after the nominal analysis time, and prior to the start of the assimilation cycle around the next synoptic time. Note that the lateral boundary data used in the re-forecast are also more recent, i.e., with zero age.

4 Practical implementation

The above re-forecast procedure was implemented in HIRLAM beta version 6.4.4, released on Feb. 9, 2006. The implementation was done on script level, in which boundary strategy, preparation of input

[3]The inclusion of the latter is a principle difference from other 'full' DFI schemes such as DFI launching, in which there is no 'remaining scales' kept after DFI algorithm

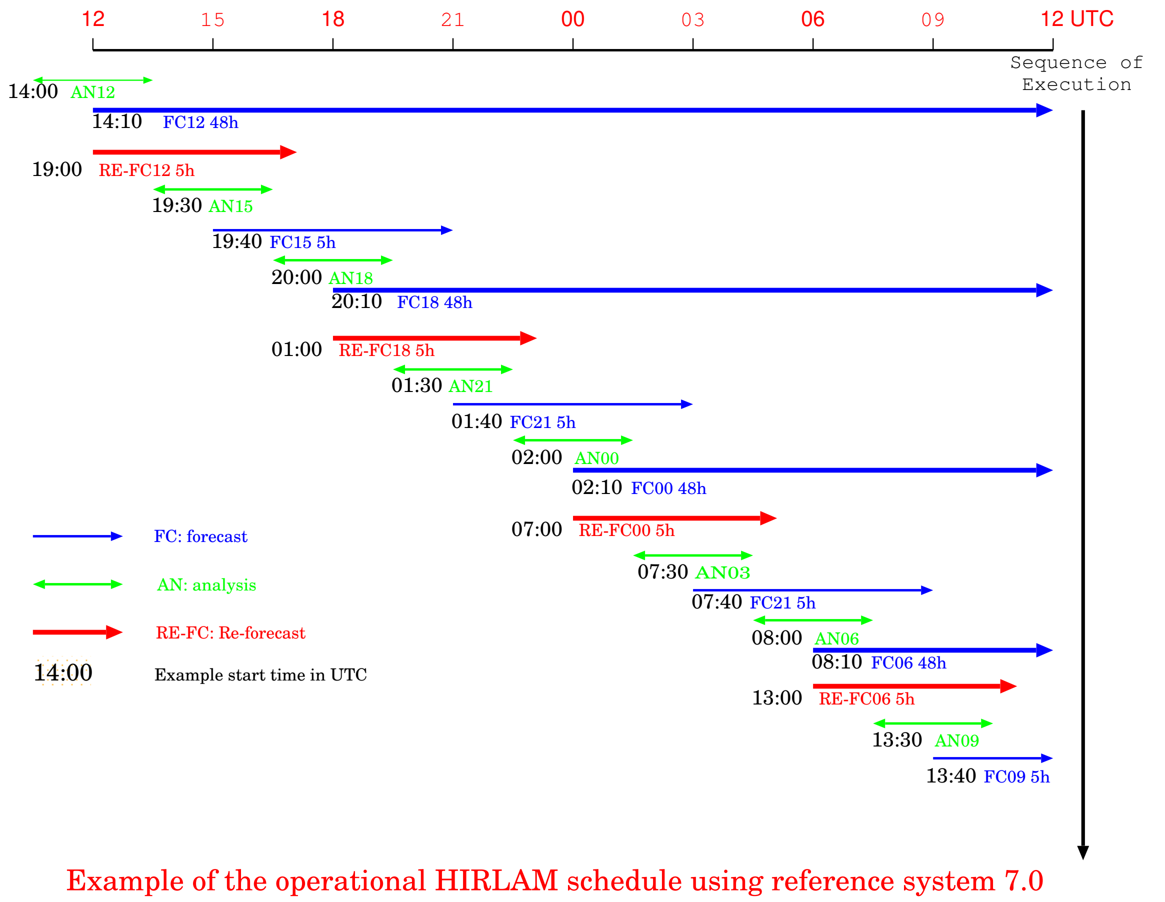

Figure 2: A diagram of the data flow in the data assimilation cycle with HIRLAM 7.0 featuring re-forecast. The assimilation interval is 3 h.

files in forecast, surface and upper air analyses have been modified to enable the addition of short range forecast. In the mini-SMS job script the re-forecast procedure is controlled by environment variables LSMIX, MIXINT and INCMOD. LSMIX (Large Scale MIXing) activates the procedure at an interval of MIXINT, which is 6 h in operational application, and finally, the blending of host analysis with the nested model field is done via IDFI using option INCMOD as 2.

5 Validation

Parallel experiments for two 2-week summer and winter episodes were performed to validate the scheme implemented in 6.4.4. Compared to 6.4.3, the main new features in 6.4.4 were the re-forecast scheme and use of AMSU-A data. The results are presented in HIRLAM's internal webpage, (`https://hirlam.org/UG/ValidationNotes/HL6_4_4V.html`). From the comparison, it is found that the updates improves on root-mean-square errors of observation verification for almost all key parameters, especially those for mean sea level pressure and upper air scores. A more comprehensive validation study can also be found in the related reports by Kalle Eerola in the current issue of the HIRLAM Newsletter.

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6 References

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