Using IFS Frames for LM Lateral Boundary Forcing: Verification Results

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1 Introduction

LM has been running daily on the VPP5000 at the ECMWF driven by the IFS model since March 2001, as a backup of LAMI (the Italian version of LM). An experimental run using IFS *frames* was implemented in June 2002. *Frames* stands for boundary condition fields defined around a boundary strip of the model grid. The use of frames in an operational LAM is advantageous, because of the saving in size of the boundary data file and in its transfer time.

The objective verification of LM are presented for runs with and without frames in the period 10 June - 20 August 2002. Mean error and root mean square error (RMSE) vertical profiles are computed for the Italian radiosounding stations (Milano, Udine, Pratica, Brindisi, Cagliari, Trapani, Bologna). Surface parameters are verified for about one hundred synop lowland stations (1) satisfying the COSMO WG5 specification ($H_s < 700m, |H_s - H_n| < 100m$, where H_s is the station height and H_n is the height of the nearest land grid point).

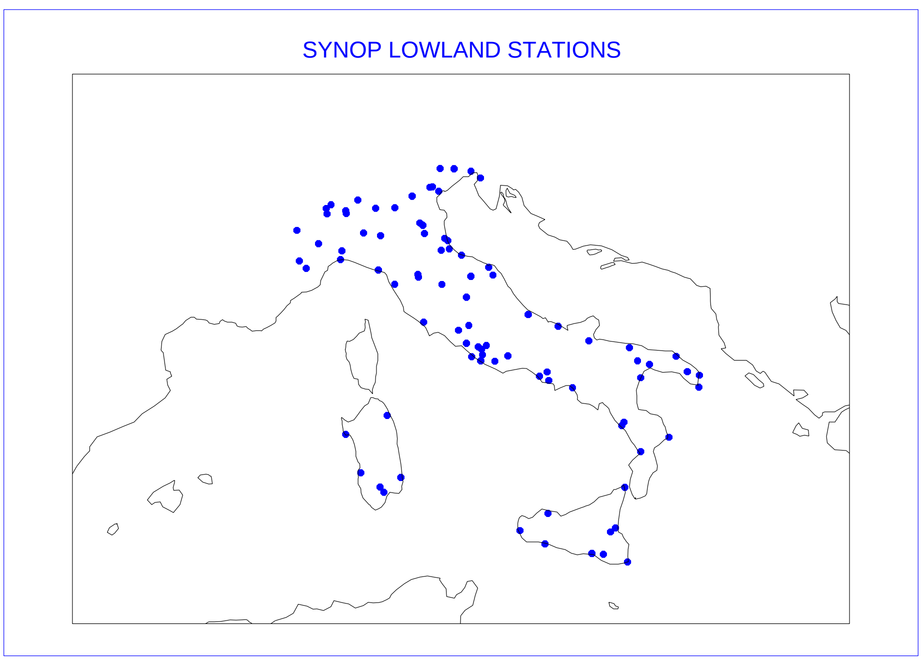

Figure 1: Synop Lowland stations in Italy

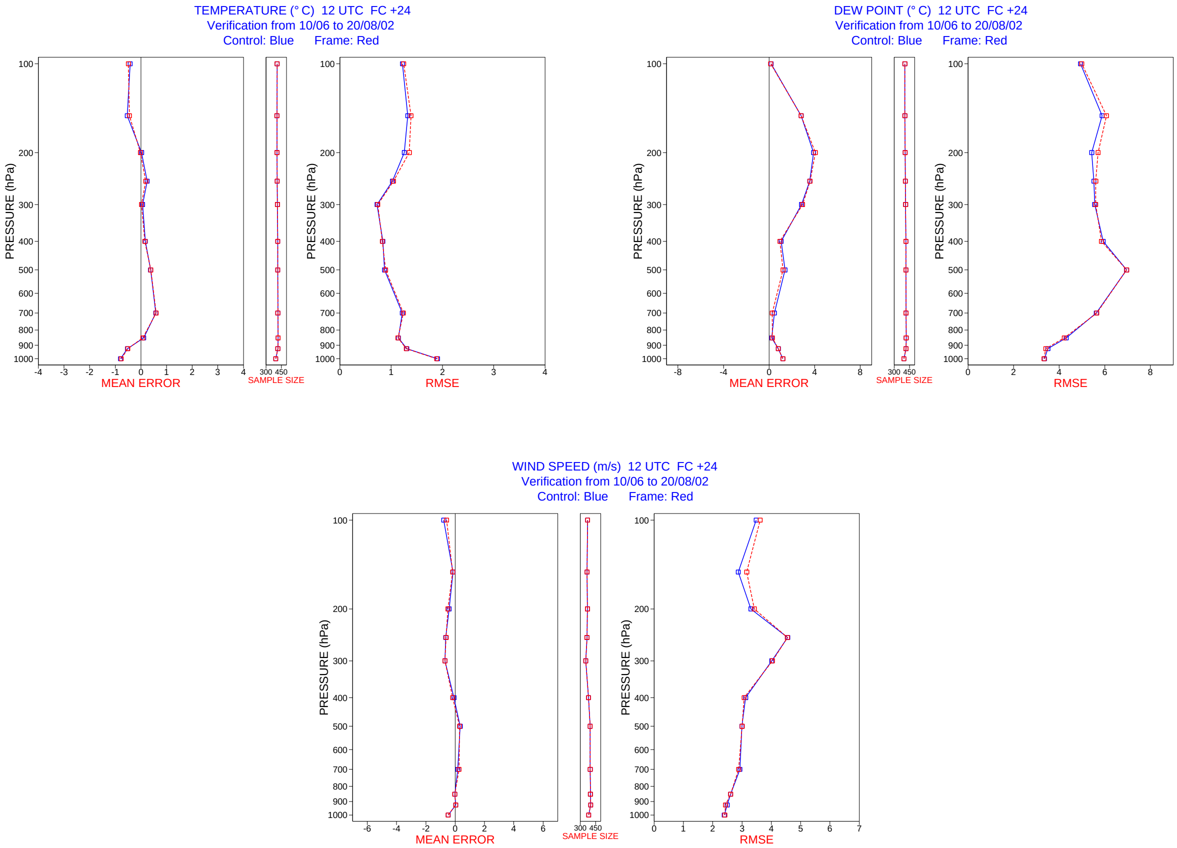

Figure 2: Temperature, Dew Point and Wind Speed

2 LM configuration

The same configuration of LAMI was basically used in this experiment as is used for the operational runs. Forecast fields of the 12 UTC operational IFS run were used as boundary data for LM runs. LM code version 2.11 needed some modifications to accept boundary condition fields defined on a frame. The new option included in version 2.19, is switched on, if `lbd_frame` is `.TRUE.` and `npstframe` > 0. `npstframe` represents the width (number of points) of the frame. Runs with frames are possible only if the Rayleigh damping in the upper levels is switched off (`lspubc = .FALSE.`). The task of this damping is to absorb upward propagating wave disturbances and to suppress the wave energy reflection at the top boundary due to the rigid lid upper boundary condition. It tends to restore the externally specified boundary fields near the top of the domain, as a consequence its application requires boundary condition fields defined on the full grid.

3 Vertical profiles

Mean error and RMSE vertical profiles of temperature, dew point and wind speed at 12 UTC (forecast +24 h) are shown in Fig. 2 for runs with (red dashed line) and without frames (blue solid line). All variables have slight differences between the two RMSE profiles in the upper levels above 250 hPa. At 00 UTC (forecast +36 h) the differences are less pronounced than at 12 UTC (not shown). No significant differences are found in the Mean Error profiles.

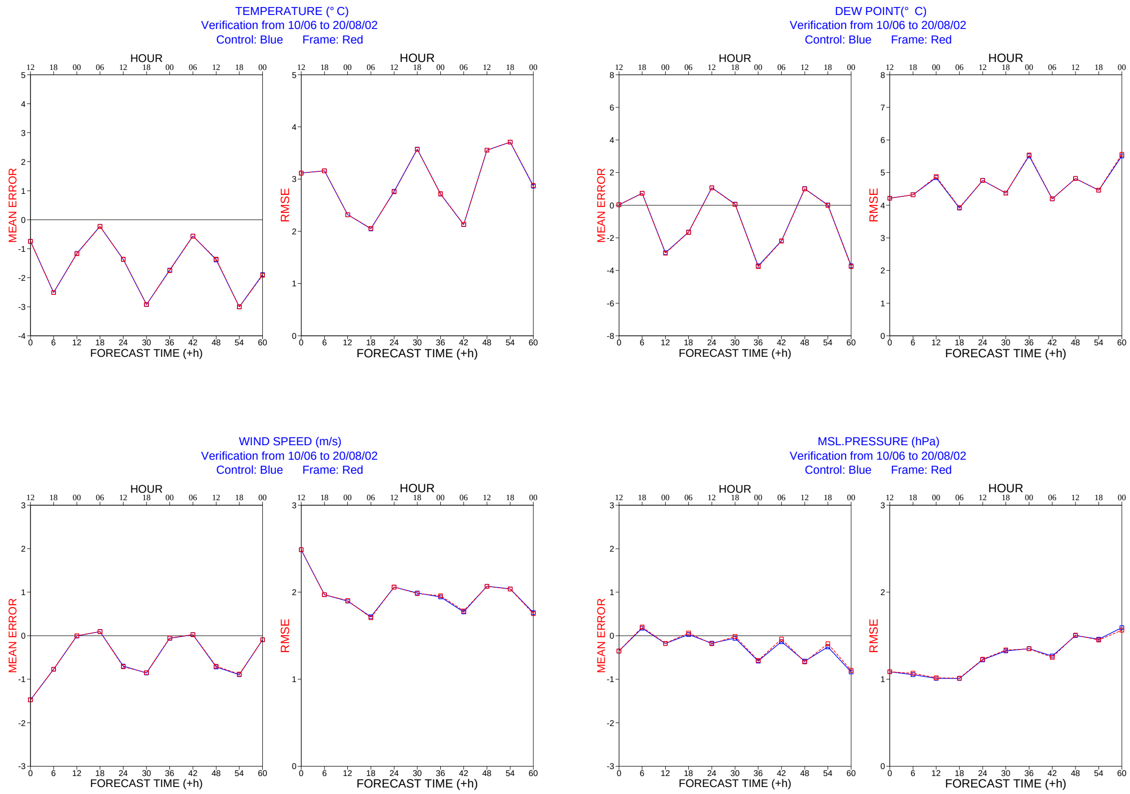

Figure 3: Temperature, Dew Point, Wind Speed and Mean Sea Level Pressure

4 Surface variables

Mean error and RMSE of temperature, dew point, wind speed and mean sea level pressure as a function of the forecast time are represented in Figure 3 for runs with (red dashed line) and without frames (blue solid line). The same Mean Error and RMSE diurnal variation for both kind of run are found for each investigated variable.

5 Comparison of results for the vertical velocity field

The behaviour of vertical velocity was investigated for both kind of runs. Maximum, minimum, mean values and standard deviation, computed using all grid points at 12 UTC (forecast +24 h), were represented in Fig. 4 for runs with (red dashed line) and without frames (blue solid line). Vertical velocity in runs with frames assumes a wider range than in runs without frames above 500 hPa (at 00 UTC above 300 hPa - not shown), but more significant above 200 hPa. Moreover vertical velocity in runs with frames has more scattered values above 700 hPa. No significant differences are found in the low levels.

5 Conclusion

The result of this verification does not show significant differences in the investigated low level and surface fields, which can be basically used in operational forecasting. Upper level fields of runs without frames show a little less variance than those of runs with frames,

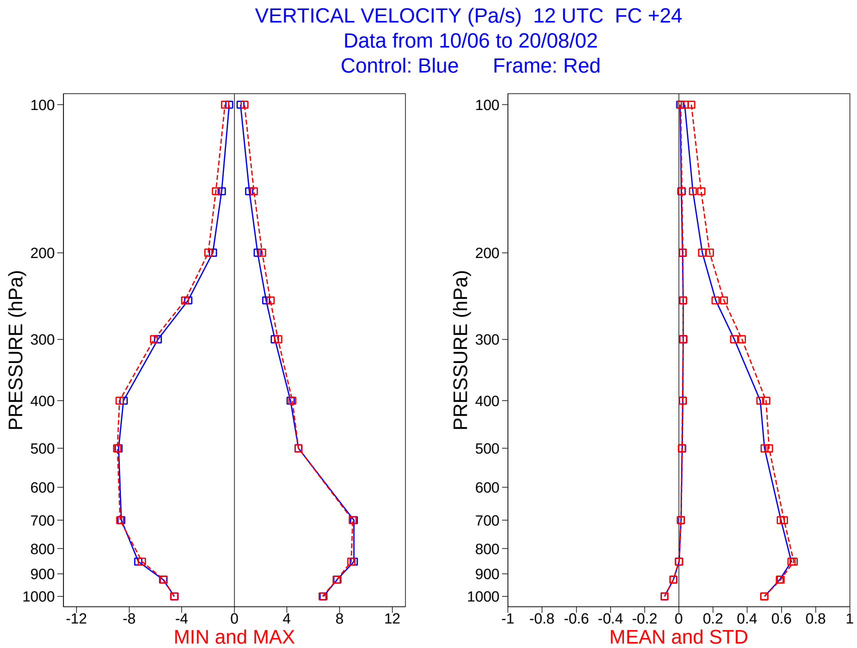

Figure 4: Vertical Velocity

because of the effect of the Rayleigh damping, which tends to restore the large scale fields specified as boundary condition. The damping layer, occupying the top portion of the model domain, contaminates that portion of the model grid with dynamical effects which are not due to the primitive equations.

On the other hand if the damping layer is not active, as in runs with frames, the upper boundary becomes a potential source of spurious reflected waves, which can be generated by orographic and convection forcing. Forecast fields of LM runs with frames are affected by the wave energy reflection at the upper boundary, in particular orographically induced flows can not be properly simulated. A more satisfactory solution to the spurious waves' problem than the damping layer would be to specify a radiative upper boundary condition at the top. Unfortunately it is not a good solution from the computational point of view.

More work needs to be done to optimize the use of boundary conditions defined on a frame in LM, but it is obviously a better solution to have boundary fields defined on the full grid for the model levels where the Rayleigh damping is active.

References

Purser, R.J. and S.K. Kar, 2002: Radiative upper-boundary conditions for a non-hydrostatic atmosphere. *Quart. J. Roy. Met. Soc.*, 128, 1343-1366.