Nonhydrostatic HIRLAM With Semi-Lagrangian Semi-Implicit Dynamic Core in High-Resolution NWP Environment

R. Rõõm, A. Männik, A. Luhamaa
University of Tartu, Estonia

1. INTRODUCTION

Since 2004 a very high resolution nonhydrostatic NWP system is running in a near-operational regime at Estonian Meteorological Hydrological Institute (EMHI). This is a collaboration effort between University of Tartu (UT), EMHI and Finnish Meteorological Institute (FMI). EMHI hosts the environment, provides communication and computing facilities, and defines the requirements and societal demand to the project. FMI provides boundary and observational data to the forecast model, and delivers its long-lasting limited area modelling and operational forecasting know-how. The role of UT is to maintain the environment, to develop nonhydrostatic core model together with high resolution physics package and ensure its scientific and operational quality.
The project aims for high-precision presentation of local effects and improvement in short range forecasting. The advances are expected mostly in precipitation event or local wind modelling and in increase of severe weather forecasting precision. In addition, it is hoped that the high resolution NWP data is beneficial to wide range of practical and scientific applications like air pollution modelling or coastal research.

2. MODEL DESCRIPTION

The NWP system is based on the NWP model of HIRLAM Consortium, and also on its semi-Lagrangian, semi-implicit nonhydrostatic (NH SISL) extension, developed at UT. The basis for dynamics are the semi-anelastic pressure-coordinate equations of motion and thermodynamics in Lagrangian form (Rõõm, Männik and Luhamaa 2005).
NH SISL uses height-dependent reference temperature and Brunt-Väisälä profiles which results in enhanced stability rates as the nonlinear residuals are minimized in vertical development equations. NH SISL tries to be as close as possible to the parent hydrostatic HIRLAM SISL scheme (McDonald 1995). The existing routines of trajectory calculations and interpolations as well as the interface to physical packages are maintained.

The NWP environment is based on HIRLAM version 6.4.0 with following set of options: Optimum interpolation for data analysis; Implicit normal mode initialization; Semi-implicit semi-Lagrangian dynamics; ISBA scheme for surface parameterization; STRACO scheme for large scale and convective condensation; Savijärvi radiation scheme; CBR-turbulence scheme.

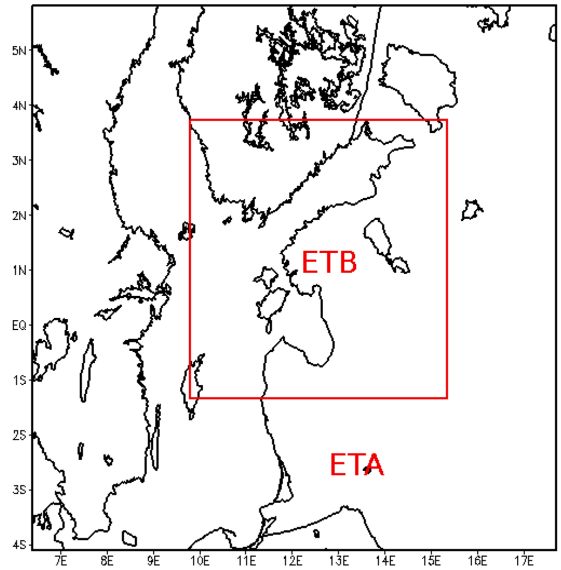

Figure 1. Modelling areas

Low resolution area ETA: Horizontal resolution 11 km, hydrostatic SISL scheme,
400 s time-step, Grid 114x100 points, 40 levels.
High resolution area ETB: Horizontal resolution 3.3 km, NH SISL scheme, 150 s time-step, Grid 186x170 points, 40 levels

ETA area serves as a reference model for comparison. Boundary fields to ETA are provided by FMI from 22 km resolution operational model four times a day with forecasting start-point at 00, 06, 12 and 18 GMT. The time frequency of boundary fields for ETA and ETB is 3h (with option to increase up to 1h for ETB).
Twice a day 36h forecasts are produced in ETA area with start-points at 00 and 06 GMT. To maintain analysis cycle, additional two 6h forecasts are produced by ETA with start at 12 and 18 GMT. Computation of analysis and forecast takes approximately 15 minutes.
The ETB area uses forecasts of ETA area as lateral boundaries. 36h forecasts are produced once per day with start at 00 GMT ETB has its own analysis with interval of 24h. The time spent on computing of forecast is about one and a half hours.

4. EXPERIENCE

To evaluate the WHR NWP system performance, larger ETA model uses standard HIRLAM package, where forecast is compared against the set of standard observations. In the case of former, small ETB domain, time series of observations were compared against forecasts at few selected stations.
Figure 2 presents monthly average of comparison of ETA, ETB and FMI forecasts against sounding station at Harku in April 2005, which was the only station which all three models shared at that period.
Figure 3 presents monthly average of verifications of forecasts of different length for ETA and ETB models against standard observations at Tõravere meteostation in April 2005.

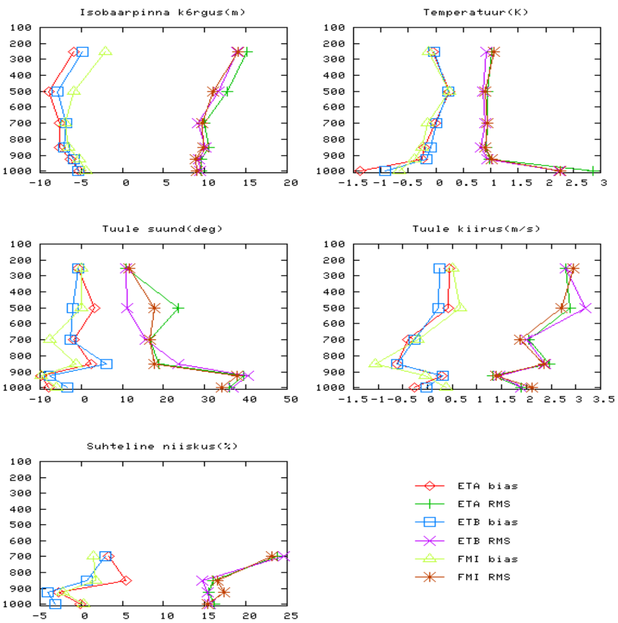

Figure 2. Monthly average of comparison of ETA, ETB and FMI forecasts against sounding station at Harku in April 2005

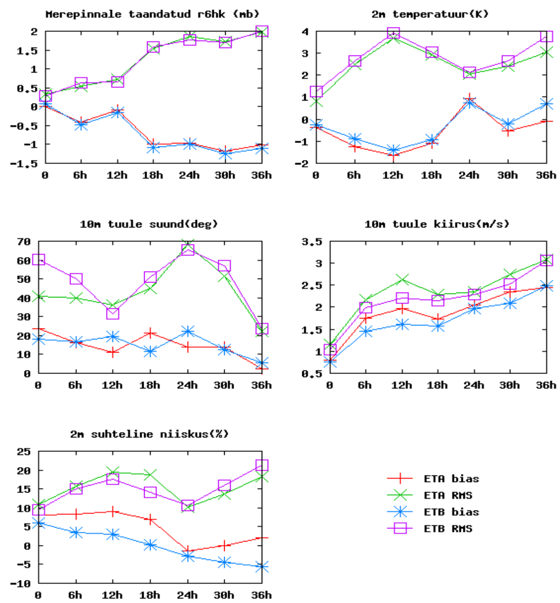

Figure 3. Monthly average of verifications of forecasts of different length for ETA and ETB models against standard observations at Tõravere meteostation in April 2005.

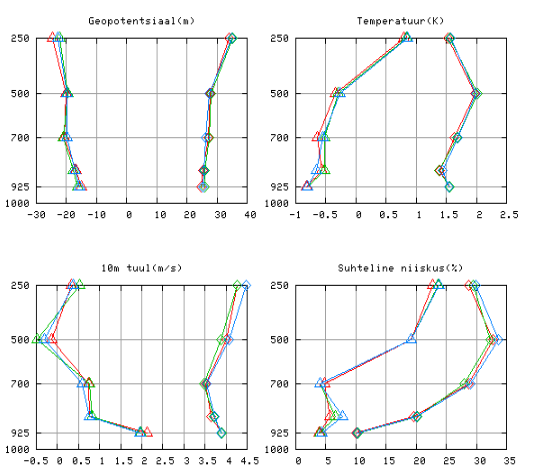

Figure 4. RMS errors (rhomb) and biases (triangle) for sea-level pressure, 2 m temperature, 10 m wind and 2 m relative humidity at different forecast lengths. Red line marks HS SISL with 3.3 km resolution, green line NH SISL at 3.3 km resolution and blue line HS SISL with 11 km resolution.

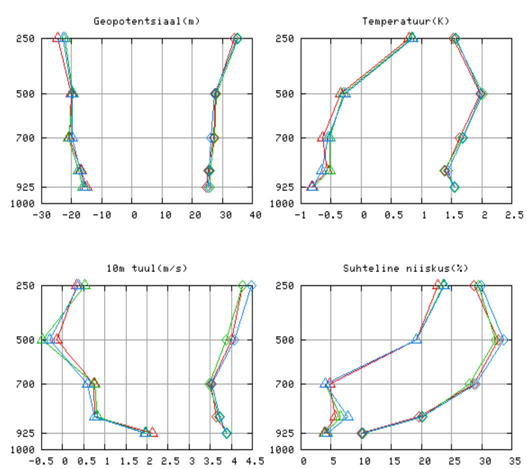

Figure 5. RMS errors (rhomb) and biases (triangle) for geopotential height, temperature, wind and relative humidity of 36 h forecast at different pressure levels. Red line marks HS SISL with 3.3 km resolution, green line NH SISL at 3.3 km resolution and blue line HS SISL with 11km resolution.

5. CONCLUSIONS

The NH SISL is implemented as the adiabatic core in Estonian B-area model (3.3 km resolution, grid 186x170, 40 levels). Since August 2005, the NH SISL code is ported to the latest official HIRLAM reference version 6.4.0, and its preoperational testing is launched at EMHI.

As the preliminary statistical testing reveals, the NH-specific effect is moderate at these resolutions for the given physical parameterization and lowlands condition. More NH behavior will be expected at very high spatial resolutions (0.5 - 1km, 100 levels), in which case NH SISL will be a suitable tool for development and testing of new physics, including the complex terrain, boundary layer, and moist convection.

REFERENCES

McDonald, A., 1995: The HIRLAM two time level, three dimensional semi-Lagrangian semi-implicit limited area, gridpoint model of the primitive equations. *HIRLAM Technical Report,* **17,** 25p.

Rõõm, R., A. Männik, A. Luhamaa, 2005: Nonhydrostatic adiabatic kernel for HIRLAM. Part IV. Semi-implicit semi-Lagrangian scheme. *HIRLAM Technical Report,* (in preparation)