Comparison of HIRLAM wind data with measurements at Estonian coastal meteorological stations

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Abstract. The possibilities of using High Resolution Limited Area Model (HIRLAM) version 6.4.0 outputs to describe wind parameters in the coastal zone of Estonia were investigated. For this purpose output from 3-dimensional variational (3DVAR) analysis and 24 h forecast files were compared with measurements at nine coastal sites during January and April–December 2007. Special attention was paid to moderate and strong winds (wind speed >5 m/s) that are responsible for sea level changes and high wave heights in the coastal area. It is shown that HIRLAM overestimates the wind speed. This overestimation is stronger in cases where HIRLAM uses an inadequate land–sea fraction in the respective cells. The model describes the angular distribution of moderate and strong winds better than that of weak winds. Except for one station, approximately 90% of HIRLAM estimates of the direction of moderate and strong winds differ less than ±22.5° from the measured values; in approximately 60% of cases the direction differs less than ±10°. The HIRLAM system approximates best the winds at the westernmost stations on the Estonian islands and in Pärnu, whereas a 24 h forecast gives somewhat better results than the winds diagnosed from 3DVAR analysis.

Key words: HIRLAM version 6.4.0, wind speed, wind direction, Estonian coastal sea.

INTRODUCTION

Coastal processes are affected by a large number of factors, of which waves and water level variations are most important. Both of these factors depend on the wind speed and direction (Soomere 2003; Suursaar et al. 2003). Wave and sea level statistics may be extracted either from long-term measurements or from numerical modelled fields. The second method requires a knowledge of wind statistics or wind conditions during the time period under consideration. For this purpose data from nearby meteorological stations (Suursaar et al. 2003; Soomere 2005) or from semi-realistic expectations of changes in wind climate (Suursaar & Kullas 2006) are used.

One of the most powerful cyclones of the last decades, Gudrun, which caused severe storm surges on the coasts of the Baltic States and Finland, has encouraged discussions on the possibilities of accurate forecasts of such events (Suursaar et al. 2006; Soomere et al. 2008). In the Baltic Sea area wind forecasts are performed by means of the numerical weather prediction (NWP) system HIRLAM (stands for High Resolution Limited Area Model; the information on HIRLAM is available at member institutes or online at http://hirlam.org). Therefore the applicability of HIRLAM outputs should be estimated.

Suursaar et al. (2003) show that in some cases high sea level values are extremely sensitive to the wind directions. For Pärnu such a critical direction of stationary and uniform wind is 220° when the relative water level increase is nearly 160 cm at the constant wind speed of 25 m/s. If the wind direction differs from this value by 40°, the sea level is approximately 35 cm lower. This refers to the necessity of predicting the direction of strong winds as accurately as possible.

Ansper & Fortelius (2003) compared HIRLAM version 4.6.2 winds during the period of 01.11.1999–31.01.2000 with surface measurements at four Finnish (Kalbådagrund, Kemi, Märket, Nahkiainen) and three Estonian (Kunda, Sõrve, Vilsandi) data. Unfortunately it is not clear what was the time resolution (averaging periods) of both data sets – model outputs and surface observations. They also do not show whether HIRLAM outputs were reduced to the 10 m altitude or not. The main conclusions of this paper were:

– the root mean square error between the HIRLAM output and ground truth wind speed increases with the forecast length, being 2.5 m/s for 24 h forecasts for the Estonian stations;

- HIRLAM overestimates the wind speed slightly at Vilsandi and Sõrve, but strongly (about 2.5 m/s) at Kunda;
- HIRLAM overestimates frictional turning for all sites;
- the model overestimates the wind speed for winds blowing from the land for Estonian stations.

Tisler et al. (2007) verified HIRLAM and MM5 (Penn State/NCAR Mesoscale Model) wind parameters output at two Finnish meteorological stations and showed that sea–land distributions in the model play an essential role in the accuracy of wind speed forecasting. This is of crucial importance when the coastal area is involved. They also pointed out that the inaccuracy of the predicted wind direction is a serious problem. Increasing the model resolution could be a solution to the problem. On the other hand, Mass et al. (2002) showed that the mean absolute error for the wind direction at 24 h forecasts by MM5 at the western coast of the Washington state was nearly 50° for a 36 km resolution and still over 40° when resolution was increased to 12 km or 4 km. These results were obtained for winds with the speed of at least 3 m/s.

The wave and sea level processes are fortunately not driven by weak winds. Therefore, in our further analysis we pay more attention to moderate (speed over 5 m/s) and strong (over 10 m/s) winds. It should be stressed that the aim of this paper is not to validate and improve HIRLAM, but to check its applicability in marine investigations.

DESCRIPTION OF THE MODEL AND OUTPUTS

The NWP data used in the study were obtained from the NWP environment of the Estonian Meteorological and Hydrological Institute (EMHI). The NWP model, which is employed in the environment, is HIRLAM version 6.4.0 with minor modifications. The HIRLAM system provides a wide range of options for modelling applications, but the following set has been used for the environment:

- HIRLAM 3-dimensional variational (3DVAR) data analysis (Gustafsson et al. 2001; Lindskog et al. 2001);
- digital filter as the initialization scheme (Lynch et al. 1997);
- semi-implicit semi-Lagrangian time integration scheme (McDonald & Haugen 1992);
- the Interface Soil–Biosphere–Atmosphere (ISBA) scheme for surface parameterization (Noilhan & Planton 1989; Noilhan & Mahfouf 1996);
- the Soft TRAnsition COndensation (STRACO) scheme for large-scale and convective condensation (Sass 2002);
- Savijärvi (1990) radiation scheme;
- the CBR-turbulence scheme (Cuxart et al. 2000).

The main modelling area, named ETA, had horizontal resolution of 11 km, and the hydrostatic semi-implicit semi-Lagrangian integration scheme with 400 s time-step was applied in the forecast model. The grid contains 114×100 points in horizontal directions and has 40 levels. Boundary fields to the NWP environment were provided by the Finnish Meteorological Institute (FMI). They are cut out from forecasts of the FMI operational model which has horizontal resolution of 22 km. The fields were provided four times a day with the forecasting start-point at 00, 06, 12, and 18 GMT. The time frequency of boundary fields for ETA is 3 h. The environment utilizes the Davies (1976) boundary relaxation scheme when nested into a larger domain.

The 54 h forecasts together with 3DVAR analysis (later abbreviated Analysis) are produced four times a day at main synoptic hours. Wind measurements at the height of 10 m, which are of special interest in the current study, are not directly assimilated within the 3DVAR approach in HIRLAM at the EMHI. Instead, to get 10 m wind values, an interpolation between the lowest model level and the surface according to the approach proposed by Geleyn (1988) is used in forecast and Analysis files. The lowest model level is located approximately 30 m above the ground.

In the current paper the Analysis and 24 h forecast results of 10 m winds are compared to observations at coastal meteorological stations. Only these two data sets are extracted from the HIRLAM outputs, because the aim of the present paper is not to analyse the dependence of the forecast error on the forecast length. Such information for three Estonian stations can be obtained from the paper by Ansper & Fortelius (2003). It is important to note that according to the above-mentioned 3DVAR analysis strategy, wind measurements from surface stations do not participate in generation of the Analysis file.

Data for the coastal points were extracted using bilinear interpolation from neighbouring grid-points. The sea–land distribution of HIRLAM grid-cells related to the coastal stations is different (Fig. 1): Virtsu, Kihnu, and Ruhnu are treated as sea cells; land fraction is 0.2–0.4 in the cells that represent Kunda, Pakri, and Ristna and 0.4–0.6 in the cells that represent Vilsandi, Sõrve, and Pärnu.

METEOROLOGICAL DATA

The HIRLAM evaluation was based on nine Estonian coastal meteorological stations (Table 1).

Wind parameters (speed and direction) are recorded at the automatic weather stations MILOS 520 that are equipped with Väisälä wind instruments WAA151 and

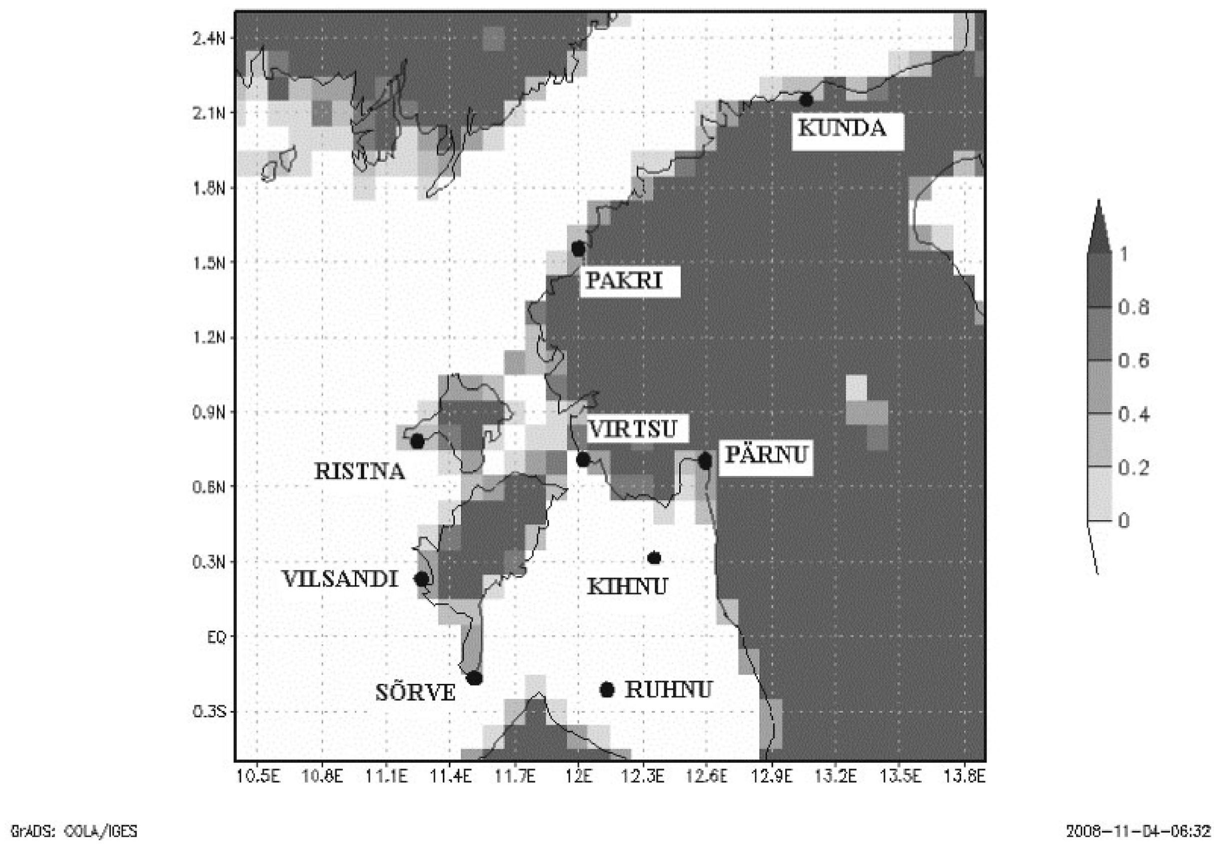


Fig. 1. Land fraction cells of HIRLAM at the EMHI in the Estonian coastal zone. The coordinates are rotated HIRLAM latitude–longitude, not true geographical coordinates.

WAV151. They measure the wind speed and direction at every second. As the new cup anemometers still have certain inertia, usually the instantaneous data are registered or used in the averaging schemes once in 10 s. In Estonia the average and extreme values are calculated and recorded over 2 min, 10 min, 1 h, and 3 h (Keevallik et al. 2007). For the current study, 10 min averages of the wind speed and direction before the synoptic observation times (00, 06, 12, and 18 GMT) were used.

Table 1. Coordinates and altitudes of meteorological stations

Station	Latitude (N)	Longitude (E)	Altitude, m
Kunda	59°31′05″	26°32′44″	2
Pakri	59°23′37″	24°02′40″	24
Ristna	58°55′14″	22°04′02″	7
Vilsandi	58°22′59″	21°48′55″	6
Sõrve	57°54′50″	22°03′35″	2
Virtsu	58°34′23″	23°30′53″	2
Pärnu	58°25′11″	24°28′10″	12
Kihnu	58°05′56″	23°58′15″	3
Ruhnu	57°47′00″	23°15′32″	2

For wind measurements the openness of the measurement site is of great importance. The openness of Estonian meteorological stations was revised in recent years and the current situation is reflected in Table 2. The last column in Table 1 shows the altitude of the measurement site. All wind measurements were carried out at the standard height of 10 m above the surface.

Table 2. Openness of the meteorological stations. ‘Plus’ means open direction, ‘minus’ means closed direction, and ‘slash’ shows restricted direction

Station & year	N	NE	E	SE	S	SW	W	NW
Kunda 2003	+	+	+	+	+	+	/	/
Pakri 2004	+	+	+	+	+	+	+	+
Ristna 2005	–	–	–	–	–	/	+(/)	/
Vilsandi 2007	+	+	+	+	+	/	/	+
Sõrve 2007	+	+	+	+	+	+	+	+
Virtsu 2005	+	+	–	–	–	–	–	–
Pärnu 2006	+	+	+	+	+	+	+	+
Kihnu 2006	–	–	/	/	+	+	+	/
Ruhnu 2005	–	+(–)	+	+	+	+	+(–)	–

The evaluation time span was 10 months: January and April–December 2007. February and March were not analysed, as the HIRLAM outputs for these months were not archived. Besides, August data for Ristna are missing, as the respective HIRLAM set was contaminated.

WIND SPEED

Both HIRLAM outputs show a consistent pattern for an average wind speed, except at Kunda where Analysis differs significantly from the 24 h forecast (Fig. 2). On average, HIRLAM overestimates the surface winds recorded at the stations slightly but systematically. This overestimation is the smallest at Vilsandi and Sõrve and the strongest at Ristna, Virtsu, and Ruhnu. Overestimation of the wind speed is consistent with findings reported by Ansper & Fortelius (2003).

The wind speed scatter plots in Fig. 3 permit one to estimate the differences between single measurements and respective model outputs. According to the plots, HIRLAM estimates the wind speed best at Sõrve and Vilsandi. At Ristna an overwhelming majority of model outputs are overestimations – an evident result of an unfavourable measurement site that is surrounded by forest. The data are most scattered at Kihnu and Ruhnu – probably due to HIRLAM land–sea mask that neglects these islands and treats the sites as sea boxes. At the northern coast (Kunda and Pakri) but also in Pärnu the Analysis overestimates the wind speed somewhat more than the 24 h forecast. At all measurement sites strong winds are modelled better than weak winds.

Our data show that a short-term forecast is a better approximation of real wind data than Analysis. On the other hand, according to the usual understanding, Analysis is expected to be very close to the observations and errors are expected to grow with the increasing forecasting period. This expectation is generally not correct as Analysis should omit site-specific effects to present a sound overall dynamic situation. In further investigations initialization (0 h forecast) should be tested from this point of view.

WIND DIRECTION

To analyse the wind direction, average frequency histograms are composed for two gradations of wind speed: all winds and moderate and strong winds with the speed over 5 m/s. Such an analysis permits one to separate local weak winds from those that are supposed to be caused by dynamic reasons and affect the coastal wave regime and sea level.

The HIRLAM system tends to overestimate the frequency of weak winds, especially for the W–NW directions (Fig. 4). At Pakri, Kihnu, and Ruhnu HIRLAM overestimates also moderate winds that blow from the west and northwest.

Observations at Kunda show high frequency of south winds that HIRLAM ignores. This peak in the measured wind rose may be caused by orography: a high cliff south of the station may distort the wind pattern (Soomere & Keevallik 2003). With this exception at 190°, HIRLAM well describes the wind rose of moderate and strong winds.

At Pakri the HIRLAM wind rose is somewhat shifted to larger angles (clockwise) in comparison with the measured angular distribution. Although being in the limits of the accuracy of measurements and calculations, this feature may be interpreted as underestimation of surface roughness

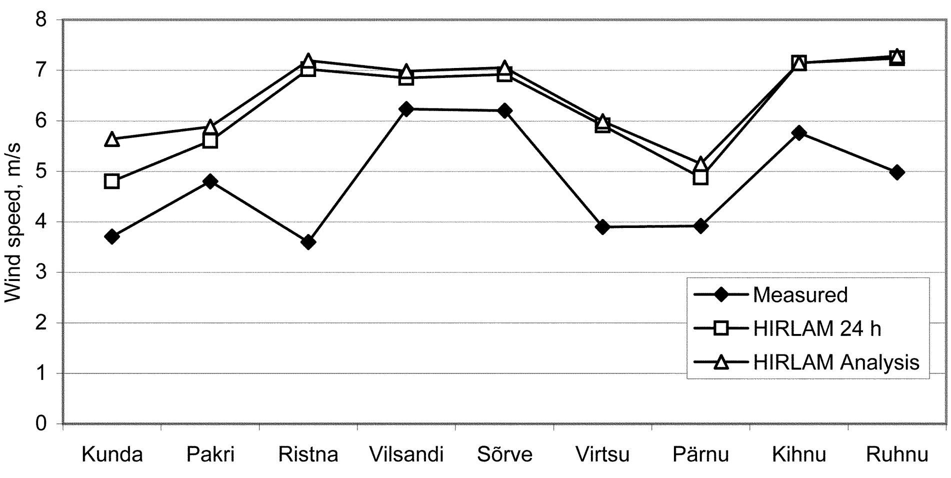
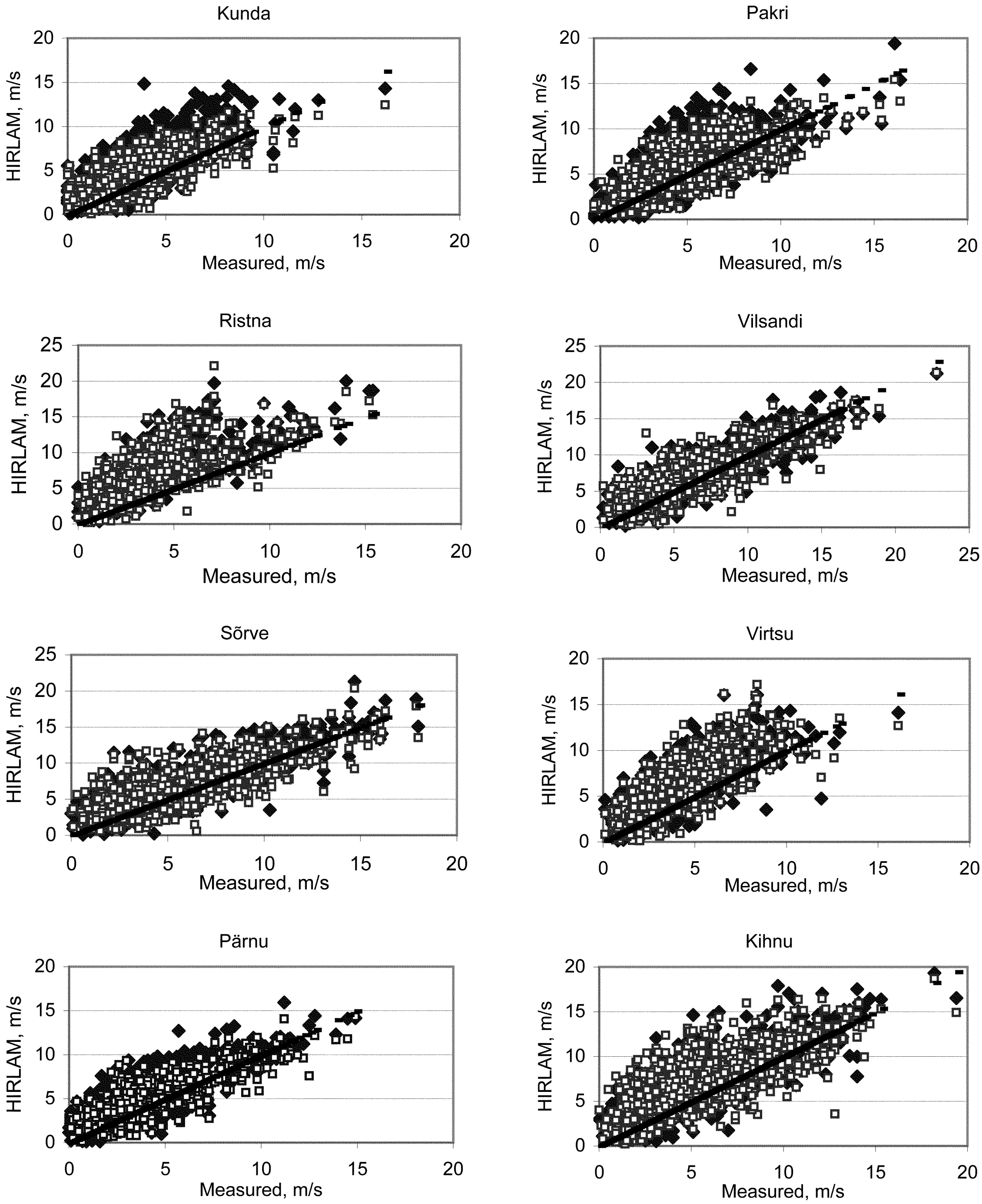


Fig. 2. Average wind speed at different meteorological stations according to surface measurements and two HIRLAM outputs.



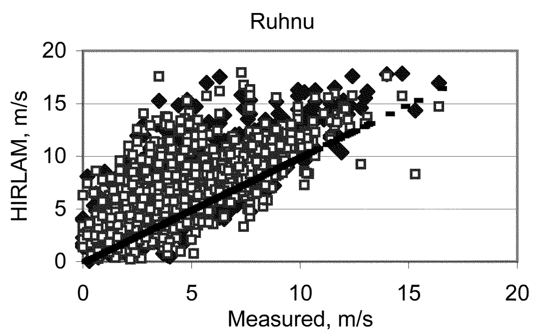


Fig. 3. Scatter plots of the wind speed measured at the surface stations and calculated by HIRLAM. Rhombs show HIRLAM Analysis, squares denote HIRLAM 24 h forecast. The dotted line shows perfect match.

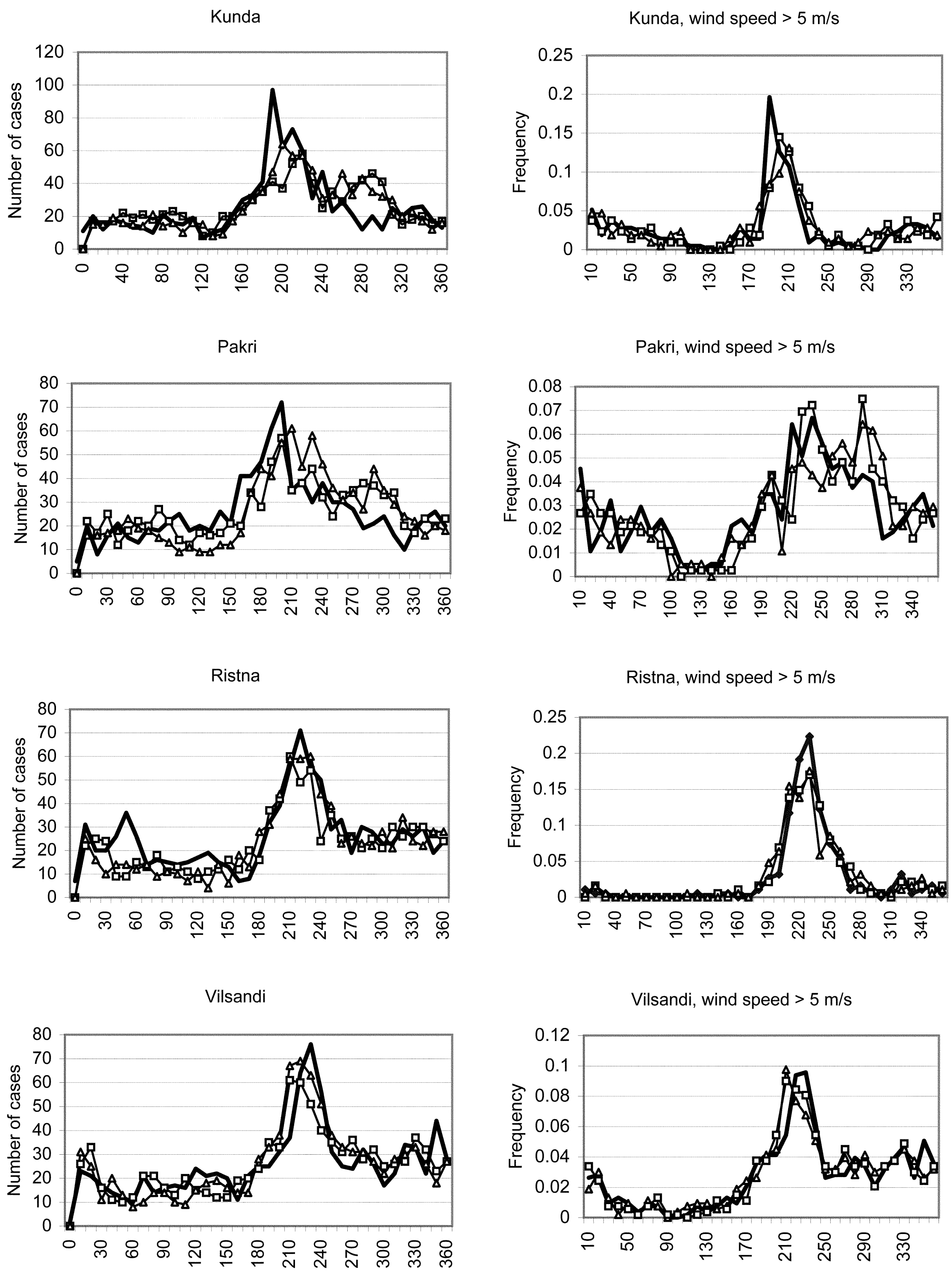


Fig. 4. Wind roses for different sites and different wind speed gradations. The solid line shows measured data, squares show HIRLAM Analysis, and triangles show HIRLAM 24 h forecasts.

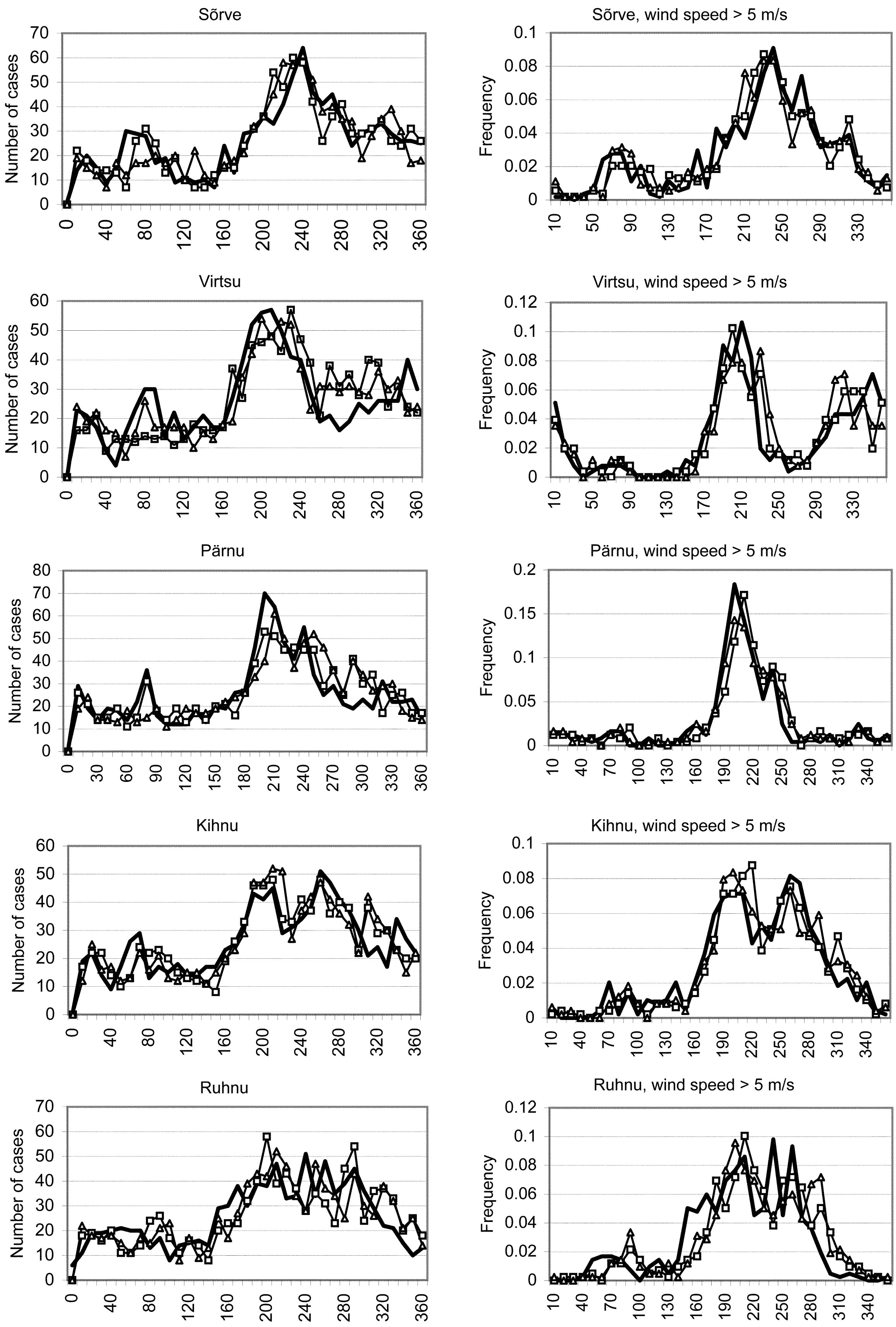


Fig. 4. *Continued.*

by HIRLAM. Similar underestimation can be seen at Pärnu and Ruhnu. Such a shift becomes even more clearly evident when only winds with the speed over 10 m/s are considered (not shown in this paper). A slight shift of the wind rose to smaller angles can be noticed at Vilsandi and Sõrve. Underprediction of the direction for winds with the speed >3 m/s at Vilsandi and Sõrve was reported also by Ansper & Fortelius (2003), who detected the largest underprediction with the mean error of –8.5° at Kunda. The wind roses in the present paper do not lead to a similar conclusion, possibly due to a different method of estimation and/or different time periods under consideration.

ACCURACY OF HIRLAM WIND DIRECTION FOR MODERATE AND STRONG WINDS

Taking into account that weak winds only little influence the wave regime and sea level, we chose from the files the cases where the measured wind speed exceeded 5 m/s. For these cases we estimated the probability that the difference between the recorded wind direction and HIRLAM outputs is less than 10° and the probability that it is less than 22.5° (Table 3).

Table 3 shows that at Ruhnu HIRLAM does not describe the angular distribution of winds with sufficient accuracy. Ruhnu is treated as a sea point and therefore the roughness length may be underestimated (see Fig. 4). However, the same feature is not observed at Kihnu, most probably due to different location of the station relative to the mainland. On the other hand, it leaves the door open for speculation that the station under consideration has measurement quality problems. As a matter of fact, during the present study significant measurement problems were identified at Narva-Jõesuu. The reasons for the problems were later fixed, but the data were unusable for the study.

Table 3. HIRLAM wind direction accuracy for moderate and strong winds

Station	Recorded wind speed >5 m/s (number of cases)	HIRLAM wind direction accuracy, %			
		<10°		<22.5°	
		Analysis	24 h	Analysis	24 h
Kunda	214	56	60	93	91
Pakri	374	47	47	87	82
Ristna	188	78	70	97	93
Vilsandi	533	66	60	93	89
Sõrve	539	64	58	90	89
Virtsu	254	58	53	91	91
Pärnu	245	54	63	89	88
Kihnu	491	53	50	91	88
Ruhnu	418	22	23	69	65

The accuracy of the wind direction is somewhat lower also at Pakri. This fact is unexpected, as the meteorological station is situated on the cliff and all directions are open to winds. It seems that the main air flow from the SW is perturbed by crossing the Estonian land and coastal areas and HIRLAM cannot follow these perturbations with a good accuracy. This explanation is supported by the circumstance that the best results can be obtained for the westernmost stations on the Estonian islands of Ristna, Vilsandi, and Sõrve. Ristna is rather a surprise in this list, as the wind speed at this station was much lower than the modelled values. On the other hand, moderate and strong winds at that site blow mostly from the west and this direction is free of obstacles at the measurement site.

DISCUSSION AND CONCLUSIONS

First of all, at such comparison of measured and calculated data, the representativeness of observations should be checked. From the point of view of the present study, it is obvious that the wind speed data at Ristna characterize only the situation over the measurement field that is surrounded by forest. On the other hand, here the difference between the real and modelled directions of moderate and strong winds is the smallest, most probably due to the fact that the measurement site is open to the most frequent wind directions. The openness of the observation field is problematic also at Virtsu, where the measurement site is free only for north and northeast winds. At Kunda the wind regime is disturbed by an obstacle south of the station. Fortunately, this influence is rather clear and could easily be identified at the evaluation.

Second, it must be kept in mind that meteorological measurements represent point data, whereas HIRLAM deals with averages over a grid cell. Therefore, perfect fit of wind data could not be expected even when unreliable or unrepresentative observations are eliminated.

It seems that correct land–sea characteristics are very important in HIRLAM when applying 3DVAR analysis or short-term forecast in hindcasting applications in the costal zone. Unsatisfactory evaluation results at Virtsu and Ruhnu may partly be caused by inappropriate land–sea mask: respective cells are treated as sea and underestimated surface roughness results in strong overestimation of the wind speed.

The unexpected result that the 24 h forecast is in better accordance with the data measured near the ground than Analysis suggests that 10 m wind observations should be included in the 3DVAR algorithm in the HIRLAM NWP environment. This might not be crucial from the point of view of the NWP model prediction quality but has certainly positive effect when the model outputs are used in the hindcasting regime. The problem is dealt with by Auria & Navascues (2006) but as stated in this paper, the usefulness of the approach is not widely acknowledged. Another possible approach could be running simple surface analysis for 10 m winds as it is done in the case of 2 m temperature in HIRLAM. Statistical bias correction approaches have also been suggested by Auria & Navascues (2006).

From the above, the following conclusions can be drawn:

– HIRLAM tends to overestimate the wind speed at the coastal sites under consideration.
– HIRLAM has problems with describing the angular distribution of weak winds; fortunately, this is a minor disadvantage from the viewpoint of coastal engineering and sea state forecast in strong storms, as waves and sea levels are mostly affected by moderate and strong winds.
– With the only exception of Ruhnu, approximately 90% of HIRLAM estimates of the direction of moderate and strong winds differ less than $\pm 22.5°$ from the measured values; in approximately 60% of cases the direction differs less than $\pm 10°$.
– HIRLAM models coastal winds best at the westernmost stations of Vilsandi and Sõrve. HIRLAM wind direction accuracy for moderate and strong winds is good also at Ristna.
– Good approximation of winds can be obtained also for Pärnu. This gives hope that HIRLAM wind forecast can be successfully used for modelling water level in the northern part of Riga Bay.
– Currently it seems preferable to use short-term forecasts of HIRLAM instead of 3DVAR analyses when 10 m winds are needed in practical applications.

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REFERENCES

Ansper, I. & Fortelius, C. 2003. Verification of HIRLAM marine wind forecasts in the Baltic. *Publicationes Instituti Geographici Universitatis Tartuensis*, 93, 195–204.

Auria, A. C. & Navascues, B. 2006. Usage of SYNOP 10 meters wind observations in HIRLAM. *HIRLAM Newsletter*, 50, 8–17.

Cuxart, J., Bougeault, P. & Redelsberger, J. L. 2000. A turbulence scheme allowing for mesoscale and large-eddy simulations. *Quarterly Journal of the Royal Meteorological Society*, **126**, 1–30.

Davies, H. C. 1976. A lateral boundary formulation for multi-level prediction models. *Quarterly Journal of the Royal Meteorological Society*, **102**, 405–418.

Geleyn, J.-F. 1988. Interpolation of wind, temperature and humidity values from the model levels to the height of measurement. *Tellus*, **40A**, 347–351.

Gustafsson, N., Berre, L., Hörnquist, S., Huang, X.-Y., Lindskog, M., Navascues, B., Mogensen, K. S. & Thorsteinsson, S. 2001. Three-dimensional variational data assimilation for a limited area model. Part I: General formulation and the background error constraint. *Tellus*, **53A**, 425–446.

Keevallik, S., Soomere, T., Pärg, R. & Žukova, V. 2007. Outlook for wind measurement at Estonian automatic weather stations. *Proceedings of the Estonian Academy of Sciences, Engineering*, **13**, 234–251.

Lindskog, M., Gustafsson, N., Navascues, B., Mogensen, K. S., Huang, X.-Y., Yang, X., Andræ, U., Berre, L., Thorsteinsson, S. & Rantakokko, J. 2001. Three-dimensional variational data assimilation for a limited area model. Part II: Observation handling and assimilation experiments. *Tellus*, **53A**, 447–468.

Lynch, P., Giard, D. & Ivanovici, V. 1997. Improving the efficiency of a digital filtering scheme. *Monthly Weather Review*, **125**, 1976–1982.

Mass, C. F., Ovens, D., Westrick, K. & Colle, B. A. 2002. Does increasing horizontal resolution produce more skilful forecasts? *Bulletin of the American Meteorological Society*, **83**, 407–430.

McDonald, A. & Haugen, J. E. 1992. A two-time-level, three-dimensional semi-Lagrangian semi-implicit, limited-area gridpoint model of the primitive equations. *Monthly Weather Review*, **120**, 2603–2621.

Noilhan, J. & Mahfouf, J.-F. 1996. The ISBA land surface parameterization scheme. *Global and Planetary Change*, **13**, 145–149.

Noilhan, J. & Planton, S. 1989. A simple parameterization of land surface processes for meteorological models. *Monthly Weather Review*, **117**, 536–549.

Sass, B. H. 2002. A research version of the STRACO cloud scheme. *DMI Tech. Rep*. 02-10, Danish Meteorological Institute, Copenhagen, Denmark [Available online at http://www.dmi.dk/dmi/index/viden/dmi-publikationer/tekniskerapporter.htm].

Savijärvi, H. 1990. Fast radiation parameterization schemes for mesoscale and short-range forecast models. *Journal of Applied Meteorology*, **29**, 437–447.

Soomere, T. 2003. Anisotropy of wind and wave regimes in the Baltic proper. *Journal of Sea Research*, **49**, 305–316.

Soomere, T. 2005. Wind wave statistics in Tallinn Bay. *Boreal Environment Research*, **10**, 103–118.

Soomere, T. & Keevallik, S. 2003. Directional and extreme wind properties in the Gulf of Finland. *Proceedings of the Estonian Academy of Sciences, Engineering*, **9**, 73–90.

Soomere, T., Behrens, A., Tuomi, L. & Nielsen, J. W. 2008. Wave conditions in the Baltic Proper and in the Gulf of Finland during windstorm Gudrun. *Natural Hazards and Earth System Sciences*, **8**, 37–46.

Suursaar, Ü. & Kullas, T. 2006. Influence of wind climate changes on the mean sea level and current regime in the

coastal waters of west Estonia, Baltic Sea. *Oceanologia*, **48**, 361–383.
Suursaar, Ü., Kullas, T., Otsmann, M. & Kõuts, T. 2003. Extreme sea level events in the coastal waters of western Estonia. *Journal of Sea Research*, **49**, 295–303.
Suursaar, Ü., Kullas, T., Otsmann, M., Saaremäe, I., Kuik, J. & Merilain, M. 2006. Cyclone Gudrun in January 2005 and modelling its hydrodynamic consequences in the Estonian coastal waters. *Boreal Environment Research*, **11**, 143–159.
Tisler, P., Gregow, E., Niemelä, S. & Savijärvi, H. 2007. Wind field prediction in coastal zone: operational mesoscale model evaluation and simulations with increased horizontal resolution. *Journal of Coastal Research*, **23**, 721–730.

HIRLAM-i tuuleandmete võrdlus mõõtmistega Eesti rannikuala ilmajaamades

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On uuritud võimalusi kasutada HIRLAM-i versiooni 6.4.0 väljundeid tuuleparameetrite kirjeldamisel Eesti rannikualal. Selleks on võrreldud 3DVAR-analüüsi ja 24 tunni ennustuste väljundeid mõõtmistega üheksas ilmajaamas kümne kuu jooksul (jaanuaris ning aprillist detsembrini 2007). Erilist tähelepanu on pööratud mõõdukatele ja tugevatele tuultele (kiirus >5 m/s), millel on suurim tähtsus meretaseme muutustes ning kõrgete lainete formeerumises. On näidatud, et HIRLAM ülehindab tuule kiirust, mis on eriti suur juhtudel, kus maismaa ja mere vahekord võrgusilmas erineb tegelikkusest. HIRLAM modelleerib mõõdukate ja tugevate tuulte nurkjaotust paremini kui nõrkade tuulte oma. Mõõduka või tugeva tuule puhul on umbes 90%-l juhtudest erinevus HIRLAM-i arvutatud ja mõõdetud suuna vahel väiksem kui ±22,5°; 60%-l juhtudest on see erinevus väiksem kui ±10°. Erandi moodustab Ruhnu, kus erinevus on suurem. Kõige paremini kirjeldab HIRLAM tuulerežiimi Lääne-Eesti saartel ja Pärnus, kusjuures 24 tunni prognoos annab mõnevõrra paremaid tulemusi kui 3DVAR-analüüsist diagnoositud tuuled.