Verification of ECMWF products at the Finnish Meteorological Institute

by Juha Kilpinen, Pertti Nurmi, Petra Roiha and Martti Heikinheimo

1. Summary of major highlights

A new verification system became operational in the end of 2008 replacing the previous one with various new features. The technical structure is totally new and enables better options for enhancements and further developments. The new system will allow for direct comparison of direct model output, post-processed model output, and end products based on gird-edited data of the forecasters. Some results are presented here.

Monthly and seasonal EPS data have been applied to produce different physical, chemical and biological variables in the Baltic Sea.

2. Use and application of model output

ECMWF output are used widely supporting the traditional weather service, and also as input for various applications like limited area NWP modelling (HIRLAM, AROME), dispersion and trajectory models, hydrological models (run by Finland's Environmental Administration), road condition models, and wave models.

2.1 Post-processing of products

2.1.2 Physical adaptation

FMI's operational 3-dimensional biogeochemical ocean model, Baleco, was adapted to produce monthly and seasonal ensemble forecasts for different physical, chemical and biological variables in the Baltic Sea. The modelled variables are temperature, salinity, velocity, silicate, phosphate, nitrate, diatoms, flagellates and two species of potentially toxic filamentous cyanobacteria. These forecasts have numerous applications from ice predictions to harmful algal bloom warnings and to be applied as a decision making tool on environmental issues in the Baltic Sea.

Ensembles are produced by creating several 30-day runs of the biogeochemical model, forced with different set of seasonal weather parameters from ECMWF's ensemble prediction forecasts. The ensembles are then analysed by statistical methods and the median, quartiles, minimum and maximum values are calculated and rank histograms made for model output variables to gain insight into the applicability of the results. Verification for the forecast method is made by comparing the results against in-situ data. As a part of this work means to illustrate probabilistic marine forecasts in an easily approachable manner were developed.

The marine environment differs from the atmosphere in many ways. On the one hand, there is a possibility of longer prediction time spans for ensemble forecasts than in atmospheric applications. This may, e.g., mean more accurate long-term forecasts for many oceanographic parameters. On the other hand, observations are at times scarce or sporadic, which presents challenges for verification.

The results of the experiments demonstrated that monthly and seasonal ensembles are a promising tool in marine forecasting. It is indeed possible to make forecasts with useful accuracy for the Baltic Sea within time spans longer than in meteorology. Development work will continue to explore seasonal forecasting further. Monthly forecasts will be produced routinely starting from summer 2009 and they will be improved according to user feedback. Some results are presented in Figures 1 and 2 (Roiha, 2009).

3. Verification of products

3.1 Objective verification

FMI's new verification system can produce various verification scores and measures of direct model output (ECMWF, HIRLAM, GFS), derived variables, as well as end products. While grid editing by forecasters (using FMI's SmartMet system) is a vital part of the forecasting process the performance of all components in the production chain can be analysed with the verification package.

Results are presented in Figures 3 through 10. Some of the figures are not produced with the new verification system. There is a weak positive trend in the time evolution of forecast error (Figures 4 and 8). The performance of ECMWF temperature forecasts is good compared with other available models (Figure 9), and the results are similar for 10 m wind speed forecasts (Figure 10).

The object-based SAL verification technique (Wernli et al., 2008) has been applied for the verification of QPF forecasts in some river catchments in Finland. The deterministic forecasts originate from ECMWF and the HIRLAM RCR and MB71 configurations. Additional QPF fields are generated by forecasters utilizing the SmartMet grid-editing facility. These alternative forecasts are disseminated to hydrological end users. Both radar-derived QPE and rain gauge based precipitation analysis are used as verifying "truth", the major reference being the radar QPE. Verification results are shown for the Kokemäki river catchment in Figure 11. The SAL measure has three independent components depicting the Structure (S), Amplitude (A), and Location (L) errors of the OPF structures. S and A are scaled between -2 to +2, and L between 0 (zero) to +2. The perfect score for all is zero. Both case studies and verification statistics indicate that higher resolution models do perform better than the coarser ones, i.e. SAL appears to tackle efficiently the double penalty feature. This is also seen in Figure 11 (the green/red numbers in the table indicate the best/worse values, respectively) (Nurmi and Näsman, 2009).

4. References

Nurmi, P. and **S. Näsman**, 2009: SAL in hydrological catchments. 4th International Verification Methods Workshop, Helsinki, Finland, 8-10 June 2009.

Roiha, P., 2009: Analysis of marine seasonal ensemble forecasts for the Baltic Sea. 4th International Verification Methods Workshop, Helsinki, Finland, 8-10 June 2009.

Wernli, H., **M. Paulat**, **M. Hagen** and **C. Frei**, 2008: SAL - A Novelty Measure for the Verification of Quantitative Precipitation Forecasts. *Monthly Weather Review*, **136**, 4470-4487.

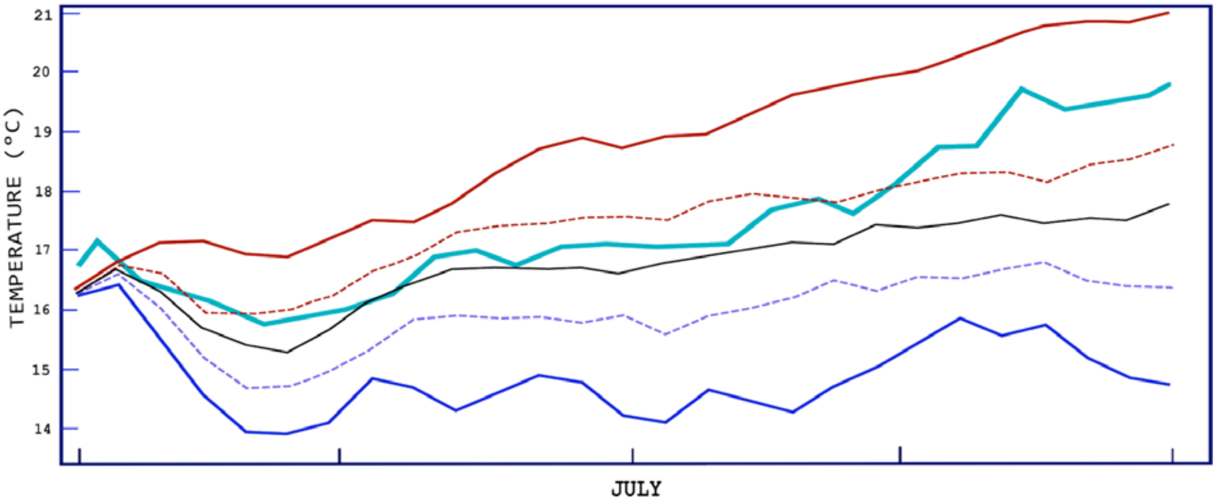


Fig 1 Characteristic values of monthly temperature ensemble forecasts for the Northern Baltic Proper wave buoy during July 2008. Maximum, minimum, median, 25 % and 75 % quartiles. The thick green line shows the in-situ observations from the same location

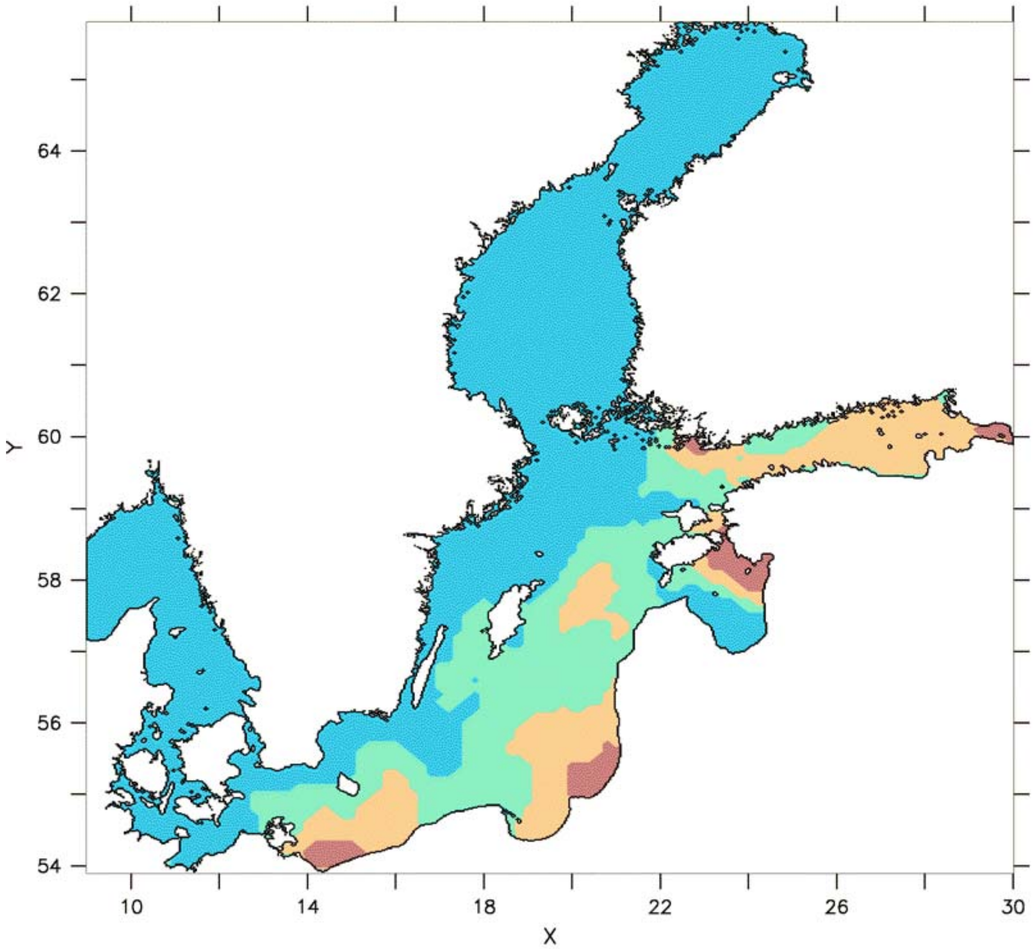


Fig 2 Experimental 30-day cyanobacterial biomass forecast (20/05/2009-17/06/2009) for the Baltic Sea on 17th of June. The blue colour indicates low probability (<25 %), green moderate probability (25 % - 50 %), orange considerable probability (50 % - 75%) and red high probability (> 75 %) to exceed the limiting value. In this example the limiting value is arbitrarily 0.12 µg/l. Comparison between observations and model results are necessary for determining this limit for operational risk analysis.

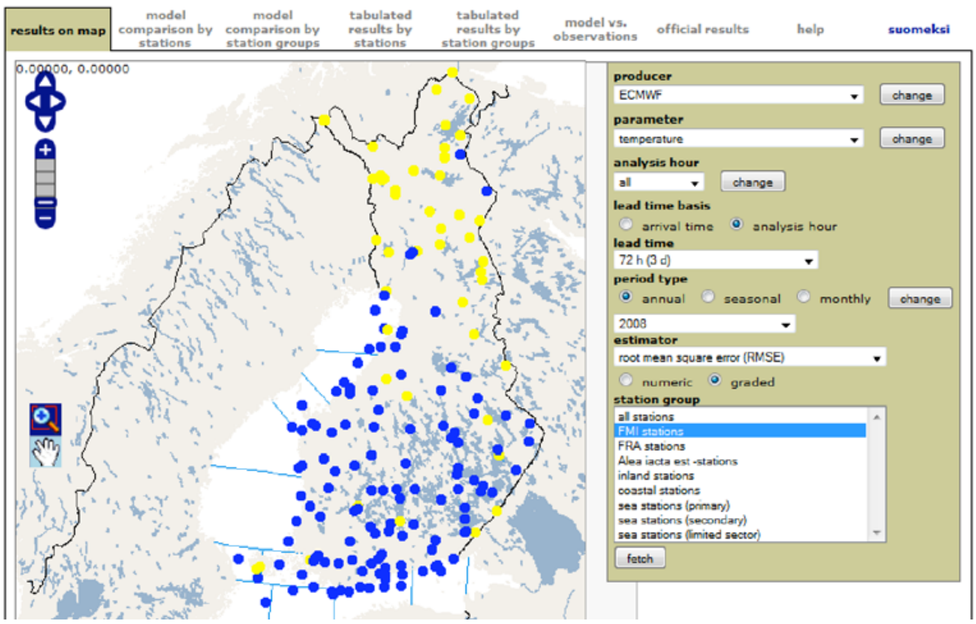


Fig 3 Example of FMI's new verification package map view: Rating of ECMWF 3-day 2m temperature forecasts. Blue dots indicate stations with RMSE< 2.5C.

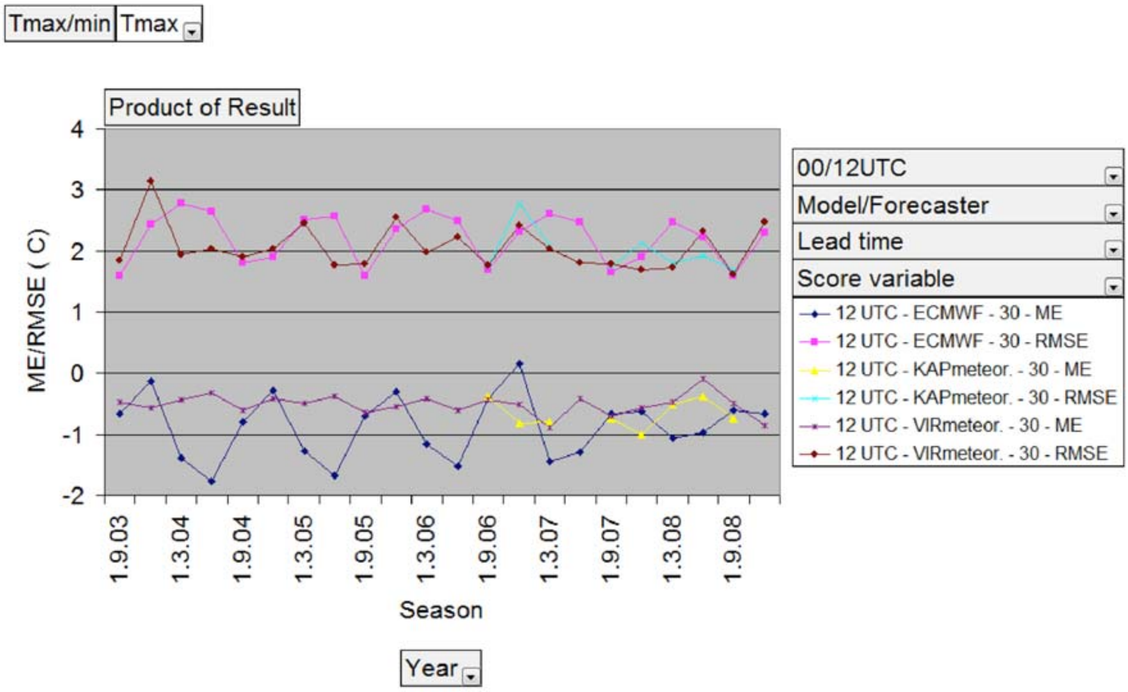


Fig 4 Mean error (ME) and Root mean square error (RMSE) of day time (06-18 UTC) T max forecasts issued at 12 UTC the previous day for: ECMWF, forecasters' grid-edited output (KAPmeteor, verified at 32 land stations), core services forecasters' (VIRmeteor, 3 land stations).

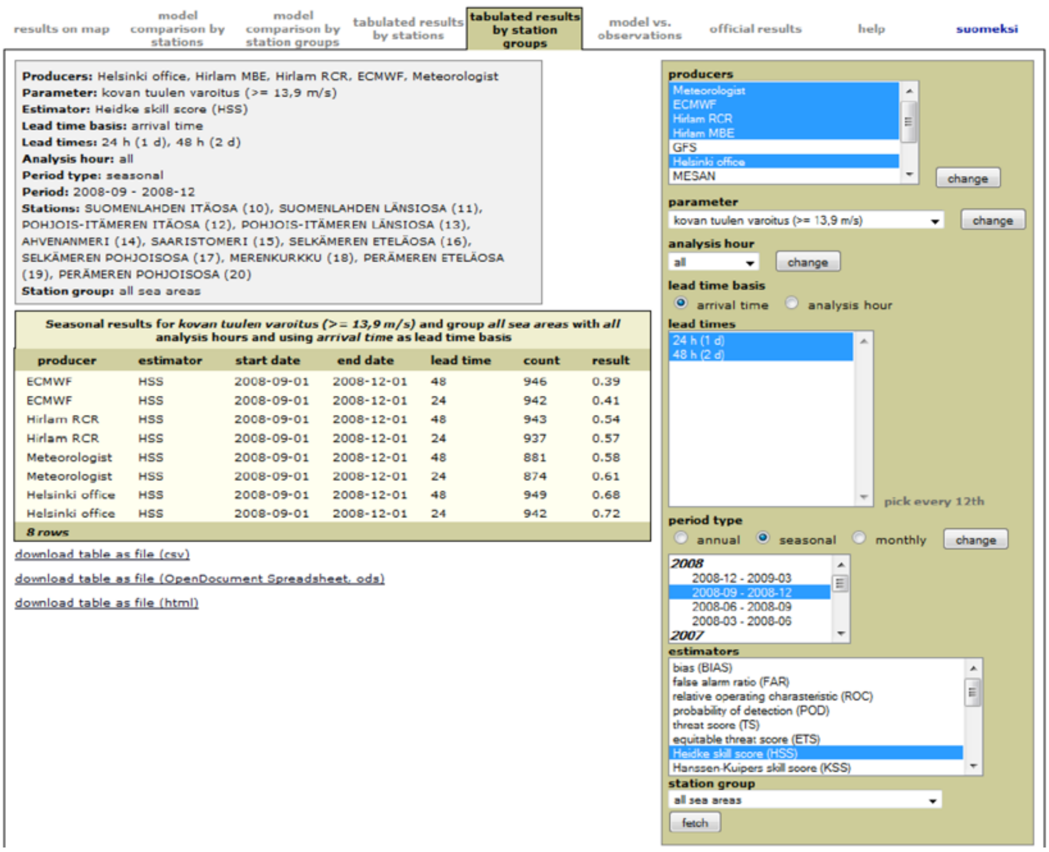


Fig 5 Heidke skill score (HSS) of near-gale warnings issued by forecasters, and ECMWF and HIRLAM_RCR output (without post-processing) for 11 sea areas (autumn 2008). Wind warnings are verified against observed maximum 10 min wind speed for the time period and sea area of the warning, therefore scores are lower for the models than for the forecasters (Meteorologist = grid editor; Helsinki office = core forecaster).

(Note: Results can be transferred as data into other programs for further analysis under this tab).

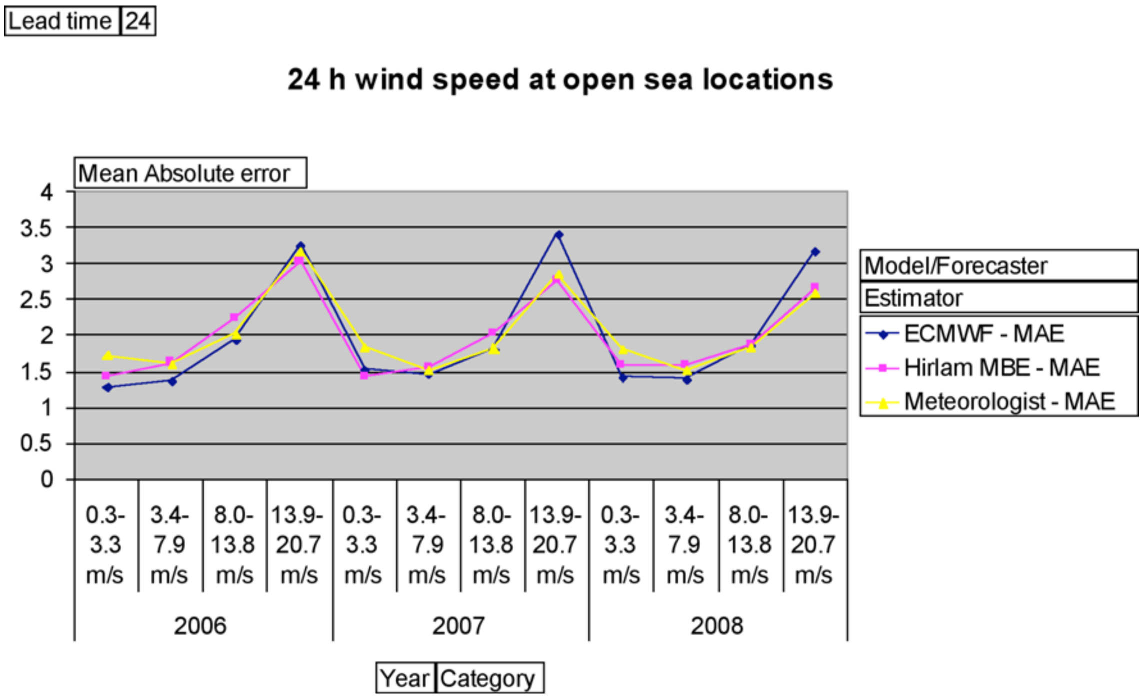


Fig 6 Mean absolute error (MAE, m/s) of 24 h wind speed forecasts verified at the primary open sea station locations in different wind speed categories. HIRLAM_MBE has a 7.5 km horizontal resolution. 'Meteorologist' denotes edited forecasts representing a c. 15 km resolution yielding, together with MBE, the best result for near-gale and gale wind speeds.

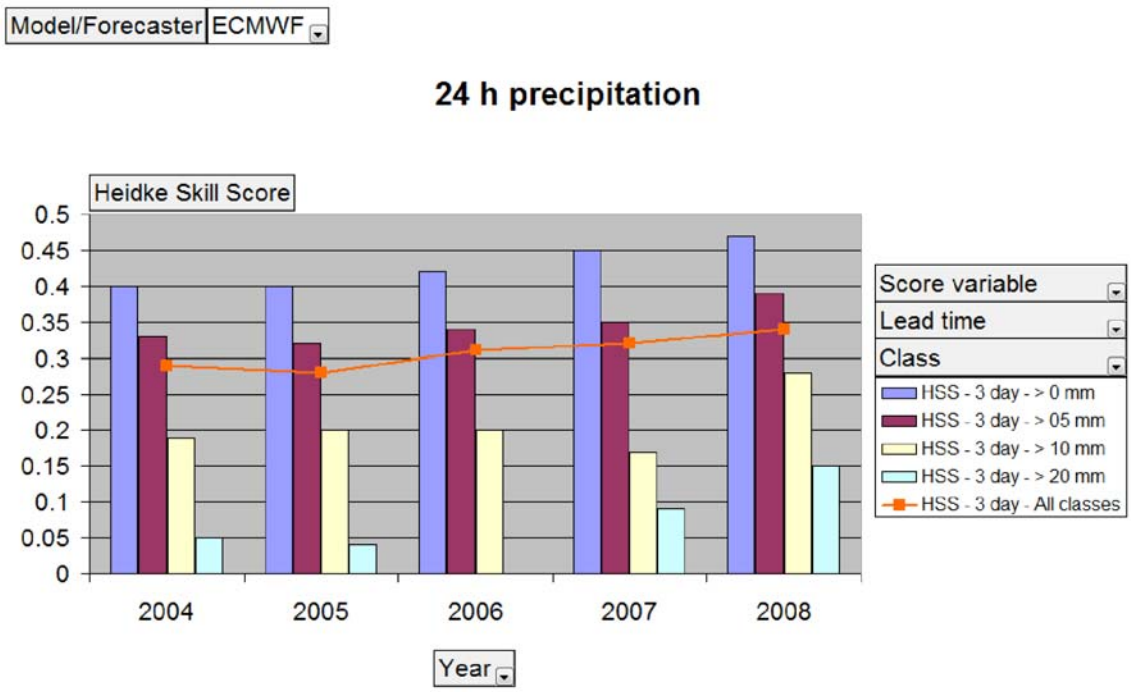


Fig 7 Heidke skill score of ECMWF 3-day 24 h precipitation forecasts for different thresholds and integrated over all categories (32 land stations).

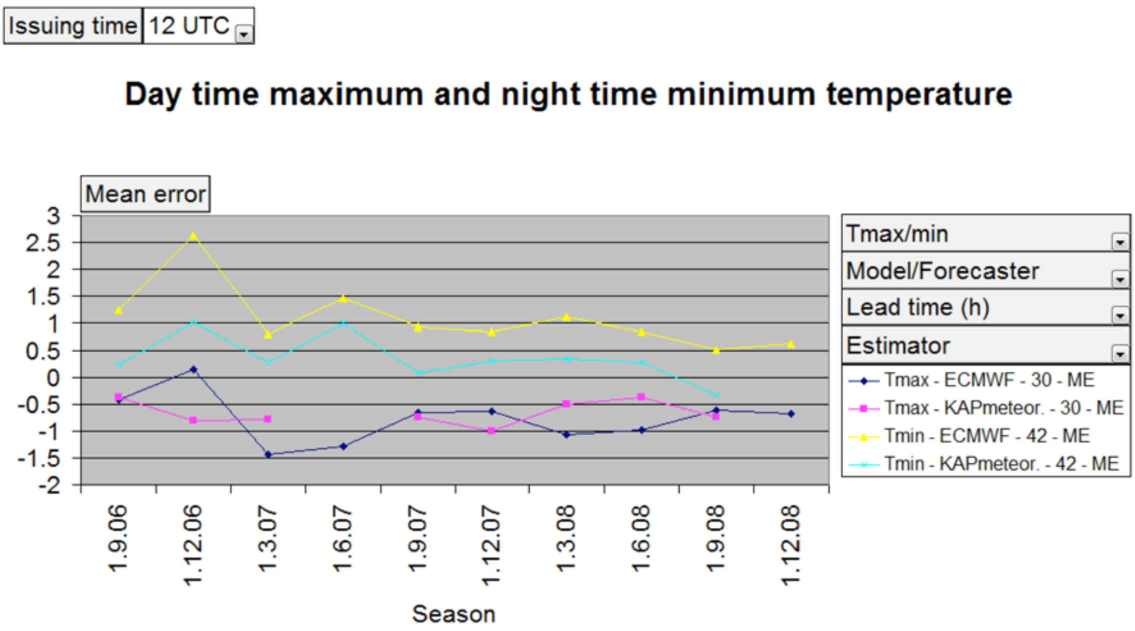


Fig 8 Mean error (ME) of T min and T max forecasts for Sodankylä observatory made at the Central Forecasting Office (KAP) and by ECMWF.

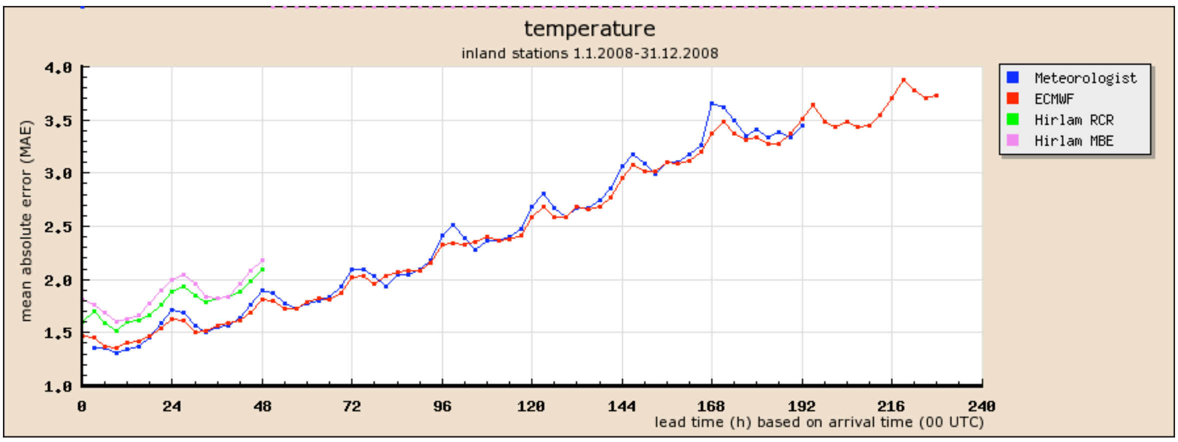


Fig 9 Mean absolute temperature error of inland stations in Finland (in 2008).

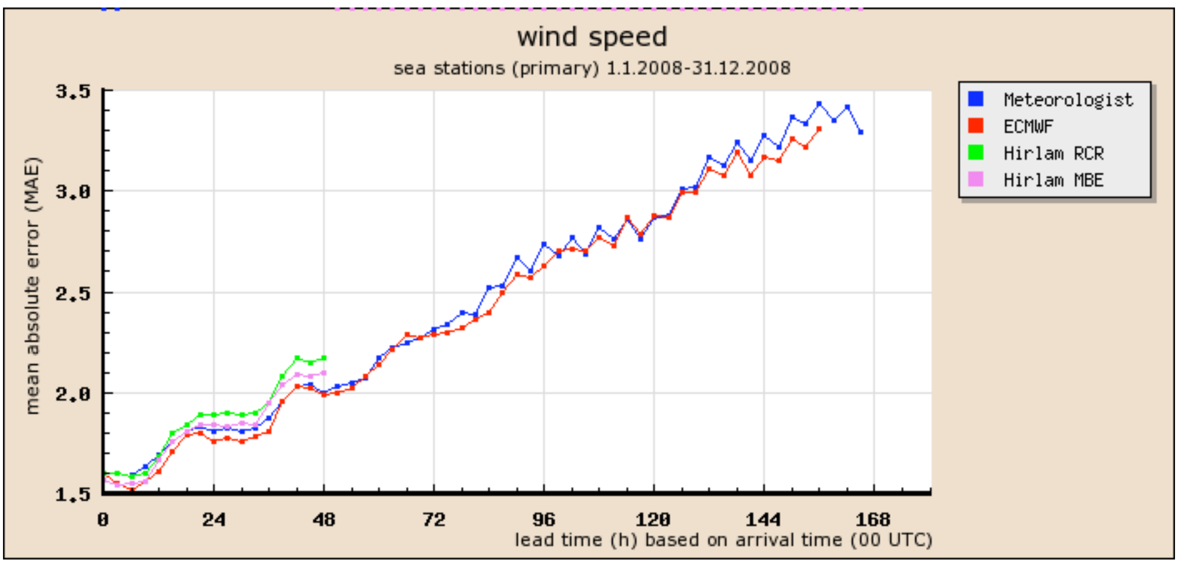
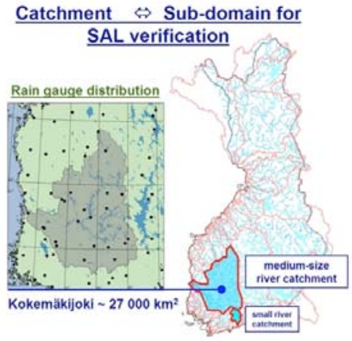


Fig 10 Mean absolute wind speed error of sea stations in Finland (in 2008).



SAL aggregated seasonal statistics

	Summer 2008						Spring 2008			Winter 2008		
	Gauge			Radar			Radar			Radar		
	S	A	L	S	A	L	S	A	L	S	A	L
ECMWF	.66	.50	.13	1.25	.27	.27	.91	.21	.12	.72	.20	.08
HIR_RCR	.18	-.10	.14	.92	-.04	.25	.64	-.21	.13	.65	-.03	.08
HIR_MB71	-.01	.28	.16	.84	.28	.26	.48	.03	.15	.39	.11	.09
MET_Edit	.38	-.28	.16	1.07	-.43	.27	.66	-.39	.16	.65	-.17	.10

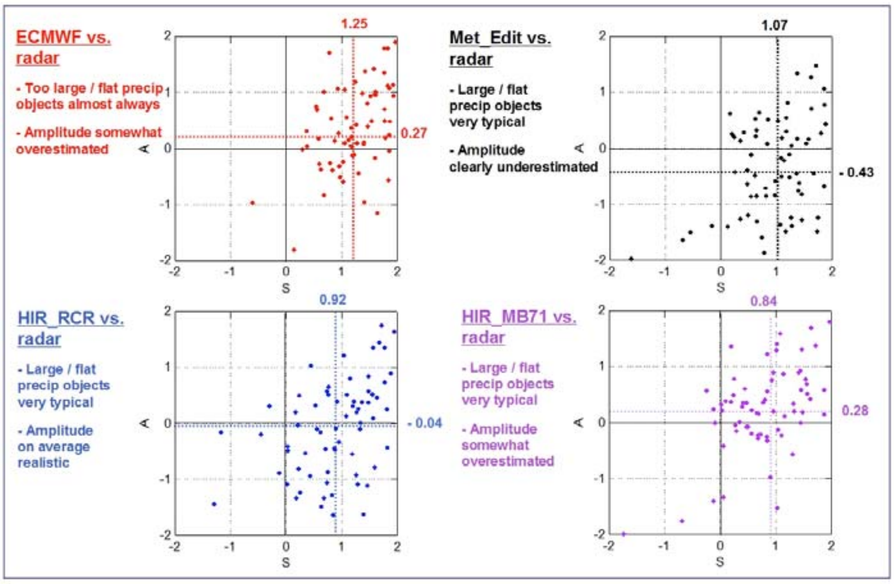


Fig 11 Map showing the medium-size, Kokemäki, river catchment in Finland used in SAL verification, and the rain gauge distribution within the area, with S vs. A scatter plots in the catchment for all individual 24 hour QPF periods during summer 2008 for ECMWF (25 km resolution), HIR_RCR (16 km) and HIR_MB71 (7.5 km), and for forecasters' grid-edited output (MET_Edit; 15 km). Radar QPE is used as verifying "truth". L values had generally small differences between models and are not shown. The table shows model comparison during three seasons in 2008. For comparison, rain gauge analysis is used as reference "truth" for the summer results.