THE USE OF NUMERICAL WEATHER FORECAST MODEL PREDICTIONS AS A SOURCE OF DATA FOR SOIL MOISTURE MODELLING

COST ACTION 718

‘Meteorological Applications for Agriculture’

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1. Introduction

The weather forecast models are at their best when describing meteorological conditions above lowest tens of meters above surface. However, nowadays also parameters like surface temperature, air moisture, wind speed or precipitation can be obtained from the models with accuracy that makes it possible to utilize this data as a data source for agricultural models.

In this report there is given some preliminary results of the use of numerical weather forecast model data for the estimation of soil moisture.

2. Material and methods

A moisture index is calculated using 3-hourly precipitation and potential evaporation data on a 10km*10 km grid covering the whole Finland. The moisture of the surface soil depends mainly on evaporation and the storage of rainwater (that depends on rainfall and percolation) in the layer. In this parameterization the ratio of actual water loss to potential evaporation (atmospheric demand), i.e. the drying efficiency, is related to the instantaneous volumetric moisture of the 6 cm thick surface layer based on experimental data. Similarly the relationship between the rainwater stored and the precipitation is defined with the help of experimental data (Heikinheimo et al., 1998).

In the parameterization the calculation of potential evaporation is done using the so-called Penman-Monteith equation (e.g. Monteith, 1981). To be able to use the equation air temperature and air moisture, wind speed, solar and long-wave radiation must be known. The needed meteorological information for the models is obtained by interpolating the point measurements made at weather station locations into the grid. Forecast up to 36 hours are made using data obtained from the High Resolution Limited Area (HIRLAM) weather forecast model (e.g. Källen, 1996).

In the present study the conditions at 11 geographical locations (Figure 1) were analysed; the forecasted values of soil moisture are compared with values obtained using measured data. In case of one station (Ilomantsi) also forecasted air temperature, air humidity, radiation balance components and wind speed values are compared with measured data.

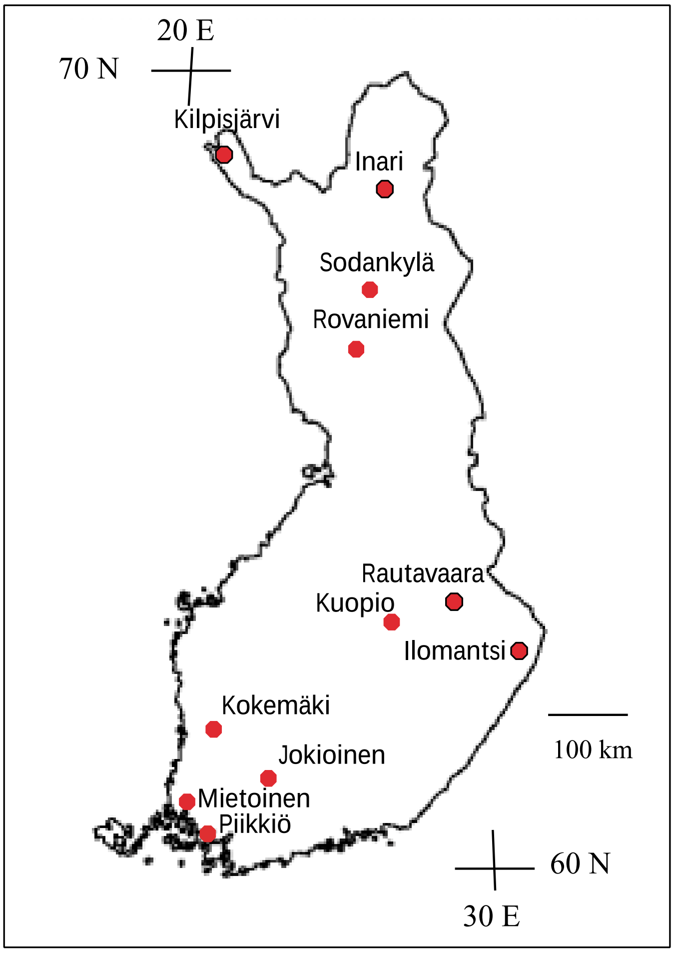

Figure 1. Location of study areas

3. Results

The volumetric moisture of 6 cm thick surface layer is relatively conservative parameter unless the precipitation forecast is strongly incorrect and thus the forecasts up to 36-hours are good (Figure 2). The conditions in Northern Finland at Kilpisjärvi are relatively wet and the moisture is almost all the time quite near the uppermost limit of the model i.e. 50 %. At more southern places the moisture varies between 10 and 50 %.

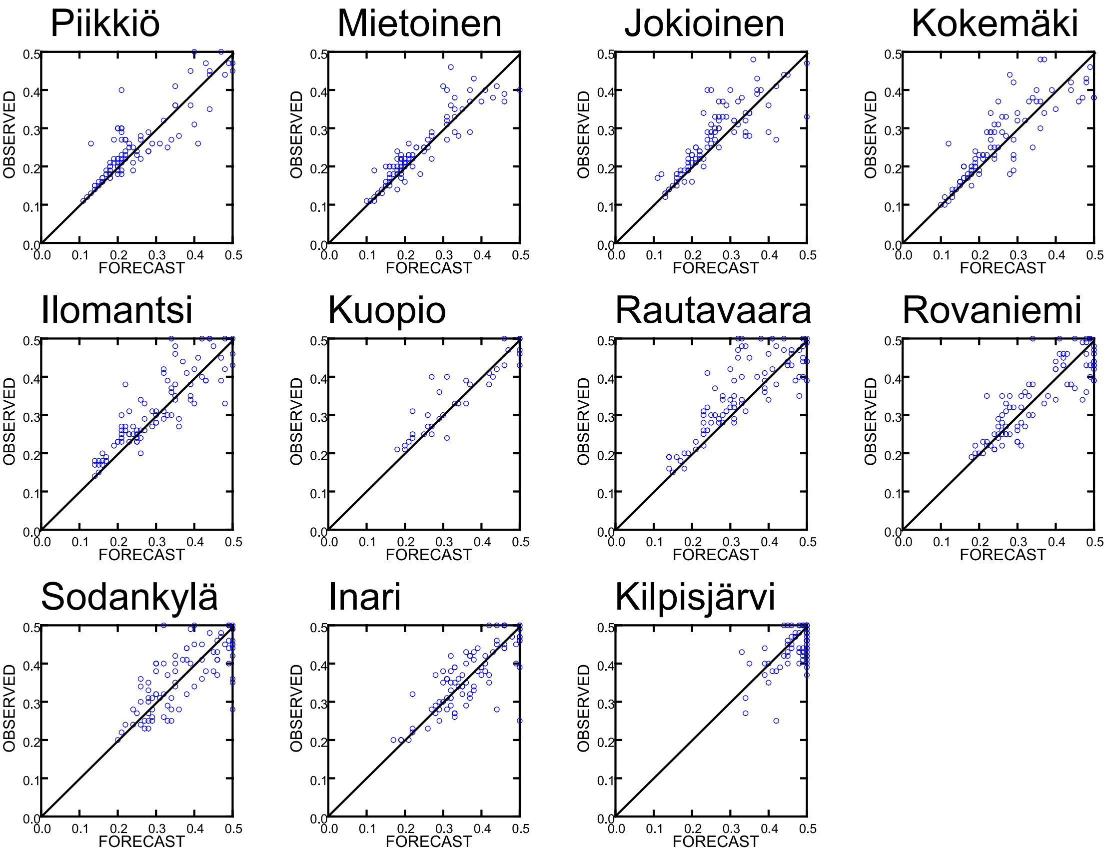

Figure 2. 36 hour forecast for surface moisture, May-August 2001

When we look potential evaporation and precipitation forecasts (Figures 3 and 4) we can see that evaporation can be predicted relatively accurately whereas the forecasts of precipitation are still to some extend unreliable. However, it is good to remember that now we are comparing grid square values and the interpolated values are exactly not the same as really measured value.

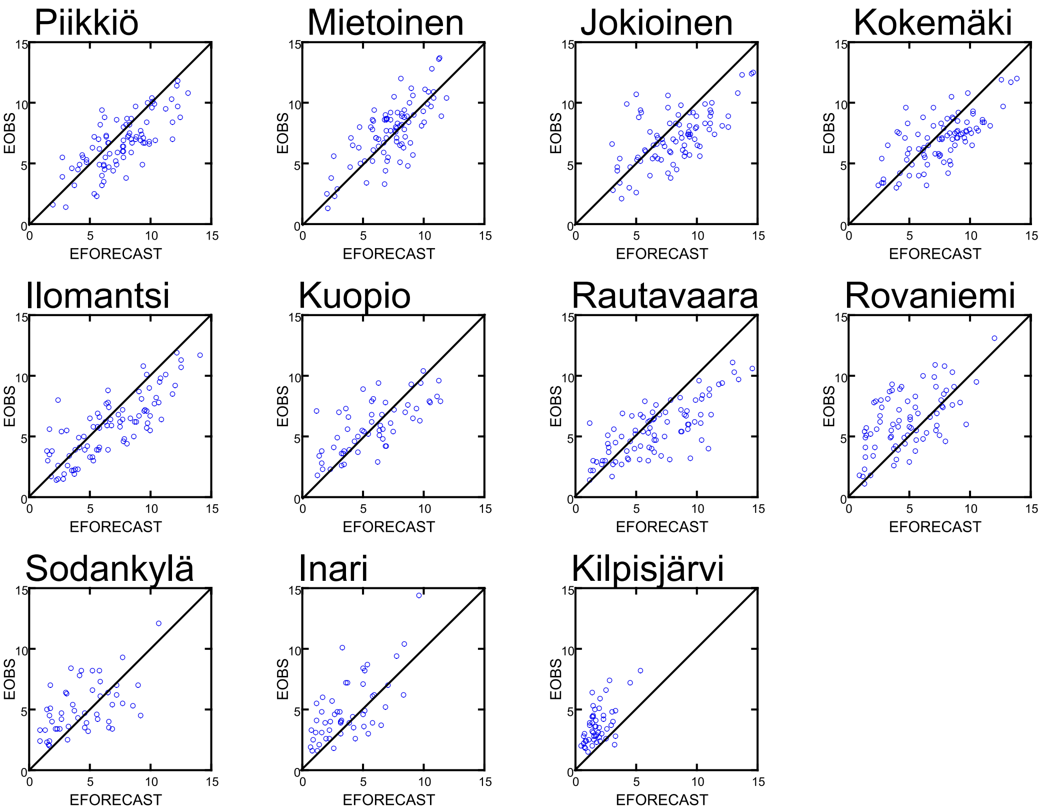

Figure 3. 36 h evaporation sum (mm) forecast and observation, May-August 2001

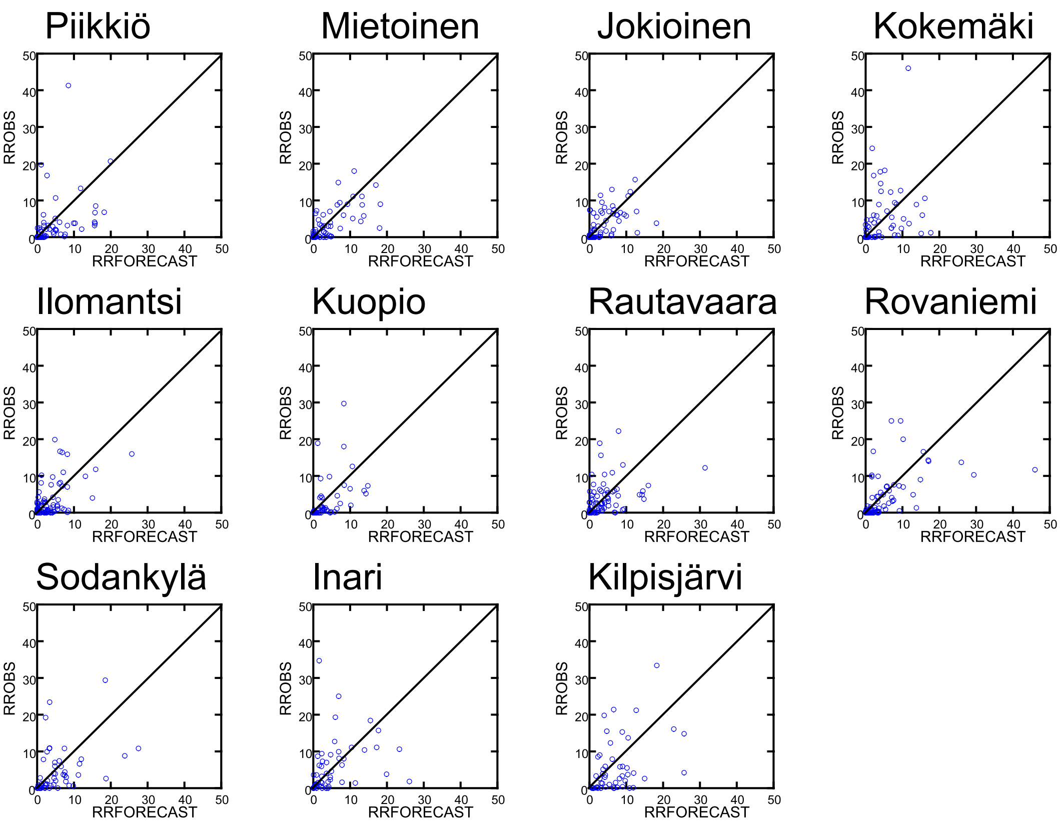

Figure 4. 36 h precipitation sum (mm) forecast and observation, May-August 2001

Let us next study more in detail one station, Ilomantsi located in eastern Finland. Evaporation and precipitation 12, 24 and 36 hour sums as well as surface moisture forecasts are given in Figure 5. The forecasted evaporation sum values are slightly higher than the values based on measurements (Figure 6). The correlation between the forecasted and measured evaporation values is 0.948 and 0.919 for 24- and 36-hour forecasts, respectively.

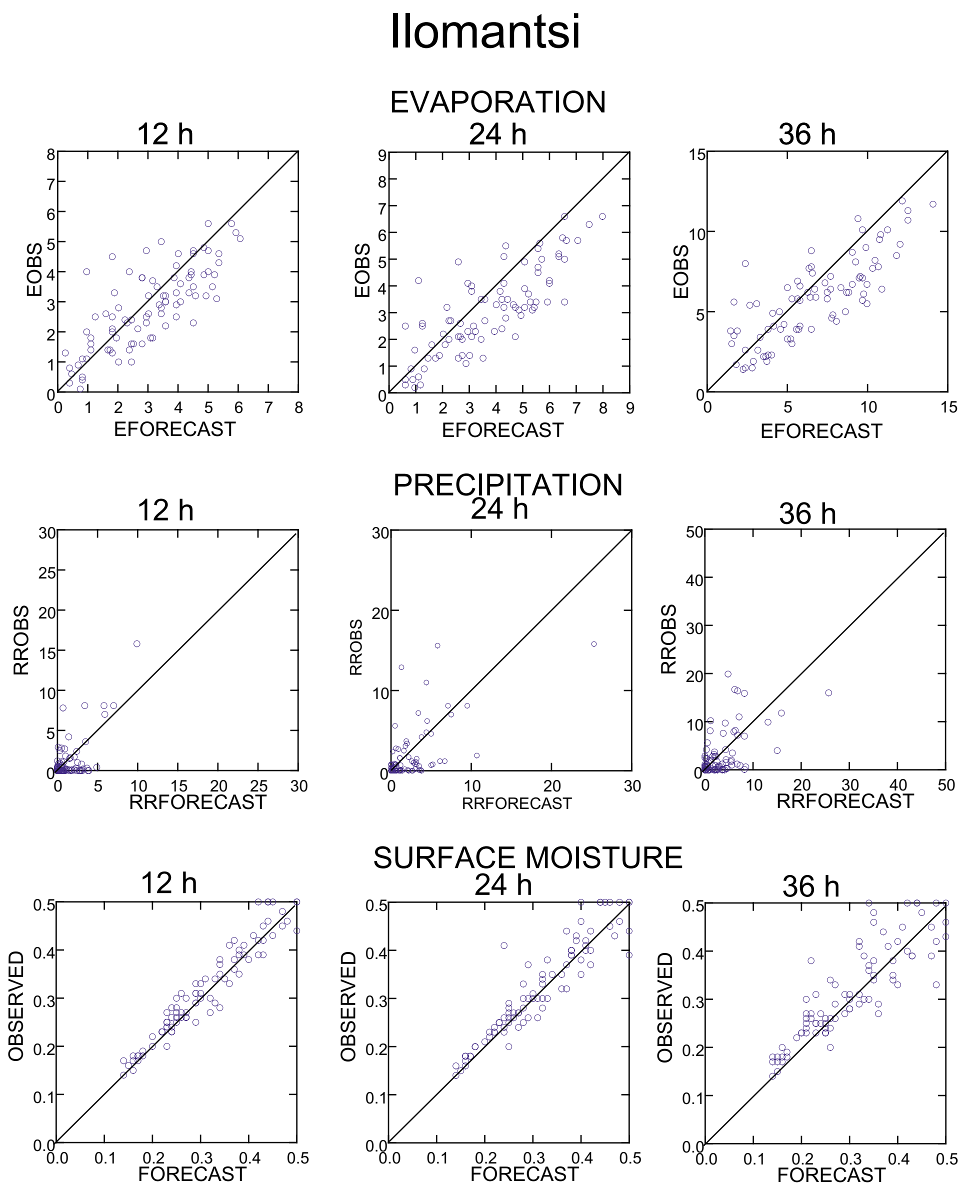

Figure 5. Evaporation (mm), precipitation (mm) and surface moisture forecasts at Ilomantsi, May-August 2001

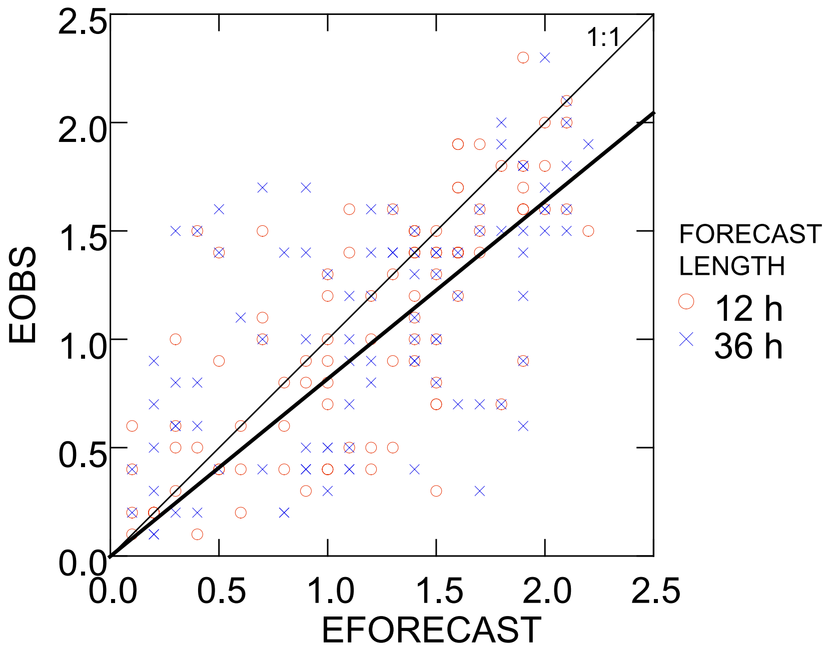

Figure 6. Evaporation (3 hour sum, mm) calculated based on observations and 12 and 36 h forecasts at Ilomantsi, May-August 2001. The thicker line depicts the best fit linear linear regression.

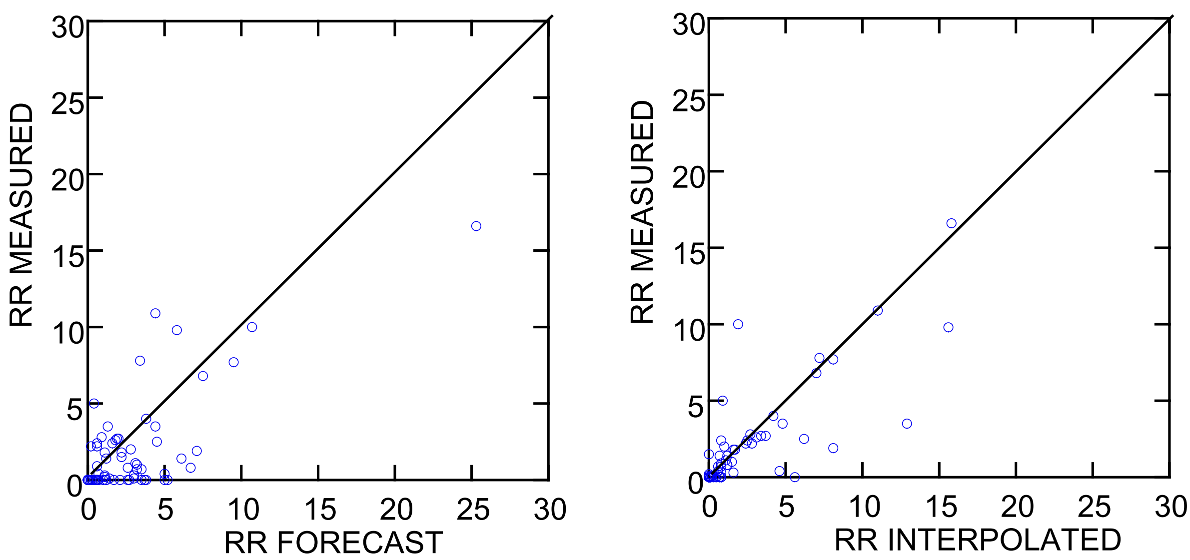

Figure 7. 24-hour precipitation sum (mm) calculated based on forecasts and as obtained from interpolated meteorological data compared with a point measurement at Ilomantsi, May-August 2001.

The correlation between forecasted and at Ilomantsi weather station measured 24 hour precipitation sum is 0.757. In soil moisture calculations the grid square values are obtained from interpolated data and the correlation between the interpolated and forecasted values is 0.635. The correlation between measured and interpolated values is 0.820.

When we look at the different components that are used for the calculation of potential evaporation we can see that in both 12 and 36 hour forecasts the highest global radiation values have been predicted relatively correctly. The 12 hour forecasts are slightly better than 36 hour forecasts. The 24 hour forecasts are naturally correct as in the middle of the night there is no solar radiation (Figure 8).

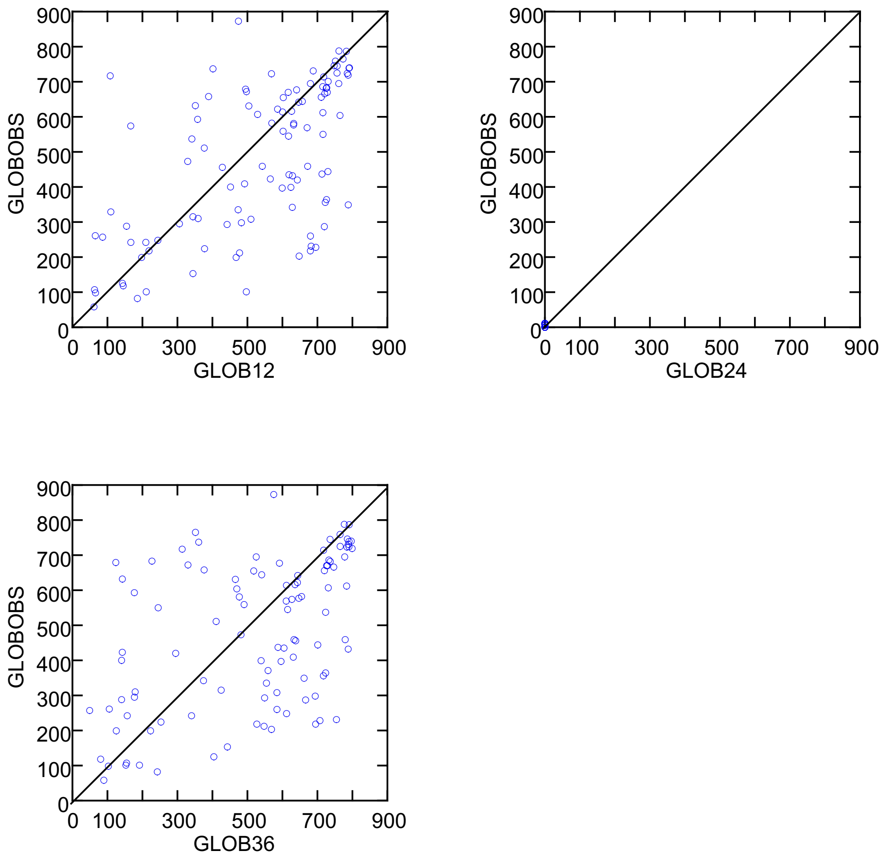

Figure 8. Global radiation (Wm^{-2}) forecasts (00 UTC+12 h, 00 UTC+24 h and 00 UTC+36 h) at Ilomantsi compared with the measured values, May-August 2001

In case of daytime (12 and 36 hour forecasts) long-wave radiation balance values the predicted highest upward long-wave radiation values are greater than on measurements based values (Figure 9). It is good to remember that the long-wave radiation values even in case of "observations" are calculated using a parameterization utilizing air temperature, air humidity and cloudiness information. The station network making cloud observations is relatively sparse and thus the long-wave radiation values also in case of "observations", with no doubt, include inaccuracies.

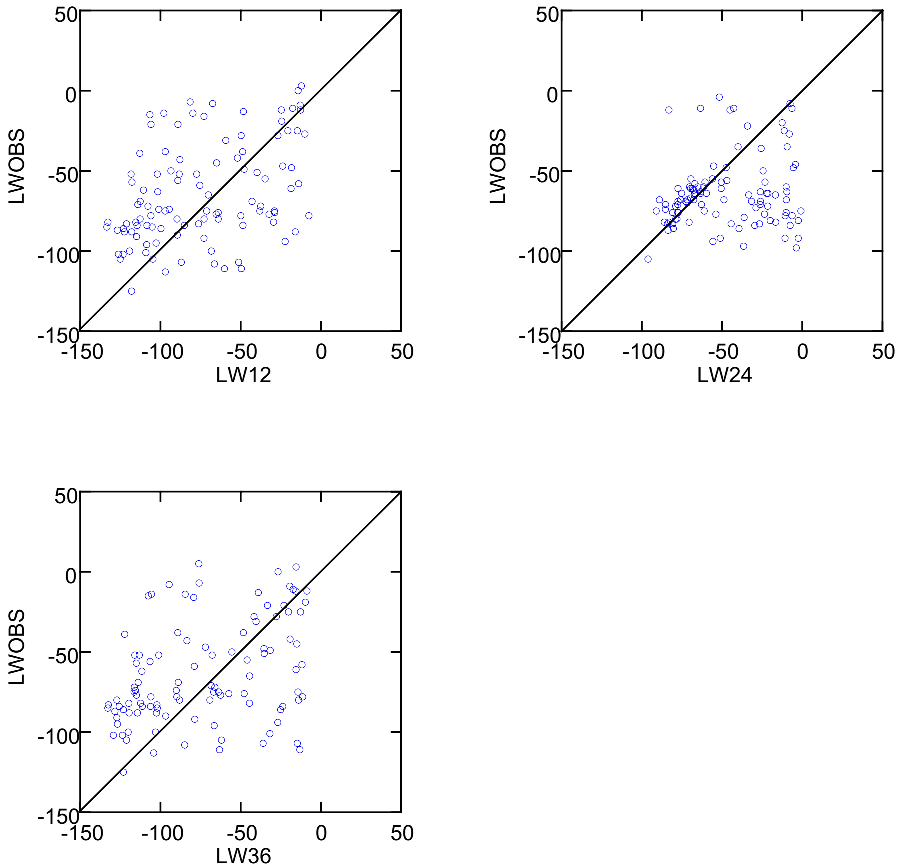

Figure 9. Long-wave radiation balance (Wm^{-2}) forecasts (00 UTC+12 h, 00 UTC+24 h and 00 UTC+36 h) at Ilomantsi compared with the measured values, May-August 2001

There is tendency that the daytime predicted relative humidity values are a little lower than the observed values (Figure 10). During the night, the values are close to 100%. Air temperature forecasts are good (Figure 11). The predicted daytime highest temperatures are a little higher that the observed. The forecasted wind speed values contain no systematic error though the scatter is relatively large (Figure 12). It is important to notice that in all these comparisons the forecasted values are compared with interpolated values that are not the same as measured values.

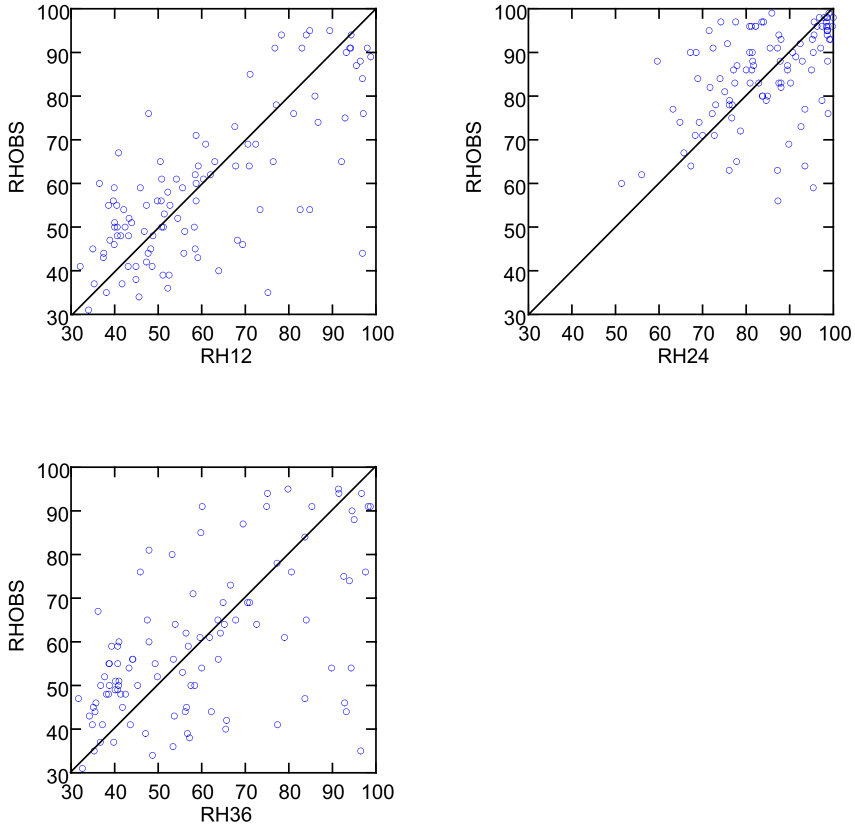

Figure 10. Relative humidity (%) forecasts (00 UTC+12 h, 00 UTC+24 h and 00 UTC+36 h) at Ilomantsi compared with the measured values, May-August 2001

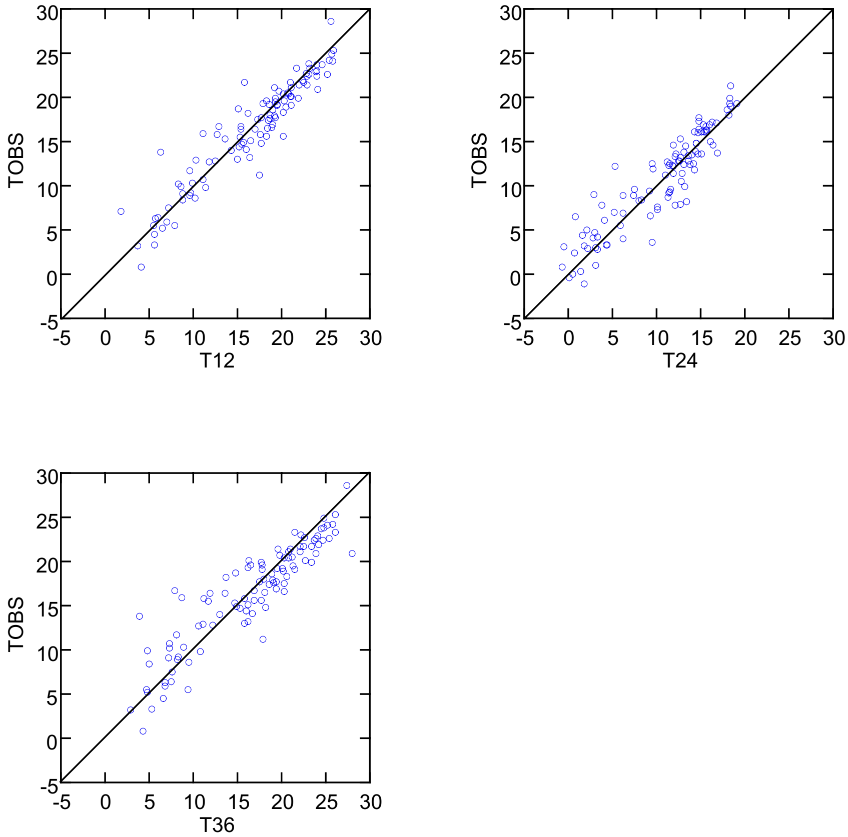

Figure 11. Air tempretaure (°C) forecasts (00 UTC+12 h, 00 UTC+24 h and 00 UTC+36 h) at Ilomantsi compared with the measured values, May-August 2001

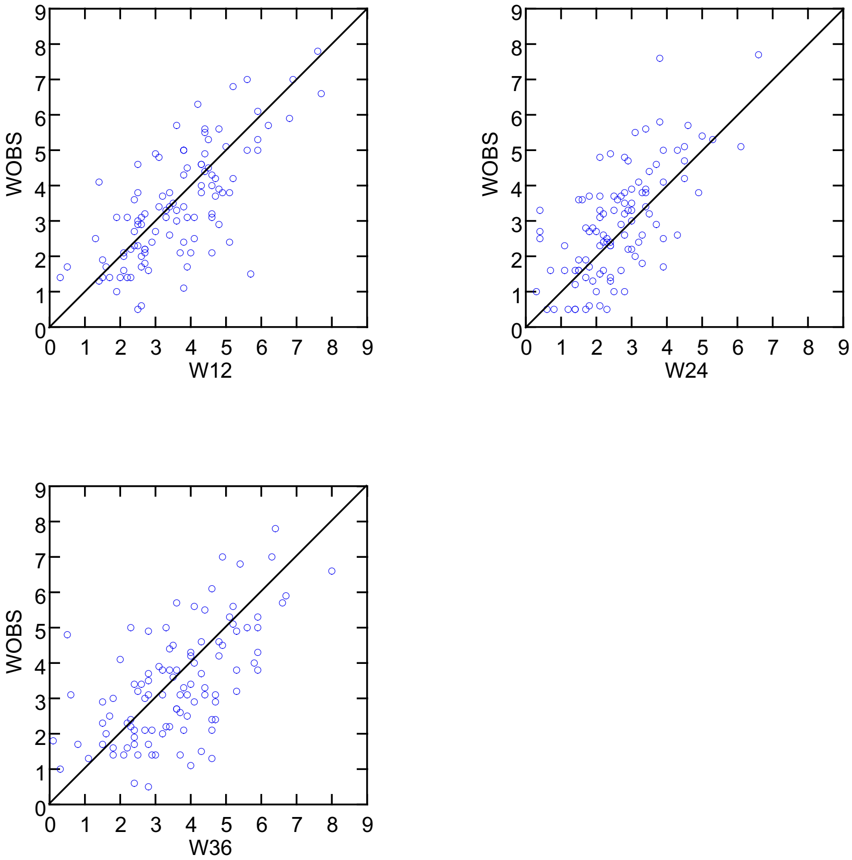

Figure 12. Wind speed (ms^{-1}) forecasts (00 UTC+12 h, 00 UTC+24 h and 00 UTC+36 h) at Ilomantsi compared with the measured values, May-August 2001.

4. Discussion and conclusions

According to this small study the use of numerical weather forecast model data seems to be a plausible alternative when input data for a soil moisture model is needed. In this data set there was no systematic differences when forecasted and into the grid interpolated measured values were compared. The scatter of forecasted values was large especially when hourly global and long-wave radiation, relative humidity or wind speed values were compared. When soil moisture is been estimated the quality of precipitation data is naturally very important and soil moisture modellers should ensure that the data is not biased.

4. References

Heikinheimo, M, Venäläinen, A., and Tourula, T., 1998. A soil moisture index for the assessment of forest fire risk in the boreal zone. In: Dalezios, N.R. (ed.), EUR 18328-COST 77, 79, 711, Proceedings of the International Symposium on Applied Agrometeorology and Agroclimatology. p. 549-555.

Källen E. (ed.), 1996. HIRLAM documentation manual. System 2.5. June 1996. Available from SMHI, S-60176, Norrköping, Sweden.