

Forecasting snow with HIRLAM5.2

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Precipitation distributed on snow and rain has been available from the condensation schemes in the HIRLAM model for many years. The snow forecasts from HIRLAM5.2 with STRACO condensation scheme (Sass, 1997) are evaluated against observations of precipitation type from the Norwegian precipitation network (about 520 stations) January 2002.

In the observation data, weather including precipitation type is described with three symbols which cover the period since last observation. The observations are made daily at 06, 12 and 18 UTC. In order to compare the observed precipitation types snow, sleet and rain with the forecasts from HIRLAM the precipitation types are given numerical values, 1, 0 and -1 respectively. When determining the value for a single observation periode the observation symbols for the periode are averaged after conversion to numbers.

From HIRLAM the 00 UTC forecasts with forecasts lengths 12, 18 and 30 hours are verified. Precipitation type from HIRLAM is given numerical values for comparison. The value is calculated from total precipitation and snow (mm): $pt = (s - r)/(s + rr)$, where $pt = precipitationtype$, $s = snow$, $r = totalprecipitation - snow$. The result is a number between -1 and 1 on a continuous scale where $pt > 0.33$ is interpreted as snow, $0.33 \geq pt \geq -0.33$ is interpreted as sleet and $pt < -0.33$ is interpreted as rain. We have not elaborated this definition further.

Figure 1 (top) shows the distribution of HIRLAM forecasts on rain, sleet and snow in cases when rain, sleet and snow are observed. In cases where the observations are sleet the HIRLAM forecasts are nearly equally distributed on snow and rain with only a few forecasts of sleet. The agreement between forecasts and observations is quite good for snow and rain.

However in a number of cases the model is forecasting snow when rain is

observed. This is related to the mainly positive difference between model orography and the real terrain particular in the valleys and the fjords. The height difference might be significant, often many hundred metres and some places more than a thousand meter.

We have tried to reduce this error by applying melting of precipitation below the model surface. The melting formula used is taken from Golding (1989):

$$\frac{\partial P}{\partial z} = -0.0028T_w P.$$

T_w is the wetbulb temperature, P is the precipitation rate. The wetbulb temperature is used because the melting of snowflakes is assumed to be delayed by evaporation from the snowflakes in subsaturated conditions. Wetbulb temperature is calculated from the temperature and the specific humidity in the lowest model layer as it is the processes of the free atmosphere we intend to model. In the nature, when precipitation is melting the 0° C-isotherm is forced downwards but in this method the cooling of the air caused by melting of snow is not considered. To compensate for this shortage the vertical gradient of the wetbulb temperature below the model surface is assumed to be very small to avoid too much melting. The wetbulb temperature that goes into the equation is the mean of the wetbulb temperature in the lowest model layer and the wetbulb temperature extrapolated to station height.

Applying this formula to the precipitation forecasts we increase the number of correct forecasts in cases where observations are rain. This gives a better agreement with the observations in cases when rain is observed but also an increase in rain forecasts when snow is observed (Figure 1, bottom). As seen in the time series from Ardal (Figure 2, which is a station by the fjord about 1000 m below the model surface, correct forecasts for rain are obtained in the first half of January. The physics behind the observed snow in the last half of January is not captured by the model. However both the temperature and the wetbulb temperature is above 0° C in lowest model layer on these days. In Figure 3 from station Bjerka-Valla which lies about 400 metres below the model surface one can see that the snow forecasted by HIRLAM in the last half of January is retained while the forecasts for the first half of January are corrected.

To conclude, the forecasts of precipitation type from HIRLAM5.2 contain valuable information. In complex terrain the snow rate is too high due to the discrepancy between the height of the monitoring stations and the model terrain. Additional calculations of snow melting based on temperature and

humidity in the lowest model layer can reduce the error but it is difficult to avoid that too much snow is melted.

References

Golding, B.W., 1989: A simple two phase precipitation scheme for use in numerical weather prediction models. Science Note **13**, UK Met Office.

Sass, B.H., 1997: Reduction of numerical noise connected to the parameterization of cloud and condensation processes in the HIRLAM model, HIRLAM newsletter, **29**, 37-45.

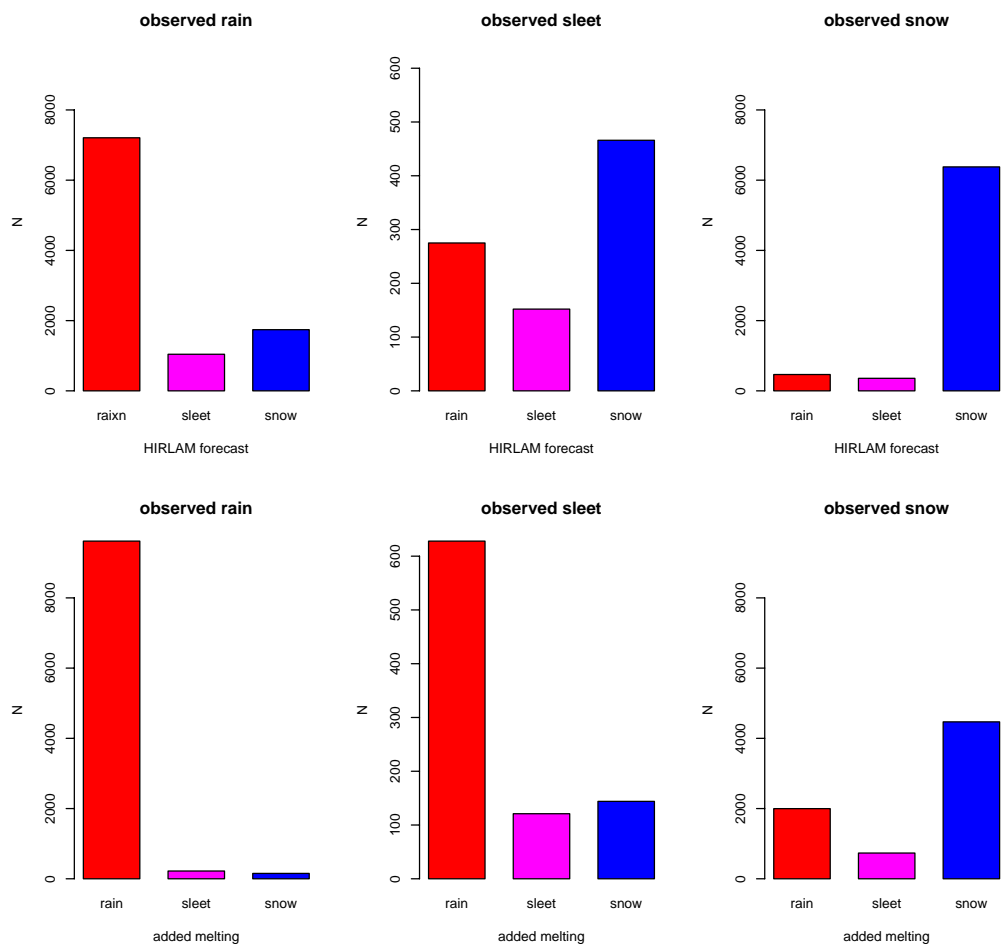


Figure 1: Summary verification of precipitation type at the Norwegian precipitation network. Top HIRLAM forecasts, bottom additional calculations for complex terrain

OEVRE_AARDAL 28 metres above sea level

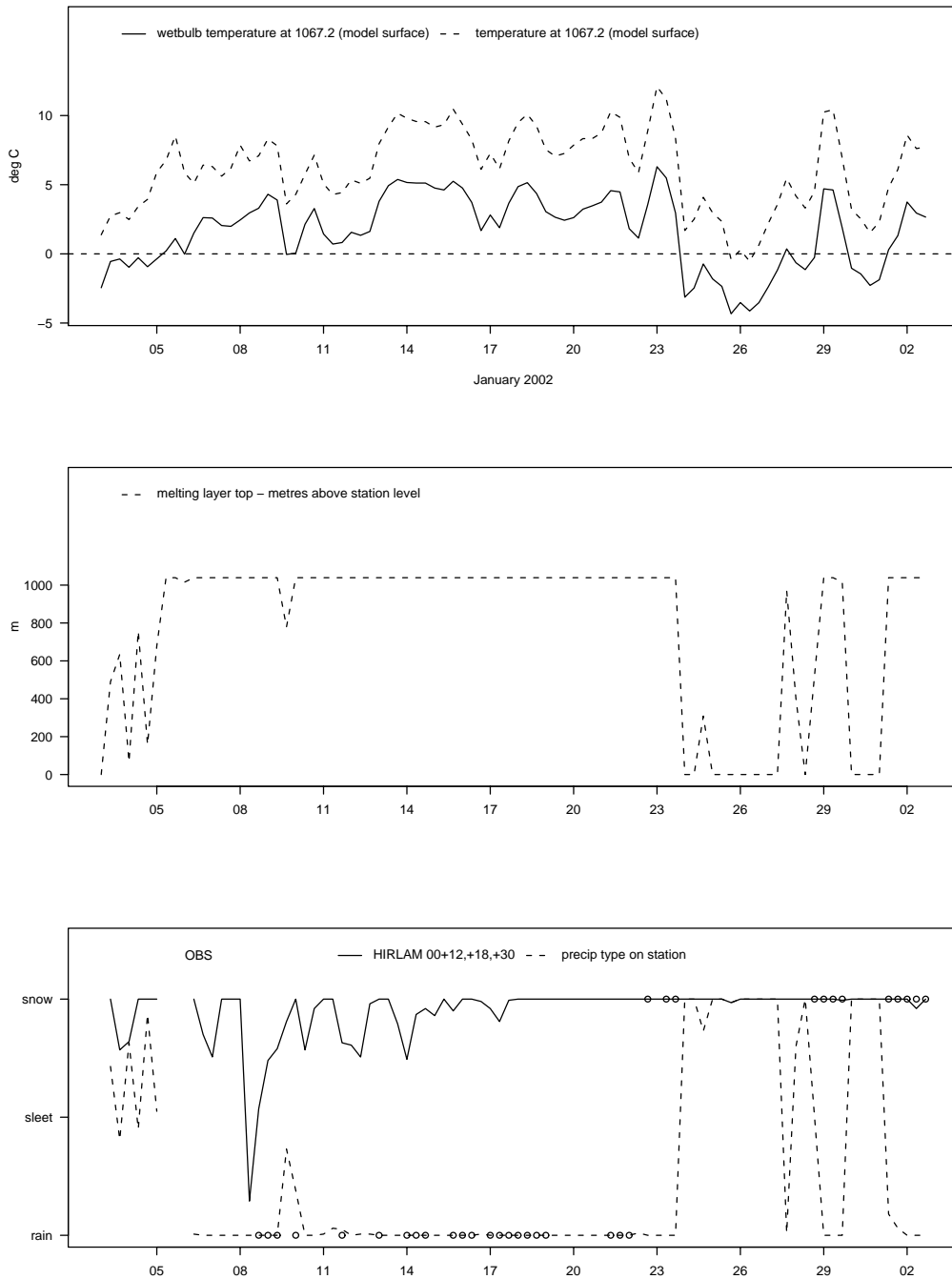


Figure 2: top: wetbulb temperature (dashed) and temperature (solid), middle: melting layer top in metres above station height, bottom: precipitation type, observed (circles), HIRLAM (solid) and calculated at station height (dashed) at station Årdal January 2002.

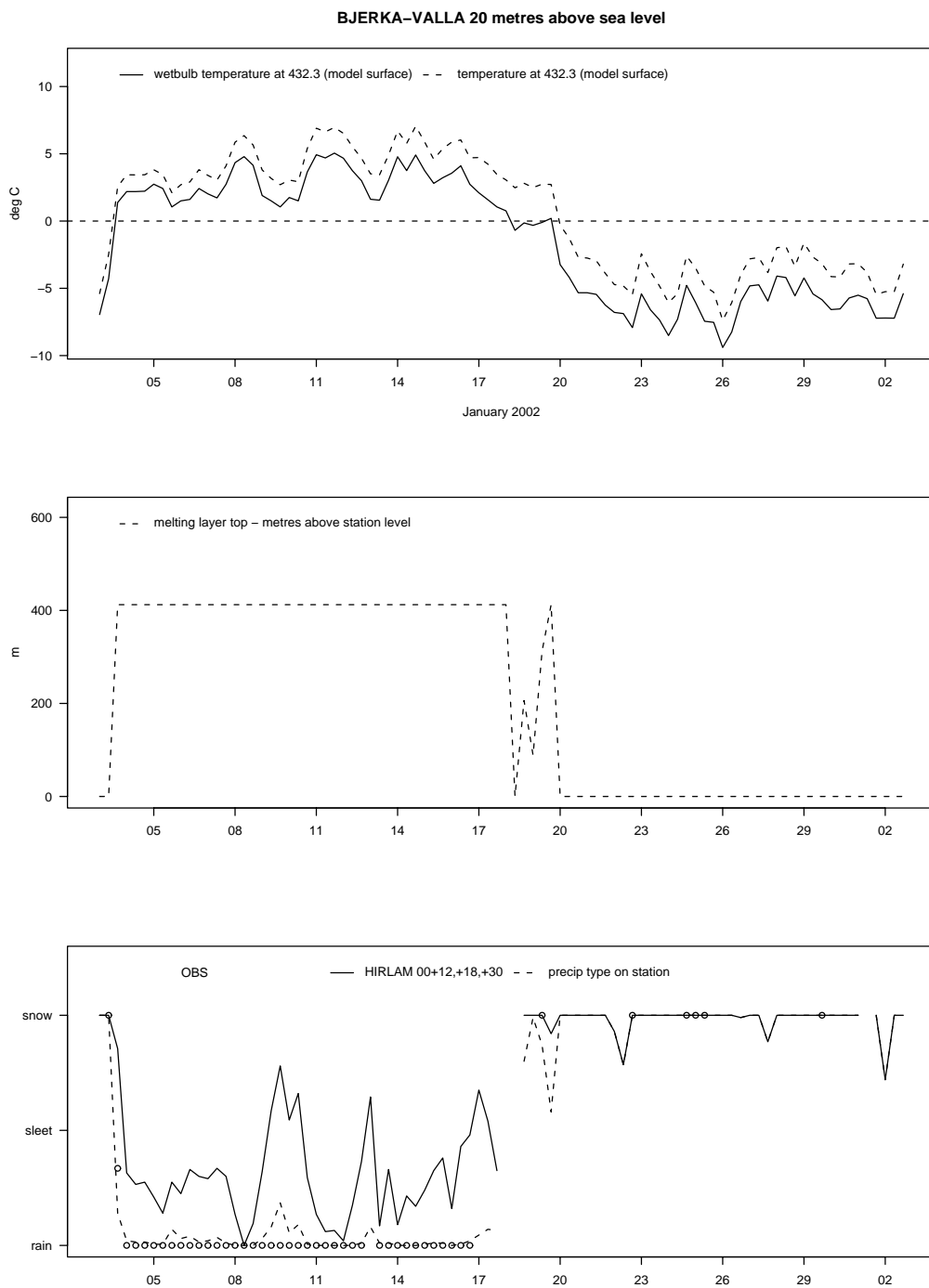


Figure 3: top: wetbulb temperature (dashed) and temperature (solid), middle: melting layer top in metres above station height, bottom: precipitation type, observed (circles), HIRLAM (solid) and calculated at station height (dashed) at station Bjerka-Valla January 2002.