EXPERIMENTAL USE OF ENSEMBLE FORECASTING AT SMHI

O. Åkesson
SMHI
Norrköping, Sweden

1. INTRODUCTION

Some experiments with ensemble forecasting of two extreme weather events during 1993 will be discussed comparing the ensemble forecast with that of the corresponding operational deterministic forecast. A brief verification study of mean 6-10 day temperature outlooks from ensemble forecasts and deterministic forecasts will be presented at the end.

2. EXTREME WEATHER EVENTS

2.1 **Strong winds on 14 Jan**

In January 1993 there were no less than 4 or 5 occasions of storm-force winds exceeding 25 m/s recorded in the surrounding sea areas of Sweden, one of which developed into a hurricane and which caused damage and loss of lives when the ferry Jan Heweliusz turned over in southern Baltic on 14 Jan 1993. The T213 short range forecasts moderated the wind but nevertheless indicated gale-force winds, albeit not exceeding 25 m/s. The winds had culminated in the morning when the storm was situated over southernmost Sweden and it caused a lot of damage also over land just to the south of the centre of the low. Fig.1 shows the surface pressure charts of the D+1 to D+5 forecasts and the verifying analysis, all valid at 12 UTC 14 Jan 1993. At that time the depression had already moved to the Baltic States.

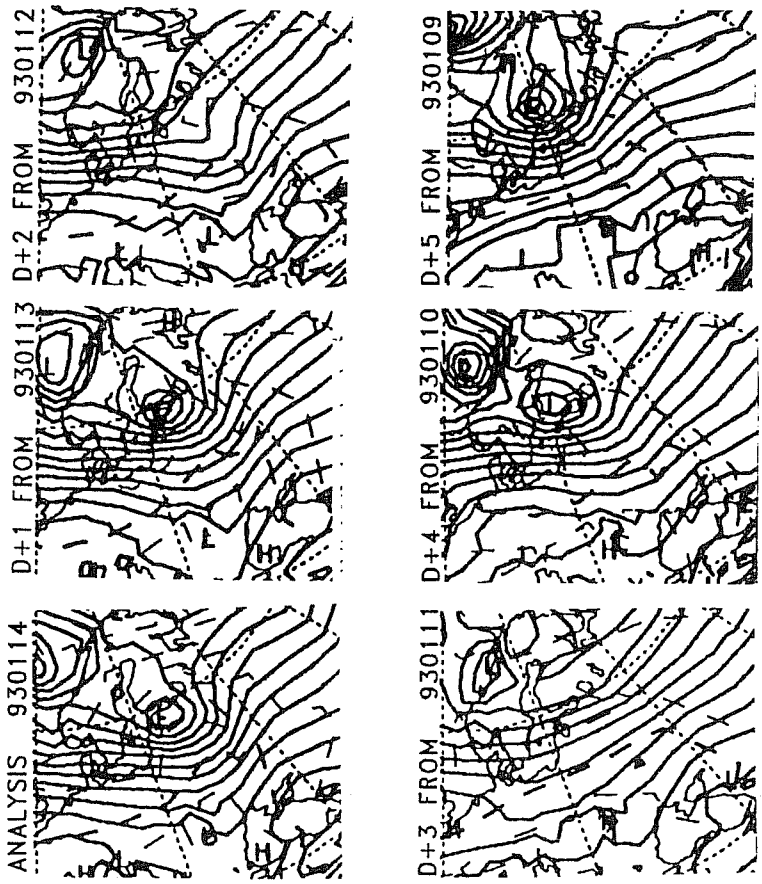

Fig. 1. ECMWF surface pressure analysis (bottom left) and D+1 to D+5 forecasts all valid on 14 Jan. 1993.

Most forecasts successfully predicted a fairly deep low, but the D+2 and D+3 forecasts did not indicate severe weather but only fresh or possibly strong winds. The ensemble forecasts from 11 Jan. were examined to find out whether any of the ensemble members had indicated severe weather, which expressed in probabilistic terms could have warned the forecasters for a rapid and severe development 72 hours in advance.

Fig. 2 shows the operational T213 10m wind from the D+3 and D+4 forecasts both valid at 12 UTC on 14 January as well as the maximum values for each gridpoint from any of the ensemble members of the corresponding ensemble forecasts. The T213 maximum wind over the Baltic was only between 10 and 15 m/s for both of the D+3 and D+4 forecasts despite the fact that the gradient seemed to be sharper for the D+4 forecast (Cf Fig. 1). The maximum ensemble forecast wind reached between 15 and 20 m/s, showing that at least some of the ensemble members indicated strong wind. This wind interval, however, only corresponds to gale force wind, whereas observations from this time still reached 25 m/s or more, ie storm force winds. Normally observed winds are exceeding those in the forecast by about 15-20 % based on verification. The bottom panel of Fig. 2 shows the calculated probabilities for wind speed exceeding 14 m/s, the limit defined in Sweden separating fresh and strong winds (gale). The highest probabity over the Baltic Sea is 60-80% in the D+3 forecast and 40-60% in the D+4 forecast.

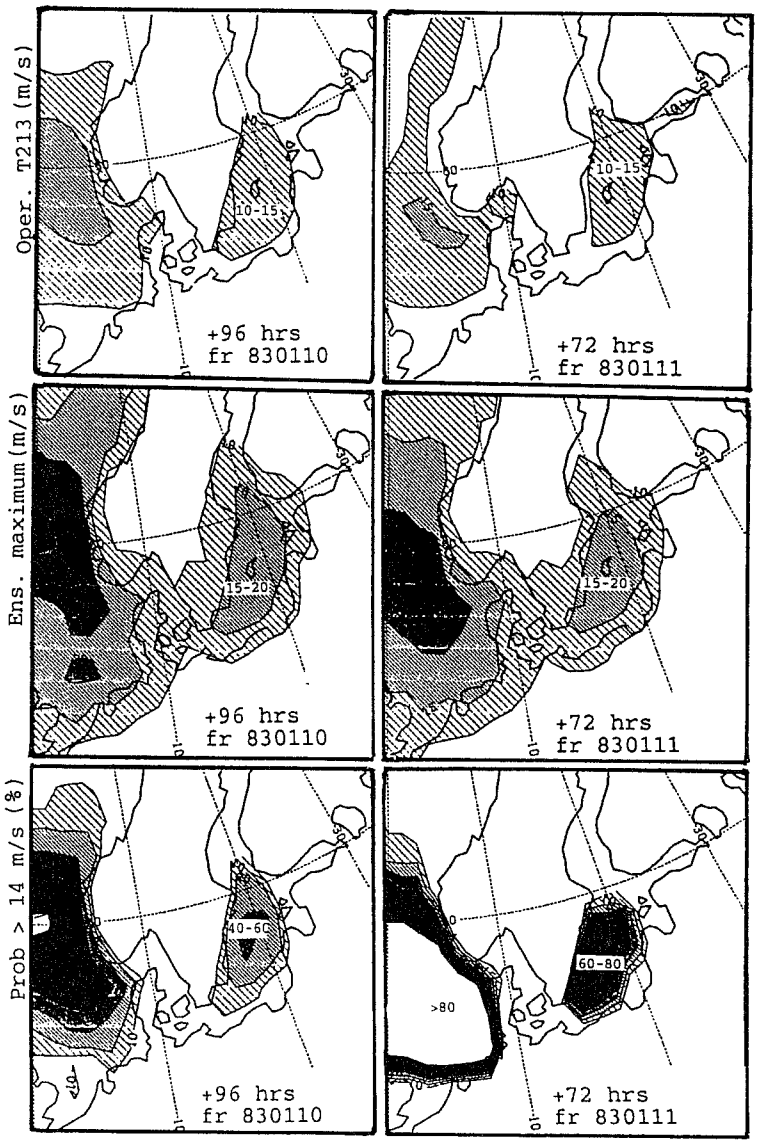

Fig. 2. Top: 10 m wind speed in the operational D+4 (left) and D+3 (right) forecasts both valid at 12 UTC 14 Jan. 1993. Middle: Ensemble maximum wind speed from D+4 and D+3 ensemble forecasts both valid at 12 UTC 14 Jan. 1993. Bottom: Probabilities for wind speeds exceeding 14 m/s based on the D+4 and D+3 ensemble forecasts resp. both valid at 12 UTC 14 Jan. 1993.

One can conclude that the D+3 ensemble forecast from 11 Jan managed to improve the poor performance of the operational forecasts somewhat, but this was not the case with the D+4 forecast from 10 January. The ensemble forecasts predicted windy but not severe weather and thus there was no early warning of this event from either of the two ensemble forecasts. This was, however, a rather small-scale feature which a T63 forecast might not be expected to resolve properly, and not at this lead time, although 72 hours is the earliest available ensemble output. Official wind warnings are normally not issued earlier than 36 hours in advance, but for ship routing purposes early warnings are necessary often 4 or 5 days in advance.

2.2 Prediction of heavy rain on 13 August 1993

During August 1993 heavy rains caused floods in many rivers in the north of Sweden. This followed a spell of heavy rains, in some places exceeding 60 mm, mainly falling in the evening of 13 August (see Fig. 3). A low moved north over northern Sweden and there was probably enhanced precipitation due to lifting over the mountainous regions between Sweden and Norway.

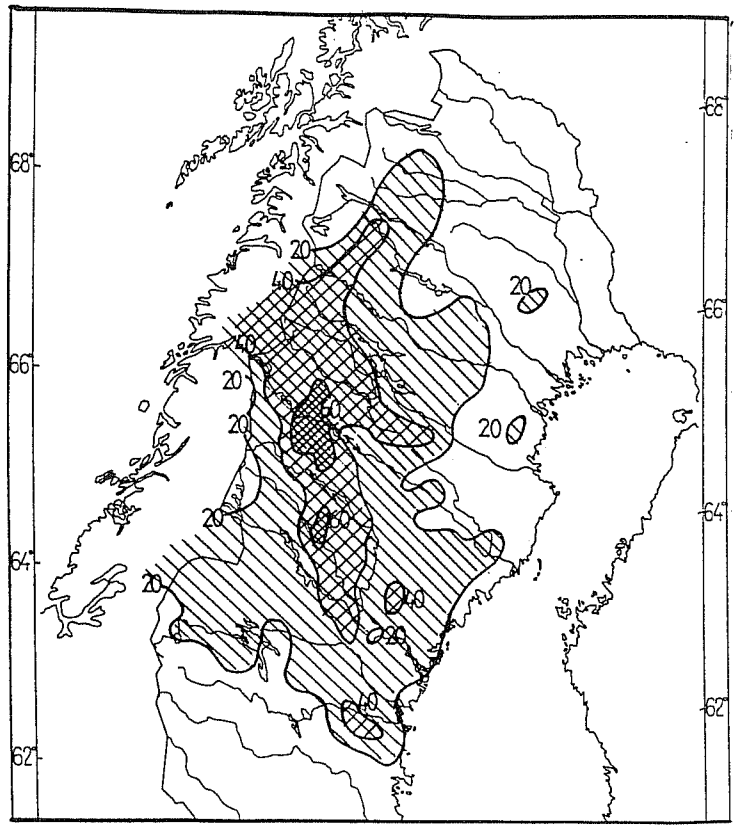

Fig. 3. Observed accumulated precipitation (mm) during the period 06 UTC 12 Aug.- 06 UTC 14 Aug. 1993.

This would not have caused severe problems if it was not for the fact that there had been another spell of rain of similar magnitude in approximately the same area 3-4 days earlier, which had caused dangerously high water levels in rivers and reservoirs. Furthermore the forecasts to the river authorities were not very successful in predicting a second spell of heavy rains. Fig. 4 shows the D+1, D+2 and D+3 forecasts for this day. The D+1 forecast, available in the morning

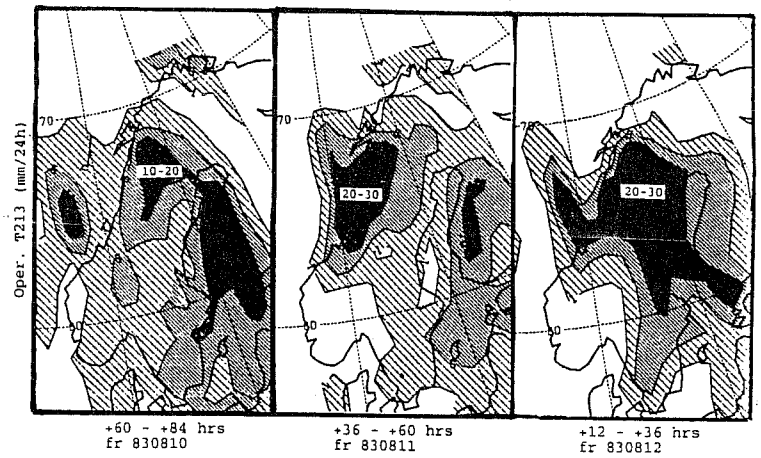

Fig. 4. ECMWF operational D+3 (left), D+2 (middle) and D+1 (right) precipitation forecasts all valid 00 UTC 13 Aug.- 00 UTC 14 Aug. 1993. Unit: mm/24 hrs.

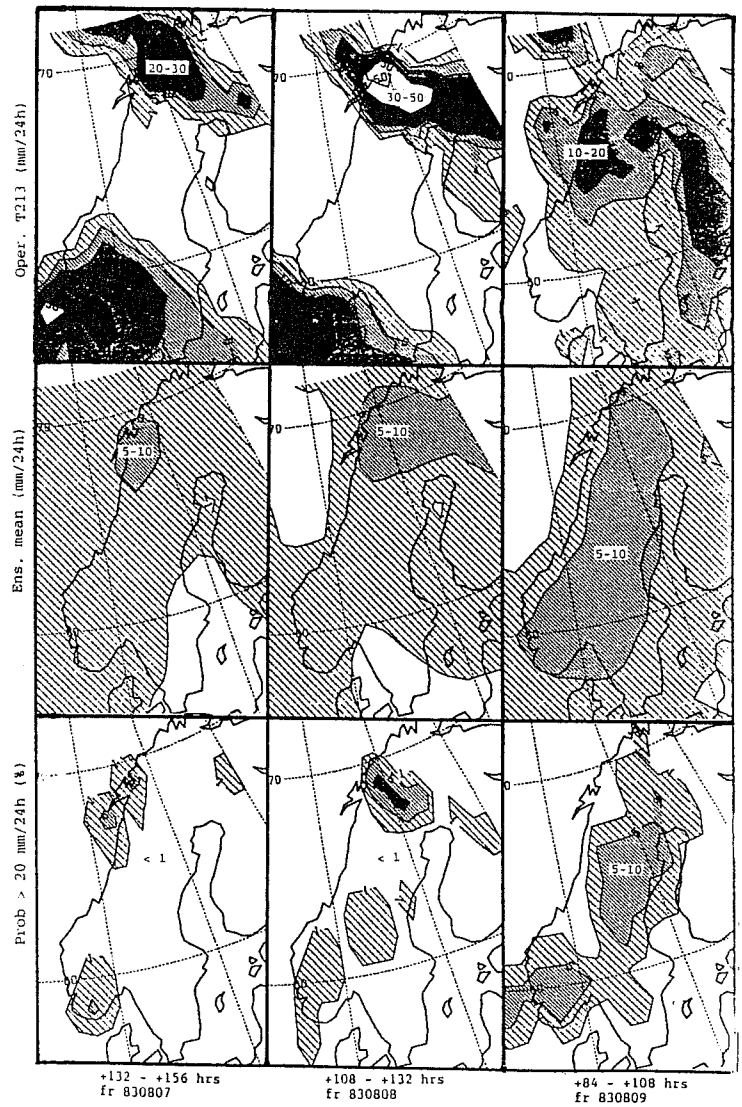

Fig. 5. Top: ECMWF operational D+6 (left, D+5 (middle) and D+4 (right) precipitation forecasts all valid 00 UTC 13 Aug.- 00 UTC 14 Aug. 1993. Unit: mm/24 hrs. Middle: Same as top but for ensemble average precipitation amounts. Bottom: Same as middle but for ensemble probability amounts exceeding 20 mm/24 hrs.

of the 13th clearly predicted the areal distribution well, but the amounts were approximately half of those observed. Even if the authorities had been warned of extreme amounts at this time, it would have been too late to prevent floods and in this case an earlier warning would have been necessary to take preventive action. The D+2 and D+3 forecasts predicted even less precipitation. The operational forecasts initiated 4 to 6 days earlier (Fig. 5) indicated rain, two of them even large amounts but in an area situated roughly 500 km too far to the north and almost no rain in the area in question.

The forecaster modified this picture and gave a forecast of 5-15 mm based on this output and on the corresponding ensemble forecasts available from these 3 days (Fig. 5). The middle panel shows the ensemble average, none of which showed more than 5-10 mm and only a few of the ensemble forecasts indicated amounts exceeding 20 mm in 24 hours. The lower panel shows the calculated probabilities for this limit and only the forecasts from the 9 August showed any skill for this area, whereas the risk for more than 20 mm in 24 hours was non-existent.

Also in this case one would not expect a T63 model to perform better or even as well as a T213 forecast in a case with orographic lifting, so one could argue that such a comparison is not fair. Nevertheless this case study is still interesting and gives an indication that both higher resolution and possibly a higher number of ensemble members might be needed to correctly forecast situations like this one.

3. EVALUATION OF 6-10 DAY OUTLOOKS BASED ON ENSEMBLE MEAN FORECASTS

850 hPa temperature ensemble averages for D+6 to D+10 have been evaluated together with the corresponding average from the operational 850 hPa temperature forecast. This product is quite popular among customers, where in addition to the mean temperature attempts to predict the trend in a more qualitative way is also sometimes indicated depending on the situation.

The verification results comparing the operational T213 forecast, the T63 control forecast and the mean ensemble T63 forecast are listed in the table below. The ensemble average showsd the highest correlation coefficient. The comparatively high scores partly reflects the half-yearly annual cycle, which has not been removed from the data prior to the calculations. Even so the ensemble mean value based on 60 cases is clearly a better predictor than using the T63 control or the T213 operational mean forecasts respectively, both of which have lower but similar skill when this is measured by correlation.

	Correlation coefficient
Temp. ens.	0.87
Temp. T213 oper.	0.81
Temp. T63 cont.	0.83