Monitoring the RCR system: first impressions and findings

Kalle Eerola
Finnish Meteorological Institute

1 Introduction

Verification and monitoring are essential parts of the operational NWP activities. Regular verification guarantees that the products are on the level they should be. On the other hand, regular monitoring can reveal deficiencies or problems in the daily operations or in the numerical forecasting system and thus help to point out the weak points and areas of further research and development work.

Concerning the operational NWP activities at Finnish Meteorological Institute, separate reports in this issue describe the current operational HIRLAM/RCR system at the Finnish Meteorological Institute (Kangas, 2004) and the verification of the the pre-operational test runs of RCR against the prevailing operational system (Järvenoja, 2004).

The agreement between the Finnish Meteorological Institute and HIRLAM project defines the extent of minimum amount of verification and monitoring of the RCR system. Work is going on to fulfill these requirements. This report discusses some aspects of RCR monitoring and the tool development by showing examples of diagnostic tools and what we have noticed during the first months of RCR. The examples of the problems discussed here concern snow analysis and possible noise in the upper levels of the forecast model. Daily monitoring can also reveal interesting features and cases for more careful investigation. An example of such a case, revealed by daily monitoring, is given by Eerola (2004).

In addition to these this report shows examples of the products in the daily and monthly monitoring reports. An overall impression is that regular monitoring is essential for daily routines.

2 Analysis of surface parameters

The surface or near-surface fields, like 2-meter temperature and humidity, snow cover, sea surface temperature, and ice coverage, are very difficult to analyze. There are several reasons for this:

- Observations are very unevenly distributed both in space and time. For instance snow depth is normally measured only once a day at 18 UTC, but some stations measure it at 06 UTC, and there are even a few stations, which observe it at 12 or 00 UTC. So the distribution of observations is very different from one assimilation cycle to another.
- The local variations in these fields and observations are very large, which in other words means that a single observation is representative only on a very small area. So the influence radius of a single observation is small.
- Different underlying surface may require different handling of observations or different selection of observations. For example, sea surface measurements over open sea cannot be used on coastal areas or over inland lakes.

- From the model field point of view this means that a single field may represent a different physical parameter on a different area. For instance, temperature over water may represent sea surface temperature or lake surface temperature, which behave very differently, but are analyzed using the same algorithm.

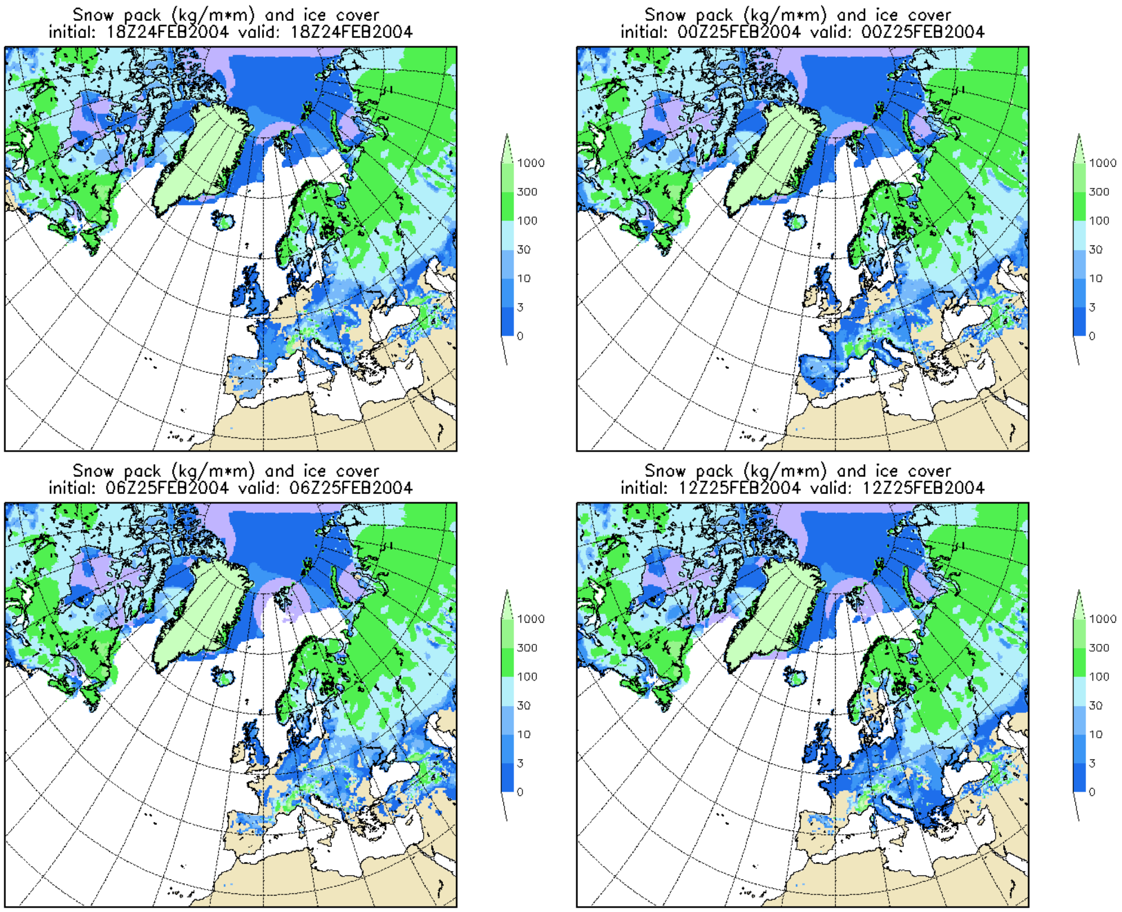

Figure 1: *Successive snow analysis with six hour intervals in February 2004.*

The following example of surface analysis problem concerns snow analysis. The current snow analysis scheme has been developed in 1990's. It is based on successive correction method and uses only information from SYNOP observations.

While looking at the snow analysis from day to day from the RCR runs, we found a strange fluctuation in the snow edge from analysis time to another. This feature was prominent in the areas with small snow amount. The examples shown here are from central Europe. Figure 1 shows the HIRLAM snow analysis with six hour intervals during one day in February 2004. At 18 UTC Feb 24 the British Isles are totally snow-covered. Then the snow partly disappears, to appear again at 25 February 18 UTC. The same phenomenon can be seen over France. Another interesting feature can be seen in Spain at 00 UTC 25 February: a sharp circular snow edge crosses the country. This is probably due to a fact that there is only one influencing observation, whose influence radius can be seen over Spain. A similar effect can be seen over the ice-covered sea around Spitzbergen.

There seems to be no problem in the areas, which are all the time covered by thick snow coverage, like Scandinavia or northern Russia.

This kind of unrealistic snow amount and fluctuation has clearly several drawbacks. First of all, the wrong snow cover affects the near-surface variables, like two-meter temperature and humidity. Secondly, if there is snow, melting requires energy and on the other hand the melted snow moistens the underlying surface affecting in this way to the surface fluxes and consequently to the near-surface fields, like 2-meter temperature, and hydrological cycle.

There are several possible explanations to this phenomena:

- The practice of making observations differs very much from observation time to another and from observing station to another. This means that the observation coverage can be totally different at different times.
- One isolated observation can affect over too large an area, because the analysis draws very close to observations. This can especially affect if only very few observations are available.
- All observing stations do not report, if there is no snow (0 cm of snow). This makes it difficult to analyze the edge of snow coverage. The effect is that snow coverage is spread over too large an area.
- If the height of the observation compared to that of the grid point is very different, the observation should not be used, because especially on mountainous areas the amount of snow is very much correlated to the height of the observing station. In the HIRLAM snow analysis there is a term, which handles this.

In the ASM meeting in Madrid, it appeared that in Spain a lot has been done with the snow analysis with very promising results.

3 Are the HIRLAM/RCR fields noisy?

There has been discussion that HIRLAM fields on the resolution of 0.2° are noisy or at least there is more "noise" than on the resolution of 0.3° (Järvenoja, 2004). This noise does not look very meteorological. This discussion is based on horizontal fields and the "noise" means here horizontal small scale features.

Looking at the analysis increments, we can sometimes see some very small scale features on the highest model levels (not shown), but mainly they are clean and smooth. This means that the 3D-VAR analysis system is healthy in this sense. However, when looking at the forecast fields, we can see small scale features, which do not look very meteorological, especially in the temperature and wind fields. These features are more prominent on the upper levels of the model. Because these features are not present in the analysis increment fields, we can conclude, that they are created by the model.

Figure 2 (produced by Carl Fortelius) brings a new element to this discussion. The left panel shows potential temperature on model level 2 in one 48 hour forecast. The right panels are vertical cross sections of potential temperature on the highest twelve levels of the model along two lines on the Atlantic Ocean close to the south-western corner of the area. We can clearly see two-delta waves in the vertical. Their amplitude is not very small, of the order of several degrees. Their origin is not at the moment clear and also the question of their relation to horizontal or vertical resolution of the model is open. The first guess would be that this is due to

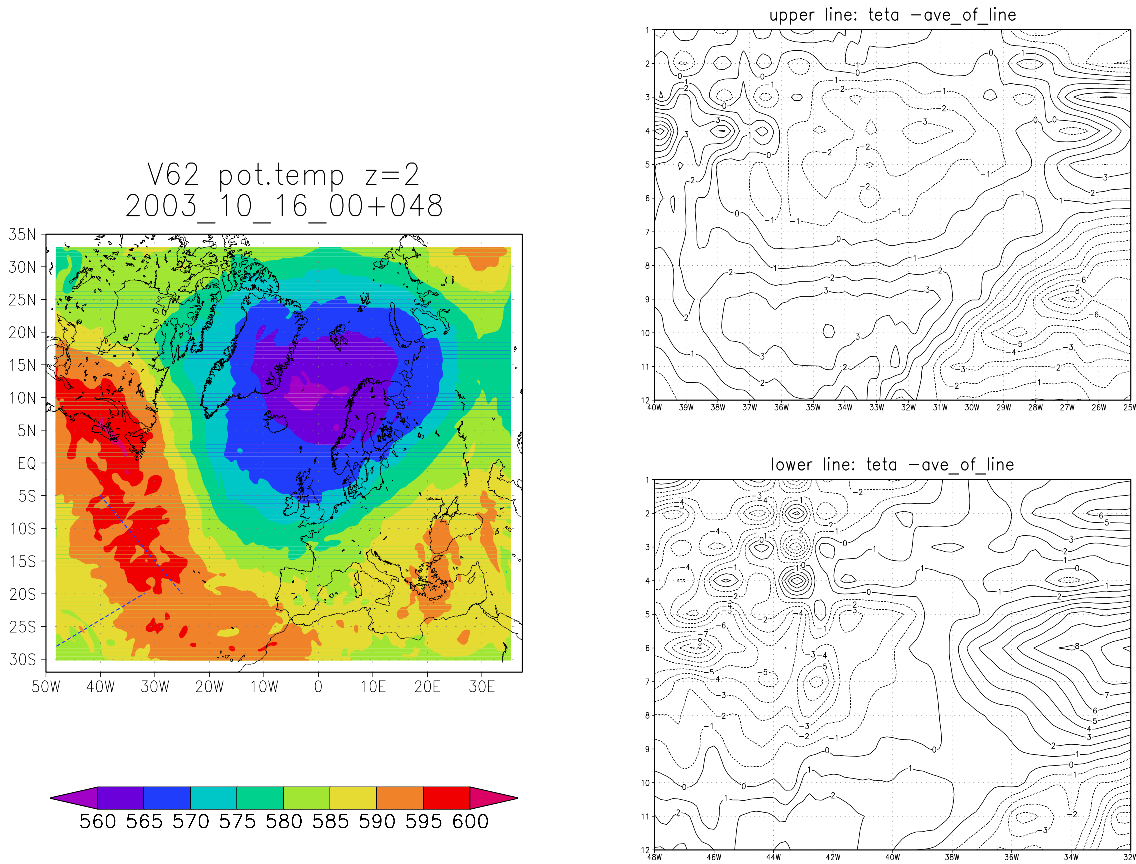

Figure 2: *Example of noise.*

the reflection from the upper boundary. Also an open question is if the vertical and horizontal noise has something to do with each other. This noise subject will be studied more carefully in the future.

4 Daily cycle of the number of observations

A comprehensive set of tools to monitor the RCR runs is under construction. One basic product is a product showing the number of influencing observations by observation type. As an example, Figure 3 shows the number of observations in different data assimilation cycles during one day. An observation here means one observed meteorological parameter. So for instance, one sounding produces an observation in this meaning for temperature, wind components and humidity for every level of the sounding, as this statistics takes every value, which is used in the analysis, as an observation. This simple tool contains a lot of information. In this section we concentrate to the daily cycle.

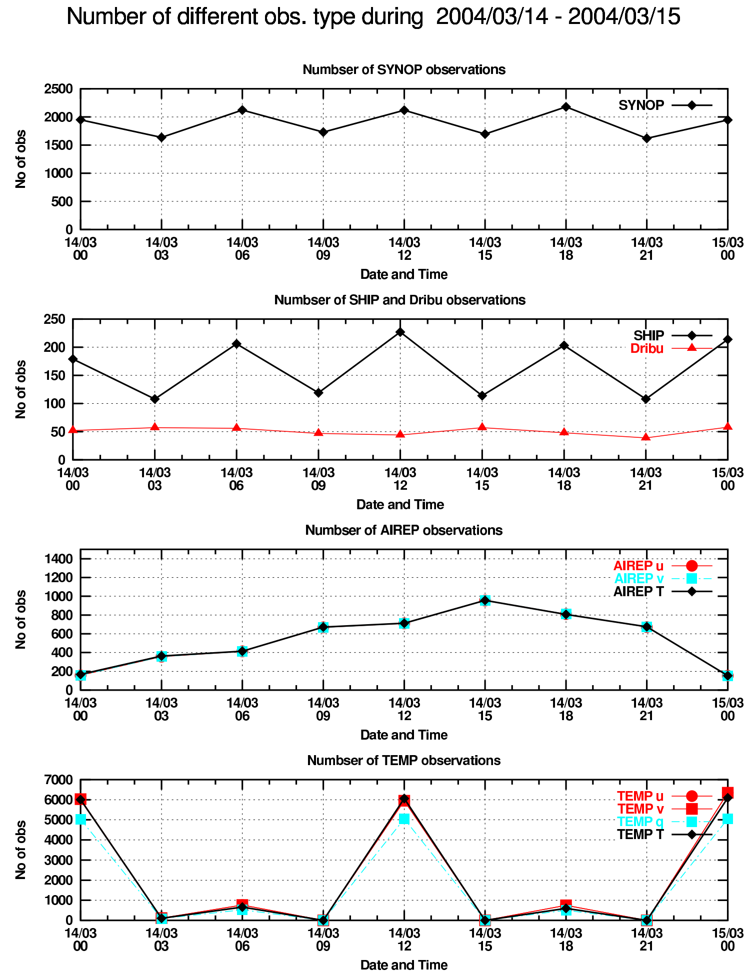

Figure 3: *Number of observations at different cycle time during one day.*

Concerning the surface observations, we see that on the intermediate cycles (03, 09 . . .) the number of SYNOP and SHIP observations is smaller than during the main synoptic hours, about 2000 vs. 1600 for SYNOP and about 200 vs. 100 for SHIP, even if the intermediate cycles have a longer cut-off time (Kangas, 2004). However, a lot of surface information is available.

There are very little of sounding data available on other than 00 UTC and 12 UTC termins.

For aircraft observations the number of observations clearly depends on the hour of the day. There is a clear maximum in the number of observations in the late afternoon, and an observation coverage maps (not shown) reveal that especially there are at that time a lot of observations over the Atlantic Ocean, received from the trans-Atlantic aircrafts. The analysis increment maps (not shown) reveal that these observations have a clear impact on the upper level analysis over the Atlantic Ocean, where only few other observations are available. It is well-known that aircraft observations are of high quality. For this reason we can suppose that RCR runs favor of having a three-hour data cycling. Of course, proving it would require extensive impact studies.

5 Examples of monitoring RCR on daily or monthly basis

The agreement between the Finnish Meteorological Institute and the HIRLAM project defines the minimum amount of verification and diagnostic products on daily and monthly basis. It says that *FMI operational forecasters will provide some real time monitoring of the production and provide comments which will be available to* HIRLAM *members e.g.on* $H_E X_{\mathrm{NET}}$. *Also it states that FMI will provide near-real time automatic monitoring results in the form of web pages with displays of data usage and fields.*

The agreement also states that *monthly verification reports will be produced and published on* $H_E X_{\mathrm{NET}}$. *They include observation verification, data assimilation observation statistics, means of data assimilation increments, fields and forecast errors. Both upper air, surface and soil fields will be handled. There will be time series of observation coverage and forecast errors. Vertical profiles of forecast errors will be produced. Means of surface energy balance components will be included as well as plots of the diurnal cycle. For each month will there be time series of certain mast data together with forecast results.*

A large set of monitoring and diagnostic tools have been built or are in progress. At the moment all the daily monitoring and verification results can be seen in the intranet of the Finnish Meteorological Institute. The purpose is to make them available in $H_E X_{\mathrm{NET}}$ to the whole HIRLAM community, but all the technical problems (for instance security) have not been solved yet. However, at the moment a full demonstration set of is available at ECMWF file server **(ec:fne/HirRCRVisu.tar.gz)**. Concerning the monthly monitoring, the purpose is to produce a printable monthly report, which contains a set of monitoring and verification products. A wider set of products will be made available through $H_E X_{\mathrm{NET}}$. In this chapter we show a few examples of the daily and monthly products.

5.1 Time series of the number of observations

It is important that operational NWP operations are monitored regularly. Concerning data assimilation, it has happened that observations of some type or from some area are missing. There are even cases in the past that this has not been noticed for a few days. A quick and good tool to check this is a plot showing the number of observations used in the data assimilation for the latest, say, two weeks. The time series reveal immediately, if there is a remarkable change in the number of observations. Figure 4 shows an example from January 2004, when RCR was in pre-operational phase and not monitored carefully enough. This plot was not available at that time, but has been created later. We can see that suddenly the number of SYNOP increased, when a problem in decoding the Russian SYNOP observations was revealed and corrected (Järvenoja, 2004). It must be mentioned that the operational routine at that time did not show this problem, because a different server was used to create observations for it.

5.2 Histograms of the obs-fg/obs-na statistics

One part of monitoring the data assimilation system is the statistics of data usage on monthly basis. An example of such statistics is shown in Figure 5. It shows histograms of deviations between observation and first guess (obs-fg) and between observation and analysis (obs-na) for period from 18 Jan 2004 to 24 Feb 2004. We can see that data assimilation does the work it should do: the fit between observation and analysis is better than between observation and first guess. So the analysis corrects the first guess fields (three hour forecast) to follow more closely

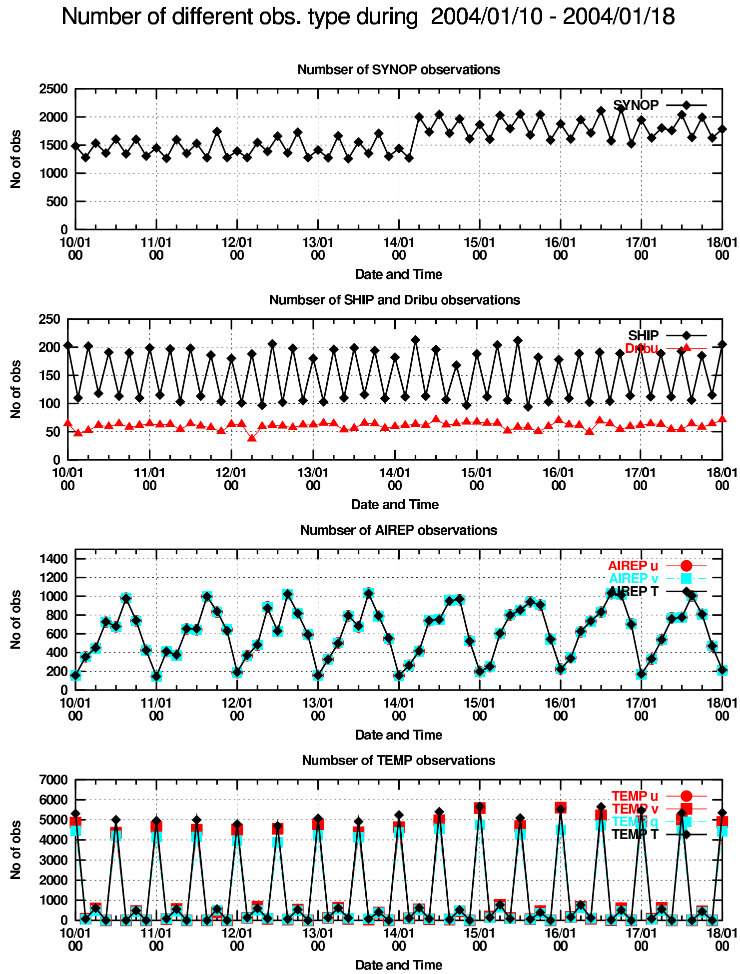

Figure 4: *Number of observations at different cycle time during a 10 day period in January 2004.*

the observations. Also we can see that for surface observation types the first guess is slightly biased to negative direction.

6 Conclusions

The RCR activities has strengthened the interest of daily and monthly monitoring of RCR/HIRLAM system at FMI. A large part of the monitoring tools and products has been re-designed to streamline the data flow and modernize the software. On daily and especially on monthly monitoring side the work is still in progress until all the products required in the RCR agreements are ready. Already now the new products and greater interest have revealed several problems and many interesting features in the operational HIRLAM/RCR system. All the benefits of the monitoring system will be seen, when all daily products are available to the whole HIRLAM community via $H_E X_{NET}$. Some technical problems must be solved before this will be the case. The monthly monitoring report will be another powerful tool to give information of the behavior of the RCR system, which very well reflects the status of the HIRLAM reference system.

This report has given some examples of the products and also discussed about some problems, which we have noticed during the first months of operational RCR activities. In these examples we have drawn attention to the following problems in the HIRLAM reference system:

- Snow analysis needs attention in the areas, where the snow edge changes from day to day.
- There seems to be vertical noise in upper model levels, which is not totally understood.

The other topics discussed here are examples of the products of daily or monthly monitoring of the RCR system.

References

Eerola, K., 2004: The benefit of frequent data assimilation: a case study. *Hirlam Newsletter*, **45**, (in this issue).

Järvenoja, S., 2004: Towards the operational RCR system - results from pre-operational test runs. *Hirlam Newsletter*, **45**, (in this issue).

Kangas, M., 2004: The operational HIRLAM at FMI. *Hirlam Newsletter*, **45**, (in this issue).

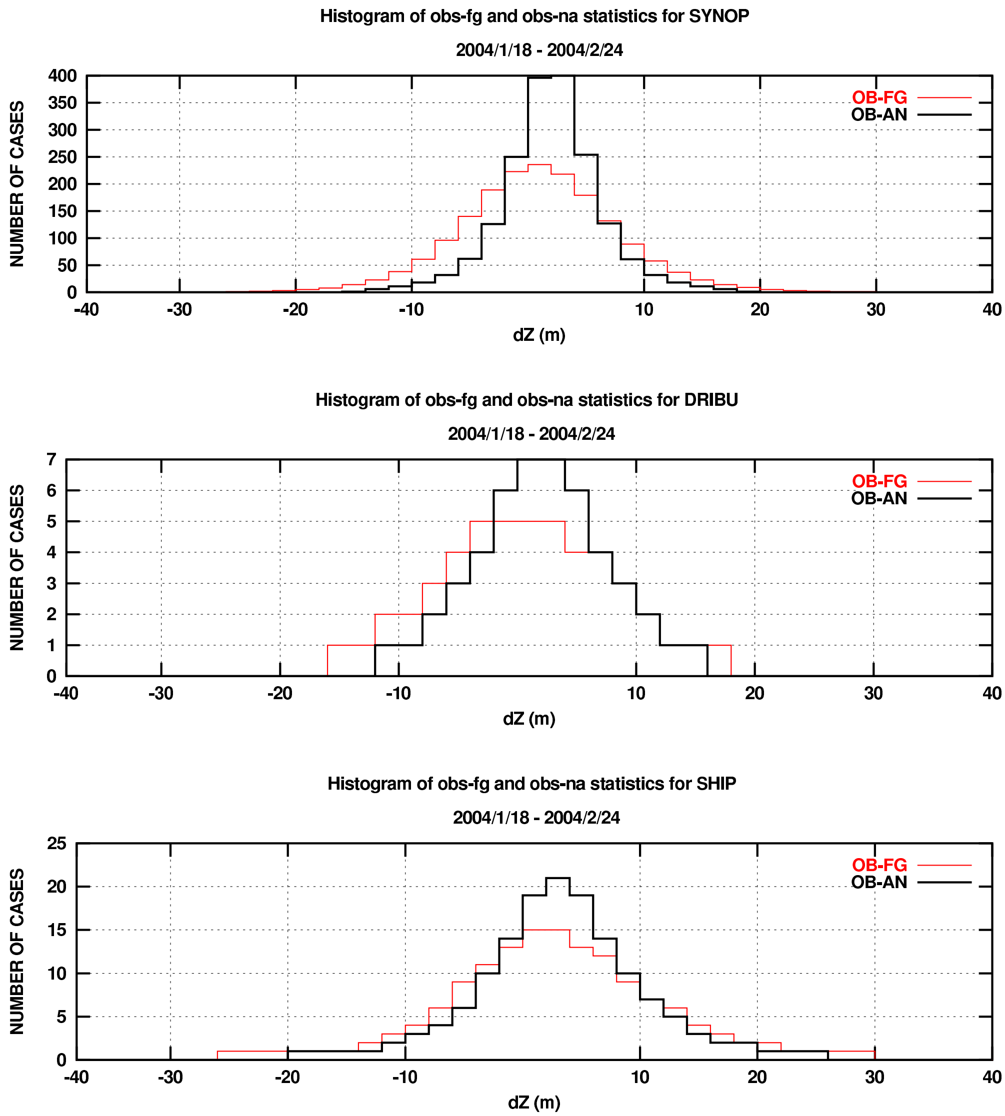

Figure 5: *Example of the observation usage statistics in the data assimilation: histogram of obs-fg and obs-na statistics for SYNOP, DRIBU and SHIP.*