The operational HIRLAM at FMI

Markku Kangas
Finnish Meteorological Institute

1 Introduction

The operational activities at FMI have been recently dominated by the RCR (Regular Cycle with the Reference) implementation and testing. Because of various problems, a continuous test run could not be started until January 2004, but in spite of this the RCR model was given operational status already on 2 February 2004.

Starting from March 2003, two operational suites, ATX (HIRLAM 5.1.4) and ATA/ENO (HIRLAM 4.6.2) have been running in parallel, as described by Eerola (2003). On the computational side, the co-operation with CSC (Finnish IT center for science, http://www.csc.fi/index.phtml.en) has been continued, allowing FMI to use the most powerful supercomputers in the Nordic countries.

This report describes the operational HIRLAM environment at FMI. First, a brief introduction to the RCR agreement is given. Next, the operational system is described from both meteorological and technical point of view. Finally, the products of the model as well as archiving are discussed.

2 RCR operations

During 2003, an FMI/HIRLAM agreement for maintaining a regular cycle with the reference system (RCR) at FMI in HIRLAM-6 was concluded. According to this agreement, FMI assumes the role of Lead Centre for RCR, which means that in general terms:

- FMI adopts RCR as its operational forecast model
  - configuration : Reference System with default settings
  - resolution as agreed, currently 0.2° and 40 levels
  - area = larger FMI Atlantic area (at least to 30°N, 0°E in the south, Fig. 1)
  - data assimilation cycle 3 hours
- FMI makes RCR products available to all HIRLAM members in near-real-time
  - observation files, initial conditions, forecast fields, diagnostics
  - default model levels, surface, post-processed at standard pressure levels
  - 4 forecasts/day to at least 48 hours
  - archiving at ECMWF
- FMI prepares a monthly verification/diagnostics report

Furthermore, the following options and procedures are given:

- Cut-off time for receiving observations is determined by FMI operational considerations
- Repeat analysis cycles of main synoptical hours may be introduced to include late observations (not implemented)
- FMI may use RCR as a host for a nested fine grid model

- The RCR products have no operational guarantee status outside FMI, support for these products can be given only during office hours
- The products will be made available to HIRLAM community as soon as possible, normally no later than a few hours after the production
- As far as possible, missing products should be generate on the next working day

According to the agreement, small deviations of technical nature from the Reference System can be implemented in agreement with the HIRLAM Management Group (MG). The main present deviations are presented in Chapter 3.

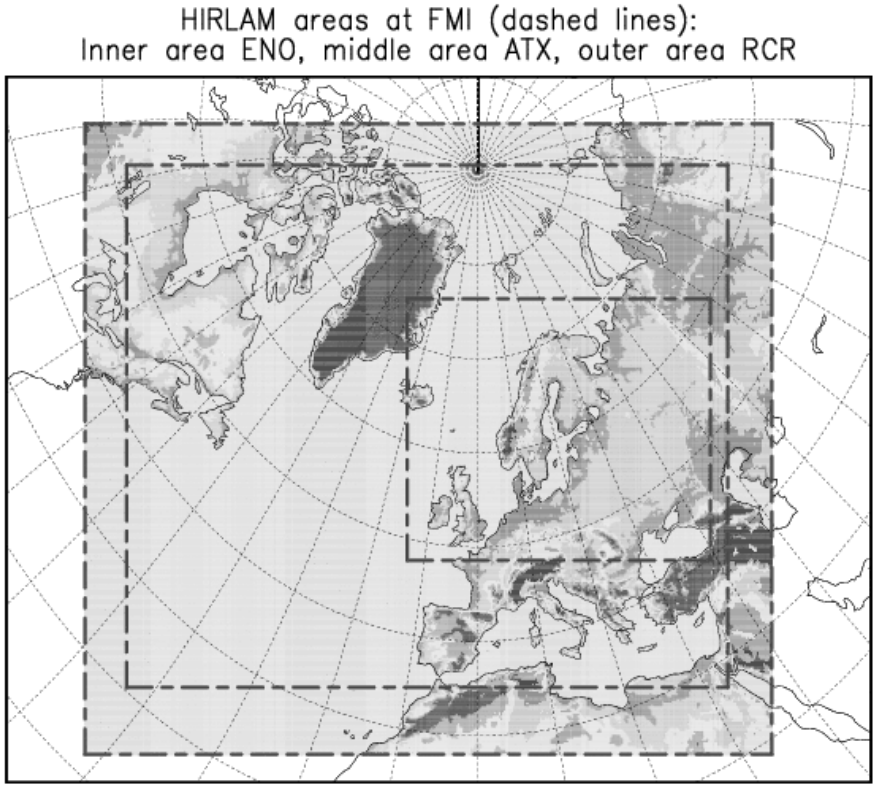

Figure 1 : The areas of the different FMI operational suites.

3 Meteorological and operational implementation

During the period March 2003 - January 2004 the main operational suite at FMI was ATX, which was based on HIRLAM version 5.1.4 (horizontal resolution 0.3°, vertical levels 40). Parallel with it, a smaller area suite called ENO (horizontal resolution 0.2°, vertical levels 31) was run. These suites have been described in more detail by Eerola (2003) and Järvenoja (2004). The ENO suite was discontinued by February 2004, and ATX suite by March 2004.

After an extensive testing (Järvenoja, 2004 ; Eerola, 2004), RCR HIRLAM was introduced into operational use in February 2004. The suite is based on HIRLAM reference model version 6.2.1, on HIRLAM 3DVAR analysis scheme, and on ISBA surface scheme. Actually, because of some fixes and corrections, the version is quite close to v. 6.2.2. Main deviations from the reference HIRLAM are (see also Järvenoja, 2004):

- full SMS control instead of mini-SMS
- surface analysis : inclusion of also
  i) Baltic SST/ice observations from FIMR (Finnish Institute of Marine Research)
  ii) climatological lake observations in the Finnish area
- boundaries received horizontally in the RCR grid with three hour intervals
- boundary data from ECMWF through Internet

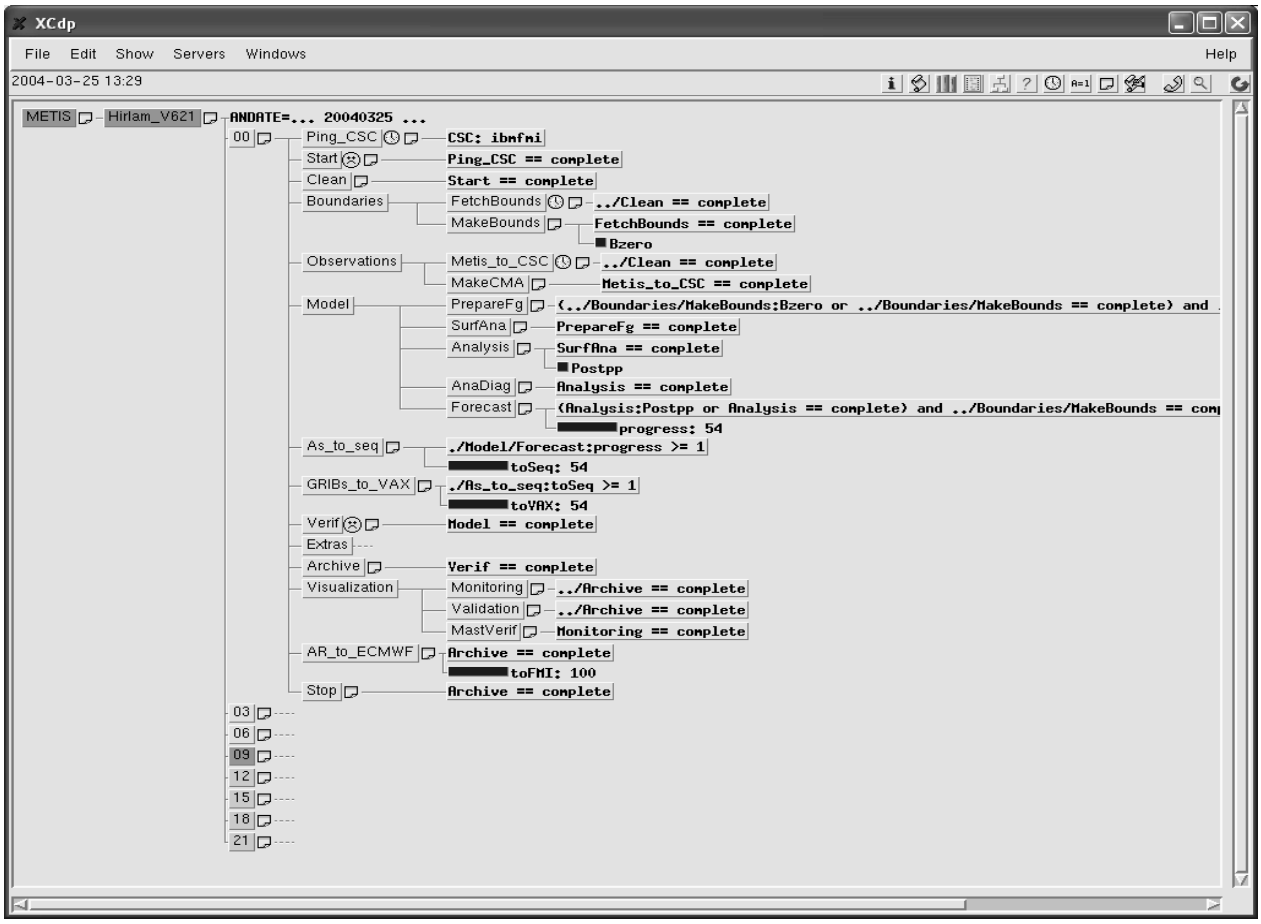

Figure 2 : SMS control window in Xcdp program.

Full SMS control is preferred because it is widely used at FMI and operators are familiar working with it. As to boundaries, they are received four times a day from ECMWF as already interpolated horizontally into the HIRLAM grid. Vertical interpolation takes place as usual. Instead of direct connections, Internet is used for transferring boundaries to FMI, because it has been found to be much faster and practically as reliable as direct connections.

In data assimilation, TEMP, PILOT, SYNOP, SHIP, AIREP, and DRIBU observations are used. The cut-off time of observations is 2 hours for the main synoptical hours (00, 06, 12, 18) and 4 hours 20 minutes for the intermediate hours (03, 09, 15, 21). Digital filter is used for initialization.

Fig. 1 shows the larger FMI Atlantic area used in the RCR suite as compared to the earlier ATX and ENO areas. As demanded by RCR specifications, the area now extends in the south to cover parts of North Africa. The horizontal resolution in RCR forecasts is 0.2° and the number of vertical levels is 40, with the lowest level at about 30 meters above ground. Number of grid points is 438 in longitudinal and 336 in latitudinal direction.

Main run of 54 hours is executed four times a day, at 00, 06, 12, and 18 hours. Between them, at remaining synoptical hours, four additional forecasts of 6 hours are run. The shorter intermediate runs are timed to finish just before the main rain run to provide (through a good data coverage) an improved first guess field for it. The suite wall clock time for the main runs is 1 hour 40 minutes, with the forecast taking 1h 10 minutes. The corresponding times for the intermediate runs are 30 minutes and 10 minutes.

Fig. 2 shows the SMS structure of a main run as seen by the Xcdp program. The structure of the intermediate runs is almost exactly the same, smaller run times being mainly due to shorter integration time.

4 Technical implementation

4.1 Data acquisition and operational control

The "heart" of the data acquisition as well as SMS control is an SGI computer Metis located at FMI. It hosts the SMS program and acts as a transfer point for data to and from the actual forecast task (Chapter 4.2).

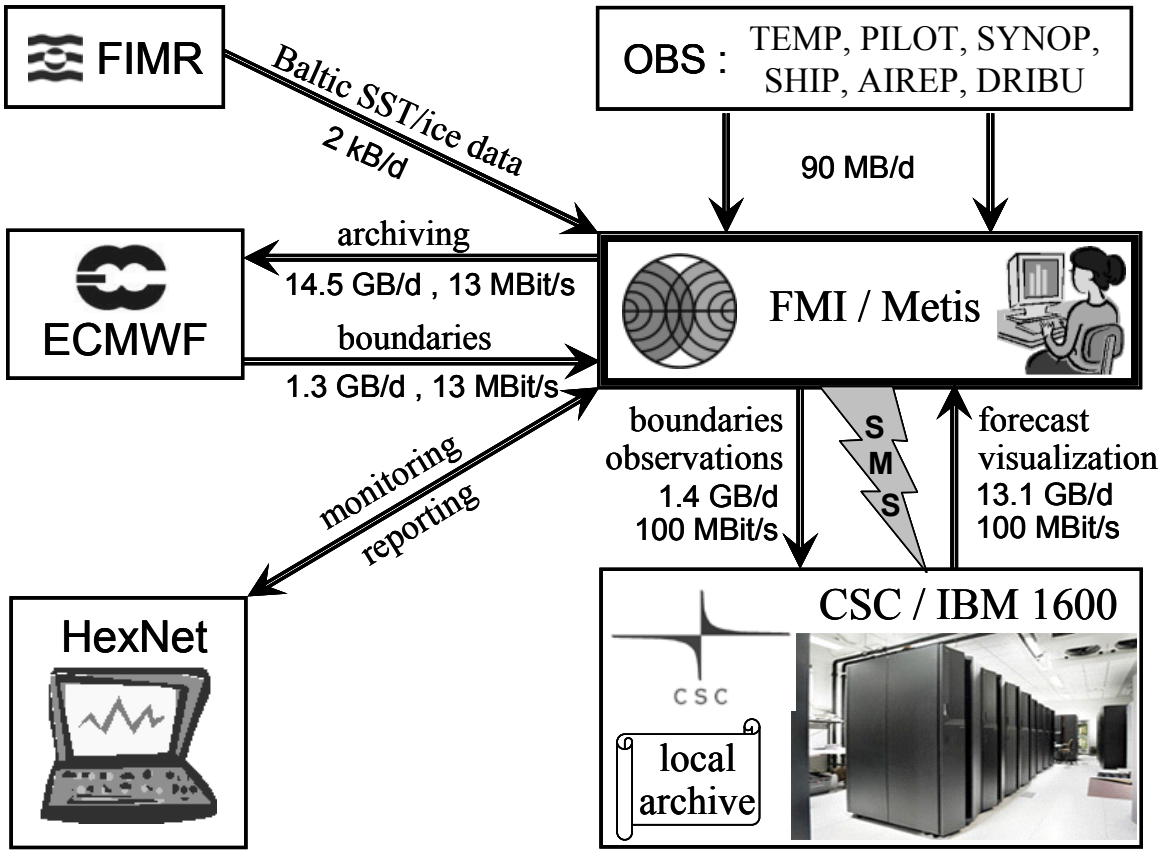

Figure 3: RCR suite data flows (d = day , s = second).

Fig. 3 shows the principal data flows in the system. The various observations (SYNOP, TEMP, etc.) as well as the Baltic ice data from the Finnish Institute of Marine Research are first collected through various channels to Metis, manipulated, and then transferred to CSC for the

actual calculations. The same applies to the boundary data obtained from ECMWF. After calculations at the CSC supercomputer, the numerical results as well as some graphical products are transferred back to Metis for miscellaneous uses by duty forecasters, researchers, and automated forecast products. At CSC, an extensive local archiving also takes place.

Finally, data output as well as selected input is archived at the ECMWF using the *ecaccess* gateway. A graphical interface to forecast products for monitoring and data visualization is also provided and will be made available to all HIRLAM researchers through HeXnet (Fig. 5).

4.2 Forecast and data assimilation

The model and data assimilation is run as previously (Eerola, 2003) at CSC, or the Finnish IT center for science. The computer is IBM eServer Cluster 1600 supercomputer, which consists of 16 IBM p690 nodes, each with 32 1.1 GHz Power4 processors (i.e., total number of 16 x 32 = 512 processor). Its theoretical maximum performance is 2.2 TFlop/s, total memory being 512 GB, and the size of disk system 0.5 TB.

One node of 32 processors and 32 GB of shared memory is totally dedicated to FMI. Of these processors, the HIRLAM suite uses 28 for parallel processing, the rest of processors being reserved for other FMI uses.

One of the remaining nodes is reserved for backup to be used for HIRLAM if the FMI node is down.

With the introduction of the RCR suite, the wall clock time demand has risen from the 30 minutes required by the ATX suite (Eerola, 2003) to 1 h 40 minutes required by the RCR main runs (forecast from 20 minutes to 1 h 10 minutes). Actually, some of the visualization tasks in the main runs add another 30 minutes to the wall clock time demand.

5 Forecast products and archiving

5.1 ECMWF archive

As defined in the RCR agreement, a specific set of model output and input is to be archived at ECMWF for use of the HIRLAM project.

A major change in archiving policy has taken place with the introduction of the present RCR forecast suite. Instead of big *tar* files used earlier, the data is now archived without compressing into a descriptive directory structure. The naming of the directories is based on appropriate analysis time, being of the form:

```
/rui/hirlam/RCRa/yyyy/mm/dd/hh
```

where *yyyy* is the analysis year, *mm* calendar month, *dd* calendar day, and *hh* the daily hour. The data that is archived includes

- contents of AR*.tar files
- contents of VE*.tar files
- boundary files (all *used* boundaries)
- observations
- FIMR Baltic ice data

- log files

The data is transferred first from CSC to FMI and then to ECMWF using *ecaccess* and Internet. The reason for this transfer to take place via FMI is that there is no *ecaccess* gateway at IBM. With this system, files will be in the archive about 6 hours after the nominal analysis time (i.e. 00 data at 6 UTC).

5.2 Local archives

As mentioned above, an extensive data archiving takes place locally at CSC. The present practice is to store a comprehensive set of data for possible uses (various applications, forecast reruns etc.). Because of the significantly larger data sets introduced with RCR, this practice is, however, becoming untenable, as suggested by Fig. 4, which shows the amount of data in the local archive by the end of year 2004 if present practice is continued. By the end of 2005, this would lead to an amount of data approaching 20 TB, which is two thirds of the total archiving capacity of CSC.

A new practice to circumvent this problem that is being considered is to store a minimum possible data needed for reruns, and limiting the comprehensive archive needed for e.g. verification for only 3-4 months. The solution to this problem is, however, still under consideration.

Another problem, not related to archive size but to the speed of operations, is the use of *tar* files. The problem has grown more serious now that data amount is much larger. A directory based archive structure such as that is now being used in central archiving to ECMWF, should be also considered in the local archiving of the reference HIRLAM.

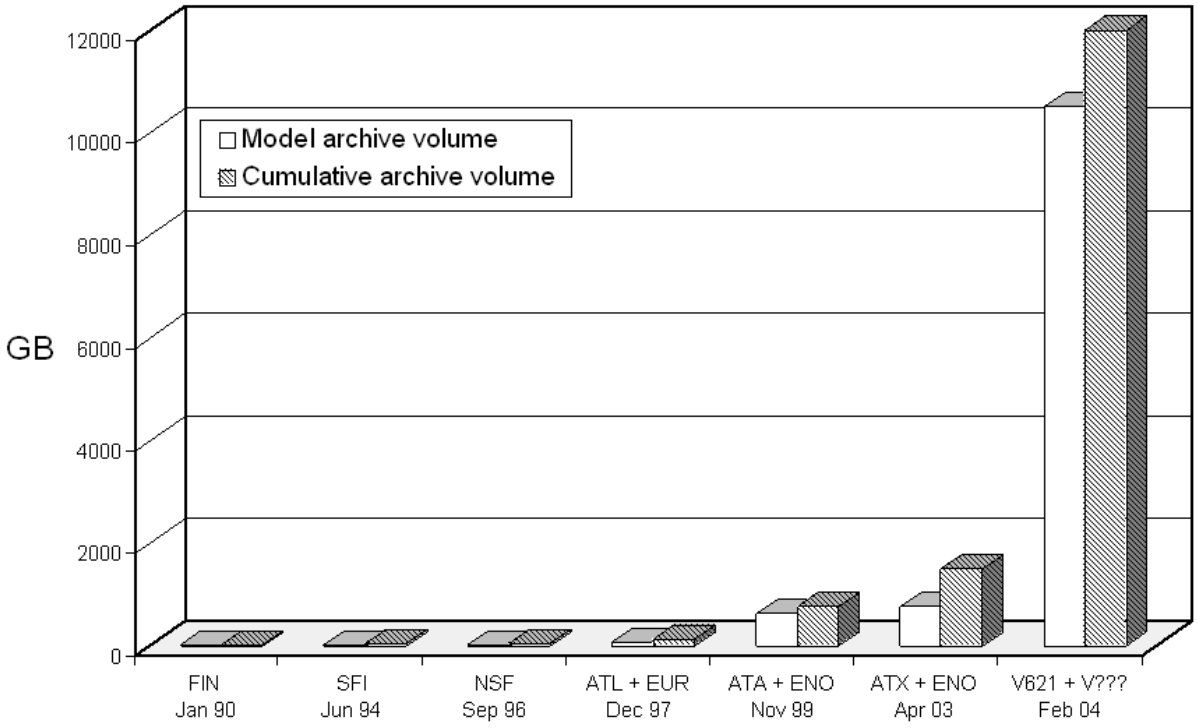

Figure 4 : Local archive volume at CSC with business-as-usual approach by the end of 2004.

5.3 Graphical products and monitoring

According to RCR agreement, the reference operational suite should provide an access to forecast output for research and monitoring purposes to all the members of the HIRLAM community. For this purpose, we have developed and extended our present graphics routines to cope with the increased demands.

The idea is to provide one general, flexible interface to the forecast products for operational personnel, researchers and duty forecasters alike (Eerola, 2004). Because of the more or less constant need for system maintenance and development, ideally the system should be located at FMI, with HIRLAM community provided a view to the interface through HeXnet.

The first version of the graphics interface is already up and running locally It is also described by Eerola (2004). The arrangement and details for the HeXnet gateway, however, are still under development. The present contents of the interface include

- weather maps : temperatures, pressures, wind speeds, pseudo satellite pictures etc. for various forecasts and for smaller and larger area
- Baltic sea wind maps
- meteogramms for various locations
- mast verification plots : Sodankylä etc. mast measurement v. forecasts
- Statistical verification plots for various areas (as in HeXnet now)
- monitor window showing e.g. observation coverage maps and history

Fig. 5 shows a few examples of the available plots. Further development work is under way to include also

- wind etc. temporal animations
- enhancement of meteogramms to larger area
- model documentation

The model documentation is intended to provide, information about the numerical forecasts products, contents of output files etc.

6. Conclusions

The operational system for HIRLAM RCR reference forecast model and other operational activities at the Finnish Meteorological Institute have been described. HIRLAM reference version 6.2.1 has been in operational use since 2 February 2004, with no major difficulties.

The monitoring interface defined in the RCR agreement has been developed and is so far in use locally. Some technical problems remain still to be solved, however, before the interface can be made accessible to all HIRLAM participants. The revised policy and practice of archiving data into ECMWF has also been described.

In the future, the FMI activities will include the development of a fine grid (10 x 10 km) model to be run inside the RCR operative integration area. Procedures for running and testing pre-operational HIRLAM reference model versions will also be developed further.

References

Eerola, K., 2003 : The operational HIRLAM at the Finnish Meteorological Institute. *Hirlam Newsletter*, **43**, 20-28.

Eerola, K., 2004 : Monitoring of the RCR - benefits of updated data assimilation. *Hirlam Newsletter*, **45** (this issue).

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

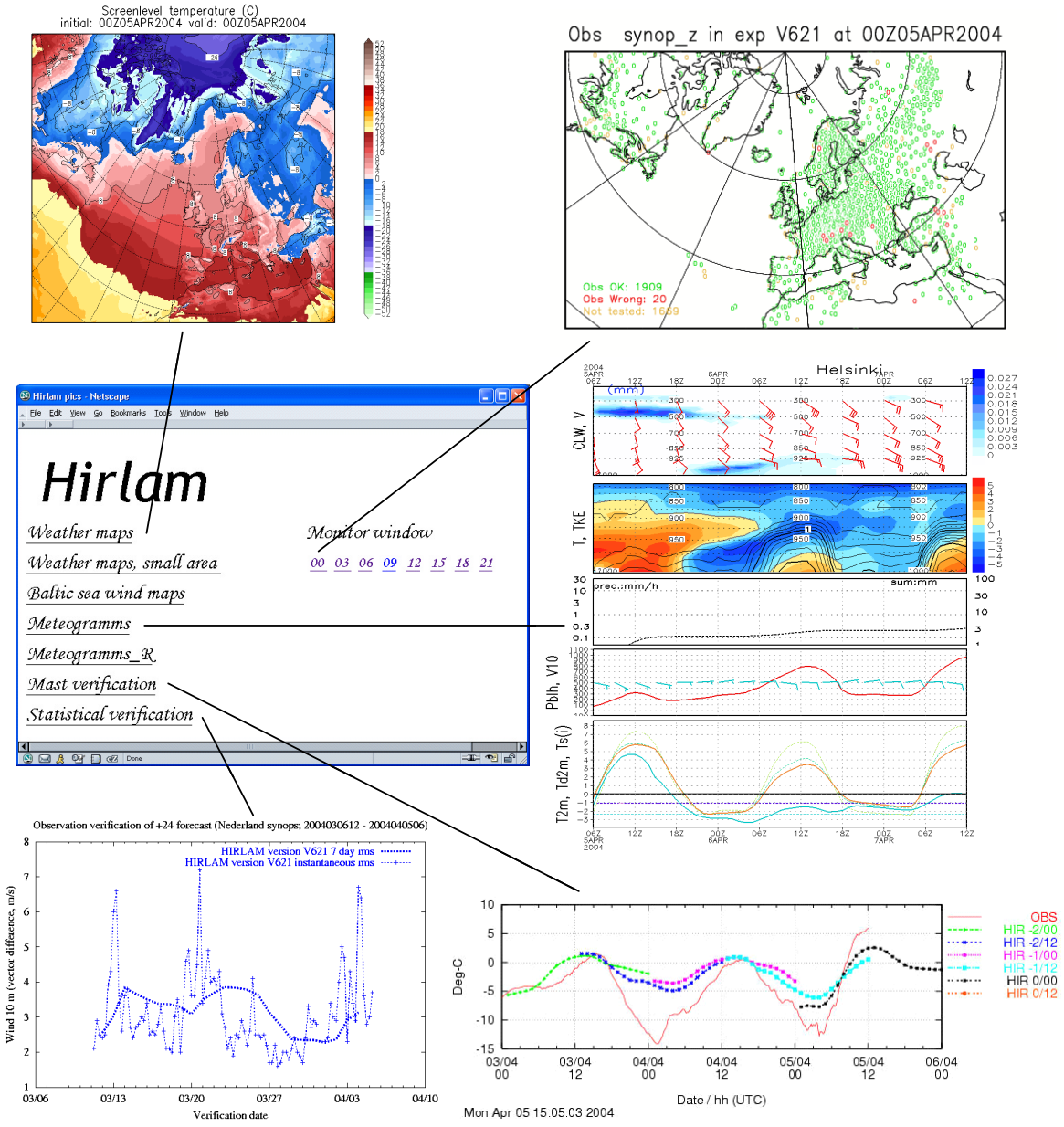

Figure 5 : Graphics interface with some example pictures.