# HIRLAM training workshop
# Riga, Latvia, 19-29 October 1998

The possibility to establish a collaboration between the HIRLAM 4 Project and the weather services in Estonia, Latvia and Lithuania has been discussed over the last few years. The HIRLAM 4 Council has considered, however, that it would be a too heavy burden for the HIRLAM management group to directly extend the HIRLAM 4 research program with contributions from three future new member countries. Therefore, the Council recommended the SMHI to establish a direct contact with the three weather services. The directors of the weather services in Sweden, Estonia, Latvia and Lithuania met during spring 1998 and agreed to cooperate on HIRLAM-related research and development. It was furthermore agreed that the weather services in the three Baltic states would contribute with scientific work corresponding to one full time person each and, finally, that a HIRLAM training workshop would be arranged during autumn 1998. A second planning meeting arranged at the Arlanda Airport with participation also from the FMI and from the BALTEX research community.

## The lectures

Through a SMHI initiative and through the kind offer by the Latvian Hydrometeorological Agency (LHMA) to be the host, the first HIRLAM training workshop was arranged in Riga 19-29 October 1998. The weather services in Sweden, Finland, Norway and Ireland contributed with teachers. Lectures were also given by Rein Rõõm from Tartu University in Estonia. The emphasis was on the theoretical background to the HIRLAM forecast model and on practical use of the HIRLAM model for operational and research applications. Therefore the lectures covered a wide range of subjects - basic HIRLAM model equations, numerical techniques, physical parameterization schemes, validation, verification, the model code, UNIX scripts and visualization with the MetgraF package. The workshop program is presented below. Lecture notes will be put together in html-format to be available for future use.

## The students

A list workshop participants is presented below. There were four participants from the Estonian Meteorological and Hydrological Institute (EMHI), the Head of the research department and three meteorologists/students. In view of the strong tradition of agricultural meteorology at EMHI, the participants from EMHI expressed their interest to work with soil and surface processes in HIRLAM. From Estonia participated also two Ph.D. students from the Tartu University. A strong competence in Numerical Weather Prediction, and in particular in non-hydrostatic modelling, is being developed at the Tartu University. There were five participants from the Latvian Hydrometeorological Agency (LHMA), all are at present working as duty forecasters. Due to this, there is a strong interest to set up an operational HIRLAM system at the LHMA. The two participants from the Lithuanian Hydrometeorological Service (LHMS) have background in mathematics and statistics. With this background, it would be possible for them to participate for example in HIRLAM data assimilation research.

## Workshop exercises

The second week of the workshop was devoted to experimentation with the HIRLAM model on two Digital Alpha workstations that were brought as gifts from the SMHI. The two workstations will now be used for HIRLAM work at EMHI and LHMS. A third Digital Alpha workstation will later be given as a gift from FMI to LHMA.

Four data sets, consisting of ECMWF re-analysis data, were available for the experimentation. Most of the experiments were carried with the following two data sets:

- The 'Öland storm' case 23 -24 July 1985, which includes a mesoscale low pressure development over the Swedish east coast. This case has previously been studied by Per Kållberg at SMHI.
- The 'Baltic Sea convective snow-band' case, 10-12 January 1987. This case has been studied by Tage Andersson and Nils Gustafsson at SMHI.

The experimentation with the HIRLAM model was enthusiastically carried out by the workshop students under the guidance of Nils Gustafsson and Ulf Andræ. Results from the three experimentation groups are presented below in separate reports.

It may be of interest to note that a realistic development of the Öland storm was only made possible through a return to the old KUO/COND convection and condensation schemes. These were used also by Per Kållberg in his successful simulation of the storm. The failure of a more advanced scheme, the Sundquist scheme, has not yet been understood.

## The HIRLAM system as a workshop tool

The two workstations used during the workshop had been loaded in advance with the HIRLAM 2.7.15 Reference system, including html-based documentation. In general the reference system turned out to be quite easy to work with for the students. Modifications were introduced to environmental variables that describe experimentation domain and model setup, to namelist variables in order to modify output and model parameters, as well as to some Fortran subroutine codes. A few problems were encountered:

- It was not possible to run the HIRLAM model adiabatically just by changing the namelist variables, neither with Eulerian nor with semi-Lagrangian time-integration. We managed to by-pass this problem by code changes to the subroutines EULER and SL2TIM.
- The vertical interpolation of initial and lateral boundary data failed intermittently in the VINETA package, when 2 meter temperature and humidity are calculated by the model physics from the climate surface data and the ECMWF boundary data. We managed to by-pass this problem by deleting the call to model physics in VINETA.

## Some views of the students

During the last day of the workshop, we asked the students to give their views on the lectures and the workshop exercises. We have extracted some of these views:

- It would be better to have some written material available before the workshop.
- The content of the lectures was ”fine” (”quite good”). More examples would have improved the lectures. More about data assimilation is needed.
- The experiments did cover the theory only partly.
- We learned more about the model through the experiments.
- It would be better to have some printed example/introduction for the first exercise. It would have made the work more efficient and given a correct material for the further work.
- All of us are forecasters, so we do not need so much theoretical information. May be, it would have been better to add more information about practical and operational use of the HIRLAM model (examples are Marko Kaasik’s and Priit Tisler’s lectures). The workshop exercise was more interesting to us. We have got more information about the HIRLAM model structure and the operational system (Latvian group).
- Many thanks from the bottom of my heart to all groups for their kindness, dedication in work and respect (Lithuanian group).

## Future collaboration

The workshop was carried out in a very positive and stimulating atmosphere. All teachers and participants were convinced that a continued collaboration between the HIRLAM Project and the weather services in Estonia, Latvia and Lithuania will be of great benefit to all parties. Also the University in

Tartu with its existing NWP group should find their role in such a collaboration. We will summarize some ideas on this future collaboration.

**Operational application of the HIRLAM system**

The participants from the Latvian Hydrometeorological Agency expressed a strong interest in applying the HIRLAM system operationally. From an operational point of view, early HIRLAM runs on midnight data (00UTC) up to +12 h and +24 h would be of greatest interest, since no numerical products are now available as guidance for early morning forecast production. This makes it necessary to apply data assimilation as well as forecast runs, with lateral boundary data taken e.g. from a 18UTC SMHI HIRLAM run. Such a future operational application of the HIRLAM system in Latvia requires:

- Education in data assimilation; It will therefore be useful to arrange a second HIRLAM training workshop on data assimilation during 1999 (in Vilnius or Tallinn?).
- The formal aspects of using the HIRLAM forecast system operationally in Riga must be considered by the HIRLAM Council.
- GTS observational data are available in Riga, but software to convert GTS messages to the BUFR data format, required by HIRLAM, must be installed.
- HIRLAM forecast data are already now transmitted in GRIB format between SMHI and LHMA and this transmission must be extended with model level data needed for lateral boundary conditions.
- Some assistance for installation of the complete HIRLAM system in an operational environment is needed.

Some further aspects on the operational application of the HIRLAM system operationally are discussed in the report by the Latvian group below. Also the weather services in Estonia and Lithuania are interested in an operational application of the HIRLAM system.

**University education in meteorology**

There are at present quite limited resources for education of meteorologists in the Estonia, Latvia and Lithuania. The Marine College in Tallinn has a basic education of forecasters on their program and the University of Tartu gives courses on Meteorology. The forecasters educated by the Marine College can extend their education to a Bachelor degree by taking courses in mathematics and physics at the Tallinn University. Most forecasters in Riga and Vilnius have had their basic education in St Petersburg. The Latvian Hydrometeorological Agency is trying to establish collaboration with the Department of Geography at the Riga University for education in meteorology.

A strong request was expressed by several of the workshop participants that additional education in meteorology, and in particular in modelling aspects of meteorology, could be obtained from universities abroad. Existing courses on dynamical meteorology, NWP and HIRLAM given by the Universities in Stockholm and Helsinki would fulfil these requests and could for example, serve as an academic education (Batchelor or Master) to complement existing national education programs. Formal and economical aspects of such education ideas need further investigation.

**Reseach collaboration.**

Lectures, workshop experimentation and discussions during the workshop pointed to some areas where research collaboration could already now be established:

- The interest and experience of agricultural meteorology at EMHI would make a participation in HIRLAM research on soil and surface parameterization fruitful. FMI is a natural cooperation partner, since FMI is participating actively in the development and validation of the new HIRLAM surface scheme.

- The Tartu university group has already started to develop a non-hydrostatic version of HIRLAM. This work should be coordinated with the HIRLAM 4 Project activities, where plans for a non-hydrostatic HIRLAM are being elaborated by Ivar Lie, DNMI.
- The competence in mathematics and statistics of the Lithuanian workshop participants could be efficiently utilized for HIRLAM data assimilation research. A natural framework could be the BALTEX data assimilation and a natural partner is SMHI.

A limiting factor for participation of scientists from Estonia, Latvia and Lithuania in international research projects is the lack of funds for travelling to other institutions and to international conferences. Somebody from the HIRLAM community, preferably from Sweden or Finland, should be appointed responsibility for coordination of an application of the necessary research funds to fill this need.

## Some final words

From a personal point of view, we found our two weeks in Riga really worth the effort. We have been working enthusiastically with a group of qualified and nice persons from three countries, close in distance to Sweden, that until now have been rather un-known to us. We have had great fun! We are full of confidence for a continuation of this successful collaboration.

We would also like to thank all teachers for their contributions.

Norrköping 2 November 1998

Nils Gustafsson and Ulf Andræ, SMHI

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**Workshop Program**

Monday October 19

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|---|---|
| 10.00 - 10.45 | The HIRLAM Project (Peter Lynch) |
| 10.45 - 11.15 | HIRLAM data assimilation research (Nils Gustafsson) |
| 11.30 - 12.15 | HIRLAM forecast model - Basic model equations (Jan-Erik Haugen) |
| 13.30 - 14.15 | HIRLAM forecast model - Horizontal and vertical discretization (Jan-Erik Haugen) |
| 14.15 - 15.00 | HIRLAM forecast model - Semi-implicit time integration (Nils Gustafsson) |
| 15.15 - 16.00 | Graphical display with MetgraF Lecture 1 (Ulf Andræ) |

Tuesday October 20

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|---|---|
| 09.00 - 09.45 | Semi -implicit semi-Lagrangian time integration Lecture 1 (Jan-Erik Haugen) |
| 10.00 - 10.45 | Semi -implicit semi-Lagrangian time integration Lecture 2 (Jan-Erik Haugen) |
| 11.00 - 11.45 | Operational application of HIRLAM at SMHI (Nils Gustafsson) |
| 13.00 - 13.45 | Physical parameterization in HIRLAM - introduction (Stefan Gollvik) |
| 14.00 - 14.45 | HIRLAM Radiation (Laura Rontu) |
| 15.00 - 15.45 | Comparison of HIRLAM orography and roughness fields with Estonian orography and land use maps (Marko Kaasik) |
| 16.00 - 18.00 | Evening Exercise - MetgraF |

Wednesday October 21

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|---|---|
| 09.00 - 09.45 | Initialization (Jan-Erik Haugen) |
| 10.00 - 10.45 | HIRLAM vertical diffusion Lecture 1 (Stefan Gollvik) |
| 11.00 - 11.45 | Clouds and condensation - introduction and microphysics (Laura Rontu) |
| 13.00 - 13.45 | HIRLAM vertical diffusion Lecture 2 (Stefan Gollvik) |
| 14.00 - 14.45 | Clouds and radiation in HIRLAM (Laura Rontu) |
| 15.00 - 15.45 | Graphical display with MetgraF Lecture 2 (Ulf Andræ) |
| 16.00 - 18.00 | Evening Exercise - MetgraF |

Thursday October 22

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| 09.00 - 09.45 | Convection (Laura Rontu) |
| 10.00 - 10.45 | Structure of the HIRLAM model code (Nils Gustafsson) |
| 11.00 - 11.45 | HIRLAM surface parameterization (Stefan Gollvik) |
| 13.00 - 13.45 | Use of HIRLAM at FMI for marine forecasting (Priit Tisler) |
| 14.00 - 14.45 | Running the HIRLAM model on work-stations (Nils Gustafsson) |
| 15.00 - 17.00 | Evening Exercise - Running the HIRLAM model on work-stations |

Friday October 23

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|---|---|
| 09.00 - 09.45 | Diagnostics and validation of physical parameterizations (Laura Rontu) |
| 10.00 - 10.45 | Non-hydrostatic formulation of HIRLAM Lecture 1 (Rein Rõõm) |
| 11.00 - 11.45 | Exercise - Validation of the workstation run with reference HIRLAM |
| 13.00 - 13.45 | Non-hydrostatic formulation of HIRLAM Lecture 2 (Rein Rõõm) |
| 14.00 - 14.45 | How to modify the reference HIRLAM (Nils Gustafsson) |
| 15.00 - 15.45 | Discussion : Definition of experiments to be carried out during the second week |

Saturday October 24

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| 09.00 - 16.00 | Excursion to Sigulda |

October 26 - 29

Experimentation with HIRLAM under the guidance of Nils Gustafsson and Ulf Andræ.

## Sensitivity to initial soil moisture in the summer case.

Tasks of the numerical experiments: 1. To solve the summer case (23 July 1985) in reaction to heat fluxes in very wet surface conditions. 2. To solve the summer case (23 July 1985) in reaction to heat fluxes in very dry surface conditions.

**Wet conditions**: In subroutine INIPHY the soil wetness was changed to a maximum value (0.02 m). The area was not changed and the computation time was about 15 minutes (50x50x16 gridpoints, 55 km resolution and semi-Lagrangian time integration). The resulting fluxes of latent heat and sensible heat were compared with the standard version (solved on the bases of climatological surface water content). It appeared that after changes in soil wetness the latent heat flux increased and the sensible heat flux decreased above the ground surface. These results were in accordance with experimental data. There were also some changes above sea surface, but these can not be easily explained. Maybe it is connected with heat advection from land areas.

**Dry conditions**: In subroutine INIPHY the soil wetness was changed to its minimum value (according to computational demands 0.0005 m). As expected the flux of latent heat decreased and the flux of sensible heat increased. A possible problem was that in the case of a absolutely dry surface the evaporation was still considerably high.

Differences between sensible heat fluxes in the initial wet and dry conditions are presented in Figure 1 and differences between latent heat fluxes in initial wet and dry conditions are presented in Figure 2.

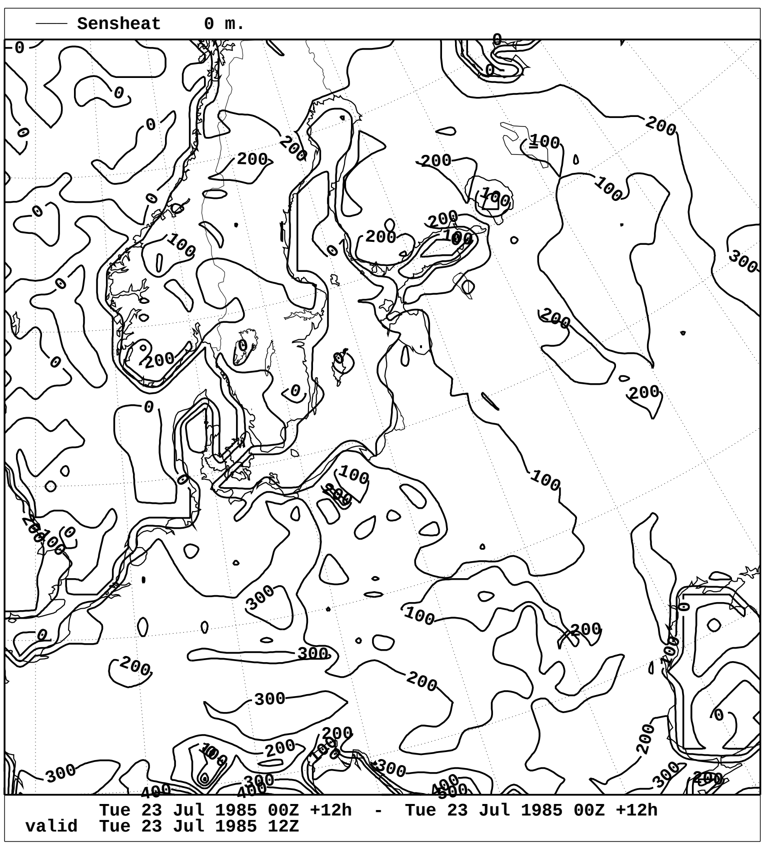


**Figure 1**: Differences between sensible heat fluxes ($Wm^{-2}$) in initial wet and dry conditions.

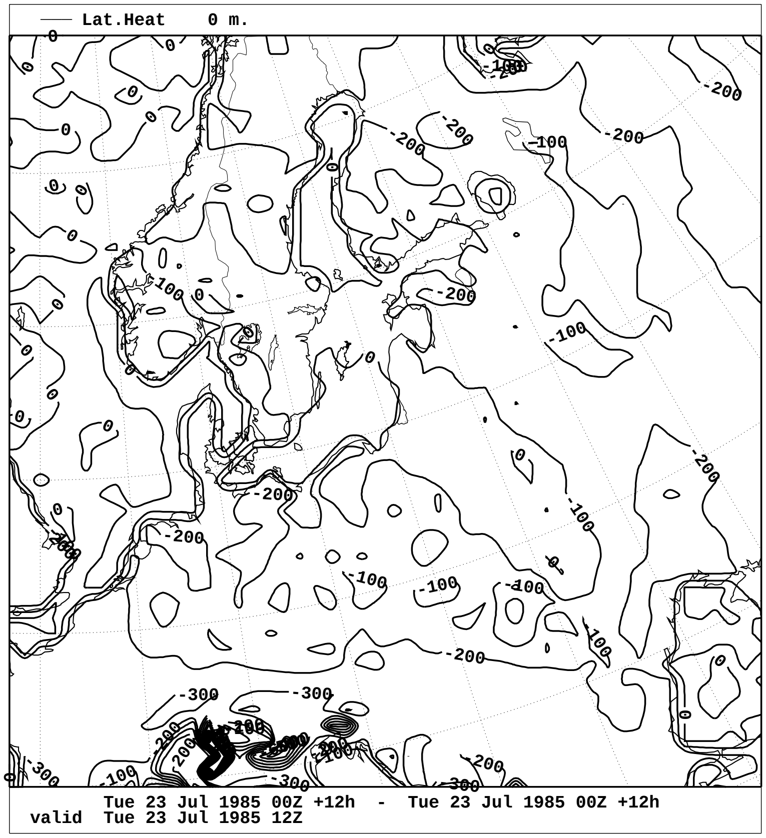


**Figure 2**: Differences between latent heat fluxes ($Wm^{-2}$) in initial wet and dry conditions.

**Comparison of temperature and cloudiness in wet and dry conditions**: In addition to heat fluxes, the near surface temperature and cloudiness were compared for different soil wetness conditions. As expected, in wet conditions 2 meter temperature was in average to 2-3 K lower than in dry conditions above land surfaces. Above water surface the differences were small. There were no remarkable differences in cloudiness amongst different initial soil wetness versions.

Estonian experimentation group

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## Why did the summer case not develop as we wished ?

The tasks of the numerical experiments were:

1. To decrease the asymptotic mixing length.
2. To run HIRLAM without physics.
3. To change the condensation scheme.

**First experiment**: In the program VDIFF the asymptotic mixing length (300 m in the boundary layer and 30 m in the free atmosphere) was replaced with a constant value (30 m). It was expected, that a larger mixing length slows down the wind speed and wind directions turns more towards the center of the low. The decreased surface friction with a decreased mixing length ought to intensify the mesoscale low pressure development. From results the fields of 10m winds, 2m temperature and mean sea level pressure were compared. No remarkable differences between standard maps and the maps where the mixing length was changed, did appear. It shows that changing of asymptotic mixing length will not solve the problem in the present case.

**Second experiment**: First attempt to execute HIRLAM without physics failed, because some parameters used in adiabatic runs are determined in HIRLAM's physical part. After changing these parameters to constants the experiment succeeded. The comparison of standard maps and maps without physics showed that the center of the low had shifted eastward. Considerable differences were observed in winds near surface. The winds without physics were much stronger and closer to geostrophic winds than the standard ones. These results show, that in the adiabatic version the subsequent development of the mesoscale cyclone does not occur. It can be considered, that the development of the observed cyclone was caused by physical processes.

**Third experiment**: The Sundquist condensation scheme was replaced with a simpler one. In this case the pressure field and winds were the most similar to real analysed results. But according to the condensation scheme the map of precipitation became too variable and noisy.

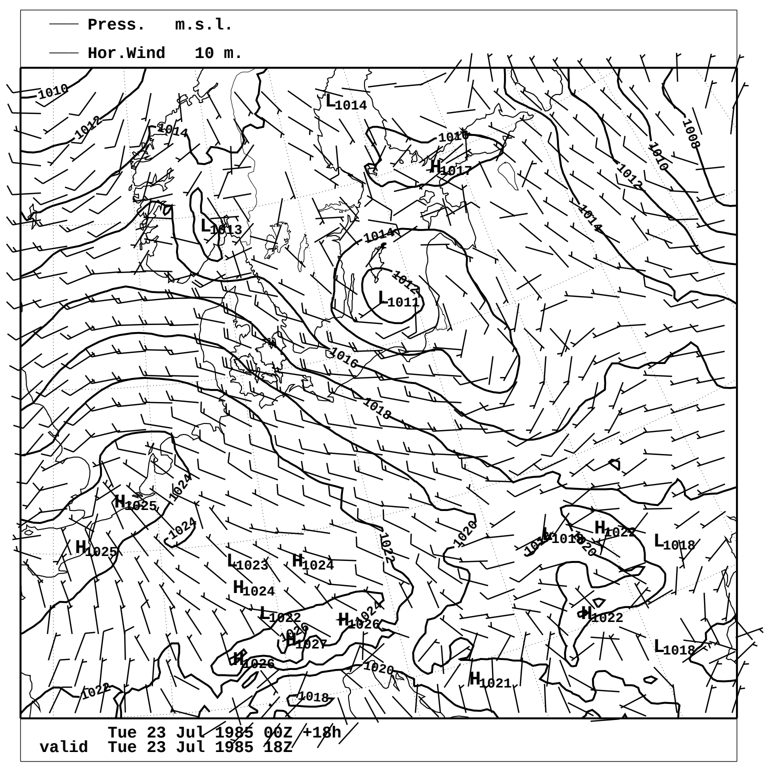


**Figure 1**: Mean sea level pressure and 10 meter winds, 23 July 1985 00 UTC +18 h. With the Sundquist condensation scheme.

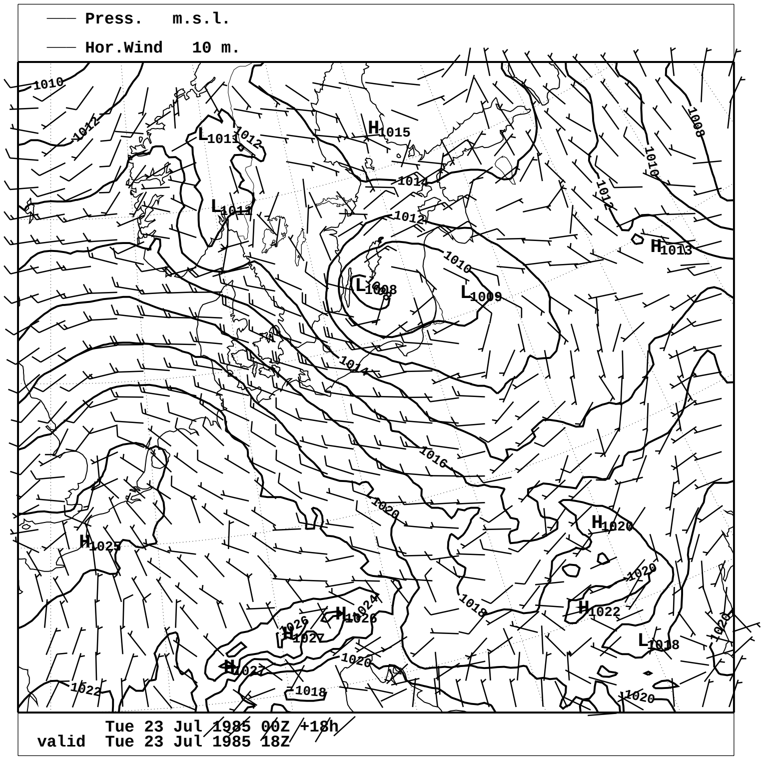


**Figure 2**: Mean sea level pressure and 10 meter winds, 23 July 1985 00 UTC + 18h. With the KUO/COND condensation schemes.

Forecast maps valid at +18 h of mean sea-level pressure and 10 meter winds are presented for Experiment 1 (Sundquist condensation) in Figure 1 and for Experiment 3 (KUO/COND condensation) in Figure 2. Both experiments were carried out at 22 km horizontal resolution and with 16 vertical levels.

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## A possible future operational Latvian HIRLAM

At first we decided to investigate weather forecast for 24 hrs for Latvia. Then we need to know initial data from a large part of Europe, possibly excluding the southernmost area. The territory of Latvia is not so large, so we are interested to use a high horizontal resolution. If we take the resolution of 10 km, then the number of gridpoints in the chosen area will be very large (40000) - too large for available computers at LHMA. So the resolution 20 km will be quite good for us. To set up an operational HIRLAM for our area, we considered an area of 102x102=10404 gridpoints and with a resolution of 20 km.

We prefer the center of the chosen area located not over Latvia, but more westerly, because the radiosonde network in the eastern part is not so regular as in western regions. And the other reason; we have usually synoptic developments from the west.

The coordinates of the proposed area are the following:
Southernmost latitude = -10.2, Northernmost latitude = +10.0,
Westernmost longitude = 0.0, Easternmost longitude = +20.2,
all in HIRLAM rotated coordinates with the South pole in 30S 0E. The proposed forecast area is illustrated in Figure 1.

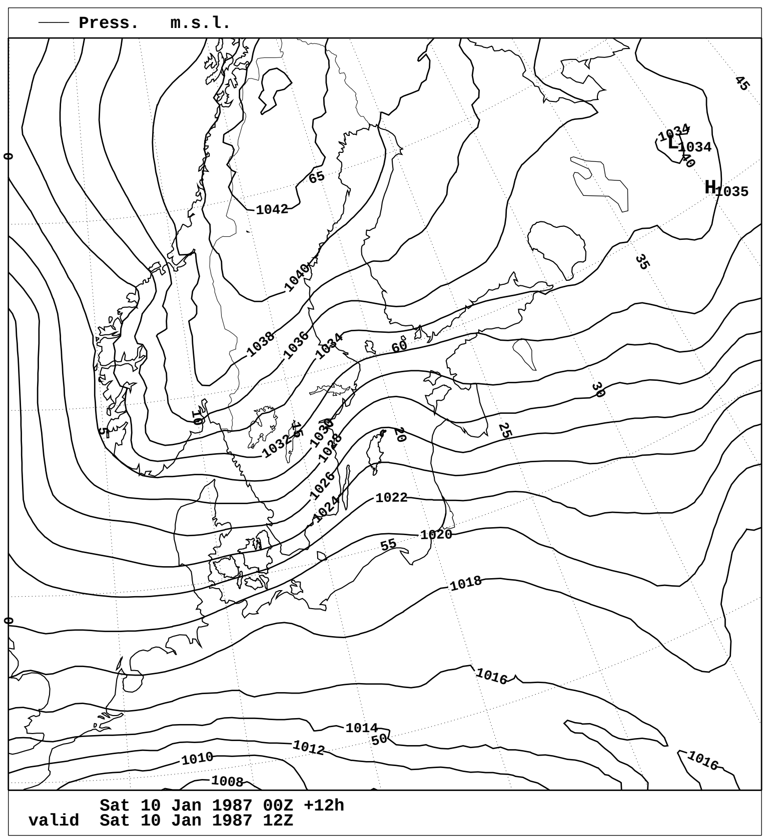


**Figure 1**: Forecast of mean sea level pressure, 10 January 1987 00UTC + 12 h, on the proposed area for LHMA and with 16 vertical levels.

The other parameters for using the forecast model are:

- 16 vertical levels
- 24-hour forecast
- 360-sec time step (semi-Lagrangian time integration)

Boundary data need to be transmitted from the 0.4 degree HIRLAM at SMHI in 50x50x31=77500 gridpoints. With two wind components, temperature and specific humidity this will be approximately 1 MB (1 million bytes) of data for each forecast length. Since the transmission speed from Norrköping to LHMA is 19 kbits/s, it will not take more than 10 minutes for transmission of each forecast file (files for +6h, +12h, +18h, +24h, and +30h will be required if, for example, 18UTC SMHI boundaries will be used for the 00UTC run at LHMA).

The calculation for a 24-hr forecast takes approximately 100 minutes, with assimilation included it takes approximately 120 minutes. If we use initial data at 00 UTC, which include radiosonde data that are available at 01.30 UTC, the forecast will be ready near 06 hrs local time. This is too late for the morning forecast, because we have to prepare it at 05 hrs. So we decided to make shorter the forecast length, we changed it to 12 hrs. Time schedule for the operational start is 1h 30min. The calculation takes approximately 60 minutes, thus the forecast calculation will be ready about 04 hrs 30 minutes local time. It is quite good for our weather service.

The next step of our experiment was the changing of the number of vertical levels from 16 to 31.Calculation of the 12-hrs forecast in this case took about twice the time compared to the 16-level model. We compared results of the 16-level and the 31-levels models in m.s.l. pressure (Figures 1 and 2), wind, precipitation fields and cross-sections of potential temperature and wind between points 57N,15E and 57N,30E (Figure 3). But the results were not so much different. We can assume that a 16-level model is enough for short-range forecasts, such as 12-hr forecasts.

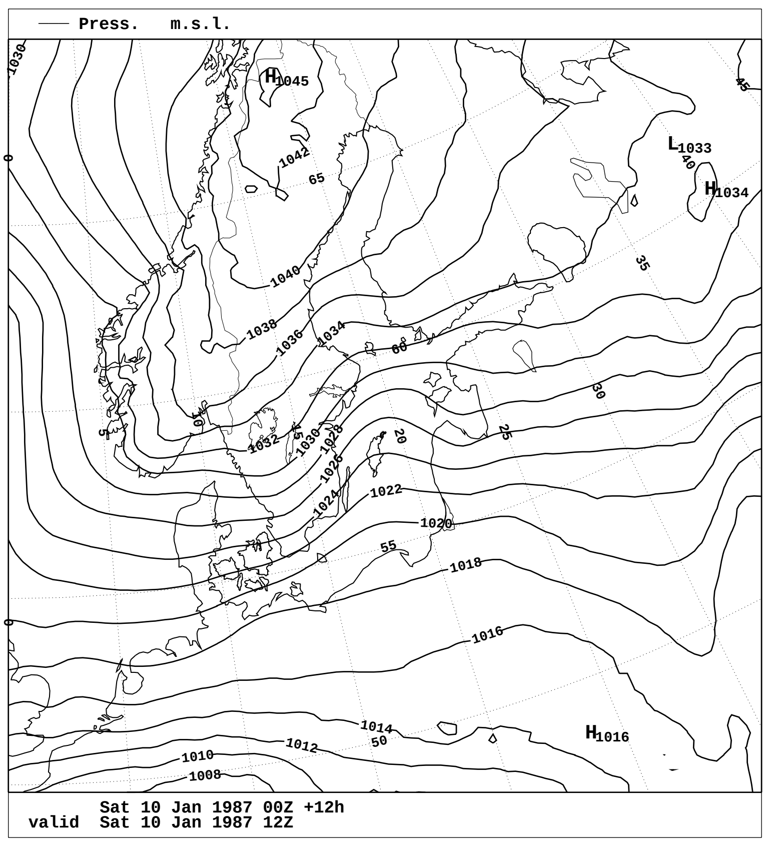


**Figure 2**: Forecast of mean sea level pressure, 10 January 1987 00UTC + 12 h, on the proposed area for LHMA and with 31 vertical levels.

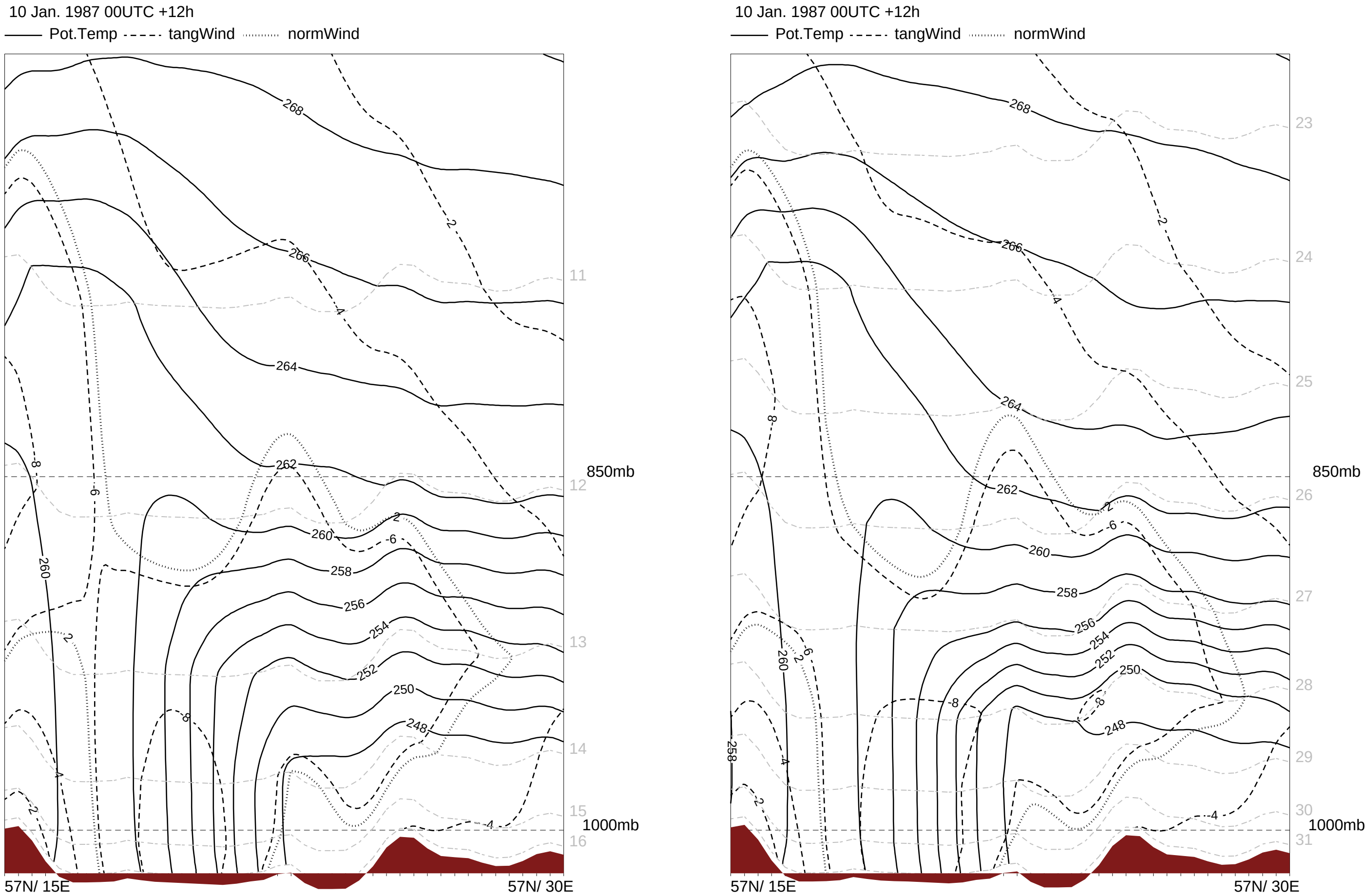


**Figure 3**: Vertical cross section, 10 January 1987 00UTC + 12 h, with 16 vertical levels (left) and with 31 vertical levels (right).

We have no high resolution climatology and physiography data over Latvia for use in the model yet.

Latvian experimentation group

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## Sensitivity to initial surface data in the winter case

During our training we have performed a lot of different experiments connected with influence of initial surface data on prognostic variables.

**Our conclusions**:

In the January 10, 1987 the weather situation was much deviating from the normal climatological average. It was extremely cold on those days in the Northern part of Europe. Initial data for the atmosphere were given by analysis fields from ECMWF while surface data were taken from HIRLAM climatology. Studying maps of the first experiment (without any changes), it became clear that boundary conditions produce noisy and not realistic waves. It can be noticed studying isobars. So the maps performed after the first experiment are almost unrealistic. After discussion we have made the conclusion that climatological temperature data are too high (-5, -15) in comparison with initial data (-25, -45). So we decided to change the code in the initialization program INIPHY.f so the difference would be smaller. Surface temperature was made equal to the temperature on the lowest model level if the difference was bigger than 5 degrees. It was a very good decision but it was not our own. Studying maps performed after the second experiment it can be seen that influence of changes was in right direction. The isobars became a bit smoother, so some noisy waves were removed (Figure 2).

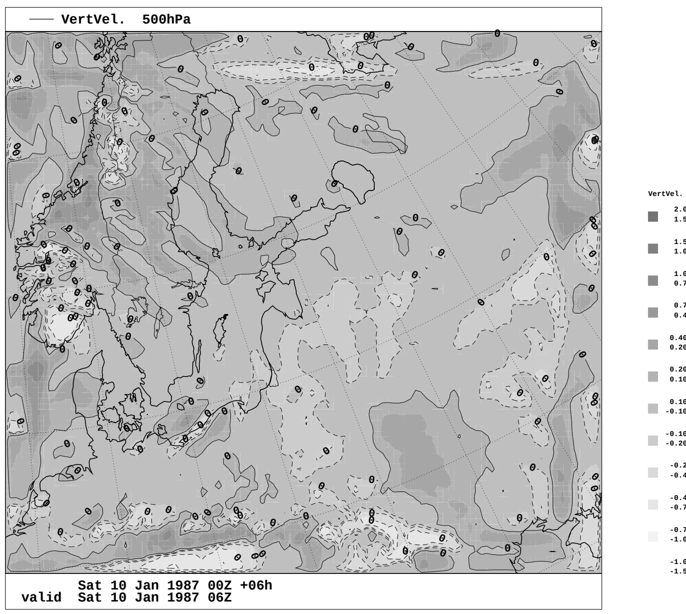


**Figure 1**: 500 hPa vertical velocity (Omega), 10 January 1987 00UTC + 06 h, 20 km horizontal resolution and 16 levels.

There was an extreme cold in the reality at that time. So we have changed the snow depth everywhere where the temperature on the surface was less then -10 to be bigger than 0.05 m . And in accordance with the NOAA satellite image, we have also changed the fraction of ice to be more realistic than the climatological ones. A small program was installed in INIPHY.f and a file of ice observations was created and a lot of changes were made with it (common forces were used). We have run these two experiments also.

The most interesting results from comparing of all the maps were:

It really became colder over land areas due to the changes. Evaporation became more concentrated over the open water (sea area). Maps of the first experiments, run at high resolution, of vertical velocity were awful: unreliable and unuseful almost at all. So much noisy waves were observed here. It produced a very very unstable situation that is unrealistic. Our changes have not removed these noisy waves (Figure 1). Studying the map of the last experiment, we made the conclusion that we need a more detailed study, because we have noticed small disturbances in all boundary areas that may be produced by noisy waves. It was very interesting to notice that these disturbances became smaller in a 24 hour forecast than in a 6 hour one. So the numerical scheme has a tendency to make the situation more stable.

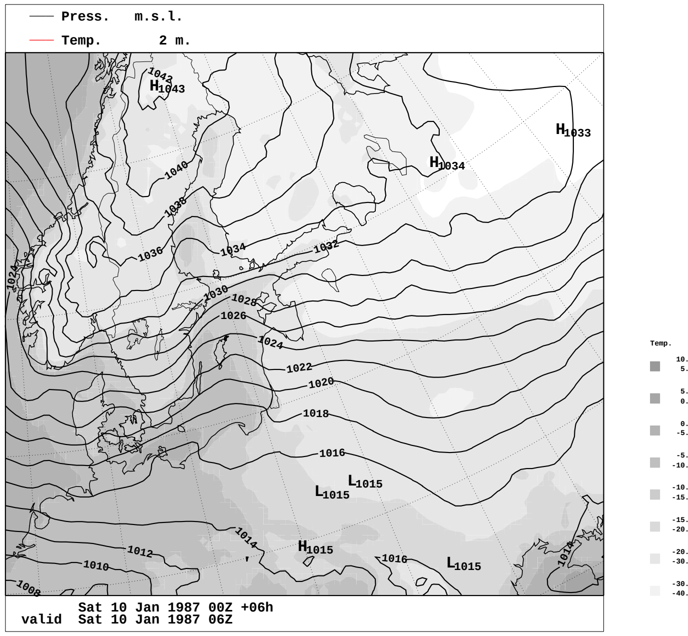


**Figure 2**: Mean sea level pressure and 2 meter temperatures, 10 January 1987 00UTC + 06 h, 20 km horizontal resolution and 16 levels.

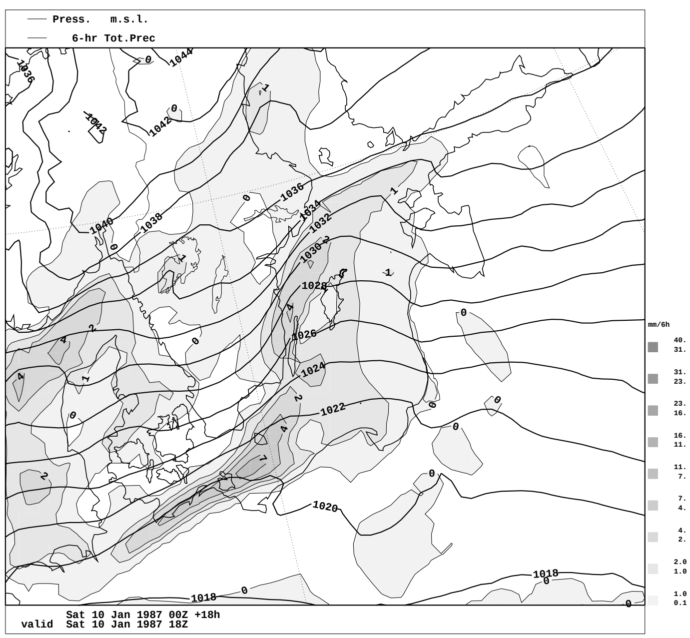


**Figure 3**: Mean sea level pressure, 10 January 1987 00UTC + 18 h, and accumulated precipitation +6 h - +18 h, 20 km horizontal resolution and 16 levels.

Maps performed after the first (low resolution) experiment show unrealistic precipitation and cloudiness. Our changes especially in the fraction of ice cover produce changes in the right direction. Cloudiness and precipitation are in good connection. The tendency of their movement is also very nice. What processes are involved, we can understand from a cross section (Figure 4). Cloudiness is initially concentrated near open water where evaporation is big and moves with the area of low pressure . A lot of precipitation is produced in that area in the south and nothing in the north where pressure is very high. Very good results have been seen in the snowbands in the sea area in comparison with the NOAA observations due to the improving of the fractions of ice, influencing evaporation.

We have also compared experiments run in two resolutions. So higher resolution produced smallest gradient of ice cover. And, in connection to it, more realistic precipitation was produced in the area with corrected fraction of ice (Figure 3). But high resolution increases problems of noise. Maps with low resolution are more realistic in this aspect. We decided that further studies with filters and improving of the boundary conditions are needed. We have not performed them due to lack of time.

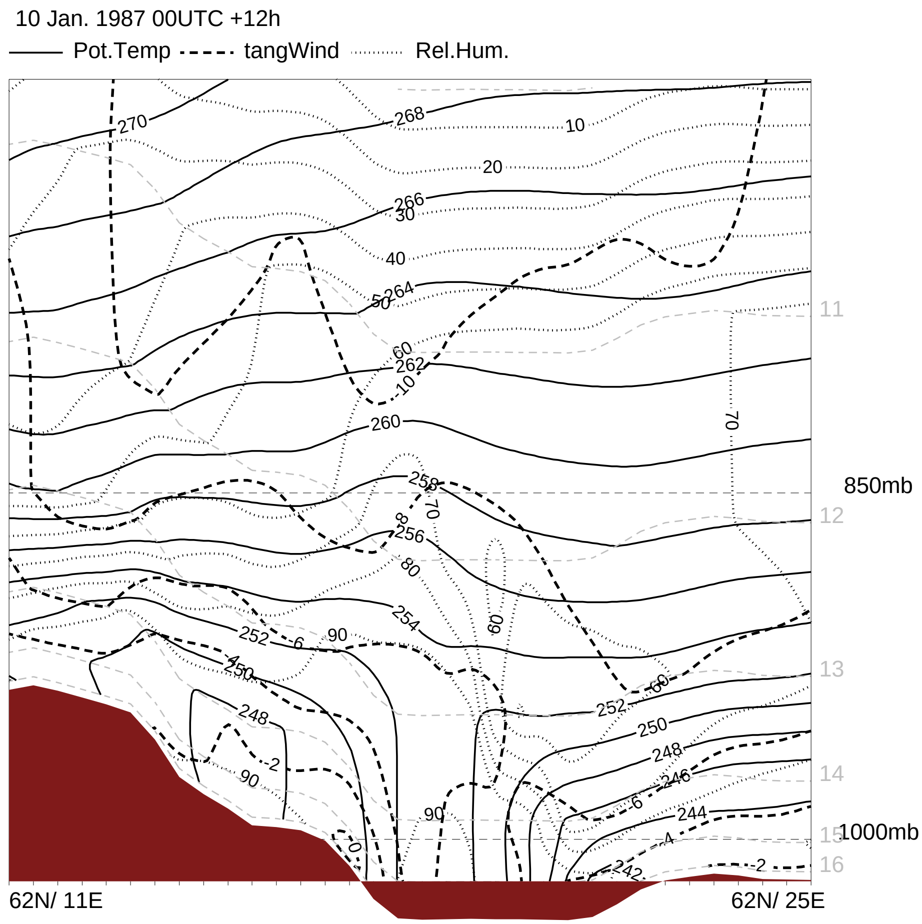


**Figure 4**: Vertical cross-section with potential temperature, tangential winds and relative humidity. 10 January 1987 00UTC + 12 h, 20 km horizontal resolution and 16 levels.


Lithuanian experimentation group

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