WWW TECHNICAL PROGRESS REPORT ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM (GDPFS), AND THE ANNUAL NUMERICAL WEATHER PREDICTION (NWP) PROGRESS REPORT FOR THE YEAR 2005

SWISS CONTRIBUTION TO THE WMO TECHNICAL PROGRESS REPORT ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM

1 Summary of highlights

- The Sun Solaris and Windows server infrastructure has been continuously renewed and further consolidated throughout the past year; the migration of the Wide-Area-Network (WAN) from single line connections to Internet Protocol Services Switch (IPSS) technology was successfully completed.
- MeteoSwiss further developed its own short-range forecasting system (aLMo). A continuous assimilation cycle has been implemented, currently ingesting mainly conventional observations. aLMo is calculated on a 385x325 mesh, with a 1/16° mesh size (about 7 km), on a domain covering most of Western Europe.
- Within the framework of the national NCCR climate research programme, MeteoSwiss has established access to the ECMWF monthly forecast data. Post-processing and visualization procedures have been developed and are operated in a test mode on a quasi- operational basis. Products include weekly forecasts of probability maps over various regions.
- The MeteoSwiss forecast verification method OPKO has now been in use for 21 years. During that period the quality of the forecast has improved from 79% to 86%.

2 Equipment in use at the Centre

(AUTHORS: STEFAN SANDMEIER/PETER NAEF)

The Sun Solaris and Windows server infrastructure has been continuously renewed and further consolidated throughout the past year. As part of this on-going process, we upgraded the firewall system, partly replaced the communication system of our meteorological network, restructured the demilitarized zone (DMZ), and separated the production and development environment. A new middleware architecture based on BEA’s Weblogic software was introduced along with a first service for internal data dispatching. The migration of the Wide-Area-Network (WAN) from single line connections to Internet Protocol Services Switch (IPSS) technology was successfully completed. The new service allows redundant connections between the main location and the various local sites of MeteoSwiss with a much higher availability. Further progress was achieved in automating the monitoring of the information technology infrastructure. For the clients, a strategic decision was made towards replacing Sun Solaris workstations with PCs wherever possible.

3 Data and Products from GTS in use

(AUTHOR: CHRISTIAN HÄBERLI)

At present nearly all observational data from GTS are used. Further in use are GRIB data from Bracknell, Washington and Offenbach. Additionally most of MOTNE and OPMET data are used as well. The typical figures on message input for 24 hours did not change significantly since 2004. .

4 Data input system

(AUTHOR: CHRISTIAN HÄBERLI)

A fully automated system is used. A bulletin entering the Message Handling System (MHS) is stored, after some format validation and related on this some automatic format error correction, to the database. SYNOP, TEMP/PILOT and some national station reports are decoded on MHS for further distribution to related systems or customers. METAR and TAF are formatted back to old code format (removing keyword METAR/TAF) from every station report) for internal use and national customers..

5 Quality control system

(AUTHOR: CHRISTIAN HÄBERLI)

Format based quality control for ASCII coded bulletins is done on input and can be switched off or on for every bulletin type desired. Bulletins failing this format check are routed to the operators workplace for manual correction, if possible. Currently SYNOP and TEMP/PILOT are corrected as well as OPMET data for indicators LSSW.

METARs are checked on errors of data and format in the editing tool of the observers.

Automatically measured data are checked in the SYNOP encoder, before the SYNOP Bulletin is generated. The monitoring of the quality of the observations is done on the national scale..

6 Monitoring of the observing system

(AUTHOR: CHRISTIAN HÄBERLI)

Surface observations are monitored on the national level. A computer aided network monitoring is used for the automatic surface weather stations. For the manual weather stations a semiautomatic system is used for the monitoring..

7 Forecasting systems

7.1 System run schedule and forecast ranges

(AUTHOR: PHILIPPE STEINER)

Medium and extended range forecasting are based on external NWP sources, but MeteoSwiss runs its own short-range forecasting system. The core of this system is the non-hydrostatic Local Model developed by COSMO (the Consortium for Small-Scale Modelling currently composed of the national weather services of Germany, Switzerland, Italy, Greece and Poland – see cosmo-model.cscs.ch). It is operational at MeteoSwiss since April 2001, with IFS frames as lateral boundary conditions provided by the ECMWF BC special project.

A continuous assimilation cycle has been implemented, currently ingesting mainly conventional observations. A main assimilation suite has been defined with a cut-off time larger than 4 hours, implemented with 3-hour assimilation runs; an additional short cut-off suite is also calculated to provide initial conditions for the operational forecasts and for other near-real time requirements. Two daily 72 hours forecasts are calculated, based on the 00 and the 12 UTC analyses, with a 90 minutes cut-off time. The time critical forecast products are available in about 105 minutes.

A sophisticated set of scripts controls the whole operational suite, and allows for a very high reliability of the system, with less than 2% of the forecasts requiring manual intervention. This same environment is also used to run parallel suites, to validate proposed modifications to the system, and to facilitate experimentation by the modelling group.

The computing resources and expertise are provided by the Swiss National Supercomputing Centre (CSCS, see www.cscs.ch). aLMo is calculated on a single node 16 processors NEC SX-5, and achieves a sustained performance of 29 GFlops, or more than 25% of the peak performance of the machine. Pre- and post-processing needs are covered by a 8 processors SGI O3200 front end platform; a large multi-terabytes long term storage is used for archiving purposes, and a 100 MBit/s link connects the MeteoSwiss main building with the CSCS (on the other side of the Alps!).

7.2 Medium range forecasting system (4-10 days)

MeteoSwiss does not run a medium range forecasting system.

7.3 Short-range forecasting system (0-72 hrs)

(AUTHOR: PHILIPPE STEINER)

7.3.1 Data assimilation, objective analysis and initialization

Data assimilation with aLMo is based on the nudging or Newtonian relaxation method, where the atmospheric fields are forced towards direct observations at the observation time. Balance terms are also included: (1) hydrostatic temperature increments balancing near-surface pressure analysis increments, (2) geostrophic wind increments balancing near-surface pressure analysis increments, (3) upper-air pressure increments balancing total analysis increments hydrostatically. A simple quality control using observation increments thresholds is in action.

Currently, conventional observations are assimilated: synop/ship/buoys (surface pressure, 2m humidity, 10m wind for stations below 100 m above msl), temp/pilot (wind, temperature and humidity profiles) and airep/amdar (wind, temperature) as well as wind profiler data. Typical 24 h assimilation at MeteoSwiss ingests about 120 vertical soundings, about 15000 upper-air observations and about 32000 surface observations. Assimilation of GPS derived integrated water vapour, as well as a radar based 2-dimension latent heat nudging scheme are being developed.

The snow analysis made by the German Weather Service is used in aLMo; it is based on a simple weighted averaging of observed values. Effort is currently under way to derive a new snow analysis from MSG satellites combined with dense observations. All other surface and soil model fields are obtained by interpolating IFS analysis. These fields are updated twice daily by direct insertion in the assimilation cycle. Finally, the ozone and vegetation fields are based on climatic values.

In addition to the MARS retrieving system, the full ECMWF decoding, quality control and database software have been installed on our front end machine. The cut-off time for the main assimilation cycle is at least 4 hours, and the oldest lateral boundary conditions are 3 hours old. Based on this main cycle, additional short cut-off cycles (90 minutes) are calculated to produce the initial conditions for the operational forecasts.

7.3.2 Model

A thorough description of the Local Model itself can be found on the COSMO web site. aLMo is a primitive equation model, non-hydrostatic, fully compressible, with no scale approximations. The prognostic variables are the pressure perturbation, the cartesian wind components, the temperature, the specific humidity, the liquid water content, cloud ice, rain, snow and turbulent kinetic energy.

The model equations are formulated on a rotated latitude/longitude Arakawa C-grid, with generalized terrain-following height coordinate and Lorenz vertical staggering. Finite difference second order spatial discretization is applied, and time integration is based on a 3 time levels split explicit method. Fourth order linear horizontal diffusion with an orographic limiter is in action. Rayleigh-damping is applied in the upper layers.

aLMo is calculated on a 385x325 mesh, with a 1/16° mesh size (about 7 km), on a domain covering most of Western Europe. In the vertical a 45 layers configuration is used; the vertical resolution in the lowest 2 km of the atmosphere is about 100 m. The main time step is 40 seconds.

7.3.3 Numerical weather prediction products

A suite of post processing modules are available:

- Kalman filtering of model output for 2 meter temperature and dew point temperature;
- visualization software based on the ECMWF MetView package and on in-house developments at MeteoSwiss and at CSCS; static maps, 2- and 3-dimensional loops with texture based flow visualization are created;
- a trajectory model providing guidance on transport route (hot air balloons, pollutants);
- a lagrangian particle dispersion model to calculate dispersion and deposition of radioactive materials.

Based on these modules, a standard set of products is provided to the MeteoSwiss bench forecasters, and are used as guidance for short-range forecasts. In case of necessity the two last modules can be run by the on-duty forecasters at any time (on-demand mode).

Besides that a large quantity of tailor made products, based on direct model output, are disseminated to internal and external clients.

MeteoSwiss contributes to the improvement of the limited-area ensemble prediction system COSMO-LEPS based on global ECMWF Ensemble forecasts and on the COSMO Local Model. COSMO-LEPS has been developed at ARPA-SIM, Bologna, and runs operationally at ECMWF. It makes probabilistic high-resolution short to early-medium range forecasts available at MeteoSwiss, visualized in the form of probability maps and meteograms for various parameters. The probability maps complement the deterministic aLMo products while the meteograms combine the output from both systems. Fig 7-1 shows an example of such a meteogram as derived from COSMO-LEPS and the aLMo output in terms of precipitation and 2m temperature.

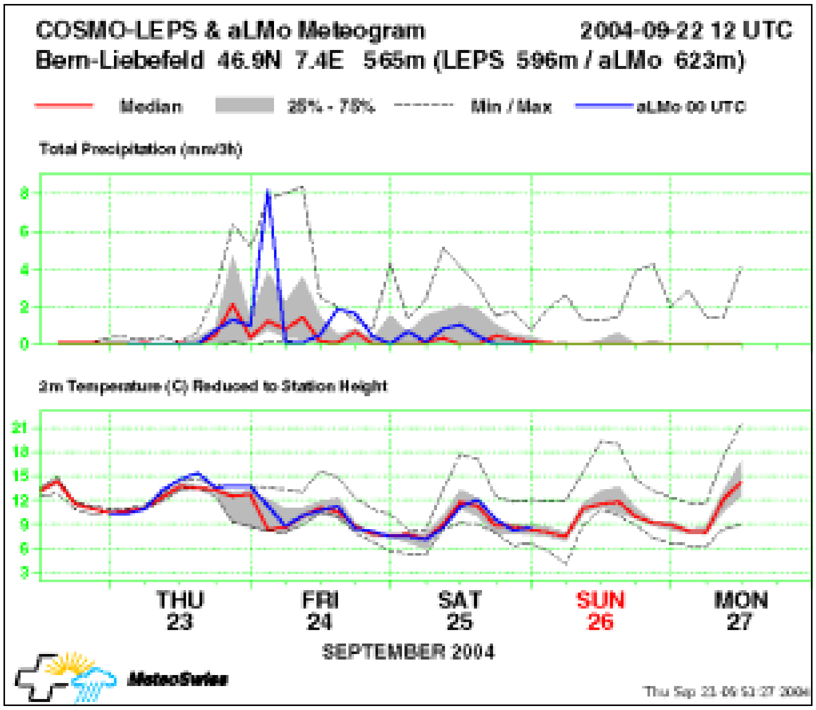


Figure 7-0 Meteogram with precipitation and 2m temperature as derived from the COSMO-LEPS and the aLMo output. Example for Berne from a forecast starting on 22 September 2004. Red lines: median of the 10 COSMO-LEPS members; grey shaded area: the middle two quartile (25 to 75% probability of occurrence); dashed lines: the highest and lowest values, respectively; blue line: the operational deterministic model at MeteoSwiss, aLMo.

7.4 Specialized numerical predictions (on sea waves, sea ice, tropical cyclones, pollution transport and dispersion, solar ultraviolet (UV) radiation and air quality forecasting etc.)

No report available.

7.5 Extended range forecasts (10 days to 30 days) (Models, Ensemble, Methodology and Products)

(AUTHOR: MARK LINIGER)

Within the framework of the national NCCR climate research programme, MeteoSwiss has established access to the ECMWF monthly forecast data. Post-processing and visualization procedures have been developed and are operated on a quasi-operational basis. Products include weekly forecasts of probability maps over various regions. The ongoing developments profit from the experience from seasonal forecasts. In particular, calibration and visualization techniques are applied in a similar manner.

7.6 Long range forecasts (30 days up to two years) (Models, Ensemble, Methodology and Products)

(AUTHOR: MARK LINIGER)

MeteoSwiss issues long range forecasts on the basis of the ECMWF seasonal forecast system 2. Research results from the NCCR Climate project optimized the calibration of the forecasts. Further, verification of grid point and large scale climate mode forecasts are conducted. The operational products are available on the password protected webpage to ease the interpretation of the products, e.g. climagrams and probability charts. A climate outlook bulletin for Switzerland is currently under development with the goal to inform the public in an appropriate way about probabilistic climate forecasts.

8 Verification of prognostic products

(AUTHORS: PETER ALBISSER/HEINZ MAURER)

For decades MeteoSwiss has assessed the quality of its forecasts. 21 years the method OPKO (**O**bjektive**P**rognosen**Ko**ntrolle) has been in use. The verification method of the official forecasts will be described in the following paragraph. The available results will be presented and commented according to different criteria.

Method

Several times a day MeteoSwiss issues forecasts in three languages for the general public trough its regional centres. These forecasts are assessed on a regular basis. First of all the texts have to be coded. The verbal contents are transferred into numerical codes according to precise regulations. This is quite easy with temperatures, but becomes a little more difficult with other meteorological data.

To assess the cloudiness, the relative sunshine time will be taken in account. This means the measured time in relation to the maximum sunshine possible, the later changing daily according to the shape of horizon. The difficulty with this method is the conversion of terms describing sunshine or degrees of cloudiness into a code number. We have determined the corresponding categories on the basis of a public opinion poll and our forecasters are obliged to write their texts according to these binding categories.

Also the precipitations are coded according to clear and binding regulations. The same applies to wind in cases where gusts of more than 25 knots are expected. Altogether it is quite a demanding, time-consuming job, which is still carried out manually for the time being.

The forecasts are assessed taking into account the measurements of our automatic observation network. 67 stations are used, however the temperatures of mountain-stations are not considered. The measured values are compared with the coded weather data. Fixed scores quotients are used to evaluate the results.

Results

The overall forecast results for the climatological year 2005 show the following scores:

Central and eastern part of Switzerland	86%
Western part of Switzerland and Valais	87%
Southern part of Switzerland and Engadine	84%
The whole of Switzerland	85.5%

The forecast analysis of 21 years with this same method shows in the beginning results around 79% and now around 86%. The results in flat areas are generally better, because forecasting in mountain regions is more difficult.

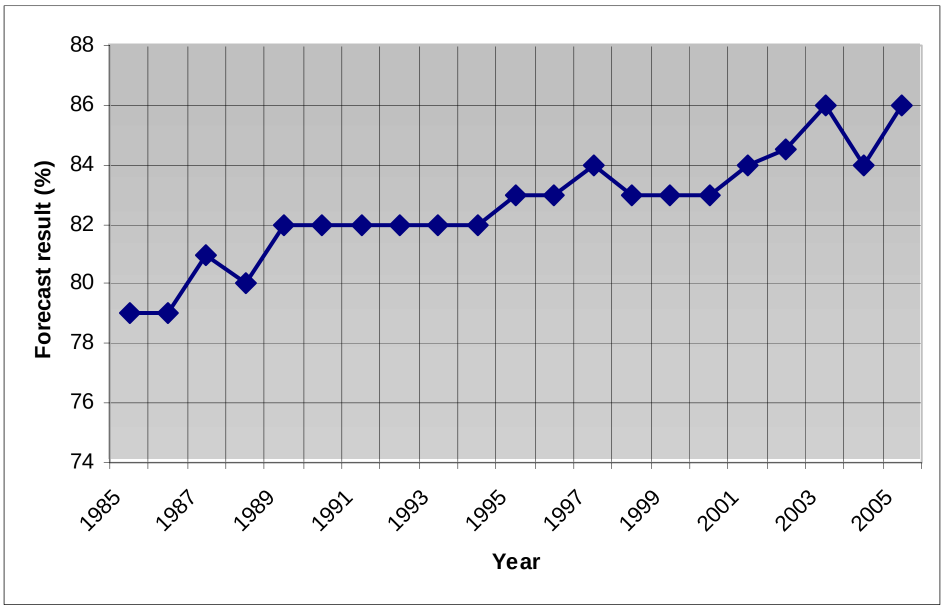


Figure 8-1: 21 years of forecast quality assessment with OPKO

Outlook

The above described method will continue to be used for the moment. Deficiencies are known, especially because we cannot compare our results with those of other weather services. We are currently analysing other verification methods with a view to introducing an improved method in the near future.

9 Future plans

9.1 Development of GDPFS

(AUTHOR: CHRISTIAN HÄBERLI)

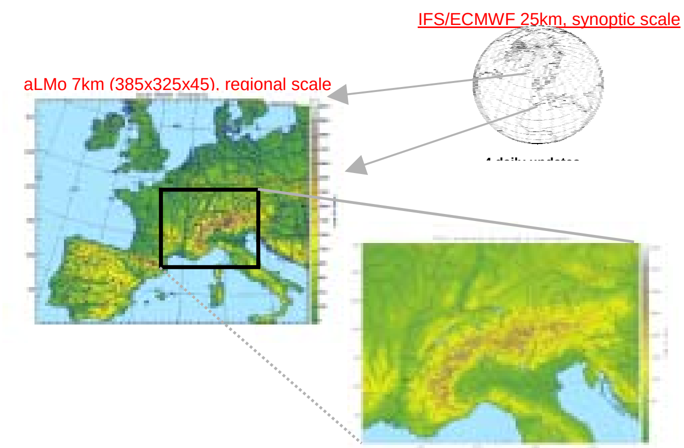
2006, another 25 automatic weather stations of the ground based monitoring system will be renewed. A new tool for the observers, which helps to get a better quality of the observations, will be implemented. The renewing will be done station by station and should be finished by 2008. Eventually, a total of about 130 sites will be automatically operated..

9.2 Research activities in NWP

(AUTHOR: PHILIPPE STEINER)

The development of a very high resolution model has started in 2005. The motivation is to get an automatic generation of local forecast products in complex topography being used for general forecast purposes and contributing to the security of the Swiss population by the generation of warnings/alarms, e.g. in case of incidents in nuclear power plants, floods or avalanches. It will also allow MeteoSwiss to develop and maintain its key competence in Alpine meteorology.

The new model called aLMo2 will get its boundary conditions from the actual aLMo, have a mesh size of about 1/50°~2.2km and its domain of 480 x 350 grid points with 60 levels will be centred on the Alps. In addition to the current forecasts, it will produce 8 times a day 18 hours forecasts. It is planned to be pre-operational in 2007 and operational in 2008.



The probable setup will be based on a new numerical kernel, 2-timelevel third order Runge-Kutta, with a main time step of about 15 seconds. It will use improved physics with e.g. new schemes for graupel and shallow convection (the deep convection being resolved), as well as with implementation of the topographic effects on radiation and the use of a new multilevel soil model. New types of measurement will be used: radar data (using the latent heat nudging), VAD, SODAR, GPS data (using tomographic methods to derive humidity profiles) for assimilation and satellite data for snow analysis.