LACE Working Group for Physics
Report 2005

Neva Pristov
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Contents

1 Introduction

Short overview of research and developments in the frame of LACE working group for physics in the year 2005 is presented. In the beginning of the year important decision was made in ALADIN project for continuous evolution of the mesoscale physical parameterizations with different degree of sophistication/complexity appropriate for the scales from 2-20km. To allow smooth transition towards higher resolutions developments on physical parameterizations (turbulence, radiation, convection, microphysics) started. Support came from working group for dynamics, some researcher devote their time to physics topic and also some money for support was replaced.
Furthermore there was some work on validation environment (such as DDH) and externalized surface scheme (diffusion scheme) which are also a benefit to AROME. Many validation, case and sensitivity studies were also done.

2 Progress in reseach topics

2.1 PBL cloudiness

- **Stratus prediction**

Objective: Improve ALADIN forecast of low stratus. A large improvement was already achieved with the Seidl-Kann scheme but a few open questions still need to be clarified.
Realization: Some case studies with low horizontal diffusion of temperature were done. Before the operational use the impact of other developments (SLHD scheme, the prognostic liquid water, the modification in vertical diffussion) on inversion and stratus formation has to be studied.
Effort: 1 person x month
Contributors: A. Kann (At)
Documentation: not available

2.2 Prognostic cloud water + orographic precipitation

Objective: Improve ALADIN forecast of orographic precipitation. The model over-forecasts rainfall amounts at windward slopes and on peaks and ridges, and under-forecasts precipitation in valleys. There is also a tendency of the model to overestimate rainfall from low stratus (drizzle).

Realization: The Lopez microphysics scheme was available in the latest aladin export version so a comparison between the operational precipitation scheme and Lopez scheme was done for strong precipitating event. In the precipitation fields obtained with Lopez scheme is seen that peak values in the upslope areas are reduced, values on the down-wind side are increased to more realistic values. This is the sign that advection of cloud (and precipitable) water to the lee side can be handled in more realistic way.
Effort: 1 person x month

Contributor: C. Wittmann (At)
Documentation: information in ALADIN Newsletters 28

Realization: A prognostic precipitation scheme (prognostic precipitating water and ice, use of the pseudo-fluxes between 5 water phases, collection, sedimentation of precipitation) which is harmonized with physical-dynamical constrains of the ALARO framework was prepared by Bart Carty. The code was implemented into ALADIN cycle29 (modifications to data flow, corresponding interfaces were introduced) and tested. Corrected code was ready only at the end of the stay, so evaluation of the behavior of the scheme with DDH on four already selected cases with (mainly stratiform) precipitation continued in the begining of 2006.
Effort: 1.5 person x month (3 weeks LACE stay in Ljubljana)
Contributors: D. Drvar (Hr), J. Cedilnik (Si)
Documentation: report of the stay (after one additional week stay in 2006)

2.3 Parameterization schemes, diagnostic tools

- **Parameterization of turbulence**

Objective: Improve diagnostic treatment of turbulent flux with introducing prognostic equation for turbulent kinetic energy.
Realization:
Prognostic TKE scheme was coded (scheme under aplpar, belonging GFL structure plus tendency computation). During validation some problems appeared (unrealistically high TKE value, negative values, a gradual increase of the average TKE in the atmosphere). Strong dependency to the order and way of computation was noticed so numerical reorganization of the code was needed. Some reformulation (retuning of the existing vertical diffusion, some modifications related to exchange coefficients) was done also to finally get confident scheme which is ready for further evaluation.
The work is continuing in 2006.
Effort: 3 person x month (1 month stay CHMI)
Contributors: F. Vana (Cz), J. Cedilnik (Si)
Documentation: in preparation

Another approach is the work with TKE scheme implemented in ARPEGE/ARPEGE-clima in collaboration with Meteo-France team. We tried to find the answer about vertical discretization (half levels versus full levels) and to the problem of advection.
First step was learning 1D model, running it on the GABLS II field experiment with focus to turbulence. The first experiment (using conversion from half to full levels and back every time step) show some impact to the stability and accuracy in the lower boundary. To have some conclusion more test should be done with newer version (1D model based on cy29t2)
To answer the question if advection of turbulent kinetic energy is needed and on which scale

basic setup for experiment is prepared.
The work is continuing in 2006.
Effort: 1 person x month (0.5 month LACE stay at Meteo-France, 0.25 during phasing at Meteo-France)
Contributors: F. Vana (Cz), J. Cedilnik (Si)
Documentation: not available yet

- **<u>Work on "mixed" radiation scheme</u>**

Objective: Current radiation scheme used in ALADIN model (ACRANEB) divides radiation just into 2 bands (solar and thermal) and this will be kept. To achieve good cost/efficiency ratio in the radiative computation some other modifications will be developed, such as better description of the transmission function for computation of optical depths and cloud optical properties.

Realization:
For validation and improvement of the gaseous transmission function for computation of optical depths, some programs were ported: 1D model with some modifications used as the tuning tool for the new transmission function, a program to get current settings in ACRANEB and program LBLRTM (LineByLineRadiativeTransferModel) to get more precise input data needed in describing temperature dependences of the coefficients of the equivalent widths in the band model. This dependency is then incorporated into reduced absorber amount. The next step is fitting the Pade approximation which already works quite fine. Problems are still in the temperature dependency part.
The work is continuing in 2006.
Effort: 2.5 person x month (local work)
Contributor: A. Trojakova (Cz)
Documentation: not available yet

Cloud optical properties can be updated since microphysics scheme will provide prognostic cloud water and ice. The main task is to parameterize saturation effect for very broad band considerations and taking into account cloud properties and "geometry" of cloud layers above and below (overlaping). For this purpose an idealized cloud simulation model was created, which solves radiative transfer equation in clouds wavelength by wavelength, taking into account only diffuse fluxes and ignoring the effect of gases. Reference values for new parameterized scheme are obtained from model simulation. New scheme was tested for some simple cases (homogeneous clouds, 3-layer non-homogeneous clouds, 3-layer non-uniform clouds), where results of comparison of transmittance and reflectance with new/old scheme are encouraging.
The work is continuing in 2006.
Effort: 2.5 person x month (2 months LACE stay at CHMI)
Contributor: J. Mašek (Sk)
Documentation: New parameterization of cloud optical properties proposed for model ALARO-0

- **<u>Convection scheme</u>**

Objective: Improve the convective rainfall forecast with better scheme which can be used at "grey zone" and can be also a substitution for convection scheme in the 10 km version of Meso-NH.
Realization: The prognostic convection scheme from Luc Gerard where the convection is extincting gradually with the resolution increase, is the basis. The idea from Jean-Marcel Piriou on the parameterized convective water cycle (convective tendencies are expressed directly in therms microphysics and transport) is used. The task was to incorporate and adapt all this into code with requirements for modularity. Most changes are needed in microphysics and thermodinamics (same as for large scale precipitation), options to choose various closures are added.
The work is continuing in 2006.
Effort: 3 person x month (2 months stay at CHMI, two one-week visits to Meteo-France, one from LACE found)
Contributor: I. Stiperski (Hr)
Documentation: Short report after stay at CHMI on the convection scheme in ALARO0

- **<u>Triggering of convection</u>**

Objective: Improve the convective rainfall forecast of ALADIN, especially in mountainous areas. In summer, ALADIN often forecasts convective rainfall on days where none was observed.
Realization:
Part of the INCA system is nowcasting of convective cell initialization and development which requires detailed analysis of the state of the mountain convective boundary layer. For this purpose high-resolution analysis of many fields (convergence and specific humidity in the boundary layer, LCL, CAPE,CIN, several stability indices, the difference between temperature and trigger-temperature) are routinely generated. Their quality and predictive potential is under evaluation.

The other planed method is postponed due the fact that the new parameterization of convection is under development and it is better to see behavior and performance of the new scheme first.

Effort: person x month
Contributors: F. Wimmer (At), T. Haiden (At)

- **<u>Diagnostic tool DDH for AROME and ALARO.</u>**

Objective: The DDH (Diagnostic par Domaines Horizontaux) diagnostic package exist in ARPEGE and ALADIN and is very useful diagnostic tool for physics development. The plan

is to extend the DDH to the AROME, ALARO model.
Realization: For the DDH implementation into AROME budgets of Cartesian type are introduced. Budgets are used for storage of contribution of each term in tendency equation for prognostic variables. These contributions to variable changing between two time steps can be either from real physical processes (advection, turbulence, various microphysical processes, etc.) or numerical procedures (like filters). Configuration and initialization of budgets in AROME is slightly different from that one in MesoNH and tendencies from MesoNH has to be transformed into the fluxes.
Efforts: 2 person x month(1.5 month LACE stay at Meteo-France)
Contributor: T. Kovačić (Hr)
Documentation: Report from the stay

2.4 Externalized surface

- **<u>Diffusion scheme in ISBA</u>**

Objective: When running externalized surface scheme in offline mode with diffusion scheme in ISBA a bug was observed: At points where ice water is present in the soil, the first few level's temperature decreases dramatically in time (near -60 degree of Celsius), and it needs several hours to relax to the 'right' value (the value calculated with force-restore scheme).
Realization: The origin of the problem is in initialization of the water and ice content and is inconsistent with the calculation used for melting/freezing procedure. Recalculation of the water and water equivalent ice content was used in the case of diffusion surface scheme. With this modification the observed temperature decrease at begin of integration disappeared.
Efforts: 2 person x month
Contributor: L. Kullmann (Hu)
Documentation: Problem with diffusion scheme - report

- **<u>The air-sea exchange scheme</u>**

Objective: Implementation of the air-sea exchanges into externalized surface module.
Methods: Improvement of gustiness parameterization, the correction of roughness length over sea for strong wind cases is already implemented in ALADIN in Prague.
Realization: canceled, decision for other method was taken.

2.5 Validation, case studies, sensitivity studies

- **Soil moisture sensitivity**

Description: Research in previous year showed that initial soil moisture field is a major cause for negative T2m bias during daytime on summer sunny days.
Realization: Environment (data flow, scripts) for modifying initial soil moisture from real history of precipitation is prepared.
The work is continuing in 2006.
Efforts: 1 person x month
Contributor: H. Seidel (At)
Documentation: Not available yet.

- **Study of micro physics scheme**

Objective: Study of different microphysics schemes on MAP case.
Realization: Lopez microphysics scheme and modified Kain-Fritsch deep/shallow convection scheme were tested over mountainous area for intense rainfall period (MAP IOP2b). Some of the conclusions are: the most benefits to precipitation forecast can be noticed over complex areas when the Lopez microphysics is used together with modified Kain-Fritsch deep convection, some spurious strong precipitation on the windward side of the montain has been removed by the Lopez scheme, the modified Kann-Fritsch convection scheme alone doesn't improve the forecast, but it makes the convection more organized.
Effort: 1.5 person x month
Contributors Y. Wang (At), *also Eric Bazile, Dr. Xu (China Meteorological Administration)*
Documentation: ALADIN Newsletters 28

- **Case studies using improved parameterization schemes**

Objective: Include recent improvements (e.g. from ALADIN/CZ operational model) into other local operational models.
Realization: Improvements (cloudiness, radiation, gravity wave drug schemes) were implemented of into ALADIN/HR. Studies on a synoptic case marked by a strong temperature inversion in inland part of Croatia lasting for several days with radiation and cloudiness scheme combined with different cloud overlap assumptions improved the forecast of the low cloudiness and the surface temperature (2m AGL) diurnal pattern for certain configurations.
Removal of envelope and changes in gravity wave drug parameterization (tested for bora cases) result in stronger winds on the windward and slightly weaker winds on the leeward side of the obstacles, as well as mountain wave amplitude reduction and smoothing.
Effort: 4 person x month
Contributor: M. Tudor (Hr), V. Tutis (Hr), D. Drvar (Hr), I. Stiperski (Hr)
Documentation: ICAM-MAP proceedings, presentations at 15th ALADIN workshop, ALADIN Newsletters 28

- **Experiments with atmosphere-wave-ocean model**

Objective: ALADIN wind forecast used in ocean and wave model.
Realization: The impact of the forecast surface wind field from ALADIN model in two resolutions was studied in the wave model with some promising results concerning wave heights in the Adriatic.
Efforts: 1 person x month
Contributors: M. Tudor (Hr), *I. Janeković (Hr)*
Documentation: ICAM-MAP proceedings, paper in preparation

- **Testing new options of the mixing length** (added)

Realization: A new computation of mixing length using Ayotte-Tudor method for computation of PBL height was introduced and tested in parallel suite. This modification changes the results only in typical winter situations with the blocking effect of the mountains when improvement of temperature and wind scores at the top of PBL (850hPa) are obtained. Unfortunately temperature below becomes colder.
Efforts: 1.75 person x month (3 weeks stay at CHMI, fund MFSTEP)
Contributor: R. Brožkova (Cz), J. Cedilnik (Si)
Documentation: report from the stay, web, CHMI parallel suit results,

- **Evaluation of ALARO at grey zone resolutions**

Realization: It was decided to code new schemes first and evaluation follows after.

- **Model application and validation in the nowcasting range (INCA)**

Remark: This is not a physics topic per se but can provide a lot of information on model performance, relevant for ongoing and future physics developments.
Realization:
The analysis and nowcasting system INCA uses ALADIN forecasts as a basis for improved forecasts issued on a high temporal frequency (15 minutes for precipitation, 1 hour for other fields) and high spatial resolution (1km grid mesh). For temperature, humidity and wind 3D ALADIN forecast fields serve as a background on which corrections derived from comparison with observations are superimposed. In the case of precipitation and cloudiness, the forecasts obtained by extrapolation methods is merged asymptotically with the ALADIN precipitation forecast.
Contributor: Austria team
Documentation: Integrated Nowcasting through Comprehensive Analysis (INCA): System overview

3 Summary of means

The following table is a short overview of the work done on the field of physics. All together 17 scientists contributed to 39 working months, 10 from this are work on INCA.

Table 1: Overview of the effort in 2005.

Topic	**Realized effort** (person x month)	**LACE support**
PBL cloudiness	1	-
Prognostic cloud water	2.5	4 p x w
Parameterization schemes, diagnostic tools: turbulence radiation convection diagnostic tool DDH	 4 5 3 2	 2 p x w 8 p x w 1 p x w 6 p x w
Externalized surface	2	-
Validation, case studies, sensitivity studies INCA	9 10*	-
Total	**38.5 p x m**	**21 p x w**

*The Austrian NWP group focus strongly on the analysis and nowcasting system INCA, which is based on ALADIN fields and provides frequently updated analyses based on station observations and remote sensing data, so one can count it as a downstream application of ALADIN. Estimated effort on INCA is 30 person months for 2005, part is counted as research connected to physics topics.

List of workshops in 2005 with participants from LACE countries:
ALADIN workshop, Bratislava
AROME training, Poina Brasov
EWGLAM meeting, Ljubljana
HIRLAM-ALADIN Mini-workshop on convection and cloud processes, Tartu
HIRLAM-ALADIN Mini-workshop on physics and diagnostics, Oslo

4 Presentation of the results

To get some additional impression of these developments, there are a few selected topics presented with some graphical material.

Parameterization of turbulence

A very first set-up of the prognostic TKE scheme was available in the beginning of 2006. The main idea is to add advection and vertical diffusion terms of turbulent kinetic energy (TKE) to the current scheme. Description of the method was sent to WGNE Blue Book
http://collaboration.cmc.ec.gc.ca/science/wgne/BlueBook/ .
This version was tested separately in a research e-suite in Prague in January 2006. The scores were neutral with a slight improvement in the PBL, which is considered as a good result given the freshness of the development (its tuning is very likely not definitive).

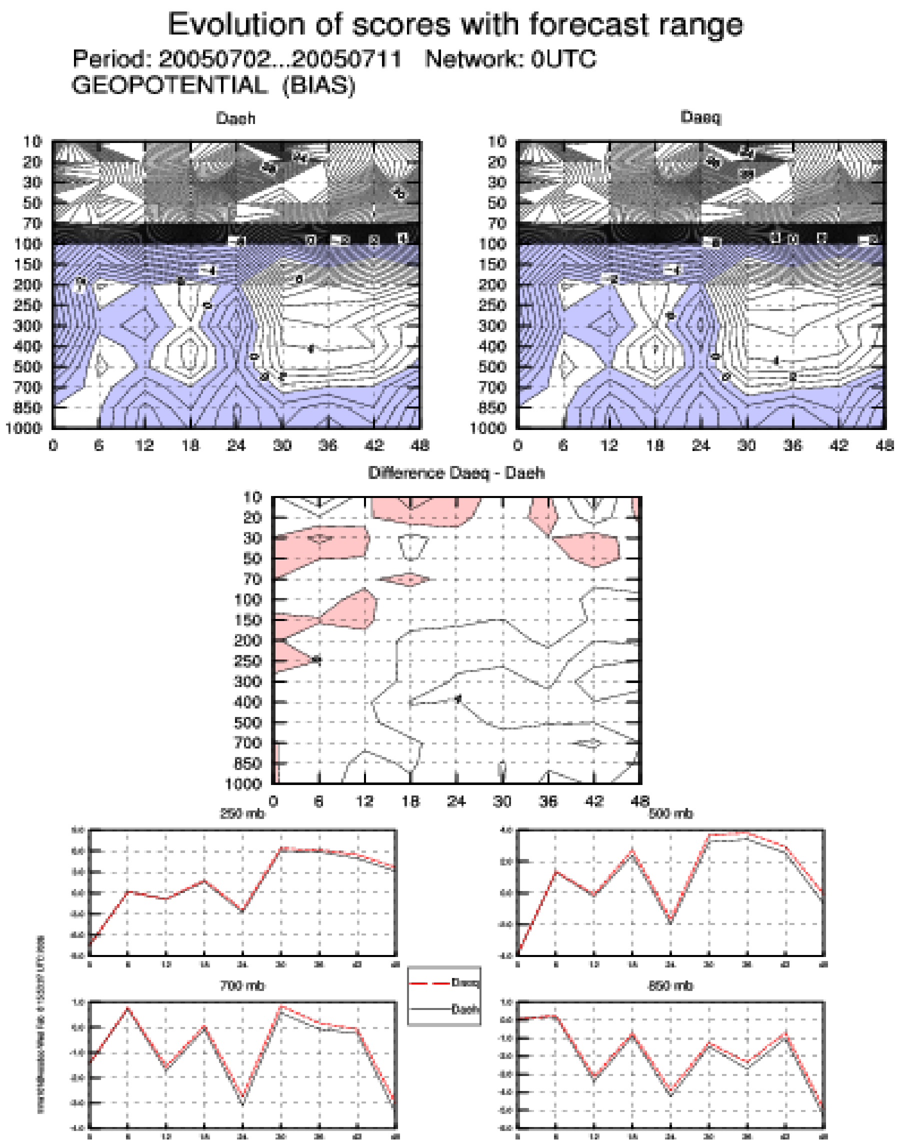


Figure 1: Statistical scores for geopotential on 10 days period. AEH (black lines) is the reference experiment (current CZ operational suite, run for a summer 2005 period), AEQ (red lines) is the test experiment with the described prognostic TKE scheme.

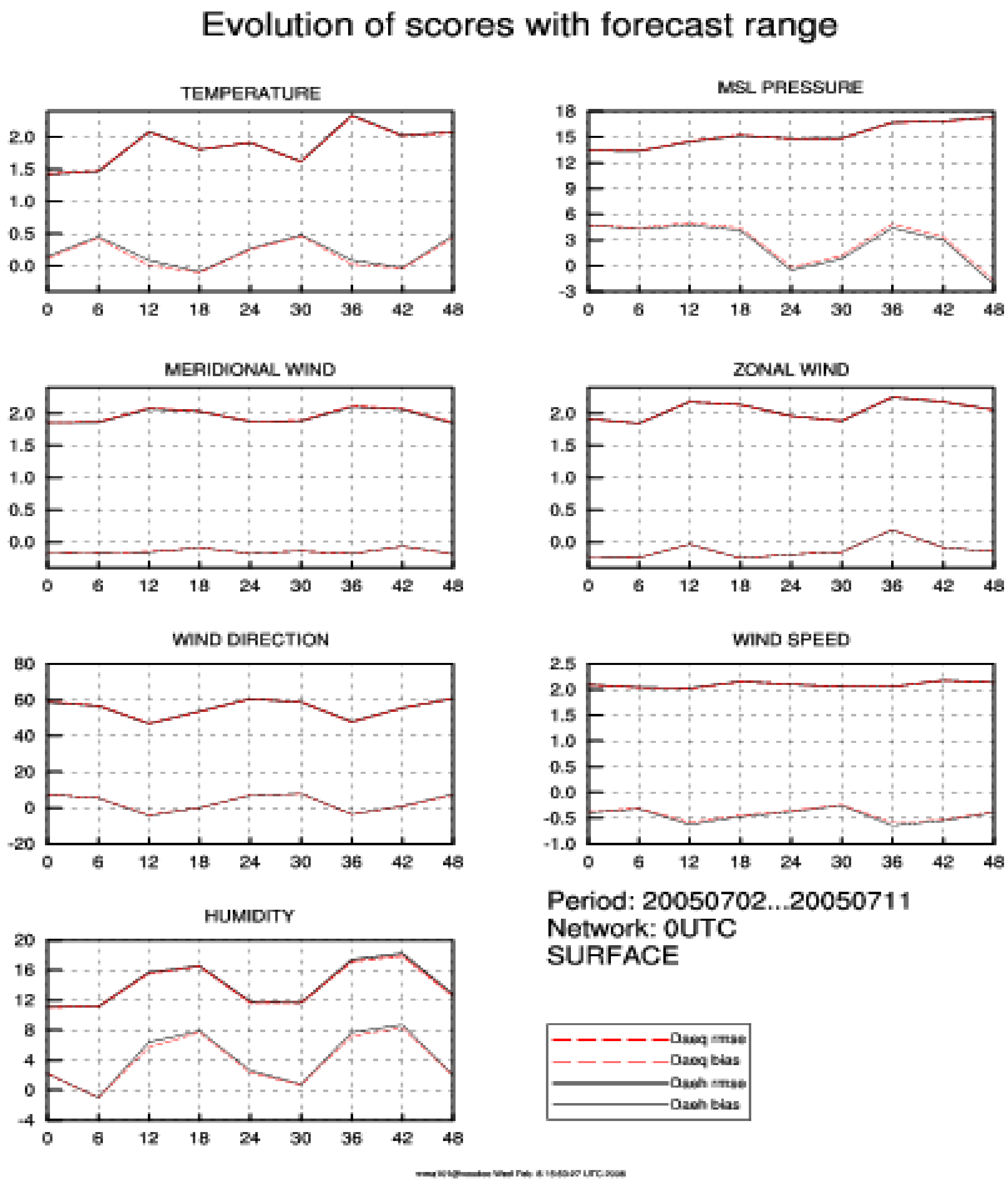


Figure 2: Statistical scores (BIAS and RMSE) for surface parameters on 10 days period. AEH (black lines) is the reference experiment (current CZ operational suite, run for a summer 2005 period), AEQ (red lines) is. the test experiment with prognostic TKE scheme.

New parameterization of cloud optical properties in the radiation scheme

An idealized cloud simulation model was created from which reference values for the new scheme were obtained. New scheme was first tested on some simple cases and results are very promising. To get some impression a few pictures are included. More of them can be found in the document.

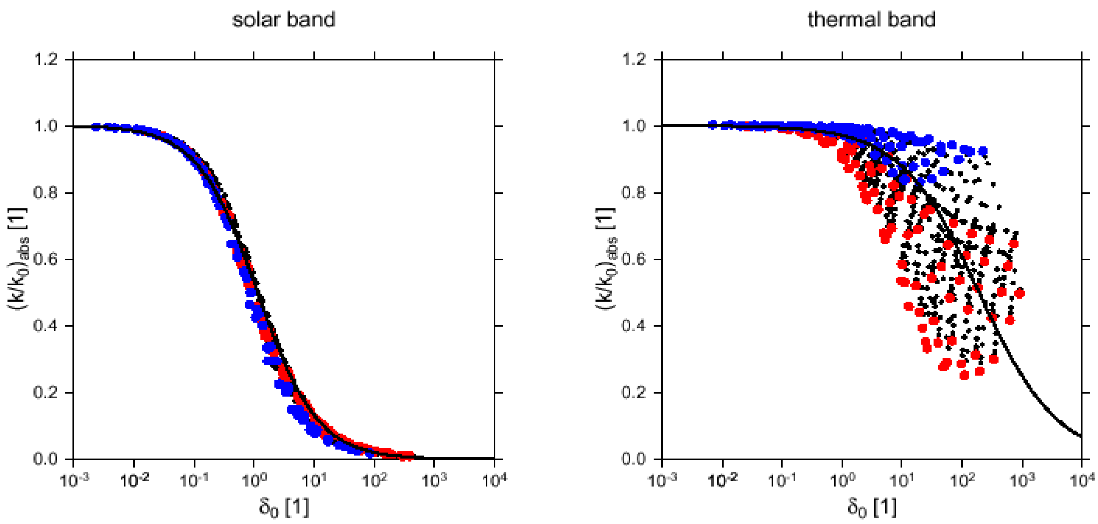


Figure 3: Dependency of saturation factors on unsaturated optical depth in solar band (left) and in thermal band (right). Sample for homogeneous clouds. Red dots – liquid clouds, blue dots – ice clouds, black dots – mixed clouds, black line – fitted dependencies.

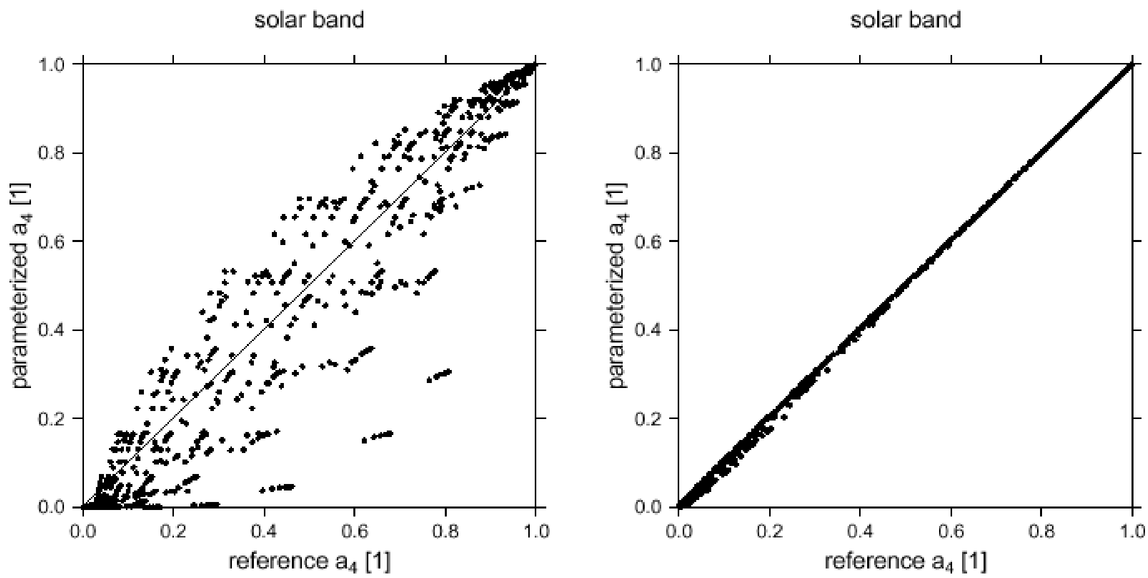
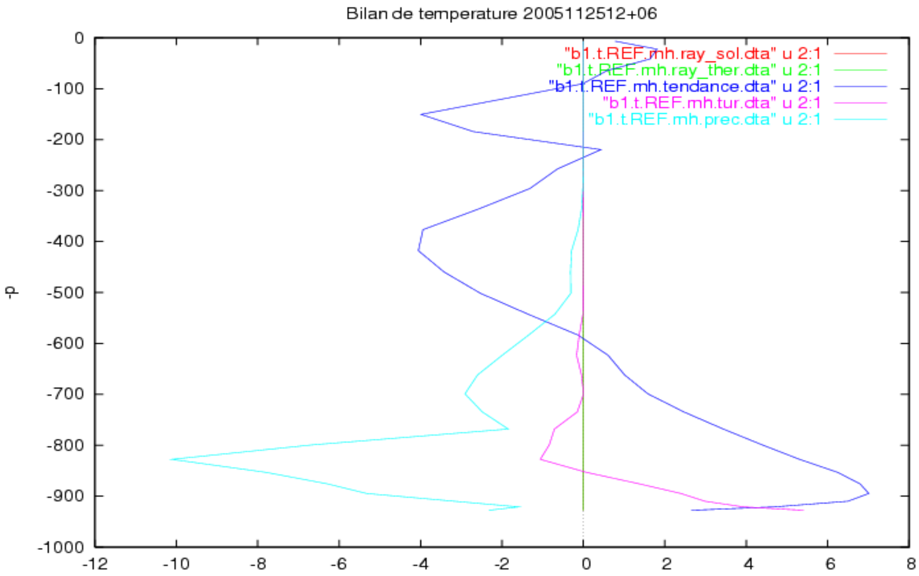


Figure 4: Parameterized versus reference cloud transmittance (a_4) for old scheme (left) and new scheme (right). Sample of homogeneous clouds, solar band.

A prognostic precipitation scheme

A prognostic precipitation scheme is still under development. There were only some initial tests performed with the preliminary version of the scheme with the purpose of trying to evaluate the impact on the model thermodynamics. DDH was used for evaluation tool for this purpose.



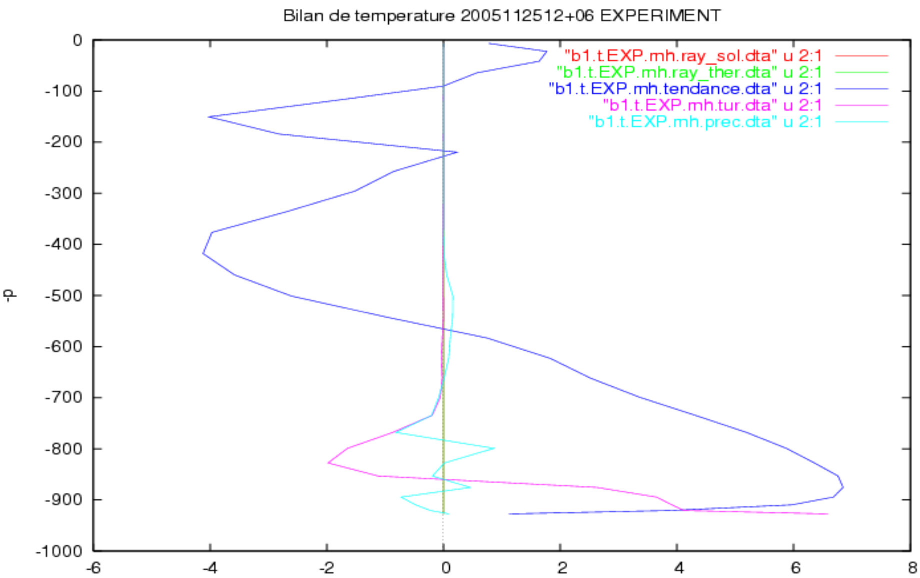


Figure 5: One example of DDH results of the new scheme's influence on temperature budget for current model version (top) and with the prognostic precipitation scheme (bottom). There is a slight change in the turbulence impact (magenta) and quite a difference in the impact of precipitation fluxes (cyan) in the lower troposphere.

Diffusion scheme in ISBA

A problem was detected at the points where ice water is present in the soil. In those gridpoints temperature in the first few levels decreases dramatically. With the proposed solution the problem was cured.

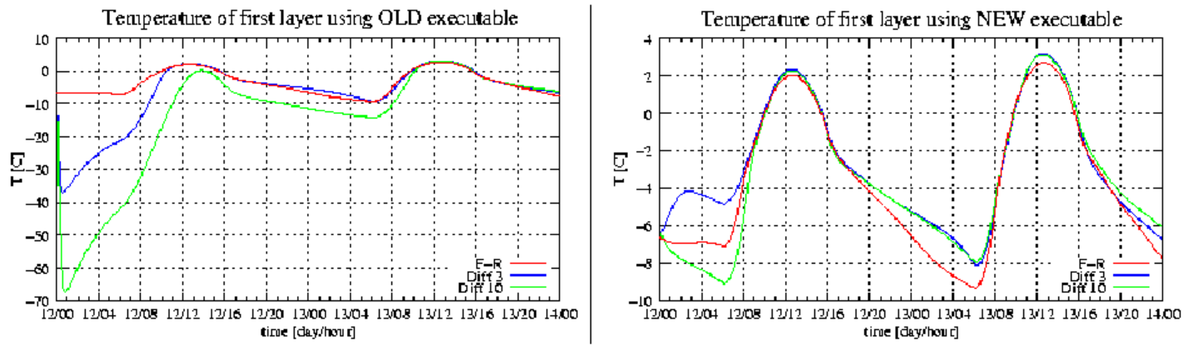


Figure 6: Time evolution of the first layer temperature for original (left) and modified (right) code.

Study of micro physics scheme

For a strong precipitation event in the Southern Alpine area in Austria during November 2000 a comparison between the operational precipitation scheme and the Lopez-scheme was made. A rather unrealistic precipitation pattern in some downwind areas, creating over pronounced upslope precipitation amounts and significantly underestimated amounts on the lee side (Gail valley, Drau valley and the Klagenfurt basin) can be noticed, while in the simulation with Lopez scheme precipitation fields are closer to reality and also the peak values in the upslope areas in Italy and Slovenia are reduced.

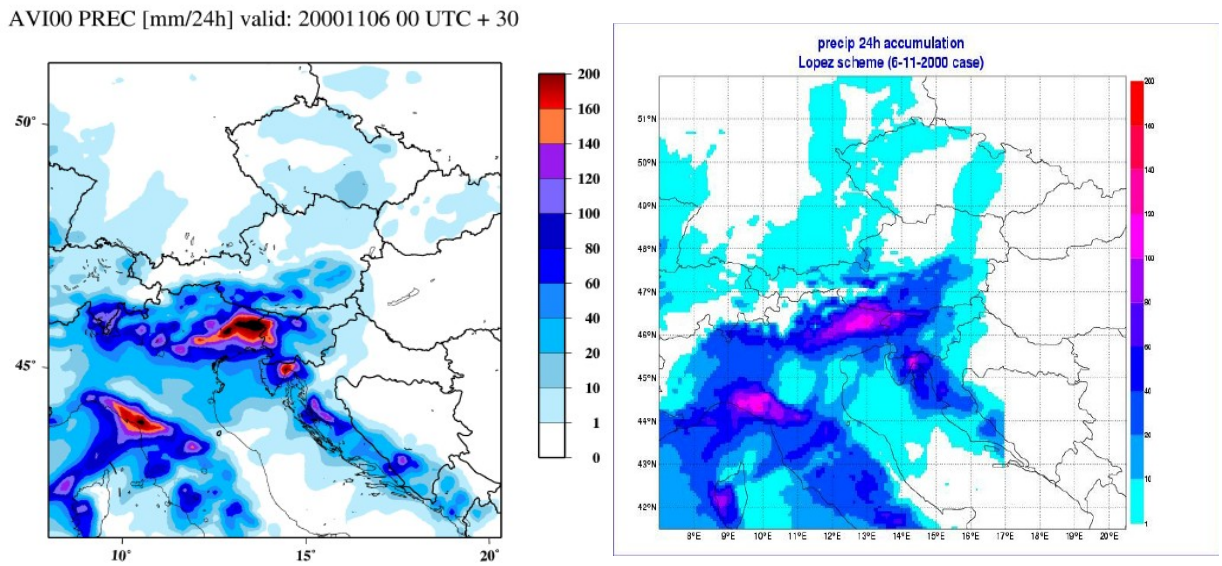


Figure 7: 24h precipitation forecast for the period 6.11.2000 06 – 7.11.2000 06 UTC operational scheme (left) and Lopez-scheme (right).

The analysis and nowcasting system INCA

Use of INCA/ALADIN in convective nowcasting (figure 8), in flood prediction (figure 9) and in snowfall prediction (e.g. for winter road maintenance) (figure 10) is presented.

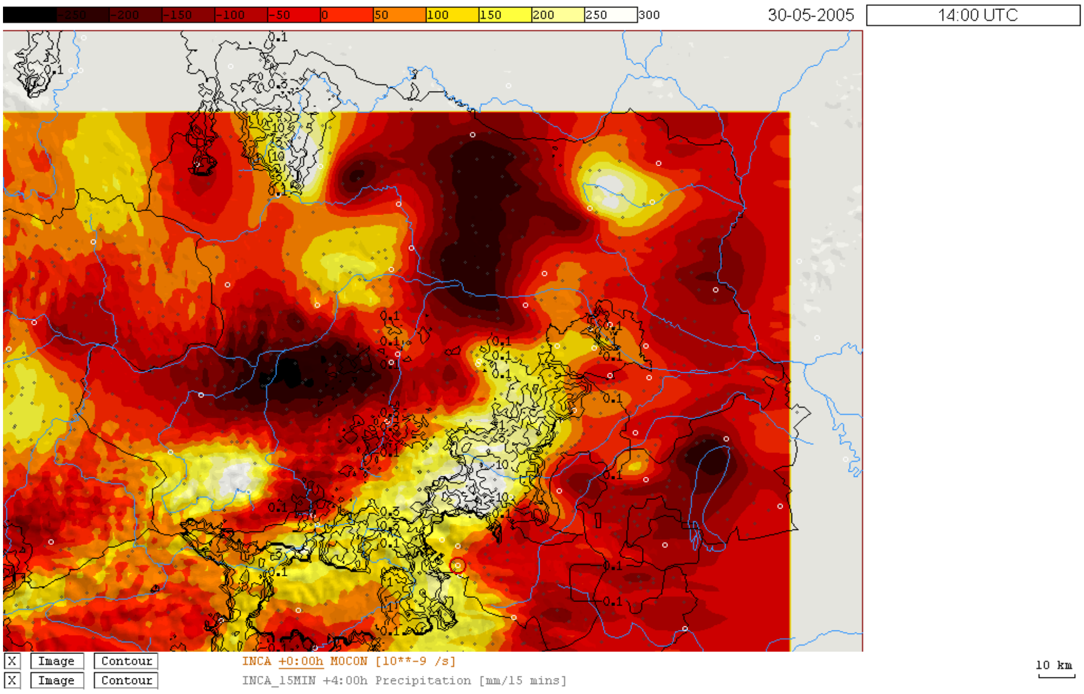


Figure 8: INCA moisture convergence based on ALADIN background + local surface observations on a convective day (30.5.2005, 12Z), shown in colors. Subsequent (14Z) precipitation activity due to newly triggered cells shown in black isolines. The figure illustrates that the INCA/ALADIN moisture convergence is a valuable predictor for +2 hr convective nowcasts.

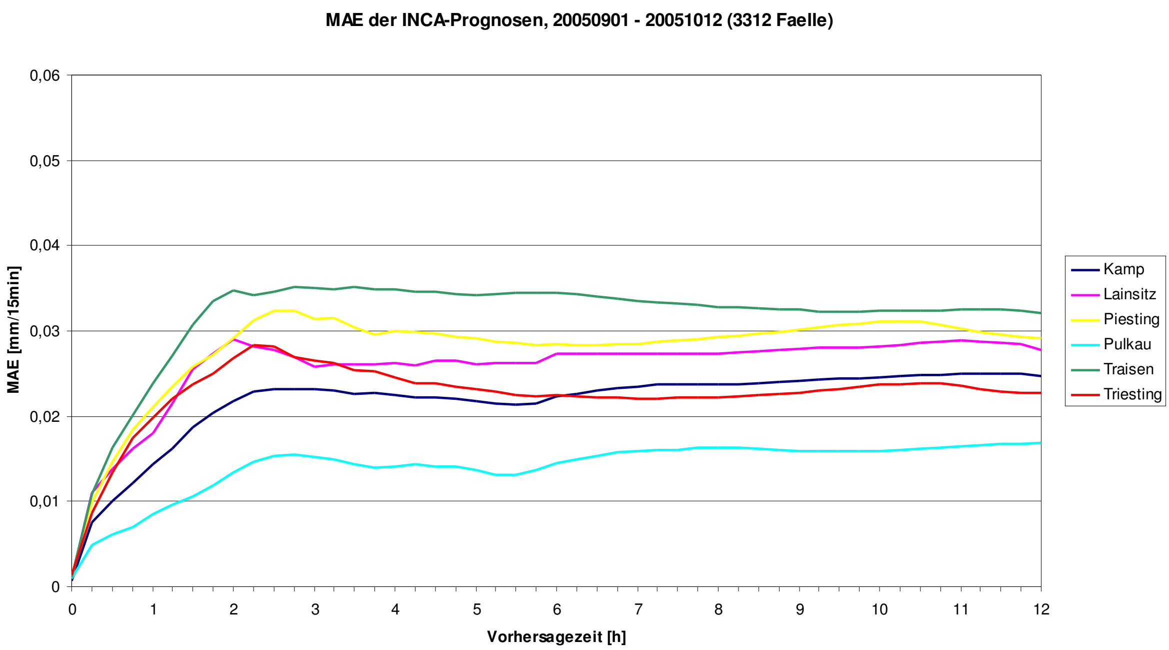


Figure 9: INCA precipitation forecast error as a function of lead time for different small catchments in Lower Austria. The beneficial effect of the nowcasting algorithm extends to ~2 hours.

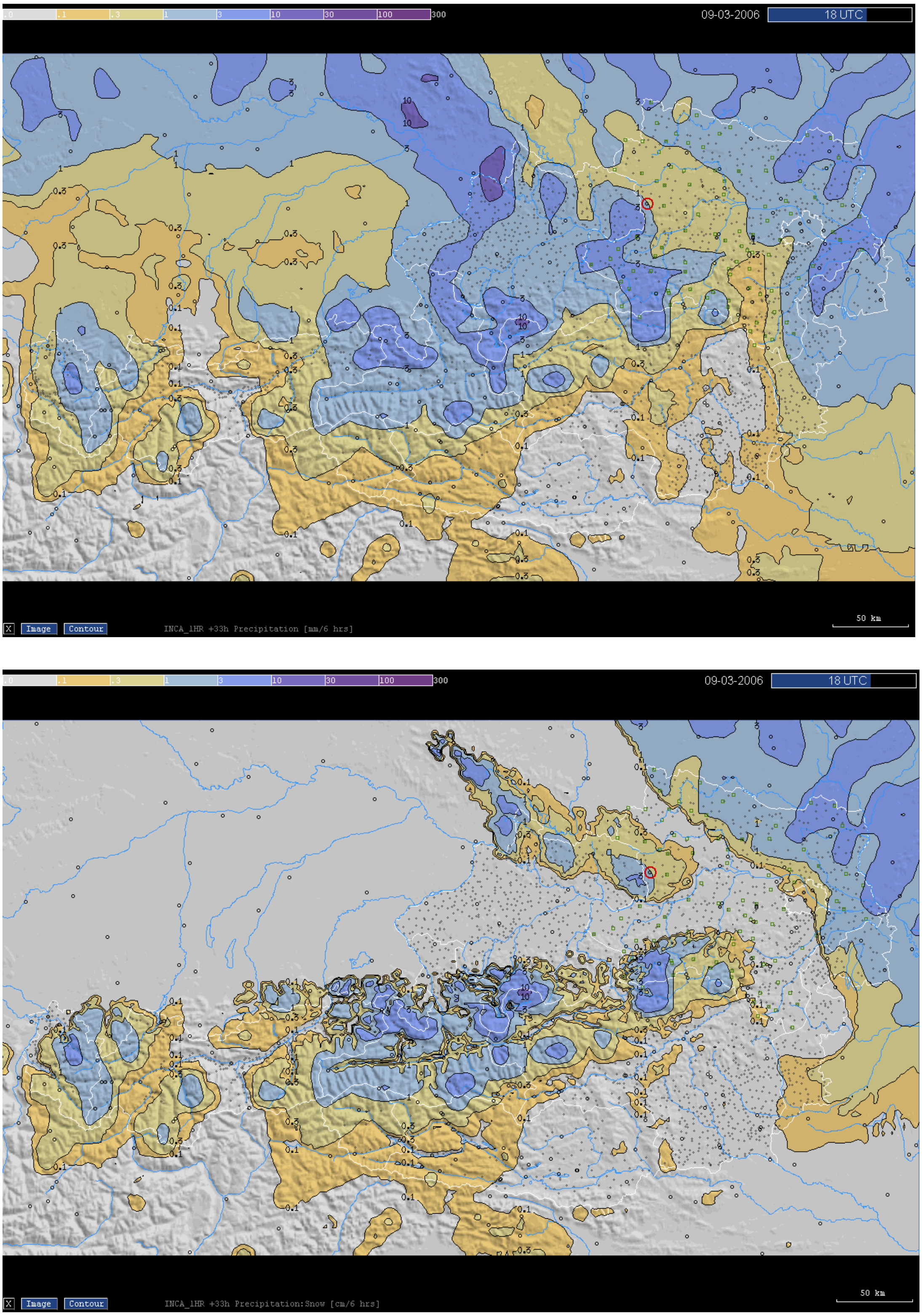


Figure 10: INCA +42h, 6-h total precipitation forecast (top) and snowfall part (bottom). The INCA forecast outside the nowcasting range is based on a linear combination of ALADIN and ECMWF forecasts. The computation of snowfall line is based on an externalized routine that takes into account temperature and humidity. The high-resolution INCA topography is used to identify areas above and below the predicted snowfall line.