# Operational ALARO configuration at scales around 5km mesh-size

Project summary
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Responsible Center: CHMI
Project duration: 2008-2010

## 1. Introduction

For the quality of the NWP model results the reliable description of the atmospheric processes is crucial (and most of them are considered through the physical parameterisation packages of the NWP models). The use of the ALARO-0 physical package (declared as ready to use in March 2008) has improved the model performance at the scales around 9 km. The next target was to provide good quality model forecasts at the scales around 5km mesh-size and still keeping in mind the constraint of reasonable amount of computational time. This is the main objective of the ALARO 5km project (2008-2010) which was approved by the LACE Council in 2008.
During the execution of the project the hardest task was to validate the treatment of deep convection inside the so called 3MT framework (this process is partly resolved and partly parameterized and is scale dependent). Also other schemes, such as description of radiation and turbulence, has been checked and improved. At the same time efforts were also devoted to the code stabilization, efficiency and modularization.

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The quality of model prediction has been clearly improved. The result is the first operational implementation at CHMI (4.7 km, 87 vertical levels, 25 October 2010), the next one is at ZAMG (4.8 km, 60 vertical levels, 1 March 2011). At EARS similar version and resolution is in regular daily computation, while in NMA Romania the operational model has resolution of 6.5 km mesh-size.

## 2. Results

<u>Description of physical process progressed substantially and now allows us to increase model horizontal resolution.</u>

We can follow this process through next examples.

The development and validation focused on deep convection (which is still not resolved at these scales). This can be illustrated with a convective summer case. On Figure 1 the difference between simulations using 3MT and previous convection scheme at two different model resolution (9.6 and 4.7 km) are shown. Concerning the structure of precipitation it can be noted that with the 3MT scheme precipitation patterns at both resolutions are more realistic. Unfortunately computer resource limitations does not allow us yet to run model configurations at 2.5 km, so the duplication of the horizontal resolution would not be possible without investment into the further development of 3MT.

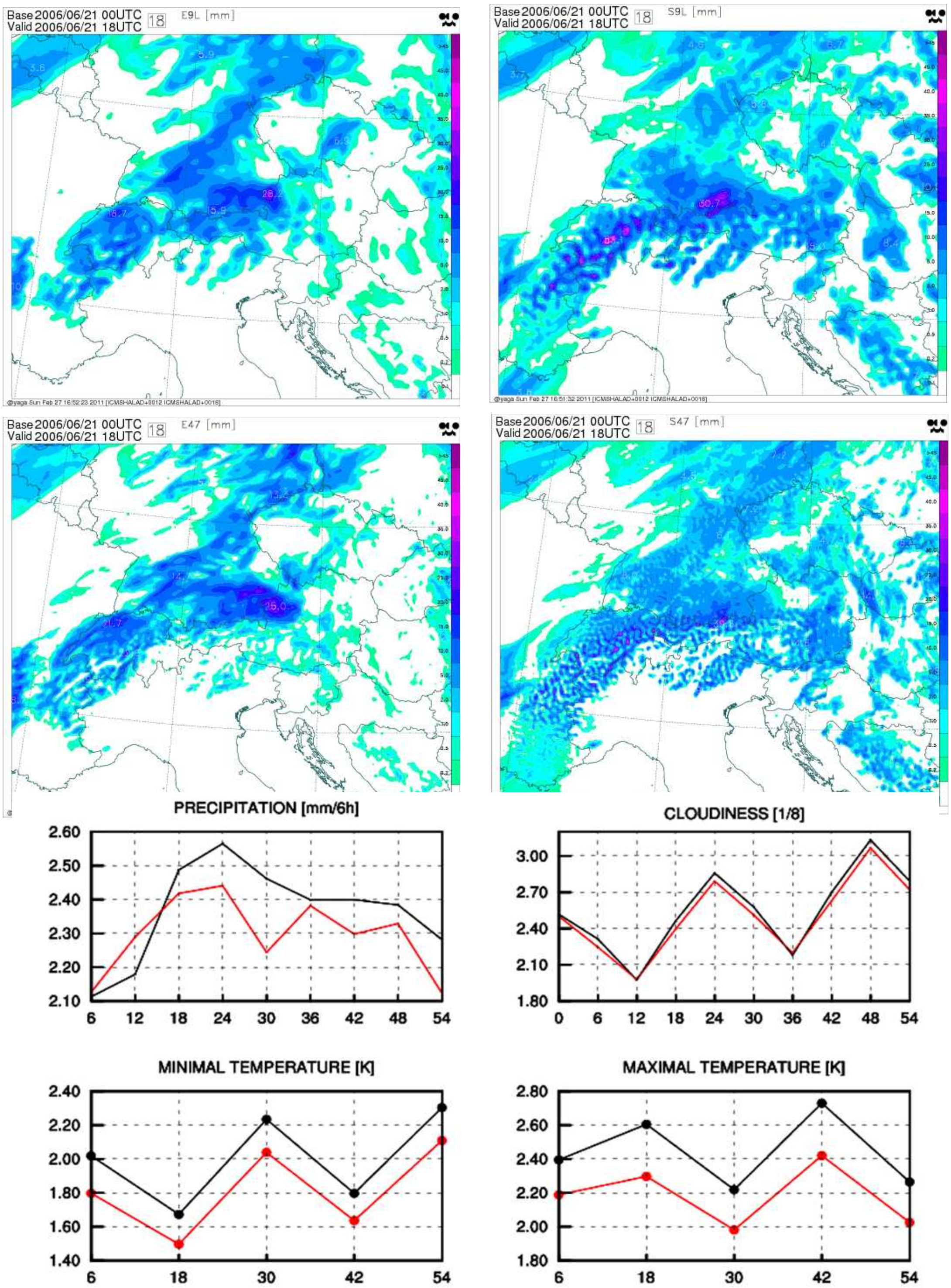


Figure 1: 6h precipitation for the 21 June 2006 obtained with current model version (at CHMI) at 9.8 km (top left) and 4.7 km (bottom left); with model version using previous

convection scheme at 9.8 km (top right) and 4.7 km (bottom right).

The change in horizontal and vertical resolutions improved most of the verification scores (verification scores from CHMI validation can be seen on figure 2). SAL verification method for precipitation gives significantly better structure score and a slight improvement of quantitative precipitation.
Figure 2: Verification scores (standard deviation) from the CHMI e-suite, comparison of forecasts at 9.6 km (black) and 4.7 km (red) for period between 26 August and 20 September 2010.

During winter time very often the situation with low stratus cloudiness appears over the flatlands in Central Europe and it is usually quite difficult to be captured by the model. Comparison among operational forecasts available on www.rclace.eu (few are presented on Figure 3) clearly show capabilities of different model configurations.
ALARO physics together with increased vertical resolution perform well and it is foreseen that with the TOUCANS scheme the problem of low stratus over sea will be represented better.

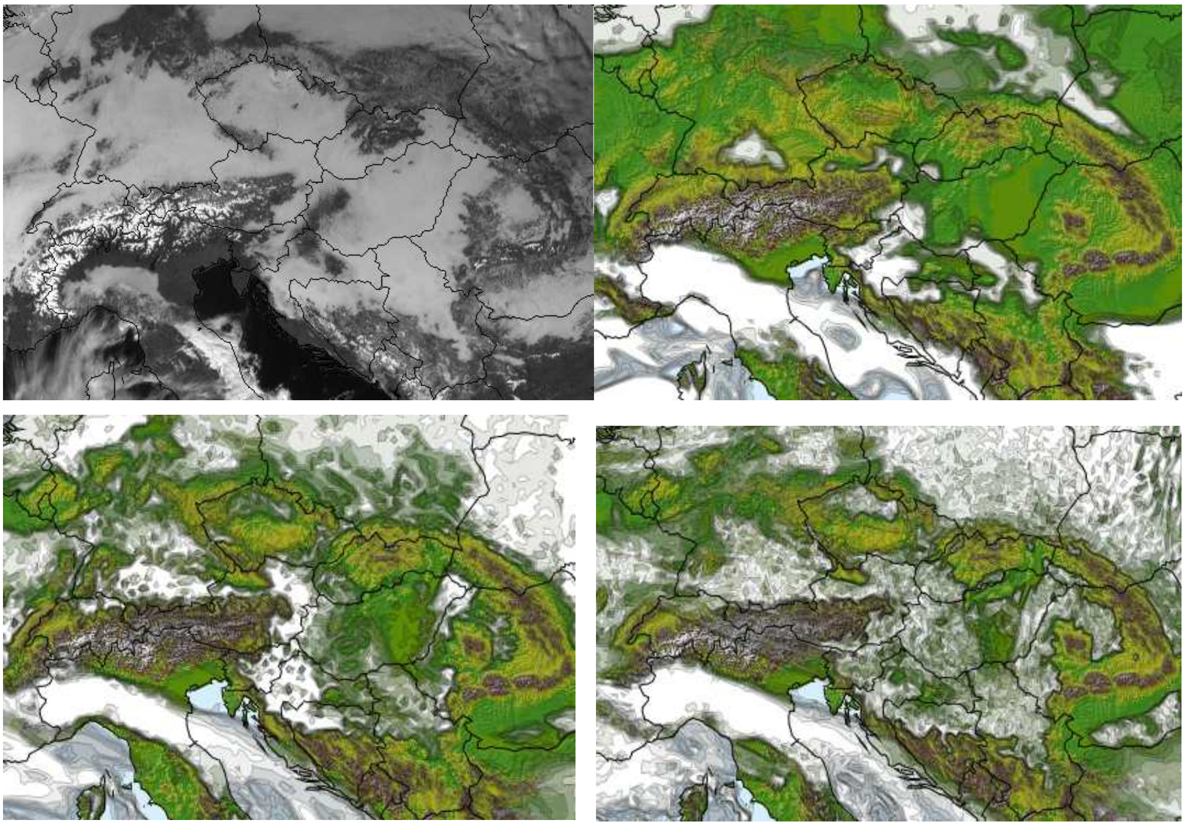

Figure 3: Total cloudiness at 31 January 2011 12UTC, satellite image in visible channel (top left), forecast without ALARO physics (top right), forecast using ALARO physics at 9.6 km (bottom left) and 4.7 km (bottom right).

Better model forecasts are also of great value for the issuing of warnings for severe weather events.
For example, forecasters in Slovenia found the ALADIN forecasts very good in two severe bora wind events and one flood case in the year 2010.
In September 2007 the exceptional rainfall event occurred in west part of Slovenia and caused flash floods. On Figure 4 it can be seen how the model forecast improved in the last years (24h precipitation from the operational model at that time is presented with the one provided by the current setup at the Slovenian Meteorological Service). Distribution and

amount of precipitation are better, however there is still space for improvements. Although this case is not really simple from the models' point of view (due to fact that the quasi-stationary prefrontal convection bands can be localized only with some limitations), the opinion of operational forecasters was that already a spatially more correctly placed signal for precipitation is very valuable (in spite of the fact that only 80mm/24h precipitation was simulated instead of the measured 485mm).

*On Figure 4 it can be seen how the model forecast improved in the last years (24h precipitation from the operational model at that time is presented with the current setup at Slovenian meteorological Service). Distribution and amounts of precipitation are better, on the other hand there is still place for improvements. Although this case is not easy to depict with models due to fact that bands of quasi-stationary prefrontal convection were responsible for locally up to 485mm of rain within 12 hours (model peaks up to 80 mm/24h) the opinion of operational forecasters is that already a spatially more correctly placed signal for precipitation is very valuable.*

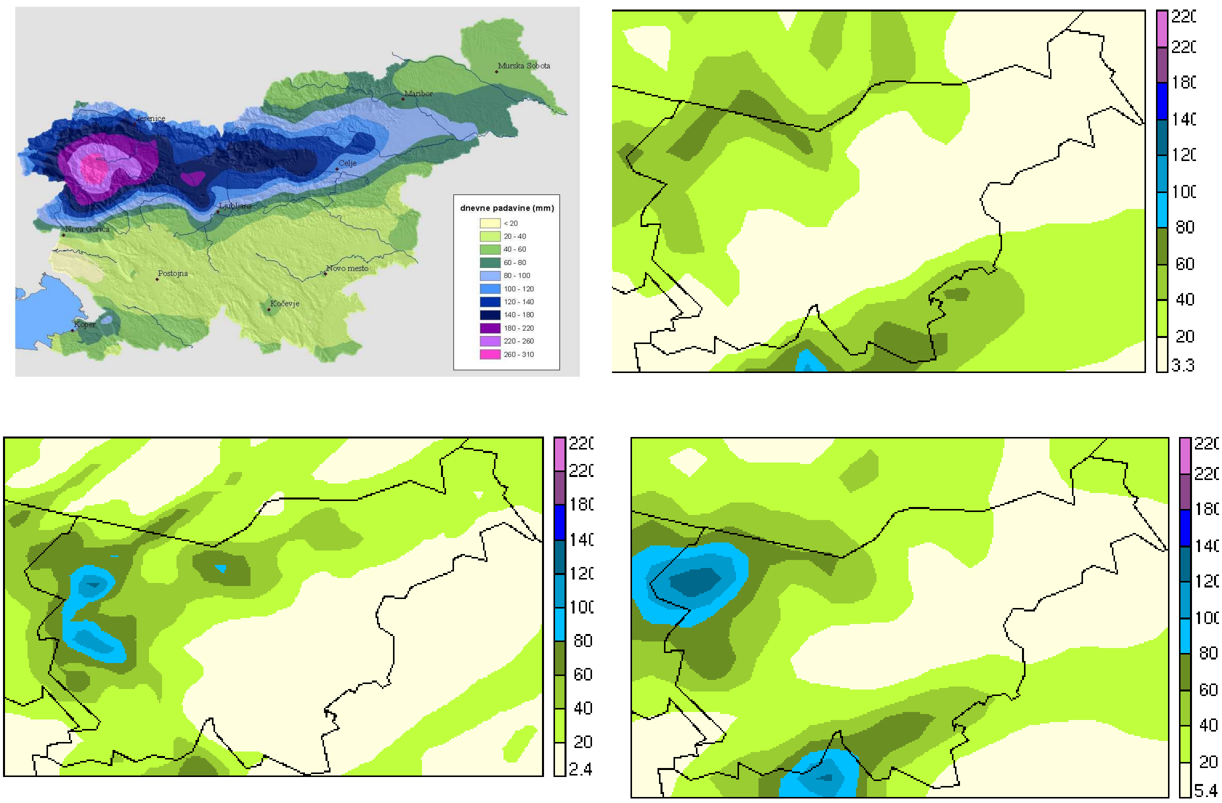


Figure 4: 24h precipitation for the 18 September 2007, analyses (top left), forecast at that time (top right), current model version at 4.4 km (bottom left) and 9.6 km (bottom right).

## 3. Project results/deliverables corresponding to the scientific/working Plan

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### *3.1 Research - development of the schemes*

#### *3.1.1 Turbulence scheme*

During the work on further sophistication of the current turbulence scheme several approaches have been tested. The outcome of this work is the scheme named TOUCANS (Third Order moments Unified Condensation-Accounting and N-dependent Solver) with many theory novelties inside. Its main characteristics are the more consistent computations of vertical and horizontal exchange coefficients, distinction between momentum and heat, anisotropy effects and introduction of the parameterization of third order momentum effects and its impact on PBL. Various formulations of the 'moist' mixing length computation have been prepared. The way how to include moist effect is also considered. At the moment all parts are coded and the scheme is ready for validation.
Deliverables: implementation into the ALADIN code (some parts), documentation, PhD thesis, publication.

*3.1.2 Radiation scheme*

The current radiation scheme with a low computational cost has been improved. The new fits of gaseous broad band transmission functions for thermal band are available, in the computation of optical depths for composite of gases additional terms are added, the usage of 6 different aerosol types, apart from a single standard one, is also available. The optical properties of continental, maritime, desert, urban, volcanic and stratospheric aerosol types are accounted for in both thermal and solar bands.
**Deliverables**: implementation into the ALADIN code (some parts)

*3.1.3 Cloudiness scheme*

Based on the work on the sophistication of various parameterization schemes we obtained the message that an unified cloud scheme is needed and has big importance. The first step into this direction is the computation of a 'shallow convective cloud cover' needed for simulation of the moist turbulence.
The model verification outcome was a need for the improvement of the cloudiness forecast Additional option in cloudiness diagnostics for total, low, medium, high (and convective) cloud cover routine is now available and with its use the cloudiness distribution has been improved.
**Deliverables**: implementation into the ALADIN code (some parts), documentation.

### *3.2 Scientific maintenance*

In order to have well organized code the 3MT code was checked and cleaned, routine with radiation computation has been modularized and optimized. Discovered bugs in the code were reported and corrected. Validated code was phased into the ALADIN code cy36t1.
Regular model evaluation showed the strengths and weaknesses of the model performance. The need for the better description of PBL processes was confirmed so more effort was put to the development of TOUCANS. Validation also showed that radiation should be rechecked. It is important to diagnose the screen level parameters (2m temperature and humidity) and many related studies were realized. For the precipitation verification new methods were implemented (SAL). The attempt to improve diurnal cycle of convection with the use of 'prognostic' entrainment has not been successful yet. Nevertheless the cleaned code brings new chances to obtain better results.
The scientific and technical maintenance capacity inside LACE countries is concentrated in a group of few persons and would be desirable to enlarge it.

**Deliverables**: implementation into the ALADIN code, documentation, publication, ALARO-1 working days.

### *3.3 Operational implementation*

The model configuration with 4.7 km horizontal resolution and with double vertical resolution (87 model levels) has been prepared and tested at CHMI. At this resolution the model still uses hydrostatic dynamics. The quality of model is acceptable so the first operational implementation at CHMI started on 25 October 2010 and the second one at ZAMG (4.8 km 60 vertical levels) started on 1 Marc 2011. At EARS model with resolution 4.4 km is in regular daily computations, in NMA Romania the operational model has now the resolution of 6.5 km (9 February 2010) and in SHMU new model setup with resolution around 5 km is under preparation.
Guidance and recommendations for the users are under preparation.

**Deliverables**: operational implementation, documentation.

## 4. Related documentations and publications during 2008-2010

Scientific papers:
Geleyn, J.-F., B. Catry, Y. Bouteloup and R. Brožková, 2008: A statistical approach for sedimentation inside a micro-physical precipitation scheme , Tellus A, Volume 60 Issue 4, pp 649-662.
Gerard, L., J.-M. Piriou, R. Brožkova, J.-F. Geleyn, D. Banciu, 2009: Cloud and precipitation parameterization in a meso-gamma scale operational weather rediction model , Monthly Weather Review, Volume 137 Issue 11, pp 3960-3977.
J.-F. Geleyn, M. Vanandruel, I. Bašták, D. Degrauwe, F. Váña, 2010: An alternative method for handling the interactions between turbulence and phase changes, The Working Group on Numerical Experimentation (WGNE) Blue Book, 4-03.
Wittmann, C., Haiden, T., and Kann, A., 2010: Evaluating multi-scale precipitation forecasts using high resolution analysis, Adv. Sci. Res., 4, 89-98, doi:10.5194/asr-4-89-2010, http://www.adv-sci-res.net/4/89/2010/.

PhD Thesis:
Ivan Bašták Ďurán: Turbulent scheme eTKE, 4. September 2009.

Documents, reports:
Doina Banciu, 2009: Convection diurnal cycle and prognostic entrainment in the ALARO framework , report from stay 17 August - 25 September 2009 in Prague.
Ivan Bašták Ďurán, 2009: eTKE scheme and preparations for TOMs , stays 17 February - 13 March, 17 August - 12 September, 4-27 November in Prague.
Nuno Lopez, 2008: Verification of ALARO 3MT on 4.4km resolution , report from stay 13 October - 7 November 2008 in Ljubljana.
Neva Pristov, Christoph Wittmann, 2008: An overview of the namelist settings in ALARO.
Lora Taseva, Neva Pristov, Jure Cedilnik, 2009: Sensitivity/Validation of the operational ALADIN model in Slovenia (ALADIN_SI) & Some preliminary results from the local implementation of CANARI snow analysis scheme in the ALADIN_SI , Appendix , ALADIN-FR/LACE stay at the EARS, Slovenia, 15 November - 12 December 2009.
Christoph Wittmann, 2009: Evaluation of ALARO-0 5km over Madeira , ALADIN-FR/LACE stay at the Institute for Meteorology (IM), Portugal, October 2009.
Christoph Wittmann, 2009: Near Maximum Overlap Version for ACNPART.
Christoph Wittmann, 2010: Evaluation of ALARO-5km near surface parameters over Austria with special emphasis on 2m temperature.
Christoph Wittmann, 2010: Evaluating different options for screening level diagnostics within

ALADIN/ALARO, ALADIN-FR/LACE stay at the Institute for Meteorology (IM), Portugal, October 2010.

Presentations:
Radmila Brožková: Time-steps consistency aspects of 3MT, The 18th ALADIN and HIRLAM Workshop , Bruxelles, 7-10 April 2008.
Radmila Brožková: ALARO physics; development of 3MT, 30th EWGLAM and 15th SRNWP Meetings , 6-9 October 2008, Madrid.
Ivan Bašták Ďurán : From ’p-TKE’ to ’e-TKE’: suppressing restrictive conditions, validating the extension of the ALARO-0 approach and exploring links with other methods.
Ivan Bašták Ďurán, Jean-François Geleyn, Filip Váňa: TOUCANS : An attempt at synthesising new findings in turbulence + diffusion over the past 10 years, The 20th ALADIN and HIRLAM Workshop, Crakow, 13-16 April 2010.
Tomas Kral : Revitalization of gaseous transmission functions in ACRANEB radiation scheme utilizing RRTM database, The 19th ALADIN and HIRLAM Workshop , Utrecht, 12-15 May 2009
Neva Pristov: ALARO physics developments, 31st EWGLAM and 16th SRNWP Annual Meetings,28 September -1 October 2009, Athens, Greece.
Neva Pristov: ALARO physics developments, 32nd EWGLAM and 17th SRNWP Annual Meetings, 4-7 October 2010, Exeter, Great Britain.

ALARO-1 Working days (Budapest, 16-19 February 2010) were organized by the ALADIN PM, the Area Leader for Physics of RC LACE and hosted by the Hungarian Meteorological Service. 25 participants from 13 countries (ALADIN, LACE, HIRLAM consortia and Russia) came together to spread the knowledge about the ALARO, to discuss and start actions for further developments.

## 5. Project team

LACE scientists: Doina Banciu (Ro), Ivan Bašták Ďurán (Sk), Radmila Brožková (Cz), Tomas Kral (Cz), Jan Mašek (Sk), Mirela Pietrisi (Ro), Neva Pristov (Si), Filip Váňa (Cz), Christoph Wittman (At), Mark Žagar (Si)
Other ALADIN scientists (ALADIN visits to LACE counties): Nuno Lopez (Pt), Joao Rio (Pt), Lora Taseva (Bg), Martin Vanandruel (student), Bart Catry (Be), Jean-François Geleyn (Fr), Luc Gerard (Be), Meral Sezer (Tr), Jadwiga Woyciechowska (Pl)

## 6. Summary of resources/means in person /month

**2008:**

| 2008 | Planed in 2008 | Executed |
|---|---|---|
| LACE funding | 3.5 | 3.5 |
| total | 15.5 | 19 |

**2009:**

| 2009 | Planed in 2008 | Executed |
|---|---|---|
| LACE funding | 2.5 | 5.5 |
| total | 28 | 28.25 |

**2010:**

| 2010 | Planed in 2009 | Executed |
|---|---|---|

| | | |
|---|---|---|
| LACE funding | 4 | 2.5 |
| total | 10 | 13 |

**Summary (2008-2010):**

| 2008-2010 | Planed in 2008 | Executed |
|---|---|---|
| LACE funding | 10 | 11.5 |
| total | 53.5 | 60.25 |

## 7. Conclusions and outlook

The main goal of the project to have good quality model forecasts at the scales around 5 km mesh size has been achieved. The concept of scale-independent ALARO physics has been confirmed for scales between 4 and 10 km. Research and development continue with the aim to increase the model resolution even to resolutions of kilometric scale. The system is very efficient and is available to all members. At the same time more scientific and technical knowledge have been gained.