LACE Working Group for Physics

Report 2006

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Contents

1 Introduction

In this document a summary of the work realized in the field of physics in 2006 is presented, following the structure of the research plan.
Main developments were made inside the radiation and turbulence scheme. A lot of effort was made for including all the developments into the base-line code ALARO-0, bearing in mind the computational efficiency and modular code structure. Here it can be pointed out (among others) that new prognostic variables (TKE, hydrometeors) have been included and that a way of describing the water cycle, where the interaction between the various parameterisations' takes place, is neither fully parallel nor fully sequential.

2 Research topics

An overview of the research and development is presented. For developments started already in 2005, only the description of what has been done this year is included. More details can be found in documents with report for 2005 and plan for 2006. One new topic is included, namely computation of mixing length.

2.1 PBL cloudiness

- **Stratus prediction**

The Seidl-Kann cloudiness scheme has been implemented into cy29t2. Scheme is working well, threshold values has been tuned. Studies on some fog/low stratus cases from autumn 2005 have been performed with this model version (using Lopez microphysics) in the frame of COST722 project. Inter-comparison among a few other 3D model simulations will be part of the final report. It can be pointed out that some realistic maps of horizontal visibility has been obtained.
Incorporation of liquid water into the scheme has been postponed and is planed for the next cycle with ALARO-0 developments.

Efforts: 1 person x month, local work
Contributors: A. Kann (At), H. Seidl (At)
Status: ongoing
Documentation: planed for ALADIN Newsletter 32, final report of COST722 project (in preparation)

2.2 Prognostic cloud water

A prognostic precipitation scheme in ALARO-0 (prognostic precipitating water and ice, use of the pseudo-fluxes between 5 water species, collection, statistical treatment of the

sedimentation process for precipitation, parameterization of Wegener-Bergeron-Findeisen process) was available end of September. Tuning of the scheme and study of the behavior in various resolutions has started already at the end of 2005 when scheme was still unstable. Validation continued in October, some tests were repeated and few more were added. Precipitation fields obtained with new scheme are much smoother with lower extremes and better distribution. Sensitivity tests for the Wegener-Bergeron-Findeisen autoconversion in a case with mixed rain/snow event showed that scheme is well tuned. Prognostic cloud condensates produced by the micro-physics compared to ones produced by cloudiness scheme are of the same order of magnitude. Stratiform precipitation fluxes in new and old schemes have similar vertical distribution and the values are very similar throughout the entire integration period.

Efforts: 1 person x month local work, LACE stay in Ljubljana (2.10.-14.10.)
Contributors: D. Drvar (Hr), J.Cedilnik (Si)
Status: completed
Documentation: LACE stay report available at www.rclace.eu

2.3 Parameterization schemes, diagnostic tools

- **Parametrization of turbulence**

Pseudo-prognostic TKE scheme, completed at the end previous year, has been coded into ALADIN cy29t2 and further evaluation has been done.
Efforts: 1 person x month local work
Contributors: F. Vana (Cz), R. Brožkova (Cz), J. Cedilnik (Si)
Status: completed, inside ALARO-0
Documentation: presentation at 16th ALADIN workshop, document on ACDIFUS_prog (www.rclace.eu)

New topic
A new formulation of mixing length representation has been prepared and tested. It is fitting better into pseudo-prognostic TKE scheme (for both K- and TKE part of computation). First part of the work (looking for appropriate formula) was done in single column model with data from GABLS2 experiment. This enabled to compare the scheme proposals with observations and with various parameterizations. Outcome is a proposed computation which is a merge of the previous empirical formula and of Bougeault-Lacarrere parameterization (used in AROME). In this way mixing length computation dependens on meteolological parameters and is very suitable for convective cases and mixed planetary boundary layer. Preliminary results on case studies show rather neutral impact on surface meteorological quantities (wind, mean sea level pressure). Differences can be observed rather on parameters, which are very sensitive on turbulent fluxes (e.g. on vertical profiles of diagnosed TKE, more production of TKE in areas of strong jets or

low static stability).

Efforts: 1.25 person x month, 4 weeks LACE stay in Prague
Contributors: A. Simon (Sk), F. Vana (Cz)
Status: completed
Documentation: LACE stay report available at www.rclace.eu

Work on the vertical discretization in the TKE scheme, mostly done already last year, has been completed. Further experiments with new version of 1D model (based on cy29t2) show that performance of half level or full level scheme do not differ so much.
Efforts: 0.5 person x month
Contributors: F. Vana (Cz)
Status: completed
Documentation: report available at www.rclace.eu

Studies were done to get an idea how important is advection of turbulent kinetic energy (TKE), at which scales is needed. A simple primitive equation model (COAMPS) was used to estimate the order of advection term and the entire right hand side (RHS) of the full TKE equation for resolutions 1, 2, 3, 6, 9, 18 and 27 km. Results show that the ratio of horizontal advection and RHS is significant (higher than 10%) at resolutions 1, 2 and 3 km.
A few cases were run with AROME at 2.5 km resolution with TKE advection either switched on or off. The impact is small, mostly noticed at distribution of wind field at the lower model levels.
Efforts: 1 person x month
Contributors: J. Cedilnik (Si)
Status: nearly completed
Documentation: report available soon

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

A new algorithm for cloud transmissivities and reflectivities (incorporating a multi-layer view of the saturation effect) developed in 2005 has been coded into ALADIN cy29t2 (AC_CLOUD_MODEL). Final treatment of cloud geometry and final form of Pade fits has been done, direct solar flux and surface albedo has been included into cloud simulation. Additional effort has been put to reach the optimization of the code.
Real case experiments revealed two problems. First problem was too strong backward scattering resulting in too high cloud albedo. After literature survey the problem was mitigated by rescaling of asymmetry factor. Second problem was too strong solar absorption peak around model level 20, leading to excessive heating of relatively thin layer of air around 400 hPa level during daytime. Introducing physically motivated

vertical dependency of solar saturation, which replaced old ad hoc treatment, diminish also this problem. The scheme should be now in final shape.
Efforts: 3 person x month, local work
Contributors: J. Mašek (Sk), R. Brožkova (Cz)
Status: completed, inside ALARO-0
Documentation: presentation at 16th ALADIN workshop

To diagnose temperature dependency of the gaseous transmission functions a ”reverse engineering” procedure has been developed. Report about current status has been written.
Efforts: 1.5 person x month, local work
Contributors: A. Trojakova (Cz)
Status: nearly completed, waiting
Documentation: status report available at www.rclace.eu

For a more accurate the thermal radiation computations some thermal exchange therms can not be neglected. To avoid of an unacceptable increase of computation time an approximate treatment of these additional terms was introduced. It can be shown, that the values are between two computations (one with maximum and one with minimum estimated optical thickness for the additional fluxes between layers). The best possible estimate can be defined statistically. Existing statistical method for the weighting function between max and min inter-layer gaseous exchange terms has been improved.
Efforts: 0.75 person x month, 3 weeks stay in Prague
Contributors: N. Pristov (Si)
Status: completed, inside ALARO-0
Documentation: not available yet

- **ALARO-0 version (turbulence, microphysics, precipitation, convection)**

Preparation of ALARO-0 base-line version was going on whole year. During the action in Brussels (begin of the year) pseudo-prognostic TKE scheme, mixing length computation using Ayotte PBL height and introduction of GFL fields for new prognostic/diagnostic variables (TKE, hydrometeors, cloud fraction for the updrafts/downdrafts, convective vertical velocity of the updraft/downdraft,...) has been included into cycle al29t2 and tested. Contributions from microphysics and convection have been also implemented (compilation was finally successful) but many problems stayed unsolved. Attention has been put to respect interfacing rules and barycentric equations, to harmonize switches with IFS/ARPEGE. Routines should produce fluxes or their updates and they can be re-used in other contexts. In April phasing and cleaning continued in Prague when clean basis to include moist physics has been obtained. New developments in radiation part (cloud optical properties, more complex statistical method for the weighting function) and revised method for statistical sedimentation of precipitation has been included (end of June). Code has been prepared to validate microphysics without convection part (3MT

developments). Microphysics routines are called in prognostic precipitation calculation and later when convection part is ready microphysics processes will be split. In the second half of the year main effort has been put to 3MT part, its structure inside APLPAR. Corrections of negative humidity and water species, which may occur within advection, has been introduced. A parameterization of Wegener-Bergeron-Findeisen process and a diagnostic type of a graupel effect parameterization is included into microphysics scheme
In September Martin Bellus phased the ALARO-0 including the 3MT skeleton in APLPAR into cycle 31T1.
After numerous intermediate suites and the e-suite for a winter period (November 2006) and summer period (June-July 2006) the first stable version of ALARO-0 (without 3MT) within cycle 29T2 is available and is already used in operational service in Prague since the end of January 2007.

Efforts: 8 person x month,action in Brussels, local work, LACE stay in Prague, stay in Toulouse
Contributors: M. Tudor (Hr), J. Cedilnik (Si), R. Brožkova (Cz), M. Janoušek (Cz), M.Belluš (Sk), *L. Gerard (Be), B. Carty (Be), D. Banciu (Ro), J.-F. Geleyn, K. Essaouain (Ma)*
Status: ongoing
Documentation: ALARO-0 document (www.lace.eu), presentations at 16th ALADIN workshop

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

The DDH (Diagnostic par Domaines Horizontaux) diagnostic package has been extended to the AROME model. Some modifications in budgets outputs have been needed in order to obtain all possible fluxes inside AROME physics packet. Instruction for users has been written.

Efforts: 2.5 person x month, stay in Toulouse (Meteo-France support), local work
Contributor: T. Kovačić (Hr); supervisor J.-M. Piriou
Status: completed
Documentation: DDH for AROME (description,www.rclace.eu)), presentation at 16th ALADIN workshop

2.4 Externalized surface

- **Diffusion scheme in surface**

For a detailed analysis of diffusion scheme in ISBA model version cy30 has been installed and tested. AROME with diffusion scheme technically works within this cycle. Due to other duties behavior of diffussion scheme was not studied.

Effort: 0.25 person x month
Contributors: L. Kullmann (Hu)
Status: postponed

2.5 Validation, case studies, sensitivity studies

- **Evaluation of parameterization developments**

Basic tests for some parameterization (pTKE, prognostic precipitation, improvements in radiation scheme) has been performed. ALARO-0-3MT version with prognostic precipitation and current convective scheme (without 3MT developments) has been tested in testing suites and also for longer winter and summer periods. Code was compiled in Zagreb and Ljubljana. Case studies done in Zagreb pointed out same problems detected already in Prague. Initialization of additional prognostic variables (hydrometeors) is important. When starting with zero values the spin-up in the dynamical adaptation mode is not so negligible.

Effort: 1.5 person x month, local work
Contributor: local teams Cz,Hr,Si
Status: ongoing in 2007
Documentation: national reports in ALADIN Newsletters 30,31

- **Tuning of the precipitation forecast**

The comparison of forecast precipitation and cloudiness fields from cy25 and cy29 (Lopez microphysics scheme with prognostic precipitation) with INCA analysis has been done for a one month period. For the cloud cover, where upgrading of some physics and setup routines in cy29 has been needed, scores with cy29 are better. Precipitation fields obtained with Lopez scheme are smoother and better distributed around mountain chains. But these more realistic precipitation patterns are not confirmed with scores (probably one month verification period is to short).

Efforts: 1 person x month 1 week stay in Toulouse, local work
Contributors: C. Wittmann (At), F. Wimmer (At), Y. Wang (At), *E.Bazile (Fr)*
Status: completed

Documentation: ALADIN Newsletters 30, report from stay

- **Soil moisture sensitivity**

Nothing new was done after preparing technical environment last year.

Efforts: -
Contributor: H. Seidel (At)
Status: no progress

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

Most of the research was related to nowcasting of convective precipitation where main problem was how to predict convective cell development (=intensity changes, in contrast to pure cell translation). It is shown that the pure translational forecast of convective cells can be improved by using a decision algorithm which is based on a subset of the convective analyses fields (CAPE, CIN, moisture convergence, trigger temperature deficit), combined with visible satellite imagery.
In 2006, new fields were added to the INCA-System, algorithmic improvements were made, and the code was restructured to increase the portability of the system. Also, two additional INCA domains (INCA-SK, INCA-CH) were created. The new fields are global radiation, surface temperature, and precipitation type (snow, rain, sow/rain mix, freezing rain). Algorithmic improvements concentrated on the temperature field, specifically the analysis and nowcast of inversions in valleys and basins. The portability was increased by creating a standard grib interface between INCA and the NWP model, and by putting most of the parameter settings into a single header file.

Efforts: 6 person x month, local work, (work related to physics is counted)
Contributors: Austrian team
Status: continues work
Documentation:
Haiden, T., 2007: Predicting snowfall line and precipitation type from ALADIN forecasts. ALADIN Newsletter, 31 (submitted)
Haiden, T., A. Kann, K. Stadlbacher, M. Steinheimer, und C. Wittmann, 2007: Integrated Nowcasting through Comprehensive Analysis (INCA) - System overview. ZAMG report, 43p., www.zamg.ac.at/fix/INCA_system.doc
Steinheimer, M., and T. Haiden, 2007: Improved nowcasting of precipitation based on convective analysis fields. Adv. Geosci., 10 (in press).
presentation prepared for 16th ALADIN workshop

3 Summary of means

The following table is a short overview of the planned effort and its realization and LACE support.

Table 1: Overview of the planned and realized effort in 2006.

Topic	**Estimated effort** (person x month) planned/realized	**LACE support** (person x month) planned/realized
PBL cloudiness	2 / 1	
Prognostic cloud water	1.5 / 1	1 / 0.5
Parameterization schemes, diagnostic tools: – turbulence – radiation – ALARO-0 – DDH	 2 + 1.25 / 3.75 4 / 5.25 4 / 8 2 / 2.5	 0+1 / 1 0.75 / 0.75 1 / 1
Externalized surface	1 / 0	
Validation, case studies, sensitivity studies: – evaluation of ALARO-0 – tuning of precipitation forecast – soil moisture sensitivity – INCA	 6 / 1.5 3 / 1.5 2 / 0 6 / 6	 0.25 / 0.25
Total	**33.5+1.25/ 30.5**	**3+1 / 3.5**

Overview of LACE support for stays:

Christoph Wittmann – Toulouse – (1 week) – Lopez scheme
Martina Tudor - Prague - 4 weeks - ALARO-0 base-line version
Neva Pristov - Prague – 11.6.-30.6. (3 weeks) – radiation
Andre Simon – Prague – 1.9.-30.9. (14.10.) (4 weeks) – mixing length computation
Dunja Drvar - Ljubljana – 2.10.- 14.10. (2 weeks) - prognostic precipitation scheme

LACE supported to action in Brussels (preparing ALARO-0 base-line version):
Jure Cedilnik – Brussels – 15.1.-11.2. – plane ticket
Martina Tudor – Brussels – 15.1.- 15.2. – plane ticket
Neva Pristov – Brussels – 8.2.-12.2. (5 days)