Working Area Physics

Progress Report

Prepared by:	Area Leader Neva Pristov
Period:	2012
Date:	March 2013

1 Progress summary

The efforts towards the achievement of a scale-independent ALARO physics package have continued in 2012.

The ALARO-0 baseline version was announced and then distributed in December. Several improvements were implemented into this physics package which serve now as a basis for further developments and it is already operational at CHMI. The moist deep convection diurnal cycle and the precipitation amount, in convective and in the light/moderate precipitation cases are better captured thanks to the developments and tunings of the moist physics. Global simulations show that ALARO-0 is performing well (also at the tropics) at much coarser resolution.

Research allowing significant upgrades of the ALARO physics is ongoing since 2009, and is still in accordance with that long-term plan. ALARO-1 working days (organized in June 2012) were devoted to an overview of current status and to update future plans. Ongoing developments will be assembled into the next release, to be named ALARO-1. Target resolution for the use of this package will be from 10 km to down to 1 km.

Additionally, two research activities can be pointed out. The TOUCANS turbulence scheme has been under extensive testing in a 3D environment in order to seek the optimal settings for the operational implementation. The scheme is already available in the ARPEGE/ALADIN model library. The solutions for better description of shallow convection have to be still validated. In the radiation scheme, substantial progress with the new gaseous transmissions was achieved. Parameterized broadband thermal transmissions were improved by including correction for emitter's temperature being different from local one, introducing pressure and temperature dependent corrective fits and better treated spectral overlaps between different gases.

2 Scientific and technical main activities and achievements, major events

Development of the schemes

Action/Subject/Deliverable: Turbulence scheme TOUCANS

Description and objectives: TOUCANS (Third Order moments Unified Condensation Accounting and N-dependent Solver) is a turbulence scheme in which several ideas in turbulence parametrization are integrated: no existence of critical Richardson number, anisotropy of turbulence, prognostic treatment of Turbulence Kinetic Energy (TKE), Third

Order Moments (TOMs) parametrization, and parametrization of shallow convection inside turbulence scheme.

Different options have been tested (RANS or QNSE approach, various mixing length closures) for various situations (stable and unstable PBL), among them suitable setup for the operational implementation was searched. Bug corrections, tuning of various options, extensive testing both in 1D and 3D environment, especially from the point of view of the moist part, have been done. The scheme was prepared in implemented into cycles 38 and 39 of the ARPEGE/ALADIN model library.

Better description of shallow convection and specific computation of the shallow convection cloudiness have been added, scientific evaluation and validation has still to be completed. Additionally there are ideas for possible extensions of the scheme. Prognostic handling of mixing length and estimating prognostic shallow convection cloudiness (Tompkins approach) have been studied and coded, first tests are ongoing. The idea to include prognostic turbulent potential energy (beside TKE) was checked and it was confirmed that scheme can use stability functions to emulate EFB (energy and flux budget, Zilitinkevich et al. 2012) approach. As prognostic variable total turbulent energy (sum of potential and kinetic turbulent energy) suites better to the scheme design.

Efforts: 8.5 person months

Contributors: I. Bašták Ďurán (Sk,Cz), F. Váňa (Cz)

Documentation: technical documentation, presentations at ALARO-1 WD and at various meetings

Status: ONGOING, available for tests in pre-operational use

Action/Subject/Deliverable: 1D2D turbulence scheme

Description and objectives: Simulation of the 3D effects of turbulence in the ALADIN model can be achieved with the extension of vertical turbulence scheme TOUCANS by consistent components for horizontal part obtained from SL interpolation stencil. A first version of this 2D extension of the present 1D turbulence scheme is already available in the model. First task would be validation of the existing code and inter-comparison with some LES and/or academic simulations to get experience how the TOUCANS and 3D extension behaves in resolutions between 100 m and few km (where the horizontal eddies should already play a role).

Efforts: none

Contributors: none

Documentation: no

Status: POSTPONED TO 2013
Nothing new, this task has lower priority, can start when the first ALARO-1 version is available.

Action/Subject/Deliverable: Radiation scheme

Description and objectives: During 2012, substantial progress with the new gaseous transmissions was achieved. Main concern was parameterization/fitting of broadband thermal transmissions.

Transmission fits are still based on SPLIDACO narrow-band reference, but heuristically estimated H2O e-type continuum was replaced by much more reliable MT_CKD data. After extensive testing and comparison against published ICRCCM results it was proven that combination of SPLIDACO with MT_CKD data gives acceptable reference for H2O transmissions, as well as for (H2O, CO2+, O3) mixture.

The new fits of transmission functions were tested in full 3D model environment after implementation of all improvements from previous year. Unexpectedly, the new fits deteriorate results in the lower atmosphere, where too big cooling effect was noticed mainly due to influence of water vapor in thermal band computations.

Subsequent tests showed persisting problem with accuracy of thermal heating rates in non-isothermal case. To identify the problems a set of 1D tools was prepared, main parts are externalized radiative transfer schemes (ACRANEB and new version ACRANEB2) and reference tool based on narrowband emissivity-type computations with explicit spectral averaging. Testing then continued in 1D clear sky framework, using idealized ICRCCM cases and comparing against published reference. Threefold reason for insufficient accuracy of thermal computations was found:
1) Accuracy of ACRANEB2 broadband transmission fits accounting for secondary saturation proved to be insufficient, they were improved with temperature dependent corrective fits.
2) Fundamental problem was then discovered in broadband thermal transmissions, which should depend not only on local temperature of the layer, but also on temperature of emitting body (via Planck function used as weight). This fact was ignored in the original scheme where the two temperatures were assumed equal in all fits and NER computation. The reference narrow-band emissivity type computations proved that such assumption has strongly detrimental effect on heating rates and must be relaxed. Solution was to introduce temperature of emitting body as a linear correction, using two sets of broadband quantities - first weighted by Planck function, second by its derivative with respect to temperature. In order to get required heating rate accuracy ~0.1K/day for single gases, it was necessary to introduce additional pressure dependent correction.
3) Having accurate transmission fits of individual gases, accuracy of parameterized gaseous overlaps was tested. It was found that effect of triple overlaps cannot be neglected when

H2O e-type continuum was treated as separate pseudo-gas H4O2 (i.e. H2O dimer). Solution was that water vapor and its e-type continuum are treated as single gas and separate pseudo-gas was thus abandoned. H2O e-type continuum became part of H2O fit which now depends also on specific humidity and their spectral overlap is treated in an implicit way.

Further tests showed that accuracy of fitted pair overlaps obtained on sample of homogeneous optical paths is insufficient. Reason was too large spread given by the fact that in atmosphere long optical paths are necessarily inhomogeneous. Refitting gaseous overlaps on sample of optical depths obtained from 5 ICRCCM cases brought desired accuracy. It was also seen that gaseous overlaps can be ignored completely in solar band.

Efforts: 8.75 person months

Contributors: J. Mašek (Cz)

Documentation: presentation at ALARO-1 working days, CZ poster at EWGLAM meeting 2012

Status: ONGOING, few remaining issues need to be solved

Action/Subject/Deliverable: Cloud scheme

Description and objectives: Sub-grid scale cloud treatment is essential to achieve the necessary harmony between physical parameterization schemes (convection, turbulence and radiation). The aim is to arrive to a unified cloud scheme.

First studies have started with the literature overview. Tompkins approach with prognostic skewness and saturation deficit has been studied to verify if it can be used for computation of the prognostic shallow convection cloudiness.

Efforts: 1.5 person months

Contributors: I. Bašták Ďurán (Sk,Cz), R. Brožková (Cz)

Documentation: no

Status: ONGOING, started with shallow convection cloudiness

Scientific maintenance

Action/Subject/Deliverable: ALARO-0 baseline

Description and objectives: The ALARO-0 physics underwent several improving modifications during this year. The result is ALARO-0 baseline version which was prepared

and declared in December. This is now a base for further developments and is recommended to be implemented into the operational use at resolutions down to 4 km.

A study of moist physics dependency on spatial resolution and on formulations of microphysical processes led to couple of improvements in the microphysics and in the horizontal scale dependency formulation of thermodynamic adjustment. In the first half of the year the following modifications were prepared: sedimentation of cloud water and ice has been added; the presence of convective condensation below the diagnosed lifting condensation level is forbidden; several corrections in the code for updraft and downdraft computation, retuning of cloudiness, convection and sedimentation schemes has also been done. With all these updates the simulated precipitation amounts in case of light and moderate precipitation increased, and overestimation in convective part decreased.

The problem of too early diurnal cycle of simulated convection has been studied during second part of the year. Many modifications have been implemented and tested inside 3MT framework. Three important modifications which entered into code are:
- the pure moisture convergence closure was replaced by a mixed-type closure (for a weak forcing it becomes of the CAPE-type), like that not all converging moisture is immediately consumed in condensation, thus convection onset is shifted to later afternoon;
- detrainment was made dependent on the previous history of total evaporation and so adapted to precipitation activity;
- the entrainment rate is dependent on relative humidity of the cloud environment (decreases when relative humidity increases).

Comparison of simulated hourly precipitations amounts with measurement over testing period (June-July 2009) of tropical-type intense convective events over Central Europe shows better timing of the forecast daily cycle and more realistic maximum amounts. Furthermore, the simulations at 2.2 km are very similar to those at 4.7 km and convection is better organized as in simulation without convective parametrization (3MT switched off).

Efforts: 4 person months

Contributors: R. Brožková (Cz)

Documentation: document "Moist physics developments and tunings in ALARO", presentation at ALARO-1 WD, document "ALARO-0 baseline", presentation in Helsinki

Status: COMPLETED, ALARO-0 baseline version available

Action/Subject/Deliverable: 3MT in ARPEGE

Description and objectives: The 3MT scheme with the use of operational ARPEGE physics was prepared and tested with the LAM set-up in the year 2011. While this year, simulations

were carried out on the globe on coarser resolution. With the help of François Bouyssel unstretched T224 (90km) configuration was prepared and different model set-ups (operational ARPEGE with and without 3MT, ALARO-0) have been compared. ALARO-0 is performing well also at much coarser resolution and all over the globe including tropics. After these studies some aspects of the ALARO-0 behavior are better understood, most of recognized deficiencies were eliminated by tuning of some parameters. 3MT behavior in tropics showed also importance of some details in the sedimentation treatment. It turns out that this is a very good research and validation tool and would be also very useful in the future.

Efforts: 2 person month

Contributors: R. Brožková (Cz)

Documentation: report and technical documentation, presentation at ALARO-1 WD

Status: COMPLETED, configuration on globe for validation available, should be maintained in future

Action/Subject/Deliverable: Validation of complementary subgrid updraft and non saturated downdraft

Description and objectives: Luc Gerard consolidated the developments around his new concept named the complementary sub-grid updraft and non saturated downdraft (CSD); in September the version of the stabilized code and corresponding documentation were ready.

The LACE contribution was the help by validation, code checking and the documentation study.

In the first part of the year the validation was concentrated to find the best solution for triggering of the convection aiming to work properly at various horizontal resolutions. Several experiments at different resolution were done in a academic framework to find suitable way of triggering method.

The new routines for the complementary sub-grid updraft and non saturated downdraft were implemented within the cycle 36t1 ALARO-0 base-line model version by D.Banciu and L.Gerard during their stay in Prague in December. The first tests carried out proved a reasonable behavior of the model with the new parameterization schemes of the convective updrafts and downdrafts.

Efforts: 3 person month (3 weeks stay in Brussels,2 weeks stay in Prague)

Contributors: D. Banciu (Ro)

Documentation: presentations at ALARO-1 WD

Status: ONGOING, implementation into ALADIN library has started

Action/Subject/Deliverable: SURFEX with ALARO

Description and objectives: The externalized SURFEX framework of coupled models (for snow and ice, lake and sea, urban environment, forest and vegetation, heat and moisture fluxes in the soil etc.) is used for the model description of the surface/canopy layer and below. Adaptation of the SURFEX code for the operational use with ALADIN/AROME is ongoing inside ALADIN/HARMONIE. Working week was organized in September in Brussels to propose technical solution how to prepare SURFEX fields in parallelized way. Due to lack of skilled experts LACE is not active in these subjects but F. Meier participated and contributed to studies about requirements for the coupling between SURFEX and TOUCANS scheme. R. Hamdi was working on this subject also during his stay in Prague when the coupling between SURFEX and the pTKE, TOUCANS without and with TOM's parametrization was done. A solution of the interface (adding some new arguments: drag coefficient, neutral drag coefficient, the fluxes and some soil parameters) was proposed and tested. Technically it is working, scientific validation with detailed investigation of the effect of the tiling approach inside SURFEX on the boundary layer when using the TOUCANS scheme, should follow.

In order to increase number of SURFEX experts inside LACE, 4 participants attended the SURFEX training course in Toulouse (October 2012).

Efforts: 0.25 person month, 1 person month training

Contributors: F. Meier (At), I. Bašták Ďurán (Cz), A. Stanešić (Hr), M. Pietrisi (Ro), I. Kruzselyi (Hu)

Documentation: reports (SURFEX WW, stay in Prague)

Status: ONGOING, LACE contribution is rather small

Operational implementation

Action/Subject/Deliverable: Operational implementation

Description and objectives: ALARO physics package is in the operational use inside all LACE meteorological services. Besides the local deterministic models with resolutions between 8 and 2 km it is also part of ensemble systems of LACE-LAEF (current and new version) and at HMS. At CHMI it is used in the regional climate simulations.

Reports on ALARO-0 experience, local implementations and evaluation have been presented during the ALARO-1 working week. Presented problems were mainly linked to screen level diagnostics (2m temperature bias), amount of low stratus cloudiness and precipitation (triggering of convection is too early, overestimation of convective precipitation, under estimation of precipitation over flatland areas).

ALARO physics was introduced in the operational deterministic system in Hungary in March 2012, in the ensemble system has been since November 2011 (both of them runs at 8km resolution). Modifications were done in screen level diagnostics to improve 2m temperature and humidity. Cloudiness and wind gust were retuned.

New operational configuration is under preparation in Slovakia. Basic characteristics are: 3.3 km horizontal resolution size 2640 x 2227 km (800 x 675 points), 62 vertical level and time step 180 s. Testing is ongoing with ALADIN CY36T1 using updated ALARO-0 version and SLHD tuning.

Substantial validation of modification in moist physics were done in Austria and included in the operational configuration in January 2013. Besides, various wind gust parametrizations were evaluated and an empirical sub-inversion cloudiness scheme was revised to improve stratus forecast over valleys and basins in mountain regions.

The ALARO-0 baseline physics is already in the operational use in CHMI since December 2012.

Efforts: 6 person month

Contributors: local teams

Documentation: presentations at ALARO-1 WD, posters at ALADIN workshop and EWGLAM meeting

Status: PERMANENT, quality of NWP products is improved

3 List of actions, deliverables including status

Subject: Turbulence scheme TOUCANS

Deliverables: implementation into ALADIN library (CY36, CY38, CY39)

Status: ONGOING, ready for the operational use

Subject: 1D2D turbulence scheme

Deliverables: -

Status: POSTPONED TO 2013

Subject: improvements in the radiation scheme

Deliverables: external tools for calling ACRANEB and ACRANEB2 in single column mode, multilayer SPLIDACO (narrowband reference in thermal band) ACRANEB2/SPLIDACO (narrowband reference in solar/thermal band)

Status: ONGOING

Subject: cloud scheme

Deliverables: -

Status: ONGOING

Subject: ALARO-0 baseline

Deliverables: implementation into ALADIN library (CY36, CY38, CY39)

Status: FINISHED

Subject: 3MT in ARPEGE

Deliverables: configuration at globe for validation, upgrade of ALARO library

Status: DONE

Subject: Validation of the complementary sub-grid updraft and non saturated downdraft

Deliverables: implementation into ALADIN code (cy36t1 in Brussels and Prague)

Status: ONGOING

Subject: SURFEX with ALARO

Deliverables: -

Status: ONGOING

Subject: ALARO operational implementation

Deliverables: reports on local validation

Status: PERMANENT

---

4 Documents and publications

List of reports:

Brožková R. 2012: 3MT in ARPEGE, report and technical documentation, an update
Available online: http://www.rclace.eu/?page=12

Brožková R. 2012: Moist physics developments and tunings in ALARO, documentation
Available online: http://www.rclace.eu/?page=12

Brožková R. 2012: ALARO-0 Baseline, documentation, December 2012
Available online: http://www.rclace.eu/?page=12

Termonia P., N. Pristov 2012: Synthetic Report and Plan of ALARO-1 working days (3-15 June 2012) Available online: http://www.rclace.eu/?page=136

Hamdi R. 2012: Coupling SURFEX with pTKE, TOUCANS, and TOM's, report from stay in Prague Available online: http://www.rclace.eu/?page=12

List of presentations:

Bašták Ďurán I., J.-F. Geleyn, F. Váňa: "General Third Order Moments parametrisation for turbulent schemes with prognostic TKE", COST ES0905 workshop, WG1+2 meeting on similarity theory, 1-2 February 2012, Reading, Great Britain, (presented by I. Bašták Ďurán)

Bašták Ďurán I., J.-F. Geleyn, F. Váňa: "Compact stability dependence model for turbulent schemes with prognostic TKE and without critical Richardson number: 3 parameter system of functions for the whole range of Richardson numbers.", Parameterization of Stable Boundary Layer in Numerical Weather Prediction Models, December 3 - 5 2012, Helsinki, Finland (presented by I. Bašták Ďurán)
Available online: http://netfam.fmi.fi/Stable12/Bastak_presentation.pdf

Geleyn J.-F., I. Bašták Ďurán, F. Váňa, H. Wouters: "Third Order Moments parametrisation for turbulent schemes with prognostic TKE: non-local extension of local heat/moisture diffusion with a complete, simple and stable solver.", Parameterization of Stable Boundary Layer in Numerical Weather Prediction Models, December 3 - 5 2012, Helsinki, Finland (presented by J.-F. Geleyn) Available online: http://netfam.fmi.fi/Stable12/Geleyn_presentation.pdf

Brožková R., N. Pristov, I. Bašták Ďurán, C. Wittmann, J. Mašek J.-F. Geleyn and L. Bengtsson: Harmonization of Cloud and Precipitation concepts in the ALARO Physical Package, ECMWF workshop on parametrization of Clouds and Precipitation across Model resolutions (poster), 5 to 8 November 2012, Reading, Great Britain, (presented by J.-F. Geleyn) Available online:

http://www.ecmwf.int/newsevents/meetings/workshops/2012/Parametrization_clouds_precipitation/index.html

Brožková R., J.-F. Geleyn, I. Bašták-Ďurán: Convective clouds and microphysics; Scale independency via two first unification steps. COST ES0905 Workshop, 8-11 May 2012, Hamburg, Germany, (presented by R. Brožková)

Brožková R.: Multi-scale view of the deep convection diurnal cycle: mixed closure and cold-pool linked "adaptive" detrainment. COST ES0905 Workshop, 29-30 November 2012, Helsinki, Finland (presented by R. Brožková)

Pristov N.: Latest developments in ALARO, 34th EWGLAM and 19th SRNWP meetings, 8 - 11 October 2012,Helsinki, Finland, (presented by N. Pristov)
Available online: http://srnwp.met.hu/Annual_Meetings/2012/

National posters at Joint 22nd ALADIN Workshop & HIRLAM All Staff Meeting, 7-10 May 2012, Marrakech, Morocco: Austria, Croatia, Czech Republic, Hungary, Slovakia, Slovenia, Romania, Available online: http://www.cnrm.meteo.fr/aladin/spip.php?article237

National posters at 34th EWGLAM and 19th SRNWP meetings, 8 - 11 October 2012, Helsinki, Finland: Austria, Croatia, Czech Republic, Hungary, Slovakia, Slovenia
Available online: http://srnwp.met.hu/Annual_Meetings/2012/

All presentations from ALARO-1 Working days 2012, Ljubljana, 13-15 June 2012
Available online: http://www.rclace.eu/?page=136

5 Activities of management, coordination and communication

- Organization and preparation of the ALARO-1 Working days.

  ALARO-1 Working days (Ljubljana, 13-15 June 2012) were organized by the ALADIN PM, the Area Leader for Physics of RC LACE and hosted by the Slovenian Meteorological Service. 25 participants from 13 countries (LACE, ALADIN, HIRLAM consortia) gathered to spread the knowledge on recent ALARO physics developments (turbulence-diffusion, precipitation aspects, convection and moist physics) and discuss about plans. More information available on http://www.rclace.eu/?page=136

- Joint 22nd ALADIN Workshop & HIRLAM All Staff Meeting 2012, 7-10 May 2012, Marrakech, Morocco (participation of Neva Pristov)

- 34th EWGLAM and 19th SRNWP Meeting, 8-11 October 2012, Helsinki, Finland (participation of Neva Pristov, presentation)
- Networking, 3 - 7 December ,CHMI, Prague, Czech Republic

6 Summary of resources/means

Subject/Action/deliverable	Resource		LACE		ALADIN Flat-rate	
	planned	realized	planned	realized	planned	realized
TOUCANS	6	8.5	2	2		
1D2D turbulence scheme	2	0				
Radiation	5	8.75				
Cloud scheme	2	1.5				
ALARO-0	2	4			0.5	0.5
3MT in ARPEGE	1	2				
Validation of CSD	2	3	1	0.5	1	1
SURFEX with ALARO	4	0.25	3x0.25	0.25	0.5	0.5
Local oper. application	4	5				
ALARO-1 WD	2.25	2.25	6x0.25	1.5	3x0.25	0.75
Networking, supervision	5	5	0.25	0.25		
Total:	**30.25**	**40.25**	**5.5**	**5**	**2.75**	**2.75**

LACE supported stays:

Ivan Bašták Ďurán: TOUCANS, Prague, 16 January - 10 February 2012
Ivan Bašták Ďurán: TOUCANS, Prague, 4 - 29 June 2012
Doina Banciu: Validation of the last CSU developments, Prague, 3 - 15 December 2012

LACE supported participation at working weeks/days:

ALARO-1 Working days, 13-15 June 2012 in Ljubljana: Martina Tudor, Maria Derkova, Christoph Wittmann, Doina Banciu, Michaly Sucs, Ivan Bašták Ďurán
The SURFEX Working week, Brussels, 24-28 September 2012: Florian Meier

Flat-rate stays in connection to physics subjects:

Doina Banciu: Work on the CSU scheme, Brussels, 0.75 month
Luc Gerard: TOUCANS + deep convection, Prague, 0.25 month
Rafiq Hamdi: Interface between TOUCANS and SURFEX Prague, 0.5 month
Joris Van den Bergh: Microphysics, Prague, 0.5 month
Luc Gerard, Daan Degrawne, Ersin Kucukkaraca: ALARO-1 Working days

7 Problems and opportunities

In the process of research and development there were many novelties, innovative solutions, which were leading to important outcomes. Consequently, there is a lot of scientific material for scientific peer-reviewed publications but it seems that it is difficult to find time for writing them down. Frequently, the priority is to continue with further research, where plenty of additional new ideas have to be verified and tested. Beside all this, there are also requirements to insert improvements into the main AREGE/ALADIN library and into the operational applications, which also involves meaningful technical work.

The developments in the radiation scheme needed much more research effort than anticipated originally due to hurdles discovered during the work. Many problems could not been foreseen in advance, there were dead-ends, unexpected bad surprises, etc., but this is of course the characteristic of the research work (so it should be considered as normal). Consequence is the delay of the next ALARO-1 physics package delivery with the respect to the 2012 plan.

It is also crucial to continue the existing good collaboration with the other ALADIN/HIRLAM partners. Particularly, the main partner in preparing ALARO-1 is the Belgian team. The operational implementation of SURFEX can be done only in collaborative effort and LACE should have more contribution there.