Working Area Physics

Work Plan

Prepared by:	Area Leader Neva Pristov
Period:	2017 (and further)
Date:	8 March 2017 (updated version form November 2016)

1 Introduction and background

The focus of the research and developing activities inside LACE is to achieve a scale-independent ALARO physics package which allows us to produce operational forecast at the resolution between 10 and 1 km mesh-size. The developments of physics schemes for high resolution gathered into ALARO-1 has been ongoing for more than 5 years. They have reached the step of the individual tuning and validation; the tuning and further validation of the whole model where these modules interact together is going on.

A baseline version of the ALARO-0 (available in December 2012), the first version ALARO-1vA (available in December 2014) and also the newest second version ALARO-1vB are used in the operational applications. The version ALARO-1vB (already used at CHMI) is going to be available soon in 2017.

Benefits of the high resolution with the ALARO-1 version are already seen. The goal is to obtain a baseline version of full ALARO-1.

2 Goals

The highest priority is to optimize the performance of the LAM for resolutions in the 1 to 5 km range. Quality of simulations can be improved with better representation of clouds, as they are treated by a combination of different schemes (input to radiation, turbulence). With including of the refinements of the parameterization of the convective drafts it is expected to achieve seamless solutions across a wide range of horizontal resolutions, including the grey zone of moist deep convection, down to 1km.

Research will continue to enhance the description of physical processes also at sub-km resolutions (study of turbulence at grey zone, two-moment microphysics scheme). Experiments in very fine resolution (with ALARO and AROME) will indicate the problems which should be tackled. Additionally enhanced description of atmosphere-surface link available in SURFEX should be implemented. Better description of the (stable) boundary layer behaviour, low cloudiness, daily cycle of precipitation and convection under unstable circumstances are one of the most wished improvements.

It will be encouraged (as always so far) and supported that novelties enter the operational applications. ALARO physics package is already used regional clime simulations, in LAEF, Hungarian ALADIN-EPS and GlamEPS ensemble system and in a convection-permitting ensemble system.

3 Main R&D activities

Main research activity in the year 2017 is the improvement of the description of cloudiness in various processes. The new researchers are going to continue their work (turbulence (TOUCANS), convection (CSD) and microphysics) started in 2016. The newest ALARO-1vB version is recommended for the (pre-)operational use. Additionally, coupling with SURFEX and preparation of new diagnostic meteorological parameters are also important tasks.

Action/Subject: Turbulence scheme TOUCANS

Description and objectives:

The turbulence scheme TOUCANS is integrated into ALARO-1 version. This scheme has many modern options for computation of turbulent fluxes of momentum, heat, water vapour and cloud condensed water. It includes also the description of shallow convection (non-precipitating) which is already available in the newest version ALARO-1vB. Further validation is still needed to profit from many available options and to update the selected set-up used the operational applications (some options remained the same as in ALARO-0).

Research and developments continue on mixing length computation, some improvements are possible in the shallow convection closure. Verification of wind forecast quality and the improvement wind gust diagnostics are also possible tasks.

Actions in 2017:
- shallow convection closure: tuning, possible improvement in the vertical profile definition and with new fit to a function;
- check and examine coding of some part of TOUCANS (TOMs, ...);
- test available options for mixing length computation;
- prepare a scientific paper with focus on TTE;

Proposed contributors, Estimated efforts: R. Brožková (Cz), P. Smerkol (Si), M. Hrastinski (Hr), 9 months, 1+0.5 month LACE stays

Planned timeframe: whole year

Planned deliverable: code modification, documentation updates

Action/Subject: Radiation scheme

Description and objectives:

Radiation scheme ACRANEB2 is integrated into ALARO-1 versions. Improvements in the cloud-radiation interaction are planed by taking into account better information on cloud cover (see under "Cloud scheme") and (in future) by getting microphysical cloud condensates into radiation scheme.

Parameterization of an impact of cloudiness on broadband surface albedo, which is an important issue for the schemes using single SW interval, can be prepared.

The ACRANEB2 scheme is part of the HARMONIE radiation comparison. Adaptations to improve also climate simulations can be studied.

Actions in 2017:
- code, validate and phase efficient calculation of clear sky fluxes in ACRANEB2
- parameterization of an impact of cloudiness on broadband surface albedo (suitable/waiting for a newcomer)

Proposed contributors, Estimated efforts: J. Mašek (Cz), 0.5 months

Planned timeframe: whole year

Planned deliverable:

Action/Subject: Cloud scheme

Description and objectives:

The objective is unification of the cloud-cover concept within ALARO-1. After careful analysis, it was decided not to aim at a single computation of cloudiness, like for instance in Tompkins (2002), but go for an alternative approach, to build bilateral correspondences and/or combinations for all cases where two parameterisations interact at the level of the cloud-cover definition. For example, in precipitation process combination of stratiform and deep convective cloudiness is used.

An issue is the harmonization of radiative cloud and condensates with the microphysical cloud fraction and prognostic condensates. Presently, the radiative condensates are re-estimated, the 'stratiform' part (contrary to the cloud scheme) does not include phase and mesh size dependencies, the convective condensates are re-estimated from the 'protected' historic convective cloud fraction.

Recent case studies of winter-type stratocumulus (clouds are not kept) have shown a tendency of the model to remove the sharp gradient at the inversion top. It does not seem to be a priori a problem of the cloud scheme, e.g. when data assimilation restores the gradient, we get clouds. Therefore a more in depth analysis of the processes involved is needed.

At short term, the radiative cloudiness should be further re-tuned, in the spirit to reduce the difference with the adjustment; a re-unification of adjustment and radiative cloudiness is desirable at longer term.

Relatively small upgrades with respect to current ALARO-1 version are needed. This transversal change is touching many feed-back loops, hence its practical consequences is quite unpredictable.

Action in 2017:
- analysis of the process involved in dissipation of low clouds in winter situations
- unify the treatment of stratiform cloudiness in radiation and thermodynamic adjustment (modification and testing)
- further steps will be defined according to the outcomes

Proposed contributors, Estimated efforts: R. Brožková (Cz), J. Mašek (Cz), 3 months

Planned timeframe: whole year

Planned deliverable: code modification, testing and validation

Action/Subject: Microphysics

Description and objectives:

Current microphysics schemes in AROME are ICE3 and ICE4. The ICE3 sensitivity to the time step length has been reduced recently, while ICE4 is under re-evaluating procedure as some bugs related to hail were fixed inside ICE4 in Meso-NH.

LIMA is a two-moment microphysics scheme, which treats the number concentration of cloud condensation nuclei prognostically, and thus permits a physically more realistic treatment of aerosol-cloud interactions. Scheme was developed within Meso-NH, research version is implemented in AROME (cy42t1). Evaluation is ongoing in AROME.

Action in 2017:
- validation of the modifications made in ICE3 for improving forecasts of super

cooled rain in AROME
- the sensitivity study of ICE3 to the time stepping or sensitivity tests with LIMA (topic for a stay in Toulouse is not yet defined)

Proposed contributors, Estimated efforts: V. Homonnai (Hu), 5 months, 1 month LACE stay

Planned timeframe: whole year

Planned deliverable: testing and validation

Action/Subject: Operational applications: from ALARO-0 to ALARO-1, SURFEX

Description and objectives:

Currently 3 versions of ALARO physics package are used in the operational applications in LACE countries. Local teams are encouraged to replace the ALARO-0 baseline with newest ALARO-1 version. Validation and tests of the newest ALARO-1vB version for the (pre-)operational will continue and experiments at resolutions around 2 km shall be performed to see benefits at higher resolutions. Support will be available.

For the model description of the surface/canopy layer and below, 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 ALADIN/AROME. To profit from latest developments we decided to couple ALARO-1 with SURFEX version 8 which is implemented in the aladin code CY43T2. Adaptation needed for the turbulent scheme are prepared and technically ALARO-1 coupled with SURFEX is working, extensive validation is still needed before the usage in the operational. Besides the export version of CY43T2 should be available for this action.

The parameterization of orographic shadowing in radiation implemented inside SURFEX (used in AROME) can be coupled also with ALARO-1vB physics (TOUCANS, ACRANEB2).
Validation and sensitivity study of the parameterization of orographic shadowing in radiation with respect to the primary (radiation fluxes, temperature) and secondary (convection, low stratus in valleys, local circulation) effects has lower priority.

Actions in 2017:
- validation ALARO-1 coupled with SURFEX ;
- preparations for the SURFEX usage in operational ALARO applications;
- *lower priority, implementation of the ororad scheme in the ALARO-1vB/SURFEX system;*

Proposed contributors, Estimated efforts: R. Brožková (Cz), N. Pristov (Si), C. Wittmann (At), M. Derkova (Sk), M. Szucs (Hu), M.Tudor (Hr), ?(Ro), M. Dian (Sk), 10 months months (1 month LACE stay)

Planned timeframe: whole year

Planned deliverable: report

Action/Subject: The ALARO-1 version

Description and objectives:

The current well-tuned ALARO-1 version is ALARO-1vB (ALARO-1vA, modified screen-level interpolation, shallow convection scheme in TOUCANS, exponential-random cloud overlaps in radiation and cloud diagnostics, improved sunshine duration and direct solar flux at surface, 10m wind interpolation) is the base for further developments. Next step is to assemble the unsaturated downdrafts (an extra extension for the 3MT scheme), and if developments are ready also improved description of cloud cover and prognostic graupl.

In the second stage then all other planed developments; i.e. CSD, TOUCANS evolution, prognostic graupl, unified cloud treatment. CSD stands for the complementary sub-grid draft (research work of Luc Gerard, including both up- and down- drafts) scheme which enable a more realistic transition from parameterized to explicit convection when going to higher resolutions. Tuning of this scheme in the ALARO-1 environment will be needed.

The validation will be in the range 5 km to 1 km and suitable validation testbeds (common with AROME and ARPEGE) for facilitating cross testing of various parameterizations should be also prepared.

Actions in 2017:
- tuning of non-saturated down draft inside ALARO-1vB;
- implementation and validation of prognostic graupl computations;

Proposed contributors, Estimated efforts: R. Brožková (Cz), S.Briceag (Ro), 2 months (1 month LACE stay)

Planned timeframe: whole year

Planned deliverable: code, documentation

Action/Subject: Interfacing physics parameterizations

Description and objectives:

Impact study and validation of the physics-dynamics interface has high priority in ALADIN community. Scientific and practical constrains for redesign of physics interfaces (APL_AROME and APLPAR), which should enable the various physics packages (and also to exchange their individual parameterization schemes) are proposed. Actions are spread among many people, LACE contribution is to adopt ALARO part of computations in APLPAR routine. Radiation scheme in already in proper shape, code linked to turbulence and shallow convection should be analyzed and adopted. Very demanding part on 3MT will follow after.

Action in 2017: Support to phasing TOUCANS scheme will be available.

Proposed contributors, Estimated efforts: R. Brožková (Cz), P. Smerkol (Si), 0.5 month

Planned timeframe: whole year

Planned deliverable: code, documentation

Action/Subject: Various products for users (forecasters)

Description and objectives:

Many requests from the user side, mainly forecasters, asking for additional forecast parameters has arrived. For this new features should be coded in post-processing part which would enable output of model fields. Continuation of this topic is foreseen on the base of good experience with enlarged convection diagnostics. The methods for lightening diagnostics have still to be evaluated and final solution should be proposed. Additional diagnostic meteorological parameters can be added: visibility, precipitation type (also wet snow, freezing rain), icing parameter, UV index, snowfall line, computation of real snow height.

Actions in 2017:
- implementation of precipitation type diagnostics (with freezing rain),
- evaluation of lightening diagnostics,
- study the methods for the visibility computation

Proposed contributors, Estimated efforts: J. Cedilnik (Si), C. Wittmann (At), N. Pristov (Si), 2 month (0.5 month LACE stay)

Planned timeframe: first half of the year

Planned deliverable: code, documentation

Action/Subject: Very Fine Resolution Experiments

Description and objectives:

More and more teams are now able to perform VFR experiments with ALADIN NH-based models (with AROME and ALARO physics, within or without HARMONIE framework).

Few teams have started experiments at higher horizontal resolutions with AROME or ALARO-1 package (to be used also at the kilometric and hectometric scales). Several aspects on high resolution should be investigated (low stratus in valleys, initiation of convection over orography, etc.).

Study of the turbulence in the grey zone (resolved and parameterized description of eddies) is performed as part of PhD work of Dávid Lancz. The aim is to modify the EDKF scheme used AROME in such way that parametrization of non-local eddies in the planetary boundary layer extinguish with higher horizontal model resolution and are handled by the model's dynamics.

Actions in 2017:
- continuation of research with modified EDKF scheme (turbulence in the grey zone);
- preparation and validation of VHR model set-up, comparison ALARO-1 (4 km -2 km -1 km), AROME;

Proposed contributors, Estimated efforts: D. Lancz (Hu), J.Cedilnik (Si), M.Tudor (Hr), 7 months

Planned timeframe: whole year

Planned deliverable: report

4 Summary of resources

Subject	Manpower	LACE	ALADIN
TOUCANS	9	1.5	
Radiation	0.5		
Cloud scheme	3		
Microphysics	5	1	
ALARO-0/ALARO-1/SURFEX	10	1.25	*0.5*
ALARO-1	2	1	*0.25*
Physics interface	0.5		
Additional fields	2	0.5	
VFR Experiments	7	*1*	
Total:	39	5.25 *+1*	*0.75*

LACE scientific stays:

- Simona Briceag (ro), Unsaturated downdraft, Prague, 4 weeks
- Mario Hrastinski (hr), Turbulence related topic, Prague, 4 weeks
- Peter Smerkol (si), TOUCANS - code validation of TOMs, Prague, 2 weeks
- Christoph Wittmann (at), Additional products for users, Ljubljana, 2 weeks
- Viktoria Homonnai (hu), AROME microphysics (ICE4 and two-moment scheme), Toulouse, 4 weeks
- Martin Dian (sk), ALARO – SURFEX, Prague, 4 weeks

- Neva Pristov (si), ALARO, Prague, 1 week
- *David Lancz (hu): VFR experiments, Toulouse, 4 weeks (optional)*

ALADIN Flat-Rates Stays (foreseen):

- *Luc Gerard: Convection, Prague, 0.25 month*
- *Rafiq Hamdi: SURFEX in ALARO, Prague, 0.5 month*

5 Meetings and events

1) 26st ALADIN Workshop and & HIRLAM All Staff Meeting, 2017, Helsinki, Finland
2) 39th EWGLAM & 24st SRNWP joined meetings, 2017,
3) Working week(s) organized by ALADIN/HIRLAM community:
   cloud meeting, working group on radiation,
4) Web meetings
   physics-dynamics interface; geospatial data in NWP;

6 Risk and constrains

The core team for the ALARO developments is a very small one. Colleagues in Prague are in this year occupied with migration to the new server and have limited time for developments. Despite, they are ready to host developers for the research stays. Simona Briceag, who started to work on convection in previous year, is returning back to ECMWF. Anyway she fulfilled her planed research stay and helped with the validation of unsaturated downdraft.

It is crucial to continue good collaboration with other ALADIN/HIRLAM partners. Opportunity is cloud working group where LACE scientists could become more active. We issued an initiative for a coordinated effort on post-processing work to obtain more diagnostic fields for the end-users. Also progress on ALARO-SURFEX coupling could be faster if someone can devote part of working time to this subject.