Working Area Physics

Work Plan

Prepared by:	Area Leader Neva Pristov
Period:	2018 (and further)
Date:	12 March2018 (original 18 September, updated 11 October 2017)

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. Most of individual schemes 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 (available February 2017) are used in the operational applications. 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.

This plan is reflected in the ALADIN/HIRLAM/LACE Work Plan for 2018, majority of tasks are under Work Packages PH3 (Development of ALARO physics), some in PH1 (Developments of AROME (and ARPEGE) physics), aim is to contribute to work inside PH4 (Common 1D MUSC framework for parameterization validation) and HR1((Sub)-km configurations and turbulence R&D activity). There are also other Working packages under “Surface analysis and modeling” with contribution from RC LACE countries, SU3 (Validation of existing SURFEX model options for NWP) and SU6 (Coupling with sea surface/ocean) which could be part of the plan for physics but are not (yet) included.

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.

3 Main R&D activities

In 2018 we plan to continue the work on already ongoing topics. Main research activity in the year 2018 is the improvement of the description of cloudiness in various processes, validation of TOUCNAS will continue. The newest ALARO-1vB version is recommended for the operational use, the next very important step is to start validation of ALARO-1 coupled with SURFEX also for the operational use. Additionally, some effort will be put to prepare new model output products which will suite to end-users.

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) (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 2018:
- shallow convection closure: tuning, possible improvement in the vertical profile definition and with new fit to a function;
- check and examine coding of some parts of TOUCANS (still in TOMs part, after reorganization);
- study and test mixing length computation;

Proposed contributors, Estimated efforts: R. Brožková (Cz), J. Mašek (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. Climatological aerosol optical properties can be replaced with those (daily) provided by Copernicus Atmosphere Monitoring Service (CAMS MACC products). 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.

Adaptations to improve also climate simulations can be studied. First step is more efficient computation of clear sky fluxes.

Actions in 2018:
- 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: code, report

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.

At short term, cloud diagnostic in radiation should be re-tuned, in the spirit to reduce the difference with the thermodynamic adjustment. 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.

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.

Action in 2018:
- 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), 4 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 (prognostic hail included but not in operational use). Evaluation LIMA scheme is ongoing in AROME. 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.

The implementation of prognostic graupel was done by Michiel Van Ginderachter and Joris Van den Bergh few year ago (within cy38). Bogdan Bochenek phased it into ALADIN code cy43t2 and cy45/cy45t1, technical and scientific validation should continue and it is expected some tuning inside microphysics is needed,

Action in 2018:
- aerosol initialization in LIMA scheme
- hail diagnostic in ICE3
- validation of the modifications made in ICE3 for improving forecasts of super cooled rain in AROME
- validation of prognostic graupel computation in ALARO-1

Proposed contributors, Estimated efforts: V. Homonnai (Hu), 3 months (1 month LACE stay), B.Bochenek (Pl), 1 month OPLACE stay

Planned timeframe: whole year

Planned deliverable: testing and validation, report

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 the latest 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 ARPEGE and AROME. To profit from latest developments we decided to couple ALARO-1 with SURFEX version 8 which is implemented in the aladin code CY43T2. The export version of CY43T2 needed for this action is plan to be delivered in 2018.

In order to be able to use SURFEX with ALARO-1 physics package many issues have to be tackled. Modifications are needed in TOUCANS and SURFEX side (work of Rafiq Hamdi), scientifically consistent transition of ALARO from ISBA surface scheme to SURFEX should be also ensured. Attention must be paid not only to code differences, but also to different file formats and datasets used. Only after we can proceed to more advanced SURFEX options (3 layer scheme, tiling, TEB, ...).

When moving to higher horizontal resolution, the parameterization of orographic shadowing in radiation implemented inside SURFEX (used in AROME) become important. It 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 2018:
- validation and operational use of ALARO-1vB in local applications;
- validation of ALARO-1 coupled with SURFEX ;
- preparations for the SURFEX usage in operational ALARO applications;
- propose a solution for a problem with screen level temperature above snow in ISBA;
- simulations with the FLake model;

Proposed contributors, Estimated efforts: R. Brožková (Cz), N. Pristov (Si), C. Wittmann (At), M. Derkova (Sk), M.Tudor (Hr), M. Niculae (Ro), D. Lancz (Hu); M. Dian (Sk), J. Mašek (Cz), B. Szintai (Hu), S. Tascu (Ro), S.Penežić (Hr); 12 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, plus 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). This is now the base for further developments. Next step is to assemble the unsaturated downdrafts (an extra extension for the 3MT scheme), prognostic graupel and improved description of cloud cover when available.

In the second stage then all other planed developments; i.e. CSD, TOUCANS evolution, prognostic graupel, 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 from 5 km down to 1 km. Suitable validation testbeds (common with AROME and ARPEGE) for facilitating cross testing of various parameterizations should be also prepared. Clean comparison of ALARO and AROME can be done with 1D model.

Actions in 2018:
- testing and tuning of non-saturated down draft inside ALARO-1vB;
- code cleaning and reorganization, contribution for main code cycle;
- implementation and validation of 1D MUSC with ALARO;
- comparison AROME/ALARO in 1D model

Proposed contributors: R. Brožková (Cz), J. Mašek (Cz), B.Szintai (Hu), *B.Bochenek (Pl)*

Estimated efforts: 3 months,

Planned deliverable: code, report, documentation

Action/Subject: Interfacing physics parameterizations

Description and objectives:

Impact study and validation of the physics-dynamics interface has high priority in ALADIN community (CPDY4). 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 2018: Support to phasing TOUCANS scheme will be available.

Proposed contributors: R. Brožková (Cz), P. Smerkol (Si)

Estimated efforts: not planned

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 2018:
- 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), J. Kemetmüller (At), N. Pristov (Si), 6 month (0.5 month LACE stay)

Planned timeframe: whole 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) will continue. The modification of shallow convection parameterization in AROME allows now to compute the turbulence parametrization scale-adaptively, the subgrid turbulent flux is extinguishing with higher horizontal resolution (100 – 1000 m) as the resolved turbulent flux increases. The effect of this modification is visible but is small and can be only part of final solution for the turbulence treatment in grey zone. Study will continue in direction of quasi 3D turbulence.

Actions in 2018:
- continuation of research on turbulence in the grey zone
- preparation and validation of VHR model set-up, comparison ALARO-1 (4 km -2

km -1 km), AROME;
- tuning of TOUCANS for the dynamical adaptation for wind

Proposed contributors, Estimated efforts: D. Lancz (Hu), J.Cedilnik (Si), M.Hrastinski (Hr), R.Brožkova (Cz), P. Scheffknecht (At), 10 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	4		
Microphysics	4	1	*1 (OPLACE)*
ALARO-0/ALARO-1/SURFEX	12	1	1.25
ALARO-1	3		0.5
Physics interface	-		
Additional fields	6	0.5	
VFR Experiments	10	1	
Total:	46.5	5	1.75+*1*

LACE scientific stays:

- Mario Hrastinski (hr), TOUCANS – mixing length definitions, Prague, 4 weeks, 14.5.-8.6.
- Peter Smerkol (si), TOUCANS - code cleaning and validation, Prague, 2 weeks, 19.-31.3.
- Jure Cedilnik (si), Additional products for users, Vienna, 2 weeks
- Viktoria Homonnai (hu), AROME microphysics: initialization of aerosol in LIMA, Toulouse, 4 weeks
- Martin Dian (sk), ALARO coupled with SURFEX, Prague, 4 weeks, (4.-15.6.+2weeks)
- David Lancz (hu): Study of the turbulence grey zone: quasi-3D turbulence in deep cloud scheme in AROME, Toulouse, 4 weeks

ALADIN Flat-Rates Stays:

- Luc Gerard: Convection, 2 weeks, Prague
- Rafiq Hamdi: SURFEX in ALARO, 1 week, Prague
- Piotr Sekula: Validation of ALARO-SURFEX coupling, 4 weeks, Ljubljana

Stay related to OPLACE:

- Bogdan Bochenek: Validation of prognostic graupel, ALARO 1D model (MUSC), 4 weeks, Prague

Working days: comparison ALARO AROME with 1D model, 3-4 participants, proposal, not yet confirmed

5 Meetings and events

1) 27st ALADIN Workshop and & HIRLAM All Staff Meeting, 2018, Toulouse, France
2) 40th EWGLAM & 25st SRNWP joined meetings, 1-4 October 2018, Salzburg Austria

3) ECMWF workshop: Radiation in the next generation of weather forecast models, 21-14 May 2018, Reading (Jan Mašek)

4) Working week(s) organized by ALADIN/HIRLAM community:
ALADIN-HIRLAM Cloud workshop, not yet defined
HIRLAM/ALADIN/LACE/SURFEX surface working days , not yet defined

5) Web meetings
physics-dynamics interface; geospatial data in NWP; (not very active)

6 Risk and constrains

The core team for the ALARO developments is a very small one. Effort and human resources should be increased in order to keep ALARO competitive in operation and climate applications. Candidate interested to work on convection (unsaturated downdraft, CSD) is searched, potentially one from Romania is expected for 2019.

It is crucial to continue good collaboration with other ALADIN/HIRLAM partners. Topics from this plan are included in ALADIN/HIRLAM/LACE rolling work plan 2018 in various working packages. Opportunity is cloud working group where LACE scientists could become more active. Everyone can also profit from a coordinated effort on post-processing work to obtain more diagnostic fields for the end-users and from common validation tool for VFR.