Working Area Physics

Progress Report

Prepared by:	Area Leader Neva Pristov
Period:	January - December 2014
Date:	March 2015

1 Progress summary

The efforts towards the achievement of a scale-independent ALARO physics package have continued in 2014. This report gives a brief overview of research and development.

The first version of ALARO-1 physics package has been created. After extensive validation it is already in the operational use in CHMI since January 2015. One of ingredients is substantial updated radiation scheme with many new achievements, the second one is turbulence scheme TOUCANS, with one selected setup from many available options and third ingredient is group of improvements in the cloud and precipitation microphysics. This significant upgrade of the physics schemes improves the convection diurnal cycle and some other improvements are expected to be confirmed during further validation.

ALARO-1 working days took place in May 2014 where an overview of current status and plans for the future were presented. Development of schemes to improve description of physical process continues, experiments in very fine model resolution have started.

The ALARO-0 baseline version is in the (pre-)operational use in all services from LACE countries.

2 Scientific and technical main activities and achievements, major events

Action/Subject/Deliverable: Turbulence scheme TOUCANS

Description and objectives:

Turbulence scheme TOUCANS was integrated together with radiation scheme (ACRANEB2) into first version of ALARO-1, where scientific validation continued. Significant work was invested into increasing numerical efficiency and code check. The first pre-operational set-up was chosen from various available options and includes a new type of stability functions (so-called model II), moist third order moments, turbulent diffusion of cloud condensates and the use of total turbulent energy TTE, but still the same type of length scale computation as in pTKE and the shallow convection as in ALARO-0. Each novelty added meant slight improvement; the most remarkable impact was reached by introducing the Total Turbulent Energy. Tests with other turbulence models (QNSE, EFB) were also made, their results are quite reasonable but are slightly less good than the 'Model II' choice.

To obtain the complete TOUCANS scheme a better diagnostics of Shallow Convection Cloudiness (SCC) is needed. SCC is crucial for computation of moist buoyancy flux (non-linear relationship dependent additionally on skewness parameter - (Marquet and Geleyn, 2013)), but also for turbulent diffusion of cloud condensates and TOMs computation. Additionally it is planned to use it as input for radiation scheme.

Lewellen and Lewellen paper proposes to use simplified mass-flux type computations for determining the SCC. First test indicates that this improved non-local approach of SCC diagnostics could be used in TOUCANS scheme. Illustration of some relations used in computations for both approaches is shown in Figure 1.

Computation of mixing lengths is another open issue where more studies are need.

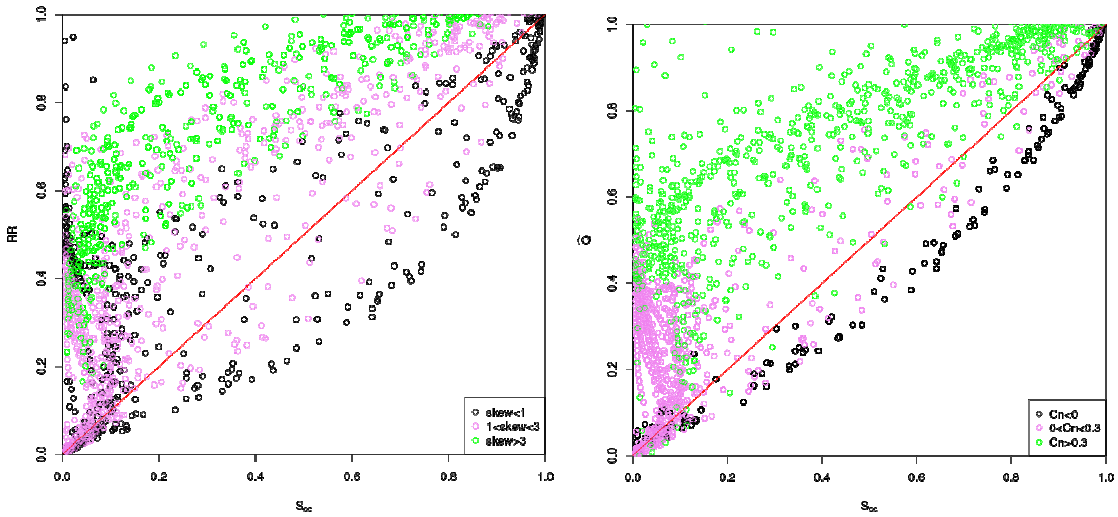

Figure 1: Illustration of an approach for shallow convective cloudiness computation in Lewellen and Lewellen paper (left) and in TOUCANS (right). Improvements are in less dispersion, clearer extreme borders and more continuous effect of the new linking parameter.

Efforts: 9 person months

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

Documentation: presentations at ALARO-1 Working days, technical documentation, stay report, scientific paper published in JAS

Status: ONGOING, assembled into ALARO-1

Action/Subject/Deliverable: Radiation scheme

Description and objectives:

Developments of radiation scheme continued in 2014 with the aim to improve the description of shortwave radiation part of ACRANEB2 baseline version.

New dependency of direct surface albedo on sun elevation was implemented for the use with ISBA scheme. It discriminates between solid surfaces and open water, introducing nonzero proportion of Lambertian reflection for the former (tuned to 0.6 for land, ice and snow). Dominant is the effect on surface temperature, modifying its diurnal cycle and affecting other physical processes like convection.

In order to validate broadband scheme and to parameterize spectrally unresolved effects, narrowband SW reference including gaseous absorption, Rayleigh scattering, surface reflection and absorption/scattering by liquid and ice clouds was constructed. Liquid and ice broadband cloud optical properties (both SW and LW) were then refitted against recent datasets and SW optical saturation of ice clouds was separated from liquid clouds.

Unsaturated cloud optical properties are now fitted not directly against liquid/ice water content, but with respect to water droplet effective radius or ice particle effective dimension. Conversion from cloud water content to effective particle size is done using appropriate relations found in the literature.

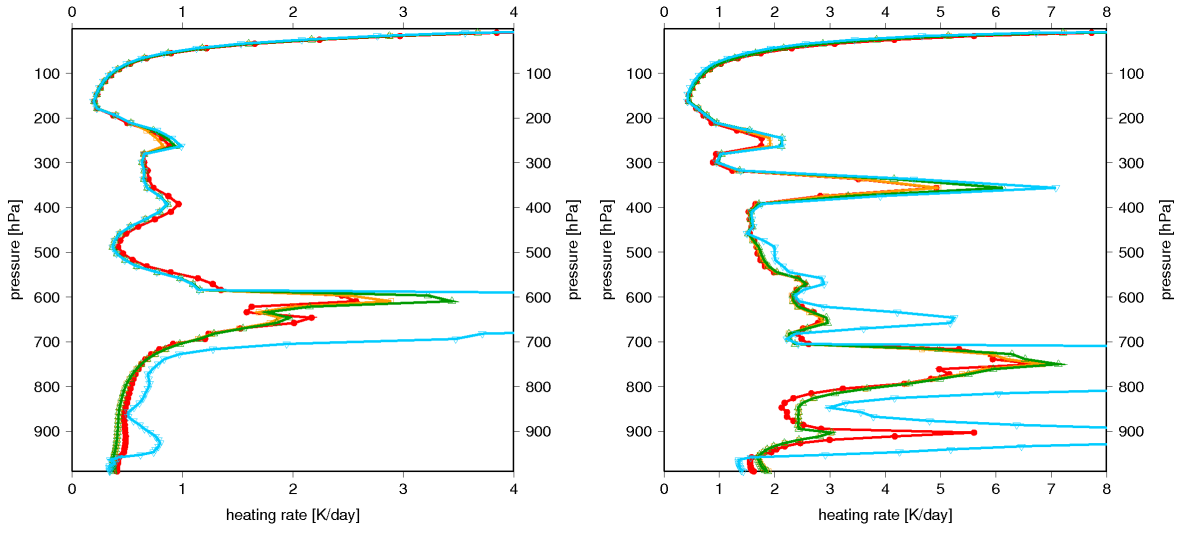

Figure 2: Shortwave heating rates for summer convection day in Prague (29.6.2009) in the morning (5 UTC, low sun, left) and at noon (11 UTC, high sun, right). red - narrow band reference, orange - broadband scheme (ACRANEB2), green - broadband with no gas-cloud overlap, blue - broadband with no cloud optical saturation.

Functional form of broadband fits was changed to better match reference data and at the same time to automatically ensure values within physical limits. Concept of effective cloud optical depth was reworked, with better justified vertical dependency across the cloud. Gas-

cloud SW spectral overlap was parameterized and tuned on set of profiles extracted from NWP model run. The quality and the importance of two parameterized effects is demonstrated with Figure 2.

In order to improve efficiency, intermittent update of shortwave gaseous optical depths was implemented, and 1 hour update frequency was found to be reasonable compromise between cost and accuracy.

Efforts: 7.5 person months

Contributors: J. Mašek (Cz), P. Kuma (Sk student)

Documentation: poster at ALADIN workshop, report, presentations at ALARO-1 Working days, presentation at 5th HIRLAM radiation WW, stay report, scientific paper (submitted)

Status: ONGOING, assembled into ALARO-1, used in climate simulation (25 km resolution).

Action/Subject/Deliverable: Cloud scheme

Description and objectives:

The objective is an 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. The cloud radiation interaction is also very important.

The cloudiness used in radiation was retuned in ALARO-1 to work well with new scheme ACRANEB2. As shallow convection cloudiness computation is not yet available, it was decided to modify the computation of cloud water content of the stratiform part of radiative cloudiness. Stratiform clouds are made less opacue with height, this means more cloudiness in lower levels (in winter) and less in higher levels (not to suppress radiation and convection in summer). During ALARO-1 validation it was shown that description of moist deep convection diurnal cycle does not depend on the parameterization of convection only, but also on the feedback coming from the interaction of radiation and clouds schemes.

Efforts: 0.5 person months

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

Documentation: Document with roadmap

Status: ONGOING, started with shallow convection cloudiness (see TOUCANS)

Action/Subject/Deliverable: 1D2D turbulence scheme

Description and objectives:

Efforts: none

Contributors: none

Documentation: no

Status: POSTPONED TO 2015 Nothing new, this task has lower priority, can start when the first ALARO-1 version is available.

Action/Subject/Deliverable: Baseline of the ALARO-0 version

Description and objectives:

The ALARO-0 baseline physics is in the operational use in Austria since January 2013, in Hungary and in Romania since 1 January 2014, in Slovenia since March 2014 (number of vertical levels is doubled) in Croatia since January 2015 (still 8 km and 37 vertical levels). Pre-operational suite is running in Slovakia on daily bases with horizontal resolution 4.5 km and 63 vertical levels. ALARO-0 which was used in CHMI since December 2012 was already replaced with ALARO-1 in January 2015. Code version cy38 is mostly used except in Austria and in Hungary where validation showed same quality as with cy36, so replacement was not done yet.

In Croatia, simulations with ALARO-0 baseline were done for period of 2 months (January and May 2014) on their 8 and 4 km domains with 37 and 73 vertical levels, with hydrostatic and non-hydrostatic dynamics. Current operational version is planed to be replaced with 4 km resolution and 73 vertical levels.

There were many evaluations with ALARO-0 baseline physics: validation of cy38 In Slovenia many changes were implemented and can not be judged what is coming from ALARO-0 baseline. Verification scores pointed out the lack of humidity in mid atmosphere (850 hPa, 700 hPa) and negative bias for 2m temperature is still present. Significant overestimation of cloudiness has been noticed in new set-up in Slovakia. Forecasts during summer 2014 were quite problematic, some missing events, problem with convection during night, inconsistency in consequent forecasts has been noticed. Forecast of the extreme precipitation event (mid May, flooding in Austria, Croatia) were relatively good (warning alarms were issued on time), areas with intense rain were located well, but highest precipitation amounts were underestimated. Evaluation of several precipitation cases in Romania shows that precipitation above 10mm/day are better for the first day and often position is shifted. The freezing rain event (Jan/Feb 2014, si, at, hr) was not so well

simulated, the vertical temperature profile with warm air layer (app.1000-2000m) from the analysis was not kept through integration.

Brief summery: precipitation should be further improved, near surface air temperature suffers from quite large biases, there is too much cloudiness in summer, especially at higher levels and over night, while during winter cloudiness is underestimated, especially low level clouds. Later is also the reason for systematically overestimated surface insolation during cold season.

Efforts: 8 person month

Contributors: local teams

Documentation: presentation and posters at ALADIN workshop, presentations at ALARO-1 Working days, reports, ALADIN-HIRLAM Newsletter

Status: PERMANENT, quality of NWP products is improved

Action/Subject/Deliverable: The ALARO-1 version

Description and objectives:

The first version of ALARO-1 was prepared. Turbulence scheme TOUCANS, radiation scheme ACRANEB2 and some improvements in the microphysics description were assembled together. The vertical geometry of cloudiness and falling precipitation is improved with the introduction of a bit of randomness to the maximum-random overlap. Degree of additional randomness is computed for each level as a function of its pressure thickness normalized by a reference thickness (parameter of the scheme).

Parameterization of rain drop size distribution was adjusted after Abel and Boutle (2012) proposal. Higher amount of small drops lead to their easier evaporation. It helps to diminish amount of drizzle/light rain overestimation especially in winter. At this occasion the collection and phase changes formulations for snow were also improved.

During the validation process operational set-up for TOUCANS was selected from many available options. For the time being some are kept from ALARO-0 and other novelties will be tested and included later.

Also retuning was needed as an introduction of new schemes usually breaks down compensation errors mechanism. This is not straightforward, because sensitive quantity - water vapour amount - has complex feedbacks with radiation, clouds, precipitation and surface processes.

Pre-operational evaluation was done in CHMI, one of already standard comparison is presented in Figure 3. Code pack for version cy38t1bf3 was available for validation by other teams in January 2015.

The complementary sub grid drafts (CSD) and non saturated downdraft parameterization, developed by Luc Gerard, was implemented in the frame of the ALARO-1 version in Prague (cy38t1_bf3) . Experiments were carried out for the developments validation and tuning. The main part was dedicated to the non saturated downdraft which was foreseen to be merged with the developments in radiation and turbulent diffusion parameterisation in the first version of ALARO-1. Validation showed that a re-tuning of the updraft part is absolutely necessary. Additionally, some code adaptations are still needed so inclusion of non saturated downdraft is postponed into next ALARO-1 version.

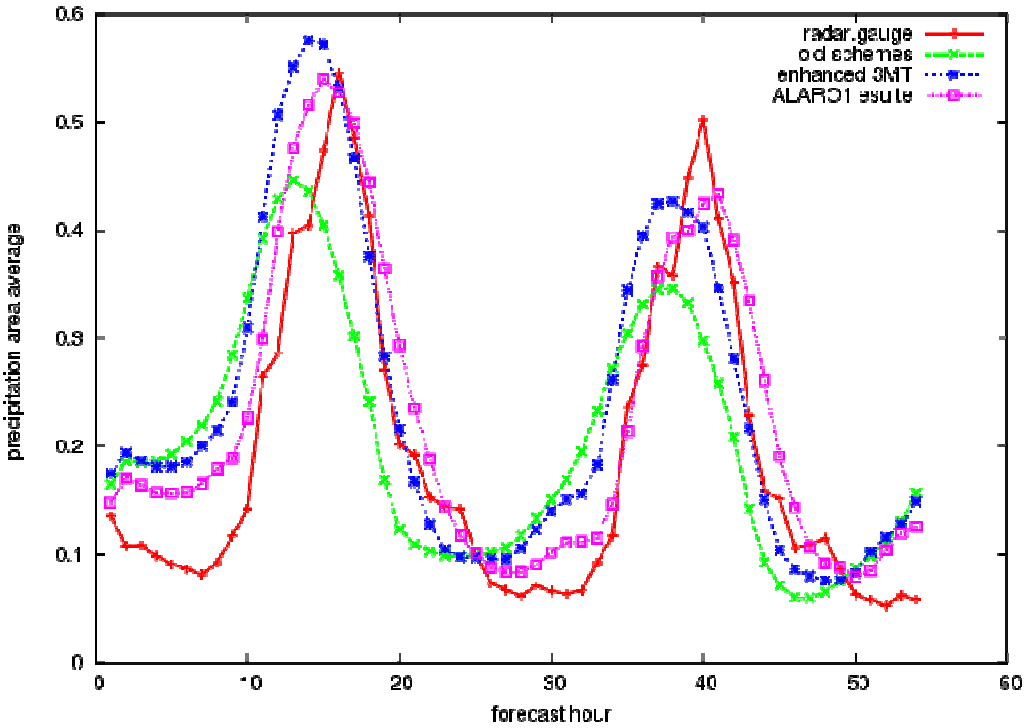

Figure 3: Precipitation averaged over Czech Republic for 11 days in June/July 2009, situation with exceptional quasi-tropical diurnal convective conditions over Central Europe, red - measured precipitation by radar and rain-gauges, green - ALARO-0, blue- ALARO-0 baseline (improved 3MT sheme), magenta - ALARO-1. To early diurnal cycle of convection is improved in the newest version.

Efforts: 5 person months

Contributors: R. Brožková (Cz), D.Banciu (Ro)

Documentation: stay report, presentations at ALADIN workshop, presentations at ALARO-1 Working days, Technical note: ALARO 1 Configuration with ACRANEB2 and TOUCANS scheme –Version A

Status: validation is ongoing

Action/Subject/Deliverable: Interfacing physics parameterizations

Description and objectives:

In the framework of testing new flexible physics-dynamics interface (Daan Degrauwe) a study of the approximations in the thermodynamics was done. The exact and approximate computations of temperature tendency show that transport of heat by precipitation has the largest impact. The interface should conserve the energy in order that various schemes can be combined.

New physics-dynamics interface will allow usage of physics packages in consistent way, our further aim is also to exchange individual parameterization schemes between various physics packages. For this significant reorganization and cleaning of the physics code is needed. This modification would enable better orientation in the code and also simplify further development. Modularity of the code would also increase, which leads to more straightforward exchangeability of schemes for parameterizations.

Reorganization of the ALARO computations inside APLPAR routine which can be done only in many stages. It started with radiation scheme and is now continuing with turbulence and shallow convection parameterizations. The new radiation scheme ACRANEB2 code is already written in modular way and was as feasibility test successfully included under APL_AROME. The next step in this cleaning procedure is adaptation of turbulence scheme. First ARPEGE/ALARO subroutines for computation of surface parameters used in turbulence parameterization were analyzed, separate blocks of computations were identified and new organization was proposed and tested under separate switch. Same procedure will follow also for other parts of turbulence scheme.

Efforts: 1.25 person months

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

Documentation: wiki page at HIRLAM: https://hirlam.org/trac/wiki/phys-dyn, stay report

Status: ongoing

Action/Subject/Deliverable: SURFEX issues

Description and objectives:

The coupling between SURFEX and TOUCANS scheme is prepared, the interface is done via the neutral drag coefficient Cdn. Scientific validation has not started yet.

The orographic radiation parameterization for short and long wave radiation fluxes was implemented into SURFEX. Method is based on paper of Muller and Scherer (2005) and on

its implementation into HIRLAM model (Senkova et al. 2007). Preparation of required input data has an important part. Orographic parameters (directional fraction of slopes, slope angles, local horizon angles) are obtained from high resolution surface elevation source data (SRTM 90m), based on this data slope, shadow and sky view factors are derived, aggregated to the model resolution (PGD tool) and written to LFI file. Procedure is technically working and was tested with AROME integration. First results are promising, extensive validation should follow. Significant differences in the temperature field in the Alps area are present, alpine valleys are colder, mountain slopes warmer, differences between sunny and shady slopes (see Figure 4 for an illustration).

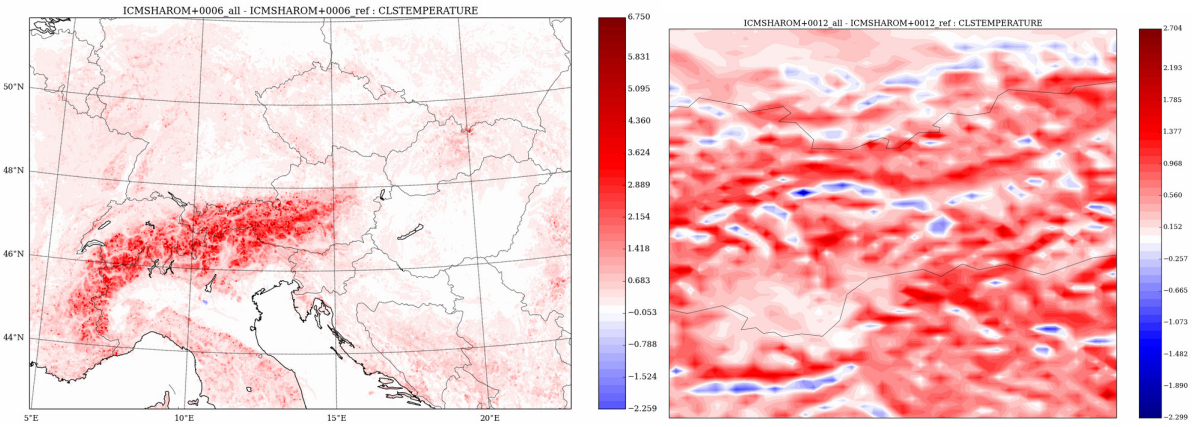

Figure 4: Differences for 2m temperature between AROME using orographic radiation parameterization and AROME reference for sunny day over Central Europe, 12.3.1014, at 6UTC (left) and at 12 UTC on zoom around Innsbruck (right).

Efforts: 4 months

Contributors: C. Wastl (at)

Documentation: presentation at ALARO-1 Working days; page https://hirlam.org/trac/wiki/ororad, stay report

Status: ongoing

Action/Subject/Deliverable: Various products for users (forecasters)

Description and objectives: Mixed layer CAPE, storm motion vector, vertical wind shear, relative helicity and temperature laps rate are available as a full-pos parameter. Code was prepared and checked, so called convection package is available for testing. Methods for lightning diagnostics are also prepared, but results of the evaluation process are not very promising. Tested methods have quite different results (one example is shown on Figure 5), their combination should be also validated. It turned out that this parameter should be

implemented as cumulated parameter inside model computation, average lightning activity over time interval can have larger information than one value at selected time.

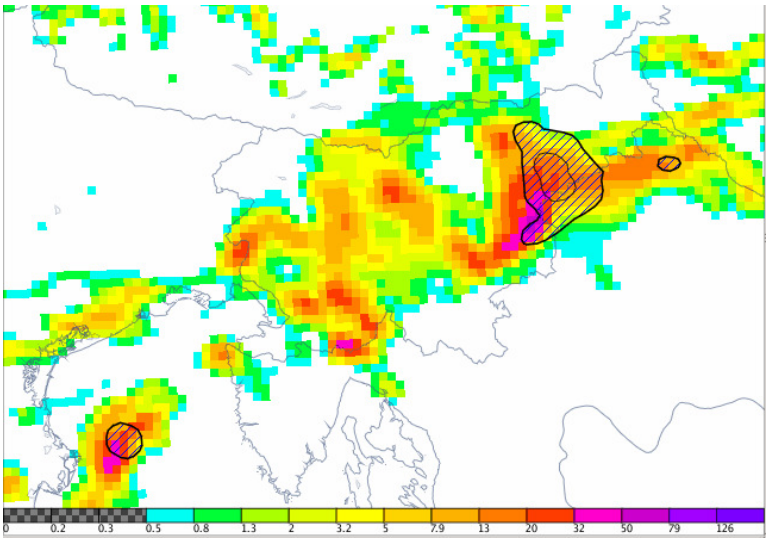

Figure 5: One of proposed product: simulated radar reflectivity (colors) combined with lightening density (black).

Efforts: 2.5 months

Contributors: J. Cedilnik (Si), C. Wittmann (At)

Documentation: report, convection package

Status: Ongoing, validation needed

Action/Subject/Deliverable: Very Fine Resolution experiments

Description and objectives:

Case studies (local, large scale and mixed type convection situations) with AROME 1km using different coupling models (AROME, ALARO, ECMWF) have been performed in Austria, evaluation focused the triggering of convections is ongoing.

Study of the turbulence in grey zone (question related to resolved and parameterized description of eddies) has started. AROME idealized runs at various resolutions (8,4,2,1 and 0.5 km) were prepared and are compared to MesoNH LES at 62.5m resolution (from Rachel Honnert) as a reference. The ratio between resolved and subgrid TKE was studied at various resolutions and for simulations with and without shallow convection scheme EDKF (Eddy Diffusion and mass-flux parameterization with Kain Fritsch approach) for the IHOP (International H2O Project) cases. Results from AROME simulations differ from the LES ones, the structure of TKE profiles are not closer to the LES one also at 1 km, so it is assumed that the shallow convection parameterization can not be neglected at this horizontal resolution.

The idea is to adjust the mass-flux computation part in the EDKF scheme (describing vertical fluxes caused by shallow convection) in such a way that scheme is active only at resolutions where it is necessary. The conditional sampling method to receive mass-flux from LES results was used to examined how the initial mass-flux at the surface depends on the horizontal resolution. It was confirmed that relation between subgrid mass flux and scaled vertical velocity can not be independent on horizontal resolution. The goal is to describe this relation.

Efforts: 10 months

Contributors: D. Lancz (Hu), N. Awan (At)

Documentation: stay reports

Status: ongoing

3 List of actions, deliverables including status

Subject: Turbulence scheme TOUCANS

Deliverables: paper published in JAS, implementation into ALADIN library (CY41T1)

Status: ONGOING

Subject: Radiation scheme

Deliverables: ACRANEB2 scheme, implementation into ALADIN library (CY41T1)

Status: ONGOING

Subject: Cloud scheme

Deliverables:

Status: PENDING

Subject: 1D2D turbulence scheme

Deliverables: -

Status: POSTPONED TO 2015

Subject: ALARO-0 baseline (operational implementation)

Deliverables:

Status: PERMANENT

Subject: The ALARO-1 version

Deliverables: code pack for CY38T1_bf3, implementation into ALADIN library (CY41T1)

Status: ONGOING, first operational application

Subject: Interfacing physics parameterizations

Deliverables:

Status: ONGOING

Subject: SURFEX

Deliverables: scheme for orographic shadowing parametrization in SURFEX code

Status: ONGOING

Subject: Various products for users (forecasters)

Deliverables: convection package

Status: ONGOING

Subject: Very Fine Resolution experiments

Deliverables:

Status: ONGOING

4 Documents and publications

List of reports:

Radmila Brožková, 2014: A general description of the "ALARO" concept and its realisation

Ivan Bašták Ďurán: Report from stay in Bratislava, 5 April - 2 May 2014 (TOUCANS local implementation, reasonable setup, case studyTKE based mixing length)

Dávid Lancz: Evaluating idealized AROME runs at different resolutions, LACE stay report, Toulouse, 10 March – 21 March 2014

Luc Gerard, Doina Banciu Complementary sub-grid updraft and non-saturated downdraft, stay report, Prague, 25 November – 13 December 2013

Christoph Wittmann, Jure Cedilnik, 2014: Extending the functionality of "convection diagnostics" in the ALADIN/ALARO/AROME, part 3, Report from stay in Ljubljana, 24 March - 4 April 2014

Ivan Bašták Ďurán: Users documentation for turbulence scheme (pTKE, TOUCANS), version from December 2014

Ivan Bašták Ďurán: Interfacing physics schemes under APLPAR: study for TOUCANS , Brussels, 5 - 21 December 2014

Scientific papers:

Ivan Bašták Ďurán, Jean-François Geleyn, and Filip Váňa, 2014: A Compact Model for the Stability Dependency of TKE Production–Destruction–Conversion Terms Valid for the Whole Range of Richardson Numbers. J. Atmos. Sci., 71, 3004–3026.
doi: http://journals.ametsoc.org/doi/abs/10.1175/JAS-D-13-0203.1

Mašek J, Geleyn JF, Brožková R, Giot O, Achom HO, and Kuma P: Single interval shortwave radiation scheme with parametrized optical saturation and spectral overlaps. Submitted to QJRMS

List of presentations:

ALARO-1 working days http://www.rclace.eu/?page=148

Joint 24th ALADIN Workshop & HIRLAM All Staff Meeting, 2014, 7 - 11 April 2014, Bucharest, Romania http://www.cnrm.meteo.fr/aladin/spip.php?article166

- Radmila Brožkova : Microphysics in 3MT and Grey Zone Experiments
- Neva Pristov : ALARO-1 - an overview of developments
- Jan Mašek : Validation of ACRANE2 Radiation Scheme (poster)
- National posters

Jan Mašek: Tuning of direct albedo in ACRANEB2, 2014 5th HARMONIE Radiation Working Week

Radmila Brozkova, J. Masek, I. Bastak-Duran, J.-F. Geleyn: Anticipating some future challenges for operational parameterizations in high resolution Numerical Weather Prediction, WWOSC 16-21 August 2014, Montreal, Canada

Neva Pristov: The physics of the model (ALARO), Aladin Forecasters Meeting, 10-11 September 2014 in Ankara, Turkey

Brožková R. and N.Pristov: Assembling Scientific Novelties in ALARO, 36th EWGLAM & 21th SRNWP joined meetings, 29 September - 2 October, 2014, Offenbach, Germany

14th EMS Annual Meeting & 10th European Conference on Applied Climatology (ECAC), 6 – 10 October 2014, Prague, Czech Republic
http://meetingorganizer.copernicus.org/EMS2014/orals/16063

Radmila Brožková and Jean-François Geleyn: Multi-scale parameterization concept ALARO: an example of its concretization

Ján Mašek, Jean-François Geleyn, Radmila Brožková, Tomáš Kráľ, Olivier Giot, Haliima Okodel Achom, and Peter Kuma: ACRANEB2 radiative transfer scheme - pushing the limits of broadband approach

Ivan Bašták Ďurán, Jean-François Geleyn, and Filip Váňa: Extension of turbulent scheme with prognostic TKE towards higher order solutions - prognostic TPE and parametrisation of TOMs

Jean-François Geleyn, Ivan Bašták Ďurán, and Pascal Marquet: Extending a dry turbulence scheme towards all moist aspects - main challenges, guidelines for maintaining consistency and practical solutions

Jean-François Geleyn, Jan Mašek, Radmila Brožková, and Peter Kuma: Band approach with selective intermittent strategy - a new way of doing effective and yet accurate radiative transfer calculations?

5 Activities of management, coordination and communication

Meetings:

- 24st ALADIN Workshop and & HIRLAM All Staff Meeting 2014, Romania (participation of Neva Pristov)
- ALARO-1 Working days, Vienna, Austria, 12-14 May 2014 (one of organizer Neva Pristov)
- Aladin Forecasters Meeting, 10-11 September 2014 in Ankara, Turkey (participation of Neva Pristov)
- 36th EWGLAM & 21th SRNWP joined meetings, 29 September - 2 October, 2014, Offenbach, Germany Turkey (participation of Neva Pristov, Radmila Brožkova)

- Working week(s) organized by ALADIN/HIRLAM community
  - working week on radiation, Prague, 10-12 March 2014 (Jan Mašek)
- Web meetings on physics-dynamics interface (participation of Radmila Brožkova, Neva Pristov, Jan Mašek)
- Web meetings on Implementation of orographic effects on radiation into SURFEX (participation of Christoph Wittmann, Clemns Wastl, Neva Pristov)

6 Summary of resources/means

Subject/Action/deliverable	Resource		LACE		ALADIN Flat-rate	
	planned	realized	planned	realized	planned	Realized
TOUCANS	6	9	1	1		
Radiation	6	7.5		0.5(2011)		
Cloud scheme	2	0.5				
1D2D turbulence	2	-				
ALARO-0	4	8				
ALARO-1	6	5	1	-	0.25	0.25
Physics interface	1	1.25			1	0.5
SURFEX	8	4	1	1	0.5	-
Additional fields	1	2.5		0.5 (2013)		
VFR experiments	8	10	1	1		
Total:	**44**	**47.75**	**4**	**3+1**	**1.75**	**0.75**

LACE scientific stays:

Ivan Bašták Ďurán: TOUCANS, Bratislava, 5 April - 2 May 2014

Christoph Wittman: Additional post-processed products, Ljubljana, 24 March - 4 April 2014 (*from 2013)*

Dávid Lancz: Study of the turbulence grey zone (AROME 1km runs), Toulouse, 10 – 21 March 2014 and 15 -26 September 2014

Clemens Wastl: Orographic shadowing in radiation (AROME, ALARO), Toulouse, 15 September - 10 October 1014

Peter Kuma: ACRANEB2, Prague, 8-19 September 2014 (from 2011)

ALADIN Flat-Rates Stays

Luc Gerard: CSD, Prague, 8-19 September 2014

Ivan Bašták Ďurán: Interfacing physics schemes under APLPAR: study for TOUCANS , Brussels, 5 - 21 December 2014