LACE Research and Development on Physics

Working Area Report 2011

Neva Pristov, LACE Area Leader for Physics
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1. Introduction

The efforts to achieve a scale-independent ALARO physics package have continued in 2011. This report gives a brief overview of the current status of research and development. Development of turbulence scheme has continued and work on radiation scheme has restarted. The necessary steps for operational implementation of SURFEX has started with validation.
The following achivements can be pointed out:

- the final design of the turbulence scheme TOUCANS with the treatment of shallow (non precipitating) convection,
- the improved computations in the radiation scheme,
- an academic environment for testing the 3MT novelties,
- the 3MT scheme can also use operational ARPEGE physics.

ALARO physics package improves the model performance in operational and ensemble systems. One of the challenges how to improve diagnostics of screen level parameters (temperature and wind) remains. It is expected that use of TOUCANS and improved radiation scheme should bring some improvements.

2. Research and development during 2011

2.1 Development of the schemes

2.1.1 Turbulence scheme TOUCANS

The turbulence scheme TOUCANS which consists the full TKE scheme is available for further testing and validation. Different options are available (RANS or QNSE approach, various mixing length closures). The scheme is designed to work for all stability regimes and also treats the effect of shallow convection (via the parameterization of third order momentum effects). The surface is also treated consistently to the upper air scheme
Current shallow convection parameterization is realized through modification of Richardson number. A new approach of shallow convection parameterization within TOUCANS turbulence scheme is possible with moist entropy potential temperature, which is well mixed quantity also for turbulent flow with phase changes of water.

Two approaches were coded and tested. The first approach is based on a modification of Richardson number with better diagnostic (through moist entropy potential temperature) of shallow convection occurrence and intensity. The second approach uses direct computation of a) moist Richardson number from cloud fraction and is used for computation of all source/sink terms in turbulent kinetic energy equation and b) Richardson number directly connected to moist entropy potential temperature in computation of turbulent exchange coefficient for heat/moisture.
It is expected that this new approach of shallow convection parameterization improves mainly (but not only) forecast of PBL in cases when phase changes of water occur.
Extensive testing in 3D environment and preparation for testing in parallel suite is ongoing.
Efforts: 11.5 person months
Contributors: I. Bašták Ďurán (Sk), F. Váňa (Cz)
Documentation: in preparation, poster at the ECMWF/GABLS Workshop on "Diurnal cycle and the stable atmosphere boundary layer"
Deliverables: implementation into ALADIN code (CY37)

2.1.2 Radiation scheme

Work on existing radiation scheme (ACRANEB) with low computational cost restarted in 2011. Functional form of broadband gaseous transmissions was revisited, using Malkmus formula with continuum term and final 2-parametric rescaling which replaced problematic 10-parametric Pade fits. Both solar and thermal fits (including pressure and temperature dependencies) were redone in homogeneous case, using SPLIDACO transmissions as reference. Their accuracy improved significantly with respect to the old fits. Comparison of homogeneous thermal transmissions showed good agreement with those delivered by externalized RRTM scheme (tool created by T. Kral). Treatment of water vapor e-type continuum was redesigned by introducing H4O2 (i.e. H2O dimer) as a degenarate fourth gas (on top of H2O, CO2+ and O3), enabling consistent treatment of non-homogeneous optical paths using Curtis-Godson approximation. Unavoidable step was treatment of non-random gaseous overlaps, especially important for (H2O, H4O2) pair. It was sufficient to fit pair gaseous overlaps, since the effect of triple or quadruple overlaps is negligible. This fact made all procedure feasible.
Work continued in full model, starting from modularized version of ACRANEB created by T. Král and finalized this year by R. Brožková (validation and introduction of intermittent computation of thermal gaseous transmissions). The change of gaseous transmissions (due to pressure/temperature/composition changes) happens on longer time scales than change of cloudiness, so the update frequency can be reduced (this also compensates CPU increase due to more costly computation of new fits). New gaseous fits and overlaps were coded and evaluated in isothermal case with respect to FMR/RRTM schemes. Results in solar band are outstanding, while in thermal band there is still some discrepancy with RRTM. One known source is different treatment of H2O e-type continuum (which is itself very uncertain), but single gas comparison revealed also problem for CO2+ which is currently being investigated. It is strongest for overlapped H2O/H4O2, where it is due to different treatment of e-type continuum in SPLIDACO reference. Reason for small but systematic discrepancy visible for CO2+ and O3 could not be identified so far, it still might be due to not completely clean comparison between ACRANEB and RRTM in full 3D model environment.

Efforts: 7.5 person months
Contributors: J. Mašek (Cz), R. Brožková (Cz), P. Kuma (Sk)
Documentation: in preparation
Deliverables: test implementation into ALADIN code, research environment software

2.2 Scientific maintenance

Tests have shown that several refinements of the deep convection parameterization are required to assure consistent behavior of 3MT at very high resolutions. The new concepts (more realistic downdraft scheme, novelties in updraft description) have been developed by Luc Gerard. There was a need for an academic validation environment to study multi-resolution behaviour. The initial state was prepared following the ideas of Weisman and Klemp (1982), allowing the modifications of different convection development conditions. These academic tests are being performed with the non-hydrostatic version at resolutions between 8 and 1 km.
Efforts: 1.5 person month
Contributors: D. Banciu (Ro)
Documentation: stay report
Deliverables: academic environment set-up

Additional extra work was invested to interface the 3MT scheme with the ARPEGE physics used in operational set-up. In order to best obey of the 3MT way of cumputations of various processes modifications in the code and namelist choices has been prepared. Simulations were compared also at the grey zone resolutions.
Efforts: 3 person month
Contributors: R. Brožková (Cz)
Documentation: report and technical documentation
Deliverables: test implementation into ALADIN code, namelist settings

A very extensive validation of the SURFEX scheme was kicked off during SURFEX working week. The full reproducibility of the model behaviour ALADIN/ALARO using SURFEX-ISBA scheme instead of current ISBA scheme was not expected, forecast performance is mostly neutral in the terms of verification scores. Based on these tests it can be concluded that usage of SURFEX (including also novel features) has much potential for improving forecast performance, although there are some problems and open questions to be addressed to the SURFEX Steering Committee.
Efforts: 3 person month (plus 1 month flat rate)
Contributors: L. Kullmann (Hu), S. Schneider (At), J. Cedilnik (Si)
Documentation: reports
Deliverables: -

Studies of wind gusts diagnostics has been started. There are three new versions for gust computations coded: Brasseur method, Schreur and Geertsema method and ECMWF method. Validation is still on-going. Together with the two existing gust parameterizations there will be five options available, both for deterministic models and ALADIN-LAEF multi-physics.
Efforts: 0.75 person month
Contributors: C. Wittmann (At)
Documentation: not available yet
Deliverables: test implementation into ALADIN code

2.3 Operational implementation

The model configurations with resolutions below 5 km using ALARO physics package are in the operational use at CHMI (4.7 km, 87 model levels), ZAMG (4.8 km, 60 model levels,

1 March 2011) and ARSO (4.4 km, 43 model levels, 30 March 2011). At NMA Romania the operational model has now the resolution of 6.5 km and in SHMU new model setup with resolution around 5 km is under preparation. Regular daily computations at resolutions of 2 km started in summer 2011 in Croatia.
ALARO physics is used in LACE-LAEF and new multi-physics setting with different options and tuning was developed and is in test in new LAEF version.
At HMS ALARO was tested in a parallel suite and is now used in their ensemble system. Upper-air results are good but still there are some problems with (near) surface parameters which should be solved before operational implementation.
Guidance for the users is under preparation.

Contributors: local teams, Area Leader for physics

3. Status of deliverables

D1: New scheme TOUCANS:

- Finish coding and phasing it to cycle CY37. DONE
- Test it in 1D model, then 3D model. ONGOING
- Prepare for testing in parallel suite. ONGOING

D2: improvements in the radiation scheme

- Review of the fits of gaseous broad band transmission functions for thermal band NEW ACHIEVEMENT - DONE
- The new fits of gaseous broad band transmission functions for solar band ONGOING
- prepare for testing in parallel suite ONGOING

D3: cloud scheme:

- finish analysis of harmonization. Make first tests. PENDING (dependent on D1 and D2)

D4: Guidance with the recommendations for the ALARO 5km operational use. ONGOING

D5: 3MT in high resolution

- validation in academic environment ONGOING

D6: SURFEX in ALARO

- first validations, SURFEX Working week, plans for implementations ONGOING

New: 3MT in ARPEGE
interfacing the 3MT scheme with ARPEGE physics DONE

4. Summary of resources/means

2011	Planed // Fullfield (person/month)	
LACE funding (stays)	5 // 3.75	
Networking, supevision	5 // 5	
Developments	20 // 27	+ flat rate 3.5 // 2.75
total	30 // 35.75	

LACE long stays:

- Ivan Bašták Ďurán: TOUCANS, Prague, 17 January - 11 February
- Peter Kuma: General gaseous transmission functions for radiative transfer - a cost vs. accuracy study, Prague, 28 March -8 April
- Ivan Bašták Ďurán: TOUCANS, Prague, 16 May - 10 June
- Ivan Bašták Ďurán: TOUCANS, Prague, 27 June - 22 July
- Peter Kuma: General gaseous transmission functions for radiative transfer - a cost vs. accuracy study, Prague, 2 weeks postponed to 2012 due to health problem
- Doina Banciu: Validation of the last developments in deep convection parameterization, 3 weeks, Brussels instead of Prague canceled
- Neva Pristov: Networking, Prague, 5 - 9 december

Flat-rate stays:

- Laszlo Kullmann: SURFEX: externalization, analysis of the numerics of the Best&al. Interface, Brussels, 1 month
- Doina Banciu: Deep convection, Brussels, 0.75 month
- Joris Van den Bergh: Microphysics, Prague, 0.75 month
- Rafiq Hamdi: Interface between ALARO-1 (namely TOUCANS) and SURFEX Prague, 0.25 month (change of duration and subject)

The SURFEX Working week, Brussels, 18-12 April 2011
Laszlo Kullmann, Stefan Schneider, Jure Cedilnik

Link to HIRLAM:

Bjorn Stensen (HIRLAM) was in Prague to get familiar with TOUCANS.
Tomislav Kovačić participated at HARMONIE MUSC working days, 29Nov - 2 Dec 2011, Helsinki, where he had presentaion on DDH toolbox

Presentations, posters:

- Radmila Brožkova : On the role of entrainment at the grey zone scales, 21th ALADIN and HIRLAM Workshop, 5-8 April 2011,Norrkoping, Sweden
- *Lisa Bengtsson: An approach to deep convection organization using cellular automata, 21th ALADIN and HIRLAM Workshop, 5-8 April 2011,Norrkoping, Sweden*
- Filip Váňa: TOUCANS - new turbulence scheme for ALARO physics, 33rd EWGLAM and 18th SRNWP meetings, 10 - 13 October 2011,Tallinn, Estonia
- Neva Pristov: Latest developments in ALARO, 33rd EWGLAM and 18th SRNWP meetings, 10 - 13 October 2011,Tallinn, Estonia
- Ivan Bašták Ďurán, Jean-François Geleyn, Filip Váňa:TOUCANS - A compact parametrization of turbulence for GCM to meso-scale models valid for whole range of Richardson numbers. The ECMWF/GABLS Workshop on "Diurnal cycles and the stable atmospheric boundary layer ", Reading, 7 to 10 November 2011

5 Appendix: Illustration of few selected developments

The turbulence scheme TOUCANS has been comprehensively tested. The best results are obtained using QNSE approach with the modified Bougeault-Lacarrere mixing length closure. Comparision between curent PseudoTKE and TOUCANS schemes for a weather situation with strong anticylonic inversion is presented in figure 1. Strength and compactness of the inversion layer (blue in the middle of the cross-section) is significantly improved. Air mixing in PBL better described with TOUCANS as turbulence is treated more consistent also near the surface.

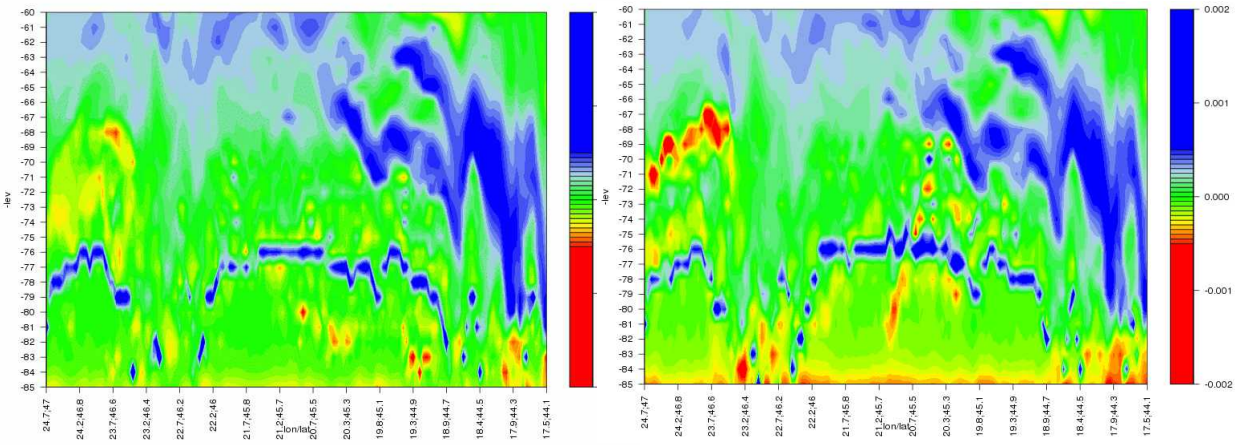

Figure 1: Vertical cross section for Brunt–Väisälä frequency (BVF) after 30 hours of simulation starting at 3. 3. 2011 6:00 UTC on operational ALADIN/CZ domain obtained with current turbulence scheme PseudoTKE (left) and TOUCANS (right).

After testing several approaches, final fits of broadband gaseous transmission functions were obtained for homogeneous case. Pade fitting, the most non-trivial and problematic part of current ACRANEB transmissions, has been replaced by simple 2-parametric rescaling controlling the slope at saturation. This new approach was implemented and validated, dramatically improving results of idealized tests (see figure 2 for thermal H2O). These tests proved high accuracy of the new fits for all gases/bands. Residual problems seen in 3D real cases are most probably due to approximate treatment of nonhomogeneous optical paths, as well as uncertain reference for H2O e-type continuum.

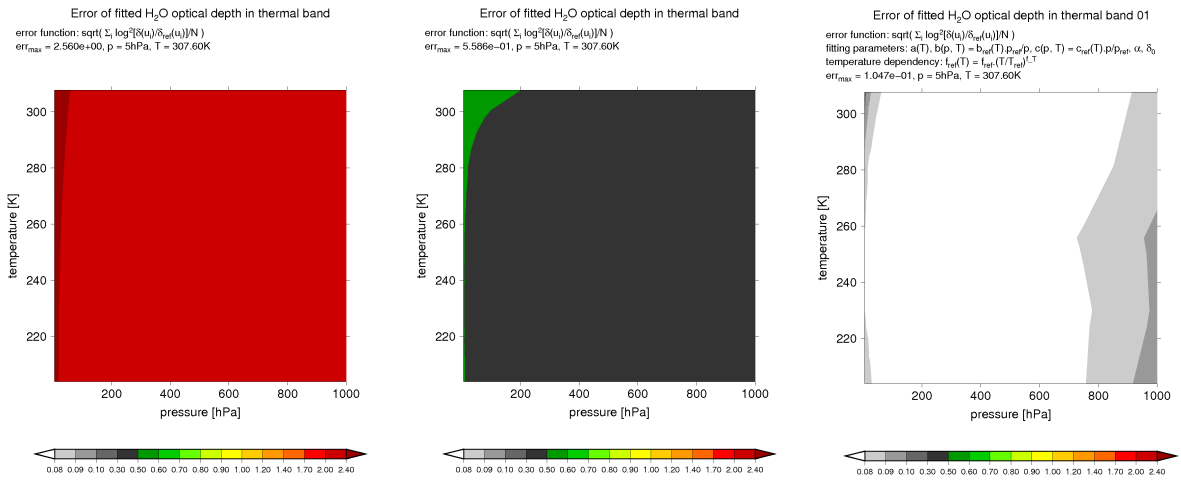

Figure 2: Error of fitted H2O optical depth (without e-type continuum) in thermal band with respect to pressure and temperature: left – current ACRANEB scheme; middle – fit from 2009; right – new fit. Errors below 0.3 (white and light grey color) mean almost perfect fit, errors between 0.3 and 0.8 (green) are acceptable, errors above 0.8 (yellow, red) are questionable.

The 3MT scheme was tailored to use operational ARPEGE physics. Various simulations were carried out in order to obtain an objective comparison. One example is shown in figure 3 where the two different model set-ups (operational ARPEGE with and without 3MT) are compared at two different resolutions. At both resolutions 3MT produces more realistic (less noisy) precipitation structures.

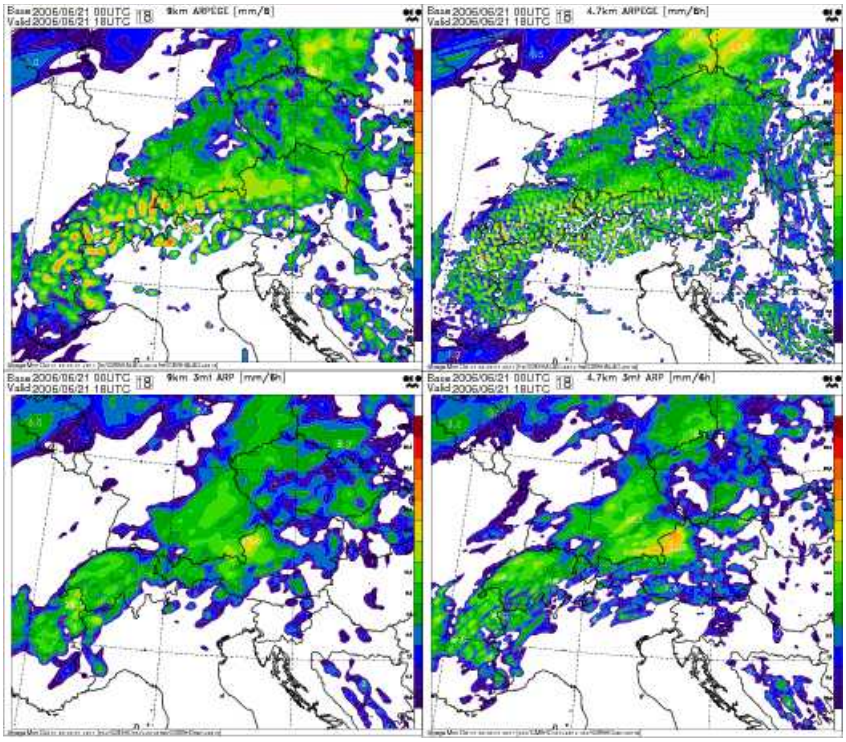

Figure 3: 6 hour accumulated precipitation amounts for the period 12UTC to 18UTC starting on 21/06/2006 00UTC on ALADIN-CZ domain (43 vertical levels) obtained with
ALADIN transcription of the native ARPEGE set-up at 9.0 km mesh-size (top left) and 4.7 km mesh-size (top right) and with "3MT in ARPEGE" basic set-up at 9.0 km mesh-size (bottom left) and 4.7 km mesh-size (bottom right).