ALARO-1 Working days 2016

Brussels, 12-14 September 2016

Synthetic Report and Plan

Scope

The development of new physics for high resolution to be part of the ALARO-1 has been the holy Graal for more than 5 years, now. The wide ambition of the initial plans has not been lost. The different modules that have been developed along these years 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.

The recent developments of ALARO-1 physics have concerned:

- an improved radiation scheme (ACRANEB2) and its interaction with clouds
- the turbulence scheme TOUCANS, including handling of shallow clouds transport using a simplified mass-flux-type scheme;
- computation of screen-level properties (diagnostic at 2m)
- cloud overlap strategies
- non saturated downdraught scheme
- improved scale-aware deep convection scheme (CSD)

Further efforts will have to be put also on SURFEX and microphysics.

Local ALARO experience

Comparisons and case studies have been performed in different countries. Experiments have been performed down to 1.3km resolution, showing already benefits of the high resolution with the ALARO-1vA in cy40t1 version.

Climate experiments are done in Belgium and in Sweden.

Belgium participates to the Coordinated Regional Climate Downscaling Experiment (CORDEX) using the ALARO-0 model at 50km and 12.5km resolution with runs over 30-year periods, in the past (1979-2010, using ERA-interim reanalysis) and in the future based on different climate scenarios. The runs for the evaluation period show good performance of ALARO-0 compared to other models. The local CORDEX-BE project makes a further downscaling at 4km resolution around Belgium with ALARO-0, COSMO-CLM and MAR, to provide an ensemble of high-resolution climate runs to feed local impact models.

Sweden continues with ALARO experiments over Europe at 15 and 6km resolutions, and with AROME experiments over Central Europe at 2km resolution, including case studies of heavy rainfall and sensitivity studies of deforestation. This allows to make apparent some biases of the model as well as their improvement with the new cycles and configurations.

Points of attention and further developments

- The newly introduced shallow cloud treatment in TOUCANS uses internally a `shallow cloud fraction'; however this value is a separate diagnostic, while the interaction with the model fields takes place through transport. Hence the (so-called 'stratiform') Xu-Randall cloud scheme condensation automatically includes the condensation in shallow clouds. This is different from (complementary) deep convection condensation computed explicitly in a separate parametrisation.

- A big issue is the harmonisation of radiative cloud fraction and condensates with the microphysical cloud fraction and prognostic condensates.
  Presently (LNEB_FP=.F.), the radiative condensates are re-estimated. The 'stratiform' part is obtained from total water using a critical relative humidity profile (HUC) that (contrary to the cloud scheme) does not include phase and mesh size dependencies. The convective condensates are re-estimated from the historic convective cloud fraction. These two re-estimated condensates are added, and the radiative cloud fraction is obtained by direct application of the XR formula (with parameter QXRAL corresponding to QXRAL_ADJ in the cloud scheme). Additional parameters further affect the estimation of radiative condensates and cloud fraction. 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 (possibly a direct use of prognostic condensates and adjustment cloud fraction into radiation, with LNEB_FP=.T.).

- <u>TOUCANS:</u> some parts and options have further to be tested / improved:
  - different functional dependencies to Ri of the stability functions: model I, model II, emulation and extension of turbulence schemes EFB, QNSE,
  - mixing length combinations (CGMIXELEN='EL0' to 'EL6'), conversion between the TKE-based mixing lengths and Prandtl mixing lengths (RMC01),
  - impact of the Third Order Moments (TOMs),
  - further tuning and improvement of shallow convection part,
  - interfacing TOUCANS with SURFEX (TOMs interact strongly with surface fluxes, while these should stay externalised => conflict to be solved, especially for urban areas (TEB)).

- <u>Radiation:</u> parameters have rather fixed physical values, so that tuning possibilities are very limited. Recent developments include intermittent update of the shortwave gaseous transmissions, revised cloud optical properties and optical saturation, optimal bracketing of the exchange between layers, introduction of generalized cloud overlap and improved sunshine duration estimation. Further improvements may concern the treatment of aerosols, considering the radiative effect of falling

hydrometeors, and parameterizing impact of clouds on the broadband surface albedo.

A big challenge are 3D cloud effects. For lower horizontal resolutions they can be parameterized within 1D radiative framework. In kilometric and finer resolutions, however, 3D cloud effects become resolved. Unfortunately, cost and complexity of truly 3D radiative calculations are beyond the scope of NWP. For the time being it is not clear what the optimal solution will look like. Literature on the subject should be monitored.

- Non-saturated downdraught: the new scheme is able to produce a better correlation between the downdraughts and the precipitation. A fixed version of the code is in CY43T2, and a first tuning with 3MT has been validated.
- Convection: the CSD updraught scheme has shown to produce a smoother transition towards fully explicit convection at very high resolution. The dynamical behaviour (location and evolution of the precipitation fields) is generally improved. The tuning and validation is going on in ALARO-1, with some interactions with the tuning of the cloud scheme (adjustment) and the radiative clouds.

  The behaviour at high resolution when deep clouds are substantially resolved by the model grid is sensitive to the turbulent diffusion tuning; it can also be improved by the use of cellular automaton in the convective scheme. The code in CY43T2 includes this option.
- Microphysics: prognostic graupel has been coded by Michiel V., should be phased. Prognostic hail does not appear important. At longer term, could go to a 1.5 moment scheme (i.e. introducing number concentration for rain only).
- New physics-dynamics interface is working; the DDH (diagnostics on horizontal domains) should now work properly with the flexible interface in CY43T1.

Prospects on ALARO-1 versions

The first well tuned version was ALARO-1vA available in February 2015 (export cy40t1, also modset for cy38t1), in May 2016 the improvement of the screen-level properties (modset for cy40t1 and cy38t1) was distributed. Now next well tuned version named ALARO-1vB has been prepared (is already used at CHMI). Its ingredients (in addition to ALARO-1vA, screen-level interpolation) are: mass flux type of shallow convection scheme in TOUCANS, exponential-random cloud overlaps in radiation and cloud diagnostics, improved sunshine duration, direct solar flux at surface and 10m wind interpolation. This code is available in cy43t2 and it was proposed to prepare a modset for cy40t1. Updates of the CSD code also entered cy43t2. It was proposed that the current code in cy43t2 is a base for further developments and tunings, also for the coupling with SURFEX.

Foreseen future version (ALARO-1vC) could have non-saturated downdaught and possible additional novelties (prognostic graupel, revision of mixing length and TOMs in

TOUCANS). And finally, a baseline version of the full ALARO-1 will contain CSD.
Steps to the full ALARO-1 baseline are as follows, including validations and proposed namelist settings:

- complete TOUCANS with mass flux type of shallow convection
- idem + non-saturated downdraught
- possible additional novelties (prognostic graupel, revision of mixing length and TOMs in TOUCANS)
- idem + CSD will make a baseline version of the full ALARO-1