***R**egional **C**ooperation for*
***L**imited **A**rea **M**odelling in **C**entral **E**urope*

LACE
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ALARO going forward

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On interoperability and convergence

There are many benefits to having multiple physics options.
(the obsolete options can be abandoned during regular maintenance)

Interoperability would allow exchanging parametrisations across CSCs
- different: assumptions, param processes, input and output vars
- some parts more flexible that other (radiation)

ALARO has closely knit turbulence – deep convection – microphysics that scientifically works as a single block (with a number of choices)

Multiple physics options are beneficial for probabilistic forecasts, reduce forecasting system limitations, valuable alternatives ...

Overview

Developing further the existing parametrisations and

Setting some goals:

1. have ALARO+SURFEX config for DAVAI
2. 3D physics – radiation and turbulence
3. tool for tuning using ML
4. stochastic physics
5. should we have an ALARO specific overiview publication?
6. code refactoring, aplpar splitting and GPU adaptation
7. MUSC with ALARO – needs to be used more widely
8. how much tuning do we need when changing resolution, dyn, ...

These are not choose one path options

ALARO with SURFEX in DAVAI

- export version is currently tested only on ALARO without SURFEX
- it is possible to run ALARO with SURFEX (problems tstep related?)
- MUSC test cases all assume using SURFEX

Have a working example of ALARO with SURFEX
- example (documented) namelist
- validated from cycle to cycle (at least for the export versions)
- have more people working on it ...

Stochastic physics and turbulence

Kober, K., & Craig, G. C. (2016). Physically Based Stochastic Perturbations (PSP) in the Boundary Layer to Represent Uncertainty in Convective Initiation, JAS, 73(7), 2893-2911.

Small scale variability due to unresolved physical processes
- depend on weather regime and model resolution,
- is simulated using stochastic perturbations.

The amplitude of perturbations is based on turbulence parametrisation
Spatial and temporal correlations are based on length scale and timescale of turbulence

These stochastic perturbations triggered additional convectie cells and improved precipitation forecast when synoptic forcing was weak.

Kober and Craig (2016) cont.

The perturbations are added to the tendencies of three model variables (temperature, moisture, and vertical velocity).

- computed as the product of a random number field, the flux information from turbulence, and a constant scaling factor.

- the introduction of perturbations was mainly confined to the BL

- precipitation of all intensities was increased with perturbations

A single parameter multiplying the amplitude of all stochastic perturbations must be tuned to give optimal results.

They assume deep convection is resolved at 2.5 km res

Simulating model uncertainty of subgrid-scale processes by sampling model errors at convective scales (Van Ginderachter et al. 2020)

- diagnose model error linked to specific phy process
- the flux diff between model with and without deep cnv is the model error
- used to pertutb stochastically perturb the fluxes of the target model

1. perfect model: running a validated reference configuration of a full NWP model,
2. target model: switching off one of the parameterizations (or replacing it)
3. verifying that the target performs worse than the reference and
4. computing the model error.

The stochastic flux perturbations increased overall spread but reduced the erroneous small scale spread -> more skillful ensemble

Van Ginderachter et al. 2020 cont

The ensemble without the deep-convection parameterization exhibits too much spread as a result of inadequate representation of the convective processes at the convection-permitting scales.

Analysis of the error fluxes reveals the importance of the vertical correlation structure, as well as of the inter-variable correlation.

the stochastic flux perturbations can increase the probabilistic forecast skill in an ensemble context in such a way that it compensates for the lack of parameterization.

the ensemble system with the stochastic perturbations along with the IC and LBC perturbations compensates for the absence of the parameterization scheme.

- could treat 3D phy, other expensive parts of rad/turb/microphy for oper EPS

Using ML for tuning physics

COSMO work (Voudouri et al. 2021, Avgustoglou et al. 2022):

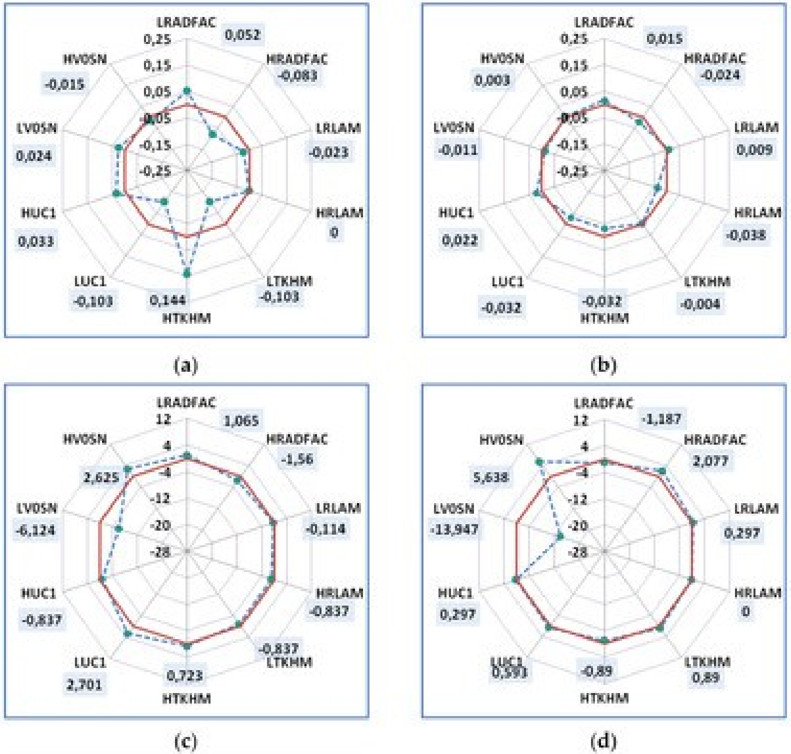
The objective calibration method is applied to a 0.01° (approximately 1 km) horizontal resolution COSMO model over a Swiss domain.
Five tuning parameters of the parameterization schemes affecting turbulence, soil-surface exchange and radiation were chosen.
Simulated for tuning - A full year was simulated, with the history of the soil included (hindcast) to find the optimal parameter value. 21 simulations needed for calibration.
For validation - A different year has been used to give an independent assessment of the impact of the optimization process.
The operational MeteoSwiss model was already a well-tuned configuration, the results showed a slight model performance gain.

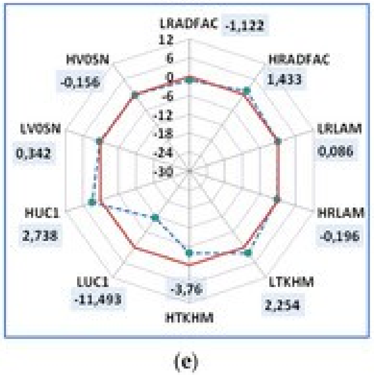
Sensitivity experiments

Sensitivity values (S) on the spider graphs for precipitation, snow and total cloud cover are defined as:

S(%)=(Ftest−Fdef)/Fdef

where Ftest is the meteorological field value (precipitation, snow, total cloud cover) when a test value of the parameter considered is used and Fdef represents its default parameter value.



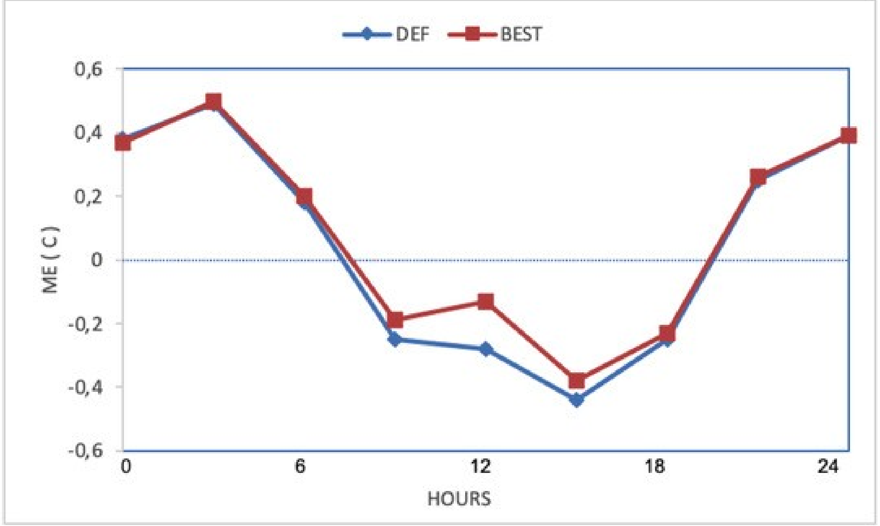


Yearly sensitivity of (a) 2 m temperature, (b) dew point temperature (c) precipitation (d) snow and (e) total cloud cover with respect to all selected parameters for the year 2013.

Table 2. Statistics of selected meteorological fields for 2013 and 2017.

Parameter	T2 m (°C)				Td (°C)				10 m Wind Speed (m/s)			
Year	2013		2017		2013		2017		2013		2017	
Measure/Simulation	DEF	BEST	DEF	BEST	DEF	BEST	DEF	BEST	DEF	BEST	DEF	BEST
ME	0.01	0.04	0.18	0.09	0.06	−0.01	−0.029	−0.029	0.13	0.11	0.115	0.104
RMSE	2.07	2.07	2.22	2.21	2.31	2.33	2.37	2.36	1.9	1.9	1.955	1.954
MINOBS	−30.7		−29.6		−73		−54.8		0		0	
MINMOD	−28.6	−28.5	−30.2	−30.0	−37.48	−38.67	−44.41	−45.47	0.007	0.001	0.0012	0.0013
MAXOBS	40.8		42		39		41.2		46		40.1	
MAXMOD	42.7	42.6	44.03	43.38	25.24	25.77	24.86	25.00	29	29	28.19	28.04

Daily cycle (averaged over the entire year and entire model domain) of 2 m temperature ME when using default (blue line) and optimum (red line) parameter values for 2013.



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Summary

There are developments made on all ALARO params (presented during the ALARO WDs)

Some physics developments might be computationally expensive
 - code them anyway and develop perturbations for oper EPS

Multiple physics options allow to estimate the error introduced by different assumptions/methods/processes modelled and omitted.

Changing resolution/domain/dynamics options/surface might require some retuning (especially when close to partially resolved processes)
 - develop a tool for objective tuning