

Annex A:

Project description: Snow cover Atmosphere INTERactions (COSMO-SAINT)

An improved snow cover scheme for numerical weather prediction and climate models

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The seasonal mountain snow cover strongly influences boundary layer processes such as turbulence, radiation and surface exchange of mass and energy. Therefore, knowledge of the current state of the snow cover on the ground is of paramount importance for numerical weather prediction (NWP). This is especially true since the horizontal resolution (up to 1 km) of NWP models strongly increased in recent years. Currently, most NWP models use simplified – typically one snow layer – snow cover schemes, which are in general not capable to model the complex processes relevant for snow cover formation and evolution. One-layer models cannot reproduce melt and refreezing of deeper snow to just name one example.

Therefore, the proposed research builds up on work conducted during a joined project between MeteoSwiss and the WSL Institute for Snow and Avalanche Research SLF. Within this project initial work has been carried out developing a new multi-layer snow cover scheme for the current operational version of COSMO.

The current code – with regard to the available snow cover schemes – implemented in the latest version of COSMO has been validated and a new multi-layer snow cover scheme as well as its implementation has been proposed to the consortium. Initial testing and coding especially for the surface-atmosphere exchange and the internal heat transport has been carried out. However, essential physical parameterizations of the proposed multi-layer snow cover scheme and the implementation into the land-surface scheme TERRA as well as its full implementation into the model COSMO and ICON are still pending.

We therefore propose a project – starting January 2019 – with a duration of total 18 month, which can be separated into 4 phases. The 4 phases will be briefly described in the following.

Phase 1 – Implementation of relevant physical parametrizations (6 months). As written above initial programming has already been carried out and new subroutines and modules for the new multi-layer snow cover scheme have been implemented. Improvements for the snow surface temperature – a key factor for snow cover evolution – compared to the currently used single-layer scheme have been shown. However, phase changes, i.e. melt and refreeze, water transport as well as settlement relevant for an accurate modelling of the snow cover evolution are not implemented yet. Therefore, phase 1 is dedicated to implementing phase changes, water transport and settlement. Together with the already implemented layering and heat transfer through the snow cover, a multi-layer snow cover scheme meeting the minimum requirements will be available for further validation.

The implementation of the new multi-layer snow cover scheme needs to be coordinated in close collaboration with colleagues of the COSMO consortium (especially with the DWD, e.g. Matthias Raschendorfer). Therefore, time is also reserved during phase 1 to allow a proper implementation of the multi-layer scheme and to ensure an easier transition to the ICON model.

Milestone 1: Base model implemented in the current version of COSMO.

Phase 2 – Validation and further improvements (6 months): In a first step the base model, as developed within phase 1, will be validated and further improved during this phase. Validation of the simulations will be done against measurements of high alpine automated weather stations located across the Swiss Alps measuring – besides other parameters – snow surface temperature, snow depth as well as internal snow temperature. Initial we will concentrate on shorter periods (days to weeks) to identify

possible shortcoming of the base model (numerically and physically) as well as finding the optimal settings for relevant parameters. During the validation phase additional improvements of the snow cover scheme as well as affected parametrizations might become necessary. This includes e.g. absorption of solar radiation or adjustments of the diagnostics for the near surface air temperatures. Once a satisfying model setup has been found, longer (month, i.e. winter seasons) will be carried out, which will require computational resources. A proposal in order to apply for these resources will be prepared and submitted to the CSCS.

In parallel, and in close collaboration with colleagues of the COSMO consortium we further propose the implementation of the multi-layer snow cover scheme into the ICON model. The code structure of the base model is then already prepared for such a task.

Milestone 2: validation of the base model in terms of snow cover and affected near surface atmospheric parameters (diagnostics). Preparation CSCS proposal for computational resources. Possible implementation of the multi-layer snow scheme into ICON.

Phase 3 - Consolidation (4 months): During the consolidation phase we aim on building up on the work performed in phase 2. Possible shortcomings of the improved scheme – again numerically and physically – shall be identified and fixed in order to assure numerical stability to meet requirements of the operational COSMO version. A new snow cover scheme will also require adjustments in terms of data assimilation as well as input and output parameters (re-start files, grib, netcdf etc.). Therefore, phase 3 also aims on assessing and meeting the requirements for an operational version of the multi-layer scheme.

Milestone 3: Final version of the multi-layer snow cover scheme, ready for operational use.

Phase 4 - Documentation (2 months): In the final phase 4 required documentations in forms of internal work reports (COSMO consortium) as well as scientific publications for peer-reviewed journals will be prepared.

Milestone 4: Documentation (work report, scientific publication)

Schedule: The above-mentioned duration and schedule assumes a 100% employment of the main scientific collaborator (Dr. Sascha Bellaire); in case of part-time employment it changes accordingly.