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Forecasting the weather
- ensemble techniques
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# Adapting numerical weather prediction codes to future hardware technologies: Porting the physical parametrizations on GPUs using a directive based approach

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The available computer power is the most important constraint limiting the horizontal resolution, the complexity of the model system, and the number of ensemble members of numerical weather prediction and climate models. In order to leverage future supercomputers, which will tend to have an increasing number of compute cores with reduced memory access speed per core, current models will have to be adapted. To this end, the HP2C COSMO project carried out in the framework of the Swiss HP2C (High Performance High Productivity Computing) initiative aims at re-engineering the numerical weather prediction and regional climate model COSMO (Consortium of Small-Scale Modeling) with the aim to run efficiently on both massively parallel scalar machines as well as heterogeneous systems with GPUs (Graphical Processor Units). The project encompasses a complete redesign of the dynamical core, including a GPU capable version, as well as a new data structure layout to optimize memory usage.

Since a complete rewrite of the full model code is neither feasible nor acceptable by the developer community, a different strategy for GPU porting has to be chosen for the remaining parts of the model. Concerning the GPU implementation of the physical parametrizations, a directive based approach has been selected ensuring that this part of the code remains accessible and can easily be modified by the large user community within the COSMO consortium. In order to fully take advantage of the various parallelism levels available on GPU hardware, several modifications are considered, in particular concerning loop orders and data management, and the advantages and drawbacks of different implementations are discussed. Performance results of the most time consuming physical parametrizations, namely the microphysics, radiation and turbulence schemes are presented. A speedup of up to a factor 10 is shown with respect to comparable CPU results, thus illustrating the potential of GPUs for atmospheric modelling. As a result of this study, general guidelines for designing physical parametrizations in numerical weather prediction and climate models that ensure easy porting to GPUs using compiler directives while retaining high CPU performance will be presented.