Uncertainties in meteorological modelling: is it weakness or strength?

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The Earth system is composed of atmosphere, hydrosphere, cryosphere, land surface and biosphere, including highly non-linear feedbacks between them [1]. The future evolution of the system and its individual elements can be determined by numerical modelling. Numerical models consist of the mathematical description of the governing physical processes and the numerical solution of the underlying equations. Atmosphere is the most well-known, at the same time the most rapidly changing part of the Earth system; numerical weather prediction is concentrating on the short-range description of the atmospheric features. The further components of the climate system have a variety of adjustment time scales changing from years to hundreds of thousand years; and the climate models simulate the asymptotic behaviour of the complex system. Although this principle sounds simple, there are various uncertainties in the description of the system and the modelling process. Therefore, it is indispensable to consider and more importantly account for all these uncertainties and quantify them for the benefit of the users of the various forecasts (projections).

The most important uncertainty components of the meteorological modelling are the choice of the model description (different horizontal and vertical discretization and parameterization schemes, etc.) and the initial conditions [2]. While in the everyday numerical weather predictions the uncertainty is stemming mainly from the initial conditions, in climate change projections the initial conditions have negligible role and additional sources as the internal climate variability (as natural source) and the unknown future evolution of the anthropogenic activity (considered in terms of emission scenarios) are also important ingredients [3]. In practice, the uncertainties in the weather predictions and climate projections are quantified by the ensemble approach: on short-range the multi-analysis and multi-model techniques are applied, while on climate scale the multi-model and multi-scenario methods are used.

In the presentation the scientific basis of meteorological numerical modelling (for weather and climate) is introduced with special focus on the predictability of the model simulations. Some examples will be sketched for the intrinsic value of uncertainty information in the weather predictions and climate projections.

[1] K. McGuffie, A. Henderson-Sellers, A Climate Modelling Primer, *Third Edition, John Wiley & Sons, New York,* **2005**, 280 pp.
[2] R. Buizza, Chaos and weather prediction, *ECMWF Meteorological Training Course Lecture Series,* **2002**.
[3] E. Hawkins, R. Sutton, The potential to narrow uncertainty in regional climate predictions, *Bulletin of American Meteorological Society,* **2009**, *90*, 1095–1107.