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Limits of deterministic predictability in limited area models due to sensible dependence on initial conditions

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In the late 50ies and the 60ies the limit of predictability of weather has been shown to be 5 to 14 days by theoretical and numerical studies as consequence of sensible dependence on initial conditions. The simulation of an ensemble is the standard approach to address this uncertainty. Climatological means over time scales of 30 years are regarded as "certain" under constant climate forcing conditions. A systematic analysis of predictability limits on different space and time scales in the earth system is still missing. It is relevant in particular for time scales between the time scales of weather and climate and helps avoiding misinterpretation of the results and/or to find an optimal configuration for the ensemble.

In terms of statistics, the predictability of weather can be associated with the predictability of 6h and 100 km mean values. In mid latitudes it reaches a saturation value at the time scale of baroclinic instability T_i of 3-5 days. In the case of a purely stochastic process, this uncertainty is decreasing with $\sqrt{N}$ where N is the number of instability time periods.

One of the open questions is, which field variables exhibit a purely stochastic behavior and where. The application of Earth System Models is computationally demanding. Chaotic behavior may occur in some regions at certain conditions affecting the analysis. A huge number of degrees of freedom makes very long simulation times necessary. The application of limited area modeling opens the opportunity to analyse the behavior in different regions independently und thus to investigate the stochastic properties in different climates. Three different regions Europe, Africa and Central America have been simulated twice (reference and disturbance run) at standard grid resolution of 18 to 25 km using the community model COSMO-CLM. In Europe a purely stochastic behavior was found for the momentum, pressure and precipitation. A strong memory effect was found for soil moisture and temperature and a weak memory effect for the atmospheric temperature. The analysis of the simulation for Africa and Meso-America is ongoing.

Predictability limits for different thresholds and variables can be calculated in terms of the ensemble size needed to keep the uncertainty below the threshold. Such maps will be presented and the differences between the variables and regions will be discussed.