Intermittent divergence in phase space – noise in regional models of atmospheric and oceanic dynamics

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The Nobel Prize in Physics 2021 has led to a renewed interest in the challenge of the competition of externally forced and internally generated variability in simulations of atmospheric and oceanic dynamics. The internally generated variations, which are not directly provoked by external factors, we call "noise". The noise emerging in regional systems, which are often subject to strong forcing (such as lateral forcing in case of atmospheric limited area models, or atmospheric forcing in case of marginal sea models), has received insufficient attention in the past.

When evaluating simulations of such systems, three aspects may be considered – the (cyclo-stationary) mean state, the externally forced variability and the internally generated variability. This can be done by building ensembles – then the (daily) average across the members of the ensemble estimate the forced variations, while the (daily) standard deviations the intensity of the noise.

Such ensembles may be built in different ways – one being to shift the time of initialization, or to run the same model on different computers. Doing so introduces miniscule differences into the trajectories of the different simulations, which can repeatedly grow for a limited time, forming large-scale, persistent and significant deviations from the externally forced state. This phenomenon has been named „intermittent divergence in phase space", which may be framed by the dynamics of Hasselmann's „Stochastic Climate Model".

The presence of noise implies the need for statistical hypothesis testing, when numerical experiments are utilized to determine the effect of an experimental modification (which is common practice in global atmospheric models since decades of years). In. some cases, the „Stochastic Climate Model" allows to determine, how the change comes about. An example, dealing with tides in a marginal sea, is presented.