„Noise“ – an integral part of climate modelling

Hans von Storch[12], Chen Xueen[2] and Tang Shengquan[2]

[1]Helmholtz Zentrum Geesthacht, Germany

[2]Ocean University of China, Qingdao, China

In the traditional view, climate variations are related to some causes. However, having the presence of noise in mind, some variations, also long-term variations, may be generated internally

Key components of the climate system, in particular the oceans and the atmosphere, are systems associated infinite many nonlinear, often chaotic processes. As a result, the trajectory of the system can be described as an inert system subject to internally generated variations, which may be conceptualized as “noise” (Hasselmann, 1976). Quasi-realistic models (Müller and von Storch, 2004) of the oceans, the atmosphere, and coupled systems mimic this stochastic behavior. Without such “noise” (von Storch et al., 2001), the dynamics of the oceans, the atmosphere and the climate system are incomplete and lack significant features.

When models describe macro-turbulence, then the noise generation should take place – in particular in models of the atmosphere, which resolve “weather” (as opposed to conventional energy balance models). Ocean models, which describe eddies, should do as well.

In our paper, we address three aspects – first the general character of noise in ocean, atmosphere and climate models, second an experiment with climatologically forced ocean models on the formation of internal variability, and eventually a discussion about the implication for climate analysis

Our experimental set-up makes use of a series of ocean models, which are subject only to climatological (cyclostationary) atmospheric forcing (no weather disturbances, merely monthly mean conditions; Tang et al., 2018). The first model in the hierarchy is global and is hardly generating eddies; the second model with a grid resolution of 0.4^{o} is embedded into the global model and covers only the West-Pacific. The third with a grid resolution 0f 0.04^{o} is embedded in the West Pacific model and describes only the South China Sea. We examine the generation of internal variability in the South China Sea. Already the coarsest (global) model such variability is generated, which is becoming larger when we increase of the grid resolution (and by doing so, the ability to generate eddies).

The presence of “noise”, i.e., of variations unrelated to any external factors, leads to a number of challenges. Two of them are:

- The discrimination between internally generated variability and changes related to external factors. This process goes under the technical name of “Detection and Attribution”.
- The understanding that “downscaling”, for describing regional climate, must be understood as a “conditioning” by large scales and not as a “determining” by large scales.

References

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