SUBGRID-SCALE PARAMETERIZATION AND LOW-FREQUENCY VARIABILITY - A RESPONSE THEORY APPROACH

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Weather and climate models are limited in the possible range of resolved spatial and temporal scales. However, due to the huge space- and time-scale ranges involved in the Earth System dynamics, the effects of many sub-grid processes should be parameterized. These parameterizations have an impact on the forecasts or projections. In particular, it could affect the low-frequency variability present in the system (such as the one associated to ENSO or NAO). An important question is therefore to know what is the impact of stochastic parameterizations on the Low-Frequency Variability generated by the system and its model representation.

In this context, we consider a stochastic subgrid-scale parameterization based on the Ruelle's response theory and proposed in Ref. [1]. We test this approach in the context of a low-order coupled ocean-atmosphere model, detailed in Ref. [2], for which a part of the atmospheric modes is considered as unresolved. A natural separation of the phase-space into a slow invariant set and its fast complement allows for an analytical derivation of the different terms involved in the parameterization, namely the average, the fluctuation and the long memory terms.

The stochastic parameterization is then applied for two cases: a weak and a strong (natural) coupling between the resolved and unresolved components. For the weak coupling, the method accurately corrects the low-frequency variability along the invariant subset. For the strong coupling, the low-frequency variability in the ocean is still very well corrected while a less important, but still impressive, correction is found within the atmosphere. This new approach of scale separation opens new avenues of subgrid-scale parameterizations in multiscale systems used for climate forecasts.

References

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