Geophysical Research Abstracts
Vol. 18, EGU2016-6404, 2016
EGU General Assembly 2016

Local stochastic subgrid-scale modeling for a one dimensional shallow water model using stochastic mode reduction

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Due to the finite spatial resolution in numerical atmospheric models subgrid-scale (SGS) processes are excluded. A SGS parameterization of these excluded processes might improve the model on all scales. To parameterize the SGS processes we choose the MTV stochastic mode reduction (Majda, Timofeyev, Vanden-Eijnden 2001, A mathematical framework for stochastic climate models. Commun. Pure Appl. Math., 54:891–974). For this the model is separated into fast and slow processes. Using the statistics of the fast processes, a SGS parameterization is found. To identify fast processes the state vector of the model is separated into two state vectors. One vector is the average of the full model state vector in a coarse grid cell. The other describes SGS processes which are defined as the deviation of the full state vector from the coarse cell average. If the SGS vector decorrelates faster in time than the coarse grid vector, the interactions of SGS processes in the equation of the SGS processes are replaced by a local Ornstein-Uhlenbeck process. Afterwards the MTV SGS parameterization can be derived. This method was successfully applied on the Burgers-equation (Dolaptchiev et al. 2013, Stochastic closure for local averages in the finite-difference discretization of the forced Burgers equation. Theor. Comp. Fluid Dyn., 27:297-317).
In this study we consider a more atmosphere like model and choose a model of the one dimensional shallow water equations (SWe). It will be shown, that the fine state vector decorrelates faster than the coarse state vector. Due to the non-polynomial form of the SWe in flux formulation an approximation of all 1/h (h = fluid depth) terms needs to be done, except of the interactions between coarse state vector to coarse state vector. It will be shown, that this approximation has only minor impact on the model results. In the following the model with the local Ornstein-Uhlenbeck process approximation of SGS interactions is analyzed and compared to the initial SWe model. In a further step a time scale separation factor, characterizing the timescale of different interaction terms, is introduced. The models reaction to the numerical limit of the infinite time scale separation will be shown.
In the future we plan to derive the MTV SGS parameterization.