J3.2 HYBRID NUMERICAL CLIMATE AND WEATHER PREDICTION MODELS COMBINING DETERMINISTIC AND STATISTICAL LEARNING MODEL COMPONENTS.

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1. INTRODUCTION

A new approach to numerical climate and weather modeling, namely hybrid numerical models (HNMs) based on combining deterministic modeling and statistical/machine learning components, is introduced and formulated. Conceptual and practical possibilities of developing HNMs, as an optimal synergetic combination of the traditional first principles modeling (like that used for solving PDEs on the sphere representing model dynamics of global climate and weather models) and machine learning components (like accurate and fast neural network emulations of model physics or chemistry processes), are discussed. Examples of developed HNMs, hybrid climate models [Krasnopolsky et al. 2005; Krasnopolsky and Fox-Rabinovitz 2006a,b] and a hybrid ocean wind-wave model [Krasnopolsky et al. 2002]) illustrate the feasibility and efficiency of the new approach for modeling extremely complex multidimensional climate and weather prediction systems. Advantages and challenges of the HNM approach are discussed.

2. THE PRESENTATION CONTENTS

The presentation will include the following topics:

1. Introduction
   1.1. Formulation of the approach
   1.2. Introduction to NN emulation techniques
2. Examples of successful applications of the HNM approach
   2.1. Neural Network (NN) emulations for the National Center for Atmospheric Research (NCAR) Community Atmospheric Model (CAM) long wave and short wave radiations and their use for the model climate simulations (see also [Krasnopolsky et al. 2007])
   2.2. NN emulation for the nonlinear wave-wave interactions for an ocean wind-wave model
3. Advantages of the HNM techniques
   3.1. High accuracy and significant acceleration/speed-up of calculations resulting in the overall improvement of the computational performance for complex numerical models
   3.2. Improvement of the description of processes (physical, chemical, etc.) included in the model
      3.2.1. The possibility of using developed but computationally prohibited more advanced and sophisticated, model components**.**
      3.2.2. Development of new more advanced model components using leaning from data capabilities of NN emulations.
4. Challenges related to the HNM techniques
   4.1. Complexity of the model components to be emulated with NNs
   4.2. Controlling a small amount of larger approximation errors:
      4.2.1. Possible approaches to detecting larger NN emulation errors
      4.2.2. Using a Compound Parameterization (CP) framework for controlling and reducing the larger errors.
      4.2.3. Using NN ensemble approaches to reduce the amount of larger errors
   4.3. Multiple correlations between inputs (outputs) and their possible negative and positive effects. The possibility of using the correlations for an additional improvement of the computational performance of NN emulations
5. Conclusions

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