Grid Adaptation Using Genetic Algorithm with High-Performance Computing for Numeric Weather Predictions

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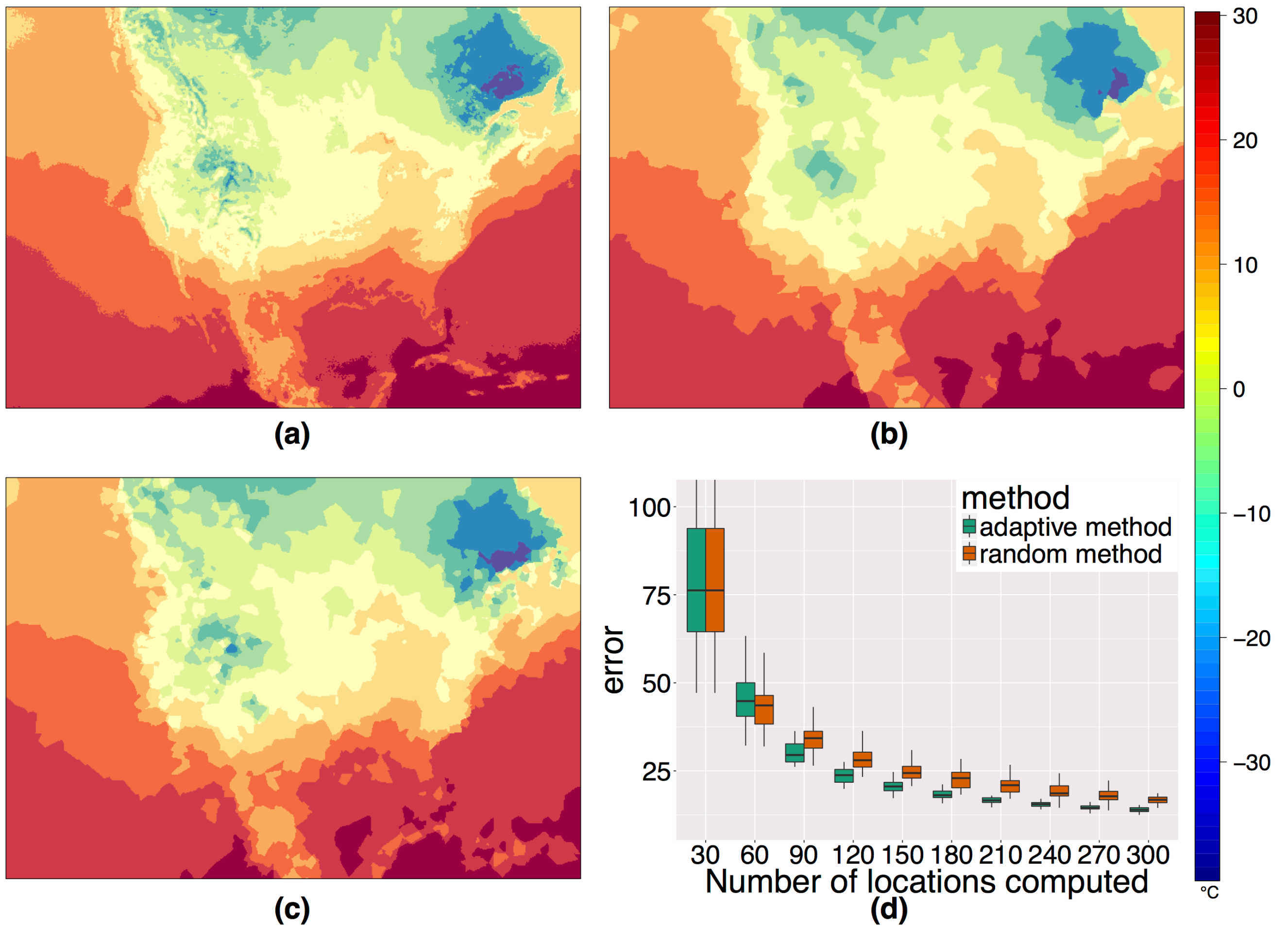
The Analog Ensemble is a statistical technique to generate probabilistic forecasts using a current deterministic prediction, a set of historical predictions, and the associated observations. It generates a probabilistic density function by first identifying the most similar past predictions to the current one, and then summarizing the corresponding observations. This is a computationally efficient solution to ensemble modeling because it does not require multiple Numeric Weather Prediction (NWP) simulations, but instead a single model realization.

Despite this intrinsic computational efficiency, the required computation can grow very large because atmospheric models are routinely run with increasing resolutions. Conventionally, NWP models use a structured grid to represent the domain, despite the fact that certain physical changes occur non-uniformly across space and time. For example, temperature changes tend to occur more rapidly in mountains than plateaus. However, it is unnecessary to perform computation on each of the grid points because of spatial and temporal features of the variable.

An innovative genetic algorithm is therefore proposed to dynamically and automatically learn the optimal unstructured grid pattern of the weather variable. This iterative evolutionary algorithm is guided by a mixture of Darwinian and non-Darwinian rules and instantiation to identify better grid vertices. Analog computations are performed only at vertices. Therefore, minimizing the number of vertices and identifying their locations are paramount to optimize the available computational resources, minimize queue time, and ultimately achieve better results. The optimal unstructured grid is then used to perform probabilistic forecasts for a variety of applications like uncertainty quantification or renewable energy prediction, and it can be very helpful when having a limited amount of computing resources available.

Previous results are shown in figures attached. Figure (a) is a 12-km temperature prediction map on December 20th, 2016 at midnight from the North American Mesoscale forecast system (NAM), which contains over 262,792 regular grid points. To minimize the computation, figure (b) and (c) are interpolated temperature prediction maps from 1,800 grid points, but gird points on figure (b) is randomly selected and grid points in figure (c) is adaptively searched. Areas with higher temperature variance tend to have more details in figure (c) compared with (b). Figure (d) shows the distributions of the errors, and the adaptive search method tends to have a lower error and smaller distribution.

Keywords: Higher-Performance Computing, Grid Adaptation, Numeric Weather Prediction, Ensemble Modeling, Genetic Algorithm


(a)
(b)
(c)
(d)
method
adaptive method
random method
error
100
75
50
25
30
60
90
120
150
180
210
240
270
300
Number of locations computed
30
20
10
0
−10
−20
−30
°C