Wavelet-based Lossy Compression of Barotropic Turbulence Simulation Data

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Data storage issues pose a potential problem in the performance and analysis of turbulence simulations. Current practice is to frequently output data from the simulation scaled to 8 bits for use in visualizations. Less frequently, data is output from the simulation in a floating point format (typically single precision) which is capable of capturing the accuracy of the simulation for the purpose of calculating various statistics. As the resolution of simulations and the speed of computer systems increase, the spacing between the times when output in floating point occurs becomes a factor in the simulation performance. However, the interval between the collection of the statistics which are computed from the floating point simulation outputs cannot be increased to the extent necessary to deal with the performance problems.

One tool that has successfully addressed such performance problems in other domains is data compression. Unfortunately, data from turbulence simulations does not usefully compress with lossless methods. In this work, the compression of data from a simulation of barotropic turbulence using wavelet-based lossy coding is examined. The resolution of the data used is 512 by 512. The output of this simulation is the relative vorticity as single precision floating point values.

A number of quantities are computed from the relative vorticity. The numerical error in these quantities is evaluated along with visualizations of the vorticity and error correlation with the uncompressed data. It is found that depending on the quantities of interest and the evaluation criteria, compression ratios of 4:1 to 256:1 are achievable. Under a conservative definition of acceptable error, it is possible to recover quantities of interest from data compressed 4:1 (8bpp), the data rate that in existing practice is used for visualization.

*This research supported in part by NSF Grant GER-9355046
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