Wavelet-Based Lossy Compression of Turbulence Data*

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Modelling of turbulence is among a class of Grand Challenge applications that severely strain data storage capabilities. The rate at which data is generated can actually limit the performance of the application. One tool that can assist is data compression. Unfortunately, lossless compression performs very poorly on such data. Lossy compression is the only choice for turbulence data.

Lossy compression preserves the absolute characteristics of turbulence data well. However, the statistics of the data are poorly preserved. It is believed that various structures in turbulence determine the behaviour of the various statistics. Designating these structures as regions of interest and using a region-of-interest (ROI) coder is one potential approach to preserving these statistics better.

In this research, data from a quasi-geostrophic model of incompressible turbulence is used[1]. The output data of this model is vorticity. The data resolution is $512^2$. The data is represented as single precision floating point values. The error in the vorticity, velocity, energy, energy spectrum and vorticity spectrum and the Weiss condition is examined. $\| (\bar{x} - x)/x \|_2$ is the means of evaluating the vorticity, velocity and Weiss condition. The spectra are evaluated via logarithmic plots.

The base coder is a layer coder. The wavelet used is the biorthogonal $18/10$ pair published by Tsai et al[2]. Two ROI coders were tested. The first coder enhanced coefficients corresponding to the region of interest in all subbands by an equal degree. The second coder enhanced coefficients to a common minimum level of quantization. The results from these coders suggested that certain subbands were particularly important so a coder that further decomposed those subbands was tried.

For both ROI coders, two different regions of interest were examined. One corresponded to vortex locations in the data. The second consisted of regions without vortices.

The results from these experiments suggest that ROI coding is a ineffective use of bits when compressing turbulence data. A more effective use of bits seems to be simply coding the data at a higher bit rate. Also, it appears that wavelet-packet best-basis coding of this data needs to be explored in detail.


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