A DETAILS OF THE DATASETS

The **Red Sea** dataset is a time-varying three-dimensional flow field and scalar field that changes over the regular grid. We have taken the scalar field from one time step for our experiments. This dataset is from the IEEE Scientific Visualization Contest 2020 [5].

The **Adenine Thymine** dataset represents a molecular simulation detailing electron density confined to a plane within a three-dimensional space. This dataset is from the TTK Tutorial Data [10].

The **Viscous Fingering** dataset consists of an ensemble simulation that captures the viscous finger inside a cylindrical container filled with pure water and topped with an infinite amount of salt. The viscous finger represents regions of high concentration and occurs due to diffusion processes. Their formation is because salt is denser than water, causing the denser liquid to collect towards the lower half of the cylinder. This dataset is from the IEEE Scientific Visualization Contest 2016 [4].

The **Nyx** dataset [9] is a series of simulation datasets generated from the cosmological hydrodynamics simulation code Nyx [8]. It is a three-dimensional spatial array of data for post-analysis, including dark matter density and temperature.

The **Earthquake** dataset [9] is an ensemble dataset representing a physical simulation of a magnitude 7.7 earthquake south of the San Andreas Fault. The dataset was obtained using a finite-difference code on the DataStar computer at the San Diego Supercomputer Center (SDSC). This dataset is from the IEEE Scientific Visualization Contest 2006 [3].

The **Heated Flow** dataset is an ensemble simulation of two-dimensional flow generated around a heated cylinder, produced using the Gerris flow solver. In our experiments, we utilized a single time step from the data. This dataset is from the Computer Graphics Laboratory [1].

The **CESM-ATM** dataset is an ensemble simulation of atmospheric conditions using the Community Earth System Model (CESM) [11] with 60 time steps; we used one of the time steps in our experiment. The dataset is available at Scientific Data Reduction Benchmarks [7].

The **Integrated Vapor Transport** dataset provides an ensemble of hourly integrated vapor transport (IVT) data from the MERRA-2 reanalysis. This data indicates the amount of water vapor transported over a single grid per second. The dataset can be accessed through the Earth System Grid Federation portal [2].

The **Combustion** dataset is an ensemble simulation the intricate dynamics of turbulent combustion processes. These simulations provide detailed insights into flames' behavior, fuel and oxidizer mixing, heat release, and turbulence-chemistry interactions. The dataset is made available by Jackie Chen at Sandia National Lab through the SciDAC Institute [6].

B EVALUATION METRICS

We review the evaluation metrics used in our paper. In this context, N represents the number of data points.

PSNR distortion refers to the trade-off between the bitrate and PSNR. It describes how the bitrate affects the PSNR of the decompressed data, where a higher bitrate generally results in a higher PSNR, indicating better quality. This is typically represented as a curve with the x-axis showing the bitrate and the y-axis showing the PSNR of the decompressed data.

Assuming f and f' represent the original and decompressed scalar values, respectively, the Peak Signal-to-Noise Ratio (PSNR) is calculated using the following equation:

$$\text{PSNR} = 20 \cdot \log_{10}\left(\frac{\text{MAX}_f}{\sqrt{\text{MSE}}}\right) \tag{1}$$

where MAX_f is the maximum possible value of the original data f, and MSE is the Mean Squared Error between the original and decompressed data, defined as:

$$\text{MSE} = \frac{1}{N}\sum_{i=1}^{N}(f_i - f_i')^2 \tag{2}$$

Right labeled ratio is the percentage of points in the data with correct MSS labels. Assume that N_f is the number of data points with the wrong MSS label; the right labeled ratio is calculated by the following equation:

$$\text{Right labeled ratio} = 1 - \frac{N_f}{N} \tag{3}$$

MSS distortion refers to the trade-off between the bitrate and Right labeled ratio. It is similar to PSNR distortion, except that the y-axis is replaced with the right labeled ratio.

C ADDITIONAL EXPERIMENTS

Discussion on error distribution We visualized the error map between

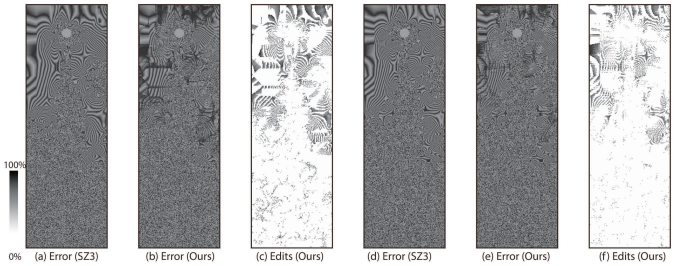

Fig. 1: Spatial distribution of error and edits with error bounds of 7×10^{-4} (a, b, and c) and 10^{-3} (d, e, and f) based on SZ3.

the decompressed data from SZ3/Ours-SZ3 and the original data, as shown in Figure 1 (a), (b), (d), and (e). Additionally, we visualize the edits applied by our method, as illustrated in (c) and (f). Our edits are sparsely distributed yet form continuous patches within the domain. This observation justifies our approach of sorting the edit indices in ascending order and then compressing the differential sequence.

References

[1] Computer graphics laboratory. https://cgl.ethz.ch/research/visualization. 1

[2] Earthsystemgrid. https://www.earthsystemgrid.org/dataset/ucar.cgd.artmip.tier2.source.merra2.hourlyIVT.html. 1

[3] Ieee scientific visualization contest 2006. https://sciviscontest.ieeevis.org/2006/. 1

[4] Ieee scientific visualization contest 2016. https://www.uni-kl.de/sciviscontest/. 1

[5] Ieee scientific visualization contest 2020. https://kaust-vislab.github.io/SciVis2020. 1

[6] Sandia national lab. https://www.sandia.gov/research/. 1

[7] Sdrbench. https://sdrbench.github.io/. 1

[8] A. S. Almgren, J. B. Bell, M. J. Lijewski, Z. Lukić, and E. Van Andel. Nyx: A massively parallel amr code for computational cosmology. *The Astrophysical Journal*, 765(1):39, Feb. 2013. doi: 10.1088/0004-637x/765/1/39 1

[9] C. Biwer. Nyx cosmological simulation dataset, 2019. doi: 10.21227/zh6w-kt72 1

[10] T. Contributors. Ttk data repository. https://github.com/topology-tool-kit/ttk-data, 2020. Accessed: yyyy-mm-dd. 1

[11] J. E. Kay, C. Deser, A. Phillips, A. Mai, C. Hannay, G. Strand, J. M. Arblaster, S. C. Bates, G. Danabasoglu, J. Edwards, M. Holland, P. Kushner, J.-F. Lamarque, D. Lawrence, K. Lindsay, A. Middleton, E. Munoz, R. Neale, K. Oleson, L. Polvani, and M. Vertenstein. The community earth system model (cesm) large ensemble project: A community resource for studying climate change in the presence of internal climate variability. *Bulletin of the American Meteorological Society*, 96(8):1333 – 1349, 2015. doi: 10.1175/BAMS-D-13-00255.1 1