Prediction and Modelling of Turbulence based on Machine Learning

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Abstract

Turbulence models play essential roles in aerospace science and technology, such as flows around aircraft and of planetary atmospheres. They are rapidly empowered by machine learning methods and will be a crucial building block of aerospace science and technology in the near future. The present study aims to integrate physics and data-driven methods for turbulence modeling.

Ref. URL: https://x.com/MasaInubushi

Reasons and benefits of using JAXA Supercomputer System

The reason to use JAXA Supercomputer System is that we can develop these methods based on training data of turbulent flows with high-resolution, numerical calculations requiring a massively parallel supercomputer.

Achievements of the Year

In a research field of atomospheric and ocean dynamics, two-dimensionality of fluid motion plays a key role. In this academic year, we have conducted numerical anaylsis of the two-dimensional Navier-Stokes equations, and revealed a fundamental property related to data-assimilation of that flows. We presented it at the synposium at the University of Cambridge, the Cambridge Centre for Climate Science (CCfCS) Winter Symposium 2024 (Inubushi and Caulfield, 2024). In addition, we have published papers including neural network prediction for chaotic dynamics (Ohkubo and Inubushi, Sci. Rep., 2024) and modeling for turbulence dynamics (Matsumoto, Inubushi, and Goto, Phys. Rev. Fluids, 2024).

Publications

- Peer-reviewed papers

Akane Ohkubo and Masanobu Inubushi,
"Reservoir computing with generalized readout based on generalized synchronization",
Scientific Reports 14, 30918 (2024).
Satoshi Matsumoto, Masanobu Inubushi, and Susumu Goto,
"Stable reproducibility of turbulence dynamics by machine learning",
Physical Review Fluids 9, 104601 (2024).

Usage of JSS

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	16 - 64
Elapsed Time per Case	30 Hour(s)

JSS3 Resources Used

Fraction of Usage in Total Resources[*1](%): 0.04

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	365,770.90	0.02
TOKI-ST	141,048.68	0.14
TOKI-GP	0.00	0.00
TOKI-XM	0.00	0.00
TOKI-LM	0.00	0.00
TOKI-TST	0.00	0.00
TOKI-TGP	0.00	0.00
TOKI-TLM	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2 (%)
/home	269.00	0.18
/data and /data2	66,460.00	0.32
/ssd	2,510.00	0.13

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2 (%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

- **ISV Software Licenses Used**

ISV Software Licenses Resources		
	ISV Software Licenses Used (Hours)	Fraction of Usage*2 (%)
ISV Software Licenses (Total)	0.00	0.00

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.