Investigation on Fine-scale Scalar Mixing in High Reynolds Number Turbulent Jets

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Abstract

In this research, large scale direct numerical simulation of turbulent flow is performed on supercomputer to clarify the role of very small-scale turbulence in the mixing process of fuel and air. We try to clarify the role of fine-scale turbulence by analyzing the data obtained by simulations with varying the Reynolds number which is a parameter that governs the turbulence intensity.

https://kaken.nii.ac.jp/en/grant/KAKENHI-PROJECT-15K05817/

Reasons for using of JSS2

In order to clarify the role of fine-scale turbulence in scalar mixing process, statistical data by DNS is required for high Reynolds number condition. For performing DNS under high Reynolds number condition of Re > 10^4, a numerical mesh of the order of one billion points is required. Such large-scale simulation can be executed only on a supercomputer, and therefore, supercomputer system is indispensable for carrying out this research.

Achievements of the Year

DNSs were performed for turbulent planar jets at Re = 3×10^3, 10^4 and 3×10^4 on 0.1billion to 1.3 billion grid points with 9-th order spatial accuracy. It was confirmed by comparison with past experimental data and evaluation of Kolmogorov length scale that Re-dependence of planar jet is correctly reproduced by the present DNS (Fig.1). By filtering DNS data, it is found that the contribution to turbulent scalar mixing due to turbulence with scales less than 60 and 100 times of kolmogrov length scale are negligible at Re = 3×10^3 and 10^4, respectively.

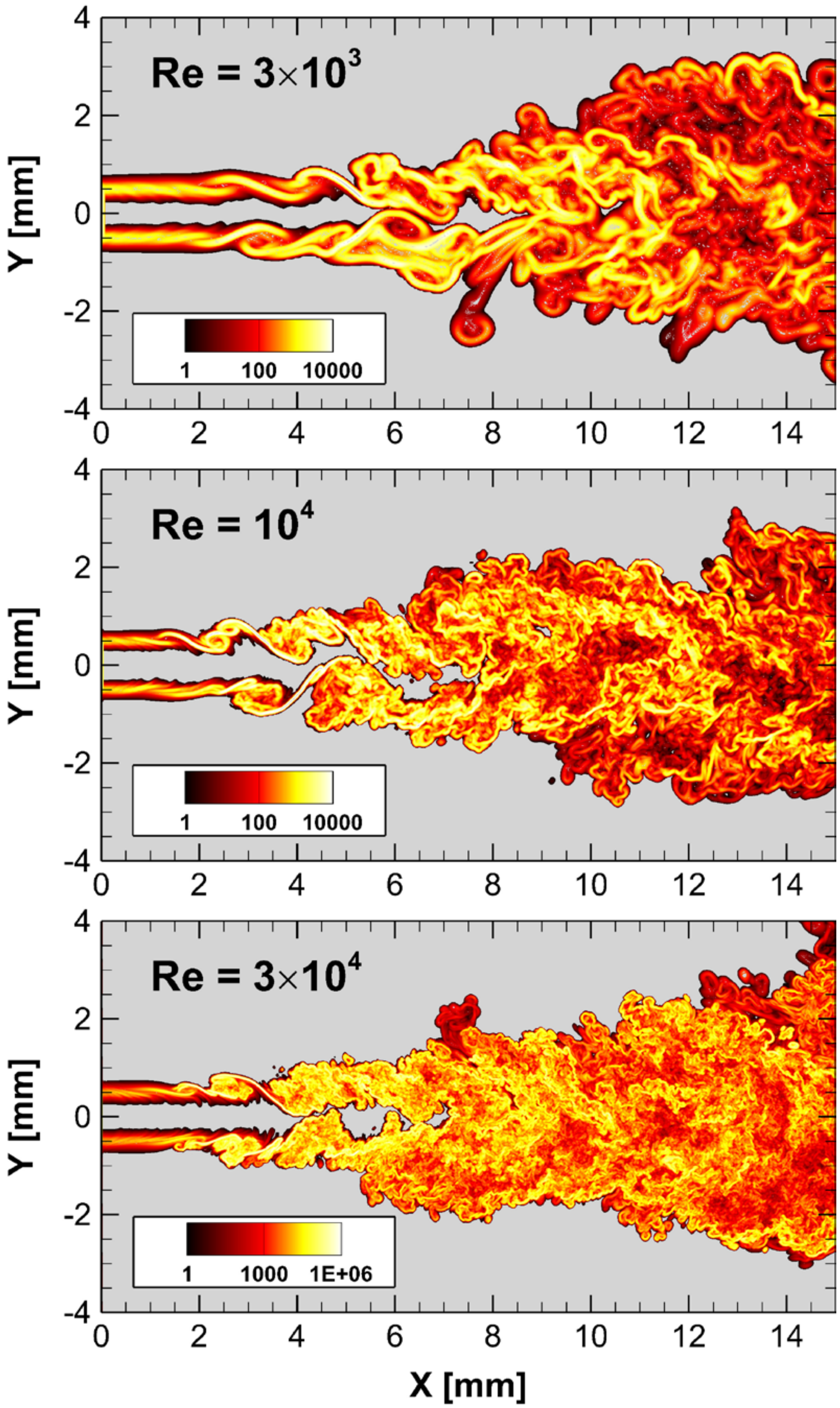

Fig.1 Instantaneous contours of scalar dissipation rate on the x-y plane (z = 0) for the DNS at Re = 3×10^3,10^4 and 3×10^4 (from top to bottom). Cited from non peer-reviewed paper [2].

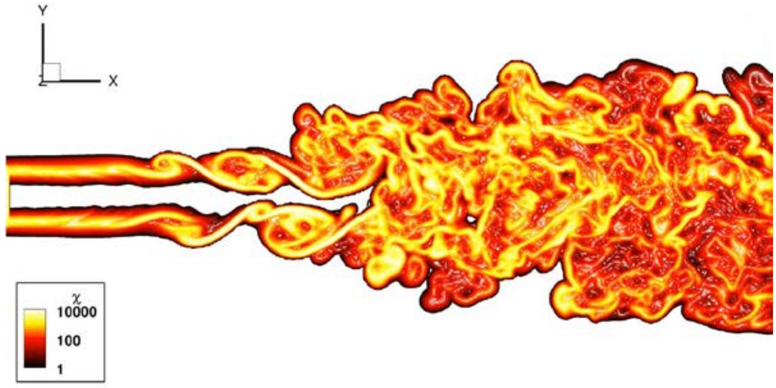

Fig.2 Movie of scalar dissipation rate for the DNS at Re = 3×10^3.

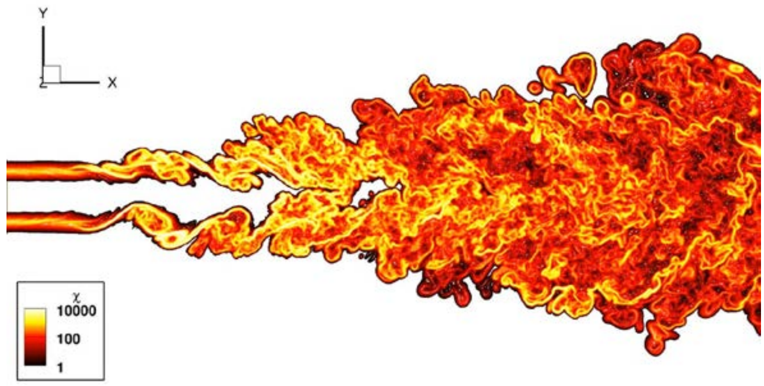

Fig.3 Movie of scalar dissipation rate for the DNS at Re = 10^4.

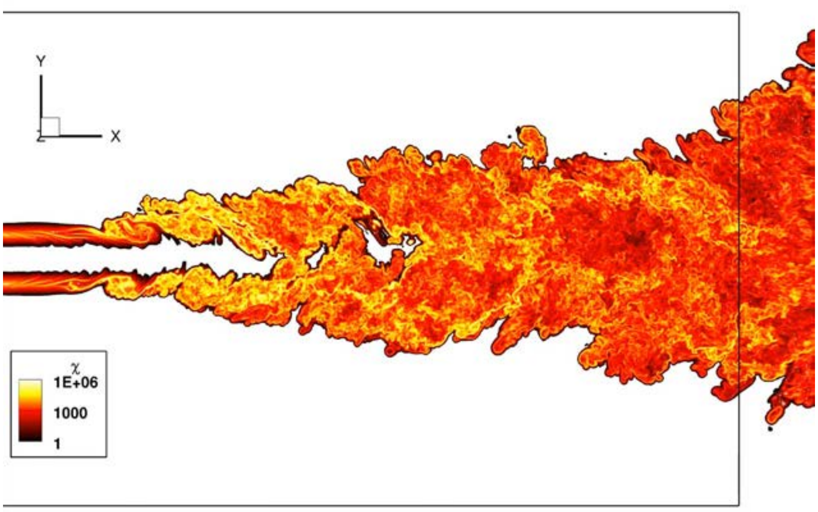

Fig.4 Movie of scalar dissipation rate for the DNS at Re = 3×10^4.

Publications

- Non peer-reviewed papers

1) Shingo Matsuyama, "Direct Numerical Simulation of a Turbulent Plane Jet with Scalar Mixing", proceedings of the 48th JSASS annual meeting, 2C15, 2017.
2) Shingo Matsuyama, "DNS of a Turbulent Plane Jet with Scalar Mixing", proceedings of the JSFM Annual Meeting 2017, 2017.

- Presentations

1) Shingo Matsuyama, "Direct Numerical Simulation of a Turbulent Plane Jet with Scalar Mixing", the 48th JSASS annual meeting, 2017.
2) Shingo Matsuyama, "DNS of a Turbulent Plane Jet with Scalar Mixing", the JSFM Annual Meeting 2017, 2017.

Usage of JSS2

- **Computational Information**

Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	286 - 924
Elapsed Time per Case	1,000.00 hours

- **Resources Used**

Fraction of Usage in Total Resources*1 (%): 2.67

Details

Computing Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2 (%)
SORA-MA	22,602,550.63	3.00
SORA-PP	0.00	0.00
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage assigned(GiB)	Fraction of Usage*2 (%)
/home	598.94	0.41
/data	2,849.03	0.05
/ltmp	488.28	0.04

Archiver Resources		
Archiver System 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