Study of compressible thermal turbulent boundary layer

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Abstract

The aim of this study is to numerically investigate the physics of compressible thermal turbulent boundary layer, and direct numerical simulations (DNS) are performed. The understanding from the DNS analysis will be utilized for building a wall model of large-eddy simulation for high Reynolds number flows.

Reasons for using of JSS2

High-fidelity simulations of compressible turbulent flow need huge computational cost. Consequently, massively parallel computations with a supercomputer are required.

Achievements of the Year

A wall heat flux is one of the most important design parameters for thermal fluid devices. However, the physics of compressible thermal turbulent boundary layer hasn't been investigated in detail. A Wall Modeled LES (WMLES) is an effective approach for a real scale unsteady flow simulation. However the predictive capability of WMLES hasn't been validated on thermal flow fields.

For a numerical analysis of a wall-bounded compressible turbulent boundary layer with strong wall heat fluxes, we firstly simulated an adiabatic-wall boundary layer. The DNS code has been verified against a reference of turbulent boundary layer flow (Fig. 1, 2). In addition, we developed a high-order-accurate physically-consistent kinetic energy conservation scheme on curvilinear grids, based on the approach of Kuya and Kawai (2018). Next year we intend to simulate isothermal-wall boundary layers using the scheme.

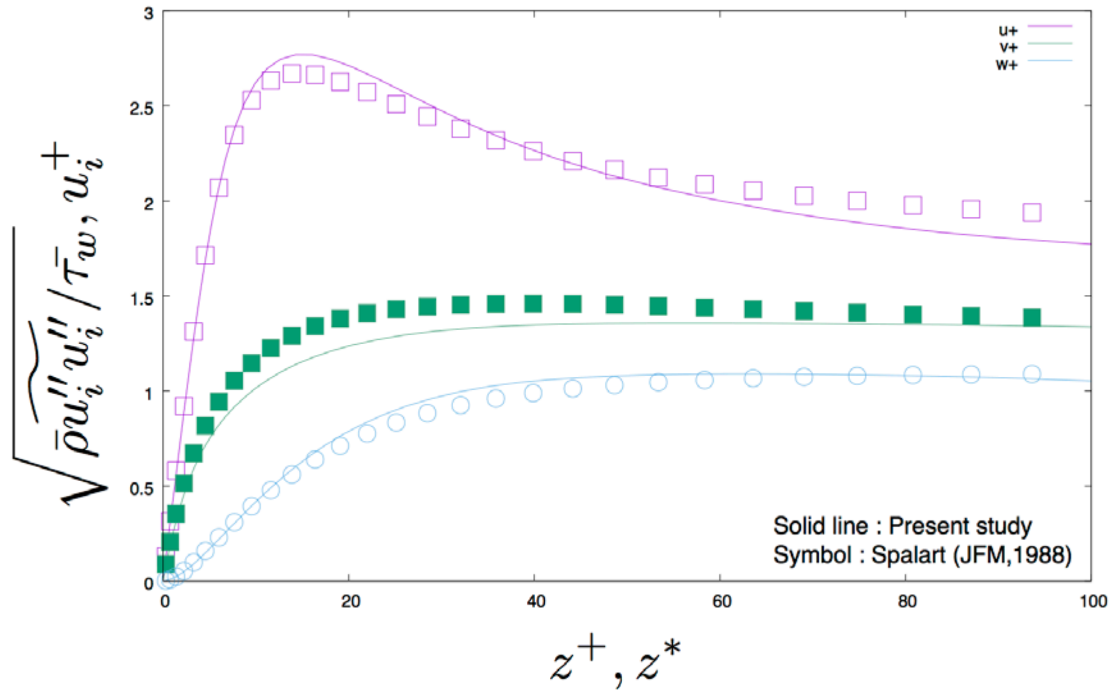

Fig.1 Density-scaled turbulence fluctuations in inner scaling.

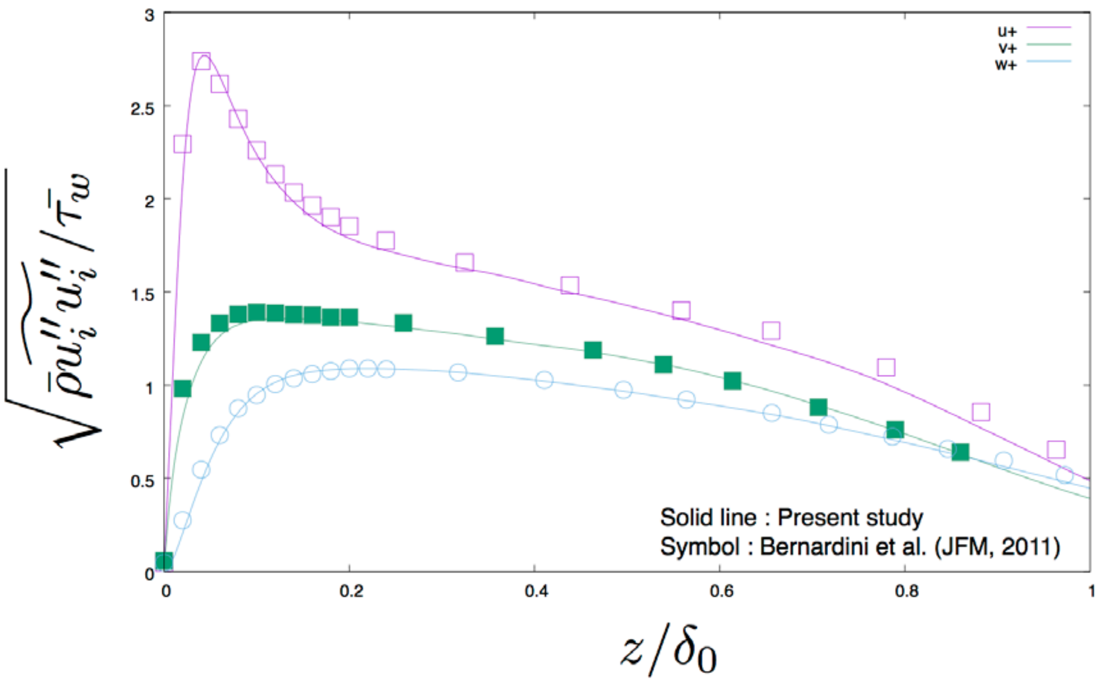

Fig.2 Density-scaled turbulence fluctuations in outer scaling.

Publications

N/A

Usage of JSS2

Computational Information

Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	384 - 512
Elapsed Time per Case	210.00 hours

Resources Used

Fraction of Usage in Total Resources*1 (%): 0.09

Details

Computing Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2 (%)
SORA-MA	733,046.84	0.10
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	005.83	0.00
/data	4,893.41	0.09
/ltmp	1,193.58	0.09

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