Study of compressibility effect on low-Reynolds-number flow over a plate

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Abstract

large-eddy simulations (LES) of the compressible flow around the plate with Reynolds number O (10^3) -O (10^4) is performed. The compressibility effects on the laminar separation bubble formed around the leading edge of the flat plate and turbulent transition are investigated. The flat plate is one of the basic shapes the same as a sphere and cylinder. Under the incompressible flow condition, the formation of laminar flow separation bubbles and the the turbulent transition occurs in the Reynolds number region investigated in this study. These are important phenomena for the understanding of the low Reynolds number flows. In this study, we will investigate the effect of compressibility on them in detail.

Reasons and benefits of using JAXA Supercomputer System

In this study, unsteady simulations of turbulence using a high-order scheme are carried out. Hence, large-scale parallel computation is required.

Achievements of the Year

This year, we calculated the flow at the Mach numbers 0.2, 0.5, 0.8, 0.95 with Reynolds number of 20000. Figures 1 and 2 are visualization images at Mach numbers 0.2 and 0.8, respectively. The isosurface is the second invariant of the velocity gradient tensor, and the isosurface and contour are colored by the streamwise velocity normalized by the freestream velocity. For these figures, when the Mach number is 0.8, the laminar separation bubble formed at the leading edge is longer, the two-dimensionality of the flow field is maintained, and the turbulent transition is significantly delayed.

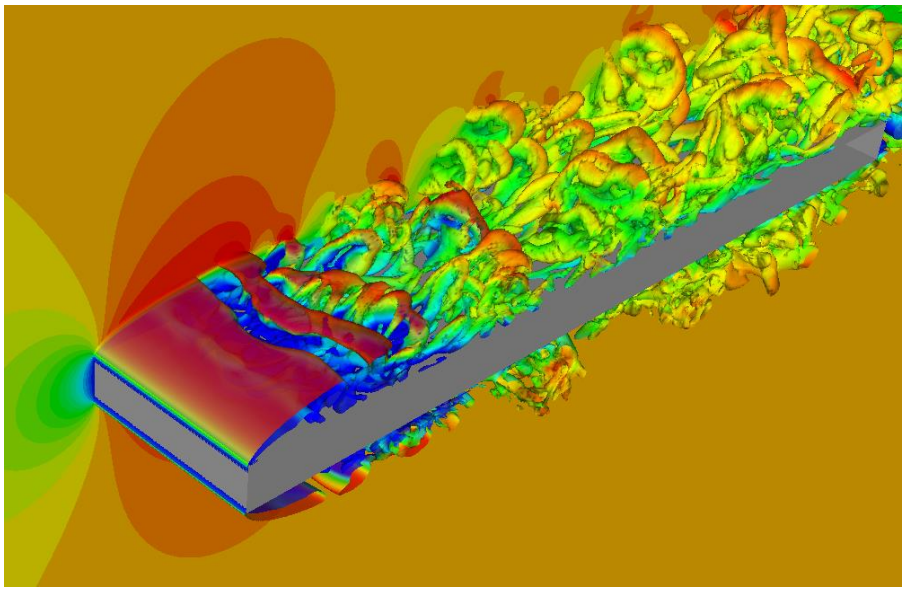

Fig. 1: The vortex structure and streamwise velocity distribution at the Reynolds number of 20000 (M = 0.2).

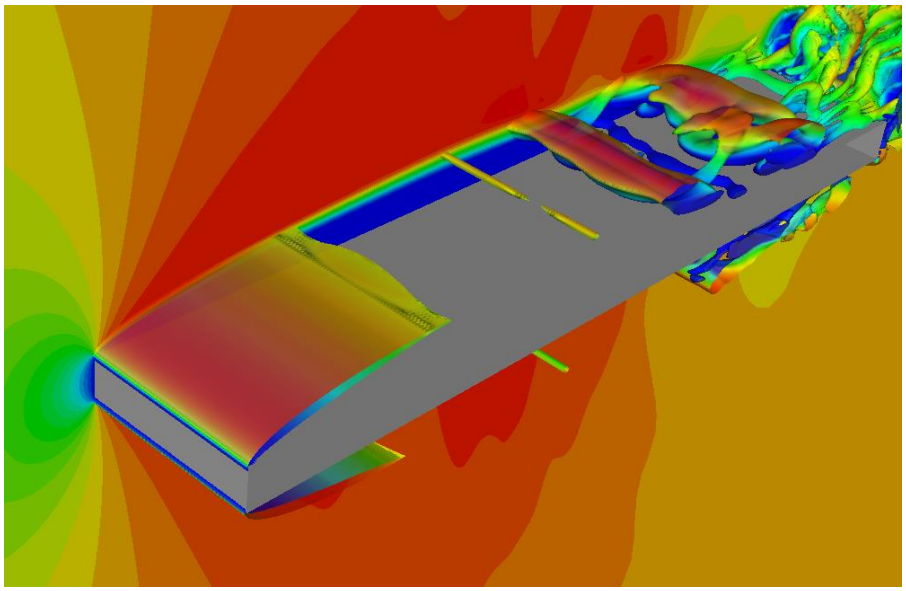

Fig. 2: The vortex structure and streamwise velocity distribution at the Reynolds number of 20000 (M = 0.8).

Publications

N/A

Usage of JSS

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	OpenMP
Number of Processes	60
Elapsed Time per Case	130 Hour(s)

JSS3 Resources Used

Fraction of Usage in Total Resources[*1](%): 0.29

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	6,794,326.94	0.33
TOKI-ST	0.02	0.00
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	52.50	0.05
/data and /data2	113,152.00	1.21
/ssd	35.00	0.01

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	22.95	0.16

*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.