Physics understanding and modeling based on high-fidelity numerical analysis

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Abstract

The aim is to model key phenomena of turbulence, fuel atomization, and combustion based on a deep understanding of physics through detailed, high-fidelity simulations, thereby leading global research in the field of turbulence and spray combustion.

Reasons and benefits of using JAXA Supercomputer System

The computational resources necessary to conduct the world's leading studies in this field can only be obtained through JSS3.

Achievements of the Year

"Modification of AMM turbulence model"

We have introduced a ratio of mean vorticity and mean strain (an indicator of the streamline curvature) into the eddy viscosity expression of the AMM model to improve the accuracy of the stall prediction. We have tested the modified model against NASA CRM at Re = 2 x 10^6 at high attack of angle (5.72 degrees). As a result, the prediction of the 3D separation at the med span of the wing is improved up to about 30 percent.

"Validation of primary fuel atomization analysis"

An improvement method for detailed atomization analysis using the coupled Eulerian-Lagrangian approach is proposed. A comparison with experimental data on droplet size distribution in crossflow fuel atomization is conducted, demonstrating that quantitative evaluation is possible with an error margin of approximately 30%.

"Improvement of the SGS stress transport equation model for LES of turbulent jet"

LES analysis using the SGS stress transport equation model was performed for turbulent plane jets from Re=1500 to 16500, showing good reproduction of DNS results (Re dependence of mean velocity field and RMS

fluctuation field).

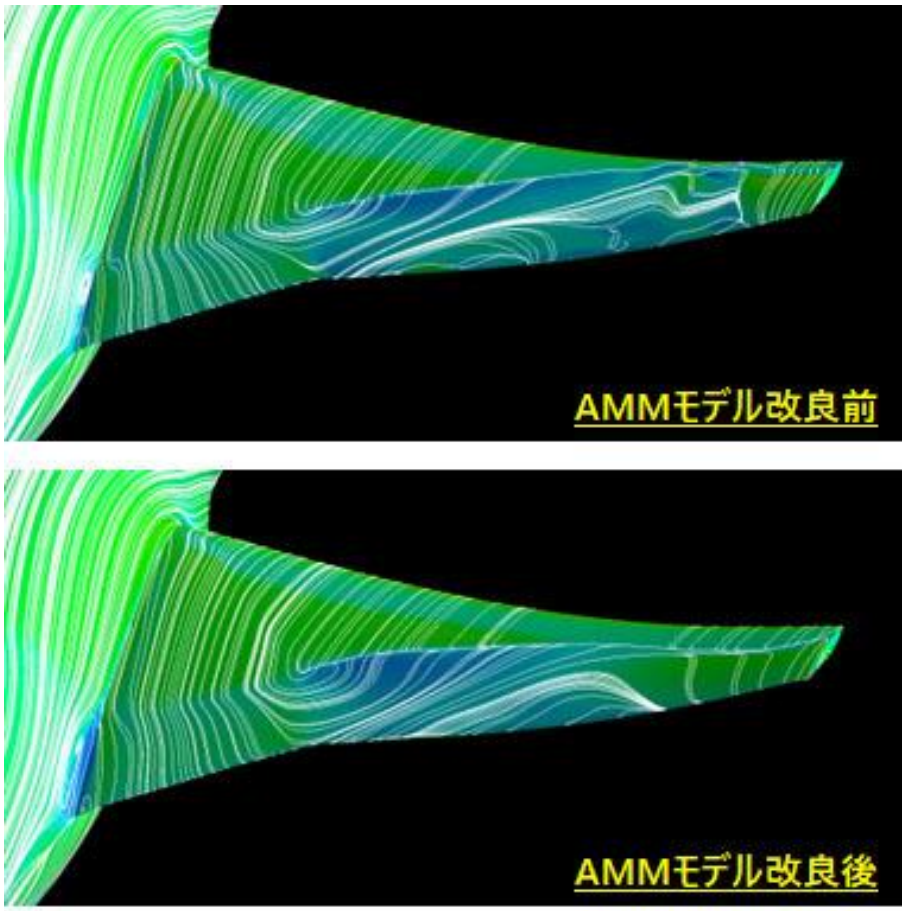

Fig. 1: Prediction for the NASA CRM using the AMM-QCRcorner model

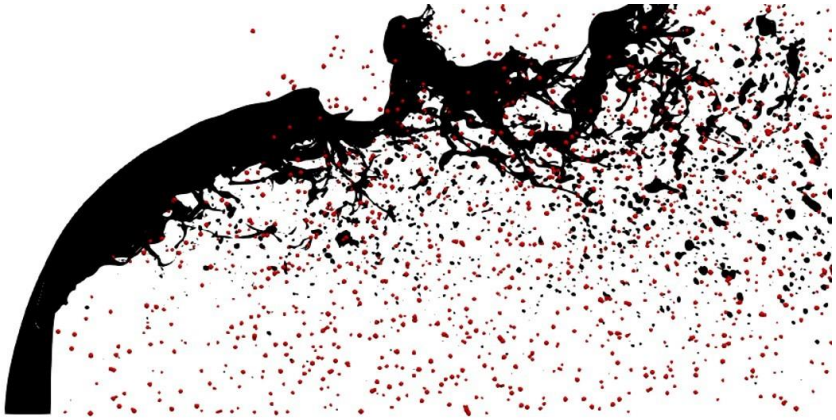

Fig. 2: Detailed Analysis of Crossflow Atomization Using the Euler-Lagrange Coupled Approach

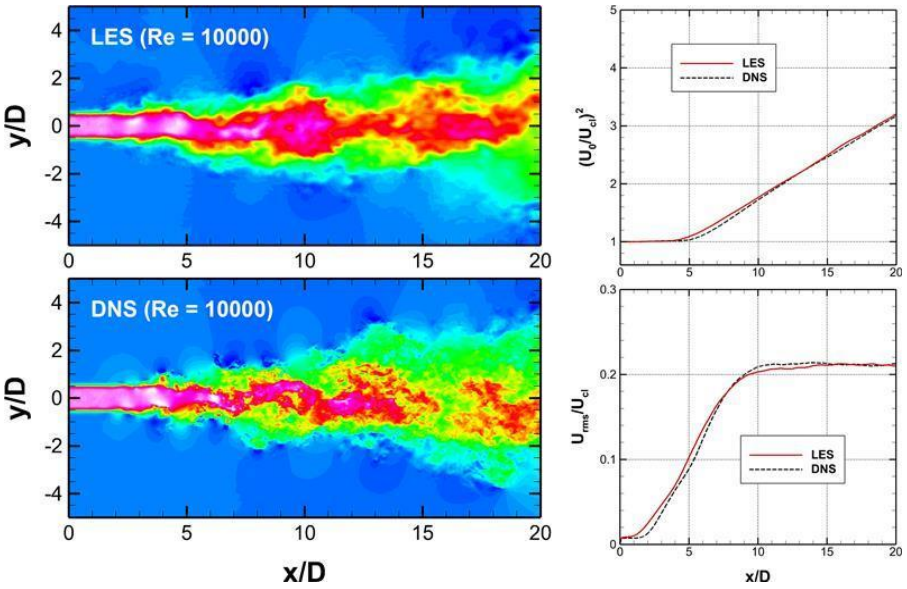

Fig. 3: Results of comparison between LES using SGS stress transport equation model and DNS

Publications

- Oral Presentations

1.Nambu et.al.,Improving the Accuracy of Detailed Analysis of Fuel Atomization Using the Euler-Lagrange Coupling Method, The 62nd Symposium (Japanese) on Combustion

2. Nambu et.al.,Verification of Heat Loss Impact Due to Combustion Mode Changes upon Wall Impingement in LES Analysis of Diesel Spray Combustion, 35th Internal Combustion Engine Symposium (in Japan)

3. Takagi et.al.Investigation on Wall Heat Flux from OME Blend Fuel Spray Flame, 35th Internal Combustion Engine Symposium (in Japan)

4. Matsuyama, Professor ..., LES Does not Give Me a Grid Converged Solution., 56th Fluid Dynamics Conference / the 42nd Aerospace Numerical Simulation Symposium

5. Matsuyama, LES Study on Reynolds Number Dependence of a Turbulent Plane Jet, JSFM Annual Meeting 2024

Usage of JSS

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	8 - 14472
Elapsed Time per Case	168 Hour(s)

- **JSS3 Resources Used**

Fraction of Usage in Total Resources[*1](%): 3.58

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	97,379,680.22	4.46
TOKI-ST	46,792.48	0.05
TOKI-GP	0.00	0.00
TOKI-XM	49.78	0.02
TOKI-LM	2,675.43	0.19
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	1,365.20	0.92
/data and /data2	132,035.36	0.63
/ssd	33,462.06	1.79

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2 (%)
J-SPACE	35.24	0.12

*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)	268.78	0.18

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