

Digital Innovation for Fluid Mechanics

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Digital Innovation by High-performance computing Infrastructure (HPCI)

What to do by Exa(10^{18}) ~ ?
 スーパーコンピュータで何をすべきか？

Exa Flops

History of Supercomputers

Peta Flops

Tera Flops

Performance

1GFlops

1MFlops

1KFlops

1940

1960

1980

2000

2020

- ENIAC (USA)
- Colossus (UK)
- ABC (USA)
- Zuse Z3 (Germany)

CDC 7600

CDC Star-100

CDC 6600

IBM 7030

Cray-1

Cray-1

SX-1, 2 (NEC)

Cray X-MP/4

HITAC S-810 (Hitach)

FACOM VP-100 (Fujitsu)

FACOM VP100

Earth Simulator

ASUKA (Intel)

NWT (Fujitsu)

SX-3 (NEC)

ETA 10-G/8

Blue Gene/L (IBM)

ES2

T2K

TSUBAME

Road Runner (IBM)

Next-generation (Top 500 in Japan)

FUGAKU

京 (K)

x1000 for a decade

? ~ : 5th generation ?

Quantum computer ?

2020 ~ : 4th generation

Massive parallel/GPU

1995~2020: 3rd generation

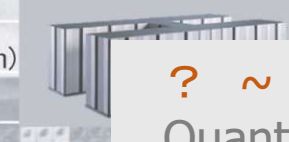
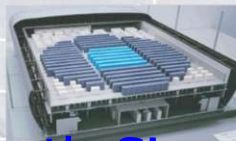
Parallel computing

1985~1995: 2nd generation

Vector processor

1970~1985: 1st generation

Supercomputer



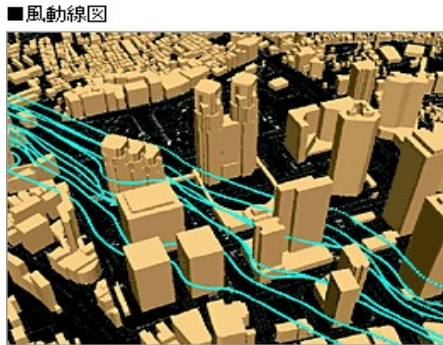
Complexity of Fluid Mechanics

Where does “complexity” of flow come from ?

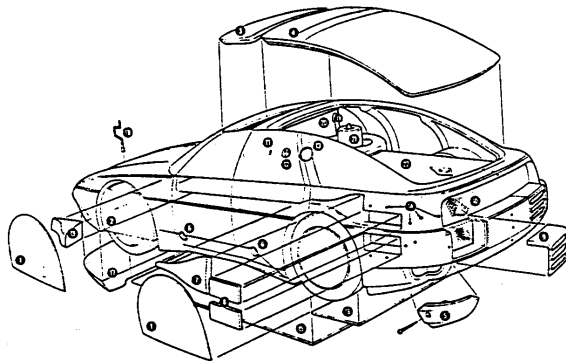
流れの複雑性はどこから生じるか？

Structures of nature/artifacts

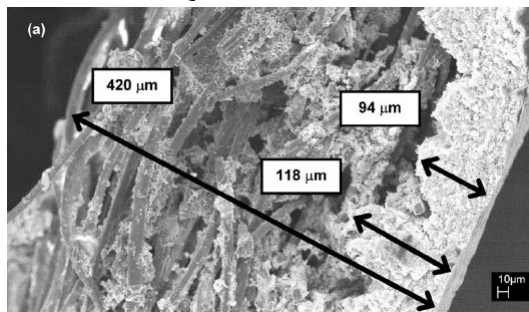
Ex.
Geography
地形, 建物など



Ex.
Machines
装置構造



Ex.
Porous
Materials
多孔質



Interfaces of phase/reaction

Ex. Bubbles 気液界面



Ex. Flame 火炎



Solutions of flow motions

Ex. Turbulence 乱流

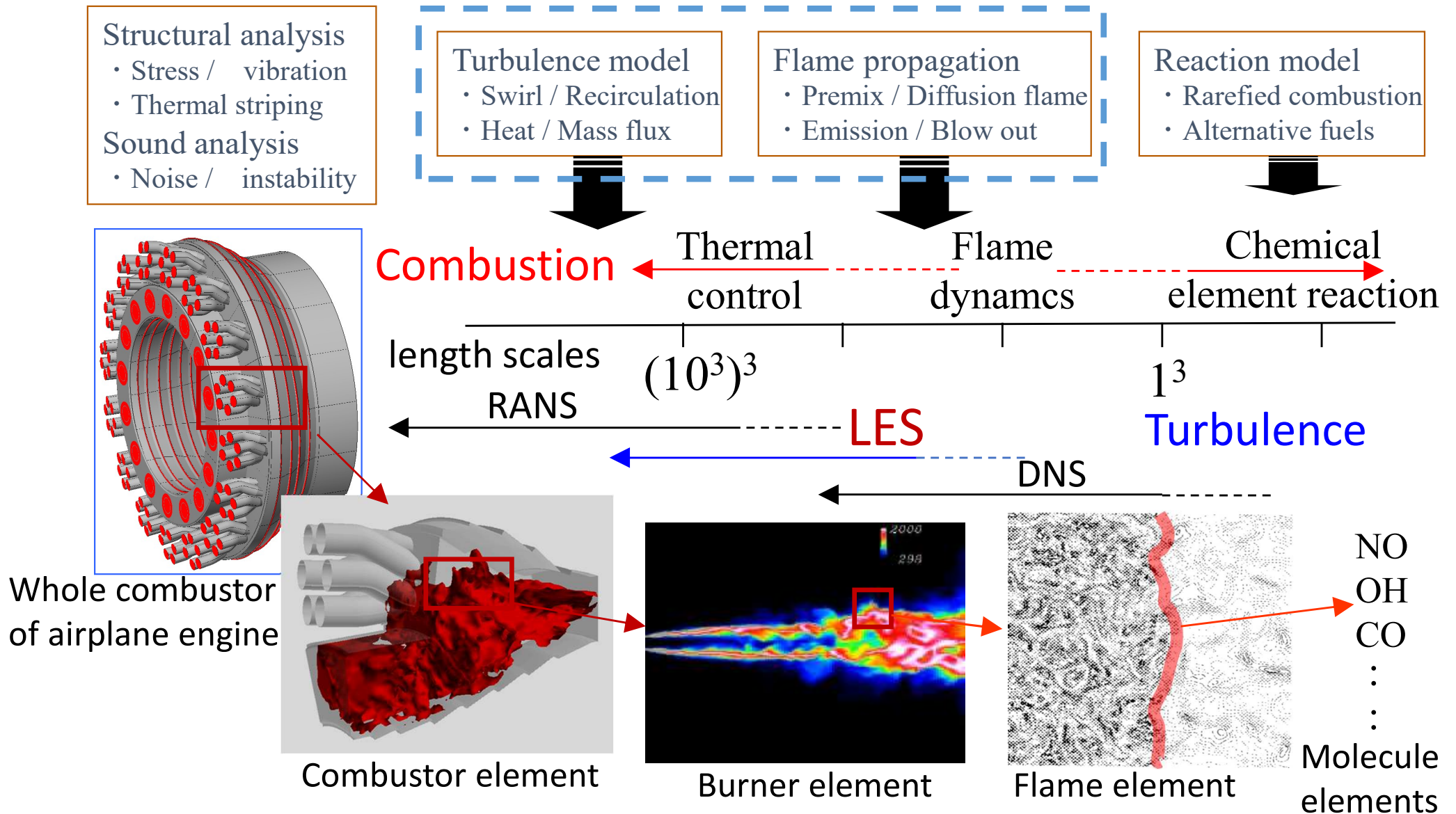


Ex. Shock wave 衝撃波



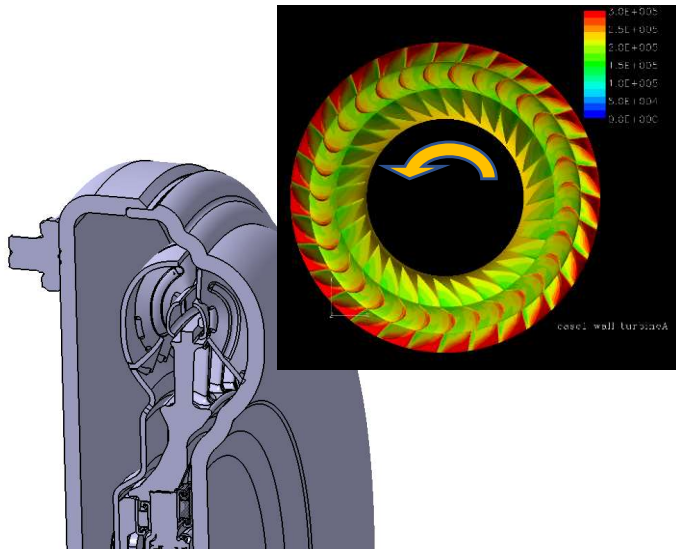
Multi-scale design of flow phenomena

Strategy of simulation for turbulence and combustion flows 乱流と燃焼の数値シミュレーション戦略

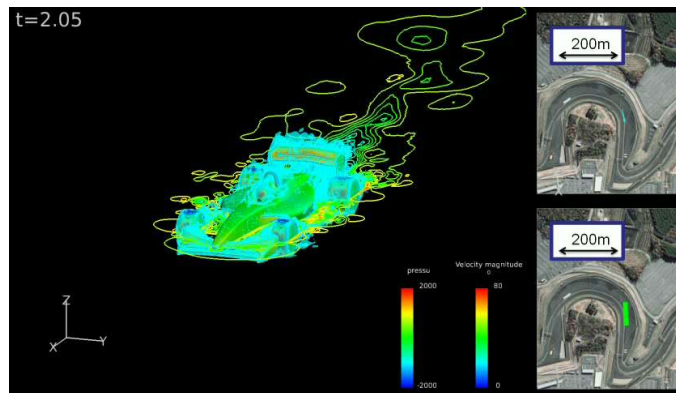


Digital design of Complex Flows

Moving objectives
移動物体

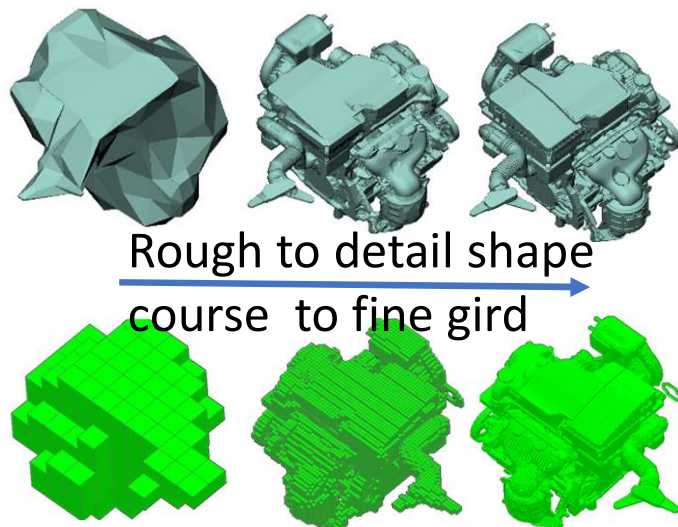
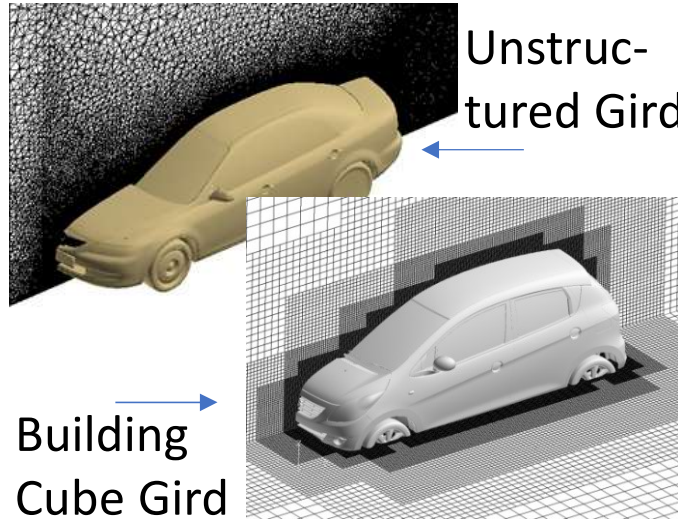


Ex. Torque converter



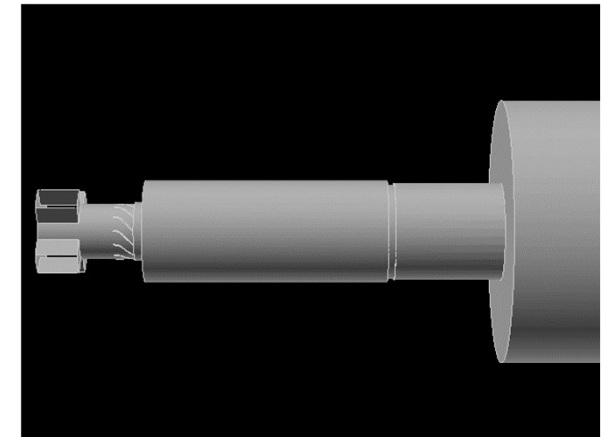
Ex. Racing car

Complex objectives
複雜形状

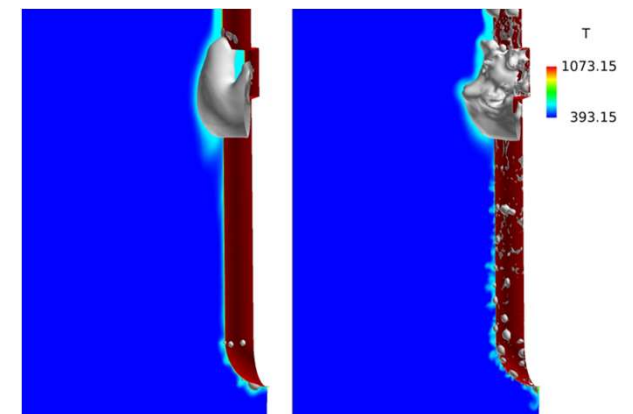


Ex. Engine block cooling

Interface phenomena
界面現象



Ex. Gasturbine combustor

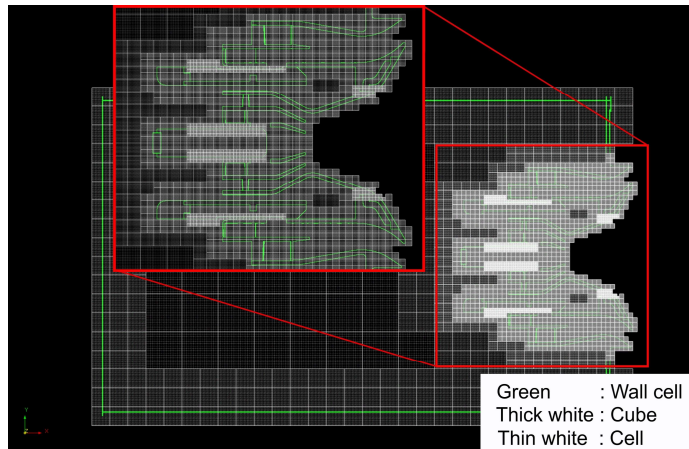


Ex. Boiling on metal quench

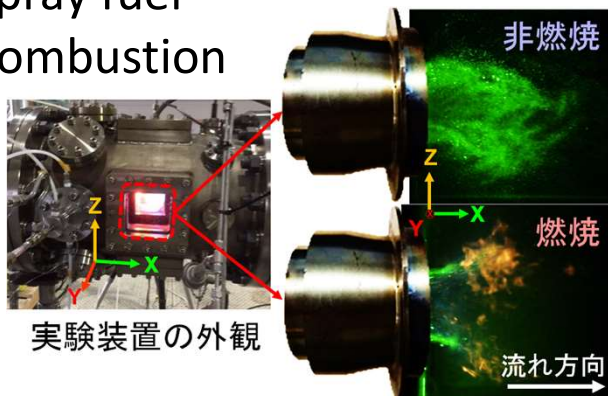
2023 projects under Oshima's Gr.

HPCI by "FUGAKU"

For 1,000,000,000 mesh
/ 1,000,000 parallel



spray fuel
combustion



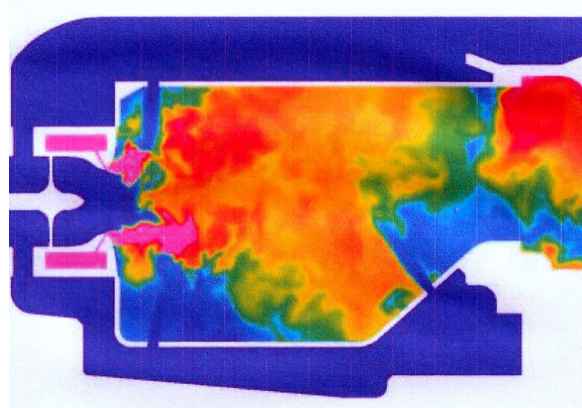
CUBE

H2 gasturbine

For renewable energy
/ H2 society



Portable H2 gasturbine



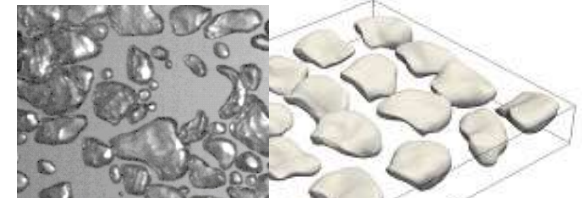
FrontFlow/red

Bubble Flows

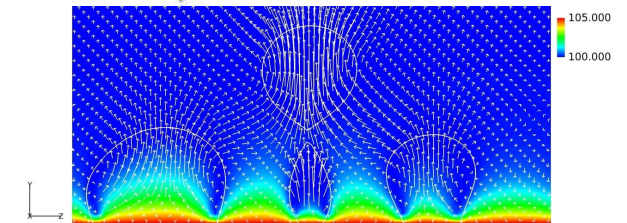
For flow control
/ saving energy



Ship drag reduction



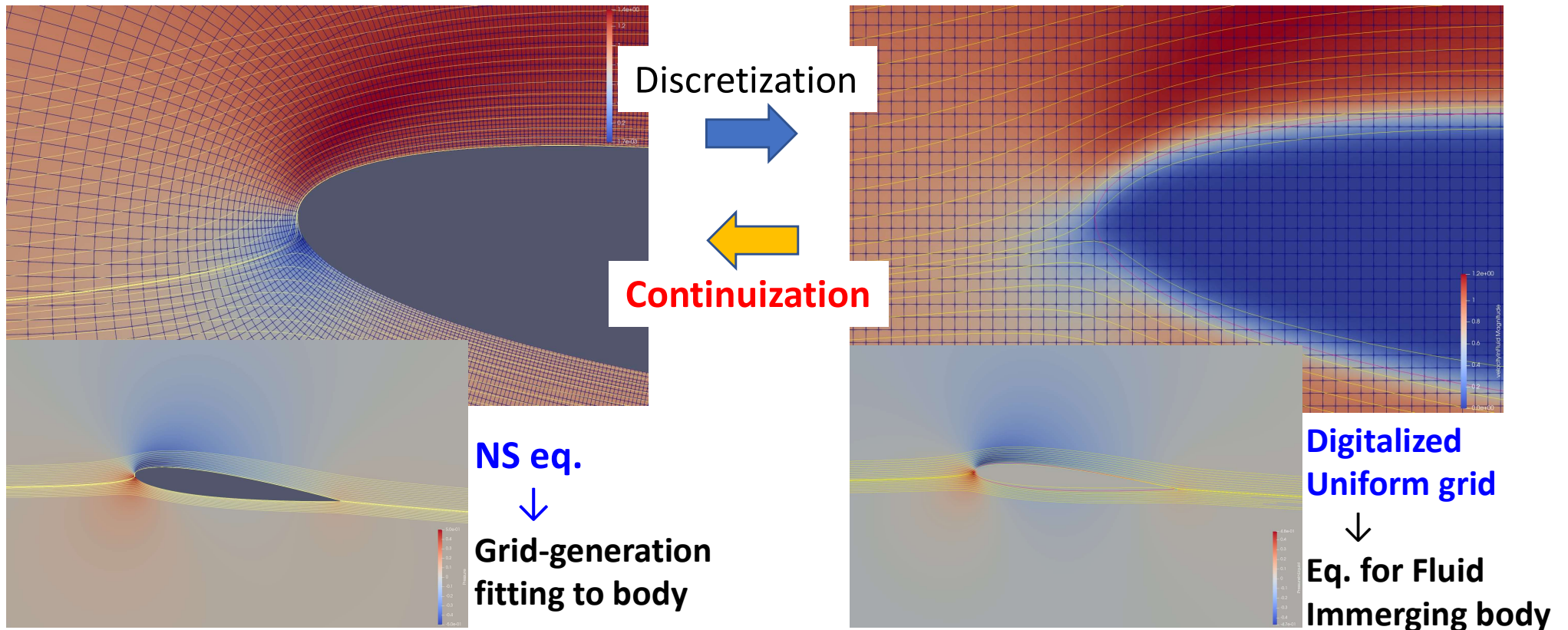
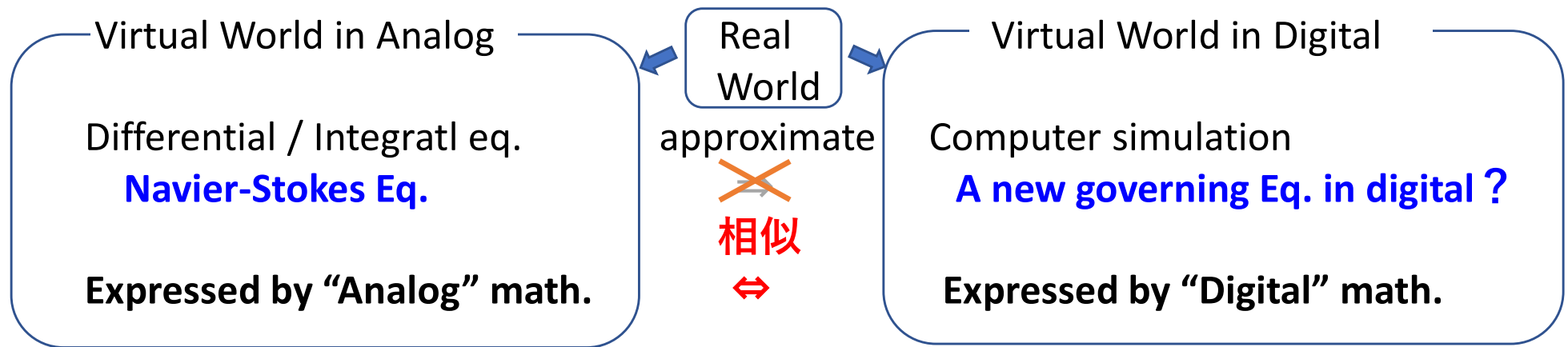
Bubbles
in boundary layer



Boiling of metal quench

OpenFOAM

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