DNS simulation of a periodic channel

- This simulation was conducted at a Re_τ equal to,

$$Re_\tau = \frac{U_\tau \times h}{\nu} = 590$$

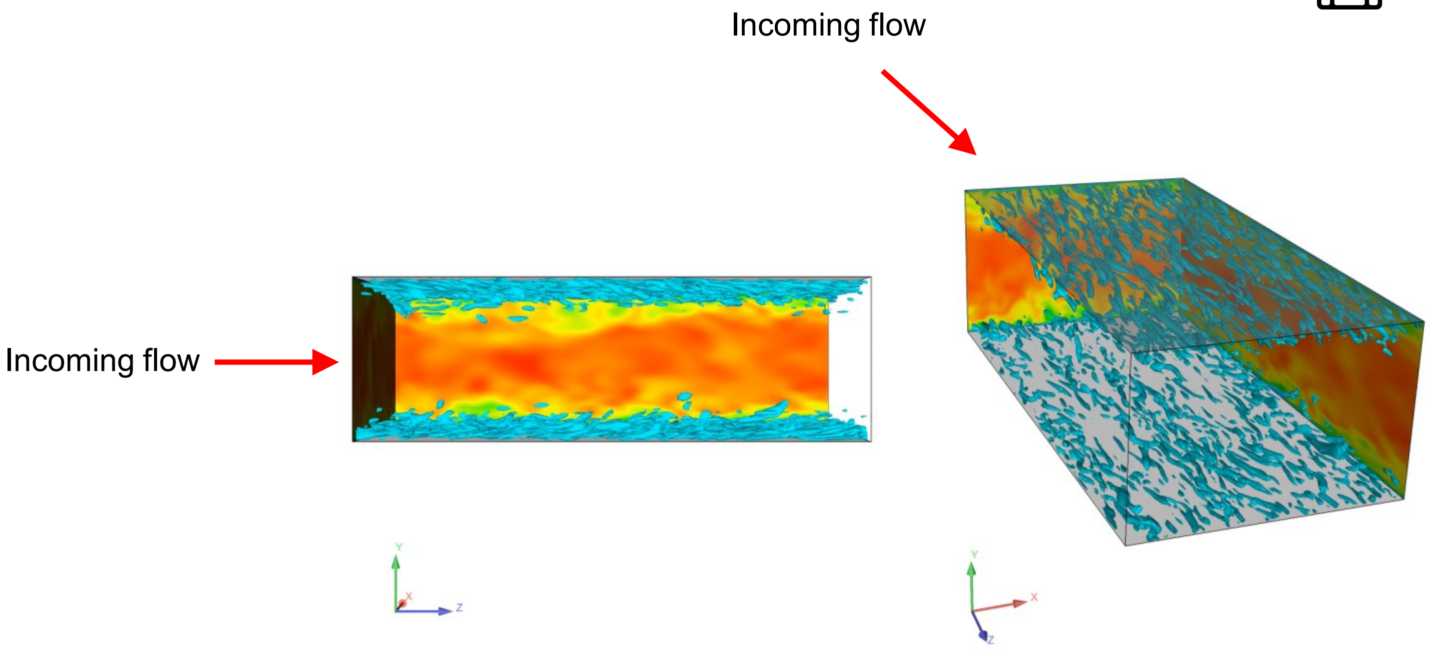
- With the following parameters,

$$\rho = 1\frac{kg}{m^3}$$

$$\mu = 0.001695\frac{kg}{m\,s}$$

$$h = 1\,m$$

- Where h is equal to the channel semi-height (1 m)
- Periodic boundary conditions in the streamwise (z) and spanwise (x) directions were used.



DNS simulation of a periodic channel

- With these conditions and according to the theory of equilibrium for channels, the equilibrium between the imposed pressure drop and the wall shear stresses is given by,

$$\frac{\partial P}{\partial x} = -\frac{\tau_{wall}}{h}$$

- To force the flow, a pressure drop must set.
- In this simulation, the pressure drop was set in the streamwise direction (z) and is equal to,

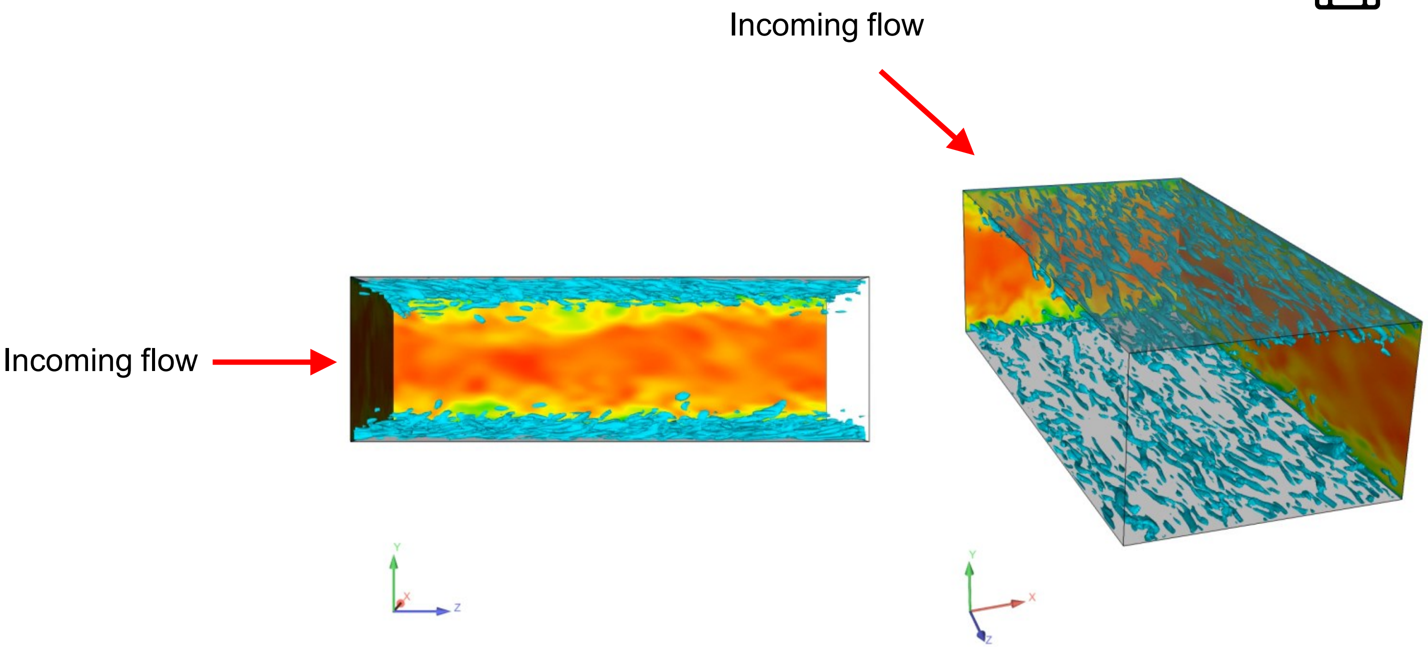
$$\frac{\partial P}{\partial x} = -1\frac{Pa}{m}$$

- Therefore, the shear stresses at the wall are equal to,

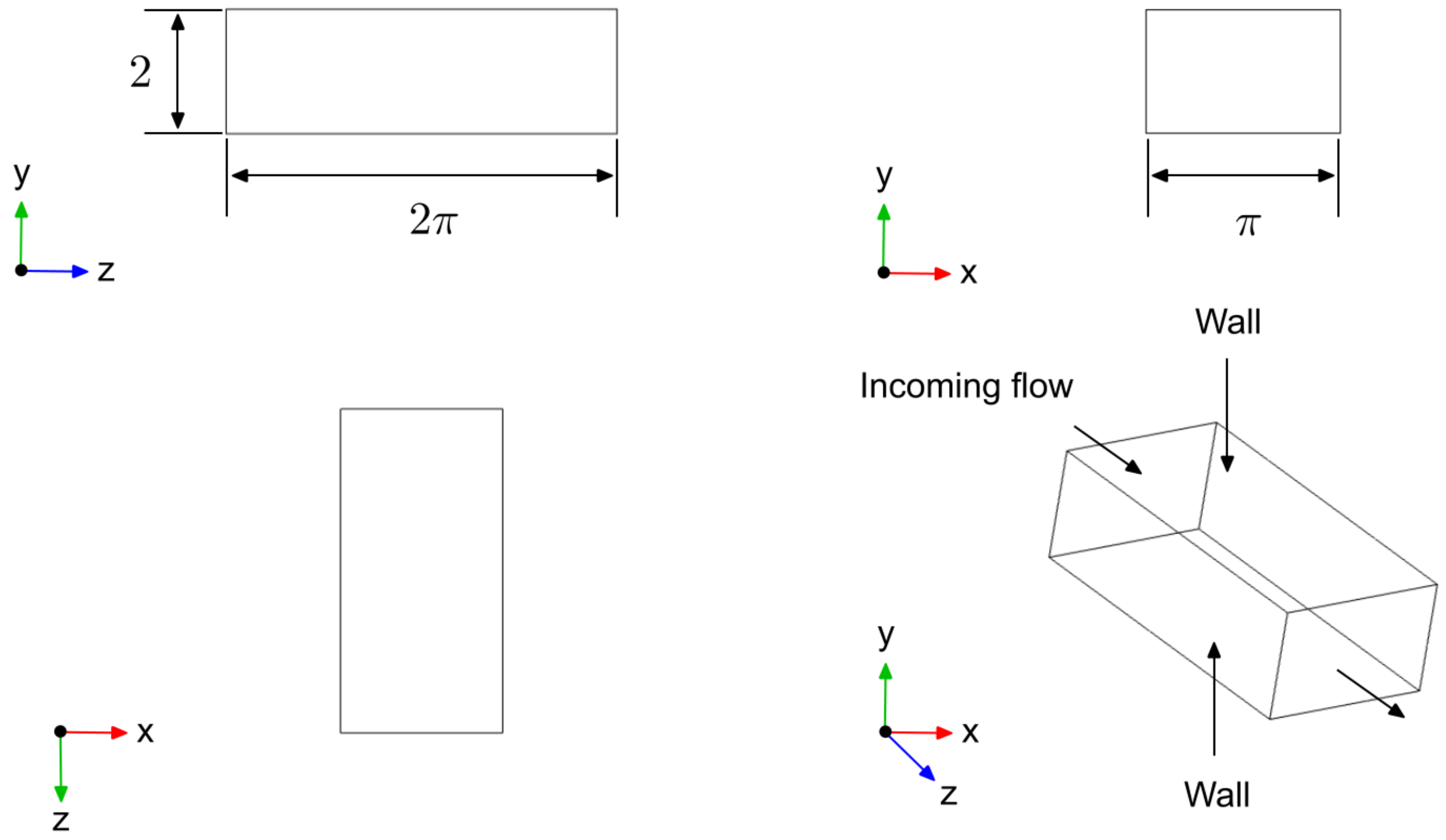
$$\tau_{wall} = 1\,Pa$$

- Finally, the shear velocity is equal to,

$$U_{\tau} = \left(\frac{\tau_{wall}}{\rho}\right)^{0.5} = 1\frac{m}{s}$$



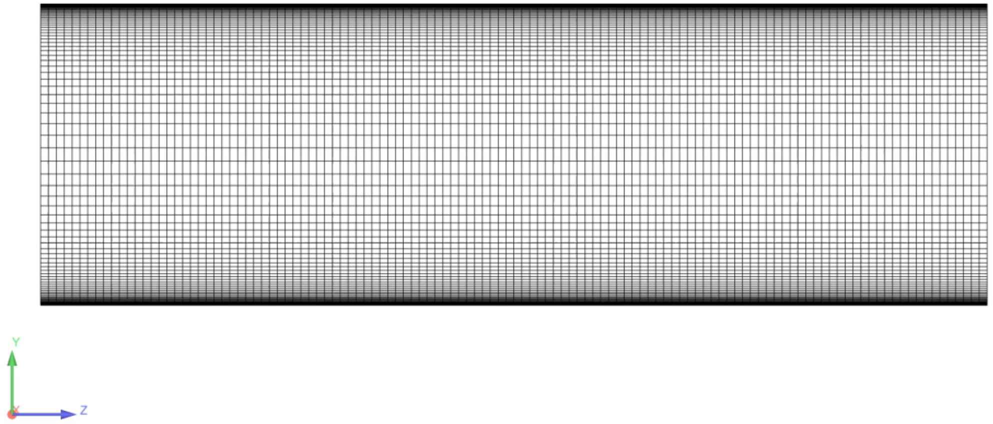
DNS simulation of a periodic channel

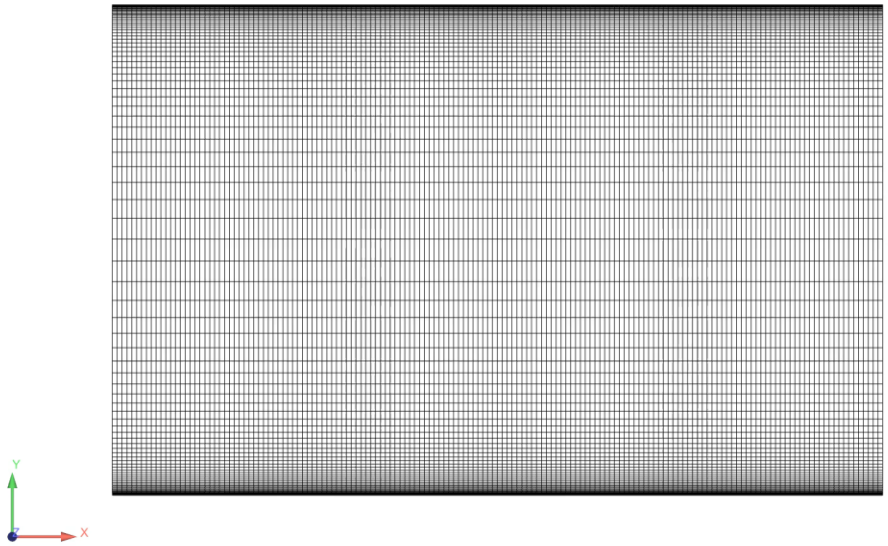


Periodic boundary conditions in the streamwise direction (x) and spanwise direction (z)

Domain dimensions and boundary conditions

DNS simulation of a periodic channel

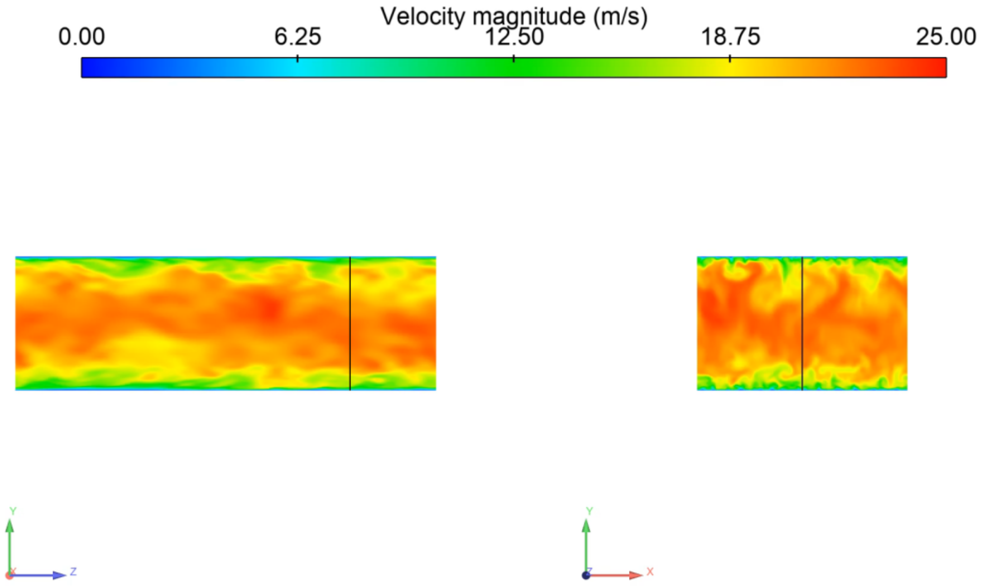




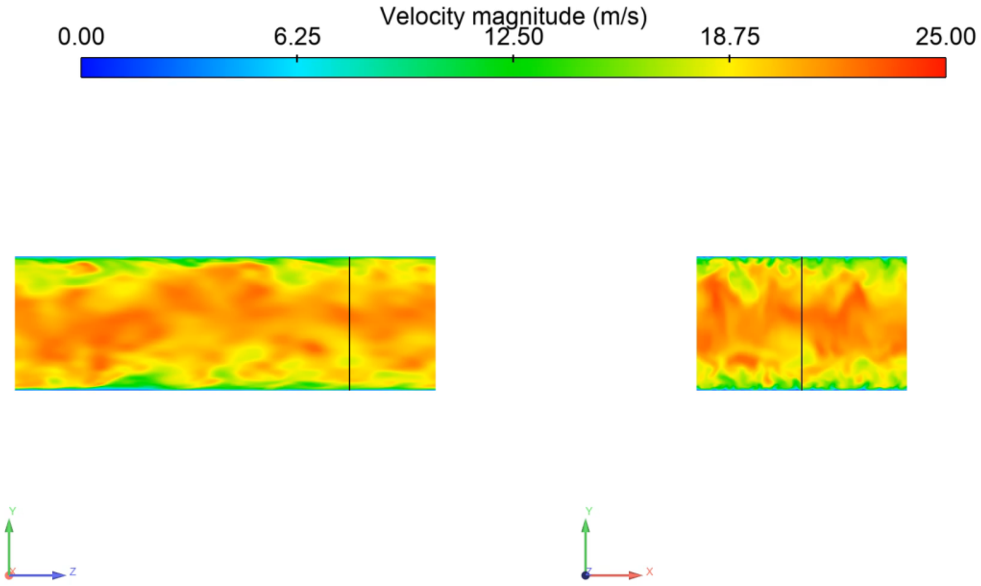
Mesh

Orthogonal hexahedral mesh – Approximately 1.8 million elements

DNS simulation of a periodic channel

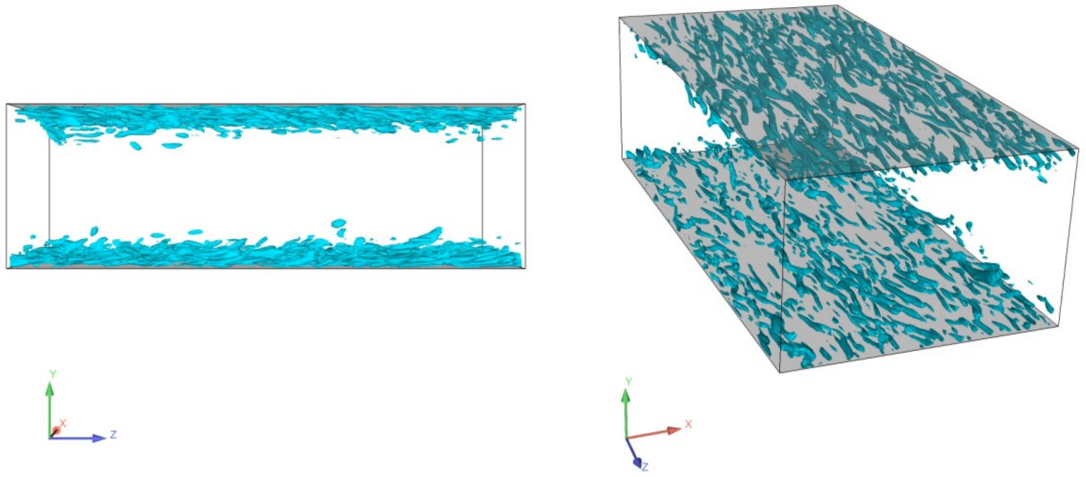


DNS simulation

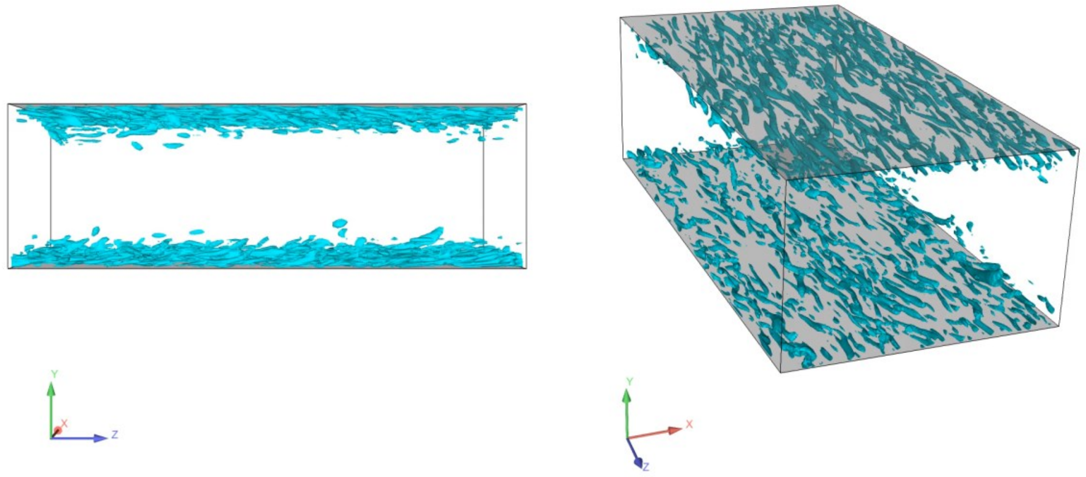


LES simulation (WALE)

DNS simulation of a periodic channel

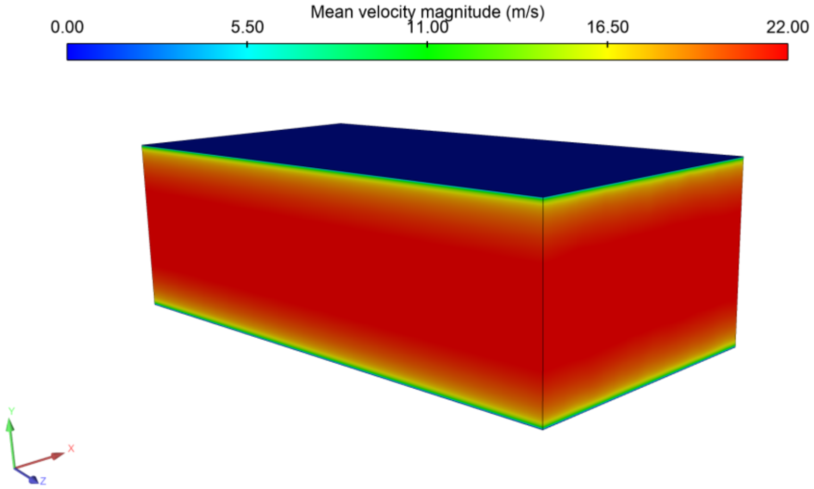


DNS simulation

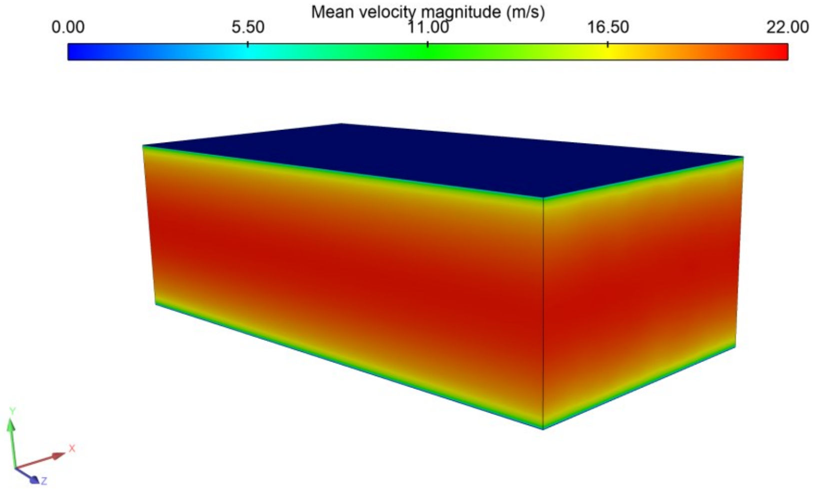


LES simulation (WALE)

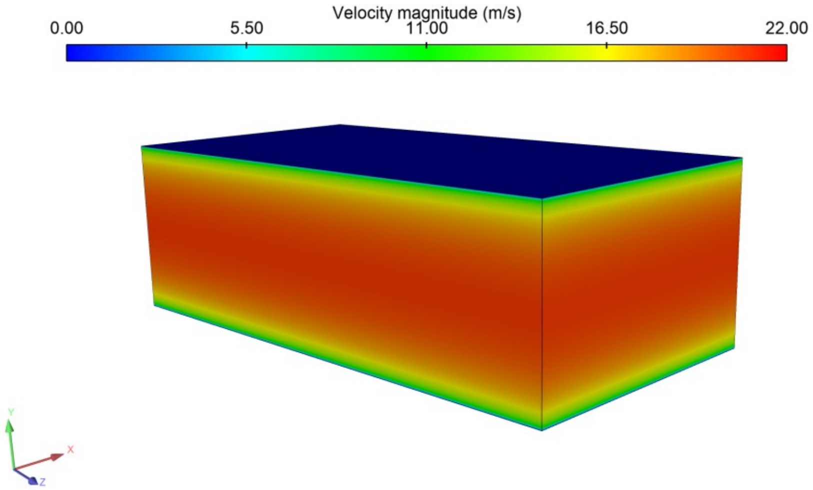
DNS simulation of a periodic channel



DNS simulation – Mean velocity magnitude

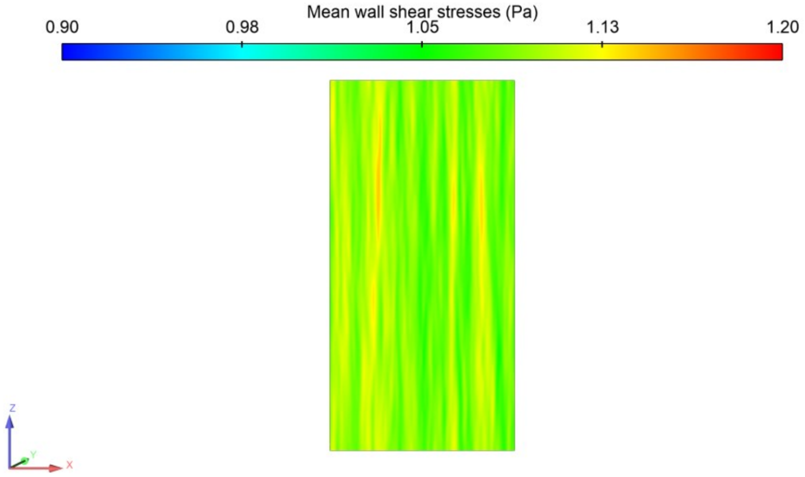


LES simulation (WALE) – Mean velocity magnitude

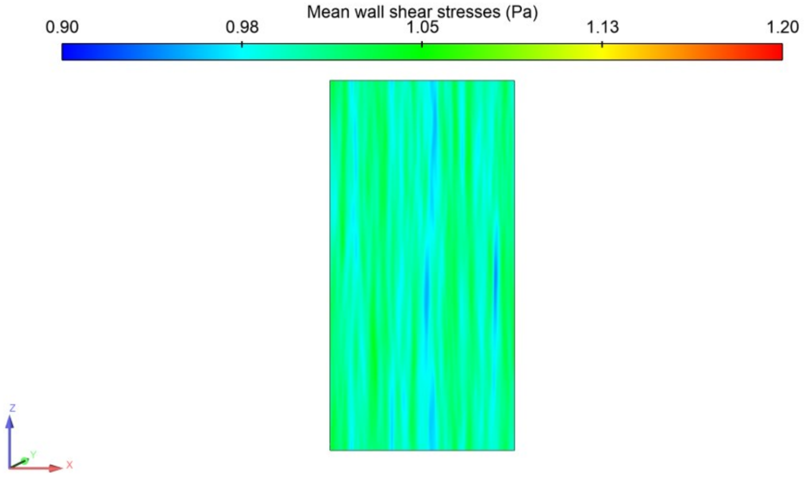


RANS simulation (k-omega SST)

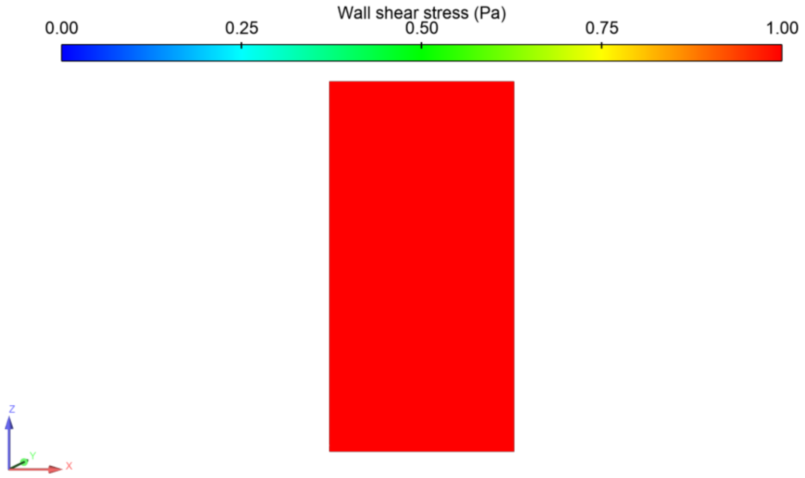
DNS simulation of a periodic channel



DNS simulation – Mean shear stresses

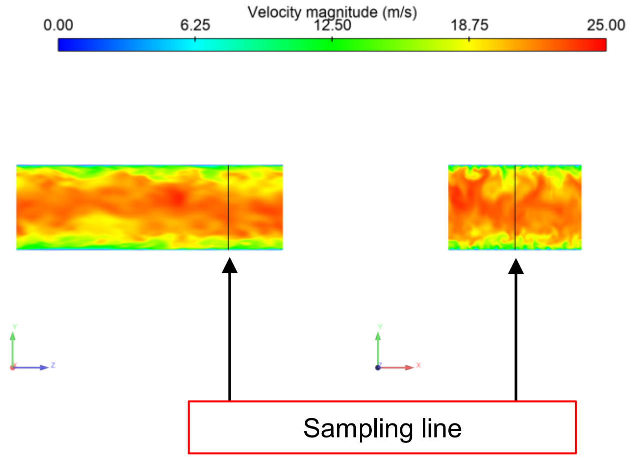


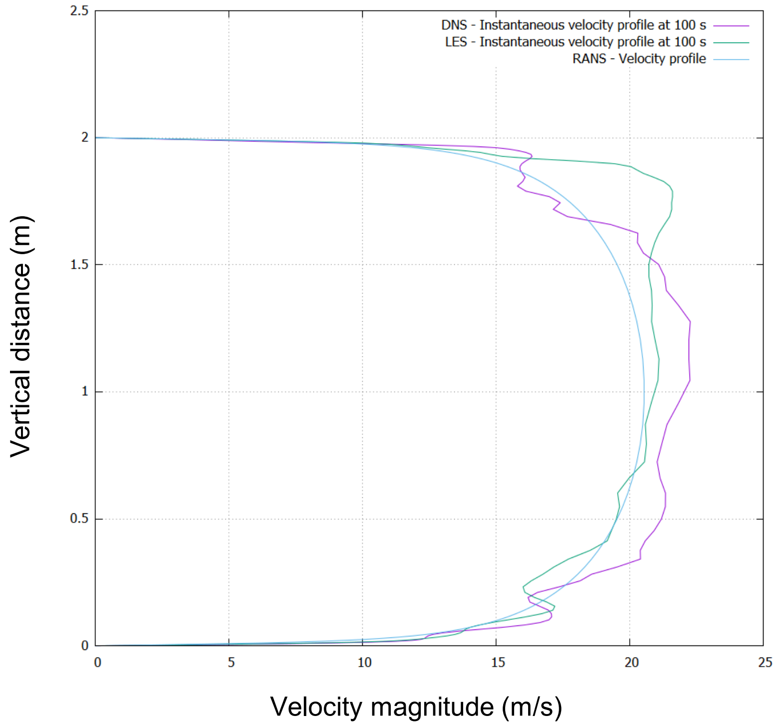
LES simulation (WALE) – Mean shear stresses

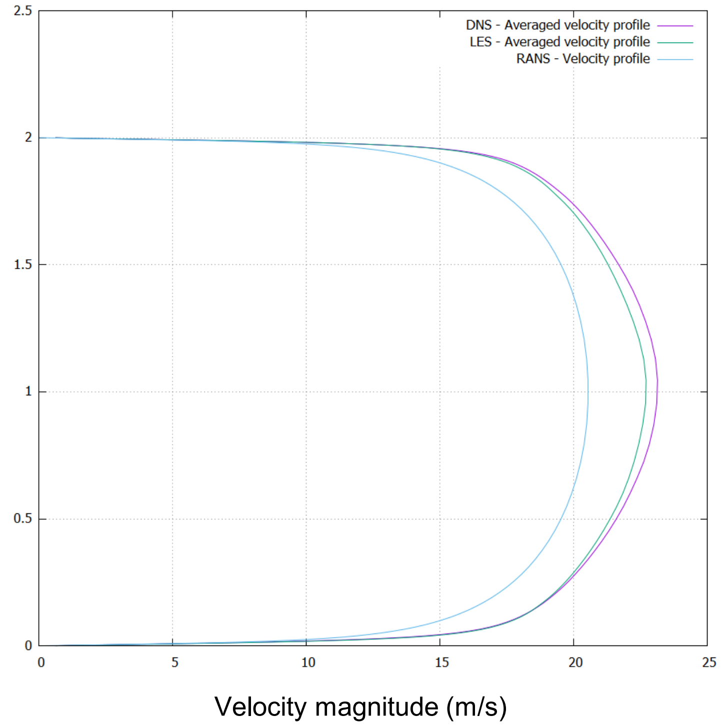


RANS simulation (k-omega SST)

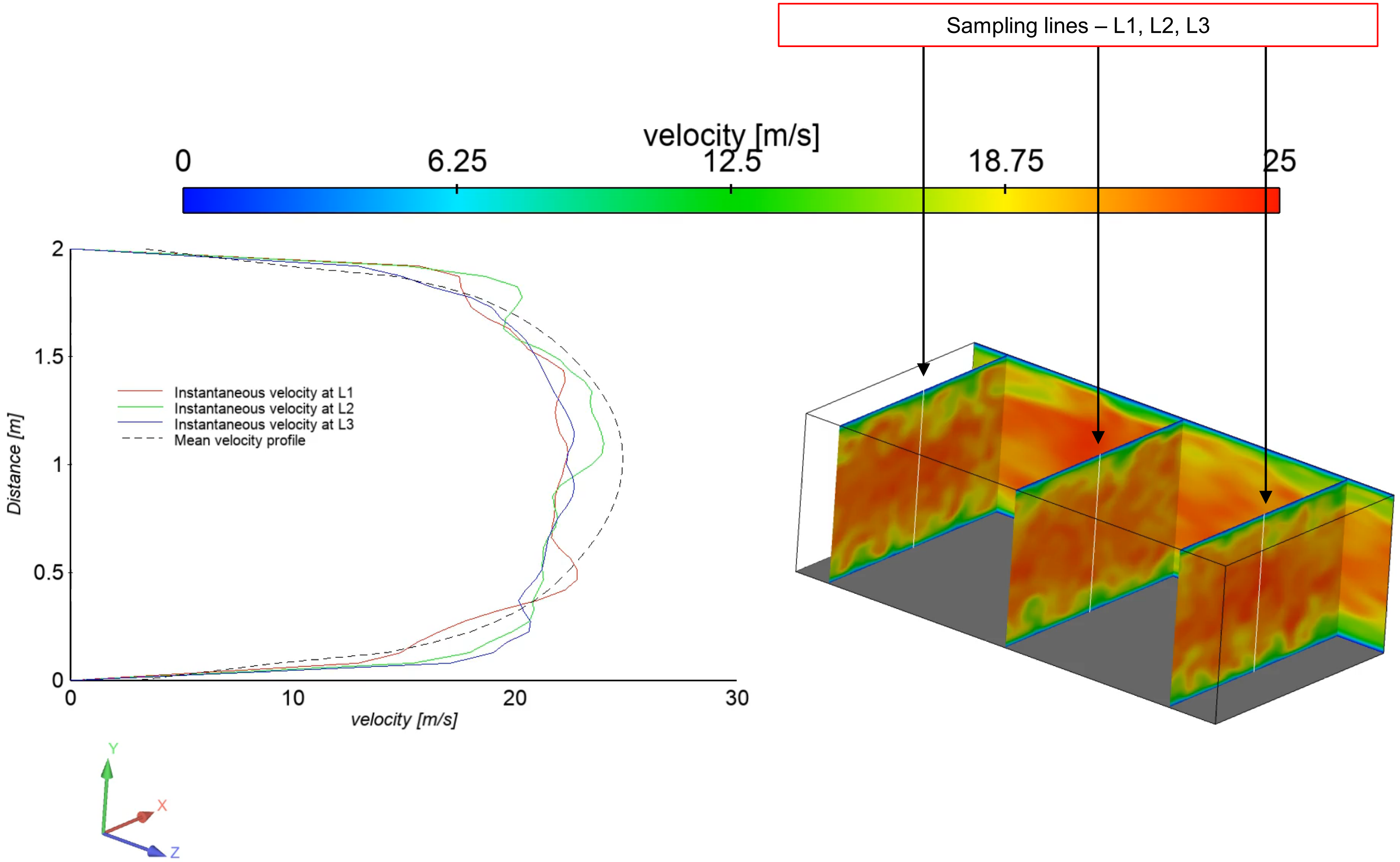
DNS simulation of a periodic channel





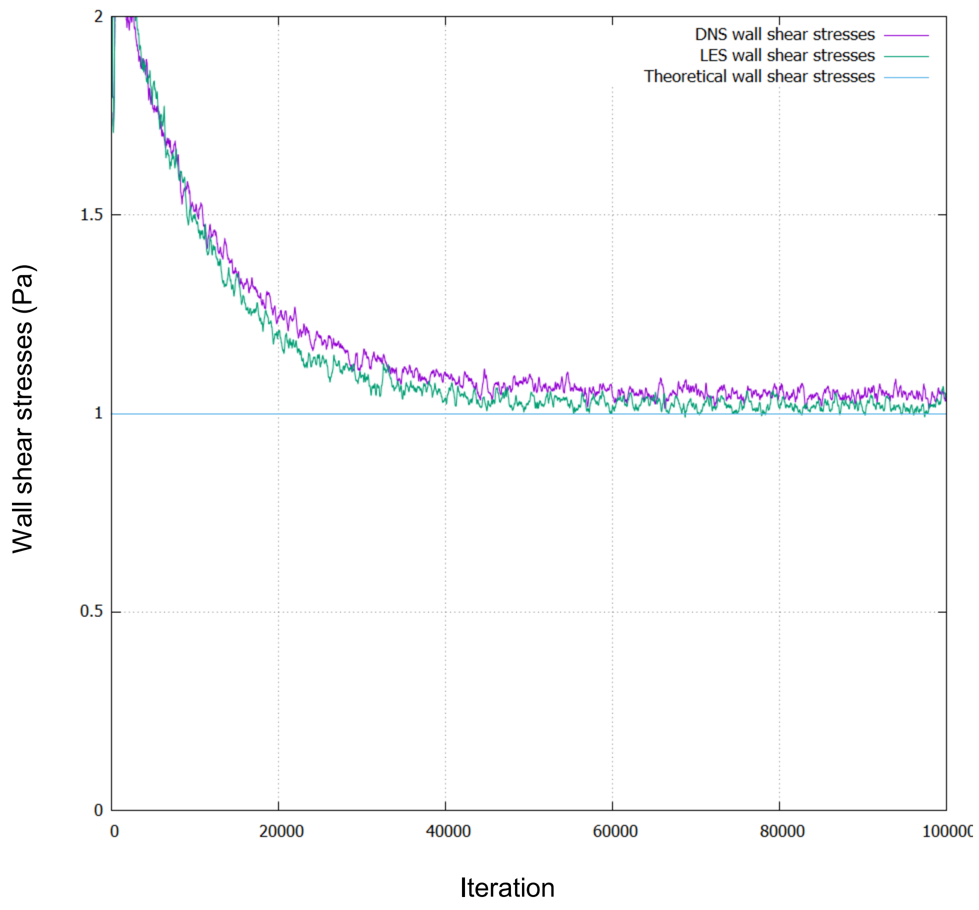


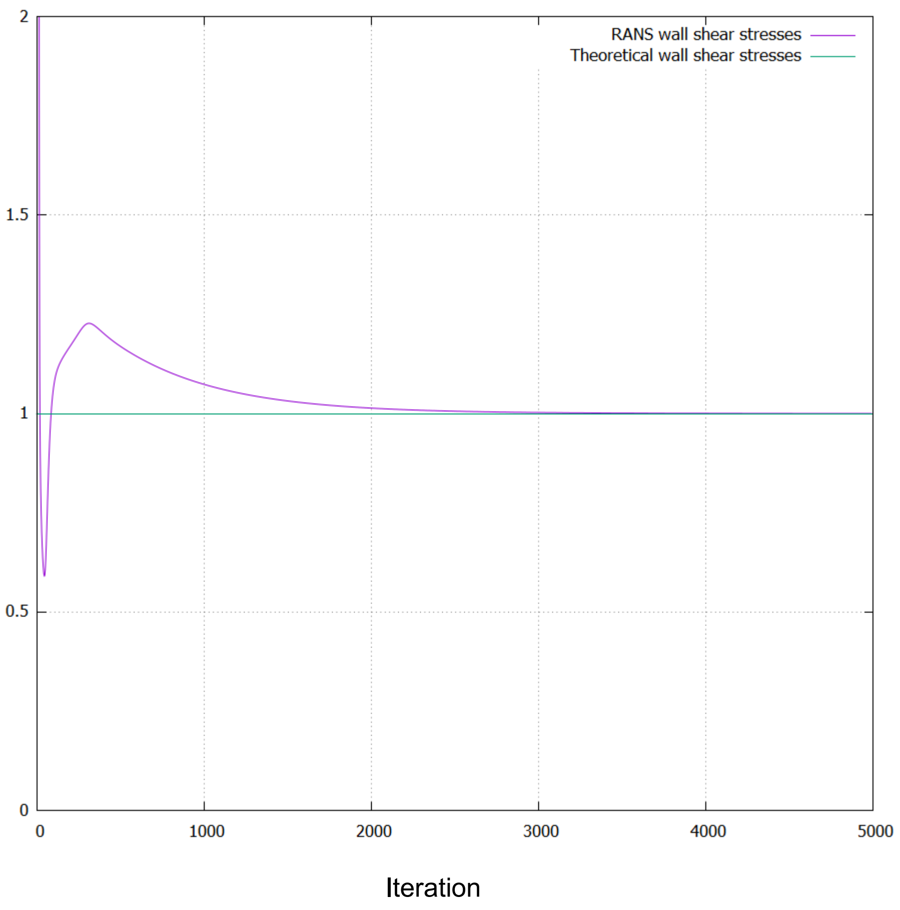
DNS simulation of a periodic channel



Time = 101.00100

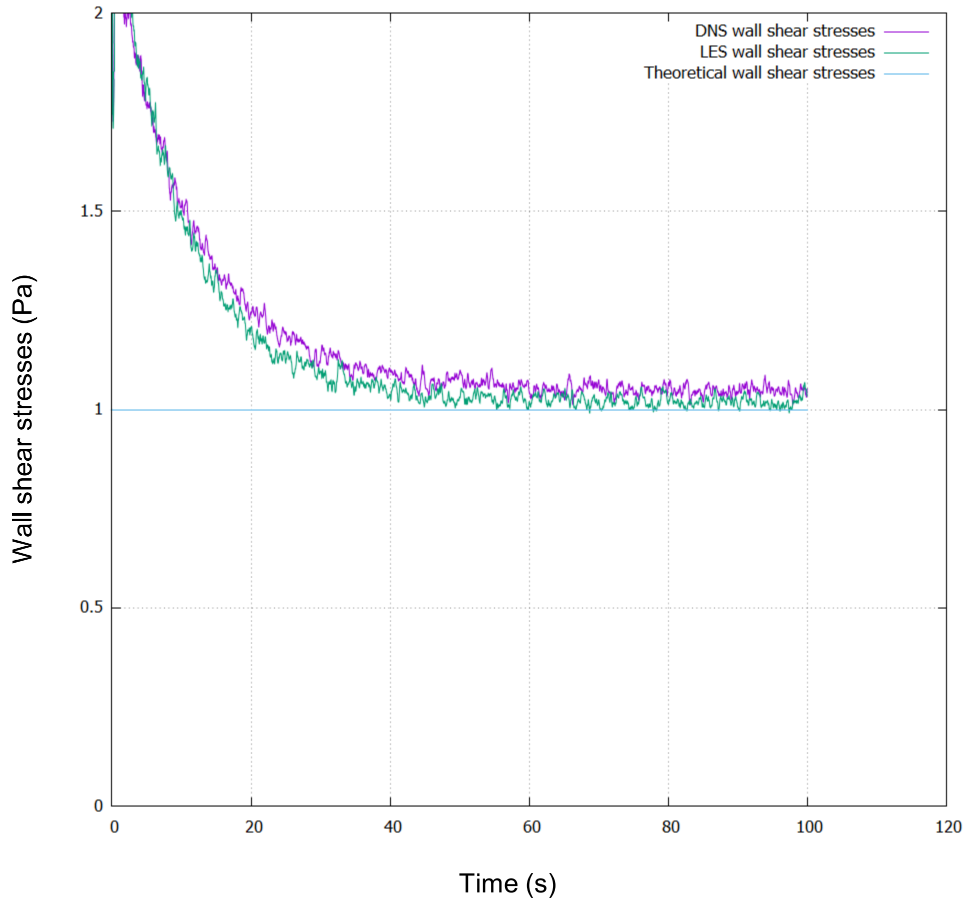
DNS simulation of a periodic channel

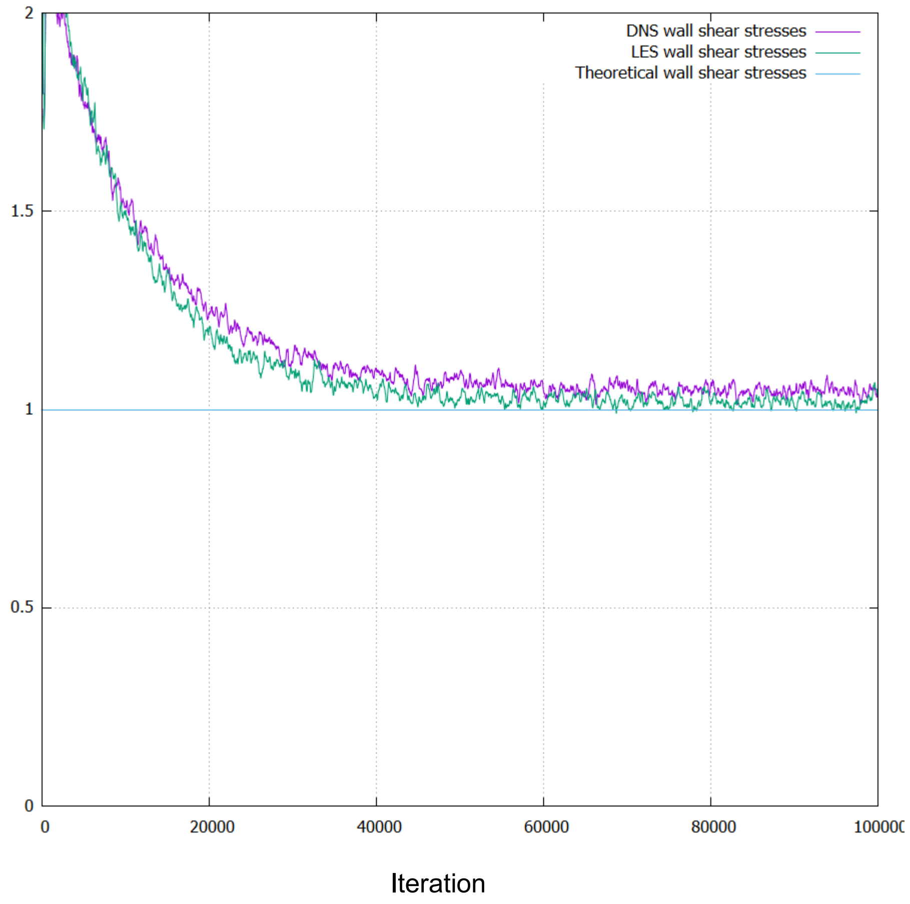




- The RANS simulation took approximately 1 hour to reach 20000 iterations (4 cores).
- The DNS and LES simulations both took approximately 150 hours with a CFL < 1 (12 cores).

DNS simulation of a periodic channel





Case	Wall shear stresses (Pa) – Mean value
DNS	1.0492
LES	1.0215
RANS	1.0
Theoretical value	1.0