

3D forward-facing step flow at $Re_H = 8304$ (turbulent inflow)



Database in progress ... it is currently uncompleted

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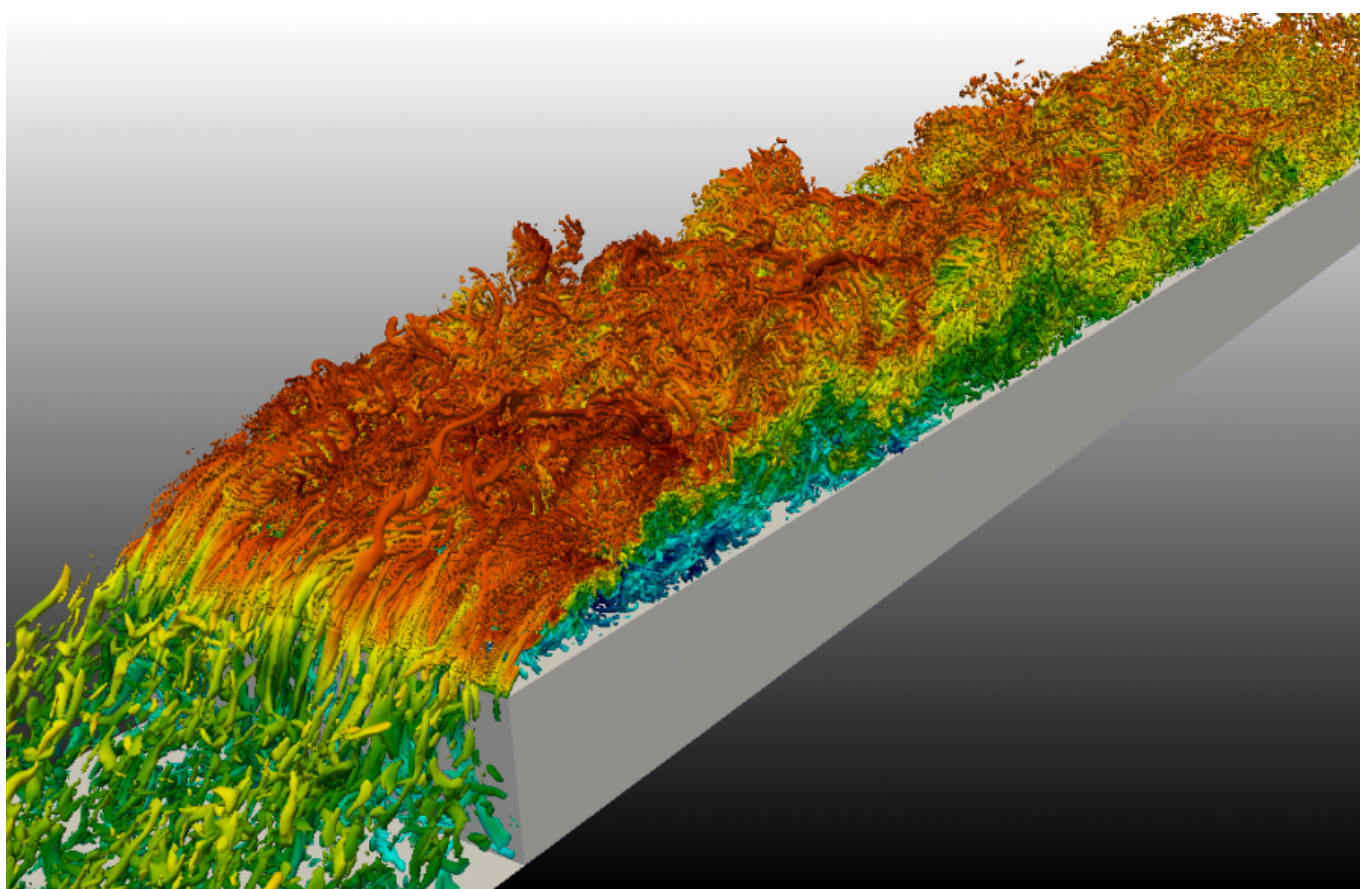
Date : August 2020

Simulation type : DNS ([Sunfluidh code](#))

Location : DATABASE_FORWARDFACINGSTEPFLOW2_RE8000_DNS

Status : Restricted access

Data size : ~ 5.0 Tb

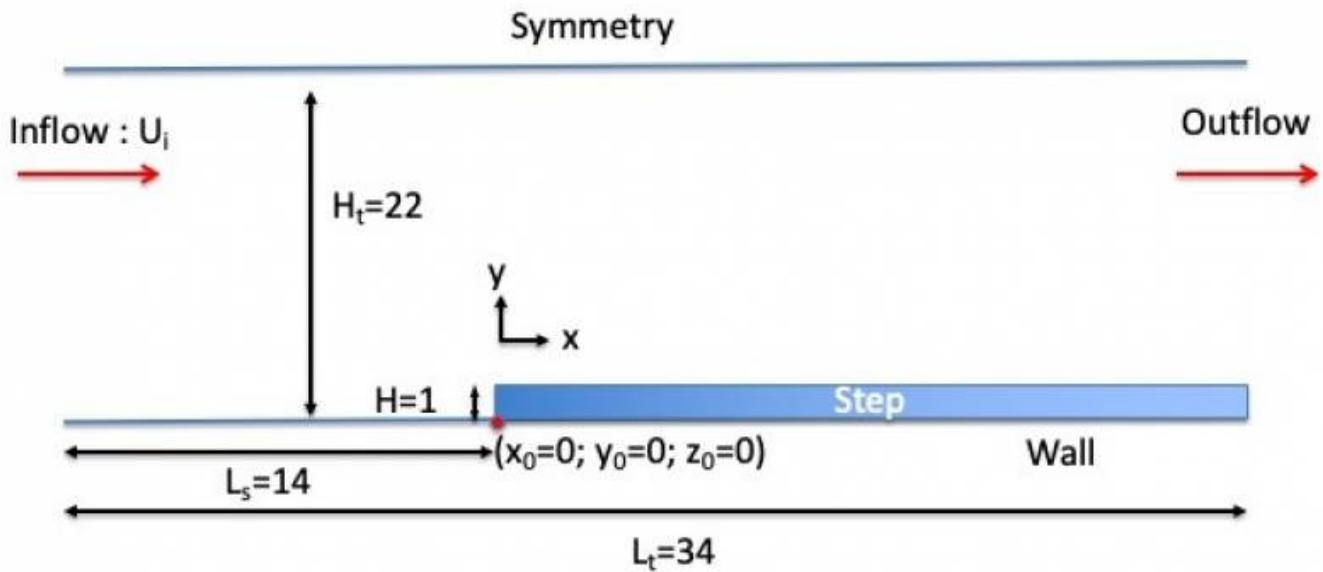


[A video is available here](#)

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Simulation settings

2D sketch



Referential : cartesian geometry

1. axes :
 - $x(i)$: downstream direction
 - $y(j)$: normal direction
 - $z(k)$: spanwise direction
2. origin :
 - $x_0 = 0$: the step
 - $y_0 = 0$: the bottom wall of the domain
 - $z_0 = 0$: the left side of the computational domain

Reference scales

- Density : mass density of the fluid (ρ_0)
- Length : step height (H)
- Velocity : inlet bulk velocity (U_i)
- Dynamic viscosity : dynamic viscosity of the fluid (μ_0)
- Reynolds number : $Re_H = \frac{\rho_0 \cdot U_0 \cdot H}{\mu_0} = 8304$

Non-dimensionalised data

- velocity : $U^* = \frac{U}{U_i}$
- density : $\rho^* = \frac{\rho}{\rho_0} = 1$
- coordinates : $x^* = \frac{x}{H}$, $y^* = \frac{y}{H}$, $z^* = \frac{z}{H}$

Computational domain

1. Domain scope

- Downstream direction(x) : $L^* = 37.0$
- Normal direction (y) : $H_t^* = 22.0$
- Spanwise direction (z) : $L^* = \pi$
- Step position : $L_s^* = 17.0$
- Step height : $H^* = 1$

2. Boundary conditions

- Inlet : Turbulent boundary layer at $X_{in}^* = -17.0$, $\delta_{in} = \frac{H}{3}$ (boundary layer's thickness)
 $Re_{\theta} = 300$, fluctuations generated from the SEM approach.
- Outlet : Orlansky's type at $X_{out}^* = 20.0$
- Wall conditions : Top and low walls of the domain
- Periodicity : lateral ends of the domain

3. Domain decomposition (200 MPI subdomains)

- Along the downstream direction :
 - 15 (between the inlet and the outlet, above the step)
 - 10 (between the inlet and the step)
- Along the normal direction : 4
- Along the spanwise direction : 4
- 2D sketch of domain decomposition in a plan {xy} (MPI process distribution (1))


```

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 0 0 0 0 0 0 0 0 0 0
      
```

4. Spatial resolution

- Grid : $128 \times 192 \times 96$ per subdomain (471.859.200 cells over the domain)
- About cell-size
 - $\Delta x_{min}^* = 1.0 \times 10^{-2} \approx \Delta x_{max}^* = 2.5 \times 10^{-2}$ (downstream direction)
 - $\Delta y_{min}^* = 1.5 \times 10^{-3} \approx \Delta y_{max}^* = 7.5 \times 10^{-2}$ (normal direction)
 - $\Delta z_{min}^* = \Delta z_{max}^* = 8.18123 \times 10^{-3}$ (spanwise direction)

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Data features

- Time series from probes** : U,V,W,P (velocity components & pressure)

- Physical quantities : velocity components along x, y and z directions (u,v,w) and pressure (p)
- 5 probes
- Time step= 0.00945 time unit
- Time range : from 120 to 454 time units
- Locations (In vertical plan at $z=1.57$)
 - $X_i = -0.250$, $X_j = 0.250$, $X_k = 1.57$ - MPI Subdomain ID :
 - $X_i = 0.125$, $X_j = 1.125$, $X_k = 1.57$ - MPI Subdomain ID :
 - $X_i = 1.000$, $X_j = 1.125$, $X_k = 1.57$ - MPI Subdomain ID :

- $X_i = 1.000$, $X_j = 1.250$, $X_k = 1.57$ - MPI Subdomain ID :
- $X_i = 4.000$, $X_j = 1.125$, $X_k = 1.57$ - MPI Subdomain ID :
- File name (per physical quantity): $x_ins_yyyyy.d$ with $x = u, v, w, p$ and 'yyyyy' the MPI subdomain ID
- **3D snapshots**
 - Instantaneous fields : velocity components in x, y and z directions (U, V, W) and pressure (P)
 - first dataset :
 - Recording rate : **0.5** time units
 - Time range from 120 to 454 time units
 - File name : $res_xxxxx_yyyyyyy.d$ (xxxxx : MPI subdomain ID, yyyyyy : Time ID)
 - MPI subdomain ID: from 0 to 199
 - Time ID : from 53 to 721
- **2D slices**
 - Instantaneous fields : velocity components in x, y and z directions (U, V, W) and pressure (P)
 - Recording rate : **0.1** time units
 - Time range from 120 to 454 time units
 - 4 slices are considered :
 - slice 1 : normal direction z - position : $z = 1.57$ - MPI subdomains ID :
 - MPI subdomains ID : 1 to 197 with a stride of 4
 - slices 4,5,6 : Wall pressure only
 - File name : $slice_n_idir_xxxxx_yyyyyyy.d$ (n : slice number ID, $idir$: direction= 1: $x(i)$, 2: $y(j)$, 3: $z(k)$, xxxxx : MPI subdomain ID, yyyyyy : Time ID)
 - slice 4 : normal direction y - position : $y = 0.0$ **WARNING : available only from Time ID = 139 (corresponding to time > 386)**
 - slice 5 : normal direction x - position : $x = 0.0$
 - slice 6 : normal direction y - position : $y = 1.0$
 - MPI subdomains ID : 4 to 7
 - MPI subdomains ID : 20 to 23
 - MPI subdomains ID : 36 to 39
 - MPI subdomains ID : 52 to 55
 - MPI subdomains ID : 68 to 71
 - MPI subdomains ID : 80 to 83
 - MPI subdomains ID : 92 to 95
 - MPI subdomains ID : 104 to 107
 - MPI subdomains ID : 116 to 119
 - MPI subdomains ID : 128 to 131
 - MPI subdomains ID : 140 to 143
 - MPI subdomains ID : 152 to 155
 - MPI subdomains ID : 164 to 167
 - MPI subdomains ID : 176 to 179
 - MPI subdomains ID : 188 to 191
 - Time ID : from 54 to 160
- **Statistics**
 - fields : (i, j : indexes of direction x, y or z)
 - Mean fields of velocity components ($\langle U_i \rangle$) and pressure ($\langle P \rangle$)
 - Mean fields of quadratic quantities ($\langle P^2 \rangle$, $\langle U_i U_j \rangle$)
 - Time and space average computation (along the spanwise direction)

- Time startup = 100.0 time units
- Time range per file = 20.0 time units
- Total time range from 100.0 to 450 time units
- file name : rst_XXXXX_YYYYYYY.d (XXXXX : MPI subdomain ID, YYYYYYY : Time ID)
 - MPI subdomain ID : from 0 to 49 (MPI process rank where results about space average computation are stored)
 - Time ID : from 1 to 17

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Database organisation

Data size : ~ 5.0 Tb

Main directory :

/vol/DATABASE_MECA/RESTRICTED_ACCESS/DATABASE_FORWARDFACINGSTEPFLOW2_RE8000_DNS

For more details about files, see the [the wiki doc of Sunfluidh](#)

Directories & files

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/GRID : contains all ASCII files about grid setup
input data file      : data_meshgen.d
report on grid features : report_meshgen.d
grid files for sunfluidh: maillx.d, mailly.d, maillz.d
check files (ASCII)   : check_mesh_I.d, check_mesh_J.d, check_mesh_K.d
                        (3 columns : indices, cell-face coordinates,
cell size)
/DATASETUP           : ASCII files
input data file for sunfluidh : input3d.dat
data file for MPI subdomain distribution (MPI graphical topology):
data_mpi_subdomain_layout.dat
/TIMESERIES          : contains time series recorded over the time range
[120,454]
                        ASCII files : x_ins_YYYYY.d   with x= u,v,w,p
                        time series files are sliced in storage directories CAS-
MPI200-n (n from 53 to 160)
/SNAPSHOTS           : snapshots binary files res_XXXXX_YYYYYYY.d with a
recording rate of 0.9 time unit
                        files stored in archive files : res_YYYYYYY.tar for each
time ID
/SNAPSHOTS_FS        : snapshots binary files res_XXXXX_YYYYYYY.d with a
recording rate of 0.3 time unit
                        files stored in archive files : res_YYYYYYY.tar for each
time ID
/STATISTICS          : statistics binary files rst_XXXXX_YYYYYYY.d
                        files stored in archive files : res_z.tar , z is an ID
number (from 1 to 17)

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/SLICES : slice binary files slice_n_idir_XXXXX_yyyyyyy.d
files stored in archive files : slices_z.tar , z is an ID
number (from 53 to 160)
/RESTART_AR : backup/restart archive save_t145.tar and save_t45.tar at
time=145 and 454 respectively

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