

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



Database in progress ... it is currently uncompleted

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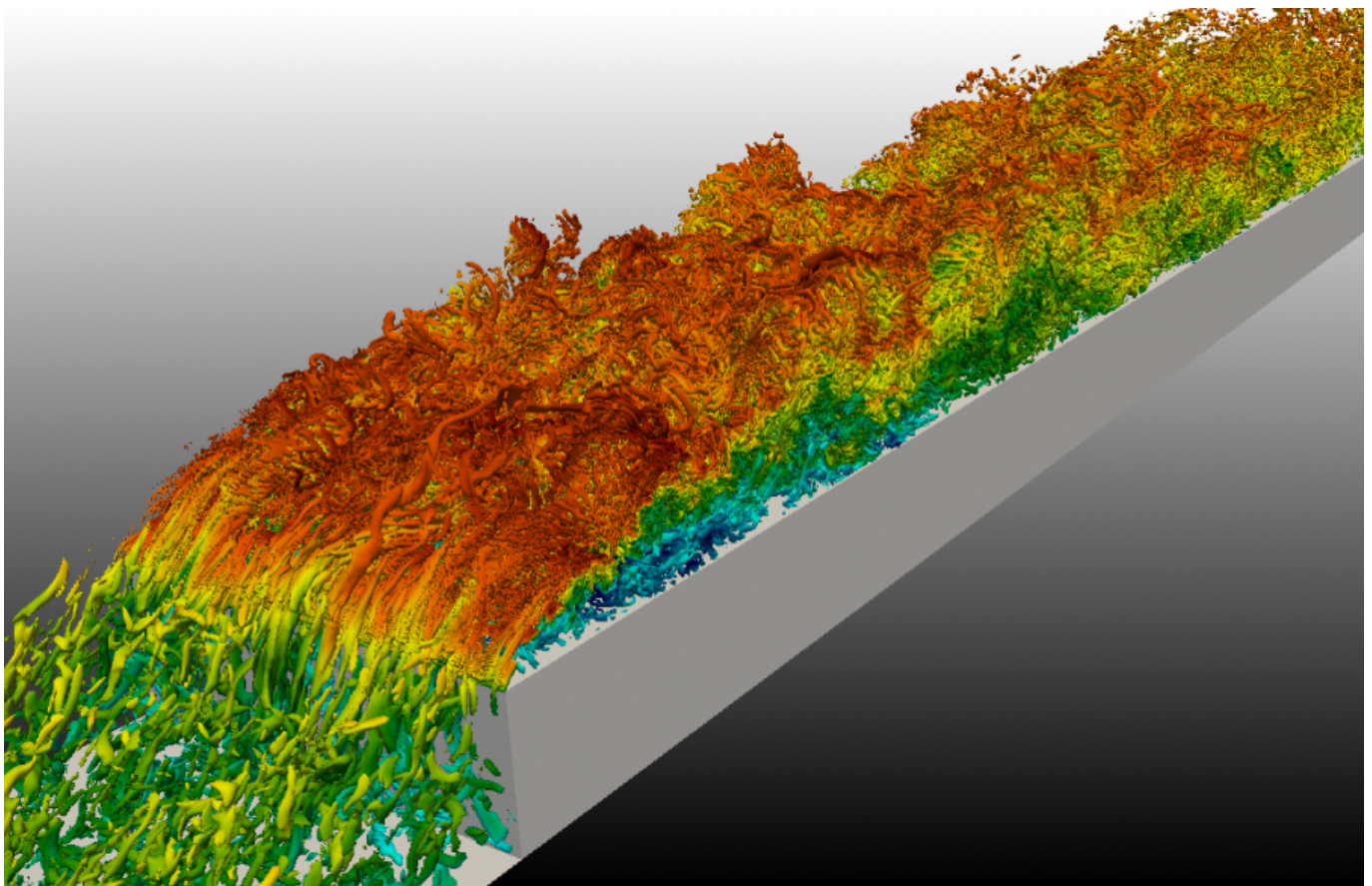
**Date** : August 2020

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

**Location** : DATABASE\_FORWARDFACINGSTEPFLOW2\_RE8000\_DNS

**Status** : Restricted access

**Data size** : ~ 5.2 Tb



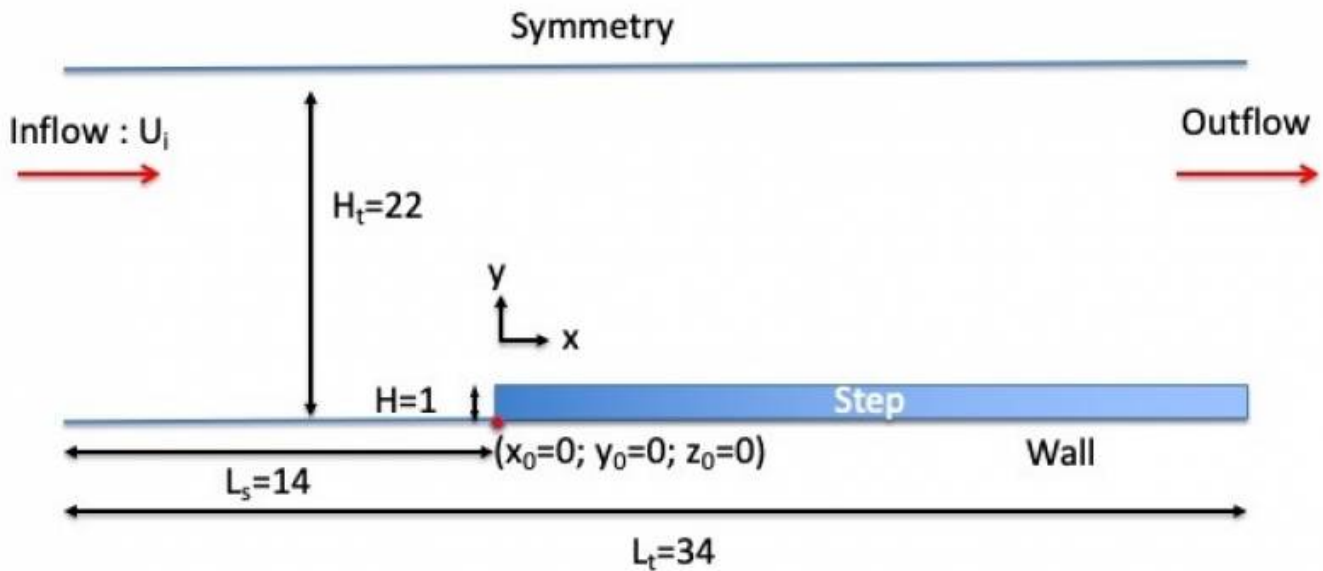
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**Simulation settings**

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

## 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 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
  - $\Delta x_{min}^* = 1.0 \times 10^{-2}$   $\Delta x_{max}^* = 2.5 \times 10^{-2}$  (downstream direction)
  - $\Delta y_{min}^* = 1.5 \times 10^{-3}$   $\Delta y_{max}^* = 7.5 \times 10^{-2}$  (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):  $x\_ins\_yyyy.d$  with  $x = u,v,w,p$  and 'yyyy' 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 (<U<sub>i</sub>>) and pressure (<P>)
  - Mean fields of quadratic quantities (<P<sup>2</sup>>, <U<sub>i</sub>U<sub>j</sub>>)
- Time and space average computation (along the spanwise direction)
- Time startup = 200.0 time units
- Time range per file = 10.0 time units
- Total time range from 200.0 to 450 time units
- file name : rst\_XXXXX\_YYYYYYY.d (XXXXX : MPI subdomain ID, YYYYYY : 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

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**Data size** : ~ 3.2 Tb

**Main directory** :

/vol/DATABASE\_MECA/RESTRICTED\_ACCESS/DATABASE\_BACKFACINGSTEPFLOW\_RE6000\_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
[188.37,??]
                          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 130 to ??)
/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
/SHOTS_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 files rst_xxxxx_yyyyyyy.d
                          files stored in archive files : res_z.tar , z is an ID
number (from 1 to ??)
/SLICES                  : slice binary files slice_n_idir_xxxxx_yyyyyyy.d
                          files stored in archive files : slices_z.tar , z is an ID
number (from 131 to ??)
/RESTART_AR              : backup/restart archive save.tar at time ??

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