

3D backward-facing step flow at $Re_H = 6000$

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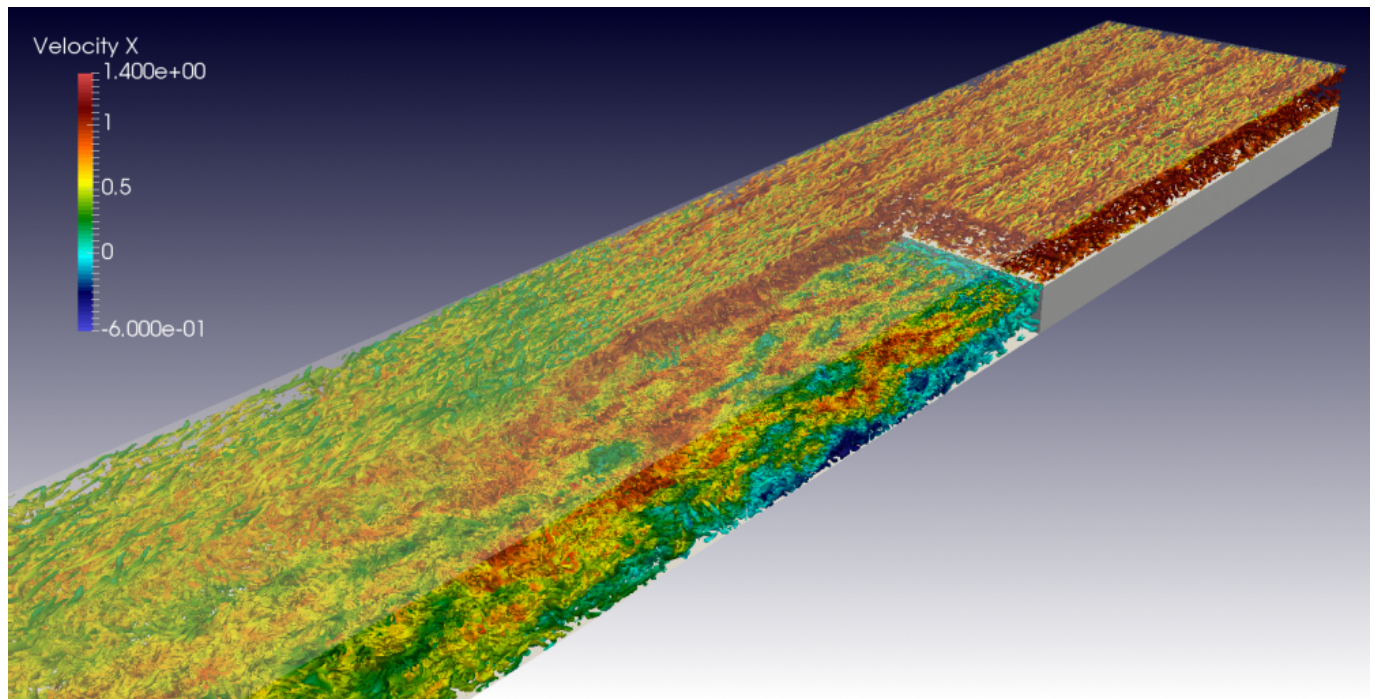
Date : August 2018

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

Location : DATABASE_BACKWARDFACINGSTEPFLOW_RE6000_DNS

Status : Restricted access

Data size : ~ 4.4 Tb

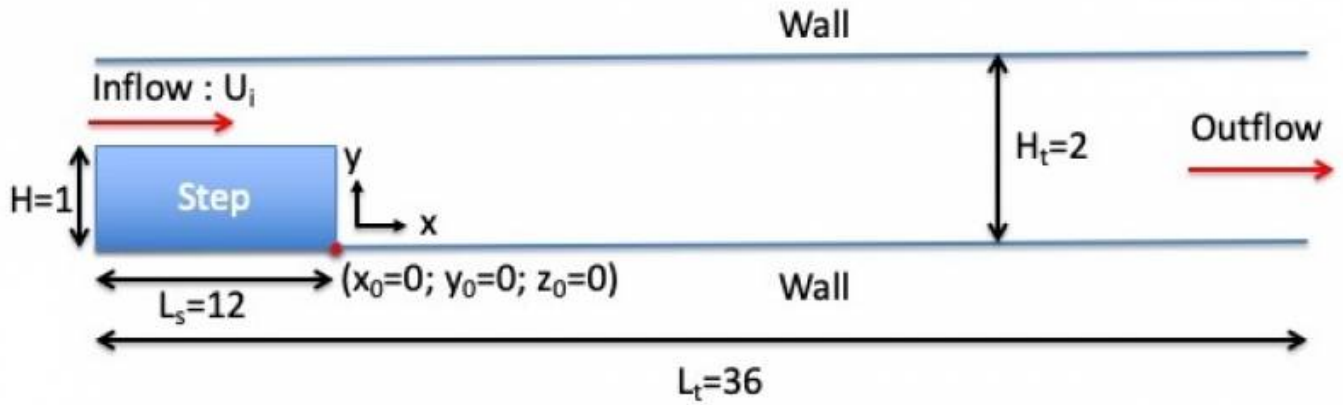


[A video is available here](#)

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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 : $Re_H = \frac{\rho_0 \cdot U_i \cdot H}{\mu_0} = 6000$

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) : $L^* = 36.0$
 - Normal direction (y) : $H_t^* = 2.0$
 - Spanwise direction (z) : $l^* = 2\pi$
 - Step position : $L_s^* = 12.0$
 - Step height : $H^* = 1$
2. **Boundary conditions**
 - Inlet : Uniform profile at $X_{in}^* = -12.0$

- Outlet : Orlansky's type at $X_{out}^* = 24.0$
- Wall conditions : Top and low walls of the domain
- Periodicity : lateral ends of the domain

3. Domain decomposition (160 MPI subdomains)

- Along the downstream direction :
 - 12 (between the inlet and the outlet, above the step)
 - 8 (between the step and the outlet)
- 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
0 0 0 0 1 1 1 1 1 1 1
0 0 0 0 1 1 1 1 1 1 1
      
```

4. Spatial resolution :

- Grid : $128 \times 64 \times 64$ per subdomain (83.886.080 cells over the domain)
- About cell-size
 - $\Delta x_{min}^* = 1.0 \times 10^{-3}$ $\Delta x_{max}^* = 2.456 \times 10^{-2}$ (downstream direction)
 - $\Delta y_{min}^* = 1.1 \times 10^{-3}$ $\Delta y_{max}^* = 1.653 \times 10^{-2}$ (normal direction)
 - $\Delta z_{min}^* = \Delta z_{max}^* = 2.4543 \times 10^{-3}$ (spanwise direction)

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Data features

• Time series from probes

- Physical quantities : velocity components along x, y and z directions (u,v,w) and pressure (p)
- 11 probes
- Time step = 0.01 time unit
- Time range : 200.0 to 513.3 time units
- Locations (In vertical plan at $z=3.14$)
 - $X_i=-4.00$, $X_j= 1.50$, $X_k= 3.14$ - MPI Subdomain ID : 17
 - $X_i=-2.00$, $X_j= 1.50$, $X_k= 3.14$ - MPI Subdomain ID : 25
 - $X_i= 0.10$, $X_j= 1.00$, $X_k= 3.14$ - MPI Subdomain ID : 37
 - $X_i= 4.00$, $X_j= 1.00$, $X_k= 3.14$ - MPI Subdomain ID : 53
 - $X_i= 4.00$, $X_j= 0.01$, $X_k= 3.14$ - MPI Subdomain ID : 49
 - $X_i= 6.00$, $X_j= 1.00$, $X_k= 3.14$ - MPI Subdomain ID : 69
 - $X_i= 6.00$, $X_j= 0.01$, $X_k= 3.14$ - MPI Subdomain ID : 65
 - $X_i= 8.00$, $X_j= 1.00$, $X_k= 3.14$ - MPI Subdomain ID : 69
 - $X_i= 8.00$, $X_j= 0.01$, $X_k= 3.14$ - MPI Subdomain ID : 65
 - $X_i=16.0$, $X_j= 1.00$, $X_k= 3.14$ - MPI Subdomain ID : 117
 - $X_i=16.0$, $X_j= 0.01$, $X_k= 3.14$ - MPI Subdomain ID : 113
- 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)
- Recording rate : 0.1 time unit
- Time range from 185.3 to 513.3 time units
- File name : res_XXXXX_YYYYYYY.d (XXXXX : MPI subdomain ID, YYYYYY : Time ID)
 - MPI subdomain ID: from 0 to 159
 - Time ID : from 186 to 3465

- **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 = 180.0 time units
- Time range per file = 10.0 time units
- Total time range from 180.0 to 510.0 time units
- file name : rst_XXXXX_YYYYYYY.d (XXXXX : MPI subdomain ID, YYYYYY : Time ID)
 - MPI subdomain ID : from 0 to 39 (MPI process rank where results about space average computation are stored)
 - Time ID : from 1 to 33

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Database organisation

Data size : ~ 4.4 Tb

Main directory :

/vol/DATABASE_MECA/RESTRICTED_ACCESS/DATABASE_BACKFACINGSTEPFLOW_RE6000_DNS

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

Directories & files

```
/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
[200,513.3]
```

```
ASCII files : x_ins_yyyyy.d   with x= u,v,w,p
time series files are sliced in directories CAS-MPI160-n (n
from 121 to 330)
WARNING : possible underlying of time series for these data
couples :
                n = (243,244)
                n = (246,247)
                n = (259,260)
                n = (260-261)
                The directory CAS-MPI160-260 contains 2 groups of
                consecutive timeseries files placed in
directories DIR-A and DIR-B
  /SNAPSHOTS   : snapshots binary files res_xxxxx_yyyyyyy.d
                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 : rst_z.tar , z is an ID
number
  /RESTART_AR  : backup/restart archive save.tar at 513.27 time units
```

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