

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

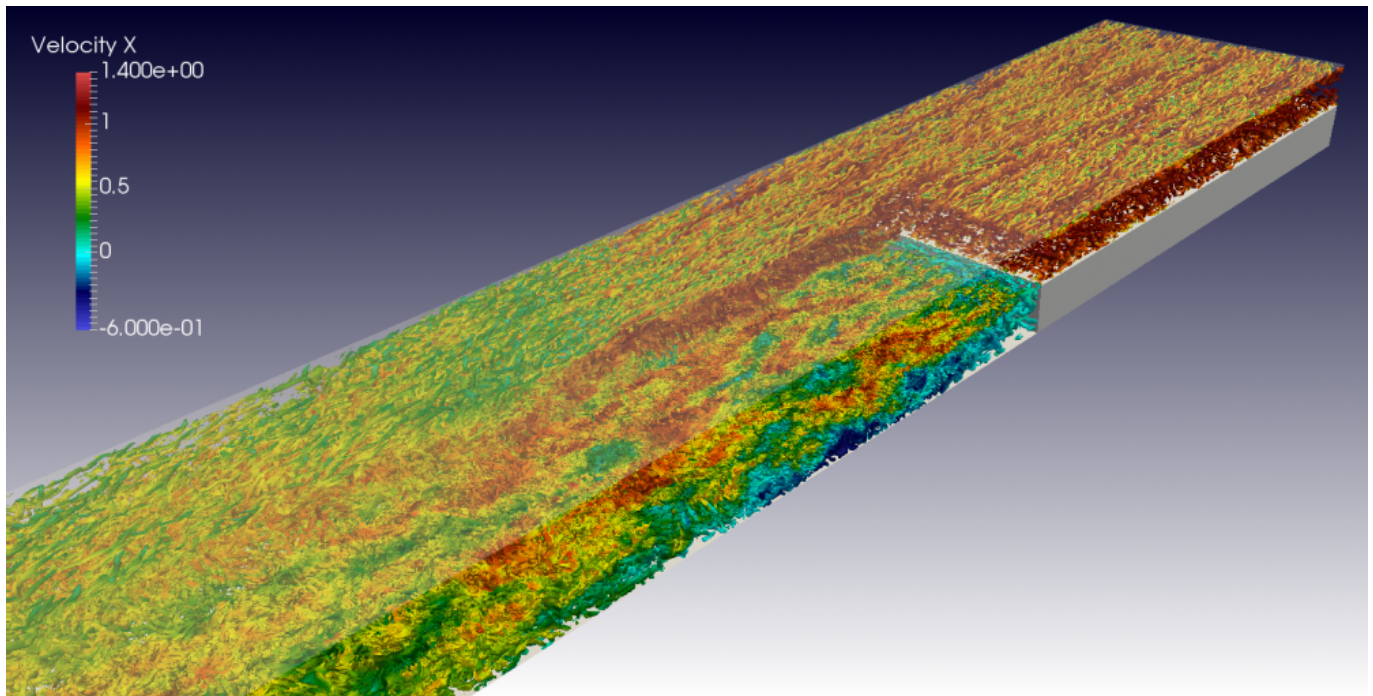
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**Date** : August 2018

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

**Location** : DATABASE\_BACKWARDFACINGSTEPFLOW\_RE6000\_DNS

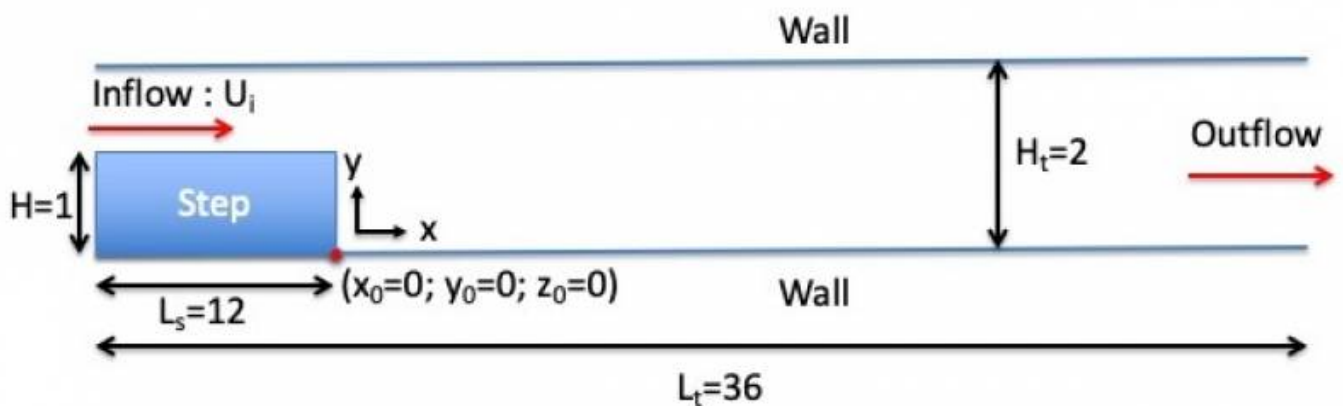
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[Come back to first page](#)

### 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 ( $\rho_0$ )
- Length : step height ( $H$ )
- Velocity : inlet bulk velocity ( $U_i$ )
- Dynamic viscosity : dynamic viscosity of the fluid ( $\mu_0$ )
- Reynolds number :  $Re_H = \frac{\rho_0 U_i H}{\mu_0} = 6000$

## 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 1 1
```

0 0 0 1 1 1 1 1 1 1 1

0 0 0 1 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)

[Come back to first page](#)

## Data Recording : information about data types

### • 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 from 185.3 to 513.3 time units
- File name :  $res\_xxxxx\_yyyyyy.d$  (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, yyyyyyy : 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

[Come back to first page](#)

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## Database organisation

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**Data size** : ~ 4.4 To

**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

[Come back to first page](#)

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