3D forward-facing step flow at $Re_H= 8000$ (turbulent inflow)

Database in progress ... it is currently uncompleted

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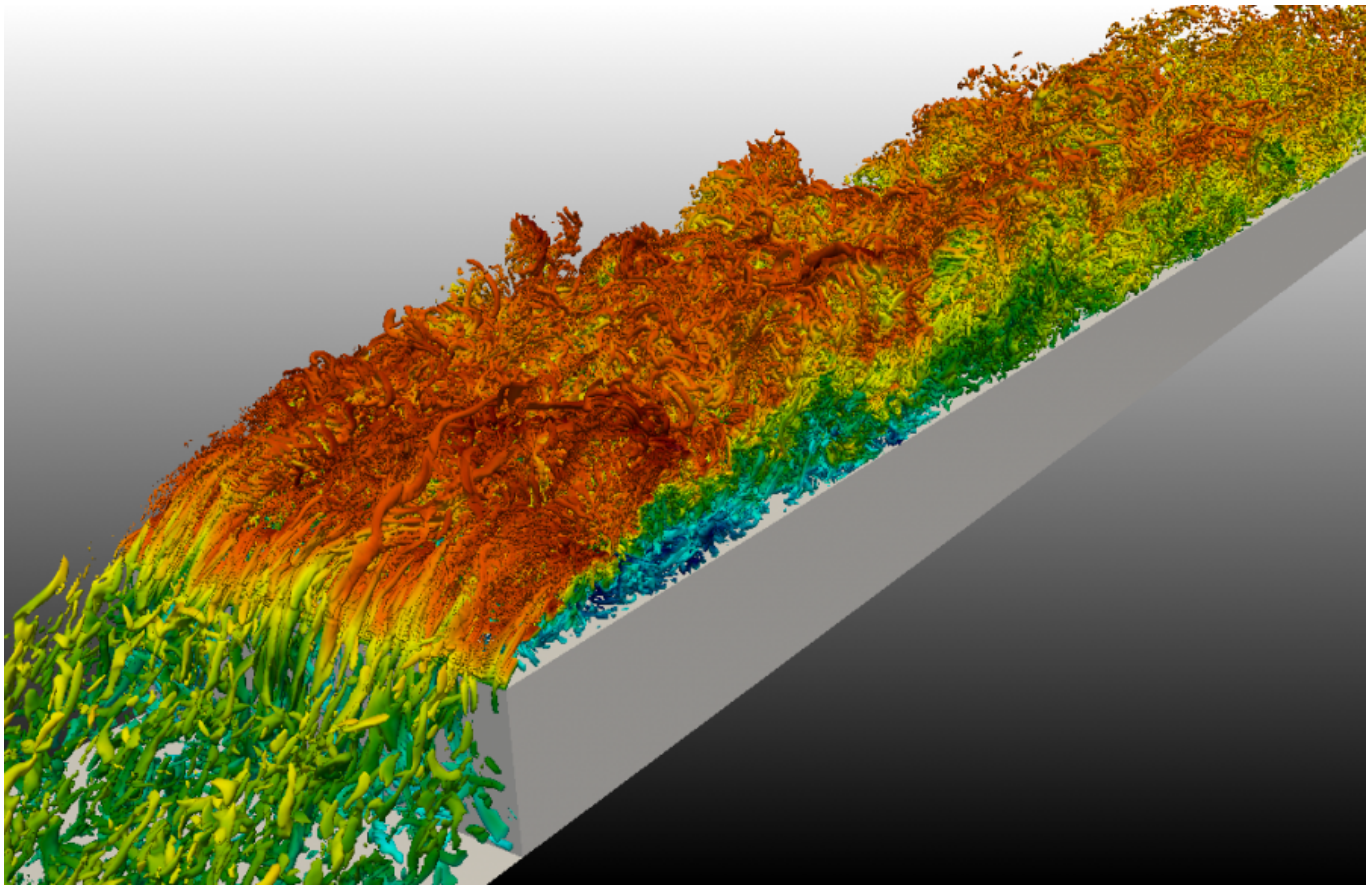
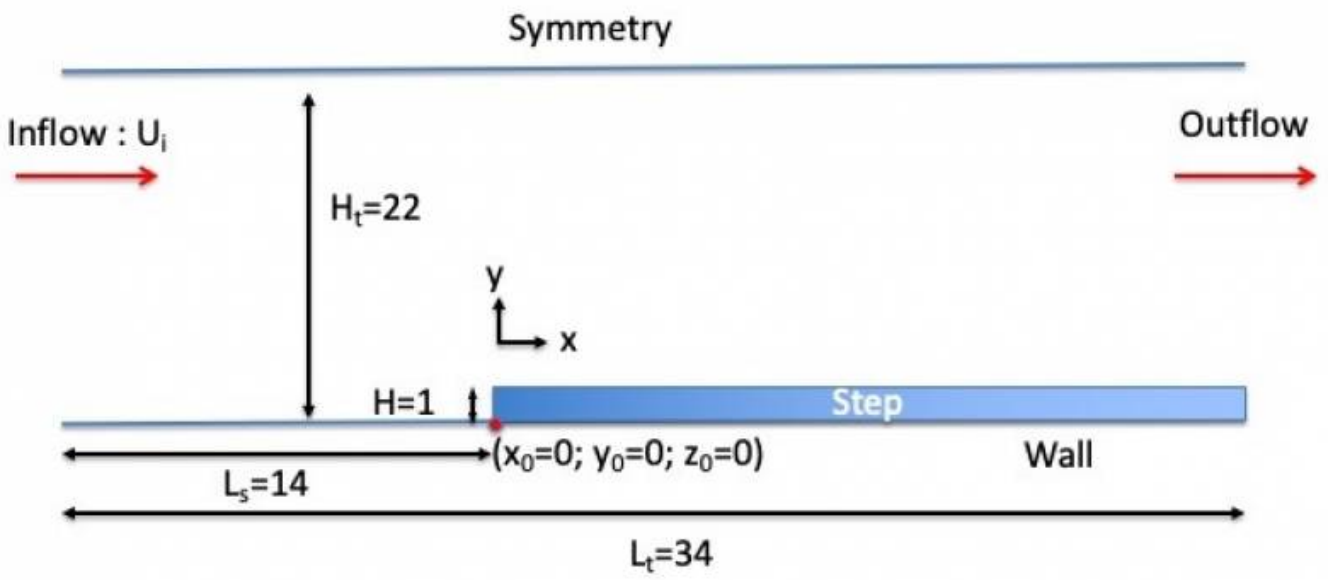
Simulation type : DNS (Sunfluidh code)
Location : DATABASE_FORWARDFACINGSTEPFLOW2_RE8000_DNS
Status : Restricted access
Data size : ~ 5.2 Tb



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 (ρ_0)
- Length : step height (H)
- Velocity : inlet bulk velocity (U_i)
- Dynamic viscosity : dynamic viscosity of the fluid (μ_0)
- Reynolds number : $Re_H= \frac{\rho_0.U_0.H}{\mu_0}= 8000$

Non-dimensionalised data

- velocity : $U^*=\frac{U}{U_i}$
- density : $\rho^*= \rho/\rho_0= 1$
- 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
     - $\Delta x_{min}^*= 1.0 \, 10^{-2} \quad \Delta x_{max}^*= 2.5 \,10^{-2}$ (downstream direction)
     - $\Delta y_{min}^*= 1.5 \, 10^{-3} \quad \Delta y_{max}^*= 7.5 \,10^{-2}$ (normal direction)
     - $\Delta z_{min}^*=\Delta z_{max}^*= 8.18123 \, 10^{-3}$ (spanwise direction)

Come back to first page

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 : – to – time units
  - Locations (In vertical plan at $z=1.57$)
    - Xi=-0.250 , Xj= 0.250 , Xk= 1.57 - MPI Subdomain ID :
    - Xi= 0.125 , Xj= 1.125 , Xk= 1.57 - MPI Subdomain ID :
    - Xi= 1.000 , Xj= 1.125 , Xk= 1.57 - MPI Subdomain ID :
    - Xi= 1.000 , Xj= 1.250 , Xk= 1.57 - MPI Subdomain ID :
    - Xi= 4.000 , Xj= 1.125 , Xk= 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 — to — time units
    - File name : res_xxxxx_yyyyyyy.d (xxxxx : MPI subdomain ID, yyyyyyy : Time ID)
      - MPI subdomain ID: from 0 to 199
      - Time ID : from – to –

- **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 from – to – 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
  - slice 4 : normal direction y - position : y= 1.0 (for time < 386) - y= 0.0 (for 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
- 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, yyyyyyy : Time ID)
  - MPI subdomain ID: ??
  - Time ID : from 748 to ??

- **Statistics**
  - fields : (i,j : indexes of direction x, y or z)
    - Mean fields of velocity components (<Ui>) and pressure (<P>)
    - Mean fields of quadratic quantities (<P2>, <UiUj>)
  - 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 390 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 19

Come back to first page

Database organisation

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

```
  /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
  /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 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 ??
```

Come back to first page

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