

# Fully-developed, pressure-driven flow of an incompressible, isothermal fluid through a plane closed channel flow : data from DNS

## References:

Bauer, C., Sakai, Y., Uhlmann, M. (2024). *Direct numerical simulation of turbulent open channel flow: Streamwise turbulence intensity scaling and its relation to large-scale coherent motions*. Progress in turbulence X, Springer proceedings in physics 404, p. 311-317, [https://doi.org/10.1007/978-3-031-55924-2\\_42](https://doi.org/10.1007/978-3-031-55924-2_42)

Bauer, C., Sakai, Y., Uhlmann, M. (2025). *How far does the influence of the free surface extend in turbulent open channel flow?* Flow Turbulence Combust, <https://doi.org/10.1007/s10494-025-00665-4>

## Description of the flow

We are considering the flow of an incompressible and isothermal fluid in a plane closed channel flow of half-height  $h$  (cf. figure 1). The flow field is assumed to be periodic in stream- and spanwise direction over periods of length  $L_x$  and  $L_z$ , respectively. A constant flow rate is imposed at each time step.

## Flow parameters

The problem is governed by a single parameter, the bulk Reynolds number  $Re_b = u_b h / \nu$ , where  $u_b$  is the bulk velocity and  $\nu$  the kinematic viscosity. Table 1 shows the simulated Reynolds number values.

## Numerical method

The data was obtained from direct numerical simulations of closed channel flow using a pseudo-spectral method which solves the wall-normal velocity/vorticity formulation of the Navier-Stokes equation introduced by Kim et al. [1].

- Euler implicit scheme for the viscous terms;
- three-step low-storage Runge-Kutta method for the non-linear terms;
- truncated Fourier series in streamwise and spanwise directions (2/3 de-aliasing), Chebyshev polynomials in the wall-normal direction on a Chebyshev-Gauss-Lobatto (CGL) grid;

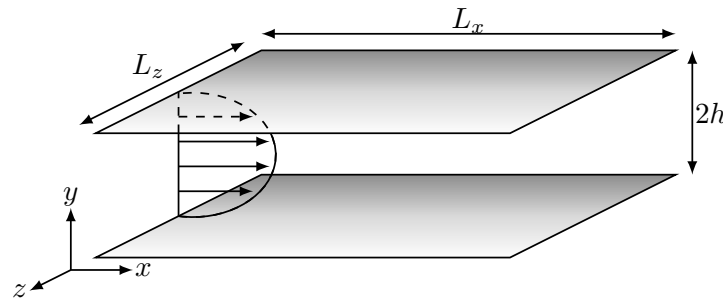


Figure 1: The geometry of the problem and the computational domain.

- no-slip and impermeability boundary conditions at the bottom wall the top wall, periodic boundary conditions in  $z$  direction;

## Numerical parameters

The data included in this repository is characterized by the following features:

- friction Reynolds numbers:  $200 \leq Re_\tau \leq 890$ .
- streamwise domain length:  $L_x = 12\pi h$ .
- spanwise domain length:  $4\pi h \leq L_z \leq 12\pi h$ .
- time step:  $CFL \leq 0.5$ ;
- streamwise grid spacing:  $\Delta x^+ \leq 15$ ;
- spanwise grid spacing:  $\Delta z^+ \leq 5.5$ ;
- maximum wall-normal grid-spacing:  $\max(\Delta y^+) \leq 7.3$ ;

case	$Re_\tau$	$Re_b$	$L_x/h$	$L_z/h$	$N_x$	$N_y$	$N_z$	$\Delta x^+$	$\Delta z^+$	$\Delta y_{min}^+$	$\Delta y_{max}^+$
C200	199.71	3170	$12\pi$	$4\pi$	768	129	512	9.8	4.9	0.06	4.90
C200W12	199.73	3170	$12\pi$	$12\pi$	768	129	1536	9.8	4.9	0.06	4.90
C400	396.96	6969	$12\pi$	$4\pi$	1536	193	1024	9.8	4.9	0.05	6.49
C600	593.14	11047	$12\pi$	$4\pi$	1536	257	1536	14.6	4.9	0.04	7.28
C900	889.15	17512	$12\pi$	$4\pi$	3072	385	2048	11.0	5.5	0.03	7.27
case	$\nu$		$u_\tau$		$u_b$		$t_{stat}u_b/h$				
C200	2.10287e-04		0.0419971		0.666667		8600				
C200W12	2.10287e-04		0.0420004		0.666667		3403				
C400	9.56608e-05		0.0379735		0.666667		3260				
C600	6.03501e-05		0.0357958		0.666667		1757				
C900	3.80692e-05		0.0338494		0.666667		1013				

Table 1: Simulation parameters: bulk Reynolds number  $Re_b$ , friction-velocity Reynolds number  $Re_\tau$ , number of streamwise and spanwise Fourier mode  $N_x$  and  $N_z$ , number of wall-normal Chebyshev polynomials  $N_y$ , streamwise and spanwise grid spacing in wall units  $\Delta x^+$  and  $\Delta z^+$ , minimum and maximum wall-normal grid spacing in wall units  $\Delta y_{min}^+$  and  $\Delta y_{max}^+$ , respectively, kinematic viscosity  $\nu$ , friction velocity  $u_\tau$ , bulk velocity  $u_b$ , statistics interval  $t_{stat}$  in bulk units.

## Available data

The folders are structured as follows. Each case folder contains statistical data in ASCII file format similar to the ones provided by <https://turbulence.oden.utexas.edu/>. Statistical quantities are obtained by averaging in time as well as in streamwise and spanwise direction. They are usually normalised in wall units, otherwise mentioned in the data file header.

### profiles: wall-normal profiles of one-point statistics

<i>case.means</i>	mean velocity profile
<i>case.reystress</i>	Reynolds stress profiles
<i>case.vort</i>	root-mean-square vorticity profiles
<i>case.tautot</i>	shear stress profiles
<i>case.velp</i>	velocity-pressure correlation profiles
<i>case.highorder</i>	velocity skewness and flatness profiles

**corr: 1D two-point correlations at different wall distances**

*case.xcorr.yplus* streamwise velocity correlations at  $y^+ = yplus$   
*case.zcorr.yplus* spanwise velocity correlations at  $y^+ = yplus$

**spectra: 1D velocity spectra at different wall distances**

*case.xspec.yplus* streamwise velocity spectra at  $y^+ = yplus$   
*case.zspec.yplus* spanwise velocity spectra at  $y^+ = yplus$

**corr2d: 2D two-point correlations at different wall distances**

*ruu\_reX\_ypY\_Zp.dat* positive streamwise velocity correlation iso-contours  
 at  $Re = X$ ,  $y^+ = Y$  in  $Z=b(ulk)/w(all)$  units  
*ruu\_reX\_ypY\_Zp.dat* negative streamwise velocity correlation iso-contours  
 at  $Re = X$ ,  $y^+ = Y$  in  $Z=b(ulk)/w(all)$  units

**Data format and location**

Data is presented in the form of ASCII files. Further information is given in the header of the corresponding file. The data is located below the following URLs:

[doi.org/10.4121/88678f02-2a34-4452-8534-6361fc34d06b](https://doi.org/10.4121/88678f02-2a34-4452-8534-6361fc34d06b)  
[https://www.iwu.kit.edu/nfm/dns\\_data/channel/smooth/open/](https://www.iwu.kit.edu/nfm/dns_data/channel/smooth/open/)

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**References**

- [1] John Kim, Parviz Moin, and Robert Moser. Turbulence statistics in fully developed channel flow at low Reynolds number. *Journal of Fluid Mechanics*, 177:133–166, 1987. [doi:10.1017/S0022112087000892](https://doi.org/10.1017/S0022112087000892).

**Links to other repositories**

Other DNS databases for closed channel flow can be found under

<https://torroja.dmt.upm.es/turbdata/>  
<https://turbulence.odn.utexas.edu/>  
<http://www.vremanresearch.nl/channel.html>  
<https://jaxa-dns-database.jaxa.jp/channelflow.html>  
<http://newton.dma.uniroma1.it/channel/>