Dataset description

Turbulent Ekman flow ($Re_D = 1300$, $Ri = 0$)

Direct numerical simulation – Set-up and vertical profiles

Cedrick Ansorge [1]*, Sally Issa *, Anika Horst **

* *Freie Universität Berlin, Institut für Meteorologie*

** *Universität zu Köln, Institut für Geophysik und Meteorologie*

March 22, 2024

1 Metadata

Collection This data set is part of the collection *Turbulent wall-bounded flow*[2].

The collection is freely available and hosted by Refubium, the institutional repository of Freie Universität Berlin.

DOI 10.17169/refubium-42508

HPC systems The data was generated under the project `HKU24` on the supercomputer `JUWELS` at John-von-Neumann Institute for Computing (NIC) at Forschungszentrum Jülich (Germany).

Code The data was generated by the tool-suite for turbulence simulation tLab[3]

Related Publications

10.1007/s10546-018-0386-y
10.1017/jfm.2018.693

2 The dataset

2.1 Contents

The dataset files, collectively named with grid information and the date of creation of the data on the High-Performance Computing (HPC) system. Each file of the collection contains time-series of a namelist files name dns.ini which is a plain text file holding the configuration of the tLab code (for documentation, please refer to Open-source code available under github.com/turbulencia/tlab).

[1] cedrick@posteo.de
[2] `refubium.fu-berlin.de/handle/fub188/42710`
[3] `github.com/turbulencia/tlab`

2.2 Physical case

This case of simulation conducted with a Reynolds number (Re) of 1300, corresponding to a friction Reynolds number Re_τ of 2122, delves into the study of the turbulent flow. Utilizing a computational grid measuring 2560 x 5120 x 640 collocation points with a spatial resolution of 8.9 $\times$ 4.5 $\times$ 0.99 wall units, the domain size is scaled to $L_x = L_y = 0.54\ \Lambda$, where Λ is the Rossby radius.

2.3 Variable information

The statistical data is available in self-documented netCDF format, and it contains a wide array of parameters, encompassing vertical profiles of velocity and scalar variables (temperature/buoyancy as active and for some cases also passive scalars), scalar and momentum budget terms, as well as statistical moments up to the fourth order of velocities, scalars, and derivatives. These parameters provide a comprehensive perspective on Ekman flow dynamics. They are organized into distinct groups. Within the subsequent table, you will find numerous variables grouped together, accompanied by their descriptions and associated equations.

Mean		
rR	density (RA)	$\overline{\rho}$
rU	u, x-component of the velocity (RA)	$\overline{u}$
rV	v, y-component of the velocity (RA)	$\overline{v}$
rW	w, z-component of the velocity (RA)	$\overline{w}$
rP	π dynamic, reduced pressure (RA)	$\overline{\pi}$
rT	T, caloric temperature (RA)	$\overline{T}$
re	e, internal energy (RA)	$\overline{e}$
rh	h, enthalpy (RA)	$\overline{e+(\Gamma_0-1)Ma^2\frac{p}{\rho}}$
rs	s, entropy (RA)	$\overline{s}$
rB	B, buoyancy (RA)	$\overline{B}$
fU	u, x-component of the velocity (FA)	$\langle u\rangle$
fV	v, y-component of the velocity (FA)	$\langle v\rangle$
fW	w, z-component of the velocity (FA)	$\langle w\rangle$
fT	T, caloric Temperature (FA)	$\langle T\rangle$
fe	e, internal energy (FA)	$\langle e\rangle$
fh	h, enthalpy (FA)	$\left\langle e+(\Gamma_0-1)Ma^2\frac{p}{\rho}\right\rangle$
fs	s, entropy (FA)	$\langle s\rangle$
Fluctuations		
Tke	Turbulence kinetic energy	$\overline{\frac{1}{2}u_i'u_i'}$
Rxx	Reynolds stress R_{11}	$\overline{u'u'}$
Ryy	Reynolds stress R_{22}	$\overline{v'v'}$
Rzz	Reynolds stress R_{33}	$\overline{w'w'}$
Rxy	Reynolds stress R_{12}	$\overline{u'v'}$
Rxz	Reynolds stress R_{13}	$\overline{u'w'}$
Ryz	Reynolds stress R_{23}	$\overline{v'w'}$
rP2	Pressure fluctuation (RA)	$\overline{\pi'\pi'}$
rR2	Density fluctuation (RA)	$\overline{\rho'\rho'}$
rT2	Temperature fluctuation (RA)	$\overline{T'T'}$
fT2	Temperature fluctuation (FA)	$\langle T'T'\rangle$
re2	internal energy fluctuation (RA)	$\overline{e'e'}$
fe2	internal energy fluctuation (FA)	$\langle e'e'\rangle$
rh2	enthalpy fluctuation (RA)	$\overline{h'h'}$
fh2	enthalpy fluctuation (FA)	$\langle h'h'\rangle$
rs2	Entropy fluctuation (RA)	$\overline{s's'}$
fs2	Entropy fluctuation (FA)	$\langle s's'\rangle$
DerivativeFluctuations		
U_y1		$\overline{\partial_y u}$
V_y1		$\overline{\partial_y v}$
W_y1		$\overline{\partial_y w}$
U_ii2		
U_x2		$\overline{(\partial_x u')^2}$
U_y2		$\overline{(\partial_y u')^2}$
U_z2		$\overline{(\partial_z u')^2}$
V_x2		$\overline{(\partial_x v')^2}$
V_y2		$\overline{(\partial_y v')^2}$
V_z2		$\overline{(\partial_z v')^2}$
W_x2		$\overline{(\partial_x w')^2}$
W_y2		$\overline{(\partial_y w')^2}$
W_z2		$\overline{(\partial_z w')^2}$
U_x3		$\overline{(\partial_x u')^3}$
U_y3		$\overline{(\partial_y u')^3}$
U_z3		$\overline{(\partial_z u')^3}$
V_x3		$\overline{(\partial_x v')^3}$
V_y3		$\overline{(\partial_y v')^3}$
V_z3		$\overline{(\partial_z v')^3}$
W_x3		$\overline{(\partial_x w')^3}$
W_y3		$\overline{(\partial_y w')^3}$
W_z3		$\overline{(\partial_z w')^3}$
U_x4		$\overline{(\partial_x u')^4}$
U_y4		$\overline{(\partial_y u')^4}$
U_z4		$\overline{(\partial_z u')^4}$
V_x4		$\overline{(\partial_x v')^4}$
V_y4		$\overline{(\partial_y v')^4}$
V_z4		$\overline{(\partial_z v')^4}$
W_x4		$\overline{(\partial_z w')^4}$
W_y4		$\overline{(\partial_z w')^4}$
W_z4		$\overline{(\partial_z w')^4}$
VarDilatation	Variance of Dilatation	$\overline{(\partial_{x_i}u_i-\partial_y\overline{v})^2}$
VarUx		$\overline{(\partial_x u')^2}$
VarUy		$\overline{(\partial_y u')^2}$
VarUz		$\overline{(\partial_z u')^2}$
VarVx		$\overline{(\partial_x v')^2}$
VarVy		$\overline{(\partial_y v')^2}$
VarVz		$\overline{(\partial_z v')^2}$
VarWx		$\overline{(\partial_x w')^2}$
VarWy		$\overline{(\partial_y w')^2}$
VarWz		$\overline{(\partial_z w')^2}$
SkewUx		
SkewUy		
SkewUz		
SkewVx		
SkewVy		
SkewVz		
SkewWx		
SkewWy		
SkewWz		
FlatUx		
FlatUy		
FlatUz		
FlatVx		
FlatVy		
FlatVz		
FlatWx		
FlatWy		
FlatWz		
Vorticity		
Wx	Vorticity (x-component)	$\overline{\partial_z v-\partial_y w}$
Wy	Vorticity (y-component)	$\overline{\partial_x w-\partial_z u}$
Wz	Vorticity (z-component)	$\overline{\partial_y u-\partial_x v}$
Wx2	Fluctuation of x-Vorticity	$\overline{\partial_z v'-\partial_y w'}$
Wy2	Fluctuation of y-Vorticity	$\overline{\partial_x w'-\partial_z x'}$
Wz2	Fluctuation of z-Vorticity	$\overline{\partial_y u'-\partial_x v'}$
RxxBudget		
Rxx_t	Time-rate of change of R_{11}	$\overline{\partial_t R_{11}}$
Bxx	buoyancy production	$2b_x\overline{u'B'}$
Cxx	advection in y-direction	$-\overline{v}\ \partial_y\overline{u'u'}$
Pxx	shear-production	$-2\ \overline{u'v'}\ \partial_y\overline{u}$
Exx	viscous dissipation	
Fxx	Coriolis production	$2f_y\overline{u'w'}$
Txxy_y	divergence of T_{112} turbulent transport	$\partial_y R_{112}$
Txxy	vertical transport T_{112}	$\overline{u'u'v'}-2\nu\overline{\partial_y(u-\langle u\rangle)}$
Gxx	pressure variable-density term	0
Dxx	viscous variable-density term	
RyyBudget		
Ryy_t	Time-rate of change of R_{22}	$\overline{\partial_t R_{22}}$
Byy	buoyancy production of Ryy	$2b_y\overline{v'B'}$
Cyy	advection in y-direction	$\overline{v}\ \partial_y\overline{v'v'}$
Pyy	shear production	$-2\overline{v'v'}\partial_y\overline{v}$
Eyy	viscous dissipation	
PIyy	pressure–velocity correlation Π_{22}	$2\overline{v'p'}$
Fyy	Coriolis production	0
Tyyy_y	divergence of T_{222} turbulent transport	$\partial_y R_{222}$
Tyyy	vertical transport T_{222}	$\overline{v'v'v'}+2\overline{v'p'}-2\nu\overline{(\partial_y v)(v-\langle v\rangle)}$
Gyy	pressure variable-density term	$2(\overline{v}-\langle v\rangle)\partial_y\overline{p}$
Dyy	viscous variable-density term	
RzzBudget		
Rzz_t	Time-rate of change of R_{33}	$\overline{\partial_t R_{33}}$
Bzz	buoyancy production	$2b_z\overline{w'B'}$
Czz	advection in y-direction	$-\overline{v}\ \partial_y\ \overline{w'w'}$
Pzz	shear production	$-2\overline{v'w'}\partial_y\ \overline{w}$
Ezz	viscous dissipation	
PIzz	pressure–velocity correlation Π_{33}	$2\overline{w'p'}$
Fzz	Coriolis production of Rzz	$-2f_y\overline{u'w'}$
Tzzy_y	divergence of T_{332} turbulent transport	$\partial_y R_{332}$
Tzzy	vertical transport T_{332}	$\overline{w'w'v'}-2\nu\overline{(\partial_y w)(w-\langle w\rangle)}$
Gzz	pressure variable-density term	0
Dzz	viscous variable-density term	
RxyBudget		
Rxy_t	Time-rate of change of R_{12}	$\overline{\partial_t R_{12}}$
Bxy	buoyancy production	$b_x\overline{u'B'}+b_y\overline{v'B'}$
Cxy	advection in y-direction	$-\overline{v}\partial_y\overline{u'v'}$
Pxy	shear production	$-\overline{u'v'}\partial_y\overline{v}-\overline{v'v'}\ \partial_y\overline{u}$
Exy	viscous dissipation	
PIxy	pressure-velocity correlation Π_{12}	$\overline{p'\,(\partial_y u-\partial_x v)}$
Fxy	Coriolis production of Rxy	$f_y\overline{v'w'}$
Txyy_y	divergence of T_{122} turbulent transport	$\partial_y R_{122}$
Txyy	vertical transport T_{122}	$\overline{u'v'v'}+\overline{u'p'}$
Gxy	pressure variable-density term	$(\overline{u}-\langle u\rangle)\partial_y\overline{p}$
Dxy	viscous variable-density term	
RxzBudget		
Rxz_t	Time-rate of change of R_{13}	$\overline{\partial_t R_{13}}$
Bxz	buoyancy production	$b_x\overline{u'B'}+b_z\overline{w'B'}$
Cxz	advection in y-direction	$-\overline{v}\ \partial_y\overline{u'w'}$
Pxz	shear production	$-\overline{u'w'}\ \partial_y\ \overline{w}-\overline{v'w'}\ \partial_y\overline{u}$
Exz	viscous dissipation	
PIxz	pressure–velocity correlation Π_{13}	$\overline{p'\,(\partial_z u-\partial_x w)}$
Fxz	Coriolis production	$f_y(\overline{w'w'}-\overline{u'u'})$
Txzy_y	divergence of T_{132} turbulent transport	$\partial_y R_{132}$
Txzy	vertical transport T_{132}	$\overline{u'w'v'}$
Gxz	pressure variable-density term	0
Dxz	viscous variable-density term	
RyzBudget		
Ryz_t	Time-rate of change of R_{23}	$\overline{\partial_t R_{23}}$
Byz	buoyancy production	$b_y\overline{v'B'}+b_z\overline{w'B'}$
Cyz	advection in y-direction	$-\overline{v}\partial_y\overline{v'w'}$
Pyz	shear production	$-\overline{v'v'}\ \partial_y\ \overline{w}-\overline{v'w'}\ \partial_y\overline{v}$
Eyz	viscous dissipation	
PIyz	pressure–velocity correlation Π_{23}	$\overline{p'\,(\partial_z v-\partial_y w)}$
Fyz	Coriolis production	$-f_y\overline{u'v'}$
Tyzy_y	turbulent transport divergence	$\partial_y R_{232}$
Tyzy	vertical transport T_{232}	$\overline{v'w'v'}+\overline{w'p'}$
Gyz	pressure variable-density term	$(\overline{w}-\langle w\rangle)\partial_y\overline{p}$
Dyz	viscous variable-density term	
TkeBudget		
Tke	Turbulence kinetic energy	$\frac{1}{2}R_{ii}$
Buo	buoyancy production of TKE	$\frac{1}{2}B_{ii}$
Con	advection in y-direction	$\frac{1}{2}C_{ii}$
Prd	shear production	$\frac{1}{2}P_{ii}$
Eps	dissipation	$\frac{1}{2}E_{ii}$
Pi	pressure–velocity correlation	$\frac{1}{2}\Pi_{ii}$
Trp	sum of transport terms	$\frac{1}{2}T_{ii2}$
Trp1	transport due to triple correlation terms	$\overline{u_i'u_i'v'}$
Trp2	transport by pressure–velocity correlation	$2\overline{v'p'}$
Trp3	viscous transport	$-2\nu\overline{(\partial_y u_i)(u_i-\langle u_i\rangle)}$
Trp1_y	divergence of triple correlations	$\partial_y\overline{u_i'u_i'v'}$
Trp2_y	divergence of pressure–velocity correltion	$2\partial_y\overline{v'p'}$
Trp3_y	divergence of viscous transport	$-2\nu\partial_y\overline{(\partial_y u_i)(u_i-\langle u_i\rangle)}$
G	pressure variable-density term	$\frac{1}{2}G_{ii}$
D	viscous variable-density term	$\frac{1}{2}D_{ii}$
Phi	Mean viscous dissipation rate	
UgradP		$\overline{u_i\partial_{x_i}p}$
HigherOrder		
rU3		
rU4		
rV3		
rV4		
rW3		
rW4		
Acoustics		
gamma		
C2		
Rho_ac		
Rho_en		
T_ac		
T_en		
M_t		
rRP		
rRT		
RhoBudget		
RhoFluxX		
RhoFluxY		
RhoFluxZ		
RhoDil1		
RhoDil2		
RhoTrp		
RhoProd		
RhoConv		$-\overline{v}\partial_y\overline{\rho'\rho'}$
Stratification		
Pot	potential energy	
rRref	background density profile	
rTref	background temperature profile	
BuoyFreq_fr	buoyancy frequency	
BuoyFreq_eq	buoyancy frequency	
LapseRate_fr	lapse rate	
LapseRate_eq	lapse rate	
PotTemp		
PotTemp_v		
SaturationPressure		
rPref	background pressure profile	
RelativeHumidity		
Dewpoint	dewpoint temperature	
LapseRate_dew		
Source		
rSb		
PotTemp_fr		
PotTemp_eq		
rP0		
rPmod		
Ri_f		
Ri_g		
Scales		
Eta	Kolmogorov Scale	
LambdaUx	Taylor micro-scale in x-direction	
LambdaVy	Taylor micro-scale in y-direction	
LambdaWz	Taylor micro-scale in z-direction	
ReLambdaUx	Taylor-Reynolds number in x-direction	
ReLambdaVy	Taylor-Reynolds number in y-direction	
ReLambdaWz	Taylor-Reynolds number in z-direction	
ReLambdaIso	Taylor-Reynolds number	
TurbDiffusivities		
EddyDiff	turbulent eddy diffusivity (for scalar)	
EddyVisc	turbulent eddy viscosity (for momentum)	
TurbPrandtl	turbulent Prandtl number	
ShearThicknesses		
Delta_m		
Delta_m_p		
Delta_w		
MixingThicknesses		
Delta_hb01		
Delta_ht01		
Delta_h01		
Delta_hb25		
Delta_ht25		
Delta_h25		
FrictionTerms		
FrictionVelocity	magnitude of surface shear stress	$u_\star$
FrictionThickness	height-scale related to surface friction	$u_\star/f$
FrictionAngle	angle α of negative surface shear stress with the x-axis	