Square Channel "DNS" Rtau=300

Unsteady laminar flow in a square channel with a grid too coarse to be DNS. The example is similar (same Rtau) but not identical, to the square channel example in paper AIAA-2014-2780, "Using Multi-Dimensional Linear Discretization Over Unsteady Convection Adapted Control Volumes", by Joan G. Moore and John Moore.

The calculations are set up in 6 runs using 3 grids, a coarse grid (grid a, 14x27x27), a grid with refined near wall grid spacings (grid b, 14x35x35), then a grid with refined dx spacing (grid c, 26x35x35). The first run starts from uniform flow; fewer iterations per timestep and a weaker tolerance on continuity errors allows for 'turbulence' to develop from numerical errors. The following runs, 2-6, give more time-accurate results. Each run is started from the results of the previous run.

Unix instructions to run the example

Bring up a terminal window and cd to chansq.DNS.Rtau300.example then

```
mkdir out
../../a.m4d < in.grida0.run1.2steptest > out/print      2 timestep test of input
../../a.m4d < in.grida0.run1 > out/print                the complete run1 calculation
mv out out.grida0.run1

mkdir out
../../a.m4d < in.grida250.run2 > out/print
mv out out.grida250.run2

mkdir out
../../a.m4d < in.gridb300.run3 > out/print
mv out out.gridb300.run3

mkdir out
../../a.m4d < in.gridc350.run4 > out/print
mv out out.gridc350.run4

mkdir out
../../a.m4d < in.gridc375.run5 > out/print
mv out out.gridc375.run5
```

```
mkdir out
../../a.m4d < in.gridc400.run6 > out/print
mv out out.gridc400.run6
```

Input/Output

The primary input files, in.g…..run1-6, use other input files for specific tasks.

inn.grida.01c.1dx.46x6cyz

inn.gridb.006c.1dx.46x6

inn.gridc.006c.1dx.24x6 - grid setup files for grids a, b, and c. Set up the grid from the master geometry, geom.cartesian, set up for block pressure solution, then calculate other geometric arrays.

Input/Output files common to all runs

inn.init - initial the velocity (uniform), density, pressure, ITER (timestep count), and TIME. Set dpdx and the laminar viscosity from parameters D, Rd, Rtau. Note: runs 2-6 override the initial velocity by reading the results from the previous run.

inn.step.dns - take 1 time step. Uses:

inn.subiter.dns - one iteration over the timestep for velocity and pressure. Uses: inn.cont for extra continuity sub-iterations to improve the velocity.

Note: inn.step.dns, inn.subiter.dns and inn.cont all add convergence info to out/converge.

inn.unsteadytime - add to accumulated sums for determining time averages.

inn.dump - dump current results to file out/u#ITER, unsteady sums to out/unsteady. Uses:

inn.unsteadytimeave.sq to calculate time averages, then dumps time average results to out/unsteadyave and out/unsteadyaveocta.

inn.plot - Make plots using:

inn.plotU - U1 contours U2 U3 vectors at x=0 and x~xmid, out/U0x#ITER.gif, out/Umidx#ITER.gif.

inn.plotUxa - x/oct ave at current time. Gives out/Uxoct#ITER.gif.

inn.plotUave - time/x ave then oct ave of that. Gives out/Uave#ITER.gif, out/Uaveoct#ITER.gif.

inn.plotconv - convergence plot U2 Rd drho/dt versus time. Gives out/conv.gif.
The primary input file dumps to out/varinit the results in a form which can be interp. to a different grid.

Restart Files

in.grida250.run2 uses out.grida0.run1/u500 read with command arrayread (same grid)
in.gridb300.run3 uses out.grida250.run2/varinit read with command varinit (different grid)
in.gridc350.run4 uses out.gridb300.run3/varinit read with command varinit (different grid)
in.gridc375.run5 uses out.gridc350.run4/u200 read with command arrayread (same grid)
in.gridc400.run6 uses out.gridc375.run5/u200 read with command arrayread (same grid)

Summary of runs and their differences

			parameters							At end of run	C.P.U (jgm)	overall Rd
run	start_from	grid	dy_n.w.	dx	dt	SUBITERS	ITCONT	drhodtlim	timesteps	t start-end		min max
1	uniform	a	0.01	0.46	0.5	5	5	0.3	500	0-250	37 min	4121 4777
2	run1	a	0.01	0.46	0.25	7	10	0.03	200	250-300	24 min	4690 4956
3	run2	b	0.006	0.46	0.25	7	10	0.03	200	300-350	51 min	4949 5112
4	run3	c	0.006	0.24	0.125	7	10	0.03	200	350-375	94 min	5112 5207
5	run4	c	0.006	0.24	0.125	7	10	0.03	200	375-400	96 min	5207 5254
6	run5	c	0.006	0.24	0.125	7	10	0.03	200	400-425	90 min	5232 5251

Total 6.5 hrs

Compare results with those obtained by jgm. Note turbulence is chaos.

Very small changes in starting conditions, or roundoff simply from a different compilation of the code, can result in different instantaneous results. However, the average results should be similar over long periods of time.

Post-processing of output by jgm

Reduce out/print files to cover only up to the start of the calculation, then the final c: end.
Delete restart files of form out/u200 but keep the ones of form out/varinit which can be used to restart on the same or a different grid.
Delete unsteady results files out/unsteady, out/unsteadyave and out/unsteadyaveoct.
Also delete some plot files.
Move all results directories into out.jgm.