

CFD Assignment 2

AEM-ADV19

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1

Run a first simulation with $Re = 200$ (line 646 of the 2D_compressible.f90 file) and $n_x \times n_y = 129 \times 129$ for $n_t = 10000$ time steps with a second order Adams-Bashforth scheme (itemp=1) and a CFL equal to 0.25. Generate 4 visualisations of the vorticity field for $n_t = 2500, 5000, 7500, 10000$. Briefly comment on the results in less than 100 words. (Note : The code should be configured for this question, no changes are needed).

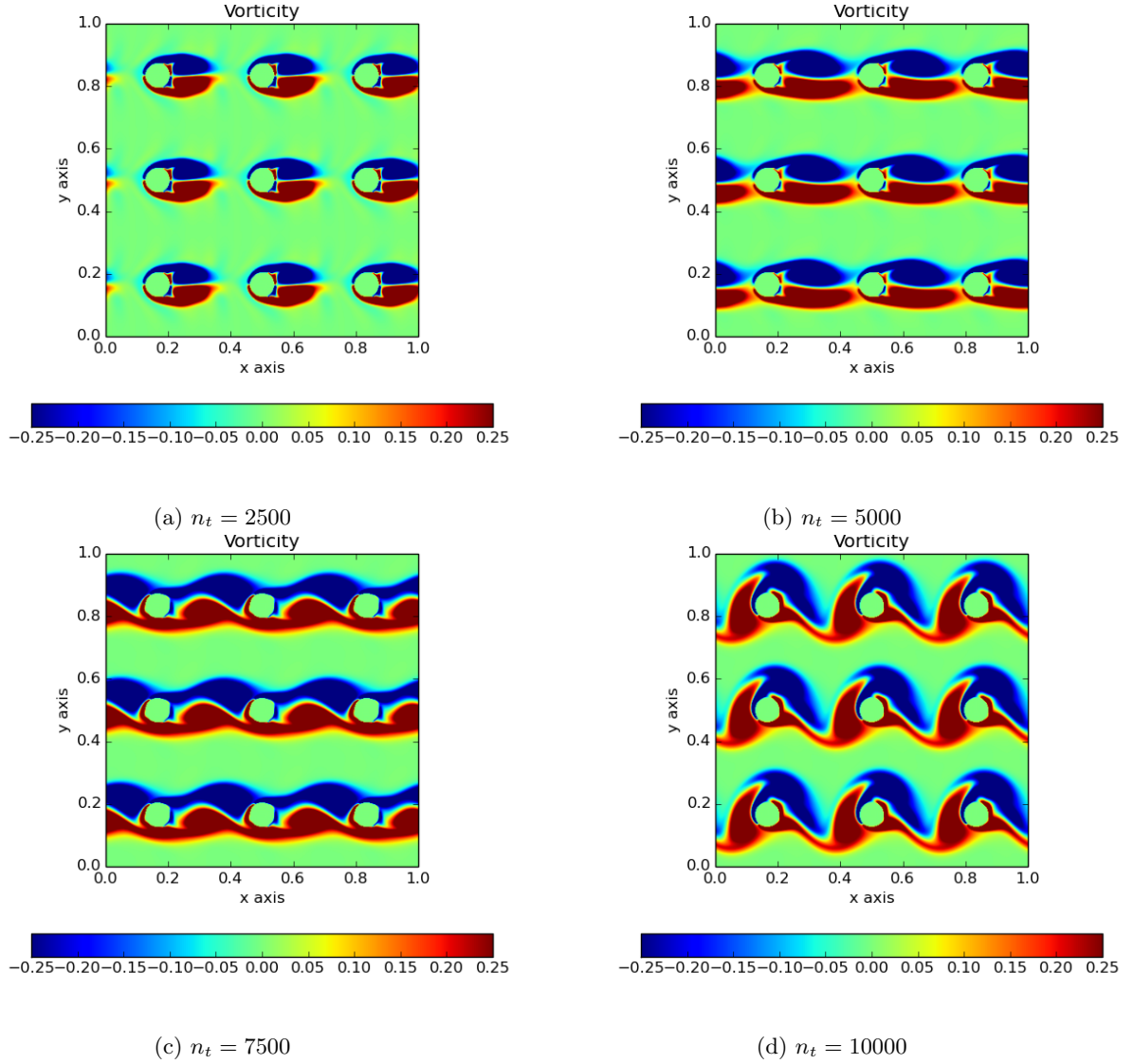


Figure 1: A figure with two subfigures

2

We want to increase the CFL number in order to reduce the cost of the simulation. Using the same second order Adams-Bashforth scheme (`itemp=1`), is it possible to run a simulation with a CFL of 0.75? If yes, generate 4 visualisations of the vorticity field for $n_t = 2500, 5000, 7500, 10000$ and briefly comment on the results in less than 100 words. If not, try to explain why in less than 100 words.

It is not possible to run the simulations with a CFL of 0.75.

3

Complete the subroutine `rkutta` in which a third-order Runge-Kutta scheme will be used for the time advancement (use the skeleton provided in the code). The scheme is described in section 4.3. Run a simulation with the same parameters as in the first simulation but with a $CFL = 0.75$ and the newly implemented third-order Runge-Kutta scheme (`itemp = 2`, line 38 of the `2D_compressible.f90` file)). Generate 4 visualisations of the vorticity field for $n_t = 2500, 5000, 7500, 10000$. Briefly comment on the results in less than 100 words and copy-paste the subroutine `rkutta` in your report.

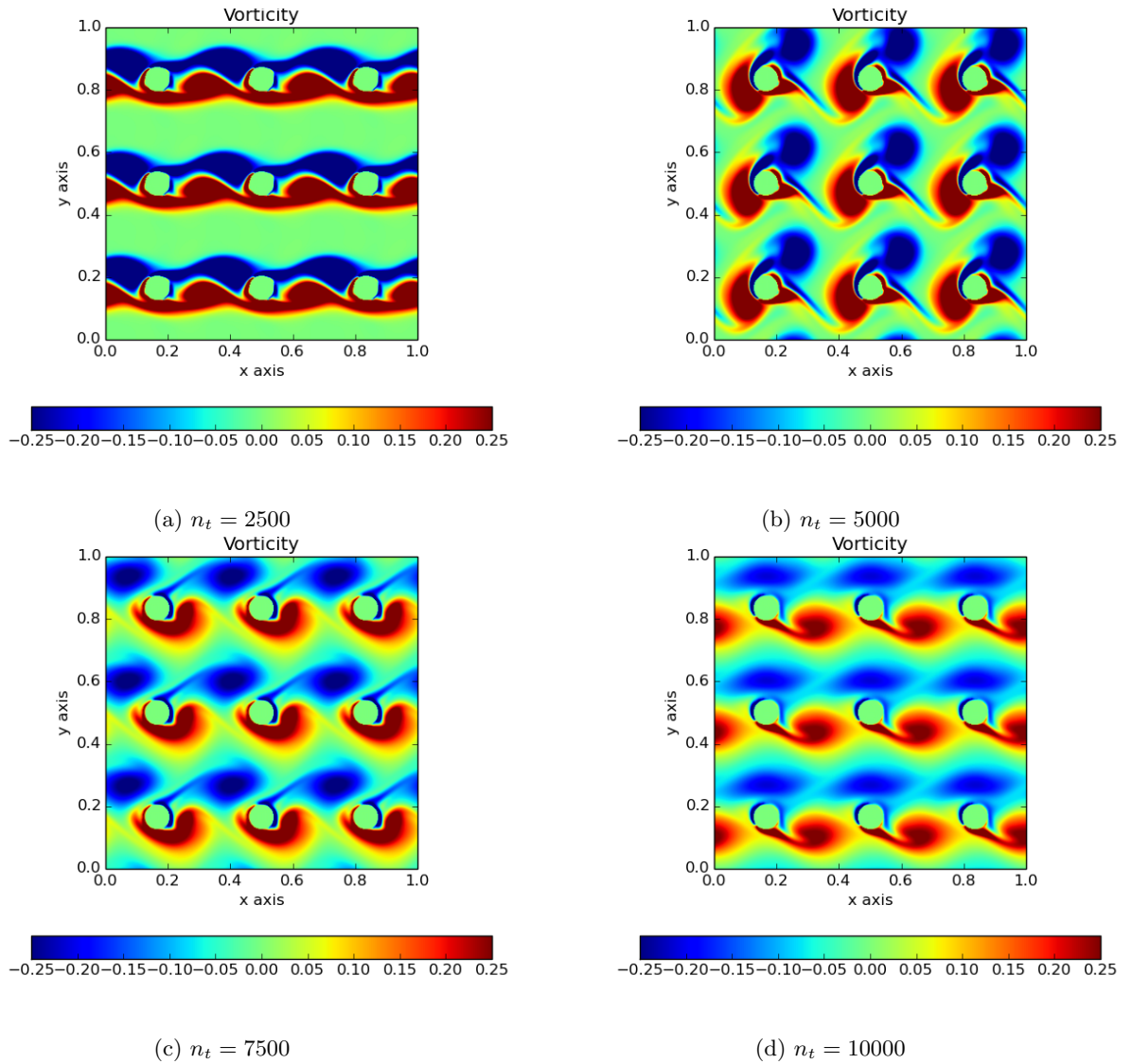


Figure 2: A figure with two subfigures

4

Instead of circular cylinders, run a simulation using the same parameters as in the first simulation (second order Adams-Bashforth scheme, $itemp=1$, $CFL = 0.25$) but with square cylinders. The subroutine `initl` needs to be modified, in particular for the array `eps`. For example, you can define `imin,imax,jmin,jmax` where `(imin,jmin)` is the bottom left corner of the square, `(imin,jmax)` the bottom right corner, `(imax,jmin)` the top left corner and `(imax,jmax)` the top right corner. The length of the square will be equal to the diameter `d` of the circular cylinder. Generate 4 visualisations of the vorticity field for $nt = 2500, 5000, 7500, 10000$. Copy-paste the new 2D loop for the square cylinder in your report and briefly comment on the results in less than 50 words.

5

We want to use centered fourth-order schemes for the first and second derivatives in the two spatial directions. Write four new subroutines, using the skeletons provided in the code: `derix4`, `deriy4`, `derxx4` and `deryy4`. In the subroutine `fluxx`, replace the second-order first and second derivatives with the new fourth-order ones. Then run a simulation with same parameters as the first simulation (question 1) but with the new the fourth-order schemes. Generate 4 visualisations of the vorticity field for $nt = 2500, 5000, 7500, 10000$. Briefly comment on the results and discuss the differences (if any) with the first simulation (question 1) in less than 100 words. Copy-paste the four new subroutines in your report.

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What will happen to the flow if you run the simulation in question 1 for a very long time? Justify your answer in less than 100 words.