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Research data supporting
"Experimental properties of continuously-forced, shear-driven, stratified turbulence"

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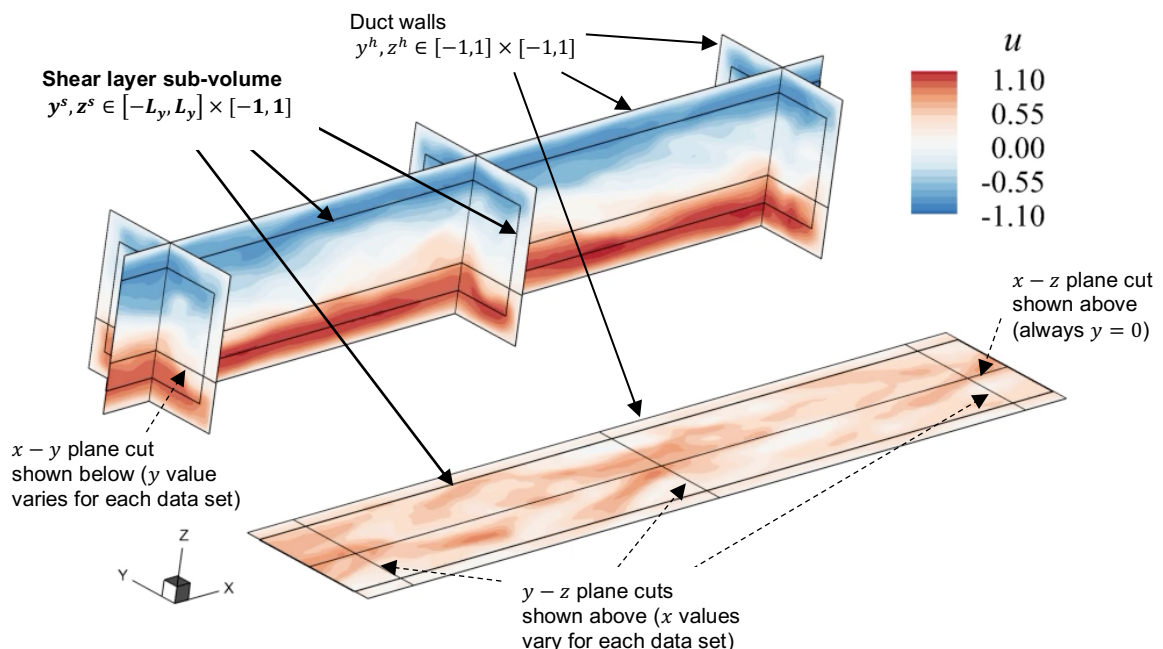
0. Data sets

We provide all the **16 shear-layer rescaled and cropped data sets** (as explained in Part 1, §3.5) used throughout Part 1 and Part 2: **L1_SL.mat, H1_SL.mat, H2_SL.mat, ..., T3_SL.mat**. They are given in Matlab format and contain the variables u, v, w, r (4-D single-precision arrays) the axes x, y, z, t (1-D arrays), as well as most of the experimental parameters found in Part 1, table 1 and table 3. Arrays containing these parameters for all data sets are also given in `all_shear_layer_properties.mat`.

1. Movies

We provide a single .zip archive containing movies showing, for all 16 data sets:

- **A collage of 3D plots of all five key flow variables u, v, w, ρ, ω^2 .** (**L1.m4v, H1.m4v, H2.m4v, ..., T3.m4v**). Those 16 MP4 movies are at 3300x1400 pixel resolution and display 5 frames per second (fps), although they had to be exported at a misleading 12 fps (1 frame corresponding to a volume scanning time of Δt advective time units). For more details about these data sets, refer to Part 1, tables 1 and 3. We used the same shear-layer non-dimensionalisation introduced in Part 1 §3.3 and used throughout the two parts. However, in addition to showing the shear-layer sub-volume used throughout the two-part paper, *we also show for completeness the near-wall data (from the "shear layer" to the solid duct walls) that we excluded from our analyses*. This allows the reader to appreciate what part of the flow we focussed on and what part of the flow we discarded. The boundary of the shear-layer sub-volume extracted from each data set (as explained in Part 1, §3.5 and figure 1e) is shown by black lines on each movie sub-panels, as sketched below. We also highlight the location of the various plane cuts below.



We only show the time series after the small initial barotropic (net) flow oscillations between the two reservoirs have decayed sufficiently (as explained in Part 1, §3.5). This means that some data sets have relatively short time series (for parameters, see Part 1, table 3) compared to the original data sets of Lefauve, Partridge & Linden (2019a,b).

- **Individual 3D panels of u, v, w, ρ, ω^2** (`L1_u.mp4`, `L1_v.mp4`, `L1_w.mp4`, `L1_rho.mp4`, `L1_enstr.mp4`, and so on for H1, H2, ..., T3) i.e. a total of $5 \times 16 = 80$ MP4 movies at $\sim 1000 \times 1000$ pixel resolution and 5 fps. These were created by the software Tecplot 360, using automation with the python scripting interface (PyTecplot). We are very grateful to our colleague Dr Xianyang Jiang for developing this type of visualisation and helping us produce these movies.
- **Simple 2D gifs of u, v, w, ρ** (`L1.gif`, `H1.gif`, `H2.gif`, ..., `T3.gif`) created with only a few lines of code on Matlab directly from the above data sets. These only show the shear layer data and only show the plane cut $y = 0$ (although the code is easily modifiable to show any plane cut).

2. Codes

We provide all Matlab codes used to generate and manipulate the above data, and to produce all figures. These files are provided “as is”; they have not been specifically commented or tidied up for general re-use and are only shared to the reader interested in reproducing some of our results or applying similar post-processing. These codes may require some small amount of tidying up (e.g. all directory paths must be changed and adapted to your machine).

- `Analyse_SL_Data.m` This important code loops through and loads the 16 .mat data sets downloaded from the repository Lefauve, Partridge & Linden (2019b): `L1.mat`, `H1.mat`, `H2.mat`, ..., `T3.mat` and feeds them to the subroutine below.
 - `getShearLayerProp.m` This important subroutine takes each data set, computes averages (see sketch in Part 1, figure 1), produces the “shear-layer rescaled and cropped” data sets and non-dimensional parameters used in Part 1 and Part 2, and saves them. This creates the data sets shared above. Easy!

The main routine also saves the shear layer properties which were shared in the file `all_shear_layer_properties.mat` above.

- `makeGifs.m` requires the user to load a data set in the workspace (e.g. `H1_SL.mat`) and then allows to generate the simple gifs shared (see top of this page).
- `ColorMaps.m` is often called in other codes to load basic colourmaps that have nice properties. I use `viridis`, `rdbu` and `magma`. It uses subroutines from the folder `colormaps`.
- The folder `altmany-export_fig-5f4c67c` has subroutines to export publication quality figures, including .eps). Just have this folder in the path where you run Matlab, and then to export any figure visible on the screen (“what you see is what you get”), type in the command window “`export_fig figure.eps`” or “`export_fig -r500 figure.tiff`” (can also use `.jpg` `.png` ... where the `-r` flag is the resolution desired in dpi). This folder was downloaded on matlab.com.

Below we also share the raw codes used to generate the figures in the papers

!!! These codes have not been checked since last use, they contain old fragments not used for the figures, and may need some substantial editing to work properly !!! However most codes should run fairly smoothly with minimal editing.

Part 1:

- **Figure 2** (mean parameters) and **Figure 8** (turbulent fractions fits)

`plotOutputParams.m`

`colourByRegime.m` and `colourByState.m` are subroutines for the marker styles only, both are very similar but are used in different functions. The names are a bit misleading!

`findBestFit.m` and `multiVariateRegressionToFindBestFit.m` are also used for the fits of figure 8.

- **Figure 3** (mean flows)

`plotMeanFlows.m`

- **Figure 4** (Reynolds averages)

`plotReynoldsAverages.m`

- **Figure 5** (Richardson numbers)

`plotRichardsonNumbers.m`

`shade.m` is a subroutine used to make the grey shading

- **Figure 6** (Turbulent fractions statistics)

`plotTurbulentFraction.m`

`myCurl.m` is a subroutine used to calculate vorticity

- **Figure 7** (Turbulent fractions snapshots)

`movieTurbulentFraction.m` makes movies of enstrophy and density and their fractions, from which snapshots were then extracted.

Part 2:

- **Figure 1** (energy reservoirs), **Figure 2** (energy fluxes) and **Figure 3** (profiles in y, z, t)

`analyseSLenergetics.m` is a kind of main file looping through all 16 data sets and executing a few subroutines. It then produces figures 1 and 2 (after calling the subroutines below).

`getSLTurbEnergetics.m` is the most important subroutine; it computes the kinetic and scalar energy reservoirs, various averages, as well as the fluxes introduced in Part 2. The output is then fed into `plotSLTurbEnergetics.m` (see immediately below).

`plotSLTurbEnergetics.m` is a subroutine that takes the output from `getSLTurbEnergetics.m` to produce the y,z,t profiles of figure 3.

- **Figure 4** (x spectra) and **Figure 5** (x y z t spectra)

`spectraSL_forall_Duran2017.m` computes the mean and perturbation (turbulent) signals and plots all the spectra.

`computeEnergySpectralDensity.m` is the key subroutine that actually computes the spectra following the procedures in Part 2 Appendix A. This required testing to ensure energies are conserved etc (testing codes not included here).

- **Figure 6** (Lumley triangles), **Figure 7** (anisotropy tensor structure) and **Figure 8** (anisotropy of velocity gradients)

`analyseSLanisotropy.m` is a main file looping through all 16 data sets and calling `getSLanisotropy`. This main file produces the top part of figure 6.

`getSLanisotropy.m` is a subroutine that outputs the mean xi and eta for the top part of figure 6, while producing the individual plots for the bottom part of figure 6. It also produces the plots of figure 7.

`getSLDissipationAnisotropy.m` is a subroutine that computes the data required for figure 8 and outputs them in the main for plotting.

- **Figure 9** (lengthscales)

`lengthscale_hierachy.m`

- **Figures 10-12** (parameterisations)

`analyse_SL_parameterisation.m` is a main looping through all 16 data sets. It calls a subroutine below which gives the mean values of eddy diffusivities, mixing lengths, mixing coefficients etc. These mean values are then plotted as shown in the right column of figures 10, 11, and the bottom row of figure 12.

`plotSLParameterisations.m` is the subroutine analysing each data set separately and plotting the clouds of data points and their respective fits as shown in figures 10-12.

Some of these plots require energetics data generated by the code used in figures 1-3. These data should have been saved somewhere and must then be simply re-loaded to help producing figures 10-12.

3. Figures

We provide *all* the raw .fig Matlab figures that were used in Part 1 and Part 2, as well as the Part 1 fig1.eps (setup).

All matlab figures were exported to .eps or .tiff using the “`export_fig`” command (see above), after being correctly sized and fitted on a large monitor.

References

LEFAUVE, A., PARTRIDGE, J.L. & LINDEN, P.F. 2019a Regime transitions and energetics of sustained stratified shear flows. *J. Fluid Mech.* 875, 657–698.

LEFAUVE, A., PARTRIDGE, J.L. & LINDEN, P.F. 2019b Research data supporting “Regime transitions and energetics of sustained stratified shear flows” [Dataset]. doi.org/10.17863/CAM.41410.