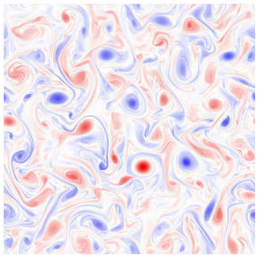
Data-driven Subgrid-scale Models for 2D forced Turbulence

Data

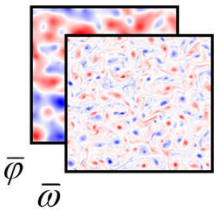
ω, kf=10, NX=1024



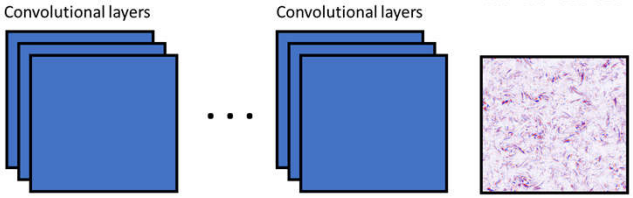
2D forced turbulence flow is solved using a pseudo-spectral method. Re=20,000.

Filtering

$$\bar{U}(x) = \int_{-\infty}^{\infty} G(r)U(x-r)dr$$

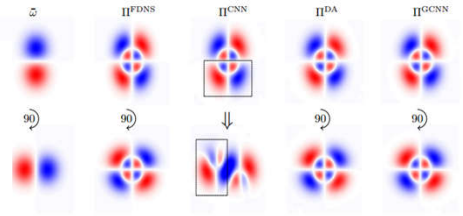


CNN

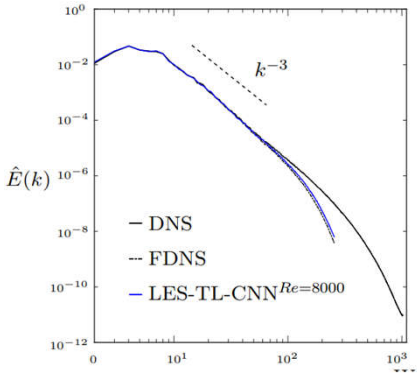


Closure term: $\Pi = J(\bar{\varphi},\bar{\varpi}) - \overline{J(\varphi,\omega)}$

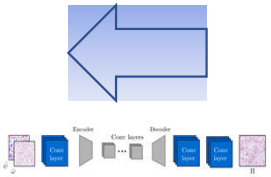
Illustration of translational and rotational equivariance



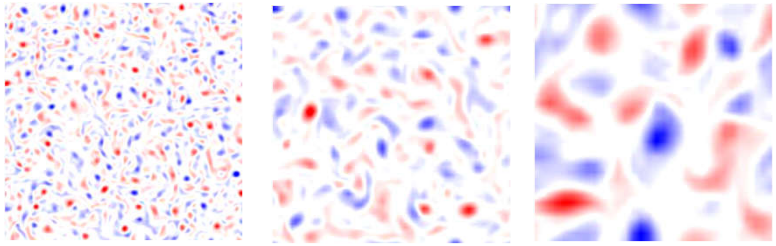
A posteriori analysis (GCNN)

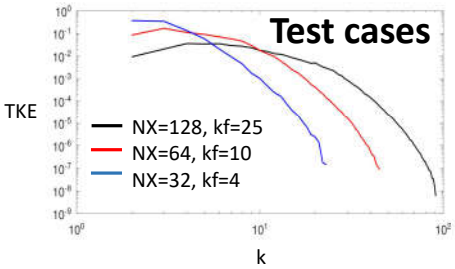


Transfer learning



kf=25, NX=128 | kf=10, NX=64 | kf=4, NX=32





[1] Guan, Yifei, Ashesh Chattopadhyay, Adam Subel, and Pedram Hassanzadeh. "Stable a posteriori LES of 2D turbulence using convolutional neural networks: Backscattering analysis and generalization to higher Re via transfer learning." *arXiv preprint arXiv:2102.11400* (2021)

[2] Subel, Adam, Ashesh Chattopadhyay, Yifei Guan, and Pedram Hassanzadeh. "Data-driven subgrid-scale modeling of forced Burgers turbulence using deep learning with generalization to higher Reynolds numbers via transfer learning." Physics of Fluids 33, no. 3 (2021): 031702.