Progress Log: Jan 14 2025

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1 Summary

- Fixed turbine wake calculation bug in `WInc3D`
- Reran single-fidelity and manual-alternation multi-fidelity campaigns (2.1)
- LES boundary condition bug fixes, power output throughout LES is now far more stable (2.2)
- Significant internal software development. On the horizon:
  - Adaptive selection of GCH/LES using BoTorch's `qMultiFidelityKnowledgeGradient` (which uses a cost-aware utility function)
  - Simulations with varying inflowing wind *direction*. Changing wind speed is more difficult.
  - Adaptively selecting the *duration* of a large-eddy simulation.

2 Results

2.1 New BO Campaigns

The LES-only campaign (Figure 1) finds a slightly better configuration (14.9MW) whereas the multi-fidelity campaign's optimum is 14.6MW (Figure 2). However, the multi-fidelity run is able to find a near-optimal value of 14.5 MW within 15 LES evaluations (3 batches), whereas the single-fidelity campaign requires over 50 LES evaluations (10 batches) before finding a configuration that produces more than 14MW.

It appears that the GCH evaluations are lower on average, meaning the GCH approximation *underestimates* power production.

I'm curious to reproduce these results for a more challenging problem with more turbines, where the lack of samples may hurt the LES-only run even more.

The following figures show the instantaneous and mean (over 2 simulated hours) velocity for the best layouts found by the single fidelity (Figure 3) and multi-fidelity campaigns (Figure 4).

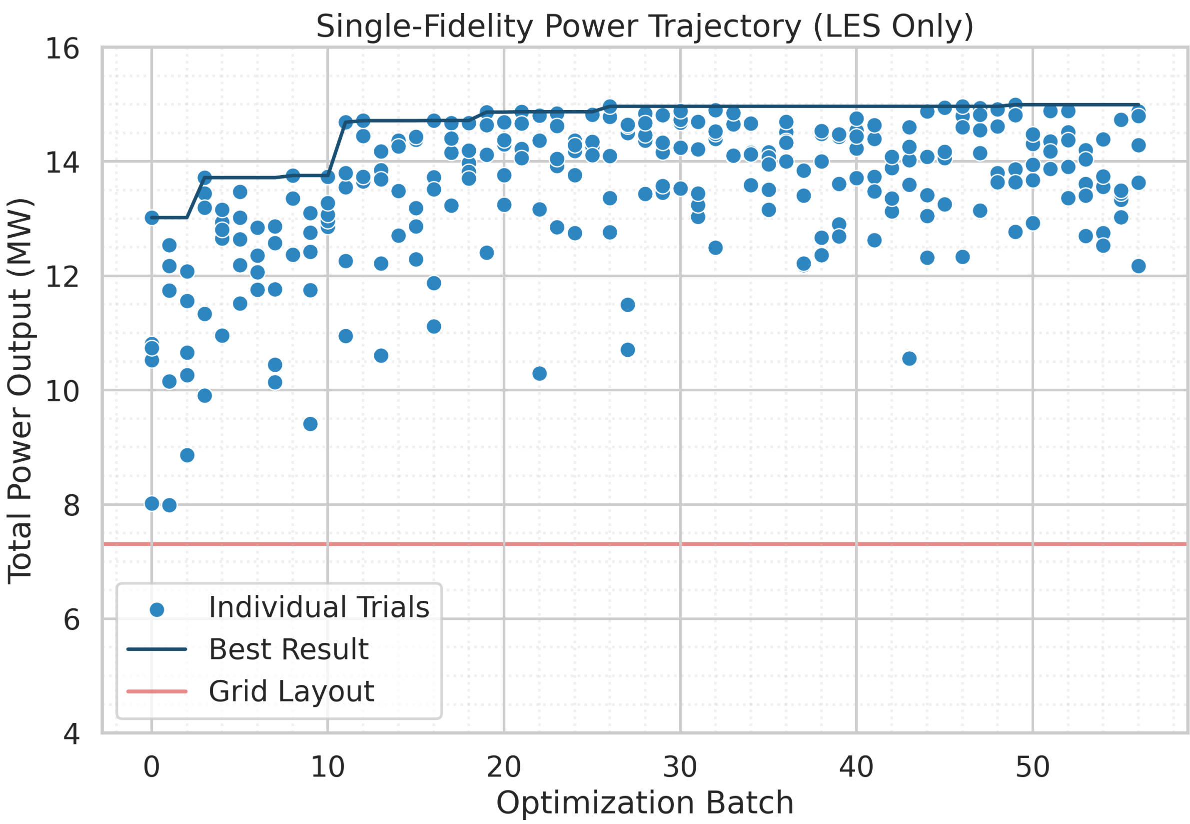

Figure 1: LES-only Campaign Power Trajectory. Each batch is 5 LES trials.

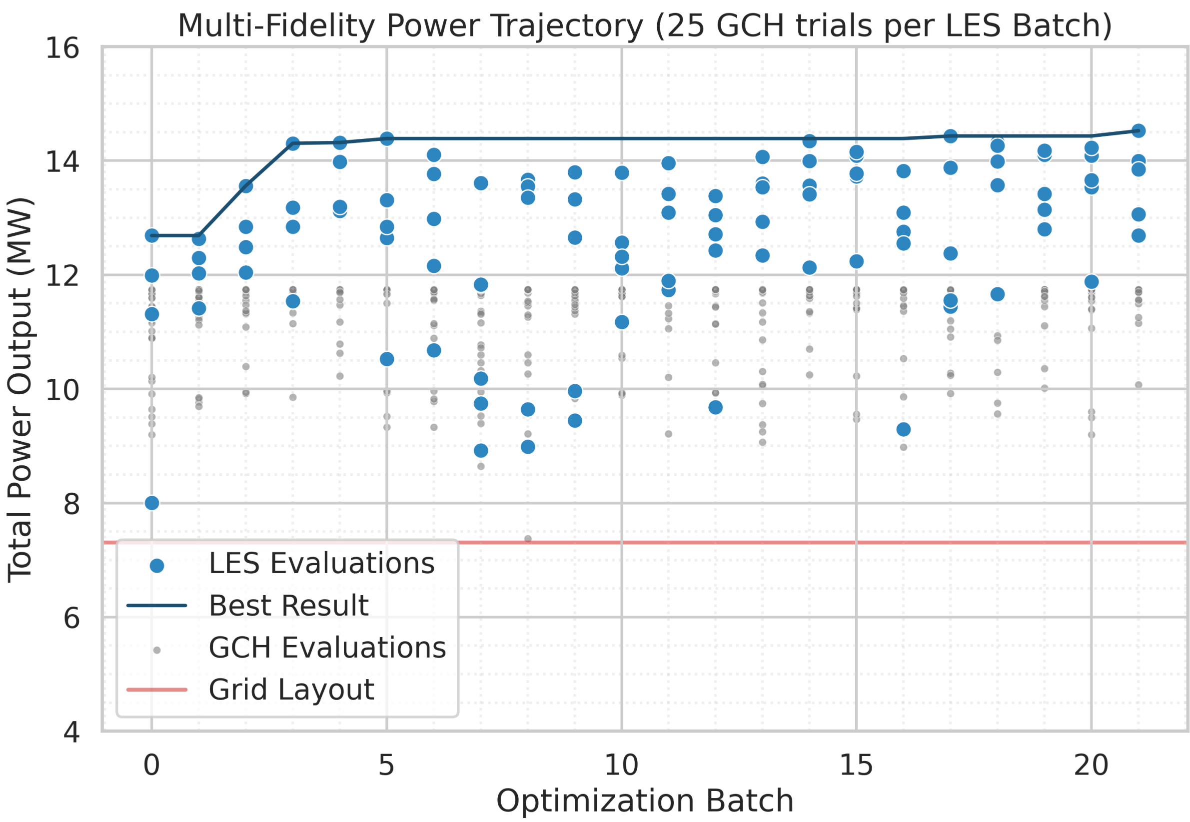

Figure 2: Multi-fidelity power trajectory. Each "optimization batch" represents 5 GCH batches of 5 trials each, and one LES batch of 5 trials. GCH evaluations are in grey, and LES evaluations are in blue.

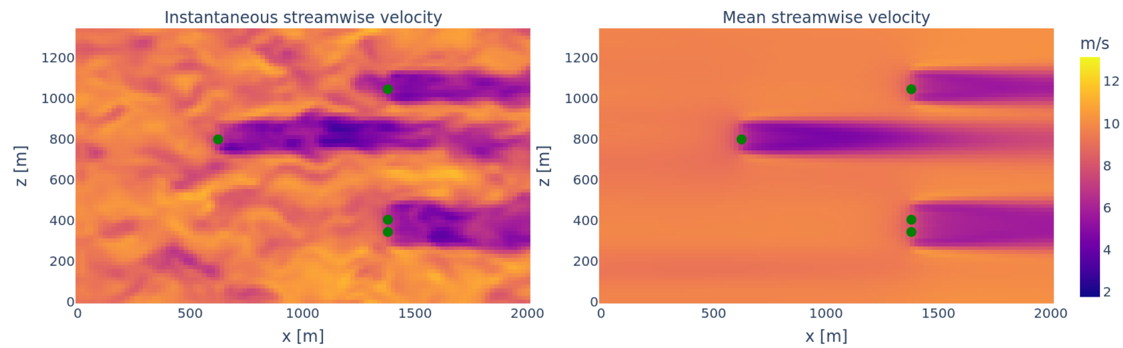

Figure 3: Best configuration found by the LES-only campaign. Instantaneous snapshot of the velocity flow at 1hr of simulated time past spinup, mean flow averaged over a 2hr period.

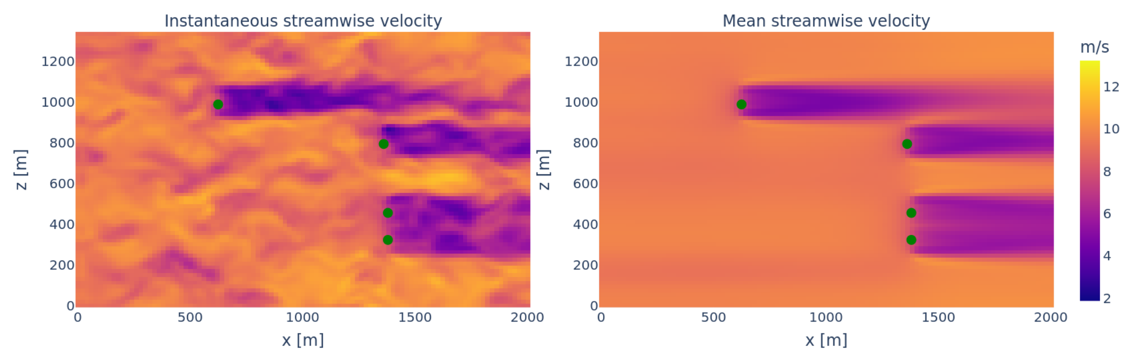

Figure 4: Best configuration found by the multi-fidelity campaign. Instantaneous snapshot of the velocity flow at 1hr of simulated time past spinup, mean flow averaged over a 2hr period.

2.2 Fixed BCs

Before, a periodic boundary condition was used in the streamwise direction, artificially adding more turbulence than should occur. I fixed this, and find that it stabilizes power production throughout the duration of a large-eddy simulation.

Figure 5 shows the instantaneous and time-averaged power production of simulations with two different layouts. Figure 6 shows the same layouts, under the OLD simulation with incorrect boundary conditions. Compare the left-hand plots in Figure 6 to those in 5 (both use precursor simulations).

This increased stability suggests to me that we can dramatically reduce the duration for which we run a simulation with limited loss in accuracy of the time-averaged power output.

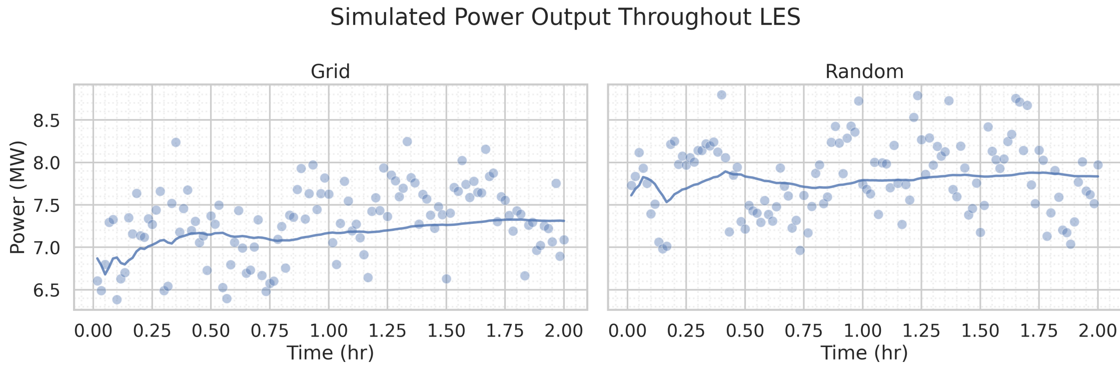

Figure 5: Power convergence throughout a large-eddy simulation, for a grid layout and a randomly generated turbine layout.

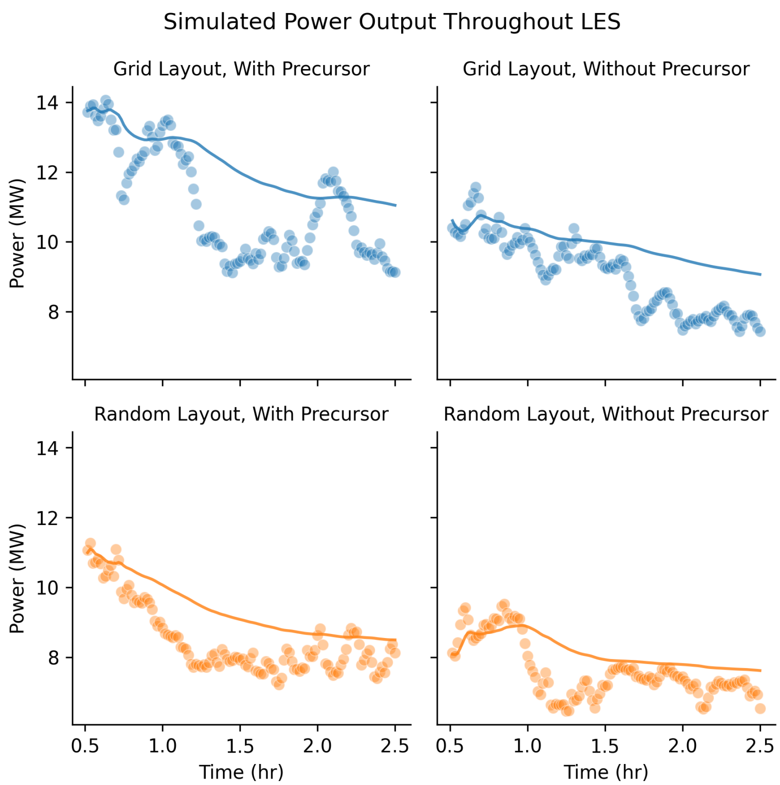

Figure 6: Old power convergence, with INCORRECT boundary conditions, with the same layouts.