Sandia National Laboratories
Wind Energy Technologies Department

Comparison of a mid-fidelity free vortex wake method to a high-fidelity actuator line model large eddy simulation for wind turbine wake simulations
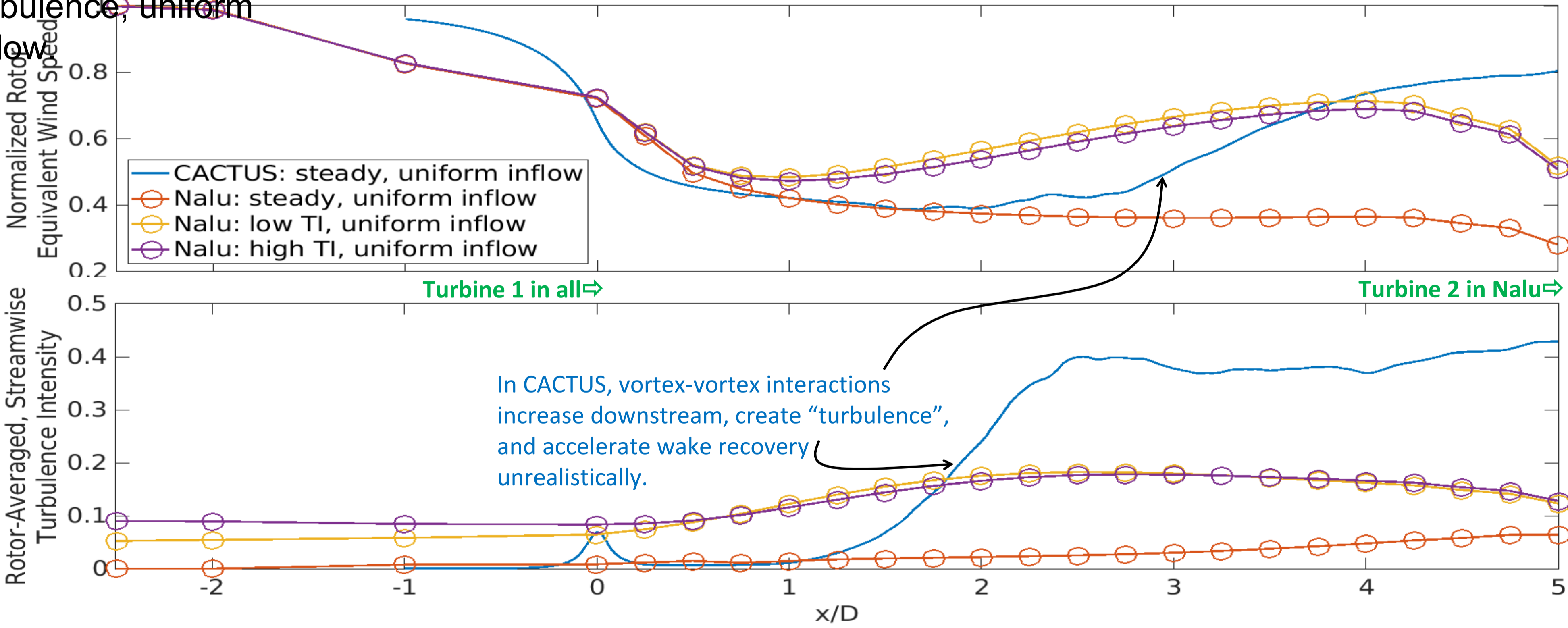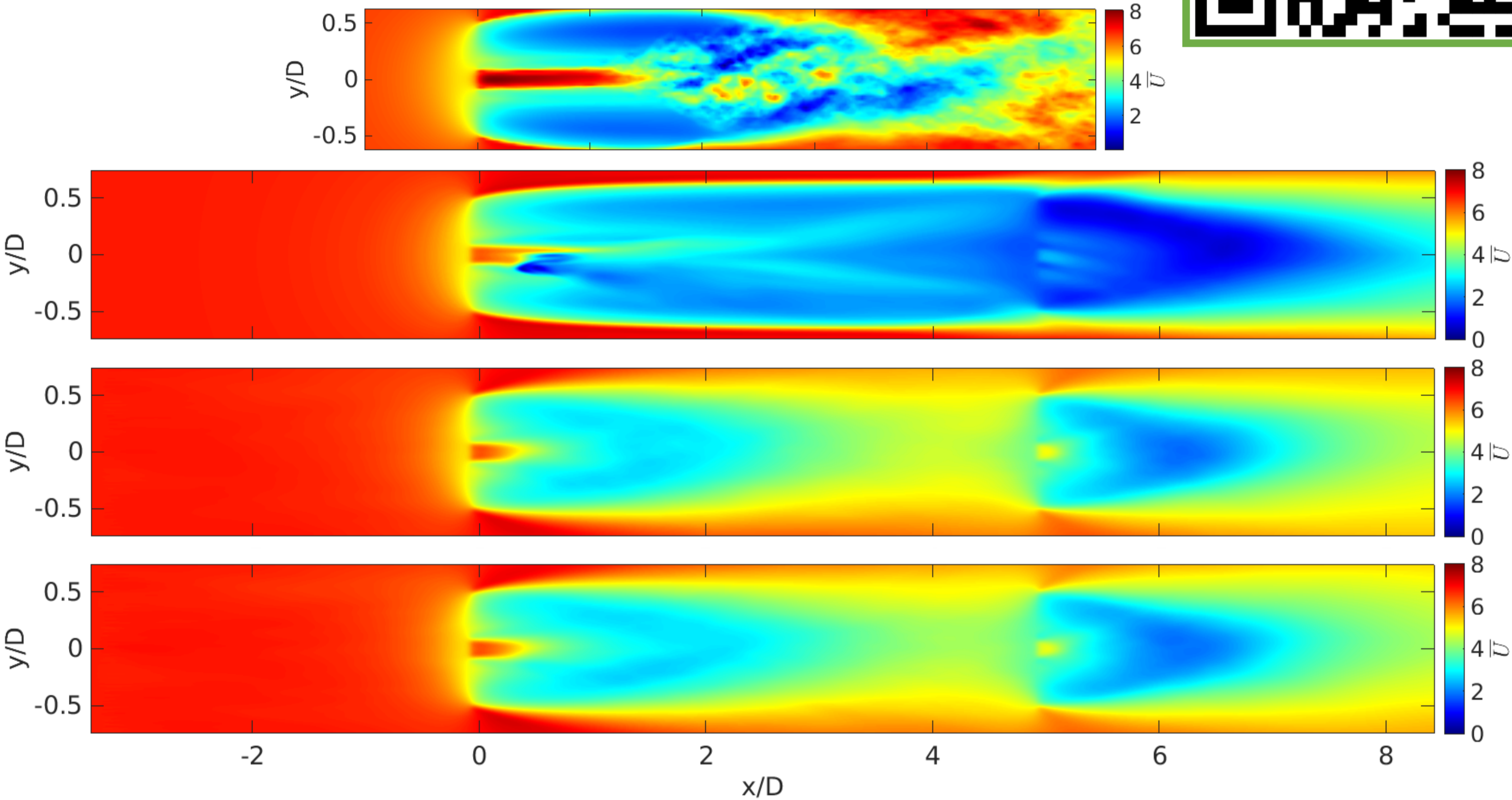
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CACTUS, a mid-fidelity FVWM:	Nalu-Wind, a high-fidelity ALM LES:
Faster, especially if multi-threaded	Slower, but parallelized
Easy to save full 3D flow field	Difficult to save full 3D flow field
Only steady, uniform inflows	Inflows with shear, veer, and turbulence
Vorticity equation, assumes potential flow	Navier-Stokes with pressure projection
Loses accuracy with wake length/age	Accurate throughout domain
Only one turbine	Multiple turbines

Read the paper!

All: Hub height horizontal contour of the time-averaged streamwise velocity. Full domains shown.

Top to bottom: CACTUS with a steady, uniform inflow. Nalu with a steady, uniform inflow. Nalu with a low turbulence, uniform inflow. Nalu with a high turbulence, uniform inflow.

Turbine 1 in all ⇨   Turbine 2 in Nalu ⇨

- CACTUS: steady, uniform inflow
- Nalu: steady, uniform inflow
- Nalu: low TI, uniform inflow
- Nalu: high TI, uniform inflow

In CACTUS, vortex-vortex interactions increase downstream, create "turbulence", and accelerate wake recovery unrealistically.

QoI	CACTUS	Nalu-Wind
Rotor performance	✓ only steady, uniform inflows	✓ all inflows
Near-wake (<1D)	✓	✓
Far-wake	✗	✓
Vortex dynamics	✓ in near-wake	✓ if resolved

Turb. 1 Coeff.	CACTUS	Nalu, steady	Nalu, low TI	Nalu, high TI
C_P	0.505	0.466	0.471	0.481
C_T	0.935	1.000	0.996	1.003

Use **caution** when interpreting far-wake results from CACTUS.