

Beyond Küssner Theory: Understanding Nonlinear Gusts

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the problem

Do computations predict the actual physics of gusts?

- Effect of gust on the airfoil
- Effect of airfoil on the gust
- Transverse and in-plane gusts

Modeling an "ideal" gust versus a "real" gust

- Moving airfoil versus airfoil through a jet (gust)

previous approaches

Inclusion of source terms to make Navier-Stokes equations consistent with the addition of transverse gust terms

- Reduction of gust strength (airfoil effect on gust)
- Behavior of shed vorticity more physically consistent with theory
- Modeling of linear Küssner function matches theory well

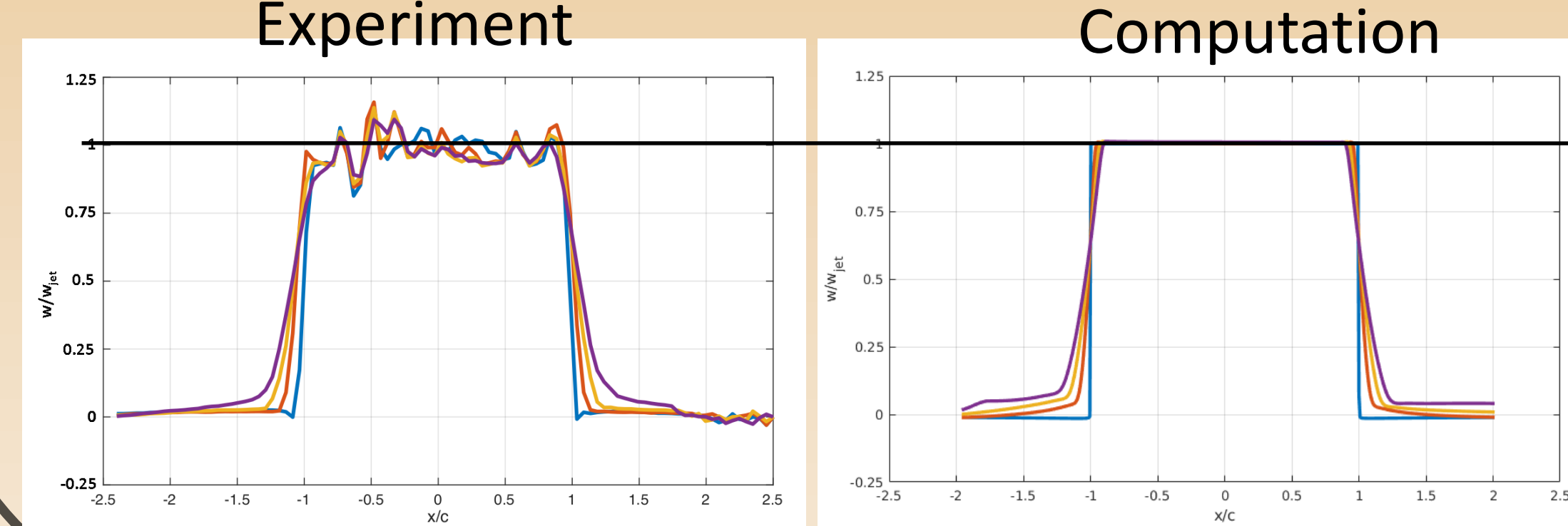
Surge (inplane gust) predictions

- Comparison with AFRL experiments (Granlund et al.) for linear and nonlinear angles of attack (6, 20 degrees)
- Poorer correlation than transverse gusts
- Correlation worsens with increasing free stream speed
- Earlier separation with sources
- Water tunnel not modeled

the approach:

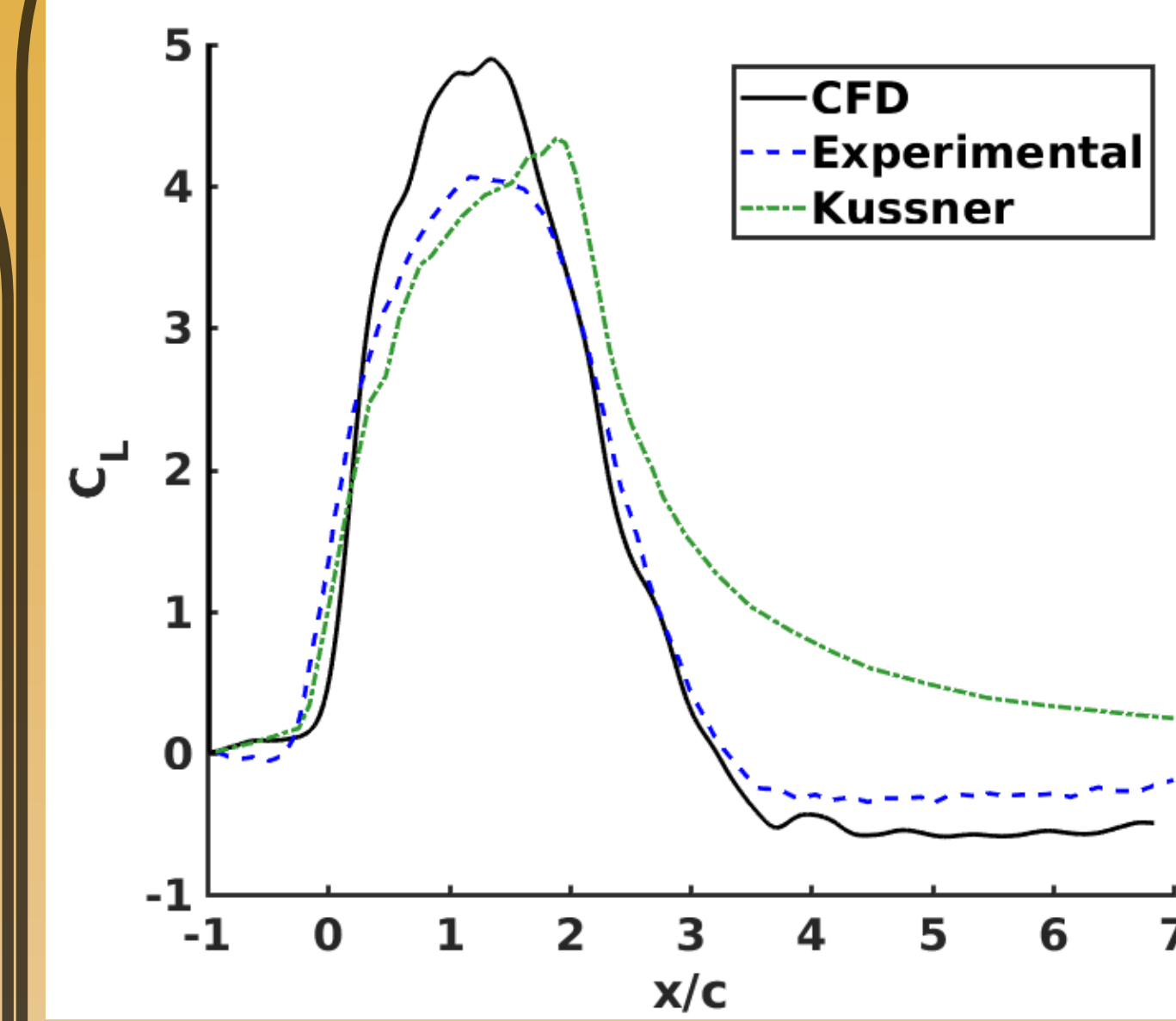
Model gust via Jet Inflow

- Experimental conditions: flat plate moving through a two chord wide jet inflow with a gust ratio of 1 and a chord Reynolds number of 5000 (Corkery and Babinsky, U Cambridge)
- Match these conditions in a simulation using overset grids
- Background grid: Cartesian grid with jet BC on a portion of $-z$ boundary
- Near body Plate Grids: series of mutually overset grids which follow prescribed plate motion
- Jet initialized in a steady run, no free-stream velocity
- Plate is perfectly flat with no thickness.

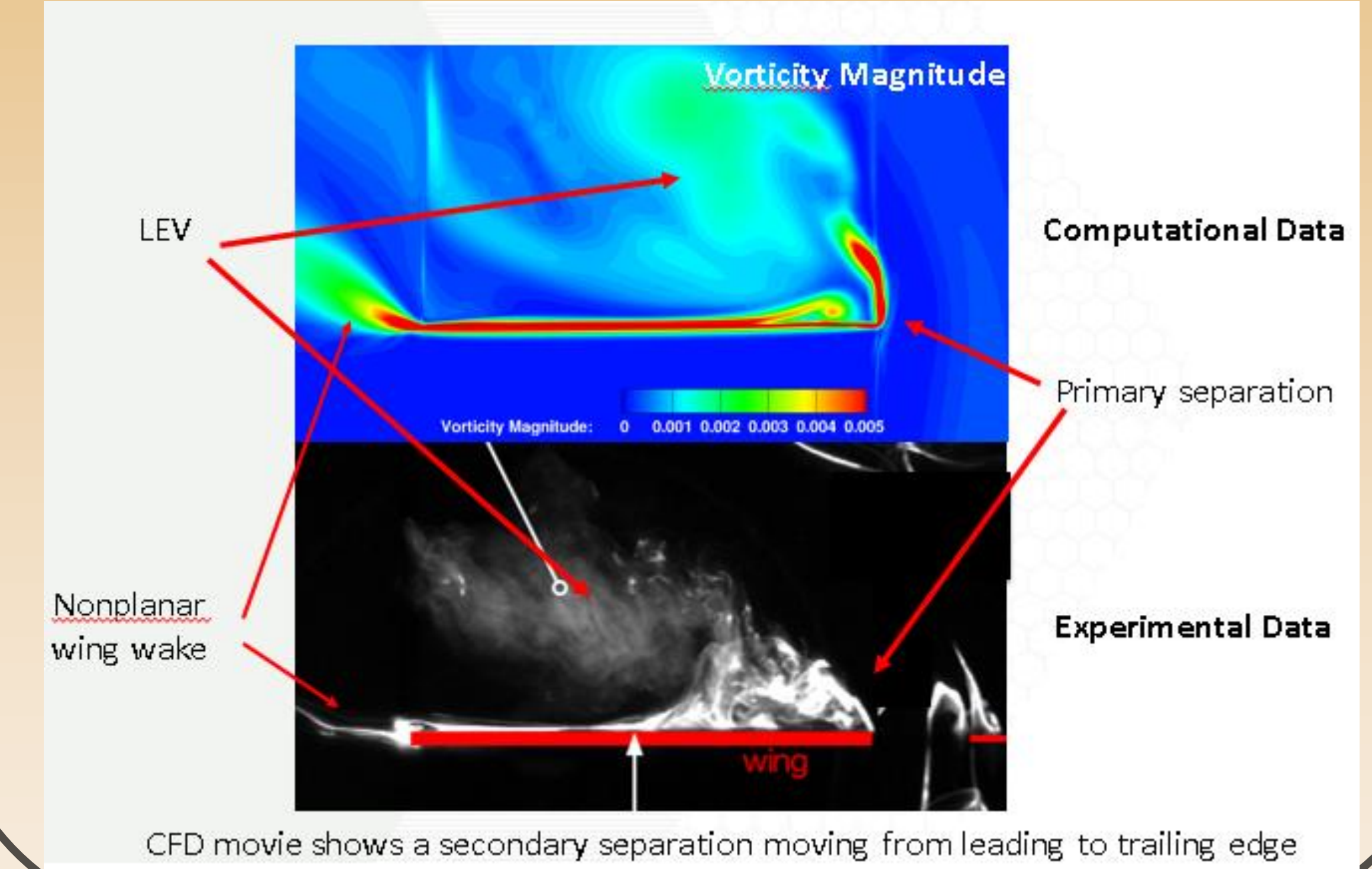
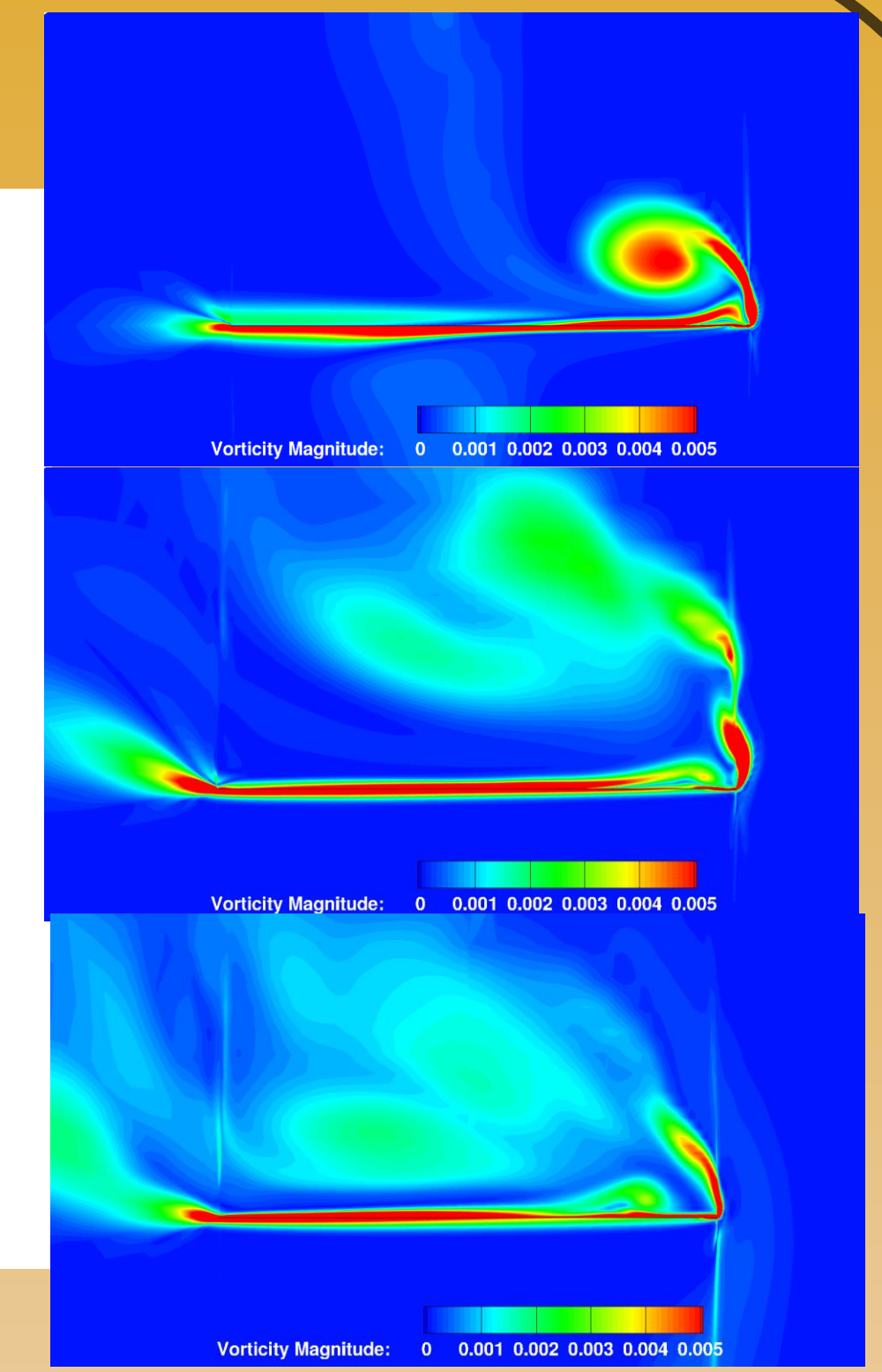


Jet profile comparison at various z-locations

the results



Video: imgur.com/XijNw0v



the grids

Near Body Grids: 12 overset points around the edges of the plate for each grid

Background Grids: Viscous walls on +/- y planes, outflow on all other boundaries except for region of jet inflow on $-z$ boundary

