Non-dimensional velocity magnitude

Direct numerical simulation of the flow past a leading edge inflatable tube wing
Direct Numerical Simulations of Flow Past a Leading-Edge Inflatable Wing

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Leading-edge inflatable wings, such as used in the TU Delft’s kite power prototype, are commonly used to harness wind energy at high altitudes. The wing is composed of a thin canopy, with an inflated tube at the leading edge and pressurized struts to support the membrane. Although the kite power concept has demonstrated its efficiency in harnessing wind energy, the detailed aerodynamics of the wing is still unclear. It is particularly interesting to understand the interactions between flow vortices and the membrane wing, and their impact on the system performance.

In this work, a fully nonlinear Navier-Stokes solver \cite{1} is used to compute the flow past a leading-edge kite power wing. At this stage, relatively low Reynolds numbers ($Re \approx 5000$) are considered in order to be able to perform direct numerical simulations. The code is first validated on a well-benchmarked NACA0012 profile at similar Reynolds numbers. It is then applied to the TU Delft kite power wing. For the latter, dynamic mesh adaptivity \cite{2} is used to resolve the shear layers developing near the kite boundary and in the wake. It is observed that the vortices shed at the leading-edge impact on the canopy, hence potentially generating strong fluid-structure interactions when the wing is made of deformable fabric materials. This result is expected to hold at higher Reynolds numbers, although this will be further investigated through large-eddy simulations.

![Two-dimensional view of the velocity contours of flow past a three-dimensional kite wing at $Re = 5000$.](image)

References:
