Numerical investigation of the flow around a cyclist subjected to crosswinds

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Introduction

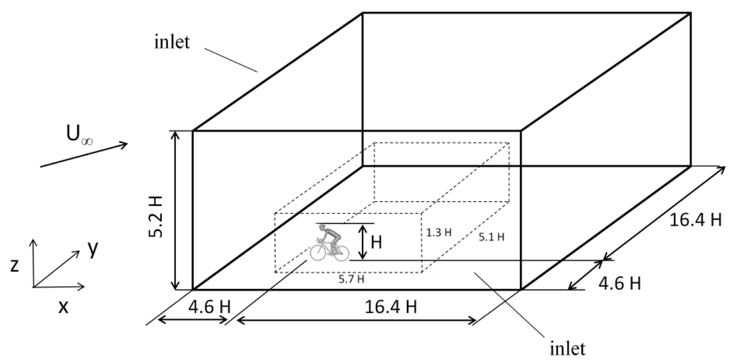
Crosswinds can have an impact on the performance, stability and safety of cyclists, e.g., ~5% of all single bicycle accidents are caused by crosswinds (Schepers & Wolt, 2012). Despite several fatalities, relatively little work has been undertaken investigating the effect of crosswinds.

Aims

The aim of this study was to investigate the flow structures around a cyclist and the corresponding aerodynamic responses in crosswinds.

Methods

- RANS (k-ε, k-ω) models, DES and LES simulations.
- Reynolds number of 1.0×10^6
- Crosswind angles, β: 0,15,30,60°,90°



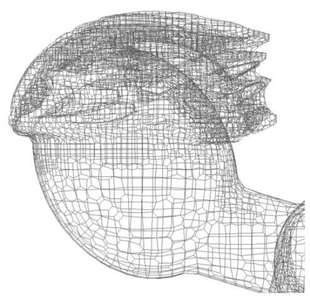


Fig 1 Computational domain and surface mesh

Aerodynamic forces

- The aerodynamic forces have been calibrated against a series of wind tunnel experiments.

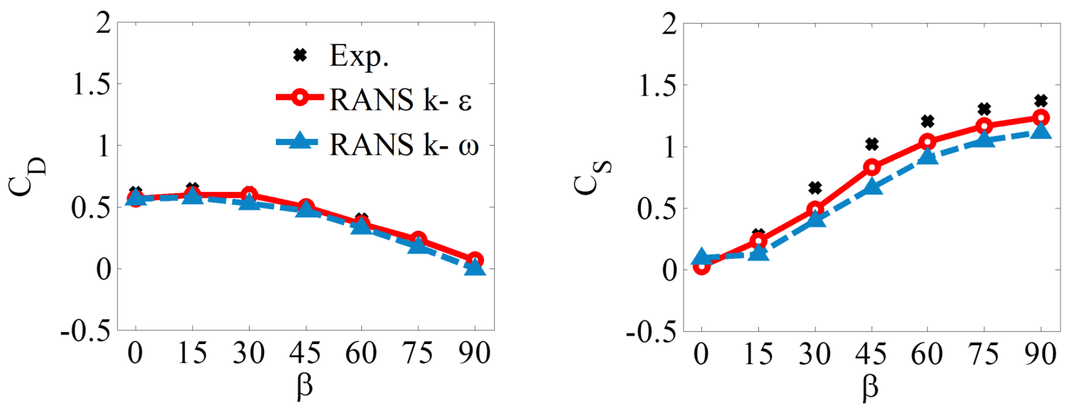


Fig 2 Aerodynamic forces as function of yaw angle: drag force C_D, side force C_S and lift force C_L

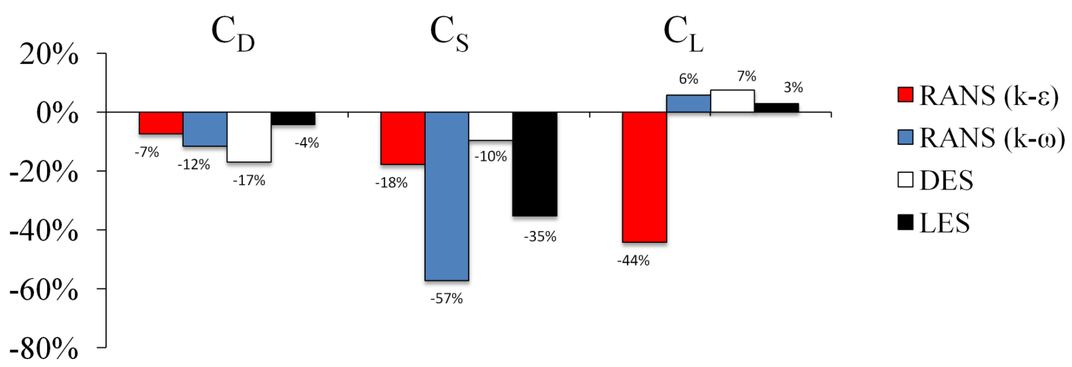


Fig 3 Aerodynamic forces: drag force C_D, side force C_S and lift force C_L

Flow structures

- The RANS results showed the development of large flow separation around the bicycle with increasing yaw angles

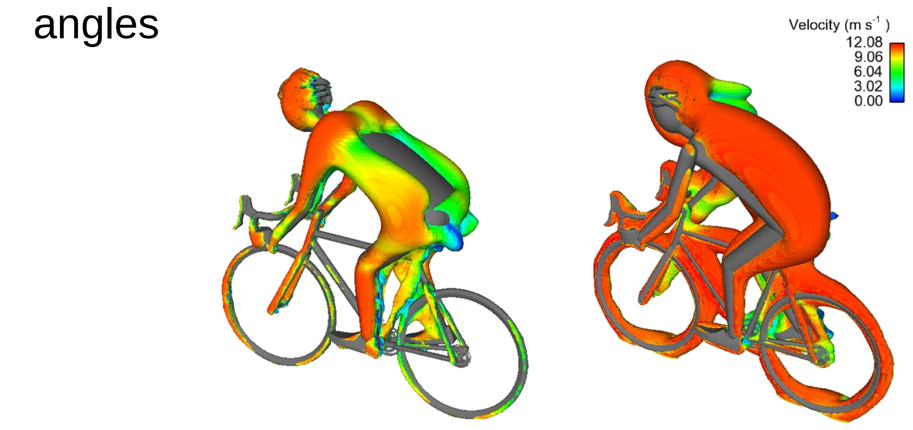


Fig 3 Isosurface of the time-averaged pressure at different crosswind yaw angles

- The instantaneous flow structures show large vortices shed at the back and leeward side of the body into the wake flow. The flow separates at the back side of the helmet and the back of the cyclist to form large unsteady structures.

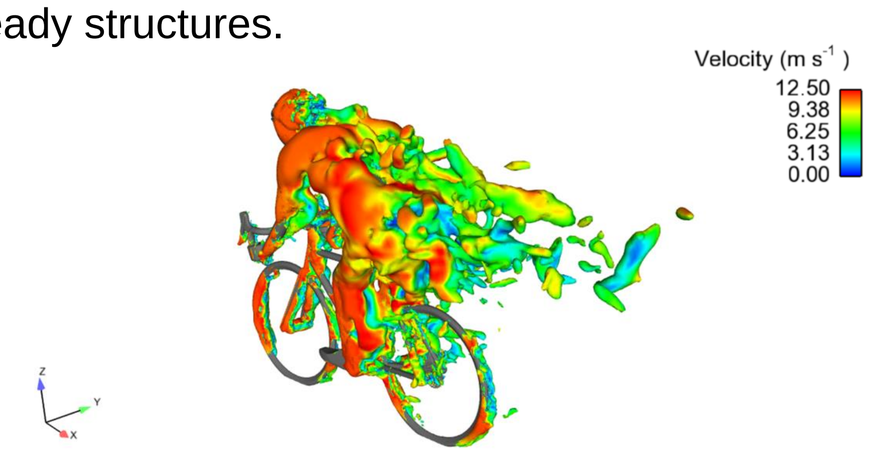


Fig 4 Isosurface of the instantaneous pressure at 15° yaw angle (DES)

Spectral analysis

- Power Spectral Densities are calculated to evaluate the distribution of the power of the signal over the frequencies. The DES is able to predict the dominant frequencies, E1-E5, found in the physical experiments

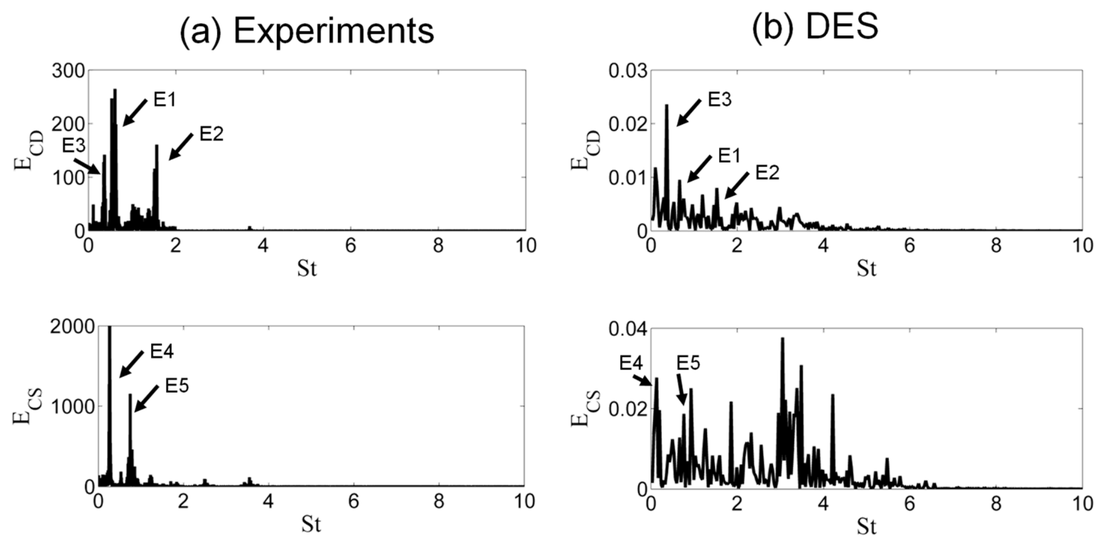


Fig 5 Auto spectral density of the aerodynamic coefficients

Conclusion

- This work has provided an improved understanding of the flow characteristics around a cyclist in crosswinds that will hopefully help to improve the safety of cyclists.

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Schepers, P., & Wolt, K. (2012). Single-bicycle crash types and characteristics. *Cycling Research International, 2*, 119-135. doi: citeulike-article-id:11188952