JOHNS HOPKINS
Center for Environmental
& Applied Fluid Mechanics

Monday, March 19, 2018
3:00 PM, 210 Hodson Hall

"Data-Driven Spectral Filters for Identifying Structure in the Streamwise Turbulent Kinetic Energy of Turbulent Boundary Layers"

Presented by Dr. Woutijn Baars
University of Melbourne

Even though flow-induced jet noise and wall-turbulence are highly broadband in nature, both physical phenomena exhibit a strong coherence in the acoustic pressure and velocity fields, respectively. In the first part of this seminar, a short overview will be provided on the acoustic signatures emitted by high-speed jets. Using an acoustic similarity parameter developed for a characteristic jet sound source, we highlight that nonlinear acoustic waveform distortion can be substantial, but, only under certain combinations of operating conditions and geometric scale of the jet.

The second, main part of this seminar focuses on the appearance of organized motions in wall-bounded turbulence. An organization is evidenced by the classification of distinctly different flow structures, including large-scale motions, such as hairpin packets, and very large-scale motions. In conjunction with less organized turbulence, all these flow structures contribute to the streamwise turbulent kinetic energy. Since different class structures comprise dissimilar scaling behaviors of their overlapping imprints in the velocity spectra, their coexistence complicates the development of models for the wall-normal trend of the energy statistics. Via coherence analyses of two-point data we derive spectral filters for stochastically decomposing the velocity spectra into sub-components, representing different types of statistical flow structures. In the process we reveal a Reynolds-number invariant wall-scaling for a portion of the outer-region turbulence that is coherent with the near-wall region; this supports the existence of a wall-attached self-similar structure embedded within the logarithmic region. It is also explored how these findings affect our ongoing work in the unique high-Reynolds-number boundary layer facility at Melbourne, including real-time control of the coherent scales to investigate their responsiveness to wall-based actuation.

Dr. Woutijn Baars received his B.Sc. (2006) and M.Sc. (2009) degrees from Delft University of Technology, where he experimentally studied the effects of icing on the stability of light aircraft. In 2013, Dr. Baars received his Ph.D. degree in Aerospace Engineering and Engineering Mechanics from the University of Texas at Austin. At UT Austin, his research investigations included the acoustic signatures generated by high-speed jets and the unsteady wall-pressure induced by shock wave boundary layer interactions in overexpanded nozzle flows. Currently he is a Post-Doctoral Research Fellow at the University of Melbourne, where he focuses on high-Reynolds-number wall-bounded flows. His ongoing research interests include the stochastic structure of wall-turbulence and how this organisation can assist active flow control for skin-friction drag reduction.