INVESTIGATIONS OF TURBULENCE: A JOURNEY FROM NANOMETER TO KILOMETER

MARCUS HULTMARK
Princeton University

October 20, 2017
4:00 PM
Maeder Hall, ACEE

Our inability to predict turbulence introduces significant uncertainty in the design of many engineering applications. Many theoretical predictions and models have been developed for turbulence in the limit of infinite Reynolds numbers. However, no real-world application operates at infinite Reynolds number, and it is typically unknown how large the Reynolds number needs to be in order to expect the theoretical predictions to hold. It is also not well understood how low Reynolds numbers affect the flow dynamics and how to best model them. What makes turbulent flows particularly challenging—theoretically, numerically and experimentally—is the large range of spatial and temporal scales contained within them, with the smallest eddies typically many orders of magnitude smaller than the largest eddies. To enable fully resolved investigations of high Reynolds number turbulent flows, a range of novel subminiature sensors have been developed. To ensure accurate representation of the flow field, the thermal and mechanical properties of the sensors and sensor systems are characterized in detail. This knowledge acts as a guide for further sensor improvements. In combination with extreme facilities, these sensors allow unique insights into flows that previously have not been possible. A model wind turbine setup has been developed that allows—for the first time—well-controlled laboratory tests at dynamic similarity to the full scale machine. The effect of Reynolds number on the performance of wind turbines is characterized and compared to field measurements and it is shown that the machine reaches a Reynolds number invariant state, but at Reynolds numbers higher than those experienced in the field.