The Statistical Description of Turbulence:

The most common approach to studying and analyzing turbulence is to consider the "average" properties of a turbulent flow.

Of course, "average" is a relative term. So what do we average over?

In turbulence, we often discuss ensemble averages in which we average over an ensemble of nominally identical flows.

However, even this is not specific enough!

Example: Three techniques for generating an ensemble for flow in a wind tunnel.

1. Use a single wind tunnel and repeatedly make measurements.
2. Build a large number of nominally identical tunnels and test all at once.
3. Do a measurement in a large number of tunnels of different designs and exploit dimensional analysis.

Results may differ between all of the above ensembles! This is due to unknown, uncontrolled, or even uncontrollable inputs:
- Inlet fluctuations
- Vibrations
- Geometry imperfections

Fortunately, turbulence statistics are largely generic. That is, different detailed inputs yield similar results! Moreover, when differences arise, we can attempt to characterize the differences and their causes. This allows for enhanced predictability. Keep in mind this is not always successful (e.g., the effect of surface roughness on boundary layers is not fully understood).

In what follows, we will develop the statistical tools needed to study turbulence.