Environmental Fluid Dynamics

ME EN 7710 | Project #2 | Due May 1

Atmospheric Surface Layer Turbulence Analysis

Overview

You will investigate various aspects of turbulence using data from the MATERHORN field campaign conducted at Dugway Proving Ground. Information on the campaign can be found at: http://www3.nd.edu/ dynamics/materhorn/. Additional project resources are posted on Canvas and the course website. Each group should obtain the sonic anemometer/thermometer data directly from me.

The purpose of this project is to understand the physics of turbulent flow occurring at the measurement site. You will need to come up with a general scientific objective and hypothesis that you intend to test, present on, and write-up. For example, a group may choose as an objective: "To better understand the effect of atmospheric stability on turbulence for a canyon outflow" and a hypothesis that might be tested could be: "Night-time turbulence is enhanced by the formation of surface level jet."

You must first select a time period for analysis. You may select the entire day for simple statistics and tethered balloon analysis, but you will want to focus on a shorter time period for the turbulence analysis that is required and outlined below. You may work in groups of two or three. Please select a project topic as soon as possible and obtain my approval.

Oral presentations: **Monday, May 1 from 10:30a-12:30p**. Final report due: **Monday, May 1 at 5:00p**.

Assignment

Using the Sonic Anemometer data, please perform the following analysis:

1. **Simple Time Averaging:** calculate (a) 30-minute averages of u, v, w, and T, as well as (b) $\overline{ws}$, $\overline{wd}$, σ_u, σ_v, σ_w, $\overline{w'T'_s}$, u_*, H_s, tke, L, and w_* (if appropriate), where $\overline{ws}$ and $\overline{wd}$ are average wind speed and direction, respectively. Describe the stability during the analyzed period.
2. **Probability Distributions:** For a representative 30-minute averaging period, generate a CDF and PDF for u, v, w, and T and report the skewness and kurtosis.
3. **Autocorrelation:** Calculate the autocorrelation of at least one 30-minute period. What does this indicate?
4. **Dissipation:** Using Taylor's frozen turbulence hypothesis, calculate the dissipation rate of turbulent kinetic energy for several 30-minute periods. Calculate the Kolmogorov length scale.
5. **Turbulence Spectra:** For at least one 30-minute averaging period, calculate the following turbulent energy spectra: S_{uu}, S_{vv}, S_{ww}, S_{TT}, as well as the following cospectra: S_{uw}, S_{vw}, S_{wt}. What do these spectra indicate about the analyzed boundary layer? Is there an inertial subrange?