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**Homework/Lab 4: Due May 2nd 2024**

**Part I: Eddy Covariance Theory**

1. Derive the general turbulence flux equation for any gas; from this general equation derive the specific turbulence flux equations for latent heat and sensible heat fluxes. Clearly explain all your steps in the derivation of each flux equation.  
   A notebook with writing on it

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2. State the main assumptions behind the eddy covariance method.  
   **Negliable air density variation  
   Assume negliable mean vertical air flow for horizontal homogeneous terrain**
3. What are some of the main sources of error associated with the eddy covariance method? What would you do to minimize those errors?  
   **The main error from eddy covariance is the number of things that can affect the readings. Improper location or placement can affect the readings as well as usual malfunctions. There is also random noise that can happen which requires data filtering.**
4. What are the general rules of thumb for sensor height installations and fetch requirements for eddy covariance?  
   **We need to be at least 1.5m above smaller plants like strawberries or grasses. But 2-3 m above taller plants like trees. The fetch should also be around 50-100 times smaller than the desired amount**
5. What are the two basic instruments required for a minimalist eddy covariance flux station?  
   **A sonic anemometer and a fast gas analyzer**
6. Please explain why it is important to include Biomet sensors in a robust eddy covariance flux tower installation. List some of the Biomet sensors typically installed with an eddy covariance flux tower.  
   **Bio-met sensors are used to validate readings from an eddy covariance flux tower**
7. Explain why using eddy covariance to measure ET in a vineyard on a sloping hill in Napa Valley would be a bad idea.   
   **The hills would influence the constant flux zone and give inaccurate readings, a sloping profile would also have an affect some assumptions made in the turbulence flux equation.**

**Part II: Hands-on practice with Eddy Pro**

1. Follow the steps below to process raw data from an eddy covariance flux tower in a commercial almond orchard located near Corning, California.

* Average the Soil heat flux data and plot H, LE, Rn, and G in the same plot. Which component dominates the energy during the given period?  
    
  **During the day Rn seems to dominate the energy balance while at night the LE dominates.**
* Following the procedures described in the Moorhead paper, you reviewed in Lab 3, make a plot of available energy versus latent heat plus sensible heat fluxes. What was the energy balance closure during this period?   
    
  **The energy balance closure is given by the regression slope which is 59.4%**
* Why is the energy balance closure less than 100%?  
  **When we take measurements with sensors, we cannot expect exact measurements there will be some error in the measurements. There may also be conditions at the recording site that negatively affects some of the measurements that were taken.**
* Plot hourly ET from column AN, and on the plot add ETc estimates as a product of CIMIS hour ETo for the same period and almond Kc of 1.0. Obtain CIMIS from the Gerber South station.

**Part III: Generating a windrose using measured wind direction and speed**

Determining a prevailing wind direction is an important step in assessing site suitability for the installation of an eddy covariance flux tower. Using CIMIS hourly measurements of wind speed and wind direction (Jan 1st, 2018 to Dec. 31st, 2022), generate a windrose for the UC Davis Campbell Track Research Farm located adjacent to the Davis CIMIS station (#006). You can use the Python script provided by ChatGPT or alternatively write your own script that plots a windrose using measured wind data. Compare your windrose to that generated from the Iowa Environment Mesonet at <https://mesonet.agron.iastate.edu/> for the same weather station. Explain any differences between the two windroses. Submit the two windroses, an explanation of differences, and the code that you used to generate the windrose.  
A diagram of a wind rose

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A diagram of a weather forecast

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**The chart from Iowa may have measurements that have different conditions that the station that is in davis. Building or nearby hills can influence the prevailing wind direction. We can see that in our data the prevailing wind direction is from the NE, while in the Iowa windrose the prevailing wind is from the NW**