The Science Behind Measuring Depletions

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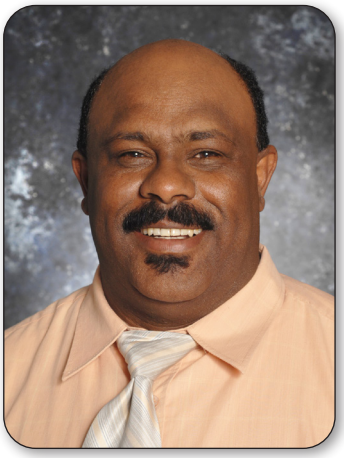

Salim Bawazir is Associate Professor in the Civil Engineering (CE) Department at NMSU. He joined NMSU's CE Department as Assistant Professor in 2003. He holds BS, MS and doctorate in CE (2000) from New Mexico State University, with a minor in environmental management. He also holds a BS in agricultural engineering from NMSU. He teaches undergraduate and graduate courses in water resources engineering related fields. Salim's research is primarily in the area of water resources (hydrometeorology). He has authored and co-authored several peer-reviewed journal articles, proceedings, book chapters, technical reports, monographs, and over 200 poster and oral presentations. He has more than 15 years of field experience in instrumentation and measurement of evapotranspiration from agricultural crops, riparian vegetation, and evaporation from reservoirs.

Figure 1. Measuring depletions.

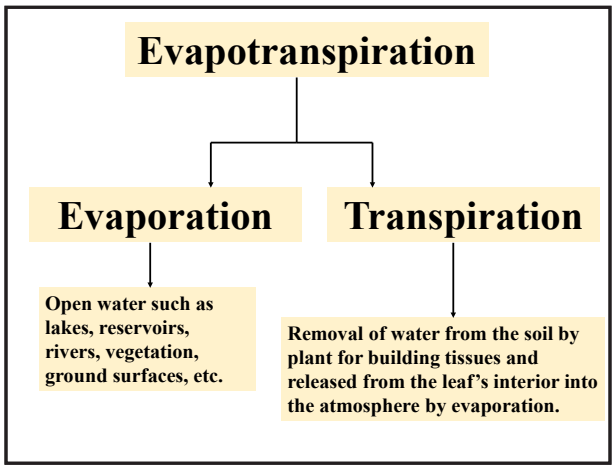

Figure 2. Evaporation and transpiration.

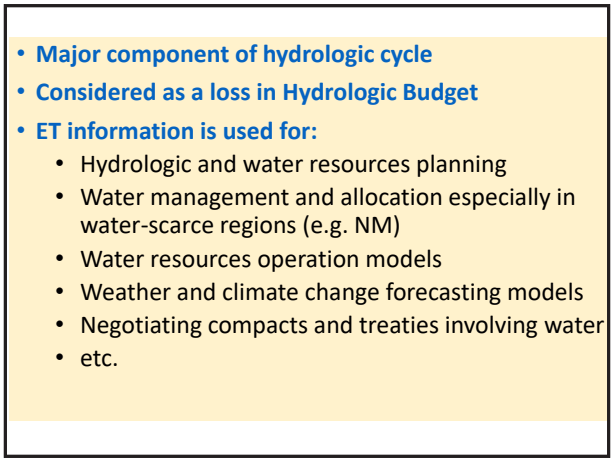

Figure 3. Why evapotranspiration (ET)?

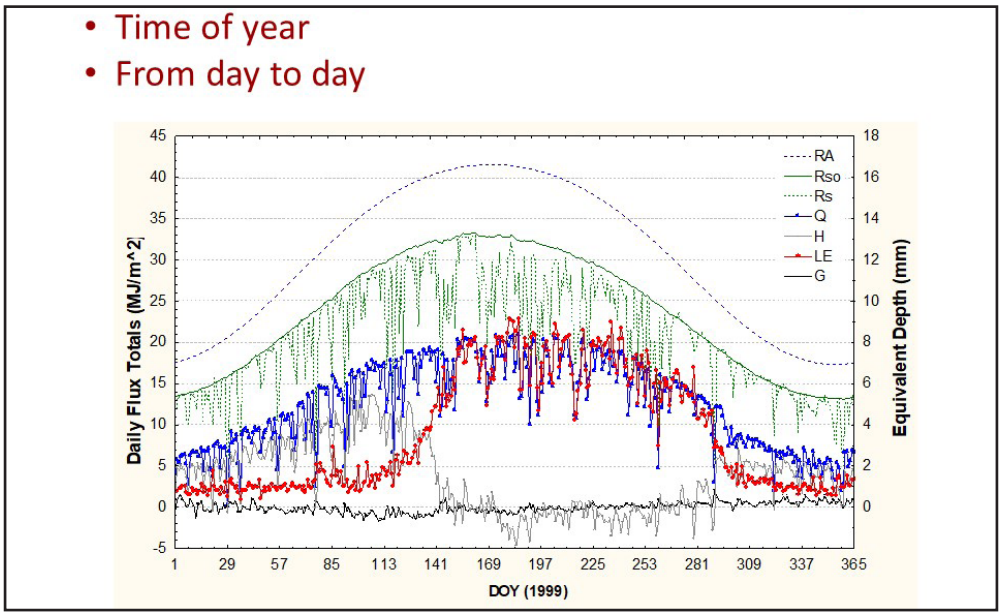

Figure 4. Daily flux varies widely.

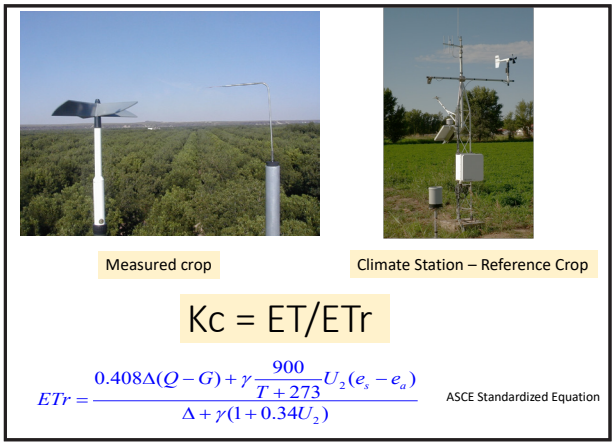

Figure 5. Traditional method of estimating evapotranspiration (ET).

- **LIght Detection And Ranging - LIDAR (Raman Water-Vapor Lidar)**
- **Heat Pulse Technique (Transpiration)**
- **Lysimetry – Lysimeters (extensively used to provide baseline information for other ET methods) – Error 5 to 40%**
- **Measure the change in soil water over a period of time**

Figure 6. Alternative ET methods.

- **Micrometeorological methods (Bowen Ratio Energy Balance, Eddy Covariance..) LE = (Rn-G)/(1+β); H/LE**
- **Scintillometers – Measures small fluctuations in the refractive index of air caused by temperature, humidity, and pressure induced variations in density (Optical Transmitter and receiver) –** Measures sensible heat flux only;
  - **Error 10 to 50%**
- **Remote Sensing**
- **Gas Exchange – Stomata Conductance**
- **Class A Pan**

Figure 7. Alternative ET Methods (cont.).

Figure 8. LiDAR (Raman Water-Vapor Lidar) on a trailer (in the back).

Figure 9. Transpiration measurement using heat pulse technique.

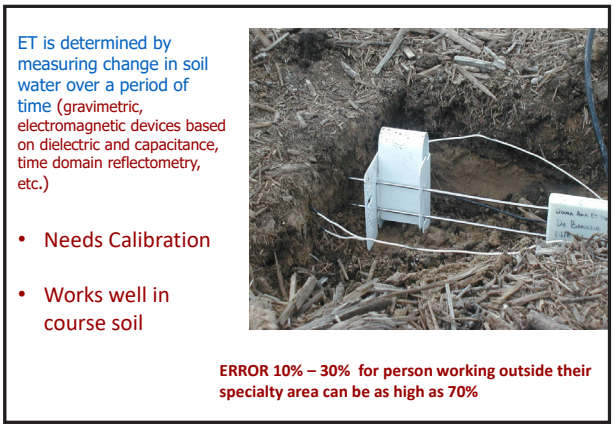

Figure 10. Evapotranspiration based on measurement of soil moisture.

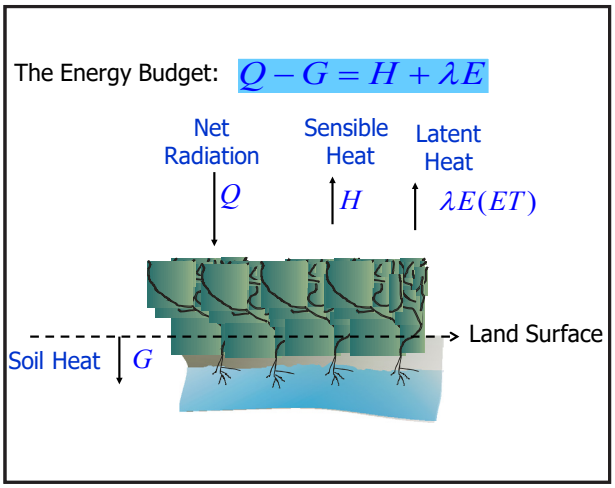

Figure 11. The Energy Budget equation.

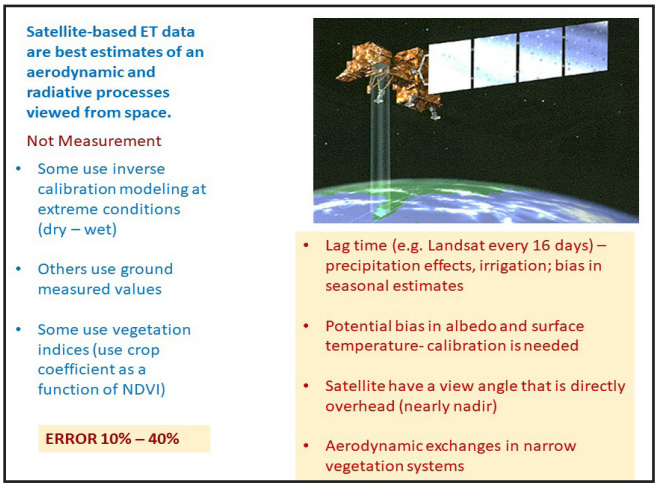

Figure 12. Satellite-based ET.

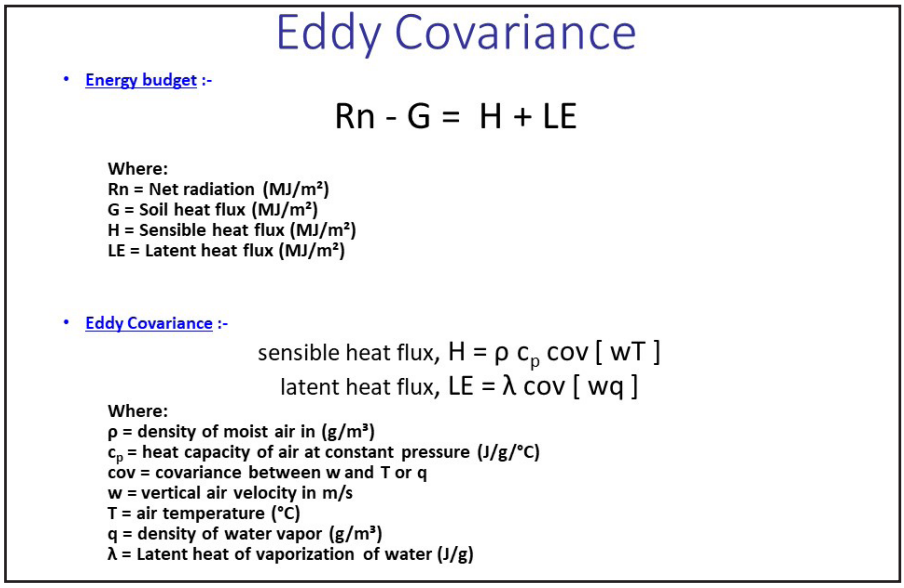

Figure 13. Energy Budget and Eddy Covariance.

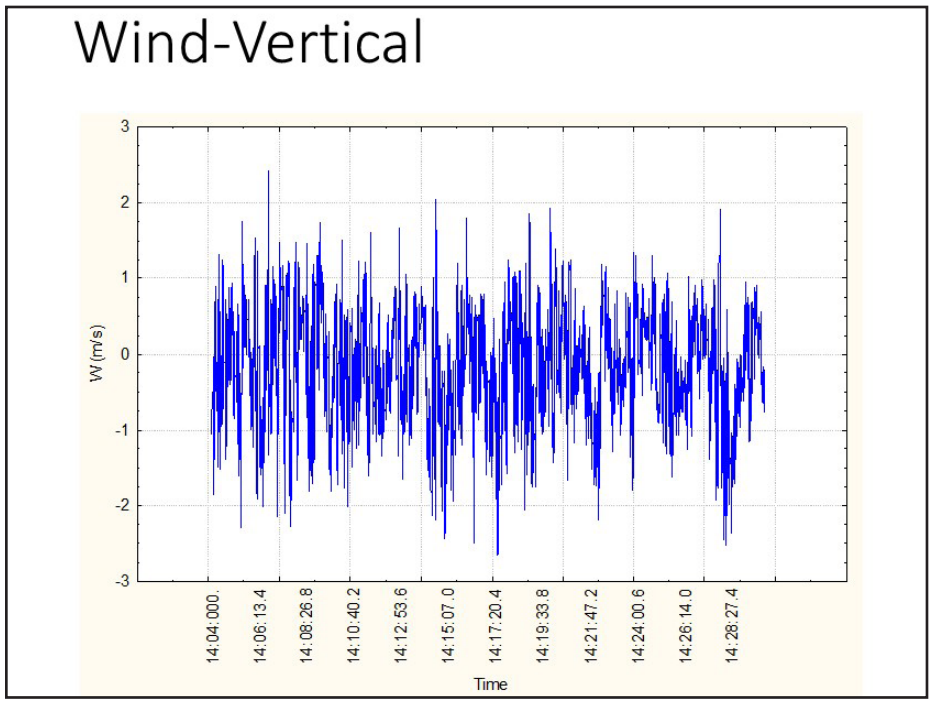

Figure 14. Vertical wind speed measured at high frequency.

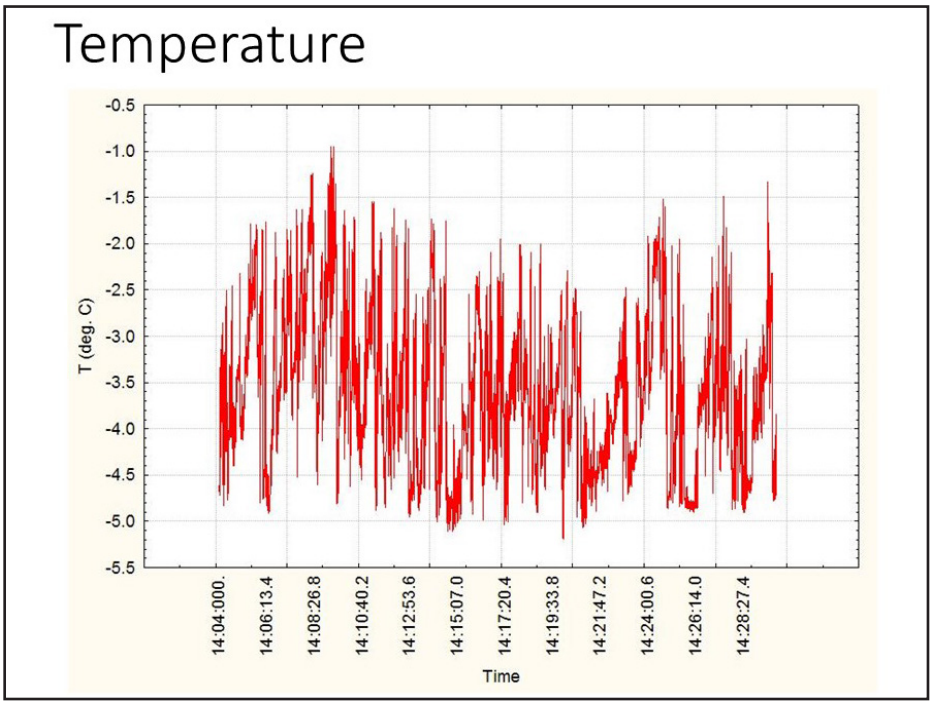

Figure 15. Ambient temperature measured at high frequency.

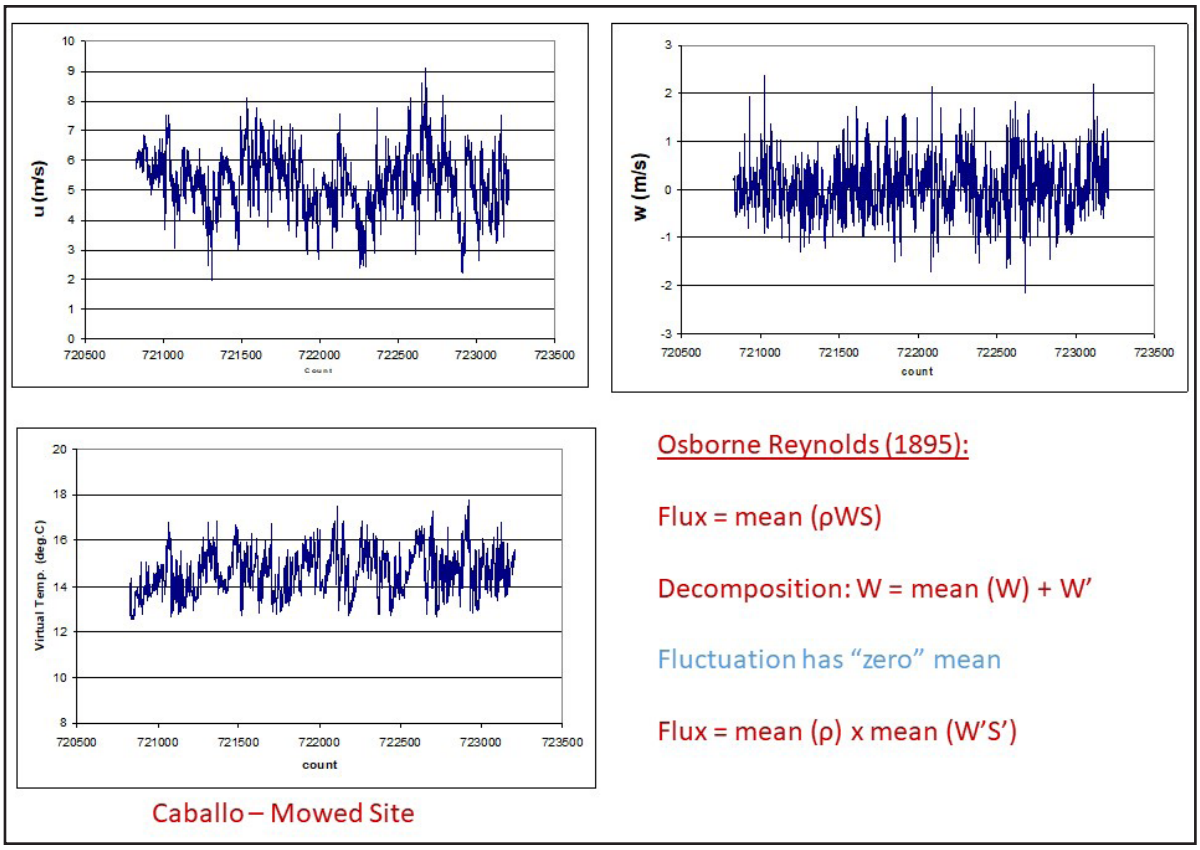

Figure 16. Basic derivation and formulas.

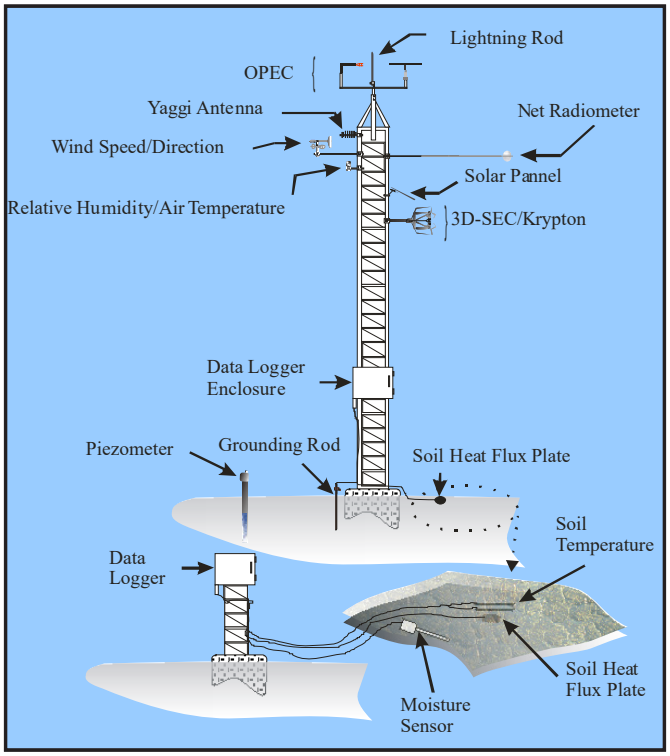

Figure 17. Instrumentation setup for evapotranspiration studies.

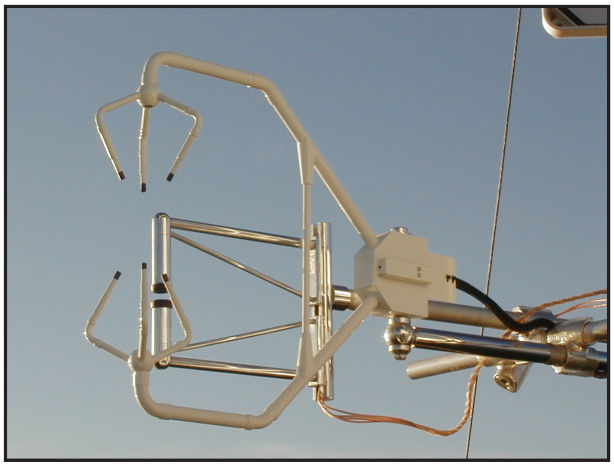

Figure 18. 3-D Sonic Anemometer and Krypton Hygrometer.

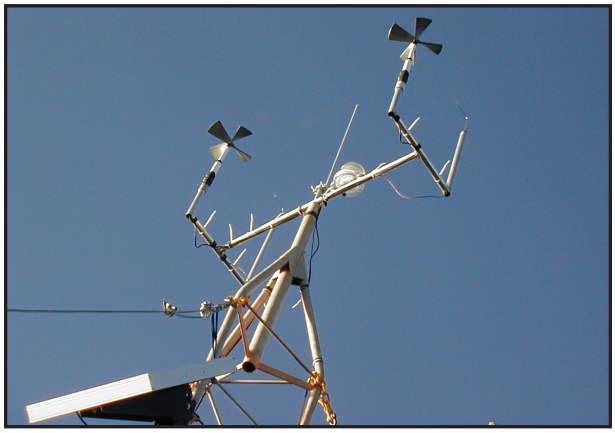

Figure 19. One Propeller Eddy Covariance (OPEC) system.

Figure 20. LI-7500 and Krypton Hygrometers with 3-D Sonic Anemometer.

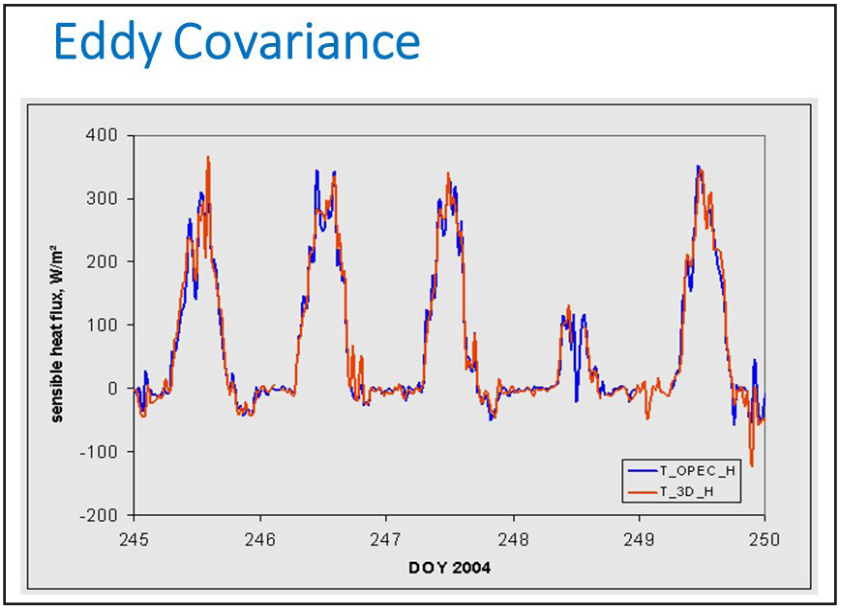

Figure 21. Daily cycle of measured sensible heat.

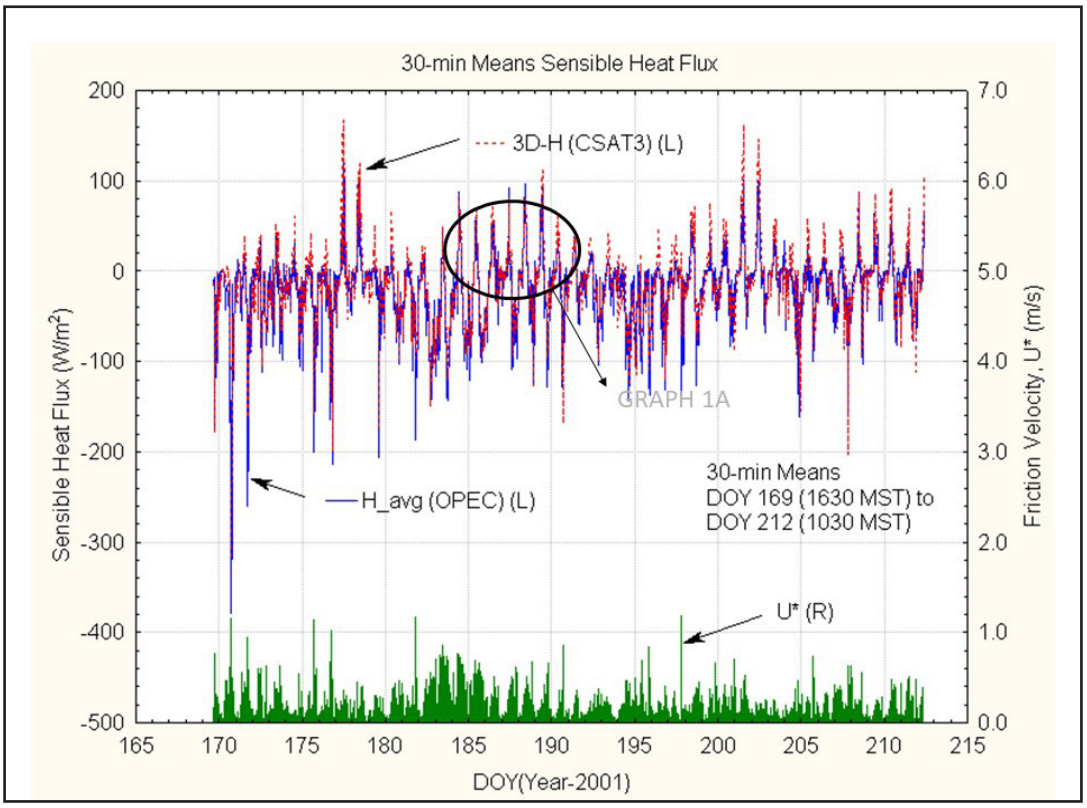

Figure 22. 30-minute Means Sensible Heat Flux.

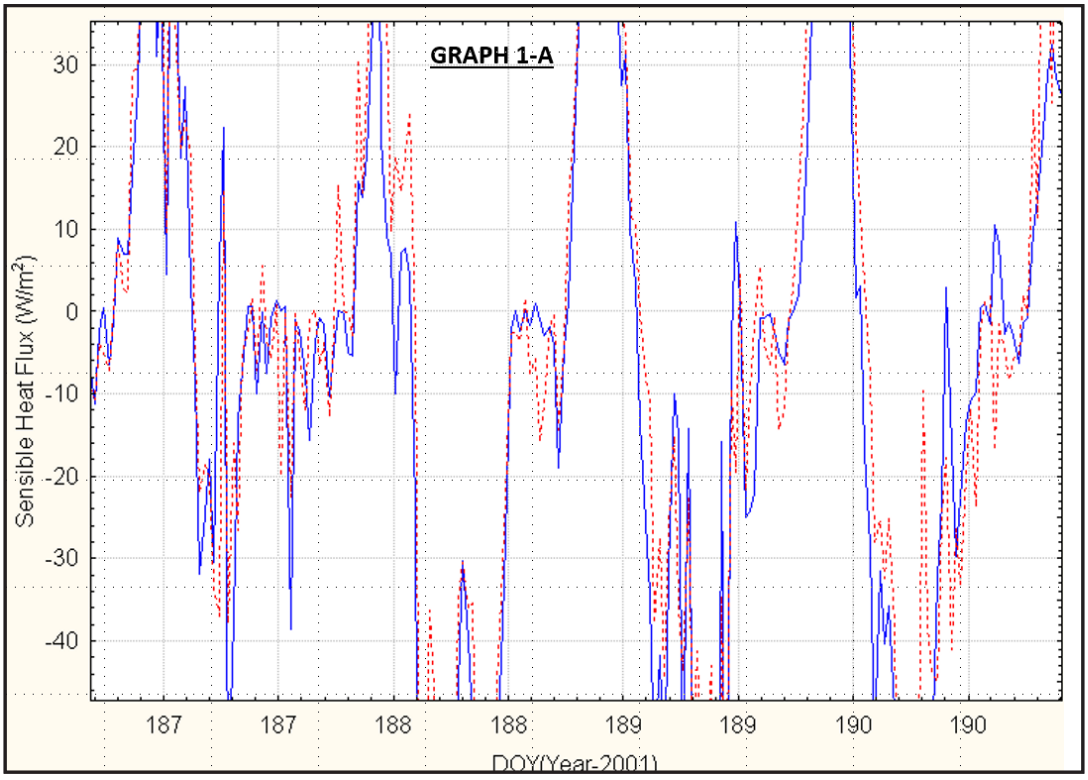

Figure 23. 30-minute Means Sensible Heat Flux-3D Sonic v. OPEC.

Figure 24. Evaporation flux tower at Elephant Butte Reservoir.

Figure 25. Net radiation measurement above dense saltcedar.