9.6 CHARACTERISTIC TURBULENCE SPECTRA ABOVE AND BELOW A TAMARISK CANOPY

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1. INTRODUCTION

Many riparian eco-tones in the southwest U.S. are dominated by dense stands of *Tamarisk* (salt cedar), a non-native phreatophyte ranging in height from 4-7 m for mature stands. *Tamarisk* is suspected of depleting large quantities of water from the Rio Grande through evapotranspiration. Predicting accurate water loss from *Tamarisk* is essential to effective river management decisions attempting to balance growing demands with an increasingly scarce resource. These stands generally exist as relatively narrow ribbons of wet soil, vegetation and surface water surrounded by immense expanses of desert landscapes. As a consequence, turbulence exchange processes for narrow riparian zones are routinely influenced by the advection of sensible heat. In addition the physical structure of a mature *Tamarisk* stand is such that it possess qualities similar to a forest. Under such conditions, exchange processes of scalars and mass can occur simultaneously below and above the canopy as functions of different spatial and temporal scales. A study was conducted to evaluate turbulence characteristics above and below a *Tamarisk* canopy under varying local micro-meteorological conditions and determine how these conditions can affect sensible and latent heat flux exchange. A Raman Lidar was incorporated to provide information on the water vapor fields above the canopy near the measurement site.

2. SITE, INSTRUMENTATION, AND DATA

This study was conducted in a riparian corridor densely vegetated with a species of phreatophyte *Tamarisk* along the Rio Grande river in the Bosque del Apache Wildlife Refuge located in south central New Mexico. A 12 m tower was erected in the middle of a dense stand of *Tamarisk*. Two eddy covariance (EC) systems and pertinent ancillary measurements were mounted 3.7 m above the canopy and 1 m above the ground surface below the canopy. In addition, a Raman Lidar was deployed near the tower to measure multi-dimensional water vapor fields. The Lidar produces visual images of water vapor transport using two-dimensional scans. Eddy covariance measurements were acquired at a scan rate of 20 Hz. Data acquisition typically began in the early morning hours (0700 hrs) and continued into the late afternoon periods. The data were screened for integrity, continuity and formatted into one-hour blocks. Time series data were evaluated for evidence of non-stationarity (red noise) typically associated with transition periods during early morning and evening hours. Power spectra and co-spectra of various turbulence components were computed for periods representing a range of diurnal conditions above and below the canopy. Latent and sensible heat fluxes were computed from the times series data and evaluated.

3. SPECTRAL ANALYSIS

After the data were evaluated and detrended, discrete Fourier analysis was conducted to transform the data into frequency space. This was performed on the individual components of velocity (u, v, w) as well as air temperature and specific humidity (T and q). Spectral density distributions were computed and plotted. For individual periods of interest, co-spectra analysis was conducted for wt, wq and Tq. Results were smoothed using a Daniel window. Results from the spectral analysis were used to compute appropriate averaging periods, eddy length scales and evaluate co-spectral energy distributions as related to local micrometeorological parameters and *Tamarisk* vegetation.

4. RESULTS

Typical local climatic conditions during the study were characterized by clear skies and low winds from early to late-morning with convective clouds developing in the afternoon hours. Winds were generally low (0-1 m s^{-1}) and out the north in the early morning hours gradually rotating to the south and increasing to 1-2 m s^{-1} by mid-morning. During afternoon and evening, winds were generally from SE to SW increasing to 2-4 m s^{-1}.

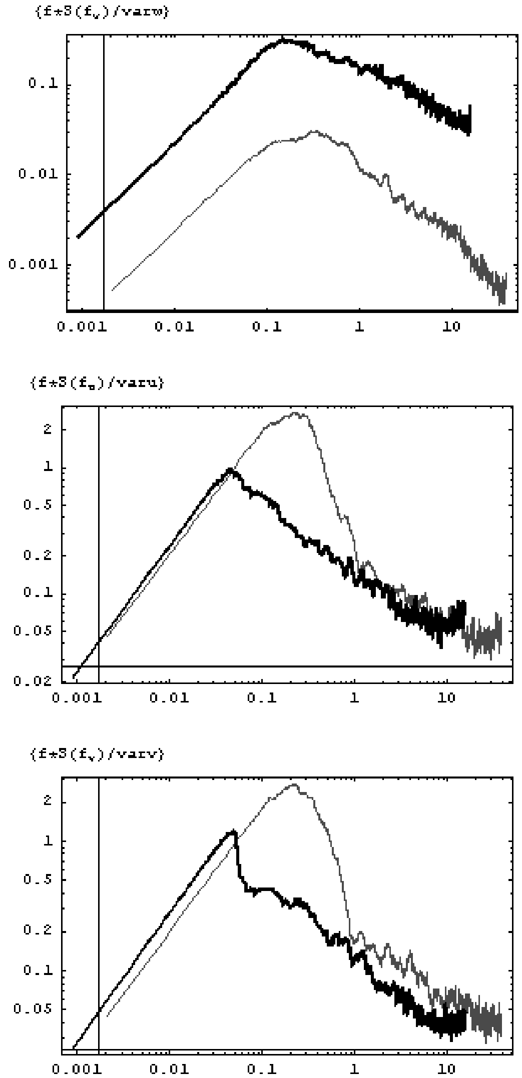
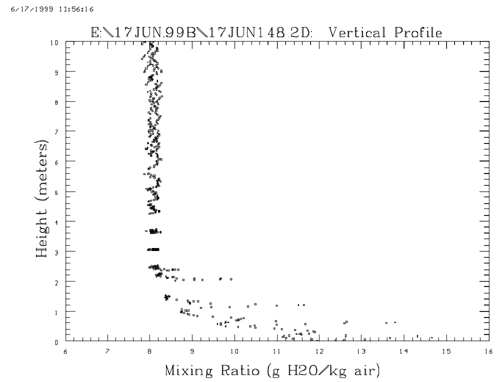


Fig.1: Power spectra of w, u and v wind components for DOY 168 at 1100 hours over the Tamarisk canopy (dark thick line) and below the canopy (light thin line).

Figure 1 presents power spectra for the vertical, stream wise, and lateral wind velocities for two sonic anemometers located below and above the *Tamarisk* vegetation for DOY 168 at 1100 hours. For this period mean air temperature and wind speed were 20 °C and approximately 2.5 m s^{-1} respectively, with the wind direction out of the southeast. The power spectra density values for the individual components were normalized by the natural frequency and the total variance for the 1100-hour period. Frequency values for each sonic were made dimensionless by normalizing by the measurement height z and the mean wind speed computed at the measurement height.



The results in Fig. 1 show the shape of the individual spectra for both heights with prominent and broad peaks present depending on the individual component. The spectral density peaks for the vertical component *w* occurs at similar frequencies for below and above canopy locations with the above canopy peak occurring at a slightly lower frequency. Recall the spectral densities have been normalized by the variances. Actual density values were greater (by a factor of 10) for the above canopy case. Spectral peaks for u and v components occur at considerably higher normalized frequencies below the canopy indicating turbulence degradation as eddies from above penetrate the canopy and come into contact with *Tamarisk* vegetation elements. Figure 2 shows the humidity profile over the Tamarisk canopy during the same period expressed as a mixing ratio. These data were measured with a Lidar and demonstrate a unique feature of the roughness sub-layer. Preliminary results indicate the humid layer was temporally and spatially dynamic. This has implications for interpreting the EC results above the canopy for this specific study. At times the EC was well within the humid sub-layer, while at other times clearly out of the layer. This complicates the interpretation of the EC results, since when it was above this layer it was not measuring air in equilibrium with the canopy fluxes. Further analyses of the turbulence data will hopefully yield a better understanding of the processes that govern the fluxes from this ecosystem. Future analyses will include relating eddy length scales and saturation deficit entrainment from aloft to latent and sensible heat flux exchange above and below the canopy.

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