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SPATIAL PROPERTIES OF WATER VAPOR SCALAR AND FLUX OVER A RIPARIAN CORRIDOR

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The measurement of fluxes such as evapotranspiration from complex canopies and terrain are challenging the technological resources of both the meteorological and hydrological sciences.

Evapotranspiration is one of the critical variables in both water and energy balance models of the hydrological system. The hydrologic system is driven by the soil-plant-atmosphere continuum, and as such is a spatially distributed process. Traditional techniques rely on point sensors to collect information that is then averaged over a region. The assumptions involved in spatially averaging point data is of limited value (1) because of limited sensors in the arrays, (2) the inability to extend and interpret the measured scalars and estimated fluxes at a point over large areas in complex terrain, and (3) the limited understanding of the relationship between point measurements of spatial processes. Remote sensing technology offers the ability to collect detailed spatially distributed data.

To this end, the Los Alamos National Laboratory's volume-imaging, scanning water-vapor Raman lidar has been shown to be able to estimate the latent energy flux at a point. The extension of this capability to larger scales over complex terrain represents a step forward. This work outlines the techniques used to estimate the spatially resolved latent energy flux over Cottonwoods in a riparian corridor in southern Arizona as part of SALSAMEX. The scanning Raman lidar was fielded along with an array of various point sensors along a reach of the San Pedro river in early August of 1997, and collected data over an 8 day period.

Preliminary analysis of the data has begun with the first part being an inspection of the vertical lidar scans of water vapor. Latent energy flux is computed from 25 m wide vertical profiles derived from vertical scans using Monin-Obukhov similarity theory, and initialized with u_* estimates from external sources (Cooper et al., 1996). During SALSAMEX a Sodar acquired wind field information down to 30 m that will be used to estimate u_*. Lidar vertical scans were typically 500 to 600 m long and 75 m high at a range of 500 m. Scan elevation steps are 0.1 per step, with a user defined number of steps per scan. Vertical profiles derived from these scans can have a s much as 0.1 m vertical resolution. During SALSAMEX, lidar vertical scans were also stepped every 5 degrees in azimuth, to form a 40 degree swath that will ultimately create 30 minute flux maps with 25 m horizontal resolution. Each vertical scan will be partitioned into twenty 25 m wide profiles that will be used later for flux estimates, and by combining the fluxes from the 40 degree swath will produce a flux map.

An example of two profiles---25 m wide---extracted from a vertical scan acquired on August 11, 1997 at 0911 LST is shown in the accompanying Figure, where the top portion was acquired over the grass-shrub assemblage on the San Pedro flood plain, and the bottom portion of the figure was acquired over the Cottonwoods in the riparian zone. Due to publication considerations, the lidar vertical scan is difficult to show without color reproduction. A cursory inspection of the data reveals some interesting properties of the canopy top when compared to the relatively flat grass area. The cottonwoods show extensive coherent plume structure directly over the tree canopy, while the grass area shows little convective features at this time. The means of the two profiles are roughly the same however, the range of the variation over the trees are about 2.5 times larger than over the grass. Secondly, there appears to be a steep highly unstable zone about 1 meter deep directly over the tree canopy that is not seen over the grass. Interestingly, the size of the turbulent structures in the profiles for both surfaces is about 10 to 12 meters in size. Coherent plumes and structures over the trees are two to three grams per kilogram higher than the background of 11 to 12 g/kg. Over the grass, the structures are somewhat weaker in intensity.

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Presumably, the well watered trees are transpiring at a higher rate than the dry grass, giving rise to more intense turbulence, mixing, and coherent structures. In addition, the high water vapor exchange between the trees and the surface layer might be responsible for the thin but strong internal boundary layer The higher intensity turbulence over the trees would explain the variability of the Cottonwood profile. The 1 meter deep inversion is probably due to the development of a internal boundary layer with low winds at the top of the canopy, with vertical winds increasing with height.

These hypothesis and observations will be tested with further data analysis in the near future, and maps of the latent heat flux will be generated from the grass and cottonwood biomes.

D. Cooper, W. Eichinger, J. Archuleta, W. Cottingame, M. Osborn, and Tellier, L., 1996: Estimation of spatially distributed latent energy flux over complex terrain using a scanning water-vapor Raman lidar. 22nd Conf. on Ag. And Forest. Met. Atlanta, GA pp. 231-234.

Note: 2 figures not included in online pdf file