

**VARIABILITY AND COUPLING OF METEOROLOGICAL AND
HYDROLOGICAL STATES IN THE VALLES CALDERA NATIONAL
PRESERVE, NEW MEXICO DURING THE NORTH AMERICAN MONSOON**

Alex Rinehart and Enrique Vivoni
Earth and Environmental Sciences
New Mexico Tech

Final Report
May 11, 2007

The spatiotemporal distribution of soil moisture and its coupling with the atmosphere are poorly understood phenomena. We performed a large-scale preliminary study between July 22 and August 1 in the Valles Caldera National Preserve (VCNP), New Mexico that focused specifically on the controls of topography and vegetation on the state of the land surface and the coupling of the atmosphere with the surface. Most previous work has either been done with hydrological or meteorological models or at a few intensely instrumented locations. While the modeling efforts have been distributed in space, they generally have not used detailed spatial measurements for verification and have not been well validated in complex topography and vegetation. Point measurements yield a tremendous amount of information at single locations. The generality of the inferences drawn from these locations are difficult to test, especially when examining variably vegetated regions with heterogeneous relief.

To address these gaps in understanding, we developed a measurement campaign centered around the highest peak in the Jemez Mountains, Redondo Peak. This high point is located in the VCNP and consists mainly of subalpine forest and grasslands. The dominant vegetation types are mixed conifer forest, ponderosa pine forest, subalpine grassland, subalpine wetlands and bogs, quaking aspen stands and stands of blue spruce. The soils have predominantly silty loam textures. The region is geologically complex, with extensive lacustrine sediments in the valleys and rhyolitic rocks. The area has been extensively logged during the twentieth century and many of the forest are extremely dense. Redondo Peak has an elevation of 11,254 ft, while the large valley surrounding it has a minimum elevation of 8,500 ft. The streams draining off of Redondo Peak are small perennial streams fed mainly from snowmelt.

We organized the campaign along Redondo Creek, Jaramillo Creek and along the southern edge of Redondo Peak. The seventy-one measurement locations were organized into four transects along with four sites along the upper northeast flank of Redondo Peak. The transects were organized into five to ten hillslope elements, each with three to six sites. The measurement locations were placed along the stream, in the grassy midslope and under the forest canopy. The slope, aspect, vegetation type and location on hillslope was recorded for every plot. In some locations, more measurement sites were placed in order to ensure a representative range of slope, vegetation and aspects. At each site, an

event rain gauge and a 1 m² plot were collocated. The amount of precipitation, soil moisture at five positions in the plot, soil temperature at 2 cm, 5 cm and 10 cm, air temperature, dew point, relative humidity, windspeed and air pressure were recorded daily at every site, going from highest to lowest elevation along each transect. Soil moisture within the plot was measured with an impedance probe. Volumetric soil samples were taken every day in order to eventually allow for a accurate calibration of the impedance probe.

Two sets of analysis have currently been taken out. The first examined regional controls of vegetation on soil moisture, without considering the effects of a site's location on a hillslope. It was found that grasslands are generally the wettest, followed by the meadows on midslope, then forested areas. In transects that received the most rain, the control by vegetation type was strongest, but even in the driest regions, the vegetation control on soil moisture was significant. The second set of preliminary analysis was examining the covariance structure of soil moisture circumferentially around Redondo. In this analysis, each the soil moisture of each cluster, or set along the same hillslope, was found as the average of the sites in that cluster. The covariance of soil moisture as a function of linear distance between clusters was computed for each day. On July 21 and July 27, regional scale rain events occurred. It was found that clusters that were circumferentially close to one another had very similar soil moistures immediately after the rain events, with mean correlations of approximately 90%. As the region dried, local soil and vegetative heterogeneity is thought to have become dominant, as the correlation structure becomes random. Radially organized correlation was negligible. The circumferential organization of the soil moisture after wetting is thought to represent the development of discrete local storm cells around the peak, causing homogeneity in swathes around the mountain.

There are currently two publications in preparation. The first is a general overview of and results from the field campaign, focusing directly on the controls of aspect, slope, vegetation and relief. The second is a brief letter elucidating the covariance structure of soil moisture and precipitation in roughly conical montane topography. Two conference posters have been presented from this work.

Méndez-Barroso, L.A., Rinehart, A.J., Aragón, C.A., Bisht, G., Cardenas, M.B., Engle, E., Forman, B., Frisbee, M.D., Gutiérrez-Jurado, H.A., Hong, S-H., Tai, K., Wyckoff, R.L., Vivoni, E.R. 2005. Spatial and Temporal Analysis of Hydrometeorological Conditions in the Valles Caldera, New Mexico during the North American Monsoon. American Geophysical Union, Fall Conference, San Francisco, CA.

Rinehart, A.J., Vivoni, E.R., Frisbee, M., Aragón, C.A., Bisht, G., Cardenas, M.B., Forman, B., Gutierrez, H.A., Hong, S-H, Mendez, L.A., Tai, K., Wyckoff, R.L. 2005. Design and Implementation of a Hydrometeorological Field Campaign in the Valles Caldera, NM. New Mexico Water Research Conference. Socorro, NM.