Using Time-Lapse Digital Photography to Monitor Changes in the Critical Zone

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1. Abstract

Within the critical zone (CZ), important interconnected physical, chemical, and biological processes influence the mass and energy exchange that governs everything from biomass production to water storage. However, many of these processes operate over different temporal and spatial scales, and little is known about how these processes interact. We have begun to link these processes by analyzing time-lapse digital images. These images have the potential to quantitatively link processes across different disciplines, such as snow hydrology and ecology. In December 2009 and March 2010, we collected time-lapse enabled digital cameras and eddy covariance towers within the Santa Catalina Mountain and Jemez River Basins of the University of Arizona CZ Observatory, respectively. We mounted an eddy camera at the top of each of the eddy covariance towers and three understory cameras at heights of 1 m within the footprints of the towers. All cameras record images hourly. Here we describe our methodology for processing these hourly images and show preliminary results from our image analysis.

2. Focus Questions

• How does the timing of phenological events in our ecosystems contribute to the spatial and temporal variability in the partitioning of energy, water, and carbon partitioning in the critical zone?
• What are the environmental triggers of phenology for the different plant species within our ecosystems?
• How can we use data from digital images to better link flux data to remote sensing data?
• How can we use data from digital images to better inform our critical zone models?
• How might climate change impact the phenology of these plant species, and ultimately impact the future interactions within the critical zone?
• How can we use digital images to gain information about snow dynamics?
• How can we use digital images to link phenological changes to stream chemistry?

3. Approach

Four cameras installed at each of two mixed conifer sites above 2500 m:
• One understory camera mounted near the top of the eddy covariance tower just above the LiCor 7500, oriented into the direction of the main wind.
• One understory camera mounted near the top of the eddy covariance tower.
• One understory camera mounted within the footprint of the eddy covariance tower.
• All four cameras record images hourly.
• Images can be analyzed alongside flux and meteorological data from the tower.

4. The Images

Santa Catalina Mountains - 2500 m 
Mount Bigelow Eddy Covariance Tower

Jemez River Basin - 3000 m
Jemez Mixed Conifer Eddy Covariance Tower

The images collected from each of these sites represent a valuable archive of information from which multiple types of information can be extracted. In the images above, we show that understory vegetation is an important component of the ecosystem in the Jemez River Basin, but not in the Santa Catalina Mountains. From the Bigelow eddy camera, we can see evidence of mortality in the overstory. The overstory camera in the Jemez River Basin has dramatic cloud formations in addition to distant fires.

5. Preliminary Results

5.1 Snow monitoring in the understory

• Interannual variability of snow cover is captured with the understory camera.
• Site to site differences are evident; at Bigelow the nearest camera experiences the least snow, while at Jemez the warmest camera experiences the most snow.

5.2 Greenness in the understory

We selected a region of interest (ROI) for each camera, and analyzed them for greenness throughout the year.

6. Examples of Future Directions

6.1 Contribution of understory vegetation to ecosystem carbon and water fluxes

Undersory vegetation dynamics are clearly different between these two mixed conifer ecosystems. How does this play a role in the carbon and water fluxes that are seen from the measurements at the eddy covariance towers at each of these sites? Does more understory vegetation translate to more carbon uptake and more evapotranspiration?

6.2 Snow patch dynamics controlled by vegetation

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