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Rocky Mountain Hydrologic Research Center

The forerunner of the Rocky Mountain Hydrologic Research Center was the Rocky Mountain Hydraulic Laboratory organized under the laws of the State of Colorado on September 5, 1945. Chesley Posey found a site for the laboratory on the North St. Vrain Creek below Highway 7 near Allenspark, Colorado. At this 20-acre site alongside the North St. Vrain Creek, several hydraulic flumes were constructed and portions of those flumes can be seen today. Research was focused on bridge scour and open channel hydraulics. About 1960, the hydraulic research activity declined but the site has been used for more diverse research in recent years.

In 1991, the name was changed to the Rocky Mountain Hydrologic Research Center to reflect new research goals of conducting a broad range of hydrologic and environmental science investigations in this headwater area of the Rocky Mountains. The site has had little disturbance in the last 50 years. The site is still available for research and anyone interested need only contact any one of the Trustees of the Rocky Mountain Hydrologic Research Center listed below.

Cover: Photo of Sangre de Cristo Mountains in Southern Colorado near Villa Grove
Editor: John A. Moody

Assessing the spatial and temporal influence of surface waves on benthic sediments: Implications for management and restoration of shallow, eutrophic lakes

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Benthic sediments may play an important role in the regulation of water column nutrient concentrations, particularly in shallow, eutrophic lakes. Where water column turbulence is high, the physical resuspension of sediments and nutrient-rich interstitial water may enhance eutrophication and confound restoration efforts aimed at improved water quality. Ecosystem restoration projects and management plans for shallow lakes must therefore account for the spatial and temporal distribution of potential sediment resuspension by mechanisms such as wind-driven surface waves. Here, we demonstrate a technique for assessing the potential for surface waves to influence benthic sediments in a shallow (Z_{mean} = 2.9m), eutrophic lake (TP_{mean} = 188 mg·L^{-1}). The technique couples physical wave models with a GIS analysis of the lake basin, providing estimates of the spatial and temporal distribution of bottom influence. Results suggest that the when wind speeds exceed 10 m s^{-1} (22 mph), >46% of the lake's benthic surface area may be influenced by surface waves. Wind speeds >20 m s^{-1} (44 mph) can influence >98% of the lake bottom surface area. Intensive monitoring over a wind-event showed that total phosphorus concentrations can increase by over 100% over a diel period and ammonia concentrations increase to near toxic levels during daily peaks in wind speed.

The influence of a rock glacier and other alpine landforms on surface water chemistry in the upper Green Lakes Valley, Colorado

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Little research has been conducted on the chemical content of ice and runoff from rock glaciers. However, recent work has refocused efforts on the potential of rock glaciers to indicate past climate signals and reflect current changes in climate. Furthermore, rock glaciers have the potential to affect biogeochemical processes, water quality, and buffering capacity in alpine systems. In this study, we examine water quality from the Green Lake 5 Rock Glacier outlet stream in the Green Lakes Valley, Colorado Front Range. We compare the stream water quality with that of precipitation and outlet streams from the nearby Arikaree Glacier and Martinelli Snowpatch. Precipitation samples were collected year round, and stream water samples were collected roughly between May and October in the years 1998 to 2002. Water samples were analyzed for ANC, NH^4, Ca, Mg, Na, K, Cl, NO^3, SO^4, and Si. The water quality from all three land types was strongly controlled by chemical weathering and hydrologic flow paths, among other variables. In contrast with the other land types, solute concentrations in the rock glacier were lowest at snowmelt and then increased through summer and into early fall. Solute concentrations in snowpatch and glacial runoff were highest during snowmelt. On average, the solutes from chemical weathering products were often an order of magnitude higher in the rock glacier runoff. For example, mean Ca was 447 μL at the rock glacier compared with 17 μL at the Arikeree glacier and 66 μL at the Martinelli snowpatch. Mean NO^3 concentrations were also higher at the rock glacier at 50 μL compared with 8-12 μL in the glacial and snowpatch runoff. The exception is that Na and Cl concentrations were not significantly different between the rock glacier and snowpatch (95 % confidence level). The high concentrations of solutes in the rock glacier, especially in late summer/early fall, suggest the melting of old ice and change of climatic conditions. The increased yield of chemical weathering products indicates that rock glaciers have the potential to alter water quality and buffering capacity locally, and this land type should be considered when modeling water quality at fine spatial scales.

Floodplain stabilization by woody riparian vegetation during an extreme flood along headwater tributaries of East Plum Creek, Colorado

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Dense woody riparian vegetation acts to reduce flow velocities and boundary shear stresses on floodplain surfaces during large overbank flow events. Throughout the semi-arid west, woody riparian vegetation has been progressively thinned as the result of land use practices, such as grazing, and extensive reduction in beaver populations. When woody vegetation is sparse, the floodplain surface is vulnerable to high rates of erosion during overbank flows. Unraveling of a floodplain surface occurs when flow is deep enough and fast enough to cause the surface to erode. Once erosion begins, it proceeds rapidly, leading to transformation from a narrow, single-threaded stream to a much wider, braided stream, as occurred along most of the mainstem of East Plum Creek, Colorado, during an extreme flood on June 16, 1965. Effects of this flood along headwater tributaries of East Plum Creek were documented in large scale (about 1:2,500) aerial photographs taken two days after the flood. Evidence in the photographs along with available map data and field examination clearly show overbank flows were deep (on the order of 3 meters), yet the floodplain remained intact at sites with dense shrubs (sandbar willow). Two days after the flood, the shrubs were still lying bent over by the flood flow, and their canopy sizes and densities could be measured from the photographs. Within a 1.5-km reach, the downstream sequence of sites examined included: 1) locations where the floodplain surface and vegetation remained intact; 2) a location with less dense woody vegetation where the floodplain surface had just begun to erode; 3) locations with minimal woody vegetation, where the entire floodplain surface had begun to erode but a new channel had not yet formed; and 4) locations where erosion had caused a new, much wider channel to form and almost all pre-flood woody vegetation was removed. Estimates of pre-flood vegetation types and densities were made at each of these four sites. Boundary shear stresses were then calculated for each site using a process-based model that included drag on the sandbar willows (Smith, 2001). When compared to critical shear stresses for erosion estimated for each site, calculated boundary shear stresses accurately predict the observed site of initiation of unraveling.

Generation and verification of flow-model-produced rating curves in the Whitewater River network, Kansas

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In hydrologic research there are many situations in which river discharge is required at several locations for which the establishment of standard USGS gaging stations is too expensive or impractical. Under these circumstance, installation of pressure gages at judiciously chosen field sites and conversion of the stage measurements to discharge with a rating curve generated using appropriately designed flow and ancillary models is a viable and reasonably accurate alternative. As part of an NSF-supported investigation of the hydrology and meteorology of the Whitewater drainage basin in Kansas, we are developing and verifying the flow, sediment transport, and geomorphic adjustment models required for this purpose. Our current focus is on verifying our flow model for widespread application in the Whitewater drainage network. In order to be useful for generating discharge-rating curves, a flow model must be able to treat curved channels with irregular boundaries without employing any empirically adjusted parameters. Consequently, the model must explicitly calculate the effective flow resistance as a function of stage from measurements of (1) the physical roughness of the riverbed, (2) the physical roughnesses ofthe channel banks, (3) the physical characteristics of the bank vegetation and floodplain vegetation, (4) the physical roughness of the floodplain, and (5) the physical characteristics of the floodplain vegetation. We will give an overview of the methods we have developed to do this and present results from the first test of our model-based rating method, which was conducted on the Rock Creek Branch of the Whitewater River immediately downstream of a USGS gage.

Watershed characterization in Alaska's national parks

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This project is designed to develop a systematic method for basin classification in national parks in southwestern and central Alaska. The first phase involves the delineation of major basin boundaries falling within the national parks. The second phase of the project will characterize each basin with data available for use in geographic information systems (e.g. soils, topography, climate). The third phase will employ statistical comparison of these basin attributes to develop a typology of basins within the parks. A variety of purposes for such a project have been explored, including use as a tool for monitoring network installation, a baseline for analyzing basin evolution as new data becomes available, and as a tool for understanding processes with complex dynamics (e.g. anadromous fish distribution in rivers).

Watershed boundary and river network delineation in glaciated areas is often problematic. Tightly meandering reaches give way to complex braided sections with no well-defined channel. Much of this complex hydrology is located in subtle topography, which is poorly described by available topographic data. Watersheds with large distributary networks emptying into the ocean or lakes present their own set of problems. This poster will explore some of the problems encountered when attempting to delineate Alaskan basins using automated basin delineation techniques. It will also present some work in progress to address these problems

Applying tree-ring data to sustainable water management

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Sustainable water management in the western U.S. requires knowledge of the natural variability in water supply over time to plan for probable future conditions. The main, if not sole, basis for this knowledge has been gaged records of streamflow, which are at most 100 years long --too short to capture the full range of that variability, as the surprise generated by the "unprecedented" low streamflows in 2002 indicated. Reconstructions of streamflow derived from the ring-widths of moisture-sensitive trees, however, span 300 years or more and thus more fully describe the natural variability in water supply, including extreme low-flow events of concern to water managers.

In 2002, we began the TreeFlow project by partnering with water management agencies to develop high-quality reconstructions of annual streamflow in the upper Colorado, South Platte, and Gunnison River basins using a new network of ring-width chronologies from moisture-sensitive trees in Colorado. In the past year, we have generated reconstructions of annual flow for some 20 gages relevant to the operations of water management agencies that include Denver Water, the Northern Colorado Water Conservancy District, and the U.S. Bureau of Reclamation - Aspinall Unit. The reconstructions are from 300 to 600 years long, and explain more than 62% of the variance in the gaged records. The reconstructions indicate that the streamflow variability seen in the gaged records is not representative of the prior two to five centuries, and that the extreme events (e.g. 2002) have been exceeded in severity in the past. Water management agencies are now incorporating these reconstructions into water system models to test their systems' ability to perform under a broader range of conditions than contained in the 20th century gage records.

We continue to collaborate with water managers to develop meaningful hydroclimatic reconstruction products. Issues of particular interest include (1) the specification of uncertainty in the reconstructions, (2) the fidelity of the trees in reproducing the severity of 2002 flows, and (3) the feasibility of reconstructing summer flows and water demand. Two tasks undertaken recently are the collection and analysis of the 2002 tree-ring (see Lukas and Woodhouse abstract), and the development of an ensemble approach to streamflow reconstruction, which better describes the uncertainty in the reconstructions. Future work will include reconstructions using the latewood portion of the annual growth ring to reconstruct summer flow. We also continue to update and expand our network of tree-ring chronologies and reconstructions. An online resource, *TreeFlow: Tree-Ring Reconstructions of Streamflow for Colorado* (http://www.ngdc.noaa.gov/paleo/streamflow/) contains the reconstructions generated to date, as well as information on the quality of the reconstructions and the processes used in the reconstruction development.

Investigation of subglacial and englacial hydrology using borehole slug tests; Bench Glacier, Alaska

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Slug tests in groundwater applications have long been used to determine the hydraulic conductivity of aquifer formations in the immediate vicinity of monitoring wells. However, slug tests have rarely been used to help determine englacial and subglacial hydrological characteristics. A series of slug tests were performed on Bench Glacier, Alaska in order to characterize the subglacial and englacial hydrology. A total of 16 slug tests were performed over a period of one week in early June 2002, with an additional 20 slug tests performed over a period of 10 days in June 2003. The slug tests were performed at various times of the day in boreholes drilled to the bed of the glacier. During the 2002 field season, water levels were recorded in the slug hole and an adjacent hole approximately 10 meters away. In 2003, water levels were recorded in the slug hole and 5 adjacent holes (within a grid of 16 boreholes) located between 20 and 60 meters away. Responses to the slug of water varied from an overdamped, slow drain to an underdamped, oscillation of the borehole water levels. Modeling of the amplitude and frequency for the underdamped response reveals information on the geometry, capacity and configuration of the subglacial and englacial drainage systems. Analysis of the slug tests within the grid shows both temporal and spatial changes in the response and thus the system, providing insight into the development of the subglacial and englacial hydrologic systems.

The 2002 drought and the tree-ring record in Colorado

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Streamflow in water year 2002 was the lowest on record at most stream gages in Colorado. This "unprecedented" event motivated water managers to consider using tree-ring reconstructions of streamflow in order to place the 2002 event into a much longer context than that provided by gaged records. Of particular interest to water managers was how well the 2002 tree ring captured the extreme low flow values in 2002, and, by extension, how well other extreme one-year drought events might be captured in the tree-ring record. To address this, 12 tree-ring sites in western Colorado first collected in 2000 and 2001 were recollected in June 2003. The 2002 tree ring at these sites was compared to narrow rings in the 20th century and previous centuries, and to records of streamflow, snowpack, and precipitation. Similar analyses were performed for six tree-ring sites collected in the last year along the Colorado Front Range. These analyses show that (a) tree growth closely reflected the extreme low streamflow values in 2002, and (b) the 2002 drought event stands out from the paleorecord in its consistent severity across a broad swath of Colorado both east and west of the Continental Divide.

The Boulder Creek /St. Vrain Coordinated Hydrometeorological Observatory

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Several recent, national research strategies have stated that there is a critical need for coupled hydrometeorological research in regions such as mountain fronts due to marked surface heterogeneity and strong mechanical and thermodynamical forcing. Research has indicated that there are several catchments throughout the Front Range region of Colorado, which could serve as candidate basins. To minimize overall project costs, this effort has sought to maximize the use of existing observational infrastructure. It is clear from these analyses that the Boulder Creek/St. Vrain (BCSV) watershed possesses a remarkably dense network of instrumentation, sponsored by a number of agencies and institutions, which has been operational in various forms for several decades. Additionally, the BCSV watershed encompasses a large diversity of terrain landforms, eco-regions and climatic zones. As human population within the BCSV rapidly expands, multiple human interfaces are emerging which, when combined with the previous attributes, provide a rich environment for both basic and applications research. Despite possessing these assets, there currently does not exist a single, consolidated database, which archives and makes readily accessible, both historic and ongoing hydrometeorological measurements for the entire basin.

The purpose of this presentation is to outline plans to develop an inter-agency/inter-institutional Coordinated Hydrometeorological Observatory (CHO) and database, which will maintain and centralize critical data from a variety of new and existing sources and to make available such information in standardized formats to a diverse community of researchers within the BCSV-CHO and beyond. The vision for the BCSV-CHO and its components will be presented and active partnerships will be sought.

An Investigation of the hydrology of the Whitewater drainage basin, Kansas

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Comprehensive scientific investigations of regional hydrologic processes require strong meteorological input. This begins with accurate, spatially and temporally distributed rainfall rates, but also includes water loss from the vados zone through evaporation and transpiration into the atmospheric boundary layer. These meteorological processes, in turn, require accurate knowledge of (1) the surface topography, (2) the composition and spatial distribution of the vegetation covering the surface, and (3) the spatial structure of the soil moisture field. The U. S. Weather Research Program's Prospectus Development Team on Hydrology has recommended that comprehensive joint, regional scale hydrological/ meteorological investigations be carried out in what they called *natural laboratories*. One of the natural laboratories identified by this committee was the CASES site in the Walnut River drainage of Kansas. In preparation for a concerted joint investigation of the Walnut basin, a set of smaller preliminary meteorological and hydrological studies are now being undertaken in the Whitewater drainage basin, a sub basin of the Walnut River Natural Laboratory. Currently there are four major hydrological components to this investigation. First, the University of Iowa is examining the rainfall over the Whitewater basin using rain gages and various types of radar. Second, the University of Colorado is investigating the scaling structure of peak flows in the Whitewater river network. Third, the University of Colorado, together with the U.S. Geological Survey, is investigating stream flow in the links of the Whitewater river network. Four, all three of the above-mentioned groups are jointly examining how the rainfall runs off the landscape and into the river network and how this runoff is affected by land use. Additional comprehensive investigations of vados zone hydrology and groundwater recharge will be added as the project matures. The comprehensive scientific investigation of regional hydrologic processes requires at its foundation accurate knowledge of (1) the spatially and temporally distributed rainfall rates over the region and (2) discharge in a large number of links in the regional flow network. Owing to the cost of USGS gaging stations and the current existence of only two such gages in the Whitewater basin, the latter requirement has necessitated the development of a new method for gaging the streams in this network. This new approach permits stage to be measured at a large number of geomorphically stable sites that are remote from bridges and cableways, but it requires the rating curve for conversion of local stage to local discharge to be based on a flow model that explicitly accounts for the form drag on the physical roughness elements of the bed, banks, and floodplain (including trees and shrubs) in each measurement reach. By comparing rating curves generated with the new flow-model-based method to the one produced using standard USGS techniques for the furthest upstream of the two USGS gages, the new technique has been shown to be extremely accurate.

The effects of gradient on transport thresholds and channel morphology in mountain watersheds

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In mountain watersheds channel and bed-material properties can change abruptly over short distances owing to differences in valley morphology, hillslope and tributary sediment supply, woody debris, and the effects of glaciation. These factors are often related to changes in channel slope, both as cause and effect, and, as a result, slope exerts a strong influence on channel form. Downstream changes in channel gradient often reflect both the energy available for sediment transport as well as differences in flow resistance due to woody debris, immobile bed material, and the degree of bed armoring. The difficulty in applying stable channel theories to high-gradient streams thus relates to complexities in defining the critical shear stress for sediment motion (τ_c) and in estimating the shear stress (τ) available for sediment transport. Therefore, interpretations of channel form and sediment transport potential can possess large error related to inaccuracies in defining these quantities. This study assesses the variability of sediment initiation in mountain streams by utilizing coupled measurements of sediment transport and flow from over 40 gravel-bed streams representing a range in bankfull discharge (1-650 cms), slope (0.2-5%), and median surface grain size (0.027-0.21 m). Thresholds for sediment transport were defined for each study site by a dimensionless reference shear stress (τ^*_{ref}) corresponding to the value of τ^* associated with a small non-zero transport rate ($W^* = 0.002$). Values of the reach-average dimensionless reference shear stress (τ^*_{ref}) were found to be positively correlated to reach slope, and comparison to bankfull channel dimensions suggests a consistent ratio of excess shear stress, τ^*_{bf}/τ^*_{ref}, throughout the range of study sites. Channel morphology data from 27 study reaches from the Halfmoon Creek stream network in the Sawatch Mountains were used to test the applicability of this relation to a watershed with no sediment transport data. Downstream changes in sediment texture and channel morphology occur systematically throughout the watershed resulting in values of τ^*_{bf} that support the relation between τ^*_{ref} and slope. These observations suggest a consistent relationship between sediment initiation and bankfull channel morphology in Halfmoon Creek, and suggest that some, if not many, segments of mountain streams possess characteristics that can be explained in terms of rational theories for stable channels.

Changes in sediment loads of the San Juan and Green Rivers: Dams or climate change

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An index to the ability of rivers to transport sediment (Sediment Transport Capacity Index or STCI) was used to investigate changes in sediment loads in the Green River (Utah) and the San Juan River. It is well know that annual sediment loads in the Green River have been less following the beginning of storage in Flaming Gorge reservoir (November 1962) and in the San Juan River following the beginning of storage in Navajo reservoir in June 1962. In the San Juan River at Shiprock, New Mexico, the suspended sediment load was 10467 kilotons per year for the period 1952-1961 prior to storage; this became 6603 kilotons per year following construction (1964-1986). For the Green River at Green River, Utah the suspended sediment load prior to storage (1930-1962) was 19938 kilo-tons/year compared to 9524 kilotons per year in the 1964-1984 period following storage. There are two extremes in the range of explanations for the reduction of sediment loads in the Green and San Juan Rivers: 1) all of the reduction is caused by the reservoirs, or 2) all of the reduction is caused by climatically induced hydrologic change. The purpose of this presentation is to apply an index to sediment transport capacity in an attempt to determine the relative importance of climate change and the reservoir for the two rivers. There are two forms of the equation for the daily sediment transport capacity index (stci): 1) stci = {(qd-qcrt)/qref}**b and 2) stci = {[(qd-qcrt)**(b-1)]*qd}/(qref**b). The terms are where qd is the daily discharge, qcrt is some critical discharge, qref is a reference discharge and b is a power term derived from measured loads where possible and assumed based on experience if data is not available. Usually b is estimated from the load versus discharge relation or assumed to be 2.0. The critical discharge is determined from the available sediment load data. The annual value (STCI) is the sum of the daily values for a year. In the Green River analysis the pre-dam period was subdivided into two periods (1930-1944 and 1945-1962). A relation between the STCI and suspended sediment loads in the Green River was determined for the three periods; based on these relations the annual suspended sediment load at an STCI of 36700 kilo-tons for 1930-1944, 17598 for 1945-1962, and 11324 for 1965-1984. The STCI for the three periods was 202, 260, and 199. The tentative conclusion for the Green River is that the changes in the sediment yield caused by climate change are at least as large as the changes caused by reservoir construction. An analysis of the San Juan River resulted in the tentative conclusion that changes in sediment load of streams crossing the Colorado Plateau are mostly caused by changes in the nature of summer and fall storms on the plateau. An analysis of the channel maintenance was made using an index (CMCI) similar to the STCI and the assumption that only daily streamflows larger than the median annual maximum daily streamflow are effective in maintaining a channel. The pre-dam CMCI for the San Juan River at Shiprock was 460 compared to 3.2 following construction. The Animas River at Shiprock is little influenced by storage; the 4696 for the period prior to storage in Navajo reservoir and 1209 for the period following storage. The conclusion is the reservoir has a major impact on the ability of the San Juan River to maintain its channel but that climate change is also important.

The Colorado drought of 1999-2002 and how the March 2003 storm ended it locally

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This talk surveys the extent and severity of recent drought conditions in Colorado. It discusses the role of La Niña in creating multi-year droughts, and the role of El Niño in ending them. Special attention will be given to the March 17-20 storm that brought record amounts of moisture to the Northern Front Range in Colorado. I will close out with my most recent climate forecast for the upcoming winter.

The effect of hydrologic variability on the diversity of benthic invertebrates in a meandering gravel-bed river

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Sediment transport in natural channels affects benthic macroinvertebrate habitat integrity in two opposing ways: (1) In times of higher bed transport the potential for production of periphyton, the food source for most benthics, may be reduced or eliminated. Also, extremely high bed load transport increases mortality rates for taxa living on the channel bed. (2) In periods of low to zero sediment mobility, interstices between gravel particles may be reduced in size or quantity by the progressive infilling of fine sediment, which decreases habitat availability for macroinvertebrates. Therefore, there should be an ideal bed disturbance frequency or magnitude that would maintain the pore space in the sediments without eliminating the macroinvertebrate communities or their food supply. This hypothesis was tested in a meandering reach of the upper Colorado River in Rocky Mountain National Park for 2002 and 2003. The large 2003 spring snowmelt flood mobilized the entire bed of the channel and therefore provides a case where bed disturbance is recent and somewhat spatially-uniform. Contrastingly, the small 2002 snowmelt event limited particle mobility to local patches while the majority of the channel bed area was immobile. Thus, the 2002 and 2003 seasons provide end-member cases with which to evaluate the connection between ecosystem integrity and hydrologic variability in stream channels. Benthic macroinvertebrates were collected in the field using a Surber sampler at the same 6 locations for both years. Numbers of individuals of the orders ephemeroptera (mayflies), plecoptera (stoneflies), trichoptera (caddisflies), and diptera (e.g. chironomids) were determined in the lab and applied to indices of species evenness and richness. These data were combined with the topography and sediment characteristics of the sample reach. Preliminary results support the hypothesis that flow variability affects species diversity for stream invertebrates. This may have important implications for ecosystem restoration in gravel-bed rivers in mountain environments.

Relationship between surface characteristics and the surface energy budget in a Sand-Sagebrush steppe ecosystem

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The surface energy budget is strongly influenced by a variety of environmental factors such as the amount of vegetation and the soil moisture content. Understanding how the physical environment impacts the surface energy budget is important for numerous reasons ranging from ground-truthing satellite data to validating land-surface models and describing hydrologic processes. The objectives of this study were to determine both how the surface energy budget varied spatially and how physical environmental factors, such as leaf area index (LAI) and soil moisture, influenced that variation in a semi-arid sand-sagebrush steppe ecosystem. To accomplish this, surface energy budget data collected using a pair of eddy covariance stations located at the Platteville Atmospheric Observatory in northeast Colorado were compared. The use of these data allowed the variation in the components of the surface energy budget, as well as the physical characteristics of the study site, to be mapped on a fine-scale on the order of tens of meters. In addition, these data allowed the spatial correlation (as well as the temporal correlation) of both the components of the surface energy budget and the physical characteristics of the site to be calculated. This analysis demonstrated a strong relationship between how the energy was partitioned and the spatial pattern of LAI. This suggests that fine-scale variations in surface characteristics such as LAI can impact the partitioning of the surface energy budget. As a result, these fine-scale variations must be a consideration when ground-truthing satellite data or modeling land surface processes.

Spatial and temporal variability of soil moisture in response to fire

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Wildfires greatly impact western US ecosystems, where dry summertime conditions are ideal for forest fire ignition and expansion. The Hi Meadow fire of June 2000 was a high intensity burn that destroyed more than 5,000 ha of ponderosa pine dominated forest outside of Bailey, Colorado. This research addresses the impacts of the Hi Meadow fire upon the forest microclimate, focusing on changes in soil temperature and moisture. Microclimate characteristics were measured in a burned and unburned area of the forest in order to determine the impacts of the fire upon the burned area. The objectives of the research included comparing the variability of soil characteristics between and within each of the two sites and determining the main factors contributing to variability between the sites. A 100 by 100-m grid, divided into 36 points, with each point 20-m apart, was constructed in each site. Soil moisture, soil temperature and snow depth were measured at each of the points on a weekly basis from October 6, 2002 until present. In addition, canopy cover at each of the points was measured using an LAI-2000. Litter depth was measured at each of the points within the unburned site. The litter layer was completely combusted at the burned site, so depth at each of the points was zero. Marked differences exist between the soil characteristics at each of the sites, suggesting that the Hi Meadow fire did have an impact on the soil characteristics. The differences in soil characteristics were attributed to fire-induced differences in the burned area such as loss of canopy cover, loss of litter layer and changes to soil texture. Results from this study can be used to predict impacts of wildfire in similar environments, allowing for better management of forests after a fire. Additionally, the results can be used to assess the contribution of wildfire to energy changes on local, regional and global scales.

Understory vegetation characteristics in response to fire

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The forest canopy in a montane environment greatly affects the microclimate beneath it. The Hi Meadow Fire of June 2000 was a high intensity burn that devastated more than 5000 ha of ponderosa pine dominated forest outside of Bailey, Colorado. As a result, canopy cover was drastically reduced, and the soil's organic matter was completely combusted. To compare the effects of fire on understory vegetation, measurements of vegetation characteristics were taken in adjacent burned and unburned plots. Significant differences were noted as understory vegetation density, particularly of grasses, was far greater in the burned area. This variation is thought to be a direct result of the fire since after the burn, reseeding of different grasses took place. At present, grasses are abundant despite the absence of a littler layer. Comparison of soil data found the absence of a litter layer and reduced canopy cover greatly influenced soil characteristics at the burn site. Large soil temperature variability, decreased soil moisture content, decreased precipitation interception, and decreased leaf area index were all found at the burned plot. Forest overstory characteristics were also evaluated. Stand density was 35% greater at the burned site, while mean DBH measurements were 29% lower. Implications are that the Hi Meadow fire drastically changed the soil and canopy characteristics resulting in temperature and moisture conditions more suitable for a dense, understory vegetation cover, which may in turn preclude the germination of more desirable species.

Tracking dinosaurs around the world

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Dinosaur tracks are the nearest thing we have to movies of these extinct animals. Unlike skeletons which represent the dead, tracks represent live animals. They are also common and relatively easy to study as shown by recent finds of thousands of sites from around the world, including hundreds in Colorado and the Rocky Mountain west. They provide us with insight into many aspects of the life of dinosaurs including individual and social behavior, ecology and biases in the fossil record. Because dinosaur tracksites must be preserved in place, as part of the modern landscape, they are also a valuable field tool for science education and a challenge for resource management and conservation programs.

Prediction uncertainty in simulations of environmental systems

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Prediction uncertainty is the likely discrepancy between predictions used to manage a system and actual, unrealized system response. Contributions to uncertainty include anything that makes a simulation produce inaccurate predictions. This means that to reduce and accurately quantify uncertainty, each step of the modeling process needs to be carefully considered. Here, three aspects of the modeling process commonly omitted from discussions of prediction uncertainty are considered: (1) errors and limitations in model equations and numerical methods, (2) errors in field measurements and consequences for model calibration, and (3) using sensitivity analysis methods to trace the contributions of uncertainty from measurements, through model parameters, and to predictions.

The future of world water resources

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An increasing number of areas in the world are experiencing extremely difficult water shortages. Notable are problems in North Africa and the western part of the United States. At the same time, there is a super abundance of water resources in the world in the form of the oceans, the streams, the precipitation and the ground water. To solve the problem of water shortages, we must look not only at the problem of reduction in the conventional sources of water due to droughts but also the way in which we are now using our water. In the USA, 38 percent of our water is used for cooling of thermoelectric power plants that produce our electricity. A similar amount is used for irrigating our crops. Much is also used for industrial processes. These facts suggest that we need to rearrange our priorities wherever possible.

Since we have virtually unlimited sources of energy from the sun, the wind, and the oceans, it is possible to supplement our existing water supply by desalting seawater.

This paper discusses the ways in which the foregoing facts interact and can be used to solve, or at least mitigate, the very serious water problems with which we are now confronted.

The community collaborative rain and hail study -- CoCo RaHS

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The Fort Collins flash flood of July 1997 was the impetus behind a Colorado Front Range volunteer weather observing program. Since then, the project has grown to include over 1000 volunteers in Colorado and is spreading to western and southern portions of the state. Support from the National Science Foundation Informal Science Education Program will lead to further expansion into Wyoming, Nebraska and Kansas in 2004 and 2005. A high-density precipitation monitoring network along the Front Range has already revealed a number of fascinating characteristics of precipitation. This presentation will summarize some of the key findings during the first five years of this project.