Hydrology [H]

H21F MCC:level 2 Tuesday 0800h

Groundwater Resources Assessments Under the Pressures of Humanity and Climate Change Posters

Presiding: T R Green, USDA Agricultural Research Service; M Taniguchi, Research Institute for Humanity and Nature

H21F-1082 0800h

Factors Affecting the Sustainability of Groundwater-Source Cooling

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The use of groundwater in thermal applications has grown in popularity due to increases in environmental awareness and rising energy costs. While this source of energy is generally seen as beneficial to the environment, changes in subsurface temperatures resulting from thermal development and other factors may make this practice unsustainable. An example of such changes in subsurface temperatures has been observed in Winnipeg, Manitoba, where groundwater is extensively used for cooling applications. Temperatures in a regional aquifer beneath the city were found to be as much as ten degrees Celsius greater than those measured in surrounding rural areas. Numerical modeling indicates increases in temperature of up to 5 degrees Celsius can be attributed to downward heat flow originating in buildings in many cases. Areas where increases in temperature were found to be greater corresponded to areas where water is being injected into the aquifer. This water is being produced in the process of using groundwater for cooling applications, such as air conditioning and industrial cooling, and is being injected back into the aquifer to maintain hydraulic head and reduce the demand on Winnipeg's sewer system. In most cases, the heat introduced by injecting this water is significantly affecting temperatures at the production well of the same system and numerical modeling indicates that this is inevitable with the current method of development. The combination of heat loss from buildings and injection of heated water is largely responsible for a reduction in the efficiency of groundwater as a coolant and may eventually make the use of groundwater in cooling applications unsustainable.

H21F-1083 0800h

Influence of Land Cover on Regional Scale Groundwater Recharge: Analysis With NEXRAD Precipitation Data

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Most regional watersheds in Michigan experienced significant land use change over the last one hundred years. The potential impacts of these changes on regional groundwater and surface water systems have gained significant attention of stakeholders, yet the current scientific evidence is inadequate for policy makers to incorporate into watershed management decisions. We attempt to bridge this gap by exploring the dependence of groundwater recharge on land use and land cover in regional watersheds. Our approach involves identifying the base flow component of stream flow by analyzing stream flow response to NEXRAD derived precipitation data using statistical techniques and computer models. We then link this information with land use and other physical characteristics of regional watersheds to examine the influence of land use on groundwater recharge. The results of this research are expected to provide policy makers with the necessary information to implement more informed watershed management decisions.

H21F-1084 INVITED 0800h

Satellite Monitoring of Global Groundwater Resources

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In this presentation we discuss research and opportunities for satellite observations of global groundwater resources. We review the recent Gravity Recovery and Climate Experiment (GRACE) mission, including pre-launch and post-launch studies on monitoring aquifer storage changes, as well as plans to develop a set of global data products for exploring the role of groundwater in the global water cycle. These products will primarily be developed from GRACE observations, but would include other sensor data, in situ observations and model output as appropriate. Products may include global, monthly fields of groundwater recharge rates and storage changes; groundwater storage changes for a discrete subset of the world's major unconfined aquifers; and estimates of submarine groundwater discharge along continental margins. Such information could help constrain the storage, residence times, recharge and baseflow rates for the saturated subsurface, and would facilitate development or enhancement of groundwater parameterizations in the land component of climate models. Further, such information can help elucidate the role of progressively deeper soil moisture and groundwater storage in land memory and climate feedback processes.

H21F-1085 0800h

A Review of Climate Change and Societal Impacts on Groundwater: Implications for a UNESCO Initiative

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Global change issues have gained widespread interests, but hydrologic studies of the effects have been largely limited to surface and very near-surface processes. Global climate change/variability and human activities may also have pronounced effects on groundwater systems, including groundwater storage and fluxes (recharge and discharge rates). A new initiative in collaboration with the UNESCO International Hydrological Programme (IHP) will address various subjects (groundwater fluxes, storage, and quality), methods (simulation, data analysis, remote sensing, and paleo-reconstruction), and regions of the world. The aim is to investigate a range of high-priority research areas, including: 1) spatial and temporal scaling issues; 2) quantitative plant physiology and succession for environmental stress responses; 3) hydrological boundary conditions, including sea-level and snow-pack changes; 4) coupled atmospheric-hydrologic-oceanographic processes and their feedbacks; and 5) feedbacks associated with societal adjustments in land/water resource management. In this presentation, we review published and ongoing investigations in these areas to identify knowledge gaps and potential for collaborative research under the umbrella of a proposed international project on Groundwater Resources Assessments under the Pressures of Humanity and Climate change (GRAPHiC).

http://www.chikyu.ac.jp/USE/GRAPHIC/GRAPHIC.htm

H21F-1086 0800h

Climate and Human Pressures on Fresh Groundwater in Coral Atoll Island Nations in the Pacific

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Population centres in low, coral atolls have water supply problems that are amongst the most acute in the world. Limited land areas and highly permeable soils severely restrict surface water storage, forcing heavy reliance on groundwater. Fresh groundwater is extremely vulnerable to contamination through both natural processes, such as seawater intrusion following storm surges, sea-level rise and droughts, and human activities, such as overpumping, sewerage and waste disposal. Restricted land areas and seawater intrusion also limit fresh groundwater quantities, particularly in frequent ENSO-related droughts. Demand for water is increasing due to natural population growth, inward migration and to growing urbanisation. There are few water professionals in many small island nations. Assessment of groundwater resources is inadequate and application of conventional hydrology often gives erroneous information, such as the assumption of potential evaporation from coconut trees. Water use for traditional and introduced crops competes with community water supplies. Limited resources and isolation restrict the potential for exports so that reliance on aid is systemic. The agendas of developed world aid institutions sometimes conflict with traditions and cultures of small island communities. At the core of water management problems are lack of resource assessment and demand and land tenure and conflicts between the requirements of urbanised societies and the traditional values and rights of subsistence communities. Reforms of governance and provision of water resource knowledge to communities are critical. Long-term, regional partnerships and tools for reducing conflicts over water resources are needed to promote self-reliance.

H21F-1087 0800h

Capture Zone of a Pumping Well Between two Parallel Rivers

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We have presented analytical and semi-analytical solutions for the capture zones of a pumping well in a homogeneous, confined aquifer bounded by two parallel rivers, which are directly connected to the aquifer. We use complex potential to describe the flow field and use infinite image pumping/injecting wells to simulate the two lateral boundaries. This model is different from the previous model that has only one nearby river and required only one well to simulate the lateral boundary. Since we assume that the rivers are fully penetrating into the aquifer and the vertical recharge is negligible, the extracted water must be originated from one of the two rivers or both. Thus the model can be used to determine percentages of extracted water originated from each river. Normalized curve are presented as a tool to determine the shape, the stagnation points of the capture zone, and percentages of extracted water originated from each river. This study is particularly useful for planning or managing water supply wells located near two surface water bodies.

H21F-1088 0800h

The Impact of Climate Variability on the Water Resource Management of Ping-Tung Plain, Taiwan

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The annual average precipitation of Taiwan is 2515 mm, which is 2.6 times of the world annual average precipitation. However, due to steep topography of the island, only 15 percent of the total precipitation is available for the use of water resources. The recent climate change makes the situation even worse. To evaluate the impact of climate change on groundwater resources management, Ping-Tung Plain was taken as a research area. A conceptual hydrogeological model based on lithology, geophysics and geochemistry was constructed. Numerical modeling using Modflow-Surfact is conducted to investigate the impact on water resource due to the climate change in the southern Taiwan. The results show that under the condition of climate change the groundwater level in the mountain area of ping-Tung Plain will be affected most serious. Since the mountain area is the most important recharge area of Ping-Tung Plain, the lowering water level may show an alarm for the decrease of available groundwater of this area in the future.

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Geologically Mediated Groundwater Storage can be a First-Order Control on Streamflow Response to Changing Climate

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Previous research has revealed that spatial patterns of summer streamflow in the Cascade Mountains of Oregon vary dramatically between the geologically distinct High and Western Cascade regions. A key control on streamflow response between these two regions is the partitioning of water input between a fast-draining shallow subsurface flow network (Western Cascades) versus a slow-draining deeper groundwater system (High Cascades). These differences result from extremely high contrasts in rock permeability and porosity and drainage density between landscapes dominated by young versus old volcanic rocks. We consider how geologically-based differences in groundwater storage capacity can significantly alter streamflow response to climatic warming. In particular, we expect that for the young volcanic terrains comprising the High Cascade Range of Oregon and Northern California, ground water storage is of sufficient magnitude to buffer potential changes in snowpack volume, hence summer streamflow, due to changing climate. Older volcanic and granitic landscapes in the Oregon Western Cascades and California Sierras, in contrast, will be much more sensitive to diminished snowpacks and summer streamflow changes. Even within the Sierras, local variations in bedrock geology and associated differences in volume and seasonal fluxes of subsurface water will likely result in significant spatial variability in sensitivity to climate forcing. Taken together, these results imply that current models linking climate and streamflow changes need to account for differences in groundwater storage as a first-order control.

http://www.fsl.orst.edu/wpg

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Predicting Contrasting Responses to a Warmer Climate for Groundwater and Shallow Subsurface Dominated Systems in the Oregon Cascades

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Recent studies predict that projected climate change will lead to significant reductions in summer streamflow in the mountainous regions of the Western US. Hydrologic modeling applications directed at quantifying these potential changes have focused on the magnitude and timing of spring snowmelt as the key control on changes in streamflow regimes. In this study we use a process based, hydrologic modeling approach to explore the importance of geology as a regional scale control on summer streamflow sensitivity to climate variability. In the Oregon Cascades, our previous empirical analysis of streamflow patterns indicates strong spatial differences in summer streamflow behaviour between the High and Western Cascade geologic provinces. While differences in climate forcing contribute to the distinct flow regimes of the High and Western Cascades, our empirical analysis suggests that geologic based flowpath differences are the dominant control. We hypothesize that the prevalence of deeper groundwater spring systems in the High Cascades maintains higher and more consistent summer streamflow volumes relative to those of the shallow subsurface dominated Western Cascades. In this current research, we use a spatially distributed, process-based hydro-ecological model, RHESSys, to explore the relative roles played by climate and geologic-based difference in flowpaths in creating the distinct summer streamflow signatures of the High and Western Cascades. RHESSys is applied to two case-study watersheds of similar elevation and drainage area, Lookout Creek in the Western Cascades and Clear Lake in the High Cascades. A Monte-Carlo based hydrologic calibration is used to quantify difference in geologic based drainage efficiency between the two watersheds. Simulation scenarios using a range of climate forcing data are used to explore differences in the sensitivity of High Cascade and Western Cascade watersheds to predicted climate change. Results indicate that the groundwater system of the High Cascade site is likely to buffer the impact of increasing temperature and associated changes in snow accumulation and melt. Simulation results for the Western Cascade site, on the other hand, show responses similar to those predicted by previous larger scale hydrologic modeling efforts. These results illustrate the importance of groundwater flow mechanisms as a key control on climate change sensitivity in Oregon. We discuss future modeling efforts designed to extend this analysis to explore the impact of different groundwater flow mechanisms in the Sierras and to investigate the role of vegetation dynamics as a secondary control on summer flow regime sensitivity to climatic change.

H21F-1091 0800h

Environmental problems associated with groundwater flow system in the North China Plain

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Environmental problems in the North China Plain (NCP) have arisen since 1980s, when the national economy started to recover from a long time of stagnation. Population, resource, environment and development are four factors closely integrated, and environmental problems may occur when these four factors are not well balanced. Groundwater, as itself a factor of environment and resource, plays a key role in the sustainability of a certain area. Located in the eastern part of China, the North China Plain (NCP) is a very important region of agriculture in China. The project of water transfer from the South to the North was initiated in 2002 solve the water shortage problem of the area, and great environmental impacts on water cycle and groundwater flow system are to be expected. Three environmental problems are to be discussed in a detail: nitrate pollution in the groundwater, salination, and groundwater level draw down. Many environmental problems are closely related to groundwater in terms of either flow system or resource in the North China Plain. The accumulation of salt in the unsaturated zone and regional salination may become worse under the condition of extra water transferred from the south though the groundwater level is expected to recover to some extent. Nitrate pollution pattern and nitrate transport along groundwater flow system under new condition remain to be resolved as complicated biochemical processes are involved in nitrogen cycle.

H21F-1092 0800h

The interaction between irrigated water, groundwater and sea water in the Ise Plain, Japan

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A rice field is one of the most popular land utilization at the plains and delta in Japan. The large amounts of irrigated water used and stored at the rice field growing the rice, expanding the surface water areas, the irrigated water recharges strongly to the shallow groundwater during on-season for irrigation. So in this season, it is possibly considering that the water qualities and the water level of the shallow groundwater will change, and the interaction between shallow groundwater and seawater will be also changed by shallow groundwater discharge. The rice crop is one of the most important human activities that effect to the surface water-groundwater interactions. So it is important to understand surface water-groundwater interactions in order to plan for land utilization and water management on groundwater at Ise Plain and Ise Bay. The purposes of this study have been made (1) to evaluate the actual condition of the groundwater flow system in the inland area, (2) to evaluate the effect of irrigated water at the rice field due to seasonal changes in land utilization and water management on groundwater and Ise Bay. The pore-water resistivities were measured with using resistivity cable to evaluate seawater-freshwater interface in February, 2004 during off-season for irrigation, when the amounts of recharge irrigated water is essentially zero. So we can evaluate the almost natural condition of groundwater flow in this area. The other field surveys were carried out at 40 observation wells in each month from November 2003 through August 2004 to make clear the seasonal change of groundwater qualities and groundwater level. Water samples were analyzed for major cations and anions and NO3. Observation results show the fresh water discharges at the coast and the bottom of the sea, and groundwater level in on-season for irrigation is higher than that in off-season. In addition, chemical ions concentration in on-season for irrigation was lower than that in off-season. These suggest that the fresh water is recharged by the irrigated water, and effect to the chemical component of the seawater, when the fresh water discharges to the sea especially in on-season for irrigation.

H21F-1093 0800h

Terrestrial Sources of Perfluorinated Gases: Excess CF$_{4}$ and SF$_{6}$ in Mojave Desert Groundwaters

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The recent discovery of perfluorinated gases in fluid inclusions of granites and fluorites suggests a geologic source for the estimated 40 parts-per-trillion (ppt) of tetrafluoromethane (CF$_{4}$) and $<$0.006 ppt of sulfur hexafluoride (SF$_{6}$) in the preindustrial atmosphere. The accumulation of these gases in groundwaters with long residence times enables the detection of even small emissions from the surrounding aquifer material. We have measured high concentrations of CF$_{4}$ and SF$_{6}$ in groundwaters from the Mojave Desert, California. Dissolved SF$_{6}$ was extracted by a purge and trap technique and analyzed by gas chromatography with electron capture detection. Dissolved CF$_{4}$ was sampled by headspace extraction, using liquid helium to cryofocus the analytes prior to injection into the Medusa gas chromatograph/quadrupole mass spectrometer analytical system. Current precisions and accuracies for these measurements are on the order of 2% for both gases. Initial measurements of dissolved CF$_{4}$ concentrations range from $\sim$0.05 to $\sim$1.5 pmol kg^{-1}, about 5 to 15 times higher than expected for water in equilibrium with the preindustrial atmosphere at the local temperature and altitude of the recharge site. SF$_{6}$ concentrations range from $\sim$0.3 to $\sim$16 fmol kg^{-1}, up to several thousand times higher than expected for air-saturated water. Taking into account the large uncertainties in the estimated preindustrial atmospheric concentration of SF$_{6}$, and in the estimated atmospheric lifetimes of both SF$_{6}$ and CF$_{4}$, the ratio of their excess abundances in Mojave Desert groundwaters agrees within an order of magnitude with the estimated ratio of natural fluxes required to sustain their preindustrial atmospheric concentrations. Relationships among dissolved CF$_{4}$ and SF$_{6}$ concentrations and the other geochemical properties of the aquifer, including groundwater residence times (ages), helium abundances and isotopic ratios, and fluoride concentrations will be presented.

H21F-1094 0800h

Estimating Natural Recharge in a Desert Environment Facing Increasing Ground-Water Demands

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Ground water historically has been the sole source of water supply for the community of Joshua Tree in the Joshua Tree ground-water subbasin of the Morongo ground-water basin in the southern Mojave Desert. Joshua Basin Water District (JBWD) supplies water to the community from the underlying Joshua Tree ground-water subbasin, and ground-water withdrawals averaging about 960 acre-ft/yr have resulted in as much as 35 ft of drawdown. As growth continues in the desert, ground-water resources may need to be supplemented using imported water. To help meet future demands, JBWD plans to construct production wells in the adjacent Copper Mountain ground-water subbasin. To manage the ground-water resources and to identify future mitigating measures, a thorough understanding of the ground-water system is needed. To this end, field and numerical techniques were applied to determine the distribution and quantity of natural recharge. Field techniques included the installation of instrumented boreholes in selected washes and at a nearby control site. Numerical techniques included the use of a distributed-parameter watershed model and a ground-water flow model. The results from the field techniques indicated that as much as 70 acre-ft/yr of water infiltrated downward through the two principal washes during the study period (2001-3). The results from the watershed model indicated that the average annual recharge in the ground-water subbasins is about 160 acre-ft/yr. The results from the calibrated ground-water flow model indicated that the average annual recharge for the same area is about 125 acre-ft/yr. Although the field and numerical techniques were applied to different scales (local vs. large), all indicate that natural recharge in the Joshua Tree area is very limited; therefore, careful management of the limited ground-water resources is needed. Moreover, the calibrated model can now be used to estimate the effects of different water-management strategies on the ground-water subbasins.

H21F-1095 0800h

Using Spectral Analysis to Relate Climate and Land-Use Changes to Processes Influencing Stream Flow

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Stream flows are influenced by changes in both climate and land use. Understanding these factors is essential to accurately predict changes in future water resources. For instance, large-scale urbanization, reforestation, and climatic cycles alter peak, mean, and minimum annual flows-three key stream behavior indicators. Analyses of long-term hydrograph data in Michigan have revealed distinct trends in these indicators. For instance, in several regional Michigan watersheds, mean and minimum flows have increased over the last 70 years while peak flows have declined. These indicators, as well as the precise shape of the hydrographs, are governed by the interplay of hydrologic processes influenced by climate and land-use. Efforts at interpreting hydrographs often focus on characteristics of hydrograph peaks and recession curves and on extracting baseflow contributions from groundwater. These methods are all are limited by the complexities of the processes involved, as well as by the fact that some changes that may be ascribed to land-use effects rather than competing climatic effects. Spectral analysis can extract information about processes that influence stream flow by transforming time-series data into the frequency domain via algorithms such as the Fast Fourier Transform (FFT) or wavelet analyses. In this study, spectral analysis is performed on stream flow, precipitation, and groundwater head data from two regional watersheds in Michigan. The fluctuations in the forcing functions of stream flow, precipitation and groundwater, are then related to the stream flow spectrum. Additionally, climatic cycles, trends, and land-use change data from a Land-Transformation Model (LTM) are incorporated in order to explain super-annual trends in the spectral data.

H21F-1096 0800h

Predicting nitrate contamination in recently recharged groundwater: High Plains regional aquifer

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The High Plains regional aquifer, a nationally important groundwater resource, has widespread elevated nitrate concentrations in recently recharged groundwater. This condition has created a potential health concern for nearly 2 million people who rely on the aquifer for drinking water. Concentrations and spatial distribution of nitrate are influenced by anthropogenic activity, particularly from non-point source contamination. A novel groundwater vulnerability assessment encompassing the entire High Plains aquifer is presented that predicts areas of the aquifer where nitrate concentrations are expected to exceed a background value of 4 mg/L as N in recently recharged groundwater, defined as less than 50-years old. This model couples particle-tracking simulations and multivariate logistic regression analysis within a GIS framework, thereby incorporating site-specific hydrogeologic parameters and the groundwater flow regime. Contributing areas, delineated by a 90-degree sector, represented the capture zone up gradient from the well location and defined the area for GIS-based extraction of explanatory variables for statistical modeling. Particle-tracking simulations identified the appropriate radial length for the sector and well screen depths corresponding to recently recharged groundwater. Horizontal and vertical particle movements were most sensitive to hydraulic conductivity and estimates of recharge, respectively. The final multivariate logistic regression model demonstrated statistical significance ($p < 0.001$), produced an excellent model fit ($R^{2} = 0.912$), and was validated with an independent nitrate data set ($R^{2} = 0.856$). Statistically significant explanatory variables in the contributing areas included percent agricultural land ($p < 0.001$), depth to water table (p = 0.001), soil infiltration score (p = 0.013), nitrogen applied as fertilizer on irrigated agricultural land (p = 0.050), and percent clay in the unsaturated zone (p = 0.040). Predicted groundwater vulnerability corroborated our conceptual model that nitrate concentrations are directly related to nitrogen loading at land surface and infiltration in the soil zone, and inversely related to impedances to downward advective chemical movement through the unsaturated zone. The nitrate vulnerability model and map offer a predictive tool for water resource managers to identify likely areas of non-point source contamination and evaluate the impact of anthropogenic activity on nitrate distribution in groundwater.

H21F-1097 0800h

The Sensitivity of the Northeast Colorado Moist Convective Environment to Upstream Soil Moisture Conditions

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Statistical evidence supports a hydro-dynamic link between severe thunderstorm activity in Northeast Colorado and antecedent snow condition in the upstream higher elevations. Two subsets of seven runoff seasons were created, based on the criteria of anomalously high and low cumulative streamflow discharge from the Colorado Rockies. Observational evidence suggests that the morning time lower atmosphere, during the months of May and June, over Denver, is cooled and moistened following an anomalously large runoff season when compared to seasons of meager runoff. Furthermore, comparison of Northeast Colorado severe thunderstorm reports reveals that severe weather occurrences of hail greater than _ inch in diameter, tornados, and damaging thunderstorm downdrafts, occurred on average 51 minutes earlier following years of anomalously high runoff compared to the low runoff years. The character of severe weather also appears to be altered so that high runoff years yield a significantly reduced percentage of tornadic reports over the Northeast Colorado plains. The proposed mechanism put forth to explain the presumed alteration of the lee plains' convective environment and the nature of severe thunderstorm activity, links alpine surface moisture conditions to lagged thermal and moisture attributes of the downstream elevated mixed layer which caps the convective boundary layer. Moist surfaces attributed to snowpack, ponding of melt water, and saturated soils are known to increase evapotranspiration so that the coupled boundary layer is cooler and moister than would be observed under drier conditions. The nocturnal decoupling of the boundary layer from the surface forms a residual layer which is surmised to retain the attributes imparted to it according to the degree of soil moisture present during the previous day. Mean late spring/early summer prevailing wind velocity supports the likely presence of an elevated mixed layer, with similar attributes of the aforementioned residual layer, to overly the downstream lee plains during the course of the following day. Consequently, the apparent atmospheric response over Northeast Colorado to (increased /decreased) surface moisture at upstream high elevations is to (weaken/strengthen) the capping layer. It follows that the warming of the capping layer, which would follow dry conditions in the upstream higher terrain, should lead to a reduction in boundary layer depth, a delay in the diurnal timing of thunderstorm formation, and an increase in the spacing between penetrating deep moist convective cells, all of which are known to increase the likelihood and/or magnitude of severe weather in this region, while at the same time, reducing areal coverage of convective rainfall. Observational evidence supports this conclusion.

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Impact Of Initial Soil Wetness On Seasonal Climate Prediction

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This study investigates the importance of initial soil wetness in seasonal climate predictions with ECHAM4.5 AGCM (T42). Three experiments are performed, each consisting of five ensembles of AGCM integrations from February to May 1979-1998. In the first experiment, all ensembles are initialized with NCEP reanalysis-2 soil wetness data set, and use monthly varying climatological SSTs. In the second experiment, all ensembles are initialized with model climatological soil wetness, and use observed SSTs. In the third experiment, all ensembles are initialized with NCEP reanalysis-2 soil wetness data set, and use observed SSTs. After initialization, the AGCM predicts the evolution of the soil wetness fields in all experiments. The contribution of both SSTs and initial soil wetness to the climate variability over East Africa during March-April-May season (i.e., long rains) is examined. Both SST forcing and initial soil wetness anomalies exert some influence over East Africa. But each forcing alone is not strong enough to capture the observed climate variability. With both forcings in the AGCM, the model can reproduce the observed atmospheric circulation. The results suggest that seasonal atmospheric prediction over East Africa could be enhanced by using a realistic initial state of soil wetness.

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Development of a Statewide, Interbasin Flux Network to Monitor Evapotranspiration Changes During and Following Riparian Restoration in New Mexico

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Local, state, and federal legislation has made millions of dollars available for the removal of saltcedar from Western waterways. These programs are based upon the assumption that enormous water salvage will be obtained through such restoration efforts. To test these assumptions, flux towers are being established in restored and un-restored sites in the Canadian and Pecos river basins. These systems are being integrated into a flux network with long-term riparian flux stations in the Middle Rio Grande. This network is based upon the data-sharing model presented by FluxNet (AmeriFlux, EuroFlux, etc). Predictive and functional relationships between groundwater (e.g., depth, rate of change), vegetation (e.g., leaf area index, leaf chlorophyll content, water source, and transpiration), micrometeorological conditions (e.g., friction velocity, vapor pressure deficit, wind speed, and wind direction), and fluxes have been generated for saltcedar and cottonwood forests along the Middle Rio Grande. This prior knowledge will be used to parameterize and test the role of remote sensing imagery and hydrological models on the Canadian and Pecos Rivers. From such a functional understanding of energy, carbon, and water cycles in a regional context, more precise and accurate estimates of water salvage are obtained for whole basins under a range of restoration scenarios.

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Impact of Land use Change From Natural to Agricultural Ecosystems on Groundwater Recharge

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Recharge is a critical component of the water cycle for groundwater resources. The purpose of this study was to evaluate the impact of land use changes from natural to agricultural ecosystems on groundwater recharge in the Amargosa Desert, Nevada and Southern High Plains, Texas. A variety of approaches were used to evaluate groundwater recharge, including noninvasive electromagnetic induction, matric potential monitoring, and chloride and nitrate profiles. The results of the study indicate that recharge is highly correlated with land use: negligible recharge beneath natural ecosystems, moderate recharge beneath nonirrigated agricultural ecosystems, and augmented but variable recharge beneath irrigated agricultural ecosystems. Low matric potentials, upward potential gradients, and accumulations of chloride and nitrate indicate little or no recharge beneath large areas of native vegetation. High matric potentials, low chloride and nitrate concentrations, and rising groundwater tables indicate induced recharge beneath areas of nonirrigated agriculture. High matric potentials and low to moderate chloride and nitrate concentrations indicate substantially augmented recharge beneath areas of irrigated agriculture according to type and amount of irrigation. Conversion of native vegetation to irrigated agriculture is accompanied by increases in matric potential and downward displacement of accumulated chloride and nitrate in the Amargosa Desert. However, lower irrigation application rates result in negligible drainage below the root zone beneath center pivot irrigation systems in the Southern High Plains as shown by matric potential monitoring. Noninvasive EM induction proved useful in distinguishing subsurface flow beneath natural and nonirrigated agricultural areas and may be used as a reconnaissance tool to map the effects of agriculture on subsurface water movement. The point data from the vadose zone are consistent with regional increases in groundwater levels of 10 - 20 m during the last 30 to 50 yr beneath nonirrigated agricultural regions in the Southern High Plains. Degradation of groundwater quality over that time may be attributed to flushing of salts into the underlying aquifer. Combining different approaches for estimating groundwater recharge provides a more comprehensive understanding of the impacts of land use change on groundwater recharge over different space and time scales. Understanding forcings and feedbacks between land use change and recharge is critical for optimal management of groundwater quantity and quality in the southwestern United States.

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