Session: Mississippi Alluvial Plain Groundwater Project

Coupling Modeling with Monitoring to Assess Water Availability in the Mississippi Alluvial Plain

Tuesday, December 5, 2017: 10:40 a.m.

101 C (Music City Center)

https://ngwa.confex.com/ngwa/2017gws/webprogram/Paper11819.html

Wade Kress, Lower Mississippi-Gulf Water Science Center, U.S. Geological Survey, Nashville, TN

Brian Clark, Lower Mississippi-Gulf Water Science Center, U.S. Geological Survey, Fayetteville, AR

Jeannie Barlow, PhD, Lower Mississippi-Gulf Water Science Center, U.S. Geological Survey, Jackson, MS

The Mississippi Alluvial Plain (MAP) is one of the most important agricultural regions in the United States, and crop productivity relies on groundwater irrigation from a system that is poorly understood. Groundwater use from the Mississippi River Valley alluvial aquifer (MRVA) has resulted in substantial groundwater-level declines and reductions in baseflow in streams within the MAP. These impacts are limiting well production and threatening future water availability for irrigation in the region. Accurate and ongoing assessments of water availability in the MAP region are critically important for making well-informed management decisions about sustainability, establishing best practices for water use, and identifying predicted changes to the regional water system over the next 50-100 years. To provide stakeholders and water-resource managers with information and tools to better understand and manage available water resources within the MAP, the U.S. Geological Survey (USGS) initiated a regional water availability project funded by the Water Availability and Use Science Program (WAUSP). The MAP project couples modeling with monitoring to improve the characterization of the alluvial aquifer system in an existing numerical-groundwater-simulation model. The premise of the investigation is to evaluate the existing groundwater model and produce an estimate of the uncertainty of the model inputs, such as hydraulic conductivities, storage, streams, recharge, and water use. Based on the uncertainty results, additional data are collected (monitoring) to improve the model. After which, the uncertainty will be estimated again, and the process will be repeated as necessary. Through this iterative method of modeling and monitoring, a more dynamic, 'living', numerical model will be available to more accurately represent groundwater flow in the system. The MAP groundwater model can then be used to help manage water resources, evaluate potential future effects of water-use changes, conservation practices, construction of diversion-control structures, and climate change.

Quantifying Water Use in the Mississippi Alluvial Plain

Tuesday, December 5, 2017: 11:00 a.m.

101 C (Music City Center)

https://ngwa.confex.com/ngwa/2017gws/webprogram/Paper11863.html

Drew Westerman, Lower Mississippi-Gulf Water Science Center, U.S. Geological Survey, Little Rock, AR

Wade Kress, Lower Mississippi-Gulf Water Science Center, U.S. Geological Survey, Nashville, TN

Jeannie Barlow, PhD, Lower Mississippi-Gulf Water Science Center, U.S. Geological Survey, Jackson, MS

The Mississippi Alluvial Plain (MAP) is one of the most important agricultural regions in the United States with an estimated water-use demand for irrigation to be over 10 billion gallons per day. Crop productivity relies on groundwater irrigation from the Mississippi River Valley alluvial (MRVA) aquifer - an aquifer system that is not fully understood in terms of water-level response to pumping, sources of recharge and the water budget components. Withdrawals from the MRVA aquifer have resulted in substantial declines in groundwater-levels and reductions in stream baseflow, and a realization that continued rates of withdrawal may not be sustainable to maintain the aquifer as a source for irrigation in the region. To address this need in the MAP, the U.S. Geological Survey has initiated a regional water-availability study to improve characterization of the MRVA aquifer system. Understanding the water-use demands within the MAP region is imperative before questions of water availability and sustainability can be addressed. Water-use represents one of the largest components of the water budget and is significant variable in groundwater-flow models. The USGS plans to improve water-use estimates by establishing a regional water-use monitoring network and enhancing the existing State networks within the MAP region. These data along with multiple remotely-sensed (or GIS) data variables will be evaluated geostatistically to develop a dynamic irrigation water-use model to provide a consistent and improved estimate of water-use throughout the MAP. The irrigation water-use model will include variables such as; remotely-sensed data, climate data, crop types, soil types, and amount of irrigated acres to estimate water-use both spatially and temporally for the MAP region. Improving estimates of water use will improve groundwater-flow model predictions, and help guide management strategies to improve sustainability of water resources to meet the needs of humans and ecosystems.

Development of Monthly Water Budget Estimates for the CONUS and Application to the Mississippi Alluvial Plain

Tuesday, December 5, 2017: 11:20 a.m

101 C (Music City Center)

https://ngwa.confex.com/ngwa/2017gws/webprogram/Paper11827.html

Meredith Reitz, National Research Program - Eastern Branch, U.S. Geological Survey, Reston, VA

Ward E. Sanford, U.S. Geological Survey, Reston, VA

Gabriel Senay, EROS Data Center, U.S. Geological Survey, Ft Collins, CO

Wade Kress, Lower Mississippi-Gulf Water Science Center, U.S. Geological Survey, Nashville, TN

David Ladd, Lower Mississippi - Gulf Water Science Center, U.S. Geological Survey, Nashville, TN

As water resources become increasingly strained in the US and globally, the development of reliable methods of water availability estimation becomes ever more critical for making informed water use management decisions. Here we present new monthly 1km-resolution estimates of the set of water budget components of evapotranspiration (ET), surface runoff, snow storage, and recharge for the modern time period of 2000-2013. We use a combination of remote sensing products and empirical estimates from ground-based data, to leverage both the spatial/temporal resolution of remote sensing and the overall magnitude checks from field data. For ET we use a combination of the MODIS-based USGS SSEBop data set and long-term ET magnitude estimates based on water balance data. We estimate runoff with an empirical regression against soil and surficial geology data, and use the SNODAS snow water equivalent product of the National Snow and Ice Data Center to incorporate snow storage. Recharge and groundwater storage change are then estimated as the balance of the precipitation for the month. After presenting the methods and CONUS-scale maps, we show an application of this work to understanding water availability in the Mississippi Alluvial Plain region, which has seen significant impacts on water resources due to irrigation and groundwater pumping. Our monthly timescale estimates are compared with results from other methods, and synthesized into a summary of water budget trends in the region.

Evaluation of Recharge and Evapotranspiration Estimation Methods in the Mississippi Alluvial Plain

Tuesday, December 5, 2017: 11:40 a.m.

101 C (Music City Center)

https://ngwa.confex.com/ngwa/2017gws/webprogram/Paper11832.html

David Ladd, Lower Mississippi - Gulf Water Science Center, U.S. Geological Survey, Nashville, TN

Meredith Reitz, National Research Program - Eastern Branch, U.S. Geological Survey, Reston, VA

Brian Clark, Lower Mississippi-Gulf Water Science Center, U.S. Geological Survey, Fayetteville, AR

The Mississippi River Valley alluvial aquifer which underlies the Mississippi Alluvial Plain (MAP) is heavily used for irrigated agriculture and is one of the top three aquifers in the U.S. in terms of groundwater withdrawals for irrigation. Recharge and evapotranspiration (ET) are critical components of the overall water budget in the MAP area. Variations in the magnitude and spatial distribution of these water-budget components due to differing estimation methods could affect the results of the groundwater flow model developed for the Mississippi Embayment Regional Aquifer System (MERAS) used to simulate flow in the MAP area. A comparison of available methods to estimate recharge and ET points out the variability in estimates of these water budget components in the MERAS area. The results for recharge estimates from the PRISM-based calculations used in the original MERAS model are compared to those from the Soil-Water-Balance (SWB) model and from long-term Empirical Water Budget (EWB) estimates. The recharge estimates are examined in areas of differing irrigation intensity, and compared to field-based estimates where available.

Characterizing Groundwater and Surface-Water Interaction in the Mississippi Delta Using Hydrograph Separation

Tuesday, December 5, 2017: 1:20 p.m.

101 C (Music City Center)

https://ngwa.confex.com/ngwa/2017gws/webprogram/Paper11828.html

Courtney Killian, Geosciences, Mississippi State University, Mississippi State, MS

Jeannie Barlow, PhD, Lower Mississippi-Gulf Water Science Center, U.S. Geological Survey, Jackson, MS

Paul Barlow, U.S. Geologic Survey WRD, Northborough, MA

Wade Kress, Lower Mississippi-Gulf Water Science Center, U.S. Geological Survey, Nashville, TN

Darrel Schmitz, PhD , Geosciences, Mississippi State University, Mississippi State, MS

Understanding the relationship between groundwater withdrawals and aquifer response can allow for the estimation of changes in groundwater availability over time and help determine best water-resource-management practices to sustain groundwater and surface water resources for agricultural irrigation, ecological flow, and other uses. An increase in groundwater withdrawals from the Mississippi River valley alluvial (MRVA) aquifer for agricultural irrigation has resulted in stream and groundwater level declines in the Mississippi Delta region, in northwest Mississippi. In 2016, the U.S. Geological Survey (USGS) began a study to better understand the effects of pumping on groundwater availability in the alluvial aquifer. Two USGS continuous continuous-gaging stations and co-located piezometers provided hydrologic data to characterized groundwater/surface-water interaction at two sites in the Delta. The sites are located at the Sunflower River at Sunflower, Mississippi and the Tallahatchie River at Money, Mississippi. Baseflow, the amount of groundwater that contributes to streamflow, was estimated at each site using hydrograph-separation and trend-analysis techniques provided in the USGS Groundwater Toolbox open-source software. Recently collected streambed resistivity data provided insight into the variability of hydraulic connectivity along streambeds and values were compared with the hydrograph separation and trend analysis results. This combination of techniques allowed for better characterization of the hydrogeologic conditions and the groundwater/surface-water interactions at the selected site. Characterizing hydrologic relations such as this will help refine a regional groundwater model of the Delta that will aid water-resource managers in future decisions pertaining to groundwater availability of the alluvial aquifer.

Geophysical Surveys to Characterize Geologic Controls on Aquifer Recharge and Surface Water–Groundwater Exchange

Tuesday, December 5, 2017: 1:40 p.m.

101 C (Music City Center)

https://ngwa.confex.com/ngwa/2017gws/webprogram/Paper11831.html

Ryan Adams, Lower-Mississippi Gulf Water Science Center, U.S. Geological Survey, Nashville, TN

Wade Kress, Lower Mississippi-Gulf Water Science Center, U.S. Geological Survey, Nashville, TN

Steven Peterson, Peterson , Nebraska Water Science Center, U.S. Geological Survey, Lincoln, NE

Brian Clark, Lower Mississippi-Gulf Water Science Center, U.S. Geological Survey, Fayetteville, AR

The U.S. Geological Survey (USGS) developed a groundwater-flow model of the Mississippi Embayment Regional Aquifer System (MERAS) that incorporated multiple aquifers including the Mississippi River Valley alluvial (MRVA) aquifer. In addition to groundwater withdrawal, two major fluxes in the model are recharge from precipitation and surface water-groundwater exchange. In order to determine appropriate values for recharge to the MERAS model, the USGS has utilized two published datasets- the geomorphology of Quaternary deposits and local soil surveys. At a regional scale, recharge in the MERAS model correlate well with large-scale geomorphological features. However, there is little spatial variability, so local-scale variations in recharge are not adequately represented. Higher resolution data such as soil coverages provide a more spatially-variable estimates of recharge, but, soil-survey data often characterize the shallow soil horizon and do not reflect the generalized geomorphological features in which the horizon lies. In addition, streambed sediments may differ greatly from the mapped geomorphologic areas and shallow soils due to alteration from stream mechanics. Thus, geomorphologic maps and soil information are both types of surficial information that may not accurately reflect the underlying hydrogeology that controls infiltration of recharge water or the composition of streambed sediments.

In 2016-17, the USGS conducted several waterborne geophysical surveys to characterize the near-surface (<12 m) lithology that controls recharge to the MRVA aquifer and surface water-groundwater exchange at selected locations within the Mississippi Alluvial Plain (MAP). Two-dimensional vertical profiles of resistivity identified differences in geoelectrical properties of the streambed. High resistivity values are associated with coarse grained sediments and low values are indicative of fine grained materials. These resistivity-derived lithologies were then transformed using several techniques to inform the estimated hydraulic conductivity of the simulated streambed and refine the characterization of streamflow interactions in the MERAS groundwater-flow model.

Initial Assessment of Agricultural Water Management Scenarios in the Mississippi Delta

Tuesday, December 5, 2017: 2:00 p.m.

101 C (Music City Center)

https://ngwa.confex.com/ngwa/2017gws/webprogram/Paper11903.html

Connor Haugh, Lower Mississippi-Gulf Water Science Center, U.S. Geological Survey, Nashville, TN

Jeannie Barlow, PhD, Lower Mississippi-Gulf Water Science Center, U.S. Geological Survey, Jackson, MS

The Mississippi River alluvial plain in northwestern Mississippi (referred to as the Delta), once a floodplain to the Mississippi River covered with hardwoods and marshland, is now a highly productive agricultural region of large economic importance. Water for irrigation in the Delta is supplied primarily by the Mississippi River Valley alluvial aquifer. Although the aquifer has significant storage capacity, there is evidence that the current rate of water use is exceeding the available supply from, the aquifer. In an effort to better understand the impacts of different water-management scenarios on water availability and to identify additional monitoring needs in the Delta, the U.S. Geological Survey and the Mississippi Department of Environmental Quality are collaborating to update and enhance an existing regional groundwater-flow model. As a result of this collaboration, the model has been updated through 2013 with the most recent water-use data, precipitation and recharge data, and streamflow and groundwater-level data. The updated model has been used to evaluate alternative water-supply scenarios in order to assess impacts to the alluvial aquifer and identify data needs for future groundwater management modeling. Alternative water-supply options assessed to date include: 1) increased irrigation efficiency; 2) tailwater recovery and on-farm storage; 3) surface-water augmentation; 4) inter/intra-basin surface-water transfers; and 5) groundwater transfer. A relative comparison approach was used to calculate the simulated water-level response due to each scenario. Water-level response is the difference between water-levels simulated by the alternative-supply scenario and those simulated by a base case or “no action” scenario. Water-level response in the alluvial aquifer varied for each scenario based on the location and magnitude of the implemented alternative-supply option. These initial model results will serve to develop and assess conjunctive water-management-optimization scenarios as well as improve and enhance current and future monitoring activities within the Delta.

Using a model's purpose to guide model updates: The case of the Mississippi Alluvial Plain aquifer

Tuesday, December 5, 2017: 2:20 p.m.

101 C (Music City Center)

https://ngwa.confex.com/ngwa/2017gws/webprogram/Paper11866.html

Brian Clark, Lower Mississippi-Gulf Water Science Center, U.S. Geological Survey, Fayetteville, AR

Jeremy White, US Geological Survey WRD Texas Water Science Center, Austin, TX

Daniel Tebo, Texas Water Science Center, U.S. Geological Survey, Austin, TX

Wade Kress, Lower Mississippi-Gulf Water Science Center, U.S. Geological Survey, Nashville, TN

Uncertainty and data-worth analyses evaluate the reliability of computer model outputs and estimate which model inputs are contributing most to model output uncertainty. These analyses direct decision makers to well-informed decisions and allow practitioners to estimate data importance for reduced model output uncertainty.

These techniques have been applied to the existing Mississippi Embayment Regional Aquifer System (MERAS) model to guide data collection and model dataset construction for the proposed Mississippi Alluvial Plain (MAP) aquifer model. The focus of the MAP model is to forecast aquifer water levels and surface-water/groundwater (SW-GW) exchange under different climatic and water-use conditions. Forecasts of interest (FOIs) simulated by the MERAS model include water levels and SW-GW exchange along major surface-water features under conditions of less recharge and increased water use. Preliminary results from the uncertainty analysis indicate streambed conductance values may better constrain uncertainty in water-levels and streamflow, which can be used to guide data collection in the field. These results will be presented and discussed in the context of data collection and model data preparation.

Poster Session:

Informatics of Water-Level Measurements for the Mississippi River Valley Alluvial Aquifer, USA

Monday, December 4, 2017

Davidson Ballroom Foyer (Music City Center)

https://ngwa.confex.com/ngwa/2017gws/webprogram/Paper11885.html

William Asquith, Ph.D., P.G. , U.S. Geological Survey, Lubbock, TX

Wade Kress, Lower Mississippi-Gulf Water Science Center, U.S. Geological Survey, Nashville, TN

Ronald Seanor, U.S. Geological Survey, Ruston, LA

The Mississippi River Valley alluvial aquifer (MRVA) underlies much of the Mississippi River alluvial plain (MAP). A large regional study by the U.S. Geological Survey (USGS) of the hydrogeology and numerical groundwater-flow models of the MAP is on going (c. 2016–2021). The poster describes some research into the MRVA water-level database (16,756 wells; 285,429 measurements). A complex history of MRVA data collection exists over the past century by the USGS and equally important, numerous other local, state, and federal agencies. Data anomalies potentially represent erroneous information and hinder scientific study—Objective large-scale identification of such data is the primary focus of groundwater informatics for the MRVA. Two types of anomalous data are sought: (1) time-series outliers and (2) spatial outliers. Time-series data permit well-hydrograph visualization and temporal trend analyses using generalized additive (GAM) and support vector machine (SVM) models. Measurements exceeding a residual magnitude of 20 feet are flagged as outliers and relayed to database administrators (DBAs) for further scrutiny. Spatial outlier detection is based on period-of-record minimums using a two-dimensional (2D) GAM. Wells with data "out-of-place" in a local region are flagged as outliers and relayed to DBAs for further scrutiny. Patterns in decadal means for 2000 and 2010 are depicted. Exploratory long-term monitoring network identification using a 2D-SVM is made. Wells "supporting" the 2D-SVM are more informative than those not supporting it.

Using a Groundwater Model To Analyze Depletion Mapping For The Mississippi Alluvial Plain Groundwater Project

Monday, December 4, 2017

Davidson Ballroom Foyer (Music City Center)

Steven Peterson, Peterson, Nebraska Water Science Center, U.S. Geological Survey, Lincoln, NE

https://ngwa.confex.com/ngwa/2017gws/webprogram/Paper11774.html

The Mississippi Alluvial Plain (MAP) is among the most productive agricultural regions in the United States. This agriculture is enhanced through substantial groundwater irrigation, resulting in groundwater level declines in parts of the area. Efforts are currently (2017) underway to update the information and science available to support water-resources decisions and sustain future water availability. Groundwater models representing the major regional groundwater flows in a larger area encompassing the MAP have been published from 2009-2017. Even prior to integration of new data and approaches, these groundwater models also can be used in their current state to map depletions, which are like responses to increased stresses.

For a depletion mapping analysis, a model of an area for a specified time period is first run under a baseline condition. Simulated groundwater flows to various simulated boundary conditions are recorded, such as for streams, groundwater levels, and wells. Next, a new well is added to one model cell, the model is rerun, groundwater flows to various boundaries are again recorded, and the results are compared with the baseline condition. Results are commonly expressed as the change in the boundary flow as a percentage of the new well's flow. Subsequently, the new well is moved from one cell to the next, and each cell is mapped. Depletion maps have been used to establish water resources management boundaries in Nebraska for more than a decade. In addition, these maps reveal characteristics of the groundwater system of an area and of the simulation representing that system. Depletion maps generated for the MAP area demonstrate where the new wells caused increased groundwater level declines (loss of storage) or decreased groundwater discharge to streams. The depletion maps also show some characteristics and details of the groundwater model inputs, such as variations in the hydraulic conductivity assigned to simulated streams.