12-1-2010

Closure to "Estimation of the Water Balance Using Observed Soil Water in the Nebraska Sandhills"

Venkataramana Sridhar
Boise State University

K. G. Hubbard
University of Nebraska-Lincoln

Closure to "Estimation of the Water Balance Using Observed Soil Water in the Nebraska Sandhills"

Venkataramana Sridhar
Boise State University

K. G. Hubbard
University of Nebraska-Lincoln

We are thankful to Szilagyi [2010] for providing us an opportunity to discuss the important points of our paper [Sridhar and Hubbard, 2010]. We demonstrated a seasonal water balance assessment using the Modified Thornthwaite-Mather (TM) model in the Nebraska Sandhills. We computed the water budget for a few representative weather monitoring stations located in the Sandhills using the high resolution soil moisture data to assess the storage. In our water balance analysis, soil moisture storage is determined based on observed soil moisture and actual evapotranspiration, ET_{act} was computed for each month using the change in storage in soil water and precipitation. If the change in storage is positive based on our observed soil moisture, we considered two scenarios and the least of the two is considered for computing actual ET. If the change in storage is positive, which is the case in our study area as shown in Figure 3 where soil moisture storage in the root zone is above 100 mm (except May, June and July where it was close to 50 mm), that additional soil water beyond the soil column storage is available for ET. In other words, the study sites were only energy constrained and not soil water constrained. We do not believe that the overall ET in the Sandhills exceeds the precipitation. However, at the four stations examined, mainly valley and wet meadow locations, it was found that the ET exceeded precipitation almost at the potential rate where there is plenty of soil moisture and these sites are located in the valley floors within the Sandhills. As shown in our website (www.hprcc.unl.edu), Gudmundsen is a wet meadow site with dunes in the distance. The same is true of Arapahoe prairie. In the locales of Ainsworth and O'Neil the valleys are much wider; however, these sites are in large meadows. In fact many of the meadows in the Sandhills begin the spring wet and cannot be mowed for hay until much later in the summer.

Szilaygi's [2010] claim that higher evapotranspiration (ET) can not be representative of the regional pattern is not disputed by us, however, our study does not go beyond the selected sites within the Sandhills ecosystem. In fact, in another study Sridhar and Wedin [2009] demonstrated the implementation of a land surface model (LSM) covering both uplands and lowlands at the field scale (< 2 km^2) in the Sandhills and estimated ET close to 600 mm which is also higher than the amount of precipitation received. The LSM is a robust, physically-based model and its estimates agree with the estimates of our study (ie. energy-controlled). While this study is conducted at the local scale and the plant-water dynamics is in agreement for many studies [Sridhar et al., 2006; Gosselin et al., 2006; Radell and Crowe, 2008; Sridhar et al., 2008], we state that regional assessment of recharge to groundwater cannot be directly compared with our assessment merely because of the scale artifacts.

Indeed, we substantiate this in our discussion whereby the regional ground water table had a general rise in the Fall and Spring season and it subsequently depleted in the growing season due to root water uptake before being recharged again. However, there is a strong gradient in the ground water system across the region and in our earlier study we had demonstrated a strong correlation between ground water and evapotranspiration [Gosselin et al., 2006]. Szilagyi [2010] argues that there is no decline in the ground water system. There have been recent studies, however, suggesting a general decline in the ground water over the High Plains region, including the Sandhills [Gurdak et al., 2009] and human-induced changes (pumping) in addition to demand due to natural climate variability may be significant. The scope of our study is limited to the root water extraction and the unlimited supply of water (in meadows) during some times of the growing season and hence the computation of water balance at the seasonal scale. Furthermore, our results should not be taken to mean that there would be a general decline in the ground water. Whether or not this kind of water budget alters the regional ground water table is still an open question and needs to be addressed.

Finally, Szilagyi [2010] argues that there is a difference in our model estimates. Clearly, each model represents different physical processes to determine evapotranspiration. In this present study, ET is not constrained but limited by storage whereas in the Robinson and Hubbard model [Robinson and Hubbard, 1990] which uses the Penman method water use is primarily energy-constrained. While it is true that we had used the same locations for the study, the inputs used to drive these different schemes are different. In our current study, we used only precipitation and soil moisture while the Robinson and Hubbard model uses precipitation, temperature, humidity, solar radiation and wind speed.

In conclusion, the water balance behavior of the Sandhills can not be simplified over short time and spatial scales as stated by Szilagyi [2010] and us. The regional aquifer behavior needs an assessment at the decadal or greater time step that has hydraulic connectivity beyond portions of the Sandhills. Following the facts from Gurdak et al. [2009], we would go further and reiterate that a study that tightly and dynamically couples both surface and groundwater is critical to explain the ground water exchanges where the large scale behavior is studied with the same detail as that of the local scale attributes, although the complexities can be simplified at larger scales.

References

Gurdak, J.J., McMahon, P.B., Dennehy, K., and Qi, S.L. (2009). “Water Quality in the High Plains Aquifer, Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming, 1999–2004”, National Water Quality Assessment Program, Circular 1337, U. S. Department of Interior, USGS, pp 63.

Radell, D.B. and Rowe, C.M., (2008). “An observational analysis and evaluation of land surface model accuracy in the Nebraska Sand Hills”, Journal of Hydrometeorology, 9, 601-621, doi:10.1175/2007JHM913.1.

Szilagyi, J. (2010). Comment on “ Estimation of the water balance using observed soil water in the Nebraska Sandhills”, Journal of Hydrologic Engineering (this issue)

Sridhar, V., and Hubbard, K.G. (2010). “Estimation of the water balance using observed soil water in the Nebraska Sandhills”, Journal of Hydrologic Engineering, Vol. 15, No. 1, DOI: 10.1061/(ASCE)HE.1943-5584.0000157.

Sridhar, V., and Wedin, D.A. (2009). “Hydrological behavior of Grasslands of the Sandhills: Water and Energy Balance Assessment from Measurements, Treatments and Modeling”, Ecohydrology, 2, 195-212, DOI:10.1002/eco.61

Sridhar, V., Hubbard, K.G., and Wedin, D.A. (2006). “Assessment of soil moisture dynamics of the Nebraska Sandhills using Long-Term measurements and a hydrology model”, ASCE Journal of Irrigation and Drainage Engg. Vol. 132, Issue 5, pp 463-473, 10.1061/(ASCE)0733-9437(2006)132:5(463).

Gosselin, D.C., Sridhar, V., Harvey, F.E., and Goeke, J.W. (2006). “Groundwater fluctuations in interdunal environments and evapotranspiration estimates for a wet meadow in the Nebraska Sand Hills, U.S.A.”, Great Plains Research, Vol. 16, No. 1, pp.17-28.