Using GRID to evaluate different methods to estimate evapotranspiration

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Abstract:

The Rio Grande runs through a water scarce region. Portions of the riparian forest are estimated to use as much as forty percent of the water budget. Thus, accurate estimates of riparian evapotranspiration (ET) are imperative to water managers. Three-dimensional eddy covariance towers have been established and maintained throughout the Middle Rio Grande Valley to measure ET. The tower data has been used to scale ET data to the corridor using remote sensing imagery. Alternatively, a number of researchers have used imagery with energy balance methods to estimate ET in the corridor. Researchers using the different methods to estimate ET for the corridor were asked to supply their ET results in a GRID format to enable the use of ArcGIS for calculation of difference grids. The difference grids highlight where the methods compute the most similar/different results enabling further development of ET estimation methods.

Background:

The Rio Grande flows from southern Colorado, through New Mexico, forms the Texas-Mexico border and discharges into the Gulf of Mexico (Figure 1). The riparian corridor along the Rio Grande is known locally as the bosque (Spanish word for wooded area). The bosque is comprised of native Cottonwood trees, native willow trees, native grasses, and invasive salt cedar and Russian olive trees. The Rio Grande provides an oasis in this water scarce area. At the same time, the dense riparian forest accounts for as much as 40% of the water budget (Papadopulos, 2004). The bosque is currently being managed for various reasons including fire fuel reduction, exotic species removal, endangered species habitat, recreation, and water consumption (Coonrod, 2005). Previous research by Cleverly et al and Dahm et al show that evapotranspiration in the Rio Grande bosque is highly variable and depends not only on tree species but location, soils, and whether the climate has been drier or wetter than usual. Point measurements have been made in the Middle Rio Grande (defined as the portion of the Rio Grande between Cochiti and Elephant Butte reservoirs) using 3-D eddy covariance systems on towers located in the

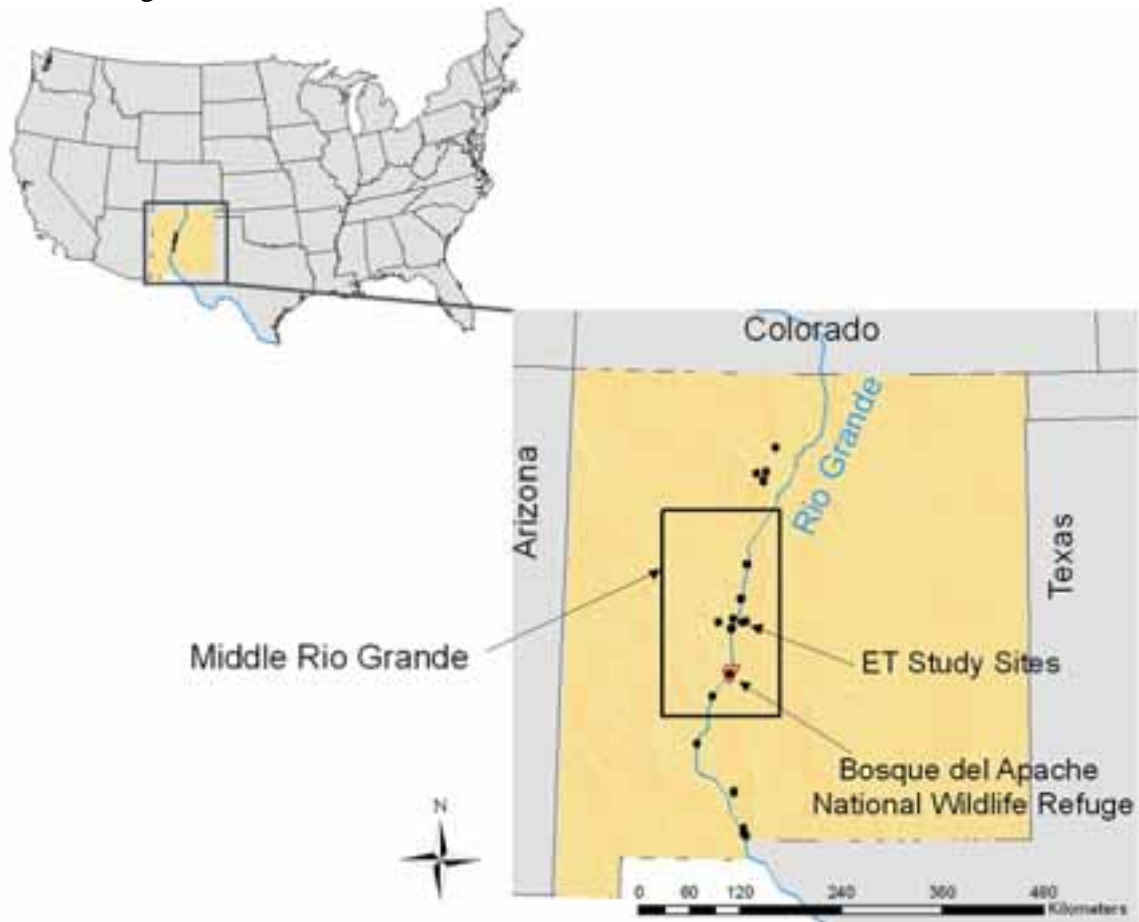bosque. The network of towers is currently being expanded to include all the towers shown in Figure 1.

Figure 1. ET towers located along the Rio Grande

McDonnell's dissertation (2006) focused on methods to scale the evapotranspiration measurements from the towers to the entire bosque, or riparian corridor, using satellite imagery. Meanwhile, a number of researchers have employed energy balance methods using satellite imagery to estimate evapotranspiration over regional areas. This work uses ArcGIS to compare these different methods of estimating ET for the riparian forest located in the Bosque del Apache National Wildlife Refuge.

Methods:

We utilized McDonnell's methods, adapted them to ArcGIS and computed a grid with daily ET values for a Landsat image dated May 31, 2002. We requested grids from other researchers who were employing energy balance methods in the same area so that we could compare results. So that the grids could be comparable, we requested each researcher to create a daily ET grid for a similar date with a specified origin and a 30 meter cell size. We received daily ET grids from 3 research teams using energy balance methods. Jan Hendrickx and Sung-ho Hong from New Mexico Tech used SEBAL[NM] with a Landsat image of the same date. Louis Scuderi from the University of New

Mexico used a method employing digital elevation models and a MODIS image. Zorab Samani of New Mexico State University used REEM with an ASTER image dated June 10, 2003. Utilizing the Spatial Analyst and the Raster Calculator, difference grids were created as seen in Figures 2, 3, and 4.
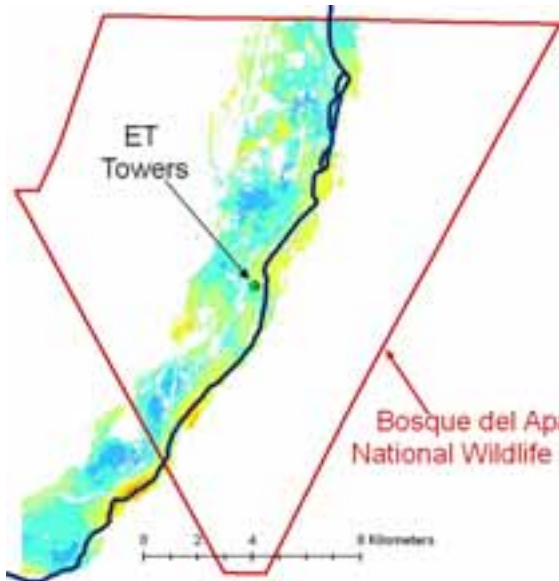

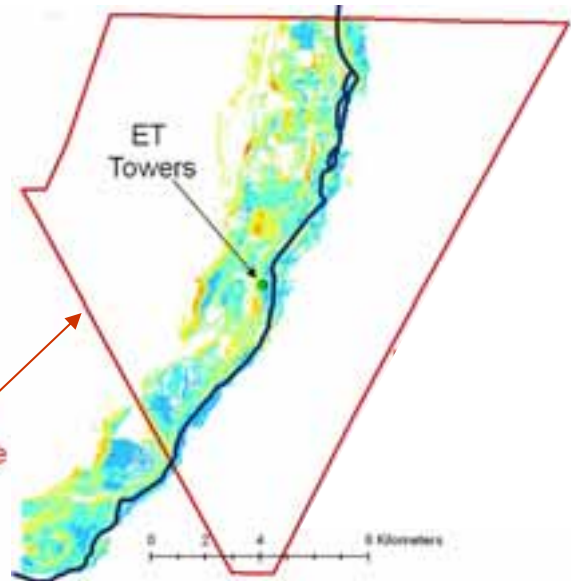
Figure 2. [Scaling] - [MODIS]
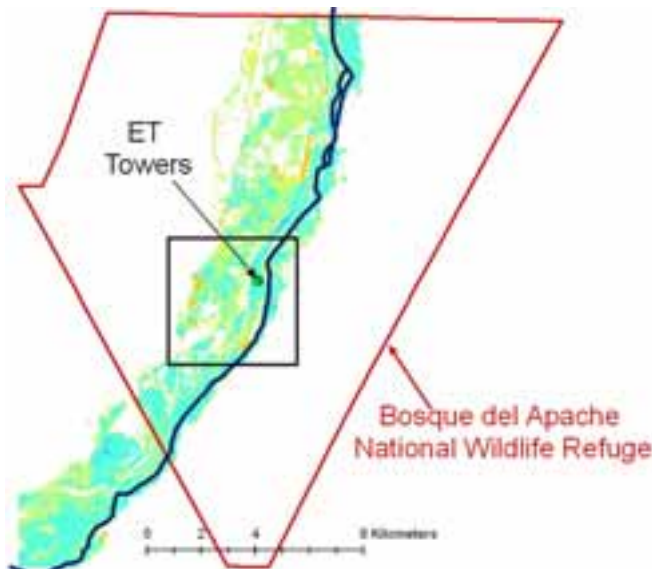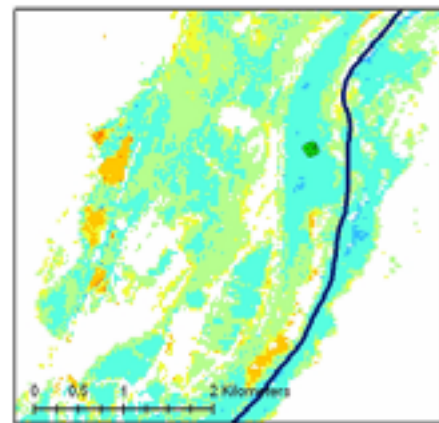

Figure 3. [Scaling] - [REEM]

Difference (mm/day)

(-7.56) - (-6)	(-3.99) - (-2)
(-5.99) - (-4)	(-1.99) - 0
	0 - 2
	2.01 - 4
4.01 - 6	
6.01 - 8	
8.01 - 10	

Figure 4. [Scaling] – [SEBAL^{NM}]

Inset close up

The mean and standard deviations of the difference grids are readily available in ArcGIS and summarized in Table 1.

Methods compared	Mean (mm/day)	Standard Deviation (mm/day)
[Scaling] – [MODIS]	0.34	1.83
[Scaling] – [REEM]	0.28	2.01
[Scaling] – [SEBAL^{NM}]	0.40	1.43

To further evaluate the methods, histograms of the difference grids can be generated using the Layer Properties Symbology as shown in Figure 5.
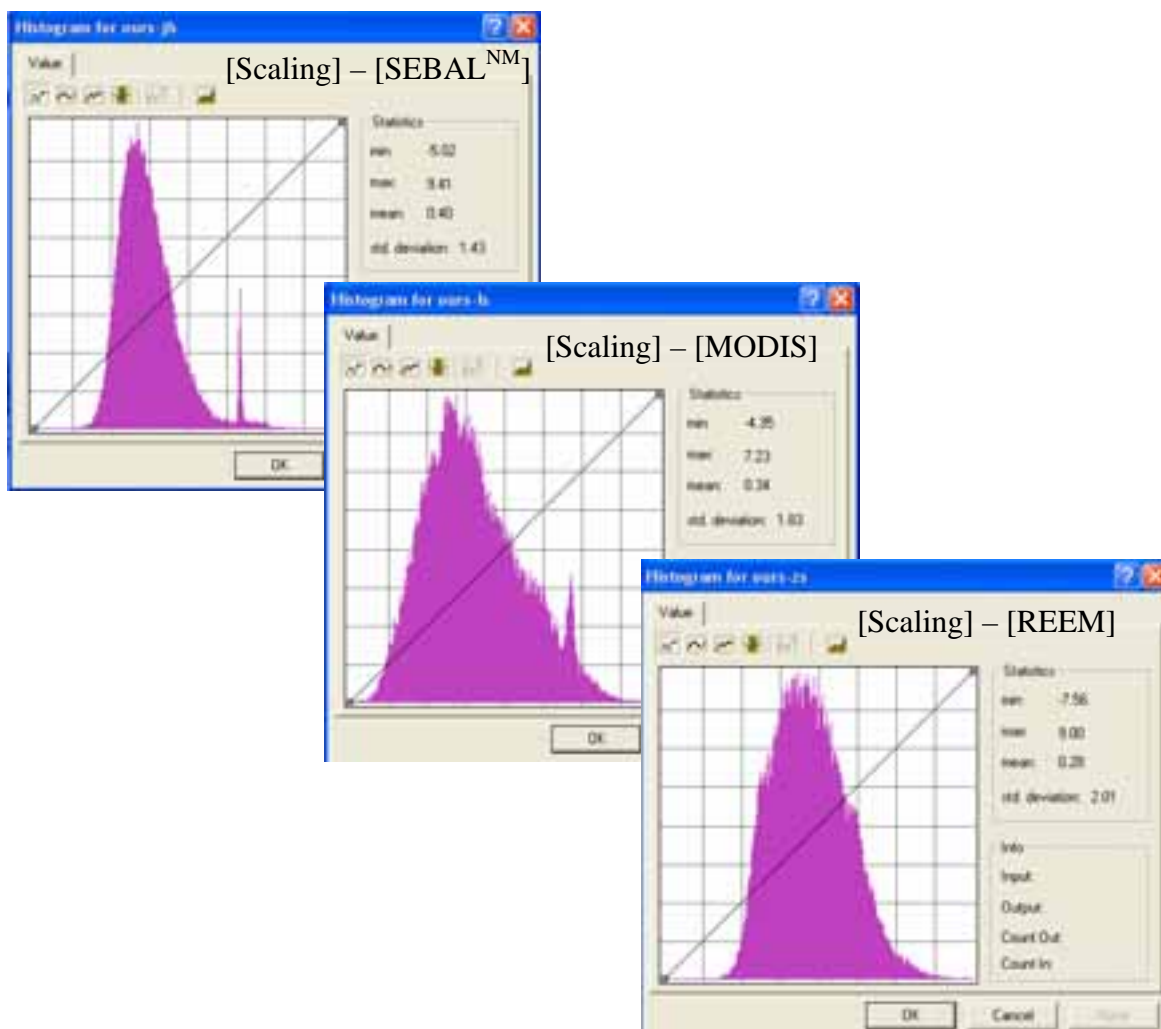

Figure 5. Histograms created for each difference grid in ArcGIS

It is inappropriate to compare the evapotranspiration estimating methods purely based on the mean or the standard deviation. The means can compare well if there is as much overestimation as there is underestimation. If this were altered by taking the absolute values of the differences, it would not be clear if one method overestimated or underestimate values compared with another. By viewing the histograms and the standard deviations, it is clear that the scaling method agrees most with the SEBAL^{NM} method.

Conclusion & Future Work:

Evapotranspiration is highly variable. Comparing estimation methods for one day and one area cannot be considered conclusive. In some instances, the largest differences found between methods occurred along the edges of the riparian zone where averages across a grid cell could have a large impact on the estimated evapotranspiration. Comparisons across more temporal and spatial domains are needed. Further comparison of these estimation methods along with difference investigation will result in improved methods for estimating evapotranspiration. ArcGIS is a useful tool to perform such comparisons.

Acknowledgments:

References:

Cleverly, J.R., C.N. Dahm, J.R. Thibault, D.J. Gilroy and J.E. Allred Coonrod. "Seasonal estimates of actual evapotranspiration from Tamarix ramosissima stands using 3-dimensional eddy covariance," *Journal of Arid Environments,* October, 2002; v.52, no.2, p.181-197.

Coonrod, J. *The Middle Rio Grande: History and Restoration*, ASCE Watershed Management Conference (Managing Watershed for Human and Natural Impacts: Engineering, Ecological, and Economic Challenges) July, 2005

Dahm, C.N., J.R. Cleverly, J.E. Allred Coonrod, J.R. Thibault, D.E. McDonnell* and D.J. Gilroy. "Evapotranspiration at the land/water interface in a semi-arid drainage basin," *Freshwater Biology*, special issue on "Riverine Landscapes", April, 2002, v. 47, no. 4, p.831-843.

McDonnell, D. *Scaling evapotranspiration in the Middle Rio Grande*, Dissertation, University of New Mexico, expected August, 2006.

Papadopulos, S.S. & Associates (2004) Middle Rio Grande Water Supply Study, prepared for U.S. Army Corps of Engineers (Albuquerque District) and New Mexico Interstate Stream Commission. (www.seo.nm.us/water-info/mrgwss)

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