Mapping Evapotranspiration in New Mexico

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The Driving Question and What We Did

Water has been one of the main driving forces of expansion in the American Southwest for over a century. This compound has allowed urban centers, populations, and even agricultural areas to expand in places where it was once thought impossible. Most of the water that the American Southwest receives originates from two sources; rivers and precipitation. In a water budget created for the Arroyo Seco watershed situated in California; results indicated that precipitation and evapotranspiration were the biggest components of that study area [Brick 2010]. Evapotranspiration is the total sum of transpiration (water transpiring from vegetation canopies) and evaporation (water evaporating from the land surface) that occurs on a daily basis. Knowing that evapotranspiration and precipitation are the biggest components of water budgets, this project aims to find an operational evapotranspiration model that is accurate for the entire state of New Mexico and that could be incorporated into a statewide water budget.

How We Did It

The assessment of evapotranspiration was done through GIS analysis of various models. Dr. Thomas Schmugge assisted in acquiring the following ET models: ALEXI from the USDA Agricultural Research Service, SSEB from the USGS Earth Resources Observation Systems Data Center, and MOD16 from The University of Montana Numerical Terradynamic Simulation Group while Dr. Jan Hendrickx also assisted in acquiring METRIC, from The University of Idaho. In order to validate these models, field data were acquired from various flux towers scattered across New Mexico. A flux tower records the daily evapotranspiration rate, daily temperature, carbon fluxes, and records precipitation events out in the field. Data from the models were extracted using centroids, the pixel's center, based on the geographic space of each of the flux towers. These extracted values were then used to create an ordinary linear regression between modeled and observed values of evapotranspiration.

What We Found Out And Why It's Important

Each model analyzed in this study performs differently and with varying degrees of accuracy. METRIC creates non-natural features in the study areas while MOD16 showed very low correlations between observed and modeled values. The newest version of ALEXI, V7, performs poorly in non-mountainous areas and its overall yearly correlation was low compared to observed values. However, it is important to note that that ALEXI V7 is still considered a research version, which means that it is not thoroughly quality controlled.

On the other hand, SSEB V3 had the best linear fit with yearly and monthly values, therefore this model represents ET more accurately across the study area. SSEB V3 had a yearly r^2 value of 0.58, the highest out of the models analyzed when comparing yearly values. Like any model, SSEB includes a degree of bias. A key component of this model is that it uses a topographic correction based on an atmospheric lapse rate for land surface temperature in order to reduce errors [Senay et al 2013]. Even with this topographic correction, most of the biases and overestimations in this model are originating from the air temperature grids used as input variables, the use of a constant temperature difference function across large geographic space, and the use of the K parameter that scales up or down reference ET. These biases are what are causing the model to have these low r^2 values. Several implementations can be applied to reduce these biases such as improving the air temperature grids to a finer spatial resolution and verifying the reference evapotranspiration used in the model with actual field measurements. Since the K parameter is based on a continental scale, the development of a K parameter specifically for New Mexico might be needed.

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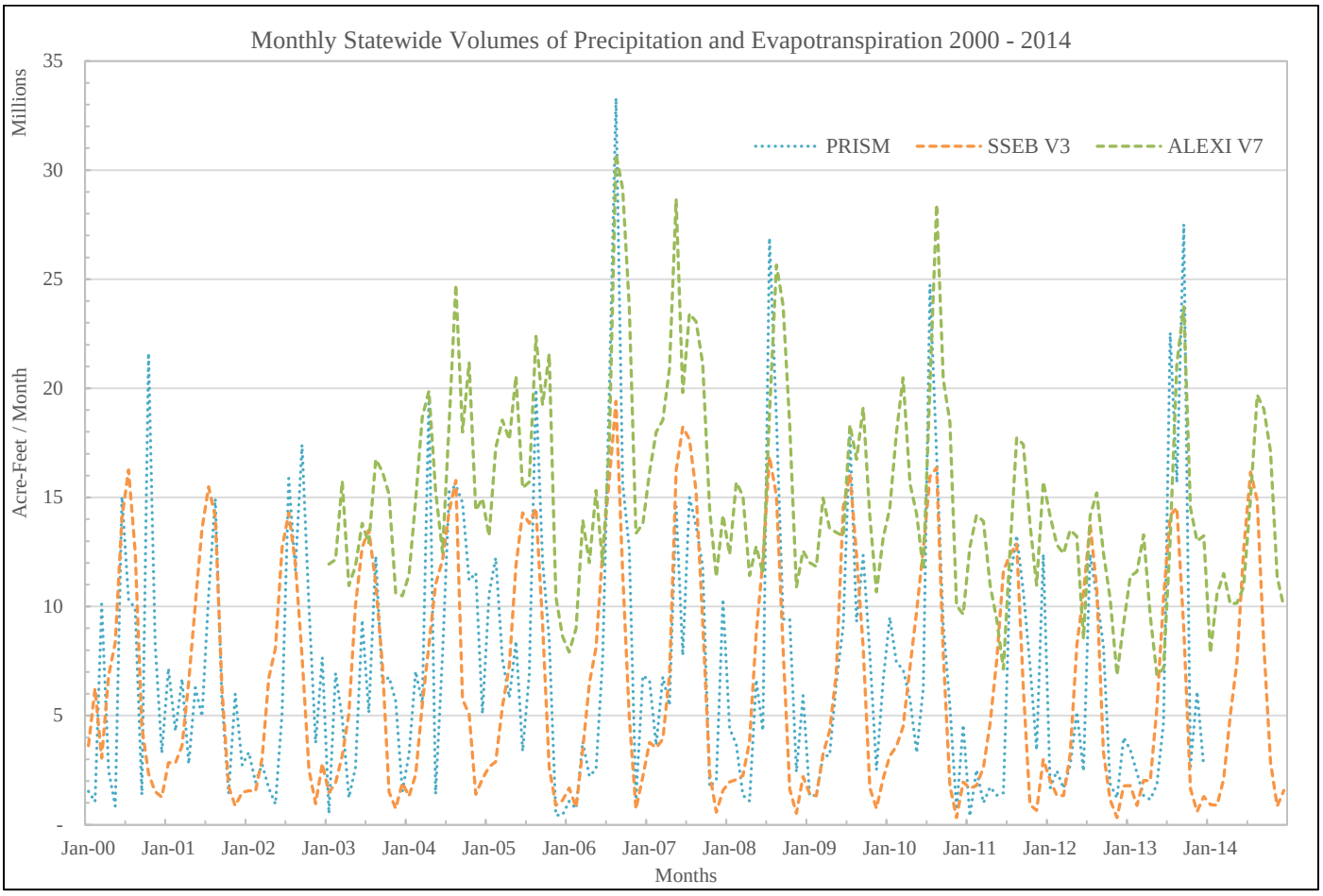

Figure: The figure above demonstrates the monthly statewide volumes of precipitation and evapotranspiration for the area within the political boundaries of New Mexico. SSEB V3 captures the seasonal fluxes of evapotranspiration, while ALEXI V7 is overestimating. In some instances, evapotranspiration exceeds the total amount precipitation for both models. For precipitation estimates, 800m PRISM data from the Oregon Climate Group were used.

Flux Station	Station ID	Year	R^2
Bosque	Bosque	2005	0.89
Valles Caldera	Vcp	2007-2008	0.88
Williard	Wjs	2008	0.83
Jornada	Jornada	Nov 2010– Aug 2011	0.78
Valles Caldera	Vcm	2007-2010	0.73
Sevilleta	Ses	2007-2010	0.70
Sevilleta	Seg	2007-2010	0.64
Mountainair	Mpj	2008-2010	0.58

Table: The table shown depicts the monthly regression results between observed evapotranspiration at the different flux stations and modeled SSEB V3 values that correspond to the centroid of the pixel situated over each respective flux station. Out of the eight flux stations, SSEB V3 performed the best in Bosque Salt Cedar Flux Station, having a r^2 value of approximately 0.89. However, it did not perform as effectively in the Mountainair flux station having a r^2 value of 0.58. These correlations are statistically significant based on a 95 % confidence level.

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