Improving Water Demand Forecasting in the Middle Rio Grande River Basin

Kristi Arsenault
UMBC Goddard Earth Sciences and Technology Center, NASA GSFC, Greenbelt, MD
Richard Stodt
U.S. Bureau of Reclamation, Technical Service Center, Denver, CO
Ana Pinheiro
NASA GSFC Postdoc, Greenbelt, MD
Paul Houser
Center for Research on Water and Environment (CREW)/GMU, Calverton, MD

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Abstract

Evapotranspiration (ET) from irrigated crops and riparian vegetation, and evaporation from open-water surfaces are the primary consumers of surface water in the Western U.S.. To quantify these water requirements, the U.S. Bureau of Reclamation (Reclamation) has developed and implemented the Agricultural WAter Resources Decision Support (AWARDS) system, which is an automated information system to assist water managers and users by providing easy access to rainfall and daily crop water use estimates. Building on the AWARDS decision support tool (DST), Reclamation has developed the Evapotranspiration Toolbox (ET Toolbox) which adds land cover/use information within selected Hydrologic Rainfall Analysis Project (HRAP) grid cells when estimating daily surface water use. Currently, the AWARDS ET Toolbox utilizes NCEP Eta 12km meteorological forecasts, and Doppler Radar products as input forcing, and a modified Penman equation and derived crop coefficients (Kc) to estimate ET for the different land cover types.

To help further investigate the use and potential benefits of different land surface models (LSMs) and remote sensing datasets in estimating ET and water consumption, a team at NASA Goddard Space Flight Center is customizing the Land Information System (LIS) modeling environment for comparison and validation studies with the AWARDS ET Toolbox DST in the Middle Rio Grande River Basin area. The AWARDS ET Toolbox land cover classification dataset and meteorological forcing datasets have been implemented in LIS. This will allow for a thorough comparison study between the different LIS LSM (i.e., Noah 2.7, CLM2, and Mosaic) ET-based algorithms and the AWARDS DST's current operational setup. Also in this comparison study, the LSMs and AWARDS ET Toolbox will be validated against in-situ eddy covariance flux and other meteorological tower data for various vegetated areas (i.e., riparian, agricultural). All models and algorithms will be forced using local meteorological data, but some additional experiments will be made using the Eta 12 km and North American Land Data Assimilation forcing datasets. Finally, some Terra and Aqua MODIS remote sensing products (e.g., leaf area index, land surface temperature) have been developed further for use and assimilation in some of the LIS LSMs, to evaluate the usefulness of NASA's satellite derived products within the AWARDS decision support tool.

AWARDS ET Toolbox

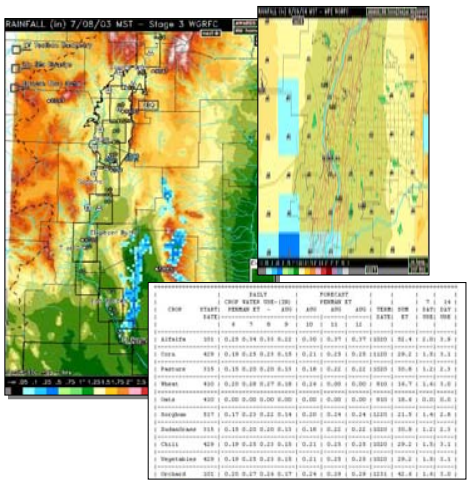


Figure 1. Reclamation's AWARDS ET Toolbox interactive webpage that provides daily data to its user community.

The AWARDS ET Toolbox Land Class Background

- ET Toolbox uses a merged Ikonos/Utah State University (ref.) land class dataset
- Land class pixels are aggregated to 4km HRAP grid system – areal acreage and fraction of each class is accounted for in each HRAP cell – "subtiling"
- A network of in-situ meteorological stations, maintained by the Middle Rio Grande Conversancy District (MRGCD) in New Mexico, is used as the main weather information that drives the daily ET Toolbox algorithms.
- Eta 12 km forecasts are used to derive ET forecasts up to three days in advance and are done for each land cover class within each HRAP gridcell for the region.
- A modified Penman equation is used with crop coefficient (Kc) information to calculate daily ET.

LIS Model Experiments

- LIS land surface model experiments were first conducted using standard model parameters. However, local vegetation, soils and elevation information were used for the station-model validation comparison. For vegetation, both cottonwood and saltcedar trees were mapped to the UMD class of deciduous broadleaf (class = 4).
- The Noah LSM (version 2.6), Community Land Model (version 2, CLM2), and Mosaic LSM were run with their standard parameters. CLM2 used however UMD vegetation-fit parameters and MODIS version 4 leaf area index and derived stem area index 5-year climatologies for the area.
- LSMs are forced with the North American LDAS forcing dataset (NLDAS forcing; Cosgrove et al., 2003), and the hourly fields are reinterpolated to the 0.01 deg (Lat-lon) LIS domain.

UNM In-Situ Data

- The University of New Mexico (UNM; Cleverly et al., 2006) has set up a few eddy covariance flux towers that employ instruments like the Licor gas analyzer and CSAT anemometer to measure energy fluxes and meteorological fields at select vegetated points along the Middle Upper Rio Grande River.
- The following corrections have been made to their flux and ET estimates: coordinate rotations, frequency response corrections (Massman 2000, 2001), flux effects on density (Webb et al., 1980). Also, a daytime budget closure check is also applied.
- ET measurements are normally taken about ~1.3 meters or so above the canopy.

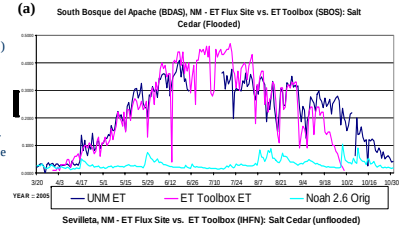
Bosque UNM - ET Tower Stations (Cleverly et al., 2006)

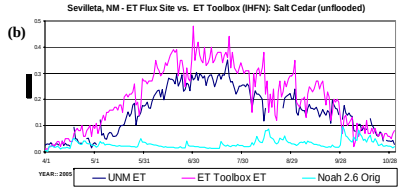
Station	Location	Date Began	Long. (NAD83)	Lat (NAD83)	Vegetation
SHK	Shirk, NM (Albuquerque)	3/16/2000	**-106.683**	**34.959**	Cottonwood (unflooded)
BLN	Belen, NM	3/15/2000	**-106.749**	**34.590**	Cottonwood (flooded)
LARO	Near La Joya SGR (Socorro Co)	3/4/2003	**-106.859**	**34.347**	Russian Olive (flooded)
SEV	Sevilleta National Wildlife Refuge	11/30/1999	**-106.868**	**34.266**	Saltcedar (Unflooded)
BDAS	Bosque del Apache (South)	2/10/2000	**-106.877**	**33.781**	Saltcedar (flooded)

NASA ET Tower Stations

Station	Location	Date Began	Long. (WGS84)	Lat (WGS84)	Vegetation
CFMN	Candelaria Farms	11/1/2005	**-106.683**	**35.133**	Alfalfa field
RGNC	Rio Grande Nature Center	1/1/2006	**-106.683**	**35.133**	Grass-based river bank

Daily ET Summary Validation





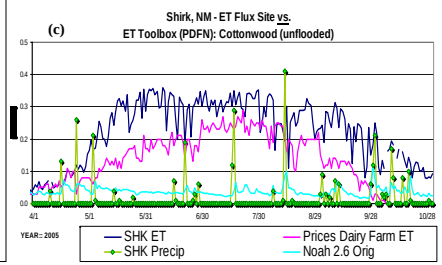
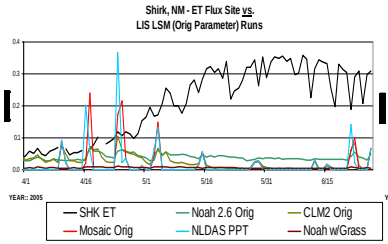


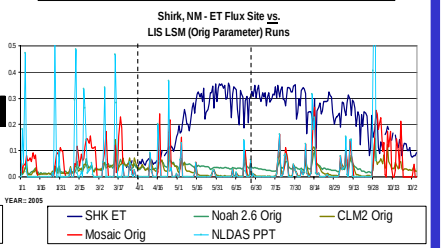
Figure 3. In-situ UNM daily evapotranspiration values (in inches) are compared with the AWARDS ET Toolbox daily estimated ET summaries and daily ET from Noah 2.6 (with original parameters but local vegetation and soil class information) for spring and summer seasons of 2005. Three stations were chosen due to availability and continuity of data available.

ET Toolbox Validation

ET from the ET Toolbox shown in Figure 3a-3c was computed with a modified Penman equation in conjunction with accumulated growing degree day based crop coefficients (Kc) for saltcedar and cottonwood (New Mexico State University, 2000, personal communication). Figure 3a shows comparison between measured ET flux from the UNM tower with the ET estimate from the ET Toolbox for flooded saltcedar. Figure 3b is the same for unflooded saltcedar and Figure 3c is the same for unflooded cottonwood. Saltcedar has been shown to have ET rates varying between 300 and 1300 mm/yr (Nagler, et.al.,2005).

The ET Toolbox uses only one saltcedar Kc which as expected compares well with measured ET flux at the flooded saltcedar location but overestimates ET somewhat at the unflooded saltcedar location. Cottonwood has been shown to have the highest annual ET rates (1100-1300 mm/yr) of western river riparian plant communities (Nagler, et.al.,2005) while comparison of the cottonwood and saltcedar Kc-s used in the ET Toolbox implies that cottonwood produces 25-30 percent less ET than saltcedar which may explain the underestimation of ET by the ET Toolbox with respect to the flux tower measurements shown in Figure 3c.





A LIS LSM Comparison

In terms of daily ET summaries, these three LSMs in LIS respond more to precipitation events in this region for 2005 and capture no real annual solar cycle influence. There is also an anti-correlation found with LSM ET values increasing immediately after a precipitation event but the observations show a decrease, relating mostly to the shutoff of vegetation transpiration. One additional experiment was made with Noah by changing the UMD vegetation type to grassland (class=10). The simulation resulted in very small daily ET values.

Conclusions and Current Work

In this current validation study, the AWARDS ET Toolbox is capturing the annual trend of daily ET estimates as found with the observations for 2005 for these UNM sites. The LSMs in LIS were currently run with default type parameters and no calibration performed, resulting in no apparent annual cycle and also an underestimation of the daily ET compared with observations.

This project is currently finishing this validation study and additional experiments with local forcing and performing parameter estimations of the model parameters to try and improve the LSM estimated ET and other energy and moisture fluxes and budgets.

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