Water Availability and Use Science Program
ET: FY 2016 End-of-Year Report
October 28, 2016

(1) PROJECT ACCOMPLISHMENTS/CONTRIBUTIONS (FY 2016)

There are two main components of this project:

1) Actual evapotranspiration (ET) estimation (led by Gabriel Senay)
2) Cropland classification (led by Prasad Thenkabail)

Actual ET Estimation

Senay's group uses satellite temperature data to estimate actual evapotranspiration (ET) using the Simplified Surface Energy Balance-operational model (SSEBop). The SSEBop ET model has been evaluated against flux tower data and other models and the results are encouraging, showing stability and good accuracy (< +/- 20% error at the monthly scale). Details on ET evaluation studies can be found in the recent publications listed in section 4 of this report.

Satellite data used thus far includes MODIS and Landsat. MODIS-based ET appear to underestimate ET depths in sparsely irrigated regions from early evaluation assessments in Montana. This can be attributed to the coarse resolution of MODIS (1 km2) which is 100 times lower than Landsat (0.01 km2) in area terms. This points to the importance of using Landsat based approach, at least in combination with MODIS for more accurate representation.

The ET estimation project is directly supporting water use estimation in Water Census Focus Area Studies and nationally. Some specific products developed this year include:

- Produced 2015 nationwide crop water use map at county scale
- Completed 2015 Landsat scale Rio Grande River Basin ET
- Completed 2015 Landsat scale ET estimates for Red River FAS.
- SSEBop V4 monthly ET estimates for the CONUS have been updated at the USGS Geoportal

In addition, Senay's group helped to produce a USGS EROS fact sheet on "Mapping Water Use: Landsat and America's Water Resources" (see publications list). They have also developed a web-based drought monitoring product (http://earlywarning.usgs.gov/useta) that shows up to date monthly and seasonal anomalies in ET for CONUS.

Cropland classification

The main objectives of Thenkabail's group is to develop automated cropland classification algorithms using data obtained from remote sensing. The group is further working towards crop water productivity modeling and mapping.

Thenkabail's group has developed a model called the Fallow-land Algorithm based on Neighborhood and Temporal Anomalies (FANTA) model . FANTA has been applied to California and, more recently, to Arizona.

The model uses MODIS data to capture cropland dynamics and response to drought. It has good accuracies based on field data collected in 2014 and 2015. The model asks four questions:

- Does the pixel LOOK like a crop relative to its history?
- Does the pixel ACT like a crop relative to its history?
- Does the pixel LOOK like a crop compared to its neighbors?
- Does the pixel ACT like a crop compared to its neighbors?

If the answer is "No" for at least two questions, then the pixel is considered fallow. In this way, all the different expressions of fallowed cropland are captured. Sometimes cropland that is left unplanted is still managed, and will remain free of vegetation -- with low greenness. In other cases, cropland that is left fallowed and unmanaged may become filled with weeds, giving a strong greenness signal. In both cases, however, the field will not be very dynamic -- i.e., will not go from bare soil to vibrant crop to harvested field.

Other work is being conducted to classify different types of crops in agricultural areas.

(2) PROJECT WORKPLAN AND BUDGET FOR FY 2017

Evapotranspiration estimation, Senay:

			Item, $K	Group, $K
I	**Model Application and Production**			105
	A	Complete and update MODIS scale 2016 ET and stage data to the CIDA Geo Portal sever, using SSEBop V4. This will include any model re-runs of previous years (since 2000) if a new version of the model is developed.	40	
	B	Produce Landsat based ET for the Rio Grande focus area study for a year that is chosen by PI. Map for 2015 already completed.	60	

		This will include any follow up work to the Red River 2015 annual ET that was produced in FY2016.		
	C	Collaborate with Bureau of Reclamation to leverage WaterSMART funding to produce Historical ET for the lower Colorado River basin. Note: USBR is interested to fund the project, WaterSMART activities will simply be used to synergize the effort.	5	
II	**Model output evaluation and opportunities**			100
	A	Working closely with Molly Maupin of the NWC Water Use Team to evaluate the performance of the 2015 CONUS-wide, county-based crop consumptive use estimates created using MODIS-based data stream and submitted in FY16. This will require creating a common understanding on the product and both quantitative and qualitative approaches will be followed.	30	
	B	Evaluate the performance of Landsat ET in the Rio Grande river basin using station based flux tower data that is sourced in collaboration with NMWSC.	35	
	C	Coordinate with Water Census hydrology modeling group to identify complementary parameterization and reconcile differences so both remote sensing based diagnostic ET output and prognostic models are inter-calibrated to produce consistent model outputs for use in water budget studies.	35	
III	**Model Algorithm and Performance improvement**			90
	A	Improve model parameterization to handle differences in lapse rate between the air and surface temperatures, which causes an over-estimation bias in high elevation areas.	45	

	B	Improve the emissivity correction for the desert and semi-arid regions which tends to reduce the MODIS-based ET in rainfed, low ET areas.	25	
	C	Improve model implementation efficiency using high computing platforms, especially for Landsat based processing. This work will pave the way for Landsat-scale ET estimation for large areas.	20	
IV	**Synthesis and Reporting: Manuscript Development and Presentations**			55
	A	Manuscript preparation and publication for identifying blue (irrigation) vs green (rainfall) water sources in irrigated systems.	30	
	B	Work with Arizona Water Science and New Mexico Water Science centers to document the performance of SSEBop as compared with field methods.	20	
	C	Presentations at annual meetings such as AGU and WaterSMART workshops.	5	
TOTAL				**350**

<u>Croplands classification, Thenkabail:</u>
Thenkabail's group plans to continue refinement of their crop classification systems over the next year. In particular, they intend to work on:

i) Further refinement and perfection of cropland vs. cropland fallow automated cropland classification algorithms (ACCA) for California using MODIS data;
ii) Scaling the ACCA algorithms for entire USA using MODIS and Landsat data;

iii) Further development of ACCA algorithms for major rainfed and irrigated crops for entire USA using MODIS and Landsat data;
iv) Development of crop productivity, crop water use, and crop water productivity models for the irrigated croplands of California;
v) Release of above developed algorithms, products to public through a project web portal;
vi) Publication of peer-reviewed articles on the above research, including a paper on FANTA model refinements and comparison to NASA models.

FY2017 budget: $150K?

(3) NOTEWORTHY COLLABORATIONS, MEETINGS, TECHNICAL TRANSFER ACTIVITIES, SPIN-OFF PROJECT DEVELOPMENTS, AND ACKNOWLEDGEMENTS

Senay made presentation at New Mexico State University with the presence of the NMWSC director on the mapping of Landsat-based ET for Rio Grande.

Senay has been working with Meredith Reitz and Ward Sanford on evaluation of ET products. That work will continue in FY2017.

Senay will be working with the Water Census flow estimation team in FY2017 to further evaluate ET in the context of the water budget.

Thenkabail and Senay discussed their mutual projects during the mid-year progress reviews. They identified areas of mutual interest, but have not yet identified concrete plans for working together.

(4) Report Products, Bibliographic Update, Data Releases

ET:

Mingshi Chen, Gabriel B. Senay, Ramesh K. Singh, James P. Verdin, (2016) Uncertainty analysis of the Operational Simplified Surface Energy Balance (SSEBop) model at multiple flux tower sites, Journal of Hydrology (536) 384-399, http://dx.doi.org/10.1016/j.jhydrol.2016.02.026.

Gabriel Senay, MacKenzie O. Friedrichs, Ramesh K. Singh, Naga Manohar Velpuri (2016) Evaluating Landsat 8 evapotranspiration for water use mapping in the Colorado River Basin, Remote Sensing of Environment (185) 171-185, DOI: 10.1016/j.rse.2015.12.043.

Ramesh K. Singh, Gabriel B. Senay (2016) Comparison of four different energy balance models for estimating evapotranspiration in the Midwestern United States, Water (8), DOI: 10.3390/w8010009.

U.S. Geological Survey, 2016, Mapping water use—Landsat and water resources in the United States: U.S. Geological Survey Fact Sheet 2016–3037, 2 p., http://dx.doi.org/10.3133/fs20163037.

Croplands:

Michael T. Marshall, Prasad S. Thenkabail, Trent Biggs, Kirk Post (2016) Hyperspectral narrowband and multispectral broadband indices for remote sensing of crop evapotranspiration and its components (transpiration and soil evaporation), Agricultural and Forest Meteorology (218-219) 122-134, DOI: 10.1016/j.agrformet.2015.12.025.

Christian, B. Joshi, N., Saini, M., Mehta, N., Goroshi, S., Nidamanuri,R.R., Thenkabail, P., Desai, A.R., Krishnayya, N.S.R. 2015. Seasonal variations in phenology and productivity of a tropical dry deciduous forest from MODIS and Hyperion, Agricultural and Forest Meteorology, Volumes 214–215, 15 December 2015, Pages 91-105, ISSN 0168-1923, http://dx.doi.org/10.1016/j.agrformet.2015.08.246.

Marshall, M.T., and Thenkabail, P.S. 2015. Advantage of hyperspectral EO-1 Hyperion over multispectral IKONOS, GeoEye-1, WorldView-2, Landsat ETM+, and MODIS vegetation indices in crop biomass estimation. International Society of Photogrammetry and Remote Sensing (ISPRS) Journal of Photogrammetry and Remote Sensing (ISPRS P&RS).

(5) PROJECT TEAM DIRECTORY -

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(6) PHOTOS, ANIMATIONS, AND GRAPHICS –

This website provides a view of up to date ET anomalies:

http://earlywarning.usgs.gov/useta

These two fact sheet have nice illustrations of the detail available from Landsat scale ET estimates.

http://eros.usgs.gov/udall50thanniversary/documents/fs20163037.pdf

https://pubs.usgs.gov/fs/2015/3080/fs20153080.pdf

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