2016-2017 TWRI Graduate Student Research Programs

Basic Information: Applying for Mills Scholarship Program

1. **Title:**

   Combined High-Resolution Remote Sensing for Measuring Evapotranspiration in Brazos County, TX

2. **Student Name:** Xiangmin Sun
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   Ecosystem Science and Management
   Doctorate (Fall 2013–Summer 2017, expected)
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4. This grant will support our ongoing NSF research program to study woody plant encroachment in the Southern Great Plains. I am at the stage of field experiment on evapotranspiration and its partitioning with isotopic approach.
5. **Abstract**

Terrestrial evapotranspiration (ET) is the amount of water exchanged between the atmosphere and the land surface, accounting for about 75% of continental precipitation globally(Brooks 2015). Because ET is a major hydrologic flux, estimation of ET quantity and partitioning is constantly an important topic in water resources planning for changing landscapes such as those in Brazos County. Brazos County has witnessed dramatic land cover changes—especially urbanization and woody plant encroachment. Thus the increasingly fragmented and heterogeneous landscape poses significant challenges for accurate ET estimation.

The uncertainty of ET estimation under these changing landscapes could be dramatically reduced by high-resolution remote sensing data and physically-based ET modeling. So we plan to stack high-resolution Light Detection and Ranging (Lidar) data and National Agriculture Imagery Program (NAIP) data via a voxel-Principal Component Analysis (PCA) approach. With the combined vertical and horizontal vegetation information, we will develop an improved hybrid dual-source ET model to estimate two sources of ET: evaporation from bare ground and from below-canopy surfaces, as well as transpiration from vegetation layers. After revision and validation with field-observed data, this dual-source ET model can generate maps predicting ET for different future scenarios of urbanization and woody plant encroachment.

6. Description:

a) Statement of critical regional or state water problems:

According to the 2012 State Water Plan, the Brazos River accounts for more than 75% water supply for this region. With growing population and urbanization, water demands cannot be met during drought events or after 2040 (Board 2012). Meanwhile precipitation entering catchments exits as either runoff or evapotranspiration (Syed et al. 2010)—which means that available water supply would be the water remaining after evapotranspiration. Therefore, strategic planning and management of water resources requires accurate and reliable estimation of ET and its components.

b) Nature, scope, and objectives of the research, including a timeline of activities:

The nature of this project is a multidisciplinary effort to improve ET estimation through the use of newly available high-resolution remote sensing technology and improved hybrid ET modeling. It involves remote sensing, micrometeorology and hydrology for ET computation.

The scope and objectives of this research program can be described by three primary tasks:

- Land cover classification: Integrate NAIP (1m resolution) and Lidar data (0.5 m in 2015 and 2 m in 2011) to detect and classify land use changes in Brazos County.
- Development of a hybrid dual-source ET model for different ecosystems, including deciduous broadleaf forest, woody savanna, grassland, cropland, rangeland, and urban areas. Horizontal (patch) and vertical (layers) components are applied for quantifying soil evaporation, vegetation transpiration, and under-canopy evaporation (Yang). Combination of the retrieved canopy and soil surface resistances from stacked NAIP-Lidar images with the newly available Soil Moisture Active Passive (SMAP) data for surface soil moisture will enable this hybrid dual-source ET model, once validated against field data, to compute regional ET and its dynamics.
- Use of the developed model to predict ET and its spatial-temporal distribution under different scenarios of urbanization and woody plant encroachment, and to predict the water supply situation under varying precipitation and land cover scenarios.

Timeline of Activities in 2016

- *Jan.–Feb. Literature review and data acquisition from Evans Library, TNRIS, etc.*
- *March Voxel extraction of Lidar data, resampling with same resolution with TNRIS, and stacking of all images for PCA analysis*
- *April–May Land use classification and accuracy assessment by ENVI*
- *Jun. SMAP data processing and accuracy assessment*
- *July–Sept. Hybrid dual-source ET model development*
- *Oct.–Nov. Drafting of report and writing of journal paper*
- *Dec, Document s submission and presentation*

c) Methods, procedures, and facilities

The methods that would be extensively used are mainly remote sensing and quantitative simulation based on field data and improved empirical formulae, and geospatial statistical analysis to compare the distribution of ET with different landscapes. The procedures are largely NAIP image processing and Lidar point cloud voxel extraction. Facilities include our departmental Spatial Sciences Laboratory, for access to remote sensing software, e.g., ENVI (Exelis), Quick Terrain Modeler, ArcGIS, and LAStools; Evans Library, for archive imagery for Brazos County back to the 1940s; and the 2011 Lidar data from GIS & Map Library at Texas A&M University.

d) Statement of expected results or benefits

High-resolution ET maps will be produced for annual and monthly time scales for Brazos County. The factors driving the distribution and dynamics of ET will be explained. Maps of future ET under different scenarios will be proposed, to provide concrete support for water resources planning and sustainable management in Brazos County.

7. Intended career path:

I would seek a faculty position in academia, if possible.

Citations:

Brooks, J.R. (2015) Water, bound and mobile. Science 349(6244), 138-139.
Board, T.W.D. (2012) 2012 State Water Plan, p. 148, Austin.
Syed, T.H., Famiglietti, J.S., Chambers, D.P., Willis, J.K. and Hilburn, K. (2010) Satellite-based global-ocean mass balance estimates of interannual variability and emerging trends in continental freshwater discharge. Proceedings of the National Academy of Sciences of the United States of America 107(42), 17916-17921.
Yang, Y. Evapotranspiration over heterogeneous vegetated surfaces : models and applications.