Bushland Evapotranspiration and Agricultural Remote Sensing System (BEARS)

Prasanna H. Gowda[1] Agricultural Engineer

Jerry E. Moorhead[1] Biological Science Technician

Daniel E. Holman[2] Software Application Developer

Dana O. Porter[2] Associate Professor

Thomas Marek[3] Agricultural Engineer

George Paul[3] Assistant Research Scientist

Paul Colaizzi[1] Agricultural Engineer

Terry A. Howell[1] Ret. Laboratory Director

[1]USDA-ARS Conservation and Production Research Laboratory, Bushland, TX; [2]Texas A&M AgriLife Research & Extension, Lubbock, TX; [3]Texas A&M AgriLife Research & Extension, Amarillo, TX

ABSTRACT

High-resolution daily evapotranspiration (ET) maps would greatly assist irrigation scheduling and hydrologic modeling. Numerous remote sensing-based ET algorithms that vary in complexity are available for estimating spatially and temporally variable daily ET at a regional scale. However, implementation of these algorithms for deriving ET maps on a daily basis requires high level remote sensing expertise and expensive specialized software. In this study, we present the Bushland Evapotranspiration and Agricultural Remote sensing System (BEARS), a standalone application being developed using the Java Programming Language for deriving ET maps from Landsat 5/7 and Moderate Resolution Imaging Spectroradiometer (MODIS) data. This is a collaborative project between USDA-ARS (Bushland), Texas AgriLife Research (Amarillo) and Extension (Lubbock), and Kansas State University that would bring us one step closer to implementation of an operational ET remote sensing program for irrigation scheduling purposes. Users will have the option of selecting one of the five energy balance based ET methods: Mapping Evapotranspiration with Internalized Calibration (METRIC), Surface Energy Balance Algorithm for Land (SEBAL), SEBS (Surface Energy Balance System), Two Source Model (TSM), and Simplified Surface Energy Balance (SSEB) for deriving ET maps interactively or in a batch mode. Other capabilities of the BEARS include spatial interpolation of selected climatic variables and reference ET maps using point datasets, accuracy assessment of interpolated maps, and numerous GIS techniques for managing remote sensing data and ET maps. At present, efforts are being made to include capabilities for deriving ET maps from MODIS data. The BEARS is designed for use by extension specialists and groundwater districts, with minimal background in remote sensing and agrimeteorology, for irrigation scheduling and ground/surface water management purposes. This package can also be used by climate change and watershed modelers to develop historical ET databases at a regional scale to assist with accurate prediction of spatially variable water budgets.

INTRODUCTION

Remote sensing based energy balance (EB) models can be used to convert satellite sensed radiances into land surface based characteristics such as albedo, leaf area index, vegetation indices, surface emissivity, and surface temperature to estimate ET as a residual of the land surface energy balance equation as defined by:

$$LE = R_N - G - H$$

where R_N is the net radiation resulting from the energy budget of short and long wave radiation, LE is the latent heat flux from ET, G is the soil heat flux into the ground, and H is the sensible heat flux (all terms in units of W m^{-2}) to the atmosphere. LE can be converted to ET (mm h^{-1} or mm d^{-1}) by dividing it by the latent heat of vaporization.

Numerous remote sensing algorithms are available today for estimating magnitude and trends in regional ET. Widely used models include the Two-Source Model (TSM; Norman et al., 1995), Surface Energy Balance Algorithm for Land (SEBAL; Bastiaanssen et al., 1998), Mapping Evapotranspiration with Internalized Calibration (METRIC™; Allen et al., 2007), Surface Energy Balance System (SEBS; Su, 2002), and Simplified Surface Energy Balance (SSEB; Senay et al., 2007; Gowda et al., 2009a). A detailed review of different ET algorithms can be found in Gowda et al. (2008). However, implementation these methods requires high-level remote sensing expertise and strong background in agrimeteorology.

OBJECTIVE

Development of a platform-independent, user-friendly geographic information system (GIS) and image processing software for deriving hourly, daily, and seasonal regional evapotranspiration maps using Landsat and MODIS data.

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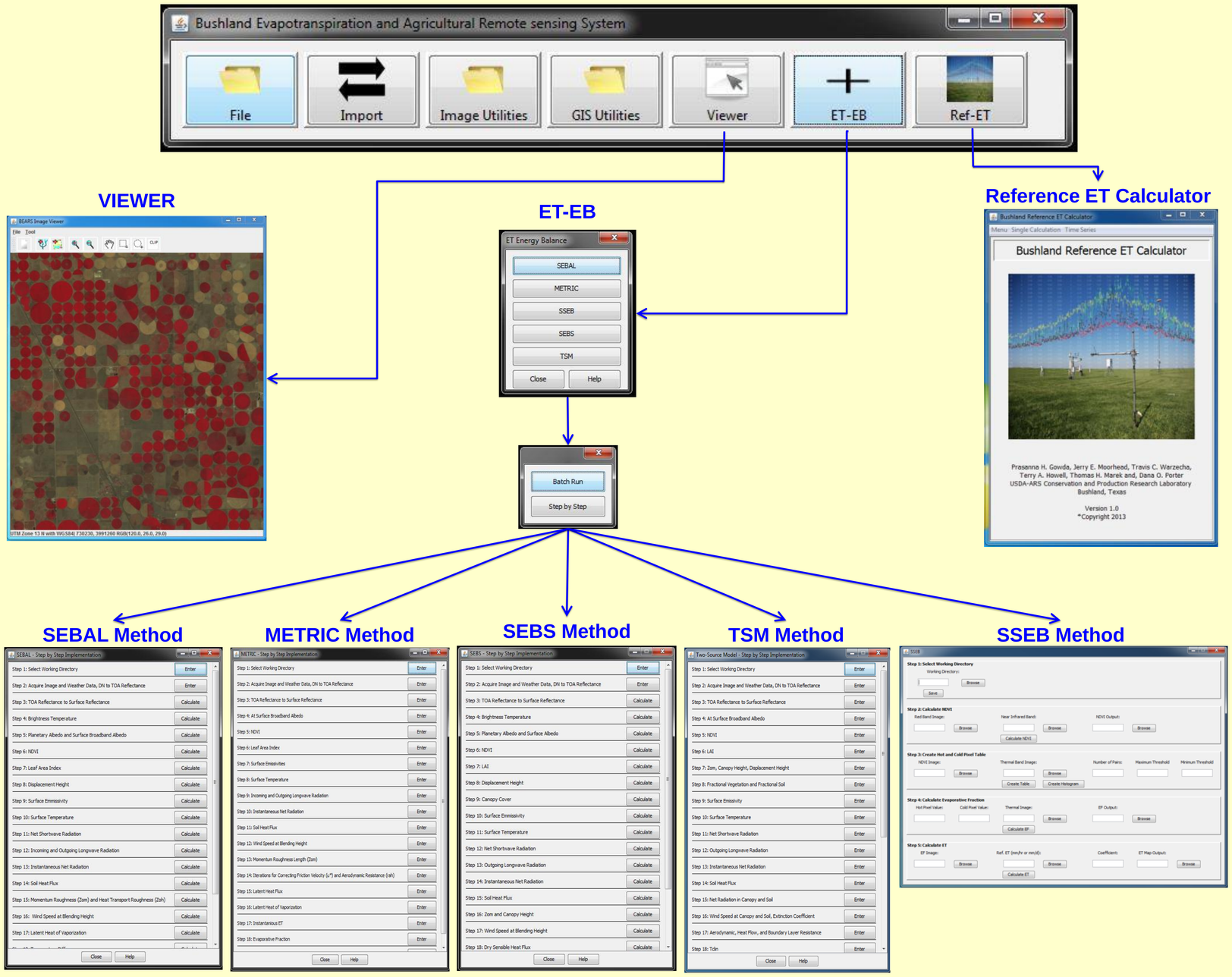
BEARS' CAPABILITIES

- BEARS is a standalone GIS and image processing software for deriving regional ET maps using thermal remote sensing data.
- Java Programming Language
- SEBAL, METRIC, SEBS, TSM, and SSEB are available for deriving ET maps interactively.
- Other capabilities include (1) three different methodologies for automated selection of hot and cold pixels; (2) downscaling algorithms to develop high temporal and high spatial resolution ET maps from coarser resolution remote sensing data; (3) spatial interpolation of selected climatic variables and reference ET maps using point datasets; (4) Bushland Reference ET Calculator; and (5) numerous GIS techniques for managing ET maps.
- Implementation of the energy balance models is done in two modes: (1) Step-by-step and (2) Batch.
- Step-By-Step mode: User can implement the energy balance method one step at a time.
- In batch mode, users provide only image information and weather data in one-step to develop an ET map without any other user interactions.
- Hot and cold pixel selection for implementing SEBAL, METRIC, and SSEB methods include three options that are being developed by another project.
- A viewer is designed to display and query image and GIS data.
- Other capabilities of the viewer include zoom in and zoom out images, panning, search by geographic coordinates, and clip the area of interest on the image for evaluating and reporting purposes.

USER INTERFACE



Summary

- Programming and testing of five energy balance models using Landsat TM/ETM+ data is completed.
- Numerous GIS and image processing capabilities are being added to the Viewer
- Complete software is expected to be released for public use during 2015 ASA-CSSA-SSSA annual meeting at no cost.