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Editorial: Special issue on remote sensing of crop evapotranspiration for large regions

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Essentially all countries on planet Earth are striving to improve their means for managing water resources, including management and distribution of irrigation water. The impetus for improved management is to increase food production to sustain the human population and to preserve the health and integrity of the Earth's environment. Increased levels of water management require increased accuracy and sophistication in how we quantify components of the hydrologic cycle, including evapotranspiration (ET). ET from irrigated crops represents a huge consumption of fresh water around the globe, and this ET is highly variable over time and with type of vegetation.

Because water shortages reduce ET rates and thus food production, it is imperative that water managers, planners and hydrologists determine in detail its spatial and temporal distribution. This task is bolstered by the information that can be gleaned from remotely sensed imagery. Much progress has been made in using satellite imagery to predict ET over large areas. ET determined using remotely sensed data is now sufficiently accurate and dependable to apply ET "maps" to planning and management activities and to evaluations of irrigation project performance and crop yields.

This special issue of Irrigation and Drainage Systems contains 10 papers describing a broad range of science and application of remote sensing for ET determination. These papers were originally solicited and presented at the ICID sponsored International Workshop on Use of Remote Sensing of Crop Evapotranspiration for Large Regions. That one-day workshop was held in Montpellier, France on 16 September 2003, with the primary objectives of illustrating the benefits of quantifying and managing ET in irrigated agriculture, examining the current state-of-the-art to determine ET from remote sensing, and to review the applications of remote sensing to irrigated agriculture and extended applications for prediction of soil moisture, crop yield and irrigation uniformity and scarcity. The objectives for the series of papers in this special issue are the same. Each paper has received substantial peer review and editing prior to its publication in this issue.

The introductory paper by Perry (*Irrigation reliability and the productivity of water: A proposed methodology using evapotranspiration mapping*) provides background, vision and motivation for bringing remotely sensed ET information into an irrigation performance framework. The paper discusses the problem of having indicators for irrigation performance assessment that cannot be applied because of incomplete data sets. Inherent to that, the author suggests a different set of performance indicators that are based on measurable technologies, of which remote sensing must be a significant input. This call for a shift in performance assessment as a general issue deserves attention throughout the irrigation community. Perry discusses the need to describe and quantify the reliability of irrigation systems and farmer responses to that reliability and how this can be achieved through remote sensing.

Courault, Seguin, and Olioso (*Review on estimation of evapotranspiration from remote sensing data: From empirical to numerical modeling approaches*) provide a good overview of the work done within the international community over the last 25 years related to thermal remote sensing. The inclusion of some fundamental equations and relationships help the reader understand some of the major differences among the various methods developed. The paper provides some intercomparisons among ET models using the same dataset (Alpilles Reseda Project) and a summary of advantages and disadvantages of the different approaches and practicalities in applying remote sensing techniques, such as reliance on input data. Some schematic summaries allow the reader to quickly glean essential differences among the model approaches and to assess the progress of the TIR research community.

Allen, Tasumi, Morse, and Trezza (*A landsat-based energy balance and evapotranspiration model in western US water rights regulation and planning*) describe the potential for and application of surface temperature based models to predict areal ET for water resources planning, monitoring and evaluation in the Western US. The work provides an example of achievements and of potential applications in the US, including ground-water modeling, water rights enforcement, prediction of streamflows of shared rivers (among states), and determination of populations of crop coefficients.

The paper of Bastiaanssen and Harshadeep (*Managing scarce water resources in Asia: The nature of the problem and can remote sensing help?*) paints a clear picture of why remotely sensed ET is imperative for quantifying and solving a variety of water resource problems and uses scenarios from several Asian countries to illustrate important points. The paper describes the application of remote sensing techniques over a wide range of water management and crop production questions and provides stimulating ideas for application.

The paper by Gieske and Meijninger (*High density NOAA time series of ET in the Gediz Basin, Turkey*) describes the processing and assemblage of an impressive 70 NOAA/AVHRR satellite images obtained from the Satellite Active Archive over a single growing season for an area in western Turkey. Gieske and Meijninger applied the SEBAL model to obtain ET and compared results with integrated ET derived from sensible heat flux measured over the area using scintillometer and temperature fluctuation systems. This work demonstrates the value of near-real time processing of inexpensive, low spatial resolution (1 km pixel size) but high temporal resolution (every few days) imagery to determine seasonal ET for vast irrigated river basins on an operational basis.

Garatuza-Payán and Watts (*The use of remote sensing for estimating ET of irrigated wheat and cotton in NW Mexico*) provides an example of combination of thorough field measurements and remote sensing for assessing the water use in a large irrigation scheme in Mexico. The technique used is a combination of remotely sensed (satellite) vegetation indices and uses geostationary satellites to predict impact of cloud cover on solar radiation. The satellite-based solar radiation maps are used to predict spatial distribution of potential ET. The paper describes a method to assess actual ET for homogeneous and well irrigated wheat and cotton crops, based on reflectance-based crop coefficient functions derived from vegetation indices at the local scale and potential ET at the regional scale.

The paper by Neale, Jayanthi, and Wright (*Irrigation water management using high resolution airborne remote sensing*) is the only paper to describe the application of remotely sensed data obtained by airplane and at very high (0.5 m) resolution. The authors describe the derivation of canopy reflectance based mean and basal crop coefficient curves for use with remotely sensed vegetation indices and subsequent prediction of ET by field for intensively irrigated areas. Crop water needs are assessed from the actual condition of the standing crop and in-field variability. Indications are given on how both aerial and satellite remote sensing data can be used in a complementary fashion to increase spatial information.

Calera-Belmonte, Jochum, Cuesta-Garcia, Montoro-Rodriguez and Lopez-Fuster (*Irrigation management from space: Towards user-friendly products*) describe how Earth observation (EO) products are used in a practical way to improve irrigation operations on a weekly basis. Their satellite-derived product for crop coefficients by field provides Irrigation Advisory Services (IAS) means to achieve better efficiency in the use of irrigation water. The goal of project DEMETER (DEMonstration of Earth observation TEchnologies in Routine irrigation advisory services) is to assess and demonstrate how performance and cost-effectiveness of an IAS are improved by the incorporation of EO techniques and information society technology into day-to-day operations.

Tasumi, Trezza, Allen, and Wright (*Operational aspects of satellite-based energy balance models for irrigated crops in the semi-arid US*) provide background on intensive testing of some application extensions to the SEBAL energy balance model. They compare ET predicted by the energy balance models to ET measured by lysimeters along with analyses on sensitivity to atmospheric correction and repeatability among satellite paths and operators. They discuss how a well formulated internal calibration procedure such as used by SEBAL can compensate well for error in surface temperature, albedo and atmospheric correction. The paper demonstrates how ET mapping by satellite can be used to confirm traditionally applied crop coefficient curves.

The paper of Olioso, Inoue, Ortega-Farias, Demarty, Wigneron, Braud, Jacob, Lecharpentier, Ottlé, Calvet, and Brisson (*Future directions for advanced evapotranspiration modeling: Assimilation of remote sensing data into crop simulation models and SVAT models*) provides an intensive review of modeling experience and research work in remote sensing by the French community. The paper describes how soil-vegetation-atmosphere transport (SVAT) models can be driven using remotely sensed data and the necessary data assimilation techniques. Validation comparisons help the reader gain confidence in the methods presented. Although the practical impetus is limited, it shows the progress of deterministic modeling into demystifying the roles of key physical processes that link irrigation water supply to water use, carbon assimilation and crop yield. Olioso's paper provides a glimpse into the future when operations in irrigation and drainage will be benefited by crop simulation and SVAT models that are driven spatially and in time by remotely sensed data.

The editors wish to thank all of the authors of this special issue for their substantial efforts in assembling these papers describing the state-of-the-art in remote sensing of evapotranspiration for irrigation and drainage. The papers provide illumination of what is currently possible today, where we will be tomorrow, and the tremendous benefits and economies gained.