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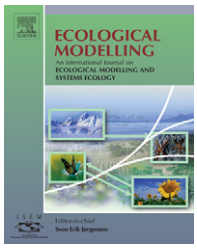

An evaporation estimation model using optimized fuzzy learning from example algorithm with an application to the riparian zone of the Middle Rio Grande in New Mexico, U.S.A.

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ABSTRACT

The existing temperature difference method for estimating soil-water evaporation using infrared thermometry requires the use of simplifying assumptions that were generally found to be invalid. Attempts to develop an evaporation estimation method without these assumptions have produced methods that are expensive in labor and require substantial equipment to be applied at remote locations. In this study, a method is proposed that eliminates the necessity of using these assumptions, while retaining model simplicity and versatility. The proposed method uses an optimized fuzzy learning from example (OFLFE) algorithm to develop the model. The use of fuzzy methods enable the OFLFE to deal with modeling and experimental uncertainty, which are difficult to handle using the existing temperature difference method. The proposed method was used to estimate soil-water evaporation in the riparian zone of the Middle Rio Grande of New Mexico, U.S.A. The proposed method was capable of reducing the prediction error by 71% compared to the existing temperature difference method. The use of the proposed method in practical estimation of evaporation from field data is also discussed.

1. Introduction

As demands on the over allocated waters of the Rio Grande Basin (Fig. 1) continue to increase, methods are needed to quantify the various water uses and losses. This is becoming an increasingly critical issue, as the United States federal government has identified the Upper Rio Grande as having a high potential for conflict and crisis, especially in drought conditions (U.S.D. of Interior, 2003). One of the most difficult sources of water loss to measure is evapotranspiration (ET) along riparian zones. ET, which is the combination of soil-water evaporation and vegetation transpiration, represents a significant source of water loss in the Rio Grande Basin. According to Papadopulos and Associates (2003), water losses due to ET in the riparian environment of the Middle Rio Grande of New Mexico account for 37% of the total losses, the largest single source of water loss in the basin.

Currently, ET is measured at numerous sites along the Rio Grande riparian zone using eddy covariance towers (Dahm et al., 2002). A limitation of the eddy covariance method is that the soil-water evaporation and transpiration are estimated as a single value. A method is needed to decouple the soil-water evaporation and transpiration components of ET to enable the determination of water loss due to various types of vegetation.

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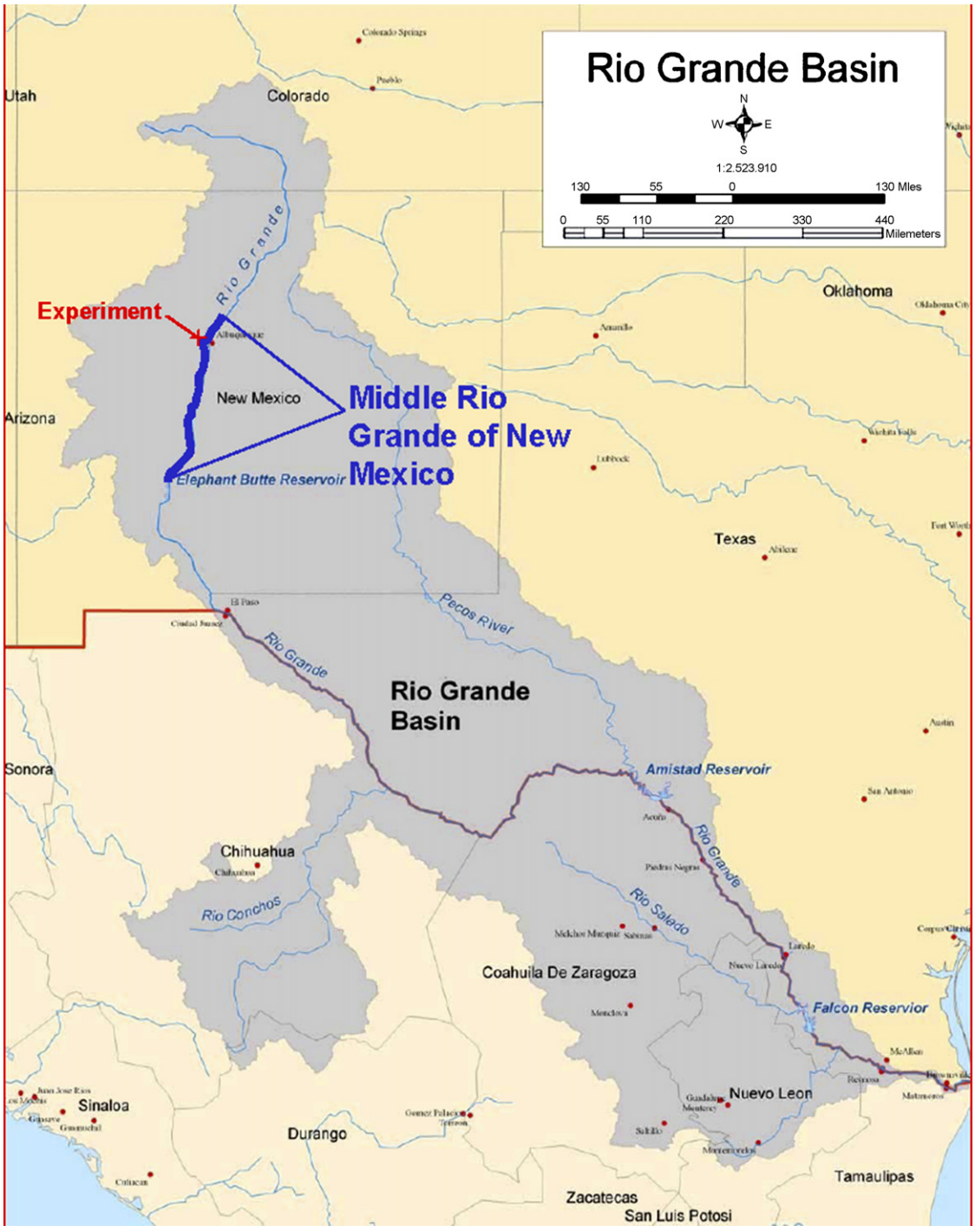

Fig. 1 – Rio Grande basin with Middle Rio Grande and experiment location marked in red. Information from Central Southwest/Gulf Coast Information Node. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

A method is also needed to rapidly measure the soil-water evaporation from the numerous sand bars typically exposed along the river, as well as bare soil exposed in devegetated areas, a common consequence of various stages of habitat restoration and riparian zone management. A soil-water evaporation estimation method using fuzzy modeling is proposed here to fill these needs.

Existing methods of evaporation estimation have focused on determining water losses from irrigated fields. The main objective of this research has been to determine agricultural practices to reduce water losses (Ben-Asher et al., 1983; Evett et al., 1994; Qiu et al., 1998, 1999). Similar methods can be applied to riparian zones to estimate soil-water evaporation, with the objective of determining habitat restoration and riparian zone