Global and Planetary Change 67 (2009) 78–86

Contents lists available at ScienceDirect

Global and Planetary Change

journal homepage: www.elsevier.com/locate/gloplacha

Satellite-based modeling of transpiration from the grasslands in the Southern Great Plains, USA

Joseph G. Alfieri [a], Xiangming Xiao [b], Dev Niyogi [a,c,*], Roger A. Pielke Sr. [d], Fei Chen [e], Margaret A. LeMone [e]

[a] Department of Agronomy, Crop, Soil, and Environmental Sciences, Purdue University, West Lafayette, Indiana 47907, USA
[b] Institute for the Study of Earth, Oceans, and Space, University of New Hampshire, Durham, New Hampshire 03824, USA
[c] Department of Earth and Atmospheric Sciences, Purdue University, West Lafayette, Indiana 47907, USA
[d] Colorado State University, Department of Atmospheric Science, Fort Collins, Colorado 80523, USA
[e] National Center for Atmospheric Research, Boulder, Colorado 80307, USA

ARTICLE INFO

Article history:
Accepted 8 February 2009
Available online 3 January 2009

Keywords:
Moderate Resolution Imaging Spectroradiometer (MODIS)
2002 International H2O Project
IHOP_2002
Southern Great Plains
Vegetation Transpiration Model
Vegetation Photosynthesis Model
evaporation
transpiration

ABSTRACT

Data from the 2002 International H_2O Project (IHOP_2002), which was conducted during May and June 2002 in the Southern Great Plains of the United States, was used to validate a remote sensing-based Vegetation Transpiration Model (VTM). The VTM is based on the linkage between transpiration and photosynthesis, and has been successfully tested over forest landscapes. This study is the first evaluation of the VTM model over grasslands. Since grasslands represent a significant proportion of the Earth's terrestrial surface, this research marks an important step toward applying a satellite-based transpiration model over a landscape that plays a critical role in numerous biogeochemical cycles on both regional and global scales. Comparison of the model output with observer transpiration showed the VTM tended to overestimate transpiration under sparely-vegetated conditions and overestimate transpiration when the vegetation was full. These results indicate that explicitly incorporating the effects of LAI into the VTM could improve model estimates of transpiration; they also underscore the importance of soil evaporation in grassland environments and consequently the need for a companion soil evaporation model that works with the VTM.

1. Introduction

Evapotranspiration (ET), the combined transport of moisture from the land surface to the atmosphere by soil evaporation and vegetation transpiration (TR), is a fundamental process linking numerous hydrologic, atmospheric, and ecological processes. Globally, nearly two-thirds of the precipitations that falls over land is returned to the atmosphere via ET (Baumgartner and Reichel, 1975); thus, ET is clearly an important component of the water cycle and hydrologic processes. Furthermore, as an integral component of the surface energy budget, ET is also linked to a variety of atmospheric processes (Pielke et al., 1998, 2007) ranging from the development of mesoscale circulation patterns (Hanesaik et al., 2004; Raddatz, 2007) to the evolution of the atmospheric boundary layer (LeMone et al., 2002, 2007a) and the development of convective storms (Pielke, 2001). The TR component of ET is closely connected to many ecological and biogeochemical processes ranging from nitrogen cycling (Schulze et al., 1994) to carbon uptake through photosynthesis (Farquhar and Sharkey, 1982).

Many researchers have sought to use remotely sensed data to understand and model the role of the land surface in environmental processes (e.g. Potter et al., 1993; Ruimy et al., 1994; Prince and Goward, 1995; Jiang and Islam, 2001; Norman et al., 2003; Anderson et al., 2004; Tian et al., 2004; Batra et al., 2006; Jin and Liang, 2006). This study applies a remote sensing-based photosynthesis model, the Vegetation Photosynthesis Model (VPM), and specifically the transpiration or Vegetation Transpiration Model (VTM) component of that model, over grasslands using data collected as a part of the 2002 International H_2O Project (IHOP_2002; Weckworth et al., 2004; LeMone et al., 2007b). The VTM is built on the close relationship between photosynthesis and transpiration and utilizes water use efficiency (WUE) and gross primary production (GPP) to estimate transpiration. GPP data are estimated by the VPM using satellite imagery, air temperature, and photosynthetically active radiation (PAR; Xiao et al., 2004a,b, 2005).

While the VPM and the VTM previously have been validated over forested regions (Xiao et al., 2004a,b, 2005, 2006), they have not yet been tested against observations collected over grasslands. Such a model evaluation is important because these ecosystems are a major component of terrestrial land use and land cover. Grasslands constitute approximately 52.5×10^6 km^2 or 41% of the earth's terrestrial, ice-free surface (White et al., 2000). This includes 41% of the land cover of North America (Suyker and Verma, 2001) and 22% of Europe (Soussana et al., 2007). Due to the ubiquitous nature of grasslands, they play an important role in land–atmosphere exchange

* Corresponding author. Department of Agronomy, Purdue University, 915 W. State Street, West Lafayette, Indiana 47907, USA. Tel.: +1 765 494 6574; fax: +1 765 496 2626.
E-mail address: dniyogi@purdue.edu (D. Niyogi).

0921-8181/$ – see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.gloplacha.2008.12.003