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Application and Validation of a MODIS-based Vegetation Transpiration Model Over the Southern Great Plains Using IHOP 2002 Data

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Introduction:

The International H2O Project 2002 (IHOP 2002), which was conducted during May and June 2002, sought to better understand spatial and temporal variations in the water vapor field in the Southern Great Plains (SGP). One fundamental influence on this water vapor field is transpiration. Data collected at five IHOP 2002 surface sites (Figure 1), which are representative of the crop and grassland environments typical of the SPG, were used to validate a remote sensing based vegetation transpiration model (VTM). While VTM has been tested over forest environments, this is the first evaluation of the model over crop and grassland environments. Since these land use types represent a significant proportion earth's terrestrial surface including nearly 40% of the land cover of the contiguous United States, this research marks an important step toward modeling transpiration over a region that plays a critical role in numerous biogeochemical cycles on both regional and global scales.

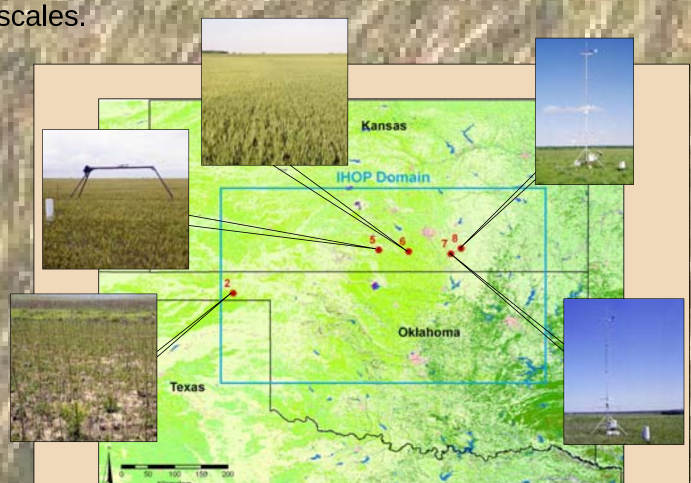

Figure 1 The IHOP Domain and the location of the field sites used are shown. A photo of each surface site is also shown.

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Methods:

The VTM was driven using a combination of surface observations – air temperature, Photosynthetic Active Radiation (PAR), and leaf area index – and satellite derived vegetation and surface indices such as NDVI. The output from the model was then compared to the observed flux. The evaluation focused on five IHOP surface sites (Table 1) representing both winter wheat and grassland environments.

Table 1 The land cover type for each of the IHOP surface sites used in this study are provided.

Site Number	Land Cover
2	Grassland
5	Winter Wheat
6	Winter Wheat
7	Pasture
8	Grassland

Model Description:

The VTM combines surface observations with remotely sensed data to determine both Gross Primary Production (*GPP*) and transpiration. *GPP* is first calculated as follows:

$$GPP = \varepsilon_g \times FAPAR_{chl} \times PAR$$

where ε_g is light use efficiency and *FAPARchl* is the fraction of photosynthetic active radiation absorbed. Next, transpiration (*TR*) is determined as a function of *GPP*:

$$TR = \beta_g \times GPP$$

where β_g is the transpiration ratio.

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Conclusions:

These results suggest that the VTM is able to accurately model transpiration over grassland environments. However, the analysis also underscores the need to further develop the VTM. The model would be greatly enhanced by incorporating a soil evaporation component so that the VTM is able to consider this moisture exchange pathway as well. This would allow VTM to accurately describe the total moisture flux following rain events, such as were observed at IHOP Site 2, or when the surface is only partially vegetated, such as at IHOP Site 5 after the winter wheat crop was harvested.

Results

Typically, the modeled transpiration was slightly less than the observed total moisture flux. However, important exceptions are evident at different sites during specific time periods (Figure 2).

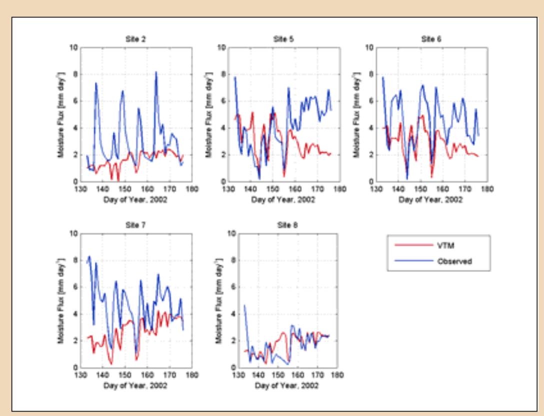

Figure 2 The modeled and observed moisture flux is shown for each of the IHOP surface sites.

The time periods when modeled transpiration and the observed moisture flux diverged are linked to changes in environmental conditions that preferentially enhance soil evaporation. For example, spikes seen in the observed flux at IHOP Site 2 follow precipitation events (Figure 3). When days for which there was precipitation are omitted from the analysis modeled transpiration averaged 1.74 mm day^{-1} or 63% of the total observed moisture flux.

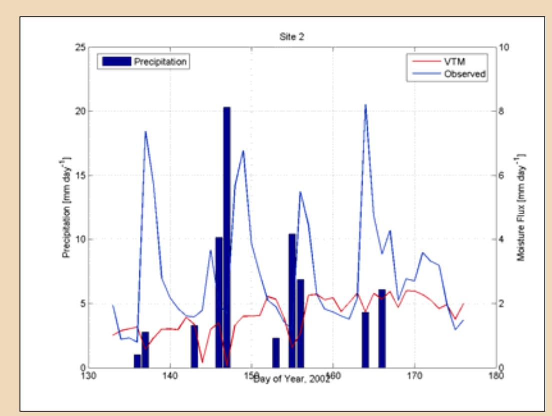

Figure 3 Differences in the modeled and observed moisture flux diverge following rain events at IHOP Site 2.

Similarly at IHOP Site 5, the VTM reproduced the observed moisture flux until June 9 (Day of Year 160) when the fluxes diverge (Figure 4). This can be linked to vegetative cover. Prior to June 9, the site was cropped with winter wheat and the primary exchange pathway was through transpiration. The modeled and observed moisture flux were on average within 0.15 mm day^{-1} or 5% of one another. After June 9, when the crop was harvested, soil evaporation was the primary pathway for moisture transfer. As a result, the observed moisture flux was as much as 5 mm day^{-1} or more than 3 ½ times greater than the modeled transpiration.

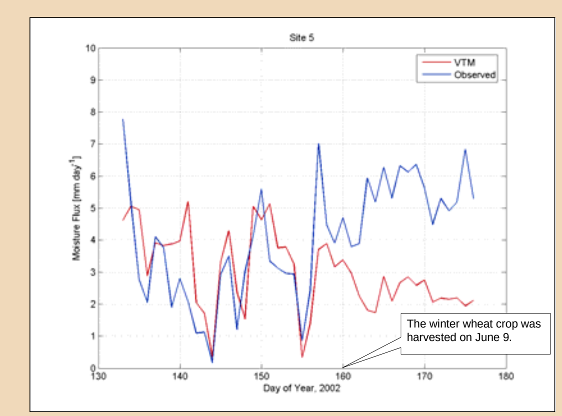

Figure 4 Differences in the modeled and observed moisture flux after the harvest.