Land Use Effects on Green Water Fluxes from Agricultural Production in Mato Grosso, Brazil

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Introduction

The blue water/green water paradigm is increasingly used to differentiate between subsequent routing of precipitation once it reaches the soil. “Blue” water is that which infiltrates deep in the soil to eventually become streams and aquifers, while “green” water is that which remains in the soil and is either evaporated ("non-productive" green water) or transpired by plants ("productive" green water) (Fig.1 in Falkenmark & Rockström, 2006). This differentiation in the fate of precipitation has provided a new way of thinking about water resources, especially in agriculture for which better use of productive green water may help to relieve water stresses. The state of Mato Grosso, Brazil, presents a unique case for the study of green water fluxes due to an expanding agricultural land base planted primarily to soybean, maize, sugar cane, and cotton. These are highly dependent on green water resources in Mato Grosso where crops are almost entirely rain-fed. In this study, we estimate the change in green water fluxes from agricultural expansion for the 2000-2008 period in the state of Mato Grosso based on agricultural production data from the Instituto Brasileiro de Geografia e Estatísticas (IBGE, 2010a) and the Penman-Monteith equation.

Green Water

Green water plays an important role in rain-fed agricultural systems where it is the only water source available for production. Land management practices can greatly change the amount of green and blue water in a field. Shifting soil evaporative fluxes to productive crop transpiration can greatly improve yields in areas of the world which depend on rain-fed agriculture (de Fraiture, et al., 2009).

Green water also plays an important role in renewing local precipitation as it feeds the atmosphere with water vapour. Changes in land use affect the partitioning of water in blue and green components with possible effects on the renewability of precipitation.

Fig. 1: Green and Blue Water (Falkenmark & Rockström, 2006)

Research Area and Objective

State of Mato Grosso, Brazil

The region is home to some of the most productive soils in the world. Agriculture has greatly expanded since 2000. Main crops are soybean, maize, sugar cane and cotton and are almost entirely rain-fed.

In 2009 (IBGE, 2010a):
- Total harvested area: 8,757,373 ha
- Total harvested area (annual crops): 8,702,562 ha
- Total harvested area (perennial crops): 54,811 ha
- Irrigation (2006): 148,425 ha

Research objective

To determine the change in green water fluxes with agricultural expansion in Mato Grosso (2000-2008).

Fig. 2: The state of Mato Grosso in Brazil’s Legal Amazon

Methodology

The Penman-Monteith equation in used to estimate green water fluxes based on reference evapotranspiration (ET0) and crop coefficients Kc specific to each event (Fig. 3, Allen, et al., 1998):

\[ \Delta(R_e - G) + \rho_c C_{rs} \left( e_s - e_a \right) \frac{1}{\rho_g r_s} \left( \Delta + \gamma (1 + \frac{L}{{L'}}) \right) = K_c \times ET_0 \]

Input data was obtained from the Brazilian National Meteorological Institute (INMET, 2010) which represent a variety of climates and biomes in the state.

Preliminary Results

Fig. 3: Crop coefficients Kc during the crop development cycle (Allen, et al. 1998)

References


INMET. 2010. Climate stations, 2000-2008 (All data obtained from the Brazilian National Meteorological Institute (INMET, 2010) Forest cover, 2000 (INMET-PRODES, 2010)).

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Further work: calculate total change in agricultural green water fluxes relative to available water under current and future climates.