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Combined modeling of hydrology and land use in flat landscapes

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Agriculture must feed a growing and wealthier global population while protecting natural capital, enhancing livelihoods, yielding economic profits, and responding to emerging demands such as biofuel production. Moreover, these challenges must be faced within the multi-faceted contexts of climate variability and change. Food and energy production and the associated use of land and water make agriculture a major contributor to global change; one of the major pathways for this contribution is through interactions between water and agriculture.

This paper aims to characterize the complex, non-linear and reciprocal linkages between climate, hydrology and land use in flat sedimentary landscapes of the Argentine Pampas, one of the main cereal and oilseed producing regions of the world. Most of the Pampas have a very flat topography and poorly developed drainage networks that limit horizontal evacuation of water surpluses. Groundwater typically is close to the surface and tightly coupled to surface water. Shallow water tables can have opposite impacts on crops. On one hand, water tables can be a valuable source of additional water to crops when rainfall is insufficient. Above a certain water table depth (WTD), however, the positive influence of groundwater is replaced by the negative impacts of waterlogging and anoxia. Finally, when water tables reach the surface they may trigger massive flooding events. The flat landscapes of the Pampas historically have displayed cycles of floods and droughts with important economic, social and ecological impacts. Frequency of floods and droughts has been tied to strong precipitation variability in the region. Climate fluctuations have interacted with technological innovations and economic contexts to shape land use. In turn, land use changes have strong implications for climate/water/nutrient interactions and the frequency of floods and droughts. Crops have expanded considerably, replacing grasslands and pastures and reducing carbon and energy available to soil food webs. As crops occupy a field only part of the year, annually they consume less water than pastures or grasslands. Consequently, groundwater recharge increases and water tables rise. Moreover, recent practices such as no tillage cropping leave the soil undisturbed and covered with stubble, reducing evaporation and raising WTD. In contrast, developments such as the wheat-soybean double crop or cover crops increase C inputs to the soil, nutrient retention, and evapotranspiration that lowers WTD. These options can be used to maintain groundwater at desired depths while, at the same time, enhancing agricultural sustainability. Despite their interesting complexity, interactions between hydrological and ecosystem processes mostly have been neglected by crop scientists and land managers, and seldom included in land use decision models. These important linkages will be explored through a fully-distributed and physically-based hydrological model.

Biography

Pablo E. García is Ph.D. student at the Buenos Aires University. He is member of the Computational Hydraulics Program of the National Institute for Water (Argentina) and the Mathematical ModellingLaboratory of the School of Engineering of the Buenos Aires University (Argentina).

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