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Roles of atmospheric and land surface data in dynamic regional downscaling

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[1] In studies dealing with the impact of land use changes on atmospheric processes, a key methodological step is the validation of simulated current conditions. However, regions lacking detailed atmospheric and land use data provide limited information with which to accurately generate control simulations. In this situation, the difference between baseline control simulations and different land use change simulations can be quite different owing to the quality of the atmospheric and land use data sets. Using multiple simulations at the Monteverde cloud forest region of Costa Rica as an example, we show that when a regional climate model is used to study the effect of land use change, it can produce distinctly different results at regional scales, depending on the amount of data available to run the climate simulations. We show that for the specific case of land use change impact studies, the simulation results are very sensitive to the prescribed atmospheric information (e.g., lateral boundary conditions) compared to the land use (surface boundary) information.

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1. Introduction

[2] Land use change affects atmospheric properties and processes such as surface temperature [*Fall et al.*, 2009], boundary layer processes [*Niyogi et al.*, 1999], radiation balance [*Nair et al.*, 2007], convection [*Pielke*, 2001], mesoscale circulations [*Baidya Roy and Avissar*, 2002], cloud cover and properties [*Ray et al.*, 2003, 2006a], atmospheric dispersion [*Wu et al.*, 2009] and precipitation [*Marshall et al.*, 2004; *Ray et al.*, 2006b; *Pielke et al.*, 2007; *Douglas et al.*, 2009; *Niyogi et al.*, 2010; *Kishtawal et al.*, 2010]. A key methodological step in land use change studies has been to first conduct baseline simulations using the current land use and the initial and lateral boundary conditions. The latter is usually provided from the global or regional reanalysis [e.g., *Mesinger et al.*, 2006; *Ray et al.*, 2009]. The baseline simulations are then evaluated against independent observations. Follow-up simulations are then performed with changed land use but retaining the initial conditions and the atmospheric state for the lateral boundaries of the model domain identical to those of the baseline simulations. The differences (Δ) in model output (meteorological fields) between the simulations are used to quantify the impacts of land use conversion.

[3] The impacts of land use change on regional weather or climate measured through differences have at least two types of uncertainties or errors, besides the uncertainties related to imperfect models: (1) errors due to insufficient atmospheric information (uncertainty in input meteorological data) at the initial state and for the lateral boundary conditions (ε_{Atm}) and (2) errors due to uncertainty in the land information for the current condition (ε_{Land}), such as due to spatially incorrect land use types and/or inaccurate leaf area indices.

[4] Usually, land use change studies have dealt with the impact of converting pristine/forested land to current conditions [e.g., *Marshall et al.*, 2003; *Ray et al.*, 2006a; *Douglas et al.*, 2009] and evaluated by taking differences between meteorological fields such as air temperature, cloud cover, and precipitation between the two model simulations (denoted as F and C in equation (1), respectively). The impact of further land conversion/deforestation was computed in such studies using equation (2) (denoted as C for current and D for further deforestation in equation (2), respectively),

$$\Delta_{F\rightarrow C} = (C - F), \tag{1}$$

$$\Delta_{C\rightarrow D} = (D - C), \tag{2}$$

where the arrows in $\Delta_{F\rightarrow C}$ and $\Delta_{C\rightarrow D}$ show change from F to C and change from C to D, respectively. Differences taken with equations (1) and (2), however, include errors

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