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Exploring the impacts of land-use change on tropical rainfall using satellite remote sensing and atmospheric back trajectories

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Vegetation affects precipitation patterns through altering moisture, energy and trace-gas fluxes between the surface and atmosphere. Here we explore the effect of tropical vegetation and land-use change on precipitation using satellite remote sensed observations of precipitation from the tropical Rainfall Measuring Mission and other satellites combined (TRMM3B42) and leaf area index (LAI) from the Moderate Resolution Imaging Spectroradiometer (MODIS). We combine these observations with a Lagrangian atmospheric transport model which we use to describe daily variability in atmospheric transport patterns. We calculate cumulative exposure of air masses to tropical vegetation and explore relationships between this exposure and observed precipitation. We use remote sensed observations of land-use change that has occurred over recent decades to explore how exposure of air masses to vegetation has changed.

We find that for more than 60% of the tropical land surface, air that has experienced a large cumulative exposure to vegetation in the preceding few days produces at least twice as much rain as air that has little exposure to vegetation. To understand potential mechanisms behind this relationship we explore the atmospheric water budget along analysed back trajectories using specific humidity from analysed meteorological fields combined with global land-surface model output of evapotranspiration (ET). We find that ET in air masses with large exposure to vegetation maintains atmospheric moisture sufficiently to explain observed relationships with precipitation.

We estimate the impact of 2000-2010 land-use change on the exposure of air masses to vegetation. We focus on regions of rapid-land use change and explore how these changes have altered air mass exposure to vegetation. We attempt to identify locations where large enough changes may have already occurred to allow an observable impact on precipitation. Finally we use a business-as-usual scenario of Amazonian deforestation that was developed using deforestation rates for the period 1997 to 2002 to estimate reductions of 12 and 21 per cent in wet-season and dry season precipitation respectively across the Amazon basin by 2050, due to less-efficient moisture recycling.