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Regional vegetation impacts on tropical precipitation: observational evidence

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Climate model studies typically predict that large-scale deforestation results in substantial declines in regional precipitation. Observational studies that have attempted to confirm these modelling predictions have yielded conflicting results, likely due to the masking of land-cover induced changes by large temporal and spatial variability in precipitation. Here we explore the effect of tropical vegetation on precipitation using satellite remote sensed observations and a Lagrangian atmospheric transport model. We calculate daily $1^o \times 1^o$ precipitation for the period 1998 to 2009 from the Tropical Rainfall Monitoring Mission (TRMM) 3B42 3-hour $0.25^o \times 0.25^o$ satellite product, globally between 50^oS and 50^oN . Kinematic five-day atmospheric back trajectories, arriving daily at the centre of each grid square were calculated for the same period using meteorological analyses from the European Centre for Medium-range Weather Forecasts (ECMWF). For each back trajectory we calculated cumulative exposure of the air mass to vegetation by overlaying the back trajectory on MODIS satellite-observed leaf area index (LAI). We compared air masses with the same initial moisture content (defined by specific humidity from ECMWF analysis) and found that over large regions of the tropics air masses that passed over more vegetation produced significantly more precipitation. Over the Amazon basin satellite observed precipitation increased by between 0.03 and 0.18 mm day-1 per unit of LAI (m^2/m^2) exposure with correlations significant at the 98% level ($p<0.02$). To our knowledge this is the first observational evidence for a strong effect of forests on tropical precipitation at the regional scale. We use these empirical relationships between exposure of air masses to vegetation and precipitation to estimate the impact of a 2050 business-as-usual scenario of Amazonian deforestation on regional precipitation.