Cascading effects of deforestation in the Amazon on moisture recycling and forest resilience.

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Feedbacks between vegetation and climate - in particular the moisture recycling process - play an important role in the Amazon region. The evapotranspiration from the canopy and the ground surface is an important source of moisture for local rainfall but also for downwind precipitation. Deforestation in the Amazon induces changes in the evapotranspiration rate, which reduce moisture locally and downwind and might lead to a drier regional climate. This in turn creates feedback with vegetation and might lead to an “Amazon rainforest dieback”, i.e. shift from rainforest to savannah, two alternative stable states (tipping point). We analyze vegetation cover estimation (MODIS) in relation to terrestrial evapotranspiration from earth land surface estimation (MODIS) and rainfall estimation (TRMM) by satellite remote sensing data. We use a statistical approach to quantify the probability of rainforest dieback in relation to mean annual precipitation (stability landscape) and to determine the evapotranspiration rate for the two alternative stable states. In addition, we use the Water Accounting Model (WAM) which is based on the atmospheric water balance applied on moisture that is of a certain origin. This model is used to track moisture backward in time, i.e. to determine relative sources of moisture that contribute to rainfall in a particular location. The input of the model are rainfall estimation (TRMM), evapotranspiration estimation (MODIS), wind fields, specific humidity and surface pressure from reanalysis data (ERA Iterim) at 1.5° spatial resolution. The output is an adjacency matrix that indicates the sources of relative moisture contribution to rainfall in each grid cell. We built from this output a complex network in which the grid cells represent the nodes and the sources of moisture represent the links. Using complex network measures (such as degree centrality, betweenness centrality, closeness centrality, clustering coefficient and geographical link distance), we investigate the topology and architecture of the network and determine key regions in moisture recycling and transport network. Finally, we determine key regions in which land use change (deforestation) induce cascading failure and we draw probability maps of cascading vegetation changes in the Amazon.