Geophysical Research Abstracts
Vol. 19, EGU2017-19365, 2017
EGU General Assembly 2017

Detecting the effects of deforestation as a driver of change to terrestrial water partitioning

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Anthropogenic land use change is known to cause shifts to the partitioning of water between runoff, evapotranspiration (ET) and storage within catchments. Whilst deforestation is assumed to result in a decrease of ET, this has not been adequately examined across scales and between catchments of different regions and biomes. Further, recent research has presented differing effects on ET, with both increases and decreases to the fraction of rainfall returning to the atmosphere, resulting from deforestation. Using a hydroclimatic approach, here we attempt to assess the effects of deforestation on ET within boreal, temperate and tropical catchments of North and South America at meso-to-macro scales. Using remote sensing and model-derived quantifications of deforestation for 73 catchments experiencing varying degrees of forest loss, changes to the partitioning of precipitation between runoff and ET were identified for the period 1980-2010. Forty-two catchments experiencing a net forest loss greater than 5% of the total catchment area (loss catchments), and 31 catchments with a net loss smaller than 2% (control catchments), were selected. For each catchment, using the University of East Anglia – Climate Research Unit global data set, annual precipitation (P) and potential evapotranspiration (PET) were derived, and annual runoff (Q) was obtained from the Global Runoff Data Centre discharge data. Annual evapotranspiration (ET) was then estimated from the available water balance components (P and Q). We studied the movements of these basins within the Budyko space, and the respective climate ($\Delta\Psi$c) and landscape ($\Delta\Psi$l) components of $\Delta\Psi$. We found that tropical loss catchments of South America experienced an area weighted mean $\Delta\Psi$ of 0.005, with counteracting effects of $\Delta\Psi$c and $\Delta\Psi$l (0.073 and -0.078 respectively). This contrasts with the results seen within the control catchments of South America, which had $\Delta\Psi$, $\Delta\Psi$c and $\Delta\Psi$l of -0.038, -0.048, and 0.009, respectively. The boreal and temperate catchments of North America showed negative $\Delta\Psi$, $\Delta\Psi$c and $\Delta\Psi$l in both loss (-0.025, -0.001, -0.024) and control catchments (-0.060, -0.003, -0.057 respectively). This suggests that forest loss may have a negative effect on Ψ within tropical locations, but a positive effect within boreal and temperate locations. This difference may be due to: 1) differences in post-clearance land use, 2) a more pronounce effect of land use change on local climate within tropical catchments compared to northern boreal and temperate locations an 3) the role of other important drivers of water partitioning besides forest loss and changes in the aridity index. This work demonstrates the need to improve our understanding of scale-response effects when assessing the vulnerability of water resources to land use change. It serves to inform decision makers working with water resource and land management of the complex interaction between land and the atmosphere.