Geophysical Research Abstracts
Vol. 17, EGU2015-5297, 2015
EGU General Assembly 2015

Element export from a small catchment in the tropical montane forest of Ecuador responds to climate change

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In a very remote tropical montane rain forest in the Ecuadorian Andes on the rim of the Amazon basin, increasing temperatures, longer dry spells, and an associated reduction in soil moisture were observed in the past 15 years. In the study ecosystem, element exports from a 9-ha large catchment with stream water are linked to the depth of water flow through soil because of vertical variations in soil chemical properties. The further increase in temperature and precipitation, as predicted by climate models, will have an impact on the water flow paths in soil and therefore alter element exports. Hence, we investigated how future element exports from this catchment in Ecuador will develop under the emission scenarios A1B and B1 for the decades 2050-2059 and 2090-2099 compared to current element exports.

Discharge from the study catchment was measured in 1998-2013, partly in high resolution. Element concentrations in stream water (total organic carbon, NO_3-N, NH_4-N, dissolved organic nitrogen, PO_4-P, total dissolved phosphorus, S, Cl, K, Ca, Mg, Na, Zn, Al, Mn) were measured in 1998-2012 in weekly resolution. Based on catchment properties, measured climate, and water flow data, discharge in 1998-2013 was simulated in daily resolution with the hydrological model WaSiM. From the hydrograph of surface flow, three flow classes (baseflow, intermediate, storm) were separated and linked with stream chemical properties. Element concentrations in stream water were grouped according to the flow classes and mean concentrations per flow class were calculated. Subsequently, the mean element concentration was multiplied with the mean of the annual discharge sums per flow class resulting in current element exports. For estimations of future element exports with stream water, discharge was simulated under the emission scenarios A1B and B1 for the decades 2050-2059 and 2090-2099 and separated into the three flow classes. Future element exports per scenario were calculated according to the current element exports.

In both climate scenarios and decades, the number of days with high discharge rates (storm) increased and with low discharge rates (baseflow) decreased. Mean discharge rates increased by 7.5-21 % until the end of the 21st century. Annual exports of most elements were predicted to increase, particularly exports of the metals Al, Zn, and Mn (up to + 53% by the end of the 21st century) but also of NO_3-N (+ 27%) while P exports remain unchanged. Our results demonstrate that climate change might considerably affect future element exports from this tropical montane catchment because of changing water flow paths through soil.