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Flood severity along the Usumacinta River, Mexico: identifying the anthropogenic signature of tropical forest conversion.

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Global climate change and anthropogenic activities are disrupting flood frequency-magnitude distributions along many of the world's large rivers, posing critical threats to rising populations and infrastructure. Isolating a single discharge signal amidst the multitudes of competing anthropogenic signatures is a persistent, yet important challenge if we are to mitigate against their negative consequences. The Usumacinta River in southern Mexico provides an ideal opportunity to study an anthropogenic driver in isolation: tropical forest conversion. The Usumacinta flows unobstructed along the entirety of its course, meaning the 55-year discharge record (1959 – 2014) represents the river's response to a changing landscape under climatic variability. This paper employs a novel approach to disentangle the anthropogenic signal from climate variability, and provides valuable insight into the impact of forest conversion on flood severity.

Here we analyse continuous daily time series of precipitation, temperature, and discharge to identify long-term trends, and compare ratios of catchment-wide precipitation totals to daily discharges in order to account for climatic variability, and identify an anthropogenic signature of tropical forest conversion at the intra-annual scale. We successfully reproduce this signal using a distributed hydrological model (VMOD), and demonstrate that the continued conversion of tropical forest to agricultural land will further exacerbate large scale flooding.

We find statistically significant increasing trends in annual minimum, mean, and maximum discharges that are not evident in either precipitation or temperature records. We also find that mean monthly discharges have increased between 7 and 75% in the past decade, in contrast to mean monthly precipitation, which has decreased during the dry-season. Model results demonstrate that forest cover loss is responsible for raising the 10-year return flood by 20%, and the total conversion of forest to agricultural land may result in an additional 23% rise. Meaning the return period for a flood on the order of the 2008 peak discharge would fall from the current estimate of 41 years to just 12 under the total forest conversion scenario.

These findings highlight the need for a holistic approach to catchment-wide land management in developing tropical regions that weights the benefits of agricultural expansion against the consequences of increased flood prevalence, and the economic and social costs that they incur.