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Extreme droughts and floods in the Amazon forest

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In recent years, the Amazon forest has experienced several major droughts (2010, 2015/16) and floods (2012, 2014, 2021). Extreme events represent a threat to the Amazons important functions, but these perturbations also provide valuable insights into the underlying mechanisms. Here we studied the most recent massive drought and flood events in detail, and quantified their severity and spatiotemporal extent relative to a multi-year baseline.

First, we describe the anomalous hydrological status of these events, by bringing together a large variety of data sets, including in-situ observations and reanalysis products for precipitation, discharge, vapor pressure deficit and soil moisture. During the strong El Niño conditions following the dry season of 2015, the precipitation fell below its climatological values. This was soon reflected in low discharge rates and soil moisture levels, persisting far into the year 2016 for some regions. In contrast, we find anomalously high precipitation over the northern Amazon during the first months of 2021, resulting in high discharge rates, and rising river levels that have led to massive floods in downstream regions.

Finally, we quantified the impact of the 2015/16 drought on vegetation using the inverse model CarbonTacker South America (CT-SAM) and remote sensing proxies for photosynthesis. To address the uncertainty in prior emission estimates, we have used a range of different biosphere models (SiBCASA, SiB4), including a biosphere model linked to a detailed hydrological model (PCR-GLOBWB). For the fire flux we used multiple data sets (GFAS, SiBCASA-GFED4), including a modified version based on CO inversions performed with the TM5-4DVAR system. We find that

photosynthesis was reduced during the 2015 drought, especially in the drier, southern part of the Amazon. This was followed by a recovery in the first months of 2016, but during the subsequent dry season a secondary impact on photosynthesis was found. The inversely derived net CO_2 fluxes do not have the same high resolution as the satellite products, but when assessed over larger scales, a consistent drought signal is derived.