Sensitivity and Feedback Analysis of Spatio-Temporal Variability of Rainfall to Land Cover Change across the Amazon Basin

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Abstract

Amazon Basin deforestation has been driven by agricultural expansion and other developments. Interactions between deforestation, fire, climate, and drought have led to changes in precipitation patterns and river discharge. Previous work suggests that these changes are amplified by land use. Therefore, it is important to understand the degree of change in precipitation patterns and rainy season characteristics. We used long term daily gauge measurements and remote sensing data to analyze the variability and seasonality of rainfall patterns over the Amazon Basin. We focused on the PERSIANN-CDR and CHIRPS precipitation datasets from 1983 to 2018 to quantify trends in predefined indices. The indices that were analyzed to assess variability of precipitation are NDD (Number of dry days); NXE (number of extreme events) during both wet and dry seasons; ORS (Onset of Rainy Season); and ERS (End of Rainy Season). We analyzed the trends for statistical significance and spatial similarity to identify hot spots of change. To connect pattern to process, we also simulated the land-atmosphere system using WRF to assess coupling strength and causality. We are running the simulation using CFSR 2010, with grid resolution of 16 km with the convection scheme active to capture small scale convective rainfall. Previous evidence has suggested an increasing trend on NDD during the dry season, a shift to a later onset and later cessation of the rainy season window, and an increasing trend in the NXE during both wet and dry seasons. The significance and spatial distribution of changes may vary over the region, but we anticipate that in the area with the largest percent of deforestation we will see the highest amount of changes in precipitation.

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1 Motivations and Background:

- Deforestation is the dominant human activity which has been replacing forests with farmlands.
- The effects of deforestation and agricultural expansion has local to global impacts particularly on climate and hydrologic cycles.
- changes in land surface characteristics through land cover change will affect the amounts of surface albedo, roughness, and reflectance, it will directly alter the fluxes of heat and energy.
- Partitioning of the fluxes of heat and energy are the most important parameters in rainfall distribution and variability.

Here we investigate the variability of rainfall, its correlation with land cover change, and land-atmosphere coupling strength using:

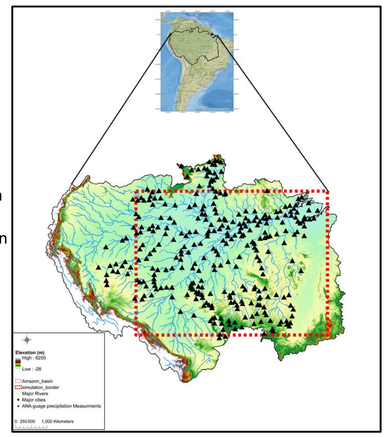
- **CHIRPS** (gridded daily precipitation data, 1982-2018)
- **ANA** (Daily rain gauge datasets from the Brazilian National Water Agency,1982-2018)
- **ESA** (The European Space Agency land cover products, 300m spatial resolution)
- **CFSR** (Boundary condition of simulation, 2010) move to intro

Research Objectives:

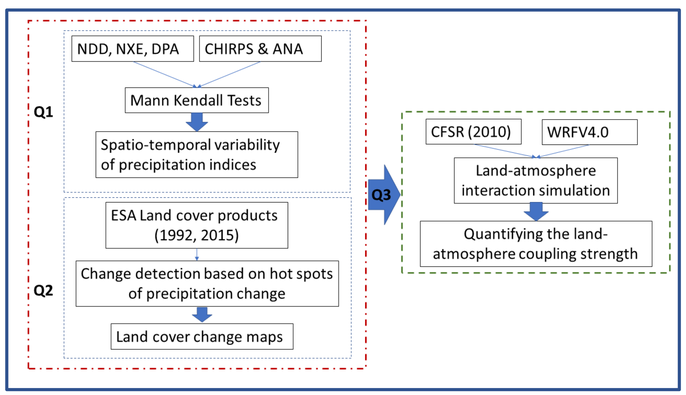
Q1- Analysis of spatio-temporal variability and seasonality of Precipitation
Q2- spatial analysis between land cover change and precipitation change
Q3- Quantifying the coupling strength of land-atmosphere interactions

2 Methodology

- **Number of Dry Days** (NDD) : Days <2 mm precipitation
- **Number of Extreme Events** (NXE) : Days >20mm precipitation
- **Wet season:** Dec 1st to Apr 30th
- **Dry season:** May 1st to Nov 30th
- **Daily Precipitation Amount** (DPA): mm/day



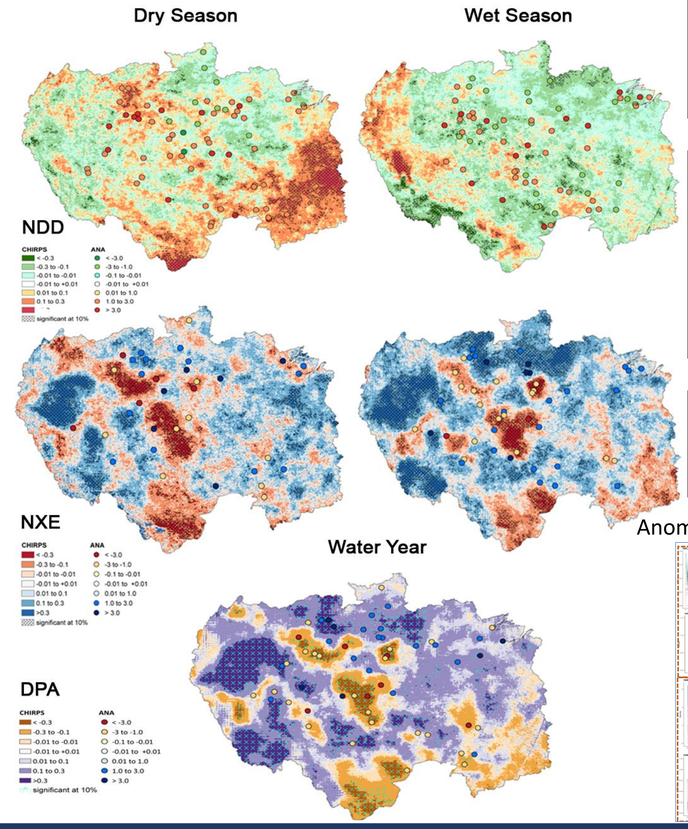
Study area and simulation domain



Conceptual diagram of Methodology

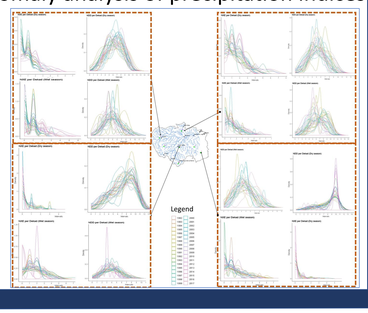
3 Q1: Precipitation Variability

variability of NDD, NXE, and DPA



- NDD of dry season significantly increased in east and south, mostly in the middle of the season.
- NDD in wet season increased in south and northwest, mainly at the beginning and end of the season.
- NXE of dry season shows a significant downward trend from south to north, mostly after 15th dekad of the season.
- NXE of wet season shows significant decreasing trend in the south and center of the region, in the middle of the season.
- Trends in DPA is highly spatially consistent with NXE variability. Hatched areas show 90% significance level.

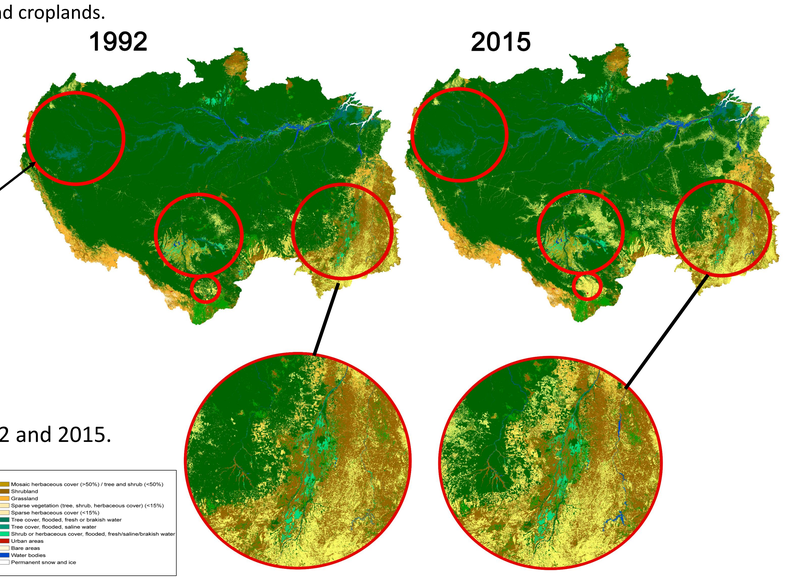
Anomaly analysis of precipitation indices



4 Q2: Land Cover/Land Use Change Analysis

- Expansion of farms and croplands.
- Urbanization
- Deforestation

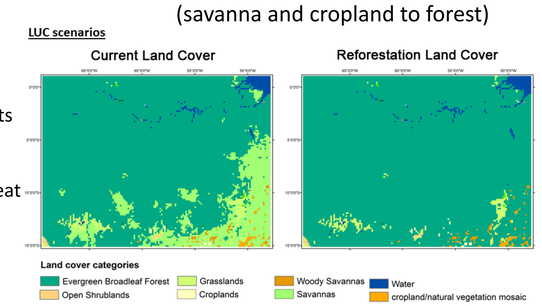
Minimum Land cover change



Land cover maps of 1992 and 2015.

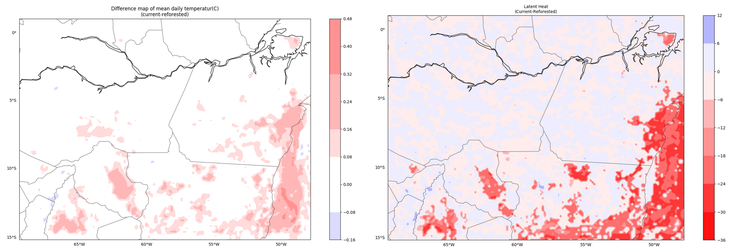
5 Q3: Simulated Land-Atmosphere Interactions

Land cover map (left: current, right: reforestation) (savanna and cropland to forest)



- Reforestation temperature impacts up to 1° C.
- Current land cover shows less latent heat in the atmosphere than the reforested land cover.

Difference Maps of Mean Annual Temperature and Latent Heat (Current – Reforested)



6 Conclusions and future work

- ✓ Strong consistency between precipitation variability and land cover change.
- ✓ Agricultural land and urban expansion around Porto Velho consistent with dry season NXE decrease.
- ✓ Amount of daily precipitation is highly influenced by the NXE.
- ✓ Land surface strongly governs Amazon Basin fluxes of heat and energy.
- ✓ Deforestation in the southeast of the basin increased temperatures up to ~1° C.
- ✓ Deforestation reduces latent heat flux, reducing precipitation recycling.

Future work:

- Define an index of coupling strength to analyze the coupling strength of land-atmosphere in the region.
- Quantifying changes in all important parameters and the coupling strength.
- Analyzing the hydrologic cycle changes in the region using simulation results.

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