Process-Based Evaluation of Tropical Forest Responses to Drought at the Amazon Tall Tower Observatory

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Introduction & Motivation

Tropical forests are important to the global carbon cycle, but their response drought remains uncertain. The Amazon stores large amounts of carbon, so small shifts in the system's carbon balance can have large consequences[1].

Terrestrial biosphere models (TBMs) struggle to capture seasonality and with hydrology[2].

Research Aim

Aim: Evaluate QUINCY simulations at ATTO and identify causes for mismatches between modeled and observed net ecosystem exchange (NEE).

Approach: Compare modeled and observed NEE across seasons and interannual variability in relation to ecophysiological drivers.

Purpose: Identify causes for mismatches in NEE patterns in order to guide further investigation on the process level and targeted model development and parameterization.

Data & Model

ATTO:

The Amazon Tall Tower Observatory (ATTO), located in the central Amazon northeast of Manaus, provides long-term eddy-covariance, meteorological, soil-water, and vegetation-related observations that allow for detailed process evaluation.

QUINCY:

Baseline site-level QUINCY[3] simulations were run for ATTO with the carbon cycle active and evaluated against eddy covariance flux data.

Definitions & Processing

Filtering:

Observed NEE extremes were filtered by removing the lower and upper 1% of valid observed values.

Seasons:

February – June = Wet Season;

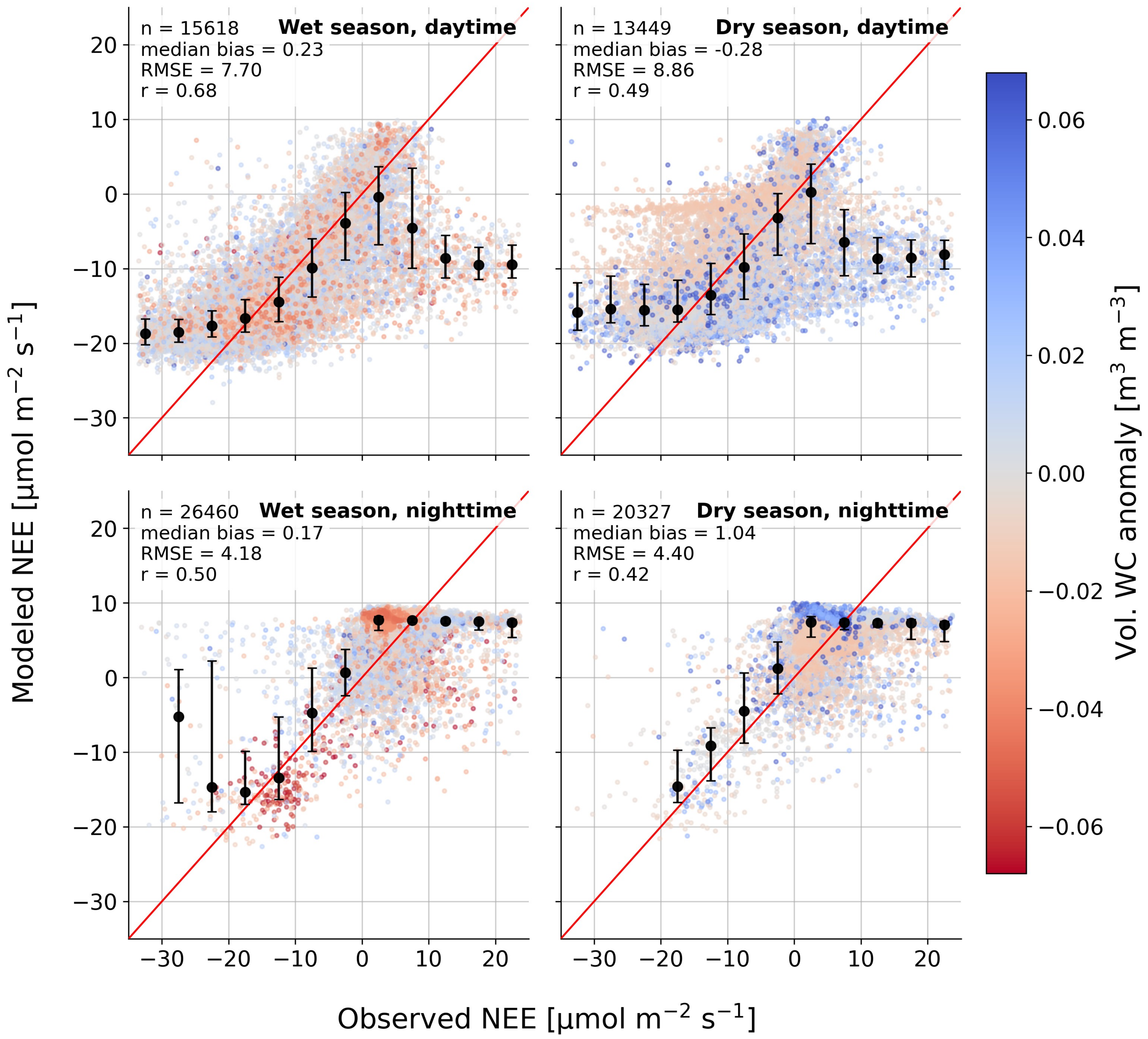
July–October = Dry Season

Daytime:

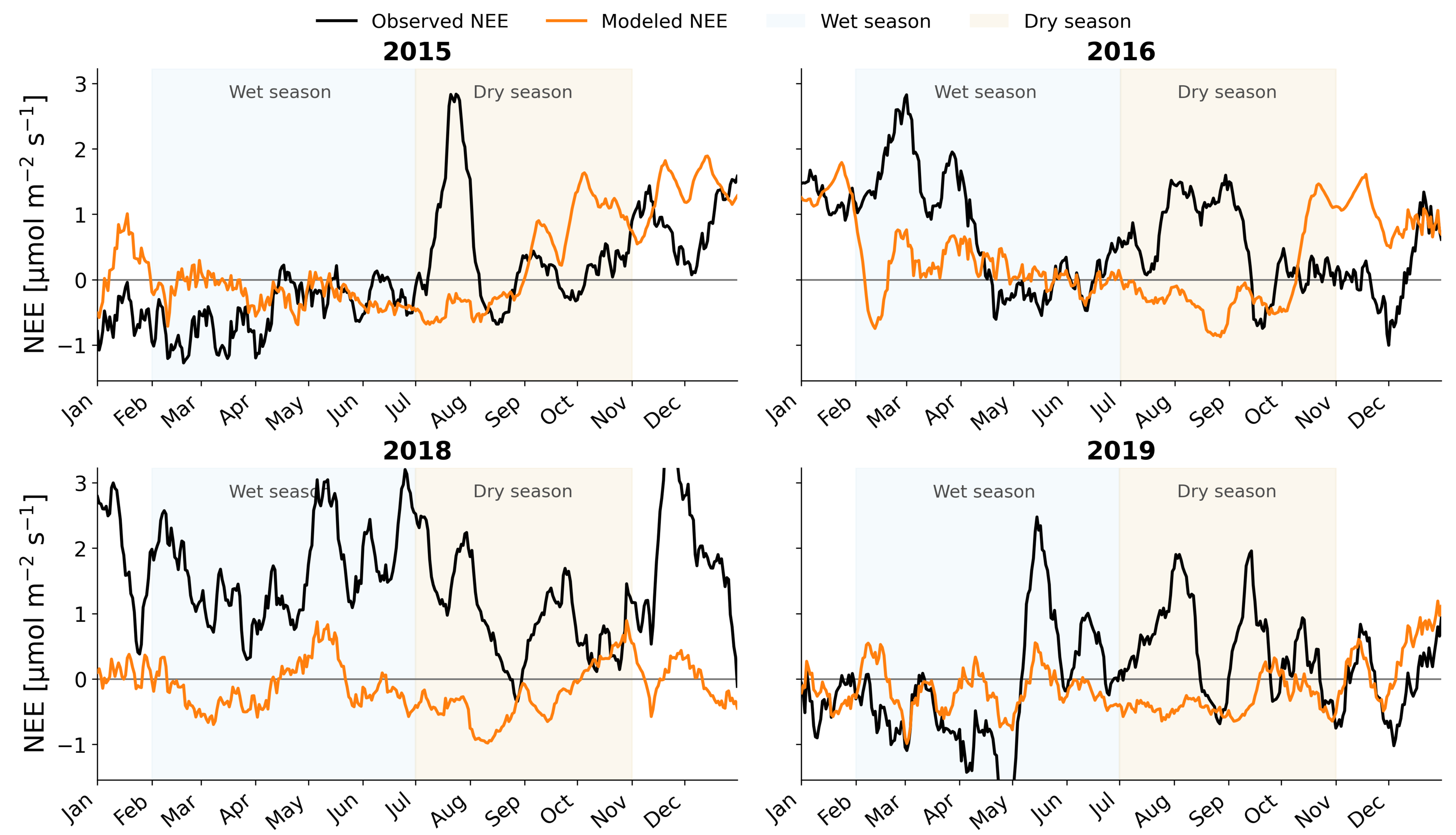
A timeframe is treated as "daytime" when incoming shortwave radiation (*SW_IN*) > 100 W m^{-2}

Main Findings & Outlook

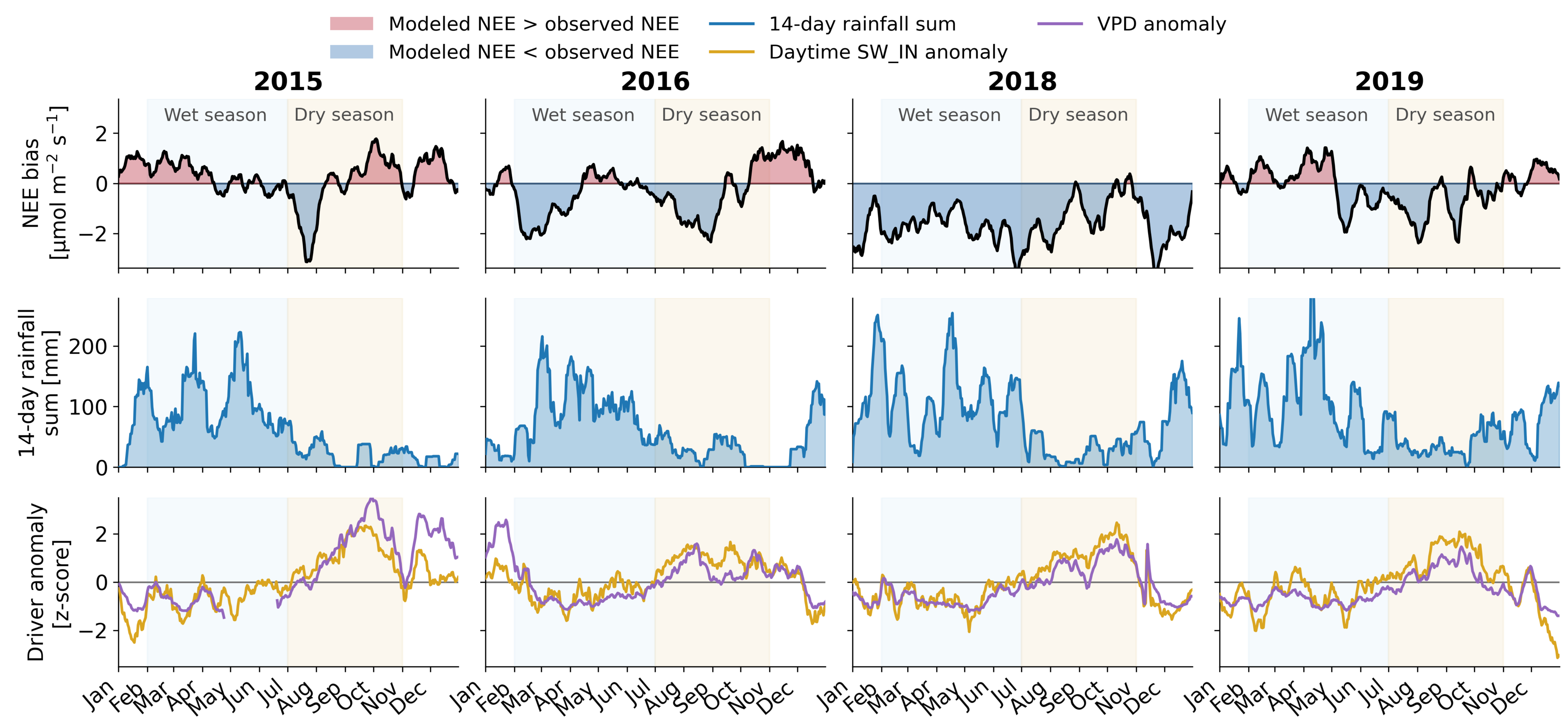
- QUINCY broadly captures observed NEE variability.
- Modeled NEE is compressed relative to observed NEE.
- Recurring seasonal bias appears around the transition from wet to dry season.
- Next steps are to include more ATTO observations such as carbon isotopes, phenocam- and sap flow data.



Point color shows volumetric water content anomaly at 100 cm depth, calculated relative to the median VWC of the corresponding season, day/night regime and hour of day. Black markers show the median modeled NEE within observed NEE bins with width 5 μmol m^{-2} s^{-1}; whiskers show the 25-75 % range. Bins with n < 30 where omitted.



Lines show daily mean NEE smoothed with a 14-day centered rolling mean. Blue and beige shading indicate wet season (Feb–Jun) and dry season (Jul–Oct), respectively. 2015 and 2016 are El Niño/drought years.



Bias is modeled minus observed NEE; positive values indicate modeled NEE is more positive than observed. Bias, daytime SW_IN and VPD are shown as 14-day rolling means; precipitation is shown as a 14-day rolling sum. SW_IN and VPD are shown as z-score anomalies across selected years

References:

1 Rosan, et al.(2024). Synthesis of the land carbon fluxes of the Amazon region between 2010 and 2020. Communications Earth & Environment, 5 (1), 46.

2 Restrepo-Coupe, et al.(2017). Do dynamic global vegetation models capture the seasonality of carbon fluxes in the Amazon basin? Global Change Biology, 23 (1), 191–208.

3 Thum et al. (2019). A new model of the coupled carbon, nitrogen, and phosphorus cycles in the terrestrial biosphere (quincy v1. 0; revision 1996). Geoscientific Model Development, 12 (11), 4781–4802.

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