Modeling methane dynamics in a bottomland hardwood wetland

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WHY ?

Vegetation acts as an important emission pathway by providing an alternative route for methane (CH_4) that may otherwise be oxidized in surface waters and shallow soils.

Emerging science suggests that tree knees and stems in wetlands emit methane (Barba et al., 2019; New Phytologist; Covey & Megonigal, 2019, New Phytologist).

There have been limited attempts to model the fluxes and pathways of CH_4 dynamics in bottomland hardwood forests and forested wetland swamps.

Our objective is to improve the representation of wetland CH_4 dynamics by incorporating emissions from temperate bald cypress (*Taxodium distichum*) trees and their knees (Figure 2) – woody structures that form above the root of the bald cypress – in a carbon modelling framework.

WHAT ARE KNEES ?

Taxodium distichum is commonly known as bald cypress, or cypress, or swamp cypress.

Bald cypress trees are valued for their durable lumber, decay-resistant properties, ecological importance, and their ability to facilitate wetland restoration.

The presence of knees is an inherited characteristic of bald cypress, yet, little is known about the knees, their development and functions.

Knees conduct respiration and promote gas exchange between the roots and air.

Experiments show that forested wetland systems will emit more methane under carbon dioxide (CO_2) enriched atmosphere (Vann & Megonigal, 2003, Biogeochemistry).

Figure 1: Murphy's pond, Kentucky

WHERE ?

Field data (chamber based CH_4 fluxes, CO_2 fluxes, water table, soil properties) from Murphy's pond (Figure 1) and Clark's River National Wildlife Refuge (Figure 3), and are being collected and will be used in the model.

Data from five eddy covariance flux towers (AmeriFlux stations) representing upland, bottomland hardwood, and forested wetland sites from different parts of the United States are being used to model the total methane flux estimate. The five sites are:

1) US-HO1: Howland Forest (main tower)
2) US-LA1: Pointe-aux-Chenes Brackish Marsh
3) US-Myb: Mayberry Wetland
4) US-NC4: NC_AlligatorRiver
5) US-PFa: Park Falls/WLEF

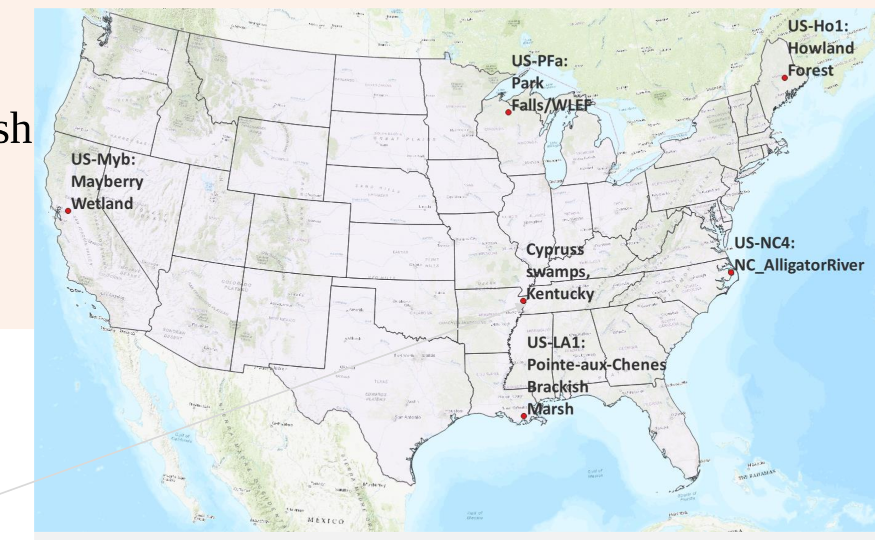

Figure 5: Study area

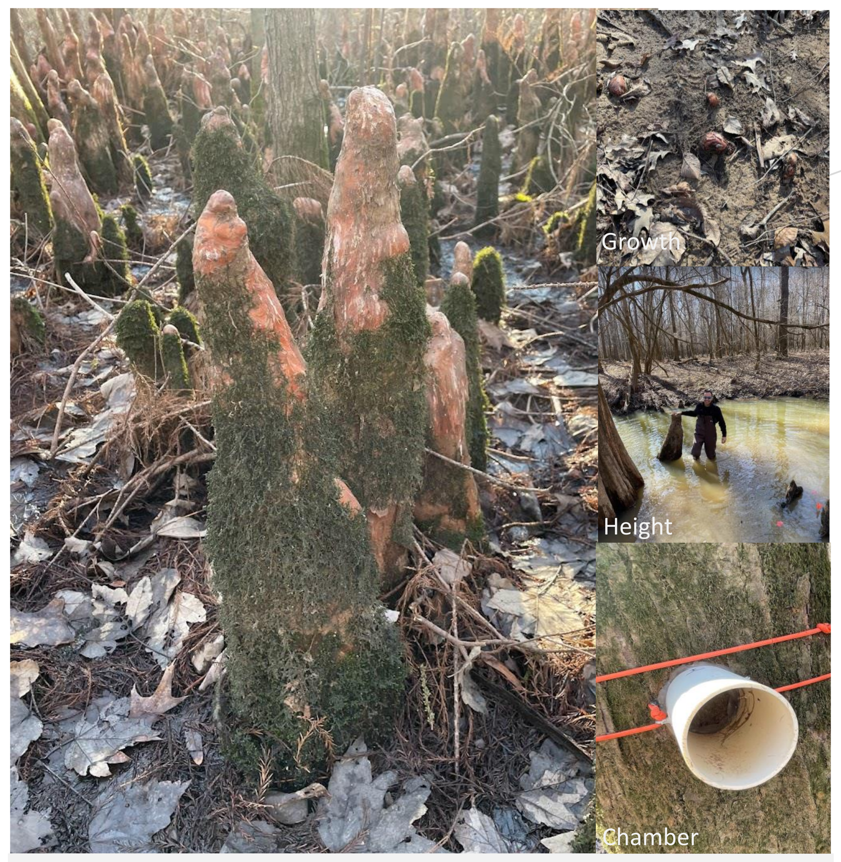

Figure 2: Knee of *Taxodium distichum*

Figure 3: Clarks River, Kentucky

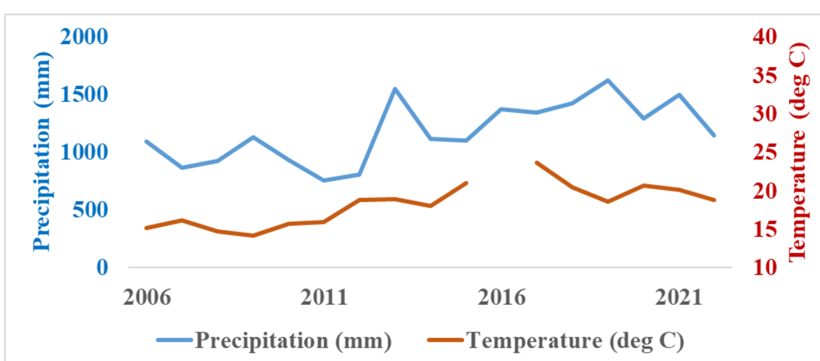

Figure 4: Mean annual precipitation and annual average air temperature at Murray State University's Hancock Biological Station

HOW ?

Peatland Ecosystem Photosynthesis Respiration and Methane Transport (PEPRMT) model (Oikawa et al., 2017) is a process-based biogeochemical model designed to estimate wetland CO_2 and CH_4 fluxes.

It is being modified to represent CH_4 and CO_2 emissions from bottomland hardwood forests, forested wetland swamps, and bald cypress knees.

Plant mediated transport will be improved in the model.

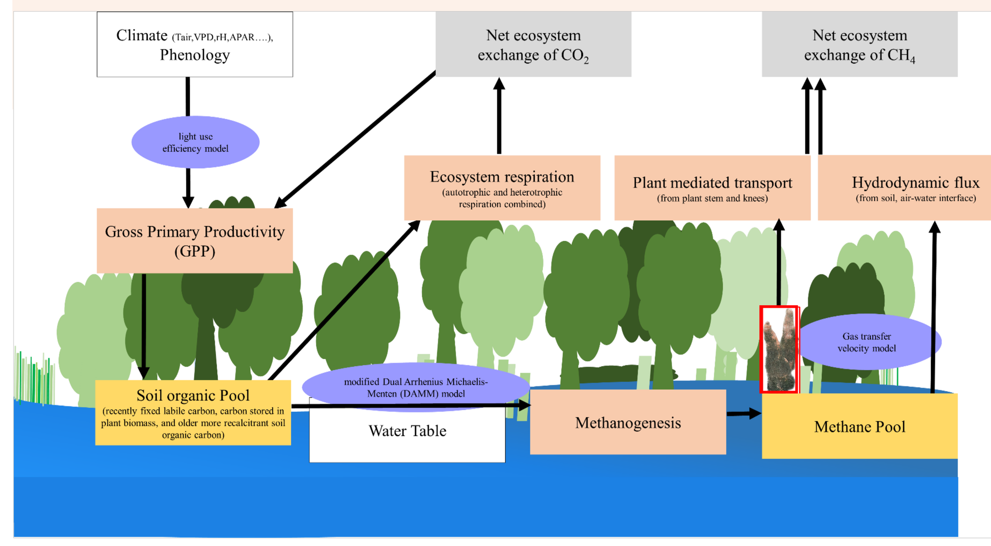

Figure 8: Schematic diagram of PEPRMT model.
Inputs are shown in white, outputs in grey, processes in orange, equations/model in purple, and pools are yellow boxes.
(Modified from Oikawa et al., 2017, JGR: Biogeosciences)

HOW ARE THE INITIAL PLOTS ?

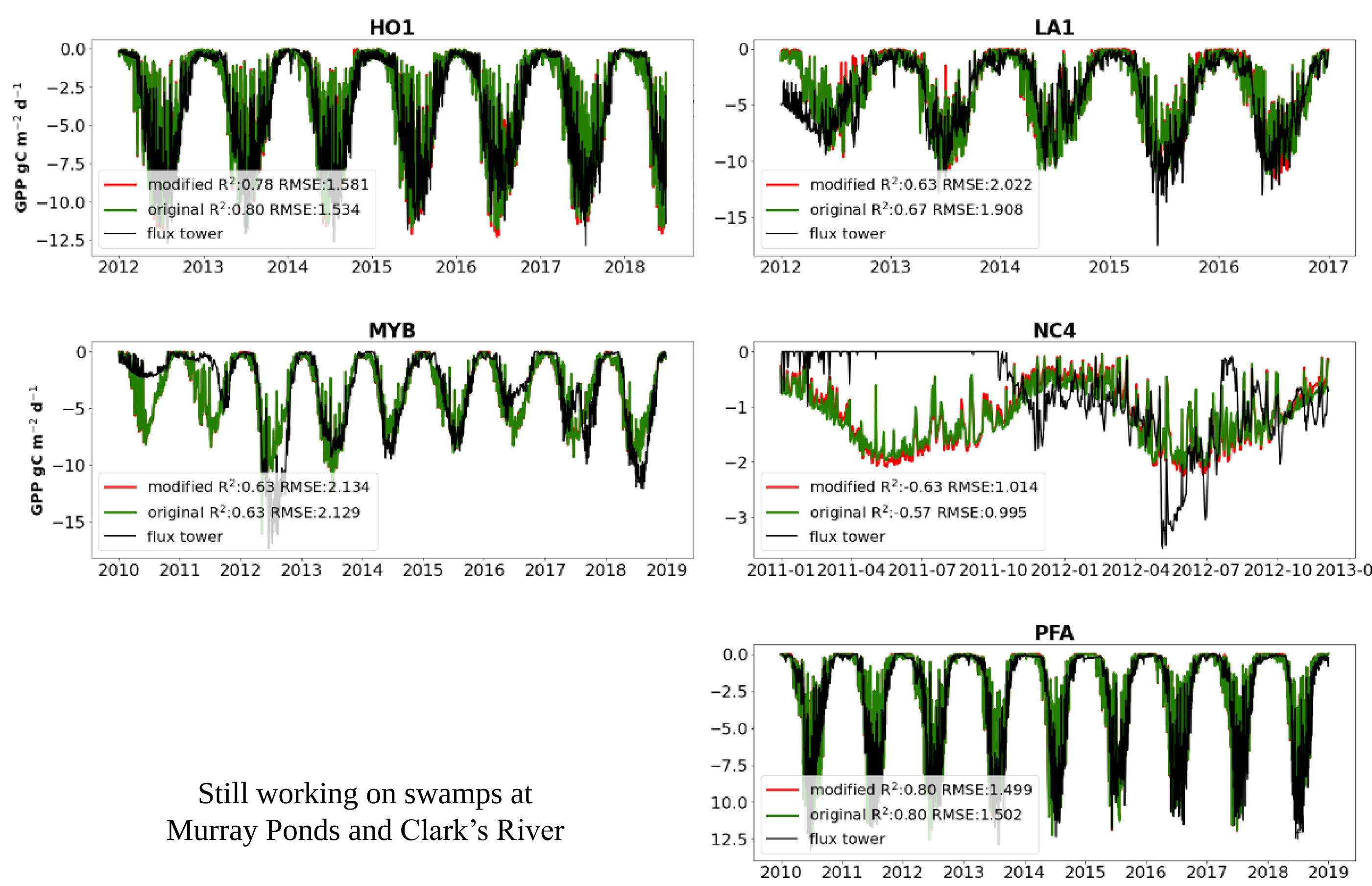

Figure 6: Calibration of Gross primary productivity (GPP) at AmeriFlux stations from other forested wetland sites

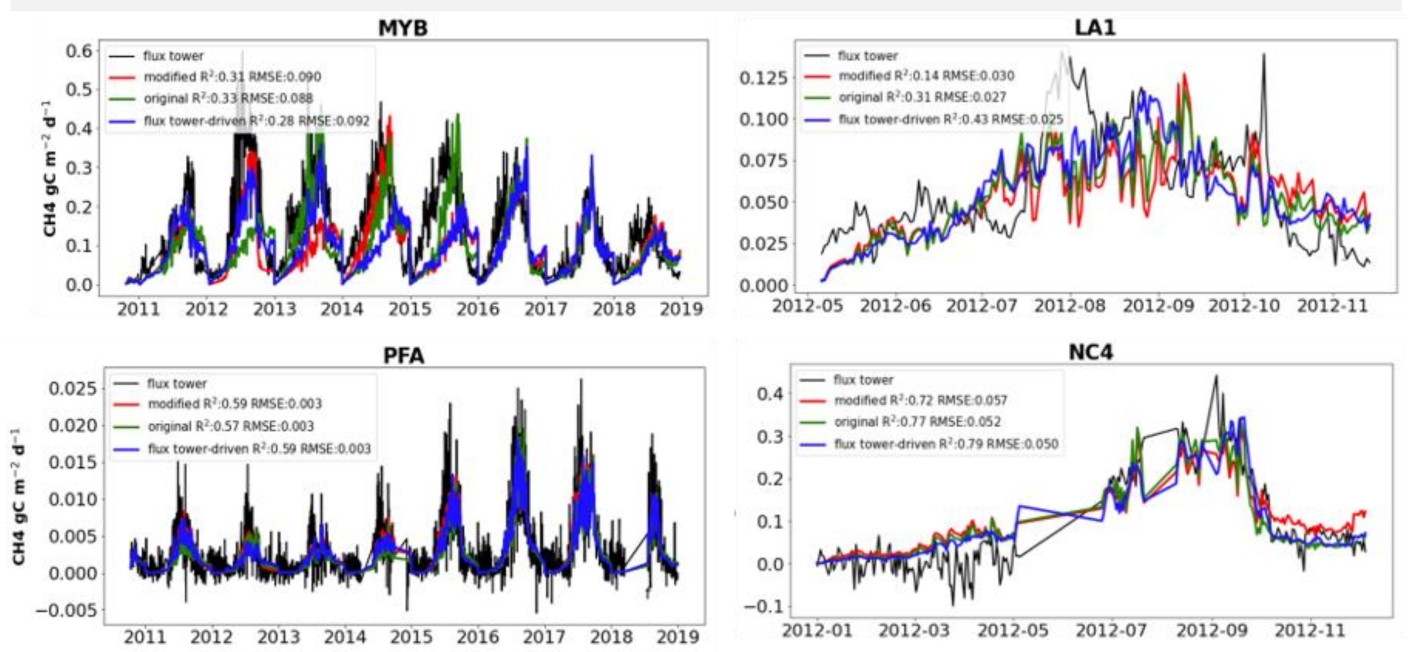

Figure 7: Calibration of methane (CH_4) flux at AmeriFlux stations from other forested wetland sites

PEPRMT model is able to replicate the GPP in most of the stations, and in all stations, the R2 value is greater than 0.6 and RMSE is 1 in most of the stations (Figure 6).

The model does display patterns of methane release, it still requires further calibration to improve its accuracy (Figure 7).

Based on the Hancock Biological Station, the mean annual precipitation is 1175 mm/year and in increasing trend. The annual mean air temperature is 18 deg C and is slightly increasing in latest years (Figure 4).

WHAT'S NEXT ?

Improve parameterization of PEPRMT model to evaluate spatial and temporal variability in CH_4 flux in the cypress swamps in Murphy's pond and Clark's River.

Validate the model using data from similar sites and AmeriFlux stations.

WHAT IS THE ULTIMATE GOAL ?

Improved representation and understanding of methane dynamics will increase the accuracy of methane flux estimates from woody wetland ecosystems in their current state and provide better knowledge for future climate change scenarios.

WHO ?

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Project: Methane dynamics described through vegetation-soil interactions in bald cypress and other bottomland hardwood forests