Runkle CMS 2020 {redacted}

A national quantification of methane emissions from rice cultivation in the U.S.: integrating multi-source satellite data and process-based modeling

UNIVERSITY OF ARKANSAS COLLEGE OF ENGINEERING

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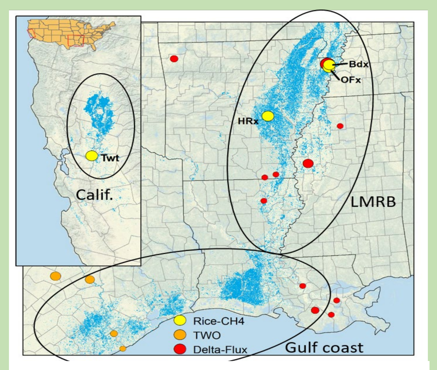
Motivation

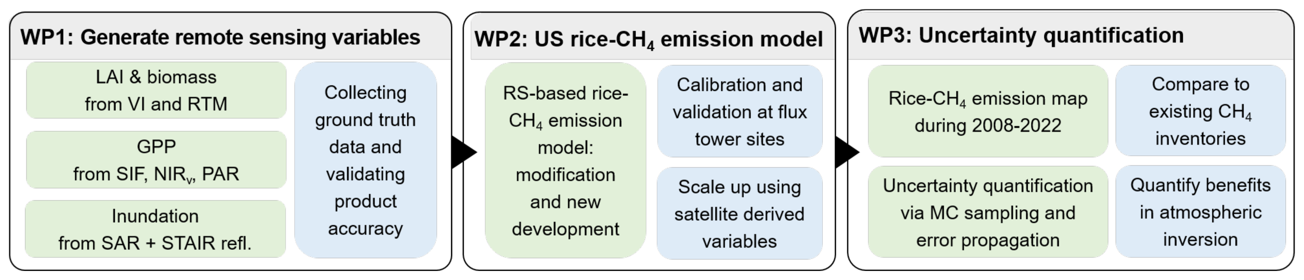


Rice production in the US: California, Mid-South, Gulf Coast

Globally, rice is responsible for:
10% of anthropogenic CH_4
25% of all water withdrawals
20% of human caloric intake
The US grows less than 2% of global rice supply, but is 5th largest exporter

- Current inventories of US GHG emissions give huge uncertainty around rice-CH_4 emissions (9.2-21.6 MMT CO2-eq at 95% CI)
- Inventories are annual and not fine frequency
- More information is needed to guide emissions reductions approaches

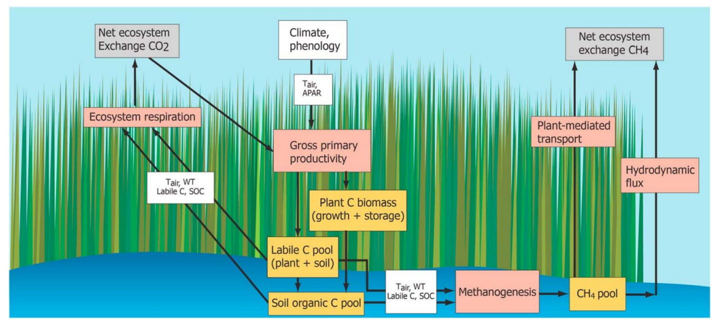
Project design



The project objective is to:
generate a consistent national, daily, 500m rice-CH_4 emission dataset (2008-2022),
- based on a daily satellite-based inundation, GPP, leaf area index (LAI) and biomass dataset,
- process-based modeling, with uncertainty estimates, and
- benchmarked to eddy covariance EC observations of CH_4 flux.

Science area 1). Daily GPP modeling

The **PEPRMT model** estimates CH_4 Flux via GPP and Reco/NEE models with labile and soil organic C pools after ecosystem respiration, from LAI, PAR, Ts observations



Oikawa et al. 2017, JGR-Biogeosciences

GPP is modeled as: $GPP = LUE*APAR*f(T_k)$

LUE: maximum light use efficiency constrained by $f(T_k)$
APAR: absorbed photosynth. active radiation
(1- exp(-k*LAI)) * PAR
Where k is the light extinguishing term

$$f(T_k) = 1*\left(\frac{H_d * \exp\left(\frac{H_a(T_k - T_{opt})}{T_k * R * T_{opt}}\right)}{H_d - H_a\left(1 - \exp\left(\frac{H_d(T_k - T_{opt})}{T_k * R * T_{opt}}\right)\right)}\right)$$

H_a, H_d, k, T_{opt} tuned using MCMC

Science area 2). SIF measurement system development and adaptation for rice

System assembly and extended testing over grass, including field calibration
- SIF/hyperspectral instruments performing well under ideal conditions
- Finishing last modifications for field deployment & improvements for radiometric accuracy (see Ph.D. student **Will Richardson's** poster here)

In the field, we now have A/C line power at two eddy covariance sites

Science area 3). Mapping inundation dynamics

Approach:
1. Use **ground truth data** to label daily flood status (flooded/not flooded)
2. Compare Reflectance/Index-based thresholding to phenology-based detection, eventually ML approach
3. Analyze **backscatter patterns** and vegetation indices, from Harmonized Landsat and Sentinel-2 (HLS)

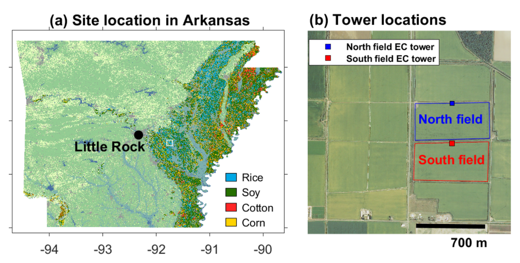
Next step:

Scalable Models

Develop scalable statistical and machine learning models that can be applied to a large region

Science area 4). CH_4 flux prediction

Here I highlight new work from our group, demonstrating the effectiveness of simple flood inundation duration in predicting CH_4 fluxes



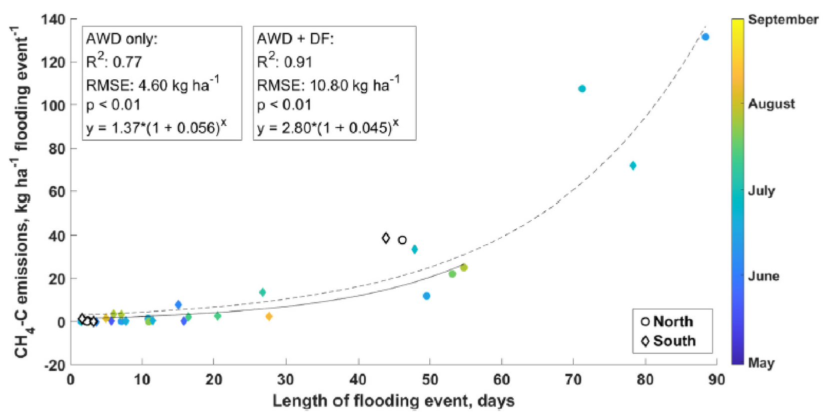
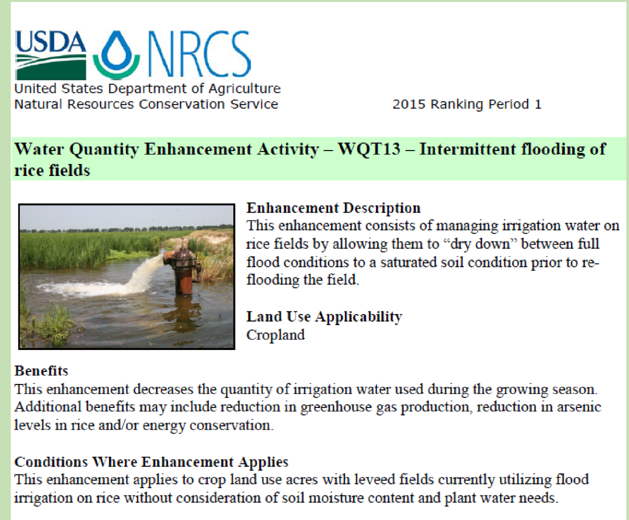


Fig. 7. : Cumulative CH_4 emissions per each flooding event for all field-seasons managed. The dashed line indicates the relationship for all main field-seasons (26 independent flooding events) while the solid line indicates the relationship for all main field-seasons managed with AWD (23 independent flooding events). The black outlined points indicate flooding events during the ratoon season and were not included in model creation. Each main season flooding event is color-coded by the month at the midpoint of the event. Note that the cumulative emissions include the 2 days following each event to catch any spike in emissions at the beginning of the drying event that is attributable to the release of trapped CH_4 generated during the flooding event.

Leavitt et al. 2023, *Agric. Ecosys. Envt.*

Stakeholder engagement

NRCS: Adam Chambers


USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service
2015 Ranking Period 1

Water Quantity Enhancement Activity – WQT13 – Intermittent flooding of rice fields

Enhancement Description
This enhancement consists of managing irrigation water on rice fields by allowing them to "dry down" between full flood conditions to a saturated soil condition prior to re-flooding the field.

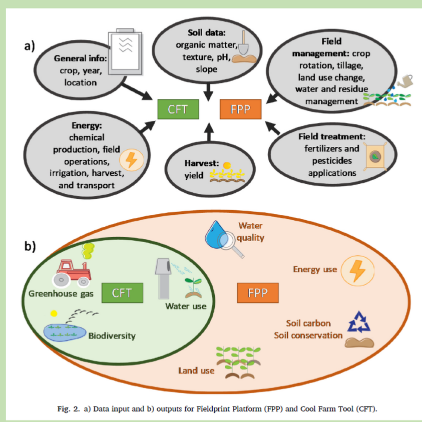
Land Use Applicability
Cropland

Benefits
This enhancement decreases the quantity of irrigation water used during the growing season. Additional benefits may include reduction in greenhouse gas production, reduction in arsenic levels in rice and/or energy conservation.

Conditions Where Enhancement Applies
This enhancement applies to crop land use acres with leveed fields currently utilizing flood irrigation on rice without consideration of soil moisture content and plant water needs.

Unilever: Stefani Millie Grant

Work by Beatriz Moreno García, University of Arkansas



Moreno-García et al. 2021, *JCP*

Next: Environmental Defense Fund: Joe Rudek & team

Ongoing synthesis work

Optical sensing workshop + follow-up

Prasad Bandaru's Crop CMS
- Contributing data from 20+ field sites in Arkansas, multiple years
- LAI, soil moisture, inundation, crop staging, etc.
- Data from 'newer' production practices like furrow-irrigated rice