REPLY TO WASSMANN ET AL.:

More data at high sampling intensity from medium- and intense-intermittently flooded rice farms is crucial

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Here, we briefly respond to critique of our study (1) by Wassmann et al. (2). A detailed response to their letter is available online (edf.org/riceN2O).

Field Design

It is not necessary to compare intermittently flooded farms with continuously flooded farms serving as controls to understand the impacts of multiple aeration events on soil redox conditions and resulting rice-N_2O. Wassmann et al. (2) define alternate wetting and drying (AWD) as a mitigation strategy, whereas we consider AWD as intermittent flooding that includes alternating dry and wet periods regardless of the cause (active drainage and/or percolation). Our study was conducted in farmers' fields which, as stated previously (1, 3), often means that water management does not align precisely with recommendations. The farmers in our study considered the "baseline" condition as continuous flooding. However, daily water-level measurements highlighted that frequent irrigation does not actually mean continuous flooding. Low clay content of soils cannot be the sole reason of our high rice-N_2O results: A previous study has shown high rice-N_2O under deliberate AWD in clay-rich soils (4).

Sampling Frequency

Wassmann et al. (2) cite studies with high-frequency sampling that are not relevant because they were performed under conditions that should not trigger high rice-N_2O—that is, continuous (5, 6) or lowland flooding (7), no waterlogging (post–rice-harvest dry period) (8), or midseason drainage (a form of mild intermittent flooding) (9). We call for high-frequency sampling measurements from medium- or intense-intermittent flooding regimes.

Interpolation Errors

We did not use broad peaks but instead used an exponential curve interpolation method described earlier (10), because we recognized errors introduced using other interpolation methods. Our supporting figures show broad peaks because they present linear interpolation of raw data, not plots based on exponential decay of the peaks that were used to estimate seasonal N_2O emissions.

Model Development

Our model is constrained to linear functions characterizing known mechanistic drivers of fluxes, and the result is an excellent fit. We are not advocating for our model relative to others. Other models [including denitrification–decomposition (DNDC)] might have rice-N_2O risks similar to ours if they incorporate updated fertilizer use, empirically determined high rice-N_2O, and intense-intermittent flooding regimes (1).

Interpretation of Risks

We do not claim that all practices result in high rice-N_2O: Our extrapolation under the continuous-flooding scenario suggests negligible rice-N_2O. We do assert that precise management/flooding condition maps at farmer-managed farms and high-frequency sampling measurements at intense-intermittent flooding regimes are required to fully understand N_2O trade-offs of recommendations designed for reducing methane emissions.

We posit that many farmers practicing AWD might be deploying mild-intermittent flooding regimes that will minimize both methane and rice-N_2O emissions. We agree that more data are necessary to better assess both the conditions that trigger high rice-N_2O

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emissions and the spatiotemporal variability of those conditions globally. We hope that the global community will collect additional data that can be used to validate and improve our model and others that predict emissions (e.g., DNDC and Daycent). Weekly measurements are clearly insufficient to capture rice-N_2O emission dynamics, and we encourage future collections to be at least once every 2 d.

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3 Kritee K, et al. (2018) Reply to Yan and Akiyama: Nitrous oxide emissions from rice and their mitigation potential depend on the nature of intermittent flooding. *Proc Natl Acad Sci USA* 115:E11206–E11207.

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