

April 1, 2014

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Dear Dr. Chow:

Thank you for the opportunity to comment on the informal discussion draft of the Rice Cultivation Compliance Offset Protocol. Thank you also for your detailed answers to our questions at the Workshop held on March 17, 2014. We greatly appreciate the openness with which you have asked for input on the discussion draft. Below we have compiled a set of answers to some of your questions posed in the discussion draft, and provide additional recommendations and questions of our own. We look forward to discussing many of these details over the next several months through the Technical Working Group process, and to working with you to produce as effective and robust a protocol as possible. Our comments are organized thematically into seven sections.

1. Treatment of nitrous oxide (N₂O) emissions and the threshold-approach to moisture content for Alternate Wetting and Drying (AWD) projects

We appreciate the conservative choice to not credit N₂O emissions reductions, and only to debit N₂O emissions increases, given the scientific uncertainty of the controls of N₂O fluxes from rice fields and DNDC's ability to accurately capture spikes in N₂O emissions, which occur as rice fields are drying out. This conservative choice is reflected in the PER_i portion of Equation 5.4 in the term $\text{MIN}[\text{N}_2\text{O}_{\text{B},i} - \text{N}_2\text{O}_{\text{P},i}], 0]$.

Given that the DNDC model has not been shown to be accurate at estimating N₂O emissions from rice fields, we raise a continued concern with the inclusion of the N₂O term in the Protocol: if the DNDC model fails to capture spikes generated by drying out fields, the model's reported average project reporting period N₂O emissions (N₂O_{P,i}) may be a significant underestimate for some fields. While the term $\text{MIN}[\text{N}_2\text{O}_{\text{B},i} - \text{N}_2\text{O}_{\text{P},i}], 0]$ would likely still result in a value < 0, the absolute value of this debit from PER_i might be small relative to the true value of (N₂O_{B,i} - N₂O_{P,i}), resulting in meaningful over-crediting of PER. We cannot establish how likely such over-crediting would be because the science of the mechanistic drivers of N₂O fluxes and the controls of N₂O spikes from drying fields is ongoing.

It is worthwhile to examine other options for the treatment of N_2O fluxes. To exclude the N_2O term entirely from the PER_i equation would not make sense because this would assume a default value of “0”, when we have already determined that sometimes the value is $N_2O_{B,I} - N_2O_{P,I}$ is likely to be negative.

The concern over excess crediting due to N_2O uncertainty is not likely to be significant for Early Drainage projects. This is because in both baseline and project years, fields are drained (just at different times of year). While climatic conditions, including temperature, are likely to result in greater N_2O emissions in project years compared to baseline years, it is our understanding that there is no *a priori* reason to think that the modeled $N_2O_{P,I}$ would be more likely to underestimate a true N_2O spike in emissions than the modeled $N_2O_{B,I}$.

The principal concern over N_2O flux uncertainty arises for Alternate Wetting and Drying (AWD) projects. We appreciate the effort to limit the possibility of N_2O spikes using the requirement of maintaining soil moisture above 35%. As such, we had several questions around the 35% number:

- Is the requirement that *all* soil moisture samples be above 35% at all measurements, or simply the average of all samples (if, for example, five equally spaced samples are taken, as in 2.3(c)(4)(B))?
- If a method is used to measure soil moisture using a sensor placed in the soil, should it be placed *at* 10cm depth or simply within the “top ten centimeters”? How soils dry (i.e. whether from top to bottom) can strongly depend on soil texture and porosity and can vary greatly. Allowing measurements at either 1cm depth or 10cm depth could thus substantially affect the results. Other methods of measurement involve taking full 10cm cores and homogenizing the sample. Thus, depending on the method, it might be helpful to clarify the depth stipulation in 2.3(c)(1) by adding “throughout the top 10 cm.”
- Can an OPO continue to take soil moisture measurements until one measurement is found above 35%? It is quite likely that a range of soil moistures will be found in any actively drying field and it would be likely that a single sample could be taken that would pass the 35% threshold, while many other areas might continue to be considerably drier (with greater N_2O fluxes). Alternatively, it is likely that some areas of the field will remain saturated, while others will not. These areas are “ineligible for crediting” but how will such small areas be delineated? Daily, freely available MODIS satellite imagery is at too coarse a resolution (250m) for obtaining such delineations, and LANDSAT data (30m resolution) are only available at roughly 16-day intervals (assuming no clouds). Thus, outlining small continuously saturated areas with satellite remote sensing products that are freely available is unlikely to be possible.
- Through what process/according to what criteria was the number 35% moisture at the end of the “drying” period arrived?

The Discussion Draft Protocol requests input on how soil moisture samples should be measured to ensure “accurate data.” We offer the following observations on soil moisture sampling:

- The most straightforward and traditional method of measuring soil moisture, and likely the least expensive because it does not involve high-tech sensors, is to use *gravimetric* soil moisture analysis. In this method, soil cores are taken, homogenized and weighed. They are then dried in an oven (to remove moisture) and re-weighed. The soil moisture is calculated *by weight* from the difference between wet-weight and dry-weight. Gravimetric analysis requires only a scale, an oven, and a soil corer. However, it may be difficult for verifiers to verify where and when the cores were actually taken.
- If automated measurements are required, Time-Domain Reflectometry (TDR) could be used. TDR uses an electromagnetic pulse to measure the propagation of a high frequency wave through the soil, which is related directly to water content. TDR sensors can be installed either as a single sensor, or in an array of sensors. Data can be logged over time to assess variability of soil moisture over time. A quick search revealed that single TDR sensors cost approximately \$250, but there are wide price ranges largely dependent on durability and the accuracy of data requested. Less accurate resistive sensors are available for ~\$50.

In our experience, there is tremendous locally spatial variability in the absolute magnitude of soil moisture. Numerous samples (more than 1 or 5) would be required, ideally with randomly selected, pre-determined points of measurement.

Given the relative difficulties and challenges of including soil moisture measurements to ensure that there is not *too much* drying that could increase the possibility of N₂O spikes from AWD project fields, resulting in over-crediting, a final option would be to exclude eligibility of the AWD project-type until sufficient scientific evidence or technical advances in measurement technology allow for substantially more accurate estimation of N₂O emissions from drying fields. Emissions from spikes following single drainage events can account for 40-60% of annual N₂O emissions from rice fields (Pittelkow et al. 2013), and adding multiple drainage events in an AWD cycle could compound the problem. We believe that excluding eligibility of AWD until we are able to better constrain N₂O emissions is the easiest solution to this concern.

2. Updating structural uncertainty deductions, DNDC model bias assessments, and a request for publically available data

We greatly appreciate the inclusion of a mechanism for updating the structural uncertainty deduction factor annually for each of the rice growing regions that are eligible for crediting. We believe that such a provision will allow for a more adaptive protocol that is responsive to the latest science. We had a few clarifying questions about the description in Appendix C of the discussion draft:

- In Appendix C, two equations are given, both of which are described as μ_{struct} . What is the difference between these two equations in their intended application in Equation 5.4?
- Structural uncertainty is about uncertainty in the model *even if* all inputs are 100% accurate, which is assessed by comparing modeled and measured values. The term “ ρ ” in Appendix C, however, states that this is the “correlation between project and baseline

residuals.” Please clarify that “residuals” as used here refers to the difference between a modeled and measured value. Are all the fields that are used in developing this deduction factor fields in which emissions reduction projects have been initiated?

- How will fields be enrolled for updating μ struct? As this will likely require measurements made in the field, will there be standards or criteria for including such data?
- In Appendix C, “n” is referred to as the number of fields reporting. But “n” is not included in the equation and it is not immediately apparent what “ARB” means in each of the state-by-state columns.

It is our understanding that assessments of DNDC model bias (i.e., a significant trend in the residuals between modeled and measured values) have been made on a state-by-state basis where observations from fields in each state were compared with model outputs for those fields. We assume that the rice growing regions in California (the Sacramento Valley) in Missouri, Arkansas and Mississippi (the Mississippi River Delta) and Louisiana (the Gulf Coast) have all had model bias assessed. We greatly appreciate that this reflects our previous suggestion in informal comments sent on December 19, 2013 that such assessments of bias be made regionally, rather than in aggregate.

While these separate regional approaches to assessing model bias make sense because they reflect general soil and climatic variability, we are concerned that the assessments of model bias may not have included data from fields using rice management practices such as AWD, which are eligible for crediting under the Protocol. The model may have bias in predicting emissions from such projects, and we would not have any way of knowing this without including assessments of bias based on project type rather than region. Furthermore, recent scientific evidence has suggested that there may be model bias (i.e., a trend in residuals) for certain hybrid rice cultivars. The DNDC model, even with field-calibration, may not be validated for such rice cultivars because they are so new. We continue to believe, therefore, that an assessment of model bias should be conducted along this axis prior to granting eligibility for all project types.

Finally, there are many inputs that users enter into DNDC, including the soil input values and SOC described in detail in the input uncertainty sections of the Protocol. Under the Protocol, OPOs are able to obtain SOC values from SSURGO to be included (with $\pm 20\%$) in the Monte Carlo approach to measuring input uncertainty. We have two concerns. First, we wanted to make sure that $\pm 20\%$ in Table E.1 reflected $\pm 20\%$ of the SOC value itself (i.e. $\pm 20\%$ of, say 1.5% SOC), and not $\pm 20\%$ SOC (as in, entering a value of 20% SOC into DNDC). Second, the inclusion of SSURGO database data in the Protocol raises a few questions concerning model validation and bias assessment:

- When the model was validated and assessments of model bias were made, were data from the SSURGO database used in addition to field measurements of SOC?
- We see that the $\pm 20\%$ provision comes from a generic source on ecosystem modeling. Can we be confident that the $\pm 20\%$ for SOC derived from SSURGO would include

ranges of data from measurements made in the actual fields where soil carbon can be quite variable? This would principally be a concern if there were any bias in the SSURGO database that would be missed in bias assessments that did not include it.

As an example of how variable field-level measurements themselves can be, in grassland soils in California where we have worked, SOC measurements within a single area less than 1ha in size vary from 1.0% to 2.3% (granted these are not agricultural fields, but small-scale spatial heterogeneity is the norm in soils).

Lastly, we would also like to point out that the link to the University of Aberdeen's site – <http://www.abdn.ac.uk/modelling/cost627/Questionnaire.htm> – included as the source of the uncertainty estimate values in Table E.1 is broken and leads to a webpage that is not found.

In order to facilitate the process of public comment and input on the protocol development process, we would like to request that the details of the DNDC model validation and bias assessments, including all parameter values (whether default, measured, or taken from a database) that were used for each model run used in validation, be made publicly available. What we have received through the Technical Working Group so far is a list of many studies that generated the field data on emissions from rice production, generally using chamber-based measurements, but no information on how the model was run for validation.

3. Monte Carlo analyses and DNDC default values

In the discussion draft, the following question is posed for stakeholders:

Would 16 runs of DNDC with every possible combination of the minimum and maximum uncertainty values for each of the four identified soil parameters provide the certainty required for offset crediting?

The key question here is how the four parameters interact in the model code. It is not a given, if “H” represents the high range value for each parameter, that a run with H-H-H-H would reflect the greatest total amount of emissions in the DNDC output. Nor is it a guarantee that any of the 16 would reflect this value (this is the point of doing the Monte Carlo!). If interactions in the model are in any way counterbalancing, higher emissions could result from non-extreme values. The “16-run” approach assumes linear or non-interactive equations are used for these parameters. If this assumption holds when looking at the model code itself, then such a time-saving technique might work; otherwise, it is insufficient to assume non-interaction. The standard of practice is to choose a set of ranges randomly (Monte Carlo) from a range of values. Anything else would require absolute knowledge of the model code, which likely only the model developers at UNH could provide.

This discussion raises a broader issue: choosing default values. The soil input uncertainty deduction relies on uncertainty ranges around default values and Table 6.1 also stipulates the use of default values. At the March 17, 2014 workshop, we raised the question of who will set such defaults and based on what criteria, as it is critical to allow for scientific and public input into this process. We would like to request that at least one of the up-coming Technical Working Group meetings be dedicated to an open discussion of how default values will be set.

4. Incentives created by the Protocol not to switch to shorter season rice varieties

The current draft of the Protocol includes the eligibility requirement:

3.1(a) Offset projects developed using this protocol must: . . . (2) Grow rice of the same maturity characteristics during the crediting period as the baseline period;

This requirement could create a disincentive for farmers to switch to shorter duration rice. Shorter duration rice would use less water, and may result in less methane emissions on average because of a shorter flooding season. It is possible that there could be a BAU shift toward shorter duration rice varieties in both California and the Mid-South, in part, due to the lower water requirements of such varieties. Because of the water use benefits, and possible emissions benefits, we believe that it is important that the Protocol avoid creating a disincentive to switch to shorter duration rice.

Because actual farmer practice in the Mid-South during baseline years is not used to determine the baseline, but rather the DD50 model is used, there is no reason to require the above restriction in the Mid-South. Instead the rice variety used in the project years would be put into the DD50 model for both baseline and project years. Avoiding this disincentive is one reason the Board might consider using a model-based approach to baseline setting in California, similar to their approach in the Mid-South.

5. Avoiding the use of input parameters that are difficult to verify

We raise questions about the verifiability of several field-level input parameters. Over the last several working group meetings we have had off-and-on discussions about how to verify farmer adoption of project practices. If indeed these values are not able to be verified to avoid manipulation that results in over-crediting, then alternative methods of estimating emissions reductions must be found.

Baseline drainage dates for fields in California are difficult to verify since time-stamped photos were unlikely to be taken in the baseline years and most farm records can be easily altered, if they are kept at all. If farmers are easily able to report drainage dates in baseline years later than actual drainage dates, they would be able to generate more credits than the actual reductions that are occurring. Unless there is a reliable way to verify past drainage dates, or reason to believe that manipulation of farm records is too difficult to be done by many farmers, then such user input cannot be employed to assess baseline emissions. One solution could be to create a drainage date model of what California farmers typically do, and use those values similar to how the DD50 model is used in the Mid-South.

Fertilizer use, in both project and baseline years, is also very difficult to verify, and therefore easy to manipulate to show greater baseline emissions, or lesser project emissions. Similar to drainage date, if farmers can easily alter their records to show greater or lesser fertilizer use, they are able to generate more credits than warranted. Fertilizer purchase records do not necessarily represent actual application during one cultivation cycle, or application particularly on those fields that are participating in the offset project. Farmers can use fertilizer purchased in earlier years, and over purchase fertilizer to be used in future years; fertilizer

purchase could be applied to both offset projects and non-offset project fields. Organic fertilizer might not involve purchase records.

6. Performance standard test and a request for data availability

We are concerned that even though current project practice is understood to be relatively small, the emissions reductions from such projects could constitute a significant fraction of total reductions, thus resulting in non-additional crediting. To avoid generating credits from fields where the offset project practice is already being performed and may likely continue, such fields should be excluded from the Protocol. We recommend that only those fields where eligible practices were first adopted within one year of project listing be eligible for crediting.

This recommendation is best explained with an example. First let's assume, as was stated at the March 17, 2014 Workshop, that roughly 1-2% of rice fields are currently engaging in early drainage. If over the next 10 years, with the financial support of the Protocol, an average of 4% of fields were to drain early, then, assuming each field generates roughly equal amounts of emissions reductions, up to approximately one half of the generated credits could be from non-additional practice – fields that were engaging the practice regardless of the offset protocol. If an average of 8% of fields were to early drain over the next 10 years, then up to approximately one quarter of credits generated could be non-additional during that period. If the Board expects around 8% of fields to engage in this practice after the Protocol, then we would expect, *a priori*, 25% of credits to be non-additional.

Under the current draft of the Protocol, the exclusion of such business-as-usual practices would be less of an issue in California, since the baseline uses actual past data for the particular participating fields. However, with the use of the DD50 model in the Mid-South rice growing region, past farmer practice is ignored, and instead a model of what an average farmer does is used as the baseline. This means that in the Mid-South, fields that were already engaging in an eligible practice prior to the Protocol, would not be excluded from the Protocol. We believe that fields already engaging in the credited practices prior to project listing can be treated similarly in California and in the Mid-South by explicitly excluding from participation in the Protocol any field already being cultivated using the eligible practice.

Finally, at the Workshop on March 17, 2014, in response to a question we asked about the percentages of fields in California and the Mid-South rice growing regions that are already performing the practices eligible for crediting, Board staff indicated that the current performance levels are small, but no specific numbers or data sources were cited. We believe that it is important for Board staff to publically release the basis as well as the data on which the judgment is made that current performance levels are “small.”

7. Further discussion on the use of a simple model to set baselines in California, rather than farmer-generated data

We note that the concerns we raise in Sections 4 and 5 above would be addressed if the Board were to adopt a model approach to baseline setting in California. We also note that the errors in setting the baseline for an early drainage project using the average of 2 to 5 baseline

drainage dates (measured in time after planting) are about as large as the change in drainage time itself from an early drainage project. We understand that in an early drainage project, fields would be drained around 7 to 10 days early. We also understand that interannual variability in business-as-usual drainage date due to differences in climate and differences in rice cultivar can be up to the same number of days. If the error in the drainage dates in the baseline years lead equally to over-crediting and under-crediting over time for many fields, then the errors balance out and we would not expect the Protocol to result in over-crediting. While a shift to a modeling approach in California would take more up front analysis in developing the Protocol, it could solve two of the issues discussed above, could be less costly for participating farmers, and might not lead to any greater error in estimating the baseline drainage date, at least for early drainage projects. We haven't thought about the suggestion in the context of dry seeding. We would welcome the opportunity to discuss this idea among members of the Technical Working Group.

Thank you for providing this opportunity to provide input. We look forward to continuing to engage with you in the development of this protocol over the next several months, including on the points we raised above. We hope data on model validation, bias assessment, and performance standard assessments will be made publically available and reviewable through this process, and we hope to be able to discuss the process of choosing default values for the Board's version of DNDC and other issues raised above within the Technical Working Group.

We look forward to continuing to participate in this process.

Sincerely,

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