

# SUMMARY OF PUBLIC CONSULTATION

## VMD0053 Model Calibration, Validation, and Uncertainty Guidance for the Methodology for Improved Agricultural Land Management, v2.0

A draft of *VMD0053 Model Calibration, Validation, and Uncertainty Guidance for the Methodology for Improved Agricultural Land Management, v2.0* was open for public consultation between 15 December 2021 and 5 February 2022. This document includes a list of each comment received and a summary of Verra’s responses after the VVB assessment was completed.

### KEY QUESTIONS

Q6: Do you agree with not requiring to report the calibration of a crop growth model because this calibration does not affect the SOC model substantively?

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#	Organization	Comment	Developer’s Response
1	Bluesource	This seems like a reasonable decision so long as the justification for modifying crop growth parameters from their defaults is well documented.	While errors in the crop growth module of a soil biogeochemical model may propagate to estimates of change in soil carbon, we maintain that an additional requirement to fully document calibration of such modules and validate them in a similar manner is unduly burdensome and unnecessary. VMD0053 already requires that any parameters related to crop-growth modeling be provided with the MVR, as well as conceptual documentation of the model overall, which should specify the crop growth model structure and how it is used along

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			<p>with the soil biogeochemical module. Furthermore, in many cases crop growth models are not parameterized in a manner similar to that of soil biogeochemical models. In many cases, crop growth parameters are related to directly measurable physiological or agronomic characteristics of target species. Finally, while calibration errors for crop growth models are likely to propagate errors to estimates of soil carbon, these errors will be partially accounted for in the model prediction error term for soil carbon and corrected for periodically via remeasurement and model true-up (see VM0042, section 8.6.1.3).</p>
2	Carbon Count	<p>Crop growth model calibration should be reported since it should be impacted by land management activities and could inform auditing to improve the overall integrity of the system.</p>	<p>While errors in the crop growth module of a soil biogeochemical model may propagate to estimates of change in soil carbon, we maintain that an additional requirement to fully document calibration of such modules and validate them in a similar manner is unduly burdensome and unnecessary. VMD0053 already requires that any parameters related to crop-growth modeling be provided with the MVR, as well as conceptual documentation of the model overall, which should specify the crop growth model structure and how it is used along with the soil biogeochemical module. Furthermore, in many cases crop growth models are not parameterized in a manner similar to that of soil biogeochemical models. In many cases, crop growth parameters are related to directly measurable physiological or agronomic characteristics of target species. Finally, while calibration errors for crop growth models are likely to propagate errors to estimates of soil carbon, these errors will be partially accounted for in the model prediction error term for soil carbon and corrected for periodically via remeasurement and model true-up (see VM0042, section 8.6.1.3).</p>

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3	eAgronom	The crop growth model is very important and probably the largest source of uncertainty.	While errors in the crop growth module of a soil biogeochemical model may propagate to estimates of change in soil carbon, we maintain that an additional requirement to fully document calibration of such modules and validate them in a similar manner is unduly burdensome and unnecessary. VMD0053 already requires that any parameters related to crop-growth modeling be provided with the MVR, as well as conceptual documentation of the model overall, which should specify the crop growth model structure and how it is used along with the soil biogeochemical module. Furthermore, in many cases crop growth models are not parameterized in a manner similar to that of soil biogeochemical models. In many cases, crop growth parameters are related to directly measurable physiological or agronomic characteristics of target species. Finally, while calibration errors for crop growth models are likely to propagate errors to estimates of soil carbon, these errors will be partially accounted for in the model prediction error term for soil carbon and corrected for periodically via remeasurement and model true-up (see VM0042, section 8.6.1.3).
4	Indigo Ag	Yes. It is expected that crop growth parameters may vary at scales finer than a climate zone/region, and it is already required that these parameter sets and the rules for selecting them be documented. These requirements should allow the reviewer to adequately assess any risk of over-fitting the model.	While errors in the crop growth module of a soil biogeochemical model may propagate to estimates of change in soil carbon, we maintain that an additional requirement to fully document calibration of such modules and validate them in a similar manner is unduly burdensome and unnecessary. VMD0053 already requires that any parameters related to crop-growth modeling be provided with the MVR, as well as conceptual documentation of the model overall, which should specify the crop growth model structure and how it is used along with the soil biogeochemical module. Furthermore, in many cases crop growth models are not parameterized in a

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			manner similar to that of soil biogeochemical models. In many cases, crop growth parameters are related to directly measurable physiological or agronomic characteristics of target species. Finally, while calibration errors for crop growth models are likely to propagate errors to estimates of soil carbon, these errors will be partially accounted for in the model prediction error term for soil carbon and corrected for periodically via remeasurement and model true-up (see VM0042, section 8.6.1.3).
5	John Deere	While we appreciate the desire to reduce complexity, the crop model does play a significant role in quantification of soil sequestration. We propose revising this to match other sections that rely on published peer reviewed work, such that if the crop model used has a calibration that has been published in a peer reviewed journal, that citing that publication is sufficient, however if the crop model used does not meet that criteria, the project proponent should report calibration of the crop growth model used.	While errors in the crop growth module of a soil biogeochemical model may propagate to estimates of change in soil carbon, we maintain that an additional requirement to fully document calibration of such modules and validate them in a similar manner is unduly burdensome and unnecessary. VMD0053 already requires that any parameters related to crop-growth modeling be provided with the MVR, as well as conceptual documentation of the model overall, which should specify the crop growth model structure and how it is used along with the soil biogeochemical module. Furthermore, in many cases crop growth models are not parameterized in a manner similar to that of soil biogeochemical models. In many cases, crop growth parameters are related to directly measurable physiological or agronomic characteristics of target species. Finally, while calibration errors for crop growth models are likely to propagate errors to estimates of soil carbon, these errors will be partially accounted for in the model prediction error term for soil carbon and corrected for periodically via remeasurement and model true-up (see VM0042, section 8.6.1.3).
6	NRES-UIUC	No. Crop model can significantly influence SOC model results through influencing	While errors in the crop growth module of a soil biogeochemical model may propagate to estimates of change in soil carbon, we maintain that an additional

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		residue input.	<p>requirement to fully document calibration of such modules and validate them in a similar manner is unduly burdensome and unnecessary. VMD0053 already requires that any parameters related to crop-growth modeling be provided with the MVR, as well as conceptual documentation of the model overall, which should specify the crop growth model structure and how it is used along with the soil biogeochemical module. Furthermore, in many cases crop growth models are not parameterized in a manner similar to that of soil biogeochemical models. In many cases, crop growth parameters are related to directly measurable physiological or agronomic characteristics of target species. Finally, while calibration errors for crop growth models are likely to propagate errors to estimates of soil carbon, these errors will be partially accounted for in the model prediction error term for soil carbon and corrected for periodically via remeasurement and model true-up (see VM0042, section 8.6.1.3).</p>
7	Persistence Data Mining, Inc.	<p>There should be a report on crop growth model to establish baseline changes for monitoring. This might be balance against productivity index and changes in historical productivity index.</p>	<p>While errors in the crop growth module of a soil biogeochemical model may propagate to estimates of change in soil carbon, we maintain that an additional requirement to fully document calibration of such modules and validate them in a similar manner is unduly burdensome and unnecessary. VMD0053 already requires that any parameters related to crop-growth modeling be provided with the MVR, as well as conceptual documentation of the model overall, which should specify the crop growth model structure and how it is used along with the soil biogeochemical module. Furthermore, in many cases crop growth models are not parameterized in a manner similar to that of soil biogeochemical models. In many cases, crop growth parameters are related to directly measurable physiological or agronomic characteristics of target species. Finally, while calibration errors for crop</p>

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			growth models are likely to propagate errors to estimates of soil carbon, these errors will be partially accounted for in the model prediction error term for soil carbon and corrected for periodically via remeasurement and model true-up (see VM0042, section 8.6.1.3).
8	Terra Carbon, LLC	We agree with this approach. Requiring a full description of the calibration of a crop growth model that feeds into the SOC model would be unduly burdensome. Crop growth models likely have numerous parameters with little to no impact on SOC modeling for which describing calibration would have no bearing on the validation of the SOC model. The current process for validating the SOC model and documenting relevant crop parameters used in the project domain is sufficient to describe relevant crop inputs and to capture significant errors with how crop growth is modeled, if any.	While errors in the crop growth module of a soil biogeochemical model may propagate to estimates of change in soil carbon, we maintain that an additional requirement to fully document calibration of such modules and validate them in a similar manner is unduly burdensome and unnecessary. VMD0053 already requires that any parameters related to crop-growth modeling be provided with the MVR, as well as conceptual documentation of the model overall, which should specify the crop growth model structure and how it is used along with the soil biogeochemical module. Furthermore, in many cases crop growth models are not parameterized in a manner similar to that of soil biogeochemical models. In many cases, crop growth parameters are related to directly measurable physiological or agronomic characteristics of target species. Finally, while calibration errors for crop growth models are likely to propagate errors to estimates of soil carbon, these errors will be partially accounted for in the model prediction error term for soil carbon and corrected for periodically via remeasurement and model true-up (see VM0042, section 8.6.1.3).
9	Terra Global Capital	Documentation of all internal model parameter sets, including proof that parameter sets are defined at a resolution no finer than one climate zone or one nationally defined agricultural land region, depending on which is declared by the project (Section 5.2.2). If there is justification to claim an	No response needed (this is only a copy of the proposed module text).

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		allowance for crop growth parameter sets to vary within climate zones/nationally defined agricultural land region (e.g., varying maturity groups), documentation must be provided for each zone/region where the crop will be simulated, specifying all crop growth parameter sets used in the zone/region and the rules used to select which parameter set is used for a given simulation crop growth parameter sets sets, and their use must be documented per each LRR where the crop will be simulated. Documentation of calibration for crop growth modelling is not a requirement.	

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10	Bluesource	We agree with the requirement to prioritize geographic closeness of calibration data sets. Closer data sets will have more degrees of similarity outside of the main criteria identified in the module.	Thank you. Please see that this rule will remain in place with minor adjustments.

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11	Boomitra (ConserWater Technologies Inc.)	It is important for the datasets to be physically closest to the project geographical location, because this is the easiest way to control for different variables that affect GHG fluxes occurring in a given area. It is much more difficult when datasets are not close to the project area, hence this new rule is necessary and good.	The rule is to remain in place with minor modifications to improve clarity.
12	Carbon Count	The newly introduced rule helps however physical proximity may still not account for land management activities which have changed the landscape over time.	VMD0053 already requires that validation datasets be matched to the model domain based on land management activities and crop functional groups.
13	CIBO Technologies	This rule makes sense, but may be hard to enforce. What exactly does it mean to "prioritize" datasets, and how would an IEE determine if this rule is followed or not?	This rule has been updated to more specifically require data are from the same climate zone, country, continent, and/or nationally defined agricultural region.
14	eAgronom	If the validation datasets are in the same IPCC climate zone then it shouldn't matter. It's hard to find good quality validation datasets. We should use the best quality sets and not the closest.	The language of the proposed rule has been updated to be more specific and specifies that proximity be prioritized but that datasets must at minimum come from the same climate zone. There is additionally a path for proponents to use other, more appropriate datasets, and quality of datasets could be a key criterion for proponents to enact this exception in many cases.
15	Indigo Ag	We believe this new rule is contradictory to the goals of validation and introduces the potential for confusion and unnecessary burden for project proponents and IEEs.  First, not all experimental datasets are equal in terms of quality – design, sampling	While these points are valid, we do not agree that the rule requiring proponents to prioritize proximity would necessarily result in this scenario. Yes, data quality is equally, if not more important than proximity. But the exception to the rule allows proponents to circumvent this requirement when data proximal to the project are poor quality. We fully expect proponents to enact this exception



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		<p>techniques, duration, etc. all contribute to the quality of the data, and by extension the model validation itself. As written in Appendix 1 of the revised module, the IEE is responsible for: "Assessing the quality of model-driving input data (experimental data of soil emission reductions) and the pooled measurement uncertainty." With this new rule it is unclear how a reviewer (or the scientific community at large) is to assess the overall quality of using certain datasets if priority is given to proximity. For example, if an experiment has been shown to yield dubious results due to methodological errors, oversights, or unforeseen circumstances, that experiment should not be prioritized over higher quality experiments simply due to geographic location. Requiring a project proponent to defend the use of high-quality data over more proximal data is counterproductive to the goals of validation and increases the likelihood for disagreement and confusion between project proponents and IEEs.</p> <p>Second, meeting the minimum quantitative requirements for validation datasets is difficult and in many cases impossible due to a lack of sufficient high-quality data. Because each PC x CFG x ES combination must be validated individually, it is unlikely each combination will have sufficient data located within the project borders. The ability to draw from representative biophysical systems elsewhere in the world is a critical enabling</p>	<p>in such scenarios. More specific language to highlight just such a scenario as a justifiable deviation has been included. Furthermore, while ability to draw data from other areas in the world is a critical and, again, allowable exception, the burden of proof that such data are still appropriately matched to the model and project domains should fall on the proponent.</p>

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		feature of the requirements.	
16	John Deere	We support this rule because it will likely improve model accuracy, but it also will exacerbate the issue of finding validated data sets. If this rule is introduced, Verra could help make it feasible for Project Proponents by maintaining a repository of validated datasets for all projects to use. For large scale projects, that include all of US, this likely means more validated datasets are required to validate the model than currently exist. Without targeted effort to increase the range of validated datasets, this rule could have the unintended consequence of projects reducing their geographic footprint to areas that do have validated datasets.	While these issues may indeed result from the introduction of this rule, the intent of VMD0053 is to ensure that models are conservatively applied for project crediting and that they are appropriately matched to a project. If a project needs to reduce its geographic footprint as a result of insufficient validation data being available, that is an acceptable outcome. As use of VM0042 and VMD0053 increase, repositories of existing datasets and new datasets are likely to emerge, streamlining implementation for future users.
17	NA	Selection of validation datasets physically closest to the project geographical location should be prioritized. Where datasets from different climate zones, nationally defined agricultural land regions, countries or continents are used, the project proponent must provide rationale demonstrating why these were selected for validation.	General Q7 response: Opinions in the public comment responses to this question were split with a slight majority favoring this rule. Opinions in favor highlighted that this rule could lead to more appropriate matching of validation datasets. Opinions in opposition generally highlighted that while this rule may make sense, it may be difficult to enforce and if interpreted literally could result in proponents excluding appropriate validation data. The rule is to remain in v.2 with similar language. Given favorable opinions as to the intent and potential impact of the rule, consensus indicates that including it could result in more appropriate selection of validation data to match the model domain. Furthermore, it provides VVBs and IMEs with a guideline for assessing the appropriateness of validation datasets. In scenarios where such requirements are difficult to meet, there is an option to use other validation

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			datasets provided a justification is offered. This exception provides flexibility but appropriately shifts the burden of proof back onto the proponent.
18	Native	If measurement is used to true-up model, our general approach is that strict model requirements or difficult to use robust models limit project feasibility and scale.	Agreed. See also updates to VM0042 (section 8.6) and the true-up procedure (section 8.6.1.3), which aim to update estimates of model prediction error to be more appropriate to the project and could compensate for scenarios in which insufficient validation data that meet such requirements are available.
19	Nutrient Management Institute	Unnecessary. Key determining factors in SOC are not spatial distance but rather soil properties and moisture.	The general consensus among other stakeholders was while it may not be necessary, this rule is likely to guide users towards selection of validation datasets that are more appropriately matched, including on factors such as soil properties and moisture.
20	Persistence Data Mining, Inc.	Validation and baseline scenarios should require physical data not "nearest neighbor" estimates since geology, lithogy, and soil orders plans a huge role carbon sequestering.	Matching based on those criteria is already required by VMD0053 for the reasons you highlight. Matching based on proximity is intended to ensure appropriate matching based on other factors such as climate and typical production regimes in the project region.
21	Terra Carbon, LLC	Prioritizing datasets in close proximity to the project location but allowing for projects to use datasets that are farther away but justifiably representative is an appropriate approach to balance the need for a rigorous, relevant validation dataset with the challenges of procuring enough data to make meaningful comparisons. The proposed revisions still provide flexibility for projects to search outside of their given geography or country for validation datasets; maintaining	The rule will remain in place with a pathway for exceptions and flexibility where appropriate.

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		such flexibility is critical for projects in locations where research studies are not prevalent but it can be reasonably argued that the project location is well represented by studies conducted in other locations.	
22	Terra Global Capital	Selection of validation datasets physically closest to the project geographical location should be prioritized. Where datasets from different climate zones, nationally defined agricultural land regions, countries or continents are used, the project proponent must provide rationale demonstrating why these were selected for validation.	No response needed (this is only a copy of the proposed module text).

**Q8: Are the three new proposed rules for validating datasets in systems with organic amendments, N fertilization and irrigation both rigorous and feasible?**

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23	Bluesource	These rules seem fair in their approach to validating amendments. Additional clarity on the requirements for data sets used for this validation would be appreciated.	Additional requirements for such validation datasets are outlined in Section 5.2.3 and must be match to the project and model domains per the requirements outlined in sections 5.2.1 and 5.2.2.
24	CIBO Technologies	For the organic amendments application, it's not clear why it's necessary to allow annual	The requirement to include a single study for irrigation has been removed. The rationale for pooling across CFGs for

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		CFGs to be pooled, when this is not allowed for other practices. For N fertilization, the reasoning is clear, and the proposed rule seem fair and feasible. The irrigation rule is fine, though requiring a single irrigated study (out of hopefully dozens+) isn't going to affect model results much and so therefore this requirement seems a bit spurious; a model that does terribly at irrigation could still easy pass with low error.	organic amendments is that in annual cropping systems, carbon additions from organic amendments are so substantial that they are likely to exceed the return of carbon to soil from crop residues, and as such this practice can be adequately validated when CFGs are pooled.
25	Indigo Ag	<p>We support the three new rules for validating organic amendments, N management on legumes, and non-changing irrigation. For N management on legumes, given the rarity of this practice in general and the unlikeliness that it would be performed as a qualifying practice change, it is not expected to have a material impact on project-wide emissions reductions for large projects. There is also a lack of experimental data with which to validate the PC/CFG combination outright. Requiring the PC and CFG to be validated separately within other combinations is a logical solution.</p> <p>We support the pooling of CFGs in the validation of Organic Amendments on the basis that the amount of carbon in an organic amendment such as manure will typically far exceed the residue return rate of crops to the soil, thus outweighing any differences between common annual crop types. By this logic the effects of organic amendments are not primarily mediated by CFG and may thus</p>	All three rules will remain in place. The irrigation rule has been updated to eliminate the requirement that at least one study include irrigation based on the arguments that such a requirement seems arbitrary and that natural variation in precipitation can serve as an adequate proxy for irrigation's impacts on model accuracy.

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		<p>be justifiably combined during validation. Perennials systems may however respond differently to organic fertilization and thus it is prudent to exclude these.</p> <p>We support the rule exempting irrigation from validation when performed as a normal, unchanging part of management. To meet the model guidance requirements, a range of precipitation regimes must be included in the validation dataset for each combination of PC and CFG. The effects of this variability in precipitation serve as an adequate proxy for the effects of artificial rainfall, i.e. irrigation. Thus if irrigation is not the targeted practice for earning credits, it is reasonable to rely on the model's response to precipitation and inclusion of irrigation in the validation dataset as confirmation of the model's ability to represent irrigation as a normal aspect of management.</p>	
26	Terra Carbon, LLC	<p>The proposed rules for organic amendments and N fertilization make sense and are feasible. We also support the proposed rule for irrigation but suggest that the rule be generalized for more than irrigation in order to demonstrate that the selected model is applicable to the kinds of cropping systems and management practices that a project anticipates will be included in the project, even if those cropping systems and management practices do not change as a result of project activities.</p>	<p>All three rules will remain in place. The irrigation rule has been updated to eliminate the requirement that at least one study include irrigation based on the arguments that such a requirement seems arbitrary and that natural variation in precipitation can serve as an adequate proxy for irrigation's impacts on model accuracy.</p>

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27	Terra Global Capital	<p>When validating a model for the Organic Amendments Application practice category, data from all CFGs classified as “annual” may be pooled and the validation result may be considered applicable for crediting of organic amendment practices in any annual CFG. Each perennial CFG must still be validated separately. When validating a model for the Inorganic N Fertilizer Application practice category, it is expected that validation data may be scarce for CFGs that fix N (e.g., soybean), because these crops are often grown without fertilization. Therefore, the model may be considered validated for annual, herbaceous, C3, N-fixing crops if (1) Inorganic N fertilizer application has been successfully validated for another annual CFG, and (2) the annual, herbaceous, C3, N-fixing CFG has been successfully validated for the Cropping, Planting, and Harvesting PC. Cropping systems using irrigation as a normal part of management separate from practices intended to reduce emissions, i.e. where irrigation is present in both project and baseline, are not required to have the Water Management/Irrigation PC validated, provided that irrigation is represented in at least one study in the validation dataset.</p>	<p>No response needed (this is only a copy of the proposed module text).</p>

Q9: Under Requirement 2, does the new more flexible requirement for the validation dataset regarding soil textural classes maintain sufficient rigor compared to the original requirement?

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28	Bluesource	This approach seems like a reasonable compromise between practicality and accuracy.	Requirements regarding coverage of soil texture classes and clay content in the validation datasets have modified to present a compromise between V1 and V2. While the updated language in V2 may result in a more comprehensive validation dataset vis a vis soil texture, it would be effectively impossible to achieve such coverage in most projects, particularly large projects where nearly every soil texture class is likely to be represented in the project. The rule has been rewritten to more closely match the original language in V1, but more specifically requires that the three soil texture classes expected to be most predominant in the project must be represented in the validation dataset. This modification adds additional rigor as the proponent cannot choose datasets from studies that are largely irrelevant to the project, but remains achievable.
29	CIBO Technologies	The new requirement is more flexible in one respect, especially for smaller projects with fairly homogenous soil textures. However, for broader projects, the new requirement is more stringent, in that studies must be found to cover every single texture class without exception.	Requirements regarding coverage of soil texture classes and clay content in the validation datasets have modified to present a compromise between V1 and V2. While the updated language in V2 may result in a more comprehensive validation dataset vis a vis soil texture, it would be effectively impossible to achieve such coverage in most projects, particularly large projects where nearly every soil texture class is likely to be represented in the project. The rule has been rewritten to more closely match the original language in V1, but more specifically requires that the three soil texture classes expected to be most predominant in the project must be represented in the validation dataset. This modification adds additional rigor as the proponent cannot choose datasets from studies that



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			are largely irrelevant to the project, but remains achievable.
30	Indigo Ag	No, we believe this new requirement is overly burdensome and should be removed. While the inclusion of all soil textures and clay contents would make a more complete dataset, the new requirement makes it significantly harder, and perhaps impossible, to validate the PC/CFG/ES combinations within a project. The key principle behind the original requirement is that the model be robust in its representation of biogeochemical processes affecting GHGs and thus able to be extrapolated to new locations. A reasonable counterproposal to this new rule is that it be applicable only to the validation of empirical or statistical models, as opposed to process-based models. Process-based models are designed in part with the intention of being used under novel conditions, provided the validation process is suitably comprehensive. We feel the use of 3 soil textures and a 15% span in clay content for every PC/CFG/ES combination provides a rigorous demonstration for process-based models while remaining achievable.	Requirements regarding coverage of soil texture classes and clay content in the validation datasets have modified to present a compromise between V1 and V2. While the updated language in V2 may result in a more comprehensive validation dataset vis a vis soil texture, it would be effectively impossible to achieve such coverage in most projects, particularly large projects where nearly every soil texture class is likely to be represented in the project. The rule has been rewritten to more closely match the original language in V1, but more specifically requires that the three soil texture classes expected to be most predominant in the project must be represented in the validation dataset. This modification adds additional rigor as the proponent cannot choose datasets from studies that are largely irrelevant to the project, but remains achievable.
31	John Deere	We do not feel this generalization provides enough scientific rigor. We propose that textural ranges from all soil sampling from the similar geographic region or project area be included in the validation dataset, with split sampling where necessary. In addition,	Requirements regarding coverage of soil texture classes and clay content in the validation datasets have modified to present a compromise between V1 and V2. While the updated language in V2 may result in a more comprehensive validation dataset vis a vis soil texture, it would be effectively impossible to achieve such coverage in

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		wherever possible, soil sampling data of a similar geographic region or project area that has been included in peer reviewed papers may be included in the validation dataset to reduce uncertainty.	most projects, particularly large projects where nearly every soil texture class is likely to be represented in the project. The rule has been rewritten to more closely match the original language in V1, but more specifically requires that the three soil texture classes expected to be most predominant in the project must be represented in the validation dataset. This modification adds additional rigor as the proponent cannot choose datasets from studies that are largely irrelevant to the project, but remains achievable.
32	Nutrient Management Institute	The section is comprehensive. You can also complimentary to the term hyper-calibration use the term overfitting. This is frequently used in statistics.	Thank you for the additional suggestion. The term overfitting has been included in the text. Requirements regarding coverage of soil texture classes and clay content in the validation datasets have modified to present a compromise between V1 and V2. While the updated language in V2 may result in a more comprehensive validation dataset vis a vis soil texture, it would be effectively impossible to achieve such coverage in most projects, particularly large projects where nearly every soil texture class is likely to be represented in the project. The rule has been rewritten to more closely match the original language in V1, but more specifically requires that the three soil texture classes expected to be most predominant in the project must be represented in the validation dataset. This modification adds additional rigor as the proponent cannot choose datasets from studies that are largely irrelevant to the project, but remains achievable.
33	Persistence Data Mining, Inc.	It is more rigorous than original. This should be more detailed to account for more geological aspects, soil texture and soil orders.	Requirements regarding coverage of soil texture classes and clay content in the validation datasets have modified to present a compromise between V1 and V2. While the updated language in V2 may result in a more comprehensive validation dataset vis a vis soil texture, it would be effectively impossible to achieve such coverage in most projects, particularly large projects where nearly every

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#	Organization	Comment	Developer's Response
			soil texture class is likely to be represented in the project. The rule has been rewritten to more closely match the original language in V1, but more specifically requires that the three soil texture classes expected to be most predominant in the project must be represented in the validation dataset. This modification adds additional rigor as the proponent cannot choose datasets from studies that are largely irrelevant to the project, but remains achievable.
34	Terra Carbon, LLC	<p>Depending on the size and location of the project area being validated, these new requirements may or may not increase flexibility for a project validating their model. These requirements may in fact be more strict than the original requirement of a span of at least 15 percentage points in clay content and representation of at least three declared soil textural classes. For many larger grouped projects, this would mean the validation datasets would need to encompass the full range of clay content possible and all soil textural classes. In these cases, finding high quality research studies for every practice change/crop functional group/emissions source combination and for every soil textural class would likely pose a considerable challenge.</p> <p>Furthermore, by requiring a validation dataset to represent the full breadth of clay contents and soil textures declared in the project domain, the proposed revisions no longer provide a pathway for a project to justify validating a model even if the criteria under Requirement 2 cannot fully be met.</p>	<p>Requirements regarding coverage of soil texture classes and clay content in the validation datasets have modified to present a compromise between V1 and V2. While the updated language in V2 may result in a more comprehensive validation dataset vis a vis soil texture, it would be effectively impossible to achieve such coverage in most projects, particularly large projects where nearly every soil texture class is likely to be represented in the project. The rule has been rewritten to more closely match the original language in V1, but more specifically requires that the three soil texture classes expected to be most predominant in the project must be represented in the validation dataset. This modification adds additional rigor as the proponent cannot choose datasets from studies that are largely irrelevant to the project, but remains achievable.</p>

**Q9: Under Requirement 2, does the new more flexible requirement for the validation dataset regarding soil textural classes maintain sufficient rigor compared to the original requirement?**

#	Organization	Comment	Developer's Response
		<p>VMD0053 on page 20 reads, "If the available data fail to meet one of these minimums due to data scarcity, or fails while also exceeding the others in a way that supports a demonstrable test of generalized model performance, a case may be made for a valid exception to Requirement 2." However, the requirements for soils cannot be exceeded if the requirement is that all soil textures declared in a project domain that includes all possible soil textures must be represented in the validation dataset. Therefore, such projects have an unclear path forward to make a case for a valid exception to, for example, not meeting requirements for the representation of climate zones by representing more soil textures.</p> <p>Relatedly, the proposed changes make the rest of Requirement 2's guidance confusing and somewhat irrelevant, particularly the examples provided for how to exceed some requirements to justify not attaining others. In the paragraphs following the proposed changes on page 20-21, VMD0053 states: "... but five or more soil types are included (as opposed to three), and the furthest geographic extent between experimental sites is at least 500 km. Or, if only two of three declared soil types are included because no data could be obtained for the third, but five or more different soil types..." This language specifying the number of soil types represented is no longer applicable.</p>	

**Q9: Under Requirement 2, does the new more flexible requirement for the validation dataset regarding soil textural classes maintain sufficient rigor compared to the original requirement?**

#	Organization	Comment	Developer's Response
35	Terra Global Capital	<p>For all PC/CFG/ES combinations, each climate zone or nationally defined agricultural land region, depending on which is used, must be represented in the validation dataset. Additionally, at least three declared soil textural classes must be represented, and the range in clay contents must span at least 15 percentage points. When the number of declared soil textural classes is less than three, and all textural classes that do occur within the project's geographic extent must be included in the dataset, and there must be a range in clay contents spanning at least 15 percentage points. Once validated, a PC/CFG/ES combination will be approved for crediting within all declared climate zones/nationally defined agricultural land regions and for all declared soil textures.</p>	<p>No response needed (this is only a copy of the proposed module text).</p>

Q10: Are there any other factors, in addition to SOC content measurement technique (e.g., sampling scheme, bulk density measurement technique, etc.), worth specifying for lumping studies to compute pooled measurement uncertainty (PMU)?

Q10: Are there any other factors, in addition to SOC content measurement technique (e.g., sampling scheme, bulk density measurement technique, etc.), worth specifying for lumping studies to compute pooled measurement uncertainty (PMU)?			
#	Organization	Comment	Developer's Response
36	Bluesource	Sampling scheme seems like an important category to consider - grid sampling should have much lower accuracy than a well-designed stratification.	Thank you. Good point re: spatial variability and the use of such sampling strategies to capture it. While we agree, we do not feel it's necessary to comment on this topic in VMD0053 in relation to PMU. Sampling scheme could have important impacts on the accuracy of measures of treatment impacts, particularly in studies performed at scale. However, studies used to provide datasets for use with VMD0053 generally come from small plot studies in which simple random sampling paired with sample compositing predominate. Should a validation dataset be based on more complex sampling schemes, we foresee that either data for each point selected would be available or the standard error and mean across all points is reported. In either case the variability is propagated into calculations of bias and error.
37	CIBO Technologies	PMU could be defined as a function of cumulative soil sampling depth, rather than as the pooled uncertainty of the subset of studies that include measurements of the target depth. This would provide a more robust estimate of measurement uncertainty at deeper depths, as it will explicitly include uncertainty associated with shallower sampling schemas. We expect that the uncertainty associated with a treatment effect will increase monotonically with increasing soil sampling depth.	Thank you for this suggestion. Text has been included to suggest this as an alternate approach that proponents can choose to implement if appropriate. We changed one sentence to "... the observed rate of change for SOC stocks and associated uncertainty can differ across depth increments (generally uncertainty increases at lower depths)..."

**Q10: Are there any other factors, in addition to SOC content measurement technique (e.g., sampling scheme, bulk density measurement technique, etc.), worth specifying for lumping studies to compute pooled measurement uncertainty (PMU)?**

#	Organization	Comment	Developer's Response
38	Indigo Ag	No, we feel the requirement as written gives the right amount of flexibility for pooling studies.	No response needed, supportive comment.
39	John Deere	We see no other factors as being required, agree with the revision as it stands.	No response needed, supportive comment.
40	Nutrient Management Institute	It is very comprehensive. The figures are very clear and helpful. We did not yet encounter details on sampling design techniques, in addition to grid-based or random. In Agricultural Sciences, conditioned Latin Hypercube sampling (cLHS) is often used, it is designed to capture the variability of a plot and design a sampling strategy around it. Would it be worthwhile to add a sub section on sampling design technique and their relationship with combatting spatial variability?	Thank you. Good point re: spatial variability and the use of such sampling strategies to capture it. While we agree, we do not feel it's necessary to comment on this topic in VMD0053 in relation to PMU. Sampling scheme could have important impacts on the accuracy of measures of treatment impacts, particularly in studies performed at scale. However, studies used to provide datasets for use with VMD0053 generally come from small plot studies in which simple random sampling paired with sample compositing predominate. Should a validation dataset be based on the use of a tool like cLHS, we foresee that either data for each point selected would be available or the standard error and mean across all points is reported. In either case the variability captured by cLHS is propagated into calculations of bias and error.
41	Terra Carbon, LLC	We do not suggest additional factors for grouping studies to improve estimation of PMU, but we do suggest changes to how it is estimated across subsets of studies.  Measurement uncertainty of SOC content measurement techniques differs from the uncertainty of practice change impacts on SOC stocks. Bulk density is necessary to calculate SOC stocks, and thus measurement error of bulk density techniques should be	Thank you for this suggestion. Text has been included to suggest this a cumulative sampling depth approach to PMU as an alternate approach that proponents can choose to implement if appropriate. Additional guidance has been included regarding accounting for bulk density measurement error as well as SOC content measurement error in cases where data to calculate PMU are insufficient or unavailable. We changed one sentence to "... the observed rate of change for SOC stocks and associated uncertainty can differ across depth increments (generally

**Q10: Are there any other factors, in addition to SOC content measurement technique (e.g., sampling scheme, bulk density measurement technique, etc.), worth specifying for lumping studies to compute pooled measurement uncertainty (PMU)?**

#	Organization	Comment	Developer's Response
		<p>considered and incorporated into the estimation of PMU.</p> <p>Uncertainty in SOC stock estimates is likely to change with sampling depth, and studies used in model calibration/validation vary in total sampling depth and depth increments. Grouping studies based on sampling depths used is likely to result in study subsets too small to result in meaningful estimation of PMU. We suggest instead that Verra consider defining PMU as a function of total cumulative sampling depth to address such issues.</p> <p>Guidance should be included as to how to address studies in which SOC measurements at different time points are done using different measurement techniques.</p> <p>We also suggest that for instances where a proponent chooses to use an outside dataset for the estimation of measurement error for a given SOC measurement technique that they use data compiled as part of the Soil Science Society of America's North American Proficiency Testing program. Results from this program provide robust estimates across multiple labs and standard soils for all primary SOC measurement techniques.</p>	<p>uncertainty increases at lower depths)..."</p>



Q11: Is the proposed process for a modeling assessment by an Independent Evaluation Expert (IEE) reasonable and feasible for projects, including the criteria to be met by IEEs?

**Q11: Is the proposed process for a modeling assessment by an Independent Evaluation Expert (IEE) reasonable and feasible for projects, including the criteria to be met by IEEs?**

#	Organization	Comment	Developer's Response
42	CIBO Technologies	Looks good.	No response needed, supportive comment.
43	Indigo Ag	The proposed process is reasonable except for part (a): "Citation of own peer-reviewed scientific publication(s), as first or co-authors, presenting or using the model(s) to be evaluated." To require the independent expert to have published the specific model is overly burdensome and risks severely limiting the pool of eligible experts. It contradicts best practices in the peer-review editorial process where reviewers are chosen for their subject matter expertise, and rightly includes experts with differing approaches and experiences. The requirements of the Validation Report ensure the specifics of any given model, its structure, and intended use in a crediting project, are sufficiently transparent that any model expert could review it as any peer-reviewed publication on a model would require.	Verra agrees with this proposal in order to enlarge the number of available experts to serve as IMEs. The respective minimum qualification requirement has been accordingly adjusted.
44	John Deere	We are concerned that the language stated as-is is too restrictive and will create a bottleneck in the project development system. Rather than scientific experts with peer review in specific carbon models, independent evaluators may be experts in their field with peer-reviewed publications in models requiring parameterization. This	Verra agrees with this proposal in order to enlarge the number of available experts to serve as IMEs. The respective minimum qualification requirement has been accordingly adjusted.

**Q11: Is the proposed process for a modeling assessment by an Independent Evaluation Expert (IEE) reasonable and feasible for projects, including the criteria to be met by IEEs?**

#	Organization	Comment	Developer's Response
		experience meets the demands of assessing model inputs and rigor of results (goodness of fit, etc) to be functional, in particular as programs begin to scale outside the United States.	
45	Native	The methodology definitely needs to have looser model approval requirements. Having a peer-reviewed model like VM0026 requirements) would additionally make model use less burdensome for projects that will also be measured. IEE will add additional costs to project and it's our view that model costs take away from payments to the producers to make the necessary practice changes.	In our view, the use of biogeochemical models for SOC requires highly specific expertise. The independent assessment of the Model Validation Report by a modeling expert is a necessary requirement additional to the VVB assessment to ensure integrity of the modeled SOC gains and the resulting VCU claims.
46	Nutrient Management Institute	A small organisational note, in VMD0053 I did not find an appendix 1. I did find this: "New and novel methods for SOC monitoring will be acceptable if there is peer-reviewed support of this practice or independent expert support (" on page 16. I would recommend this for model evaluation as well. So, either use a method which is to be approved by an IEE OR use a method which has been published in a peer-reviewed scientific publication.	This is covered in the rules for assessing and validating model validation reports.
47	Terra Carbon, LLC	We support the proposed approach that project proponents contract the IEE directly as this will simplify the process for identifying and contracting the IEE and streamline response to their findings and provision of	Verra agrees with this proposal in order to enlarge the number of available experts to serve as IMEs. The respective minimum qualification requirement has been accordingly adjusted.

**Q11: Is the proposed process for a modeling assessment by an Independent Evaluation Expert (IEE) reasonable and feasible for projects, including the criteria to be met by IEEs?**

#	Organization	Comment	Developer's Response
		<p>any necessary additional documentation. The application process for IEEs with Verra should help to prevent any concerns re: conflicts of interest that could arise in model review.</p> <p>The criteria that applicants to be an IEE must provide, "Citation of own peer-reviewed scientific publication(s), as first or co-authors, presenting or using the model(s) to be evaluated" should be broadened beyond experience only with the specific model being evaluated. Many models do not have a wide user/researcher base but may still be wholly appropriate for use under VM0042. Additionally, most models are conceptually similar, thus, an IEE familiar with one model will have transferable knowledge and skills even when reviewing a different model. Allowing IEEs with in-depth knowledge of one model to assess the model validation report of a different model would provide for a more robust pool of potential IEEs and a clearer path to identify a qualified IEE who does not have any potential conflict of interest without compromising the rigor and expertise required of an IEE.</p>	

# GENERAL FEEDBACK

## Section 2: Summary of Module Description

Section 2: Summary of Module Description				
#	Organization	Reference	Comment	Developer's Response
48	Cirrus	Page 3	<p>A geographic region may represent an area with different land suitability and agricultural potential. A regional AEZ represents a spatial unit where the combination of biophysical properties has similar potential and constraints of land use and agricultural production. Model testing should be grouped according to regional AEZs that is based on regional climate, broad soil patterns and landforms (e.g. map in Hendriks office) or landcover class, and on agricultural production region with similar farming/cropping systems. The regional AEZ could be based on the climate zone specified in the 1st paragraph of page 7. The regional AEZ can be representative at the scale of IPCC climate zones or at the scale of nationally defined agricultural land regions, for example Land Resource Regions in the US, as mentioned in the 3rd paragraph of page 10.</p> <p>Proposed Change: Replace “geographic regions” with regional agro-ecological zones.</p>	<p>Further detail on this topic is provided in Section 5.2.2 and provides more specific guidance on how geographic, climate, and agricultural production factors should be considered in defining the model domain(s). The language referenced in this comment is simply introductory text and does not need to be modified.</p>
49	Cirrus	Page 3	<p>Crop types do not provide sufficient information on how crop production affect SOC sequestration, e.g. the same crop types can have different cultivation practices. A crop/farming system accounts for inter alia combination of crop types, crop rotation- and cultivation systems, and if the rotation includes cover crops and grazing. A</p>	<p>Further detail on this topic is provided in Section 5.2.2 and provides more specific guidance on how geographic, climate, and agricultural production factors should be considered in defining the model domain(s). More specifically, practice change is combined with crop functional group to define the different categories for which the model must be validated. The language referenced in</p>

## Section 2: Summary of Module Description

#	Organization	Reference	Comment	Developer's Response
			<p>maize-soybean crop types can represent three cropping/farming systems of conventional, reduced and no till.</p> <p>Proposed Change: Replace “crop types” with crop/farming systems.</p>	<p>this comment is simply introductory text and does not need to be modified.</p>
50	Cirrus	Page 3	<p>Experimental data can imply that data are obtained from experimental (research) plots, which may exclude other approaches to obtain required data.</p> <p>Proposed Change: Delete experimental from “observed experimental data”.</p>	<p>The term 'experimental' is included as the preference is for data to come from experiments that include both controls and treatments for determining the effects of improved practices on a given emissions source, against which the model can then be compared. However, data can be obtained by other means or from other types of scientific effort. This language has been updated to reflect the different options available under VMD0053.</p>
51	Cirrus	Page 3	<p>Data should be collected on changes in SOC content/stock if the project aim is to predict SOC sequestration, whereas data should be collected on soil emissions reduction if the project aim is to predict reduction in CO<sub>2</sub>, NO<sub>x</sub> and NH<sub>4</sub> emissions. If the project aim is to predict only SOC sequestration (or loss), then data on soil emissions are not required. The model can be calibrated and validated against changes in SOC content/stock without the need for data on soil emissions on e.g. CO<sub>2</sub>, NO<sub>x</sub> and NH<sub>4</sub>.</p> <p>Propose Change: Replace “soil emissions reduction” with changes in SOC content/stock and/or soil emissions.</p>	<p>The term emissions reductions is commonly used in the Verified Carbon Standard to refer to activities that result in avoided emissions or sequestration of carbon in a target pool. For clarity, we have added the term 'removals' and a parenthetical with examples.</p>
52	Cirrus	Page 4	<p>If soil emissions are highly variable, why should data not be obtained on SOC contents that are significantly more stable measurement and indicator to use for model calibration and</p>	<p>See comment above in relation to a similar comment on page 3. The term emissions removal is used in a manner perhaps different than the comment author's understanding. It is not the expectation that proponents</p>

## Section 2: Summary of Module Description

#	Organization	Reference	Comment	Developer's Response
			validation?	would use data on soil CO2 emissions instead of measurements of change in SOC stocks. The remainder of the methodology makes this clear.
53	Cirrus	Page 4	It is important that “substantively affecting model runs and the number of estimated errs” is included since a model can regularly be updated without substantially affecting these aspects.	No response needed, supportive comment.

## Section 3: Definitions

### Section 3: Definitions

#	Organization	Reference	Comment	Developer's Response
54	Cirrus	Page 7	Monitoring trials at farms to calibrate models for VDM are likely to be a data-limited situation since it will most likely not be conducted at the same level of detail and the costs than research trials	No response needed, supportive comment.

## Section 4: Applicability Conditions

### Section 4: Applicability Conditions

#	Organization	Reference	Comment	Developer's Response
55	Cirrus	Page 8	Replace "... every parameter set must be validated separately" with '... every parameter set that is	The language the comment author is commenting on is meant to indicate that proponents must validate parameter

## Section 4: Applicability Conditions

#	Organization	Reference	Comment	Developer's Response
			specific to the changes in SOC stock/soil emissions of the project must be validated separately. This excludes minimum data sets required to run the model that has not an effect on SOC stock/soil emissions.'	sets relevant to each different emissions source must be validated separately. Furthermore, the comment author mentions excluding minimum datasets required to the run the model. Such data inputs are not model parameters. Model parameters refer to coefficients or model factors that represent soil processes related to emissions. No edits are required.

## Section 5: Procedures

### Section 5: Procedures

#	Organization	Reference	Comment	Developer's Response
56	Nutrient Management Institute	Section 5.1, Page 9	<p>Independence between the datasets used for calibration and validation should be demonstrated at the crop functional group/practice category combination level.</p> <p>Proposed Change: I would avoid this for the statistical/empirical models, but allow this for process based models. This to avoid over-fitting due to site properties that control SOC dynamics.</p>	<p>It's unclear if this comment is that datasets shouldn't be independent or if they shouldn't be independent for crop functional group/practice combinations. Either way, independence should still be maintained between calibration and validation data, even if that's achieved through cross-validation and bootstrapping techniques. This requirement ensures that data used to test model fit are not the same data used to determine model parameters. If the same data were used, then tests of model fit should be considered invalid. If the comment is more concerned with the notion that overfitting could occur if datasets for each CFG/PC are completely separate. This is understandable, but it is not what the specific requirement is about. The same dataset can be used across different CFG/PC combinations (if relevant to more than one). Cal/val data are what need to remain independent from each other.</p>

## Section 5: Procedures

#	Organization	Reference	Comment	Developer's Response
57	Cirrus	Section 5.1, Page 9	<p>Deterministic models may have included the SOC simulation component as a module to the larger model (e.g. the Century model as the SOC module to the EPIC- and DSSAT models). These models do require minimum data to run the model that has no effect on the SOC prediction results, and should therefore not be included in the model validation.</p> <p>Proposed Change: Replace "... every parameter set must be validated separately" with '... every parameter set that is specific to the changes in SOC stock/soil emissions of the project must be validated separately. This excludes minimum data sets required to run the model that has not an effect on SOC stock/soil emissions.</p>	Please see Box 1 in Section 5.1. Crop growth modules are not required to be validated.
58	Cirrus	Section 5.1, Page 9	<p>Ideally, yes, one would have complete separate datasets for calibration and verification, however in practice, limited local field trials and data will limit this.</p> <p>Proposed Change: These requirements should be "preferred" but not absolutely necessary as many regions in southern and east Africa don't have adequate data.</p>	While limited data availability is a potential problem, a k-fold cross validation approach could be used in such scenarios to ensure calibration and validation data are independent. It's important that they do remain independent. Otherwise, validation tests are performed on the same data with which the model is calibrated and are therefore not valid and will indicate a model fit/accuracy that is unrealistically high.
59	Nutrient Management Institute	Section 5.2.2, Page 16	<p>"stacked effects"</p> <p>Proposed Change: very valuable, but given all experimental stations, most trials (if not almost all of them) are highly designed for single treatment effects. You might add a sentence that model validation on farmer fields or "common practices" consisting of combined treatments are preferably used to disentangle impacts of possible</p>	The point the comment author is referring to specifies that data from studies in which practices are 'stacked' can be used to validate individual practices provided that at least one of the studies in the validation dataset includes just that individual practice as a treatment. The comment author specifies that most studies focus on individual practices rather than stacked practices, which would be more suitable for validation purposes. If the comment author may instead be suggesting that 'stacked' practices



## Section 5: Procedures

#	Organization	Reference	Comment	Developer's Response
			additive/multiplicative effects. It's obvious that individual impacts cannot be stacked without correcting for interaction effects. Does that require an additional section?	should be validated as a separate practice change in order to better capture potential interaction effects of practices. While this would be a more robust way to validate the model for such scenarios, as the author suggests, such experiments are uncommon, and including such a requirement would likely prove unduly burdensome. Furthermore, remeasurement and model true-up (see VM0042, section 8.6.1.3) could help to capture the impact of such interaction effects on model prediction error not adequately captured by validating the practices individually.
60	CIBO Technologies	Section 5.2.2, Page 17	<p>Table A-1 for the linked doc is not a full list of soil textures; it is just the soil textures used for GLEAMS. The full list can be seen on any standard soil texture triangle and includes "loamy sand" and "sandy loam," which are not included in GLEAMS.</p> <p>Proposed Change: Replace this reference with a more standard list of soil textures and provide a table mapping ALL soil textures to clay content.</p>	Thank you for this suggestion. Agreed, the standard soil texture triangle is a more robust reference. The suggested edit has been implemented.
61	Cirrus	Section 5.2.3, Page 19	<p>Important to consider in cases with data-insufficient situations that may occur with monitoring trails at farms to calibrate model for VDM.</p> <p>Proposed Change: More flexibility may be needed in areas with limited data, especially the lack of experimental trials and established datasets.</p>	The point the comment authors are referring to offers sufficient flexibility to utilize studies that may not include perfect detail on model inputs, provided that the proponent reports on the processes and decisions they made to fill in such data gaps. No edits required.
62	Persistence Data Mining, Inc.	Section 5.2.3, Page 19	<p>Item 9, in reference Section 5.2.3.</p> <p>Proposed Change: This should not state that we are agnostic to the method. The method is important to define otherwise we are leaving this</p>	The term 'agnostic' does not appear anywhere in the text of either V1 or V2. We presume that this comment is generally in reference to the ninth bulleted item in Section 5.2.3, which describes expectations for methods to assemble the validation dataset. Additional reference to standard meta-

## Section 5: Procedures

#	Organization	Reference	Comment	Developer's Response
			up to too much interpretation invalidating the process.	analysis guidelines from PRSIMA have been added to address ambiguities and provide a common set of practices that proponents should follow to assemble datasets. Secondary data-processing steps are likely contingent on the specific model in question and how data from studies should be processed for adequate comparison. But key elements of data processing (e.g. depth matching, conversion to stocks) are addressed elsewhere in VMD0053.
63	Terra Carbon, LLC	Section 5.2.3, Page 22	<p>The revisions added a footnote (see page 22) that now implies that the model validation analysis should be conducted with respect to the sampling depth increments employed in the project. However, this language seems to conflict with other language in VMD0053 (see page 19). Overall, the issue of how to handle issues of depth is unclear and could use some attention in the main text.</p> <p>Proposed Change: Consider moving footnote 4 regarding depth increments to the main text, clarifying the language so that this footnote and text on page 19 do not conflict, and providing additional guidance on how to handle different depth increments in the model validation analyses.</p>	Footnote 4 has been moved to the main text in Section 5.2.3, Requirement 1, 6th bullet, related to datasets for validating SOC stock changes. Both options are permissible, and the text has been clarified to communicate this point.
64	CIBO Technologies	Section 5.2.4, Page 24	SOC content measurement PMU is not trivially converted to practice change PMU (Differential change in SOC stock). Because SOC stock is calculated from the product of SOC content and bulk density measurements, the propagation of uncertainty to SOC stock should incorporate both the uncertainties and the values of each	Text has been included to specify that measurement error of bulk density approaches should be considered in cases where substitute values for PMU must be used.

## Section 5: Procedures

#	Organization	Reference	Comment	Developer's Response
			<p>measurement.</p> <p>Proposed Change: PMU should include both uncertainty in SOC percent and uncertainty in bulk density measurements.</p>	
65	CIBO Technologies	Section 5.2.4, Page 24	<p>It is important to note that many long-term studies made initial SOC measurements using one SOC content measurement method, and later measurements with a different SOC content measurement. It is unclear how to categorize these studies.</p> <p>Proposed Change: Explain how to categorize studies that use more than one measurement technique.</p>	We have suggested that such studies be conservatively excluded from either group of studies corresponding to either measurement technique, as they cannot be reasonably expected to represent the impact of measurement of either approach on estimation of net practice impact.
66	Nutrient Management Institute	Section 5.2.4, Page 27	<p>Broaden journal scope.</p> <p>Proposed Change: You could also include the SOIL Journal from EGU in the journal list <a href="https://www.soil-journal.net/">https://www.soil-journal.net/</a> it is open source.</p>	Agreed. This journal has been included in the list.
67	CIBO Technologies	Figure 5.5, Page 31	<p>k should be k-1 (degrees of freedom).</p> <p>Proposed Change: Change k to k-1.</p>	The updated figure in V2.0 does specify degrees of freedom as (k-1). It seems confusion may have arisen given that, due to the tracked changes view, the old and new figures were both present in the document that went out for public comment.
68	CIBO Technologies	Figure 5.5, Page 31	<p>The new graph and old graph are overlapped.</p> <p>Proposed Change: It may be a formatting issue. Suggest double checking that page.</p>	This is because tracked changes are used in the document available for public comment so that reviewers can know what has been replaced. Only one figure will be in the final approved document.
69	CIBO Technologies	Section 5.3, Page 35	"If an entire CFG is not validated, substitutions may be made that entail specific replacements be	The first two sentences in Section 5.3 have been revised for further clarity.

## Section 5: Procedures

#	Organization	Reference	Comment	Developer's Response
			<p>made for the baseline and project simulations." -- This sentence is not well formed, and it is not clear what it's trying to say.</p> <p>Proposed Change: Revise sentence.</p>	
70	CIBO Technologies	Section 5.1, Page 10, and Section 5.2.3, Page 19	<p>"SOC stock changes in ... validation datasets NEED NOT be calculated on an ESM basis" is different from "SOC stock changes in validation datasets MUST NOT HAVE BEEN calculated on an ESM basis."</p> <p>Proposed Change: Clarify.</p>	This text has been adjusted to be 'need not' in both locations.
71	Terra Carbon, LLC	Section 5.1, Page 10, and Section 5.2.3, Page 19	<p>Proposed revisions in VMD0053 have added new language regarding soils collected using an equivalent soil mass approach. However, the language is not consistent.</p> <p>Page 10: "SOC stock changes in calibration and validation datasets need not be calculated on an equivalent soil mass (ESM) basis."</p> <p>Page 19: "SOC stock changes in validation datasets must not have been calculated on an equivalent soil mass (ESM) basis."</p> <p>These two phrases imply different things. "Must not" implies cannot, whereas "need not" implies that both papers that did and did not sample on an equivalent soil mass basis can still be used.</p> <p>Proposed Change: Consider replacing the language referencing equivalent soil mass approach on page 19 with "need not be" instead of "must not have been" to improve clarity and consistency.</p>	Agreed. The suggested edit has been implemented.

## Appendix 1

Appendix 1				
#	Organization	Reference	Comment	Developer's Response
72	Agoro Carbon Alliance	Page 42	<p>The MVR and the IEE assessment report will be made public as part of the project documentation in the Verra Registry.</p> <p>Proposed Change: Suggest removing this, as these documents might provide sensitive confidential information and represent know-how of project developer.</p>	<p>The Verified Carbon Standard allows proponents to petition to have certain documents related to project validation remain confidential if they maintain commercially sensitive or private information. Such case-by-case decisions are then left to the judgment of Verra staff and the VVB performing validation. The default expectation remains, however, that such items be available to the public to allow for transparent assessment of projects and the MRV methods they employ. An additional sentence has been added to highlight this option.</p>
73	Agoro Carbon Alliance	42	To clarify which experts can be selected, and how these experts will be approved by VERRA?	<p>On 12 August 202022, Verra published a clarifications document to VM0042 listing the minimum qualifications that IMEs must have. These will be adopted in Appendix 1 of VMD0053 v2.0. Please note that Verra will not approve such experts, but rather check that minimum qualifications are required and maintain a contact list that VVBs can reference in future to identify IMEs with whom they can contract.</p>

## General Feedback

General Feedback			
#	Organization	Comment	Developer's Response
74	CIBO Technologies	VMD0053 requires the use of published (and only published) data for assessment of model	The point of the commenter is the purpose of the periodic remeasurements and model true-up (see VM0042, section

General Feedback			
#	Organization	Comment	Developer's Response
		<p>bias and error. While this makes sense for the initial MVR, might it be possible to use soil sampled as part of this project to augment or replace such studies in the future? SOC values from the literature have associated error associated with them (sample design, scope of what is reported for practices, granularity of results reported) that are not specifically model error, but are nevertheless penalized against the model. Soil samples take from the project geography not only have the advantage of being geographically specific to the project (unlike published literature), but also can mitigate some of this internalized non-model error. It would be necessary to specify that the soil samples were not used for both model improvement/calibration and validation.</p> <p>Proposed Change: Consider the idea of whether PPs can use soil samples taken as part of the project for validation purposes in MVRs.</p>	8.6.1.3).
75	CIBO Technologies	<p>The spelling "modeling" appears 4 times and "modelling" appears 6 times in VMD0053. "Modeling" appears 8 times in VM0042 and "modelling" 5 times.</p> <p>Proposed Change: Pick one for consistency. Single L is preferred in the U.S.</p>	Thank you for highlighting this. The spelling 'modeling' will be used except in those locations where 'modelling' appears in a citation.
76	Nutrient Management Institute	<p>How to select the best model: There are details on how to opt for models with the lowest possible bias. One of the ways to do that is to do cross-validation on a series of</p>	Thank you for this suggestion. While this could be a useful method to employ for selecting a model, we would expect that proponents would employ this approach prior to choosing a model to validate using VMD0053. Similar

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		ML models (e.g. you run Random Forests, linear regressions and Partial Least Squares). Then you can opt for the model with the bias. That way, you know you have the best possible results with the data and circumstances that you have. This is increasingly common in environmental and earth sciences.	cross-validation procedures are a viable option for model calibration under VMD0053, however.
77	Nutrient Management Institute	Bias: it is explained that there is penalty in the carbon credits from studies with a high bias. It would be good to add some details, if they are available. But I can imagine that this will be developed at a later stage.	Details on how model prediction error and bias as determined through VMD0053 are used to calculate the uncertainty deduction for credits are provided in VM0042.
78	Nutrient Management Institute	The protocol is highly focussed on methods being part of Quantification Approach 1. When proximate sensors come in as being part of Quantification Approach 2, the calibration and validation of the underlying multivariate, machine learning or deep learning models party follow all the guidelines given in this protocol. However, there also relevant differences (avoidance spatial-temporal correlation, data leakage in normalization and standardization procedures, overfitting, and so on). It might be valuable to extend the protocol with sections focussing on these more empirical, statistical models.	Thank you for this suggestion. While we agree that some of the same methods and considerations outlined in VMD0053 would be applicable to the validation of models used with proximal sensing or other similar methods, there are no plans to expand VMD0053 to include such guidance at the moment. Instead, such guidance will be provided in Appendix 4 of VM0042 and a forthcoming, separate VCS tool on soil sampling and analysis for carbon.
79	Persistence Data Mining, Inc.	Spectroscopy should be better defined included required measurement parameters to reduce error, For example 400-2500 nm and depth of sample for baselining. For example, can we use surface or is subsurface	Neither the section nor page number referenced exist in 42 or 53. VM0042 now includes an appendix detailing allowable proximal sensing methods, which includes more specific definitions for types of spectroscopies that could be used. Also, these methods should be used as a

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		required and should this be measured at 6 inch? 12 inch? 18 inch depth?	substitute for other laboratory analytical methods, meaning they should be used on the same depth increments would otherwise be used with more conventional methods.