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Scientific Assessment - Design for Monte Carlo and Propagation of Error Uncertainty in the Full Lands Integration Tool

The reporting of uncertainty is a requirement across a range of land sector greenhouse gas accounting frameworks, from national-level greenhouse gas (GHG) inventories prepared under the UNFCCC, down to individual project-level accounting at the local scale. Although the Intergovernmental Panel on Climate Change '2006 Guidelines on Uncertainties' is often cited as the primary source of guidance on the calculation of uncertainty, specific details on methods and algorithms for all but the most straightforward of calculations are generally lacking, simply due to the vast variety of methods, models and data that can be employed to produce GHG accounts. For more complex calculations the Monte-Carlo methods is recommended, whereby numerical resampling is used to generate the required uncertainty estimates.

Because of the variety of approaches that can be used to calculate GHG inventories, generic tools for undertaking uncertainty analyses are generally lacking. In their document 'Design for Monte Carlo and Propagation of Error Uncertainty in the Full Lands Integration Tool' Moja Global have provided a blueprint for how such a generic approach to uncertainty analysis could be implemented within the Full Lands Integration Tool (FLINT).

The proposed approach is to provide the capability within FLINT to undertake analyses for propagating uncertainty through (a) simple activity area x emissions factor calculations (where e.g. C = B x A, and where the uncertainty of A and B is known), and also (b) the capability to undertake uncertainty analyses for more complex modelling, where e.g. uncertainty in input parameters and data is propagated through potentially complex models, to provide uncertainty estimates for selected key model outputs. Under (a) analytical methods are used to propagate the uncertainty, where the required calculations are mathematically straightforward and involve identifying and quantifying (as standard deviations or variances) the primary sources of uncertainty. Under (b), where the required analytical approximations are often either numerically unattainable, or unwieldy, then the Monte-Carlo approach is proposed. Both of these approaches are consistent with existing IPCC guidelines, and are also consistent with the requirements as specified within the various accounting frameworks reviewed in the first section of the document and summarised in Table 3.

The proposed approach is rigorous and scientifically sound, and provides the essential first steps in implementing a general solution to the calculation of uncertainty within FLINT. Key aspects include the ability to specify a range of probability density functions to describe the uncertainty of model input data and parameters, and their correlations; and a simple random sub-sampling approach to facilitate the analysis of very large datasets, where the inclusion of all possible spatial locations in the analysis would be otherwise computationally prohibitive. Future extensions beyond the initial implementation specification are also discussed, such are more advanced probability-based sub-sampling methods, and auto-convergence criteria for determining the stability of the Monte-Carlo results.

Extending the current FLINT capabilities to include uncertainty analysis will greatly increase the utility of the software for many users, in addition to standardising and streamlining the quantification and reporting of uncertainty estimates for GHG inventories.

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