3rd Expert workshop on lessons learned from Accuracy Assessments in the context of REDD+: Uncertainties of emission factors and biomass maps

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Minutes

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Organized by:

Basque Centre for Climate Change (BC3)
Global Forest Observation Initiative (GFOI)
Global Observations of Forest and Land Dynamics (GOFC-GOLD)

Contents

Introductions and background

Apologies: NICFI, Brazil, UNFCCC, WRI, FFPRI Japan, Georg-August-University Göttingen, University of Hawai‘i at Mānoa.

Welcome from our host (BC3): Maria Sanz
- Workshop information also available on BC3 website.

Introduction to GFOI, background and objectives: Martin Herold (PRESENTATION)
For more information on the background and objectives, and attendees see the background document.

Introduction to MGD update procedures: Carly Green
The aim is that the work from this meeting may contribute towards efforts to update the MGD, or may provide additional materials (as separate documents / modules / annexes to the MGD). Updates to the MGD are ultimately guided by the advisory group of the MGD who have requested that this group take into consideration the points listed in the boxed text below.

Overall a ‘user needs’ approach be the focus of any guidance produced on this topic and the form it takes.

MGD updates will commence after the finalization of the IPCC refinement 2019 to ensure coherence.

Discussion on objectives: All
There is an impression that the MGD guidance on Activity Data uncertainty is more comprehensive than that of EF uncertainty. There is a sense of urgency as countries are now very close to implementation of REDD+ which requires the quantification of uncertainty of emissions and removals. The MGD guidance on emission factor uncertainty and methods for integrating activity data and emission factor uncertainty across the time series could be strengthened from the wealth of country experiences. We can learn from these experiences and use to guide our discussions. Countries are coming back to donors with questions such as those outlined in the FCPF guidelines. This results in a parallel process where the countries and donors are learning, so presents an opportunity to work together to develop country needs driven guidance.

Summary of outputs from 2nd Expert workshop on lessons learned from Accuracy Assessments in the context of REDD+ which focussed on Activity Data, in Oslo, Norway, 26-28 June, 2017

Document “Summary of Country experiences and critical issues related to estimation of activity data” Carly Green (PRESENTATION)
- Purpose of the FAQ document: To clarify MGD guidance in terms of real world experiences related to estimating activity data uncertainty from remote sensing data sources, providing practical responses illustrated with examples and links to existing MGD guidance.
- Provides solutions/options to identified critical issues related to generating activity data uncertainty estimates
- Intend to publish as a document through the GFOI and REDDcompass
- This (along with any materials we produce from this meeting) should be considered for incorporation into MGD3; however that may look.

Next steps / timetable: Aim to finalize this document by the GFOI plenary on 12 March 2018.

Topic of “Reference data error”: Ronald McRoberts
- **The effects of interpreter error on activity area estimates (**PRESENTATION)
- The assumption is that the validation data is of greater quality than the map data, and is without error. But the latter part is not necessarily the case.

- What are the effects of interpreter error: They conducted a study using professionally trained interpreters, and found some key results in the stratified estimation approach.
- The assessment was done with 1,3,5 and 7 interpreters, and there is a correlation among interpreter error. They used Monte Carlo.
- In the paper (to be submitted), they propose some solutions
- Key findings
    - The interpreter was found to introduce bias into the estimate of the area, and bias into the standard error
    - The more interpreters you have, the less the bias is (the more the difference between the size of the forest and non-forest classes, the more interpreters are needed, but having for example 7 interpreters for each point is likely not feasible)
    - If you take into account the uncertainty of the interpreter error, this affects the prediction uncertainty
- Can we just assume that since the end results don't change that much, that we don't need to account for it?
    - No, because we don't know that the strata all have the same uncertainties – if this changes, then this would affect the results.
- Which way does the bias go?
    - If the forest stratum is less than 0.5 you underestimate the amount, but if it is more than 0.5, you overestimate
- Is there a way of increasing interpreter quality?
    - In this study, they assumed that they were well qualified. But they could be better trained.
    - One option would be to take a proportion (based on a number of reviewers)
- In the case of deforestation, the proportion of deforestation is very low, and the accuracy is very low:
    - So we would probably overestimate the deforestation.
    - In Colombia they use an odd number of interpreters, and they focus on areas which have conflict of opinion from interpreters to increase accuracies
- How different is this example to verification in the field?
    - The principle is the same. Even in the field it is sometimes difficult to determine if it is forest or not.
    - Giles Foodey – has a useful paper on imperfect ground data.
- How can countries include the bias of ground data into their data?
    - Here the assumption is that going into the field gives 'true data'. Uncertainties can be calculated as we propose for visual interpretation of images.
    - Erik – there are data from countries on the variability of the reference data: Guyana (or Ghana?)
- <u>Next steps / timetable: No actions – this information will be made available through the upcoming paper.</u>

Technical module on statistical inference: Pontus Olofsson
This is now included in the document which Carly presented.
- This summarized country experiences – based on real data from these countries.
- The key question was how can we decrease the CI for activity data. This was a specific case where there are strata of different sizes, so some sample units carry large area weights.
- <u>Next steps / timetable: No actions</u>

IPCC updates: Martin Herold **(**PRESENTATION**)**
- Specific sections are to be updated, not the whole document.
- Default tables for biomass densities: there are some issues with traceability of the values.
- Some information related to space data is now out of date in particular.
- The MGD component will already try to anticipate what changes will need to be made based on the first information available on the IPCC refinements.

- One of the aims of the refinement was do understand the potential to use biomass density maps in the frame of GHG inventories.
- MGD is more technical than IPCC, and there is to some extent some work in parallel, and they have different audiences. MGD can also be exploratory, whereas IPCC should be fixed. But they should be complimentary. The GFOI guidance is especially important because it is continuously refined, whereas the IPCC guidance is only updated once every 10-12 years or so.

IPCC updates: Maria Sanz Sanchez **(**PRESENTATION**)**

- Current new guidance:
    - Default emissions factors should be accompanied by default uncertainty values
    - Default uncertainty values should be accompanied by explanations on how these were calculated
- There should be a minimum criteria which is used to decide if the data are used or not. Not all data have standard deviations, and have not been collected in a systematic way, but it remains useful data. A consistent approach across all the tables is required. But how do we incorporate maps, which may have larger uncertainties than defaults? Here the temptation would be to use Tier 1, which you should not if you have Tier 2.
    - This is where the MGD can contribute – providing guidance on how to make these decisions and how to use the data.
- IPCC guidance on tier 3 is very general and information will not be provided in the IPCC GPG update.
    - This is also where MGD can contribute.

Priorities for MGD guidance: Carly Green **(**PRESENTATION**)**

- There is a formal process to get input from MGD advisory group on proposed GFOI activities
- REDDcompass had 6000 unique users over the past 2 years, and 3000 are repeat users.
- Guidance in MGD should be user needs focussed. It should be ready for countries to apply to their situation directly.
- Checklists, decision trees, tables and examples have been particularly useful for countries.
- CALM framework – tool to separate operational methods (levels 7 to 9) from those which are still at the research stage (level 6 and below), which are pre-operational.
- One request is for more guidance on Monte Carlo (also relevant to bootstrapping, and simulations).
- Guidance on probability density functions is also requested, for example how to select which option is most appropriate – for example normal distribution etc.
- **Action: Consider the development of guidance material from a user's needs perspective that addresses the suggestions from the MGD Advisory Group** . Something like the FAQ document which was prepared after the Norway meeting.
    - Outputs from the meeting in Oslo two years ago could be a starting point.

An overview of 'quantitative' methods to conduct uncertainty analysis

Suggestions from the MGD advisory group

- Guidance on how to assess the source and level of uncertainties (including variability) in biomass/C stock estimates and emission factors, and how to conduct uncertainty analysis
- Examples of quantification of uncertainty (and variability) in EFs, and quantification of uncertainty in emission estimates (combined with AD) for practical uses (including country examples of what is practical and useful).
- Provide guidance on how to minimize uncertainties (by type of factors) and on how to design collection of data to reduce uncertainties.

- Clarify when and how to apply uncertainty at the individual factor level (standard deviation) and when and how to apply uncertainties in the mean (standard error);

- Uncertainty across the time series

    - Provide guidance on how to apply time series EFs and consider their uncertainty

    - Consider correlation of uncertainties across time series (i.e. when quantifying mitigation results)

- Guidance on how both EF and AD data will be brought together to generate estimates in the context of Tier 2 and 3 methodologies (country examples could be useful)

- Discuss PDFs (possibly identifying the most common types for each factor) and how to transform to normal distribution (or otherwise apply Monte Carlo).

- In specific consideration of Monte Carlo:
    - Clarify that it must always be supplemented by the IPCC default analysis;
    - Discuss;
        - correlation of uncertainties
        - variance reduction strategies
        - sampling methods;
        - sensitivity analysis;
        - uncertainty of time series

- Discuss the issue of uncertainty and sensitivity in the context of continuous improvement

Concepts / Potential Boxed text:

- How to choose an allometry…
    - Do you create your own or use a global one?
    - Do you use one with height when it is known that the measurement of height has highly uncertain.
    - How to apply wood density if it is not available at the individual tree level

- Clarify the difference between bias (systematic error) and uncertainties (random errors)

- Provide guidance on how to evaluate and address any bias (by type of factors);

- Consider all sources of uncertainty (for each defined "factor"):
    - Statistical sampling error (sample short in size, compared to the population variance)
    - Lack of representativeness
    - Model errors (incompleteness, interpolation/extrapolation ect)
    - Measurement errors

Presentations from Donors

FAO: Assessing the quality of NFI data: Luca Birigazzi **(**PRESENTATION**)**

- What information is needed to understand if an estimate is good or not? Since we don't know all elements in the population, we need a proxy.
- Most countries use NFI data, but not model based inference.
- For the Green Climate Fund, they use a scorecard, but some of the criteria are a bit vague.
- A checklist is proposed to understand whether data are good or not. A checklist means that it is easier for the countries who are reporting and also for the reviewers
- The checklist is not only valid for NFI but also for activity data.
- Problem of no-response in samples (for those which are not accessible) – how to deal with this.
- Reporting with model based inference vs design-based inference.
- Checklist is useful however – there is not much time for the reviewers to go into details.
- The countries are encouraged to publish in scientific journals.
- It is possible that countries with bigger uncertainties have done better to really investigate all the sources of errors.
- Even when this is not a proper requirement, countries benefit from a more thorough review, this can encourage them to do more even when it is not a formal requirement. This is more guidance /recommendations.
- Reviews are in the context of continuous improvement. There is however delicate, as countries are criticized, and things become difficult. But this needs to be robust as the peer-review process is for scientific papers.
- Providing examples of good practice (from countries who have already made progress on a topic) would be an alternative for a scorecard.
- Question Martin: are any countries using biomass maps – no. Only Brazil has tried for their FREL. Model based estimation, based on maps.
- Question Allessandro: How do countries adjust for the dates of the forest inventory. For the NFI, they are all recent, so they have done the measurements in the last 2-3 years.

SilvaCarbon: Pontus Olofsson **(**PRESENTATION**)**

- SilvaCarbon is helping countries to set up NFIs.
- One example is Colombia, which has ground plots from various projects which provide valuable data, but which are not part of a probability sample, so:
    - more guidance is needed on how to incorporate existing data (which are not systematically selected / randomly located) into the NFI / reporting.
- Their deforestation rates are relatively low, which means they have a very large stable forest stratum, and this is holding back payments. Ironically, there is not enough deforestation. There have been some payments though.
- Now a new design of the NFI has been proposed with more plots.
- The P value question – should this be altered? (see Nature discussion)

WB FCPF: Andres Espejo **(**PRESENTATION**)**

- The FCPF have some guidance on uncertainty analysis that they are developing in house.
    - Action: ensure that this material is utilized where it can be a useful input into our work on this topic.
- Roughly more than 1 bn USD is ready for disbursement in the Carbon Fund.
- There are a number of countries who are in the fund, and who need to get their RL and MRV systems in line with the Carbon fund Methodological Framework and the BioCarbon Fund.
- Question, how do you get an emissions factor from a biomass map? There are several issues related to using biomass maps which we can address.
    - How to estimate biomass density from a subset or strata of a biomass map
    - How to estimate the uncertainty for each strata
    - Stratification of AD vs stratification of EF: comparing apples with apples, ground reference classification or EO classification.
    - Uncertainty analysis. This is not seen as a process but as a product.
    - Sources of uncertainty. 40% of ER programs only discuss sampling error.

    - Systematic errors vs random error. Systematic errors should be eliminated so are not always discussed.
    - Error propagation –difficulties in the application for Tier 2. So need for practical guidance and tools. How to define the pdfs (which are needed for Monte Carlo), when we don't have good data to define these pdfs.
    - Why Monte Carlo? Because it is more likely to be correct or produce larger confidence intervals if done incorrectly.
- In the FAQ there is a box on model based inference, but this should be checked against other definitions, and make sure that it is clear as there is some confusion. It might also be best to include a definition of what this is not.

Presentations from Countries

Indonesia: Haruni Krisnawati **(**PRESENTATION**)**

- Indonesian Forest Reference Emission Level: forest degradation, and deforestation, and also peat decomposition
- Forest inventory, plus allometric equation, wood density, species name index gives AGB and C stock. This process is a source of uncertainty. The NFI itself is also a source. Other sources are sampling errors, related to plot layout and size and model error.
- NFI includes systematic sample of plots every 20km conversion of lines of latitude and longitude.
- Reducing uncertainty – they stratify the forest based on 3 forest types (dry, swamp and mangrove), then based on forest condition (primary, secondary). For the mangrove EF, there were not enough systematic samples, so they derived it from research plots.
- Choosing the correct allometric equations is one way to reduce uncertainty – they compared Chave et al. (2005) with Krisnawati et al. (2012), and the decision was made to use the generalized equations in order to reduce uncertainty.
- Post deforestation C stocks are assumed to be 0.
- Degradation, is difference between primary and secondary forest.
- Plan for improvements: new FI plots, allometric equations, include other c pools and integrate modelling.
    - There is a very impressive dataset collected in Indonesia by a Solichin for a PhD (2017), and can help to update this information.

Mexico: Oswaldo Carrillo **(**PRESENTATION**)**

- Activity data
    - For the accuracy assessment of the area data, they follow the GPG.
    - The change in the Preliminary estimation of "forest land – other uses" map has a big change due to a methodological change
    - Estimates are very similar to GFW data.
    - One challenge is people to do the accuracy assessments of the reference points – due to different vegetation types this required a number of different experts. A class appeared in the reference data that was not in the map – this was one difficulty.
- Emissions factors
    - Using systematic clustered samples.
    - Information from c pools according to the national forest inventory.
    - Stock change based estimates: They don't use permanent plots, and had some problems with mis-classification in plots, so now for the future they may change approaches.
    - Using mixed linear models, they identified the variability associated with a number of different error sources.
    - For the uncertainty associated with the allometric equations, they use the approach of Magnussen & Carillo 2015.

- What is needed; GPG of how to build allometric and volume models. Also statistical criteria to select models. A sensitivity analysis related to allometric equations is being developed by Craig Wayson and Oswaldo.
- Monte Carlo simulation: only propagated related to activity data and sampling error, but ultimately they would like to propagate the complete uncertainty using this method. There are several challenges in terms of implementing Monte Carlo.
- Suggestion: including examples, scripts, and real world examples – this is not something for the GPG which is a very static document.
- Several challenges and suggestions are detailed in the presentation.

Presentations from experts

The Gain-Loss vs Stock-Change method: Ronald McRoberts **(**PRESENTATION**)**

- They looked at 3 classes, Deforested, Degraded, Undisturbed, and for the AD and EF had estimates and SEs.
- They compared three methods stock change (stratified and model assisted), gain loss
- SEs were 0.33 approx. of the emissions, partly because they had small samples
- In summary, choice of method has statistical implications.
- There is a box in IPCC on this topic – a question is whether the uncertainties of AD and EF are correlated. This would mean that the information from IPCC in this case is not conservative.

Discussion on the presentation:

- In some cases EFs are fixed over a monitoring period, and countries use gain-loss for the reference period, and stock-change in the monitoring period.
- If you don't have stocks information (i.e. NFI) at two points, then you can't calculate stock-change and you have to use gain-loss.
- In the IPCC degradation is not mentioned, so you don't need a definition of degradation, you just need to calculate a change in the stocks over time. The importance is that this is the forest-remaining forest.
- The definition of stock-change and gain-loss. The library example is an easy to grasp definition (see: GOFC-GOLD Module 2.3 video for an explanation at chapter 3 of the video). There should be some alignment of terminology in the MGD and in the IPCC documents.
- The gain loss is designed more for plantation forests. Countries may choose to use this for plantation, but stock change for other forests.

Some issues regarding biomass estimation with use of auxiliary data (e.g. maps): Erik Naesset **(**PRESENTATION**)**

- About biomass maps, they get satellite data, use a model with the aim of producing an estimate of biomass for the entire area of the map, using either model based inference or design based inference
- In design based, if you change the sample, the estimate changes.
- You can also take a model based approach which uses information from the map, and this gives more precision for small samples
- If you have a large sample, both model-based and design-based estimates will give similar answers.
- Analytical estimators – for both types of inference – we need to see whether there is an estimator that can help – the advice here is to collaborate with statisticians who can help here.

Uncertainty assessments for biomass maps: Ronald McRoberts **(**PRESENTATION**)**

- A map in itself is not enough information to estimate biomass with uncertainties – you need map metadata.

- The metadata should mean that a map user can focus in on any one piece of a biomass map and can calculate biomass based on this.
- Ground data – for example on a 1 km map – impossible to get, and also having plots which match the pixels exactly is unlikely.
- Sample variability: in model based inference, the covariance is the part which accounts for the variability which is introduced when a different sample would have been taken.
- The hybrid inferential approach (accounts both for sampling based variability and prediction uncertainty in reference data) – if you have a finer resolution (i.e. local map which you hope is of better accuracy), then this can be combined with the other map
- The principle is then that you compare the estimate from both maps, with a variance which is related to the fact that the resolution of the maps is not the same. You also have to allow for the fact that the smaller map is not truth.
- As (assumed) spatial correlation gets bigger, then the standard error gets bigger.
- This is not conceptually different from using photo-interpreters to assess activity data.
- There is a situation where the fine resolution map is less accurate, then it is not going to be useful.
- If you have control over where you are planning to fly the LiDAR then this is the best case scenario as provides good ancilliary data – although this is not always done on a probability sample.
- If the reference data are not wall to wall – have to be probability sample in order to calculate uncertainty.
- Different samples are used for different purposes:
    - to construct the course resolution map – does not have to be a probability sample
    - to construct the fine resolution map – does not have to be a probability sample
    - to estimate uncertainty – this has to be a probably sample. If you have plot data, then it is not possible.

Emissions factors in Nepal: Naikoa AguilarAmuchastegui **(**PRESENTATION**)**

- Recently they presented the national reference level to the UNFCCC
- Allometric equations – there are some from Nepal specifically – it remains a question as to whether these are better than those by Chave.
- NFI compares two forest maps, 2000 and 2010. When looking to 2014, it becomes clear that there are some discrepancies with the data.
- The aim is to use LiDAR data for the EFs – not collected on a probability sample.
- 12 m radius plots were used to calibrate data, but this is a small plot size, which means errors can be introduced if one tree is counted in or out the plot, or one which the canopy is in, but the rest not.
- The use the WISDOM model to measure degradation, using ancillary data like population, and fuelwood collection
- They incorporate estimates of length of recover, and average age of gains, but these are just estimates
- Within the area of interest, there are NFI plots and LiDAR data. LiDAR data are randomized. A group of consultants used the LiDAR data to create a biomass estimate – they had plots within these areas which were used to calibrate the map. The map was stratified based on forest type, and based on this the map was calibrated based on EFs. There is cross-validation done with the field plots, but there is likely to be autocorrelation, so is the model good, or is there over fitting etc. for example? The size of the plots (LiDAR and field plots) is not the same, so how does this effect the uncertainty of the output?
    - Pseudo plots were used to get the mean biomass per strata (but these are not very well / evenly distributed). Results for degraded and intact forest biomass are not so different using this approach
    - Stratifying based on landscape ecology may help. Based on this they can identify areas which are likely to become degraded/ fragmented – they are testing this approach based on the LiDAR data, and they find that the biomass does differ

between the strata. A change from one type of forest to another will lead to a different change in emissions.

Annual measurements of Gain and Loss in Aboveground Carbon Density: Alessandro Baccini (PRESENTATION)

- Biomass loss does not happen in the average biomass areas – so this should be a key consideration of users.
- What is the use of the pantropical dataset
    - As a layer for a better stratification of a sub-regional estimation of emissions factors (with the assumption that you can get better reference data within your area of interest)
    - To give a general indication of biomass within strata – and the information on the uncertainty can be provided
    - Some simulation for optimal plot size and distance between sub plots for NFI (you can run a variogram to get some idea of spatial autocorrelation)
- A* EF – you can assume that the C density goes to zero if you use representative biomass areas, instead of doing a stock change approach.
- Sources of error – one of the worst thing you can do is to pick the wrong allometric equation. Even if you incorporate the error related to that equation.
- Map errors at the pixel level can be for example +-43%. But when you go from 30 m to 1 ha, then you need to take into account the spatial autocorrelation, and need to run a semi-variogram analysis, and the errors tend to decrease. At the 30 km level, the errors reduce a lot.
- Depending on the landscape, the errors vary. The GLAS data have a large error on the estimate of height, so on vegetation which is low, there is a very large error.
- They mapped the contribution of each source, and found that from the errors related to: Allometry, GLAS, and MODIS, the GLAS were the most uncertain. So if you can use LiDAR instead, then this could really reduce the error.
    - This is a function of the sensor itself – the footprint is large (75m) so it is highly affected by slope. Also by definition, the sensor has an error in height (as explained). So GEDI on paper is supposed to be better, since it has a smaller footprint and it is designed for this purpose.
- The new Baccini data is now exactly spatially geo-located with the Hansen data, so that the two can be put together if desired.
- At the pixel scale, the 30m had a lower uncertainty than the larger resolution dataset
- Baccini 2017 – for each change pixel, they have a standard error which can be used to aggregate to the national level, and to report on gains and losses. But only net changes can be reported, because both can occur in a MODIS pixel.
- The net gain has a smaller uncertainty than the net and net loss, because gain often happens in homogenous forest, so there are fewer sources of uncertainty

Uncertainties in carbon stock estimates: ground-based considerations: Jerome Chave (PRESENTATION)

- Their dataset is freely available online (http://chave.ups-tlse.fr/pantropical_allometry.htm)
- Uncertainty assessment, and bias is calculated – and the sites which had the oldest data were typically found to be more biased.
- Wood density is a knowledge gap, but they are working on a database to improve this
- There is an r-package which helps people to calculate biomass and it propagates uncertainties (for data at the tree or stand level) – the question of how this relates at the national level still stands. The package uses Bayesian inference.
- TLS is now doing a good job of measuring volume, which is related to biomass.
- What is the impact of wood density errors? Possible to propagate errors from wood density maps.
- How does this relate to globalometry project?
- Our message is that trying to develop local allometries may be difficult and time consuming, and that there are already equations out there which could be useful.

- Action: Jerome happy to write some guidance on this, since scientific papers are not necessarily the best way of conveying guidance. There could be a working group on allometry, wood density etc.

The use of forest plot data for biomass map validation: challenges and opportunities: Danaë Rozendaal

- Presentation not available (in publication process - Santoro et al. in prep)
- Using forest plot data worldwide to validate a global biomass map
- They combine maps using a machine learning approach.
- Comparison with national statistics were good.
- In Europe biomass is underestimated in the map at the high biomass plots. This could be because radar data is not expected to capture these high data, and also on average plots are bigger in the tropics (where it is not so much the case).
    - This saturation seems to happen at around 200t biomass/ha
    - In MODIS because of the big pixels, the values of biomass do not reach the highest levels
- Lessons learned – comparing one pixel with one plot – shows a mismatch, but establishing larger plots, or aggregating plots is a solution.

Rapid Biomass Assessment for Dry Forest Monitoring: Christophe Sannier **(**PRESENTATION**)**

Discussion

Why countries don't use biomass maps at the moment:

- The methods are not transparent
- You cannot allocate carbon credits to particular biomass pixels – so the link with activities on the ground is difficult to make
- Ownership of maps

Discussion on the previous workshop in Oslo

On the outputs from the previous workshop in Oslo: **Action:** Carly will send around the FAQ on the accuracy assessment of AD to Jerome for inputs.
One option was to move the information on model based inference from the FAQ document to a stand-alone document but this was not decided upon.

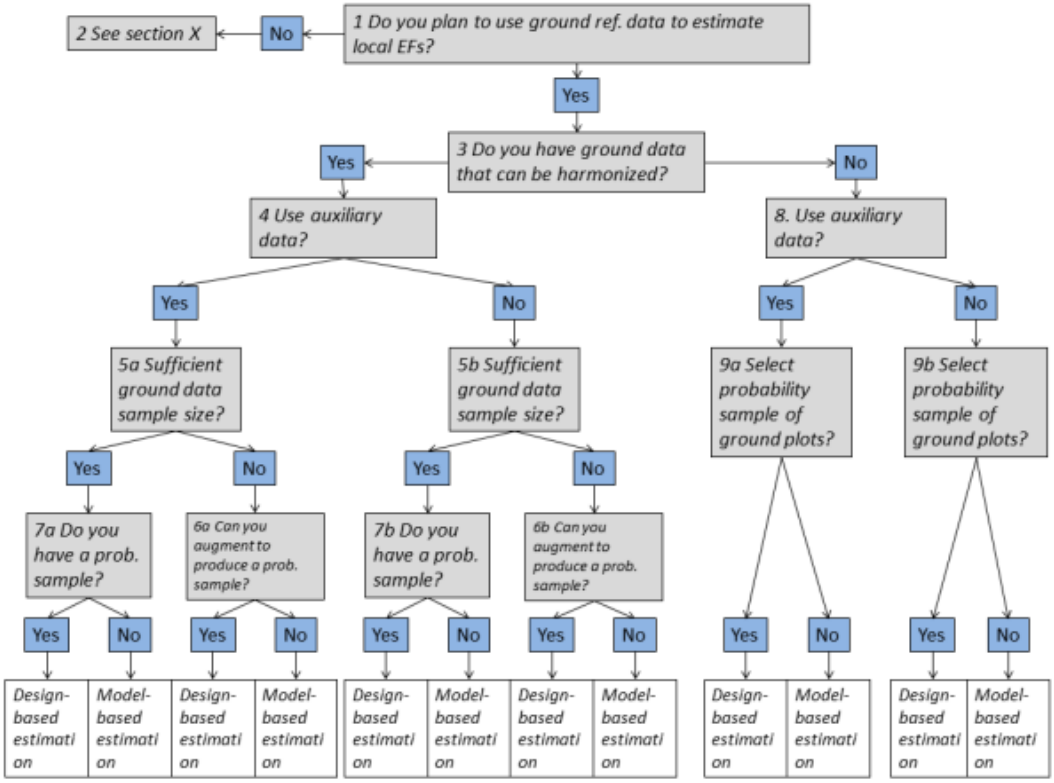
The needs for new guidance

- A document is required which contains concepts which are useful for inventory compilers. We can write up a draft that the IPCC could review
- We want an EF module – country examples are key, but also general guidance is needed so people really understand what to do.
- Sources of info to derive EFs – maps, NFI plots – there is no guidance specifically on this in the IPCC.
- We are anticipating the need for new guidance on how to use biomass maps
- We need to cover simple questions:
    - combining different data types, for example, plots, biomass maps, LiDAR data etc..
    - There are also simple questions, shall I use a biomass map for everything? Or if not when should I use it?
    - We need to point out the weaknesses of different approaches
    - There are nuances of calculating uncertainty from different approaches

- In reporting, some countries just update AD, and use the same EF.
- To what degree are EFs expected to be static – for example in Tier 2, since otherwise you use a growth model. In the stock change, people use static factors.
- There should be generic guidance on choices.
- How to do Monte Carlo, how QA QC procedures done? Examples, SOVs etc. need to be produced
- On Allometry – choice of equations. Could be interesting to know which countries use Chave, if not why not? Maybe FAO could look at this?
-

Existing work which is useful:

http://www.gofcgold.wur.nl/documents/Sciencemeeting2016/ScienceMeeting-SummaryReport.pdf



Missing elements: Allometric models, biomass maps, NFI plots...

What the MGD already contains:

- Definition of EF– based on IPCC.
- Units of EFs: Emission per unit over time (i.e. t CO_2 ha^{-1} yr^{-1})
- Information on allometric equations – Appendix F, and also in Ch 5 (5.2.11) of MGD. But there is not really anything on uncertainties – this is the gap.
- Basic information on how to calculate EFs from both the stock change and gain loss methods
- General information about integration approaches to generate time series consistent emissions and removal estimates from activity and emissions factors; this could be strengthened to include total uncertainty.

Actions

Country examples (Group 1): Pontus, Oswaldo, Haruni, Naikoa, Inge, others

- Aim to develop case studies of countries which have are good examples of how to develop EFs with uncertainties.
- Could include scenarios where they can use a global map + local airborne lidar available at certain places
- Key countries: Colombia, Mexico, Nepal, Indonesia (Example for Mexico is below)
    - Since both Colombia and Indonesia use an NFI, there should have one example of a country that does not use an NFI
    - Might be good to include a country with different issues, perhaps one that does not take a systematic approach
        - Andres can provide suggestions and can contact WB countries
        - Sylvia has good insights on this and can recommend countries.
        - Maria can give a list of countries and with a brief description of the type of approach that they are using.
    - Other country examples which use different approaches are Guatemala, who may use LiDAR data, Peru, who use carbon plots. They will include as many as possible.
- There is a need to create a template for the country examples
- It will state what is happening in the country now, not necessarily what has to be done
- Countries need to endorse this.
- Timeline: get this done end May at least a first version – there may be some more examples on the way – Pontus to lead this.

Mexico (Oswaldo Carrillo, CONAFOR)

Workflow
NFI – database SQL – query database by tree species to: clean the names of species; identify outliers (height, DBH, etc.) – search literature and select allometric equations for species according to species, genus, vegetation type, DBH range, sample size and geographic locations in a decision tree (600 equations) – also done to decide wood density (13,000 wood densities) -- wood density known for each tree -- allometric equation applied to each tree – convert biomass to carbon according to IPCC guidelines – apply a ratio estimator to estimate the carbon content per strata based on subplots and a stratification based on the land cover by INEGI (24 classes)

Perceived issues
* Reduce the scale of the EFs – provide estimates at the state scale because MRV applied at the state level -- allometric equations are not representative for certain regions
* Issue related to the identification of plots incorrectly labelled -- 15% of the plots are incorrectly labelled (e.g. plots located in coniferous forest when it's in tropical) -- want to use the INEGI map to identify which plots are incorrect but the map is incorrect -- outliers identified at the tree level and not at the plot level
* Issues related to quantify uncertainty introduced by measurement error -- estimated at 10-15% using complex procedure -- linear mix models to identify different sources of errors

Biomass maps (Group 2): Ron, Alessandro, Martin, Erik, others **(**PRESENTATION**)**

- We should provide recommendations to map makers of the information which is required (they should include information on co-variances, and correlations of errors etc.)
- The outputs will provide guidance to map makers on how to better produce useful maps – feedback to the map producing community and space data community is very important – Martin and Maria can discuss this
- One question is how to get EF from one biomass map, which is potentially in contradiction with the definition of EFs, but nevertheless it is important and we should cover it

    - The question we are therefore answering is: how (or if) one can use a biomass map to generate (or support the generation of) emissions and removals estimates with uncertainties?
        - Difficulties include the incorporation of the spatial and temporal elements, particularly when using one map only.
- There are some examples of approaches which we don't know how to do – where there are no examples in literature that we can follow. For example model based inference on two maps or on a map time series, although we know how to perform this for one map.
- How to work with a map may depend on how the map is produced – for example if there is a base year map and it is updated using a model, then there are covariances we can derive from this.
- Countries want to know when is it useful to use biomass maps? i.e. better to produce NFI or a biomass map?
    - Could be answered by a decision tree, so you would then look at what is most cost effective
- Ron McRoberts – has a paper due in September on this topic anyway from which we would be able to extract some information (although the paper is more guidance for the map producers so not guidance for countries, but things can be done in parallel)

Notes from meeting day 2: group 2

- Stratification:
    - for design-based sample to estimate EFs using ground plots
    - More complex stratification and combine w map of activity data for sampling design to increase precision
- Model-assisted estimation of biomass density
- Substitute/augment available ground plots:
    - Stratify and estimate mean biomass per stratum, depends of type of forest that is missing plots (i.e. intact, swamp plots), if same type of forest then available plots can be used for comparison and expansion
    - Pseudo plots (augmenting real plots in the ground) for training data (usually requires some higher quality local biomass map/LIDAR)
    - Pseudo plots to increase sample size
    - Pseudo plots to create probabilistic sample
- Estimate EF (single-date biomass map)
    - Can use approaches mentioned above
    - Risk of potential bias (should be assessed and reduced)
    - Average for forest types / degradation intensities used by some countries, combine with activity data
    - Use for deforestation is possible, post-deforestation biomass to be considered
    - Establishment of new forests, removal factors from biomass maps for young forests
- Emissions (factor) from multi-date/change map of change
    - Reference data of change is an issue
    - Some derive change directly (reference data have to be on change), some produce multiple (independent) maps (does not require reference data at multiple points in time/change measurements, two different reference datasets)
    - Discussion of developing separate maps versus using time series to aim for more pixel consistency for change
    - Can be used for stratification for different degradation level, particular value for "large" category of degraded/non-intact forests that some countries currently have
- Biomass map has to provide metadata to estimate uncertainties, i.e. covariance matrix, need to work out for more complex retrieval approaches (i.e. ML):
    - More dialog with map producers to provide more information on it

Estimates of uncertainties of emissions factors (Group 3): Andres, Grant, Luca, Craig, Jerome, Sarah

General document on EFs – proposed structure

This is produced in parallel to the AD document, as there are naturally lots of overlap (and maybe later be merged with the AD module) Proposed contributors are listed.

- Identification of, quantification, and then reduction of main sources of error: (need to expand on info on p 156 of MGD)
- Introductory paragraph on integration of errors (AD x EF = GHGe) at the beginning of the EF document – Andres. This would refer to the AD FAQ (need to ensure consistency with other modules)
    - Misclassification – applying an EF which is not representative of the AD. So use the same classification approaches (consistency) for AD and EFs – provide some examples
- Representativeness error (related to bias) – small section? – Grant & Luca
- Measurement error – Oswaldo Mexico example (box on post-hoc meths), Andres & Grant
    - E.g. missing trees out of plot measurements (human error?) – can potentially be a sampling error...?
    - Sarndal et al – not trivial errors in some cases. Picard et al.
    - Diameter, height...
    - This can be minimized with good procedures. But QA QC has been very poor in some cases
- Model error – allometric models – Jerome & Craig (see box below)
- Sampling error (variability) – Grant & Luca (Peru example – with a non-probability sample for EFs) – could also use the data, and demonstrate the impact of having a different sample size on the error estimates using bootstrapping. (hybrid inference will be covered by the biomass map group?)
    - probability vs non-probability samples
    - representativeness (related to non-probability samples in particular)
    - uncertainty can be calculated for probability samples
    - for non-probability samples, you can't tell if you are biased – it is a gamble
    - case of probability sample, but new area of interest – can use model based inference, or hybrid which include the non-probability samples
    - model assisted (should be outcome from biomass map)
    - having a probability sample is not necessarily required for a hybrid approach, but for model it is needed. But either way it gives more confidence in the output.
    - What do we know how to do and what do we need more (new) info on?

- Aim for end of August for draft

Questions on allometric models to answer:

- What considerations are there for selecting allometric models?
- Do I have to develop an allometric model or should I use an existing one?
- What are the components of uncertainty to consider associated with my allometric model?
- How do you estimate uncertainties of these components allometric models
- How much does allometric model uncertainty contributes to their overall uncertainty

Guidance:

- Minimum level that you should reach to produce good allometric models. – the guidelines are to move from tier 1 to tier 2, but deciding with model to choose might not be this simple.
- How to choose which to use:
    - For big trees, there is a benefit of using Chave – mostly from the TLS data.
    - A number of models produced by countries are similar to Chave's

    - A key factor is number of trees. Larger number = better model. But this number has to be stratified by size classes (large trees should be included for example)
    - To be useful at the national level, should include trees from all ecosystems, and should not only be timber species for example
    - Rule of thumb >20 trees of >10cm dbh per class where classes a range of forest types / ecosystems – this must be met for all classes.
- When not to choose Chave?
    - Where we don't have clear tree height (i.e. all trees are very small, or your trees are on the edge of being defined as trees), or wood density estimates for each species
    - No diameter information is available
    - Do have diameter but don't have height... difficult – don't capture secondary forest variation
    - Topography – a reason why trees might not grow so consistently – would not use high diameter equations in Nepal for example
    - For conifers, non-tropical areas... should be tested
    - Where locally derived height diameter relationships are known
    - For small things like shrubs, it can make sense, and it is also not difficult to do
    - Fire prone area – so not typical
    - Mangrove forests / very dry forests / multi-stemmed trees
- Produce a decision tree on how to decide which one to choose (see below)
- Validation of equations:
    - This is not easy
    - Recommend regional validation
    - Small projects good for capacity building
- <u>Chave will review what is already in the MGD on allometry and will get back to us with recommendations</u>.

Decision tree

- Do you have height information for each tree ?
    - Yes: OK...
    - No: Do you have representative samples of tree heights so as to construct height – diameter allometry locally –
        - Yes: construct local allometry
        - No: use a generic model – options include Feldpausch et al 2012, Chave et al 2014, or any other local allometric height

Other discussions in the group:

- Need to move away from the instant oxidation approach (assumption that all biomass is lost following deforestation)
- Excel spreadsheets are not now an option for data storage/ analysis, so new options should be used
- How to define the pdfs, and basic concepts require more guidance in future
- Prioritizing which overall uncertainties to focus on – i.e. ecosystems which most deforestation

Other guidance needed on Monte Carlo:

- <u>This topic could be tackled by Ron, Grant and Pontus</u>
- Tools to implement Monte Carlo – first we indicate codes /packages which are available already (excel at risk/ r/ quest: http://www.esf.edu/quest/code.htm / Crystal Ball) – <u>An example with fake(example) data can be produced (Craig)</u>
- At a later stage, we may develop our own tools.
- Additional comment from Carly (who was not present for this discussion): include countries with experience here in the context of land sector greenhouse inventories - Australia – Rob

Waterworth, Canada – Werner Kurz, US – Steve Ogle, Mexico, Kenya. There is a lot of explanation of the methods applied in national inventory reports from these countries as well.

Next workshops

Aims:

- Based on the outputs from previous workshops (including this one), to evaluate what other guidance is needed, and aim to fill those gaps
- The agenda will be guided by the MGD advisory group, and also approved by the GFOI Leads group.
- Proposed agenda:
    - One day on finalizing outputs from this workshop
    - One day on the integration of uncertainties (from AD and EFs), although the methods are simple (Monte Carlo for example), guidance on how to deal with uncertainty when using tier 3is required. We might need to look into examples – if people are really struggling with it, how do they overcome these difficulties. Should aim for fully integrated tools – which are more specific than IPCC spreadsheets (which are for Tier 1 and are not suitable for REDD+) – could be tier 2 or tier 3. Also on identification of key uncertainties.
    - Some time on Monte Carlo approaches – more guidance is needed. Need to have something more of an open source tool to run these. Including country examples

Other participants– do we need to broaden the participants and reach other people?

- Might be beneficial to involve UMD. Some of the inputs from Andres came from UMD
- Including more authors is one option or alternatively invite them as reviewers (i.e. for MGD) – the MGD author network can be utilized
- Don't want to have too many people

Venue and timing

- Mid-June or early July.
- Could be around the Oslo REDD Exchange (formerly) (27&28 June).
- One option: Start Sunday 24th & 25&26 – and 27th half day. Support for organization could come from the Space Centre (Evie).
- Or Munich. Frank Martin could host.
- Or Frascatti in June – could be the week before Oslo REDD+ exchange.
- Or Rome (FAO) but then we need budget.
- Or Wageningen.
- Cannot be the third week of June as Maria is in S Africa

Link to Capacity Building:

- There will be some more training done on Biomass estimation in the field. This will be in Colombia in November, and our guidance can feed into this training. E.g. Guatemala – had a one-time wall to wall LiDAR, and no NFI.
- Inputs into guidance can also be gathered from the countries, as some countries are quite advanced on field methods.– guidance t – at least the people here shoul present the outcomes – both to communicate what they have done, and also to show how it should be done

Future meeting ideas

- Emission factor for degradation / regeneration. (For now, we are focussing on deforestation only and emission factor uncertainty)
- Uncertainty of trends