6. Examples

Examples are used to highlight for each case only *some* aspects that appear particularly relevant for the purposes of the review.

The analysis presented here should be considered as preliminary

A) Carbon-stock Chronosequences for estimating net changes

A model based on **Chronosequences** may be used for estimating carbon stock changes.

In this case the rotation period of the vegetation type is subdivided in age classes -i.e. “stratification” of time-dependant variability of carbon stocks-

For each carbon pool the average value of the level of stock is estimated for each age class

Following the age evolution the annual dynamic of carbon stock in a pool is then calculated by assuming constant change each year;
(if the time interval is long, the assumption contrasts with evidences of, for instance, biomass growth)

In reviewing

It should be considered that:

- site fertility,
- management practices
- and climate conditions

have an impact on the carrying capacity of a land and consequently on the growth rate of forests.
It is therefore to be assessed whether the model sub-stratify for those variables and what is the impact of a lack of stratification on estimates' accuracy;

For dead wood and soil organic matter the impact of previous management activities is particularly relevant, so that the applicability of chronosequences should be carefully assessed

The impact of stand replacing disturbances (e.g. clear cut and destructive fires) is not captured by the shifting of unit of land along age classes. It should be assessed whether the model uses ancillary data on those events

The ERT should check whether and how far cronosequances reflect changes in management practices

Indeed, to take into consideration the impact of changes in management, it is needed that new datasets on stocks are used to recalculate cronosequences in following years.

It is therefore desirable:

- to have each year new data, so recalculating chronosequences each year,

- to limit the timeseries of historical data to a time period equivalent to the length of the commitment period; so that at the end of the commitment period the cronosequences fully reflect stock changes due to changes in management practices implemented during the CP

B) Soil Organic Matter

Management activities have an impact on Soil Organic Matter by modifying:

-C inputs

-humidity of soil (by irrigation and management practices that determine the land cover and modify the soil structure)

- soil temperature (by determining the land cover and modifying the soil structure) although this parameter is largely driven by climate conditions;

B- 1st example

Soil process-based model that partitions the Soil Organic Matter in three sub-pools with average half-life time of < 1 year, within a century, within a thousand years, respectively.

The model has been parameterised and validated against long-term field experiments (a century)

C inputs by manure and crop residues

The model is initiated with historical data and runs multiple times until stability, before GHG estimates are calculated.

The main driver in the degradation of soil biomass is temperature since country's climate is humid

Humification processes drive the transfer of carbon stocks within pools, from the sub-pool with shortest half-lifetime till that one with the longest

In reviewing

It should be considered that in a humid climate the main drivers that determine the balance of SOM are management practices (which determines the C input and may impact soil temperature) and soil temperature.

To assess the accuracy of outputs, it is therefore important to analyze the sensitivity to co-variation in C input and soil temperature.

It is also important to analyze the sensitivity to variation of C Inputs alone. For cropland and grazing land management, to better reflect the impact of human activities on the GHG balance, it could be an option to use average climate data collected during the commitment period to calculate anthropogenic net emissions of the base year

Moreover, the most important parameter is the half-life time of each pool which drives the model kinetics

It is therefore very important to analyze the sensitivity of the model to variation and co-variation of half-life times

Finally, steady-state models are largely used were lack of data on carbon stocks does not allow to fully populate the starting dataset of the model, as for soil organic matter.

In this case, it is very important to test whether the model has reached the steady state before it provides estimates of carbon stock changes.

The test may be done by checking whether one of the calculated variables:

- shows a trend, not explained by changes in input data, along the whole time-series, and/or

- assumes the same value along the time-series under same conditions (for checking this an artificial set of input data may be used).

B- 2nd example

Gain – Loss model (driven by statistical data) for estimating SOM changes in cropland.

The model accounts as C gains:

- fertilizer
- lime
- biomass (above and below ground) residues

and as C losses:

- soil erosion and leaching
- soil respiration

In reviewing

Particular attention should be put on how data that usually refers to different time and spatial scales have been made consistent. Indeed:

- different amounts of fertilizer are applied for different cultures and management practices (e.g. organic farming, no tillage, etc)

- different amounts of biomass residues are released on soil according to differences in yield, species, management practice;

- measures on soil erosion and leaching are usually taken at watershed level so averaging the impact of different soil morphology and types, land covers, cultures, management practices;

- soil respiration measurements:
  - are usually confined to the vegetation period,
  - strongly depend from:
    - species,
    - management practices,
    - total soil carbon stock (which usually varies among different types of soil and as a consequence of historical uses and practices to which the soil was subject).

Moreover, soil respiration data usually includes root respiration that shall therefore be excluded (root respiration is part of the belowground-biomass estimates)

In stratifying available data all those sources of variability should be taken into consideration; and therefore, the methods for gap-filling on time and space should be carefully assessed by the review

B- 3rd example

Decay model for SOM and DOM in forest land which accounts for transfers among carbon compartments and losses due to oxidation.

Compartments are:

- fine woody litter
- coarse woody litter

which are accounted under decay compartments:

- extractives
- celluloses
- lignin-like compounds
- less recalcitrant humus
- more recalcitrant humus

other main elements:

- litter inputs,
    - non-woody litter
    - fine woody litter
    - coarse woody litter

- decay rates for each compartment,
- exposure of woody litter to microbial decomposition to determine transfers to decay compartments,
(these two elements drive the kinetics of the model)

- weather data;

- steady state of the model that requires estimation of the initial values of state variables (e.g. from national forest inventory) and then some iterations from spin-up;

In reviewing

inputs data should be carefully addressed since litter inputs is the only variable that is impacted by human activities,
so that anthropogenic stock changes in SOM and DOM are driven by changes in rate of litter inputs

how much additional emissions/removals are determined per unit of change in the litter input is consequence of functions implemented in the model that determine:

- C transfers among pools/compartments, and
- CO_2 emissions due to oxidation.

The accuracy of those functions output may be evaluated by verifying with independent data the model outputs (final or intermediate outputs), as in the mass balance check

C) Model for carbon stock change estimates in all forest carbon pools

A model that mixes empirical statistical relations and processes for estimating carbon stock changes in all pools of Forest land

The model derives data for carbon stock increases in the biomass pools from statistical information i.e. yield tables
while carbon stock decreases in biomass due to disturbances are estimated by other statistics

Emissions and carbon stock transfers among DOM and SOM pools are calculated with a process-based model that is similar to other models showed, as examples, in previous slides

In reviewing models that uses yield data derived from yield tables (based on the relation age - standing volume), the ERT should assess:

1) what are the growth conditions to which the timeseries of yield data refers:

- what is the level of natural (non-stand replacing) disturbances embedded in the time-series of volume data;
- what is the density, and consequently the level of competition, to which the time-series of volume data refers;
- what is the management system of practices to which the time-series of volume data refers (and consequently how changes in management practices during the commitment period are reflected in estimates);

2) how transfers from biomass pools to DOM pools are derived from net standing-volume change data
(data from yield tables gives the [net] result of the equation:
gross increment of standing volume – mortality)

on **point 1** it shall be considered that:

- losses due to the “embedded level of disturbance” (including mortality) should not be subtracted from biomass pools since already accounted, while transfers to DOM consequent to those disturbances shall be accounted;
- growth is strictly related to the availability of resources which is inversely related to population density;
- different management practices impact differently the stand density and consequently the growth rate;

on **point 2** it shall be considered that:

- C transfers from the aboveground biomass pool to DOM pools should be consistent with yield data, so that net growth + losses due to the “embedded level of disturbance” (including mortality) should not be bigger than the gross increment

D) Model for estimating carbon stock changes in lands under conversion

A model representing emissions/removals from land-use change (e.g. forest converted to cropland) provides a single emission estimate for a given year for the whole are converted within the country.

This estimate includes net emissions from all carbon pools from the current year's conversion event and from previous years' conversion events (lagged emissions).

To ensure transparency and to be comparable with other methods, an important ' intermediate output' would be increases and decreases and net changes of stocks disaggregated by vegetation and management types and among conversion’s year

E) Super-model for carbon stock changes in the LULUCF sector

The model integrates 5 models to estimates carbon stock changes in forest land, cropland and grassland:

- A physiological growth model for forests;

- A carbon accounting model for forests;

- A carbon accounting model for cropping and grazing systems;

- A microbial decomposition model;

- A Soil Carbon Model;

In reviewing,

Checks should be applied to each sub-model and then to the whole super-model, being aware that, for instance, a sensitivity analysis of such super-model could be hard to be assessed because of the needs to take into consideration co-variation of several inputs (i.e. input data of each model and output of each model)

Since different models have different spatial and time resolution it is crucial to assess whether accuracy and consistency is ensured in calculating, from input data, spatial datasets and timeseries of parameters of each model and then spatial datasets and timeseries of the super-model

In case of super model, it is particularly important to assess both the intermediate and the final outputs in a independent way (i.e. against lower tier and/or measured data), and not to stop to the understanding of the "correct structure and functioning" of each sub-model