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| **Combining remote sensing with biophysical process modelling to track carbon stocks and flows** |
| Forest biomass and its associated dynamics play an important role in the global carbon cycle and numerous other ecosystem services. In recent years, many researchers have attempted to map forest biomass across large areas using remote sensing modelling approaches. Typically, this involves training a machine learning (or AI) model with plot-based measures, allometric equations and remotely sensed covariates. Forest biomass maps are now frequently developed by companies for use in emissions estimation for carbon markets, supply chain analysis and compliance reporting.  Although often touted as the solution for forest carbon accounting, the stated accuracies of these maps are generally low – typically in the range of 60-70% for carbon stock, and likely lower for stock change. The differences between maps and methods are not often compared or well understood by those using them.  We compared several freely available maps of forest biomass and found large differences between products. This finding was not unexpected, given that remote sensors, particularly the current freely available optical and radar satellites, do not provide direct measurements of forest structure. In addition, the plot-based measurements used to calibrate and validate models often contain large uncertainties in themselves.  As well as the allometric-type maps often having large uncertainties, they only tell part of the story. Estimating the total emissions and removals from forests requires the tracking of carbon flows through all relevant carbon pools (e.g., the atmosphere, aboveground, belowground, dead organic matter, soil, harvested wood products, etc.). Biophysical process models offer a means to track carbon flows through the various pools over time and space. By combining remote sensing products with these process models, a more holistic representation of forest carbon dynamics can be established. Another advantage of process modelling is the ability to run models forward in time to create abatement potential scenarios.  Here, we used the Full Lands INtegration Tool (FLINT) to model forest carbon in eucalypt forests in NSW, Australia. We ran the model with different configurations, using different remote sensing based products to define forest types and trigger disturbance and recovery processes. The results suggest that the accuracy of these data inputs can have a large impact on model outputs.  In conclusion, we propose that process models, in conjunction with remote sensing products, offer an effective means to track forest carbon flows over time. However, accuracy is contingent on having access to reliable data inputs. Given the global importance of carbon accounting, more attention should be given to improving the accuracy of the input datasets needed to drive modelling processes, along with the consideration of all carbon stocks and flows. |