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Biogeosciences Discussions

Interactive comment on "Implications of albedo changes following afforestation on the benefits of forests as carbon sinks" *by* M. U. F. Kirschbaum et al.

M. U. F. Kirschbaum et al.

KirschbaumM@LandcareResearch.co.nz

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Response to reviewer 2

We are glad to read the reviewer's positive overall assessment of our paper. The only substantive point noted by the reviewer was a query of our calculation of daily radiative forcing (equation 7). The reviewer wondered whether that equation might just be too simple for our purposes.

However, we believe that our equation 7

$\Delta Rd = Qs^{*}\Delta a^{*}(1\text{-}\alpha atm)$

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Interactive Discussion

Discussion Paper

is physically correct and the appropriate equation to use within the context of our analysis. The equation represents the effect of the albedo change on absorbed incident shortwave radiation at the surface, as well as estimating the subsequent change in outgoing radiation. We used daily values of Qs and Δa based on our daily site-level observations over several years. This accounts for the atmospheric absorption of incident shortwave radiation at this location, as well as the scattering by the actual cloud and aerosol cover. There would be no justification for using a model, no matter how sophisticated, when actual observations are available.

However, the impact of the albedo change on outward radiation flux, the -Qs*Δa*αatm term in equation 7, could not be based on direct observations. The equation as given only takes account of molecular absorption by the atmosphere using an empirical constant, and ignores the possibility of further back scattering by aerosols and cloud. The importance of back scattering is reduced by the fact that it would increase on days with greater cloudiness, which also reduces the amount of solar radiation reaching the surface. Because of the complex interactions between cloud cover and solar radiation reaching the surface and its likely minor significance in eq. 7, most radiative transfer schemes actually ignore the back scattering component of the outward shortwave radiation and only account for the molecular absorption term.

It leaves the question whether the absorption term αatm should be allow to vary based on the output of a radiative transfer model given estimated atmospheric profiles as input. We opted to use a fixed value for αatm of 20%, which is the standard value quoted in the literature for the average molecular absorption by the atmosphere and clouds. About 17% of the absorption is due to water vapour and CO2 in the atmosphere, and about 3% due to clouds.

Using the online radiative transfer model suggested by the reviewer, it is possible to calculate the molecular absorption of the clear atmosphere (no clouds) for a mid-latitude location in summer and winter. These are 18% and 13% respectively, with the higher absorption in summer due to the higher specific humidity of the atmosphere. It is not

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possible to run the model with a realistic New Zealand cloud cover but if we add these numbers to the global estimate of cloud absorption of 3%, it adds to 21% and 16% for summer and winter absorption, respectively, with an average value of 19%, which is very close to the generally accepted value of 20%. This gives a reasonable estimate of annual mean absorption for New Zealand and the range of values we might introduce by using a full radiative transfer scheme with daily variations in the atmospheric state.

It should also be pointed out that equation 7 is quite insensitive to variations of αatm. As such, we have chosen to keep a constant αatm at 20%, the value commonly used in simple, generalised global radiation schemes, but added an extra comment and citation in the manuscript to justify its use more explicitly.

As a minor point, the reviewer also noted disagreement with our statement that evaporation was similar for Pinus radiata and pastures. We have omitted that statement now as the only facet that matters in the context of our analysis is that total water loss is greater from trees than pastures, and there is no disagreement on that broader issue. We have also added two further references to specifically support that key aspect.

Interactive comment on Biogeosciences Discuss., 8, 8563, 2011.