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Biogeosciences Discussions

Interactive comment on "Incorporating changes in albedo in estimating the climate mitigation benefits of land use change projects" *by* D. N. Bird et al.

Anonymous Referee #2

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General comments

This paper tries to quantify on a local scale two opposing effects of afforestation/reforestation on the climate system: reduction of radiative forcing by carbon sequestration versus increase in radiative forcing by increased land surface albedo. The magnitude of those effects has been debated for some years in the climate modelling community, but neither spatial resolution nor certainty of results have been high enough to aid local decisions for or against afforestation projects for climate mitigation. The model described in this paper could fill this gap for Canada and may contribute to both policy and scientific discussion. Existing models for carbon sequestration and land

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surface albedo have been combined with Canadian forest yield tables and a simple atmospheric radiative transfer approach to estimate the net radiative forcing of afforestation projects. The components of the final model are simple compared to state-of-the art, process-based vegetation, energy transfer or albedo models. They do not interact and are driven by static climate and forest growth rates. Using simple models may be necessary in order to make local predictions, but the plausibility of model outputs needs to be shown either by validation against observed data or by comparison to more sophisticated models.

Specific comments

2.2 surface albedo

Modelled surface albedo in Fig.1 seems to be fairly low when compared to satellite-measured surface albedo (e.g. Myhre et al. 2005: Radiative forcing due to anthropogenic vegetation change based on MODIS surface albedo data). As the albedo model is rather simple, the assumptions on biomass-dependence of stem closure and height are neither obvious nor published/cited and the amount of available albedo data has greatly increased since Yin originally published his model, it would be good to see a validation of the surface albedo model either against MODIS Data or against ground based albedo measurements if available. Also, values for B_closure, H_max, B_max should be given.

2.3 TOA albedo

There is a great number of well-recognized, published atmospheric radiative transport models freely available. Using one of those models to calculate radiative forcing of surface albedo would avoid several problems in the described approach:

- atmospheric radiative transfer is highly complex; atmospheric optical depth is not only determined by cloud cover but also by aerosols etc; absorption, transmittance and reflectance are specific for each of the constituents and are highly wavelength dependent.

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With respect to radiative forcing, the different behaviour in the visible and near-infra-red range is very important and not covered in a broadband albedo approach.

- The multiple scattering at the cloud layer (equation 3) seems to miss transmittance terms from 2nd order onwards (although they are present in figure 2)

- the relationship between sunshine (the definition of % possible sunshine is not clear), cloud cover and cloud opacity may in most cases not be as simple as described

- values of kc and Ab are probably highly site- and weather-specific. If fits from the US are applied to a British Columbian site, it needs to be shown that this is a valid approach

The above points seem to be especially important with respect to the high sensitivity of the model to atmospheric opacity shown in Fig. 9 and with respect to the high importance given to cloud effects in the conclusions. At the very least, the effective albedo of this study should be compared to similar calculations with RT models.

3.1 change in CO2 concentration

it is not quite clear, what is meant by CO2 decay, why it is important in a carbon-fixation context and what is meant by "a project that removes CO2 annually";

3.2 change in albedo

This paragraph is unclear. In all calculations of solar irradiance I am aware of, irradiance is a function of the solar constant and the local solar zenith angle (which depends on latitude, solar declination and hour angle); as it is in units of W/m2, an inclusion of longitude may make the formulae unnecessarily complicated.

4 case study

it is not clear, whether carbon losses (by harvest, tree mortality, etc) are included in the carbon sequestration term; if they are not included, the carbon balance will look differently.

Technical corrections

p.1515, l 4-5: grammar

p. 1516, l 1: should probably read "reflected by ... alpha_v"

p. 1516, eq 4: E=R[alpha_c+tau_cˆ2*alpha_v(1+alpha_c*alpha_v+...)] ?

p. 1517, l 11: references missing

p. 1517, l 22: grammar

p. 1518, l 5: fig. 4

p. 1518, l 15: molecular mass of carbon dioxide

p. 1519, l 5: reference missing

p. 1521, l 3+10: grammar

p. 1523, l 11: tons of what?

p. 1523, l 13-15: grammar?

p. 1524, l 1+18-19: grammar

p. 1524, l 22: correction of what?

p. 1528, l 6: Bala et al appeared 2007

p. 1533: x-axis label wrong

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