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Committed ecosystem change due to climate change

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Future climate change and the carbon cycle are tightly coupled with many studies showing positive feedbacks which amplify climate change, reduce the natural uptake of carbon and influence global emissions pathways to stabilisation (Friedlingstein et al., 2006). Changes in climate may also alter the major biomes - especially tropical and boreal forests but the biosphere will not be able to fully respond to climate change immediately and hence we introduce the new concept of committed ecosystem change and examine the extent to which biomes may be committed to significant changes in response to climate forcing before they can be observed. We find that the terrestrial biosphere exhibits significant inertia and can continue to respond to climate changes decades after stabilisation of climate with serious implications for definitions of dangerous climate change based simply on stabilisation temperature. We conclude that absence of significant biome changes at the time of stabilisation does not preclude significant and potentially detrimental changes in subsequent decades. It is becoming increasingly evident that individual components of the climate system as well as global temperature exhibit committed change, such as sea level rise from thermal expansion or melting of the Greenland ice sheet: both likely to continue long after radiative forcing is stabilised. Here we highlight that terrestrial ecosystems might also exhibit committed change behaviour because changes in both vegetation cover and biospheric carbon storage are likely to lag behind that of changes in climate. There has been much analysis (e.g. Cox et al., 2004) into the impact of climate change on the Amazon forest simulated by the Met Office Haley Centre climate carbon cycle model, HadCM3LC. The climate warming and drying in that region causes widespread dieback of the forest and this further amplifies the drying through biophysical feedbacks on the hydrological cycle. Others have examined tropical ecosystem response under climate change simulations from a range of climate models (Scholze et al. 2006) and showed simulated reductions in tropical forest cover, especially in Amazonia, both as a result of direct climate effects and as a result of the increased fire activity there. But these studies have focussed on the period of changing forcing rather than behaviour subsequent to stabilisation. We present results to show a possible climate threshold beyond which some dieback is committed and this commitment rises dramatically for global temperature rise above 2oC, a threshold often used by policy makers in their definition of dangerous climate change. Any subsequent recovery is on such a long timescale as to make the dieback effectively irreversible on any pragmatic level. There has been little or no discussion within the climate or ecosystem research communities on the concept of commitments to ecosystem change due to climate change. We show this could be significant due to the large changes to ecosystem structure which climate change may cause and the long timescales taken for these changes to be realised. Our intention is to draw attention to committed ecosystem changes as an issue requiring serious consideration. With increasing policy focus on climate mitigation and stabilisation of climate change, quantifying such committed changes will make valuable contributions to our understanding of dangerous climate change, and to aiding development of mitigation policies. We argue that committed ecosystem changes, rather than realised changes, should be considered in any definition of dangerous climate change.

References:

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