Earth Syst. Dynam. Discuss., 2, C12–C16, 2011
www.earth-syst-dynam-discuss.net/2/C12/2011/

Earth System Dynamics Discussions

Interactive comment on "Role of volcanic forcing on future global carbon cycle" *by* J. F. Tjiputra and O. H. Otterå

C.D. Jones (Referee)

chris.d.jones@metoffice.com

Received and published: 1 March 2011

This is a clear and concise manuscript which nicely describes a neat and well contained experimental design to assess the impact of two future scenarios of volcanic eruptions on the global climate-carbon cycle system. I found the manuscript easy to follow and the arguments well laid out and explained.

The paper presents novel concepts of general interest to the ESD audience, but my main concern about the manuscript is over the motivation – is this really motivated by wanting to know the response of the carbon cycle to a repeated volcanic eruption throughout the 21st century? (in which case why?) This seems a very hypothetical and unlikely case – why would we want to study it? More likely, your motivation is to use the volcanic forcing as a proxy for geo-engineering via stratospheric aerosol injection.

This is fine I think – there is a general requirement to better understand the climate and carbon cycle implications of such schemes. But if this is your motivation then be clear about it up front rather than adding it at the end of the discussion. Secondly, if this is your motivation then why look at periodic forcing such as a 5-yearly Pinatubo eruption? Why not also consider a constant (or smoothly increasing?) level of forcing at a level which would offset incoming SW by about the same amount as GHG radiative forcing. (As an aside, there is a coordinated set of experiments called GEOMIP which might interest you to look at exactly these issues across a multi-model framework).

Other than clarifying the motivation for this work I recommend publication after addressing a few more minor issues listed below.

Chris Jones.

1. title. As described above, be clear on your motivation – if this paper is about volcanic forcing as a proxy for geoengineering then why not have a title like "role of stratospheric aerosol injection on future climate/carbon cycle"...

2. regarding the experimental design of periodic eruptions – are there any dangers of a 5-year repeating forcing accidentally hitting a resonance (e.g. with ENSO)? Have you considered a similar approach but with more randomly timed eruptions?

3. in intro and discussion you could refer to some studies on the climate/carbon consequences of geoengineering by Andy Jones: Jones et al., 2009, JGR, 114; Jones et al, 2010, ACP, 10; Jones et al., 2011, ASL.

4. just to clarify your experimental design – do you specify a perturbation to stratospheric AOD that subsequently affects SW radiation? Or do you have an interactive aerosol scheme and actually inject aerosols?

5. p.40, line 18. How do you know the reduced precip is due to cooler climate? Could it also be due to reduced surface evaporation due to reduced SW (from the perturbed AOD)?

6. p.141, line 20 "qualitatively" - why not do this quantitatively?

7. sec. 3.1 – can you discuss the role of diffuse light? Most models don't include this effect yet and given you don't mention it I assume yours doesn't either, but it could be important. See, e.g. Mercado et al, Nature, 2009 or an earlier paper by Angert et al. This could also explain an increase in NPP following an eruption.

8. p.142, line 25-27. How do you know the reduced SW doesn't have an effect? How have you separated this out from the other changes (T, precip, CO_2 etc)?

9. sec 3.2. as with diffuse light for the terrestrial carbon cycle, there are other processes which you lack in the ocean. e.g. what is the role of iron deposition from an eruption? Or other micro-nutrients to the ocean. Are these potentially important? Should they be included?

10. sec3.2. Your discussion that increases in uptake due to lower temperature in GEO_PIN balance decreased uptake due to reduced atmospheric CO_2 make sense. This seems reasonable. But it would be interesting if you could estimate the approximate size of these two competing terms – are they big? e.g. if CO_2 is roughly 10% lower then this might drive approx 10% less uptake – which is in the region 30-40 GtC by 2100. This would make these two effects relatively large (comparable to the changes on land) – it just happens that they cancel. But if this cancellation is model-specific or scenario-specific then this may still be a feature we need to know about.

11. p.144 line 18 (and figs 6/7). Why does the Arctic behave differently here? Is this due to a decrease in sea-ice maybe and hence the effective ocean area in this region increase over time? Whereas the other basins are of fixed size...

12. end p.144. Why discuss the biological pump so briefly? I'm not clear if it is important or not here. If you think it is important then discuss in more detail why it behaves differently under GEO_PIN. If it isn't important then maybe don't need to mention it at all?

13. p.145. similarly for ocean pH – if this is an important aspect of your study then it deserves more than 3 lines. Otherwise don't mention it. Questions I can think of – why is it the same for GEO_PIN? If export production is higher then wouldn't this lead to lower surface ocean pCO_2 with more carbon transported to depth? So would we expect pH to be higher here? Or how has the ocean circulation changed in these runs? The surface T is notably different in GEO_PIN so has there also been a different response of, say, THC strength? How does this affect carbon transport to depth and hence surface ph?

14. p.147. Final sentence. I'd avoid policy prescriptive phrases like this! Keep the paper scientifically objective. This isn't meant to be a policy discussion forum.

15. figure 1. can you quote or show the time-mean level of aerosol loading in these two scenarios? It's hard to tell how they compare. By eye it looks like the GEO_PIN scenario has more forcing? (5*0.15 vs 1*0.35 perturbations every 25 years). In which case why did you choose different levels? Why not compare two scenarios of equal mean forcing? This way it is hard to tell if the reduced climate impact of GEO_TAM is due to the magnitude or frequency of the forcing.

16. figure 3. you attribute the cooling in GEO_PIN by 2100 to the volcanic forcing. But there will be some reduced GHG forcing due to lower CO_2. Can you quantify this? 50 ppm less would give maybe 0.2-0.3 degrees cooling?

17. for figure 4 I think you plot T and precip over land – is that right? I think that's the best thing to do, but can you say so specifically in the caption?

18. figure 4 – can you add a 5th panel to show NET carbon balance (NPP-RH)? It can be hard to see by eye how to add panels (c) and (d).

19. figure 4. I assume the signals you show here are statistically significant? How big is the standard deviation compared with the signal? I wouldn't want you to try to plot +-sigma on these plots – that would make them cluttered. But you should at least

check the significance and mention in the text where it is/isn't a robust signal.

Interactive comment on Earth Syst. Dynam. Discuss., 2, 133, 2011.