Geosci. Model Dev. Discuss., 3, C491–C495, 2010
www.geosci-model-dev-discuss.net/3/C491/2010/

Geoscientific
Model Development
Discussions

Interactive comment on "IMOGEN: an intermediate complexity model to evaluate terrestrial impacts of a changing climate" *by* C. Huntingford et al.

C. Huntingford et al.

chg@ceh.ac.uk

Received and published: 5 November 2010

Response to reviews on paper "IMOGEN: an intermediate complexity model to evaluate terrestrial impacts of a changing climate" by Chris Huntingford et al.

Dear Editor of GMD – thank you for sending the reviews, which are helpful. We have addressed the comments as follows:

REFEREE ONE:

Regarding CPU costs, we have added to the end of the top paragraph on page 1164: "A transient GCM simulation, representing a modelled period between the start of the industrial revolution and present, and then for a prescribed emissions scenario onwards to year 2100, will typically require 3 months of computing time to complete. This is in

addition to the often considerable time required to spinup the GCM to a pre-industrial state."

Then to complement this, we place an additional sentence at the end of the last paragraph of the Introduction (p1166) "An IMOGEN simulation representing, for instance, years 1860 (pre-industrial) to 2100 can be completed in a couple of days on a fast single processor."

We have addressed the issue that referee one would like to see the derived C-stores for the oceanic pool, and for the atmosphere. These extra numbers have now been calculated, and they are provided as additional lines in Table 1 (additional numbers reproduced below, along with extra text in revised caption):

Variable Change in 2100 SRES Scenario: SRES A1Fi; SRES A2; SRES B1; SRES B2

Change in atmospheric carbon (GtC) +1964 +1642 +826 +984

Change in oceanic carbon (GtC) +549 +509 +402 +415

Table 1: .....In addition, the change since year 1860 in atmospheric carbon and carbon sequestered by the ocean are also given (both in units of GtC, and positive numbers implying a gain).

Typo pp 1165, line 28 – corrected

We have clarified that although IMOGEN runs as a yearly timescale, the fitting is made at decadal timescales. To make this explicit, we now write: "That is, if ΔTl(i) (K) is the predicted global land temperature increase by year i, then change in quantity V(i,j,k) (for month j and spatial position (gridbox) k) is then approximated as pattern (i.e. regression coefficient) XV(j,k) multipled by ΔTl(i). (The fitting is actually made against decadal mean values for each month, position and variable)."

Section number (2.2, not 2.1) has been corrected.

We agree that the NPP value of 70.9GtC/yr is towards the top of the range of current

GMDD

3, C491–C495, 2010

estimates of pre-industrial values. (The number is higher than the range of between 44.4-66.3PgC/yr as reported in Cramer et al., 1999, for the present-day from a suite of terrestrial biosphere models). However there is no direct measurement of global NPP. The MOSES land-atmosphere flux components have been tested extensively against FLUXNET towers, but of course, this only applies at single points.

REFEREE TWO:

We can partially address the reviewer's query regarding how influential are the different drivers? (i.e. their sentences starting "How well the pattern scaling could represent....." and "spatial distribution of the error from the GCM...."). Assuming the pattern-scaling to be as accurate as currently possible, this comment has led us to write the related sentence in the Discussion of "It has the potential to determine the main expected atmospheric drivers of change to ecosystem behaviour by individually switching patterns on and off for the various constituents of surface meteorology." (Once achieved in the future, this will allow us to address the partitioning of contribution of runoff changes, as queried under "specific comments" by referee two).

Continuing answering "How well the pattern scaling....": Whilst trusting the general features of pattern-scaling, and where near-linearity is certainly present in HadCM3 projections (see original H+C 2000 paper), we do acknowledge that a very detailed re-analysis is timely – as suggested by the reviewer. We have taken care to be open in the Discussion about this – please see for instance the two paragraphs starting "There remain some caveats" and "One further limitation". Significantly more GCM data will become available for the 5th IPCC assessment: higher spatial resolution, much shorter temporal scales and for some GCMs as ensembles and across multiple scenarios. We can use all of this to investigate further inherent linearity in climate models which can be exploited to allow projections for novel emissions scenarios by "pattern-scaling".

Concerning influence on NPP, runoff and other variables (referee's sentence again "In addition...."), then we are also working up an initiative to rebuild IMOGEN against

GMDD

3, C491–C495, 2010

the HadGEM family of Earth System climate models, as built by the UK Met Office Hadley Centre. We will work to minimise IMOGEN-GCM differences, and where they remain, express in terms of ecosystem quantities like NPP and runoff, as well as the climate drivers per se. Land surface response can be checked more careful in this instance, given the commonality between ecosystem parts of IMOGEN and the Hadley GCMs. However, this is a programme that will not report for at least two years. We hope Reviewer 2 is satisfied with this as a "holding" response? The reviewer queries in particular making "regional assessments", and for this reason we now add in the Discussion and after the lines requesting more GCM data for validation: "As more GCM data becomes available the pattern-scaling concept, although known to be broadly valid (Huntingford and Cox, 2000), can be revisited and analyzed specifically for key geographical regions of interest."

Regarding marine carbon storage, we have been clear throughout the manuscript that at present we rely on a simple box force-restore description. The appropriate reference is given as Joos et al (1996). We hope one day to combine our land surface emulation via IMOGEN with the equivalent level of complexity for oceanic response to raised greenhouse gas concentrations and associated draw-down of CO2.

We like the shortness of the Abstract. Can we keep this please – anyone interested in the paper will read the Discussion, where we do explain in full current limitations and caveats?

"So my understanding is that basically the system is only applicable to 2100". We now write: "Finally the pattern-scaling concept for surface climate will be rigorously tested for long stabilisation scenarios (possibly going significantly beyond modelled year 2100),...."

The general queries regarding land surface response (temperature cutoff, PFTs and runoff response: listed under referee 2's "Specific Comments") we feel are covered adequately. I have just cross-checked the manuscript and we are clear in it that the

GMDD

3, C491–C495, 2010

land surface model replicates most of that used in the surface of HadCM3. That model (MOSES/TRIFID) is very well documented, and we use references appropriately. Hence a reader of this GMD submission is only ever one citation away from MOSES/TRIFFID documentation. The Gedney et al reference describes the changing runoff result. To determine the main driver of this, then again (see above), future research will investigate switching on/off the individual patterns as a form of factorial analysis to determine main ecosystem responses.

The typos have been corrected.

GENERAL

In additional, some of the references have now been updated. Also, two people have made massive contributions recently to operationalising the IMOGEN model – I would like to see their names added to the authorship list in recognition of this activity that has been occurring in parallel to writing this paper. Through their efforts, this model is now more accessible to the community. Requests for the computer code can be provided along with the GMD open-access paper if the journal is broadly satisfied with the current version of the manuscript.

Once again, we are grateful for the thoughtful comments received. IMOGEN development is very much an on-going activity, but we hope we are at the stage where the current version is worthy of publication in GMD.

Interactive comment on Geosci. Model Dev. Discuss., 3, 1161, 2010.