Global and Planetary Change 64 (2008) 1–2

Contents lists available at ScienceDirect

Global and Planetary Change

journal homepage: www.elsevier.com/locate/gloplacha

Editorial

DGVM responses to the latest IPCC future climate scenarios

In the spring of 2006, the future looked bright and we were sure our special issue would be coming out before Christmas. It is now spring 2007 and the future has shown us that no one has a crystal ball, not even modelers, to predict the future. A new job and a major family health crisis changed the lives of the two guest editors. Furthermore delays in the original submission of the final versions of the papers after three timely reviews rendered the early 2007 events in the lives of the editors particularly ill-timed. This illustrates however what climate change experts have told us all along: extreme events (such as a life threatening emergency) will shape the response of the earth system to future conditions. This short preamble aims to thank the reviewers of our five manuscripts for their prompt comments. It also aims at thanking the authors for their patience while they waited to see their work finally come to print. Finally it also aims at thanking Elsevier for their patience while waiting for the final package to arrive. We believe this set of papers includes important information about DGVMs and about what the future may hold for world ecosystems.

This special issue means to illustrate the power of dynamic global vegetation models and their usefulness in climate change science. Dynamic Global Vegetation Models are generally designed to track simultaneously vegetation changes driven by climatic variability, together with the associated fluxes of water and carbon (possibly also energy exchanges and nutrient flows). In general, DGVMs estimate changes in short and long-term vegetation productivity (both net primary productivity, NPP, and net ecosystem exchange, NEE), competition among lifeforms (plant functional types) for resources, the effects of disturbances, and mortality. External forcings to the DGVMs include both climate and soil characteristics. Cramer et al. (1999) and Scurlock et al. (1999) emphasized the need for improving the validation methods to determine both the sensitivity and the validity of model responses to the forcing climate. Cramer et al. (2001) compared six DGVMs in the first published inter-comparison, comparing simulated vegetation maps to a satellite-derived global map and simulated carbon fluxes with published estimates. Moorcroft (2006) reiterated the need for models to be compared to observations and thus tested for accuracy.

Pilkey and Pilkey-Jarvis (2007), following Oreskes (1994), argued in their latest book “Useless Arithmetics” that models cannot be validated and even if they could, their reliability for predicting the future would still remain unproven. In essence, without validation, global vegetation models are just videogames! In this special issue, several authors present *validation* exercises with different DGVMs. In particular, Price and El Maayar tested the IBIS dynamic global vegetation model at several eddy covariance sites located in Canada and the USA (but withdrew their manuscript). The model was then run into the future with various future climate scenarios. Much of the positive response to future climate could be attributed to projected changes in CO_2 concentration, raising questions about the significance of elevated CO_2 concentrations in large-scale simulations of vegetation change. These results confirmed the importance of an accurate representation of CO_2 effects on plant processes. A similar conclusion could be drawn from Cramer et al. (2001) but at that time, the lack of data concerning CO_2 impacts at the regional scale made it impossible for the modelers to refute either the fertilization impact or the adaptation of plants to rising atmospheric CO_2 concentration. Besides the direct effects of CO_2 on plant processes, indirect effects of CO_2 could also affect simulation results. Govindasamy et al. who did not submit a paper to this special issue but participated at the AGU poster session in 2005 looked at how changes in surface properties due to increased CO_2 would feed back to the atmosphere and affect climate. Their results showed that the direct physical effect of CO_2 fertilization could be a warming over a timescale of a few centuries, mostly due to decreased albedo in the Northern Hemisphere boreal forest regions. This albedo-based warming could partially offset the century-scale cooling effect of additional CO_2 uptake due to CO_2-fertilization. These results were published elsewhere and are currently the subject of a controversy about the use of planting forests for carbon sequestration at mid- and high-latitudes (temperate and boreal regions), weighing the direct carbon storage benefit against the atmospheric feedback causing additional warming. Bala et al. (2007) showed in an elegant simulation exercise that deforestation (at mid and high latitudes) would likely have a net cooling influence on the earth's climate, mainly because of increased average winter albedo. Hence, an expansion of forested areas in regions subject to seasonal snowcover, could, contrary to popular perception, enhance the greenhouse effect. It should be noted that Bonan et al. (2007) first postulated the enhanced albedo effect of removing boreal forest in a model simulation, and that a modeling experiment by Betts (2000, noted by Bala et al., 2007) first drew attention to the possible negative impact of afforestation. A concern at that time related to the assumption that afforestation would use coniferous evergreen species: Bala et al. did not report on the possible different effects of deciduous and coniferous cover—suggesting an important future experiment for DGVM modelers.

Several authors presented results using *data assimilation* to improve model fit to observations. Baruah et al. first performed a sensitivity analysis to identify a few parameters in the ecosystem model SimCyCLE that could be advantageously replaced by remotely-sensed information. They then compared the simulated NPP with observations. Chen et al. explored the ability of a Kalman Filter to generate distributions and seasonality of model parameter values using observations at multiple forest sites: Howland (Maine, USA), Niwot Ridge Forest (Colorado, USA) and two BOREAS sites (in Saskatchewan and Manitoba, Canada). Their results showed that,

doi:10.1016/j.gloplacha.2008.01.005

with data assimilation and simultaneous estimation of parameter values, the prediction of gross primary productivity (GPP), respiration and NEE improved significantly as compared to predictions made without data assimilation.

Most DGVMs do not simulate historical or future changes in land use, so it is generally difficult to directly compare the results of the simulations with field data, although some recent studies estimate the effects of changes resulting from *prescribed* changes in land use derived from historical databases and economic and demographic projections of future human land-use pressures. Land-use impacts, forest harvest patterns as well as *natural disturbances* (e.g., fire, pests, disease) need to be taken into account during these validation exercises. Neither Baruah et al. nor Chen et al. submitted manuscripts to this special issue, but the questions they raised are important. The notion of site calibration and the use of data assimilation to improve model accuracy are still subject to intense discussions among modelers.

Delire et al. focused on the *sensitivity* of model results to changes in the fire parameters of IBIS while simulating the impacts of wildfires in Africa. They also used previously reported and new paleodata to assess the likelihood that the simulated changes were plausible. Lenihan et al. focused on the impacts of *fire* suppression and its role to mitigate carbon losses and ecosystem declines particularly in the western USA. Forest dieback is triggered by two mechanisms: reduced regional precipitation and the influence of rising temperatures on evapotranspiration. Even with the benefits of enhanced water use efficiency from elevated CO_2 and slight increases in precipitation, dramatic increases in temperature can produce widespread forest dieback coupled to increases in fire severity. These results underscored again the critical importance of addressing uncertainties with respect to ecosystem water balance and the direct effects of elevated CO_2 concentrations. Finally, Bachelet et al. compared results from two large inter-comparison projects where multiple climate scenarios were used to drive multiple DGVMs, focusing on the sensitivity of the model to different climate signals. When simulated vegetation responses to both climate change and atmospheric CO_2 enhancement were compared, the authors found quite dramatic differences between the two models which could not easily be reconciled.

In conclusion, this special issue constitutes a record of several efforts by diverse modeling teams to test, validate and improve existing dynamic vegetation models, and hence improve our collective ability to project reasonable changes in vegetation distribution and carbon sequestration potential in a warmer future. One of the most important issues to surface was that the availability of markedly different climate change scenarios can cause results from different DGVMs to seem inconsistent if not contradictory. A further problem, highlighted in the Bachelet et al. study, was that disagreements among the DGVMs may be even greater than the uncertainties implied in the forcing climate projections. Such a range of supposedly equally plausible projections therefore causes a major difficulty for policy makers and managers: should they use any or none of the model projections as preparation for an uncertain future? These concerns are made very clear by The Nature Conservancy land stewards eager to acquire wise guidance on how to enhance the resiliency of natural preserves to future changes in climate. Unfortunately neither refinements to current climate models nor improvements in the power of modern computers are likely to make projections of future climate and vegetation responses more reliable in the next few years. Political decisions and personal choices will shape the future and determine what global emissions will be in the future. The human factor trumps science in this case.

Another major uncertainty results from conflicting views about the direct impact of increased atmospheric CO_2 on vegetation. Free Air CO_2 Enrichment (FACE) researchers have documented these impacts in relatively young tree stands (presumably free of the effects of otherwise artificial conditions), while laboratory experiments have investigated variability in the responses of individual genera and species to different CO_2 concentrations. European scientists have focused on the responses of older mature forests and, and finding relatively little impact, have questioned the assumption of a large CO_2 fertilization effect in vegetation models used to project future changes in vegetation distribution, regional hydrology and forest fire activity. Moreover, the postulated positive feedbacks from CO_2-enhanced expanding forests to the warming atmosphere could affect future climate and point to the necessity of including feedbacks in future generations of dynamic global vegetation models (i.e., fully coupled earth system simulators which routinely couple terrestrial and ocean biology to the global circulation models). Fortunately state of the art models are now being developed with dynamic interactions between the earth surface and the atmosphere (ex. JULES http://www.jchmr.org/jules/), which offer the prospect of better tools to understand climate and vegetation interactions. So the overall conclusion is that DGVMs, although perhaps the best tools available today, are a far cry from the crystal ball the popular media and policy makers would like them to be. Models can help creative and knowledgeable people look at the future as an exciting challenge that can be met with interdisciplinary collaborations—but we must maintain a thorough respect for Nature.

References

Bala, G., Caldeira, K., Wickett, M., Phillips, T.J., Lobell, D.B., Delire, C., Mirin, A., 2007. Combined climate and carbon-cycle effects of large-scale deforestation. Proceedings of the National Academy of Sciences 106 (16), 6550–6555 PNAS10.1073/pnas.0608998104.

Betts, R.A., 2000. Offset of the potential carbon sink from boreal forestation by decreases in surface albedo. Nature 408, 187–190.

Bonan, G.B., Pollard, D., Thompson, S.L., 2007. Effects of boreal forest vegetation on climate. Nature 359, 716–718.

Cramer, W., Kicklighter, D.W., Bondeau, A., Moore, B., Churkina, G., Nemry, B., Ruimy, A., Schloss, A.L., the participants of the Potsdam NPP model intercomparison, 1999. Comparing global models of terrestrial net primary productivity (NPP): Overview and key results. Global Change Biology 5 (Suppl. 1), 1–15.

Cramer, W., Bondeau, A., Woodward, F.I., Prentice, I.C., Betts, R., Brovkin, V., Cox, P.M., Fischer, V., Foley, J.A., Friend, A.D., Kucharik, C., Lomas, M.R., Ramankutty, N., Sitch, S., Smith, B., White, A., Young-Molling, C., 2001. Global responses of terrestrial ecosystem structure and function to CO_2 and climate change: results from six dynamic global vegetation models. Global Change Biology 7, 357–373.

Moorcroft, P.R., 2006. How close are we to a predictive science of the biosphere? Trends in Ecology and Evolution 21 (7), 401–407.

Oreskes, N., 1994. Verification, validation, and confirmation of numerical models in the earth sciences. Science 263, 641–646.

Pilkey, O.H., Pilkey-Jarvis, L., 2007. Useless arithmetics. Why environmental scientists can't predict the future. Columbia University Press.

Scurlock, J.M.O., Cramer, W., Olson, R.J., Parton, W.J., Prince, S.D., 1999. Terrestrial NPP: Toward a consistent data set for global model evaluation. Ecological Applications 9, 913–919.

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