CLIMATE –CARBON CYCLE FEEDBACK ANALYSIS, RESULTS FROM THE C[4]MIP MODEL INTERCOMPARISON

P. Friedlingstein[1], P. Cox [2], R. Betts[3], L. Bopp[1], W. von Bloh[4], V. Brovkin[4], S. Doney[5], M. Eby[6], I. Fung[7], B. Govindasamy[8], J. John[7], C. Jones[3], F. Joos[9], T. Kato[10], M. Kawamiya[10], W. Knorr[11], K. Lindsay[12], H. D. Matthews[6,13], T. Raddatz[14], P. Rayner[1], C. Reick[14], E. Roeckner[15], K.-G. Schnitzler[15], R. Schnur[15], K. Strassmann[9], A. J.Weaver[6], C. Yoshikawa [10], and N. Zeng[16]

[1]Institut Pierre-Simon Laplace/ LSCE, CEA-Saclay, L'Orme des Merisiers, 91191 Gif-sur-Yvette, France; pierre.friedlingstein@cea,fr
[2]Center for Ecology and Hydrology,United Kingdom
[3]Hadley Centre, Met Office, Exeter, UK
[4]Potsdam Institute for Climate Impact Research, Potsdam, Germany
[5]Woods Hole Oceanographic Institution, Woods Hole MA, USA
[6]University of Victoria, Canada
[7]University of California, Berkeley CA, USA
[8]Lawrence Livermore National Laboratory, Livermore,CA,USA
[9]University of Bern, Bern, Switzerland
[10]Frontier Research Center for Global Change / JAMSTEC, Yokohama, Japan
[11]QUEST, University of Bristol, UK
[12]NCAR, Boulder, CO, USA
[13]University of Calgary, Canada
[14]Max Planck Institute for Biogeochemistry, Jena, Germany
[15]Max Planck Institute for Meteorology, Hamburg, Germany
[16]University of Maryland, USA

ABSTRACT
Ten coupled climate-carbon cycle models were forced by historical and SRES A2 anthropogenic emissions of CO_2 for the 1850-2100 time period to study the coupling between climate change and the carbon cycle. Each model ran two separate simulations in order to evaluate the climate-carbon cycle feedback. All models agree that future climate change will reduce the efficiency of the Earth system to absorb the anthropogenic CO_2. A larger fraction of CO_2 will stay in the atmosphere if climate change is accounted for. By the end of the 21st century, this ranges between 20 ppm and 200 ppm depending on the model, the majority of the models lying between 50 and 100 ppm. All models simulate a negative sensitivity for both the land and the ocean carbon cycle to future climate. However there is still a large uncertainty on the magnitude of these sensitivities. Also, the majority of the models attribute most of the changes to the land. Finally, most of the models locate the reduction of land carbon uptake in the tropics. However, the attribution to changes in net primary productivity versus changes in respiration is still subject to debate amongst the models.

INTRODUCTION
The early studies of Cox et al [2000] and Dufresne et al. [2003] showed the potential positive feedback between the climate system and the carbon cycle. Future climate change leads to a reduction of land and ocean carbon uptake, leaving more CO2 in the atmosphere, hence reinforcing the warming.

MODELLING SETUP
The Coupled Climate Carbon Cycle Model Intercomparison project (C4MIP) was initiated by WCRP and IGBP. Ten models performed two climate-carbon cycle simulations. The first (coupled run) is a scenario simulation where CO2 emissions are prescribed from historical data for 1860-2000 [*Marland et al.* 2005, *Houghton and Hackler*, 2002] and from the SRES-A2 scenario for the 21st century. The second one (uncoupled run) uses the same emissions, but the calculated CO_2 concentration has no radiative impact.

None of the model accounted for changes in land cover. Deforestation emissions were taken as an external forcing in this study.

RESULTS

All models simulate a larger atmospheric CO2 by 2100 in the coupled simulations. The additional CO2 ranges between 20 ppm and 200 ppm, with a median value around 75 ppm. By 2100 atmospheric CO2 reaches a concentration ranging between 750 and 1020 ppm (Friedlingstein et al., 2005). When compared to the atmospheric CO2 time series used for the standard IPCC-AR4 projection of climate change modeling activity, half of the C4MIP models simulate a larger atmospheric CO2 growth rate. A feedback analysis, similar to the one performed by Friedlingstein et al. (2003) reveals that the majority of the C4MIP models attribute this increase airborne fraction to a reduction of land carbon uptake. Only two models attribute it mainly to a reduction of ocean uptake. These two models also simulate a weaker than the average feedback. At the global scale, the feedback analysis shows that there is still a large uncertainty in the magnitude of the land carbon sensitivity to climate change. The land carbon loss varies between zero and 200 GtC per degree of warming. There is a lower uncertainty on the ocean carbon sensitivity to climate, the ocean carbon loss varying between zero and 60 GtC per degree of warming.

At the regional scale, the models agree on the most vulnerable region. The tropical latitudinal bands explain most of the global land carbon uptake reduction. In general, temperate and boreal regions play an opposite role. The tropics act as a positive climate-carbon cycle feedback, while the boreal regions act as a negative feedback. In the tropics, most model show a climate induced reduction in Net Primary Productivity, acting in parallel with an increase of soil carbon decomposition rate. However, the magnitude of the sensitivity of these two processes to climate is still highly model dependent.

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