The overall aim of GREENCYCLESII was to substantially improve the current understanding of the impacts of climate-biogeochemistry feedbacks on the evolution of the Earth system over the next two centuries. The specific role of this Work Package (WP3 – "Improved constraints on terrestrial processes") was to convert the improved understanding of terrestrial (or "land") ecosystem processes into improvements in the predictive capabilities of ecosystem and Earth System Models (ESMs).

This is a high-priority as feedbacks between climate change and the terrestrial biosphere, especially through the carbon cycle, are known to be amongst the largest uncertainties in projections of future climate change. Also, the largest impacts of climate change are likely to be through changes in the ecosystem services, such as food and freshwater availability, which terrestrial ecosystems provide for humanity. Terrestrial ecosystems therefore play a huge role in how climate change will unfold, and also in how this will impact on human well-being.

In order to reduce the uncertainties in how land ecosystems will affect future climate change, and be affected by future climate change, WP3 undertook a multi-pronged approach: (1) an assessment of the uncertainties associated with land carbon cycle processes in the current ESMs (through contribution to the Intergovernmental Panel on Climate Change 5th Assessment Report - IPCC AR5) ; (2) processed-based studies on some of the key uncertainties in the interaction between the Earth System and the terrestrial biosphere, such as the sensitivity of soil respiration to temperature and soil moisture, the response of plant isoprene emissions to climate factors and CO_2, the vulnerability of soil and vegetation carbon stores to drought in the Mediterranean; (3) an assessment of how the representation of such key processes influences the projected impacts of climate change on ecosystems and ecosystem services (through engagement in the ISI-MIP project and its input to the forthcoming IPCC AR5 Working Group II and III reports). We briefly summarise progress in these areas below.

Assessment of the Carbon Cycle in the latest Earth System Models
GREENCYCLESII, and specifically WP3, made a major contribution to the IPCC AR5 Working Group 1 report – carrying-out the evaluation of the carbon cycle simulations of the IPCC Earth Systems Models (ESMs) that appears in the Model Evaluation Chapter. The T3.1 fellow (Alessandro Anav) is named as a Contributing Author and the WP3 leader (Prof Peter Cox) is a Lead Author on this chapter. A long paper has also been published in the *Journal of Climate* (Anav et al., 2013) detailing the most complete evaluation of the carbon cycle components of ESMs to date. The major conclusions of this work are partially summarised in the following statement which appears in the IPCC AR5 WG1 Summary for Policymakers: "*Climate models that include the carbon cycle (Earth System Models) simulate the global pattern of ocean-atmosphere CO2 fluxes, with outgassing in the tropics and uptake in the mid and high latitudes. In the majority of these models the sizes of the simulated global land and ocean carbon sinks over the latter part of the 20th century are within the range of observational estimates*". The full evaluation also looked at the regional carbon sinks, concluding that ESMs currently misplace the global land carbon sink in the tropics rather than the northern mid-latitudes, most likely because of the neglect of nitrogen-carbon feedbacks and deficiencies in the modelling of forest re-growth.

Improved Process Understanding
New fieldwork, data syntheses, meta-analyses, and process-based model developments were carried out by WP3 fellows to elucidate key uncertainties. One of the highlights here was the development of a novel model of isoprene production from plants based on the hypothesis that isoprene production rates are primarily controlled by the excess or deficit of electrons generated by Photosystem II, relative to the needs of carbon fixation. This hypothesis alone is sufficient to reproduce widely observed responses of isoprene emission to changes in light, temperature, CO_2 concentration and drought (Morfopoulos et al., 2013). There was also a surprising finding that soil respiration varies geographically with nitrogen deposition rather than soil temperature (as usually assumed). Informed by the various process studies and meta-analyses, WP3 has been developing new representations of plant drought responses and plant nitrogen uptake, as well as soil respiration and isoprene emissions.

Impacts of Climate Change on Ecosystems and Ecosystem Services
WP3 (through the T3.6 fellow) participated actively in the influential *InterSectoral Impacts Model Intercomparison Project (ISI-MIP),* that provided cross-sectoral impact assessments based on the IPCC climate and socio- economic scenarios in time for the IPCC's Fifth Assessment Report (AR5). This model intercomparison project and subsequent analysis has led to several publications including a paper in PNAS on which the T3.6 fellow is a co-author and the GCII co-ordinator is the lead-author (Friend et al., 2013). A major finding of this study is that the key uncertainty in the response of land carbon storage to climate change is the residence time for carbon in ecosystems. This research will act to focus and prioritise new measurements and model developments.

Aside from such important research outputs, GREENCYCLESII has helped to develop a new generation of research scientists, to tackle the great challenges ahead.

This briefing statement is intended for use by Policy Makers and Journalists – if you have any questions or would like further information on the points raised above then please use contact the GCII Project Co-ordinator.

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