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Glacial-interglacial Changes in the Carbon Cycle: Terrestrial Records and Earth System Modelling

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Ice-core records of atmospheric CO_2 and CH_4 concentration between glacial maximum and typical interglacial levels document large but bounded natural changes in the carbon cycle. Understanding the natural regulation of greenhouse gas content of the atmosphere is a challenge because it involves changes in marine and terrestrial ecosystem properties that control emission sources and sinks, and changes in the oxidizing capacity of the atmosphere itself. Further complications arise because the terrestrial ecosystem properties that affect greenhouse gas sources and sinks, including vegetation distribution and productivity, fire disturbance, wetland extent and dryland soil properties, are influenced both by greenhouse-gas induced changes in climate and directly by the effect of changes in atmospheric CO_2 concentrations on plant physiology. Considerable progress is being made in understanding the multiple interactions and feedbacks involved in the natural regulation of the carbon cycle through the use of earth system models in conjunction with well-documented global reconstructions of changes in terrestrial ecosystems, including pollen and plant-macrofossil records of changes in vegetation, charcoal records of changes in fire regimes, and biostratigraphic information on changes in the extent of wetlands. However, comparisons of these records with terrestrial ecosystem simulations driven by climate change scenarios derived from multiple palaeo-climate experiments run by the Palaeoclimate Modelling Intercomparison Project (PMIP), show that there is still much work to be done.