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Observations and Simulations of Past Vegetation Changes: BIOME 6000+, PMIP2 and Model Benchmarking

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Climate influences vegetation distribution through changes in productivity, disturbance regimes and the distribution of plant functional types. Changes in vegetation distribution result in changes in land-surface characteristics and in trace gas and aerosol emissions that in turn feedback on the climate system. Understanding the complex interaction between the terrestrial biosphere and climate in the past provides the basis for predicting future climate and environmental changes.

The Palaeovegetation Mapping Project (BIOME 6000) used pollen and plant-macrofossil records to reconstruct vegetation patterns at the last glacial maximum (ca 21,000 years ago) and the mid-Holocene (ca 6000 years ago). The resulting maps show extremely large changes in vegetation distribution between glacial and interglacial states, resulting from changes in regional climates and the effects of changes in atmospheric CO_2 concentration on plant physiology. The BIOME 6000 reconstructions have provided benchmarks for the evaluation of the atmospheric general circulation model simulations made in the Palaeoclimate Modelling Intercomparison Project (PMIP) and are currently being used to evaluate the realism of fully-coupled ocean-atmosphere and ocean-atmosphere-vegetation models with the second phase of PMIP (PMIP2).

Although the existing BIOME 6000 reconstructions are a useful tool, they are not sufficient. There is an urgent need to develop similar syntheses to document changes in vegetation at centennial to millennial timescales in order to evaluate model simulations of the transient response of the climate system to external forcing and internal

feedbacks. Furthermore, terrestrial biosphere models now incorporate more realistic representations of disturbance regimes (e.g. fire) and modules predicting vegetation-controlled emissions of trace gases (e.g. CO_2, CH_4, NO_X) and aerosols (e.g. black carbon, mineral dust); these components of the models need to be evaluated separately.

A number of new data syntheses have been initiated by the international community, sponsored by the International Geosphere-Biosphere Programme (IGBP) and the UK QUEST (Quantifying Uncertainties in the Earth SysTem) programme. In addition to reconstructing changes in vegetation patterns through a complete glacial-interglacial cycle (BIOME 6000+), these new initiatives include efforts to document changes in fire regimes using charcoal records, in wetland distribution using biostratigraphic records, and changes in the relative importance of C_3 and C_4 plants using isotopic records and biomarkers from terrestrial environments. Our current understanding of the role of vegetation within the climate system is based on the confrontation of terrestrial biosphere models and global-scale syntheses of palaeoenvironmental data. These new data syntheses will make further progress possible.