

The roles of astronomical forcing and CO₂ in global vegetation distribution during nine interglacials in the past 800,000 years

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The spatial distribution of the major vegetation types on global scale are primarily determined by climatic variables which are associated with specific astronomical parameters. Atmospheric CO₂ concentration also plays a significant role in driving vegetation patterns by influencing the rate of photosynthesis and land surface temperature. Disentangling the links between terrestrial vegetation changes and astronomical forcing as well as greenhouse gases (GHGs) remains challenging. It is therefore instructive to investigate the individual role of astronomical forcing and CO₂ on global vegetation distribution, in particular during the warm periods such as the past interglacials. For this purpose, we have performed transient simulations for the nine interglacials (MIS-19, MIS-17, MIS-15, MIS-13, MIS-11, MIS-9, MIS-7, MIS-5 and MIS-1) of the last 800,000 years by using the Earth system model LOVECLIM. Our results provide a general view of the spatio-temporal distribution of different vegetation types and their relationships with climate variables, astronomical parameters and atmospheric CO₂ concentrations. We find that precipitation, temperature and vegetation respond strongly to the astronomical parameters in each interglacial, and they are predominantly influenced by precession. In many regions, precipitation and temperature contribute oppositely to tree and grass growth. Tree fraction is mainly controlled by precipitation at mid and low latitudes, whereas the role of temperature increases towards high latitudes. Precession is more important for tree growth in low latitudes than high latitudes, whereas obliquity is more important in high latitudes. The response of grass fraction to astronomical parameters is more complex and varies between latitudes and regions. Our study reveals also that the relative importance of insolation and CO₂ on vegetation varies between regions.