Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.17837

The history of atmospheric oxygen: towards an understanding of oxygen-vegetation feedbacks

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Since the emergence of land plants ~420 million years ago, atmospheric oxygen is thought to have been dynamically stable between roughly 17-40% vol. O_2. Such stability suggests mechanisms have been in place to prevent oxygen rising or falling out of these bounds. Amongst processes proposed, negative fire feedbacks are assumed to play a central role due to the sensitivity of fire to varying oxygen concentrations, controlling oxygen levels through suppressing terrestrial vegetation productivity and lowering organic carbon burial: a main source of atmospheric oxygen over geological timescales. Yet despite being prevalent in discussions of oxygen regulation and incorporated into many biogeochemical models, fire and other vegetation-based feedbacks on atmospheric oxygen remain largely untested and debated.

Here we update the LPJ-LMfire Dynamic Global Vegetation Model to include oxygen impacts on global vegetation through oxygen-fire and oxygen-photorespiration effects. Whilst previous work has suggested both photorespiration and fire could have a role in oxygen regulation, work presented here is the first to include both mechanisms and their interactions on a global scale. Through running a series of simulations over a range of oxygen concentrations we investigate the response of global terrestrial vegetation to rising oxygen concentrations through separate and joint effects of fire and photorespiration. Subsequently improving our understanding of the strength that fire and photorespiration has in providing negative feedbacks to atmospheric oxygen and hence its regulation throughout the Phanerozoic. As such, work here has widespread implications including the evolution of land plants and biomes, the development of biogeochemical models (touched on here) and ultimately providing a better understanding of the oxygen cycle – a major part of the Earth system.