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Nitrogen and phosphorous limitations significantly reduce future allowable CO_2 emissions

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Earth System Models (ESMs) can be used to diagnose the emissions of CO_2 allowed in order to follow the representative concentration pathways (RCPs) that are consistent with different climate scenarios. By mass balance, the allowable emission is calculated as the sum of the changes in atmospheric CO_2, land and ocean carbon pools. Only two ESMs used in the fifth assessment (AR5) of International Panel on Climate Change (IPCC) include nitrogen (N) limitation, and none include phosphorous (P) limitation. In this study we quantified the effects of N and P limitations on the allowable emissions using an ESM simulating land and ocean CO_2 exchanges to the atmosphere in RCPs used for IPCC AR5. The model can run with carbon cycle alone (C only), carbon and nitrogen (CN) or carbon, nitrogen and phosphorus (CNP) cycles as its land configurations. We used the simulated land and ocean carbon accumulation rates from 1850 to 2100 to diagnose the allowable emissions for each of three simulations (C only, CN or CNP). These were then compared with the emissions estimated by the Integrated Assessment Models (IAMs) used to generate RCP2.6 and RCP8.5. N and P limitations on land in our ESM led to systematically lower land carbon uptake, and thus reduced allowable emissions by 69 Pg C (21%) for RCP2.6, and by 250 Pg C (13%) for RCP8.5 from 2006 to 2100. Our results demonstrated that including N and P limitations requires a greater reduction in human CO_2 emissions than assumed in the IAMs used to generate the RCPs.

Reference: Zhang, Q., Y. P. Wang, R. J. Matear, A. J. Pitman, and Y. J. Dai (2014), Nitrogen and phosphorous limitations significantly reduce future allowable CO_2 emissions, Geophys. Res. Lett., 41, doi:10.1002/2013GL058352.