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Understanding the drivers of Amazonian evapotranspiration (ET) change in response to increased CO_2.

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Earth system models allow us to examine the complex interactions and feedbacks between land surface, vegetation and atmosphere. A more thorough understanding of these interactions is essential in reducing uncertainty surrounding the potential impacts of climate and environmental change on the hydrological cycle and the future state and extent of the Amazon rainforest.

With HadGEM2-ES simulations from CMIP5 in which CO_2 is increased at 1% per year starting from pre-industrial concentrations and reaching 4 times that after 140 years, we separate the various drivers and processes controlling ET in western Amazonia. The design of these simulations allows for radiative and physiological forcings to be examined separately and in combination, and the degree to which the combination of forcings is additive or non-linear.

We consider ET as a product of the moisture gradient between the surface and the boundary layer and a conductance term, which includes terms limiting the evaporation from stomata and from the canopy. We find that aside from the direct effects of radiative and physiological forcing, there are a number of other processes occurring: 1) reductions in ET alter the surface energy budget leading to increases in moisture gradient which drive increases in ET, 2) additional reductions in stomatal conductance when surface temperatures exceed optimum temperature for photosynthesis, leading to greater decreases in ET between 2 and 4 times pre-industrial CO_2, 3) negative correlation between moisture gradient and conductance terms leads to additional decreases in ET, 4) decreases in canopy water content increases the importance of stomatal conductance which also drives decreases in ET. A combination of these processes leads to non-linear decreases in ET between 2 and 4 times pre-industrial CO_2 when both radiative and physiological forcings are operating.

These results indicate a major role physiological forcing in the hydrological cycle of Amazonia, highlight the potential for differences in offline and models in terms of the hydrological cycle and land surface feedbacks, and the need to reduce uncertainty in the modelling the response of stomatal conductance to high temperatures.