Geophysical Research Abstracts
Vol. 19, EGU2017-2263, 2017
EGU General Assembly 2017

Photosynthetic responses to altitude: an explanation based on optimality principles

Han Wang (1,2), Iain Colin Prenticce (1,2,3), Tyler Davis (3,4), Trevor Keenan (2,5), Ian Wright (2), Changhui Peng (1,6)

(1) Northwest A&F University, College of Forestry, Yangling, China (wanghan_sci@yahoo.com), (2) Department of Biological Sciences, Macquarie University, North Ryde, NSW 2109, Australia, (3) AXA Chair Programme in Biosphere and Climate Impacts, Department of Life Sciences, Imperial College London, Silwood Park Campus, Buckhurst Road, Ascot SL5 7PY, UK, (4) United States Department of Agriculture-Agricultural Research Service, Robert W. Holley Center for Agriculture and Health, Ithaca, NY 14853, United States, (5) Earth Sciences Division, Lawrence Berkeley National Lab, 1 Cyclotron Road, Berkeley, CA 94720, United States, (6) Department of Biological Sciences, Institute of Environmental Sciences, University of Quebec at Montreal, C.P. 8888, Succ. Centre-Ville, Montréal H3C 3P8, Québec, Canada

Increasing altitude is commonly accompanied by a declining ratio of leaf-internal to ambient CO_2 partial pressures (ci:ca; hereafter, χ) and an increase in carboxylation capacity (Vcmax), while carbon assimilation (A) shows little to no change. Here we provide a consistent, quantitative explanation for these responses based on the 'least-cost hypothesis' for the regulation of χ and the 'co-ordination hypothesis' for the regulation of Vcmax. With leaf temperature held constant, our analysis predicts that the cost of maintaining water transport capacity increases with altitude (due to declining atmospheric pressure and increasing vapour pressure deficit, VPD) while the cost of maintaining carboxylation capacity decreases (due to the enhanced affinity of Rubisco for CO_2 at low O_2 partial pressures). Both effects favour investment in carboxylation capacity rather than water transport capacity. The response of A then reflects the competing effects of stronger CO_2 limitation at low ci versus increased radiation penetration through a thinner atmosphere. These effects of atmospheric pressure are expected to be most strongly expressed in herbaceous plants that can maintain leaf temperatures in a narrow range. In leaves closely coupled to the atmosphere additional effects of declining temperature on photosynthesis are expected to modify but not obliterate those of pressure.