Interactive comment on “The regulation of the air: a hypothesis” by E. G. Nisbet et al.

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As a physicist, unconstructed in biology, swimming in a biological ocean, now landing in the geosciences continent, I propose the following remarks in response to the sparkling and positive referee C 451: 1. - Rubisco carboxylation is not so sluggish. It competes successfully with oxygen, which is 660 times more concentrated. The trapping of 0.03 % CO₂ is a performance. 2. - Classical “dark” respiration in plants is saturated at a low level of oxygen (<1%); 3 – Rubisco, does it cause respiration? No, but it cause photorespiration, which is light-dependent and operates (in plants) at a rate more 10 times higher than “dark” respiration. 3. - The Oxygen Compensation Point denotes the equilibrium point where the O₂ production by plants, equals the consumption by all living biosystems consuming O₂ by dark respiration (plants, animals, micro organisms decomposer etc). 4.- In a plot of net exchange vs O₂, along the axis of the increasing O₂ there is a “crossing point” (Oₓ) where increase of the photorespiration matches the decrease of photosynthesis (see Fig.in supplement). At this point, there is equality between photosynthesis and photorespiration, which consumes half of the gross Oxygen production. The puzzling fact is that the O₂ concentration at this crossing point (Oₓ) happens to be the composition of the pre-industrial atmosphere. Feedback controls, at the compensation point, can potentially operate around this point (See curves in mirror –image in André 2011ab). From this fact, the implication is that Oₓ is also the compensation point of the pre-industrial biosystem. A symmetrical text could be written for the CO₂ compensation point and of Cₓ, near of 280 ppm. 5.- Plant Specificity is defined from the observation that photorespiration (PR), and photosynthesis (P) of green parts of plants react to CO₂ and O₂ by laws that mimic the Rubisco laws. (André and Massimino 1986; André 2011a). It is easy to definite a Plant Specificity (Sp). If expressed in the same units, there is a simple factor between the two specificities, that is the ratio between external and internal CO₂ (André 2011d). Its measure is simple, from the knowledge of Cₓ and Oₓ, where P=PR and by the equation Sp= 2Oₓ/Cₓ in % ppm⁻¹.

C452 A type of Rubisco that is very active and able to reduce CO₂ at very low level is simulated, at plant level, by the C₄ plants (such as maize or sugarcane). These have a very low compensation point. They have a compression system of CO₂ which is able, with a very sluggish rubisco (André 2011b), to have a very high plant specificity coupled with and very little photorespiration. Their Cₓ is very low but the Oₓ very high if associated with a decomposer system. There is practically no negative feedback if O₂ increases. A biosystem based on such C₄ plants is unstable; under a high O₂ atmosphere fires would make the O₂ control, as postulated during past high CO₂ period (e.g. paleofires in Berner 1999). Hence, it is not fortuitous that the large majority of plants are of C₃ type, i.e. with high photorespiration. Moreover, André (2011b) shown that the possible gain in carboxylation by the increase of the Rubisco CO₂ affinity (factor 10) was countered during evolution by an opposite effect, the increase of the maximum rate of oxygenation higher than the rate of carboxylation. That increases the regulating effect of photorespiration, i.e. the mirror effect of curves, mentioned above,
around the crossing points. Was co-evolution between plants and atmosphere possible? The Nisbet et al paper proposes mechanisms but more concrete explanations should be the subject of further work.

References


Please also note the supplement to this comment:

Interactive comment on Solid Earth Discuss., 3, 769, 2011.