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Climate change feeds climate changes

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CO_2 record levels published by World Meteorological Association, heat records and last droughts that afflicted many continents, including the related environmental, social and economic impacts, produced important and abundant discussions about their causes.[1,2] The environmental scenario produced in these discussions calls for further evaluations since local relationships between climate, power generation, land use, plant/algae physiology and the ever-increasing anthropogenic CO_2 production have been poorly voiced. It is now consensus that, besides driving global warming, green house gases change not only animal (e.g. species distribution) but also plant physiological behaviour.[3–5] For example, consistent trends in plant evapotranspiration reduction have being observed by different researchers, which suggest a decrease in plant transpiration due to higher pCO_2-induced stomatal closure or reduced density, i.e. number of stomata per mm^2 of leaf area.[6–8] The higher atmospheric pCO_2, the smaller is the need of plants to keep their stomata open to acquire further CO_2, or to produce leaves with lower stomata density, decreasing evapotranspiration in the process. At continental scales, particularly in tropical and equatorial latitudes, this phenomenon can cause significant changes in water biogeochemical cycle, shifts in rainfall patterns, including projections of freshwater availability. This physiological process (i.e. water vapor loss by the plant to the atmosphere via the opening and closure of leaves' microscopic stomatal apertures) when taken into account over a vast ecosystem such as the Amazon Forest fills "aerial rivers". Aerial rivers are huge water volumes transported through the atmosphere by air masses and trade winds. In South America, the Amazon forest feeds one of these rivers, which are directed towards southeastern Brazil by the Andes mountain range. Discharges of such aerial system from the east of the Andes to the subtropics during the last wet seasons varied between 23 to 10 Gt H_2O. Day^{-1}, a volume comparable to the Amazon River discharge.[9] This amount represents about 3.4 trillion liters per year that appear to be transported to South American's south. If plants in the Amazon forest will not keep their stomata open for as long as they have in the last 10,000 years in order to fulfill their CO_2 needs, the daily water loss may be severely decreased under future higher atmospheric pCO_2. Adding insult to injury, tropical deforestation is also contributing to further decrease in evapotranspiration rates.[1] Increasing demand for new agricultural areas along the frontiers of the Amazon system and illegal logging in the interior of the forest continues. The former is now further fueled by the above mentioned droughts in other parts of southeastern South America and the consequent reduction in productivity of local produce. Consequently, local (ex. deforestation) together with global (ex. physiological reduction of evapotranspiration due to higher atm pCO_2) factors have been regarded as significant processes associated with increase in atmospheric drought and shifts in rain patterns.[8] In countries such as Brazil that have its energetic matrix mainly grounded in hydroelectric and thermoelectric alternatives, droughts resulted in blackouts[2] and a significant increase in consumption of fossil fuels. Due to the severe reduction in water volume across hydroelectric reservoirs in drought-affected areas, thermoelectric alternatives were put to work at their maximum capacity, immediately increasing CO_2 emissions. In the last year alone, after consistent lower precipitation seasons struck Southeastern Brazil, thermoelectric production from coal and natural gas grew more than 40%, releasing more than 6 billions of $kg.h^{-1}$ of additional CO_2 into the atmosphere. This capitalization of increment in CO_2 production can induce a climate change feedback. Results from mathematical models developed from empirical data on effect of different and increasing atmospheric pCO_2 on plant evapotranspiration reinforce the existence of a consistent shift in the magnitude of terrestrial evapotranspiration occurring in the last 150 years.[10] Lammertsma et al.[8] showed that an increment of 100 ppm of atm CO_2 resulted in a 34% (±12%) reduction in maximum, diffusive water stomatal conductance (i.e. a measure of evapotranspiration), supporting scenarios of surface temperature increases and more droughts arising from reduced evaporative cooling.[10] The drought-energy production-increase in pCO_2 emissions feedback mechanism acts on plant evapotranspiration. Further reducing atmospheric humidity, precipitation rates, water reservoir levels, hydrothermal energy production, and then increase the need of more instantaneous fossil fuel based sources of energy. This process reinforces the prediction of severe droughts in the next 30-90 years, widespread over many areas with regional and global geopolitical importance.[11] Should be highlighted that this scenario is connected with aquatic and underwater environments that play key role in the climate. Dimethylsulphide (DMS) from marine environments are a major source of cloud condensation nuclei (CCN) in the clean oceanic atmosphere. Alga, despite be recognized as O_2 producers, both in planktonic and benthic communities, synthesize DMS precursor dimethylsulphoniopropionate (DSMP). Among these primary producers rhodolith beds (maerl) standout as abundant coastal bioengineers, biofactory of carbonates, and amongst the largest macroalgal DMSP producers. High CO_2 concentration and consequent low pH waters compromise the fitness of this calcified organism, reducing their potential abundance and consequent potential production of DMSP. Considering the DMSP content in rhodolith bed from representatives from north Atlantic as parameter (637.4±407.6umol. m^{-2}) could be extrapolated that for the major Brazilian rhodolith bed formation, that cover and area of more than 20,000 km_2, we should have a stock of 1.33.1013 umol of DMSP. Brazilian is recognized to shelter the biggest rhodolith bed of the world, a kind of reef system occurring from Amazon mouth to the south of Brazil,[12] where eventual impact will change regional and eventually global dynamic of DMS availability. Experiments showed in the artic that elevated CO_2 conditions somehow reduce the DMS concentrations even in planktonic environment, despite modelling studies suggest increases in DMS emission of 30to >150%. This apparent controversy or antagonistic responses, under precaution perspective, reinforce need alternative energy production matrix once the homeostasis of planetary system seems to be under unequivocal threat. These reasoning coupled with results from different forecasts and predictive models reinforce the need of immediate shifts not only in Brazil but also in the planet's energetic matrix. Eolic and solar alternatives, changes in land use, equatorial forest preservation, and the development of new low or no CO_2 emitting thermoelectrical technologies should replace greenhouse gas-producing sources of energy (e.g. current coal and gas thermoelectric power plants) or the world most likely will anticipate extreme and dramatic shifts in climate patterns as predicted by IPCC.[12,13]

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Conflict of interest

This paper was resulted of meetings in Brazil and in Portugal where climate changes feedbacks were discussed with the participation of all authors, which contributed with their expertizes providing information and all bases to hypothesis, discussions and statements.

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