Exploring the evolution of Earth's habitability regulated by oxygen cycle

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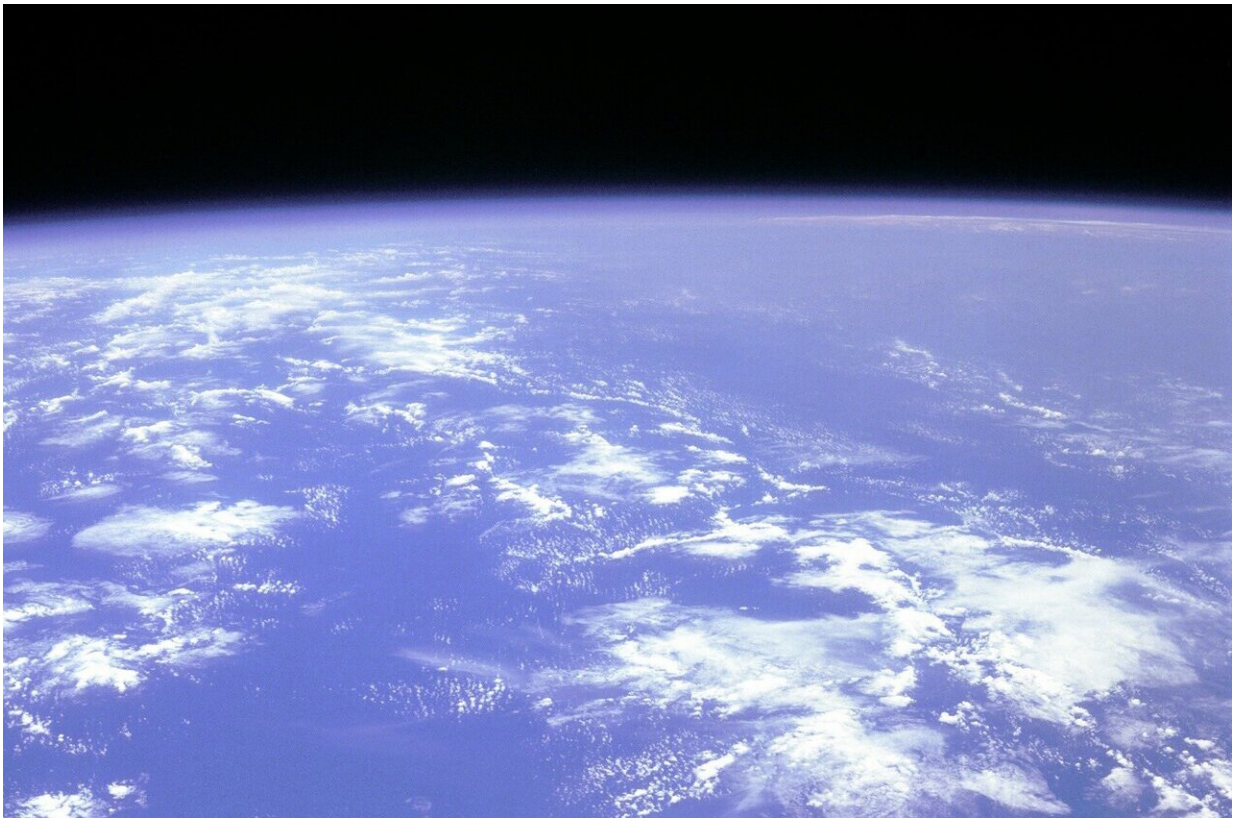

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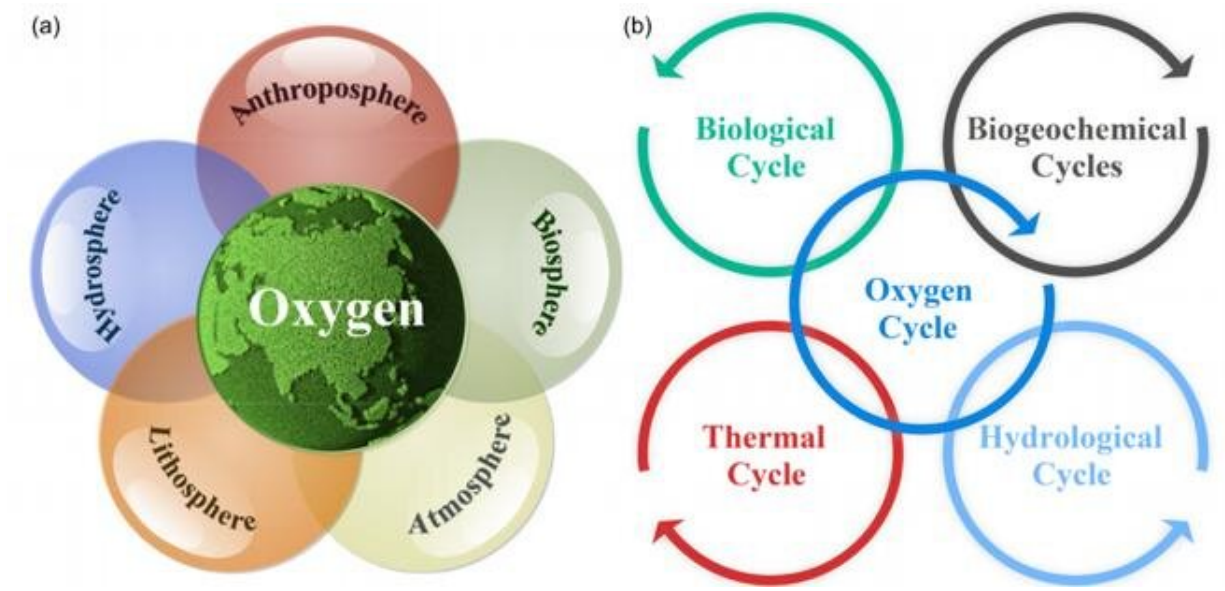
As an essential material for the survival and reproduction of almost all aerobic organisms, oxygen is closely related to the formation and development of complex organisms. A recent review provides a

systematic overview of the latest advances in the oxygen cycle at different spatial and temporal scales and the important role that oxygen plays in shaping our current habitable Earth.

Professor Jianping Huang from Lanzhou University is the corresponding author of the review entitled "The oxygen cycle and a habitable Earth," which is the cover article of the April issue *Science China Earth Sciences* in 2021.

Based on summarizing the latest research results of predecessors, the authors of this paper propose a coupling model of the five spheres of the earth system with the oxygen cycle as the core, and clarify the link role of the oxygen cycle in it. In this paper, the authors comprehensively summarized the changes of oxygen cycle and its effect on the habitability of the earth on multiple time scales including modern and geological time, and prospected the future development trend of oxygen cycle research.

"We take O_2 for granted because it is just there and we breathe it all the time, yet it took billions of years before there was enough of it to keep animals like us alive." Professor Jianping Huang of Lanzhou University, the corresponding author of the paper, points out, "These processes involve the interaction of various spheres of the Earth system, which are complex interdisciplinary issues with multiple temporal and spatial scales." In this paper, the authors illustrate how the key biochemical processes in the oxygen cycle tie together the various spheres of the Earth system through feedback and interaction. "A habitable Earth gradually formed during the long evolution of the oxygen cycle."



The status of the oxygen cycle in Earth system science (a) and its relationship with other biogeochemical cycles (b). Credit: Science China Press

The effects of current human activities on the oxygen cycle and biodiversity are also discussed. "Four of the five large-scale species extinctions that have occurred in the history of the earth are related to the lack of oxygen," Professor Huang concluded, "At present, under the compulsion of human activities, our planet is experiencing a large-scale oxygen reduction, with the ocean deoxygenation as a representative. The oxygen cycle of the Earth system is gradually out of balance, which is very worrying."

Studies of the oxygen cycle cover a wide span of timescales from daily to geologic scales. The oxygen cycles of different timescales dominate the control of atmospheric O_2 over the corresponding timescales. However, a distinct boundary that divides the long-term and short-term oxygen cycles has yet to be established, and the complex interactions between the short-term and long-term processes remain unclear. Since

the earth system is a highly non-linear and strongly coupled system, a minor perturbation can have the potential to cause a series of dramatic changes. "It is a top priority to connect the short-term and long-term oxygen cycles under a comparable timescale rather than separating them.

Effective multidisciplinary cooperation among the subdisciplines of Earth sciences (geology, oceanography, atmospheric sciences, paleobiology, etc.), and social sciences should be promoted to reveal the hidden mechanisms that control the trajectory of the Earth system and how the trajectory may influence the future of human beings." said Prof. Huang. Fortunately, efforts have been made to reverse the decline of atmospheric O_2. In China, the Green Great Wall, which was designed to mitigate desertification and expand forests has achieved overall success in past decades. Reductions in carbon emission and its related O_2 consumption have been achieved in some major cities around the world.

This study has far-reaching scientific significance and important reference value for understanding the potential link between the oxygen cycle and the biodiversity in geological history and exploring the historical evolution and future of the Earth's habitability.

More information: Jianping Huang et al, The oxygen cycle and a habitable Earth, *Science China Earth Sciences* (2021). DOI: 10.1007/s11430-020-9747-1

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