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Exploring the Earth

Element Cycles and the Climate System

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The images were provided by employees of the Max Planck Institute for Biogeochemistry,
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Our mission: to investigate how global element cycles interact with the climate system.

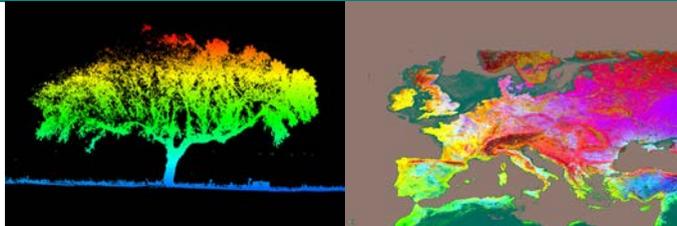
Cycles of Essential Elements

Biogeochemistry is the study of Earth's metabolism. Elements essential for life, such as carbon, nitrogen, oxygen, and phosphorous, are continuously subject to biological, chemical, and physical transformations as they are exchanged among the Earth's lithosphere, hydrosphere, biosphere, and atmosphere.

"Biogeochemical cycles" are quantitative descriptions of how elements are distributed and exchanged among these "spheres".

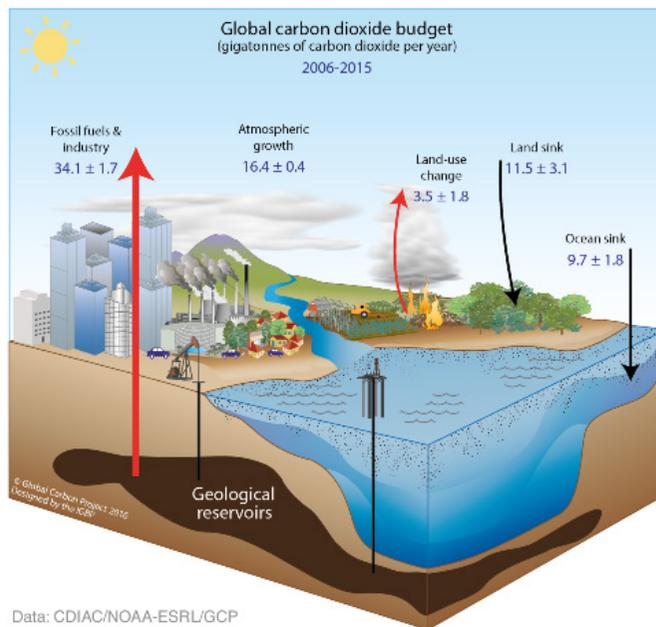
For example, the element carbon can exist as the gases carbon dioxide and methane in the atmosphere, as organic molecules in organisms, soils and sediments, and in dissolved inorganic and organic forms in surface waters and oceans. Processes exchanging carbon between organic and gaseous forms include photosynthesis, respiration, and decomposition, while soluble inorganic forms can exchange with solid carbonate minerals. Living organisms mediate most of the processes transforming carbon from one form to another and the rates vary with environmental conditions.

There is no Earth unaltered by humans available for comparison, nor can we go back in time.



Earth System and Climate

Biogeochemical cycles interact in complex ways with Earth's climate. They control variations in the atmospheric concentrations of greenhouse gases like carbon dioxide (CO₂), water vapor (H₂O), methane (CH₄), and nitrous oxide (N₂O), which in turn affect the radiative balance of the atmosphere. Large-scale changes in land surface vegetation also influence physical climate through their impact on the surface energy balance.



Disturbance of the global carbon cycle through anthropogenic activities averaged globally for the decade 2007-2016 (GtCO₂/yr), Source: Global Carbon Project <http://www.globalcarbonproject.org/carbonbudget/index.htm>

Our Research

Our Institute aims to better understand the role played by land biota in global biogeochemical cycles. We focus on land because it is where humans live, and because the role of land is among the largest uncertainties in global budgets of carbon (C), nitrogen (N), phosphorus (P), and water.

Our scientists prioritize observing and understanding current and ongoing changes in the Earth System. Activities associated with increasing human demands for energy, water and food have fundamentally altered global biogeochemical cycles and caused rapid increases in atmospheric greenhouse gases, and therefore Earth's climate.

The study of the Earth System differs from standard reductive methods of science. We have only one Earth, and its properties are inexorably linked to its unique evolutionary history.

The changes we are currently imposing on the Earth System provide opportunities to learn how it operates by observing its responses. However, we are conducting unplanned experiments, with many factors changing at the same time and no 'control' – no Earth unaltered by humans for comparison. Furthermore, our ability to observe the complete Earth System in all its aspects is quite limited.

Diversity of Methods

We take advantage of lab and field experiments, measurements in ecosystems, on aircraft, and from satellites. We analyze air, water, and soil samples using biomarkers and stable isotopes.

To handle all the complex interactions and to make large leaps in scale, we rely on conceptual and computational models and data analysis by machine learning to test our understanding of the processes determining the state of the Earth System and how it responds to changes.

