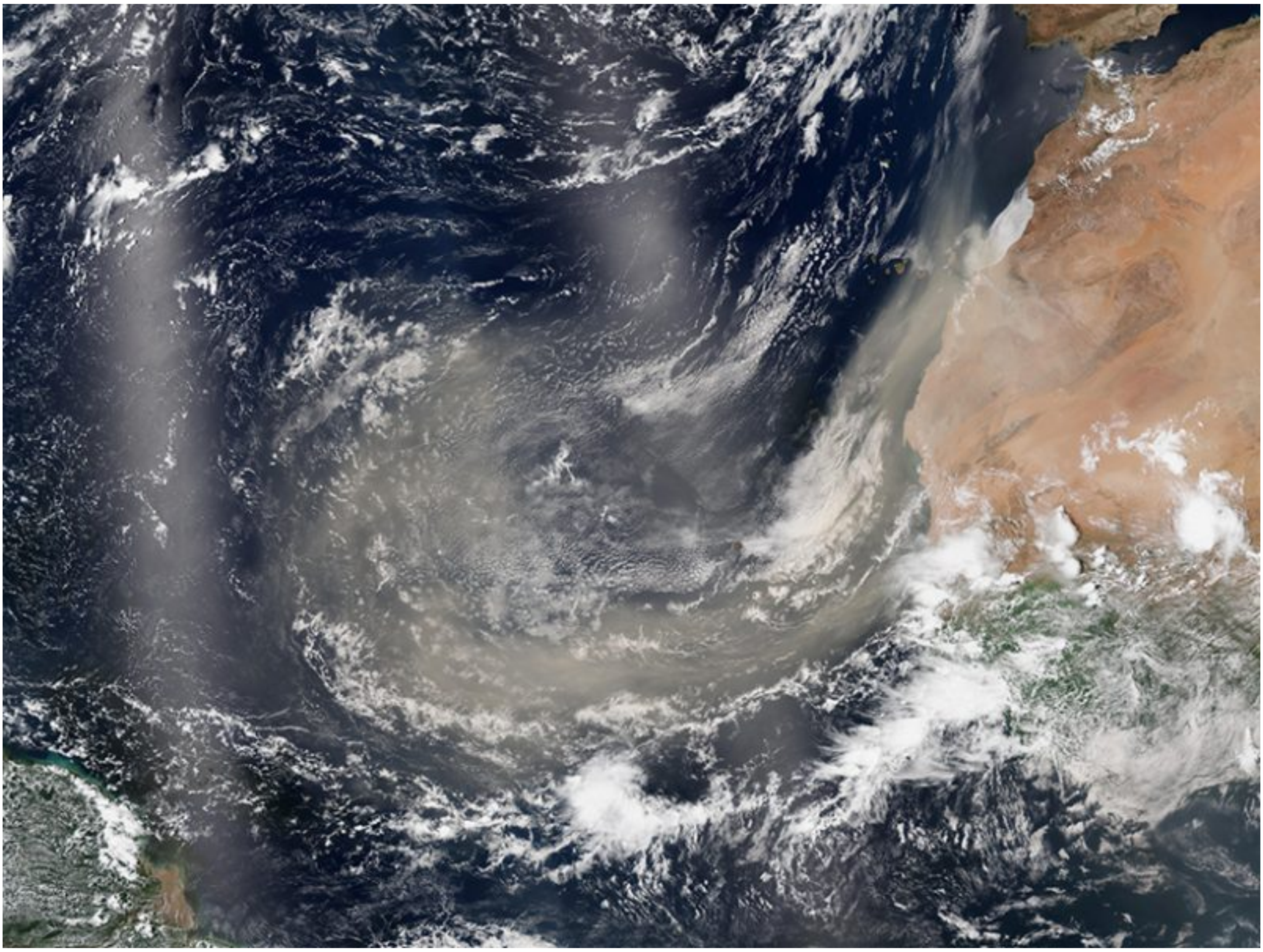
A Novel Approach Reveals Element Cycles in the Ocean

Dissolved thorium isotopes light the way to a more thorough understanding of how different elements enter marine environments—and how long they stay there.

Source: Global Biogeochemical Cycles



Dust storms from the Sahara supply many important chemical elements to the ocean. In a new study, researchers test how thorium can be used to quantify these elemental fluxes, which can be difficult to measure directly. Credit: NASA

By Aaron Sidder 16 January 2019

The ocean covers 72% of Earth's surface and plays a vital role in global biogeochemical cycles (https://nca2014.globalchange.gov/report/sectors/biogeochemical-cycles). The carbon (https://eos.org/research-spotlights/plumbing-the-depths-of-the-marine-carbon-cycle) and nitrogen cycles (https://eos.org/research-spotlights/a-new-mechanism-for-nitrogen-cycling-in-the-southern-ocean) receive ample attention because of their impact on the climate and nutrient availability for living organisms (https://eos.org/features/interpreting-mosaics-of-ocean-biogeochemistry), but many other elements contribute to both marine and terrestrial ecosystems. For instance, micronutrient trace elements can impact photosynthesis rates and carbon dioxide uptake by the ocean (https://eos.org/research-spotlights/shedding-light-on-the-southern-ocean-carbon-sink).

The lack of globally distributed monitoring equipment and environmental hurdles, both at and below the water surface, make it challenging to comprehensively measure ocean chemistry accurately. Scientists struggle to model (https://eos.org/features/assessing-a-new-clue-to-how-much-carbon-plants-take-up) abundant elements like carbon, let alone trace elements that are even more diluted. Modeled estimates of the residence time (https://www.e-education.psu.edu/earth540/content/c3_p7.html) for iron, for example, span 2 orders of magnitude, ranging from 4 to 560 years.

One way to derive the quantities of hard-to-measure elements is to use thorium, specifically, dissolved thorium isotopes. In a novel application of GEOTRACES (http://www.geotraces.org/) biogeochemical data, *Hayes et al.* (https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2017GB005839) quantified the flux of thorium entering the sea via continental sources. Thorium-230 is produced by the steady decay of uranium isotopes, and thorium-232 is released into the ocean by continental material like aerosol dust (https://eos.org/meeting-reports/the-impact-of-african-dust-on-air-quality-in-the-caribbean-basin) and seafloor sediments. By comparing the stable marine isotope with the fluctuating terrestrial isotope, the researchers tracked how much of the isotope could be attributed to continental sources.

They were able to extrapolate the thorium cycle to seven bioactive elements using the ratio between the element and thorium in water samples to derive the replacement times of each element. The replacement time is the amount of time it would take for the sources of an element to replace the amount of that element in a given volume of seawater. Using the thorium-based approach, the replacement times for the sampled bioactive elements ranged from around 5 years to more than 50,000 years.

The proof of concept presented here by the authors offers a relatively simple new approach to biogeochemical modeling while also providing insights into element cycling between land and sea. The thorium-based method proved especially useful for constraining bioactive elements like iron (https://eos.org/articles/iron-fertilization-might-not-make-oceans-better-carbon-sinks) and manganese that cycle quickly through the ocean. If specific elemental sources (e.g., groundwater and estuarine water) could be better defined, the authors believe their method could provide an even more comprehensive assessment of trace elements in the ocean. (*Global Biogeochemical Cycles*, https://doi.org/10.1029/2017GB005839 (https://doi.org/10.1029/2017GB005839), 2018)

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