Iron boost from wildfire smoke a plus for Southern Ocean carbon cycle

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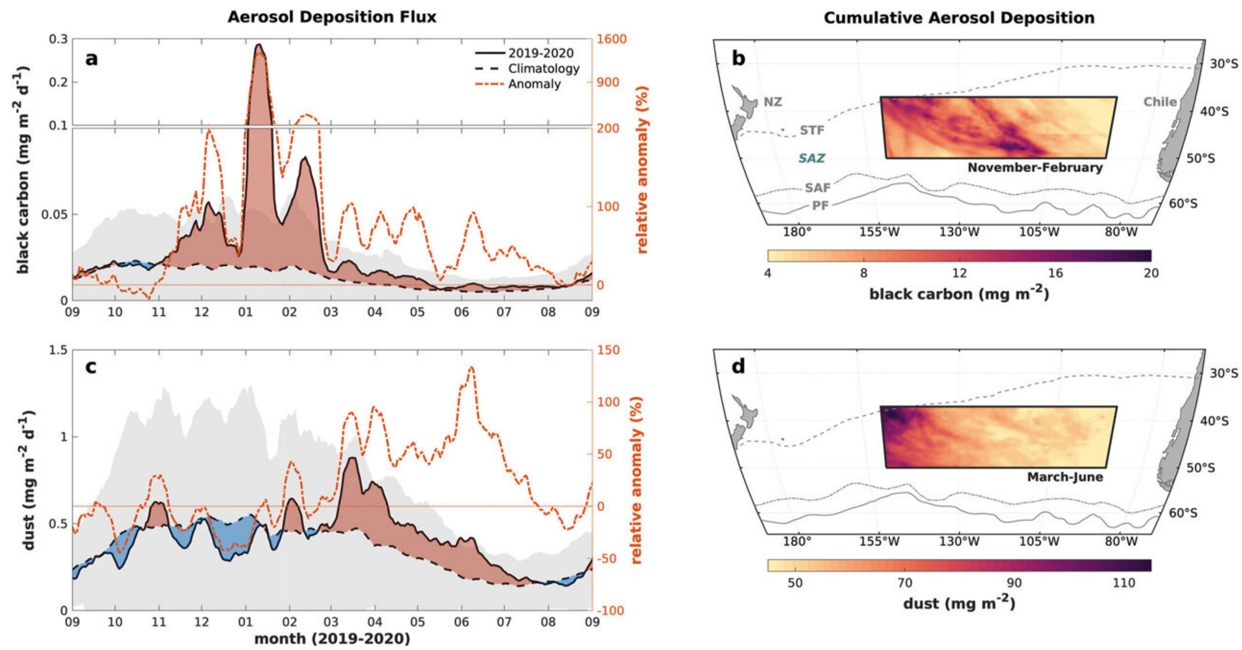

Black carbon (BC) and dust deposition over the Pacific sector of the Southern Ocean during the 2019–2020 austral summer. (a and c), September 2019–2020 BC and dust deposition fluxes averaged over the bloom region (solid lines). Climatological fluxes and standard deviations are shown as dashed lines and gray shades. Red and blue shaded areas indicate positive and negative anomalies. Relative 2019–2020 anomalies are plotted on the secondary Y-axis (red dash-dotted lines). (b and d), Cumulative BC and dust deposition on the bloom region integrated over their respective peak deposition periods. Gray lines indicate, from north to south, the locations of the subtropical front, the subantarctic zone, the subantarctic front, and the polar front (Orsi et al., 1995). Credit: *Geophysical Research Letters* (2022). DOI: 10.1029/2021GL097538

When smoke from the 2019–2020 Australian wildfires billowed across the Southern Ocean, the iron-rich particles it deposited on the ocean triggered an algae bloom bigger than Australia—and it had a rapid and prolonged impact on the Southern Ocean's marine ecosystem and its carbon cycle.

In a new Institute for Marine and Antarctic Studies (IMAS) led study, scientists found that the iron from the devastating wildfires was recycled inside the bloom, allowing it to survive for an unprecedented nine months. The unexpected iron boost also triggered distinct physiological responses in phytoplankton cells, which are the microscopic "drifting plants" at the base of the ocean's food chain.

"The Southern Ocean plays a vital role in the global carbon cycle, and is responsible for almost half of the annual transfer of carbon from surface waters to the ocean's abyss," said IMAS Ph.D. candidate and lead author, Jakob Weis.

"Phytoplankton have a key role in this transfer through a process called the ocean's biological carbon pump, which captures and shuttles carbon into the deep ocean in sinking oceanic plants and animals.

"The problem is that phytoplankton need iron to thrive, and the Southern Ocean is deficient in this essential micronutrient. So its biological carbon pump is not as effective as it could be—and that's where wildfire ash and desert dust come into play," Jakob said.

"We know wildfire ash and mineral dust are rich in iron and, as we saw after the recent wildfires, phytoplankton growth is stimulated when these particles are deposited on the Southern Ocean's surface. But the full impact of this on marine ecosystems has not been measured until now."

The intense single fertilization event from Australia's wildfires was an opportunity for scientists to study phytoplankton's physiological response to wildfire emissions, and its ability to survive on its own recycled iron.

"We used observations from satellites to study this, and found that phytoplankton cells became richer in pigments and more efficient in their photosynthesis," Jakob said. "Just like plants on land, phytoplankton absorb CO_2 and produce oxygen during photosynthesis—and when that process is more efficient, so is the biological carbon pump."

IMAS chemical oceanographer and co-author, Professor Zanna Chase, said the responses the research team identified could be directly attributed to wildfire emissions.

"They have been previously observed in iron fertilization experiments conducted during research voyages, as well as after natural fertilization from dust, volcanic ash, and iron rising up from the deep ocean," Prof Chase said. "Phytoplankton blooms don't usually survive longer than a few weeks, so the duration of this bloom was astounding and has rarely been observed before on such time scales."

The study team found that the phytoplankton bloom outlasted the wildfires by almost half a year, surviving through extended periods when iron was only sporadically supplied by wildfire emissions and mineral dust. "The iron sustaining the bloom came from iron recycling, which occurs when iron is released back into the water when a phytoplankton cell dies, to be reabsorbed by new cells," Prof Chase said.

"The bloom's ability to reuse its own iron for such a long time was likely due to its vast size, which slowed down the loss of internally recycled iron at the bloom edges—and this was helped by occasional ash and dust deposits."

Jakob said the event showed how quickly the Southern Ocean's carbon pump responds when iron reaches it in large quantities and is spread over a significant area.

"Importantly, it confirms the vital role the Southern Ocean and its plant life play in the global carbon cycle," he said.

The study was published in *Geophysical Research Letters*.

More information: Jakob Weis et al, Southern Ocean Phytoplankton Stimulated by Wildfire Emissions and Sustained by Iron Recycling, *Geophysical Research Letters* (2022). DOI: 10.1029/2021GL097538

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