

Unique features of the Southern Ocean relevant to the biological carbon pump: Freshly produced marine humics control iron biogeochemistry and likely result in extremely variable iron bioavailability.

**CHRISTEL HASSLER^{1,2,3}, MARION ANNE FOURQUEZ^{3,4},
RAFEL SIMÓ⁵, SARAH FAWCETT⁶, MICHAEL J
ELLWOOD⁷ AND SAMUEL L JACCARD²**

¹EPFL, Smart Environmental Sensing in Extreme Environments (SENSE)

²University of Lausanne, Institute of Earth Sciences

³University of Geneva

⁴Mediterranean Institute of Oceanography

⁵Institut de Ciències del Mar

⁶University of Cape Town, MARIS

⁷Australian National University

Iron is essential for marine photosynthesis but sparingly soluble in seawater. As such, iron supply controls primary productivity in up to 40% of the world's ocean, including most of the Southern Ocean - a prime region for ocean-climate feedbacks. Here, we show that primary producers' ability to acquire iron (also called iron bioavailability) is much more variable in the Southern Ocean than elsewhere¹. This variability limits our understanding of the biological carbon pump in this vast region. Iron-binding organic ligands are critical to maintaining iron in solution and modulate its bioavailability, but their unknown nature represents a major roadblock in relating iron biogeochemistry to primary productivity and the biological carbon pump. Despite recent studies showing that humics could form most iron-binding ligands in the ocean, their nature and sources remain loosely defined. Here, we present a comprehensive dataset from contrasting Southern Ocean regions that identifies exopolymeric substances from phytoplankton and bacteria as the bulk of iron-binding humics and ligands². A data compilation from the global ocean shows that this is a unique feature of the southernmost ocean waters², which incidentally could explain their highly variable iron bioavailability¹. While phytoplankton humics control iron biogeochemistry, bioavailability and cycling in surface waters, humics produced or reprocessed by bacteria affect iron cycling and residence time at the scale of the global ocean. Thus, autochthonous and freshly released organic matter critically controls primary productivity and ocean/climate feedbacks in iron-limited regions. These substances urgently deserve further attention to better constrain the biological carbon pump.

1 Fourquez, M., *et al.* Chasing iron bioavailability in the Southern Ocean: Insights from *Phaeocystis antarctica* and iron speciation. *Sci. Adv.* 9, 2023.

2 Hassler, C.S., *et al.* Biologically produced humic substances