Impacts of sea ice on the iron cycle and marine ecosystems

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with

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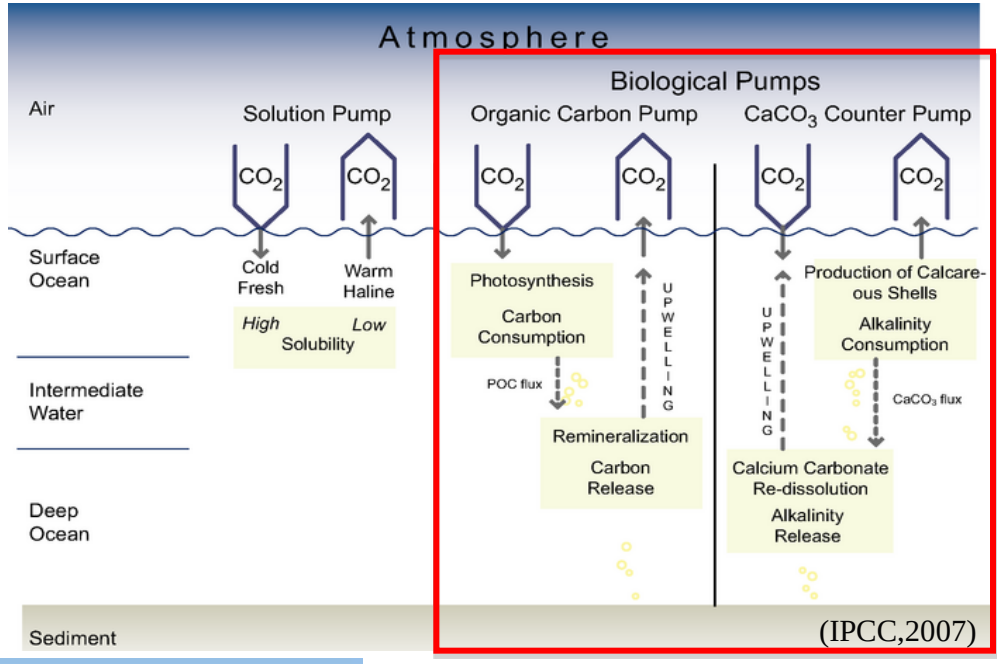
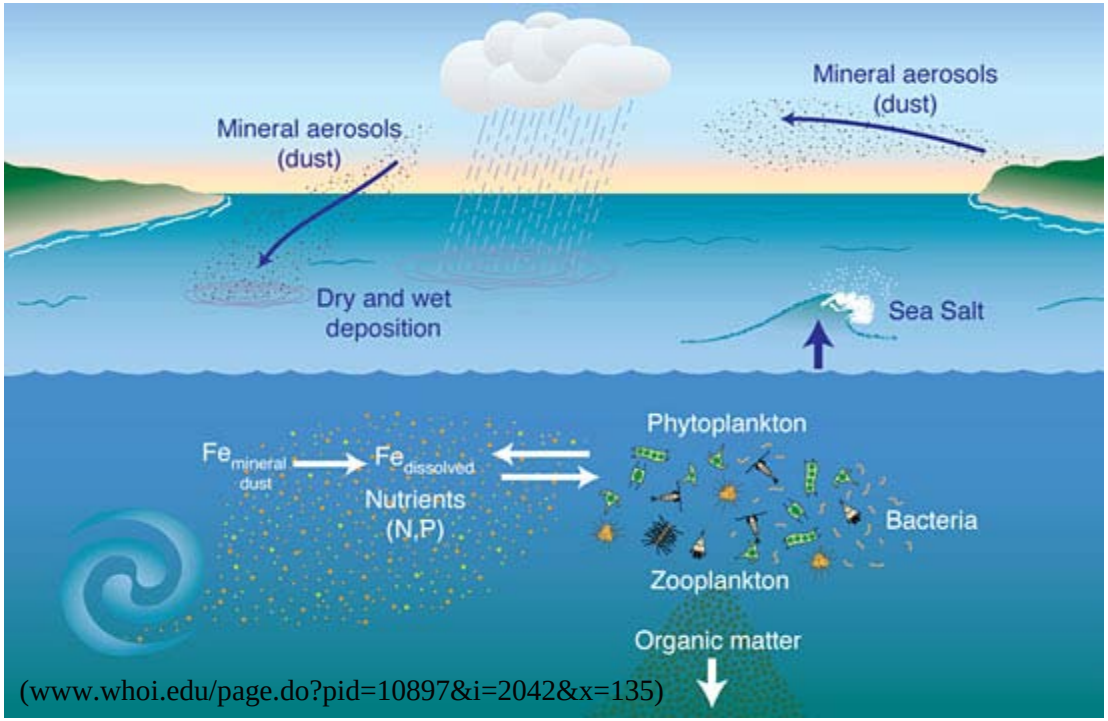
Motivation

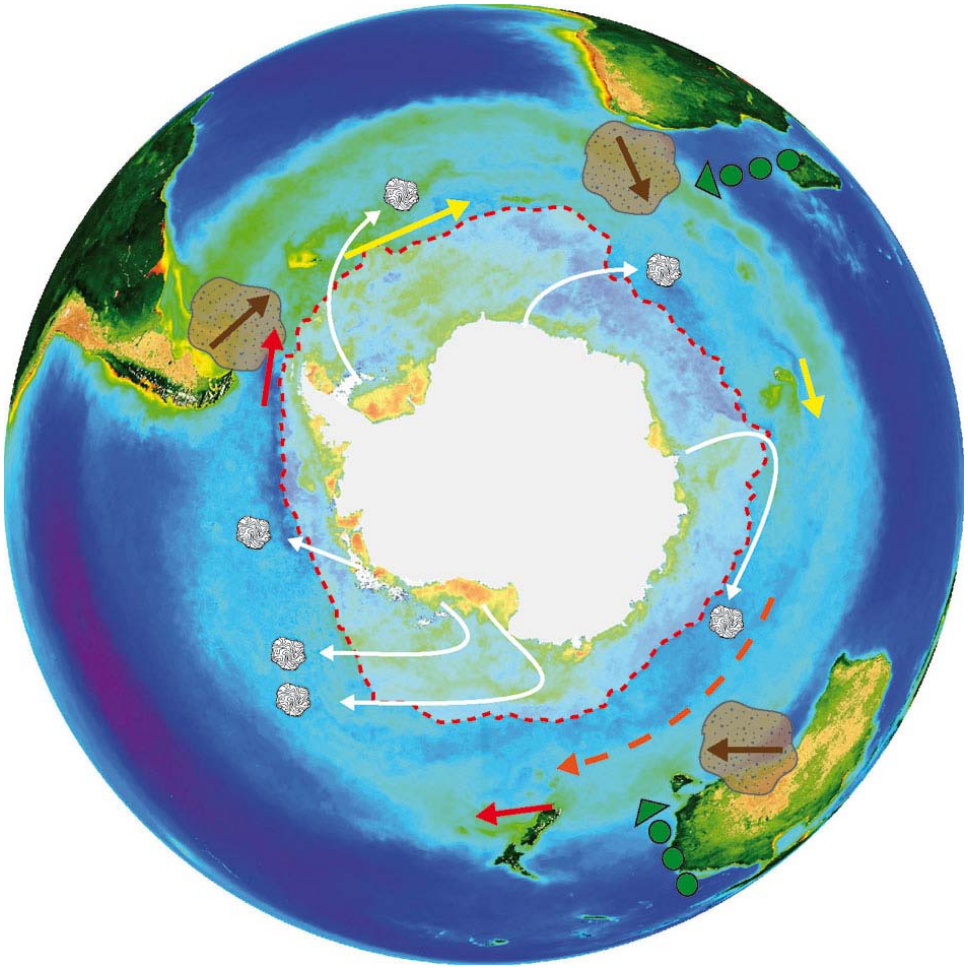
- Marine ecosystems play an important role in the global carbon cycle





- Iron is an essential nutrient for phytoplankton growth

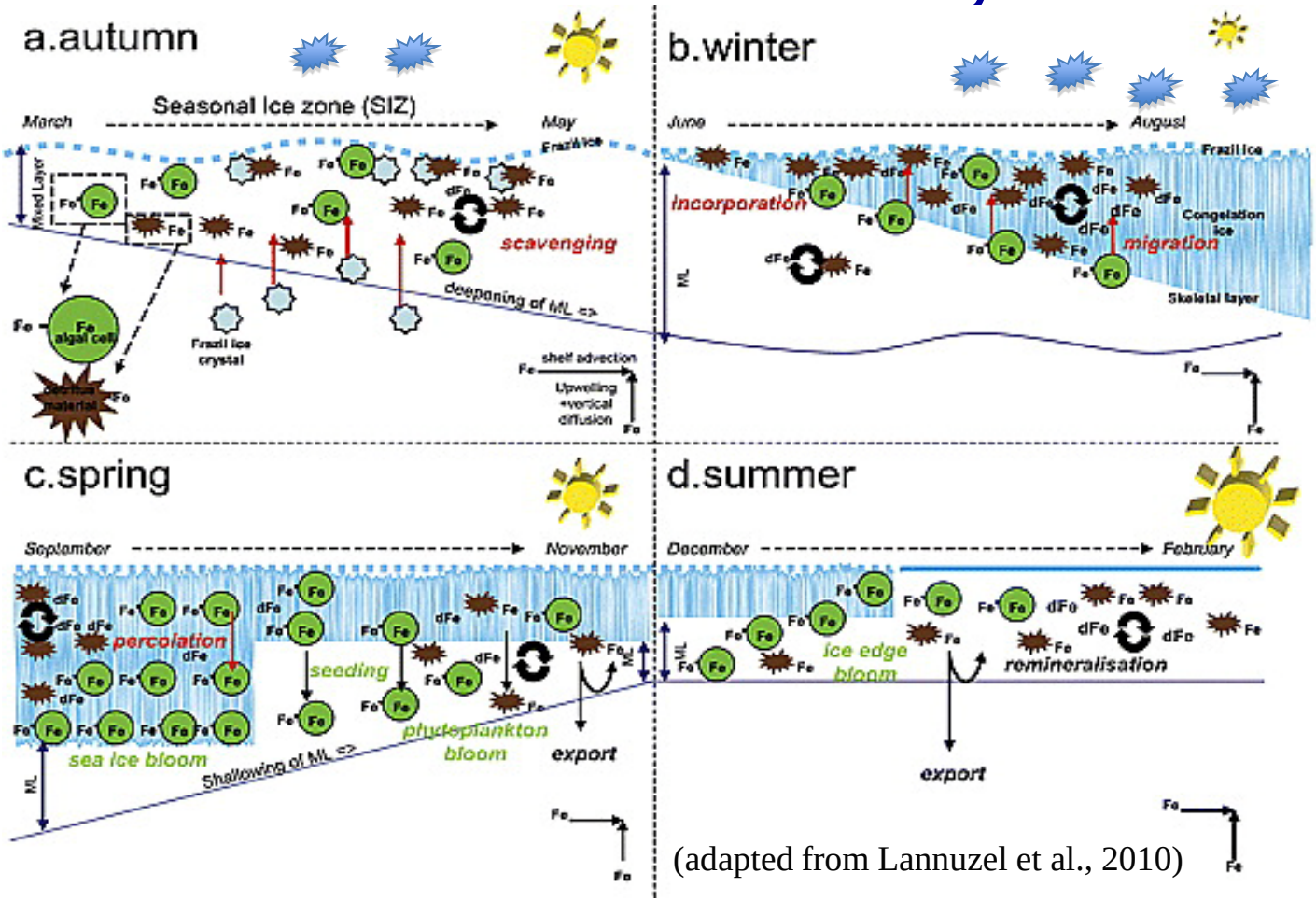
Different sources of iron to the ocean



(from Boyd and Ellwood, 2010)

- Dust deposition
- Lateral transport of iron-rich sediments
- Eddy shedding/sediment entrainment
- Bathymetric interactions
- Iceberg drift and melt
- Seasonal ice-melt

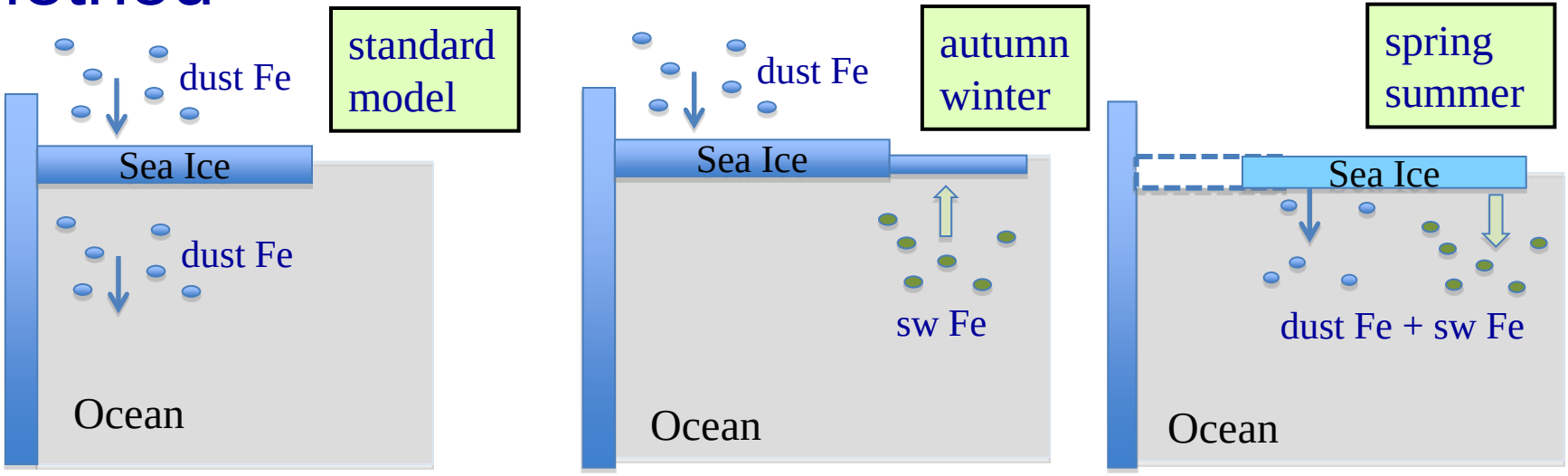
Impacts of sea ice on the iron cycle



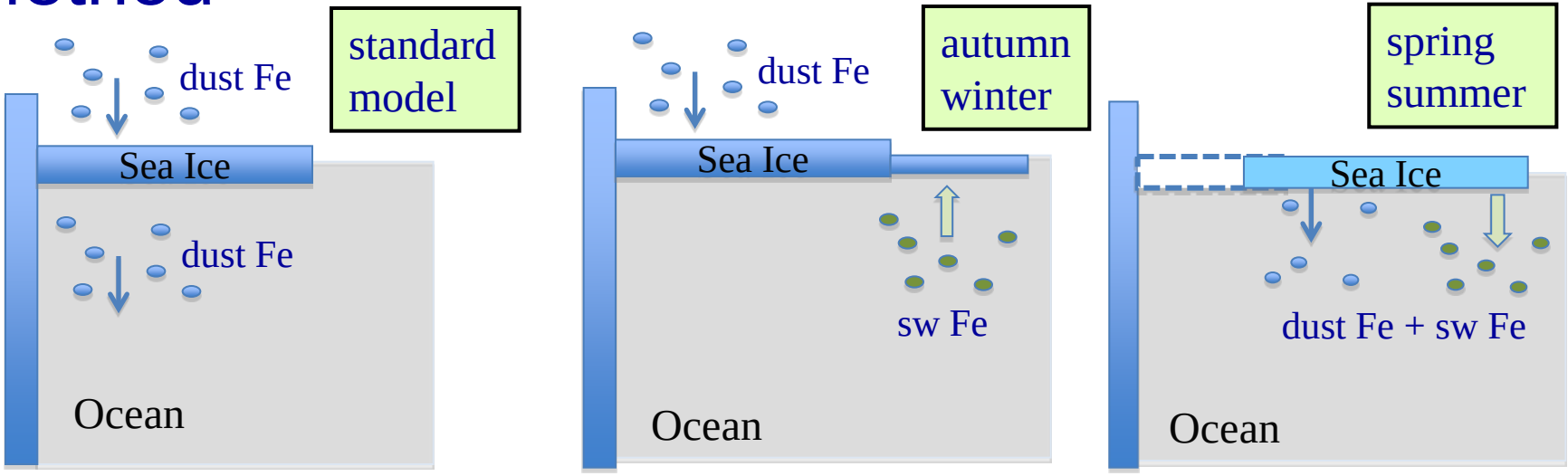
(adapted from Lannuzel et al., 2010)

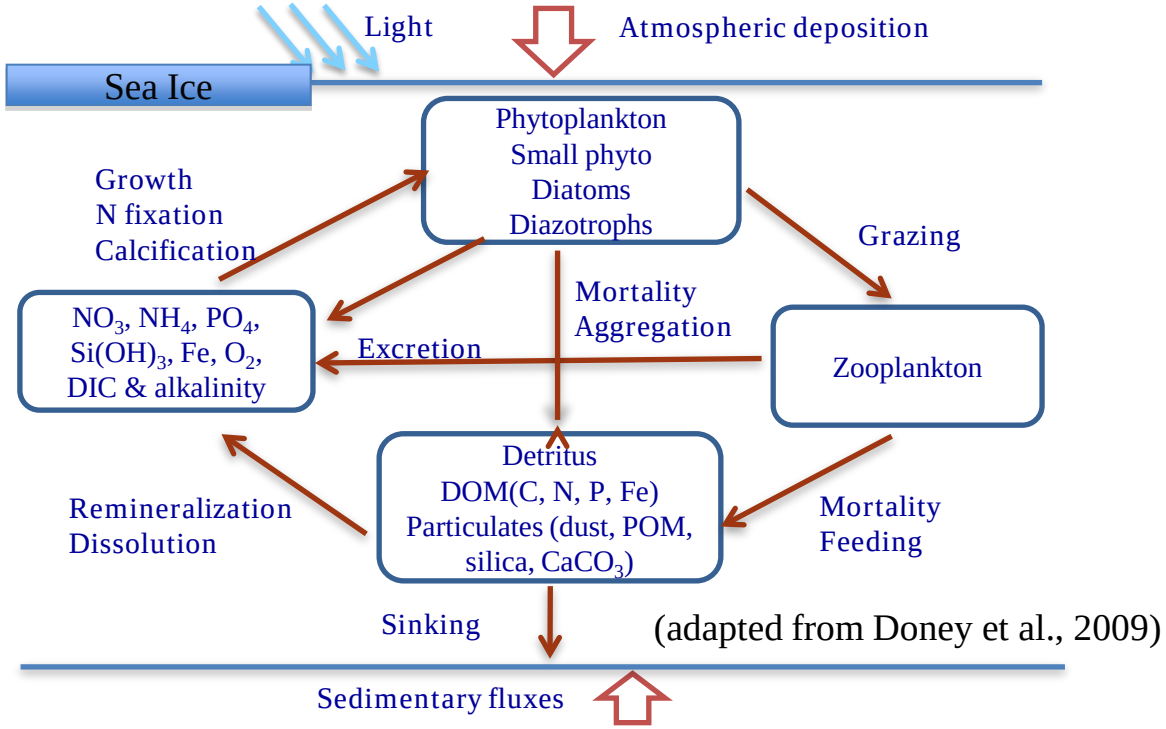
- Iron is captured from atmospheric deposition and during ice formation, transported by ice, and released during ice melt.
- How does sea-ice iron transport affect marine ecosystems?

Method


standard model
dust Fe
Sea Ice
dust Fe
Ocean
autumn winter
dust Fe
Sea Ice
sw Fe
Ocean
spring summer
Sea Ice
dust Fe + sw Fe
Ocean

Method

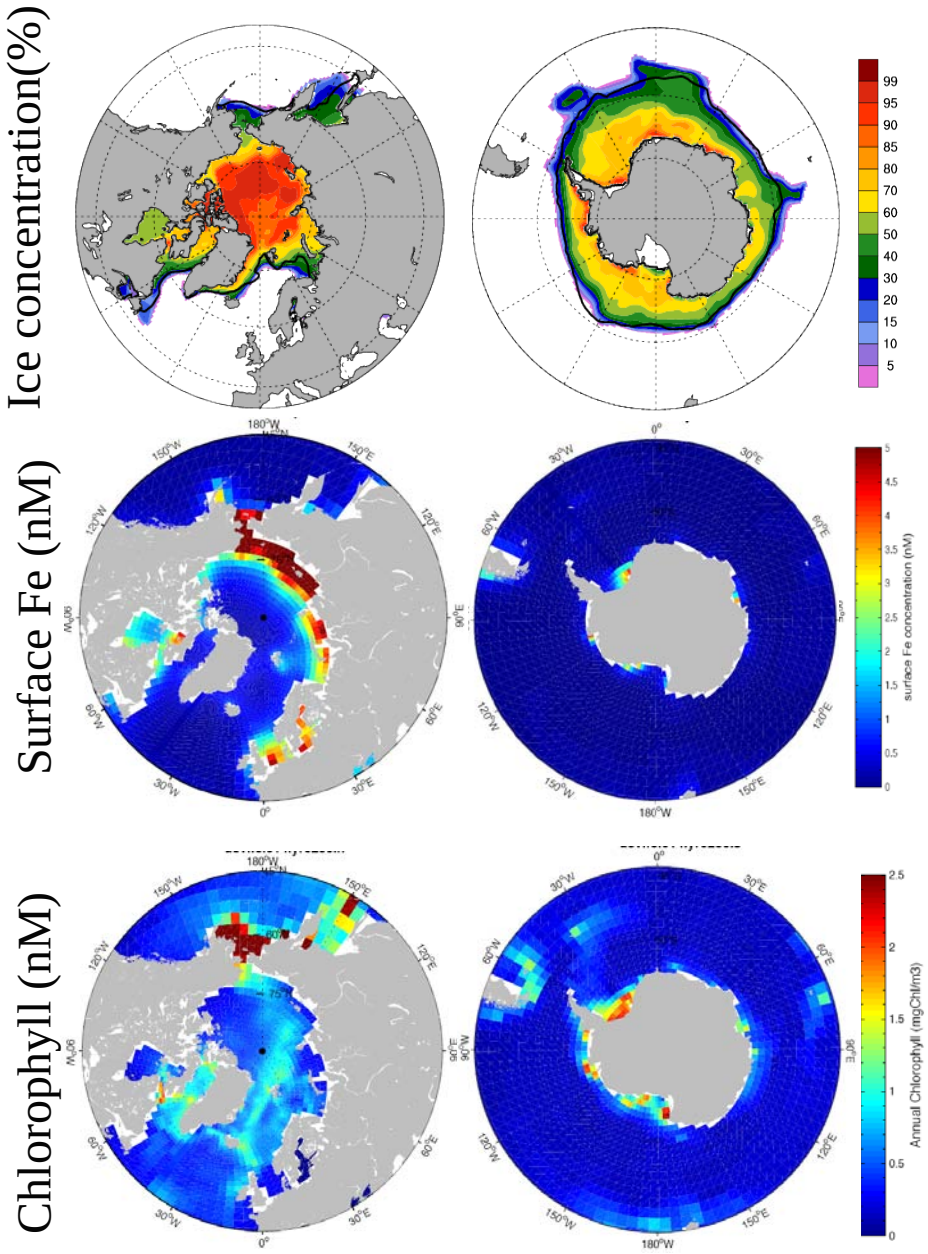




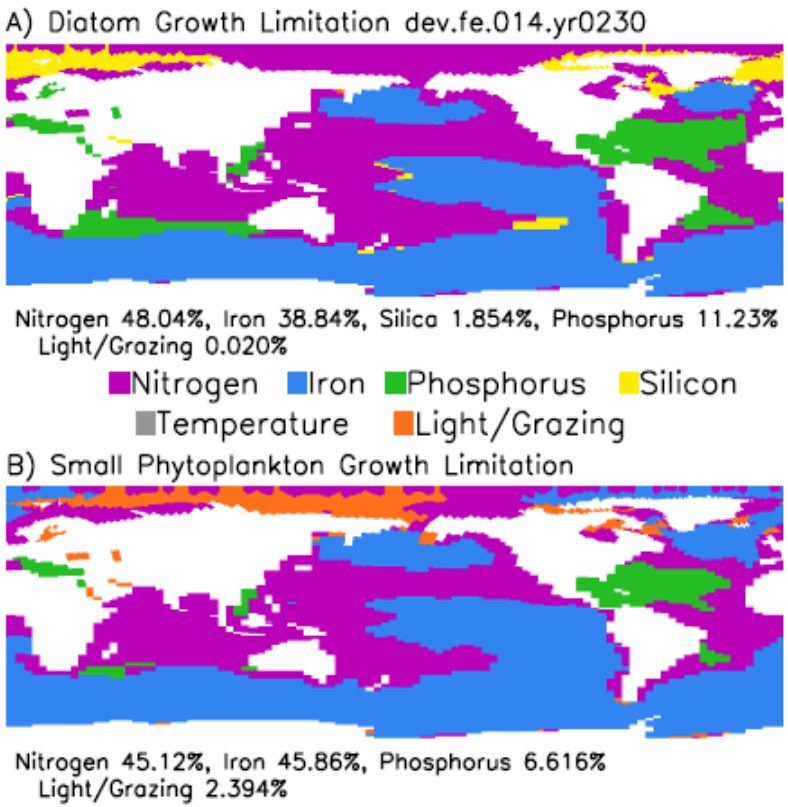
(adapted from Doney et al., 2009)

- NCAR CESM1 coarse resolution (3.6° lon x 0.9° -2.0° lat)
- Sedimentary source of dissolved iron by Moore and Braucher (2008).
- Atmospheric iron deposition from Mahowald et al.(2008).

Model Results



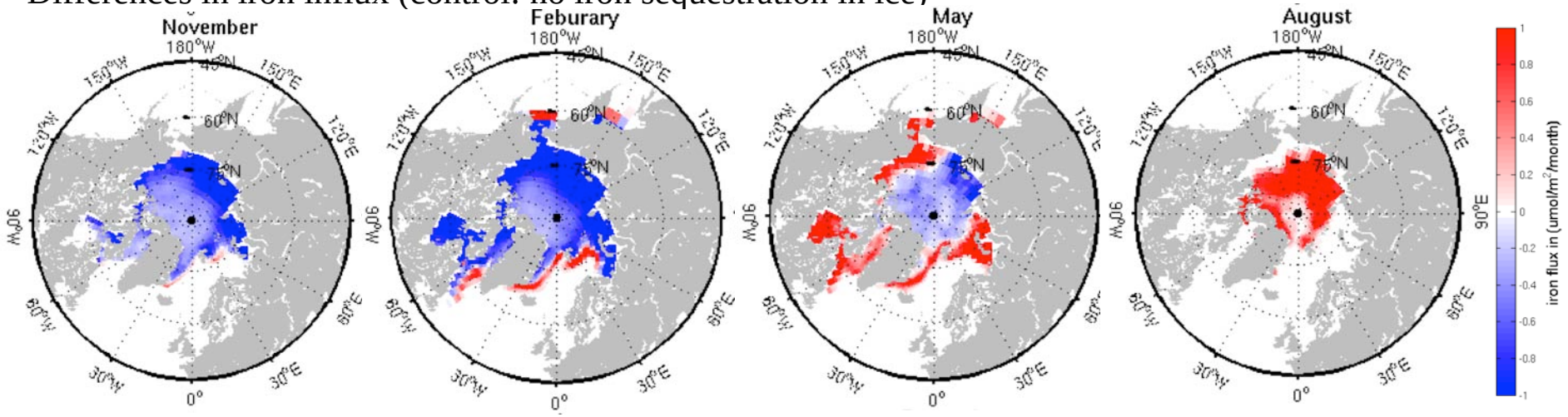
Most Limiting factors for growth



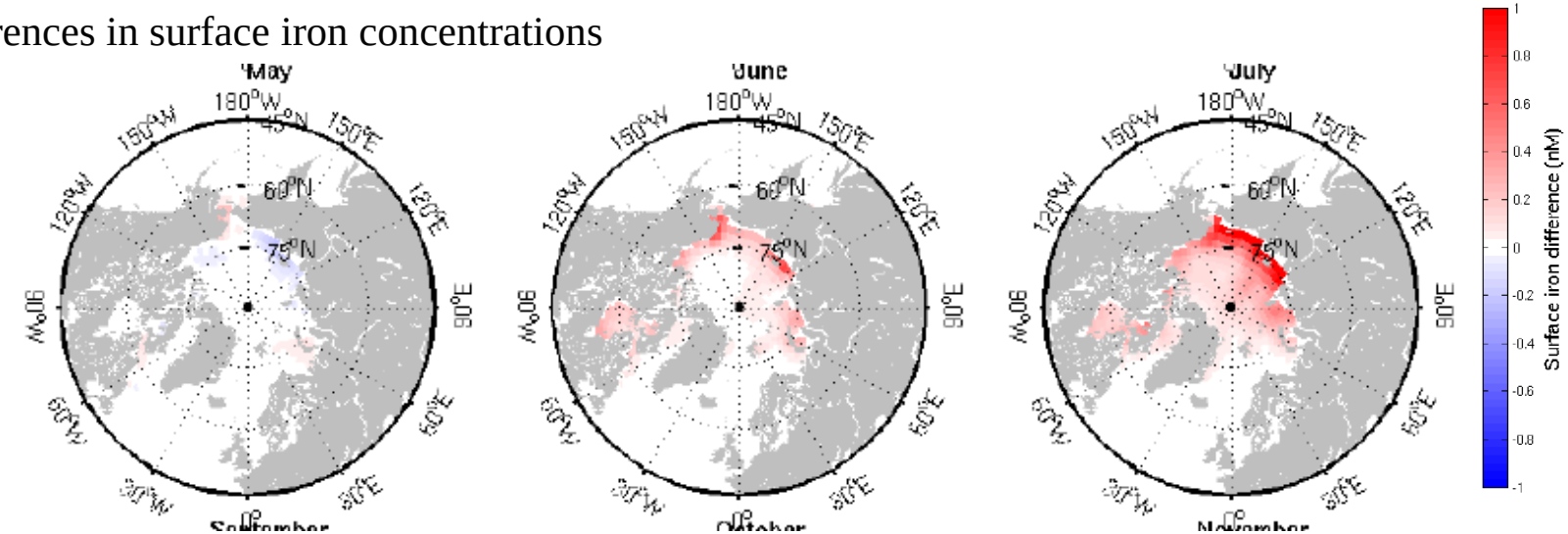
- Phytoplankton growth is mostly limited by iron in large areas of the Southern Ocean.
- Iron concentrations are generally high near Arctic.

Impacts of sea ice

Differences in iron influx (control: no iron sequestration in ice)



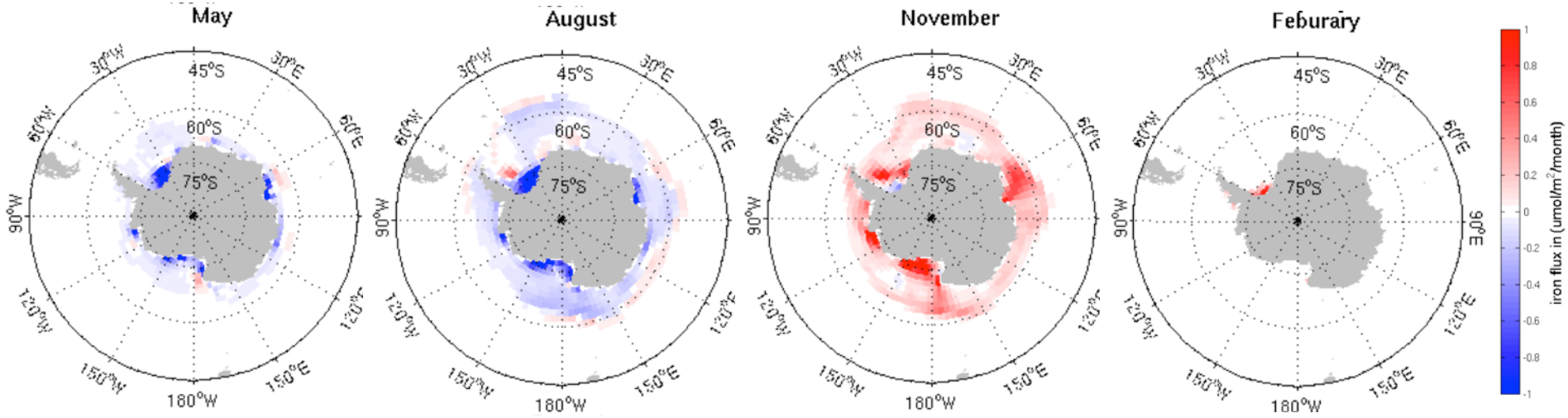
Differences in surface iron concentrations



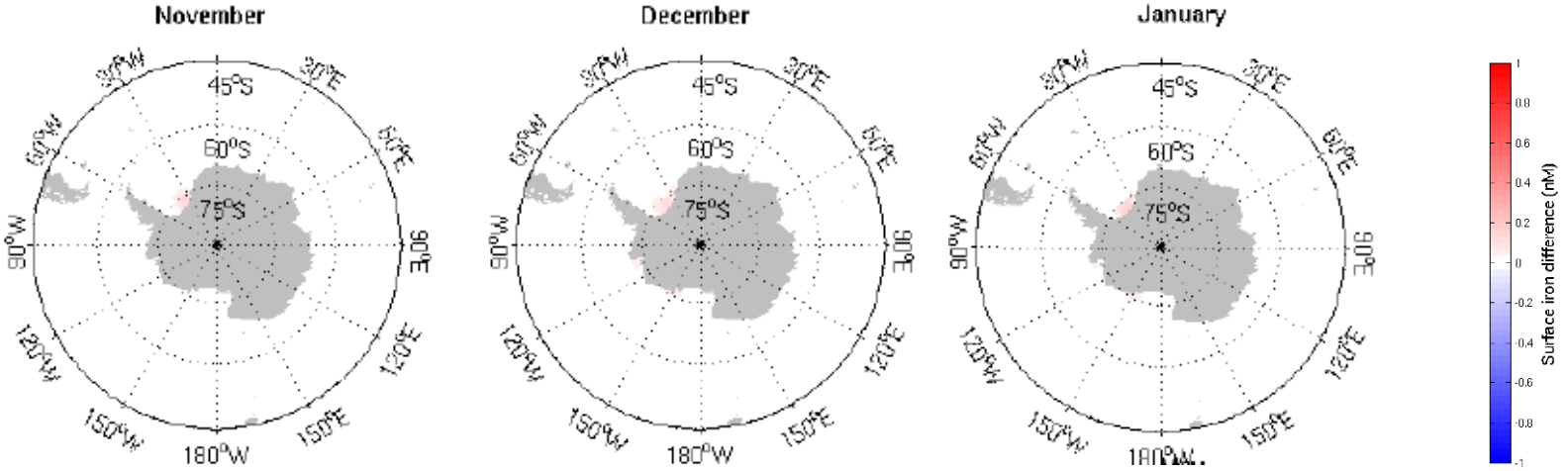
- The seasonal sea ice dynamics can alter the timing, location, and magnitude of iron fluxes into the ocean.

Impacts of sea ice

Differences in iron influx (control: no iron sequestration in ice)

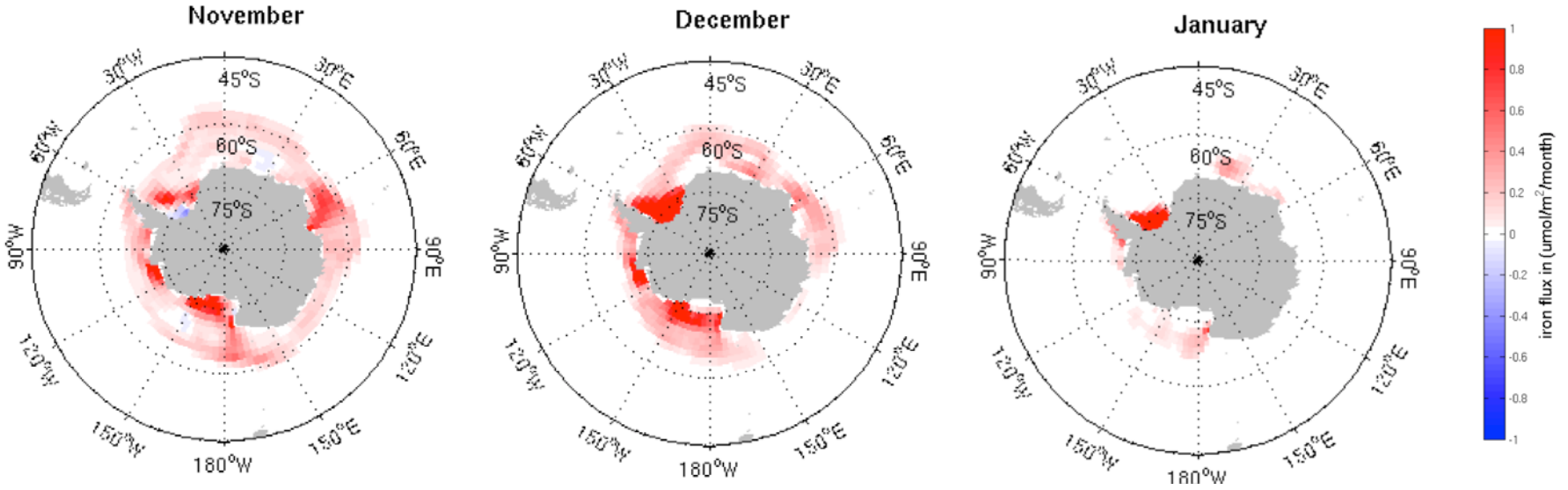


Differences in surface seawater iron concentrations

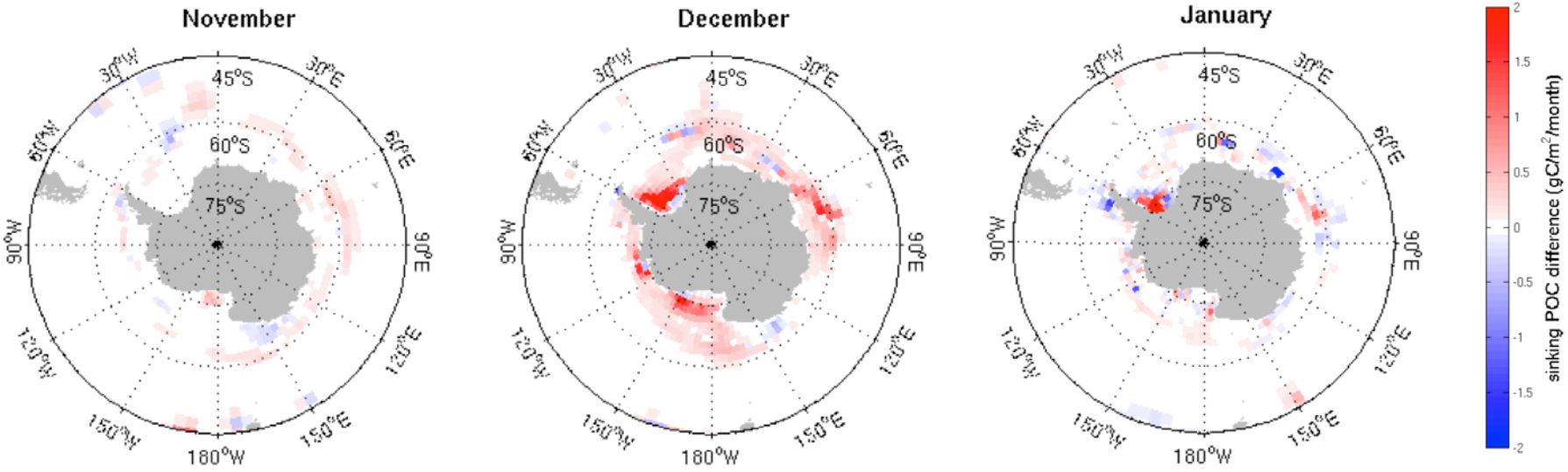


- Surface iron concentrations are also controlled by biological uptake.

Differences in iron flux

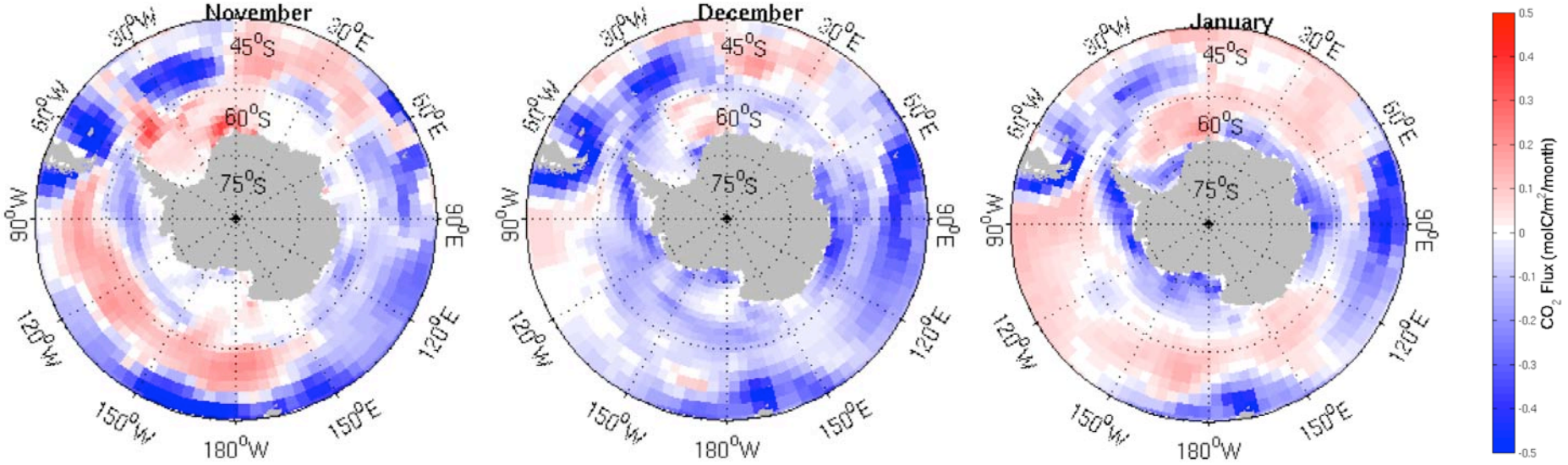


Differences in sinking POC

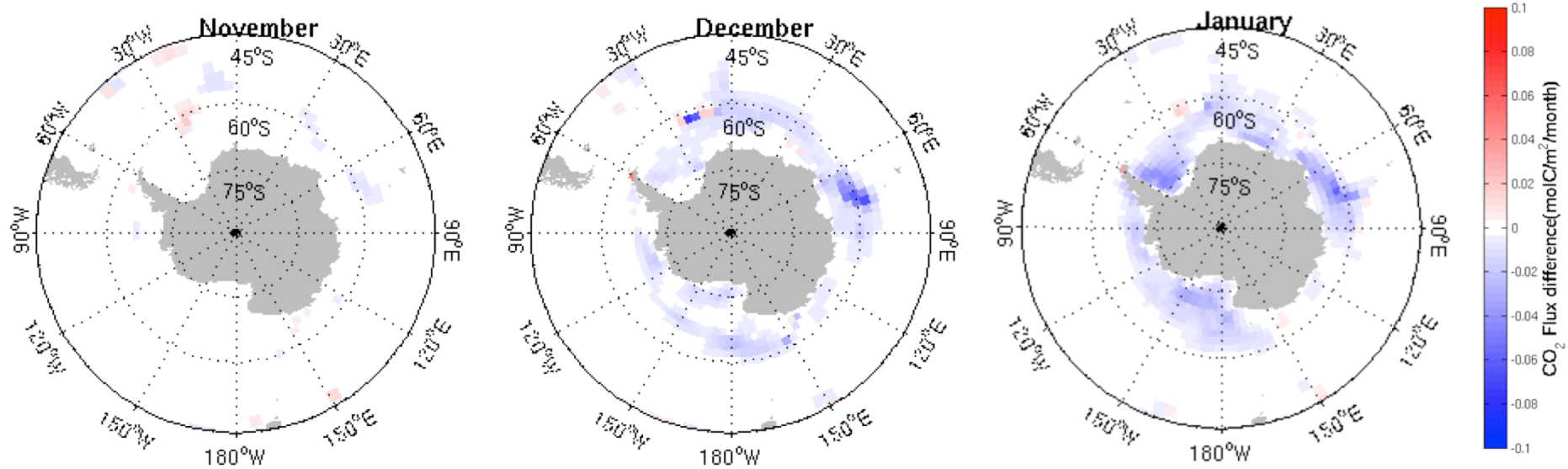


- Altered iron input due to sea ice changes affects phytoplankton production.
- There are no significant differences in production in the N.H. (not shown)

Monthly CO_2 flux

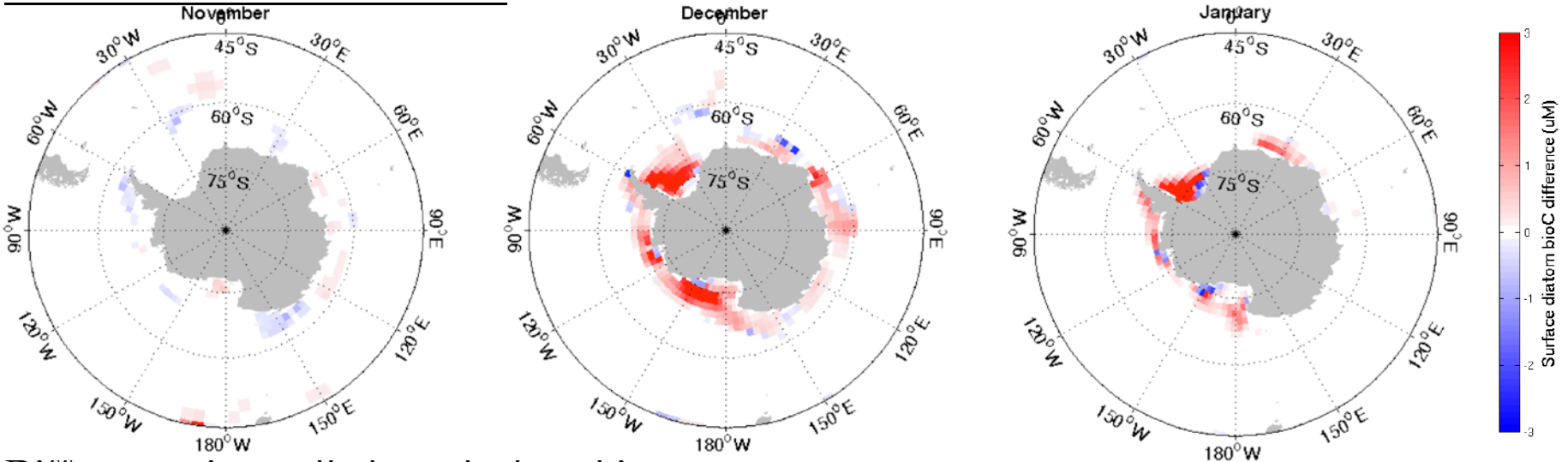


Differences in monthly CO_2 flux

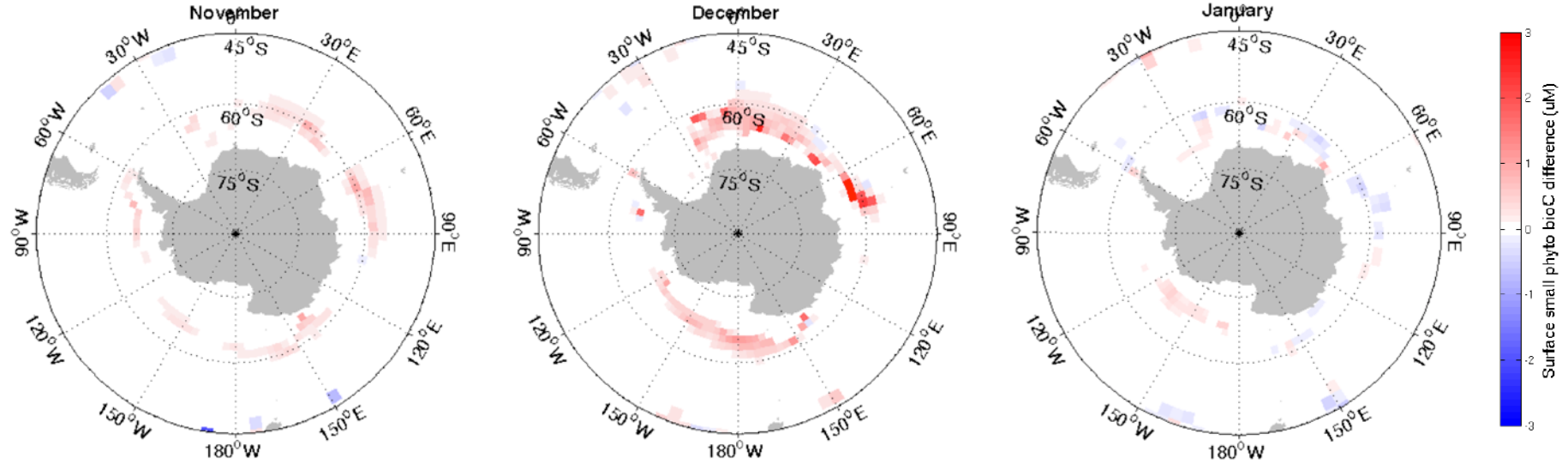


- CO_2 uptake (>60S) increased 5% and 16% in Dec and Jan, respectively.

Differences in diatom biomass



Differences in small phytoplankton biomass

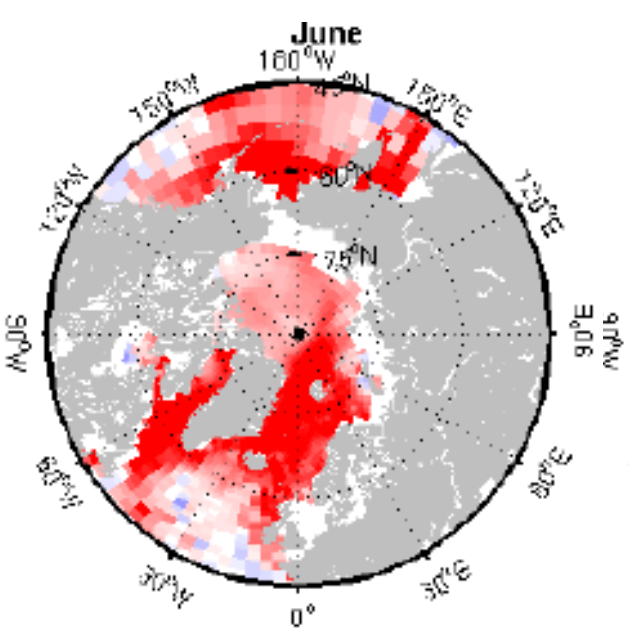


- Diatom biomass (>60S) change by 6% and 13% in Dec and Jan, respectively.
- Small phytoplankton biomass (>60S) increase 3% and 8% in Nov and Dec, respectively.

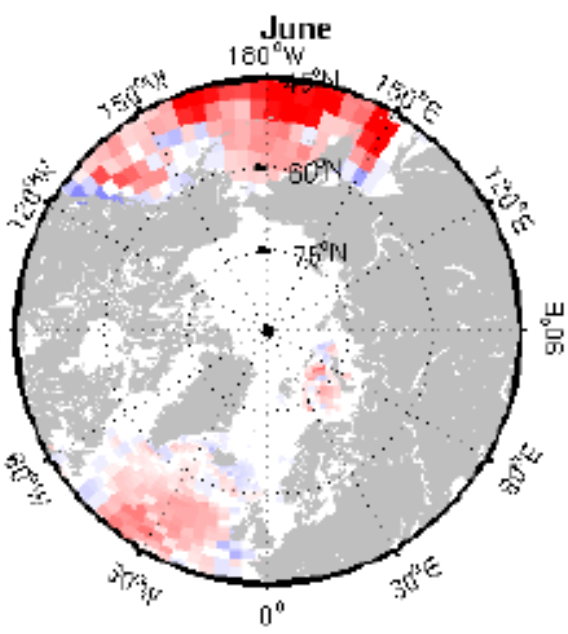
Effects of different sources of iron

Export production supported by different iron sources

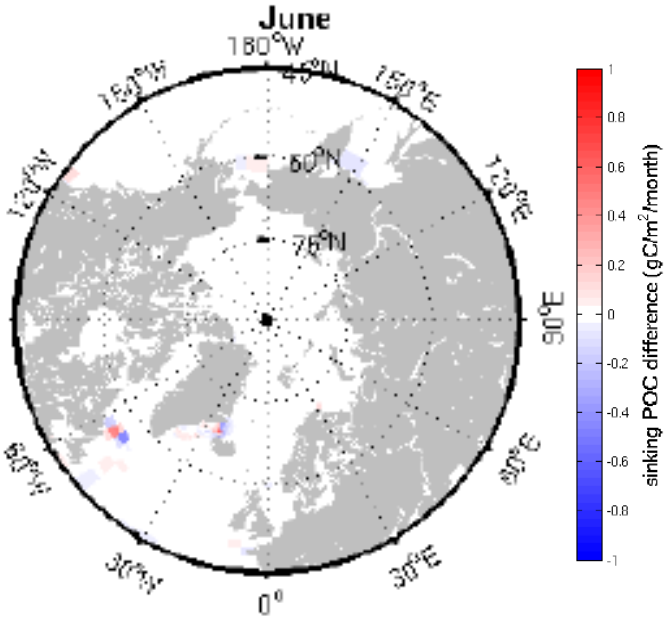
Sediment



Atmosphere



Ice

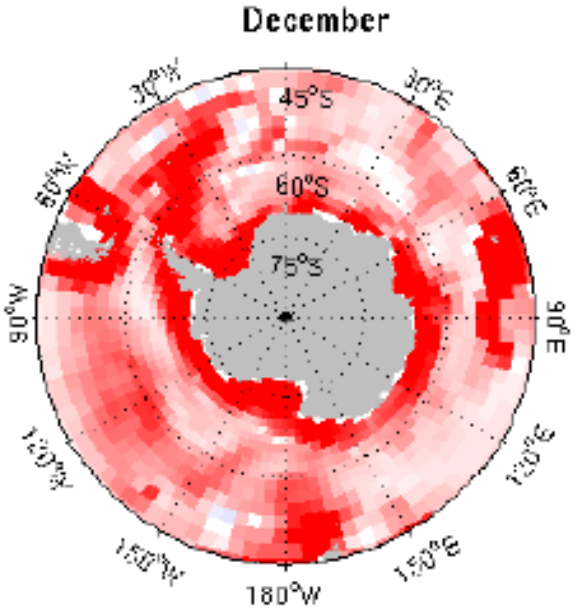


- It is a first-order estimate of the contribution of each iron source. Non-linear interactions are not considered yet.
- Sedimentary iron is the primary iron source that supports export production

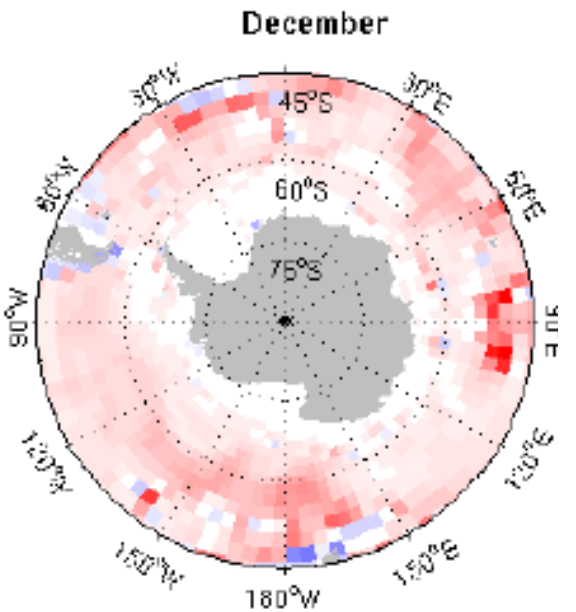
Effects of different sources of iron

Export production supported by different iron sources

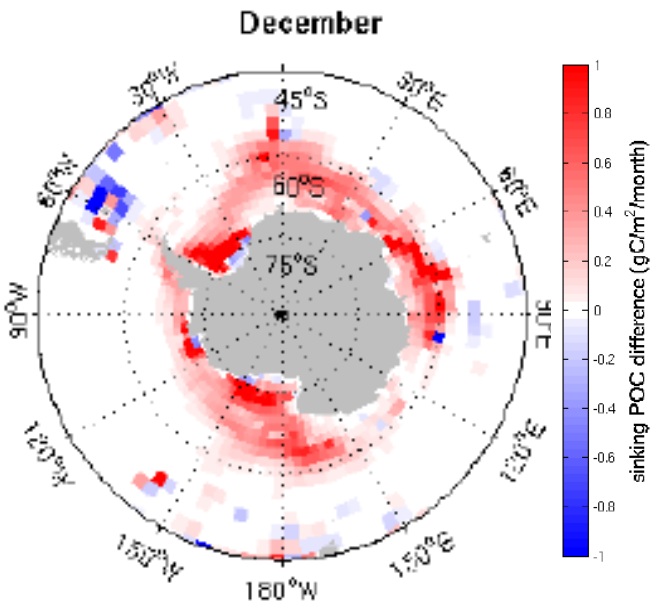
Sediment



Atmosphere



Ice

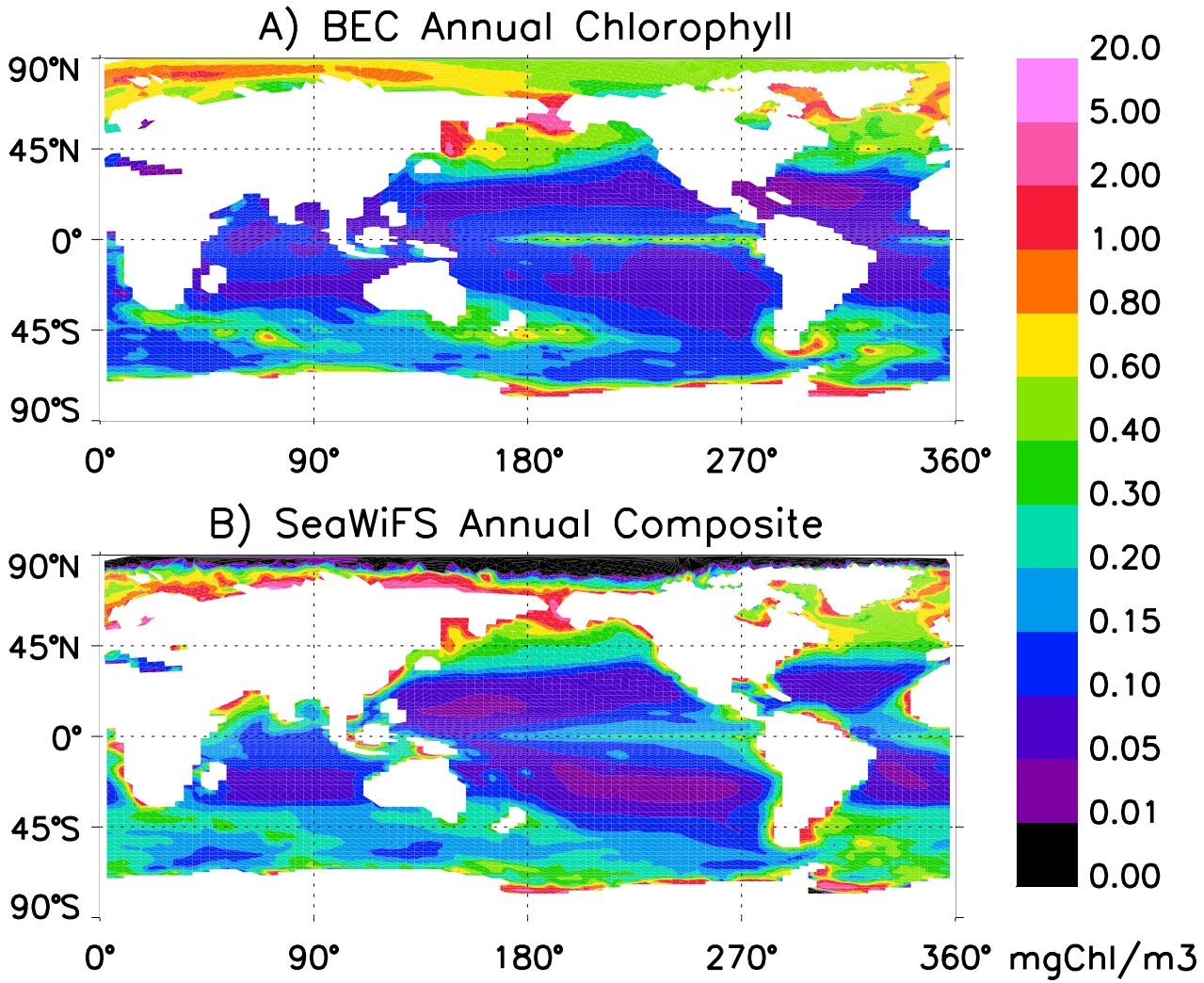


- Iron from atmospheric deposition and ice also contributes to export production in the Southern Ocean.

Summary

- Seasonal sea ice dynamics alter the timing, location, and magnitude of iron fluxes into the ocean.
- Iron from sea ice can affect phytoplankton production in the Southern Ocean.
- Community composition may be influenced by iron released during ice melting. Small phytoplankton and Diatoms have different responses to iron released from melting sea ice.
- Sedimentary source is dominant iron source contributing to phytoplankton growth around the Arctic and the Antarctic.
- There are still many uncertainties in the ice-related iron cycle.

Questions and comments?


A) BEC Annual Chlorophyll
90°N
45°N
0°
45°S
90°S
0°
90°
180°
270°
360°
B) SeaWiFS Annual Composite
90°N
45°N
0°
45°S
90°S
0°
90°
180°
270°
360°
20.0
5.00
2.00
1.00
0.80
0.60
0.40
0.30
0.20
0.15
0.10
0.05
0.01
0.00
mgChl/m3