Quantifying under-ice phytoplankton primary production in the Arctic and Southern Oceans

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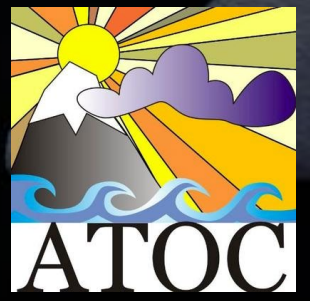
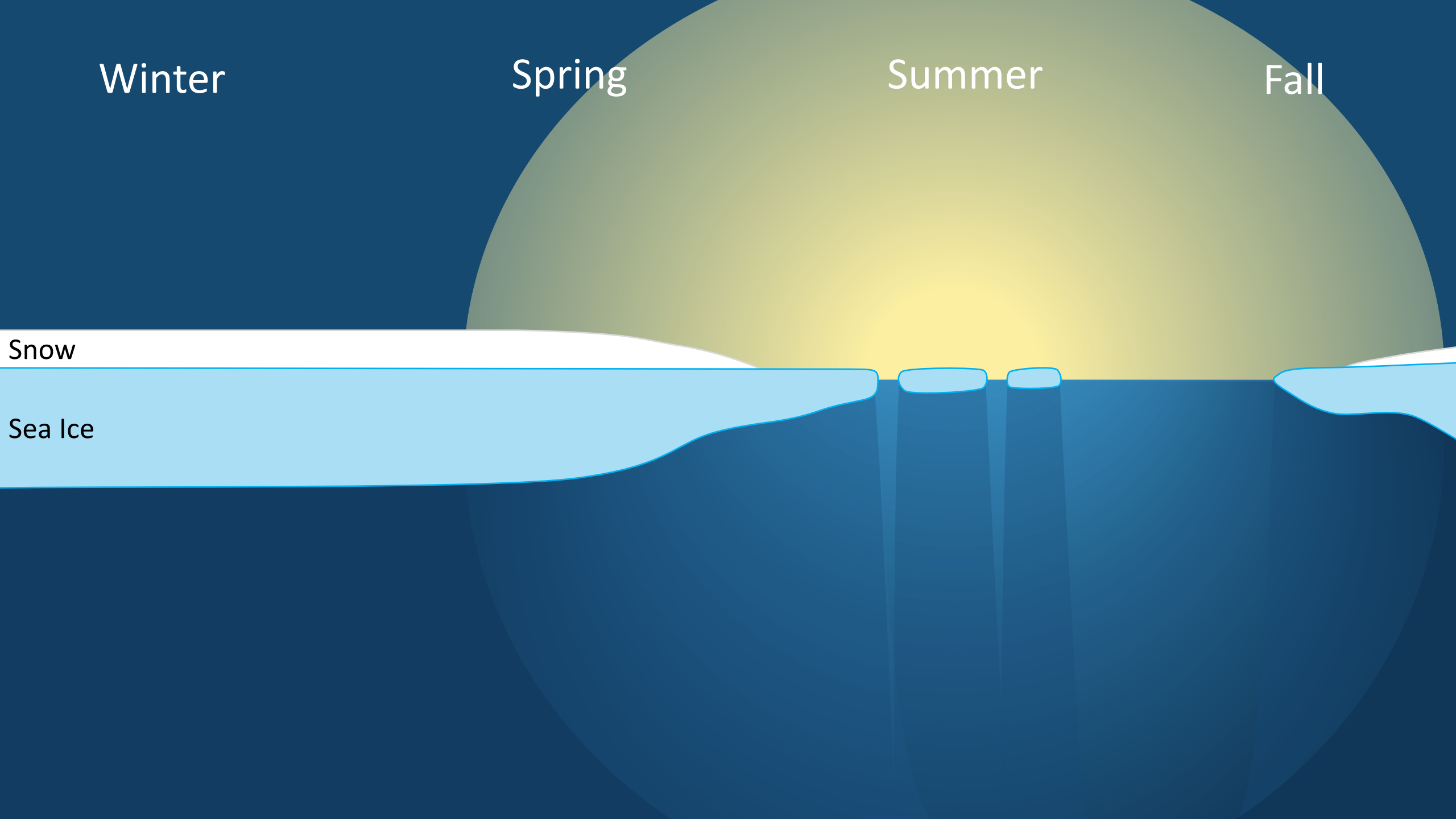
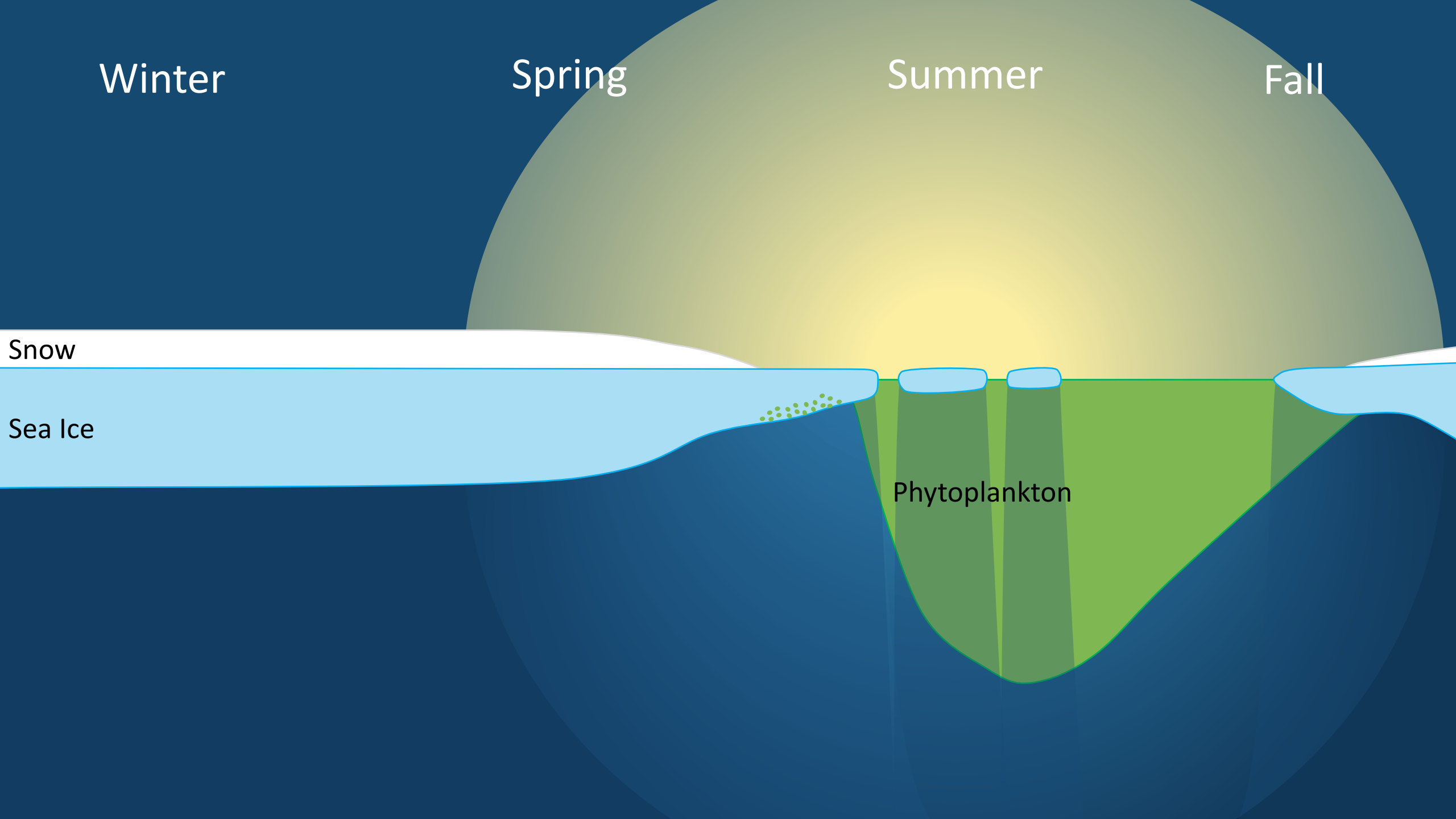
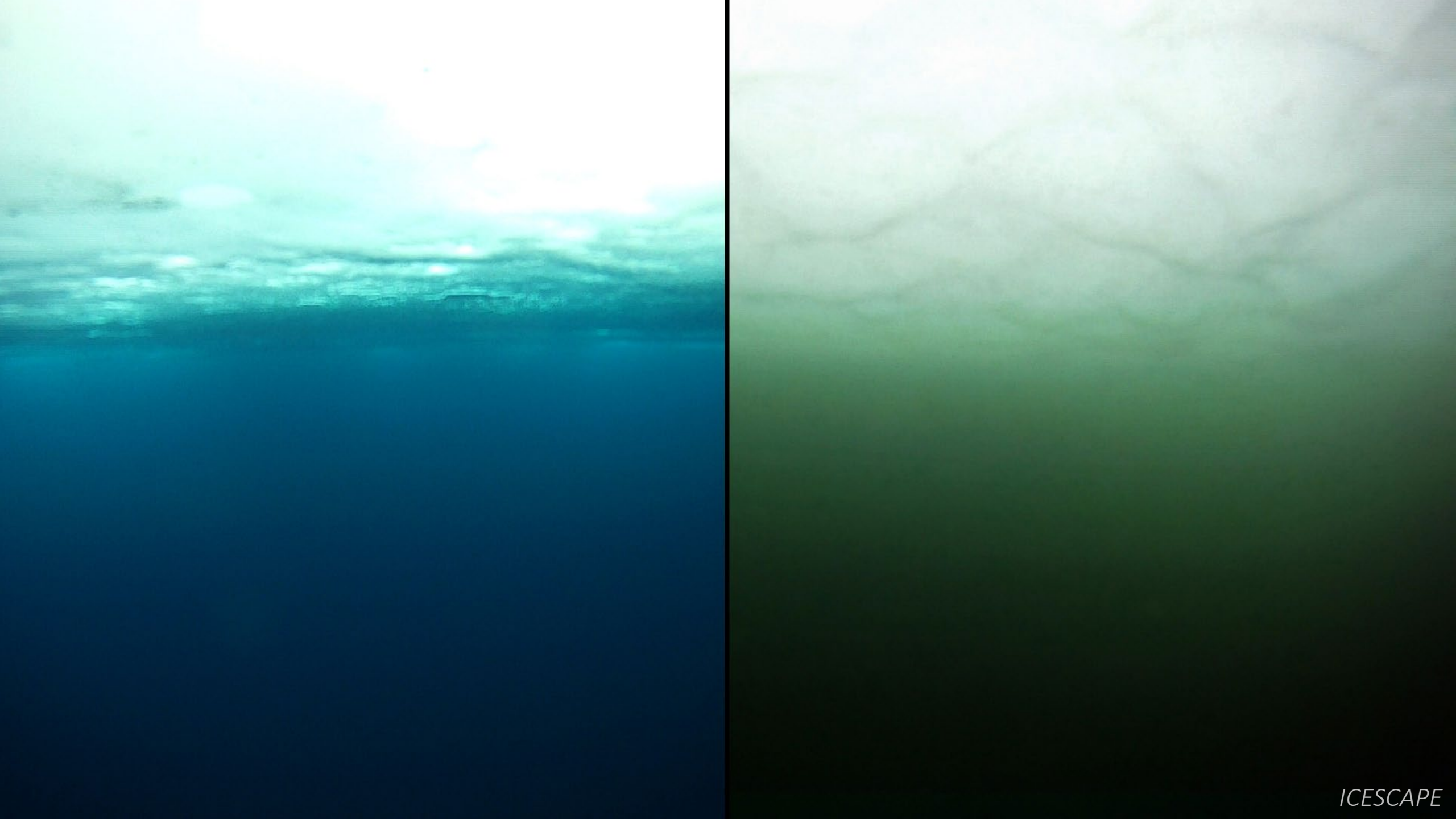


Kathryn Hansen


Winter
Spring
Summer
Fall
Snow
Sea Ice


Winter
Spring
Summer
Fall
Snow
Sea Ice
Phytoplankton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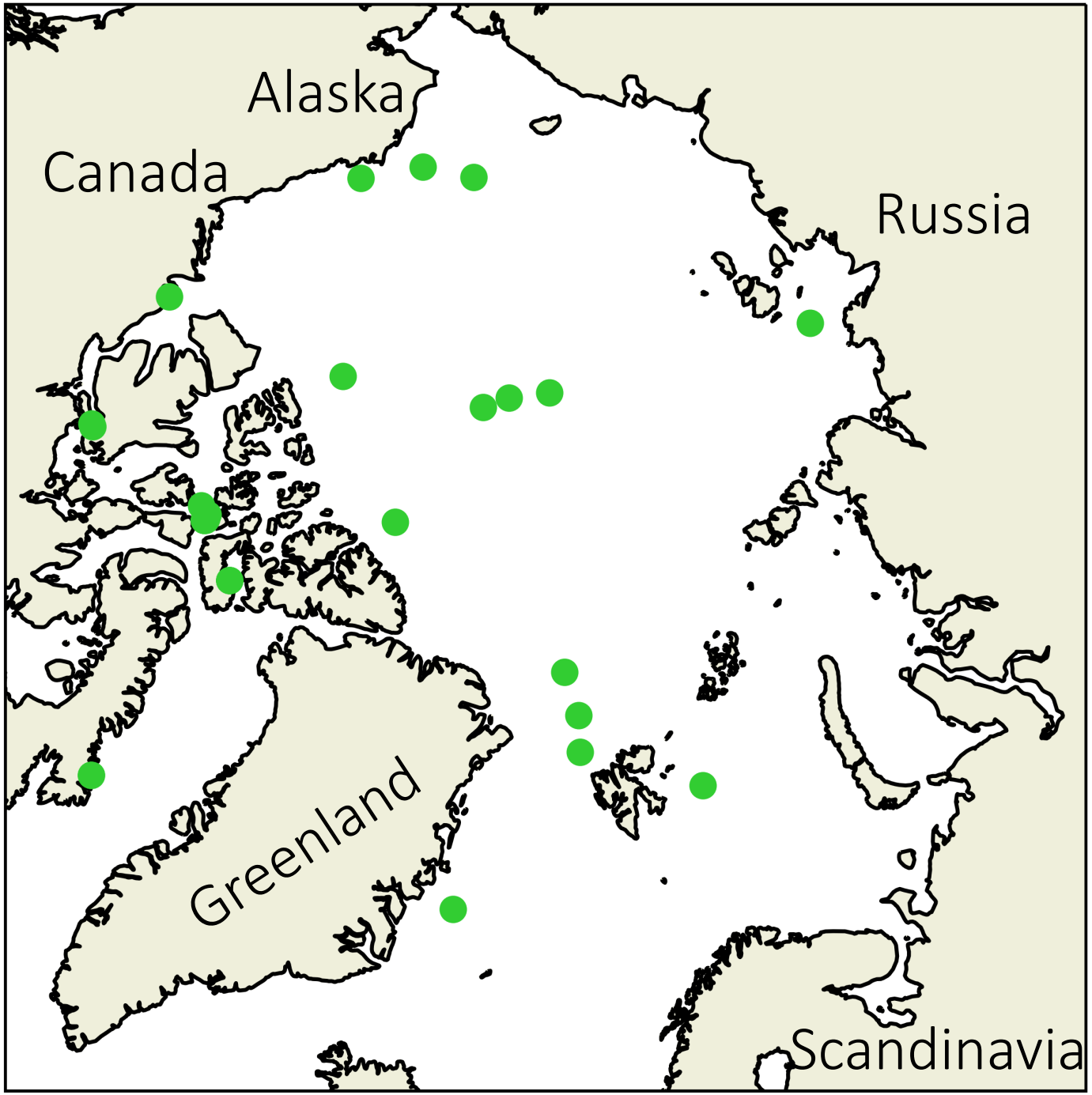
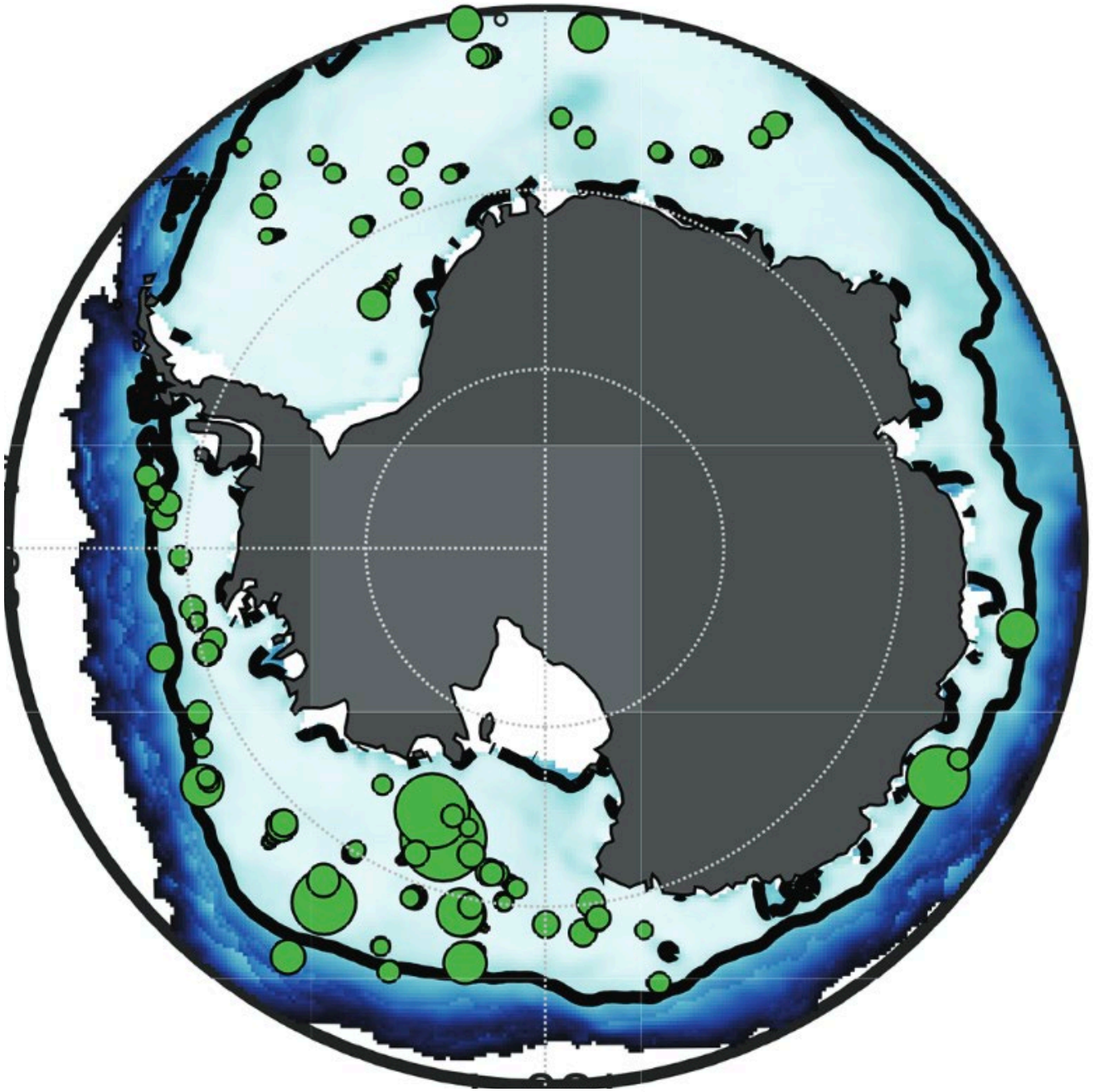


data from
Ardyna et al., 2020



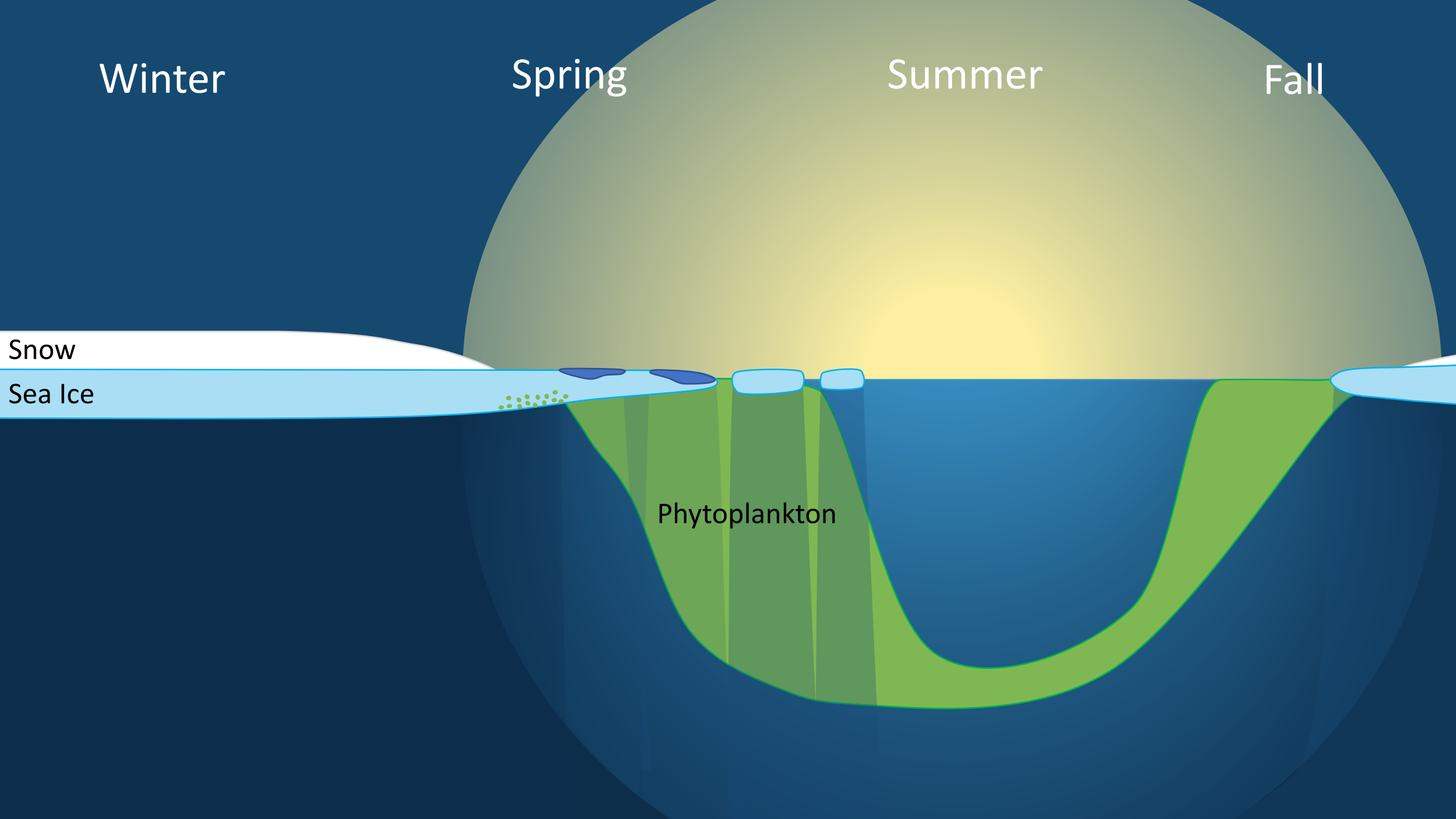
Sea Ice Concentration (%)

0 20 40 60 80 100

Phytoplankton Biomass

1 mg/m^3 3 mg/m^3

Horvat et al., 2022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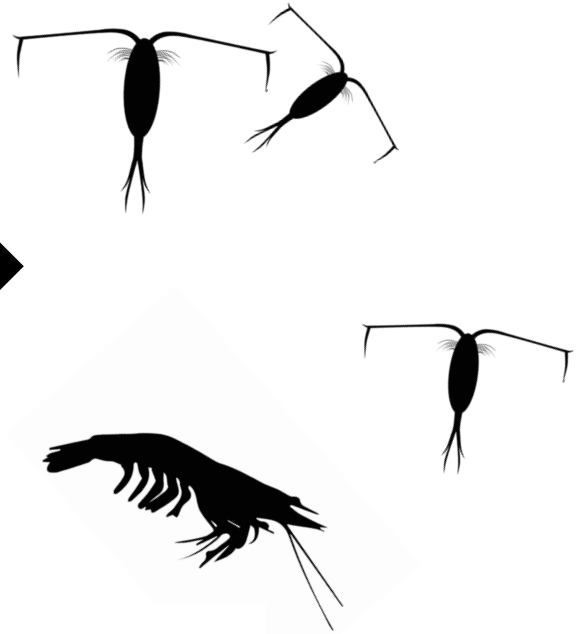
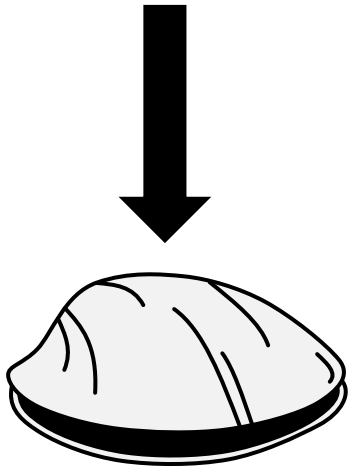
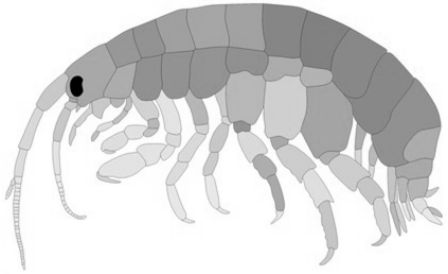
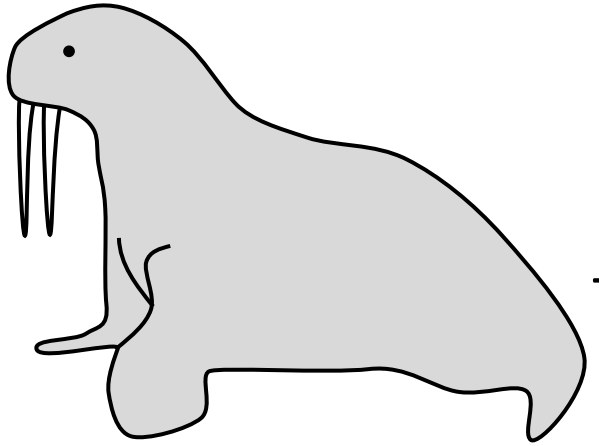








+ Carbon sequestration

+ Nitrogen Loss

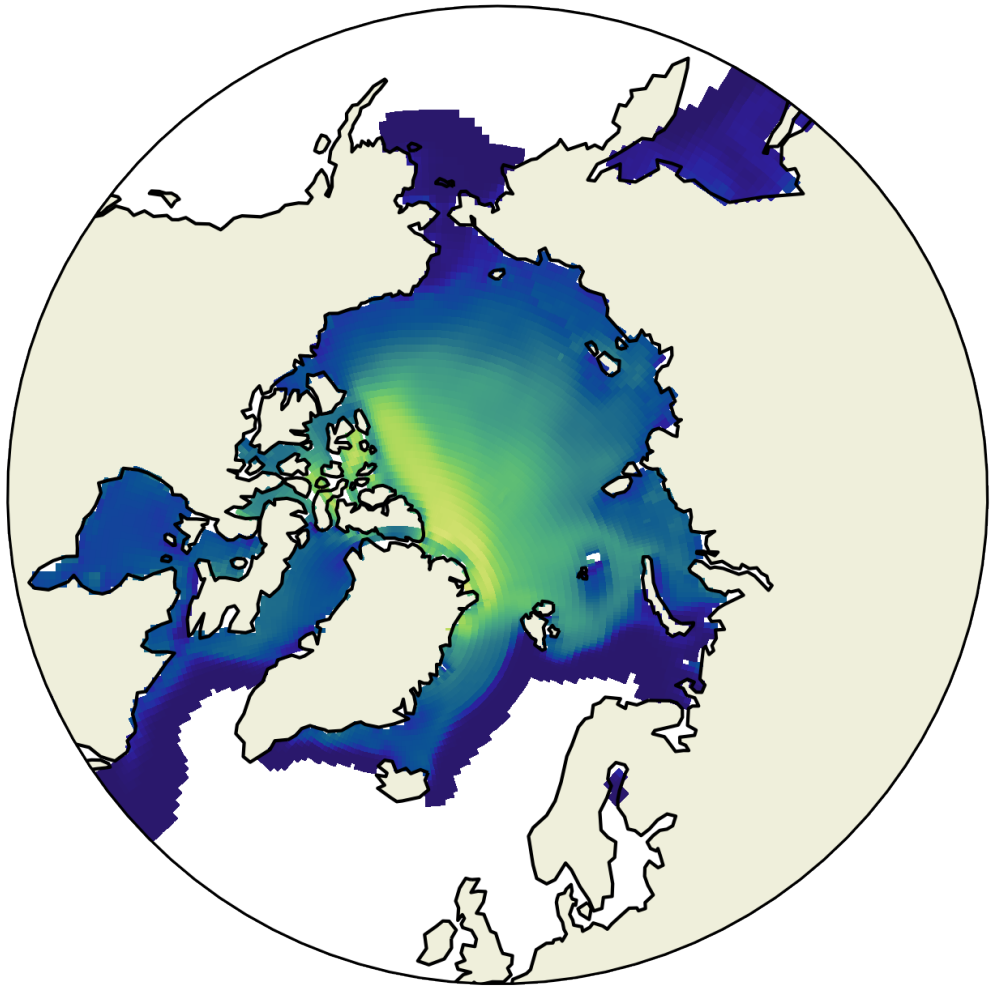
Under-ice (UI) phytoplankton net primary production (NPP)

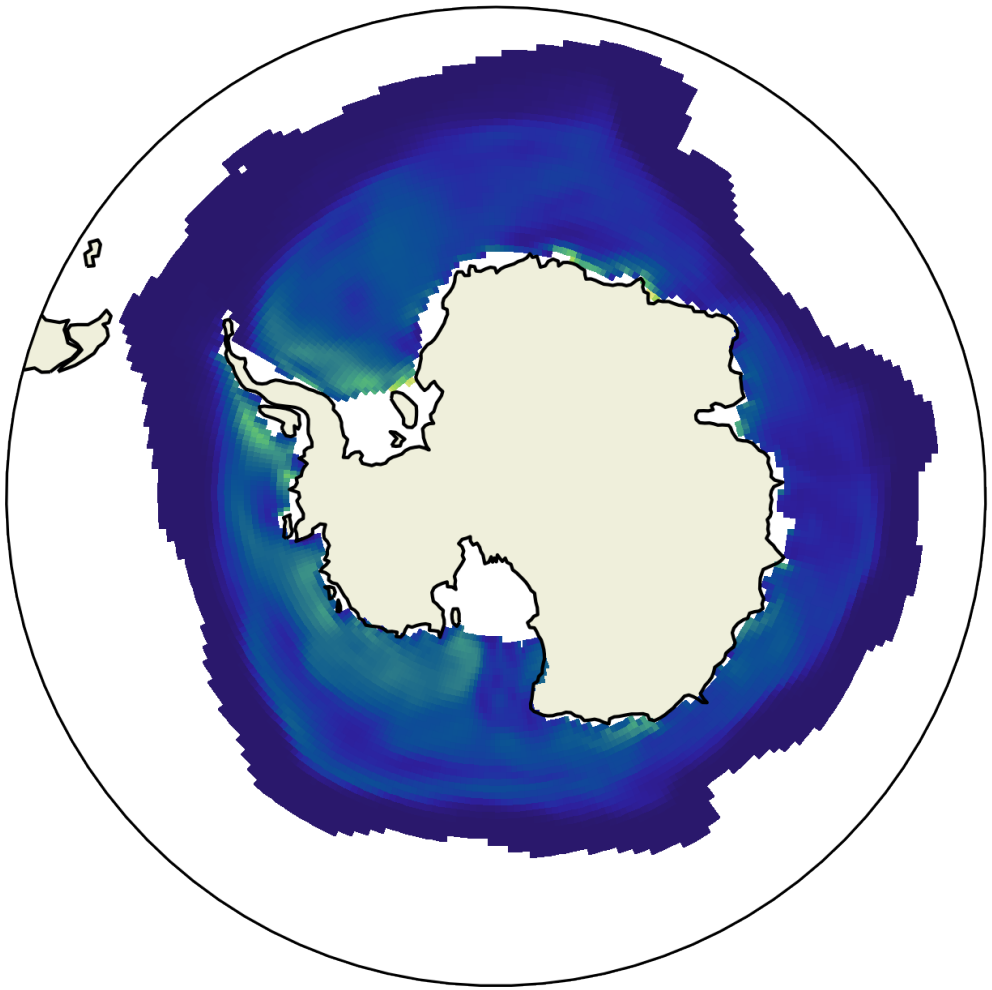
- How much phytoplankton NPP is generated under sea ice in the Arctic and Southern Oceans?
- How is UI NPP changing over time?
- Under what sea ice conditions (concentration, thickness) do UI blooms form in each region?

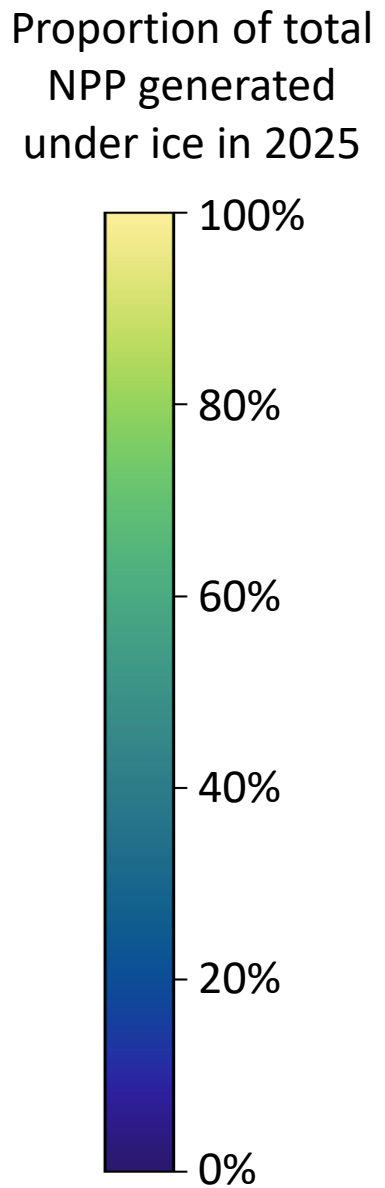
Special Community Earth System Model run

- CESM version 2, ‘less melt’ parameterized run
  - 4 phytoplankton and 2 zooplankton functional types
  - Daily output of light at the ocean surface and fractional coverage by each sea ice thickness category
- Calculated light limitation terms under each sea ice thickness category and in open water.
- Partitioned daily NPP based on light limitation terms and area of each sea ice thickness category within each grid cell.

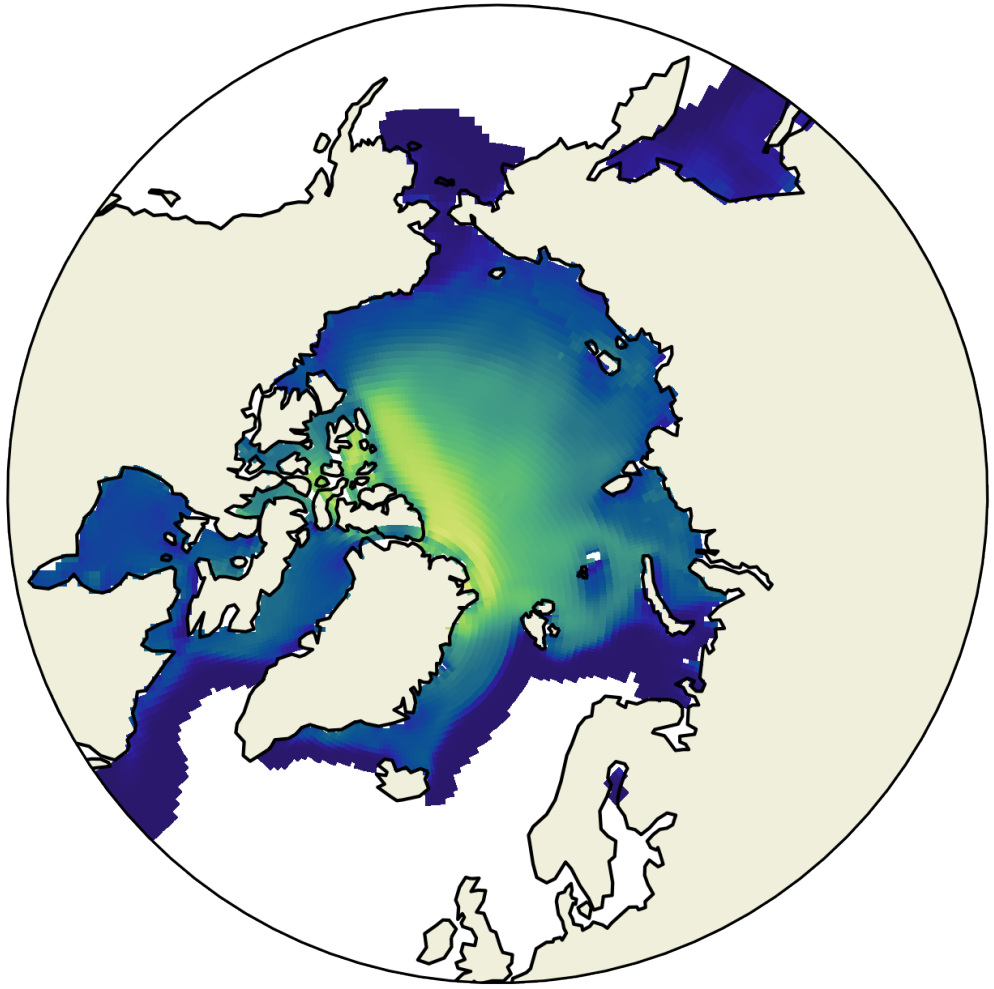
How much UI NPP is generated in the Arctic and Southern Oceans?



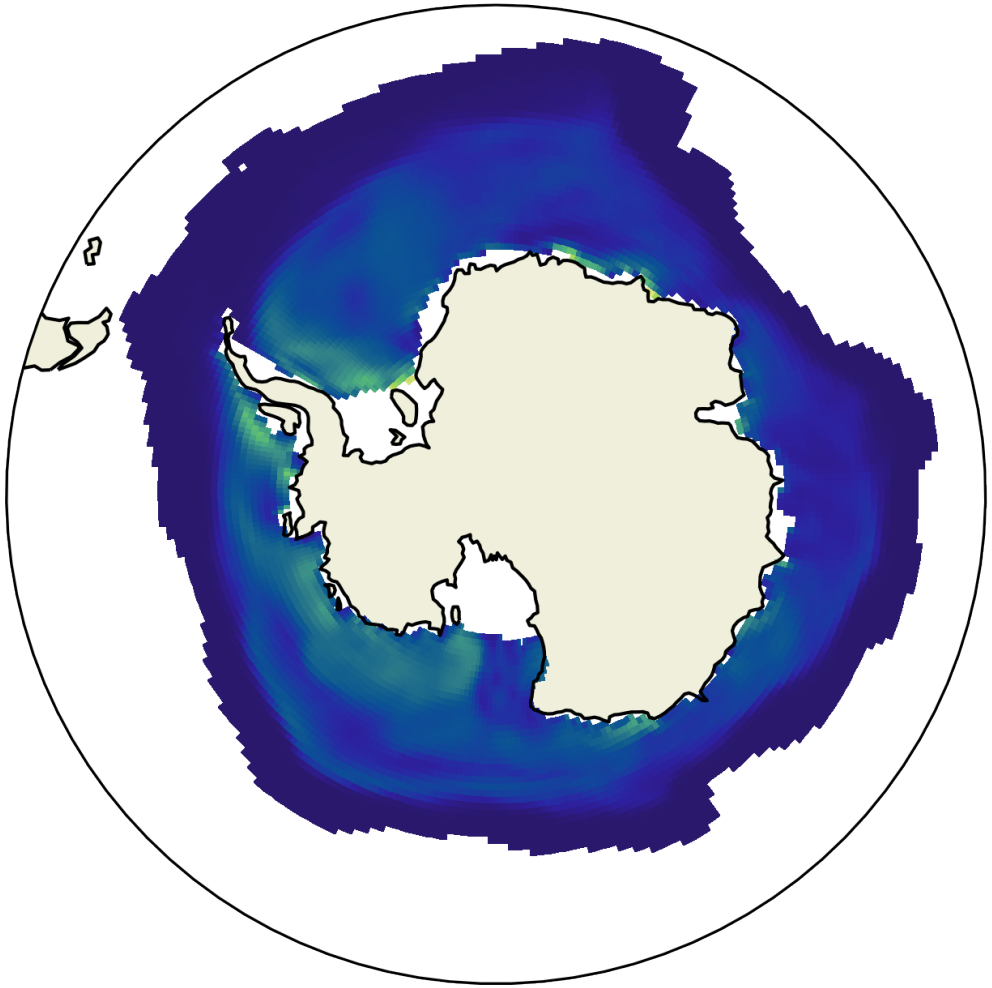




~130 Tg C yr^{-1} of NPP is generated under sea ice in each hemisphere

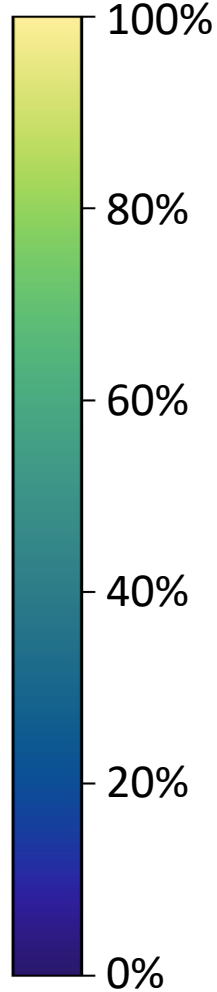


128 Tg C yr^{-1}

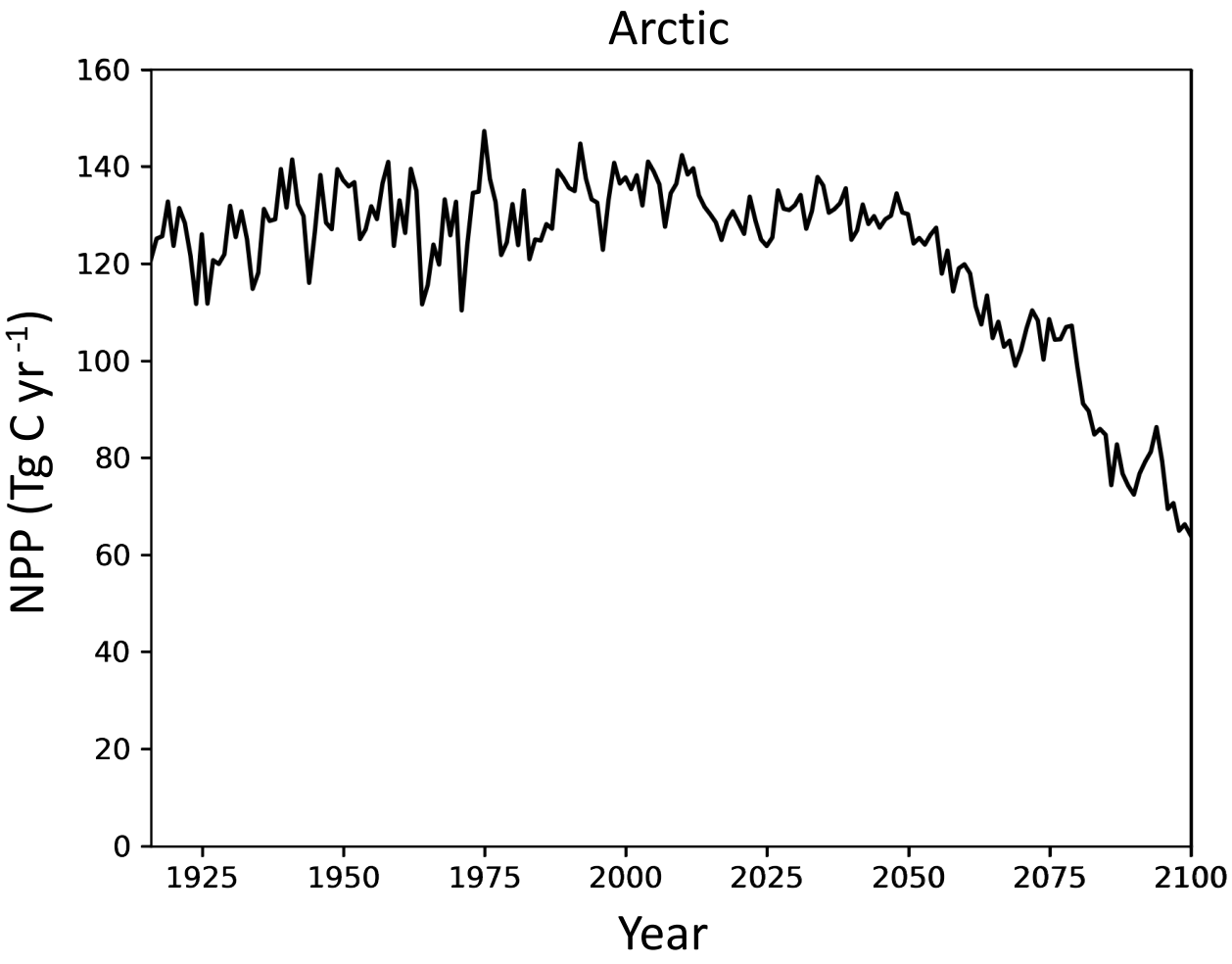


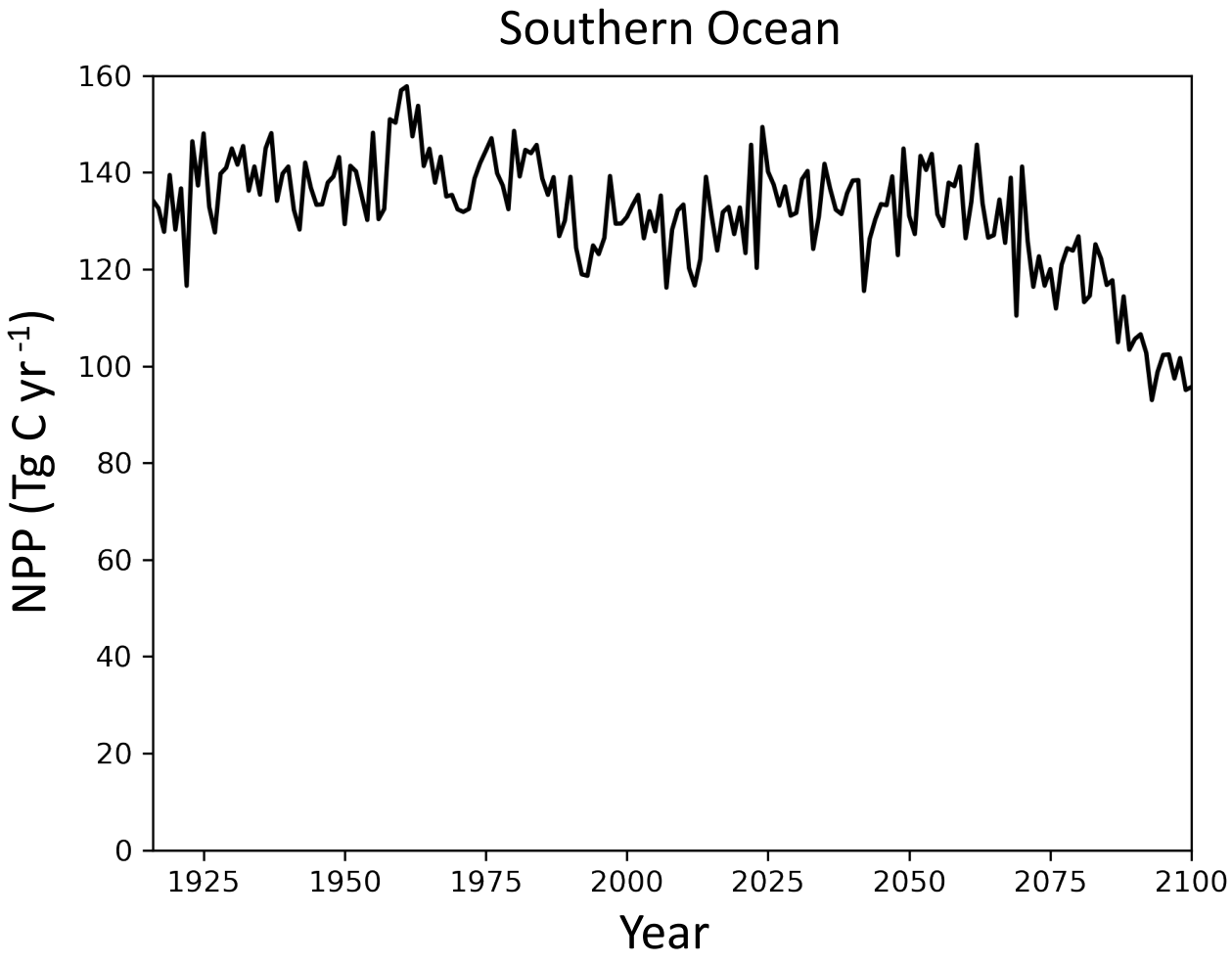
132 Tg C yr^{-1}

Proportion of total NPP generated under ice in 2025

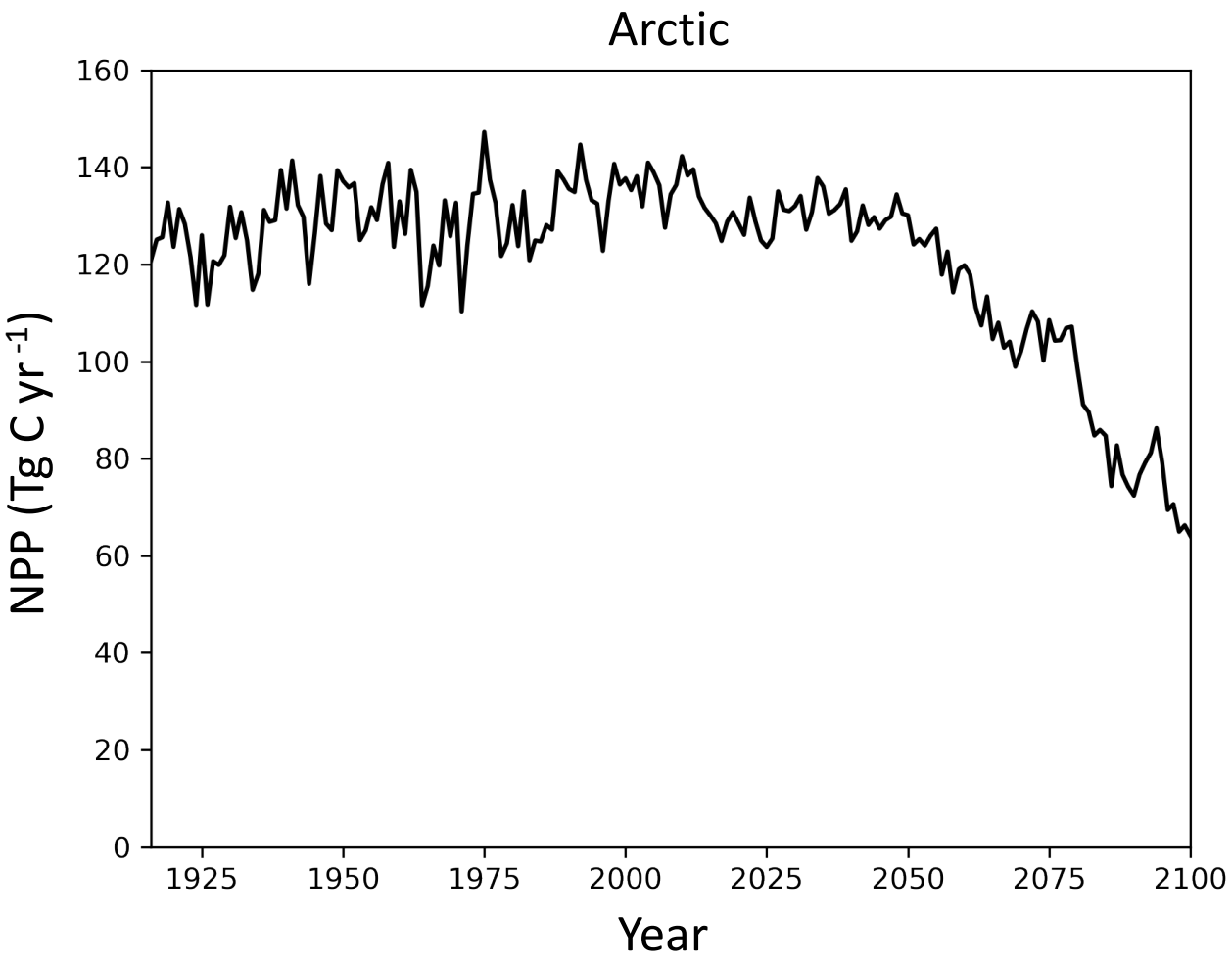


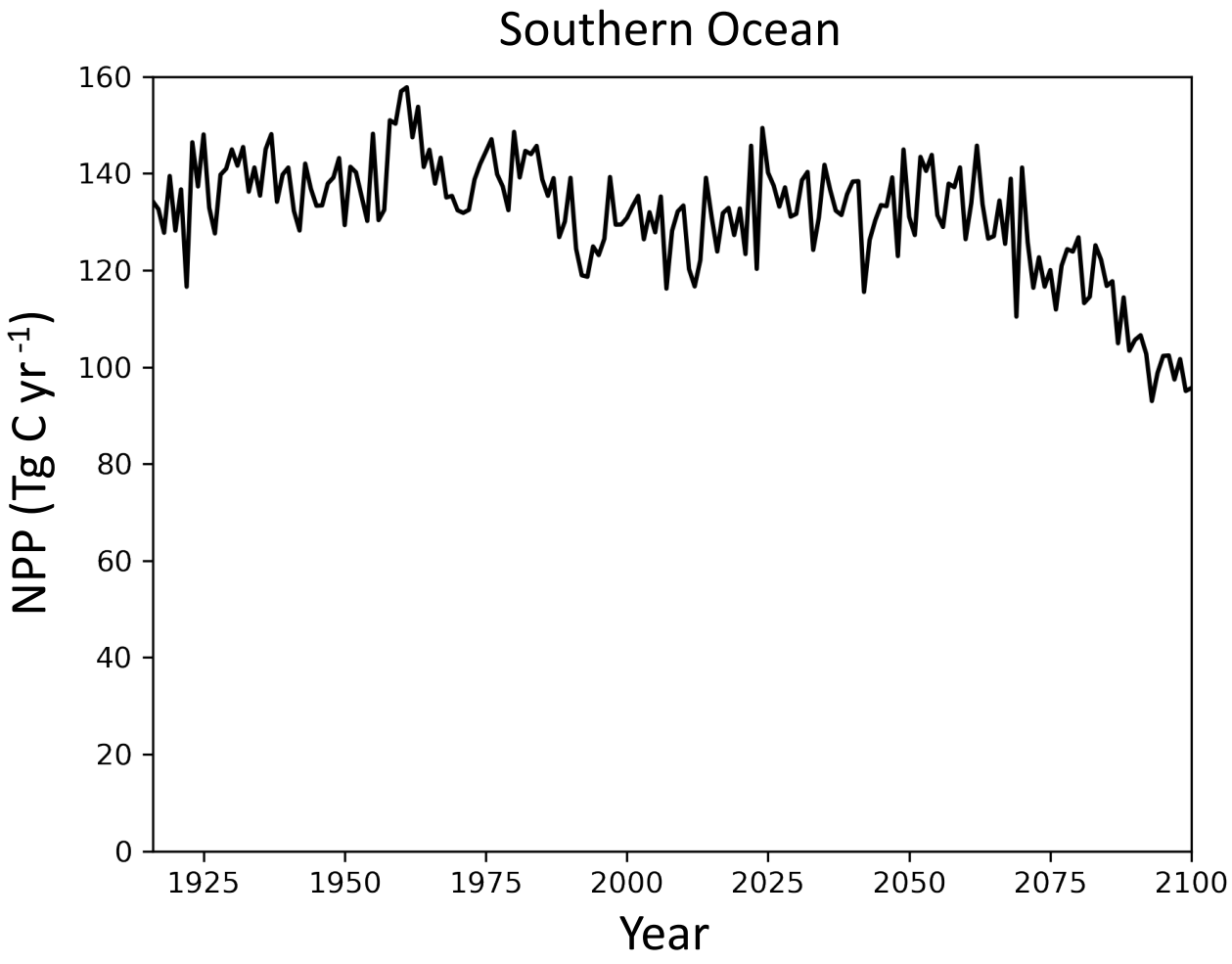
How is UI NPP changing over time?



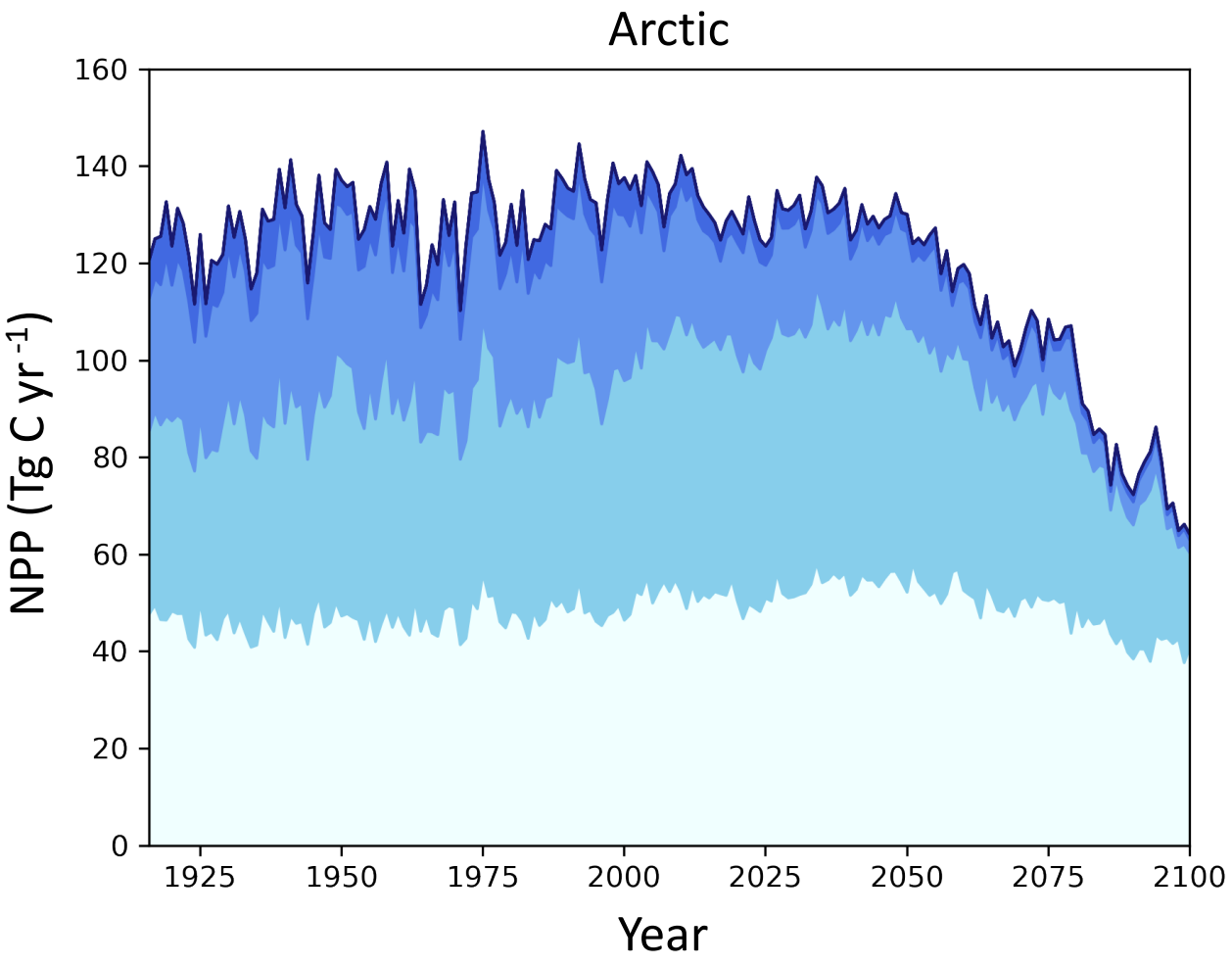


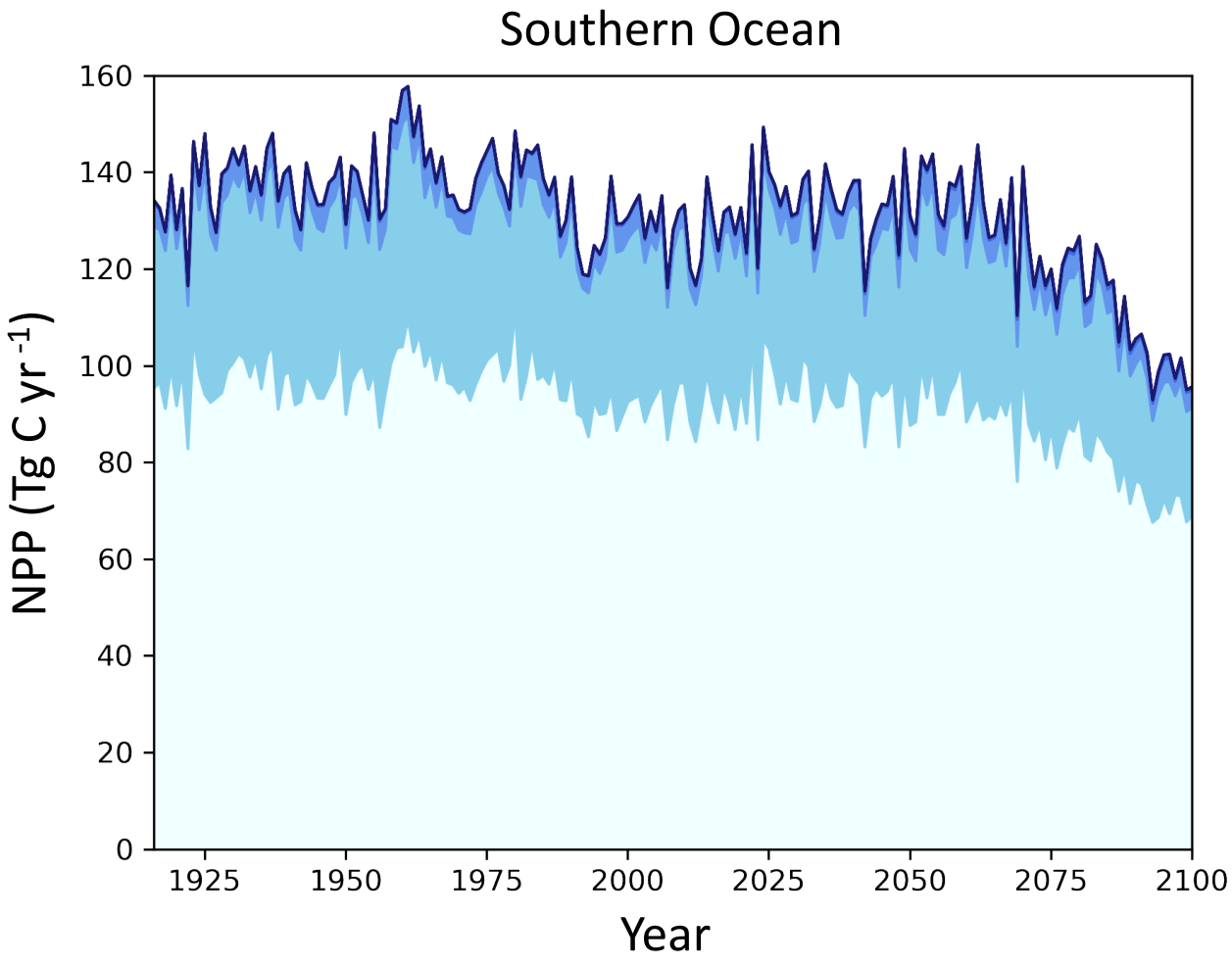
UI NPP will decline in both hemispheres





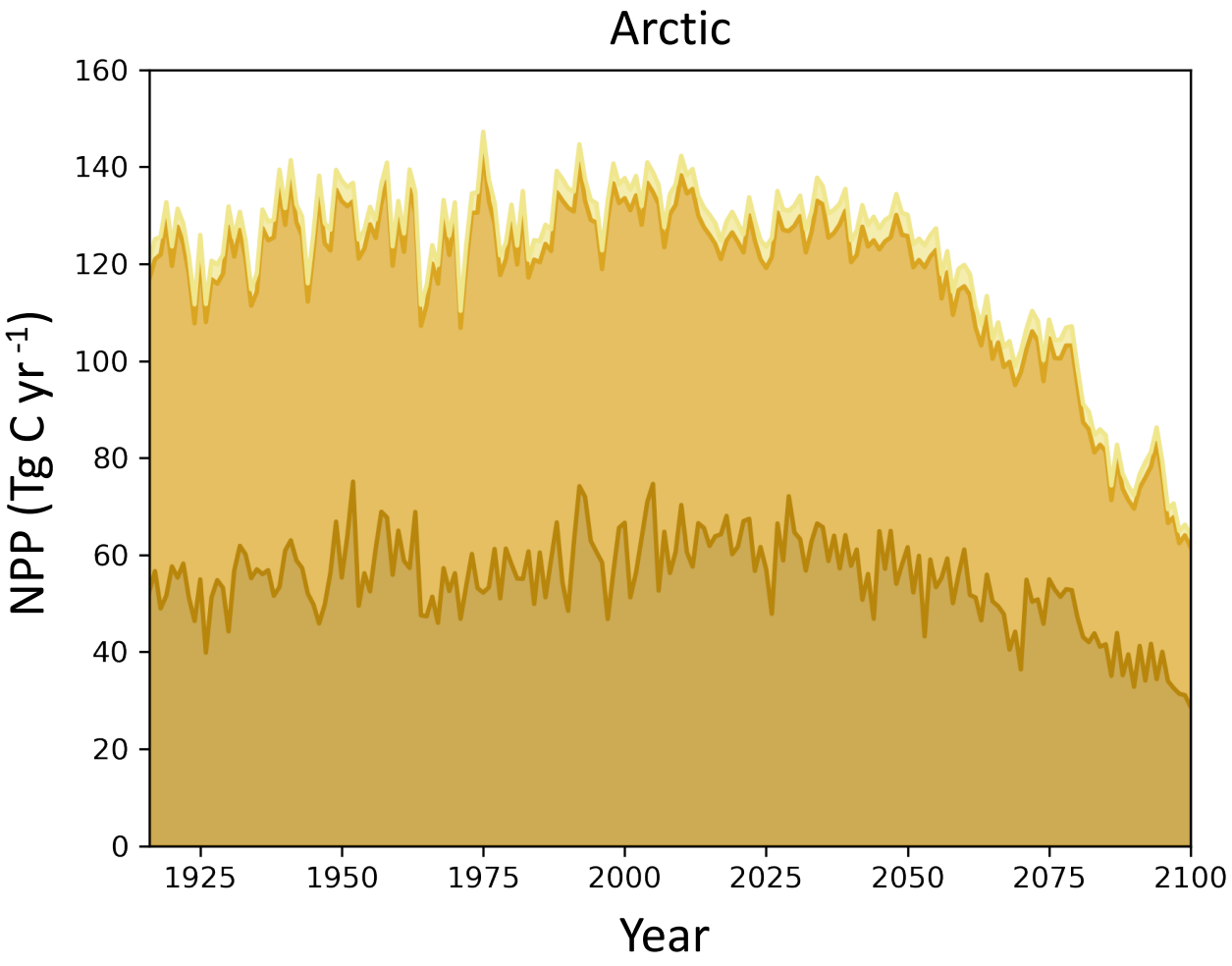
What sea ice thickness allows for UI NPP?

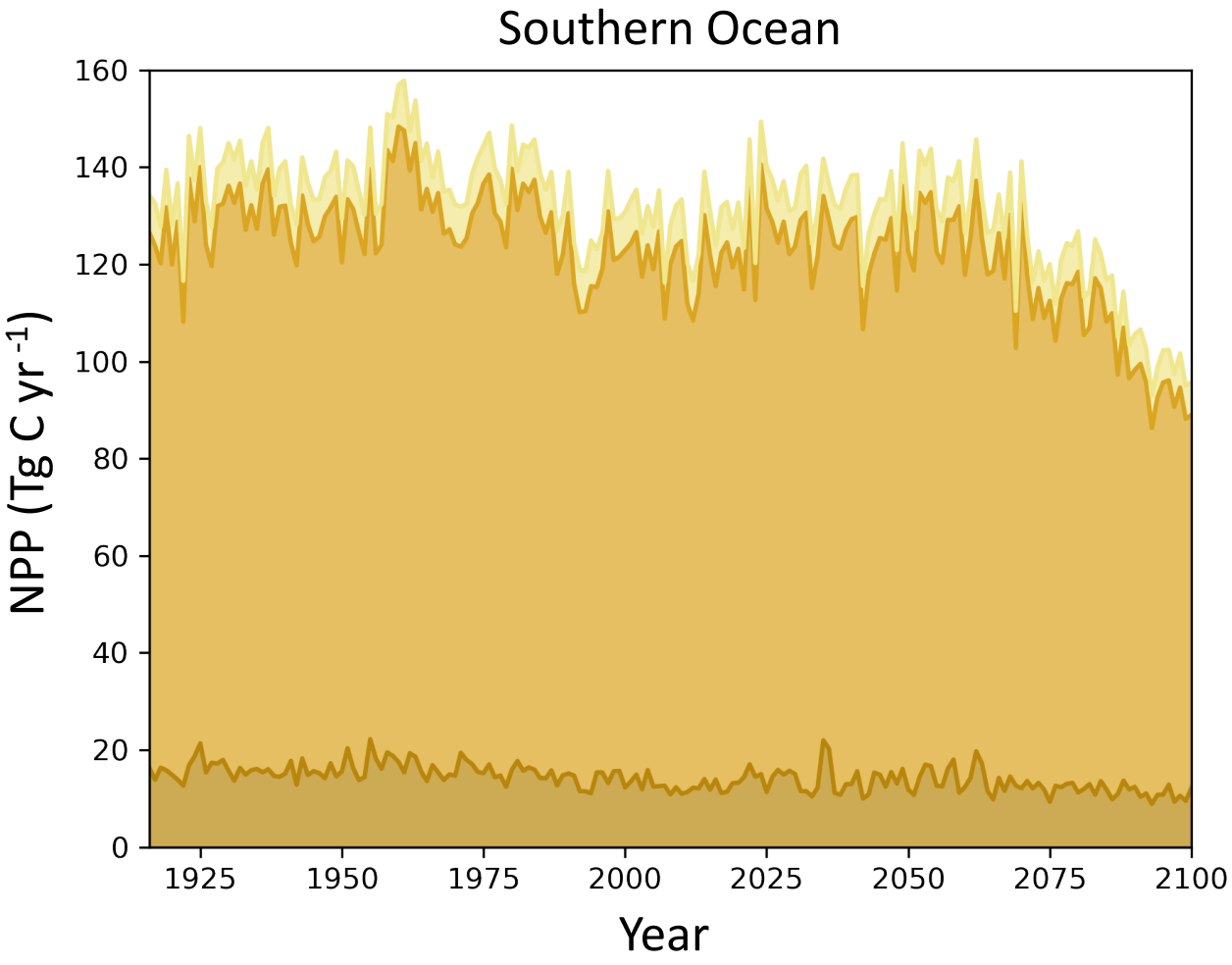




< 0.6 m | 0.6 – 1.4 m | 1.4 – 2.4 m | 2.4 – 3.6 m | > 3.6 m

What sea ice concentration allows for UI NPP?





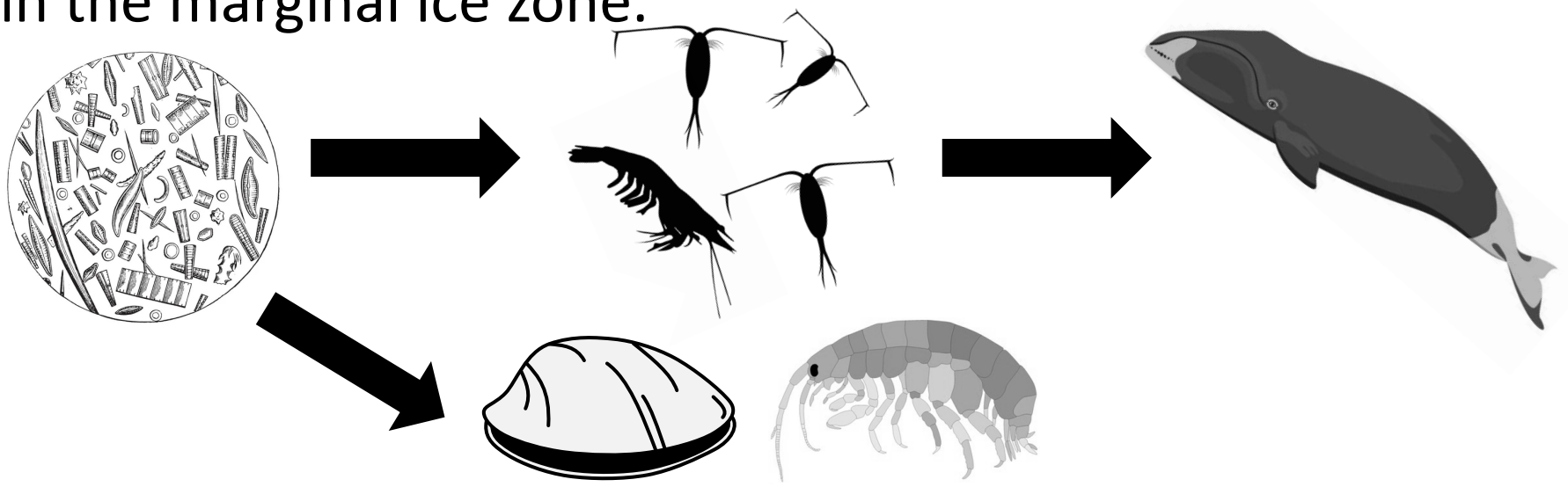
> 85% sea ice cover

15 – 85% sea ice cover

< 15% sea ice cover

Summary

- 260 Tg C yr^{-1} of NPP is generated under sea ice, split equally between the Arctic and Southern Oceans.
- NPP under ice is likely to decline over time in both hemispheres.
- Most under-ice NPP in the Arctic is generated under consolidated, thick sea ice. In the Antarctic, most under-ice NPP is generated under thin ice in the marginal ice zone.




Thank you
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NCAR
Operated by UCAR
ATOC
INSTAAR
University of Colorado Boulder
Stefan Hendricks