Mid-century projections for the Amundsen Sea Polynya (ASP)

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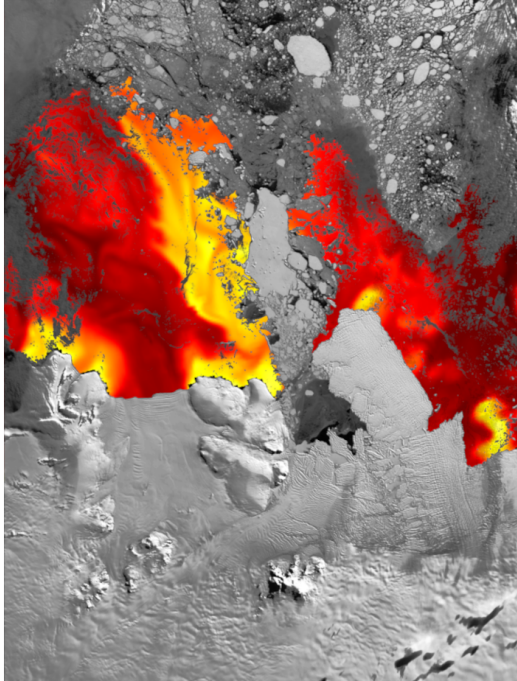


Looking at the ASP 35 years into the future

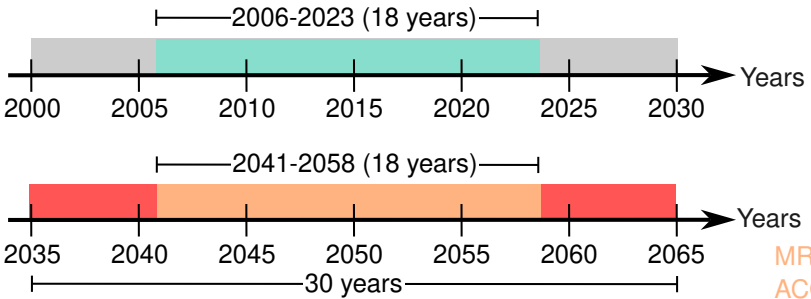
Regional model ≈ 1 km resolution for dynamical downscaling.

Historical / Mid-Century simulations, each lasting ≈ 2 decades.

Mid-century ensemble has 3 members reflecting the warming projected by different CMIP6 models.

Water + air temperature is the sole difference between Historical / Mid-century.

Model computes changes in sea ice, ice shelf basal melt, biogeochemistry... internally.

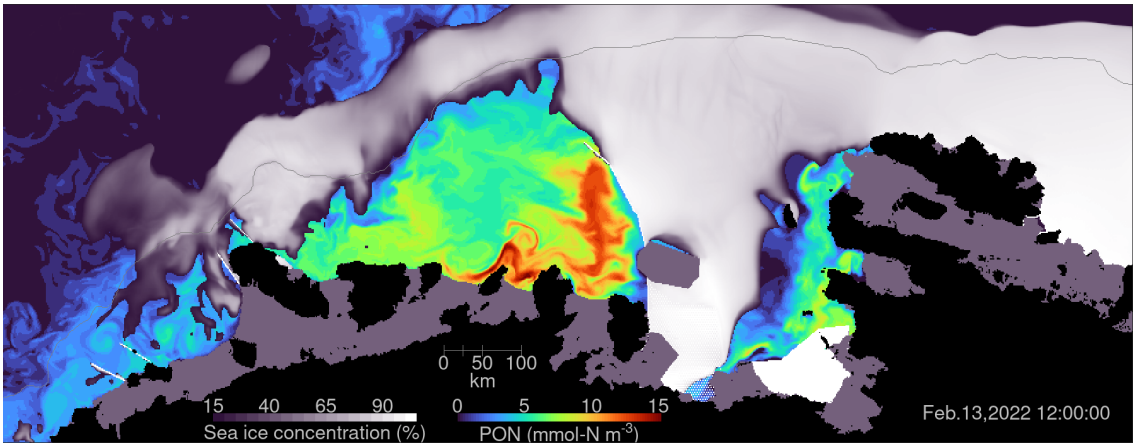


Historical simulation

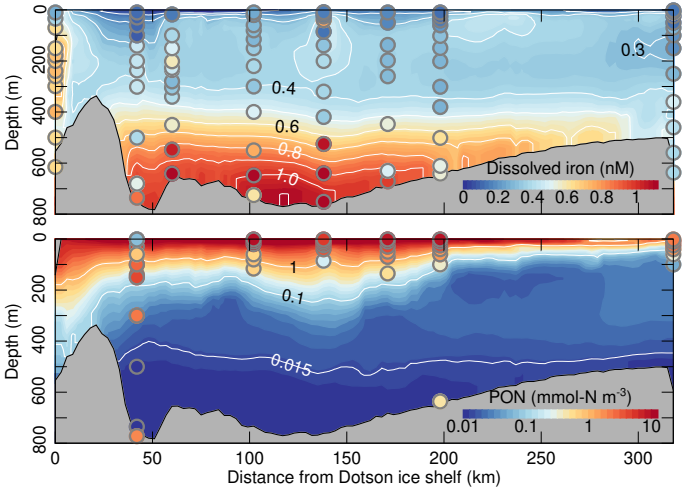
Δ_{CMIP6} = (2035-2064) – (2000-2030)

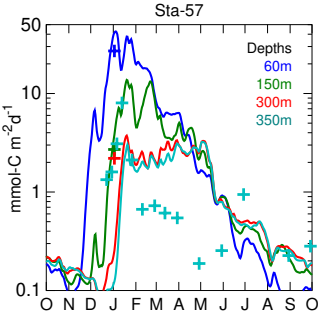
Mid-Century simulations
SSP2-4.5
MRI-ESM2-0, MPI-ESM1-2-HR, ACCESS-CM2

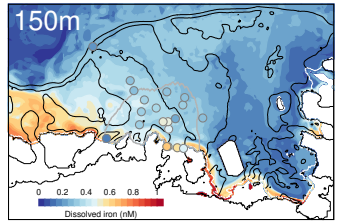
Snapshot from Historical simulation



Previous evaluations of the model

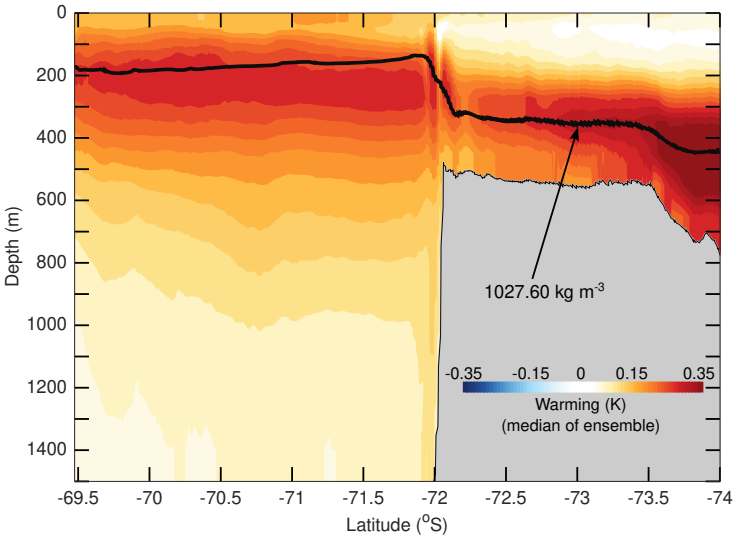






See model evaluations in St-Laurent et al. 2019

Results: Warming offshelf and on shelf

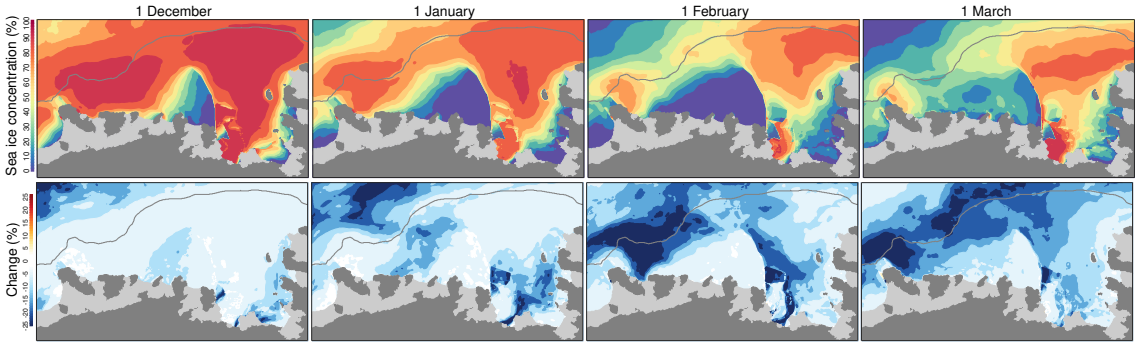


- Transect along 121°W (offshelf) then Dotson-Getz trough (on shelf).
- +0.2–0.3K in subsurface (annual average).
- Warming signal intrudes on shelf along 1027.60 kg m^{-3} isopycnal.

The warming causes:

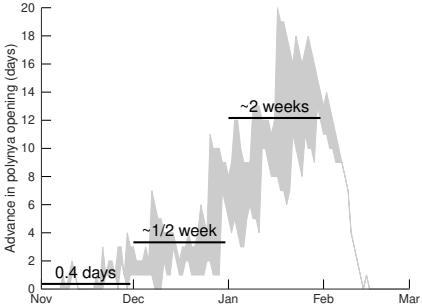
- −10% in wintertime sea ice thickness,
- +20% in ice shelf basal melt rates,
- Salinity lower by 0.05–0.10 in upper 150 m of ASP.

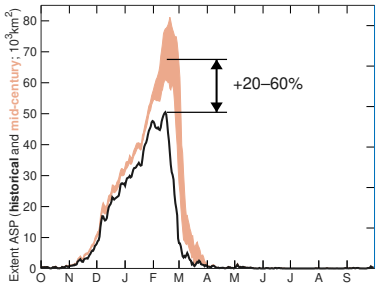
Sea ice concentrations on shelf



Recall that ASP opens east-to-west (right-to-left).
Reductions > 25% at edges of polynya, particularly the downwind/western edge.

Opening of polynya is hastened by warming





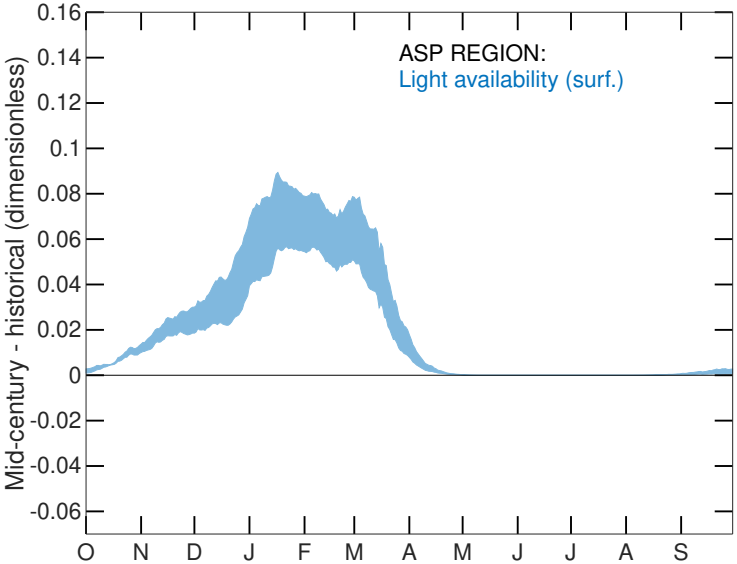
A change in timing ($\boldsymbol{\tau}$) explains more than half of the changes in sea ice concentration.

$$J = \iint \left| midcentury(x, y, t) - historical(x, y, t + \boldsymbol{\tau}) \right| \, dx \, dy$$

November:	Historical / Mid-century are neck and neck.
December:	Mid-century ahead by ~half a week.
January:	Mid-century ahead by ~2 weeks.
February:	Relationship breaks down as $t + \tau$ corresponds to period of sea ice production.

Max polynya extent is 20–60% larger in Mid-century.
Closing of ASP is delayed by ~2 weeks.

Implications for the bloom of the ASP



← Changes in the bloom's components over 110–127°W, ≥72°S.

Light ↗ from sea ice reductions.

Biomass ↗ throughout the year, +10% in Jan/Feb/March.

Production ↗ *initially*, +25–40% on 1 December, but falls to −10% in February.

dFe responsible for drop in production, lower by 25% in February.

This a consequence of:
— uptake beginning earlier in the season,
— higher biomass (more mouths to feed).

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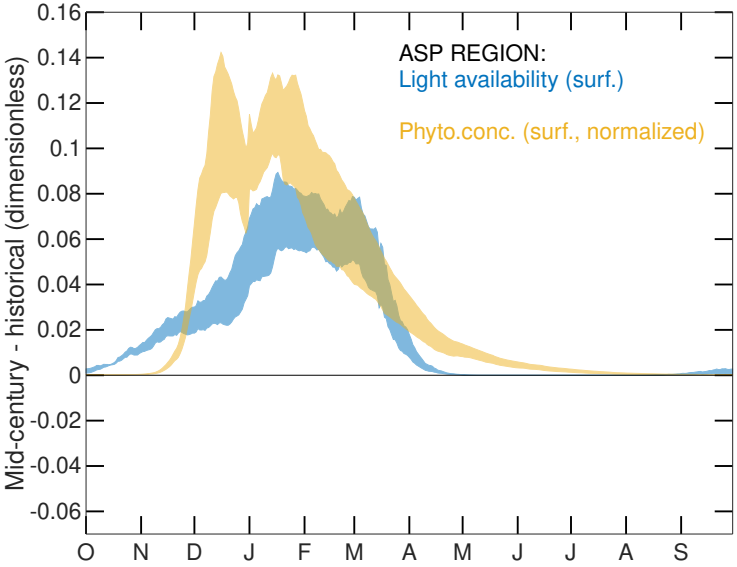

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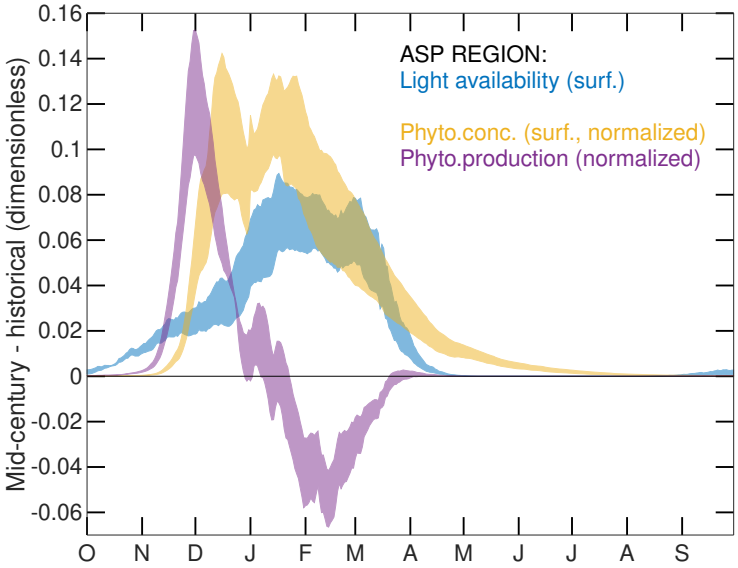

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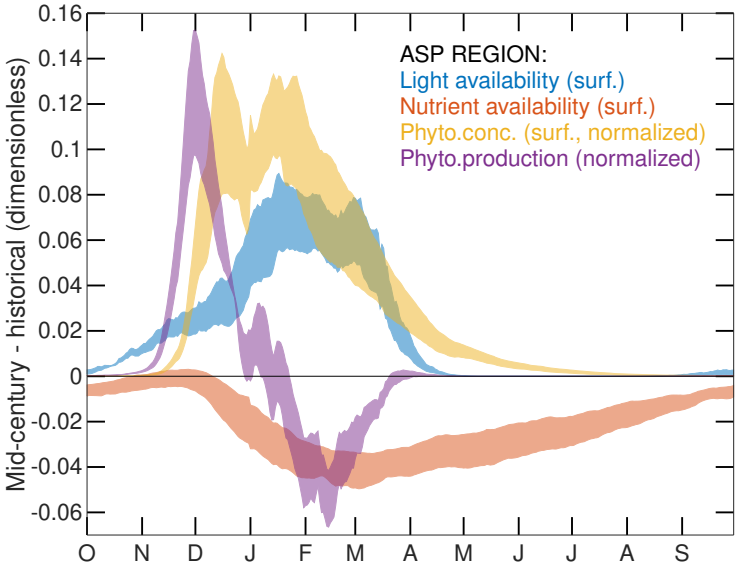

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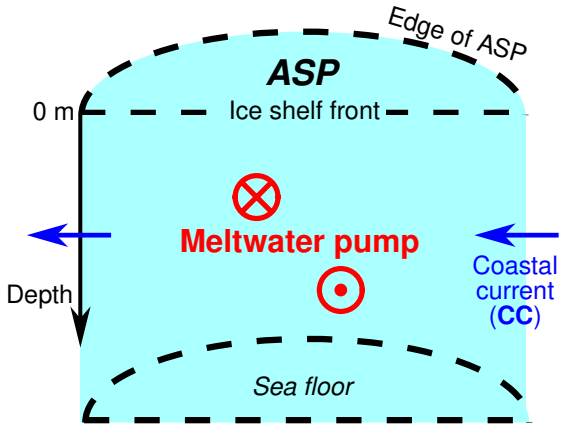
Why is the ↗ in ice shelf melt (ISM) not increasing dFe conc.?

Meltwater Pump+CC:	+0.08 mol-Fe s^{-1}
Remineralization:	+0.20 mol-Fe s^{-1}
Sinks dFe in Winter:	−0.10 mol-Fe s^{-1}
in Summer:	−0.35 mol-Fe s^{-1}

Pump contributes to building up dFe in winter (savings account) but sinks dominate the summertime budget.

+20% raises Pump+CC to +0.10 mol-Fe s^{-1}, *i.e.* a significant change for winter budget, but a minor one for summer budget.



St-Laurent *et al.* 2019.

Summary: The ASP 35 years in the future

Summer biomass increases by +10% in response to the warming.

ASP's contribution to biological pump is expected to increase by a similar amount.

However, finite dFe inventory prevents primary production from scaling up in proportion to sea ice changes.

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Thank you for your attention.