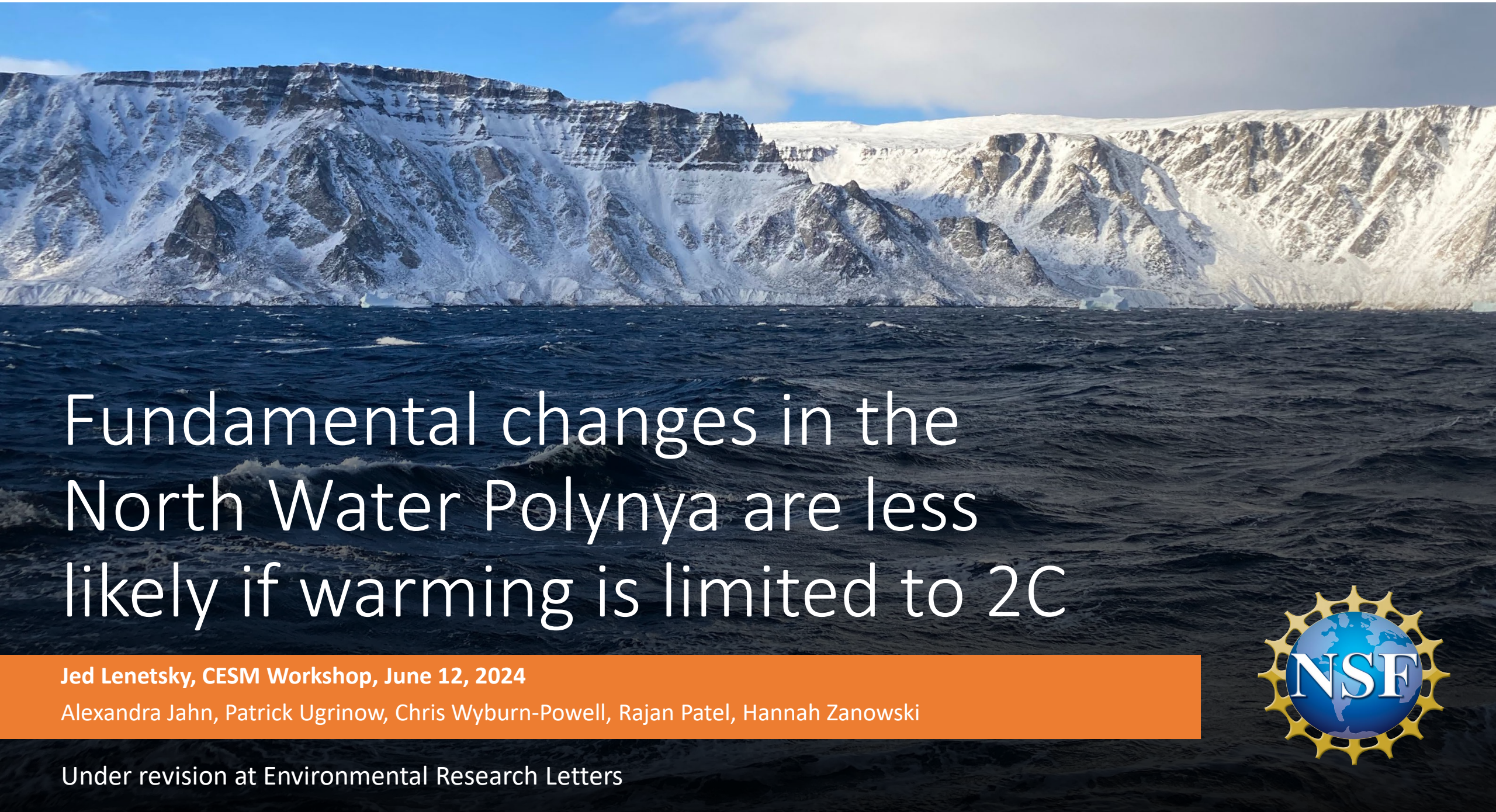


Fundamental changes in the North Water Polynya are less likely if warming is limited to 2C

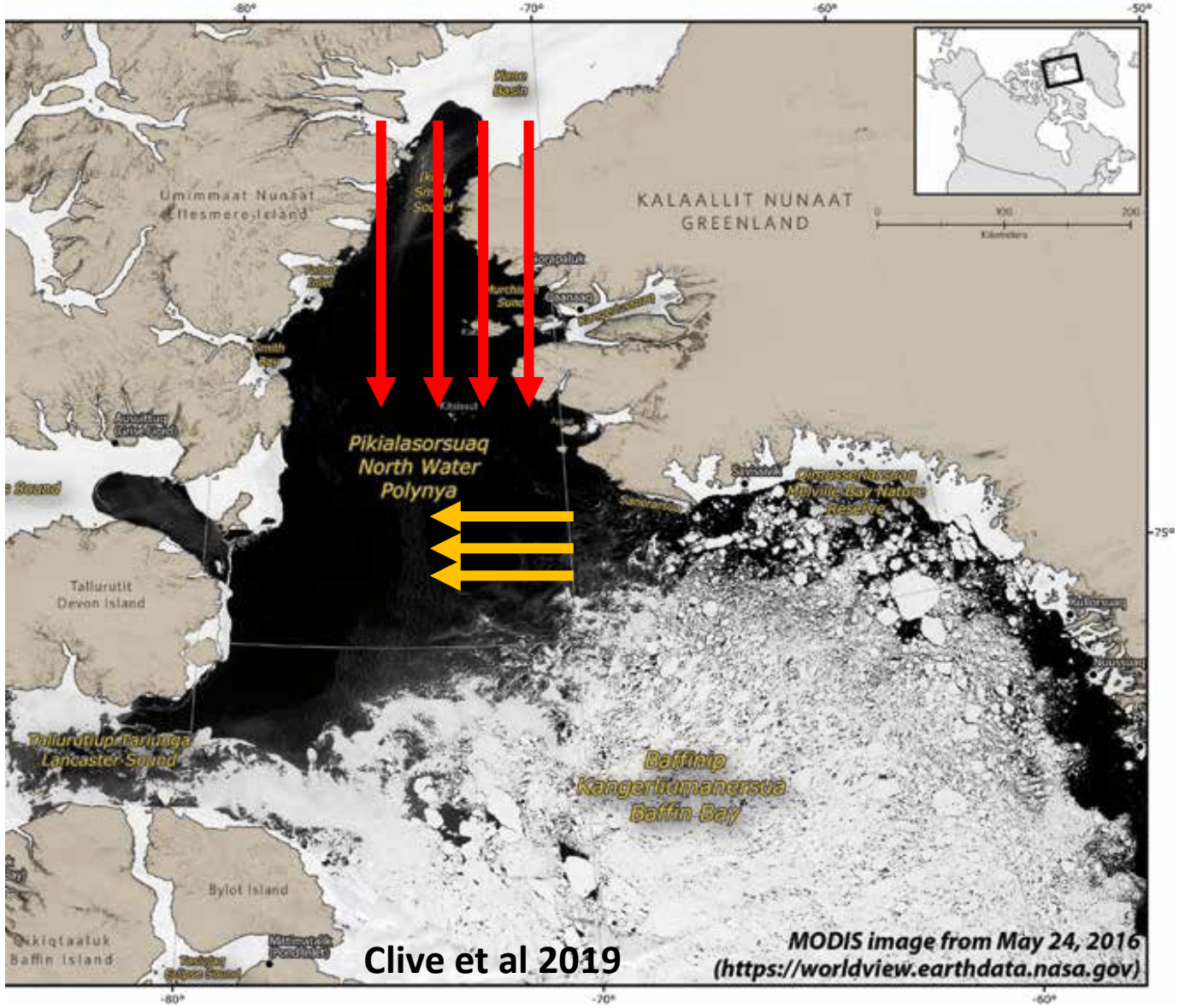
Jed Lenetsky, CESM Workshop, June 12, 2024

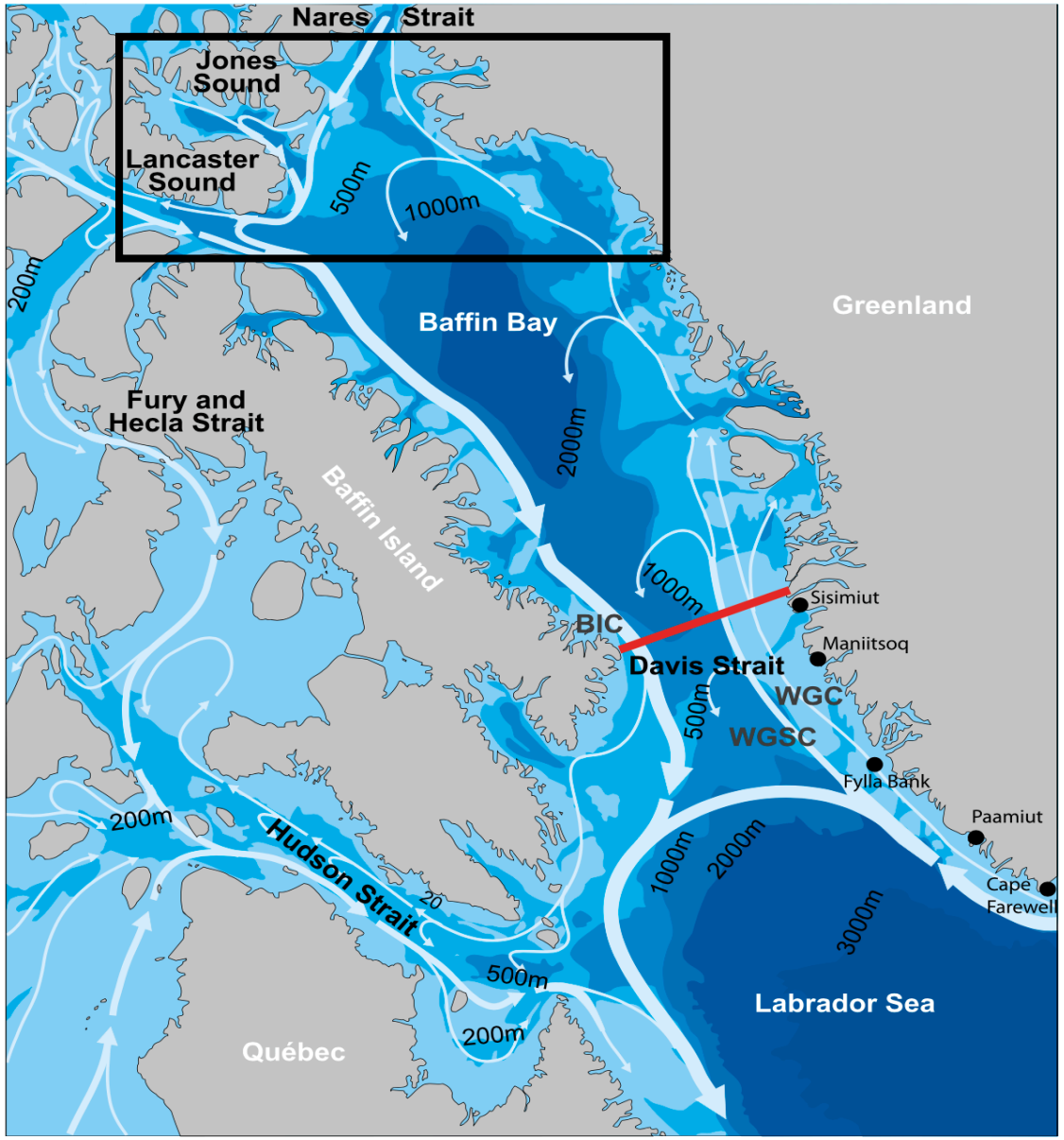
Alexandra Jahn, Patrick Ugrinow, Chris Wyburn-Powell, Rajan Patel, Hannah Zanowski

Under revision at Environmental Research Letters

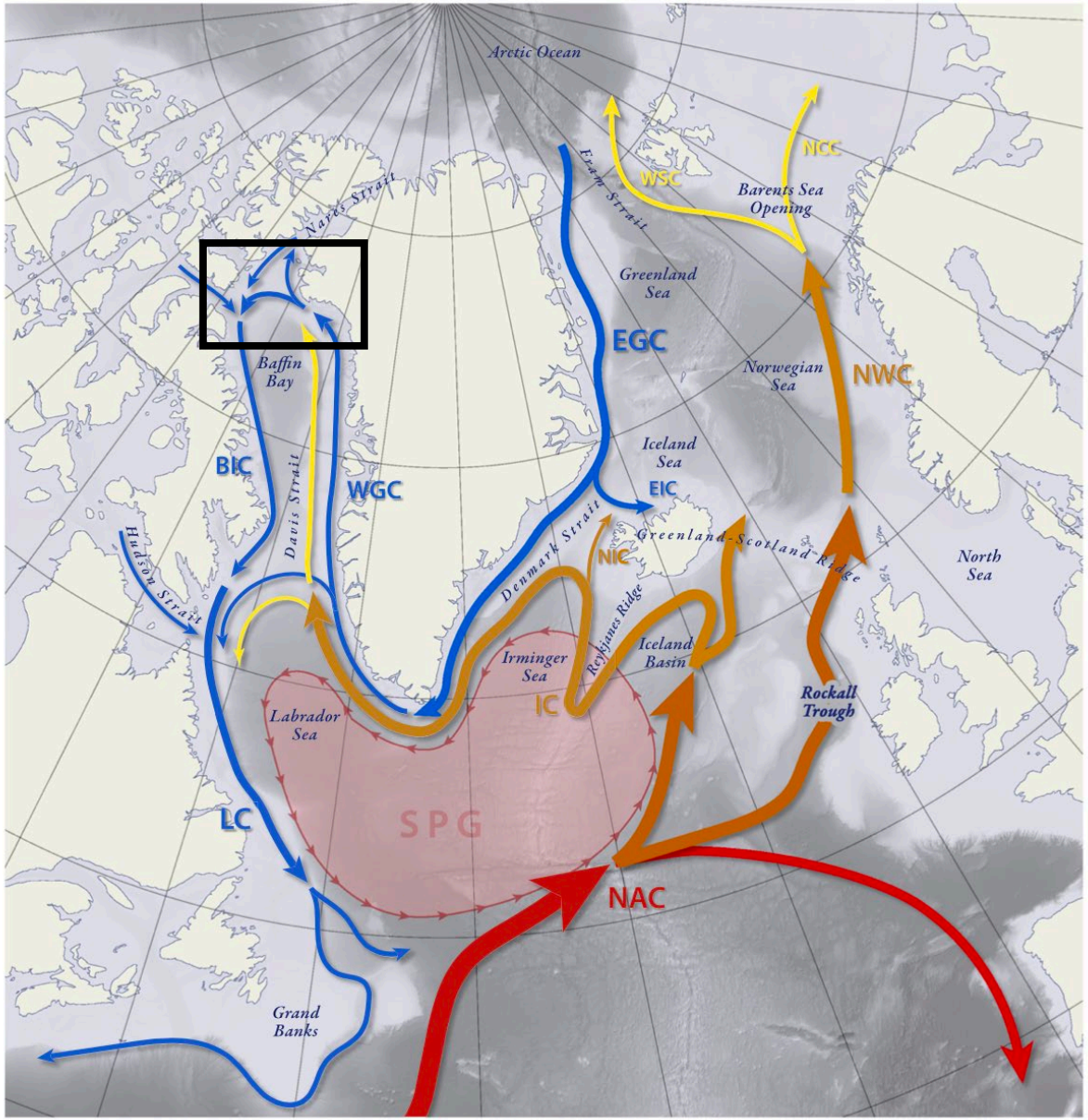
North Water Polynya (NOW) or Pikialasorsuaq

- Most productive ecosystem in the Arctic Ocean
- Maximum size is ~80,000 km^2 (= area of South Carolina)
- The NOW is a nexus point for transports of sea ice and freshwater between the Arctic Ocean and subpolar North Atlantic





Curry et al (2014)



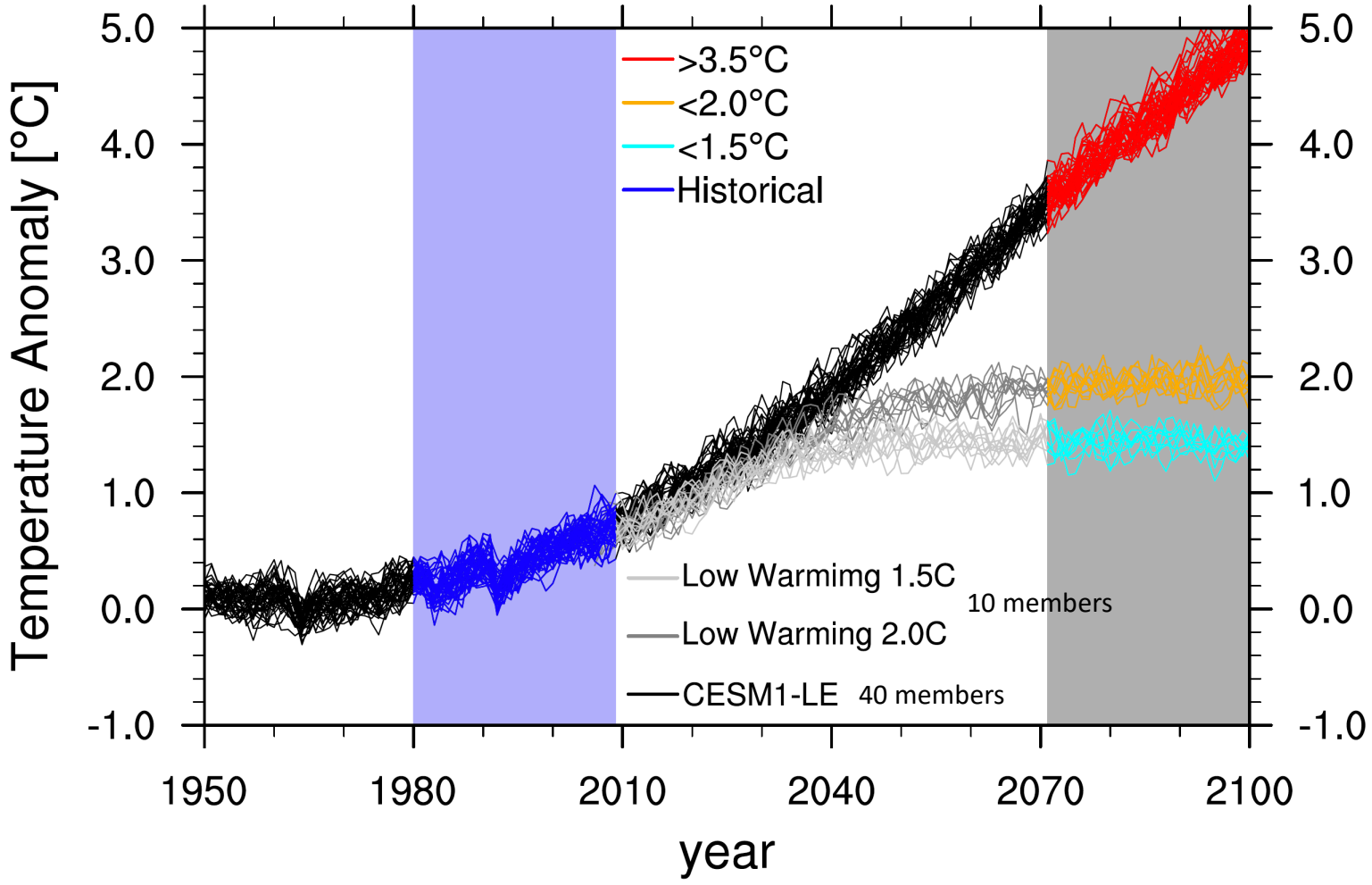
Tesdale & Haine (2020)

Guiding scientific questions

1. How does the size of the NOW change under different global warming scenarios?
2. How do oceanographic conditions in the NOW change under different global warming scenarios?
3. What are the implications of these changes on biological productivity (NPP)?

Methods: Climate simulations

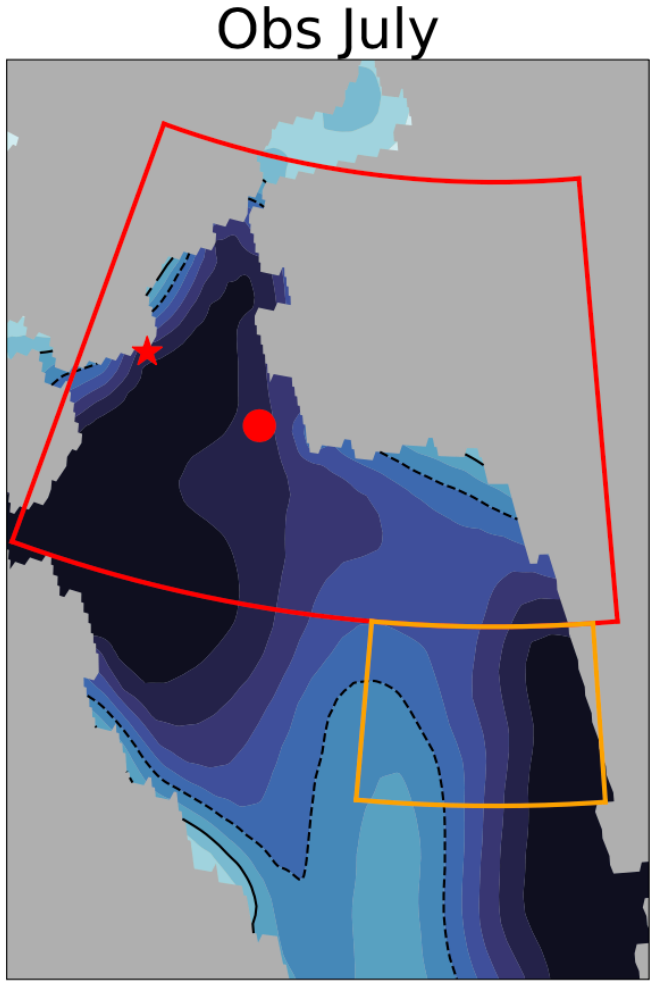
- We focus on 30 year means at specific warming levels instead of time
- Use the CESM1-LE for the historical (1980-2009) and high warming levels (2071-2100)
- Use low warming simulations (2071-2100) which branched from CESM1-LE in 2009 (Sanderson et al. 2017)



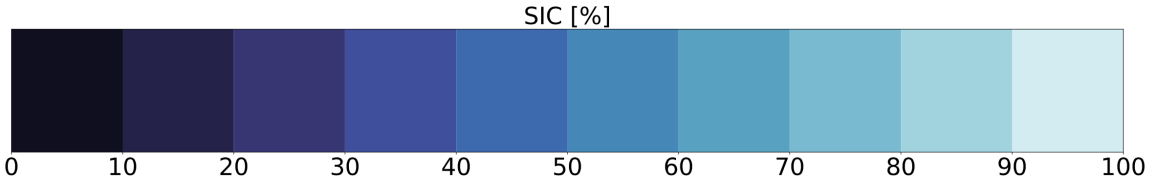
Lenetsky et al. *in revision*

How do we calculate the NOW polynya area?

- Area within red box with SIC less than 70%
- Polynya area is 0 if SIC in yellow box is less than 50%

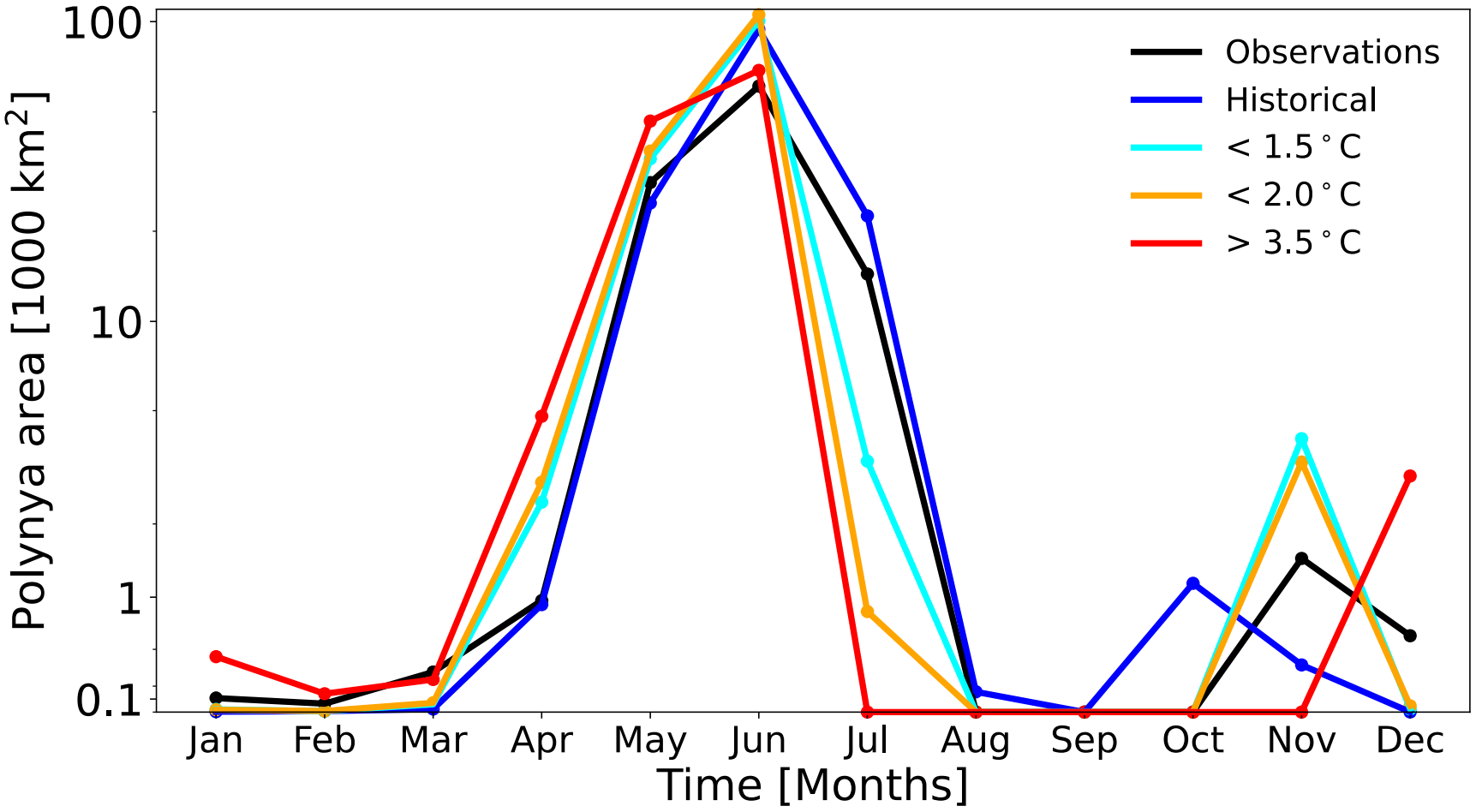


Lenetsky et al. *in revision*



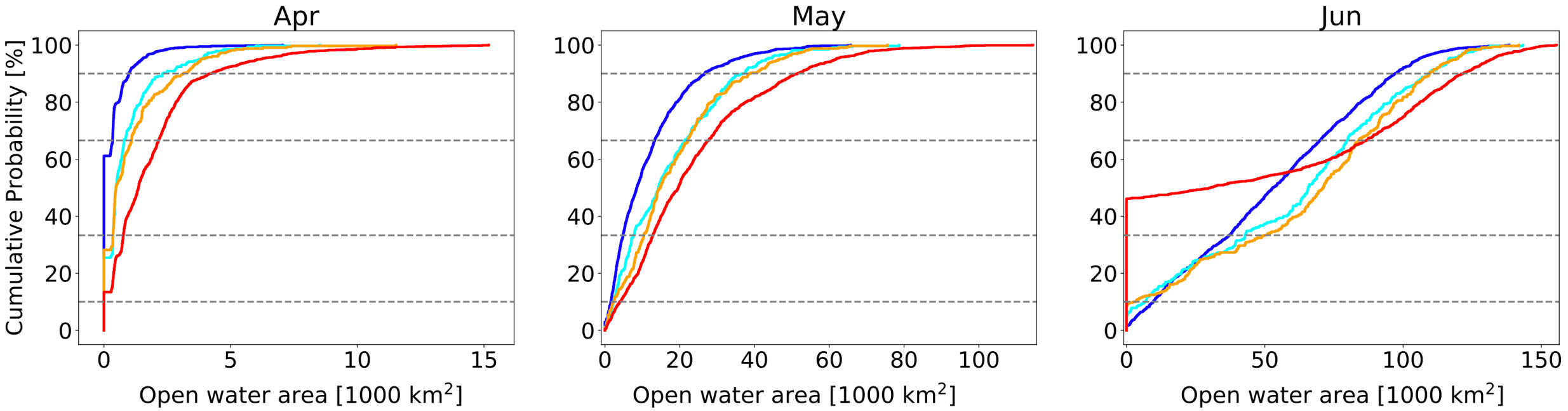
Question 1: How does the size of the NOW change under different global warming scenarios?

- As warming level increases:
  - Spring polynya areas increase
  - Polynya disappears earlier



Lenetsky et al. *in revision*

Question 1: How does the size of the NOW change under different global warming scenarios?

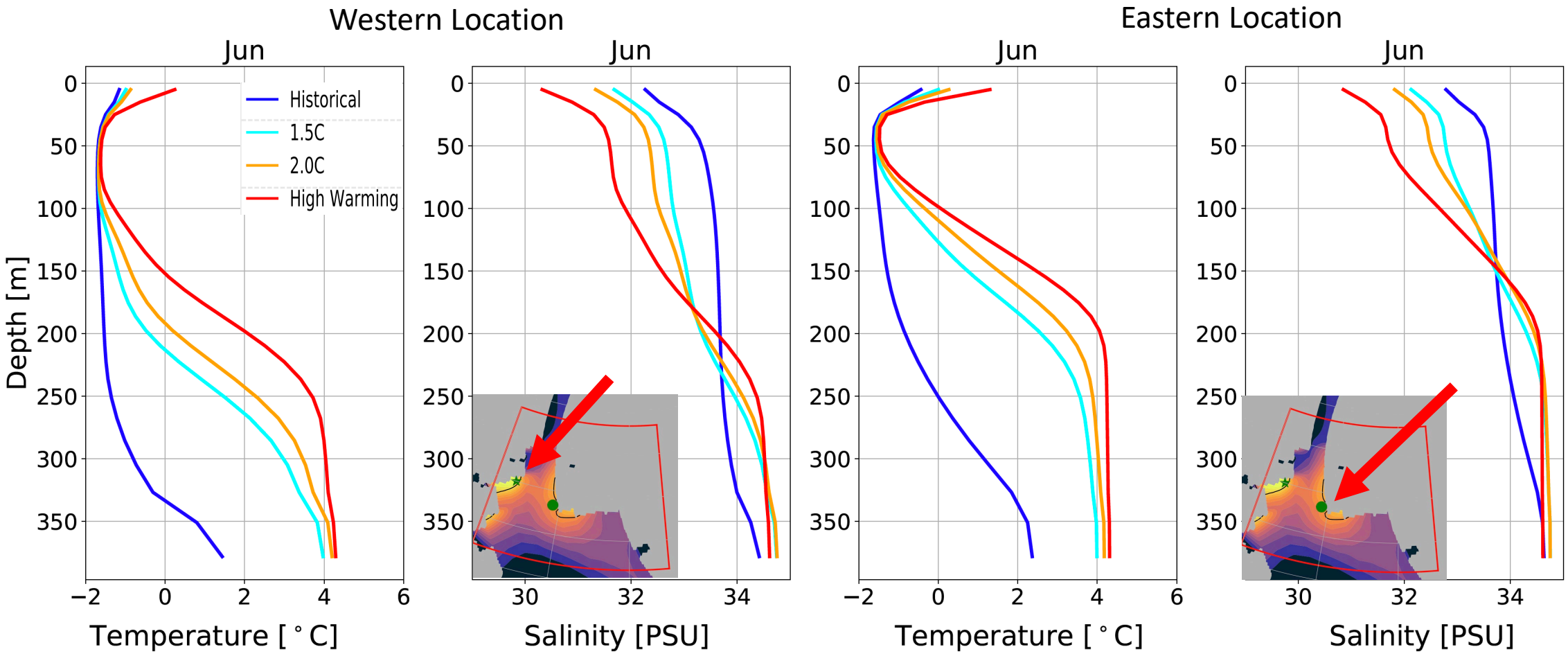


- As warming levels increase:
  - Spring polynya areas increase
  - Polynya disappears earlier

Historical
1.5C
2.0C
High Warming

Lenetsky et al. *in revision*

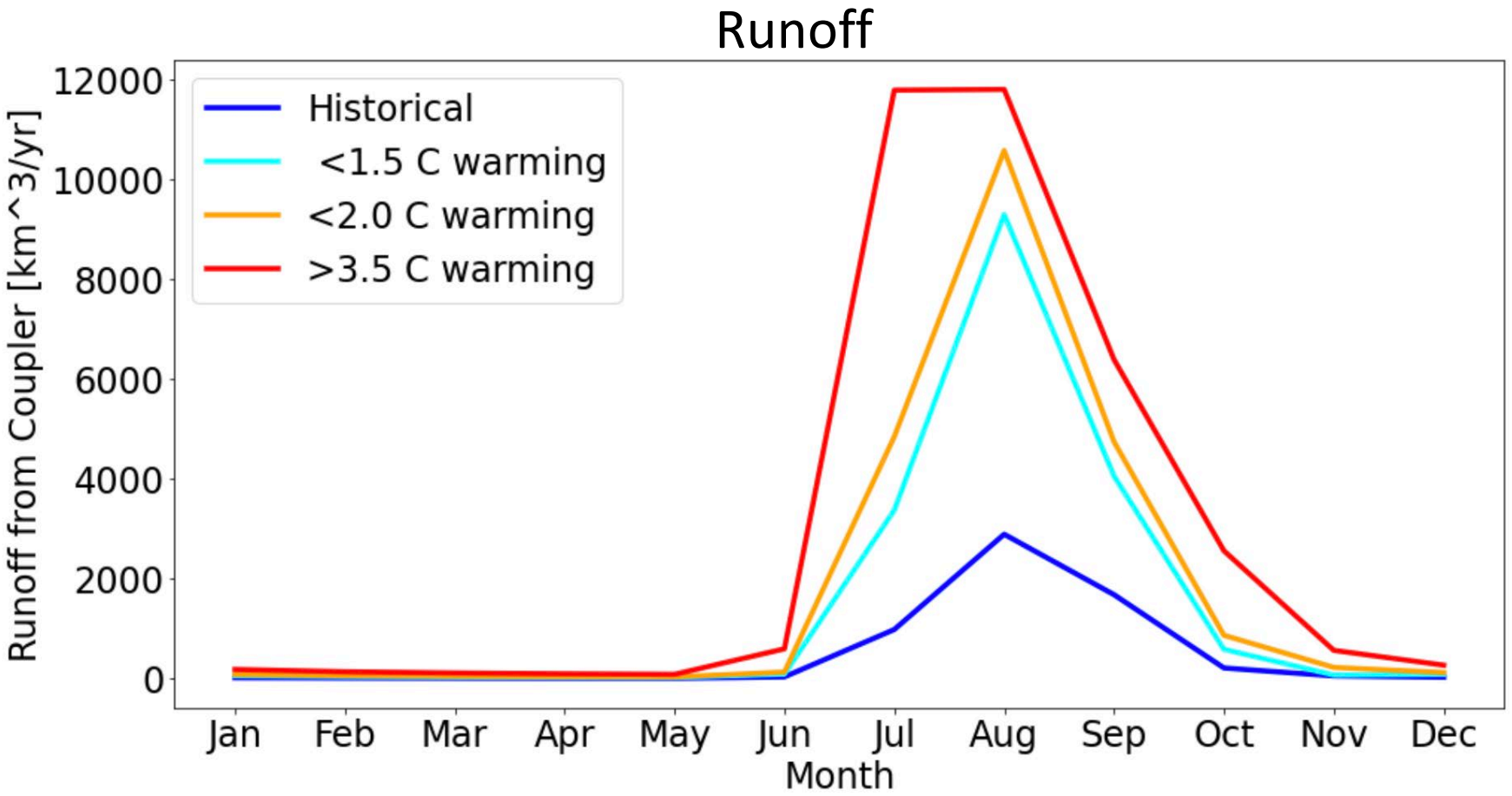
Question 2: How do oceanographic conditions in the NOW change under different global warming scenarios?



Lenetsky et al. *in revision*

Question 2: How do oceanographic conditions in the NOW change under different global warming scenarios?

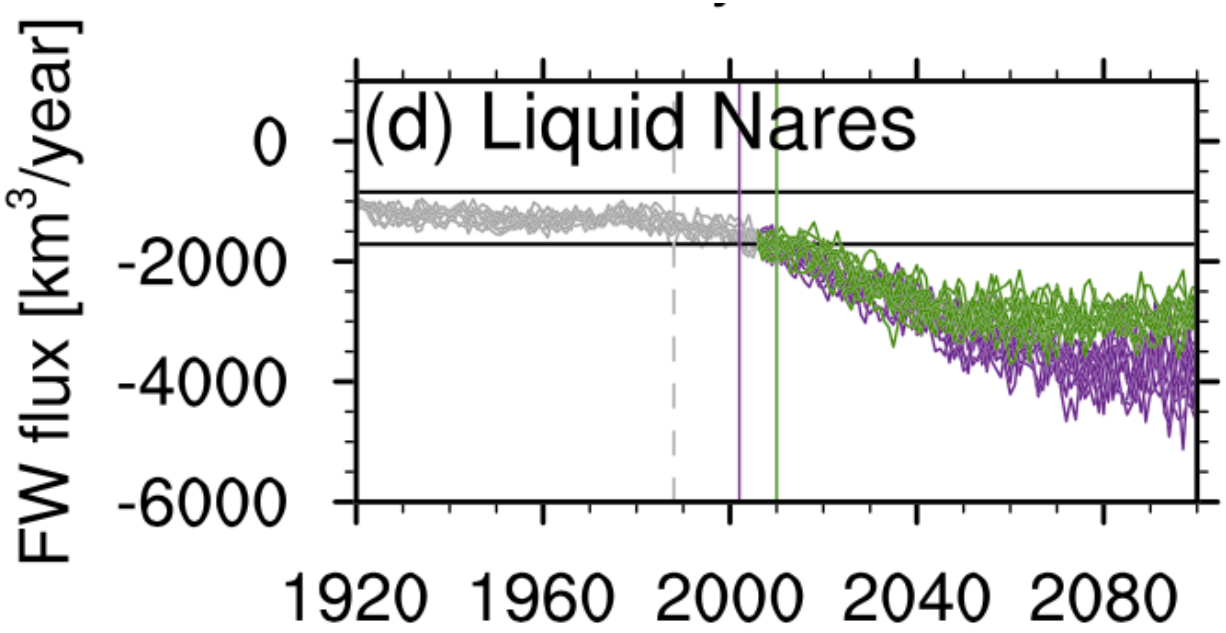
- Land runoff provides a substantial source of freshwater
- Runoff increases with warming level



Lenetsky et al. *in revision*

Question 2: How do oceanographic conditions in the NOW change under different global warming scenarios?

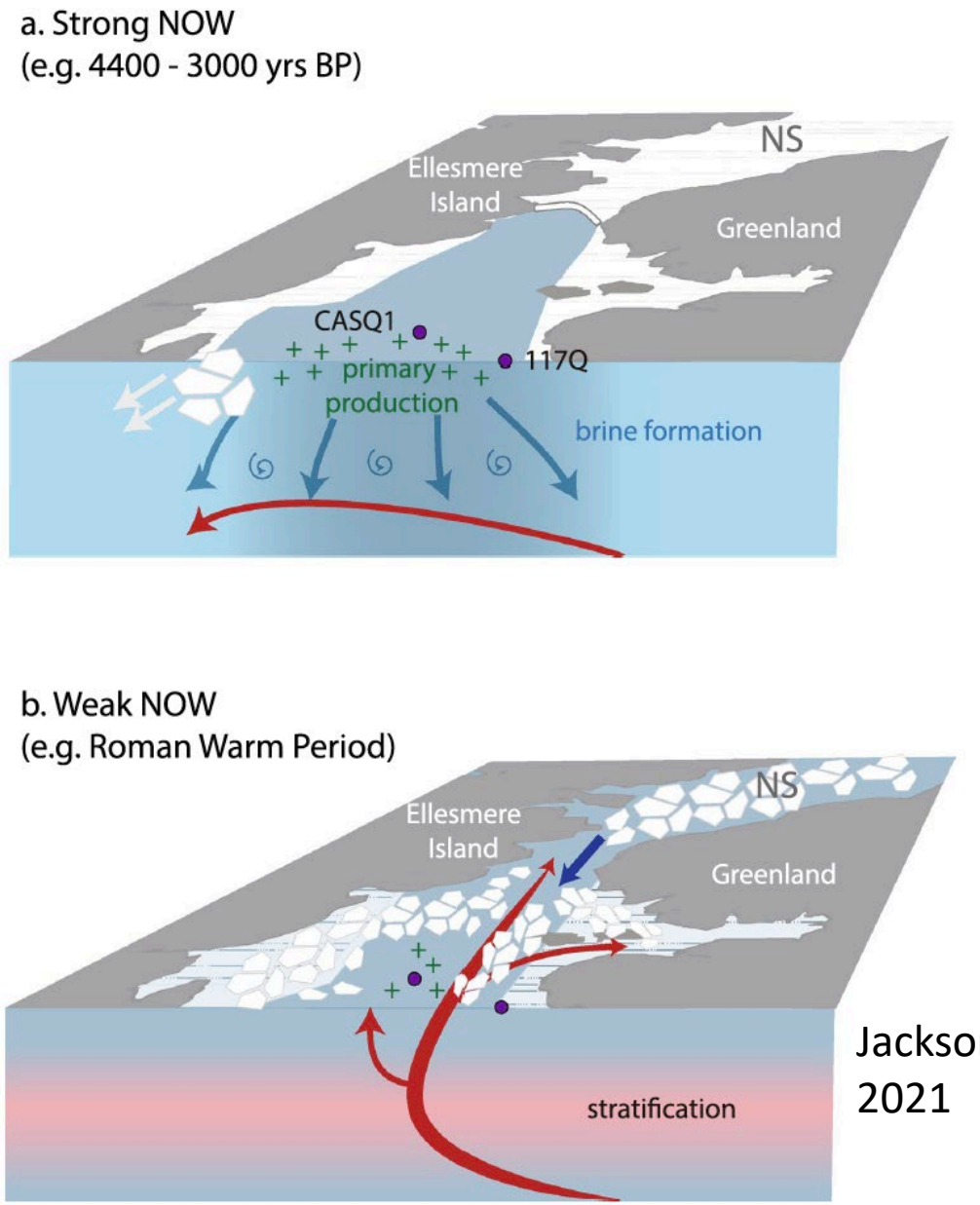
Freshwater import into Baffin Bay through the Nares Strait is projected to increase under low warming (green) and high warming (purple) climate scenarios compared to historical levels (grey).



Jahn & Laiho (2020)

Question 2: How do oceanographic conditions in the NOW change under different global warming scenarios?

- Reduced sea ice formation and brine rejection increases stratification
- Allows comparatively warm, salty, and nutrient rich west Greenland waters (WGIW) to intrude into the NOW region

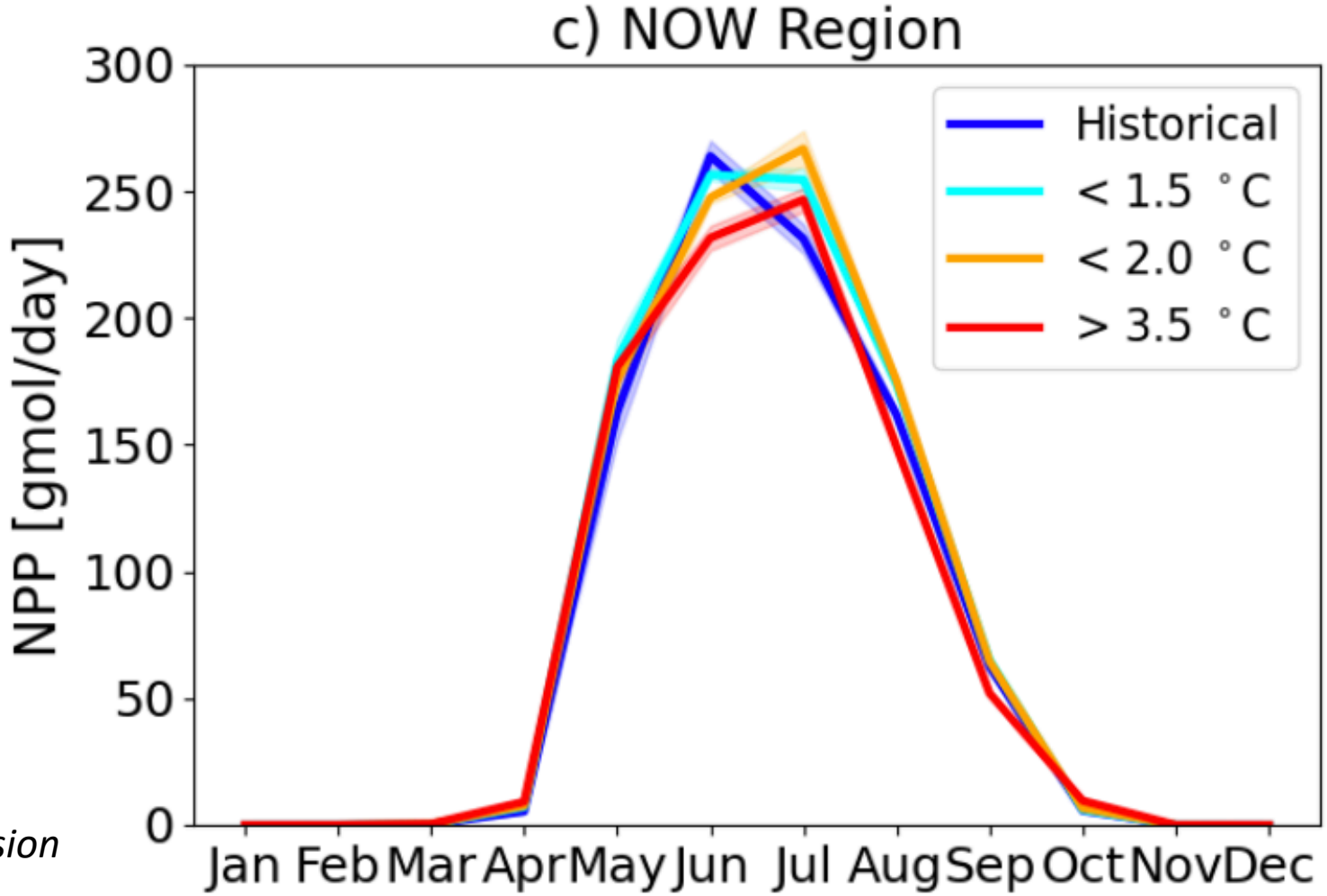


Jackson et al. 2021

Figure 8. Schematic illustration of contrasting conditions and oceanic configuration in northernm

Question 3: What are the implications of ocean changes on NPP in the NOW?

- Productivity is similar for all warming levels for January through May
- Under lower warming levels, peak NPP shifts from June to July
- Higher warming levels see an NPP shift with a slight reduction in peak NPP



Lenetsky et al. *in revision*

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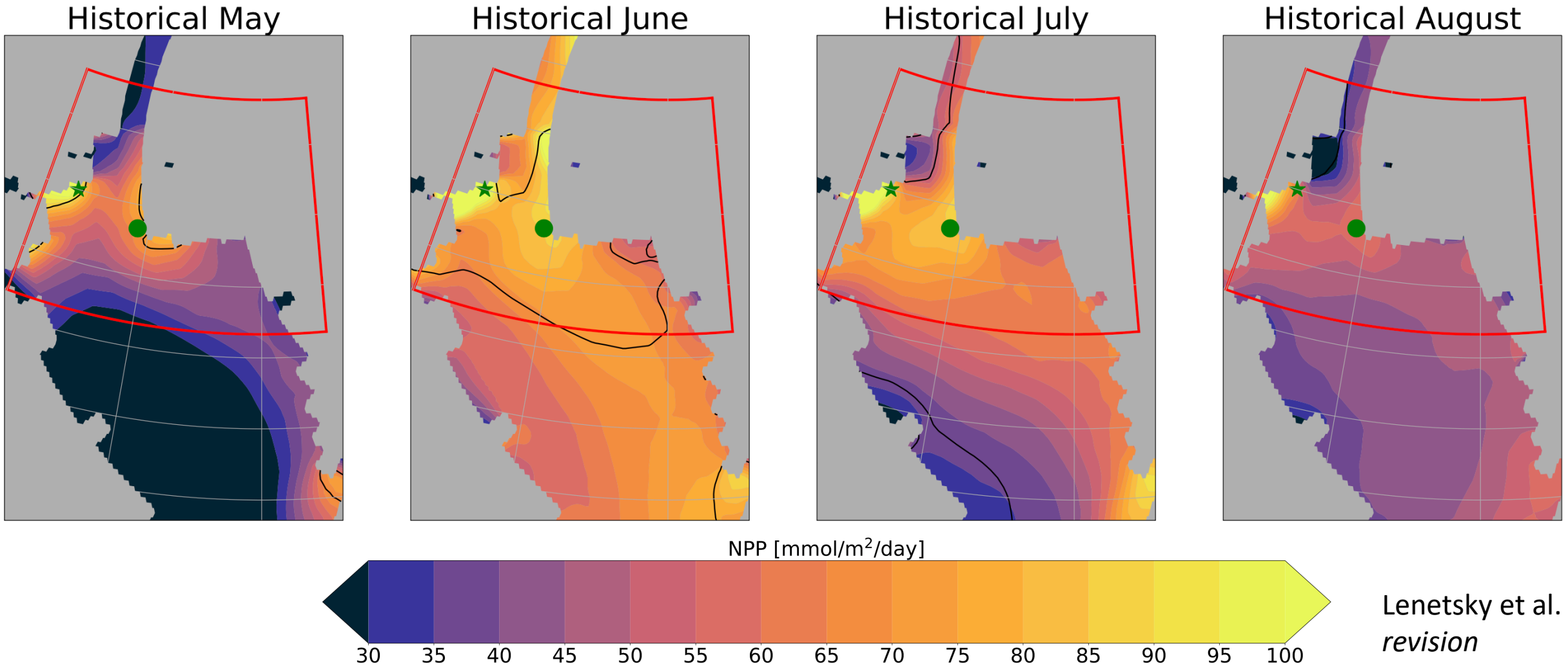
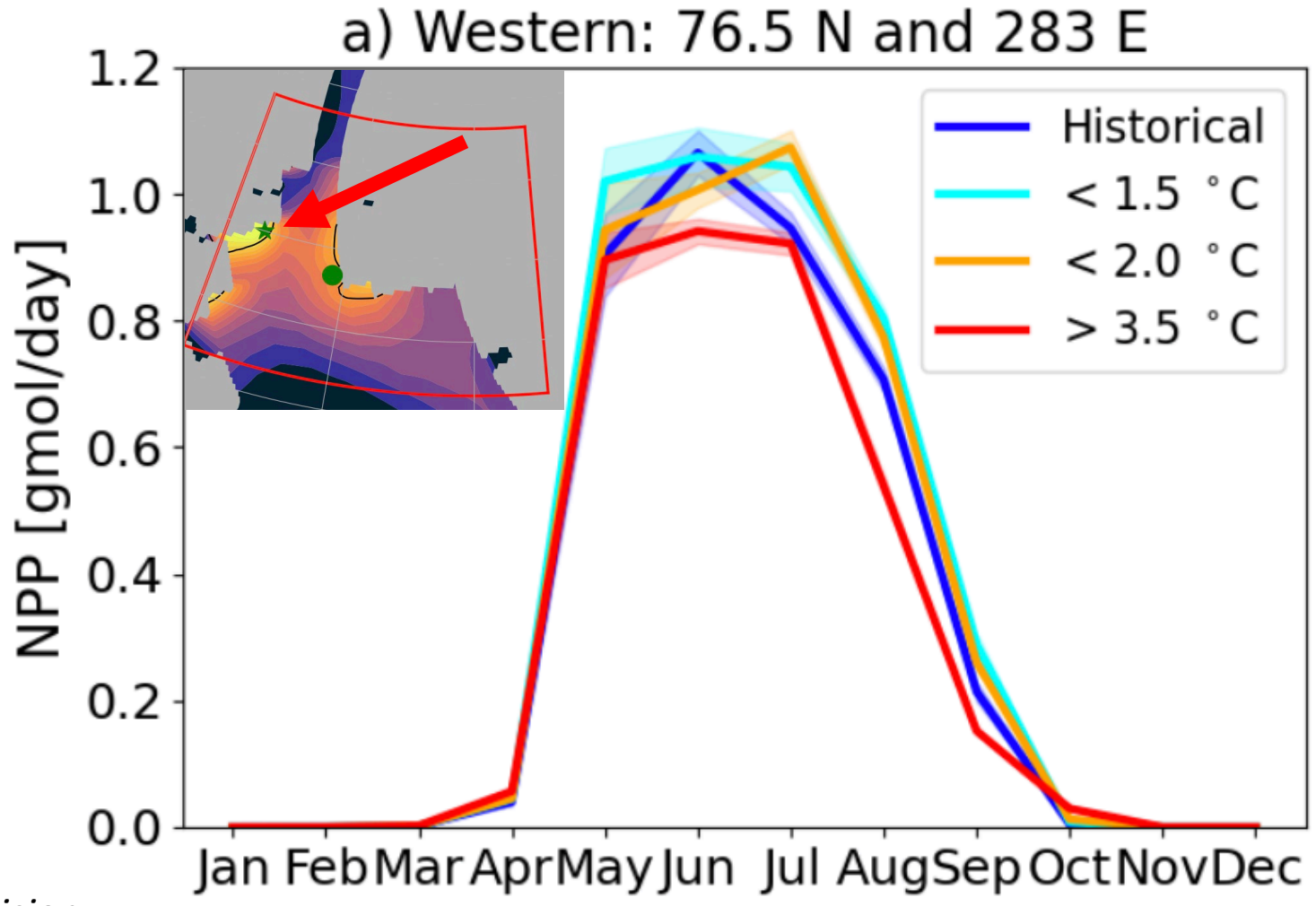


Lenetsky et al. *in revision*

Question 3: What are the implications of ocean changes on net primary productivity (NPP) in the NOW?

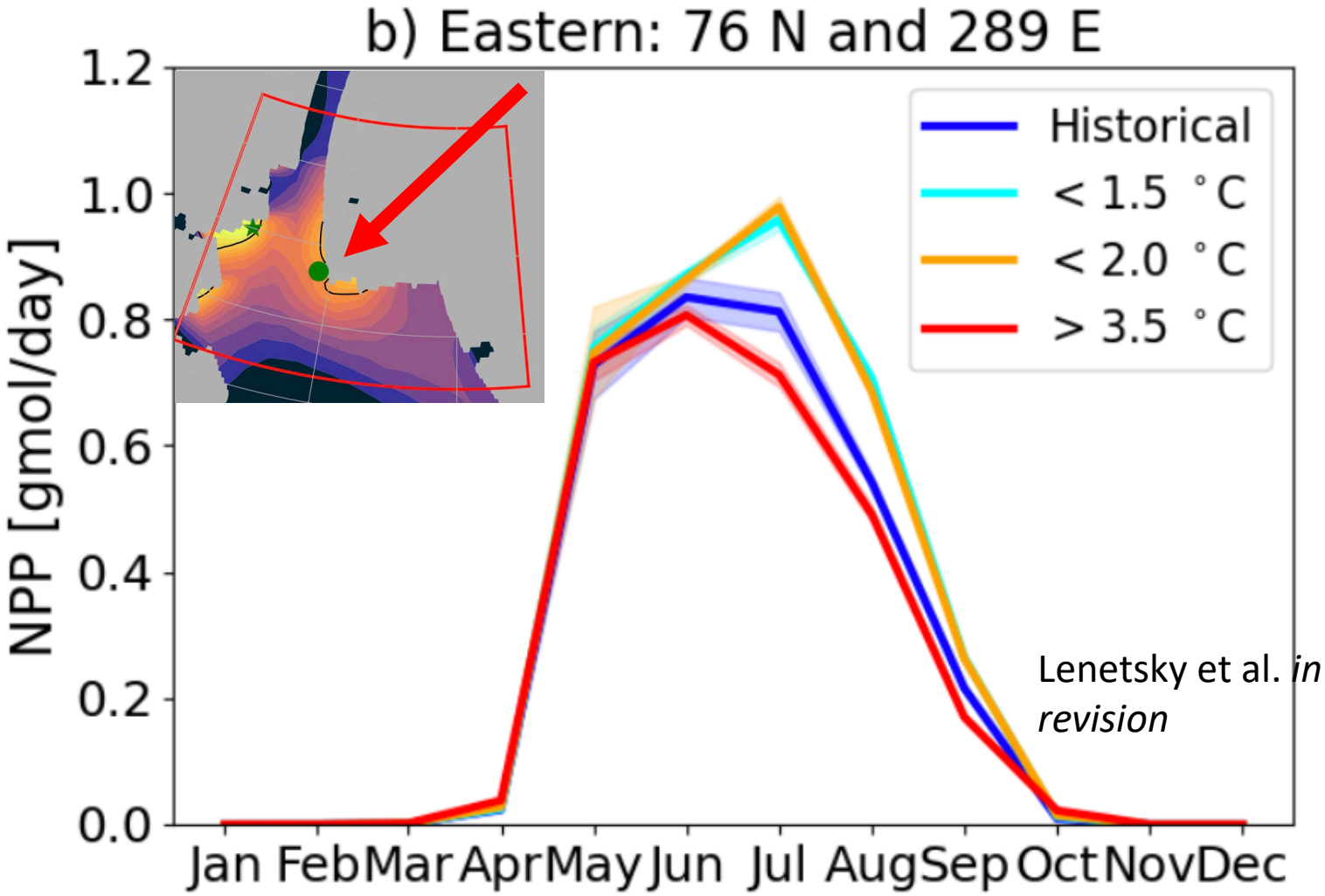
- Productivity is similar for all warming levels for January through April
- Under lower warming levels, peak NPP shifts from June to July
- Under higher warming levels, peak productivity decreases due to increased stratification



Lenetsky et al. *in revision*

Question 3: What are the implications of ocean changes on NPP in the NOW?

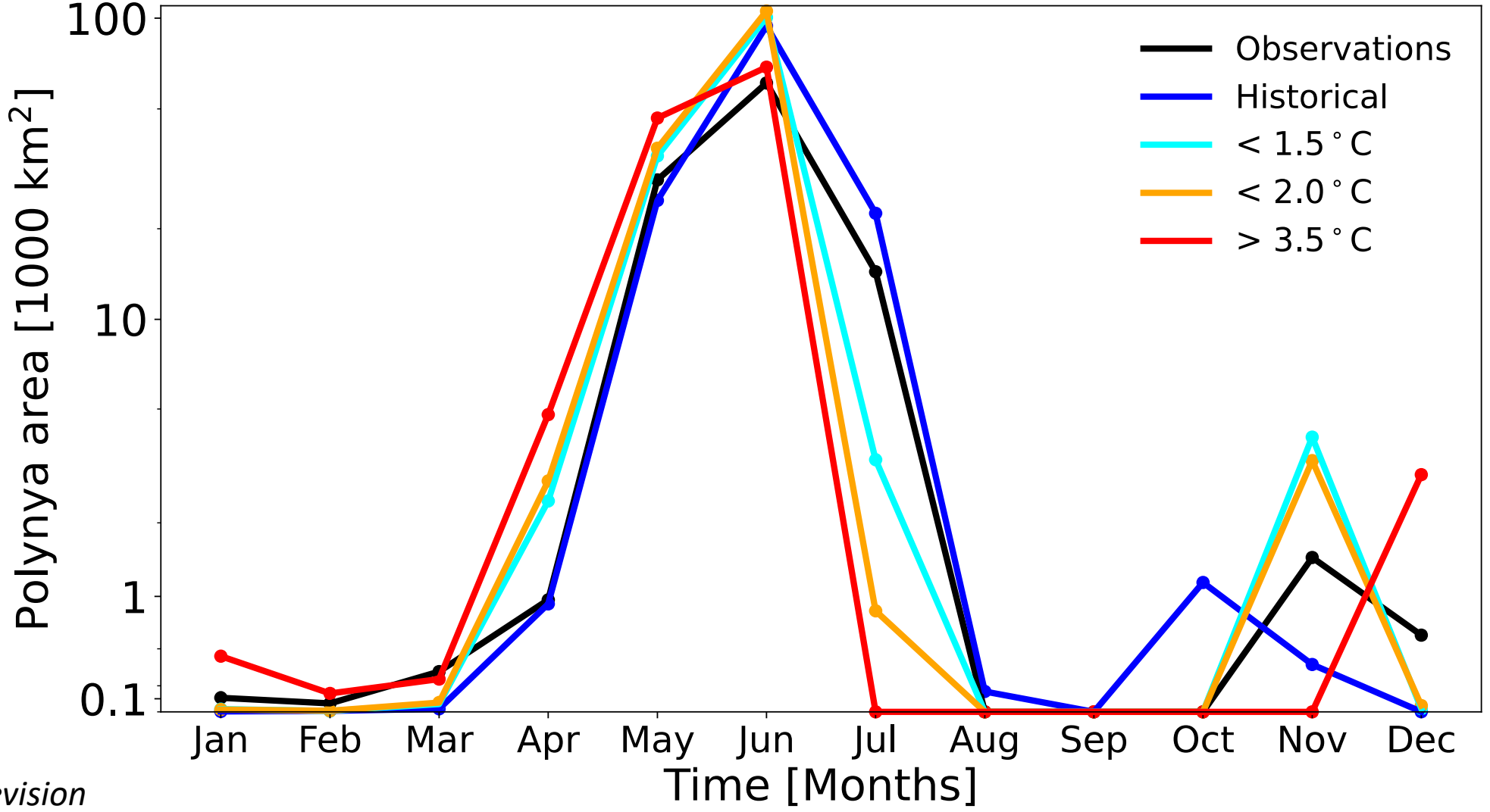
- Productivity is similar for all warming levels for January through June
- Under lower warming levels, productivity increases due to increased nutrient rich waters at depth
- Under higher warming levels, stratification is too strong for those nutrients to reach the surface from coastal upwelling



Lenetsky et al. *in revision*

Summary and conclusions

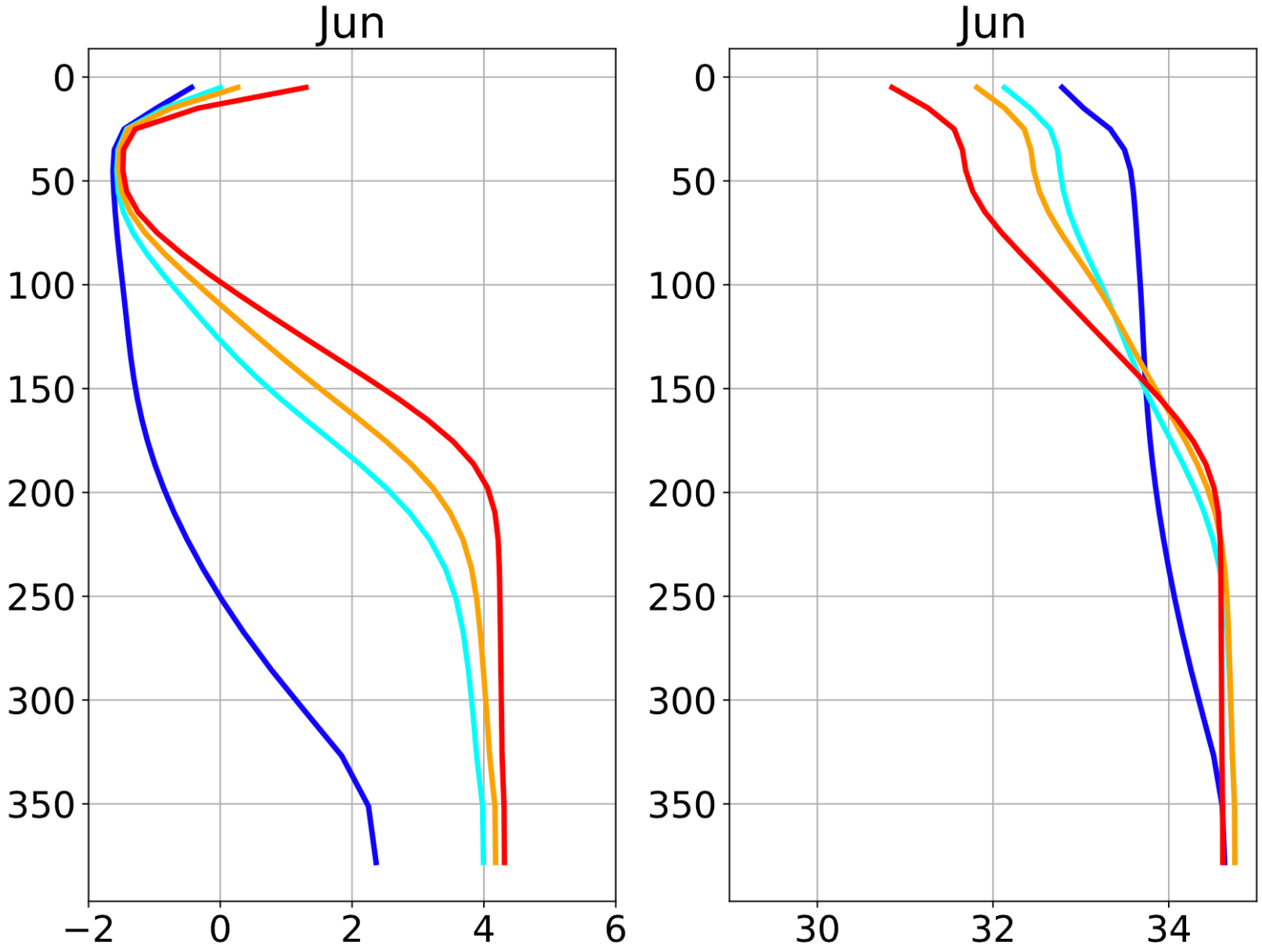
- **Question 1:** Under increased climate warming, the NOW will open and disappear earlier



Lenetsky et al. *in revision*

Summary and conclusions

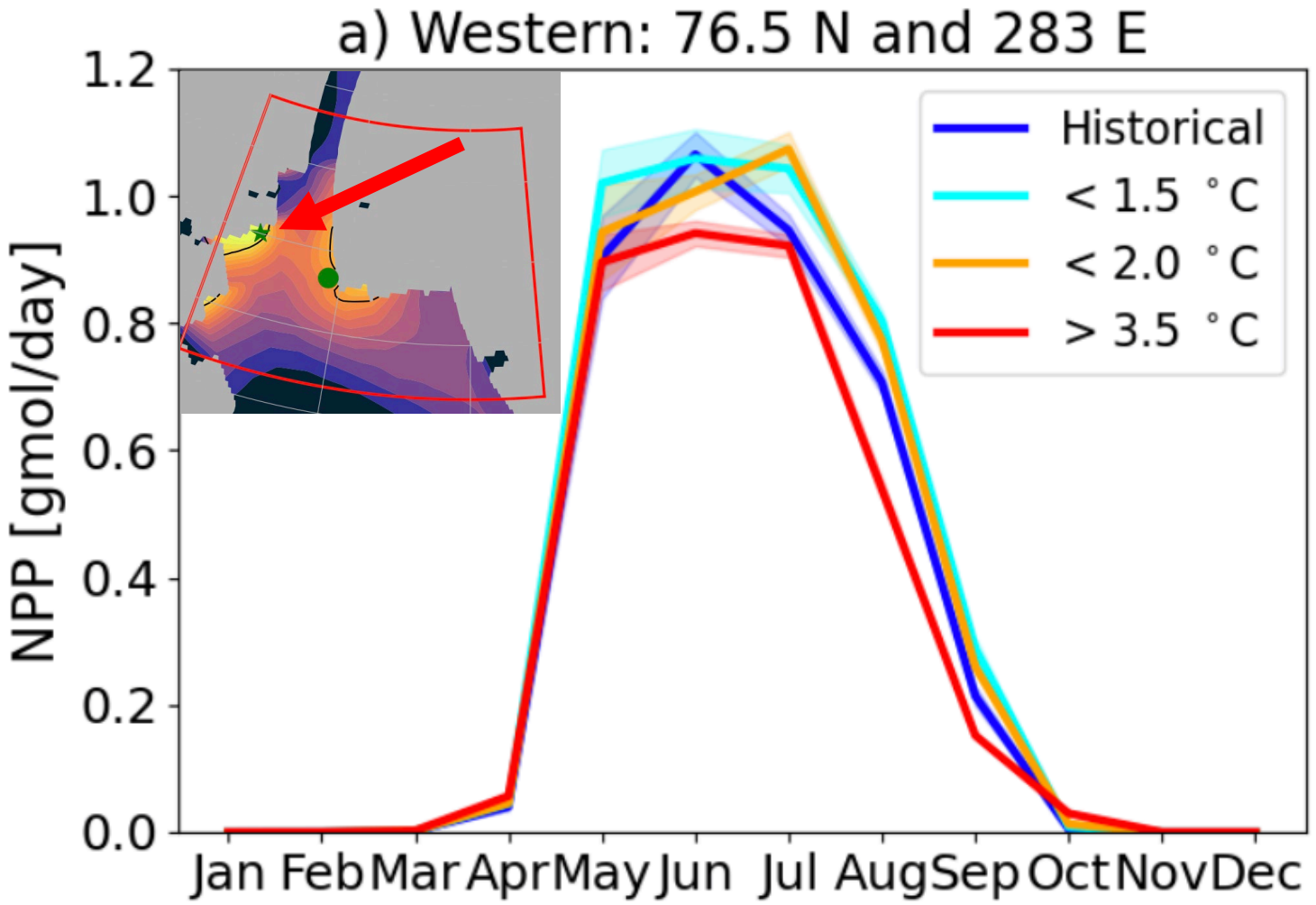
- **Question 2:** Surface stratification will increase from Arctic freshwater input and land runoff
- **Question 2:** Warm, salty, nutrient rich WGIW will intrude deeper into the NOW region



Lenetsky et al. *in revision*

Summary and conclusions

- **Question 3:** Under low warming scenarios, productivity may increase due to more available nutrients (despite increased stratification)
- **Question 3:** Under higher warming scenarios, stratification is too large to make use of increased nutrients at depth, leading to a decline in productivity



Lenetsky et al. *in revision*

Summary and conclusions

- **Question 1:** Under increased climate warming, the NOW will open and disappear earlier
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- **Question 3:** Under low warming scenarios, productivity may increase due to more available nutrients (despite increased stratification)
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These results point to the need to limit global warming to 2 deg C in order to prevent substantial and adverse environmental impacts in the NOW

Summary and conclusions

- **Question 1:** Under increased climate warming, the NOW will open and disappear earlier
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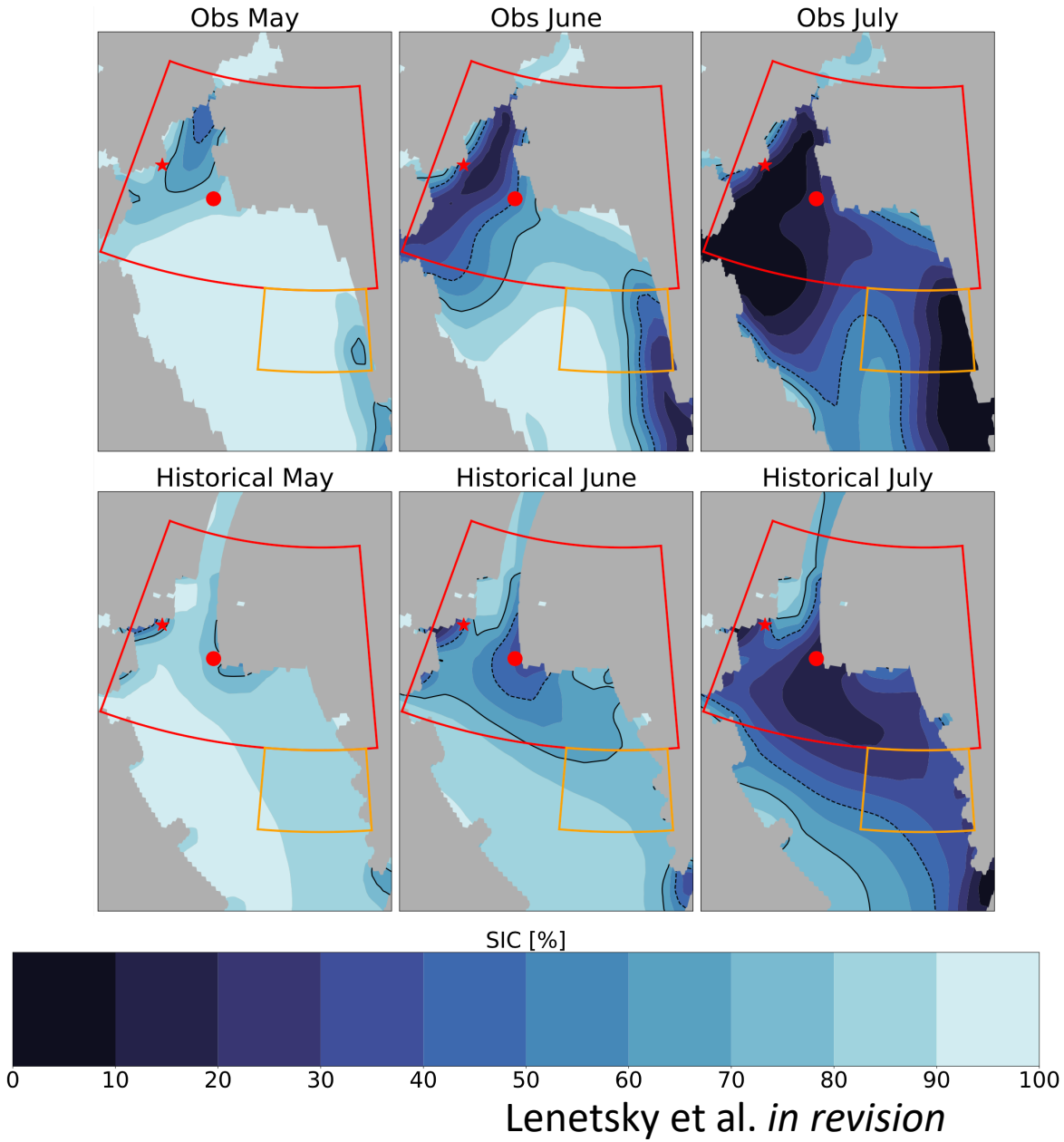
How well does the CESM1-LE simulate sea ice conditions in the NOW?

- In May, simulated SIC is lower along coastlines as opposed to southern Nares Strait in NSIDC observations
- In June, simulated open water is situated towards the southeast NOW, as opposed to the northwest
- These discrepancies are most likely due to differences in sea ice transports through the Nares Strait



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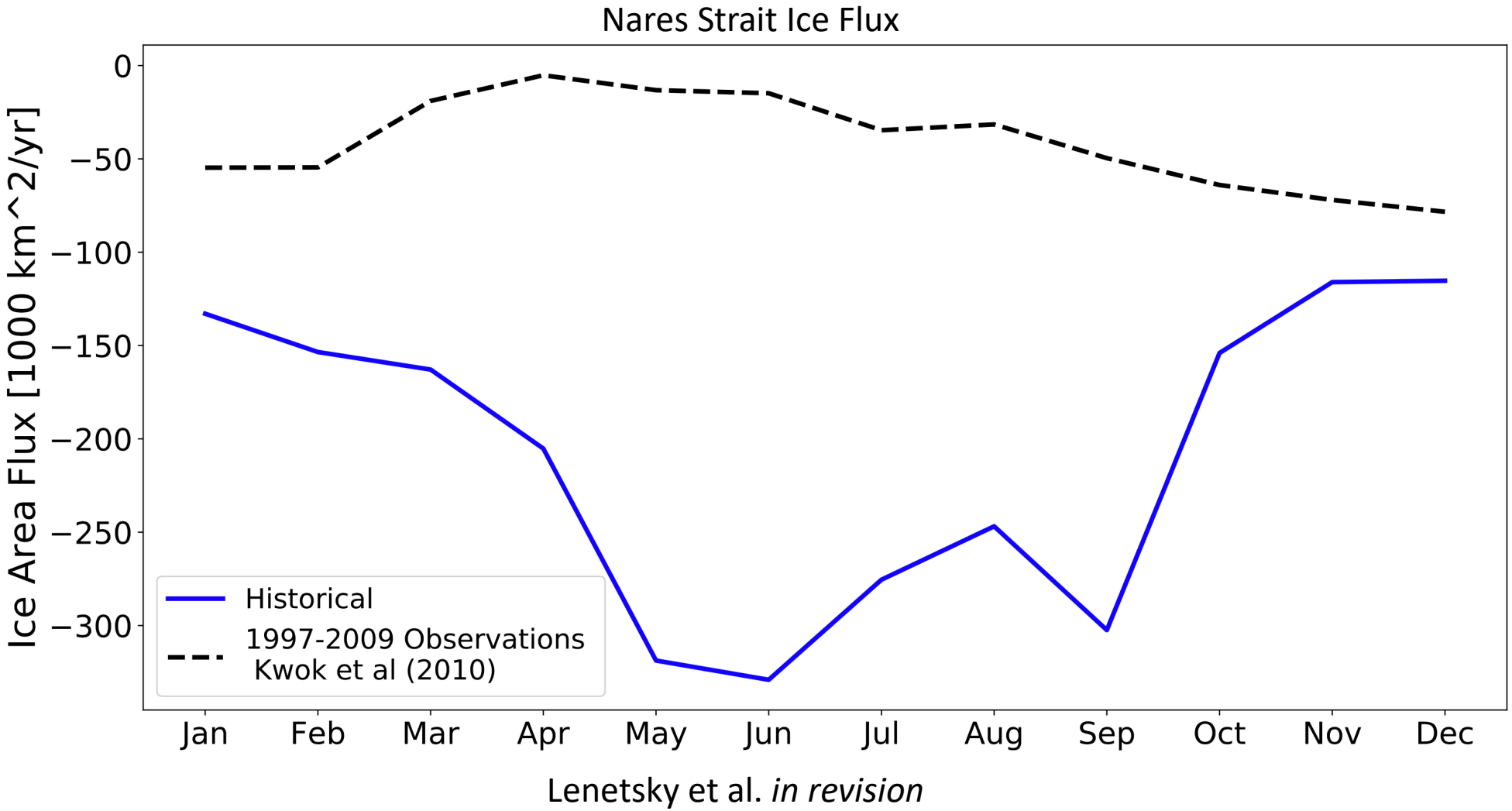
Method: How well does the CESM1-LE simulate sea ice conditions in the NOW?



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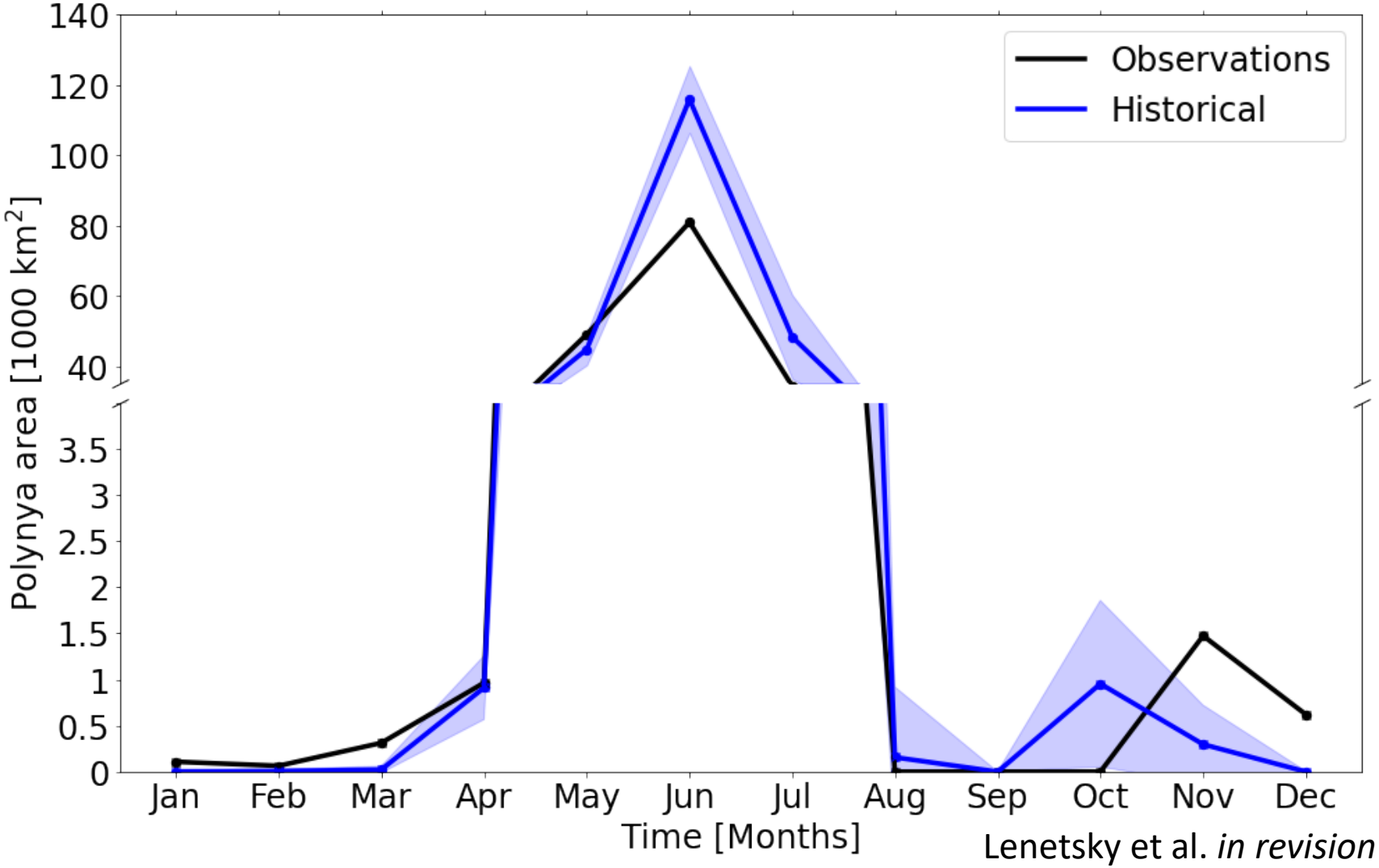
How well does the CESM1-LE simulate sea ice conditions in the NOW?

- Simulated seasonal cycles largely match observations
- Peak polynya areas are over-estimated in June but are within ensemble spread other months



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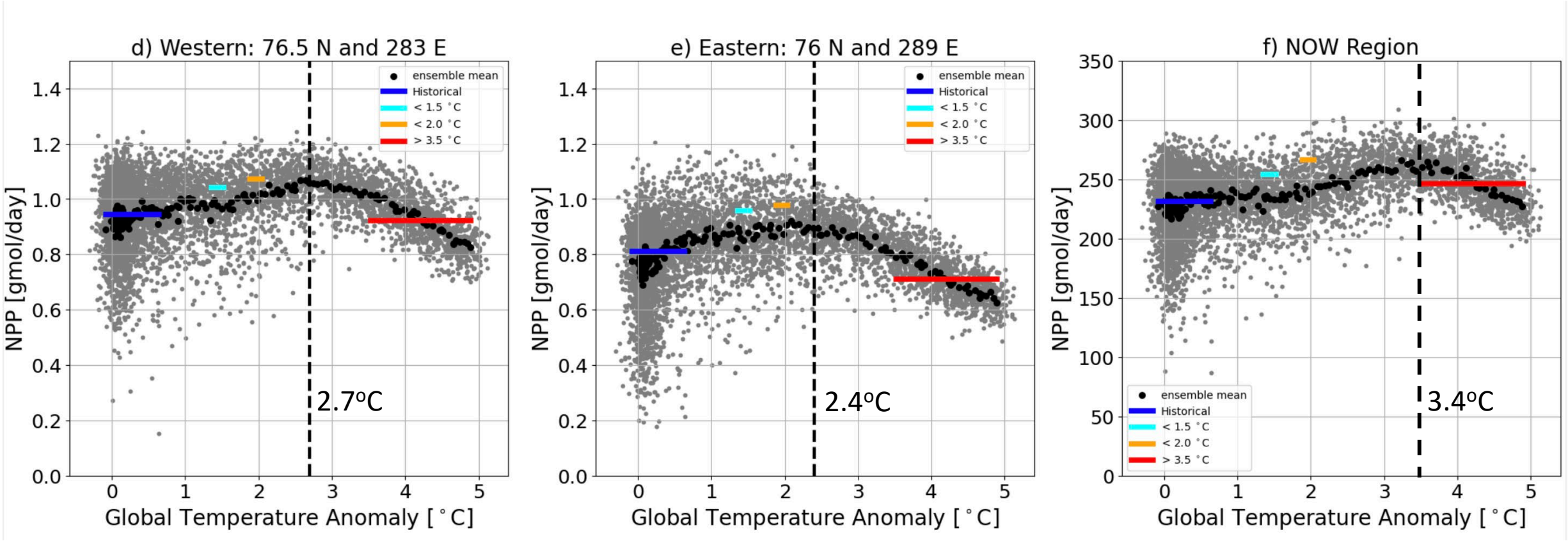
Question 3: What are the implications of ocean changes on NPP?

Segmented linear regression of July NPP vs warming level



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