

# An Idealised Model of Gyres near Pine Island Ice Shelf and Thwaites Ice Shelf

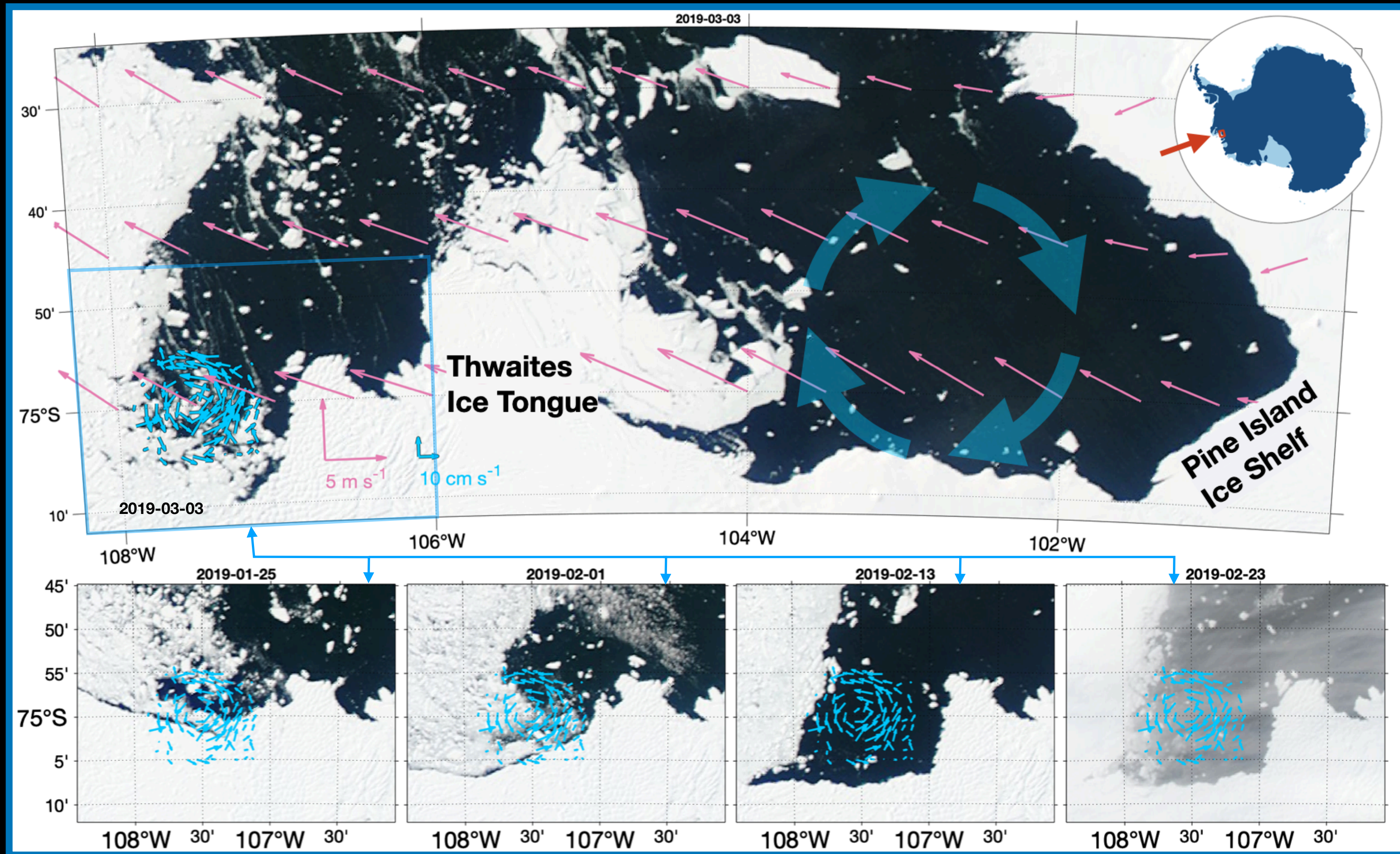
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*With special thanks to everyone who worked on the NBP 1902 cruise : )*

## 1980-2019 climatological wind field from ERA5 overlaying ice image in the Amundsen Sea in different dates



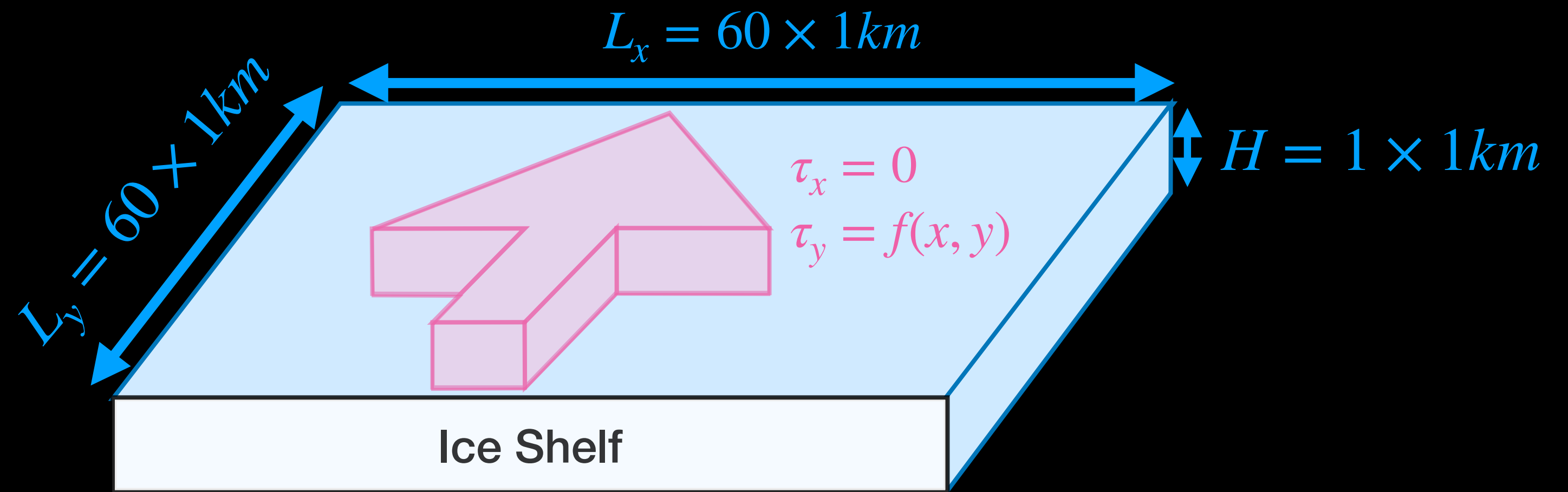
- In front of **Pine Island Ice Shelf**, a gyre has been identified by both models and observations
- In the west of **Thwaites Ice Tongue**, ship-based ADCP identified a gyre for the first time
- Gyres near ice shelves **can greatly influence the melt rate** of ice shelves
- The two gyres are forced by the **very similar wind fields** but **rotating in different directions**

Could the different sea ice conditions cause different rotations?

## MITgcm

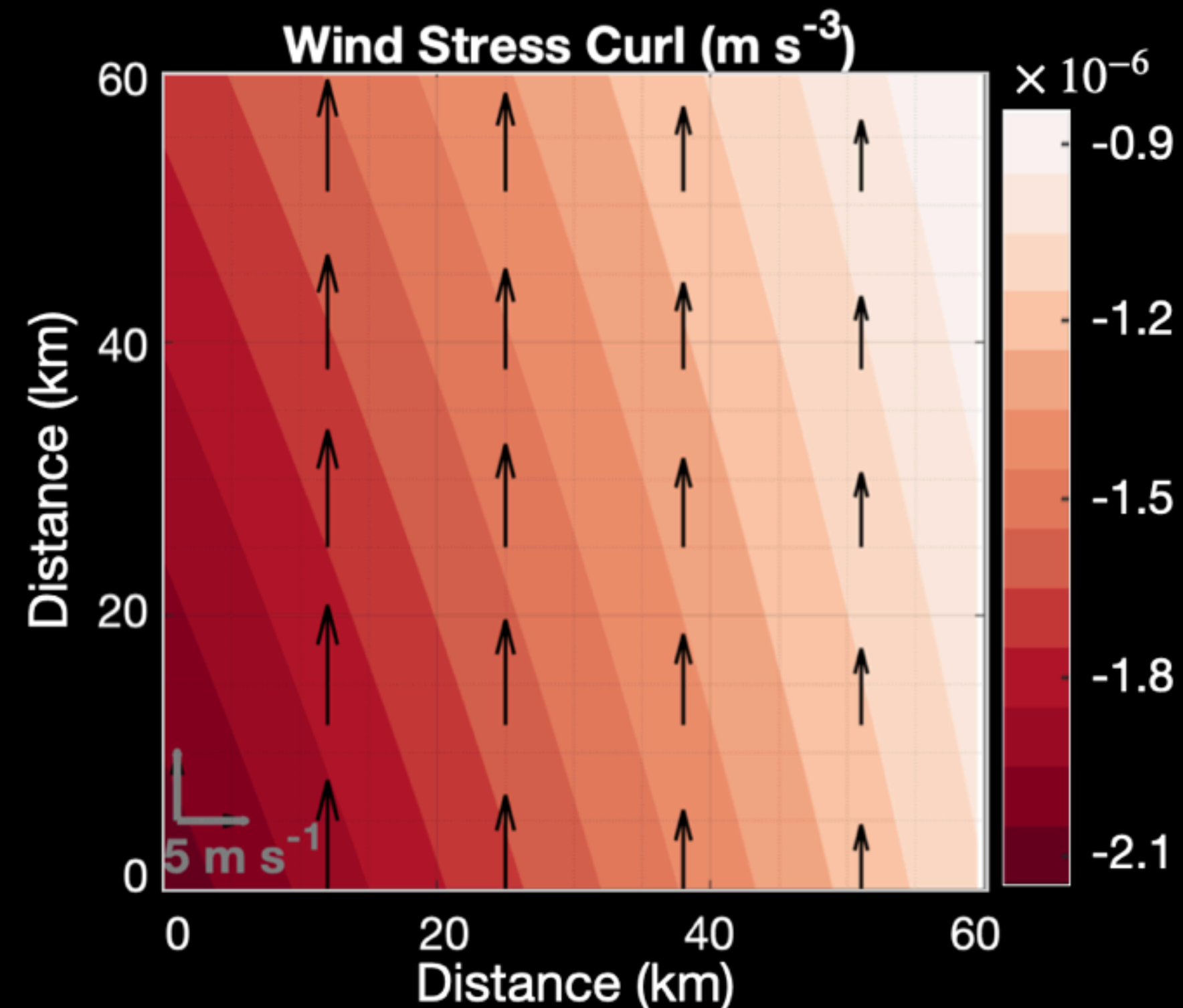
### Idealised Barotropic Set Up

- Square domain: 60 km x 60 km
- Fixed depth: 1,000 m
- 1 km horizontal spacing with a single vertical layer
- Solid boundary, free-slip bottom boundary and no-slip lateral boundary
- Time step: 120 s



### Idealised Forcing

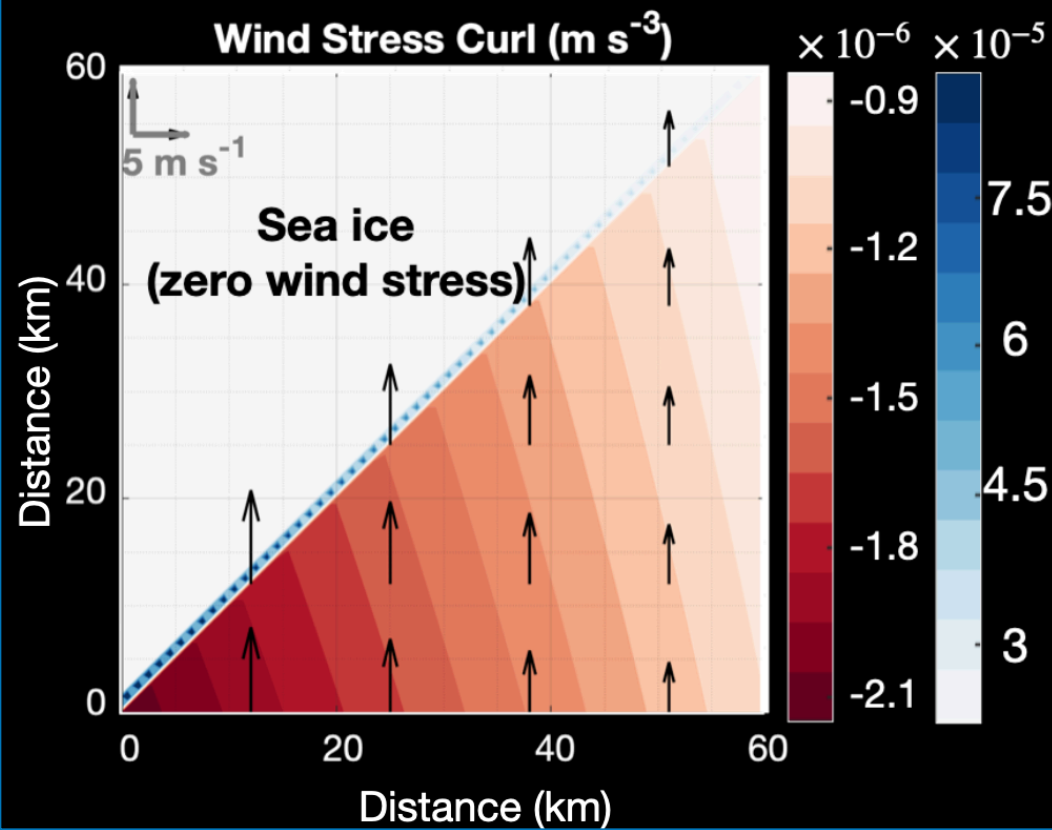
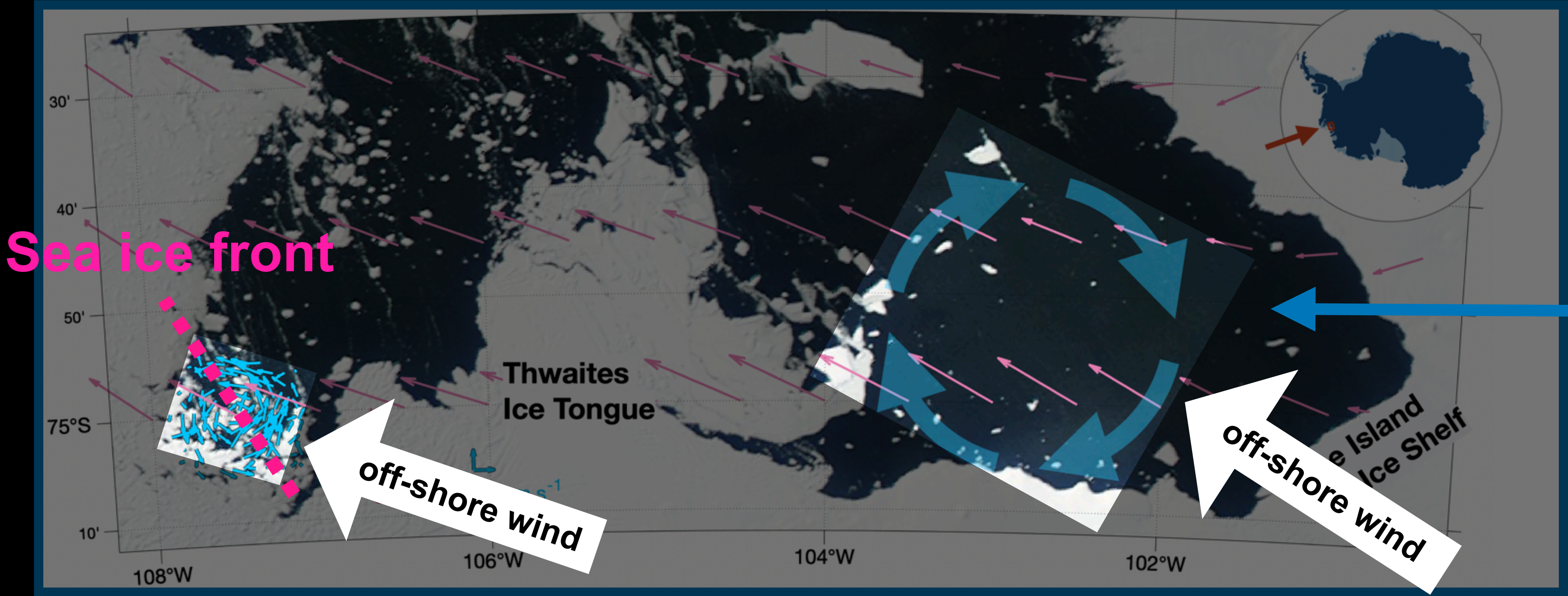
- Wind is the only surface forcing (no surface heat / freshwater fluxes included)
- Idealised constant wind field, with a negative wind street curl
- Both the size of domain and the wind field are simplified conditions from gyres we observed
- No meltwater, Circumpolar Deep Water injection included



*Similar wind fields + different sea ice conditions*

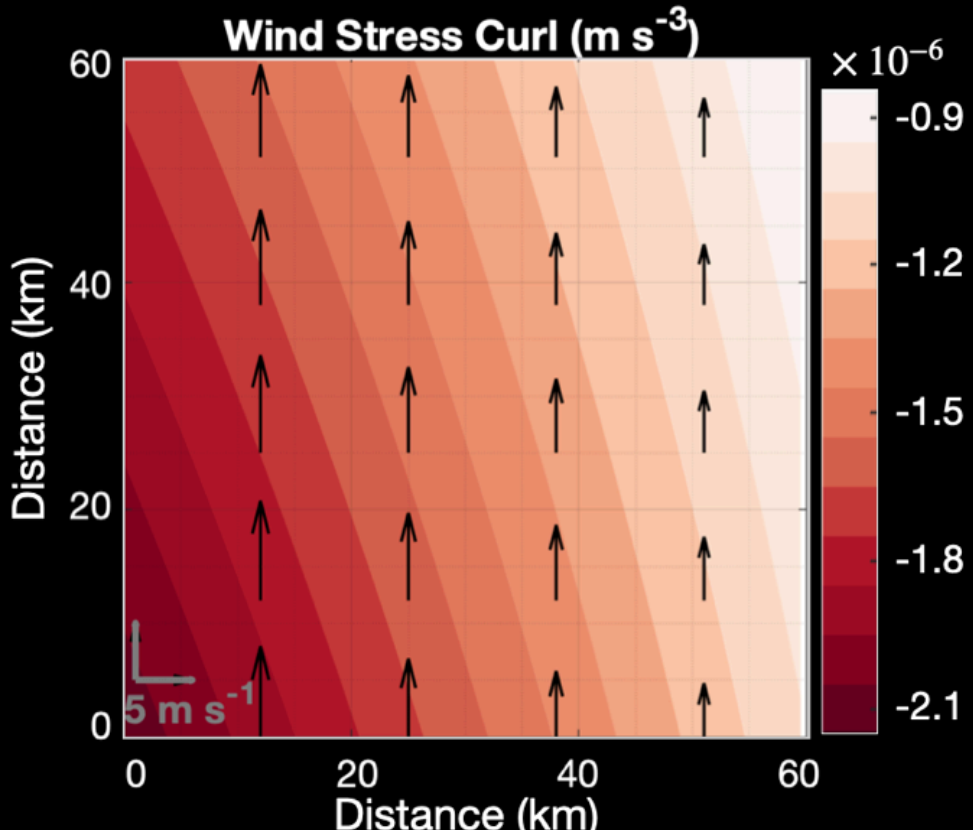
**Forcing**

- Idealised constant wind field, with a negative wind street curl



***Gyre near Thwaites Ice Shelf***

- idealised sea ice coverage and assume that sea ice completely blocks wind stress exerted on the sea surface

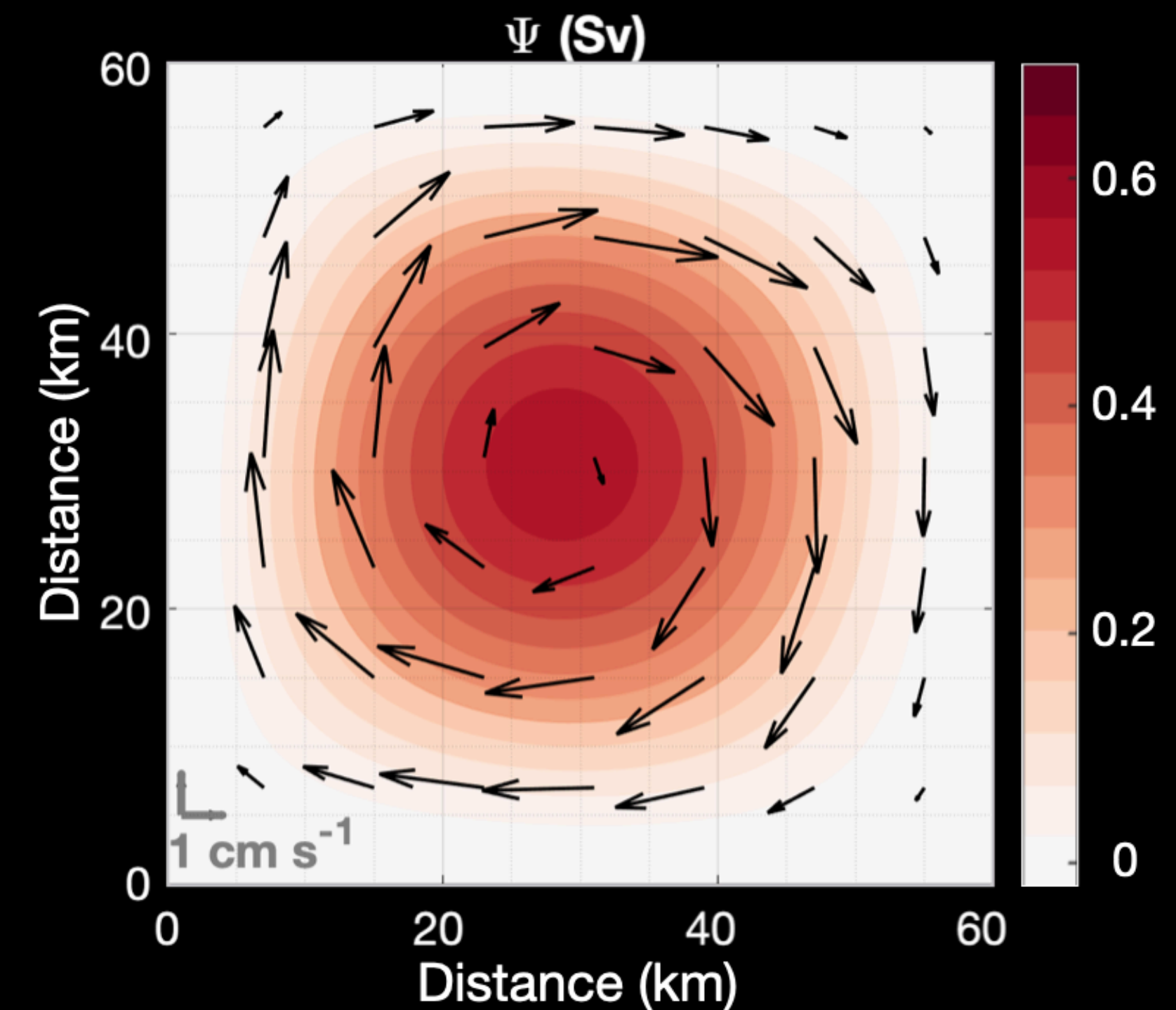
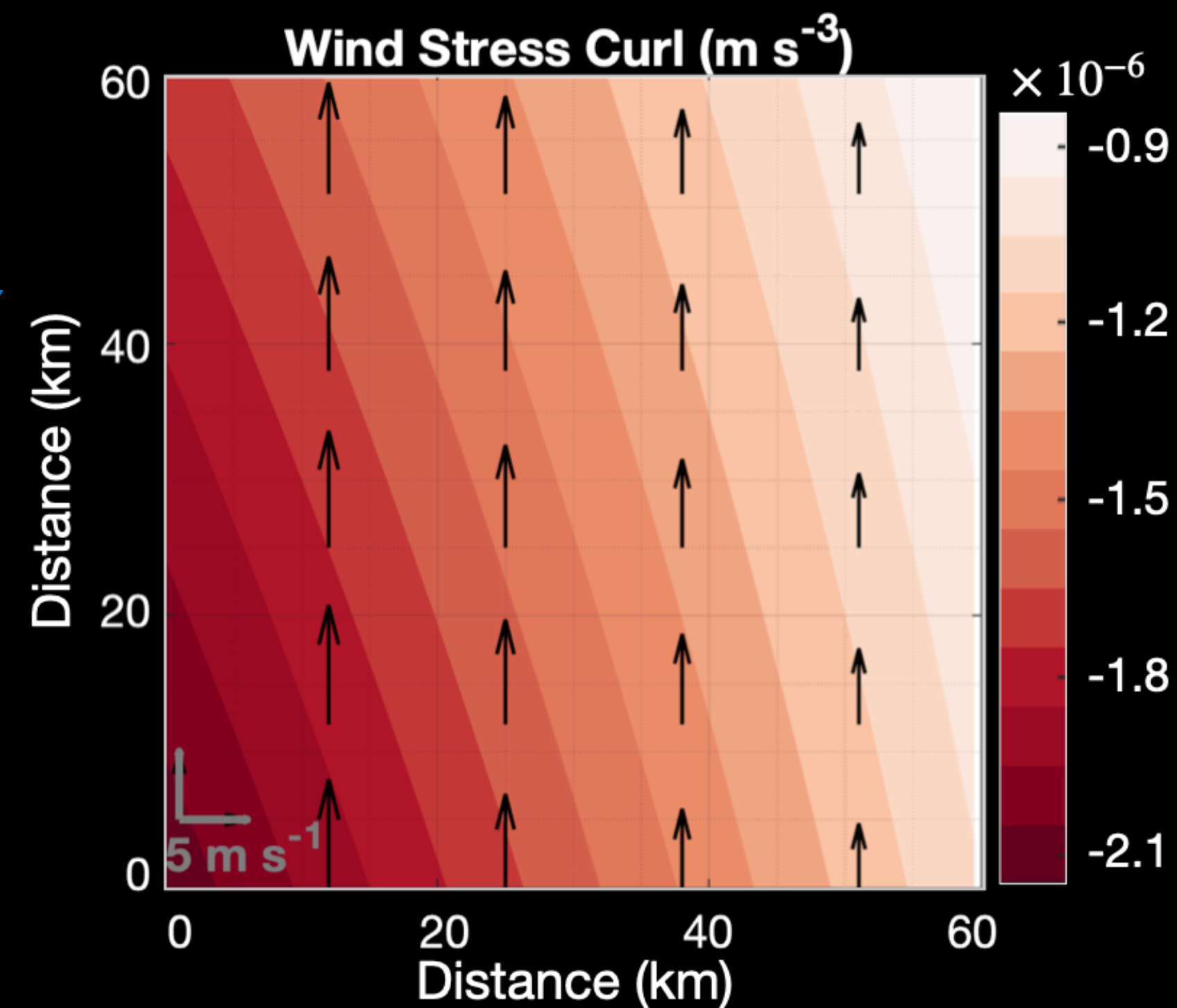
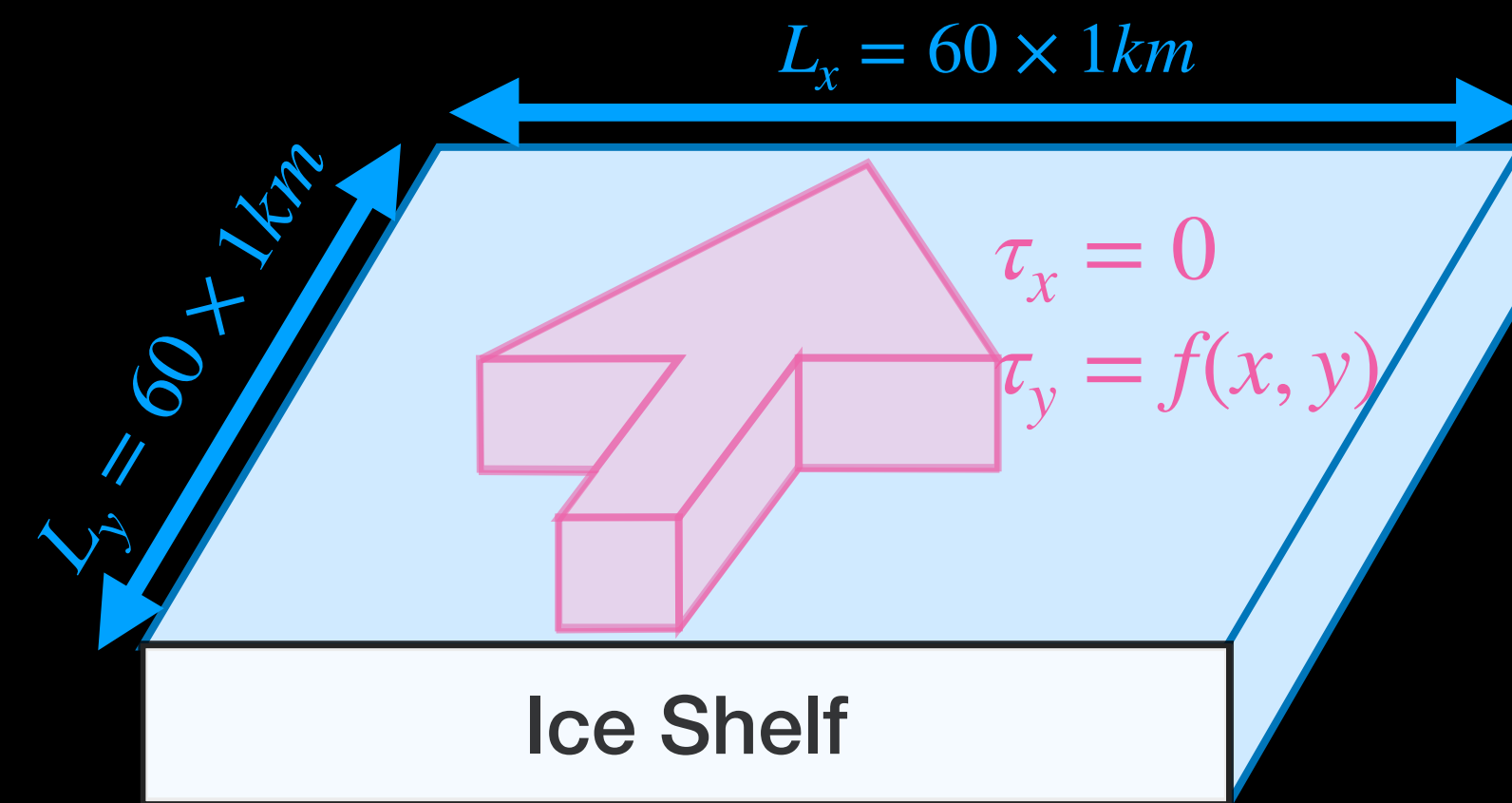
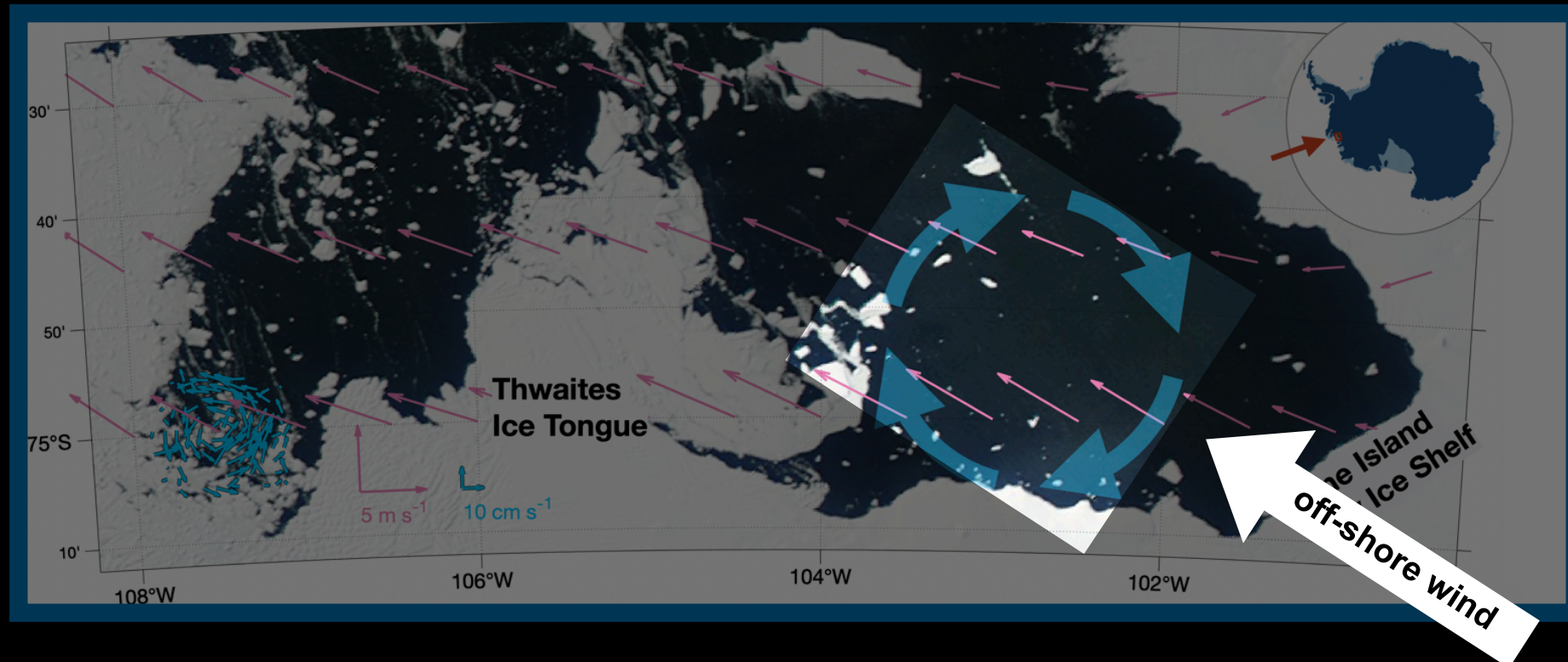


***Gyre near Pine Island Ice Shelf***

- no sea ice

# Steady-state model results

With off-shore wind and no sea ice

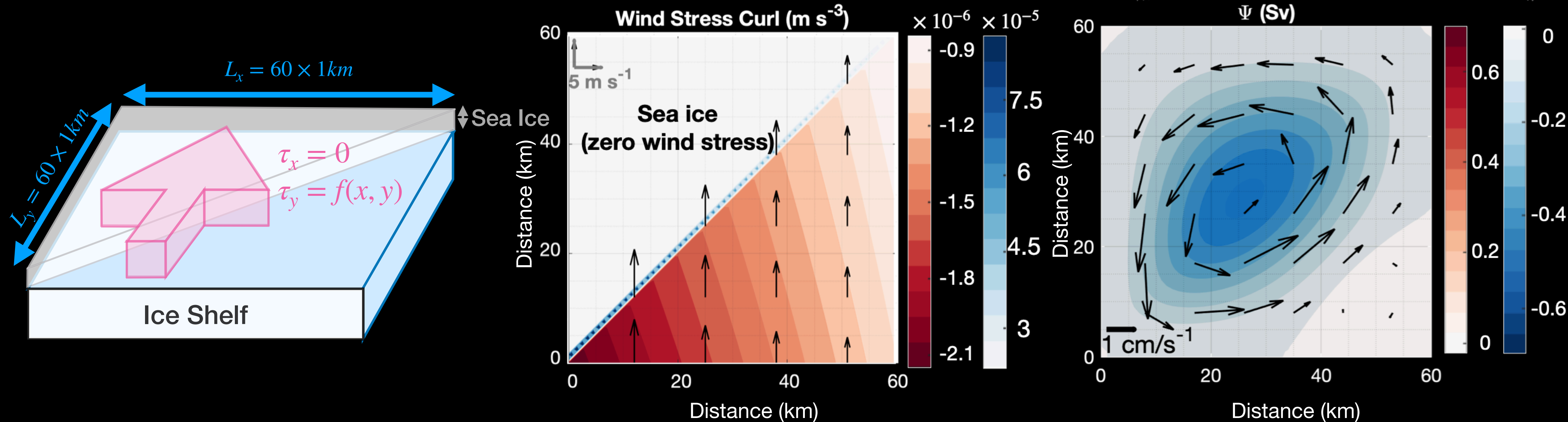
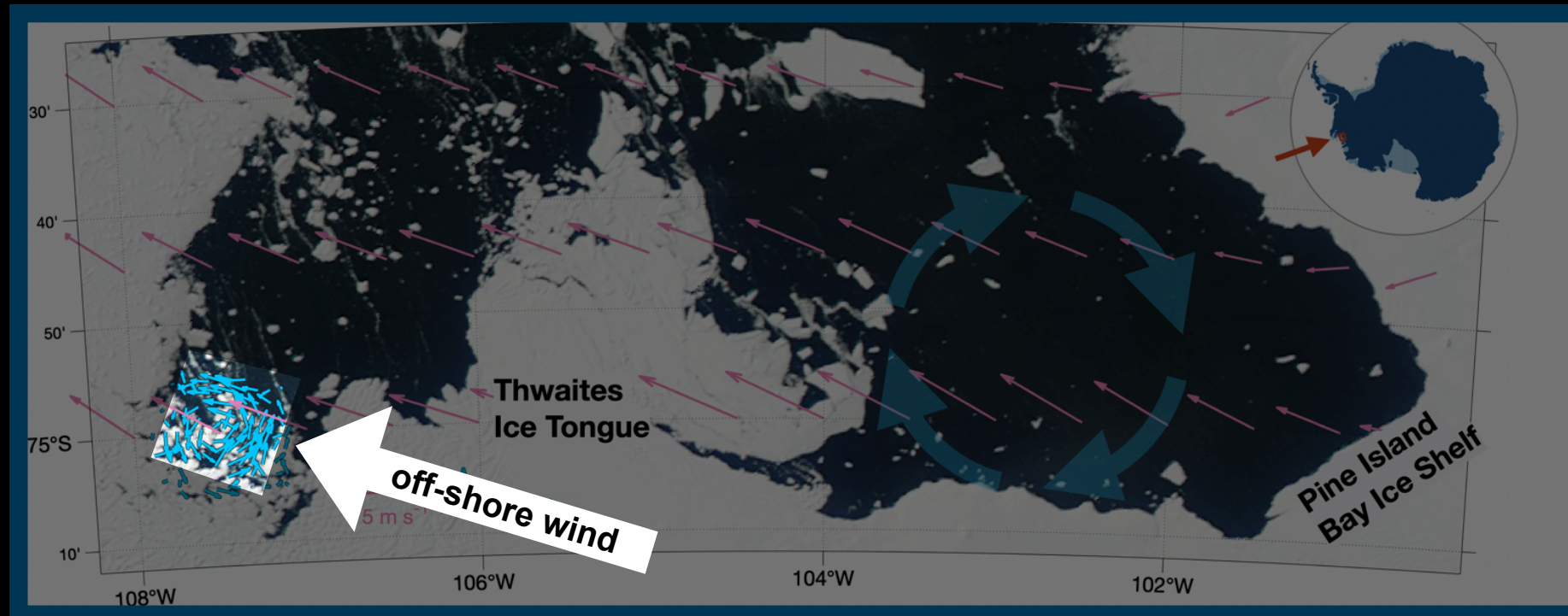


**Negative wind stress curl** everywhere

**Cyclonic** gyre

# Steady-state model results

With off-shore wind and sea ice covering half of the domain



**Negative wind stress curl** in the bottom right

**Zero wind stress curl** in the top left

**Positive wind stress curl** along the diagonal

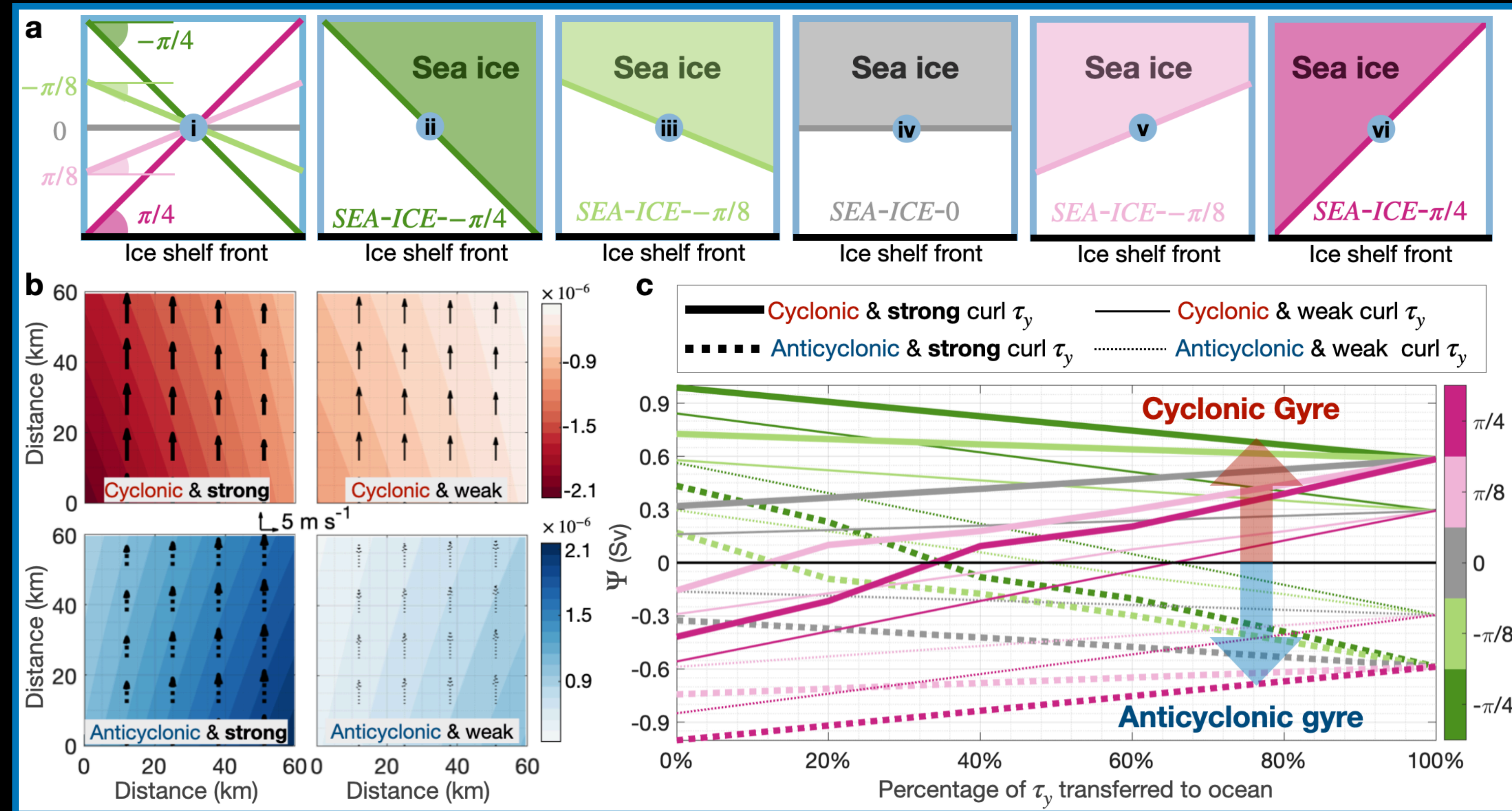
**Anticyclonic** gyre

# Model response to different sea ice conditions and wind fields

**a** Sea ice coverage (the angle between sea ice front and ice shelf front): varies from **ii**  $-\pi/4$ , **iii**  $-\pi/8$ , **iv** 0, **v**  $\pi/8$  to **vi**  $\pi/4$

**b** Wind speed (arrows) and wind stress curl ( $\tau_y$ ; shading): “strong”-simulations using forcing with wind stress curl same as what used in the previous simulations; “weak”-simulations using forcing with wind stress curl 50% weaker than what used in the previous simulations

**c** Percentages of  $\tau_y$  transferred to ocean: varies from 0, 20%, 40%, 60 %, 80% to 100%



- Wind stress curl strength in the Amundsen Sea can have generate gyres with different strength/direction when sea ice condition changes
- Both *wind stress curl* and *sea ice condition* can determine the direction of gyre
  - ➔ They should both be considered when predicting/understanding the features of ocean gyres in polar oceans

# Conclusions

- Idealised barotropic model can reproduce observed directions of gyres with simplified wind stress curl and sea ice conditions near Pine Island Ice Shelf and Thwaites Ice Shelf
  - ➡ Both wind field and sea ice condition play important roles in the gyre circulation near ice shelves
    - ➡ **Sea ice conditions can modify the wind stress curl transferred to the sea surface sufficiently to reverse a ocean gyre**
- Idealised model can simulate different gyres in response to different sea ice conditions
  - ➡ Our model might help explain some features of gyres generated in other sea-ice covered areas

# Questions?

I'll present on Wednesday, 28 April 2021, 09:07 CEST in OS 1.07 session 🌊🧊🐧. Hope to see many of you there : )

I'm also super willing to take any questions via email [Yixi.Zheng@uea.ac.uk](mailto:Yixi.Zheng@uea.ac.uk).

Your questions will make my day 🐼🐧

Photo credit: Filip Stedt