The Recent Rebound of Shelf Water Salinity in the Ross Sea Induced by Atmospheric Forcing

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1.Background and motivation

- Recent observation shown a sharp rebound in salinity of the Ross Sea High Salinity Shelf Water (HSSW) after 2014 (Castagno et al.2019; Silvano et al.2020)(Fig.1).
- Insufficient data limits the investigation of the linkage and underlying mechanisms between atmospheric forcing and shelf water salinity changes.
- Ocean-modeling experiments are therefore designed to understand the causes of reported salinity changes

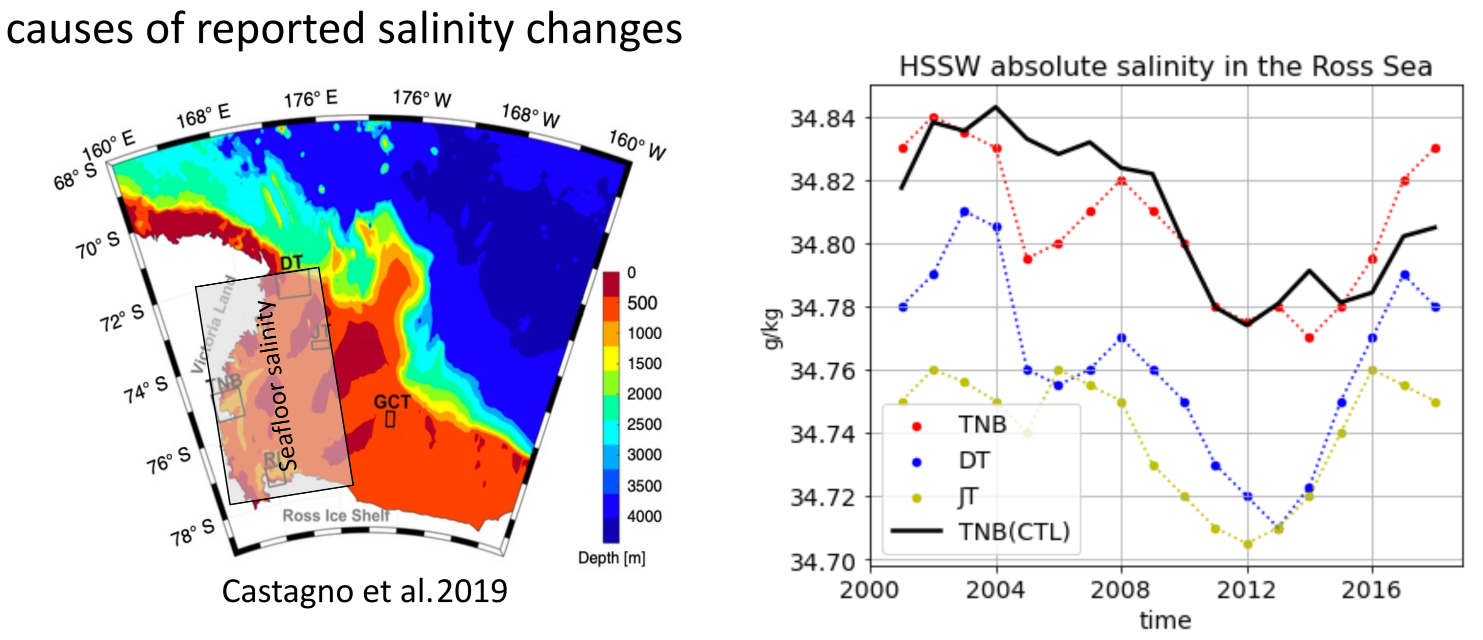


Fig.1 Time series of averaged HSSW salinity near the seafloor in the Ross Sea, from model output (CTL, black line) and observation (red, blue and yellow lines)

2.Model setup and experiment design

- Exploring the effect of atmospheric forcing on shelf salinity in the western Ross Sea, by using a series of perturbation experiments in an ocean-sea ice model (ACCESS-OM2, with 1° resolution).
- Swapping interannual-varying atmospheric forcing with repeat-year-forcing (2009-2010)

Exp name	Wind forcing	Other forcing
ALL-FIXED	Repeat year	Repeat year
WND-VARY	**Interannual**	Repeat year
ALL-VARY	**Interannual**	**Interannual**

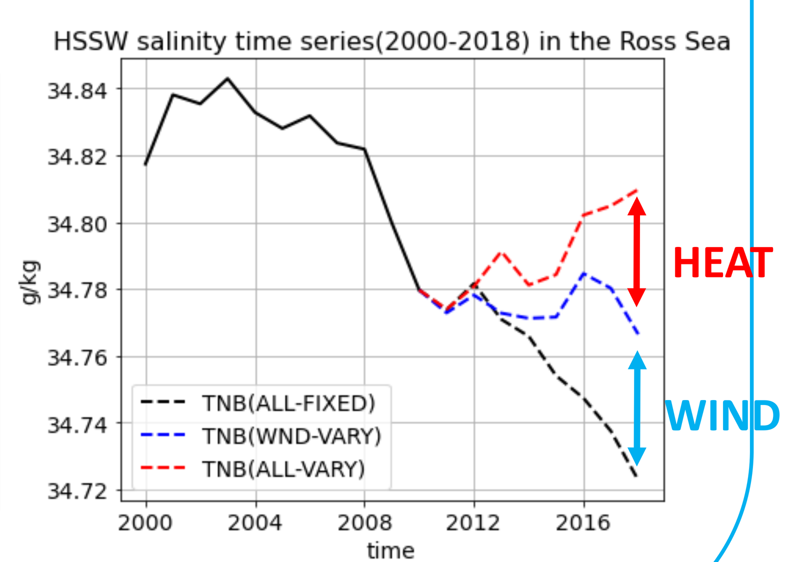
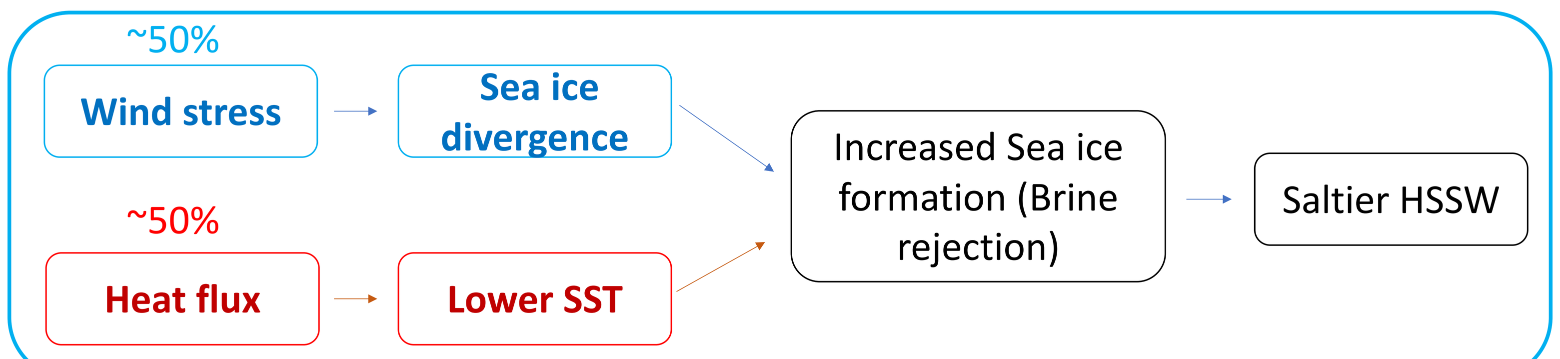


Fig.2 Time series of averaged HSSW salinity (400-700m) of each experiment



3. Salinity anomaly in the Ross Sea

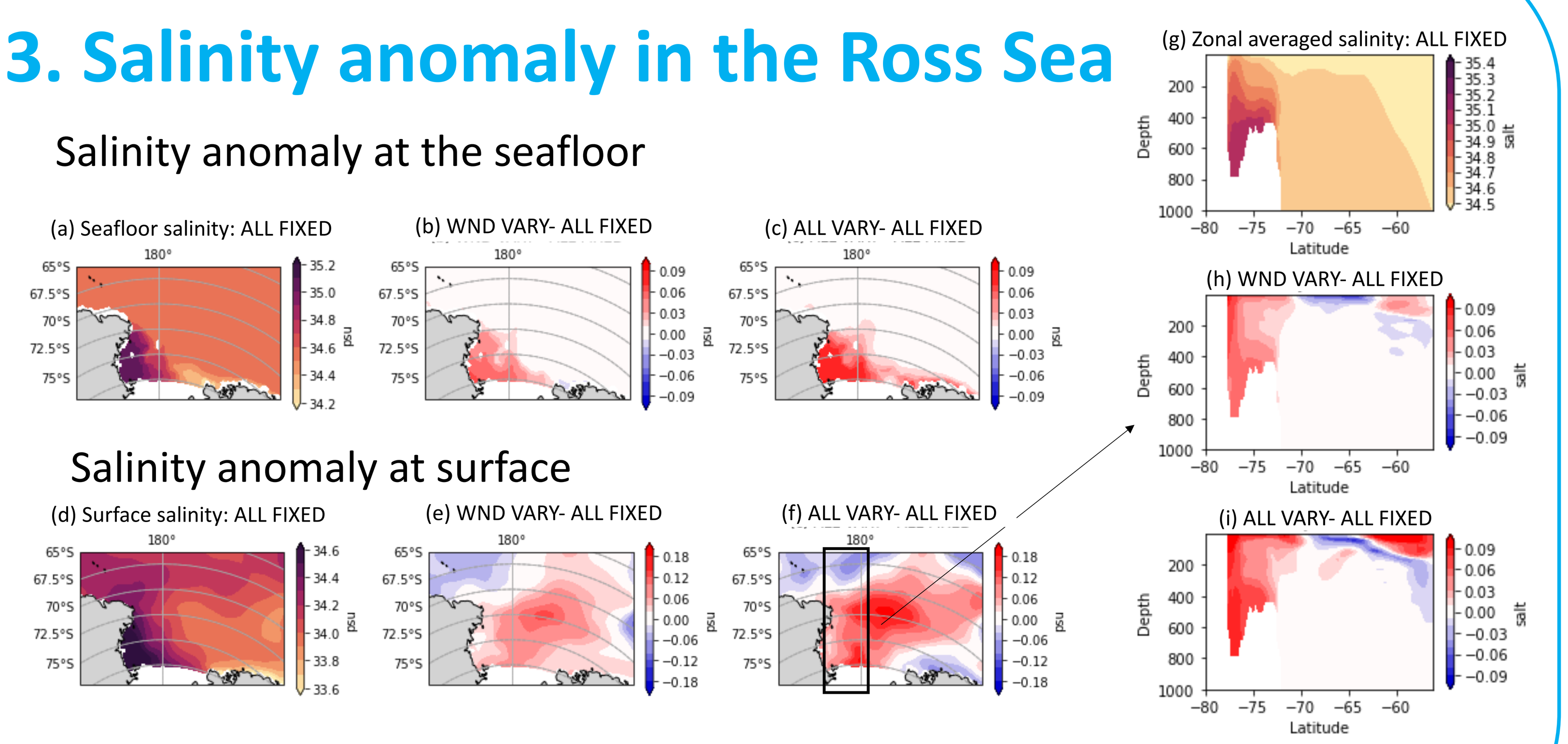


Fig.3 Salinity anomaly at averaged surface (0-50m,a-c), seafloor (400-700m, d-f) and zonal averages (g-i)

The ocean salinity budget for each grid cell can be written as follows:

$$\underbrace{\frac{\partial S_0}{\partial t}}_{\text{Salinity tendency}} = \underbrace{\frac{(E-P)S_0}{h} + \frac{I(S_I - S_0)rho_I}{h\, rho_0}}_{\text{Boundary fluxes}} \underbrace{- \vec{u}\,\nabla S - \nabla F^{sgs\text{-}adv} - \nabla F^{sgs\text{-}mix}}_{\text{Ocean dynamics}}$$

- S_0 salinity of a grid cell (g/kg)
- E is evaporation, P is precipitation, I is sea ice contribution, h is the grid cell depth
- F^{sgs} is the sub-grid scale transport

4. Salinity anomaly driven by sea ice production

- The positive surface salinity anomaly between 2014 and 2017 is mainly dominated by the increased sea ice formation
- Ocean dynamics contribute to seasonal variation in surface salinity anomaly
- ‘P-E’ anomaly has very minor effect

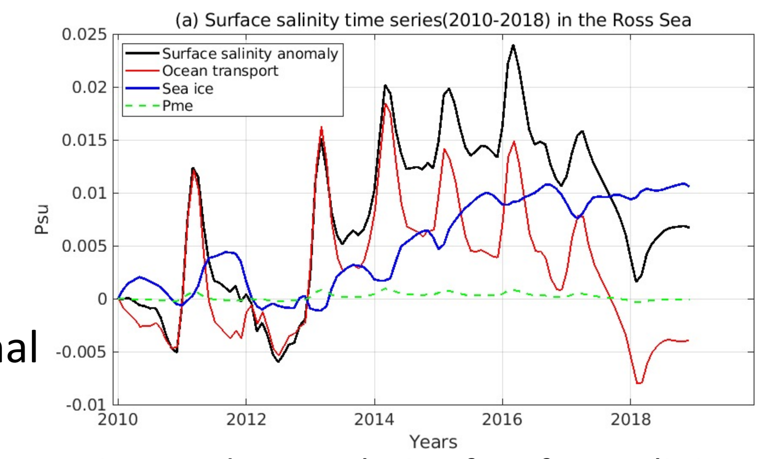


Fig.4 Budget analysis of surface salinity anomaly for ALL-VARY experiment

5. Sea ice formation driven by wind stress

Offshore winds induce sea ice to diverge, which leads to decreased sea ice thickness and concentration, further leading to more sea ice production

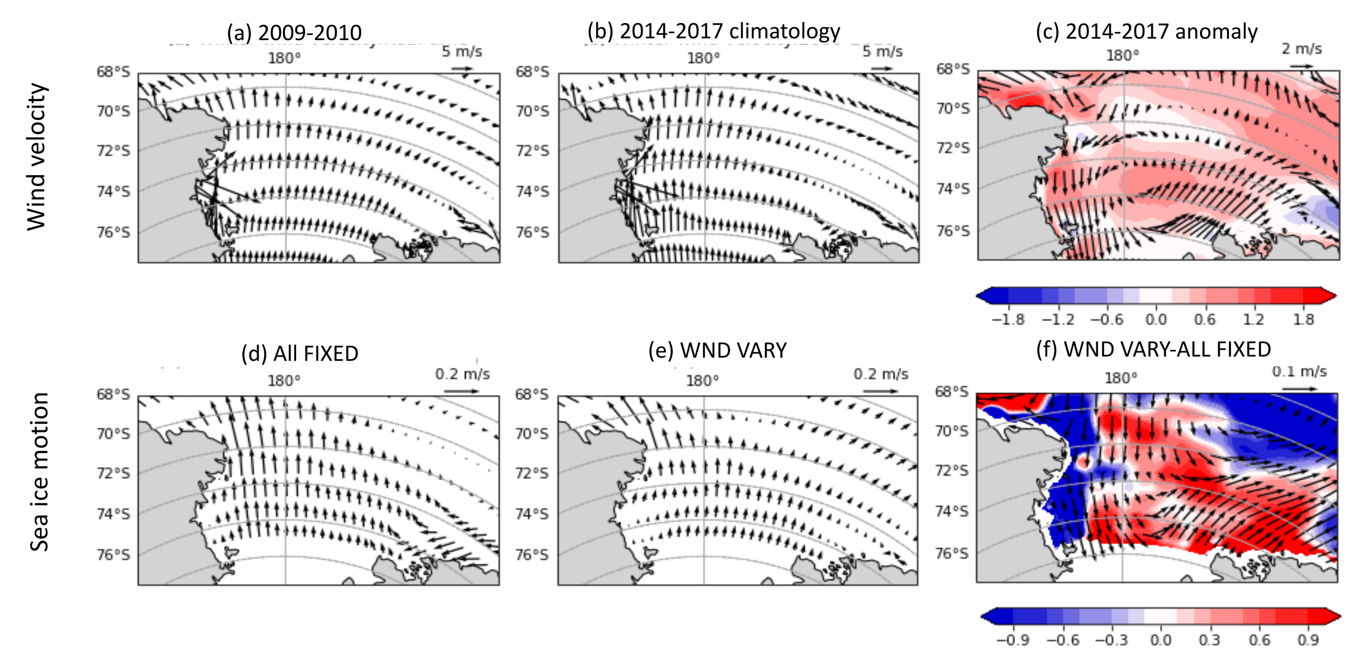


Fig.5 Wind stress anomaly and its induced sea ice motion (2014-2017)

6. Sea ice formation driven by surface heat flux

Negative surface heat flux anomaly leads to lower surface sea temperature, further leading to increased sea ice production

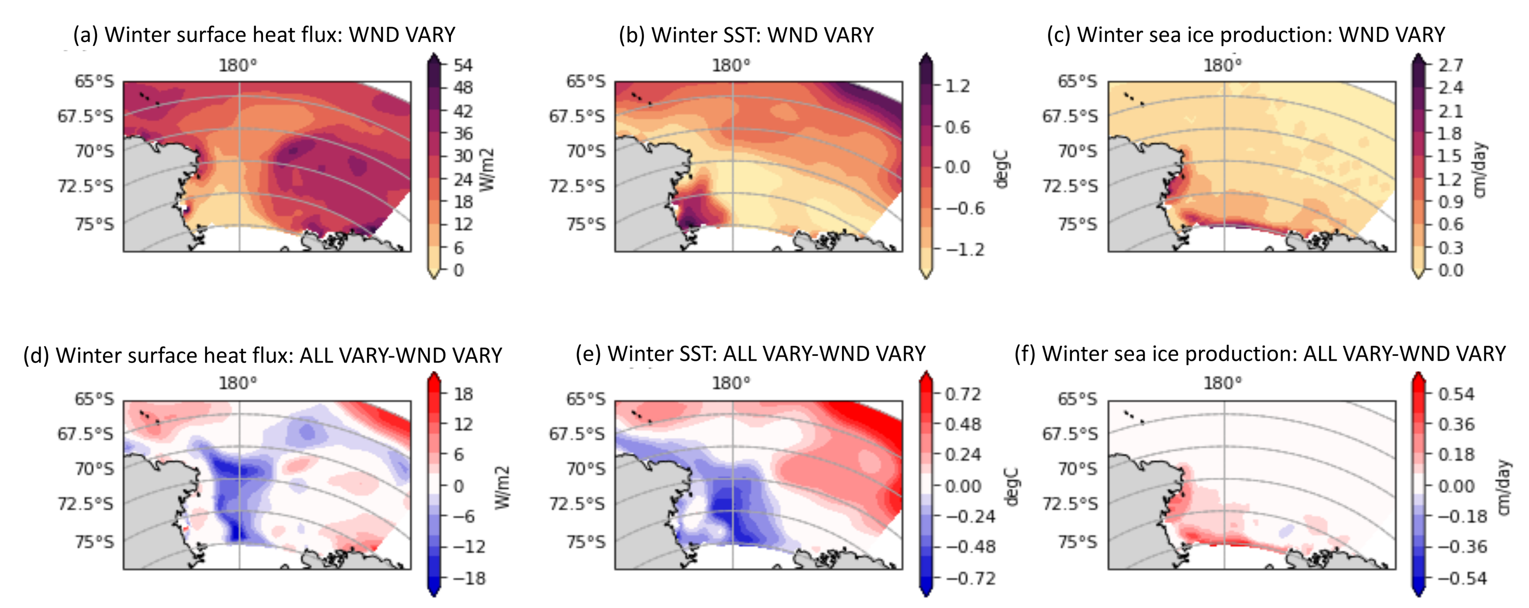


Fig.6 The anomalies of surface heat flux, sea surface temperature, and sea ice production (2014-2017)

7. Conclusion

- 1° global ocean-sea ice model has ability to simulate the recent rebound of HSSW salinity in the Ross Sea.
- This recent rebound was induced by increased sea ice formation.
- Increased sea ice formation was triggered by the combined effect of anomalous wind stress and surface heat flux.
- Our study highlights that climate anomalies can drive increases in sea ice formation (brine rejection) that offset the decrease in HSSW salinity induced by Antarctic freshwater.

For further information
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Reference
Castagno, Pasquale, et al. "Rebound of shelf water salinity in the Ross Sea." Nature communications 10.1 (2019): 1-6.
Silvano, Alessandro, et al. "Recent recovery of Antarctic Bottom Water formation in the Ross Sea driven by climate anomalies." Nature Geoscience 13.12 (2020): 780-786.

Photography encouraged

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