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Cascading and the pathways of the key biogeochemical tracers in the Canadian Basin: from models and observations

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- Using numerical models (1980-2010) we investigate cascading and pathways of Pacific waters to the Arctic Ocean
- Lagrangian particle tracking of surface waters originated in the Bering Strait shows deepening of trajectories up to 160-200m
- Uplifting of the warm and saltier Atlantic waters in the autumn and further ventilation and mixing trigger cascading

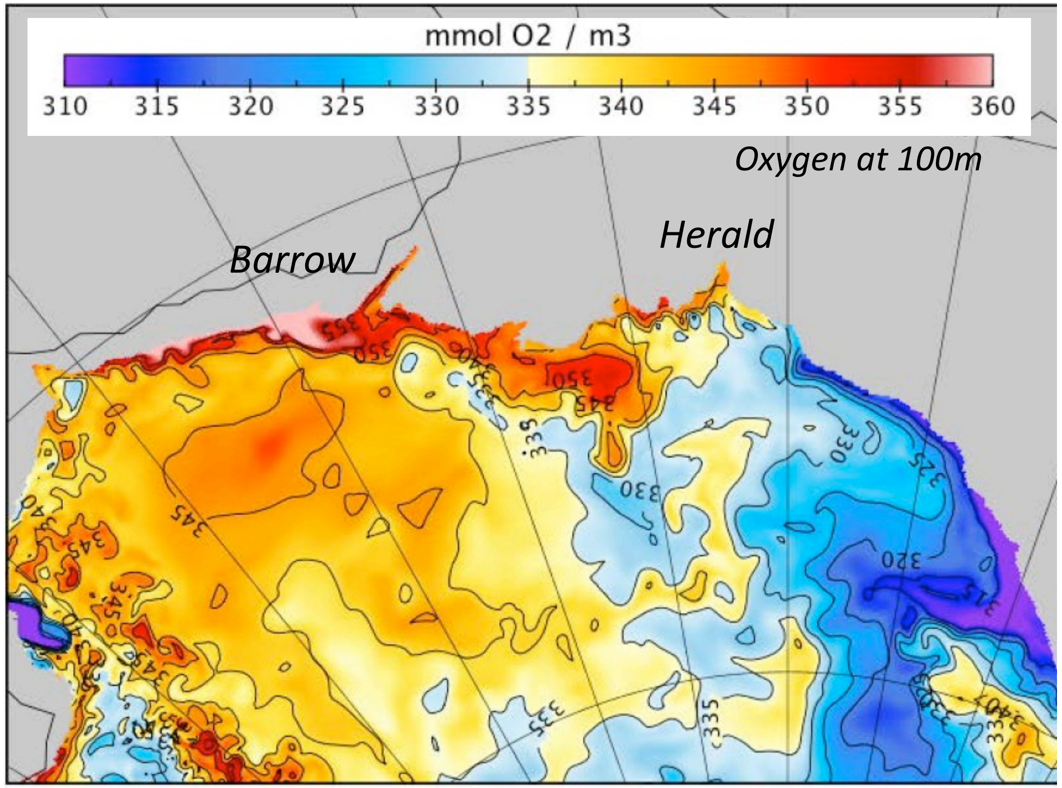
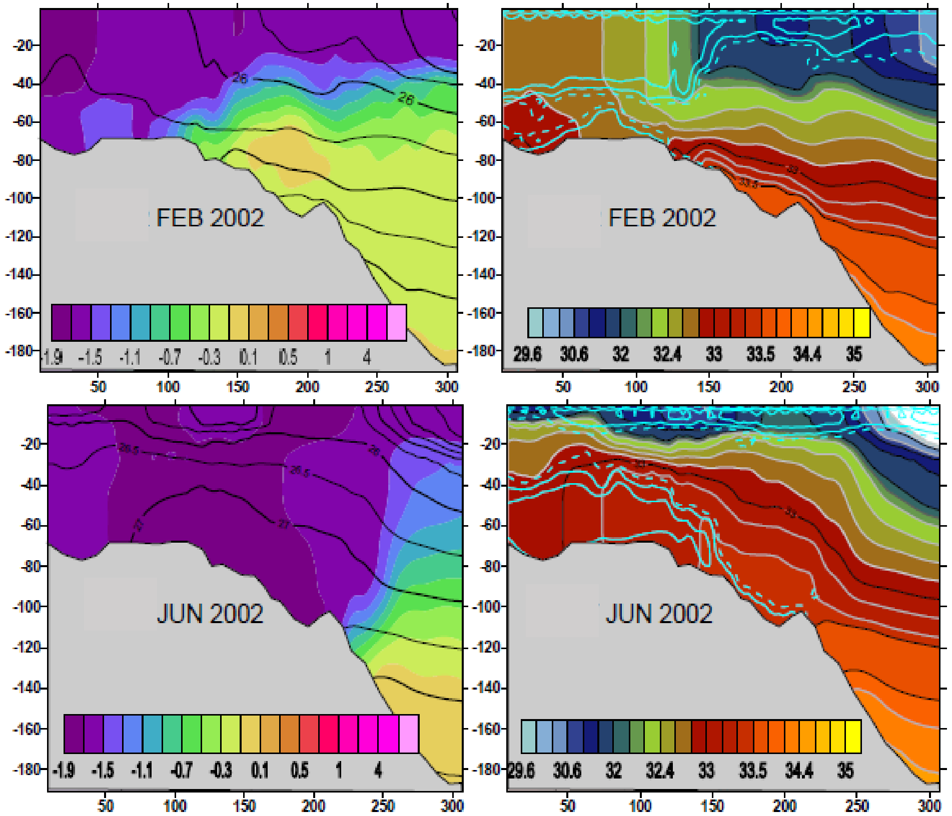


Figure 2. Oxygen at 100 m depth in the Canadian Basin, NEMO 1/12º



Evolution of T, S, density and vertical diffusivity (cyan) in the Herald Canyon.

Motivation

- Dense water cascading in the Arctic Ocean is the key mechanism for ventilation of the ocean interior and for export of carbon and biogeochemical (BGC) tracers from the shelves to the deep Arctic Ocean
- Because of the episodic nature, cascading is difficult to observe
- Our objectives are to identify potential locations of the cascading events and examine key ocean conditions and mechanisms leading to cascading
- We use high-resolution models in combination with the sparse historical observations
- We focus on the Pacific sector of the Arctic Ocean & analyse pathways of the BGC tracers.

Methods: modelling cascading preconditioning & ventilation

- Using high-resolution ocean models with Biogeochemistry we investigate cascading and pathways of Pacific waters to the Arctic Ocean
- NEMO: (1) global+MEDUSA, horizontal res. (1/12^{o}, ~3 km), vertical z-coordinates; (2) regional, res. (1/4^{o}, ~12 km), vertical hybrid coordinates
- Areas preconditioned for cascading identified by surface to bottom mixing (Fig. 1). Strong cascading defined with cross-slope fluxes > 0.1 m^2s^{-1}
- Cascading events in regional model (Fig. 1) compared with the increased oxygen concentrations & new waters formation in global model (Fig.2)

Figure 1. Salinity of the mixed waters and cascading fluxes in, NEMO 1/4^{o}

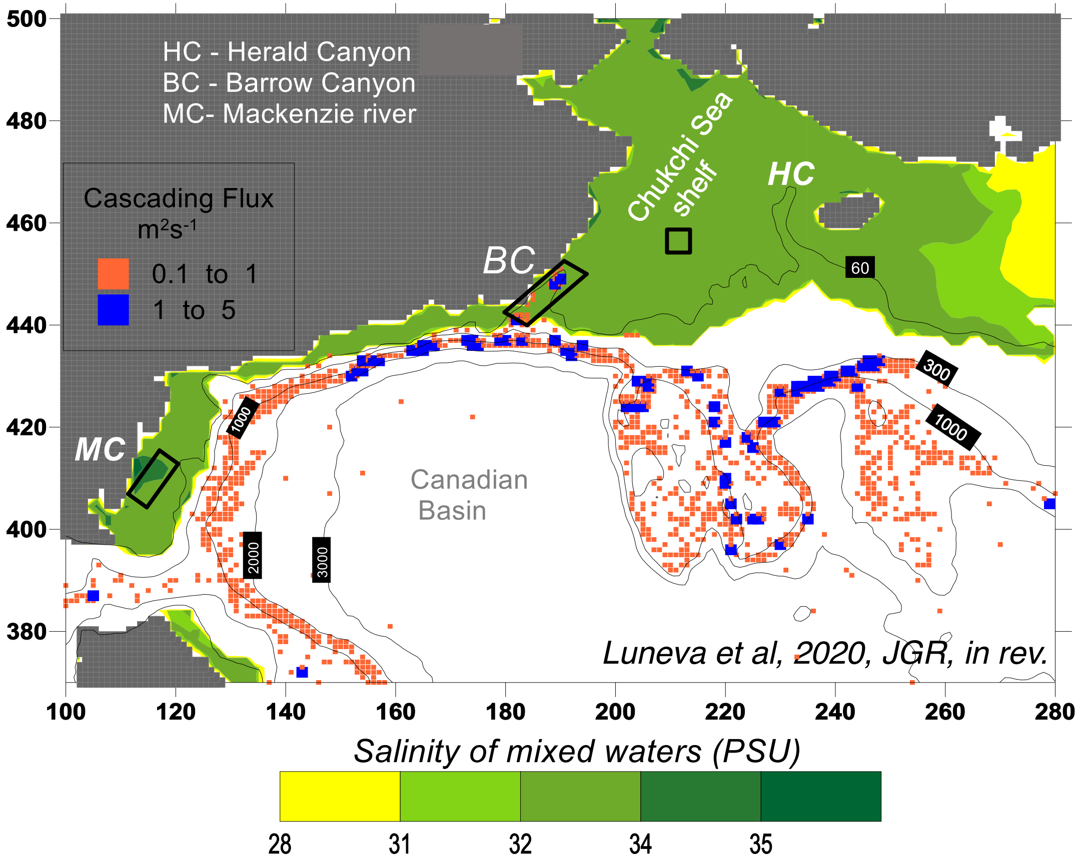
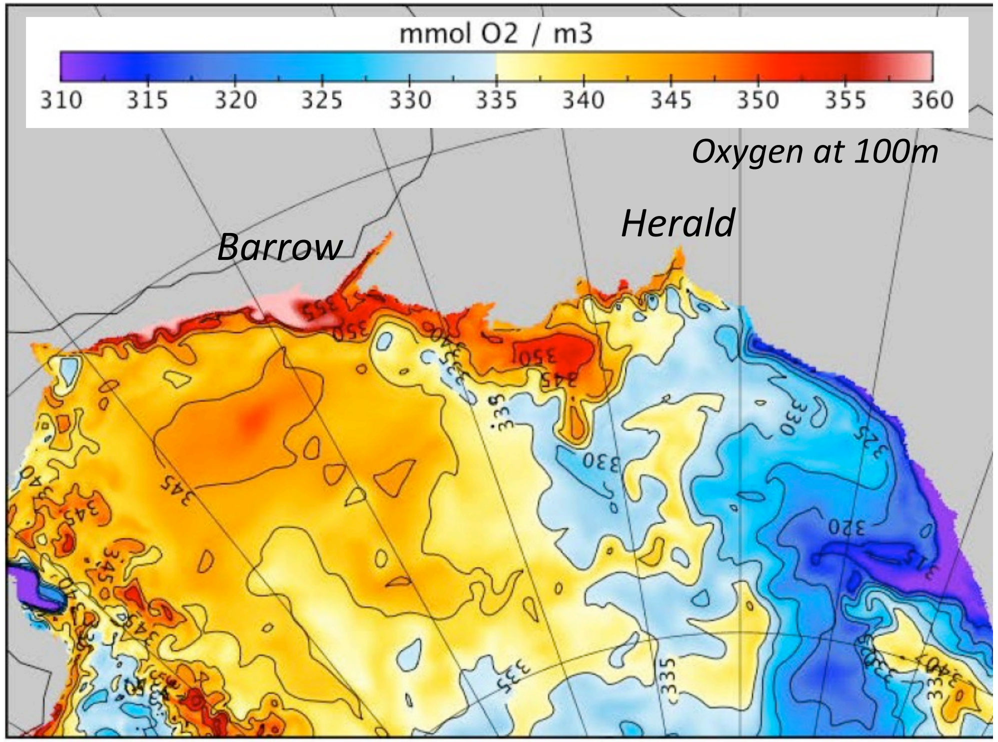
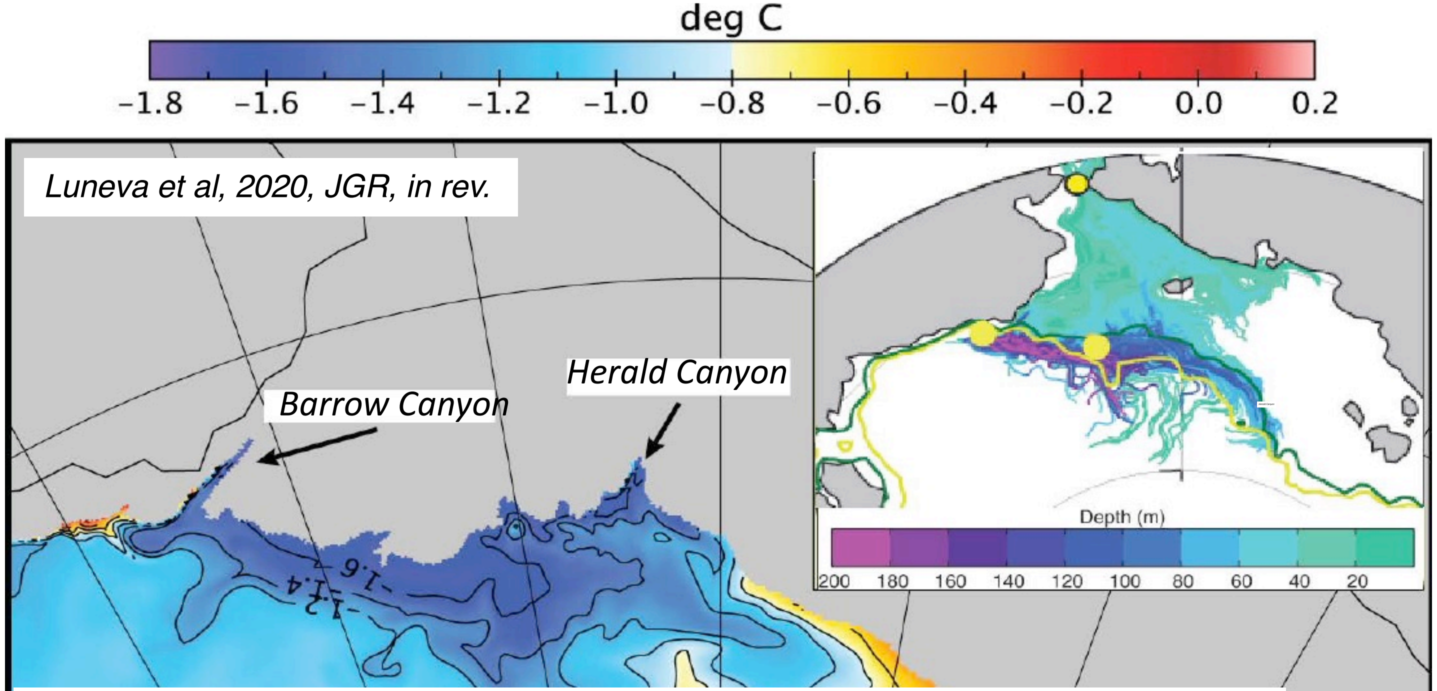


Figure 2. Oxygen at 100 m depth in the Canadian Basin, NEMO 1/12^{o}



Results: cascading of Pacific water



- Lagrangian particles, seeded in the Bering Strait, show deepening of trajectories up to 160-200m (Fig. 3)
- Cascading of Pacific water appears as a "cold spot" at the halocline depth (Fig. 3) and as high Si (Fig. 4)

Figure.3 Simulated temperature at 100m (June of 2002). Inset: depth of the off-line particle trajectories (Jan-June 2002), originated in the Bering Strait.

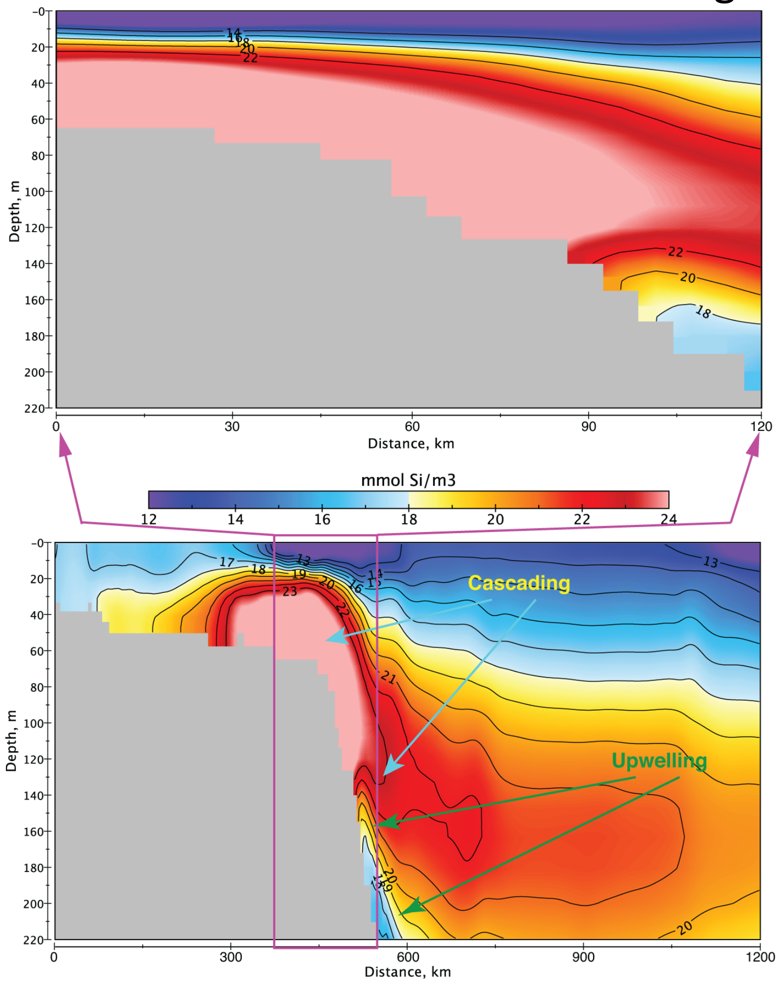


Figure.4 Simulated silica across the Chukchi shelf at 166 °W in July 2002.

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Results: preconditioning of cascading

- Upwelling of the warm and saltier Atlantic waters in the autumn/winter (seeing in observations, Luneva 2020)
- Further cooling, ventilation & mixing trigger cascading

Figure 5. T, S, density & vertical diffusivity (cyan) in winter and summer in the Barrow Canyon.

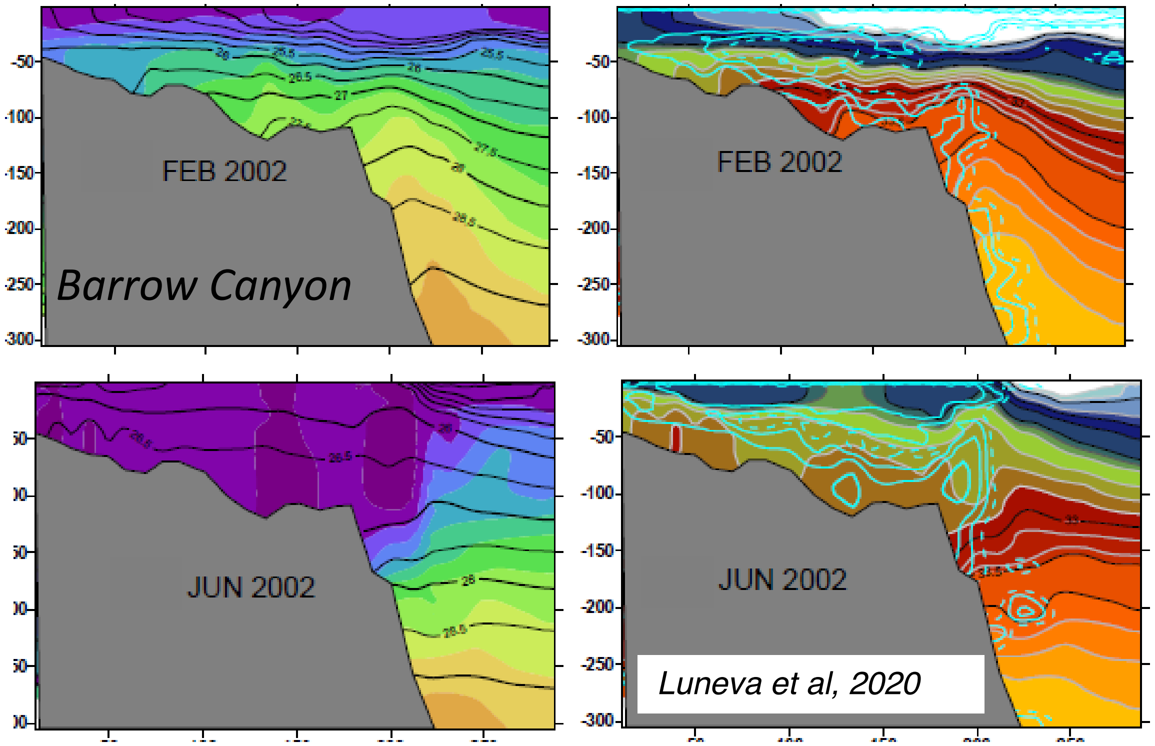
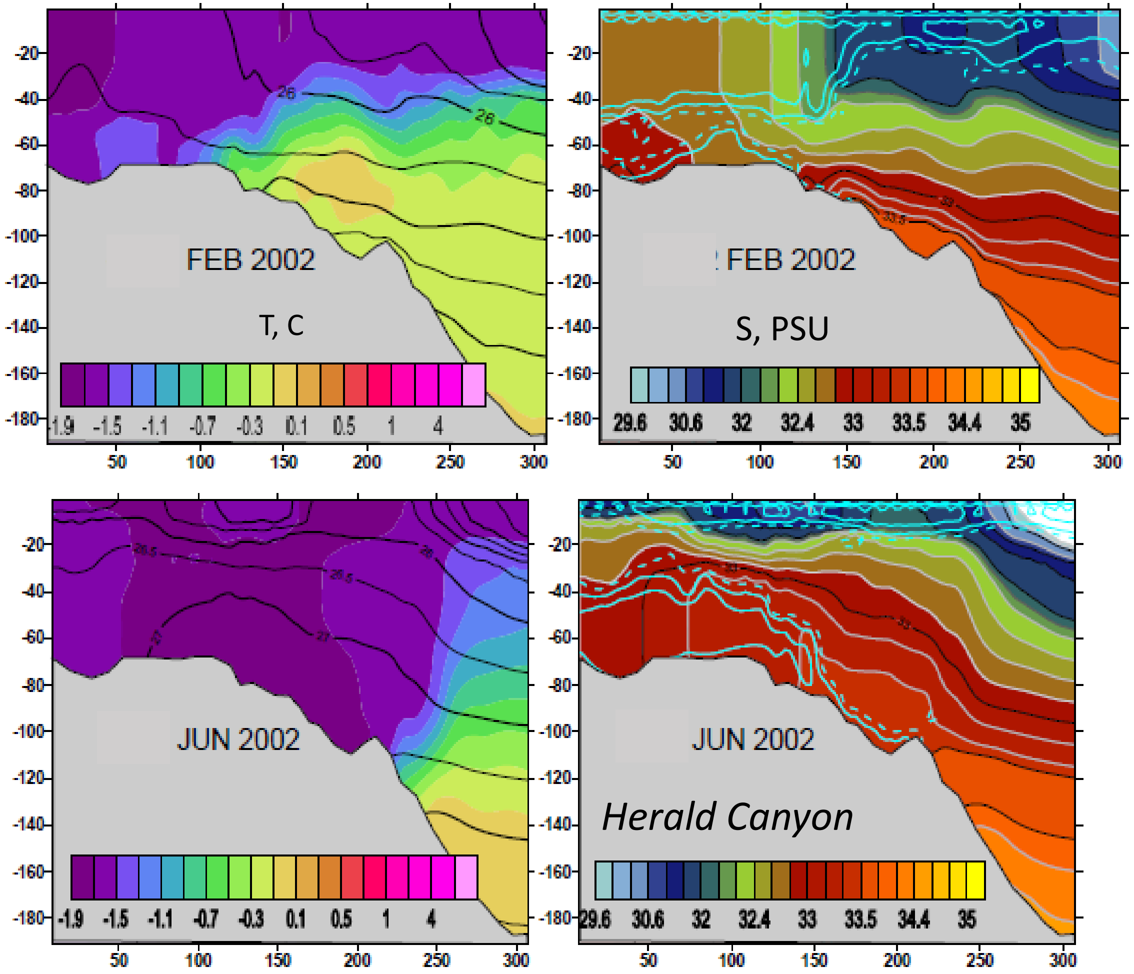


Figure 6. T, S, density & vertical diffusivity (cyan) in winter and summer in the Herald Canyon.



Conclusions

- We examined preconditioning of the shelf cascading in the Chukchi Sea
- Cascading events are preceded by upwelling of the Atlantic waters on the shelf
- Simulations and data show strong diapycnal mixing and cooling of upwelled Atlantic waters, resulting in the denser waters descending to ~160-180m
- Pacific water tracking in models suggest a counter-clockwise initial spread of the cascading waters next to the shelf-slope and a clockwise flow in the deep basin
- Cascading in the Chukchi Sea brings O_2 & Si to the lower Pacific halocline
- The time for the winter Pacific water to cross the shelf is ~3-4 months.

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In Memory of Dr Maria Luneva

The presentation was compiled after Maria passed away in March 2020

This work was inspired and lead by Maria, unfortunately she did not finished it

We have decided to show it in Maria's memory

We all will miss her great personality and scientific insight.

Yevgeny Aksenov and Vladimir Ivanov
on behalf of all the colleagues and friends

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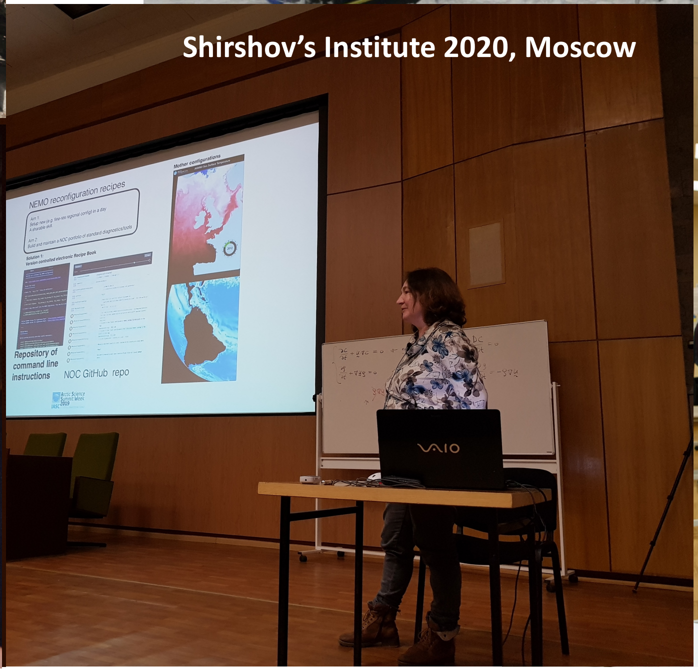
In Memory of Dr Maria Luneva

National Partnership for Ocean Predictions (NPOP), Liverpool, May 2018

DRAKKAR Snowshoe Hike 2019, Grenoble

2018 FAMOS meeting, Bergen, Norway



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