Oceanic responses to Ex-Typhoon Merbok in the Bering-Chukchi-Beaufort regions

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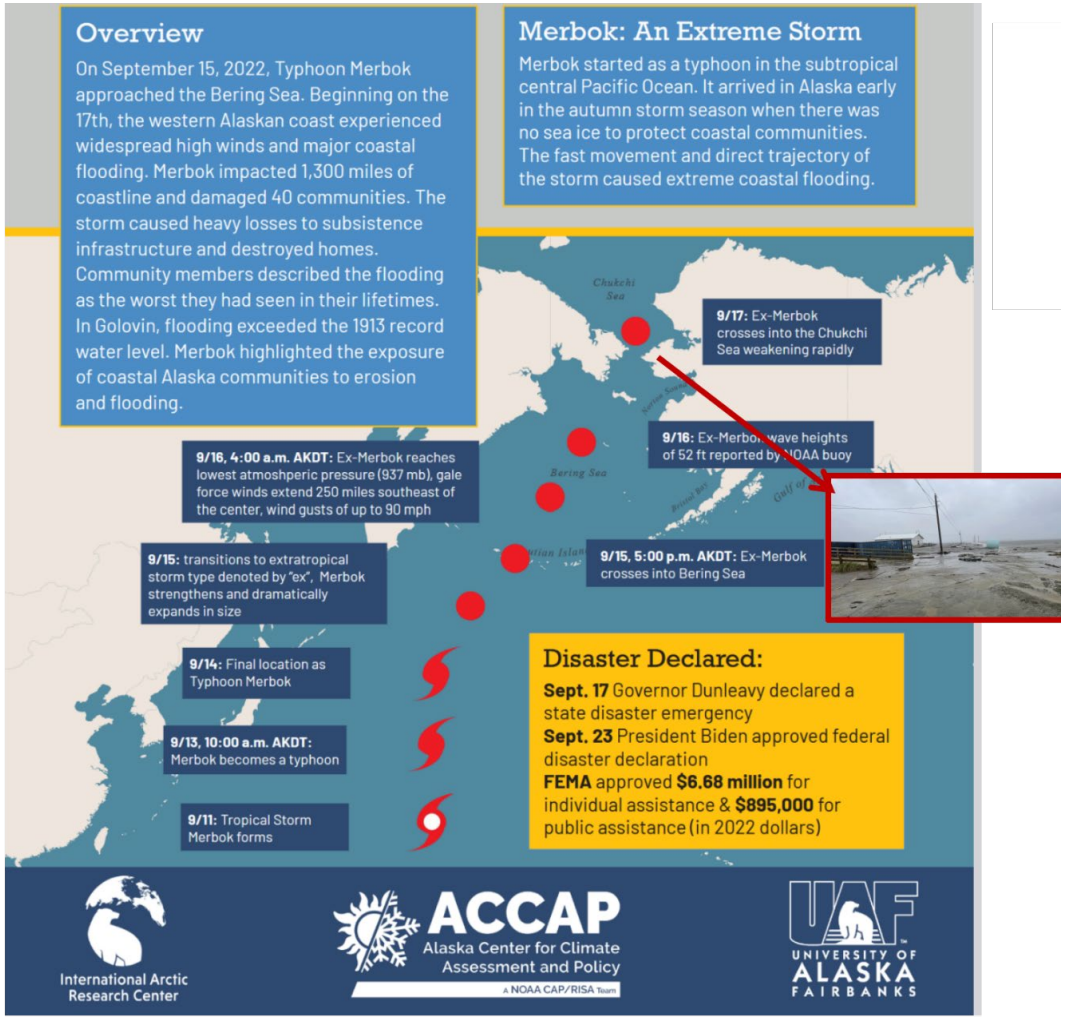
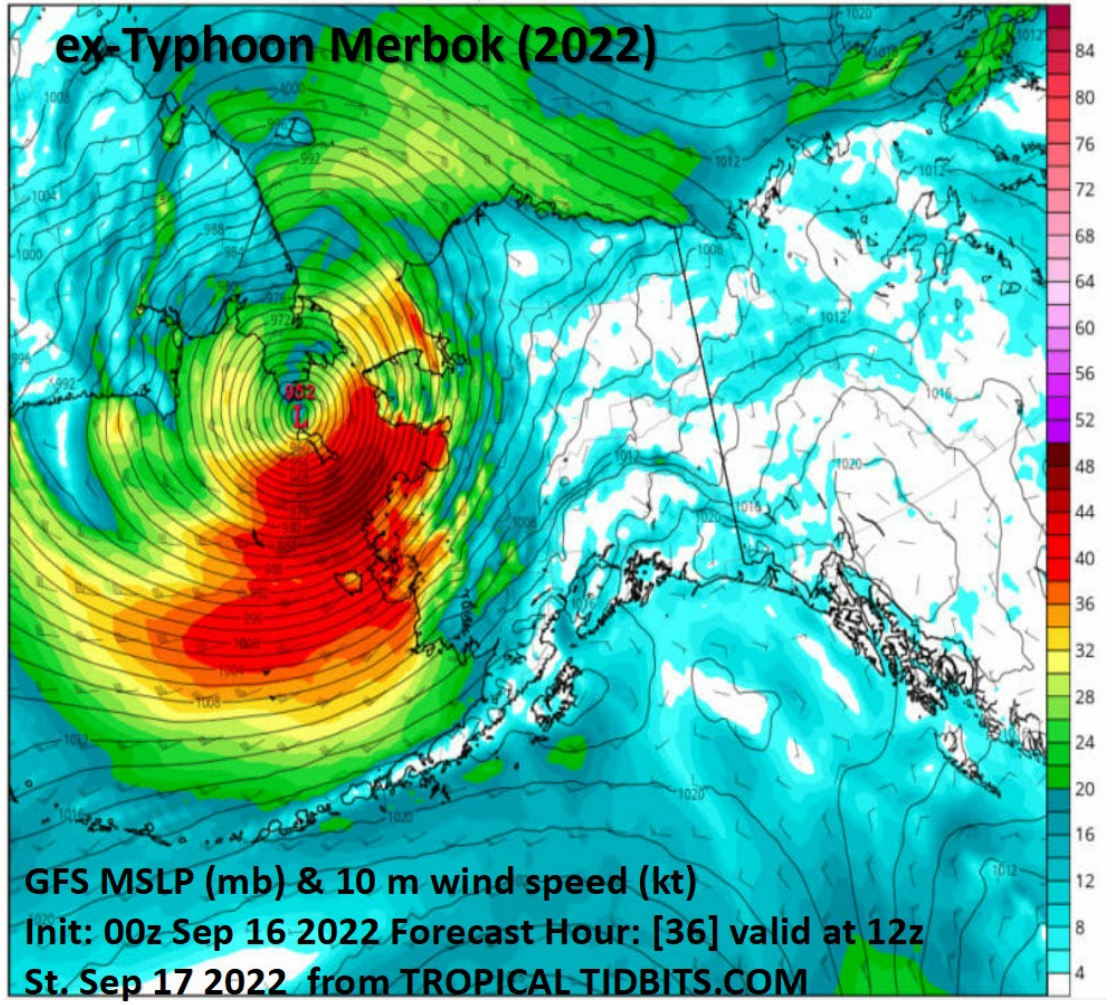




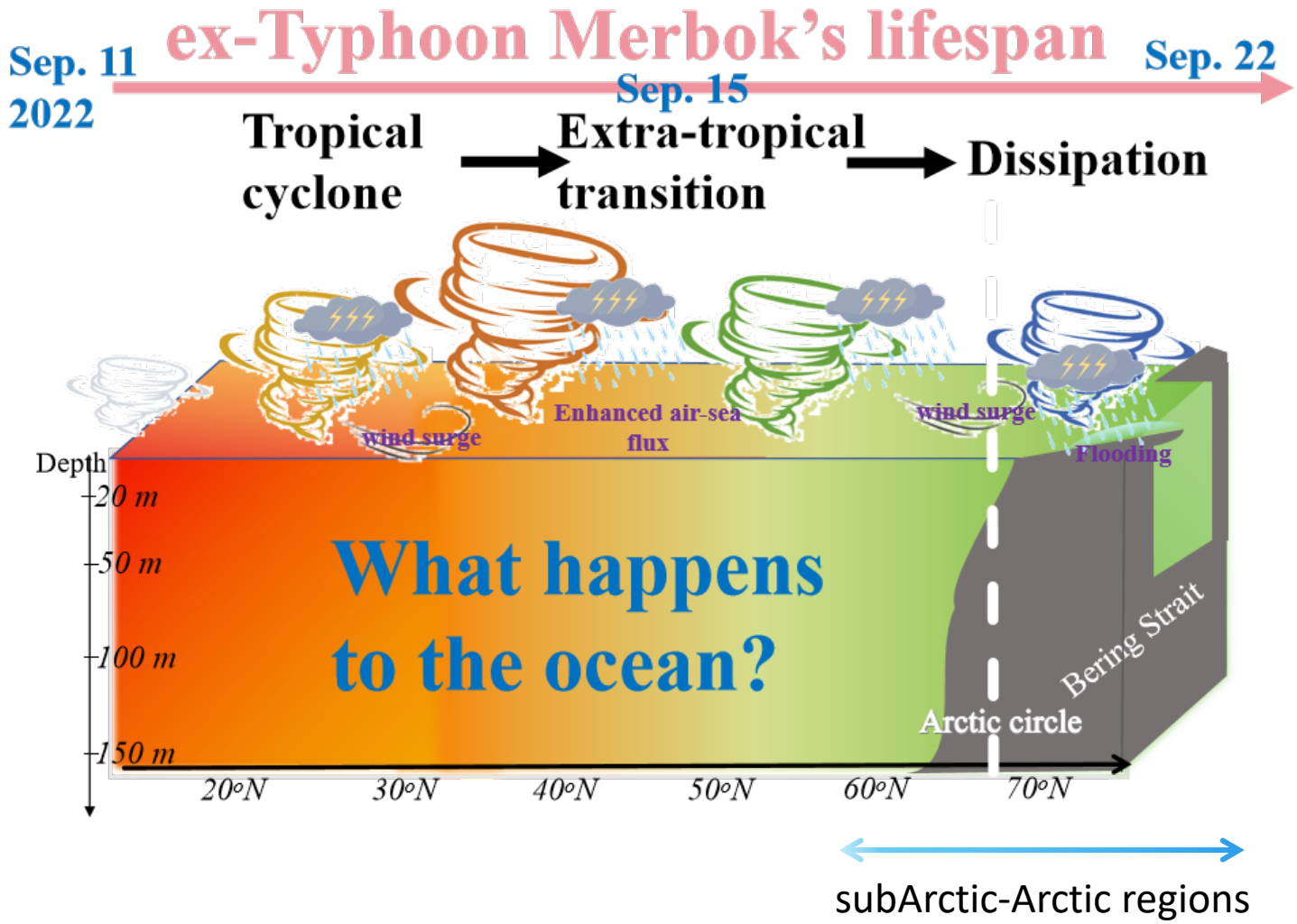
Why (motivations)

- **Record-breaking storm –** **Strongest** extratropical cyclone to enter the Arctic from the tropical western Pacific hitting Alaska in 70+ years. **(aside from Halong2025)**

- **Rare Arctic-tropical connection –** A clear example of how a tropical typhoon can travel north and affect the Arctic (synoptic-scale linkage).

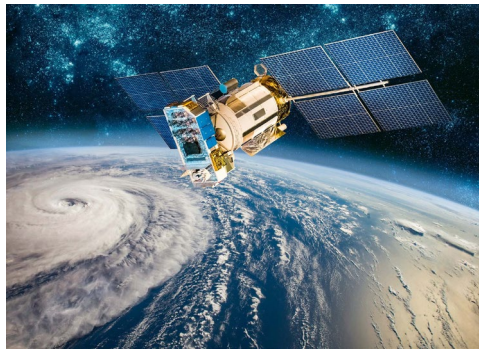
- **What happens to the ocean? –** We don't yet know how the ocean (temperature, currents, sea ice, waves, mixing) responds to such a powerful storm in this remote region.

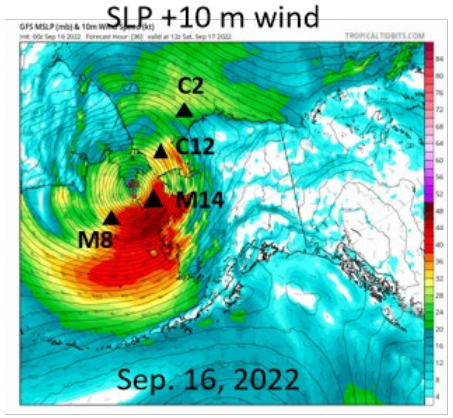
- **Future risk –** Understanding this case helps predict how more **tropical-sourced Arctic storms** might change the ocean as climate warms.

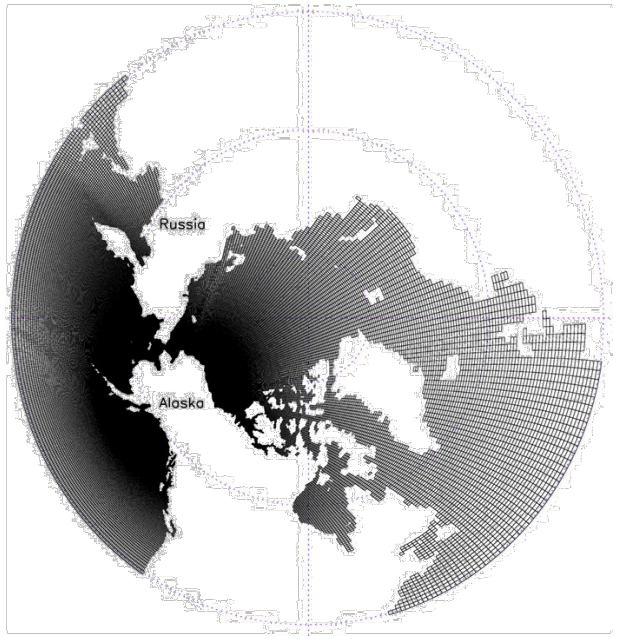


Data & methods

Data	Variable/description	Property
Satellite	SST, SSS, SSH, P-E, runoff, Chl-a	Sea surface
PMEL Ecofoci observation	M8, M14, C12, C2	Mooring data
ERA5	wind & SLP to identify the TC tracks	Reanalysis
MIZMAS	A coupled ice–ocean Marginal Ice Zone Modeling and Assimilation System, forced by NCEP/NCAR reanalysis	Model







MIZMAS Model – Brief Overview

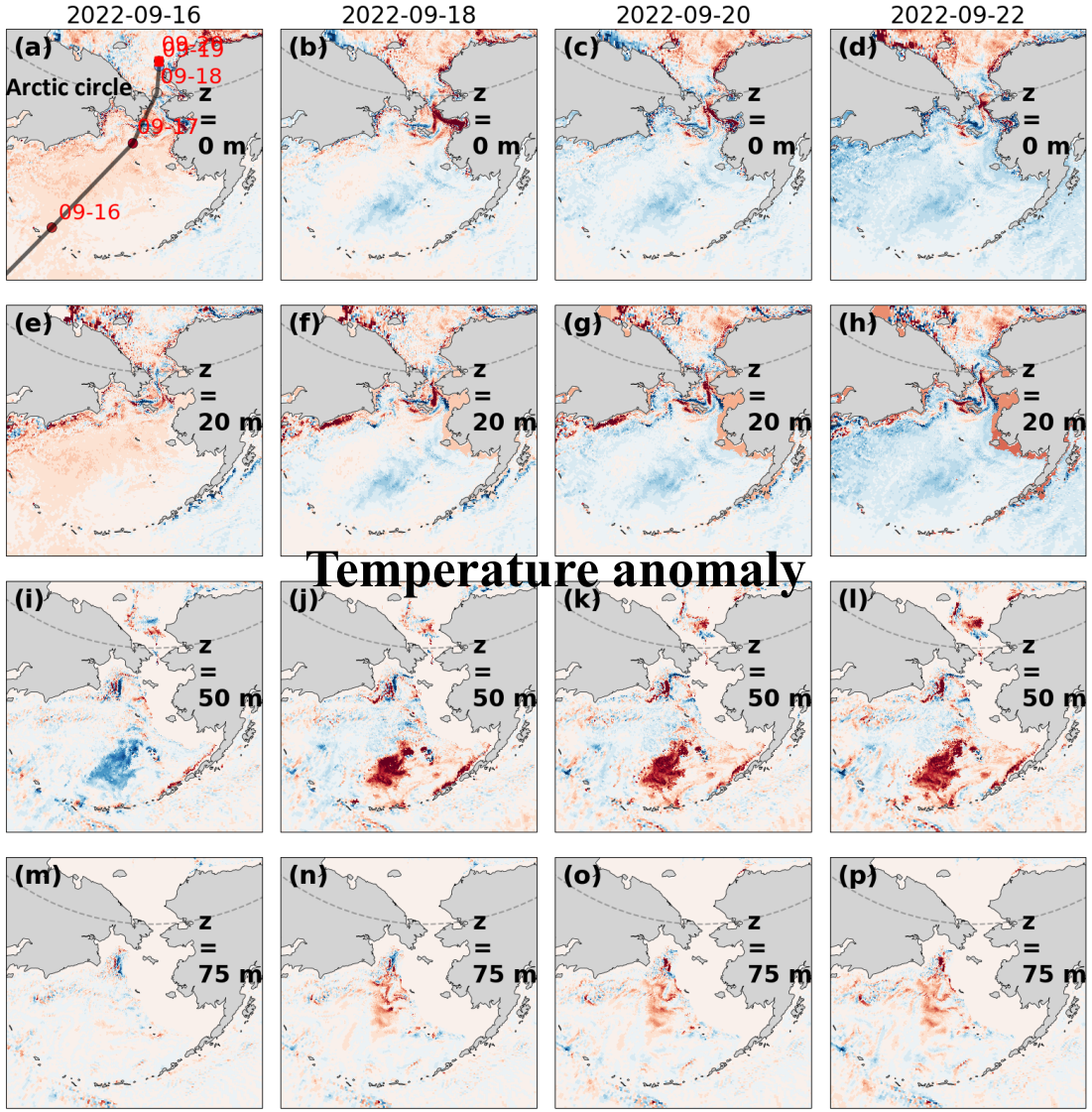
- **High-resolution regional coupled ice-ocean model** for the Marginal Ice Zone (MIZ).
- **Domain**: Northern Hemisphere north of 39°N, focused on the Chukchi-Beaufort-Bering seas.
- **Ocean component**: POP (Parallel Ocean Program) with open boundaries and tidal forcing.
- **Ice component**: TED (Thickness & Enthalpy Distribution) with multi-category **Floe Size Distribution (FSD)**.
- **Horizontal resolution**: ~4-10 km, ~3 km at Bering Strait.
- **Vertical resolution**: 40 layers.
- **Key processes**: Ice advection, thermodynamics, lateral melting, ridging/rafting, wave-induced fragmentation.
- **Data assimilation**: Satellite sea ice concentration and SST.
- **Time scales**: Short-range (6h-9d) and seasonal forecasts.
- **Developers**: Jinlun Zhang, Axel Schweiger, Michael Steele (Univ. of Washington).

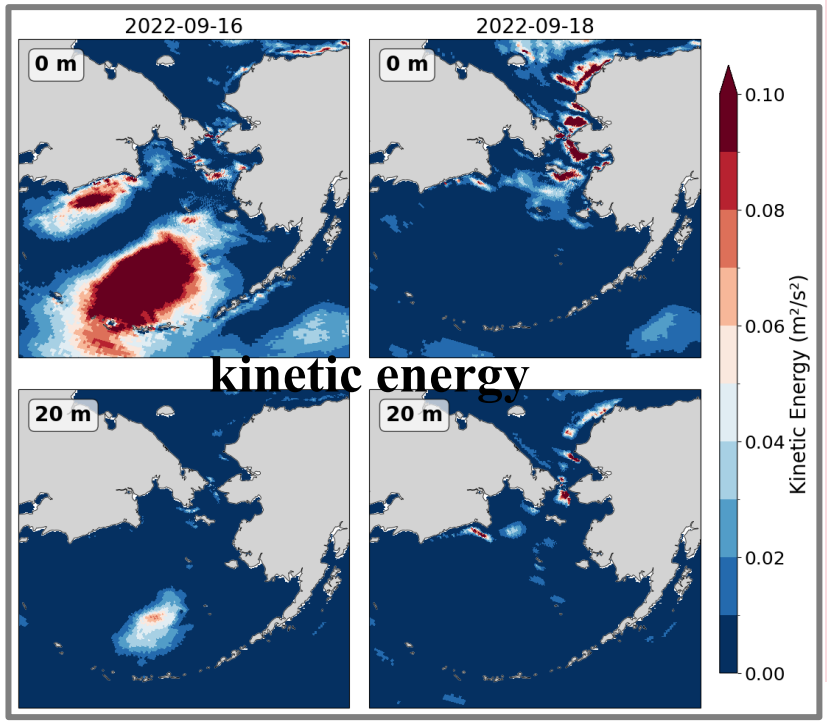
Main results - Understand how the ocean responds to Ex-Typhoon Merbok

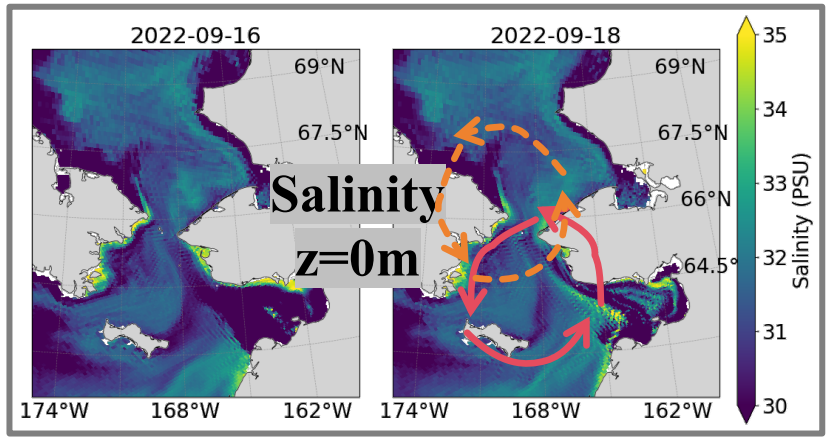
I. Merbok's impact across the Bering-Chukchi-Beaufort seas

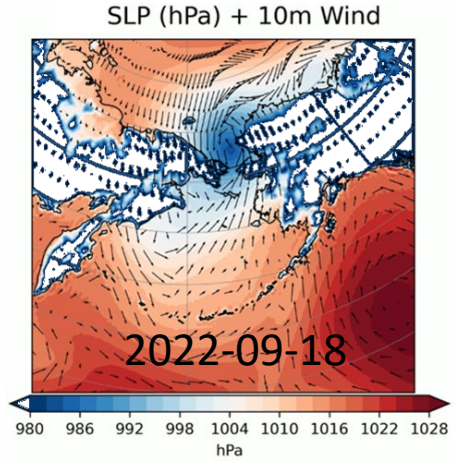
MIZMAS model

daily data — positive / negative — monthly mean









① Bering sea cooling

Bering strait warming

② ocean responses in *preconditions*

③ cascading hazards (extreme rainfall & "flooding")

④ Pacific gateway transport

Main results:

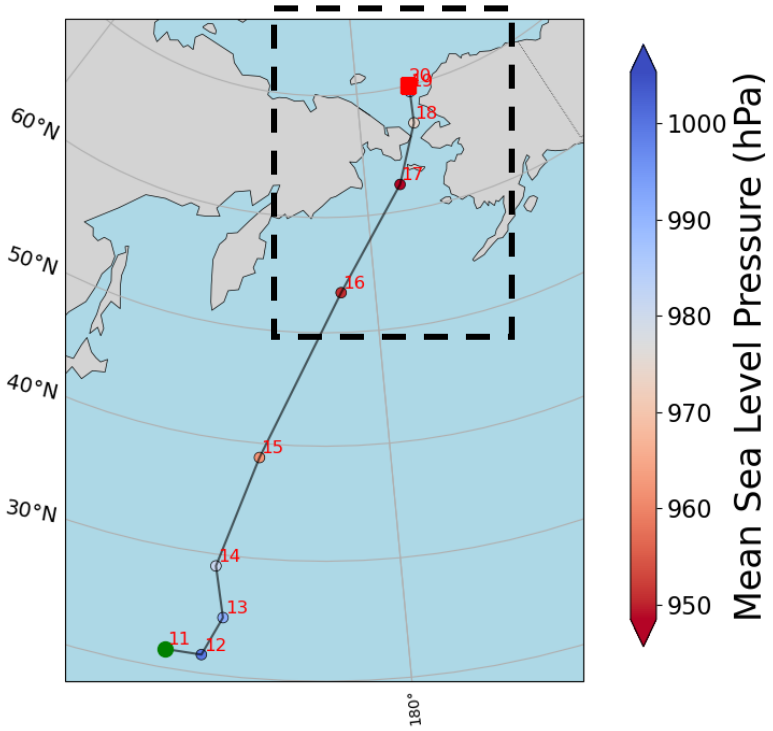
Understand how the ocean (thermodynamics & currents) responds to Ex-Typhoon Merbok

II. Along the storm's track - before, during and after the storm passage

MIZMAS model

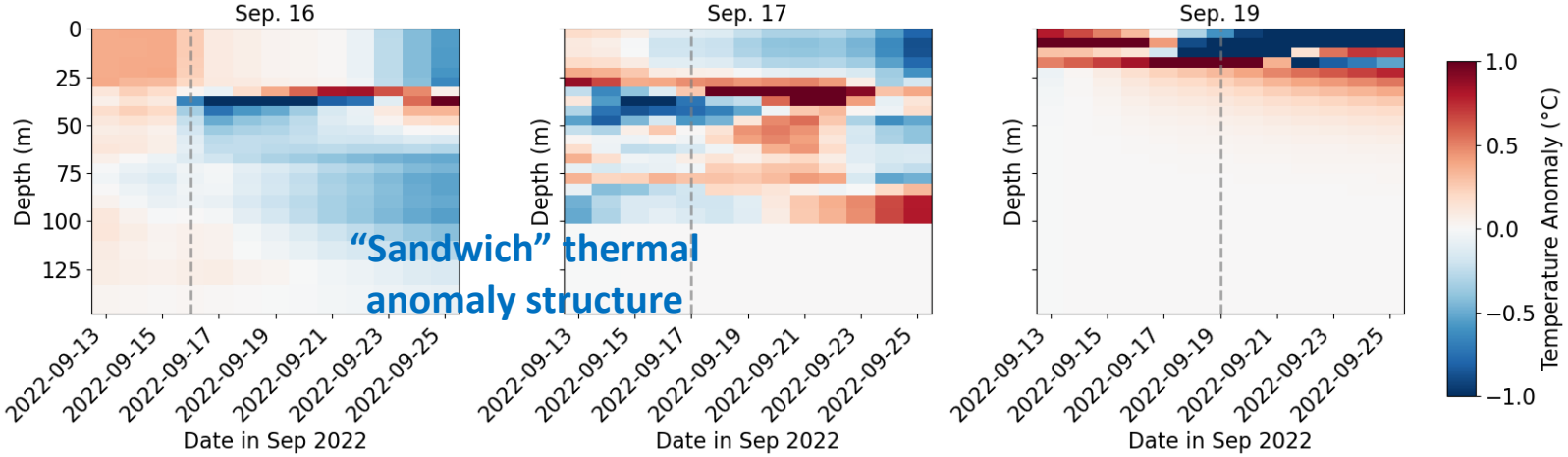
daily data — positive — negative — monthly mean

restratification? barrier layer? --- remains unclear



Temperature anomaly

surface cooling

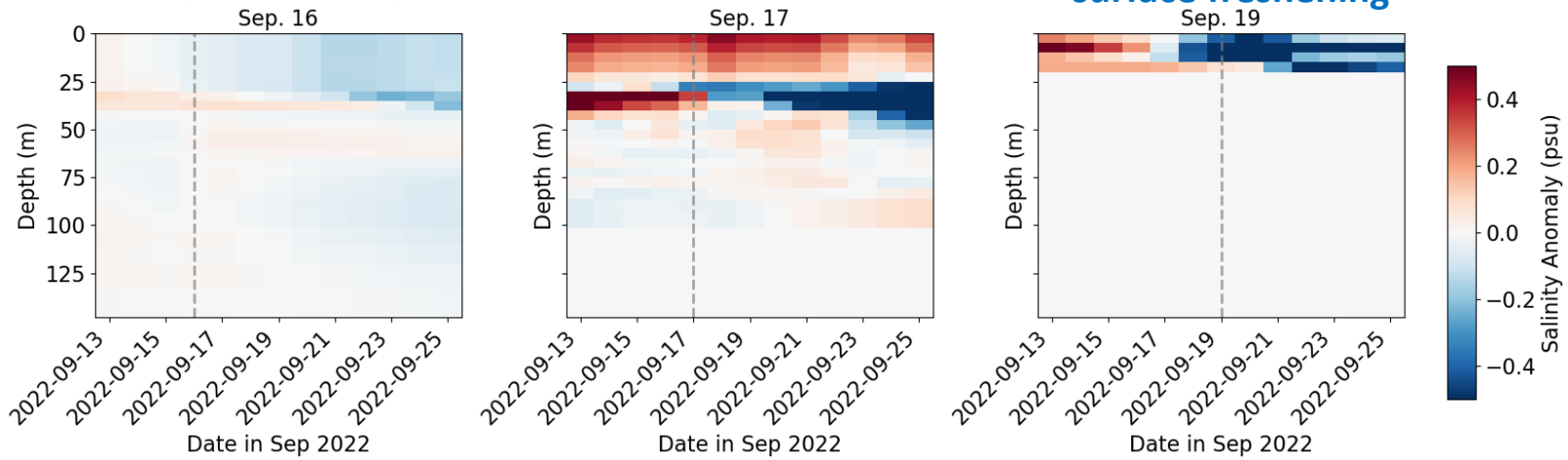


"Sandwich" thermal anomaly structure

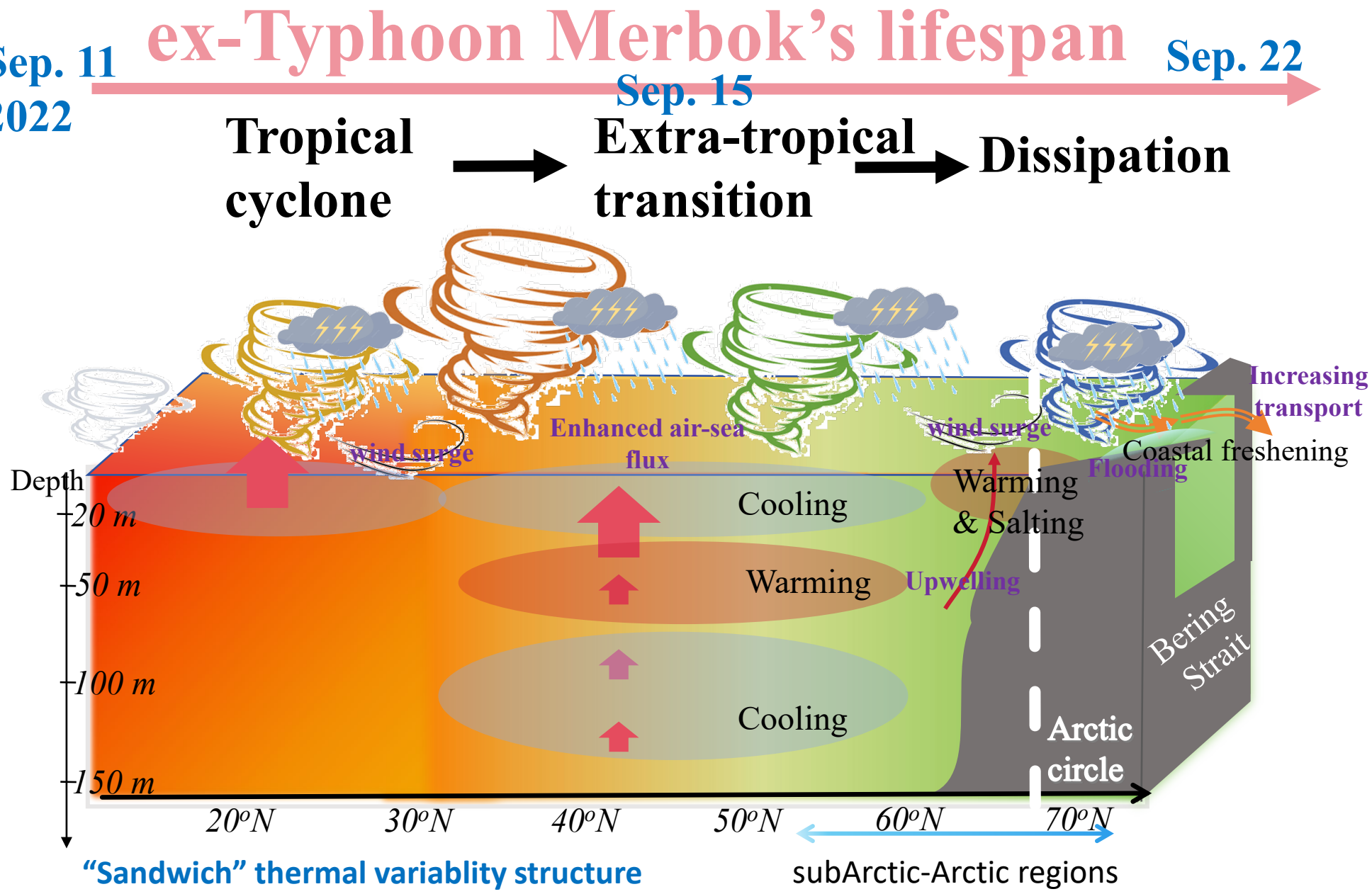
Salinity anomaly

surface salting

surface freshening



Graphyic abstract



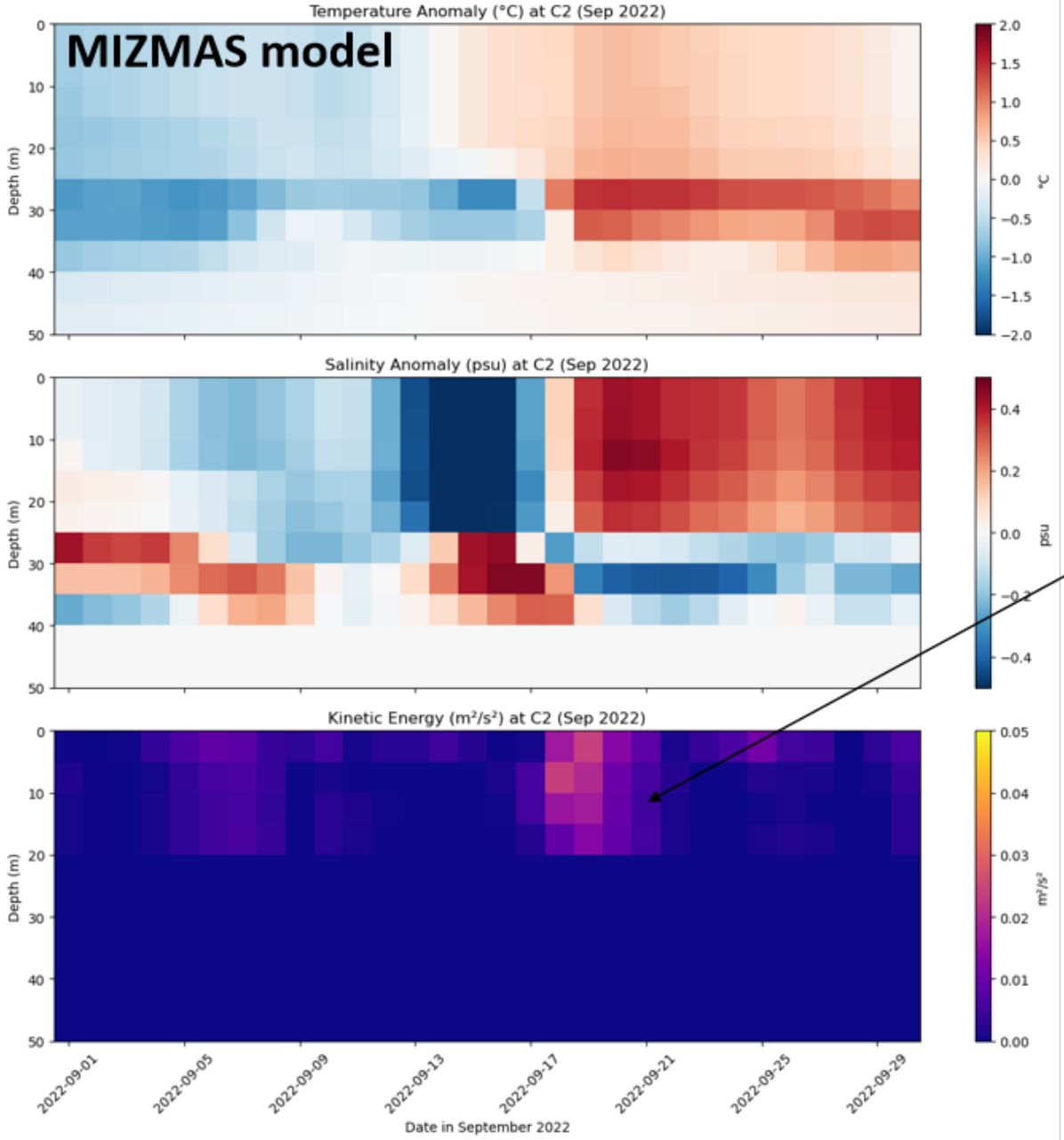
Take home message

This study adopts the coupled ice-ocean MIZMAS model to enhance understanding of how an ex-typhoon impacts the Arctic Ocean. (1) regional response across the Bering–Chukchi–Beaufort seas, (2) temporal evolution along the storm's track (pre-storm, syn-storm, post-storm).

- **Arctic-tropical connectivity** --- showing that a Pacific typhoon (ex-Typhoon Merbok) can alter the remote Arctic Ocean, highlighting the exposure of even high-latitude basins to such extreme events.
- **Impressive mixing & surface cooling** – Strong turbulent mixing brings cold subsurface water to the surface.
- **Impressive pumping & interior warming** – Vertical displacements inject warm water into the pycnocline/interior.
- **Impressive flooding & coastal freshening** – Heavy precipitation and storm surge freshen coastal waters.
- **Upwelling & increased transport** – Wind-driven upwelling supplies warm, saline water onto the shelf, enhancing along-shelf transports.
- **Capability assessment** – Current observing systems (satellites, moorings) and models (MIZMAS) can capture these multi-scale processes, but gaps remain in real-time coverage and process representation.
- **Open questions** – "Sandwich" thermal variablity structure -- restratification? barrier layer? -- remains unclear

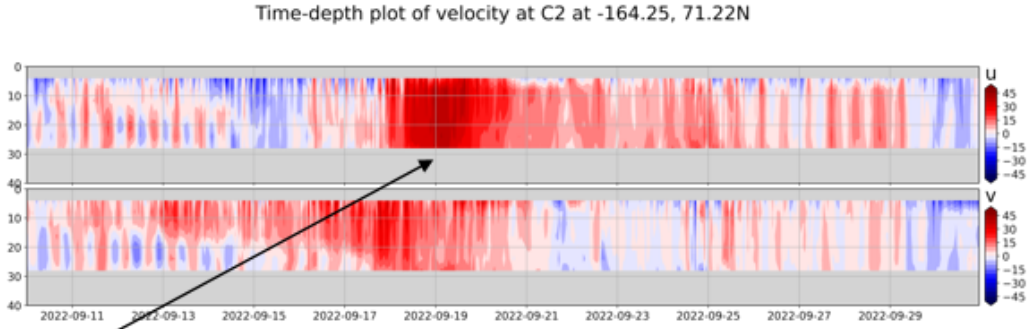
Thanks

Supplementary marterials



C2 (164.25W, 71.22N) and **C12** (168.2W, 67.91N).

Mooring records



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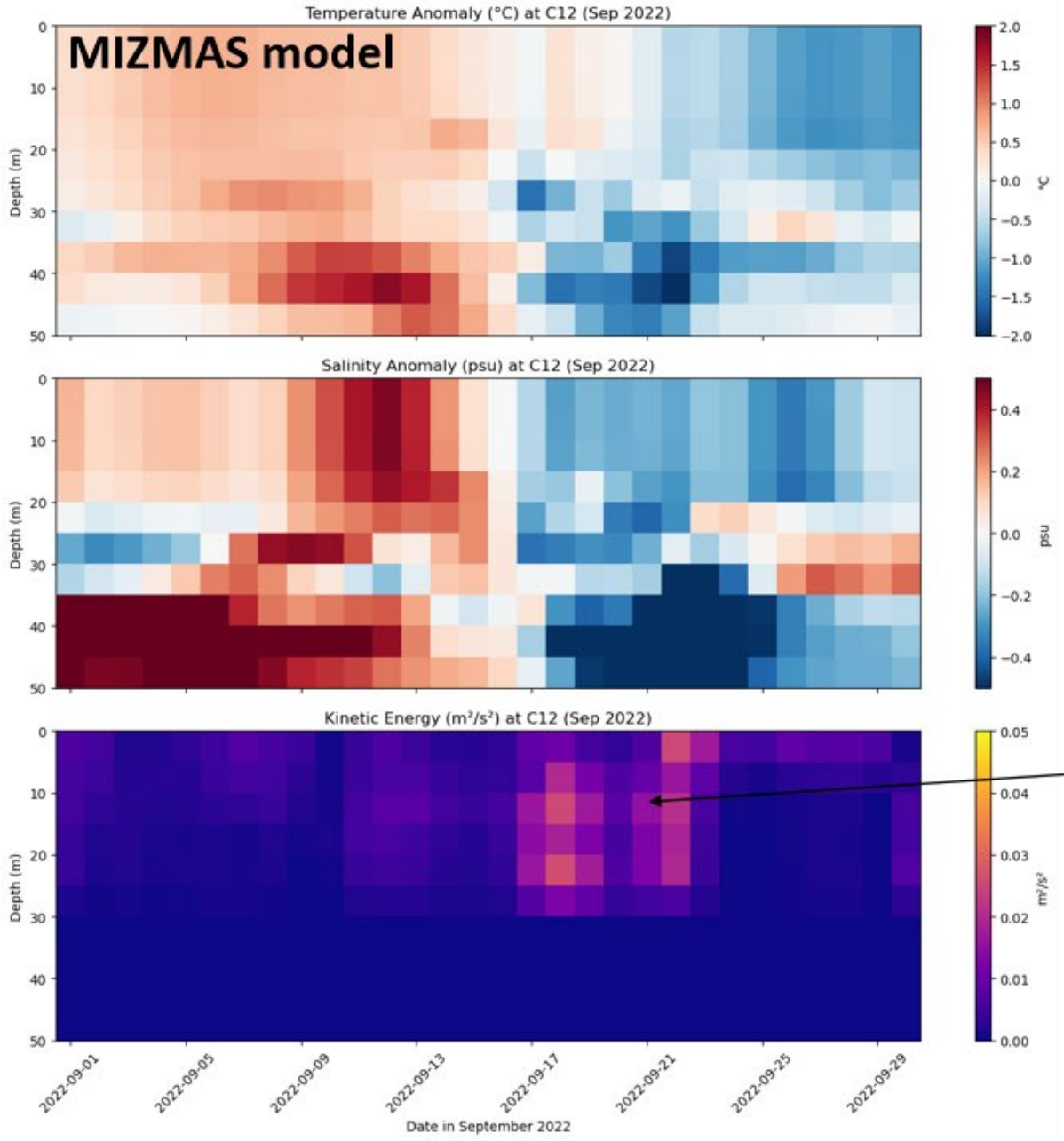

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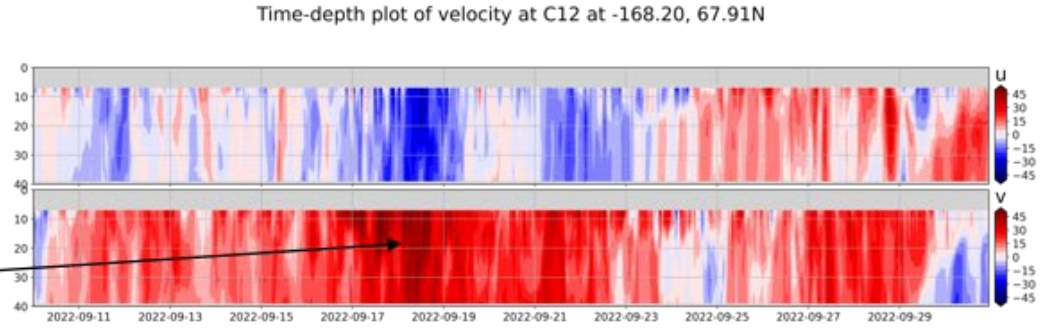

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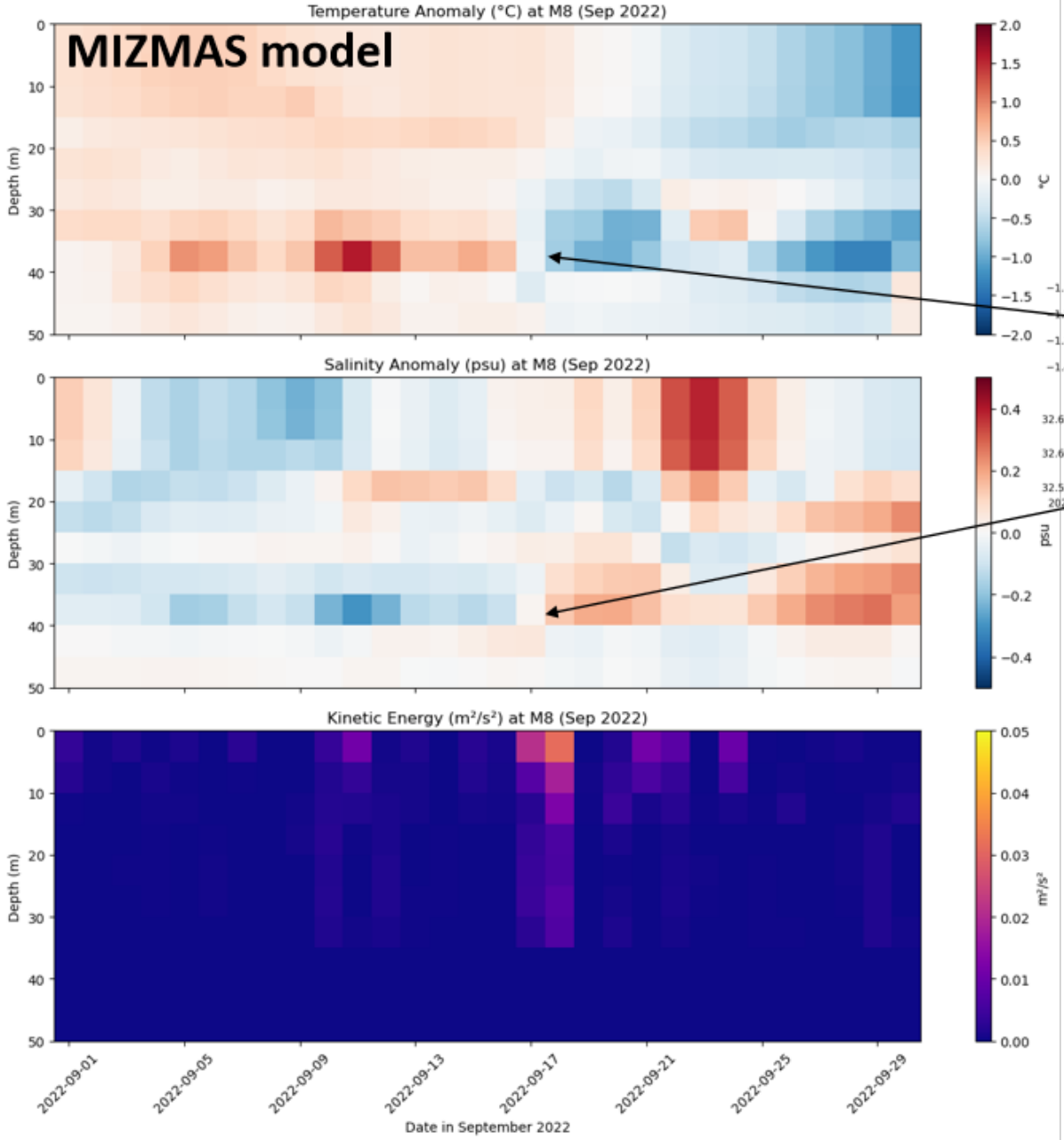
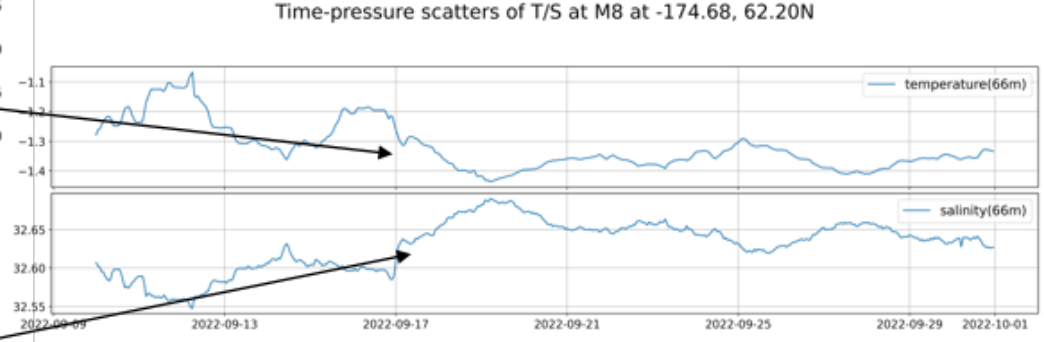


M8 (174.68W, 62.20N, 66m-depth) and **M14** (167.93W, 64.00N, ~32.5m-depth).

Mooring records



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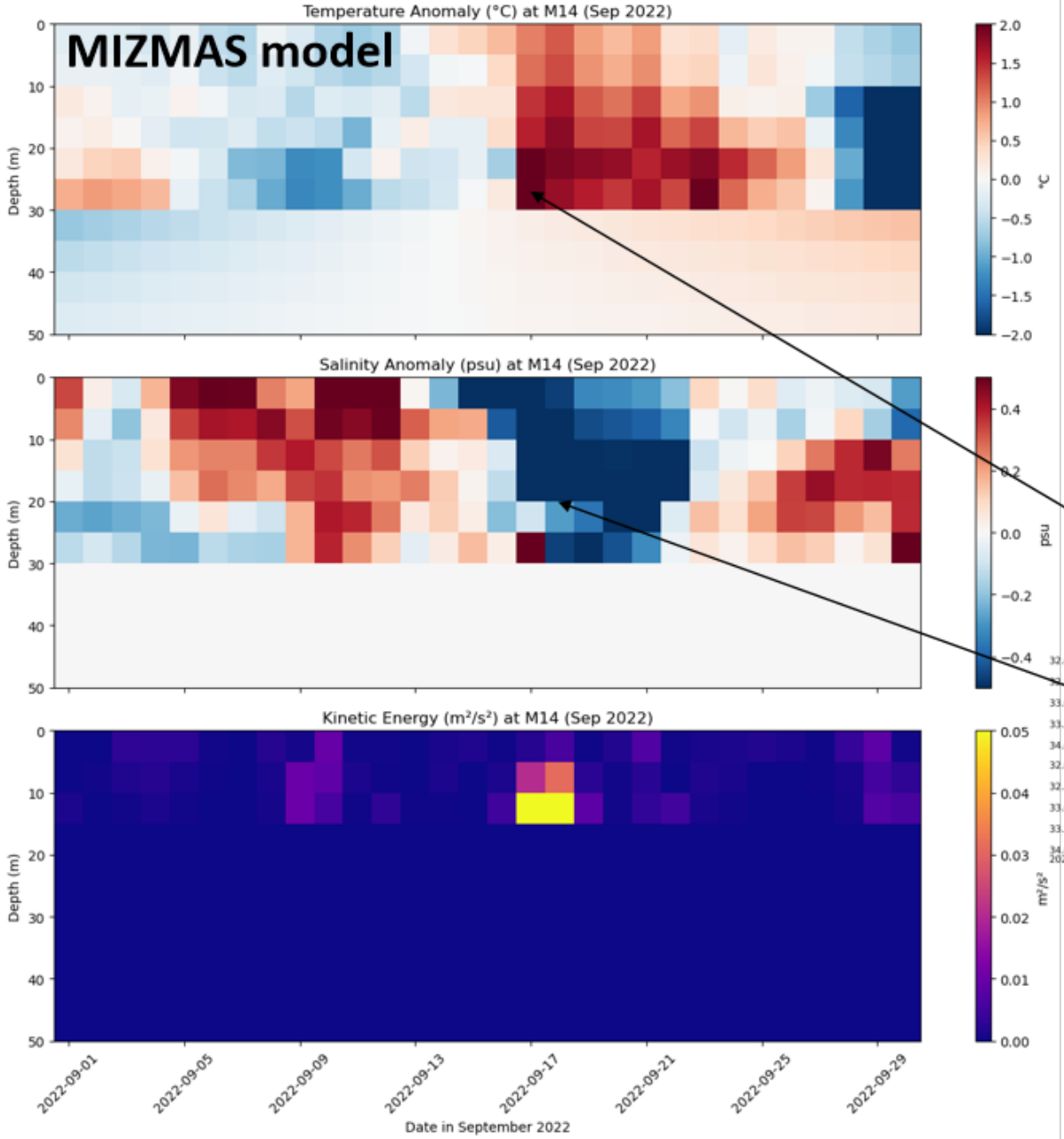

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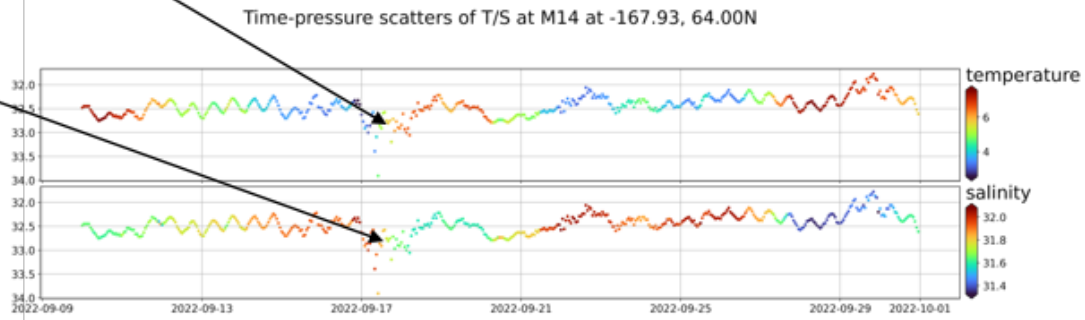
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