Numerical Modelling of Marine Heat Wave Drivers in James Bay

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Introduction

- Overall higher atmospheric and ocean temperatures are exacerbating extreme anomalous warm-water events known as marine heat waves (MHW).
- In the late 1990s, Cree and Inuit communities surrounding Hudson and James Bay reported drastic changes in the marine environment.
- Extreme MHW events have occurred concurrently with these reports, with more recorded throughout the past two decades.

Numerical Model

Ocean Model: NEMOv3.6

Sea-Ice Model: LIM2 (coupled)

Configuration: ANHA4 (Atlantic and Northern Hemisphere Atlantic ¼°)

Years: 2002-2022

Atmospheric Forcing: CGRF

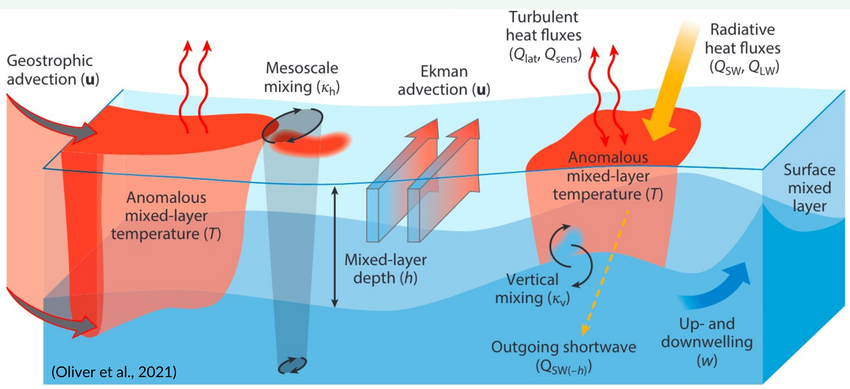
Initial Conditions: GLORYS2v3

Runoff: HydroGDF/B18

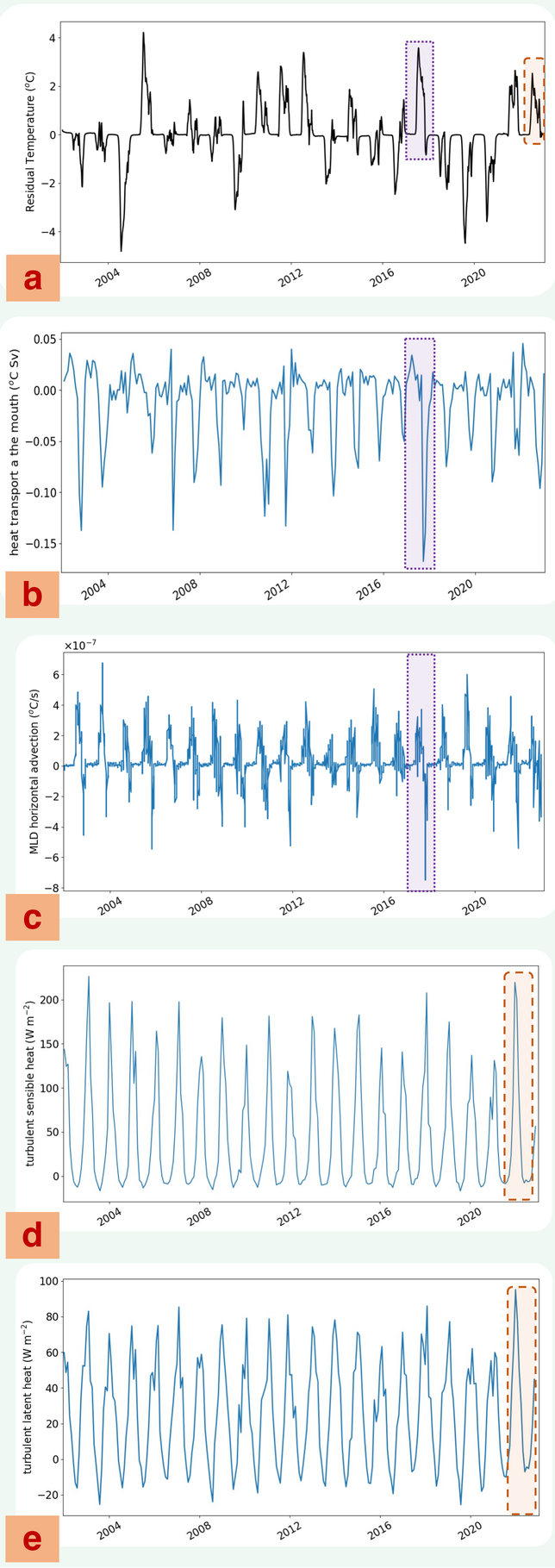
What is a Marine Heat Wave?

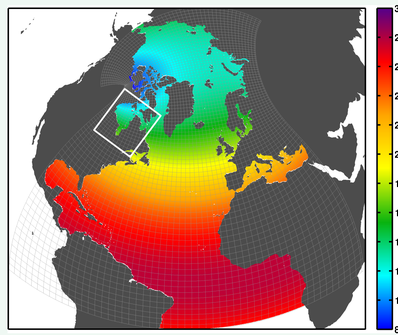
A MHW must be anomalous warming defined by a climatological threshold, prolonged for some defined period, and discrete between two events.

$$\frac{\partial T_{mix}}{\partial t} = \underbrace{\frac{Q_{net}}{\rho c_p H}}_{\text{air-sea heat flux}} - \underbrace{u_{mix} \cdot \nabla_h T_{mix}}_{\text{horizontal advection}} + residual$$



Processes that affect the mixed-layer temperature. The two processes focused on are the geostrophic advection and radiative and turbulent heat fluxes. This diagram depicts other residual processes that affect the mixed layer temperature budget such as up- and downwelling, vertical mixing, and entrainment processes.





ANHA4 Domain and Horizontal Grid [km]

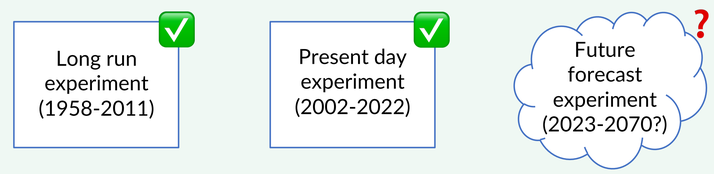
James Bay Communities & Gen. Circulation

Results

- Plots (b) and (c) show that in 2017, heat transport into James Bay at the mouth and horizontal advection (negative sign indicates positive advection into the bay) were causing drastic changes in sea surface temperature (SST) anomalies (plot (a), thus **driving a MHW**.
- However, in the same year, plots (d) and (e) show that turbulent air-sea heat fluxes were not as significant.
- Conversely, in some years— for example, 2022 shown by the orange dashed boxes—there are weaker signals of horizontal advection and lateral heat transport into James Bay while air-sea heat fluxes have stronger signals. This indicates **turbulent and radiative processes can play a significant role in driving some marine heat waves**.
- Both air-sea heat fluxes and horizontal advection are important drivers of MHWs in James Bay.
- **To further predict marine heatwaves in the future, there must be a focus on both processes**.

Next Steps and Bigger Picture

- Air-sea heat fluxes play an important role in some MHWs in the Hudson Bay region. The radiative air-sea heat fluxes— short wave and long wave radiation— should be calculated and added to the turbulent fluxes to understand the total effect this terms has on MHWs.
- Additionally, the same analysis should be done on similarly forced experiment which has run for a longer period from 1958 to 2011.



- Once the drivers of MHWs in James Bay and Hudson Bay are understood, model forecasts may be run to predict future occurrences of MHWs in a world that is rapidly warming.
- Disseminating knowledge gained from model experiments and working together with Indigenous communities around James Bay can lead to proactive planning rather than reactive responses to MHWs in the future.