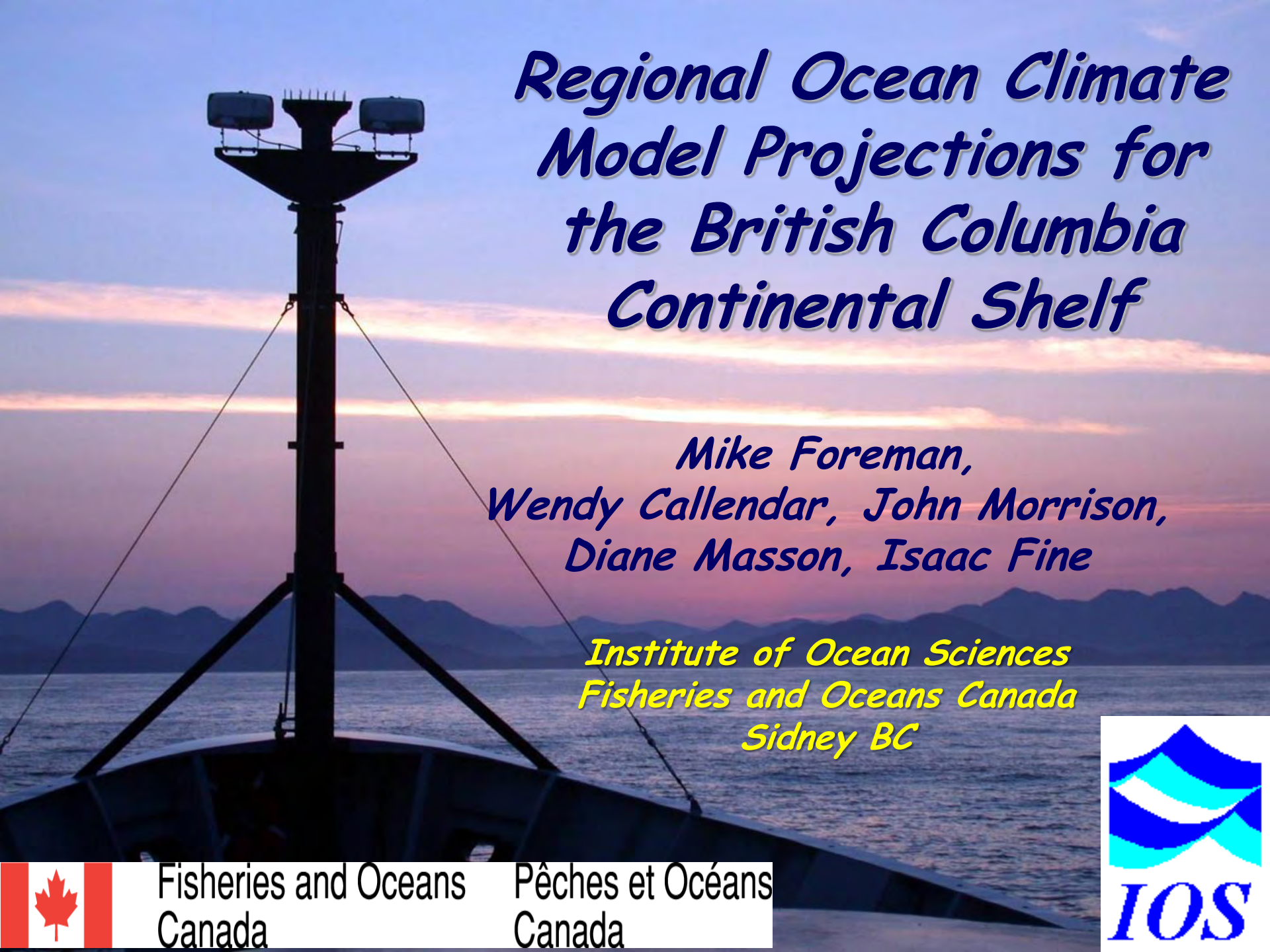

# Regional Ocean Climate Model Projections for the British Columbia Continental Shelf


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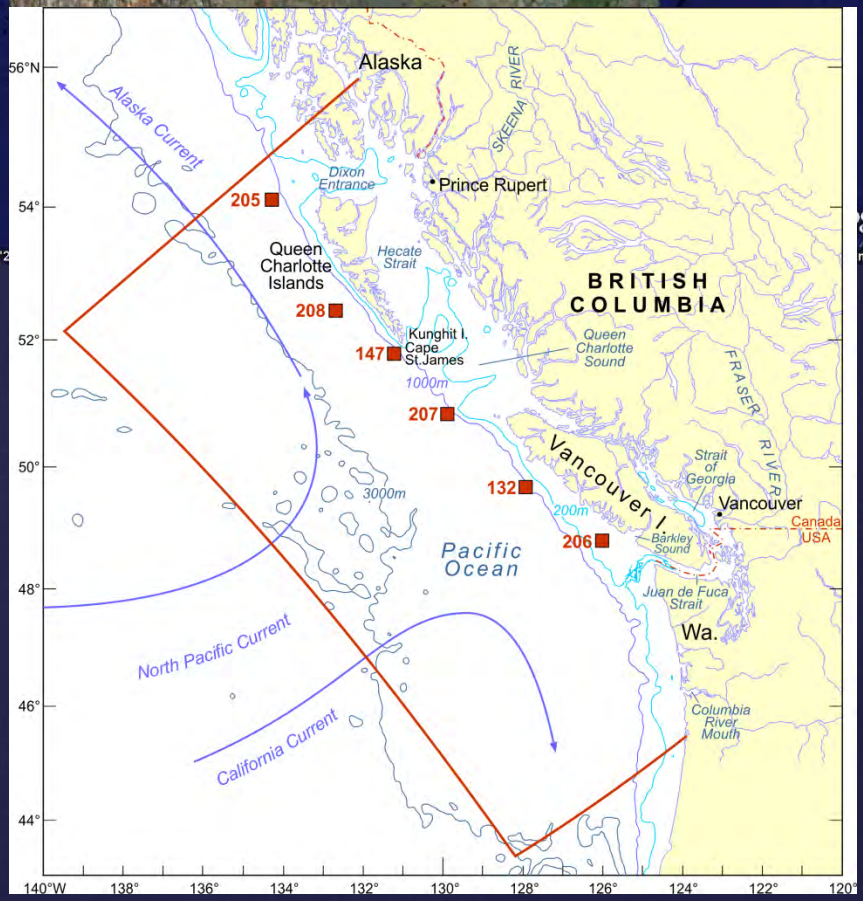
IOS

# Outline

a) future projection strategy
b) model details
c) forcing & initial fields
d) model projections
e) summary & future work



# Projections from North American Regional Climate Change Assessment Program (NARCCAP)

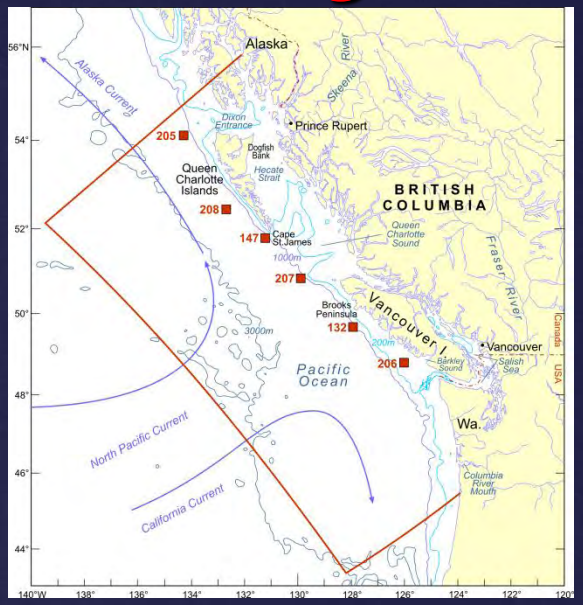
- 4 GCMs, 6 RCMs, 11 combinations
- IPCC AR4 A2 scenario

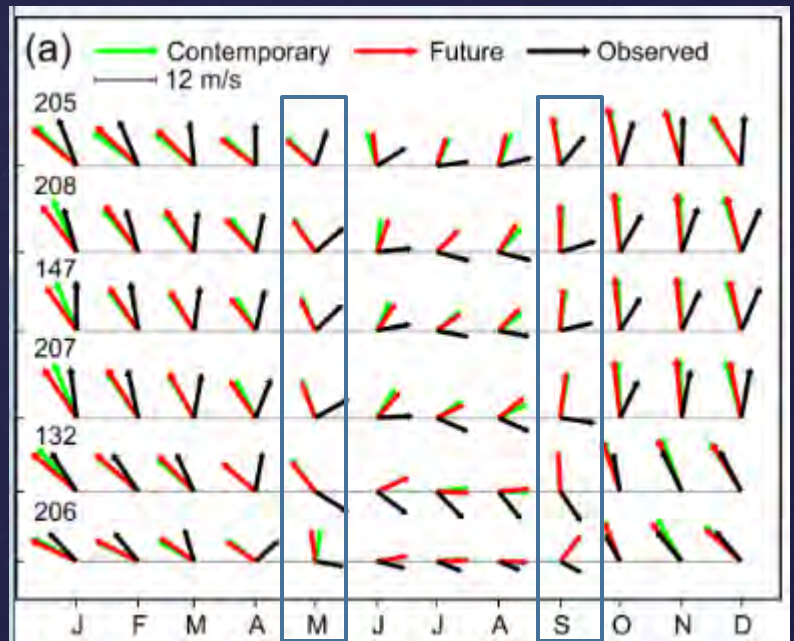
RCMs:
- ~50 km resolution vs >1° for GCMs
- atmospheric only; no active ocean
- periods: 1970-1999 & 2040-2069

- But RCMs don't capture contemporary offshore downwelling/upwelling winds & transitions accurately

➡ direct use of RCM future forcing could generate misleading ecosystem conclusions

- adopted an anomaly approach

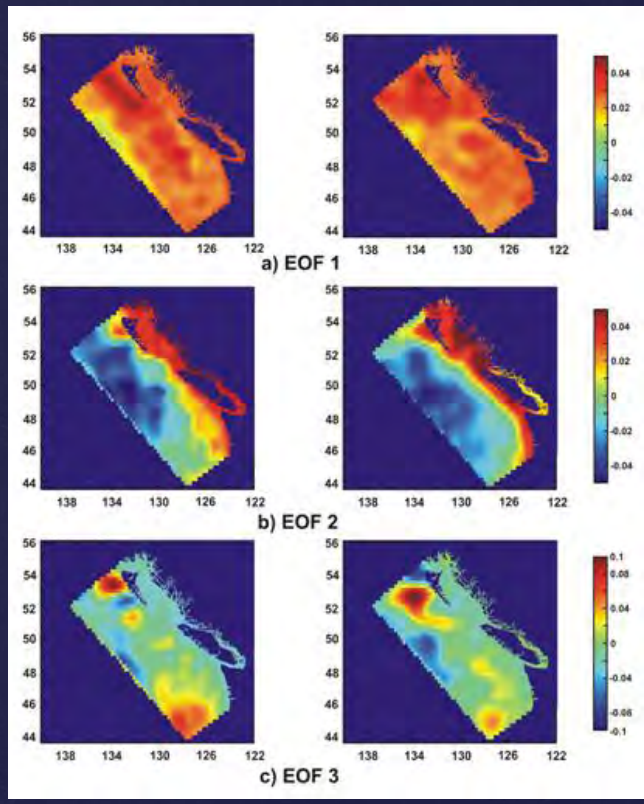


# Future Forcing Strategy

- Add NARCCAP RCM or GCM monthly average anomalies (2040-2069 minus 1970-1999) to the forcing & initial fields used by Masson & Fine in their 1995-2008 ROMS hindcast of the BC shelf (3km)
  - JGR 2012
  - 3km horizontal resolution
  - 8 tidal constituents
  - 3 hourly winds (NARR)
  - bulk formula heat flux (NARR)
  - monthly discharge from 21 main rivers
  - monthly open boundary forcing (SODA)

- so far only using CRCM/CGCM3 NARCCAP combination



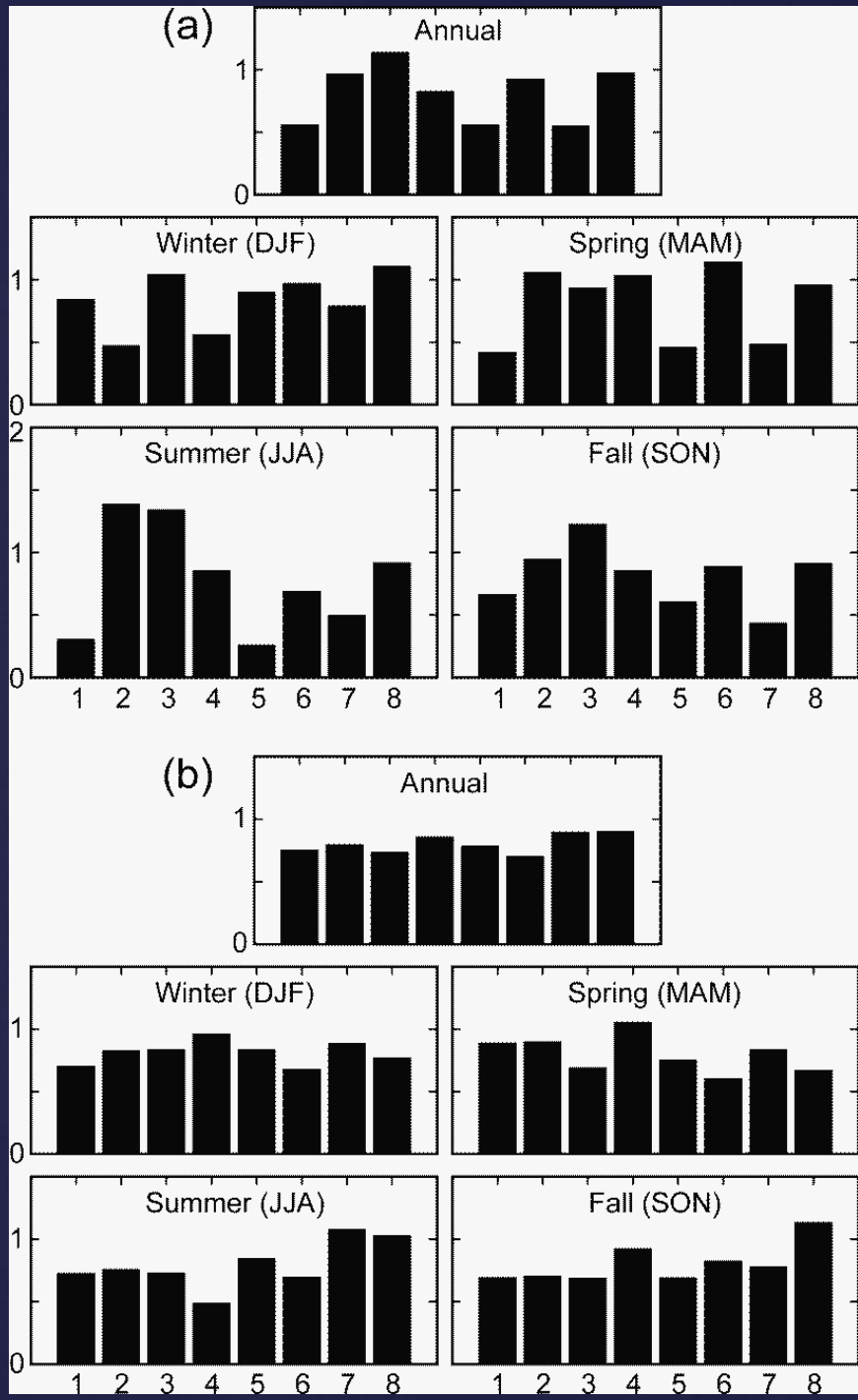

ROMS & AVISO SSH EOFs

# Representativeness of CRCM/CGCM3

- 11 RCM/GCM combinations but 3 had large data gaps
  - 8 member ensemble

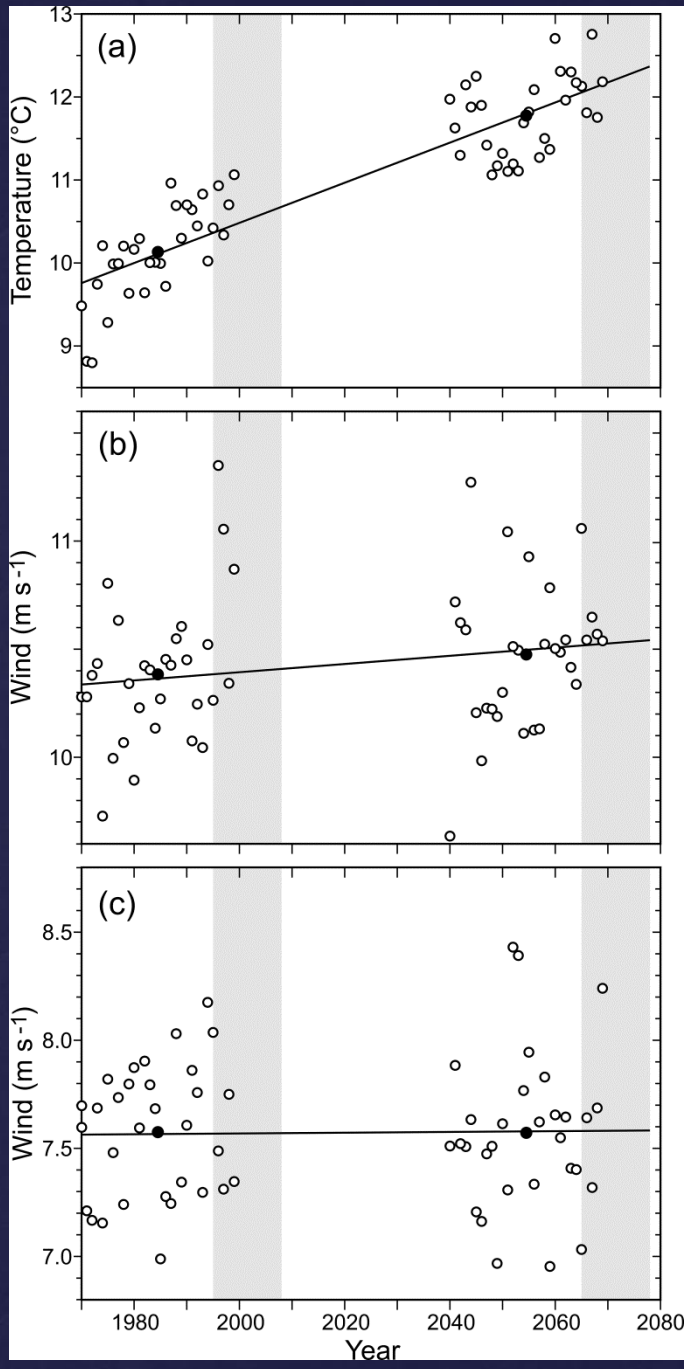
1. For each of 8 combinations, computed annual & seasonal domain-averaged mean anomalies (future - contemporary) of
   a) surface air temperature
   b) precipitation
2. computed ensemble means & standard deviations
3. Scaled difference between individual & ensemble means by ensemble SD: "studentizing"

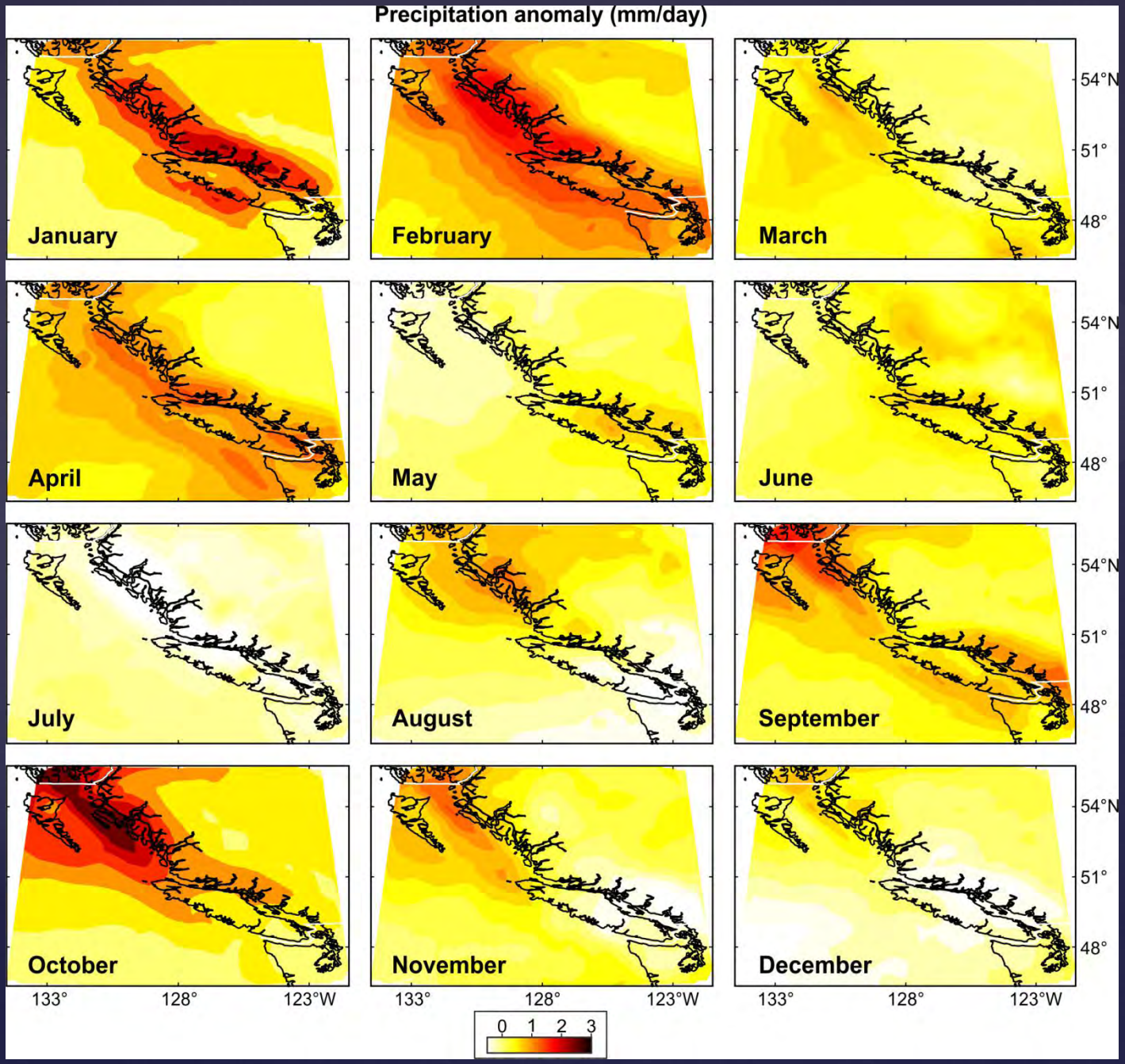
- Figure shows absolute values
- CRCM/CGCM3 is member #1



# Timing Mismatch?

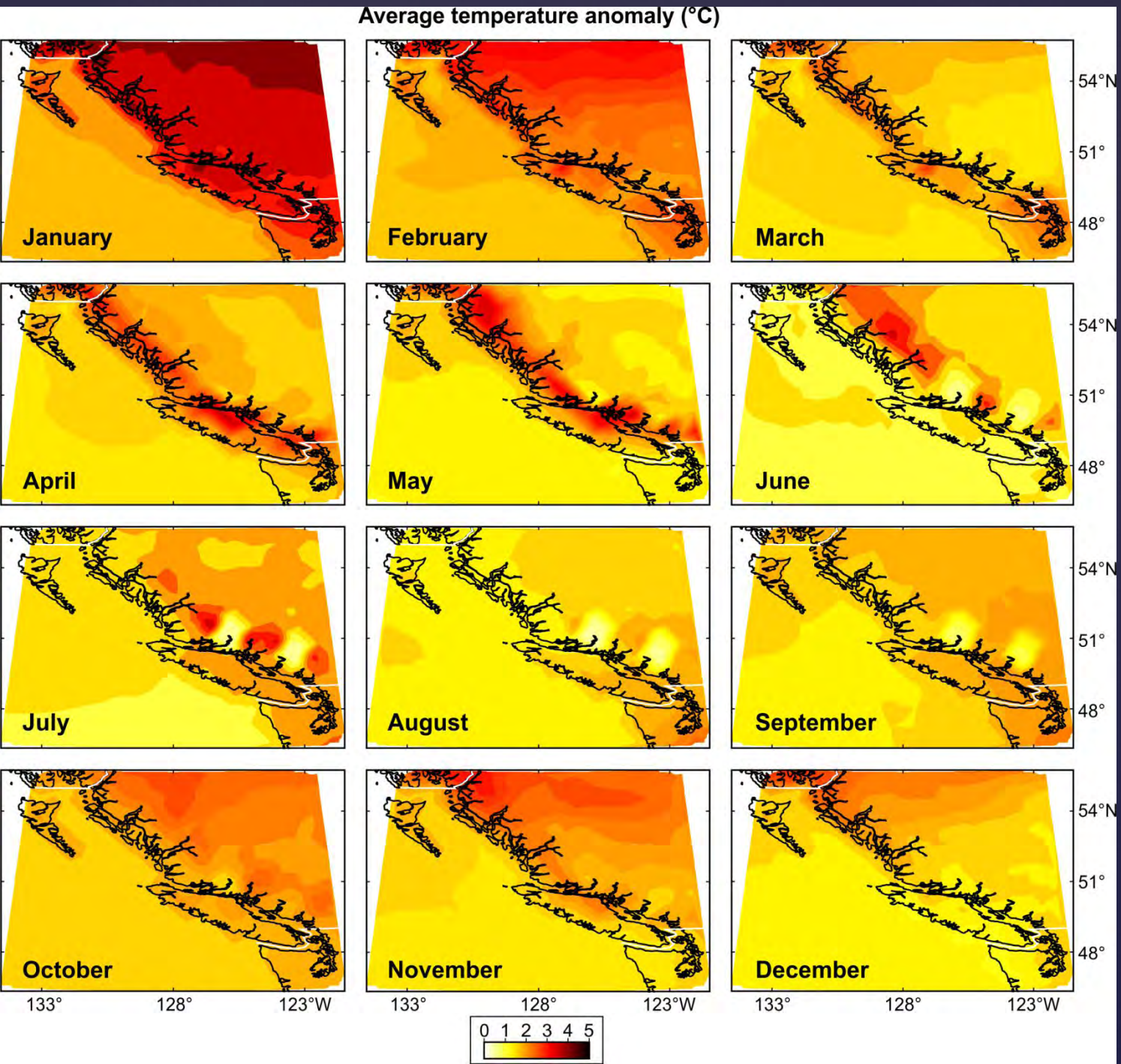
- Masson & Fine hindcast for 1995-2008 while NARCCAP periods are 1970-2000 and 2040-2069
- Figure shows CRCM/CGCM3 model domain averaged
  a) Annual air temperatures
  b) winter (Oct-Apr) wind speeds
  c) summer (May –Sep) wind speeds
  covering NARCCAP contemporary & future periods
- 100-yr trend (solid line) for a) essentially same as future 30-yr trend so reasonable to extrapolate
- b) & c) trends not significantly different from zero
- Future run may be considered for 2065-2078






# Precipitation Anomalies

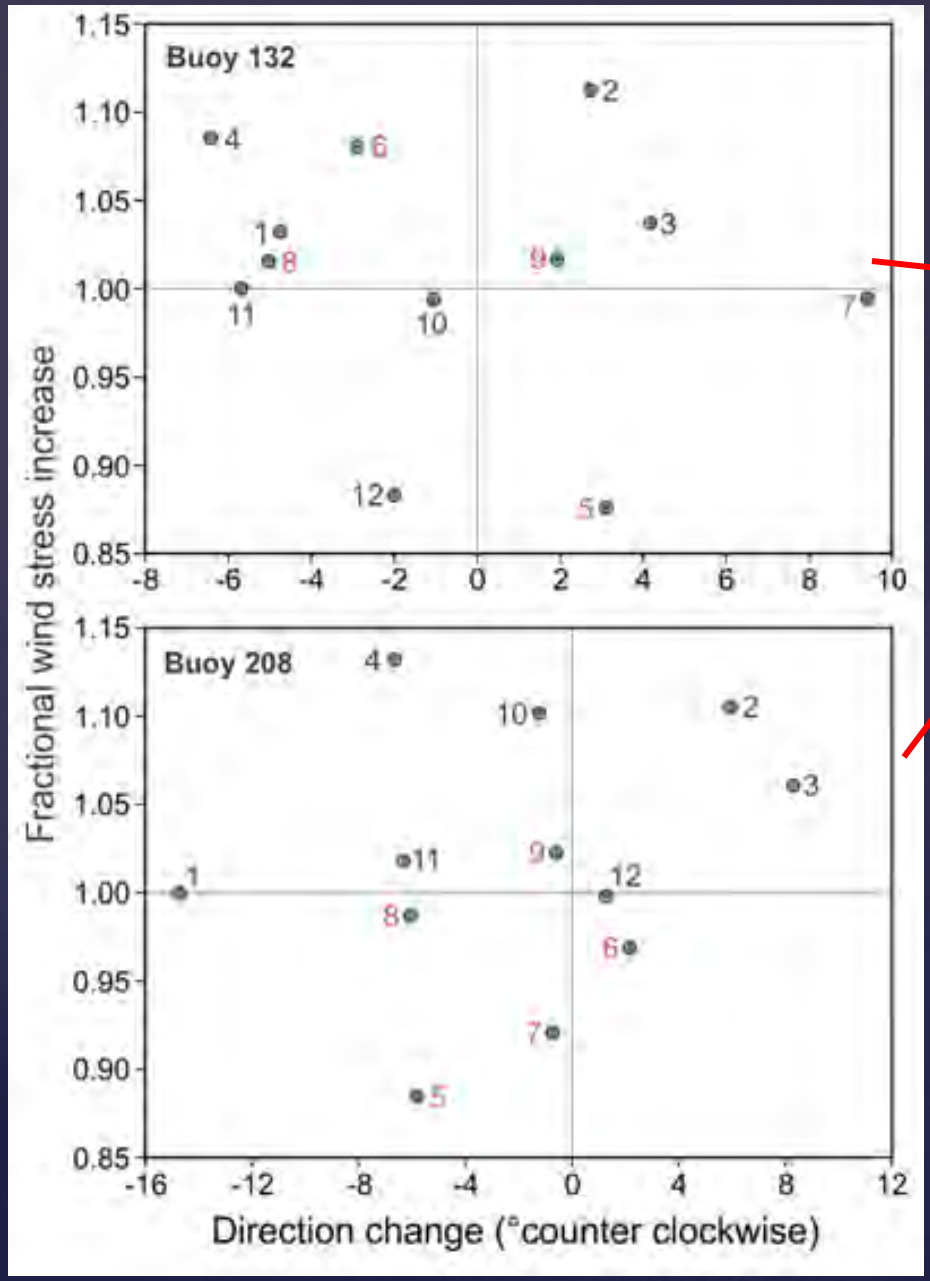
- Monthly-averaged differences 2040-2069 minus 1970-1999
- Generally wetter in winter & dryer in summer
- Average annual anomaly ~ +0.5mm/day

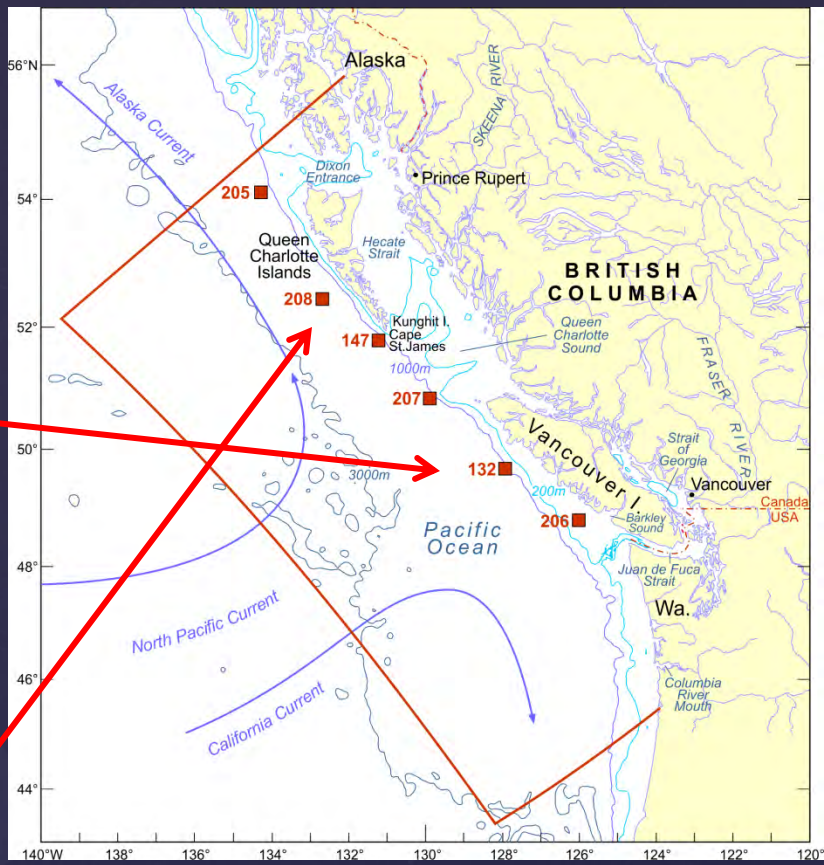



# Surface Air Temperature Anomalies

- Monthly-averaged differences 2040-2069 minus 1970-1999
- Slightly different patterns for day and night

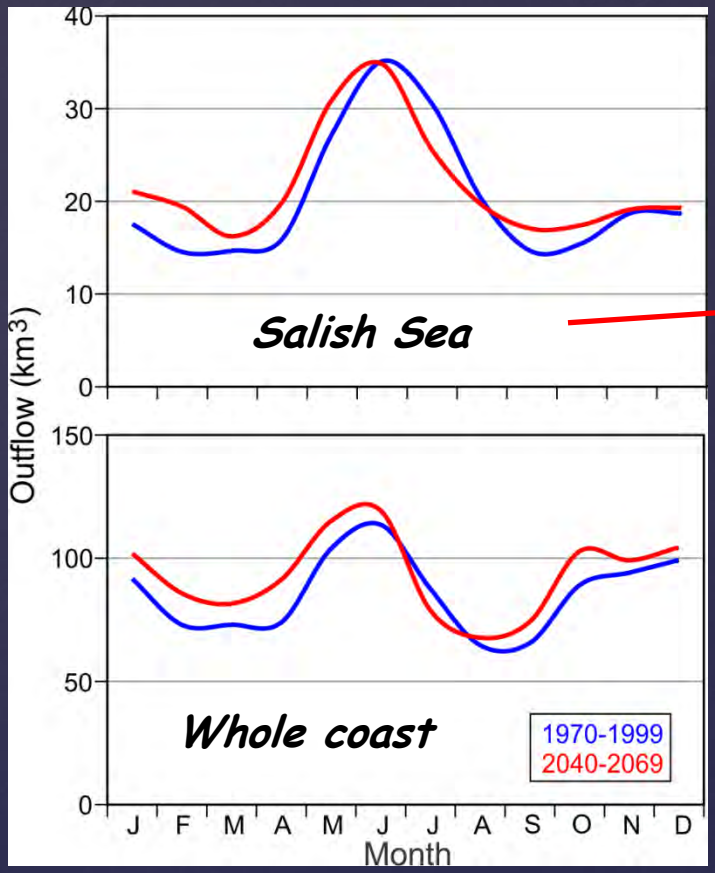
# Wind Anomalies



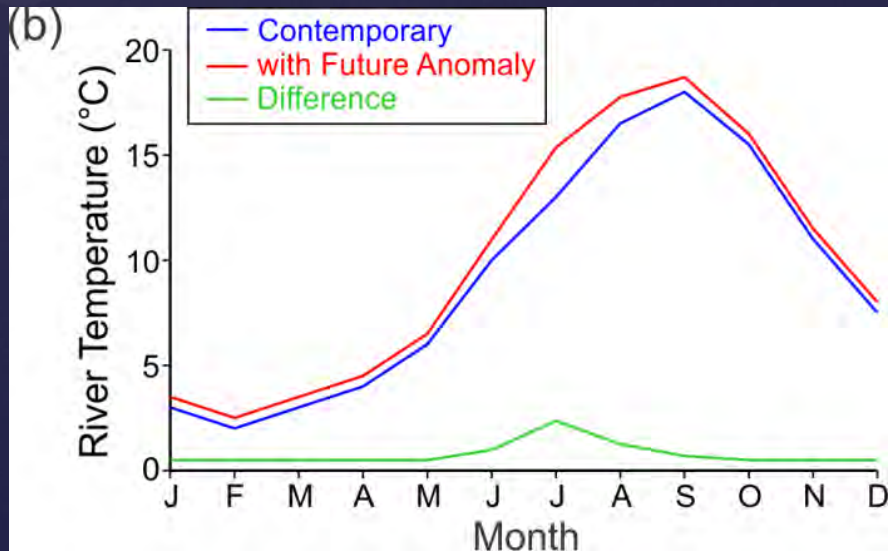




- *Numbered dots = months*
  - *Red = upwelling months*
- *Generally stronger winter winds*
- *Perhaps, stronger summer upwelling winds at buoy 132*

# Contemporary & Future Freshwater Discharges



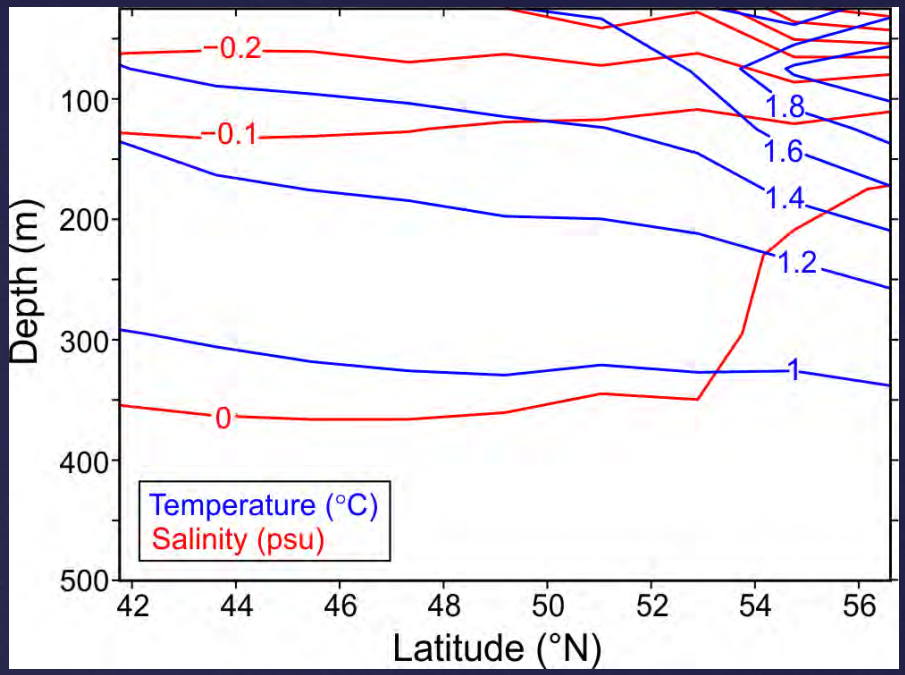




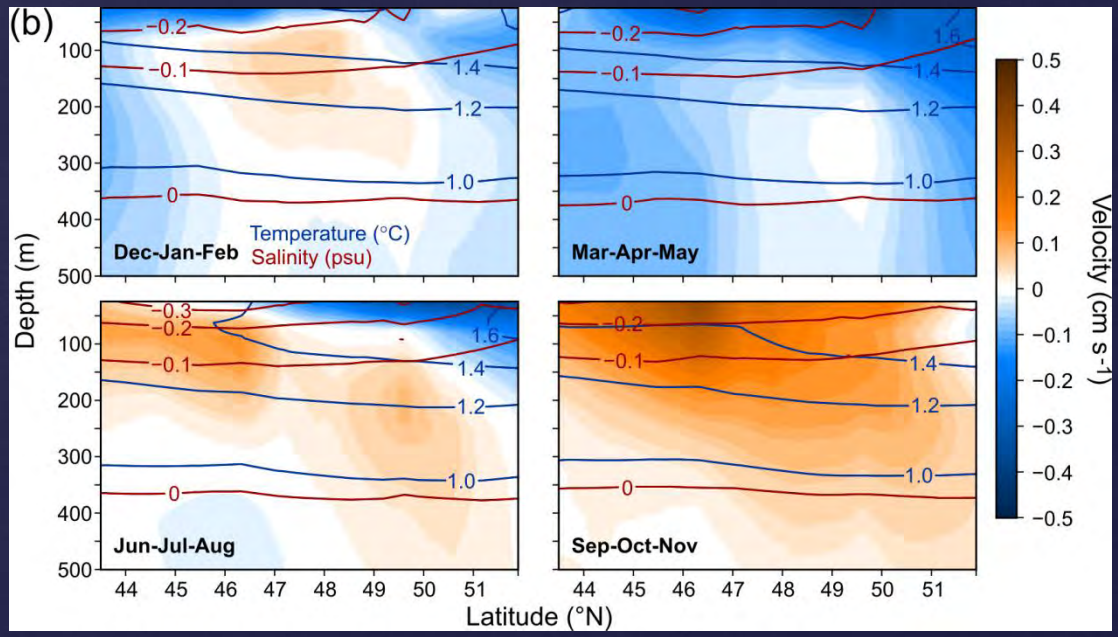

- *21 sub-basins*
- *Except for June-August, more discharge*
- *Warmer river temperatures*

# Initial and Lateral Boundary Ocean Condition Anomalies

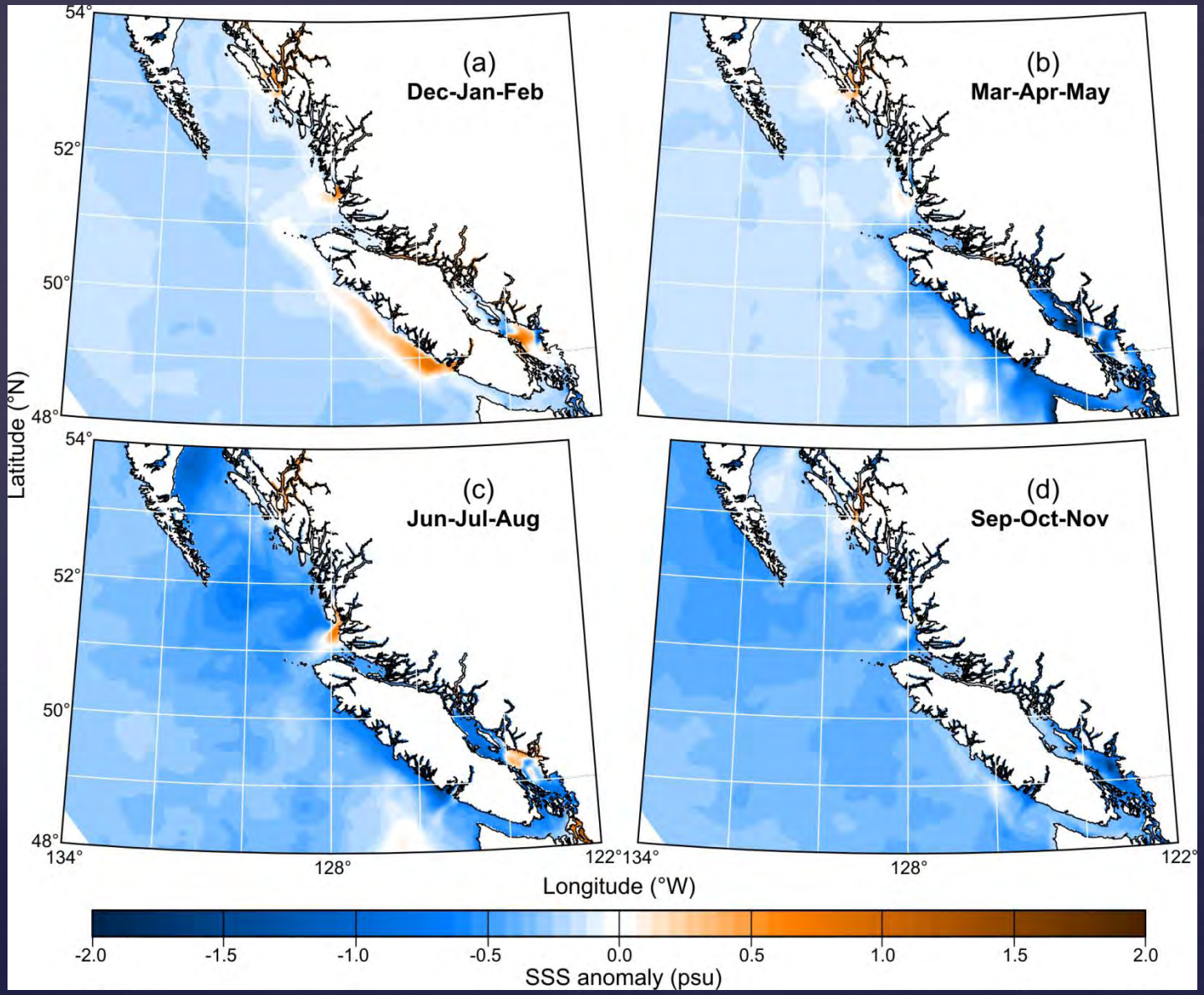
- 3D temperature/salinity initial anomalies from CGCM3
  - no active ocean in CRCM
  - Only latitudinal anomalies
  - future will be warmer and fresher




- Seasonal anomalies in temperature, salinity, normal velocity forcing along northern, western, southern boundaries
  - Brown/orange shading denotes flow into domain

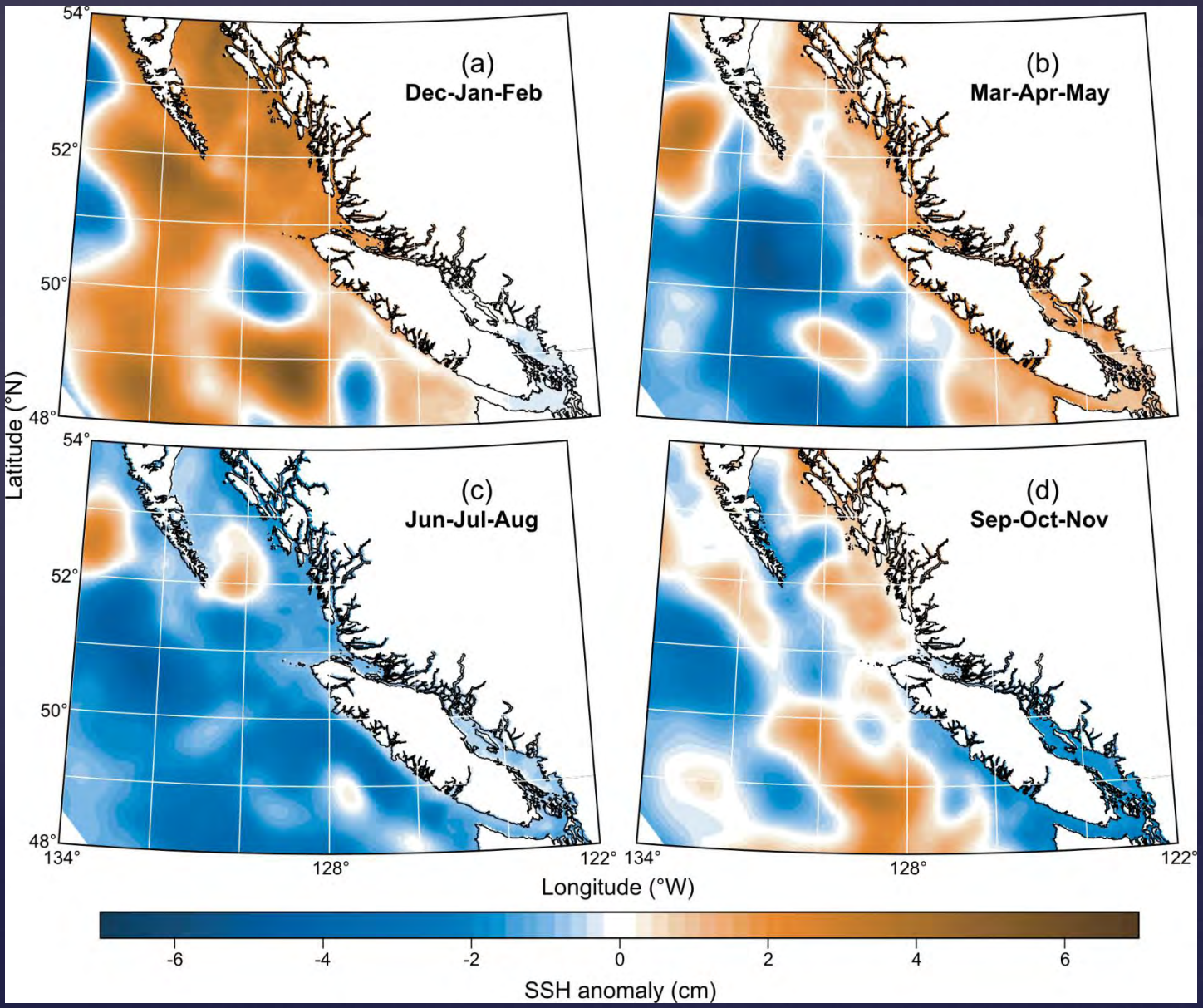


# Model Projections: SSS Anomalies (Future – Present)



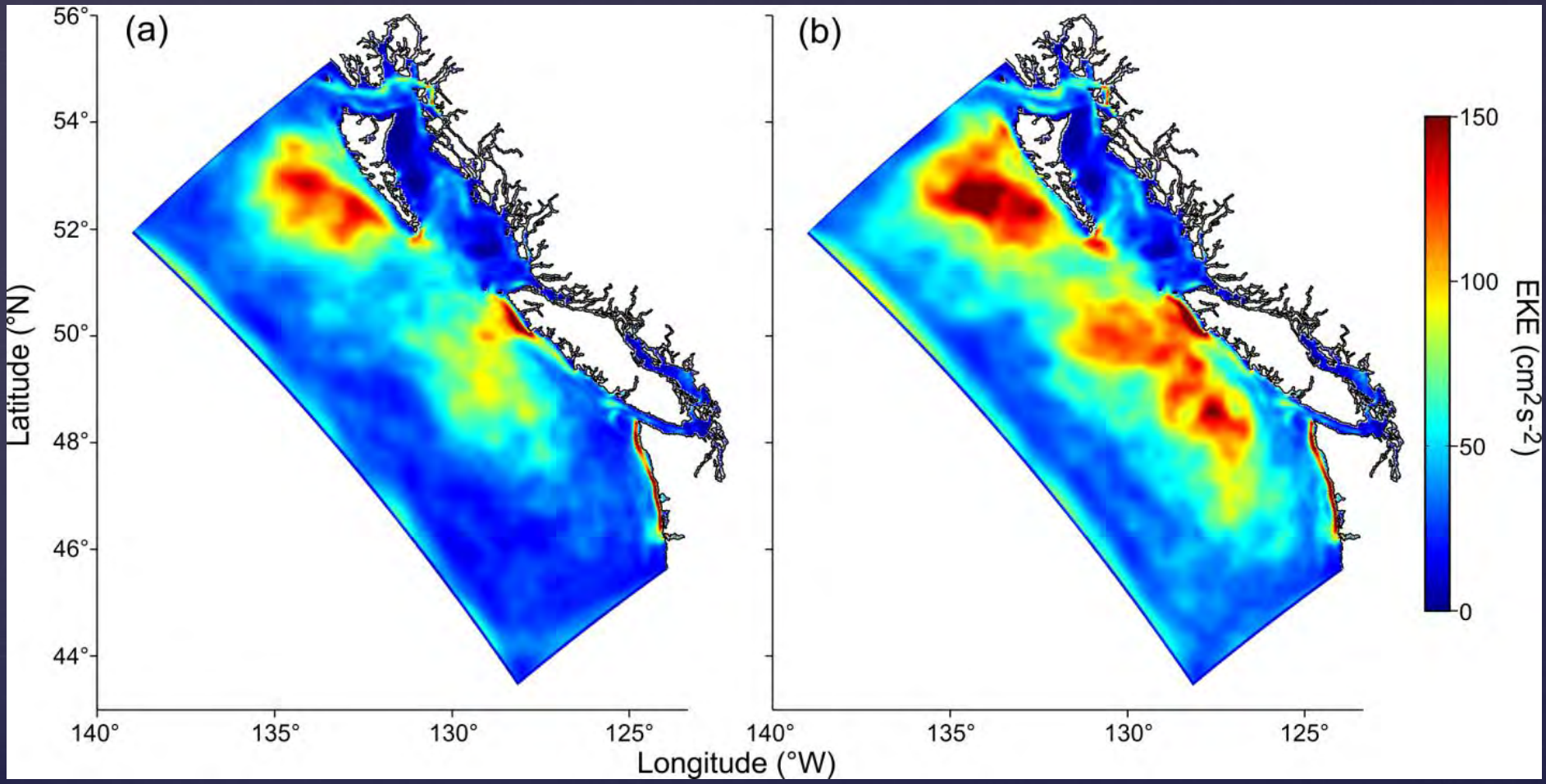

- Generally fresher
- Some timing changes result in saltier

# SSH (height) Anomalies




- *Generally higher in winter & lower in summer*
- *Changes from winds (set-up, set-down) & density (dynamic height)*
- *ROMS is Boussinesq; no volume expansion*

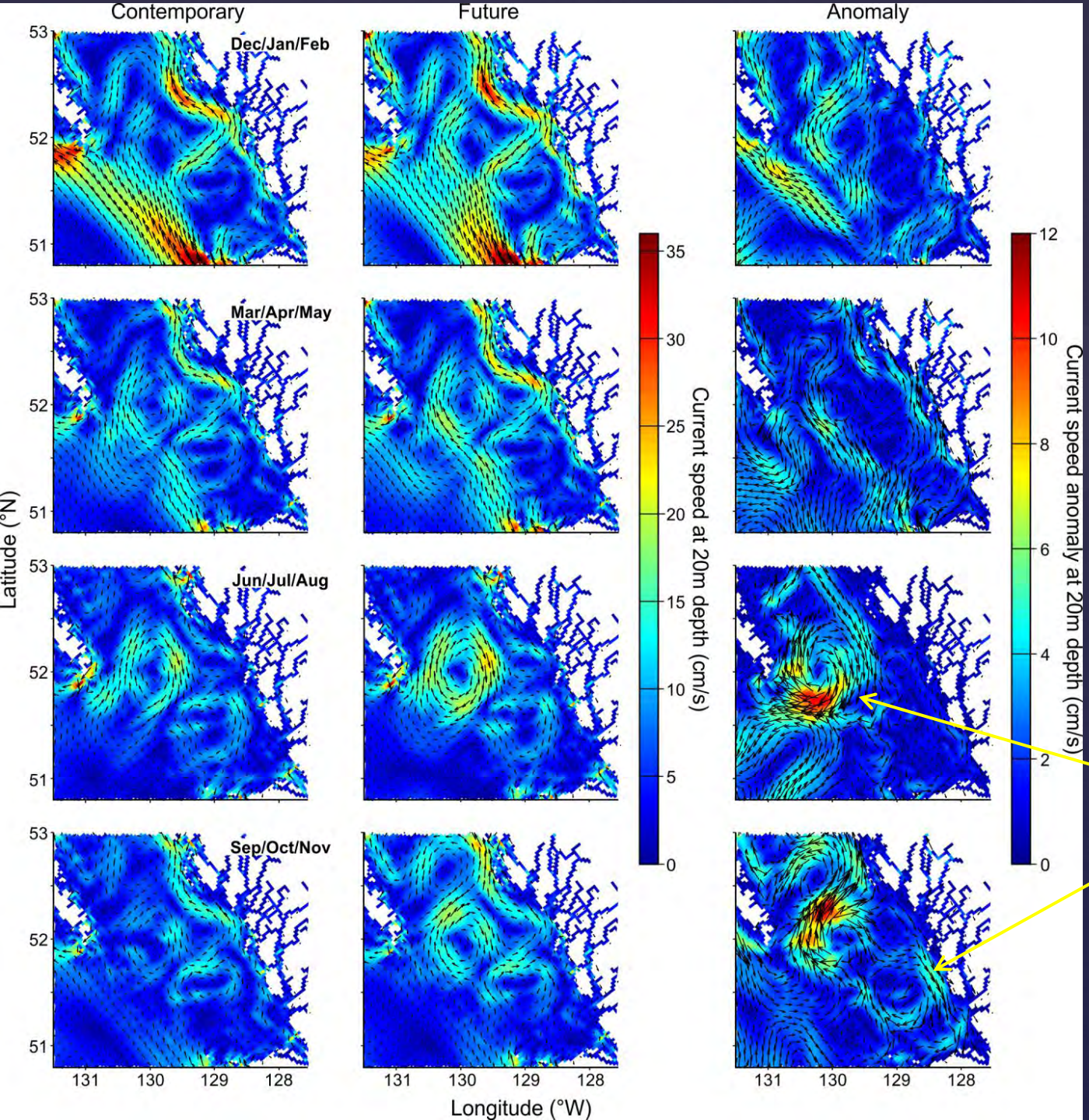
# Eddy Kinetic Energy

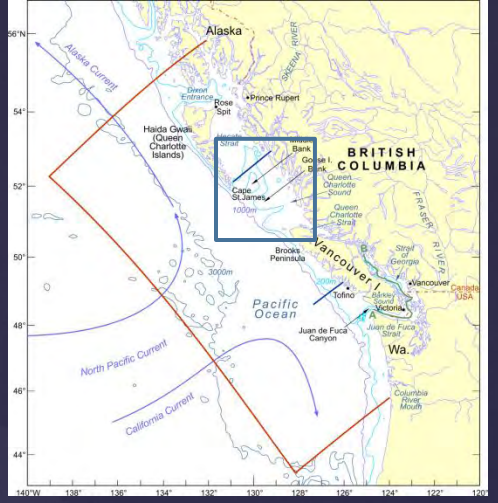



contemporary

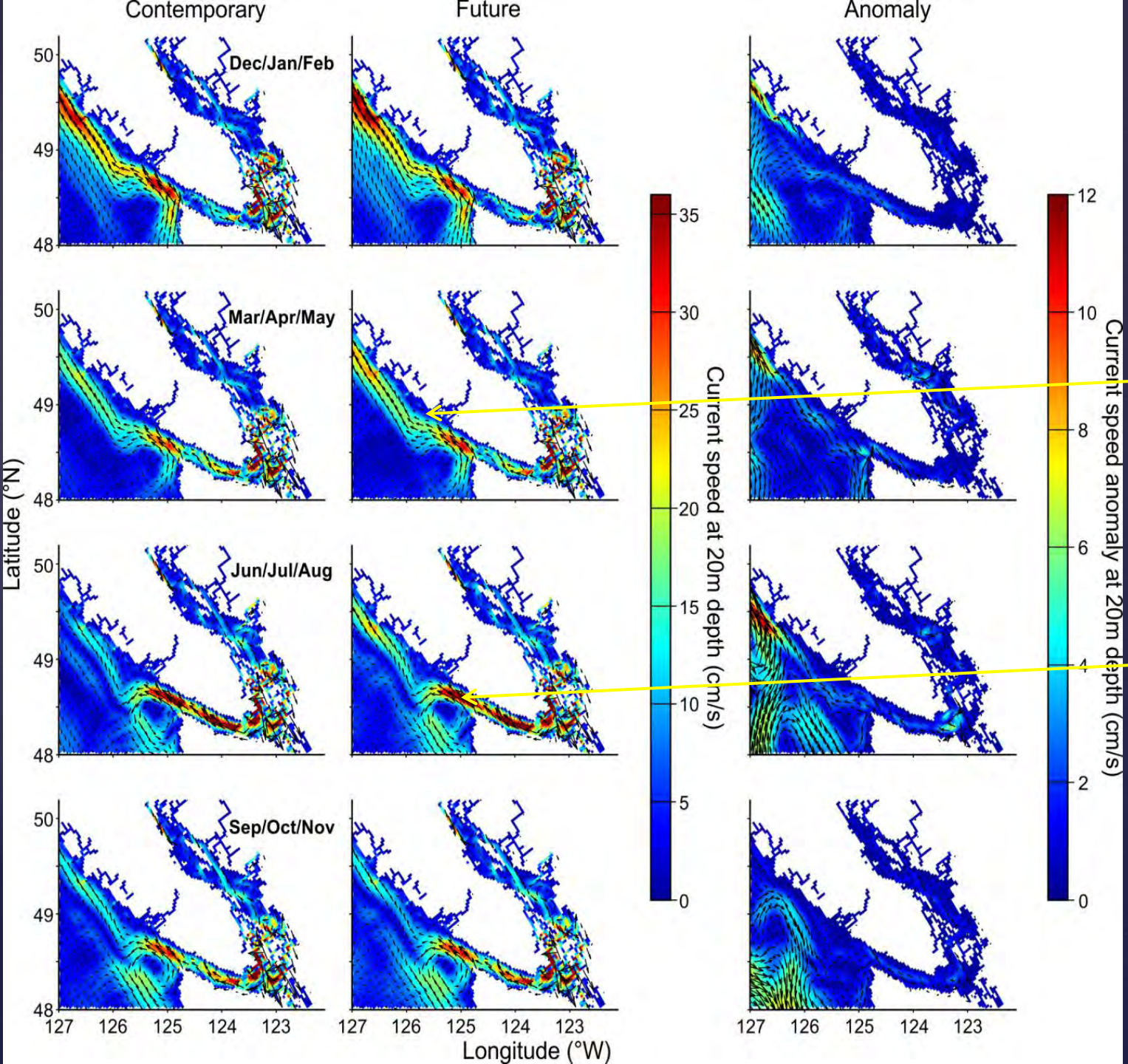
future

- Stronger, not more, Haida Eddies due to stronger winter winds



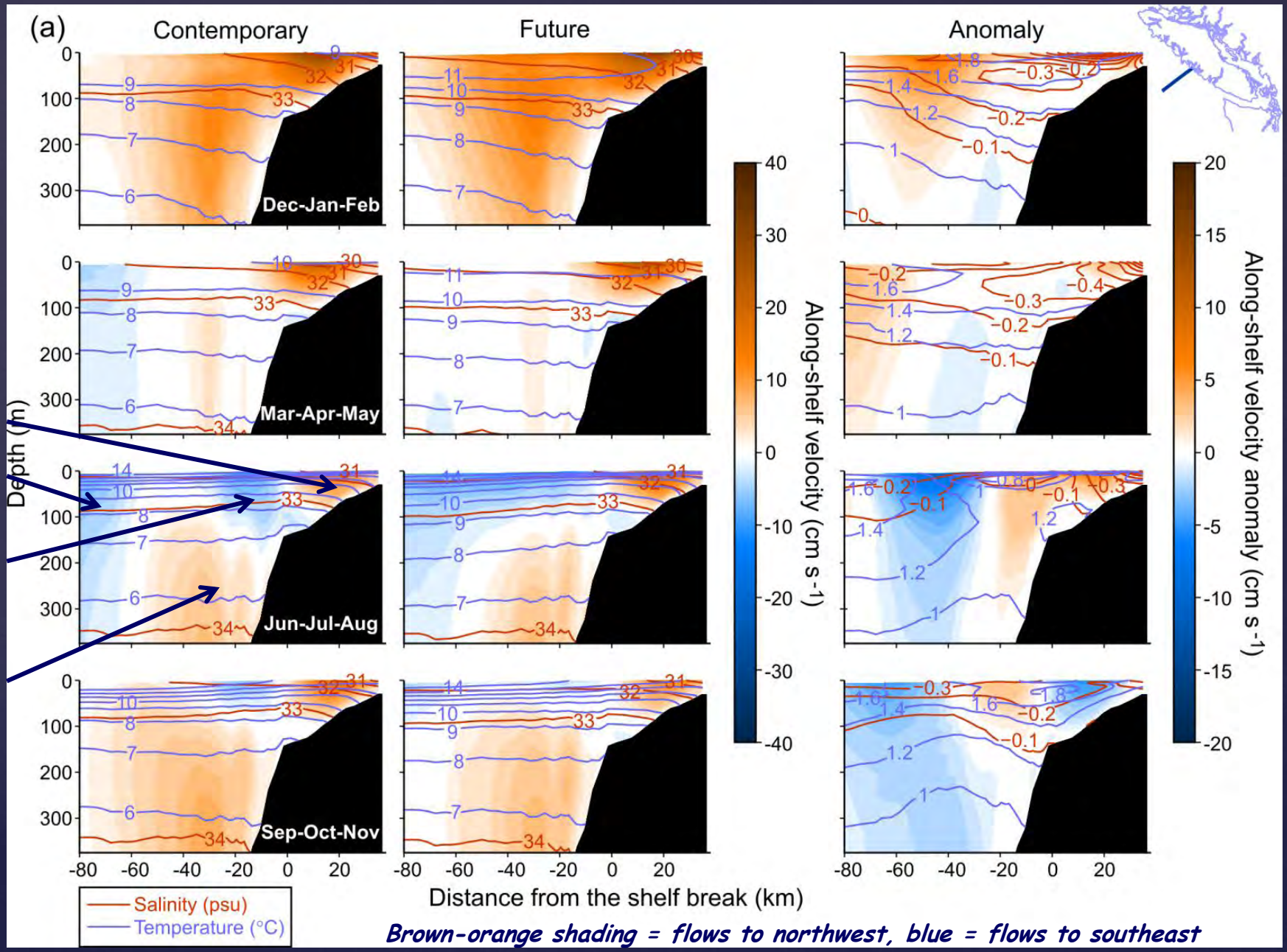




- *20m flows*
- *Stronger eddies around Middle & Goose Island Banks in some seasons*



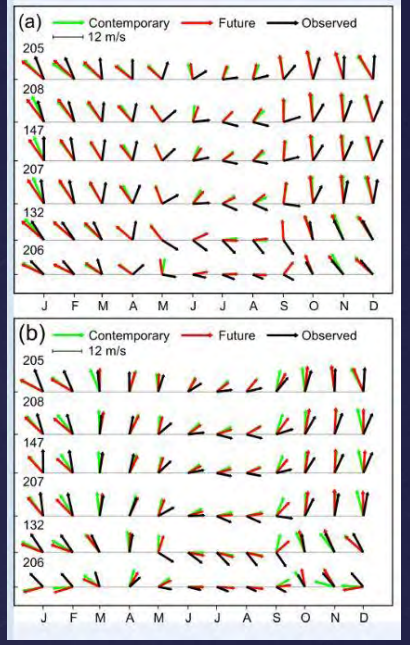

- *20m flows*
- *Stronger Vancouver Island Coastal Current*
- *Little change in Juan de Fuca Eddy amplitude (timing too)*

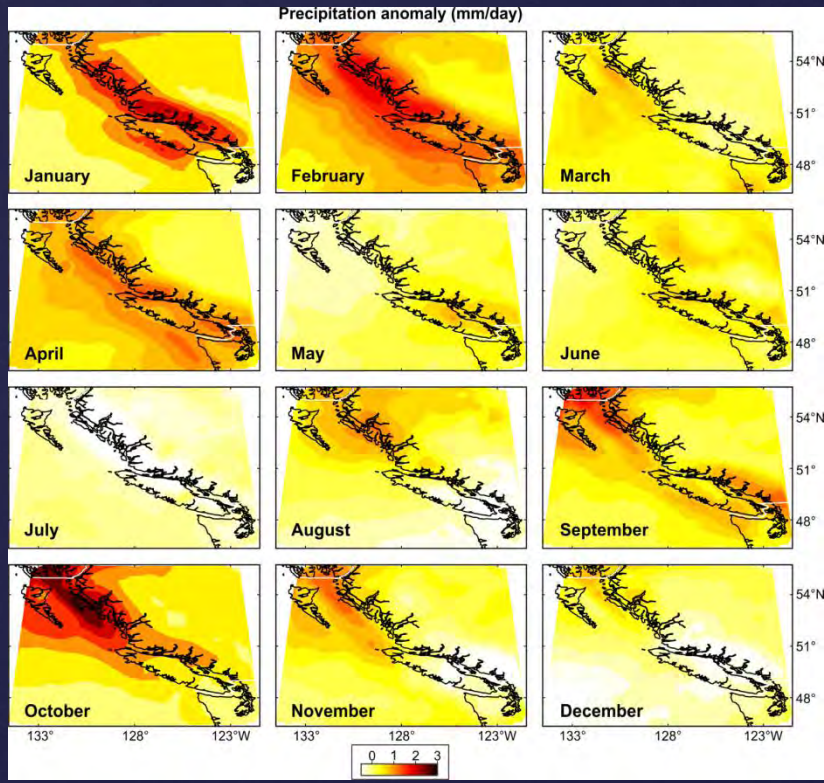
# Flows, temperatures, salinities off Vancouver Island



# Summary

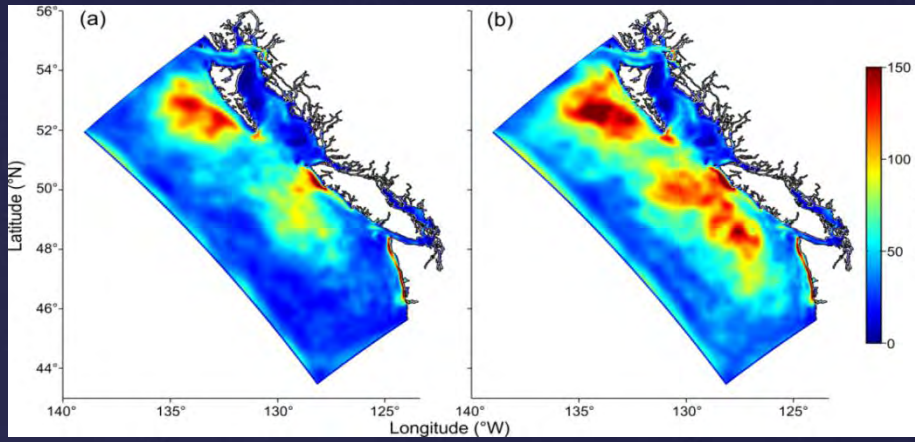
- Reran Masson & Fine (2012) for 2065-2078
- Inaccurate RCM winds
  → future forcing & initial fields computed by adding NARCCAP anomalies to Masson & Fine fields
- Representativeness of CRCM/CGCM3 within ensemble
- Timing mismatch justified
- Monthly anomaly fields
  - More freshwater discharge
  - Warmer temps

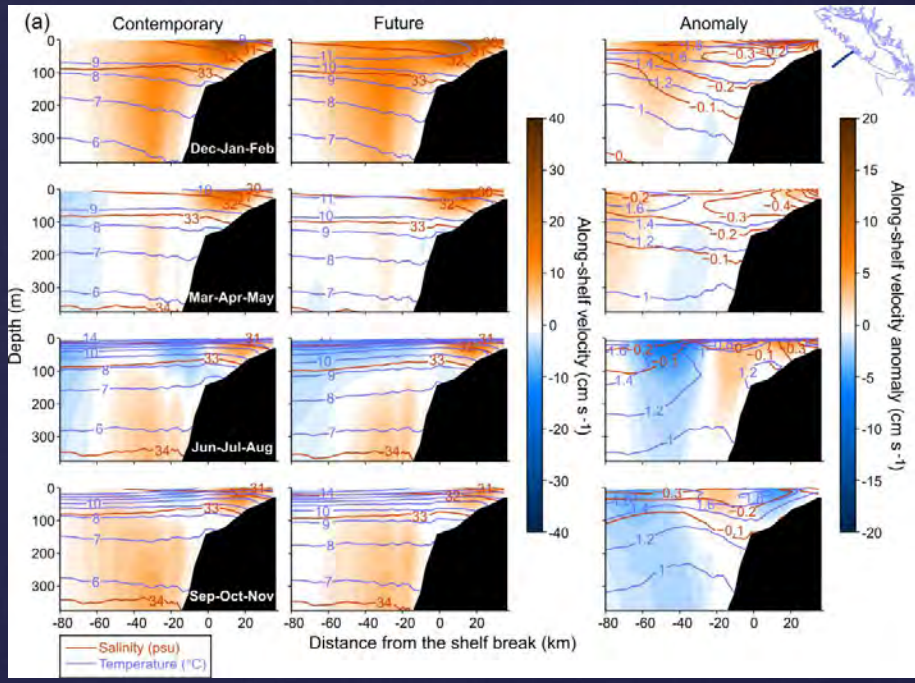


# Summary

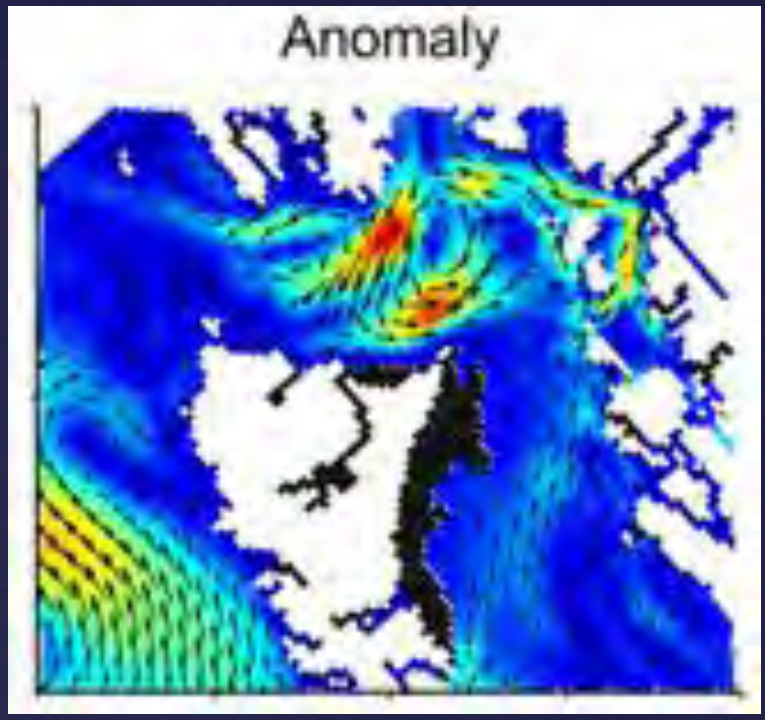
- Model projections:
  - More EKE (winter)
  - Stonger Haida, Goose Island Bank, Middle Bank, Rose Spit Eddies in some seasons
  - Generally stronger Vancouver Island coastal current
  - Little (if any) change in upwelling
  - Can't comment on California Undercurrent
- More details in 2 accepted Atmosphere-Ocean papers

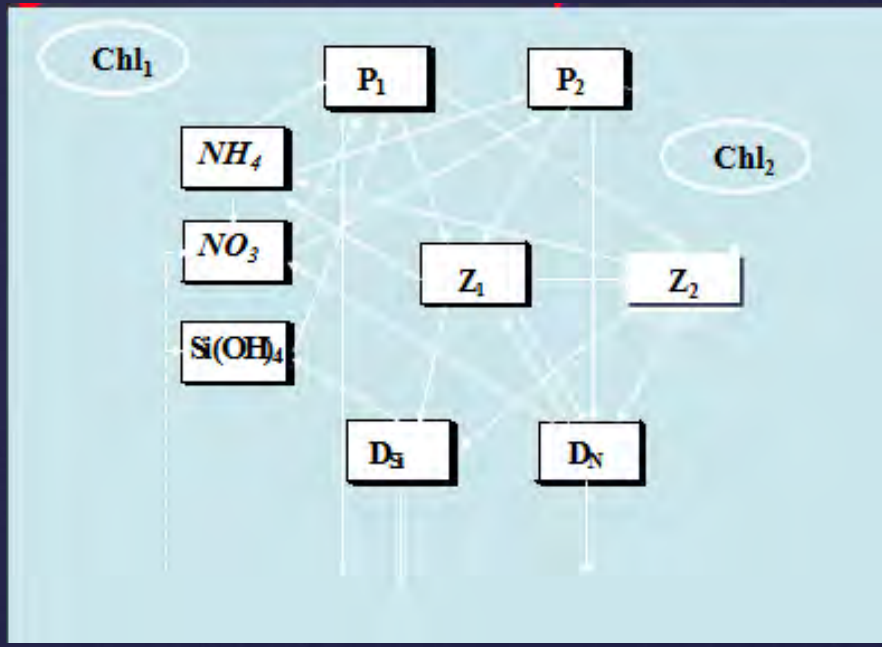


# Future Work

- Other NARCCAP AR4 RCM/GCM combinations
- AR5 RCM results
- Provide boundary forcing for 1km Salish Sea model projections
- Couple to NPZD & marine geochemical ecosystem model (Angelica Peña)



# Acknowledgements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  - Climate Change Science Initiative (CCSI)
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  - Centre for Ocean Model Development for Application (COMDA)
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- North American Regional Climate Change Assessment Program (NARCCAP)
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- Research Institute of Oceanography, Seoul National University


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