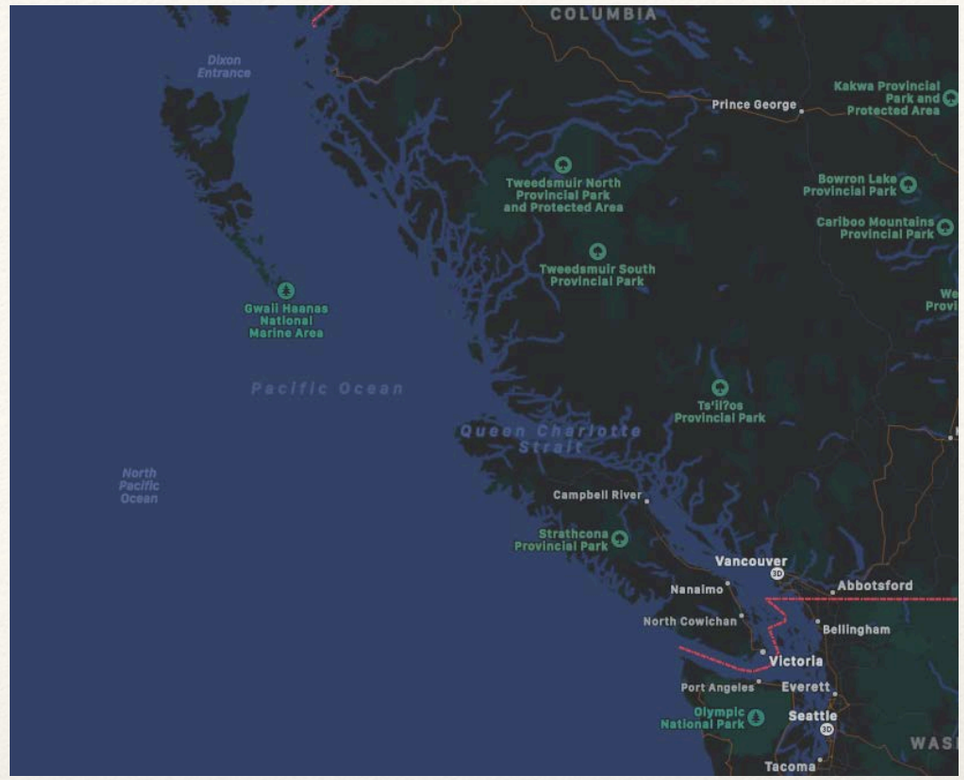

Pramod Thupaki, Hakai Institute, Victoria, BC

Modelling the Riverine Coastal Domain along the Central Coast of BC, Canada

Charles Hannah, ***Di Wan, Mike Foreman & Maxim Krassowski***
Institute of Ocean Sciences, Department of Fisheries and Oceans Canada
Hakai IT, Hydrology, Geospatial and Oceanography groups

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Outline/Next 15 mins …

- Context
- Operational (forecast) model
- Use cases of the forecast model and the way ahead …
- Model skill assessment
- Science !!
- Role of discharge on the Riverine Coastal Domain
  - Why is this a problem ?
  - Can we address this using numerical models ?
- Summary

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The Context: Towards a Predicted Coastal Ocean

- One of Hakai Institute initiatives to develop solutions for communities along the coast of British Columbia
- Primary aim was to design a *cost-effective*, *scalable*, *product* that can be implemented at 'any location'
- Continuing work, in synergy with objectives of CIOPS-West & OPP and building on WCTSS
- As a test-case: develop a high-resolution hydrodynamic model for the Central Coast of British Columbia
  - Run the hydrodynamic model in operational mode to forecast currents and surface elevation for the next 24-36 hours
  - Solid framework to develop more advanced models and applications in the future

Special Acknowledgement to:
- Eric Peterson, President, Tula Foundation, Canada
- Charles Hannah, Institute of Ocean Sciences, DFO, Canada
- Ray Brunsting, CTO, Hakai Institute, Canada

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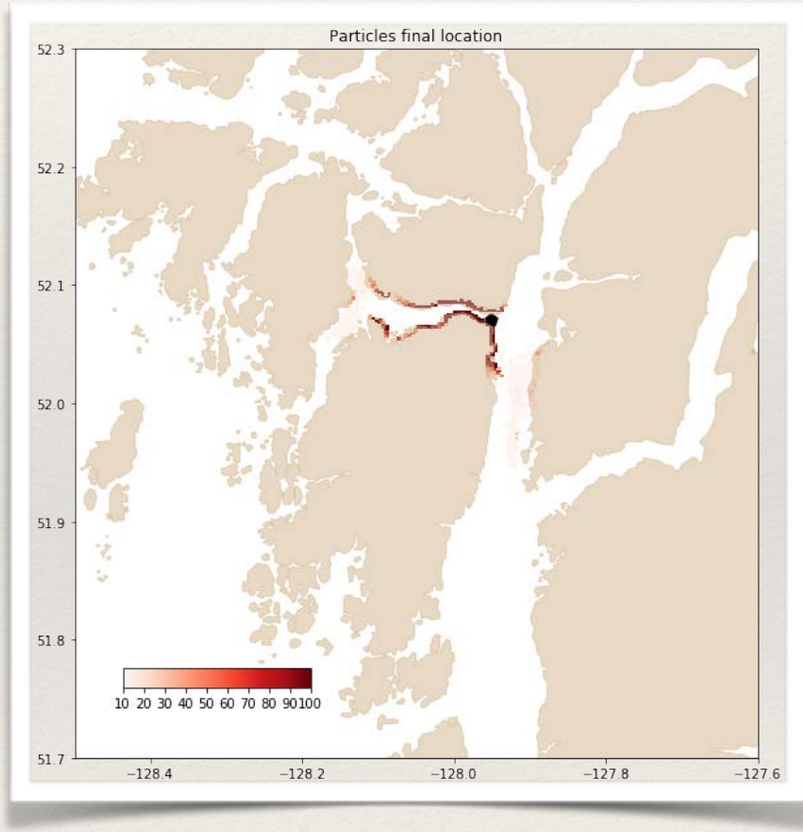
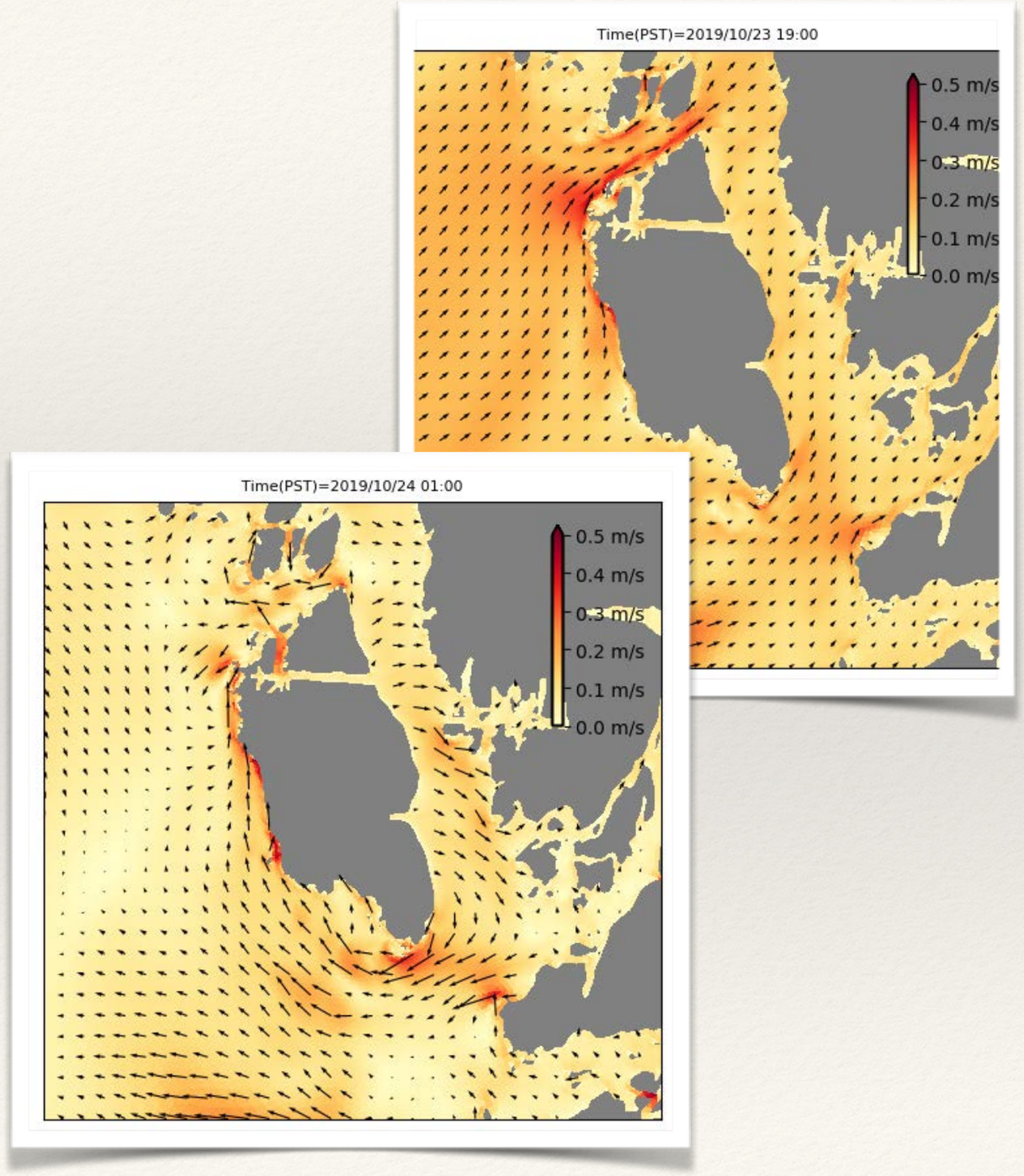
Forecast model uses

- Marine emergency response system
- Climate change mitigation/ adaptation: Oyster farms
- Monitoring and opportunistic sampling
- Optimising data collection processes, address data lacunae to constrain models better
- Outreach and public awareness



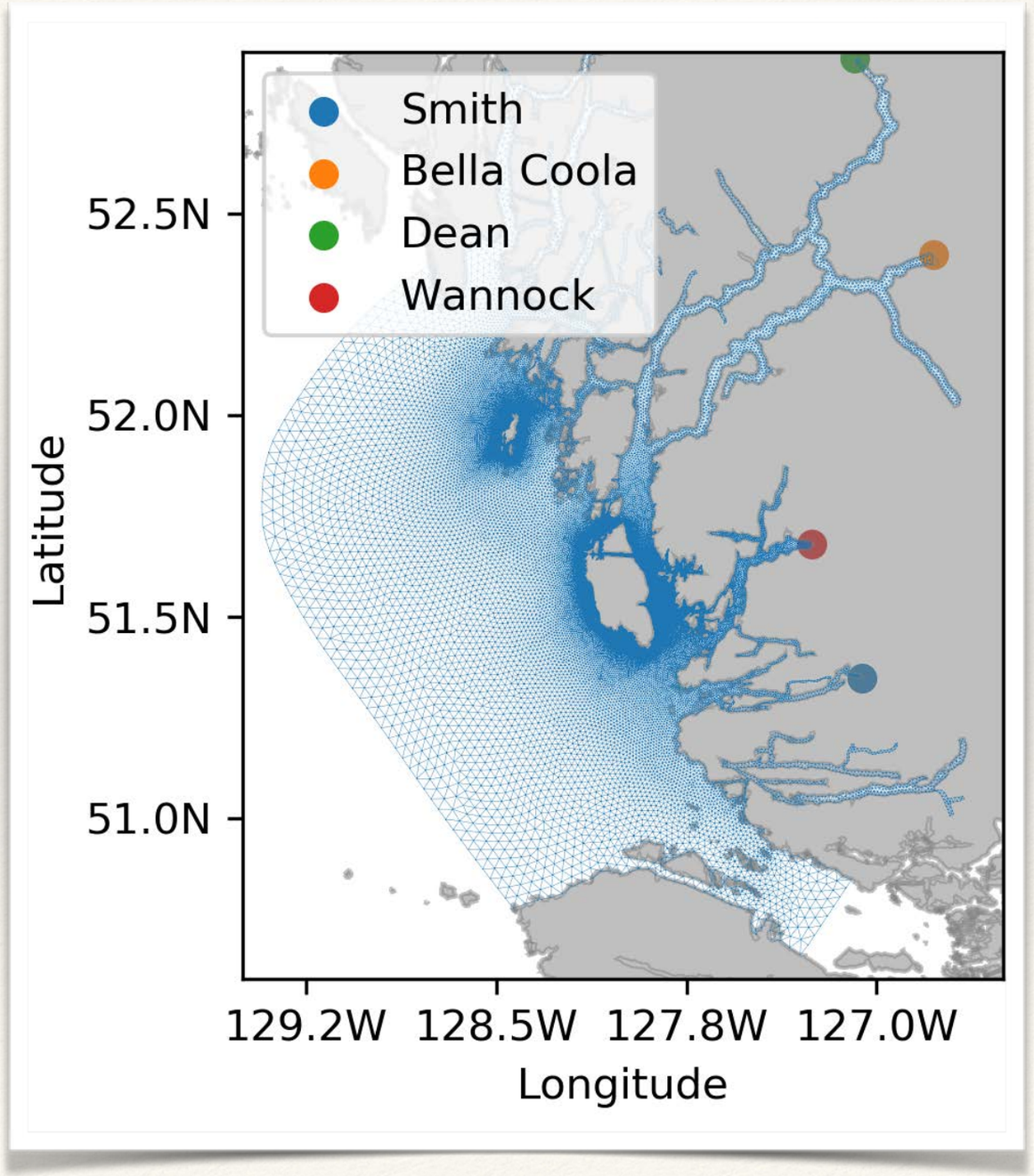
The Ocean Forecast Model

- Run 4 times a day, everyday and generates forecast for the next 24 hours; restarted from previous run
- One-way coupled to HRDPS atmospheric model (2.5 km resolution, hourly interval)
- Forced by tuned regional tidal model (WebTide); will be coupled to the regional CIOPS-West model in the ‘near future’
- Completely hosted on commercial cloud (AWS-EC2) infrastructure
- Operational cost of ~$30USD per month!



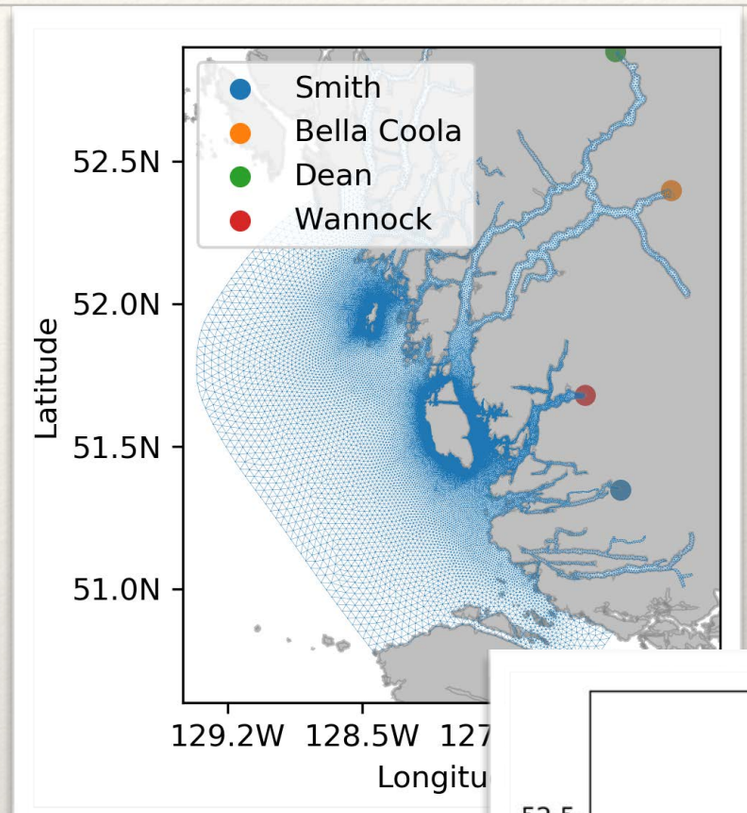
Ocean Forecast Model (contd.)

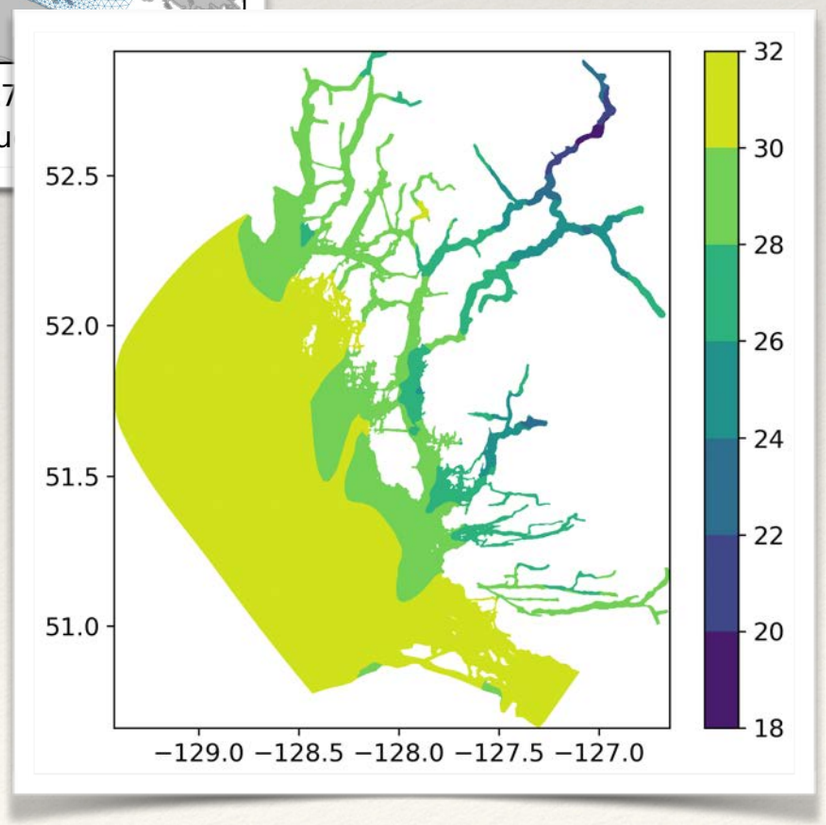
- 3D Model based on FVCOM, unstructured grid setup with 25520 nodes and 45792 elements and 21 sigma levels
- Variable resolution model: 100m-2000m
- 4 rivers (only in the hindcast model)
- Coupled watershed model (planned)
- Latest results made available to the public at: https://goose.hakai.org/opm/view.php
- > 1 year of smooth sailing (more or less)



Hindcast model (setup)

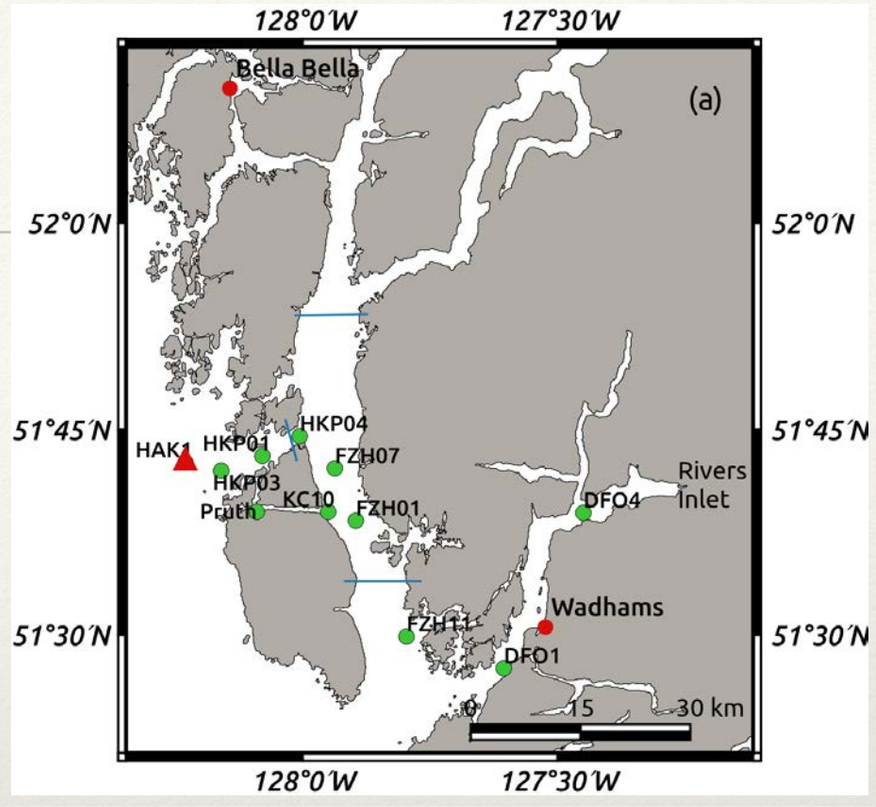
- May-Aug 2016
- Coupled to 2.5 km HRDPS atmospheric model output (hourly)
- Discharge from rivers based on climatology (Morrisson et al.)
- CIOPS-West (NEMO) Model 3D temperature boundary forcing and initial T/S conditions
- ‘Tuned’ tidal forcing at the boundary

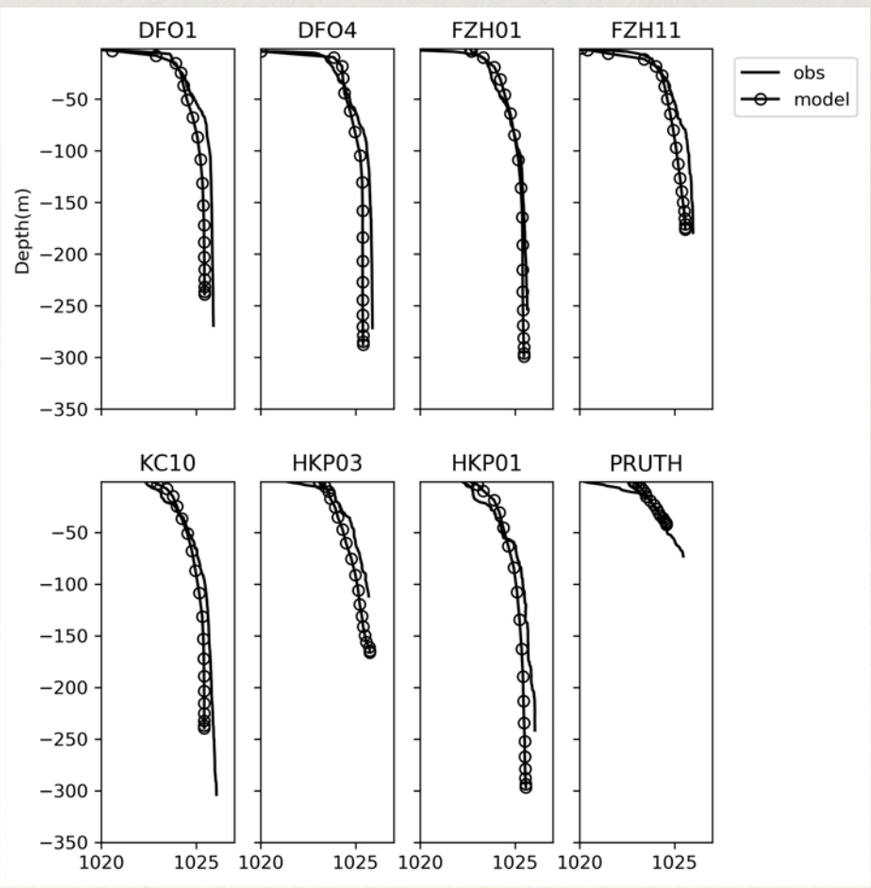


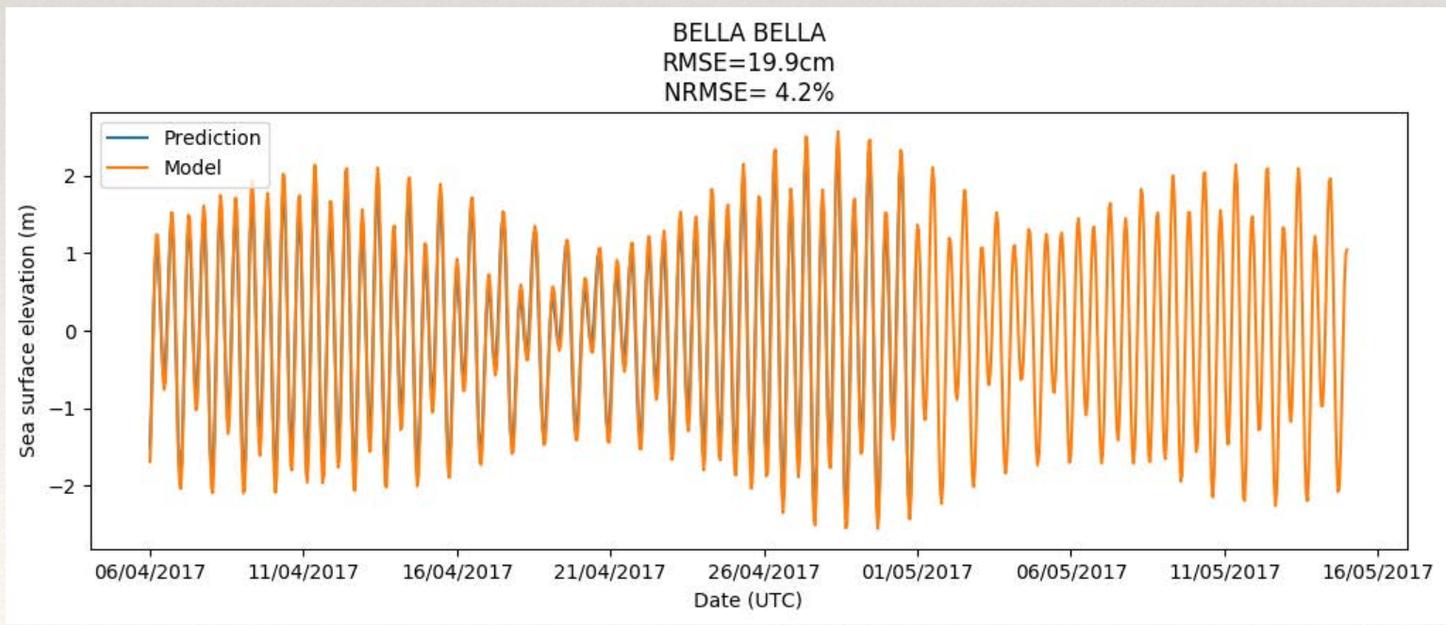


Model Skill

- Tide gages at 4 locations (< 5% NRMSE; < 10cm DS M2)
- Velocity observations from ADCP at HAK1
- Temperature/Salinity from CTD casts at 8 locations



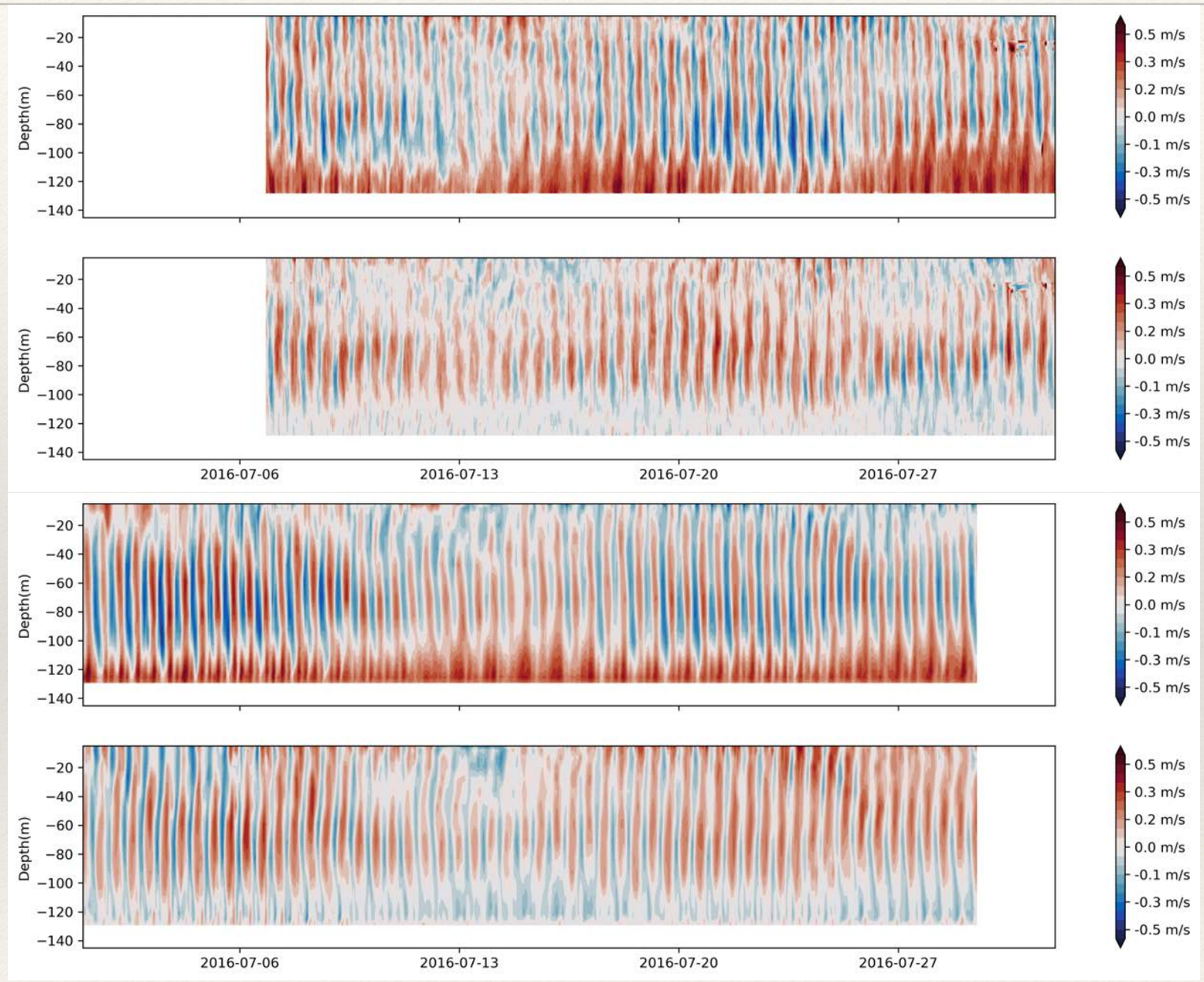




Model Skill (contd.)

Observed

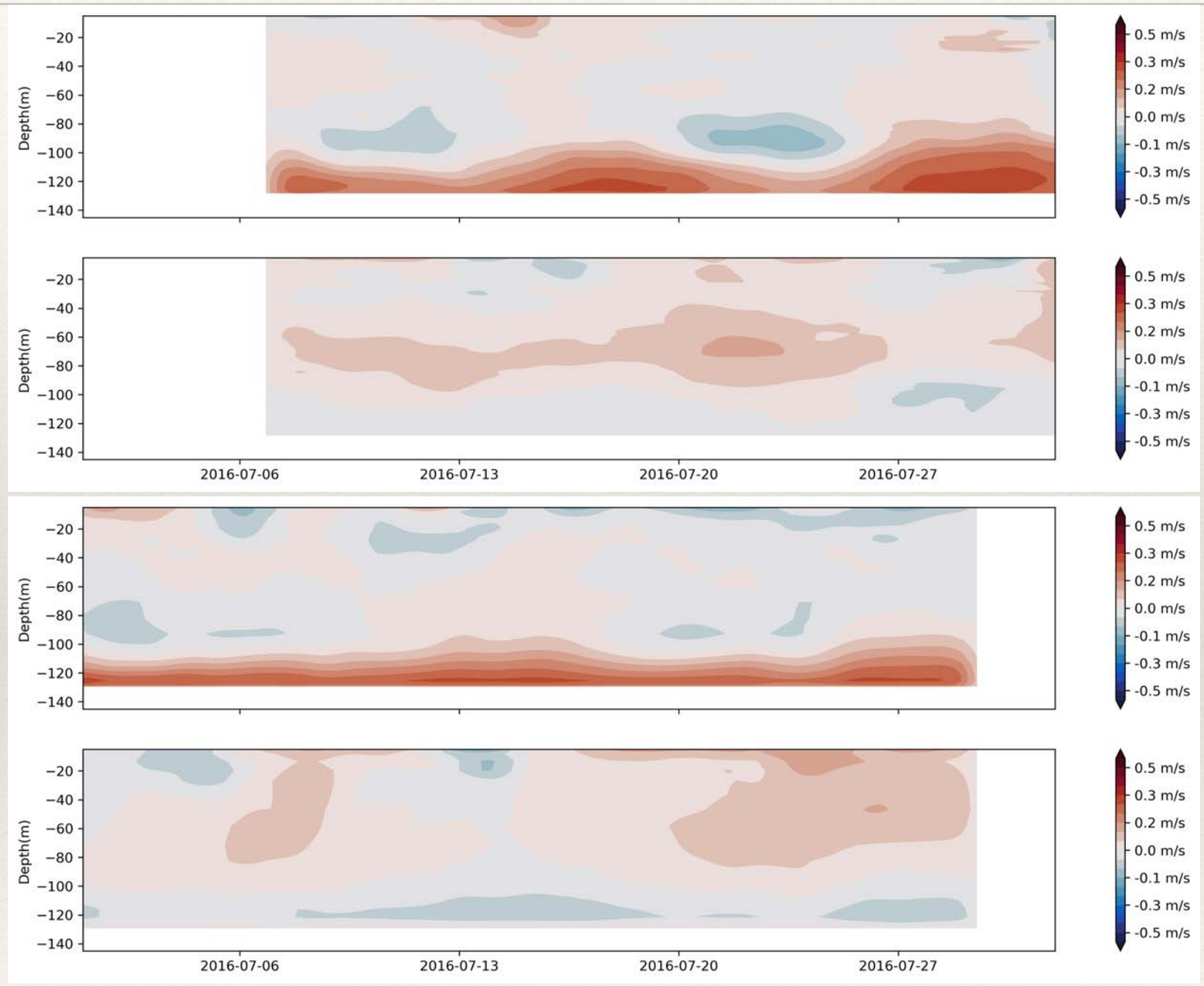
Modelled



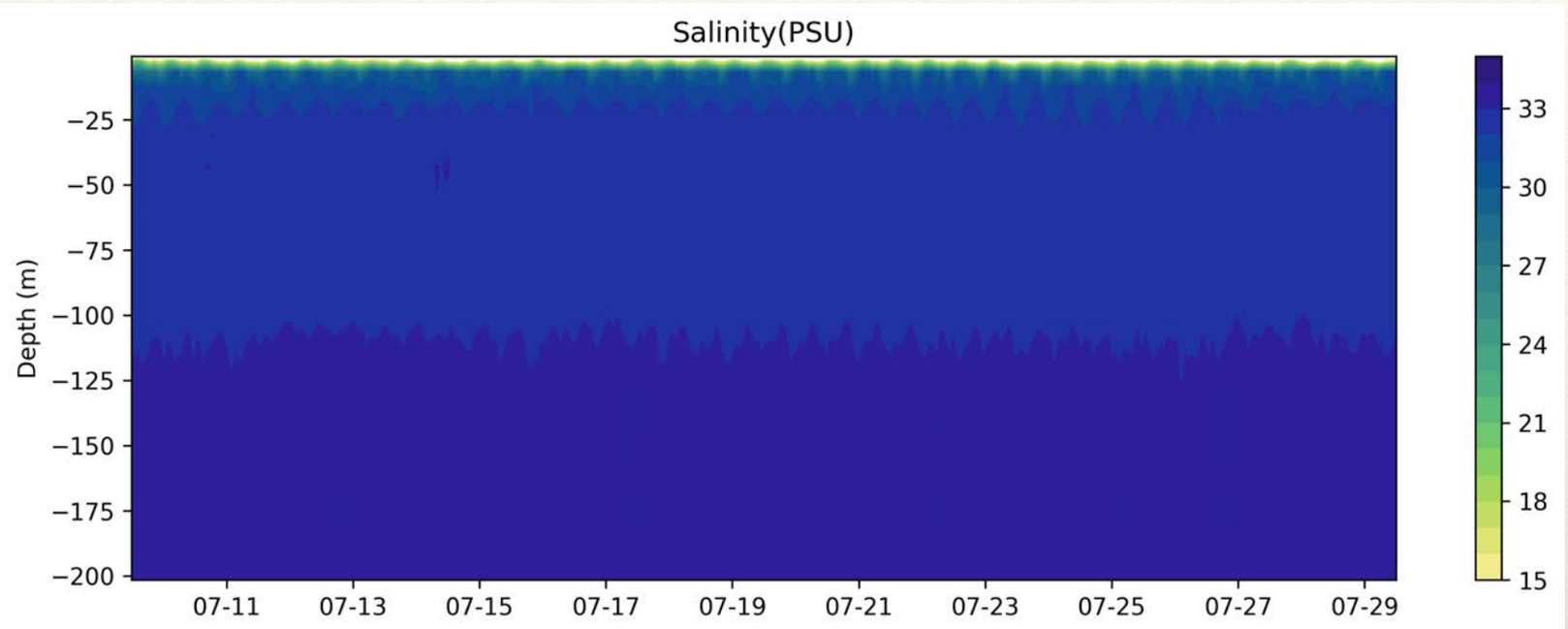
Model Skill (contd.)

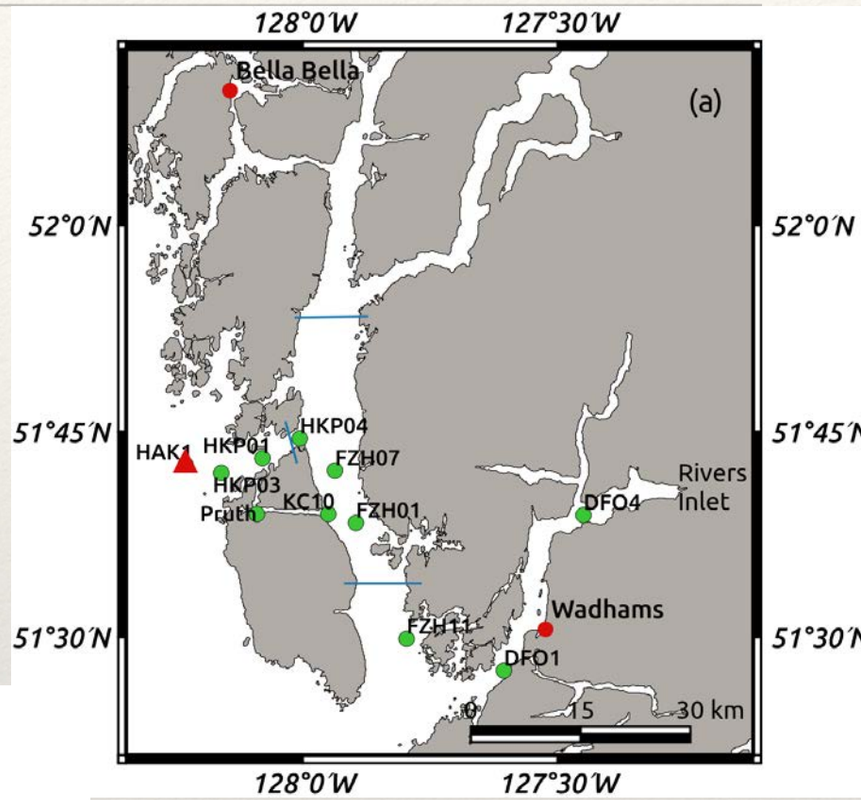
Observed

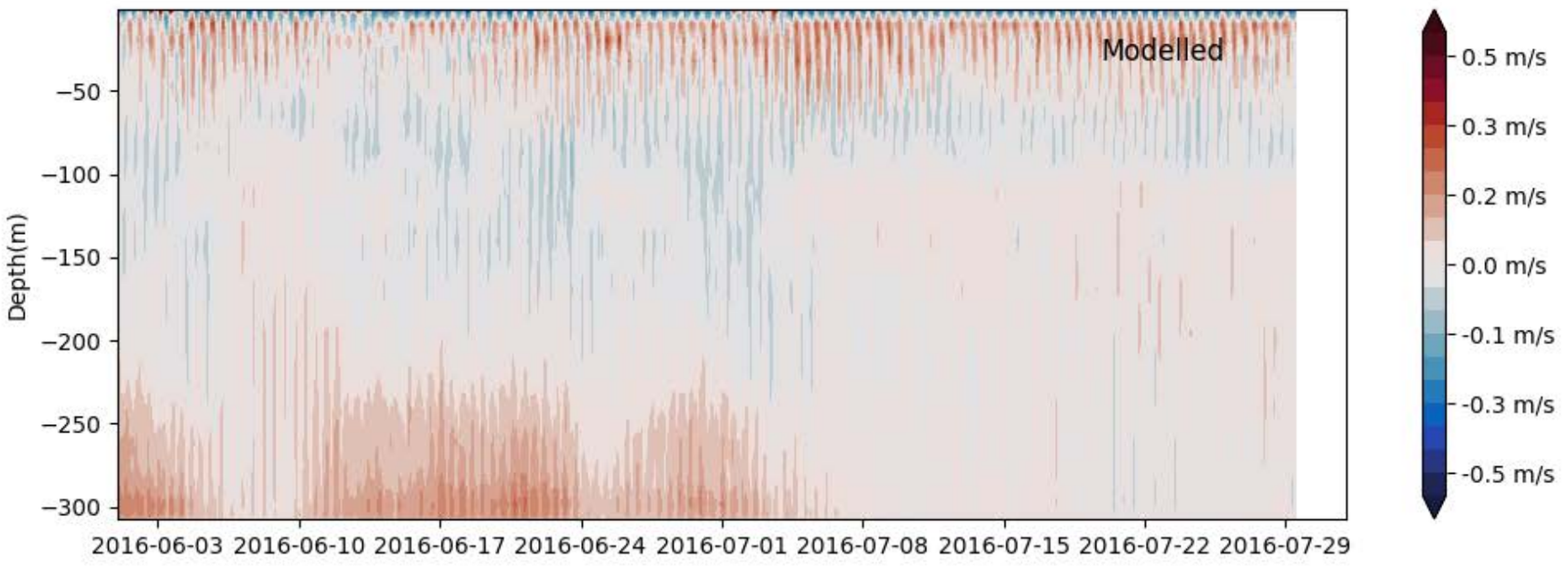
Modelled



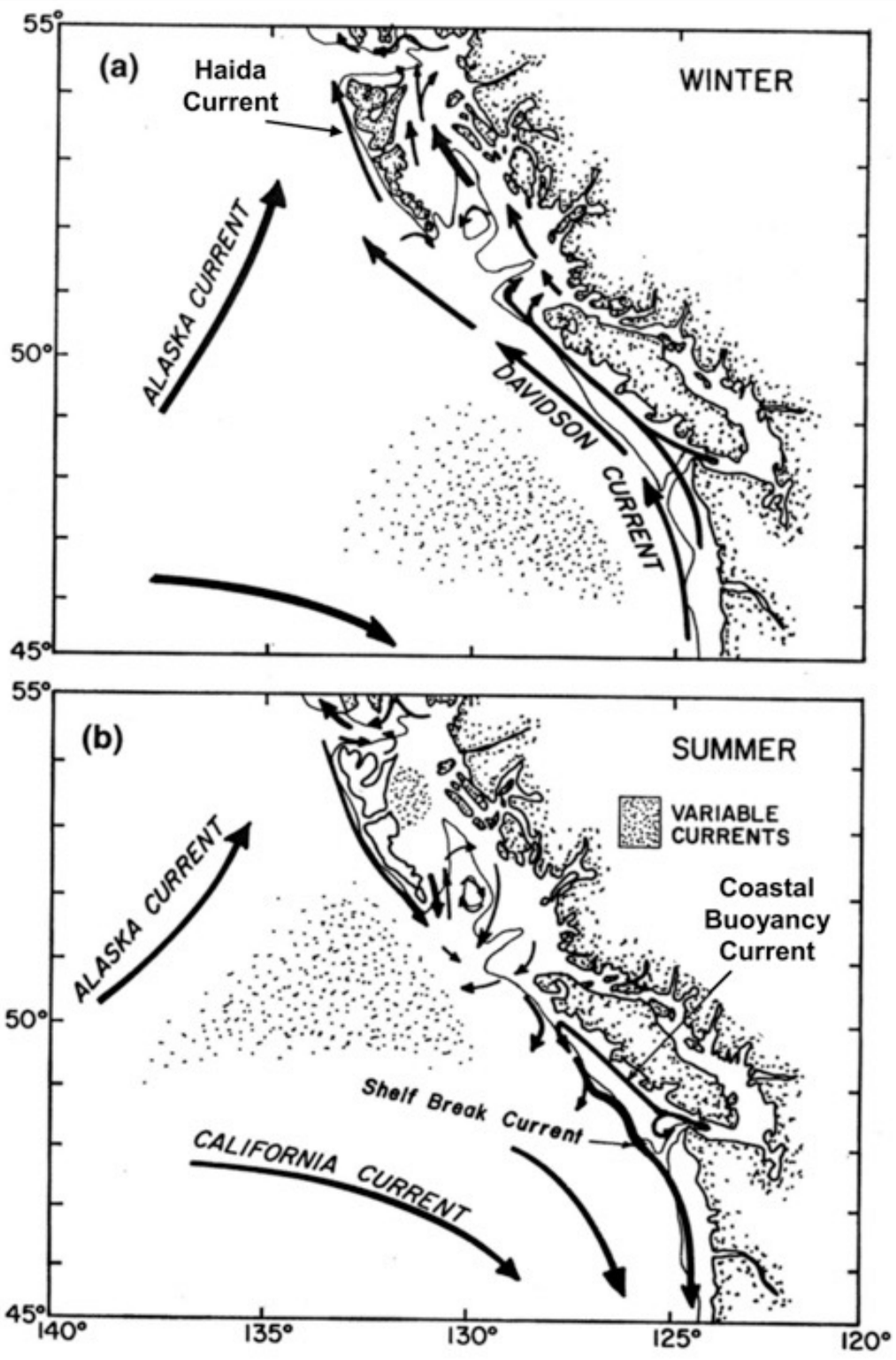
Temperature/Salinity @ DFO4



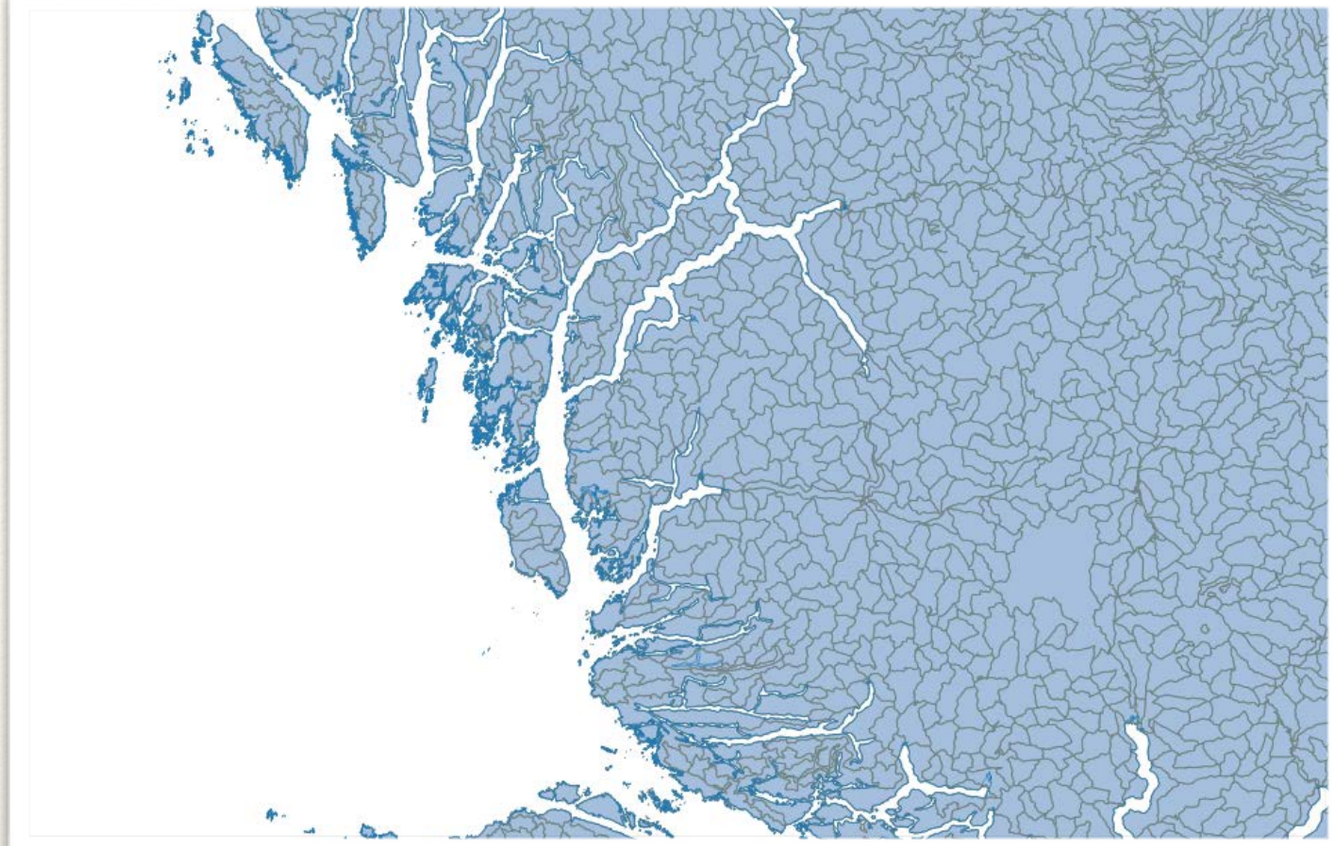


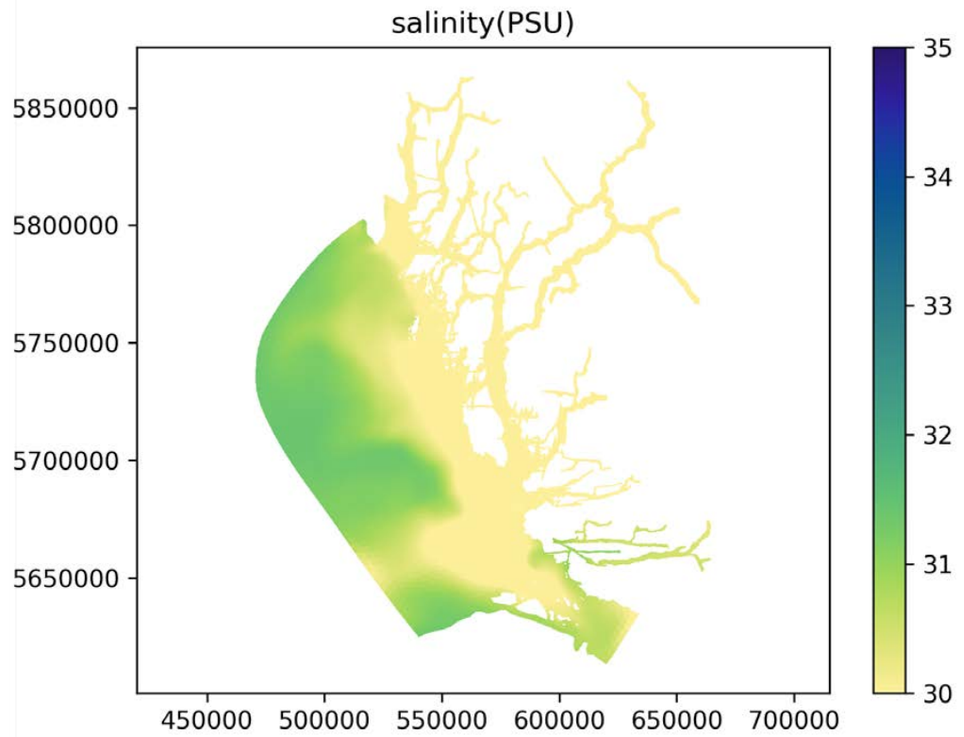


Near Wadhams



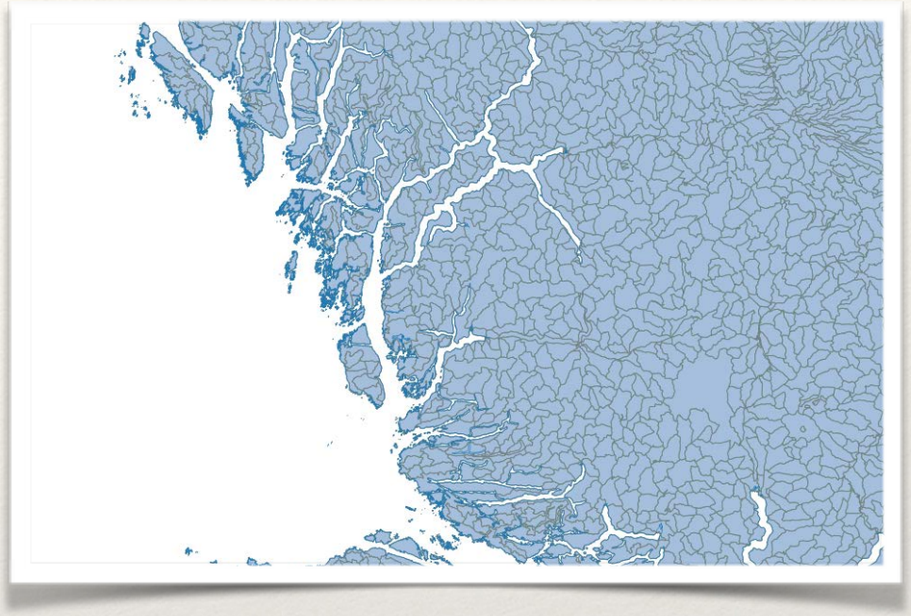
e C.2 Ocean circulation off BC in summer (b) and winter (a) (from Thor





Science Questions

- What is the extent of the Riverine Coastal Domain (RCD) ?
- Impact of freshwater coming in from the rivers on RCD
  - Spatial variability
  - Surface currents
  - Vertical structure
- Secondary objectives
  - Can the actual discharge be inversely calculated using results from the numerical model ?
  - Which observable metrics that define the RCD is most sensitive to discharge ?
  - Can changes to the RCD be forecast decades into the climate-changed future ?
- The experiment setup
  - (a) Base (30 year climatology) discharge
  - (b) +10% discharge
  - (c) +50% discharge



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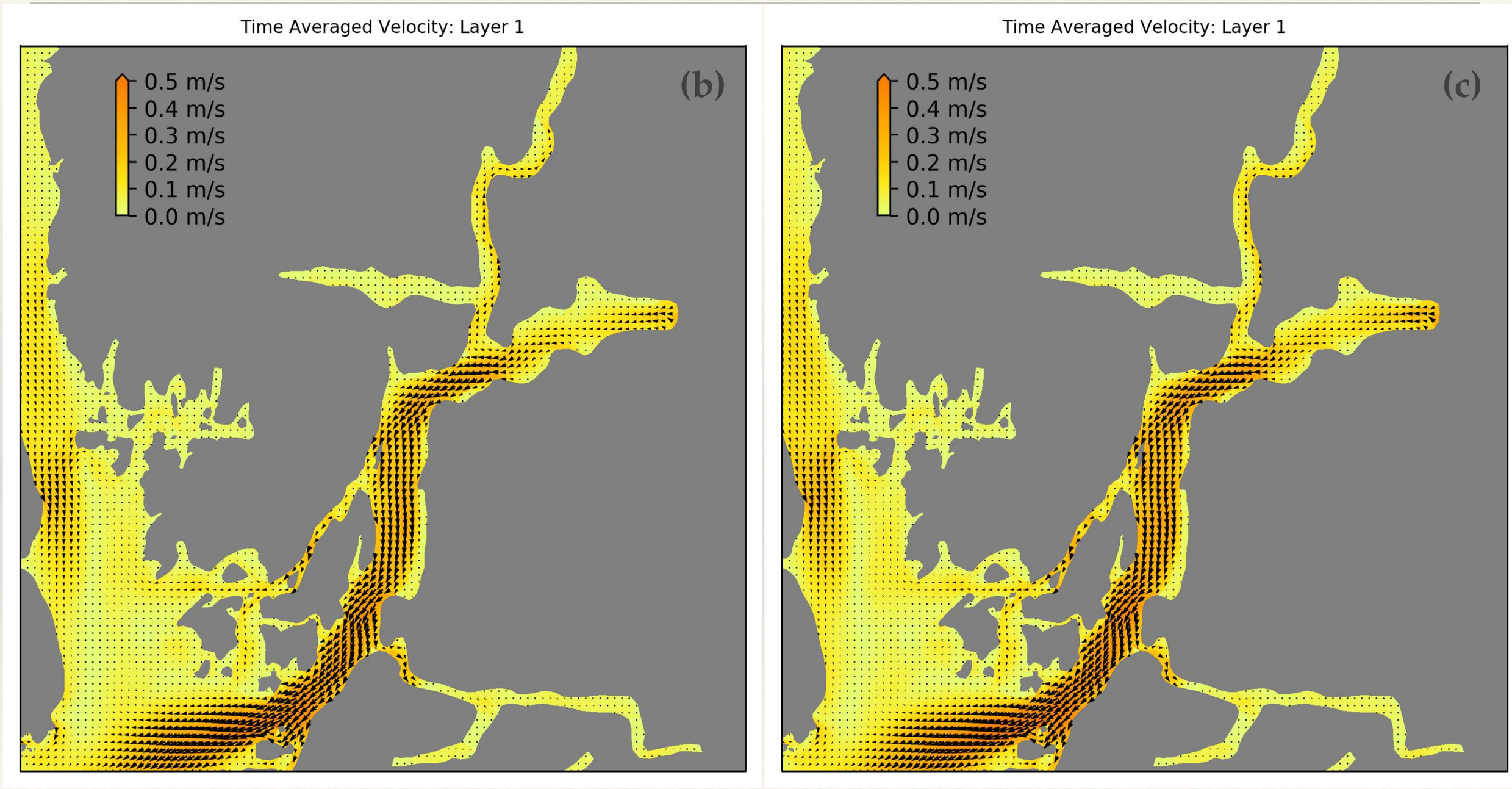
Understanding Rivers in Ocean Models

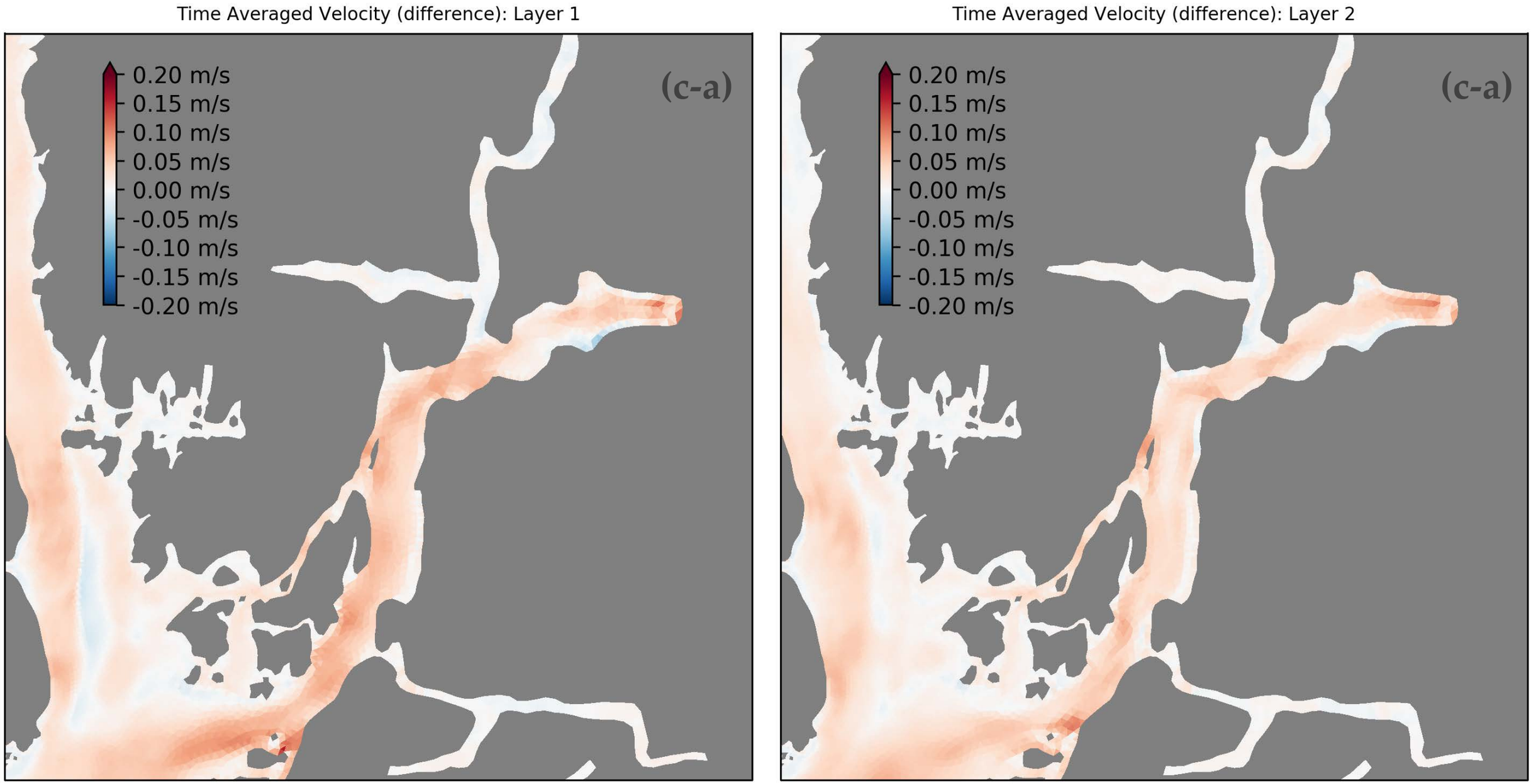
- Not all rivers are created equal !
- Choice between balancing momentum or mass (water and salinity)
- Distributed discharge sources ? Cases when river channels are not explicit
- Are river plume dynamics important ? Problem dependent!

Tidally Averaged Velocities (nearfield)



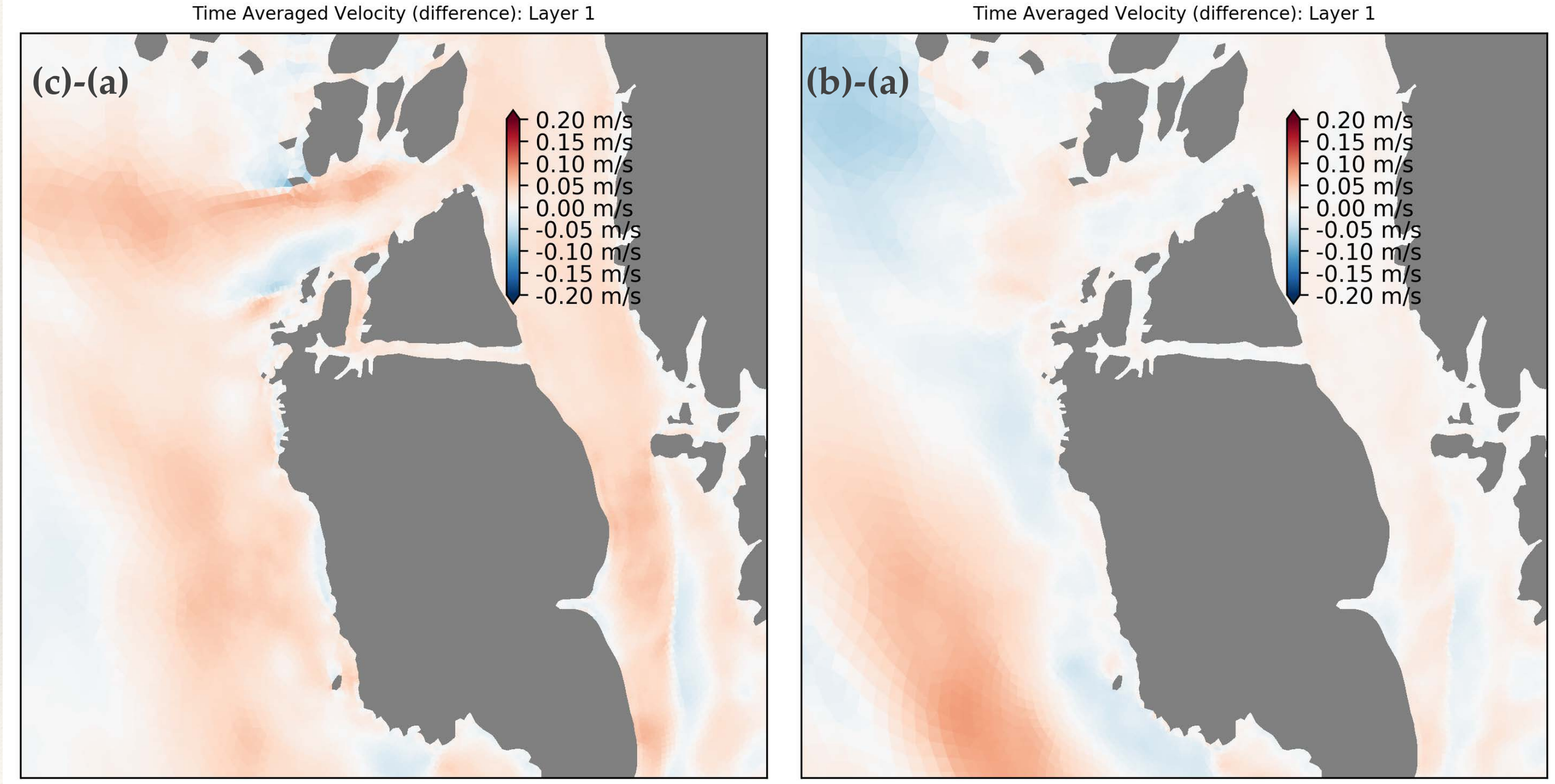
Typical estuarine circulation. Vector gridded onto 500m grid for clarity.
See plume genesis, entrainment region and cross-channel variability

Tidally Averaged Velocities (nearfield)



Order of 5cm/s difference at the surface. Effect smaller in deeper layers.

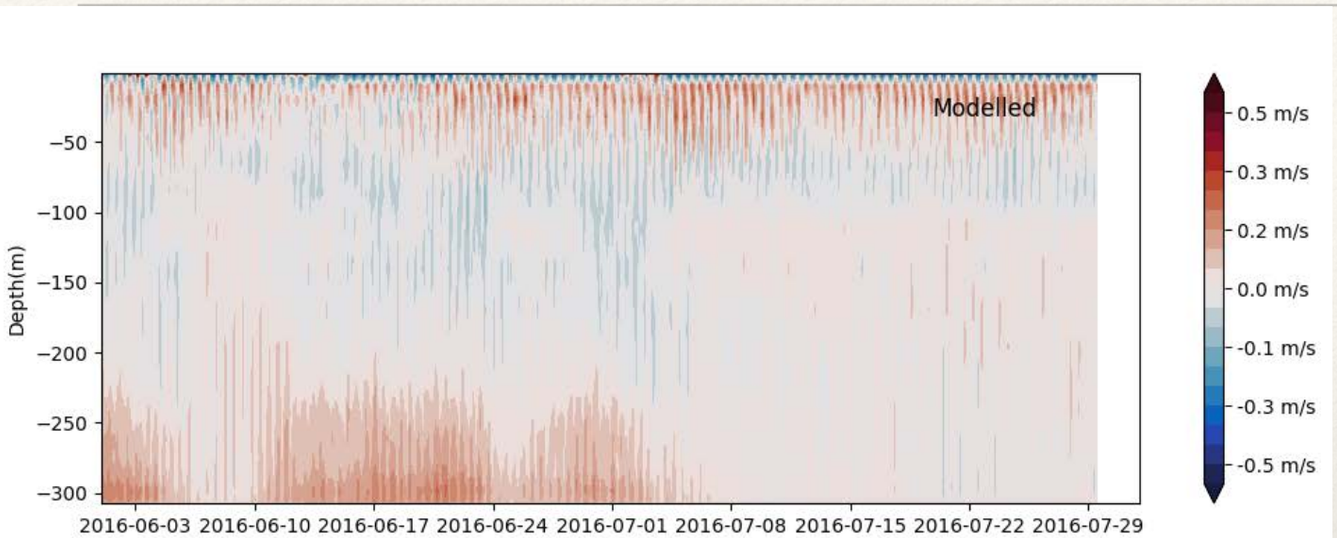
Velocities (farfield)



Order of 5cm/s difference at the surface.

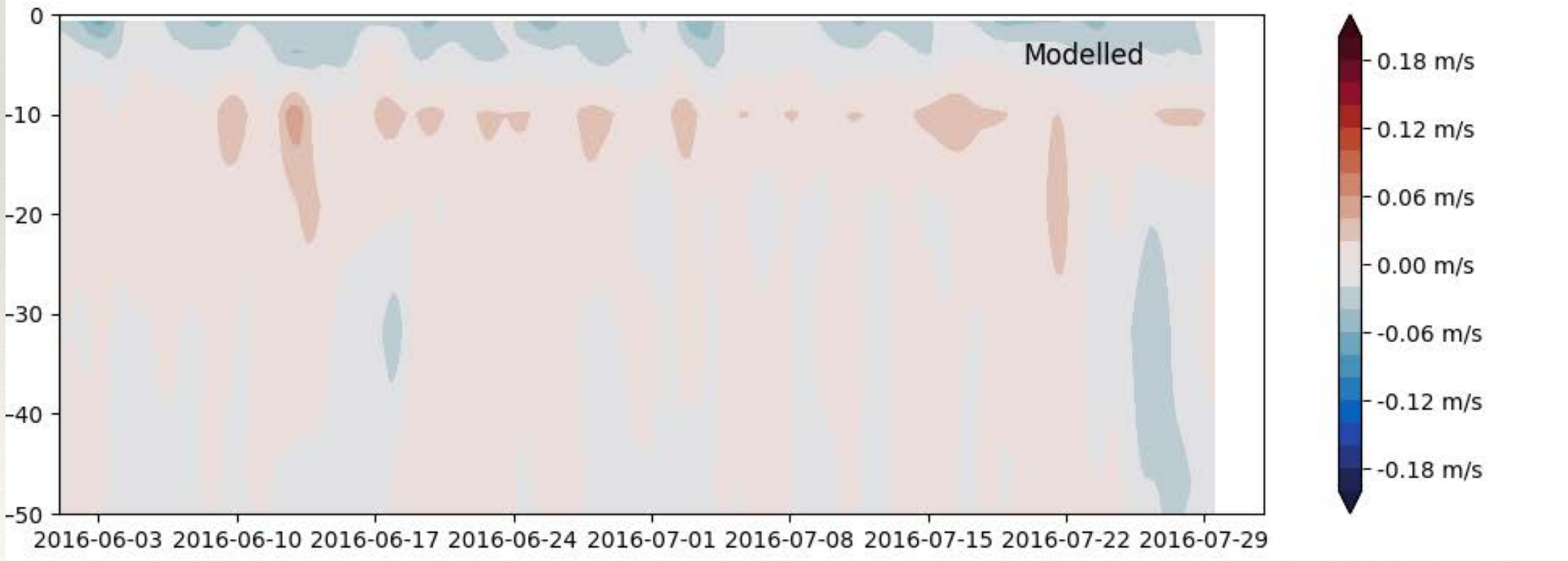
Effect varies with discharge amount. Changes reflected in the vertical structure.

Effect on vertical structure (near field)

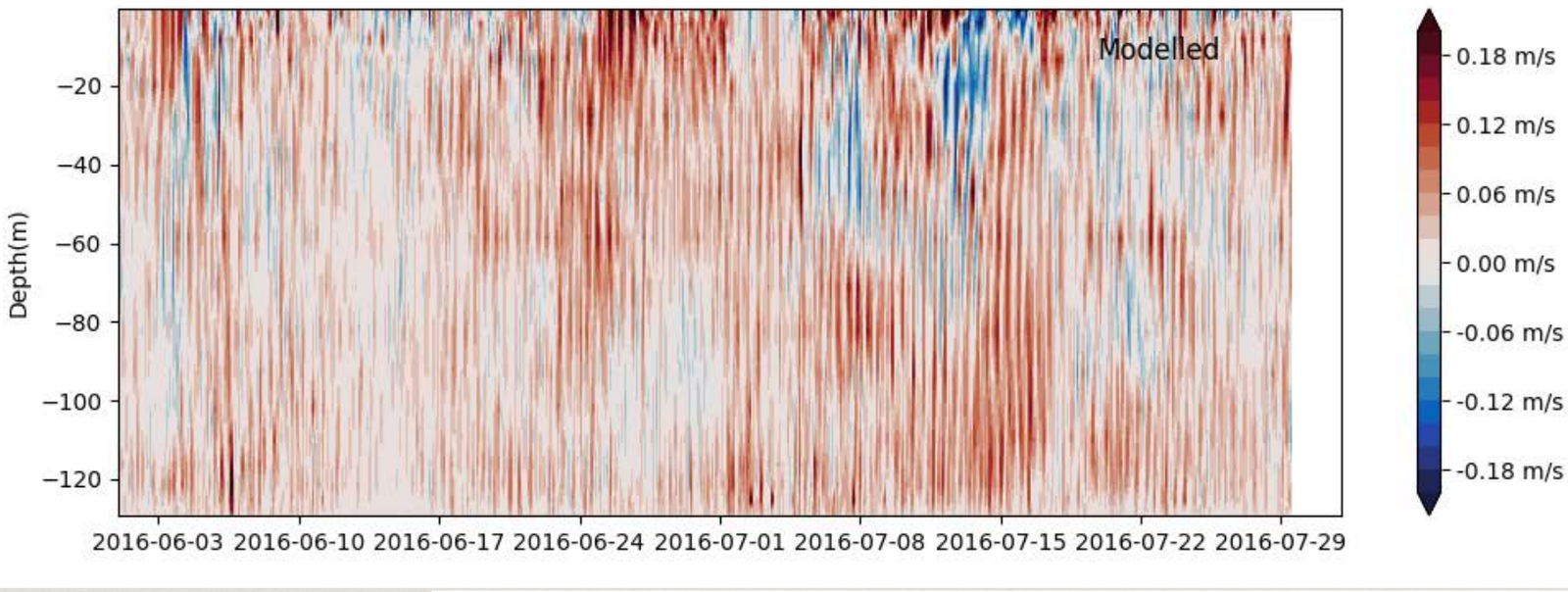


Near DFO1

(c)-(a): After applying the Godin filter and zooming into the top 50 m

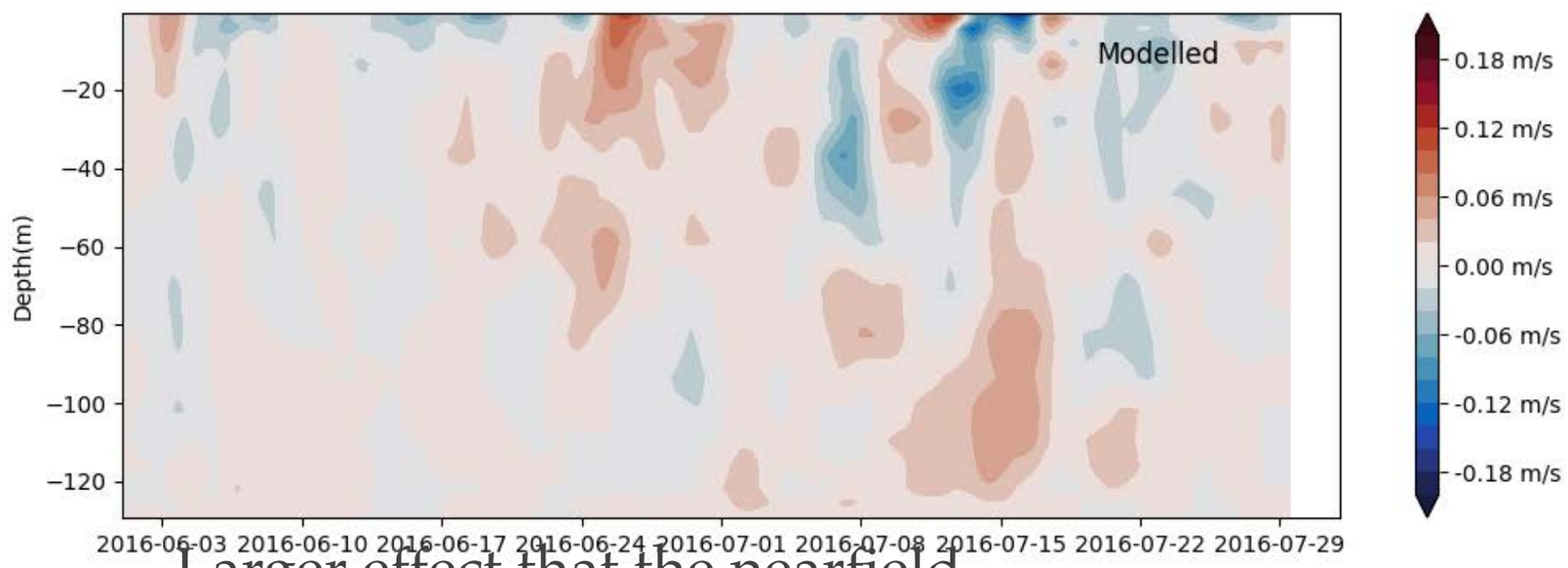


Changes to the vertical structure in the farfield



(c) - (a) at HAK1

(c) - (a) at HAK1
With Godin Filter

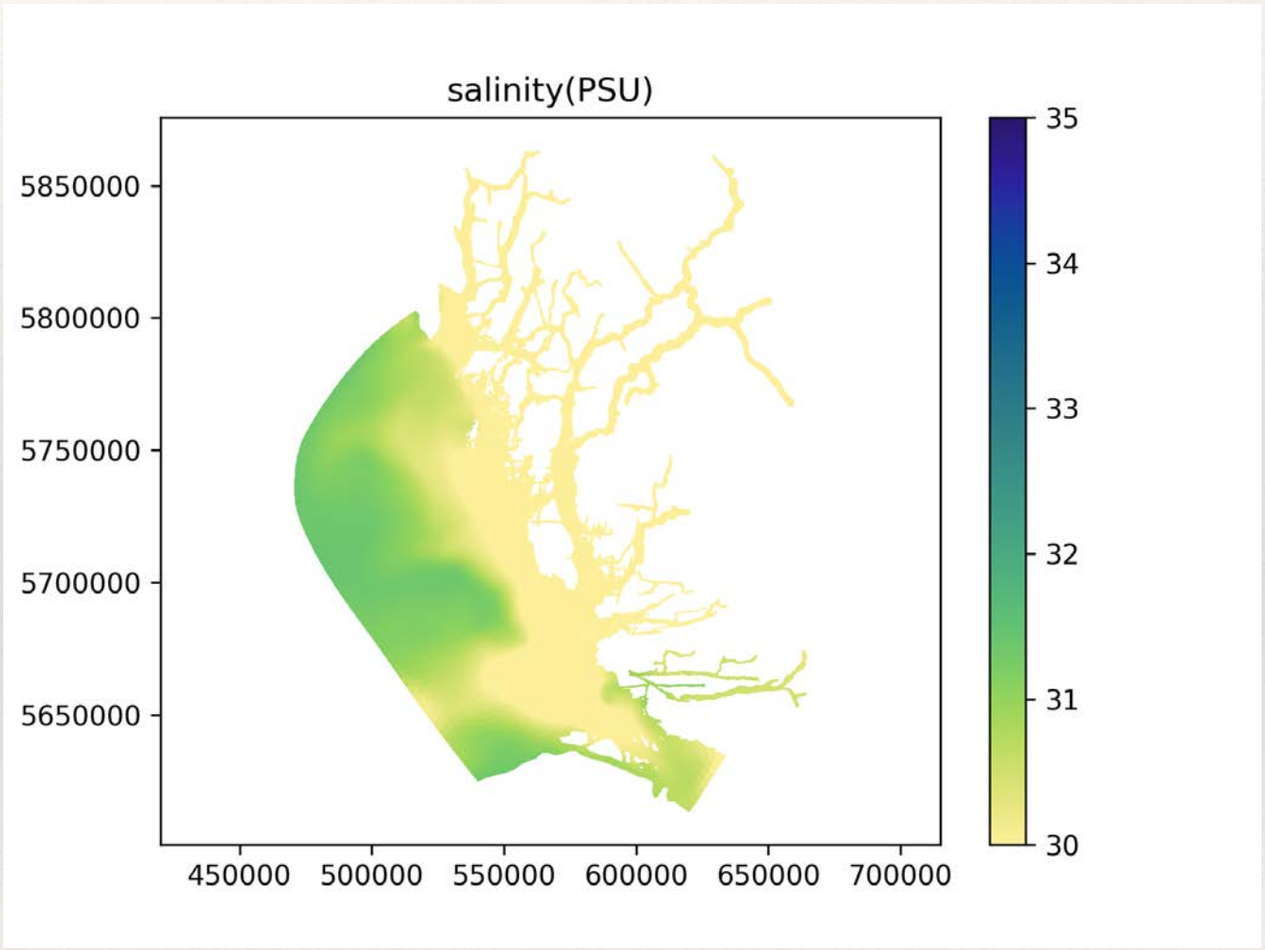


Larger effect that the nearfield.

Effect varies with discharge amount. Changes reflected in the vertical structure. Including tidal structure.

RCD Spatial Extent

- Calculate area using a threshold of 30(25) PSU at surface layer
- Area using discharge from climatology: 7111 (2108) km2
- Using 10% higher discharge: 7560 (2251) km2 (6% increase)
- Using 50% higher discharge: 8994 (2801) km2 (26% increase)



Summary

- A 3D hydrodynamic model with atmospheric, tidal and river forcing was used to test the impact of varying discharge on circulation within the Riverine Coastal Domain along the Central Coast of British Columbia, Canada
- Results of the numerical experiments show:
  - Surface speeds increases by ~5cm/s with 50% increase in discharge
  - No observable changes to the vertical structure
  - Changes to the RCD in the near field are predictable, in the far-field are less so
  - Potential increase in speeds
  - Changes to T/S profiles are O(cm)
  - Spatial extent of the RCD increases linearly
- Future work
  - Volume flux
  - Improve the river discharge model ?
  - Better understand the effect on the farfield