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Response of Salish Sea circulation and water quality to climate change and sea level rise

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Response of Salish Sea Circulation and Water Quality to Climate Change and Sea Level Rise Perturbation

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SSEC 2018
Study Area & Motivation

- How will nearshore estuarine environment be affected by climate change
  - Global predictions vs estuarine resolution

- **Objective**: Proof of concept level feasibility assessment for Salish Sea
  - Nearshore estuarine response simulation using downscaled global climate change predictions
    - Hydrology
    - Meteorology
    - Ocean boundary
    - Sea Level Rise

Example Global Climate Model output, 1.25°x0.9° (credit: NCAR)
- A fully-coupled, community, global climate model (NCAR)
  - Consists of five geophysical models: atmosphere, sea-ice, land, ocean, and land-ice, plus a coupler

Future Climate Simulations (based on future emissions scenarios)
- IPCC 5th Assessment Report (2014)
  - Representative Concentration Pathways (RCP)
    - RCP 8.5: High emissions scenario
- CESM Climate Scenarios
  - Future: RCP 8.5 2091-2100 ≈ Y2095
Sea Level Rise

- **USACE - Sea-Level Change Curve Calculator (2015.46)**
  
  [Huber and White (2015)]

- **Year 2095 SLR Prediction**
  - 1.5 m (Neah Bay)

http://www.corpsclimate.us/ccaceslcurves.cfm
Model Inputs – Historical Y2000 and Future RCP8.5 (Y2095) conditions

Ocean Boundary Condition
- T 2.4 °C ↑
- S 0.16 ↓
- Nutrient load ↑
  - 4% NH4 ↑
  - 9% NO3 ↑
  - 7% DON ↑
- 28% (1.7mg/l) DO ↓

Atmosphere (RESM - WRF – RCP8.5)
- Air Temperature ↑
  - T ↑ 3.5 °C
- Wind
- Radiation

Precipitation

River Loads – Based on Population Growth
- 44% increase in Nitrate

Salish Sea Model

WWTP nutrient loads ↑
(x 2 times NO23 for RCP 8.5)

Population Projection, Land Use Change

* All labeled numbers are annual averaged values.


May 22, 2018
Effect of SLR (1.5 m) and Future Hydrology on Estuarine Exchange flow

- $\Delta H \approx +1.3\%$
- $\Delta Q \approx -4.5\%$
- $\Delta S_{\text{obc}} = -0.16$ psu (ave)
  $= -0.5$ psu (surf)
Annual mean sea surface T & S Difference

RCP 8.5 (2095) - Historical (2000)

RCP 8.5 (2095) - Historical (2000)
Salish Sea-wide impact: Algae species change

Salish Sea-wide Chlorophyll $a$ concentration time series.

- Algae species change - Historical (2000) vs and RCP8.5 Future (2095)
Salish Sea-wide Impact: pH

Historical (2000) - RCP8.5 Future (2095)
- Salish Sea-wide future pH reduction = \textbf{0.13} units

Salish Sea-wide mean pH
**Salish Sea-wide impact: DO**

Historical (2000) - RCP8.5

Future (2095)

- Boundary DO reduction = 1.7 mg/L
- Salish Sea-wide DO reduction = 0.7 mg/L

Average DO depletion ≈1.5 mg/l in late summer
Salish Sea Hypoxia Zones (Bottom DO < 2 mg/l)

Hypoxic Zone: increase from 0.6% (Historical) to 16.9% (RCP8.5) of Salish Sea Area
Intertidal response in Snohomish Estuary

Number of days with mean temperature above 13 °C
Intertidal response in Snohomish Estuary

Number of days with maximum salinity above 5 psu

- Historical
- RCP 8.5
Summary

- Strong vertical circulation mitigates climate change impacts in *Salish Sea*
- Overall circulation is relatively unaffected
  - Effect of SLR counteracted by reduction in salinity gradient
- Overall warming of *Salish Sea* expected
  - $\Delta T = 1.8 \, ^\circ\text{C}$, dominated by global ocean warming
- Higher temperatures will cause algal species shift
  - dinoflagellates increase of 108% ↑; diatom 16% ↓.
- DO depletion in the future (RCP8.5 - Y2095):
  - Mean DO is expected to decrease by 0.7 mg/l
  - Maximum area of hypoxia (DO<2mg/l) can reach 17% of Salish Sea
- pH level decrease (acidification) in the future
  - Mean pH reduction of 0.13 units
- Intertidal habitat shifts
  - Mean surface temperature increases up to 3 °C
  - Salinity intrusion extend to RM 11 (versus RM 4 in Historical – Y2000)