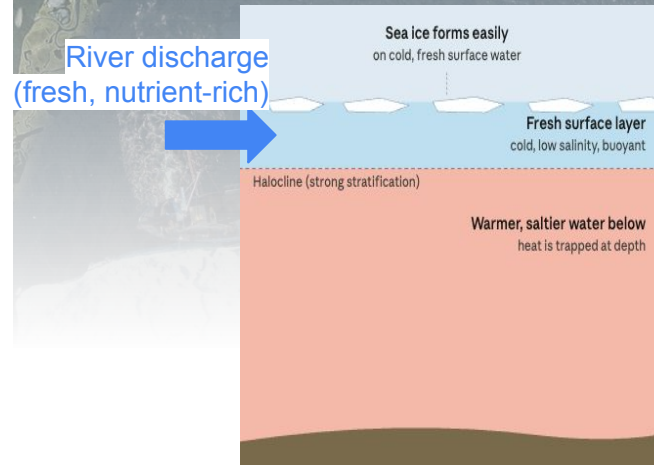




Fate of River Export and Surface Hydrology in the Arctic

Tracking water from land to delta to ocean

- Arctic Ocean holds only 1% of world's oceanic volume, yet it receives 15% of global river discharge!
- Deltas control the timing and volume of freshwater, heat, and nutrients delivered to the ocean
- *Why do we care?* Salinity controls stratification which impacts **sea ice formation**
- Arctic: among the most data-sparse regions on our planet
→ we have little knowledge of the rivers that pulse through its complicated river deltas and discharge freshwater and nutrients to the Ocean



River discharge
(fresh, nutrient-rich)

The diagram illustrates the process of ocean stratification. A blue arrow labeled 'River discharge (fresh, nutrient-rich)' points from the land into the ocean. This creates a 'Fresh surface layer' which is 'cold, low salinity, buoyant'. Above this layer, 'Sea ice forms easily on cold, fresh surface water'. Below the surface layer is a 'Halocline (strong stratification)' layer, and at the bottom is 'Warmer, saltier water below' where 'heat is trapped at depth'.

Sea ice forms easily
on cold, fresh surface water

Fresh surface layer
cold, low salinity, buoyant

Halocline (strong stratification)

Warmer, saltier water below
heat is trapped at depth

Hypotheses



How does freshwater move through the land-delta-ocean system and ultimately control the pathways that dictate the fate of freshwater in the Beaufort Sea?

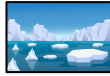
- **Land to Delta:** Discharge in the Colville River Basin varies on daily, monthly, and annual scales that affect the timing and magnitude of freshwater reaching the delta.
- **Delta to Ocean:** Processes and connectivity within the delta control the land-ocean branch of the water cycle (e.g., the timing, magnitude, and partitioning of freshwater to the ocean).
- **Ocean & Sea Ice:** Ocean pathways including mixing, sea ice formation, spreading and stratification, control the fate of freshwater in the Arctic

Who is involved

Taylor Rowley (Hydrology Team Lead)



Peter Gaube (Ocean Team Lead)



Séverine Fournier (Integration Lead)



Colin Gleason, Dongmei Feng, Wayana Dolan, Anastasia Piliouras



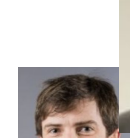
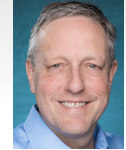
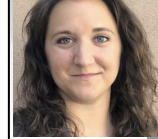
Mike Steele, Julian Schanze, Jim Thomson, Andrey Shcherbina,
Ben Kopec, Dimitris Menemenlis, Carlyn Schmidgall, Marie Zahn



Alex Wineteer, Hector Torres



Annette deCharon, Fred Bingham



Tracking water through river and delta



Hines and Piliouras, 2024



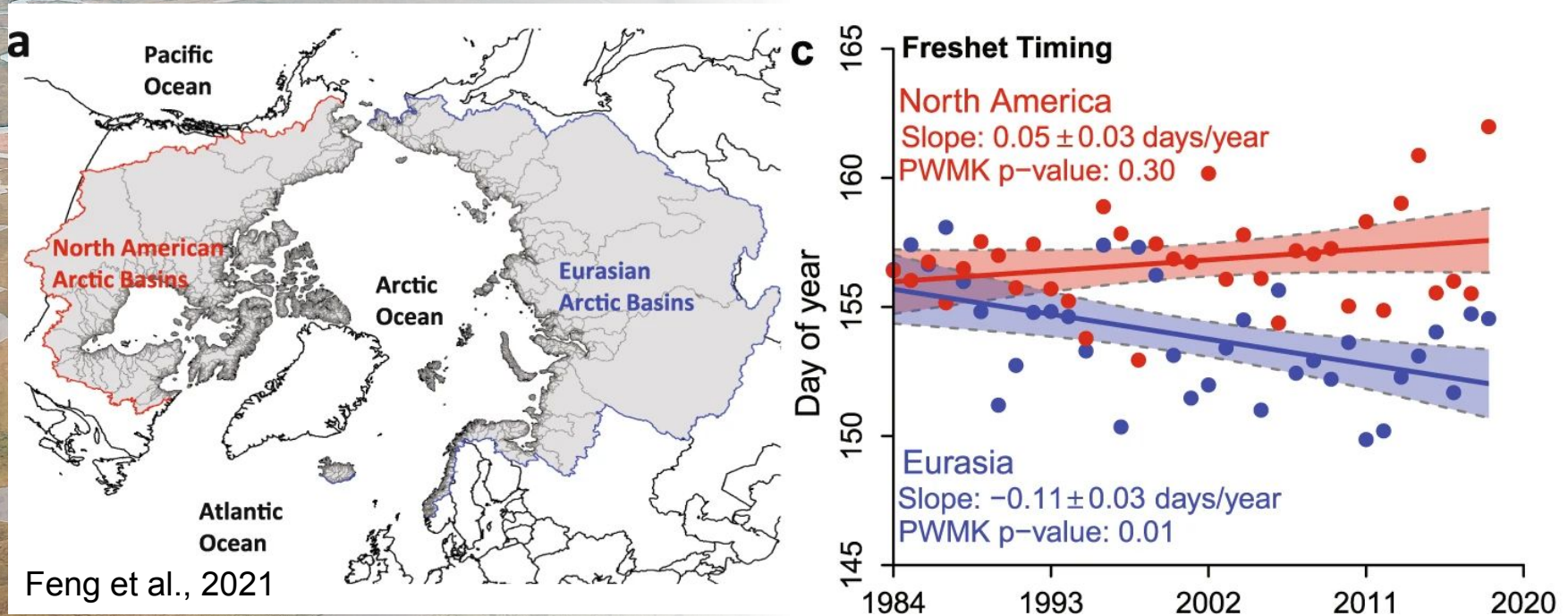
- Watershed: 50,000 km²
- Delta area: 600 km²
- Continuous permafrost landscape
- Mean annual discharge: 280 m³/s
- Mean annual sediment load: 6 million T/yr

How do we understand river dynamics?



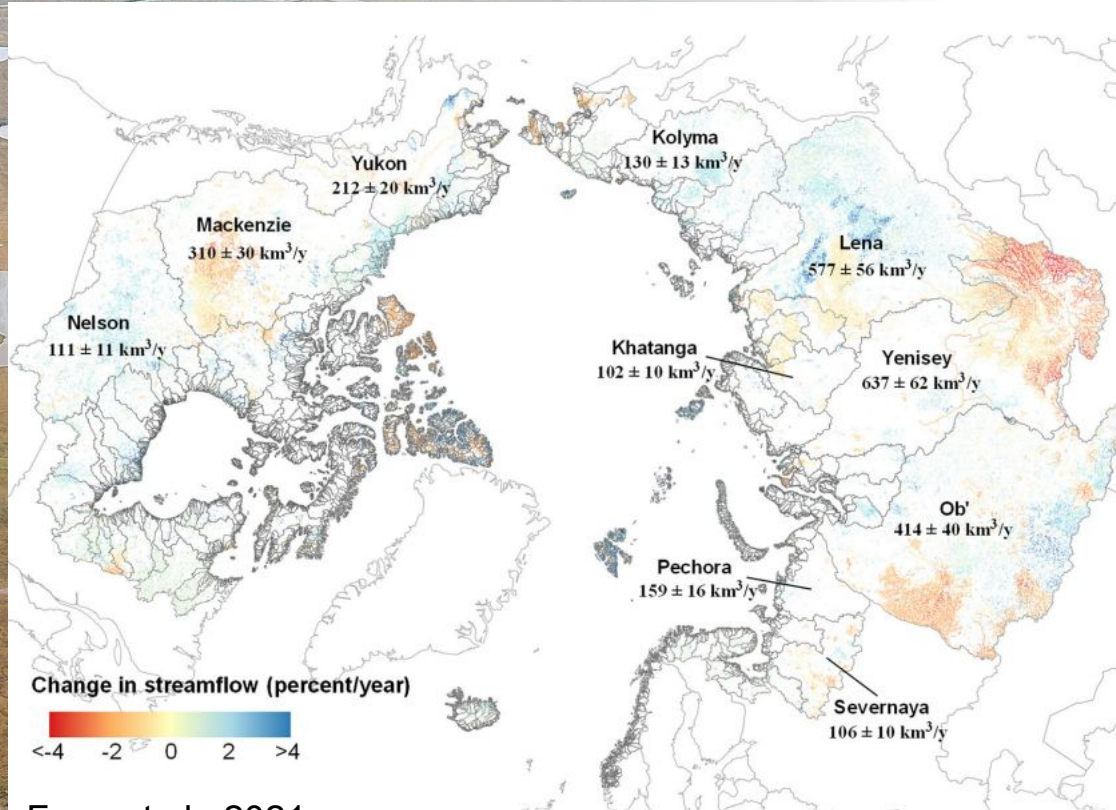
- Monitored at point locations with limited frequency
- River monitoring is limited in the Arctic
- 1 gauge on the Colville River/within the watershed

Land to Delta



Discharge in the Colville River Basin varies on daily, monthly, and annual scales that affect the timing and magnitude of freshwater reaching the delta.

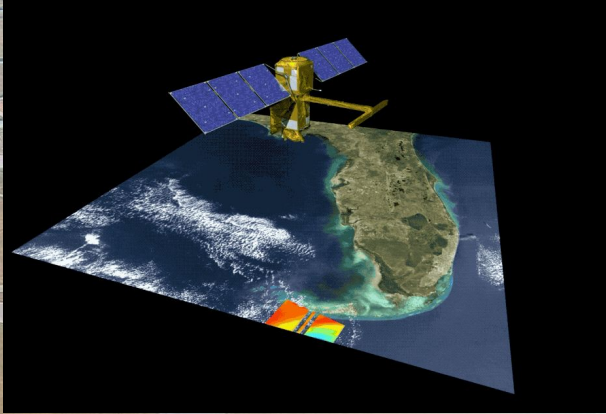
Land to Delta



Feng et al., 2021

- Remotely-sensed Arctic Discharge Reanalysis (RADR) daily discharge for 486,493 river reaches across the pan-Arctic
- Assimilated ~9.18 million discharge observations derived from 227 million river width measurements from Landsat images

Land to Delta

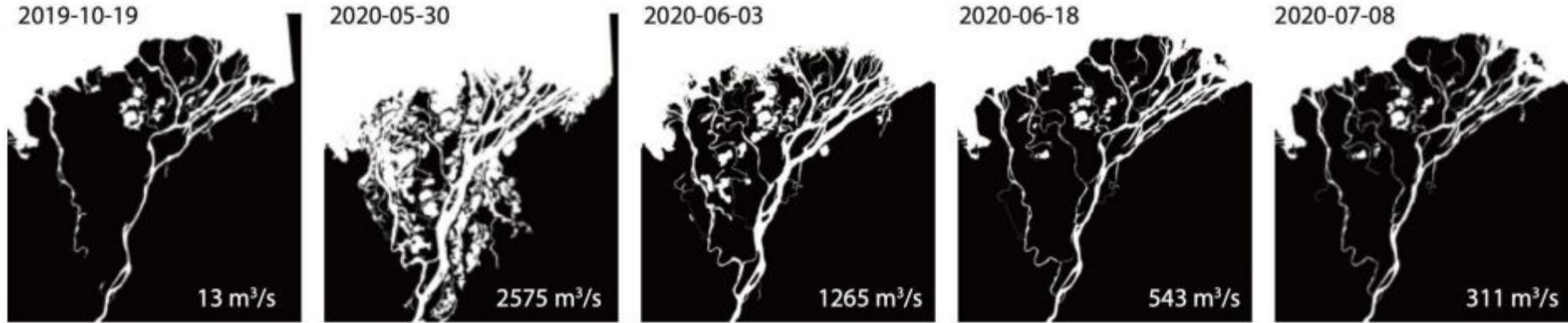


Update the model with SWOT to predict discharge on multiple time scales over 15 years in the Colville River Basin



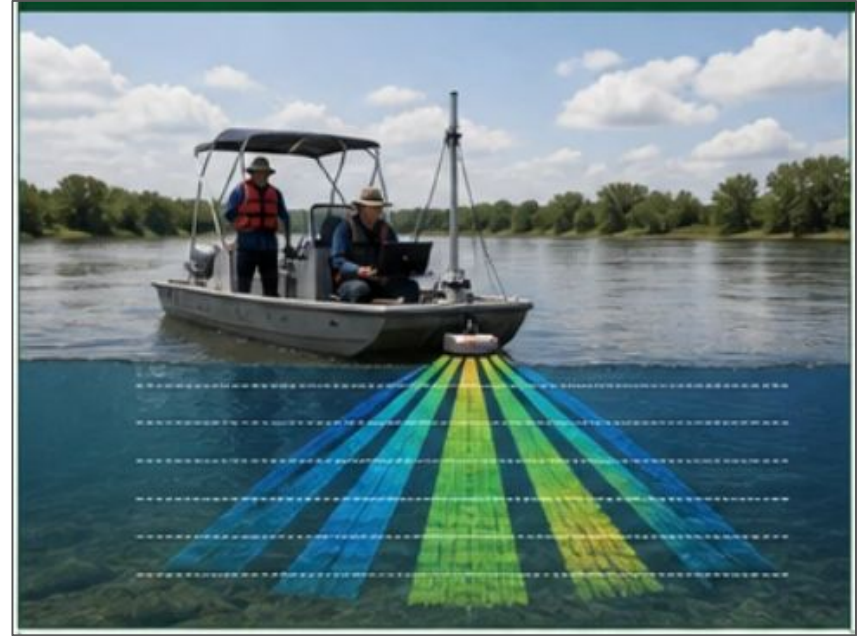
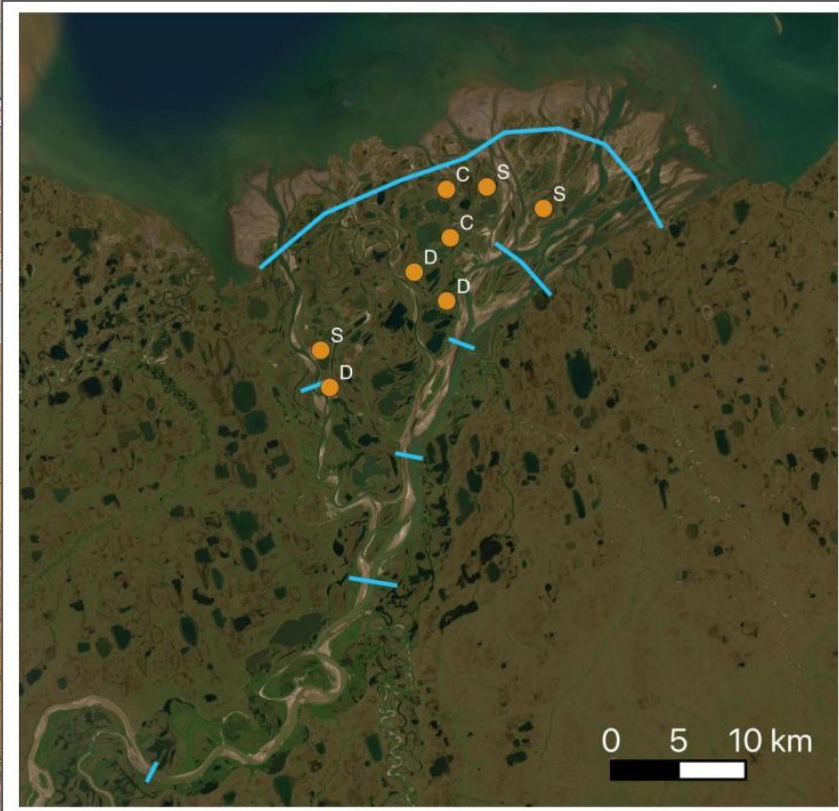
Include permafrost dynamics into the model to constrain changes in flow regime.

Delta to Ocean



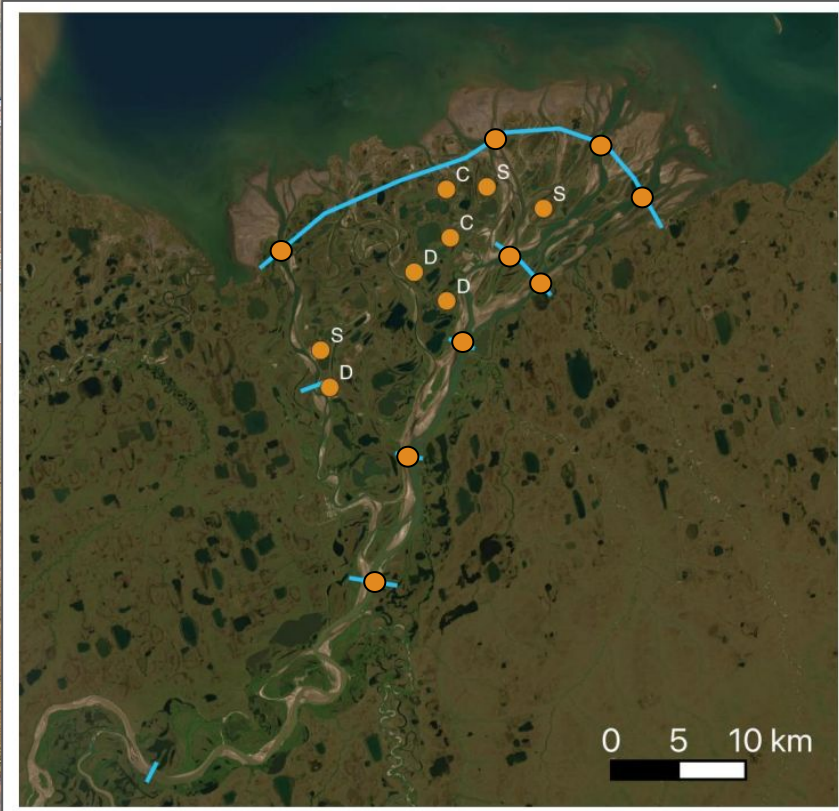
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Delta to Ocean



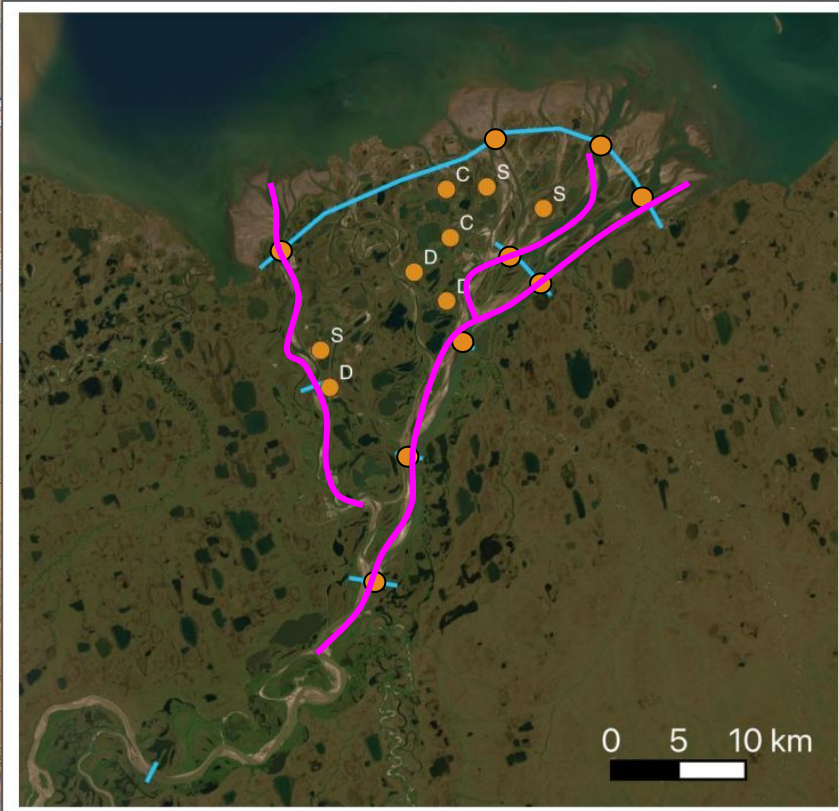
ADCP profiles for river discharge

Delta to Ocean



Pressure sensors with optical backscatter for water surface elevation and suspended sediment

Delta to Ocean

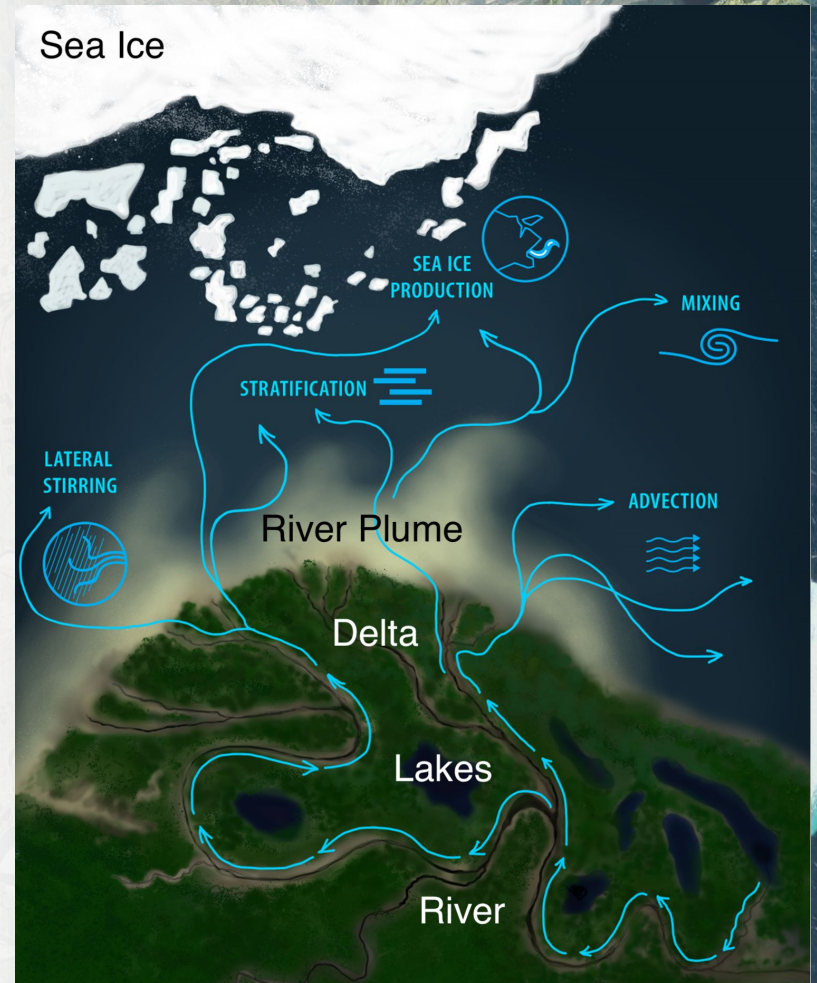


**Echosounder for channel
bathymetry**

Ocean and Sea Ice

Hypothesis: Ocean pathways including mixing, sea ice formation, spreading and stratification, control the fate of freshwater in the Arctic.

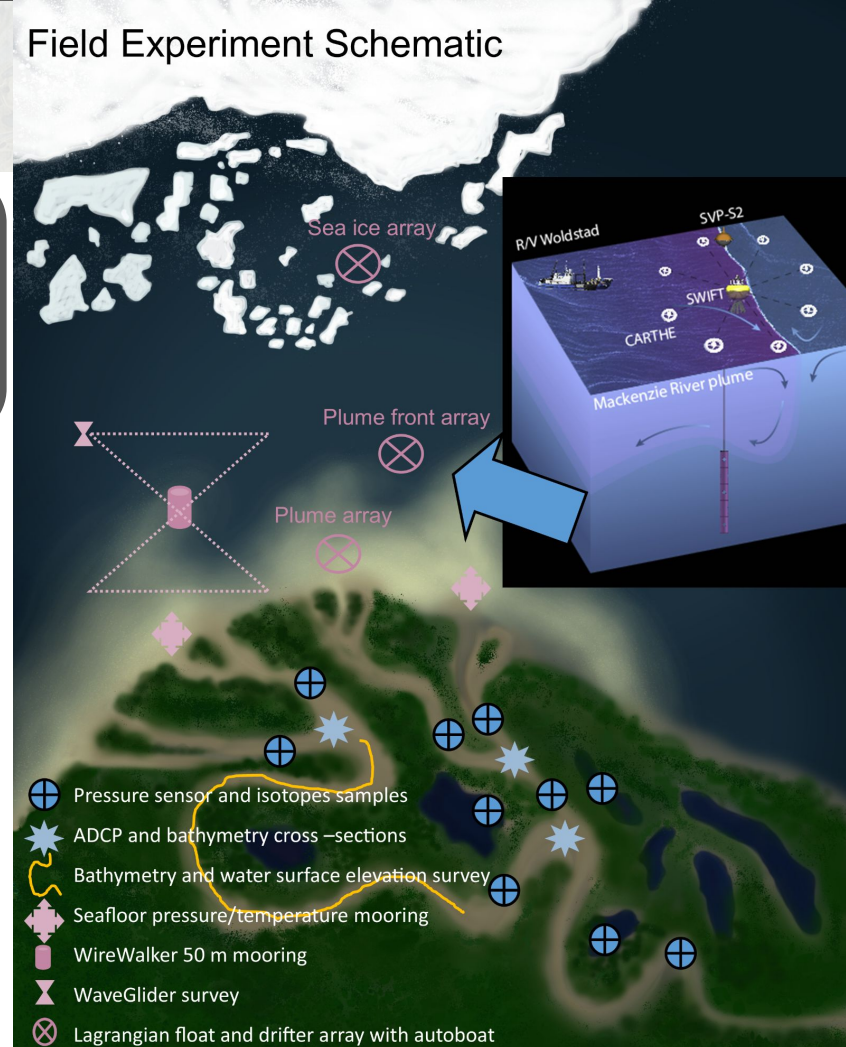
1. Tracking water using isotopes and optics
2. Measuring stratification and currents using moorings and ship survey
3. Observe spreading using focus Lagrangian studies



Ocean Sampling Plan

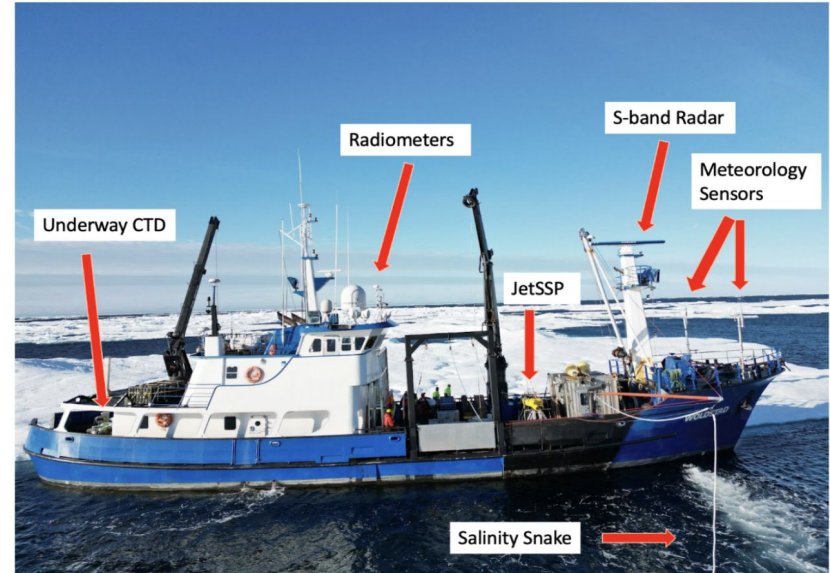
1. **Shipboard flowthrough** T/S, isotopes, optics at surface, T/S at ~3m
2. **Underway CTD** Profiles of T/S and optics to 100m spaced every 500m-1,000m
3. **Seafloor moorings** Deployed in fall 2026, records P/T
4. **Wirewalker** Profiles from surface to depth measuring T/S, optics, oxygen
5. **Drifter Arrays** Three Lagrangian arrays of drifters for process studies
6. **WaveGliders** Patrolling survey area prior to ship arrival, surface met and T/S profiles
7. **Autoboat** Shallow draft with profile of T/S from surface to 1m

Field Experiment Schematic



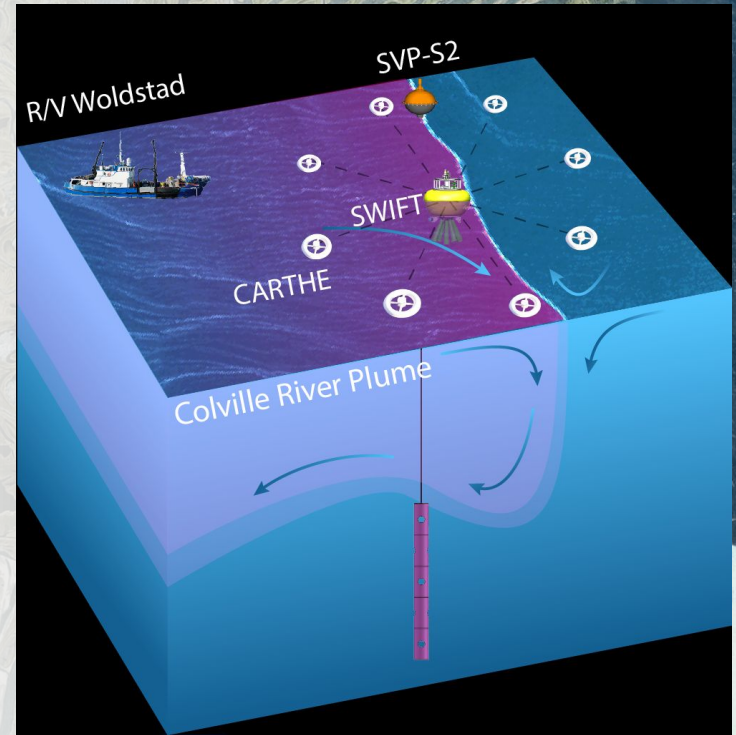
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1. Near-shore plume array
2. Plume-front array
3. Far-field array

Airborne - Dopplerscatt

Ka-Band Pencil Beam Doppler Scatterometer

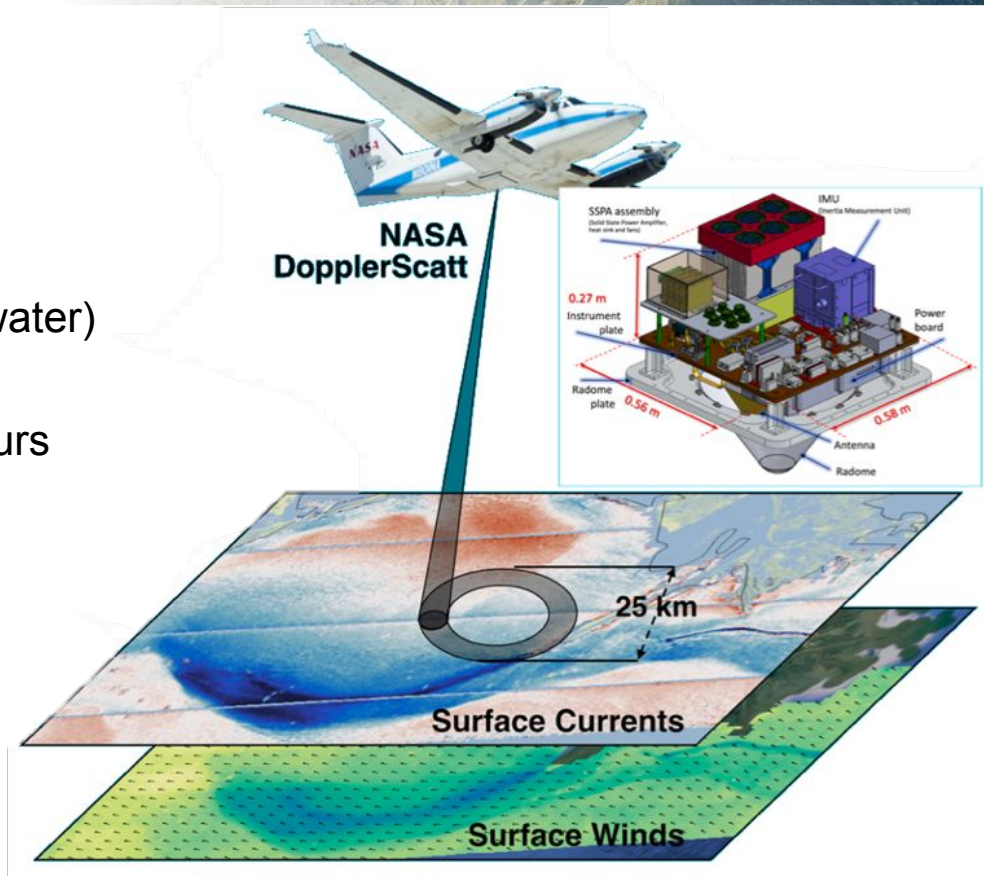
Measurements:

- Vector ocean surface currents
- Vector ocean surface winds
- Radar brightness maps (sensitive to ice/water)

Mapping capabilities: 25 km swath
maps 200km x 100km area in about 4 hours

Performance characteristics:

Current Velocity: 5-15 cm/s
Wind speed: 1 m/s for 3-20 m/s
Wind direction: 15 degrees
Spatial resolution: 200 m



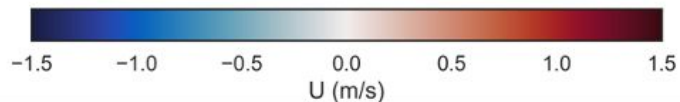
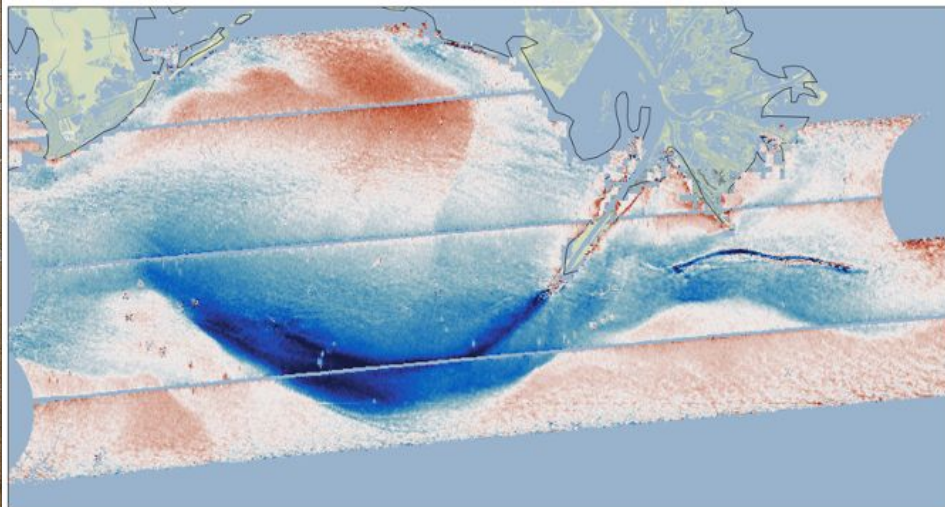
Airborne - DopplerScatt

Example Mississippi River Plume



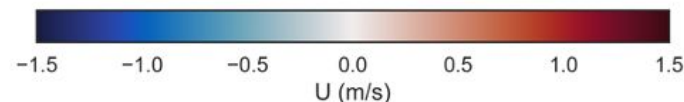
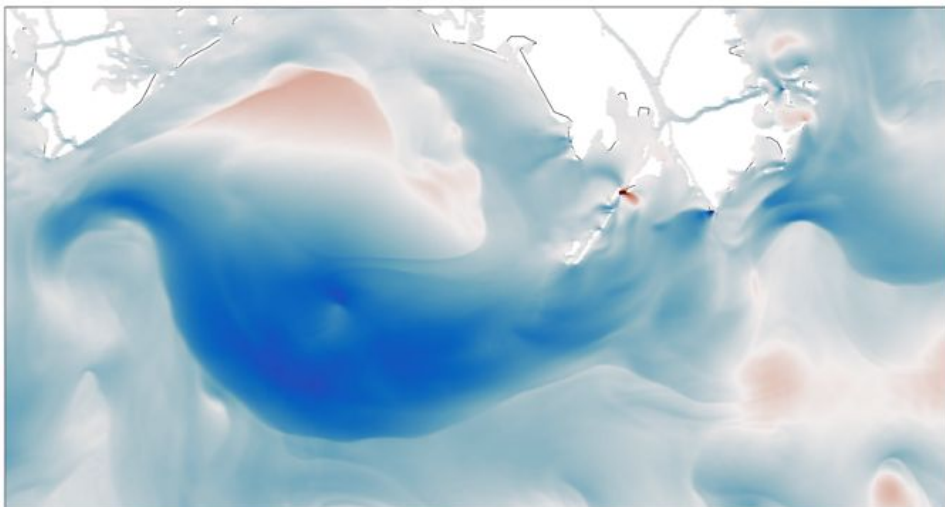
DopplerScatt

2017-04-18



Navy Coastal Ocean Model

NCOM 2017-04-18





Anticipated Outcomes

- The most accurate quantification of Colville River **daily river discharge**
- The most realistic **model of delta channel connectivity** and partitioning of water discharge into the ocean (i.e., how water is divided across different pathways within the delta)
- Direct observation of freshwater transport from the delta over the inner shelf and into the basin
- Realistic observationally-validate freshwater spreading function to model river input into ocean circulation simulations.