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1. Arctic Great Rivers Observatory

Discharge and water quality data from the primary rivers flowing into the Arctic Ocean (Mackenzie, Yukon, Kolyma, Lena, Yenisey, Ob'). Water quality data is collected up to seven times a year, starting in 2003, with 2007 and 2008 missing in all but the Mackenzie dataset. Discharge Data is collected continuously starting in 1936 for the Lena, Yenisey, and Ob' River, 1927 for the Kolyma River, 1975 for the Yukon River, and 1972 for the Mackenzie River. Detailed discharge metadata can be found here.

- Discharge data could be compared to the northern hemisphere ice cover dataset. How much flow variability in a given river (or all the rivers) is driven by ice-melt? What other factors could potentially drive the flow rate?
- Water quality and discharge data could be compared. How do high versus low flow events impact the composition of the rivers? How do cycles of high versus low flow compare between the rivers? Does the water quality in the rivers respond similarly to these high and low flow events? If there are differences found, what factors could be at play?

2. Northern Hemisphere Ice Extent

Ice cover (in square kilometers) over the northern hemisphere is calculated and reported daily based on multiple satellite based sensors by the National Snow and Ice Data Center. Data back to January 2006 is available for the entire northern hemisphere and its 16 arctic regions.

- How does the rate of ice extent change seasonally and between years? Are there certain periods that stand out?
- Are there certain areas of the arctic that are changing more quickly?
- See note on arctic great river flow comparison.
    - Are there periods when river flow is high but ice extent remains unchanged? How does the water quality during these periods compare to periods of high river flow and high ice-melt?

3. Canadian Hydrometric Data

Environment and Climate Change Canada (ECCC) provides real time and historical river data (flow and/or level) at all their presently or previously gauged rivers. The historical data will be more useful for this project, scroll to the bottom of the page, center column, to search for historical river data across the country.
The Fraser River may be of interest! The Fraser River is the largest river discharging into the Salish Sea and it the main driver of estuarine flow in the region, which allows for strong exchange with the Pacific Ocean. Daily discharge data is available at stations throughout the

river, but Hope station in particular has been collected since 1912 and covers a drainage area of more than 217,000 km2.

- Could be compared to historical climate data (temperature, precipitation). Based on the seasonal cycle, what environmental factors may drive the flow variability in the river?
- The Fraser could be compared to Skagit River discharge (see next item on list). How does the seasonal cycle of these dataset compare? Which might be more sensitive to a changing climate?
- Warm weather discharge data could be compared to biological parameters such as fluorescence (see SalishSeaCast model output section). Is there a relationship between Fraser River flow and surface productivity near the mouth of the river? Why might this be? If Fraser River flows increase or decrease in the future how might this impact the nearby marine ecology?

4. USGS Water Data

The USGS has a great (albeit dated) interface for all of their publicly available water data. They have 1.9 million sites, which provide flow and/or water quality information, so it's good to have a general idea of what you're interested in before diving in.
Similarly to the Fraser River, the Skagit River may be of interest. It is another major river flowing into the Salish Sea, the largest in Puget Sound, and drives estuarine flow in that region. Daily records of discharge (back to 1940), temperature (1962), turbidity (2016), and suspended sediment concentration (2006) are available at the Skagit River near Mount Vernon station.

- See above suggestions for the Fraser River that could similarly be applied to the Skagit.
- Water quality information could be compared with the Arctic Rivers. How does the suspended solids concentration compare between these rivers? What may drive this difference?

5. SalishSeaCast Tracer Output

SalishSeaCast is a 3D physical-chemical-biological ocean model for the Salish Sea back to 2007 with *some* of its output publicly available here (scroll down to the outputs starting with Green). You can get a multitude of information about how conditions vary over a specific location in the Salish Sea, hover over the "?" to see what variables are available in each dataset. For example, the 3D biological fields will have concentrations of different zooplankton groups. In the data download you'll need to select a time range, depth range, and the X and Y coordinates you want to look into. X and Y are a bit more complicated, since they're not simply the longitude and latitude; if you're comfortable with coding you can use the *find_closest_model_point()* function from salishsea_tools.geo_tools in python, your computer-lab TA should be able to help you if you are interested in the model data but have trouble at this step.

- Fraser river turbidity from the SalishSeacast auxiliary fields could be compared to Fraser River Flow Rate.

- Prominence of different types of zooplankton throughout the year and between years could be compared to weather data (temperature, wind, and/or solar radiation). Can you find a correlation between certain species and the weather?

6. Canadian Integrated Ocean Observing System (CIOOS)

Recently released site that integrates publicly available observation data for Canada's three oceans. Lots of data there but the map lets you draw a square around the region you're interested in and specify which variable(s) out of the 13 available you want to look at, while the variables seem limited the actual datasets provide more information (ex. If you select nutrients many of not all of the nutrient datasets specify nitrate, phosphate, and silicate concentrations). You may have to merge data together after downloading it as many of the moorings data collection restarts whenever they are serviced.

7. Sea Level

Sea levels are projected to rise due to ocean warming and ice melt. Observed sea level change (how much the sea is rising relative to the shore) is monitored at permanent stations across Canada's coast, and has been monitored in BC since 1910 and reported for Prince Rupert, Tofino, Vancouver, and Victoria.

- Sea level change across the BC coast could be compared. All stations are on the Pacific Ocean, do their observed sea level trends and overall change differ? What environmental and geological factors may lead to different observed sea level change?
- Sea level change from stations along the Northern, Eastern, and Western coast of Canada could be compared. Are there particular coasts or regions that seem more vulnerable to sea level rise? Why might this be?

8. Metro Vancouver Air Quality Monitoring Network

Hourly concentration data from Metro Vancouver air-quality stations (relevant station information summarized here) between January 1, 2009 and December 31, 2011. Not all stations collect the same measurements, but NO, NO2, NOX, O3, CO, SO2, PM2.5, and PM10 may be available depending on the location. This data is not publicly available, but the teaching team has it and would happily share it with you, just ask!
Another website that reports the daily air-quality index (a product of the measurements made at air-quality stations) for large cities around the world, including Vancouver, can be found here.

- Ground level ozone (O3) and weather could be compared. What weather conditions seem to lead to high O3?
- Compare O3 to NOX levels (and potentially also to weather). Is O3 more correlated with high NOX emissions or with the weather trend you may have observed? Why?
- Compare high PM2.5 events to forest fires occurrences (of your choosing, season summaries and specific event information can be found here). Can high PM2.5 concentrations in Vancouver be used as a proxy for forest fires in the interior or south of

the border? Is there an observable correlation between a rapid decrease in PM2.5 and a shift in wind direction or high rainfall?

9. Paloeclimatology

NOAA's national center for environmental informatics has an extensive database of paleo data with both direct proxy data (ex. corals, ocean sediment cores, tree rings) and derived earth systems data (ex. snowfall, ocean surface temperature). When we say extensive database we really mean extensive, have a general idea of what you'd be interested in looking at before trying to search for a dataset.
The search interface is really well setup and lets you specify which location (via country name or longitude and latitude range), variables, and timespan your interested in and then provides you with a list of studies that fit your criteria, you can then look through the short description of these studies and a map of where the data was collected and download a text file of which datasets you're interested in!

- Keep it simple and use derived data for your project as a way to extend your analysis long before weather was recorded in North America.

10. Vancouver Weather Data

ECCC has a great publicly available database of historical weather data at stations across Canada. Local weather (temperature, precipitation, solar radiation, etc.) is fantastic as a comparison to the other data that you look at (ex. You can use it to check how much the Fraser river flow is impacted by high rainfall). The historical data search can be found here, I would recommend starting by searching by proximity using the latitude and longitude of the other data source you are considering and inputting the times you need data in the search.
If you want a station in Vancouver with a long time series try out the Vancouver Harbour Station (1925-2022).
The site only lets you manually download data one month at a time, if you want a large chunk go to your terminal and first install homebrew if you have a mac, wget if you have a Linux OS, or Cygwin if you have a Windows OS if you don't have one of them already. Then use the command line instructions in *Command_Lines_EN.txt* here.

This will download all the data into separate files for each month. To get it into one dataset I like to use python. Below is my code as a sample of how to do this, of course you will need to change the years your data ranges between, the path to your file, and the name that your files are saved as; all fields that you may need to change are in **green and bolded**.

```
# import required libraries
import pandas as pd
import numpy as np

# set time range for filename list
years = np.arange(1958,2022)
```

```
n = len(years)
years = np.repeat(years, 12)

months = np.arange(12)
months = np.tile(months,n)

# make a list of all the files you want to merge
files =
["/home/rbeutel/courses/442/en_climate_daily_BC_1108446_{}_P1D.csv.{}"
.format(years[i],months[i]) for i in range(len(months))]

# load them all into a pandas dataframe
df = pd.concat((pd.read_csv(f) for f in files), ignore_index=True)
df

# Save the dataframe as a csv
df.to_csv("VanHarbourWeather.csv",index=False)
```

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11 Other ideas

- Electricity emission over time compared to CO2 emissions
- Our world and/on data – does this mean https://ourworldindata.org/ ?
- https://climatedata.ca/
- https://cfcg.forestry.ubc.ca/projects/climate-data/climatebcwna/