

assignment

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1 Seasonal snow assignment

Eric Gagliano, Seth Vanderwilt

CEWA 568 Final Project

1.1 Teaching goals of this notebook

Analyze how snow accumulates and melts over the water year at a key study site, Paradise in Mount Rainier National Park.

1.2 Instructions

Questions are in bold. Please fill in your answers to the questions in the markdown cells labeled *Your answer here*.

1.3 Importing code packages

```
[1]: # We'll use Metloom to quickly download a time series of measurements from our ↵  
    ↪ SNOTEL site  
    !pip install -q metloom
```

```
[2]: from datetime import datetime  
    import pandas as pd  
    import matplotlib.pyplot as plt  
    import numpy as np  
  
    from metloom.pointdata import SnotelPointData  
    from metloom.variables import SnotelVariables
```

1.4 Downloading data from Water Year 2021 (October 1st 2020 - September 30th 2021)

- Read the description of the Paradise SNOTEL site on this page:
<https://wcc.sc.egov.usda.gov/nwcc/site?sitenum=679>

1. Describe the location of this site. What is its elevation?

Your answer here

```
[3]: snotel_point = SnotelPointData("679:WA:SNTL", "Paradise")

df = snotel_point.get_daily_data(
    datetime(2020, 10, 1), datetime(2021, 9, 30),
    [snotel_point.ALLOWED_VARIABLES.PRECIPITATION,
     snotel_point.ALLOWED_VARIABLES.PRECIPITATIONACCUM,
     snotel_point.ALLOWED_VARIABLES.SNOWDEPTH,
     snotel_point.ALLOWED_VARIABLES.SWE,
     snotel_point.ALLOWED_VARIABLES.TEMPAVG,
     snotel_point.ALLOWED_VARIABLES.TEMPMIN,
     snotel_point.ALLOWED_VARIABLES.TEMPMAX,
     snotel_point.ALLOWED_VARIABLES.SOILMOISTURE2IN
    ]
)

# Change the form of our resulting Pandas DataFrame
df.reset_index(inplace=True)
df.set_index("datetime", inplace=True)

df.head()
```

```
[3]:
```

	site \
datetime	
2020-10-01 08:00:00+00:00	679:WA:SNTL
2020-10-02 08:00:00+00:00	679:WA:SNTL
2020-10-03 08:00:00+00:00	679:WA:SNTL
2020-10-04 08:00:00+00:00	679:WA:SNTL
2020-10-05 08:00:00+00:00	679:WA:SNTL

	geometry \
datetime	
2020-10-01 08:00:00+00:00	POINT Z (-121.74765 46.78265 5130.00000)
2020-10-02 08:00:00+00:00	POINT Z (-121.74765 46.78265 5130.00000)
2020-10-03 08:00:00+00:00	POINT Z (-121.74765 46.78265 5130.00000)
2020-10-04 08:00:00+00:00	POINT Z (-121.74765 46.78265 5130.00000)
2020-10-05 08:00:00+00:00	POINT Z (-121.74765 46.78265 5130.00000)

	PRECIPITATION PRECIPITATION_units \
datetime	
2020-10-01 08:00:00+00:00	0.0 in
2020-10-02 08:00:00+00:00	0.0 in
2020-10-03 08:00:00+00:00	0.0 in
2020-10-04 08:00:00+00:00	0.0 in
2020-10-05 08:00:00+00:00	0.0 in

	ACCUMULATED PRECIPITATION \
datetime	
2020-10-01 08:00:00+00:00	0.0 in
2020-10-02 08:00:00+00:00	0.0 in
2020-10-03 08:00:00+00:00	0.0 in
2020-10-04 08:00:00+00:00	0.0 in
2020-10-05 08:00:00+00:00	0.0 in

datetime	
2020-10-01 08:00:00+00:00	0.0
2020-10-02 08:00:00+00:00	0.0
2020-10-03 08:00:00+00:00	0.0
2020-10-04 08:00:00+00:00	0.0
2020-10-05 08:00:00+00:00	0.0

	ACCUMULATED PRECIPITATION_units	SNOWDEPTH \
datetime		
2020-10-01 08:00:00+00:00	in	0.0
2020-10-02 08:00:00+00:00	in	0.0
2020-10-03 08:00:00+00:00	in	0.0
2020-10-04 08:00:00+00:00	in	0.0
2020-10-05 08:00:00+00:00	in	0.0

	SNOWDEPTH_units	SWE	SWE_units	AVG AIR TEMP \
datetime				
2020-10-01 08:00:00+00:00	in	0.0	in	64.22
2020-10-02 08:00:00+00:00	in	0.0	in	61.88
2020-10-03 08:00:00+00:00	in	0.0	in	56.66
2020-10-04 08:00:00+00:00	in	0.0	in	50.18
2020-10-05 08:00:00+00:00	in	0.0	in	55.04

	AVG AIR TEMP_units	MIN AIR TEMP	MIN AIR TEMP_units \
datetime			
2020-10-01 08:00:00+00:00	degF	60.08	degF
2020-10-02 08:00:00+00:00	degF	55.76	degF
2020-10-03 08:00:00+00:00	degF	48.20	degF
2020-10-04 08:00:00+00:00	degF	42.62	degF
2020-10-05 08:00:00+00:00	degF	44.60	degF

	MAX AIR TEMP	MAX AIR TEMP_units \
datetime		
2020-10-01 08:00:00+00:00	73.22	degF
2020-10-02 08:00:00+00:00	70.70	degF
2020-10-03 08:00:00+00:00	66.38	degF
2020-10-04 08:00:00+00:00	59.00	degF
2020-10-05 08:00:00+00:00	64.40	degF

	SOIL MOISTURE -2IN	SOIL MOISTURE -2IN_units \
datetime		
2020-10-01 08:00:00+00:00	2.6	pct
2020-10-02 08:00:00+00:00	2.7	pct
2020-10-03 08:00:00+00:00	2.8	pct
2020-10-04 08:00:00+00:00	1.8	pct
2020-10-05 08:00:00+00:00	2.5	pct

	datasource
datetime	
2020-10-01 08:00:00+00:00	NRCS
2020-10-02 08:00:00+00:00	NRCS
2020-10-03 08:00:00+00:00	NRCS
2020-10-04 08:00:00+00:00	NRCS
2020-10-05 08:00:00+00:00	NRCS

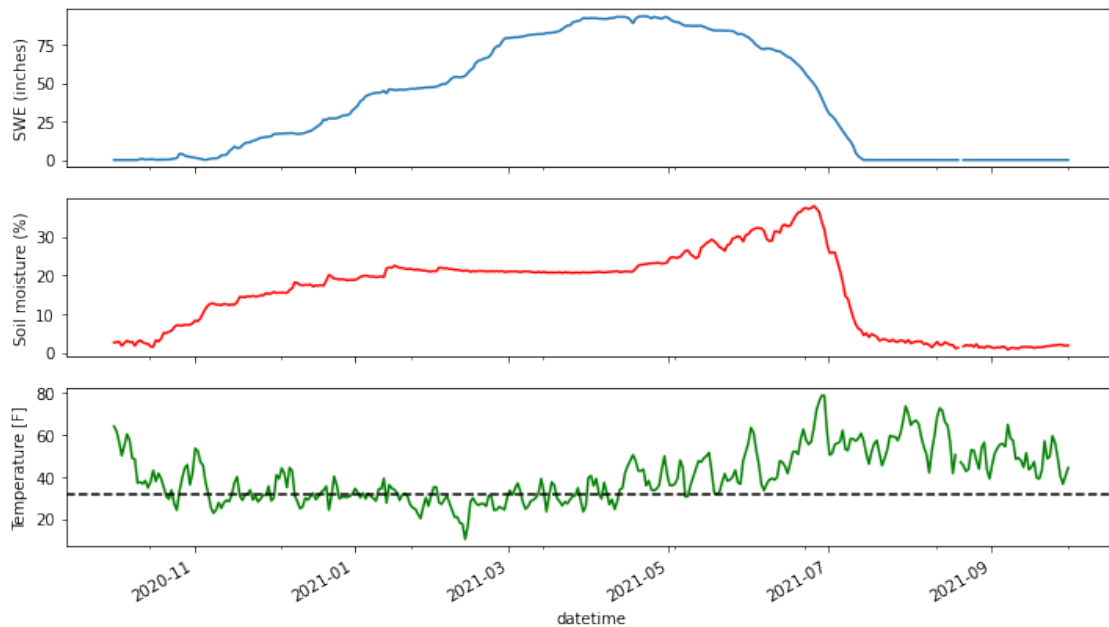
2. Which variables are measured by the sensors? What are their units?

Your answer here

1.5 Plotting SWE and other variables

```
[4]: f,ax=plt.subplots(3,1,figsize=(12,7),sharex=True)
df["SWE"].plot(ax=ax[0])
ax[0].set_ylabel("SWE (inches)")
ax[1].set_ylabel("Soil moisture (%)")
ax[2].set_ylabel("Temperature [F]")
df["SOIL MOISTURE -2IN"].plot(ax=ax[1],color='red')
df["AVG AIR TEMP"].plot(ax=ax[2],color='green')
ax[2].axhline(y=32,color='black',linestyle='--')
#for axs in ax:
#    axs.legend()
```

[4]: <matplotlib.lines.Line2D at 0x7fc914b09ac0>



3. What do you notice about the timing of SWE, soil moisture, and temperature? Is temperature important in determining melt timing?

Your answer here

1.6 Let's compare to our chart from the lecture, which is found at https://www.nrcs.usda.gov/Internet/WCIS/AWS_PLOTS/siteCharts/POR/WTEQ/V

4. Did the peak occur earlier or later than other seasons in the last 30 years? Was it higher or lower?

Your answer here

1.7 Let's add in some remote sensing data. Check out the runoff onset map and select 2021: https://egagli.github.io/view_sar_snowmelt_timing_map/

5. Zoom into the SNOTEL location coordinates. What is the approximate calendar date of runoff onset? (You should convert day of year to calendar date)

Your answer here

6. Why would we expect date of runoff onset to happen at the same time as maximum SWE? Do they end up matching?

Your answer here

1.8 Now let's combine our snow data with some river measurements

- There is (or was, until recently) a stream gage on the Nisqually River downstream of Paradise, near the Longmire Wilderness Information Center (2700 feet)
- We downloaded a CSV from <https://waterdata.morageology.com/data.php?g=4B300A32>
- As we can see below, we get several measurements that could give us some clues

```
[5]: downstream_df = pd.read_csv("longmire_wy2021.csv", parse_dates=True)

# A bit of reformatting for the date field
# What is GMT, and why do you think it's commonly used as the timestamp for
↳ measurements?
downstream_df["GMT Datetime"] = pd.to_datetime(downstream_df["GMT Datetime"])
downstream_df.set_index("GMT Datetime")

# Replace these
downstream_df = downstream_df.replace(-999.9999, np.nan)
downstream_df = downstream_df.replace(-999.0, np.nan)
downstream_df = downstream_df.replace(999.9999, np.nan)

downstream_df.head()
```

```
[5]:      GMT Datetime      Local Datetime  Stage (ft)  Rainfall (in)  \
0 2020-10-01 07:00:00 2020-10-01 00:00:00      1.0901          0.0
1 2020-10-01 07:15:00 2020-10-01 00:15:00      1.1156          0.0
```

2	2020-10-01 07:30:00	2020-10-01 00:30:00	1.0812	0.0
3	2020-10-01 07:45:00	2020-10-01 00:45:00	1.0766	0.0
4	2020-10-01 08:00:00	2020-10-01 01:00:00	1.0740	0.0

	Turbidity (ntu)	Air Temperature (°C)	Dew Point Temperature (°C)	\
0	NaN	12.530		NaN
1	NaN	12.549		NaN
2	NaN	12.478		NaN
3	NaN	12.429		NaN
4	NaN	12.369		NaN

	Water Temperature (°C)	Enclosure Temperature (°C)	\
0	6.549	12.2	
1	6.526	12.0	
2	6.506	12.0	
3	6.492	11.8	
4	6.484	11.6	

	Turbidity Temperature (°C)	10-hour Fuel Temperature (°C)	\
0	NaN	12.5	
1	NaN	12.4	
2	NaN	12.4	
3	NaN	12.4	
4	NaN	12.3	

	Relative Humidity (%)	Unnamed: 12	Water Conductivity (S/cm)	\
0	-99.0	NaN	12.629	
1	-99.0	NaN	12.612	
2	-99.0	NaN	12.604	
3	-99.0	NaN	12.601	
4	-99.0	NaN	12.624	

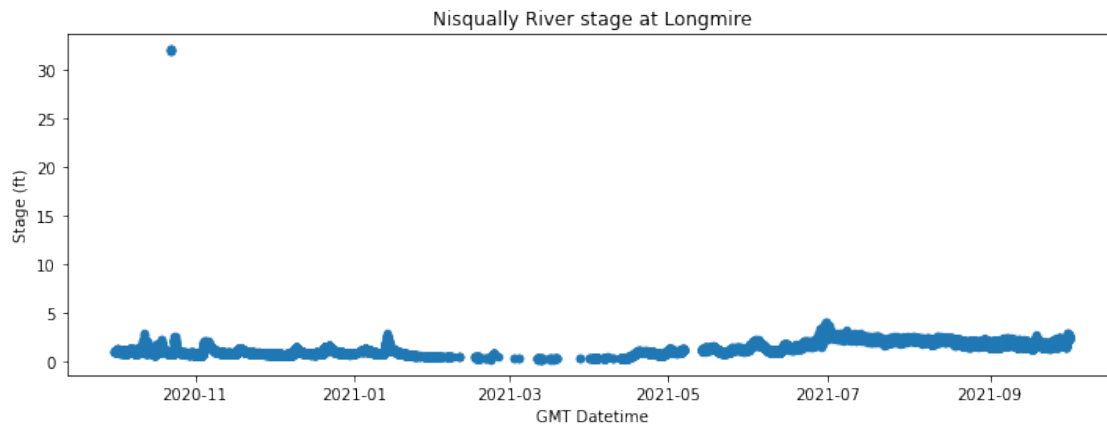
	Air Level (ft)	Water Level (psi)	Battery (V)
0	30.926	13.855	13.2
1	30.926	13.866	13.2
2	30.928	13.852	13.2
3	30.928	13.850	13.2
4	30.926	13.848	13.2

1.9 Plotting the water level over the year

In our case, we are only curious about the stage (height level) of the Nisqually River, and connecting this to what's happening relative to the snow at our Paradise site.

```
[6]: f,ax=plt.subplots(figsize=(12,4))
      downstream_df.plot.scatter("GMT Datetime", "Stage (ft)",ax=ax)
      ax.set_title("Nisqually River stage at Longmire")
```

```
[6]: Text(0.5, 1.0, 'Nisqually River stage at Longmire')
```

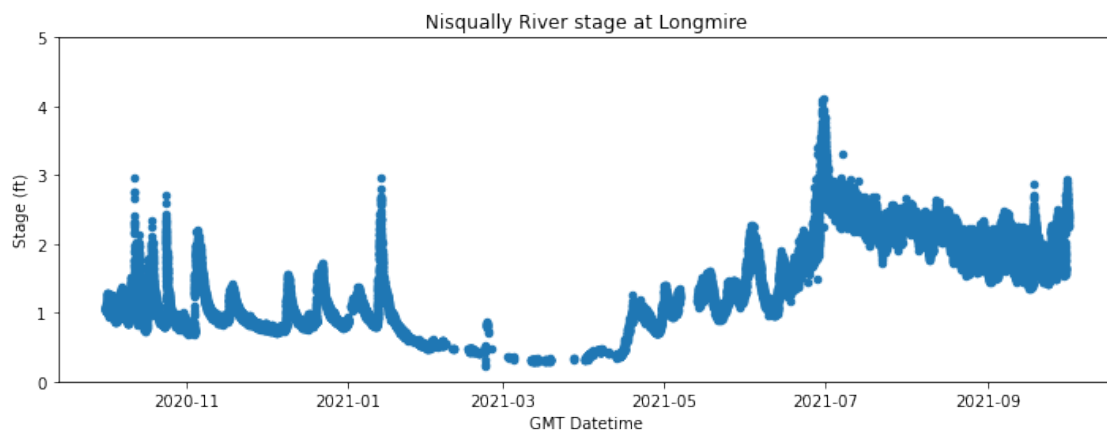


7. Hmm... is that a plausible measurement of the stage in November? What would have happened if that was real?

Your answer here

```
[7]: f,ax=plt.subplots(figsize=(12,4))
downstream_df.plot.scatter("GMT Datetime", "Stage (ft)",ax=ax)
plt.ylim(0,5)
plt.title("Nisqually River stage at Longmire")
```

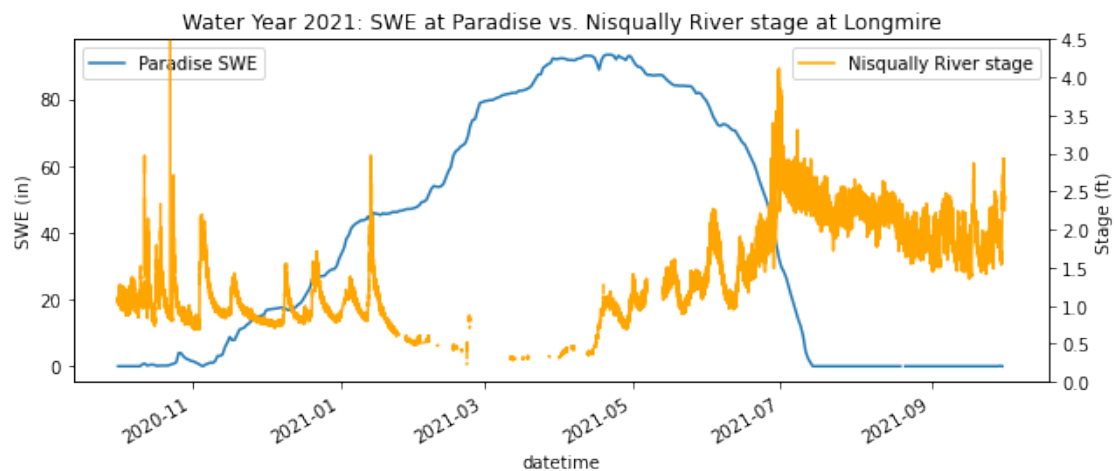
```
[7]: Text(0.5, 1.0, 'Nisqually River stage at Longmire')
```



1.10 Let's plot our two datasets together

```
[8]: fig, ax = plt.subplots(nrows=1, sharex=True, figsize=(10,4))
ax0 = ax
df["SWE"].plot(ax=ax0, label="Paradise SWE")
ax0.set_ylabel("SWE (in)")
ax0.set_title("Water Year 2021: SWE at Paradise vs. Nisqually River stage at Longmire")
ax1 = ax0.twinx()
ax1.plot(downstream_df["GMT Datetime"], downstream_df["Stage (ft)"], color="orange", label="Nisqually River stage")
ax1.set_ylim(0, 4.5)
# ax1.set_title("Nisqually River stage at Longmire (downstream of Paradise)")
ax1.set_ylabel("Stage (ft)")
# axes[2].plot(downstream_df["GMT Datetime"], downstream_df["Water Temperature (°C)"])
ax0.legend(loc=2)
ax1.legend(loc=0)
```

[8]: <matplotlib.legend.Legend at 0x7fc914718fa0>



8. Zoom in on late October-November 2020. What does the Paradise SWE measurement tell us about the spikes in the river downstream? Which other variables would help us figure out what is going on here?

Your answer here

9. What's going on in the middle of the winter?

Your answer here

1.11 Transitioning to spring

10. From the April 20th peak SWE for this year, to 0, how long does this melt process take?

Your answer here

(Bonus) Coding exercise: pick a smaller time period and plot the daily temperature range, precipitation, and SWE

[9]: `#Your answer here`

1.12 Wrapping up

11. We found a maximum SWE of 93 inches at the Paradise SNOTEL station for 2021. All of this snow eventually melted and ended up somewhere. Based on your analysis in this assignment, where do you think the water went?

Your answer here

12. Let's say you were tasked to determine the average day of snowmelt in the Nisqually River Basin. What are the benefits of using each dataset: SNOTEL station SWE, SNOTEL station temperature, Nisqually streamgage, remote sensing snowmelt map. Do you think combining datasets would lead to a more accurate prediction?

Your answer here

[]: