Snowpack Group Updates

W210 Capstone
Feb 1(or 8), 2022

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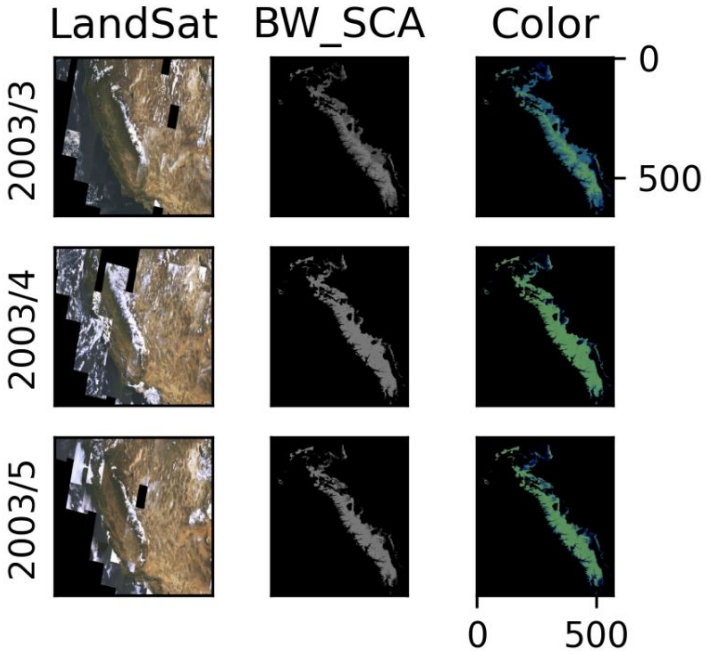
Proposed Outline

- Data/Repo Review
  - “all_data.pkl”
  - Lat/Lon
  - Satellite/Map/Image Data
- Models
  - LSTM-base-model-1b-bestmodel (Predict Groundwater Discharge (“catdef”))
    - “catdef” ?=? “Discharge”?
    - GCP GPU acquisition (SSH headaches)
- Stakeholder Engagement/Interaction
- Ideas for Next Steps & Strategy

Data Review “all_data.pkl”

col_name	col_type	dim	meaning	units
Year	<class 'int'>	1	year of data	?
Month	<class 'int'>	1	month of data	?
SCA	<class 'int'>	1	Star Camera Assembly (SCA) Precisely determines the two satellite's orientation by tracking them relative to the position of the stars. https://earth.esa.int/eogateway/missions/grace	?
Landsat_Image	<class 'PIL.Image.Image'>	(480, 480)	???	?
BW_SCA_Image	<class 'PIL.Image.Image'>	(570, 660)	???	?
Color_SCA_Image	<class 'PIL.Image.Image'>	(570, 660)	???	?
catdef	<class 'numpy.ndarray'>	(33, 37)	catchment deficit (catdef) ; The model prognostic catchment deficit (catdef) [Ducharne et al., 2000] is defined as the average depth of water that would need to be added in order to bring the catchment to saturation and is directly related to the unconfined mean groundwater table depth. https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2015WR018417	kg/(m^(2)*h)
rzexc	<class 'numpy.ndarray'>	(33, 37)	root-zone excess (rzexc) ; Root-zone excess (rzexc) is defined as the amount of water in the root-zone layer (0-100 cm) in excess of the water that would be present if the entire soil moisture profile were in equilibrium. https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2015WR018417 ; see also https://aimesproject.org/wp-content/uploads/2021/06/Girotto_AIMES_v2.pdf	?
evap	<class 'numpy.ndarray'>	(33, 37)	???	?
srfexc	<class 'numpy.ndarray'>	(33, 37)	Surface excess (srfexc) is similarly defined as rzexc but for the surface layer (0-5 cm) https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2015WR018417	?
sfmc	<class 'numpy.ndarray'>	(33, 37)	Surface soil moisture content https://journals.ametsoc.org/view/journals/hydr/22/5/JHM-D-20-0228.1.xml	?
capac	<class 'numpy.ndarray'>	(33, 37)	???	?
Snowf	<class 'numpy.ndarray'>	(33, 37)	???	?
Rainf	<class 'numpy.ndarray'>	(33, 37)	???	?
prmc	<class 'numpy.ndarray'>	(33, 37)	Profile soil moisture content https://journals.ametsoc.org/view/journals/hydr/22/5/JHM-D-20-0228.1.xml	?
sumwesn	<class 'numpy.ndarray'>	(33, 37)	???	?
runoff	<class 'numpy.ndarray'>	(33, 37)	???	?
Tair	<class 'numpy.ndarray'>	(33, 37)	??? air temperature??? https://essd.copernicus.org/preprints/essd-2020-28/essd-2020-28-manuscript-version2.pdf	?
RainfC	<class 'numpy.ndarray'>	(33, 37)	Rain from Convection (RainfC) (paper)	?
rzmc	<class 'numpy.ndarray'>	(33, 37)	Root-zone soil moisture content https://journals.ametsoc.org/view/journals/hydr/22/5/JHM-D-20-0228.1.xml	?

Lat/Long Data Identified




```
lat_file="./data/CA_GRACE_DA/csv/LAT.csv"
lon_file="./data/CA_GRACE_DA/csv/LON.csv"
lat_df=pd.read_csv(lat_file)
print(f"Latitude shape {lat_df.shape}")
lon_df=pd.read_csv(lon_file)
print(f"longitutde shape {lon_df.shape}")
print("latitude data")
print(lat_df.to_numpy(copy=True))
print("longitude data")
print(lon_df.to_numpy(copy=True))
```

```
Latitude shape (33, 37)
longitutde shape (33, 37)
latitude data
[[42.565 42.565 42.565 ... 42.565 42.565 42.565]
 [42.185 42.185 42.185 ... 42.185 42.185 42.185]
 [41.808 41.808 41.808 ... 41.808 41.808 41.808]
 ...
 [31.956 31.956 31.956 ... 31.956 31.956 31.956]
 [31.625 31.625 31.625 ... 31.625 31.625 31.625]
 [31.295 31.295 31.295 ... 31.295 31.295 31.295]]
longitude data
[[-125.66 -125.29 -124.92 ... -112.97 -112.59 -112.22]
 [-125.66 -125.29 -124.92 ... -112.97 -112.59 -112.22]
 [-125.66 -125.29 -124.92 ... -112.97 -112.59 -112.22]
 ...
 [-125.66 -125.29 -124.92 ... -112.97 -112.59 -112.22]
 [-125.66 -125.29 -124.92 ... -112.97 -112.59 -112.22]
 [-125.66 -125.29 -124.92 ... -112.97 -112.59 -112.22]]
```

LSTM-base-model-1b-bestmodel (Predict Groundwater Discharge (“catdef”))

month	snowcap	snowcap_offset_1	snov	...	sfmc	runoff	capac	catdef	Snowf	rzexc	RainfC	rzmc	prmc	evap
1.0	2.979813e+11	2.977106e+11		...	176.212138	621.445111	10.807113	308444.087	76.347303	707.258484	17.374478	194.840829	198.172161	644.21295
2.0	2.835708e+11	2.979813e+11		...	191.026888	546.750853	11.538916	284341.677	315.991364	562.804908	87.382864	207.005523	211.130071	980.11345
3.0	3.262106e+11	2.835708e+11		...	183.253912	554.630849	13.538214	279964.037	174.247548	29.251186	60.586443	207.414268	212.279017	1406.39418
4.0	3.253270e+11	3.262106e+11		...	177.384923	757.990836	21.18							1582.06131
5.0	3.315039e+11	3.253270e+11		...	158.130730	328.847681	11.06							2021.60086
...	...	...		...	...	...								...
8.0	3.126091e+11	3.213242e+11		...	65.524266	24.193515	2.87							742.89978
9.0	2.936131e+11	3.126091e+11			17512327.0									
10.0	2.987715e+11	2.936131e+11			5087669.0									
11.0	2.881262e+11	2.987715e+11			594940.0									
12.0	2.976233e+11	2.881262e+11			51564.0									

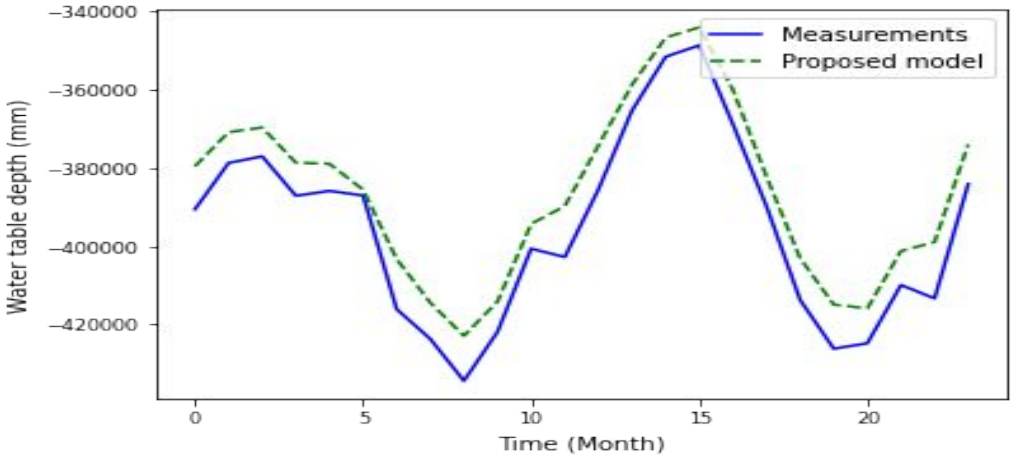
```
$head --verbose --lines=5 disc_snow.csv ~/.ssh/config
==> disc_snow.csv <==
month,discharge,snowcap
1.0,308444.087,297981316896.0
2.0,284341.677,283570815494.0
3.0,279964.037,326210606328.0
4.0,284377.60599999997,325326978657.0

==> /home/esalina/.ssh/config <==
Host *
    ServerAliveInterval 60
    ServerAliveCountMax 10
    ServerAliveInterval 10
$
```

LSTM-base-model-1b-bestmodel (Predict Groundwater Discharge (“catdef”))

```
model = RNN(input_size=inputsize, hidden_size=40, num_layers=1, class_size=1, dropout=0.5, rnn_type='lstm')
model
```

```
RNN(
  (rnn): LSTM(3, 40, batch_first=True)
  (dropout): Dropout(p=0.5, inplace=False)
  (out): Linear(in_features=40, out_features=1, bias=True)
)
```



Inputs

- month
- rzmc
- snowcap_offset_3

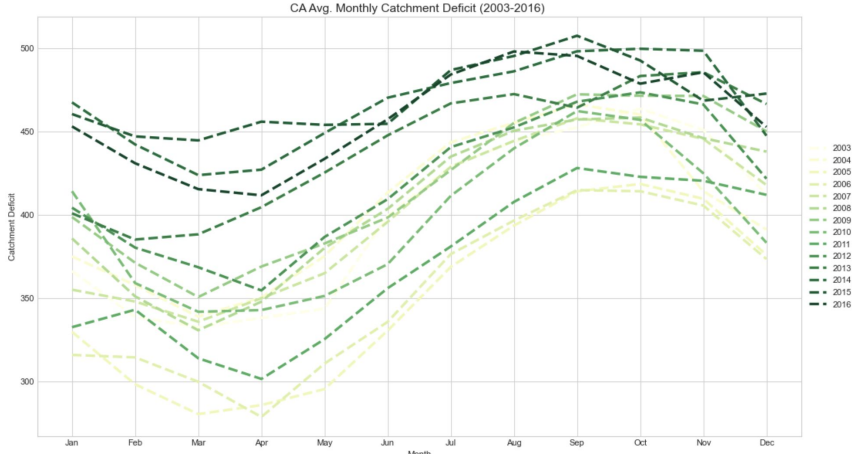
Output

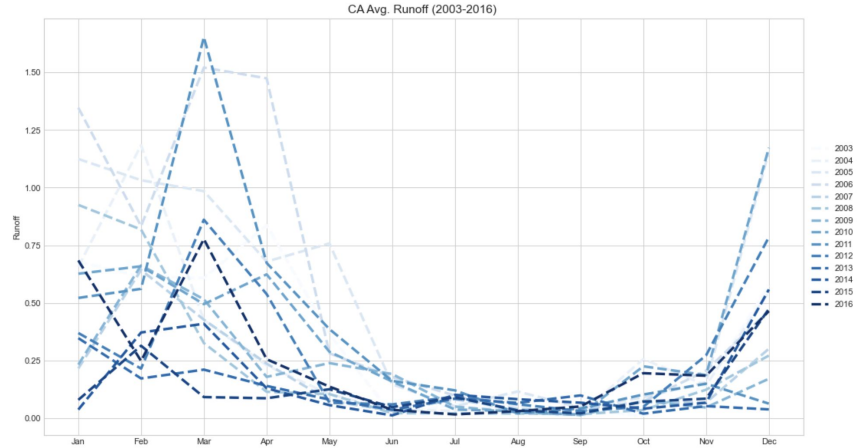
- Catdef

I was able to run it *only* in a container on a GPU-equipped GCP node

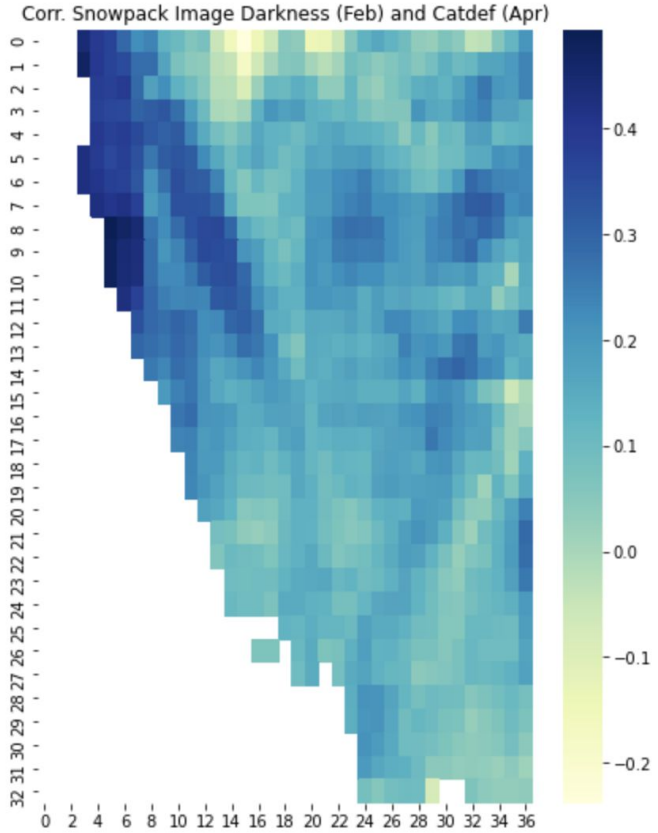
Year-Over-Year Trends of Water Measurements

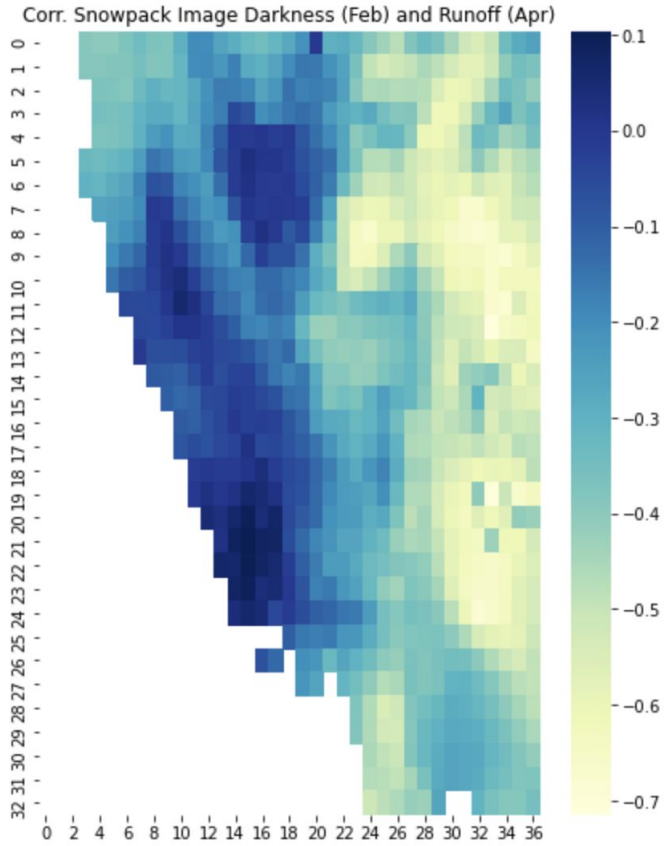
- Highlights seasonality of water table and runoff measurements (and worsening drought conditions)





Correlation Between Image Darkness and Water Measurements



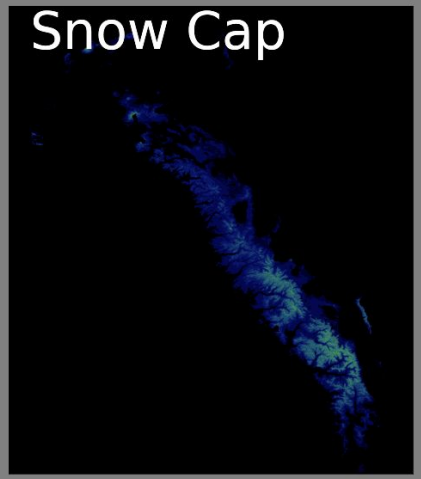


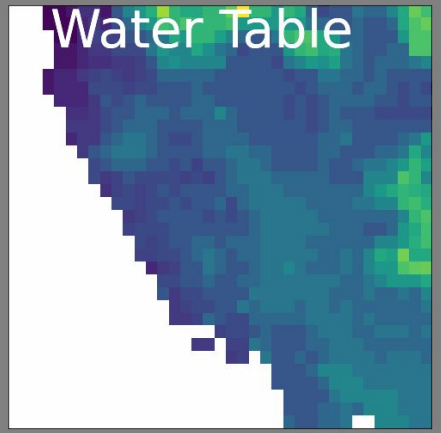
Understanding Problem Space and Domain Expert Conversations

- “The snow/groundwater connection is not as direct as the snow/streamflow connections, but it is there. E.g., the amount of groundwater pumping ends up depending on how much streamflow occurs in a given year because when surface water supplies and deliveries are down, people in the Central Valley turn to groundwater to fill in.” - Michael Dettinger, Climate Science LLC

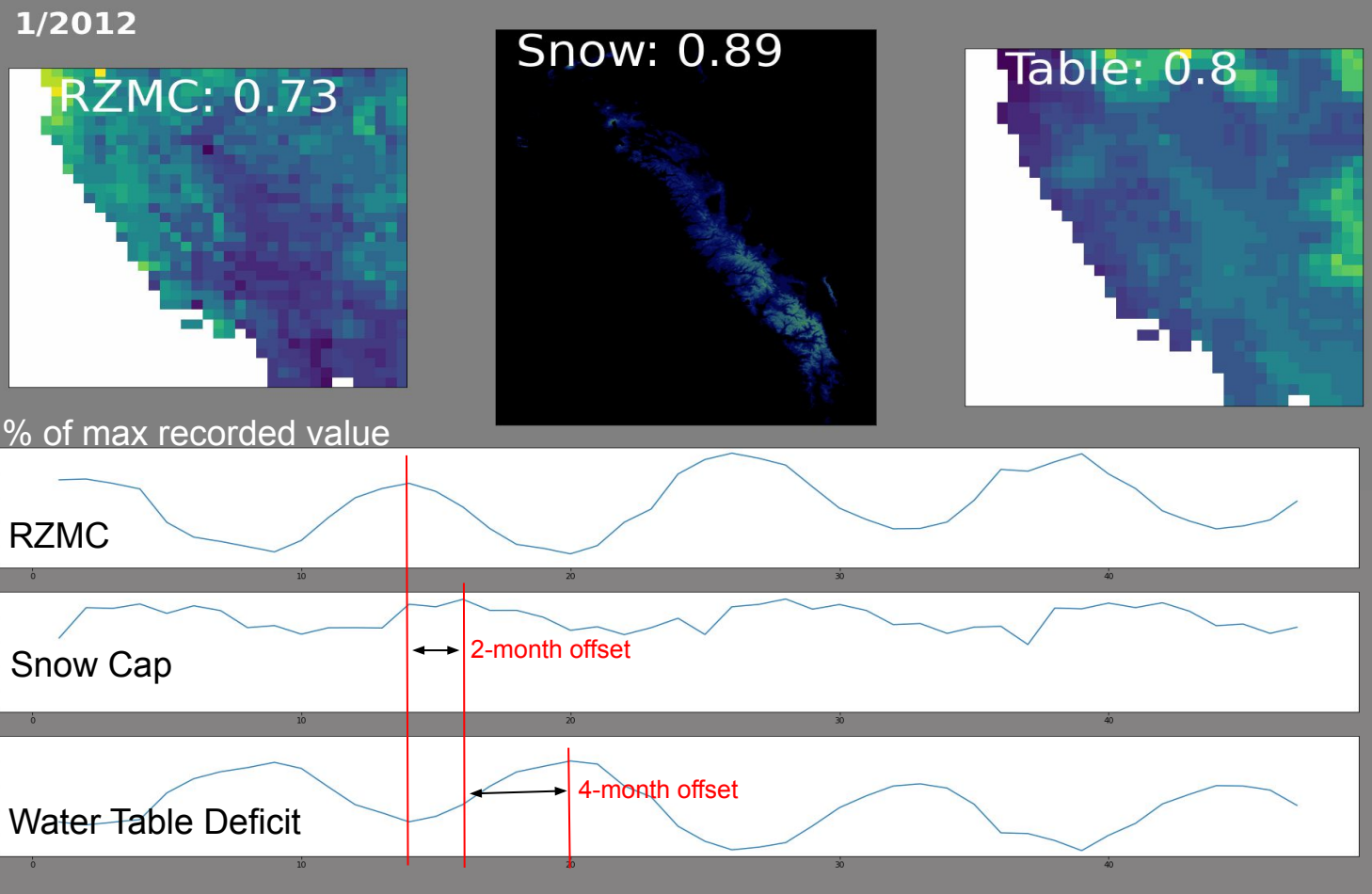
- Upcoming Feb. 7: Discussion with Alvar Escriva-Bou, Public Policy Institute of California

Water Table Prediction from Snow Cap



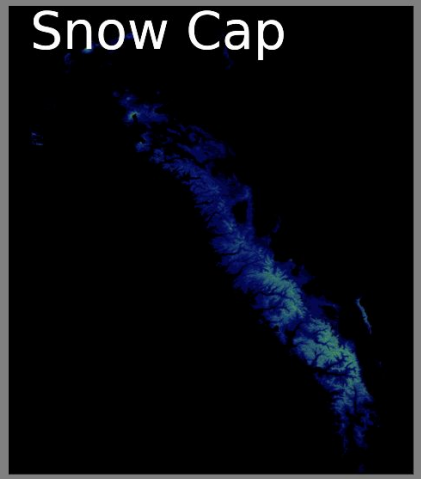


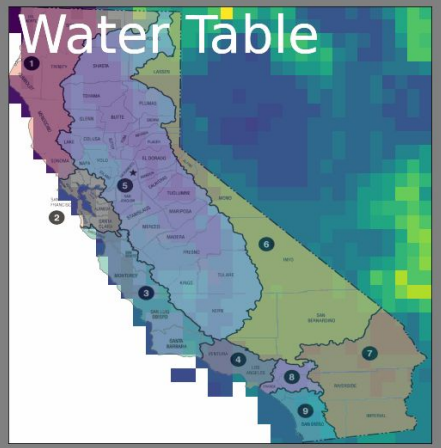
Annual Cycle Offsets



CA Water Boards (Hydrologic Regions)

Water Regions wrt Water Table Heatmap





Water Table Heatmap Simplified to Water Regions