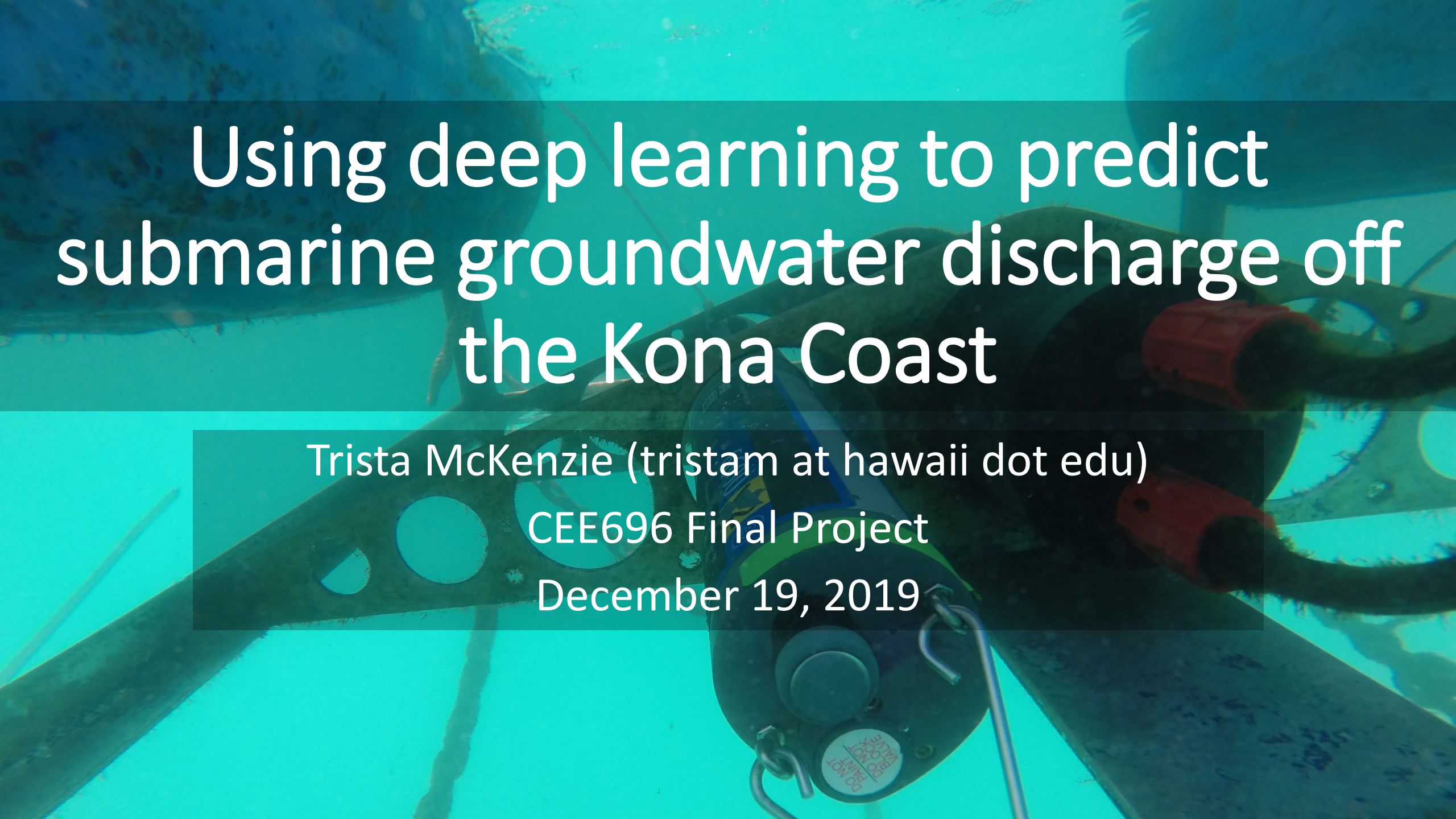


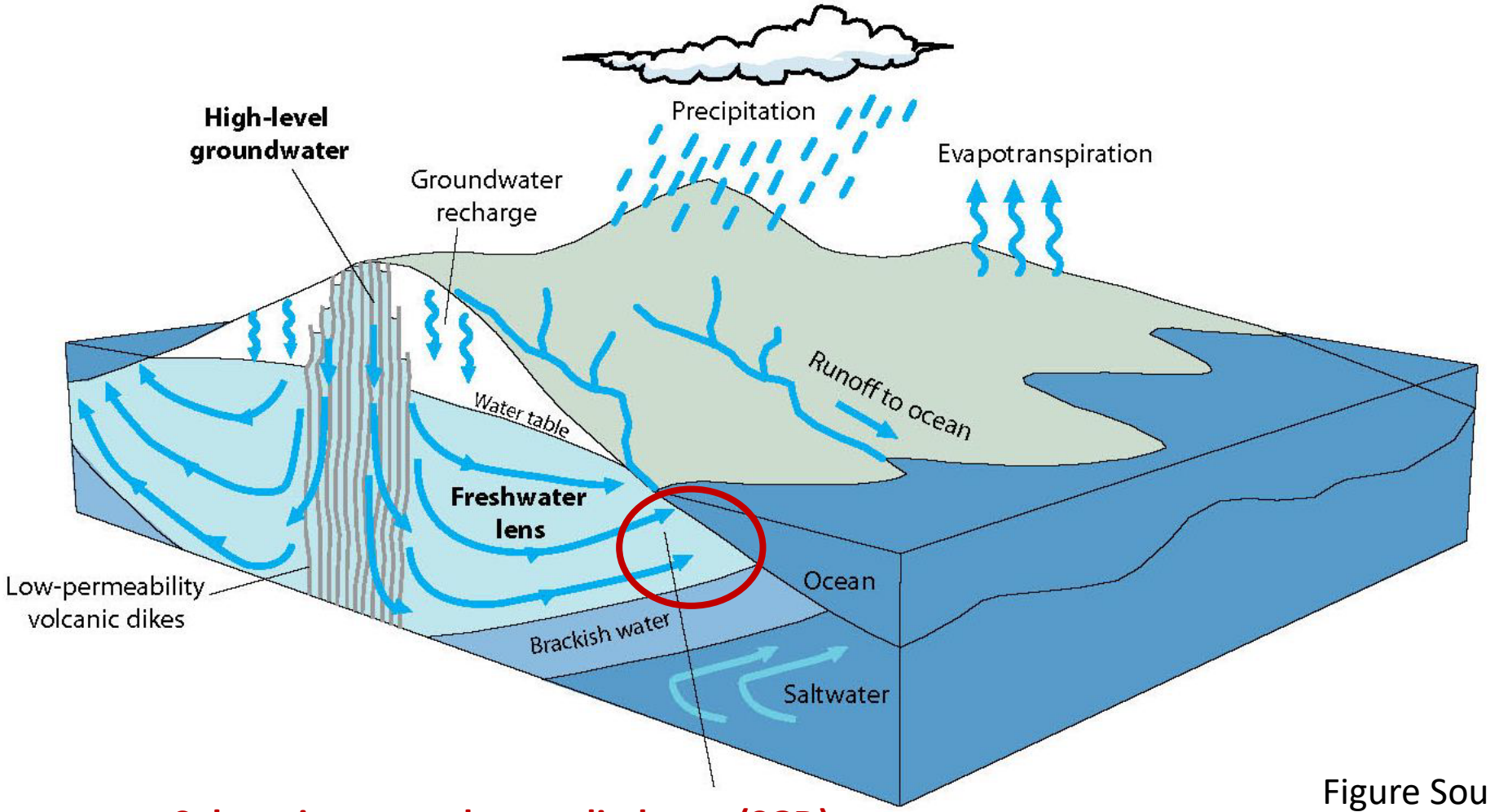
Using deep learning to predict submarine groundwater discharge off the Kona Coast

Trista McKenzie (tristam at hawaii dot edu)

CEE696 Final Project

December 19, 2019

Background



Submarine groundwater discharge (SGD)

Figure Source: USGS, 2015

Study Site

Kīholo Bay, Big Island

- Open Embayment & Lagoon
- No streamflow
- Coastal aquifer: unconfined basal lens and dike impounded water
- SGD along coastline

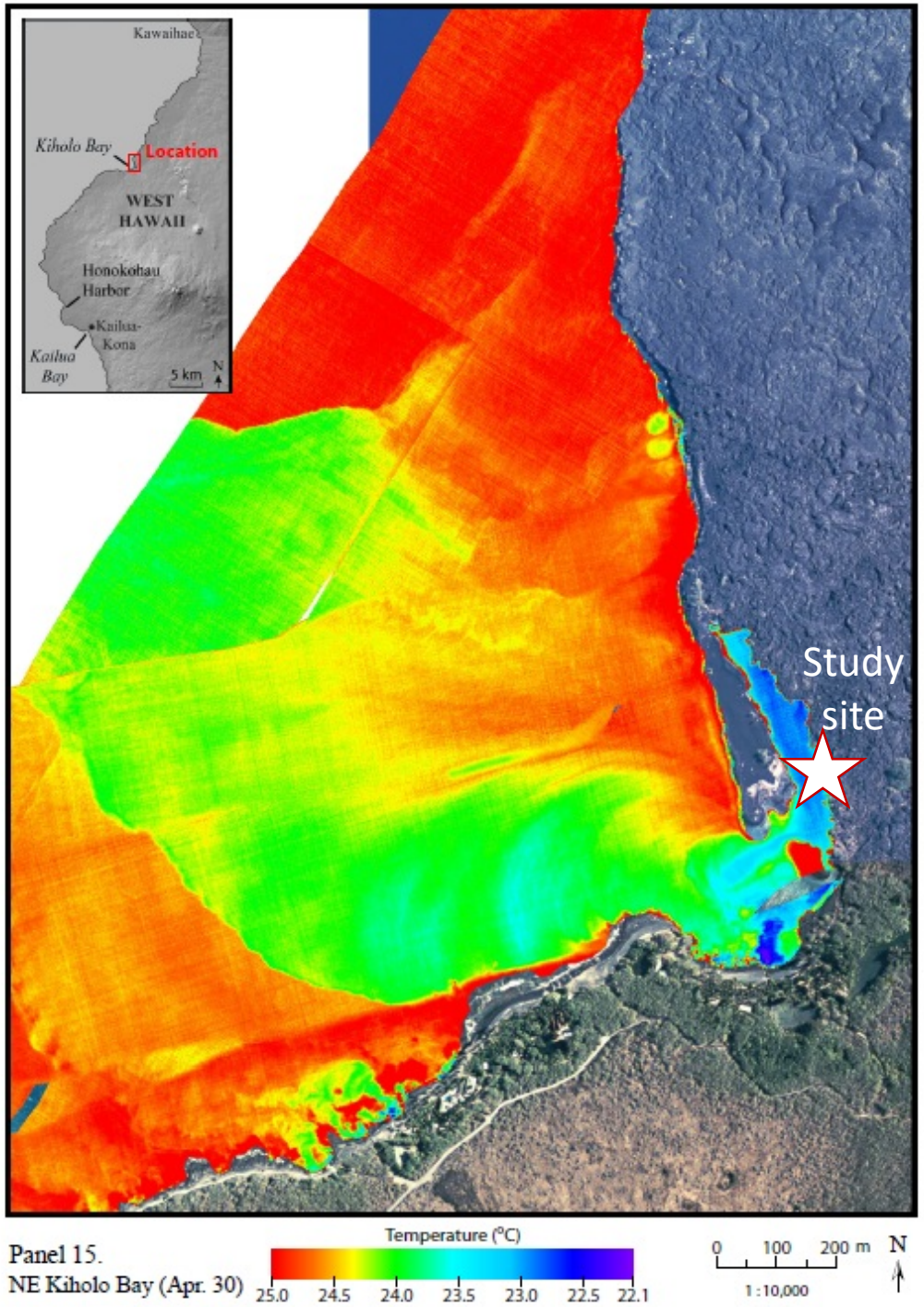
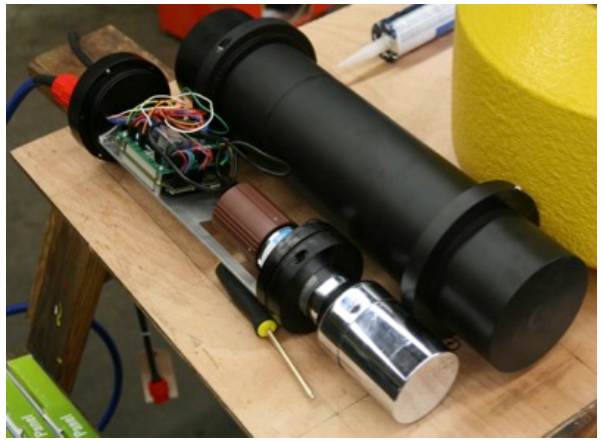


Figure Source: Johnson et al., 2008

Data Acquisition: SGD Sniffer

SGD Sniffer: fully autonomous gamma-spectrometer

- measures ^{222}Rn (radon): groundwater tracer
- 1-hour resolution Rn measurements
- Rn allows for calculation of SGD



Data

- SGD Sniffer deployed in Kīholo Bay 2014-2018
- 18,223 data points
- Tidal effects and seasonality in SGD evidenced by time series data analysis

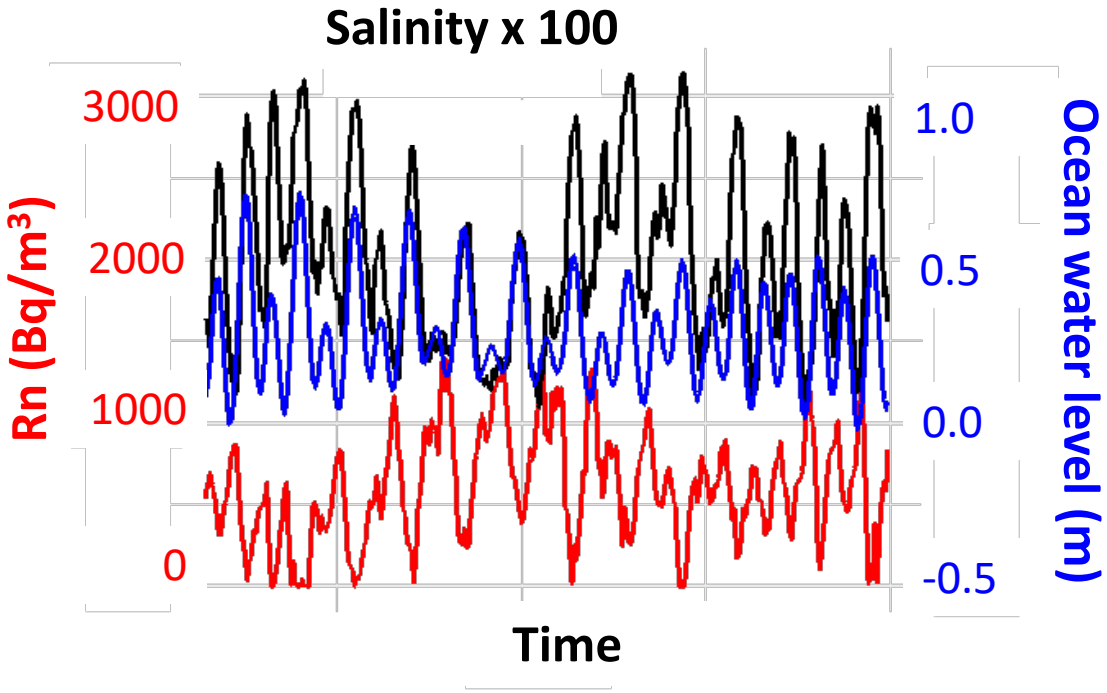


Figure Source: Dulai & Fuleky, 2018

Methods

Input: Rn, Water depth, water temperature, water salinity, groundwater level (USGS), ocean water level (NOAA), air temperature (RAWS), wind speed (RAWS), relative humidity (RAWS), precipitation (RAWS)

Output: SGD

Two models: DNN and CNN with 1DConv

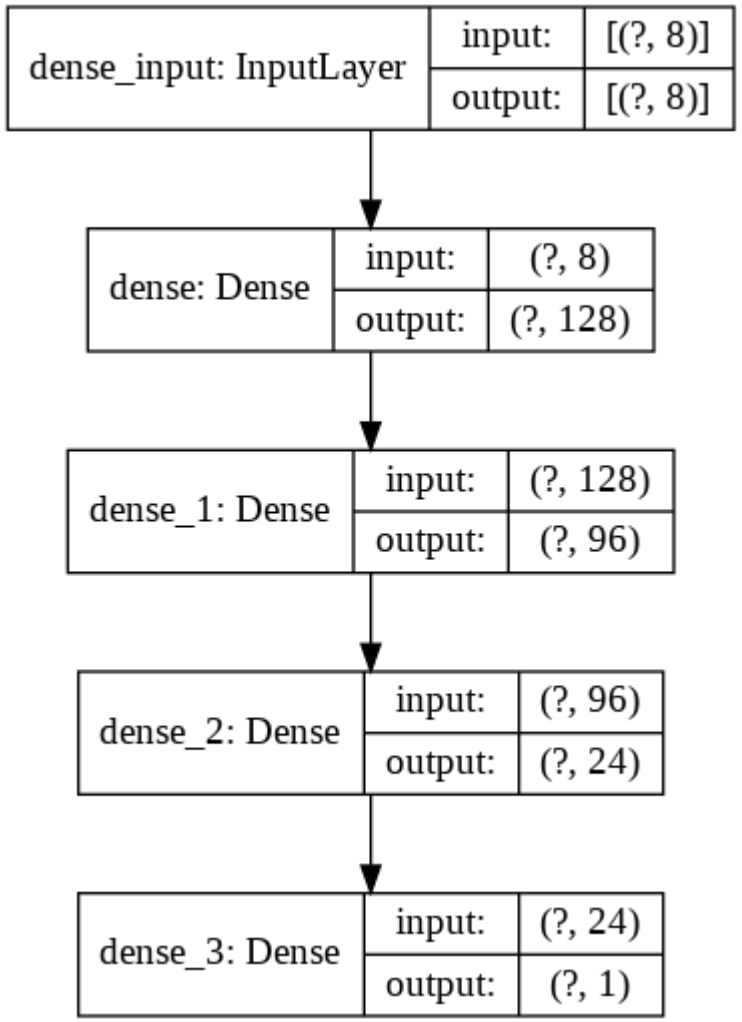
DNN Model

90/10 train/test split

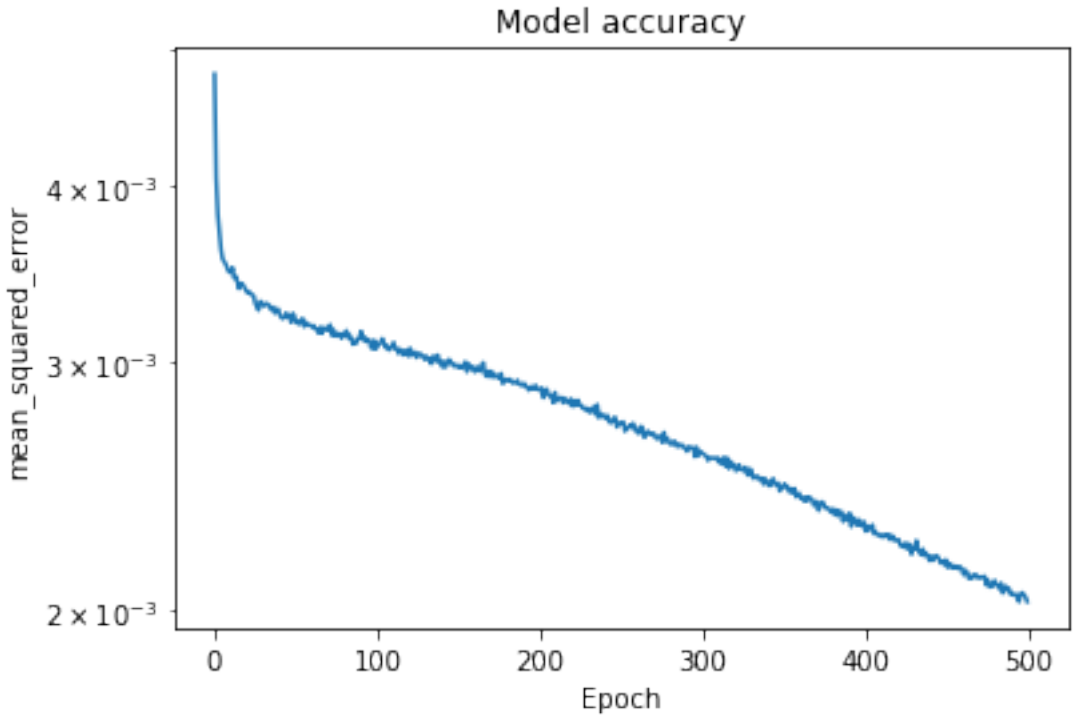
4 fully connected layers

Adam optimizer

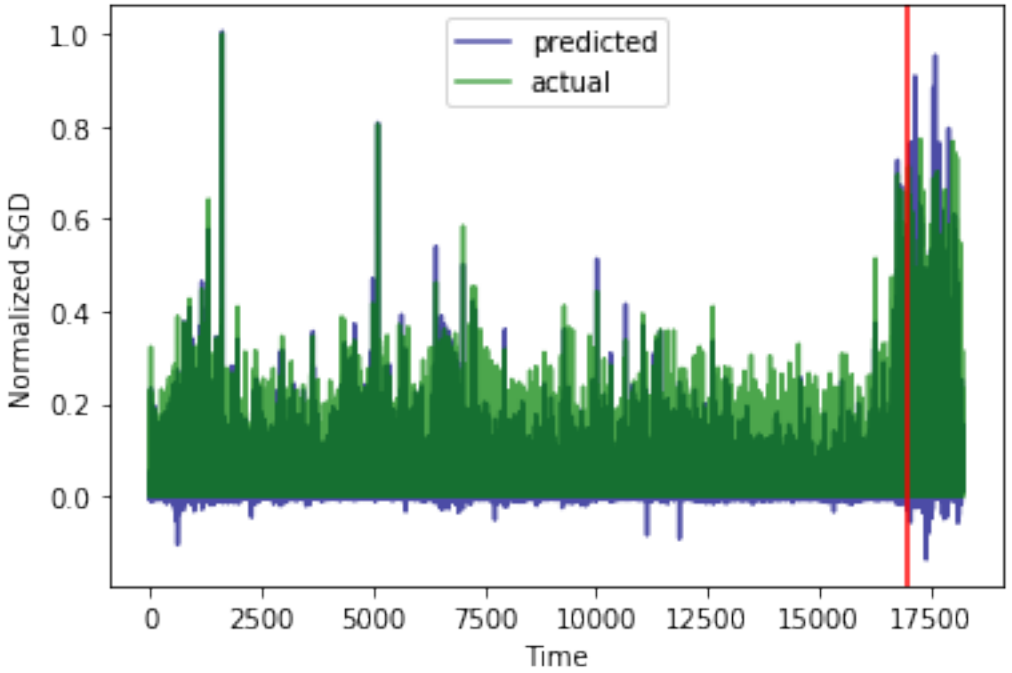
```
model1b = tf.keras.Sequential()
model1b.add(Dense(128, activation = 'relu', input_s
hape = (8,)))
model1b.add(Dense(96, activation = 'sigmoid'))
model1b.add(Dense(24, activation = 'elu'))
model1b.add(Dense(1))
model1b.compile(optimizer = 'adam', loss =
'mean_squared_error', metrics = ['mse'])
model1b.summary()
```

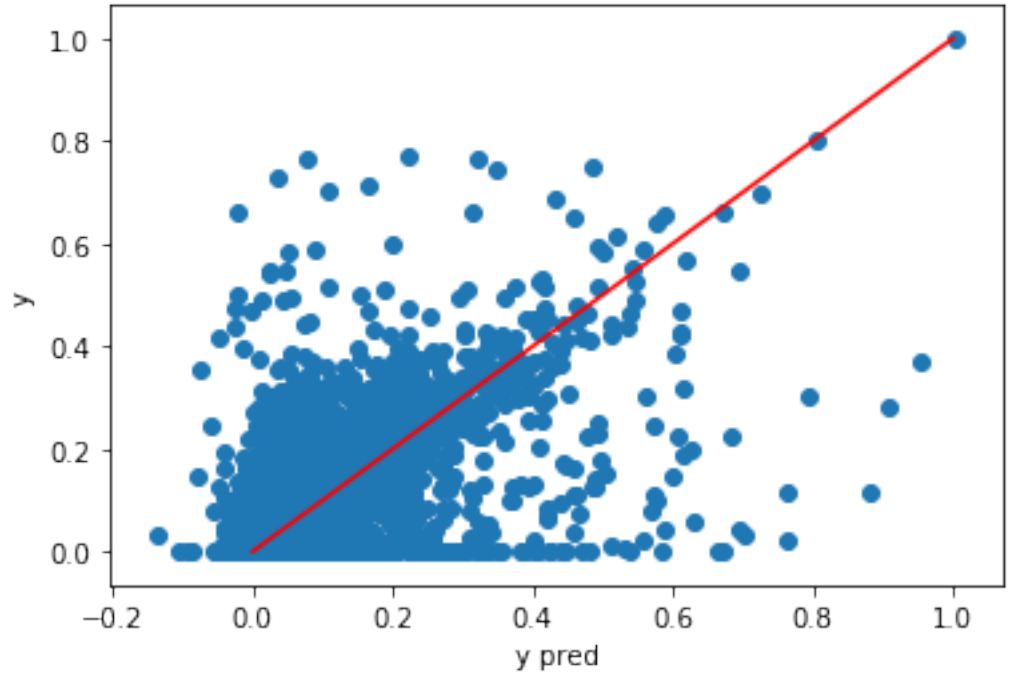


DNN Model Results

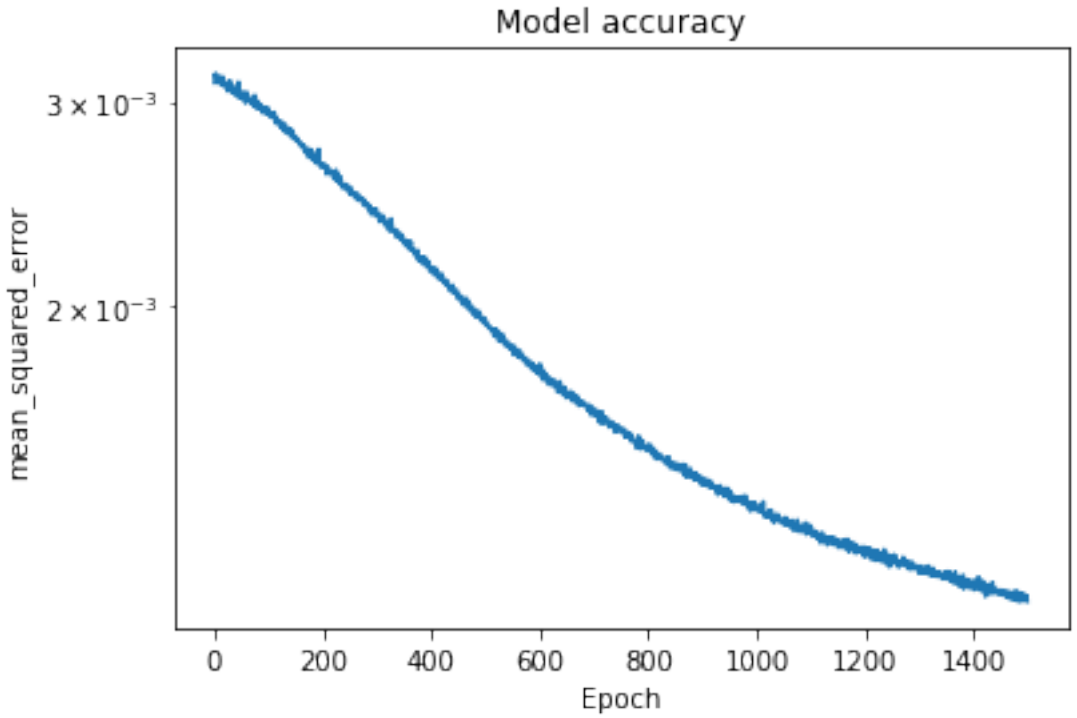



```
hist1b = model1b.fit(x_train1b, y_train1b,
epochs = 500, batch_size = 6, verbose = 1)
```

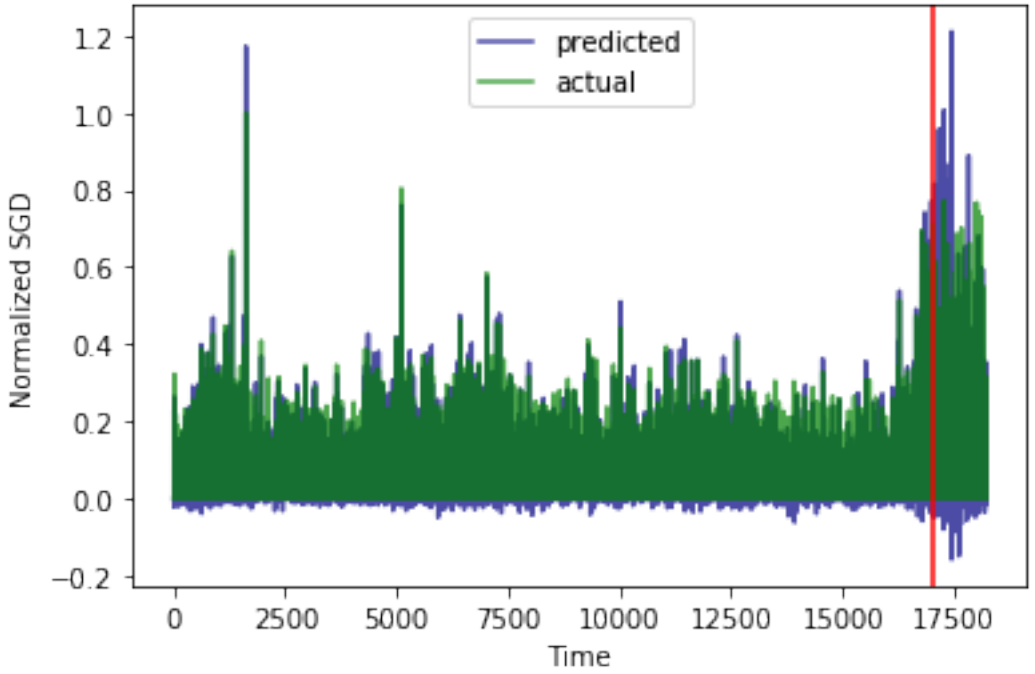


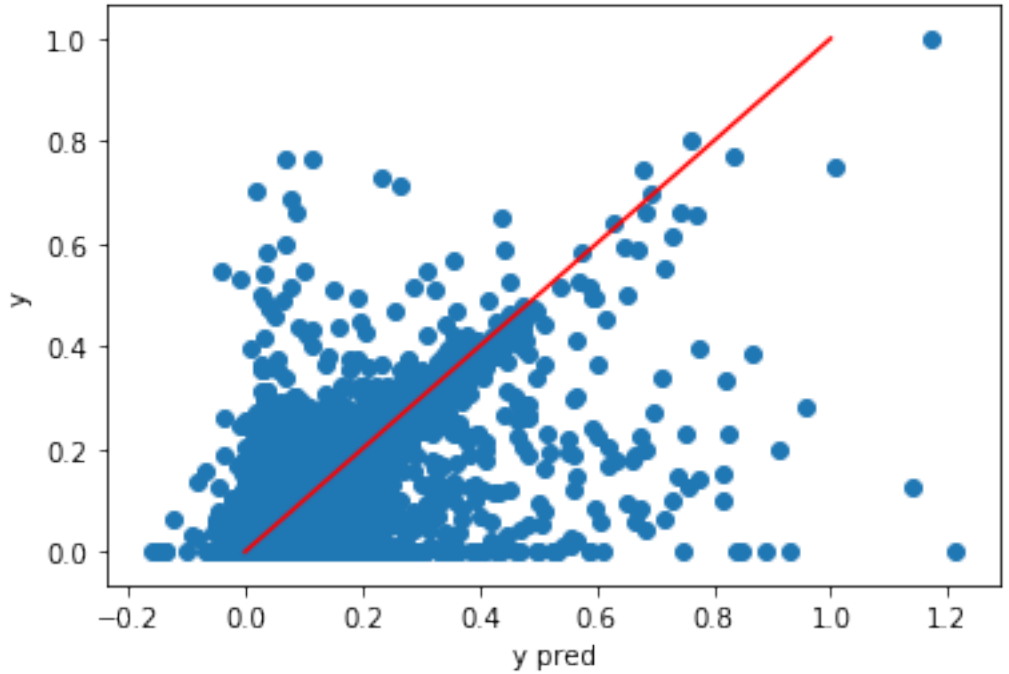


DNN Model Results




```
hist1b = model1b.fit(x_train1b, y_train1b,
epochs = 1500, batch_size = 6, verbose = 1)
```





CNN Model

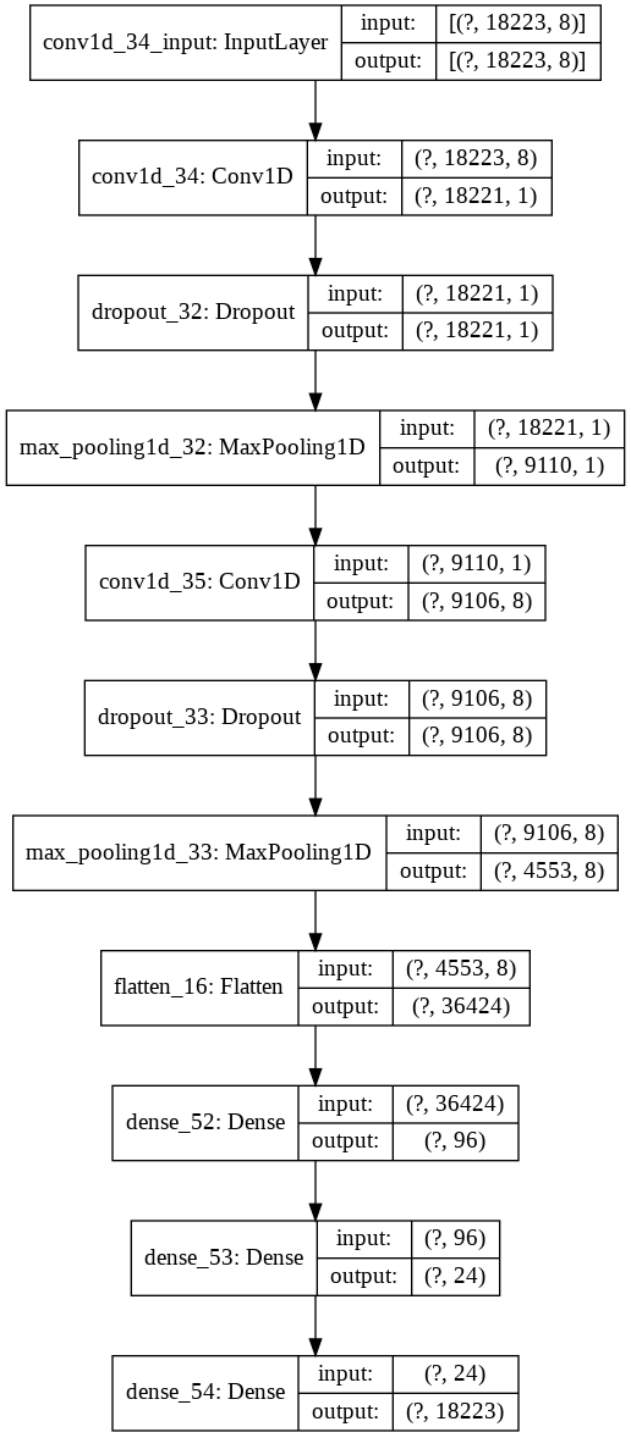
50/50 train/test split

2 CNN

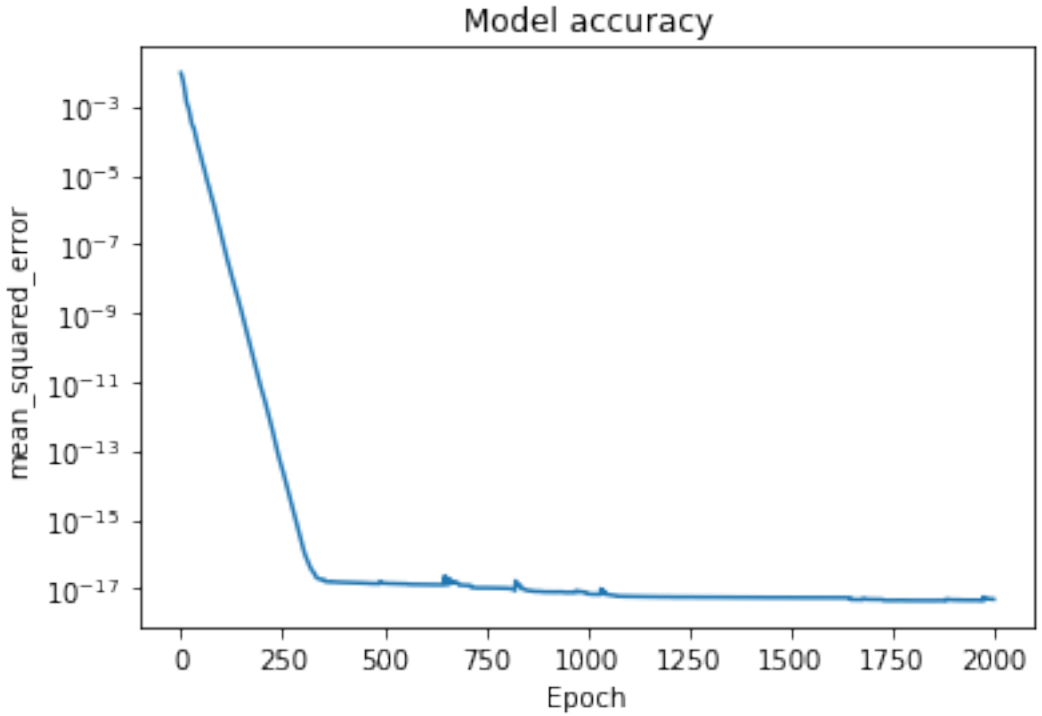
3 fully connected layers

Adam optimizer

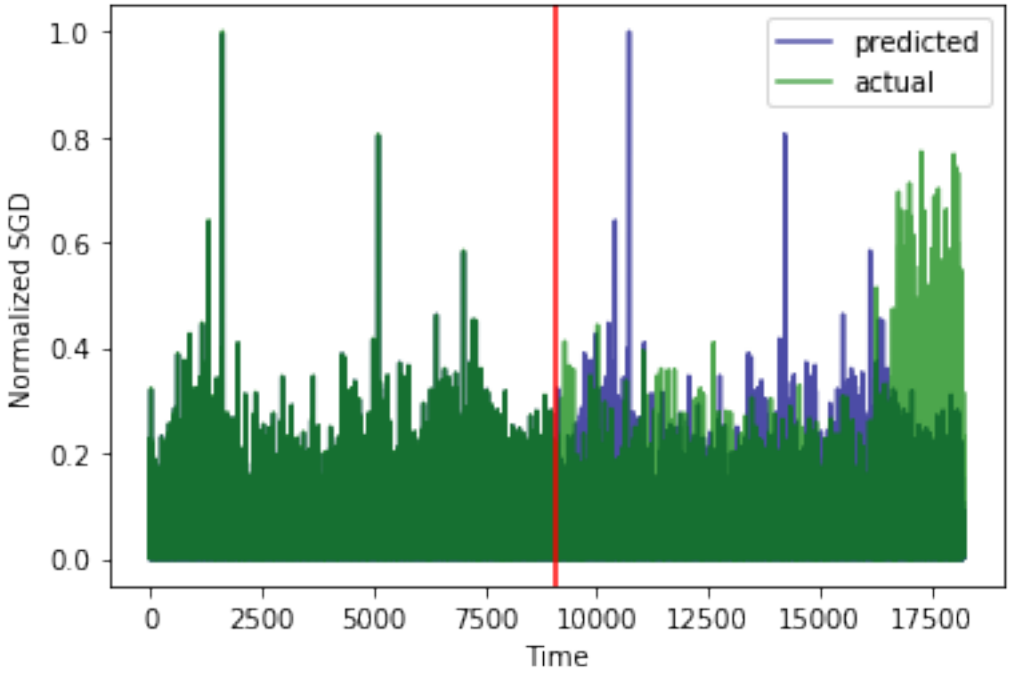
```
model5 = tf.keras.Sequential()
model5.add(Conv1D(filters = 1, kernel_size = 3, activation = 'relu',
input_shape = (N,8)))
model5.add(Dropout(0.5))
model5.add(MaxPooling1D(pool_size = 2))
model5.add(Conv1D(filters = 8, kernel_size = 5, activation = 'relu'))
model5.add(Dropout(0.5))
model5.add(MaxPooling1D(pool_size = 2))
model5.add(Flatten())
model5.add(Dense(96, activation = 'sigmoid'))
model5.add(Dense(24, activation = 'elu'))
model5.add(Dense(N))
model5.compile(loss = 'mean_squared_error', optimizer =
'adam', metrics = ['accuracy'])
```

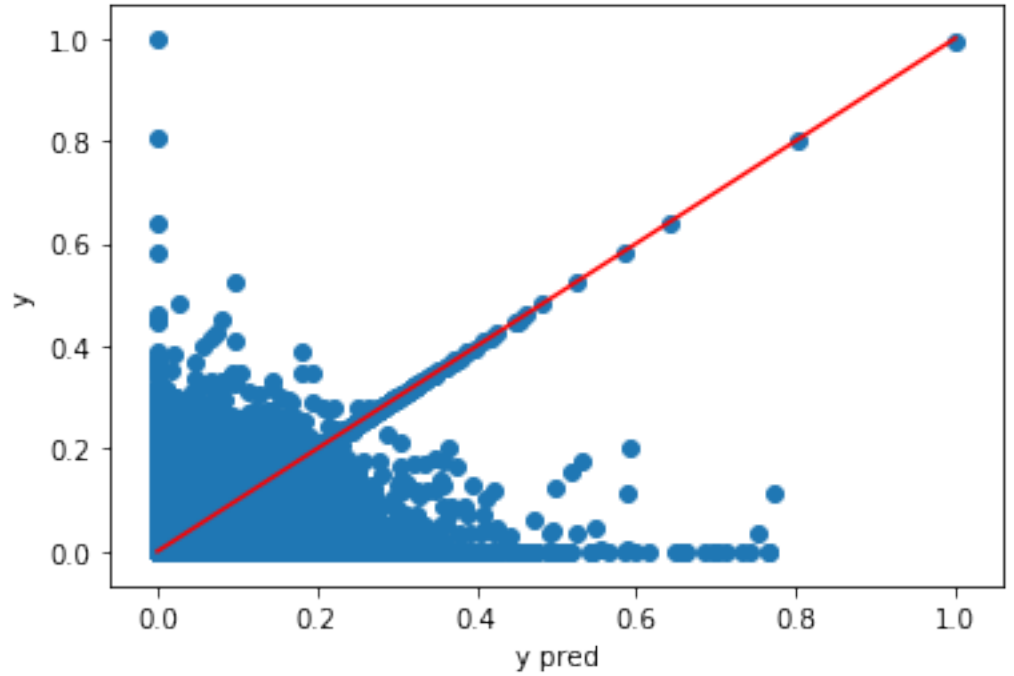


CNN Model Results




```
hist5 = model5.fit(x1, y1, epochs = 2000,
 batch_size = 12, verbose = 1)
```





Future Work & Conclusion

Future Work:

1. Improve model accuracy
2. Use model to fill in missing data

Conclusion:

1. The DNN and CNN models show promising results for modeling SGD.

Thank you!

Acknowledgements

SGD Sniffer Fabrication: Dulai et al., 2015

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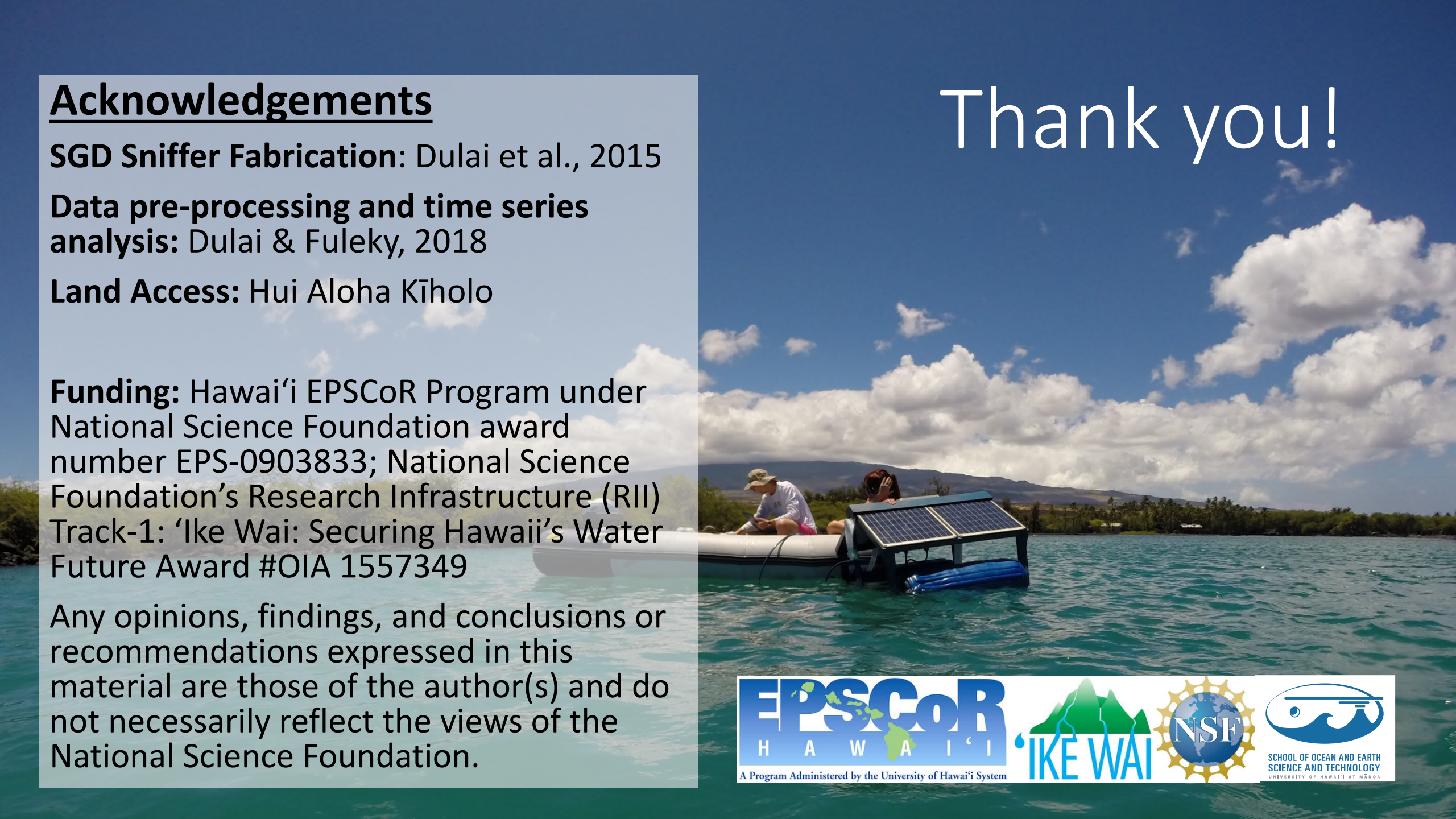

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Dulai & Fuleky, 2018. Time series analysis of a multiyear submarine groundwater discharge record from the Kona coast of Hawaii. EGU Assembly, Vienna, 2018, Abstract HS8.2.10 A.182.

Data obtained from:
Groundwater Level:: http://waterdata.usgs.gov/nwis/uv?site_no=194327156002301
For site: # USGS 083216045/ / 12/ 0 7-4360-01 Kalaoa N. Kona (W12-11), HI

Meteorology: https://raws.dri.edu/cgi-bin/rawMAIN.pl?hiHPUW

Ocean Water Level: NOAA Tides & Currents site 1617433
http://tidesandcurrents.noaa.gov/waterlevels.html?id=1617433&units=metric&bdate=20140313&edate=20140522&timezone=LST&datum=MLLW&interval=h&action=data