LLM Salinity Transportation Modeling

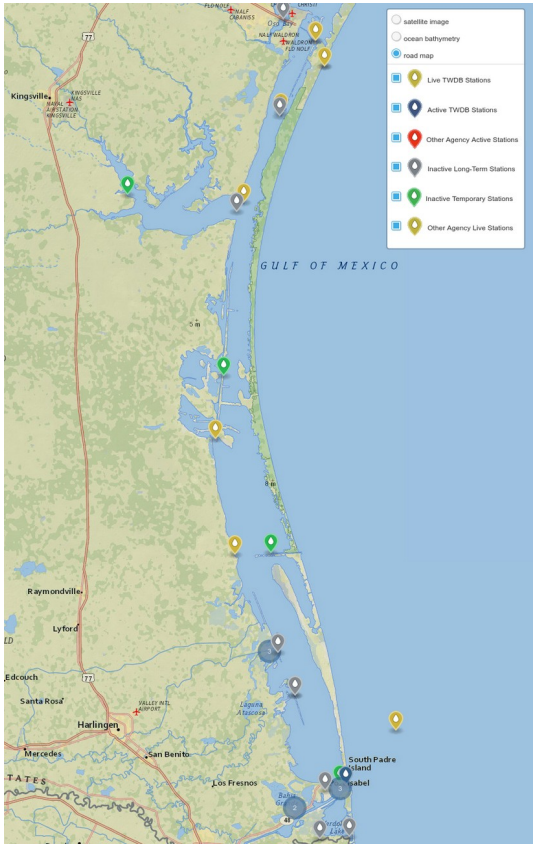
Martin Flores, Jungseok Ho, Ph.D., Dongchul Kim, Ph.D., Nazaru Fatameh, Ph.D., Jungwoo Lee, Ph.D.

Overview

- **Background**
- **Modeling Process**
- **Data**
  - Satellite
  - Salinity
- **Deep Learning (DL) Key Notes**
- **Current Modeling Results**
- **Planned Developments & Scenarios**

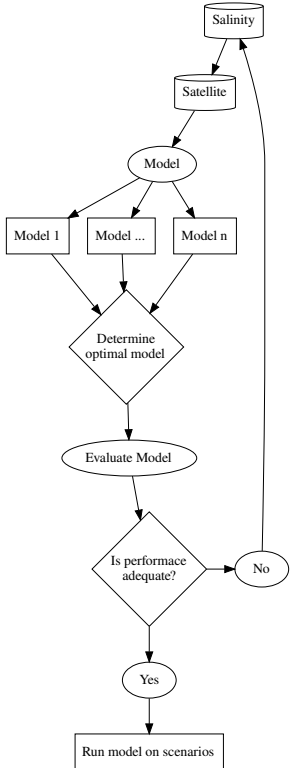
Background

- **Salinity Data in the Laguna Madre is Sparse**
  - *In Situ*
  - Spatially Lacking
- **Sea surface salinity (SSS) is key to climate forecasting and monitoring of marine ecosystems.**



Modeling Process

- **Gather Data**
- **Create Multiple Models**
  - Varying architecture
- **Evaluate Models**
- **Test Models on Scenarios**

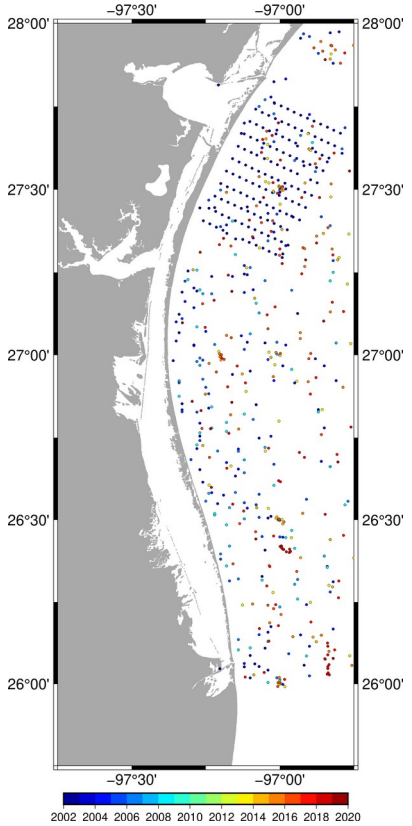


Data

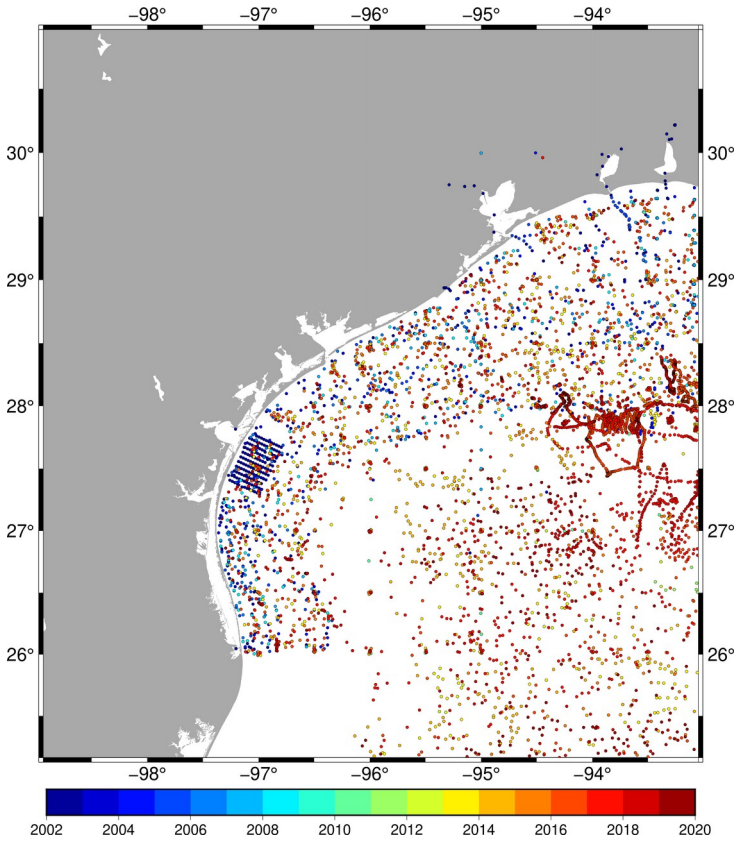
- **Salinity**
  - World Ocean Database (WOD)
  - Water Data for Texas
  - Practical Salinity Unit (PSU)
- **Satellite**
  - MODIS-Aqua
    - Ocean Color (OC)
      - Remote Sensing Reflectance (Rrs)
    - Sea Surface Temperature (SST)

Data: Salinity

- **WOD**
  - Salinity at Multiple Depths
  - Years of 2002-2020 Utilized
  - 5m chosen for study
    - Most data points
    - 3507 Sample points at depth
      - 5130 points ± 0.5 m
  - Only two data points in Laguna Madre

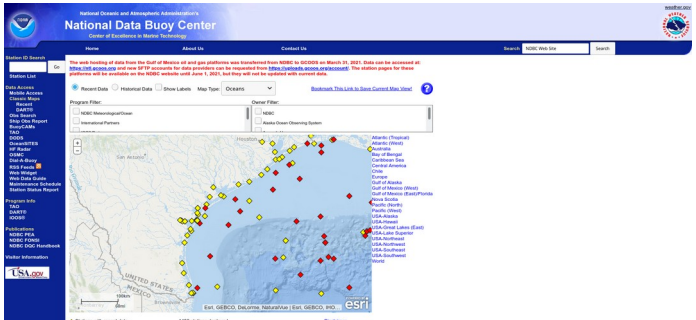


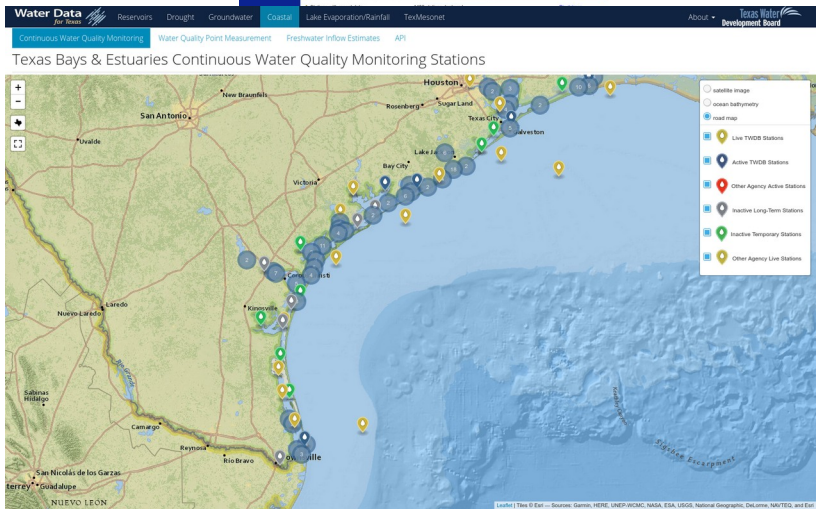
Data: Salinity



Data: Salinity

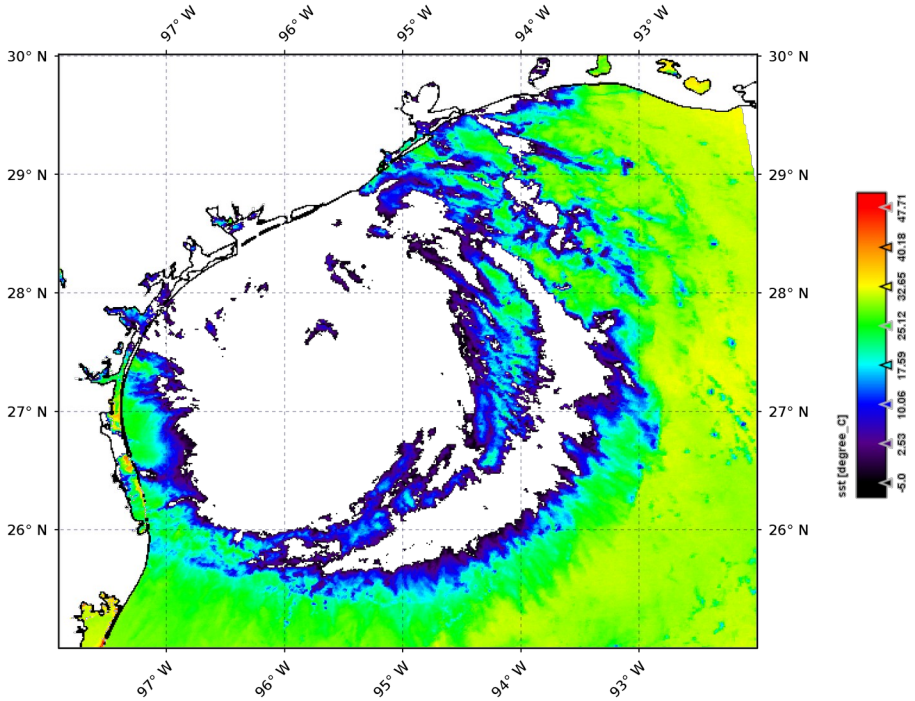
- **NOAA National Data Buoy Center**
  - Lower and Upper Laguna Madre/Off the Coast
    - No salinity data found
- **TWDB Water Data for Texas**
  - *In Situ* data for the Laguna Madre





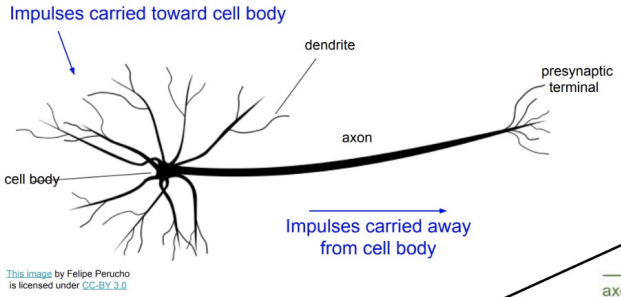
Data: Satellite

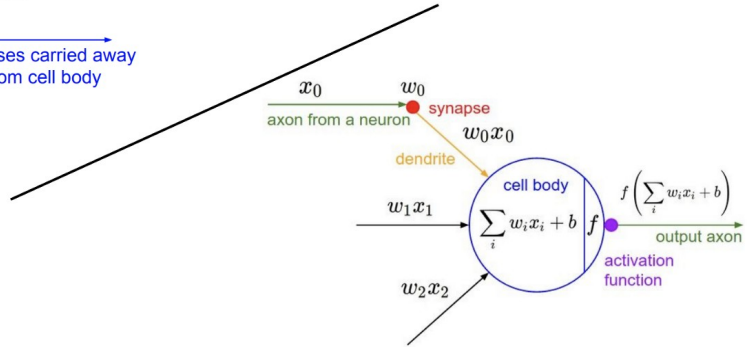
- **MODIS-Aqua**
  - Swaths
    - Irregular Grid Data
  - Subject to Cloud Interference
  - Daily Coverage
    - Coverage Area
    - Quality
      - SST
      - Rrs



Deep Learning Key Notes

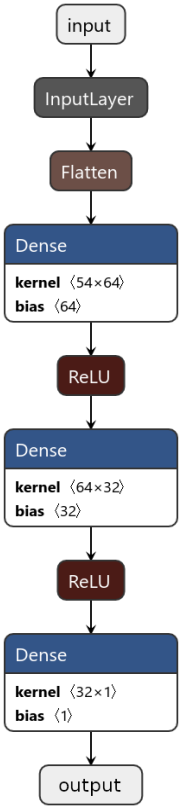
- **Neuron**
  - Core of Deep Learning (DL)
- **“Learns”**
  - Minimize Loss
    - Mean Square Error (MSE)
  - Update Weight and Biases
- **Layers**
  - Increase Dimensionality





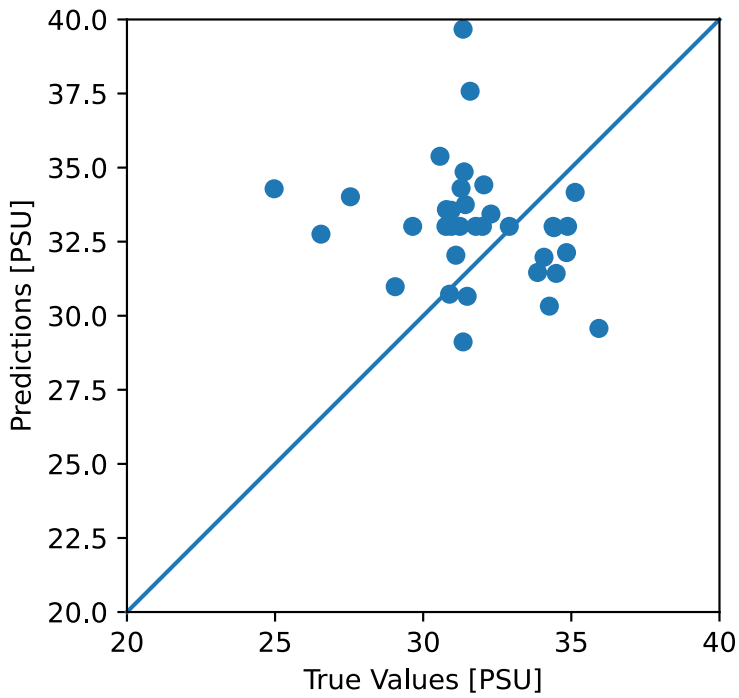
Modeling

- **Pilot Model Evaluation**
  - Now-casting model
  - 1-day forecast model
- **Planned Developments**
  - Model Architecture & Techniques
  - 2-5 day forecast
- **Scenarios of Interest**



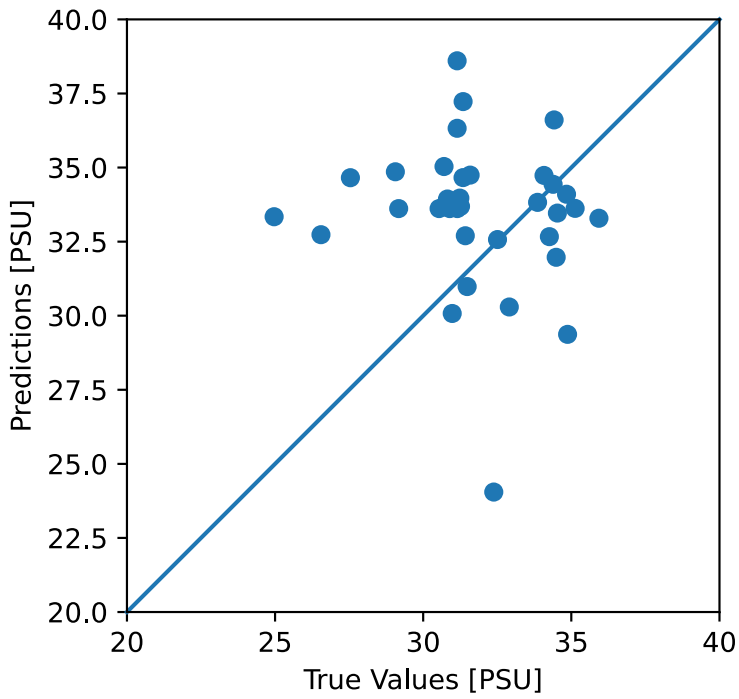
Modeling: Now-Casting

- **Simple DNN**
  - 2 Hidden Dense Layers
    - 64 & 32 Neurons Respectively
- **RMSE of ~4**
- **Results Scattered**
  - Bias towards overestimating

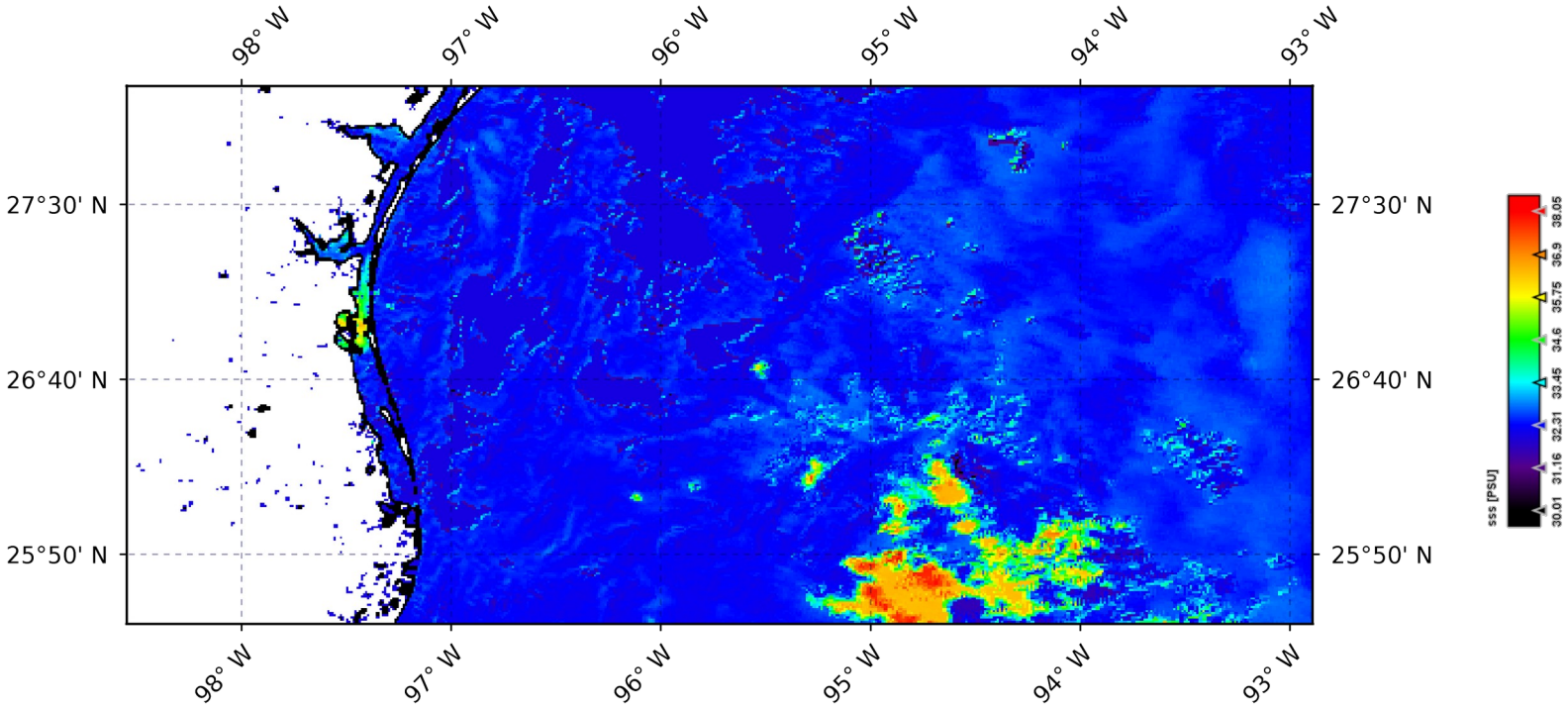


Modeling: 1-Day Forecast

- **Same architecture as previous**
- **RMSE similar to Now-Casting**
  - Slight increase in error
- **Scattered Results**
  - ~10 PSU outlier

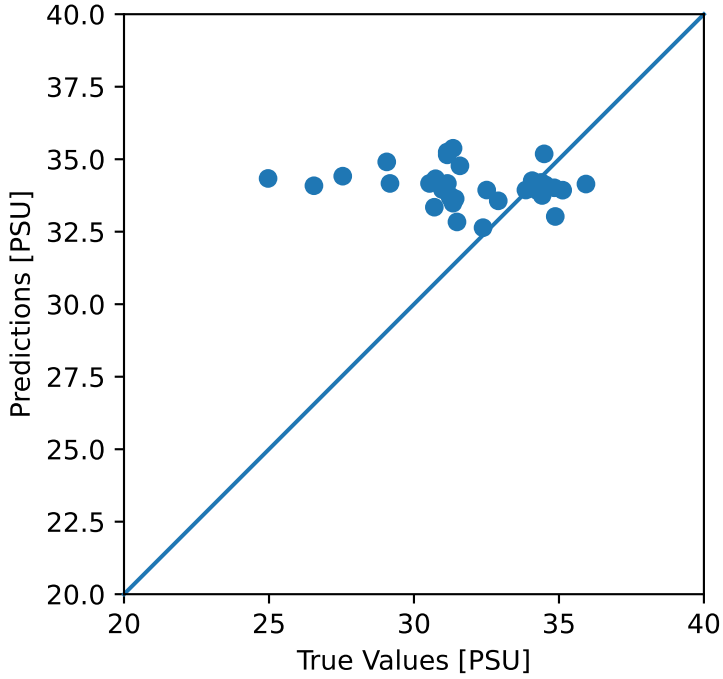


Modeling: 1-Day Forecast



Modeling: Planned Developments

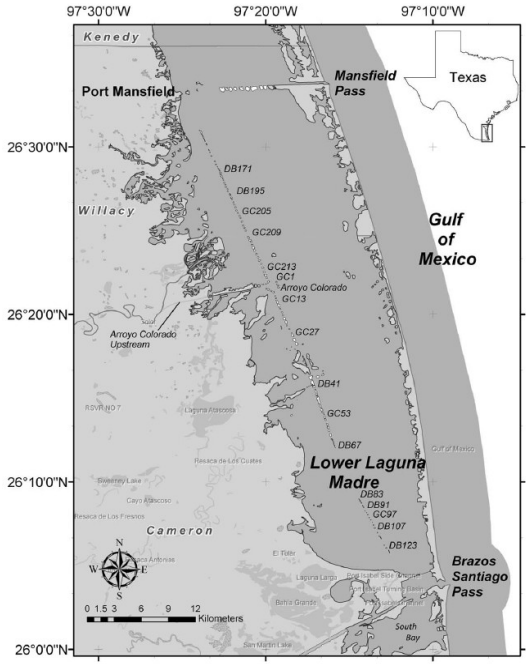
- **Prevent overfitting**
  - Dropout Layers
  - Batch Regularization
- **Different architectures**
  - CNN before Dense Layers
- **Discover cause of bias**
- **Implement 2-5 day forecasting**

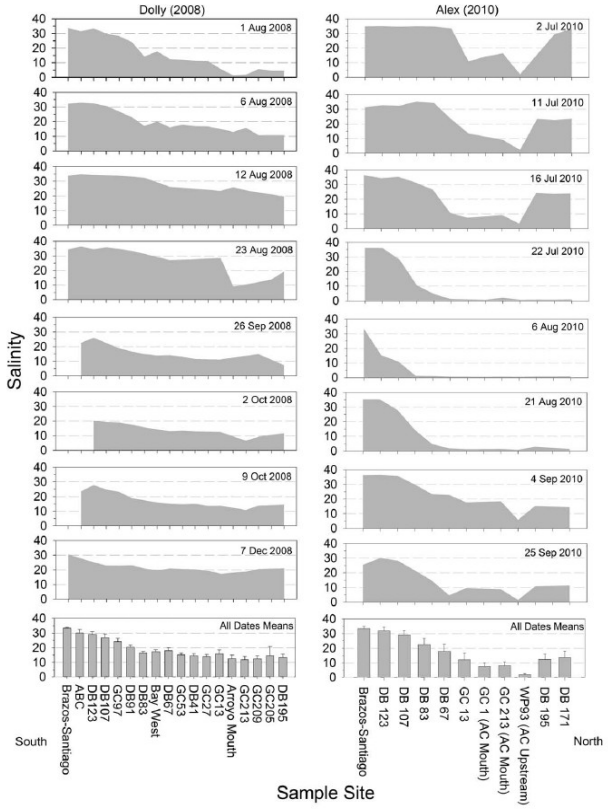


Modeling: Scenarios of Interest

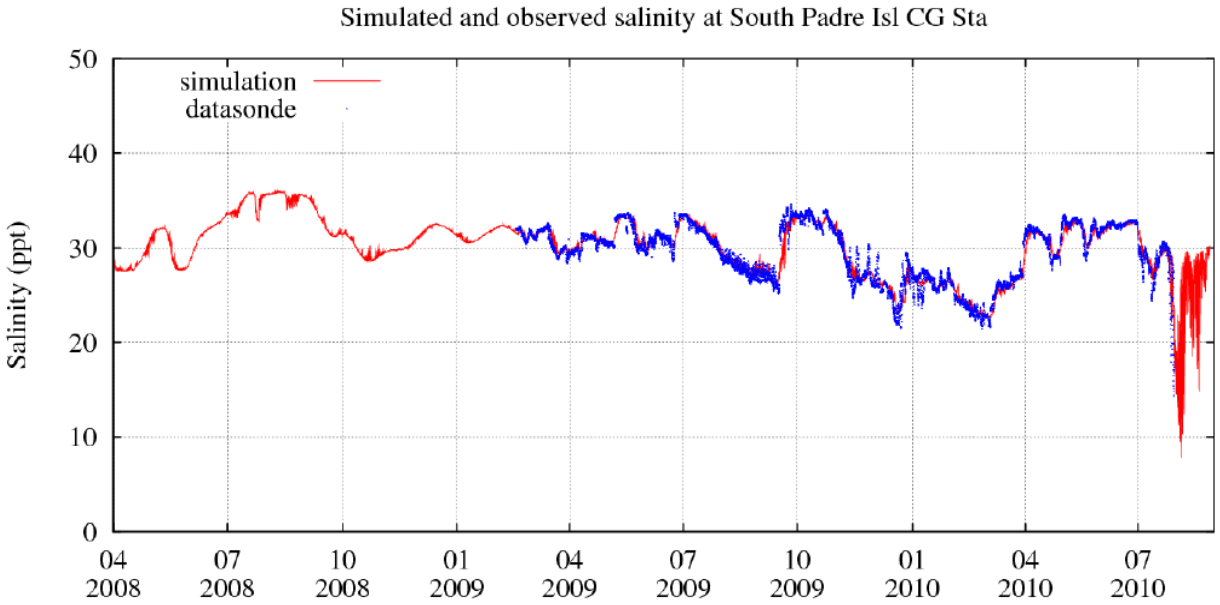
- **Hurricane Events**
  - Dolly & Alex
    - Hanna
  - Depressed Salinity Throughout
  - Arroyo Colorado Heavily Affected
- **TxBLEND**
  - Comparison to Numerical Model
    - Point Based
    - Map Based

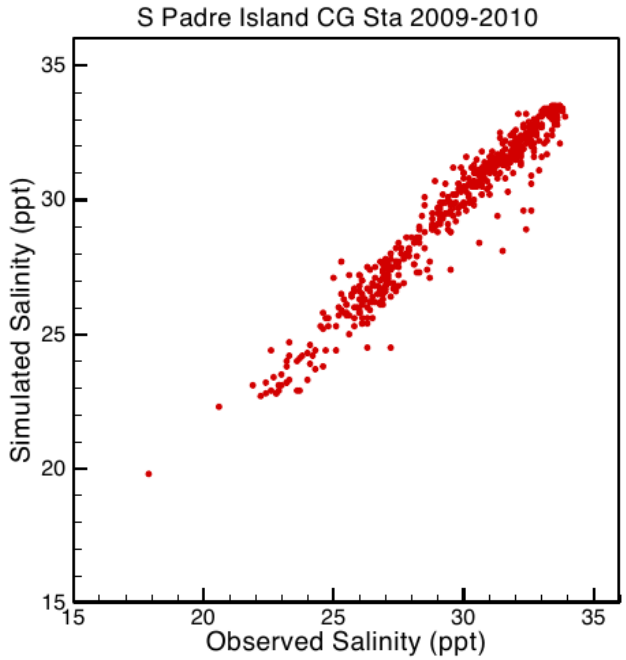
Dolly & Alex


97°30'0"W
97°20'0"W
97°10'0"W
26°30'0"N
26°20'0"N
26°10'0"N
26°0'0"N
Kenedy
Port Mansfield
Mansfield Pass
Texas
Willacy
Gulf of Mexico
DB171
DB195
GC205
GC209
GC213
GC1
Arroyo Colorado
GC13
Arroyo Colorado Upstream
GC27
DB41
GC53
DB67
Lower Laguna Madre
DB83
DB91
GC97
DB107
DB123
Cameron
Brazos Santiago Pass
South Bay
0 1.5 3 6 9 12
Kilometers

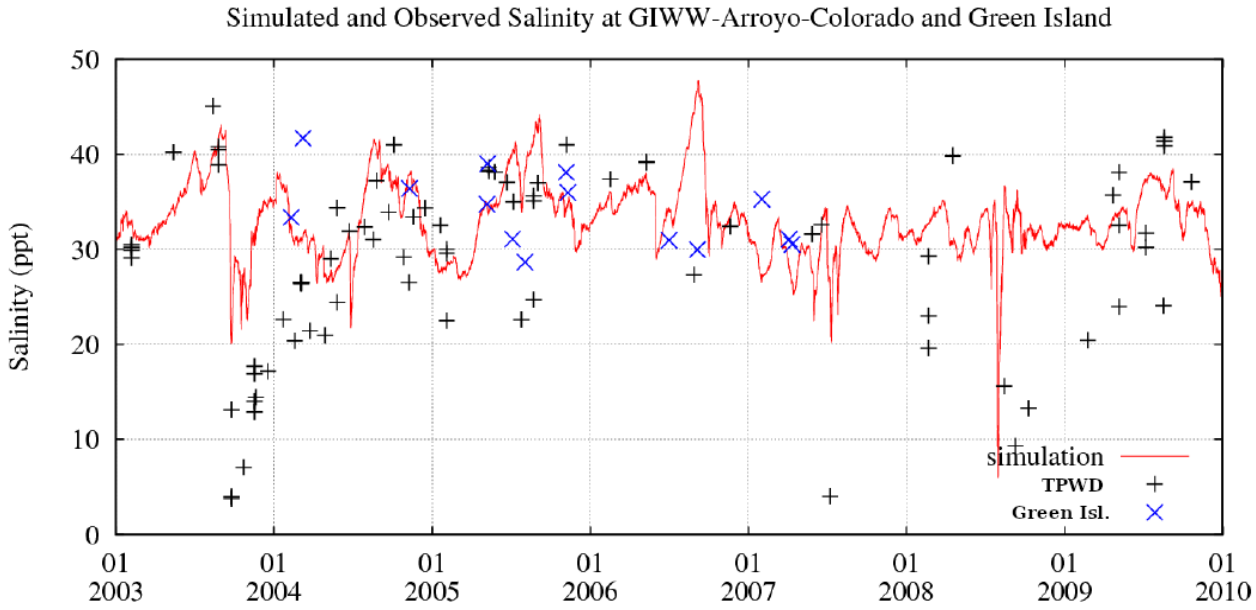

Dolly (2008)
Alex (2010)
Salinity
1 Aug 2008
6 Aug 2008
12 Aug 2008
23 Aug 2008
26 Sep 2008
2 Oct 2008
9 Oct 2008
7 Dec 2008
All Dates Means
2 Jul 2010
11 Jul 2010
16 Jul 2010
22 Jul 2010
6 Aug 2010
21 Aug 2010
4 Sep 2010
25 Sep 2010
Brazos-Santiago
ABC
DB123
DB107
GC97
DB91
DB83
Bay West
DB67
GC53
DB41
GC27
GC13
Arroyo Mouth
GC213
GC209
GC205
DB195
DB 123
DB 107
DB 83
DB 67
GC 13
GC 1 (AC Mouth)
GC 213 (AC Mouth)
WP93 (AC Upstream)
DB 195
DB 171
South
North
Sample Site

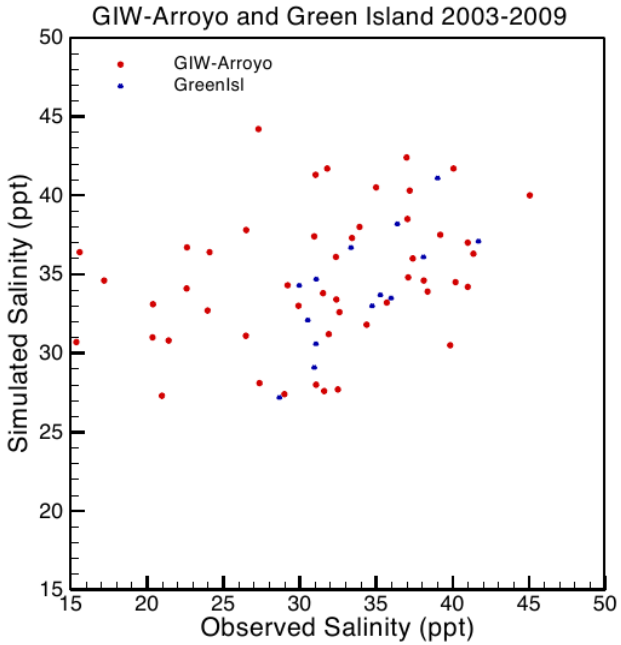
TxBLEND


Simulated and observed salinity at South Padre Isl CG Sta
simulation
datasonde
Salinity (ppt)
50
40
30
20
10
0
04 2008
07 2008
10 2008
01 2009
04 2009
07 2009
10 2009
01 2010
04 2010
07 2010


S Padre Island CG Sta 2009-2010
Simulated Salinity (ppt)
Observed Salinity (ppt)
35
30
25
20
15
15
20
25
30
35

TxBLEND


Simulated and Observed Salinity at GIWW-Arroyo-Colorado and Green Island
Salinity (ppt)
0
10
20
30
40
50
01 2003
01 2004
01 2005
01 2006
01 2007
01 2008
01 2009
01 2010
simulation
TPWD
Green Isl.


GIW-Arroyo and Green Island 2003-2009
GIW-Arroyo
GreenIsl
Simulated Salinity (ppt)
Observed Salinity (ppt)
15
20
25
30
35
40
45
50