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Land and Sea Shaping the World
Terre et Mer Façonnant le Monde

Utilization of United States Geological Service (USGS) coastal water level gauges in Louisiana to check VDatum tidal datums to NAD83 vertical separations.

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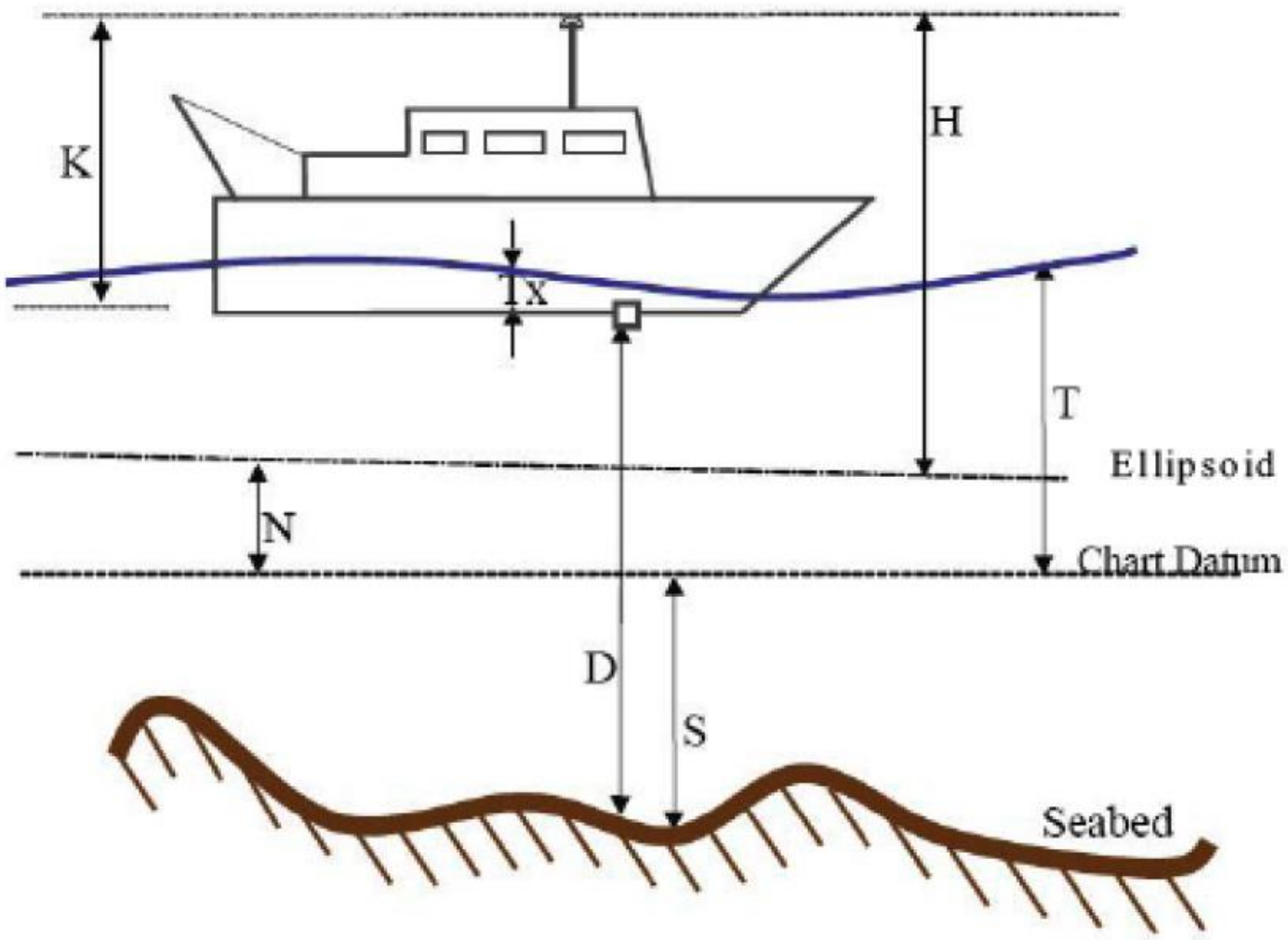
Outline

- Background – Ellipsoid Referenced Surveying (ERS)
- Issue – Separation model infrastructure (e.g. VDATUM) uncertainty
  - Determining and improving VDATUM uncertainty in GOM
  - USM activities
- Coastal USGS Gages
  - Rigolets
  - CSX railway bridge
- Results
- Future work

Ellipsoid Referenced Surveys



S=D+Tx-T

Classical:

Dynamic draft Tx

Tide T offshore

S=D+K-H-N

Ellipsoid-Referenced:

Separation model N

Challenges:

from FIG Pub 37

Separation model infrastructure

Goal - reliable consistent (seamless) transformation among various vertical spatial referencing systems:

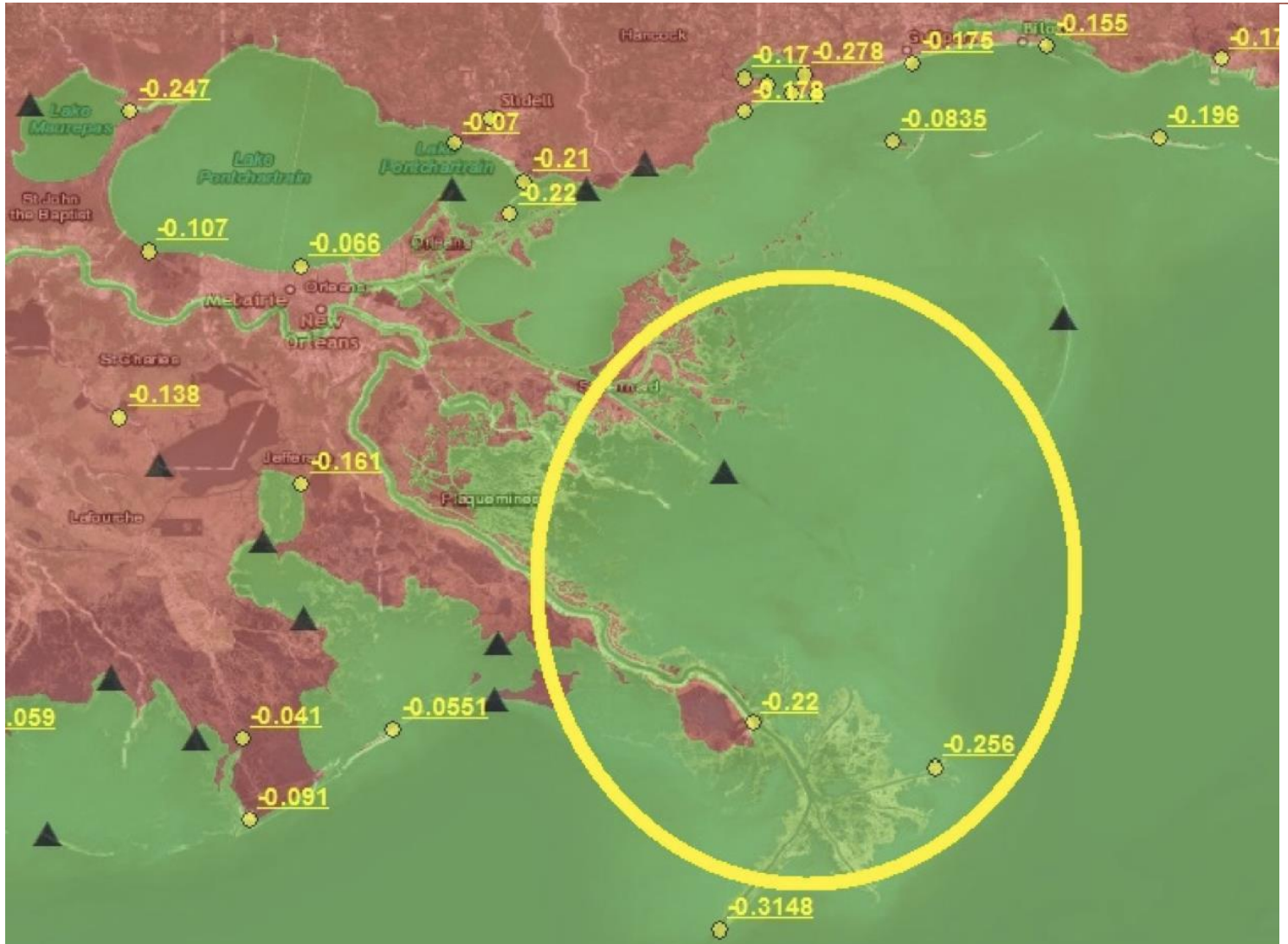
(a) with respect to gravity = **geoid**
(b) with respect to geometry = **ellipsoid**
(c) with respect to water level statistics = **chart datum**

Requirements - two sets of "separation models":

geoid - ellipsoid separation model (classical geodesy problem)
chart datum - ellipsoid separation model (our concern here)

Tools to access separation model values – e.g. VDATUM

VDATUM uncertainty in Gulf of Mexico



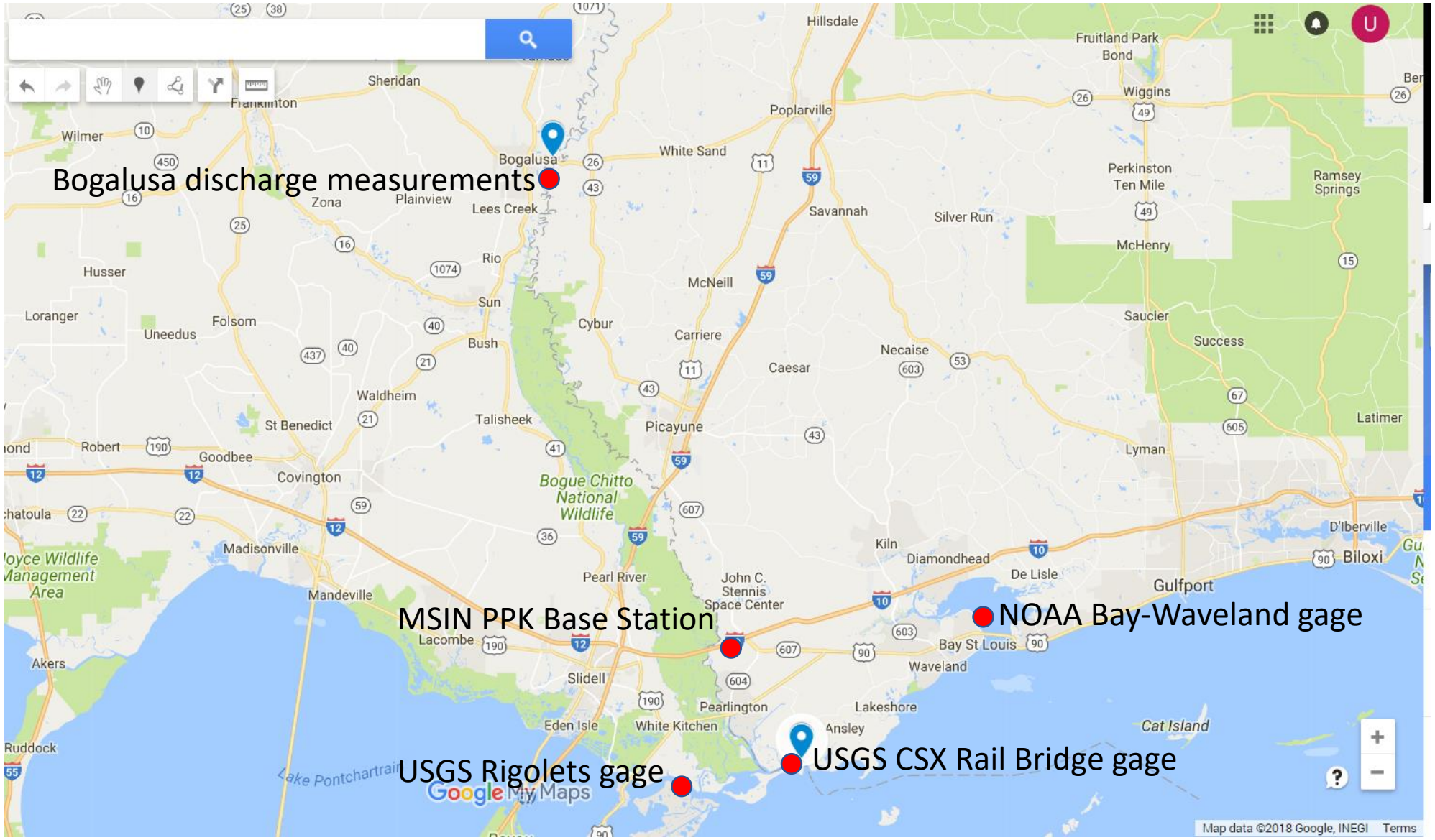
"Important: Transformation Uncertainties in the 'Louisiana / Mississippi - Eastern Louisiana to Mississippi Sound' Regional Model, have been found to range from

20 to 50 cm

in particular locations from the Mississippi River Delta north to Lake Pontchartrain. These issues most likely can be attributed to subsidence, newly established datums, and changes to the understanding of NAVD88 based on new versions of the GEOID. The VDatum Team is currently looking at resolving these uncertainties."

From https://vdatum.noaa.gov/

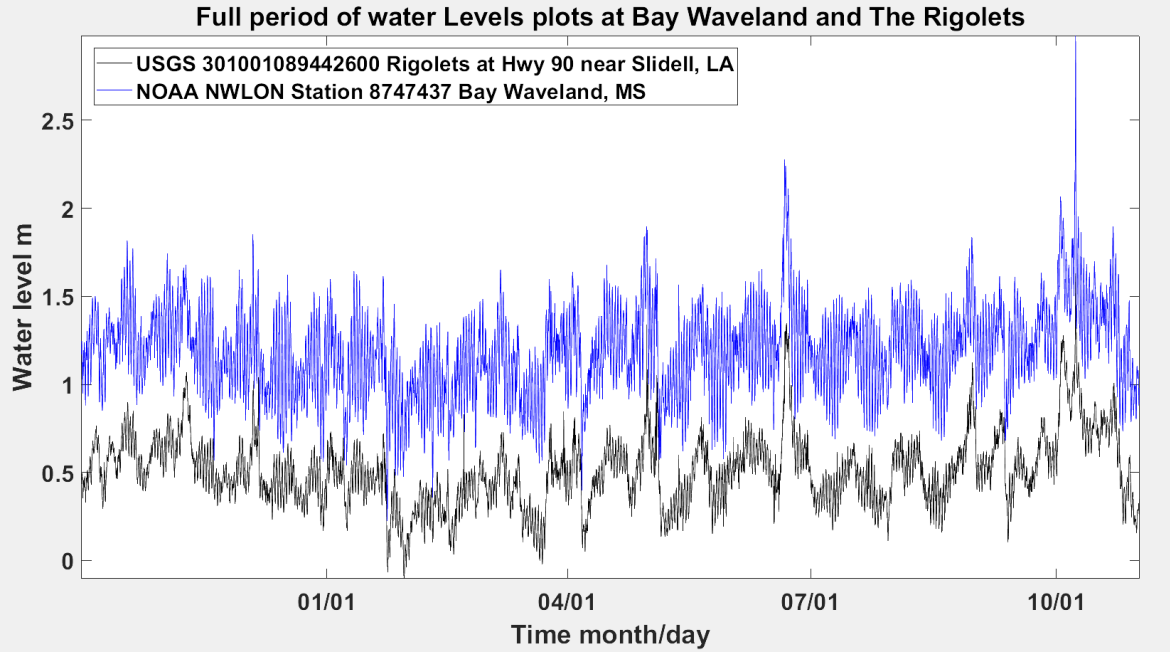
Study Location

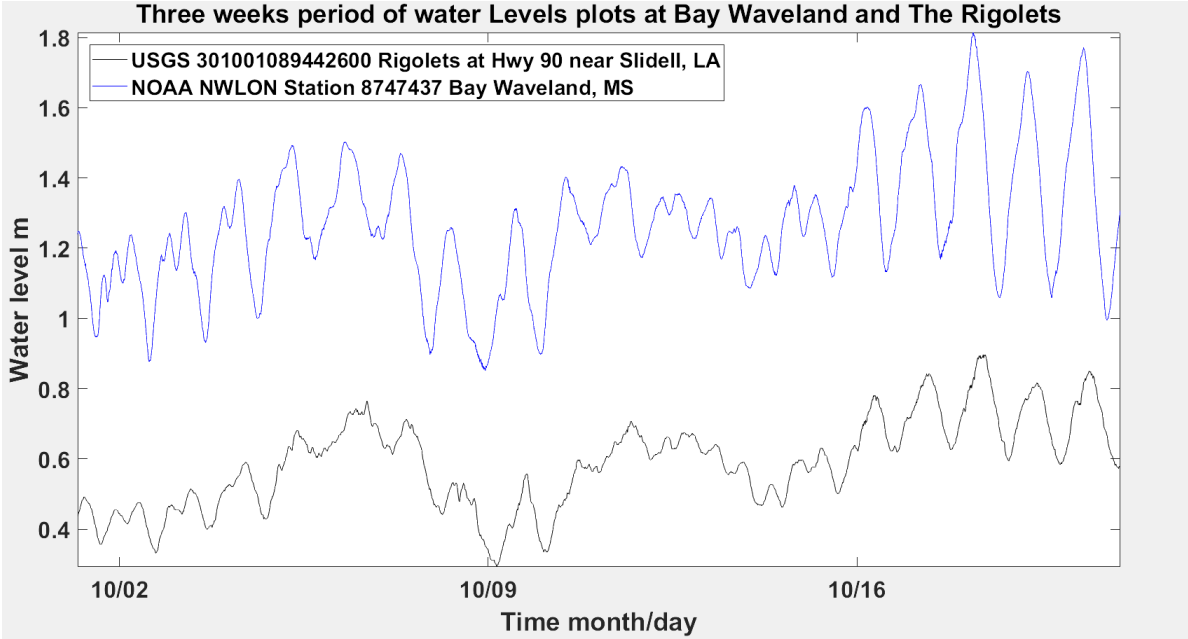


USM activities

- USGS stations
  - GNSS surveys to ellipsoid
  - Tidal datum transfers
  - Ellipsoid separation values
- Deploy tide gauges with GPS/GNSS systems for at least 3 calendar months at priority locations
  - Tidal datum transfers
  - Ellipsoid separation values
- Offshore buoy
  - Tidal datum transfers
  - Ellipsoid separation values
  - Uncertainty analysis

USGS gage at Rigolets





Transferred Datums with respect to gage datum using Modified Range Ratio	
Datum	Rigolets m
DTL	0.33 ± 0.027*
Gt	0.22 ± 0.027
MLLW	0.22 ± 0.027
MHHW	0.44 ± 0.027

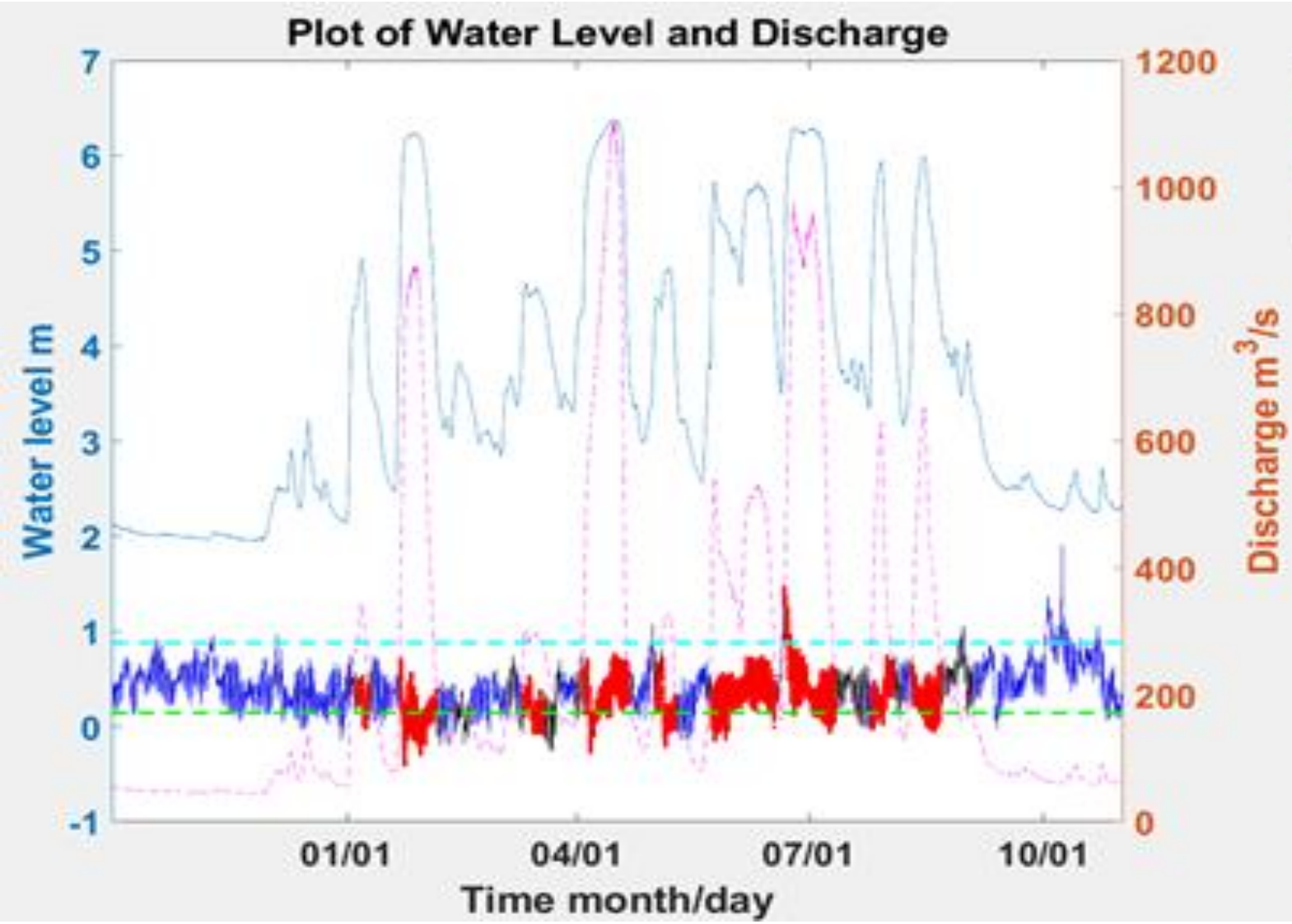
*Water level transfer uncertainties are taken from Swanson 1964, Table 6 for Gulf Coast, 12 month series length (0.09 ft = 0.027 m)

Swanson, Robert L., NOAA Technical Report NOS 64, Variability of Tidal Datums and Accuracy in Determining Datums from Short Series of Observations
U.S. Department of Commerce, NOAA, NOS, Rockville, MD., October 1974

USGS gage at CSX Railway Bridge 1/3

- This gage is located near the mouth of the Pearl River which has periodic flooding with high discharge rates / non-tidal elevated water levels.
- To detect and remove these flood periods from water level transfers, USGS discharge records from Bogalusa, 50 km up the Pearl River, were used. The 70-year mean discharge rate was calculated. Any periods with higher discharge rates than this mean were removed from the CSX water level record prior to calculating the water level transfer from Bay-Waveland.
- A sensitivity analysis has been started, on whether the 70-year mean discharge was the best choice to flag for flooding.

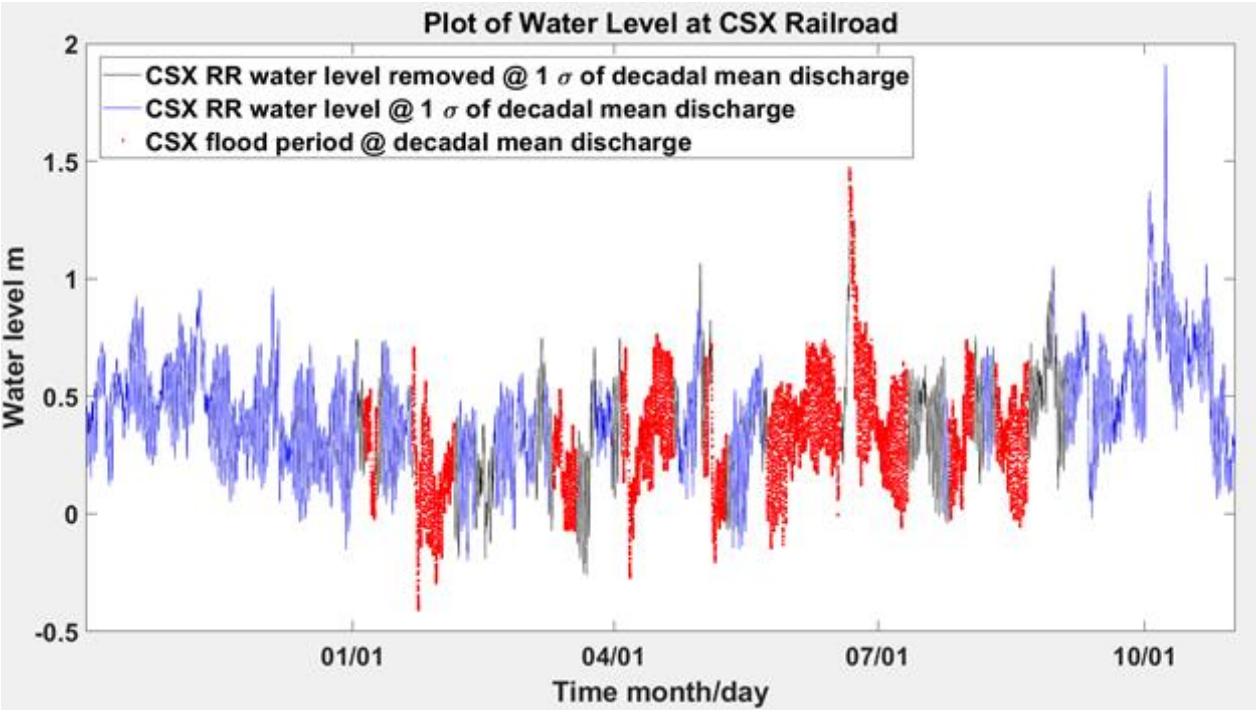
USGS gage at CSX Railway Bridge 2/3

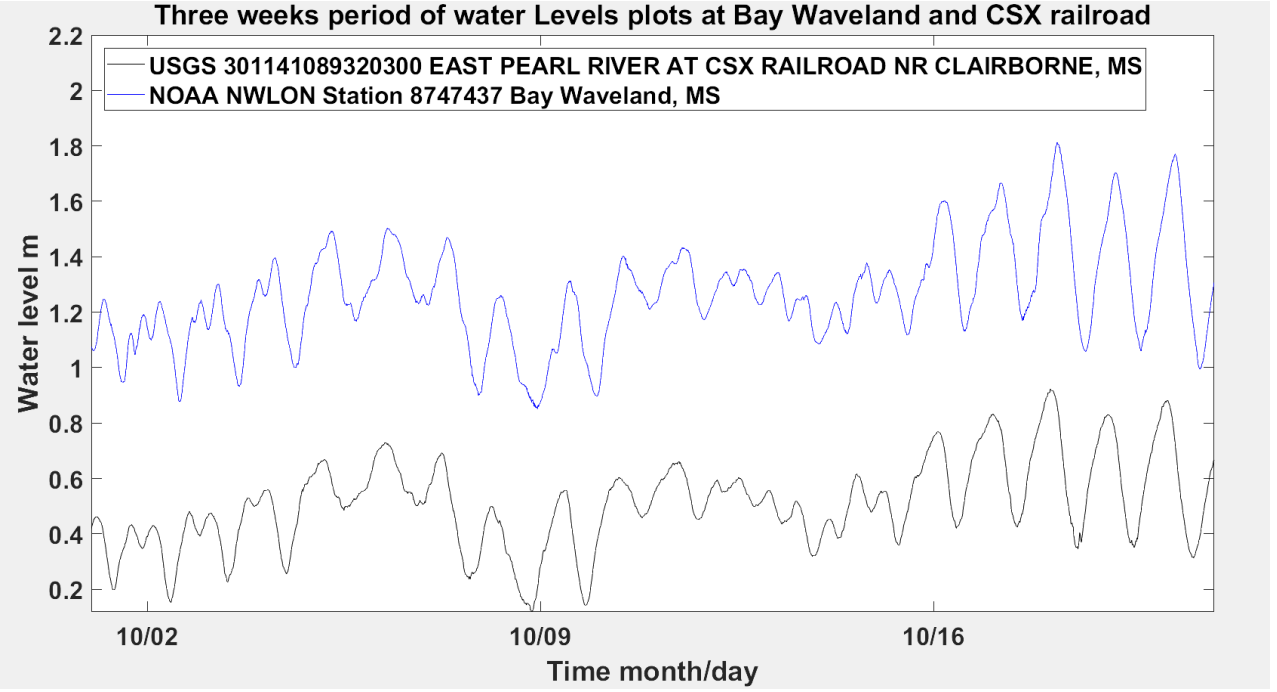


Three water level transfer calculations were done:

1) using the complete CSX water level record, including floods
2) removing CSX water levels during discharges greater than 70-year mean, shown in red
3) removing CSX water levels during discharges that were greater than (70-year mean minus 1 sigma), shown in black

USGS gage at CSX Railway Bridge 3/3





Transferred Datums with respect to gage datum using Modified Range Ratio

Datum	CSX w flood (m)	CSX w/o flood mean (m)	CSX w/o flood mean minus 1 sigma (m)
DTL	0.31	0.23 ± 0.027	0.24 ± 0.027
Gt	0.66	0.43 ± 0.027	0.42 ± 0.027
MLLW	-0.02	0.02 ± 0.027	0.02 ± 0.027
MHHW	0.64	0.45 ± 0.027	0.45 ± 0.027

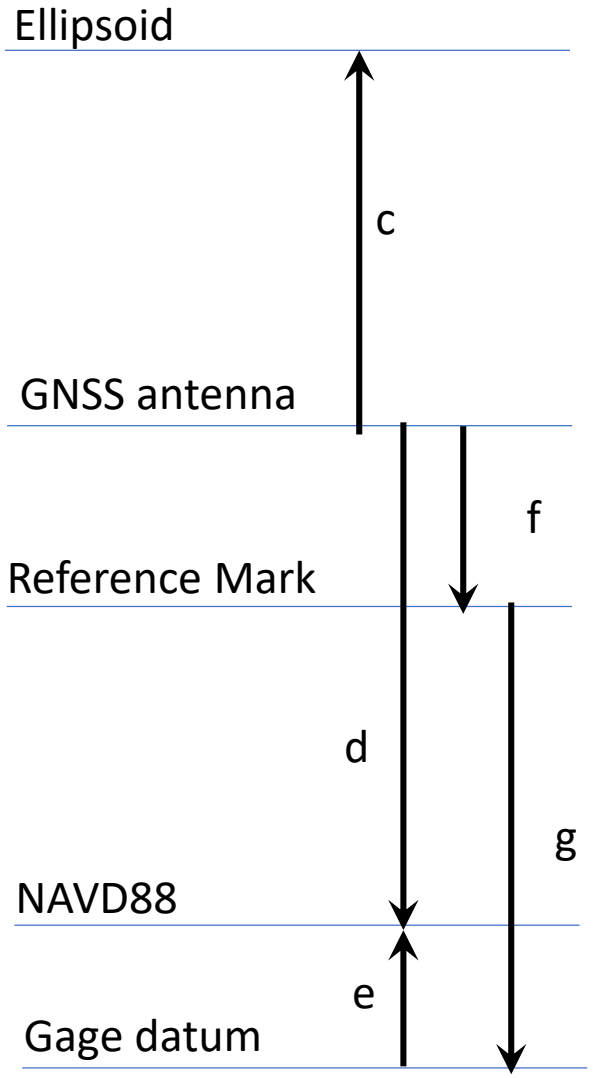
Water level transfer uncertainties were determined as standard deviation of 13 one-month transfers.

Removing flood periods significantly changed all four water level datums, but MLLW the least.

Sensitivity analysis shows that removing either discharge periods above 70-year mean, or above that mean minus 1 sigma produce results within 1 cm.

GNSS Results

	Parameters	Source	Rigolets values	CSX values
	All values except a & b in m			
a	GNSS Latitude	GrafNav8.6	30 10 15.19285	30 11 41.15220
b	GNSS Longitude	GrafNav8.6	89 44 2.92915	89 32 3.49238
c	GNSS Ellipsoidal height NAD83	GrafNav8.6	-20.245 ± 0.033	-19.17 ± 0.030
d	GNSS Orthometric height NAVD88	GrafNav8.6 (GEOID12B)	6.287	7.576
e	Gage datum minus NAVD88	USGS	-0.306 ± 0.001	-0.104 ± 0.001
f	Antenna above reference mark	USM data	1.936 ± 0.001	3.893 ± 0.001
g	Reference mark above gage datum	USGS	4.572 ± 0.001	3.789 ± 0.001
h	Gage datum ellipsoid height GrafNav	c - d + e	-26.838 ± 0.033	-26.85 ± 0.030
i	Gage datum ellipsoid height USM data	c - f - g	-26.753 ± 0.034	-26.861 ± 0.031
j	Gage datum ellipsoid height deviation	h - i	-0.085	0.011



Comparison of VDATUM & USM Uncertainty

All values in m			Rigolets	Rigolets		CSX	CSX
Datum	VDATUM		USM*	VDATUM minus USM		USM*	VDATUM minus USM
NAD83(2011)	0.000		0.000	0.000		0.000	0.00
MHHW	-26.210 ± 0.169		-26.313 ± 0.027	0.103 ± 0.171		-26.411 ± 0.027	0.089 ± 0.171
DTL	-26.331 ± 0.168		-26.423 ± 0.027	0.091 ± 0.170		-26.631 ± 0.027	0.090 ± 0.170
NAVD88 (GEOID12B)	-26.532 ± 0.073		-26.447 ± 0.027	-0.085 ± 0.078		-26.747 ± 0.027	0.018 ± 0.078
MLLW	-26.451 ± 0.170		26.533 ± 0.027	0.082 ± 0.172		-26.841 ± 0.027	0.080 ± 0.172

*USM uncertainties are taken from Swanson 1964, Table 6 for Gulf Coast, 12 month series length (0.09 ft = 0.027 m)

Except for NAVD88 at Rigolets, VDATUM and USM-determined datum values agree to within the propagated estimated uncertainty of the [VDATUM minus USM] differences.

This indicates that for these two USGS stations, the VDATUM predicted uncertainty is conservative, and not subject to the warning of higher than predicted uncertainties for an area to the south of these two stations.

It is intended to repeat this analysis at several more USGS stations, particularly those within the warning area.

Swanson, Robert L., NOAA Technical Report NOS 64, Variability of Tidal Datums and Accuracy in Determining Datums from Short Series of Observations
U.S. Department of Commerce, NOAA, NOS, Rockville, MD., October 1974

Future Work

- CSX Railway Bridge data set
  - Sensitivity analysis of discharge period editing (70-year mean ± 1 sigma)
  - Detection of multipath and blanking periods as trains passed
- Process GNSS data from buoys in Mississippi and Louisiana waters
- Install permanent tide gage with GNSS receiver in Gulfport, MS
- 3-month deployments of tide gage/GNSS Rx in NOAA region of interest
  - Tidal Datum Transfers
  - Ellipsoid survey
- Other USGS water level gages in region of interest
  - Tidal Datum Transfers
  - Ellipsoid survey

Acknowledgements

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