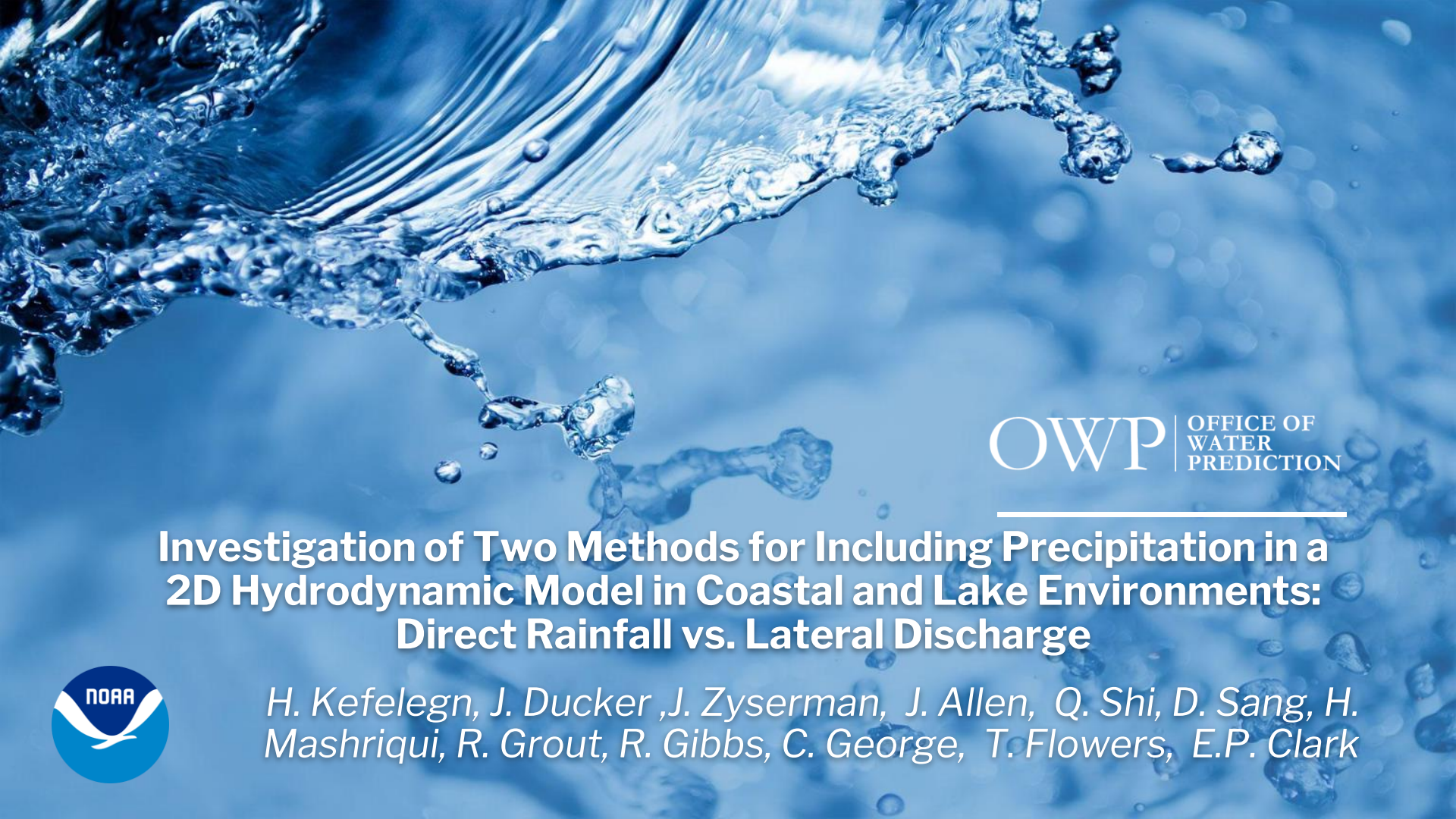

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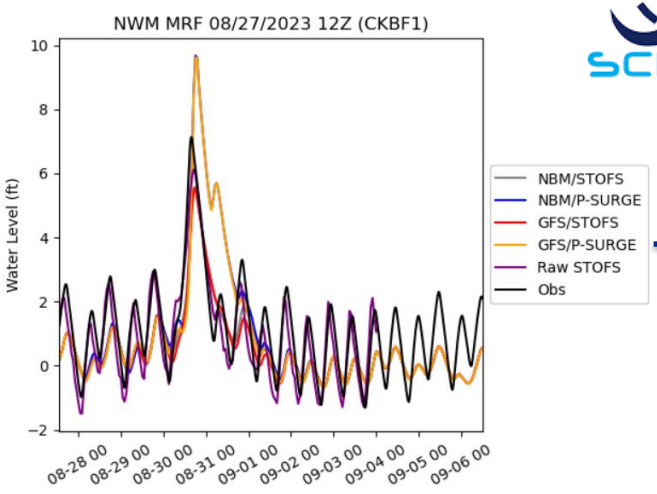
Investigation of Two Methods for Including Precipitation in a 2D Hydrodynamic Model in Coastal and Lake Environments: Direct Rainfall vs. Lateral Discharge

H. Kefelegn, J. Ducker ,J. Zyserman, J. Allen, Q. Shi, D. Sang, H. Mashriqui, R. Grout, R. Gibbs, C. George, T. Flowers, E.P. Clark

National Water Model v3.0 TWL Capability

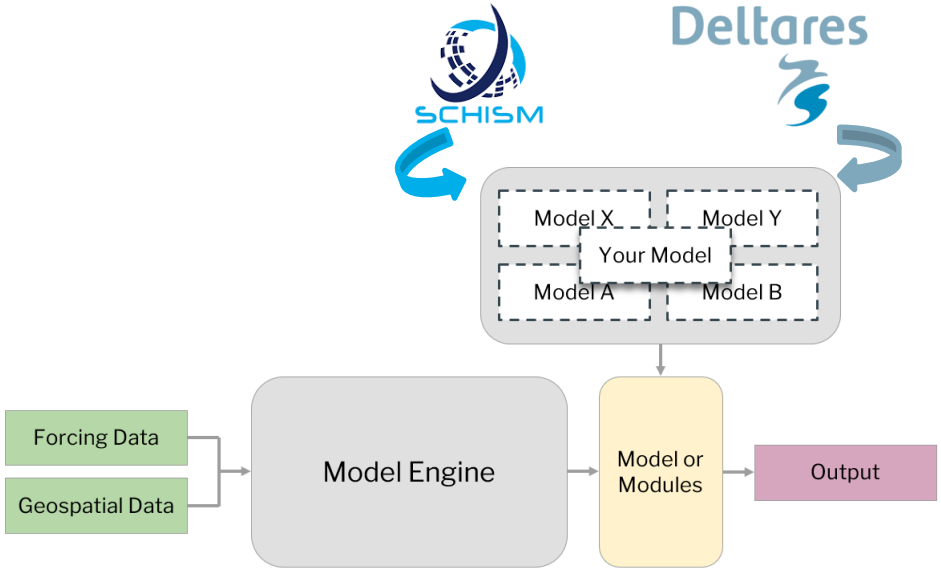


SCHISM

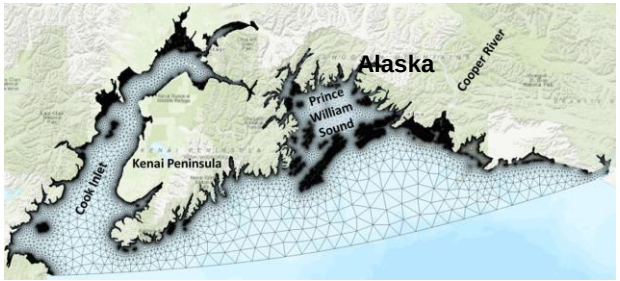
NWM v3.0: TWL Domain Coverage

Cosgrove, Brian, David Gochis, Trey Flowers, Aubrey Dugger, Fred Ogden, Tom Graziano, Ed Clark et al; 2024. “ NOAA's National Water Model: Advancing Operational Hydrology Through Continental-scale Modeling.” JAWRA Journal of the American Water Resources Association 00 (0): 1–26. https://doi.org/10.1111/1752-1688.13184.

Extending the TWL Capability in the NextGen Framework

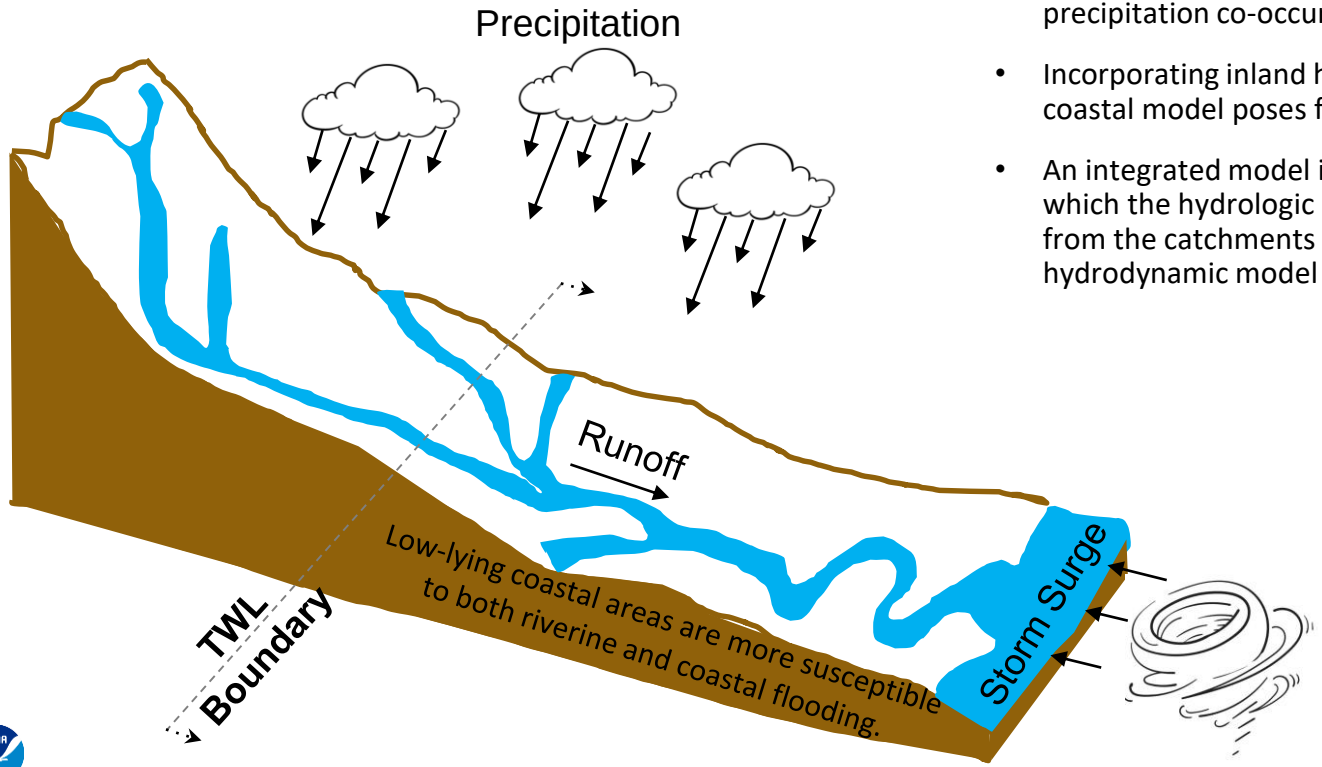


Expanding to New Regions for NWM v4.0
(Next Generation Water Resources Modeling Framework)



Goal: Optimize TWL capability using a DFlowFM modeling approach

Challenge: Modeling of TWL within inland-coastal transitional zone



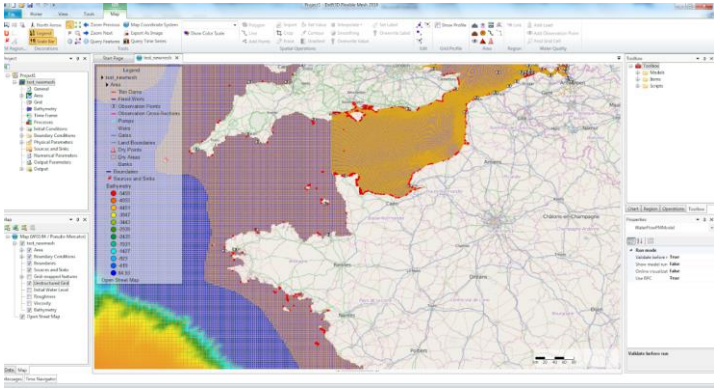
- Low-lying coastal locations, most densely populated and economically developed area, are frequently far more vulnerable to flooding when storm surge and heavy precipitation co-occur than when they do not.
- Incorporating inland hydrology and precipitation in to a coastal model poses formidable challenges.
- An integrated model is required to address this problem, in which the hydrologic model determines the lateral influx from the catchments surrounding the river reach and the hydrodynamic model directs the influx into the streams.

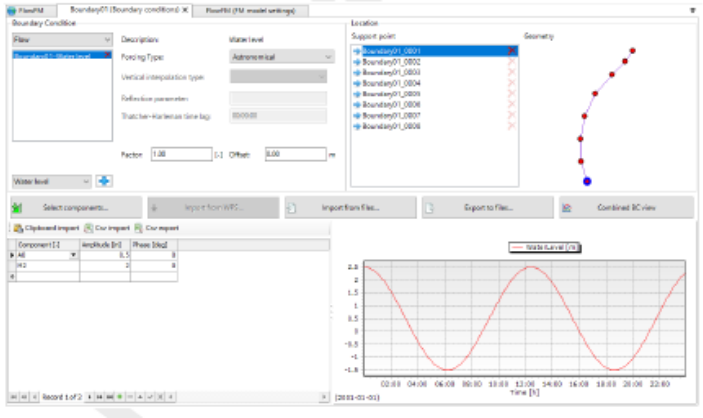
Hydrodynamic model

D-Flow Flexible Mesh (D-Flow FM)

D-Flow Flexible Mesh (D-Flow FM)

- 2D/3D hydrodynamic model.
- Works on Cartesian curvilinear or unstructured grids.
- Can be parallelized.
- Unix and Windows versions.
- Implements a finite volume solver on a staggered unstructured grid.
- Can ingest precipitation (rainfall rate) and lateral discharges as model inputs.





Direct Rainfall (DR) vs. Lateral Discharge (LD)

- Rainfall is prescribed by a data file containing the rainfall rate.
- Precipitation falling onto the surface (land or water) acts as a source of water for the system.
- Rainfall flux entering a grid cell is rainfall intensity multiplied by the grid cell area.

Advantage: There is a direct access to input data.
Limitation: Simplifies the hydrologic process. It doesn't account all the components within the water cycle that land surface water model simulate in the NWM.

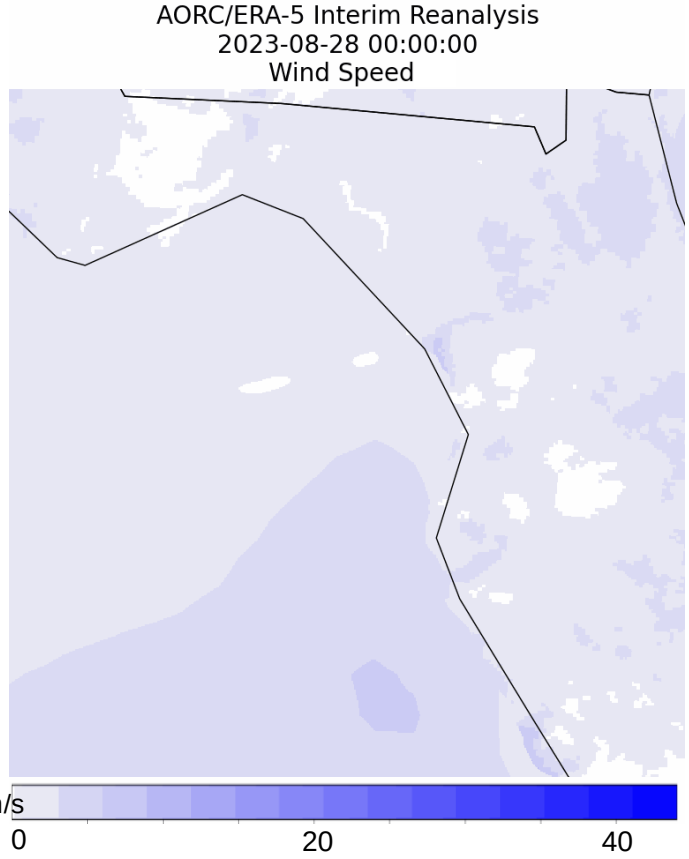
- NWM determines the lateral flow from the catchments surrounding the river reach.
- D-Flow FM directs the influx into the streams as additional inflow (outflow) on specific locations in model.
- Unlike source-sinks LD adds or extract volume to the model and no momentum.
- A polygon is defined to distribute the LD over all grid points inside that polygon.

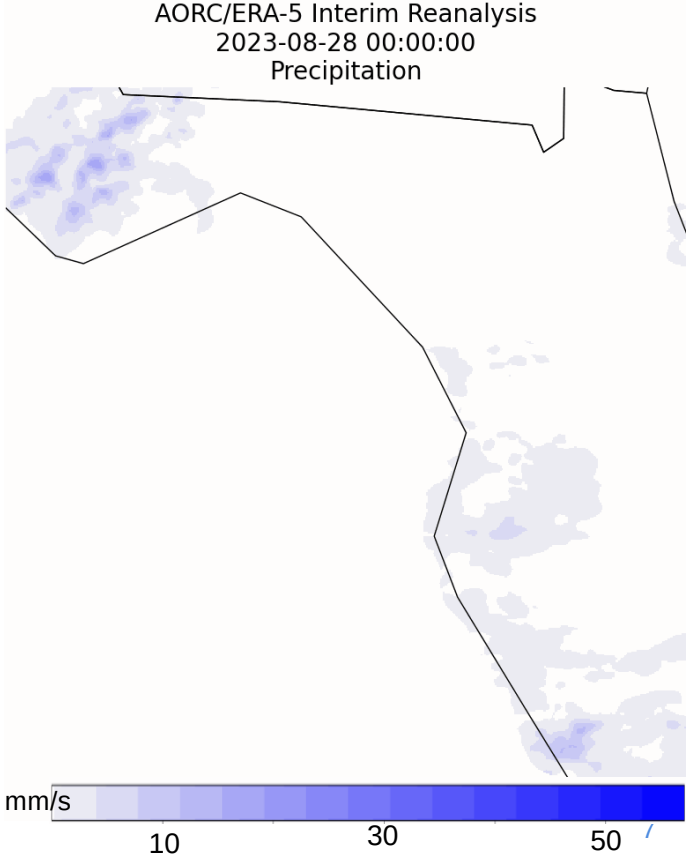
Advantage: Enables a more tight coupling of hydrologic model (eg. NWM) with coastal model.
Limitation: Potentially spreading more water over streams than physically represented. It can also reduce the peak water levels.

Meteorological Datasets (Hurricane Idalia, Florida)

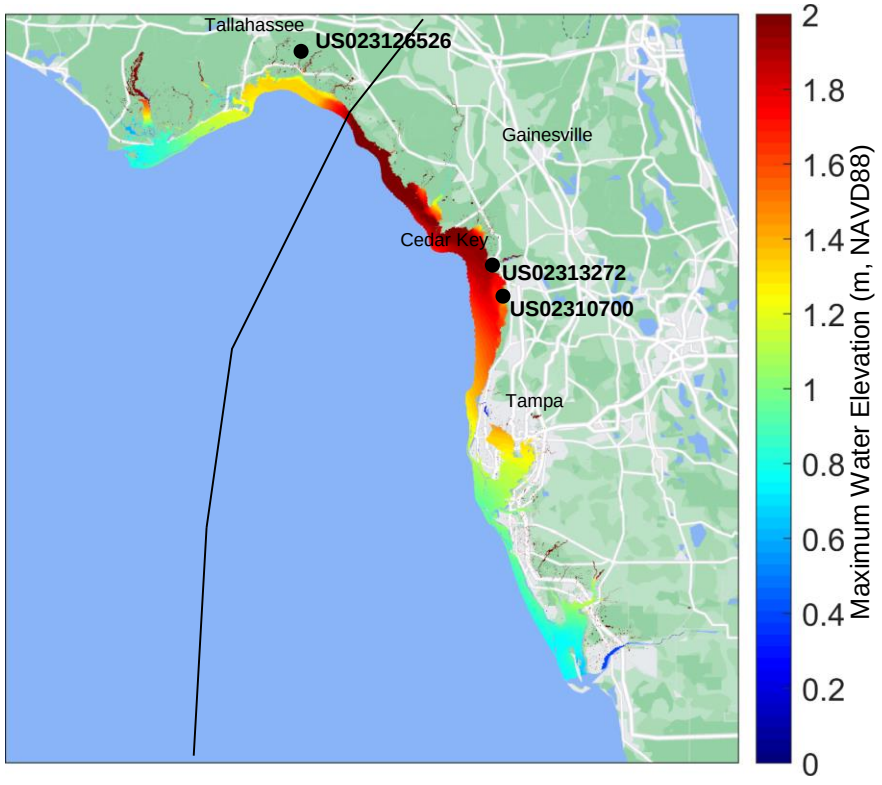
- Analysis of Record and Calibration (AORC) - 1km x 1km dataset covering CONUS land-surface features up until the coastline (Kitzmiller et al., 2018)

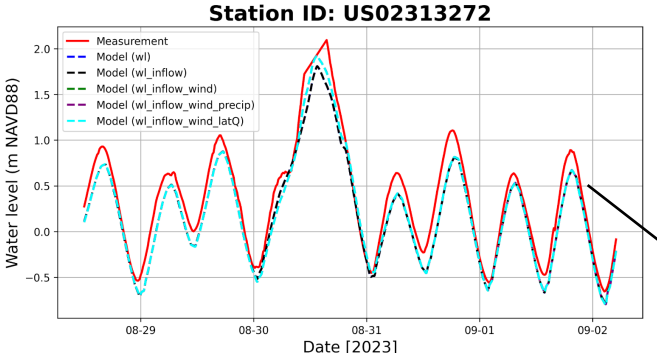
- ERA5-Interim Hourly Data - 31km x 31km dataset used to fill in the data gaps offshore of the CONUS coastline where AORC data extent ends (Hersbach et al., 2018).



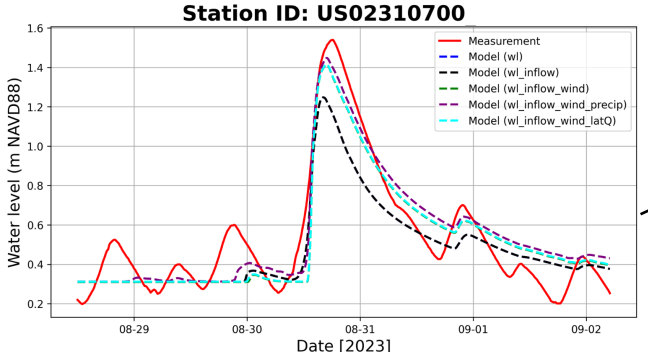


Idalia


Tallahassee
US023126526
Gainesville
Cedar Key
US02313272
US02310700
Tampa
Maximum Water Elevation (m, NAVD88)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0


Station ID: US02313272
Measurement
Model (wl)
Model (wl_inflow)
Model (wl_inflow_wind)
Model (wl_inflow_wind_precip)
Model (wl_inflow_wind_latQ)
Water level (m NAVD88)
Date [2023]
08-29
08-30
08-31
09-01
09-02


US02313272
US02310700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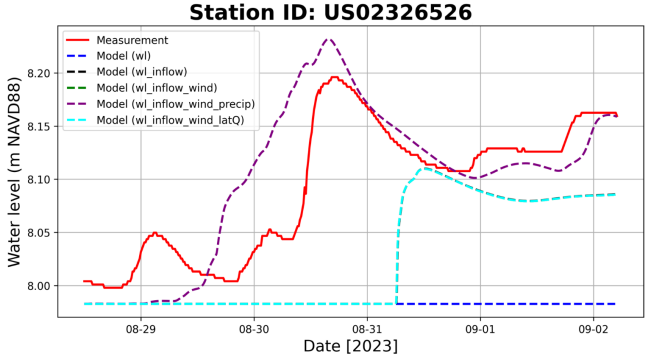
Model (wl_inflow_wind)
Model (wl_inflow_wind_precip)
Model (wl_inflow_wind_latQ)
Water level (m NAVD88)
Date [2023]
08-29
08-30
08-31
09-01
09-02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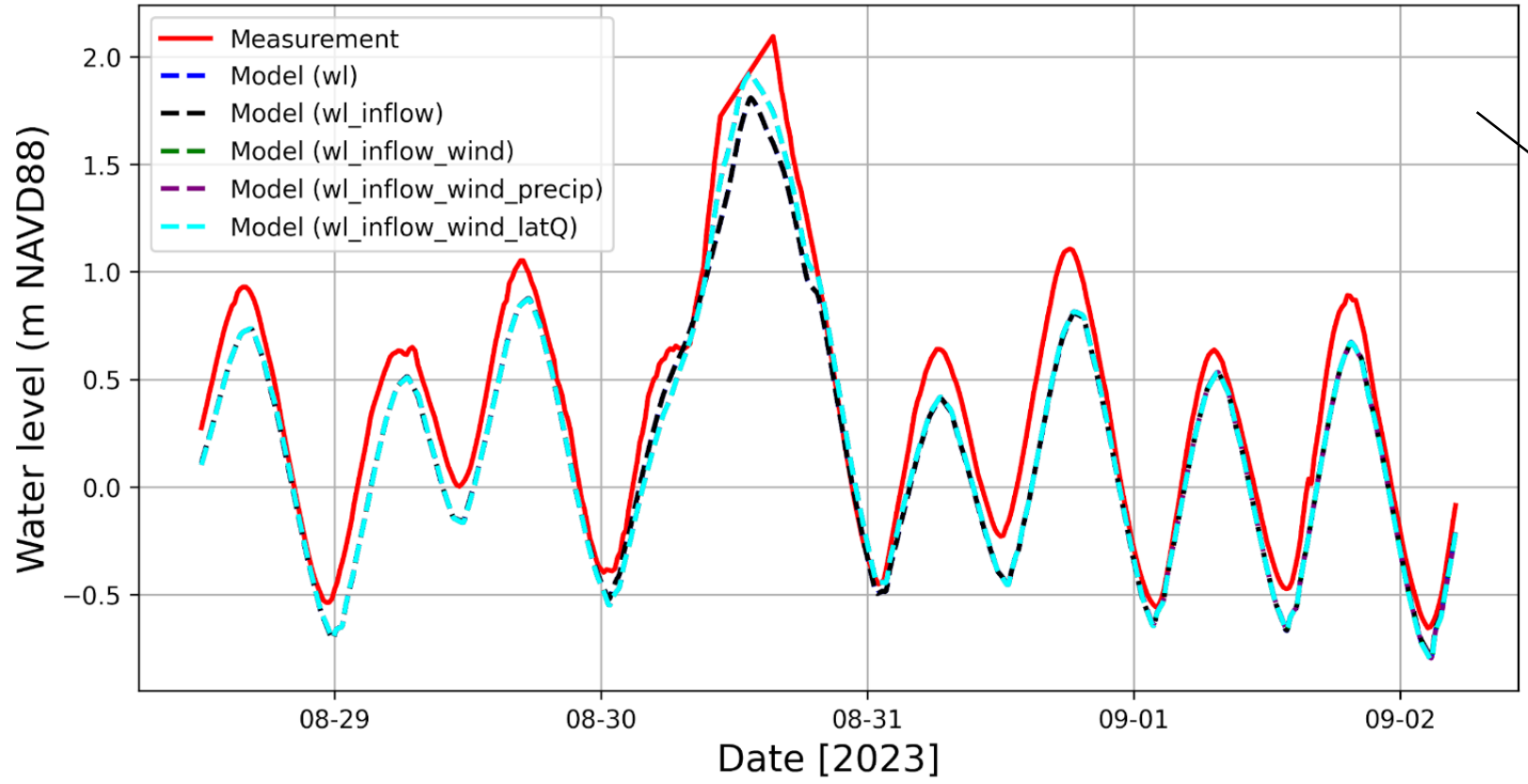
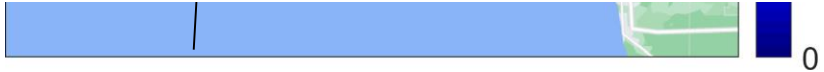
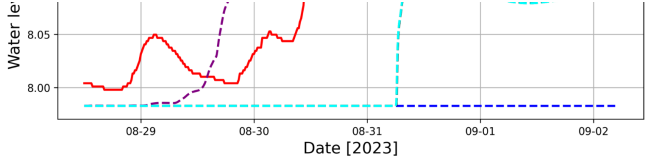
Measurement
Model (wl)
Model (wl_inflow)
Model (wl_inflow_wind)
Model (wl_inflow_wind_precip)
Model (wl_inflow_wind_latQ)
Water level (m NAVD88)
Date [2023]
08-29
08-30
08-31
09-01
09-02

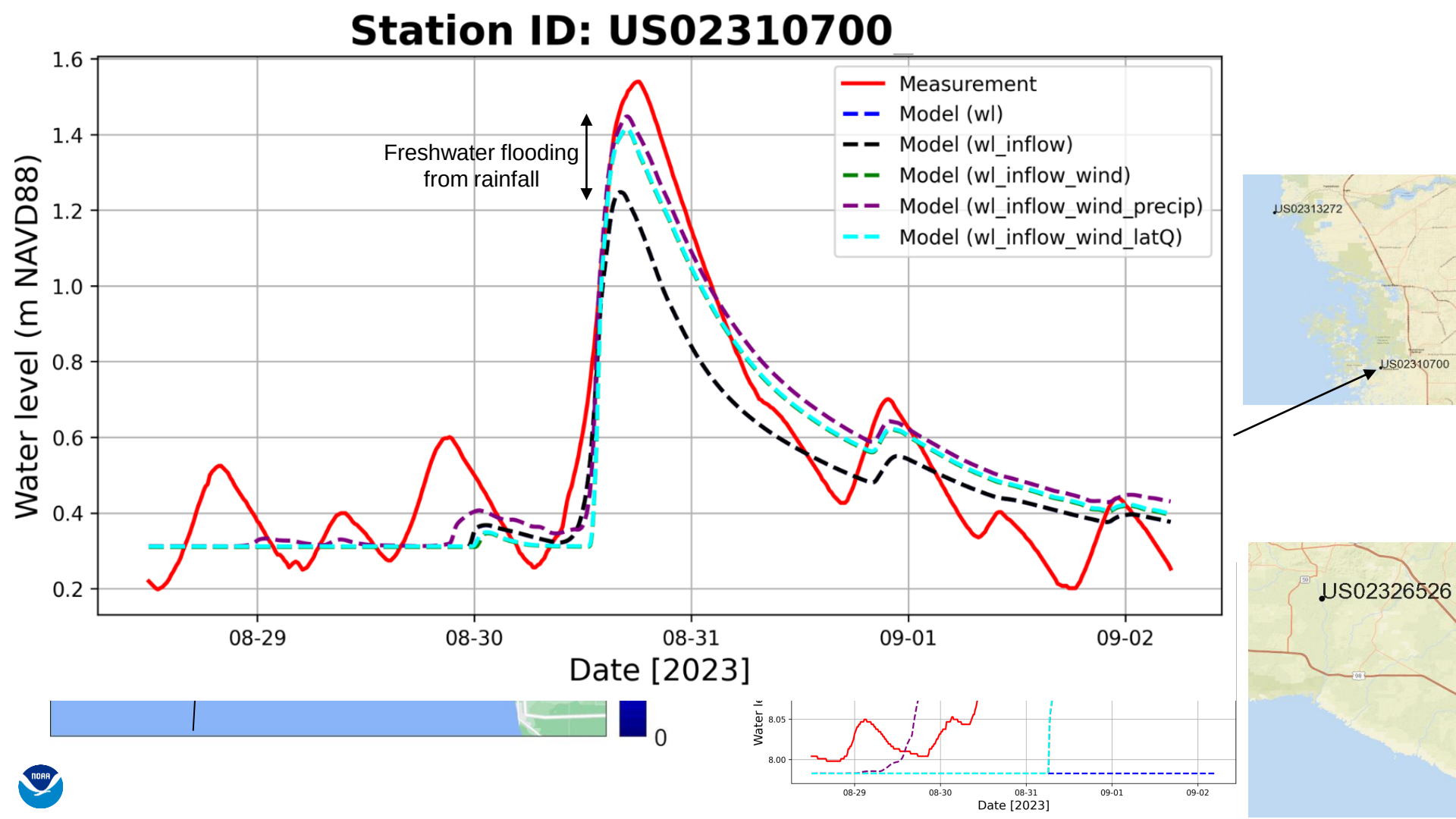

US02326526

Station ID: US02313272

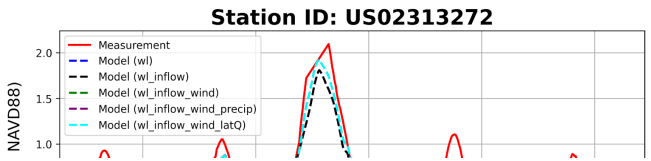


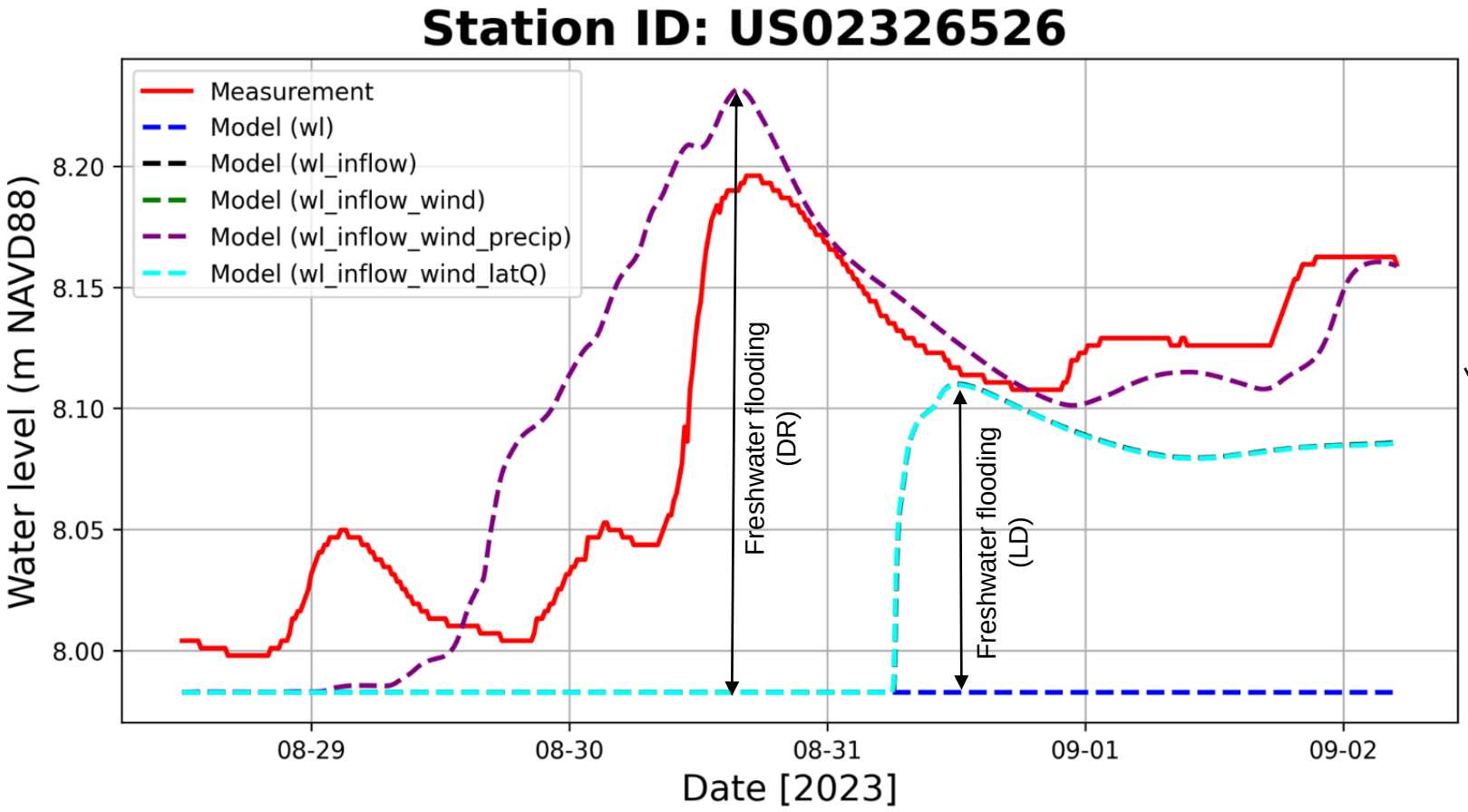





Station ID: US02310700
Water level (m NAVD88)
Date [2023]
Measurement
Model (wl)
Model (wl_inflow)
Model (wl_inflow_wind)
Model (wl_inflow_wind_precip)
Model (wl_inflow_wind_latQ)
Freshwater flooding
from rainfall
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
08-29
08-30
08-31
09-01
09-02
US02313272
US02310700
US02326526
0
8.05
8.00
08-29
08-30
08-31
09-01
09-02
Date [2023]

Idalia

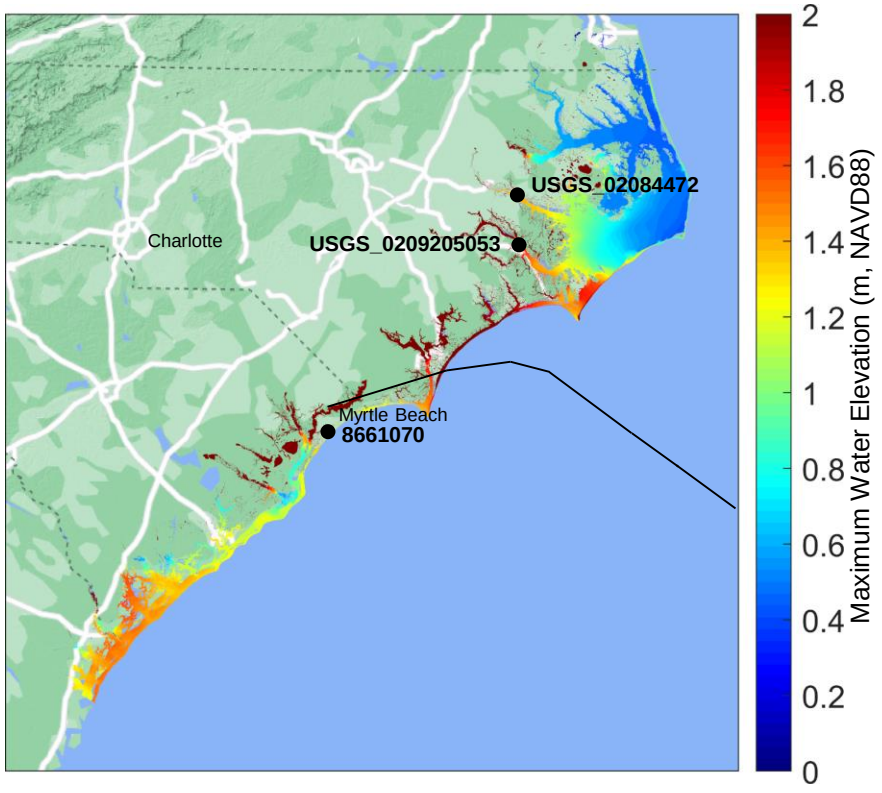

Station ID: US02313272
Measurement
Model (wl)
Model (wl_inflow)
Model (wl_inflow_wind)
Model (wl_inflow_wind_precip)
Model (wl_inflow_wind_latQ)
NAVD88)
2.0
1.5
1.0

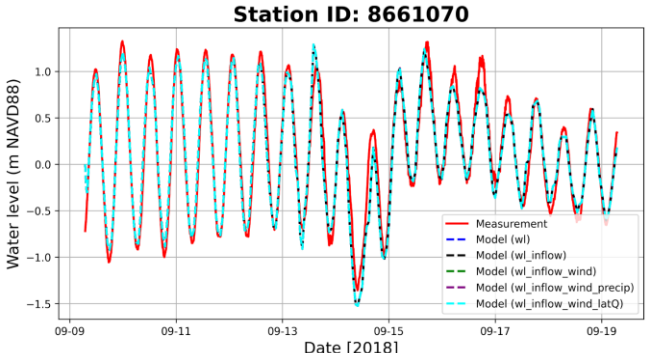

Station ID: US02326526
Measurement
Model (wl)
Model (wl_inflow)
Model (wl_inflow_wind)
Model (wl_inflow_wind_precip)
Model (wl_inflow_wind_latQ)
Water level (m NAVD88)
8.20
8.15
8.10
8.05
8.00
Freshwater flooding (DR)
Freshwater flooding (LD)
08-29
08-30
08-31
09-01
09-02
Date [2023]


US02313272
US02310700


US02326526

Florence


Charlotte
USGS_02084472
USGS_0209205053
Myrtle Beach
8661070
Maximum Water Elevation (m, NAVD88)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0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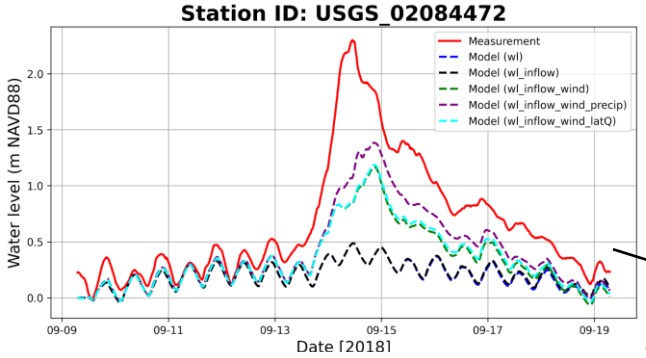
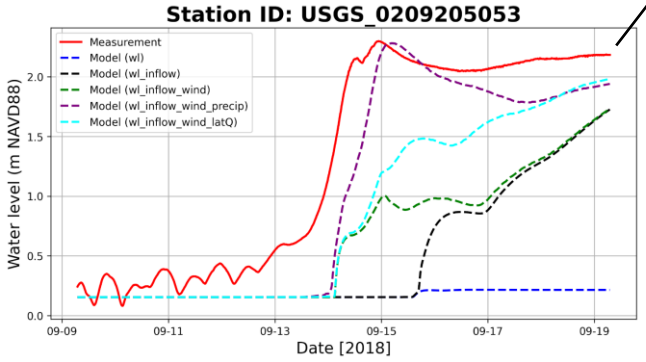
Water level (m NAVD88)
Measurement
Model (wl)
Model (wl_inflow)
Model (wl_inflow_wind)
Model (wl_inflow_wind_precip)
Model (wl_inflow_wind_latQ)
09-09
09-11
09-13
09-15
09-17
09-19
Date [2018]


8661070


Station ID: USGS_02084472
Water level (m NAVD88)
Measurement
Model (wl)
Model (wl_inflow)
Model (wl_inflow_wind)
Model (wl_inflow_wind_precip)
Model (wl_inflow_wind_latQ)
09-09
09-11
09-13
09-15
09-17
09-19
Date [2018]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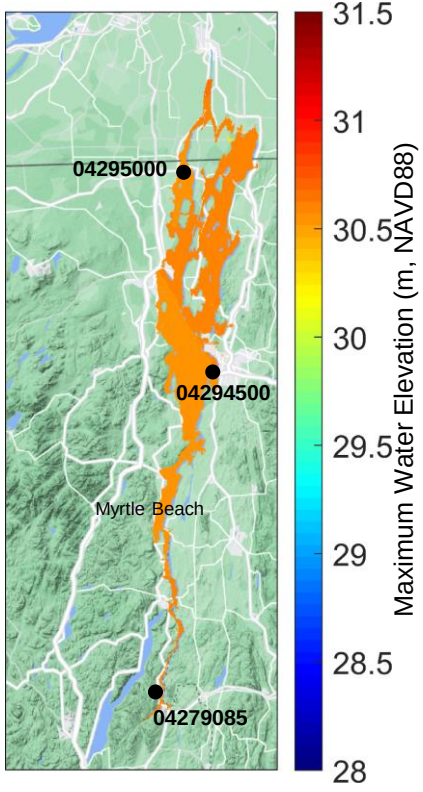
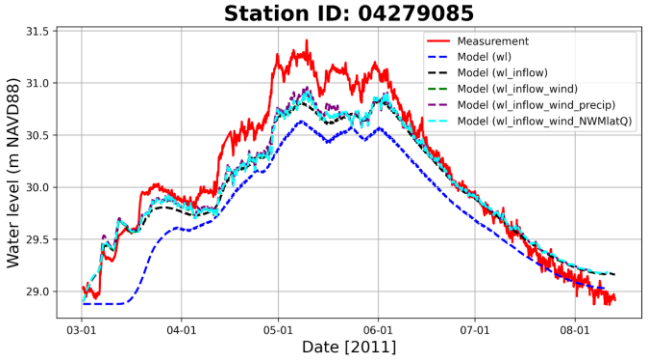
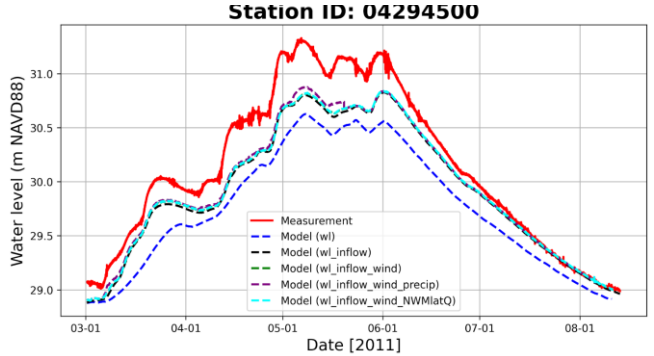
Water level (m NAVD88)
Measurement
Model (wl)
Model (wl_inflow)
Model (wl_inflow_wind)
Model (wl_inflow_wind_precip)
Model (wl_inflow_wind_latQ)
09-09
09-11
09-13
09-15
09-17
09-19
Date [2018]

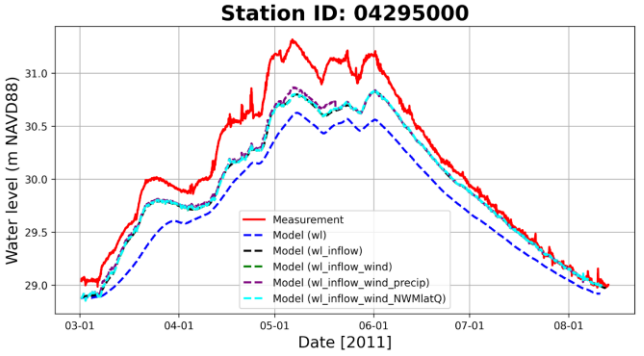

USGS_02084472
USGS_0209205053

Lake Champlain









Summary

- Optimization of TWL is an ongoing effort by OWP-NOAA.
- A direct use of precipitation as a model forcing appears to provide better results generally.
- NWM lateral discharge appears to underestimate TWLs along the coastal region.
  - Distributing inflows over the polygon (eg. HUC 12) reduce the peak water level
  - Assumptions and accuracy of the land surface model along regions near water/ocean bodies

Future Tasks

- Improving the use of direct rainfall method by adding components within the water cycle (e.g. infiltration, evaporation)
- Improving the use of NWM lateral discharge by partitioning over the channel link width instead of HUC 12 polygons.

Thank You!

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https://water.noaa.gov

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