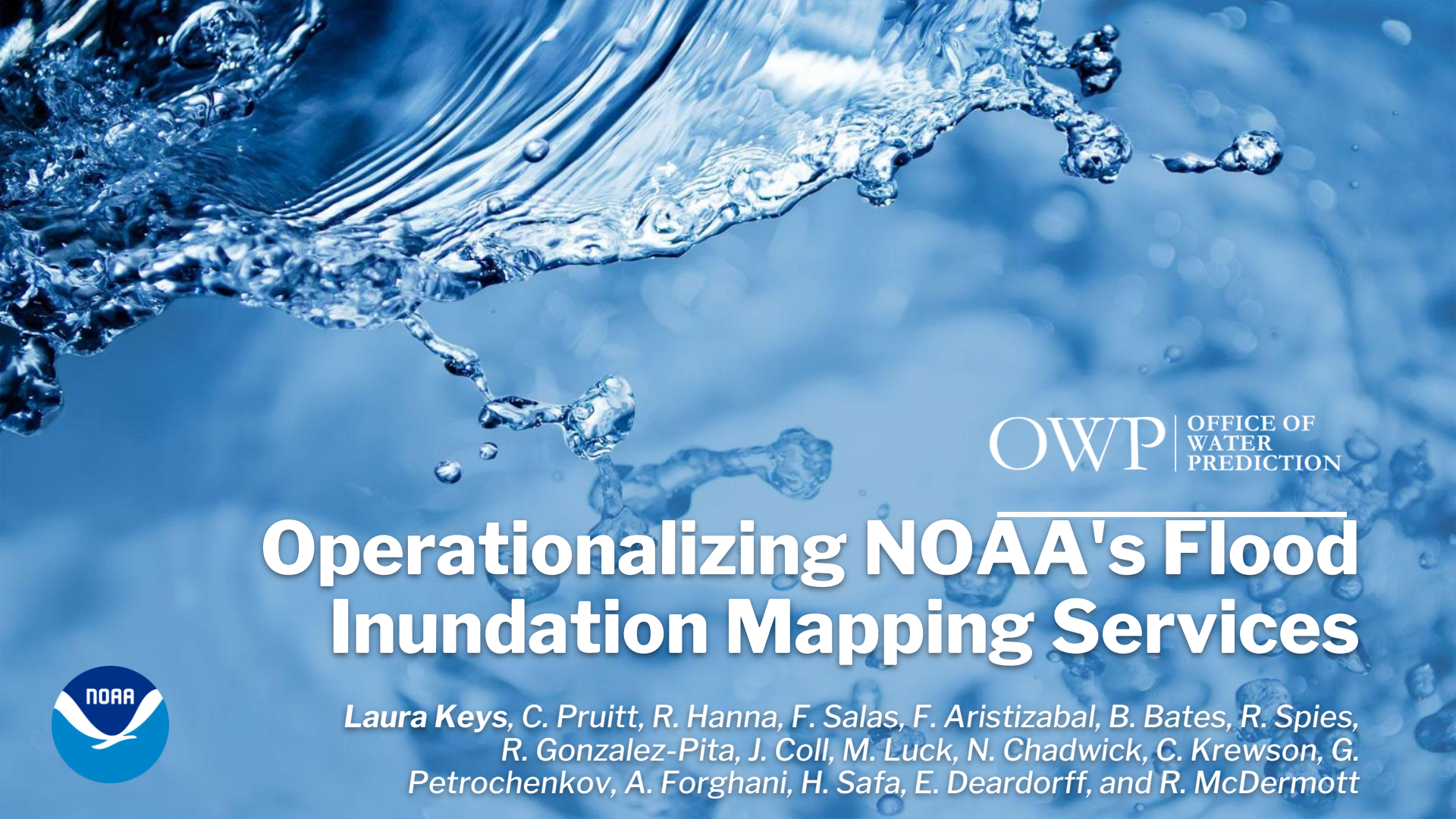
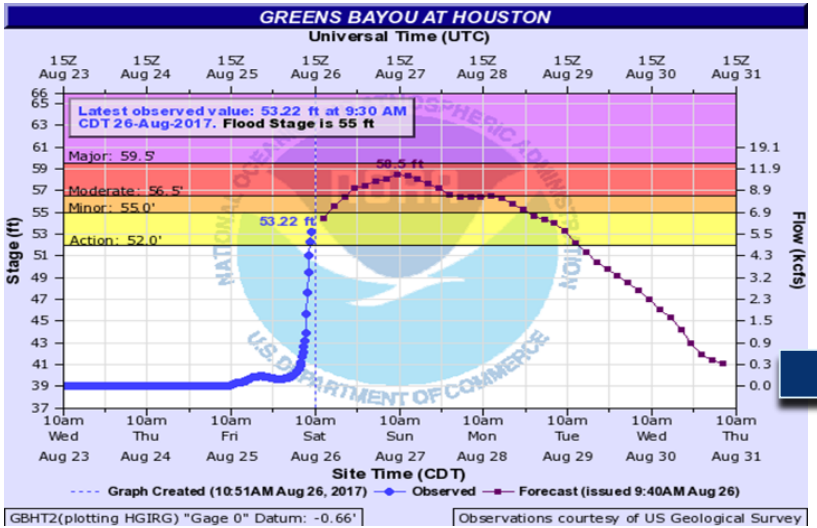


OWP | OFFICE OF WATER PREDICTION

Operationalizing NOAA's Flood Inundation Mapping Services

Laura Keys, *C. Pruitt, R. Hanna, F. Salas, F. Aristizabal, B. Bates, R. Spies, R. Gonzalez-Pita, J. Coll, M. Luck, N. Chadwick, C. Krewson, G. Petrochenkov, A. Forghani, H. Safa, E. Deardorff, and R. McDermott*

Flood Inundation Mapping (FIM) State of the Science



"This is a tool we just can't afford to wait another 5 to 10 years to have..." - Houston Office of Emergency Management Representative

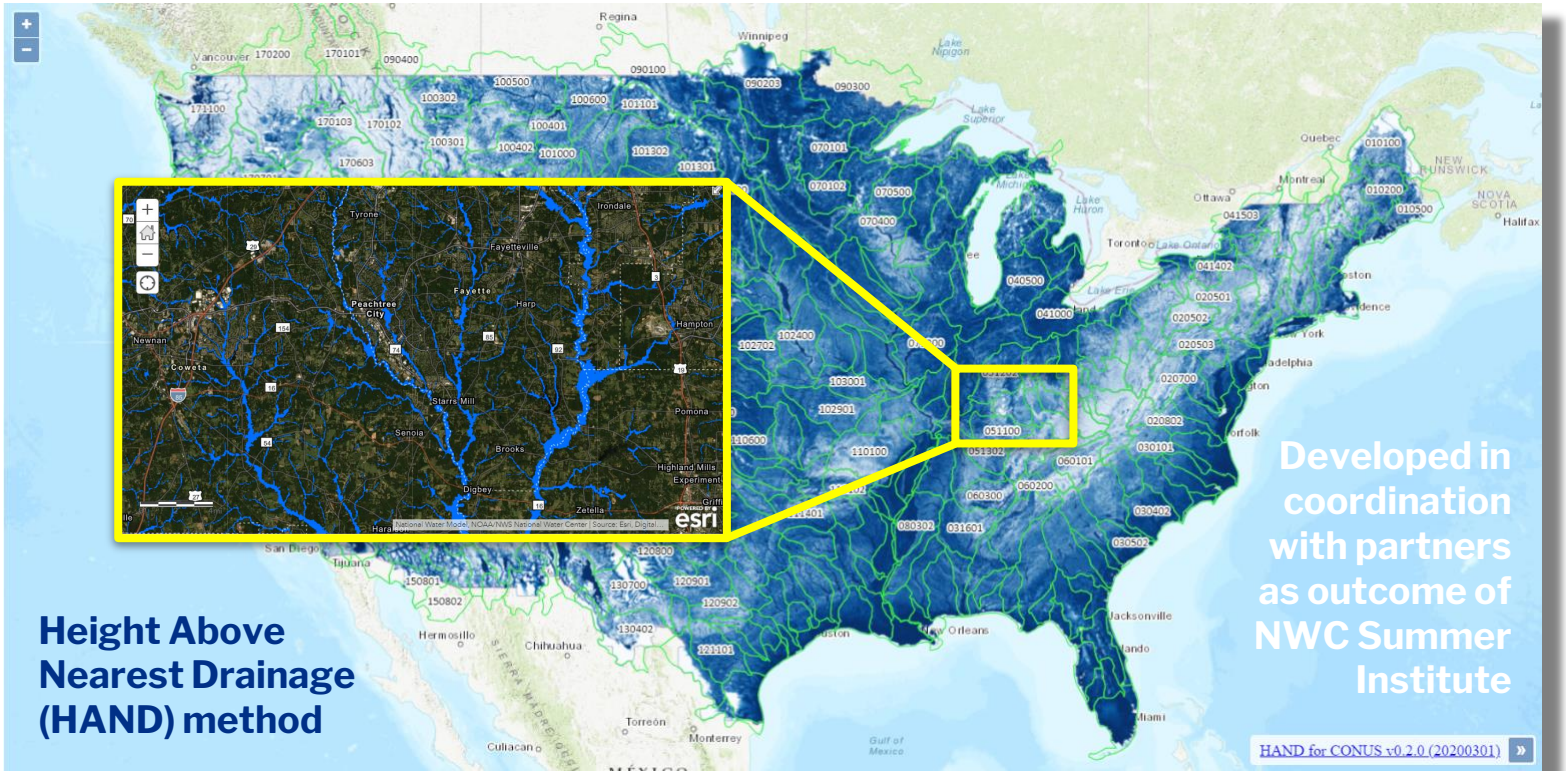
59.5 Major lowland flooding begins as home in Sequoia Estates subdivision begin flooding. Homestead Road south of the channel in innundated with one to two feet of water and water is several feet deep on the south bound feeder of U.S. Highway 59.

56.5 Moderate lowland flooding begins as streets in the Sequoia Estates subdivision and west of JFK Boulevard become innundated. The south bound feeder road of U.S Highway 59 is under close to one foot of water.

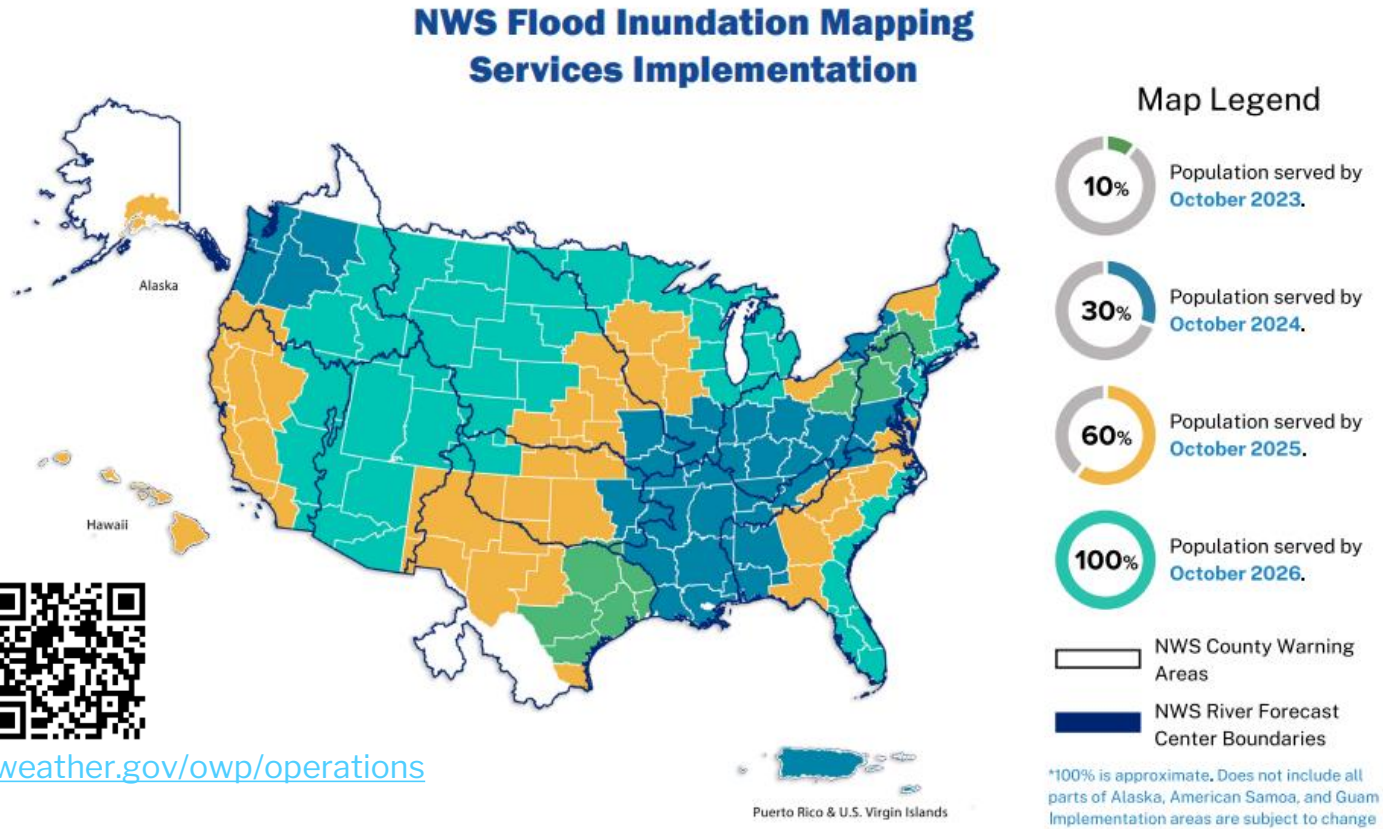
55 Minor lowland flooding begins as water escapes the north side of the upstream bank at U.S. Highway 59. Water is close to inundating the south bound feeder road south of the channel.

Continental Scale Flood Inundation Mapping System

Goal: Near-real-time FIM available to public via enterprise GIS system, based on National Water Model (NWM) and River Forecast Center (RFC) forecasts



Phased Implementation Approach Through 2026



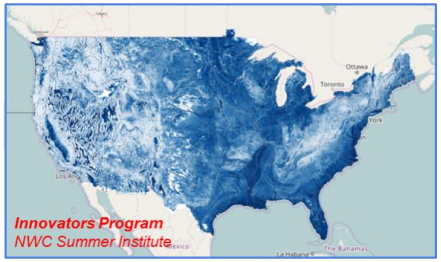
OWP Operations

https://www.weather.gov/owp/operations

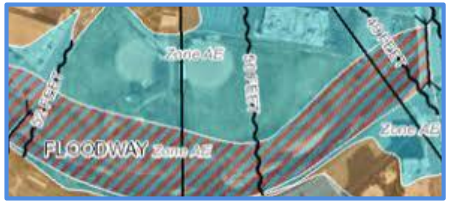
.. with all FIMs updated at NWM frequency

Integrated Mapping Capabilities and Services

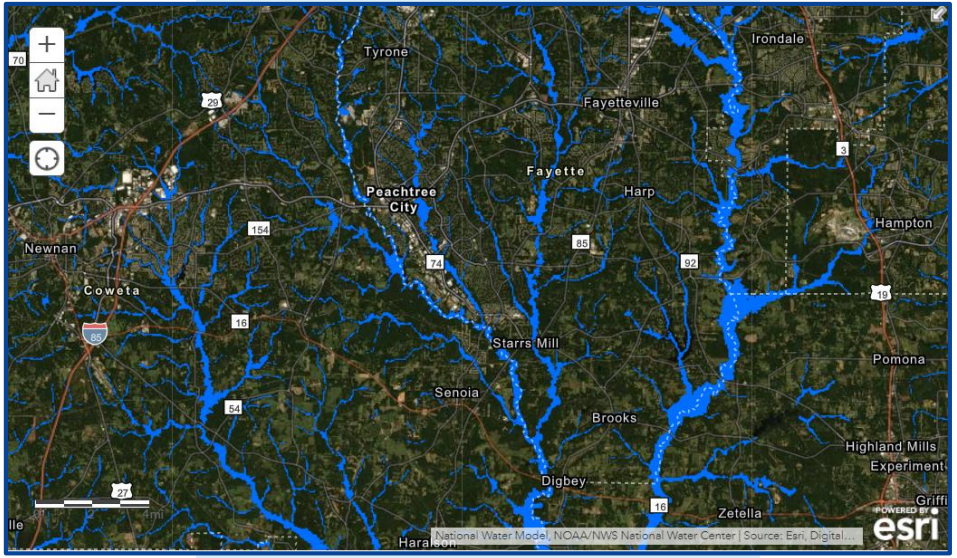
Height Above Nearest Drainage (HAND) Derived FIM



Indexed Static FIM Libraries



NWM (Total Water Level) Derived FIM



Use Best Model and Best Forecast Where Available

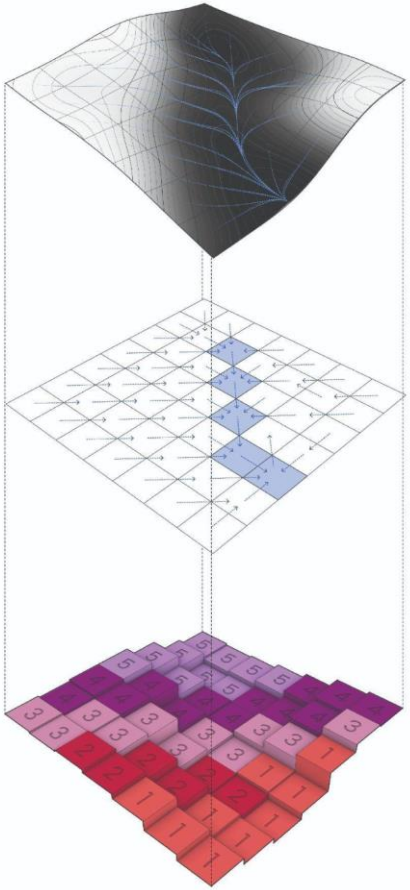
Move Towards Probabilistic Forecasts

HAND Method: detrend DEM by normalizing to nearest relevant drainage line

1) Inputs: Digital Elevation Model (DEM) and stream line network

2) Hydroconditioning

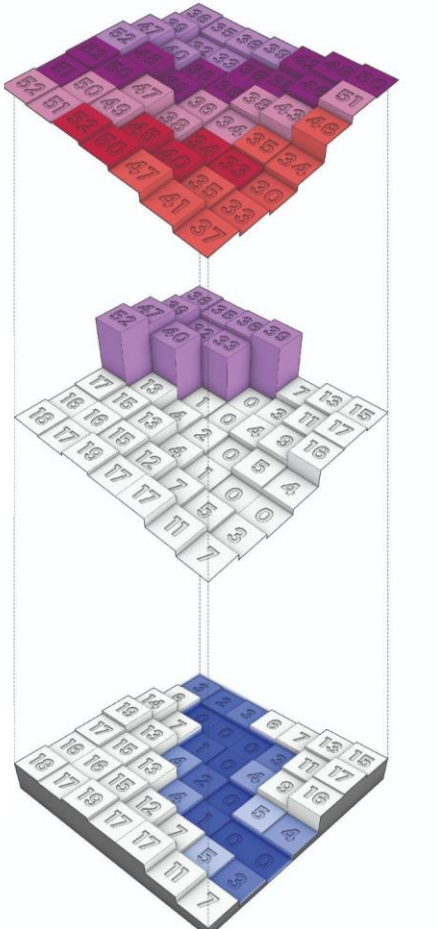
3) Delineate a drainage network and corresponding catchments



4) Convert channel elevation values to 0 elevation

5) Calculate the height above nearest drainage values for each catchment

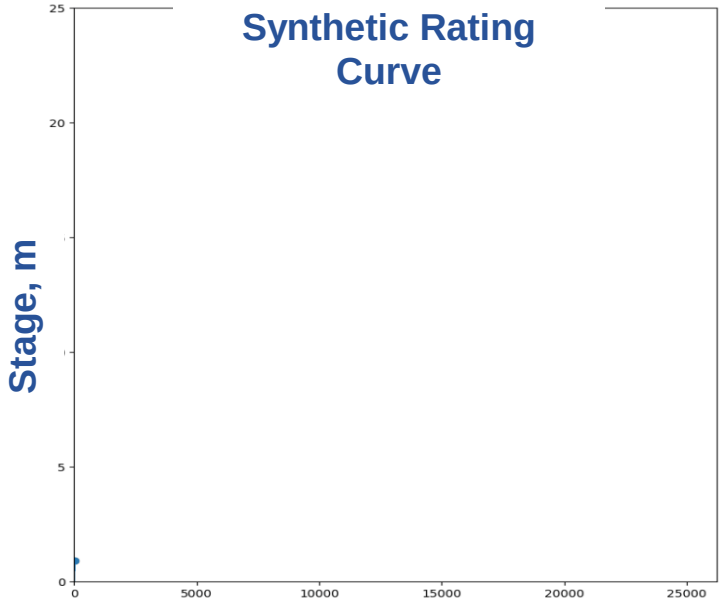
6) Compute a relative elevation model



HAND Method: Development and Deployment

HAND Catchment

Synthetic Rating Curve

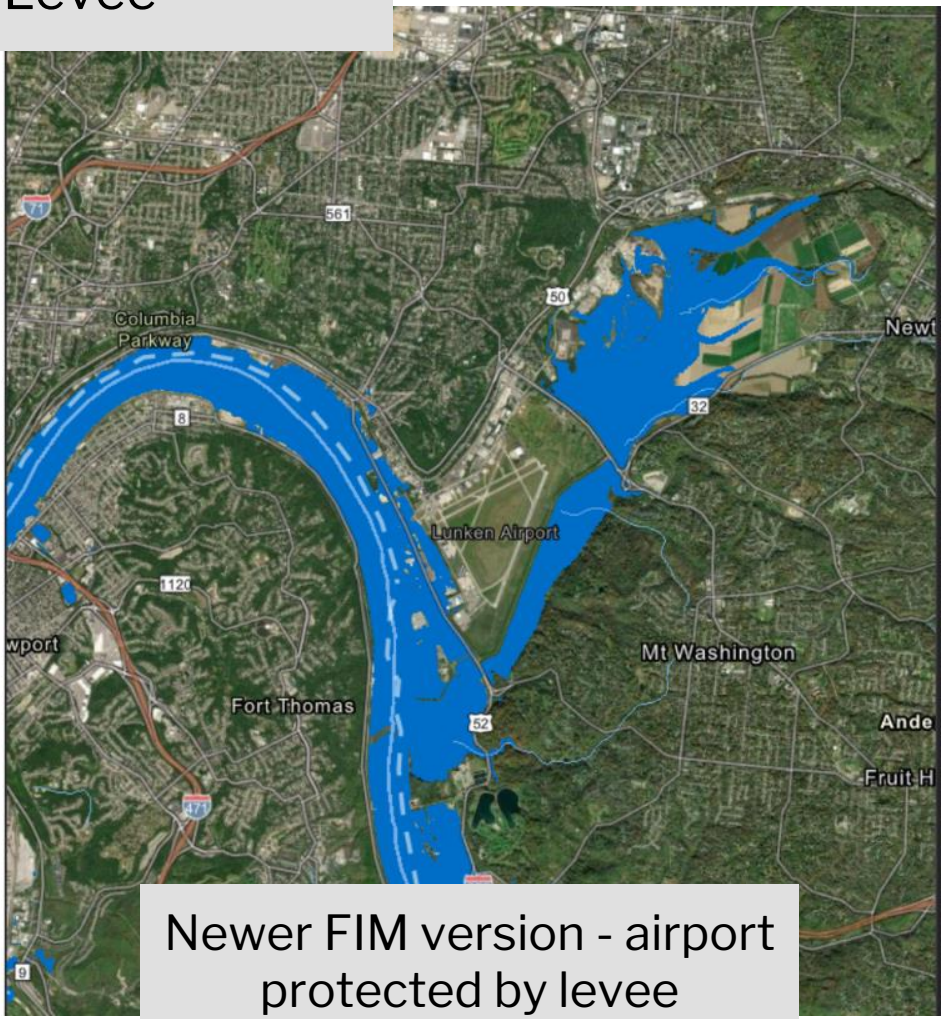


1. Build HAND library
   - Develop REM
   - Calculate rating curve
   - Generate inundation extents on REM
2. Use library for real-time service

HAND Improvements: Levee Masking

Ohio R @ Cincinnati, OH
Feb. 2023

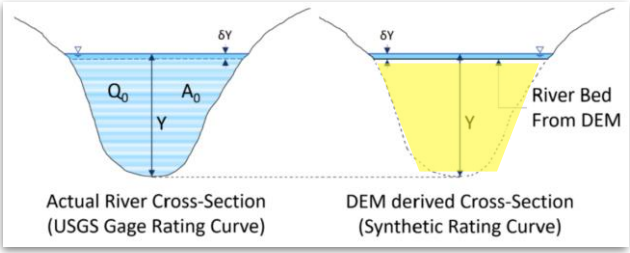
Older FIM version - airport flooded (incorrect)



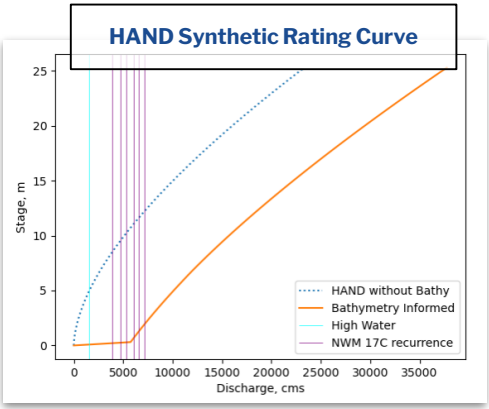
Newer FIM version - airport protected by levee

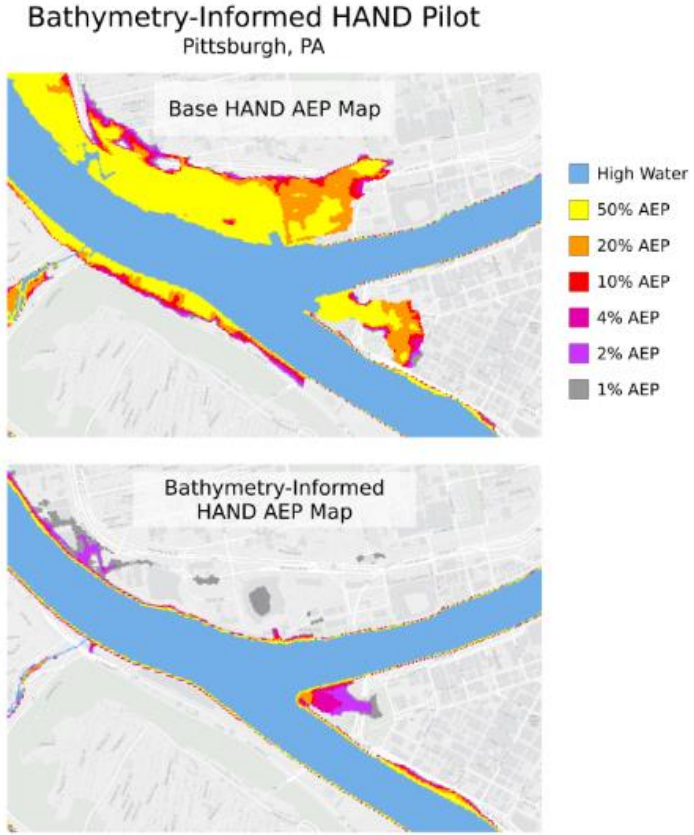
HAND Improvements: Bathymetric Adjustment

Problem: DEMs don't always have accurate depictions of river channel bed and volume

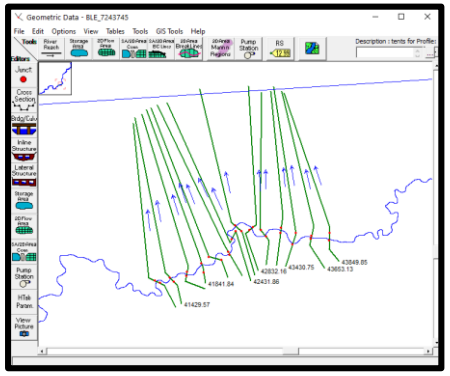


Solution: Estimate missing volume using survey data and machine learning methods, then adjust SRCs



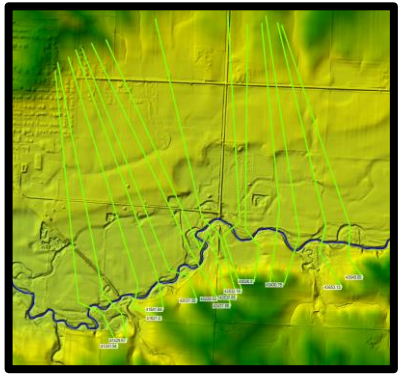


HAND Improvements: Hydraulic Models
RAS2FIM Software Solution



Geospatial
HEC-RAS 1D Model

+



Detailed Bare
Earth DEM

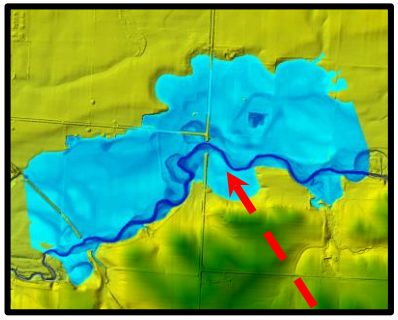
+

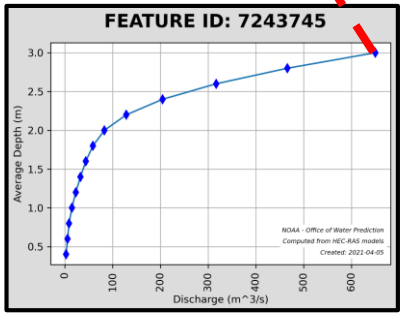
```
df_huc12 = gpd.read_file(str_huc12_area_shp)
int_huc12_index = 0

# Loop through each HUC-12
for i in df_huc12.index:
    str_huc12 = str(df_huc12['HUC_12'][i])
    int_huc12_index += 1
    print(str_huc12)

    # Constant - Folder to write the HEC-RAS folders and files
    str_root_folder_to_create = STR_ROOT_OUTPUT_DIRECTORY
    + "\\HUC_" + str_huc12

    # Select all the 'feature_id' in a given huc12
    df_streams_huc12 = df_streams_merge_2.query('huc12 == @str_huc12')

    # Reset the query index
    df_streams_huc12 = df_streams_huc12.reset_index()

    # Create a folder for the HUC-12 area
    os.makedirs(str_root_folder_to_create, exist_ok=True)

    for i in range(len(df_streams_huc12)):
        str_feature_id = str(df_streams_huc12.loc[[i], 'feature_id'].values[0])
        flt_us_xs = float(df_streams_huc12.loc[[i], 'us_xs'].values[0])
        flt_ds_xs = float(df_streams_huc12.loc[[i], 'ds_xs'].values[0])
        flt_max_q = float(df_streams_huc12.loc[[i], 'peak_flow'].values[0])
        flt_max_q = flt_max_q * FLT_MAX_MULTIPLY
        str_geom_path = df_streams_huc12.loc[[i], 'ras_path'].values[0]
        int_max_q = int(flt_max_q)

        # create a folder for each feature_id
        str_path_to_create = str_root_folder_to_create + '\\' + str_feature_id
        os.makedirs(str_path_to_create, exist_ok=True)

        # create a HEC-RAS folder
        str_hecras_path_to_create = str_path_to_create + '\\HEC-RAS'
        os.makedirs(str_hecras_path_to_create, exist_ok=True)

        print(str_feature_id + ': ' + str_geom_path + ': ' + str(int_max_q))

        # create the HEC-RAS truncated models
        try:
            # sometimes the HEC-RAS model
            # does not run (example: duplicate points)

            river = fn_create_hecras_files(str_feature_id,
                                           str_geom_path,
                                           flt_ds_xs,
                                           flt_us_xs,
```

RAS2FIM
Custom Python
Scripts

Carter et. al., (2021)

=



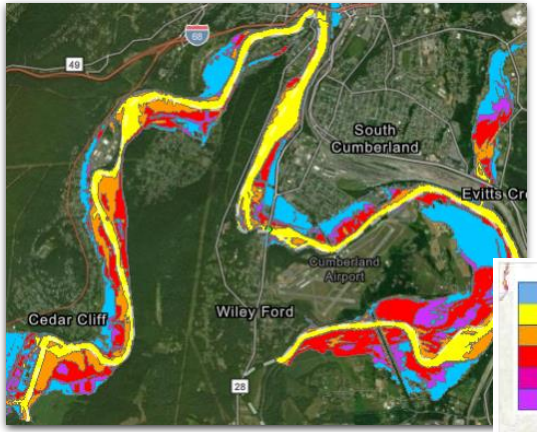


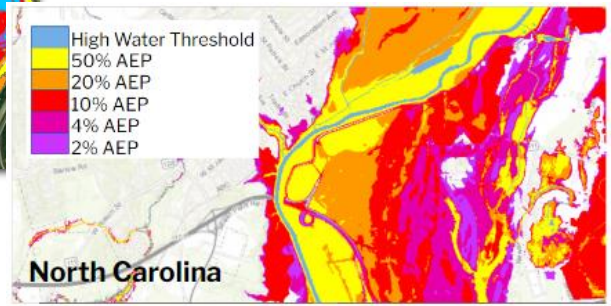
Flood Inundation
Map library and
Synthetic Rating
Curves

noaa-owp/ras2fim

Beyond FIM: Complementary Services, Actionable Intelligence

- Static FIM libraries at NWS forecast points
- Static FIM libraries at non-forecast streams based on NWM recurrence intervals
- Highlight impact hot spots

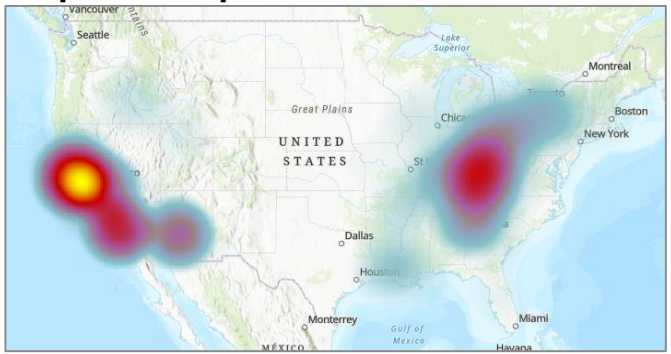




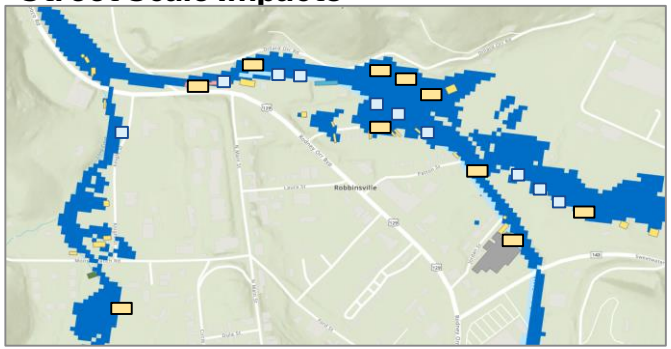
Flood Category

- Record Flood
- Major Flood
- Moderate Flood
- Minor Flood
- Action Flood

Impact Hot Spots



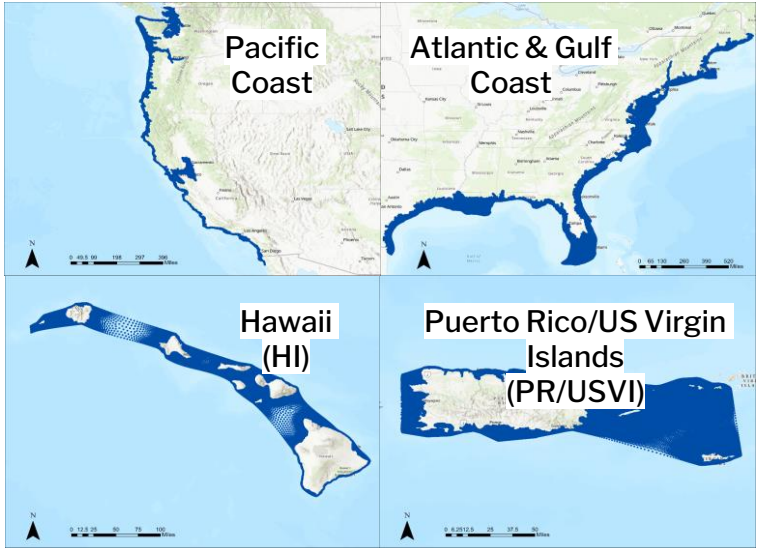
Street Scale Impacts

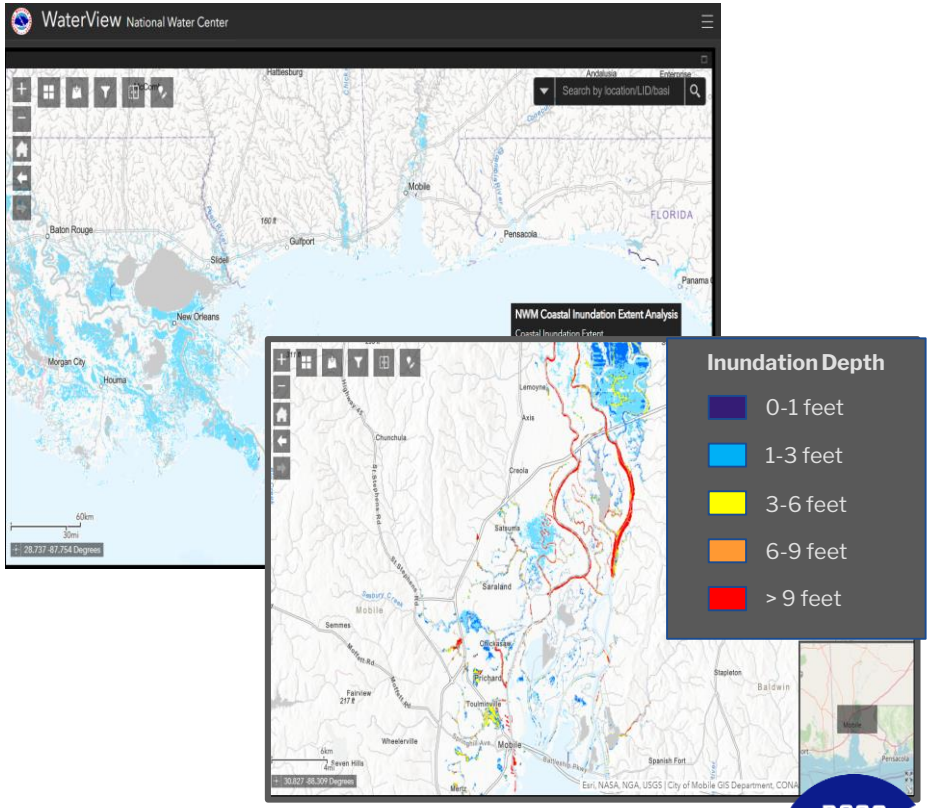


Beyond (Inland) FIM: Coastal FIM Capabilities

- Need to provide flood forecasting capability to coastal communities

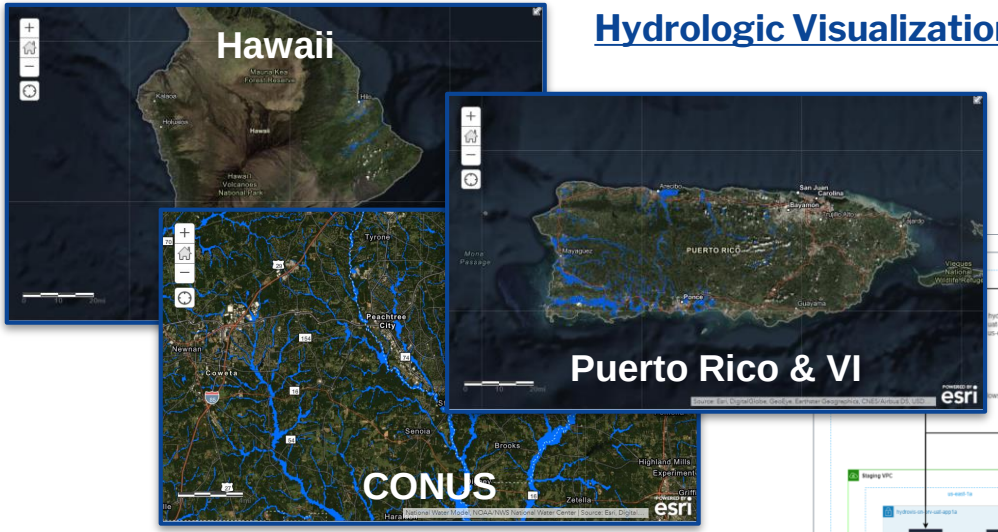
→ NWM v3.0 provides the first total water level forecast capability for CONUS, Hawaii, and PR/ USVI at existing NWM forecast frequencies.





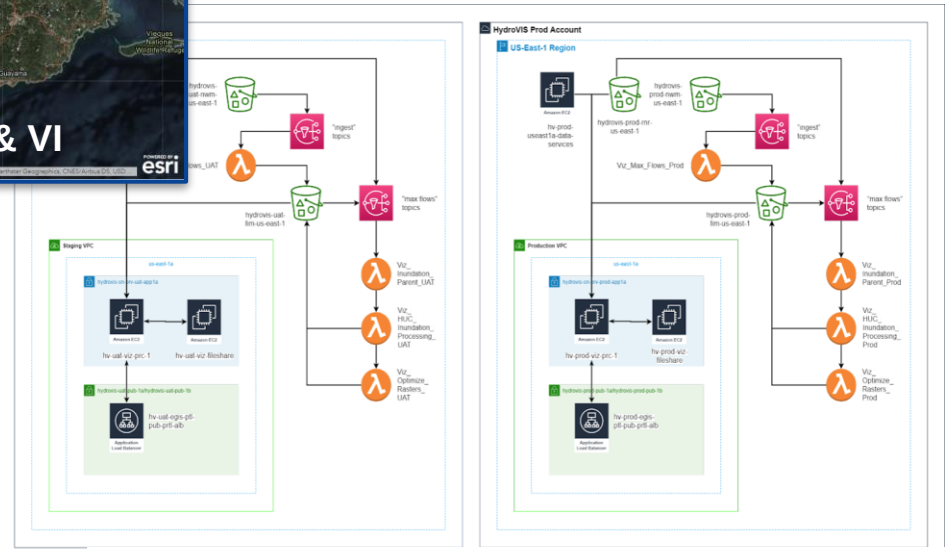
Extent and depth-based versions of TWL-derived FIM for coastal areas

Upgrade: Inundation Services in the AWS Public Cloud



[Hydrologic Visualization and Information Services (HydroVIS) System]

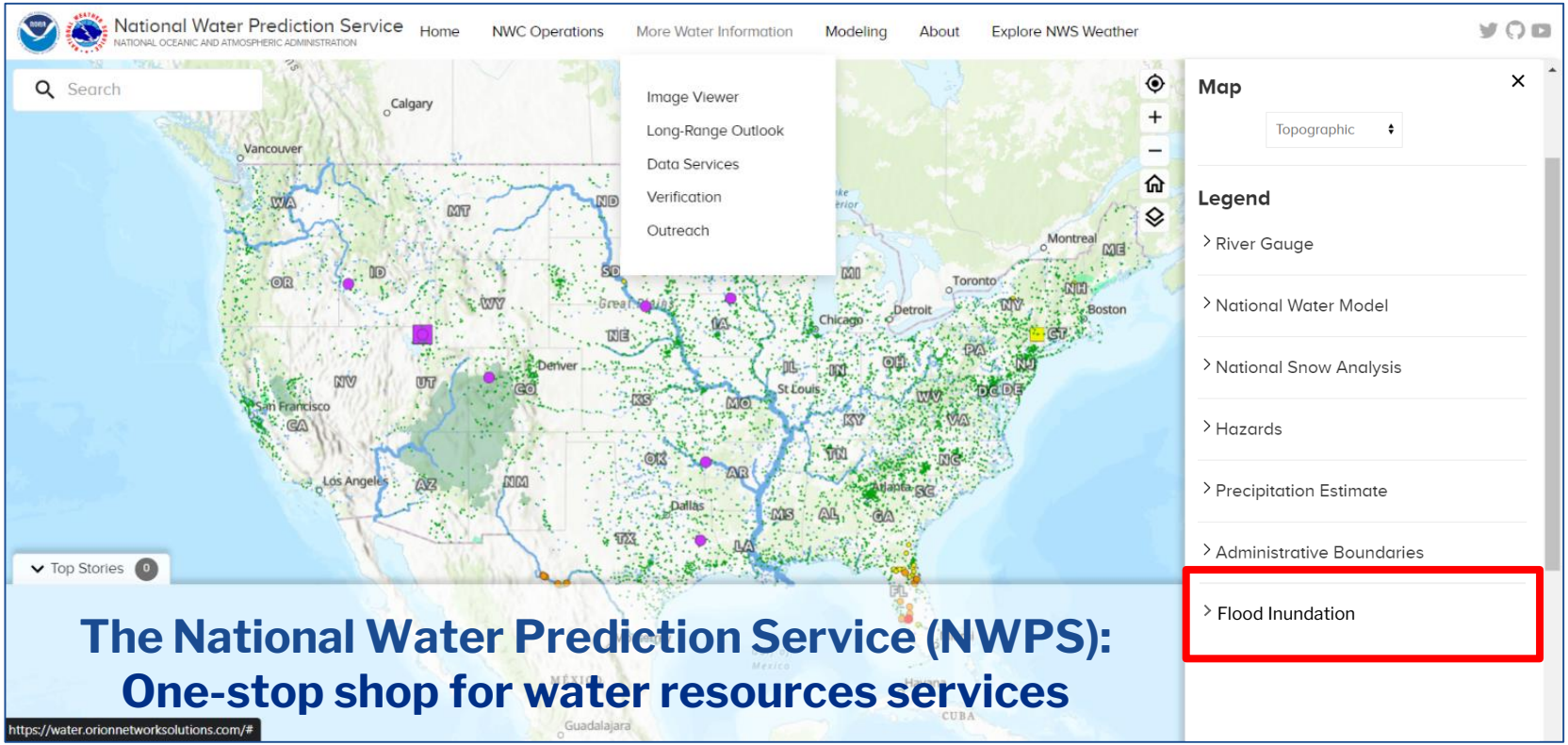
Continental FIM generated in ~10 minutes on a 10-meter spatial resolution grid.



Increased coverage and services necessitates upgrade from on-premises processing and hosting to cloud-based deployment

https://maps.water.noaa.gov/server/rest/services

Operations: Bringing it all together



Thank You!

Laura Keys

laura.keys@noaa.gov

https://water.noaa.gov

NOAA

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