Enhanced Prediction and Visualization of Coastal Inundation along the New England Coast Due to Extratropical Storms

Images: Mass.gov

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NOAA Coastal Services Center
LINKING PEOPLE, INFORMATION, AND TECHNOLOGY

Pilot Project Background

- **Project focus**
- **Project team**
- **Why?**
- **Goals**
- **Pilot communities**
- **Inundation visualization tools**
- **Future vision**

Imagery: Google Earth

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Project Focus – New England Coastal Inundation

New England routinely experiences harsh extratropical weather events known as "Nor'easters"

- Billions of dollars in damages
- Loss of life and property
- Breaching of barrier beaches

Blizzard of 1978

Image: Janet Knott/Boston Globe

Halloween Storm of 1991

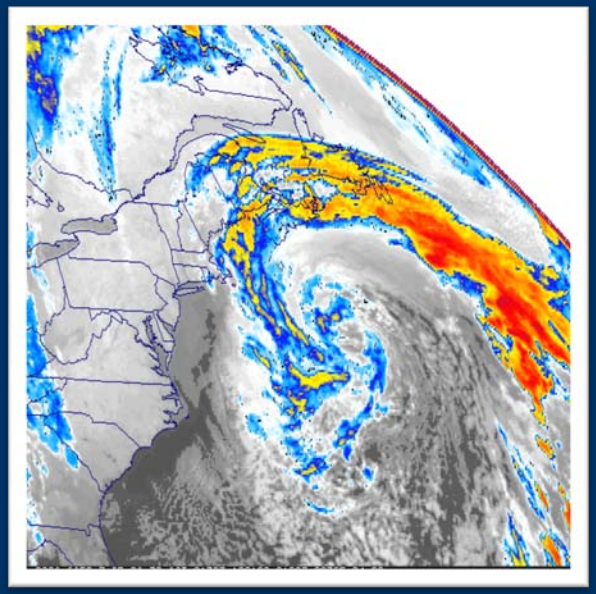


Image: NOAA

Patriots Day Storm of 2007

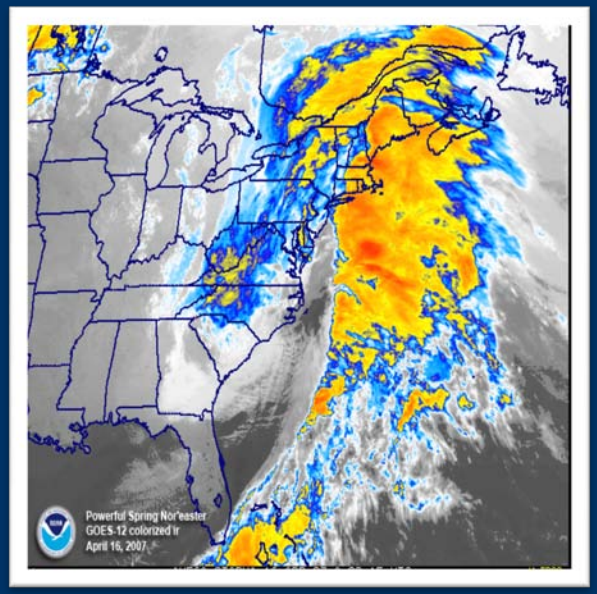


Image: NOAA

White Paper Developed to Address Issues

The current effectiveness of warning procedures is limited

- **Operational storm surge guidance limited to one model**
- **No “real-time” storm surge or inundation model**
- **Communicated through broad brush Coastal Flood Warnings**
- **Previous NOAA assessments indicated a need for Northeast customers to be able to visualize coastal inundation impacts in graphical, GIS-based formats**

White Paper Template

Title:

Enhanced Prediction and Visualization of Coastal Inundation along the New England Coast due to Extra-Tropical Storms

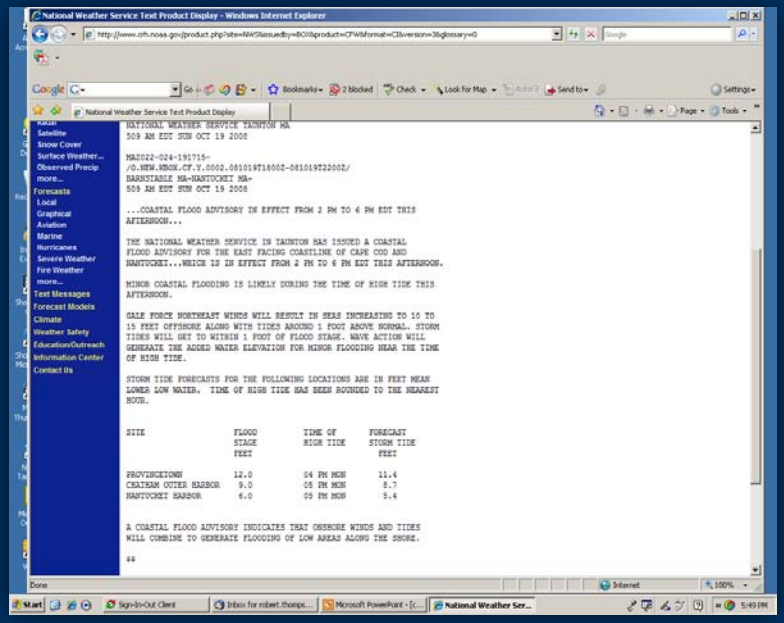
I. Overview:

Coastal New England is, and has historically been one of the most densely populated coastal areas in the nation. The long-term trend is for coastal populations to continue to increase in the Northeast, placing more people, homes and infrastructure at risk from natural hazards. With the potential for higher sea levels due to global climate change, impacts on the economies of the coasts from inundation, and storm surges could become severe. While coastal New England is not often threatened by Hurricanes, devastating storms have occurred, including the Hurricane of 1938 which killed hundreds of people in New England and caused $6 billion worth of damage in today's figures. Even though Hurricanes are infrequent, New England routinely experiences harsh extra-tropical storms or Northeasters, such as the April 2007 Patriot's day storm, which led to the destruction of a number of coastal properties, and breached a barrier beach in Massachusetts, exposing hundreds of homes to coastal erosion and future storms.

Currently, the effective means of current warning procedures for coastal inundation and storm surge in New England is limited. There is a lack of a near shore wave models for the New England coast, and coastal storm surge prediction is coarse with limited means for forecaster adjustment. In addition, operational storm surge guidance is dependent upon only one model. NOAA has the capacity for both weather forecast and modeling through regional NOAA National Weather Service offices, and storm surge and ocean data through NOAA's National Ocean Service Coast Survey Development Lab, but these systems need to be better integrated. By integrating tidal water levels (e.g. storm surge) forecasts with high resolution gridded astronomical tide prediction data, NOAA would be able to more accurately predict coastal inundation, and total water level, also called storm tide. These data, coupled with a coastal visualization tool would bring real time storm surge data to coastal and emergency managers in the event of a hurricane or extra-tropical northeaster.

Impacts from coastal inundation can be far-reaching and catastrophic to the New England coast. Having real time storm surge and inundation models, as well as a visualization tool, coastal and emergency managers will be able to predict and respond to potential coastal inundation threats. In the short-term, benefits of the project include protection of life and coastal property and improved integration of regional NOAA programs and offices. Long-term benefits include improved response of the shoreline and near shore habitats to disruptions from coastal storms, and better land use planning in light of projected sea level rise from global warming in combination with inundation.

Patriots Day Storm of 2007



National Weather Service Text Product Display - Windows Internet Explorer

NATIONAL WEATHER SERVICE TAUNTON MA
509 AM EDT SUN OCT 19 2008

MAZ022-024-191715-
/O.NEW.KBOX.CF.Y.0002.081019T1800Z-081019T2200Z/
BARNSTABLE MA-NANTUCKET MA-
509 AM EDT SUN OCT 19 2008

...COASTAL FLOOD ADVISORY IN EFFECT FROM 2 PM TO 6 PM EDT THIS AFTERNOON...

THE NATIONAL WEATHER SERVICE IN TAUNTON HAS ISSUED A COASTAL FLOOD ADVISORY FOR THE EAST FACING COASTLINE OF CAPE COD AND NANTUCKET...WHICH IS IN EFFECT FROM 2 PM TO 6 PM EDT THIS AFTERNOON.

MINOR COASTAL FLOODING IS LIKELY DURING THE TIME OF HIGH TIDE THIS AFTERNOON.

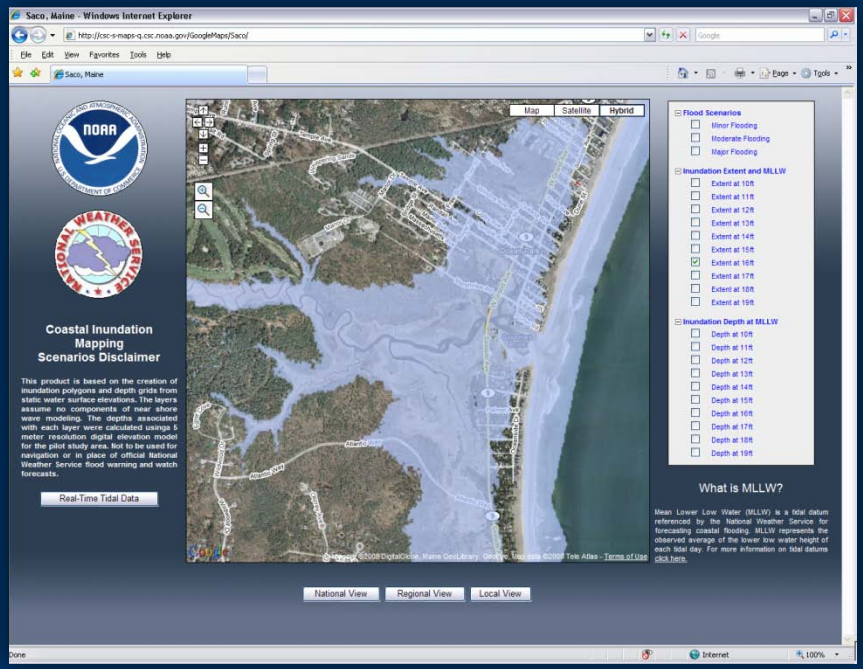
GALE FORCE NORTHEAST WINDS WILL RESULT IN SEAS INCREASING TO 16 TO 15 FEET OFFSHORE ALONG WITH TIDES AROUND 1 FOOT ABOVE NORMAL. STORM TIDES WILL GET TO WITHIN 1 FOOT OF FLOOD STAGE. WAVE ACTION WILL GENERATE THE ADDED WATER ELEVATION FOR MINOR FLOODING NEAR THE TIME OF HIGH TIDE.

STORM TIDE FORECASTS FOR THE FOLLOWING LOCATIONS ARE IN FEET MEAN LOWER LOW WATER. TIME OF HIGH TIDE HAS BEEN ROUNDED TO THE NEAREST HOUR.

SITE	FLOOD STAGE FEET	TIME OF HIGH TIDE	FORECAST STORM TIDE FEET
PROVINCETOWN	12.0	04 PM MON	11.4
CHATHAM OUTER HARBOR	9.0	05 PM MON	8.7
NANTUCKET HARBOR	6.0	09 PM MON	5.4

A COASTAL FLOOD ADVISORY INDICATES THAT ONSHORE WINDS AND TIDES WILL COMBINE TO GENERATE FLOODING OF LOW AREAS ALONG THE SHORE.

##



Saco, Maine - Windows Internet Explorer

NOAA

NATIONAL WEATHER SERVICE

Coastal Inundation Mapping Scenarios Disclaimer

This product is based on the creation of inundation polygons and depth grids from static water surface elevations. The layers assume no components of near shore wave modeling. The depths associated with each layer were calculated usinga 5 meter resolution digital elevation model for the pilot study area. Not to be used for navigation or in place of official National Weather Service flood warning and watch forecasts.

Real-Time Tidal Data

Map | Satellite | Hybrid

Flood Scenarios
Minor Flooding
Moderate Flooding
Major Flooding

Inundation Extent and MLLW
Extent at 10ft
Extent at 11ft
Extent at 12ft
Extent at 13ft
Extent at 14ft
Extent at 15ft
Extent at 16ft
Extent at 17ft
Extent at 18ft
Extent at 19ft

Inundation Depth at MLLW
Depth at 10ft
Depth at 11ft
Depth at 12ft
Depth at 13ft
Depth at 14ft
Depth at 15ft
Depth at 16ft
Depth at 17ft
Depth at 18ft
Depth at 19ft

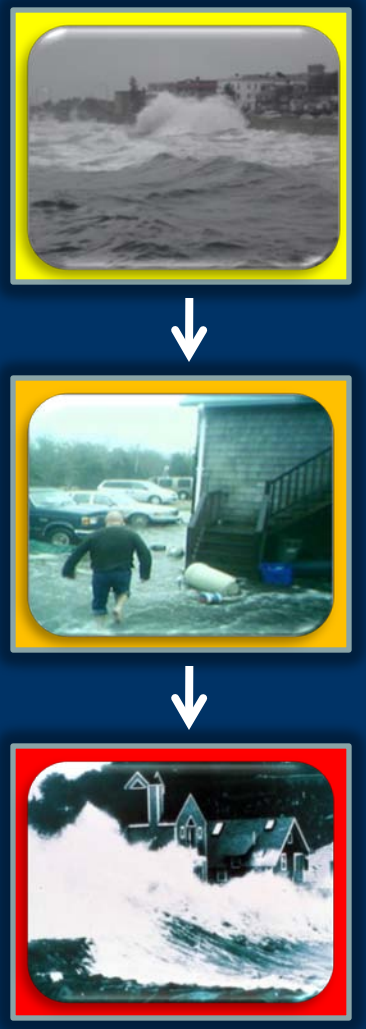
What is MLLW?

Mean Lower Low Water (MLLW) is a tidal datum referenced by the National Weather Service for forecasting coastal flooding. MLLW represents the observed average of the lower low water height of each tidal day. For more information on tidal datums click here.

National View | Regional View | Local View

Project Goals

1. **Improve forecasts of coastal inundation**
   - **Storm surge / Storm tide**
   - **Nearshore wave**
   - **Wave run-up**
2. **Establish headline criteria for coastal flood warnings and coastal flood advisories**
   - **Minor, Moderate, Major**
     - **Evoke a more effective response**
3. **Provide inundation visualization tools**
   - **Regional emergency / Floodplain managers**
   - **Decision makers**
   - **Public**
     - **Public uses National Weather Service (NWS) sites for forecasts**



Who's Involved?

- **NOAA North Atlantic Regional Team (NART)**
  - **NOAA Coastal Services Center**
  - **NWS Gray, Maine, and Taunton, Massachusetts, Weather Forecast Offices**
  - **Gulf of Maine Ocean Observing System (GOMOOS)**
  - **National Ocean Service Coast Survey Development Laboratory**
  - **NWS Meteorological Development Laboratory**

- **Town of Scituate, Mass.**
- **Town of Saco, Maine**

Scituate, Mass., and Saco, Maine
Pilot Communities

1. **Frequent flooders – large sample size to work with**
2. **Varying geographies along New England coast**
3. **Allows focus on extratropical storm activity**
4. **Availability of high-resolution lidar and topographic data**

Scituate, Massachusetts

Saco, Maine

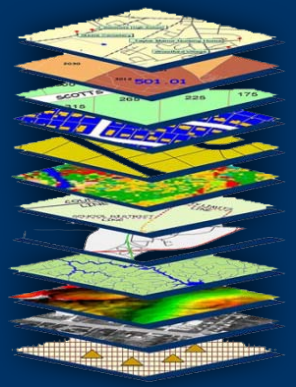
Why Should Stakeholders Care?

- **Opportunity to help improve science for better surge and wave forecasts**
- **Better tools for emergency management**
- **Improved resource to enhance public safety**
- **Opportunity to influence new forecast and decision-making aids**
- **Topic becoming more critical with sea-level rise and climate change**

New and Enhanced Visualization Tools

Inundation Map library (High-Res)

- Inundation polygons
- Depth grids
- KML and KMZ files for display in Internet mapping applications
- Historical water marks from previous storms
- Other relevant data (FEMA Special Flood Hazard Area, or SFHA, etc.)



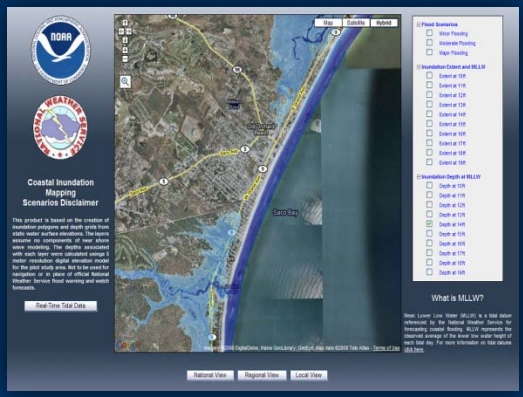
Depiction of inundation at well-known landmarks

- CANVIS visualization software
- Images from past storms

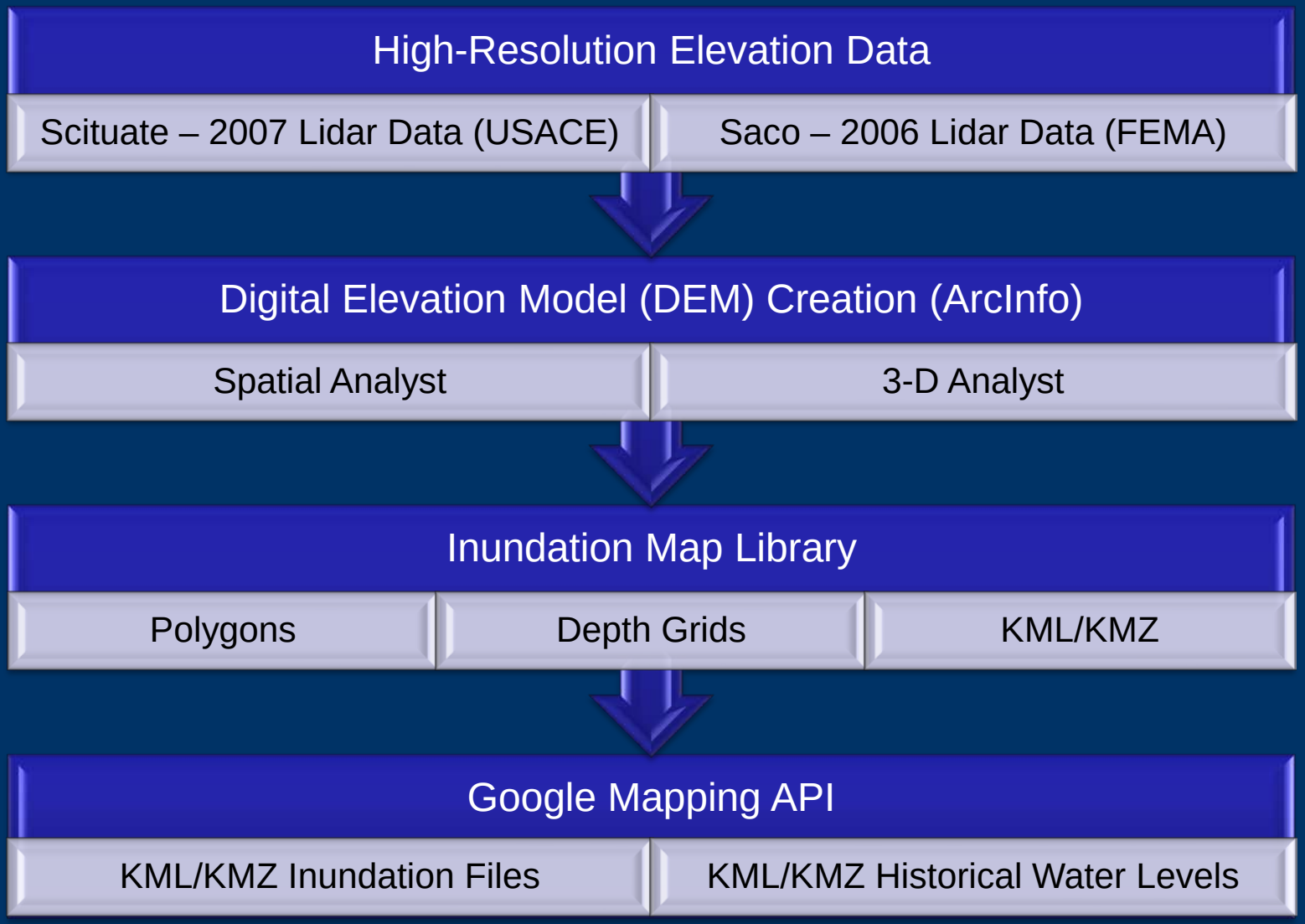
Image: Janet Knott/Boston Globe)

Internet mapping application to illustrate real-time, forecast, hindcast, and scenario-based water levels

- Google's Mapping APIs
- Application Programming Interface

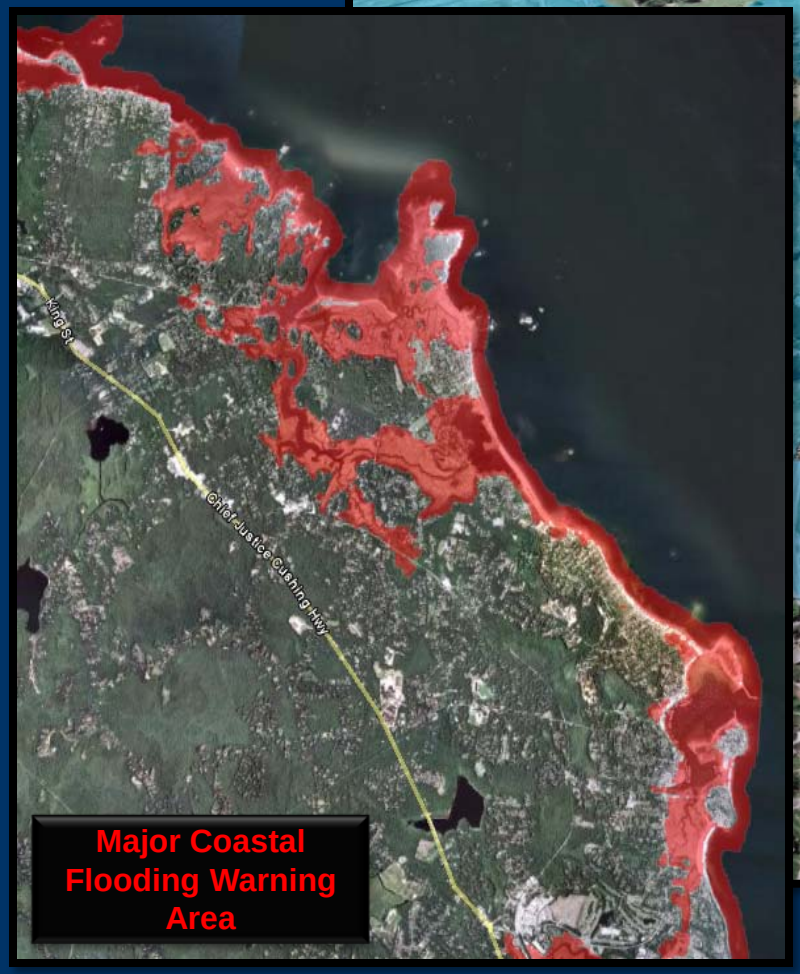


Inundation Map Library – Methods



Inundation Map Library

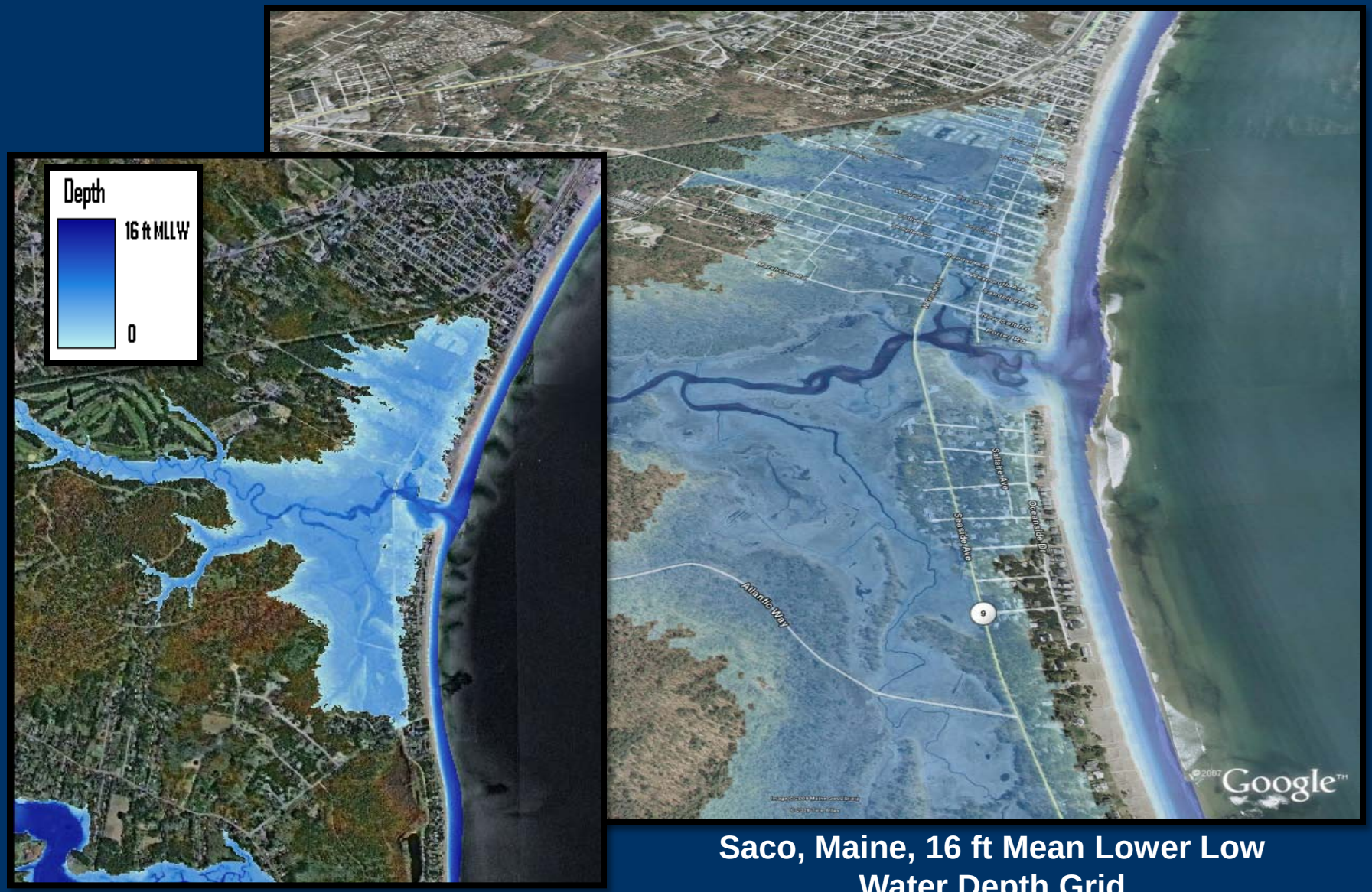
Inundation Extents



Scituate, MA, 16 ft Mean Lower Low Water Inundation Extent

Inundation Map Library

Depth Grids



Saco, Maine, 16 ft Mean Lower Low Water Depth Grid

Inundation Map Library

Integrate Data – Historic Water Levels, FEMA SFHA

Blizzard of 1978 – Scituate, MA

The Blizzard of 1978, known to New Englanders as the Blizzard of '78, which generated blizzard conditions across the Northeast, was born February 5, 1978 with the merger of a Canadian high-pressure system and a dense mass of low pressure off the Carolina coast. By the time the storm ended late on the 7th, Boston had 27.1 inches of new snow to set an all-time single storm snowfall record. Up to 50 inches fell in northern Rhode Island. A tremendous east-northeasterly gradient was set up as the low (984 mb) bucked up against an enormous 1052 mb high to the north. Winds gusted to 92 mph at Chatham, Massachusetts. Arriving at the time of a new moon, the storm produced heavy coastal flooding along the New England coast. Beachfront homes were washed away due to strong winds and coastal flooding. More than 1,700 homes suffered major damage or were destroyed and 39,000 people took refuge in emergency shelters. East facing coastal sections were then devastated by 4 successive high tides. The 14 foot tide recorded at Portland, Maine was perhaps the highest this century. 75 people were killed and total damage was estimated at 500 million dollars.

Photo courtesy of the Boston Globe

View Flood Watch and Warning Information from NWS

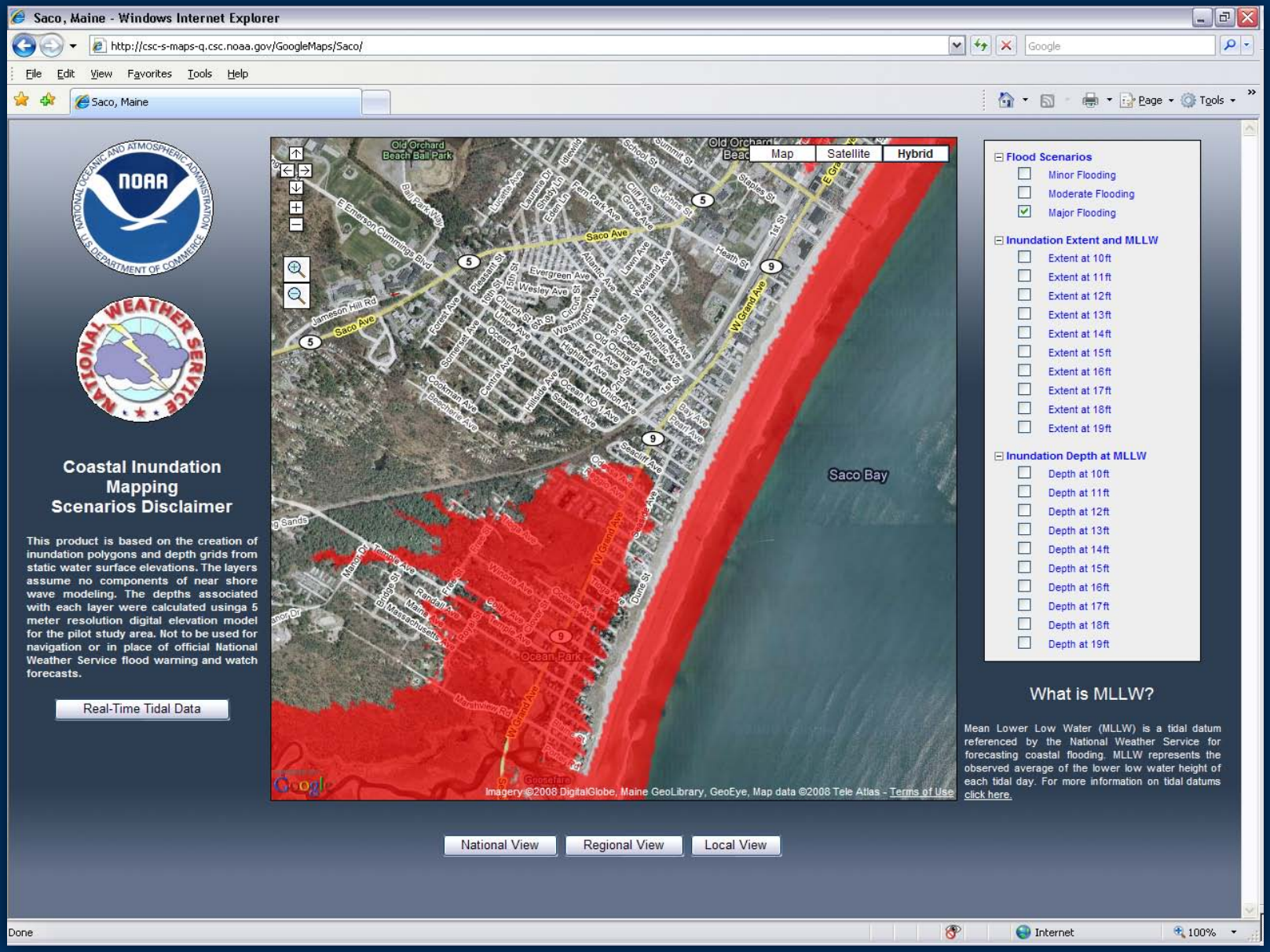
What Is a Google API?

- **Application Programming Interface**
- **Embed Google Maps in your own Web pages with JavaScript**
- **Create customized and innovative on-line mapping applications**
- **NOT a programming language – a set of functions and routines**

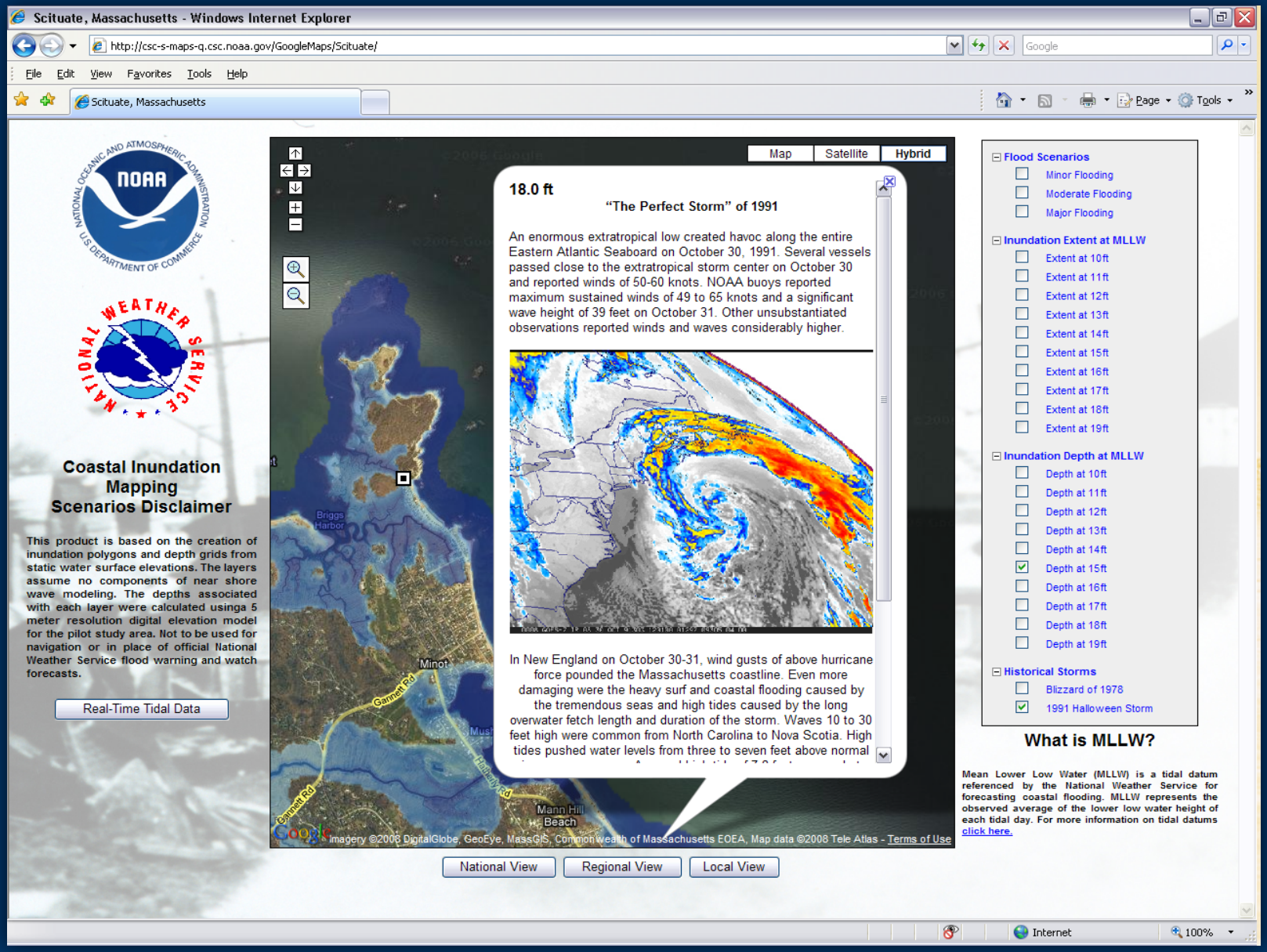
Why Use Google Maps for This Project?

- **Highly customizable for National Weather Service's needs**
- **NOAA-wide Google API Key exists**
- **Avoid expensive software, hardware, and staff training**
- **Easy to reach the audience – ease of use and audience's familiarity with Google products**

Example Pilot Location Google Maps API



Example Pilot Location Google Maps API



New / Enhanced Inundation-Based Services Project Status

- **Forecast process improvements**
  - **Forecast model implemented**
  - **Gridded storm surge output can be modified by forecasters**
  - **Wave nomogram available**
  - **Total water-level forecast available**
    - **Gridded astronomical tide + Gridded storm surge**

- **Inundation visualizations**
  - **All data created and technologies reviewed**
  - **Experimental Google-based mapping applications being implemented soon in NWS websites for review**

Future of Project

- Investigate wave run-up
- Evaluate alternative forecast models
- Event assessment
  - New tide gauge installations
  - Rapid response teams
- Help pilot communities become "StormReady"
- Incorporate new areas into project
- Produce real-time forecast visualization maps
- Sea-level rise scenarios
- Erosion
- Benthic impacts

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Questions?

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