Assessing the relevance of wetlands for storm surge protection: a coupled hydrodynamic and geospatial framework

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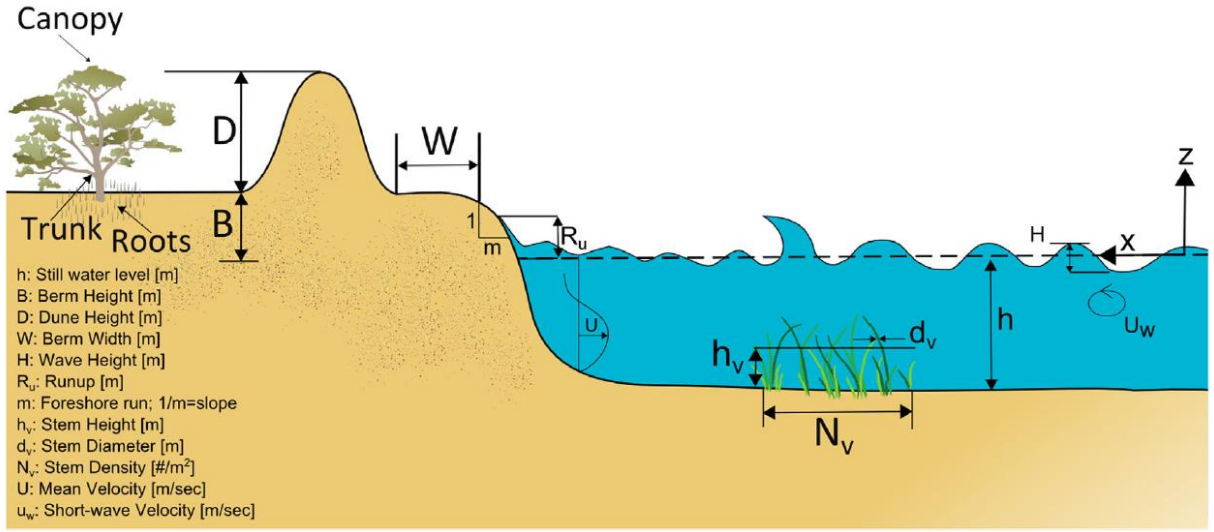
Role of wetlands in mitigating surge

- Wave attenuation by vegetation has been explored:
  - Field studies
  - Lab simulations

- Dissipation of surge energy via vegetation resistance
- Vegetation roughness impedes wind flow
- Dampening of wind-driven surface stresses

Role of wetlands in mitigating surge

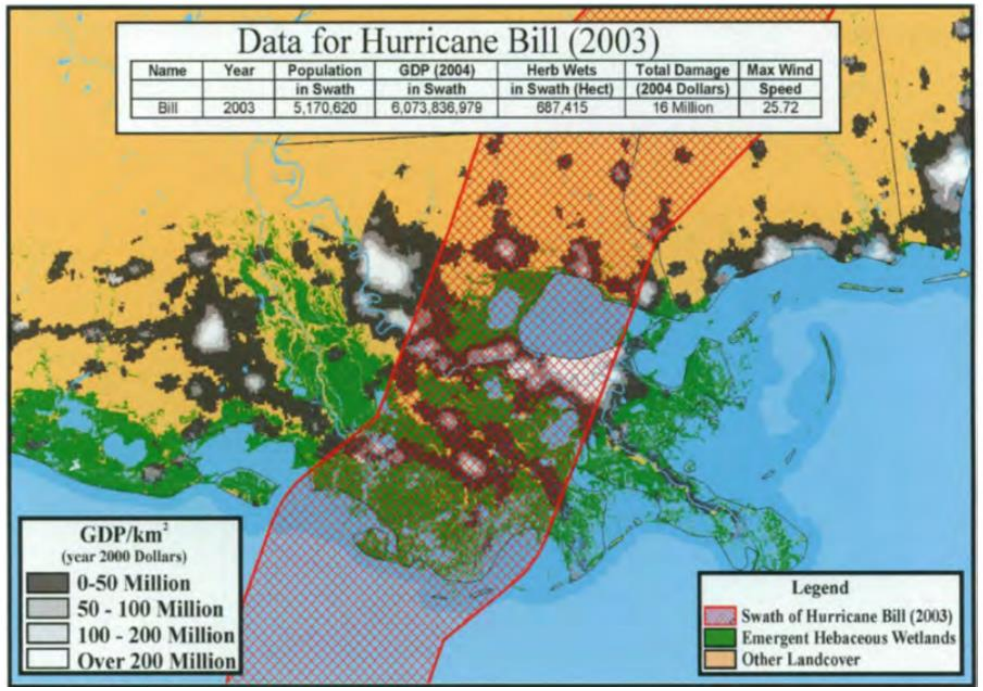
- **BUT,** effective attenuation is dependent on:
  - Micro-topography
  - Geomorphology
  - Veg. characteristics
  - Storm parameters
  - **Spatial scales**



Source: Guannel et al (2015) Integrated modeling framework the quantify the coastal protection services supplied by vegetation (Journal of Geophysical Research: Oceans)

- Numerical modeling has enhanced our understanding of interactions
  - Has reinforced need for spatial considerations for effective attenuation

Estimations of protection afforded



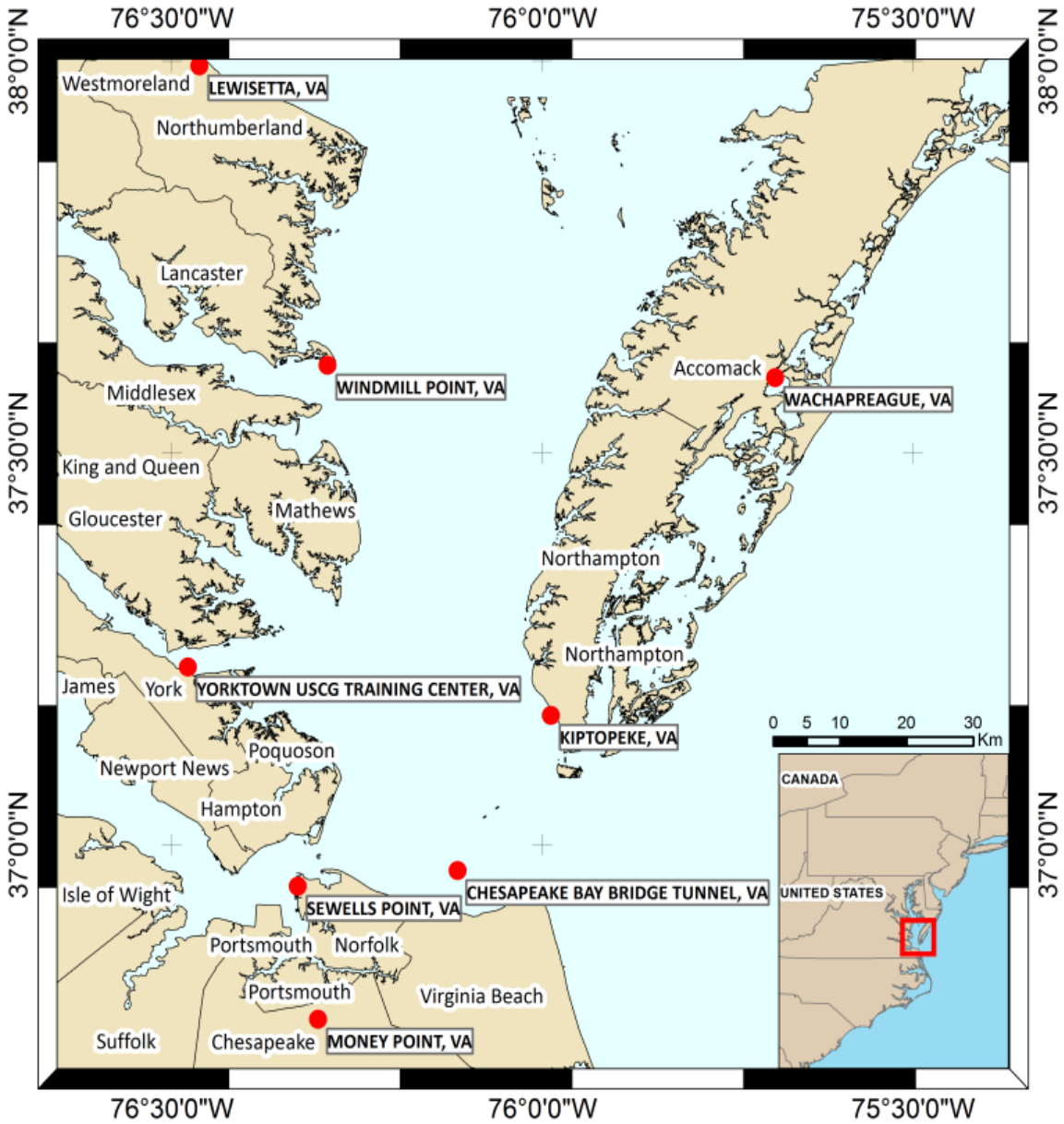
Source: Costanza et al (2008) The Value of Coastal Wetlands for Hurricane Protection (Journal of the Human Environment)

- Social, management, economic perspectives
- Requires multi-layered understanding:
  - Vulnerability: Where are the high-population areas?
  - Risk: What are typical inundation levels?
  - Resilience: Where are the wetland systems with the right spatial scales?

This study

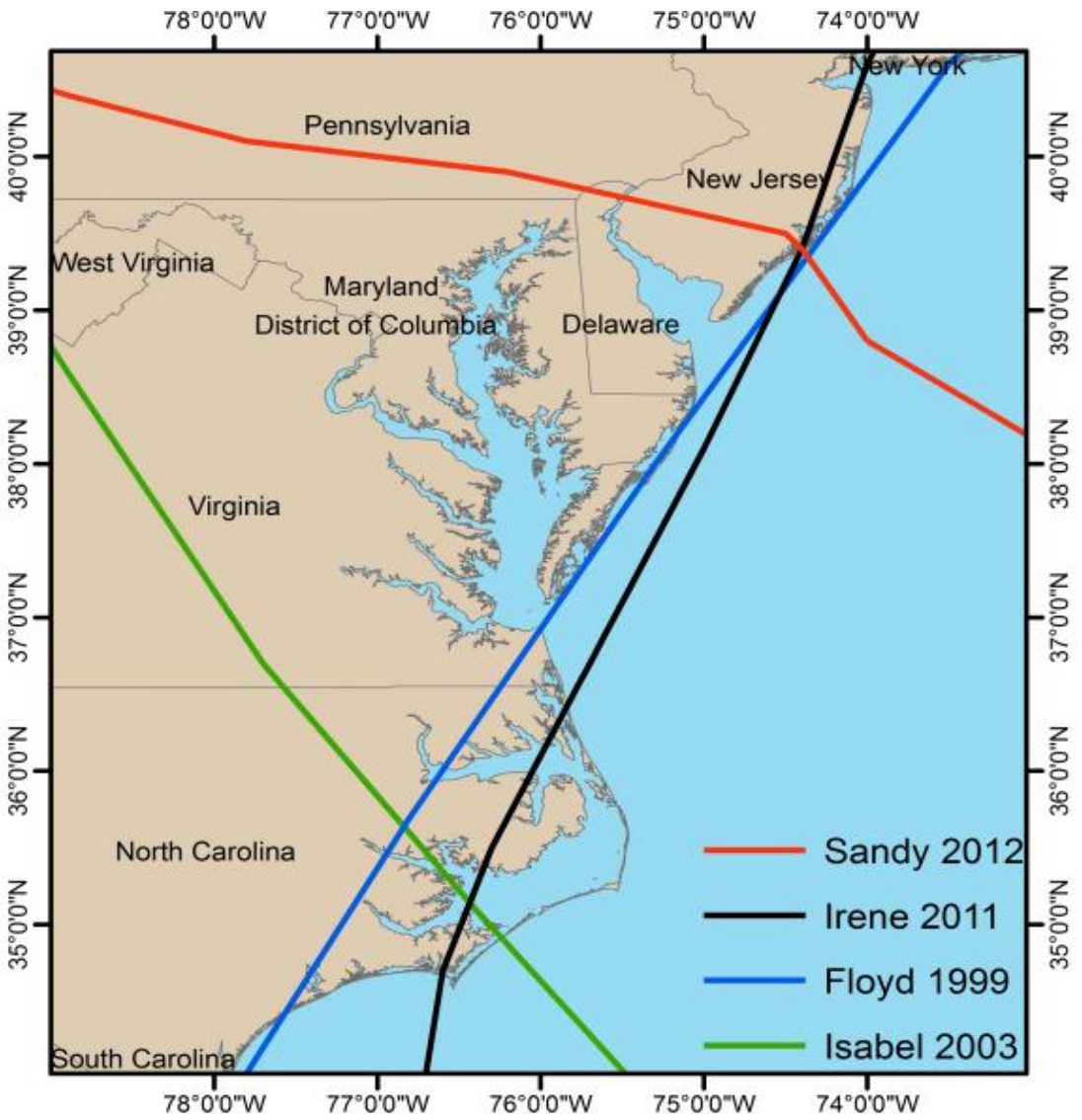
- A framework for assessing protection potential that accounts for:
  1. Incidence of surge inundation (historical storms)
  2. Consideration of spatial scales of wetlands present
  3. Proximity of communities at risk

…REGIONALLY



Hydrodynamic Modeling

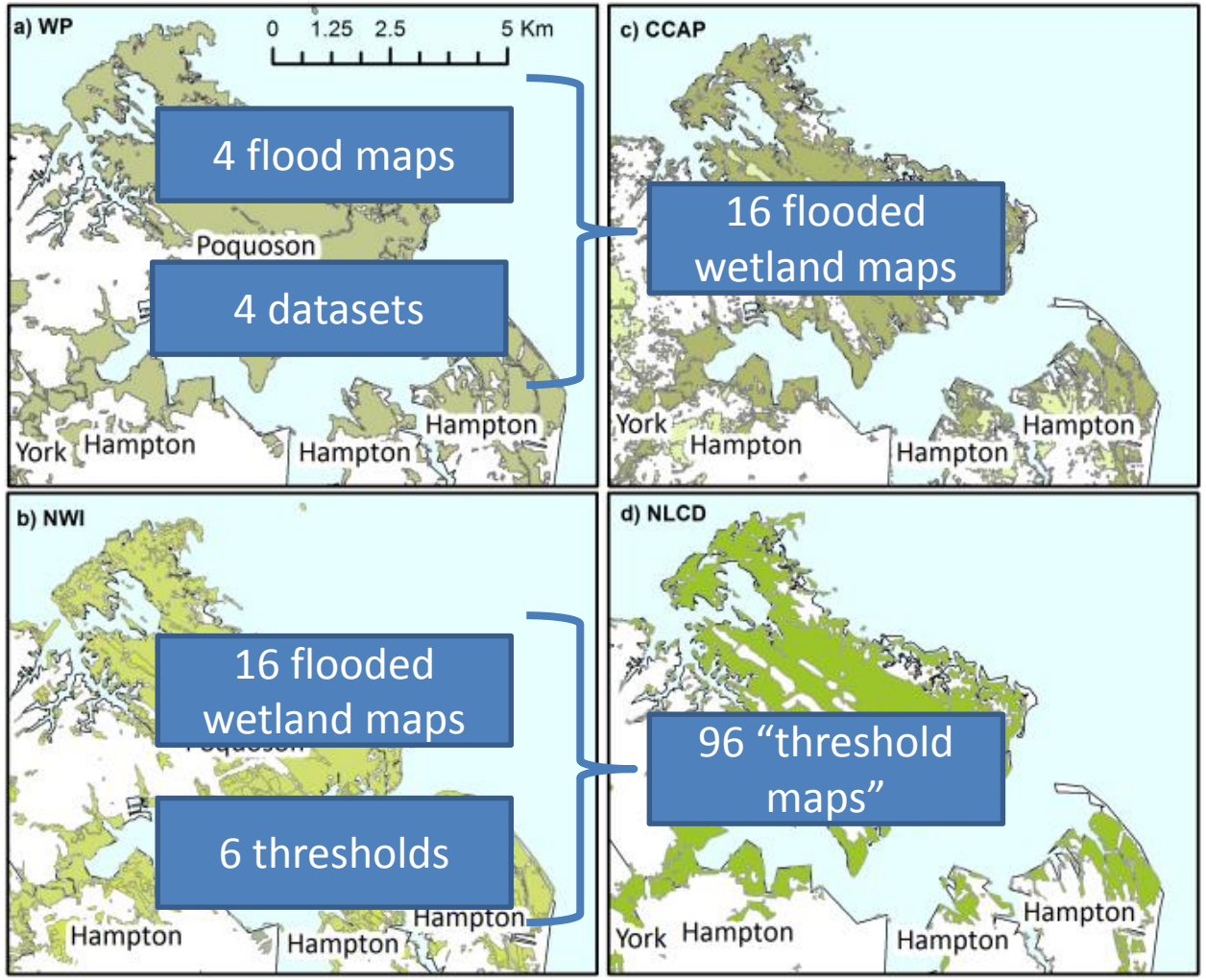
- Numerical Model
  - Coupled ADCIRC+SWAN
  - FEMA R3 Mesh
- Meteorological Forcing
  - Tides (Le Provost)
  - **4 Storms** (Nat'l Hurricane Center)
    - Floyd, Isabel, Irene, Sandy
- Flood raster generation
  - Arc Storm Surge (Ferreira et al 2014)
- Result: **4 flood maps**



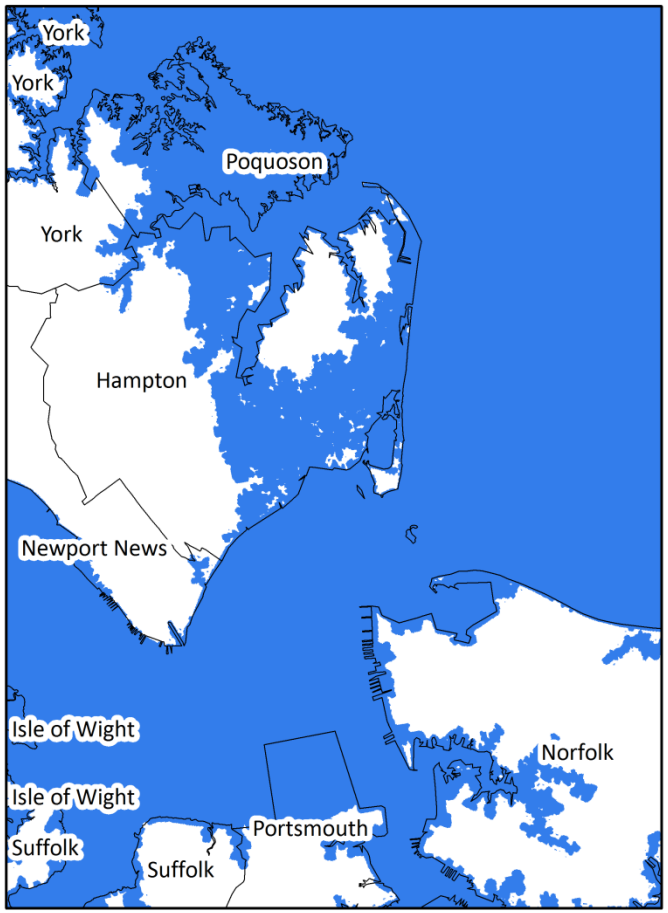
Wetland Characterization

- **4 Datasets**
  - NWI (USFWS)
  - CCAP (NOAA)
  - NLCD (USGS)
  - Wetland Potential (NOAA)

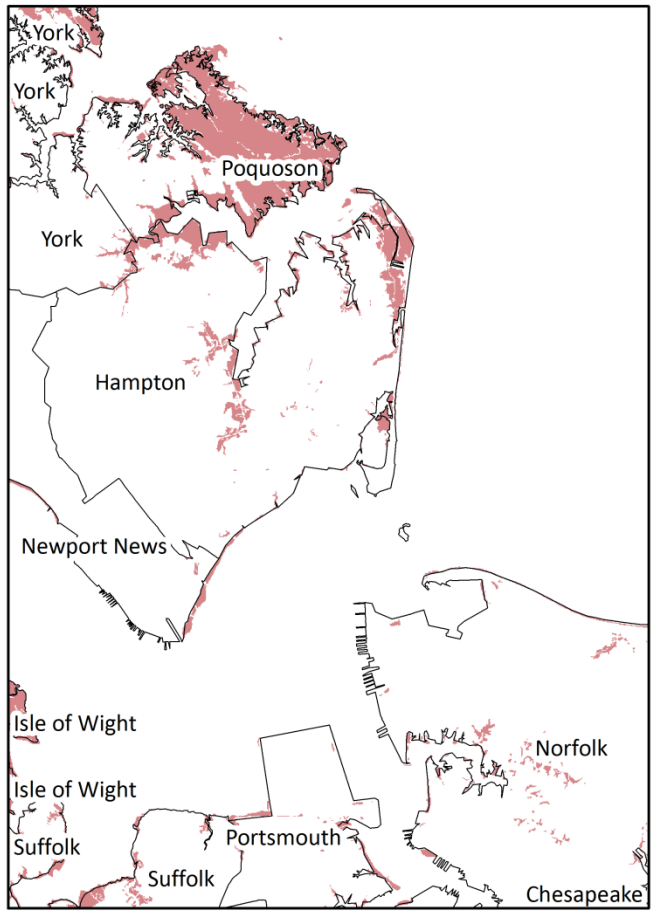
- **Spatial Scale Thresholds**
  - Lower limits of flooded wetland area
  - Account for discontinuity
  - Applied here: 0, 5 ,10, 15, 25, 50 sq. km
  - Can be adjusted based on new understanding of spatial scales needed



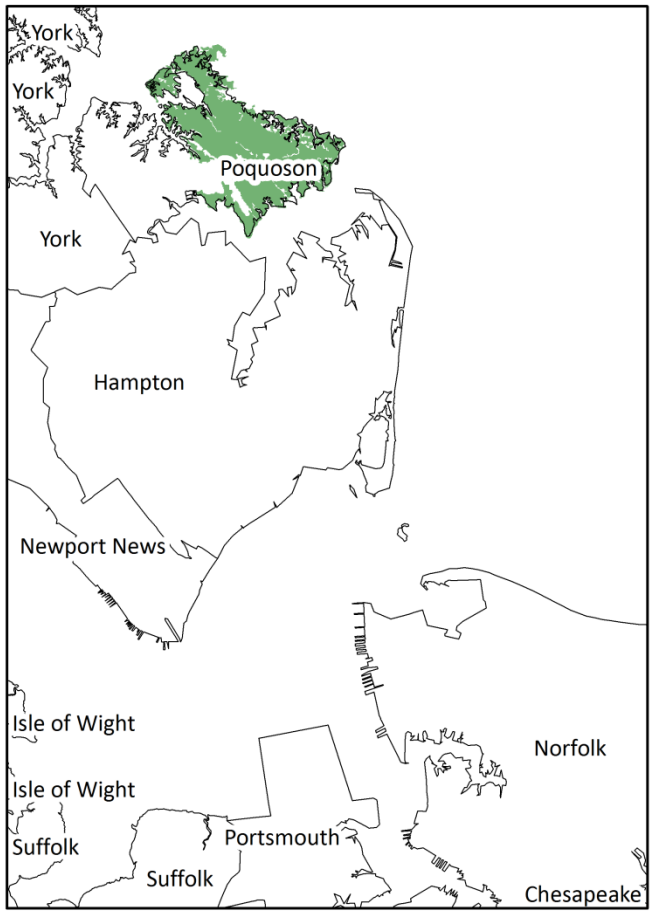
Wetland Characterization



Hurricane Irene Flood Map



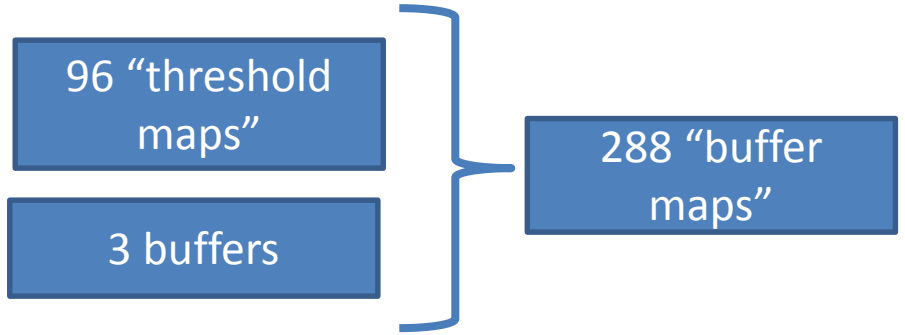
Inundated Wetlands (NOAA Wetland Potential database)



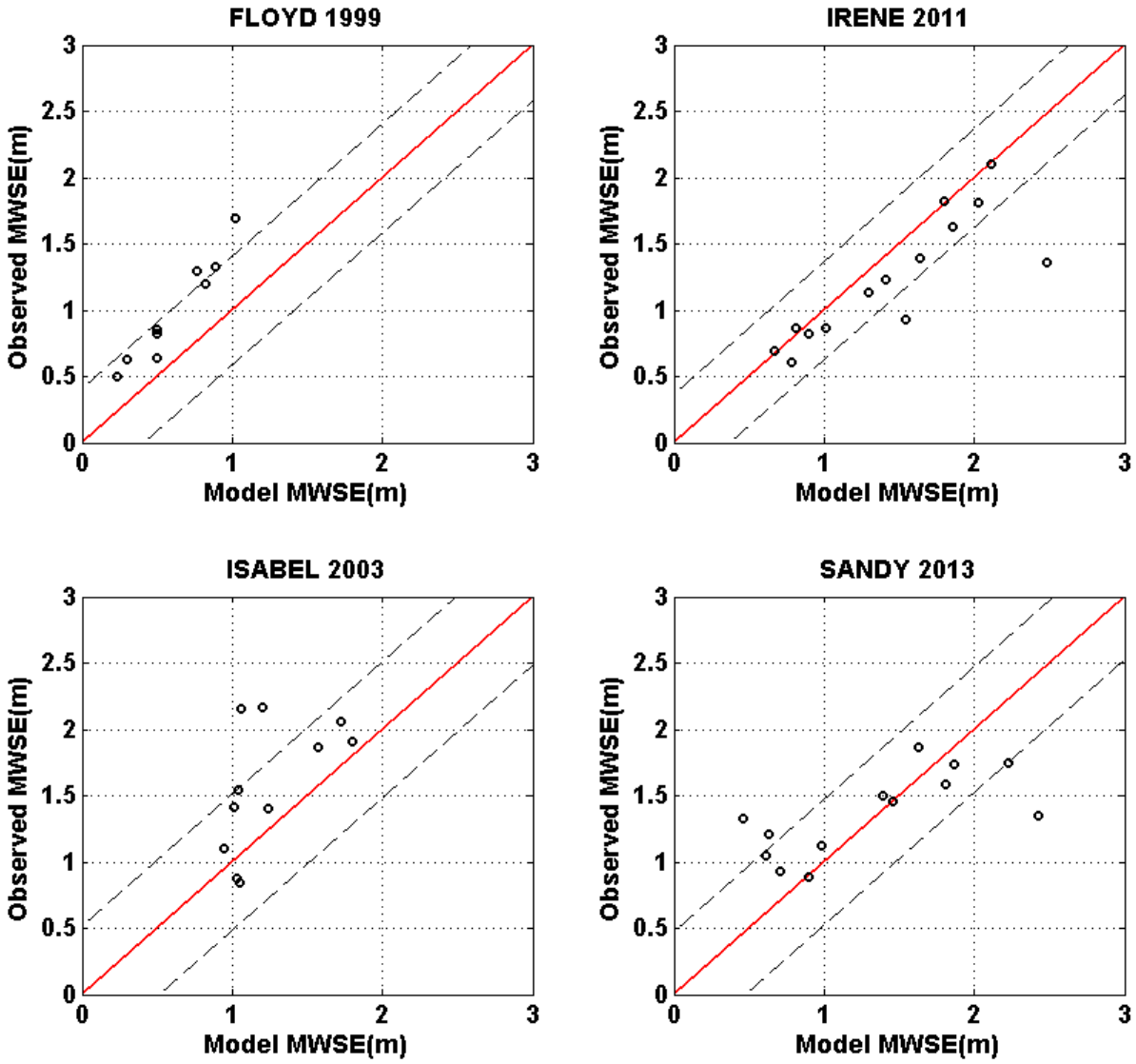
5 sq. km threshold map

Assessment of Wetland Relevance

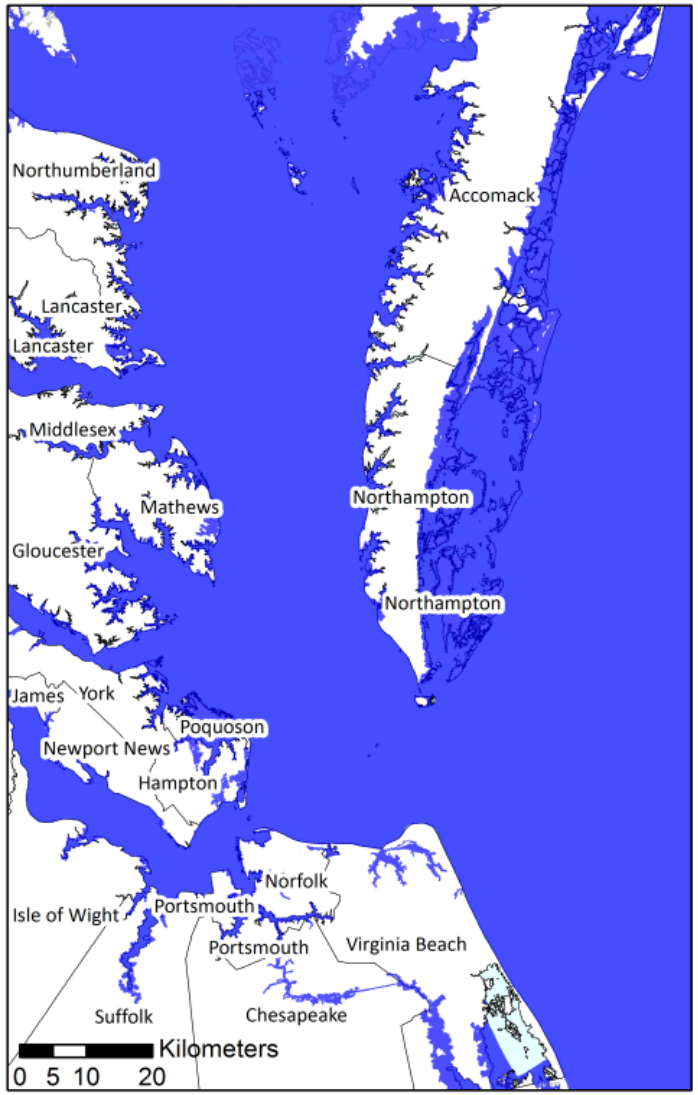
- Proximity to Storm Surge
  - **Spatial buffers** at specified distances from flooded wetlands
  - Expand the analysis area inland
  - 200, 400, 600 m
  - Can be varied based on population densities of study region
- Population Protected
  - Defined as population in buffer area by census block
  - FEMA's HAZUS MH inventory

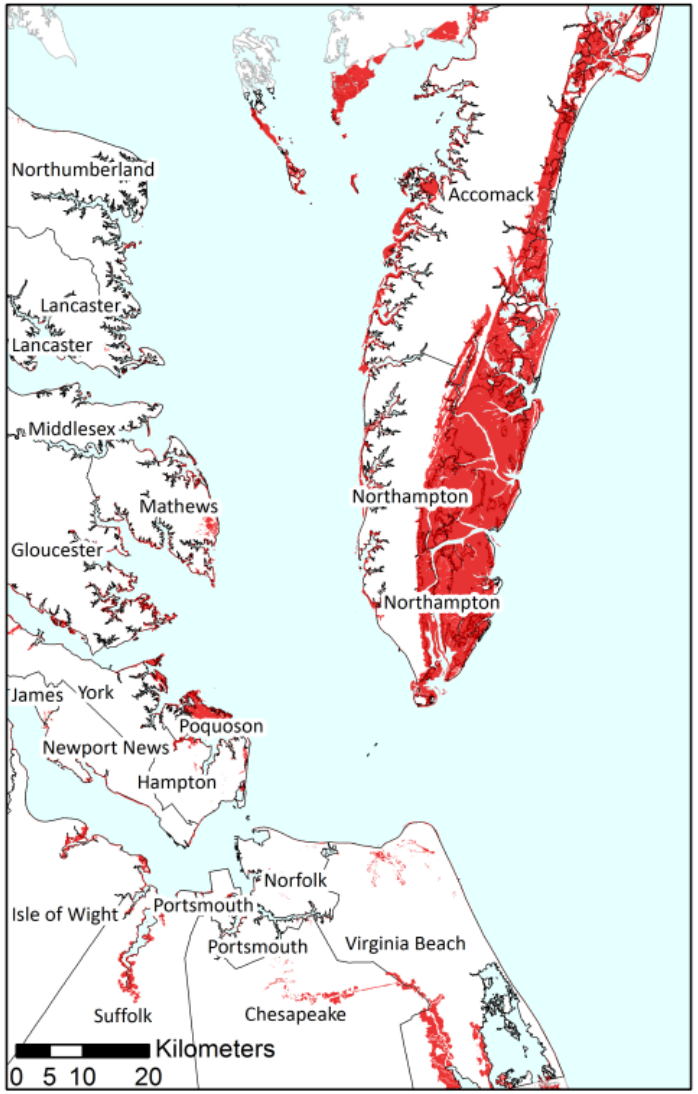


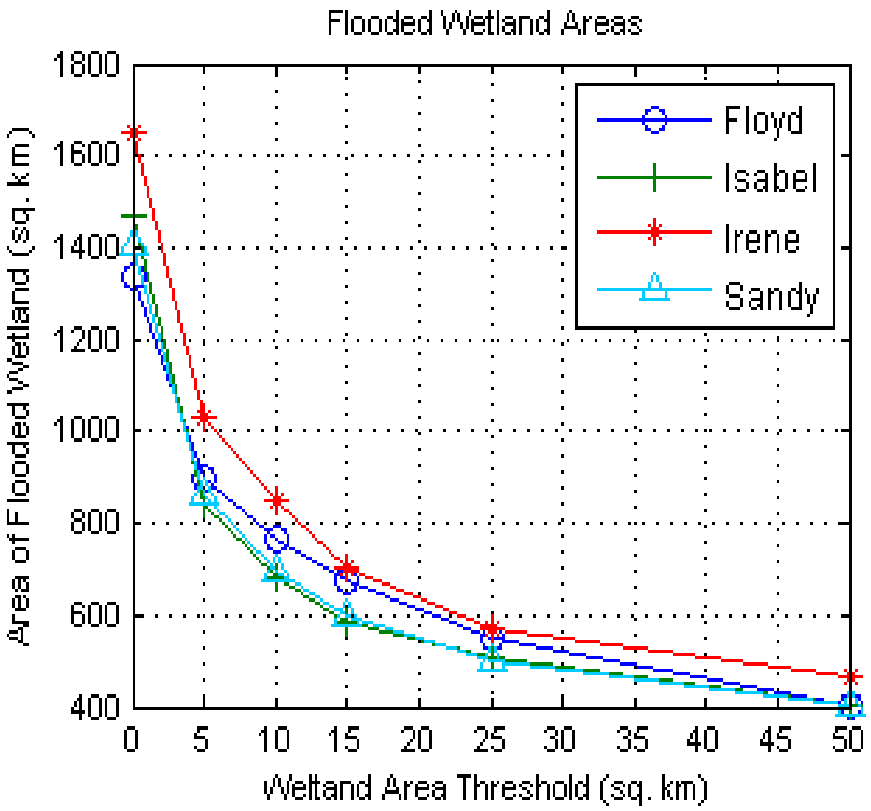
Results: Hydrodynamic Model



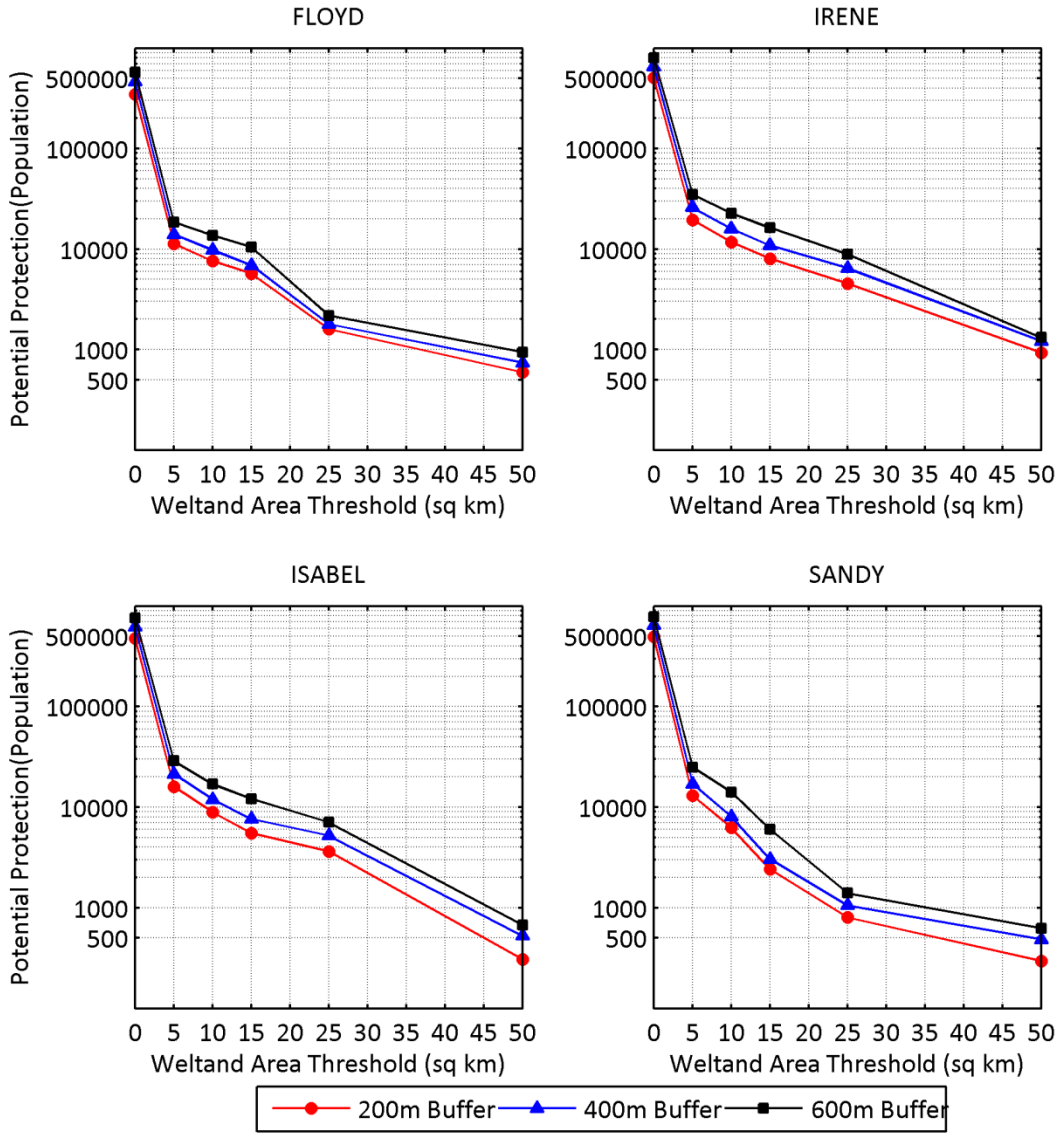
Results: Inundation of Wetlands

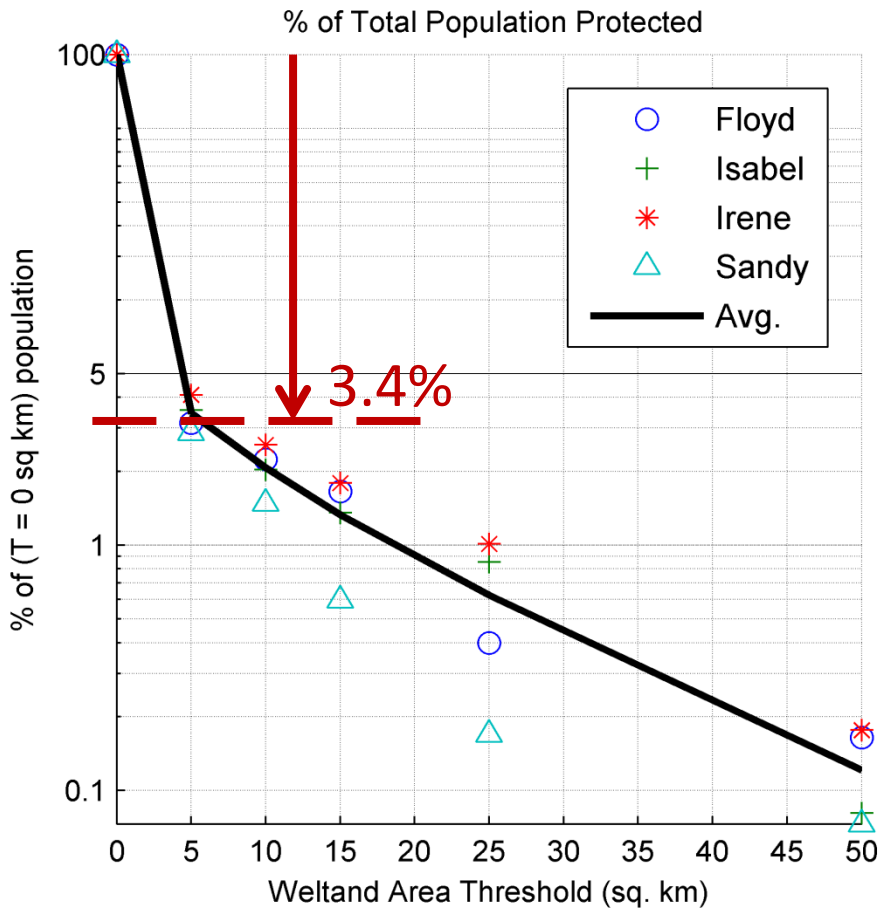






Results: Assessing wetland relevance



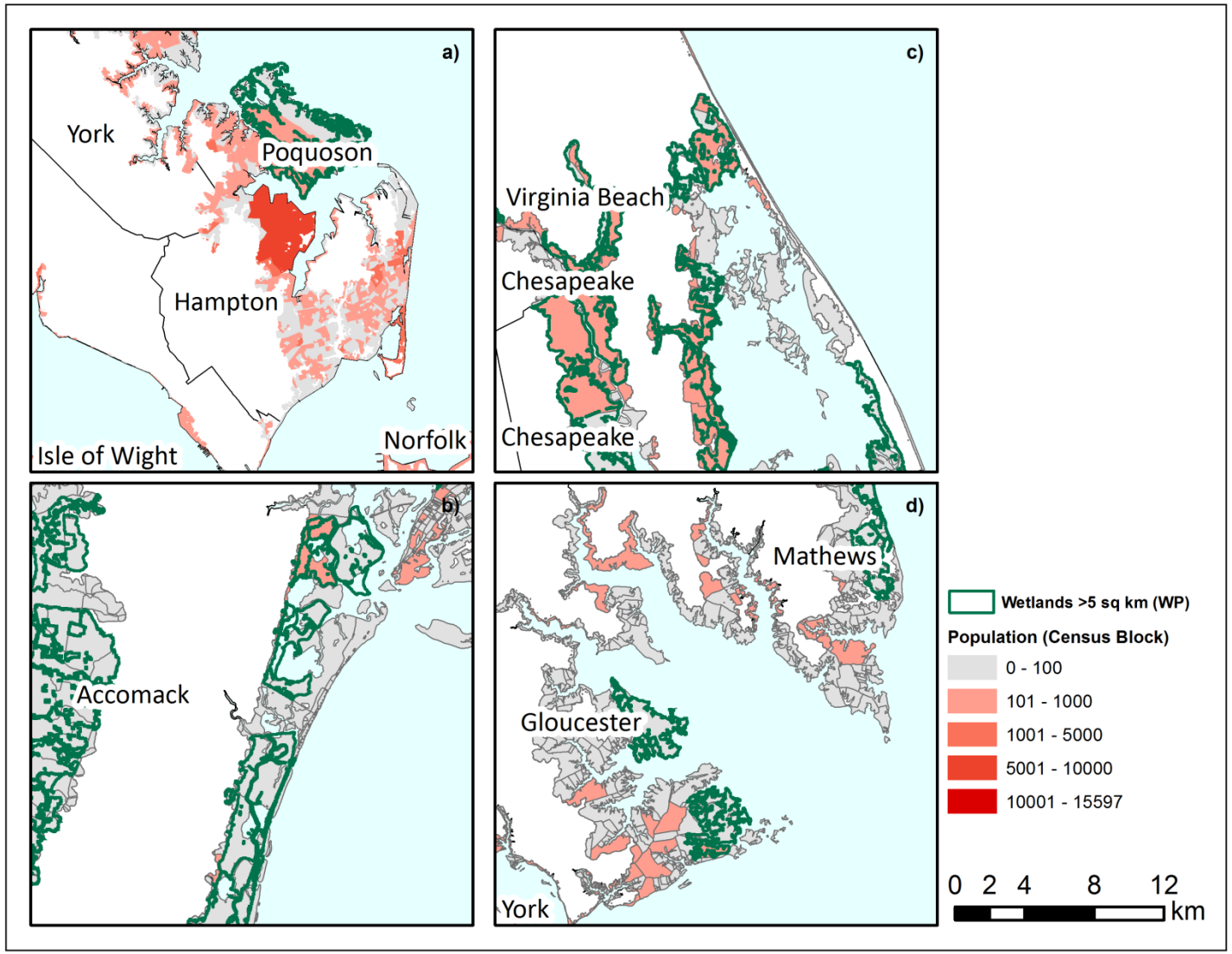


Applying 5 sq. km threshold reduces protection by 96.6%

Results: Local Analysis

- Demonstrates effect of threshold selections on a regional scale

- Criteria for identifying localities (as an example):
  1. Contained wetlands > 5 sq. km
  2. Have high direct population impacts from storm surge.



Conclusions

- Methodology allows for determination of a range of protection scenarios based on selections of spatial scale thresholds
  - To be adjusted based on improving knowledge of wetland impact on propagation of surge
- In VA's Chesapeake Bay region, threshold of 5 sq. km reduces protection by 96.6% (to 3.4%).
  - Threshold of 25 sq. km reduces that to less than 1%

Acknowledgements

The views expressed herein are those of the research group and do not necessarily reflect views of our sponsors or any sub agencies. The use of trade names does not constitute an endorsement in the use of these products by the U.S. Government.

Questions?

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