Improving the Efficiency of Wave and Surge Models via Adaptive Mesh Resolution

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DHS CRCoE Annual Meeting, Chapel Hill NC, 2-3 March 2016

Description

- Predictive models are costly – Hundreds or even thousands of CPUs, hours of wall-clock time
- Why spend resources on regions that start dry and are never flooded by the storm?

Goal and Objectives

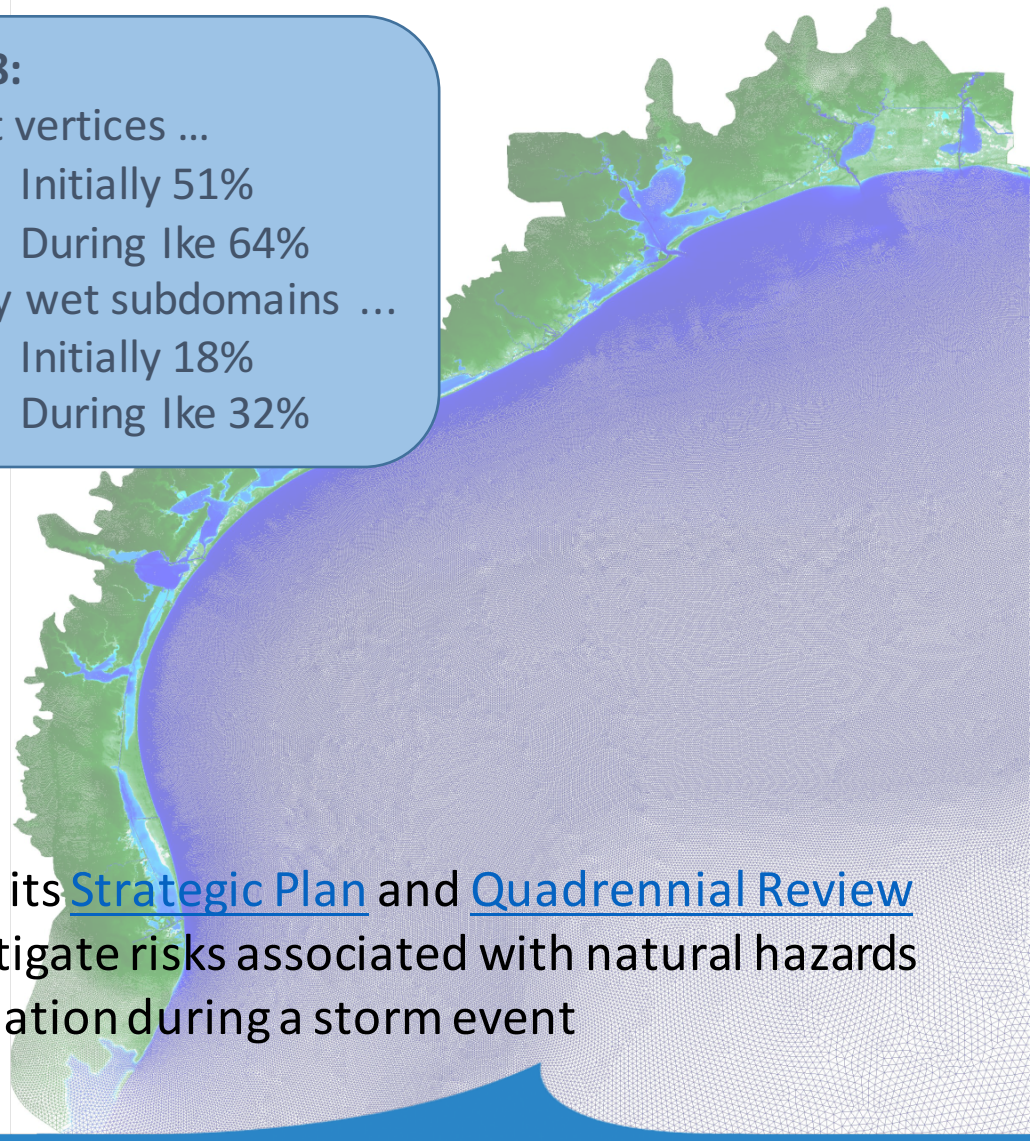
- Improve efficiencies of the ADCIRC+SWAN system
  - Optimize the computational workload
  - Adaptively modify the mesh resolution
  - Do so in a way that improves parallel efficiency

Relevance

- DHS mission to ensure resilience to disasters, as articulated in its Strategic Plan and Quadrennial Review
  - Goal 5.1 (Obj. 5.1.1 - 5.1.2) – Reduce vulnerability and mitigate risks associated with natural hazards
  - Goal 5.3 (Obj. 5.3.1) – Provide timely and accurate information during a storm event

TX2008:

- Wet vertices …
  - Initially 51%
  - During Ike 64%
- Fully wet subdomains …
  - Initially 18%
  - During Ike 32%



Technical Approach

This project will require advancements in two areas:

1. Implementing an *adaptive, multi-resolution approach* to increase resolution during a simulation
2. Optimizing the use of computational resources through *dynamic load balancing*

Adaptive, multi-resolution approach

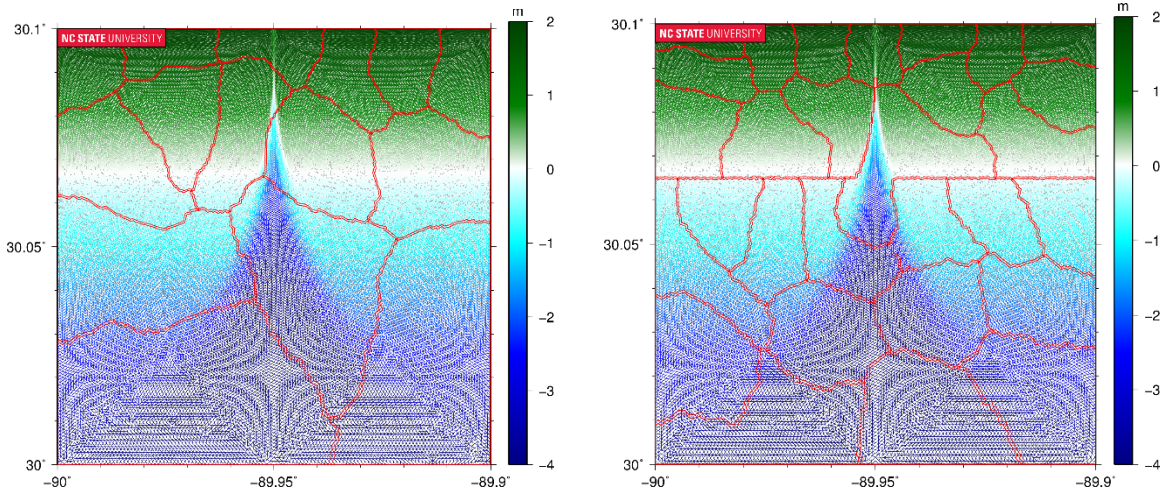
- Start with relatively coarse resolution that may not include extensive coastal detail
- As the storm approaches a coastline, extract regions from a fine-resolution mesh within our database
- The higher-resolution floodplains will be stitched into the coarse-resolution, open-water domain
- Results will be mapped onto the new portions of the mesh, and then the simulation will continue

Dynamic load balancing

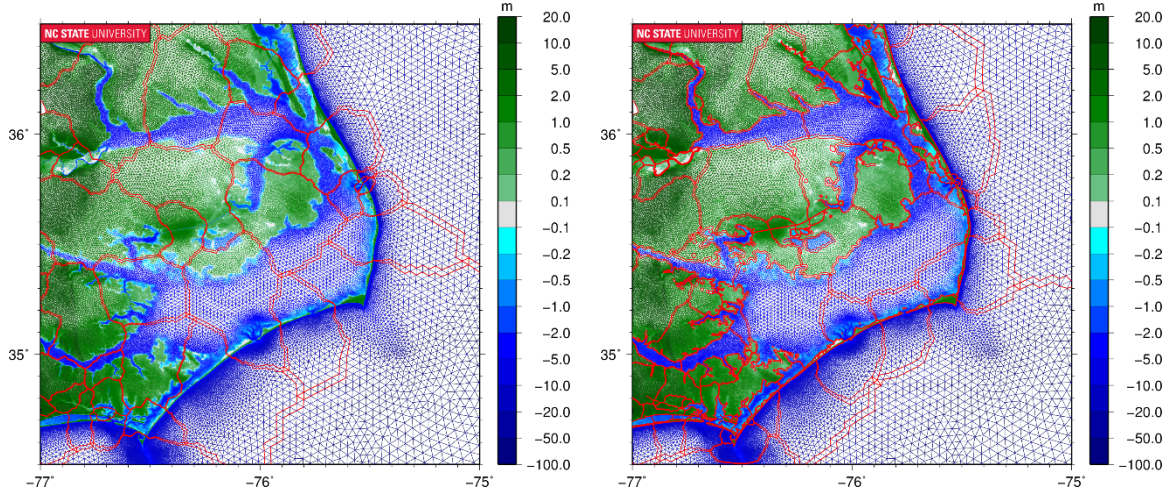
- Reallocate computational resources to improve parallel efficiency
- Each core will be responsible for developing its own input information
- Initial attempts (with Results shown on the next slide):
  - Optimize the initial domain decomposition to assign wet regions to every core
  - Decomposition is still static for now

Preliminary Results – Load Balancing

Idealized channel with wetting / drying



Hurricane Irene (2011) on NC9 mesh

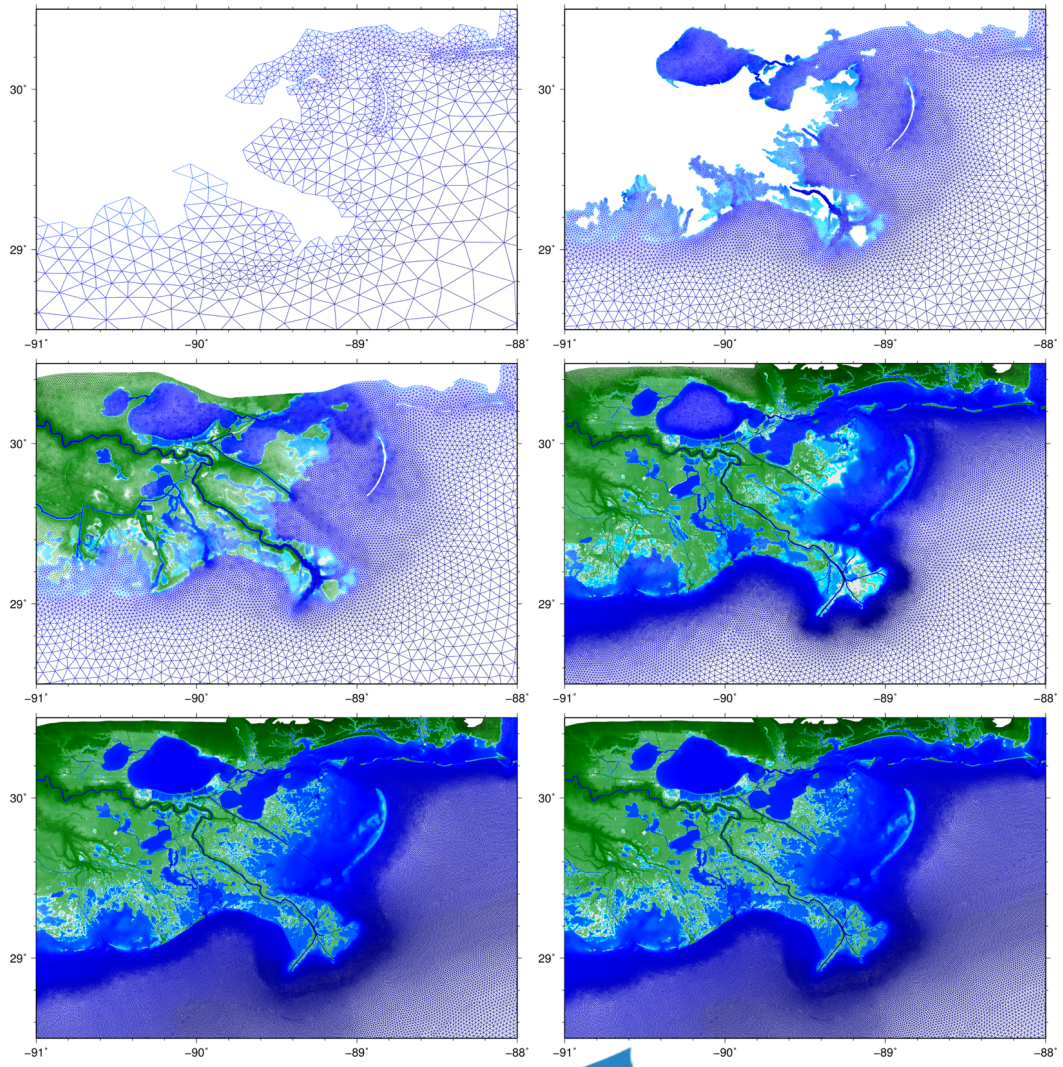


Test	Code Version	Cores	CPU-hr	% Change
Static	ADCIRC v52.22	15	0.98	
	+ load balancing		0.40	**– 58.7**
Wet/Dry	ADCIRC v52.22	15	1.13	
	+ load balancing		0.78	**– 31.3**

Test	Code Version	Cores	CPU-hr	% Change
Tides	ADCIRC v52.22	95	400.4	
	+ load balancing		313.7	**– 21.7**
Irene	ADCIRC v52.22	95	340.8	
	+ load balancing		338.7	**– 0.6**
	ADCIRC v52.22	47	327.2	
	+ load balancing		257.2	**– 21.2**

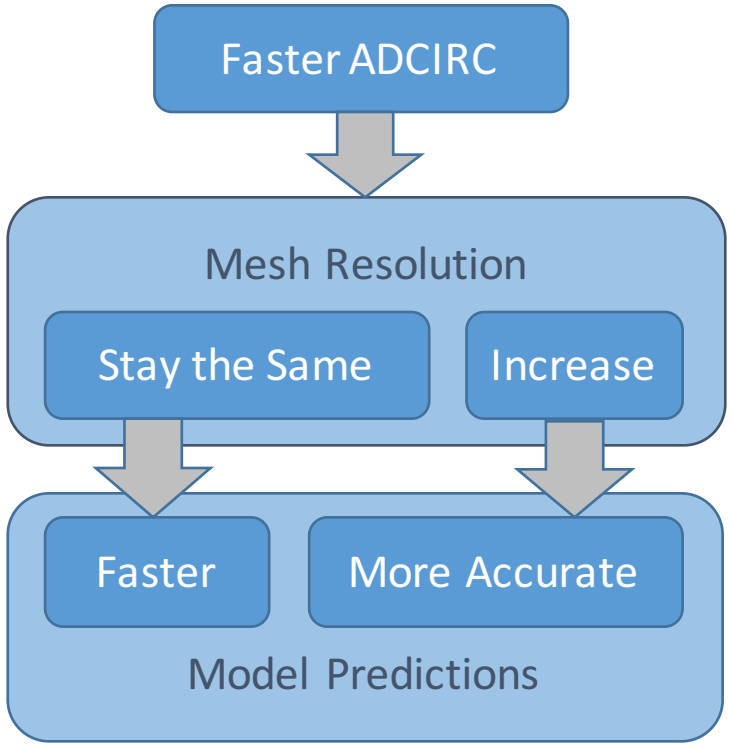
Preliminary Results – Dynamic, Multi-Resolution Approach

- Begin with a coarse mesh, then switch to a fine mesh, without stopping the simulation
- Mapping between the two meshes is done via the Earth System Modeling Framework (ESMF)
  - Optimized for parallel interpolation between unstructured meshes
  - Different fields are mapped with different methods (bilinear, first order conservative) to preserve the main properties of the fields (e.g. continuity)
- Use of the ESMF package in addition to the *hotstart* feature of ADCIRC allows for an efficient way to continue the simulation on another mesh
- This process can be repeated as many times as needed to adapt to the resolution required during the simulation



End Users

- *FEMA*
- *Texas State Operations Center*
- *USACE ERDC*
- *NOAA*
- *LSU CCT*
- *Seahorse Coastal Consulting*



Transition Activities

- Quarterly videoconferences – first scheduled for later in March
  - Share progress reports on research findings
  - Receive feedback and suggestions from end users
  - Enable transfer of technologies
- Integrate technologies into instances of the ADCIRC Surge Guidance System
  - Texas – provide guidance to Texas State Operations Center
  - North Carolina – integrate within workflow for NCFS

Major Milestones

Research / Transition Milestone	Anticipated Completion Date
Interpolation of ADCIRC results from coarse to fine meshes	06 / 2016
Developmental ASGS instance with guidance to Texas State Operations Center	
Dynamic load balancing for a static ADCIRC simulation	12 / 2016
Testing of dynamic load balancing for other ASGS instances	
Demonstration of dynamic approach with single target mesh	06 / 2017
Preliminary release of software to transition partners, training with examples	
Dynamic load balancing for an adaptive ADCIRC simulation	12 / 2017
Integration of project technologies into release version of ADCIRC	

Project Integration

- Summer internship opportunity at Univ Texas at Austin
  - Working with Robert Whalin and the Education Partners to identify an undergraduate student