

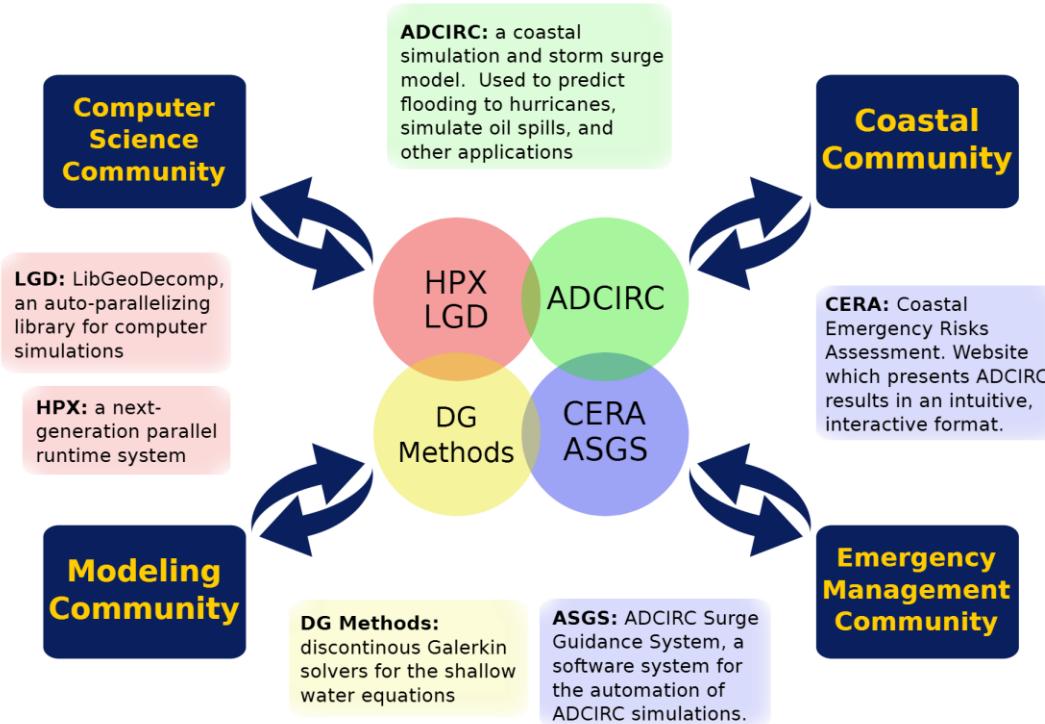


a **S**calable **T**oolkit for an **O**pen Community Supporting Near  
**R**ealtime High Resolution Coastal **M**odeling

---

ADCIRC USERS GROUP MEETING 2015  
MARCH 31, 2015  
Zach Byerly ([zbyerly@cct.lsu.edu](mailto:zbyerly@cct.lsu.edu))

# Project Scope

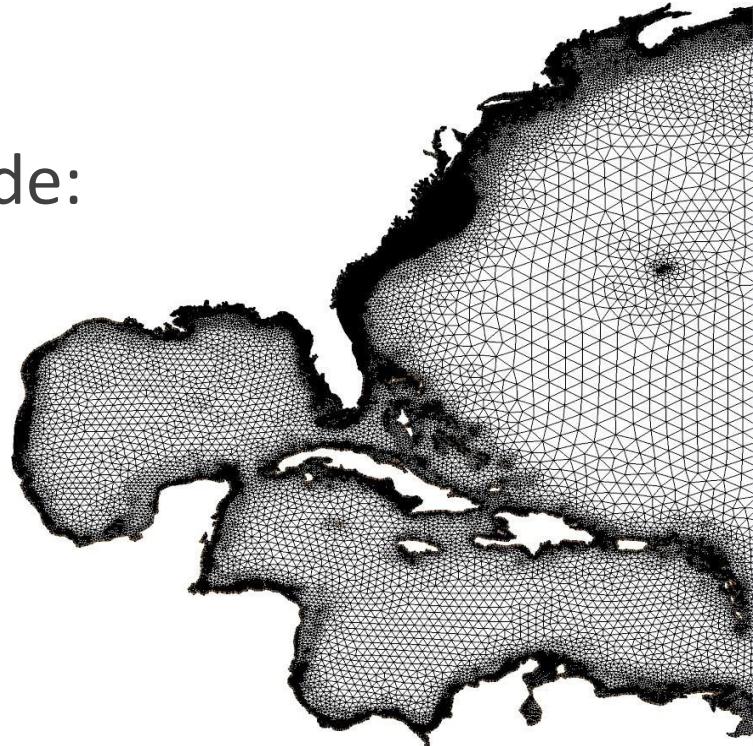


# Our Goal

---

Build a next-generation ADCIRC code:

- Sustainable
- Extensible
- Scalable
- Flexible



# The 4 Horsemen of the Apocalypse: SLOW

## Starvation

- Insufficient concurrent work to maintain high utilization of resources

## Latencies

- Time-distance delay of remote resource access and services

## Overheads

- Work for management of parallel actions and resources on critical path which are not necessary in sequential variant

## Waiting for Contention resolution

- Delays due to lack of availability of oversubscribed shared resources



courtesy of [www.albrecht-durer.org](http://www.albrecht-durer.org)

# The Challenges

---

Ways to defeat the four horsemen:

- Use fine grain parallelism to reduce Starvation
- Focus on data dependencies rather than communication
- Latency hiding rather than latency avoiding
- Adaptive locality control vs. static data distribution

---

## General Purpose Runtime System

Allows an application to be parallelized on shared memory, distributed memory, and heterogeneous architectures (GPUs, Intel Xeon Phi coprocessor)

Solidly based on a theoretical foundation - ParalleX

- A general purpose runtime system for applications of any scale
  - <http://stellar.cct.lsu.edu/>
  - <https://github.com/STELLAR-GROUP/hpx/>

Exposes an uniform, standards-oriented API for ease of programming parallel and distributed applications.

- Enables to write fully asynchronous code using hundreds of millions of threads.
- Provides unified syntax and semantics for local and remote operations.

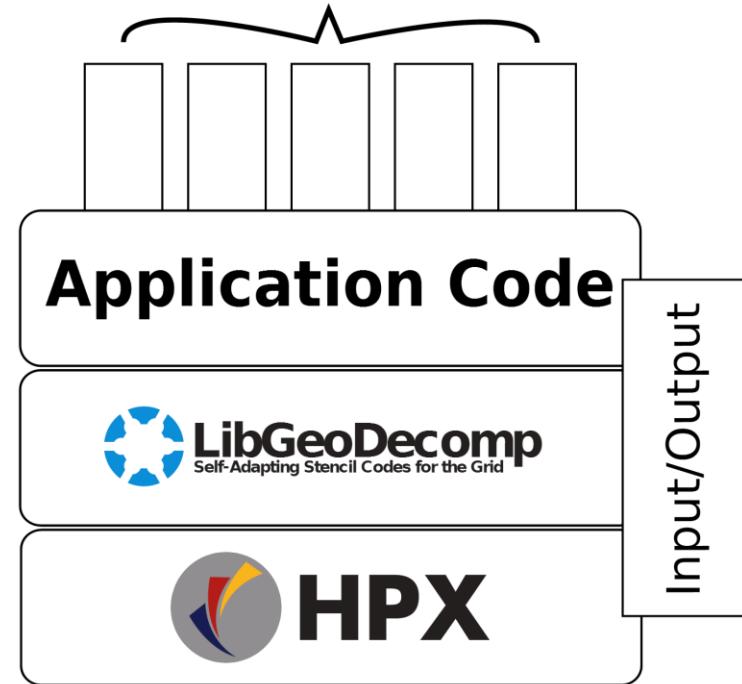
Enables writing applications which outperform and out-scale existing ones

Published under Boost license and has an open, active, and thriving developer community.

Software Stack:



## ADCIRC Physics Modules

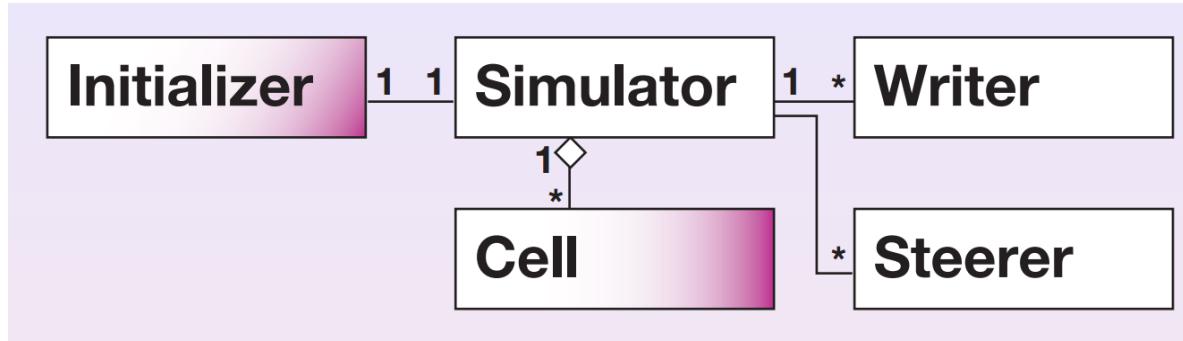


---

- Library for **Geometry Decomposition** codes
- Auto-parallelization for computer simulations
- Developed since 2006 by Andreas Schaefer @ FAU Erlangen
- Open Source development
- Library written in C++, supports custom kernels in C, C++, FORTRAN
- Design Goals:
  - Separate **Domain Science** from **Performance Engineering**
  - Support Legacy Codes
  - Scalable, Portable, Efficient

# LGD Building Blocks

---



User Defines:

- Initializer (Initial Configuration and Input, Mesh, etc.)
- Cell Update (Kernel)

Library Provides:

- Simulator (Handles spatial and temporal loops)
- Writer (Output)
- Steerer (Input)

# Current Work

---

Developing proxy application to simulate workload and communication patterns

`gameoflife_adcirc`:

- Uses decomposed ADCIRC computational mesh
- Simple “game of life” kernel implemented in FORTRAN
- Application code runs on top of LibGeoDecomp which uses HPX for parallelization

# gameoflife\_adcirc

main.cpp

```

class ADCIRCIinitializer : public SimpleInitializer<ContainerCellType>
{
    /*
    Read in fort.18, fort.80, fort.14 files
    Construct ADCIRC mesh and connectivity information
    Initialize Grid
    */
}

void DomainCell::update(const NEIGHBORHOOD& hood, int nanoStep)
{
    //Call FORTRAN subroutine
    kernel_(
        &numnodes,
        alive,
        numneighbors,
        neighbors
    );
}

```

kernel.f

```

SUBROUTINE KERNEL(N, ALIVE, NUMNEIGHBORS, NEIGHBORS)

!LOOP OVER NODES
DO I=1,N
    NEW_ALIVE(I)=0
    IF(ALIVE(I).eq.1) THEN
        NEW_ALIVE(I)=0
    ELSE
        SUM=0
        DO J=1,NUMNEIGHBORS(I)
            SUM=SUM+ALIVE(NEIGHBORS(J,I))
        ENDDO
        IF(SUM.gt.0)THEN
            NEW_ALIVE(I)=1
        ENDIF
    ENDIF
    ENDDO

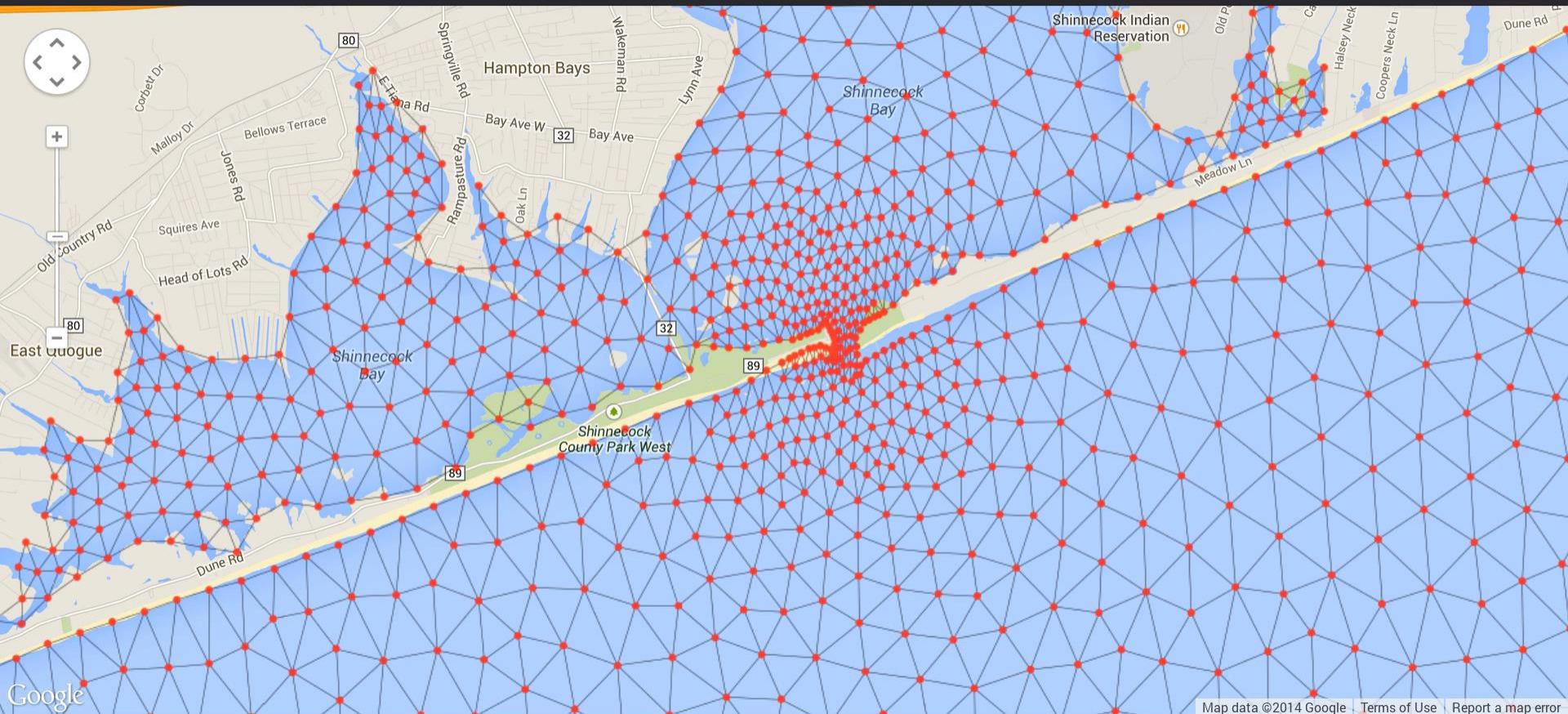
END SUBROUTINE KERNEL

```

# Coastal Emergency Risks Assessment

ADCIRC Coastal Circulation and Storm Surge Model + SWAN Wave Model

CERA Viewer



Map data ©2014 Google | Terms of Use | Report a map error

Contact us: [email](mailto:email)



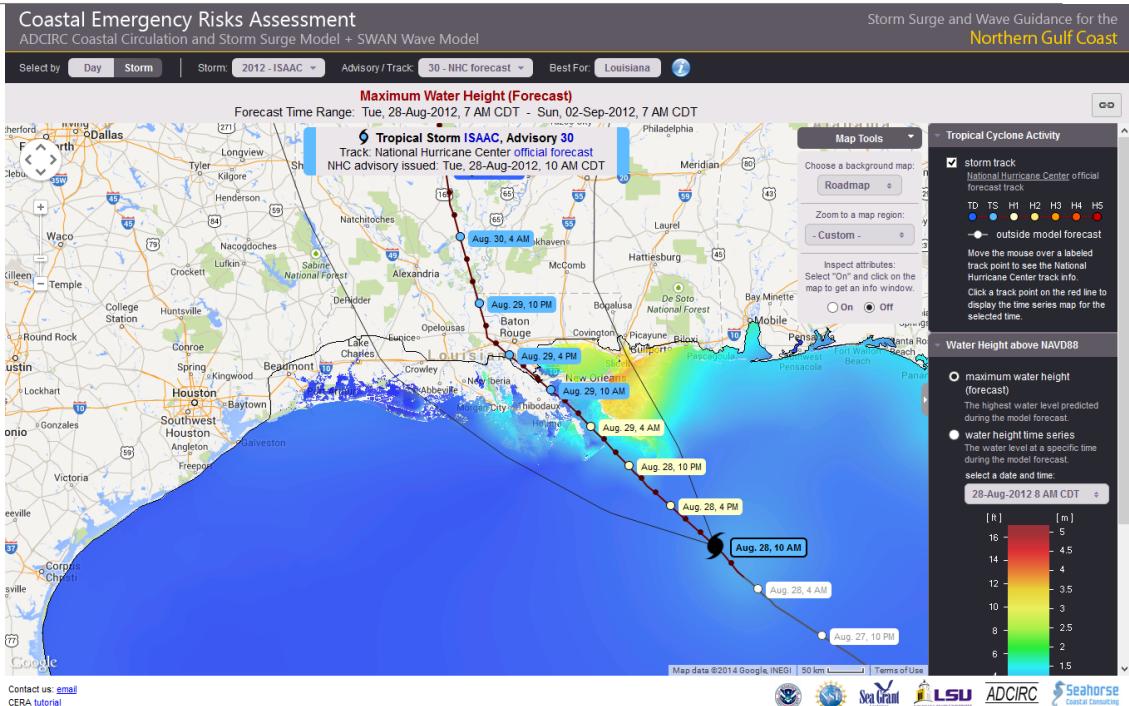
# CERA Web Interface

## Model output:

- water height (storm surge)
- water inundation above ground
- wind speed
- significant wave height
- relative peak wave

## ADCIRC node attributes

- Overlay features:
  - barriers & levees
  - shoreline
  - rainfall data (radar, real-time stations)
  - real-time water stations
  - hurricane track info



# Approach

---

- Results from ADCIRC/LGD/HPX **must** match ADCIRC/MPI results exactly
- Current ADCIRC/MPI source code left (mostly) intact
- Development of ADCIRC/MPI will continue
- Physics kernels automatically pulled from ADCIRC/MPI source code
- Frequent automatic testing

# Our Collaborators

- Joannes Westerink (University of Notre Dame)
- Rick Luettich (University of North Carolina)
- Clint Dawson (University of Texas at Austin)
- Robert Twilley (LSU, Louisiana Sea Grant)
- Jason Fleming (Seahorse Coastal Consulting)
- Hartmut Kaiser (Louisiana State University, STE|AR Group)



Supported by: NSF SI2-SSI:  
Collaborative Research

INSTITUTE FOR **COMPUTATIONAL**  
ENGINEERING & SCIENCES

 **UNIVERSITY OF  
NOTRE DAME**  
College of Engineering

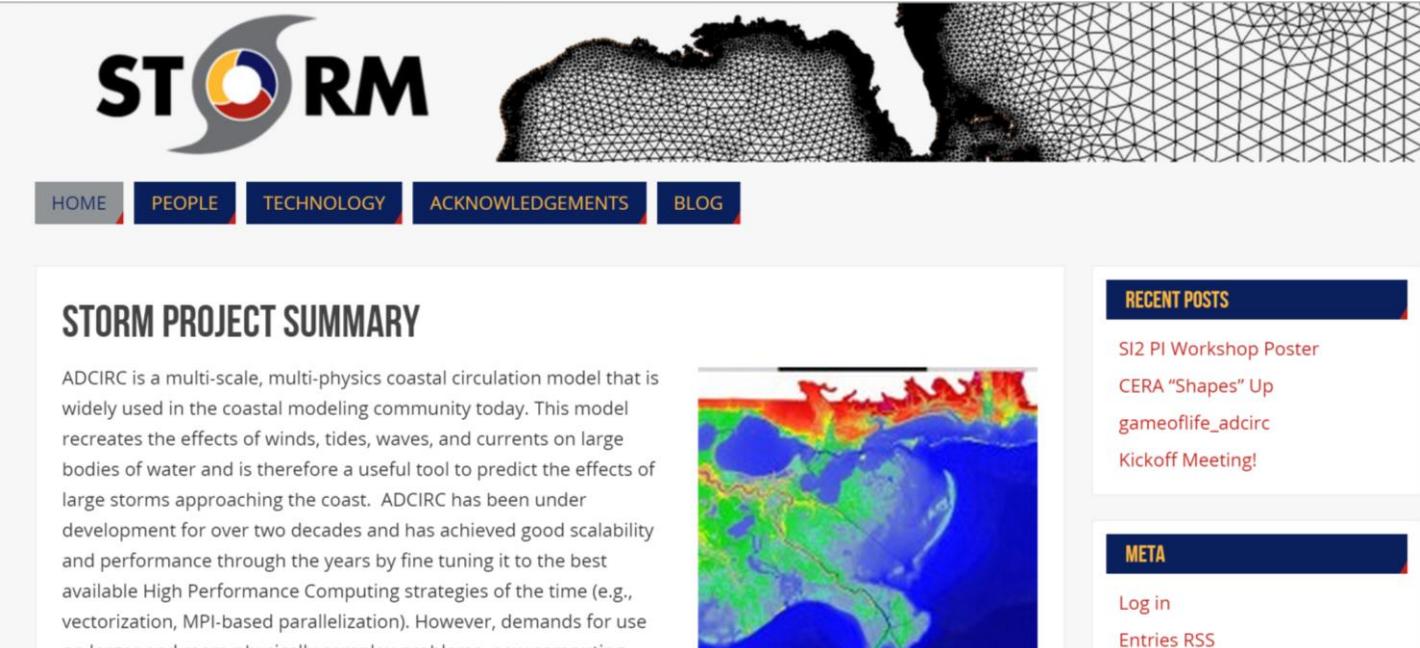
**Friedrich-Alexander-Universität  
Erlangen-Nürnberg**



**THE UNIVERSITY  
of NORTH CAROLINA  
at CHAPEL HILL**

  
**Sea Grant**  
LOUISIANA

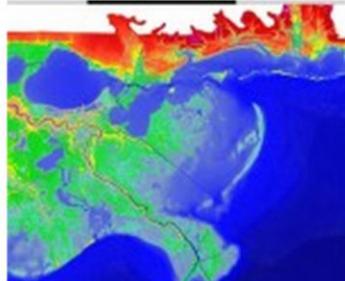
**LSU** | Center for  
**Computation & Technology**  
Interdisciplinary | Innovative | Inventive



The screenshot shows the homepage of the STORM project. At the top left is the STORM logo, which includes a stylized wave icon. To the right of the logo is a large image showing a coastal region with a complex triangular mesh overlay, representing a computational grid. Below the logo is a navigation bar with five items: HOME, PEOPLE, TECHNOLOGY, ACKNOWLEDGEMENTS, and BLOG. The HOME button is highlighted with a grey background. The main content area features a section titled "STORM PROJECT SUMMARY" with a detailed description of the ADCIRC model. To the right of this summary is a map of the coastal region with a color-coded bathymetry or circulation pattern. On the far right, there are two sidebar boxes: "RECENT POSTS" containing links to various project documents and "META" containing links for logging in and RSS feeds.

## STORM PROJECT SUMMARY

ADCIRC is a multi-scale, multi-physics coastal circulation model that is widely used in the coastal modeling community today. This model recreates the effects of winds, tides, waves, and currents on large bodies of water and is therefore a useful tool to predict the effects of large storms approaching the coast. ADCIRC has been under development for over two decades and has achieved good scalability and performance through the years by fine tuning it to the best available High Performance Computing strategies of the time (e.g., vectorization, MPI-based parallelization). However, demands for use on larger and more physically complex problems, new computing



### RECENT POSTS

- SI2 PI Workshop Poster
- CERA "Shapes" Up
- gameoflife\_adcirc
- Kickoff Meeting!

### META

- Log in
- Entries [RSS](#)