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Computing Hurricane Ike Waves, Forerunner, and Surge: Slow and Fast Flow Processes from the Louisiana-Texas Shelf to Houston

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Coastal Louisiana and Texas are characterized by tremendous complexity and variability in their geography, topography, bathymetry, continental shelf, estuarine systems, and surface roughness. Hurricane Ike significantly impacted both coastal Texas and Louisiana producing a storm surge of more than 5.3m in eastern Texas and more than 2.2 m in eastern Louisiana (more than 500 km away from the storm landfall location). Particularly important was that more than 2m of hurricane forerunner developed prior to the storm coming onto the continental shelf (more than 15 hours prior to landfall), while coastal winds were shore parallel or coming off of the land. The forerunner flooded much of western Louisiana and eastern Texas, and filled Galveston Bay in its entirety, reaching into the heart of Houston. The forerunner then propagated down the Louisiana-Texas (LATEX) shelf as a free wave, passing Corpus Christi with an amplitude of more than 1m. The forerunner is the largest ever recorded.

The rapid evolution of data collection systems allows the physical system to be accurately defined, and the rapid evolution of unstructured grid computational models allows these characteristics and the resulting waves and flows to be numerically resolved. The SWAN+ADCIRC unstructured grid modeling system has been developed to simulate fully coupled hurricane winds, wind-waves, storm surge, tides and river flow in this complex region. This is accomplished by defining a domain and computational resolution appropriate for the relevant processes, specifying realistic boundary conditions, and implementing accurate, robust, and highly parallel unstructured grid algorithms for both the wind waves and the long wave current/storm surge/tide model. Basin to channel scale domains and high resolution grids which resolve features down to 30 meters and contain up to 3.3 million nodes have been developed. This modeling system is run on up to 4,096 processors and requires as little as 18 minutes of wall clock time per day of simulation.

Hindcasts of the storm indicate an excellent match of measured wave and surge records. Numerical experiments indicate that the unprecedented forerunner was generated by very fast shore parallel currents driven by the early shore parallel winds that allow for a Coriolis driven set up to be pushed up against the coast. Achieving fast enough currents on the mid and outer shelf is vital for the driving mechanism to work. This in turn requires low frictional resistance which is consistent with the smooth and muddy LATEX shelf.