Spatial Technology and High Performance Computing for Improving Prediction of Surface Water Quality (Project Overview)

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Rita Jackson (Collaborator)

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Outline

• General overview of the project
  – Objectives
  – Deliverables

• High performance computing
  – Grid Generation/Hydrodynamic models
  – Parallelization
  – Results

• Spatial technologies
  – Estimation of nutrient concentrations using MODIS land use datasets.
Overview of the project

• Objectives
  – General
    • Contribute to coastal management decisions (Mobile Bay, Alabama-Mississippi coastal zone and Mississippi Sound) through best use of:
      – New data
      – Enhanced modeling technologies
  – Specific
    • Develop model applications (hydrology, hydrodynamics, water quality) and demonstrate the use of advanced spatial technology and high performance computing capabilities in the prediction of surface water quality.
Overview of the project

- Deliverables
  - High performance computing (HPC)
    - Model selection:
      - Environmental Fluid Dynamics Code (EFDC)
      - Adaptive Hydraulics system (ADH)
  - Grid Generation
    - EFDC: structured grids (Cartesian, curvilinear)
    - ADH: unstructured grids
  - Development a mesh generation tool
    » MGRT
  - Model Applications
    - Generate grids/meshes and model applications for Mobile Bay and surrounding ocean
Overview of the project

• Deliverables
  – Spatial technologies (ST)
    • Incorporate geospatial data to aid in the development and application of surface water quality models.
      – Generate precipitation time-series for water models
      – Erosion database development
      – Assimilate NASA-MODIS land-use/land-cover into Hydrological Program Fortran (HSPF)
  
• In summary:
  – Grid generation
  – HPC applied to hydrodynamics and water quality
  – Spatial Technologies (ST)
ADH model applications for those grids were produced.
- Intersection of MGRT grids and NOAA bathymetry generated initial ADH models and additional files (*.hot, *.bc). Geoprocessing was performed using ArcGIS.
HPC for hydrodynamic modeling

- Parallelized version of ADH was compiled in HPCC clusters
- Speed-up experiment were performed \( S_p = \frac{T_1}{T_p} \)

<table>
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<tr>
<th>Nodes</th>
<th>Processors</th>
<th>Cluster Processing time</th>
<th>Simulation time</th>
<th>Laptop processing time</th>
<th>Speed-up</th>
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![Graph showing speed-up vs number of processors](image1)

![Graph showing time vs number of processors](image2)
HPC for hydrodynamic modeling

- Improved computational mesh
  - Deleting conflictive elements and nodes
  - Renumbering
  - Improved location of boundary conditions

Elements: 48317
Frontwidth: 205
Half-band width: 208
Sharp edges

Elements: 47311
Frontwidth: 192
Half-band width: 194
Rounded edges
HPC for hydrodynamic modeling

- Additional speed-up experiment for the improved grid were performed
- With the improved grid speed up increased from 25 to 43

\[ S_p = \frac{T_1}{T_p} \]

<table>
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<th>Laptop</th>
<th>Speed-up</th>
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HPC for hydrodynamic modeling

- Generation of a structured grid for Weeks bay, AL. This grid will be used for developing a EFDC hydrodynamic model for Weeks bay.
- Comparison of EFDC model for Mobile Bay and Weeks bay to existing ADH models
HPC for hydrodynamic modeling

More details:
Poster
- Water Resources Modeling in the Mobile River Watershed and Mobile Bay
  Vladimir Alarcon; W. McAnally; J. Cartwright; R. Jackson
Spatial technologies to enhance WQ modeling: MODIS land use

- NASA MODIS land-use/land-cover data geoprocessing.

**MODIS LU/LC**
- Format: HDF ISIN coordinates
  - FORMAT CONVERSION: MODIS tools: HDF to GeoTiff
    - RE-projection: ISIN to Geo Coordinates
  - RE-PROJECTION: ArcGIS: Geo. Coord. to UTM

**RECLASSIFICATION**
- ArcGIS: MODIS LU classes to HSPF LU classes
  - DELINEATED WATERSHED polygon shape
    - User’s coordinates
      - User-provided

**FORMAT CONVERSION**
- ArcGIS: Geotiff to Grid

**TO MODELS**
- Land use characterization tables
  - DBF
  - ASCII
Spatial technologies to enhance WQ modeling: MODIS land use

- Total Nitrogen (TN) and Total Phosphorus (TP) estimations for the Upper Tombigbee watershed.
Spatial technologies to enhance WQ modeling: MODIS land use

- Total Nitrogen (TN) and Total Phosphorus (TP) estimations for the Upper Tombigbee watershed.
- From 1986 to 2003 agricultural lands increased in almost 34%, forest lands decreased in 16%.
- Maximum TP and TN concentrations seem to have increased in about 37% and 34%, respectively, from 1986 to 2003. This increase in maximum nutrient concentrations seems to correlate with the 34% increase in agricultural areas in the Upper Tombigbee watershed, from 1986 to 2003.
- TN and TP estimations used for further biological studies (Ervin, Brooks)

### Total Phosphorus

<table>
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<th>Sub-basin</th>
<th>Maximum GIRAS</th>
<th>Maximum MODIS</th>
<th>% Change</th>
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### Total Nitrogen

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<tr>
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<th>Maximum MODIS</th>
<th>% Change</th>
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HPC for hydrodynamic modeling

- More details:
- Poster
  - Water Resources Modeling in the Mobile River Watershed and Mobile Bay
    Vladimir Alarcon; W. McAnally; J. Cartwright; R. Jackson
Spatial technologies to enhance WQ modeling: SULIS

- Holistic Water Resources Management Decision Support Framework
- Healthy Watersheds, Healthy Oceans, Healthy Ecosystems
Spatial technologies to enhance WQ modeling: SULIS

- More details on SULIS
- Presentation and Poster:
  - SULIS – A Tool for Healthy Watersheds, Healthy Oceans, Healthy Ecosystems. William McAnally; John Cartwright; Rita Jackson; James Martin; Jairo Diaz-Ramirez
Publications


Publications

- **Papers**

- **Presentations and posters**
Future work

- **HPC**
  - Enhance ADH and EFDC models of Mobile Bay and Weeks Bay
  - Use adaptive features of ADH
- **Spatial**
  - Further enrich the SULIS system.
- Generate more publications