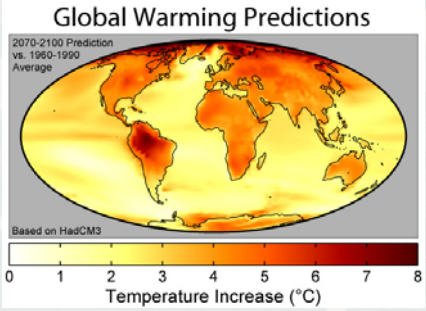
Water-Climate Interface
- Impacts and Adaptation Research



Dr Jeffery Holland
Director Research and Development
Corps of Engineers

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Arctic Landscape Changes

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Impacts and Adaptation

The Corps of Engineers needs tools that determine impacts of predicted climate change and evaluate a range of adaptations from changed land-use practices to engineering works

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Intergovernmental Panel on Climate Change (IPCC)

IPCC (2007) identified key water-climate-interface research gaps relating to impacts and adaptation

- "Impacts of changes in climate variability need to be integrated into impact modeling efforts"
- "There is a mismatch between the large-scale climatic models and the catchment scale"
- "Impacts of climate change on aquatic ecosystems (temperatures and altered flow regimes) are not adequately understood"
- "Climate change impacts on water quality are poorly understood"
- "Climate models need to be coupled with land-use change including vegetation change and anthropogenic activity"

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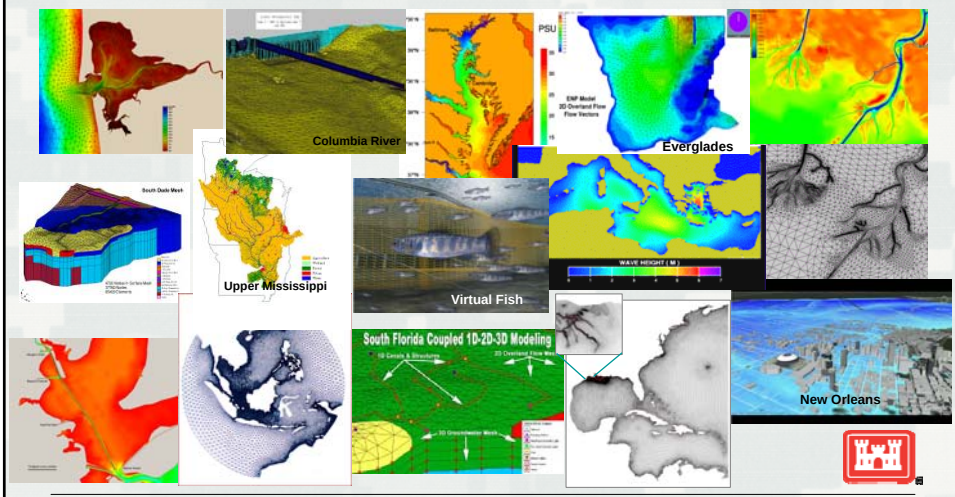
Tools to Determine Impacts and Adaptation

Past, present, and planned future Corps R&D development of tools needed to determine impacts of climate change and sustainable ways to adapt to this change



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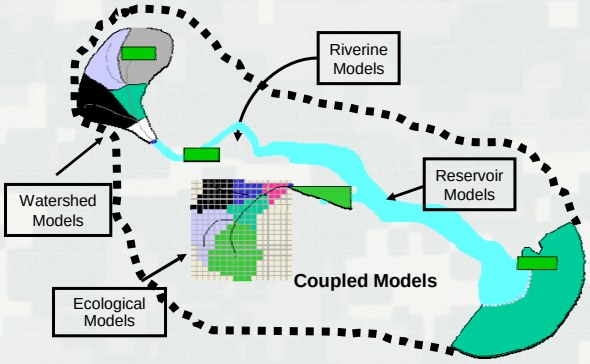
System-Wide Water Resources Program (SWWRP)

"Support the Formulation of Regional and Watershed Solutions to Water Resources Problems"

– Civil Works Strategic Goal

SWWRP is Developing the Tools Needed to Do This



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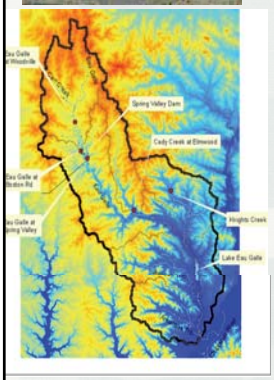
Example of SWWRP Tools to Predict Watershed Response and Adaptations



Eau Galle Watershed
402 km²

Eau Galle Watershed

Integrated models determine for time periods up to years:

- Surface water flow produced by rainfall events
- Groundwater interaction with surface water flow
- Interaction of water with reservoirs and hydraulic structures
- Rates of nutrient uptake from soil and reaction rates
- Movements of nutrients such as nitrogen and phosphorous
- Sediment movement due to rainfall including rill and gully erosion
- Sediment movement in rivers

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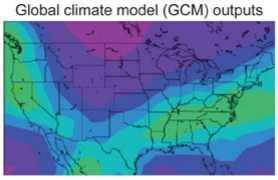
Downscaling and Resolution Issues

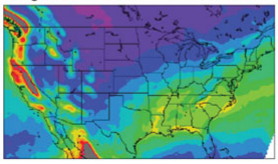
Downscaling integrates global and regional models

Global climate model (GCM) outputs



downscaling techniques

Regional climate and weather models



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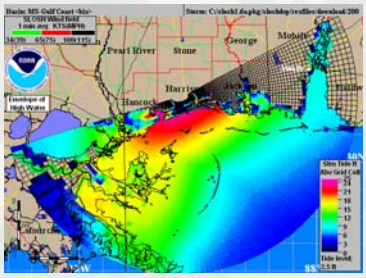
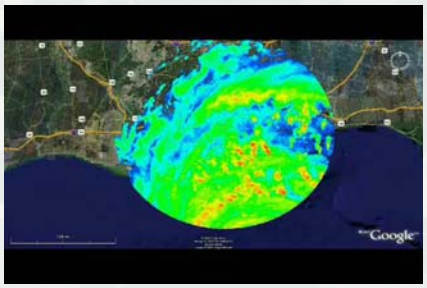
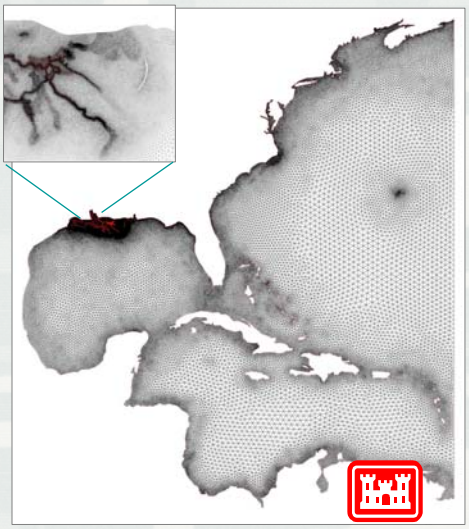
Modeling of Hurricanes Requires High Resolution Grid



Low resolution SLOSH model for evacuation



High resolution for operations and planning



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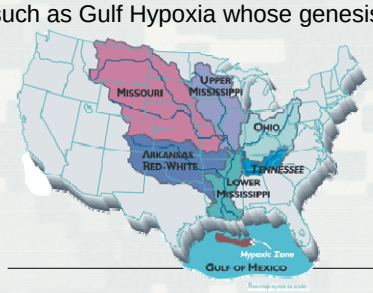
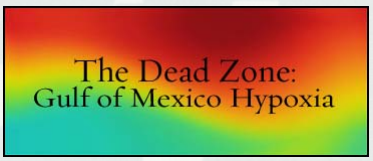
Sustainable Coasts and Estuaries R&D Program (SUSTAIN)

- A new strategic R&D analogous to SWWRP but focused on coasts and estuaries
- Will develop models that simulate regions as integrated systems and determine impacts and adaptations from project to regional scales
- Will connect with SWWRP, allowing the Corps to model, e.g., water falling in the upper Mississippi to its eventual flow into the Gulf of Mexico and its interaction with the environment on its path to the Gulf
- SUSTAIN will enable the Corps to look at coastal regions as systems and evaluate projects, but also consider climate change impacts and adaptations and problems such as Gulf Hypoxia whose genesis is thousands of miles from the problem





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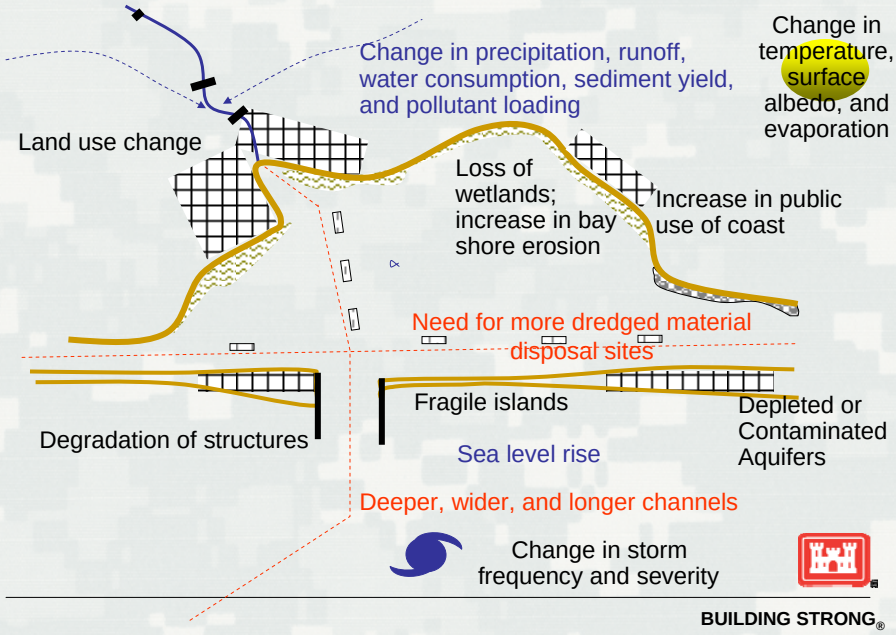
Impacts of Climate Change on Coasts and Estuaries



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12

Common Assumption is that Sea Level Rise is Accelerating

- *"Satellite and tide-gauge measurements show that the rate of sea level rise has accelerated"*
  - Copenhagen Diagnosis (2009)
- *"… there is strong scientific consensus that climate change is accelerating sea-level rise …"*
  - U.S. Climate Change Science Program (2009)
- *"The rate of sea level rise is accelerating"*
  - Sea Grant (2008)
- *"So it is now apparent that SLR has accelerated over the twentieth century"*
  - Pew Center on Global Climate Change (2009)
- *"There is increasing evidence of continued and accelerating sea-level rises around the world"*
  - Royal Society (2009)

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But, is sea level rise accelerating?

- Douglas (1992), Journal of Geophysical Research (JGR), analyzed world-wide gauges and found a deceleration from 1905-1985
- Holgate (2007), Geophysical Research Letters, found a deceleration from 1904-2003
- Jevrejeva, et al, (2006), JGR, found a deceleration for 20th Century
- Church, et al, (2004), J of Climate, found that *"There is no detectable secular increase in the rate of sea level rise over the period 1950-2000"*
- Woodworth et al. (2009) note, Int J of Climatology, *"… little evidence has been found in individual gauge records for an ongoing positive acceleration of the sort suggested for the 20th Century by climate models"*
- Woodworth (2006), Phil Trans Royal Society, *"... No definitive long-term acceleration of sea level has been identified using 20th Century data alone"*

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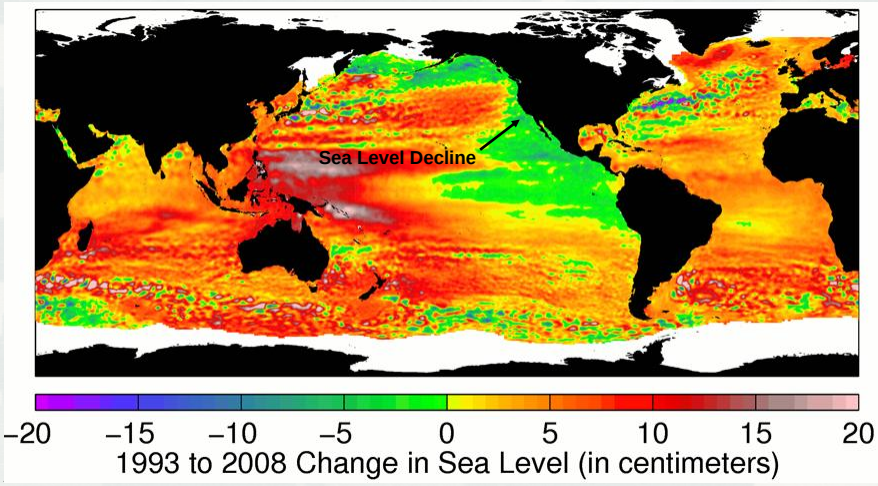
Uncertainties – Sea Level Rise Acceleration

- Satellite altimeters from 1993-2009 have shown increase in rate of sea level rise
- Remarkable spatial variability – e.g., San Francisco has had a rise of 1.9 mm/yr since 1800s, but sea level has fallen 58 mm since 1993



Measured by Satellite Altimeters

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ERDC/U of Florida Joint Sea Level Acceleration Study

- **Analysis of gauges with 60-160 years of data to 2010 including time since 1993 when satellite altimeters have measured increased rate of rise**
- **Analysis shows a mean deceleration of -0.0017 ± 0.0082 mm/yr^2**
- **Agrees with earlier world-wide studies – opposite in sign and one or two orders of magnitude less than acceleration predicted by climate models**

57 Gauges all Having at Least 60-160 Years of Data

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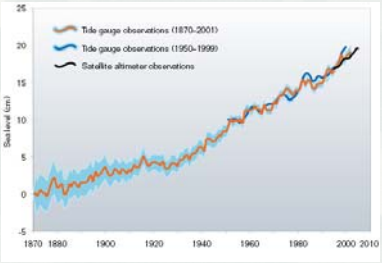
Uncertainties – Sea Level Rise Acceleration

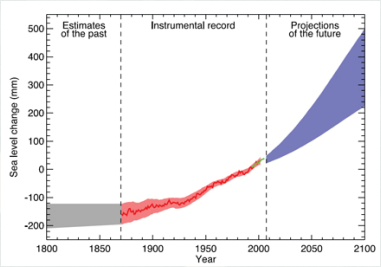
Calls to increase IPCC (2007) predictions

- Recent studies say that sea level rise accelerated 0.013 mm/yr^2 from 1870 to 2004
- This small acceleration extended for the next 100 years increases sea level by almost triple the level that would be attained at the current rate of rise

2010 ERDC/University of Florida study

- Acceleration occurred from 1870 to 1930 with no acceleration from 1930 to 2009
- The acceleration predicted by climate change models for 1930 to 2009 did not occur





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Future Research

It is difficult to project the future when we do not understand the past or present

We need to determine why sea level rise has not accelerated in the 20th Century despite warming of ~3/4º C

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Threatened and Endangered Species

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Endangered Fish Species & Climate Change

Corps needs to know impacts of climate change on endangered fish and how to change operations such as water releases to mitigate impacts

- Increased intensity of rain events producing turbidity that blocks light to submerged vegetation
- Increased nutrient runoff that produces hypoxia
- Increased temperature
- Change in water acidity
- Increase in blue green algae and cyanbacteria that may produce toxins

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Invasive Species to Become Greater Challenge

ERDC R&D has resulted in EPA/USDA approval to release host-specific predators for invasive aquatic plant species – Raised/released 4 million in 09 in 12 Districts

Asian Carp impacting Mississippi River ecosystem - a reported 90% of biomass on some stretches of Mississippi

Developing techniques to control through disruption of their reproduction

Developing controls for invasive species that threaten banks/levees through burrowing

Threatening Lake Okeechobee levees

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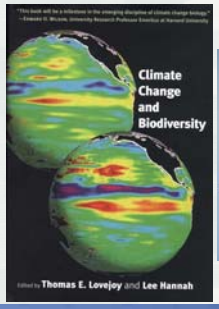
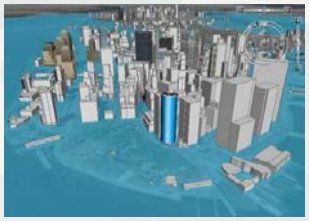
Predicting impacts and evaluating adaptation options is critical to the Corps





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