Modeling hurricane impacts on beaches, dunes and barrier islands

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Motivation

- 2004 Hurricane season hit Florida coast 4 times
- Congress awarded multi-million project MORPHOS3D to develop new physics-based model system to assess hurricane impacts
- Scope: wind-surge-waves-nearshore processes-impacts
- Play ‘what-if?’ games around Corps of Engineers projects

Figure 1 Pre- and post hurricane Ivan, Perdido Key, Florida (source: USGS)

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XBeach - approach

- open source code available for free on internet (www.xbeach.org)
- easy to use (50 registered users)
- Used in engineering, academic research, coastal management, etc.

- Short-wave averaged but long-wave resolving modeling of waves, flow and morphology change in time-domain
- Swash and overwash motions
- Dune erosion, overwashing, breaching and full inundation
- Domain from outside surfzone to backbarrier
- Driven by boundary conditions from surge and spectral wave models

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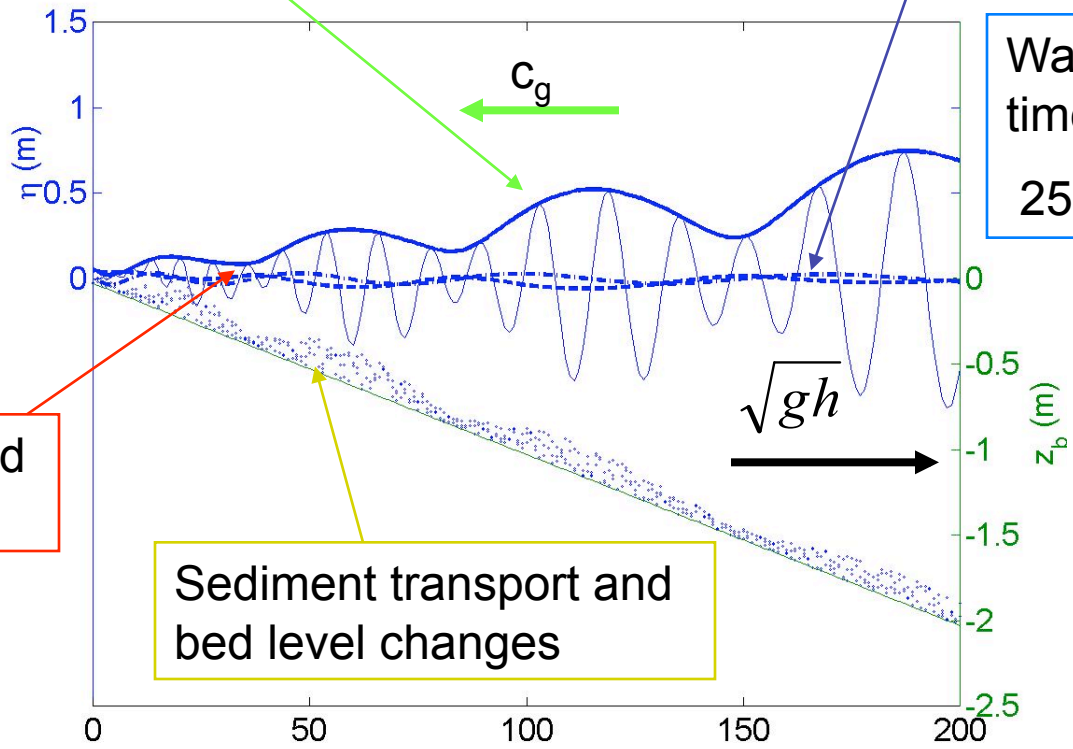
Modeling concepts

Wave groups

Bound and free long waves



Wave-flow motions time scale:

25 s <T< 250 s

Wave breaking and surface rollers

Sediment transport and bed level changes

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Dune erosion test

- Deltaflume 1993, LIP11D
- sub-test 2E: increased water level and severe waves, leading to substantial dune erosion
- Hm0=1.4 m, Tp = 5 s, water level 4.6 m (increased by 0.5 m relative to ‘normal’ conditions)

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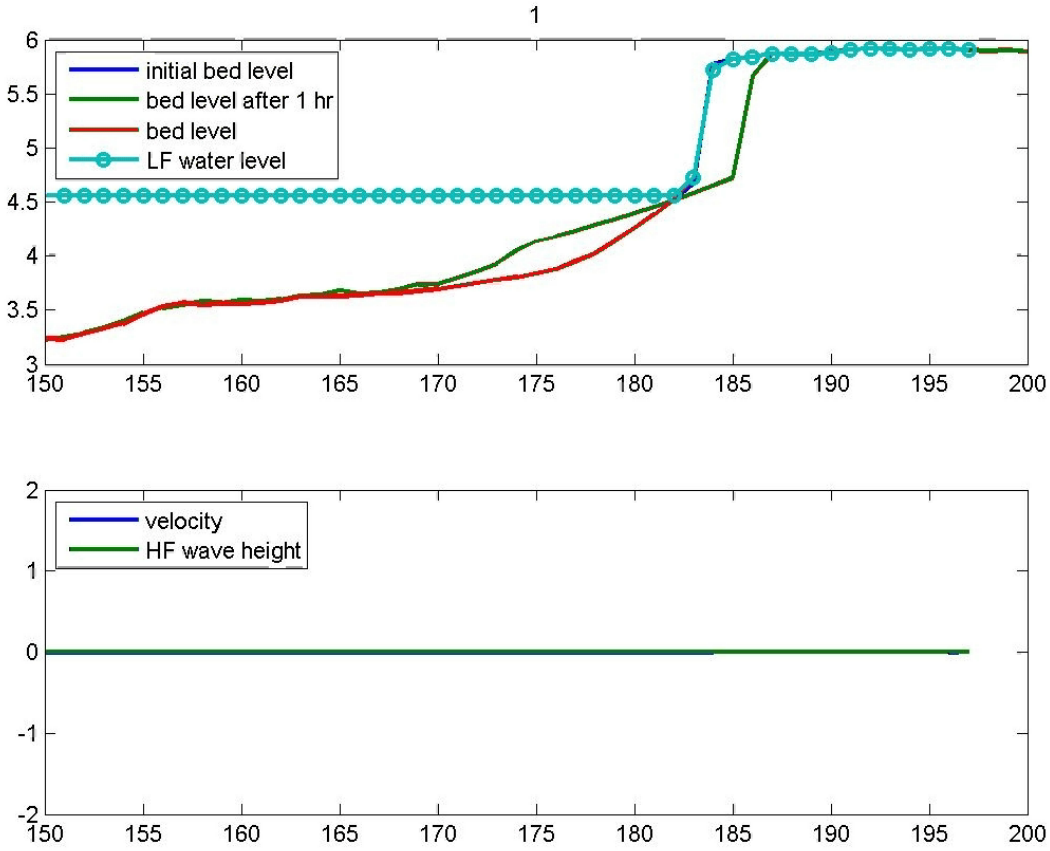
LIP11D dune erosion



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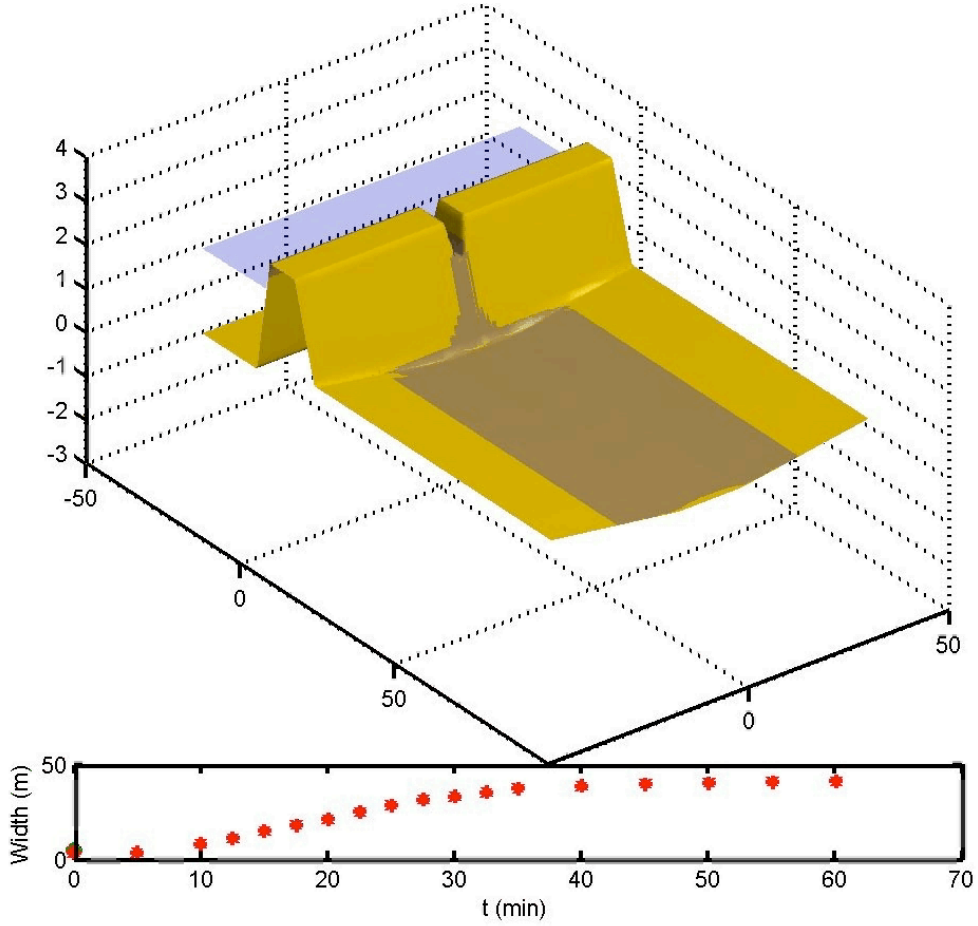
Breach development

Visser,1998



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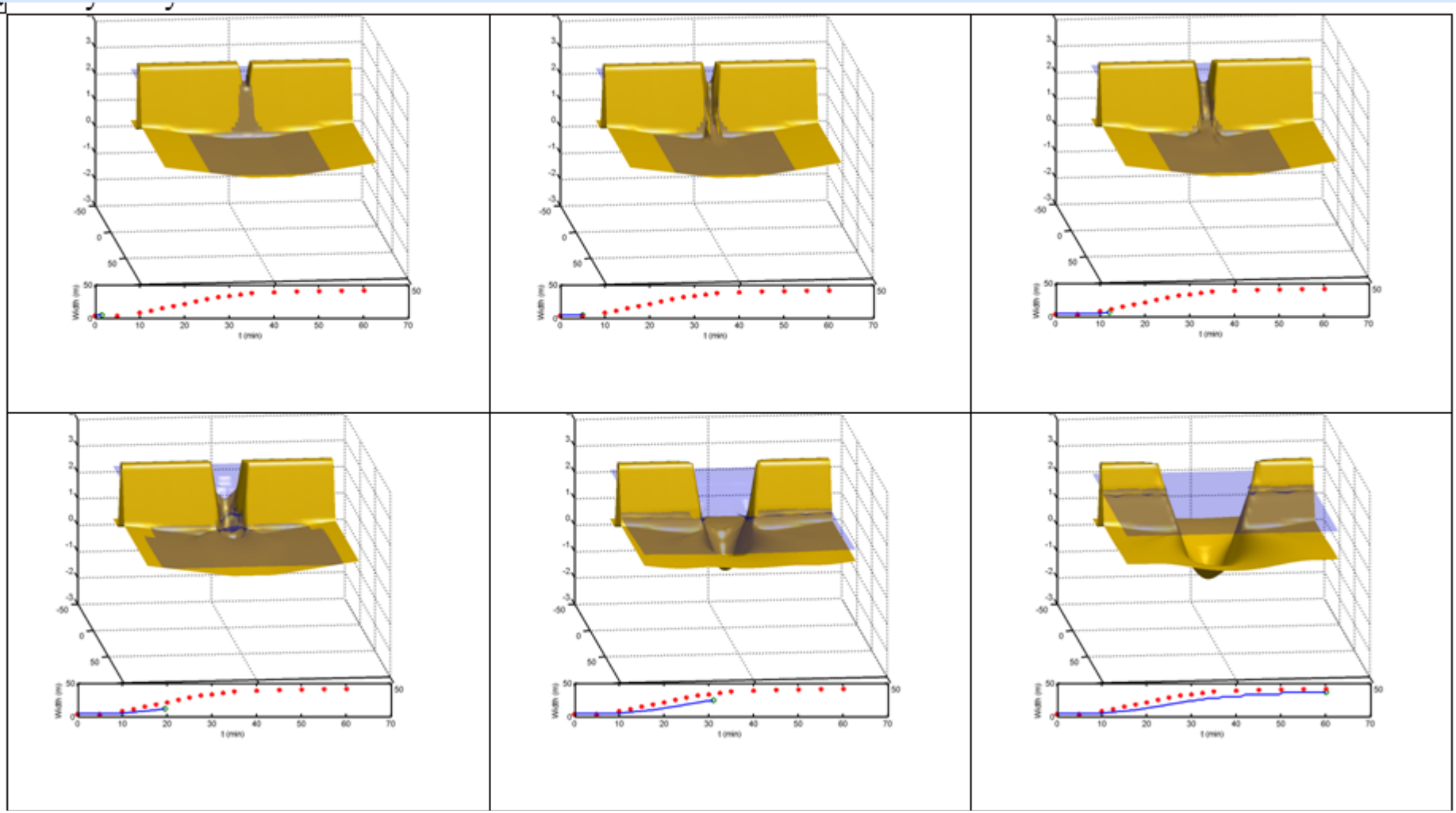
Breach development



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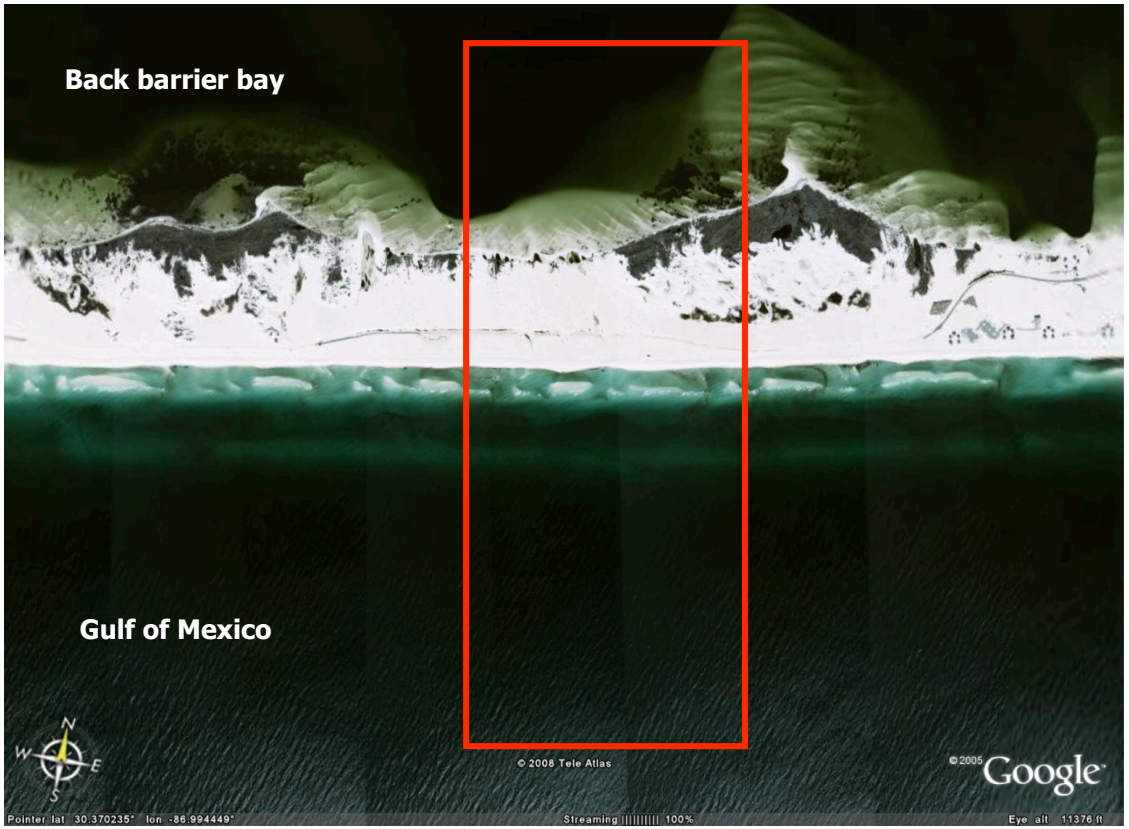
Hurricane Ivan

Cross shore : 3km

Longshore : 1km



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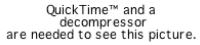
Overwash

Courtesy Dave Thompson, USGS



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Ongoing developments

- Parallellization using MPI
- Implementation of onshore processes
- Coupling with Beach Wizard
- Coupling with regional models
- Extensive testing at ERDC, USGS, Delft
- Central tool in EU MICORE project
- Interaction with structures

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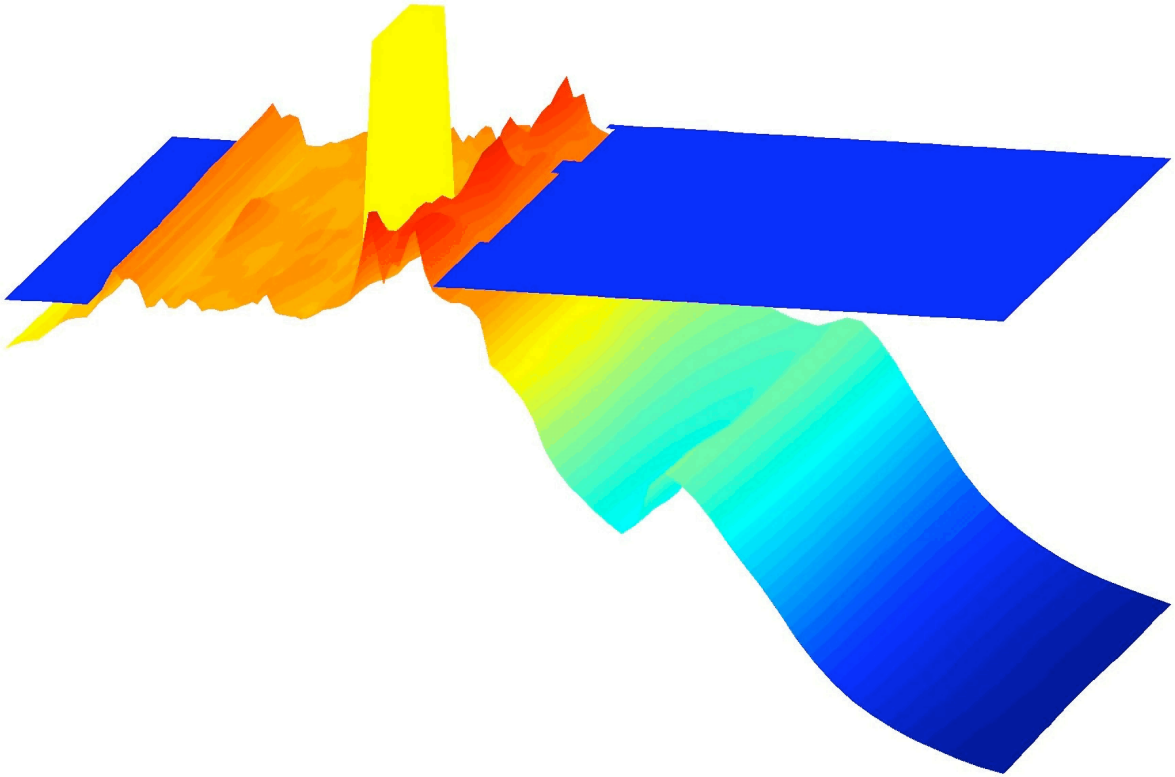
Structures



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Conclusions

- Generally applicable, 2D storm impact model
- Freely available at www.xbeach.org
- Fairly well tested for erosive flume cases
- Promising results for real-life applications
- Much more validation to be done
- Need for exchange

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Formulations

- Wave action balance
- Shallow water equations
- Advection-diffusion equation sediment
- Bed load transport
- Bed updating including avalanching