A Systems Approach to Sedimentation Modeling for the Twenty-First Century

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Objective

Discuss the factors affecting a systems approach to sedimentation modeling in coastal areas.

Outline

- Overview of sedimentation modeling applications
- Summarize different structural paradigms for sedimentation modeling
- Hardware/software/funding trends
- Examples of distributed modeling systems

Estuarine and Marine Applications

- Environmental
- Coastal engineering
- Geological
- Naval

Environmental

- Problems
  - Sediment-water nutrient exchange
  - Pore water and solid phase chemistry
  - Dredging-related releases

- Approaches
  - Bed models
  - Water quality sub-models
  - Fine grained sediment processes

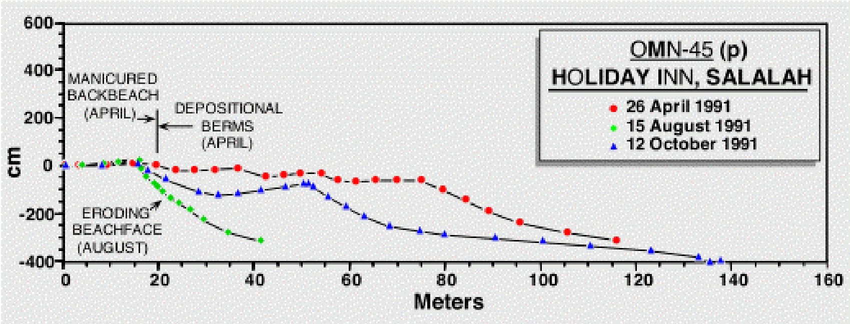
Coastal Engineering

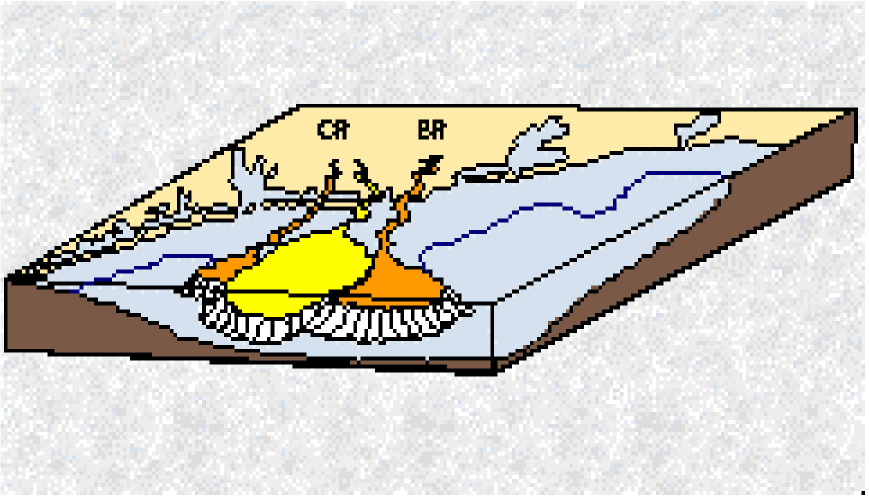
- Problems
  - Structural design
  - Morphological response

- Approaches
  - Small-scale models
  - Range of time scales
  - Dependence on measurements

Geological

- Problems
  - Strata formation
  - Geomorphology

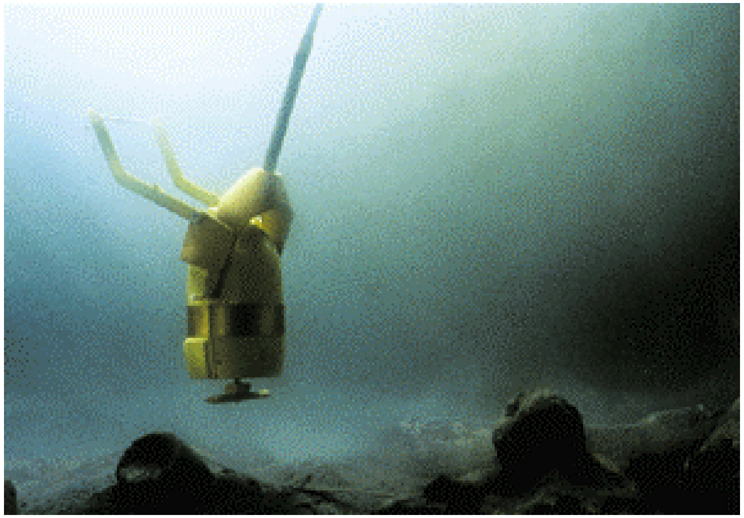




- Approaches
  - Large time and space scales
  - Parametric models
  - Mixed sediment

Naval

- Problems
  - Mine Counter Measures
  - Expeditionary warfare
  - Naval Special Warfare



- Approaches
  - Small time and space scales
  - Forecasting/nowcasting
  - Sensor performance

Comparisons

- Similarities
  - All need hydrodynamic forcing.
  - All need to calculate the quantity of sediment being entrained and/or transported.
- Differences
  - They differ in time and spatial scales.
  - Different input/output requirements

Coastal Ocean Hydrodynamic-Sedimentation Modeling Systems: Paradigms

- Tracer
- Coupled
- Linked
- Stand-alone
- Distributed

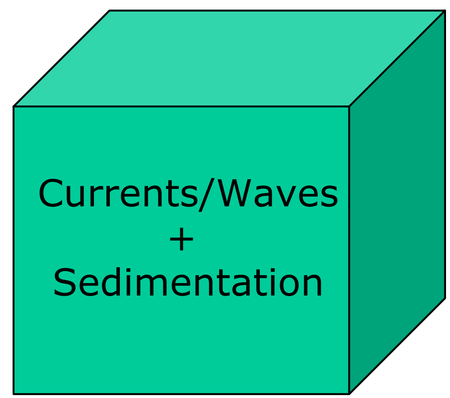
Tracer Paradigm

CHARACTERISTICS

- Uses hydrodynamic model grid
- Uses hydrodynamic model mixing.
- Global variables
- Single platform

ADVANTAGES

- Straightforward implementation
- Feedback



DISADVANTAGES

- Inefficient
- Lack of flexibility
- Numerics determined by hydrodynamic model

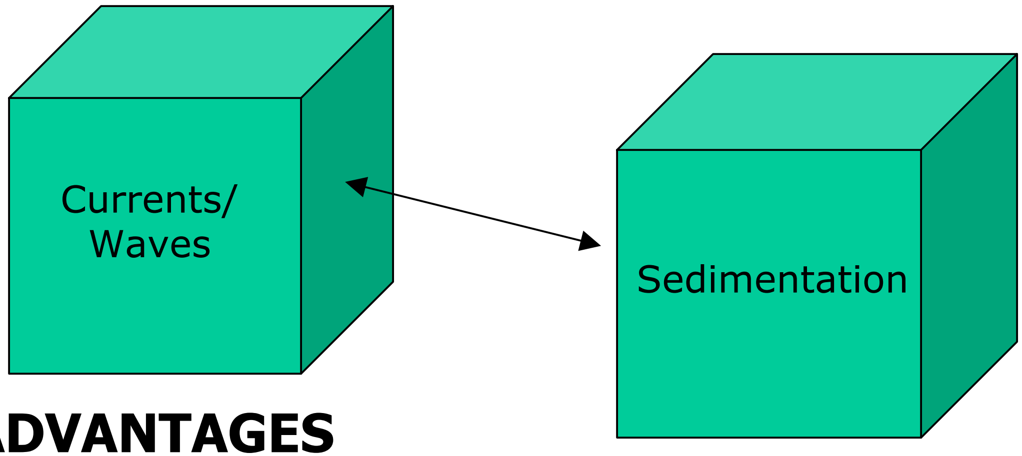
Coupled Paradigm

CHARACTERISTICS

- Same horizontal grid as hydrodynamic model
- Time step is relaxed.
- Vertical resolution can be different.
- Global and local variables
- Single platform

ADVANTAGES

- Straightforward to implement
- Sedimentation model can be more independent



DISADVANTAGES

- Limited Flexibility
- Some numerics determined by hydrodynamic model
- Limited Feedback

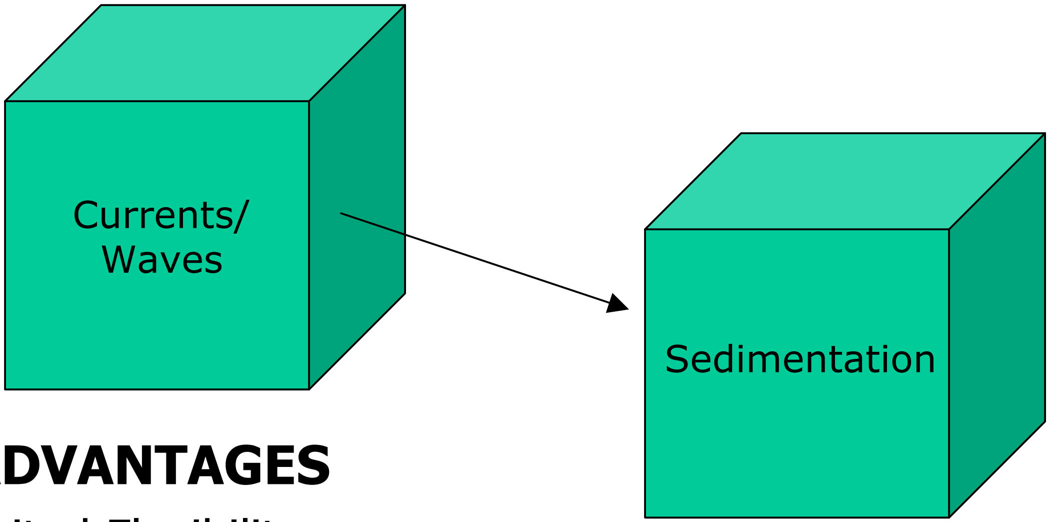
Linked Paradigm

CHARACTERISTICS

- Same horizontal grid as hydrodynamic model
- Time constraint is relaxed.
- Vertical resolution can be different.
- Local variables
- Multiple platforms

ADVANTAGES

- Straightforward to implement
- Models do not run concurrently
- Efficient



DISADVANTAGES

- Limited Flexibility
- No Feedback

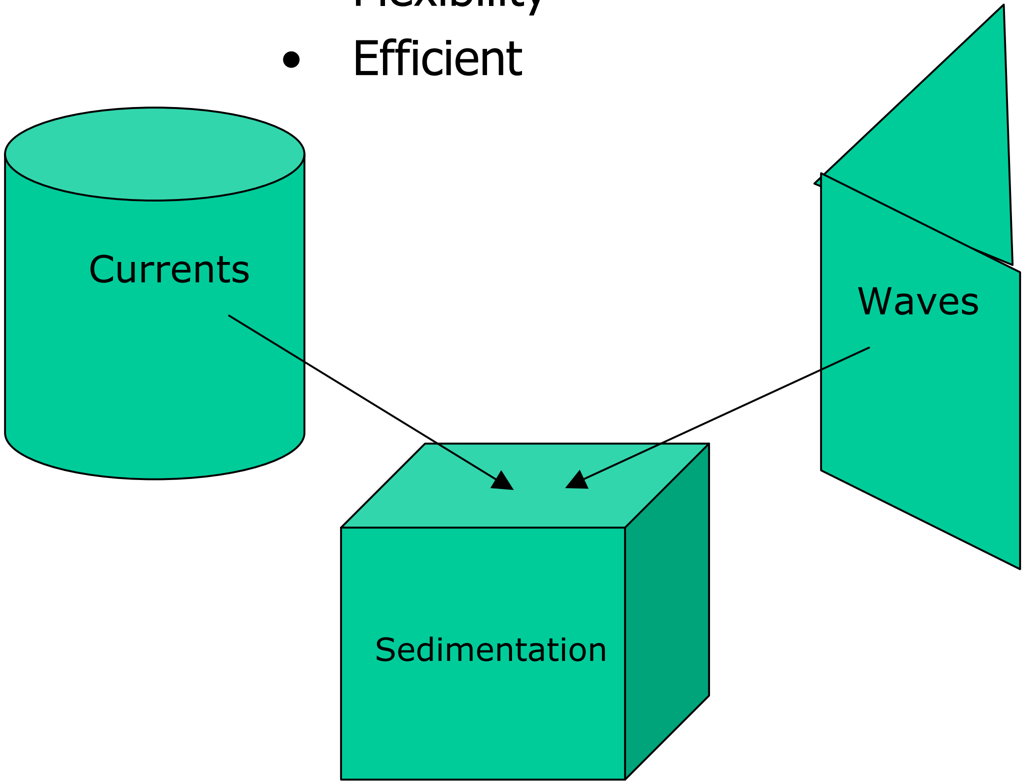
Stand-Alone Paradigm

CHARACTERISTICS

- Sedimentation model is independent
- All forcing fields interpolated
- Sedimentation model physics/numerics separate
- Local variables
- Multiple platforms

ADVANTAGES

- Easy to implement
- Flexibility
- Efficient



DISADVANTAGES

- Input processing
- No Feedback

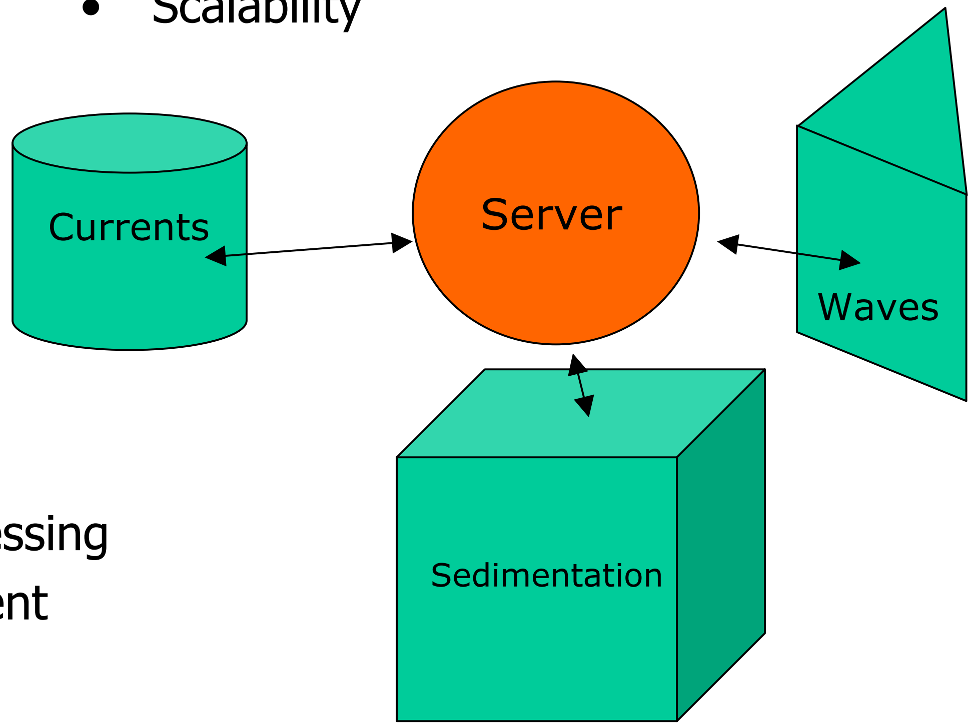
Distributed Paradigm

CHARACTERISTICS

- Sedimentation model is independent
- All forcing fields interpolated
- Sedimentation model physics/numerics separate
- Global variables
- Multiple platforms

ADVANTAGES

- Flexibility
- Feedback
- Straightforward modification
- Scalability



DISADVANTAGES

- Input/Output processing
- Difficult to implement

Trends

- Hardware, algorithms, and software
  - Scalable computers
  - Shared memory/message passing
  - Global computational grid development
  - Software Upgrading: e.g., Common High performance computing Software Support Initiative (CHSSI)
- Funding for distributed modeling systems
  - ONR: Naval Battlespace Awareness (S&T Grand Challenge)
  - NSF: Information Technology Research (ITR) for Geosciences

Examples

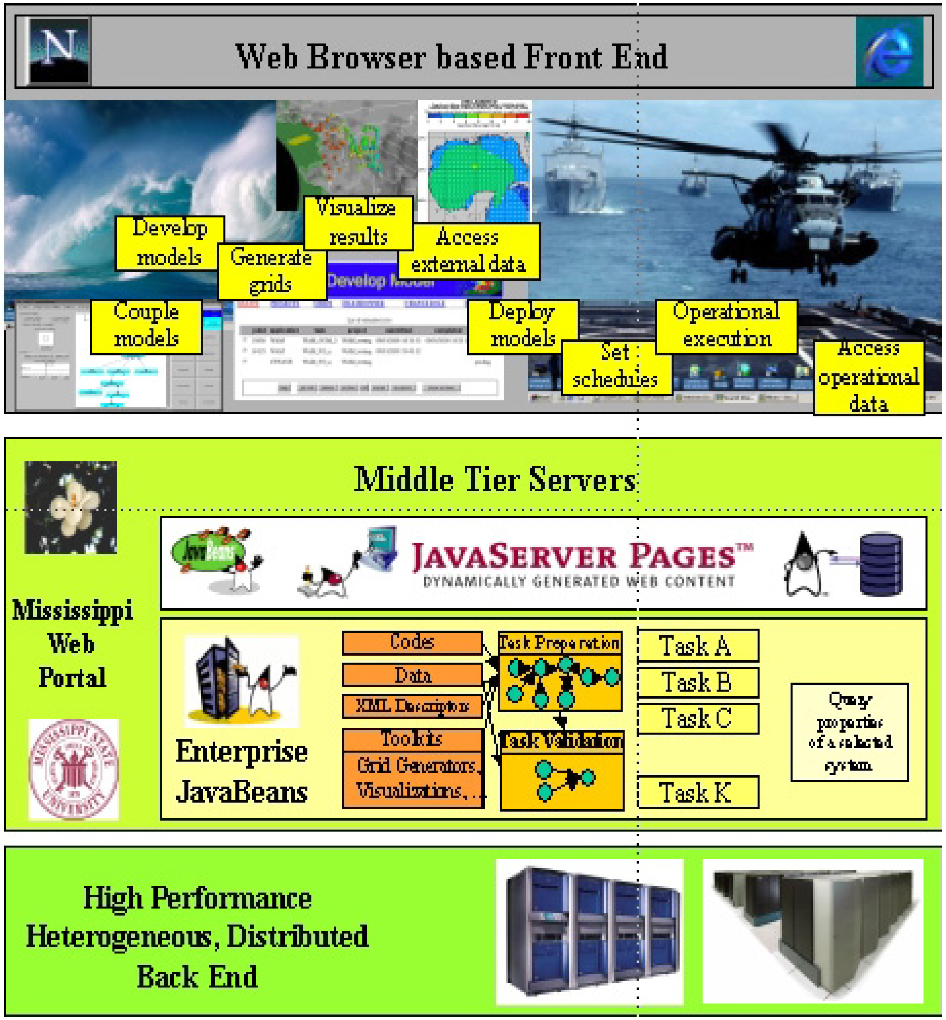
- Distributed Marine Environmental Forecast System (DMEFS)
- High Fidelity Simulation Of Littoral Environments (HFSOLE)

DMEFS

- **Research test bed:** demonstrate the integration of various technologies and components prior to DoD operational use
- **Open framework:** operate climate, weather, and ocean (CWO) models.
- **Prototype system:** couple atmosphere and ocean models into a distributed hindcast/nowcast/forecast system

DMEFS

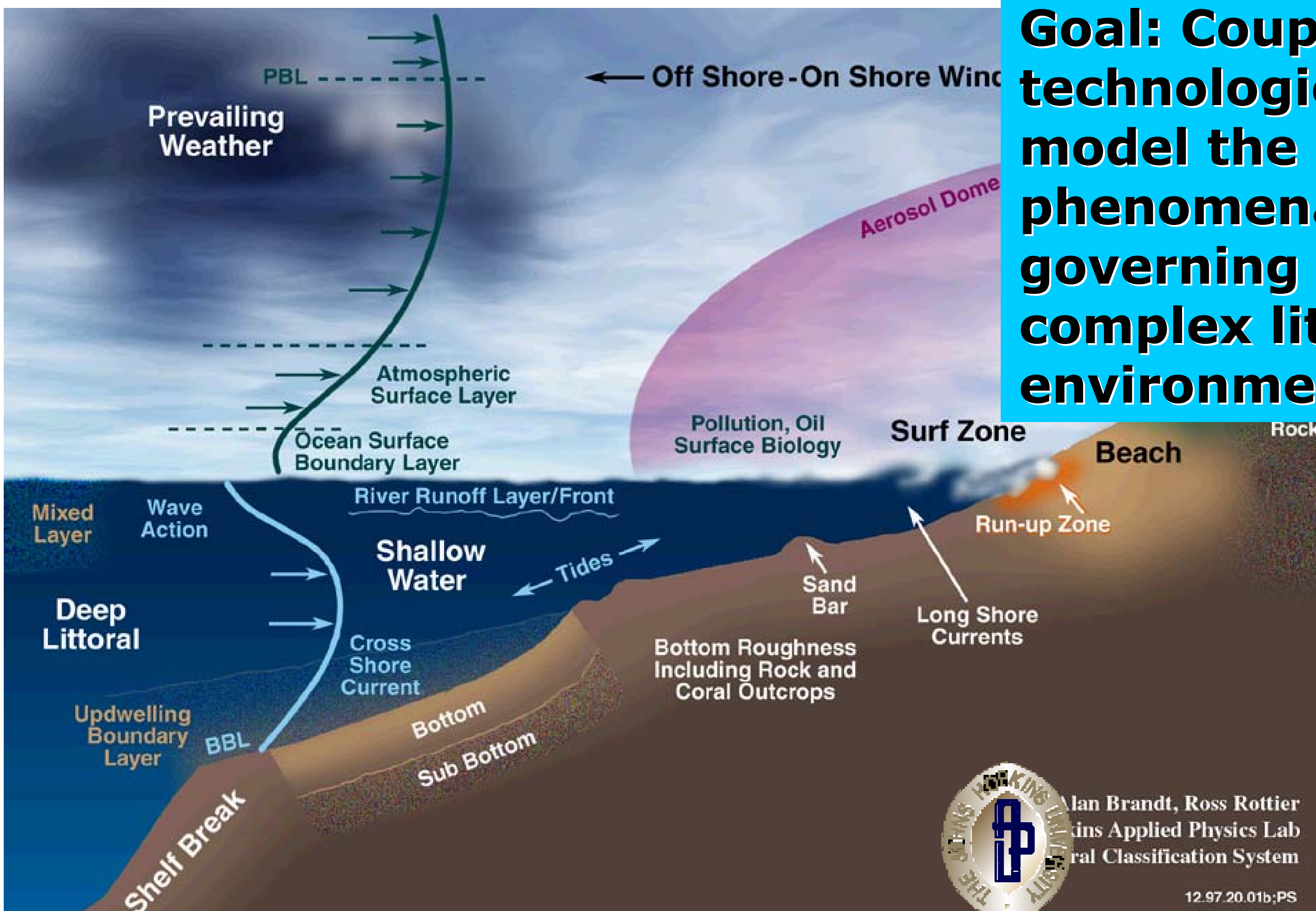
- ***DMEFS is an application and an infrastructure***
  - A collection of METOC models, applications, utilities, and services
  - A software infrastructure comprised of a user front end, middleware, and interfaces to back end processors



DMEFS Summary

- Seamless access via a standard web browser.
- User friendly
- Easy dissemination of results
- Brings powerful computational and database resources to user's fingertips

High Fidelity Simulation of Littoral Environments (HFSOLE)



Goal: Couple technologies that model the key phenomena governing the complex littoral environment

Approach

- Improve scalable nearshore models
- Link scalable CWO models
- Implement distributed capabilities on scalable DoD HPC platforms

HFSOLE: Components

- Wind: COAMPS (FNMOC)
- Waves : WAM, SWAN, STWAVE
- Currents: ADCIRC, NCOM, HYCOM
- Rivers: Adaptive Hydraulics Code (ADH)
- Sedimentation: LSOM
- Model integration framework: Common Object Request Broker Architecture (CORBA)

Conclusions

- The common denominator for the different sedimentation modeling applications is not the model itself but the need to make efficient use of results.
- Preliminary technology issues have been addressed.
- Now is the time to develop a sedimentation modeling system that allows flexibility and ease of use.

Acknowledgements

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