Simulating Braided Rivers with Swarm

SwarmFest09

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Te Whare Wānaka O Aoraki

Overview

- Braided Rivers
- A complex systems approach
- Use of Swarm
- Challenges/Next Steps

Braided Rivers

Characterised by:

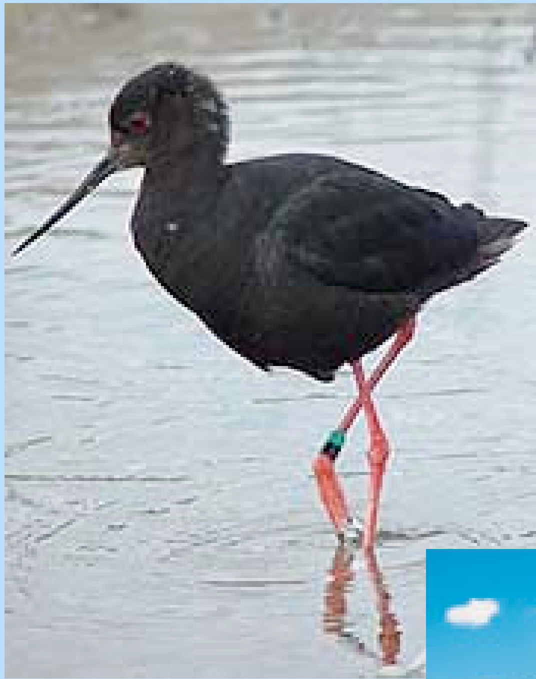
- Steep river valley slopes
- High sediment discharge
- Unconstrained laterally
- Noncohesive bed sediments (e.g shingle, gravel, sand) across a range of particle sizes
- Frequent channel shifts

Rivers "having a number of alluvial channels with bars and islands between meeting and dividing again" Lane (1957)



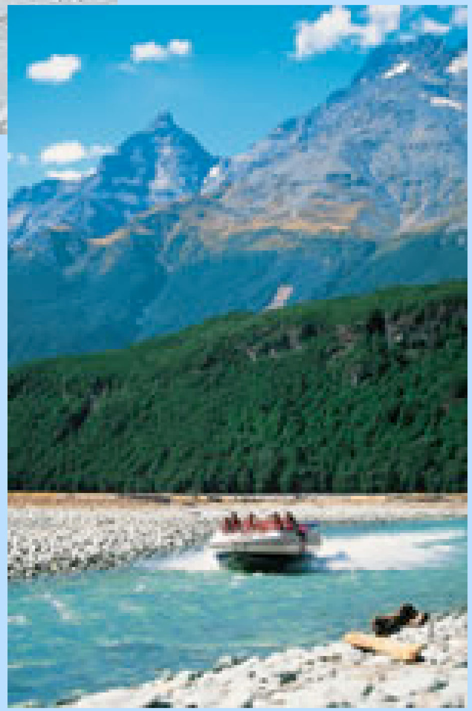
Home to…

- Salmon
- Trout
- Black Stilt (Kaki)



Important for…

- Hydro Power
- Shingle/Gravel
- Recreation



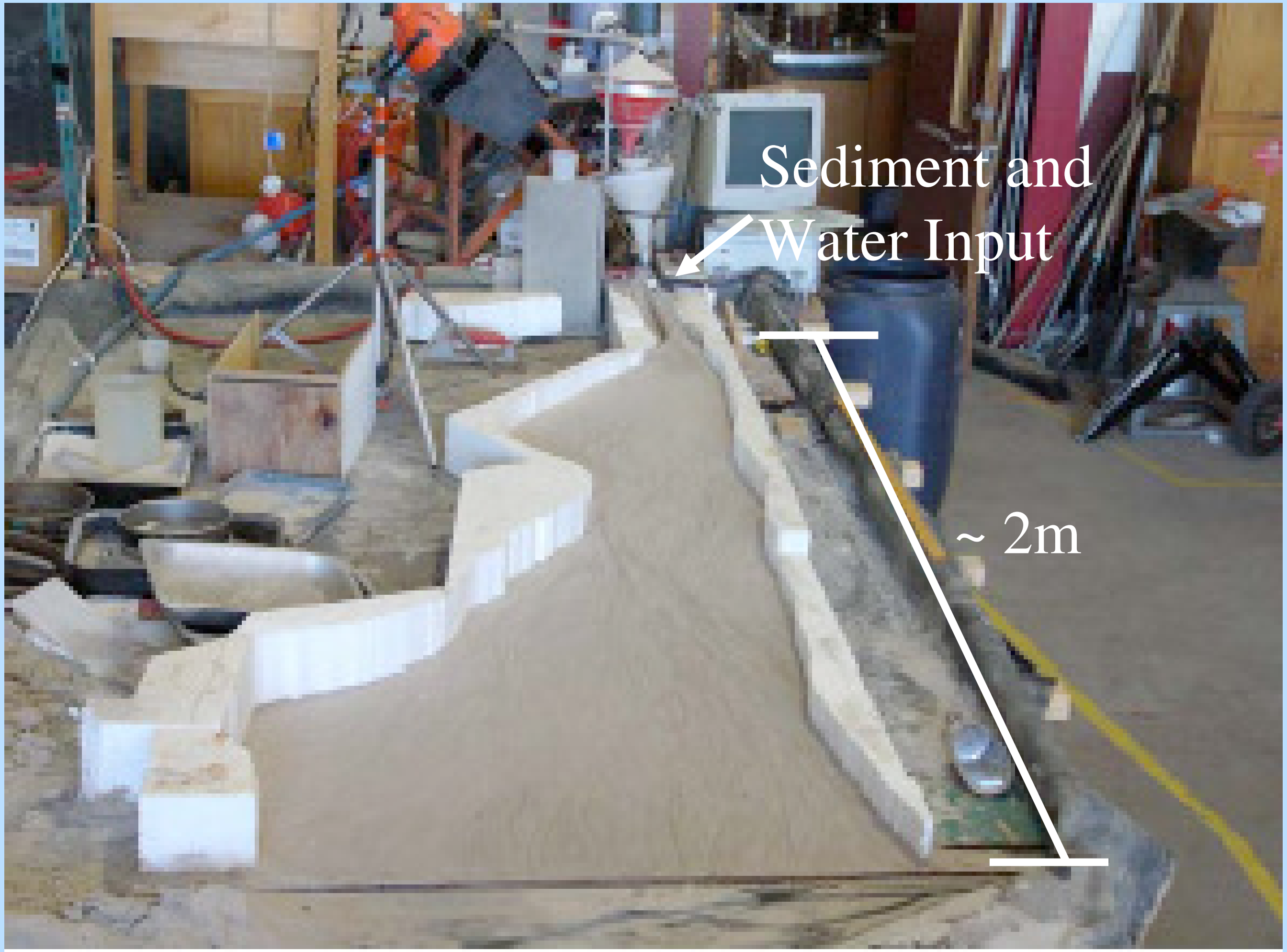
Some Interesting Properties…

Power Law Scaling – spatial and temporal

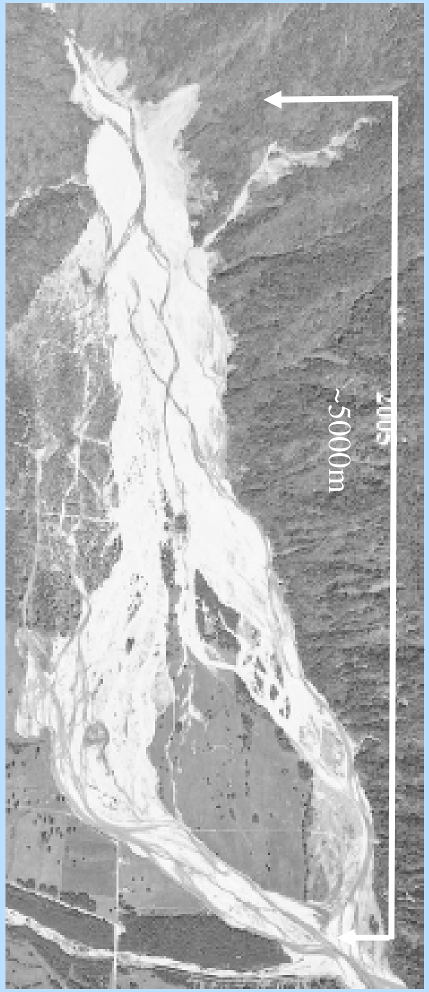
- Size and number of channels
- Size and number of islands
- Area of river bed occupied
- Frequency and magnitude of changes (channel)

- Dynamic (in space and time)
- Across a range of spatial scales

Similar behaviours across scales



~1:2500 Laboratory Model



Prototype
(Poerua River)

Some Interesting Properties…

Power Law Scaling – spatial and temporal

- Size and number of channels
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- Area of river bed occupied
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- Dynamic (in space and time)
- Across a range of spatial scales
- "Complex" System Behaviour
- Two hypotheses I'd like to test:
  - Behaviour is a result of multi-scale interactions
  - Behaviour is a result of energy dissipation modes (Macbeth's Principle)

A Complex Systems Analysis

A system of many parts coupled together in a nonlinear fashion

- **Large number of mutually interacting dynamical parts**
  - Water and sediment
  - "Local" rules create Systemic behaviour
- **Feedback loops**
  - Flowing water affects sediment which affects flowing water, etc…
- **Thermodynamically open**
  - Order increase (*entropy decreases*) despite the lack of "central control"
- **Unpredictable "emergent" behaviour"**
  - Power Law Scaling
  - Hierarchical or nested system (e.g. Turbulence)
- **The system is greater than the sum of its parts**

Swarm applied to Braided Rivers

- At this stage, a very simple model
- Riverbed elevations read in from a DEM and stored in grid cells
- Agents are “drops” of water (volumes really), moving over the surface
- Movement determined by finding the steepest downward slope from the eight surrounding neighbours
- Simple sediment transport model
- Here’s what it looks like…

Challenges and Next Steps

- **I wasn't a programmer when I started this…**
  - **Figuring out how to build the model**
    - **Heatbugs, Paul Box's Biox**
  - **Multiple agents in a cell (Paul Johnson's MultiGridCell)**
  - **I'm still not a programmer…**
- **Non-Swarm related problems**
  - **Testable hypotheses**

Challenges and Next Steps

- **Multi-scale grids**
- **Different “speeds”**
  - **Step methods that are multiples of the time step?**
  - **Asynchronus updating?**
  - **Concurrency?**
- **Better sediment transport methods**
- **Hypothesis testing**

Briefly - Macbeth's Principle

Act 1, Scene VII – Macbeth's castle

Hautboys and torches. Enter a Sewer, and divers Servants with dishes and service, and pass over the stage. Then enter MACBETH

MACBETH:

If it were done when 'tis done, then 'twere well
It were done quickly

Translation: systems select modes that dissipate energy as quickly as possible

Finally, my thanks to…

Giant shoulders:

- **Marcus Daniels – help at a desperate time**
- **Paul Johnson – MultiGridCell object code**
- **Paul Box – GIS import methods**
- **Steve Railsback – help at another desperate time**
- **Gary – for rescheduling this talk**