The Virtual Estuary: Simulation meets Visualization

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CMOP
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**CMOP: Making Sense of Data**

- **Five-component ecosystem model**
  
  - Nitrate
  - Ammonium
  - Detritus
  - Phytoplankton
  - Zooplankton

  *Spitz et al. (2005)*

- **Model of Myrionecta Rubra**: 7 components

- **Other possible model**: 12 components

**SELFE – Unstructured grid**

- Nodes: 27624, Elements: 53369
- Vertical levels: 54

**ROMS – Structured grid**

- Grid pts: 384x128
- Vert. levels: 44

**CMOP: Making Sense of Data**
CMOP: Making Sense of Data

- Observation and modeling of multiple systems at multiple scales
  - Scientists need to collaborate: biologists, chemists, oceanographers, computer scientists
- Very large number of data products, sensor measurements, and results from numerical models
- Cover more than 10 years of experiments: occupy over 30 TB of storage
CMOP Cyberinfrastructure

- Support key activities in the CMOP collaboratory: from data acquisition and analysis to result dissemination
- VisTrails is a scientific workflow system
  - Integrate simulations, data pre-processing, and analysis
  - Focus on exploratory tasks such as visualization and data mining
  - Transparently tracks provenance of the discovery process---the trail followed as users generate and test hypotheses

Open-source: http://www.vistrails.org
VisTrails: Provenance of Exploration

Reproducibility and Validation

Collaboration

Knowledge sharing: data + processes
Benefits of Provenance

- Compare data products
  - Assess data quality, understand process
- Support for reflective reasoning
- Improve training and
  “Reflective reasoning requires the ability to store temporary results, to make inferences from stored knowledge, and to follow chains of reasoning backward and forward, sometimes backtracking when a promising line of thought proves to be unfruitful. …the process is slow and laborious”

Donald A. Norman

[Freire et al., IPAW 2006]
Benefits of Provenance

- Compare data products
- Support for reflective reasoning
- Improve training and teaching
- Knowledge re-use
  - Provide suggestions to users as they construct visualizations

[Koop et al., IEEE Vis 2008]
Visualization at large and on the go

High-resolution rendering of the Columbia River virtual estuary at a display wall

Rendering of the Columbia River on an IPOD Touch
VisTrails: Science Dissemination

- Science mashups: simplify data exploration through visualization

[Santos et al., IEEE Vis 2009]
• Teaching and training
  – Lecture provenance: student can reproduce results
  – Homework provenance: provides insights regarding ask complexity and nature, student confusion
  – VisTrails has been adopted as a teaching tool at Utah, UNC, UTEP, Linkoping (Sweden)
VisTrails: Science Dissemination

- Provenance-rich documents and publications
The Importance of Visualization: Research

- A picture is worth a thousand words!
- Understand large volumes of simulation results—obtain insights
  - Identify interesting features
  - Correlate information from multiple models
  - Interactively explore data

Flow visualization
The Importance of Visualization: Education

- Intuitive representation, easier for non-experts to understand
- Visually appealing
- Teaching and outreach: encourage students and general public to learn about science
Conclusions and Future Work

- Visualization is essential for ocean observatories
- VisTrails and Provenance
  - Support reflective reasoning
  - Intuitive interfaces for simplifying the construction and refinement of visualizations
- Sharing provenance creates new opportunities
  - Workflow/provenance repositories; provenance-enabled publications
  - Expose scientists to different techniques and tools
  - Scientists can learn by example; expedite their scientific training; and potentially reduce their time to insight
Acknowledgments

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  - VisTrails group
  - CMOP cyber and modeling teams
Backup
• Conveniently explore parameter spaces and compare results

[Freire et al., IPAW 2006]
Provenance Enabling Tools

ParaView

Maya

VisIt

[Callahan et al., IPAW 2008]
VisComplete:
Data-driven Suggestions for Visualization Systems

[Koop et al., IEEE Vis 2008]