Visual Reconciliation of Alternative Similarity Spaces in Climate Modeling

Jorge Poco\textsuperscript{1}, Aritra Dasgupta\textsuperscript{1}, Yaxing Wei\textsuperscript{2}, William Hargrove\textsuperscript{3}, Christopher R. Schwalm\textsuperscript{4}, Deborah N. Huntzinger\textsuperscript{4}, Robert Cook\textsuperscript{2}, Enrico Bertini\textsuperscript{1} and Claudio T. Silva\textsuperscript{1}

\textsuperscript{1}New York University, \textsuperscript{2}Oak Ridge National Laboratory, \textsuperscript{3}United States Forest Service, \textsuperscript{4}Northern Arizona University
Visual Reconciliation of Alternative Similarity Spaces in Climate Modeling
demographics
- age, gender, race, occupation, …

patients

features
- make, model, year, mileage, …

cars

transaction
- profit, sales, customer profile, …

disease
- symptoms, medications, …

model structure
- soil conditions, process details

climate

model output
- space and time variable
Patients

Demographic similarity

Disease similarity
Challenges

Heterogeneous data spaces
Reduce visual complexity

Level of Abstraction
Ensure domain experts trust the visualization

Parameter Exploration
Develop effective navigation strategies
Contribution

A visual reconciliation technique for iterative refinement of grouping criteria which is supported by a visual feedback model for comparing the alternative similarity spaces in climate modeling.
Visual Reconciliation of Alternative Similarity Spaces in Climate Modeling
Model Simulation

ecosystem processes → carbon exchange

Input/ Drivers → Structure → Output (GPP)

Binary features

e.g., productivity, soil characteristics, etc.

e.g., vegetation type, moisture influence

e.g., temperature, pressure, humidity, etc.

Space → time

Holy grail: Analyze similarity among model input, model structure and model output
Input/Drivers

eg., temperature, pressure, humidity, etc.

Structure

eg., vegetation type, moisture influence

Output

eg., productivity, soil characteristics, etc.

(Binary features) (space) (time)

(EuroVis 2014) Previous Work - SimilarityExplorer: A Visual Inter-Comparison Tool for Multifaceted Climate Data

(VAST 2014) Visual Reconciliation of similarity between model structure and model output
Related Work

• Automated Methods
  Consensus Clustering  [Monti et al., Machine Learning 2003]
  Redescription Mining  [Ramakrishnan et al., SIGKDD 2004]

• Visual Feedback in High-dimensional Data Spaces
  Cognitive feedback model  [Hu et al., TVCG 2013],
  Representative factor generation  [Turkay et al., TVCG 2012]

• Visual Parameter Space Analysis
  Conceptual framework  [Sedlmair et al., InfoVis 2014]
Visual Reconciliation of Alternative Similarity Spaces in Climate Modeling
Binary Data

15 models
20-30 criteria

$2^{30}$ possible groupings!

Time-varying Data

15 models
12 time steps

Many possible clusterings!
How does similarity in model structure affect model output?
How does similarity in model output affect model structure?
What is the importance of the different structural criteria in model similarity?
Matrix View

color: low implementation

height: equal importance for all criteria

connectors: preserve link among columns and bars during reordering

criteria

models

group color
Time Series View

Alternative Clusterings

Small Multiples
Optimization

\[ y(x_i, x_j)^2 - \hat{d}(y_i, y_j)^2 \parallel^2 \]

\[ = 1 \]

subject to \( w_k \geq 0, \ k = 1, \ldots, q. \)
Interactions
Reconcile structure with output
Reconcile output with structure
Conclusion

• *Alternative similarity spaces are ubiquitous.* We focus on one application domain: climate modeling.

• We propose a *visual reconciliation technique* for binary data and time-varying data.

• Positive feedback from scientists
  “One of the most valuable functions of the technique is to effectively remove from consideration the complications created from model structures, that have little to no effect on outputs, and to *effortlessly show and rank the differential effects on output created by seemingly related or unrelated model structures.*”
Visual Reconciliation of Alternative Similarity Spaces in Climate Modeling

Thank You!

**Acknowledgment**: DataONE project sponsored by the NSF Grant number OCI-0830944, NSF CNS-1229185, NASA ROSES 10-BIOCLIM10-0067, and DOE Office of Science Biological and Environmental Research (BER).
Data acquired through the MASTDC (NASA Grant NNH10AN68I) and MsTMIP (NASAGrant NNH10AN68I) projects funded by NASA’s Terrestrial Ecology Program.
Collaborators: Members of the Exploration, Visualization, and Analysis Working Group under DataONE.

http://vgc.poly.edu/projects/VisualReconciliation/

jpocom@nyu.edu
adasgupt@nyu.edu