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SimilarityExplorer: A Visual Inter-Comparison Tool for Multifaceted Climate Data

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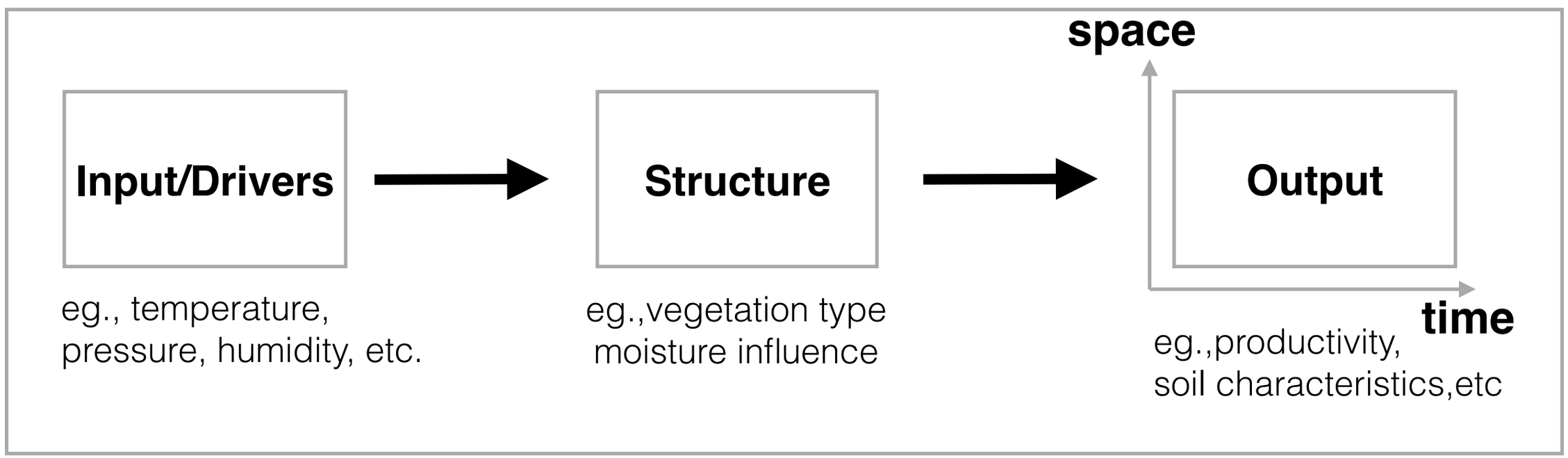
Model Simulation

ecosystem processes

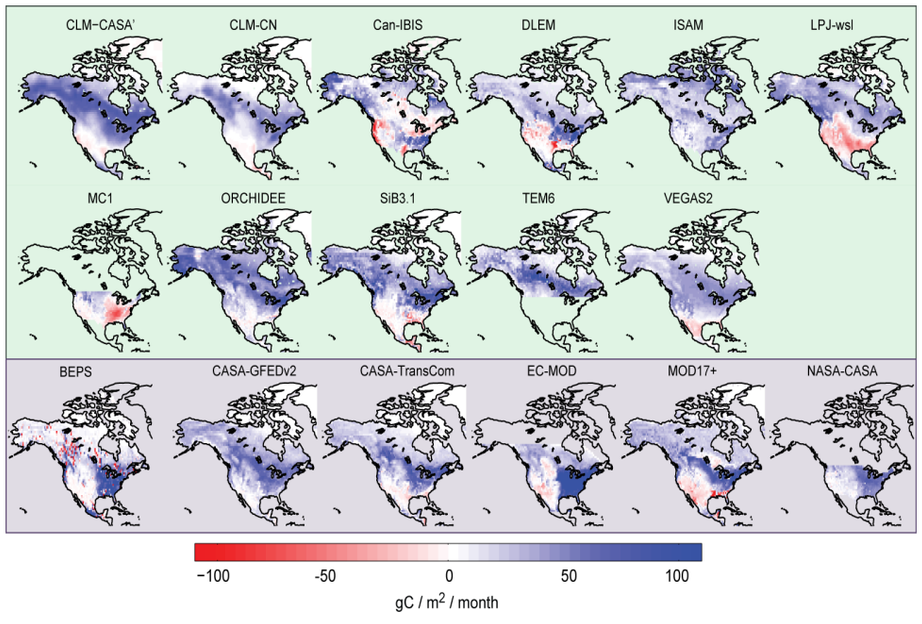
carbon exchange



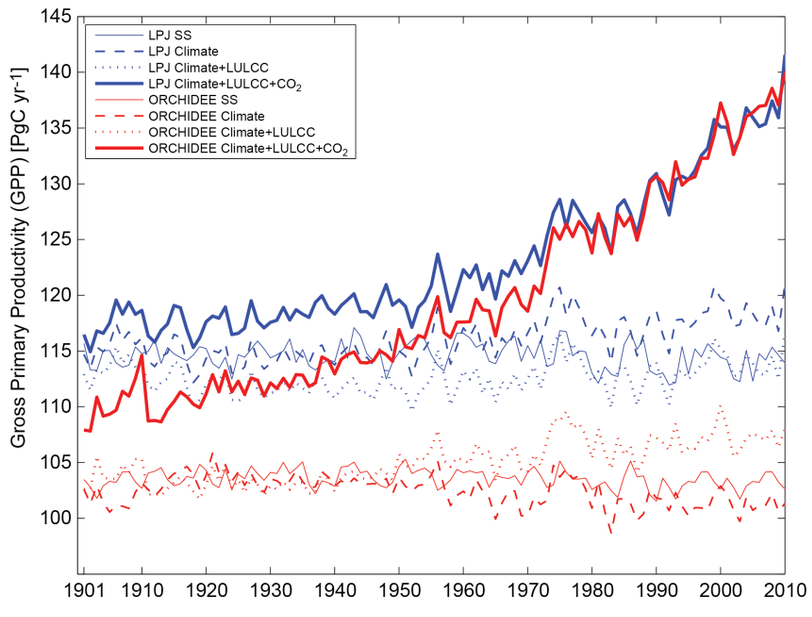
Holy grail: Analyze similarity among
model **input**, model **structure** and model **output**

Model Simulation

ecosystem processes carbon exchange



Model Output



Explore spatial similarity

Explore temporal similarity

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*Images from Huntzinger et al.,'11

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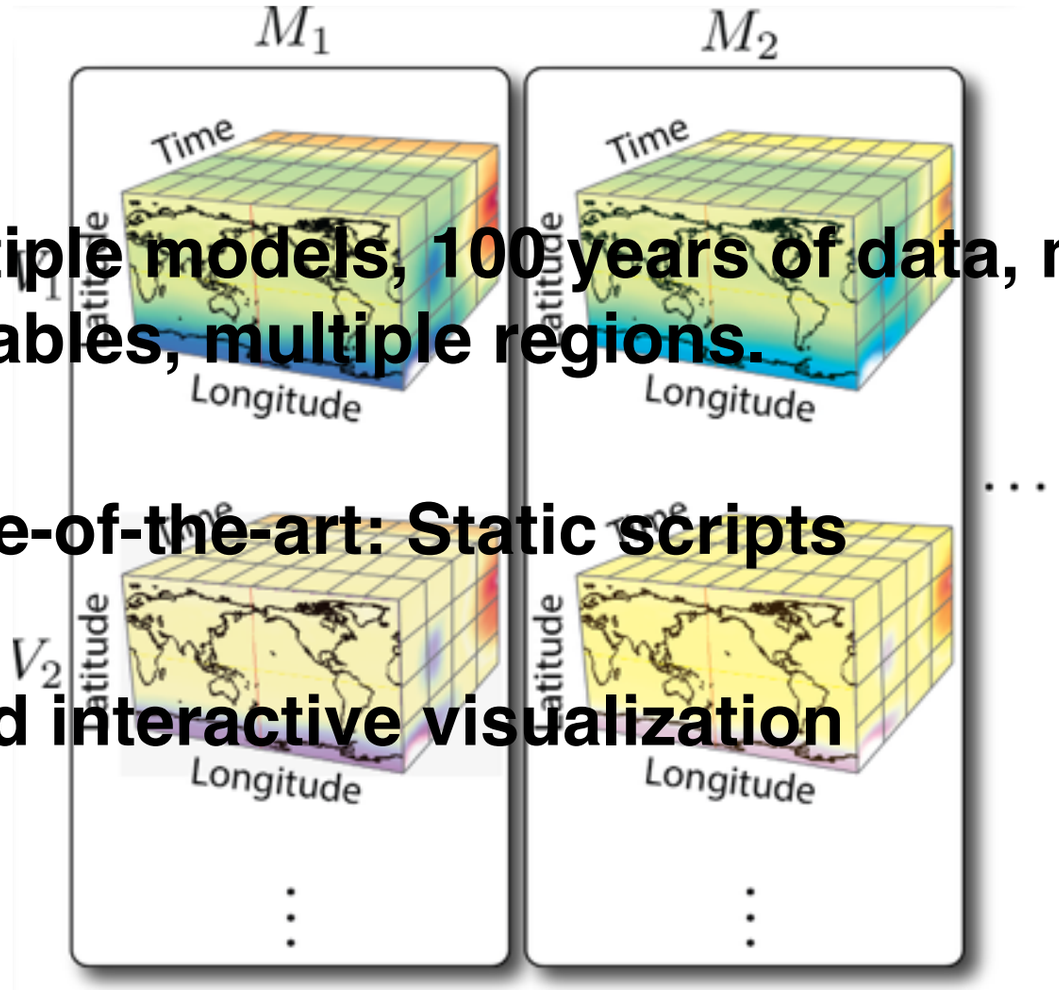
Challenges



- **Multiple models, 100 years of data, multiple variables, multiple regions.**
- **State-of-the-art: Static scripts**
- **Need interactive visualization**

“Without this tool scientists would literally print hundreds of plots and pin them on the wall, this tool solves this problem”.

Inter-comparison of multiple facets (space, time, variables, model similarity)

Where: global, regional

When: annual, seasonal, and monthly

What: multiple variables

Design Study Process

- Collaboration with climate scientists from ORNL, NAU and USFS
- Year-long association: workshops, phone interviews
- Iterative refinement of prototypes through discussions

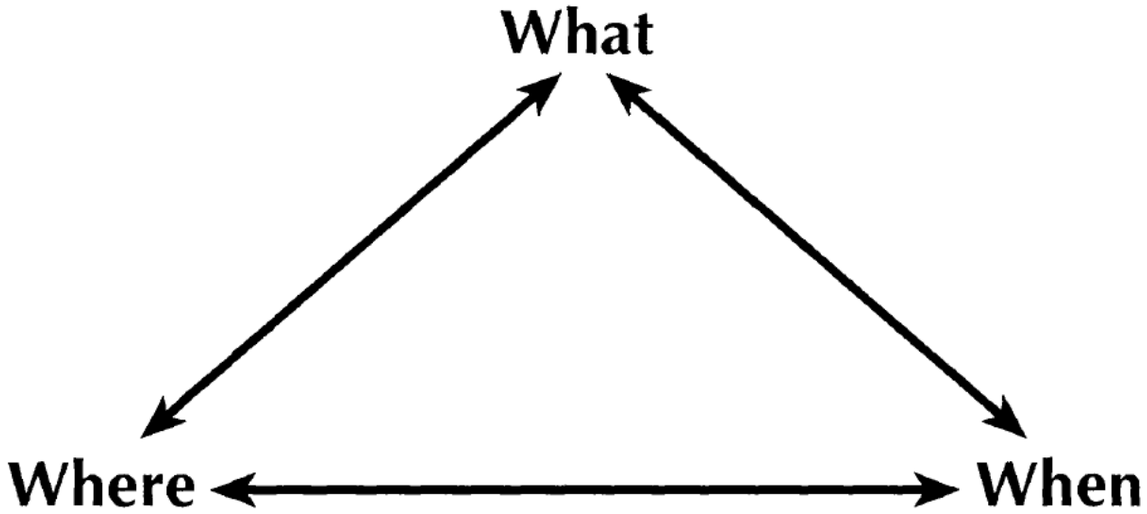
Contributions

- Domain Characterization for Model Inter-Comparison
- Characterization of the Visualization Design Space
- SimilarityExplorer tool: Output of the Design Study

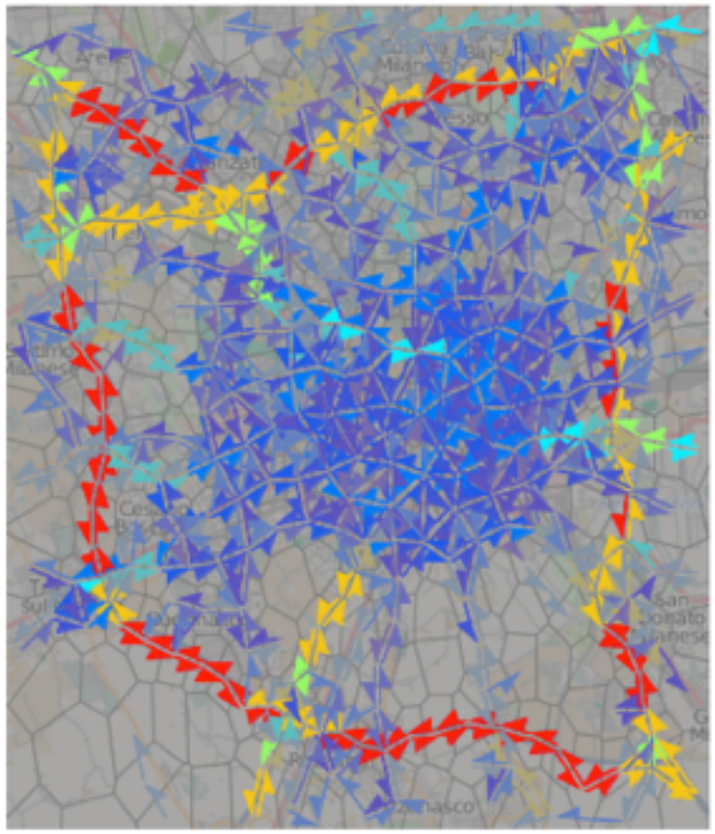
Related Work

Inspired by previous work on integration of space and time

Peaquet's triad framework ('94), Andrienko's visual analytics model (2010)



[Peu94]

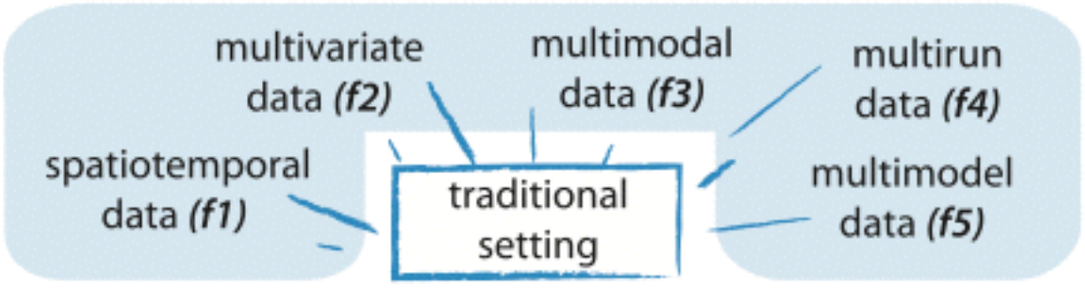


[AA10]

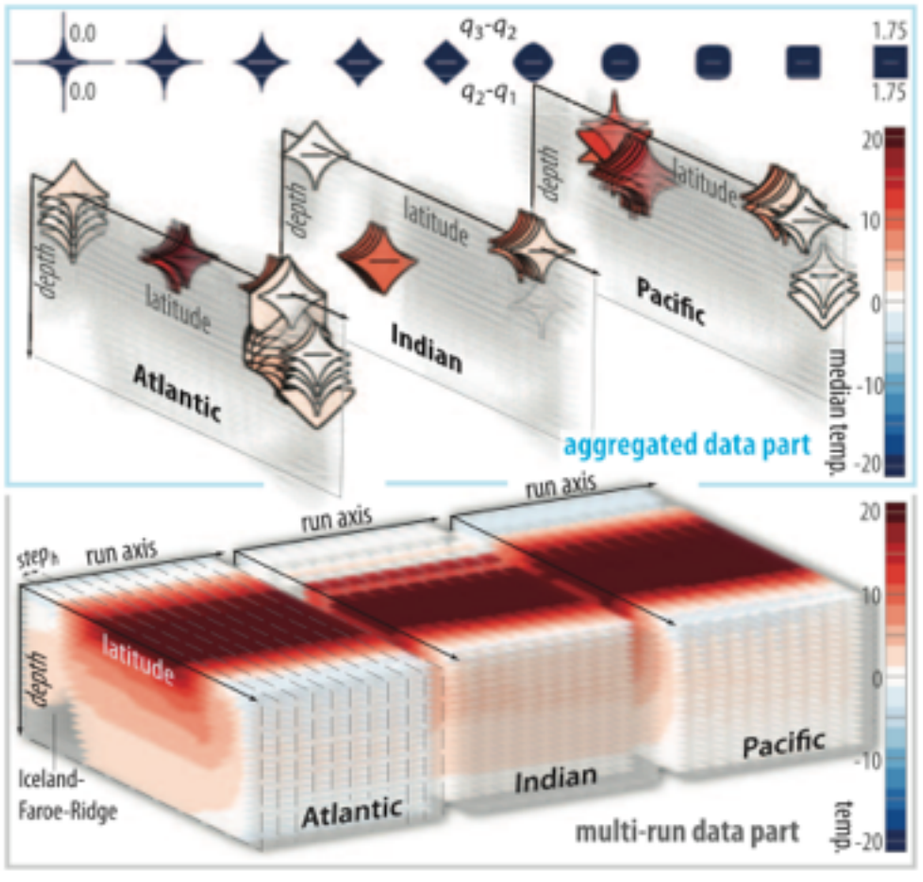
Related Work

Multifaceted scientific data analysis

Conceptualized by Kehrer'11, 13. Existing work deals with at most two facets



[Kehrer13]

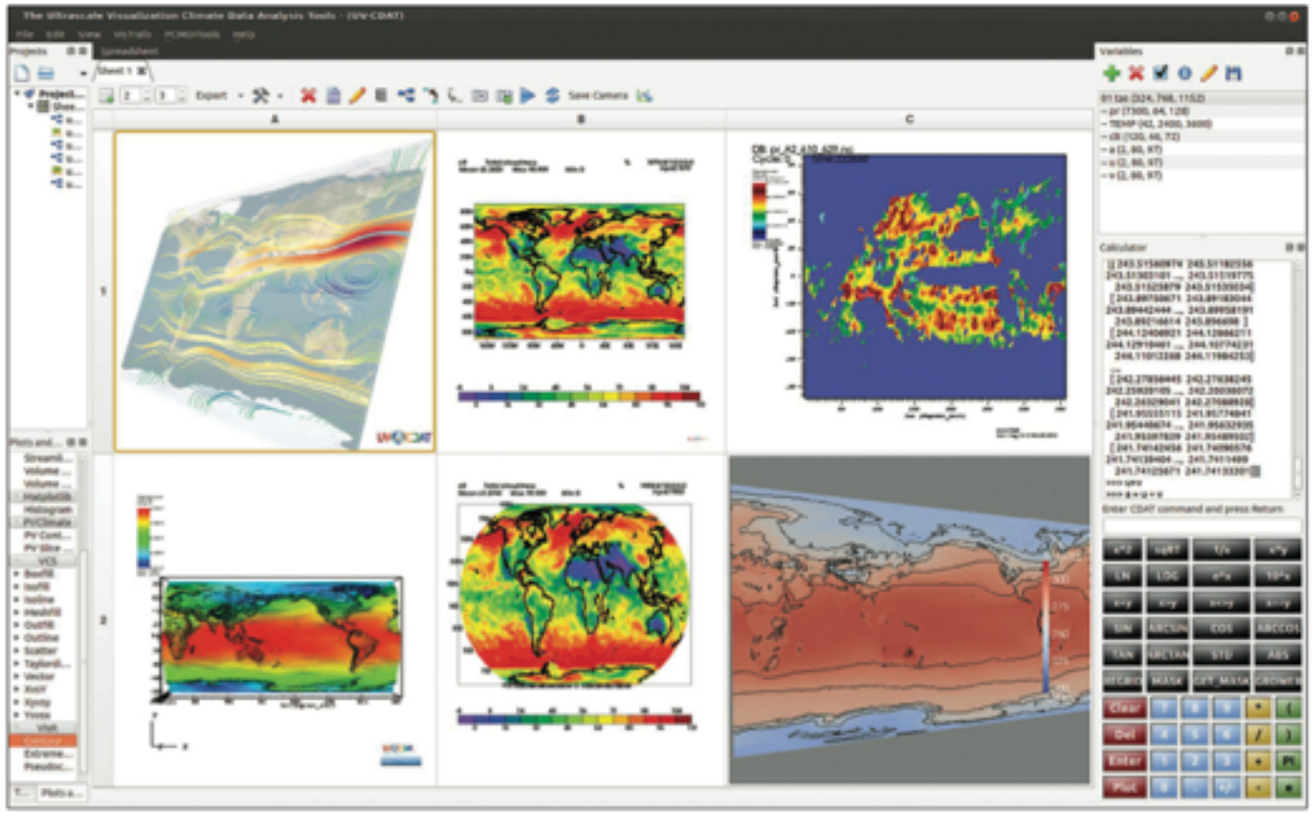


[Kehrer11]

Related Work

Climate data visualization tools

Tools like UVCDAT do not allow multi-model analysis



[WBD*13]

Domain questions

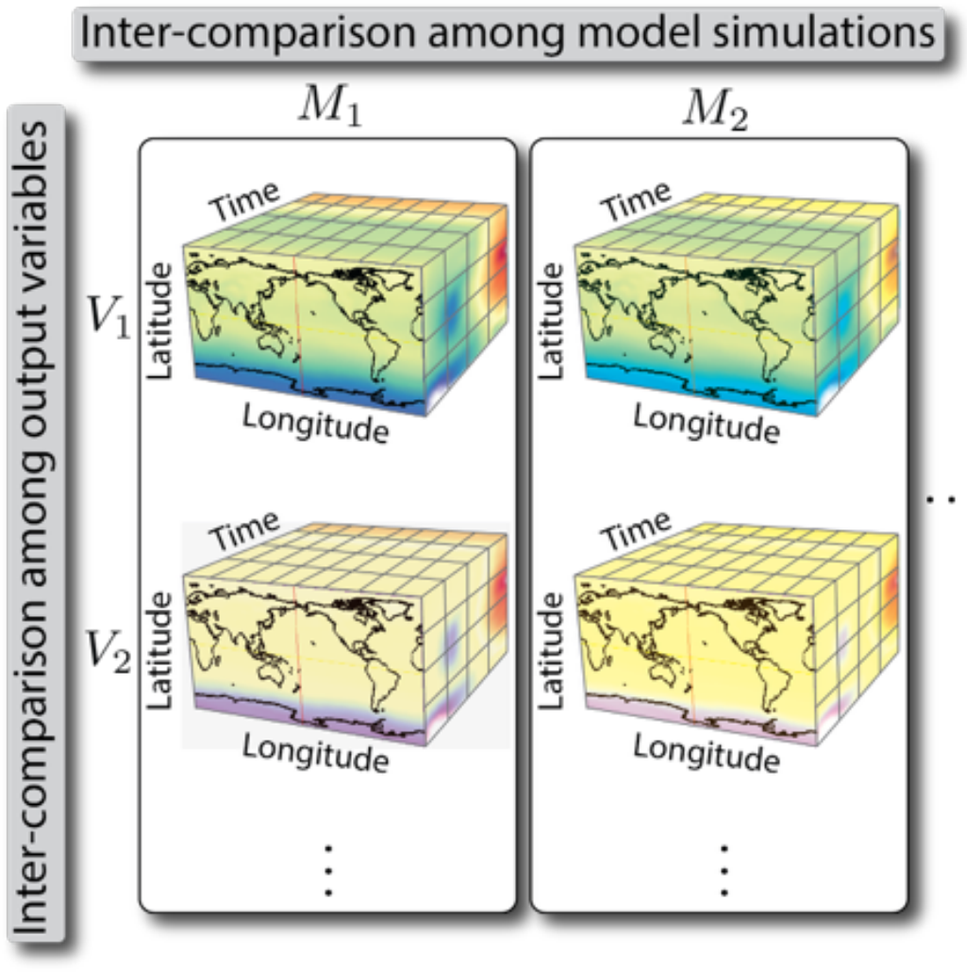
Q_1: How much similar are models, with respect to any variable?

Q_2: How does multi-model similarity vary across space and time?

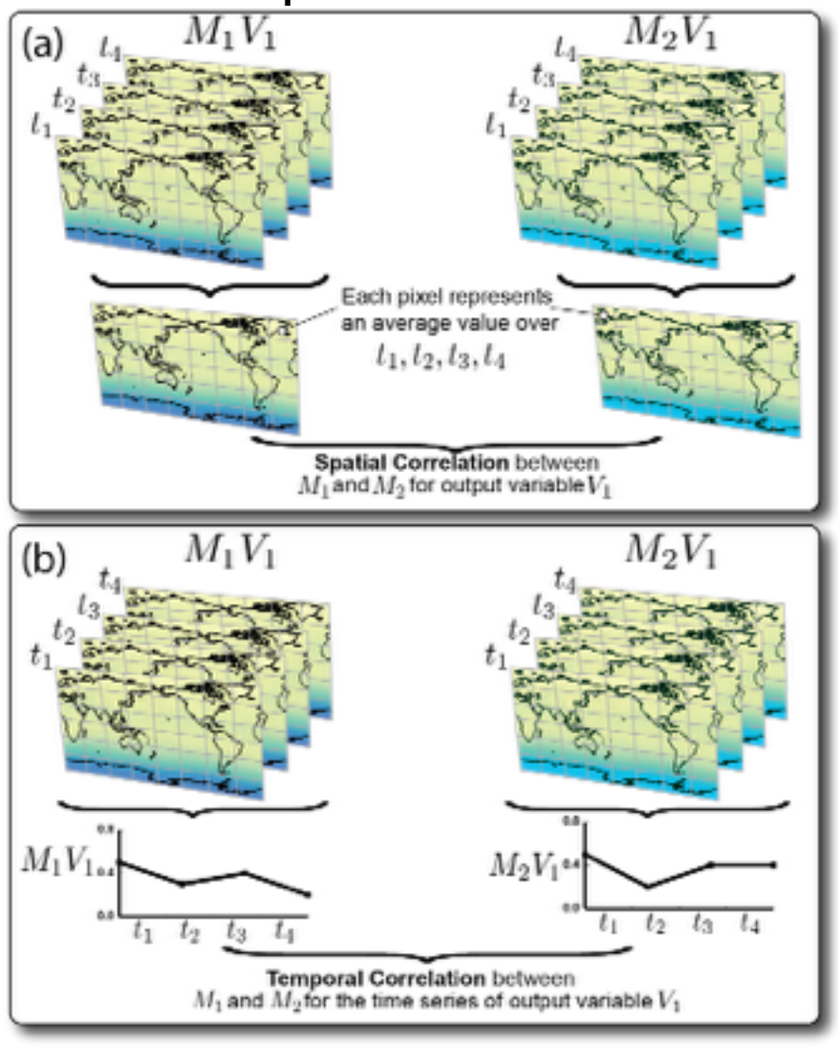
Q_3: Does global similarity agree with sub-region similarity?

Q_4: How can we associate similarity with data distribution?

Similarity Abstraction

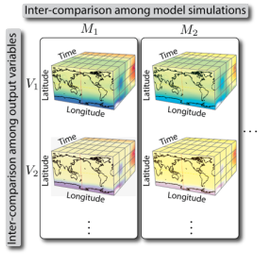


Compress time



Compress space

Design Space



Multifaceted Data

?

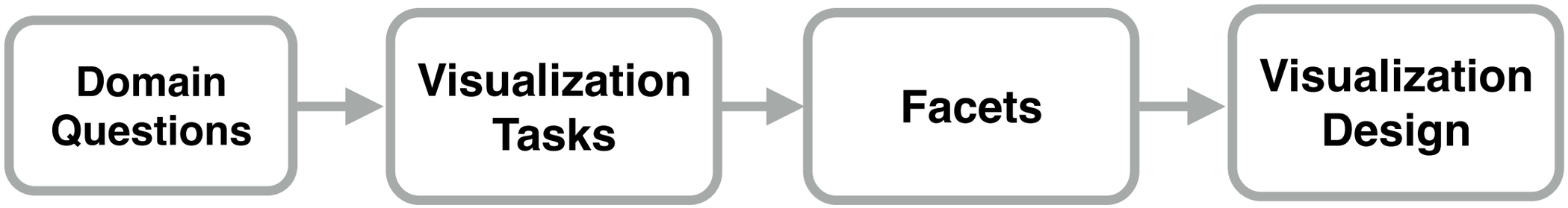
Visualization Tasks

Q_1
Q_2
Q_3
Q_4

Domain Questions

Views and Interaction

Classification Scheme



Identify
Compare
Associate
Distribution

Space
Time
Variables
Similarity

Views
Comparison
Method

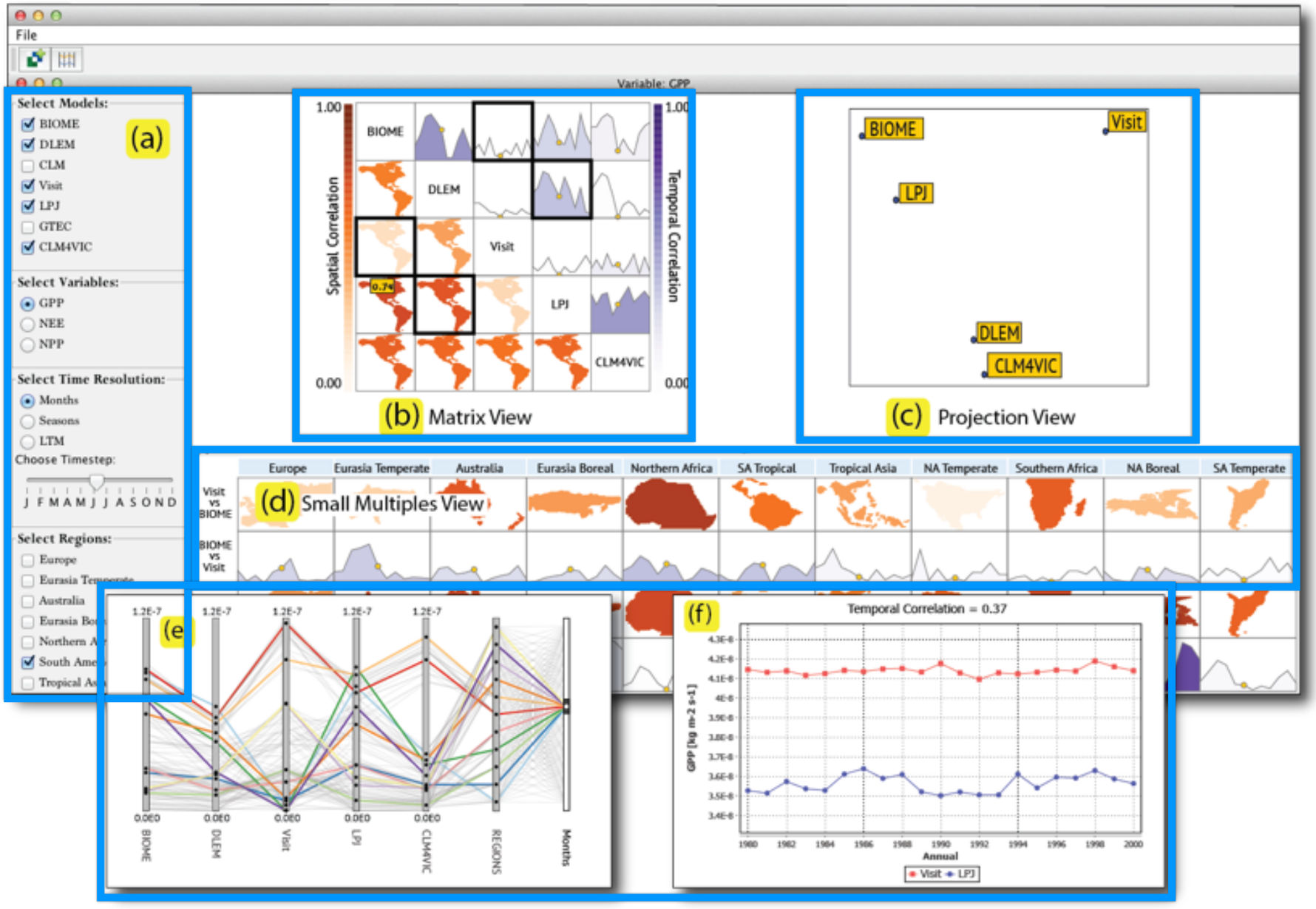
Classification Scheme

Questions	Tasks	Facets				Visualization Design	
		Space	Time	Variables	Similarity	Views	Comparison method
Q_1	*identify*(p) *identify*(t) *identify*(p,t)	g/r	$a/s/m$	single	pairwise pairwise multi-way	matrix (maps) matrix (area graph) projection	explicit encoding
Q_2	*compare*(p,v) *compare*(t,v)	g,r	a,s,m	multiple	pairwise	matrices (map) *smlt*: maps matrices (area graph) *smlt*: area graph	juxtaposition
Q_3	*associate*(p) *associate*(t)	r	s,m	single	multi-way, pairwise pair-wise	parcoords, matrix time-series, matrix	juxtaposition superposition
Q_4	*distribution*(p,v) *distribution*(t,v)	r	s,m	multiple	multi-way, pairwise pairwise	parcoords time-series	juxtaposition superposition

p: Space t: Time v: Variables g: global r: regional a: annual s: seasonal m: monthly *smlt*: small multiples

SimilarityExplorer

Filters Pairwise Similarity Multiway Similarity



Detailed Exploration:Regions Detailed Exploration:

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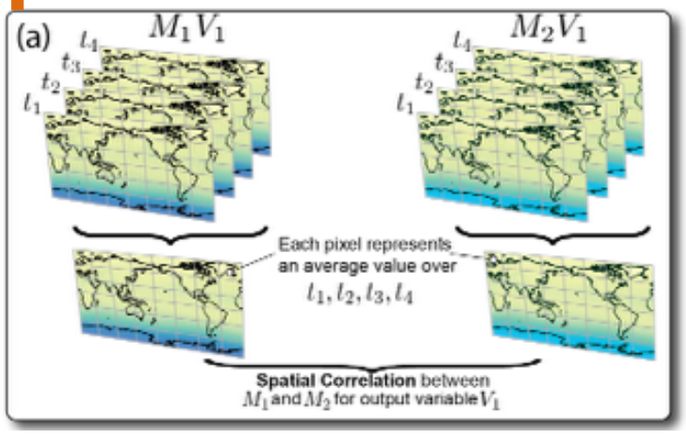
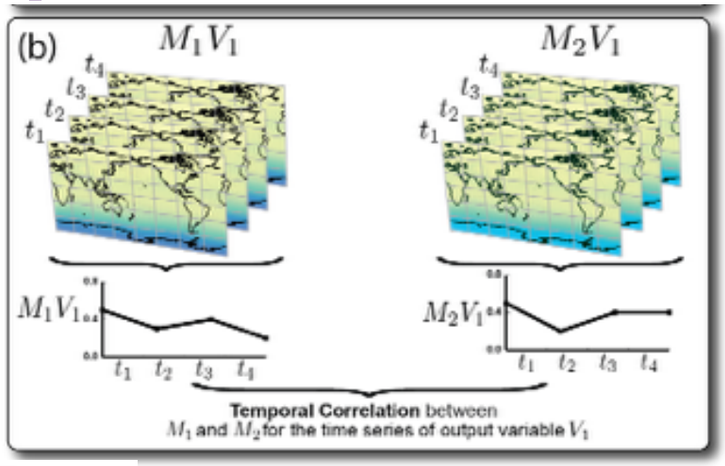
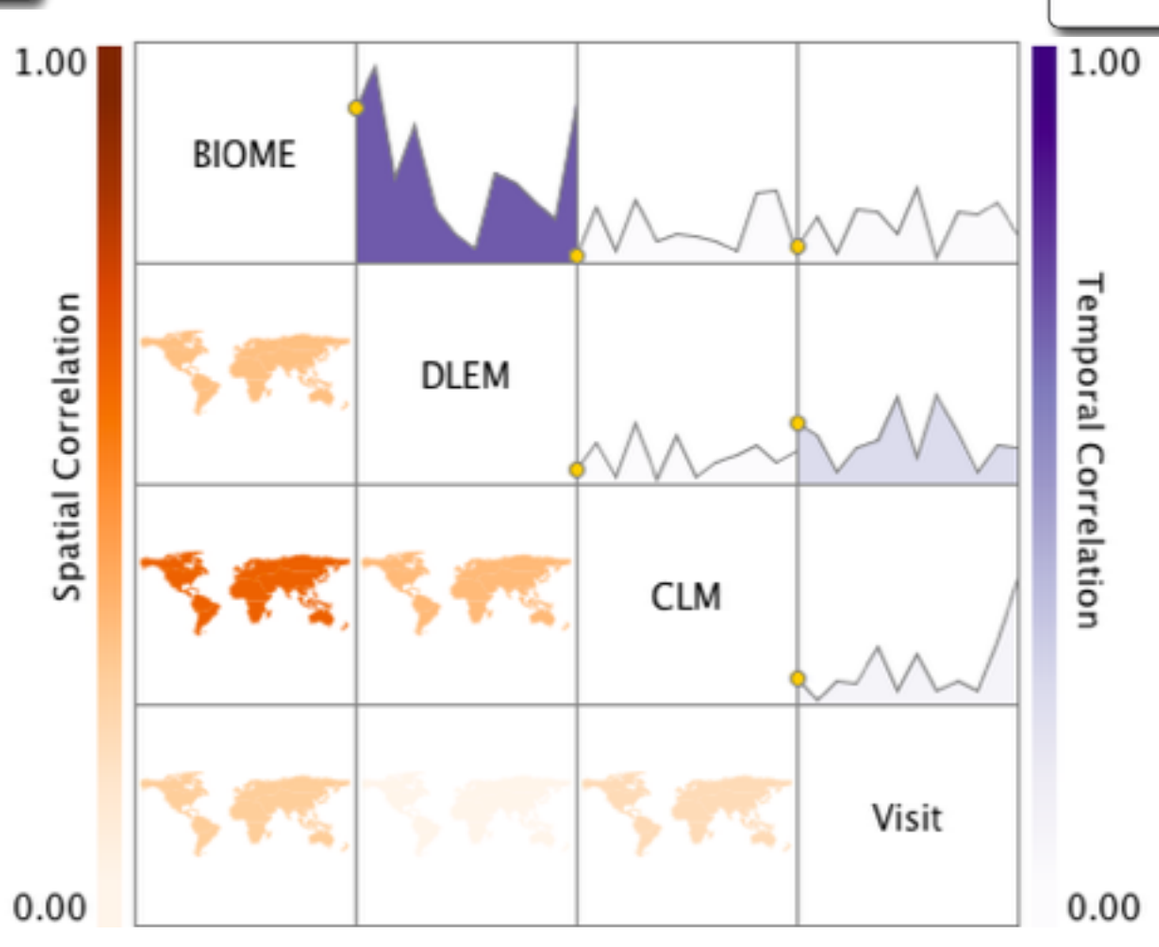
Pairwise Similarity

Spatial Correlation



Temporal Correlation





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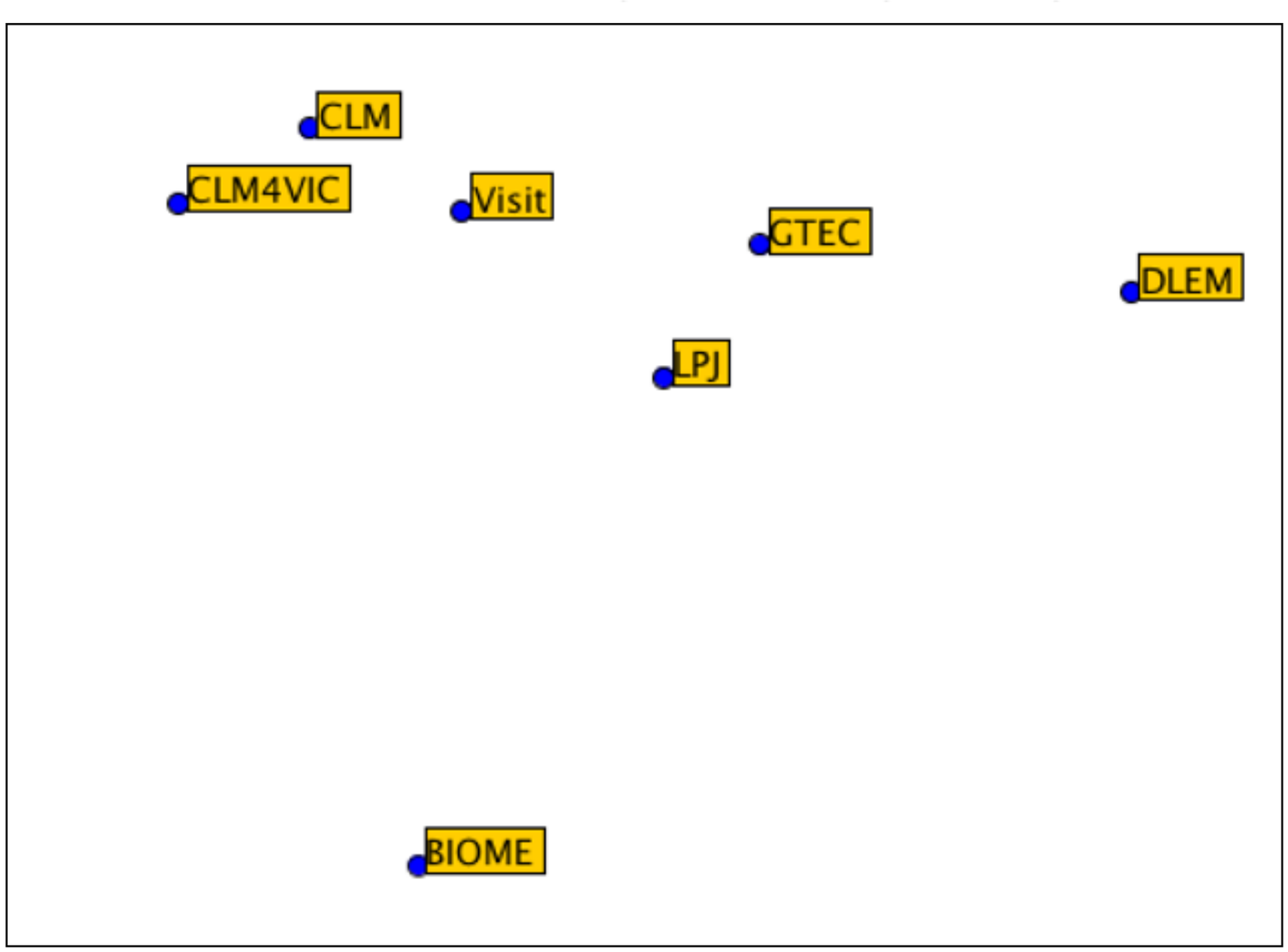
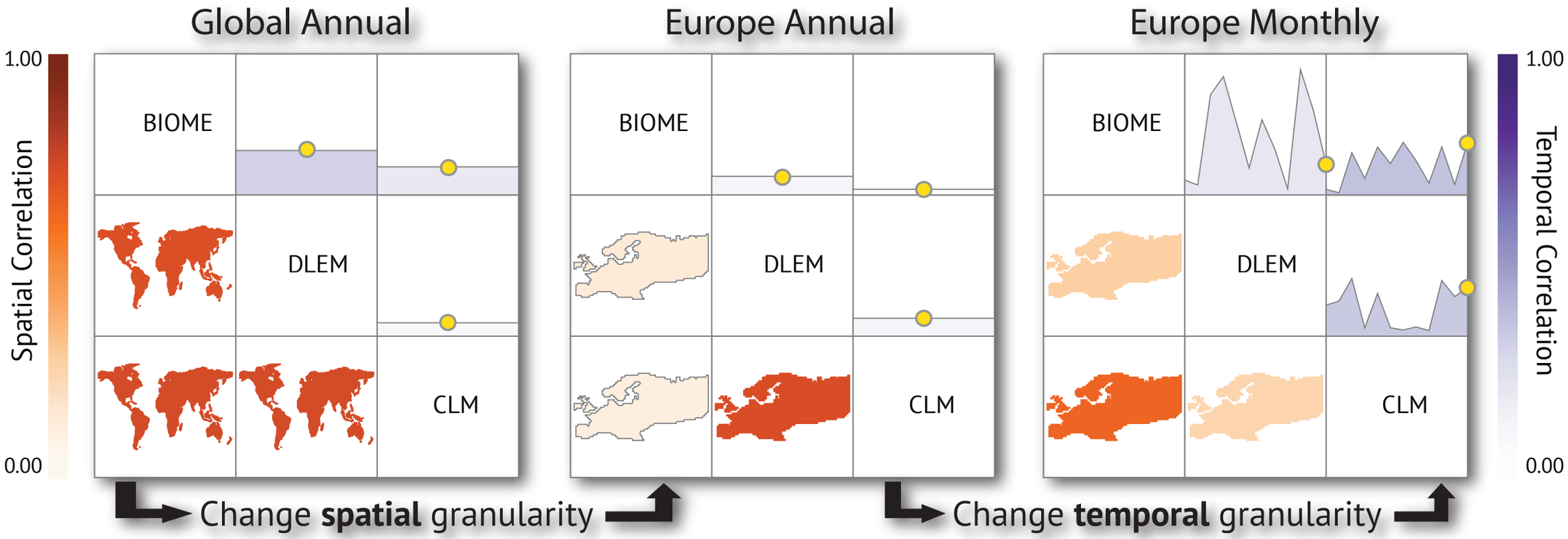
Multiway Similarity

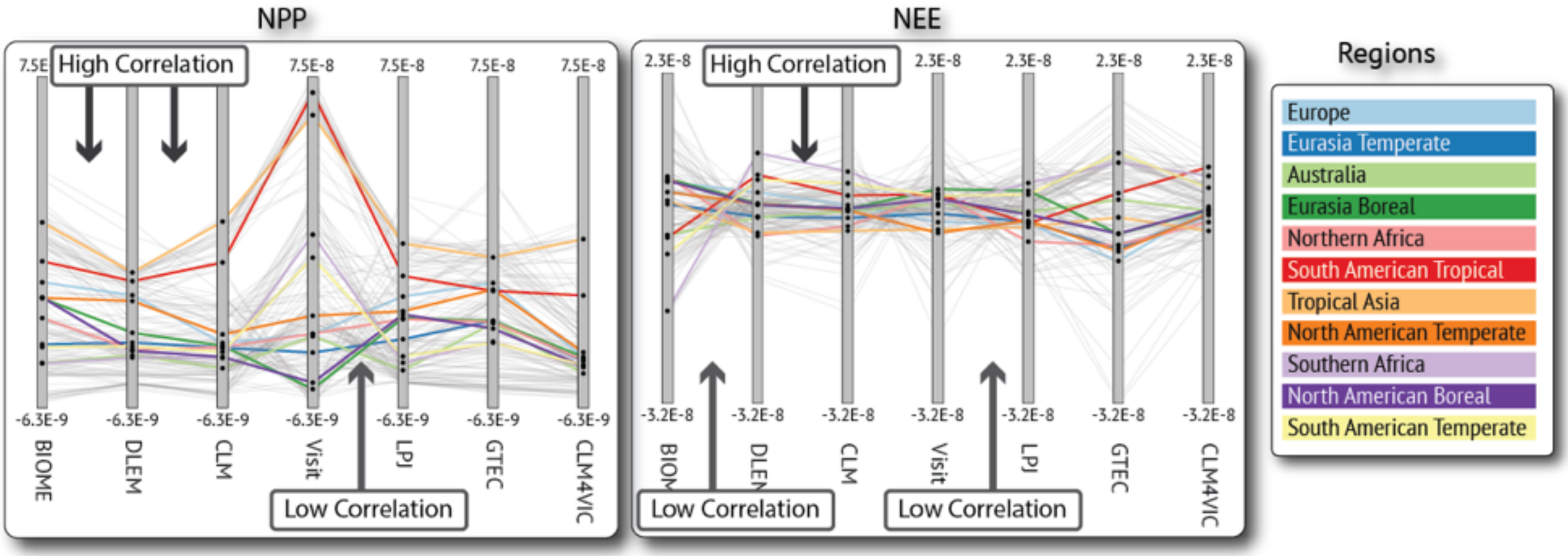


Interaction with the Matrix

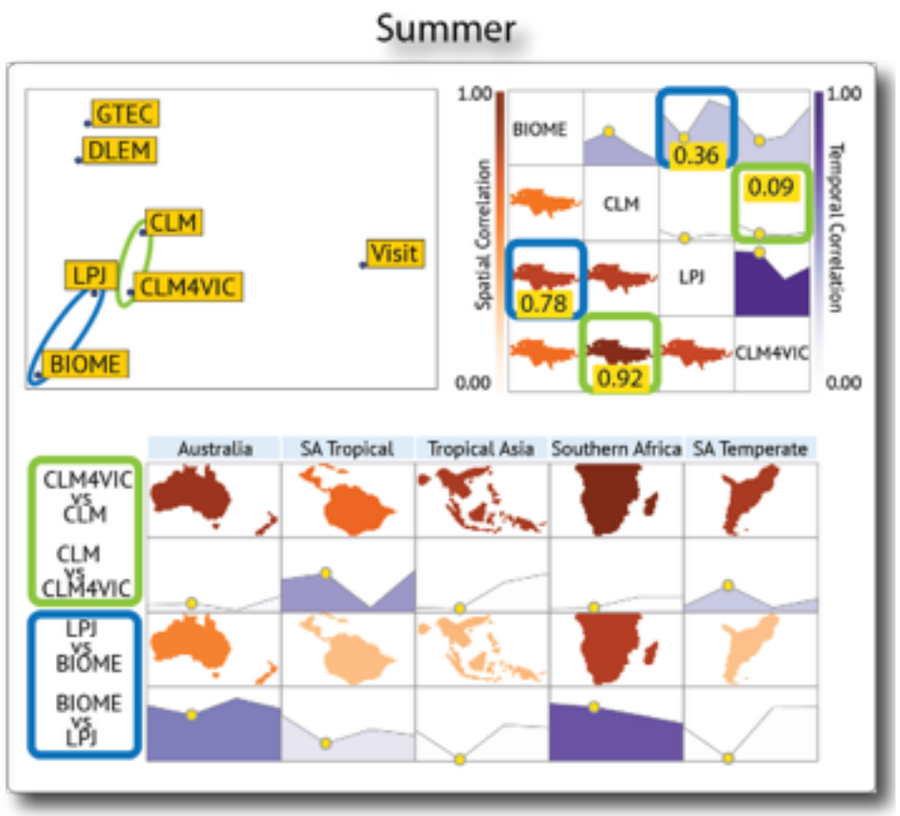


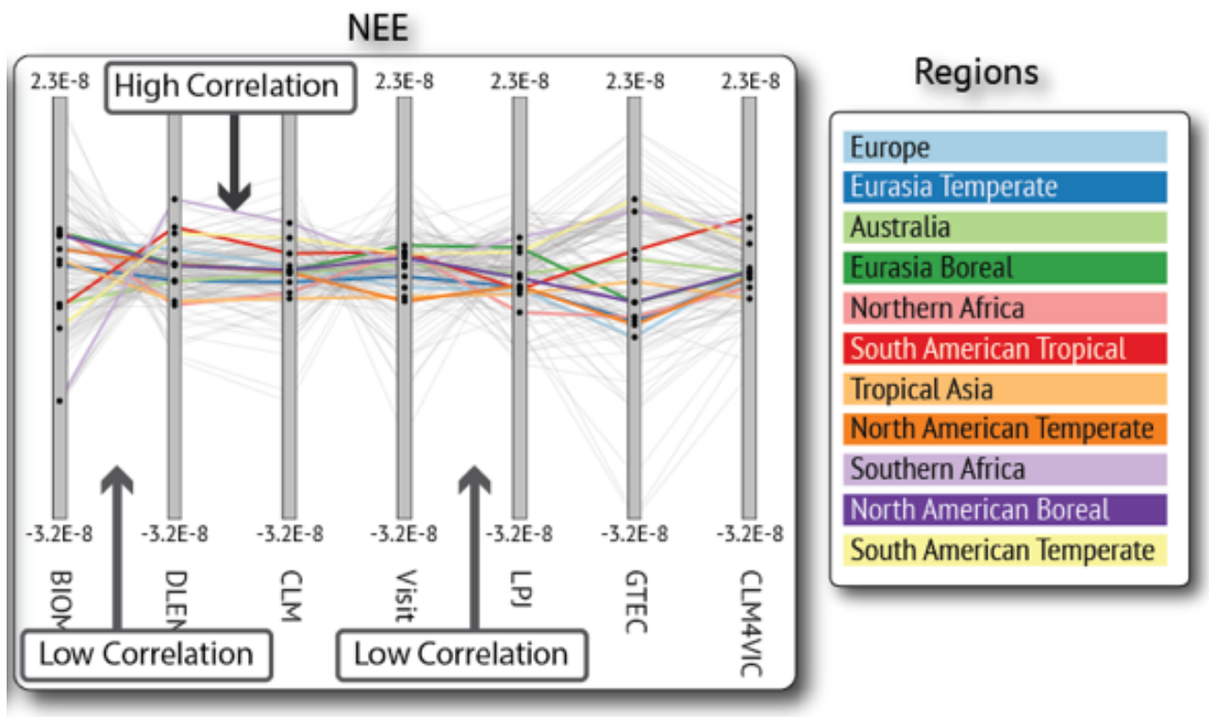
Compare regional and seasonal similarity

Data View


NPP
High Correlation
7.5E
7.5E-8
7.5E-8
7.5E-8
7.5E-8
-6.3E-9
-6.3E-9
-6.3E-9
-6.3E-9
-6.3E-9
-6.3E-9
-6.3E-9
BIOME
DLEM
CLM
Visit
LPJ
GTEC
CLM4VIC
Low Correlation
NEE
High Correlation
2.3E-8
2.3E-8
2.3E-8
2.3E-8
2.3E-8
-3.2E-8
-3.2E-8
-3.2E-8
-3.2E-8
-3.2E-8
-3.2E-8
-3.2E-8
BIOM
DLEN
CLM
Visit
LPJ
GTEC
CLM4VIC
Low Correlation
Low Correlation
Regions
Europe
Eurasia Temperate
Australia
Eurasia Boreal
Northern Africa
South American Tropical
Tropical Asia
North American Temperate
Southern Africa
North American Boreal
South American Temperate

Interaction





Compare seasonal similarity with data distribution

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- Demo

Feedback

Efficiency
“Without this tool scientists would literally print hundreds of plots and pin them on the wall, this tool solves this problem”.

Flexibility
“..the free-style nature of the exploration lends well to shift from one variable to another and support root-cause analysis”.

Prognostic value
“..this would allow them to develop hypotheses on performing additional experiments”

Conclusion

- SimilarityExplorer: A tool that support multi-model comparison for climate data

- Tool currently deployed, used, and developed further

- Build upon the multifaceted analysis paradigm and apply to other domains

Acknowledgements

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- Collaborators: Members of the Exploration, Visualization, and Analysis Working Group under DataONE.

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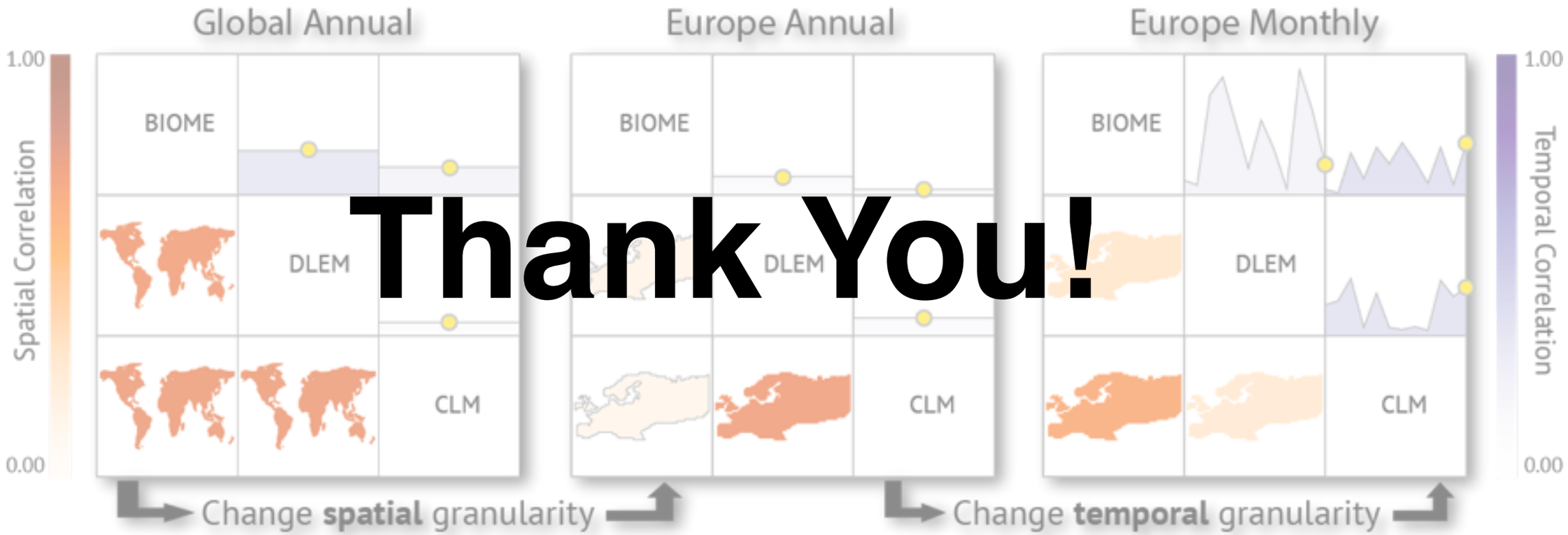

Thank You!

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