



How reliable are our models?

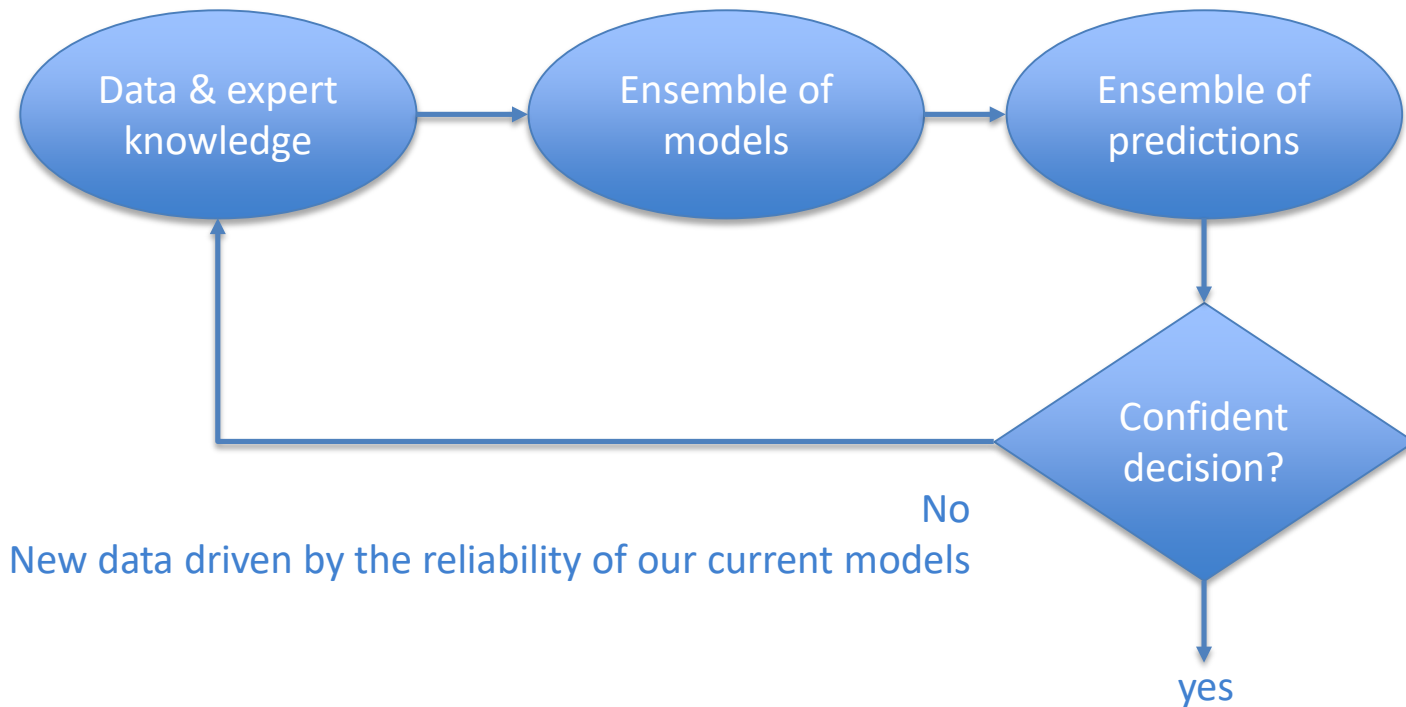
Guillaume Pirot, Mark Lindsay & Mark Jessell

guillaume.pirot@uwa.edu.au



Uncertainty Quantification & 3D Modelling

➤ Support decision making



What does reliable mean?



Locally, at a given
spatial location

- Stratigraphy
- Lithology
- Petrophysical properties

Globally
Summary statistics

- Volumes / geometries
- Connectivity
- Topology

Uncertainty indicators

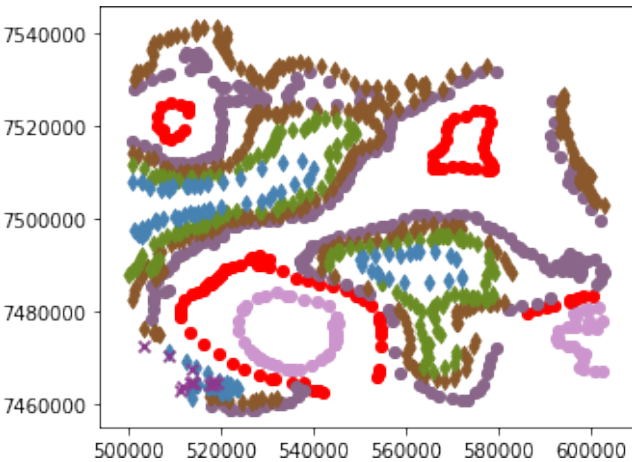


- Local
 - Cardinality
 - Entropy
- Model set ensembles
 - Categorical voxel
 - Continuous voxel
- Global (dissimilarities based on)
 - Histogram
 - Semi-variogram
 - Connectivity
 - Multiple-point histogram
 - Wavelet decomposition
 - Topological analysis

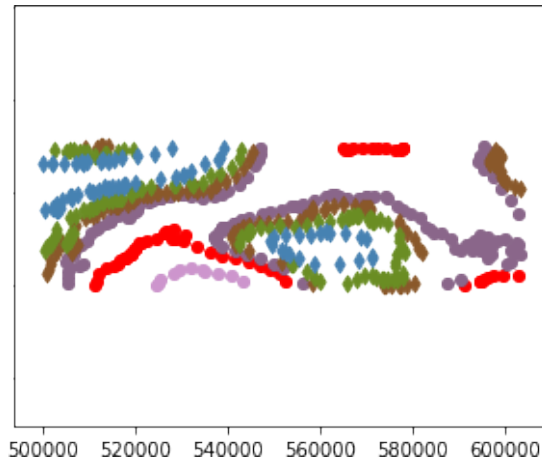
Synthetic case - illustration



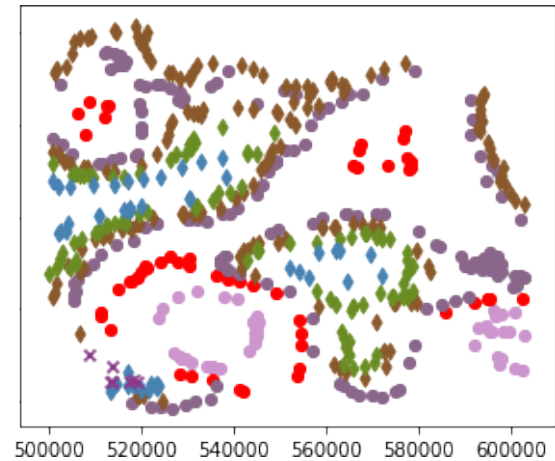
Scenario 1 – 100% data



Scenario 2 – 50% data



Scenario 3 – 50% data



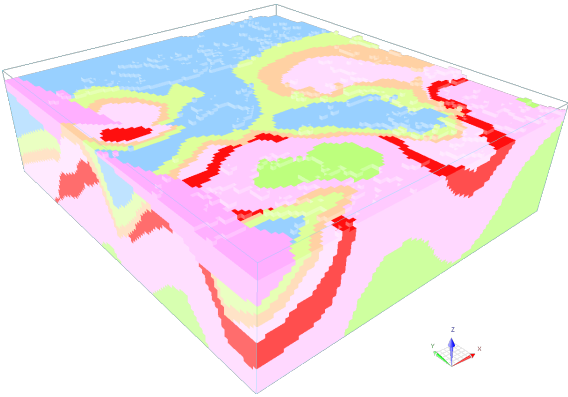
lithocode - data

3 scenarios x 10 model sets generated with Loopstructural
[Grose et al., 2021]

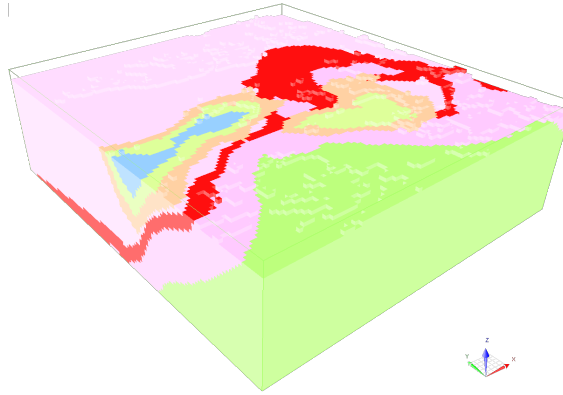
Synthetic case - illustration



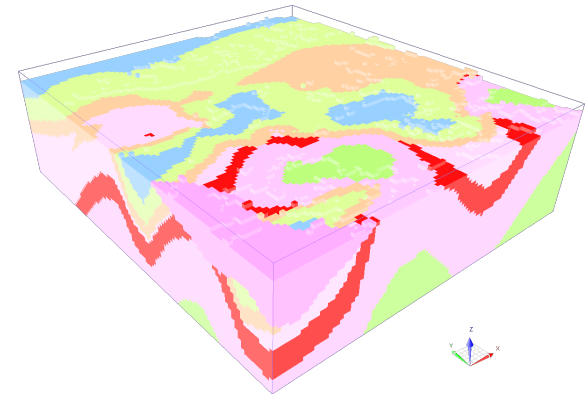
Scenario 1 – 100% data



Scenario 2 – 50% data



Scenario 3 – 50% data

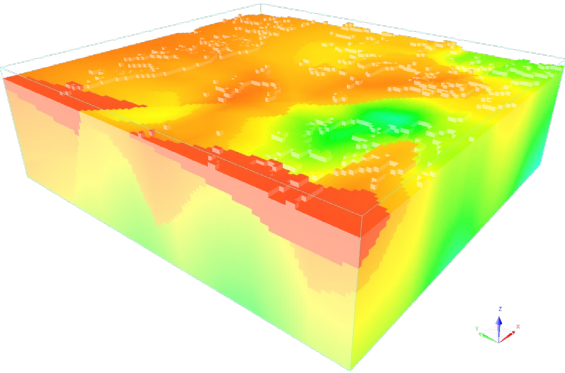


1 categorical variable: lithological unit voxets

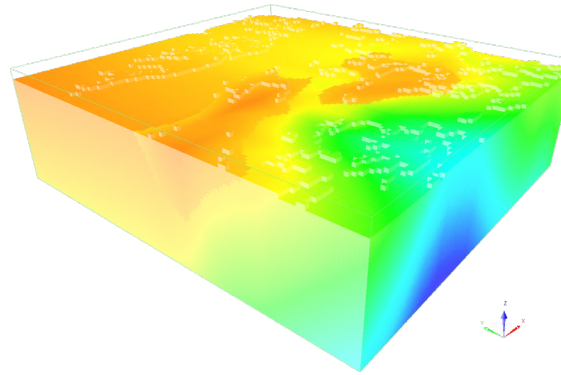
Synthetic case - illustration



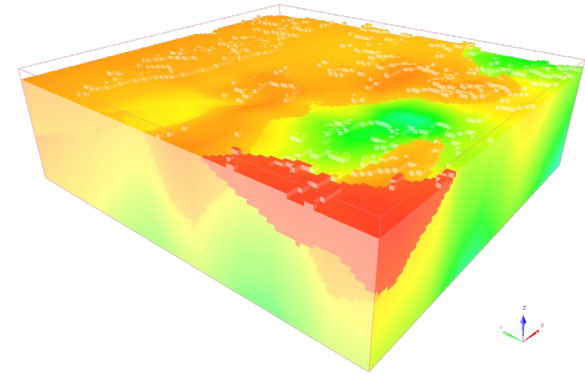
Scenario 1 – 100% data



Scenario 2 – 50% data



Scenario 3 – 50% data



scalar-field

1 continuous variable: underlying scalar-field from implicit modelling

Cardinality

[Lindsay et al., 2012]



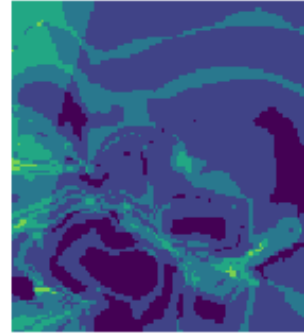
Cardinality Map S1



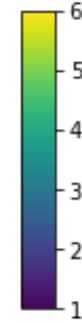
Cardinality Map S2



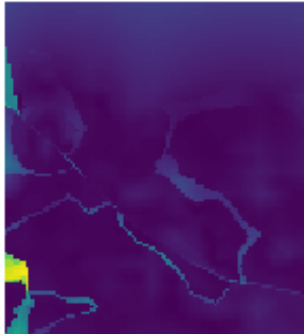
Cardinality Map S3



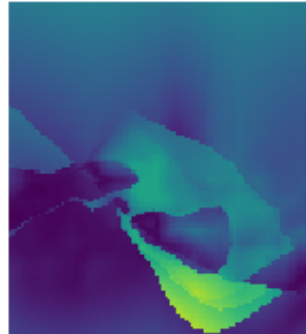
Lithocode card.



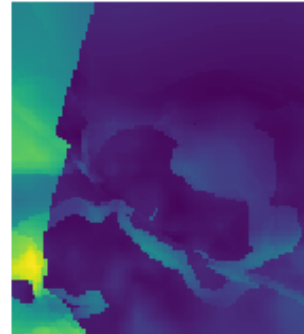
$(R_0^1 + \sigma_0^1)/2$ Map S1



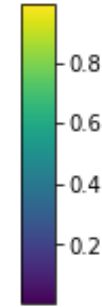
$(R_0^1 + \sigma_0^1)/2$ Map S2



$(R_0^1 + \sigma_0^1)/2$ Map S3



Scalar-field $(R_0^1 + \sigma_0^1)/2$

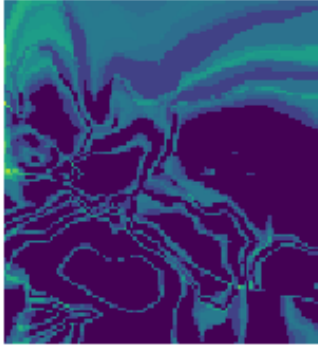


Entropy

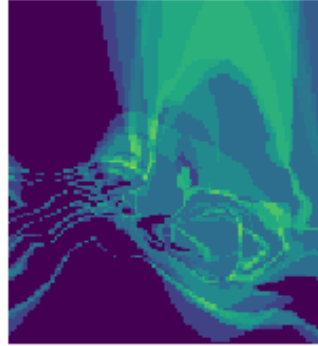
[Rényi et al., 1961]



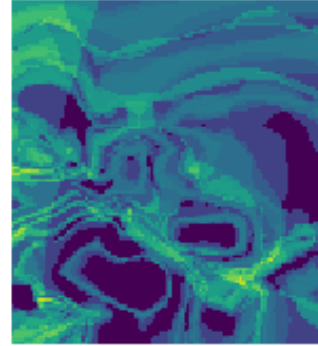
Shannon's entropy Map S1



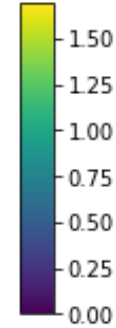
Shannon's entropy Map S2



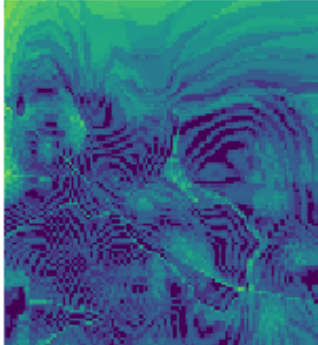
Shannon's entropy Map S3



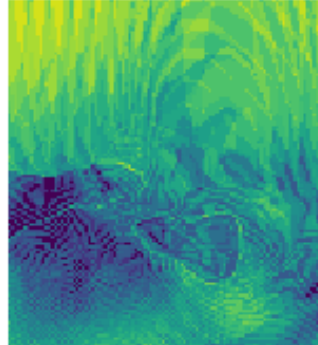
Lithocode Sh. ent.



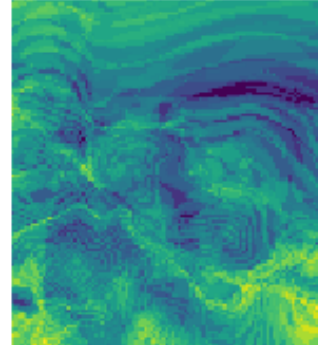
Continuous entropy Map S1



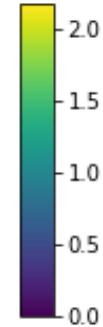
Continuous entropy Map S2



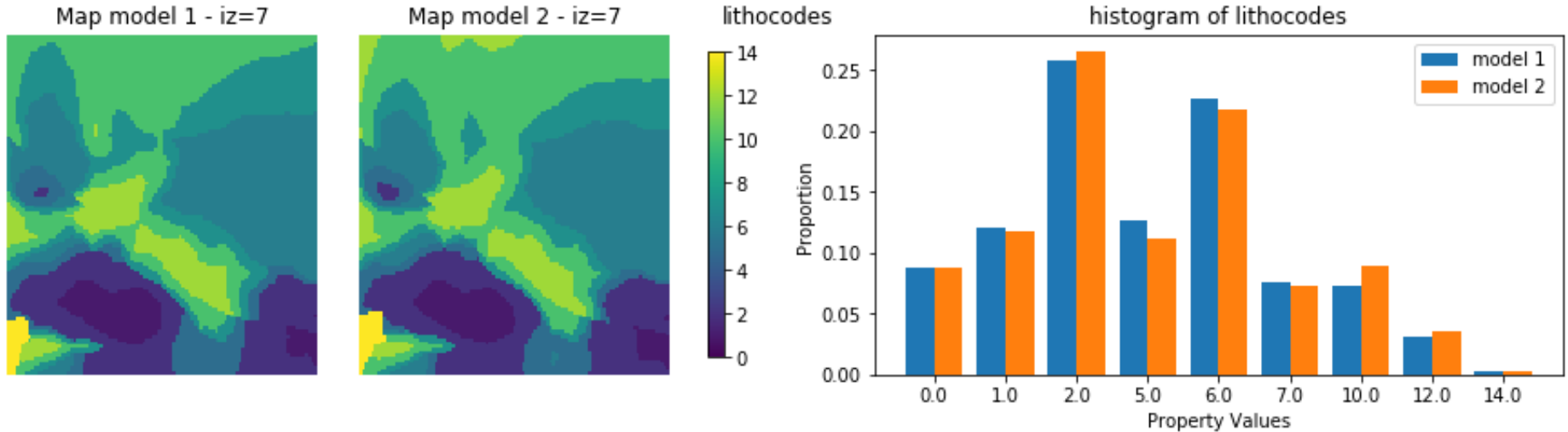
Continuous entropy Map S3



Scalar-field cont. ent.



Histogram dissimilarity

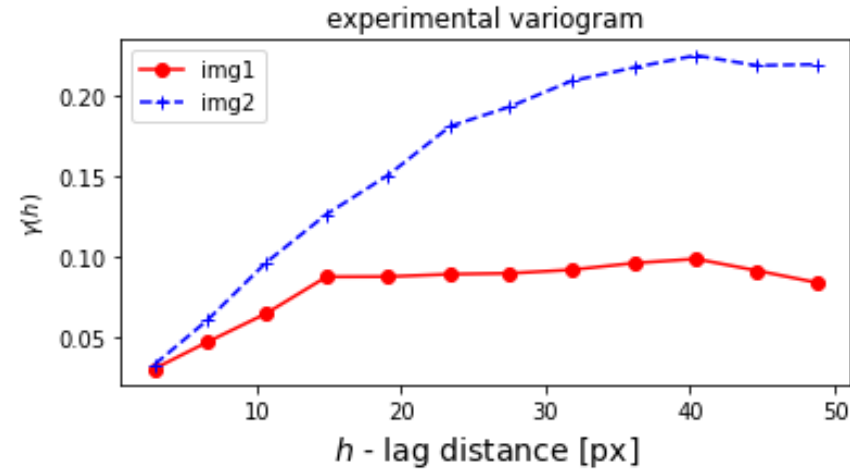
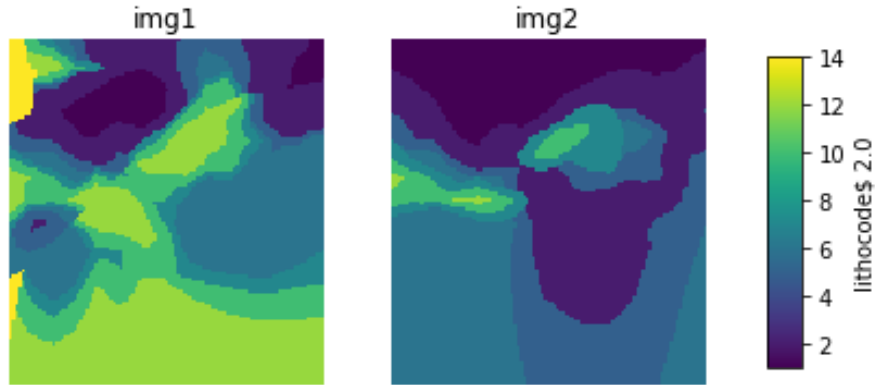


Dissimilarity based on Jensen-Shannon Divergence [Dagan et al., 1997]

Semi-variogram dissimilarity



[Matheron, 1963]

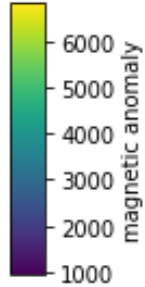
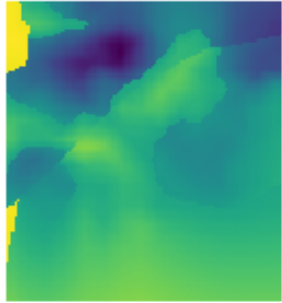


Connectivity dissimilarity

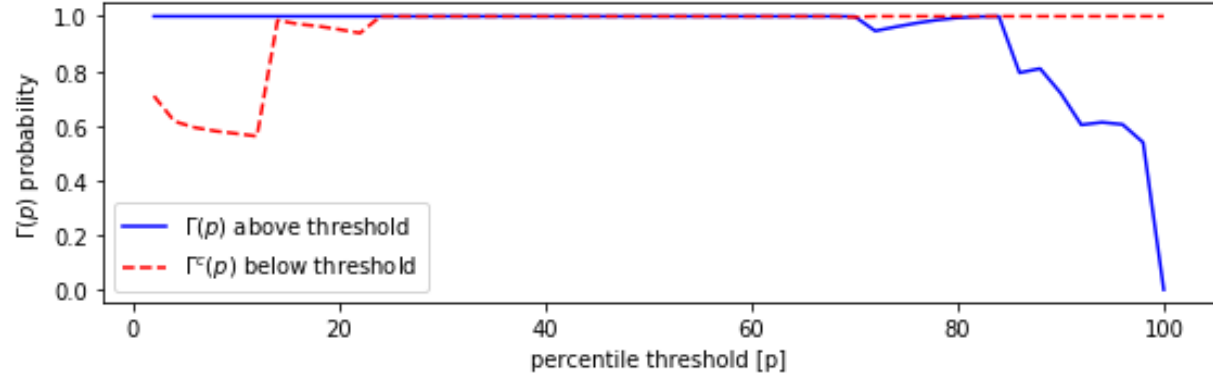


[Renard & Allard, 2013]

Map view



Thresholded magnetic anomaly Γ connectivity



$p = 10$



$p = 30$



$p = 50$



$p = 70$

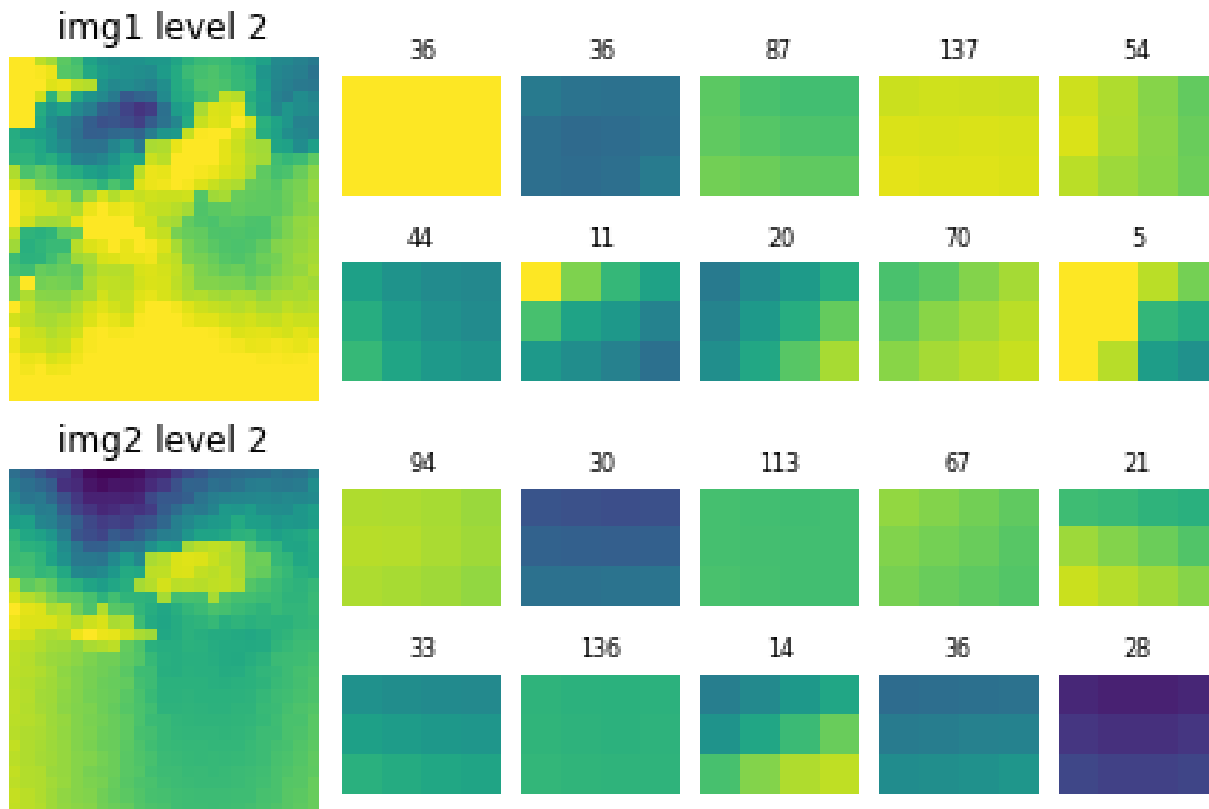


$p = 90$



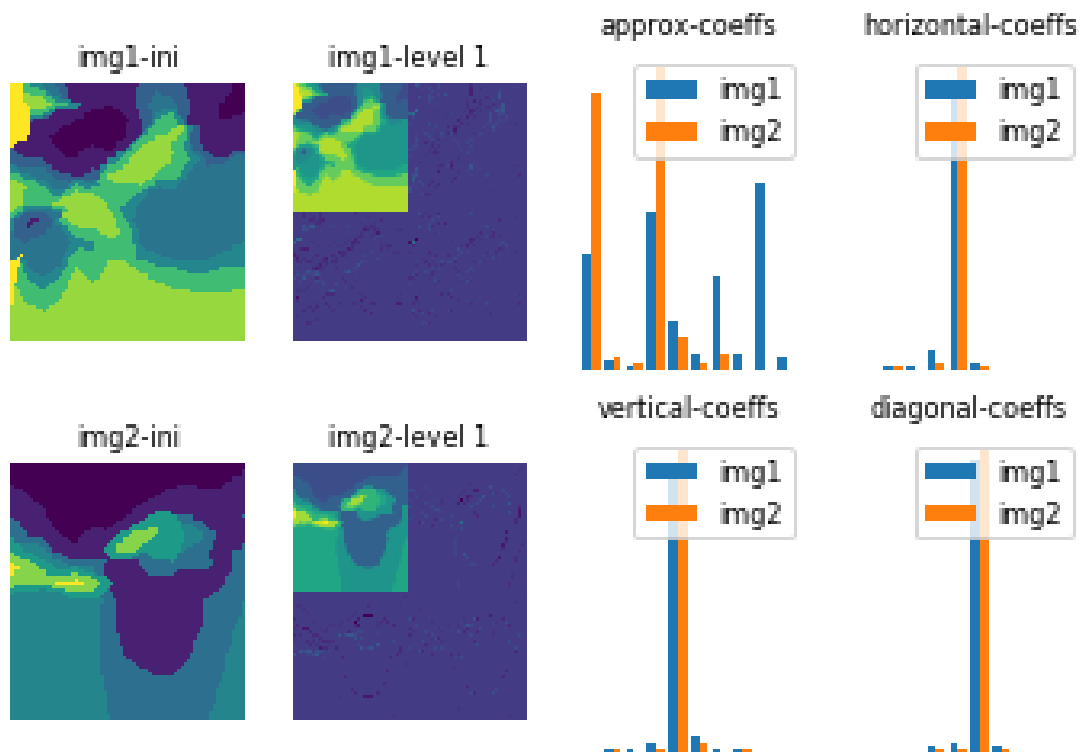
Multiple-point histogram dissimilarity

[Boisvert et al., 2010]



Wavelet-decomposition dissimilarity

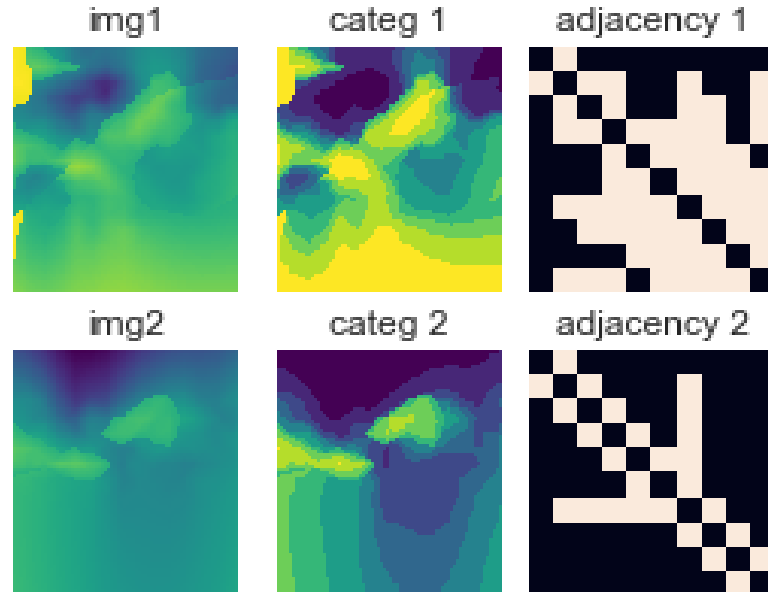
[Lee et al., 2019]



Topological dissimilarity



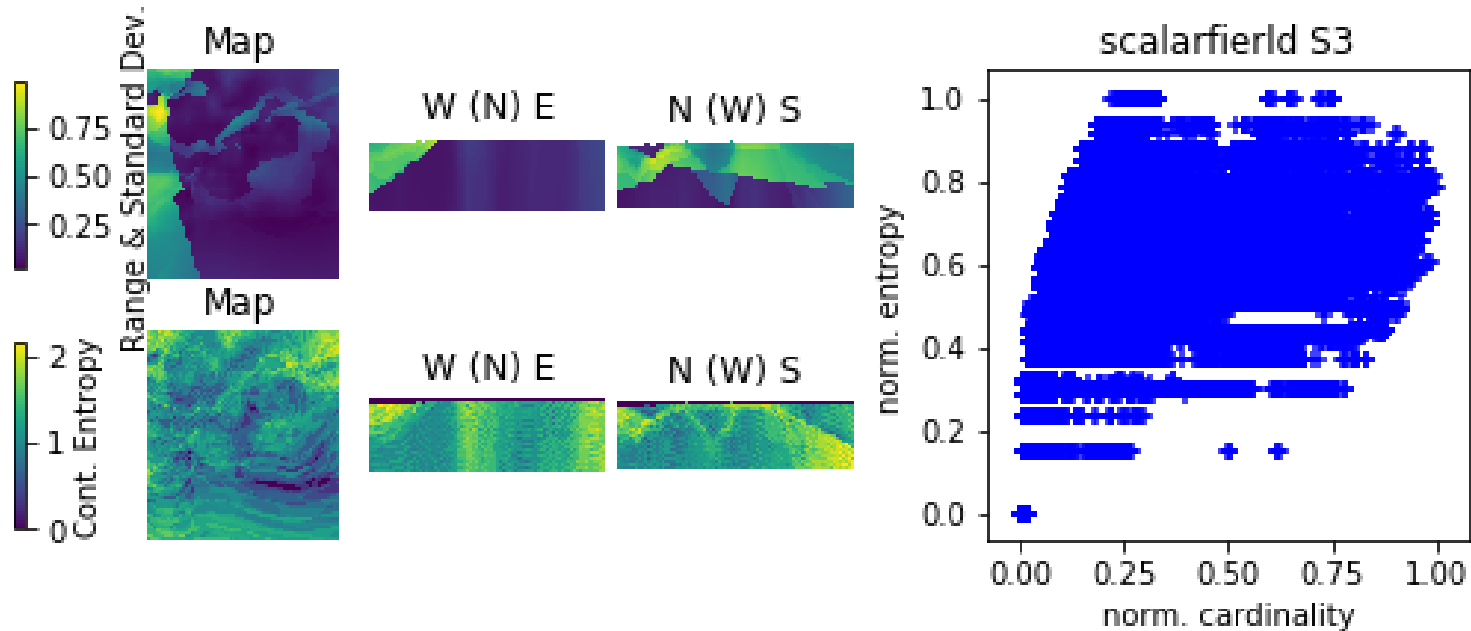
[Donnat & Holmes, 2018]



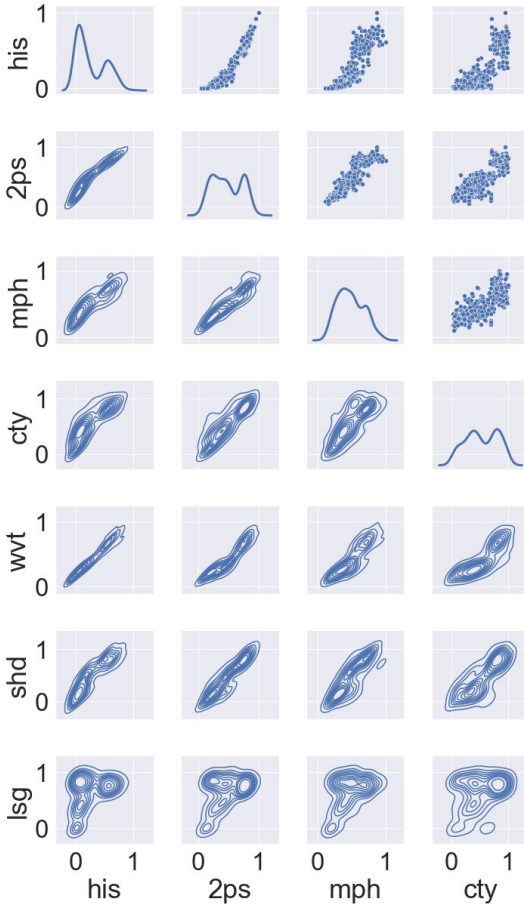
Structural Hamming Dist.: 0.333

Spectral Laplacian Dist.: 0.185

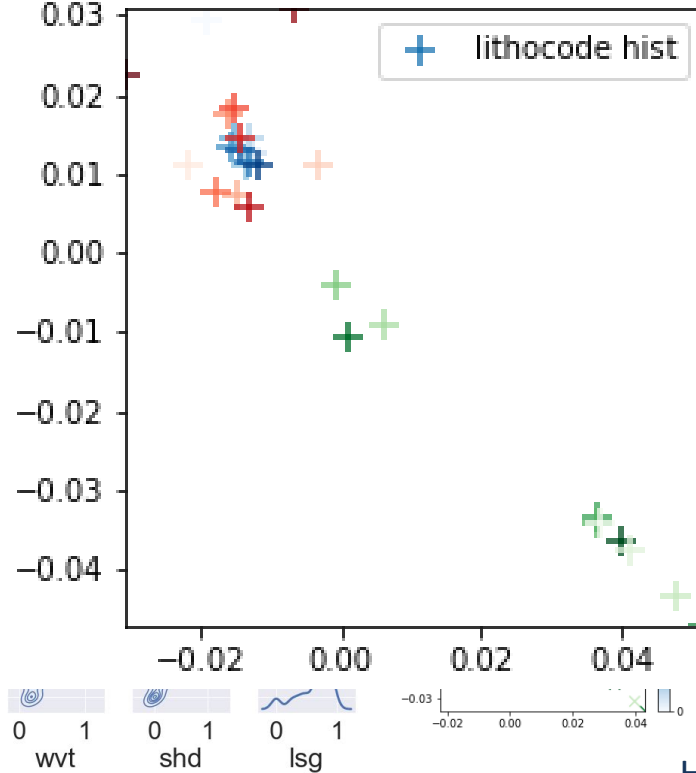
Results – local indicators



Results – global indicators



2D MDS Representation of hist. dissimilarities

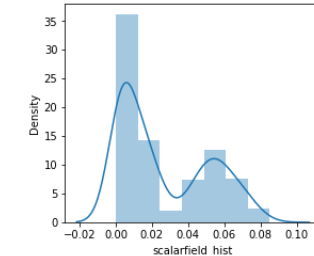
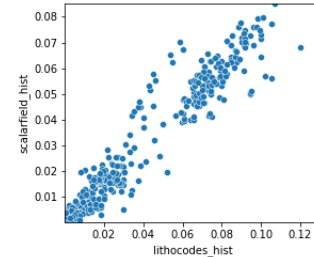
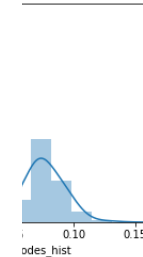


- his: histogram
- 2ps: semi-variogram

stogram

sition
g distance (topology)
distance (topology)

Histogram dissimilarities



Conclusions



- Global and Local indicators
- Categorical and Continuous variable
- Identifications of scenarios / features
- Low correlation means different information content
- Available on GitHub: <https://github.com/Loop3D/uncertaintyIndicators>



Majors, METS and Survey Participants (16)





Research Participants and Affiliates (20)



THANK YOU



minexcrc.com.au

 Find us on LinkedIn

guillaume.pirot@uwa.edu.au



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