Multi-Scale Change Detection Research of Remotely Sensed Big Data in CyberGIS

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Scale is Important in Land Use/Cover Change (LUCC) Study

DMTI, 2006, Ile des soeurs, Montreal, RGB, 0.6m

Landsat 8, 2015, Ile des soeurs, Montreal, Multispectral, 30m

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The Many Meanings of Scale in CyberGIS and LUCC

- CyberGIS
  - Scale of big data, which drives much of CyberGIS
  - Scaling of computing resources (e.g., distribution of data to VMs) & performance (e.g., I/O)
- LUCC
  - Increased amount & speed that means finer grained spatial & temporal change (also the need to move beyond pixels)
  - (the more difficult issue) Spatial & temporal scales at which phenomena, patterns and processes emerge

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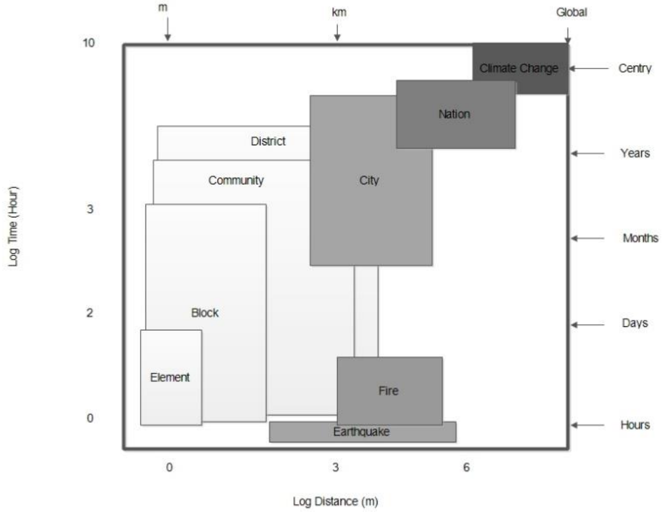
Approach

- A LUCC-CyberGIS approach, via a seamless integration of cloud-based geospatial cyberinfrastructure (GCI), LUCC analysis, and data handling, that accommodates multiple considerations of scale

- The LUCC-CyberGIS approach to explore the spatial and temporal contingency of LUCC



An Example of Stommel Diagram

- The LUCC-CyberGIS contains a feature scope layer, using Stommel Diagram to coordinate spatial and temporal scales.

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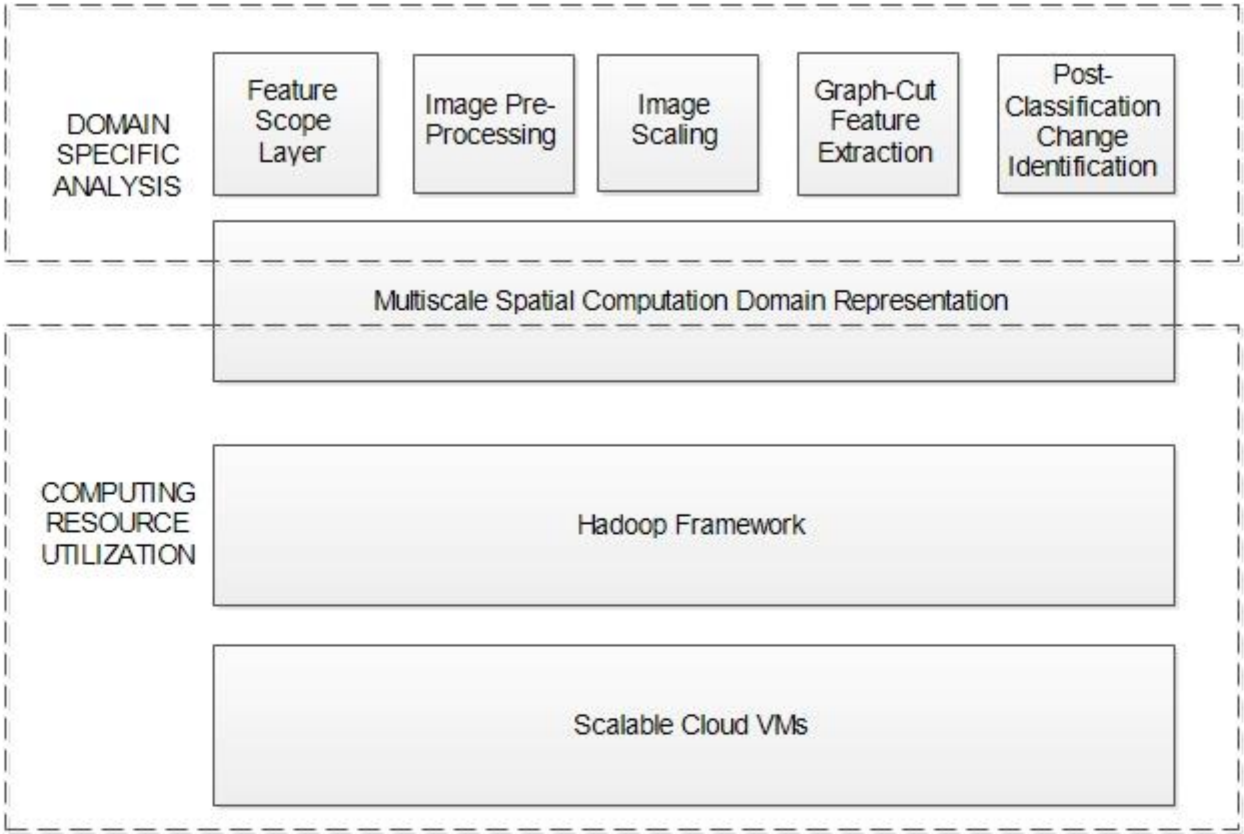
GCI Structure



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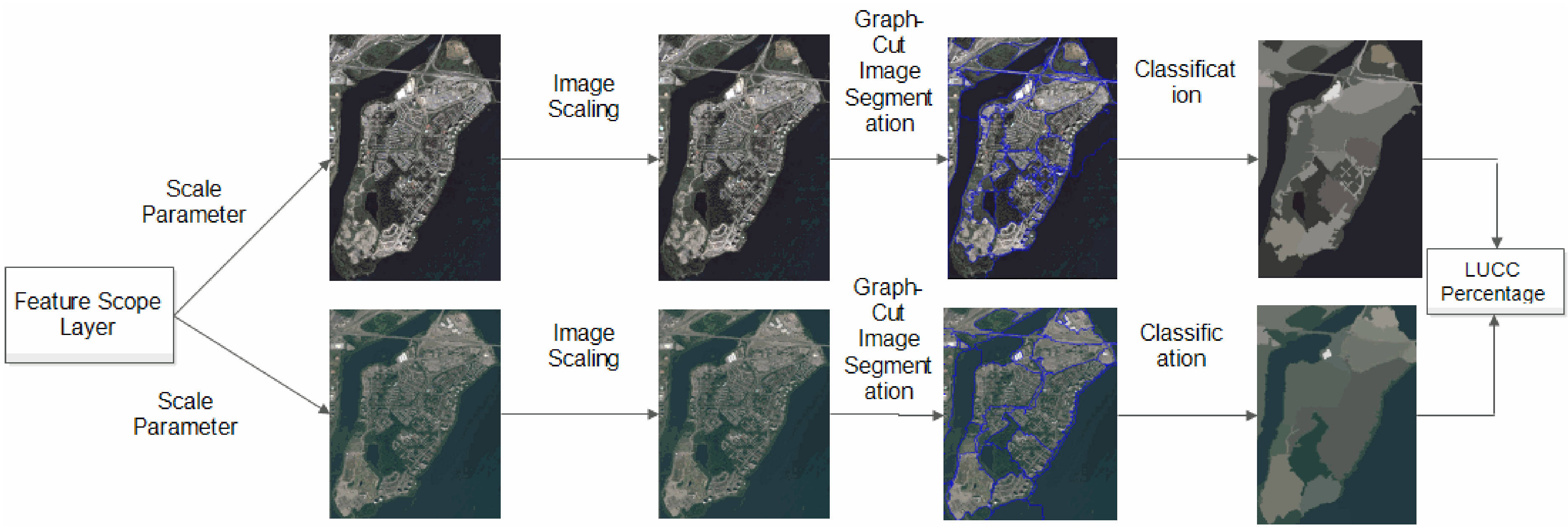
Domain Specific Analysis Layer



Spatial Computation Domain Representation

Computing resource utilization, in its spatial computation domain representation is expressed as (Wang and Armstrong, 2009):

SCDR = CPU + Memory + I/O

Multiscale Spatial Computation Domain Representation and VM Resource Allocation

MUltiscale SCDR = Scale × { VCPU + VMemory + VI/O }

We allocate the number of virtual cpu core and memory as (cloud provider dependent)

$$CPUNumber(s) = \frac{1}{2s} CPUNumber(s_0) \qquad Memory(s) = \frac{1}{2s} Memory(s_0)$$

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Experiment Datasets

Our case is urban-rural change detection in the Greater Montreal Area (2006-2015, 36,000km^2).

Year	Platform	Spatial Resolution (m)	Spectral Resolution
2006	DMTI	0.6	RGB (sharpened & fused)
2007	IKONOS	1	Panchromatic (450mm-900mm)
2009	DMTI	0.6	RGB (sharpened & fused)
2010	Quickbird	0.6	Panchromatic (450mm-900mm)
2012	DMTI	0.6	RGB (sharpened & fused)
2015	Landsat8	30	11 bands (0.43mm-12.51mm)

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Wavelet-based Image Scaling

We scale images using the Undecimated Discrete Wavelet Transformation (Melgani, Moser, and Serpico, 2002) in a cascade manner. The pixel number is equal at each level, but the details in level s is (2^s) times coarser than S_0.

S=0

S=2

S=4

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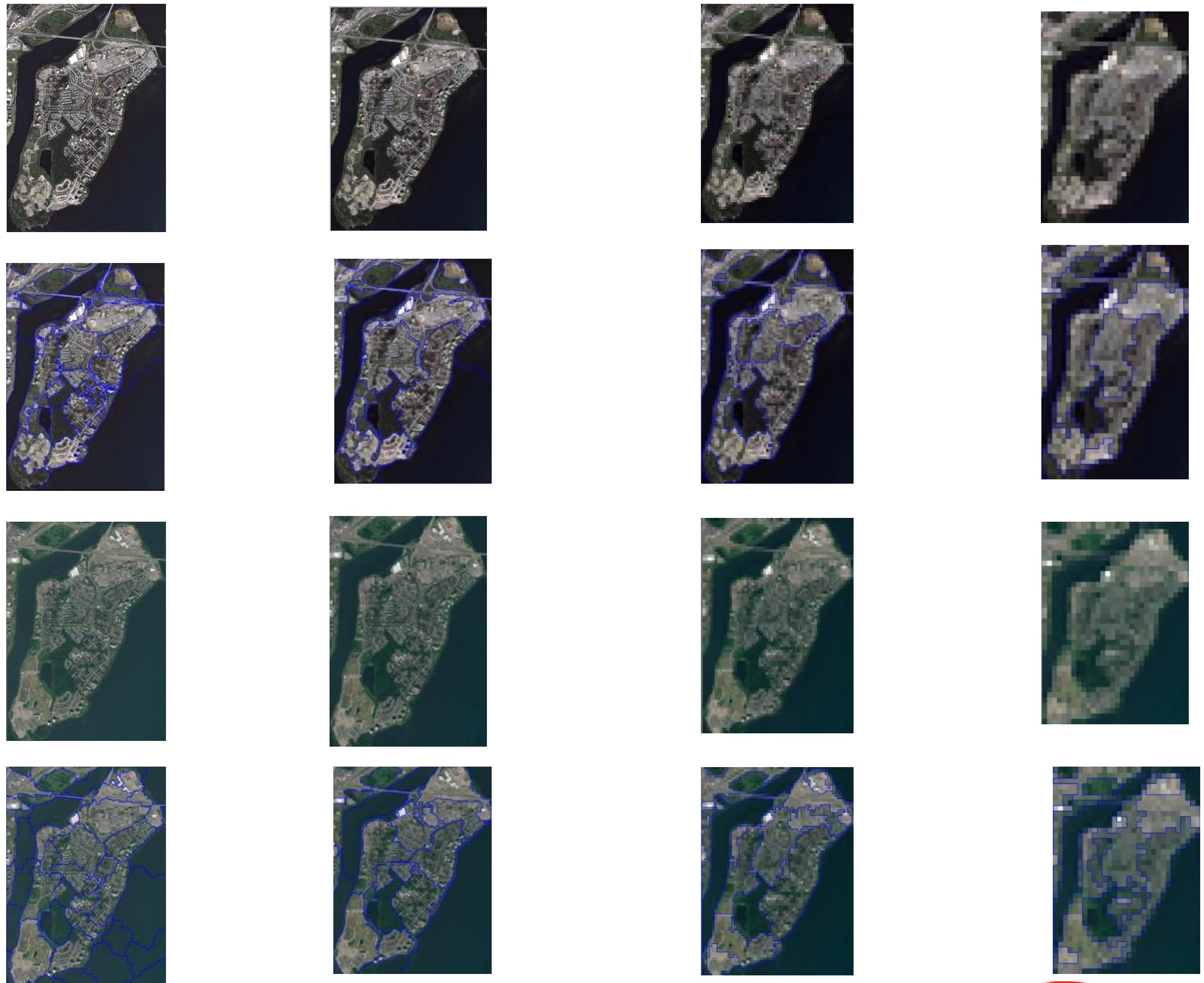
Parallel Image Scaling + Graph-Cut Image Segmentation

S=0 S=2 S=4 S=5

2006
Montreal

2012
Montreal



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LUCC-CyberGIS Built on Azure

We use Microsoft Azure to build our LUCC-GCI

Scale	# of VMs	Memory (GB)	CPU (Core)	I/O	Azure VM Type
S=0	10+6	28.0	8	Standard	D4
S=1	10+6	14.0	8	Standard	A4
S=2	10+6	7.0	4	Standard	A3
S=3	10+6	3.5	2	Standard	A2
S=4	10+6	1.8	1	Standard	A1
S=5	12+8	1.8	1	Standard	A1

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Results

- Forest and building (2006-2012) changes are extracted in the case study.

	Forest Changes (in %)				Building Changes (in %)			
	TT	TF	FF	FT	TT	TF	FF	FT
S=0	**1.2**	14.7	**63.4**	20.7	**4.3**	1.6	**81.9**	12.2
S=1	2.4	15.8	67.5	14.4	3.6	7.9	76.4	12.1
S=2	3.0	14.6	70.9	11.6	6.0	2.1	77.7	15.1
S=3	2.7	11.7	76.7	8.8	8.4	6.4	56.1	29.0
S=4	**3.3**	2.5	**89.1**	5.1	11.6	16.0	40.8	31.5
S=5	2.7	8.2	80.7	8.4	**13.0**	22.4	**25.5**	39.0

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Conclusion

- We investigate LUCC in CyberGIS, which expands CyberGIS
- The resource allocation in CyberGIS need to communicate with the domain specific layers
- We need to continue exploring the spatial and temporal contingency of LUCC

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Questions & Answers

Thank you!

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Microsoft Azure

Canada
Social Sciences and Humanities Research Council of Canada

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References

- DMTI, 2006 ,2009 , 2012. Montreal Satellite StreetView, 3_1-9_7_MONTREAL-S3XM, Markham ON: DMTI Spatial Inc., 2006, 2009 and 2012.
- Melgani, F., Moser, G., & Serpico, S. B. (2002). Unsupervised change-detection methods for remote-sensing images. Optical Engineering,
- Stommel, H. (1963). Varieties of oceanographic experience. Science,139(3555), 572-576.
- Wang, S., & Armstrong, M. P. (2009). A theoretical approach to the use of cyberinfrastructure in geographical analysis. International Journal of Geographical Information Science, 23(2), 169-193.
- Wang, S. (2010). A CyberGIS framework for the synthesis of cyberinfrastructure, GIS, and spatial analysis. *Annals of the Association of American Geographers*, *100*(3), 535-557.

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