From benchmarks to mapping: leveraging the use of labeled datasets for urban area change mapping and estimation

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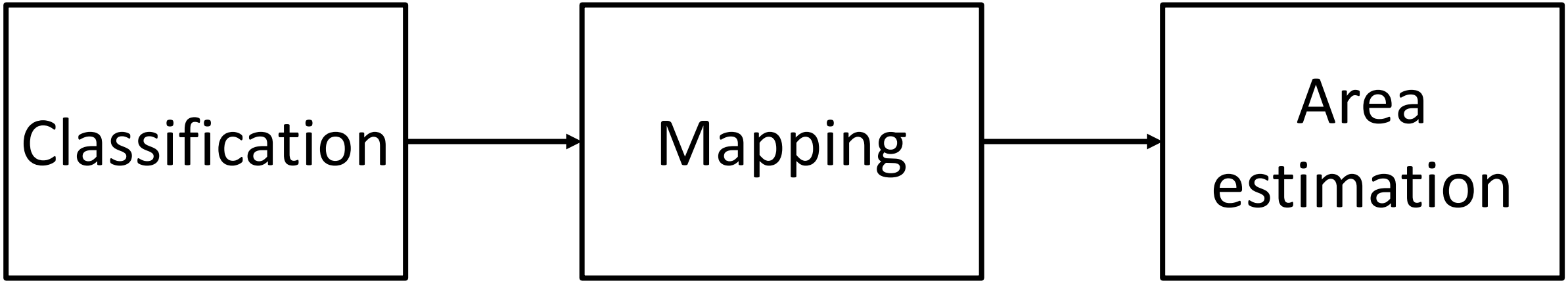
Introduction

- Economic development and populations growth has led to unprecedented **urban area changes** in the past decades

- Rapid changes due to:
  - Urban sprawl, new infrastructure, alterations, reconstructions

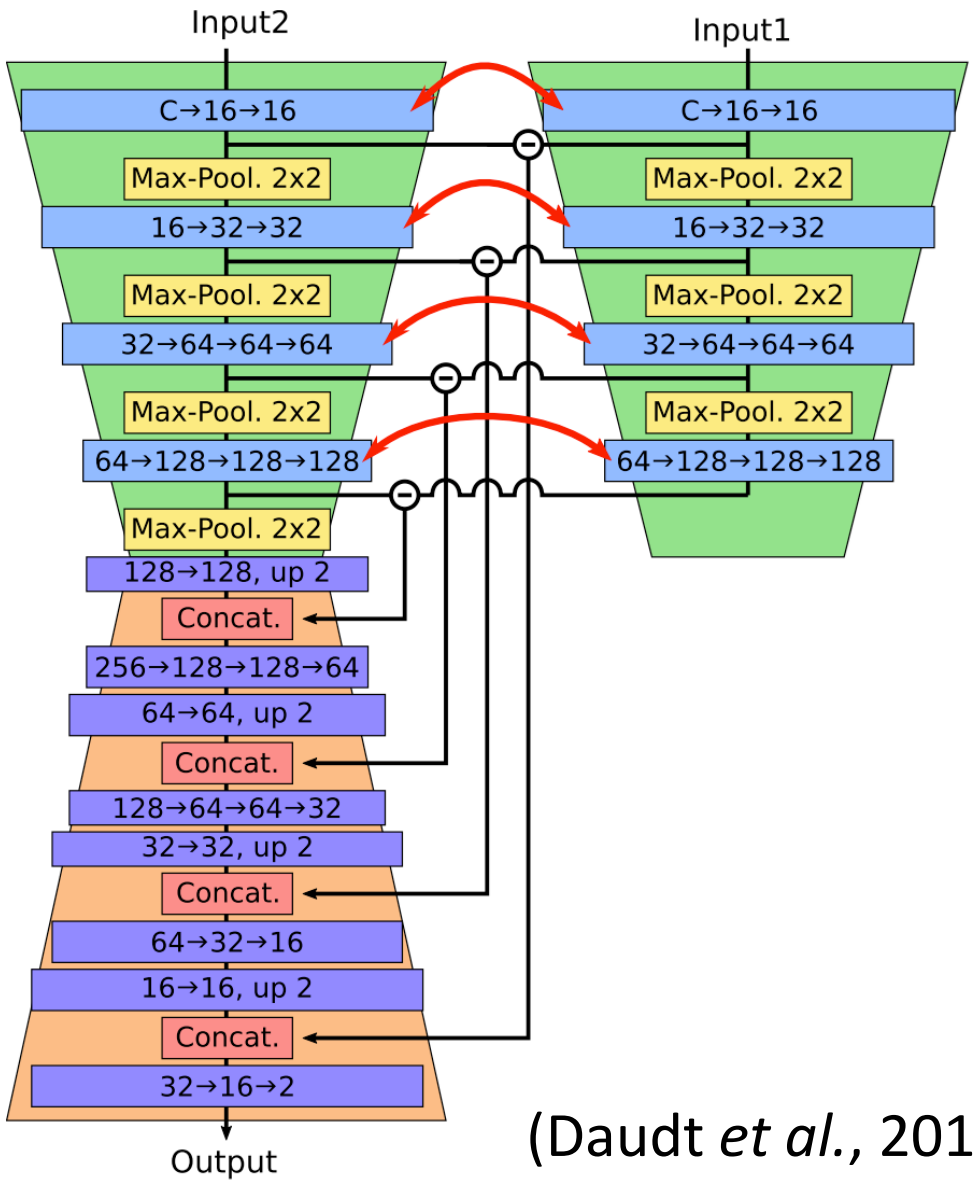
- Here, we target changes related to *zoning*
  - specifies particular land use (e.g. residential, commercial/industrial, agricultural, recreational, etc.)


Classification
Mapping
Area estimation

Dataset

- Onera Satellite Change Detection (Daudt et al., 2018)
- Multi-spectral satellite imagery Sentinel-2
- Includes 24 locations (14: training, 10: testing) over cities with urban changes between 2015 and 2018
- We re-processed:
  - atmospheric correction (LaSRC, Vermote et al., 2016)
  - co-registration (Skakun et al., 2017)

Fully Convolutional Siamese Difference (Unet)



(Daudt *et al.*, 2018)

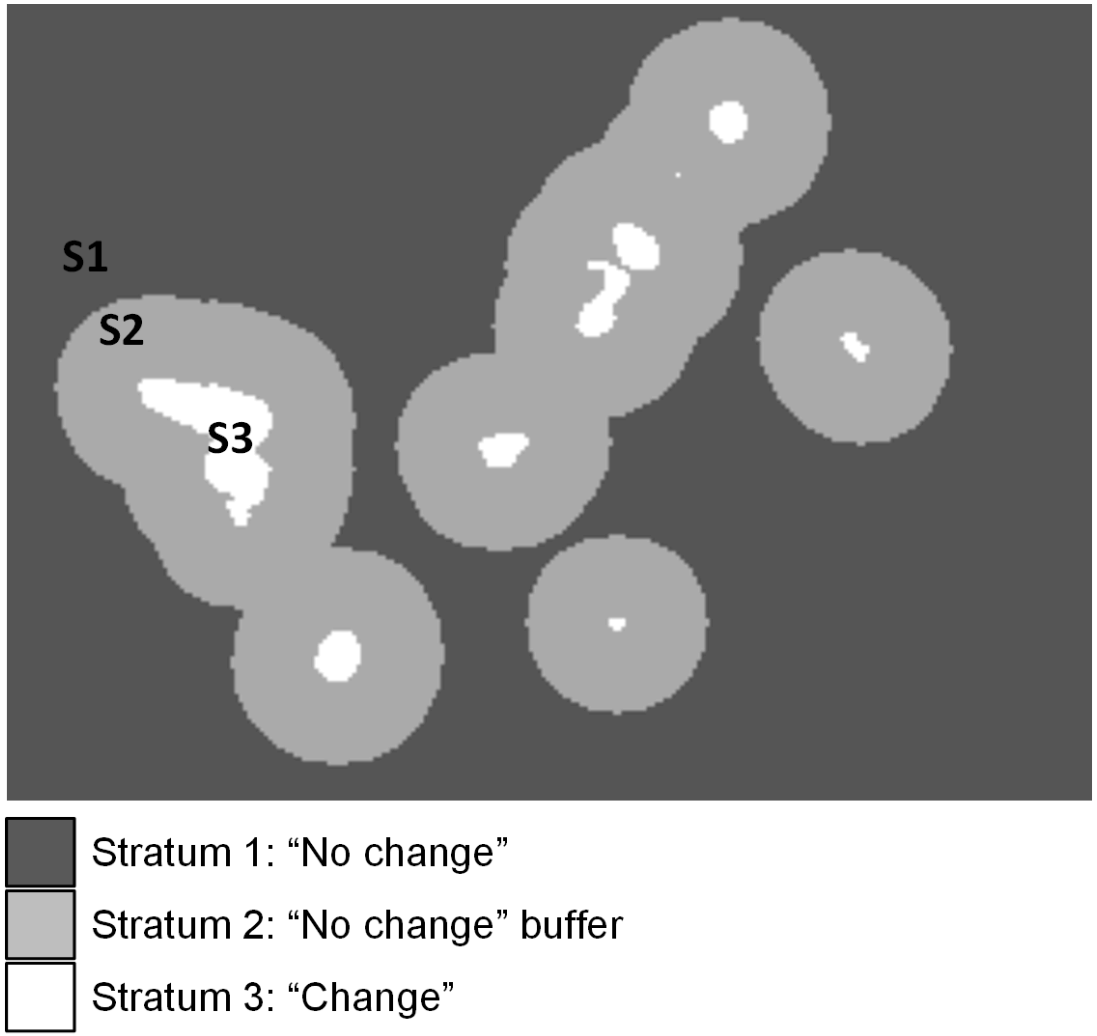
- Added dice for a loss function:

$$Loss = \alpha \times L_{dice} + (1 - \alpha) \times L_{weighted\_CE}$$

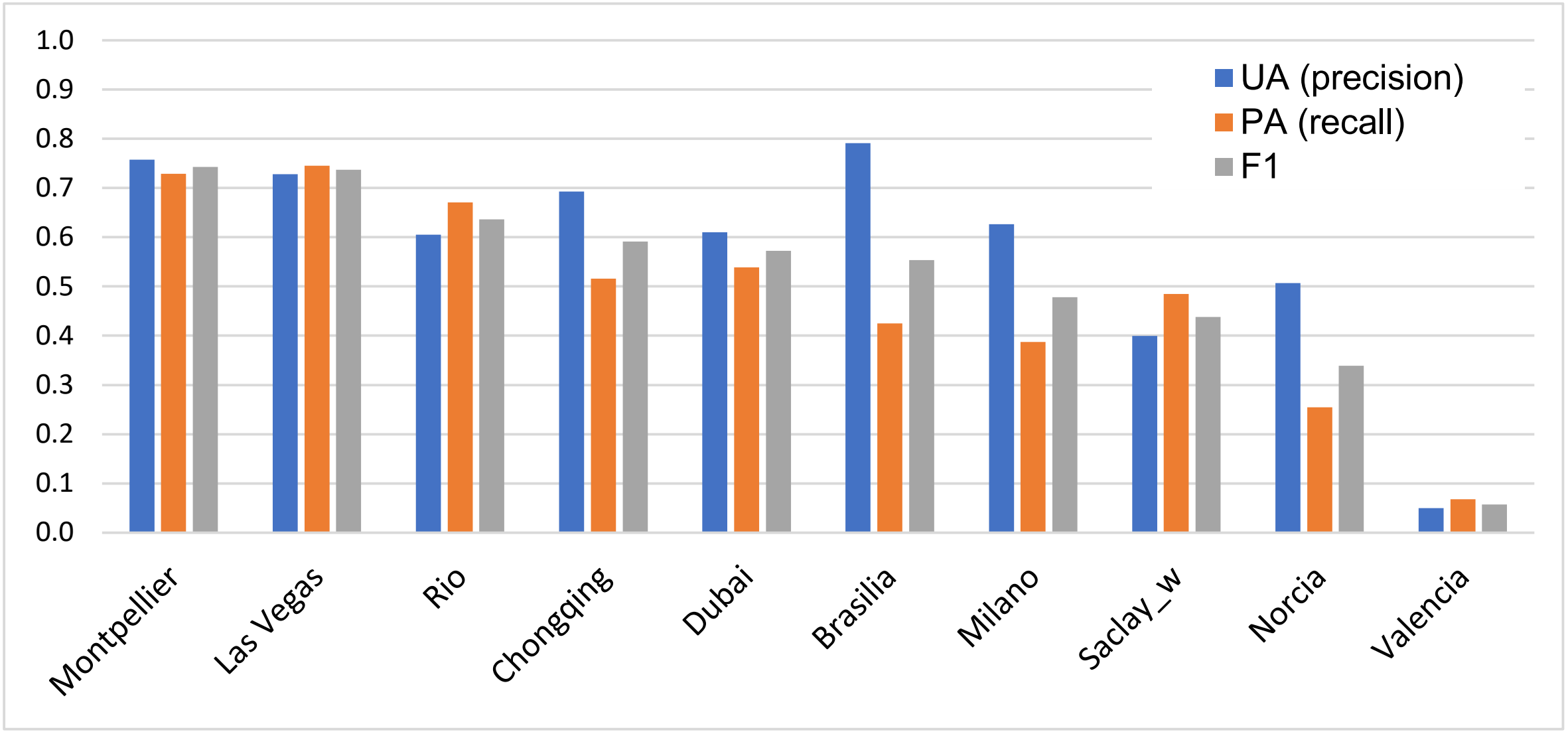
- Data augmentation
  - rotation, flips
  - simulated changes

Area assessment

- Case study:
  - Washington DC – Baltimore, MD area (2018-2019)
    - Area larger than OSCD locations
- Sampling
  - stratified random sampling (Olofsson et al., 2014)
  - three strata (Olofsson et al., 2020)
  - 500 samples
  - detailed characterization on LC/LU using GE imagery

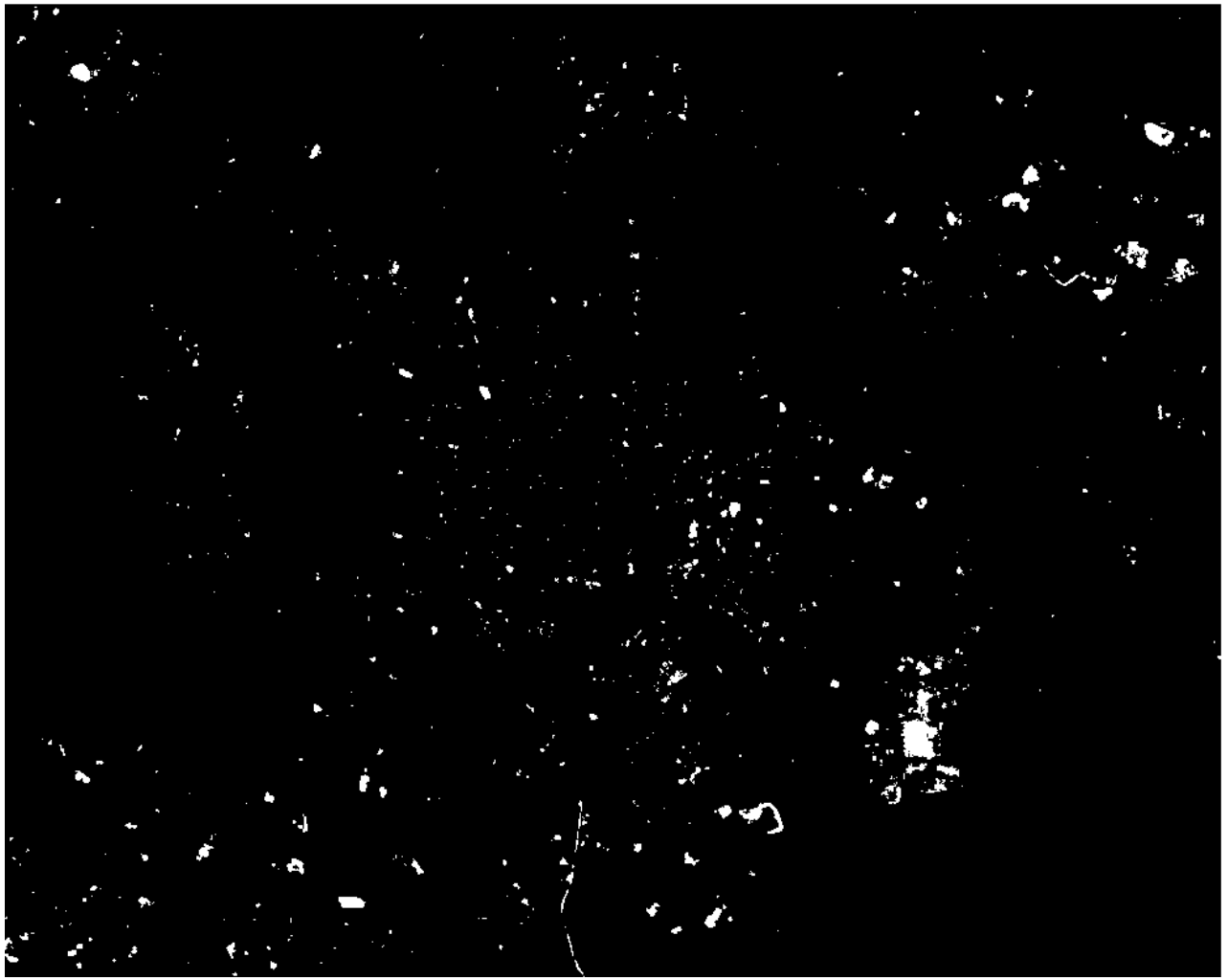


OSCD: Location-wise performance

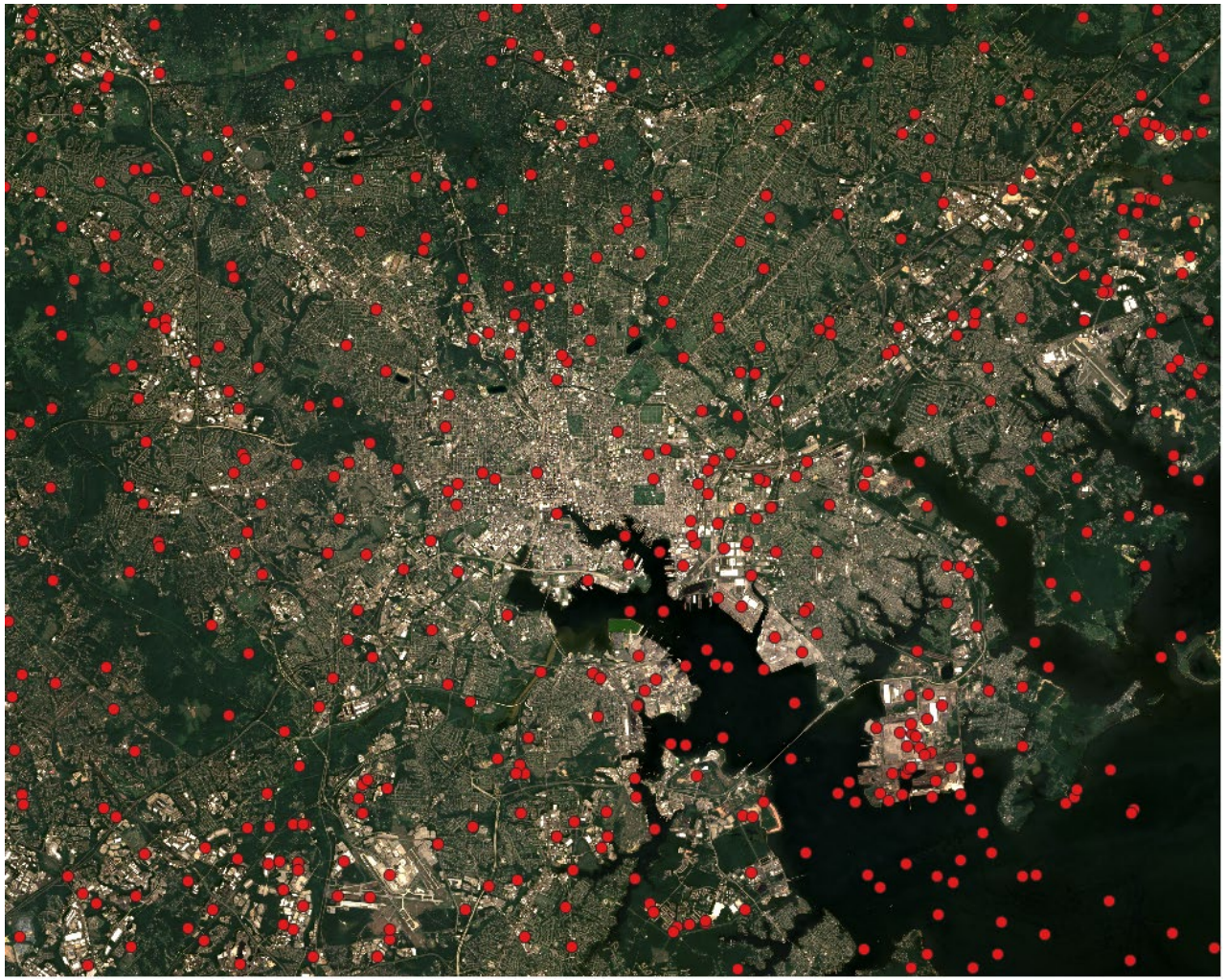


Overall: UA=0.66, PA=0.6, F=0.63

Baltimore, MD



Changes (2018-2019)



True color (2019), samples

Sample-based results for Washington DC-Baltimore

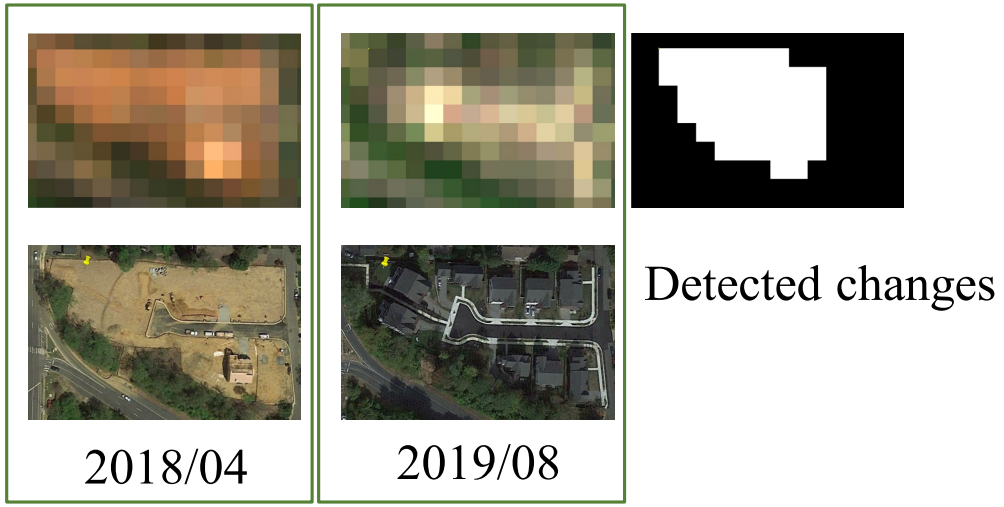
	Washington DC	Baltimore
PA, %	40.2 ± 15.9	73.1 ± 13.9
UA, %	63.0 ± 4.9	57.0 ± 5.0
Area of changes (2018-2019), km^2	10.9 ± 4.3	10.8 ± 2.2
(relative to the total area, %)	(0.85)	(0.92)

Sample-based results for Washington DC-Baltimore

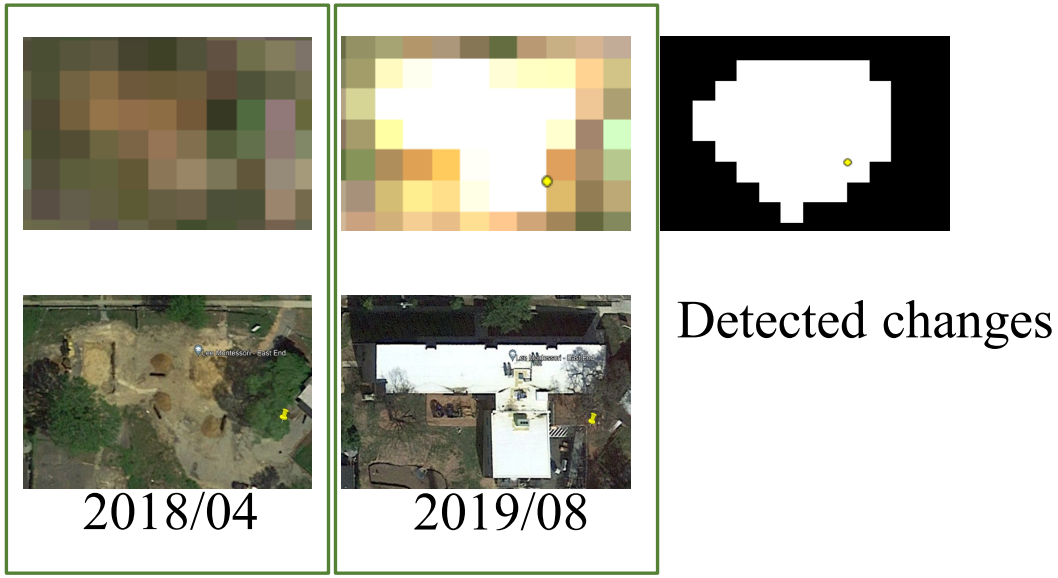
	Washington DC	Baltimore
Active constructions	78%	86%
Commercial	52%	46%
Residential	27%	21%
School (new/renovation)	8%	9%

Commercial

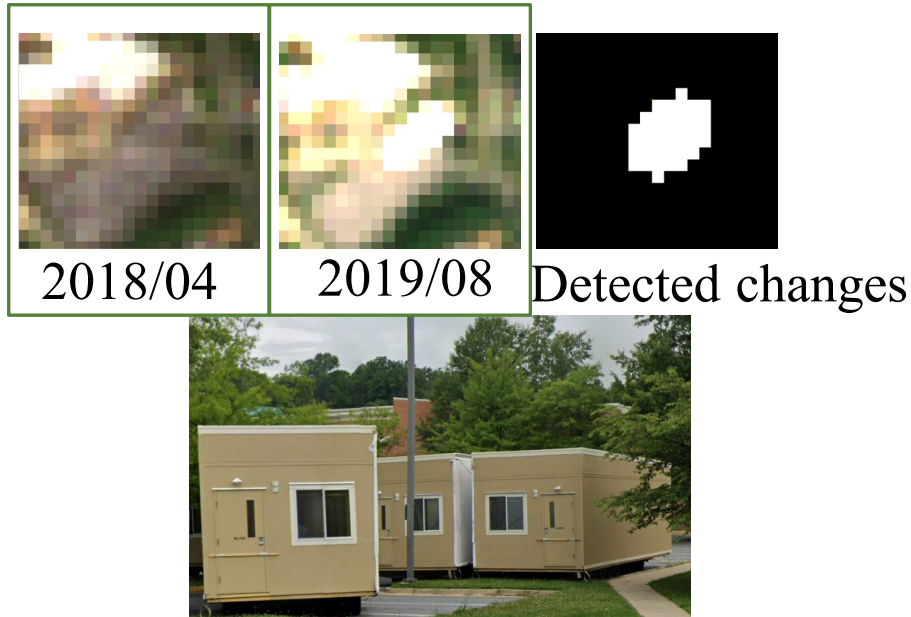
Residential



Construction of a new school

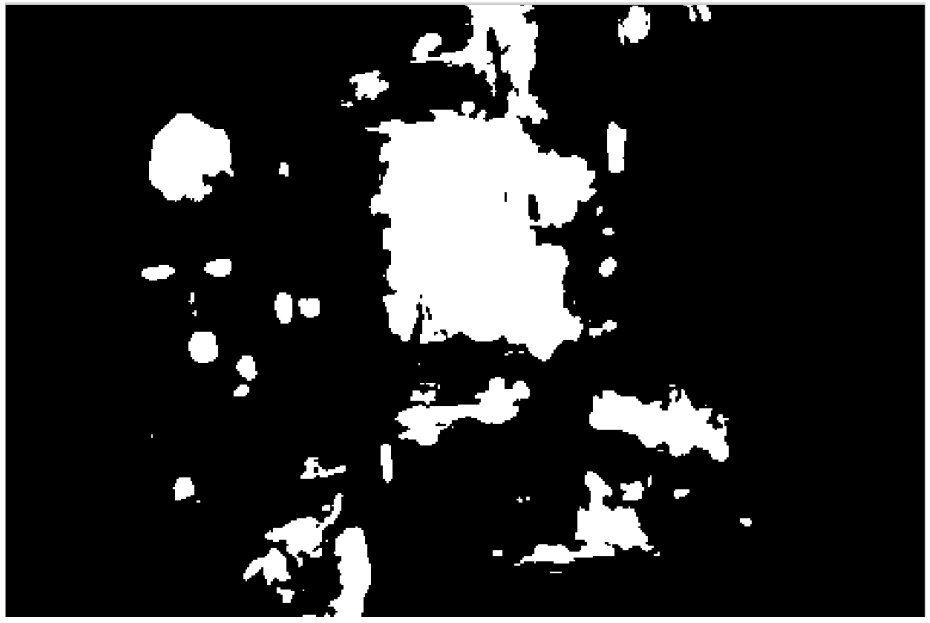


Portables (schools)



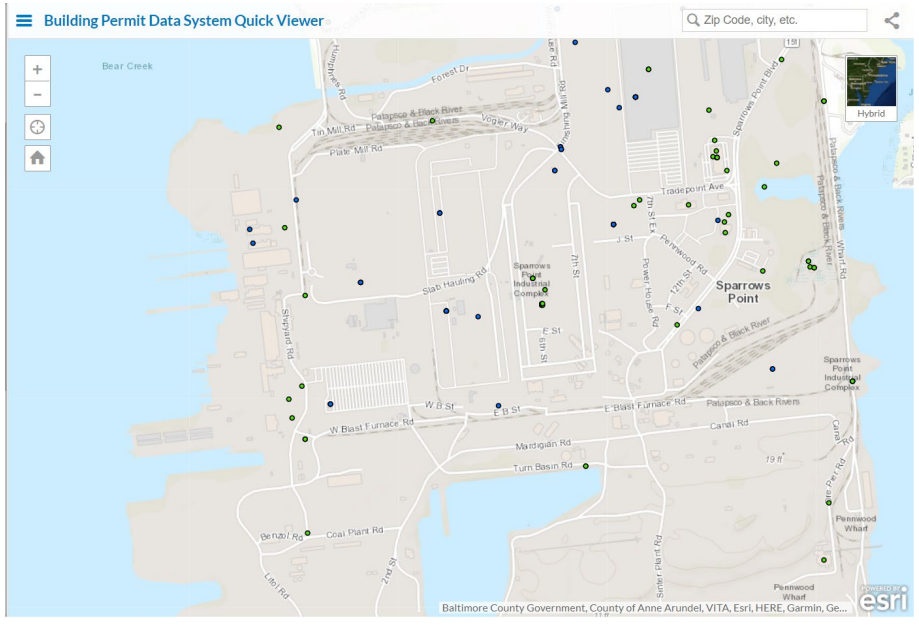
2018

Change detection



2019

Construction permits



Contributions

- Showed that the performance of the OSCD-trained model varies with location
  - Implication on the number of samples for deriving unbiased area estimates
- Characterized changes in the Washington DC – Baltimore area using OSCD-trained model and samples
- Emphasized the “classification-mapping-area estimation” workflow
  - Direct estimation of areas from maps (pixel counting) is biased
  - Statistically rigorous approach to get unbiased estimates of areas