# Change Event Dataset for Discovery from Spatio-temporal Remote Sensing Imagery

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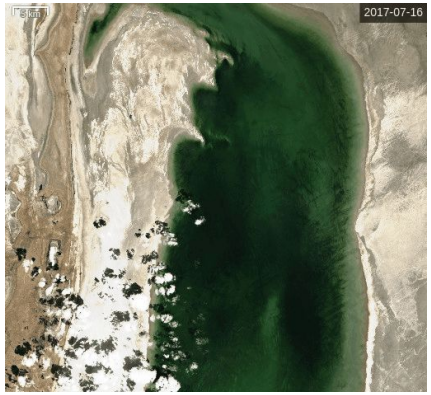
NEURAL INFORMATION PROCESSING SYSTEMS

# Plethora of Satellite Images

Number of Earth Observation Satellites are rising rapidly.


New Cities

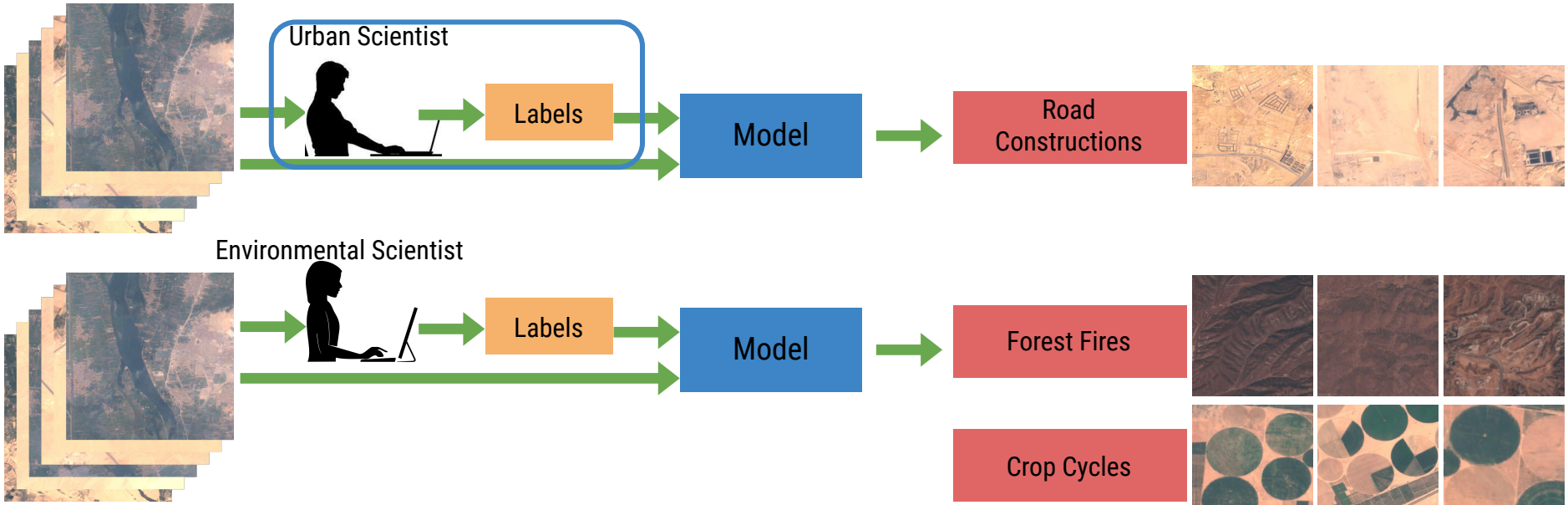



Drying Lakes

**5 Terapixel** information every week!

Need better tools to **discover** and **quantify** interesting events!

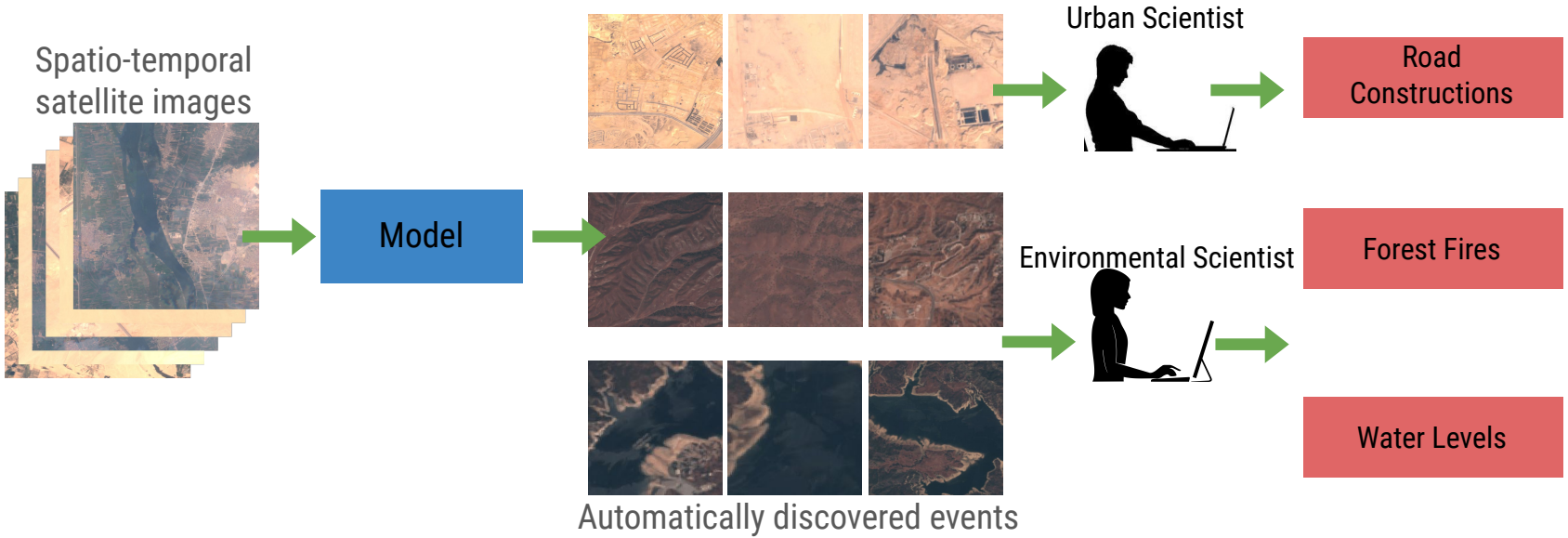
# Supervision: Costly, Specialized, and Cannot Discover Unknown




- Annotation is costly
- Application Specific
- Cannot discover unknown events

# Our Model

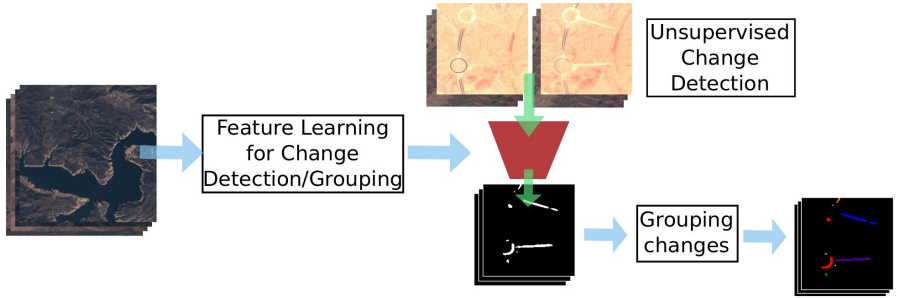
Can we automatically discover and group change events?



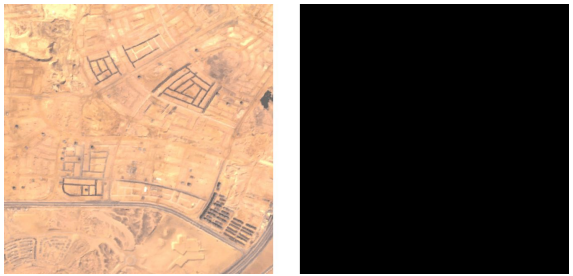

Cost-effective, general, and discovers new previously unrecognized events.

# Our Contribution

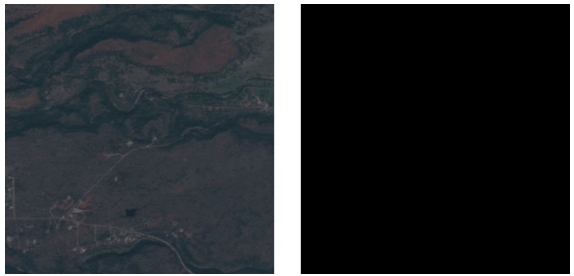
Present an **unsupervised** method to discover **change events** from spatio-temporal satellite imagery.




Propose **2 new benchmarks** created using our pipeline.



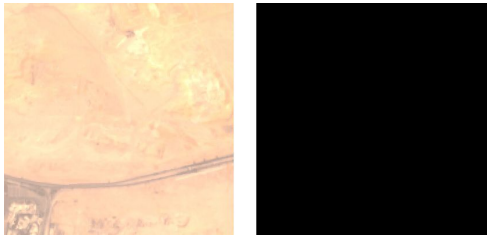
CaiRoad Benchmark



CalFire Benchmark

# Defining Change Events

Definition: a group of pixels over space and time that were changed by a single event.



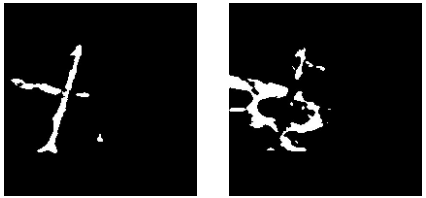
Road Construction

Water Level

Formally: $\langle V_{1\cdots l}, C_{1\cdots l-1} \rangle$

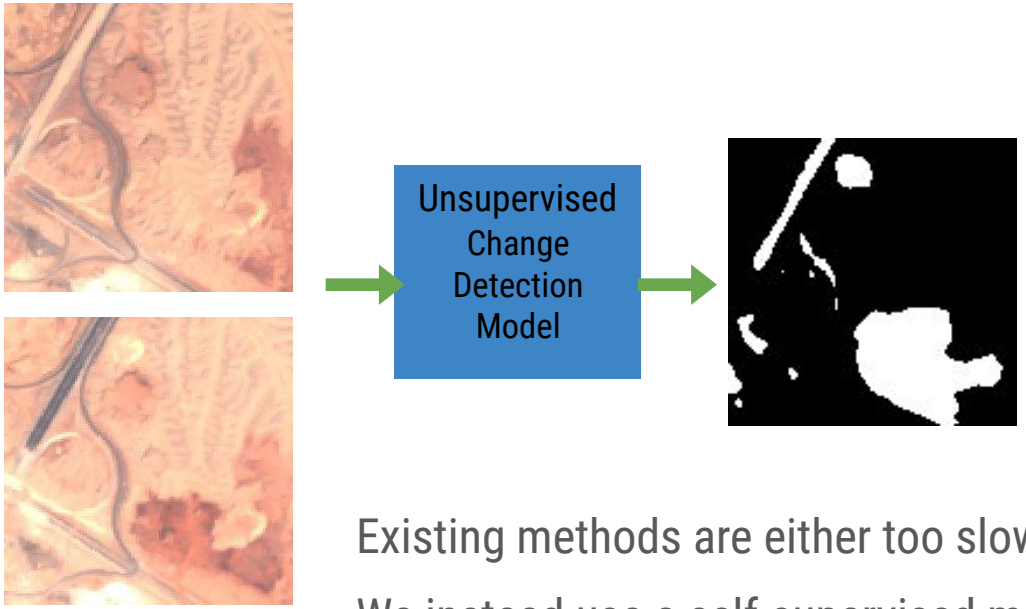
$V \in R^{l \times x \times y \times c}$

$C \in \{0,1\}^{l-1 \times x \times y}$



# Change detection

First Step: Detect all changes between consecutive images.

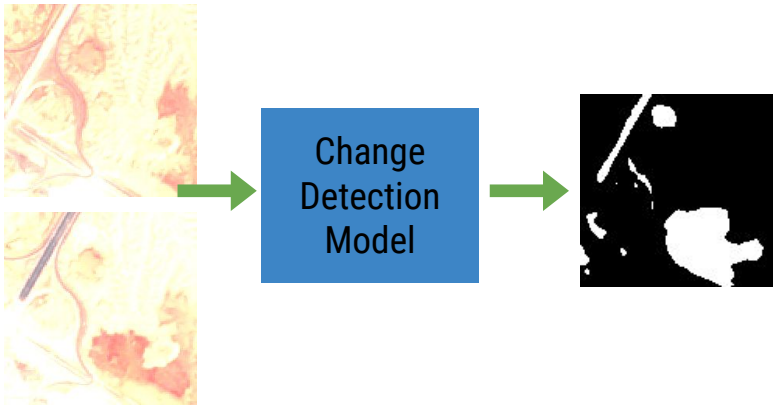



Existing methods are either too slow or less accurate.

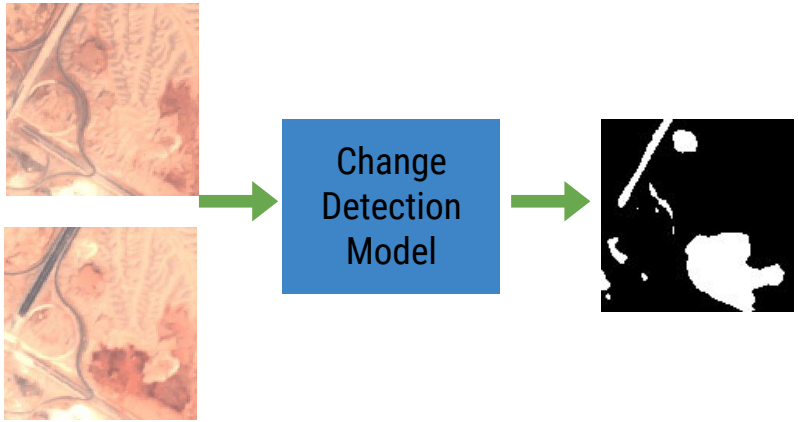
We instead use a self-supervised method!

# Self-supervised Learning for Change Detection

Self supervised learning can learn invariance and equivariance

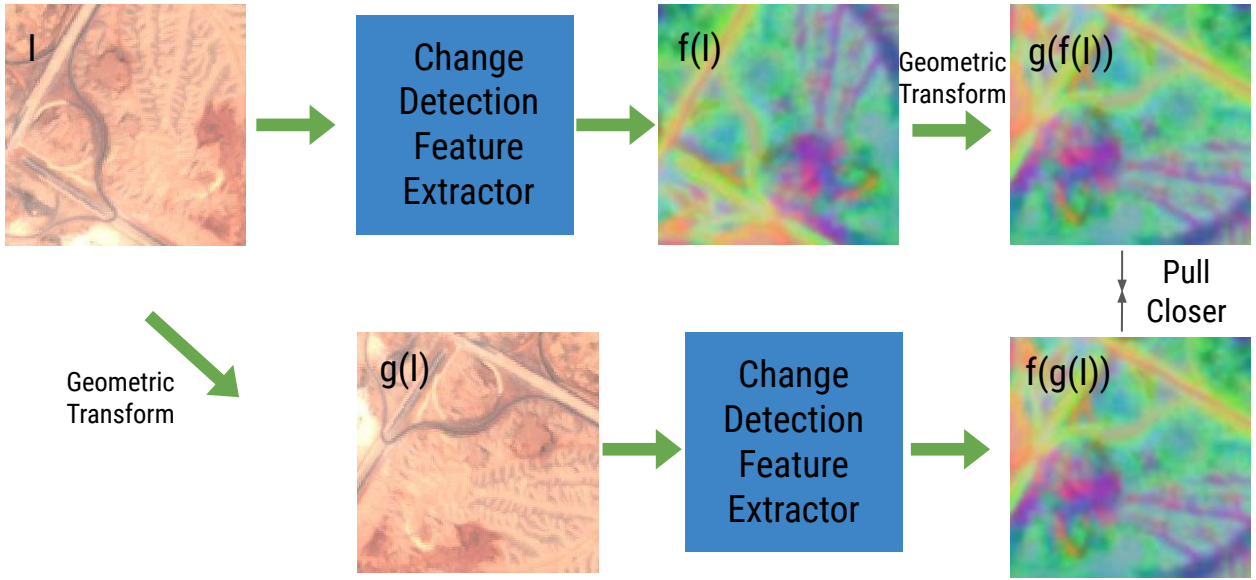



Invariance to Photometric Transforms



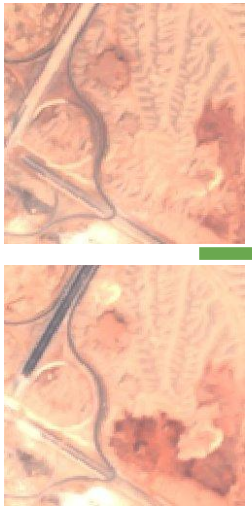

**Equivariance** to Geometric Transforms

# Equivariance to Geometry



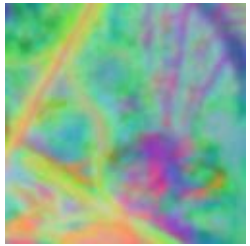

This loss enforces equivariance to geometric transforms

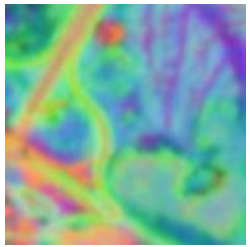
# Detection and Grouping



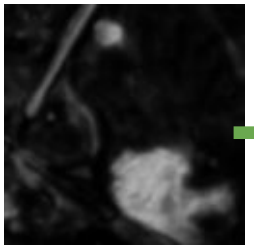


Change Detection Feature Extractor





Feature Difference



Thresholding

t=0

t=1

Changes over multiple time steps

t=0

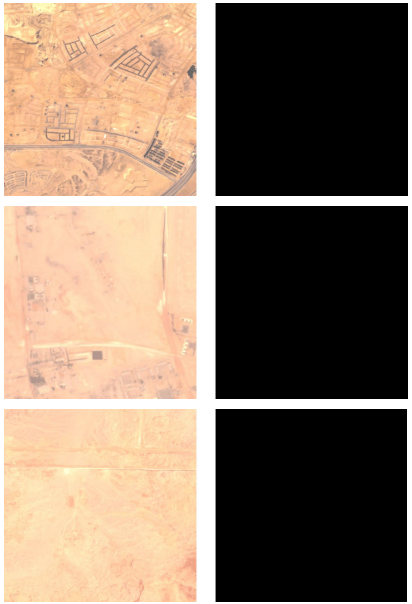
t=1

- Proximity in space-time
- Proximity in feature space

Grouping into events

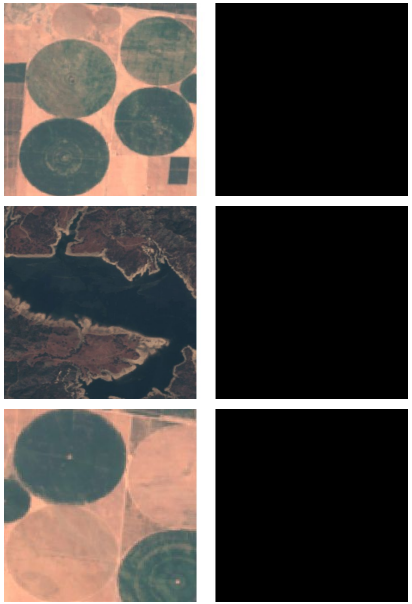
# Benchmarks

**CaiRoad Benchmark**



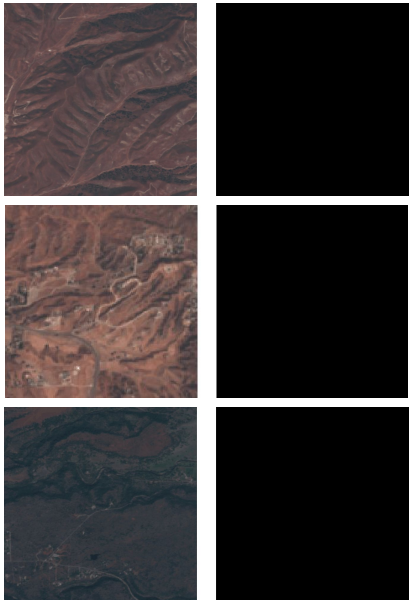
28015 Total Events

2256 Road Construction Events



Several Other Useful Events!

**CalFire Benchmark**



2172 Total Events

204 Forest Fire Events

# Results

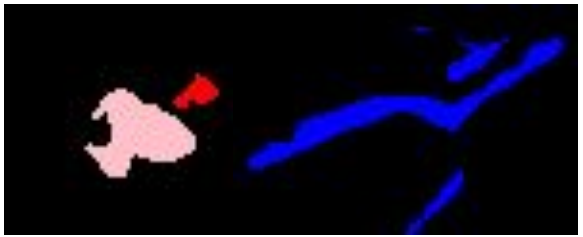
# Change Detection and Grouping

| Method | F1-Score | Run Time (s) |
|---|---|---|
| CVA | 0.268 | 1.16 |
| PCANet | 0.298 | 13.70 |
| Tile2Vec | 0.149 | 316.18 |
| DCVA | 0.255 | **0.94** |
| KPCAMNet | 0.302 | 54.46 |
| **Ours** | **0.321** | **0.94** |

Unsupervised Change Detection on OSCD Benchmark

KPCAMNet

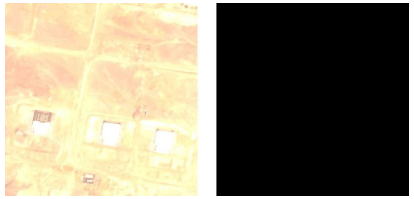
**Ours**



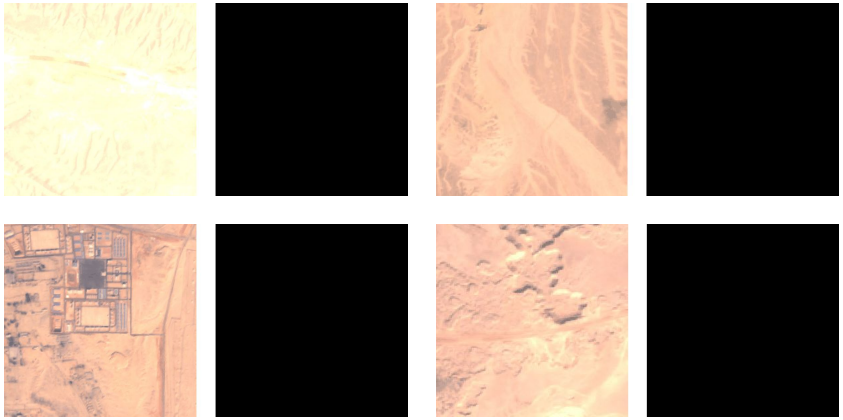
Change Grouping

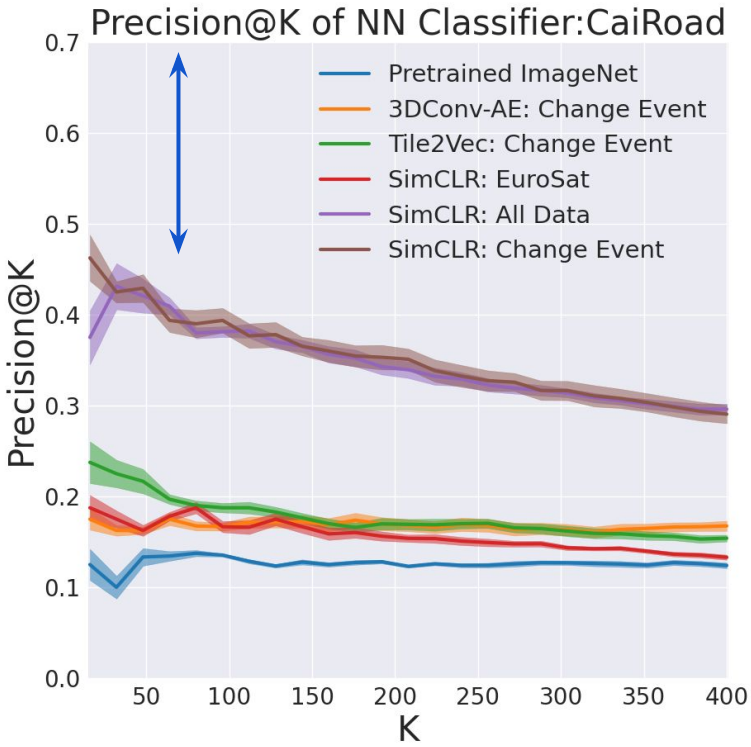
# Retrieving Positive Events

Query Event



Retrieved Events

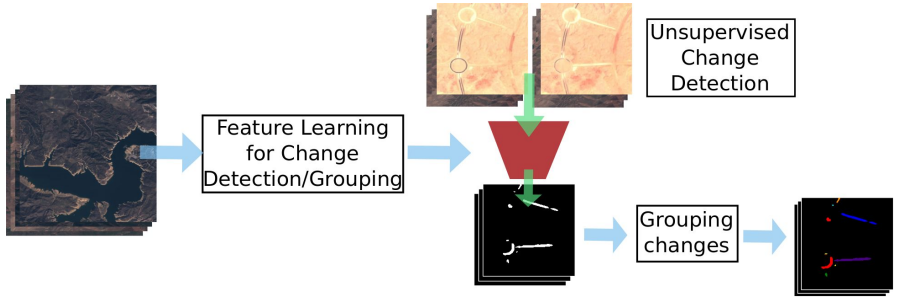





Our dataset is challenging for existing techniques.

# Conclusion

Presented an **unsupervised** method to discover **change events** from spatio-temporal satellite imagery.

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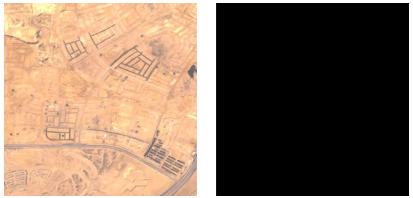

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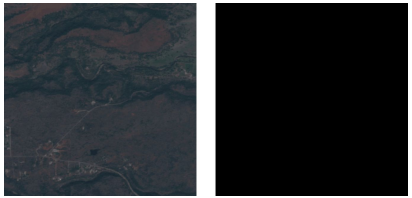

CalFire Benchmark

More work in the future is required to better encode and group these change events.

Dataset and Code

# Thank You!

https://www.cs.cornell.edu/projects/satellite-change-events/

Funding Agencies

Cornell Bowers C·IS
College of Computing and Information Science

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