

# Special Topics in Applications (AIL861)

## Artificial Intelligence for Earth Observation

### Lecture 9

Instructor: Sudipan Saha

# DCVA Result: Worldview-2

Pre-change image  
Aug 2010



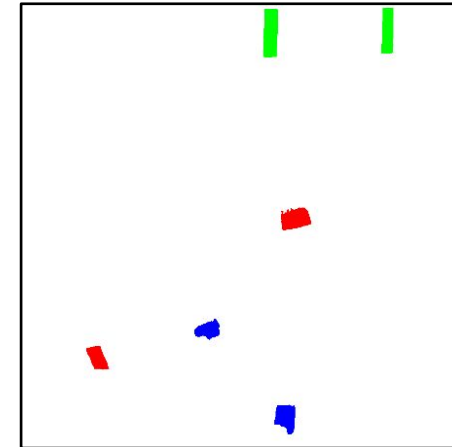
1200 pixels

1200 pixels

Post-change image  
May 2011



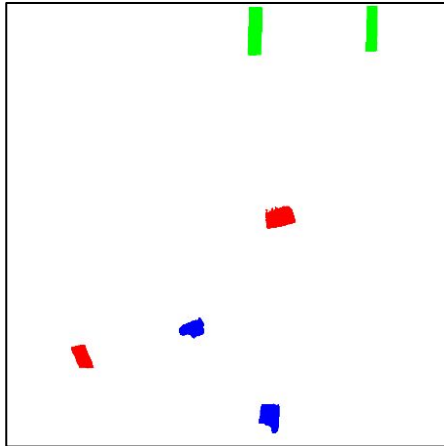
Reference map



- ✓ Very high resolution (0.5 meter/pixel)
- ✓ Urban complexity
- ✓ Different season and different acquisition angle (>6 degree difference)

# Binary CD: Worldview-2

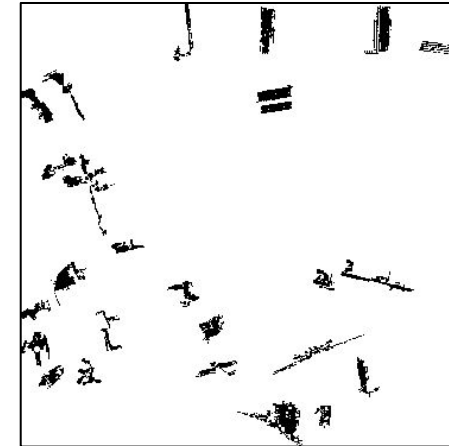
Reference map



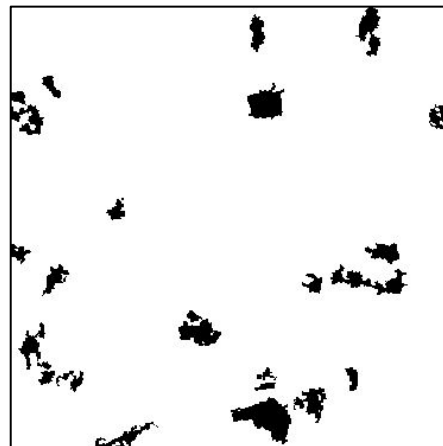
Proposed method



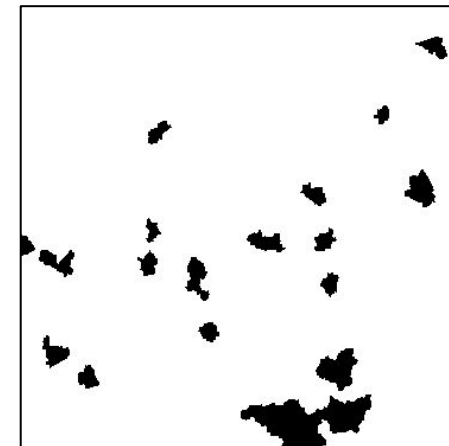
Robust CVA



Parcel CVA



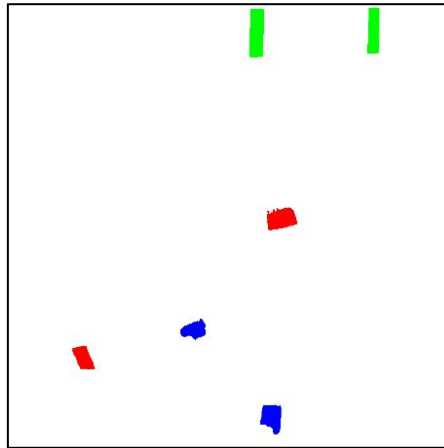
Object CVA



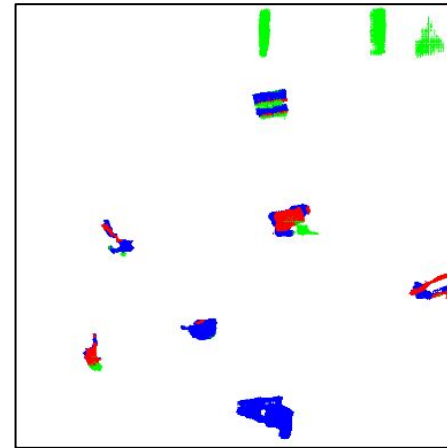
- ✓ Better sensitivity, specificity score.
- ✓ More accurately captures the changed object shape.

# Multiple CD: Worldview-2

Reference map



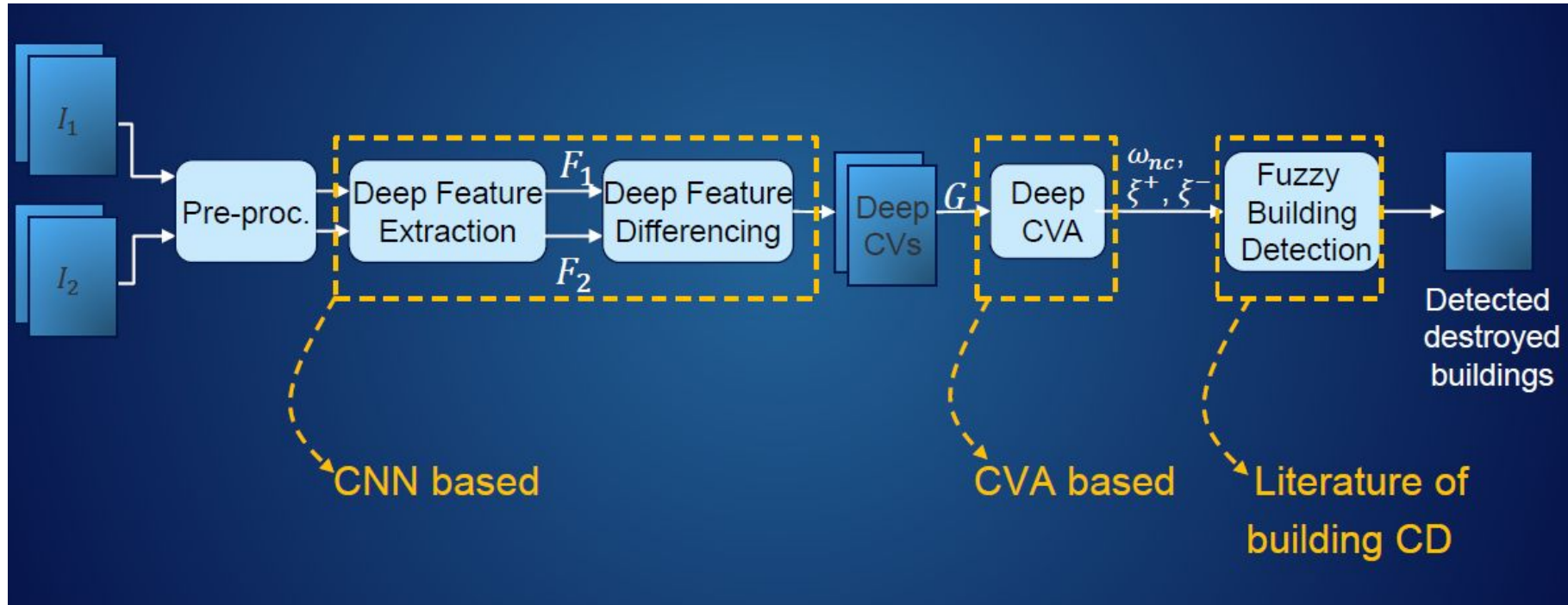
Multiple CD: DCVA



## Some Points

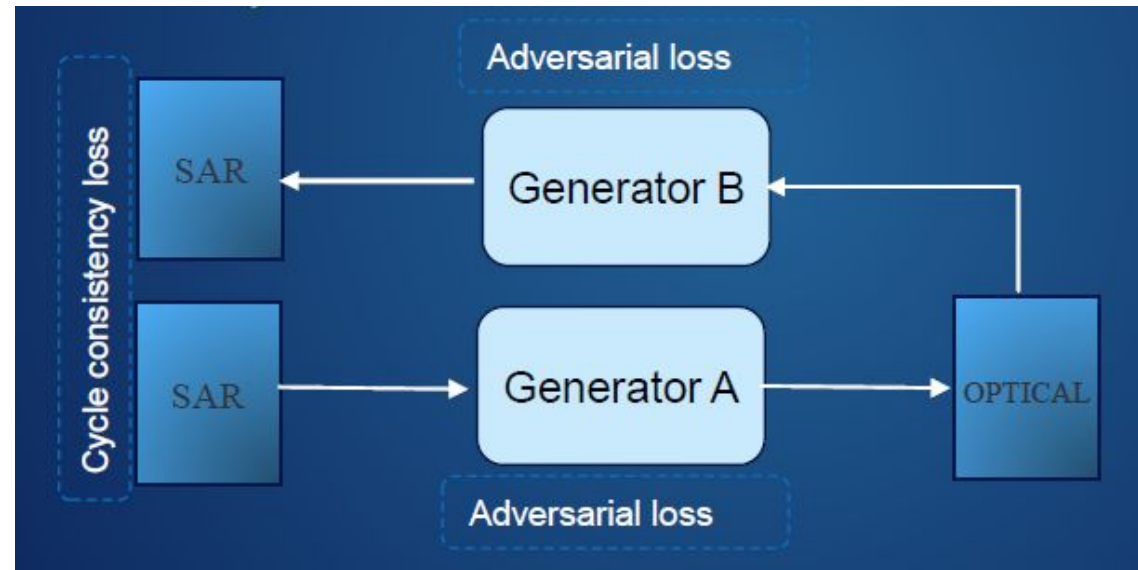
<b>Sensor resolution</b>	Very High
<b>Modality</b>	Optical
<b>Multi-temporal supervision</b>	No
<b>Pre-trained network</b>	Yes
<b>Pre-trained network training requires label</b>	Yes
<b>Applicable to time-series (more than 2 images)</b>	Requires modeling like CDM

# Building CD: VHR SAR Images



# SAR-Optical Transcoding

- ✓ SAR-optical dataset (unlabeled):
  - ❑ Cycle GAN training – two generators, two discriminators
  - ❑ Generators learn useful semantic features while trying to learn multi-modal transcoding
  - ❑ We reuse a generator as deep feature extractor in DCVA framework



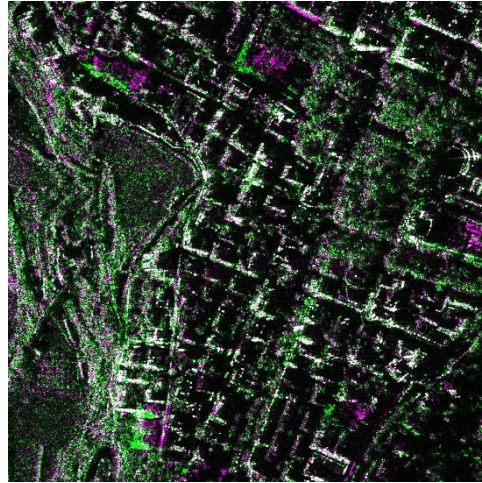


# Detecting Destroyed Buildings

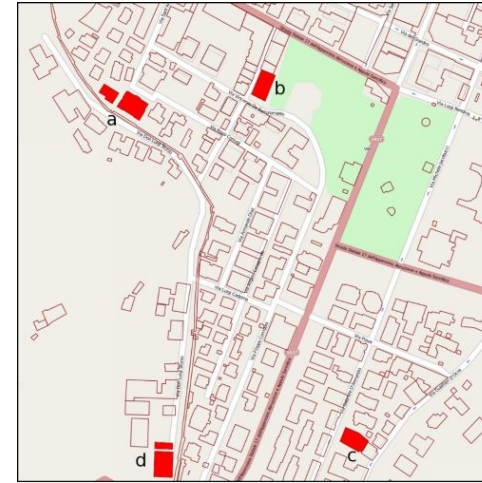
Optical image  
Pre-earthquake  
(Sept. 4, 2006)



RGB multitemporal composition  
of Cosmo-SkyMed images  
(R- Sept. 12, 2009, G- April 5,  
2009, B- Sept. 12, 2009)

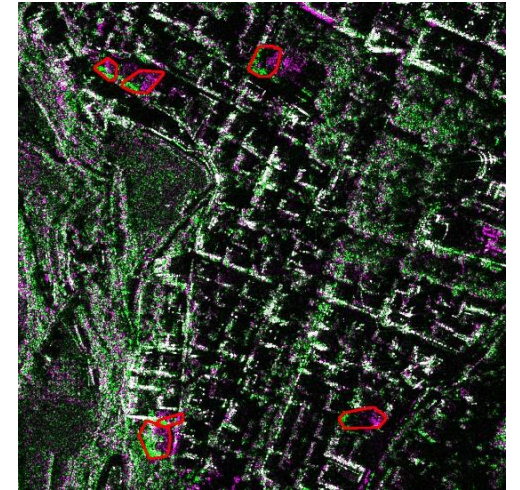


Cadastral map

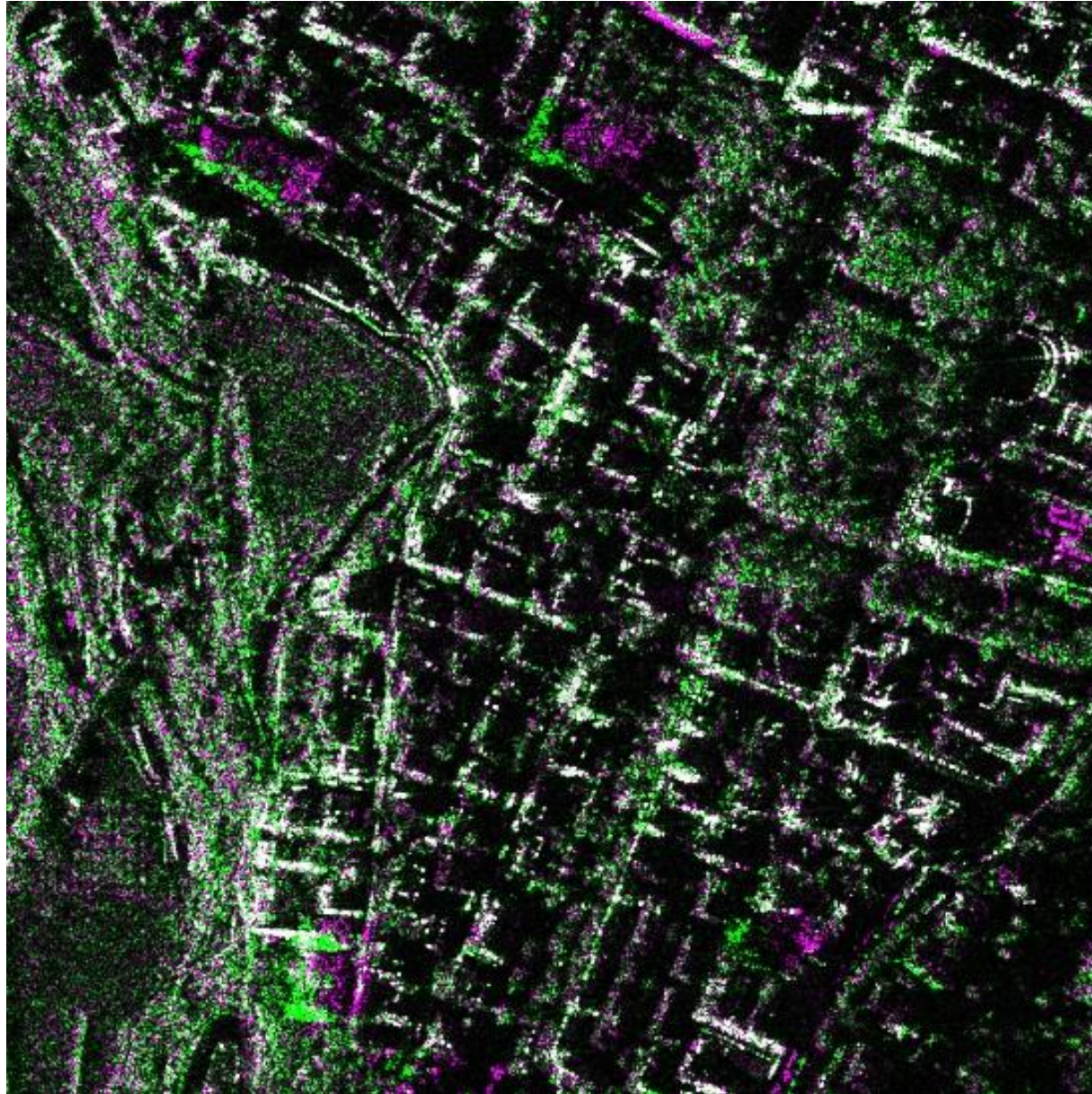


Destroyed buildings

Proposed method







## Some Points

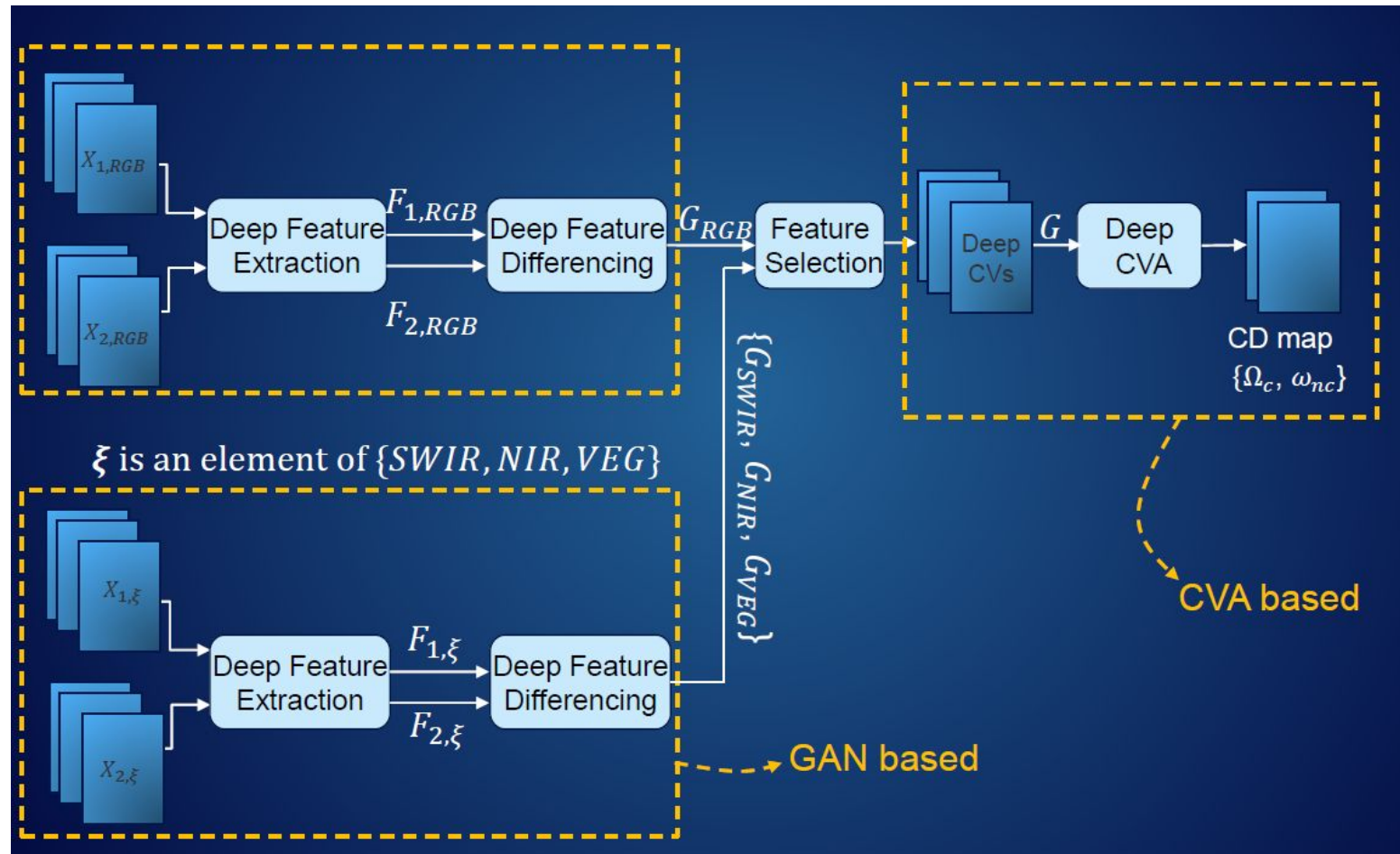
<b>Sensor resolution</b>	Very High
<b>Modality</b>	SAR
<b>Multi-temporal supervision</b>	No
<b>Pre-trained network</b>	Yes, trained by us
<b>Pre-trained network training requires label</b>	No
<b>Applicable to time-series (more than 2 images)</b>	Requires modeling like CDM

# When Bands Increase: Sentinel-2

- ✓ Sentinel-2 sensor (13 bands):
  - ❑ Is a good compromise between spatial, temporal, and spectral resolution.
  - ❑ Shows many spectral channels.
  
- ✓ Most unsupervised methods show limited capability to exploit such images and use application specific indices, e.g., NDVI.



# Sentinel-2 CD

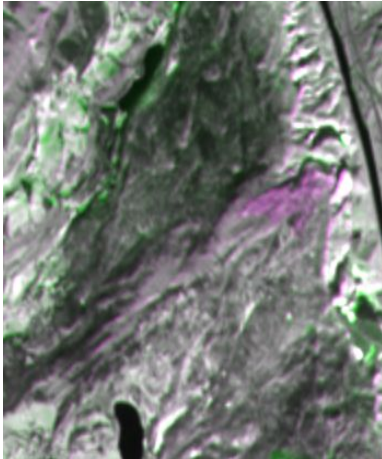


# Results: Alpine

Multitemporal FCC (SWIR)

Pre-change: 23/02/2019

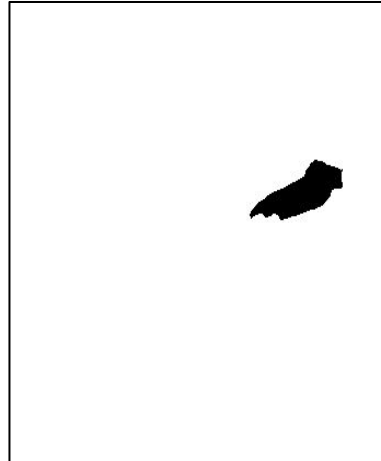
Post-change: 03/03/2019



350 pixels

350 pixels

Reference map



■  $\omega_{nc}$ : 120623 pixels  
Proposed method



RCVA (SWIR)



RCVA (NIR)



Method	Sensitivity	Specificity
Proposed	0.95	0.99
RCVA (SWIR)	0.54	0.96
RCVA (NIR)	0.64	0.99
PCVA (SWIR)	0.36	0.96
ImageNet	0.37	0.77

# Result: Agricultural

Pre-change image  
06/07/2015



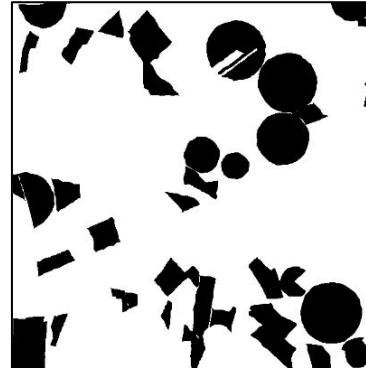
600 pixels

600 pixels

Post-change image  
16/07/2015



Reference map



Proposed method

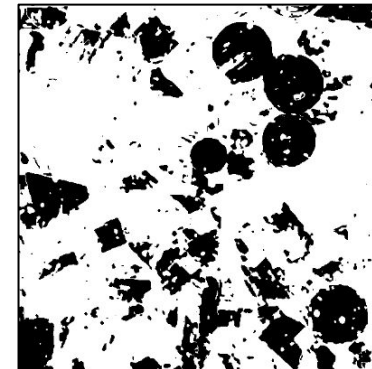


Method	Sensitivity	Specificity
Proposed	0.94	0.89
RCVA (NIR)	0.92	0.87
RCVA (VEG)	0.92	0.89
PCVA (VEG)	0.83	0.89
ImageNet	0.73	0.66

Robust CVA (VEG)



Parcel CVA (VEG)





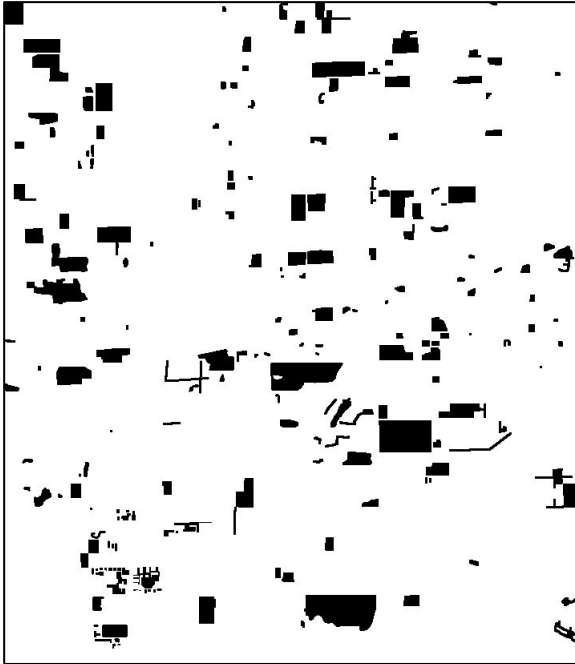
# Optical-SAR CD

- ✓ Using the principle of temporal consistency, we have designed a framework for **optical – SAR CD**.



# Optical-SAR CD

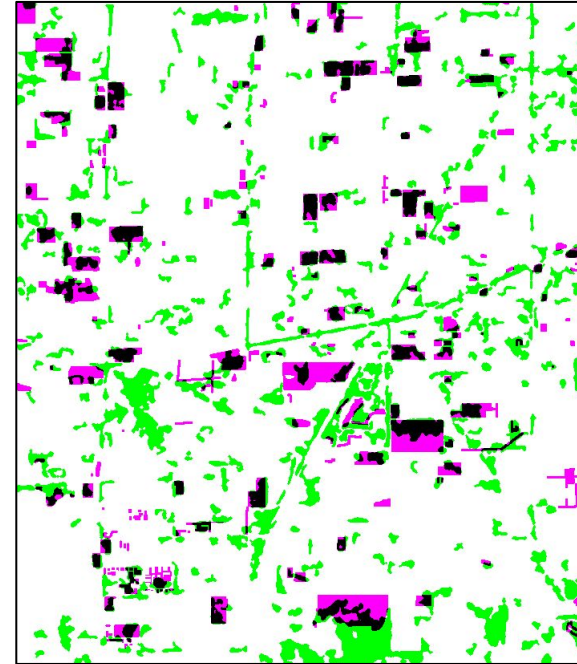
Reference



Self-supervised Proposed



FCC between proposed  
and  
self-supervised proposed



Previous state-of-the-art

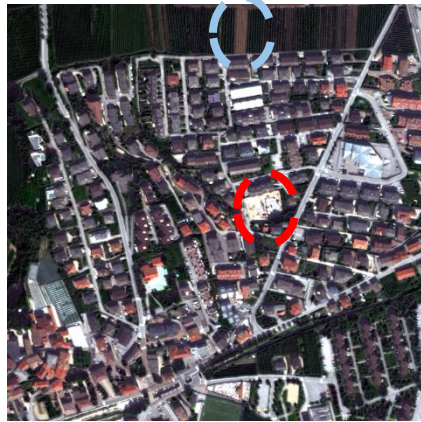


Sensor resolution	Very High
<b>Modality</b>	SAR
<b>Multi-temporal supervision</b>	No
<b>Pre-trained network</b>	Yes, trained by us
<b>Pre-trained network training requires label</b>	No
<b>Applicable to time-series (more than 2 images)</b>	Yes

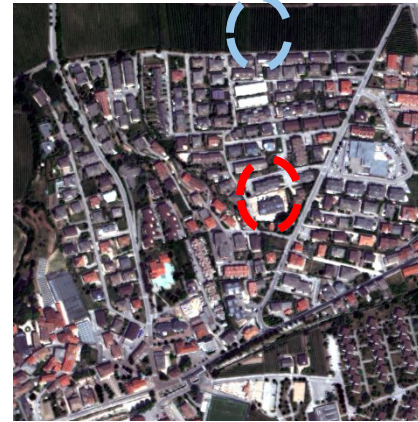
# Change Detection

- ✓ Most important aspect of multi-temporal image analysis: [change detection](#) (CD).

Pre-change

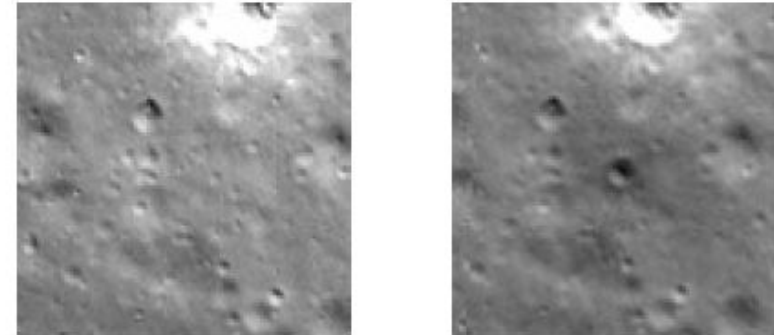


Post-change



# Challenges: Planetary CD

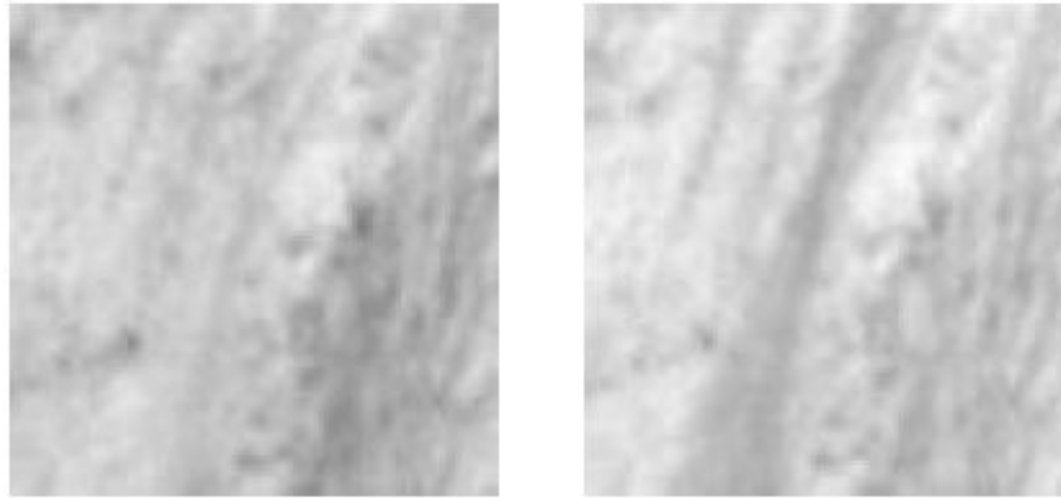
- ✓ Unsupervised CD methods assume pre-change and post-change images are near-perfectly coregistered.
- ✓ Planetary images – such [coregistration is difficult](#).
- ✓ [Patch-level outcome](#) is desired in planetary CD [1].



Kerner, H.R., Wagstaff, K.L., Bue, B.D., Gray, P.C., Bell, J.F. and Amor, H.B., 2019. Toward generalized change detection on planetary surfaces with convolutional autoencoders and transfer learning. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 12(10), pp.3900-3918.



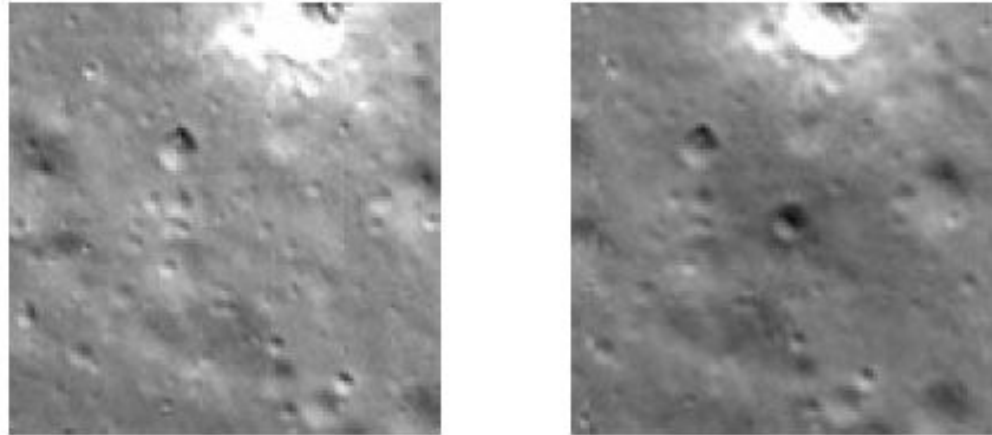
# Examples



**Mars:** High Resolution Imaging Science Experiment (HiRISE) recurring slope lineae



# Examples



**Moon:** Meteorite impact captured by Lunar Reconnaissance Orbiter Camera (LROC) camera

# DCVA for Planetary CD

