

# InSAR Forest/Non-Forest Classification Exploiting Nonlocal Pixel Similarities

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Knowledge for Tomorrow



- Introduction
- Motivation of the work
- Non-Local filtering
- Proposed framework and Experimental Result
- Open points



# Forest Classification

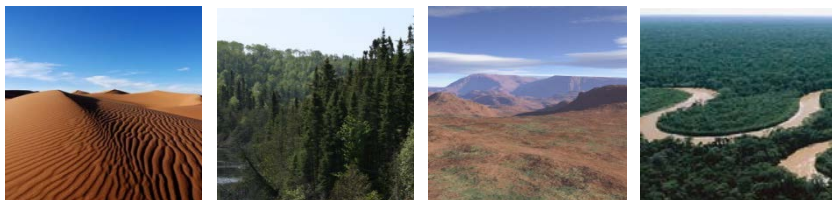
## Sensors for Global Vegetation Maps

| Sensor      | Acquisition Time Span | Resolution |
|-------------|-----------------------|------------|
| AVHRR       | 1979-1994             | ~ 1 km     |
| MODIS       | 2000-2010             | 250 m      |
| MERIS       | 2009-2010             | 300 m      |
| LANDSAT     | 2000-2010             | 30 m       |
| ALOS PALSAR | 2006-2010             | 25 m       |

## Methods for Forest Classification from SAR data

- Single-Channel:
  - Wavelet Analysis on Amplitude
  - Analysis on Cross-Pol Backscatter
  - Texture Analysis
  - Clustering
- Multi-channel:
  - Polarimetry
  - Pol-InSAR

Forest definition: **canopy height, density, cover, use, etc.**



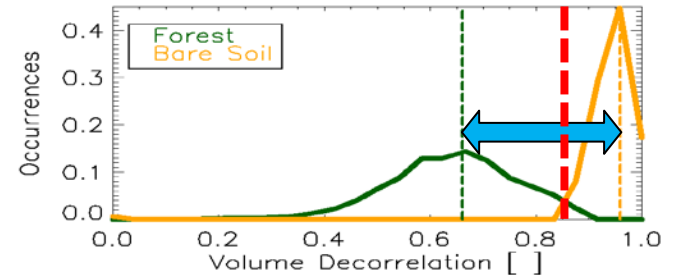
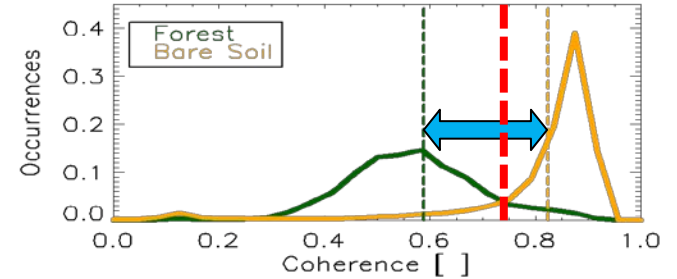
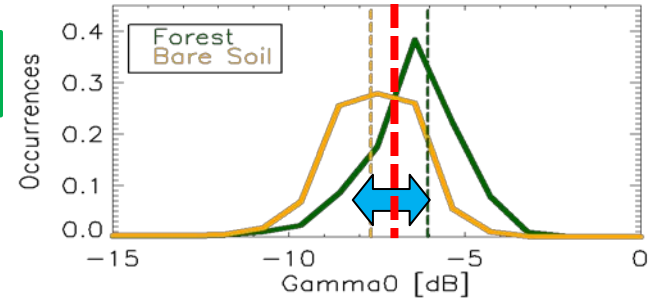
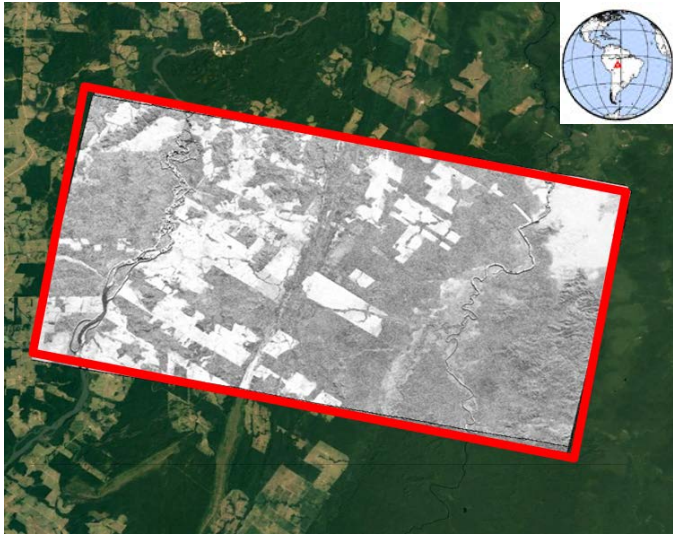
Investigate opportunities, potentials, limitations for vegetation and forest mapping and related applications from TanDEM-X interferometric data



# TanDEM-X Classification input parameters

➤ Classification on Volume Correlation Factor

$$\hat{\gamma}_{\text{Vol}} = \frac{\gamma_{\text{Tot}}}{\gamma_{\text{Temp}} \cdot \gamma_{\text{SNR}} \cdot \gamma_{\text{Amb}} \cdot \gamma_{\text{Vol}} \cdot \gamma_{\text{Rg,Az}} \cdot \gamma_{\text{Quant}}}$$



# TanDEM-X Forest Classification

✓ Fuzzy clustering classification

✓ Training on data with similar acquisition geometry

✓ LandSAT external reference

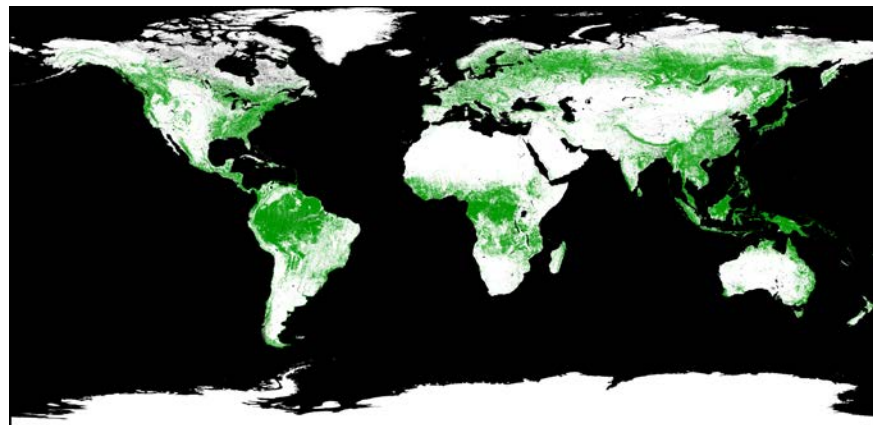
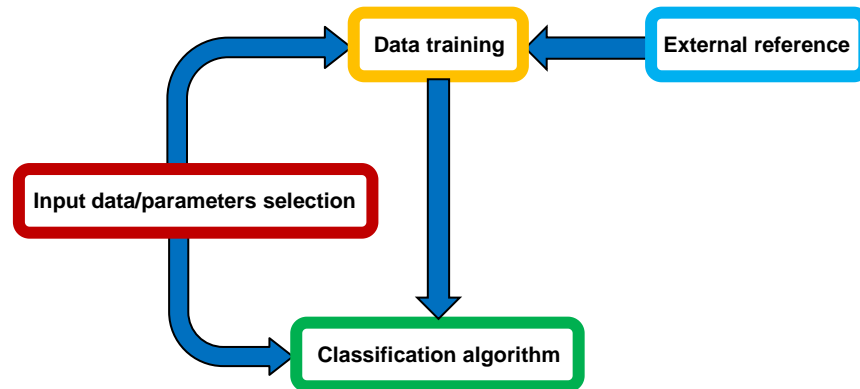
✓ QuickLook (QL) data:  
multilooked and re-quantized

✓ Ground resolution **50 m x 50 m**

Please refer to this talk:

*A Global Forest/Non-Forest Map from TanDEM-X Interferometric Data*

Paola Rizzoli, Michele Martone, Christopher Wecklich, Carolina Gonzalez, José-Luis Bueso-Bello, Gerhard Krieger, and Manfred Zink



- Introduction
- **Motivation of the work**
- Non-Local filtering
- Proposed framework and Experimental Result
- Open points

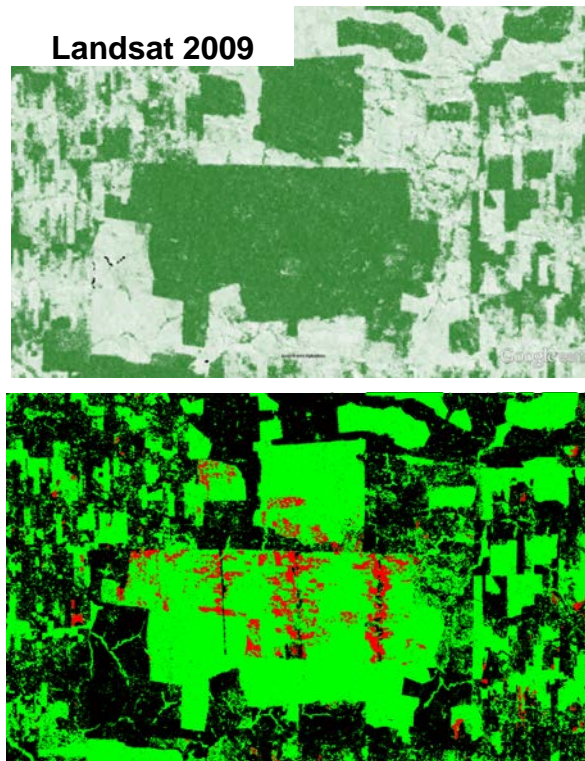




## Motivation of the work

➤ Improve the Forest Map resolution

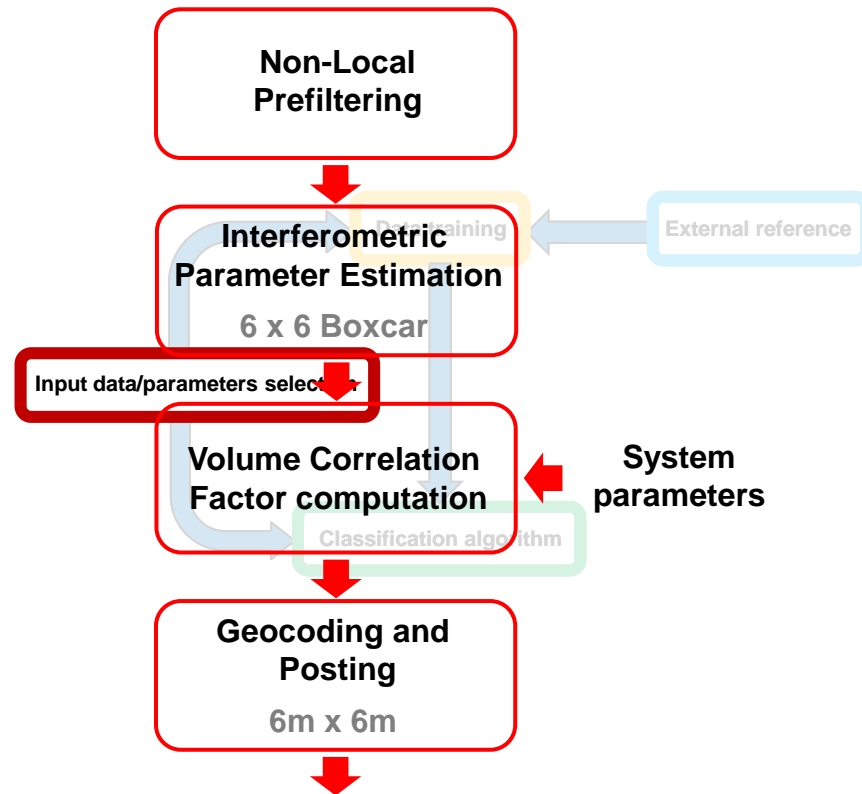
- Provide a map product that fully benefits of the TanDEM-X system high resolution
- Allow new applications as the deforestation monitoring



# Motivation of the work

➤ Improve the Forest Map resolution

- Interferometric parameter estimation: amplitude and coherence
- ML estimator on rectangular window: from 121 to 36 looks
- Unwanted effects:
  - biased Coherence
  - stronger Noise Power
- Increase the ENL with resolution preserving techniques: **Non-Local Filtering**





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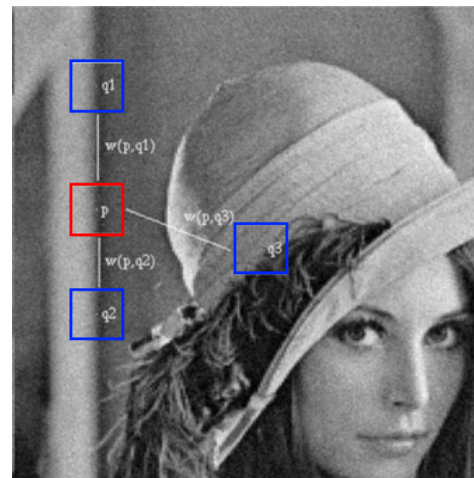


# Non-Local Filtering

- Current pixel estimated from pixels with the most similar context
- For each pixel in the image:
  - Consider the surrounding patch
  - Look for the most similar patches according to a similarity distance
  - Use the patch central pixel in the estimation
- Weighted average:

$$\widehat{x}_p = \sum_{\omega(p)} w(p, q_i) \cdot x_{q_i}$$

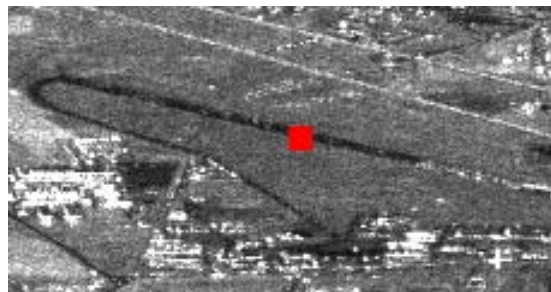
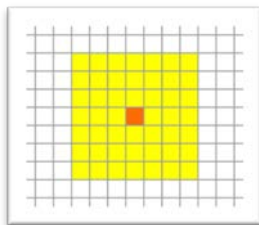
- *weights proportional to the similarity distance*
- *x pixel amplitude*
- *p current pixel*
- *q comparison pixel*



# Non-Local Filtering in SAR images

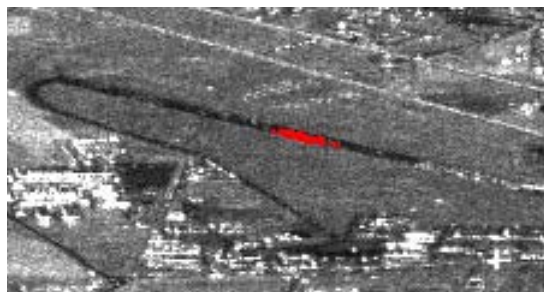
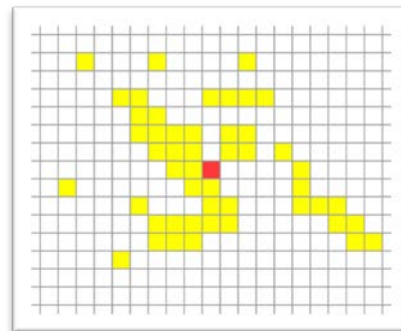
## Local window

*Closest pixels*



## Non-local window

*Pixels with the most similar context*



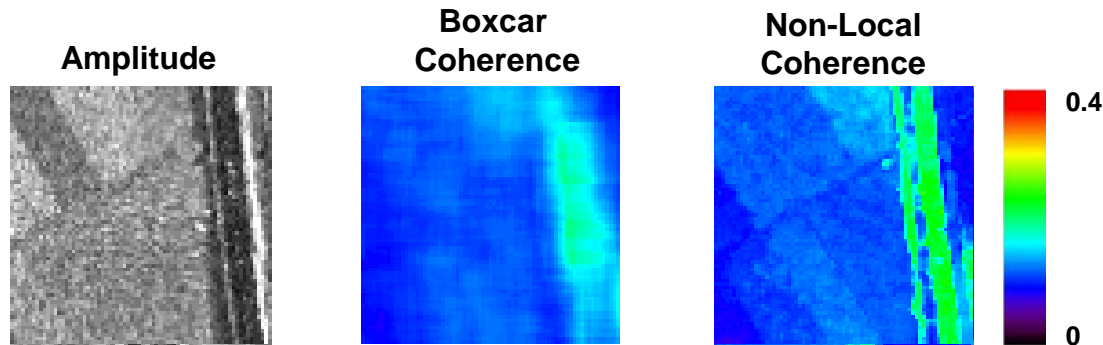
- current pixel
- (N-1) averaged pixels



# Non-Local Filtering in SAR Interferometry

Effects on coherence estimation:

- ✓ Increases the number of looks and reduces the coherence bias
- ✓ Avoid to spread the coherence of punctual strong scatterers
- ✓ Preserve the edges between areas with different backscattering properties

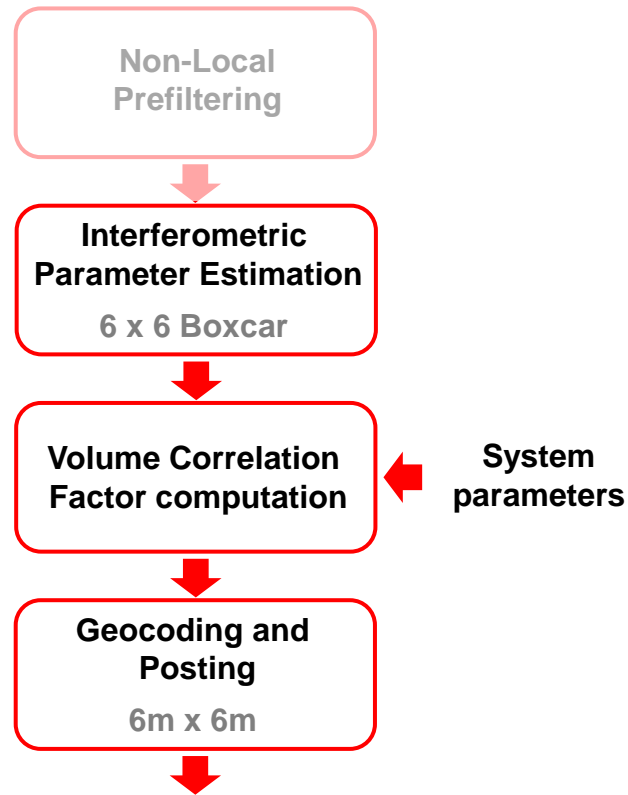


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# Proposed framework for TDX Forest Map generation

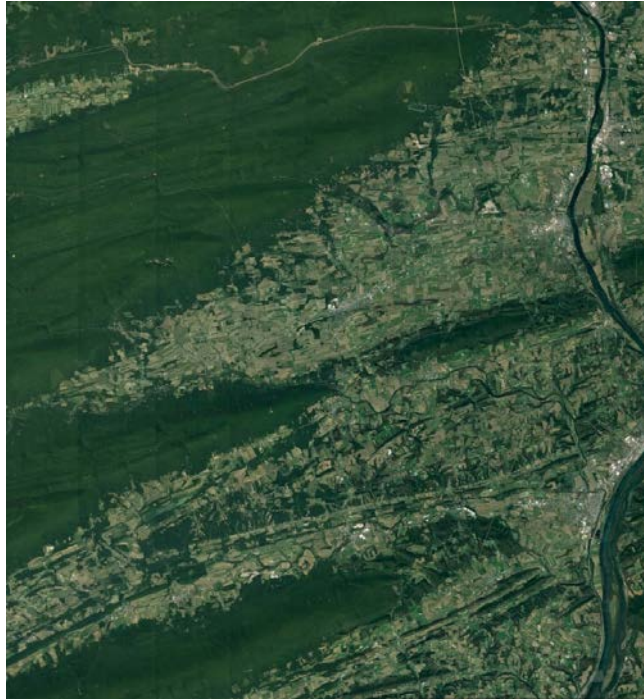
- Performance comparison:  
with vs without prefiltering
  - Boxcar 6x6 px
  - *NLSAR*  
patch: 7x7 px  
search window: 25x25 px
- Data: TanDEM-X pair on Pennsylvania
- Reference: 1m x 1m resolution  
Ground Truth available  
(Lidar + Optic)



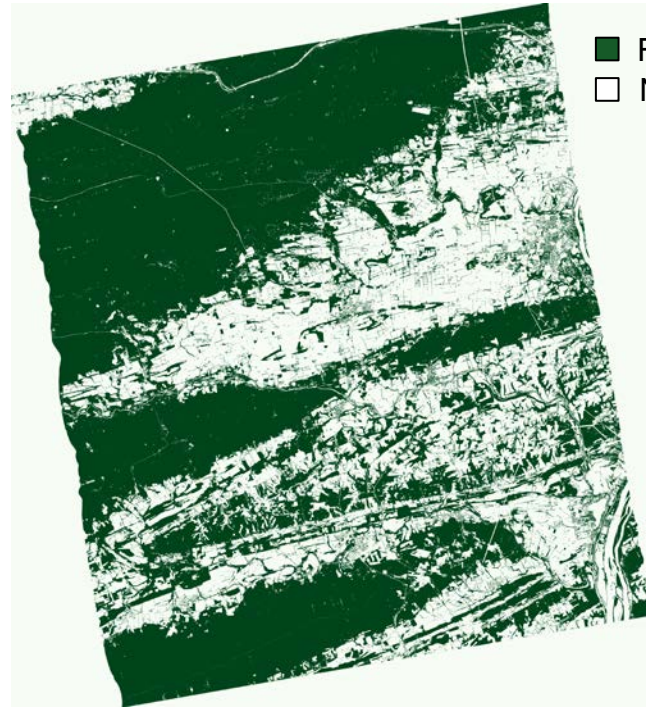


# Experimental result

Optical (Google Earth)



Reference

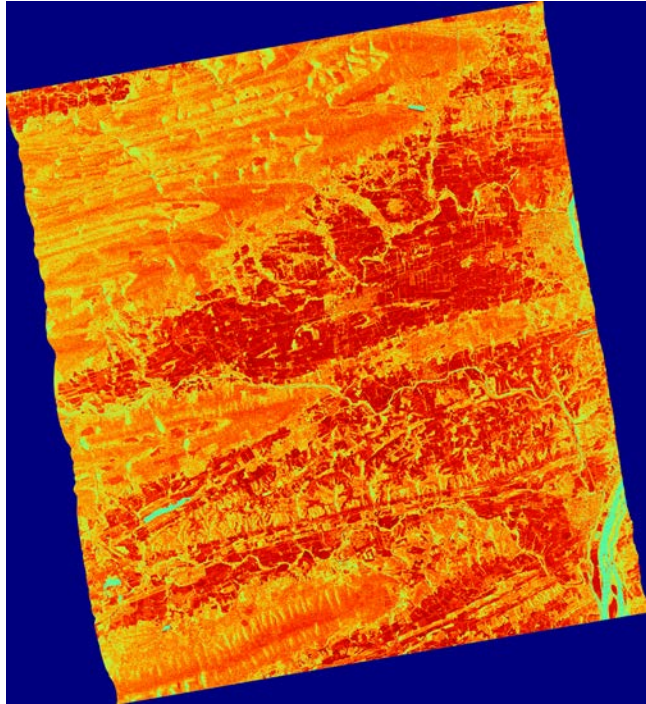


- Forest
- Non-Forest

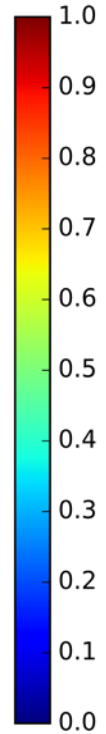
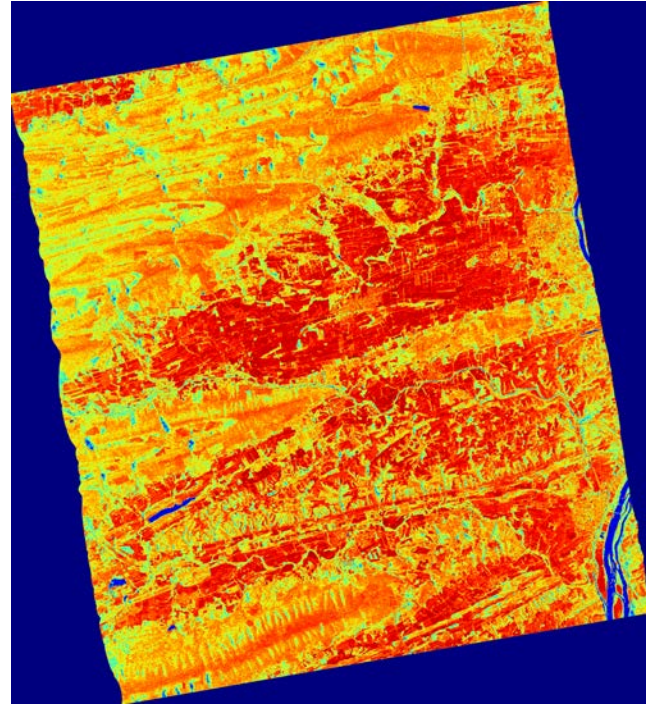


# Experimental result: Interferometric Coherence

No Pre-filtering



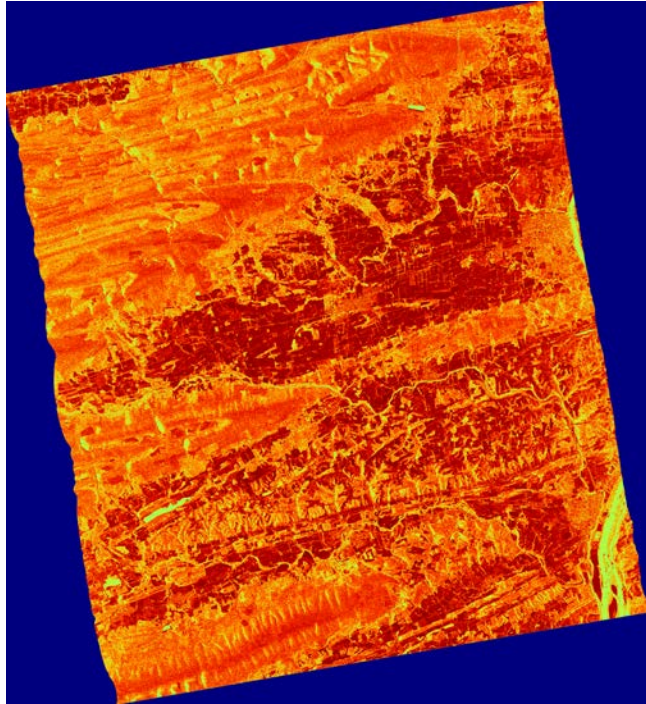
With Pre-filtering



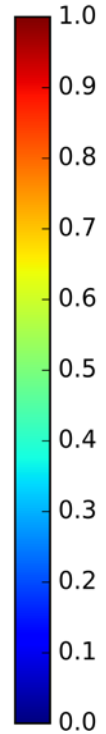
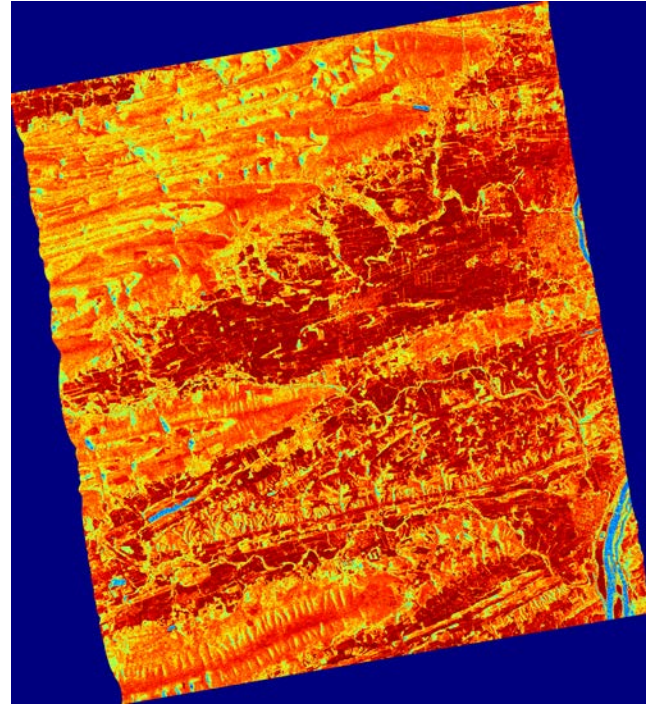


# Experimental result: Volume Correlation Factor

No Pre-filtering

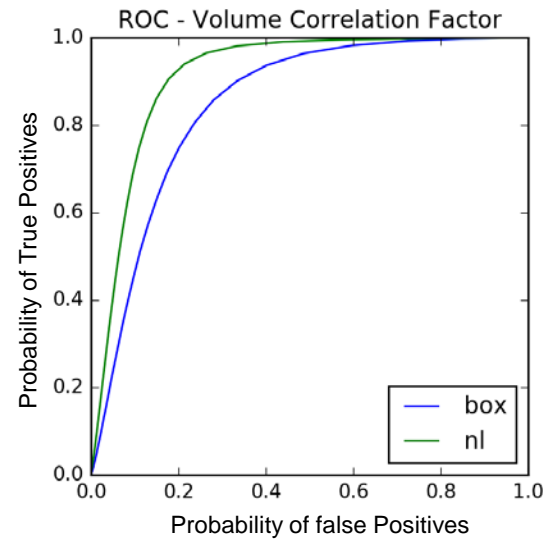
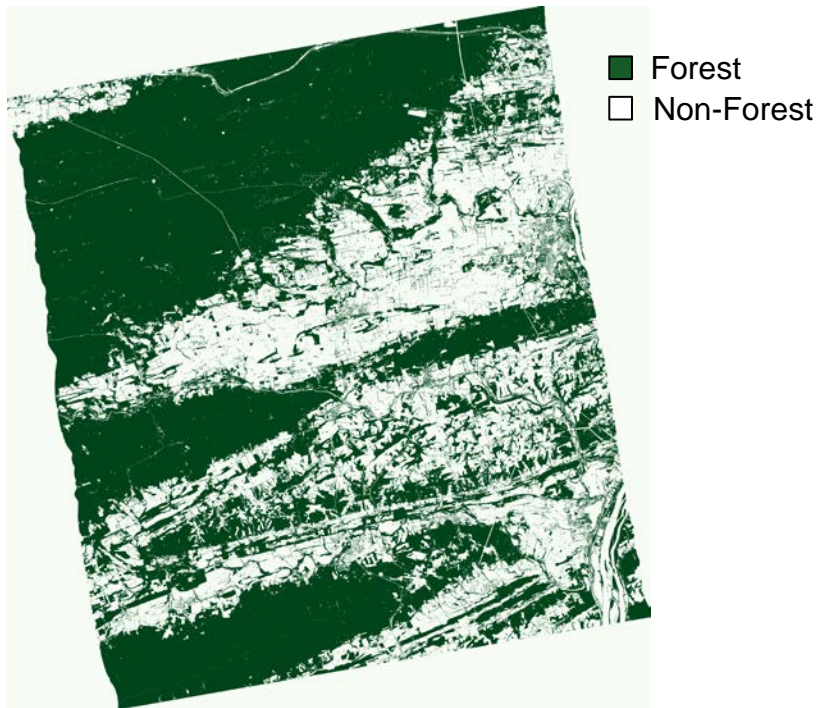


With Pre-filtering



# Experimental result

Reference



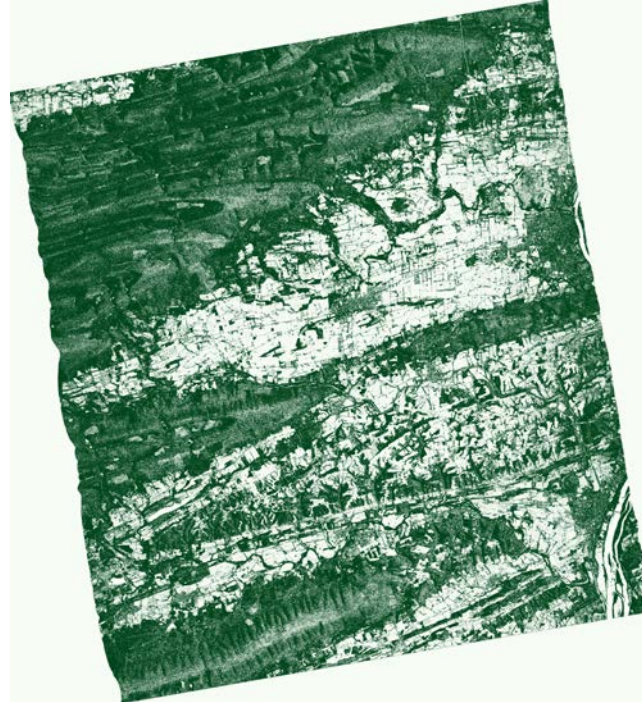


# Experimental result: Binary Classification

Reference



Without Pre-filtering



- Forest
- Non-Forest



# Experimental result: Binary Classification

Reference



With Pre-filtering



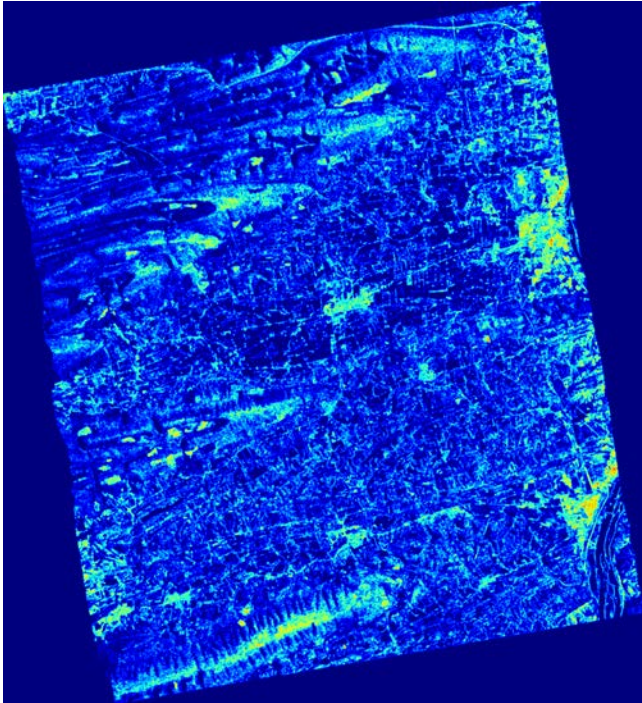
- Forest
- Non-Forest



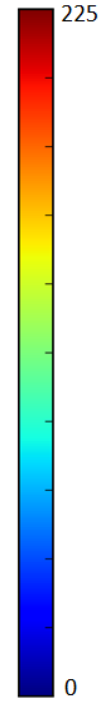
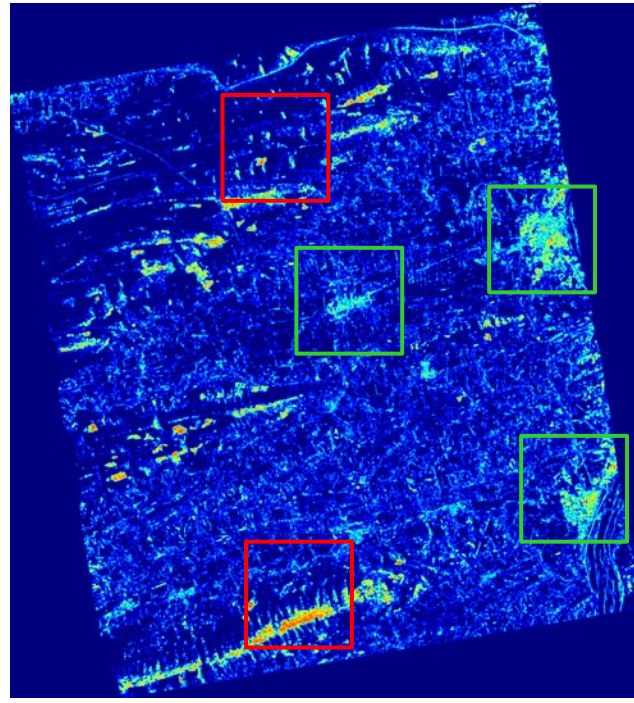


# Experimental result: Binary Classification Error

No Pre-filtering



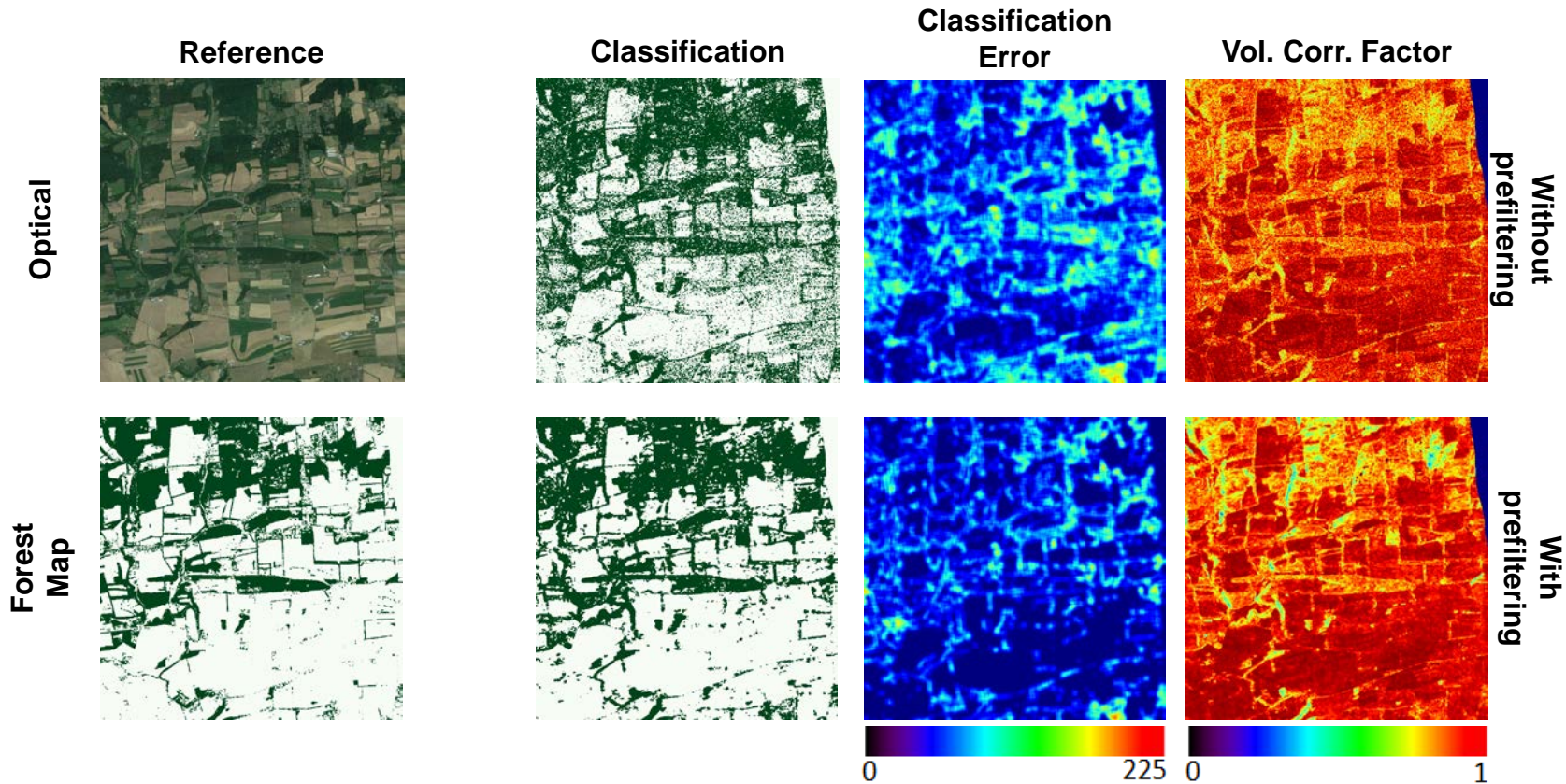
With Pre-filtering



or w.r.t. Reference  
the Reference

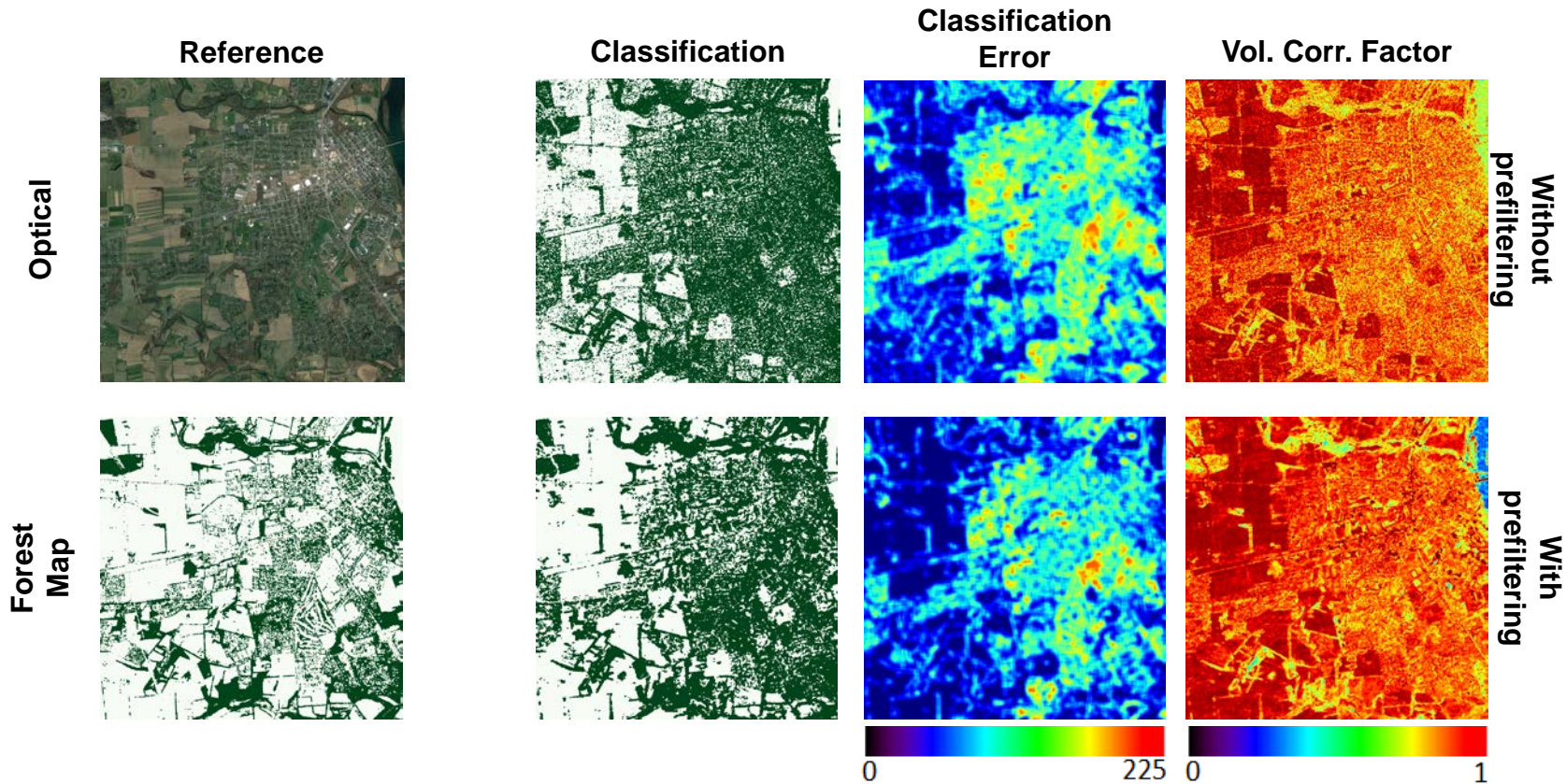


# Experimental result: crop

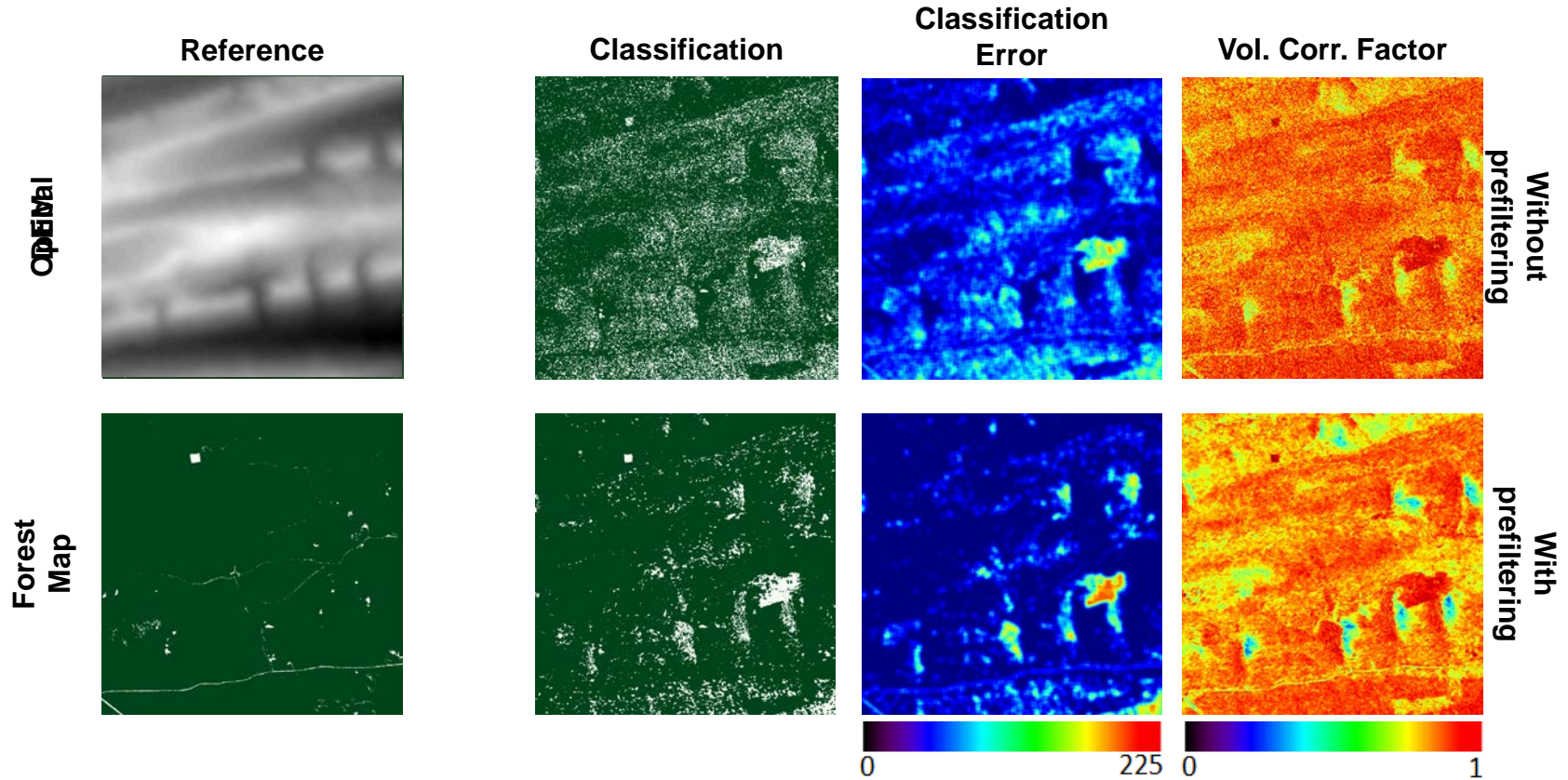




# Experimental result: crop on the city



# Experimental result: crop



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## Open points

- Exploitation of spatial similarities for classification refinement
- Investigation of the nonlocal for other features, such as the Intensity, for classification purpose
- Further investigation on Region of Interest such as cities and areas with strong topography
- Investigation at full resolution with a constant Number of Looks
- Further investigation on forest density





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Knowledge for Tomorrow



