



# EAS

ENVI ANALYTICS SYMPOSIUM



# Fusing SAR and Optical information to solve geospatial problems

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# Fusion of SAR and Optical

information

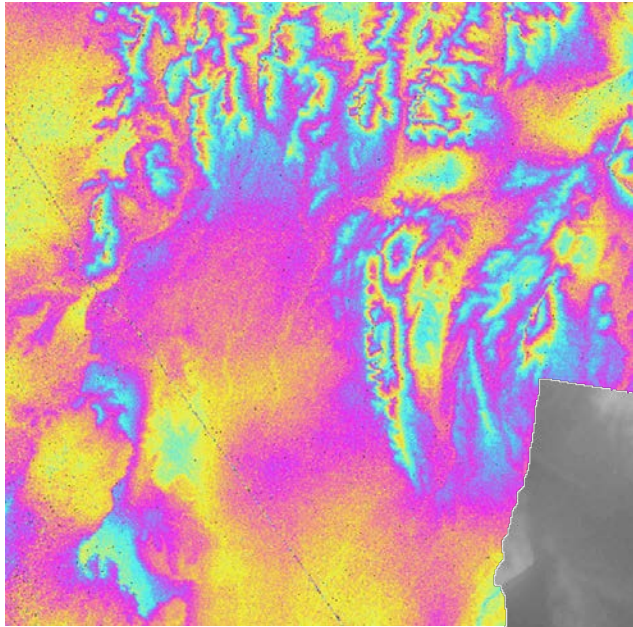
instead of

data

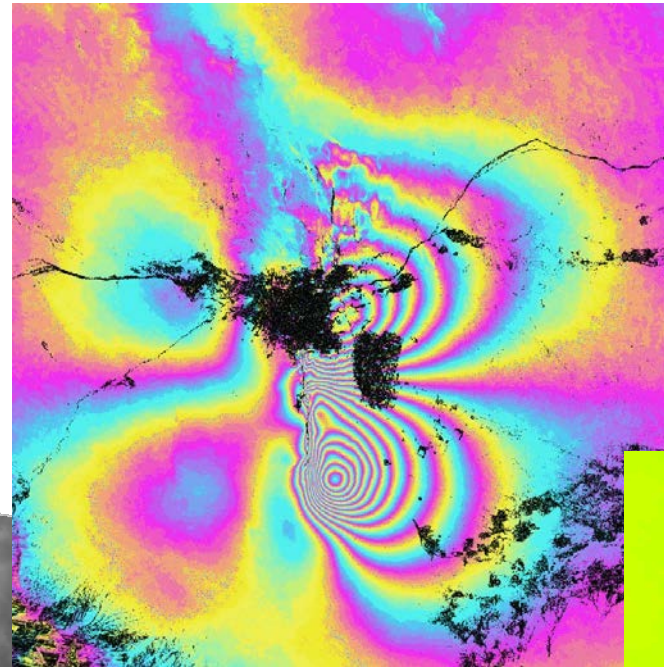
# Geometry

- Improving small terrain displacement estimation
- Improving geolocation accuracy

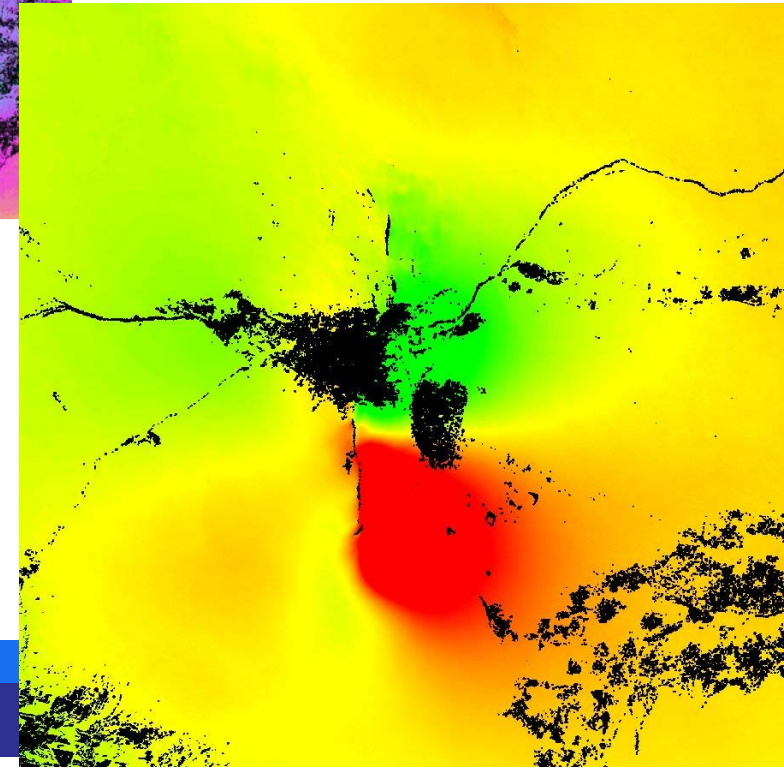
# SAR Interferometry is sensitive to height and displacement



DEM



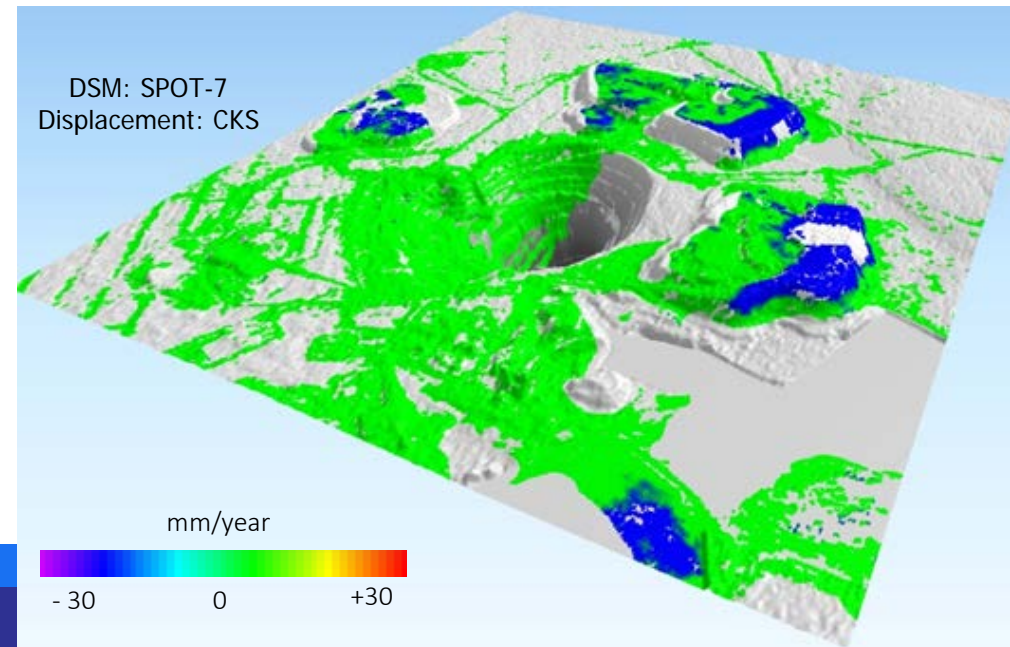
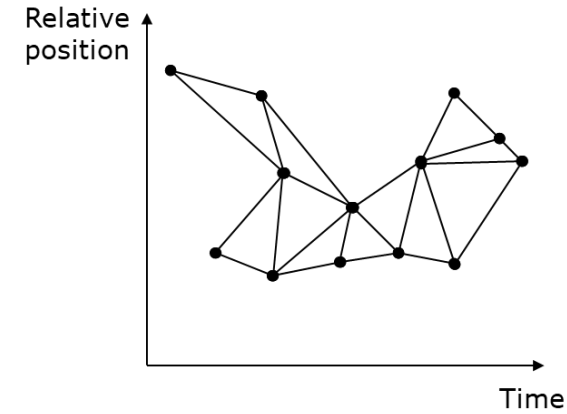
Displacement map



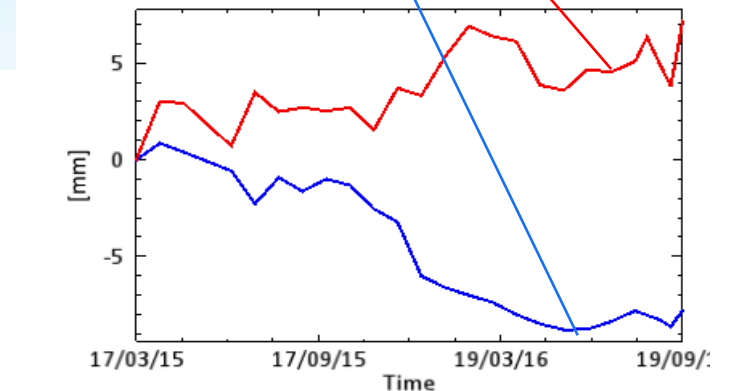
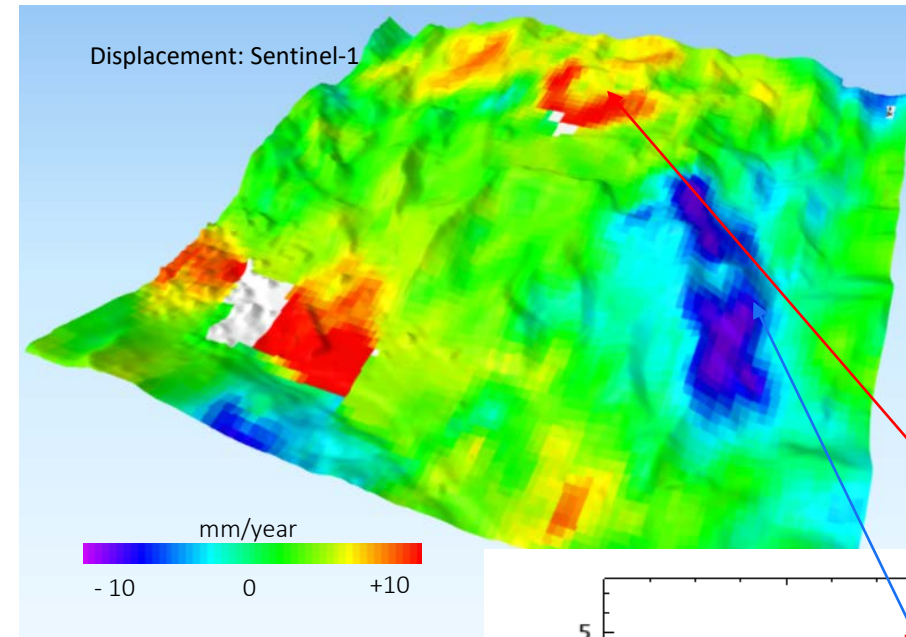
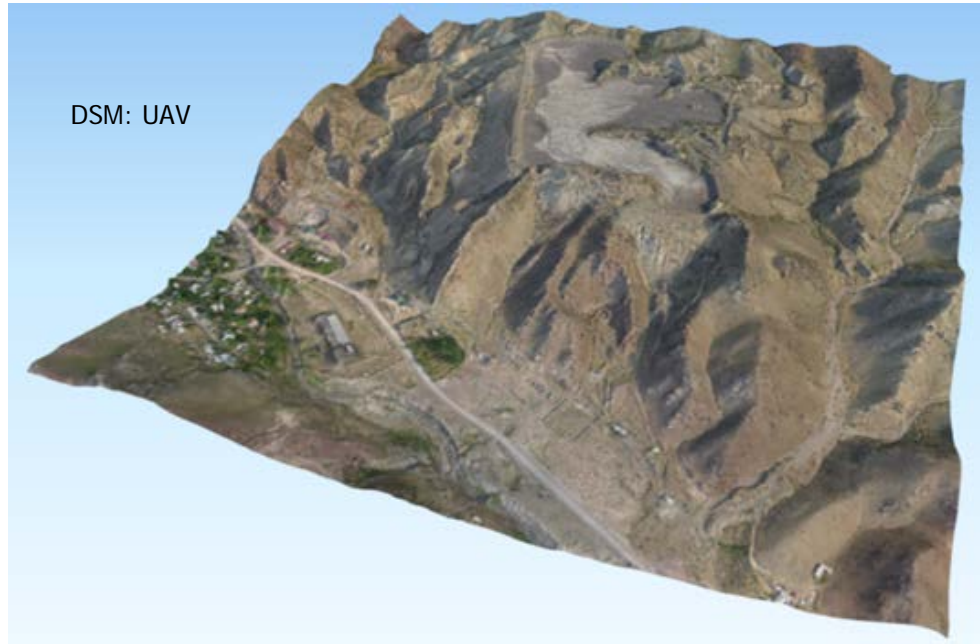


# Separating height and displacement

- If enough SAR data (20+) are available, separation is possible and accurate from SAR data only.
- If not, external information (e.g. DEM) is needed



# Separating height and displacement

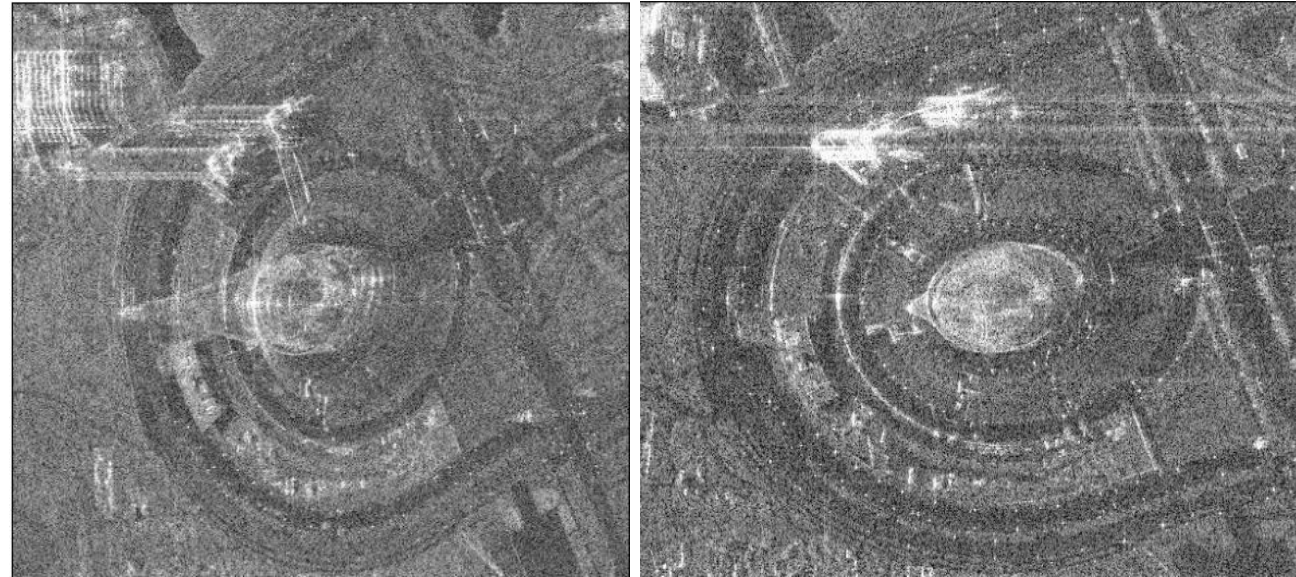
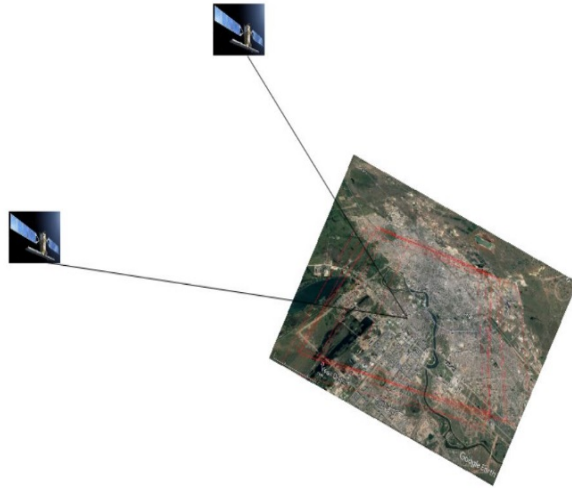


# Improving Optical geometry with SAR

- Starting point: precise optical data orthorectification requires precise Ground Control Points since geometry (attitude) of optical sensors (rational polynomials) is not very precise
- SAR geometry is very accurate. Precise geolocation can be obtained with Interferometric as well as with Stereo techniques without any GCPs
- Automatic Optical – SAR matching can work well for feature points

## Limitations of single pair stereo radargrammetry

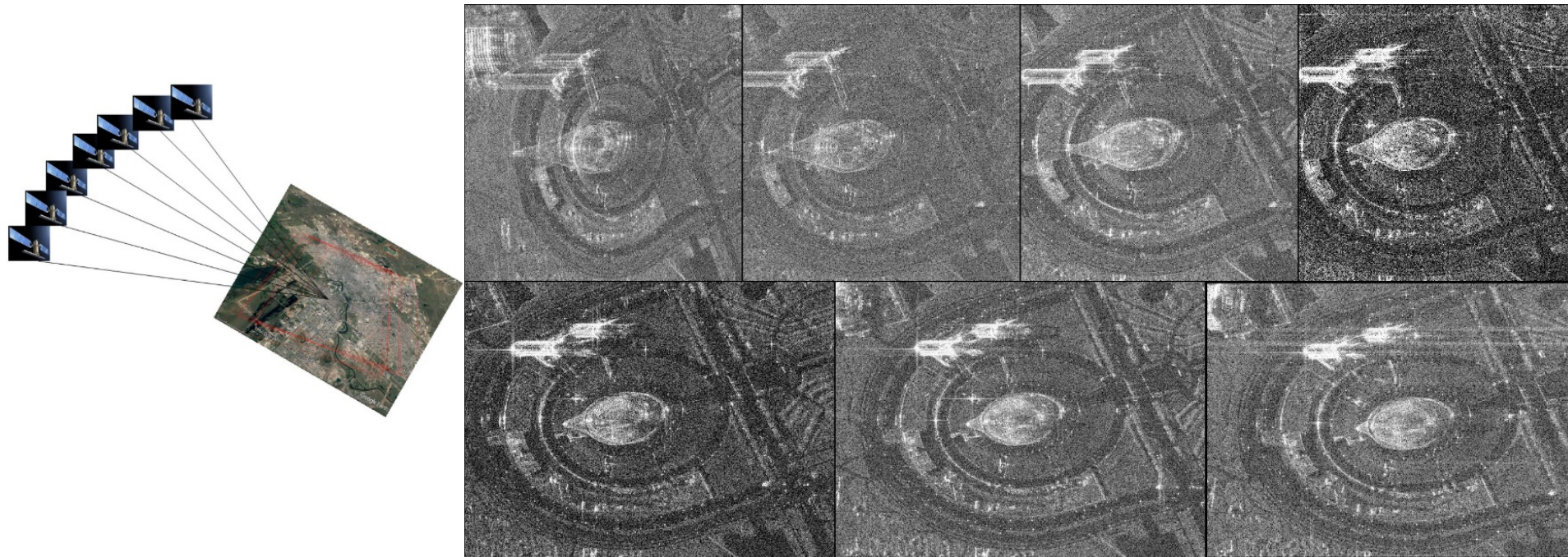
- A large baseline is required for a precise height estimate.
- A large baseline causes matching to be increasingly difficult





# The FanSAR approach

- A multi-angular approach enables matching of large baseline pairs tracking the point along the SAR «fan».

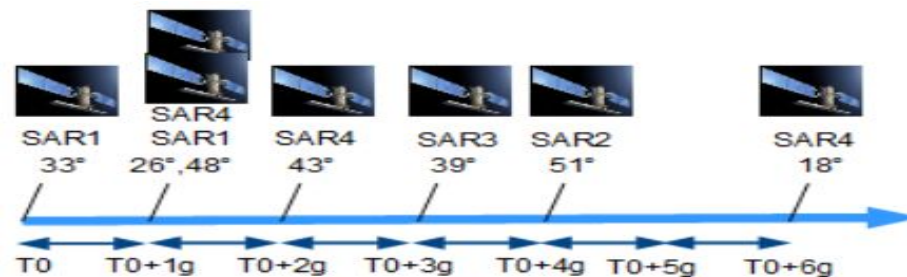




# FanSAR series acquisition time



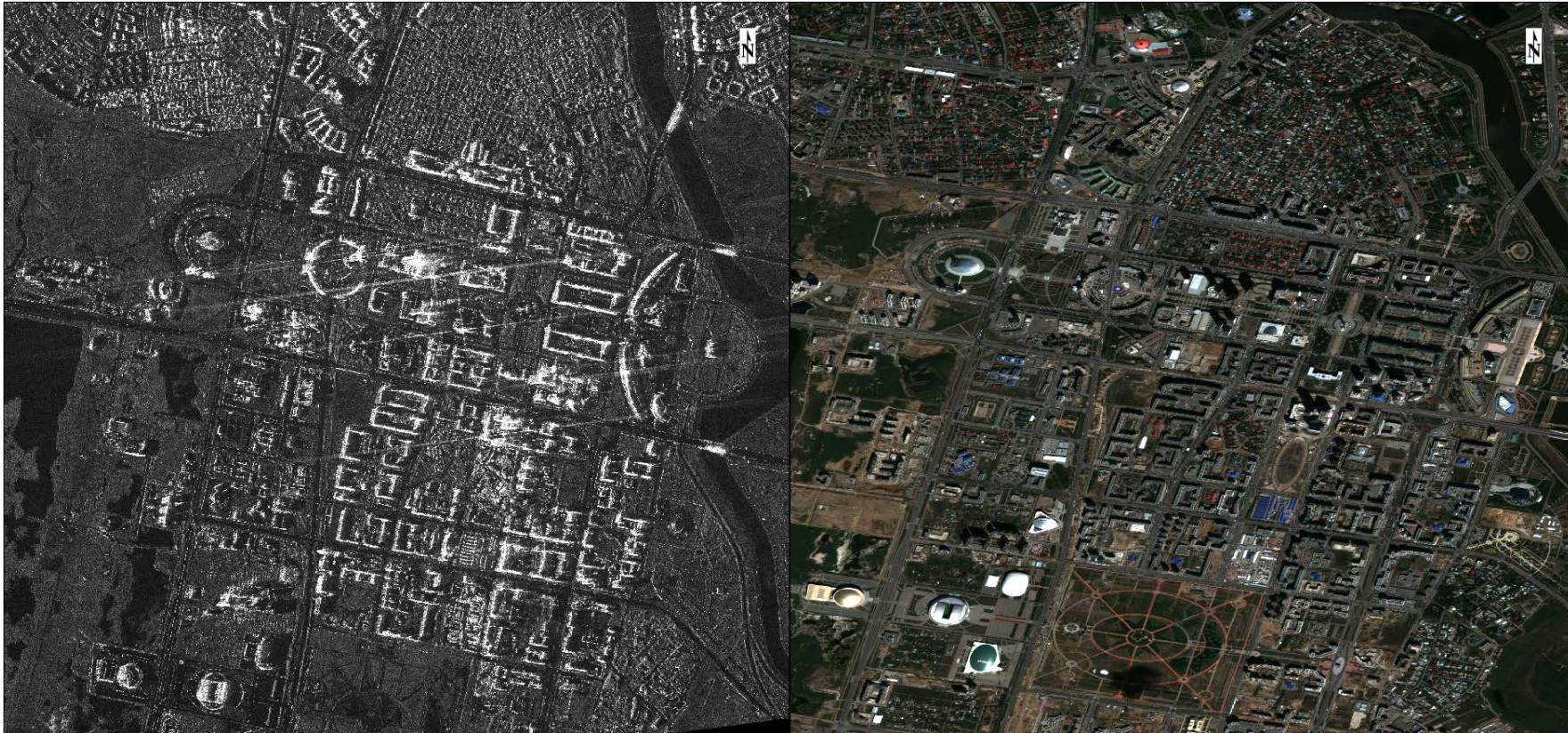
At the latitude of Astana  
(Nursultan)  $51^{\circ}10'48''$   
7 angles in 6 days with  
Cosmo-SkyMed.



Acquisition interval of FanSAR acquisitions is shorter than for InSAR stacks



# Automatic optical-SAR matching by mutual information

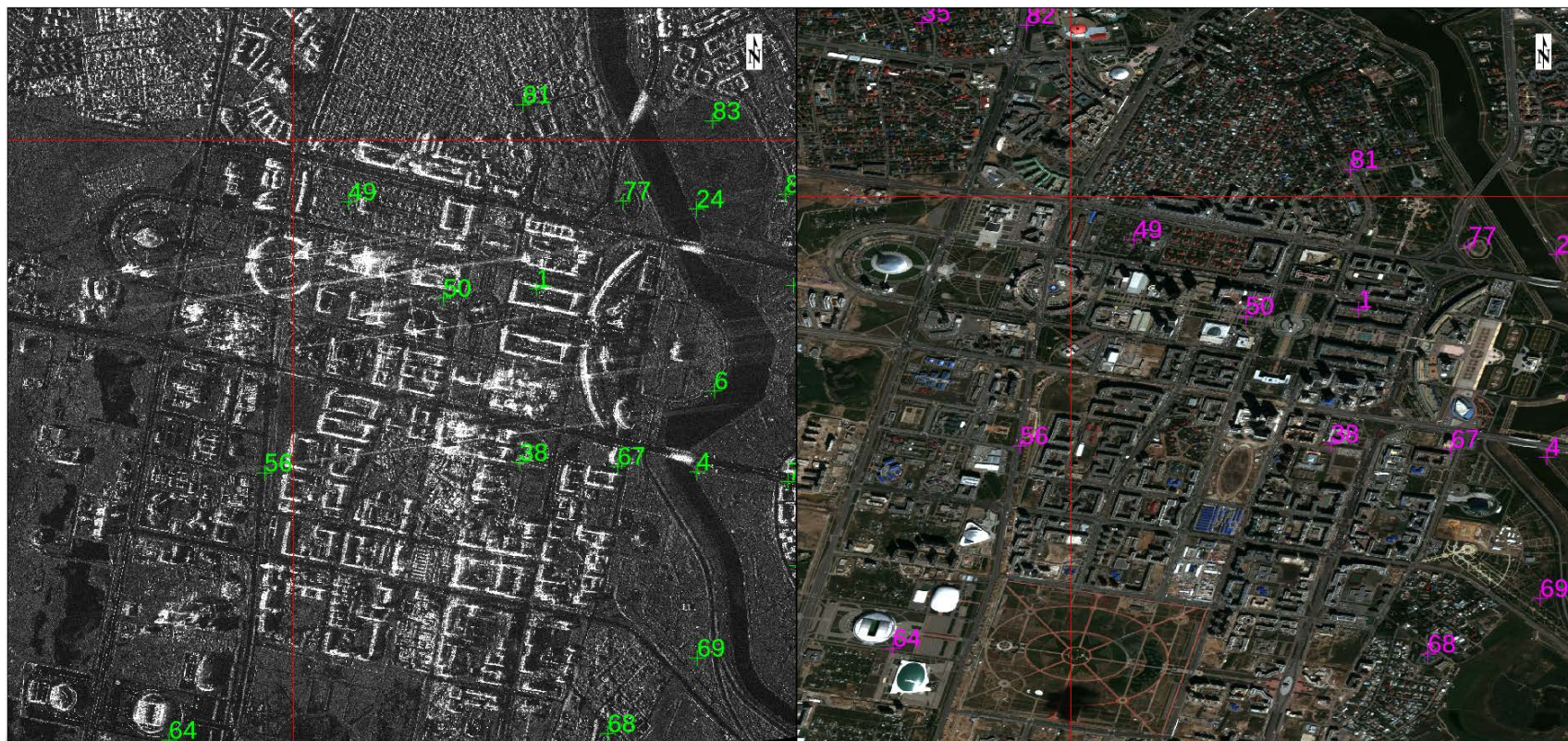


Cosmo-skymed SAR image

Pleyades optical image



# Automatic optical-SAR matching by mutual information



Cosmo-skymed SAR image

Pleyades optical image



## FanSAR for accurate DEM generation



A nice by-product

## Thematic information

- Improving deforestation monitoring
- Improving land-use / land-cover mapping



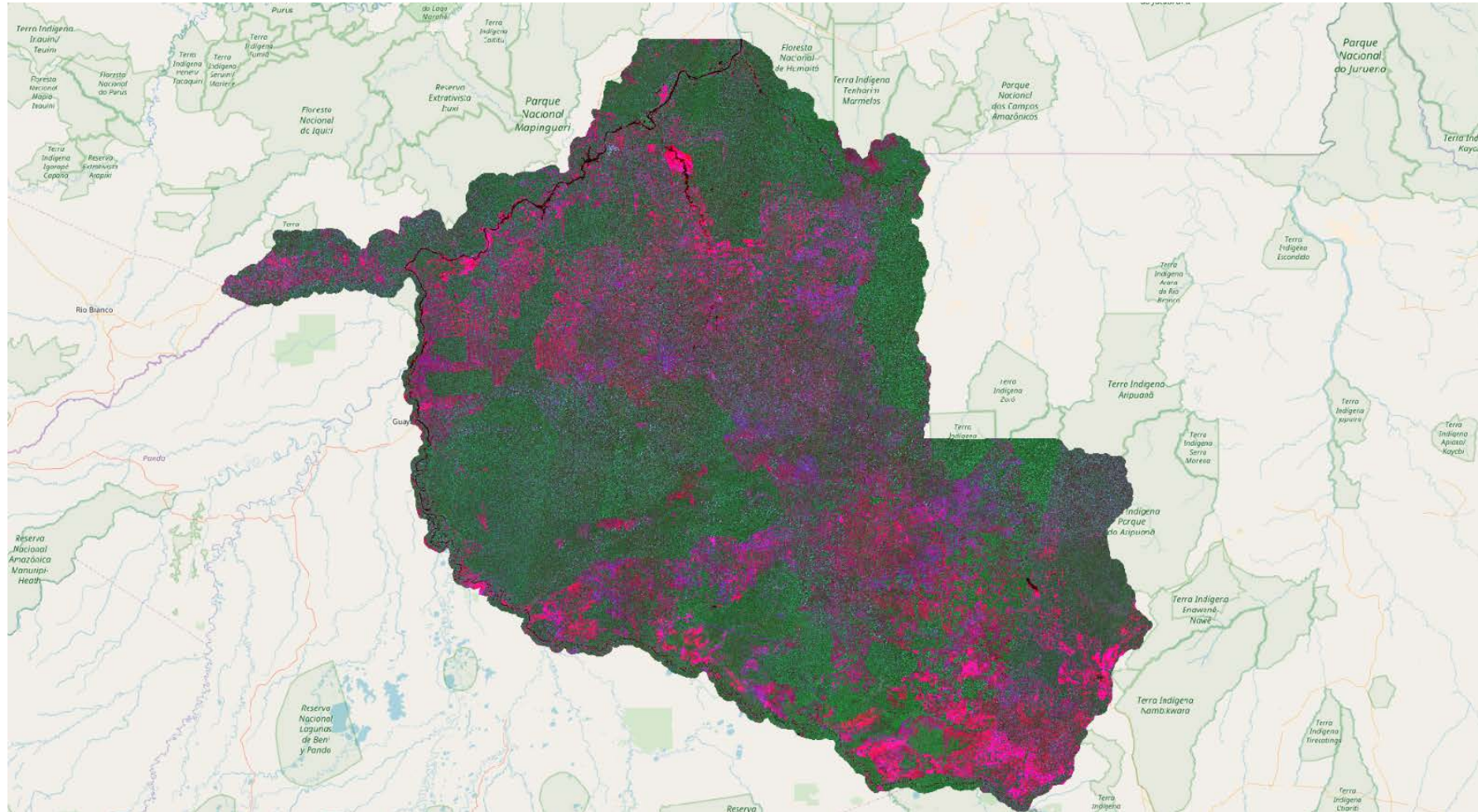
# Rondônia (Porto Velho) weather (wikipedia)

Climate data for Porto Velho (1961–1990) <span>[hide]</span>													
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C (°F)	37.2 (99)	36.4 (97.5)	38.7 (101.7)	37.1 (98.8)	36.8 (98.2)	38.8 (101.8)	37.9 (100.2)	40.9 (105.6)	39.4 (102.9)	40.0 (104)	39.7 (103.5)	38.0 (100.4)	40.9 (105.6)
Average high °C (°F)	31.3 (88.3)	31.5 (88.7)	31.7 (89.1)	31.6 (88.9)	31.6 (88.9)	31.7 (89.1)	32.7 (90.9)	34.3 (93.7)	34.0 (93.2)	33.3 (91.9)	32.6 (90.7)	31.6 (88.9)	32.3 (90.1)
Daily mean °C (°F)	25.5 (77.9)	25.5 (77.9)	25.6 (78.1)	25.7 (78.3)	25.3 (77.5)	24.7 (76.5)	24.6 (76.3)	25.9 (78.6)	26.2 (79.2)	26.1 (79)	26.0 (78.8)	25.5 (77.9)	25.6 (78.1)
Average low °C (°F)	21.7 (71.1)	21.8 (71.2)	21.8 (71.2)	21.9 (71.4)	21.0 (69.8)	19.2 (66.6)	18.3 (64.9)	19.0 (66.2)	20.8 (69.4)	21.8 (71.2)	22.0 (71.6)	22.0 (71.6)	20.9 (69.6)
Record low °C (°F)	14.4 (57.9)	15.4 (59.7)	12.0 (53.6)	12.8 (55)	12.0 (53.6)	11.8 (53.2)	7.4 (45.3)	10.0 (50)	12.1 (53.8)	17.7 (63.9)	18.1 (64.6)	11.0 (51.8)	7.4 (45.3)
Average rainfall mm (inches)	320.9 (12.634)	316.0 (12.441)	273.9 (10.783)	251.0 (9.882)	126.6 (4.984)	49.2 (1.937)	24.2 (0.953)	36.4 (1.433)	119.9 (4.72)	192.7 (7.587)	225.2 (8.866)	319.1 (12.563)	2,255.1 (88.783)
Average rainy days (≥ 1.0 mm)	19	19	20	17	11	4	3	4	11	13	16	19	156
Average relative humidity (%)	89	88	89.1	89	86	84.1	80	82	84	86	87	88.7	86.1
Mean monthly sunshine hours	107.1	98.3	124.0	140.1	183.7	226.7	259.7	234.0	186.8	166.7	137.1	124.2	1,988.4

Source: Brazilian National Institute of Meteorology (INMET).<sup>[2][6][7][3][8][9][10][5][4]</sup>

# Rondônia 9/2016 to 5/2017

- Coefficient of variation
- Mean
- Gradient



240'000 km<sup>2</sup>  
300 x 13 frames



## Sentinel-1 and Sentinel-2



Sentinel-2 8/2016



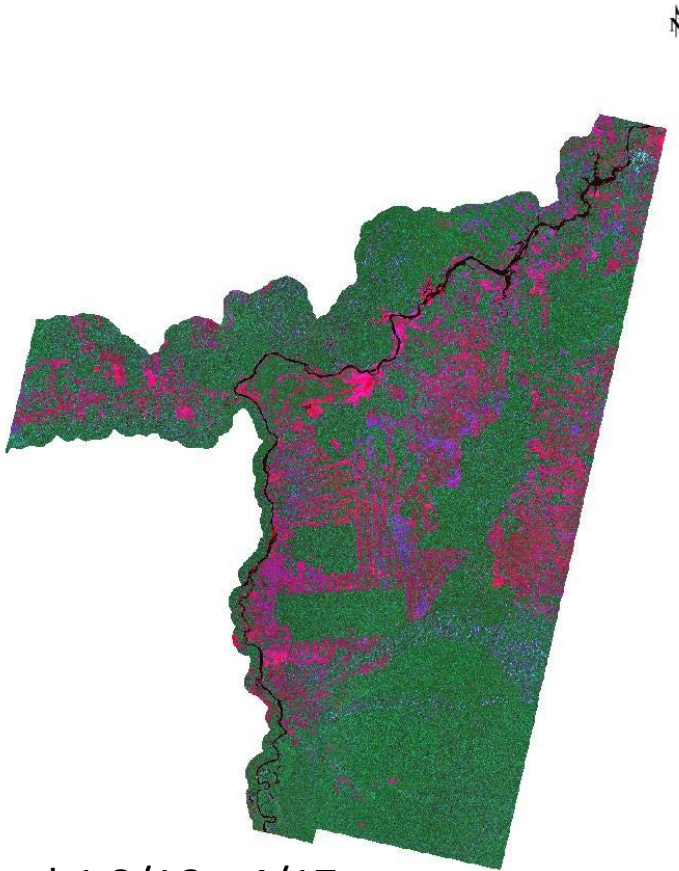
Sentinel-2 8/2017



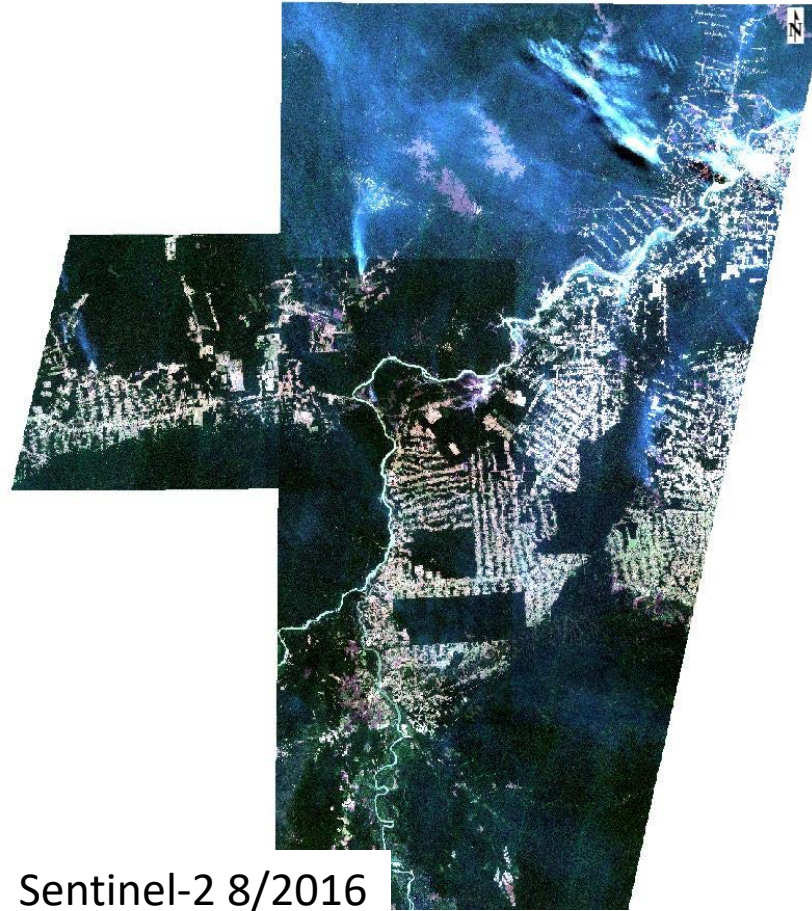
Sentinel-1 8/16 – 4/17



## Sentinel-1 and Sentinel-2



Sentinel-1 8/16 – 4/17



Sentinel-2 8/2016



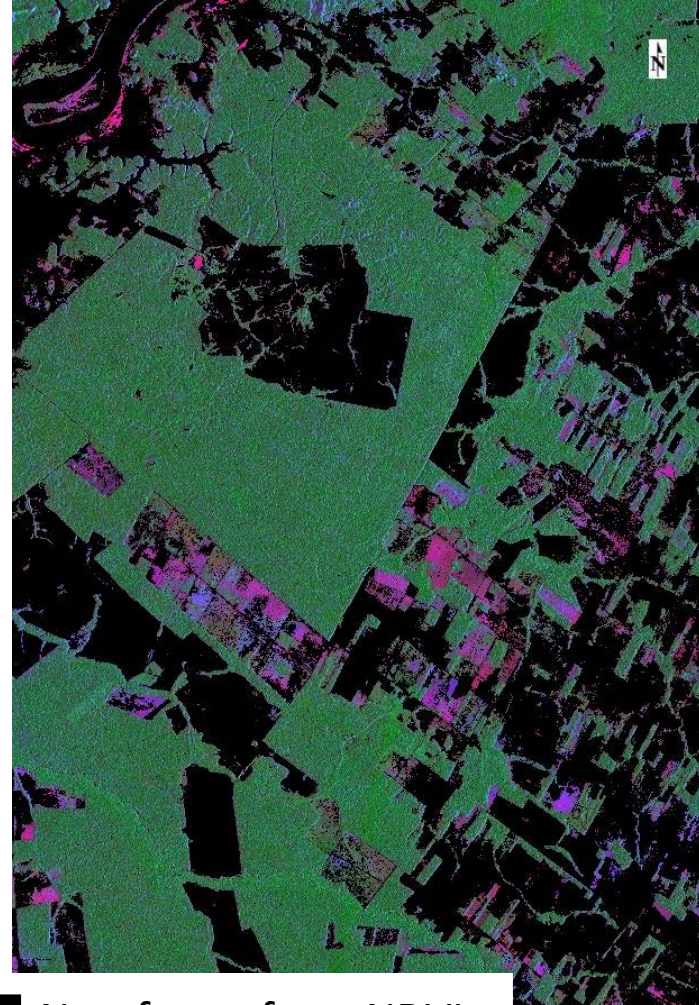
Sentinel-2 NDVI 8/2016



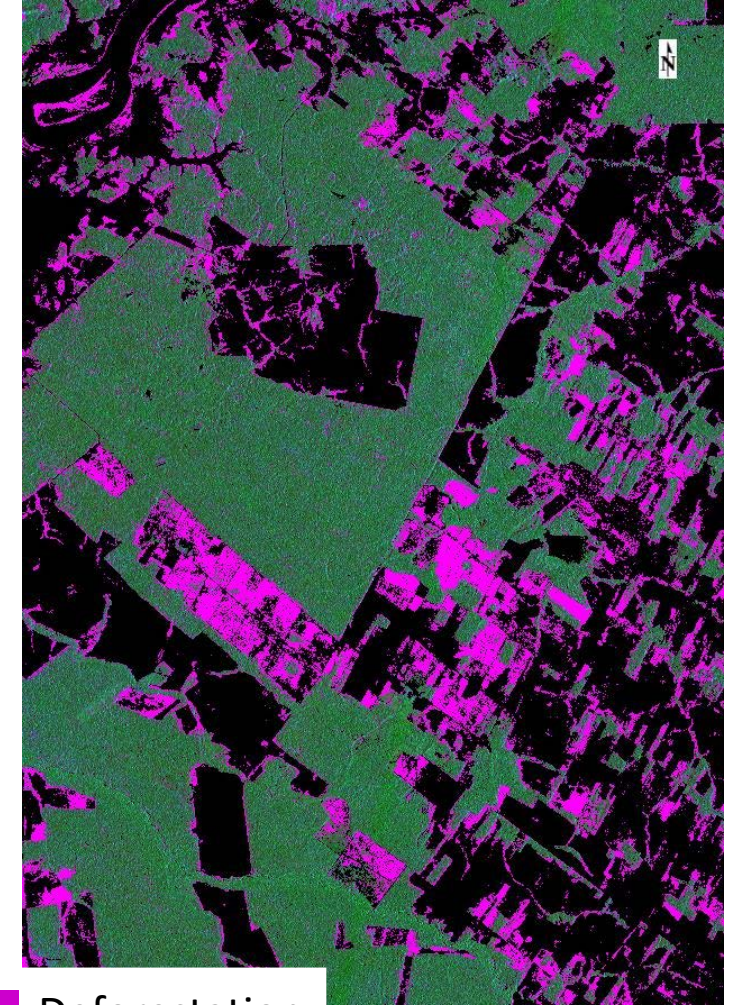
## Sentinel-1 and Sentinel-2



Sentinel-1 8/16 – 4/17



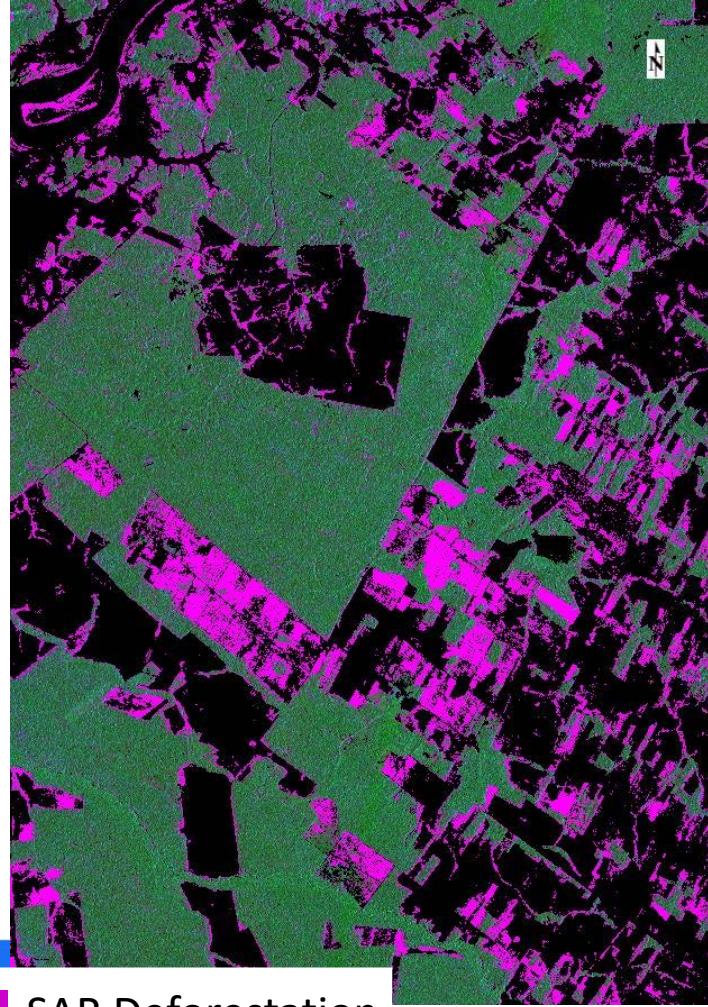
Non-forest from NDVI



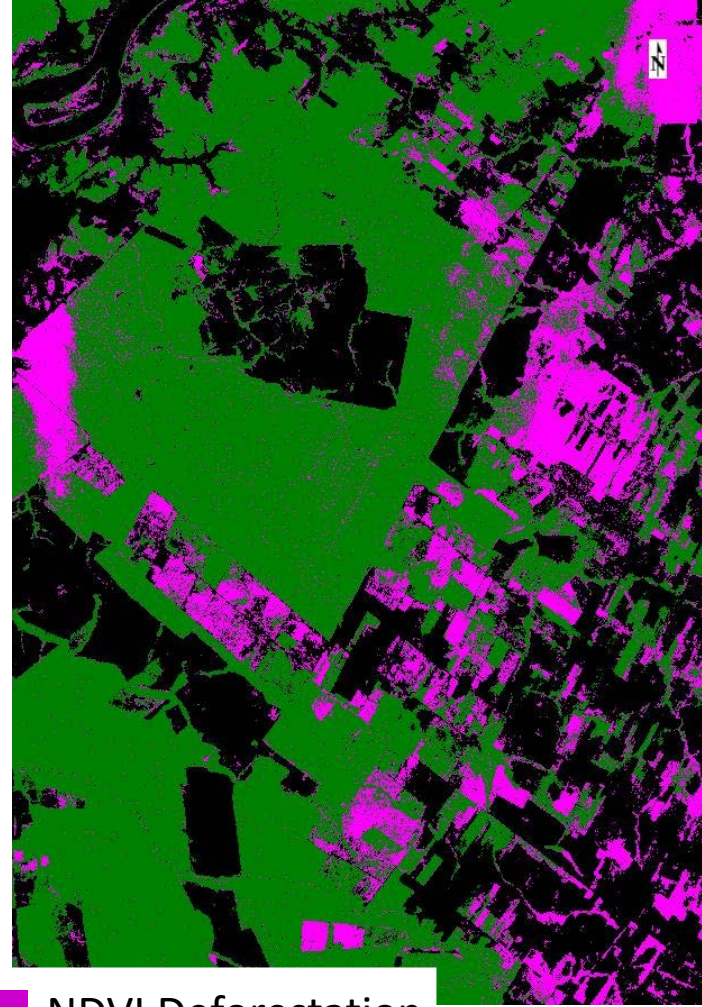
Deforestation



## Sentinel-1 and Sentinel-2



SAR Deforestation



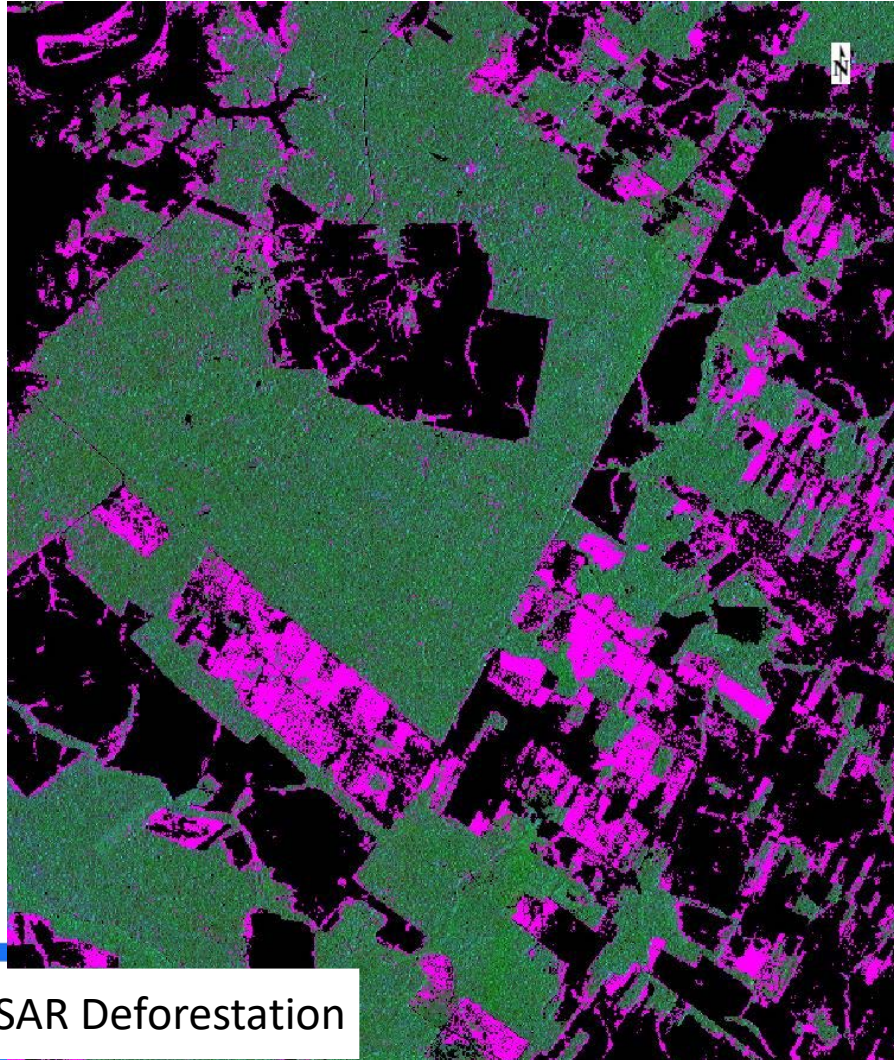
NDVI Deforestation



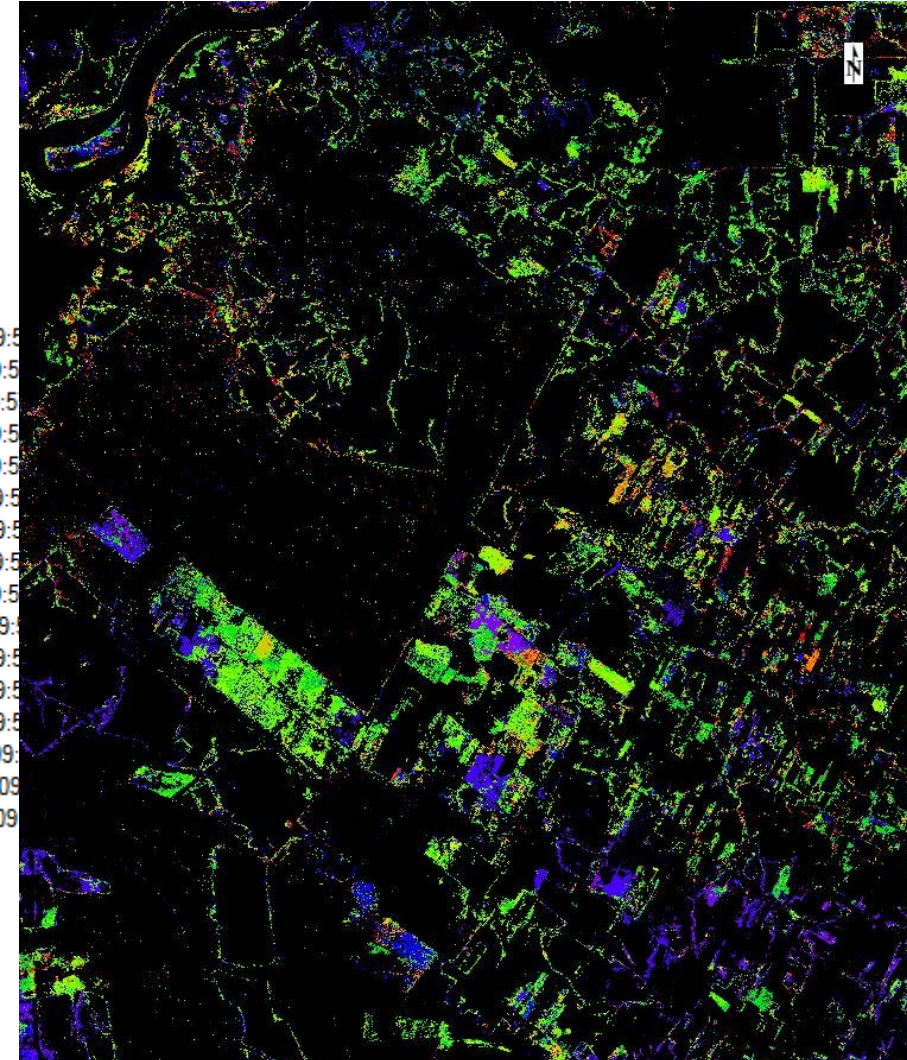
Sentinel-2 8/2017



# Sentinel-1 dates



<input type="checkbox"/>	0: Unclassified
<input checked="" type="checkbox"/>	1: 18-AUG-2016 09:56:57.61710299/06-AUG-2016 09:56:57.61710299
<input checked="" type="checkbox"/>	2: 11-SEP-2016 09:57:10.73546999/18-AUG-2016 09:56:57.61710299
<input checked="" type="checkbox"/>	3: 05-OCT-2016 09:57:00.06984300/11-SEP-2016 09:57:10.73546999
<input checked="" type="checkbox"/>	4: 17-OCT-2016 09:57:00.10247299/05-OCT-2016 09:57:00.06984300
<input checked="" type="checkbox"/>	5: 29-OCT-2016 09:57:00.26823400/17-OCT-2016 09:57:00.10247299
<input checked="" type="checkbox"/>	6: 10-NOV-2016 09:56:59.99791800/29-OCT-2016 09:57:00.26823400
<input checked="" type="checkbox"/>	7: 22-NOV-2016 09:56:59.86138000/10-NOV-2016 09:56:59.99791800
<input checked="" type="checkbox"/>	8: 16-DEC-2016 09:56:58.99469300/22-NOV-2016 09:56:59.86138000
<input checked="" type="checkbox"/>	9: 28-DEC-2016 09:56:58.72096800/16-DEC-2016 09:56:58.99469300
<input checked="" type="checkbox"/>	10: 09-JAN-2017 09:56:57.14071100/28-DEC-2016 09:56:58.72096800
<input checked="" type="checkbox"/>	11: 02-FEB-2017 09:56:56.50233699/09-JAN-2017 09:56:57.14071100
<input checked="" type="checkbox"/>	12: 14-FEB-2017 09:56:56.21764600/02-FEB-2017 09:56:56.50233699
<input checked="" type="checkbox"/>	13: 26-FEB-2017 09:56:56.14916100/14-FEB-2017 09:56:56.21764600
<input checked="" type="checkbox"/>	14: 10-MAR-2017 09:56:56.24990199/26-FEB-2017 09:56:56.14916100
<input checked="" type="checkbox"/>	15: 22-MAR-2017 09:56:56.42609799/10-MAR-2017 09:56:56.24990199
<input checked="" type="checkbox"/>	16: 03-APR-2017 09:56:56.88815299/22-MAR-2017 09:56:56.42609799



SAR Deforestation

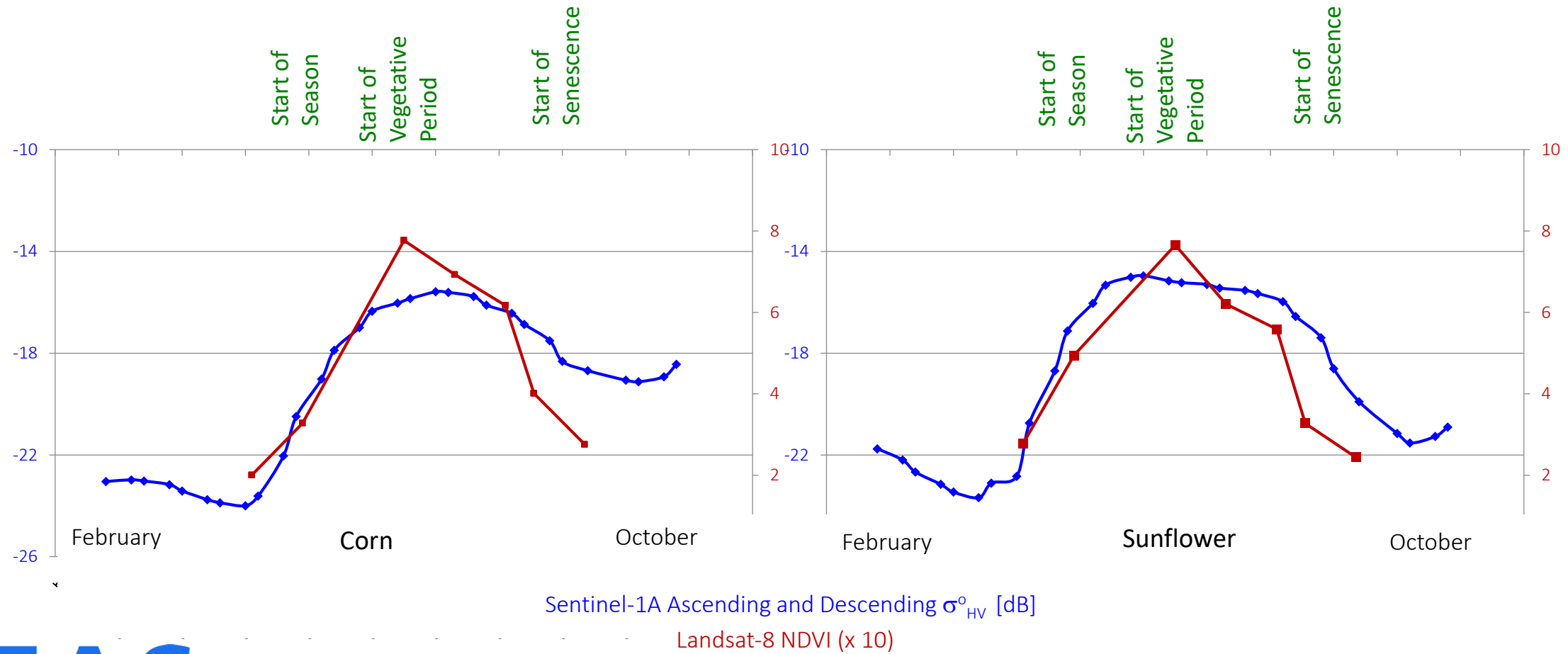




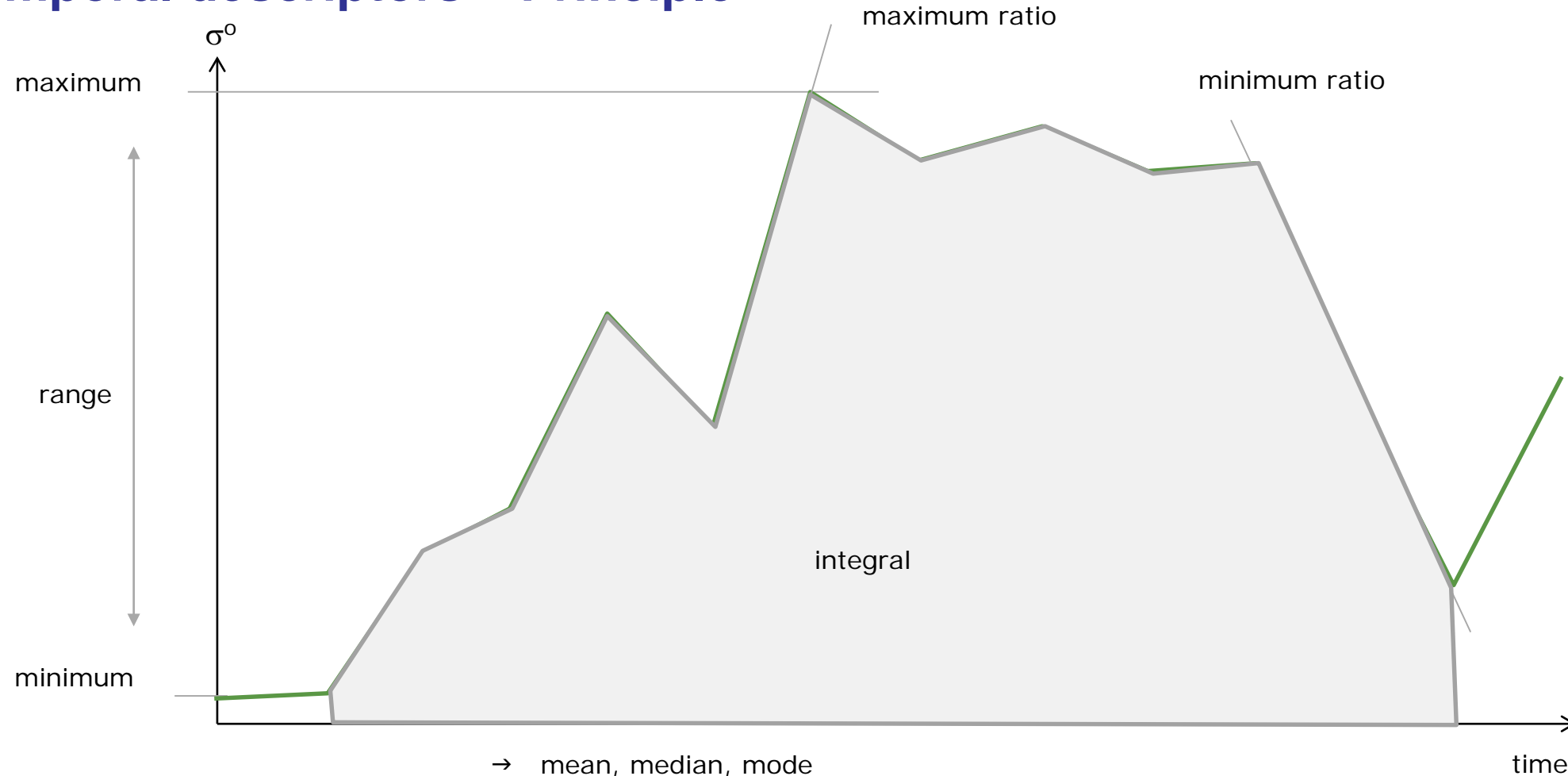
06 August 2016 09:56:57



# SAR and Optical time series



# Temporal descriptors – Principle



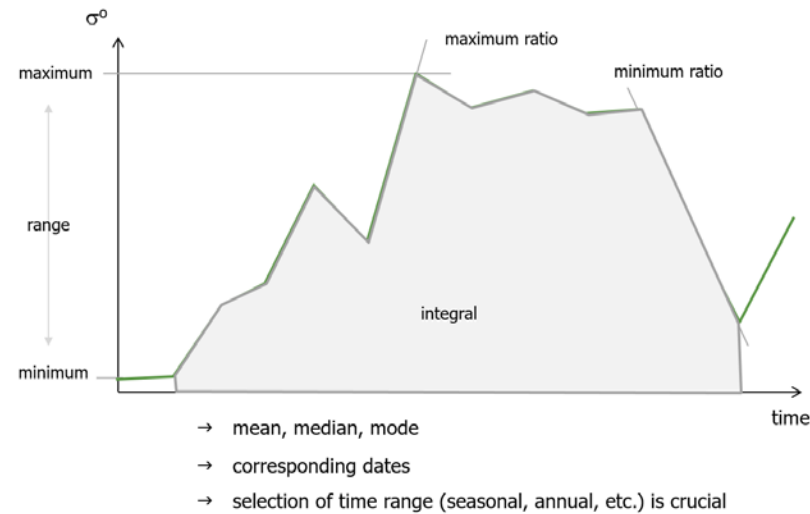
- mean, median, mode
- corresponding dates
- time range (seasonal, annual, etc.)



# How time-series can be interpreted?

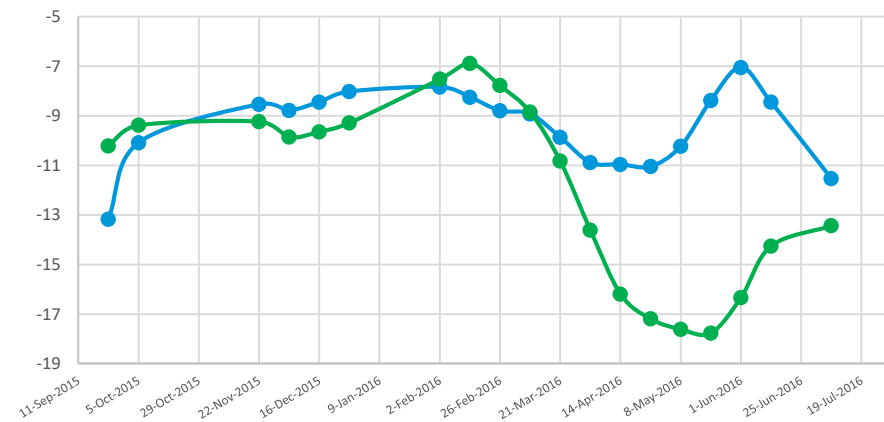
## 1. Temporal descriptors

- A priori information is not required
- Unsystematic acquisitions can be used

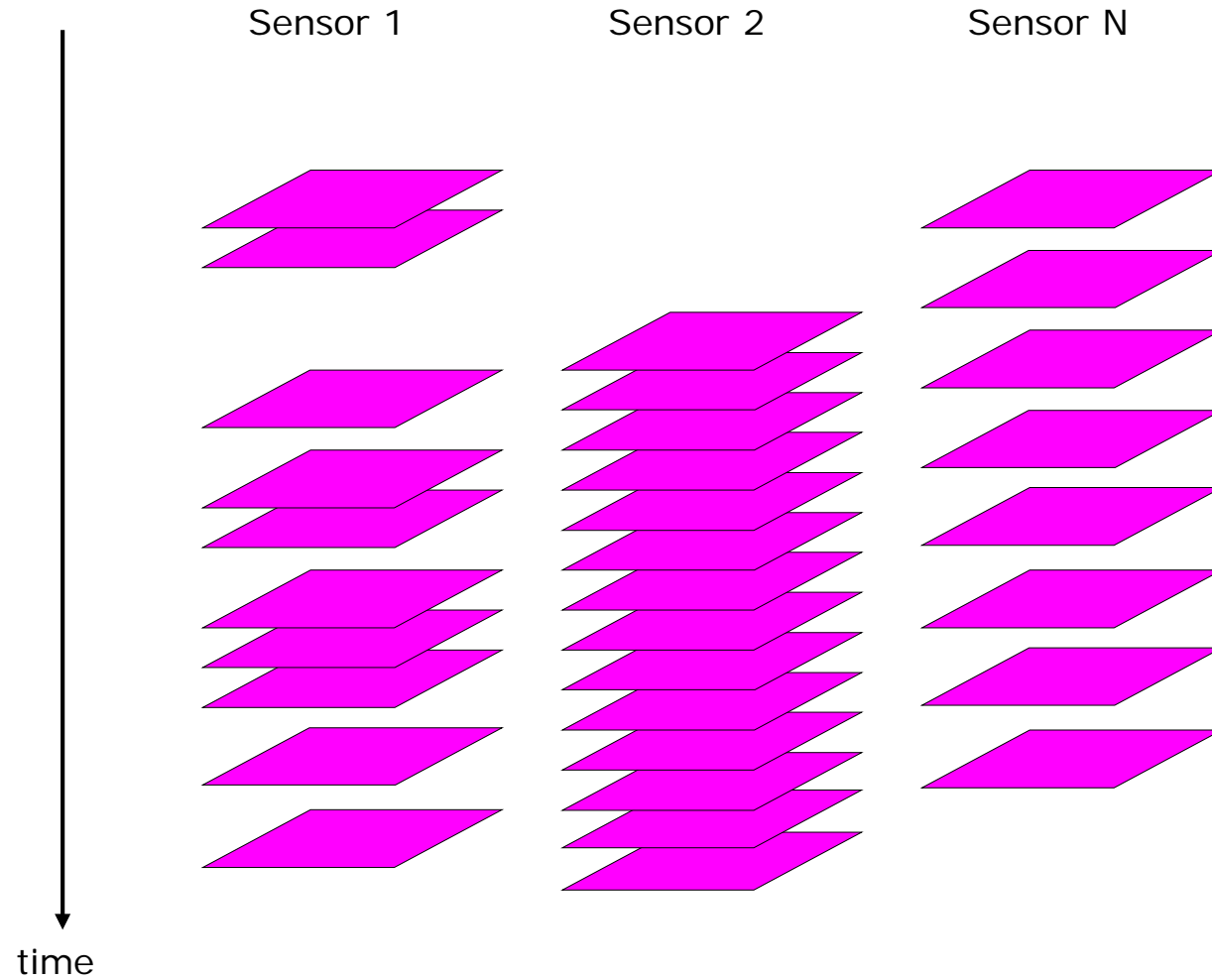


## 2. Knowledge based temporal analysis

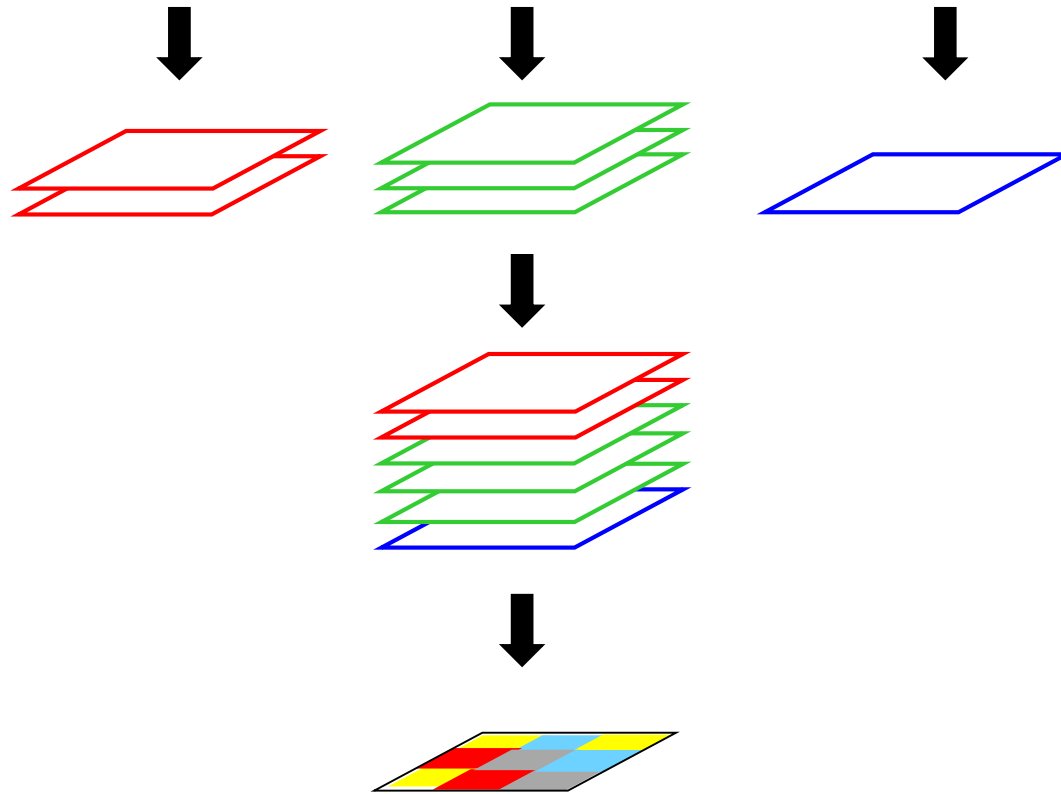
- A priori information is required, as for instance
  - crop type,
  - calendar,
  - phenology,
  - duration,
  - Practices, etc.
- Systematic acquisitions must be available



# Multi-temporal multi-spectral descriptors



# Multi-temporal multi-spectral descriptors



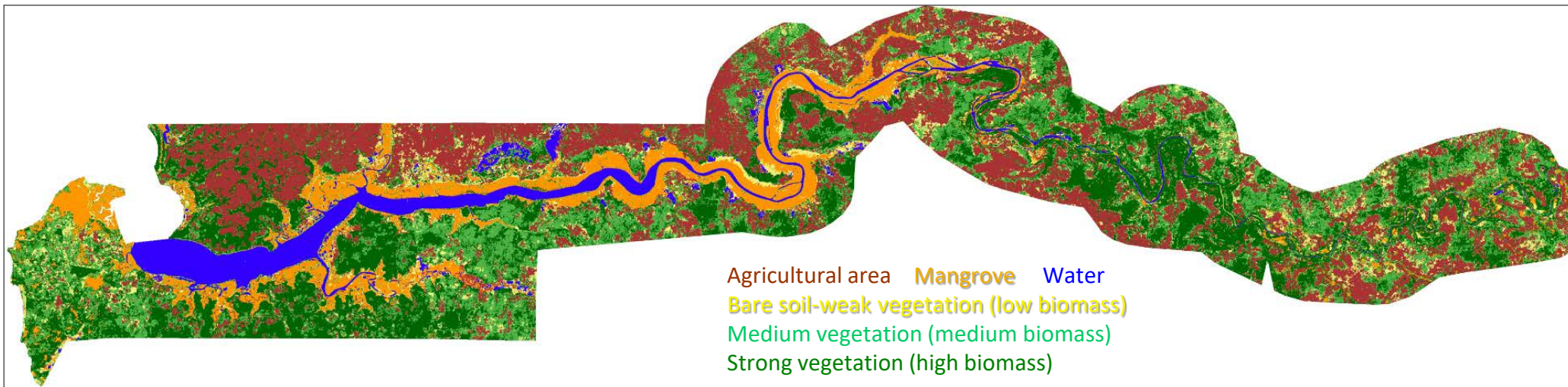
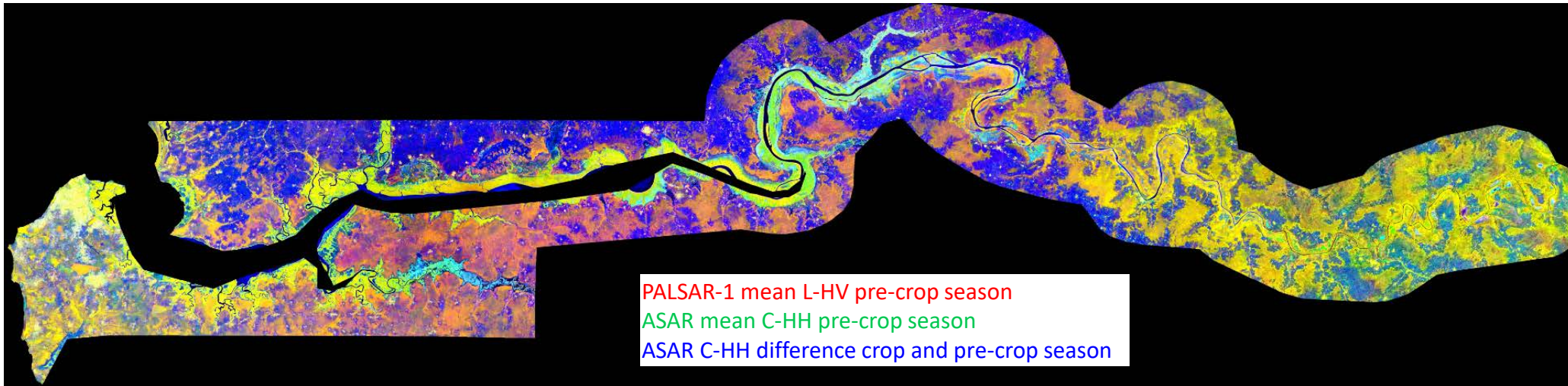
Temporal-spectral descriptors  
for selected time period(s)

Temporal-spectral descriptors selection  
based on uncorrelated features

Land Use – Land Cover Map



## Multi-temporal multi-spectral descriptors – SAR-only

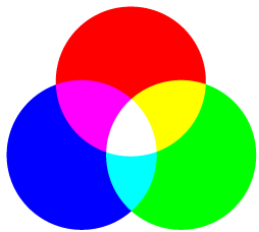


Gambia



# Multi-temporal multi-spectral descriptors – SAR and Optical

Maximum SAR coherence



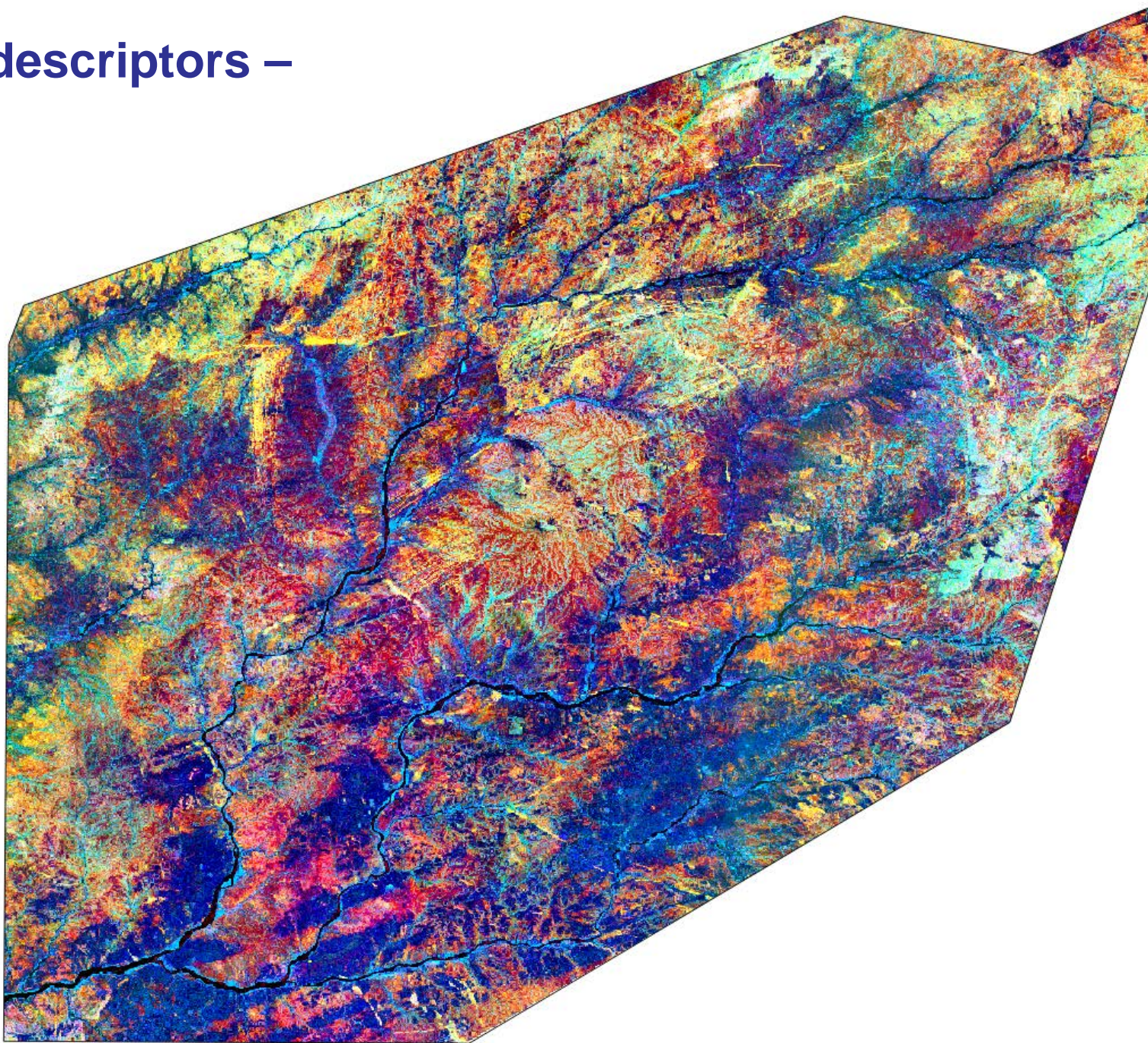
Maximum NDVI

Maximum SAR backscatter

Sentinel-1 and Sentinel-2  
dry period

# EAS

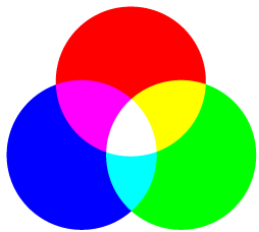
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# Multi-temporal multi-spectral descriptors – SAR and Optical

Maximum SAR coherence



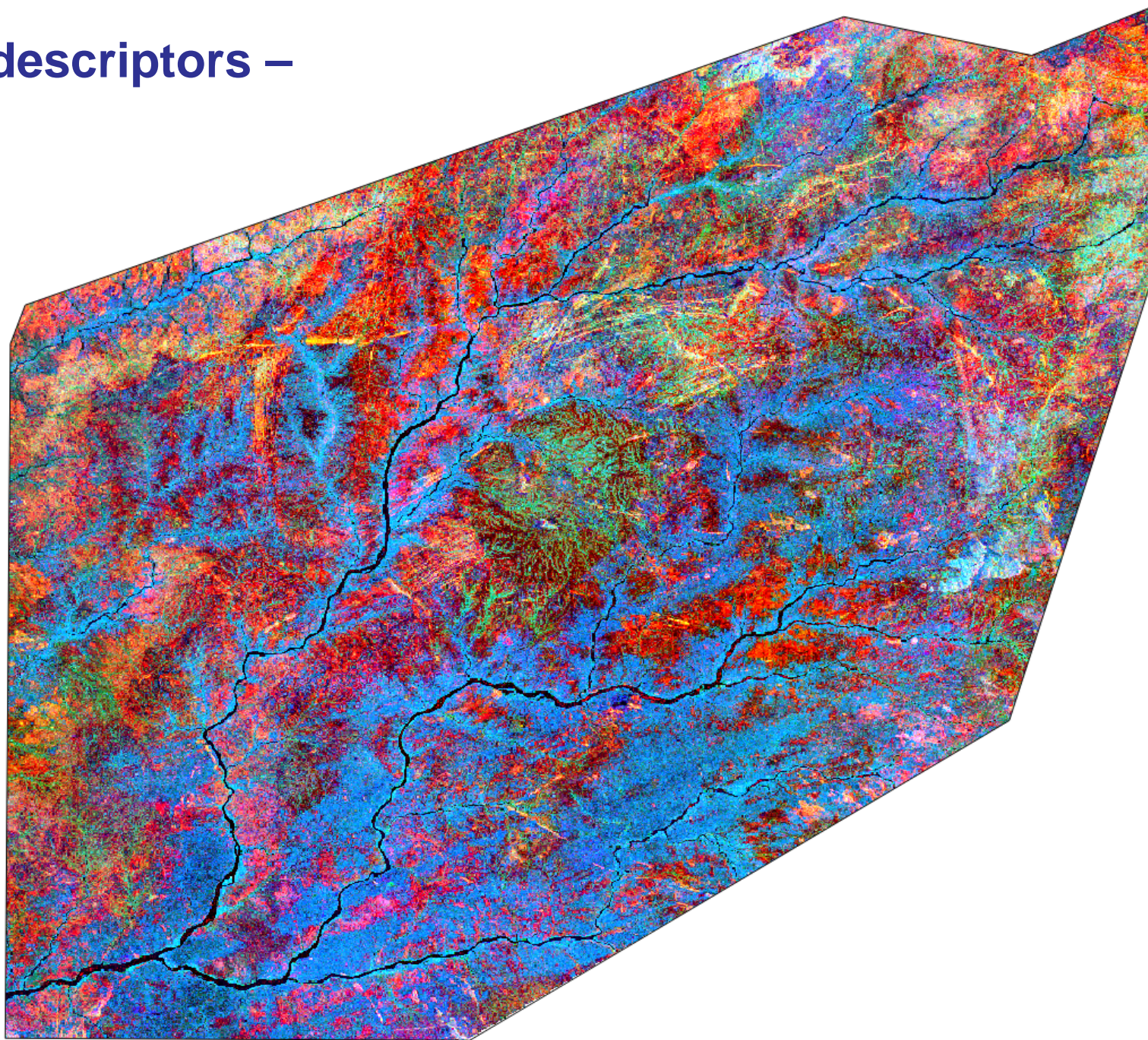
Maximum NDVI

Maximum SAR backscatter

Sentinel-1 and Sentinel-2  
wet period

# EAS

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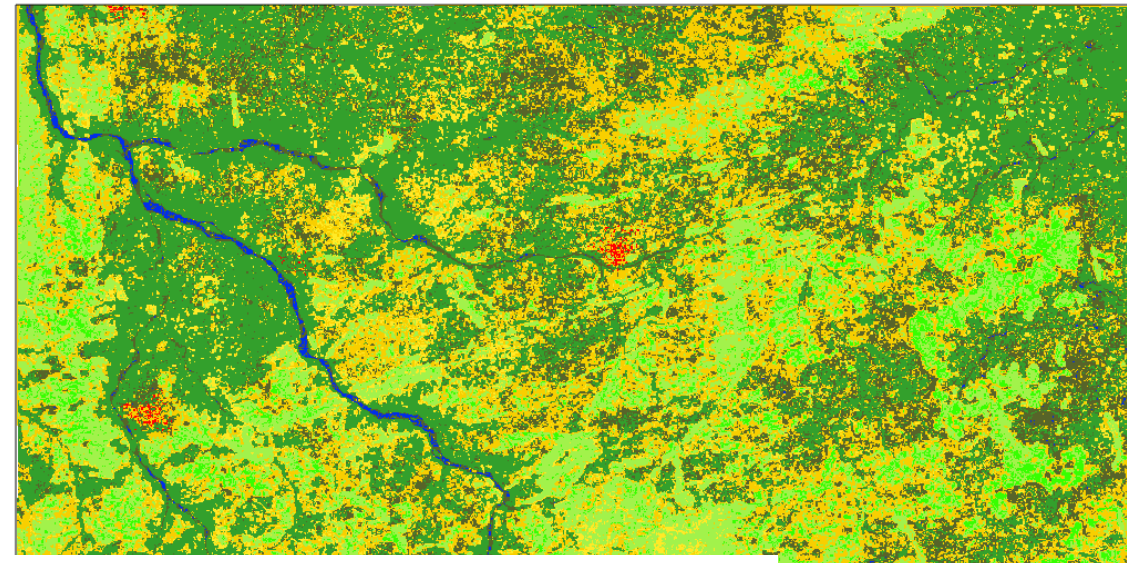
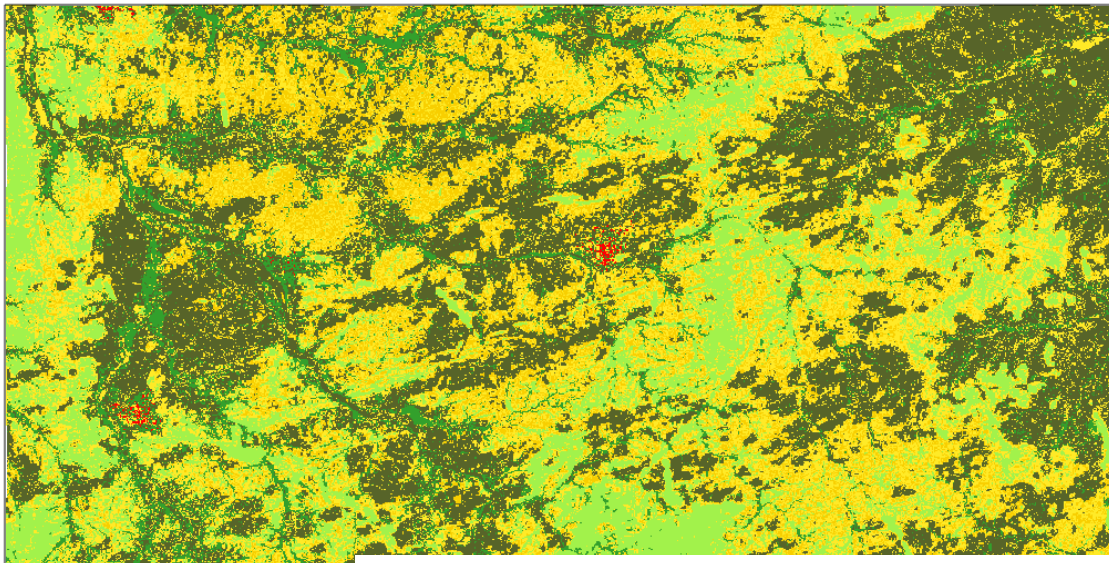
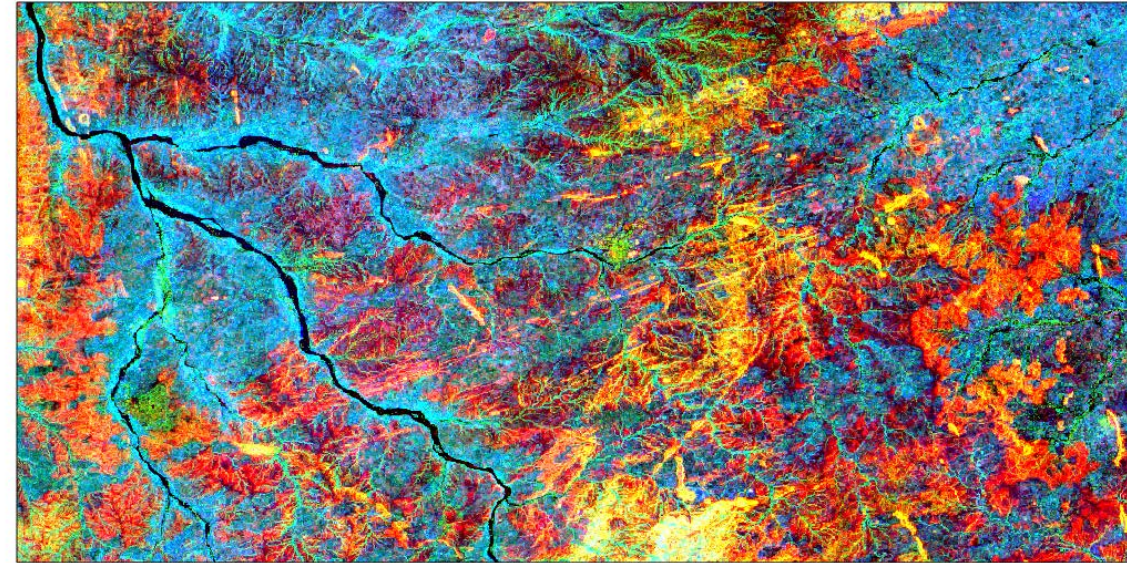
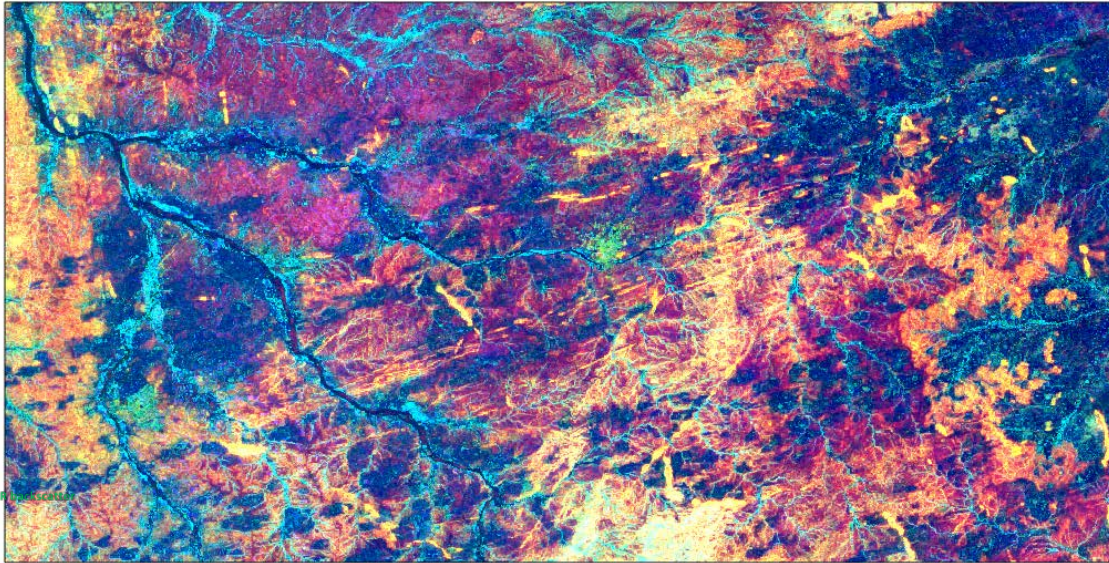
# Multi-temporal multi-spectral descriptors – SAR and Optical

Maximum SAR coherence



Maximum NDVI

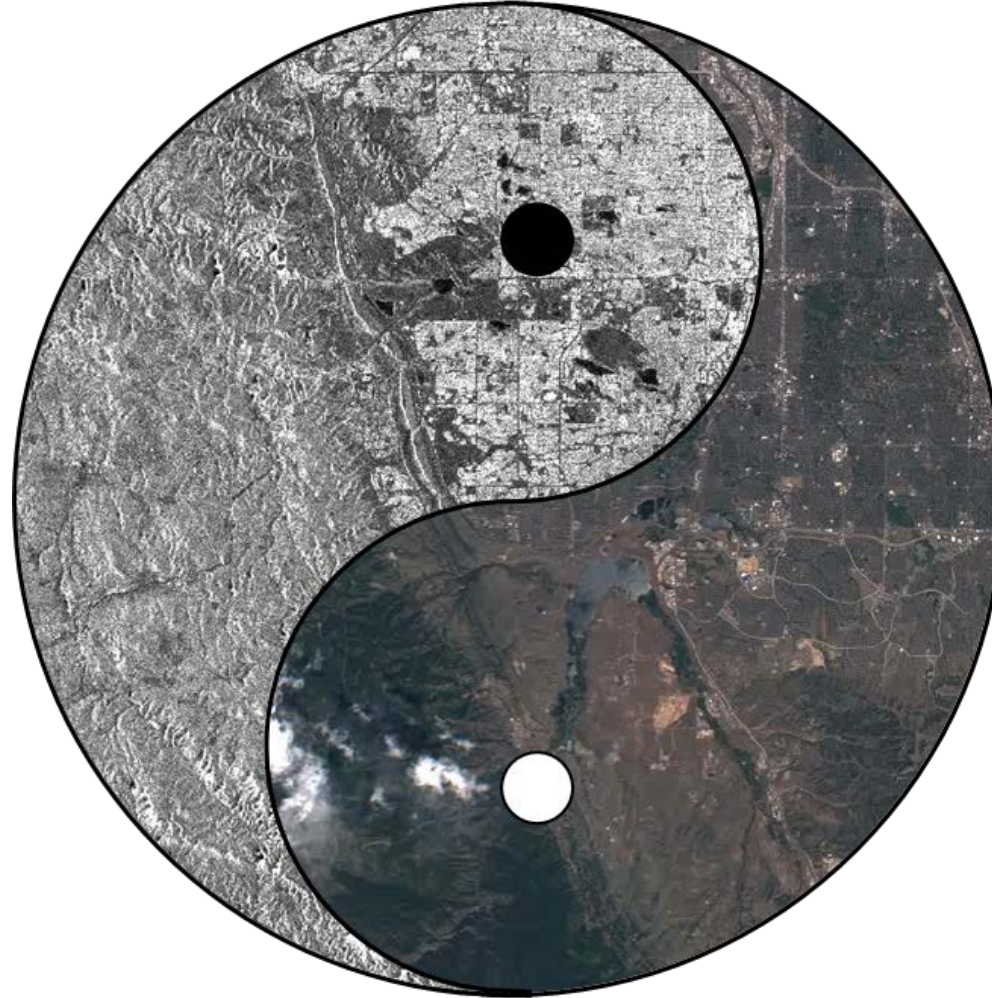
Maximum SAR backscatter



Water Bogs LowB Vegetation HighB Vegetation Bare Soil Settlements



## Yin and Yang



Thanks a lot for your attention!