Landslides triggered by 2019 extreme rainfall and flood events in Iran: Results from satellite remote sensing and field survey

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B. Akbari, M. Abbassi (FRW, Iran)

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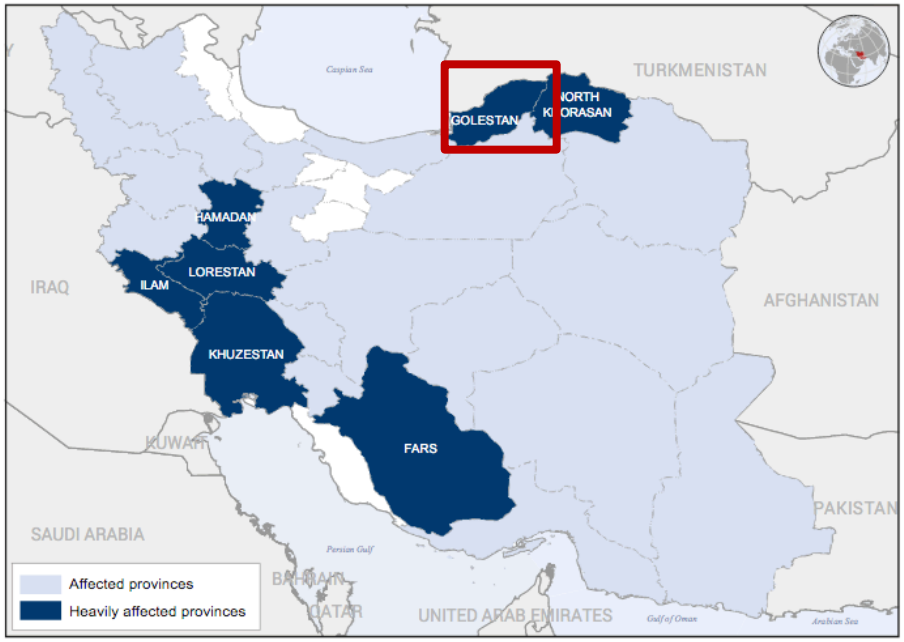
Mid-March to April 2019 flood in Iran

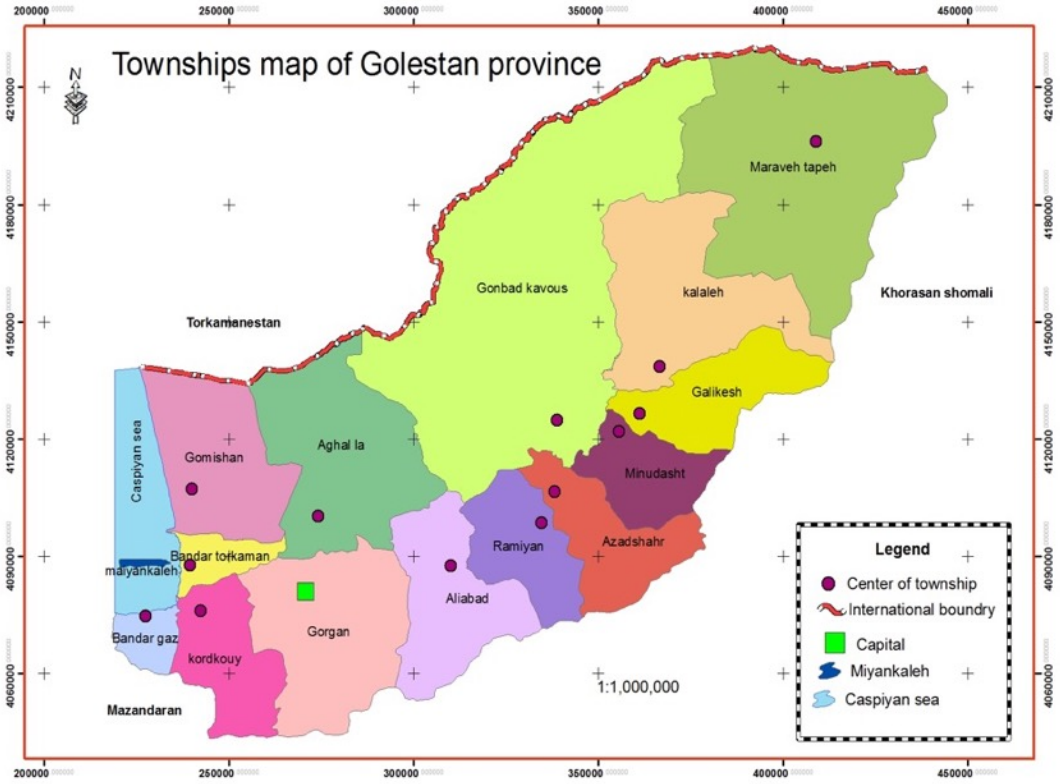


- 25/31 provinces affected
- 10 M affected, 2 M in humanitarian assistance
- At least 78 dead, 1140 injured
- 4.1$ billion, including 1.5$ billion for the agriculture sector

https://reliefweb.int/sites/reliefweb.int/files/resources/20190429-Iran_Floods_UN_Iran_Response_Plan.pdf

Golestan Province

- Golestan Province: NE Iran
- Capital: Gorgan
- Area: 20380 km²
- Population: 1.8 million
- Townships: 14
- Annual temperature: 18
- Annual rainfall: 45 cm



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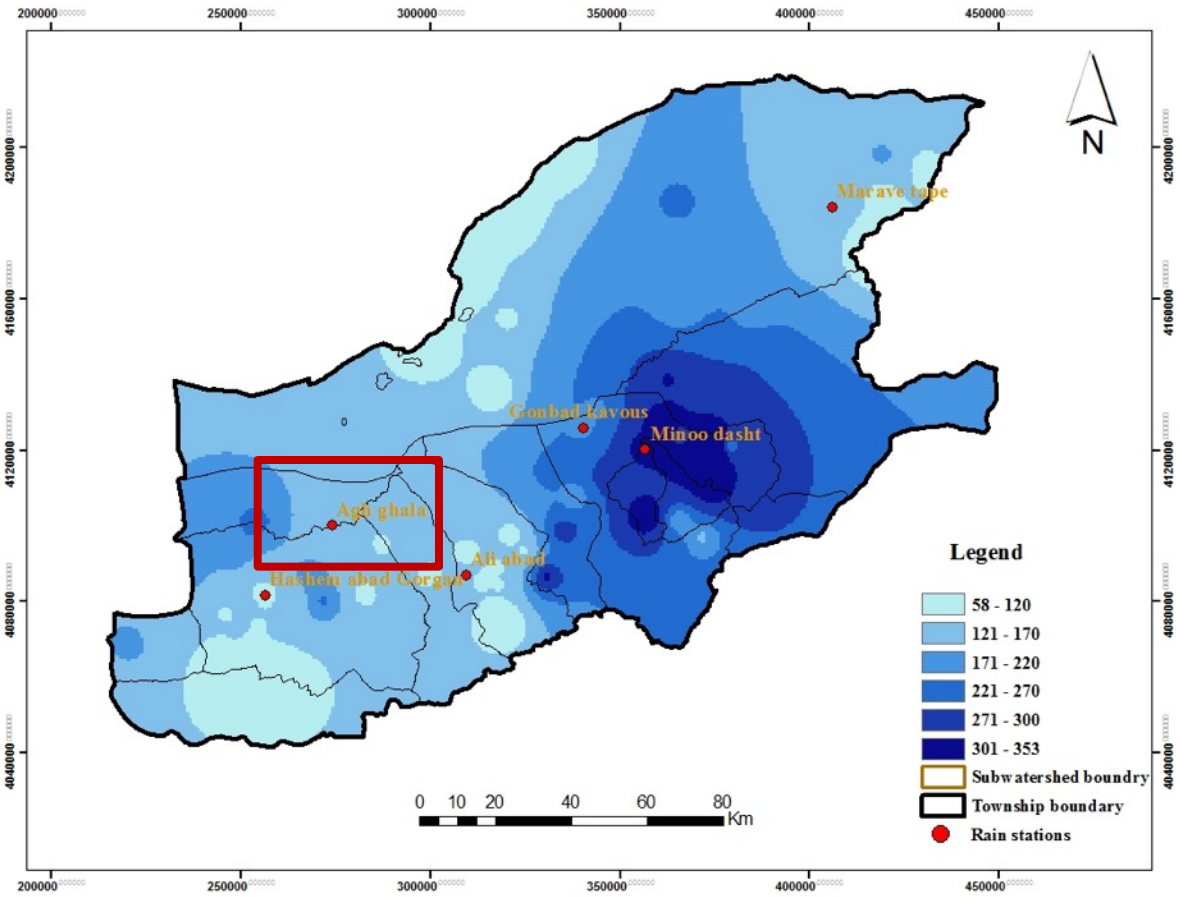
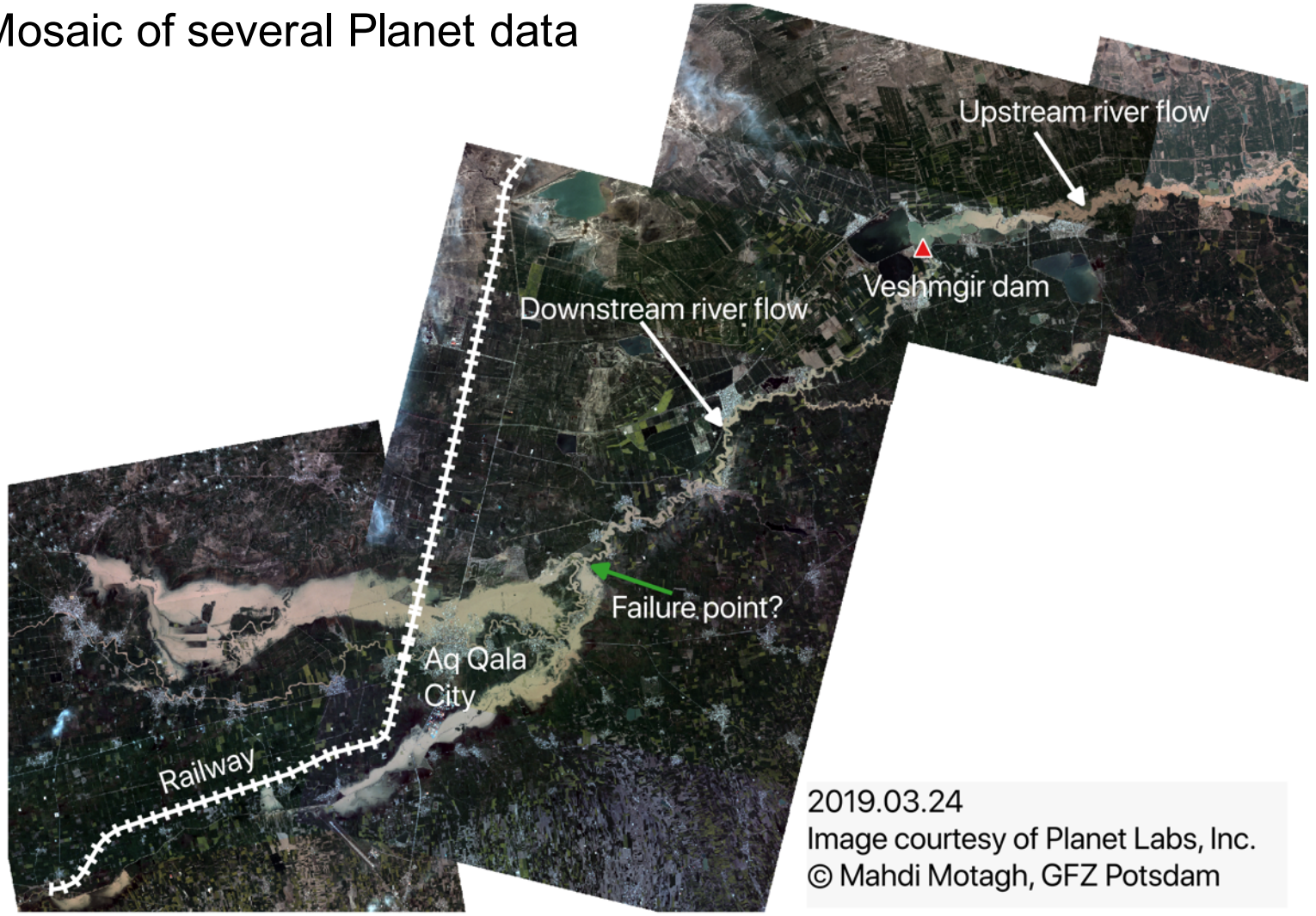
Extreme precipitation in March 2019 in Golestan

Return period: 500 yr
Maximum discharge: 830 m^3/s
Maximum rainfall: *315 mm (Duration 30 hours)*
Average rainfall : 220 mm
Bankfull discharge: 120 m^3/s



2019 Flood in Aq Qala, Golestan

- Mosaic of several Planet data



2019 Flood monitoring in Aq Qala using Sentinel-1

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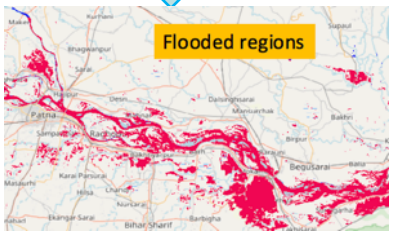
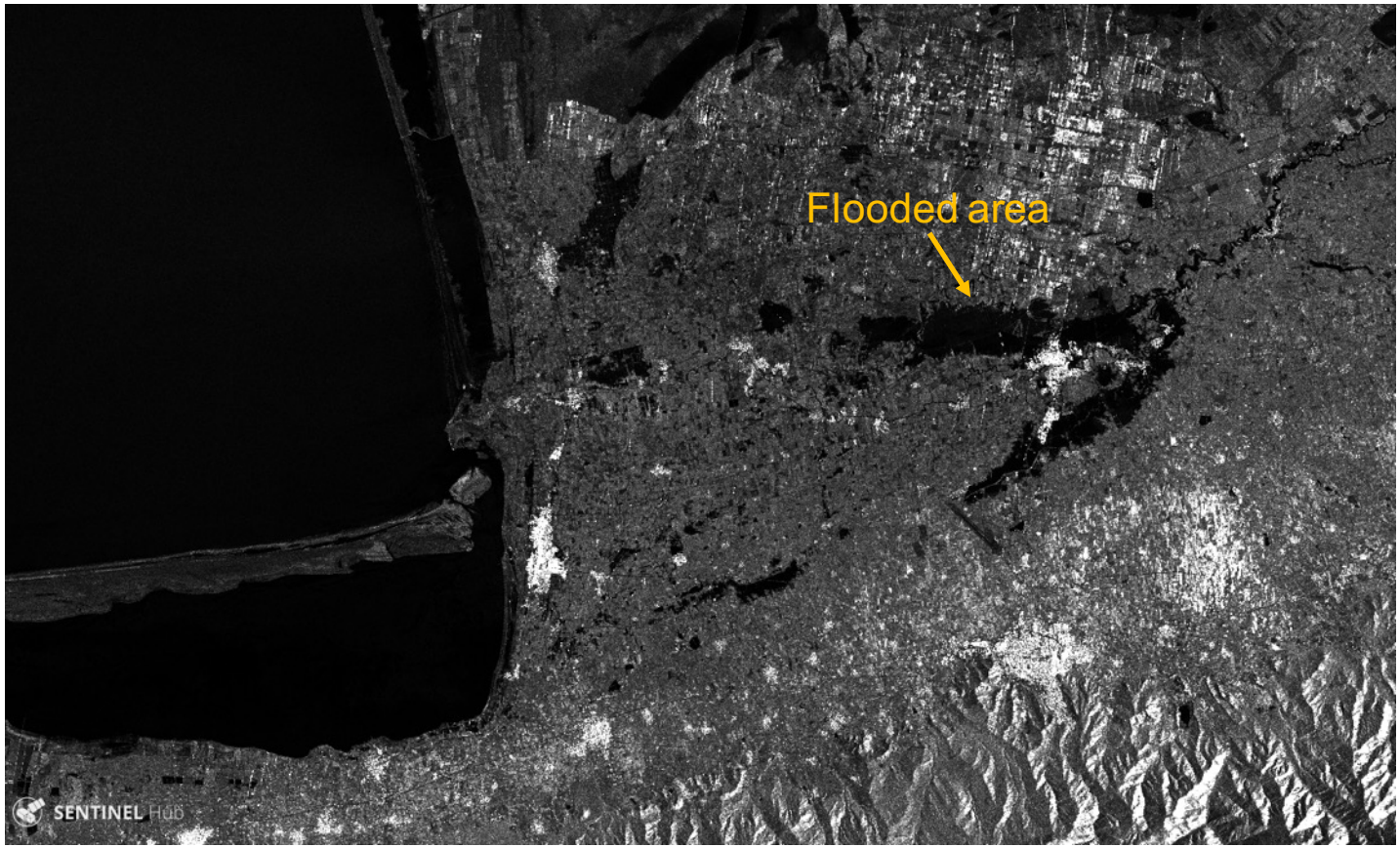
Radiometric correction

Speckle filter

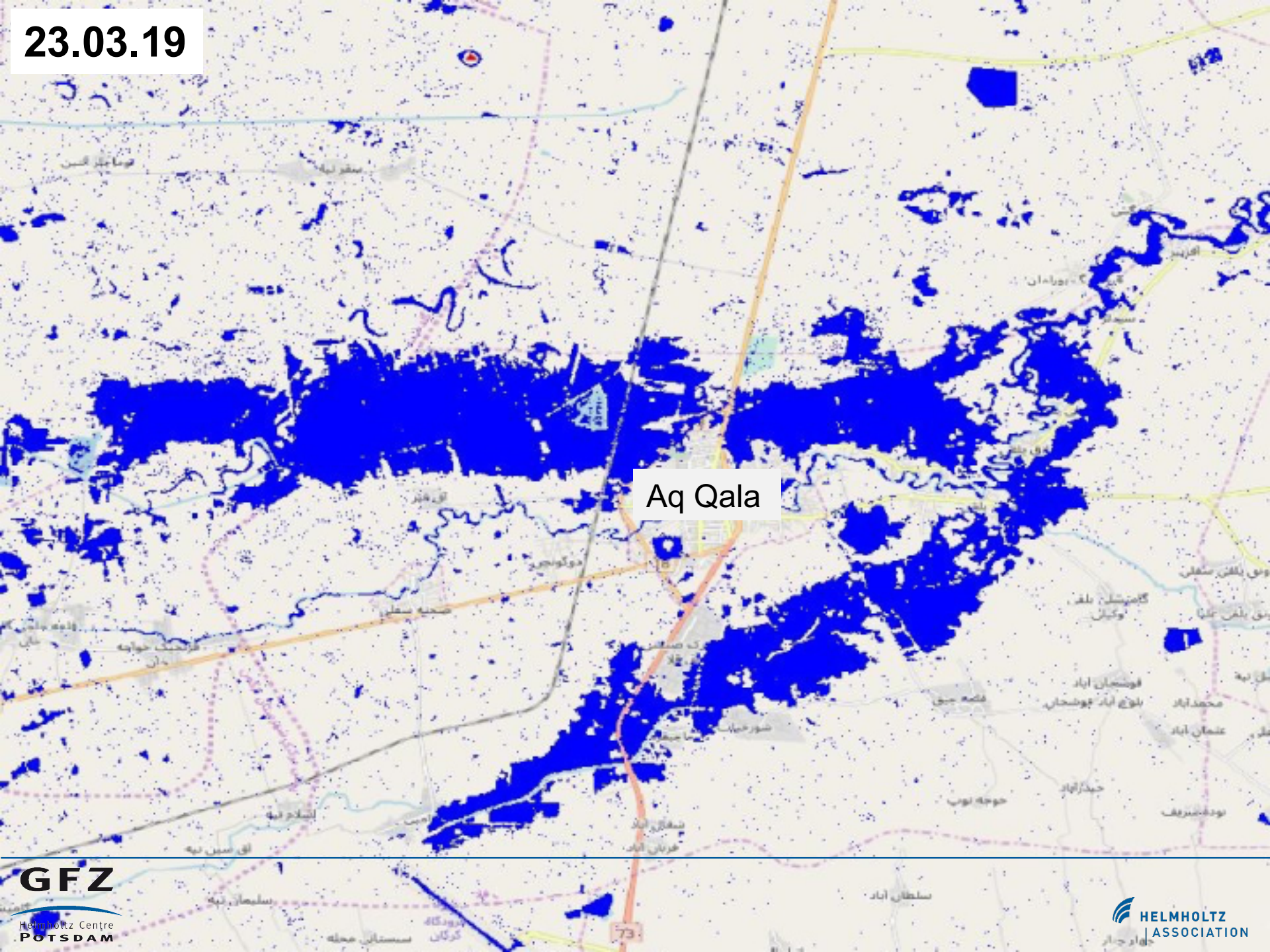
Terrain correction

Classification (Random Forest)





Tool: SNAP | Sentinels Application Platform (ESA)


23.03.19
Aq Qala
GFZ
Helmholtz Centre
POTSDAM
HELMHOLTZ
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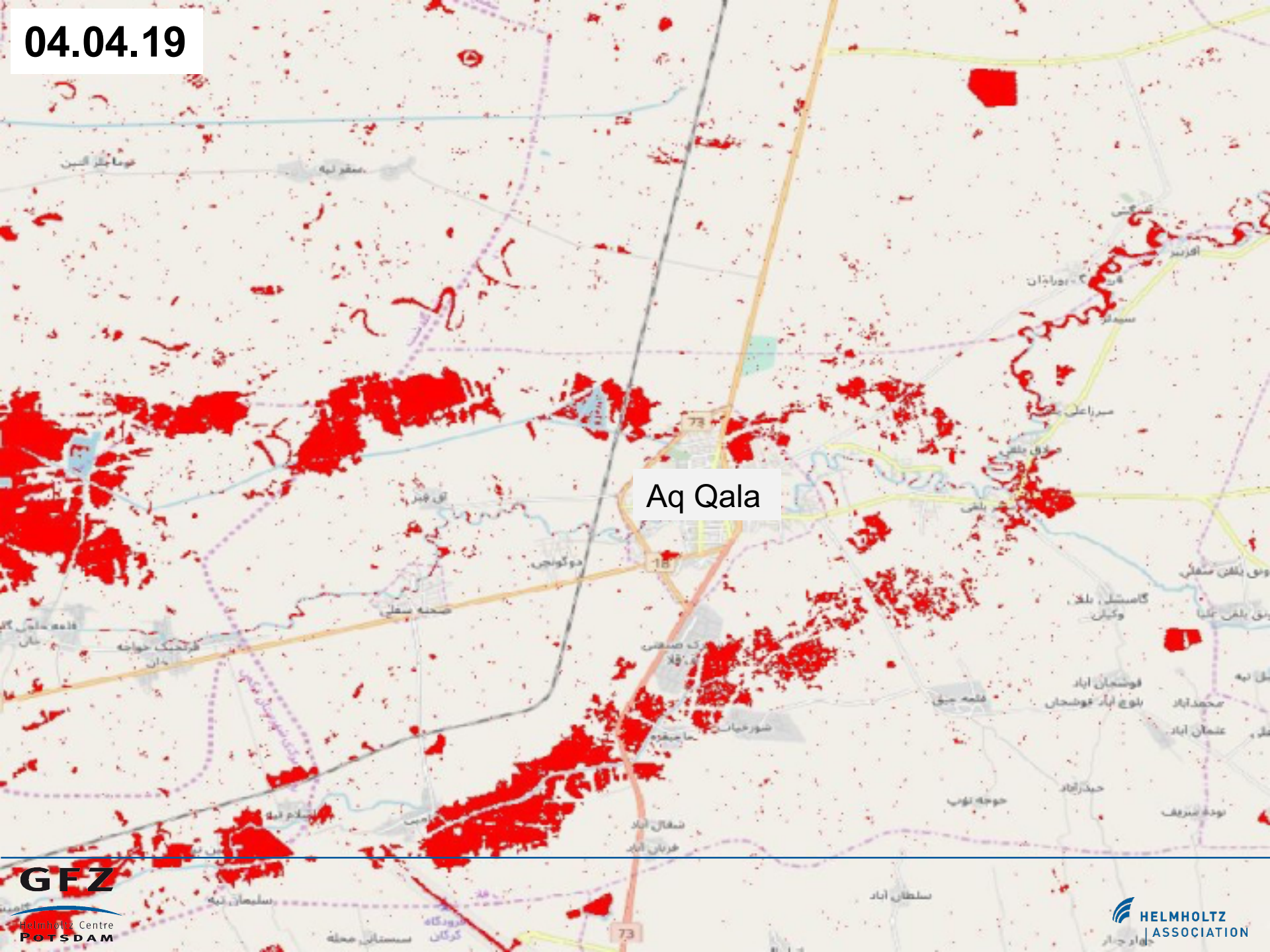
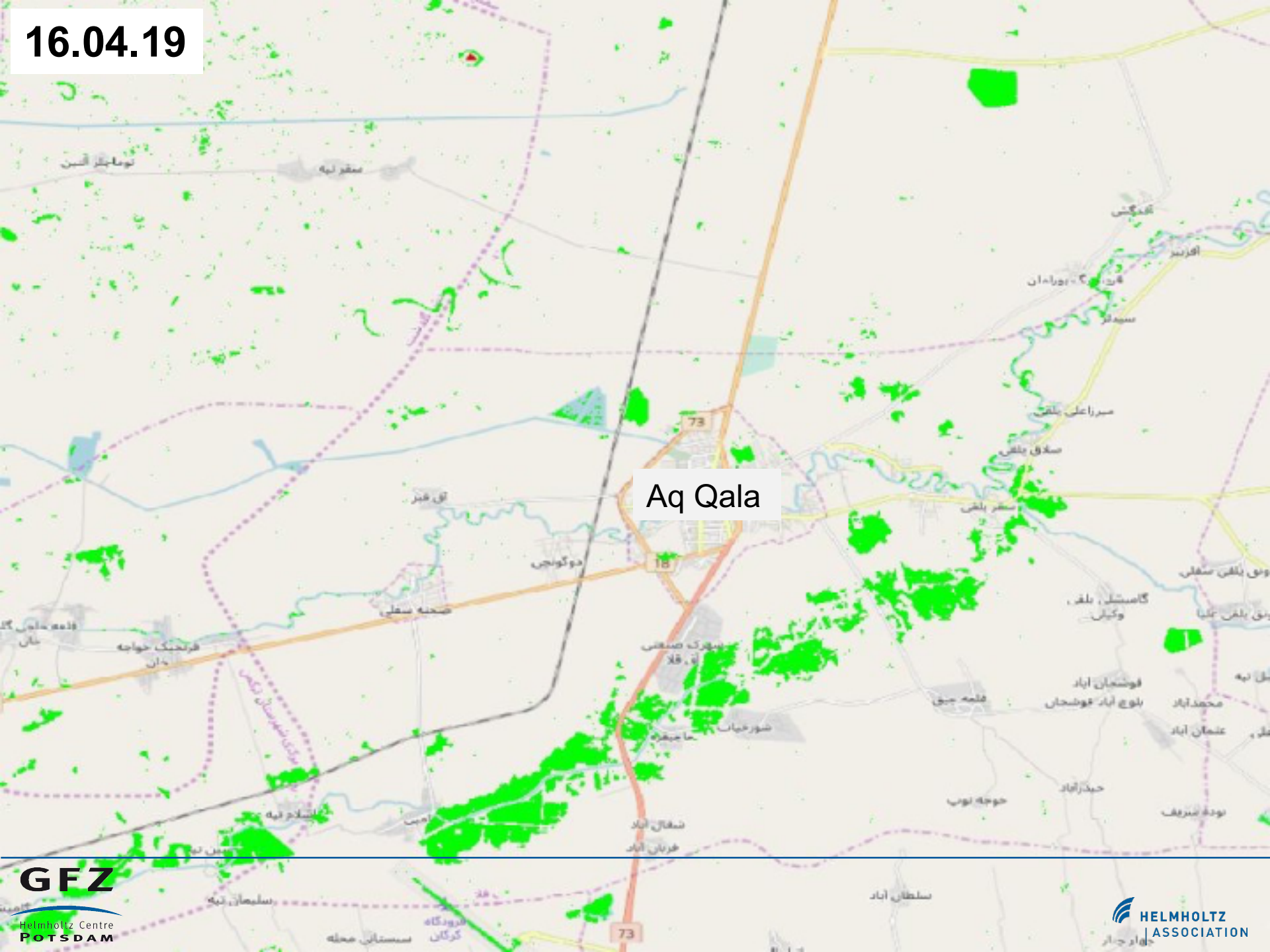
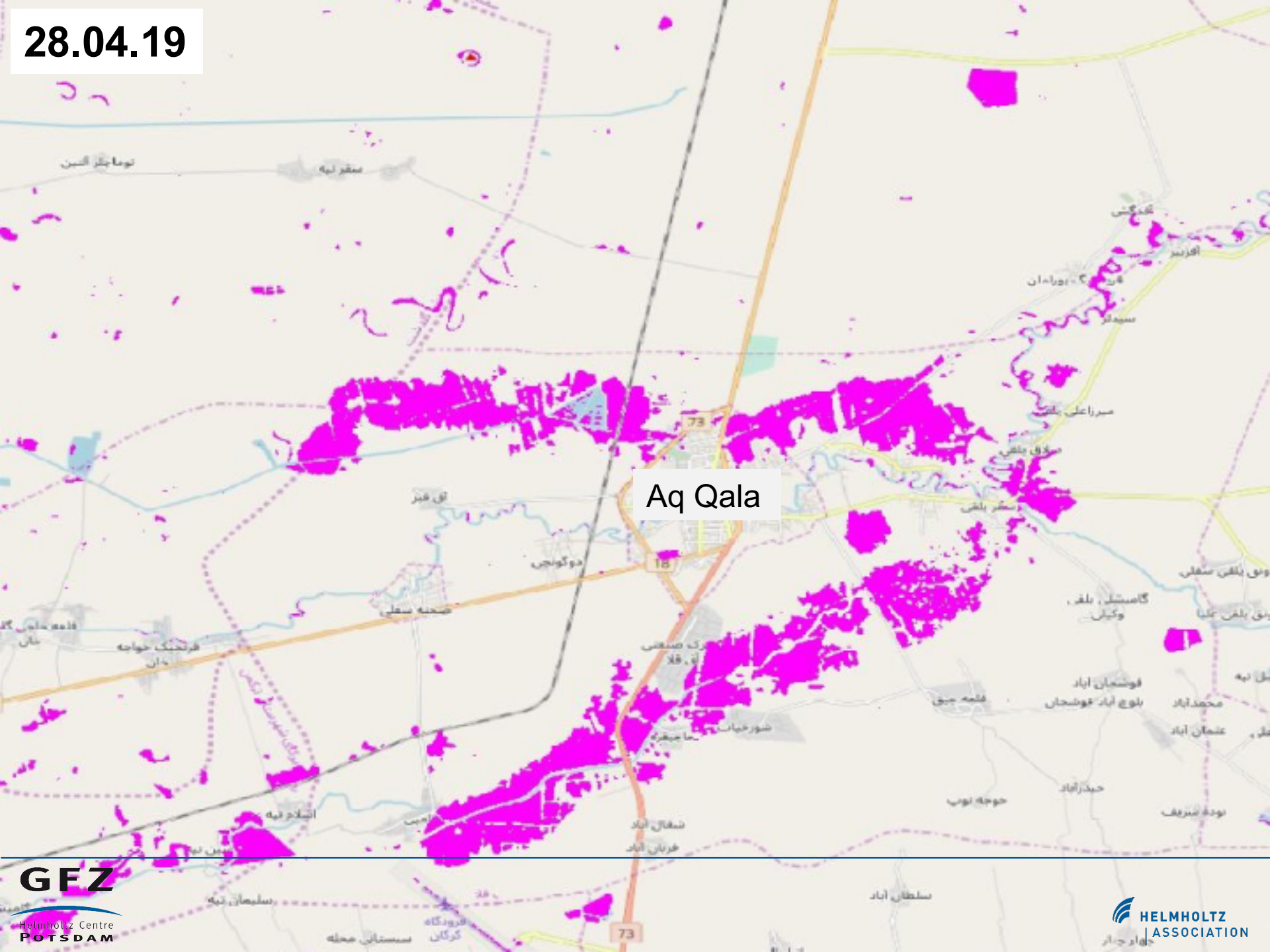
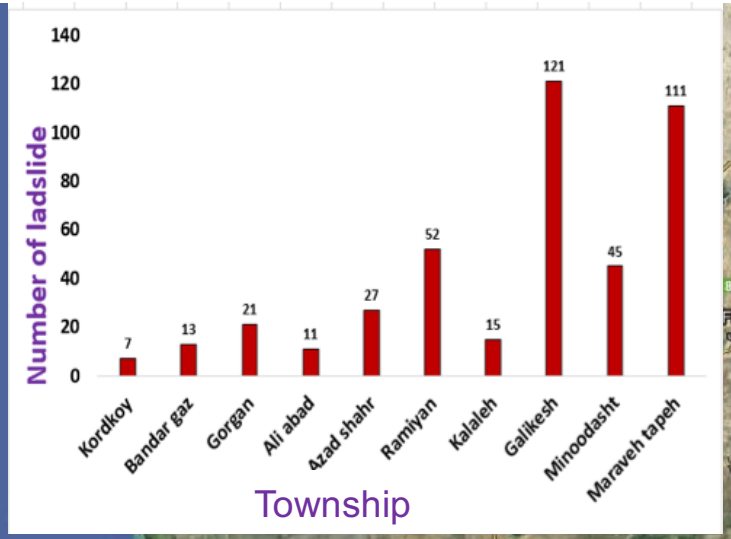

04.04.19
Aq Qala
GFZ
Helmholtz Centre
POTSDAM
HELMHOLTZ
ASSOCIATION


16.04.19
Aq Qala
73
18
73


28.04.19
Aq Qala

Inventory of rainfall-induced landslides



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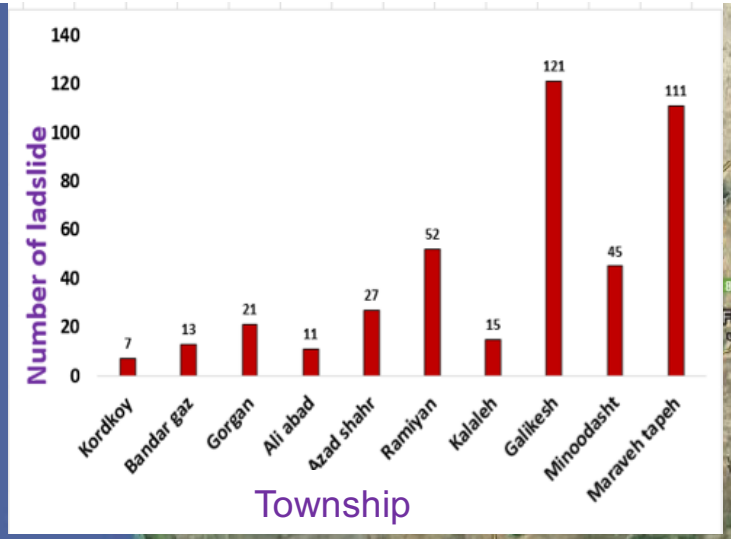
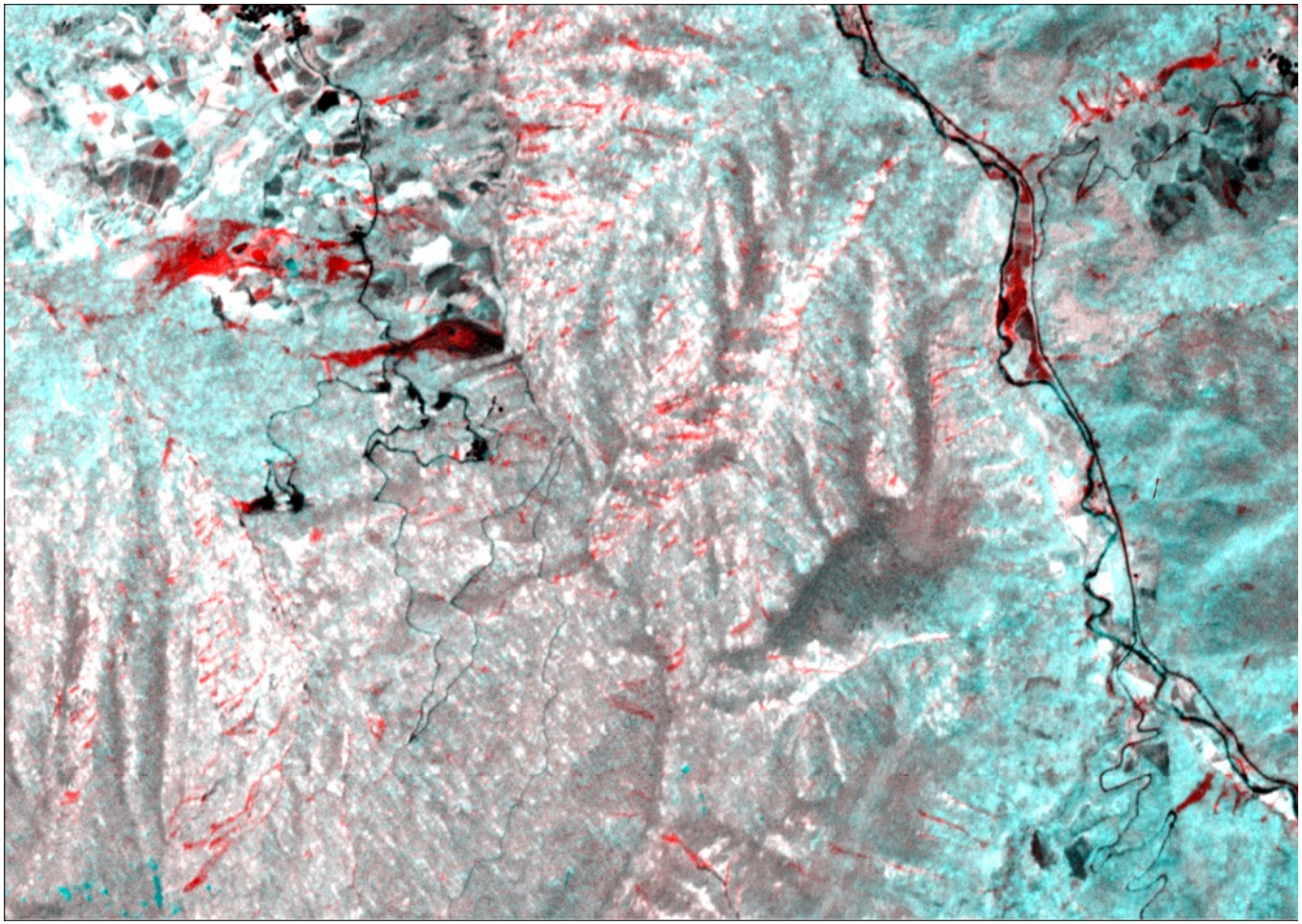
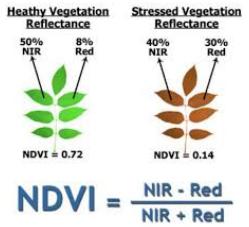
Inventory of rainfall-induced landslides



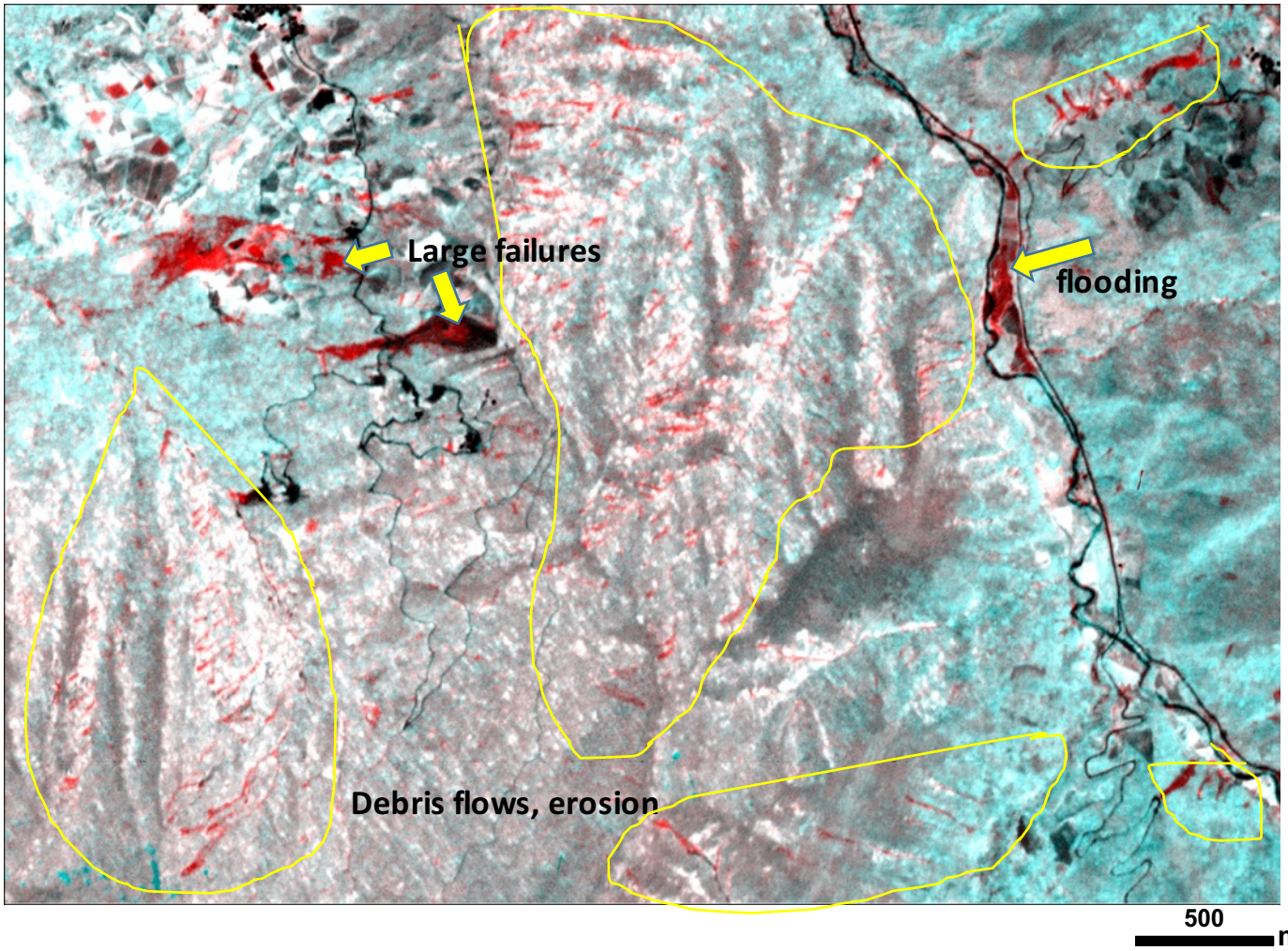
NDVI-based change analysis using Planet data

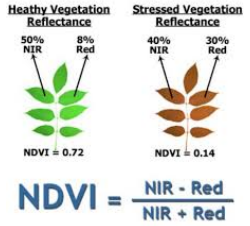




band combination R-G-B: NDVI(before, 12.03. 19)-NDVI(after, 02.04.19)-NDVI(after)
Description: red color indicates vegetation loss/disturbance -> indicator for landslides

NDVI-based change analysis using Planet data





band combination R-G-B: NDVI(before)-NDVI(after)-NDVI(after)
Description: red color indicates vegetation loss/disturbance -> indicator for landslides

Google Earth Imagery

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March 2018

Google Earth Imagery

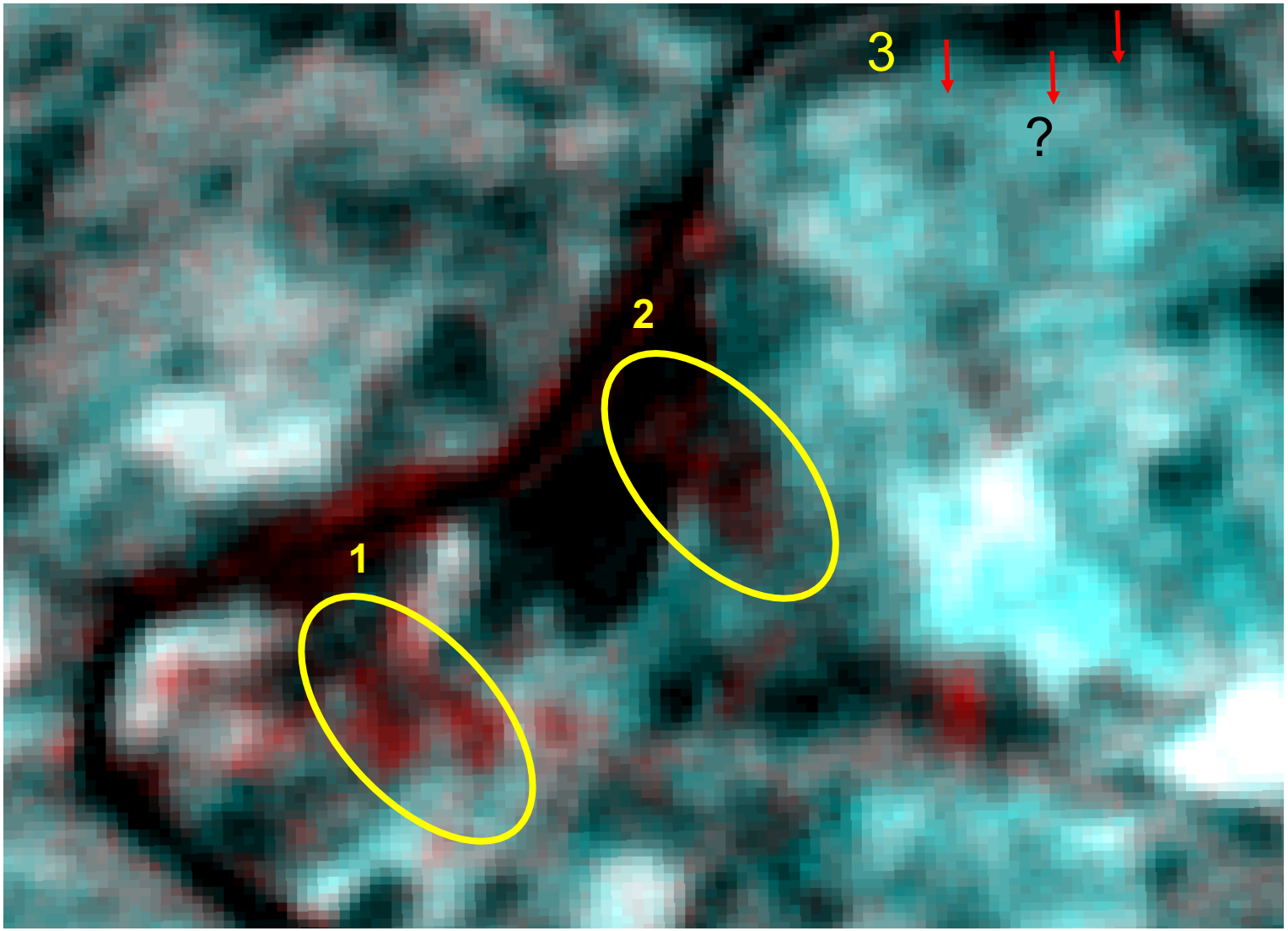
June 2019

- Combination of strong precipitation of spring 2019 with cutting the hillside for road construction

Landslide activation

- 1,2 visible in NDVI, but what about 3?

Landslide activation



Landslide activation (location 3)

Coordinate: 55.59, 37.16
Area: 13000 m^2
Length: 121 m
Width: 102 m
Heading: 155 degree
Event date: March 2019
Geological materials: Soil

Automated identification of landslide objects

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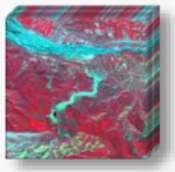
1 Pre-processing

Input

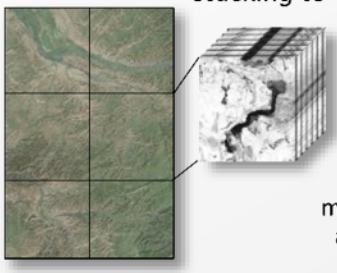


multi-sensor time series database

- *Metadata handling/homogenization*
- *Geometric Co-registration (relative & absolute)*
- *Conversion to TOA-Reflectance*
- *Masking of clouds and snow*
- *NDVI calculation*

2 Construction of NDVI Time Series Data Cubes (TS)

- *Tiling*
- *Resampling & stacking to TS*
- *Selection of bi-temporal data pairs*



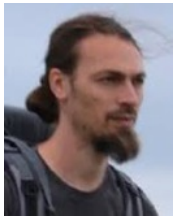
time

data

select

most comp-arable in:

- sensor
- season
- short intervals
- spatial coverage
- acquisition properties



R. Behling

3 Landslide Identification

time

data

select

pre

post

post-failure

- *B: multi-temporal (post-failure revegetation)*

high Is probability = slow revegetation

- *A: bi-temporal (vegetation disturbance)*

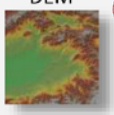
high Is probability = high disturbance

Segmentation to LC

Date refinement. First occurrence of LC between pre and post.

- *C: relief-oriented*

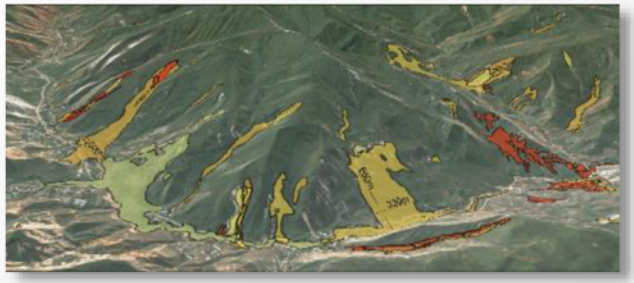
DEM



Is probability in regard to:

- slope
- river network

Result: Multi-temporal Landslide Inventory



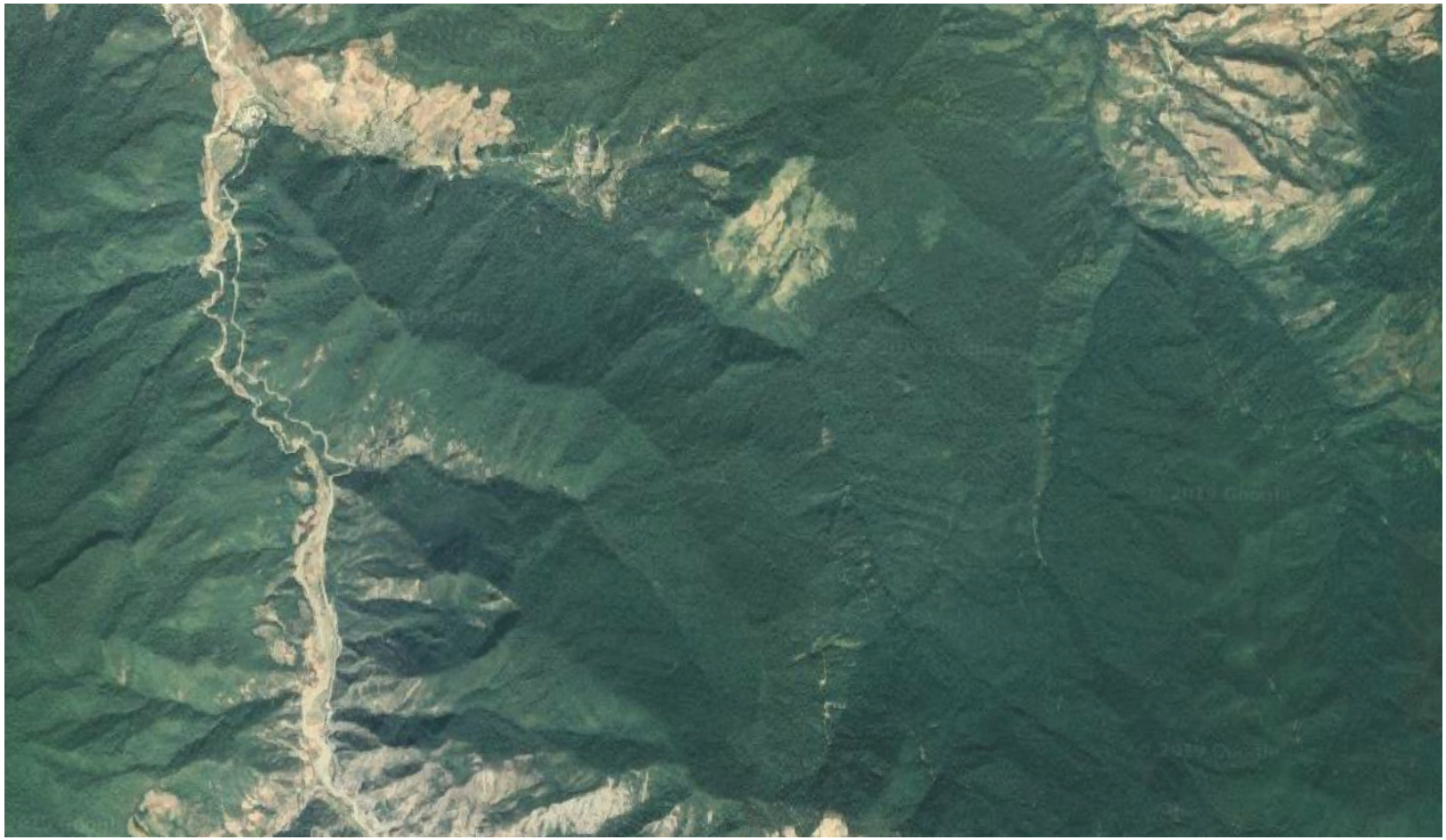
Landslide objects characterized by:

- time of occurrence (between two acquisitions)
- location and extent
- overall likelihood being a landslide (based on 3A-C)
- additional quantitative attributes (e.g. shape parameters)

Behling et al. (2014) Automated Spatiotemporal Landslide Mapping over Large Areas Using RapidEye Time Series Data. *Remote Sensing*

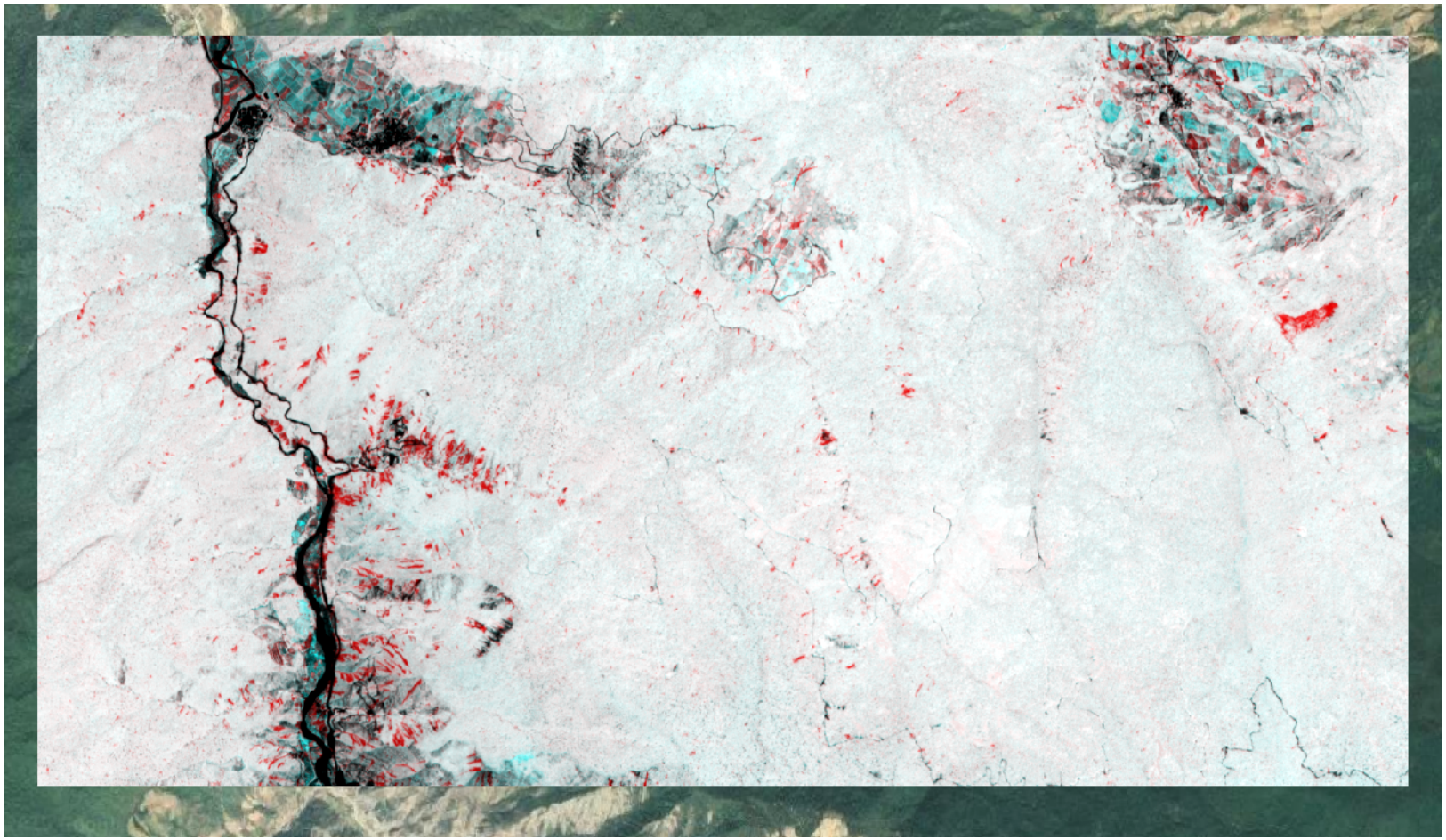
Behling et al. (2016) Derivation of Long-Term Spatiotemporal Landslide Activity–A Multi-Sensor Time Series Approach. *Remote Sensing of Environment*

Identification of landslides based on S2 - Example



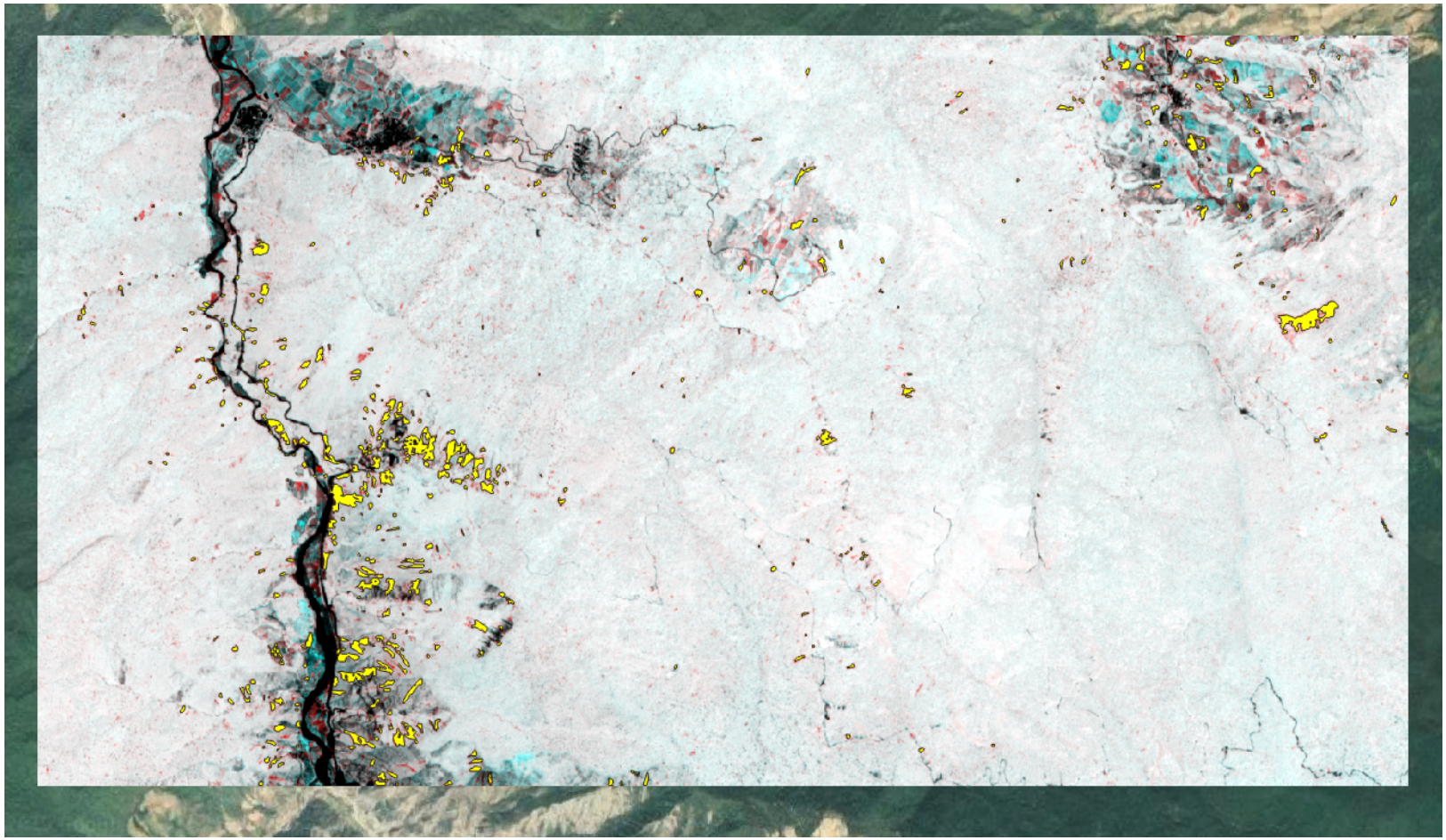
GoogleEarth 2019-05-10

Identification of landslides based on S2 - Example



Sentinel-2 NDVI composites as R-G-B (preEvent – postEvent –postEvent)

Identification of landslides based on S2 - Example



Object-based landslide mapping

Landslide kinematics

- Failure detection and monitoring: optical data (Planet)
- Log-term slope motion: radar data (Sentinel-1)

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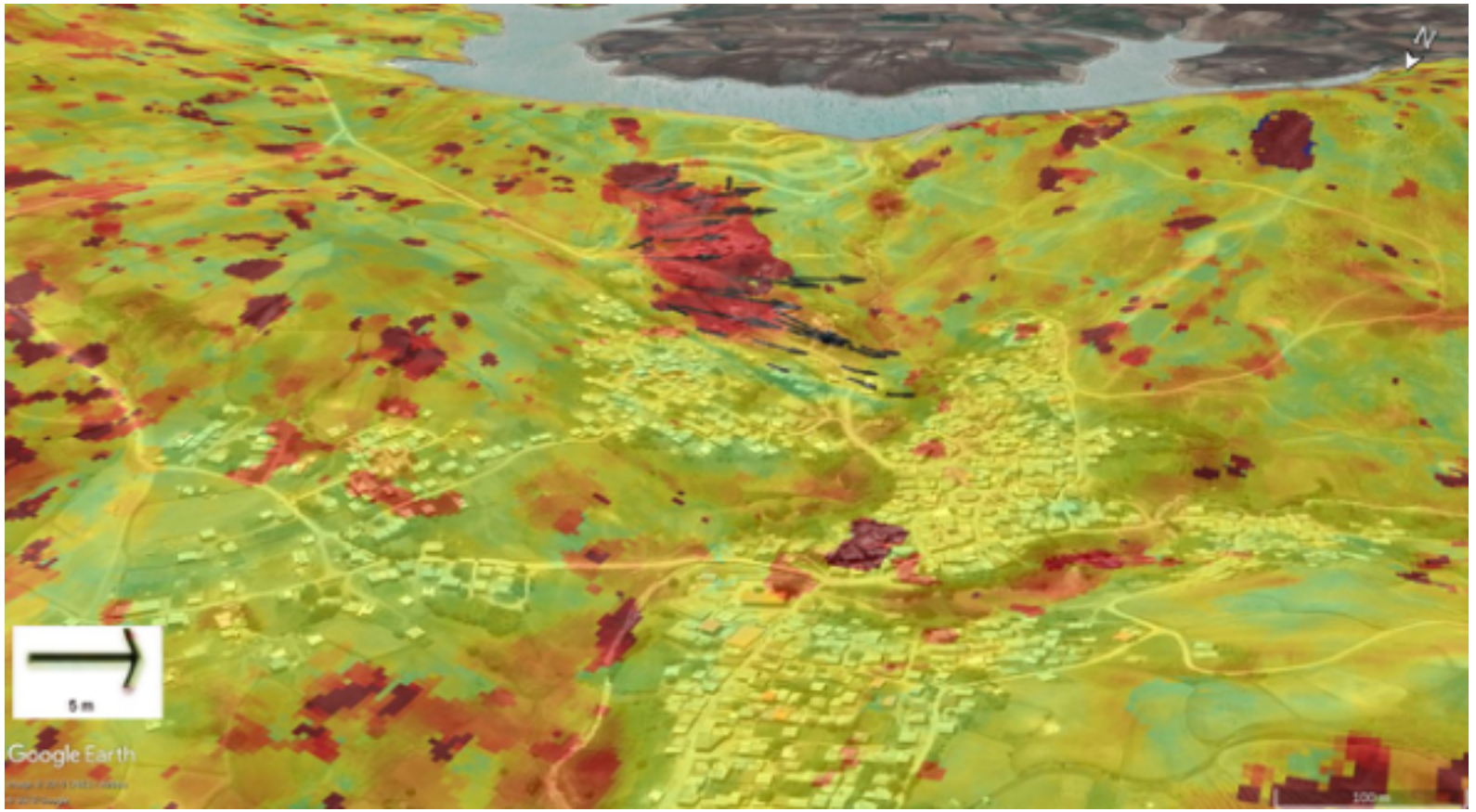
2019 slope failure

- Cross Correlation of Planet data [17/04/2019 - 18/05/2019]
- 3m resolution



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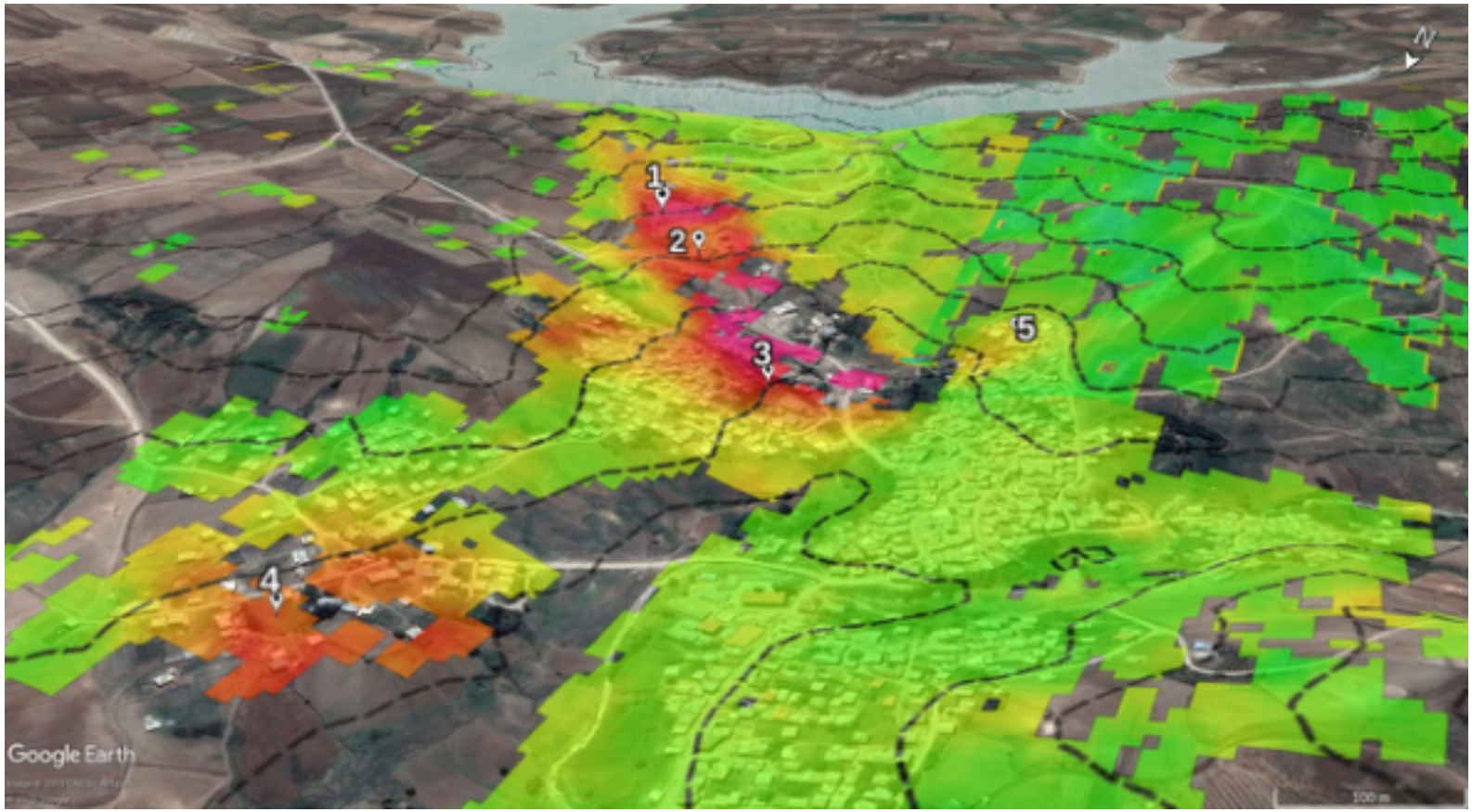
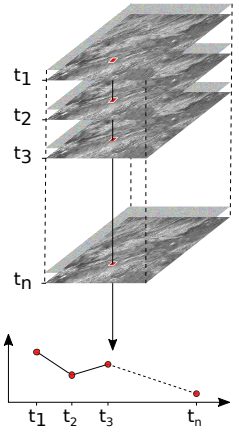
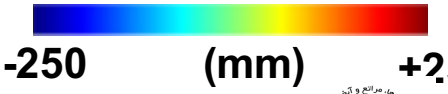
Long-term slope motion

- Method: InSAR time-series analysis
- Data: Sentinel-1 [Oct. 2014 - Nov. 2019]
- Slope projected displacement (positive values refers to downslope)







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Summary and Conclusion

- NDVI-based method: powerful for post-failure detection and only to some extent the intermediate process stages, requiring some degree of vegetation removal

- Robust and reliable change detection requires a longer multi-step and multi-sensor time series analysis

- A more complete understanding of the geological instabilities and landslide life cycle is possible only by using all data/techniques together to better determine the contribution of triggering factors