2018-2021 - University of Oklahoma - First Year Report

Land use patterns and political instability as predictors for the re-emergence of malaria in the Caucasus

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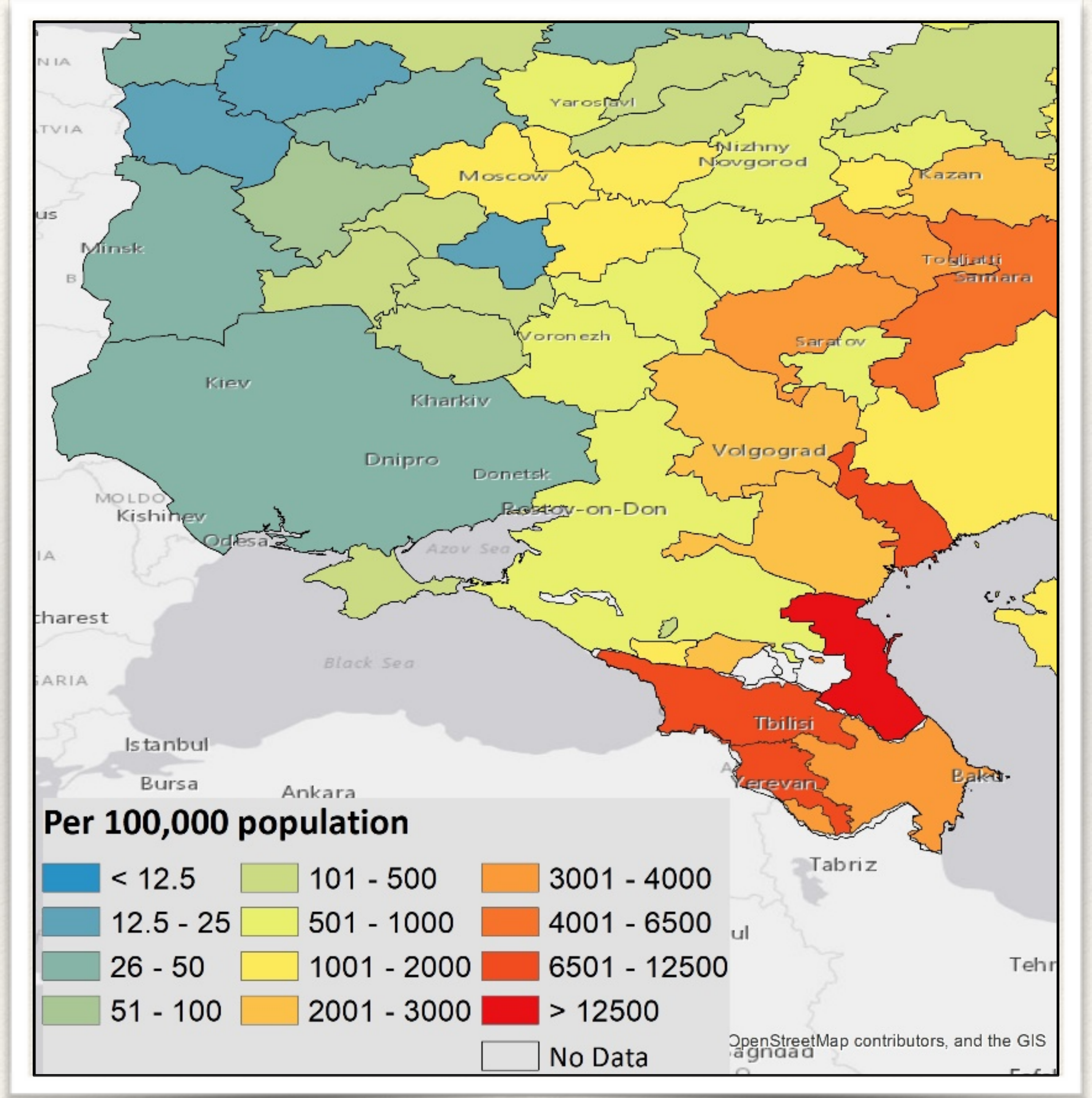
Malaria in the 1920/1930s

- The World Health Organization (WHO): ~200,000 people were ill with malaria in Armenia in the early 1930s; another 600,000 in Azerbaijan.
- The Caucasus is naturally hospitable to the malaria mosquito, but large scale eradication efforts during the Soviet period resulted in almost total disappearance (1975).



Historical malaria prevalence (cases/100,000) in the central USSR, including the Transcaucasus region in 1922 . Prevalence data: *Leonard J Bruce-Chwatt. Bull. of World Health Org. 1959, 21, 737-772.*

Soviet Collapse and Ethnic Conflict in the Caucasus

Post Soviet Conflicts in the Caucasus, 1990s

- Chechnya (Ethnic militias vs. Russian state)
- Georgia (three way civil war with breakaway regions)
- Armenia / Azerbaijan (centered in Nagorno-Karabakh)

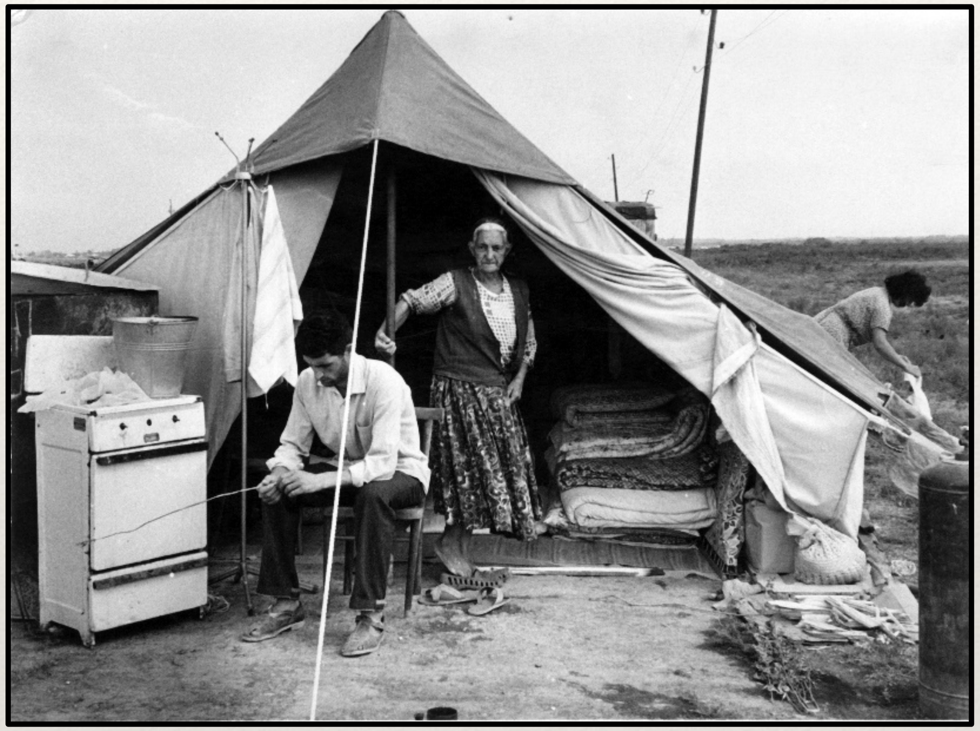


Photo of Azeri refugees, 1990s from Thomas Goltz, author of *Azerbaijan Diaries* (reprinted with permission)

Other Post-Soviet Conflicts

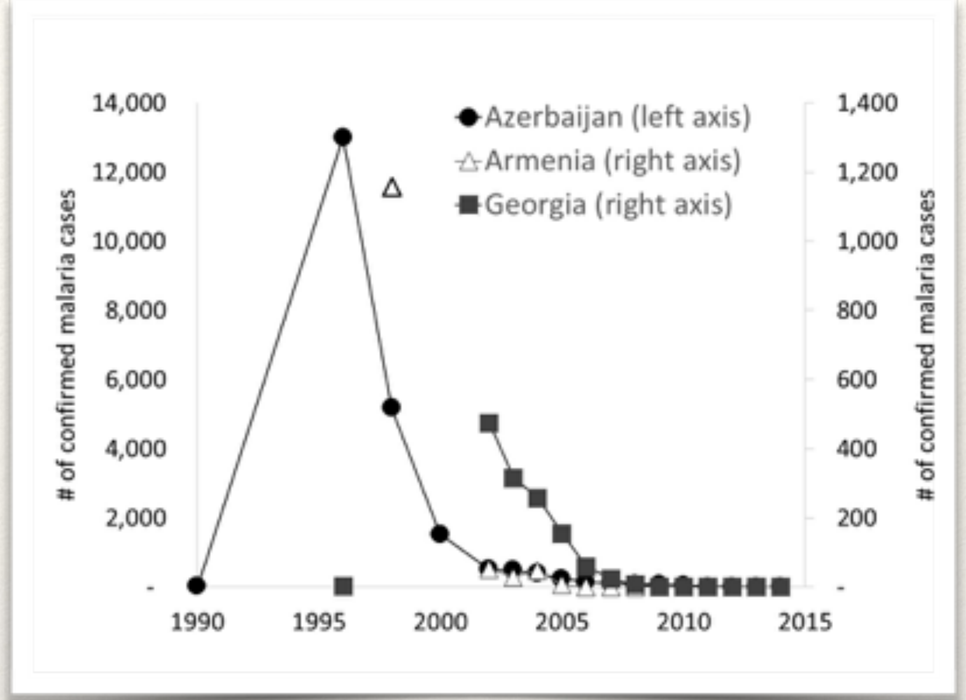
- Bosnia (genocidal ethnic violence)
- Tajikistan (civil war with profound resurgence of malaria)
- Moldova (breakaway region / separatism)

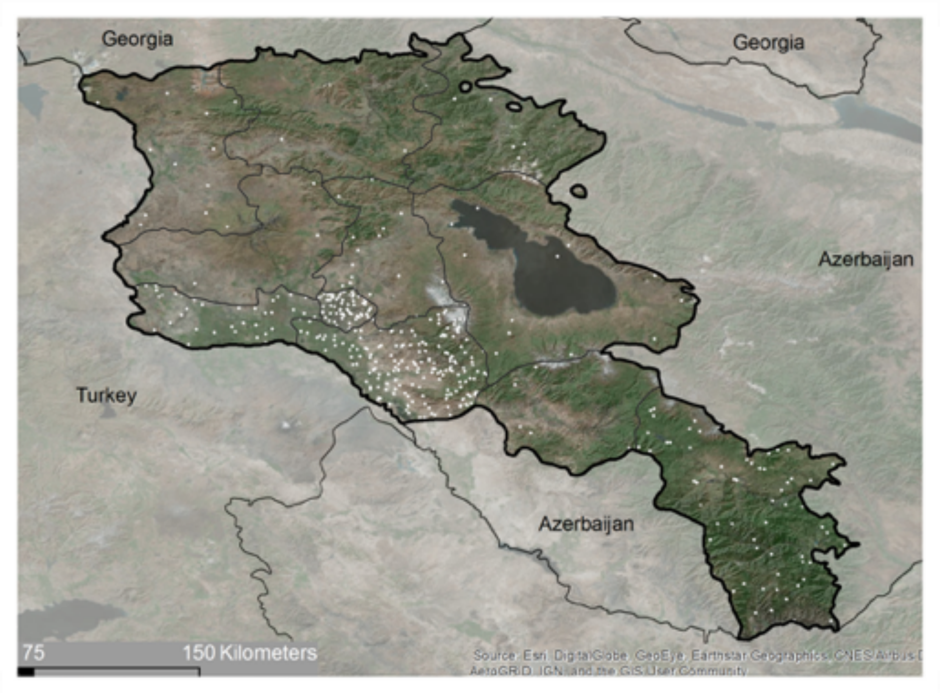
Common Features of These Conflicts

- Ethnic cleansing and displaced populations
- Territorial militias pre-date national armies and overlap with organized crime
- Stateless spaces = no public health surveillance
- **Multiple outbreaks of preventable disease**
- Conflicts freeze or resolve, pathogens continue to circulate

Malaria in the 1980/1990s

- In the 1980s and 1990s, malaria reappeared in the Caucasus, the Central Asian republics, and to a lesser extent in Russia because of the war in Afghanistan, the fall of the Soviet Union, and the appearance of unstable successor states.
- While the outbreak affected all three countries, Armenia and Georgia saw smaller numbers (~1,000 confirmed cases) than Azerbaijan.



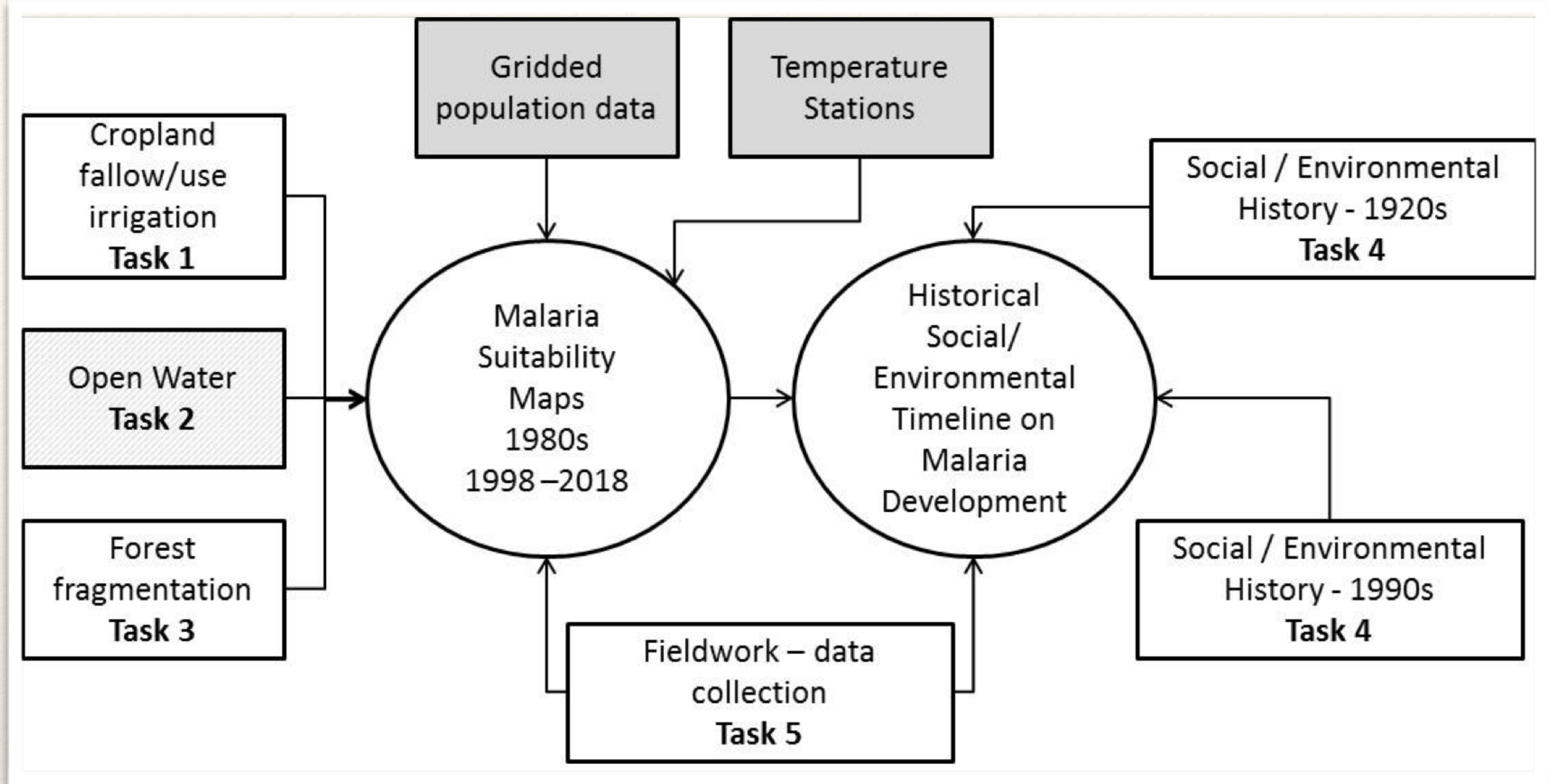


Spatial analysis

How did the outbreak happen?

And what made the natural environment conducive to uncontrolled reproduction of P. vivax in human populations during this time?

Currently, there are no empirical environmental studies linking specific events of the Soviet collapse to alterations in the landscape necessary for sustained transmission of P. vivax.



Overview of the study design

Progress report - Year 1

Task 2: Annual Open Water Maps

Water Indices - Comparison / Uncertainty

- Calculate and evaluate different water indices:
  - NDWI $\frac{(Green \quad - NIR)}{(Green + NIR)} = NDWI$
  - MNDWI $\frac{(Green \quad - SWIR1)}{(Green + SWIR1)} = MNDWI$
  - AWEIsh is formulated to distinguish water pixels from dark, built surfaces in urban areas:

$$4*(Green-SWIR1)-(0.25*NIR+2.75*SWIR2)$$

  - AWEInsh is designed to improve accuracy of water detection in areas where shadows are a major problem:

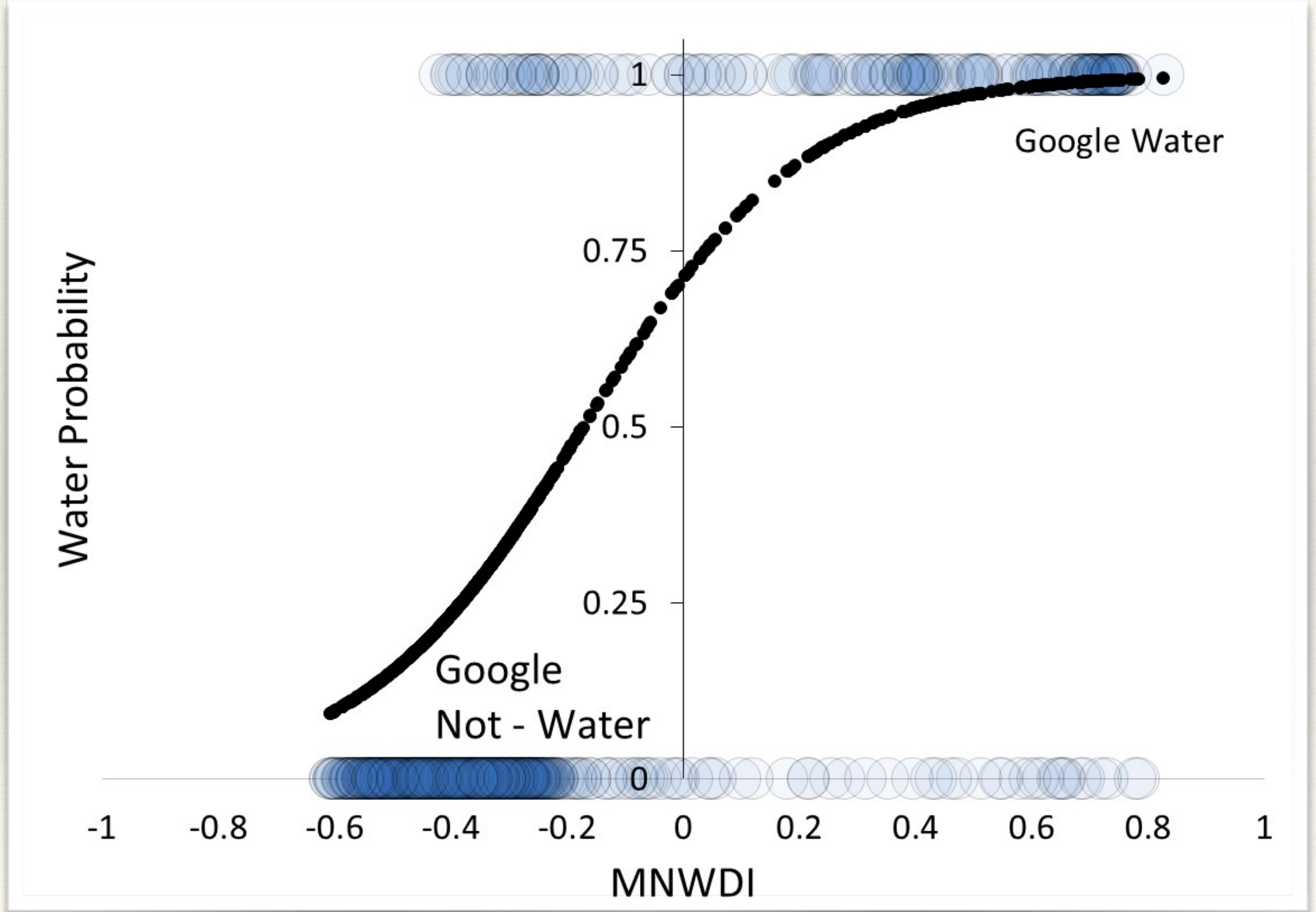
$$Blue+2.5*Green-1.5*(NIR+SWIR1)-0.25*SWIR2$$

Example site: http://tethys.dges.ou.edu/Armenia/

Google Data Collection

1,000 points per image (training/validation)

Model Development - Logistic Regression



Optimal threshold determination by image.

	Overall accuracy	*Under estimation*	*Over estimation*
JRC Water Extent (Pekel et al. 2016)	0.798	0.040	0.260
MNDWI	0.922	0.119	0.060
AWEIsh	0.924	0.142	0.046
AWEInsh	0.922	0.156	0.044
NDWI	0.899	0.029	0.029

European Extent: https://global-surface-water.appspot.com

All Areas & Seasons Combined

Preliminary Results

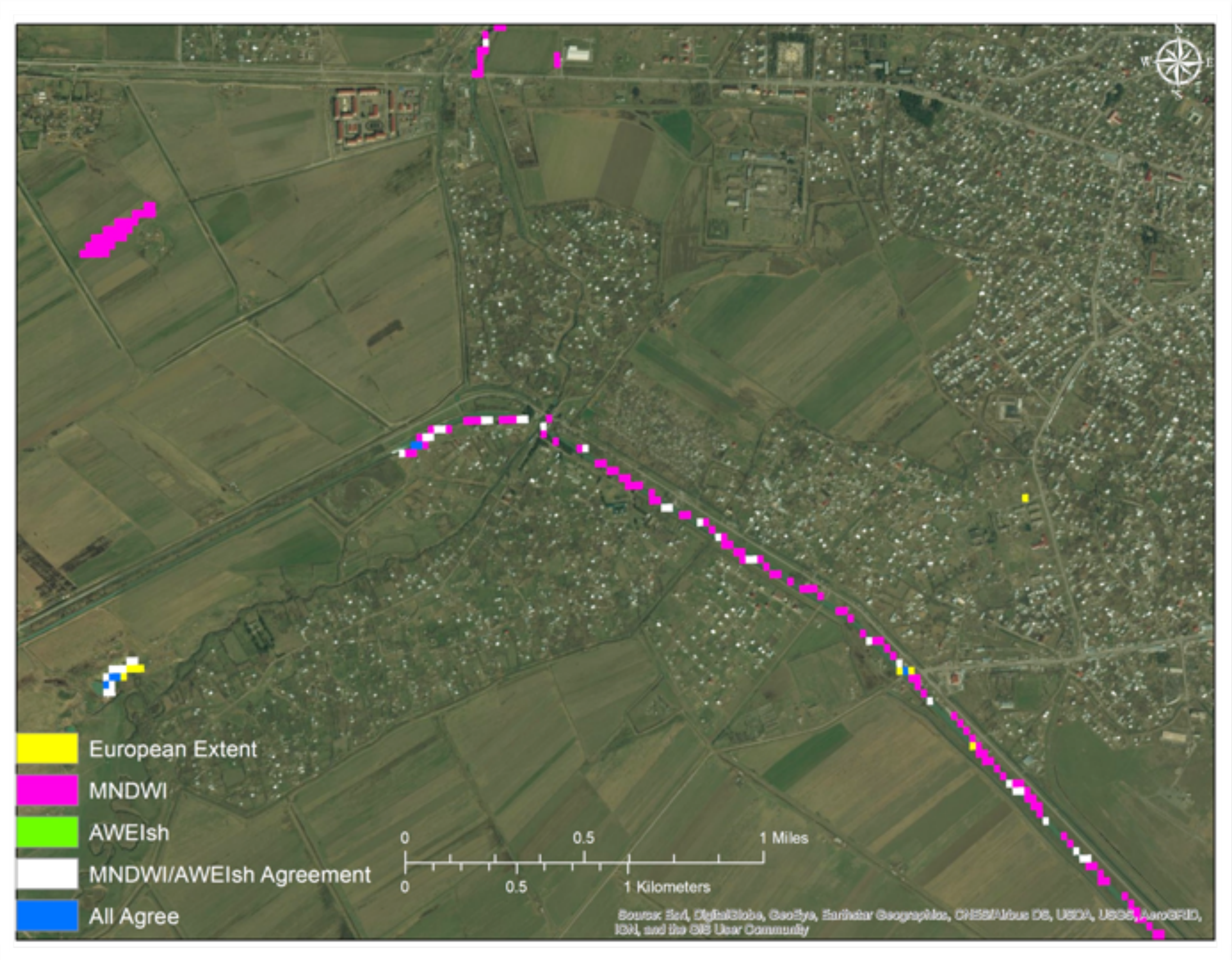
- Single-index models outperform multi-index models.
- Models perform better than open source global water data.


6/26


6/27/2018 14:45

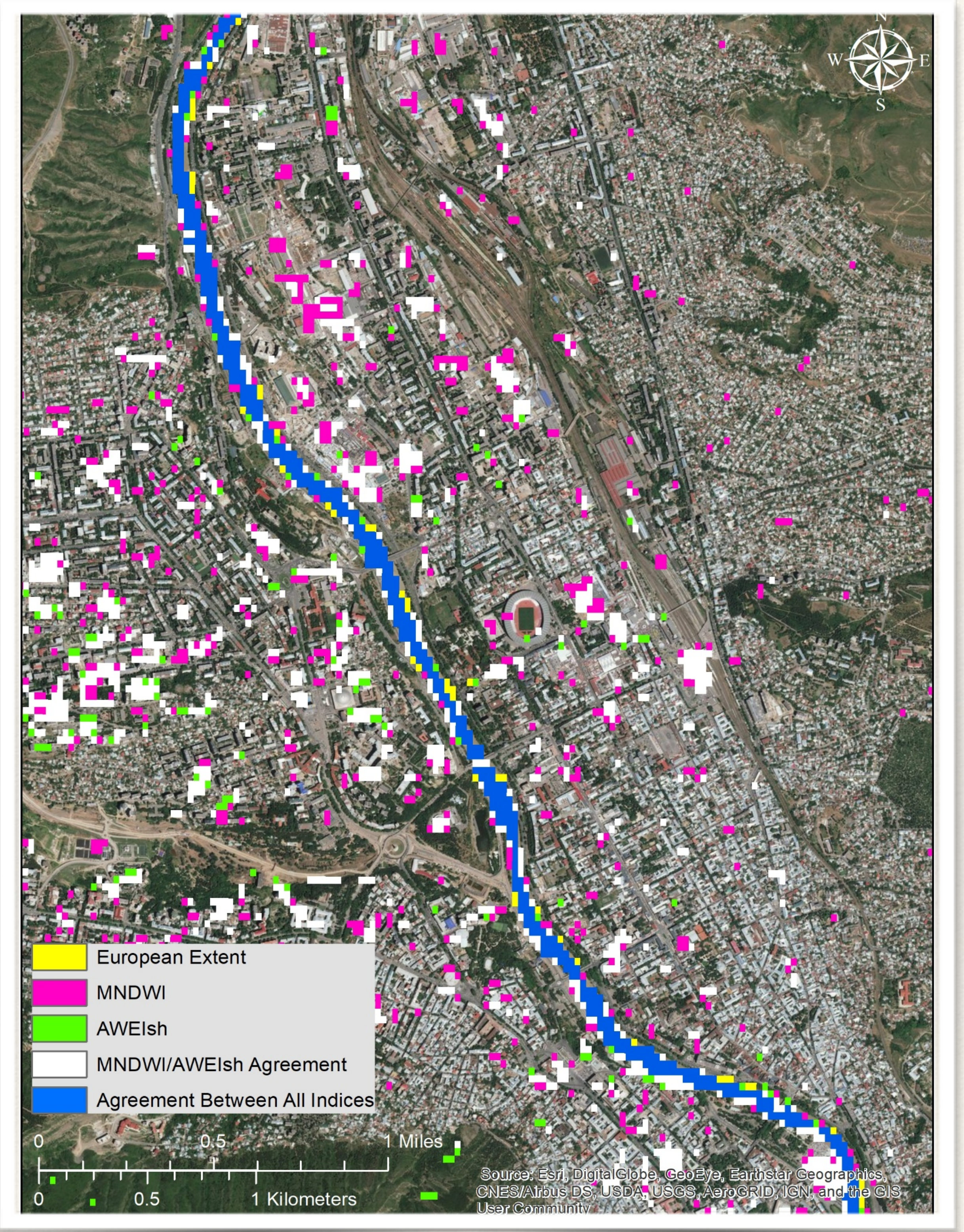
Irrigation Channel Detection

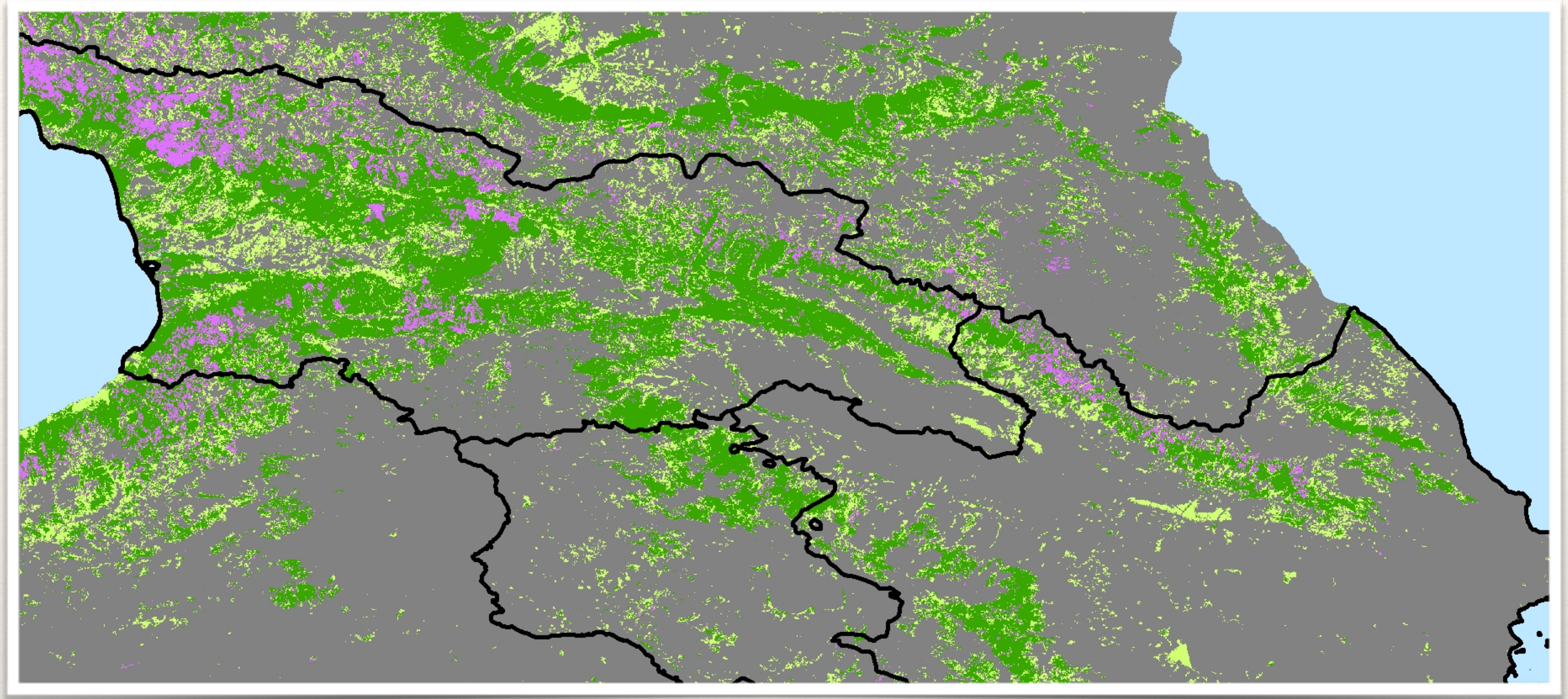
- AWEIsh exhibited a slightly better overall accuracy, but ignores smaller bodies of water.
- MNDWI detects these smaller bodies.
- Open-source water data also misses small water bodies.



Other Issues

- Over-estimation of water in dense urban areas.
- Removal with impervious surface dataset.





Landsat / Sentinel / Palsar

Task 3: Annual Forest Disturbance Maps

Caucasian forests are very heterogenous with lots of disturbance and regrowth — forest edges

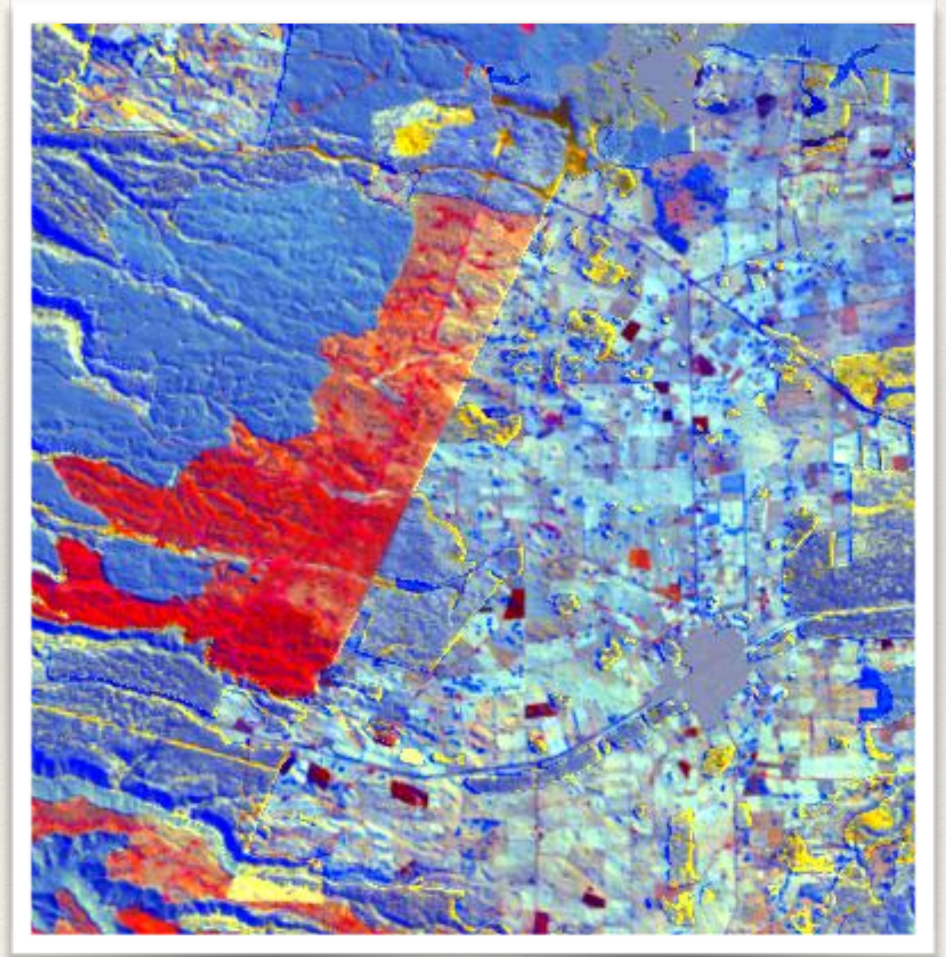
Detecting Forest Disturbance

- Linear transformation of the original bands of an image into a new set of bands: Brightness, Greenness and Wetness.
- The coefficients used to create the Tasseled-Cap bands are derived statistically from images and empirical observations.
- Calculation coefficients:

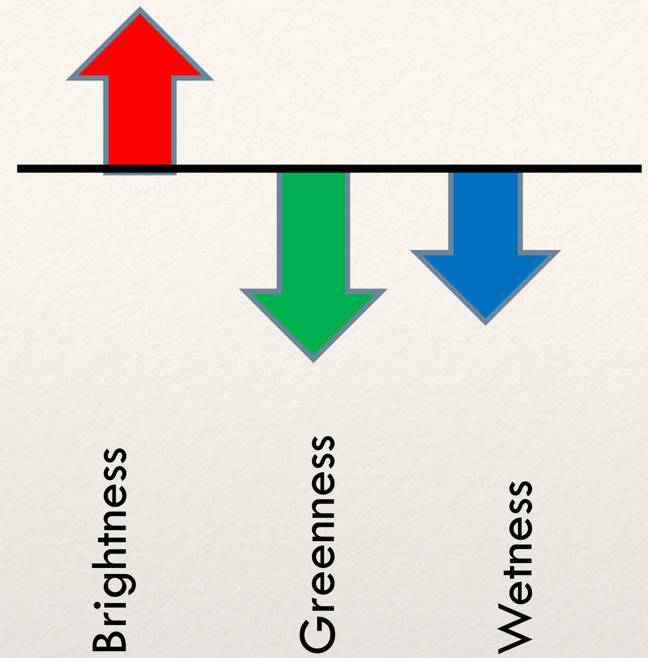
  Crist (1985) for Landsat TM/ETM+

  Nedkov (2017) for Sentinel 2

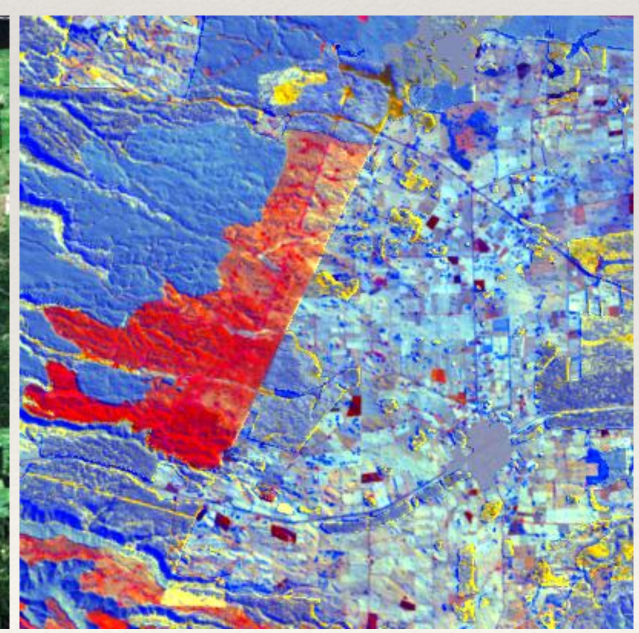
  (Lobser et al. (2007) for MODIS)

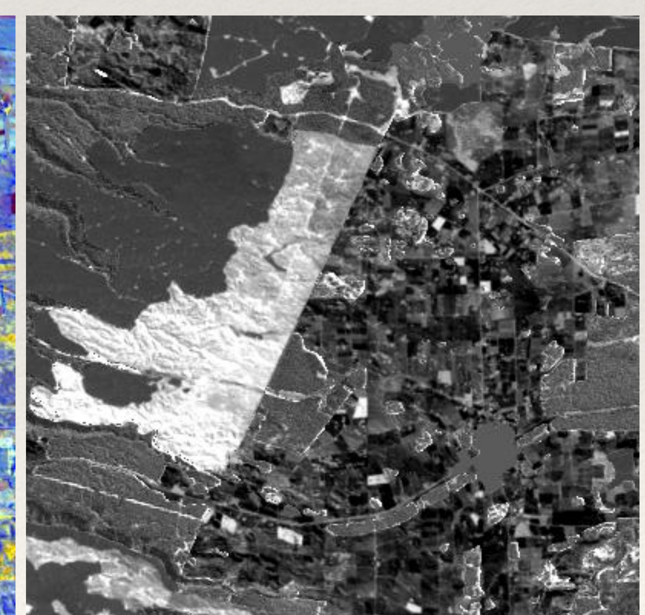


Forest Disturbance




True Color Landsat image

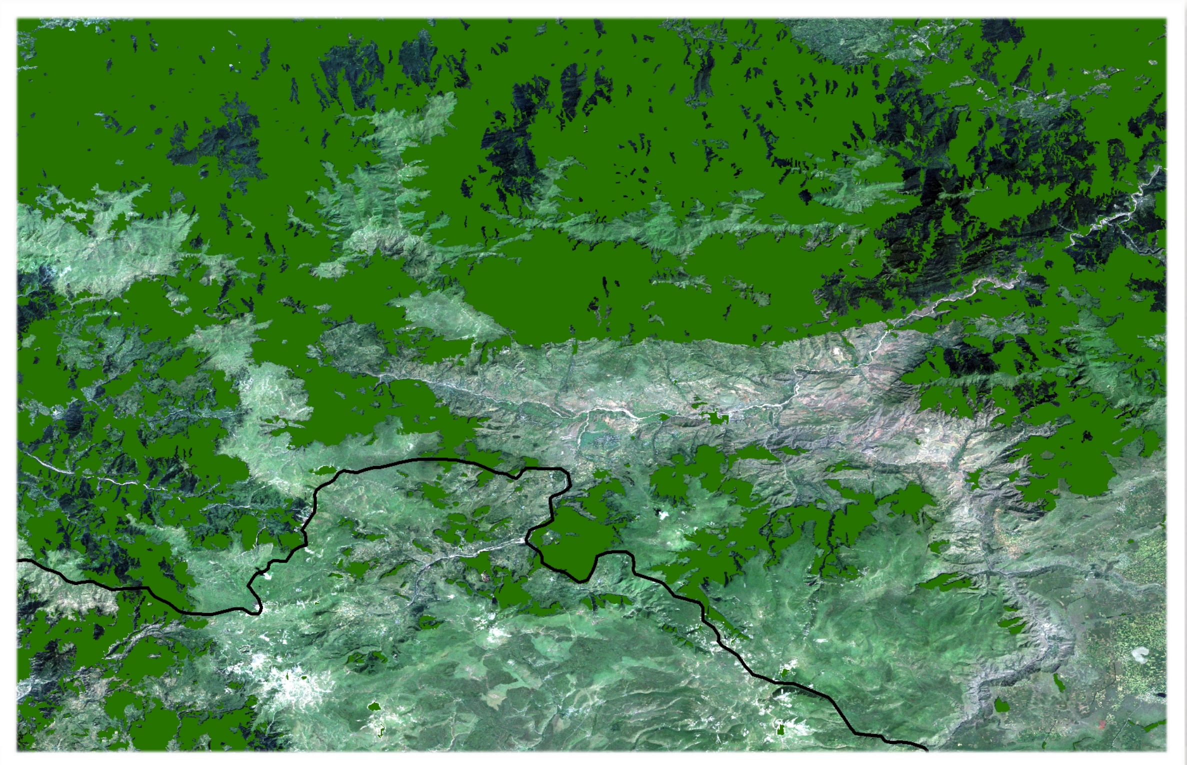

Landsat Tasseled Cap

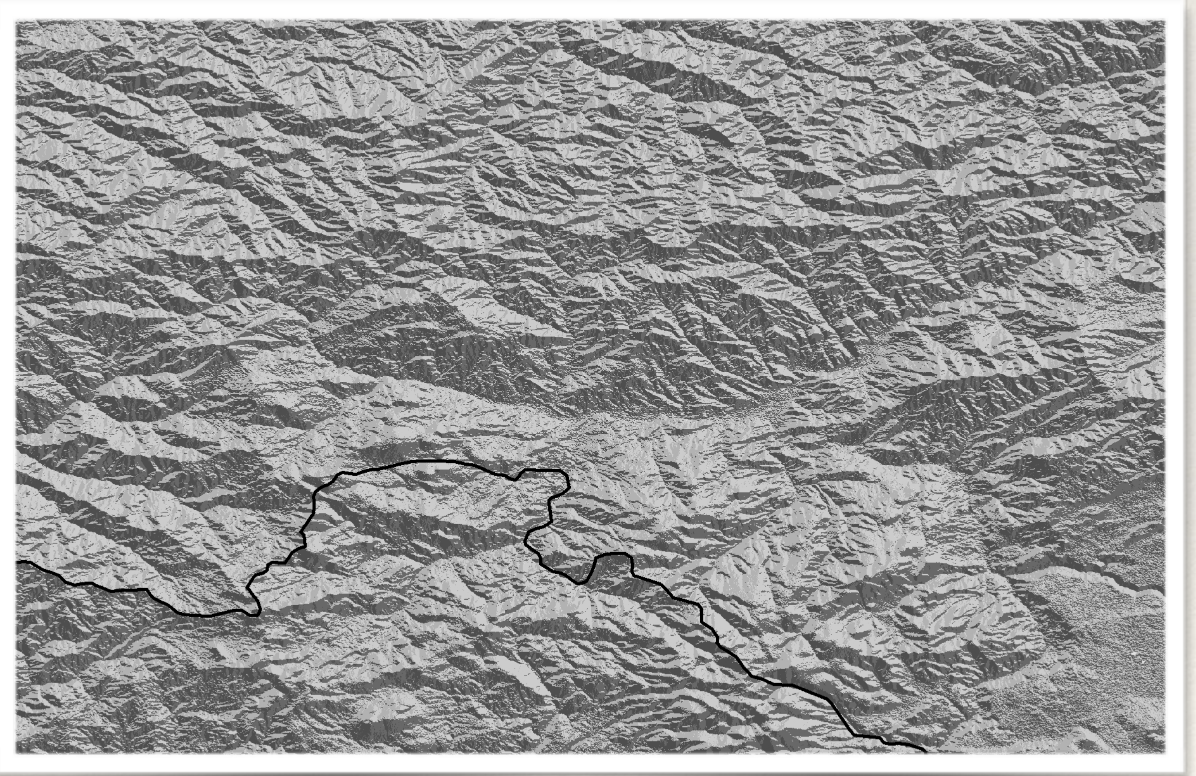

Landsat Disturbance

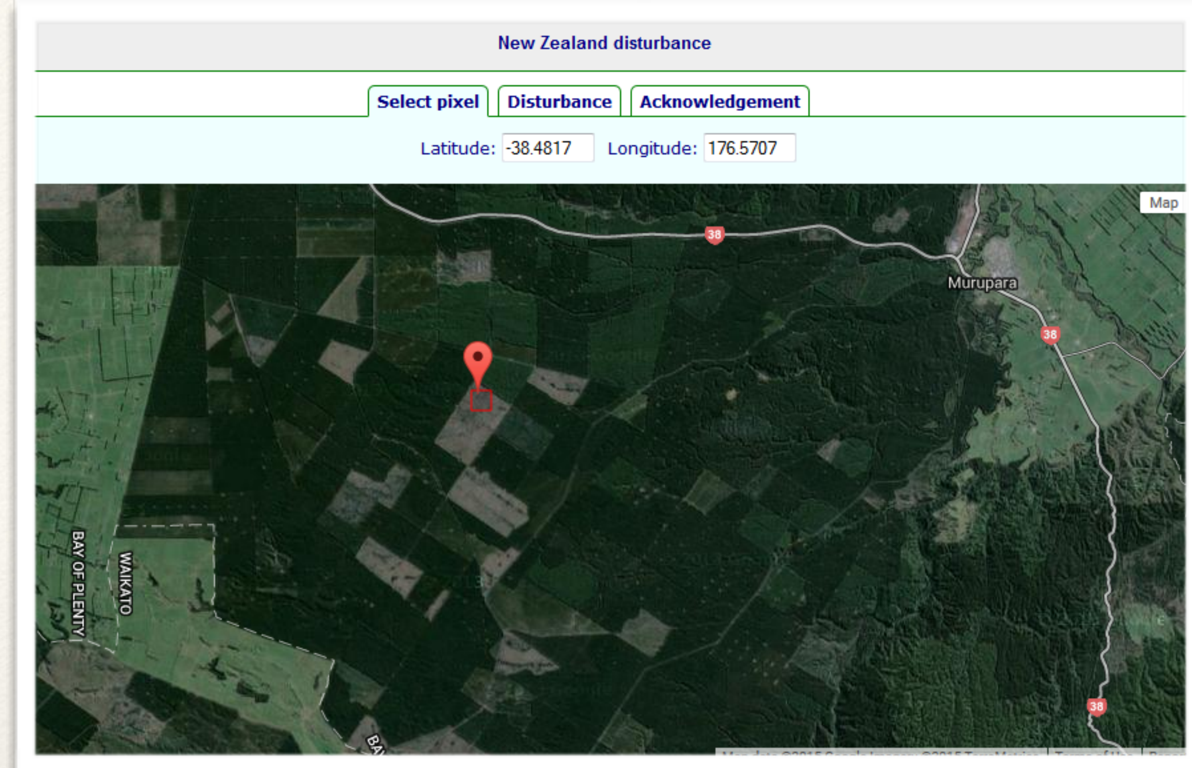
de Beurs et al., 2016, International Journal of Applied Earth Observation and Geoinformation

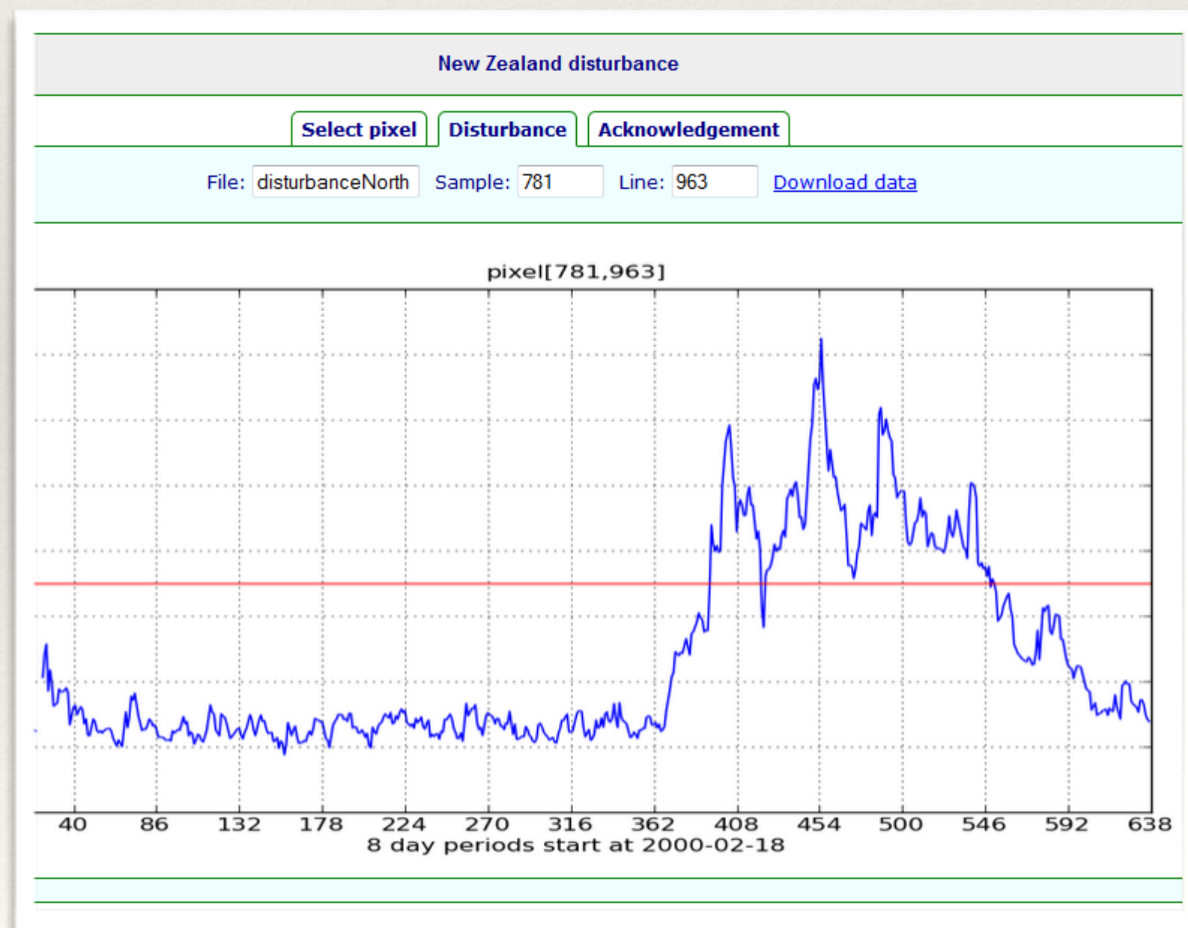
Tasseled Cap Standardization

- Each component is rescaled to a normalized distribution, e.g. normalized Brightness:
- $B_n = (B - B_\mu)/B_\sigma$
- Normalized by :
    1. Stable forest patches (2007 and 2017) which are at least 62,500 m^2 in size (100 Palsar grid cells).
    2. Aspect (North vs South facing slopes).
    3. Image path/row.









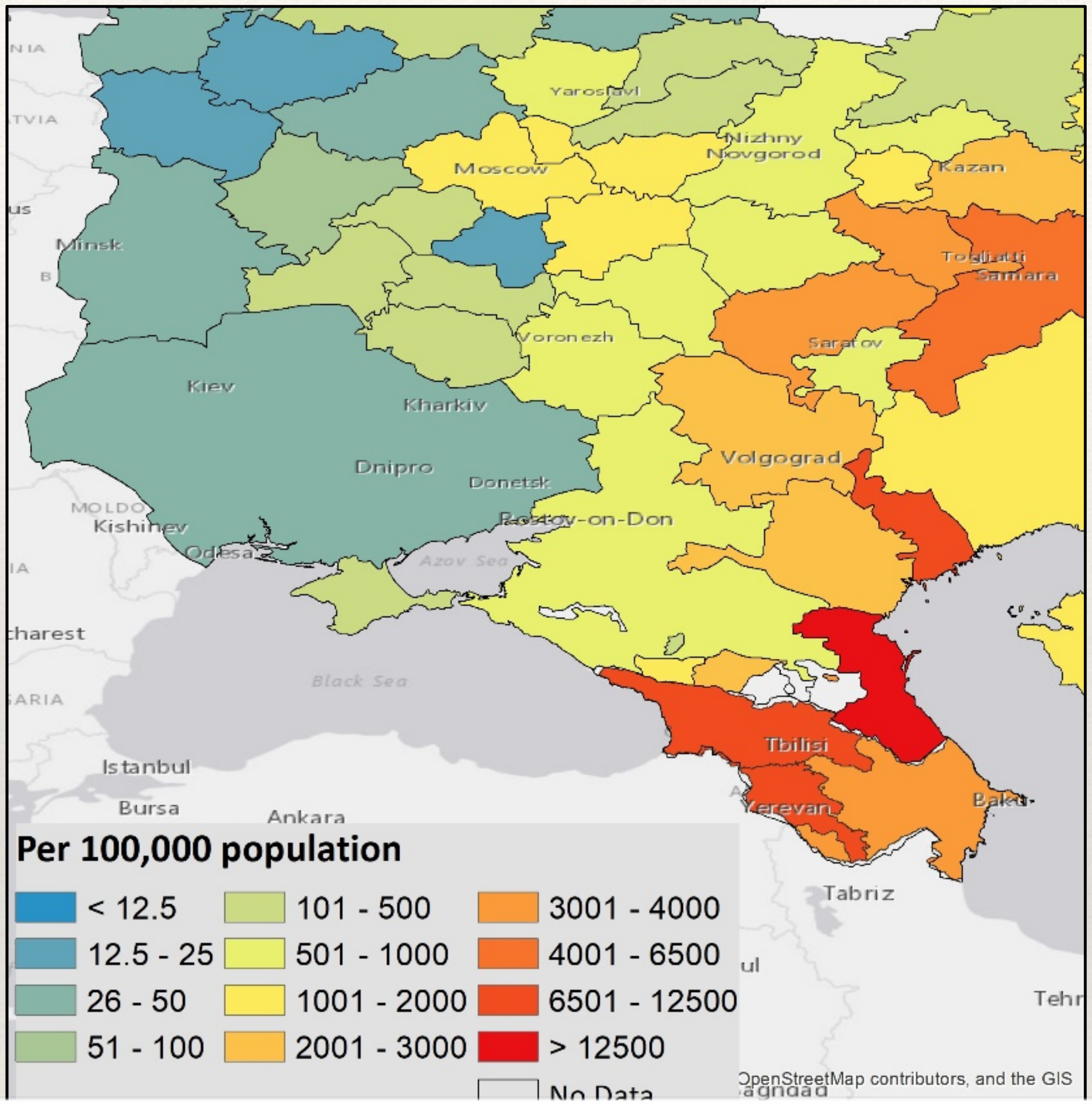
http://tethys.dges.ou.edu/NZ_disturbance

Summer 2018 and 2019

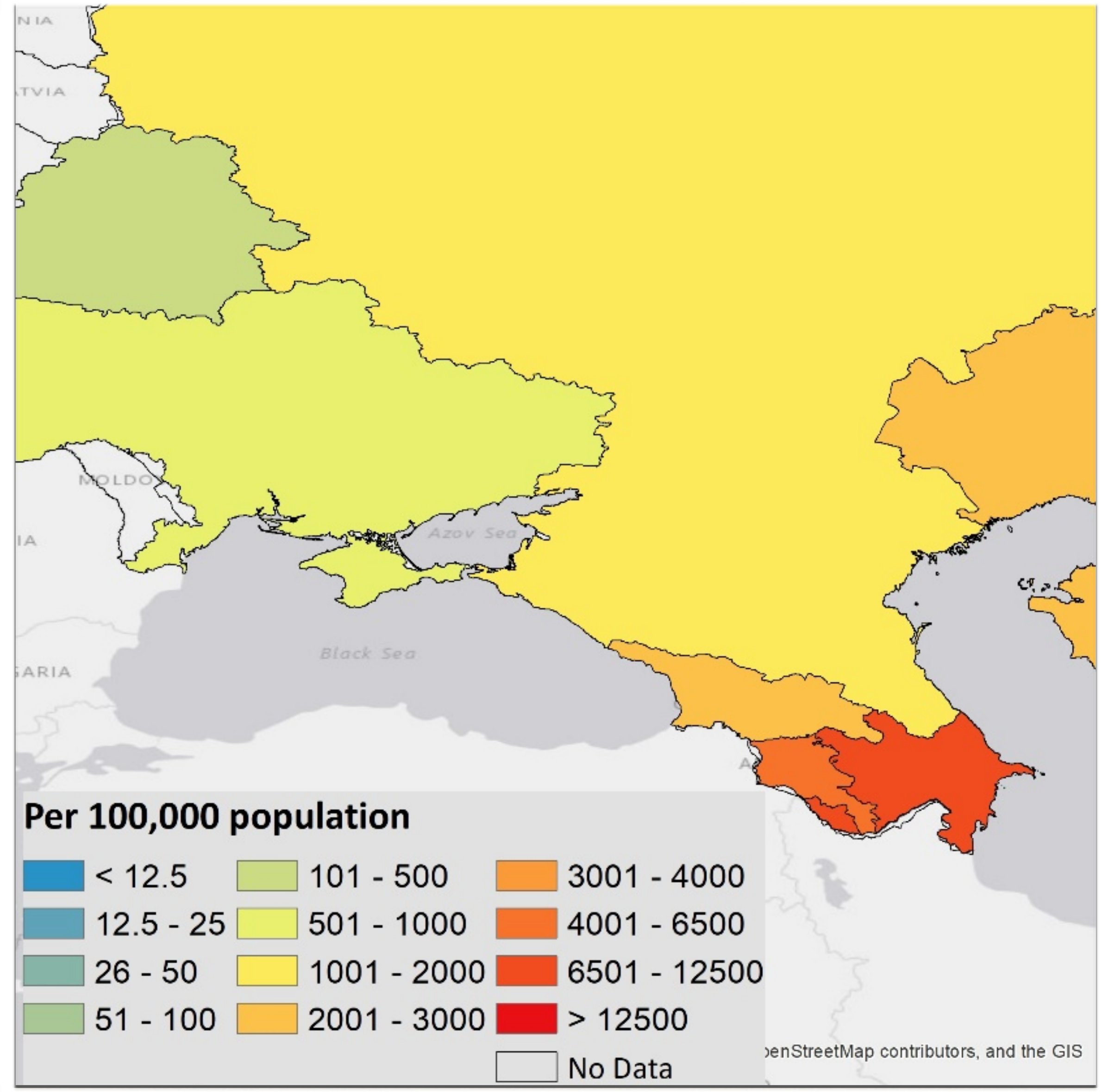
Task 4: Archival and Anthropological Research

- League of Nations malaria control records and correspondence from the 1920s.
- Early US Public Health System documents detailing malaria control in the US.
- Records of humanitarian assistance agencies during conflict.
- Diplomatic correspondence during crisis.
- Visual records from journalists.

League of Nations Records



1922



1940

June 2018 / September 2019

Task 5: Field Research

- Connect with local collaborators.
- Outreach to epidemiologists, scientists and public health professionals.
- Field validation.

Questions?

Thank you

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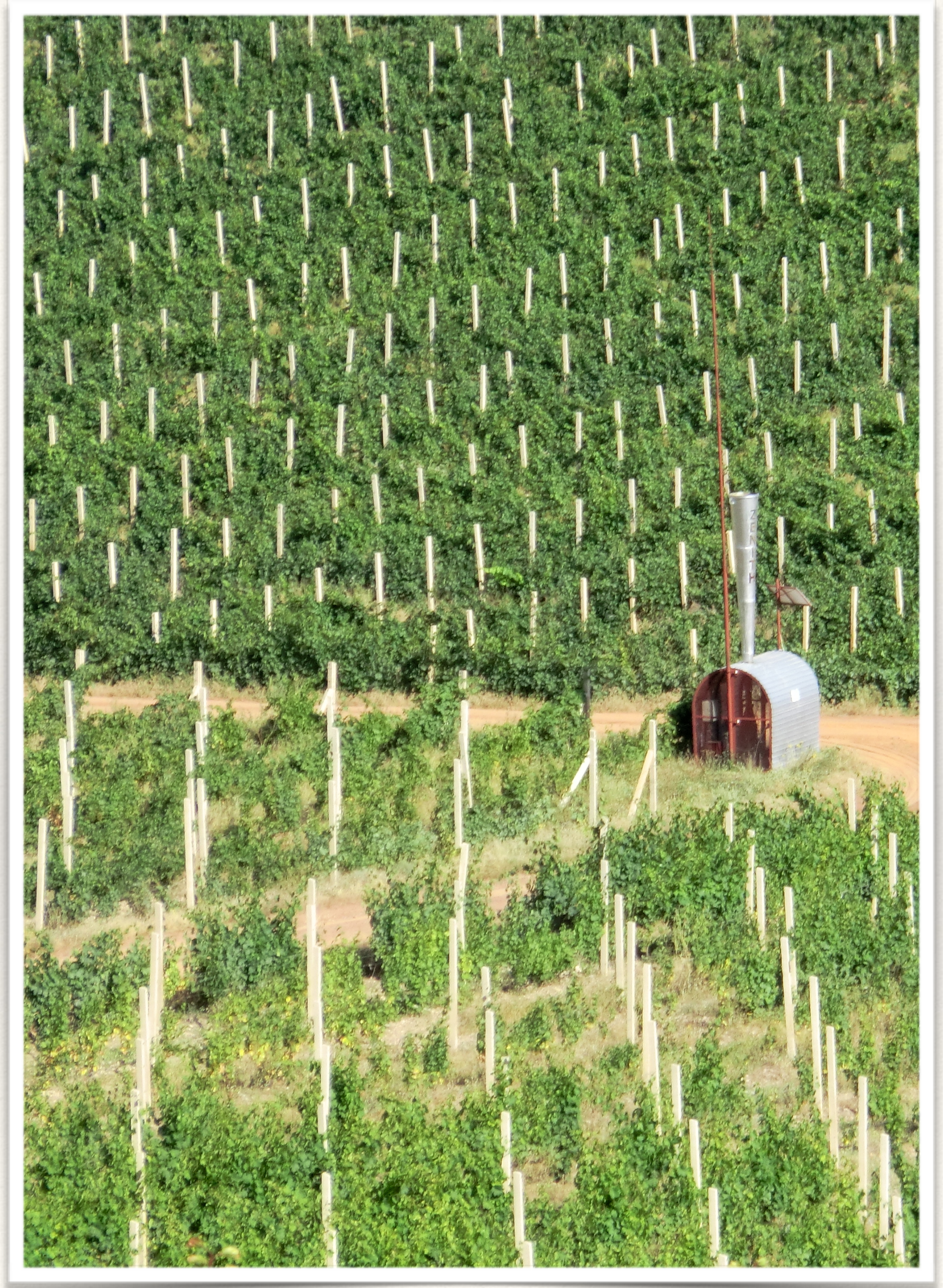

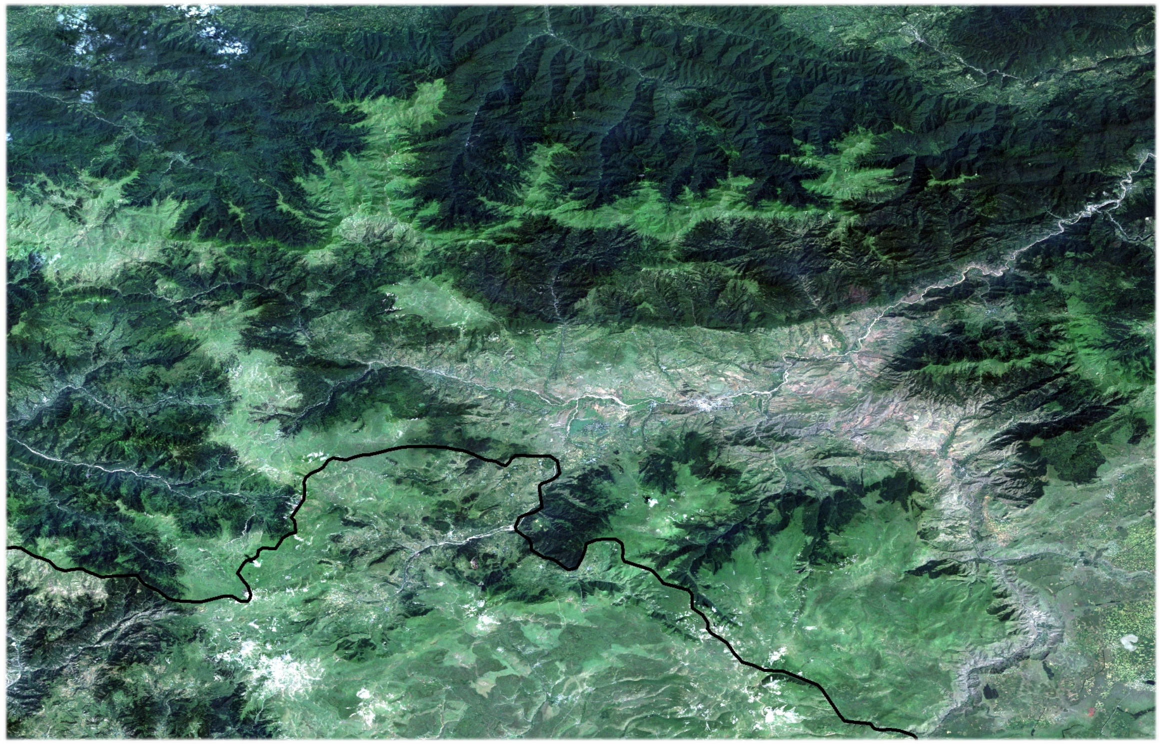
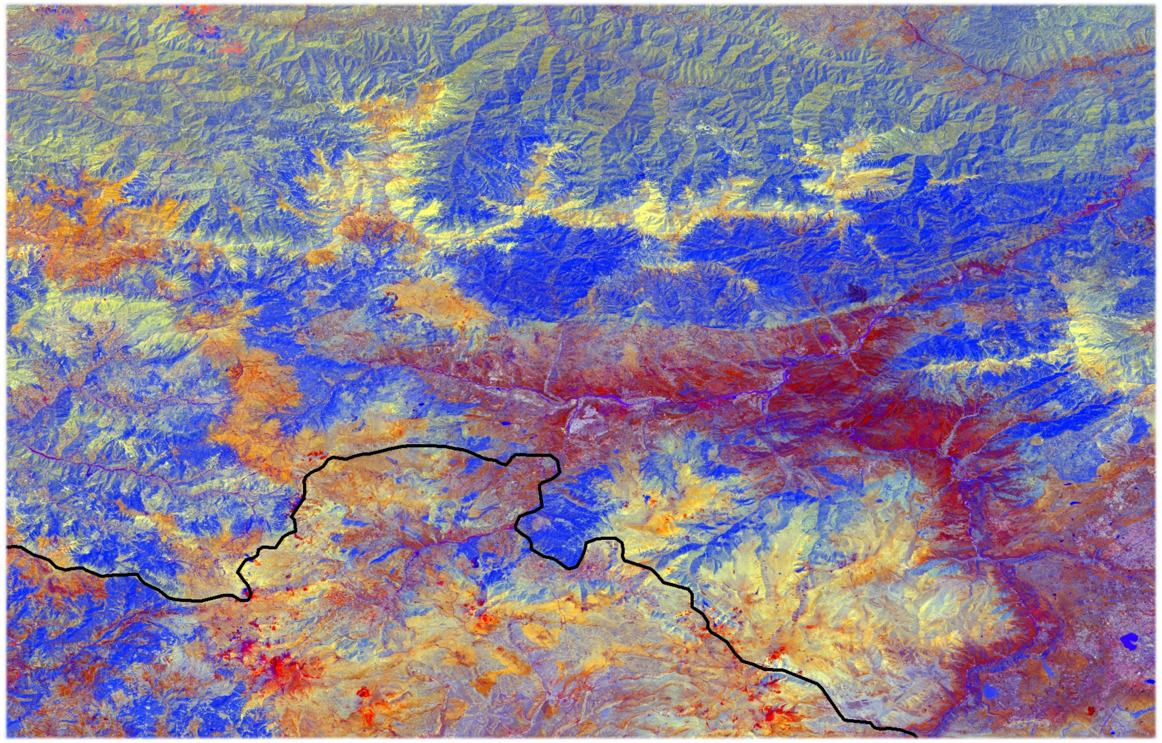
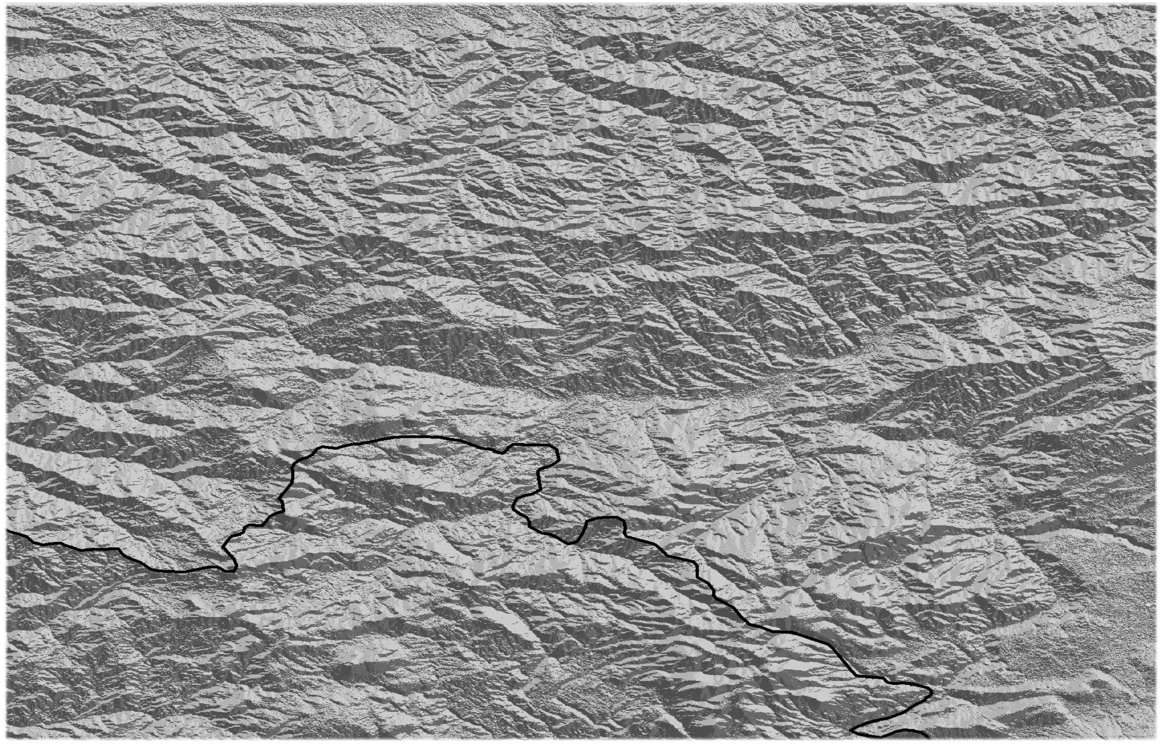
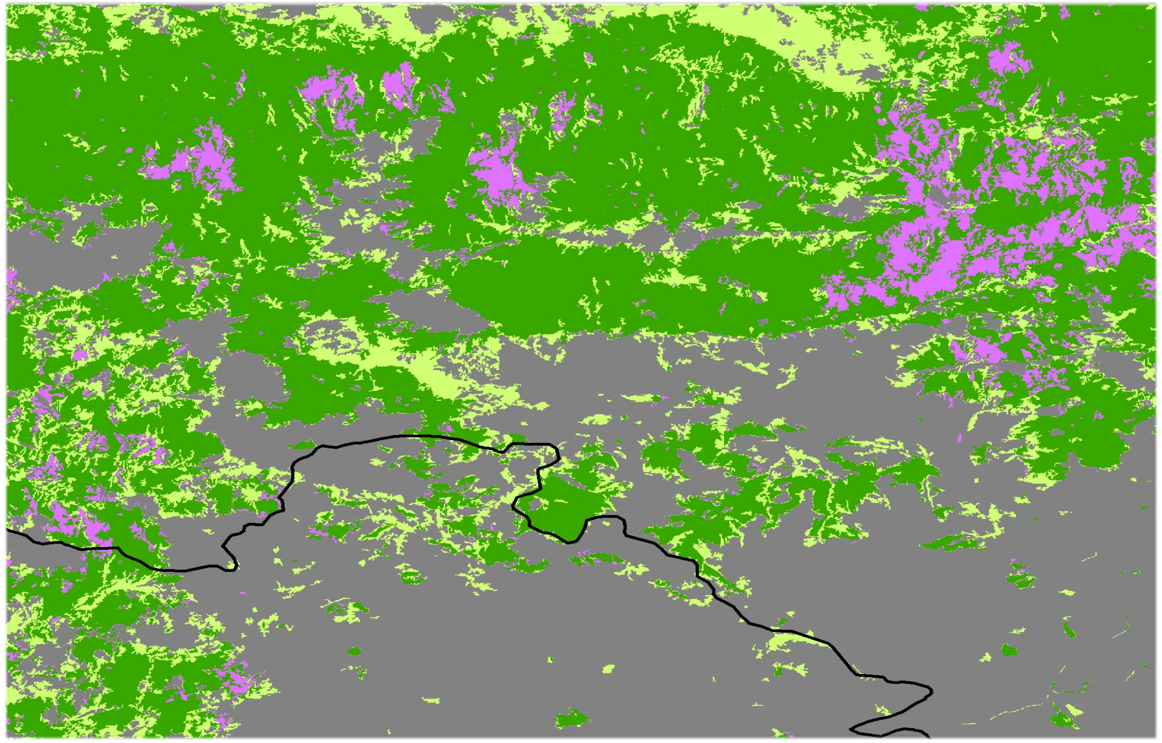

Publications (in process)

- Hirschfeld K. (2019). Insurgent Microbes: Theorizing Global Health in the Anthropocene. Anthropocene Review. Accepted with revisions.
- Brayfield BP, Hirschfeld K. (in preparation). Ethnic conflict as a risk amplifier for P. vivax malaria in temperate zones: Insights from the Caucasus conflicts of the 1990s. Conflict and Health.
- Worden J, de Beurs KM, Owsley BC. (in preparation). Open Surface Water Detection in the Caucasus Using Remotely Sensed Data. International Journal of Earth Observation and Geoinformation.
- de Beurs KM, Melkonyan A, Owsley BC, Hirschfeld K, Brayfield BP. (in preparation). Climate change and political instability: the effect on the land cover and land use in the disputed Karabakh region. Regional Environmental Change.
- de Beurs KM. Hirschfeld K, Brayfield BP. (in preparation). Mapping malaria since the1920s in Russia and the Caucasus. International Journal of Health Geographics.

Invited / Contributed Talks & Posters

- de Beurs KM, Hirschfeld K, Melkonyan A. 2018. Land use patterns and political instability as predictors for the re-emergence of malaria in the Caucasus. Lund University, Department of Physical Geography and Ecosystem Science, Lund, Sweden.(February 2019).
- de Beurs KM, Hirschfeld K, Melkonyan A. 2018. Land use patterns and political instability as predictors for the re-emergence of malaria in the Caucasus. American University of Armenia, Department of Environmental Sciences, Yerevan, Armenia. (June 2018).
- de Beurs KM, Hirschfeld K, Melkonyan A. 2018. Land use patterns and political instability as predictors for the re-emergence of malaria in the Caucasus. Armenia Academy of Science, Yerevan, Armenia. (June 2018)
- Worden J, de Beurs KM. 2018. AGU Fall Meeting. H32K-2079: Open Surface Water Detection in the Caucasus Using Remotely Sensed Data. American Geophysical Union, Washington, DC. (December 2018).
- de Beurs KM, Jami M, Owsley BC. 2018. AGU Fall Meeting. GC51G-0881: Using Remotely Sensed Data to Investigate Cropland Changes in the Caucasus. American Geophysical Union, Washington, DC. (December 2018).
- Worden J, de Beurs KM. 2018. OU GIS Day. Open Surface Water Detection in the Caucasus Using Remotely Sensed Data. (November 2018). This poster won 2nd place in the GIS Day poster competition.
- Ashworth K, de Beurs KM. 2018. OU GIS Day. Using High-Resolution Aerial Photographs to Validate Large-Scale Surface Water Datasets. (November 2018). This poster won 3rd place in the GIS Day poster competition.
- Jami M, de Beurs KM. 2018. 2018. OU GIS Day. Using Remotely Sensed Data to Investigate Cropland Changes in the Caucasus. (November 2018).
- Hirschfeld K. 2018. International Conference on Emerging Infectious Diseases. Board 92: Political Corruption and State Failure: How Macro Level Pathologies Increase the Risks of Emerging Infectious Disease. Atlanta, Georgia (August 2018).