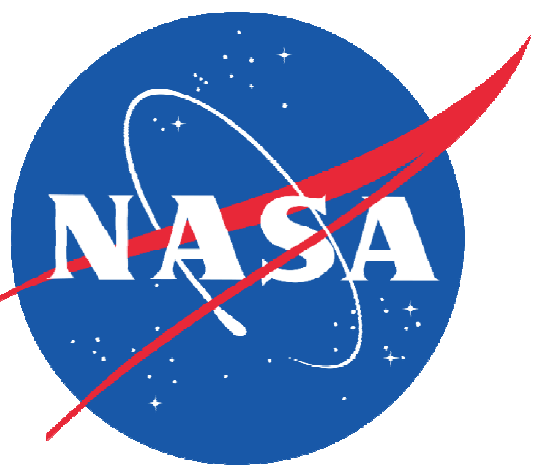




Monitoring Land Change from Resource Extraction Using Long-term Time Series Remote Sensing Data in Wyoming's Powder River Basin



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Objectives

- Classify reclamation and land disturbance throughout the Powder River Basin
- Analyze the extent and distribution of water and vegetation change around coal mines throughout the Powder River Basin over time
- Provide the Coal Mining Assessment Tool (CMAT) to the project partners, allowing them to monitor land reclamation efforts into the future and review the success of previous efforts
- Produce output data from CMAT that can be used as inputs for broader analyses on energy extraction

Methodology

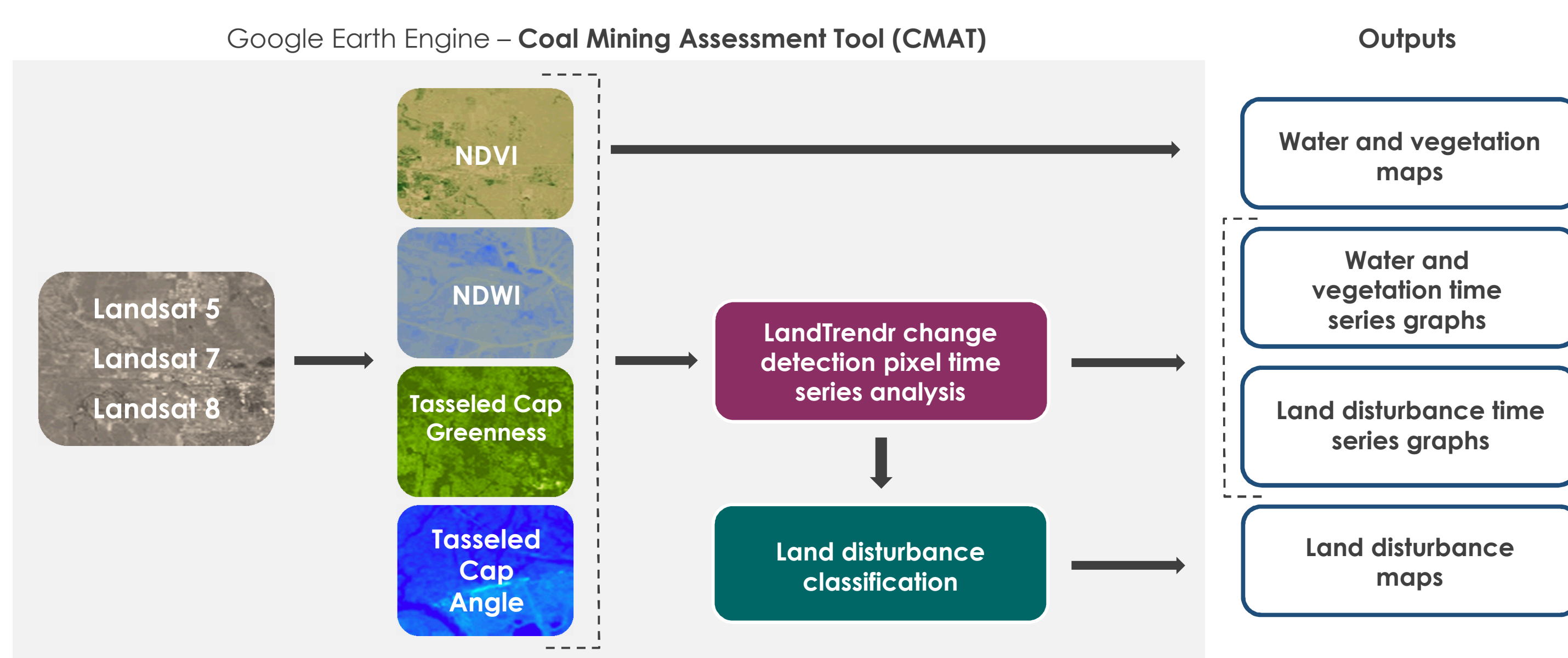


Figure 1. Visualization of data processing and workflow

Study Area

- Study Location
 - Campbell County, Powder River Basin, Wyoming

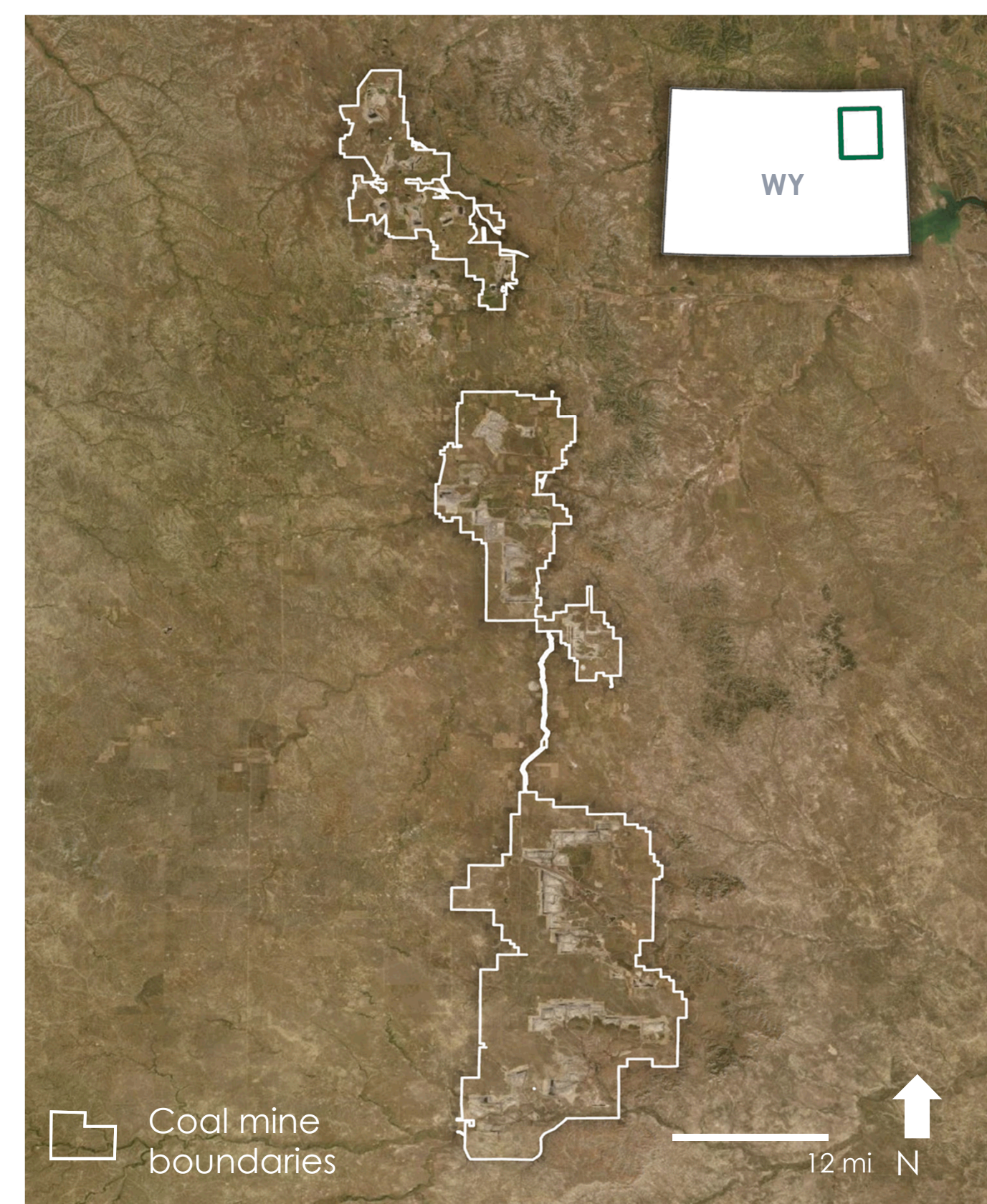
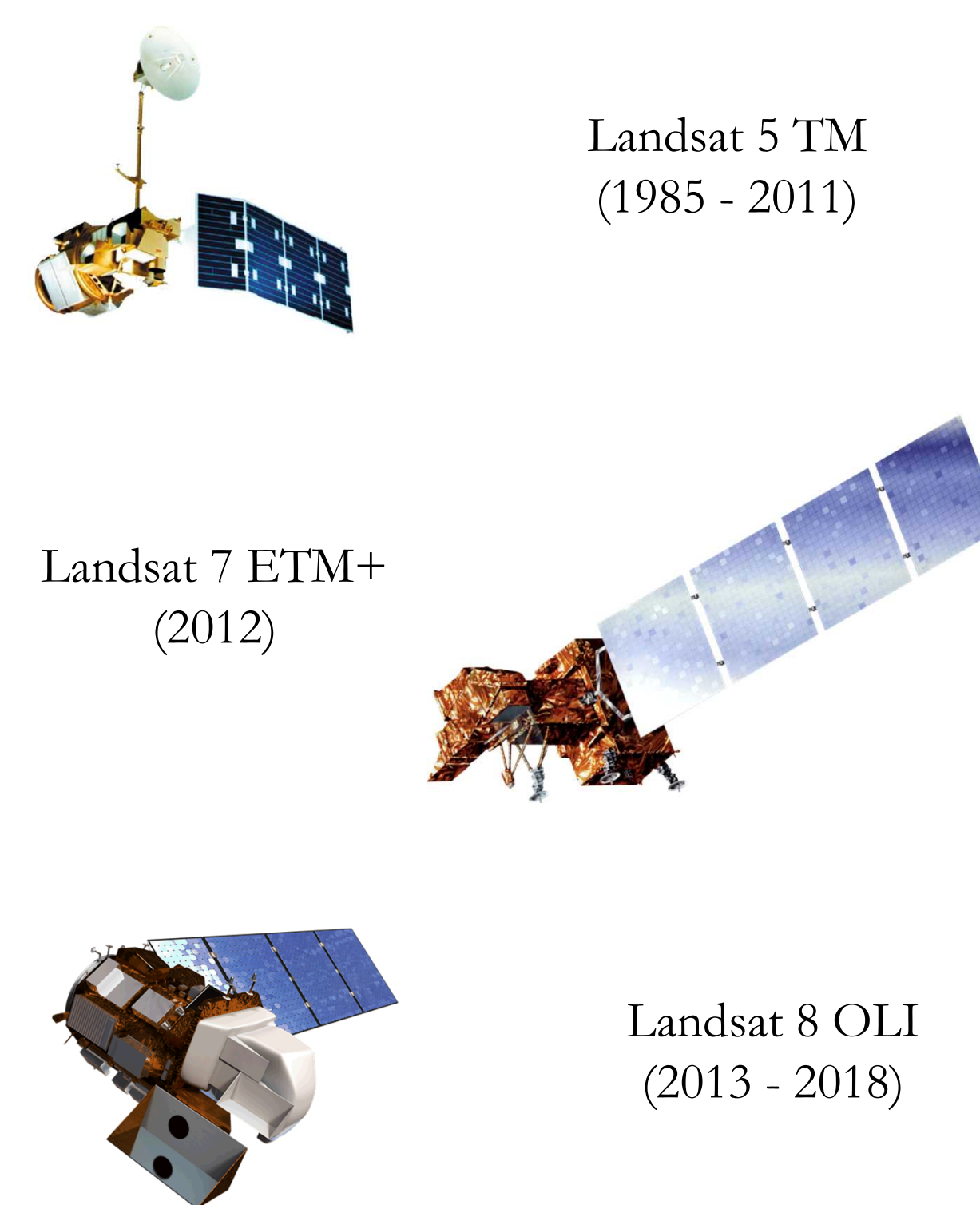


Figure 2. Study area map of all of the coal mines in Campbell County, WY

Earth Observations

- Study Period
 - 1985 to 2018
 - June 1st to August 31st
 - Least snow on the ground



Project Partners

- Powder River Basin Resources Council
- Western Organization of Resources Councils
- Clemson University, Energy-Economy-Environment Systems Analysis Group
- SkyTruth

Abstract

Using multi-sensor time series analysis, this research tracks the magnitude and duration of land disturbance associated with surface mining in the Powder River Basin and the subsequent vegetation response. Campbell County, Wyoming, in the Powder River Basin, was selected as a case study because the county has the highest production of coal in the United States. This study utilized Landsat series data to create annual composites during the growing season across 1985 to 2018. Using the Landsat Detection of Trends in Disturbance and Recovery (LandTrendr) Algorithm in Google Earth Engine, we tracked pixel-level changes to monitor land disturbance and revegetation in arid, grassland ecosystems where interannual vegetation changes can confound vegetation indices used to monitor land disturbance and vegetation health. For mining-related land disturbance, mathematical transformations (Tasseled Cap Transformation) achieved higher accuracy when identifying the magnitude and duration of land disturbance than vegetation (i.e., NDVI) or water indices (i.e., NDWI). Non-mined reference sites were incorporated to monitor interannual vegetation variation over the study period to understand the range of vegetation brightness without surface mining land disturbance. This presentation highlights how these methods can be applied to monitor both land disturbance from mining and mine reclamation. Understanding background vegetation variation helps determine vegetation change that is likely from mine reclamation management by removing noise from productive grass years. Establishing remote sensing methods to accurately track mine development and management over time can aid in regulatory and management decisions, critical for ecosystems health in post-mining landscapes.

Results

- Figure 3 demonstrates high inter-annual variability in vegetation brightness, driven by fluctuations in precipitation that make using Vegetation Indices challenging to identify mines across years
- We compared the spectral changes of mines to three reference sites per mine, chosen by similar vegetation cover to account for this variability
- Using reference sites and LandTrendr, we were able to produce a reproducible method that allows swift visualization of how surface mines change over time in arid grasslands

Changes in Tasseled Cap Angle

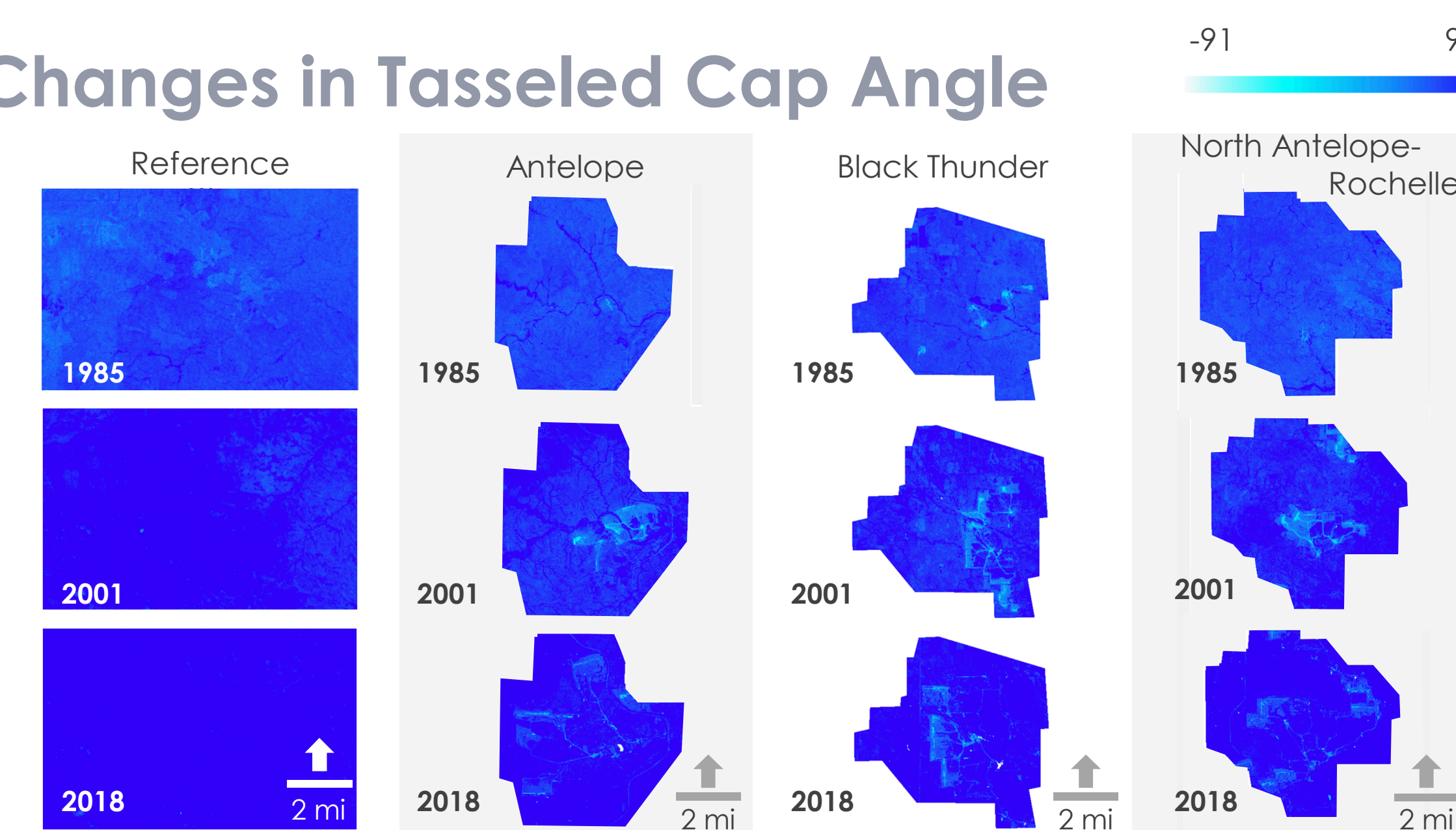


Figure 4. Maps of TCA for three time periods (1985, 2001, 2018) for a reference site, Antelope, Black Thunder, and North Antelope-Rochelle mines. Along with seeing differences in the mine location, this panel suggests the variability between the brightness of different Landsat sensors over time.

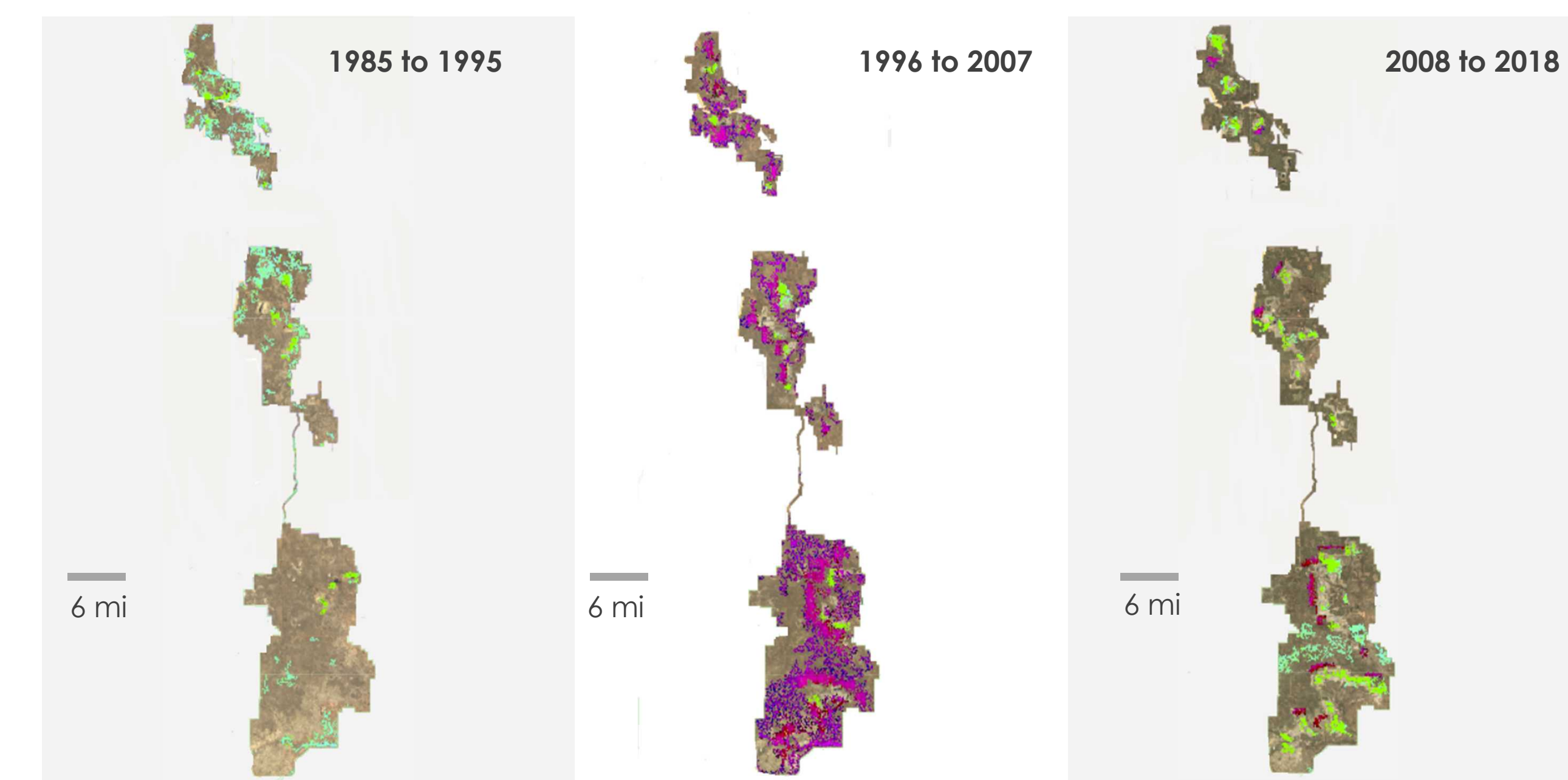


Figure 5. Graph of the ratio between the mining sites and their respective reference site for annual TCA between 1985-2015. The higher TCA ratios suggest that the mine has more reclamation activity and lower values indicate likely land disturbance.

LandTrendr Parameters

Disturbance:

- Greatest Loss; 1985-2018, Magnitude > 200; Duration > 5 years; Pre-value not used

Reclamation:

- Fastest Gain; 1985-2018; Magnitude > 600; Duration > 5 years; Pre-value not used

Figure 6. (left) Three panel map of LandTrendr outputs for the three input periods 1985-1995, 1996-2007, 2008-2018 for all of the mines across Campbell County, WY. The visualization is the same as the legend for Figure 7.

LandTrendr Visualization

We created an artificial three-band composite image that includes magnitude, duration, and pre-change spectral value of each pixel.

- Disturbance bands: Magnitude (red), Duration (green), Pre-change values (blue)
- Reclamation bands: Duration (red), Magnitude (green), Pre-change value (blue)

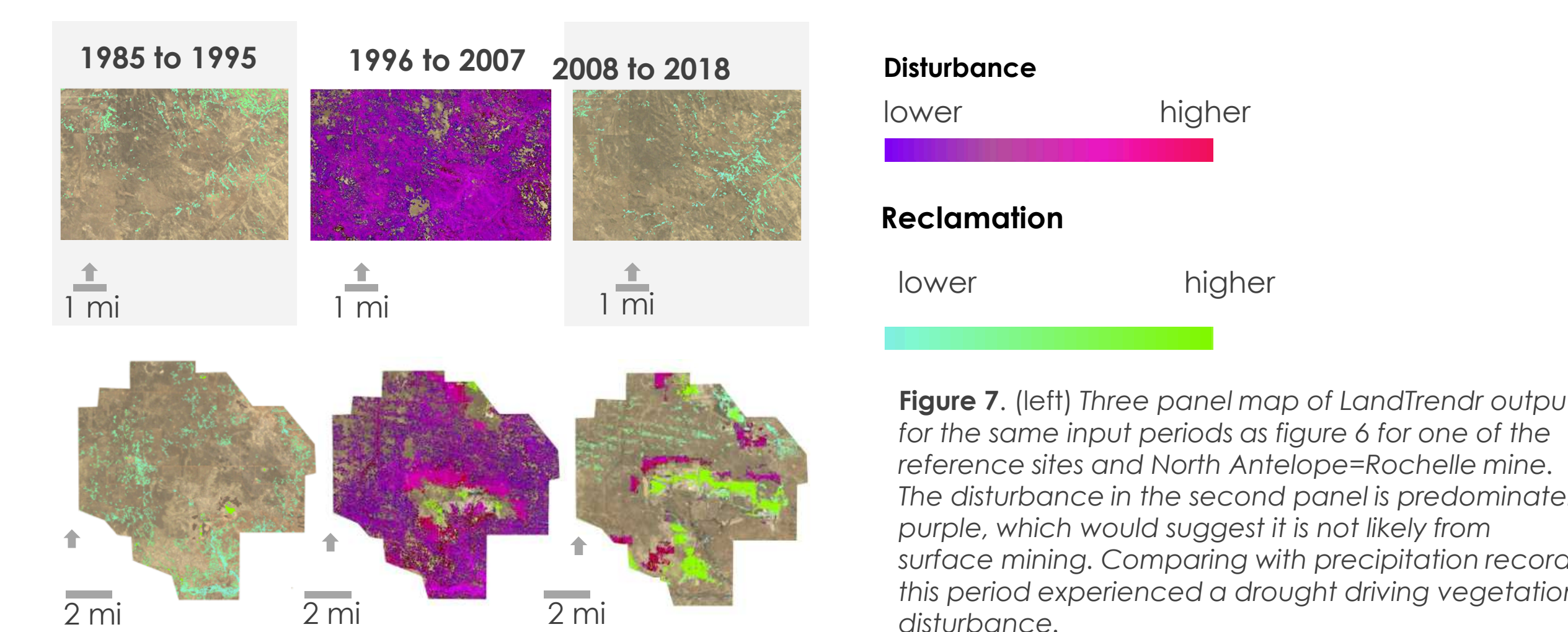


Figure 7. (left) Three panel map of LandTrendr outputs for the same input periods as figure 6 for one of the reference sites and North Antelope-Rochelle mine. The disturbance in the second panel is predominately purple, which would suggest it is not likely from surface mining. Comparing with precipitation record, this period experienced a drought driving vegetation disturbance.

Conclusions

- While NDVI and NDWI can be helpful indices for evaluating land disturbance, the spatial and temporal patterns of mining and reclamation call for **more advanced methods**.
- Tasseled cap greenness and tasseled cap angle values indicate that mines that engage in **thorough contemporaneous reclamation** can restore vegetation **up to 78% faster than other mines**.
- CMAT determines the magnitude and persistence of land change over a 34 year time period, which partner organizations can use to **effectively monitor mining land disturbance and reclamation efforts**.

Outreach: Coal Mining Assessment Tool (CMAT)

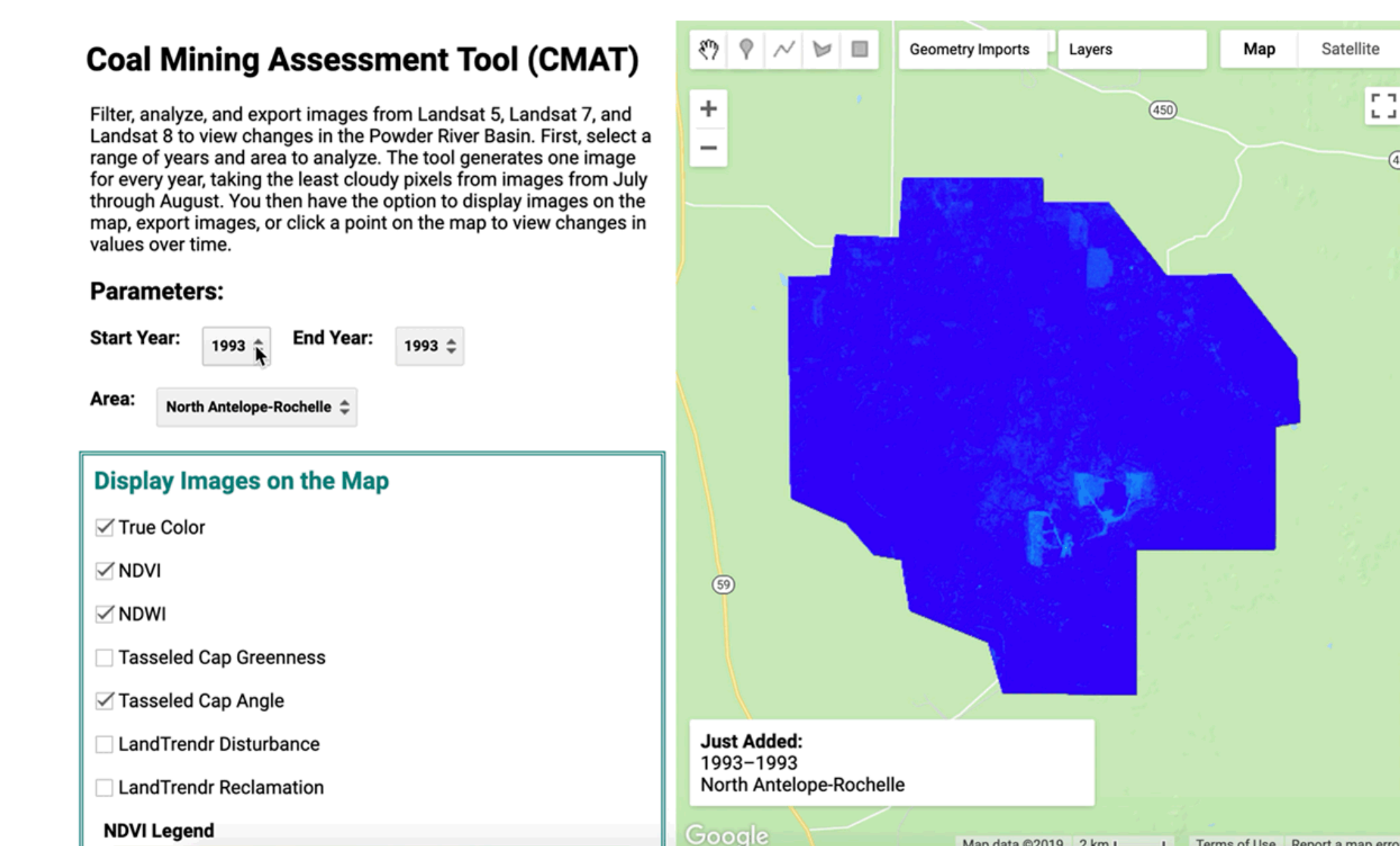


Figure 8. Screenshot of CMAT tool in Google Earth Engine

Sources of Error and Future Work

- Future work should include an accuracy assessment of the LandTrendr Disturbance and Reclamation outputs.
- Errors in the reference site selection could have introduced bias in the ratio results; we tried to find similar vegetation types under non-mining management, but there may be other types of management that impact vegetation spectral responses.
- We explored Digital Elevation Models to see if we could identify topographic changes from surface mining but the data lacked the spatial and temporal resolution to see change over time. Future work could explore newer data.

Acknowledgements

Shannon Anderson, Powder River Basin Resources Council, Staff Attorney
Dan Cohn, Western Organization of Resource Councils, Regional Organizer
Dr. Mik Carbajales-Dale, Clemson Energy-Economy-Environment (E3) Systems Analysis Group
Christian Thomas, SkyTruth, Geospatial Engineer
Dr. Juan Torres-Pérez, Bay Area Environmental Research Institute, NASA Ames Research Center, Science Advisor
Dr. Kenton Ross, NASA Langley Research Center, Science Advisor
John Dilger, Spatial Informatics Group, LLC, Science Advisor
Farnaz Bayat, DEVELOP National Program, California – Ames Node Center Lead
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About DEVELOP



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