Landscape characterization with Google Earth Engine: functionality supporting high resolution spatiotemporal analyses utilizing satellite imagery

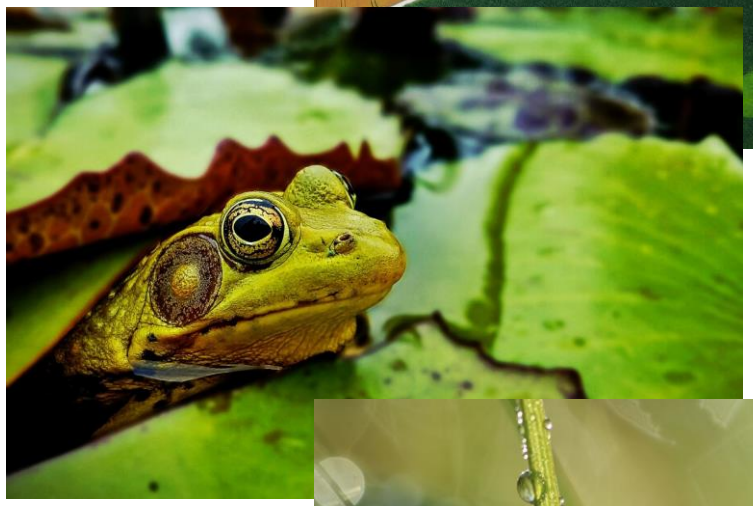
Claire Holmes and Christopher Holmes
Applied Analysis Solutions LLC

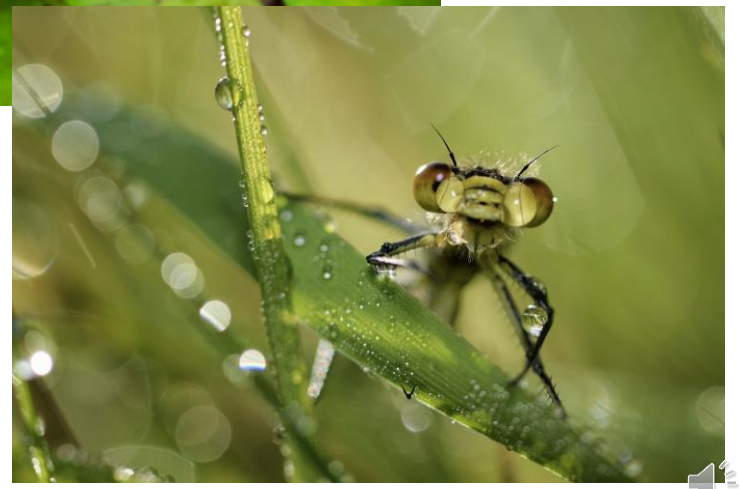
Fabian Löw

Thorsten Schad
Bayer CropScience

Introduction

- Assessing pesticide fate in the environment requires assumptions or empirical information
- Spatially explicit exposure studies incorporate locally-relevant information on a specific environment
  - Larger regional context
- More and better data and tools have become available
- Google Earth Engine increases efficiency and transparency in landscape characterization studies while reducing time and effort needed





What is Remote Sensing?

- Remote sensing is the process of detecting and monitoring the physical characteristics of an area
- Measures the reflected radiation from a distance using varying wavelengths
- Different reflectance based on surface type, composition and texture
- Relevance:
  - Easy access to latest satellite data and modern image processing methods
  - Outcomes of analysis can support landscape-scale pesticide exposure assessments

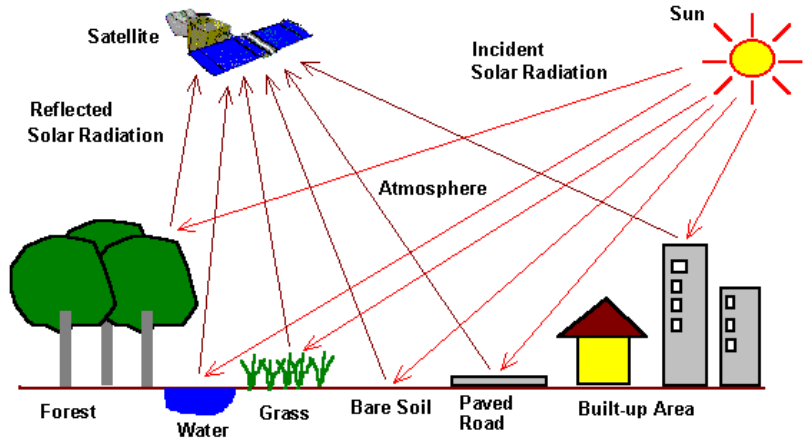
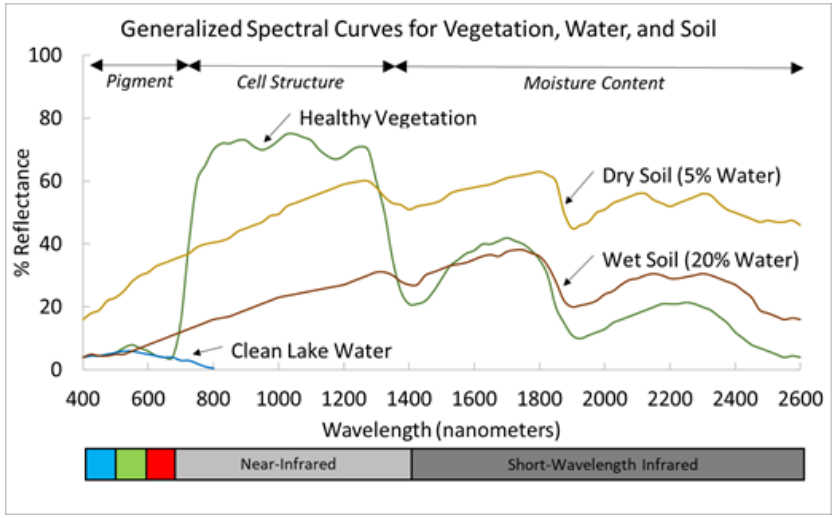
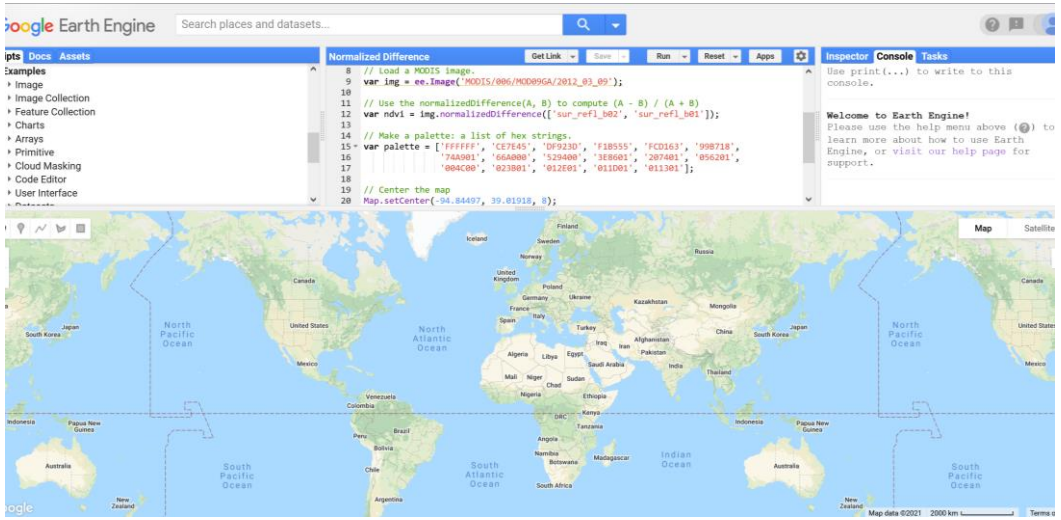


Image from https://crisp.nus.edu.sg/~research/tutorial/optical.htm

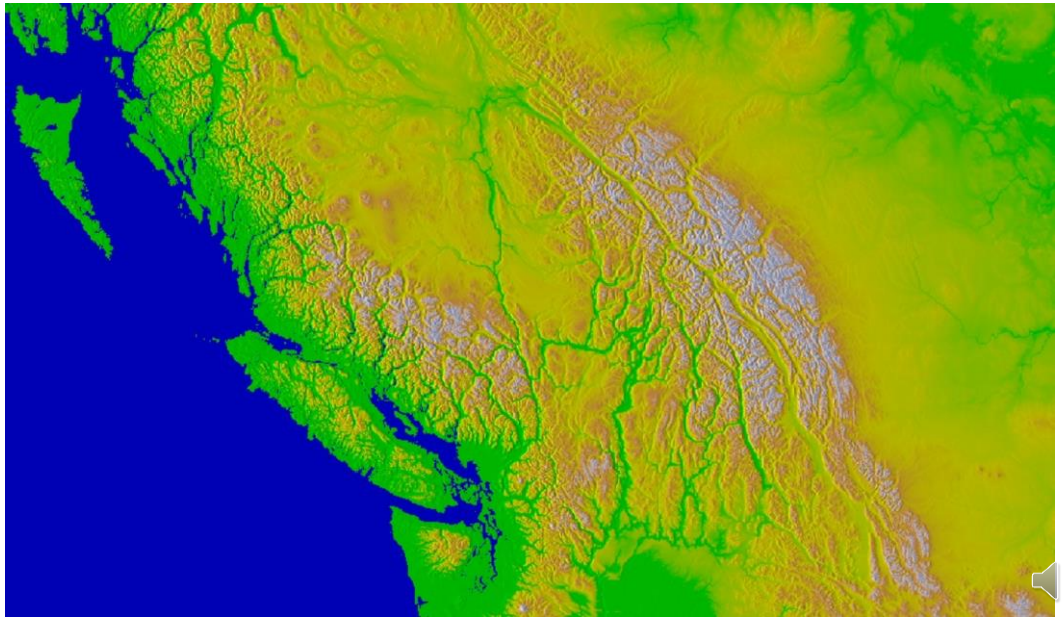


What is Google Earth Engine?

- Let scientists do science
- Platform for analysis of geospatial data and visualization of results
- Freely available pre-processed satellite imagery and datasets
- API available for JavaScript and python, web-based code editor
- Processing done on Google Cloud infrastructure



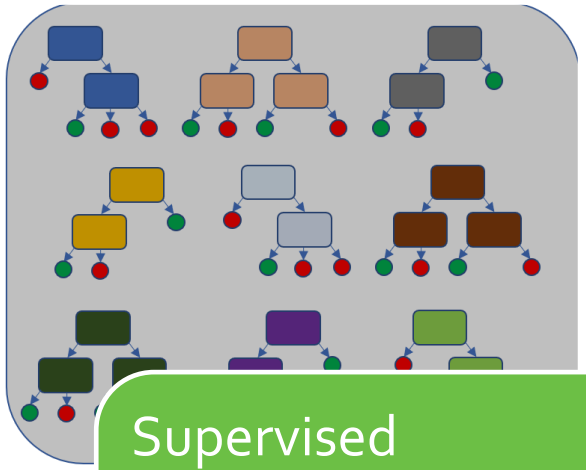
Images from Earth Engine



Land Use Land Cover Classification (LULC)

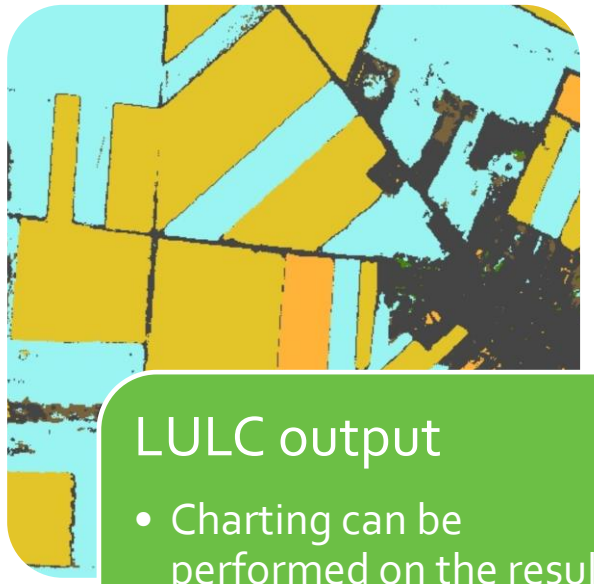
Reference Data Selection

- Unsupervised Classification (clustering)
- Manual Collection (points, polygons, user supplied data)



Supervised Classification (Machine Learning)

- Apply ML to image using trained reference data
- Fusion technique (Fabian Löw)

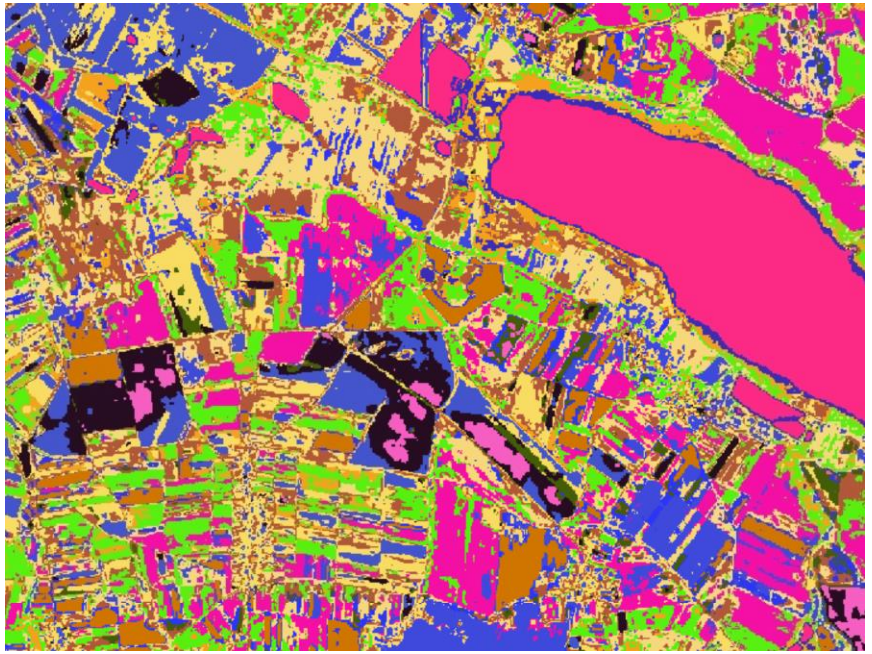


LULC output

- Charting can be performed on the result, and it can be exported for further analysis
- Assess urban growth, track habitat loss, predict impact of sea level rise

Machine Learning

- Machine learning algorithms use statistics to find patterns in large amounts of data
- Built-in functionality applied directly to data
  - Unsupervised functions: k-means clustering
  - Supervised functions: CART, Random Forest, SVM, Gradient Tree Boost, Naive Bayes
- Data fusion with multiple machine learning algorithms
- Assessment of performance using confusion matrix or traditional omission/commission error
- Automatic or manual image sampling



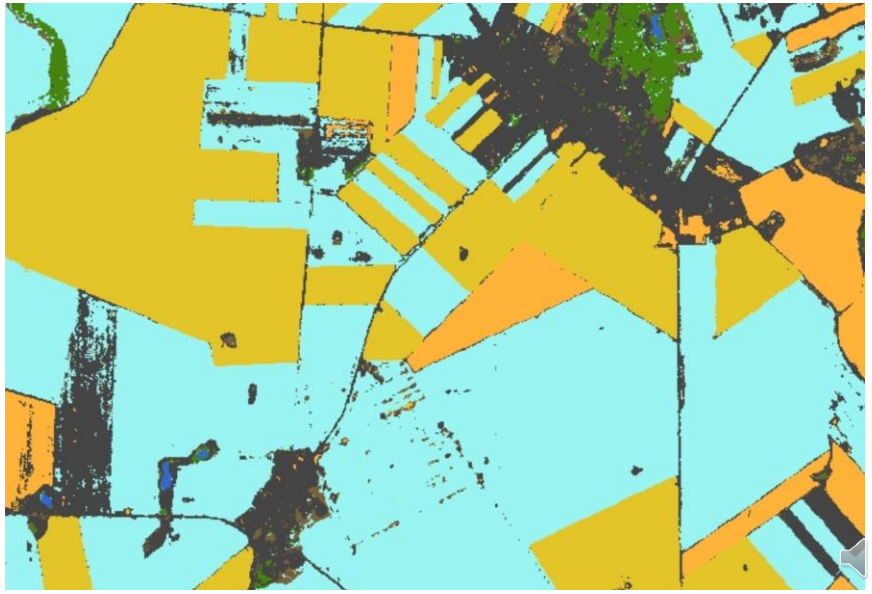
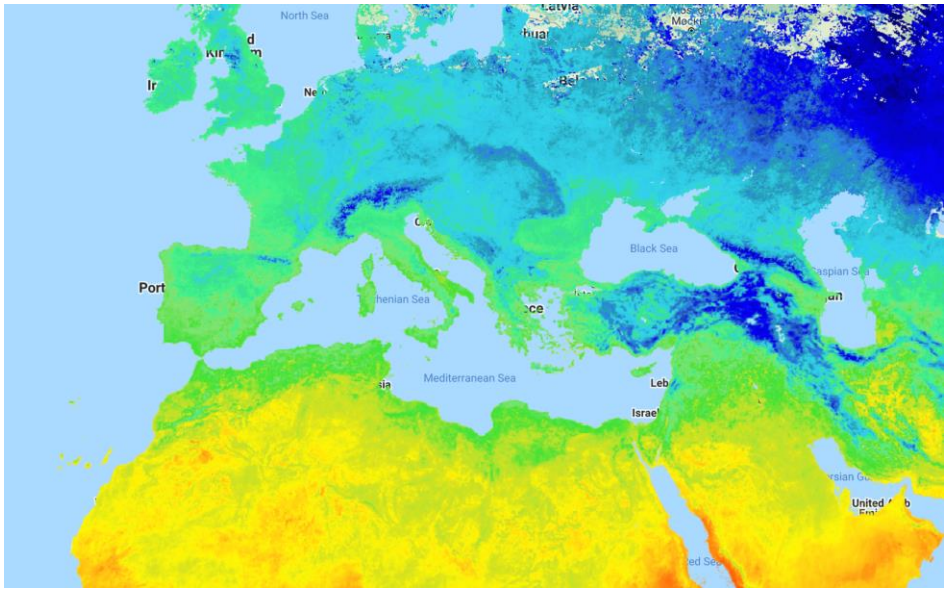


Image libraries directly available

- Imagery: Landsat, Sentinel, MODIS, high-resolution imagery (Planet SkySat, 0.8m and NAIP, 1m)
- Climate & Weather: surface temperature, climate, atmospheric, weather
- Geophysical: Terrain, Land Cover, cropland



Google Earth Engine images from left to right:

- Surface Temperature
- Elevation
- Planet (SkySat)

Vegetation indices and built-in functions

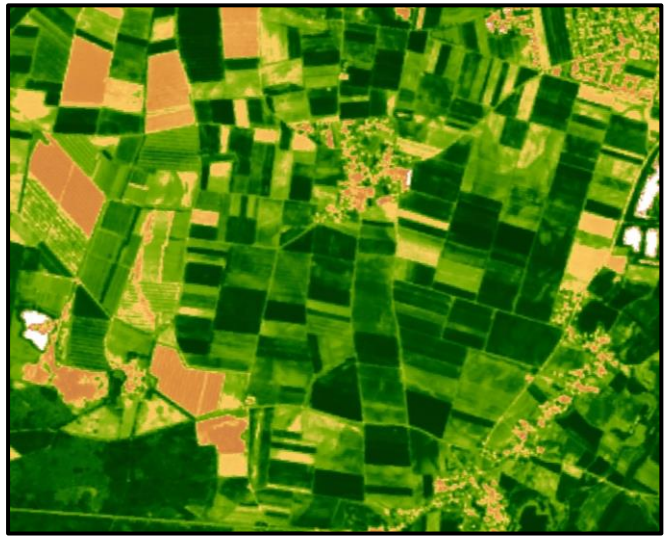
April 24, 2017

July 6, 2017

NDVI

1

0

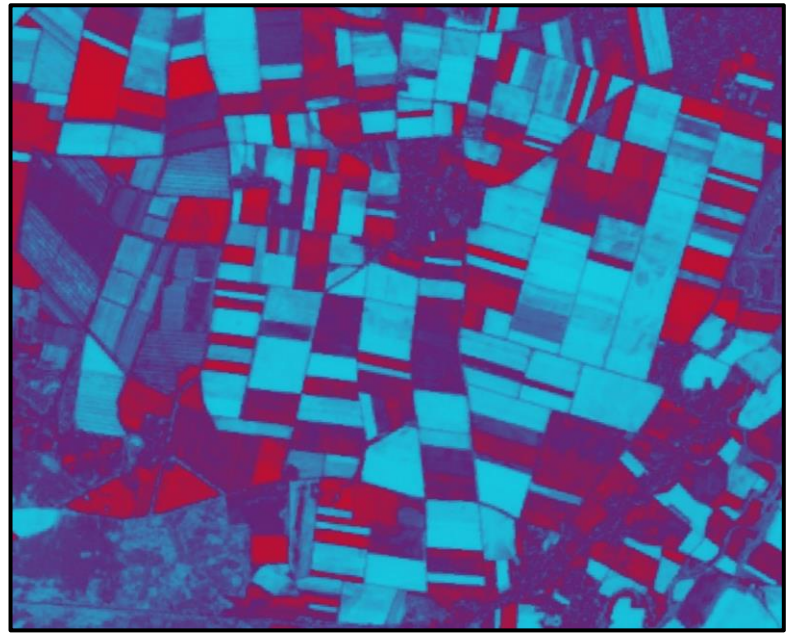


Change in NDVI

1

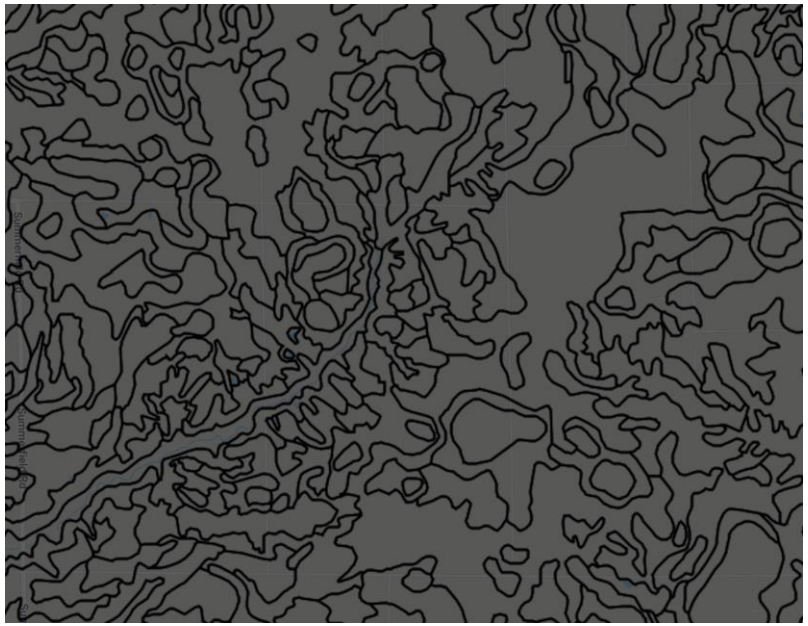
-1

Change in Normalized Difference Vegetation Index (NDVI)

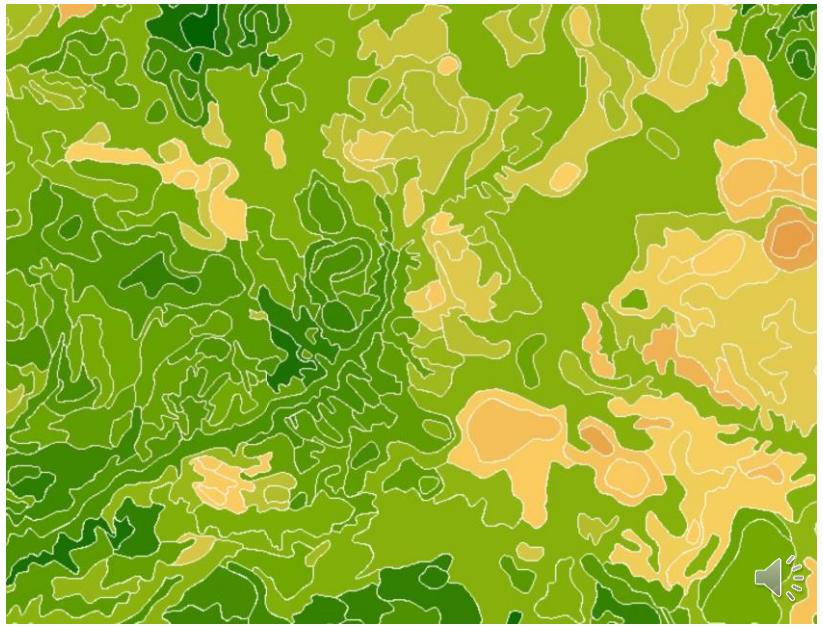


User specific data also integrated

- User Assets uploaded and used in analysis
- Raster or vector data
- Create custom geometry within Earth Engine
  - This can then be exported for use in other applications

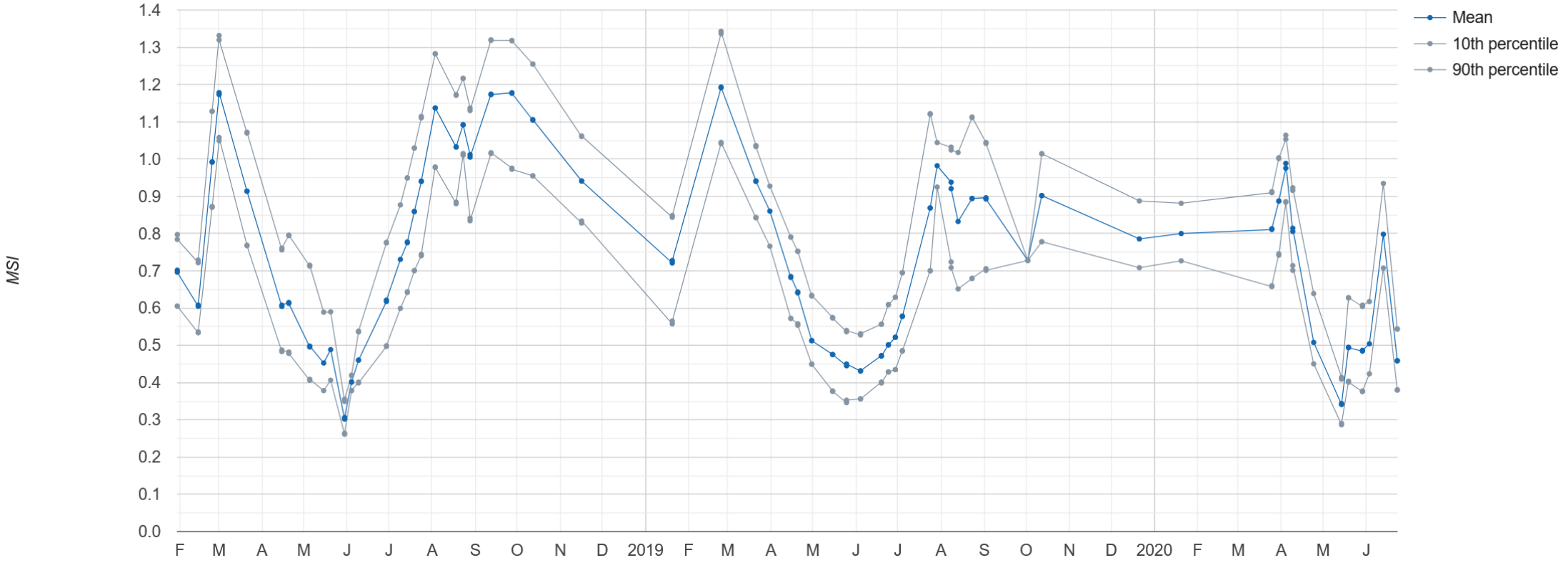


NDVI applied



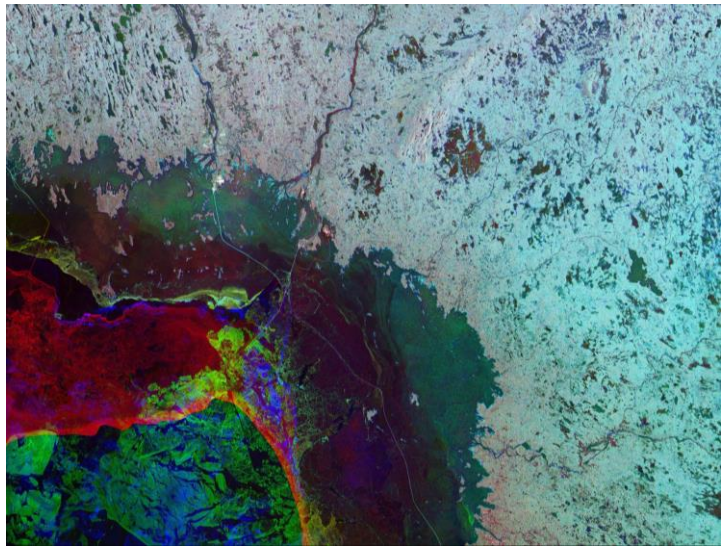
Dynamic Charting based on current map content and extent

- Chart user-defined and built-in values
- Charts based on regions defined by user or other vector layers (e.g., field boundaries)
- Example: Moisture Stress Index (MSI): mean, 10th, and 90th percentile of pixel values in a field

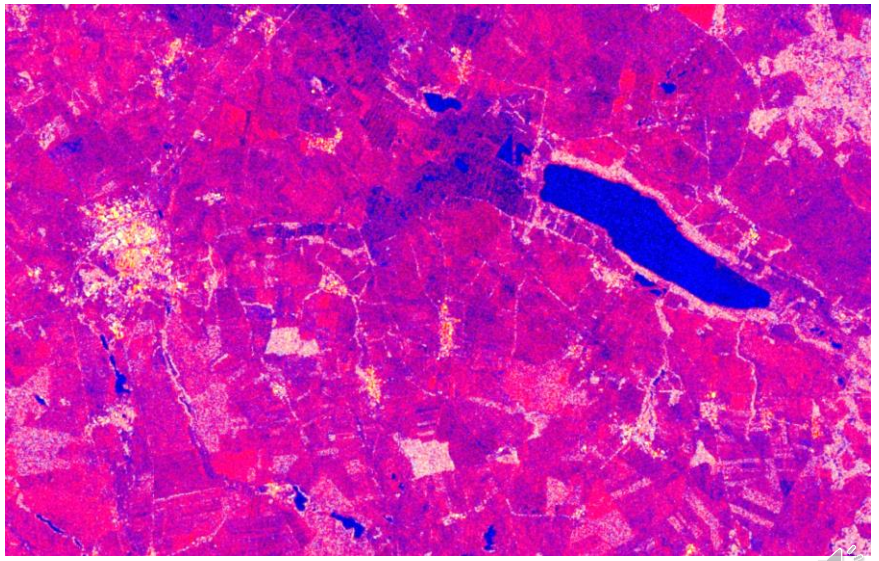


Radar data

- A common impediment with optical remote sensing is that cloud cover and haze block or scatter these wavelengths
- Wavelengths used in radar sensors are not impeded by cloud cover and can operate both day and night
- Provides information on texture and aspect of ground surface
- Sentinel-1 included in Earth Engine's library
  - Provides powerful complementary information when used together with Sentinel-2



Using Sentinel-1 for change detection
http://www.esa.int/Applications/Observing_the_Earth/Copernicus/Sentinel-1



Sentinel-1 image from Earth Engine

Resources and licensing

- Developer guide pages
- Earth Engine Developers forum, script examples in the code editor, GIS stack exchange

- Free for research, education, and nonprofit use

- Can be used for commercial evaluation, but no generated products may be sold
- Paid commercial licenses available
- App Engine can be used to build scalable geospatial applications
  - Allows users to access your application without a Google Earth Engine account

Summary / Conclusions

- New developments in remote sensing data and processing platforms can be used to improve the modeling of fate and exposure of pesticides
  - Characterizing agricultural landscapes with greater spatial, spectral and temporal resolution
  - Lower effort and cost than previously required
  - Increased ability to share
- Easier access to the latest satellite data and modern image processing methods
- Provide timely and relevant information to support landscape-scale pesticide investigations

ceholmes@vt.edu

APPLIED ANALYSIS
SOLUTIONS LLC