Working Title: Groundwater abstraction estimation using crop cycle breakpoint detection at the field level

Midpoint presentation link: <https://docs.google.com/presentation/d/19Y1ImDVDGE0rW56yoY8sKj_kVb3xiBt7d1pUs3svpfc/edit?usp=sharing>

Groundwater is often less closely regulated and monitored than surface water. The pumping of groundwater for agriculture in arid areas is of particular concern; these groundwater resources often do not replenish as fast as water is abstracted and some deeper sources like confined aquifers do not regenerate. Groundwater is a vital resource that should be afforded as much consideration as surface water, particularly for arid regions.

I am estimating groundwater abstraction in the Ica-Pisco-Chincha Alta region of Peru. I am interested in the agroindustry's use of groundwater. I will attempt to create a water use estimation or water demand metric for each field in the Ica agricultural area.

To estimate groundwater abstraction, I am delineating individual fields from Landsat-8 and Sentinel-2 imagery acquired and processed in Google Earth Engine (GEE). Once I exported the images from GEE, I created a stack of NDVI images through the composite band tool in ArcGIS. The images were taken from different times of year, to capture the vegetation change within fields. The segmentation method - Large Scale Mean Shift (LSMS) in Orfeo’s OTB toolbox - identifies segments of similar pixels. By using a stack of varying NDVI images over the course of the year, the fields were segmented according to similar land use trajectories or similar changes in NDVI. I used a field pixel radius of 0.14.

I have created a shapefile of field segmentations using LSMS of a stack of Landsat NDVI images. Within these segmented fields, I will classify crop type and generate moisture and greenness (NDVI) values using Landsat 8 and 9 and Sentinel-2 imagery.

The crop type may be a challenging classification to create. Without ground truths, it may be difficult to get training classes. Additionally, some crops may change over time or there may be a great diversity of crops within the study region, further complicating classification. To overcome the hurdle of ground truths, I will be using an unsupervised classification to identify crops. I will extract the values of the EM spectrum Sentinel-2 bands from images taken at different points in the year to each of the fields. I will use an unsupervised classification such as k-means to cluster the fields, hopefully into discernible crop types.

The moisture and greenness levels will be found over the course of a 3 year period (2019-2021) in two week intervals. I will use a data-fill technique to address missing data from clouds. I will combine values from different sensors. For all data that I cannot fill in, I will interpolate over missing values. These levels will be used in a breakpoint detection method called BFAST that will allow identification of the length and number of agricultural cycles within the year for each field. I will also determine the percent of the year that the field has high vegetation (NDVI > 0.5).

The size of each field, the number of times within a year it was cultivated, the length of each cultivation and its crop type will inform an estimation of water use at the field level. I may use the average yearly temperature for this estimation. I will represent water use either through an estimate of volume or some measure of intensity of water use. The measure of intensity may be easier to construct than attempting to accurately calculate a volume.

In Ica Peru, groundwater and surface water would be easier to discern in one of the two basins within the city. The Villacuri basin has no surface water. The Ica Basin has a combination of surface and groundwater. It will be important to delineate which areas rely more on groundwater or surface water.

The segmentation and breakpoint detection method is based on work done by [Dutrieux, Jakovac et al.](https://www.sciencedirect.com/science/article/abs/pii/S0303243415300647) on land use intensity in the Brazilian Amazon.

This method of breakpoint detection to count agricultural cycles has not yet been applied to estimations of water use in agriculture, nor in studies of arid agriculture. LandTrendr might be a good option for breakpoint detection in GEE, but may be limited if I want to use a mix-sensor time series.