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

In the United States, we monitor surface water use but not groundwater use. If you can build a pump and get groundwater, you are free to take as much as you like. This has led to over-abstraction of groundwater resources. 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 from confined aquifers do not regenerate. Groundwater is a precious resource that should be afforded as much consideration as surface water in arid regions.

I am estimating groundwater abstraction/aquifer pumping in one of two arid areas; Ica-Pisco-Chincha Alta region of Peru or California's Central Valley.

The relatively recent Sustainable Groundwater Management Act in California “requires local agencies adopt sustainability plans for high- and medium-priority groundwater basins. Under SGMA, basins must reach sustainability within 20 years of implementing their plans”. Understanding where groundwater abstraction is most intense would aid in achieving the goals of this act. It would also locate what areas are at the greatest risk for groundwater depletion.

To estimate groundwater abstraction, I am delineating individual fields from high resolution NICFI Tropical Forest satellite images in Google Earth Engine. These images have a resolution of five meters which allow the discernment of smallholder agricultural plots in addition to large, industrial-scale fields.

Within these segmented fields, I will classify crop type and generate moisture and greenness (NDVI) values using Landsat 8 and 9 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.

The moisture and greenness levels will be found over the course of a 9 year period (2012-2021) in monthly intervals. 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. 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 will consider limiting the time window to only dry season months when groundwater makes up the large majority of water resources for agriculture. I will compare small fields with large-scale operations in water use and cropping intensity and discuss policy implications of the research.

Water use estimation: This part of the project is trickier. It is difficult to separate out what water is coming from surface water and what is coming from groundwater.   
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. In this study, it might be necessary to restrict it to only the Villacuri Basin.

In California, it may be possible to determine surface water use by looking at water use rights. Access to parcel data may be challenging.

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. A very dense time series may require a mix of Sentinel-2, Landsat and maybe MODIS.

Images used for Orfeo’s large scale mean shift segmentation (LSMS) of agricultural fields:

2016-06-01\_2016-07-31

2016-12-01\_2016-12-31

2017-12-01\_2017-12-31

2015-12-01\_2015-12-31

2018-12-01\_2018-12-31

2019-06-01\_2019-07-31

2019-12-01\_2019-12-02

2020-06-01\_2020-07-31

2020-10-01\_2020-10-31

2020-12-01\_2020-12-31

2021-01-01\_2021-01-31

2021-03-01\_2021-03-31

2021-05-01\_2021-05-31

2021-07-01\_2021-07-31

2021-08-01\_2021-08-31

2021-10-01\_2021-10-31

[GEE script source](https://code.earthengine.google.com/d3964e6f527ae3531af40ccf32de7e7d)

Literature:

[Study on groundwater abstraction using well location in California’s central valley](https://www.nature.com/articles/s41598-019-52371-7) as well as Sentinel-2