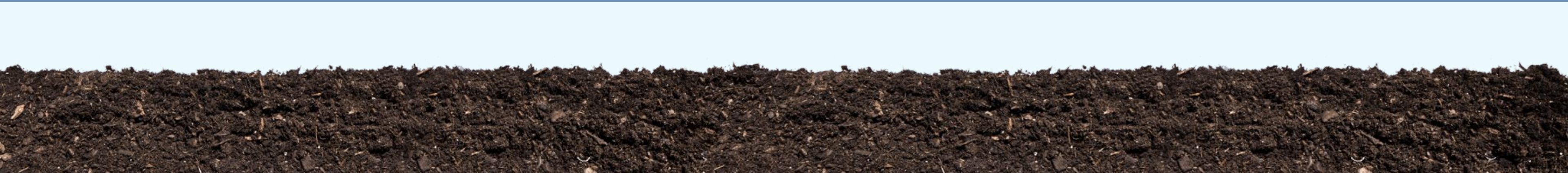
HOW AMOUNT OF SOIL MOISTURE INFLUENCES THE START DATE OF GROWING DEGREE DAYS

PIPER LOVEGREEN ANDREW CHOW COLE BROSNAN



RESEARCH QUESTION

HOW DOES SOIL MOISTURE AFFECT THE START DATE OF GROWING DEGREE DAYS?

HYPOTHESIS

FINDING A THRESHOLD OF SOIL MOISTURE WILL GIVE US A MORE ACCURATE IDEA OF WHEN TO START COUNTING GROWING DEGREE DAYS

IMPORTANCE

FIRE RISK

IF PLANTS DO NOT HAVE A GREENUP DATE FOR THE YEAR THEN THERE IS MORE OF A RISK OF FIRE SINCE THAT MEANS DEAD VEGETATION

CARBON DIOXIDE SEQUESTRATION

IF GREENUP DATE IS SHIFTING TO LATER IN THE YEAR THEN THE PLANT IS PHOTOSYNTHESIZING FOR SMALLER AMOUNTS OF TIME AND THEREFORE UPTAKING LESS CO_2

IMPORTANCE

FOR AGRICULTURAL PURPOSES:

MAXIMIZE CROP GROWTH

TIMING OF PLANTING CROPS CAN DEPEND ON GROWING DEGREE DAYS

UTILIZE PESTICIDES

KNOWING THE TIMING OF WHEN THE PLANTS WILL GREENUP CAN HELP FARMERS KNOW WHEN TO APPLY PESTICIDES

IMPORTANCE

EFFECTS OF LAND COVER AND LAND USE CHANGE (LCLUC)

- A STUDY OF AGRICULTURAL ECOSYSTEMS COMPOSED OF VARIOUS CROP TYPES SPANNING THE MIDWEST OF THE UNITED STATES WAS DONE FROM 1982 TO 2014
- SATELLITE-OBSERVED LAND SURFACE PHENOLOGY WAS ANALYZED
- THEY FOUND THAT OVERALL LONG-TERM DIRECTIONAL CHANGE IN GREENUP DATE ACROSS THESE CROPLANDS
    - ⅔ ATTRIBUTABLE TO LCLUC
    - ⅓ ATTRIBUTABLE TO CLIMATIC VARIATION

CLIMATE CHANGE

- "PHENOLOGY IS A SENSITIVE AND ROBUST INDICATOR OF BIOLOGICAL RESPONSES TO CLIMATE CHANGE
- LONG-TERM RECORDS OF PLANT PHENOLOGY HAVE CONTRIBUTED TO THE UNDERSTANDING ON BIOLOGICAL RESPONSES TO CLIMATE CHANGE
- SPECIES-SPECIFIC PHENOLOGICAL DATA HAVE INDICATED THAT TERRESTRIAL ECOSYSTEMS ACROSS THE PLANET ARE BEING MODIFIED IN RESPONSE TO CLIMATE CHANGE"

(Zhang et al., 2019)

CALIFORNIA LAND-CHANGE PROJECTIONS…HOW MIGHT THAT IMPACT GDD'S HERE?

GROWING DEGREE DAYS

"It's tough to predict plant growth based on the calendar because temperatures can vary greatly from year to year. Instead, growing degree days, which are based on actual temperatures, are a simple and accurate way to predict when a certain plant stage will occur."

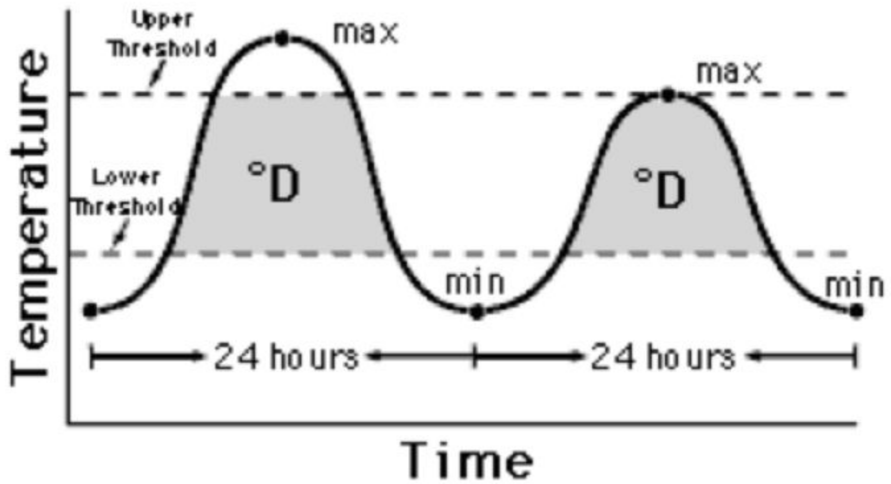
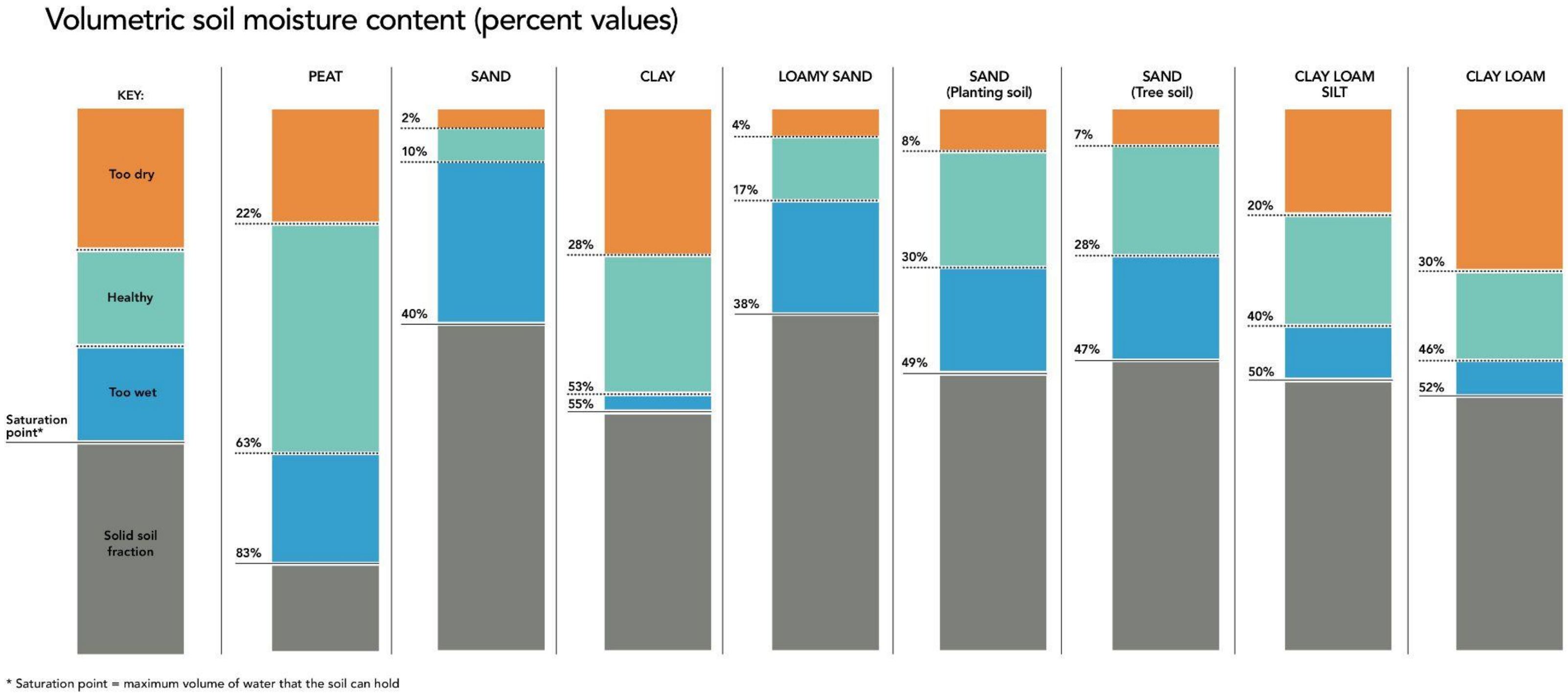


FIGURE 1. Thresholds and degree-days. Note: It takes nine Fahrenheit degree-days to make five Celsius degree-days. DD°C = 5/9 (DD°F) and DD°F = 9/5 (DD°C).

(Miller et al., 2018)

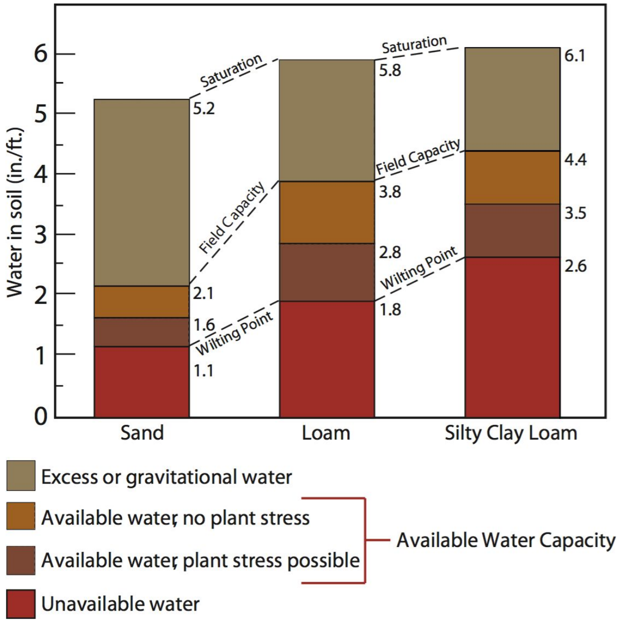
BACKGROUND

VARYING SOIL TYPES WILL INTERACT WITH WATER DIFFERENTLY

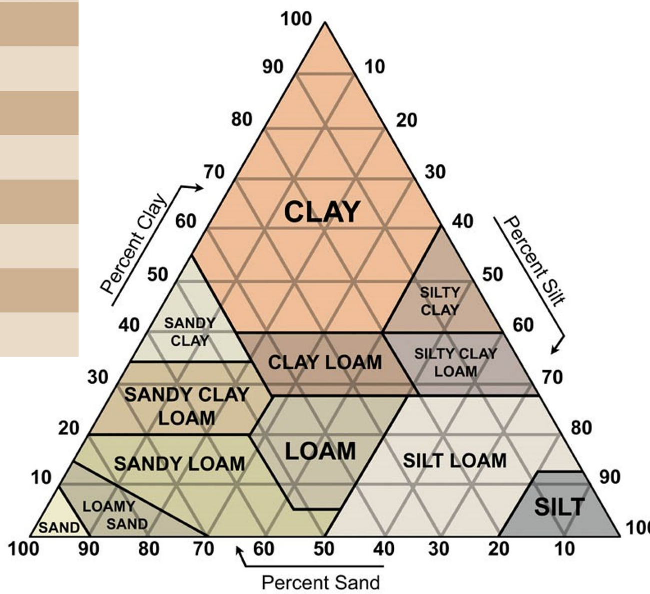


SENSOTERRA

BACKGROUND



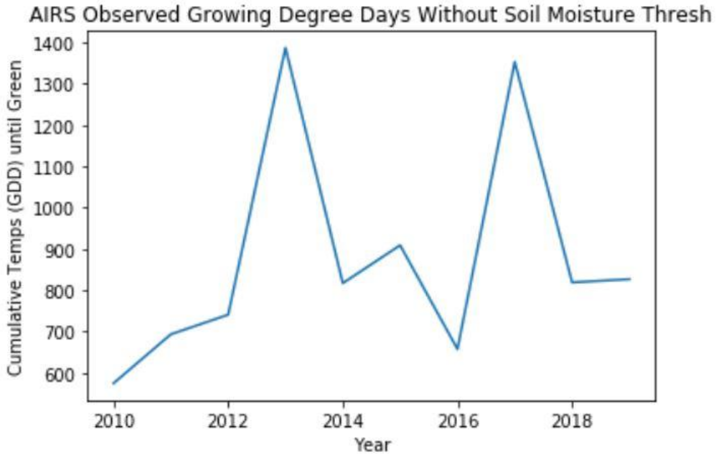
Available Water Capacity by Soil Texture	
Textural Class	Available Water Capacity (Inches/Foot of Depth)
Coarse sand	0.25–0.75
Fine sand	0.75–1.00
Loamy sand	1.10–1.20
Sandy loam	1.25–1.40
Fine sandy loam	1.50–2.00
Silt loam	2.00–2.50
Silty clay loam	1.80–2.00
Silty clay	1.50–1.70
Clay	1.20–1.50



- SOIL TEXTURE AND ORGANIC MATTER ARE THE PRIMARY CONTROLS FOR WATER-HOLDING CAPACITY
- SOILS WITH SMALLER PARTICLES, LIKES SILTS AND CLAYS, HAVE A LARGER SURFACE AREA COMPARED TO SOIL TYPES WITH LARGER SAND PARTICLES
- A LARGE SURFACE AREA ALLOWS A SOIL TO HOLD MORE WATER

RECAP

- LAST WEEK WE CALCULATED GDD'S USING TEMPERATURE AND AN ARBITRARY START DATE SELECTED: OCT 1ST
- DATASETS USED:
  - AIRS
    - TEMP DATA (TC1)
  - ClimateEngine (Huntington et al, 2017)
    - REMOTE SENSING LANDSAT(NDVI)
- GDD EQUATION USED:
  - $GDD= \sum [(T_{MAX}+ T_{MIN})/2] - T_{BASE}$
- NOTE:
  - HIGH VARIATION IN GDD'S BETWEEN YEARS
    - RANGE IS FROM 574 TO 1386
- STUDIES OF BROMUS GDD'S RANGE FROM 582 (BOZEMAN,MT) TO 1287 (STILLWATER,OK) TO 1000 (PENDLETON, OR AND PULLMAN, WA) (Ball et al., 2004)
  - *UNEXPECTED THAT ONE SITE WOULD HAVE SUCH VARIABILITY IN GDD
    - WHICH IS WHY WE ARE NOW LOOKING INTO SOIL MOISTURE TO CALCULATE GDD'S



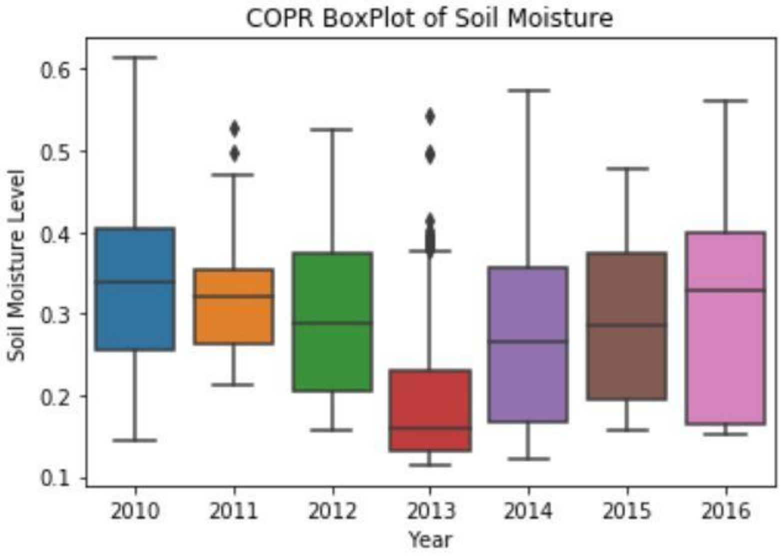
Bromus diandrus
COPR

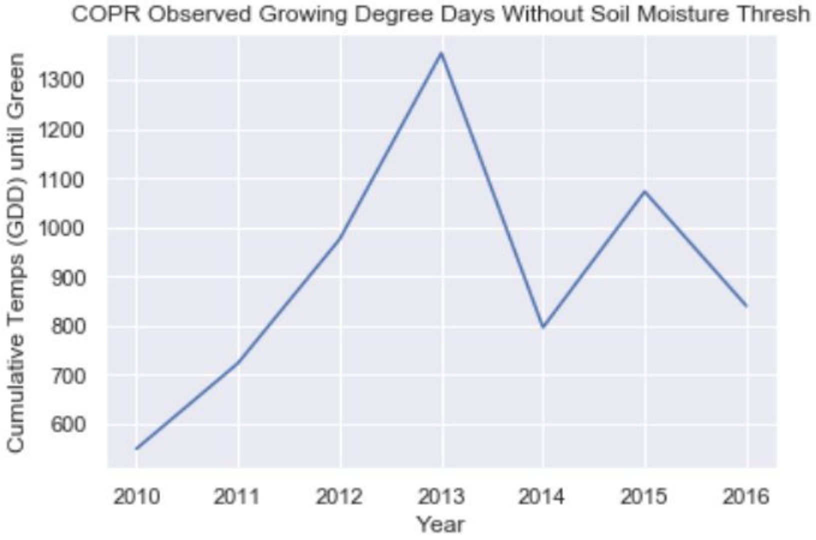
Avena barbata
AIRS

EXPERIMENTAL DESIGN

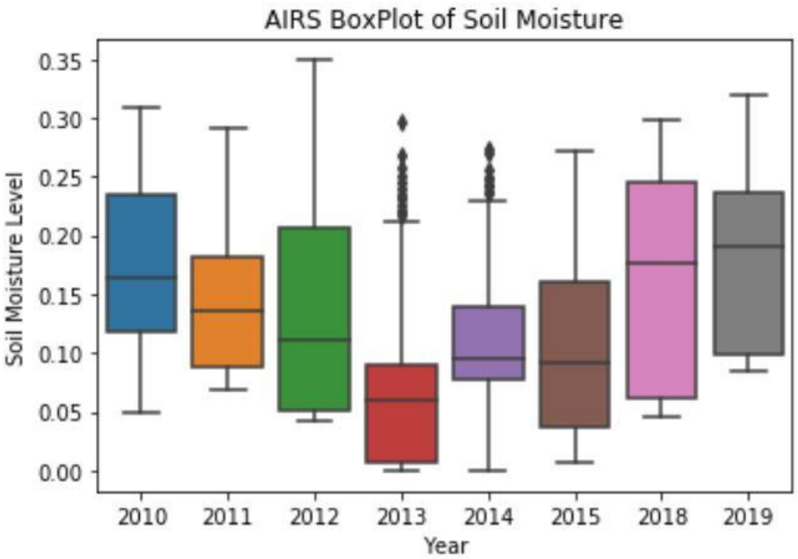
- FOCUS WAS TO RE-CALIBRATE CALCULATIONS FOR GDD USING SOIL MOISTURE AS A “THRESHOLD TRIGGER” TO BEGIN CALCULATING
  - ONCE AN AREA REACHES A CERTAIN THRESHOLD OF SOIL MOISTURE LEVEL, GDD CALCULATIONS BEGINS AS OUR LAST PROJECT
- DATASETS:
  - DOWNLOADED DATA FROM: OCTOBER 1^{ST} - APRIL 30^{TH}
  - COPR & AIRS
    - TEMP (TC1)
    - SOIL MOISTURE (SMwfv_1)
      - NOTE:
        - COPR SOIL MOISTURE DATA WAS MISSING 2017-2019
        - AIRS SOIL MOISTURE DATA WAS MISSING 2016-2017
  - ClimateEngine (Huntington et al, 2017)
    - REMOTE SENSING LANDSAT (NDVI)

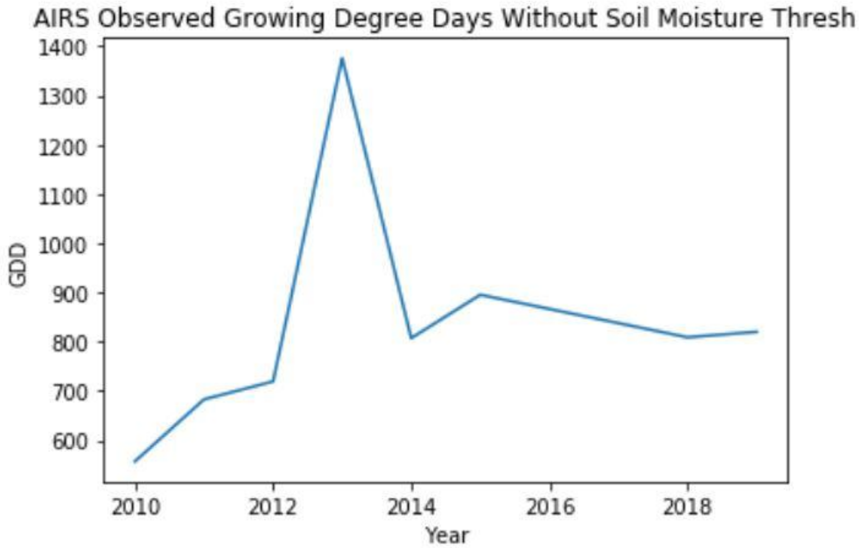
DATA EXPLORATION: COPR





DATA EXPLORATION: AIRS





NOTE: THERE WAS NO COMPLETE 2016 OR 1017 SOIL MOISTURE DATA FOR AIRS, WHICH IS WHY THE LINE PLOT Y-VALUES FOR 2016 AND 2017 ARE 'NA'
YEARS ARE ON THE X-AXIS TO SHOW THE COMPLETE TIMELINE FROM 2010-2019

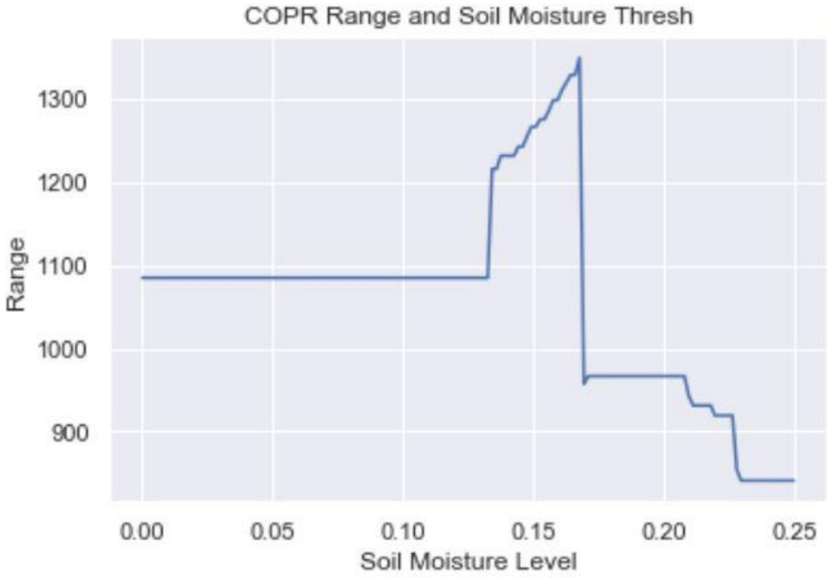
METHODS: CODE

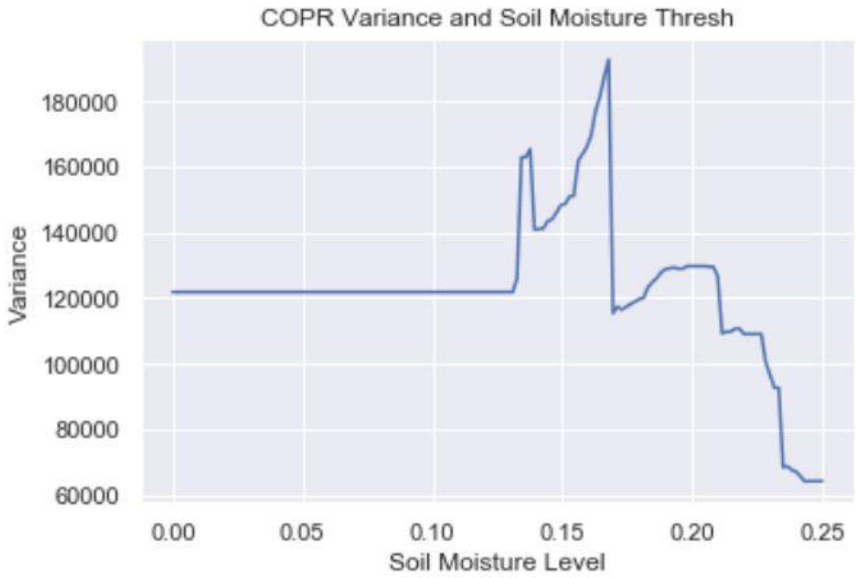
- To find optimal threshold of Soil Moisture to trigger the calculation of GDD, we ran a loop of 200 values between 0 and 0.25, calculated measures of spread (variance, range) of GDD values for one location between years and found the optimal Soil Moisture value that minimized the spread
- Some code:

```
#Initializes arrays of variances and ranges per soil moisture value
varss = []
Range = []
#creates array of soil moisture values (0,.25)
val = np.linspace(0, .25, 150)
#array of end dates calculated when NDVI reaches .4
end_dates = [thresh_date2010, thresh_date2011, thresh_date2012, thresh_date2013, thresh_date2014,
             thresh_date2015, thresh_date2018, thresh_date2019]

#Nested for loop to calculate variances and ranges per soil moisture value
for v in val:
    r=0
    GDDs= []
    for i in range(len(group_arr)):
        #passes values through soil_GDD function that calculates GDD's
        x= soil_GDD(group_arr[i],v,end_dates[i])
        GDDs.append(x)
    r = np.ptp(GDDs)
    Range.append(r)
    v = np.var(GDDs)
    varss.append(v)
```

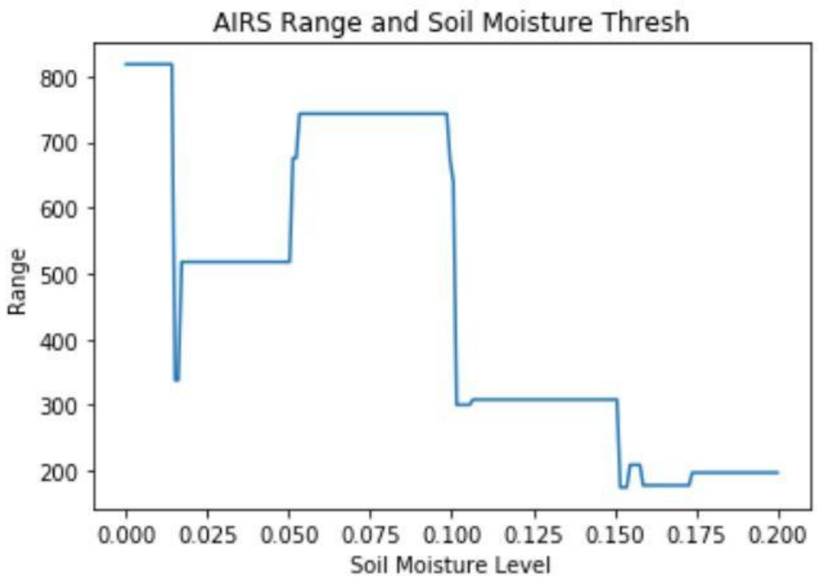
COPR ANALYSIS

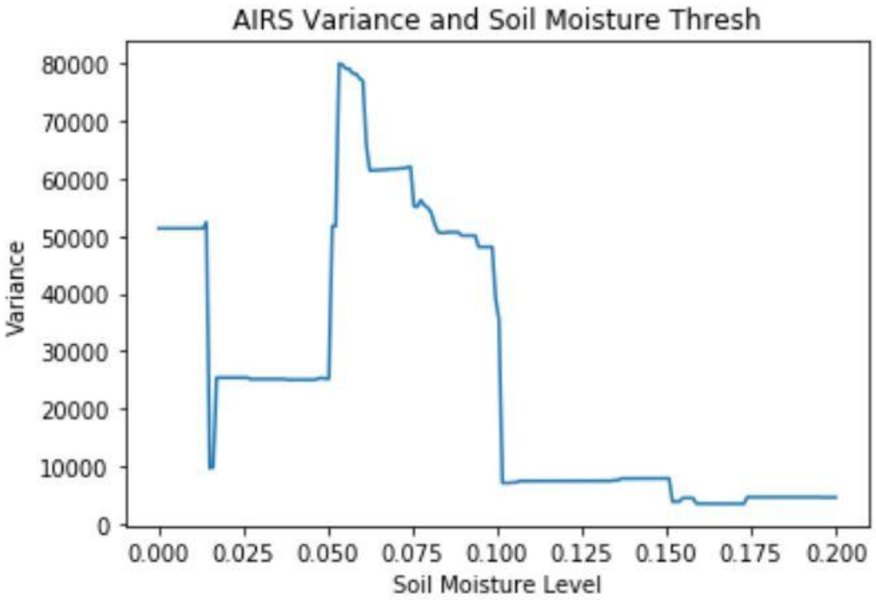




THERE IS A NOTABLE SHARP DROP IN RANGE AROUND 0.16-0.17 %VOL
THE MINIMUM OF BOTH RANGE AND VARIANCE IS 0.243289 %VOL

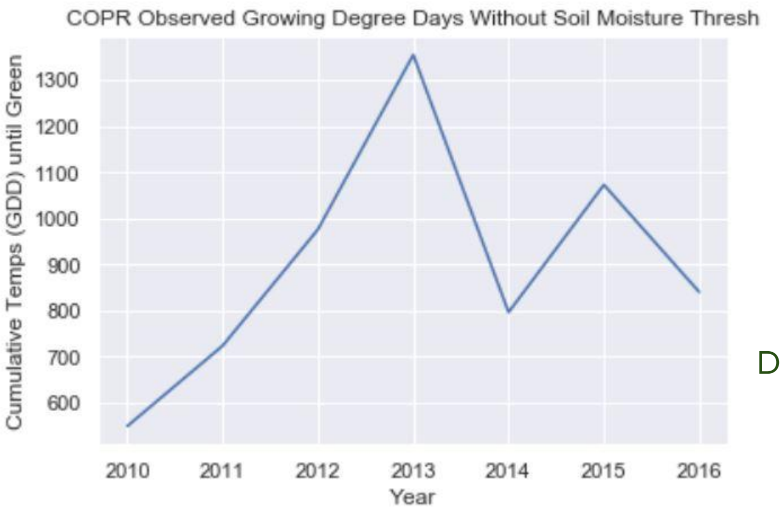
AIRS ANALYSIS



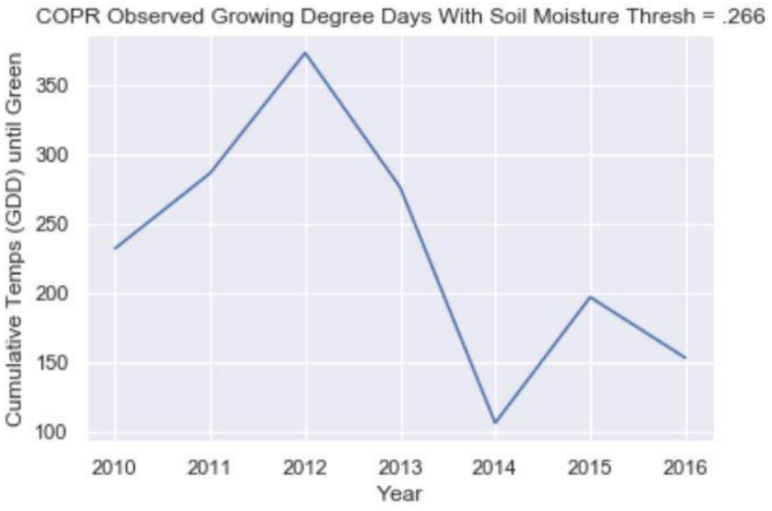


THERE IS A NOTABLE SHARP DROP IN RANGE AROUND 0.01-0.02 %VOL
THE MINIMUM OF BOTH RANGE AND VARIANCE IS 0.151759 %VOL

RESULTS: COPR



NOTE THE DIFFERENCE IN RANGE ON THE Y-AXIS



VARIANCE: 58634.51
RANGE: 805.09

VARIANCE: 6889.20
RANGE: 267.33

COPR

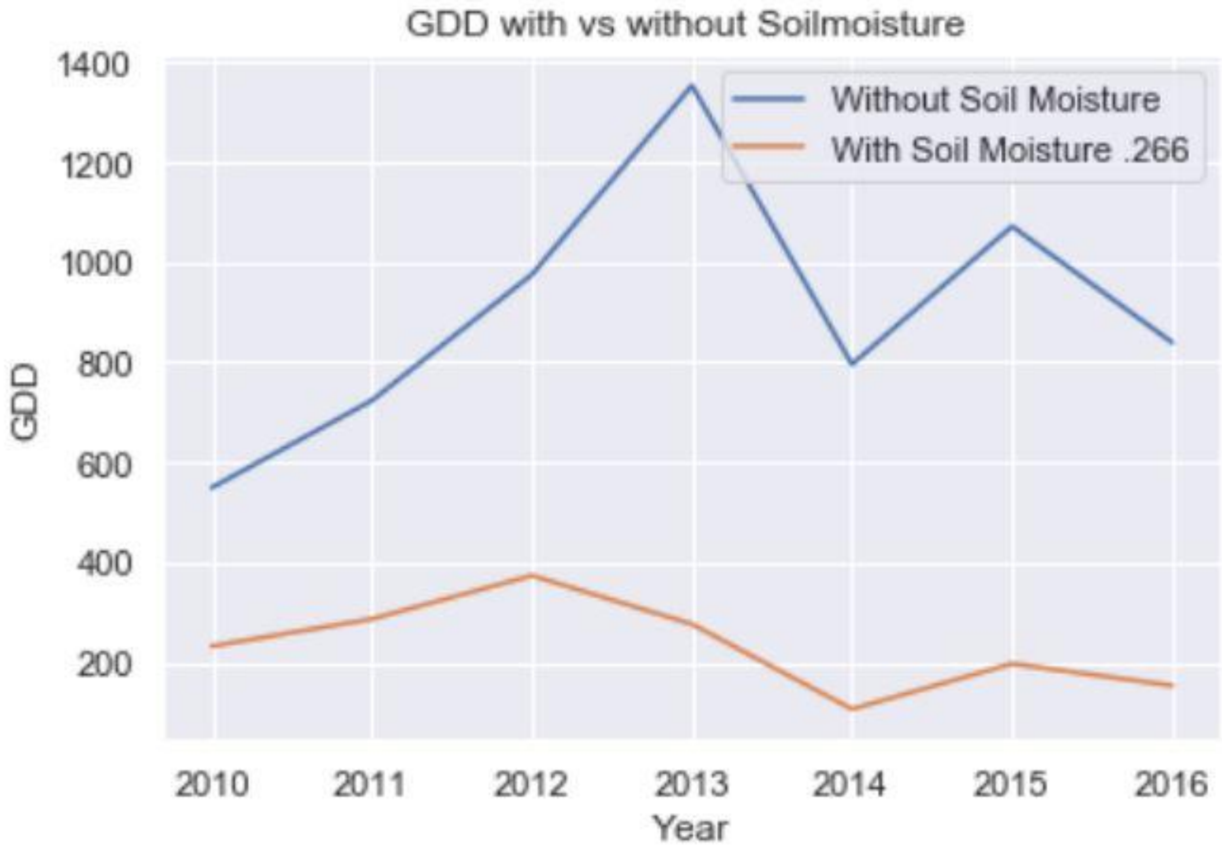
SOIL MOISTURE THRESHOLD ON OCTOBER 22TH, 2010

VIDEO LOOP IS OCTOBER 12TH - DECEMBER 22TH

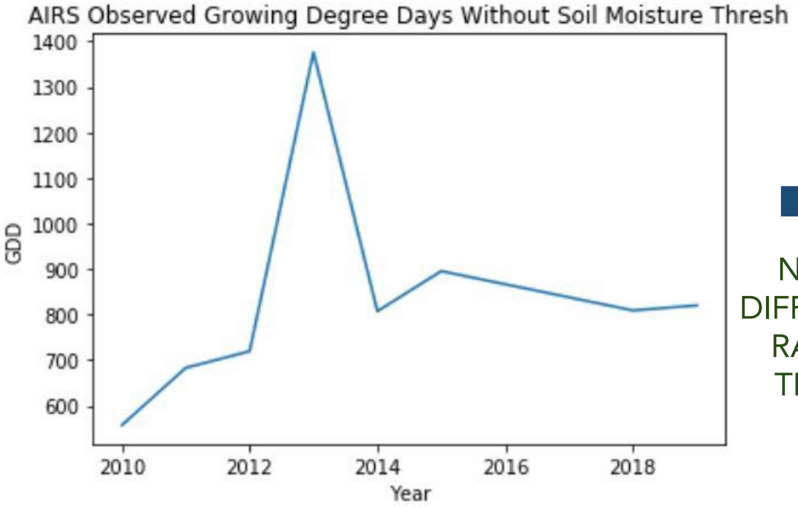
IMAGES TAKEN AT 12PM PST EVERYDAY

IMAGES FOR GIF: PanOPT (http://aten.geog.ucsb.edu/Panopt/index.html) GIF CREATED WITH: https://gifmaker.me

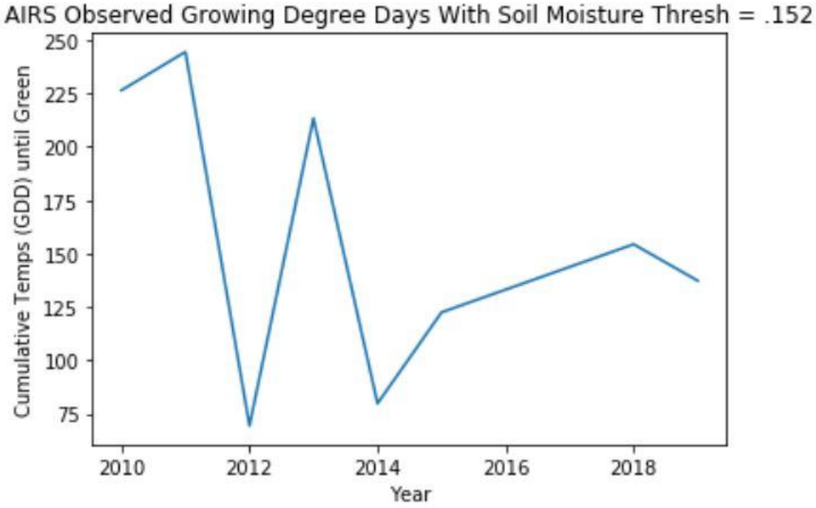
RESULTS: COPR



RESULTS: AIRS



NOTE THE DIFFERENCE IN RANGE ON THE Y-AXIS



VARIANCE: 51346.917
RANGE: 818.03

VARIANCE: 3856.24
RANGE: 175.04

AIRS

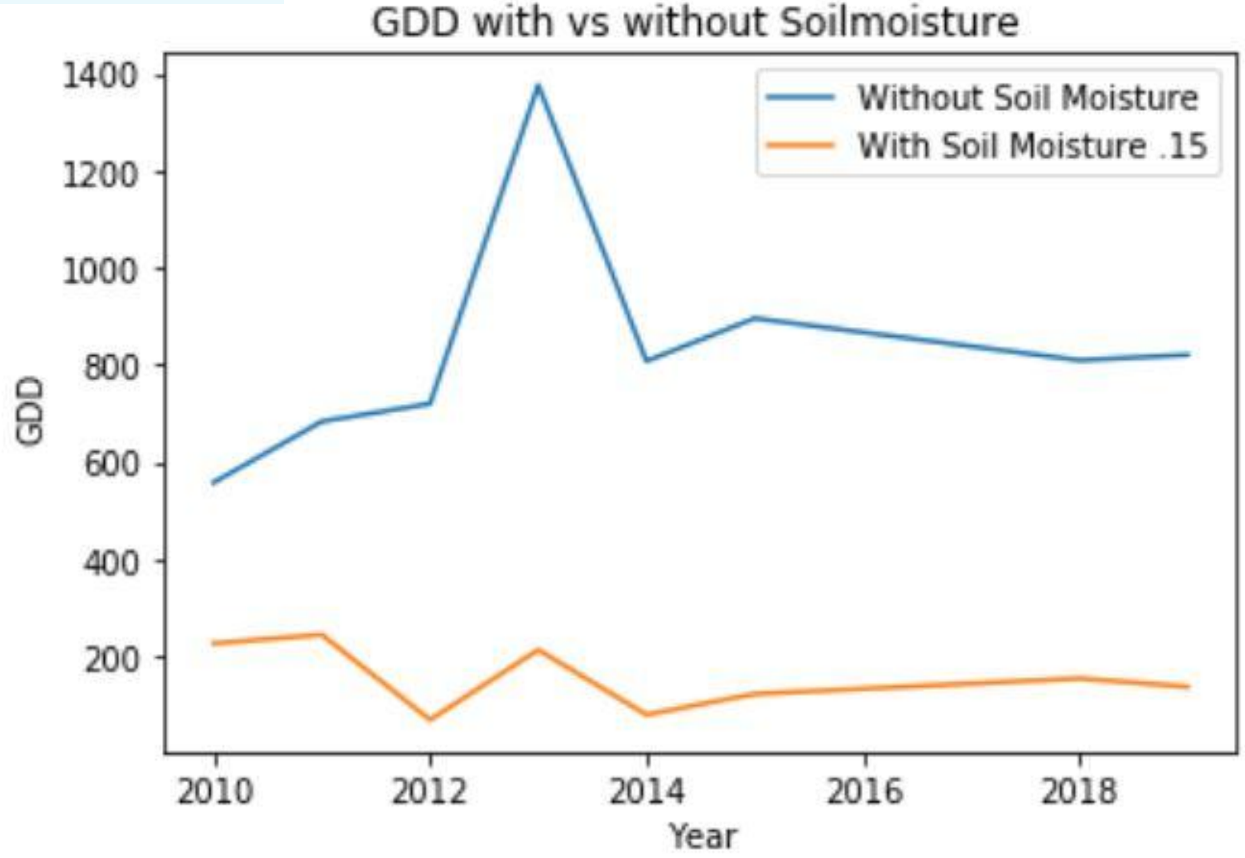
SOIL MOISTURE THRESHOLD ON OCTOBER 30TH, 2010

VIDEO LOOP IS OCTOBER 20TH - DECEMBER 30TH

IMAGES TAKEN AT 12PM PST EVERYDAY

IMAGES FOR GIF: PanOPT (http://aten.geog.ucsb.edu/Panopt/index.html) GIF CREATED WITH: https://gifmaker.me

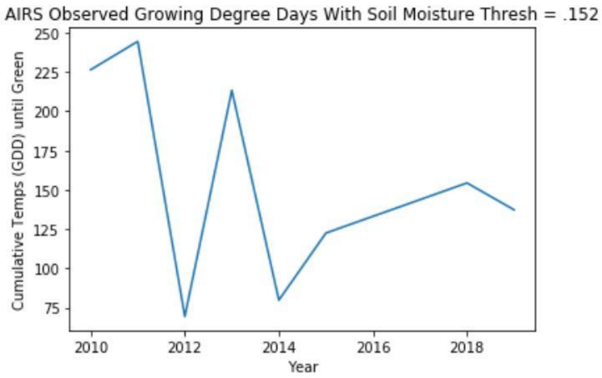
RESULTS: AIRS



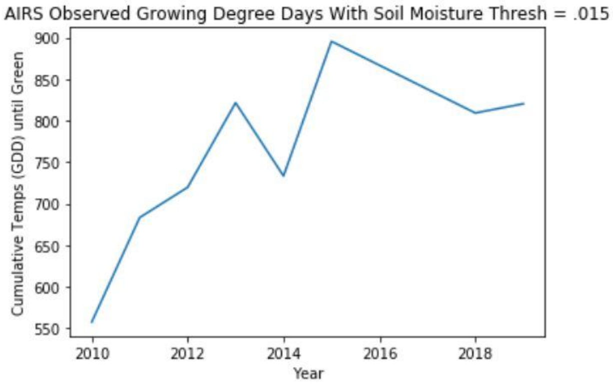
RESULTS & DISCUSSION

- COPR
  - MINIMIZING MEASURES OF SPREAD SEEMED EFFECTIVE WITH SOIL MOISTURE VALUE OF 0.267
  - CONSISTENT GDD AROUND 100-350
- AIRS
  - HAS LOWER VARIANCE AND RANGE THAN COPR
  - COULD BE BECAUSE DIFFERENT YEARS SELECTED, SPECIES OF PLANTS, OR DIFFERENT SOIL, ETC.
  - USING SOIL MOISTURE VALUE OF 0.152 LED TO SOME GDD'S BEING AROUND 75 WHICH IS EXTREMELY LOW THUS….(NEXT SLIDE)
- COMPARED TO LITERATURE MENTIONED EARLIER OF GDD OF BROMUS HAVING LEVELS BETWEEN 582-1000, WE GOT MUCH LOWER LEVELS USING OUR OPTIMIZED SOIL MOISTURE THRESHOLDS
  - THIS COULD BE BECAUSE IT IS LOCATED ON THE COAST. COULD ALSO BE FROM DIFFERENT MOISTURE LEVELS, TEMPERATURE, AND, SOIL THAN AT THE STUDY LOCATIONS LIKE BOZEMAN OR STILLWATER

AIRS DISCUSSION



VARIANCE: 3856.24
RANGE: 175.04



VARIANCE: 9649.15
RANGE: 337.91

- EARLIER WE NOTE A MAJOR DIP IN VARIANCE AND RANGE AROUND 0.01-0.02, THUS IF WE TAKE A SOIL MOISTURE LEVEL OF 0.15 WE MINIMIZE THE VARIANCE AND RANGE AGAIN (BELOW A SOIL MOISTURE LEVEL OF 0.1)
- GDD VALUES ARE MORE ALONG THE LINES OF LITERATURE STATED EARLIER OF 582-1000
- WHICH SOIL MOISTURE LEVEL THRESHOLD WOULD BE A BETTER STARTING POINT FOR GDD CALCULATIONS 0.152 OR 0.015?

CONCLUSION

SOIL MOISTURE CAN HELP MORE ACCURATELY CHOSE WHEN TO START COUNTING GROWING DEGREE DAYS

THANK YOU

ANY QUESTIONS?

WORKS CITED

Ball, D. A., Frost, S.M., Gitelman, A.I. "Predicting timing of downy brome (*Bromus tectorum*) seed production using growing degree days," Weed Science, 52(4), 518-524, (1 July 2004)

Huntington, J. L., Hegewisch, K. C., Daudert, B., Morton, C. G., Abatzoglou, J. T., McEvoy, D. J., & Erickson, T. (2017). Climate engine: Cloud computing and visualization of climate and remote sensing data for advanced natural resource monitoring and process understanding. Bulletin of the American Meteorological Society, 98(11), 2397-2410.

Miller, P., Lanier, W., & Brandt, S. (2018). *Using Growing Degree Days to Predict Plant Stages* [Ebook]. Montana State University. Retrieved from http://file:///Users/piperlovegreen/Downloads/mt200103ag.pdf

Zhang, X., Liu, L., & Henebry, G. (2019). Impacts of land cover and land use change on long-term trend of land surface phenology: a case study in agricultural ecosystems. *Environmental Research Letters*, *14*(4), 044020. doi: 10.1088/1748-9326/ab04d2

CALIFORNIA LAND-CHANGE PROJECTION GIF:
https://www.usgs.gov/centers/wgsc/science/california-land-change-projections?qt-science_center_objects=0#qt-science_center_objects

FOR SLIDE 8 “BACKGROUND”
LEFT IMAGE AND INFORMATION:
https://www.noble.org/news/publications/ag-news-and-views/2001/september/soil-and-water-relationships/
MIDDLE IMAGE:
https://www.noble.org/news/publications/ag-news-and-views/2001/september/soil-and-water-relationships/
RIGHT IMAGE: https://www.capecontours.co.za/2019/09/13/soil-science/soil-analysis-triangle/