March 4-6

**Desk**

Read agroserve papers

March 7

**Meeting**

Summer:

* Now: talk to Dave about summer plan. For the summer, use easy datasets, regression models to isolate effect of land cover. Use process network diagram to isolate effect of land use from other factors that might affect the hydroclimate metrics. May need me to do method refinement or look at a specific metric – will know in April. Use MODIS, Hansen’s forest cover from 2000 to 2016, agricultural dataset from the 1950s.
* Adding the soil/ET into the statistical model for the metrics could be both a summer or fall project. Talk to Dave about process network diagram.

General project background:

* The hydroclimate metrics came from agricultural papers – Avery found them; Avery is also in charge of output 2.1, ii).

Fall and beyond:

* Also need to think about projects for fall. Look at upwind land use change and how they affect metrics downwind. Need wind data. Could get very complicated.
* The effect of small ponds idea: could also be part of the process network diagram. Read about evaporation from lakes, lake effect on temperature, for example Jim Shuttleworth’s papers. The small dams stuff could be another addition to the process network diagram.
* Don’t do dynamic model, UNLESS it’s a toy model (which would be interesting)
* Read about food security optimization literature – the idea is that we can add a climate feedback piece. Think about asking Paolo, Avery and Scott about ways to do this in a feasible manner.

March 8-13

**Desk**

Read papers about food security, agricultural practice

Coursera: Agriculture, Economics and Nature

March 14

**Meeting**

AgroServe project for the fall: the toy model. Prescribe some land use change (x) and prescribe its evolution over time. As it changes, use AgroServe knowledge to predict how climate changes: Precipitation as fcn of x, Temperature as fcn of x, Q as fcn of x, drainage as fcn of x. then, look at how y (yield) changes as a function of these climate metrics. Make plots with percent agriculture on x axis and hydroclimate indices on y axis, like energy returned as latent heat. Can also do % land use on x axis with yield on the y axis. Run this at basin scale. If bring in ET data as part of finding hydroclimate metrics in the summer, can use this information to help determine how land use changes climate and ultimately the yield. Talk to Avery about yield and climate relationships.

Write abstract for CUAHSI on Botter suitability

PhD series: Botter gives soil moisture pdf. Can this soil moisture pdf be incorporated in hydroclimate indices for AgroServe? How does land use change the parameters lambdap, gamp, gamQ, etc?

March 15

**Desk**

Draft CUAHSI abstract

In power law recession Marc’s Way.R, added in step fit delineation of dry vs wet season in each separate year. Assumed wet season started on Jan 1 to avoid having to go back to the previous year. However, step fitting doesn’t seem to be giving good results even for individual years. Check why.

Also added guessing and a and b using log fit before putting it into simulated annealing calibration. The log fit stuff was copied from power law recession.R

March 20

**Desk**

Step fitting: problem of the function including the start of wet season. FCN\_findDrySeason\_stepfit.R is Marc’s original. FCN\_findDrySeason\_stepfit\_mean.R tries out using absolute mean values between dry and wet seasons, but seems to get the same answer as Marc’s original. Since Marc’s original works better in general than whatever I came up with, stick with that. Changed the potential range of dry season start and end dates to exactly match Marc’s but may need to justify it better.

For power law recession using simulated annealing, worked on first guessing appropriate a and b range to put into simulated annealing. Note that log means ln, and log10 means log base 10. Then, for SANN fitting in power law recession Marc’s Way.R, added large penalty whenever a <0 or b <0 so negative a and b parameters are never chosen as the optimizer.

March 21

**Meeting with Avery, Dave and Sally**

Toy model: focus on soy. We will want Land Use vs. climate plots, climate vs. yield plots, which will then be combined into a Land Use vs. yield or productivity plot. Perhaps we will also consider single vs. double cropping and other significant management practices. The climate vs. yield graph may be figured out statistically, BUT because variables might be correlated and correlations may be nonstationary, we might need to use a crop model to relate climate to yield instead.

Potential application of the Land Use vs yield plot: what does this curve need to look like in order for risk to be meaningful for the actors? Get metrics from the NGOs for what’s meaningful.

Avery will send a paper on how forest changes T, which then changes agri productivity. Maybe start by doing a sensitivity analysis of this work and come up with a functional form of LUC vs. productivity from his paper. As one first step, perhaps adapt Avery’s code into R.

Another thing to start doing is to learn the crop model and therefore also Google Earth Engine; talk to Jake, who has been using Earth Engine to run the crop model.

First thing to do: in Earth Engine, find mapbiomas dataset. Over the space of Brazil, choose different pixels (around size 1km; aggregate if mapbiomas pixels are smaller). For each pixel, add 2km and 4km rings (called neighborhood 1 and neighborhood 2). For each pixel and ring shaped neighborhood, look at four cases: 0 to 25% soy; 36-50% soy; 51-75% soy; 76-100% soy. Classify each pixel and its neighborhoods in one of these 64 cases. Try to do all pixels in Brazil; if that’s too much, sample until get a good mix of each of the 64 cases (the good mix part can be parametrized by the Gini coefficient).

Overall workflow: for a pixel type, Dave will get rainfall process parameters and generate a stochastic timeseries. The stochastic timeseries, run the crop model in Google Earth Engine to get an estimate of productivity for all the 64 cases. For me, it will be either natural vegetation or soy. The result of this crop model run is to produce a LC vs. yield graph which will help with the toy model.

March 22

**Desk**

Google Earth Engine tutorial

March 25

**Desk**

Sociohydrology papers

March 26

**Desk**

Email Paolo, Tina, Ashok, Avery to be on committee

Sally thinks I should focus on Agro Serve; will talk to Avery about getting him on board as more of an advisor. Not necessary to do Botter model suitability.

Spend 2 months in Perth

March 27

**Desk**

Sociohydrology papers

March 28

**Meeting**

Qual:

* Research wise: Before the qual, demonstrate that got pieces together. Familiar with datasets, familiar with how land use to climate change statistical models will work and how this coupling will be an input on my piece (ask Dave to give sample data to work with as an example). Run crop model and make example output data. Diagram the workflow (weather generator, crop model, spits out yields, run for many scenarios, get response curves. Those response curves will be linked for NGO targets for what’s useful or not, be a resource for coupling crop behavior with a hydrological response.)
* Lit review wise:
  + papers on land use climate change feedback in Brazil.
  + InFews proposal – look at the literature cited there.
  + Ask Avery why THIS crop model instead of other crop models (maybe b/c it’s good at dealing with management).
  + Statistical modeling piece comes from causal frameworks; if you have a process understanding of driving variables, outcome of analysis should be enough to identify cause and effect. The stat modeling is not necessary if I’m not doing the climate/land use piece. Look at Morgan’s paper for causal frameworks. Not worth looking at the specific socio hydrology models and techniques. Sally can guide me through complex models stuff if that’s of interest.
  + Look out for book by Strogatz (look at his Youtube videos from Cornell).
  + Read Mario Siquiera, Jen-yi ? Jiang) Campbell and Norman’s book An Introduction to Environmental Biophysics.
* Prospectus wise: Make prospectus look like an NSF proposal. Summary at the front, Introduction to motivate the problem, Research questions and hypotheses, tasks to execute to address those research questions. Not necessarily one to one question : task. Preliminary results may be separate section or in introduction or task list. Have a timeline – think about when I’ll get input from others. Focus initial work on something synthetic. Say land change will affect certain parameters of the rainfall statistics. Draw forest cover vs. stats, generate precipitation from these statistics, then generate yield pdfs using crop model.

Workflow:

* Regionalize Brazil into appropriate categories: Figure out “regions” in Brazil which will be “homogenous” in terms of lat long, sea surface temperature, etc. In each region, figure out the percent forest and percent soy in pixels and neighborhoods. Dave will give me the parameters of AR1 rainfall model as function of land use in pixel, land use in neighborhood, lat long, etc. my job will be to bin the lat long, etc into regions, and for each regional bin, next bin into land use percentages in the pixel and neighborhoods.
* Simulate each region and land cover percentage scenario for yield: In each region of Brazil, I will come up with the rainfall parameters for each of the (% forest in neighborhood, % forest in pixel) pair. The precipitation and temperature parameters will all come from regressions (Dave will do them). These parameters will then be used to generate P and T timeseries over e.g. 5000 years. Then use these P and T timeseries as input to crop model to generate pdf of yield.
* Obtain yields from crop model: http://www.g-feed.com/2015/05/introducing-scym.html and the accompanying article - https://www.sciencedirect.com/science/article/pii/S0034425715001637 . This is the method we will use. You’ll see that it combines a crop simulation model and a statistical model to link the simulation results to meteorological and phenological data. I’m not sure which crop sim(s) we will run. There’s some risk that the cropsim piece will be tough. If that’s so, we may need to opt for something more like the statistical model used here - https://www.nature.com/articles/s41467-017-01792-x . Run crop model for them to get yields per year. Make pdf of yields for each % forest in pixel and % forest in neighborhood. Maybe even think about regions of Brazil, ENSO endmembers, etc to develop scenarios to chunk up Brazil, then push Dave’s regression analysis through crop model. Build all this machinery for an example.
* After we get pdf of yield, presumably we can have mean yield and variance of yield over each (% forest in neighborhood, % forest in pixel) pair. Then we can link to NGO metrics (coming later). Think about at what (% forest in neighborhood, % forest in pixel) will it be bad decision making to cut down more forest. Let’s say we know mean of yield and variability of yield as a function of neighborhood forest cover. In order for soy to be profitable, the local yield needs to be at some threshold. The intersection of when “deforestation becomes bad” is when the increasing yield due to increasing ag land due to deforestation and the decreasing line relating lower ecosystem services due to deforestation. This is more a task of digestion. May be a first chapter. For the time being, we ought to model productivity i.e. output per hectare. We can then translate this metric into money by multiplying by soy prices and hectares harvested. Moving forward, we may also explore metrics such as Net Present Value, Total Factor Productivity, Project IRR, county tax receipts from the soy sector, and metrics such as likelihood of stranding of assets.
* Our goal is to ask, how does climate in a pixel respond to land use change in the pixel AND in the surrounding neighborhood? Things that will change: albedo, advection, latent heat vs. sensible heat partitioning, convective triggers for rainfall, moisture availability to rain out. We expect local change in climate due to local land use change in the pixel (things like albedo and latent heat/sensible heat partitioning in the pixel will definitely change). Pixel land use change will also impact the neighborhood (advection? Moisture in atmosphere change. Convection, convective rainfall? Convective trigger for rainfall? Land use change is happening in the pixel AND in the neighborhood, but we only care about the effect on one patch.

Less important stuff to think about/future work:

The qualitative story is that land use impacts indices such as onset, extreme degrees days, etc. Furthermore, onset, extreme degree days impact the mean yield. However, it’s hard to disentangle the effect of each of these hydroclimate indices individually on the yield (easy to take apart but hard to put together). The idea to add in soil moisture, ET stuff is to help disentangle the effect of land use change on these indices. In reality, land use change impacts hydroclimate indices indirectly through things like latent energy -> atmospheric water vapor -> precip, or sensible heat -> freq of deep convection -> precip. Use soil moisture and ET information to break down these connections instead of going directly from land use change to hydroclimate indices through statistical models. Also, don’t think about this for now.

First look at land as just a collection of pixels. List the other teleconnection stuff as future work.