**Title: How do climate change experiments actually change climate?**

**Authors**

Ailene (1?), Christy (1?), Lizzie, Yann, Isabelle, Ben, Aaron, Anne Marie, Jeff, Miriam}

**Introduction**

Experimental *in situ* climate manipulations offers several advantages to understanding biological impacts of climate change (controlled, relative speed- i.e. multiple manipulations can be conducted simultaneously, can hit higher temps, can do them in places where other data collection is hard).

These advantages come at a premium, however- experimental *in situ* climate manipulations are expensive… and tricky. (Discuss here or later in paper?)

Problem:

People want to extrapolate climate change experiments (i.e. those that manipulate temperature and precipitation to simulate some future climate scenario) to real life to understand (and forecast) biological impacts of climate change. However, a detailed assessment of exactly how these experimental treatments alter climate, and the extent to which these manipulations accurately model the real world, is lacking.

Notes from meeting with Christy: Previously analyzed as binary treatments- hard to separate act of warming vs warming itself

**Experimental climate change vs. real climate**

1. The experimental structures themselves alter temperature, in ways that are not generally examined or reported in experimental warming studies.
   1. Compare sham and ambient data on temp (mixed effects models)
2. Space: Small scale – space for time substitution not accurate….microclimate differences are important; use analysis of how much climate varies due to blocks versus across plots, versus due to treatments?
3. Time: There are seasonal variations in experimental warming effects.
   1. Christy’s plots. Statistical analysis necessary?
      1. Focus on the figure
      2. Add observational stuff back in- compare warmest years to coolest years. Plot and compare to experimental data
   2. Aren’t applied consistently over the year- IR heaters can’t apply consistent warming, and some studies stop warming in different times of year (clark)
4. Think about forecasts- how well do they compare to experimental warming? Ask a coauthor to do this. Ben or Christy could do this? Her suspicion is that ben won’t want to do it.

Effects of warming on moisture here- add Miriams analysis here,

Secondary effects of warming on important abiotic factor: moisture, air humity, people need to measure these things- one example= soil moisture.

**Biological impacts**

We have laid out several ways in which experimental warming alters environmental variables, including temperature, soil moisture. We argue that these alterations are important for scientists to fully understand and report in their research because they are likely to have biological implications.

For example, plant phenology is likely to be altered in opposing ways by the increased air tempertatures and decrease soil moisture/temperature.

Also talk about biological impacts of these effects? Use phenology as a case study to show that experiments may not be a good representation of “real life”

**Recommendations** **for future climate change experiments**

1. (Easy) things everyone should try to *do in* their experiments
   1. Include controls and collect/use/report their data. Measure before and after experiment, have shams and ambient controls, and collect all data in them
2. Things everyone should *report about* their experiments
   1. Control/Sham data
   2. Timing of warming treatment applied (e.g., summer application impacts fall events more): exact date it started and how it ran throughout seasons/years
   3. Day/night variation (across seasons)
   4. Try to collect climate data at least 2X day, ideally hourly
   5. Number of missing data points for warming and why (rodents ate sensors? Heaters went out?)
3. Regression designs for nonlinearity?
4. Community standards for reporting experimental climate data (and phenology -Chuine et al. 2017)
5. Monitoring of temperature that is more useful across designs and that is closest to what focal organisms experience

Questions from meeting with Miriam:

Miriam has been looking at soil moisture data in great detail!

She has also done comparisons of target vs. measured differences in warming.

Ask Jeff about converting Watts to degrees warming for treatment

She will look into: are there particular sites that have soil temperature that do not go below 0

Look at the methods for them all to see why soil temp may be   
took out bace because no air temp and in watts not degrees C

Next steps for Miriam:

1. Subset data to remove precip treatments and ambient plots and Chuine from analysis
2. Change model structure to use only one air temp variable and one soil temp variable
3. Change the way year is modeled. Should it bea random effect (categorical variable)? Or should year be a continuous fixed effect?
4. Try to figure out what is driving the weird cutoff in soil temp at 0 degrees (how many sites show this?)



Other things to look at:

Plots warming applied vs forecasted temp changes across all sites- is warming always above forecasted amount?

Look at the site differences (in magnitude and variation- especially in ambient) across seasons

Microclimate differences- is there as much varation in temperatire on small scale as that applied by treatments (this could explain some of the discrepancy too)