**Jacob Wynne Prospectus Outline**

**Come up with some catchy title 😊 something like: Coupling a Global Climate Scenario to GCM’s and multiple lake models to determine uncertainty in future lake thermal budgets (you can wordsmith this)**

**Understanding the lake of the future: Coupling a global climate scenario, general circulation models and lake models to determine uncertainty in the future thermal budget of a northern oligotrophic lake**

**Methods**

**In order to better understand long-term climate forecasting, four general circulation models under RCP 8.5 conditions will be modeled by the five lake models within LakeEnsemblR. Using a 30+ year historical dataset, parameters will be calibrated, and baselines will be created for each GCM. GCM climate data will then be forced through the calibrated LER and the anomalies between GCM’s will be compared using 30-year intervals up to 2099. Metrics of interest from this LER output will include thermocline depth, length of stratification and thermocline strength. An array of compiled outputs including parameter distributions, water column output, and anomaly values can subsequently be used to partition uncertainty across the climate models, parameters, lake models, total forecast and climate scenario.**

1. Download the following EWEMBI corrected general circulation models: MIROC5, IPSL-CM5A-LR, GFDL-ESM2M, HADGEM2-ES under RCP 8.5 conditions.
2. Download forcing data for Sunapee needed to drive LER. This includes historical observations of discharge, outflow, hypsography, and initial conditions, as well as EWEMBI data in place of the on-site meteorology data. EWEMBI data will be used in order to maintain consistency when transferring from historical datasets to GCM datasets within LakeEnsemblR.
3. Ensure that all models run on LER using base parameters. Once all models run, calibrate parameters for LER using a specific set of years in the historical dataset. First choice of calibration method is MCMC so that there are understandable distributions to work with.
4. When parameters are calibrated, RMSE should be within ~2C for water temperature, We will determine this by looking at observed vs modeled water temperature aggregated for the whole water column.
5. Calculate the historical anomaly for water temperature over the 30-year historical dataset. This is what we will use to compare the projections to the historical baseline.
6. Force the GCM model output for meteorology into LER and produce results for all LER models up to 2099.
7. Once results are produced, analyze projected LER water temperature over 30-year time periods from present up until 2099. 30 year time periods signify a complete climate cycle – an analysis using 30 year intervals provides a more complete and broad picture than shorter or longer intervals. There are many metrics of interest that can be calculated from LER temperature simulations, including the length of stratification, thermocline depth, and thermocline strength, among others.
8. Once metrics of interest have been calculated for each model over 30-year time periods, a comparative analysis between all LER and GCM model combinations, and the historical baseline should be carried out.
9. The comparative analysis will revolve around the spread and difference of values between the LER models.

Possibilities:

* Mean stratification duration by year with 95% confidence intervals for each LER model up to 2099. Track the average change from year to year for each model.
* Difference between surface and bottom temperature up to 2099 for each LER model. Would give more insight into the magnitude of the stratification according to each model. Unsure of how uncertainty could be quantified in this case.
* Compare water temperature per meter (0-33m), averaged yearly with a 95% confidence interval. Would give a better insight into differences in modeling the entire water column for the LER models. Maybe some models are better at upper column, middle column, lower column?

1. Move on to uncertainty partitioning.

**Uncertainty Partitioning**

1. Climate model uncertainty: Use median parameter values; Do not propagate process uncertainty; Uncertainty is defined as the width of the 95% CI of percent change in stratification duration from 2021 (ish) up to 2099.
2. Parameter uncertainty: Sample from the posterior distributions of the parameter sets; Generate separate ensembles for each climate model and calculate uncertainty by taking the width of the 95% CI of ensembles averaged across the climate models.
3. Ecosystem Model process uncertainty: Comparing different outputs using sampled parameters and using an ensemble approach; Take the width of the 95% CI averaged across models.
4. Total forecast uncertainty: propagate from previous three.
5. Climate scenario uncertainty: Difference in percent change of temperature from different climate model scenarios (RCP 4.5, RCP 8.5) using the anomaly values produced by combining LER and ISIMIP models.