Evaluating the skill of global climate models in predicting local climatic metrics

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1. Background

Despite substantial advances in climate modeling, providing farmers with locally relevant climate information is still a difficult task[1,2]. In addition, very little work is being done on verifying the information that is being provided to users[1].

Chill hours, i.e. the cumulative number of hours in winter months where temperature is less than or equal to 45°F, is a locally relevant climatic parameter for perennial fruit and nut crop farmers in California (CA). To attain optimum yields, trees must meet a certain number of chill hours every winter[3]. Chill hours in CA are projected to decrease with future climate change[4,5]. Some of this research acknowledges that projections of chill hours vary substantially among different Global Circulation Models (GCMs)[3]. However, none of the studies have assessed the skills of different climate models in predicting chill hours for CA.

An assessment of the skill of different GCMs in predicting chill hours for CA can be a step in the right direction for providing farmers with the best available information for their precise needs.

2. Project goals

This project investigates whether climate models with good skills in predicting global metrics (i.e. global average temperature), are also good predictors of specific metrics of local climate such as chill hours in California.

The specific goals of the project are to:

- Evaluate skill of the GCMs that are part of the Coupled Model Intercomparison Project Phase 5 (CMIP5) in computing chill hours for California's central valley.
- Analyze whether discarding models with low skill, leads to significant changes in the projections of future climate.

3. Methods

Project results were developed through the following tasks:

- Obtaining climate data from the CMIP5 GCMs for a 100km X 100km grid in central CA.
- Wherever available, different model ensemble members (i.e. simulations with slight perturbations in initial conditions) were included.
- Development of MATLAB code to compute annual chill hours from various climate models.
- Computation of observed annual chill hours based on data for the Fresno weather station in central CA that is located in the center of the grid cell under consideration.
- Statistical analysis through a t-test comparing the historically observed chill hours slope from 1971 to 2012 to the chill hours slope for the same period from each of the GCMs.
- Computation of long-term future projections of chill hours (2010-2050) for the RCP (Representative Concentration Pathway) 8.5 scenario.

4. Discussion and results*

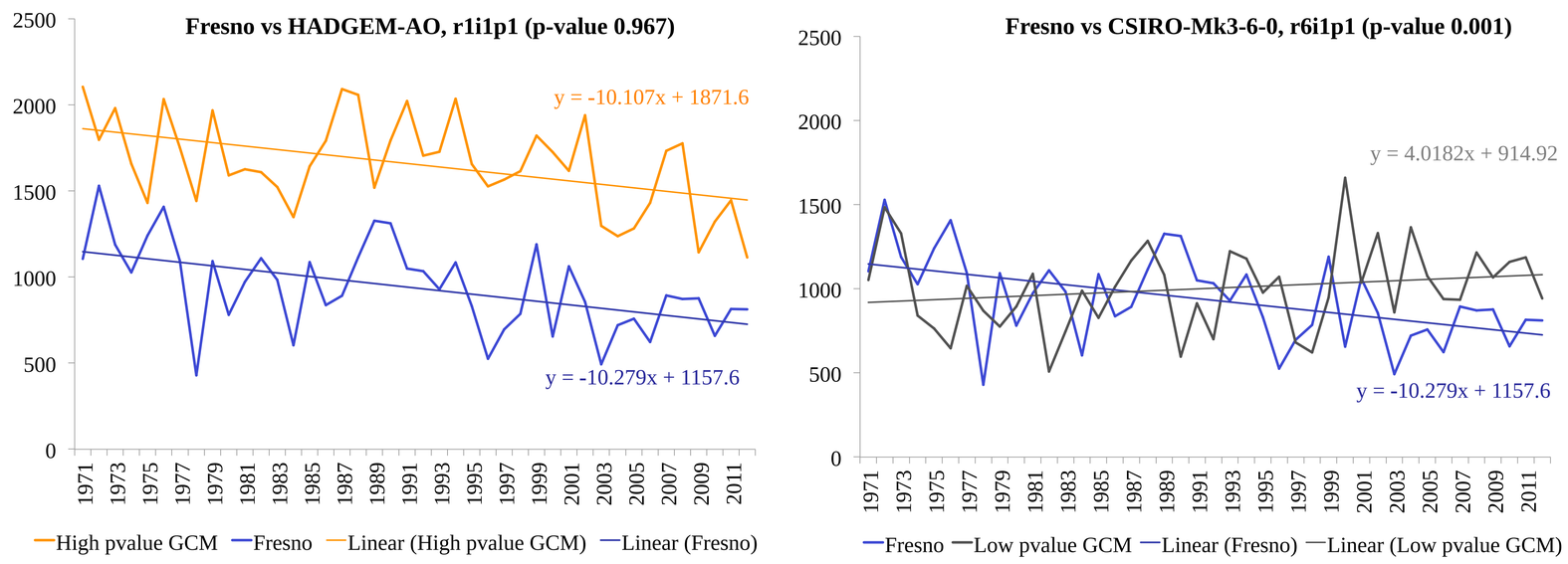
Historically observed climate data shows that chill hours in Fresno have been declining at the rate of -10 chill hours per year from 1971-2012. For the same time period, the different GCMs' predictions for the mean slope range from -15 to +4 chill hours per year, with a multi-model ensemble mean slope of -5.5.

The p values from the t-test that compared model slope to observed slope ranged from 0.001 to 0.967. p values closest to 1 represent the models whose slopes are least significantly different than the observed slope i.e. in this case higher p values represent models that predict chill hour slope closest to the observed trend.

Figure 1 shows the results from the statistical analysis. Figure 2 illustrates the varying skills of a model with a high p-value versus one with a low p-value.

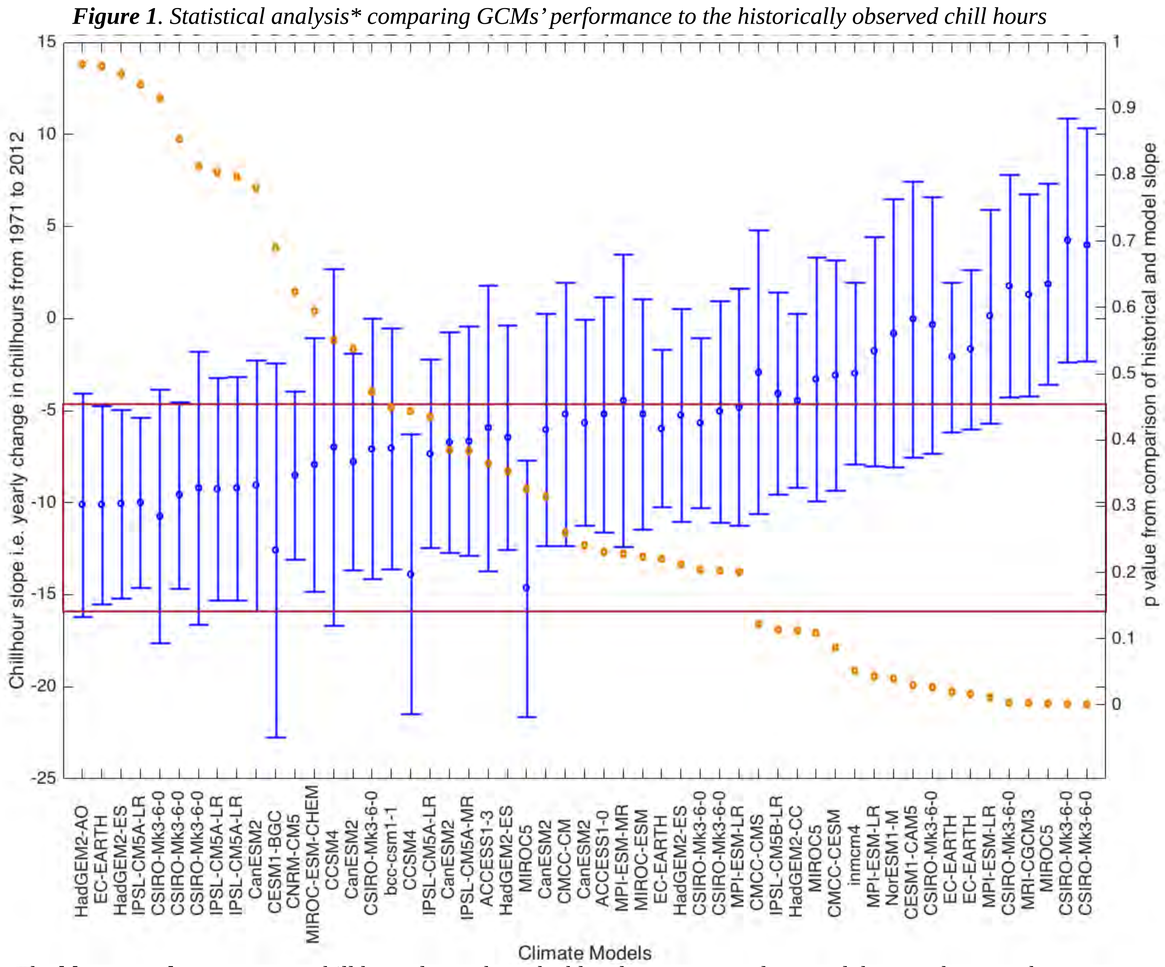
Preliminary projections of chill slope from 2010-2050 showed that both high p-value GCMs and low p-value GCMs predict a declining trend of -10 chill hours per year in the future. Figure 3 shows the future trend of chill hours from the different GCMs.

Figure 2. *Illustration of varying skill of two different climate models in predicting chill hours for Fresno, CA*



The graphs indicate that the HADGEM-AO predicts the declining trend in yearly chill hours better than the CSIRO-Mk3-6-0*
* Preliminary results - not to be cited or distributed.

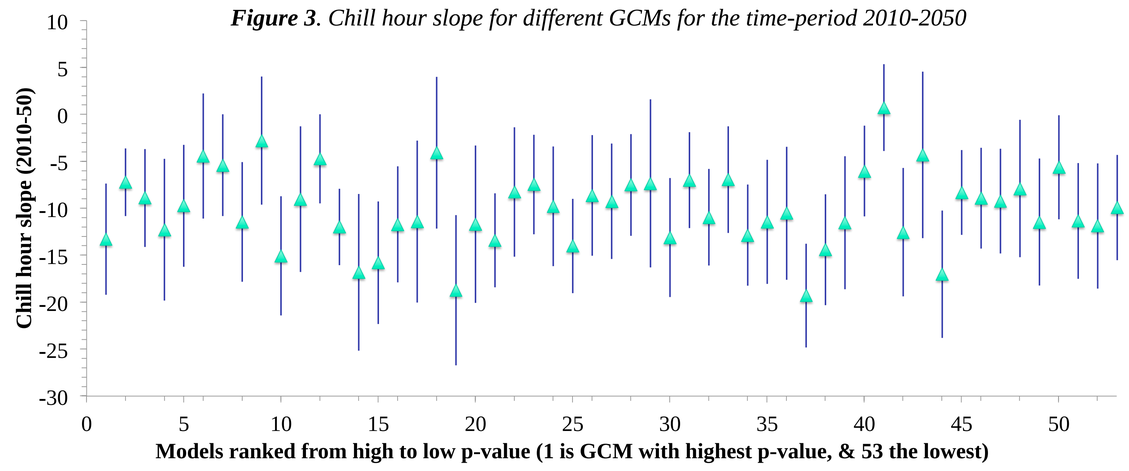
Figure 1. *Statistical analysis* comparing GCMs' performance to the historically observed chill hours*



The **blue error bars** represent chill hour slope where the blue dots are mean slope, and the error bars are the confidence intervals of the slope for each GCM. The **orange dots** are the p values corresponding to each GCM. The **red box** represents the range of the observed chill slope for the Fresno weather station. The figure indicates that the models to the left predict the past observed trend in chill hours better than models on the right.

*Preliminary data - not to be cited or distributed.

Figure 3. *Chill hour slope for different GCMs for the time-period 2010-2050*



The green triangles represent the mean slope, and the blue error bars are confidence intervals of the slope.

5. Conclusions & future goals

The skill assessment of GCMs for chill hours in California shows that different models have varying skills in predicting the historical trend in chill hours. Specific runs of HADGEM2-AO, EC-EARTH, and HADGEM2-ES have p-values close to 1 suggesting that they predict the chill hour trend of the past closest to the observed data. Despite the varying performance of GCMs in the historical time-period, the projections for the future trend in chill hours is similar from models with high and low p-values.

Further analyses are required to rank the models based on their skill for predicting chill hours and to better understand inter and intra model variability in results. Skill assessment for prediction of mean annual chill hours will also be undertaken, along with a basic bias correction of the model results.

6. References

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