Bias Corrected Regional Climate Change Projections for Agricultural Decision Making: Developing an Online Visualization Tool

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Abstract:
Reliable climate projections assist policymakers and businesses in making informed decisions about the impact of climate change on society and business practices, enabling effective resource allocation for the future. By quantifying and visualizing future climate data, we can inform about future regional climate trends, fostering informed decisions and productive changes. This study employs bias-corrected climate change projection data derived from the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) based on Coupled Model Intercomparison Project phase 6 (CMIP6) models. Five models namely GFDL-ESM4, IPSL-CM6A-LR, MPI-ESM1-2-HR, MRI-ESM2-0, and UKESM1-0-LL were used in conjunction with 3 future warming scenarios–SSP585, SSP370, and SSP126. The regions of interest are South Asia, South America, and Thailand-Vietnam, and variables of interest are minimum temperature, maximum temperature, mean temperature, solar radiation, and precipitation. The projected changes between different future periods and the historical simulation (1981-2014) are calculated to show climate change in these specific regions. In particular, the goal was to build an interactive visualization tool that illustrates change in these five variables

based on a user's selection of a specific future time, warming scenario, model, and region. This climate change information is included in a tool to provide climate forecasts on sub-seasonal (Weekly and Bi-Weekly) and seasonal (3-month out to a year) time scales. In short, it functions as an integrated tool, offering recent climate information and projections extending to the end of the century, all in one comprehensive platform.

Introduction:

Climate change continues to be a hazard to our society. Specific populations are at more risk than others. For example, South Asia's monsoon season makes for unpredictable and dangerous climate. By exploring these three regions (Thailand-Vietnam, South Asia, and South America), we can make note of trends in these regions while also building an effective app that makes for easier analysis.

We utilize CMIP6 (Coupled Model Intercomparison Project Phase 6) which allows for us to utilize a range of information from variables, climate scenarios, models, historical data, etc. As a Bias-Corrected tool, we are ensuring we use the best of the best tools to have accurate projections.

Methods:

Initial methods included creating comparison code to affirm the conversion from netCDF files to zarr files was correct. Zarr is an open-source data format and library designed for the efficient storage and retrieval of large, multidimensional arrays. It is particularly well-suited for handling scientific data, including climate and weather data, which are often large and complex. Zarr provides a scalable, chunked, and compressed storage format that is optimized for performance and accessibility. The CMIP6 data was stored as zarr files, meaning, they resided on the cloud for faster processing time and easier access. Thus, we needed to confirm that this conversion worked successfully.

Also, I created functions that created monthly averages, monthly annual averages, seasonal annual averages, and most importantly, future minus historical seasonal annual averages. These were stored in xarray format. On top of these computational functions, I also created mapping functions that called these functions and printed maps using plotly. The functions had inputs of variable, scenario, month/season, and model. I utilized Python Xarray for all of this code and worked in VSCode.

With the use of some of my code, existing code, and new code, we created an app/tool in IRI's Maprooms. This app allows a user to make certain selections to display their map.

Results:

By utilizing our methods, we were able to successfully create maps based on a users input of their model, scenario, variable and time period. The types of maps created started with monthly annual averages, then seasonal annual averages, and most importantly, seasonal difference maps.

Our main goal was to output and analyze seasonal difference maps. Below are some of the historical and future seasonal maps for the specific regions.

<u>Observational historical maps:</u>

Precipitation - All regions

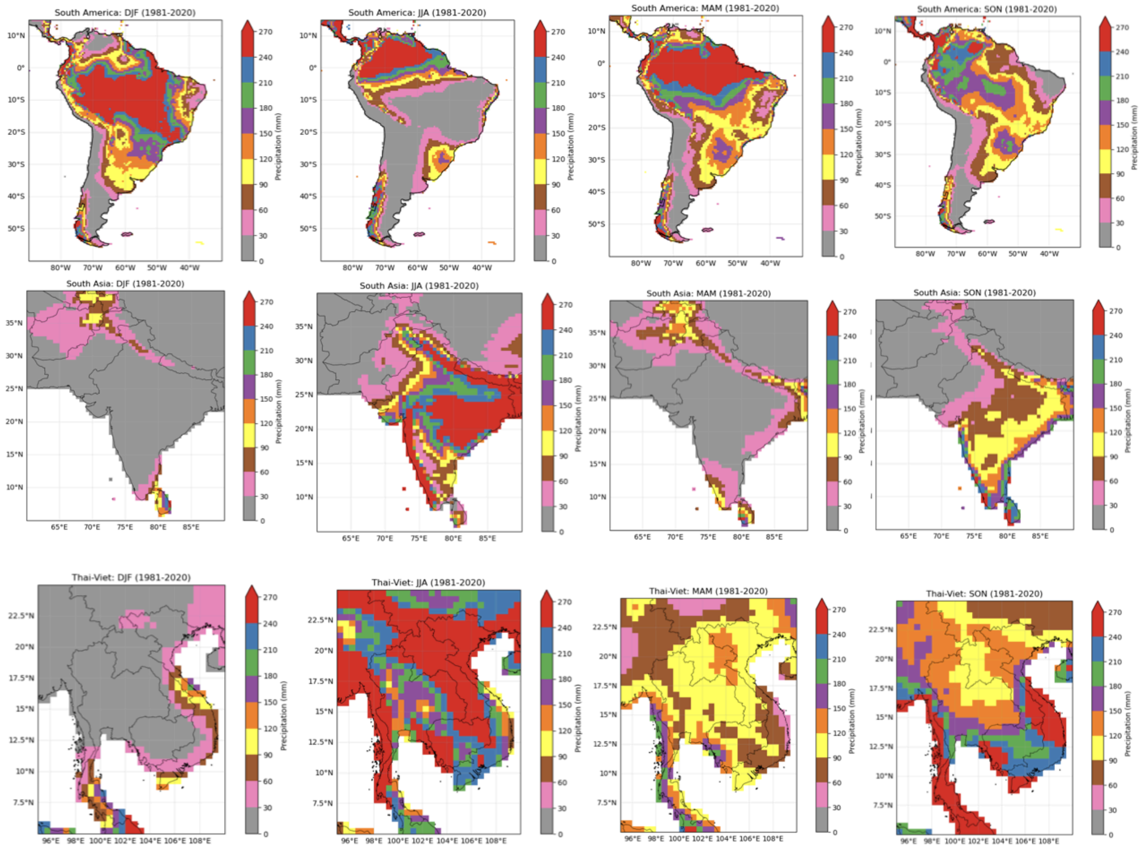

Figure 1: The maps indicate precipitation(mm)--for the specific regions–averaged over the 40 years.

<u>South Asia (temperature)</u>

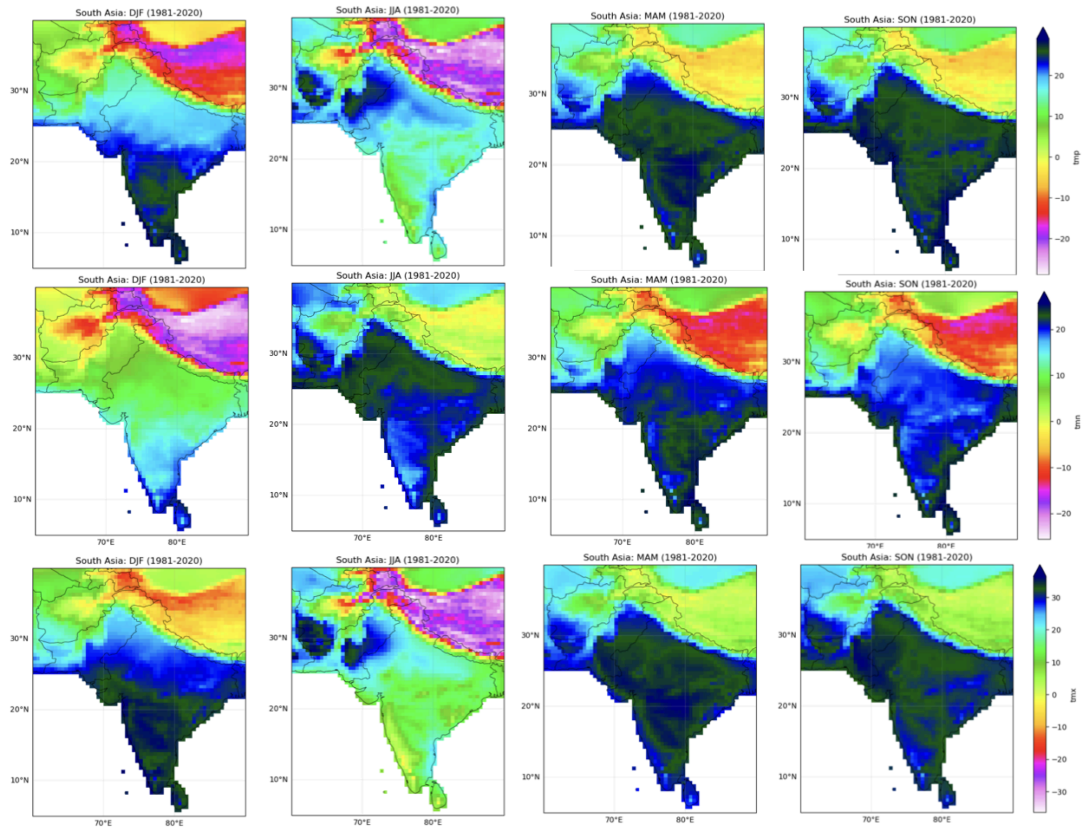

Figure 2: The maps above display the various temperature variables for South Asia averaged over 1981-2020. The specific unit is indicated next to the color bar–from top to bottom, the maps display mean temperature, minimum temperature, and maximum temperature.

<u>Thailand-Vietnam (temperature)</u>

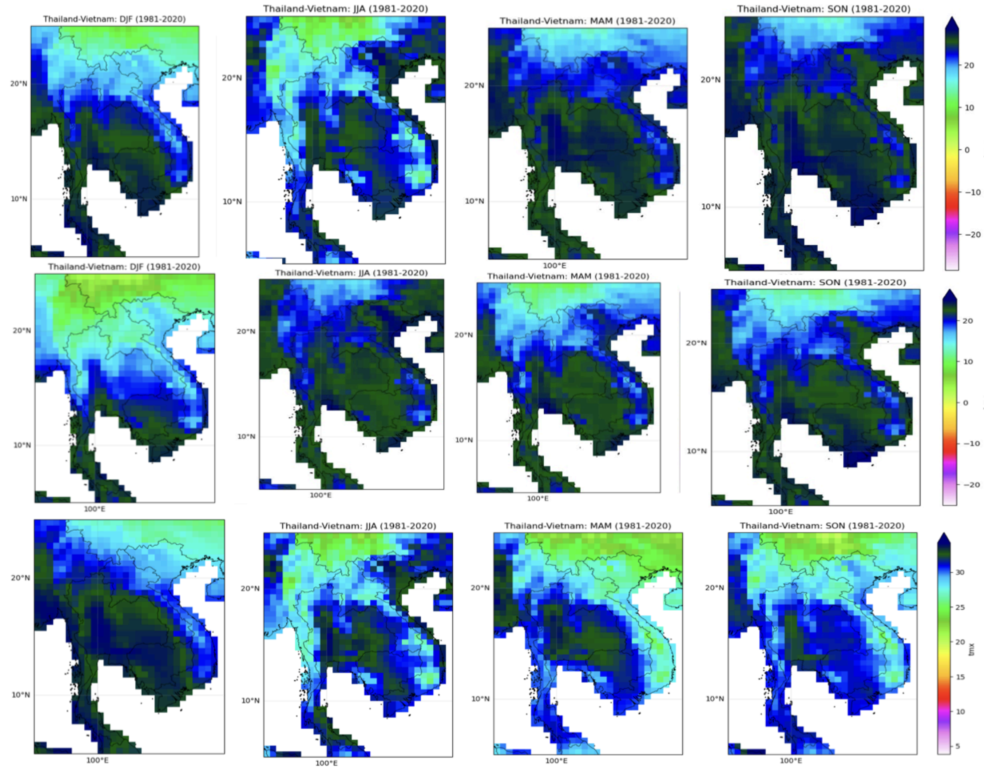

Figure 3: These maps show temperature averages over the 40 years for the Thailand-Vietnam region.

<u>South America (temperature)</u>

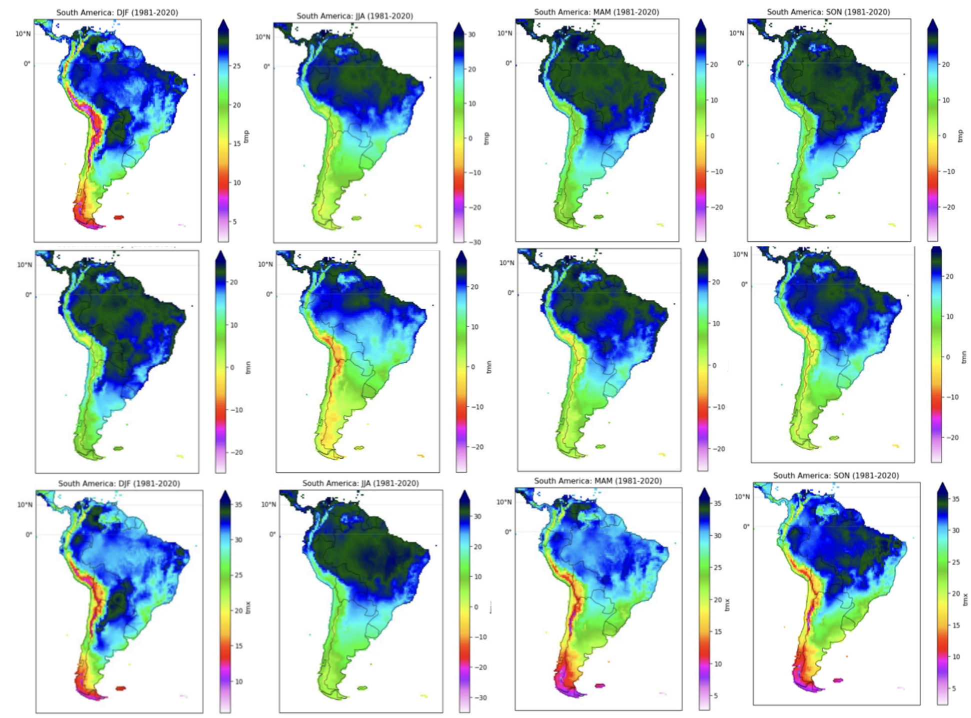

Figure 4: South America's observed average temperature from 1981-2020 can see above based on the seasons with mean temperature at the top, minimum temperature in the middle, and maximum temperature at the bottom.

Seasonal Projections:

<u>South America (temperature)</u>

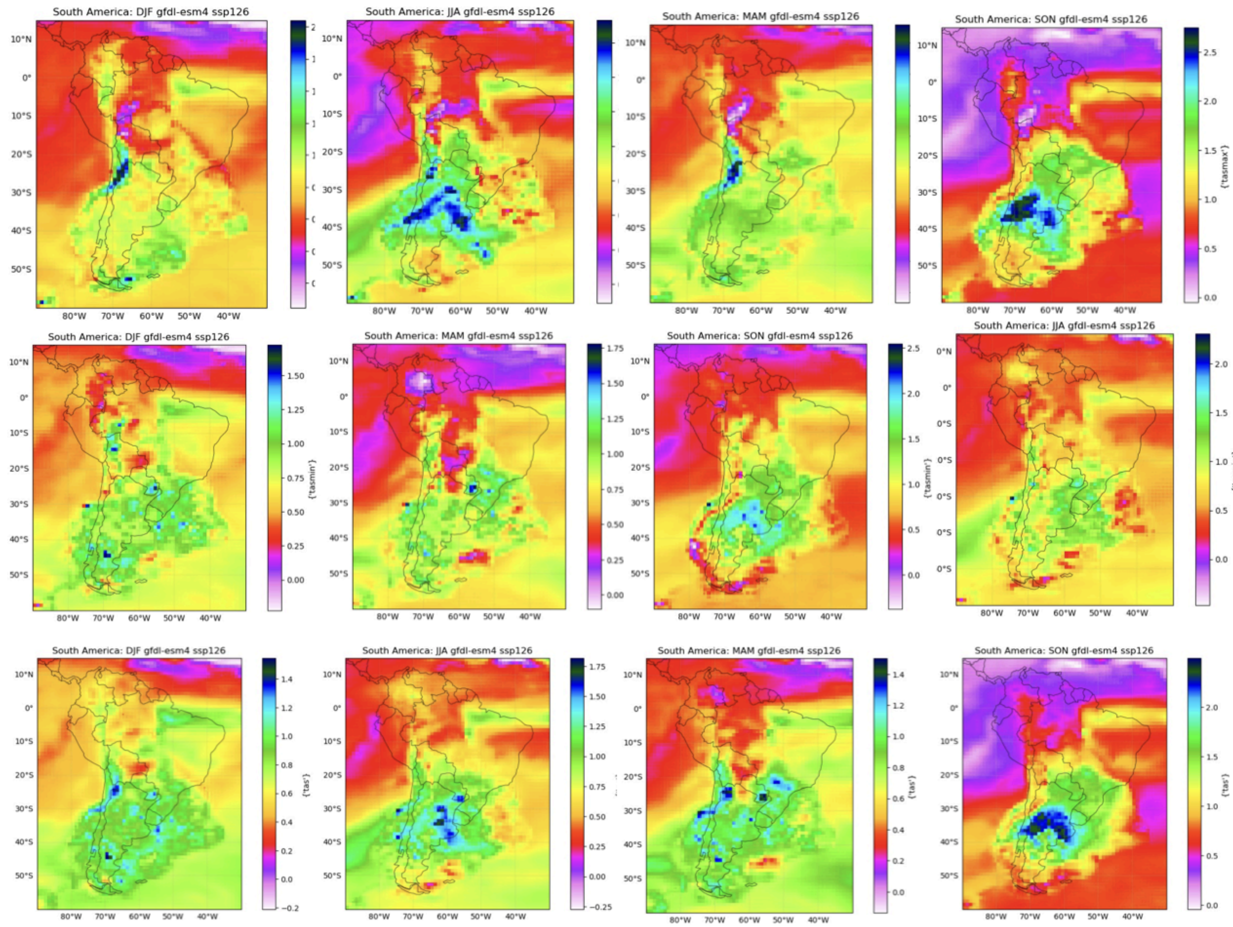

Figure 5:South America's difference in temperature between future and historical can be seen in these maps using the GFDL-ESM4 model and SSP126. Using Celsius as units.

<u>South America (precipitation)</u>

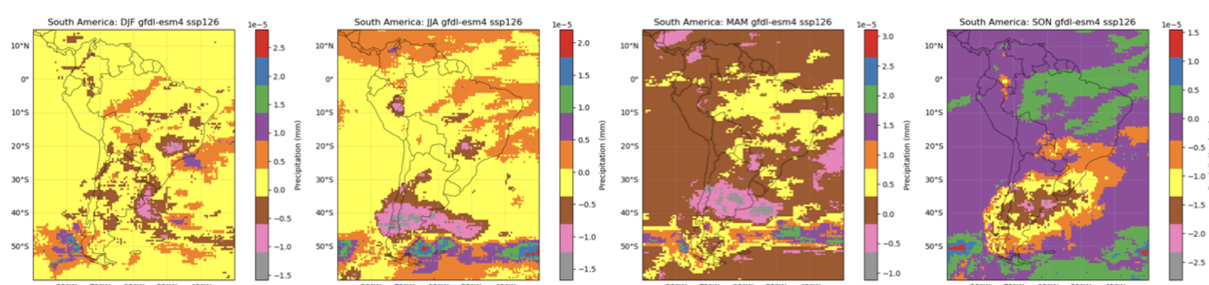

Figure 6: South Ameria's precipitation climate difference can be seen above.

South Asia (precipitation)

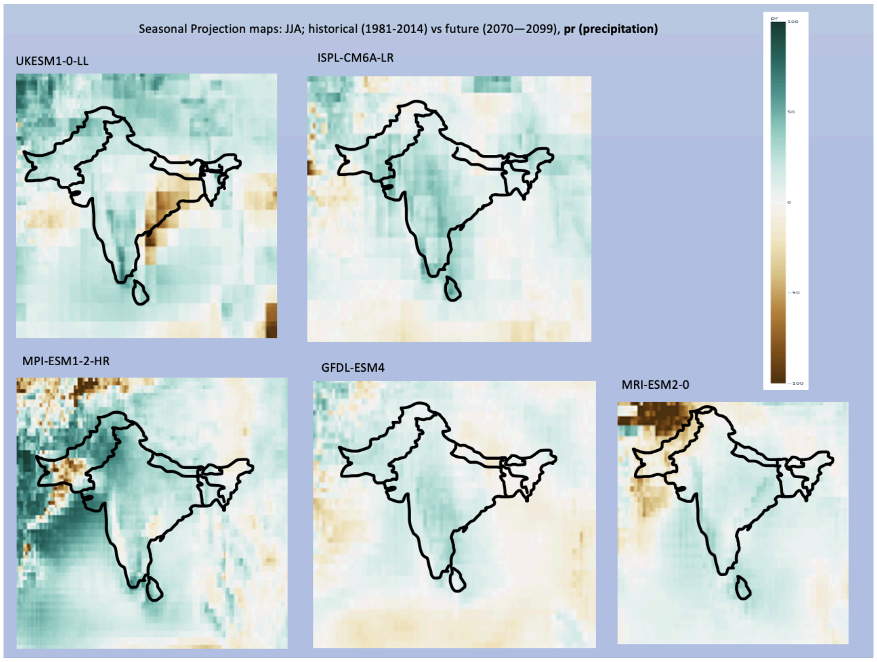

Figure 7: The maps display seasonal projection maps for South Asia based on our five models. We selected the SSP-585 as our future scenario during the time period 2070-2099 to compare with our historical scenario. This shows the change in precipitation in the region in 2070-2099 with out base year average being 1981-2014. There seems to be some inconsistencies across the models with models such has MRI-ESM2-0 and MPI-ESM1-2-HR reporting a negative percentage of precipitation in West India compared to other models.

Discussion

It is important to have these climate projections as policy makers can use this evidence to support environemntally friendly plans. When looking at a SSP-585 projection compared to a SSP-126 projection, there is an obvious increase in temperature globally when we emit more carbon dioxide that we currently do. Maps help humans better easily visualize the detrimental effects of our carbon footprint. Furthermore, for those with less of a scientific understanding, maps serve as an easy baseline to interpret. By integrating a tool, it can help plan for future agriculture. Thus, allowing corporations to cut down of crop waste.

While this is an ongoing project, it is important to note that the 5 models differ in projections. Deciding which one is best was not included in our project, but may be something to look into in the future.

Conclusions

We can continue to analyze these projections to see how different regions may be impacted by climate change. It is imperative that we take these maps and implement this knowledge into acts that help our future. Preventative measures need to be taken, otherwise, the effects seen by SSP585 may happen.

Recommendations

In the future, corporations can use these existing tools as well as our maps to see how their agriculture may face in one of these three regions. By customizing their input with our tool in conjunction with a crop model, agriculture projections can be made. Furthermore, it is important for politicians to acknowledge and understand future climate change, evidenced by our maps, to make decisions for the betterment of our society and Earth.

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