CDC Aedes Forecasting Challenge 2019: Historic Average and Ecological Niche Modeling

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Background

Within this project we sought to expand upon basic averaging forecasts by implementing climatological nice modeling with Maxent. To this end, we calculated multiple zonal statistics on historical and forecasted climate data to create variables such as mean temperature, mean precipitation level, and Growing Degree Days (GDD). After processing the data, we were able to input a combinations of presence, background, and historic climate data Maxent in order to obtain a forecasted probability for each US county in each month. However, we faced some limitations that likely affect our ability to make reliable and accurate forecasts.

Figure One A: July Historical Presence/Absence

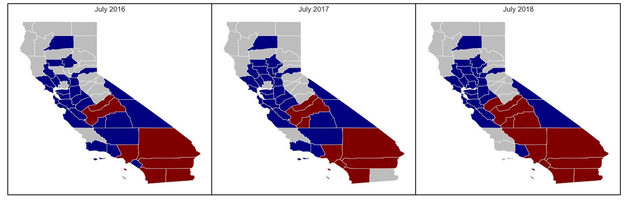


Figure One: Map of aedes aegypti presence (Red) and absence (Blue) for California, July 2016-2018.

Figure Two: Historic probability distribution of Californian aedes aegypti presence in July across years 2013-2018.

Figure Three: California July 2019 Aedes Aegypti presence probabilities based on historical average distribution

Figure Two: July Historical Average

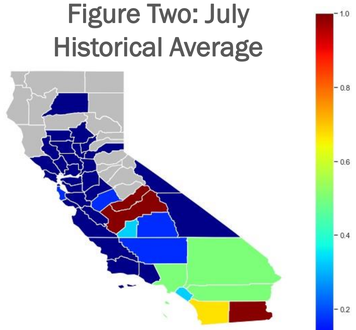


Figure Three:

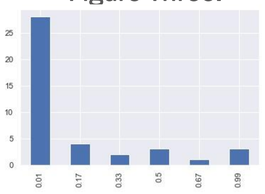
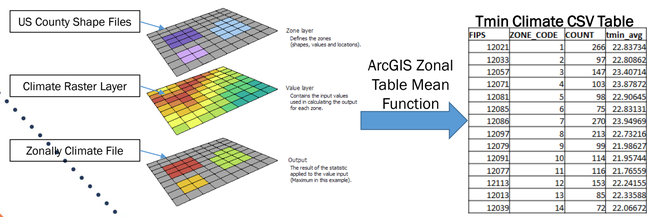


Figure Four: Preparing Data



Tmin Climate CSV Table

FIPS	ZONE_CODE	COUNT	tmin_avg
12021	1	266	22.83734
12033	2	97	22.80862
12057	3	147	23.40714
12071	4	103	23.87872
12081	5	98	22.90645
12085	6	75	22.83131
12086	7	270	23.94969
12097	8	213	22.73216
12079	9	99	21.98627
12091	10	114	21.95744
12077	11	116	21.76559
12113	12	153	22.24155
12013	13	85	22.33588
12039	14	72	22.06672

Figure Four:: Illustration of the conversion from national NOAA and PRISM climate raster data to CSV tables compatible for Maxent. This is the arrows marked [1] and [2] in Figure Five

Figure Five: Maxent Data Processing Steps

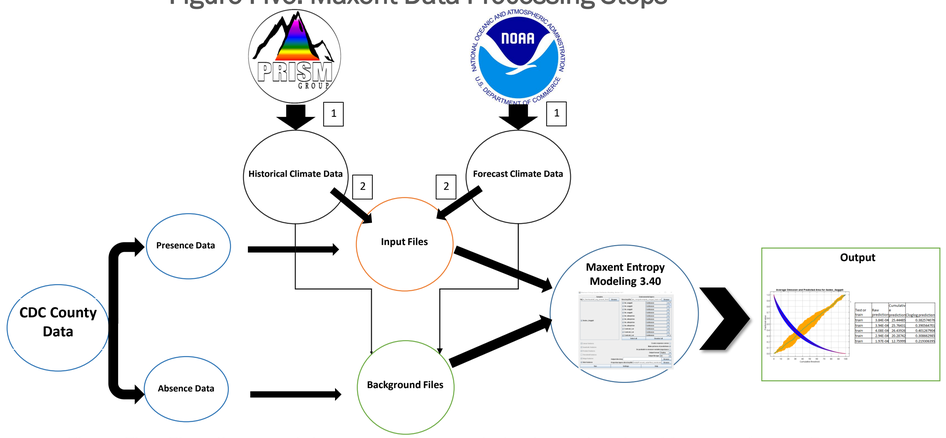
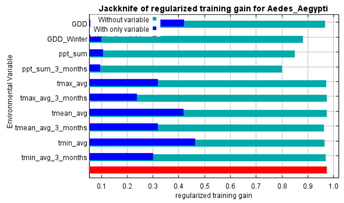
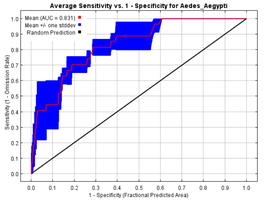


Figure Five: Flow diagram of data processing needed to input data into Maxent software. Forecast climate data obtained from Prism Group and historical climate data obtained from NOAA

Figure Six: July 2019 Maxent Result Variable Comparisons





Variable	Percent contribution	Permutation importance
GDD	31.2	7.6
ppt_sum	15.4	14.3
tmin_avg	13.6	9.6
GDD_Winter	13.3	16.9
ppt_sum_3_months	13	46
tmin_avg_3_months	8.4	0.6
tmax_avg_3_months	2.4	0
tmean_avg_3_months	2.3	4.8
tmax_avg	0.3	0.2
tmean_avg	0	0

Figure Six: Jacknife of variable importance for aedes aegypti (TL). Percent contribution (TR) and Response Curves (below) for each aedes aegypti variable individually when all others kept constant

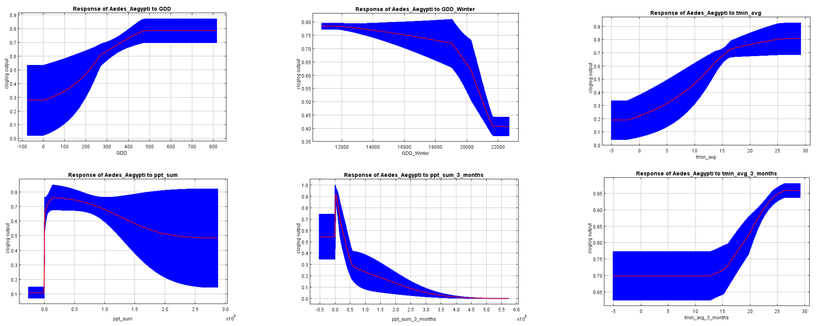
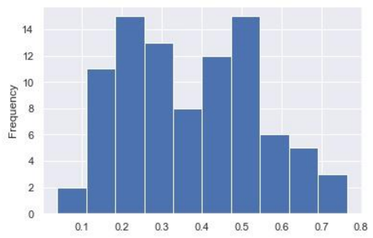


Figure Seven: July 2019 Maxent Forecast



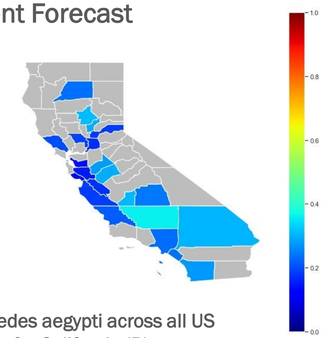


Figure Seven: Distribution of probability forecasts for aedes aegypti across all US counties in July 2019 (L). Map of probability distribution for California (R)

Conclusions And Limitations

There were many limitations in this project. First, while forecast climatological data was obtained, the data was harder to process. The variables listed in Figure Six for the historical climate data were never successfully adapted to the forecast data. Therefore, we could not overlay past climate data onto forecasted climate data when running Maxent which harms out ability to make accurate predictions. This is a significant limitation and would need to be resolved in order to proceed with further spatial forecast challenges. Furthermore, Maxent is has inherent limitations when is comes to making probability forecasts due in part to its reliance on presence-only and background data. Moreover, our forecast and historic climate data comes from different sources so there may be room for error.

Nonetheless, I have become more proficient working with climate data and niche modeling software. With this basis, I feel much more confident about approaching such projects again and have a better understanding of what I can do to improve.

References

Images:

- https://oceanservice.noaa.gov/facts/noaalogo.html
- https://wrcc.dri.edu/monitor/nev-mon/more_info.html

Climate Data

- Saha, S., ;S. Moorthi, X. Wu, J. Wang, and Coauthors, 2014: The NCEP Climate Forecast System Version 2. *Journal of Climate*, **27**, 2185–2208, doi:10.1175/JCLI-D-12-00823.1.
- PRISM Climate Group, Oregon State University, http://prism.oregonstate.edu.

Research

- Nugent, Jim. Calculating Growing Degree Days. Michican State University. https://www.canr.msu.edu/uploads/files/Research_Center/NW_Mich_Hort/General/CalculatingGrowingDegreeDays.pdf
- Johnson, T. L., Haque, U., Monaghan, A. J., Eisen, L., Hahn, M. B., Hayden, M. H., Savage, H. M., McAllister, J., Mutebi, J. P., & Eisen, R. J. (2017). Modeling the Environmental Suitability for Aedes (Stegomyia) aegypti and Aedes (Stegomyia) albopictus (Diptera: Culicidae) in the Contiguous United States. *Journal of medical entomology*, *54*(6), 1605–1614. https://doi.org/10.1093/jme/tjx163