IMPACT OF WATER LEVEL ON METHANE EMISSION IN WETLANDS

Julianne Farnham (GEOL394)

Advisors: Mojhgan Haghnegahdar and Michael Evans

INTRODUCTION

Methane has become of increasing importance in climate change over recent years, as it is one of the main contributors to global warming. Wetlands are the main natural source of methane emissions into the atmosphere and are responsible for roughly 30% of global methane emissions (EPA, 2021). Several factors contribute to the amount of methane being released from wetlands such as temperature, vegetation, microbial activity, and water level. It is unclear how large of a role water level plays in the emission of methane from wetlands.

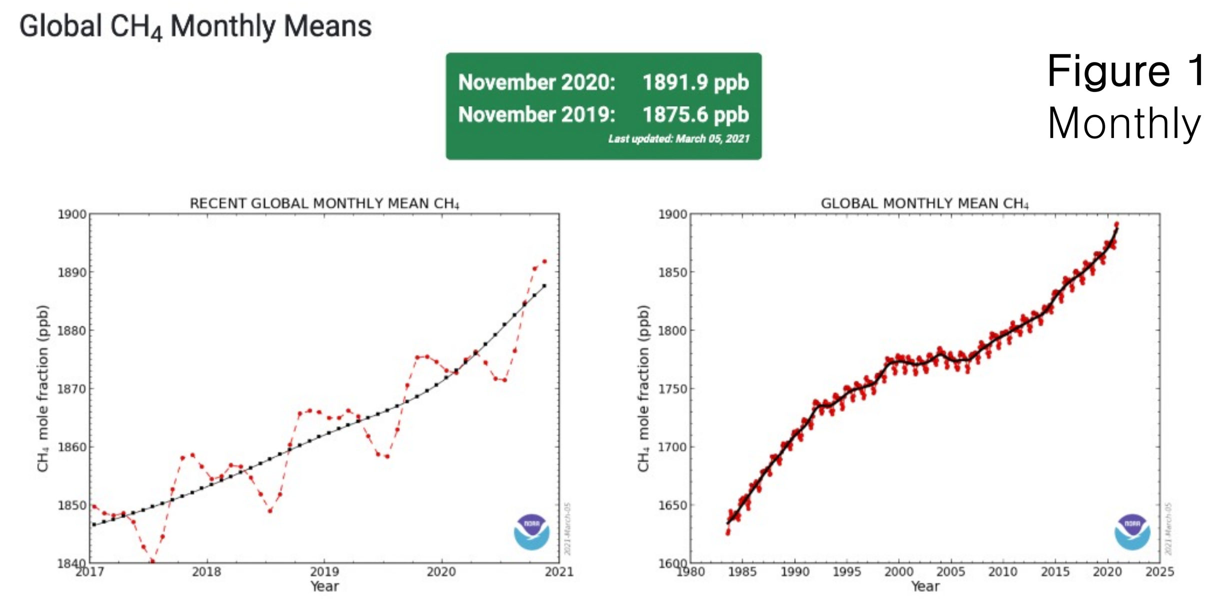

Figure 1: Recent NOAA Global Methane Monthly Means data (2020).

HYPOTHESES

- Wetlands with lower water levels/depth are expected to emit more methane than higher ones.(Barbera, et al.,2019)
  - Null: There is no relationship between methane emissions at wetlands with high water levels/depths or low water levels/depths.
- Wetlands with higher temperatures are expected to emit more methane than lower temperature wetlands.(Barbera, et al.,2019)
  - Null: There is no relationship between methane emissions at wetlands with high temperatures or low temperatures.

METHODS

- Three methane chambers were installed in the inlet and outlet of a wetland located at the University of Maryland Golf Course.
- Water levels and temperature conditions were monitored at the sites by using a ruler and a thermometer, these observations were compared with data from depth sensors and temperature loggers installed at the site.
- A bi-weekly sampling of the gas emitted from the wetland sites occurred over several months, mostly during the cold seasons of the year.
- The methane concentration is analyzed by the Gas Chromatograph (GC) to see the methane accumulation rate in 30-minute increments.

Figure 2: Photos of the three sites at the University of Maryland Golf Course.

Figure 3: A photo from Google Earth of the UMD Golf Course. The Outlet Site (upper arrow) and the Inlet Site (lower arrow).

RESULTS

Site: GO	Date	Air T (C°)	Water T (C°)	Water Depth (cm)	Methane Accumulation Rate (ppb/min)	Regression Estimate	R^2
	11/5/21	14.18	n/a	5.1	2388.10	y=2388.1x+7123.2	0.85
	11/17/21	12.3	9.72	5.4	-295.63	y=-295.63x+90353	0.26
	12/3/21	9.82	6.22	3.8	534.02	y=534.02x+119408	0.76
	2/9/22	5.4	0.64	4.5	786.22	y=786.22x+311633	0.50
	2/23/22	8.28	13.75	5	430.04	y=430.04x+128789	0.98
	3/7/22	10.46	13.7	6.3	866.50	y=866.5x+181422	0.97
	4/11/22	11.2	7.45	6.8	1917.40	y=1917.4x+165524	0.59
Site: GOP	Date	Air T (C°)	Water T (C°)	Water Depth (cm)	Methane Accumulation Rate (ppb/min)	Regression Estimate	R^2
	11/5/21	14.18	n/a	5.5	7831.80	y=7831.8x+25958	0.12
	11/17/21	12.3	9.11	8.1	1729.80	y=1729.8x+238162	0.75
	12/3/21	9.82	6.11	6.3	5766.70	y=5766.7x+969784	0.39
	2/9/22	5.4	1.25	8	4879.00	y=4879x+466820	0.80
	2/23/22	8.28	13.5	8.7	2027.10	y=2027.1x+115587	0.59
	3/7/22	10.46	14.92	8.3	2809.90	y=2809.9x+306680	0.76
	4/11/22	11.2	7.55	7.5	4850.60	y=4850.6x+192442	0.59
Site: GI	Date	Air T (C°)	Water T (C°)	Water Depth (cm)	Methane Accumulation Rate (ppb/min)	Regression Estimate	R^2
	11/5/21	n/a	n/a	n/a	n/a	n/a	n/a
	11/17/21	12.3	10.72	1.9	251.80	y=251.8x+49364	0.12
	12/3/21	9.87	9.8	0	1016.10	y=1016.1x+1.0444e6	0.59
	2/9/22	9.07	6.78	6.5	227.56	y=227.56x+309465	0.40
	2/23/22	8.48	12.39	4.6	622.81	y=622.81x+5671.2	0.99
	3/7/22	10.65	13.56	3.8	1133.10	y=1133.1x+72539	0.89
	4/11/22	13.4	10.55	5.5	227.46	y=227.46x+6734.9	0.98

Figure 4: Table showing: Air T(˚C) Water T(˚C) ,Water Depth (cm), Methane Accumulation Rate (ppb/min).The rows highlighted in red signify the data that was thrown out due to a R^2 values smaller than .5, caused by data with large variance from the regression model.

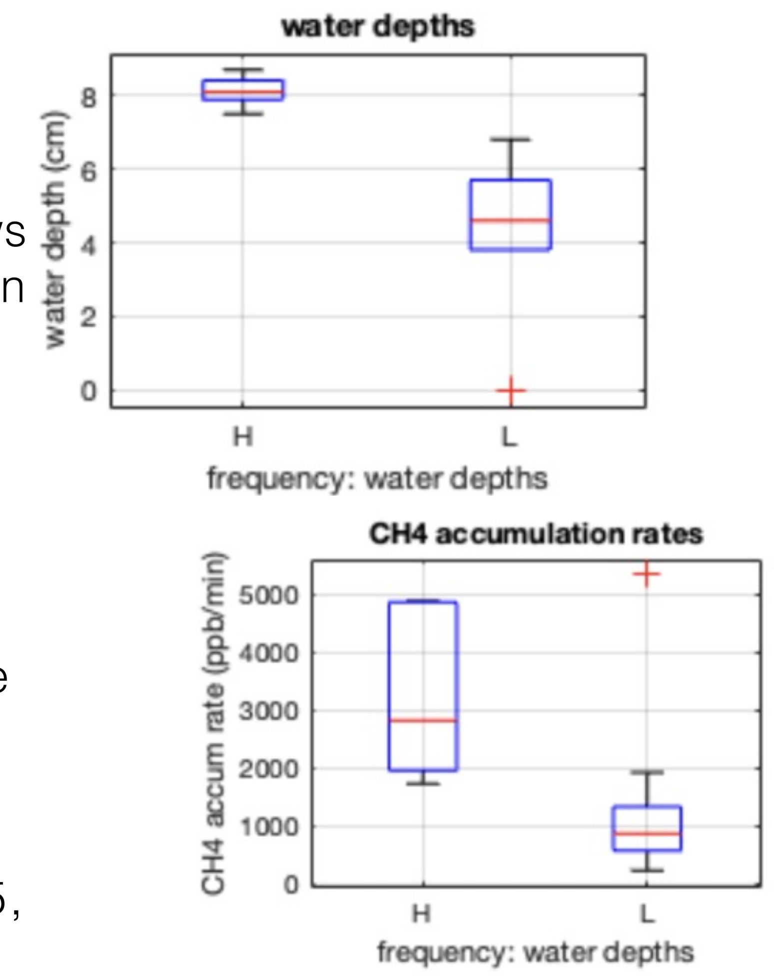

Figure 7: Boxplot 7a (top) shows the frequency of the various sampled water levels for low and high-water depths. (df:12,p-crit:.05,t-crit: 2.179, means: 5.31) Boxplot 7b (bottom) shows the frequency of different methane accumulation rates occurring at low and high-water levels. H is representative of high-water levels; L is representative of low water levels. (df:12,p-crit:.05, t-crit: 2.179, means: 2.2076).The outlier was potentially influenced by prior water level conditions, as there is a 2 to 3 weeks lag response period for microbial communities. The outlier experienced a significant drop in water level from three weeks earlier, suggesting the outlier was influenced by prior water level conditions. (removal of outlier: (df:11,p-crit:.05, t-crit: 2.23, means: 3.7054).

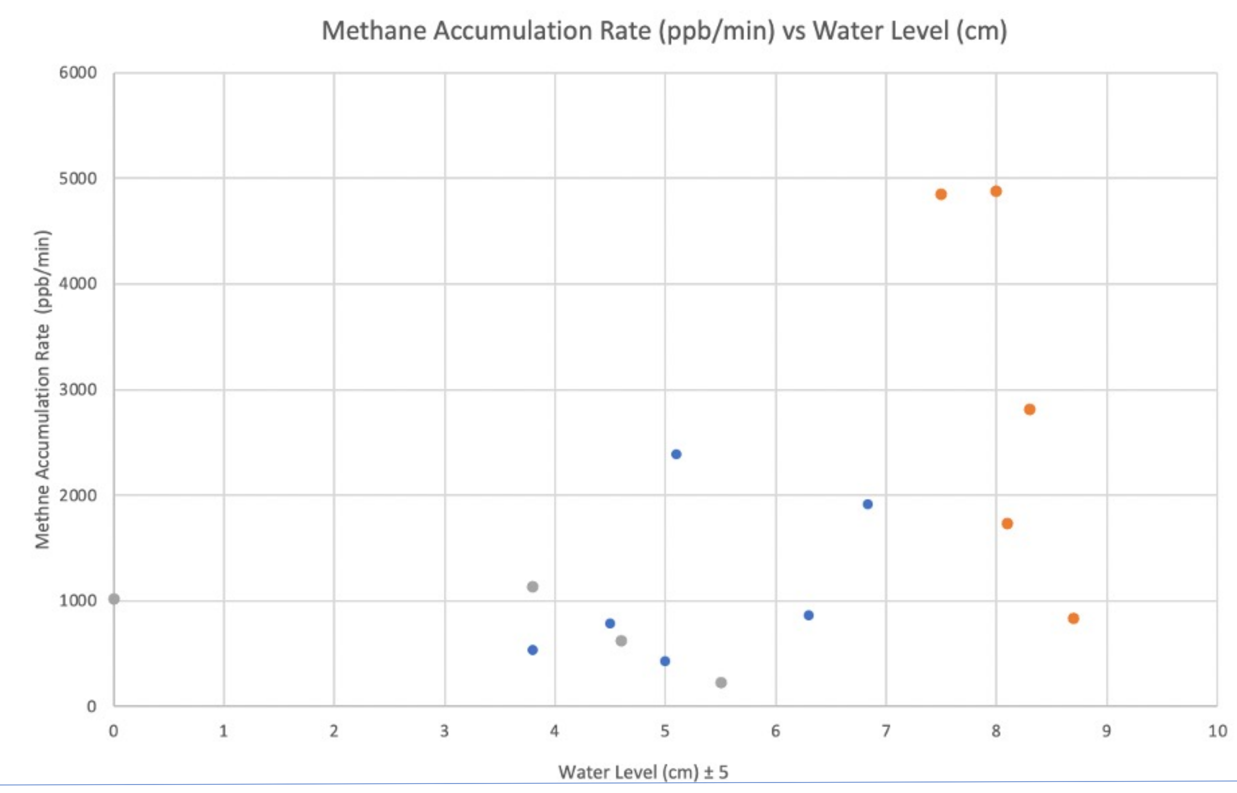

Figure 5: Graph showing Methane Accumulation Rate (ppb/min) against Water level (cm) of all three sites.

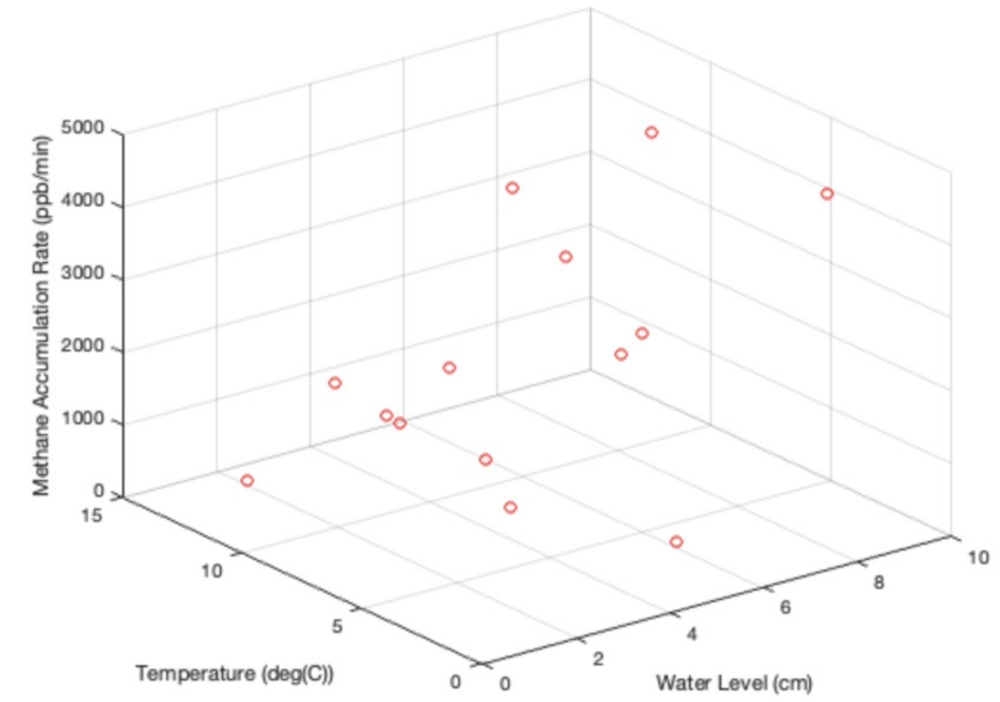

Figure 8: Three-dimensional graph plot of Methane Accumulation Rate (ppb/min) vs. Water Temperature (˚C) vs. Water Level (cm). This plot allows a look at the two variables, water level and temperature, at the same time.

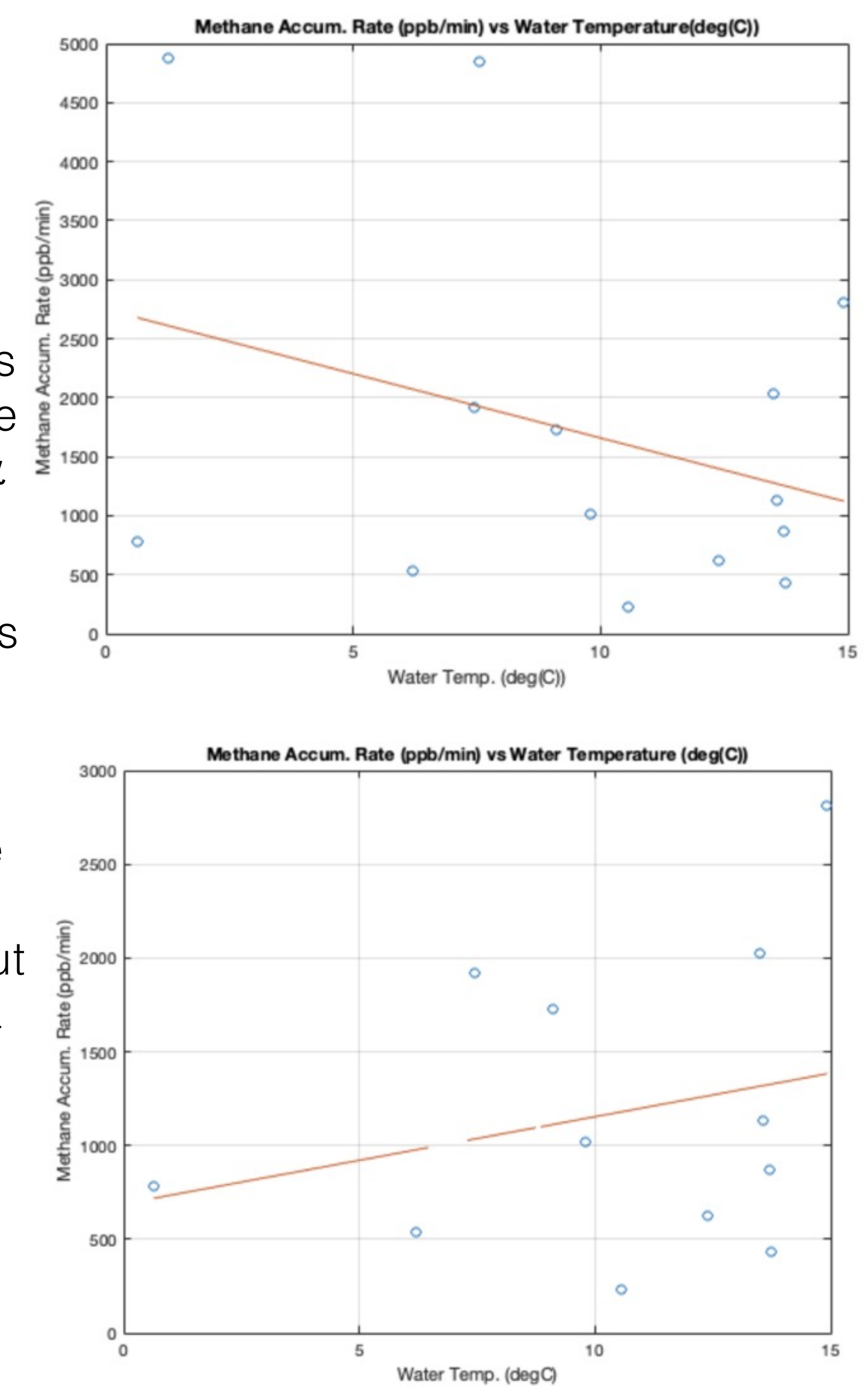

Figure 6(a,b): Figure (6a.)(top) shows Methane Concentration Rate (ppb) vs Water Temperature (˚C) of all samples fit to a linear regression model. (regression slope: -108.8293,df:12,rms error: 2.2344e+06.)The null hypothesis was accepted as the t-observed for slope (-1.2017) was inside the t-critical (α = .05) value of +/- 1.782. This means the slope between methane accumulation rate and temperature is zero and there is no predictive relationship is occurring.

Figure(6b.) (bottom) shows Methane Concentration Rate (ppb) vs Water Temperature (˚C) of samples, without the two outliers seen in (6a.), fit to a linear regression model.(regression slope: 46.4714,df: 10, rms error: 6.2905e+05) The t-observed value for slope (.806) was within the t-critical value for α = .05 (+/- 1.82).The null hypothesis was still retained.

CONCLUSIONS

- It appears the impact of temperature on methane emissions is limited, as the null hypothesis was retained in linear regression models of the data.
- Data shows there is a difference in the effect of low and high-water levels on methane emissions in wetlands
- The null hypothesis for the effect of water depth on methane flux rate was rejected, using the aggregate comparison shown in the box plots. Additional research using this experimental design the effect of water levels on methane emission can be explored further
- This experiment can provide others with additional knowledge and procedural skills to use when testing similar problems in the future.

ACKNOWLEDGMENTS & REFERENCES

- A special thanks to Dr. Prestegaard, Dr. Farquhar, Dr. Magen, Dr. Kaufman, Jiayang Sun, and Sam Voltz.

- Barbera, A. C., Vymazal, J., & Maucieri, C. (2019). Greenhouse Gases Formation and emission. *Encyclopedia of Ecology*, 329-333. https://doi.org/10.1016/b978-0-12-409548-9.10895-4
- EPA (2021). Overview of Greenhouse Gases.
- Hondula, K. L., Jones, C. N., Palmer, M. A. (2021). Effects of seasonal inundation on methane fluxes. *Environmental Research Letters*, *16*(8). https://doi.org/10.1088/1748-9326/ac1193
- NOAA Global Monitoring Laboratory, Boulder, Colorado, USA. (2021). Trends in Atmospheric Methane. *https://esrl.noaa.gov/*. https://gml.noaa.gov/ccgg/trends_ch4/.
- Water Level & Temp. data from Prestegaard, K., et al. (2022).