1

Impacts of Population Growth on CO_2 Trends in the Montane-Urban Region of Heber Valley

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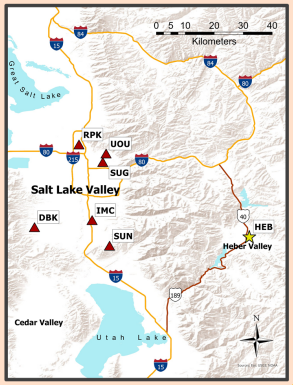
2

1. Motivation

Greenhouse gases (GHG), such as CO_2, are primarily responsible for increases in global temperature. Since the industrial revolution, the human population has overwhelmingly been the cause of increased GHG emissions. As a result, cities are a significant source of GHGs to the atmosphere. In mountainous terrain, these emissions and other harmful particulates can become entrapped. This project asks the question: "Is population growth effecting CO_2 trends significantly?"

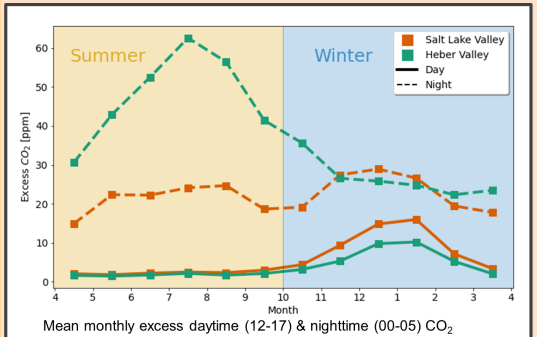


2. Contrasting Valleys

The planetary boundary layer (PBL) height acts to dilute or concentrate CO_2 concentrations within the lower troposphere. As a result of a deepening/diminishing PBL in the summer/winter, it is expected that CO_2 concentrations will decrease/increase. A similar PBL height fluctuation happens on a smaller diurnal scale with decreasing/increasing concentrations during the day/night.

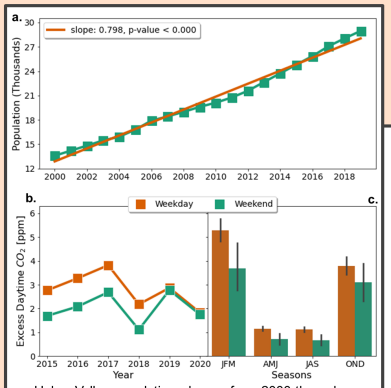
Differences between the Salt Lake Valley (SLV) and Heber Valley (HV) CO_2 concentrations as well as those of geophysical and socioeconomic nature include:

- Unexpected large nighttime concentrations in HV.
- The SLV areal extent is approximately 10x that of HV.
- HV has a population of ~28,000; SLV has an aggregated population of over one million people.
- The main industry in HV is tourism, while SLV has no dominant industry.



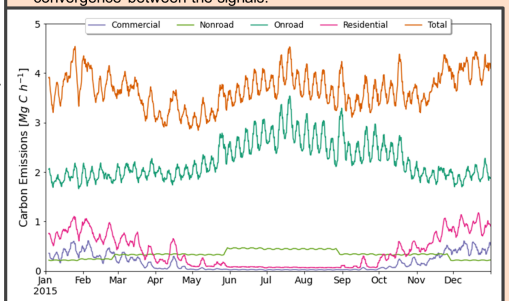
Mean monthly excess daytime (12-17) & nighttime (00-05) CO_2 concentrations at the single HV site (HEB) and the average of SLV sites (DBK, IMC, RPK, SUG, SUN, & UOU).

3. Human Influence



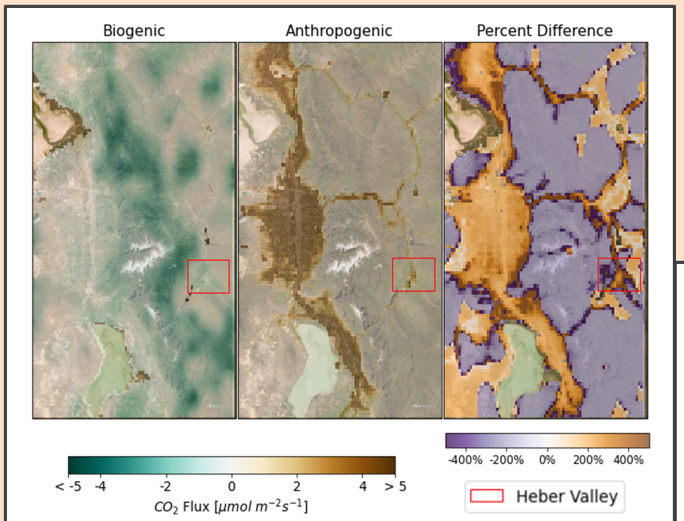
a. Heber Valley population change from 2000 through 2019 and linear fit (orange line). **b.** Mean yearly excess daytime (12:00-15:00 LST) CO_2 concentrations. **c.** Mean seasonal daytime CO_2 concentrations and 95% confidence interval (black line). Daytime hours were used for stability.

- Heber Valley has experienced a doubling of its population in the past two decades.
- Human influence is observable in the CO_2 concentration signal. Peaks in the summer and winter are, in part, due to summer tourism and winter heating of buildings.
- Weekday/weekend patterns are also distinguishable with decreased concentrations during the weekend. 2020 saw a convergence between the signals.



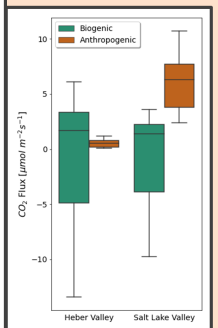
Three day rolling mean carbon emissions broken down by sector for the year 2015. Observable peaks in the summer and winter. Modelled data from the Vulcan Project.

4. Carbon Sources



Modelled biogenic and anthropogenic fluxes from the Solar-Induced Fluorescence for Modeling Urban biogenic Fluxes (Wu et al., 2021) and Vulcan v3.0 Emissions (Gurney et al, 2019) datasets. Period shown is June 1st – September 30th from 2017 and 2015 for the left and middle map, respectively.

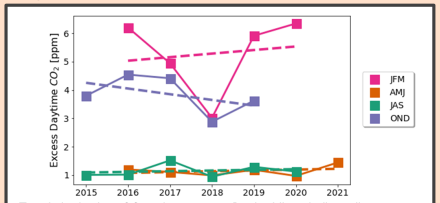
Compared to Salt Lake Valley, Heber Valley is characterized by fewer anthropogenic sources and a closer proximity to biogenic sources. The distribution plot below demonstrates that Heber Valley CO_2 concentrations are dominated by the biosphere and experiences fluxes in both directions, providing insight into the cause of the summer nighttime concentrations.



Growing season (6/1 – 9/30) flux distributions.

5. Preliminary conclusions

Despite a doubling in population in Heber Valley, there are no significant trends in CO_2 enhancement since the installation of the sensor in late 2015. Though human influences are observable in the data, the relative dominance by biogenic sources acts to obscure any significant long-term trends caused by climate change. While Salt Lake Valley is largely influenced by anthropogenic sources, Heber Valley's proximity to the biosphere is likely the cause of increased summer nighttime concentrations due to nighttime ecosystem respiration.

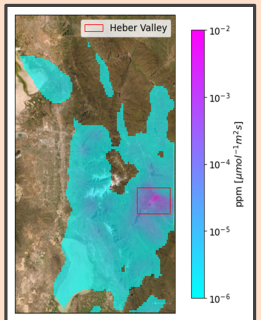


Trends in daytime CO_2 enhancement. Dashed lines indicate linear regression. For all seasons, trends are not significant ($p > 0.5$).

6. Future work?

Future work includes verifying CO_2 concentration changes using the STILT influence footprint as well as identifying specific the land cover types that exert the greatest influence. Additional questions include:

- Are there local influences that effect the carbon baseline?
- At what point does CO_2 scale with population size?
- What effect does upstream topography have on concentrations?
- What influence do the local water bodies exert?



Influence footprint created using the STILT model (Lin et al., 2003).

Acknowledgements

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