Impacts of droughts on the CO_2 seasonal and interannual variabilities in the LA Basin from in-situ measurements

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Summary

- In-situ CO_2 measurements at two sites (Palos Verdes near coast and Pasadena in the inland) in the Los Angeles basin helps tracking the natural variability of CO_2 that is essential to deducing the impact—either positive or negative—humans have had on the recent climate.
- Log-normality of the seasonal cycle over Pasadena is seen as a result of anthropogenic emissions.
- The means of the log-normal distributions have increased by ~1 ppm during the drought period starting in 2013 at both sites.
- The seasonal cycle over Pasadena has changed significantly during the drought period.

CO2 Measurements

- During daytime hours, winds from the southwest generally bring clean marine air from the ocean to the LA basin. Thus, flask CO_2 samples were collected at two locations in the Los Angeles basin:
  1. A coastal site on Palos Verdes peninsula during June 2009–February 2017 around 2 PM* PST, which measures the background CO_2 level.
  2. An inland site on the Caltech campus, Pasadena, California, during January 2004–February 2017 every other day at 2 PM* PST by an autosampler, which picks up CO_2 emissions from the LA basin.

  *2 PM is the time when the planetary boundary layer tends to be the deepest and most well-mixed during the day [Newman et al., 2016].

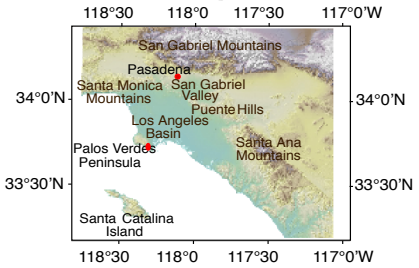

Figure 1. Map showing the location of the Pasadena and Palos Verdes peninsula sites in the Los Angeles basin.

- Air samples were collected in evacuated 1 L Pyrex flasks [Newman et al, 2008]. Uncertainties in the CO_2 concentration were ±1.4 ppm [Newman et al., 2016].

Drought periods

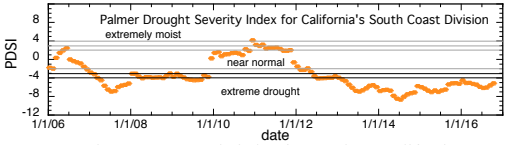

Figure 2. Drought index for Southern California

- The Palmer Drought Severity Index for this region is used to identify the cut-off time between pre-drought and drought, defining this the time when the index was consistently below the maximum index value for "extreme drought".
- Although California spent a considerable amount of time from 2008 to 2010 skirting the extreme drought cutoff, the index dipped below "extreme drought" only once 2013 started. Therefore, all of the data through 2012 was deemed pre-drought data; data from 2013 forwards was deemed to be during the drought.

Data processing

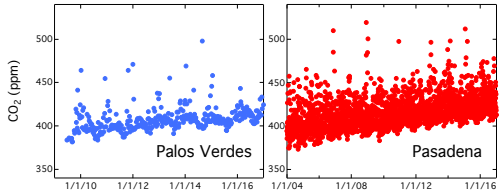

Figure 3. Raw CO_2 mixing ratios measured at the two sites.

- The raw CO_2 time series at both sites shown in Figure 3 is detrended before the analysis.
- The detrended CO_2 data in the drought and non-drought periods are fitted to a log-normal distribution.
- To examine the seasonal cycles, the detrended data are fitted with sinusoidal functions of periods 1 year (annual) and ½ year (semi-annual).

References

Newman et al. (2008), JGR, 113, D23304; Newman et al. (2016), ACP, 16, 3843; Newman et al. (2016), Abstract A51K-0233, 2016 Fall Meeting.

Log-normality of seasonal cycles

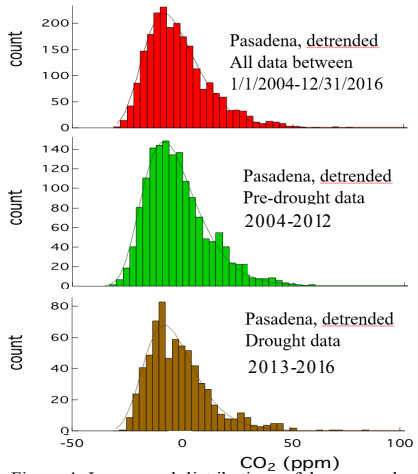

Figure 4. Log-normal distributions of the seasonal cycles over Pasadena with all data (top), pre-drought data (middle), and drought data (bottom).

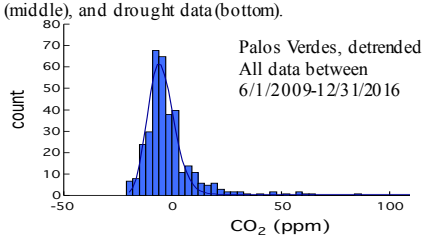

Figure 5. The distribution of the seasonal cycle over Palos Verdes to demonstrate the normality of the data. The shift of the mean from pre-drought to drought is similar to that over Pasadena and is therefore not shown here.

- The seasonal cycle over Pasadena is fitted with a log-normal distribution while that over Palos Verdes is close to a normal distribution, which clearly demonstrates the effects of anthropogenic emissions at the more urban inland site.
- The means of the distributions have increased by ~1 ppm from the pre-drought to the drought periods over both sites.

Drought impacts on seasonal cycles

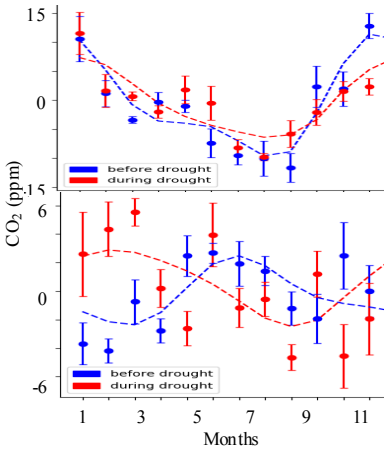

Figure 6. A comparison of seasonal cycles before (blue) and during the drought (red) over Palos Verdes (top) and Pasadena (bottom). The dashed lines are the sum of the fitted sinusoidal semi-annual and seasonal cycles.

- A significant change in the seasonal cycle from the pre-drought to drought periods over Pasadena is noted (Figure 6).
- A possible explanation of such a change may be due to the reduction of wind speed in the LA basin during the drought period (Figure 7).

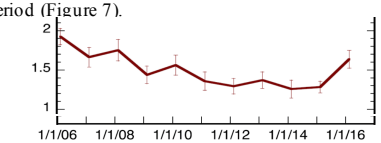

Figure 7. JFM winter wind speed over University of Southern California, Los Angeles, CA.

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