









TOWER Network Update 1017 Cooperative Tower Network Update

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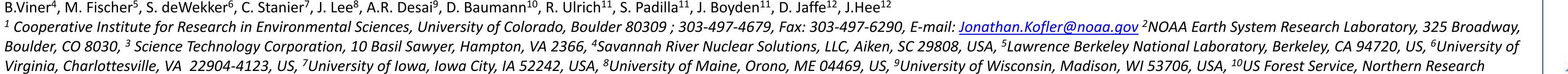








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ABSTRACT

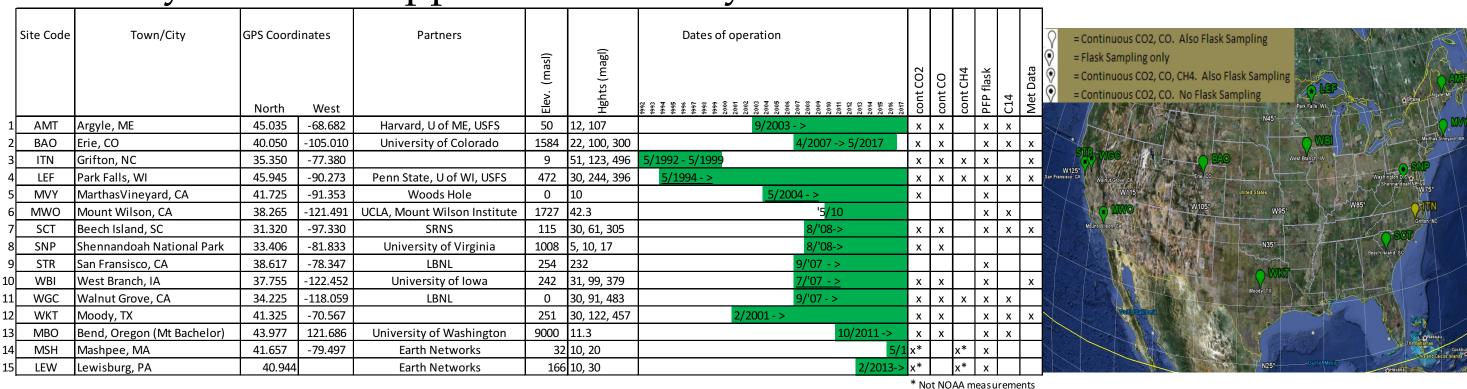
Partnerships with external collaborators have enabled the NOAA-ESRL-GMD Tower network to maintain 13 tower sites with continuous in-situ Carbon Dioxide and Carbon Monoxide sites for nearly a decade. Also, three sites include continuous Methane measurements. A summary of the hardware, an overview of the overall trends and some unique characteristics of a few sites are highlighted. Seasonal cycles in Carbon Dioxide across the network are shown, covering the time period since the tower network's inception. Relationships with climate conditions and anomalies such as drought are explored.

Introduction / Background

I joined NOAA's GMD in 2004 and, with Arlyn Andrews, began the task of assembling and deploying instrumentation at new Tall Tower sites. The goal of the NOAA tall tower expanded network was and is to have an observing network that will reliably monitor the US carbon budget with regional-scale spatial resolution and accurate attribution of fluxes among major sources and sinks. Now, nearly a decade after expanding the network (to 13 sites with regular flask samples and 9 with continuous CO and CO₂, and 3 sites with continuous CH₄) the data have been used as inputs to many models including Carbon Tracker and numerous other studies (see references & resources). Here I present an overview of the data from the past decade with a couple of case studies in this poster.

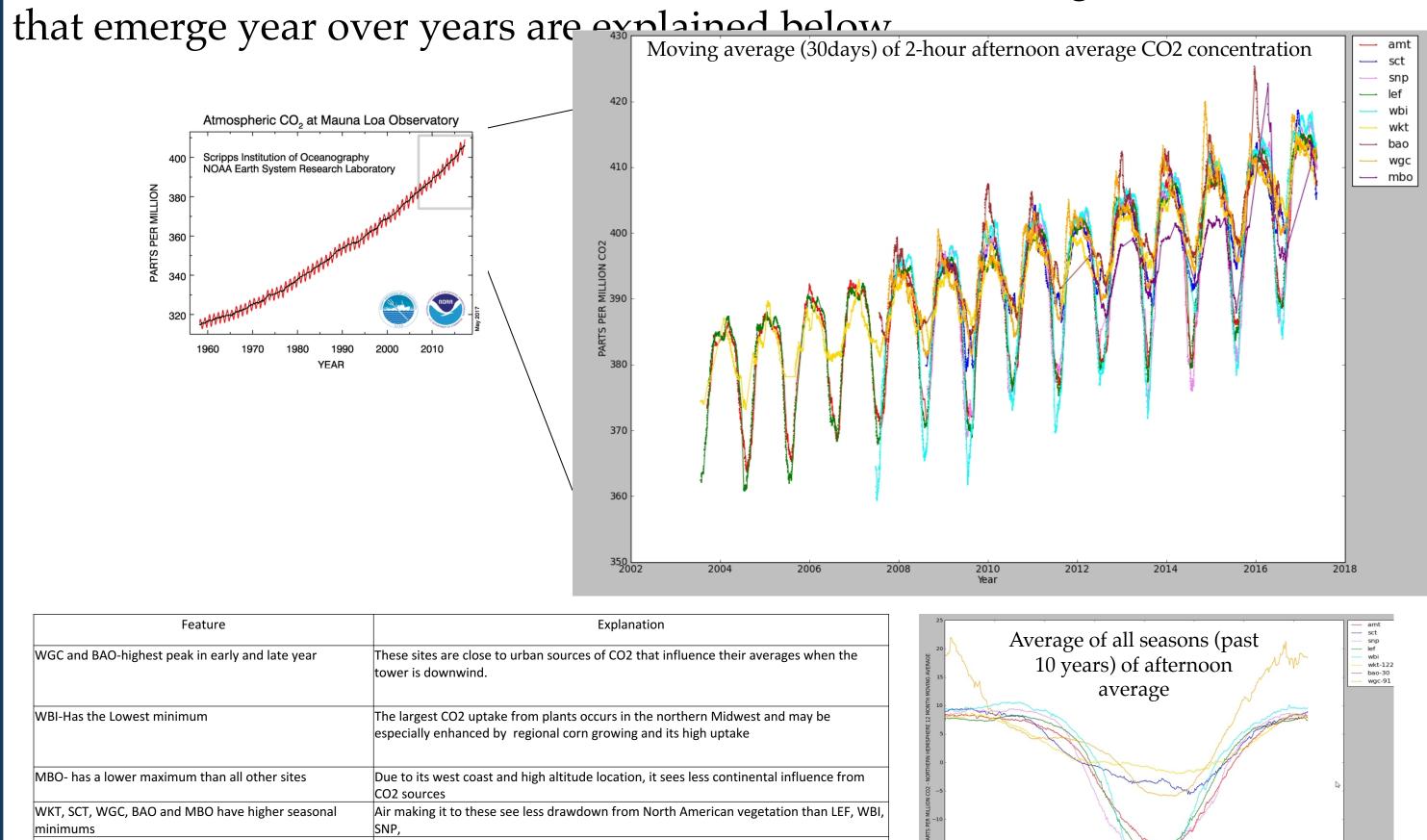
Hardware and Tower Sites

Air from high up on towers is drawn through special tubing to a shelter near the base of the tower where it is analyzed and/or collected in discrete flask samples. NDIR and cavity ring-down analyzers yield concentrations of CO₂, CO and CH₄. At sites with flasks, discrete samples are taken daily or every other day and are shipped to and analyzed in Boulder.



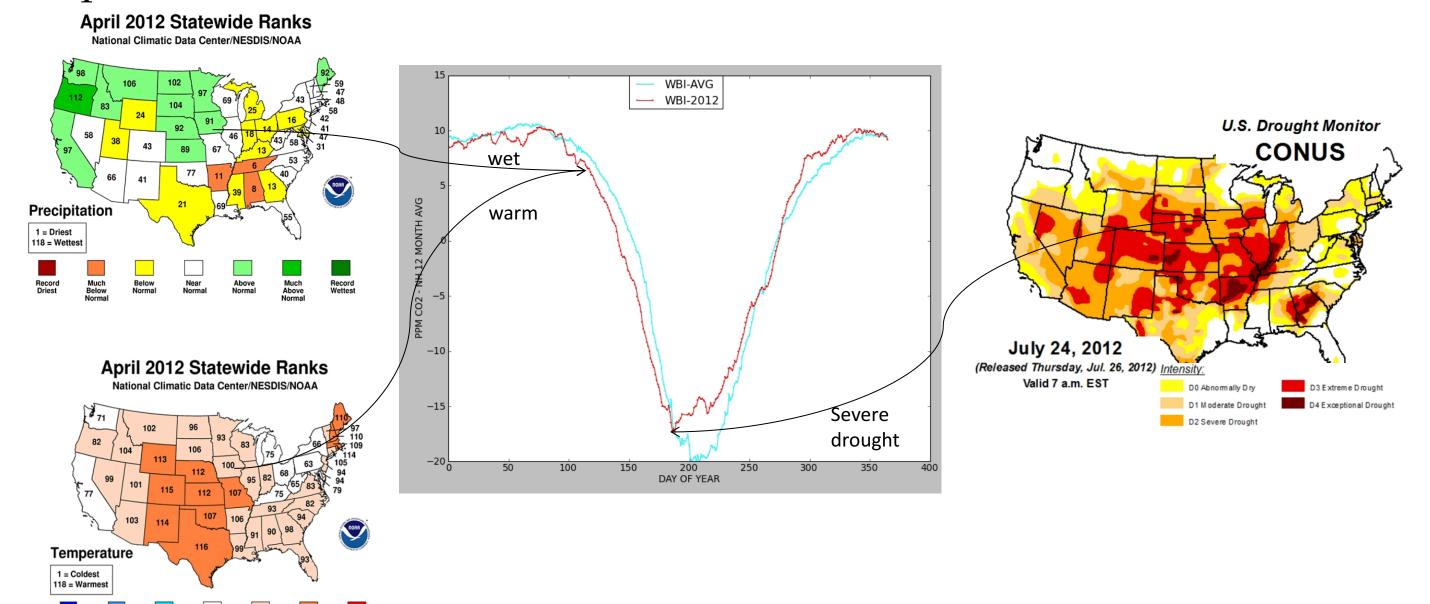
Towers Carbon Dioxide

 Continental measurements show increased variability compared to the historic Mauna Loa Record of background CO₂. The variability reveals details about continental sinks and sources of CO₂. A few general features



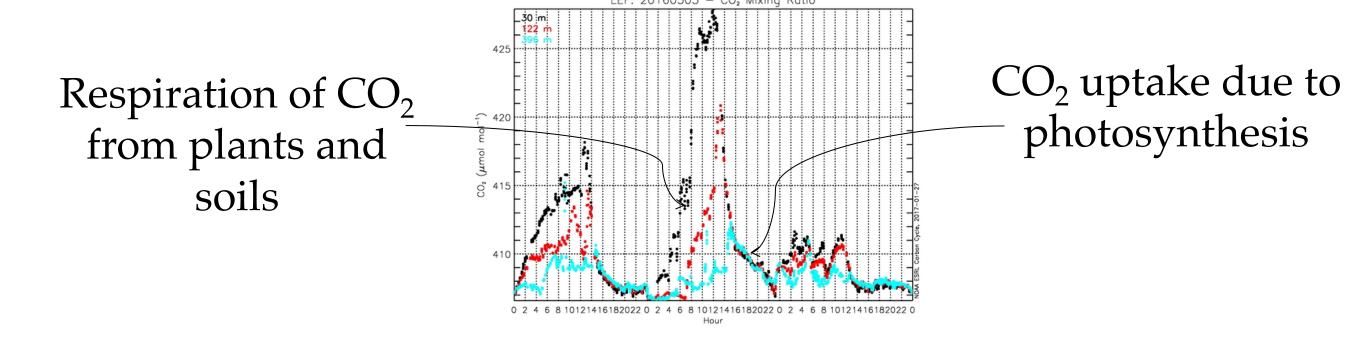
CO, Drought Response 2012

• 2012 started out warmer and wetter causing increased CO₂ uptake in April and May, but by mid-July an "extreme drought" set in, halting the uptake and resulting in a higher minimum in the CO₂ nationwide in 2012. The tower data could be used to quantify the CO₂ response to temperature and precipitation.



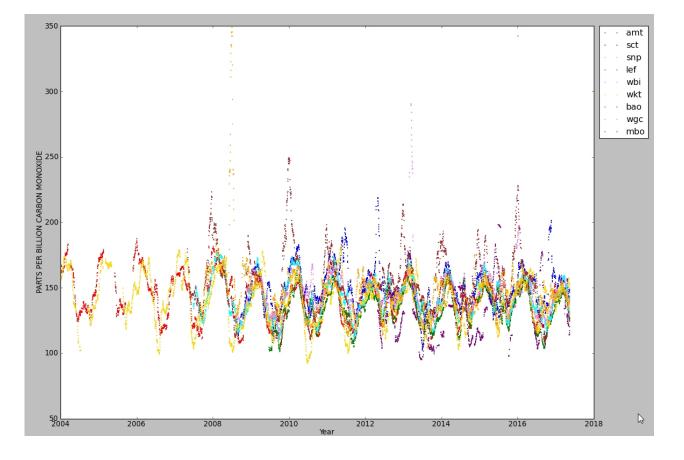
High Resolution CO₂

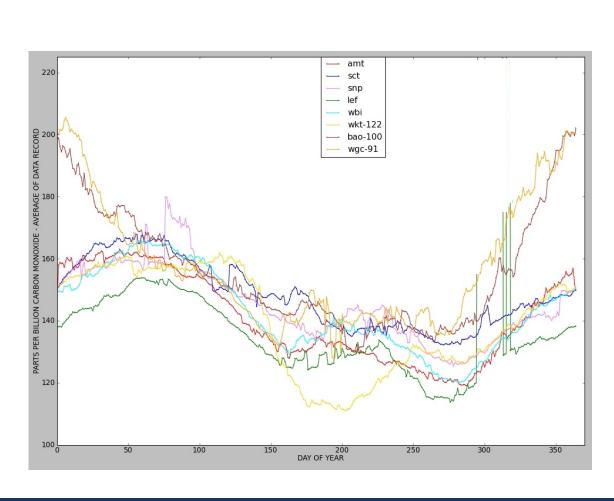
• The daily CO₂ cycle is captured at towers. At night respiration and no mixing allow buildup of CO₂ in the shallow nighttime boundary layer. During the day (especially on sunny days), the atmosphere mixes so that there is only a small vertical gradient. Also during the growing season CO₂ uptake from photosynthesis is seen in decreasing concentrations during the daytime.



Towers Carbon Monoxide

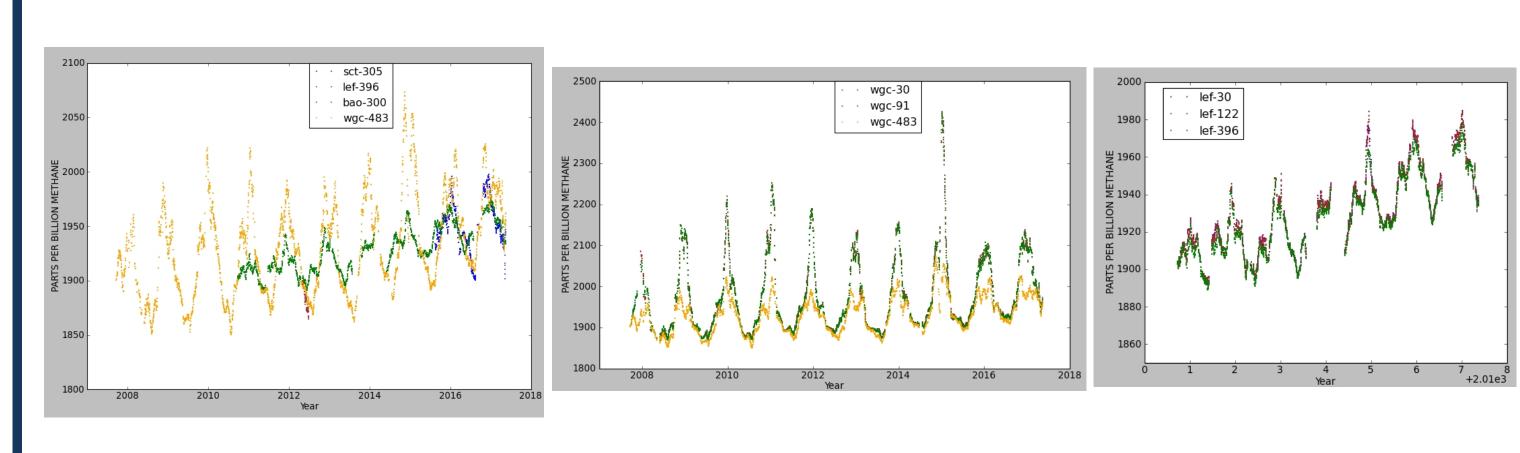
• The long-term record (left) reveals the seasonal cycle over the continent with occasional high CO events primarily from fires. BAO and WGC are close to large urban areas and see higher average wintertime concentrations.





Towers Methane

The WGC and LEF towers have the longest in-situ record for methane. As seen below, WGC and LEF show considerably different behaviors. The WGC tower is in the central valley of California and sees large enhancements in the winter months at the lower levels. A shallow boundary layer and proximity to sources of methane (most likely predominantly livestock, but wetlands and landfills may also contribute) allows accumulation. LEF sees smaller enhancements in the winter months at the lower levels.



Conclusions

- The continuous in-situ dataset from NOAA's Tall Tower network of the past 10 years contains information about continental sinks and sources of CO₂, CH₄, CO and other molecules
- •Private companies and other institutions are expanding measurements going forward, however, NOAA's dataset for the past 10 years can be harvested and learned from
- •Further examination of the data will reveal details about how these molecules respond to drought, floods, temperature anomalies, changes in transport patterns, changes in land use and other factors. There are more studies to do using these data!
- •Flask samples at the tower sites are useful in determining sinks and sources of various other chemicals and long term trends in their atmospheric concentrations.

References and Resources

- https://www.esrl.noaa.gov/gmd/ccgg/insitu/ online description of the tower network
- https://www.esrl.noaa.gov/gmd/ccgg/flask.php?active=on online cooperative Air Sampling network
- •https://www.esrl.noaa.gov/gmd/ccgg/carbontracker/ Carbon Tracker website. •http://www.atmos-meas-tech.net/7/647/2014/amt-7-647-2014.pdf "CO2, CO, and CH4 measurements"
- from tall towers in the NOAA Earth System Research Laboratory's Global Greenhouse Gas Reference Network: instrumentation, uncertainty analysis, and recommendations for future high-accuracy greenhouse gas monitoring efforts "by Arlyn Andrews. (Detailed description of Towers Measurements and uncertainties) •Recent Publications Using Tower Data
- •http://www.atmos-chem-phys-discuss.net/acp-2017-293/ -"Gradients of Column CO2 across North America from the NOAA Global Greenhouse Gas Reference Network" by Xin Lan, Atmospheric Chemistry and Physics article
- •http://www.pnas.org/content/113/11/2880 "Continued emissions of carbon tetrachloride from the United States nearly two decades after its phaseout for dispersive uses", by Lei Hu, PNAS vol 113, no 11

Acknowledgments

• Maintaining a tower network is a team effort. Our cooperative institutions and their personnel go to great lengths to keep our measurements going. I can name dozens, but don't have the space. If you are reading this, you know who you are. Thank you! Internally at NOAA's GMD colleagues on other projects, especially the aircraft group and calibrations lab (Duane, Tom & Micheal), have also gone out of their way on numerous occasions to support our tower team. Thank you too! ... and a special Thank you to Arlyn Andrews, Phil Handley, and Tom Legard for working as team mates on the tower team. And thank you to Camille Kremer who helped with some plots on this