The Cache Valley Atmospheric Mixing Project

Bruce Bugbee, Steve Sargent, Alec Hay, Randy Martin, Larry Hipps, Dave Meek, Jobie Carlisle, Ron Campbell, Mark Blonquist, Larry Jacobsen
Utah State University, Apogee Instruments, and Campbell Scientific

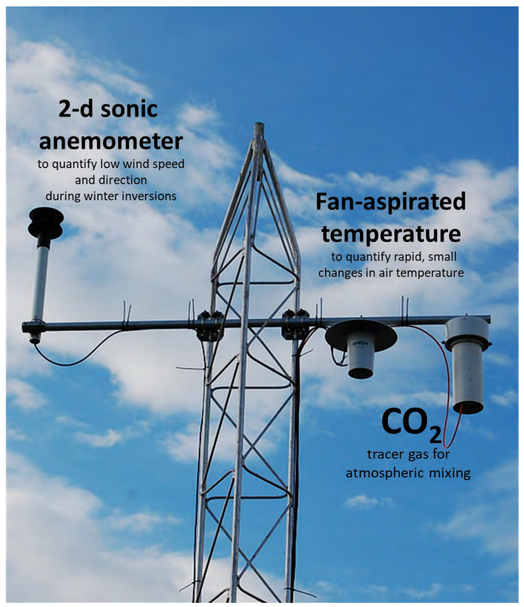
Background

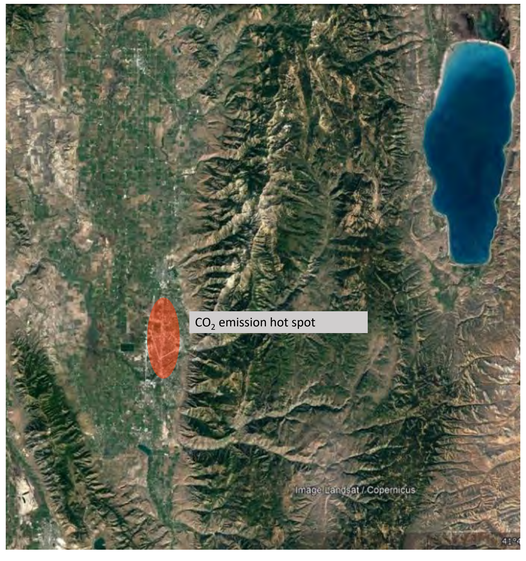
Cold air accumulates nearly every night of the year in the floor of mountain valleys. Persistent cold air pools (PCAPs) are common in winter months, especially when there is snow cover. The common assumption is that there is minimal atmospheric mixing during these PCAPs.

We are preparing to better quantify atmospheric mixing in the unique geography of our mountain valley. Cache Valley, UT has a surface area of only about 800 km2 and is bordered by mountain ranges. This confined valley is ideal for studying atmospheric mixing.

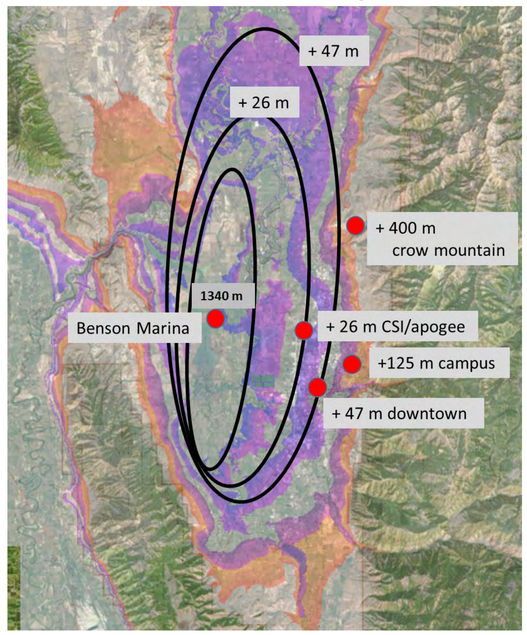
We are developing a network of weather stations at multiple elevations that use aspirated shields for precision measurements of air temperature, sonic anemometers for measurement of vertical and horizontal air movement, and infra-red gas analyzers to measure atmospheric CO2. Because we can accurately estimate the sources and location of wintertime CO2 emissions in our closed valley we are using CO2 as a tracer gas to study atmospheric mixing.

Our initial data indicate that there is more atmospheric mixing during PCAPs than commonly thought.





Location of current monitoring stations



Calculated CO2 increase per day

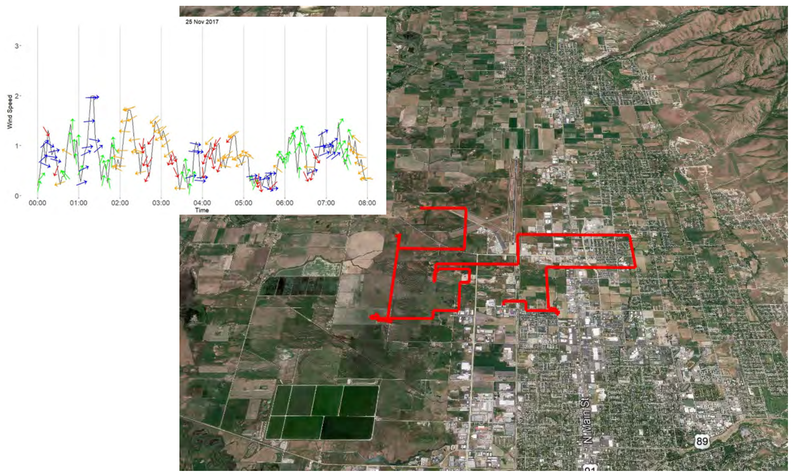
Total CO_2 input	118 x 10^6 moles CO_2 per day
Molar volume of air (100 m deep)	39 x 10^{11} moles of air
(-10 C; 1400 meter elevation = 39 moles per cubic meter volume)	
	3 x 10^{-5} moles per mole
	30 x 10^{-6} moles per mole
	30 ppm per day

Cross section of Cache Valley showing two inversion depths but with the vertical scale exaggerated

The same cross section but with vertical and horizontal scales matched

The valley air shed is more like a dinner plate than a bowl

Typical wind run during an inversion event



CO_2 input on coldest winter days (24 hours)

	kmol per day
Natural gas use for Cache Valley:	
winter peak: 80,000 DTH/day = 80*10^6 ft^3/day * 1.2 moles/ft^3 =	96,000
Vehicles:	
80,000 cars x 25 miles per day = 2,000,000 miles per day x 10 moles/mile	20,000
Total input	118,000

Volume of air in inversion layer

Surface area	10^8 m^2	depth	volume 10^8 m^3	moles of air* (10^{11})
20 x 50 km = 1000 km^2	= 10	100 m	1000	39

*molar density of air is 39 moles per m^3 at 1400 meters elevation and –10 C