

Source Distribution of Elevated Ozone in the Northern Colorado Front Range



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Article

**Source signature of volatile organic compounds (VOCs)
from oil and natural gas operations in northeastern Colorado**

Jessica B. Gilman, Brian M. Lerner, William C. Kuster, and Joost de Gouw

Environ. Sci. Technol., **Just Accepted Manuscript** • DOI: 10.1021/es304119a • Publication Date (Web): 14 Jan 2013

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“.....Through statistical regression analysis, we estimate that on average $55 \pm 18\%$ of the VOC-OH reactivity was attributable to emissions from O&NG operations indicating that these emissions are a significant source of ozone precursors.” (Gilman et al., 2013)

“ Our analysis suggests that emissions ... are most like underestimated in current inventories ” (Petron et al., JGR, 2012)

“ natural gas associated NMHC compromised 57% of OH reactivity from VOC at BAO ... ” (Swarthout et al., JGR, 2013)

“ ... inventory for total VOC emitted by O&G activities is at least a factor of two too low for May 2012, emission estimate of benzene emissions is seven times larger than the State inventory ... ” (Petron et al., JGR, in press.)

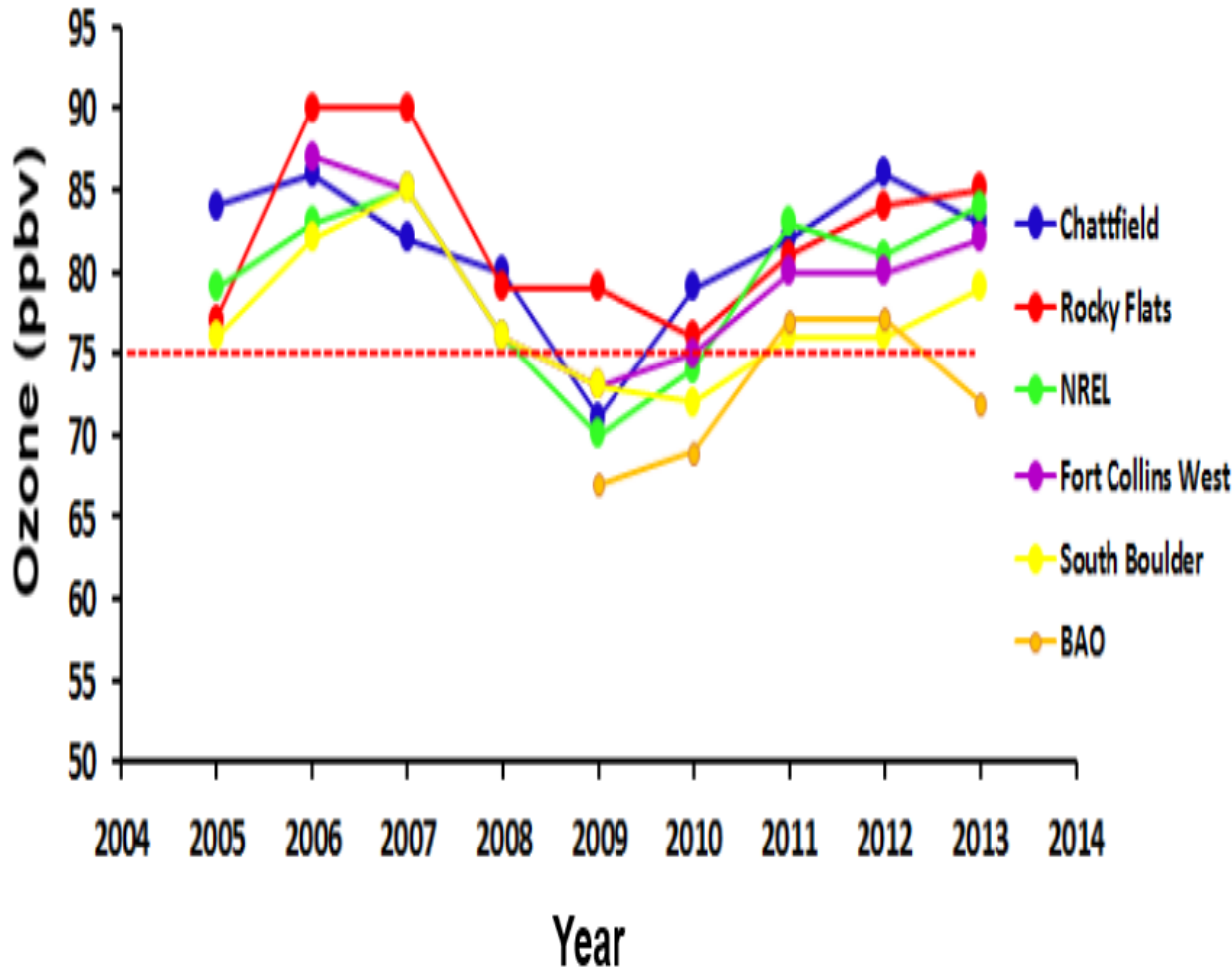
“ we find that the C2-C5 alkanes enhanced by a factor of 18 – 85 relative to the regional background. The simple alkanes contribute 10 to >50% of the total OH reactivity for the compounds measured..... ” (Thompson et al., Elementa, to be submitted)

What can we see in the ozone data?



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National Ambient Air Quality Standard (NAAQS): 4th Highest 8-Hour Mean Ozone; 3-year mean = EPA Non-Attainment Criterion



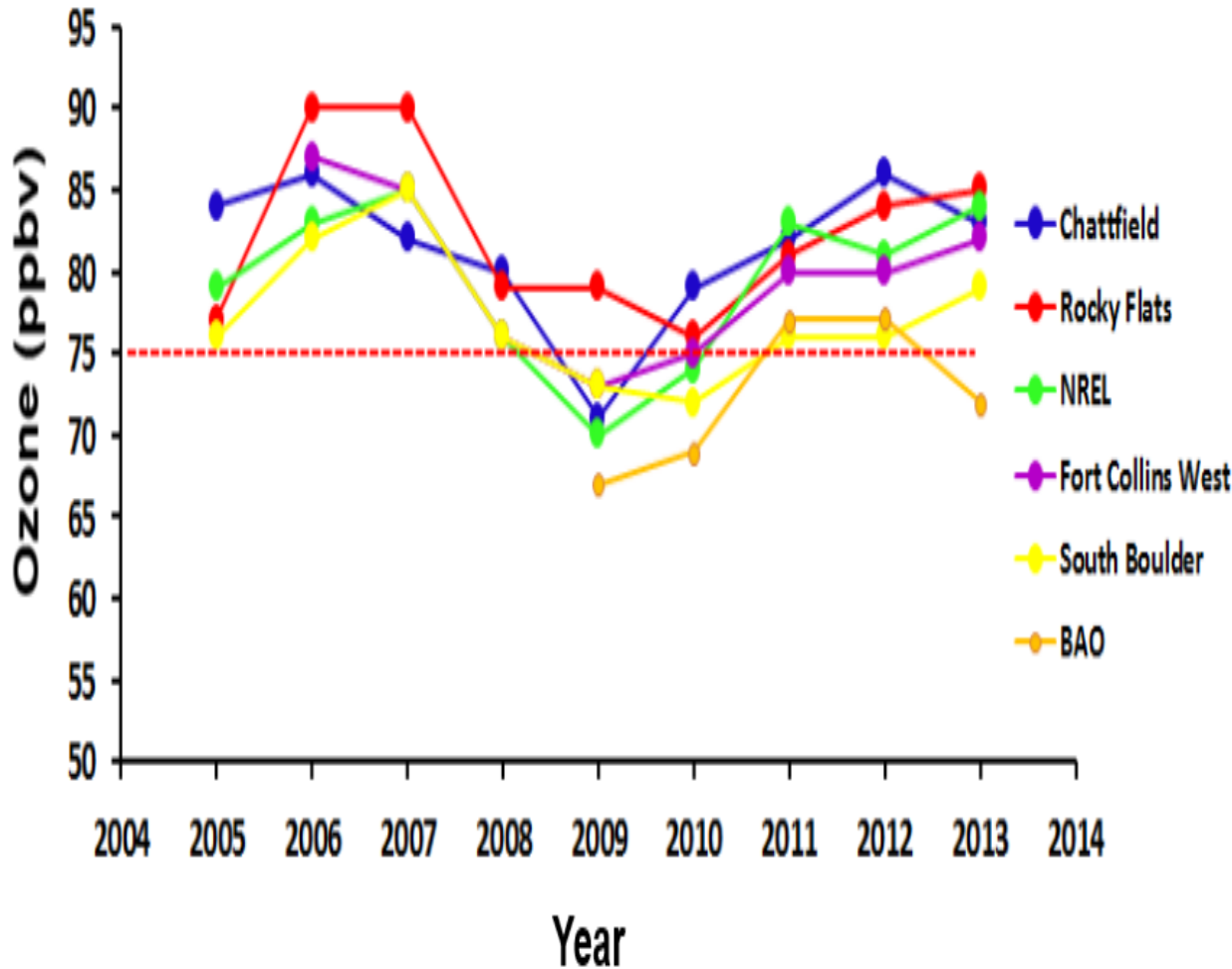
75 ppb – US NAAQS
(4th max, 8-hr)

65 ppb – Canada (8
hr)

62 ppb – EU (8 hr)

40 ppb – Health
Effects, Vegetation
Effects

Trends



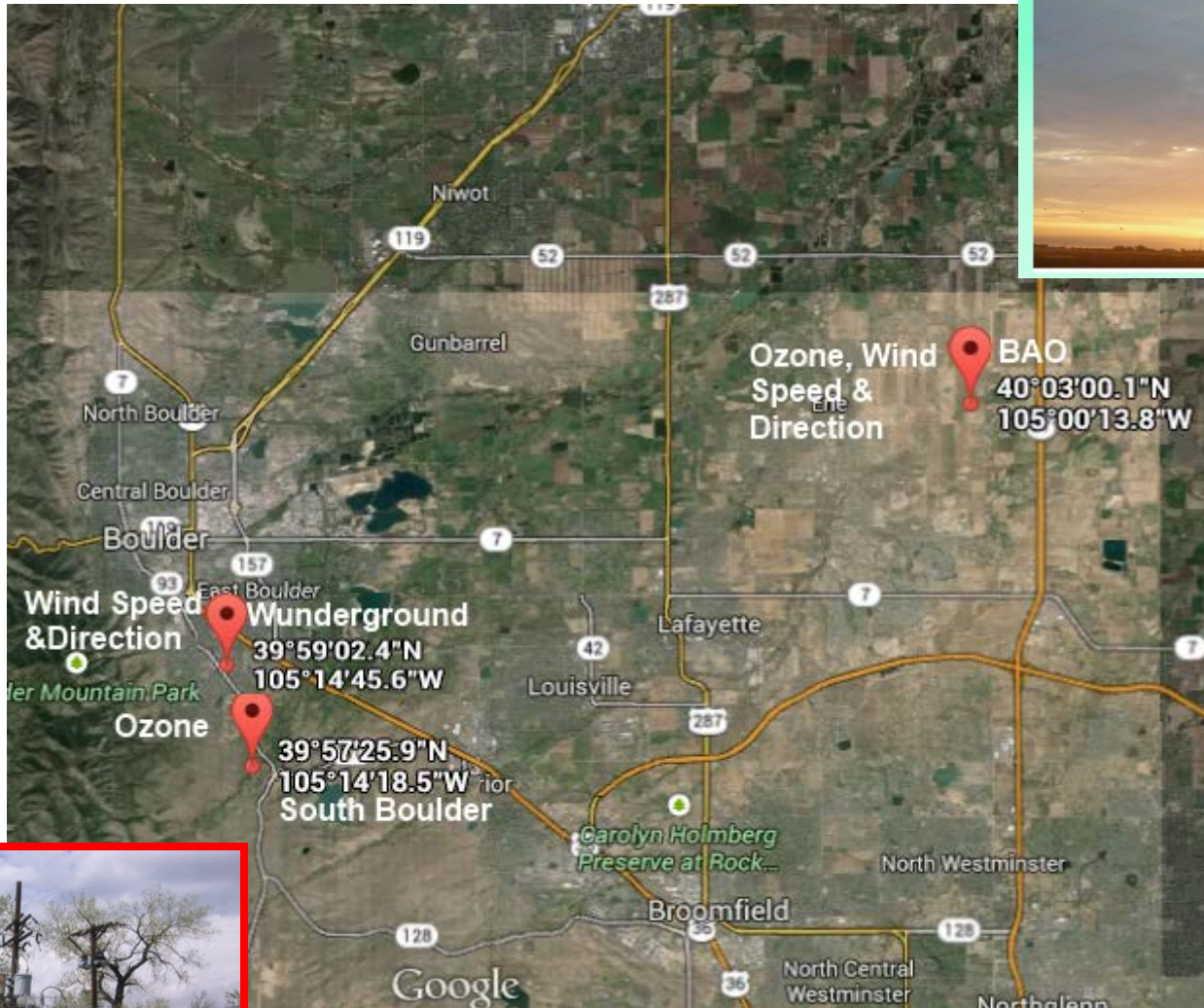
No statistically significant ($P = 0.95$) changes in 2005 – 2013 record.

FCW and NREL show statistically significant increases ($P = 0.95$) for 2009 – 2013 period.

Boulder Atmospheric Observatory, NOAA



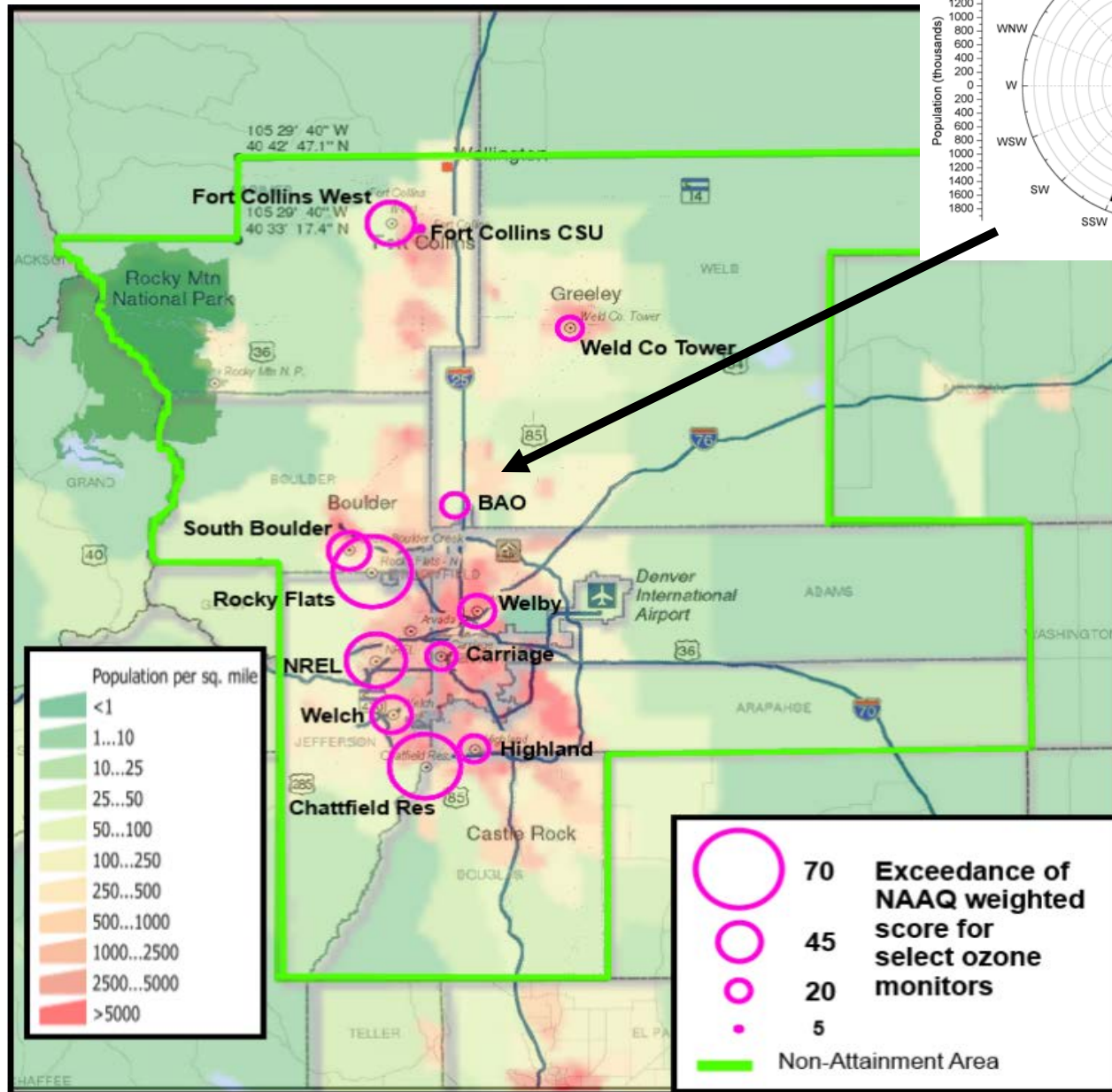
Picture by Dan Wolfe



South Boulder,
Boulder
County/CDPHE



Population Density and Year 2007-2012 Exceedances of 75 ppb Ozone, weighted in 5 ppb increments



75 km radius of BAO

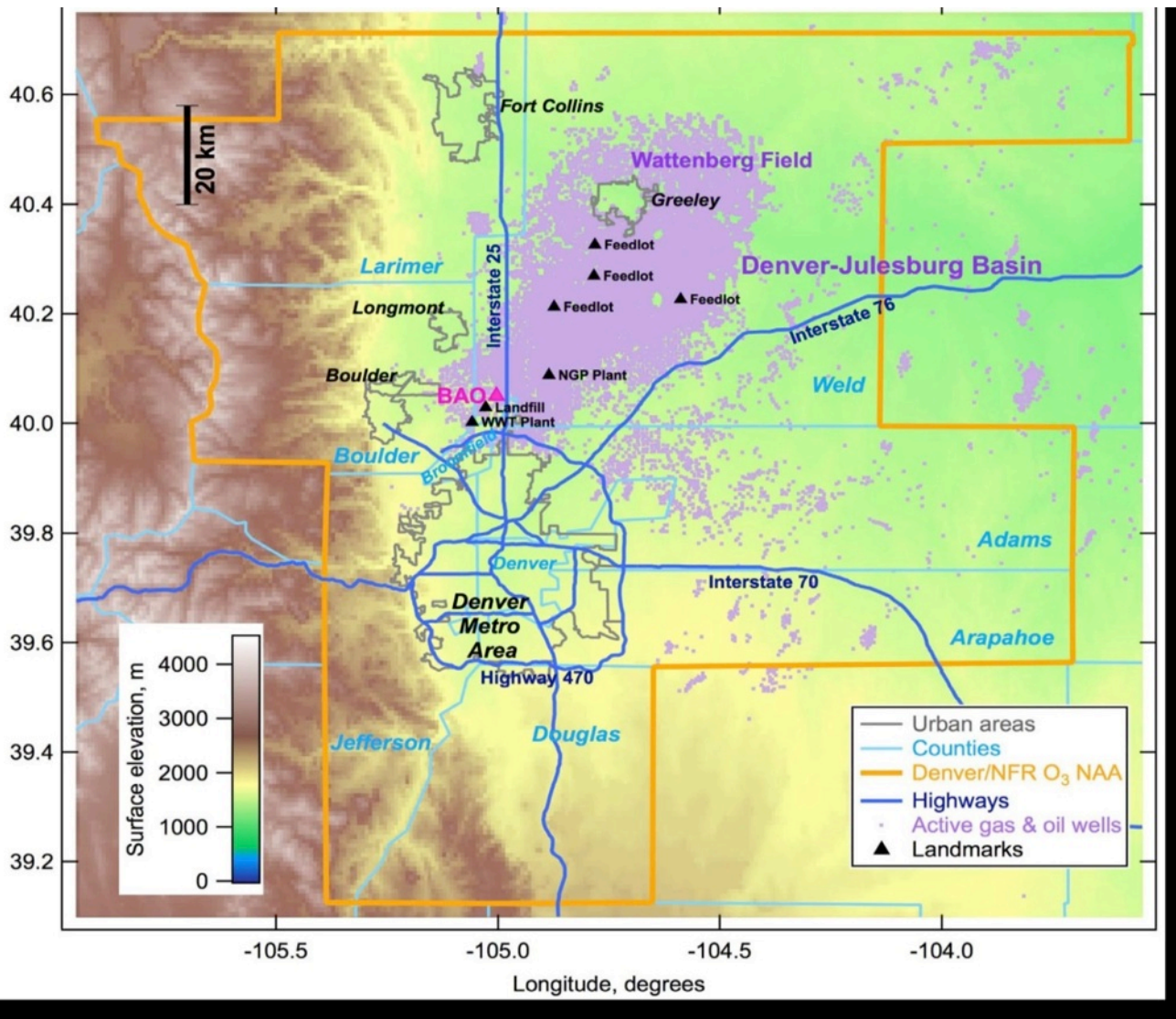
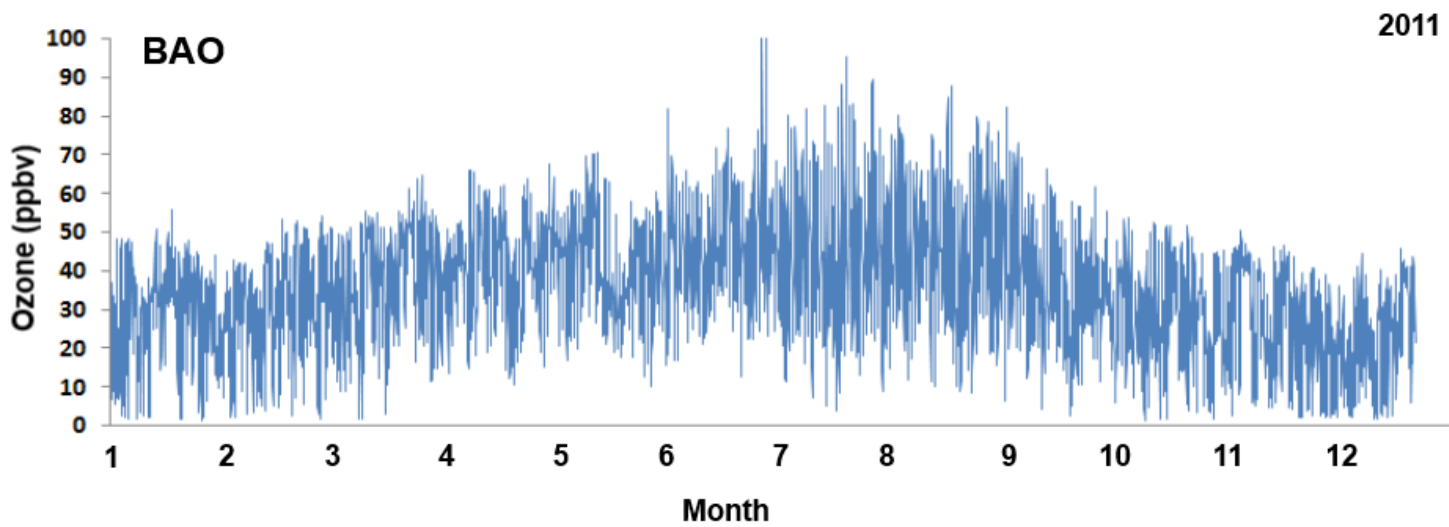
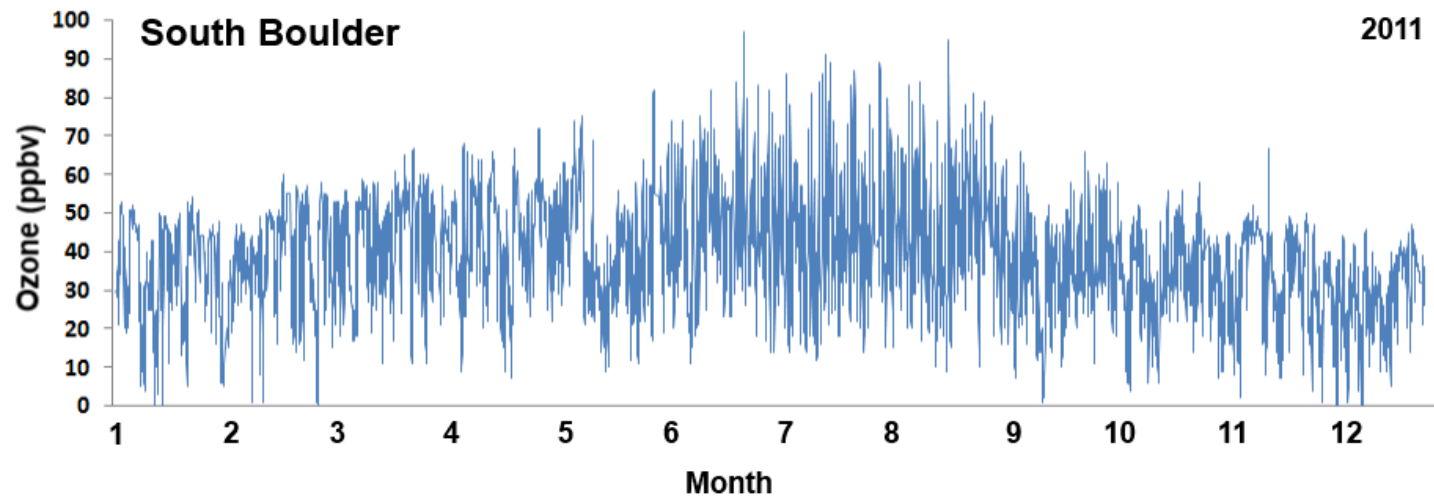
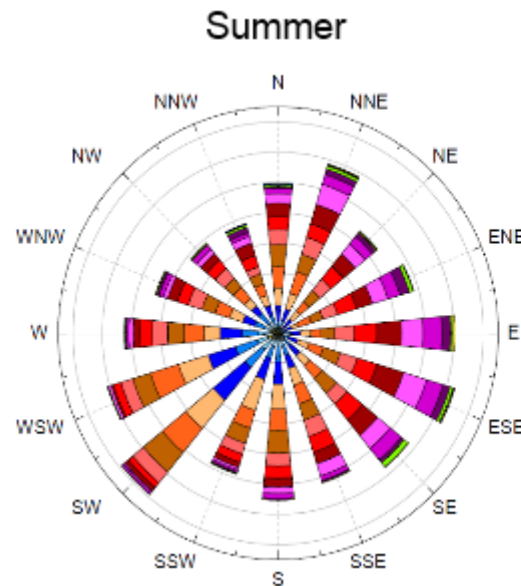
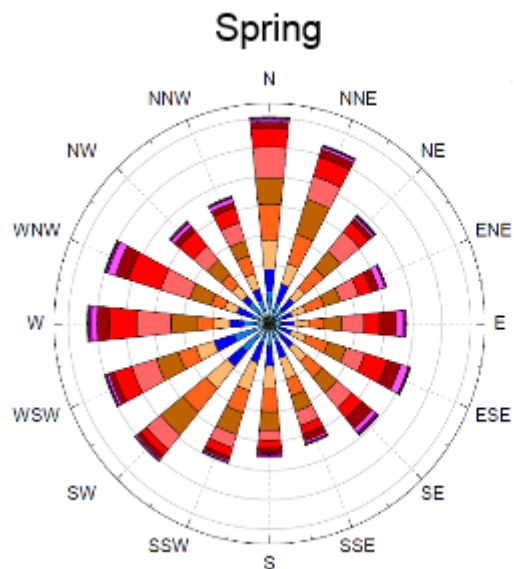
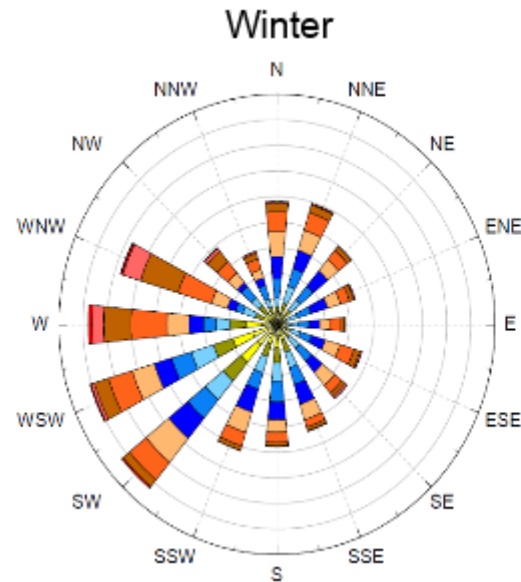
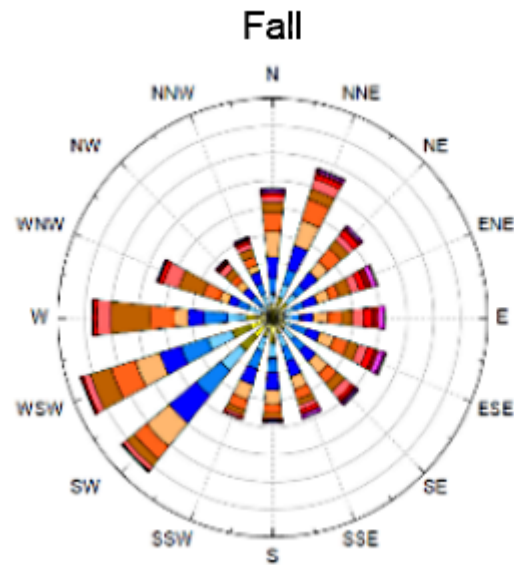


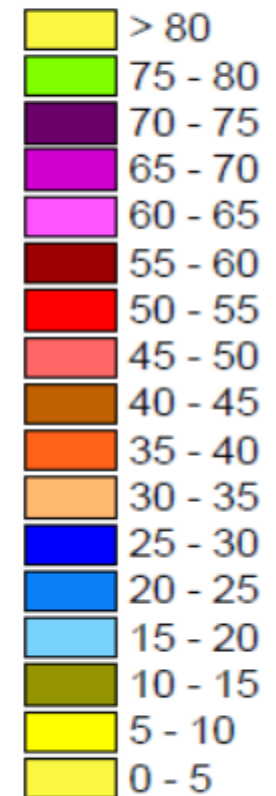
Figure from Petron et al., 2012



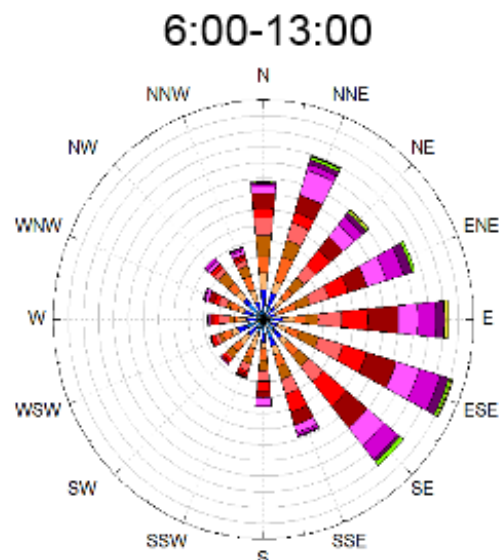
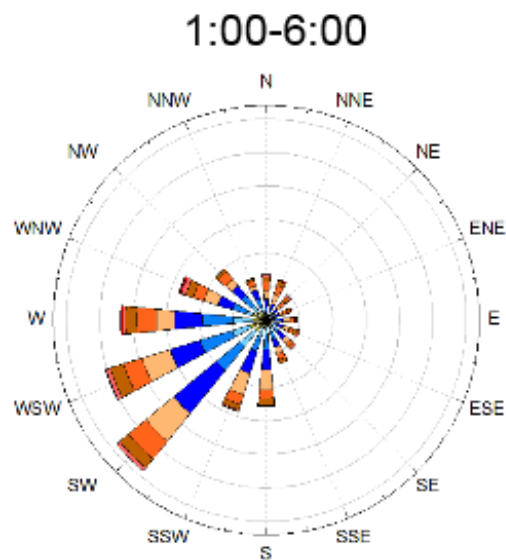
BAO



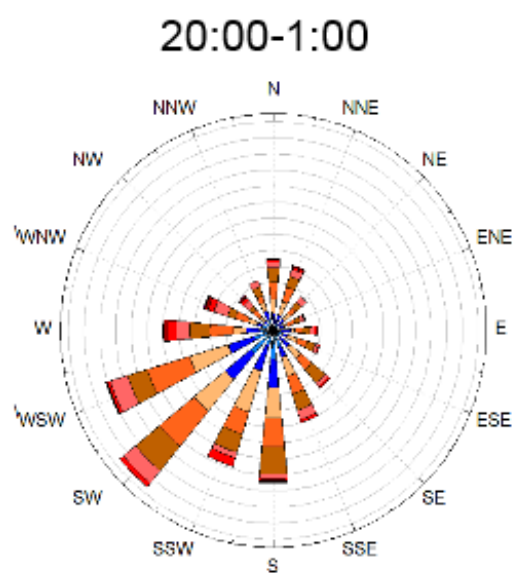
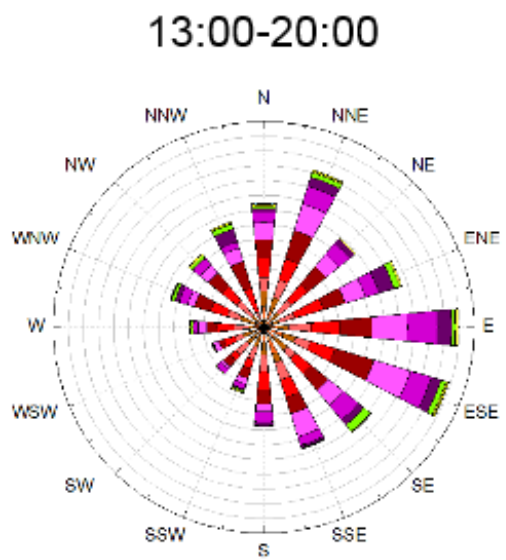
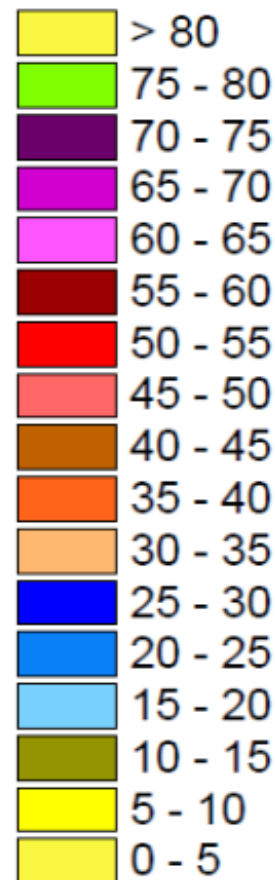
Ozone (ppbv)



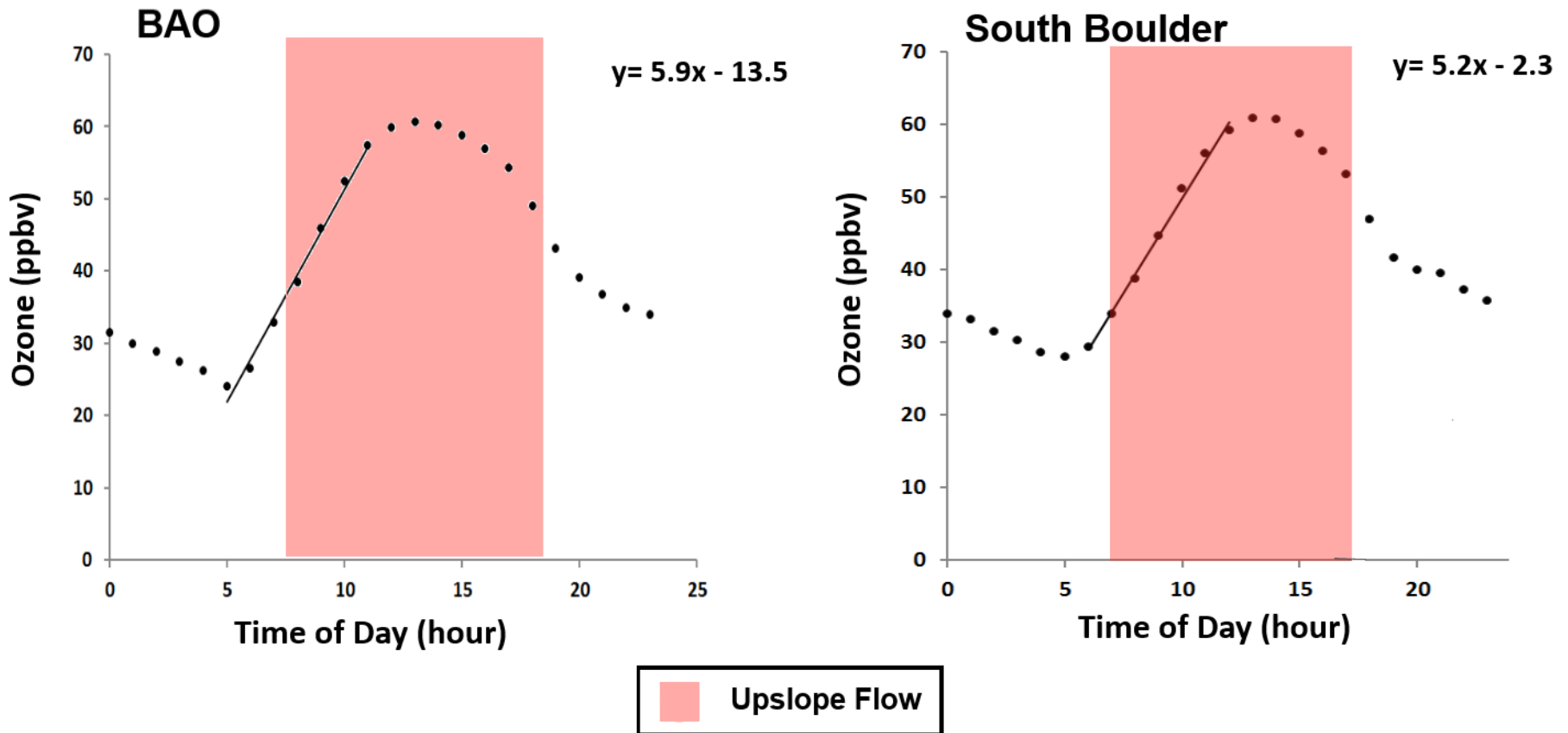
BAO Summer

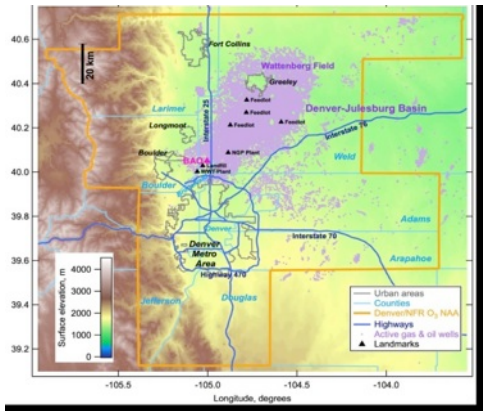


Ozone (ppbv)

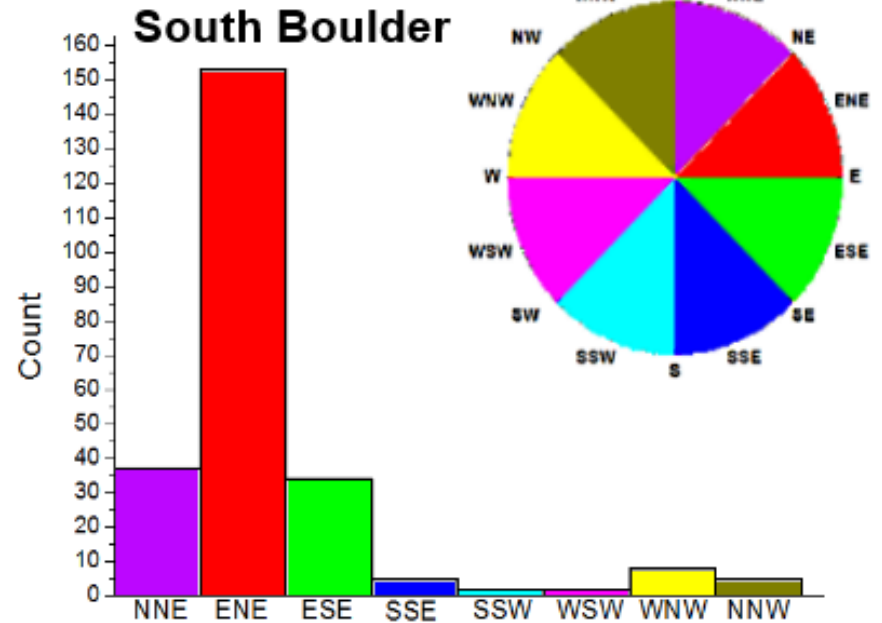
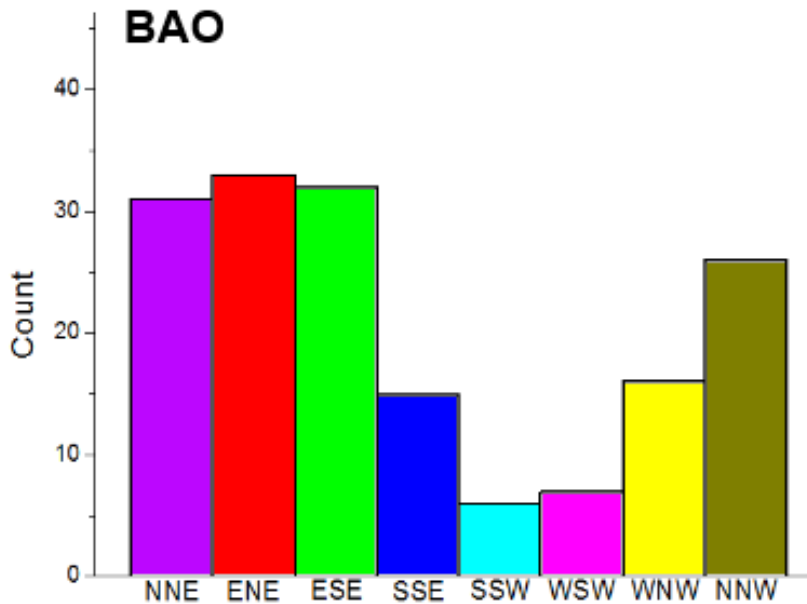
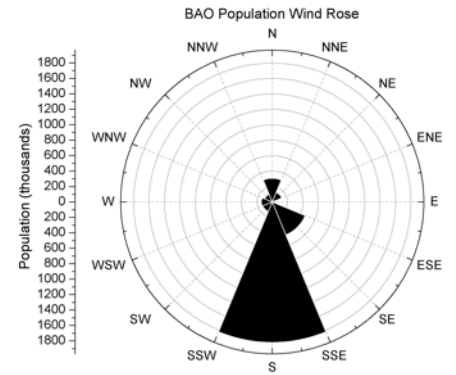


Summer Mean Diurnal Ozone Cycle

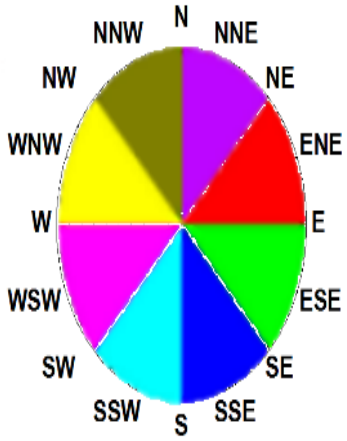
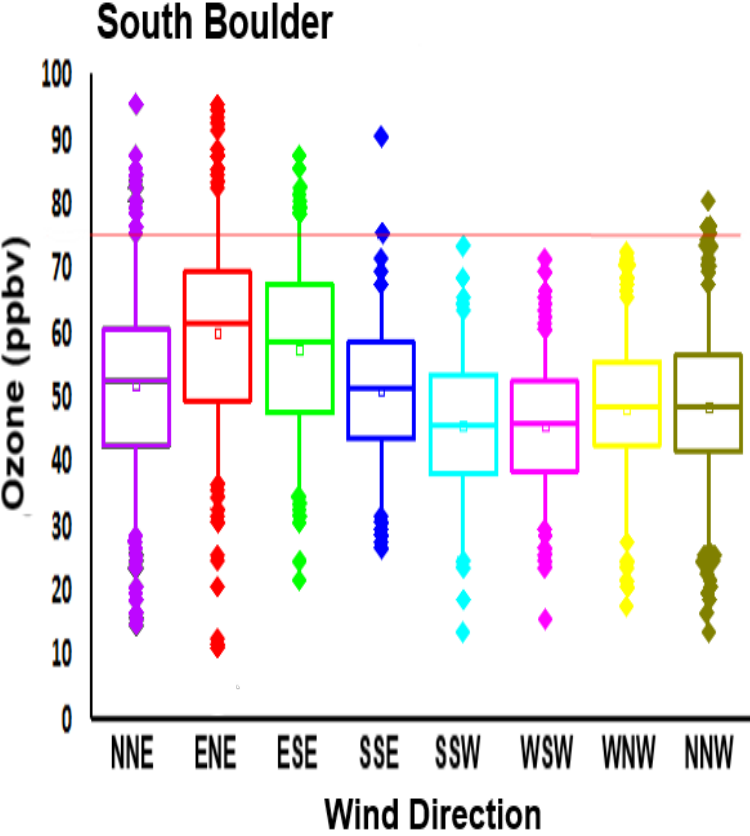
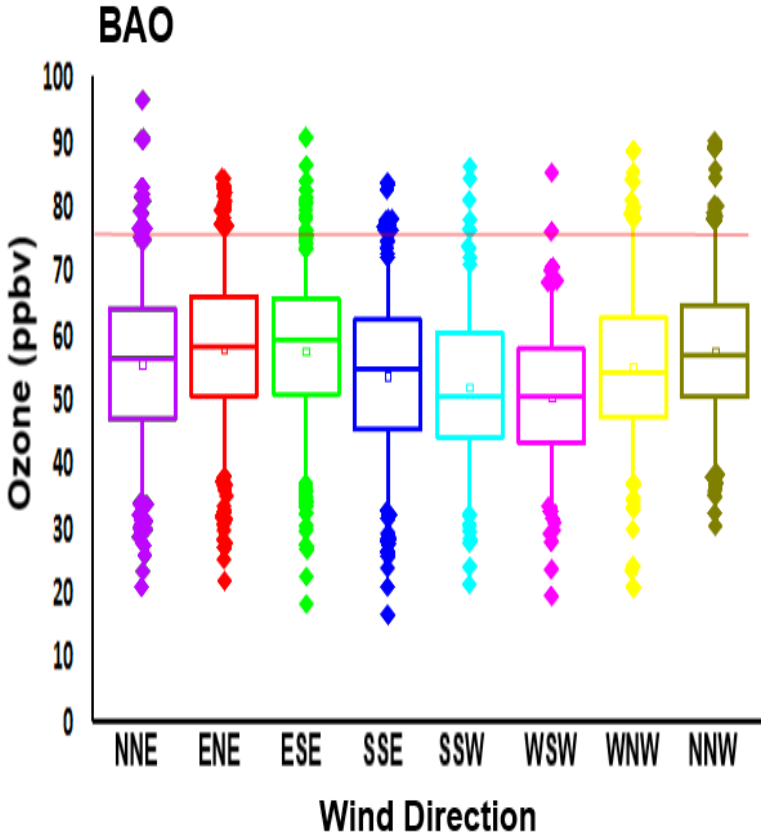




Hours of Ozone > 75 ppb (2009 – 2012)



Ozone Distribution in each Wind Direction Sector



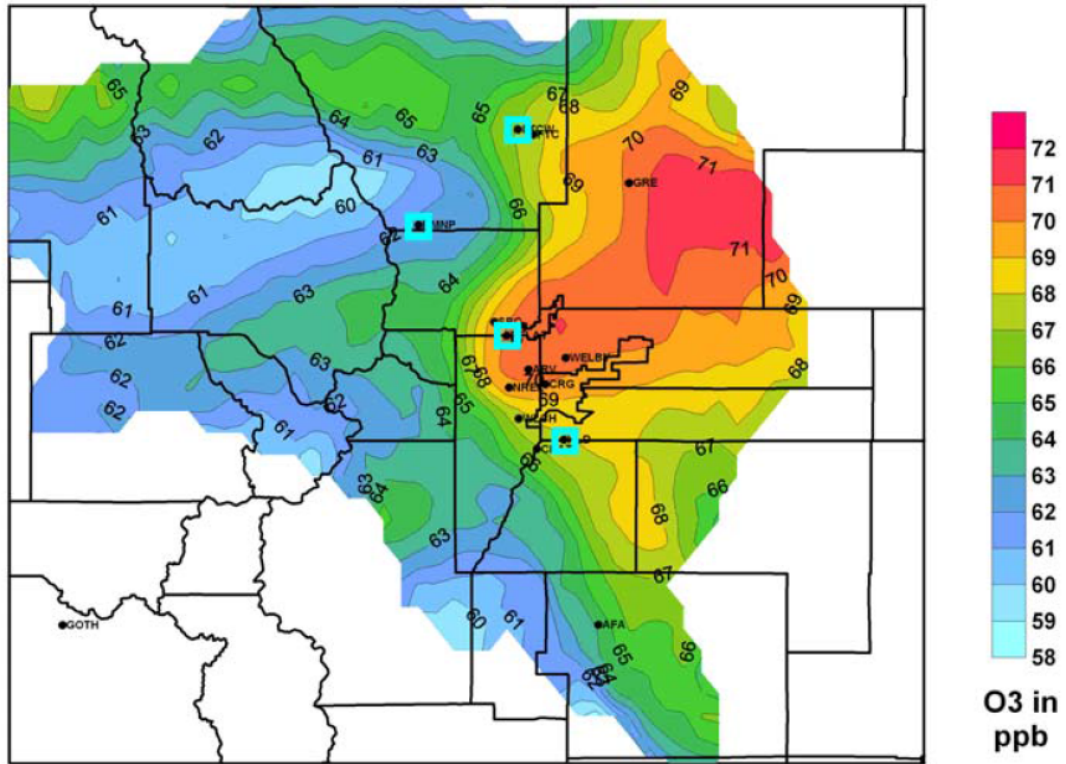


Figure 3-13: Contours of the mean May 17 – August 15, 2006, Front Range daily maximum 8-hour ozone concentrations resulting from transport from given source areas, based on a moving spatial average analysis of concentrations associated with HYSPLIT back trajectory points for FTCW, RMNP, RFN, and HLD monitors. These are the average concentrations that result at these four monitors when an air mass originates in a given area.

Source: Denver Metropolitan Area and North Front Range 8-Hour Ozone State Implementation Plan, DRAFT FINAL, October 29, 2008, CDPHE (Patrick Reddy, CDPHE)

“local sources along the Platte Valley, in the Denver metro area, and within Weld County play a key role in ozone formation during thermally-driven upslope conditions.” (SIP, 2008)

=> Despite Denver – Front Range Region in non-attainment for 10 years, no obvious improvement in ozone levels.

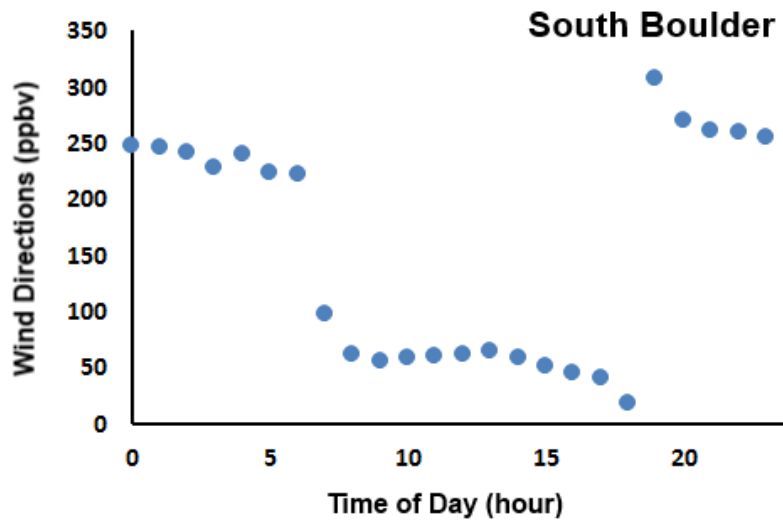
=> High ozone transport does not correlate with upwind population density, but shows strong correlation with upwind oil and gas development area.

=> Combined, VOC and ozone data indicate that very significant portion of high ozone events are influenced by Weld County oil and gas emissions.

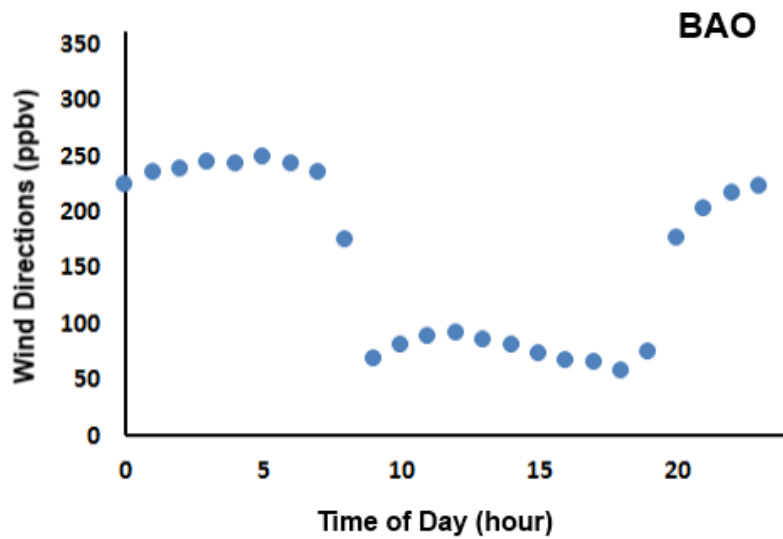
=> Analyses suggests that increases in oil and gas emissions have offset emission reductions from other sectors and possibly prevented/delayed improvements in ozone levels.

Bad Luck ... (last slide)

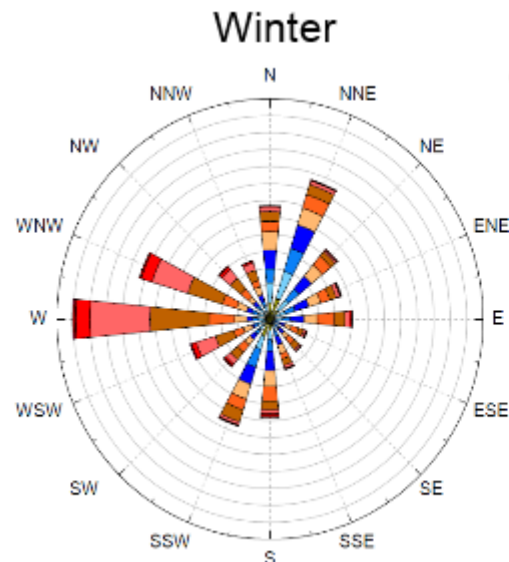
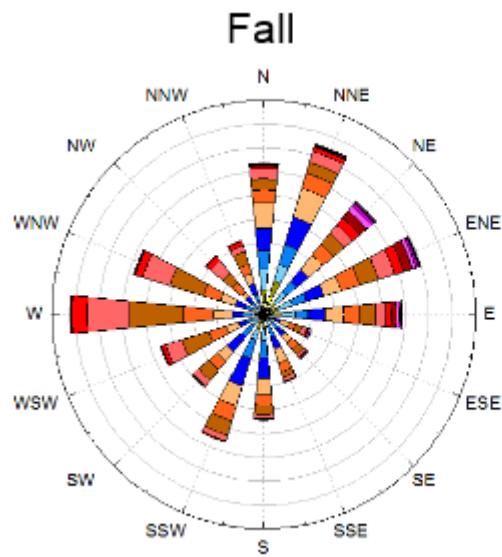




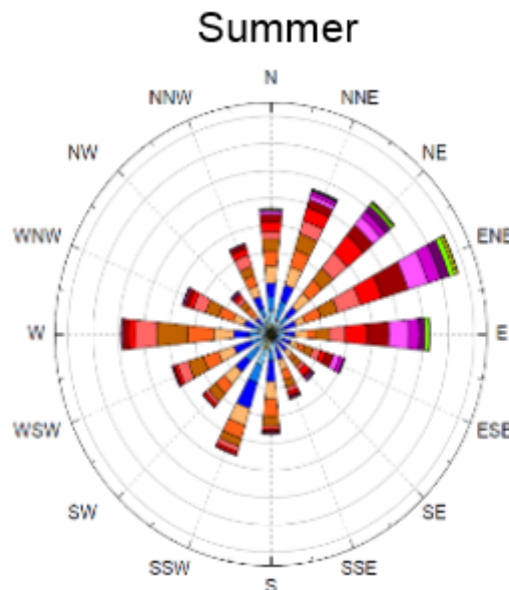
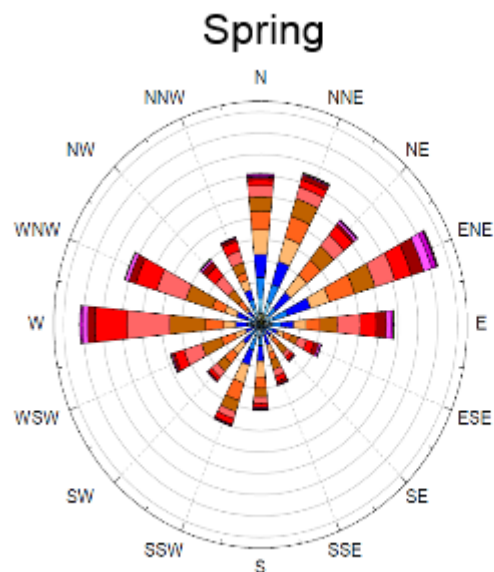
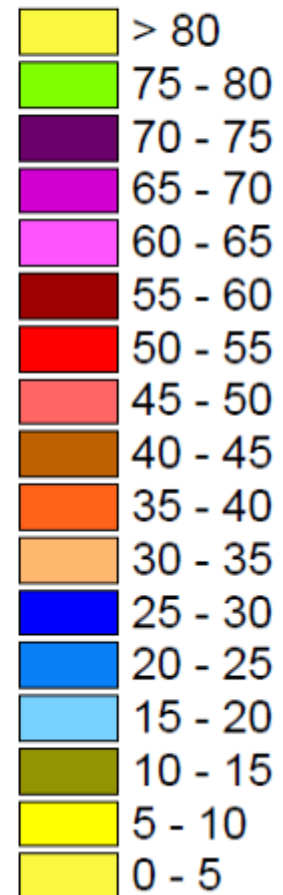
Average Diurnal Wind Direction, Summer

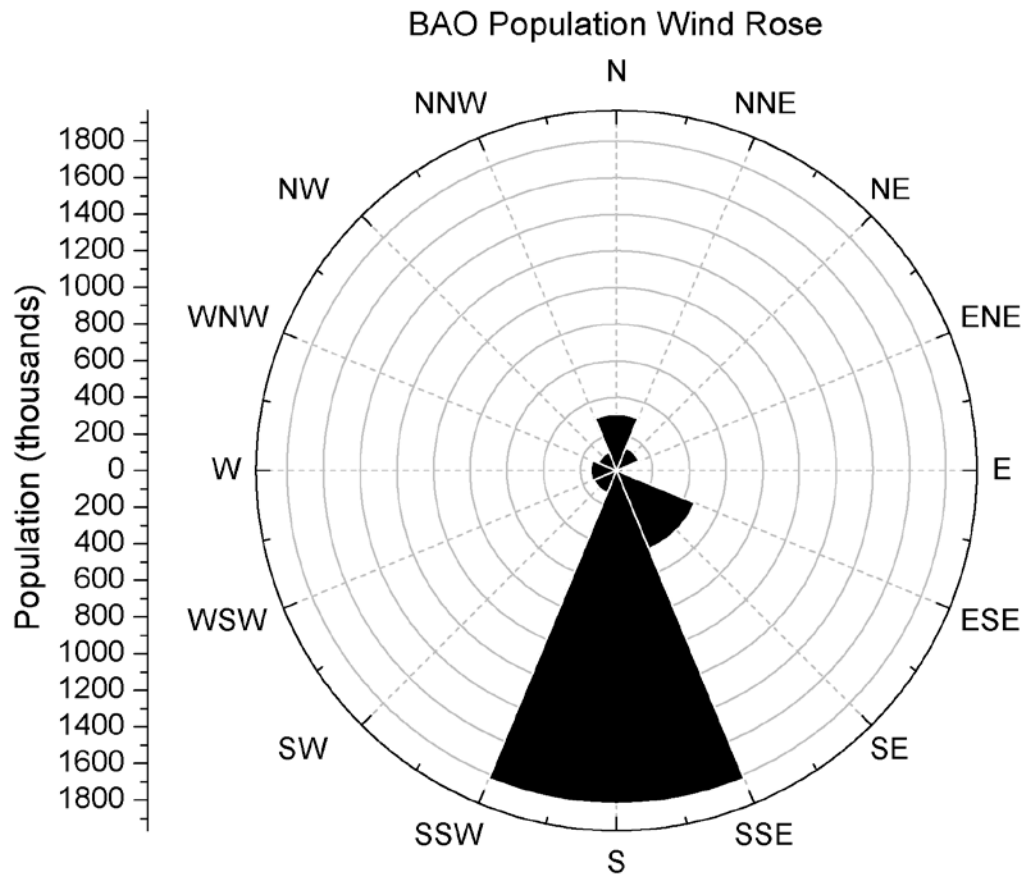


South Boulder

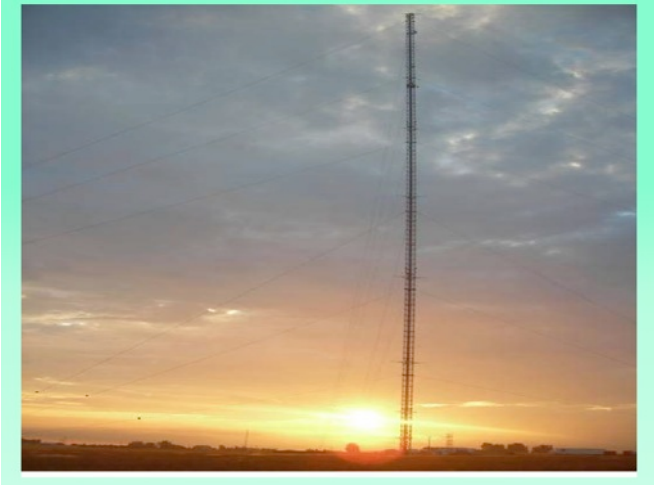


Ozone (ppbv)





Boulder Atmospheric Observatory, NOAA

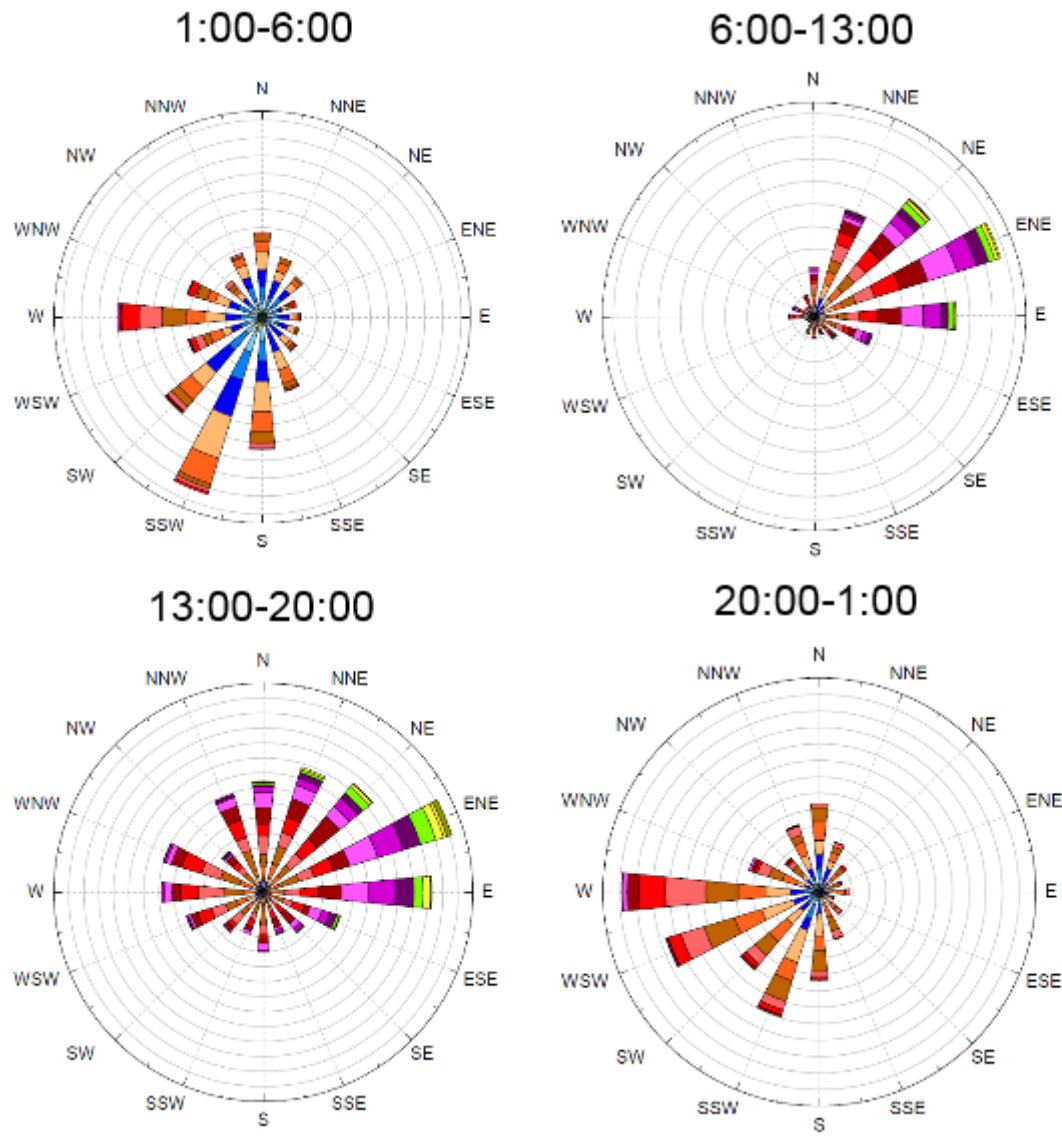


Picture by Dan Wolfe

South Boulder, Boulder County/CDPHE



South Boulder Summer



Ozone damage to vegetation

