

Estimating US Fossil Fuel CO₂ Emissions from Atmospheric Measurements of CO₂ and ¹⁴CO₂

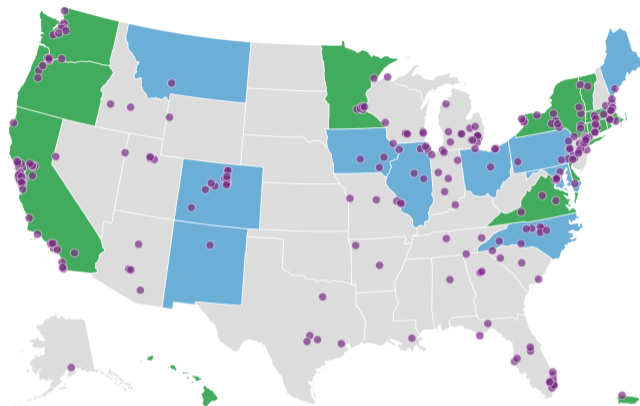
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Global Monitoring Annual Conference

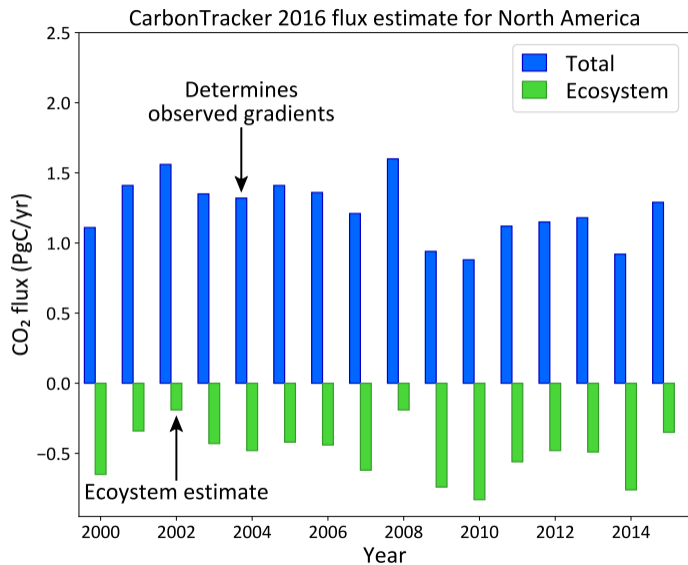
Why track US fossil fuel emissions (1)?



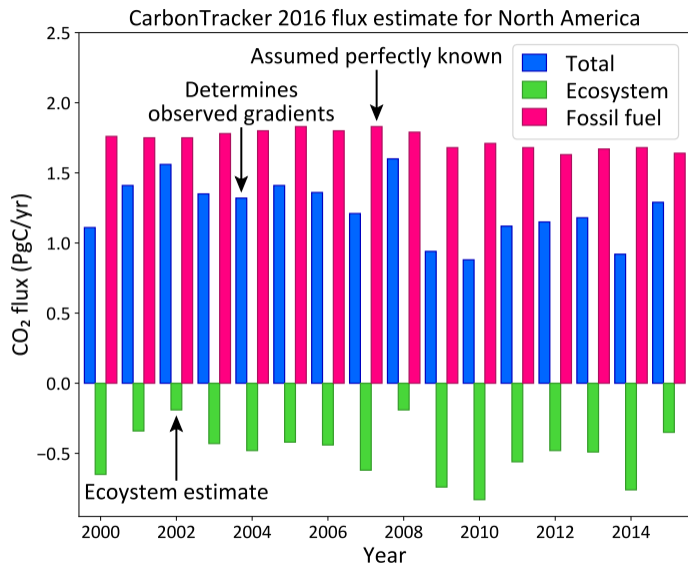
ALASKA, HAWAII, AND PUERTO RICO ARE NOT REPRESENTED TO SCALE.



Coalitions like the US Climate Alliance and the Regional Greenhouse Gas Initiative (RGGI) remain committed to emission reductions of the Paris Accord (or more). Regional emissions estimates needed to support these efforts. NOAA GMD has the capability to support the development of independent, atmosphere-based verification methods.



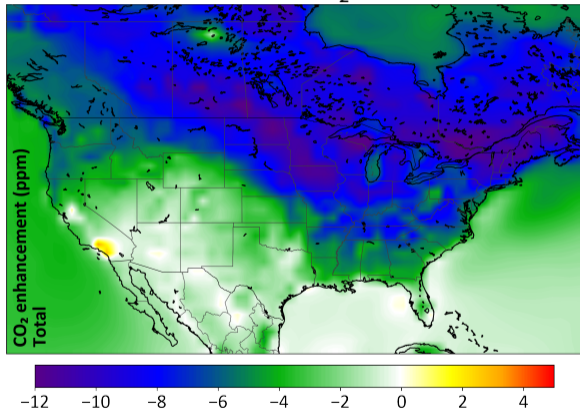
- We are interested in the climate response of land ecosystem (NEE) and ocean fluxes
- CarbonTracker-like CO₂ flux estimation systems solve for NEE from observed atmospheric gradients



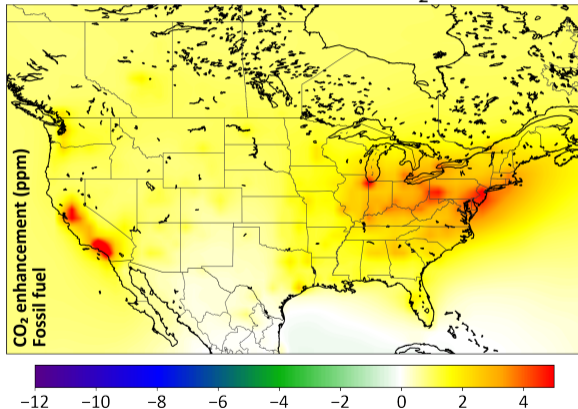
- We are interested in the climate response of land ecosystem (NEE) and ocean fluxes
- CarbonTracker-like CO₂ flux estimation systems solve for NEE from observed atmospheric gradients
- Fossil fuel emissions assumed to be perfectly known
- Errors in FF (especially seasonal) can impact diagnosed NEE anomalies and climate response

Summer-time mid-afternoon near-surface gradients

Total CO₂



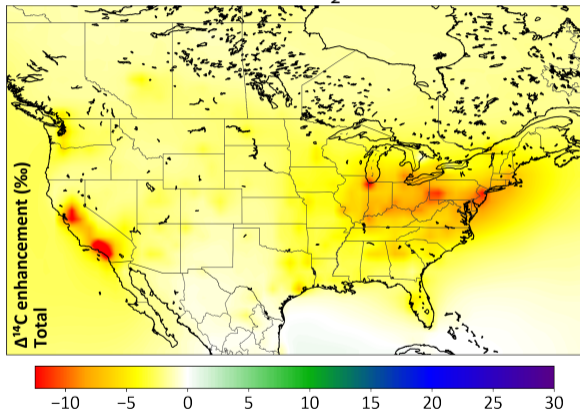
Fossil fuel derived CO₂



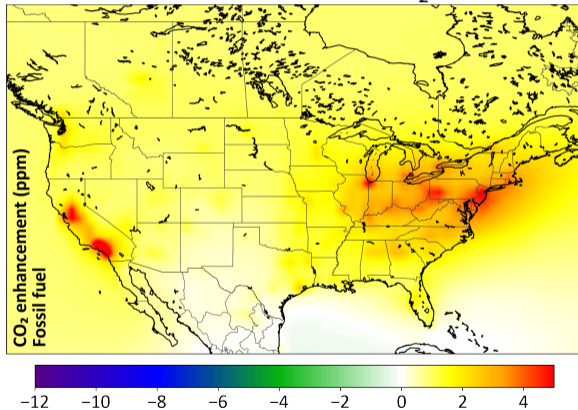
Near-surface gradients of CO₂ are completely different from that of fossil fuel derived CO₂
It is not possible to estimate the latter by measuring the former

Summer-time mid-afternoon near-surface gradients

$\Delta^{14}\text{CO}_2$

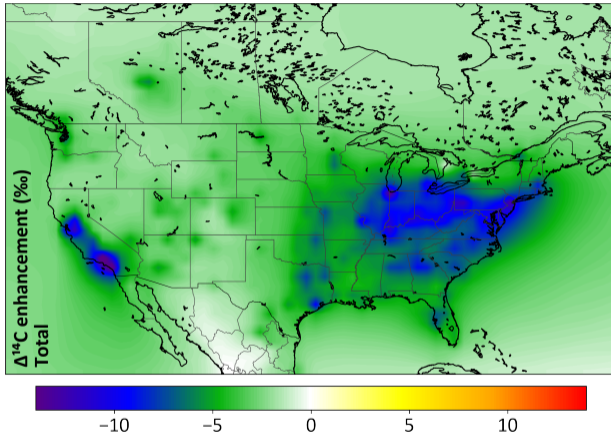


Fossil fuel derived CO₂

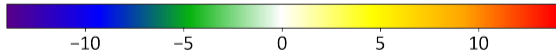
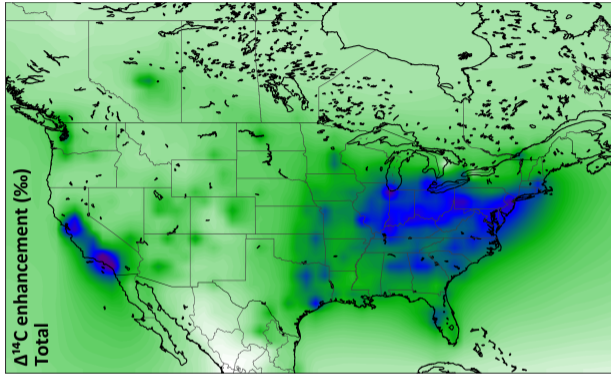


1 ppm fossil fuel CO₂ = -2.5 ‰ in $\Delta^{14}\text{CO}_2$ (roughly)

Correlation is tight enough to estimate FF CO₂ from $\Delta^{14}\text{CO}_2$ gradients

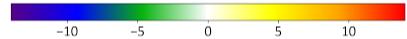
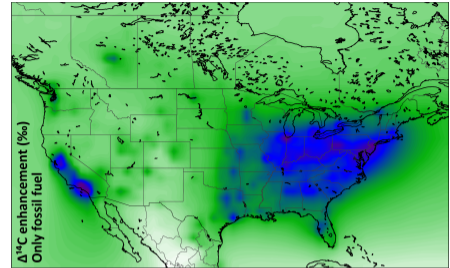


$\Delta^{14}\text{C}\text{O}_2$ gradients are determined by fossil fuel, cosmogenic production, nuclear production, and oceanic and terrestrial disequilibria

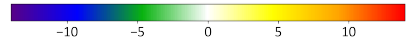
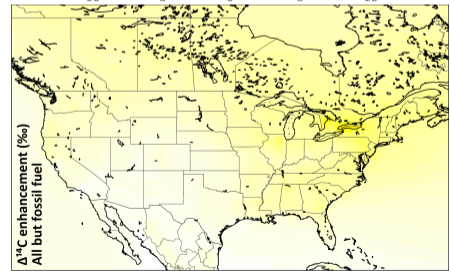


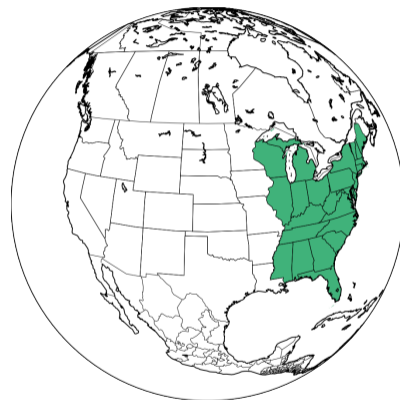
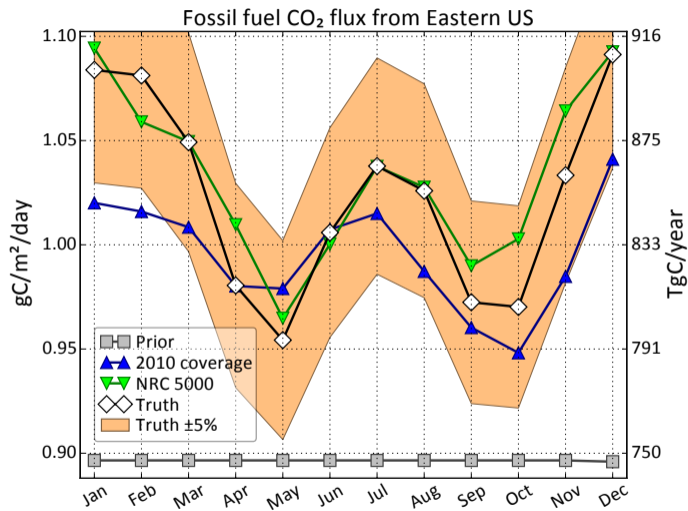
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Fossil fluxes

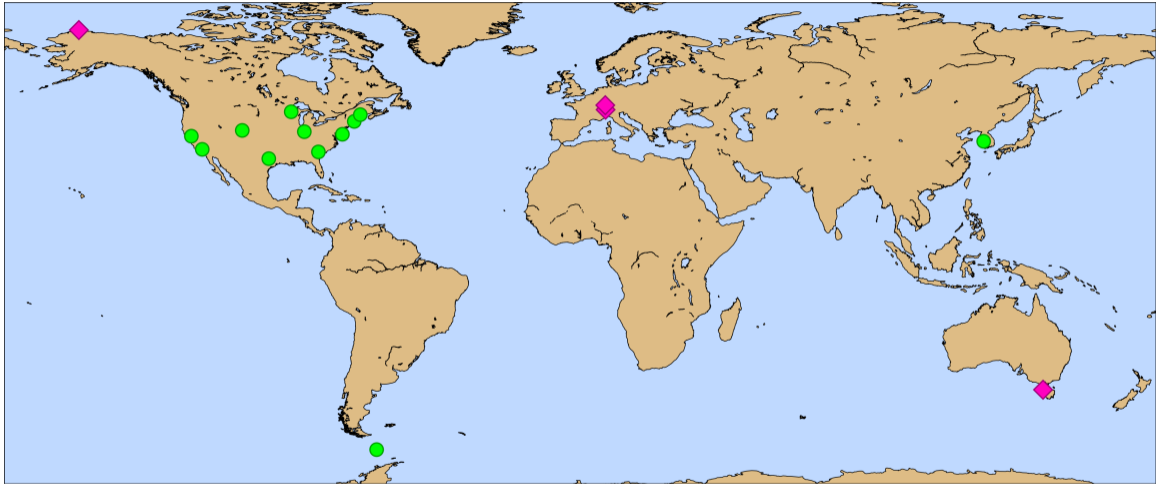


Non-fossil fluxes



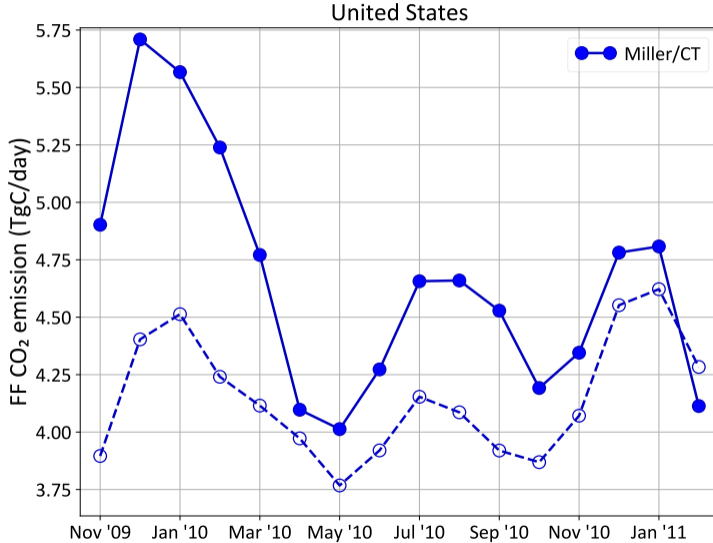


Monthly fluxes over the US and large sub-regions recovered to within $\pm 5\%$

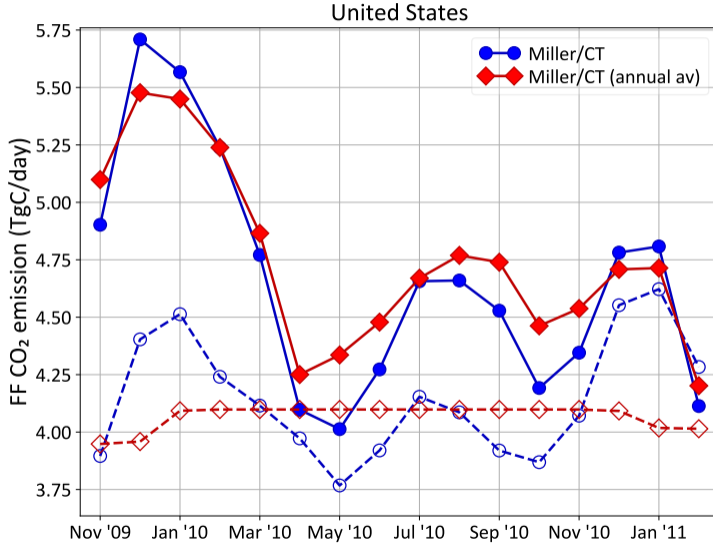


NOAA GMD/CU INSTAAR (895)

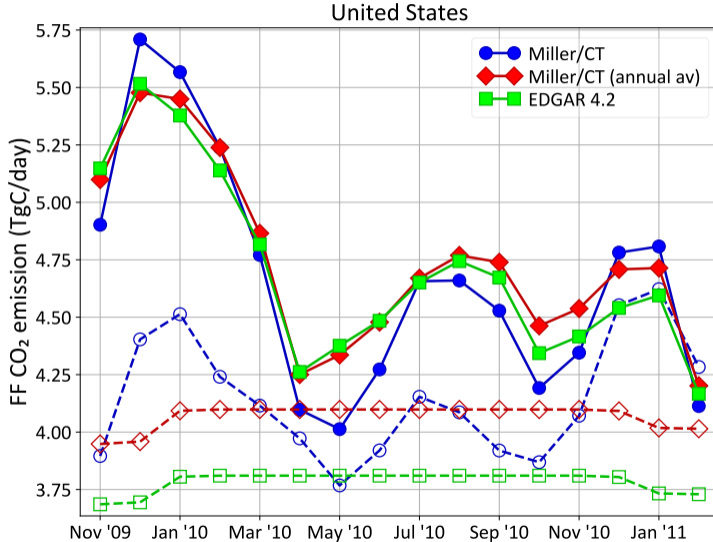
External (89)



- The inversion suggests larger fluxes and seasonality of FF emissions, with the same phasing as the prior (Blasing, 2005) seasonality

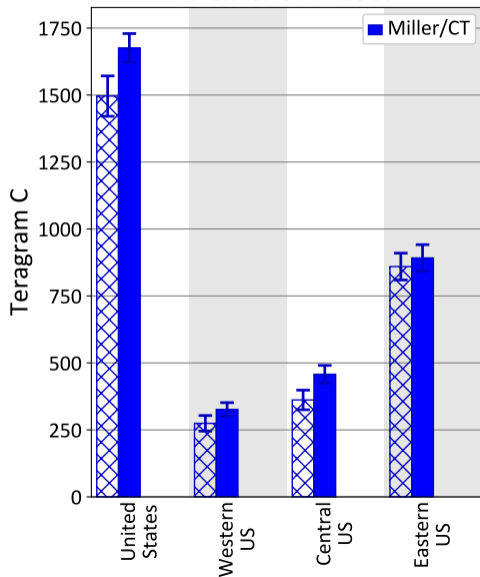


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- This is not coming from the prior, rather from the $\Delta^{14}\text{CO}_2$ data



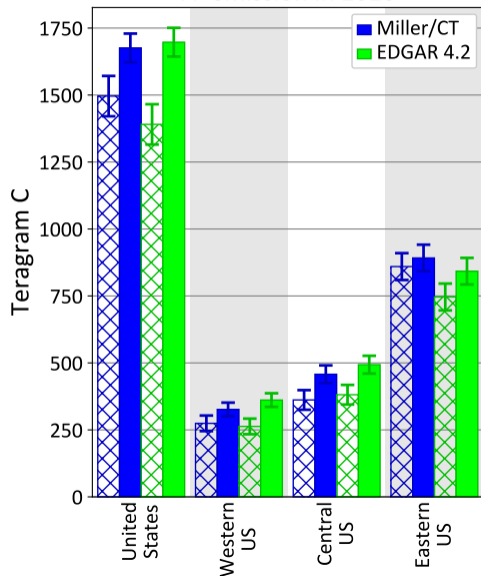
- The inversion suggests larger fluxes and seasonality of FF emissions, with the same phasing as the prior (Blasing, 2005) seasonality
- This is not coming from the prior, rather from the $\Delta^{14}\text{CO}_2$ data
- Relatively insensitive to a different prior

FF emission in 2010



- Our inversion suggests 12% higher US fossil fuel emissions in 2010 (1677 TgC) compared to the CDIAC estimate (1497 TgC)
- Considering the 1σ prior and posterior errors, this is a significant adjustment
- Vulcan 3.0 reports 1632 TgC, only 2.7% away!

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- Vulcan 3.0 reports 1632 TgC, only 2.7% away!
- Using a completely different prior, biased low and with different spatial pattern, gives 1698 TgC, so our estimate is relatively insensitive to the prior

- NOAA GMD measurement and modeling capabilities can track fossil fuel emissions independent of bottom-up inventory estimates, which remains a priority for many regional initiatives like RGGI
- Previous results suggest that we need an expansion in our ^{14}C measurement network, as recommended by the National Research Council, to obtain robust regional results
- Independently estimating seasonal FF emissions also improves our ability to diagnose biospheric fluxes and their anomalies (*a la* CarbonTracker)
- Inversions of 2010 $^{14}\text{CO}_2$ data suggest a US total emission of $1677 \pm 54 \text{ TgC}$, significantly higher than inventory estimates for that year
- The $^{14}\text{CO}_2$ data imply a larger seasonal variation in FF emissions compared to the Blasing et al (2005) seasonality, even when no prior assumptions are made regarding FF seasonality