

# Estimating fossil fuel CO<sub>2</sub> emission using a $^{12}\text{CO}_2 + ^{14}\text{CO}_2$ TM5 4DVAR

Sourish Basu, John Miller, Scott Lehman, Colin Lindsey



TM5 Meeting  
Wageningen, May 2014

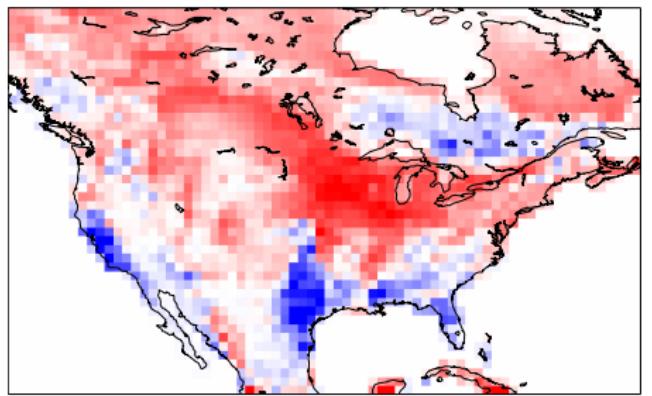


# What is the issue?

$$\frac{dC}{dt} = F_{oce} + F_{bio} + F_{fos}$$

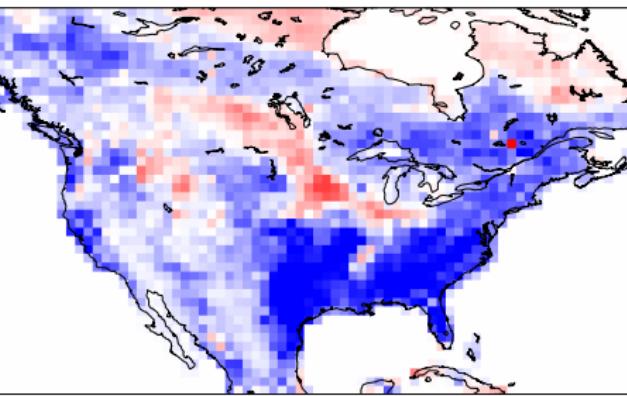
tracers transported  
fluxes estimated

# Uncertainties in CO<sub>2</sub>(ff)



-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0

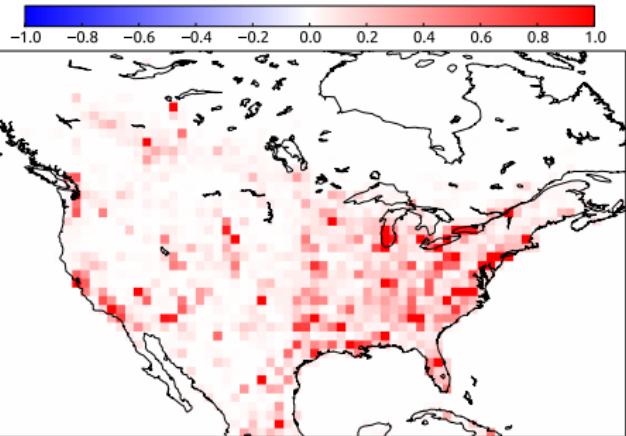
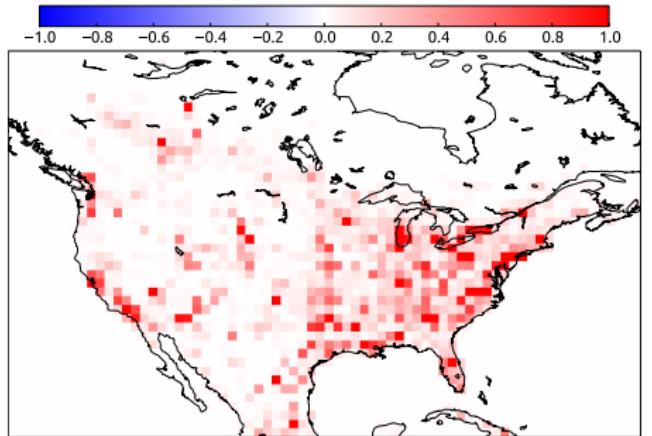
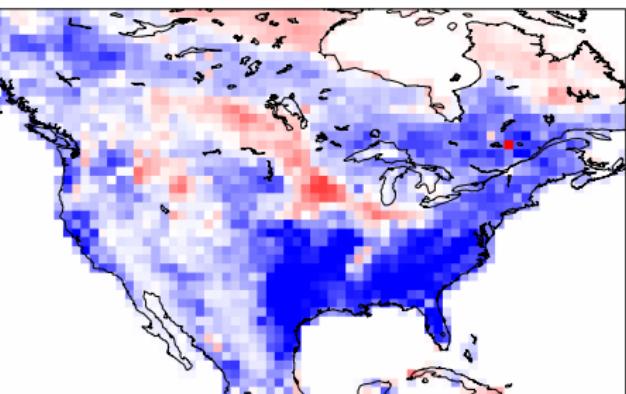
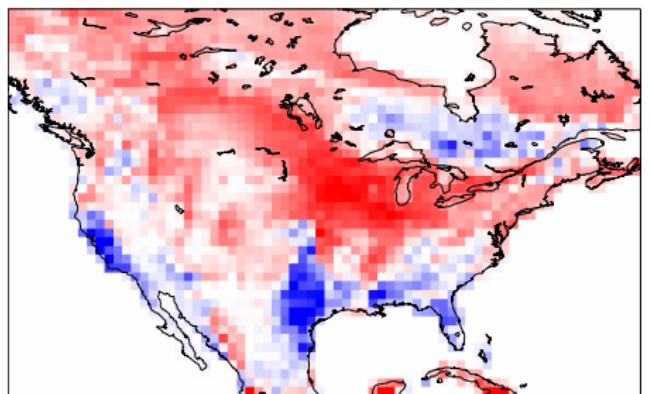
April 2010



-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0

May 2010

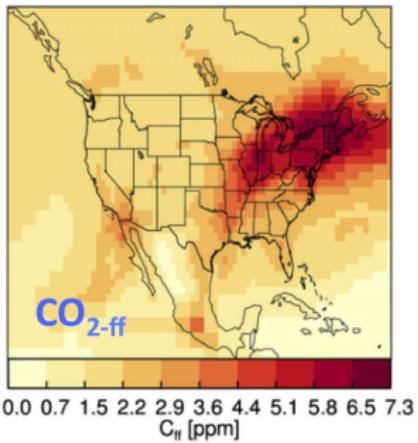
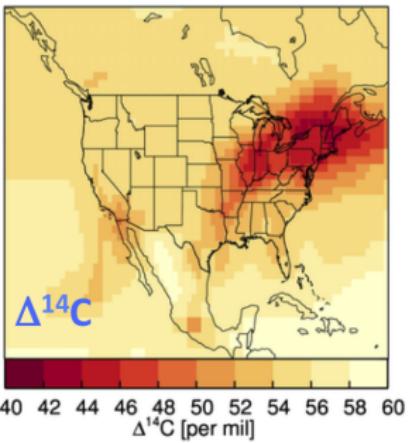
# Uncertainties in CO<sub>2</sub>(ff)

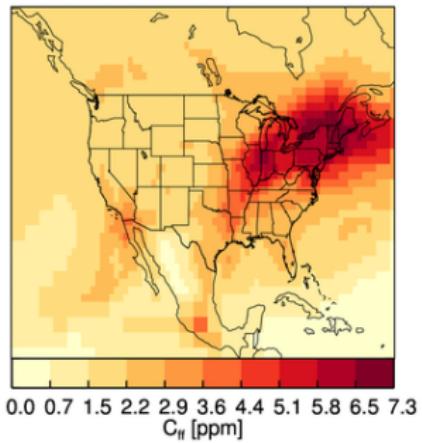
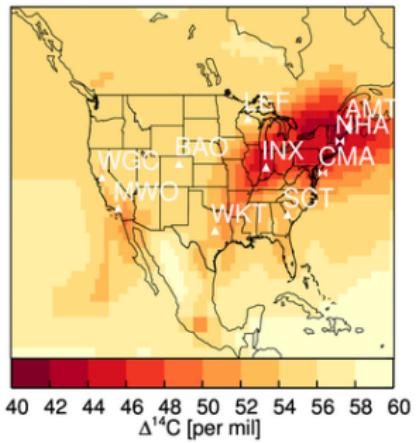


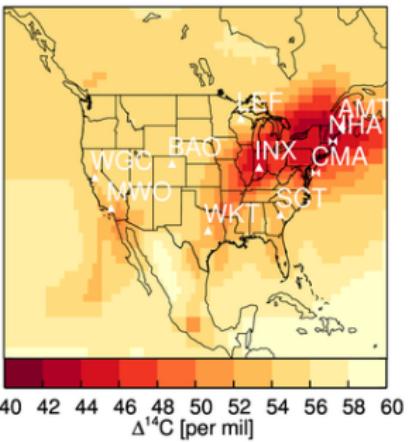
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0

-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0

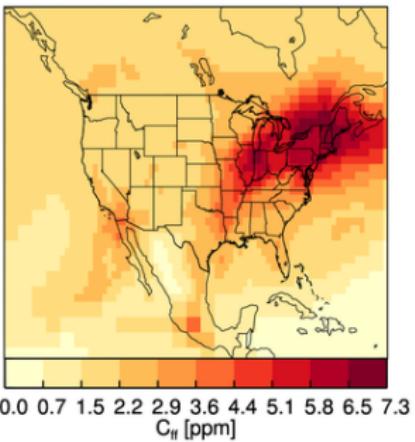




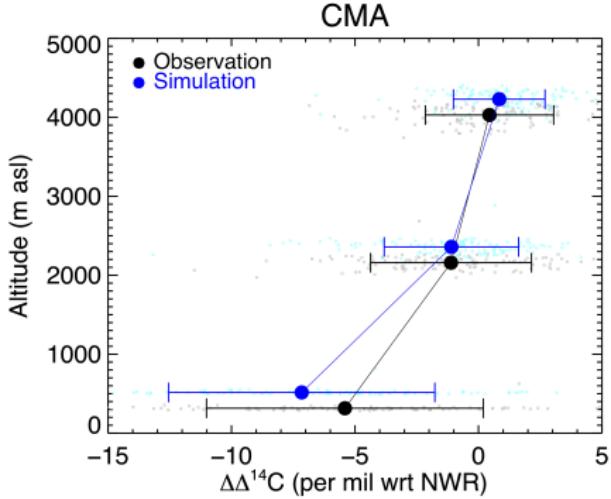
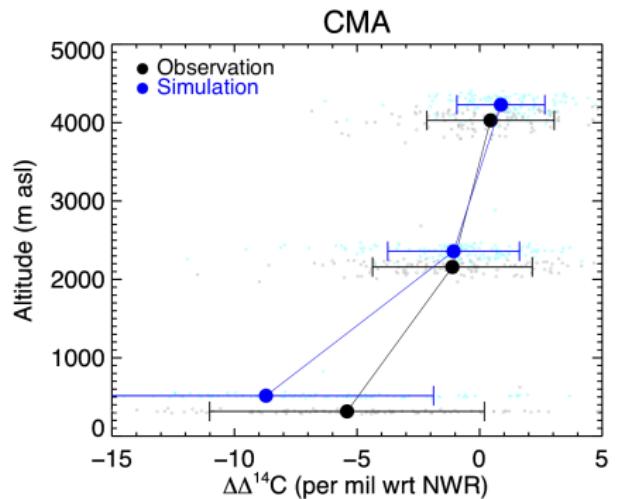




$\Delta^{14}\text{C}$  [per mil]



$C_8$  [ppm]





$$\frac{dC}{dt} = F_{oce} + F_{bio} + F_{fos}$$

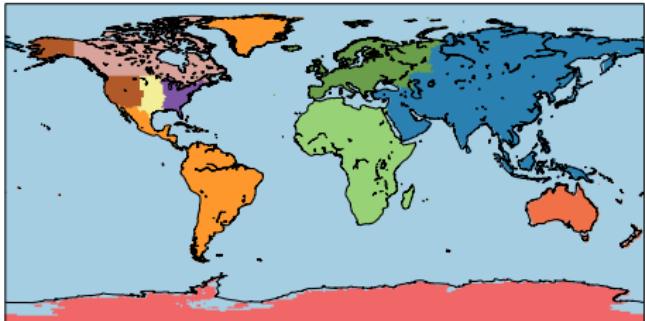
$$\begin{aligned}\frac{d}{dt}(C \cdot \Delta_{atm}) &= \Delta_{fos} F_{fos} + \Delta_{atm} (F_{oce} + F_{bio}) \\ &\quad + \Delta_{oce} F_{oce \rightarrow atm} + \Delta_{bio} F_{bio \rightarrow atm} \\ &\quad + \alpha (F_{nuc} + F_{cosmo})\end{aligned}$$

tracers transported  
fluxes estimated

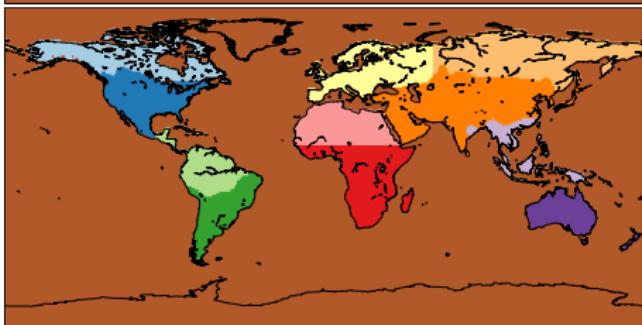
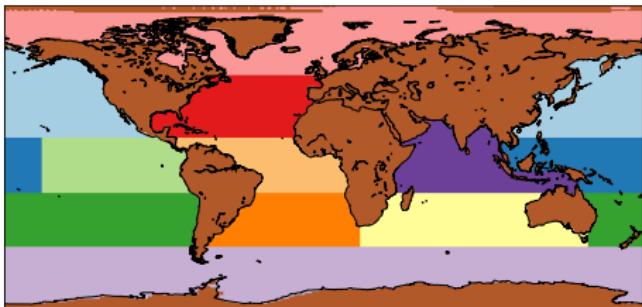
# Uncertainties



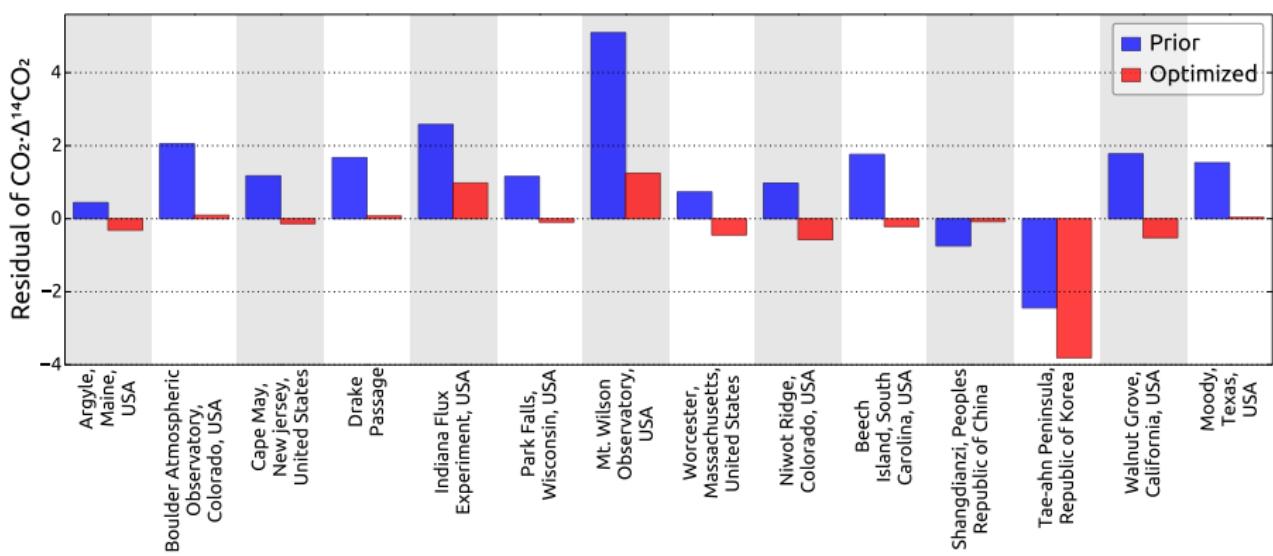
- ▶ US CO<sub>2</sub>(ff):  $5.26 \pm 0.26$  Pg CO<sub>2</sub>
- ▶ Land biosphere:  $0.25 \times$  respiration per grid cell, 200 km (e), 1 month
- ▶ Ocean:  $157 \times$  abs(net flux), 1000 km (e), 3 month
- ▶ Fossil fuel:  $2.5 \times$  inter-prior spread, 700 km hybrid, 3 month



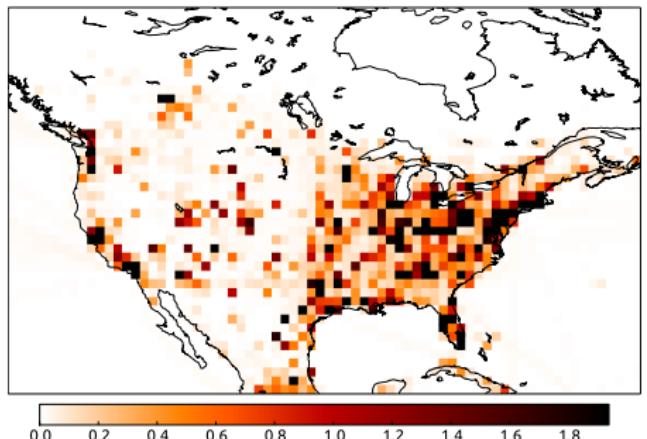
- ▶ Ocean disequilibrium:  $0.2 \times$  abs(net flux), regional, 3 month
- ▶ Land disequilibrium:  $0.1 \times$  abs(net flux), regional, 1 month



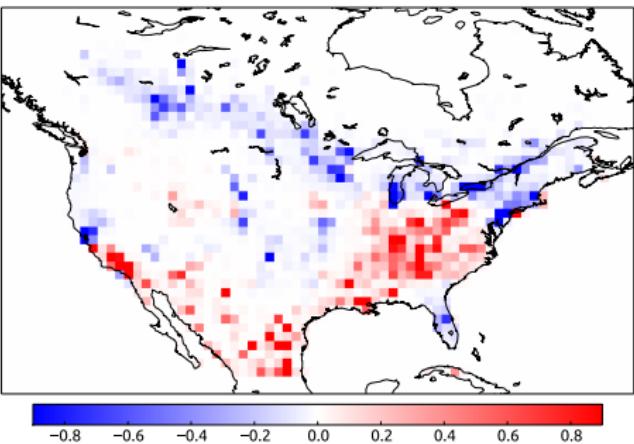
# Residuals of C $\Delta$ $^{14}\text{C}$



# Posterior emission over North America

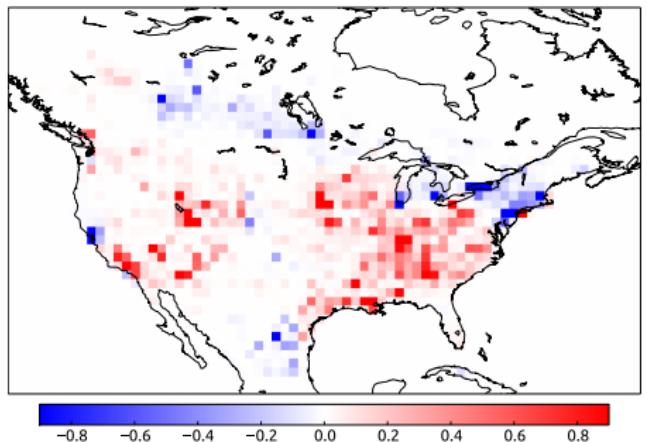


Prior  $\text{CO}_2(\text{ff})$

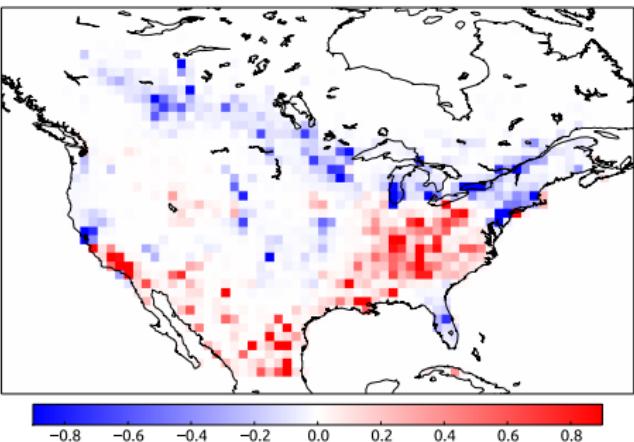


Adjustments

# Posterior emission over North America

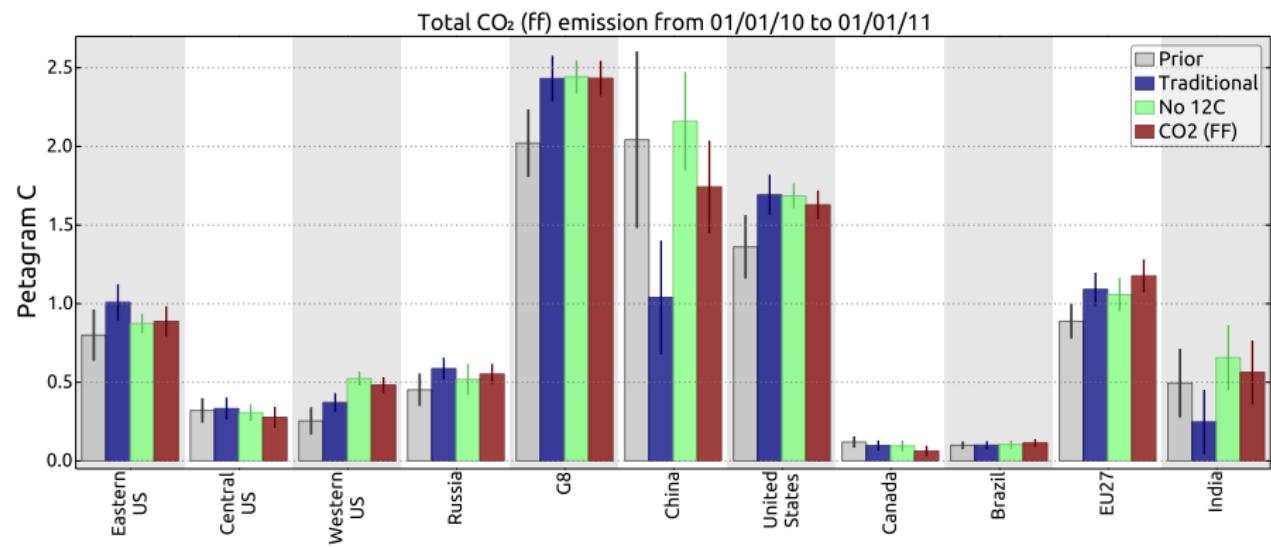


Adj without  $^{14}\text{CO}_2$

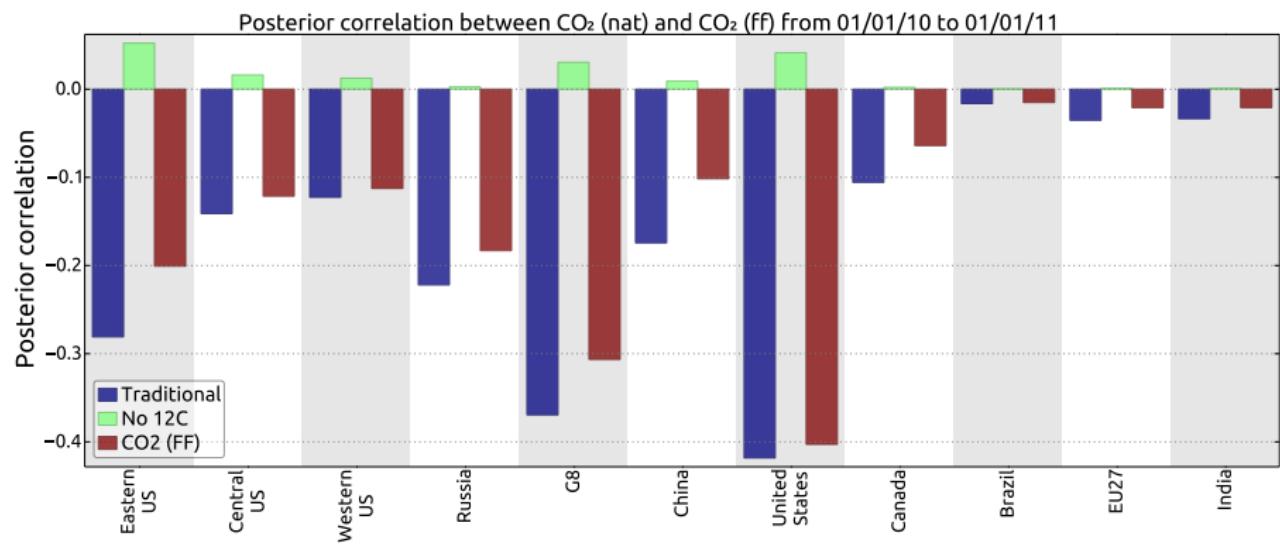


Adjustments

# Posterior emissions and correlations



# Posterior emissions and correlations





## Points to take home

- ▶ There is some signal of  $\text{CO}_2(\text{ff})$  in  $^{14}\text{CO}_2$ , but it's not large, so challenging to assimilate
- ▶ Preliminary results show a larger  $\text{CO}_2(\text{ff})$  flux from the US, for example
- ▶ Negative correlation between  $\text{CO}_2(\text{ff})$  and  $\text{CO}_2(\text{nat})$  reduced by  $^{14}\text{CO}_2$
- ▶ Current assimilation system needs improvement, posterior fits could be better