Gross uptake of carbon in the U.S. is largest in the Midwest Region

Timothy W. Hilton, Mary Whelan, Andrew Zumkehr, Sarika Kulkarni, Joseph A. Berry, Ian T. Baker, Steven A. Montzka, Colm Sweeney, Benjamin R. Miller, J. Elliott Campbell

thilton@ucmerced.edu

17 May 2016

UCMERCED

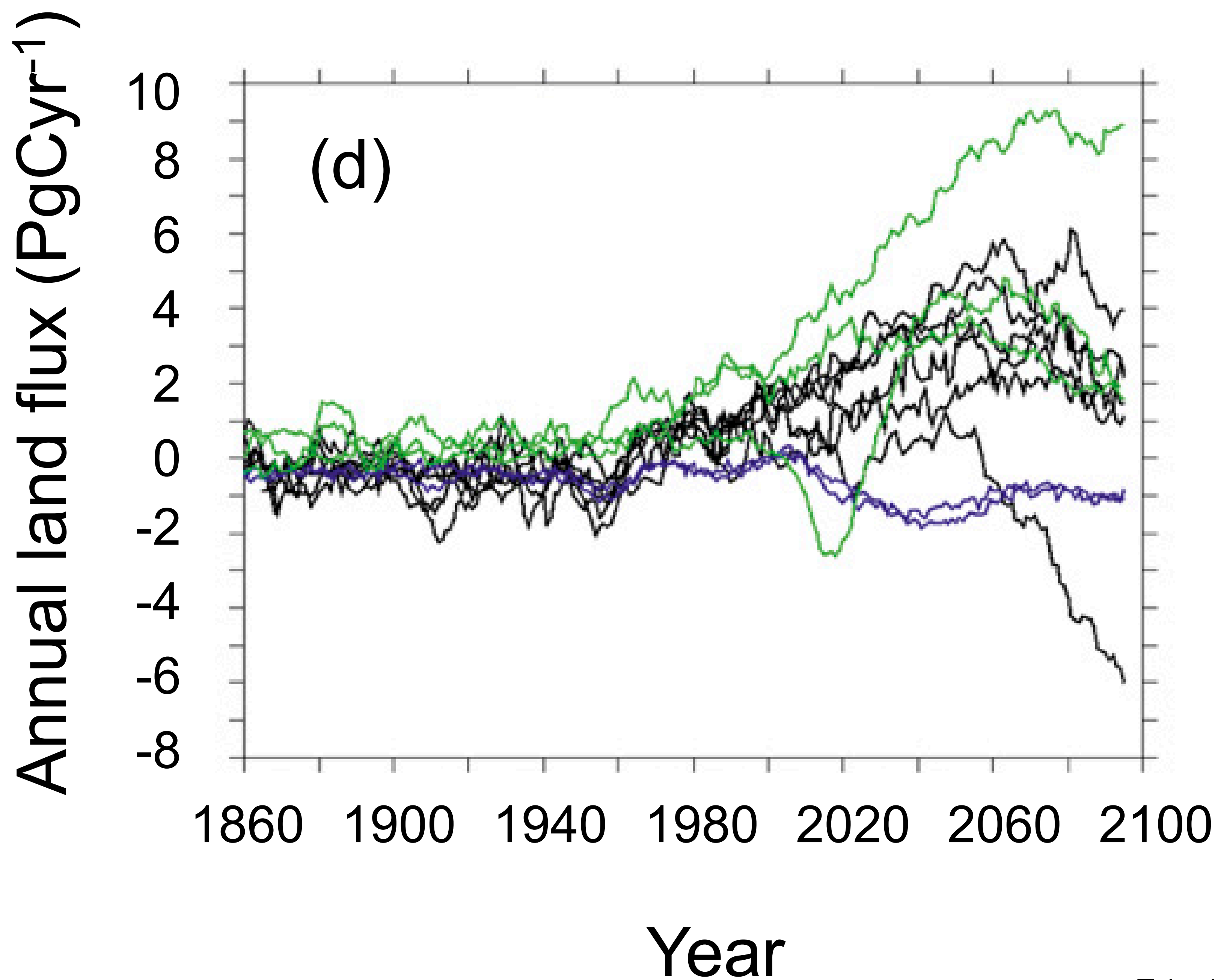
UC MERCED SNRI
SIERRA NEVADA RESEARCH INSTITUTE

Prediction is very difficult, especially about the future.

- Danish proverb

Prediction is very difficult, especially about the future.

- Danish proverb



Friedlingstein et al., 2014

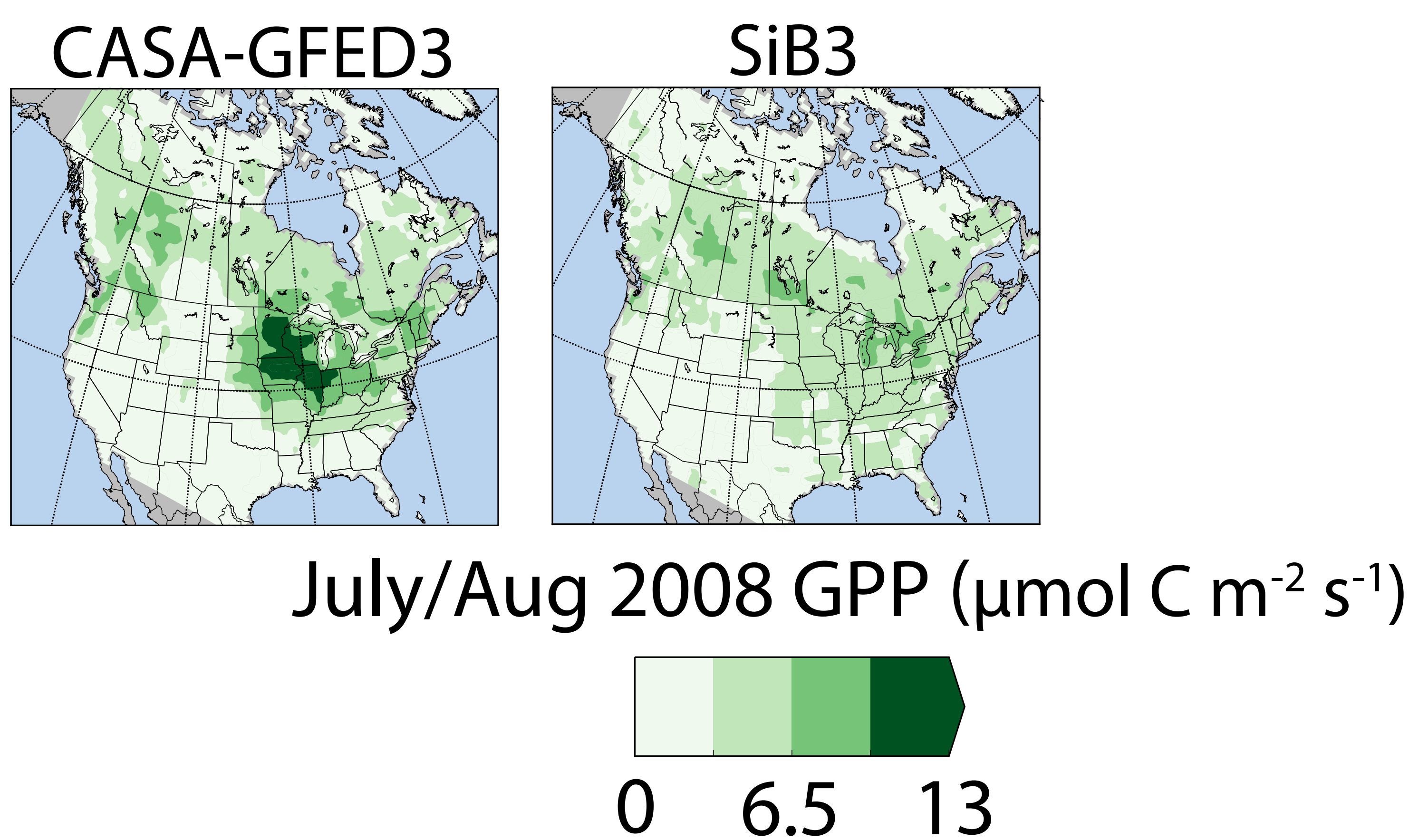
Prediction is very difficult, especially about the ~~future~~ past.

- some of us here in this room, among others

Prediction is very difficult, especially about the ~~future~~. past

- some of us here in this room, among others

GPP was Northerly/ Midwestern!

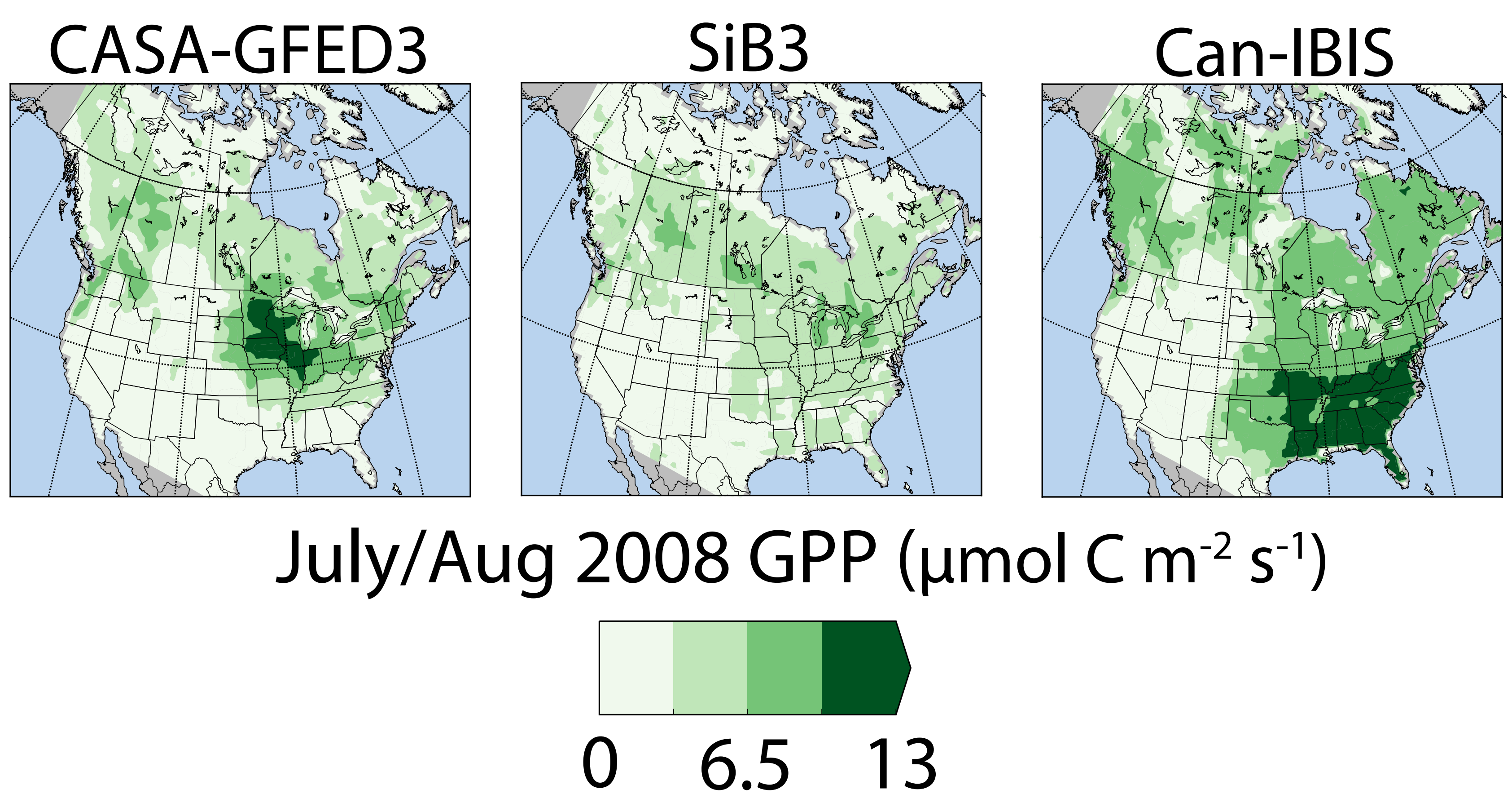


Prediction is very difficult, especially about the ~~future~~ past.

- some of us here in this room, among others

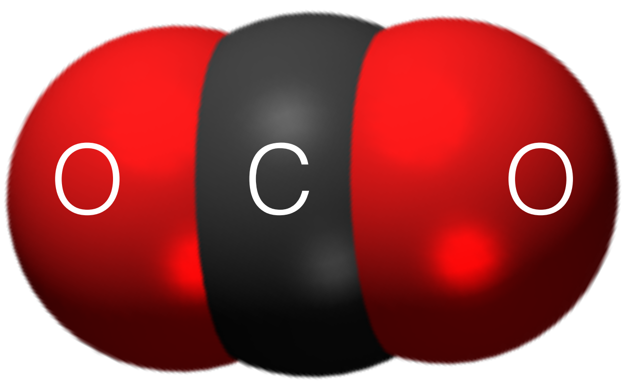
GPP was Northerly/ Midwestern!

Nope, GPP was southeasterly!

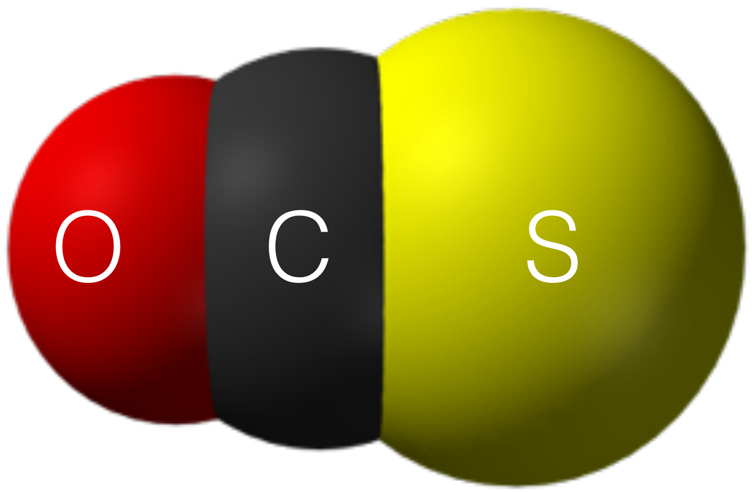


carbonyl sulfide primer

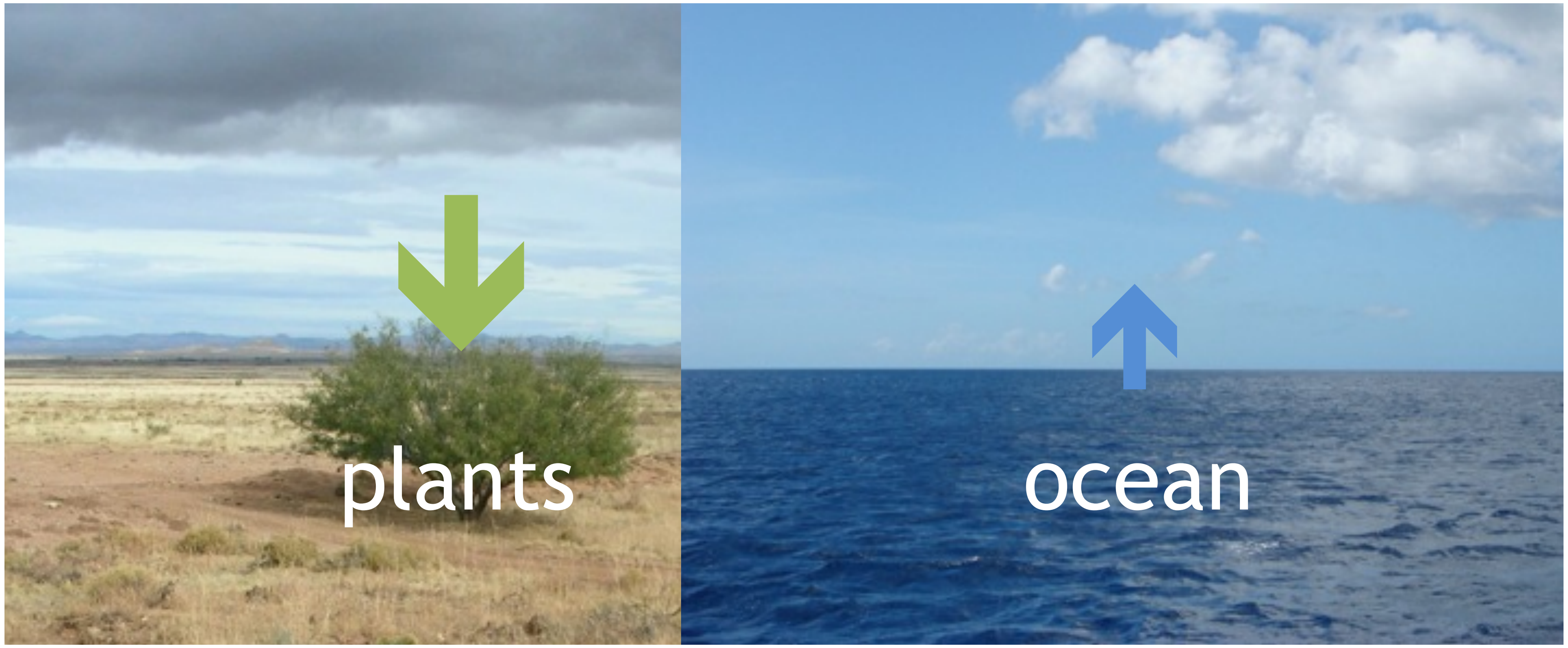
carbon dioxide
CO_2



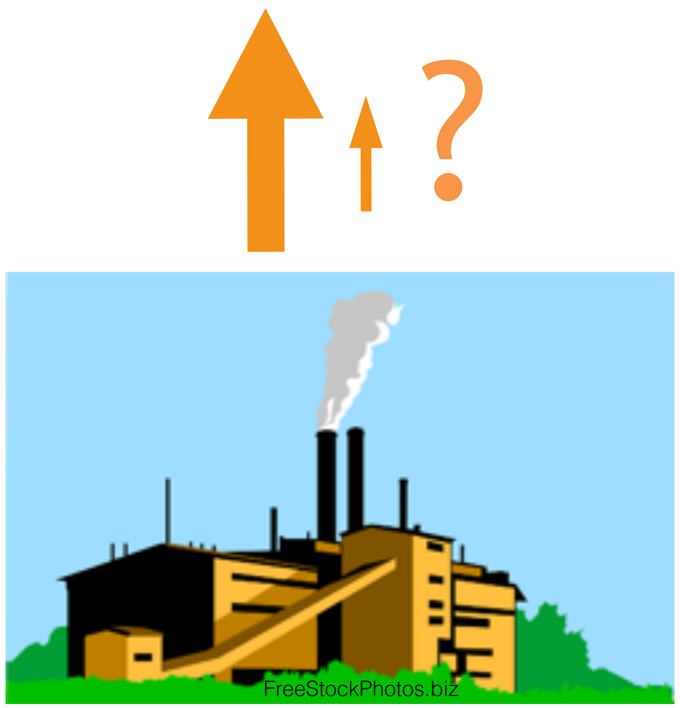
carbonyl sulfide
COS or OCS



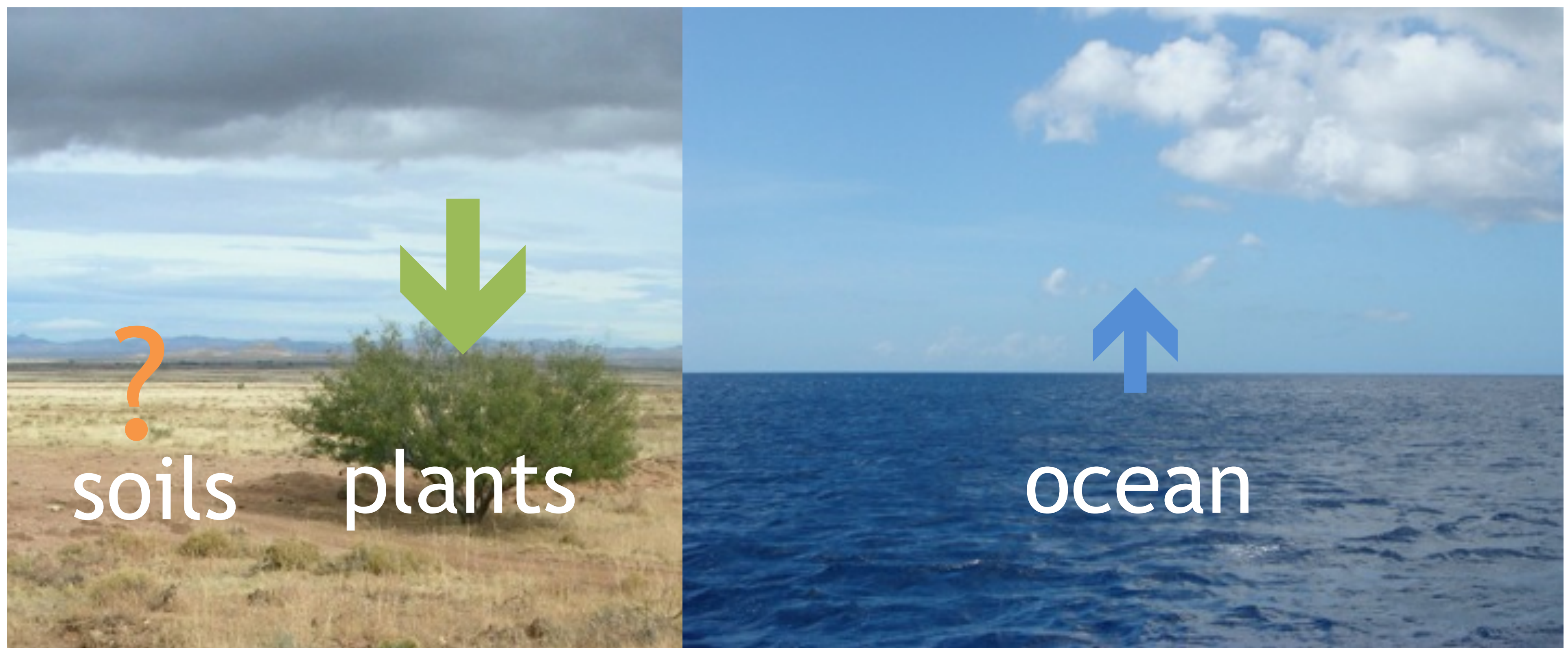
carbonyl sulfide primer



carbonyl sulfide primer



anthropogenic



Our approach

COS plant flux models

2nd-order COS surface fluxes

Regional transport model

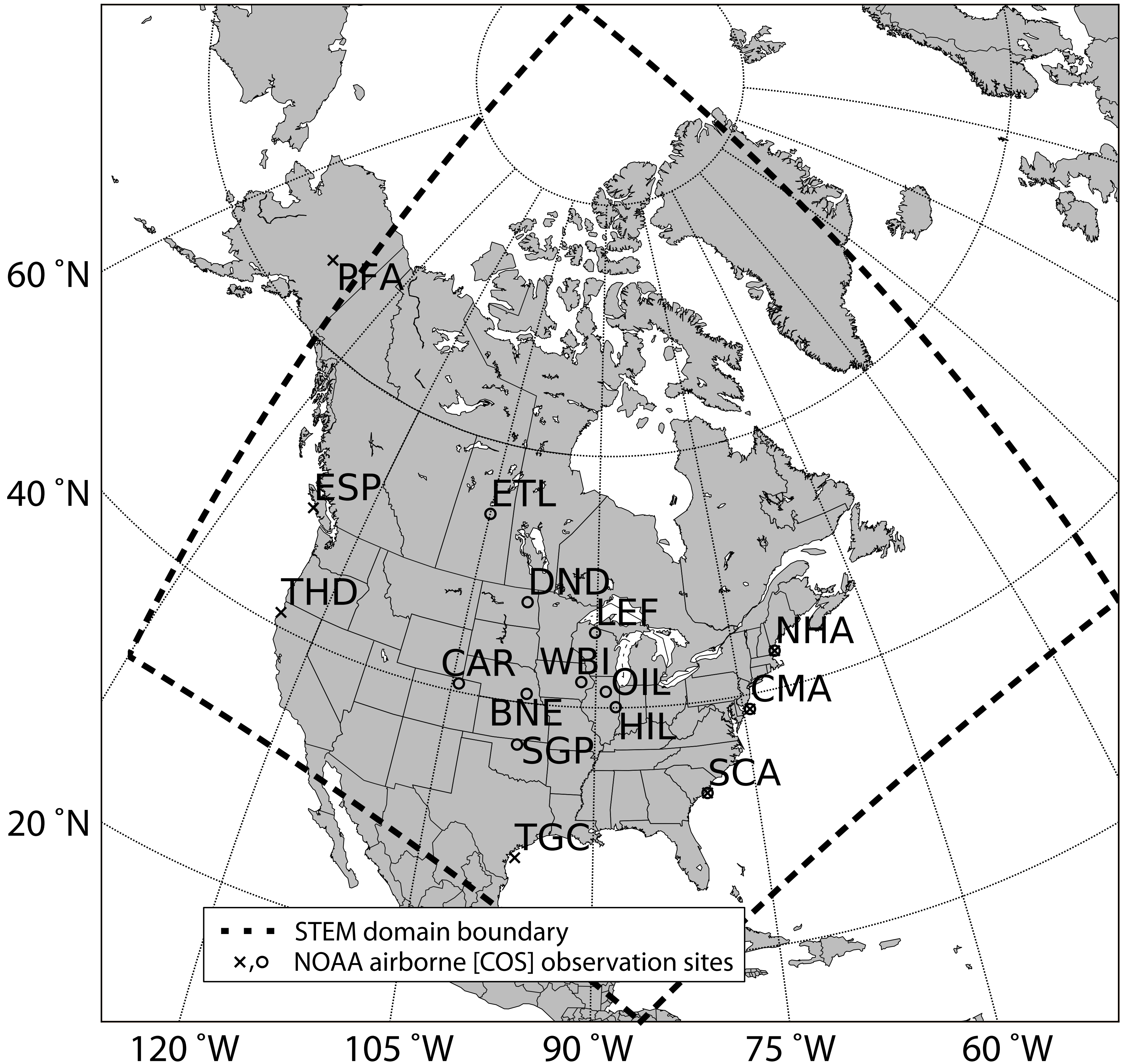
Simulated regional [COS]

compare to

NOAA airborne [COS] observations

(big thanks to Steve Montzka, Colm Sweeney, Ben Miller, et al.)

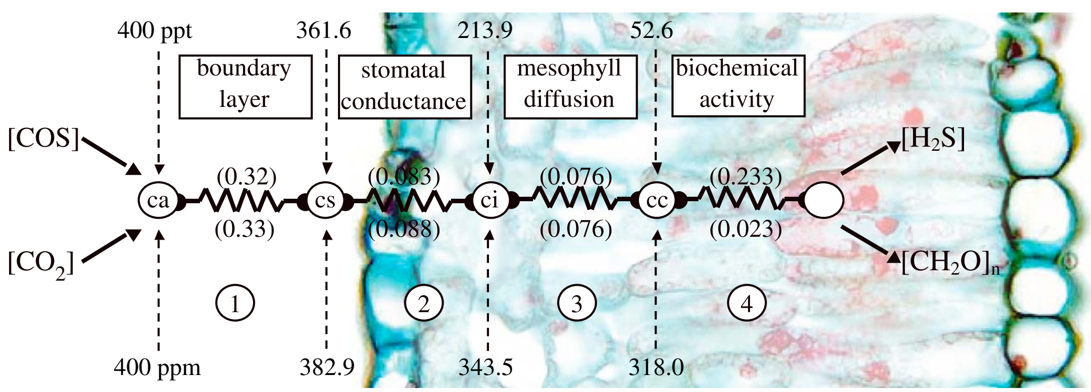
Modeling setup



COS plant flux models

mechanistic

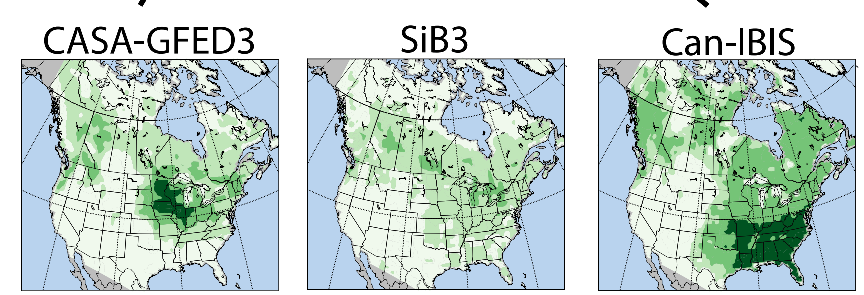
Berry et al. (2013)



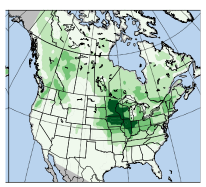
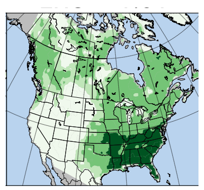
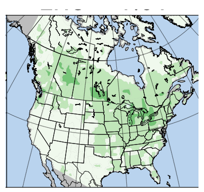
Leaf-scale Relative Uptake (LRU)

e.g. Montzka et al. (2007),
Stimler et al. (2010, 2011, 2012)

$$F_{plant} = GPP * LRU * \frac{[\mathrm{COS}]}{[\mathrm{CO_2}]}$$



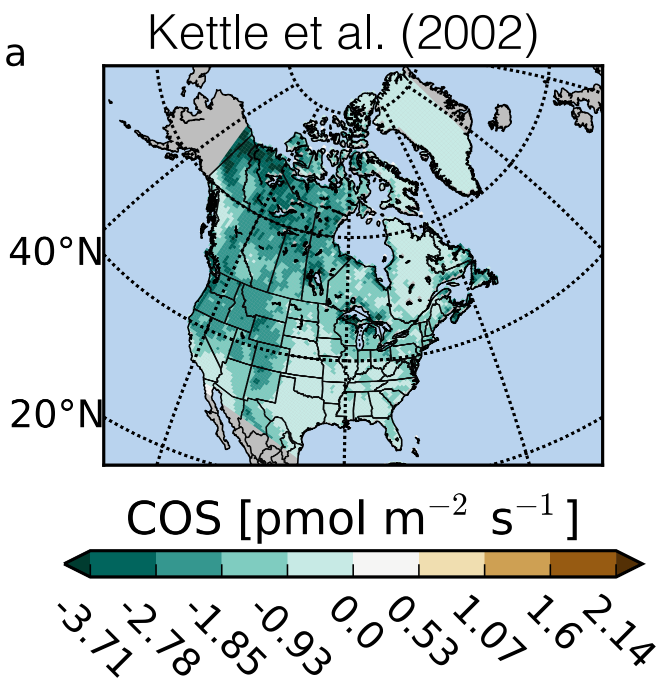
COS plant flux models

	GPP model	COS uptake model
	CASA-GFED3	LRU = 1.61
	CASA-GFED3	LRU = C3/C4 weighted
	Can-IBIS	LRU = 1.61
	Can-IBIS	LRU = C3/C4 weighted
	SiB	LRU = 1.61
	SiB	mechanistic canopy

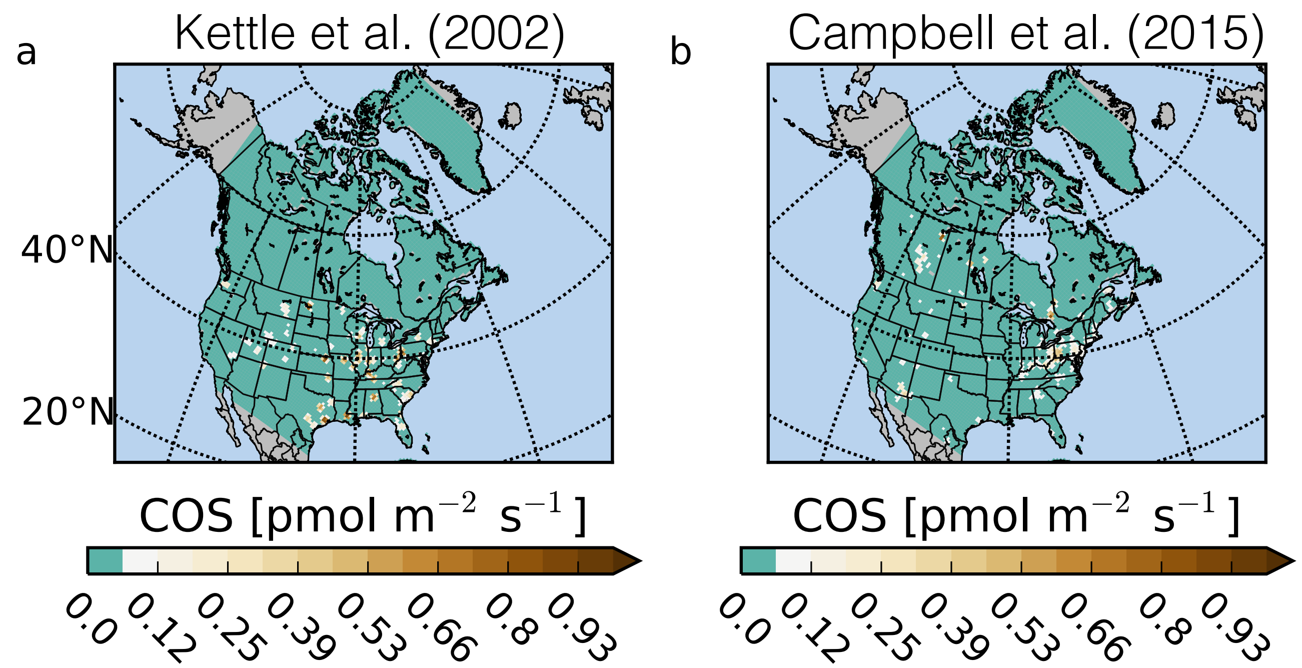
see also:
Hilton et al., Tellus B, 2015

Results I: 2nd-order COS fluxes

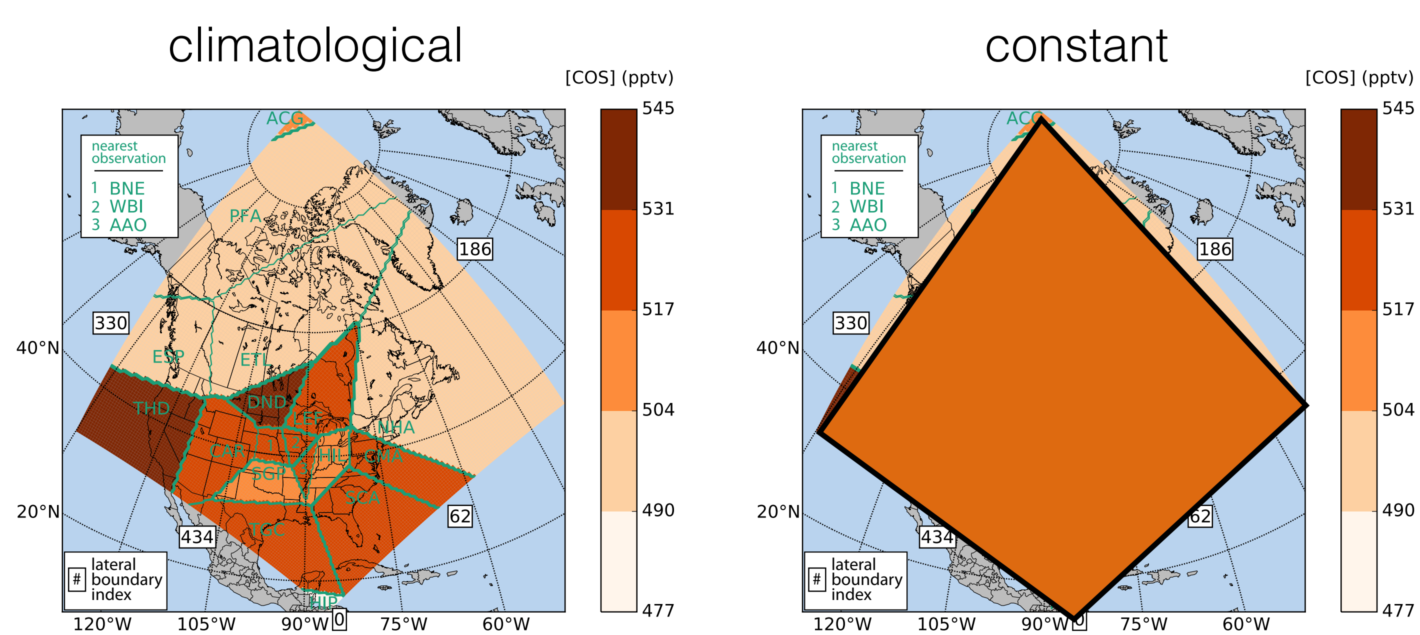
Soils



Anthropogenic

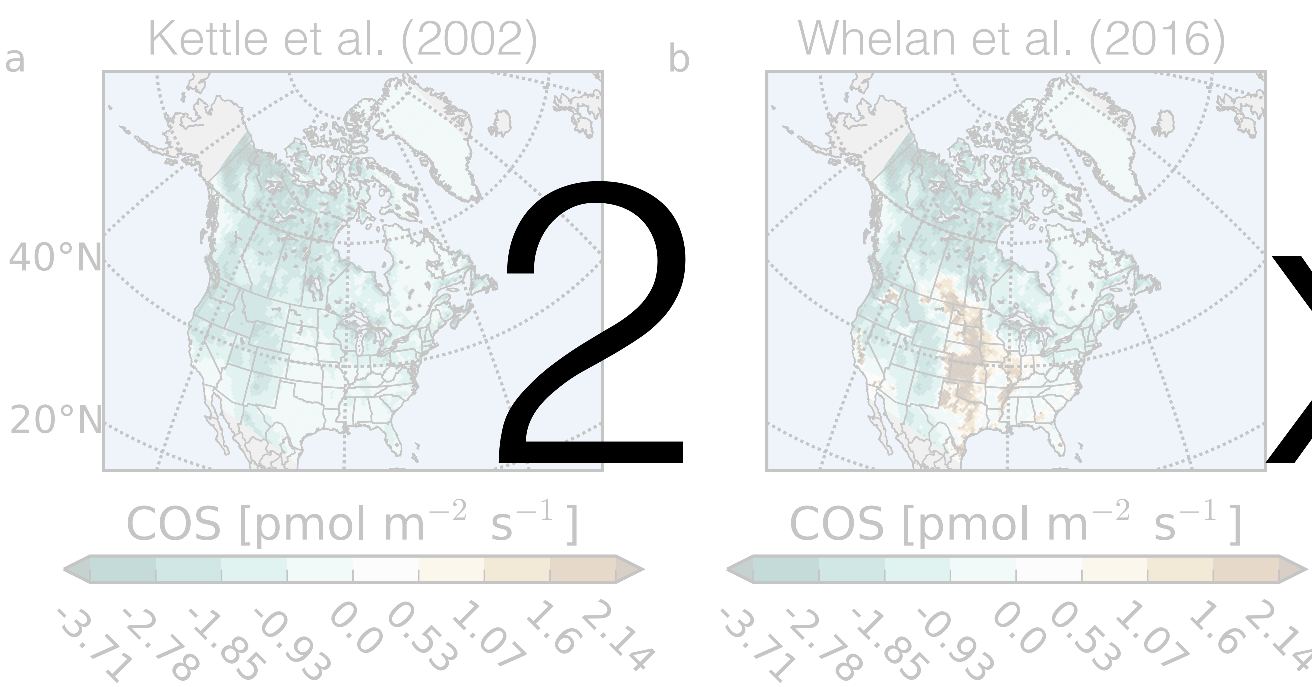


Boundaries

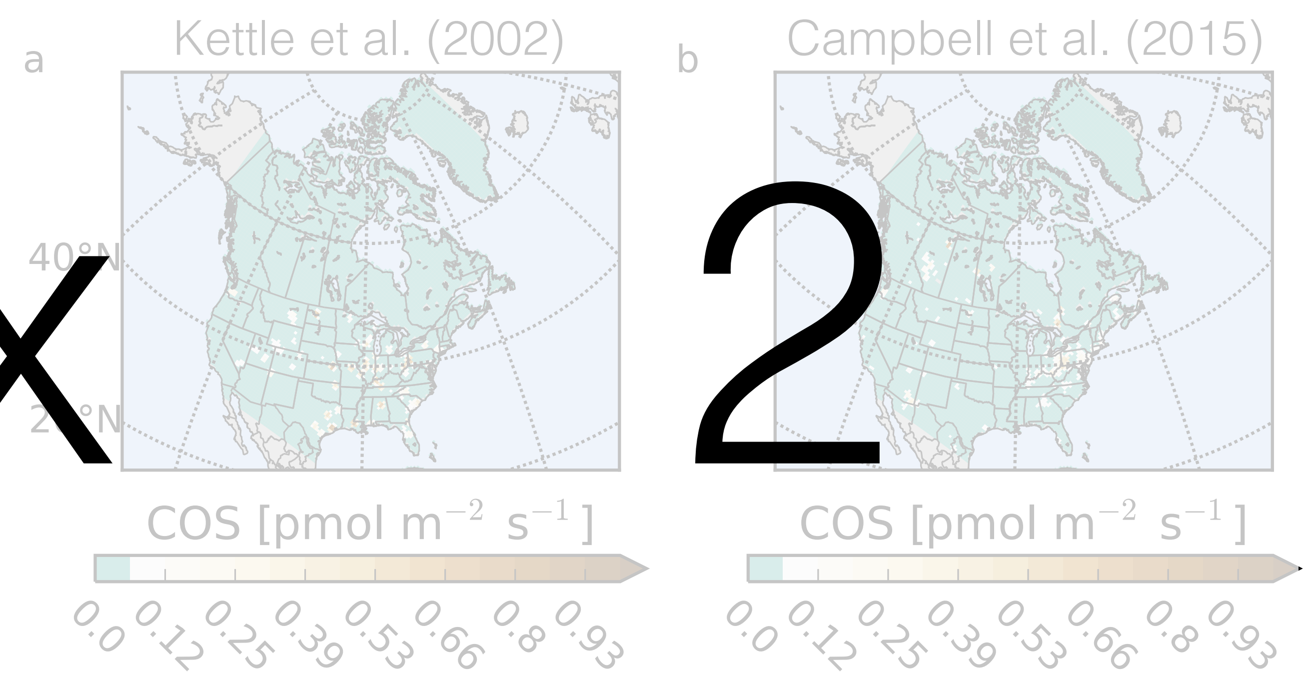


Results I: 2nd-order COS fluxes

Soils

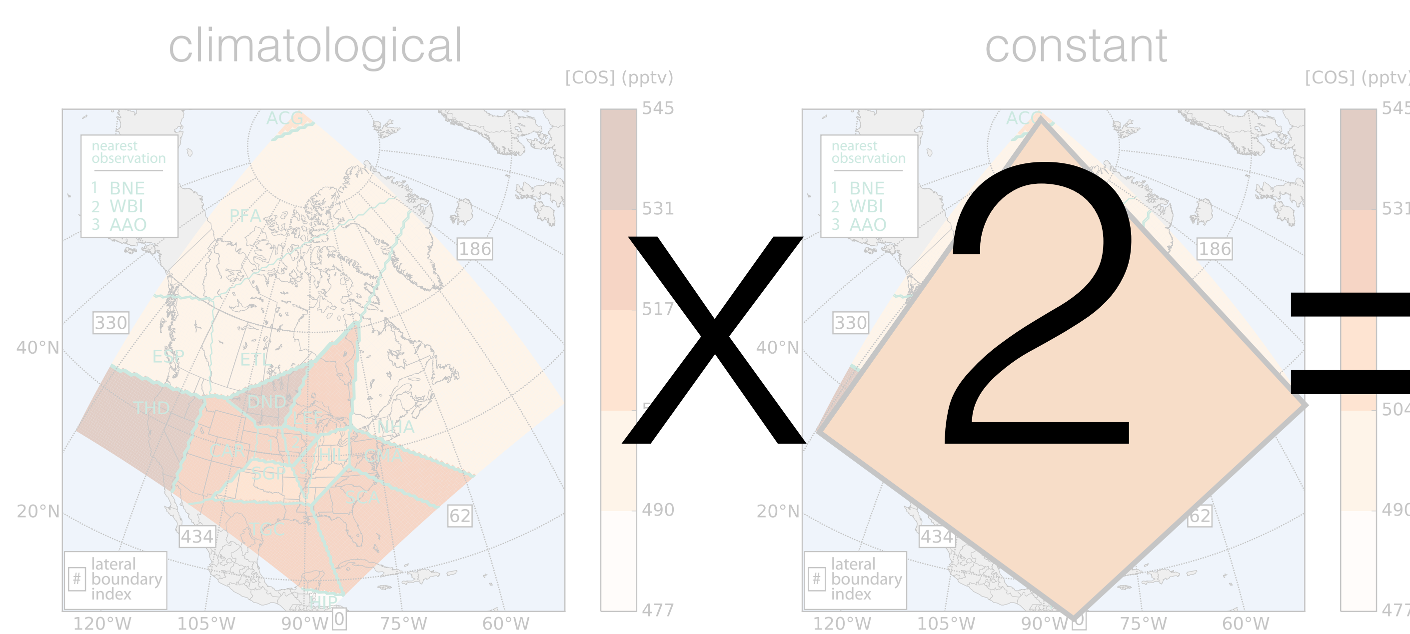


Anthropogenic

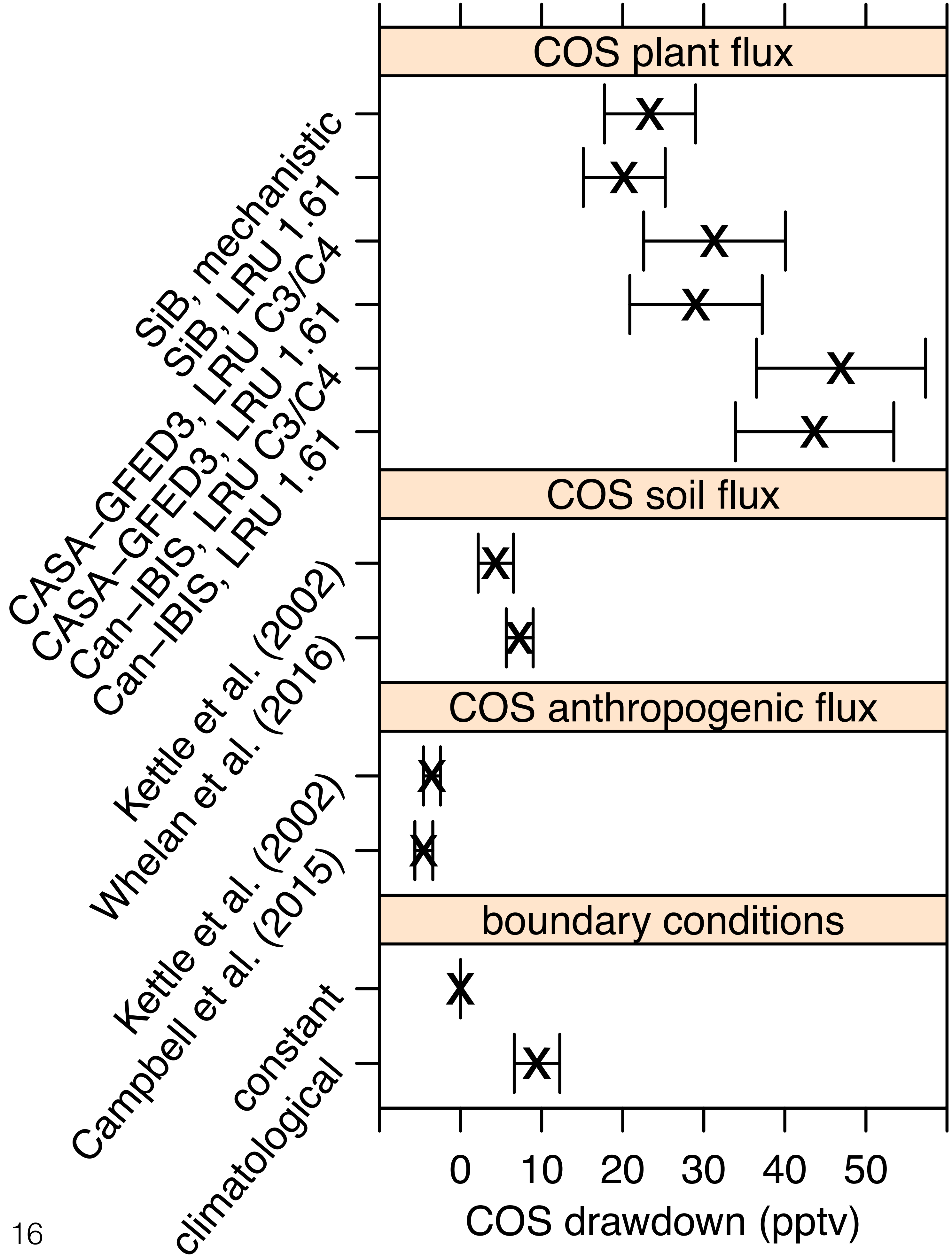


2 x 2

Boundaries



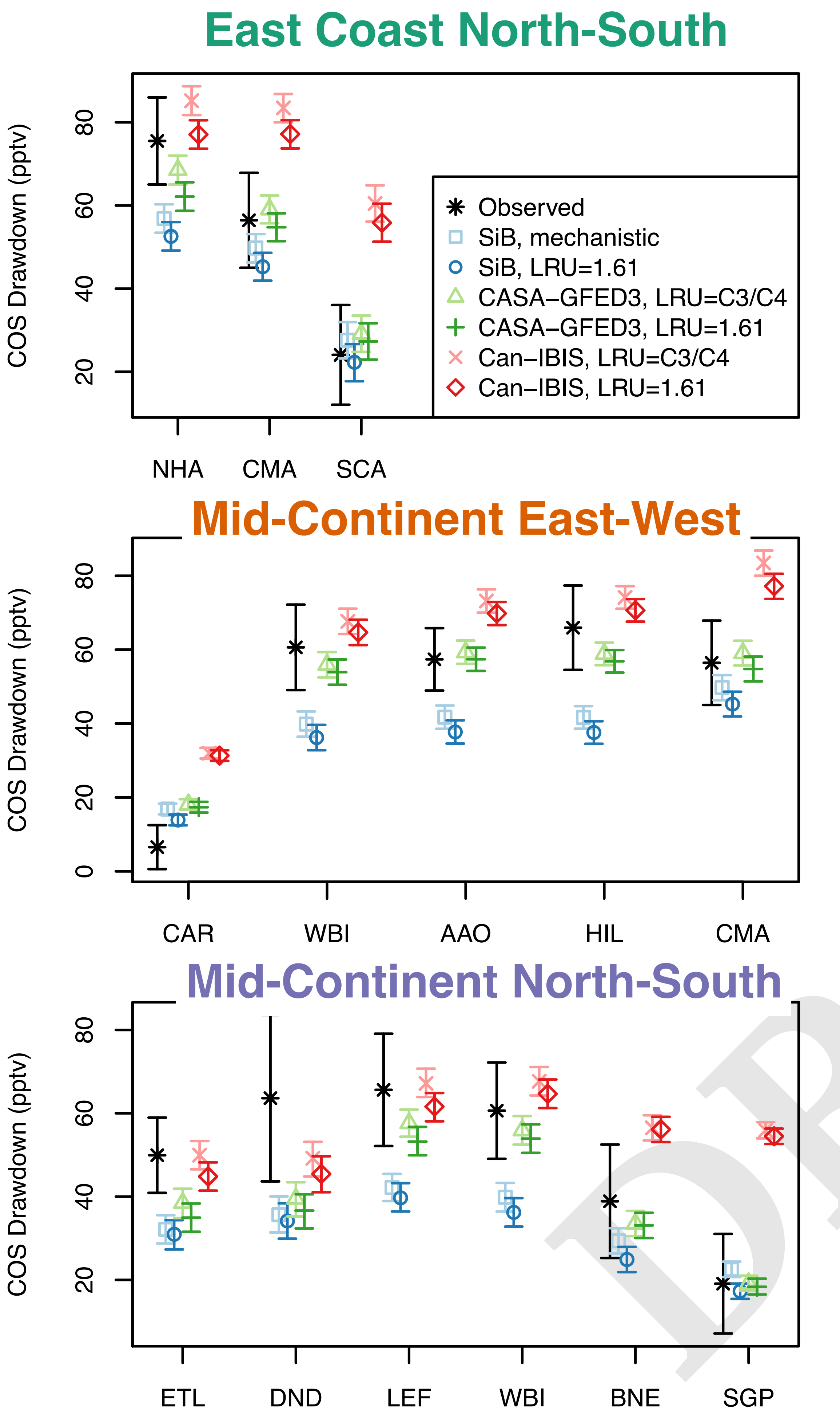
x 2 = 8

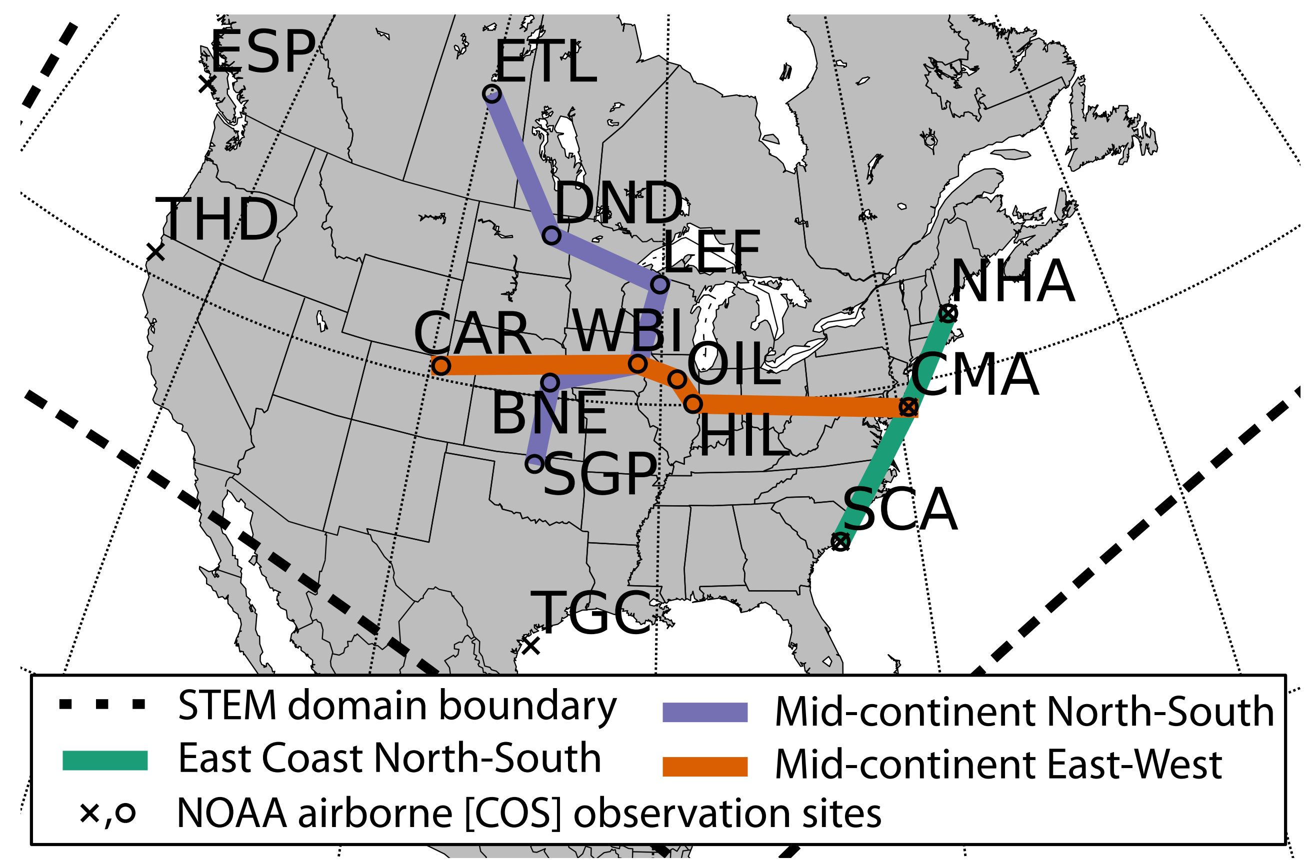


Results II: [COS] variability

drawdown variability drivers:
GPP >> [soils, anthropogenic, bounds, leaf model]

Results III: spatial diagnosis





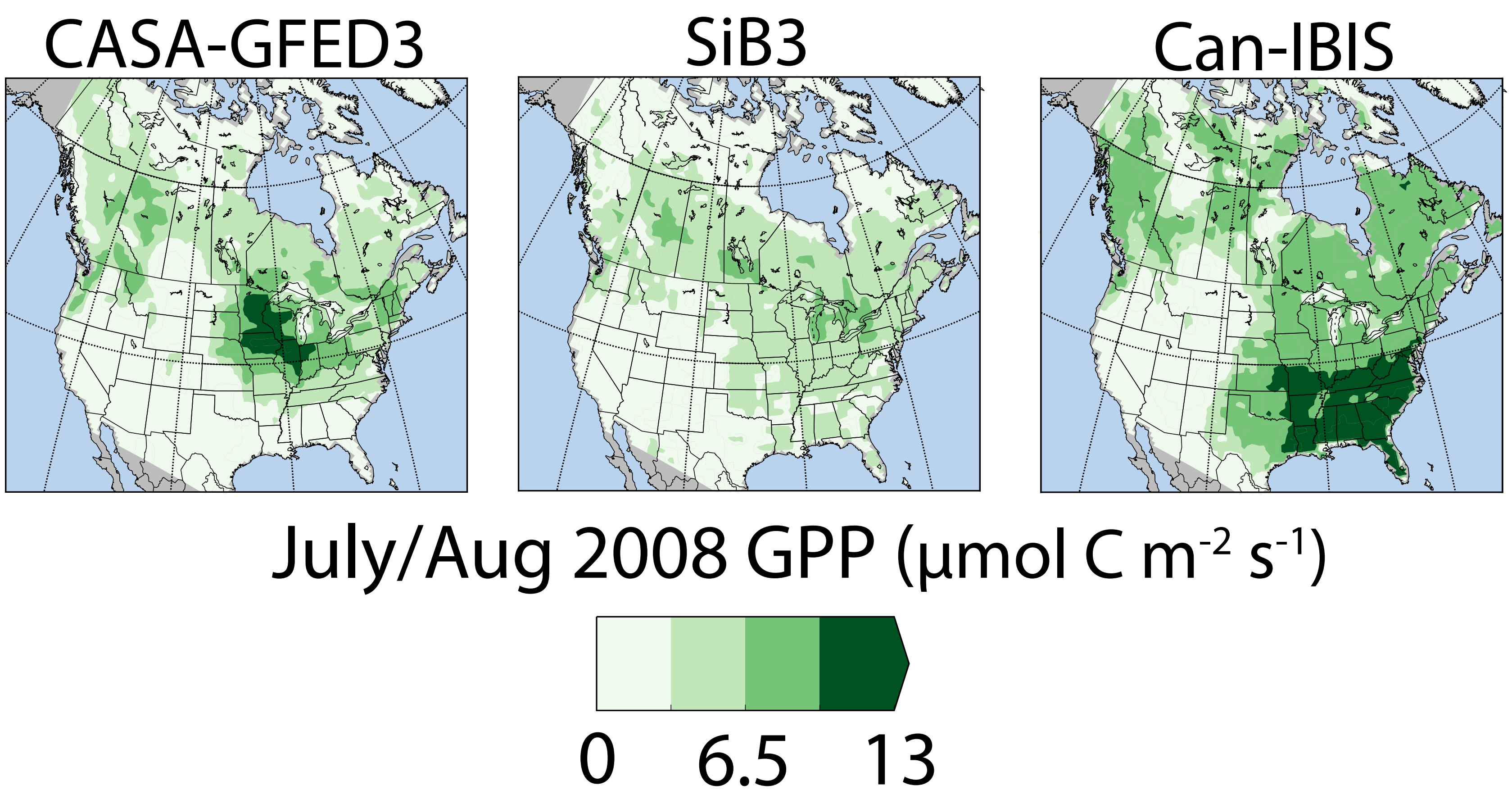
Reserve Slides

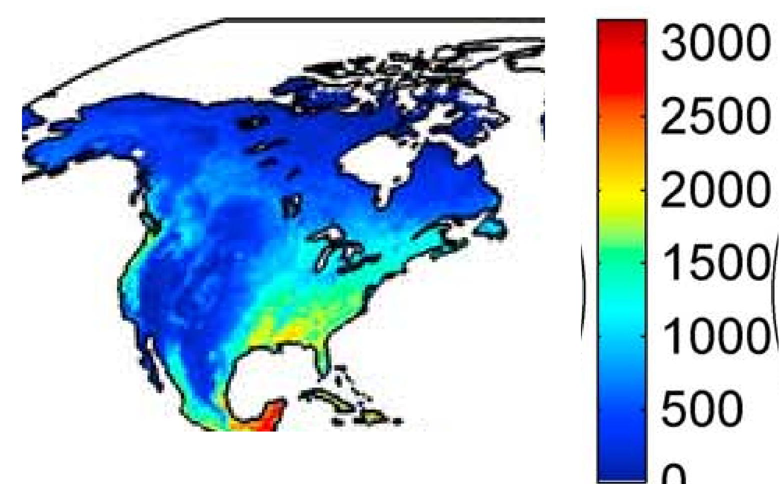
Prediction is very difficult, ~~especially~~ even about the ~~future~~ past.

- some of us here in this room, among others

GPP was Northerly/ Midwestern!

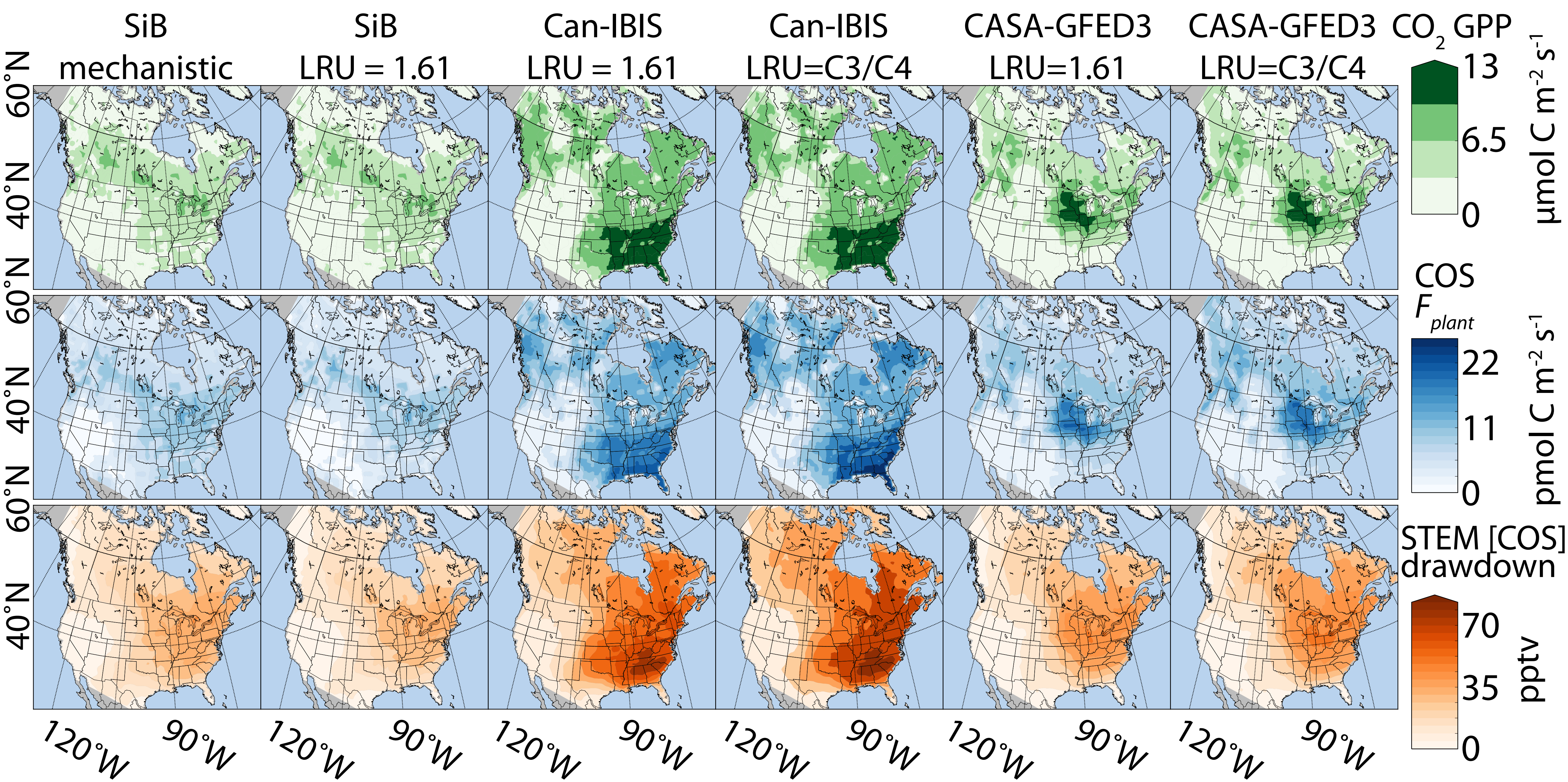
No, GPP was southeasterly!



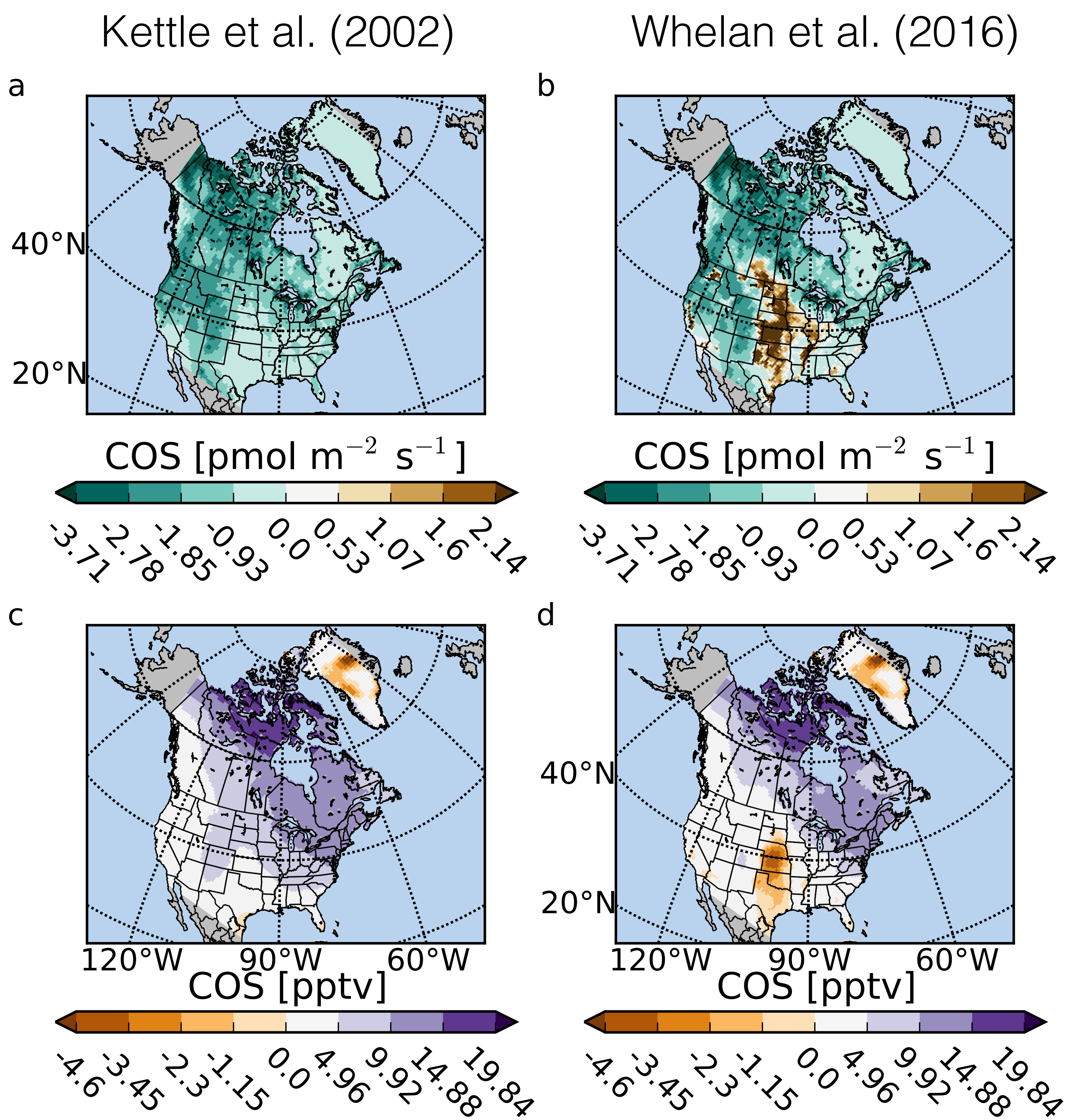


annual mean GPP [gC m^{-2} yr^{-1}]
Jung et al. (2011)

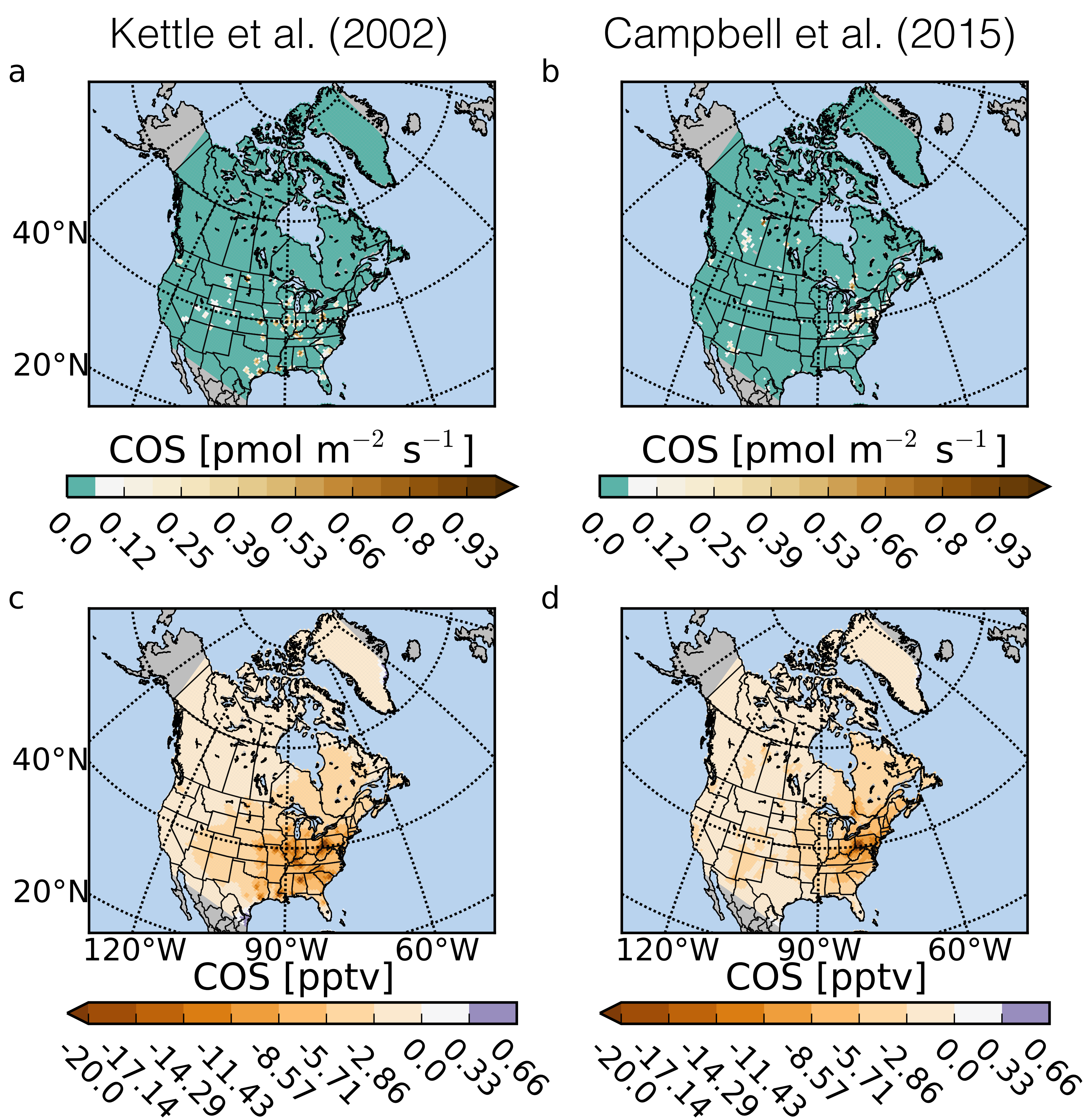
STEM input, results



Soil COS fluxes

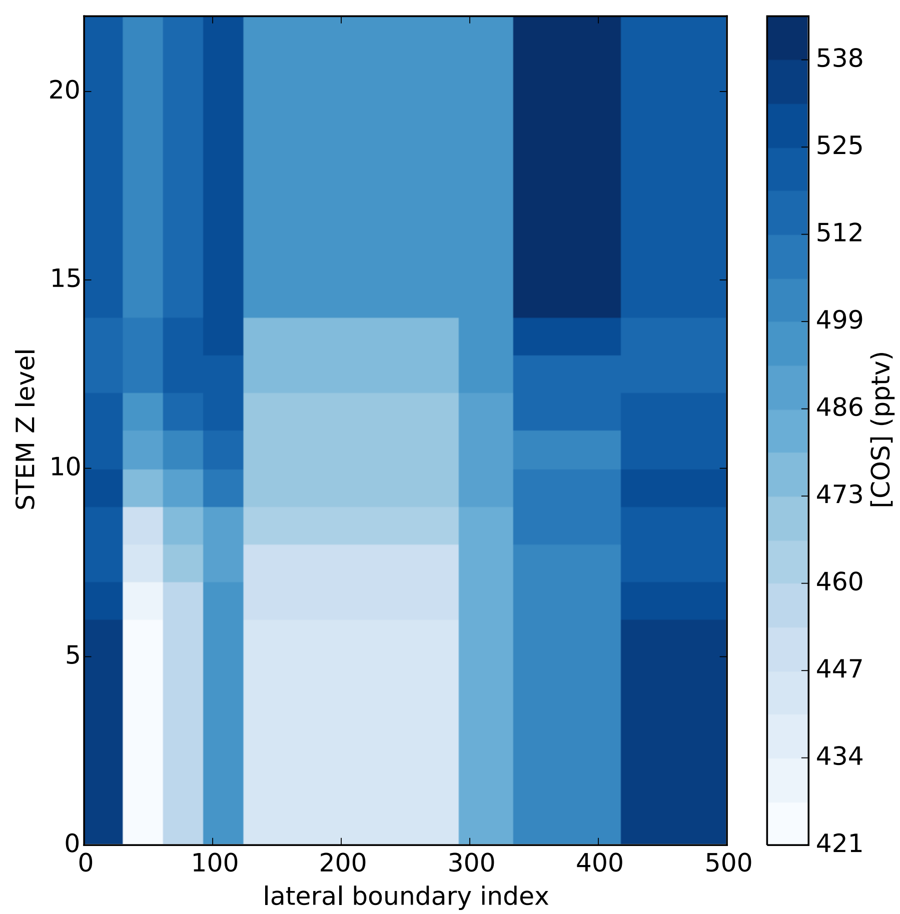


Anthropogenic COS fluxes

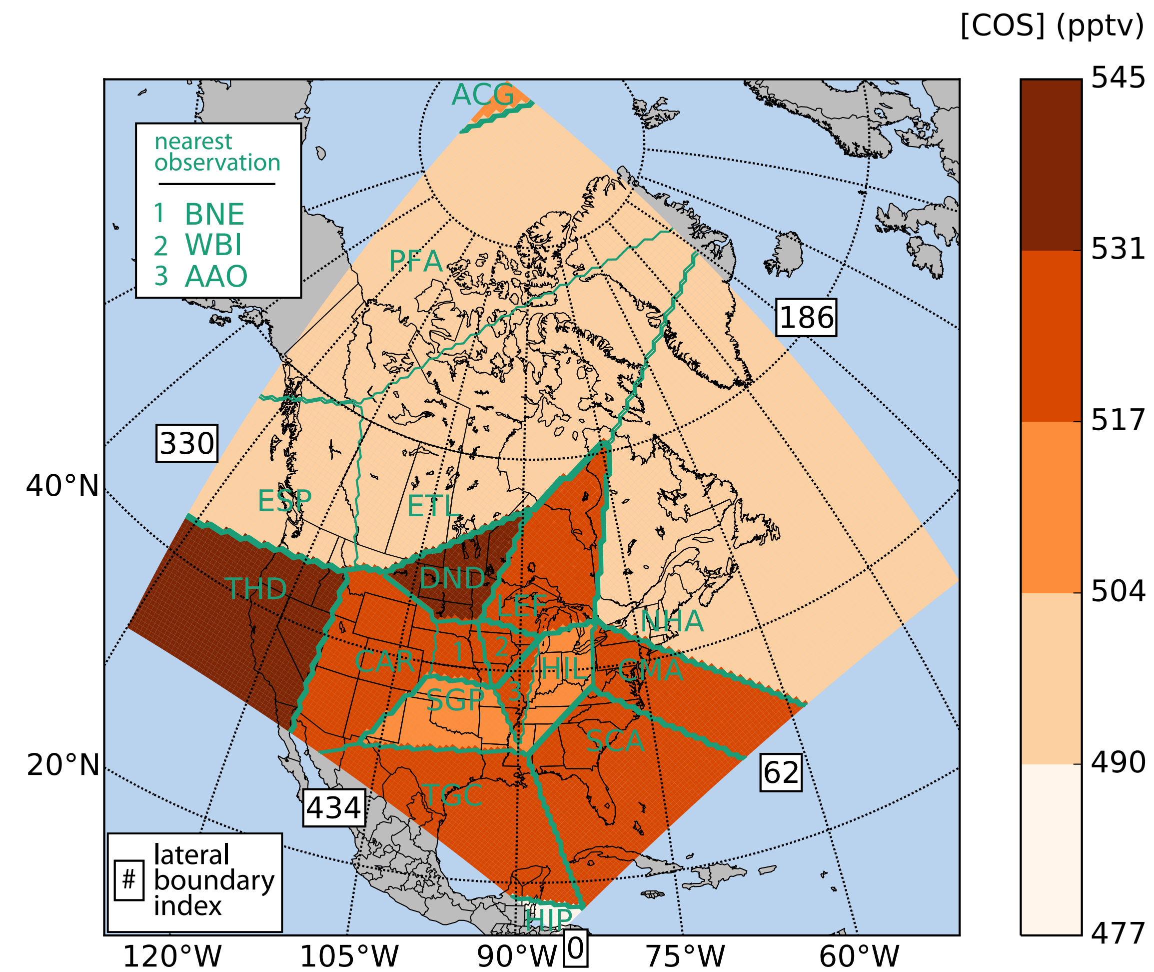


Boundary conditions

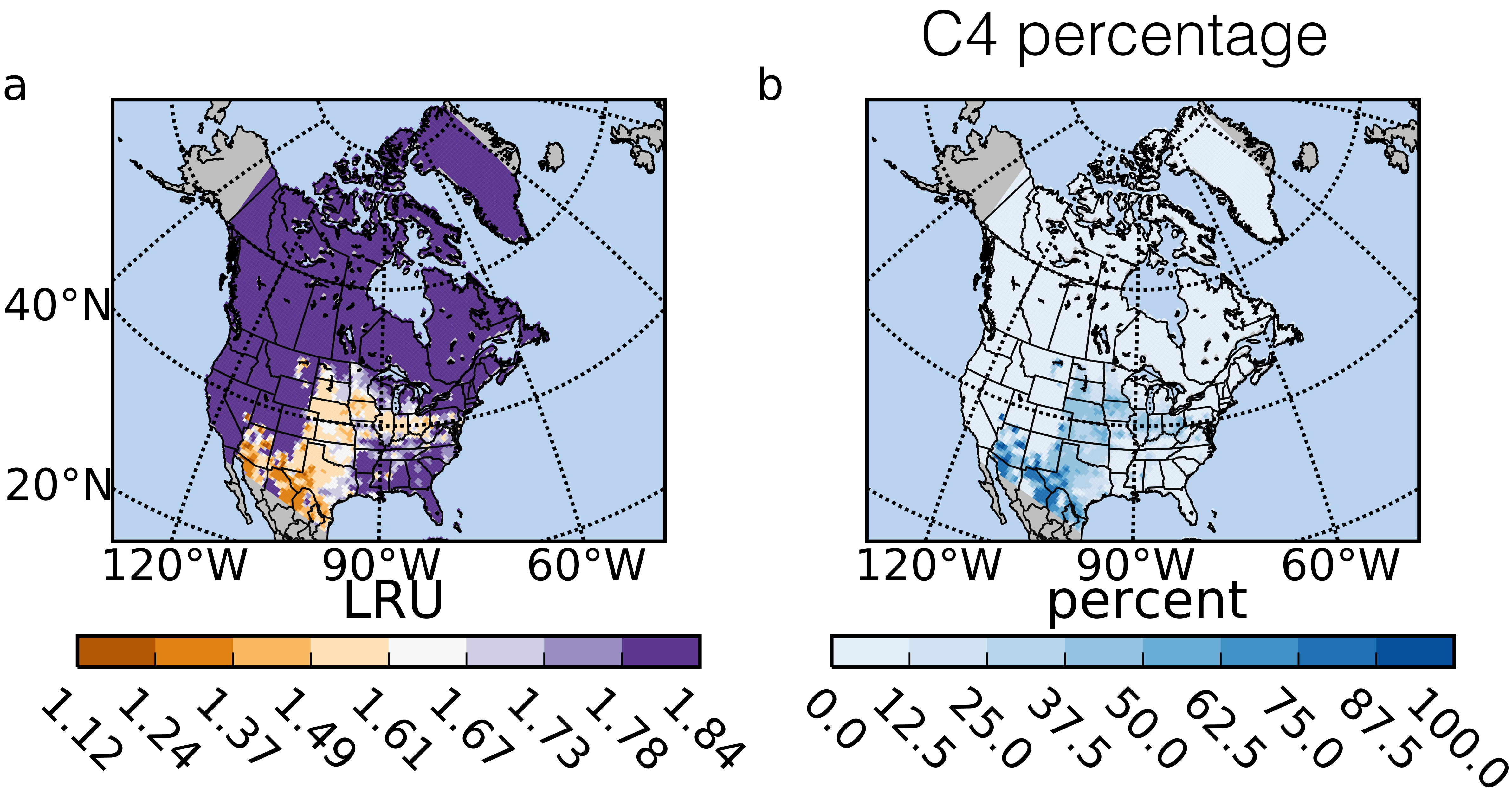
lateral



top



COS-CO_2 LRU



Still et al. (2009)

References

Berry, J., A. Wolf, J. E. Campbell, I. Baker, N. Blake, D. Blake, A. S. Denning, S. R. Kawa, S. A. Montzka, U. Seibt, K. Stimler, D. Yakir, and Z. Zhu (2013), A coupled model of the global cycles of carbonyl sulfide and CO2: A possible new window on the carbon cycle, Journal of Geophysical Research: Biogeosciences, 118(2), 842–852, doi:10.1002/jgrg.20068.

Campbell, J. E., M. E. Whelan, U. Seibt, S. J. Smith, J. A. Berry, and T. W. Hilton (2015), Atmospheric carbonyl sulfide sources from anthropogenic activity: Implications for carbon cycle constraints, Geophysical Research Letters, 42(8), 3004–3010, doi: 10.1002/2015GL063445.

Friedlingstein, P., M. Meinshausen, V. K. Arora, C. D. Jones, A. Anav, S. K. Liddicoat, and R. Knutti (2014), Uncertainties in CMIP5 Climate Projections due to Carbon Cycle Feedbacks, Journal of Climate, 27(2), 511–526, doi:10.1175/JCLI-D-12-00579.1.

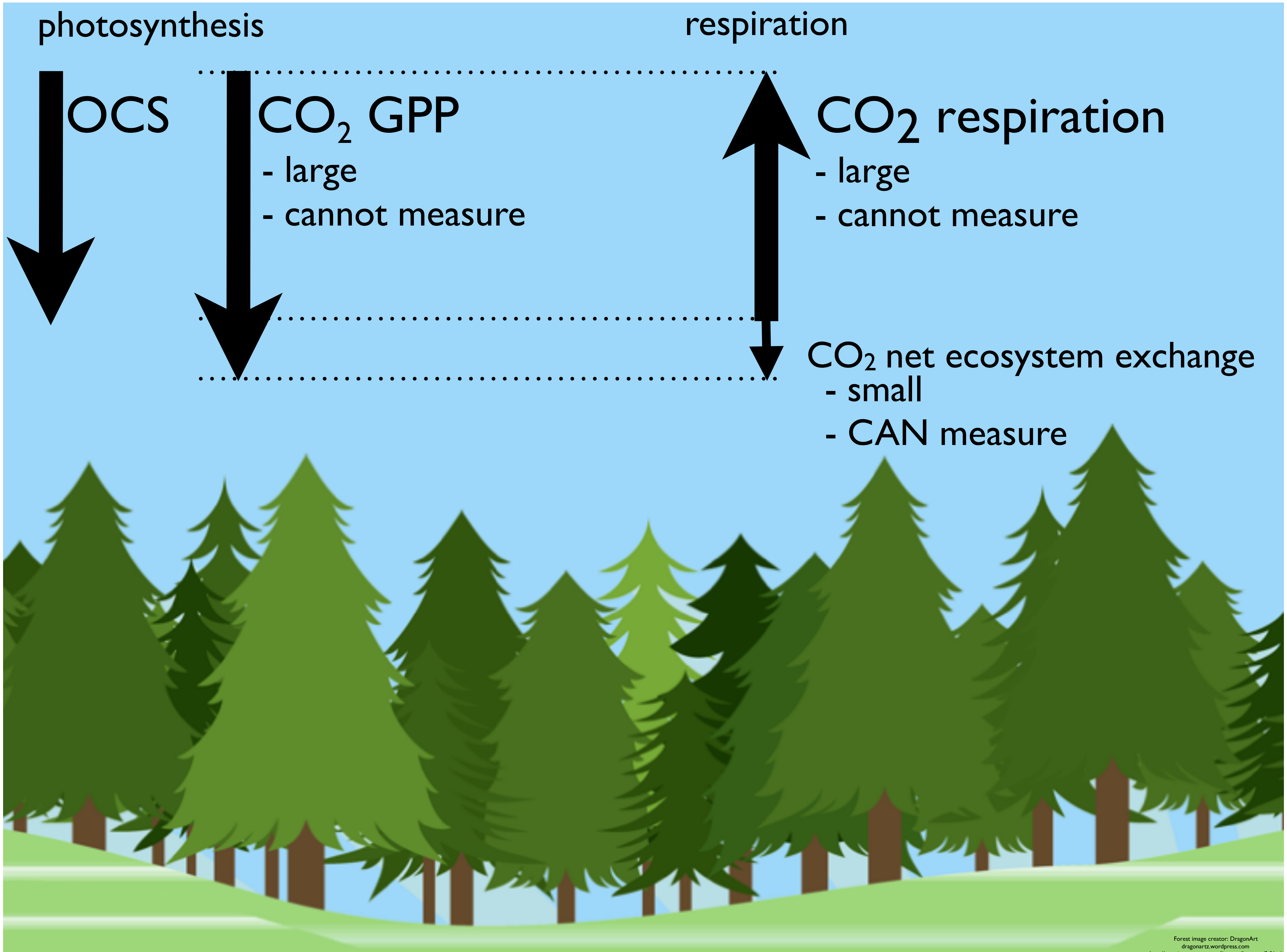
Jung, M., M. Reichstein, H. A. Margolis, A. Cescatti, A. D. Richardson, M. A. Arain, A. Arneth, C. Bernhofer, D. Bonal, J. Chen, D. Gianelle, N. Gobron, G. Kiely, W. Kutsch, G. Lasslop, B. E. Law, A. Lindroth, L. Merbold, L. Montagnani, E. J. Moors, D. Papale, M. Sottocornola, F. Vaccari, and C. Williams (2011), Global patterns of land-atmosphere fluxes of carbon dioxide, latent heat, and sensible heat derived from eddy covariance, satellite, and meteorological observations, Journal of Geophysical Research: Biogeosciences, 116(G3), n/a–n/a, doi:10.1029/2010JG001566.

Kettle, A. J., U. Kuhn, M. von Hobe, J. Kesselmeier, and M. O. Andreae (2002), Global budget of atmospheric carbonyl sulfide: Temporal and spatial variations of the dominant sources and sinks, Journal of Geophysical Research: Atmospheres, 107(D22), ACH 25–1–ACH25–16, doi:10.1029/2002JD002187.

Still, C.J. and J.A. Berry and G.J. Collatz and R.S. DeFries (2009), ISLSCP II C4 Vegetation Percentage, in ISLSCP Initiative II Collection, edited by Hall, Forrest G. and G. Collatz and B. Meeson and S. Los and E. Brown de Colstoun and D. Landis, Oak Ridge National Laboratory, Oak Ridge, Tennessee, U.S.A.

Whelan, M. E., T. W. Hilton, J. A. Berry, M. Berkelhammer, A. R. Desai, and J. E. Campbell (2016), Carbonyl sulfide exchange in soils for better estimates of ecosystem carbon uptake, Atmospheric Chemistry and Physics, 16(6), 3711–3726, doi:10.5194/acp-16-3711-2016.

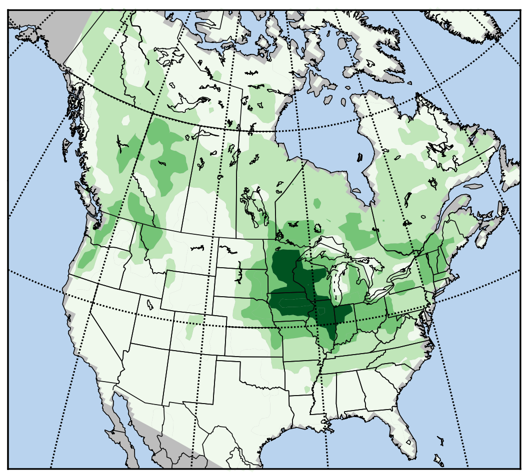
carbonyl sulfide primer



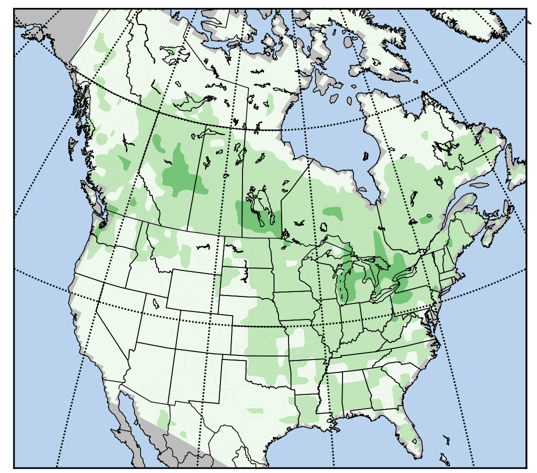
COS exchange models

GPP models

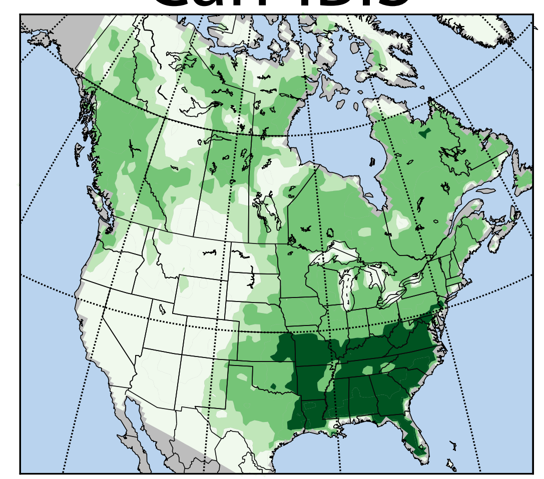
CASA-GFED3



SiB3



Can-IBIS



COS Leaf flux models

mechanistic:

$$F_{plant} = [\mathrm{COS}_a] * [1.94/g_{sw} + 1.56/g_{bw} + 1.0/g_{\mathrm{COS}}]^{-1},$$

Leaf relative uptake (LRU)-based:

$$F_{plant} = GPP * LRU * \frac{[\mathrm{OCS}]}{[\mathrm{CO_2}]}$$

COS exchange models

GPP models

CASA-GFED3 SiB3 Can-IBIS

3 X

COS Leaf flux models

mechanistic:

$$F_{plant} = [\mathrm{COS}_a] * [1.94/g_{sw} + 1.56/g_{bw} + 1.0/g_{\mathrm{COS}}]^{-1}$$

2 = 6

Leaf relative uptake (LRU)-based:

$$F_{plant} = GPP * LRU * \frac{[\mathrm{OCS}]}{[\mathrm{CO_2}]}$$