# Simulating the global distribution of $\Delta^{17}O$ in $CO_2$

Linda Schneider
Wouter Peters & Ivar van der Velde & Magdalena Hofmann

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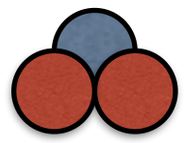
- The global budget of $\Delta^{17}O$ in $CO_2$
- Simulations with TM5+SIBCASA
- Future plans

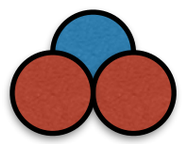
# Isotopes of $CO_2$

98.7%

$^{12}CO_2$

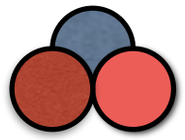


$^{13}CO_2$



1.1%

$C^{17}OO$



$C^{18}OO$

0.04%

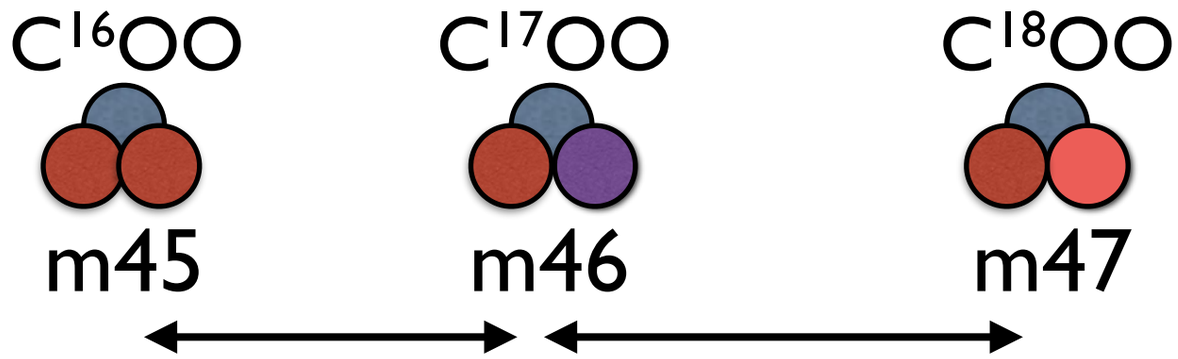
0.2%

# Isotopes of $CO_2$


- The $^{17,18}O$ isotopic composition of $CO_2$ is mainly controlled by $H_2O$ because of its abundance
- Most contact between water and $CO_2$ occurs inside leave stomata, and a bit less in ocean and soils
- This makes their interpretation very complex: one needs a full water-cycle isotope model including vegetation, soils, and atmosphere
- However, a recent discovery has sparked excitement…

**Triple-isotope composition of atmospheric oxygen as a tracer of biosphere productivity**

Boaz Luz*, Eugeni Barkan*, Michael L. Bender†, Mark H. Thiemens‡ & Kristie A. Boering§




- Because most physical processes discriminate depending on mass of a molecule, the relative abundance of $^{16}O$, $^{17}O$ and $^{18}O$ in $H_2O$ and $CO_2$ follows a fixed ratio

$$\Delta^{17}O = \ln(\delta^{17}O+1)-\lambda \ln(\delta^{18}O+1)$$

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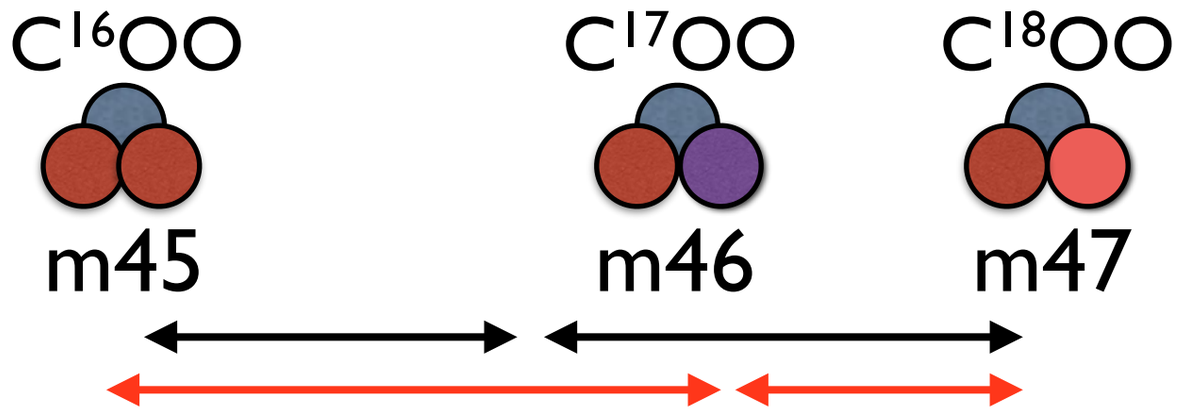
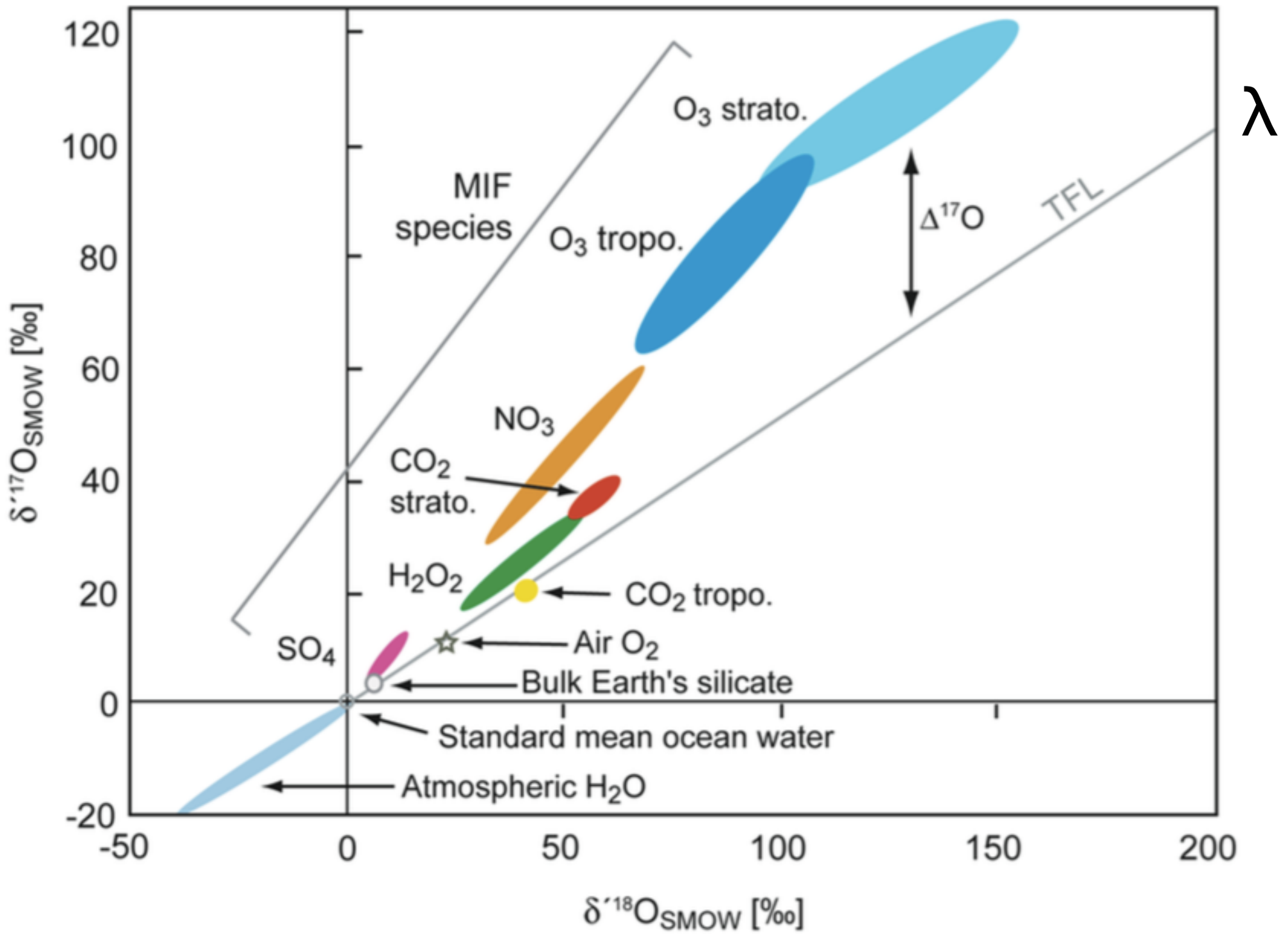



- Because most physical processes discriminate depending on mass of a molecule, the relative abundance of $^{16}O$, $^{17}O$ and $^{18}O$ in $H_2O$ and $CO_2$ follows a fixed ratio
- But in the stratosphere (>12km), a chemical reaction involving $O_3$ discriminates *independent* of mass, giving an 'excess' of $C^{17}OO$ relative to the expected fixed ratio

$$\Delta^{17}O = \ln(\delta^{17}O+1)-\lambda \ln(\delta^{18}O+1)$$




λ

Thiemens et al., 2006

# Unexpected variations in the triple oxygen isotope composition of stratospheric carbon dioxide

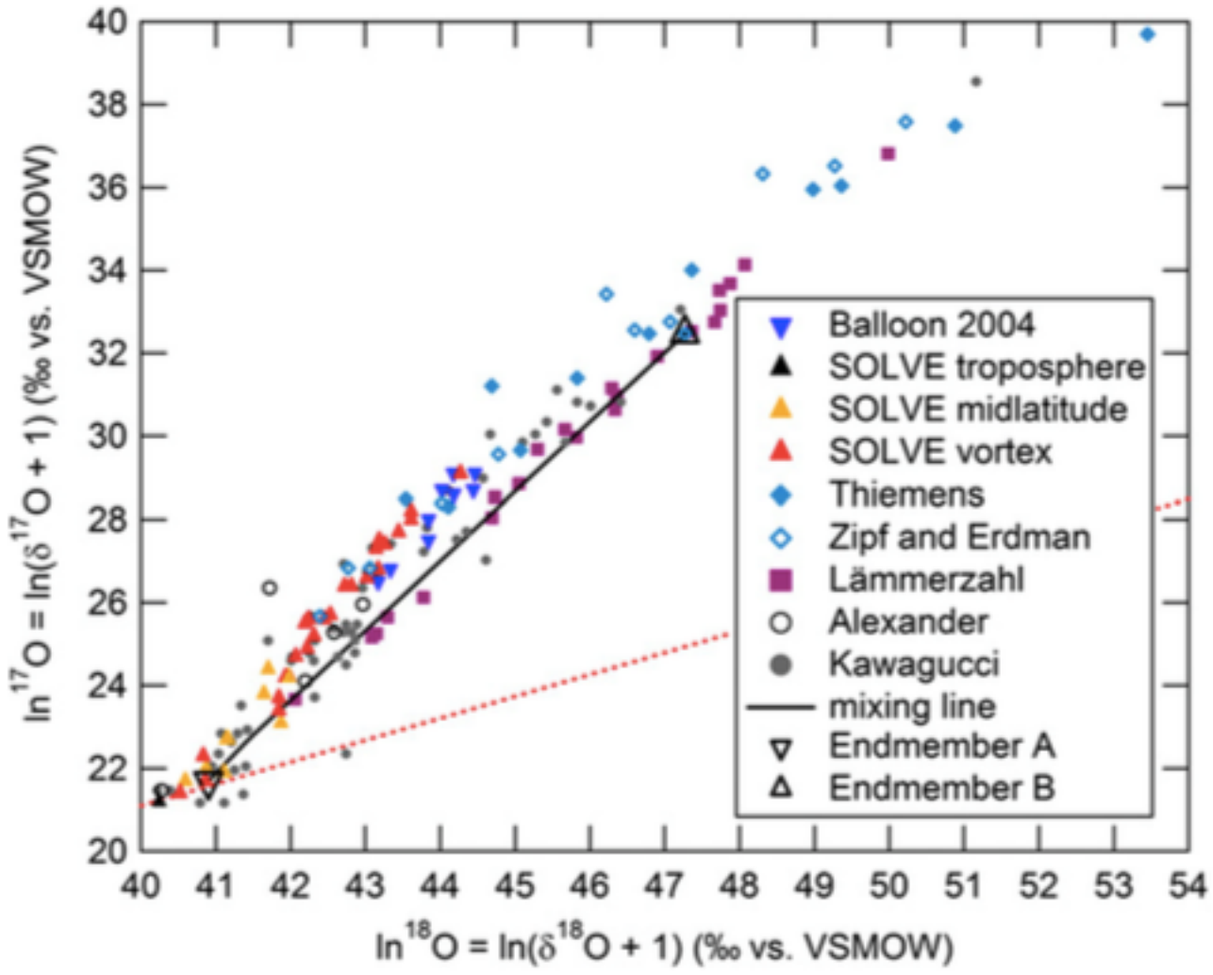
**Aaron A. Wiegel[a], Amanda S. Cole[a,1], Katherine J. Hoag[b,2], Elliot L. Atlas[c], Sue M. Schauffler[d], and Kristie A. Boering[a,b,3]**

Departments of [a]Chemistry and [b]Earth and Planetary Science, University of California, Berkeley, CA 94720; [c]Division of Marine and Atmospheric Chemistry, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL 33149; and [d]Earth Observing Laboratory, National Center for Atmospheric Research, Boulder, CO 80307

Edited by Mark H. Thiemens, University of California, San Diego, La Jolla, CA, and approved July 16, 2013 (received for review February 26, 2013)

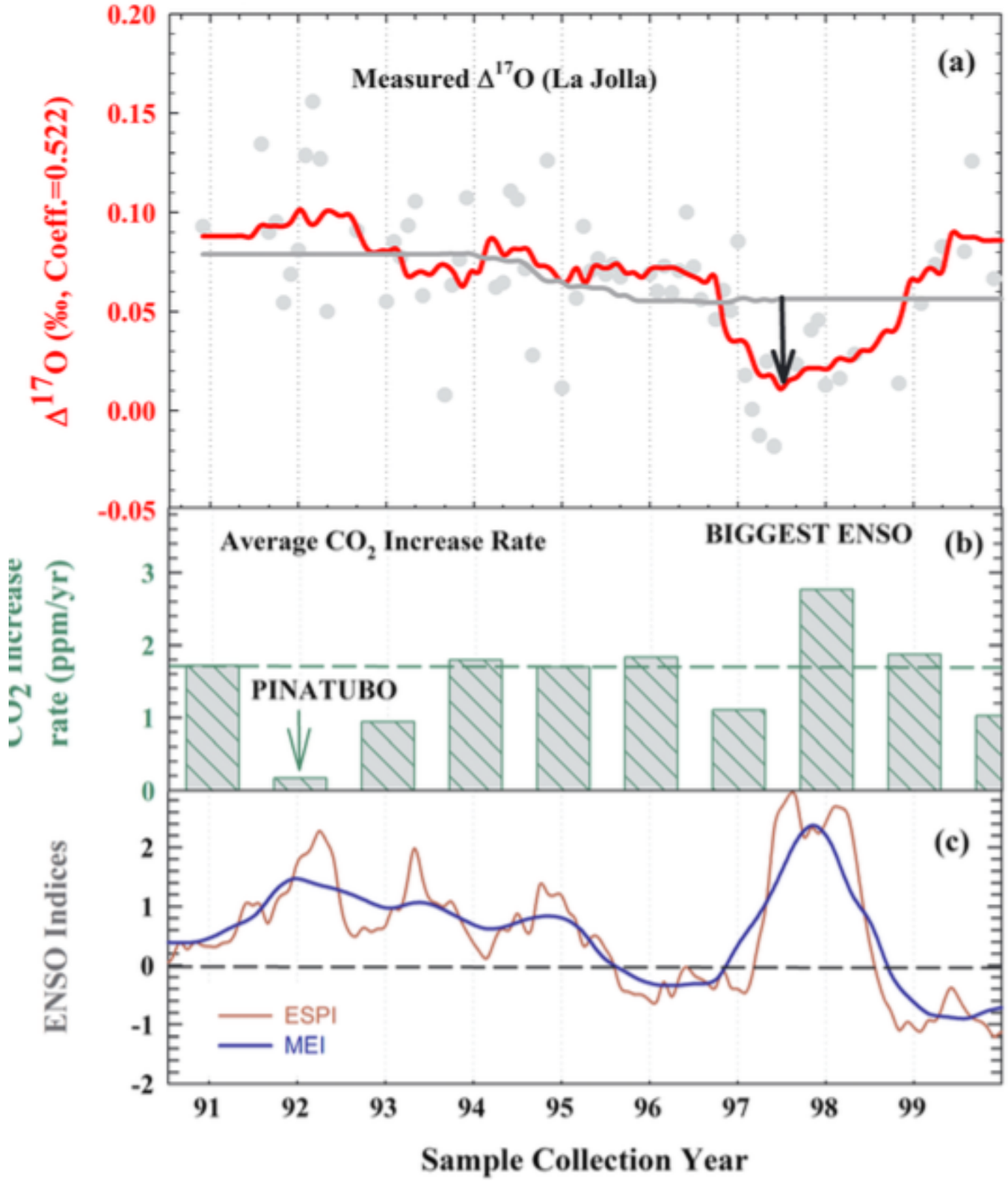
$$O_3 + h\nu \rightarrow O(^1D) + O_2(^1\Delta), \qquad [2]$$

$$O(^1D) + CO_2 \rightarrow CO_3^* \rightarrow O(^3P) + CO_2, \qquad [3a]$$



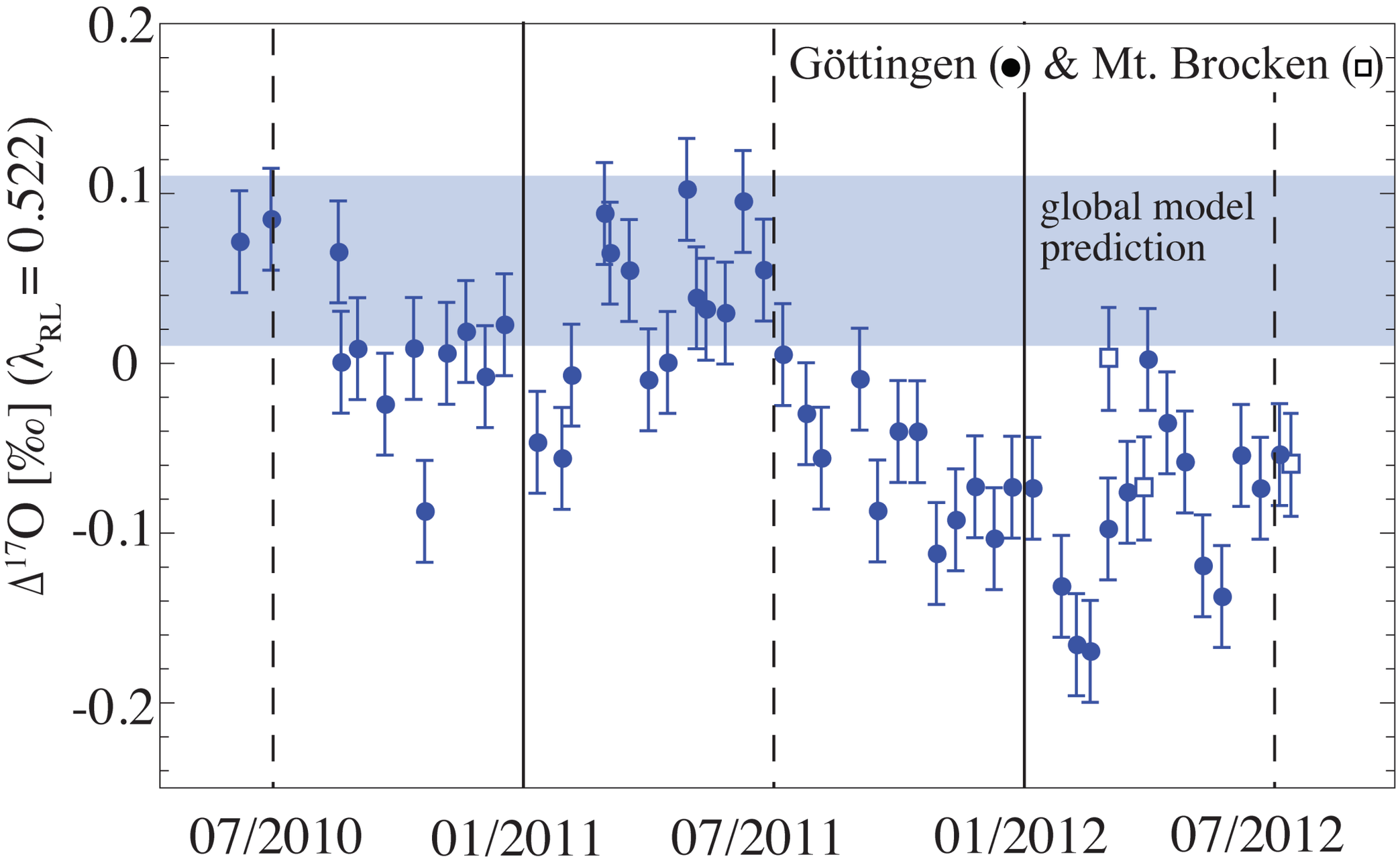

$$\Delta^{17}O = \ln(\delta^{17}O+1) - \lambda \ln(\delta^{18}O+1)$$

# Measurements




Thiemens et al., 2014

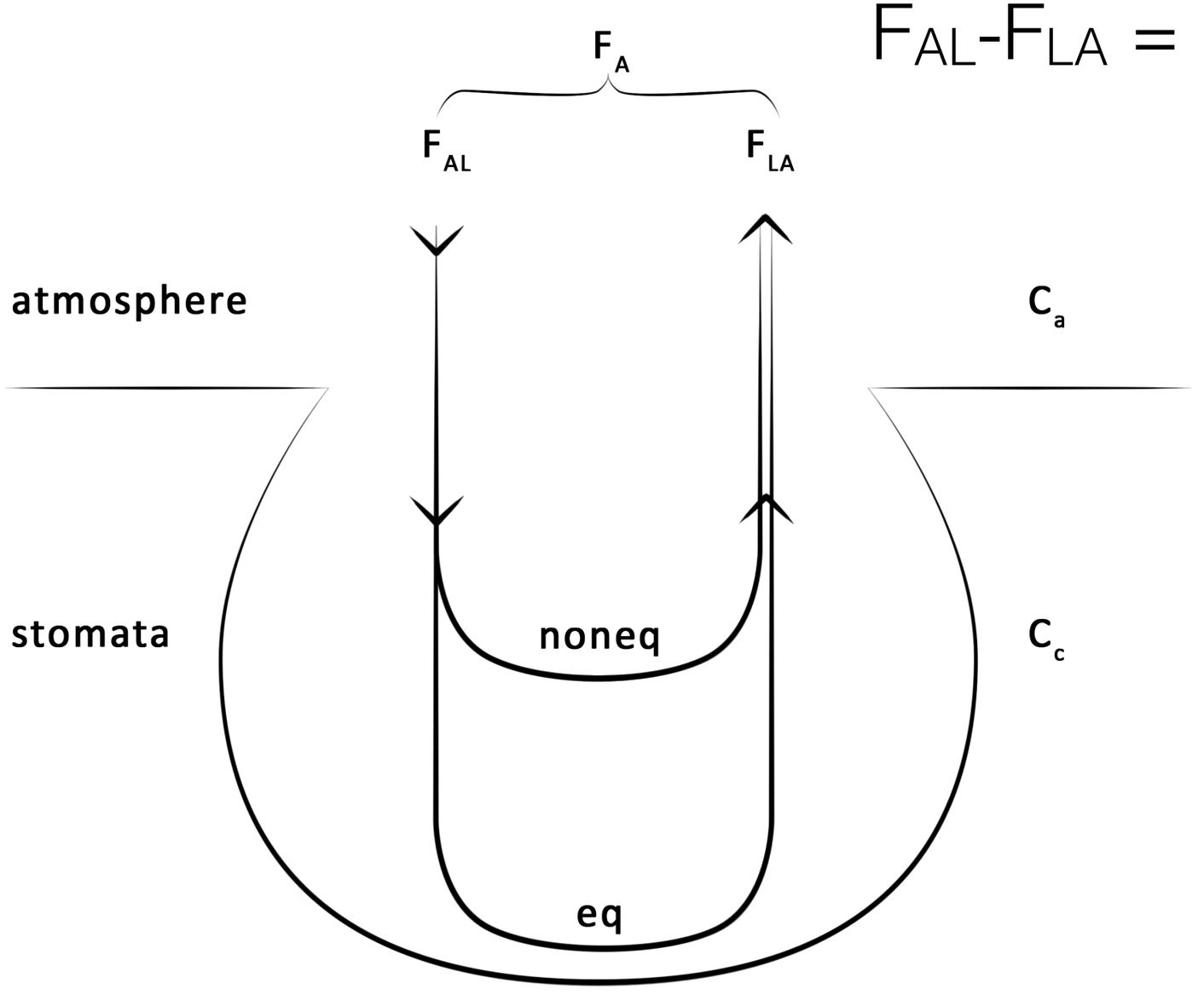
# Measurements



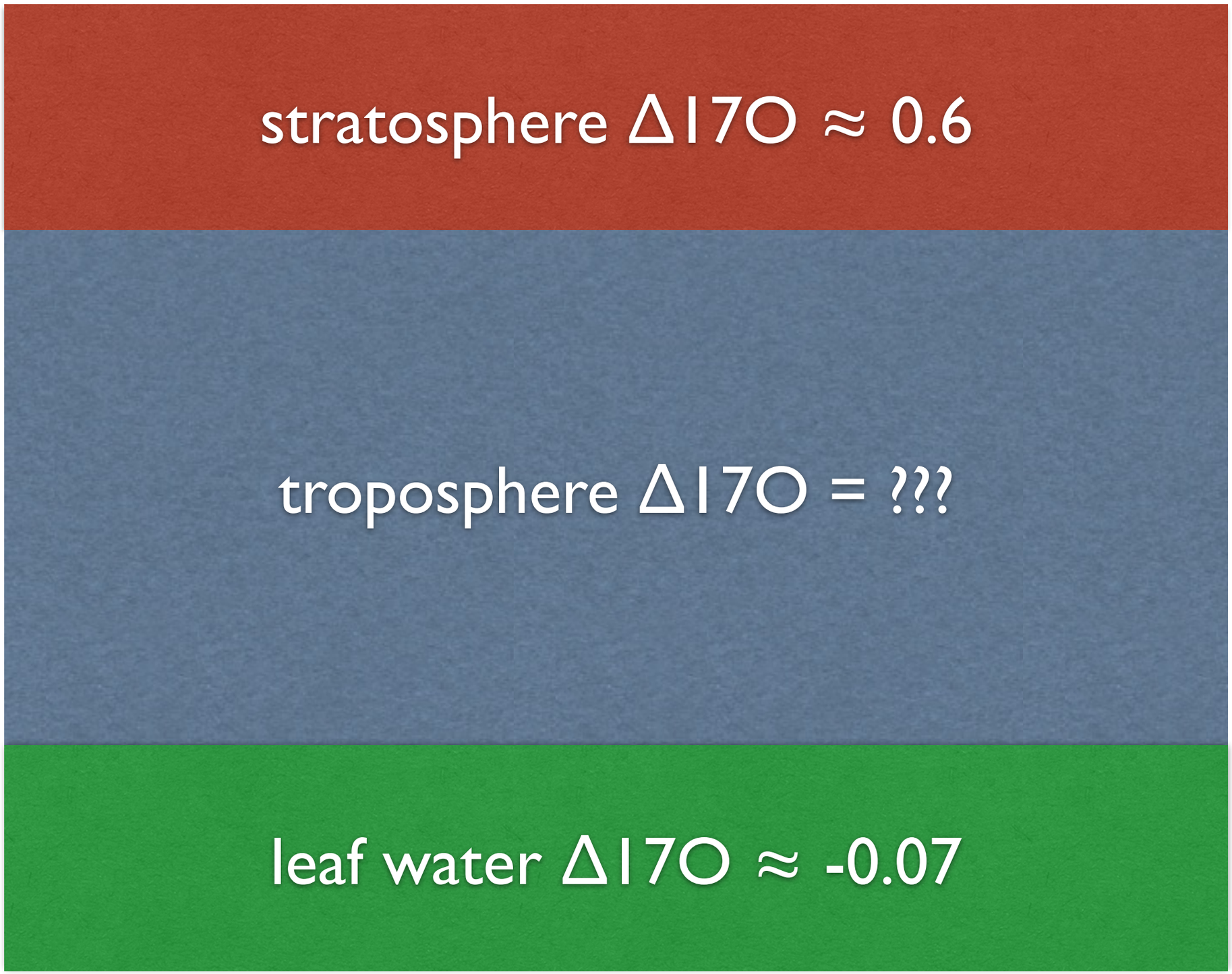

Hofmann et al., 2012

# Δ17O surface sink

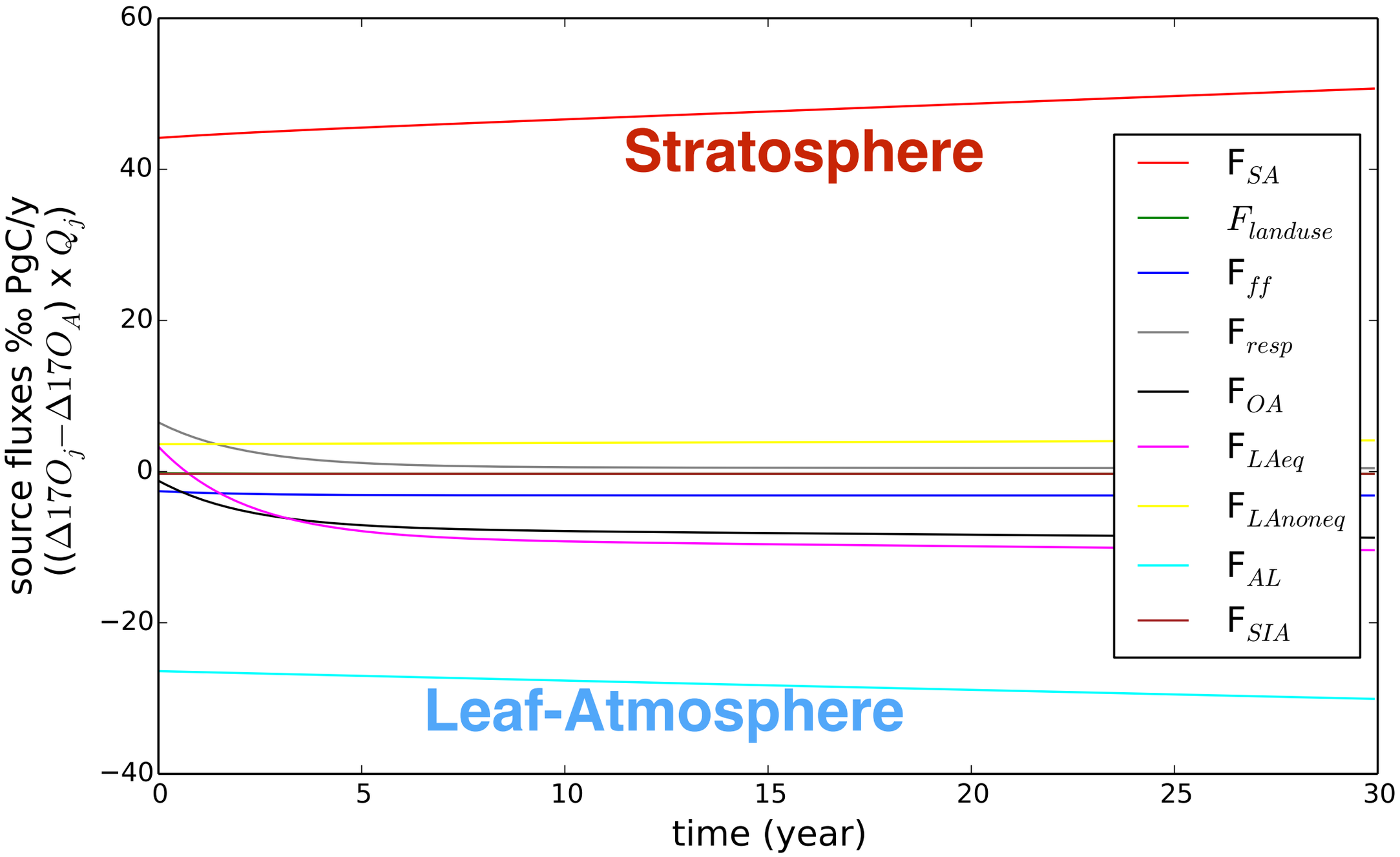
$F_{AL}$-$F_{LA}$ = GPP



# Two global box models: Hoag (2005), Hofmann (2012)



# Modeling the tropospheric $\Delta^{17}O$



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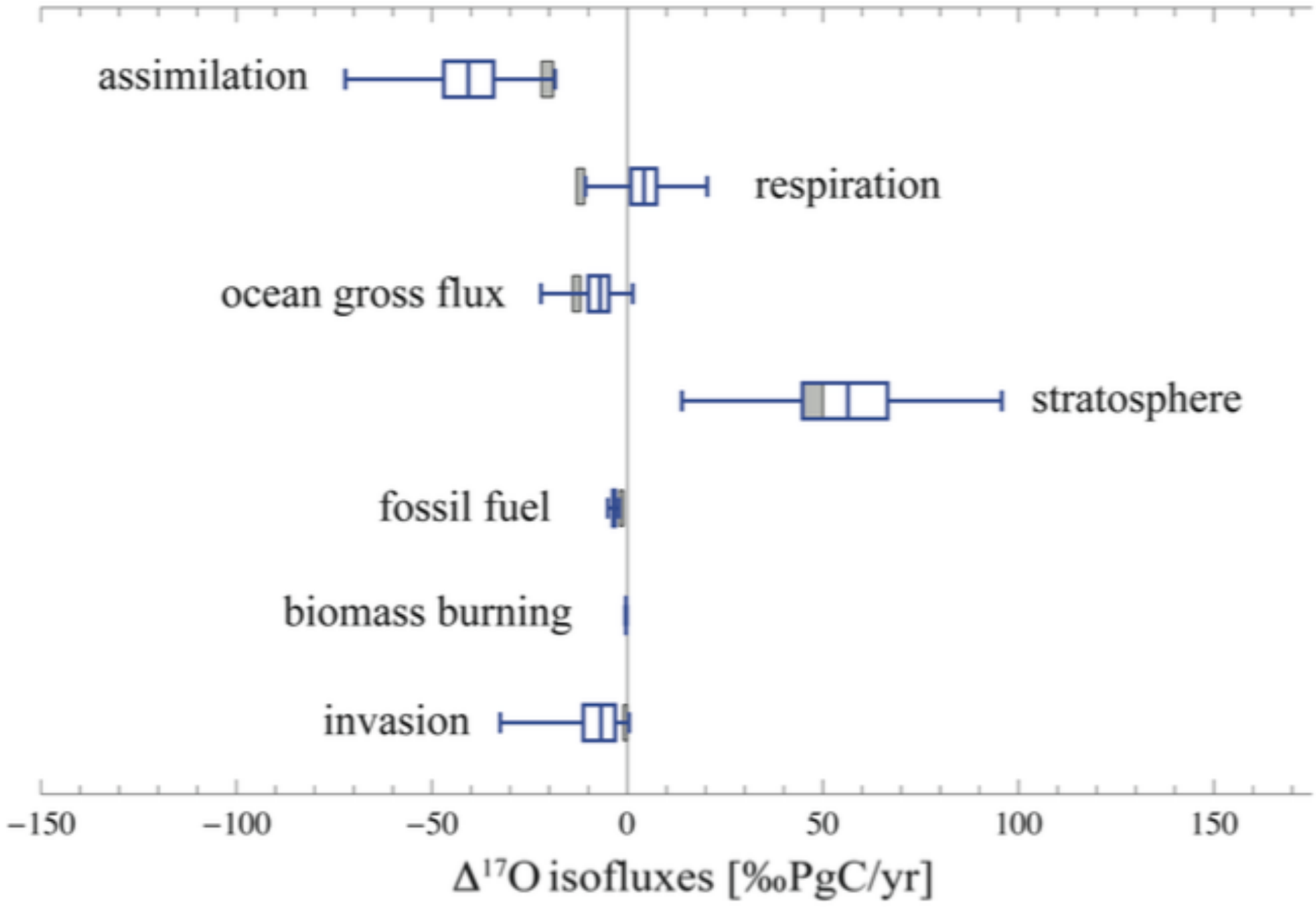
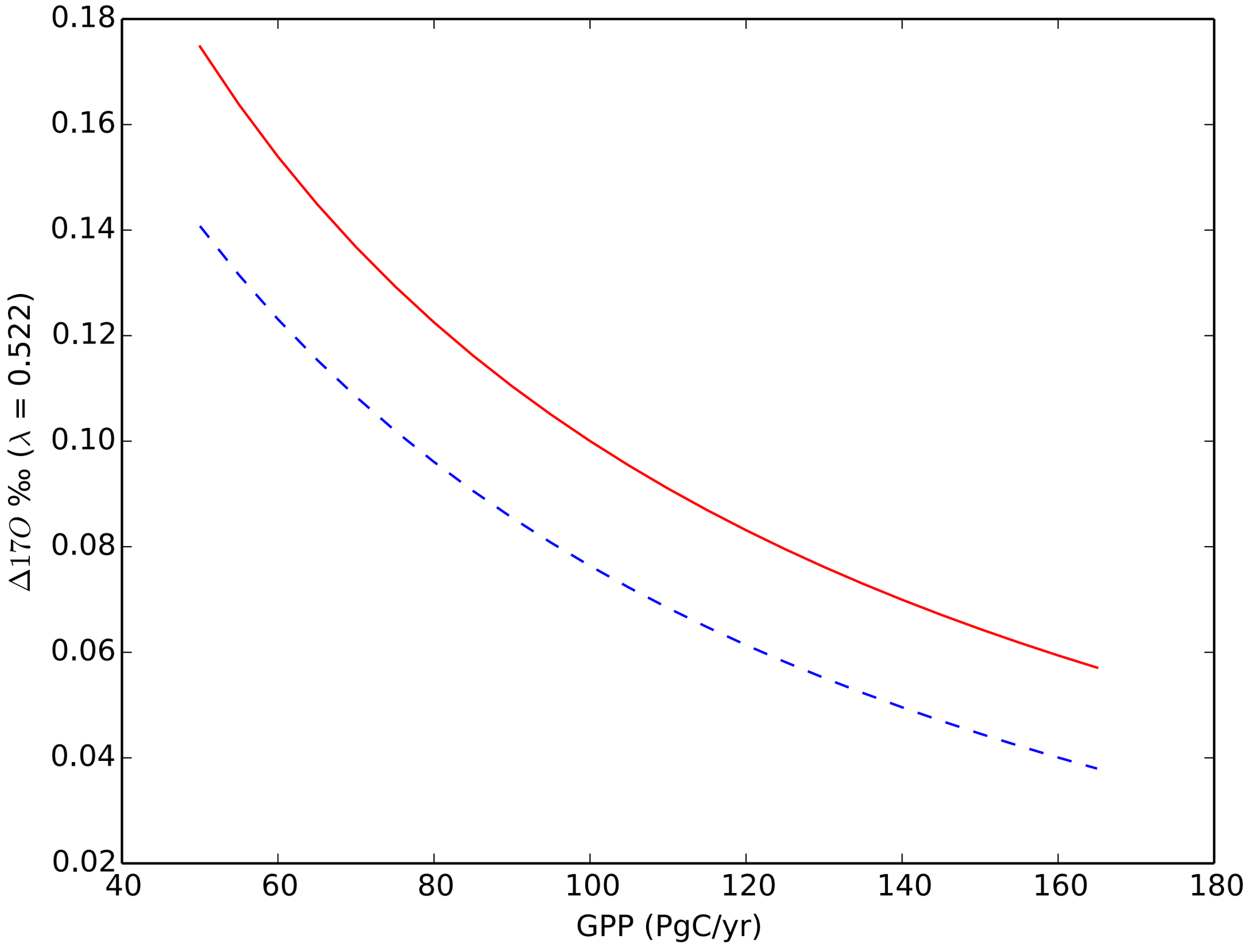
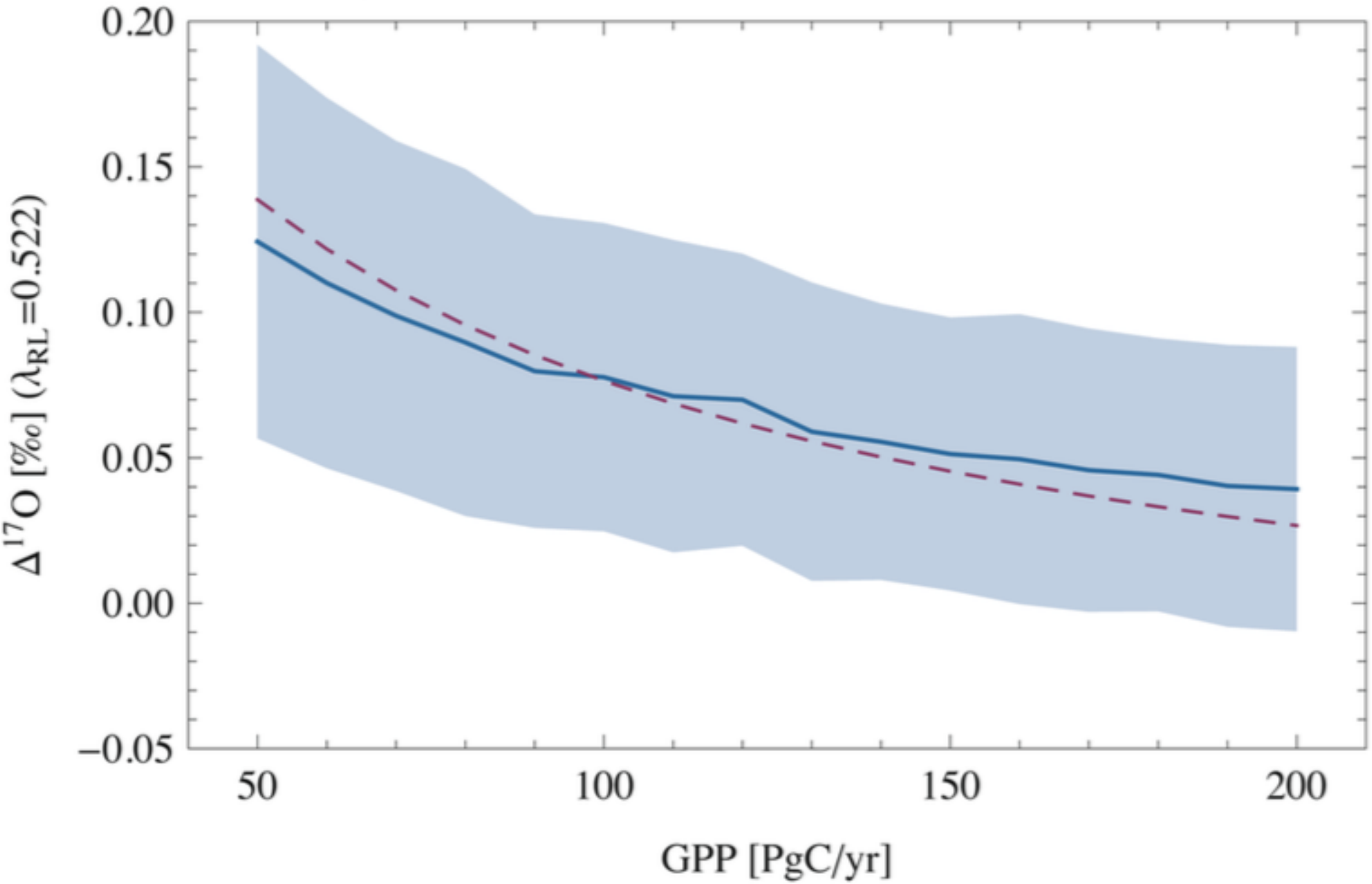


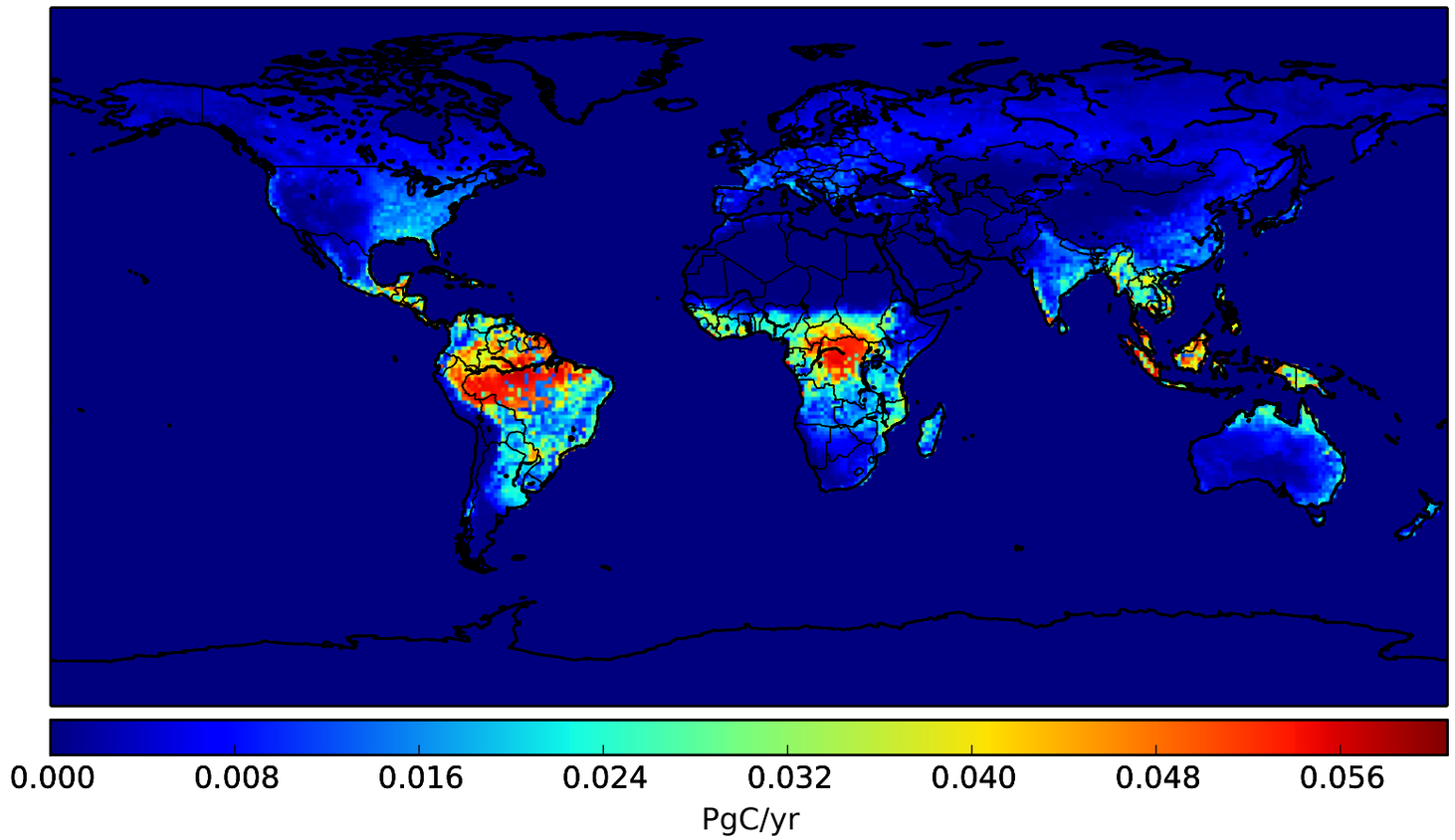



Linda's thesis work




Hofmann 2012

# Tropospheric Δ17O with TM5 & SIBCASA




Annual mean GPP

**SIBCASA (Ivar van der Velde) can provide 1x1 degree global:**

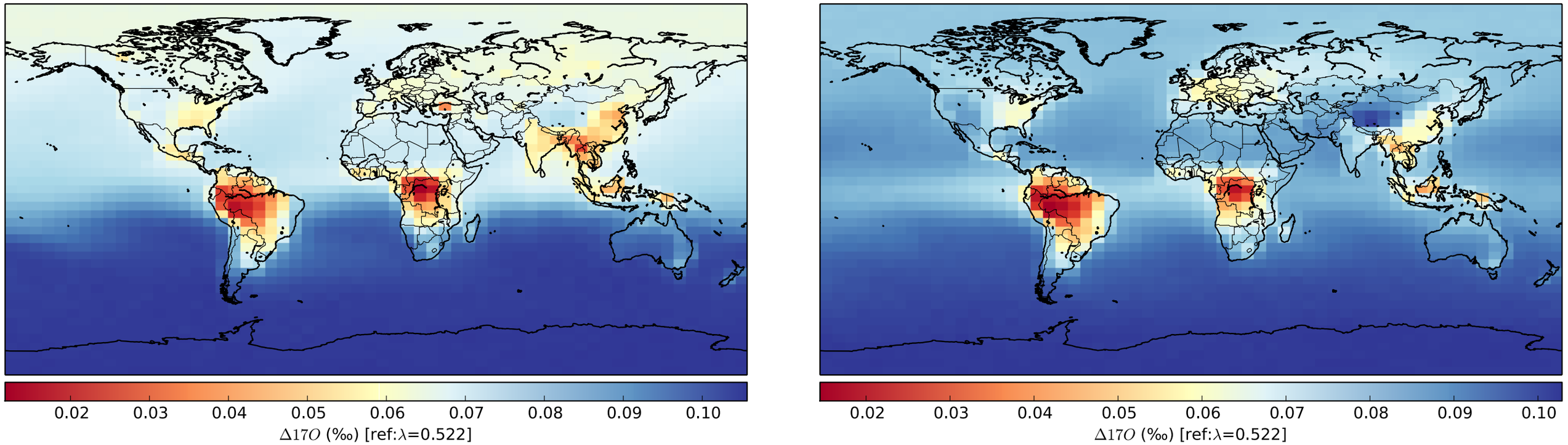
Ci/Ca, GPP, C3/C4 vegetation, Reco, RH

**TM5 can provide**

transport, STE, source term?

# Surface Δ17O in TM5

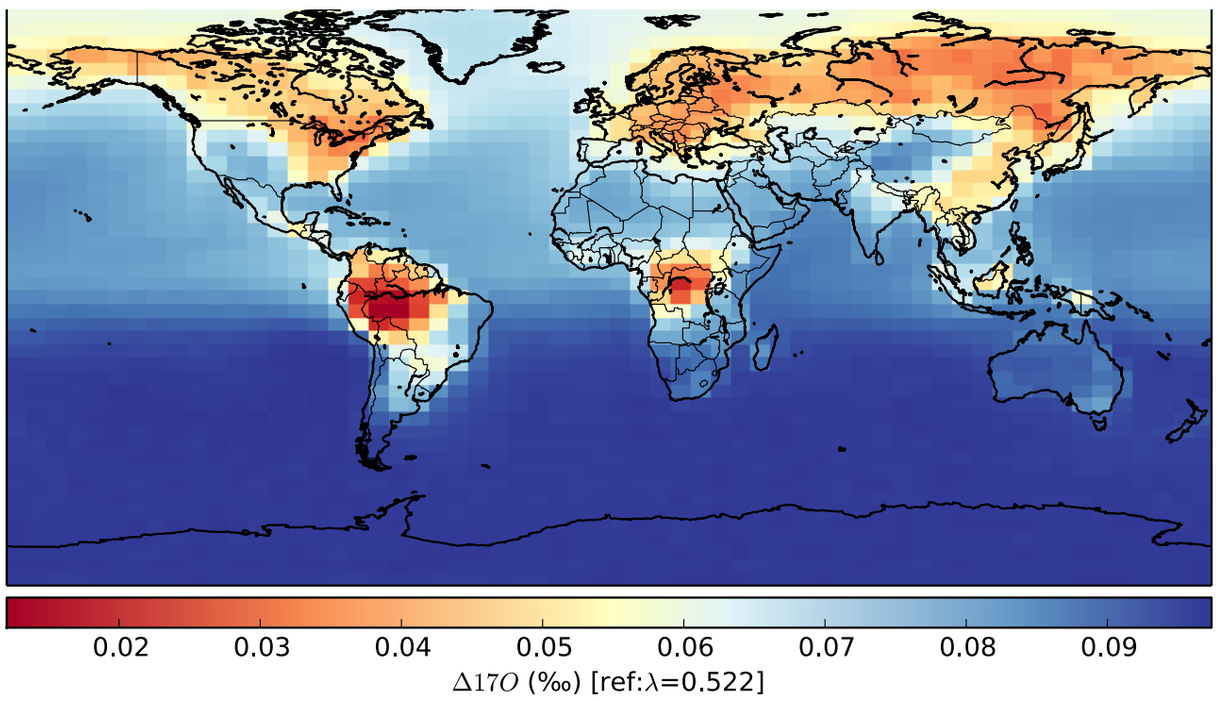
DJF



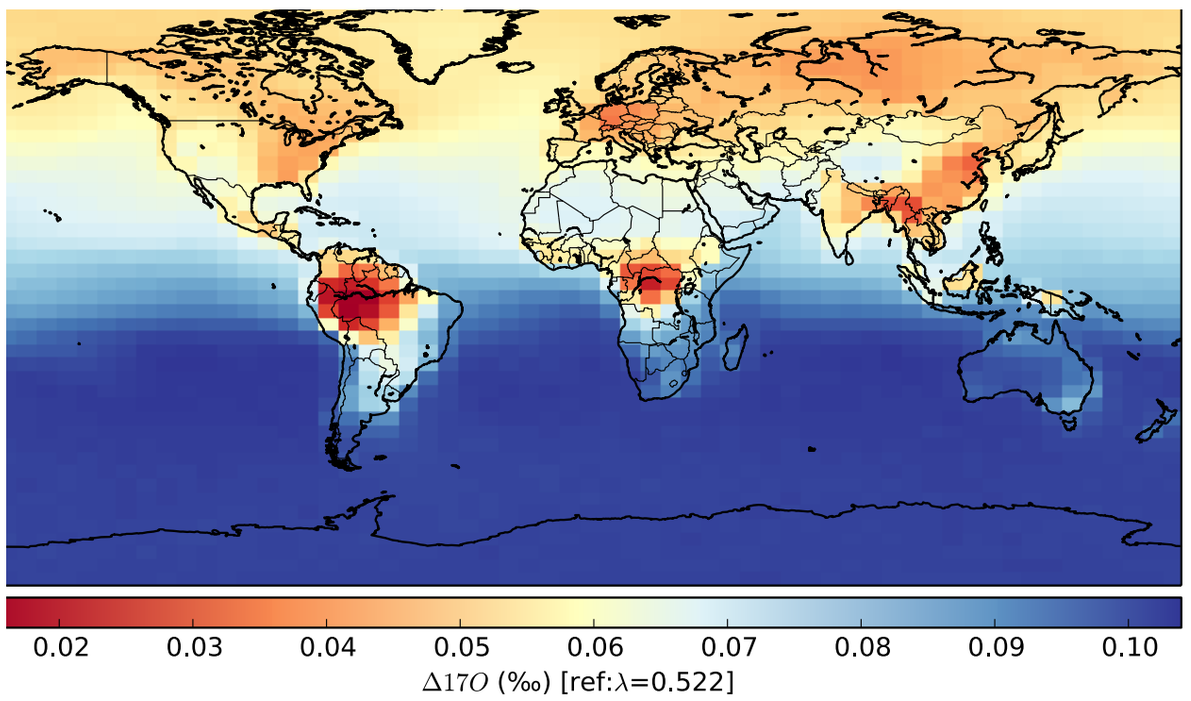

MAM



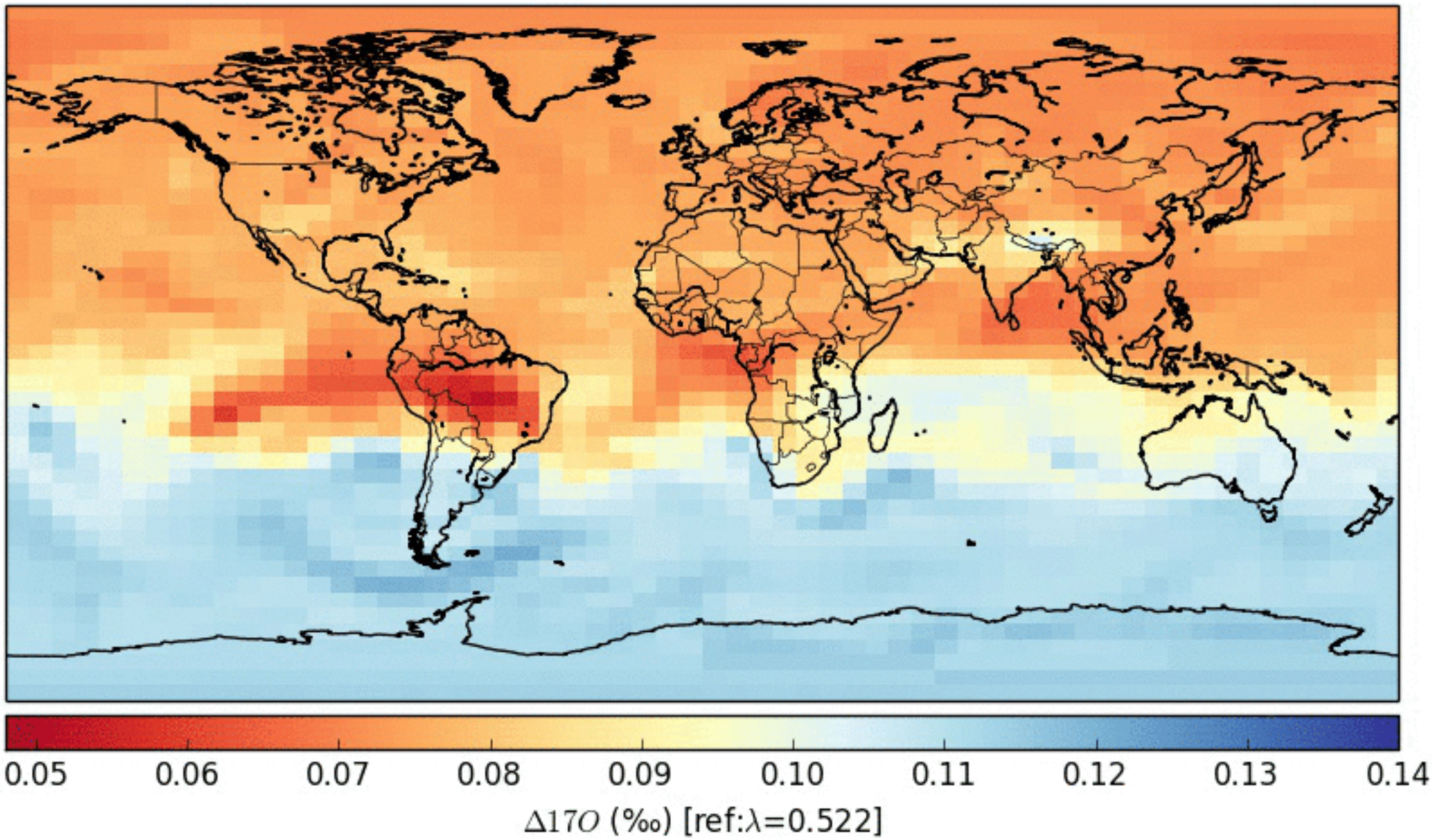

JJA




SON

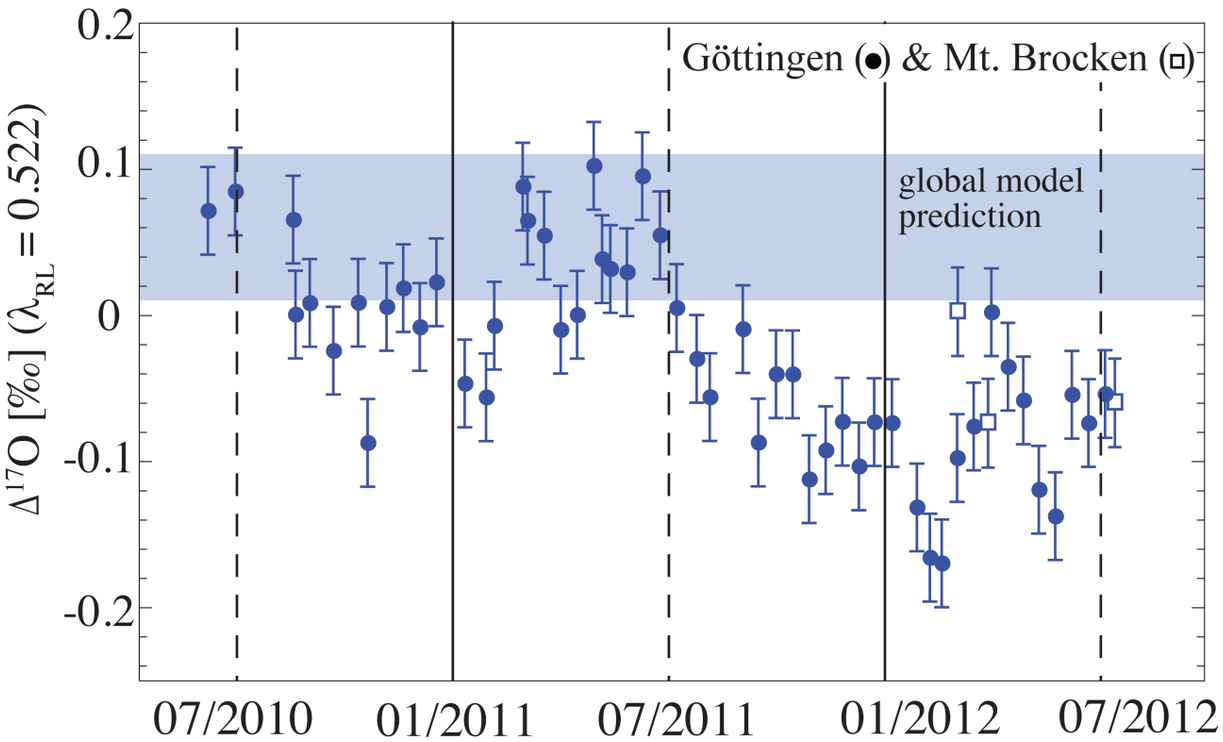


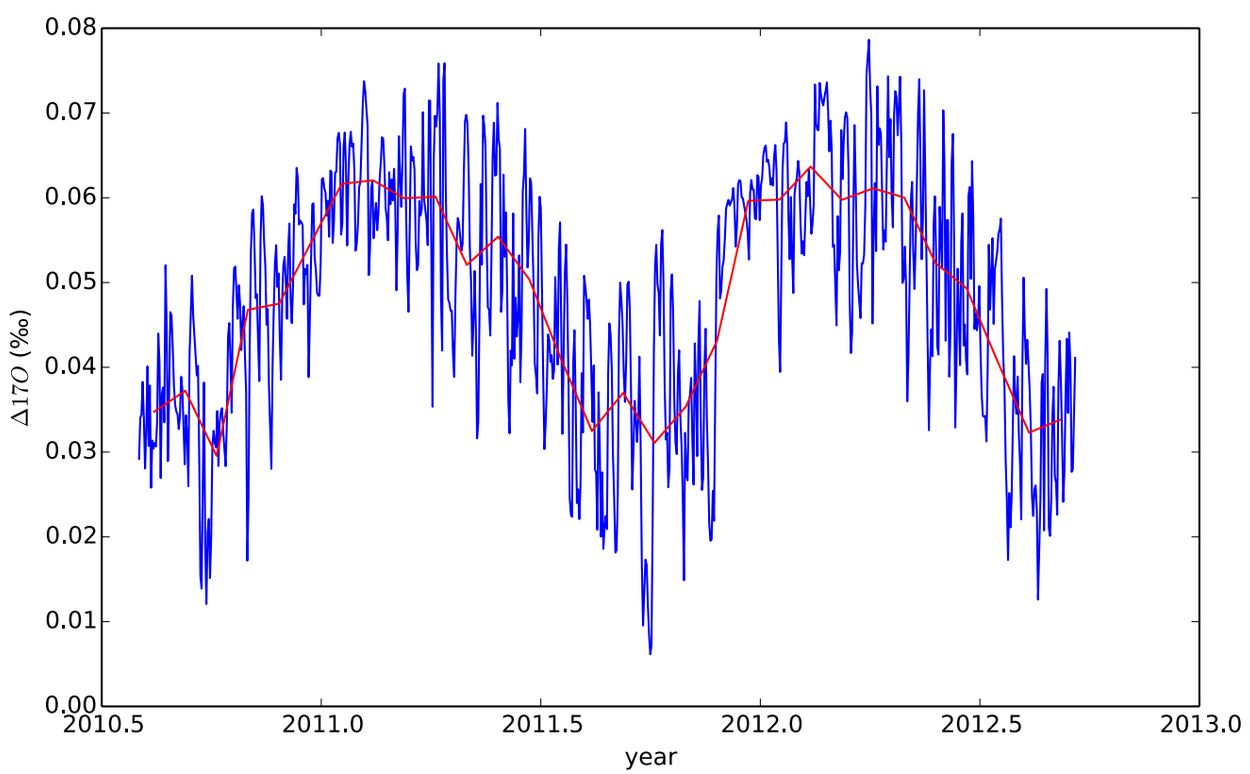
# One year simulation of $\Delta^{17}O$ with TM5, p=500 hPa



# Future plans

- Try to simulate/understand the data from Mt Bröcken
- Contrast simulated Amazon and Arctic signals
- Improve stratospheric source description
- Work on soil invasion flux & leaf-water Δ17O



# Triple oxygen isotope composition of tropospheric carbon dioxide as a tracer of terrestrial gross carbon fluxes

K. J. Hoag,[1] C. J. Still,[2] I. Y. Fung,[1] and K. A. Boering[1]