Satellite-data constraints on tropical fire carbon emissions.

A. Anthony Bloom[1], ATMOS Conference, June 8th 2015

Also: J. Worden[1], K. Bowman[1], M. Lee[1], H. Worden[2], T. Kurosu[1], C. Frankenberg[1], D. Schimel[1], A. Eldering[-1], J. Liu[1].
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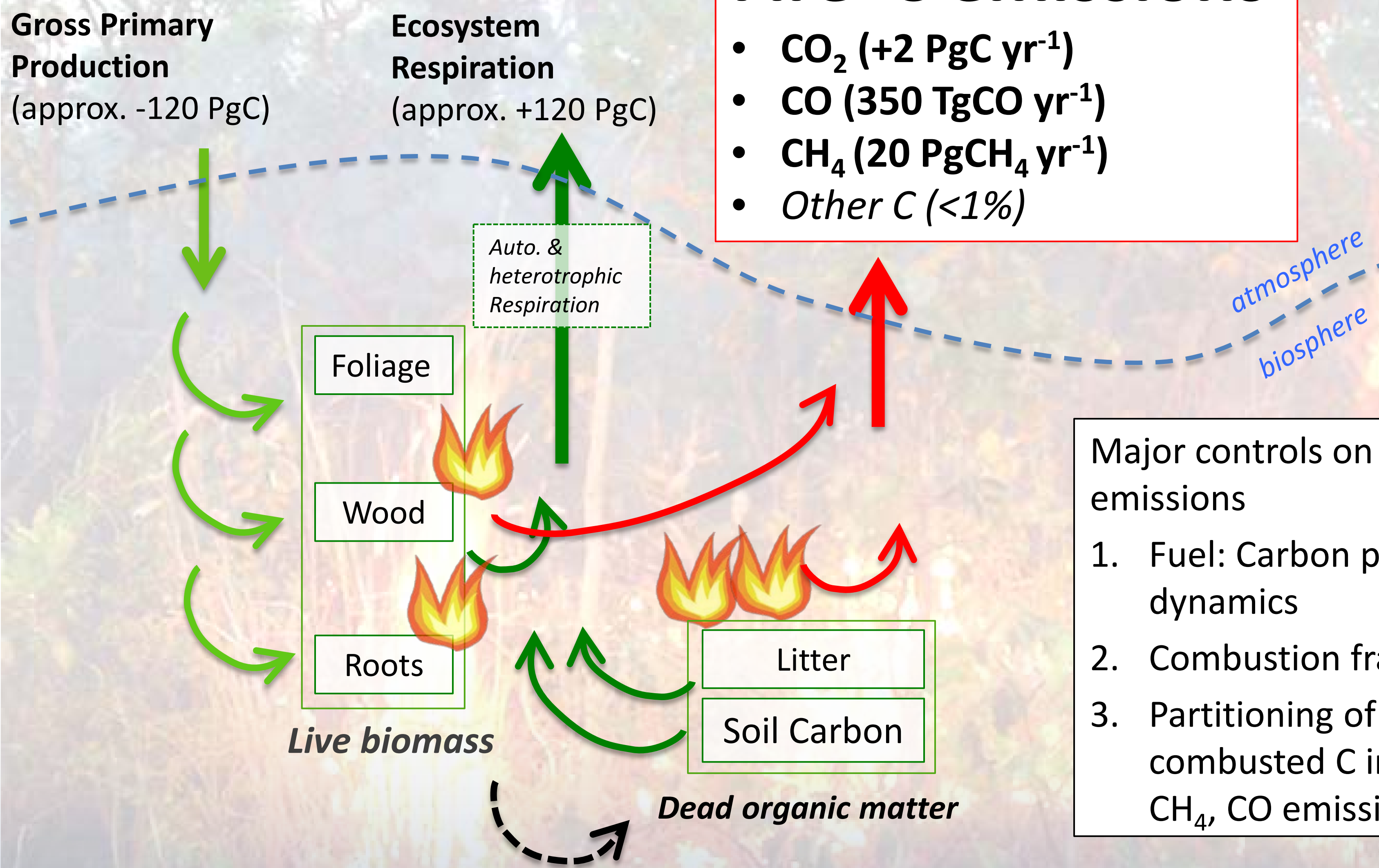
Fire C emissions

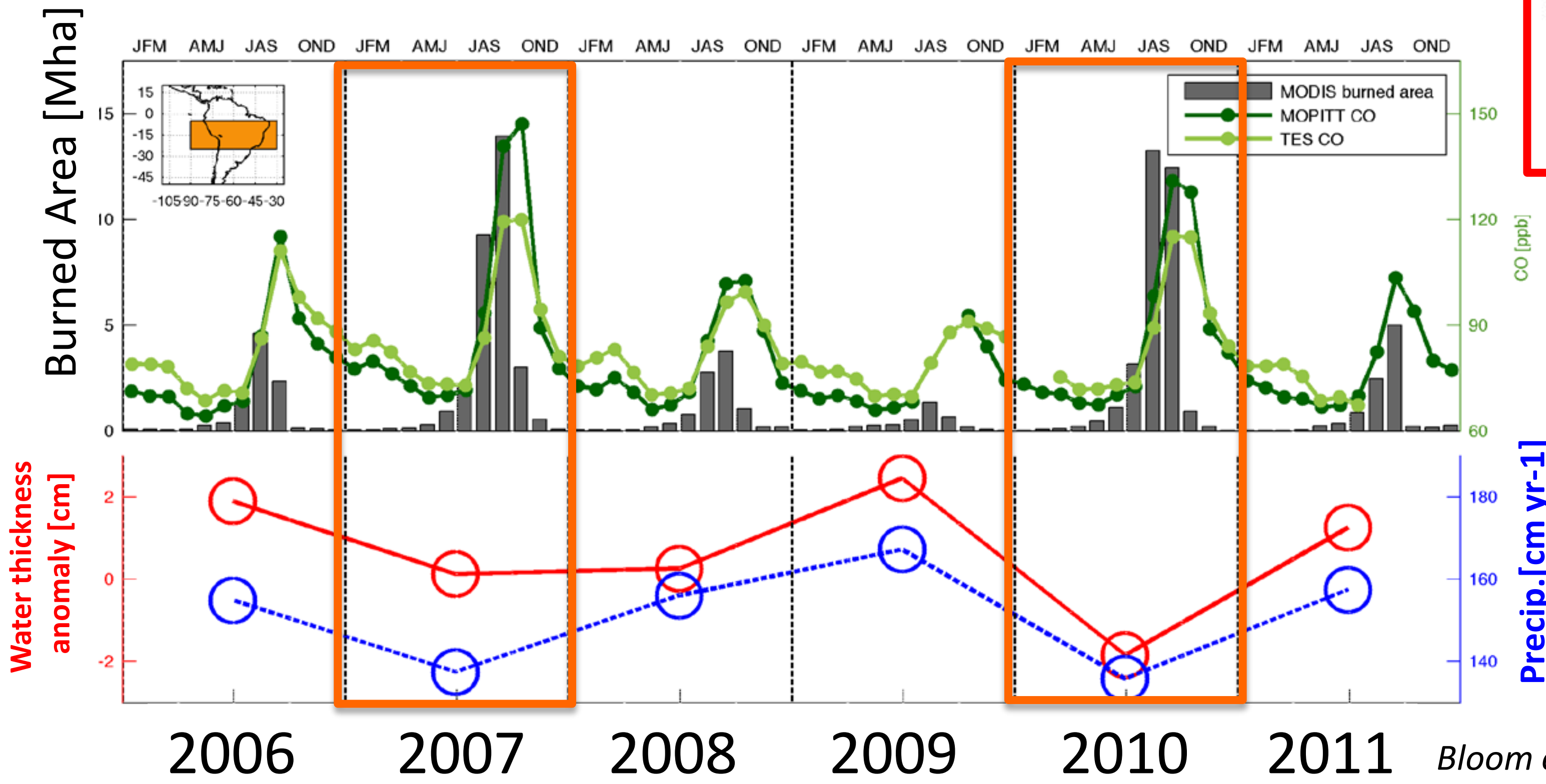
- CO_2 (+2 PgC yr^{-1})
- CO (350 TgCO yr^{-1})
- CH_4 (20 PgCH_4 yr^{-1})
- *Other C (<1%)*

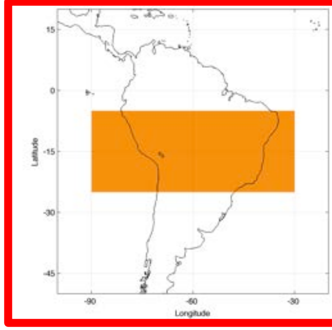


Major controls on fire emissions

1. Fuel: Carbon pools & dynamics
2. Combustion fraction
3. Partitioning of combusted C into CO_2, CH_4, CO emissions.

South America fires & drought





MODIS burned area

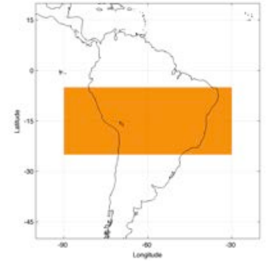
GRACE

TRMM

Bloom et al., 2015, GRL

- **2007 and 2010 were major fire years, 2010 was a once-in-a-century drought.**
- **Total C emissions in both years not known**

South America fire emissions



Savanna & grassland fires

Lower Biomass

Fires are more efficient

Drought fires, Cerrado, Brazil

CO_2:CO = 25:1

CH_4:CO = 1:28

Forest fires

Higher Biomass

Less efficient

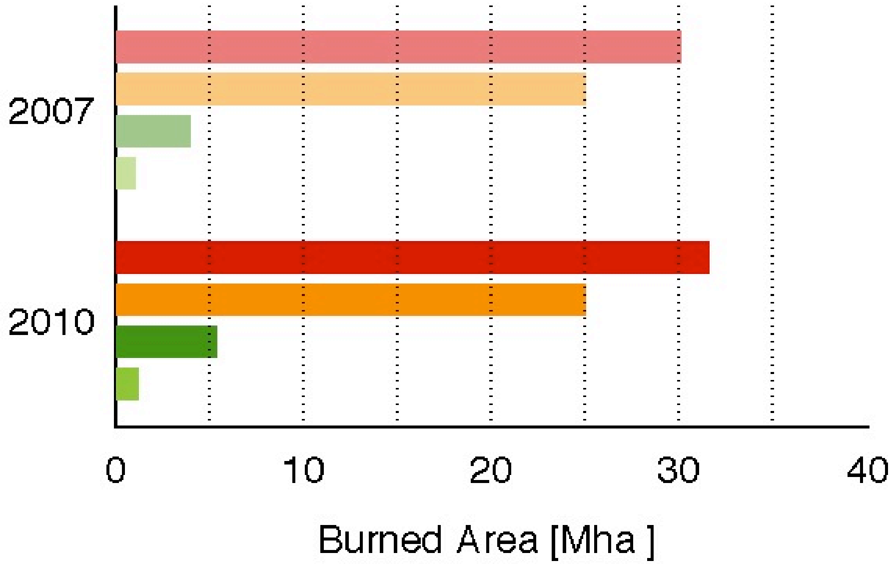
Forest fires, Amazon, Brazil

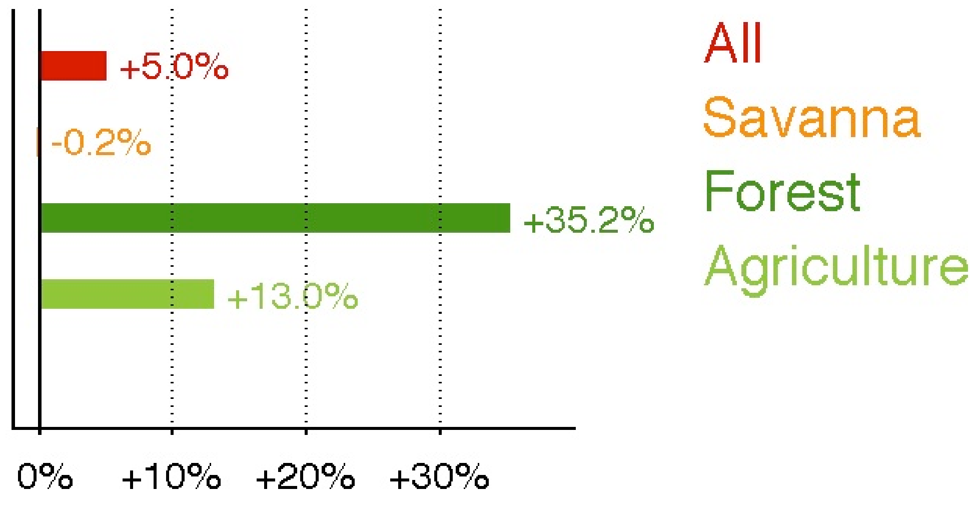
CO_2:CO = 15:1

CH_4:CO = 1:15

Burned area: 2007 & 2010

2007-to-2010 % difference



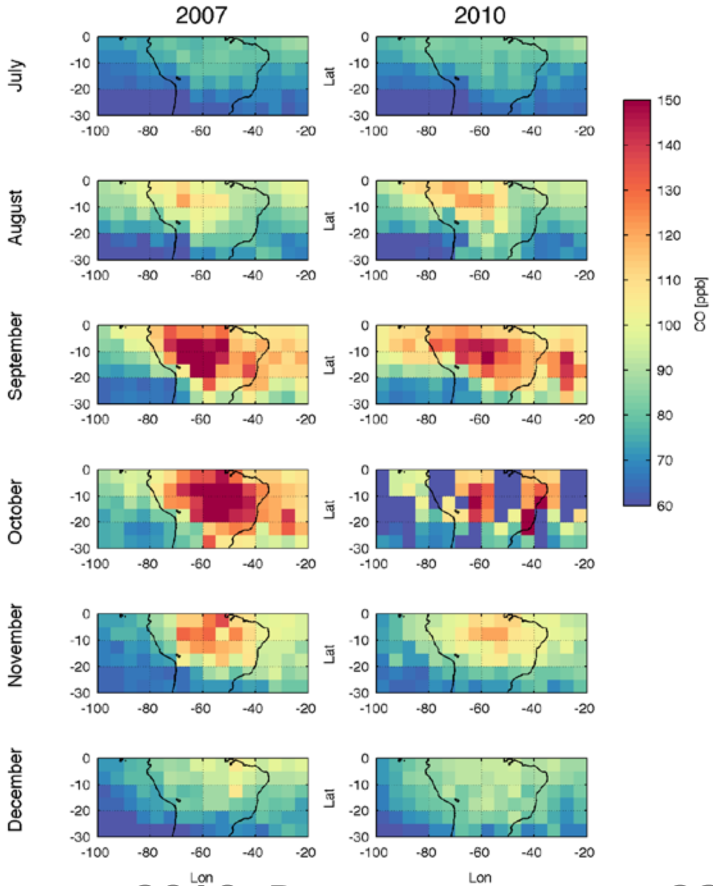


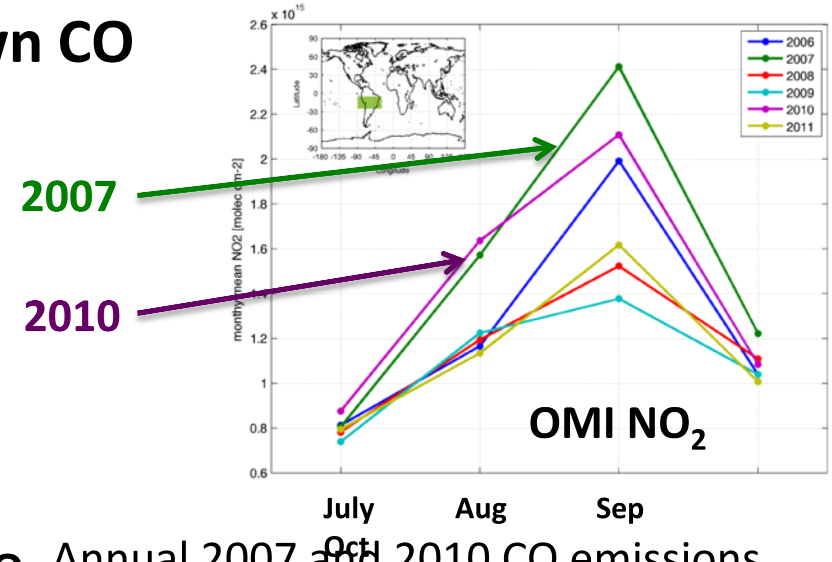
Bloom et al., 2015, in press

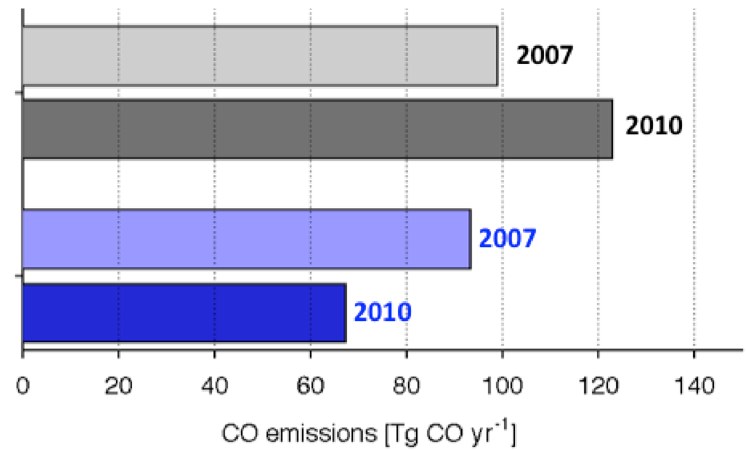
- ***2007: Moderately dry year - 2010: Once-in-a-century drought***
- ***Similar burned area***
- ***Higher percentage of forest burned***
- ***Given the biomass within burned areas, we expect more CO and CO_2 emissions in 2010***

Bottom-up & top-down CO

TES CO measurements







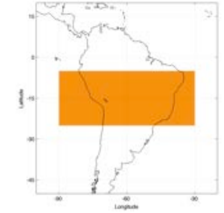
GFEDv3 CO
(bottom-up)

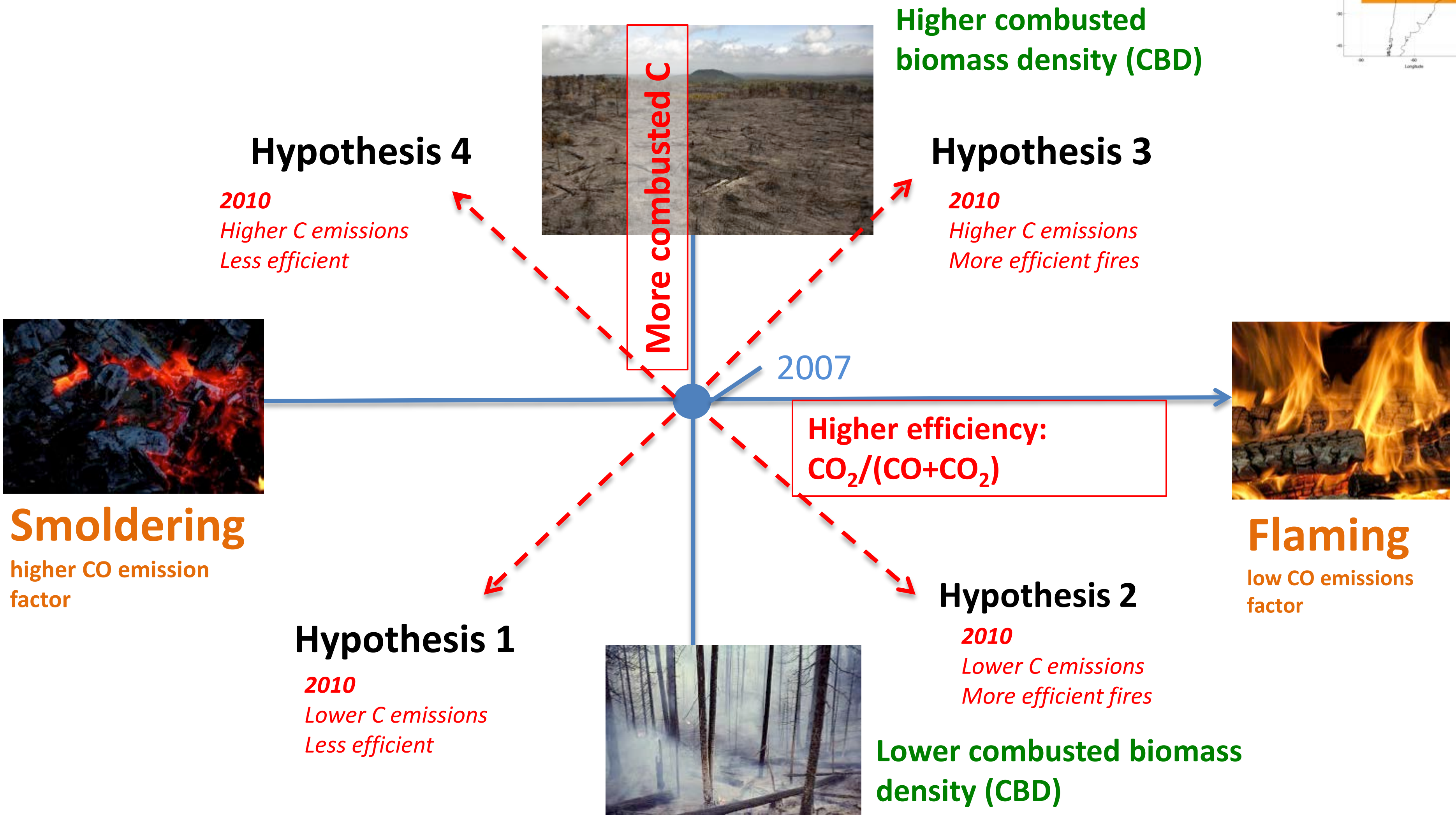
MOPITT CO inverse estimates
(top-down)

Bloom et al., GRL, 2015

- **2010: Bottom-up: more CO in 2010 top-down: less CO in 2010**
- **Q1: Why higher BA and lower CO in 2010?**
- **Q2: Did C losses increase or decrease in 2010?**

South America fire traits: did they change between 2007 and 2010?





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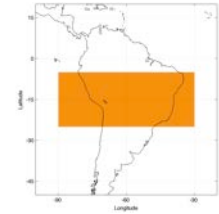
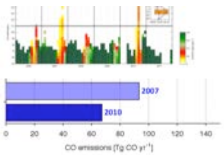
Method: model-data fusion



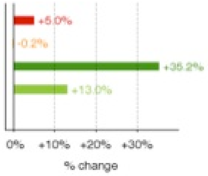
$$F_{s,b} = A_b \times CBD_b \times E_{s,b}$$

F = *fire C fluxes*
A= *burned area*
CBD* = *Combusted Biomass Density
E*=*Emission factors
b=*land-cover type (sav., for., agr.)*
s=*species (CO_2,CH_4,CO)*

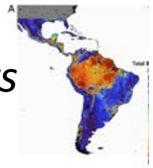
TES CH_4:CO
MOPITT CO



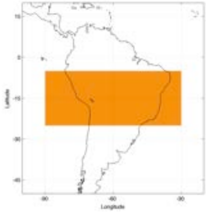
MODIS burned area



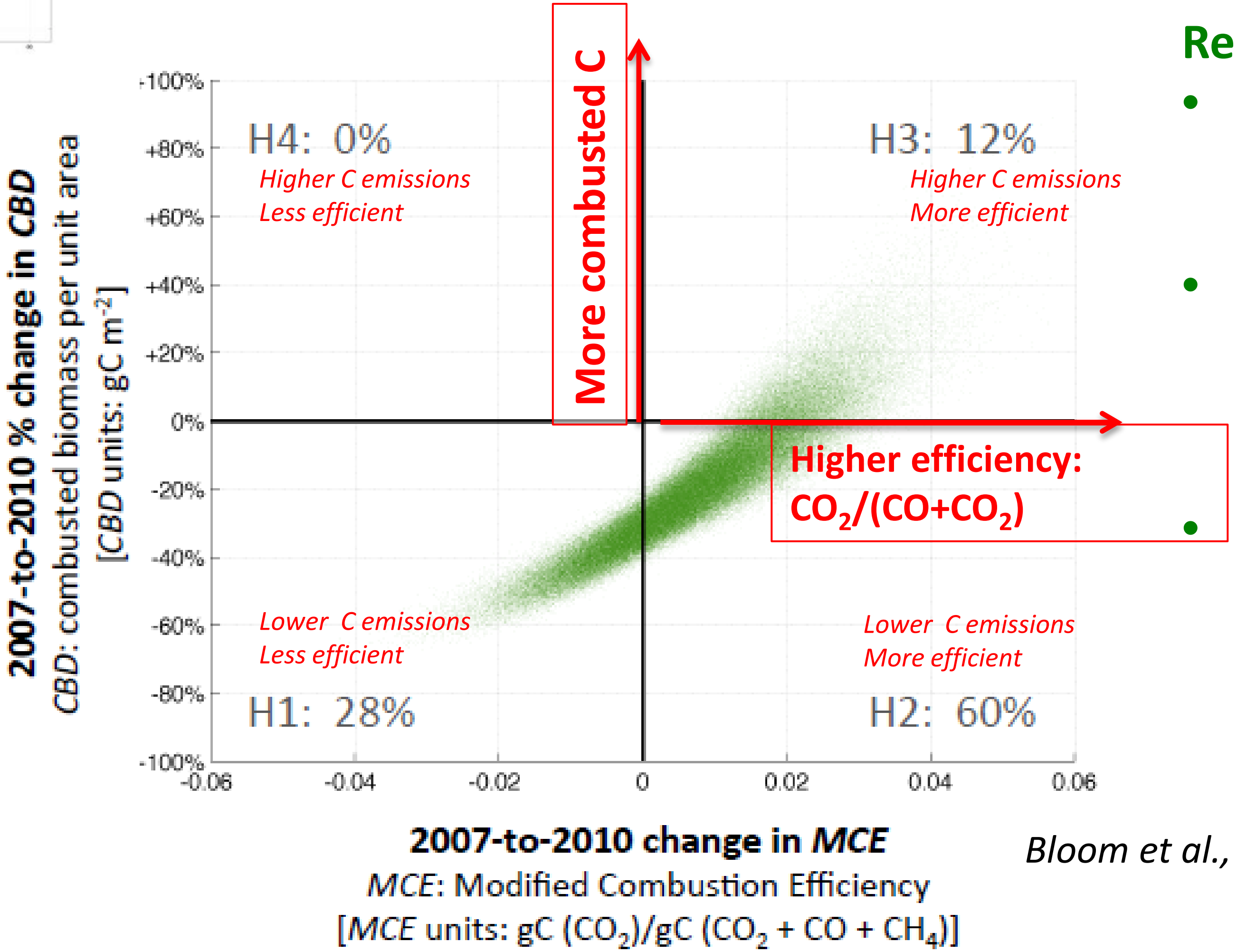
Prior information:
Land-cover type emission factors (Andreae & Merlet), biomass distribution (Saatchi et al., 2011), combustion factor range



- **We bring model and data (w. associated uncertainty) together in Bayesian framework.**
- **We quantify 2007-to-2010 study area changes in CBD and EF**



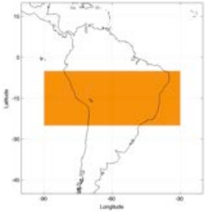
Results: 2007-to-2010 change in efficiency & carbon loss



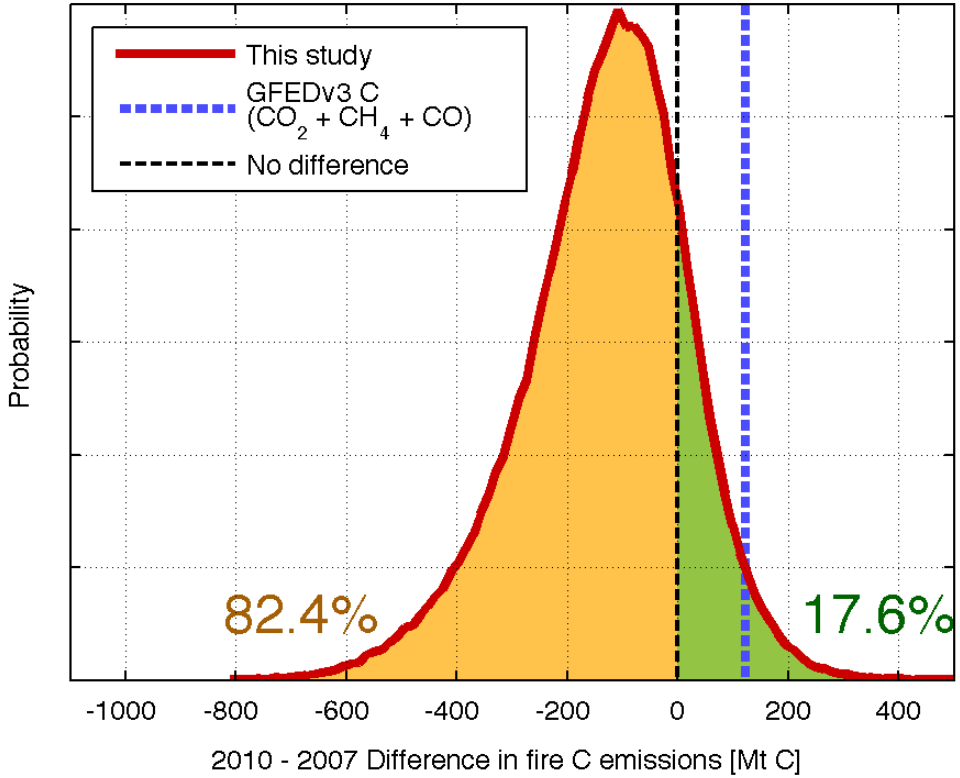
Results:

- **72% probability of more efficient fires in 2010**
- **88% probability of reduced C emissions in 2010.**
- **60% prob. 2010 fires were more efficient & less fuel was burned.**

Bloom et al., GRL, 2015



Results: 2007-to-2010 fire C loss difference



- **Bottom-up**

  GFEDv3 2007-to-2010 difference = +23%

- **Top-down**
  - (a) 2007-to-2010 difference (median) = -18%, despite larger burned area.
  - (b) Decrease a result of forest and savanna decrease in combustion completeness
  - (c) 82.4% probability 2010 C losses are lower than 2007.

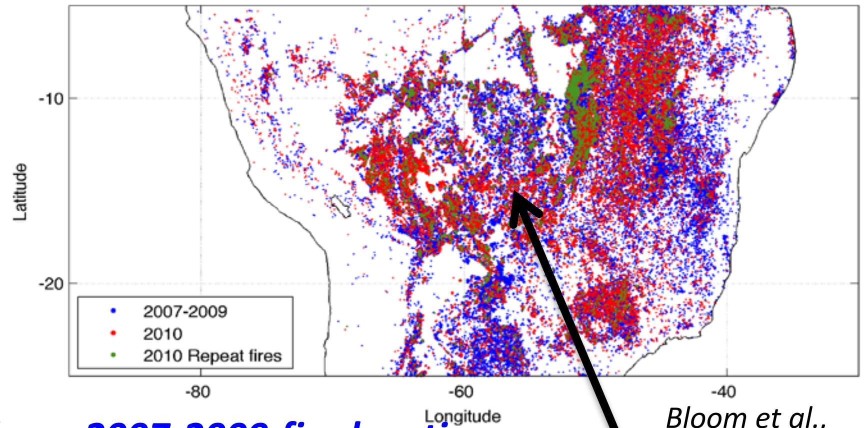
- **82% probability of lower C emissions during drought year.**
- **What mechanisms could lead to lower 2010 emissions, relative to 2007 fires?**

2007-to-2010 reduced combusted biomass

H. A: Reduced combustion factor (?)

H. B: Reduction in biomass (?)

- Reduction in GOME-2 Solar Induced Fluorescence (4-6%) suggests reduced fuel load in 2010.
- Repeat fires in 2010 (0%-8%) indicate reduction in biomass.



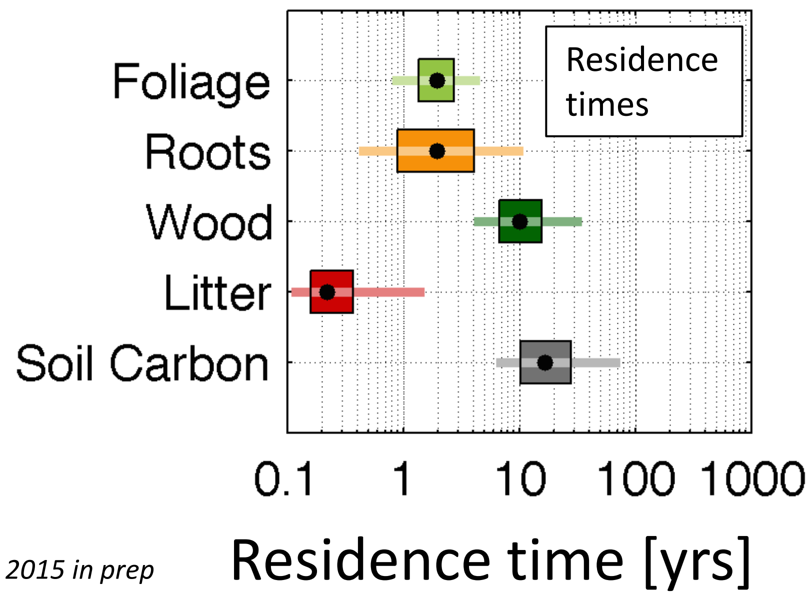
Bloom et al., GRL, 2015

Blue = 2007-2009 fire locations

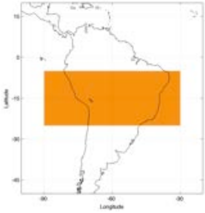
Red = 2010 fire locations

Green = Overlap

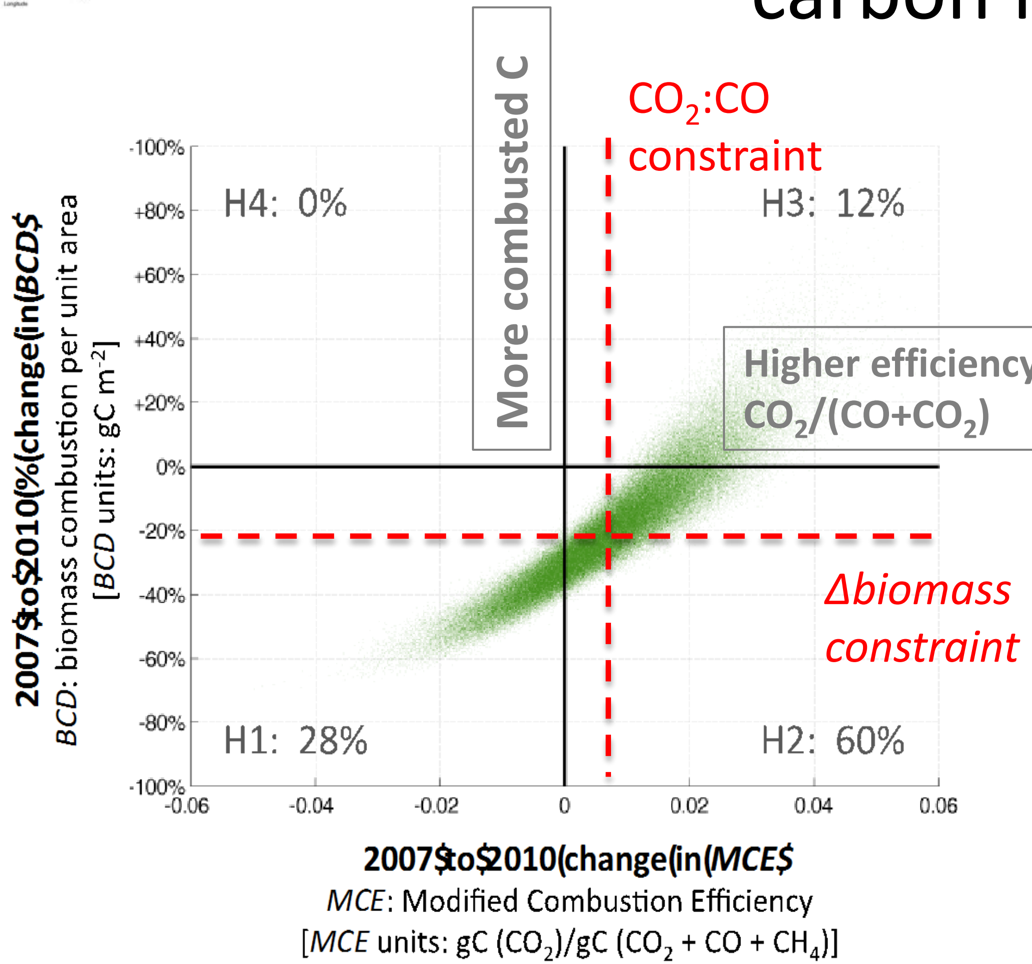
15.5°S 55.5°W



Bloom et al., 2015 in prep



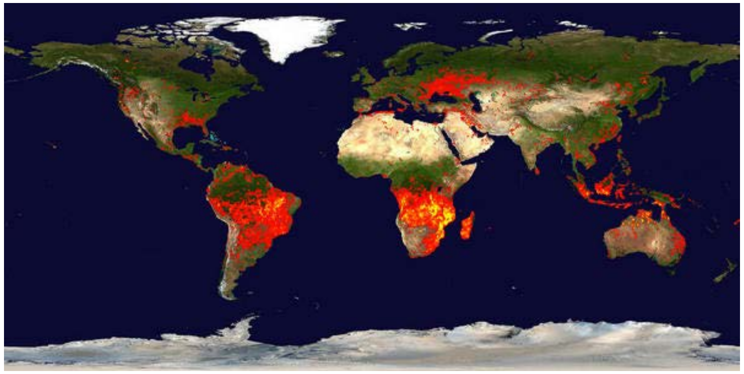
How will repeat droughts affect biomass burning carbon fluxes?



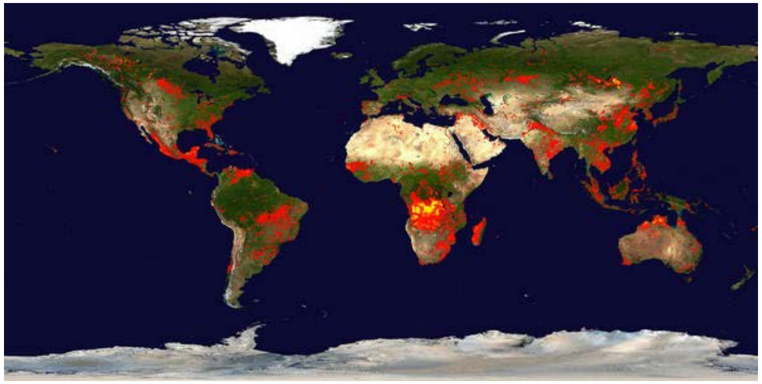
Bloom et al., GRL, 2015

- Inter-annual changes in fire carbon fluxes are not fully resolved
- OCO-2 data can be used to constrain CO:CO_2.
- Biomass change (e.g. GEDI and BIOMASS missions) can be used to constrain biomass loss rates

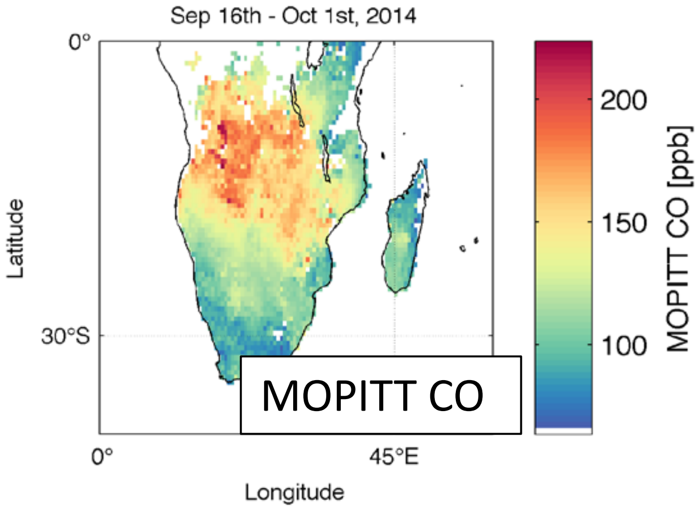
Southern Africa fires

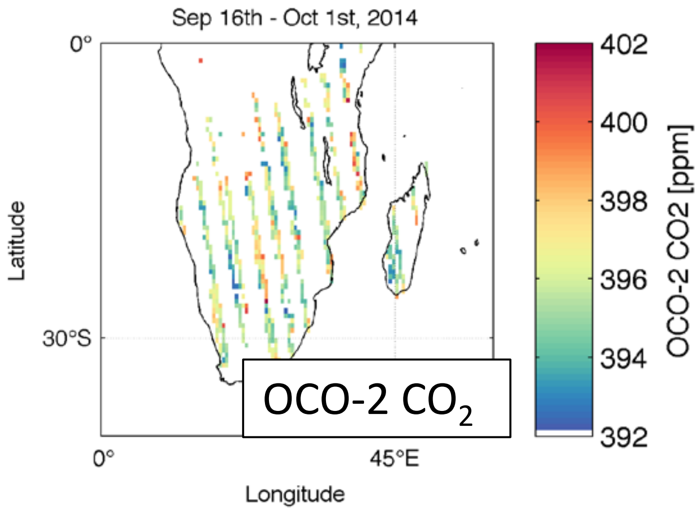


MODIS fire counts: Sep 8th – 17th



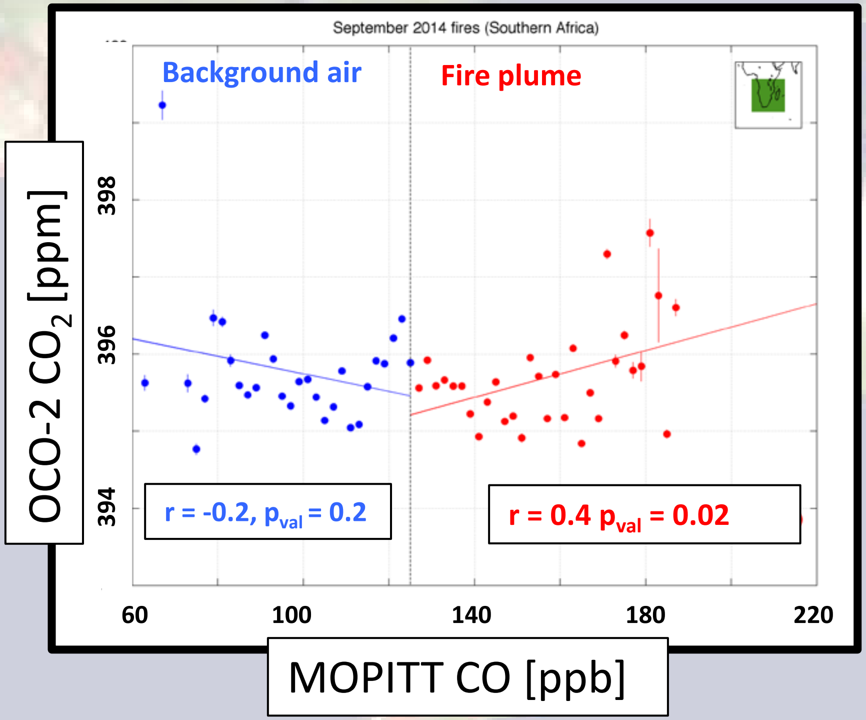
MODIS fire counts: Sep 28th – Oct 7th 2014



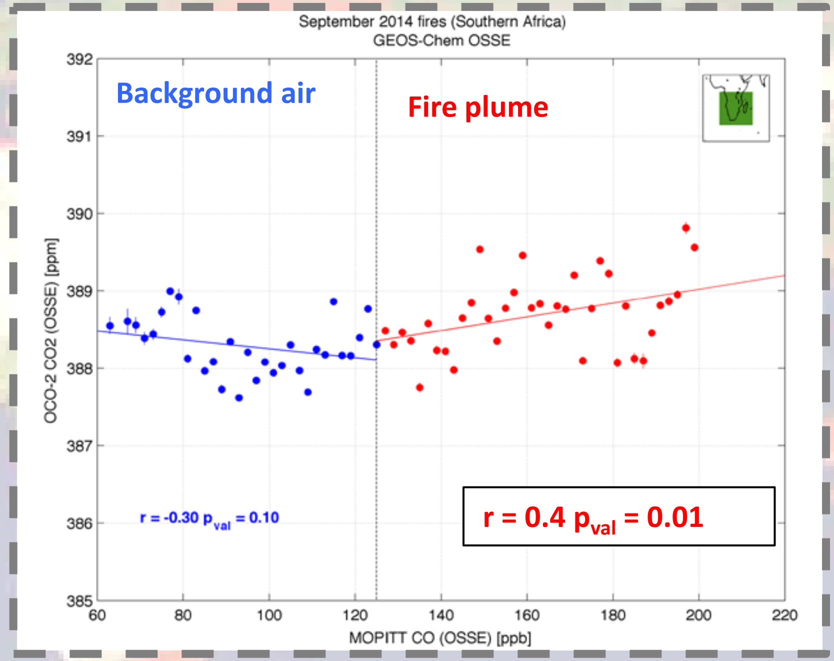


Southern Africa Fires

CO_2:CO from OCO-2 and MOPITT



CO_2:CO from model



- CO_2:CO ratios from September 2014 southern Africa fires are consistent with expected CO_2:CO emissions.
- OCO-2 and MOPITT CO values can be used to quantify fire combustion efficiency and ultimately to better constrain CO, CO_2 emissions from fires.

Conclusions

- Higher burned area but less CO emissions during the 2010 South America drought fires.
- 88% probability of reduction in combusted biomass density; 72% probability of increase in combustion efficiency
- OCO-2, TROPOMI, GEDI, BIOMASS will help resolve tropical fire emissions and processes controlling inter-annual variability in biomass burning emissions.