The Global Stocktake: a top-down view

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The Global Stocktake

2060

Achieving Stability

In the Paris Agreement, 196 governments committed to hold the temperature rise well below 2°C, pursue efforts to limit the rise to 1.5°C, and to make sure humans are not emitting more than the planet can absorb. That means we need to reach net zero GHG emissions in the second half of the century.

For 1.5°C, GHG emissions will need to reach net zero by 2060-2080; for 2°C, net zero GHG must be reached by 2080-2100.*

The Global Stocktake every 5 years (starting in 2023) will assess progress and adjust commitments towards the Paris Accord.

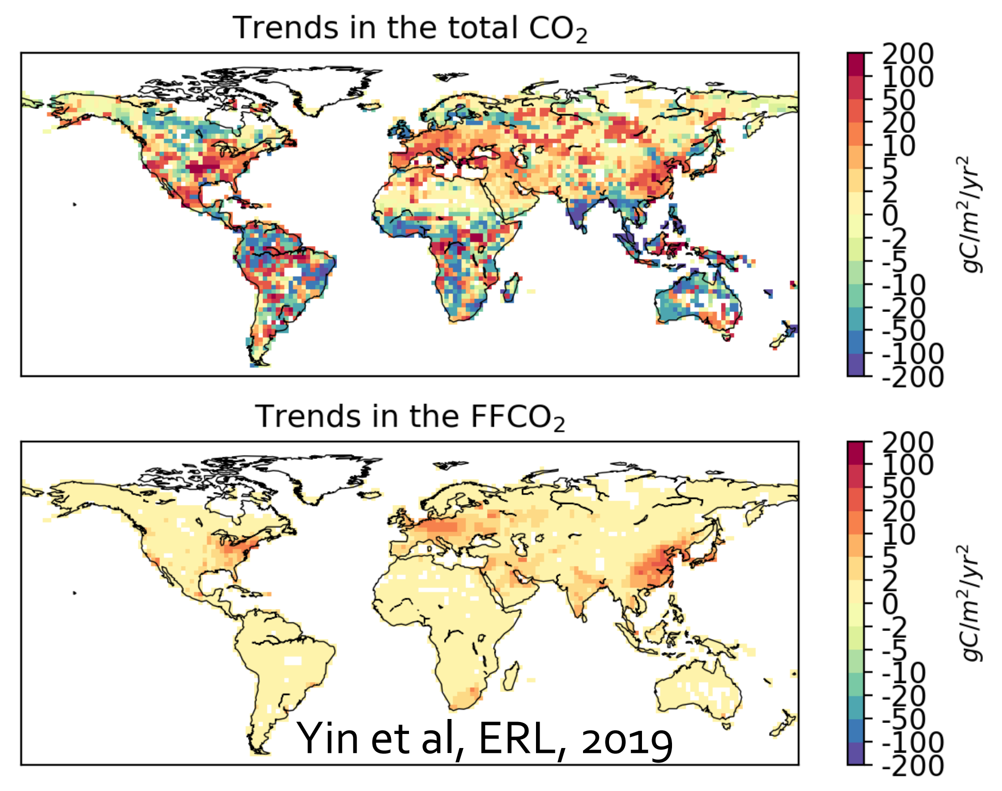
How will emission commitments be related to concentration requirements?

The gap between fluxes and concentrations

In an ideal system, the time-to-detection of total CO2 flux trends for many parts of the world is within 10-15 years (2-3 stocktakes). But, the relationship between those trends and FF trends is complex

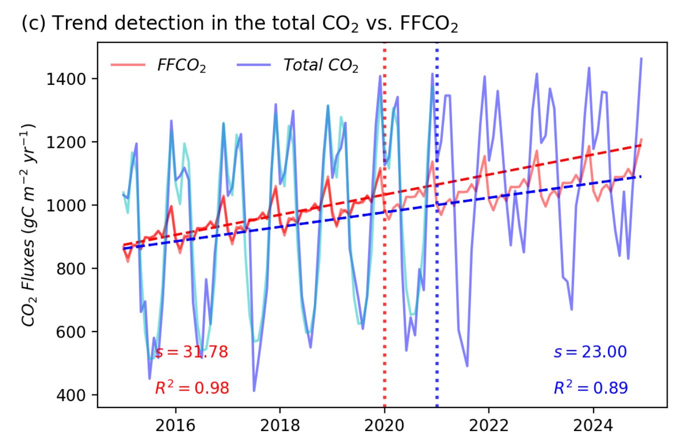
In China, about 20% of total CO2 trends is within 25% of the underlying FFCO2 trends

Both anthropogenic and natural processes drive trends at stocktake scales

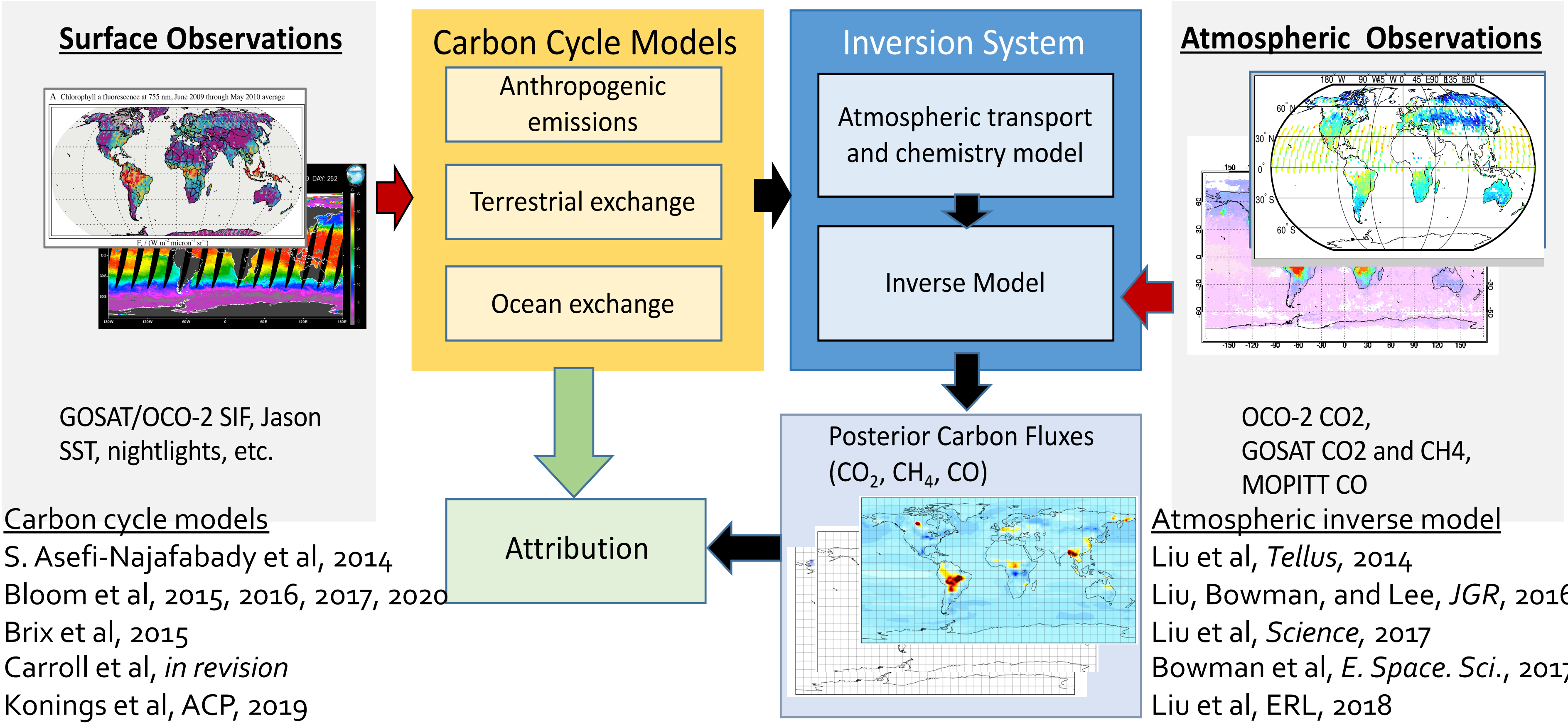

Trends in the total CO_2

Trends in the $FFCO_2$

Yin et al, ERL, 2019


(c) Trend detection in the total CO_2 vs. $FFCO_2$

Prototype Carbon Cycle Assimilation System: CMS-Flux



Surface Observations

GOSAT/OCO-2 SIF, Jason SST, nightlights, etc.

Carbon Cycle Models

Anthropogenic emissions

Terrestrial exchange

Ocean exchange

Inversion System

Atmospheric transport and chemistry model

Inverse Model

Atmospheric Observations

OCO-2 CO2,
GOSAT CO2 and CH4,
MOPITT CO

Posterior Carbon Fluxes (CO_2, CH_4, CO)

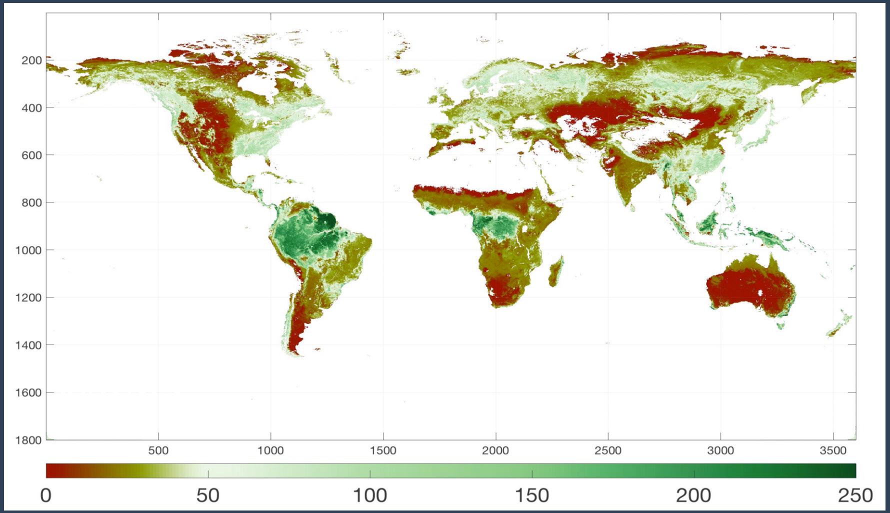
Attribution

Carbon cycle models
S. Asefi-Najafabady et al, 2014
Bloom et al, 2015, 2016, 2017, 2020
Brix et al, 2015
Carroll et al, *in revision*
Konings et al, ACP, 2019
Quetin et al, JAMES, 2020

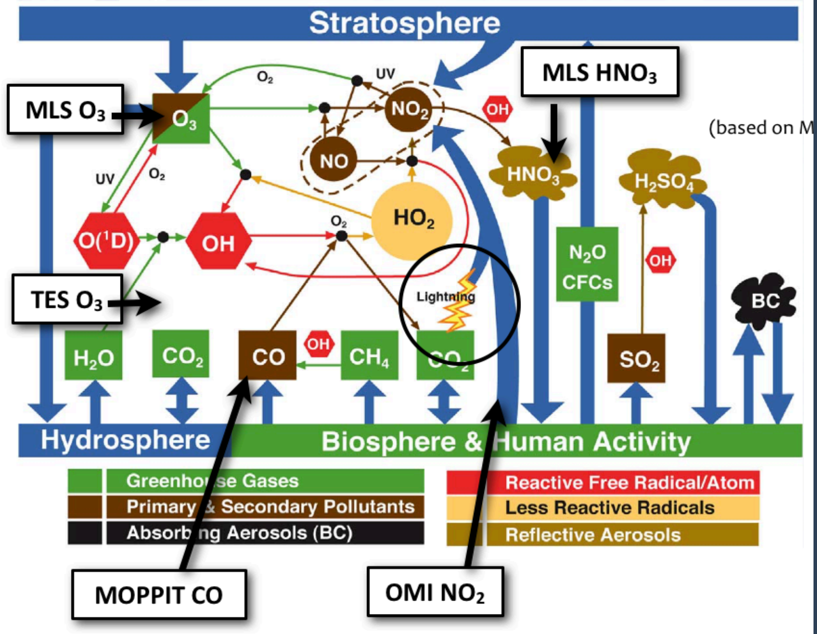
Atmospheric inverse model
Liu et al, *Tellus*, 2014
Liu, Bowman, and Lee, *JGR*, 2016
Liu et al, *Science*, 2017
Bowman et al, *E. Space. Sci.*, 2017
Liu et al, ERL, 2018

The NASA Carbon Monitoring System Flux (CMS-Flux) attributes atmospheric carbon variability to spatially resolved fluxes driven by data-constrained process models across the global carbon cycle.

Quantifying anthopogenic carbon: Insights into Land-use (biomass) and AQ (NOx)



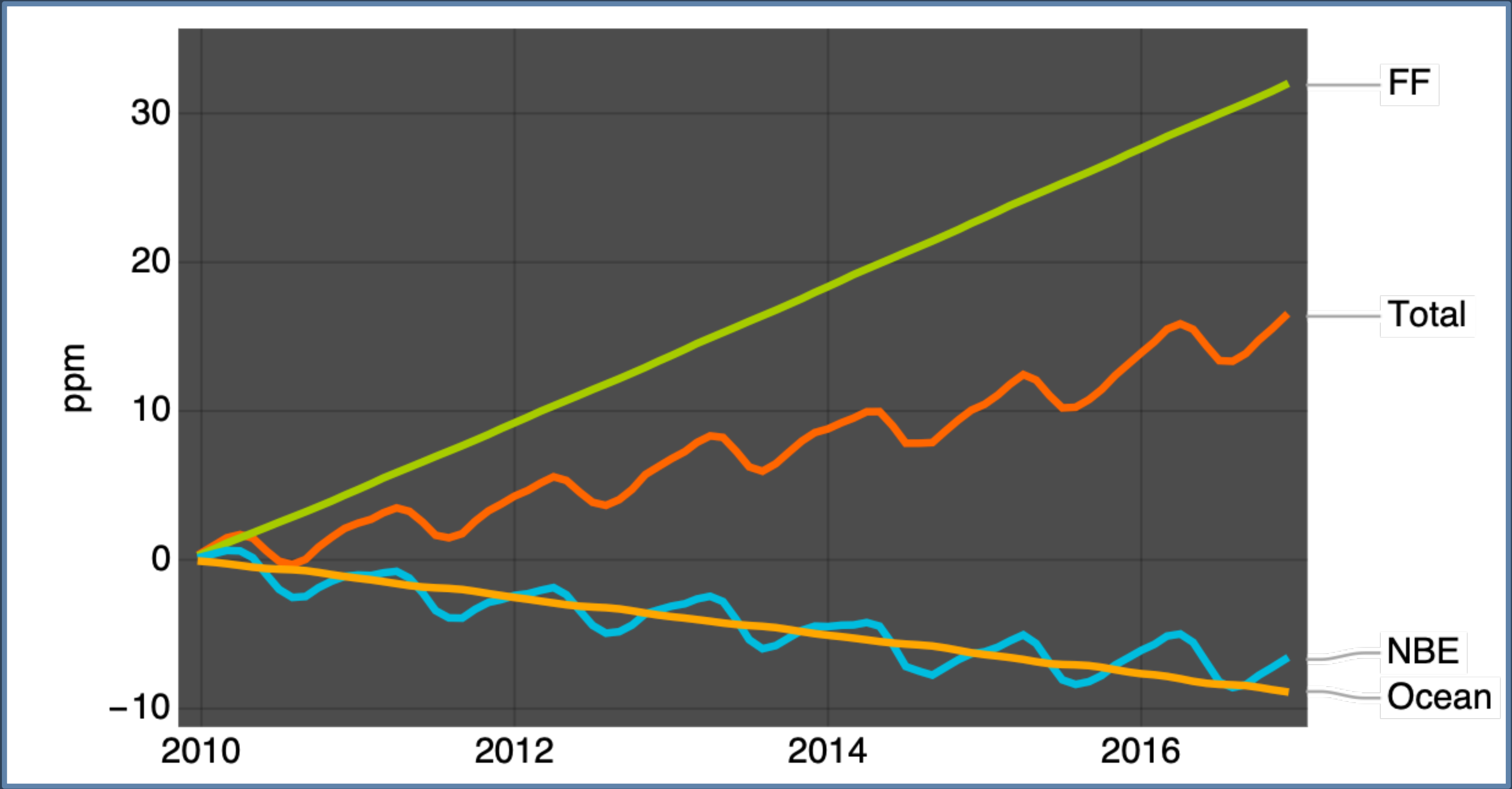
New time-varying above ground biomass (ABG) from multiple remote sensing products provide annually-resolved forest dynamics. (Xu, Saatchi, et al, in revision)



(based on M

Multi-constituent chemical data assimilation provides chemically consistent biomass burning and AQ-informed FFCO2 estimates (Miyazaki et al, 2017, Bowman et al, 2017, Miyazaki et al, 2020)

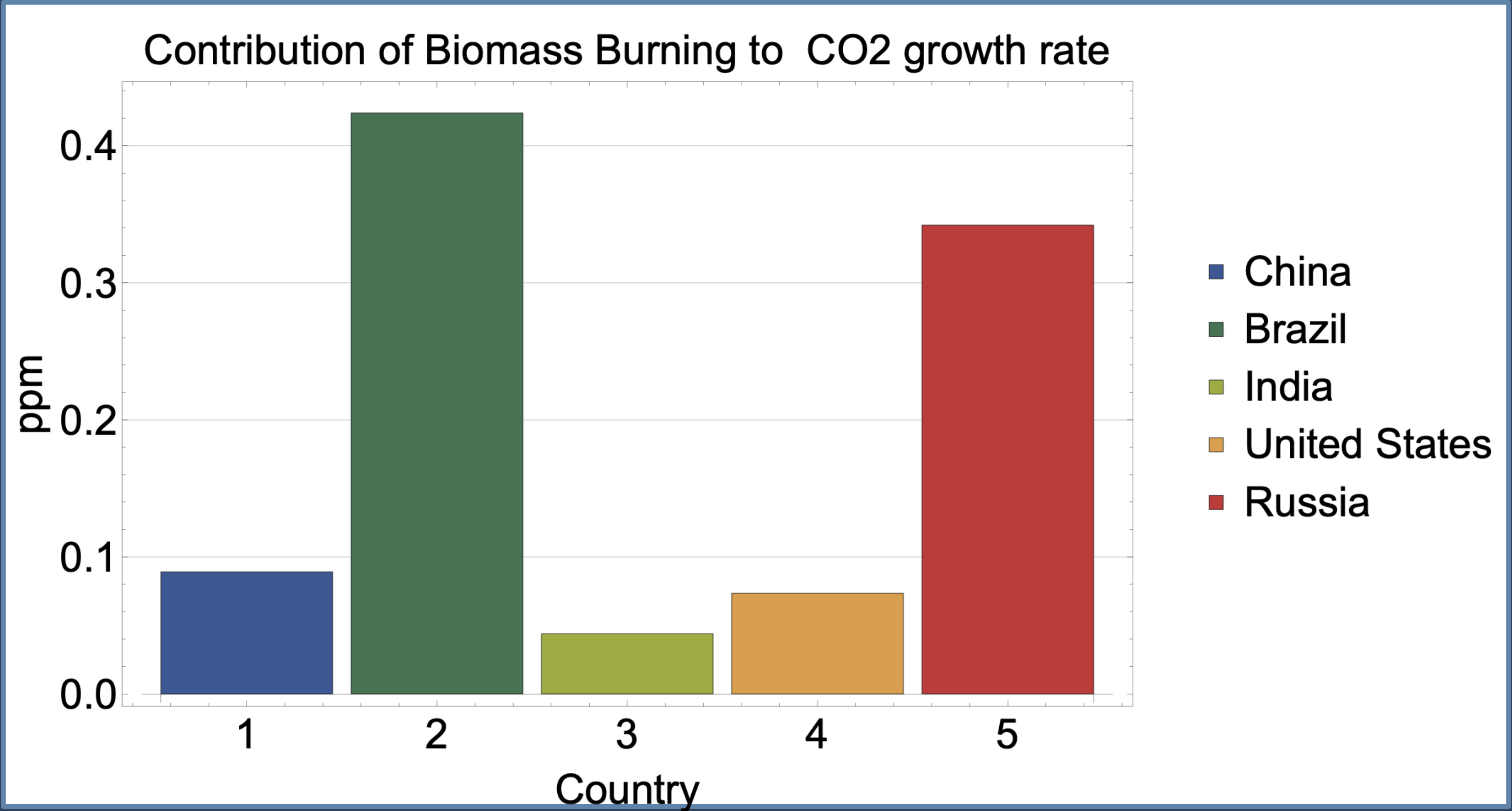
CMS-Flux Global Concentration Budget



From 2010-2016, CO2 increased by about 15ppm or a CO2 RF of 0.21 Wm^{-2} over 7 years.

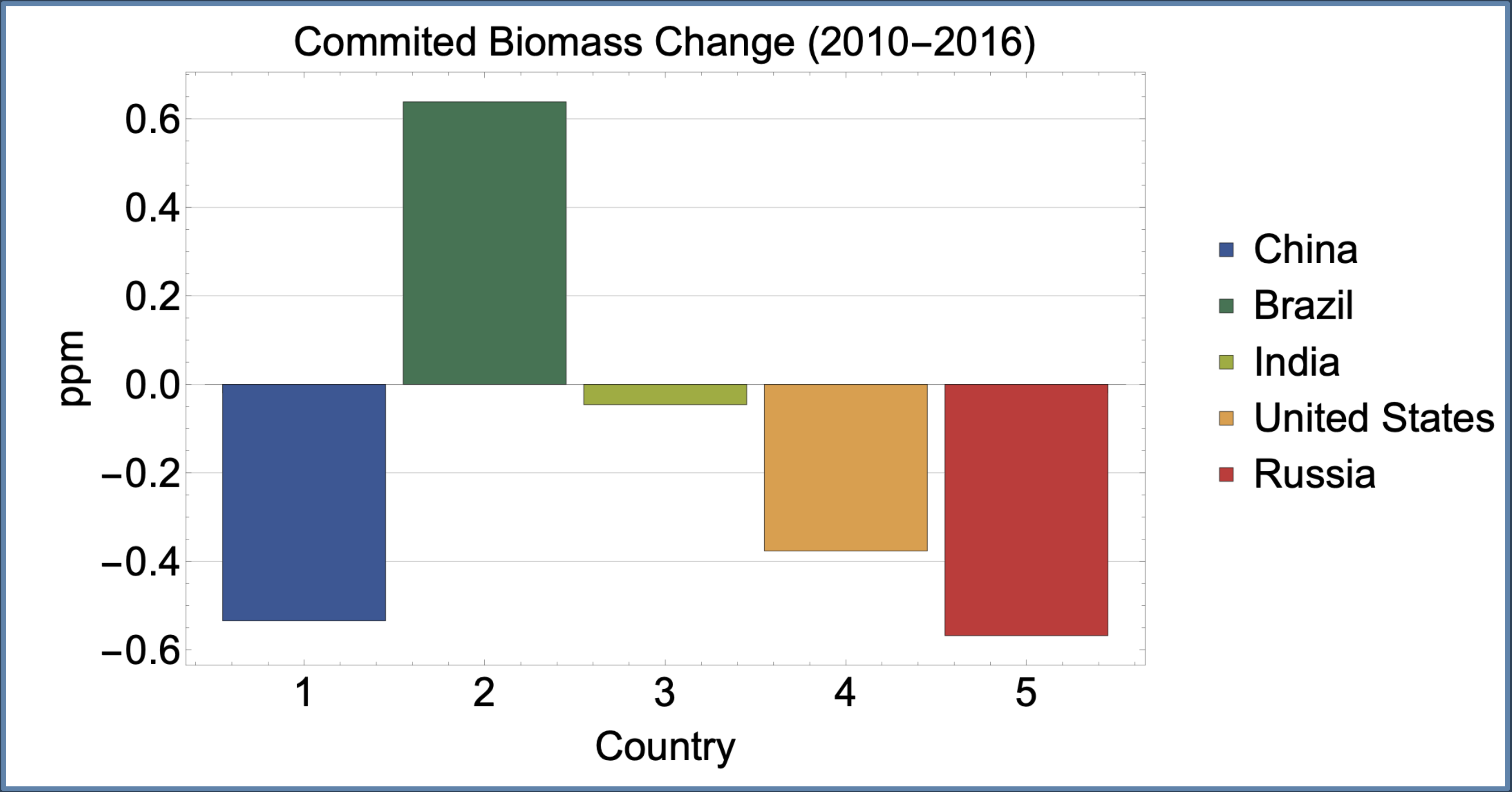
Fossil Fuel: FFDAS (Asefi-Najafabady et al, 2014)
Ocean: ECCO-Darwin (Carroll et al, *submitted*, Holger et al, 2015)
NBE: CASA-GFED (Ott et al, 2014, Bowman et al, 2017, Liu et al, 2017)

Biomass burning



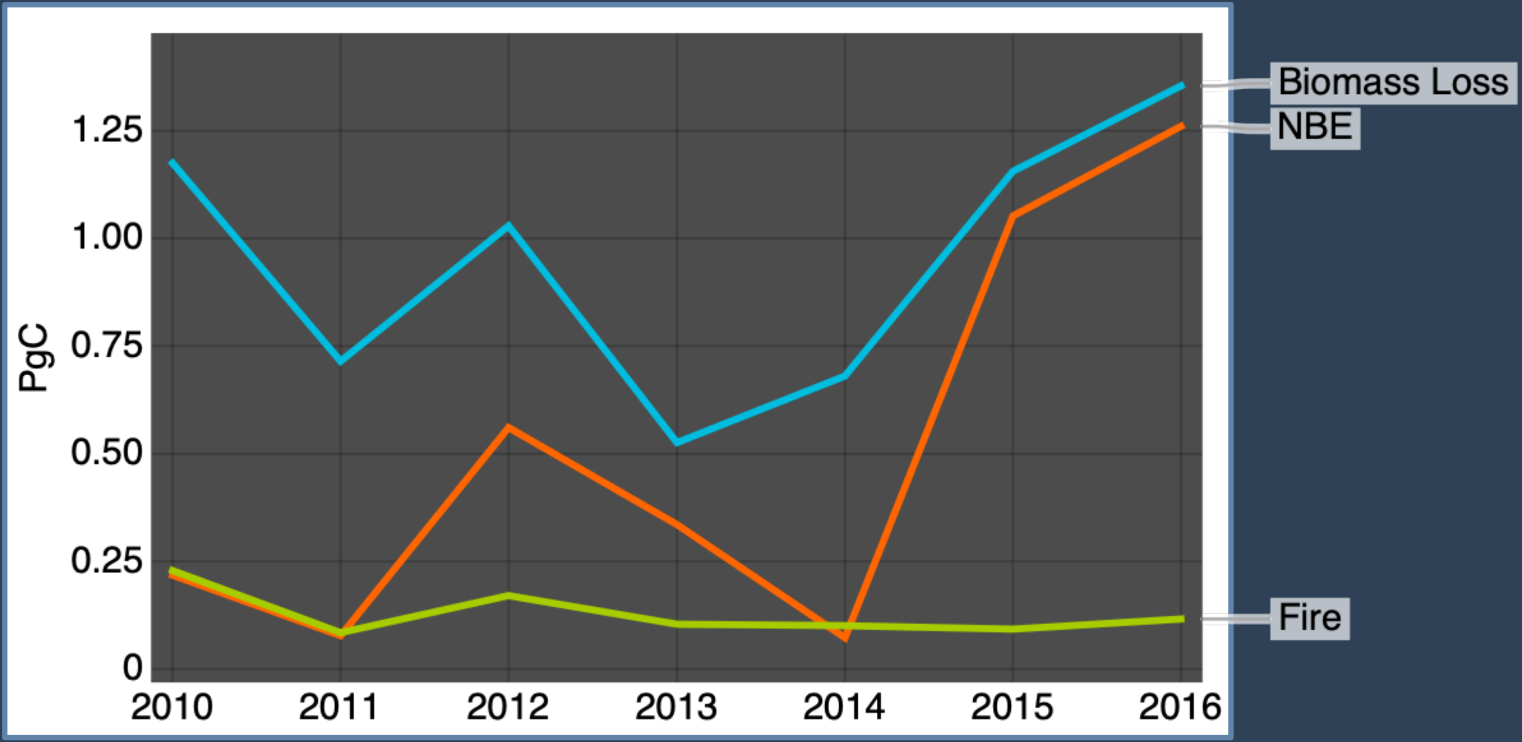
Biomass burning from Brazil and Russia accounted for most of the contribution of biomass burning to CO2 accumulation. These regions contributed about 1 ppm.

Biomass change



Biomass accumulation where driven China and Russia but offset by Brazil. The total committed change is ~0.9 ppm for these regions.

Drivers of Brazilian Flux



Biomass loss is computed relative to a 2009 reference (55 PgC). The droughts in 2010 led to a 1.24 PgC AGB loss. The post-2010 recovery was arrested by the 2015 El Nino leading to a net higher loss.

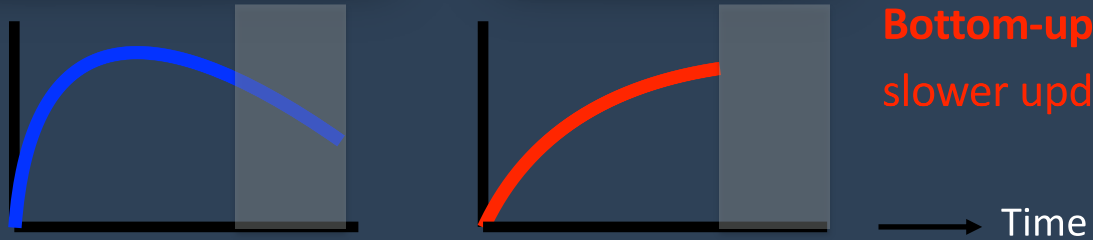
These losses are correlated with NBE variability ($R^2=0.54$) that lead to substantial flux during the 2015 El Nino (Liu et al, 2017)

While fire can explain 2010-2011 NBE (Bowman et al, 2017), its overall role is about 20% accumulated Brazilian CO2.

CO_2 flux prediction using top-down NOx emissions

Air quality (NOx)

GHG (CO_2)



Top-Down

quick update

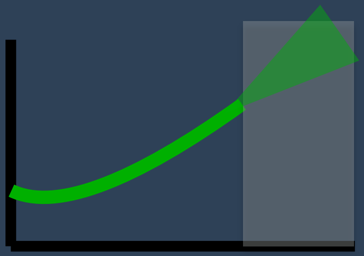
Bottom-up

slower update

Variations in emission ratios (CO_2/NOx)

(gradual changes in technology and regulation)

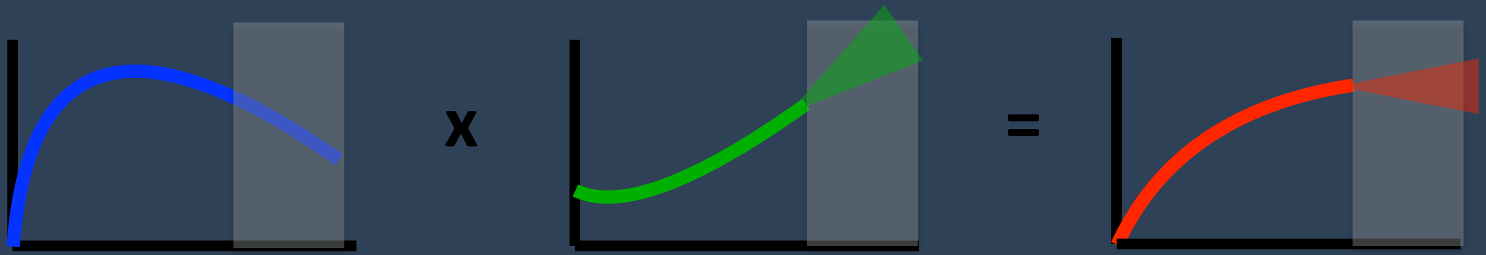
Kalman filter prediction and error estimation



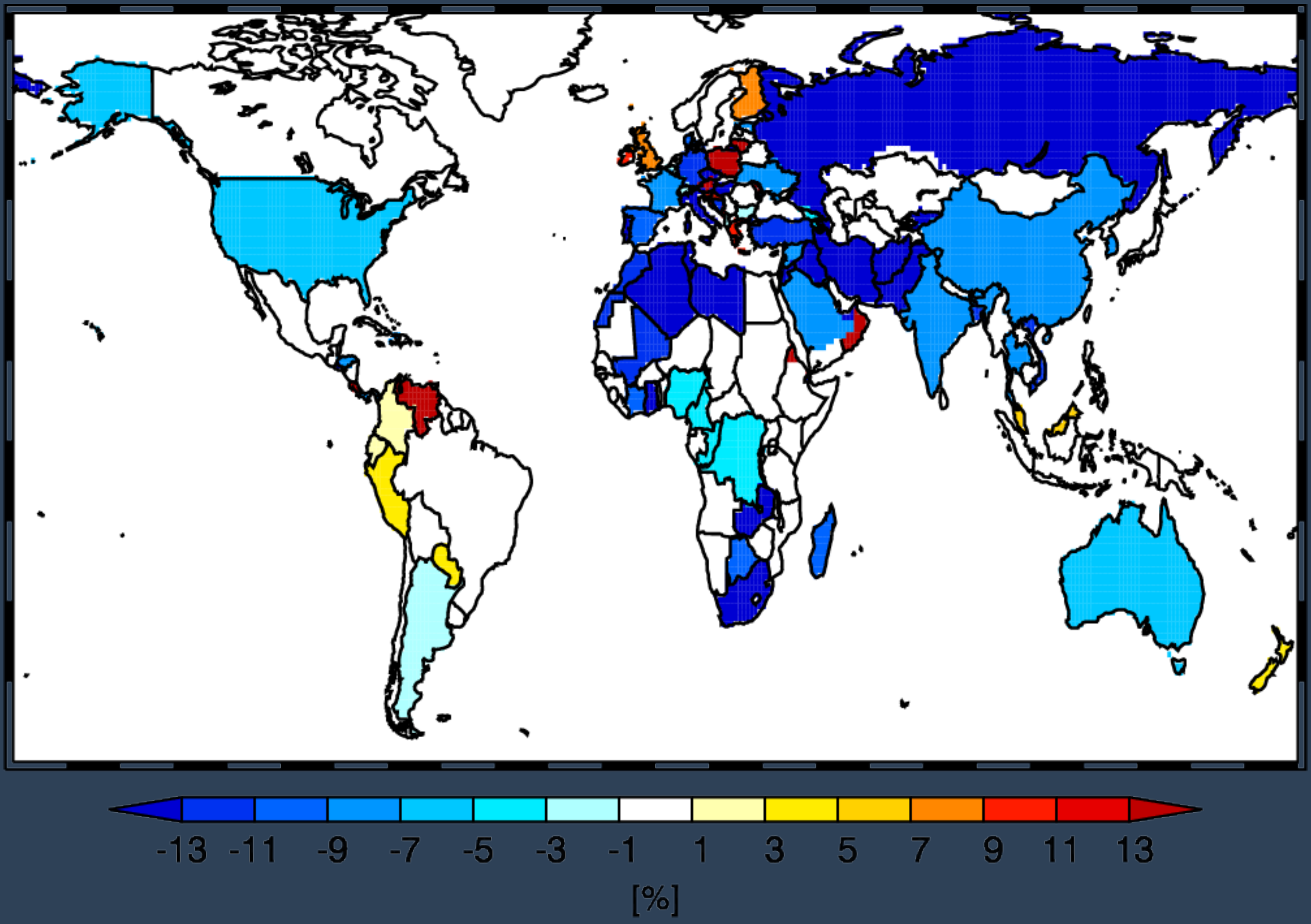
Top-Down NOx emission

Emission ratio

CO_2 flux prediction



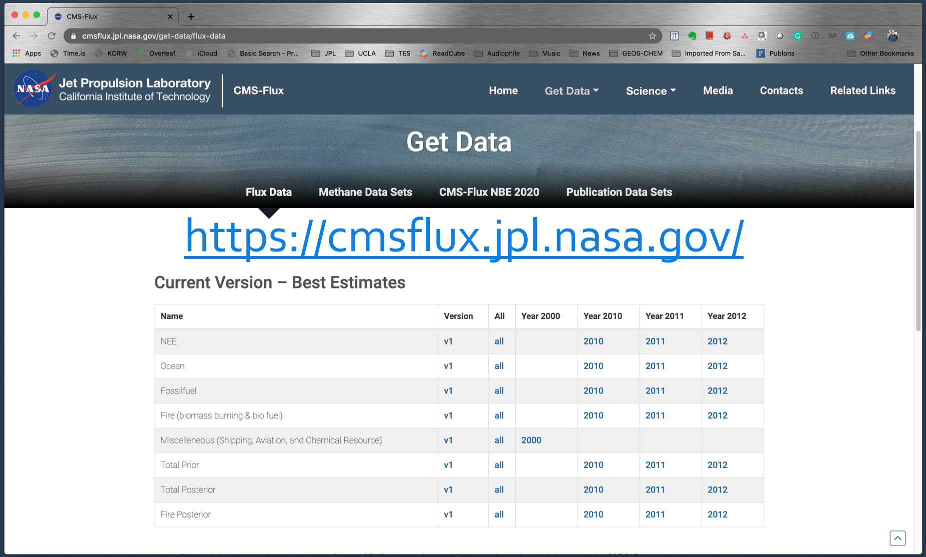
Reductions in FFCO2 from NO2 emissions during COVID-19



Percentage change in FFCO2 during each country’s lockdown relative to the month before.

Products for the Carbon Stocktake

Funding permitting, CMS-Flux will provide net surface-atmosphere ("total") fluxes, FFCO2, Net Biome Exchange (Liu et al, ESSD), GPP, total ecosystem respiration, and ocean fluxes from 2010-2020.

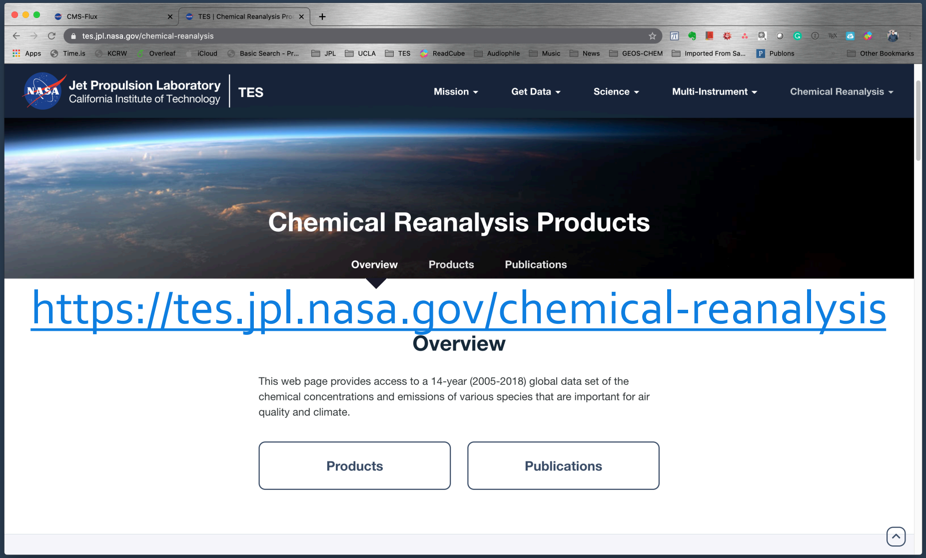


https://cmsflux.jpl.nasa.gov/

Current Version – Best Estimates

Name	Version	All	Year 2000	Year 2010	Year 2011	Year 2012
NEE	v1	all		2010	2011	2012
Ocean	v1	all		2010	2011	2012
Fossilfuel	v1	all		2010	2011	2012
Fire (biomass burning & bio fuel)	v1	all		2010	2011	2012
Miscelleneous (Shipping, Aviation, and Chemical Resource)	v1	all	2000			
Total Prior	v1	all		2010	2011	2012
Total Posterior	v1	all		2010	2011	2012
Fire Posterior	v1	all		2010	2011	2012

Using MOMO-Chem (Miyazaki et al, 2020), chemical reanalysis will provide NOx, CO, SO2, and other emissions and pollutants. Will provide basis for FFCO2 and biomass burning anomalies.



https://tes.jpl.nasa.gov/chemical-reanalysis

Overview

This web page provides access to a 14-year (2005-2018) global data set of the chemical concentrations and emissions of various species that are important for air quality and climate.

Conclusions

- The bidecadal stocktake requires a link between
  - net GHG flux ← → Concentrations (what the climate sees)
  - FFGHG ← → Emissions (what carbon mitigation sees)
- Top-down GHG monitoring systems, not the UNFCCC inventories, can make that link.
- The stability and cross-calibration of the CEOS GHG/AQ constellation will be critical considerations for trend estimates and attribution.
  - Important role for GHG OSSEs.
- GHG/AQ synergies along with biomass will be key to understand anthropogenic process
  - At decadal time scales, short-lived climate pollutants (SLCPs) must be integrated.