Air Quality and Carbon constellation: possible synergies

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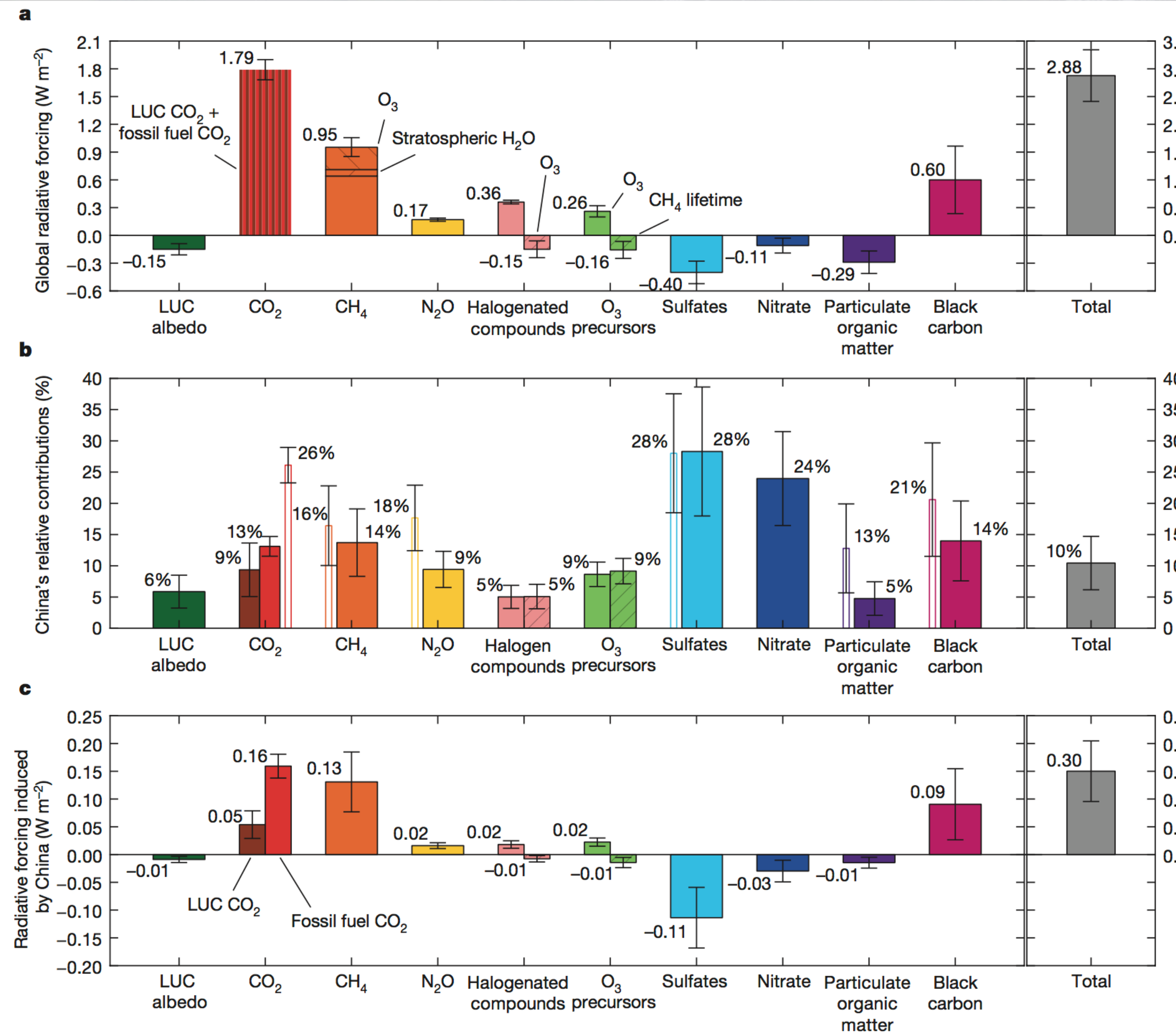
Total RF from China

- China contributes 10% ± 4% of the current global radiative forcing.
- CO2: 0.16 ± 0.02 W/m^2
- CH4: 0.13 ± 0.05 W/m^2 (includes effects on ozone and water vapor)
- Sulfates: −0.11 ± 0.05 W/m^2 (from SO_2)



How will these change
In the future?

Li et al, 2016, Nature

The ties that bind: air quality and carbon

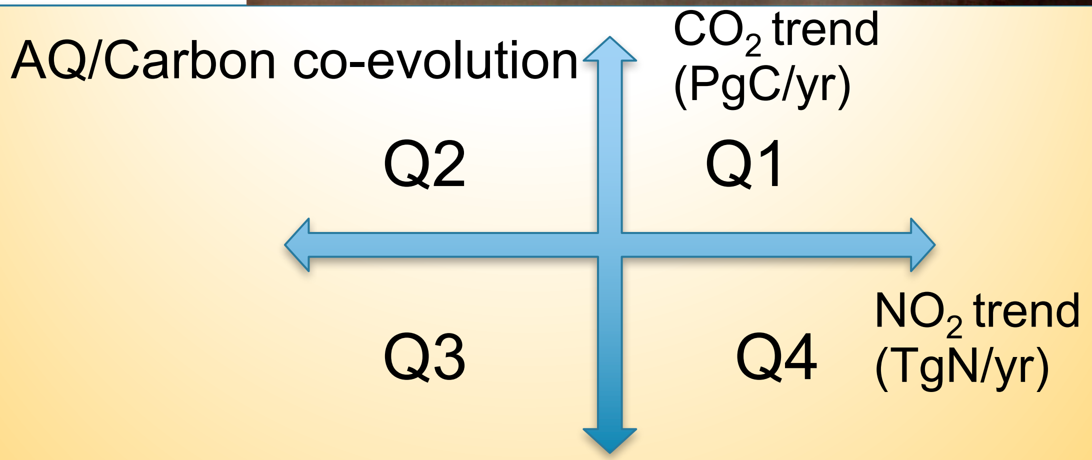
Deteriorating air quality in China such as the "Airpocalypse" in Harbin has led to ~500,000 premature deaths/yr (Chen et al, Lancet 2014) prompting a "war on air pollution" from government officials.

How will changes in air quality mitigation impact carbon emissions?

China's AQ mitigation (12th 5-year plan) effort has mainly centered on reducing, displacing, relocating, and scrubbing pollutant emissions from coal-based electrical power (Karplus et al, 2015; Nam et al, 2013).

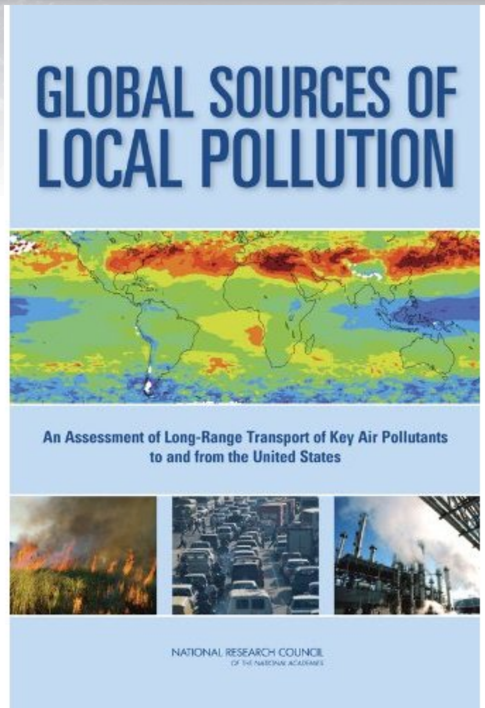
AQ improvements could ***lock in*** commitments to coal-power generation and a high carbon pathway.

Director of the Development Research Center (DRC) of China's State Council energy objectives to show a strong shift towards natural gas and renewables within a decade. (Sheehan *et al,* 2014)

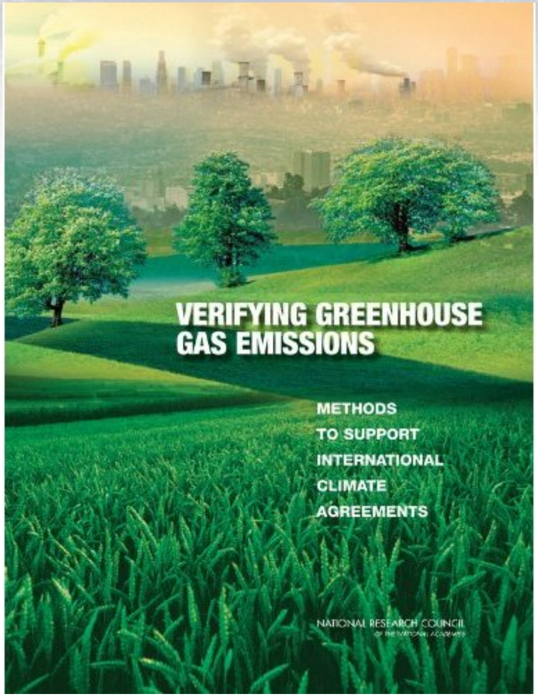


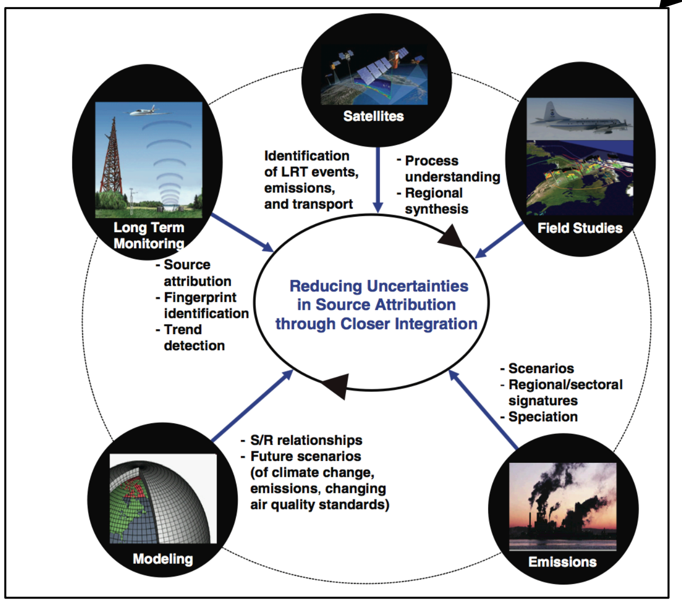
Q1: Business as usual (BAU)
Q2: AQ-only (CO_2 lock-in?)
Q3: AQ/Carbon (renewables)
Q4: Carbon-only

Supporting mitigation policies



How can we develop science-based mitigation policies and monitor their effectiveness?





COP21 · CMP11
PARIS 2015
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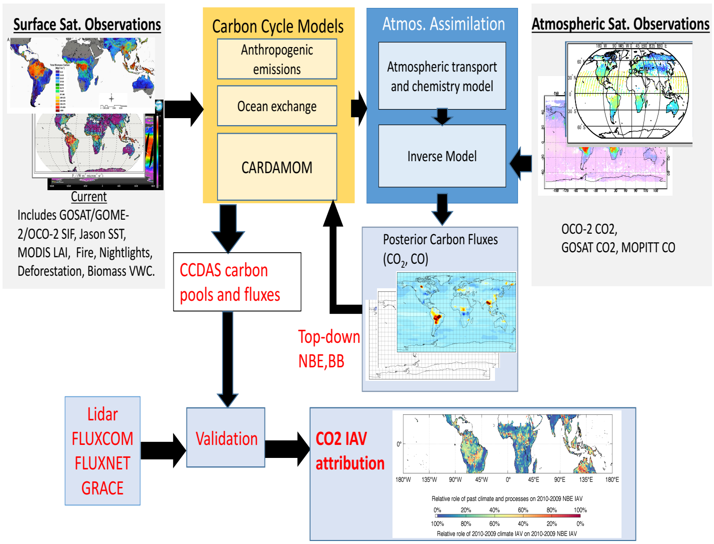
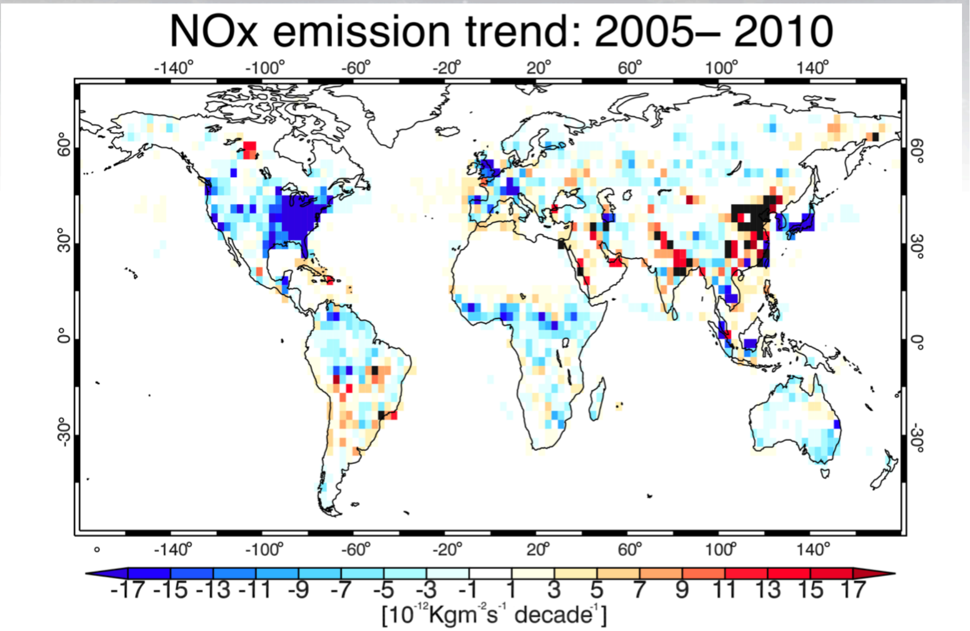
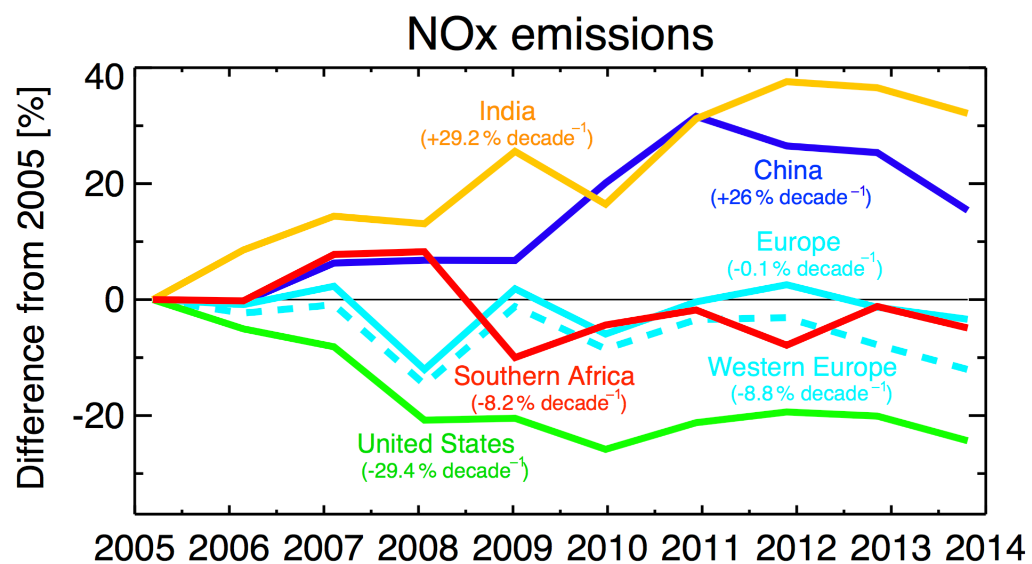
Carbon Cycle Data Assimilation System (CMS-Flux)

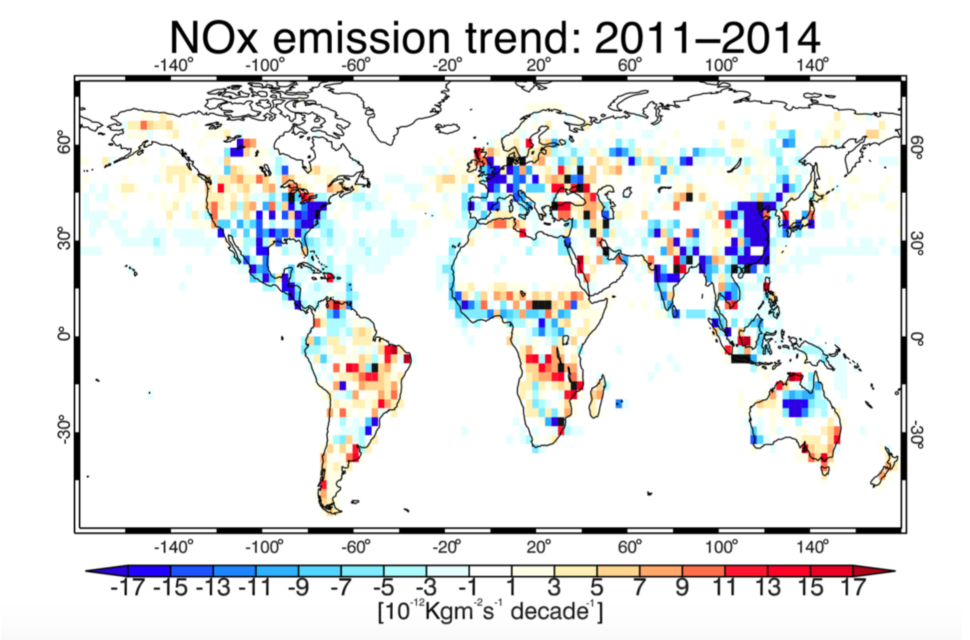


The turning point NOx emissions

Based upon a multi-constituent satellite data assimilation/inversion system (TES, MOPITT, MLS, OMI), Miyazaki et al, 2017 showed that China dramatically increased NOx emissions until turning a corner in 2011.

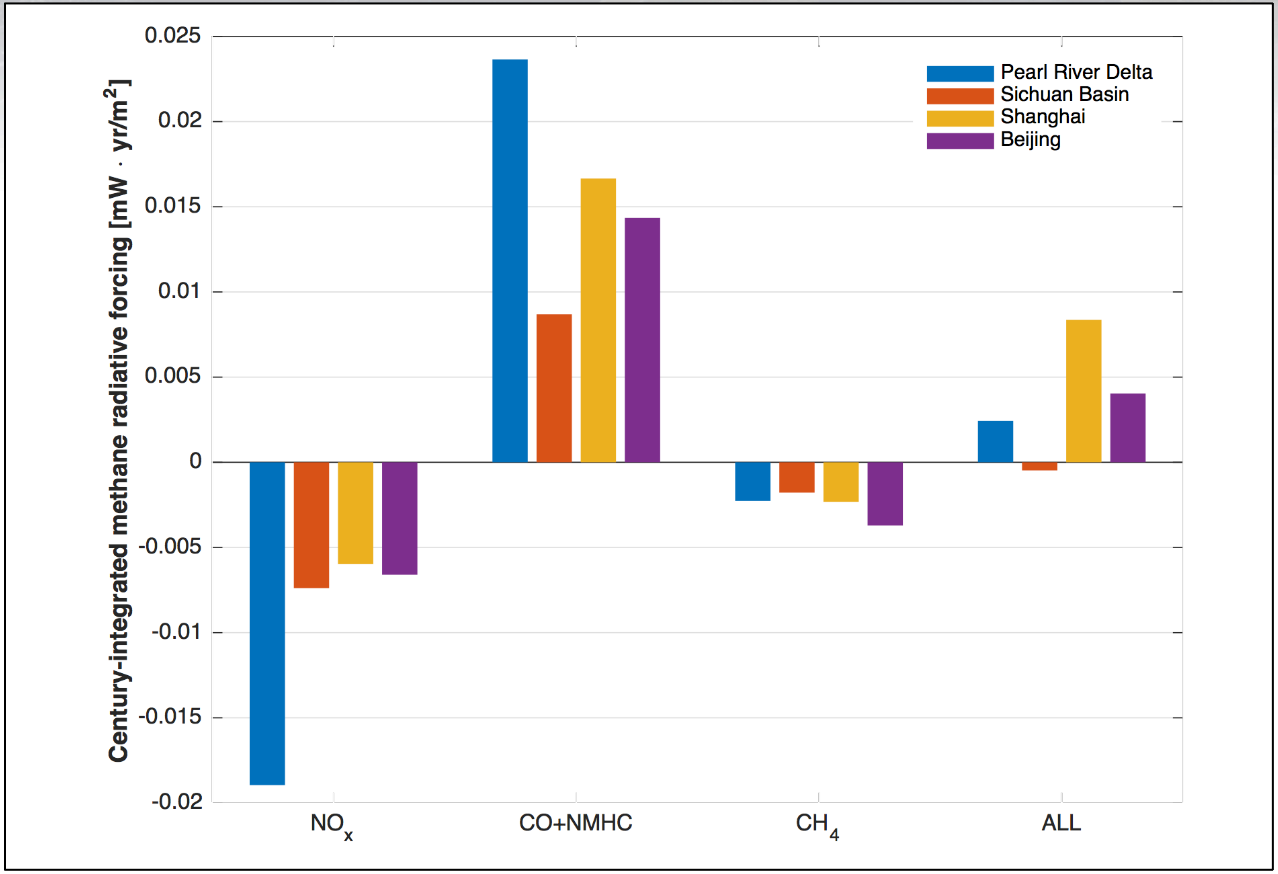






Miyazaki et al, 2017, ACP

Location matters: spatial gradients of CH4 forcing



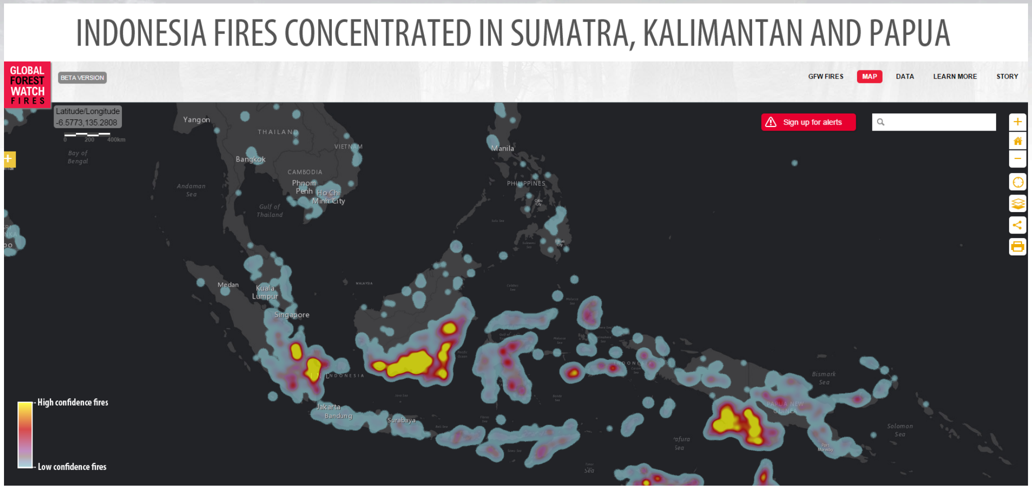
Walker and Bowman, *in Rev.*

In China, the sensitivity of global methane loss rates to precursor emissions varies by a factor of 2 between 20N and 45N for NOx and a by a factor of 7 between 120E and 90E for CO.

For RCP6, total CH4 RF in Beijing and Shanghai is dominated by CO emissions whereas Pearl River Delta and Sichuan Basin are largely balanced.

CH4 RF is driven by the balance between the magnitude of CO and NOx emissions trends and the spatially dependent sensitivity

Indonesia Fires

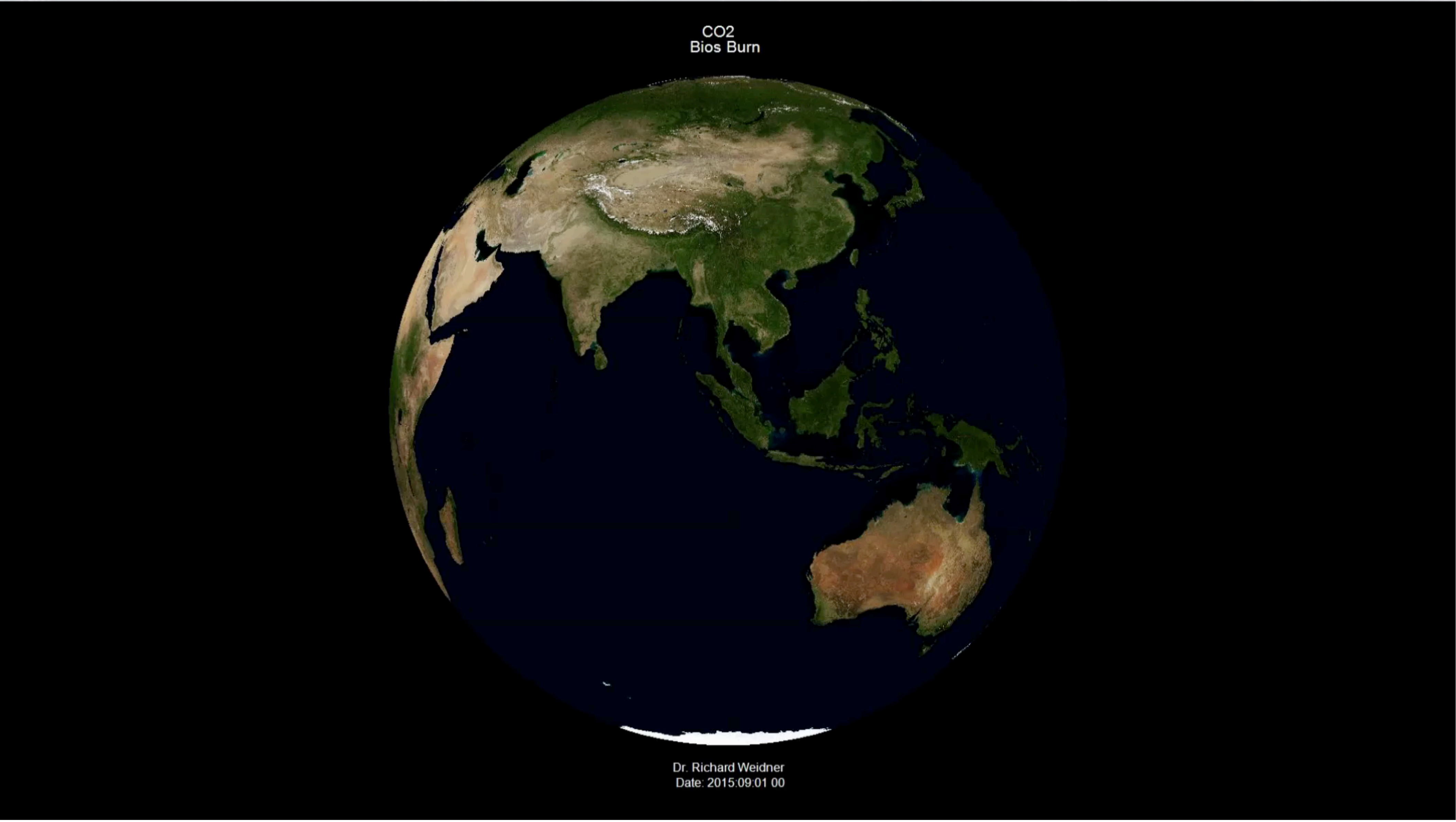


fires.globalforestwatch.org

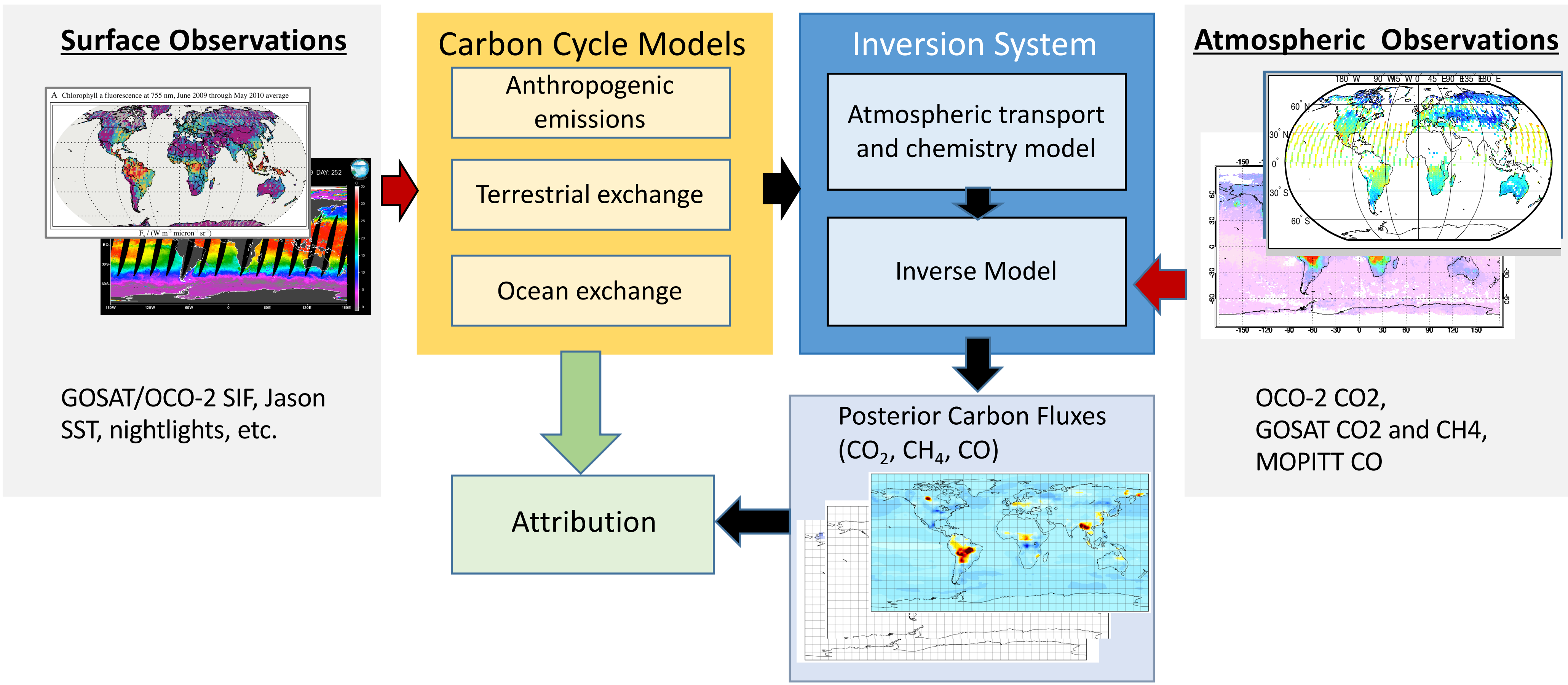
WORLD RESOURCES INSTITUTE

NASA Earth Observatory

Atmospheric signature of Indonesian composition

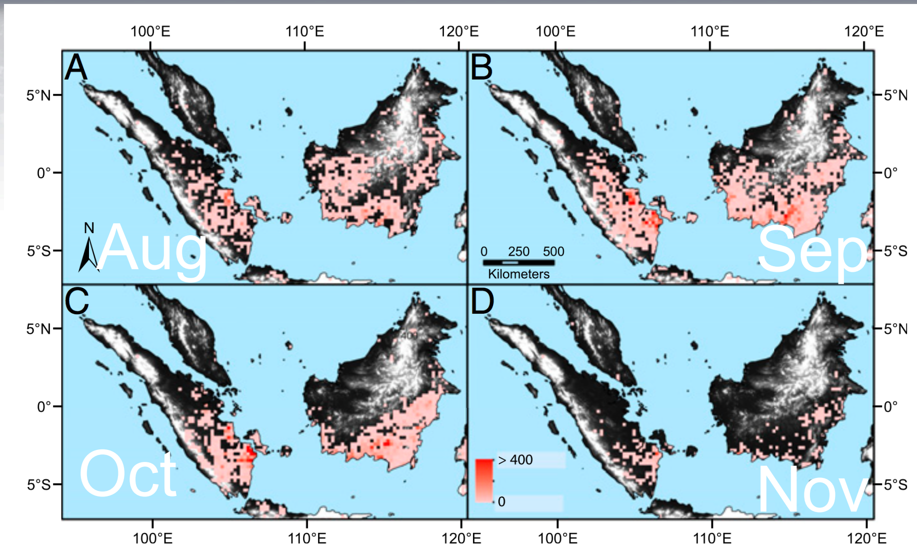


NASA Carbon Monitoring System Flux (CMS-Flux)

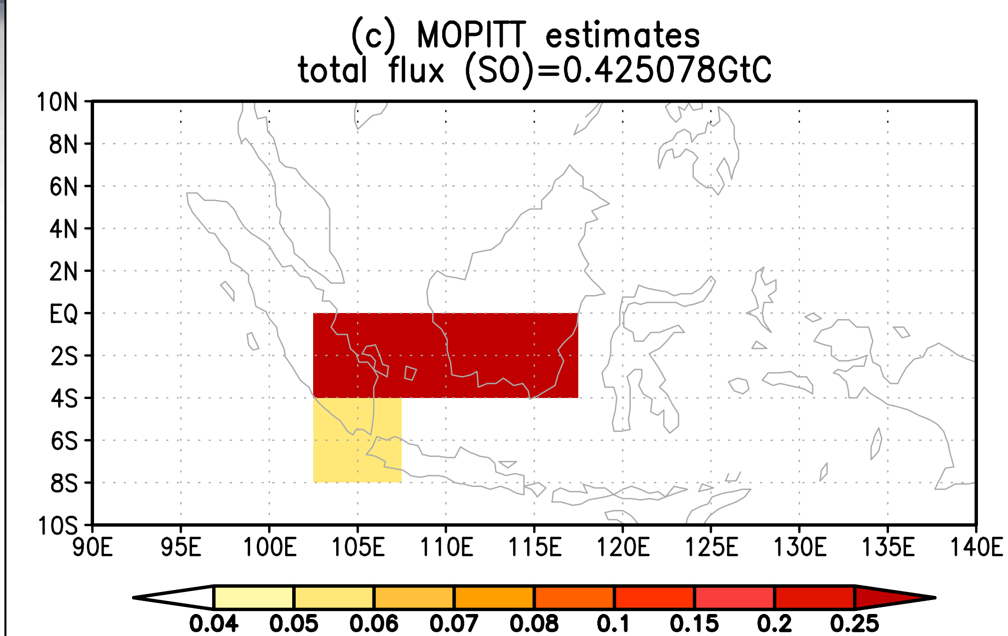


The NASA Carbon Monitoring System Flux (CMS-Flux) attributes atmospheric carbon variability to spatially resolved fluxes driven by data-constrained process models across the global carbon cycle.

CMS-Flux Carbon Fluxes



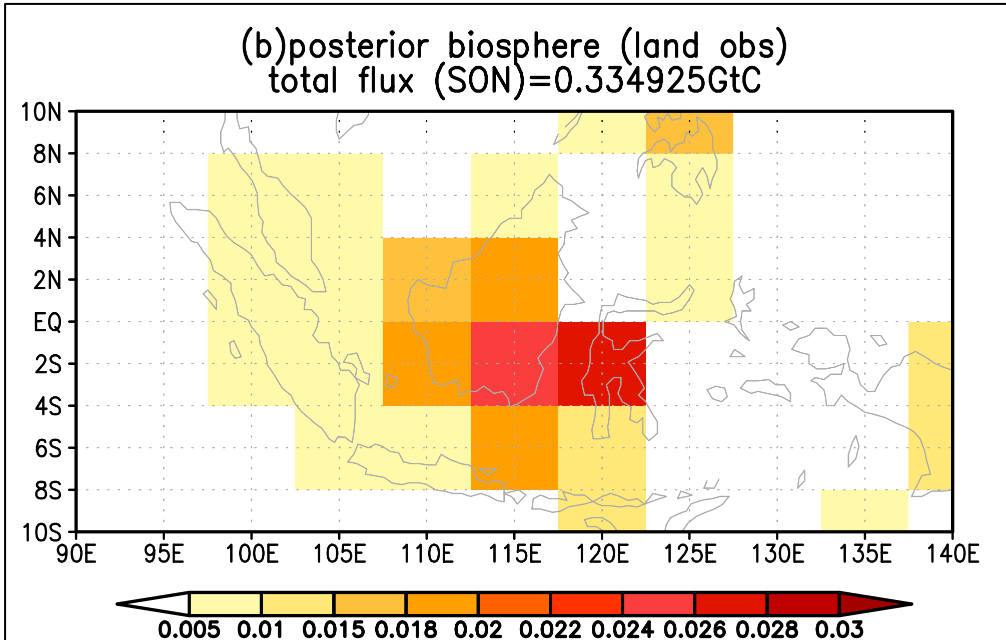
Field et al, 2016 (PNAS)



“Top-down” emissions constrained by MOPITT CO show elevated biomass burning in Sumatra and Kalimantan. CO:CO2 calculated from Stockwell et al, ACP (2016) (see E. Putra GC21C-1107).

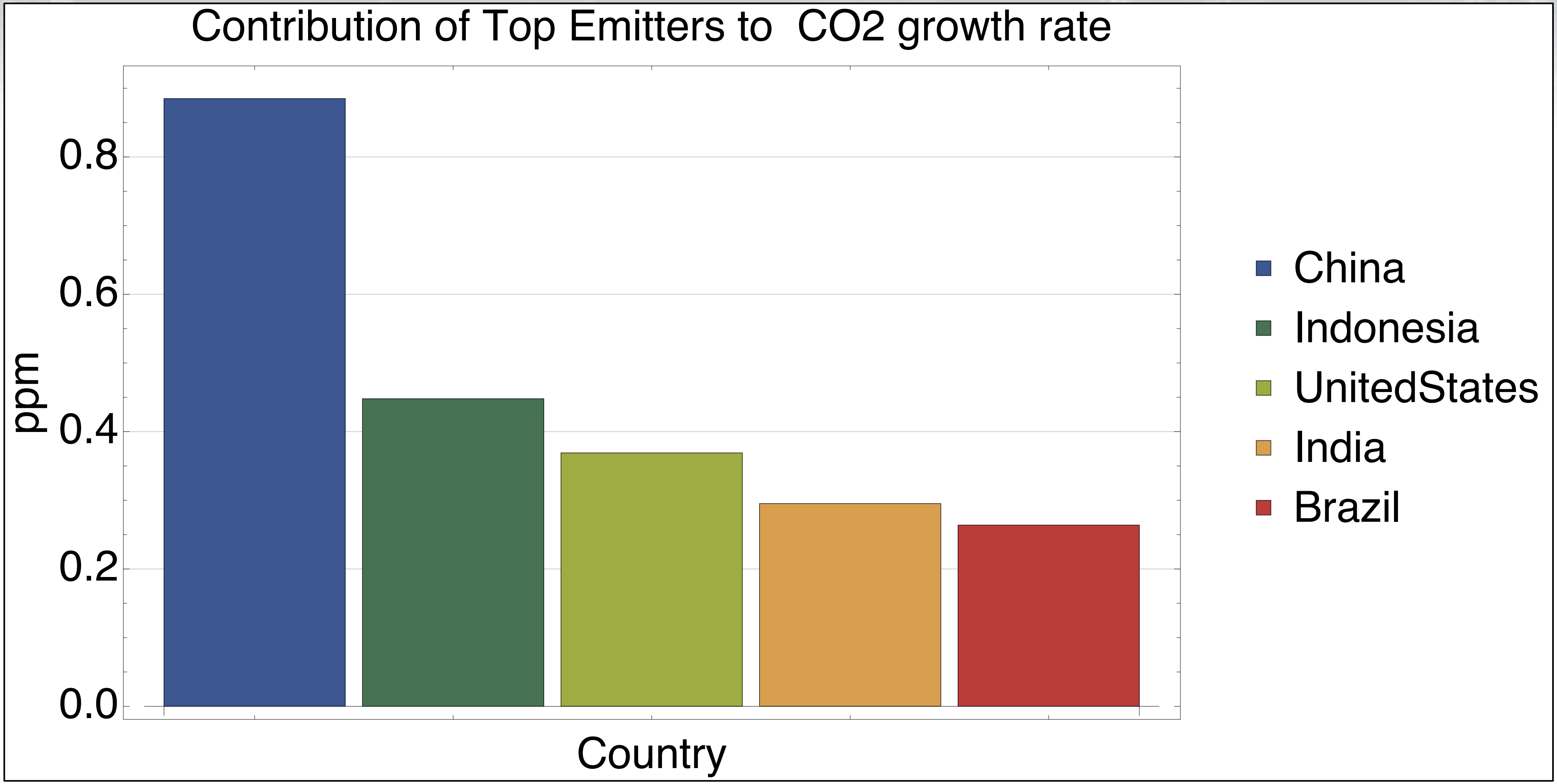
CO_2 fluxes constrained from OCO-2 are centered in S. Kalimantan.

BB CO_2 similar to 0.5 PgC in Yin et al, 2016 (GRL)



CMS-Flux SON 2015
BB CO_2 = 0.4 ± 0.03 GtC
NBE CO_2 = 0.3 ± 0.02 GtC
NEP = 0.1 ± 0.04 GtC

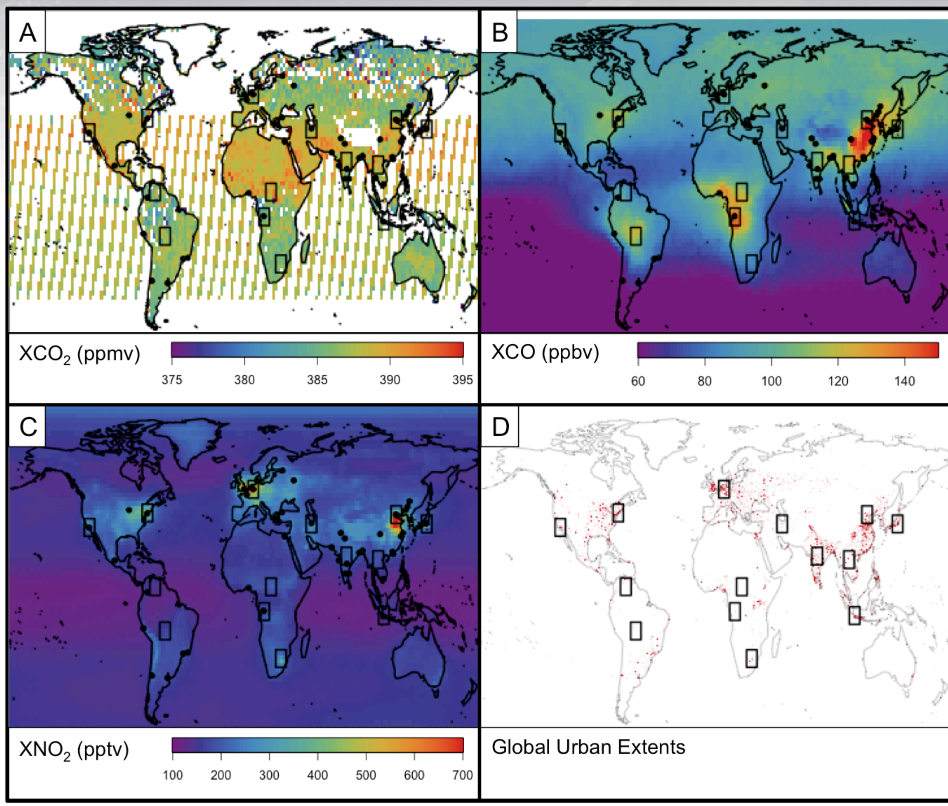
Implications for 2015 CO2 growth rate



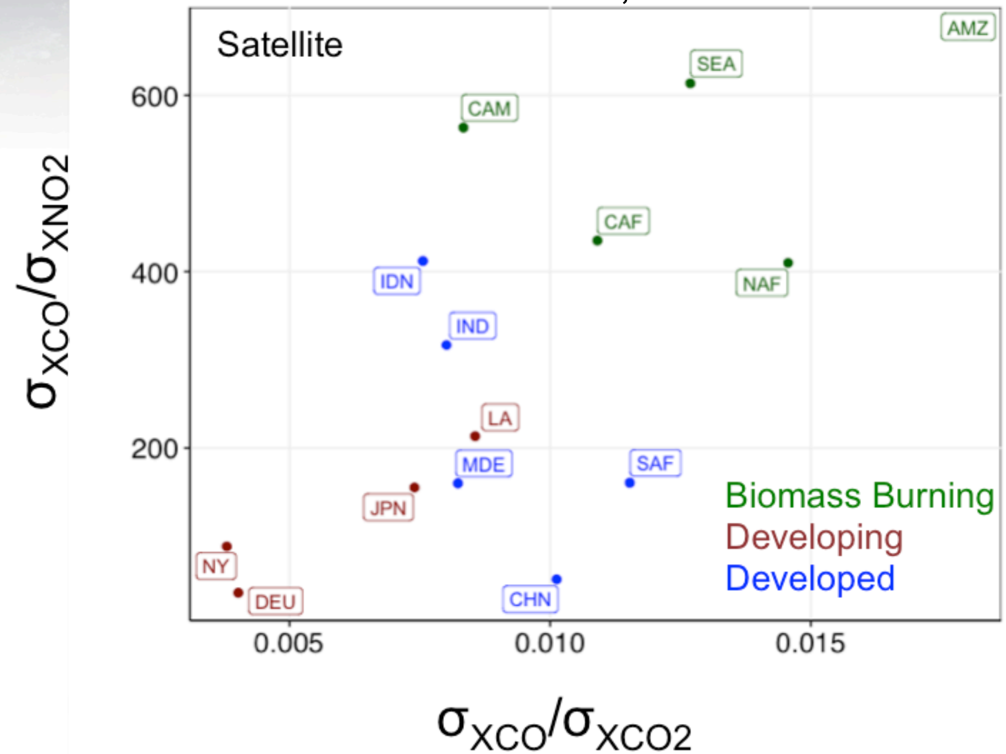
The Indonesian region was the 2nd highest contributor (0.45 ppm) in total flux to the record CO2 growth rate in 2015.

But, Brazil was almost as important.

Linking CO_2, CO, and NO_2

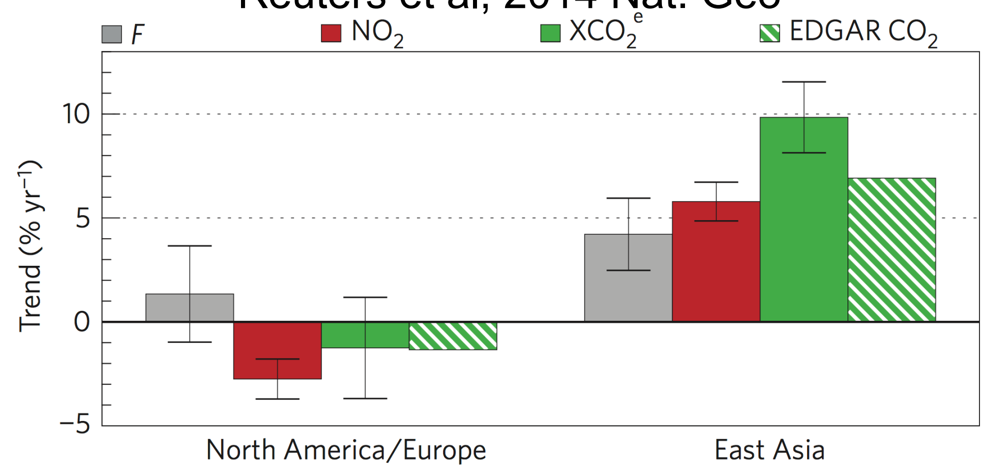


Silva and Arellano, submitted



Silva and Arellano, *submitted* show ratios of the variability in CO, NO_2, and CO_2 show distinct patterns relating to local combustion processes.

Reuters et al, 2014 Nat. Geo



Reuters et al, 2014 showed that trends Between NO_x and CO_2 are diverging

The times they are a-changing

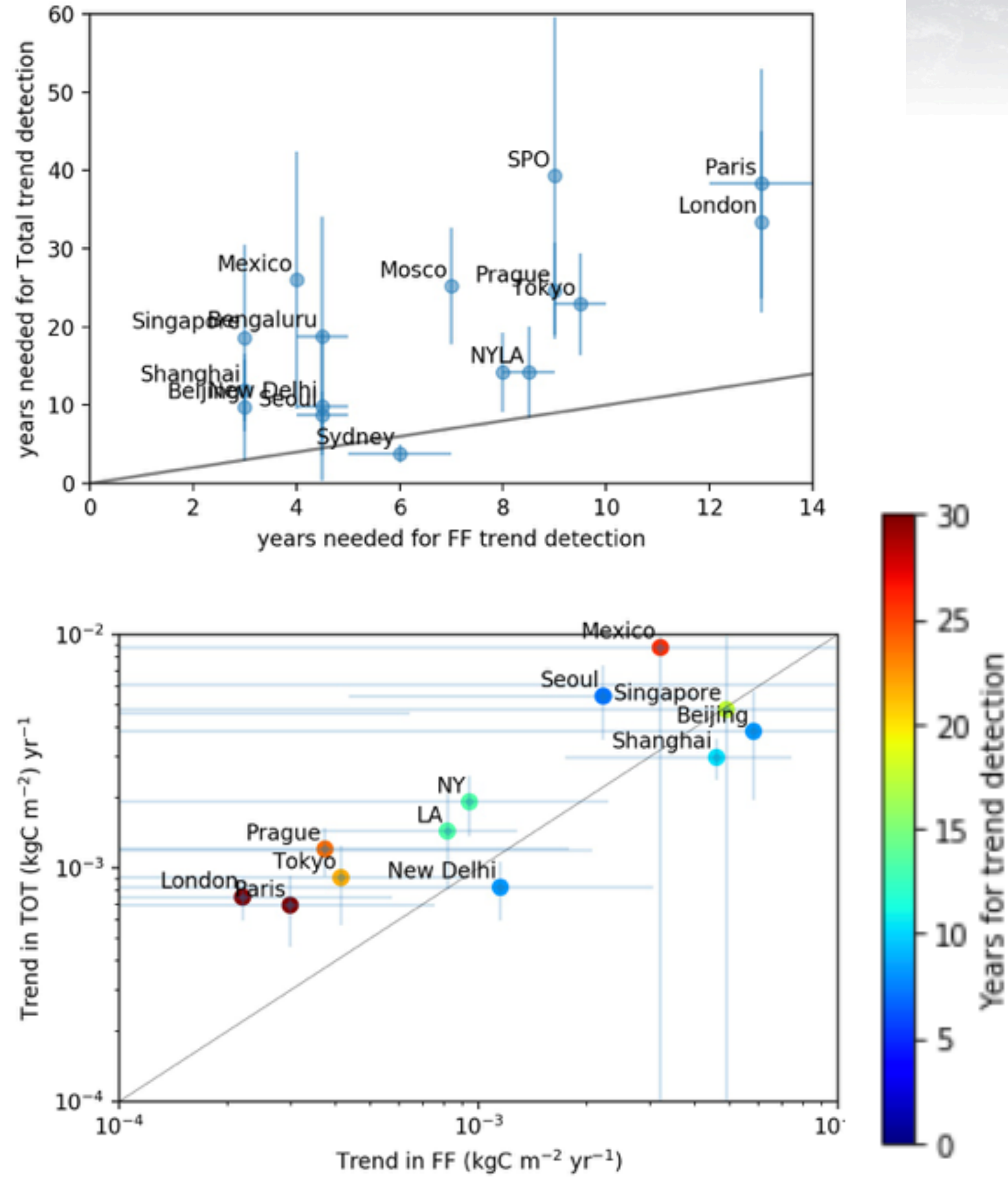
A key need for COP21 is how fossil fuel emissions are changing.

FF trend amplitude and variability leads to time-to-detection between 3 to >10 years.

However, natural carbon variability increases time-to-detection (factor 1.2 to >3)

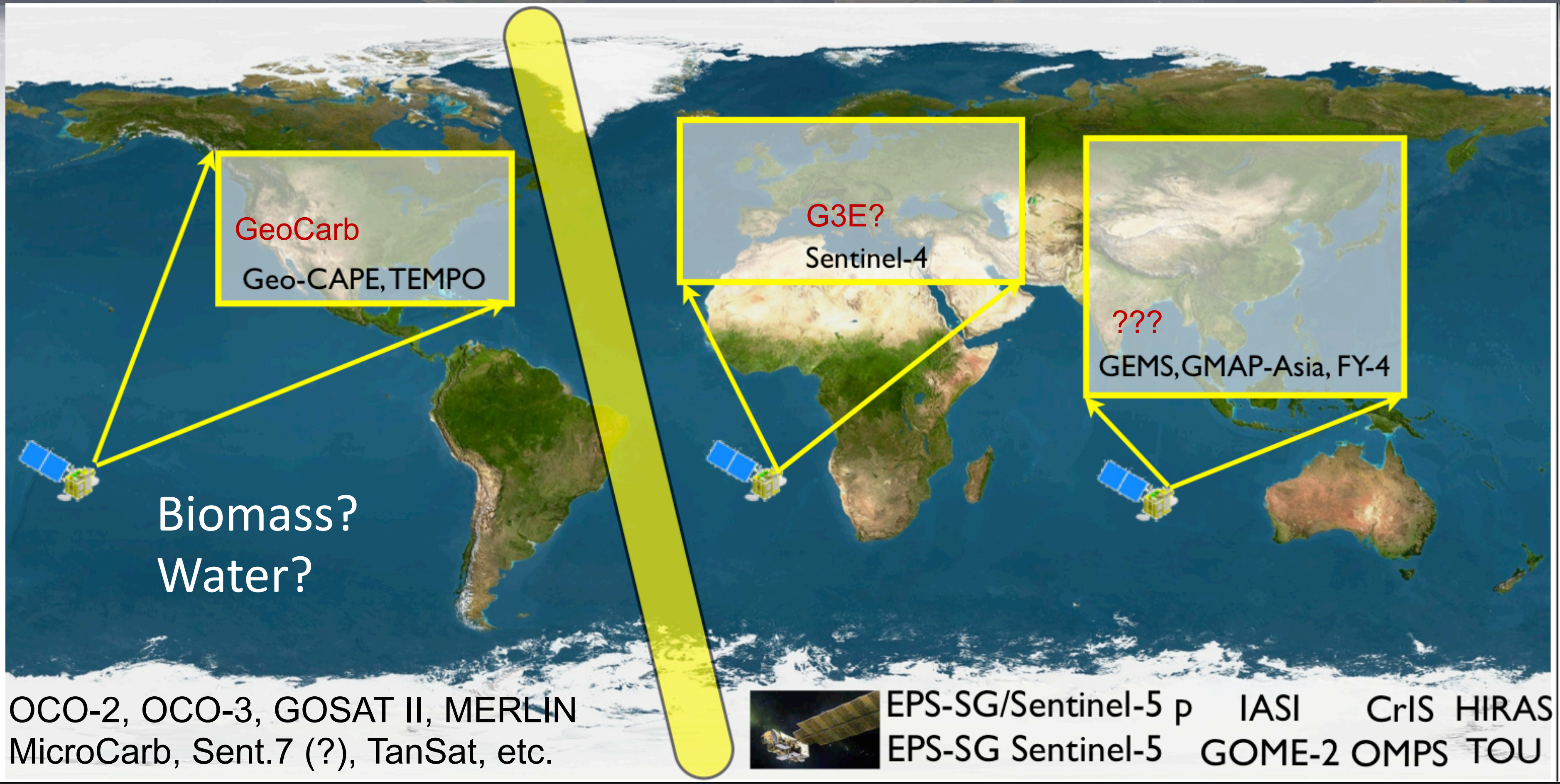
Carbon feedbacks (carbon-concentration and carbon climate) contribute their own trend.
Both are important.

Yin and Bowman



Toward an Air Quality-Carbon-Climate Constellation

Bowman et al, Atm.Env. 2013



- LEO:
  - IASI+GOME-2, AIRS+OMI, CrIS+OMPS could provide UV+IR ozone products for more than a decade.
  - Combined UV+IR ozone products from GEO-UVN and GEO-TIR aboard Sentinel 4 (Ingmann *et al*, 2012 Atm. Env.)
  - Sentinel 5p (TROPOMI) will provide column CO and CH4.
  - OCO-2+AIRS, GOSAT II (IR+NIR) could provide vertical discrimination.
- GEO
  - TEMPO, Sentinel-4, and GEMS, would provide high spatio-temporal air quality information.
  - GeoCarb and G3E could provide geo-carbon information.

Conclusions

- Climate mitigation requires an observation system of both long and short-lived climate pollutants.
- AQ mitigation in developing countries will impact the near-term trajectory of carbon emissions.
  - The co-evolution of CO_2, NO_2, CO, and particulates can provide insight
- Climate variability and feedbacks can coherently amplify AQ and carbon distributions
  - ”Extreme” events may hinder policy objectives
  - Trend detection of AQ and carbon must account for natural variability
- Integrating AQ and carbon constellations will provide an unprecedented capability
  - Need quantitative analysis of constellation(s), e.g., OSSEs.