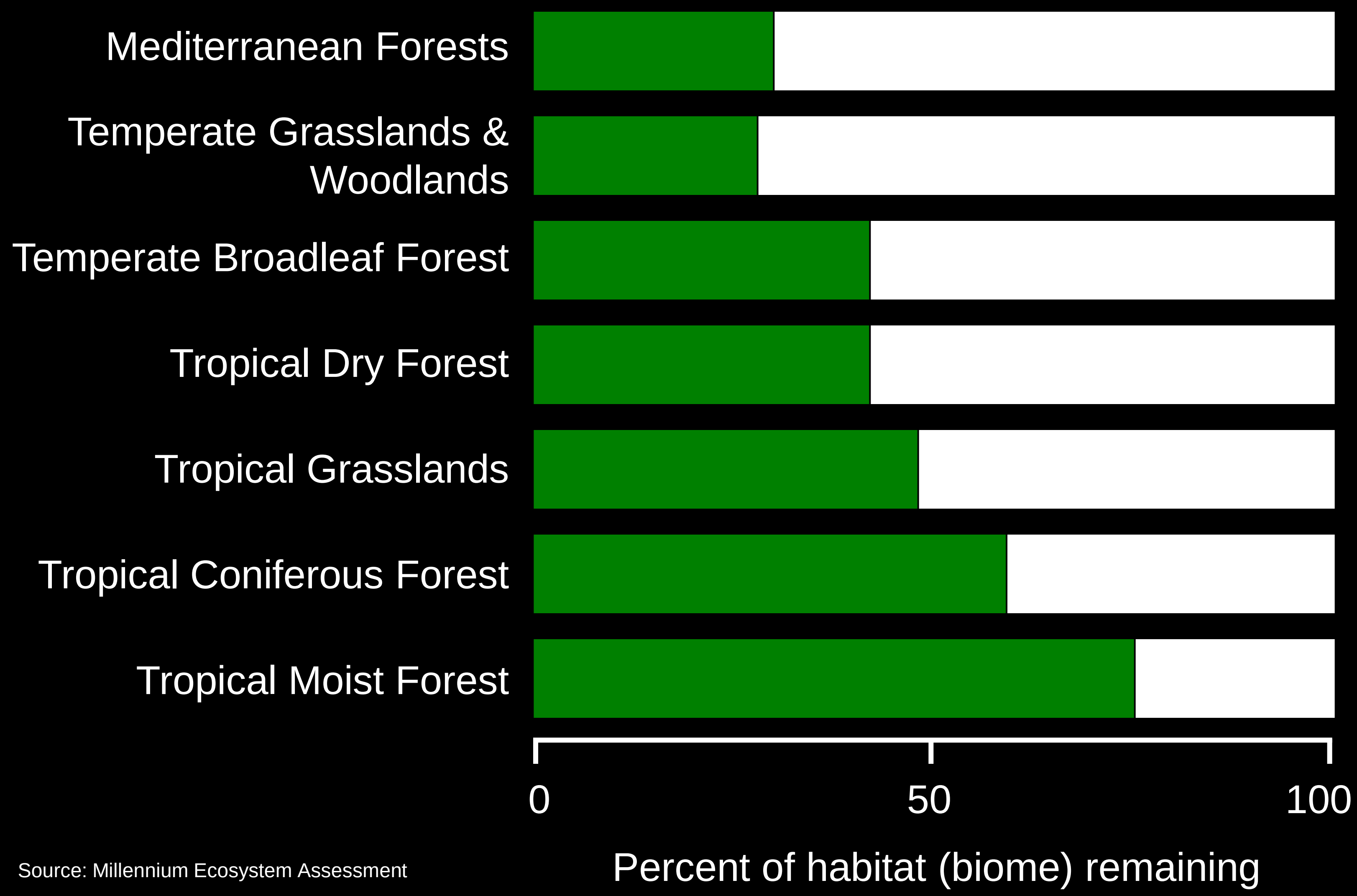
Technical Workshop on Science and Policy of Short-lived climate forcers – Mexico City, September 9-10, 2011

Biomass burning as a driver for reducing greenhouse gas emissions and regional air pollution

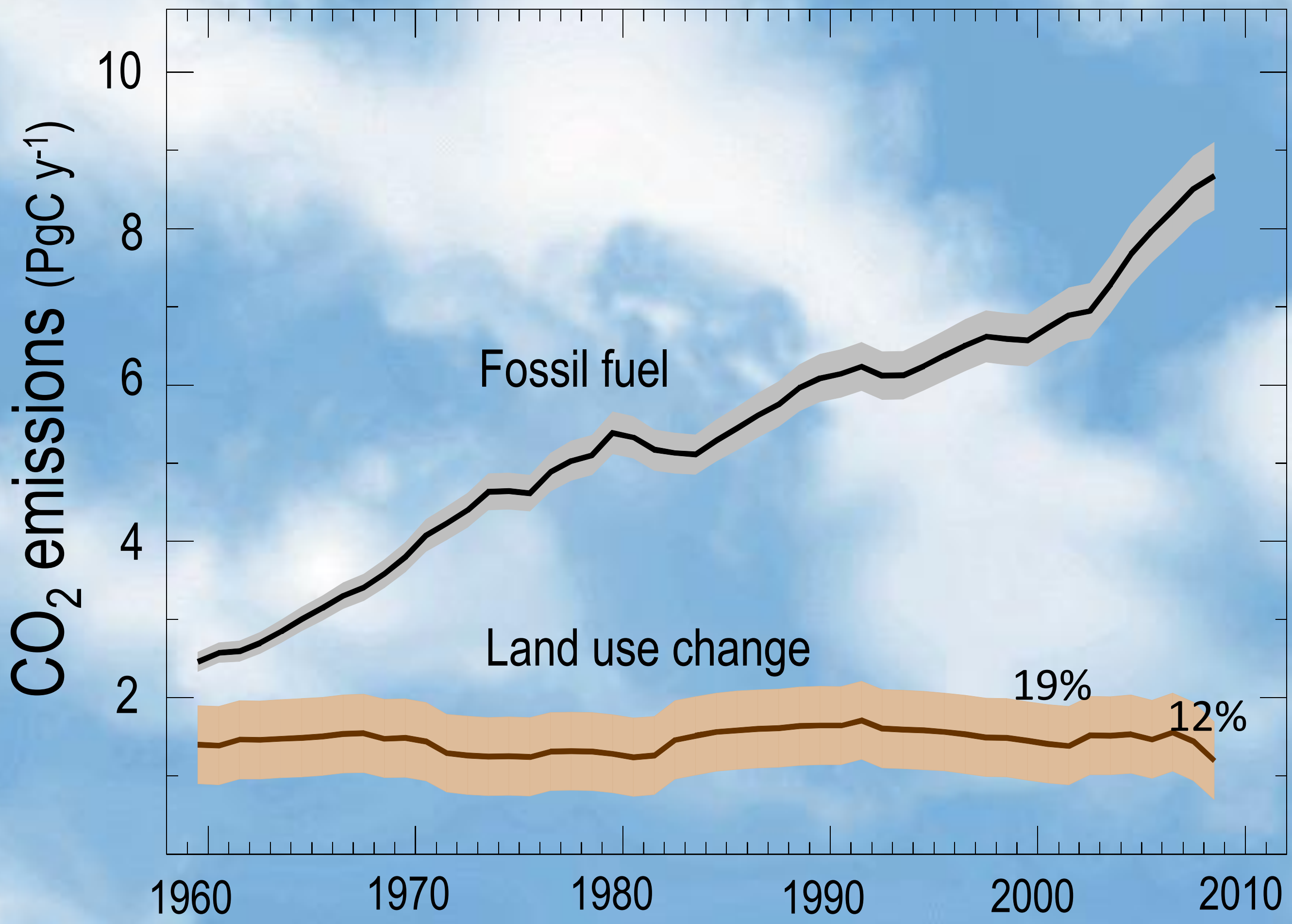
Paulo Artaxo
University of São Paulo, Brazil, artaxo@if.usp.br

Habitat Loss to 1990



Source: Millennium Ecosystem Assessment

CO_2 Emissions from Land Use Change



Le Quéré et al. 2009, Nature-geoscience; Data: CDIAC, FAO, Woods Hole Research Center 2009

Fate of Anthropogenic CO_2 Emissions (2000-2008)

1.4 PgC y^{-1}

+

7.7 PgC y^{-1}

4.1 PgC y^{-1}

45%

3.0 PgC y^{-1}

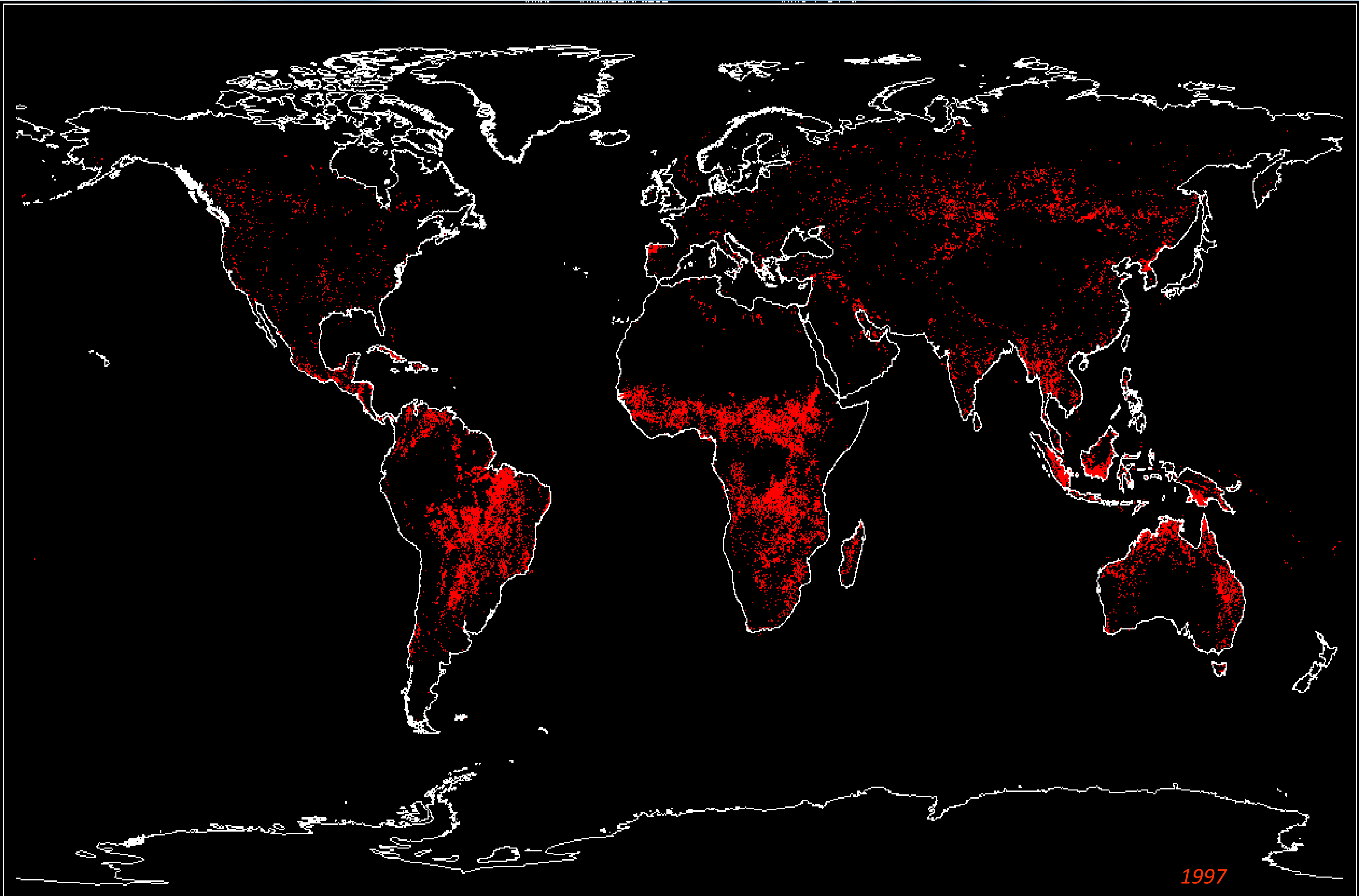
29%

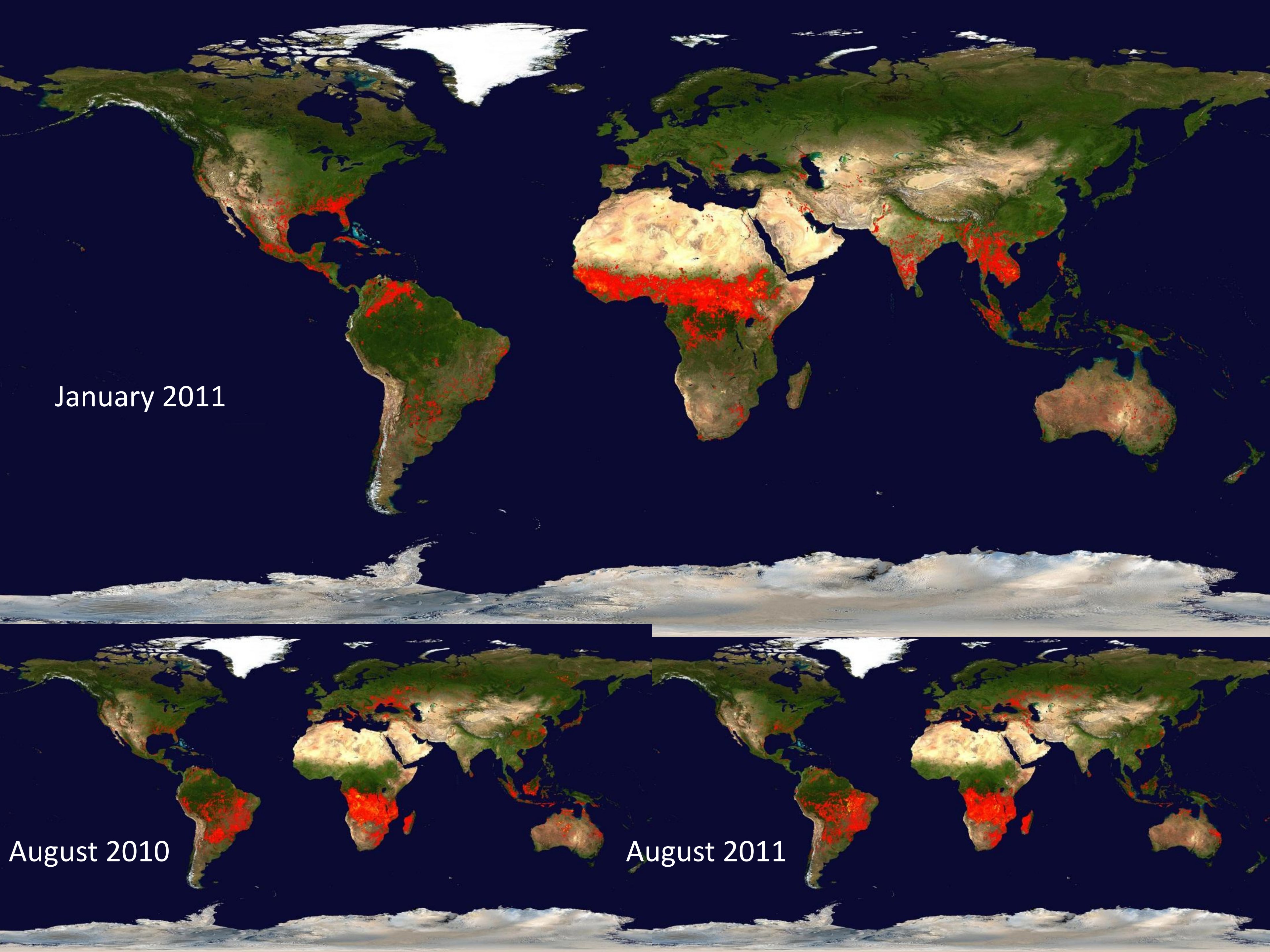
26%

2.3 PgC y^{-1}

Le Quéré et al. 2009, Nature-geoscience; Canadell et al. 2007, PNAS, updated

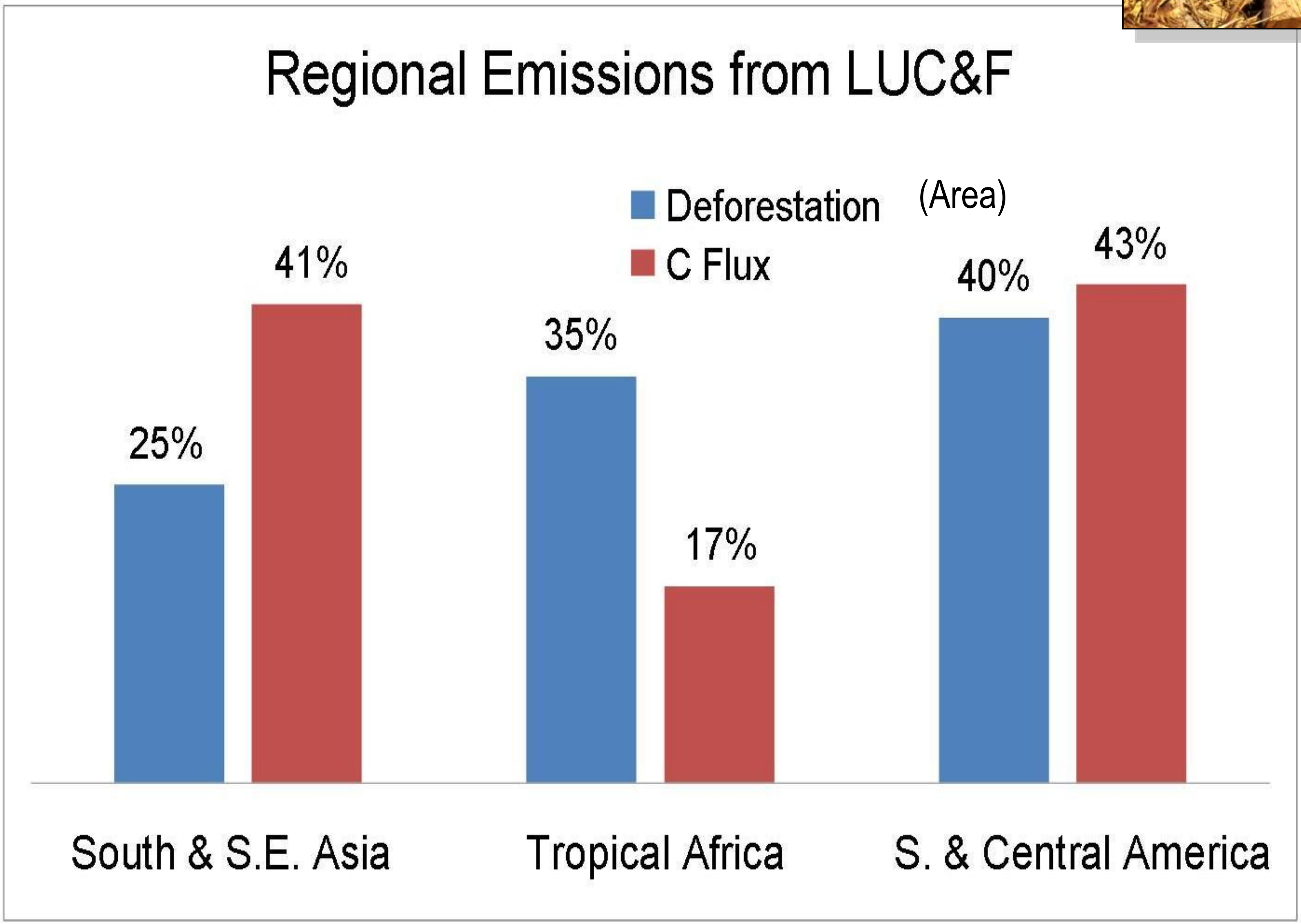
Global biomass burning



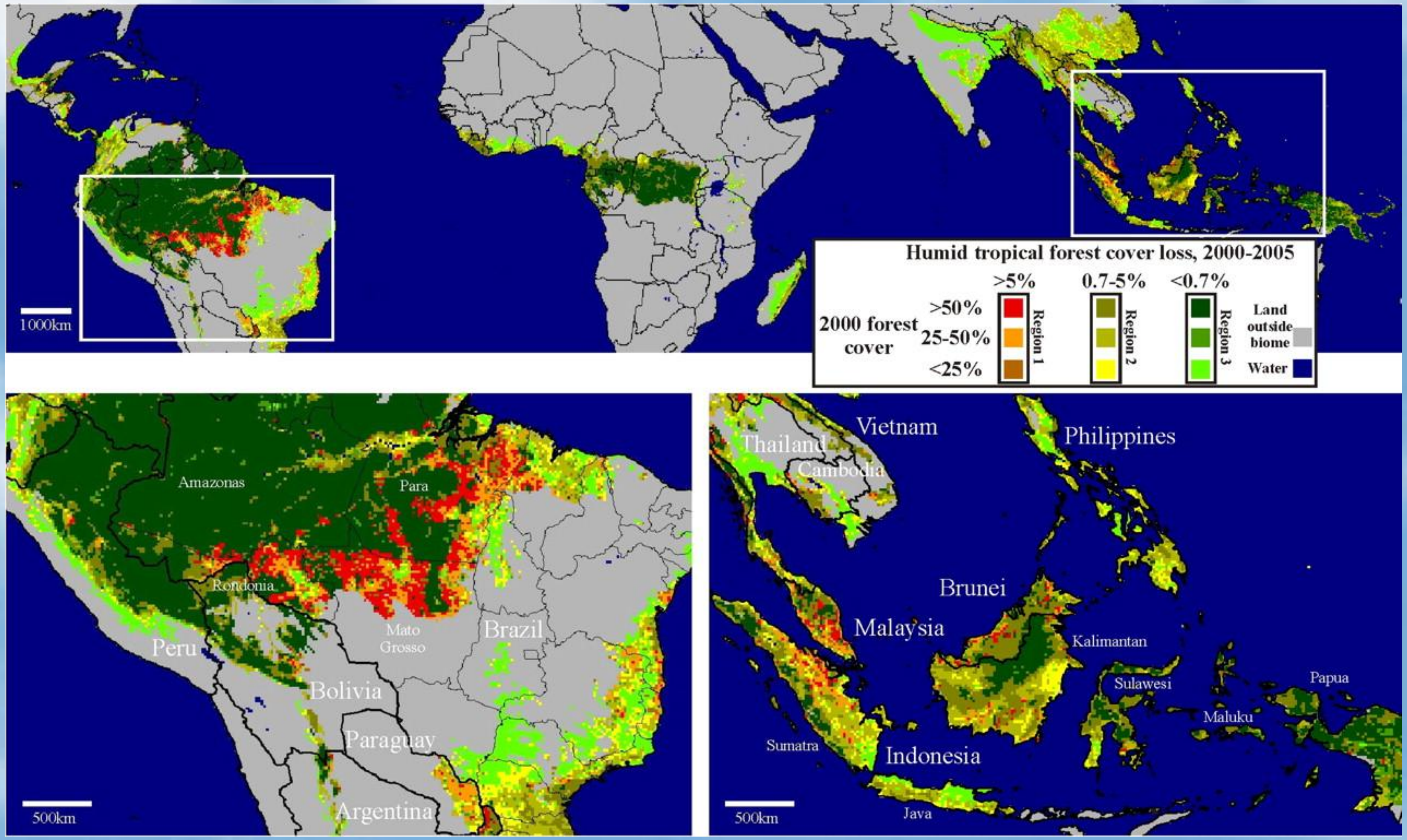

January 2011
August 2010
August 2011

Carbon emissions from Land Use Change (2000-2005)

Canadell et al. 2009, Biogeosciences



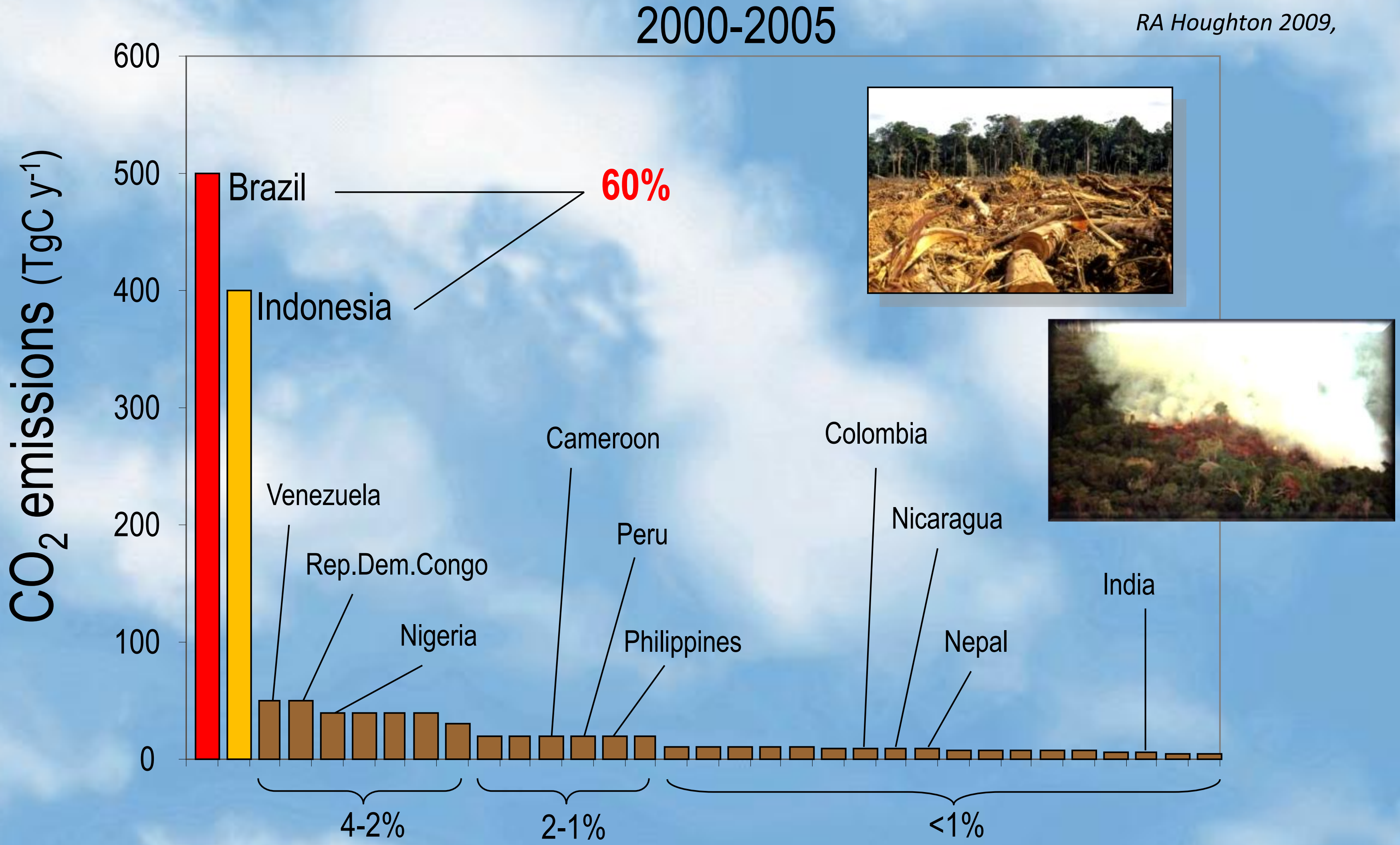
Forest clearing and forest cover in the humid tropical forest biome, 2000–2005



Forest loss in Brazil accounts for 48% of total biome clearing, nearly four times that of the next highest country, Indonesia, which accounts for 13%.

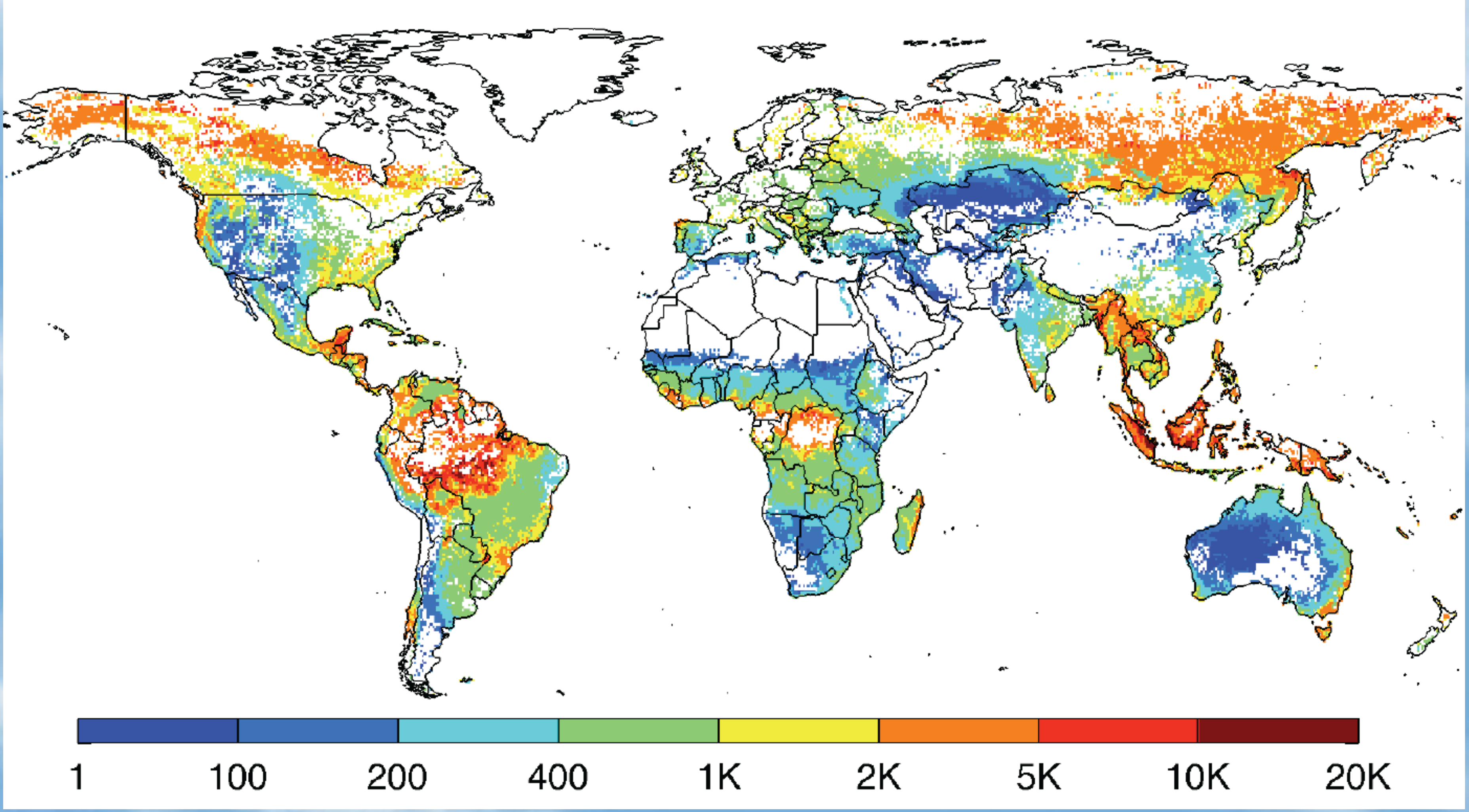
Hansen M. C. et.al. PNAS 2008

Net CO_2 Emissions from LUC in Tropical Countries



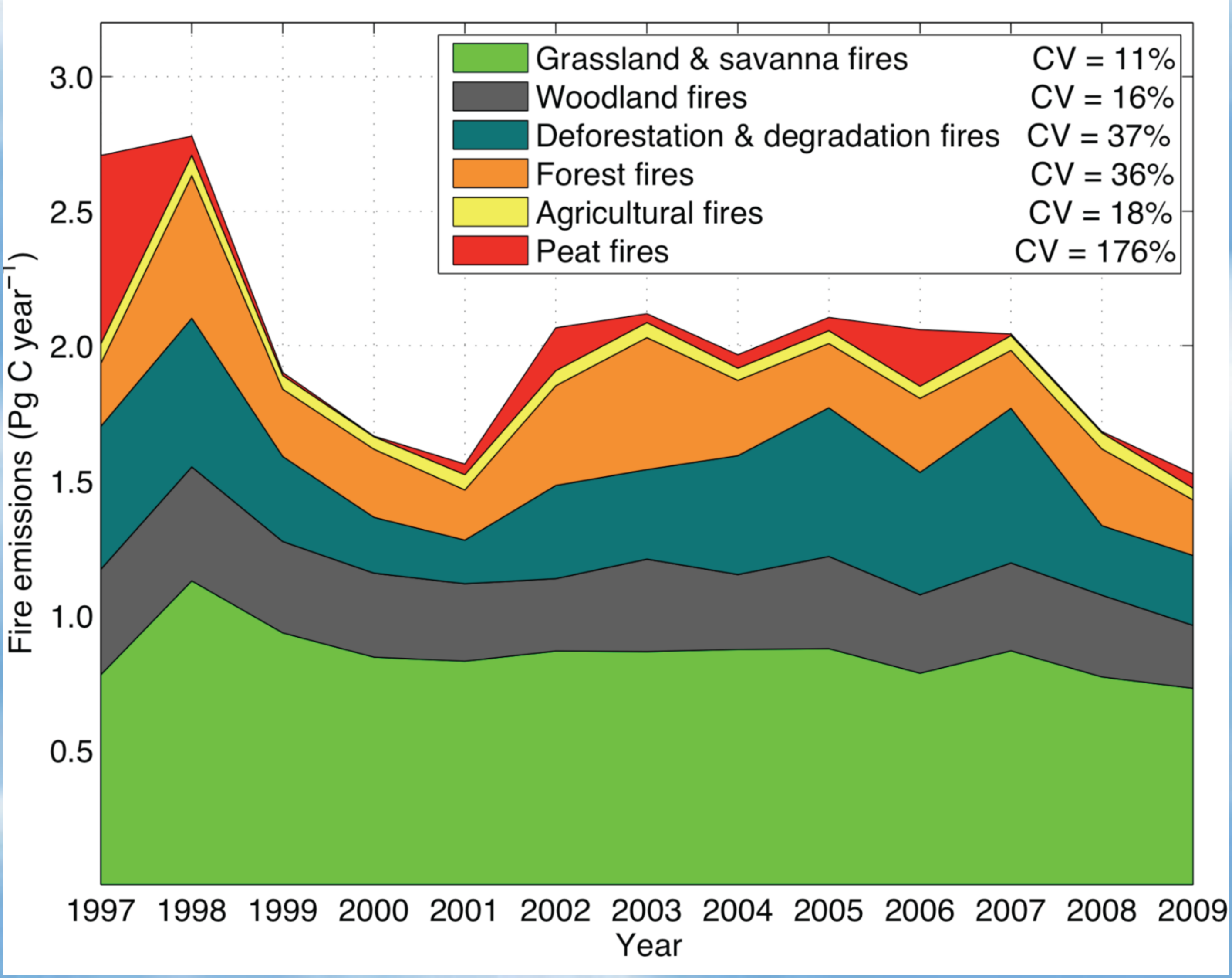
Land use change was responsible for estimated net emissions of 1.5 PgC per year over the last 15 years. This is 12% of total emissions in 2008, down from 20% in the 1990´s

Fuel consumption (g C per m² of area burned) averaged over 1997–2009.



Guido van der Werf, 2010

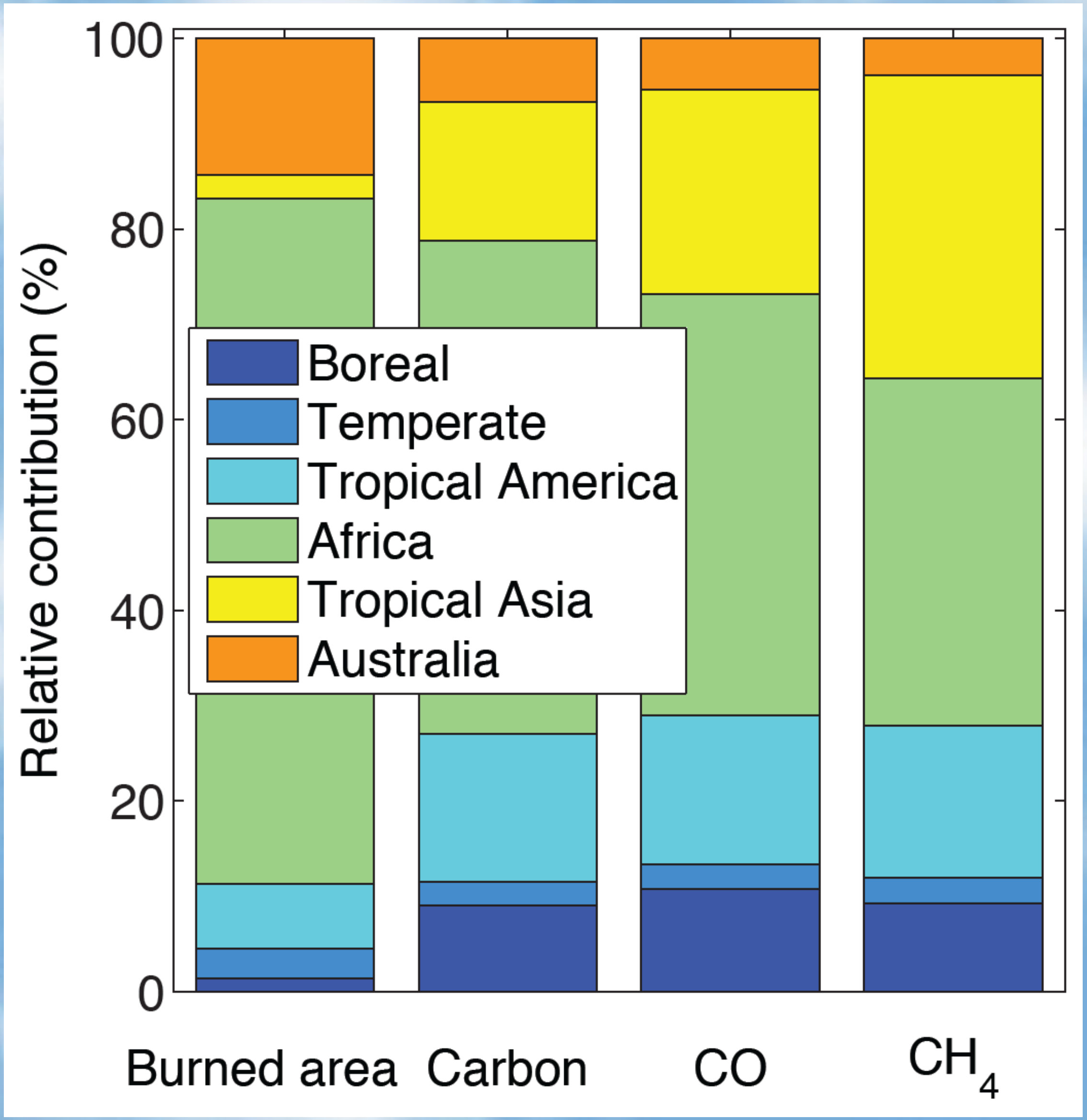
Cumulative annual carbon emissions from different fire types and their coefficient of variation (CV) (1997–2009)



Right now: ≈ 1.6 Pg C/year

Guido van der Werf, 2010

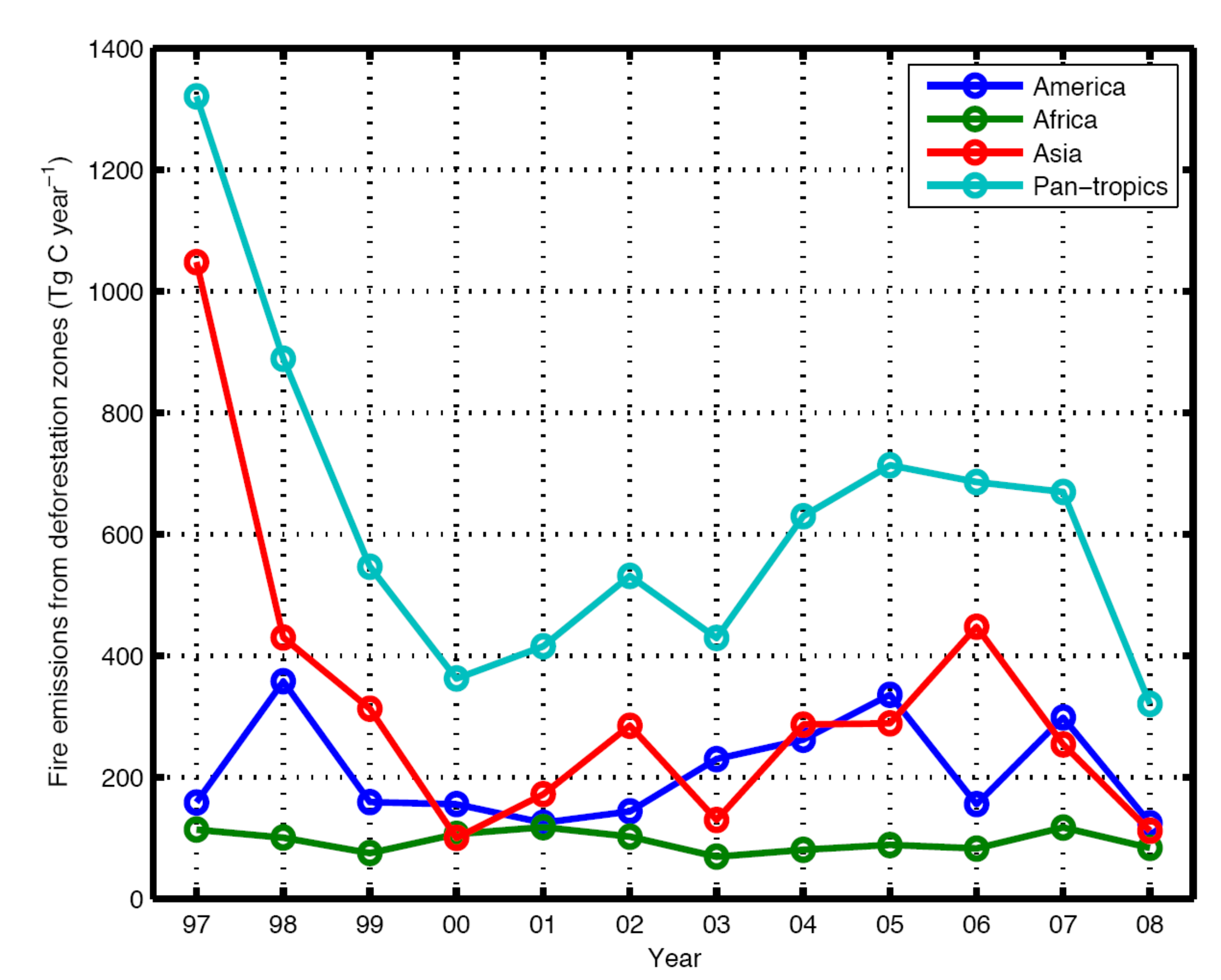
Relative contributions from different regions of CO_2, CO and CH_4 biomass burning emissions (1997-2009)



Guido van der Werf, 2010

Decreasing fire emissions from deforestation

Global Fire Emissions Dataset (vs2)

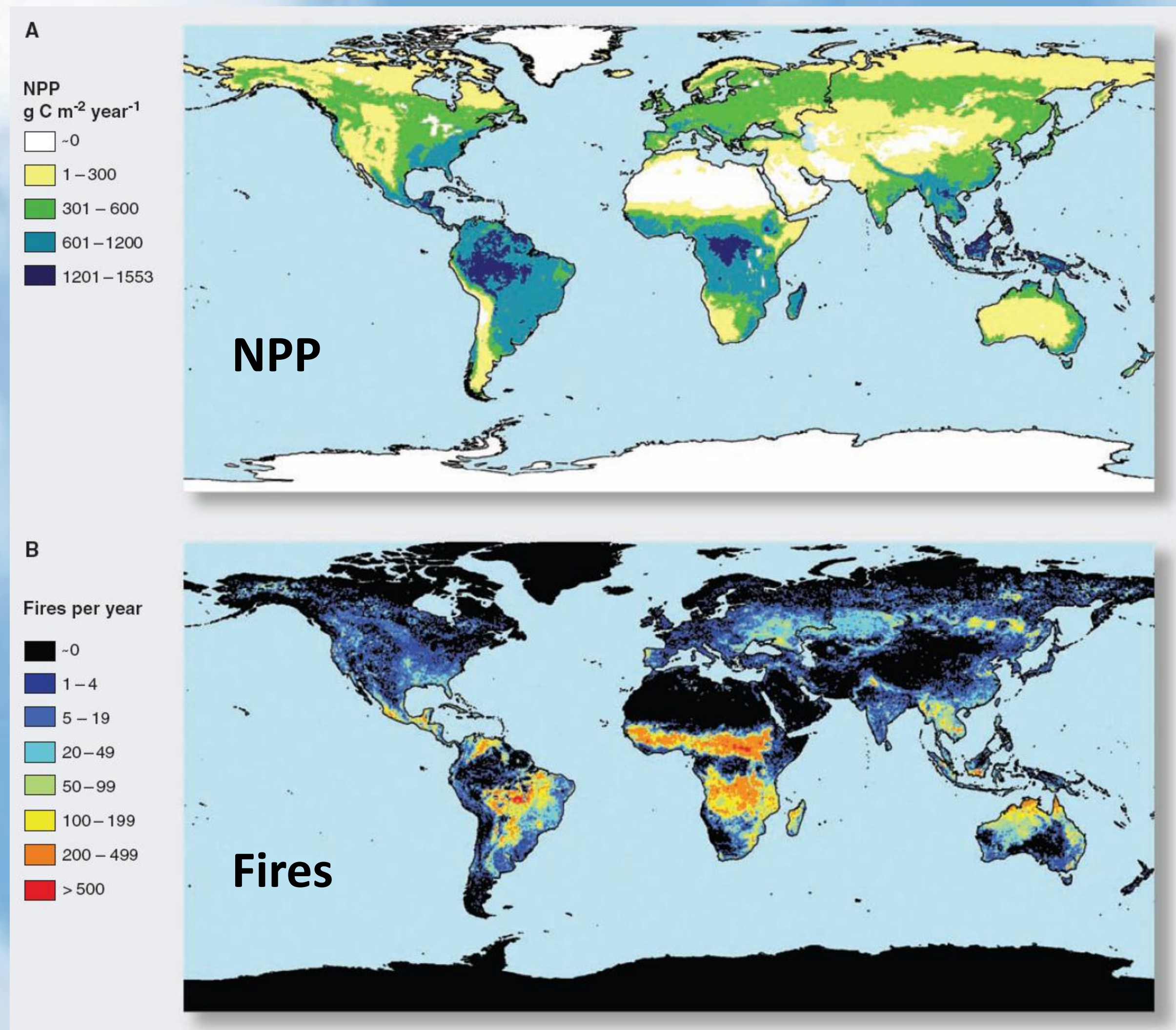


van der Werf et al. 2006, Atmospheric Chemistry and Physics, *updated*

Fire in the Earth System

David M. J. S. Bowman,[1*] Jennifer K. Balch,[2,3,4*†] Paulo Artaxo,[5] William J. Bond,[6] Jean M. Carlson,[7] Mark A. Cochrane,[8] Carla M. D'Antonio,[9] Ruth S. DeFries,[10] John C. Doyle,[11] Sandy P. Harrison,[12] Fay H. Johnston,[13] Jon E. Keeley,[14,15] Meg A. Krawchuk,[16] Christian A. Kull,[17] J. Brad Marston,[18] Max A. Moritz,[16] I. Colin Prentice,[19] Christopher I. Roos,[20] Andrew C. Scott,[21] Thomas W. Swetnam,[22] Guido R. van der Werf,[23] Stephen J. Pyne[24]

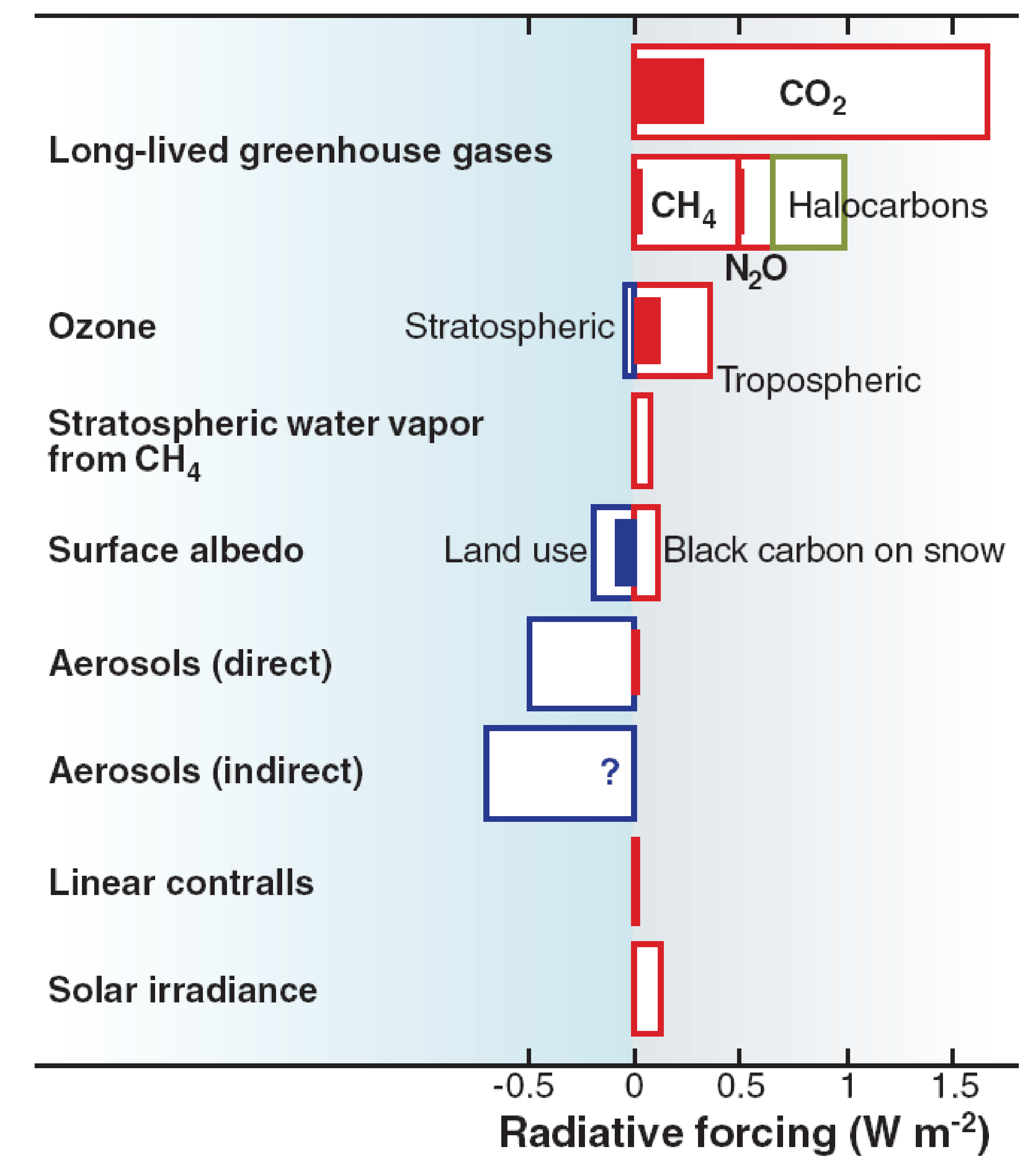
Current pyrogeography on Earth, illustrated by (A) net primary productivity (NPP, g C m^{-2} year^{-1}) from 2001 to 2006, and



(B) annual average number of fires observed by satellite

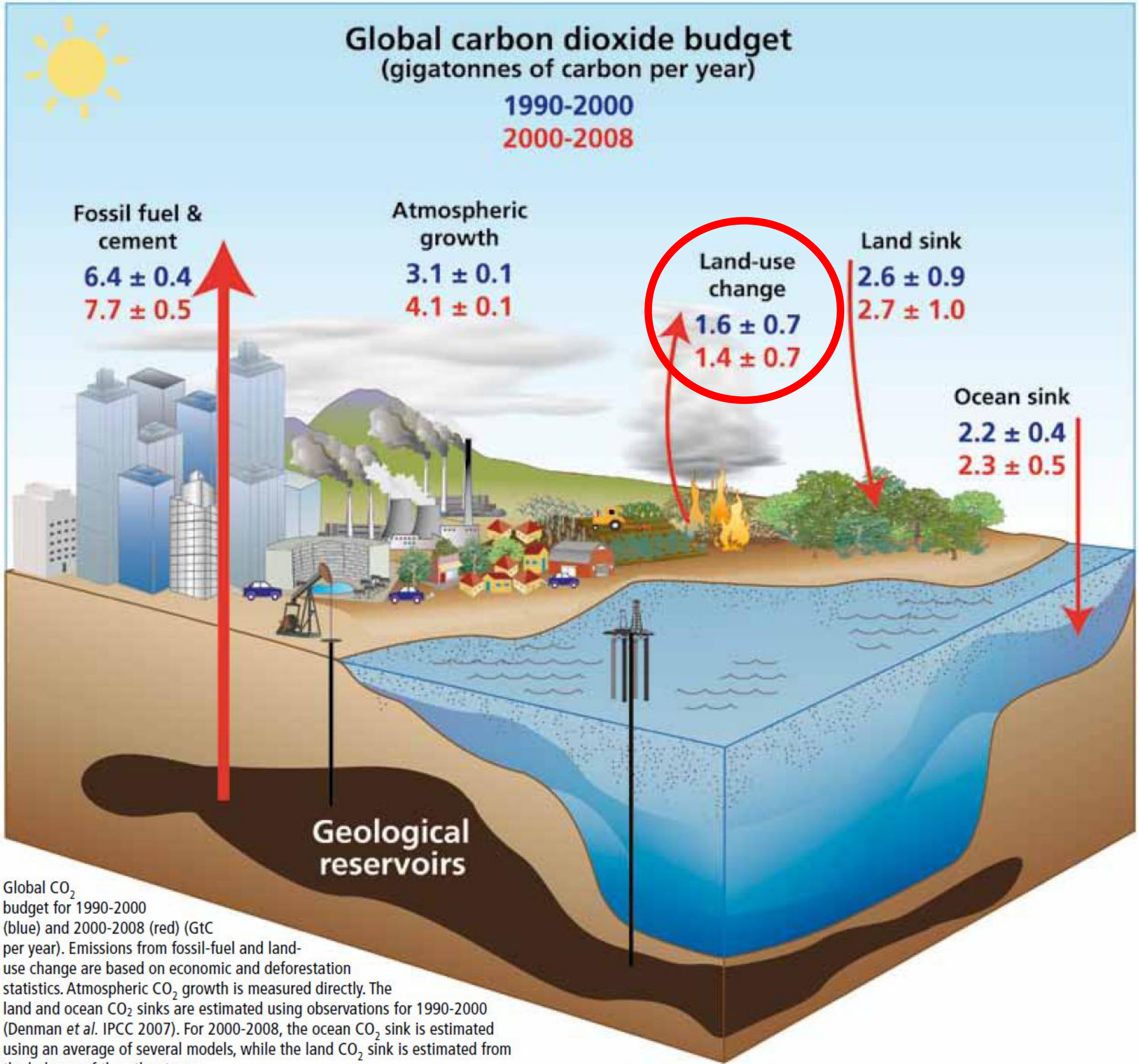
Bowman et al., Science, 2009

Global Deforestation Fires: Responsible for 19% of global radiative forcing



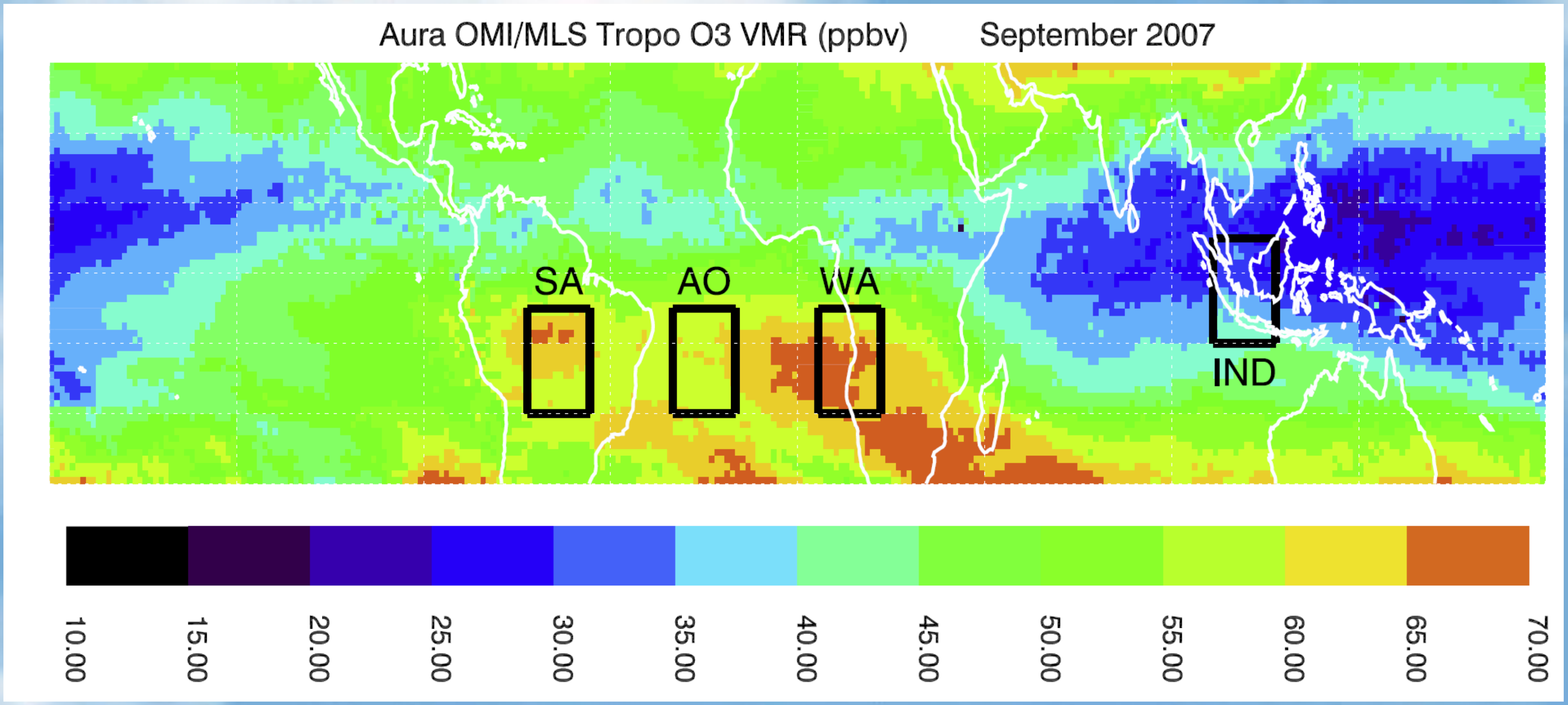
Estimated contribution of fire associated with deforestation to changes in radiative forcing compared to 1750, assuming a steady state for other fire emissions.

Bowman et al., Science, 2009



Global CO_2 budget for 1990-2000 (blue) and 2000-2008 (red) (GtC per year). Emissions from fossil-fuel and land-use change are based on economic and deforestation statistics. Atmospheric CO_2 growth is measured directly. The land and ocean CO_2 sinks are estimated using observations for 1990-2000 (Denman *et al.* IPCC 2007). For 2000-2008, the ocean CO_2 sink is estimated using an average of several models, while the land CO_2 sink is estimated from the balance of the other terms.

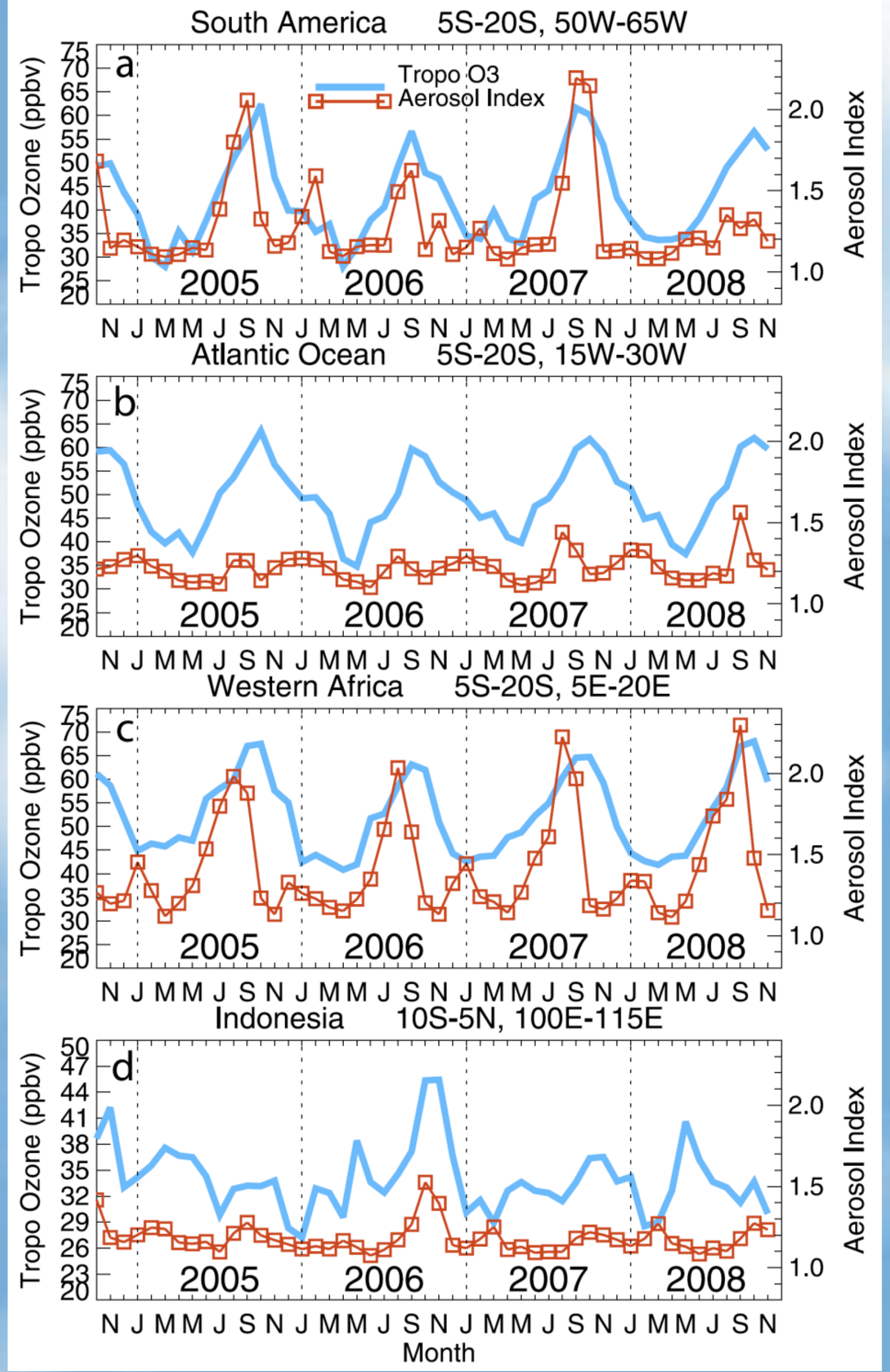
Biomass Burning is THE major driver for ozone in the Southern Hemisphere



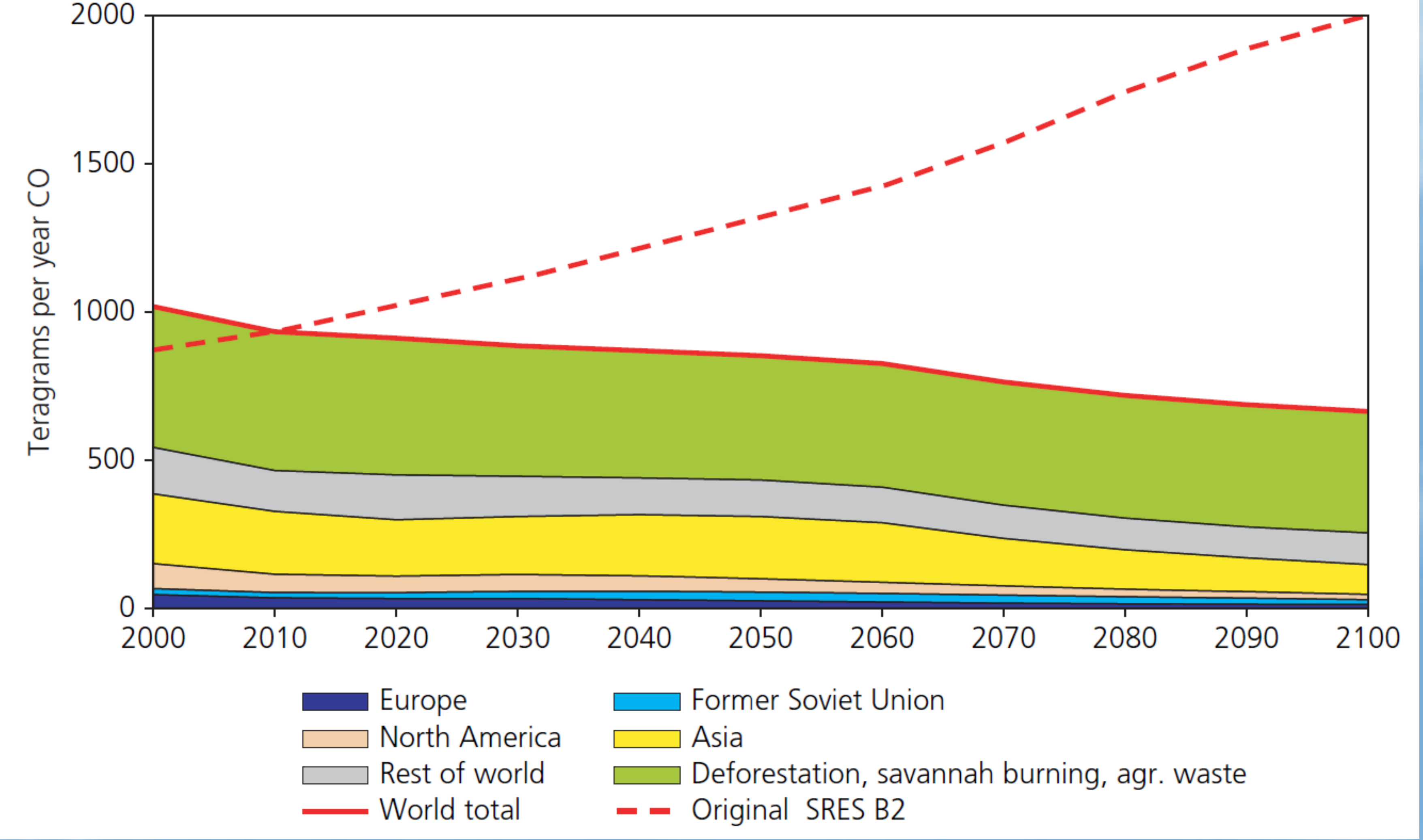
OMI tropospheric ozone mean (in ppbv) for September 2007

Ozone and aerosols from Biomass Burning

Time series of tropospheric ozone mean VMR (in ppbv) and AI averaged over four broad regions (indicated) in the southern tropics: (a) South America, (b) Atlantic Ocean, (c) western Africa, and (d) Indonesia.



Carbon monoxide from deforestation: A major source



CO emissions from human sources by world region for the new scenario (B2 CLE) compared to the original IPCC SRES B2 scenario (2000).

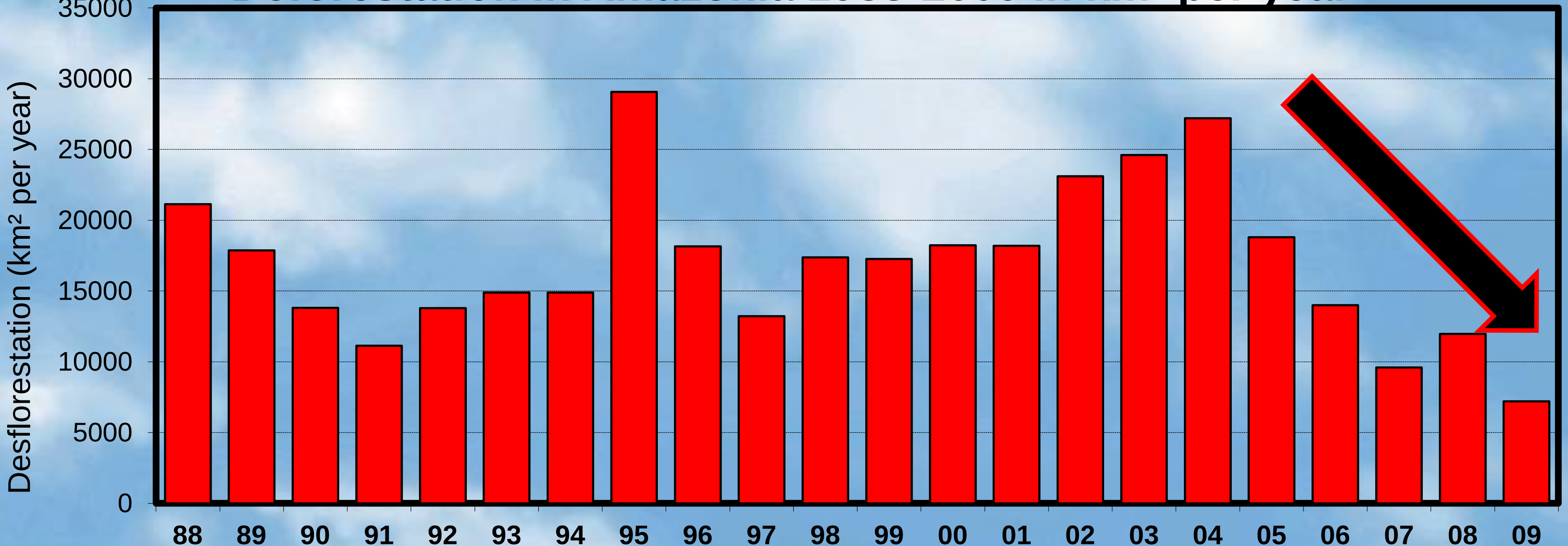
Royal *Society*: Ground-level ozone in the 21st century, 2008

Main drivers for deforestation

As of 2008, about 17% of Amazonia was deforested.

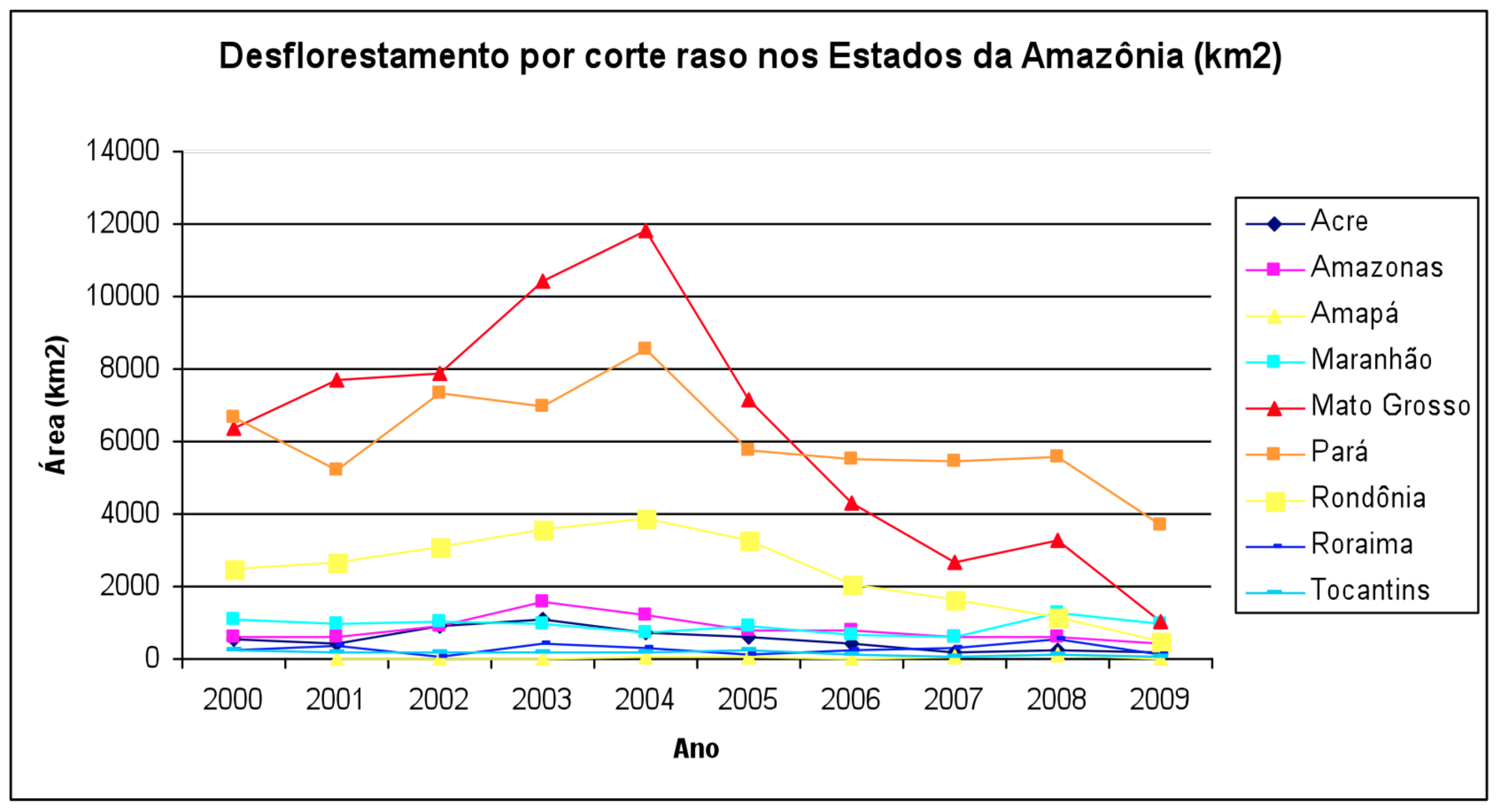
What public policies are needed to sustain this reduction over the next decades?

Deforestation in Amazonia 1988-2009 in km² per year



How was the reduction achieved? What public policies made it? Ex: Bolsa Floresta

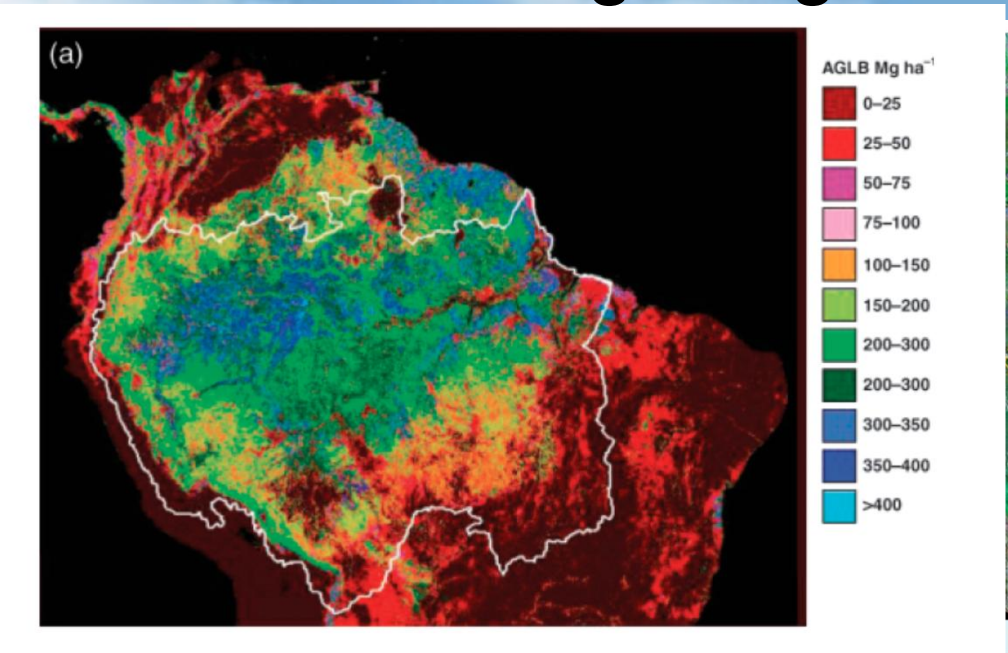
Deforestation state by state in Amazonia 2000-2009

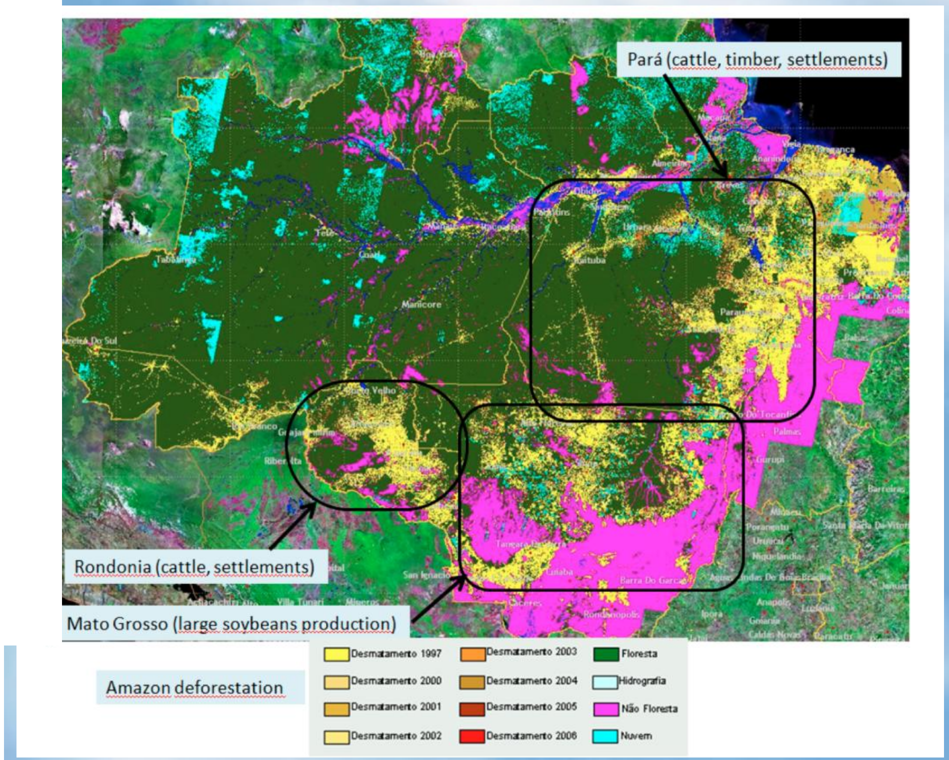


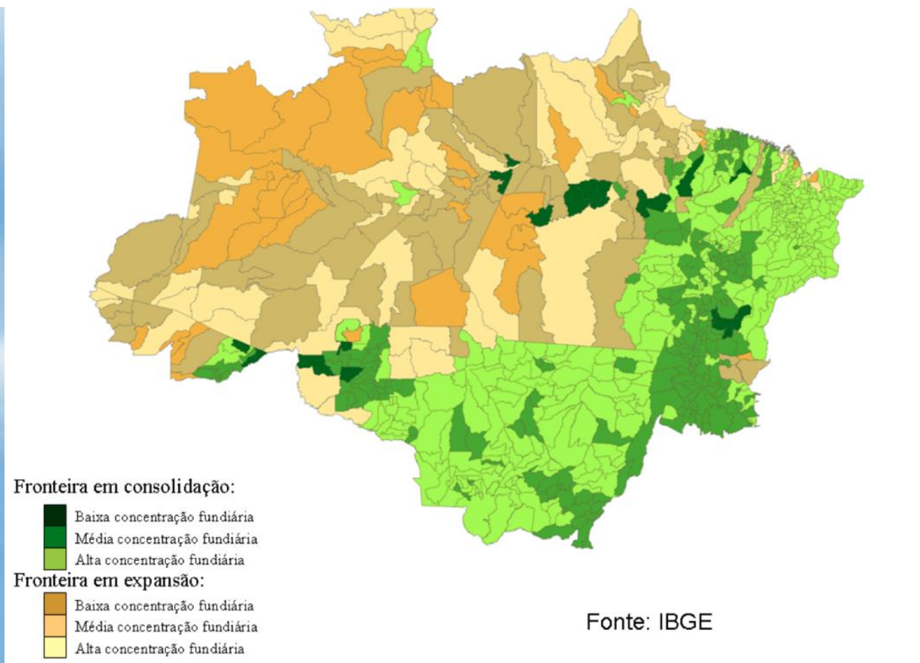
Mato Grosso and Pará states are responsible for aprox. 80% of deforestation

Ana Paula Aguiar, CST, INPE, Dez 2009

Actors in getting emissions estimates



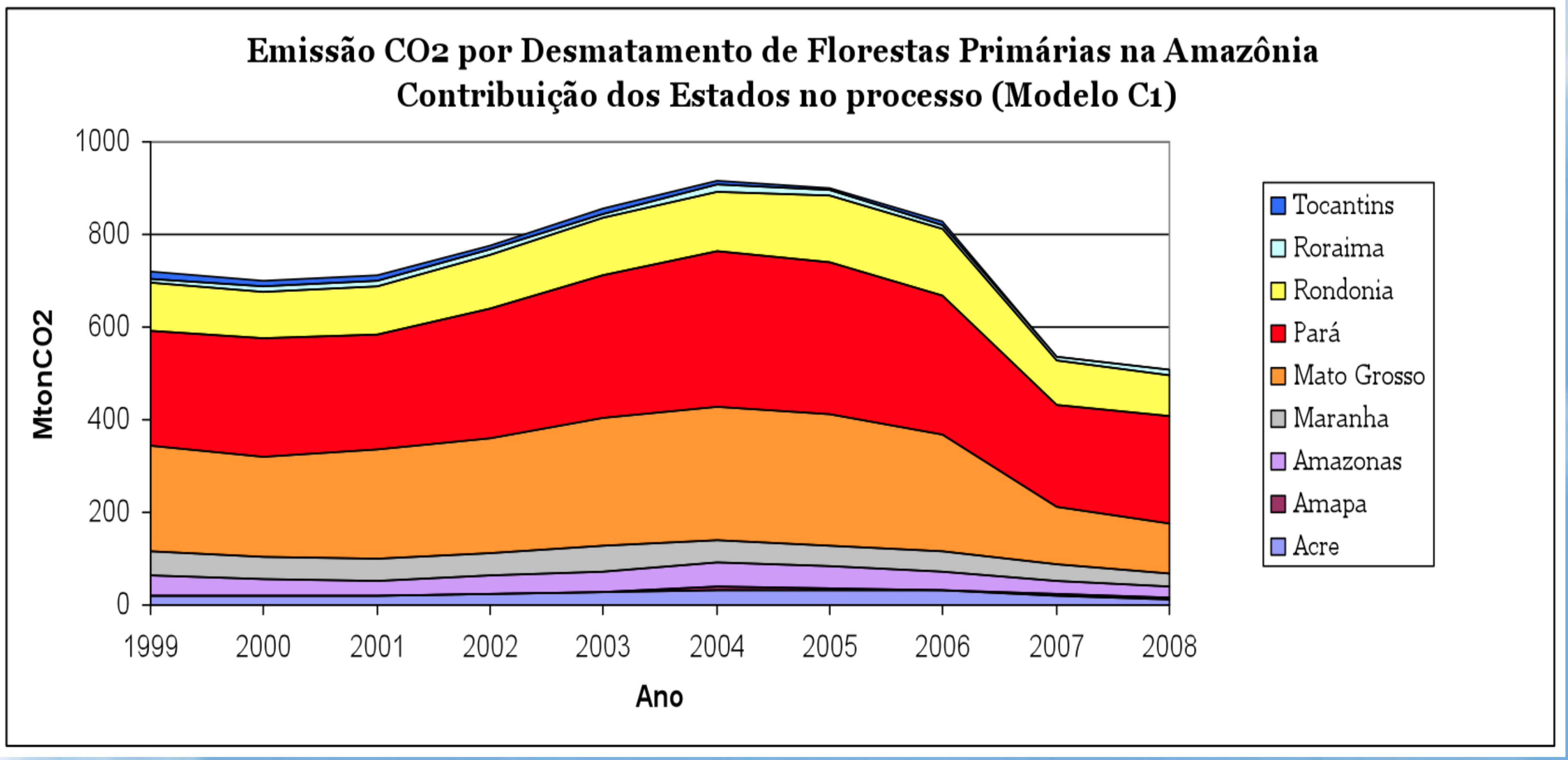




<u>Territorial Diversity</u>

(i) Biomass density data
(ii) Diversity of actors
(iii) Secondary vegetation dynamics

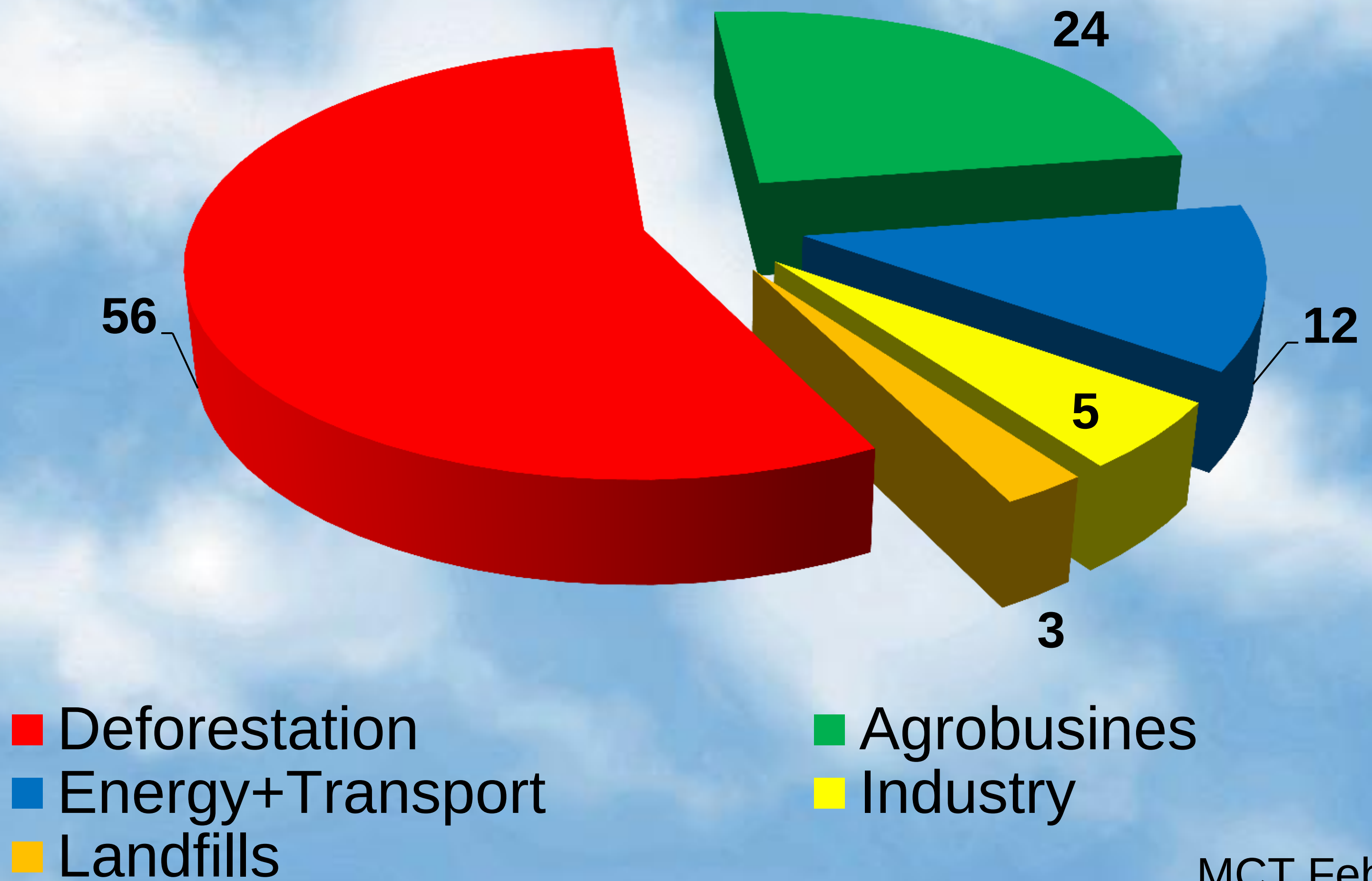
CO_2 emissions trough deforestation in Amazonia



Reduction from 900 to 500 Mtons CO_2 per year from 2004 to 2008

CCST, INPE, 2010

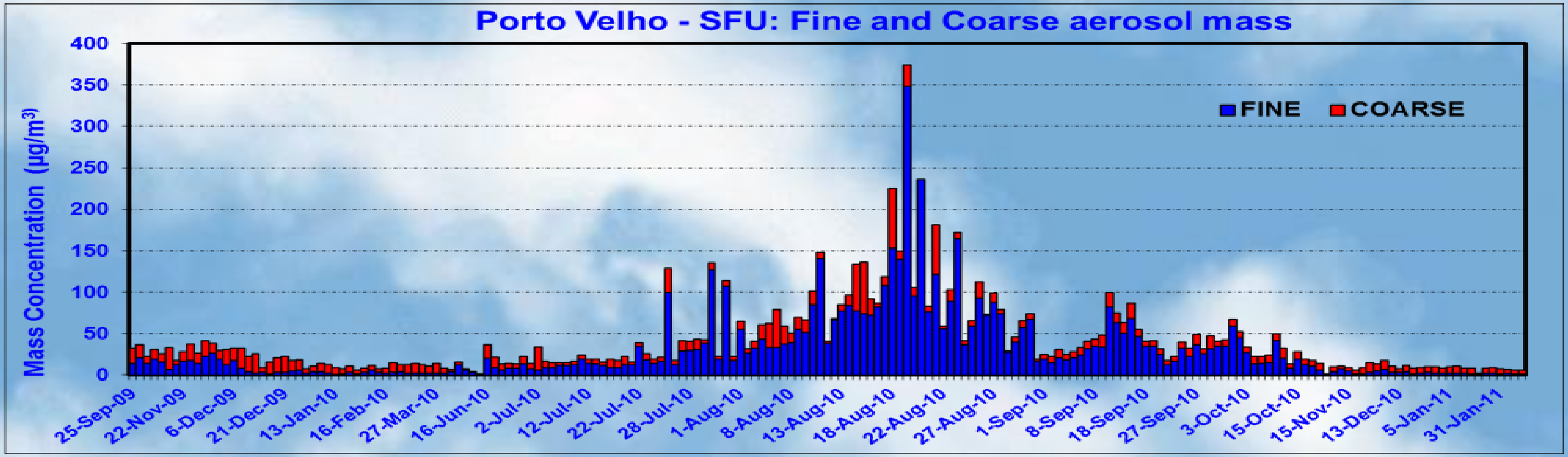
Brazilian Greenhouse Gases Emission Inventory 2005

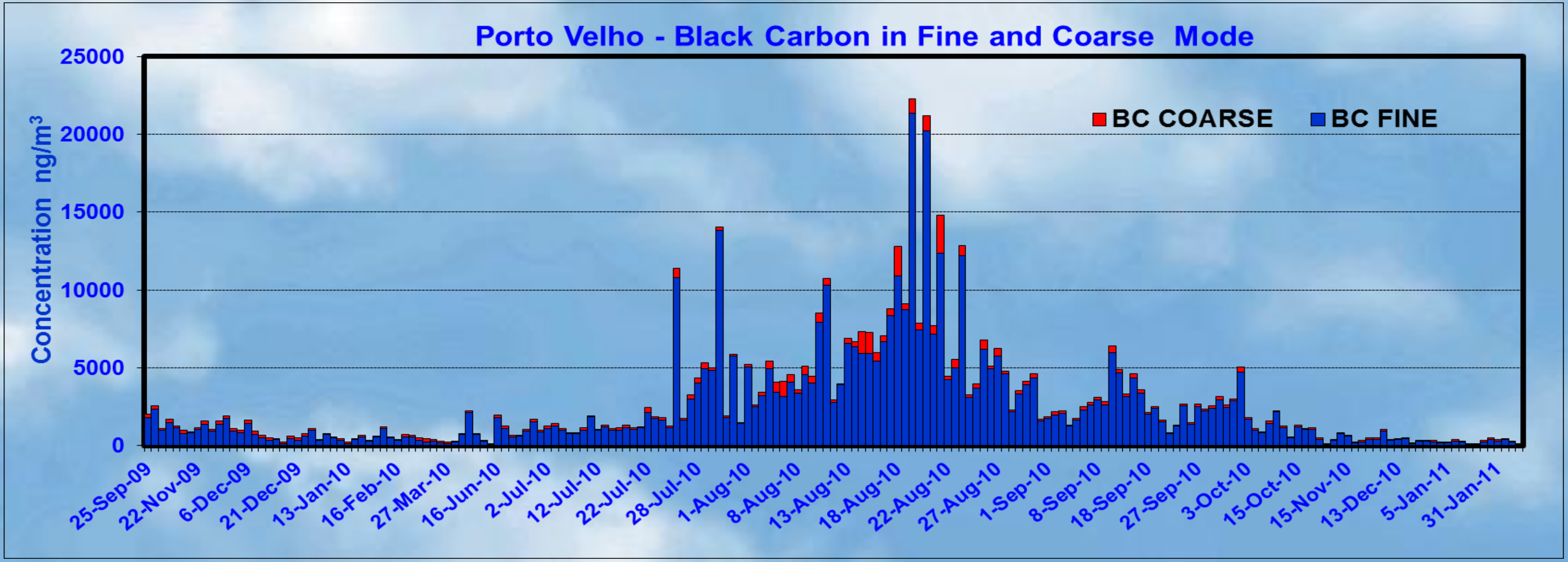


MCT Feb 2010

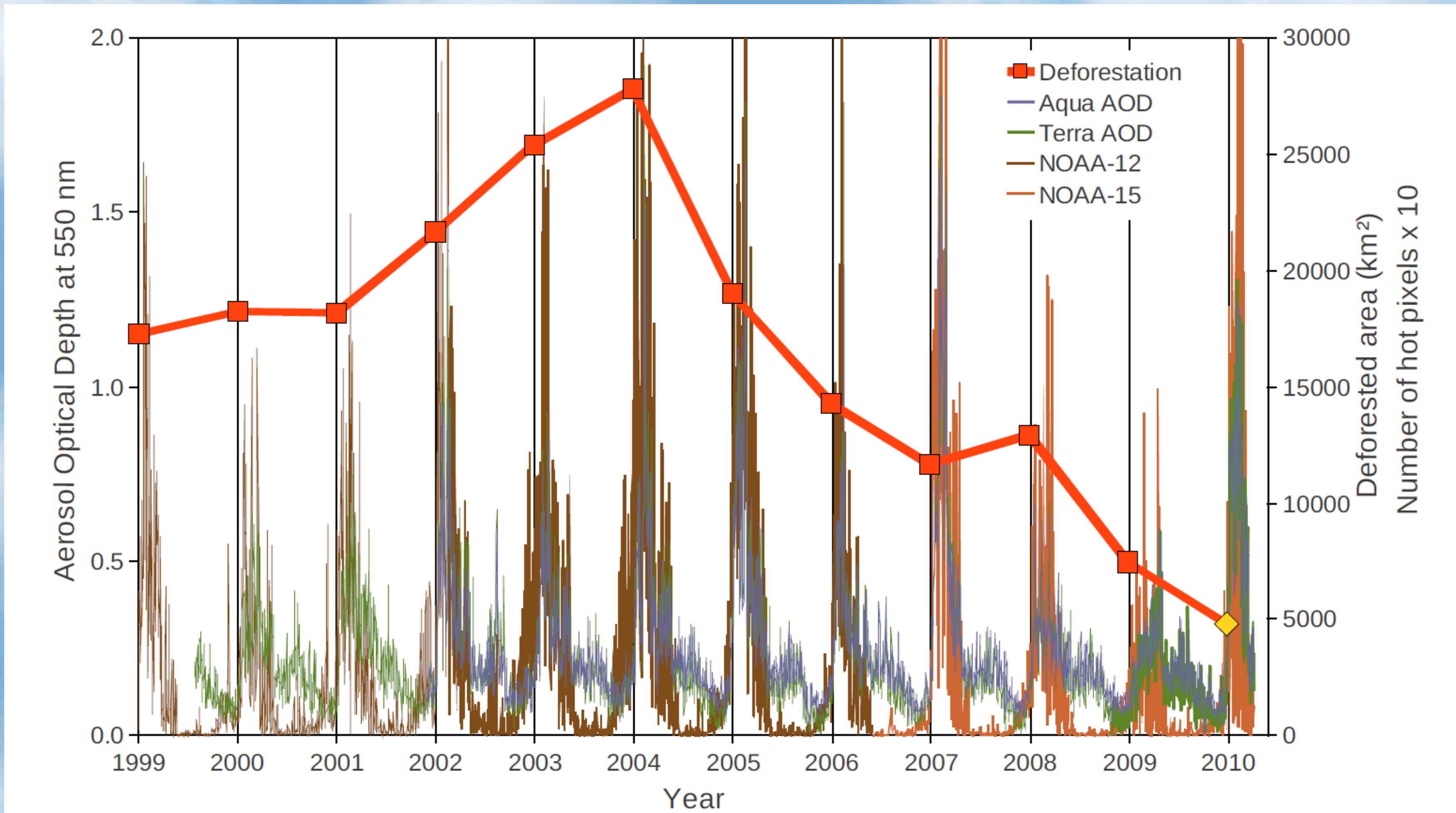
Copenhagen Commitment: Reduction in 80% emissions from deforestation in 2015 from 2004. Same target in the Brazilian law passed in Congress.

Porto Velho aerosol: $PM_{2.5}$, PM_{10} and BC 2009 - 2011





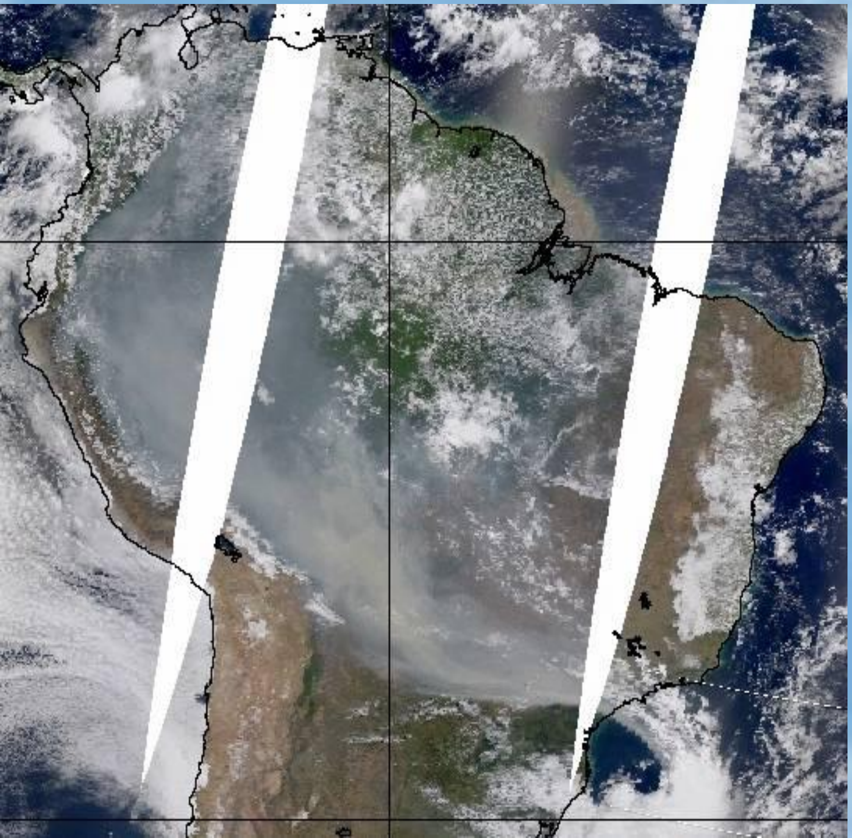
Yearly deforestation with MODIS AOD and hot pixels from NOAA-12/15

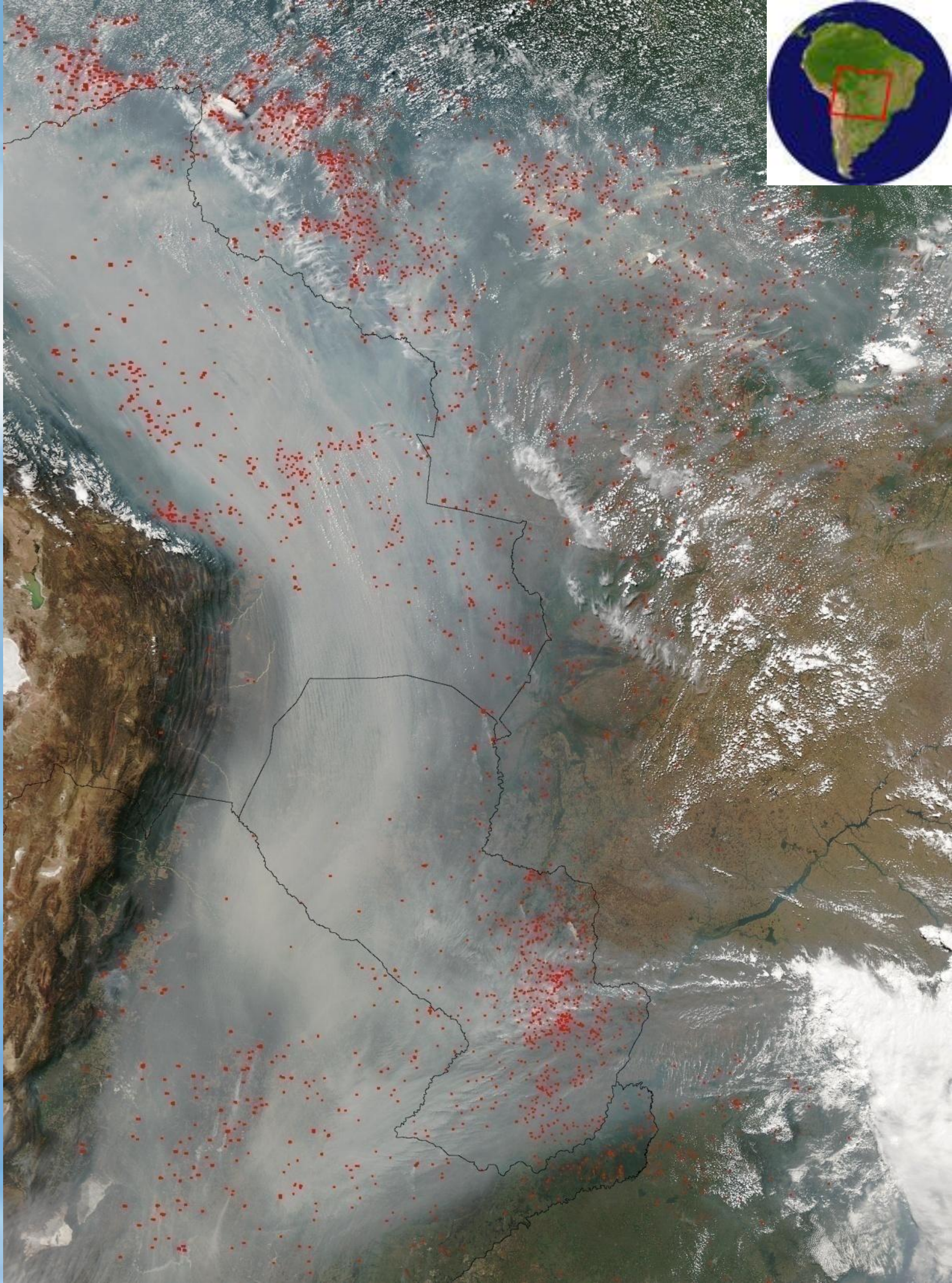


Yearly deforestation over the Brazilian Amazon region (INPE, 2010) compared to MODIS daily smoke optical depth and the daily number of hot pixels from NOAA-12 and NOAA-15. The results are shown according to the hydrological year, from August 1st of the previous year to July 31st of the years shown in the graph. The vertical lines indicate August 1st , which correspond to the onset of the burning season.

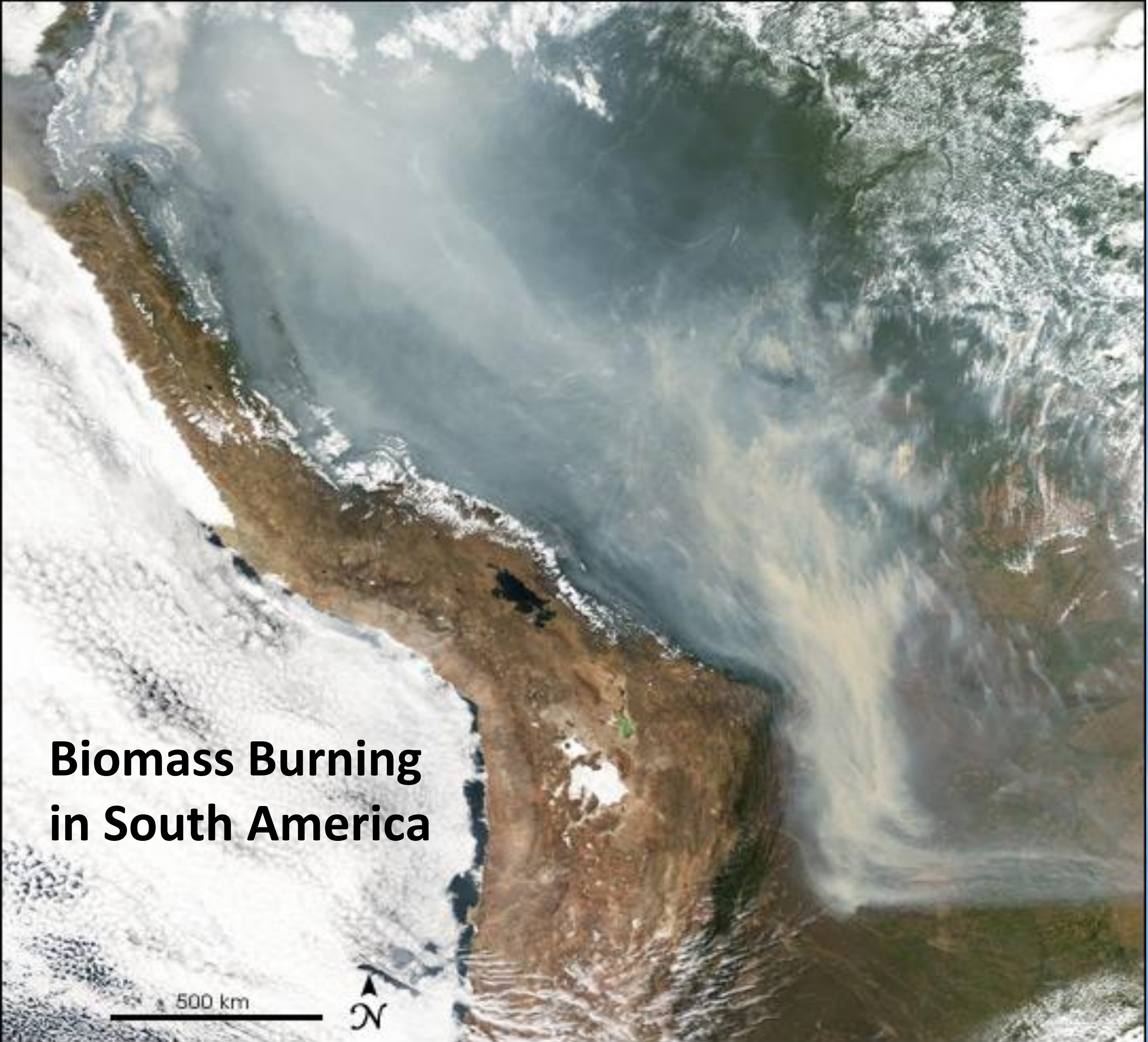
Large scale aerosol distribution in Amazonia

- Severe health effects on the Amazonian population (about 20 million people)
- Climatic effects, with strong effects on cloud physics and radiation balance.
- Changes in carbon uptake and ecosystem functioning

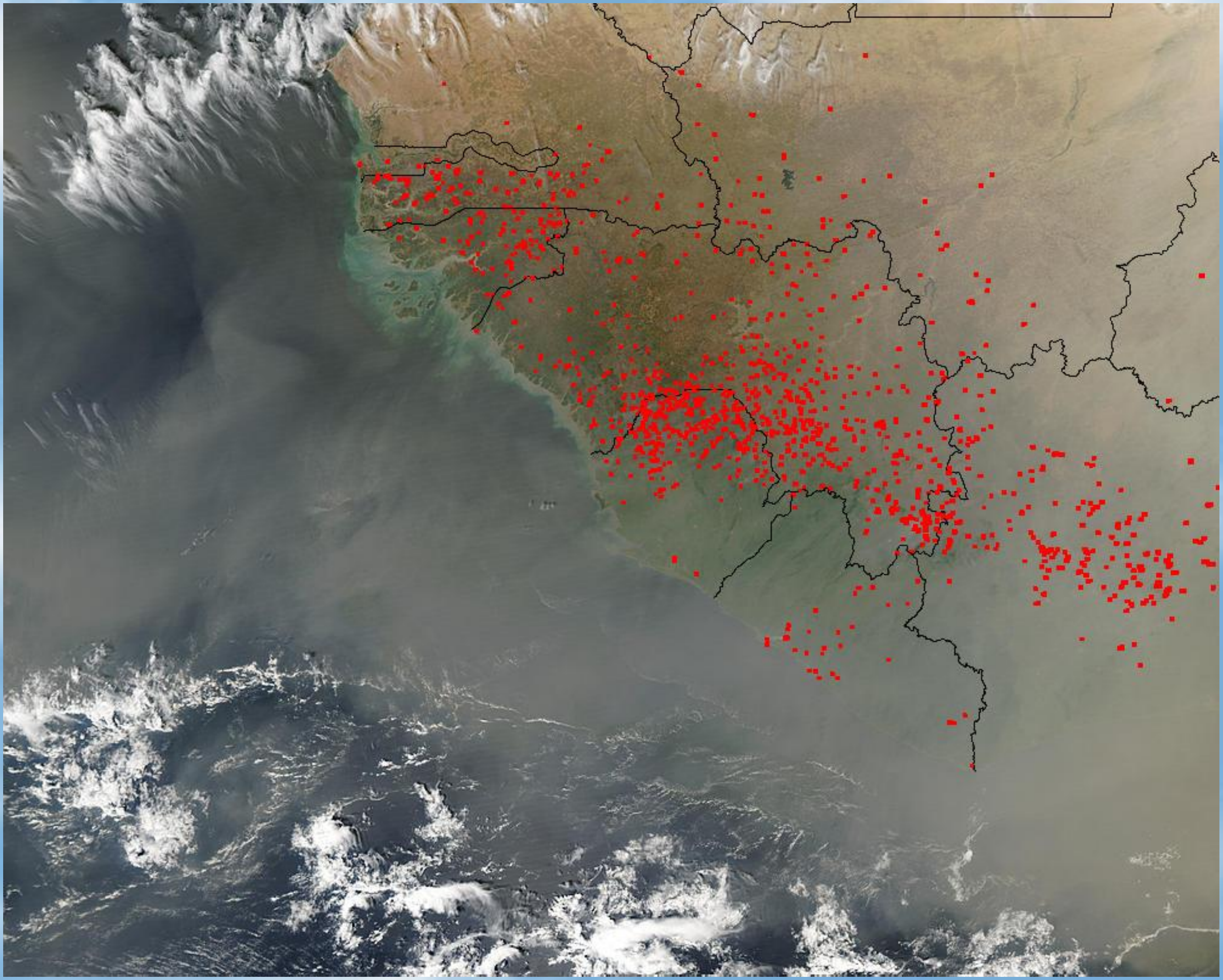




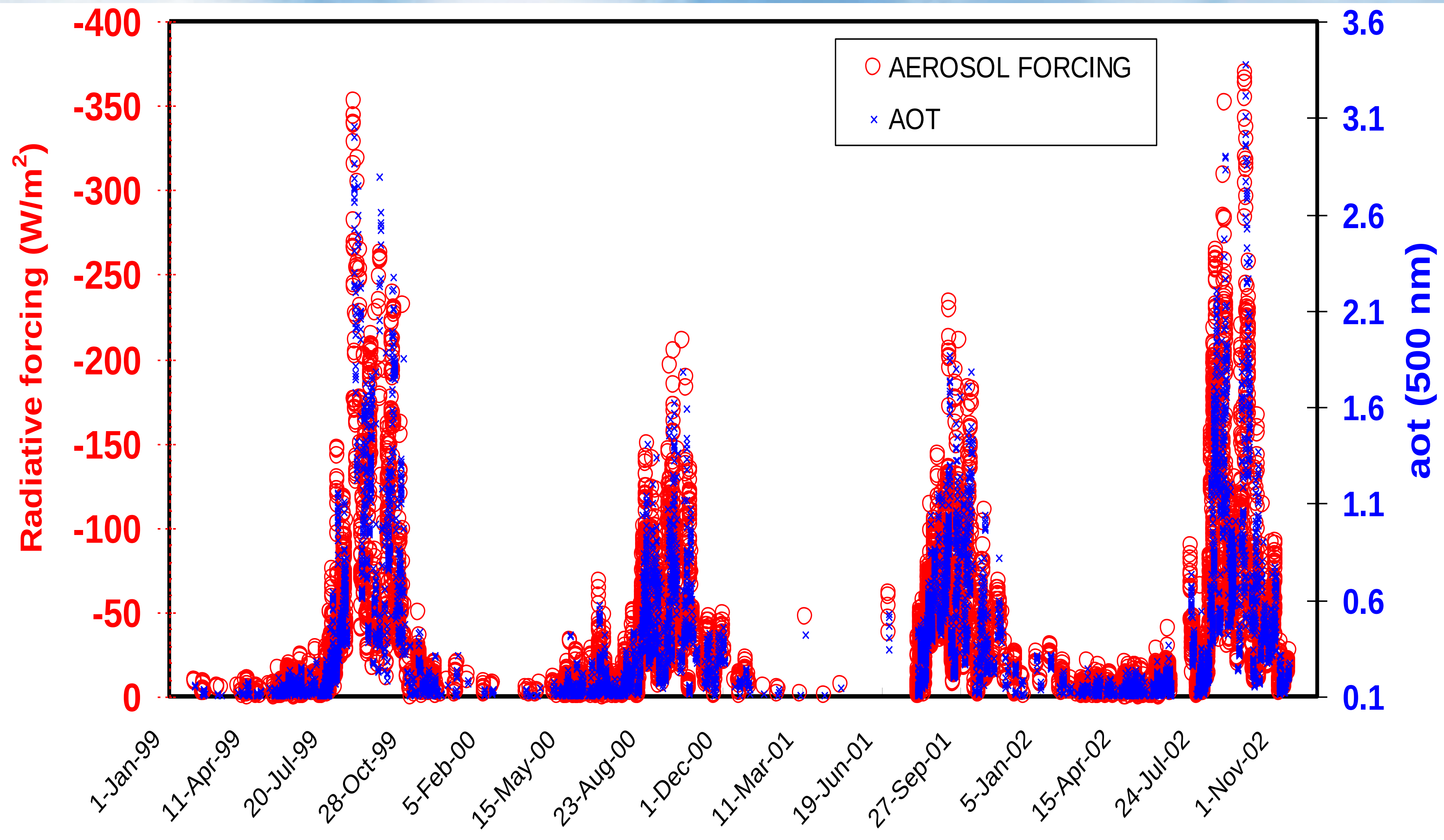
Biomass Burning in South America



Fires and Smoke in West Africa



Aerosol surface forcing in Rondonia



Aline Procópio, GRL 2006

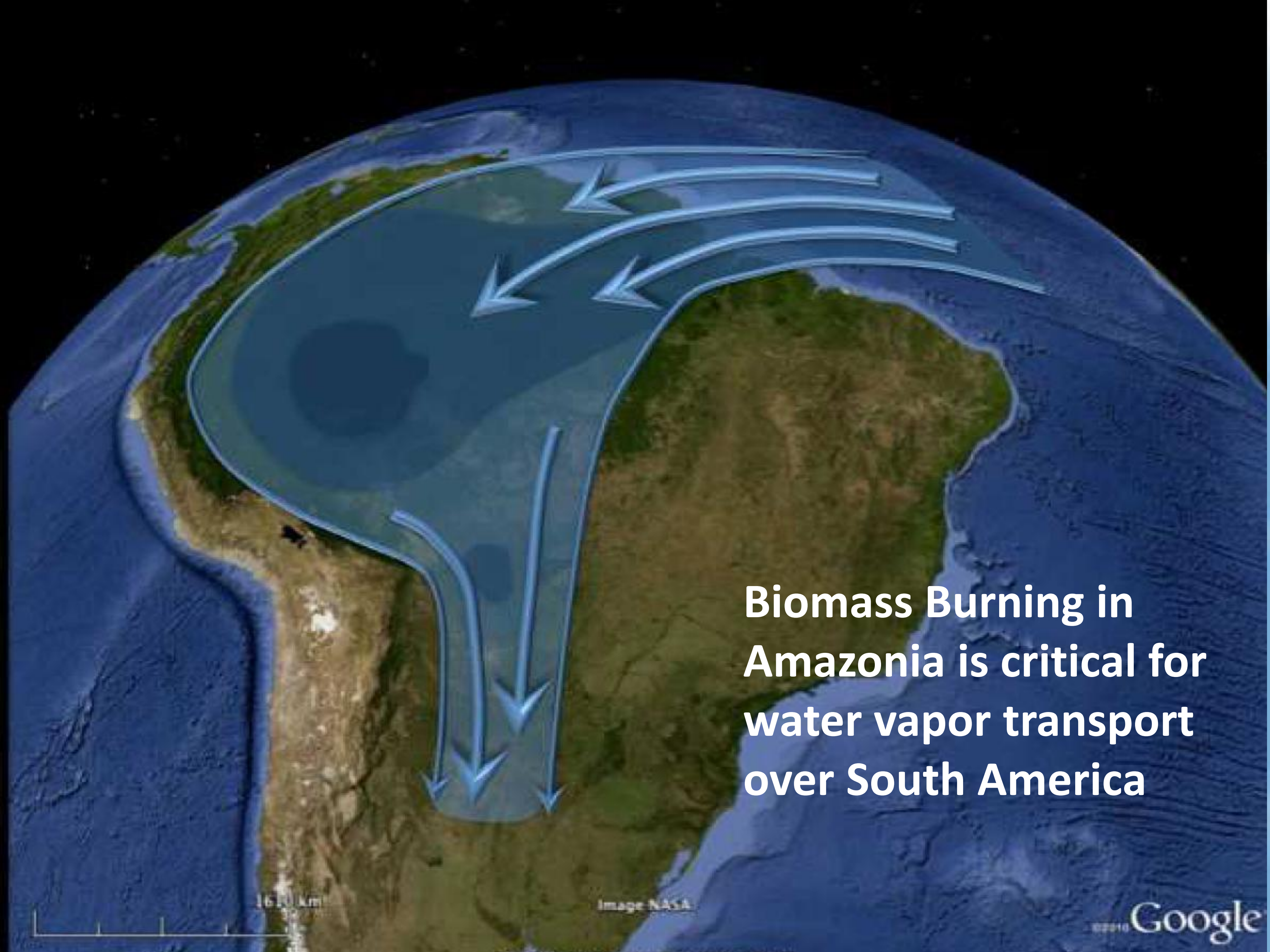
Amazonia - Average aerosol radiative forcing clear sky

Top: - 10 w/m^2

Surface: - 38 w/m^2

CO_2 forcing=-1.6 w/m^2)

Conditions: surface: forest vegetation AOT (τ=0.95 at 500nm); 24 hour average
7 years (93-95, 99-02 dry season Aug-Oct)



Biomass Burning in Amazonia is critical for water vapor transport over South America

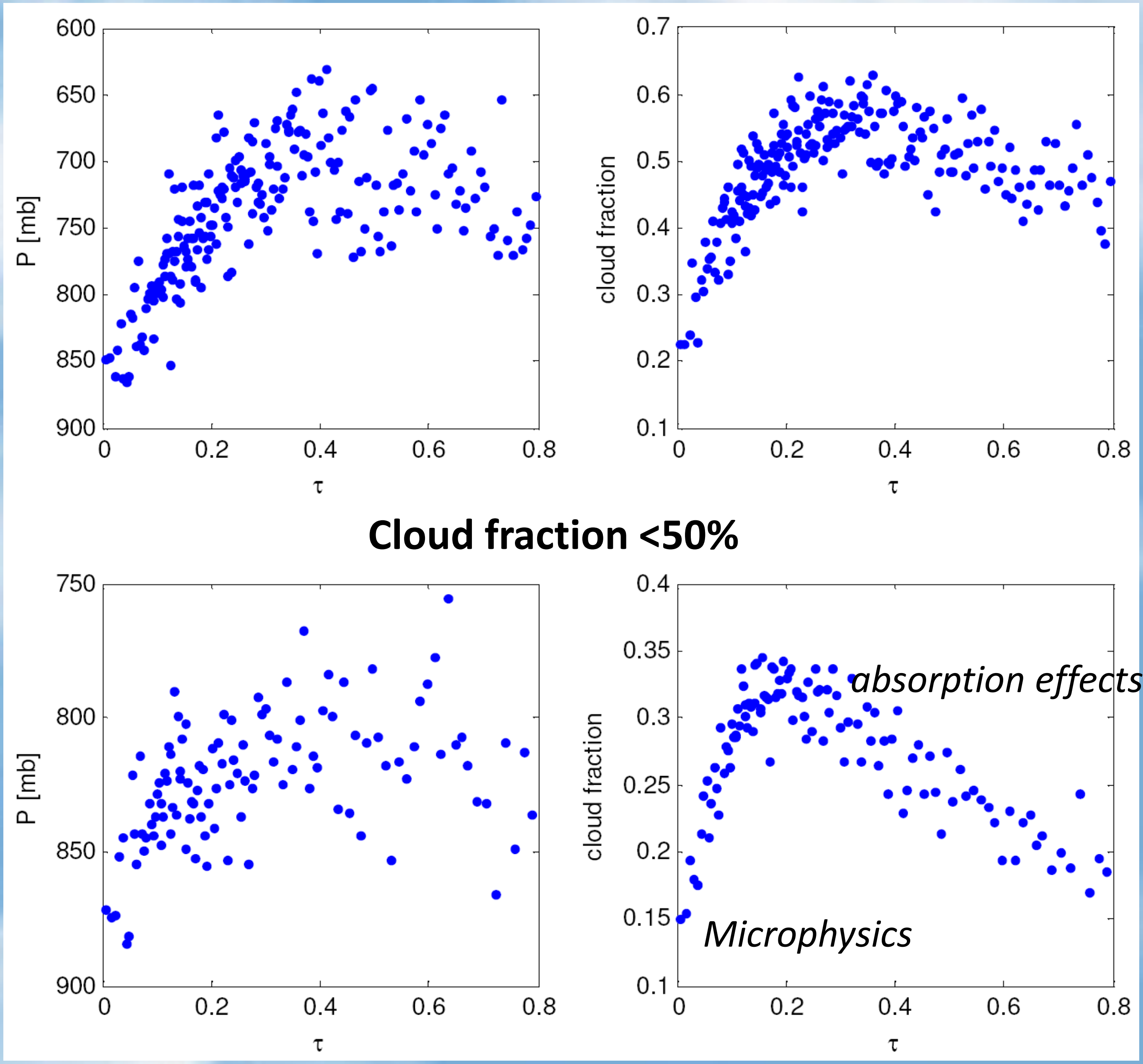
Relationships between cloud properties and aerosol loading in Amazonia

Left – cloud top pressure (P) vs. AOD. Lower P may indicate taller convective clouds .

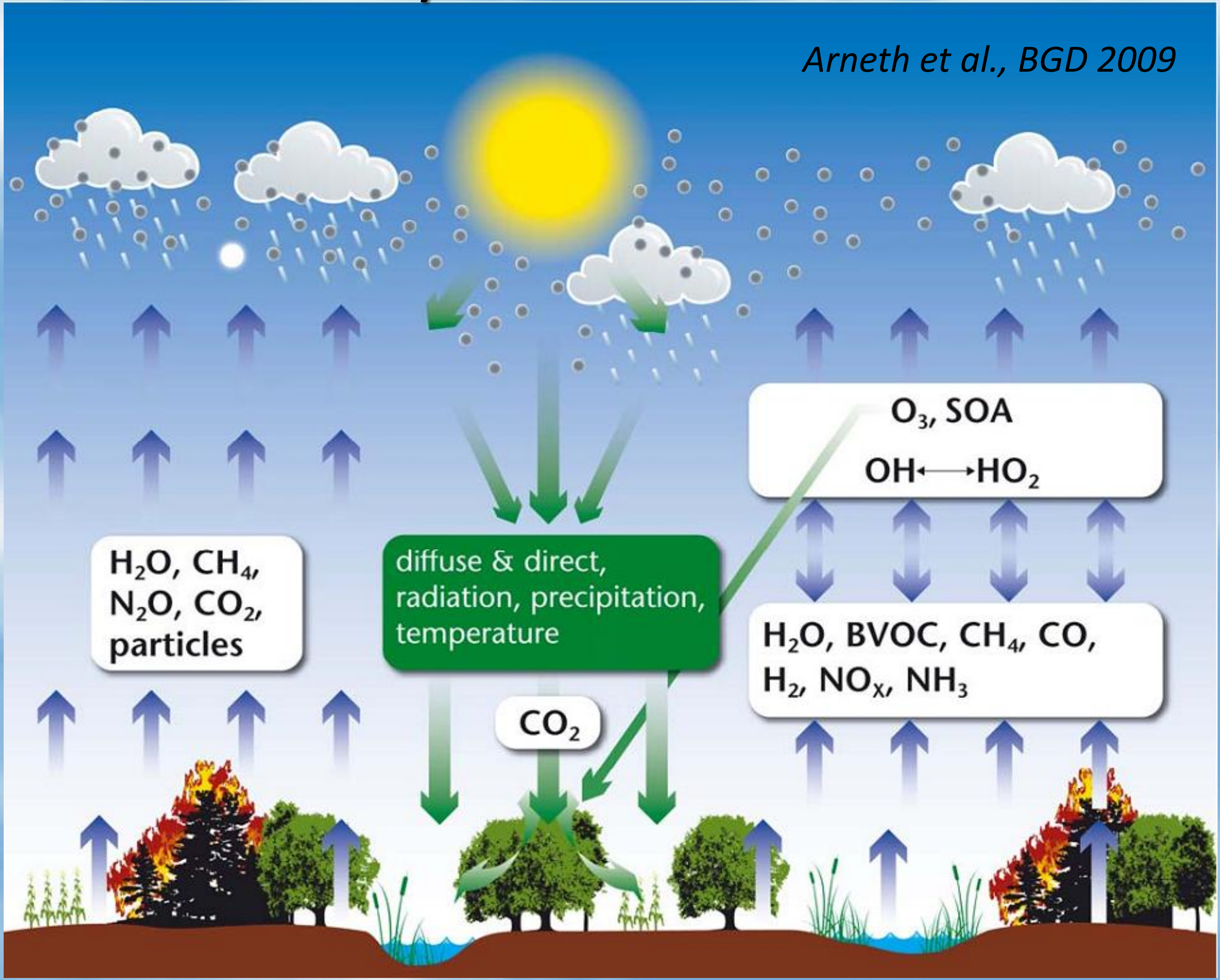
Right – cloud fraction vs. AOD.

The upper row is for all data and the lower row is for data restricted to cloud fraction less than half.

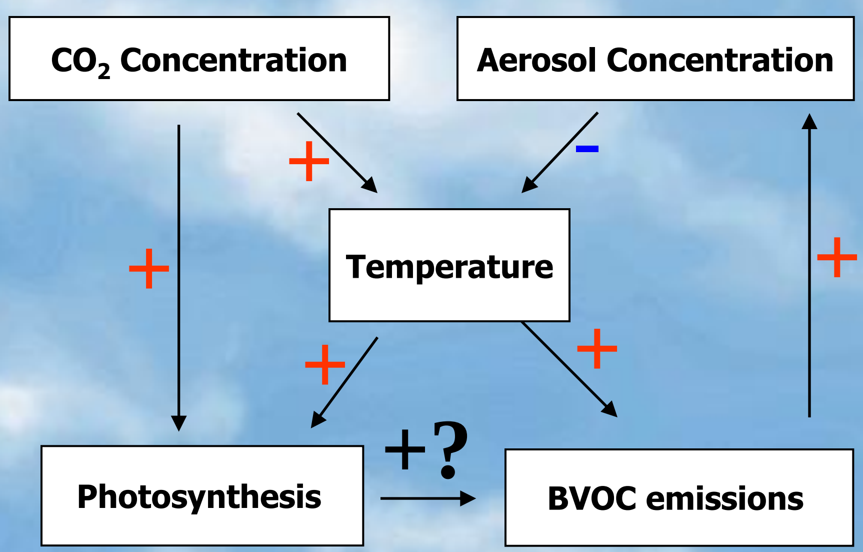
Koren et al., Science 2008



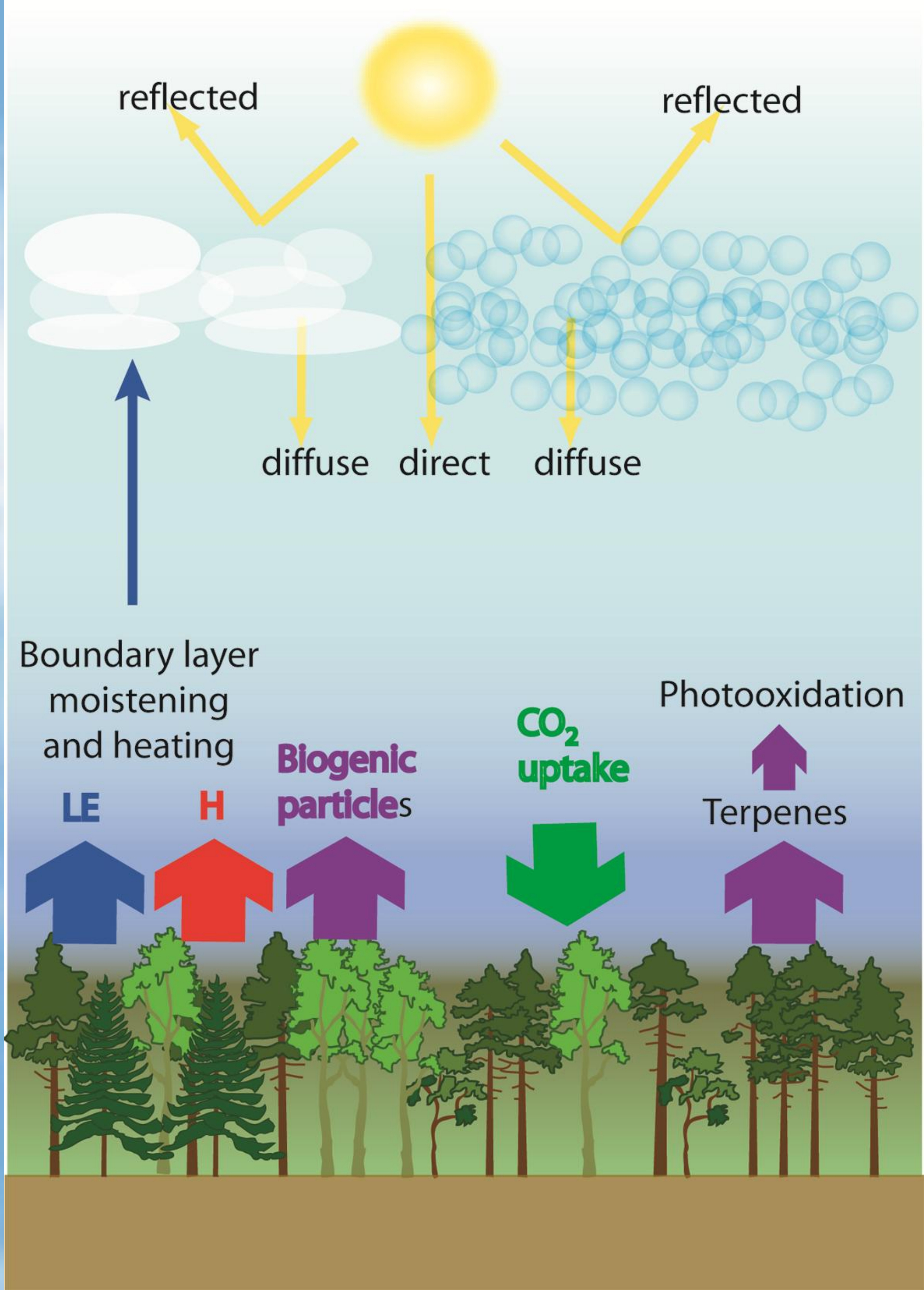
Conceptual overview of terrestrial carbon cycle – chemistry – climate interactions



Aerosol effects on the Net Plant Productivity

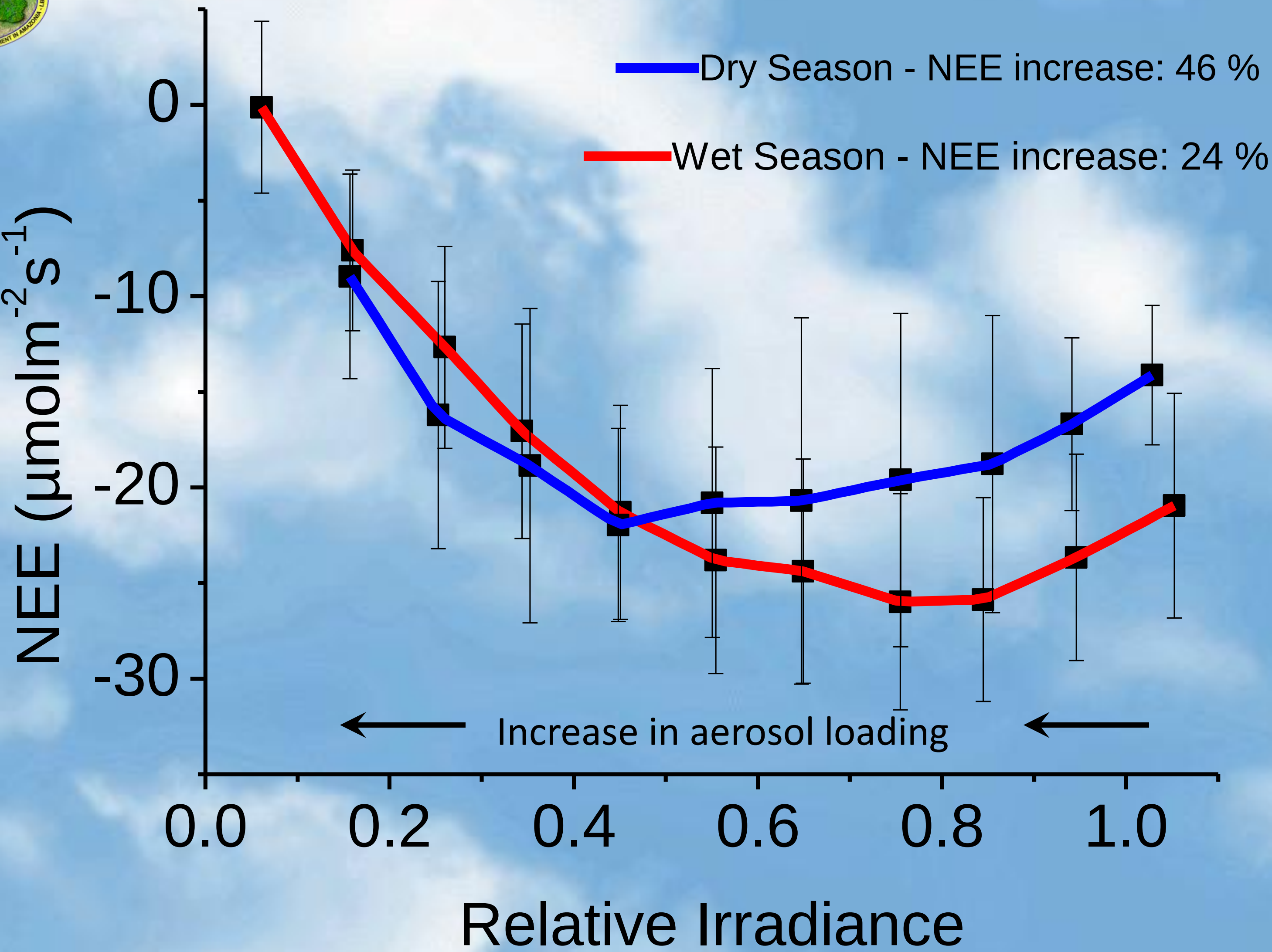


Kulmala et al., 2004



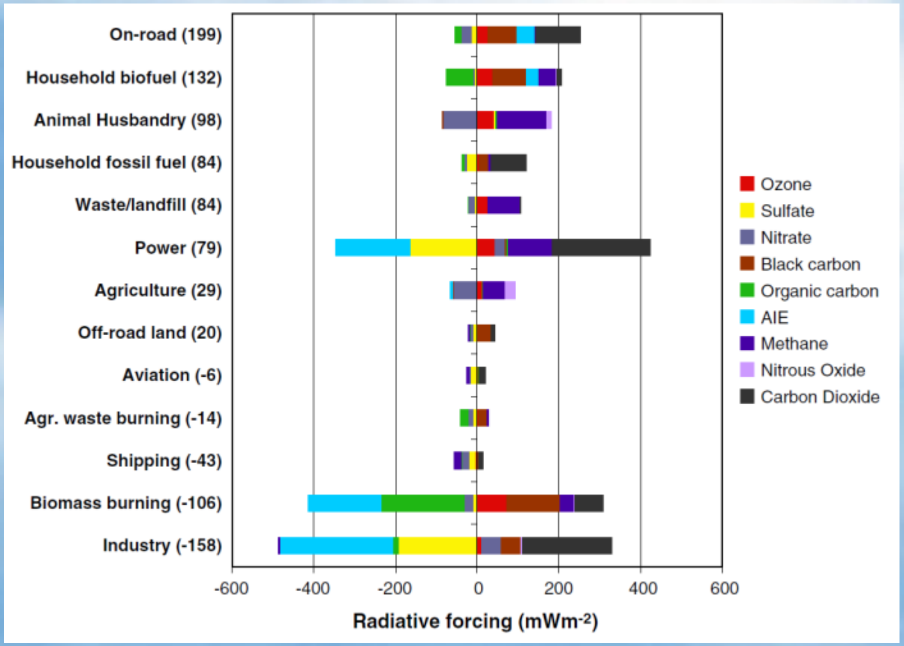
Strong aerosol effect on forest photosynthesis diffuse radiation have a large effect on CO2 fluxes

Amazonia Rondonia Forest site 2000-2001

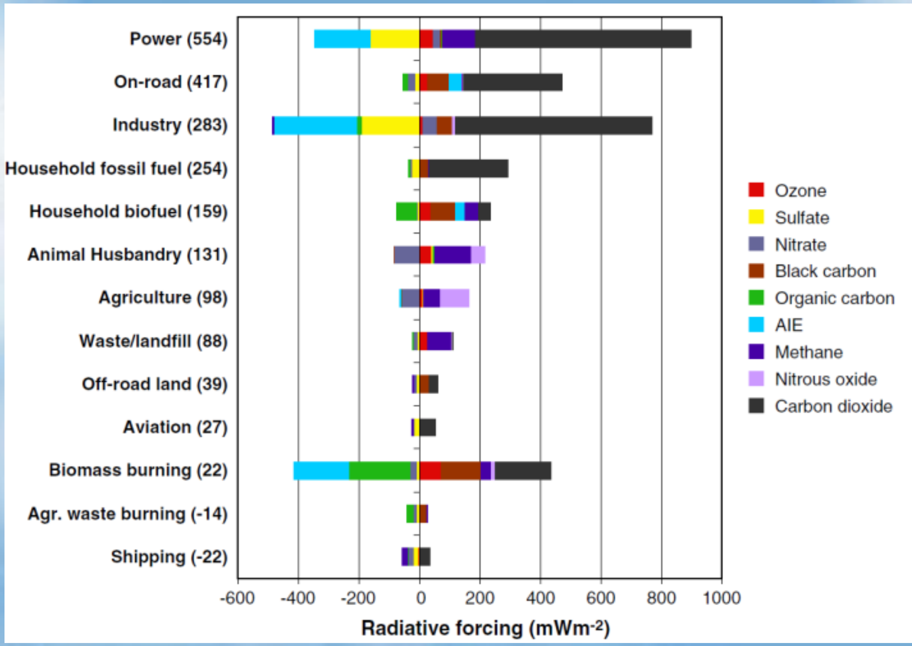


Radiative forcing due to constant year 2000 emissions grouped by sector

(a) 2020

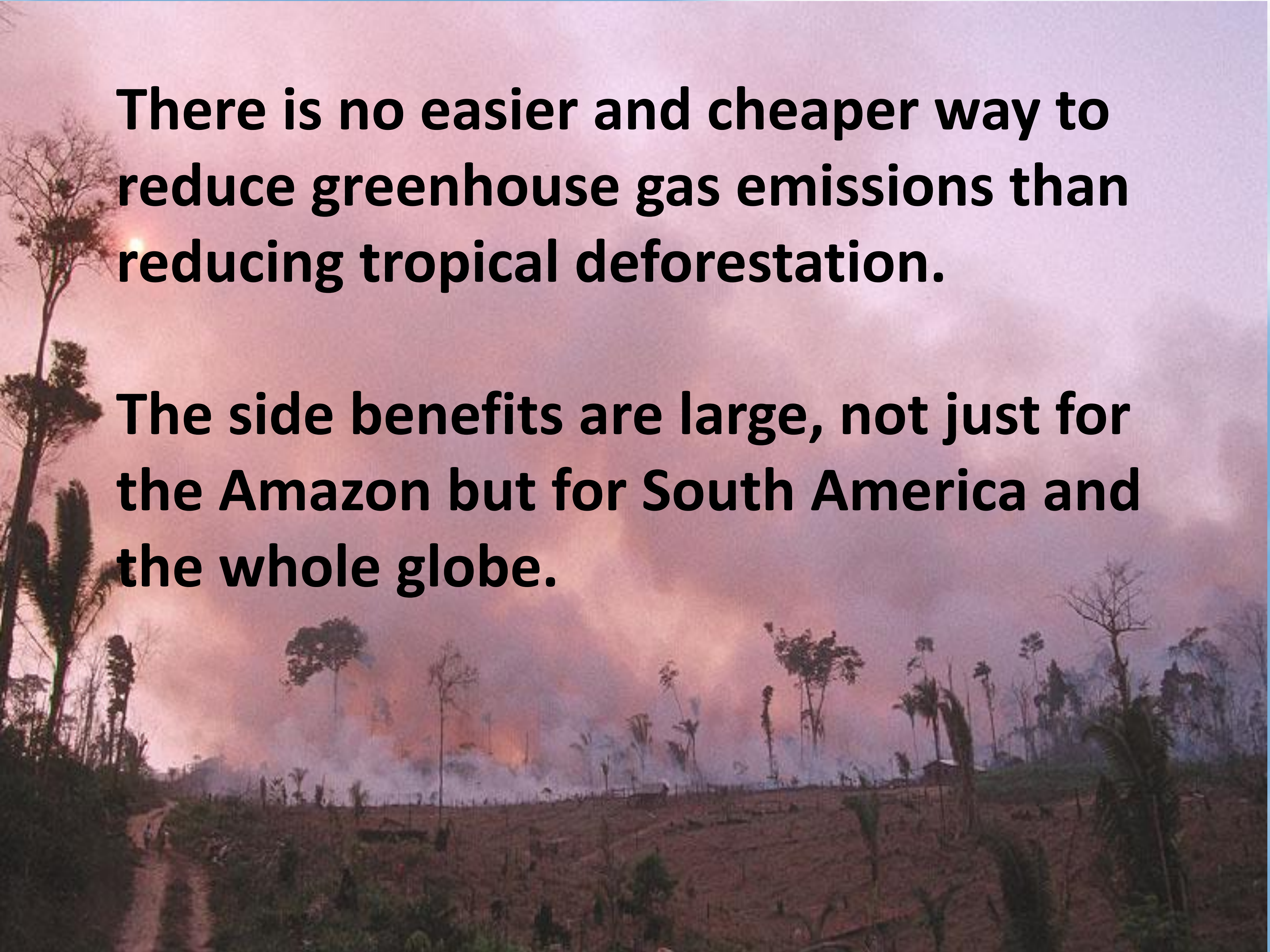


(b) 2100



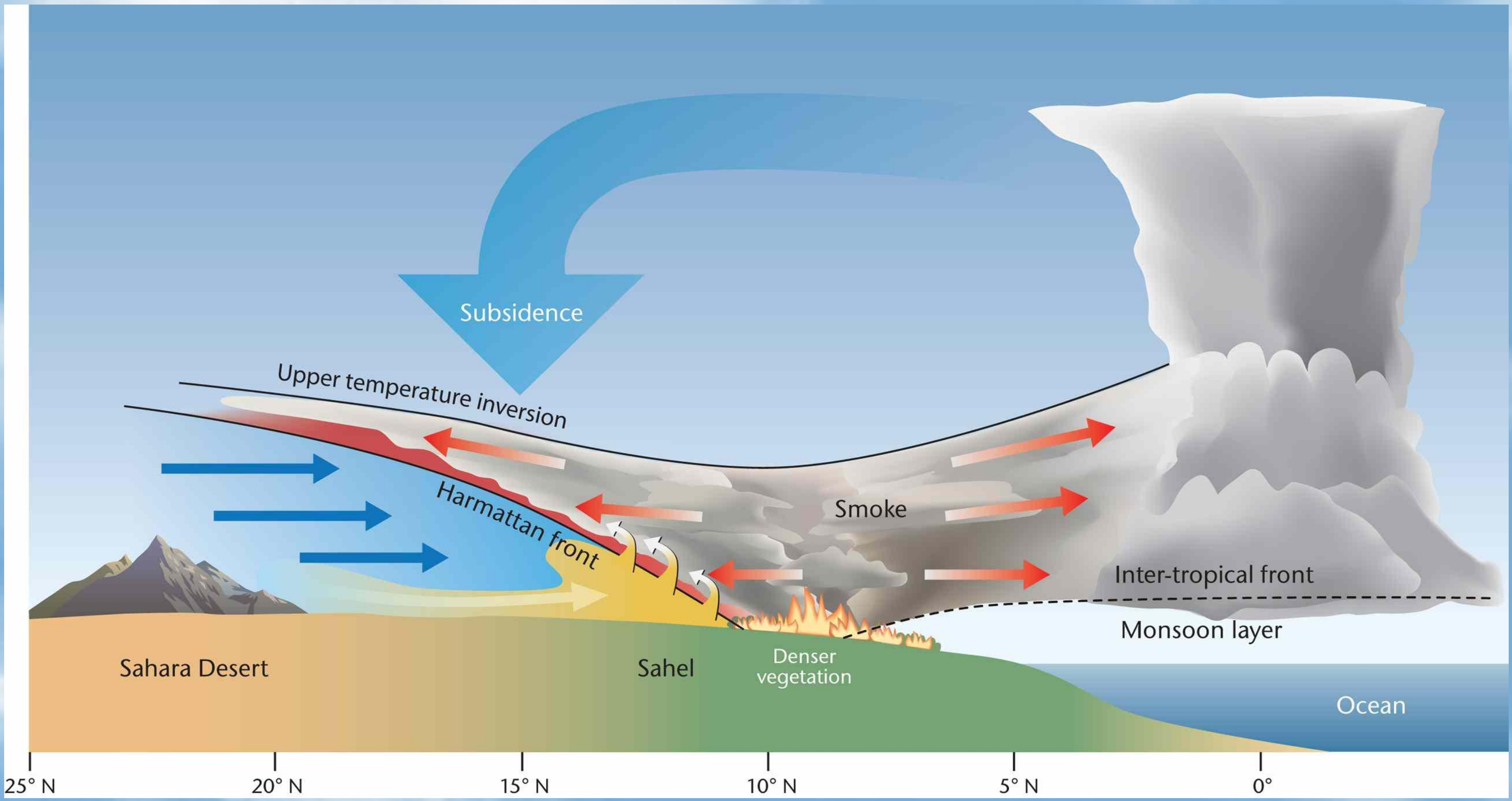
Main sectors: Energy generation, Industry and Biomass Burning

Unger N et al. PNAS 2010;


There is no easier and cheaper way to reduce greenhouse gas emissions than reducing tropical deforestation.
The side benefits are large, not just for the Amazon but for South America and the whole globe.


Thanks for the attention!!!

The Dust and Biomass Burning Experiment, W Africa, suggests that gas phase organic carbon from biomass burning may condense onto the larger surface area of mineral dust (Haywood et al., 2008).

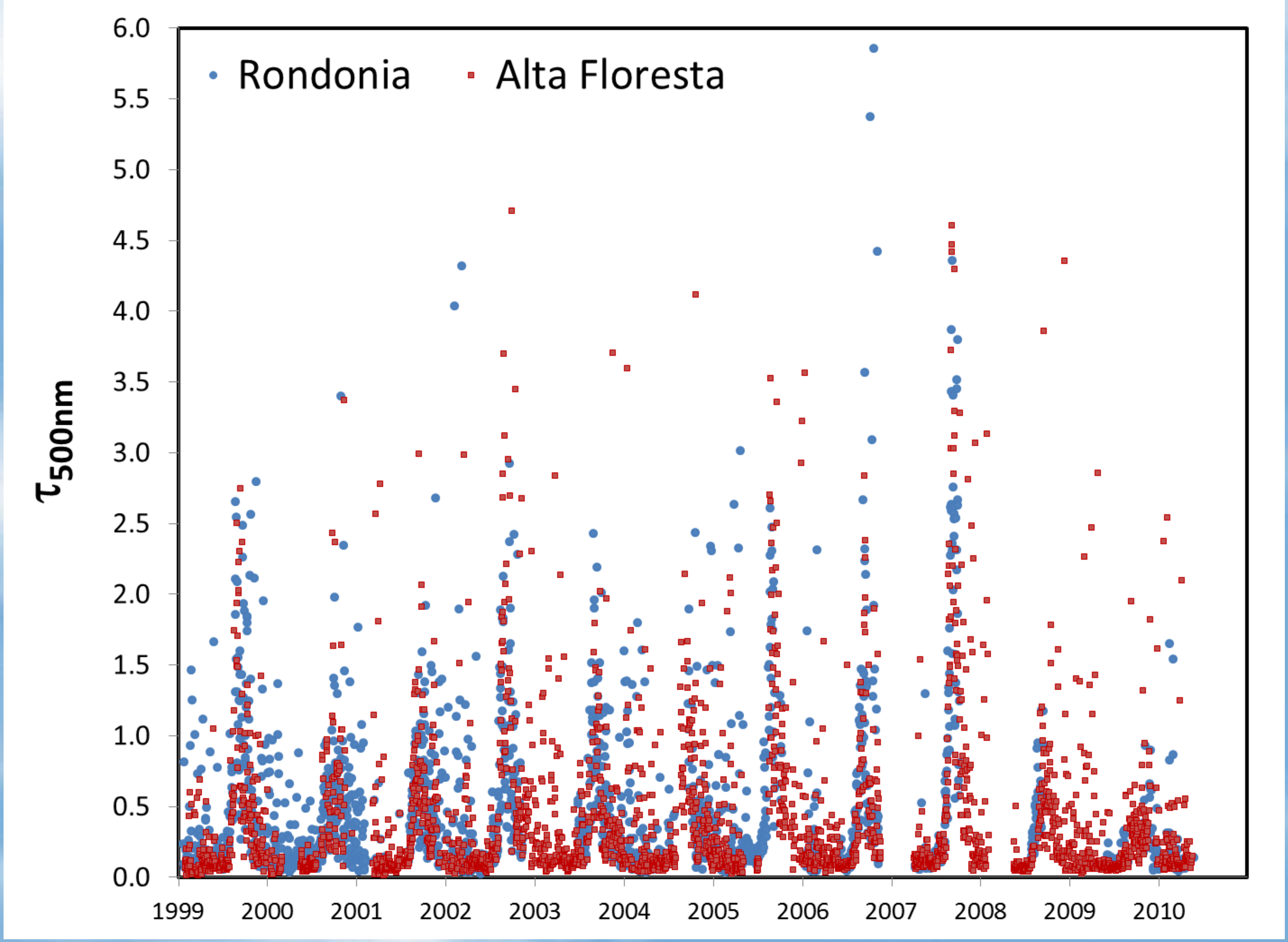


Jim Haywood, AMMA studies

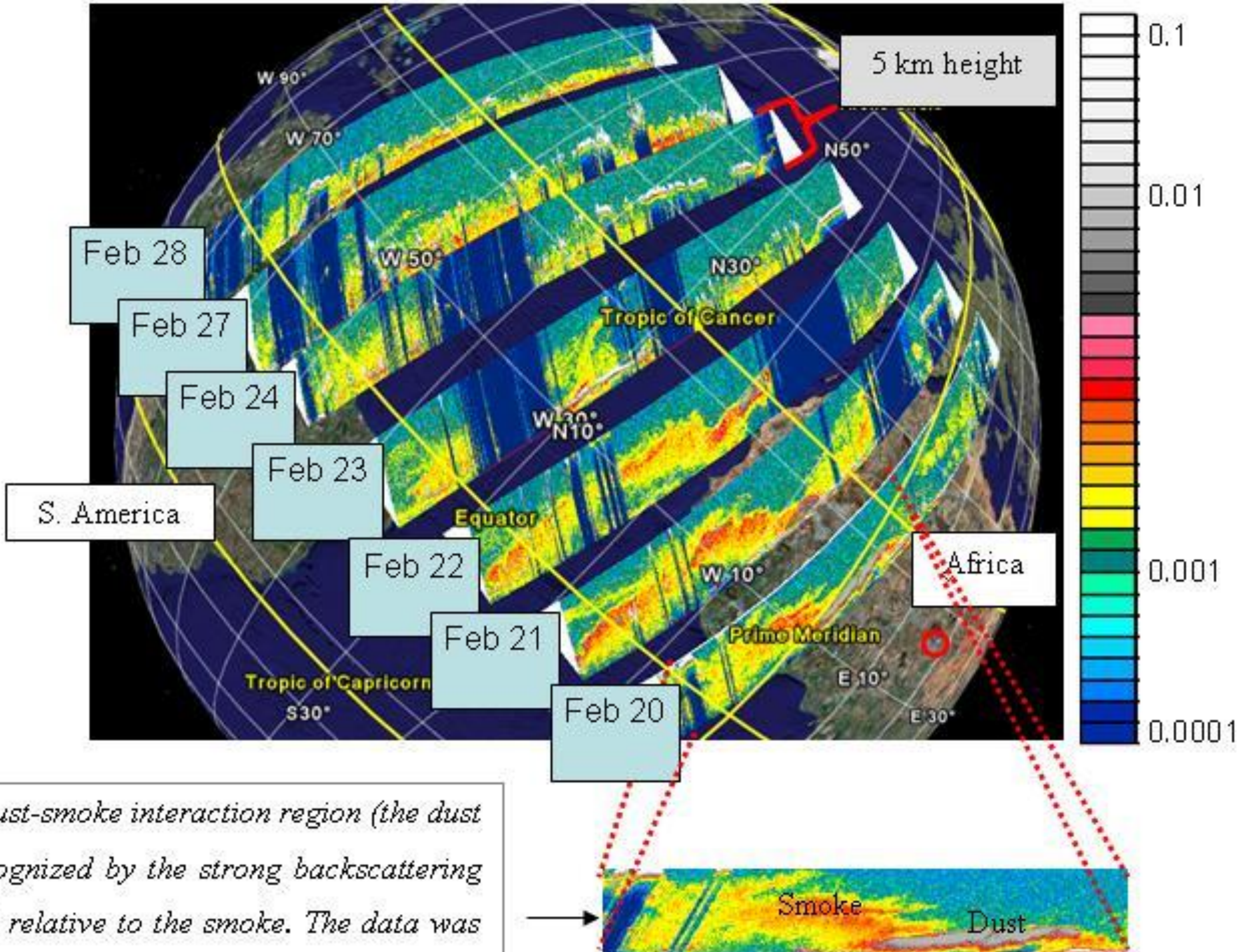
How the fire regimes have changed during the industrial era, from a representative cross-section of biomes from low to high latitudes

Biome	**Pre-industrial fire regime**	**Post-industrial fire regime**
Tropical rain forest	Very infrequent low intensity surface fires with negligible long-term effects on biodiversity	Frequent surface fires associated with forest clearance causing a switch to flammable grassland or agricultural fields
Tropical savanna	Frequent fires in dry season causing spatial heterogeneity in tree density	Reduced fire due to heavy grazing causing increased woody species recruitment
Mid-latitude desert	Infrequent fires following wet periods that enable fuel build-up	Frequent fires due to the introduction of alien flammable grasses
Mid-latitude North American seasonally dry forests	Frequent low intensity surface fires limiting recruitment of trees	Fire suppression causing high densities of juveniles and infrequent high intensity crown fires
Boreal forest	Infrequent high intensity crown fires causing replacement of entire forest stands	Increased high intensity wildfires associated with global warming causing loss of soil carbon and switch to treeless vegetation

Time series of aerosol optical thickness at 500 nm for Alta Floresta, MT and Ji-Paraná, Rondônia 1999-2010.



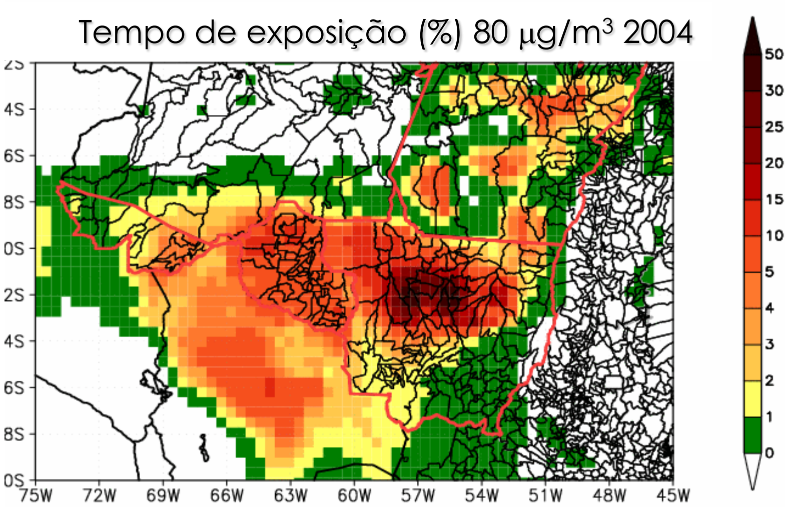
Sahara dust and biomass burning transport to Amazonia

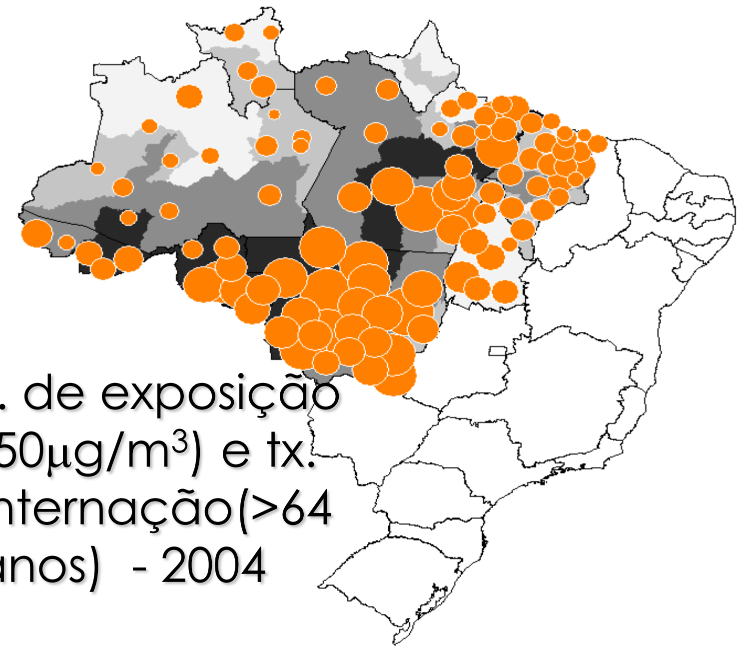


The dust-smoke interaction region (the dust is recognized by the strong backscattering signal relative to the smoke. The data was verified with MODIS image)

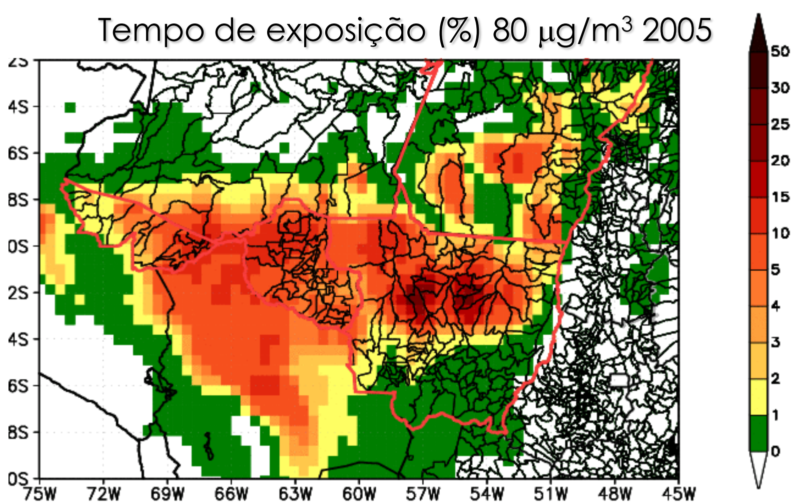
(Yuval et. al, in press).

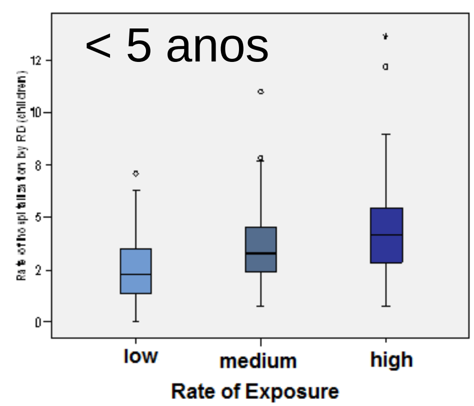
Aplications in assessing health effects INPE – FIOCRUZ-MS

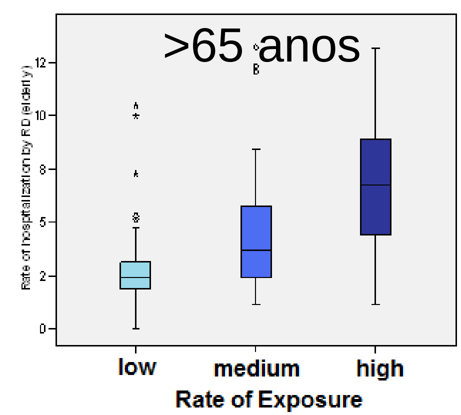




T. de exposição (50µg/m³) e tx. Internação(>64 anos) - 2004

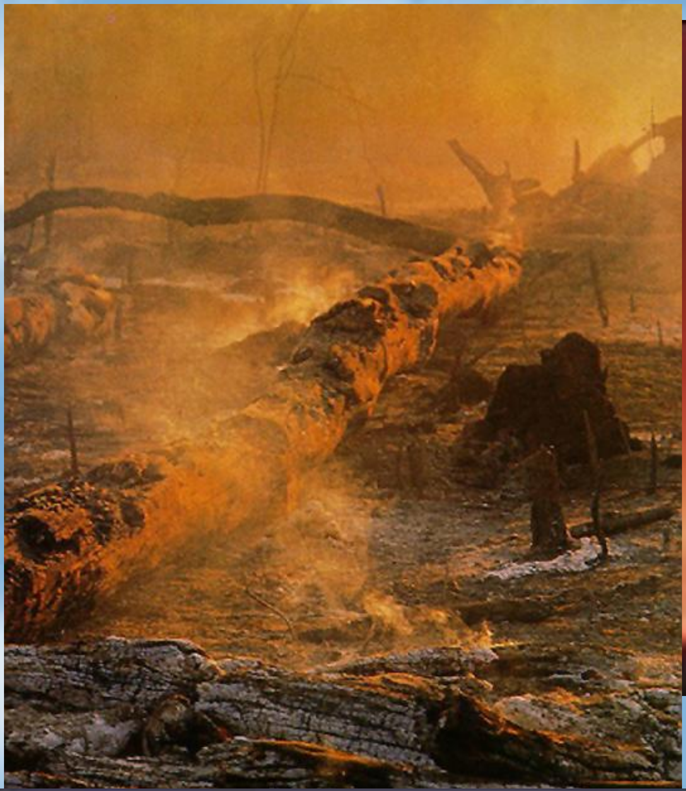






Karla Longo and Saulo Freitas, INPE

Fire and biomass burning



Pressure from Climate Change issues to reduce deforestation…

Estimate of quantitative evolution of control variables for seven planetary boundaries from preindustrial levels to the present

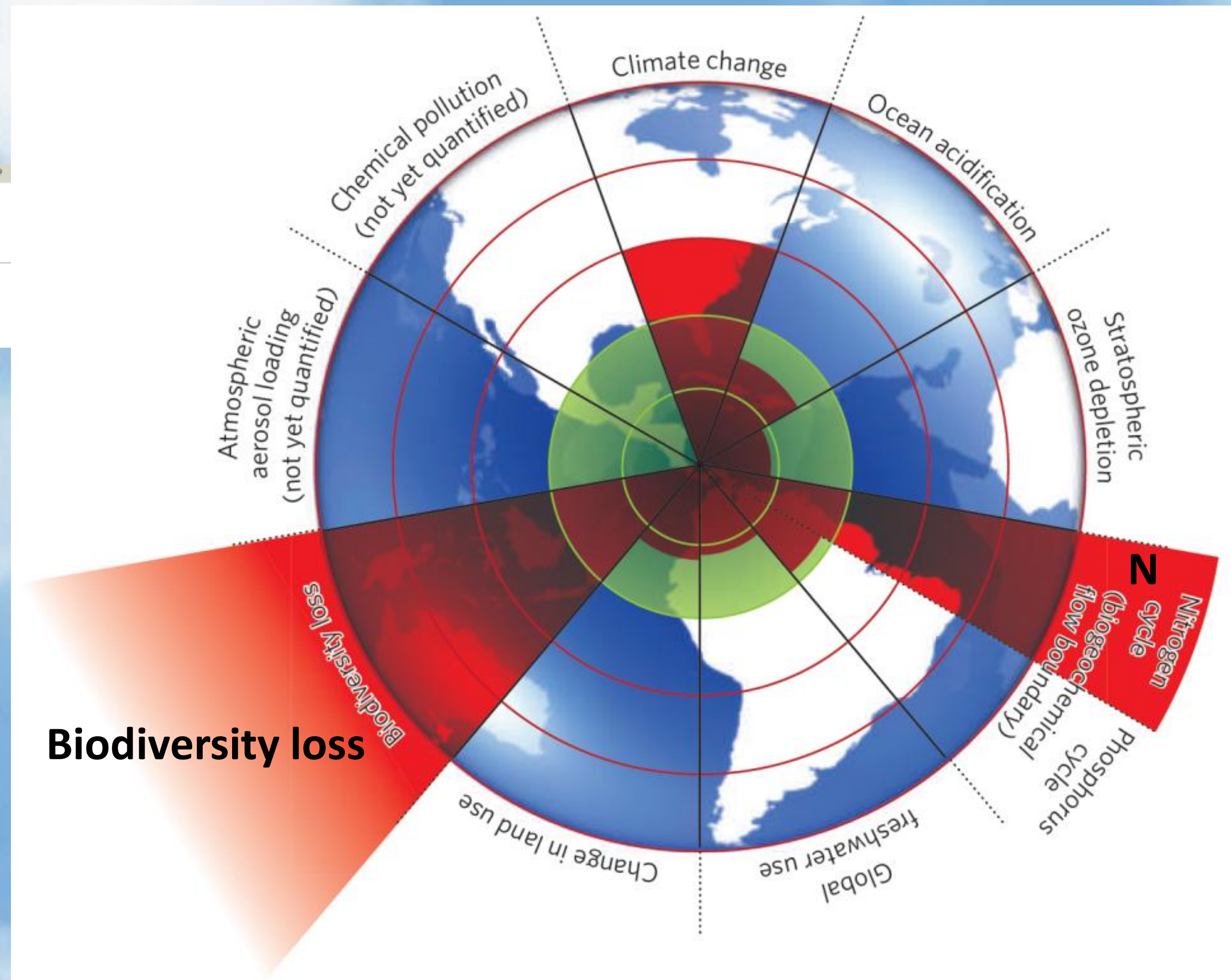

nature Vol 461|24 September 2009

FEATURE

A safe operating space for humanity

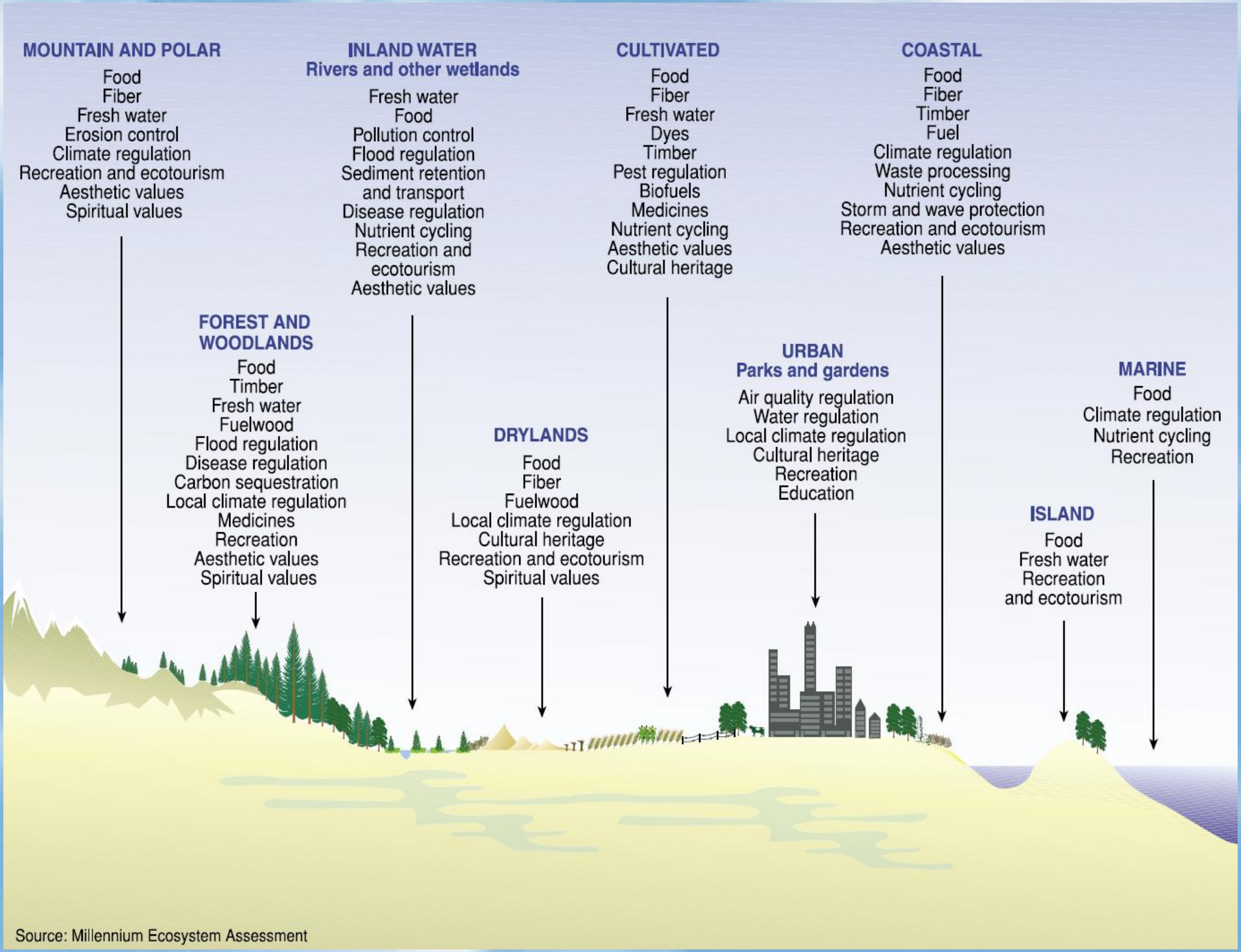
Identifying and quantifying planetary boundaries that must not be transgressed could help prevent human activities from causing unacceptable environmental change, argue **Johan Rockström** and colleagues.

Beyond the boundary. The inner green shading represents the proposed safe operating space for nine planetary systems. The red wedges represent an estimate of the current position for each variable. The boundaries in three systems (rate of biodiversity loss, climate change and human interference with the nitrogen cycle), have already been exceeded.

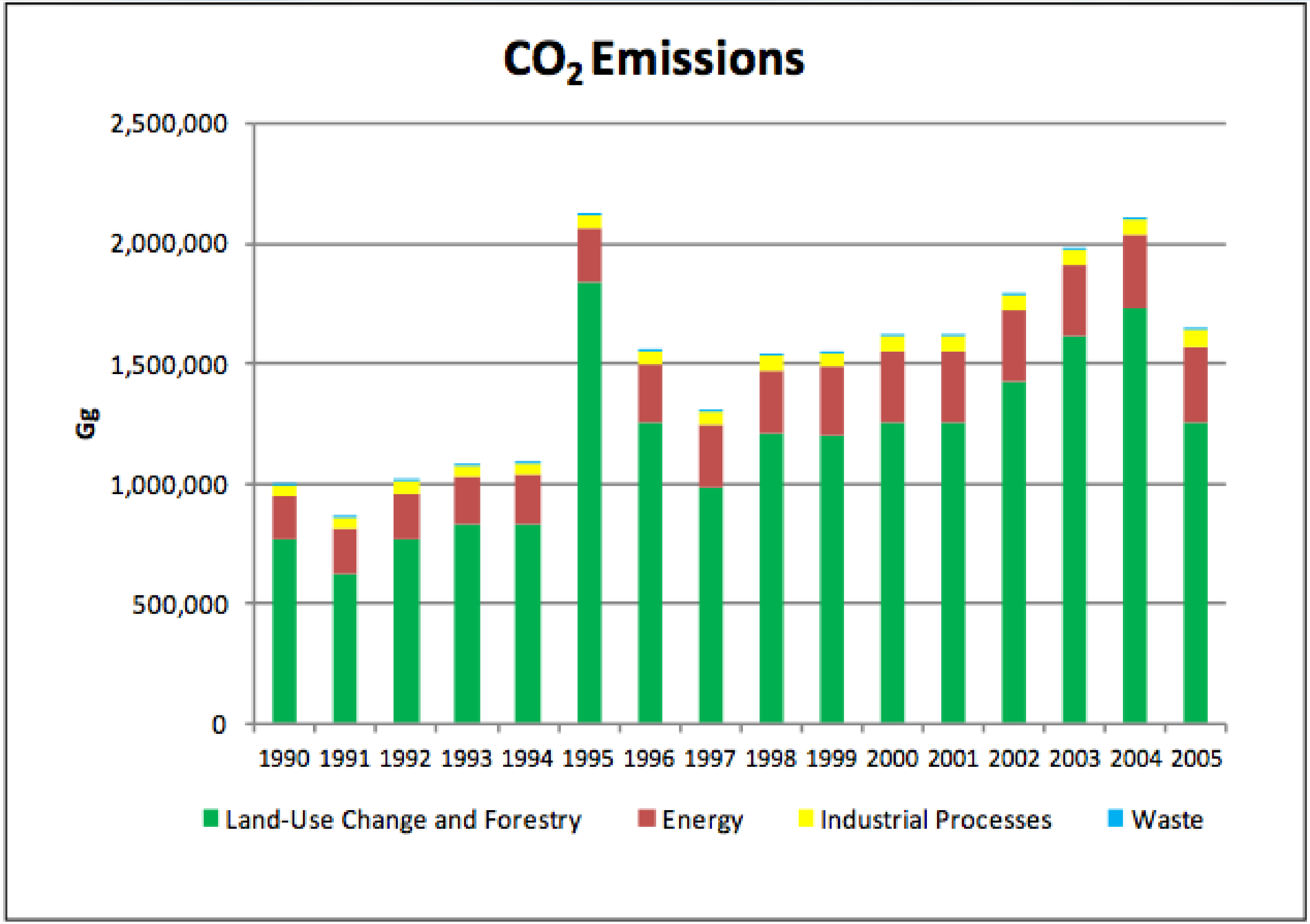


Nature, 2009

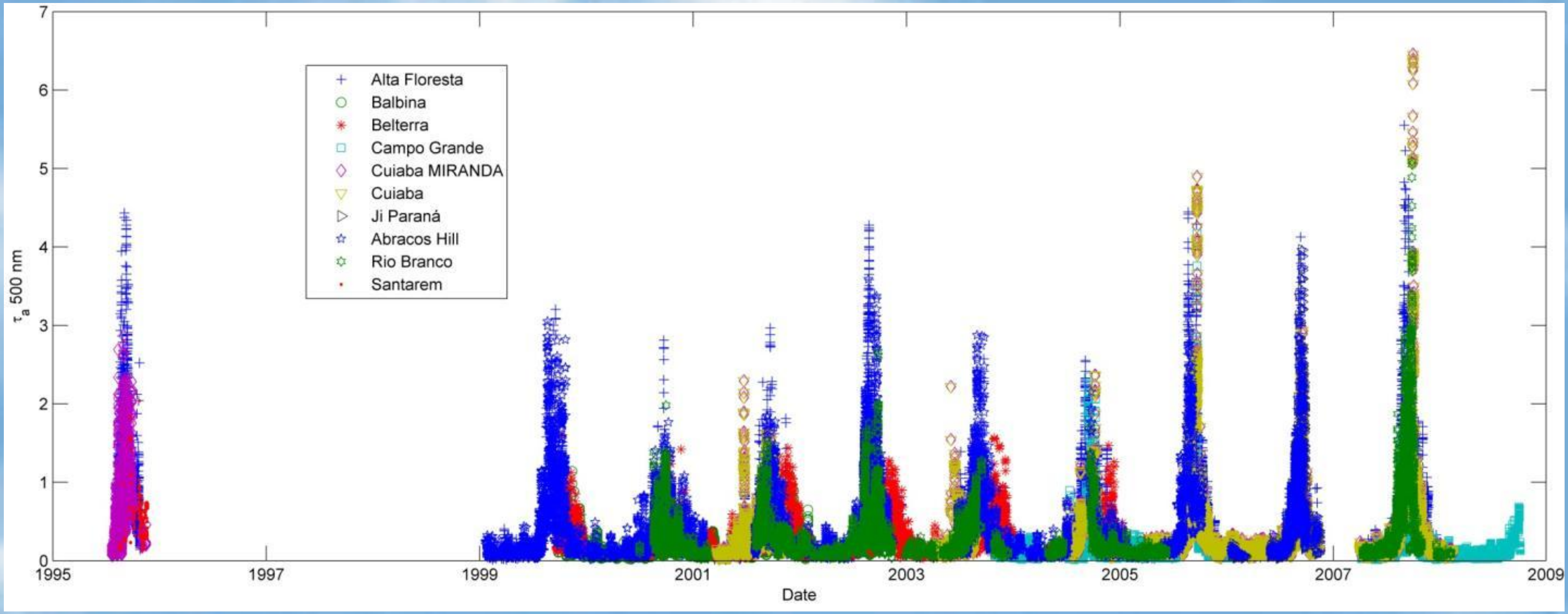
Ecosystems and Some Services They Provide



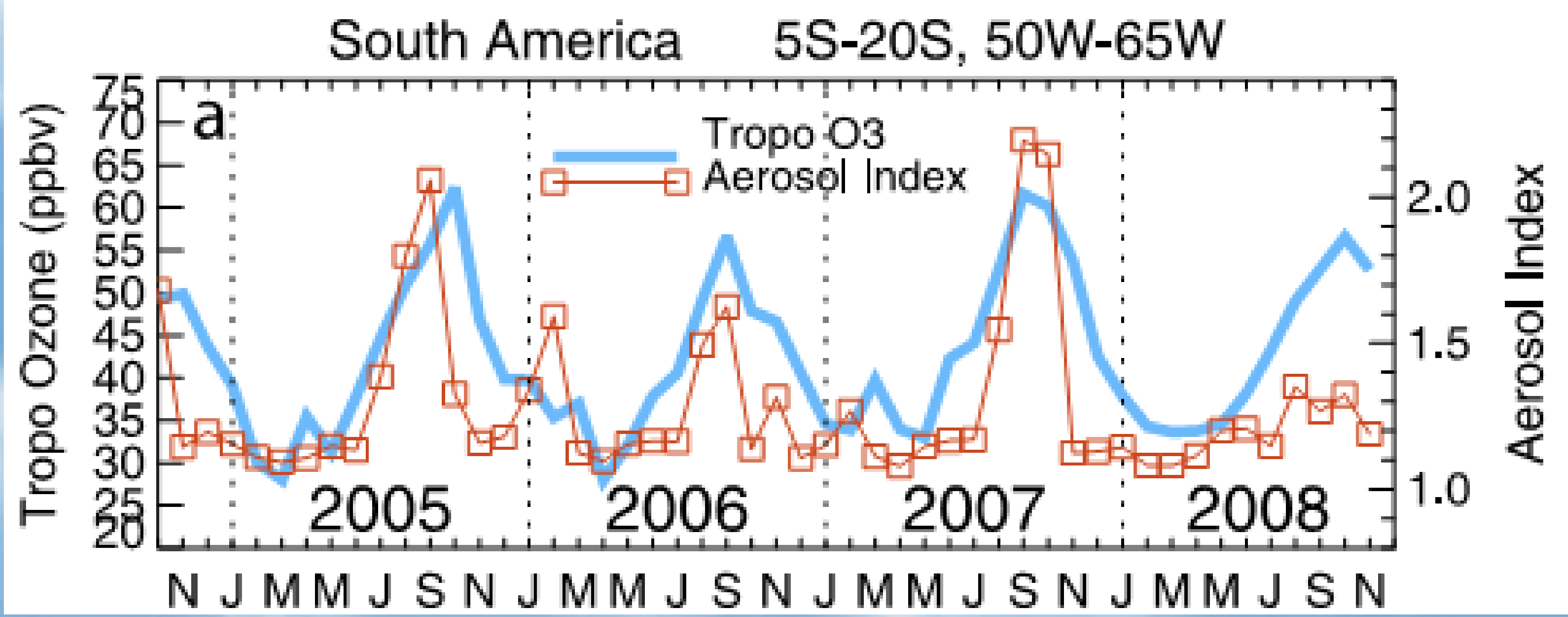
Impact of land change in Brazil's emissions



Aerosol optical depth from 1999 to 2009 for 10 sites in Amazonia



OMI tropospheric ozone mean VMR (in ppbv)



Anthropogenic burning was reduced substantially in Brazil in year 2008 compared to previous years including 2007. The OMI/MLS measurements show sizeable decreases 15 – 20% in ozone in Brazil during 2008 compared to 2007 which we attribute to this reduction in biomass burning.