AHF1

FAPESP Week France 11/20-27/2019

Mercury fate and transport in the Amazon forest

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GQA Grupo de Química Ambiental UNICAMP

IQ Instituto de Química

UNICAMP

Slide 1

AHF1 Anne Helene Fostier; 19/11/2019

Mercury

Persistent

Bioaccumulative

Toxic

Atmospheric mercury (> 90% Hg^0)

- High volatility
- Low solubility and reactivity
- Residence time ~ 1 year
- Long distance transportation

UNEP
United Nations Environment Programme

Global Pollutant

World Health Organization

UNITED NATIONS ENVIRONMENT PROGRAMME

Programme des Nations Unies pour l'environnement | Programa de las Naciones Unidas para el Medio Ambiente

Программа Организации Объединенных Наций по окружающей среде | برنامج الأمم المتحدة للبيئة

联合国环境规划署

UNEP

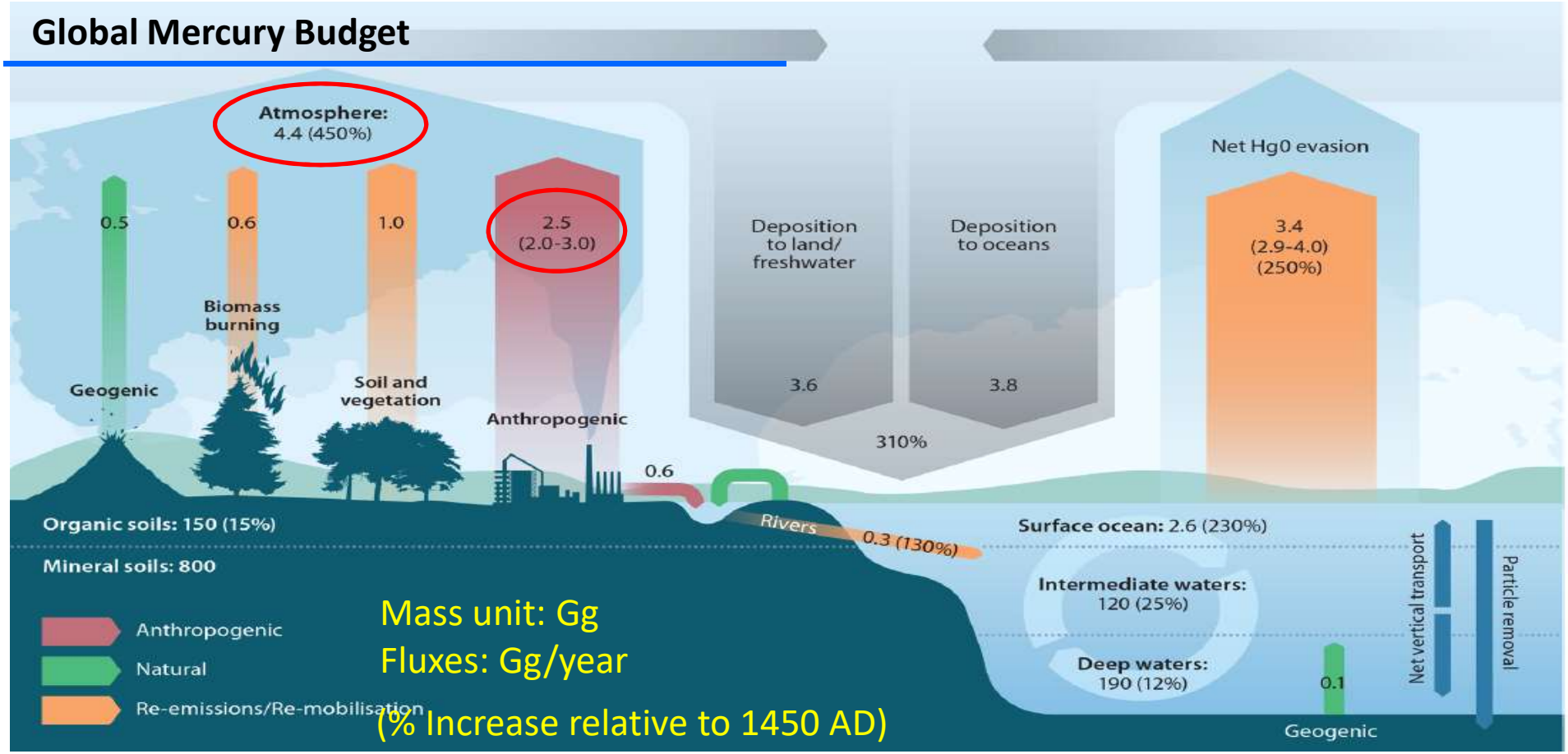
'Minamata' Convention Agreed by Nations

Global Mercury Agreement to Lift Health Threats from Lives of Millions World-Wide

Geneva/Nairobi, 19 January 2013--International effort to address mercury—a notorious heavy metal with significant health and environmental effects—was today delivered a significant boost with governments agreeing to a global, legally-binding treaty to prevent emissions and releases.

- Intergovernmental negotiations
- Already signed by 128 countries
- France ratification: 06/2017
- Brazil ratification: 08/2017

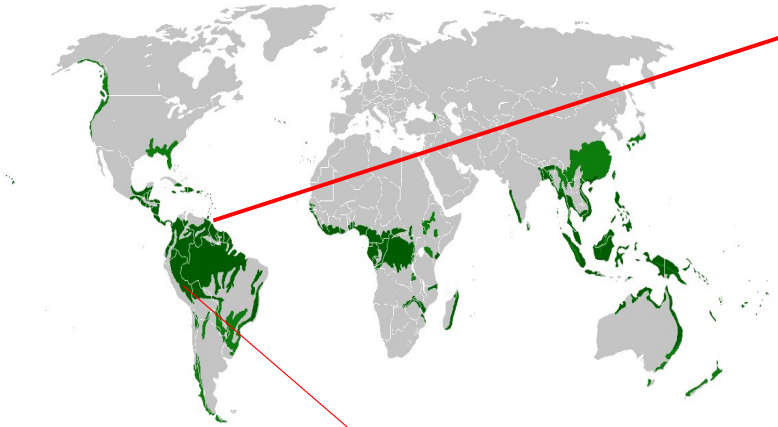
Global Mercury Budget



Outridge et al. (2018) Environ. Sci. Technol, 2018

- Anthropogenic activities have greatly altered the global Hg cycle
- Many ecosystems are threatened by exposure to elevated levels of Hg and its different species
- The neurotoxic and bioaccumulating methyl-Hg that formed under the influence of anaerobic microorganisms in a variety of natural systems.
- Many processes are still far from being understood, specially in the terrestrial ecosystems which have been poorly studied when compared to aquatic systems.

The Amazon rainforest



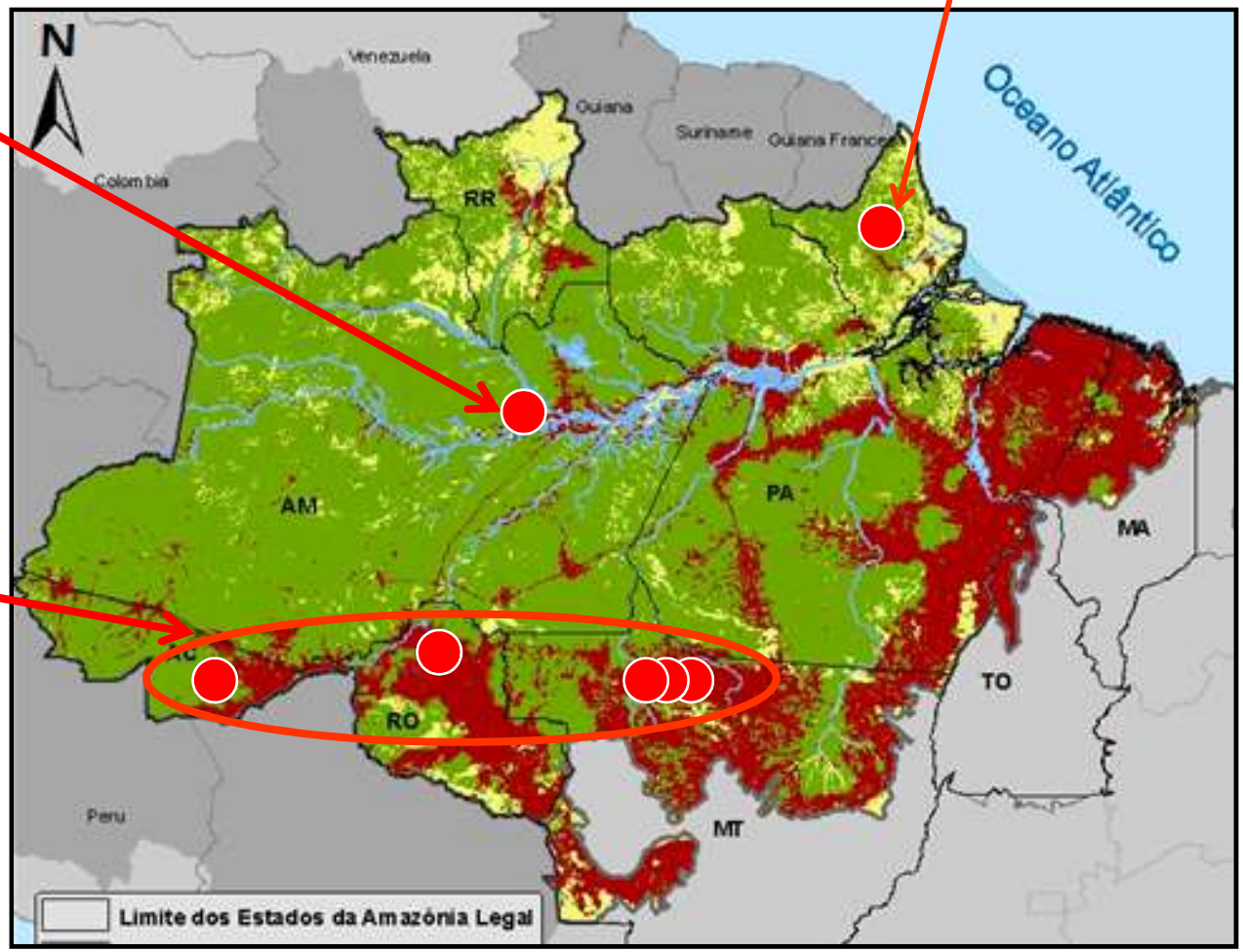
- More than half of the remaining tropical forests;
- High activity of Artisanal Small Scale Golg Mining (ASGM)
- High rate of deforestation
- One of the largest freshwater reserve.

More than 20 years of researches on the Hg biogeochemical cycle

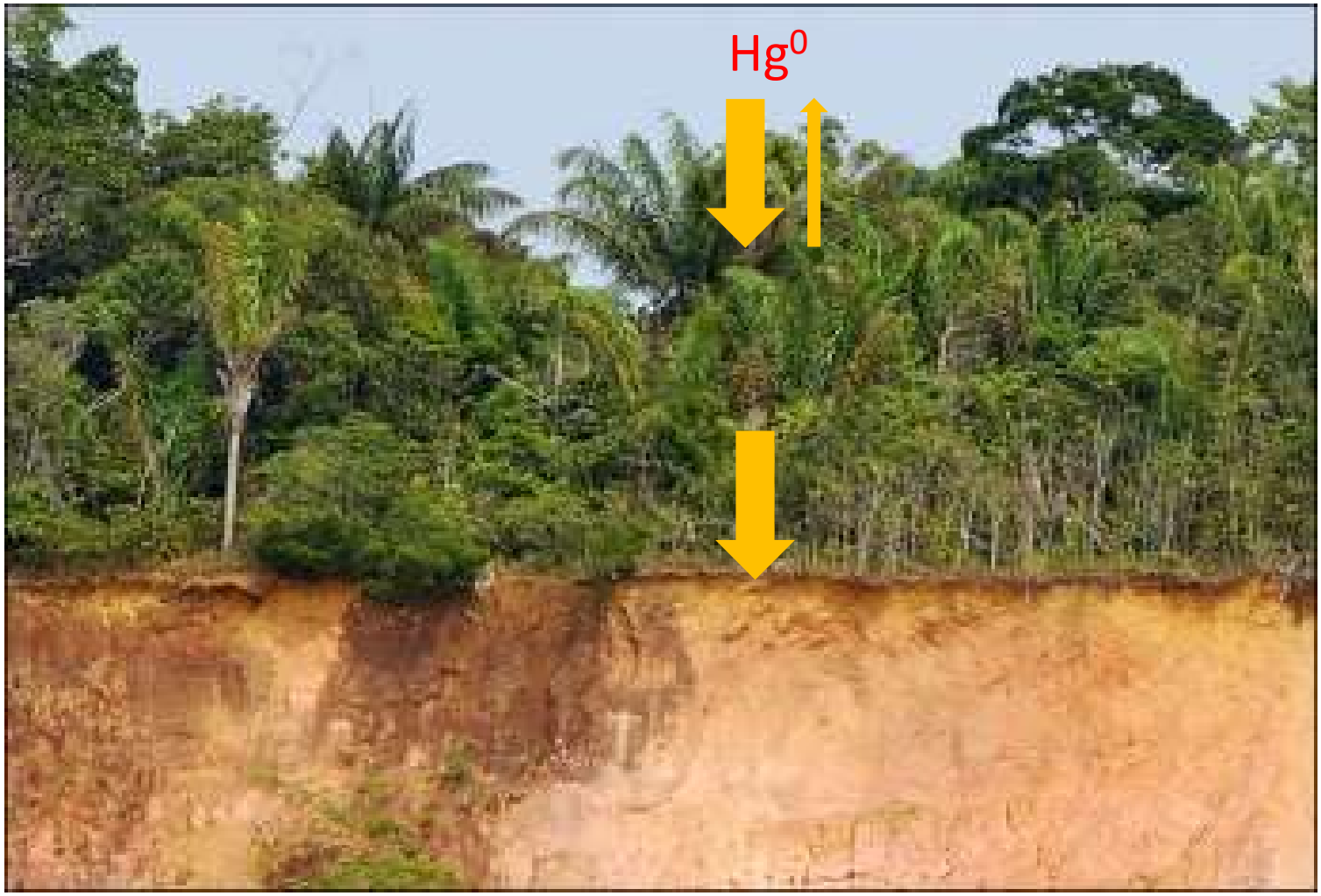
1994-1996
CNPq
USP, INPE, IRD
(France)

2000-2004
FAPESP
UNICAMP,
UNESP, INPA

2004-2014
FAPESP
UNESP, INPE,
UNICAMP,
CUNY (USA),
Univ.
Washington
(USA), Univ. Pau
(France)



Atmospheric mercury deposition in forest



Environmental Pollution 206 (2015) 605–610

Contents lists available at ScienceDirect

Environmental Pollution

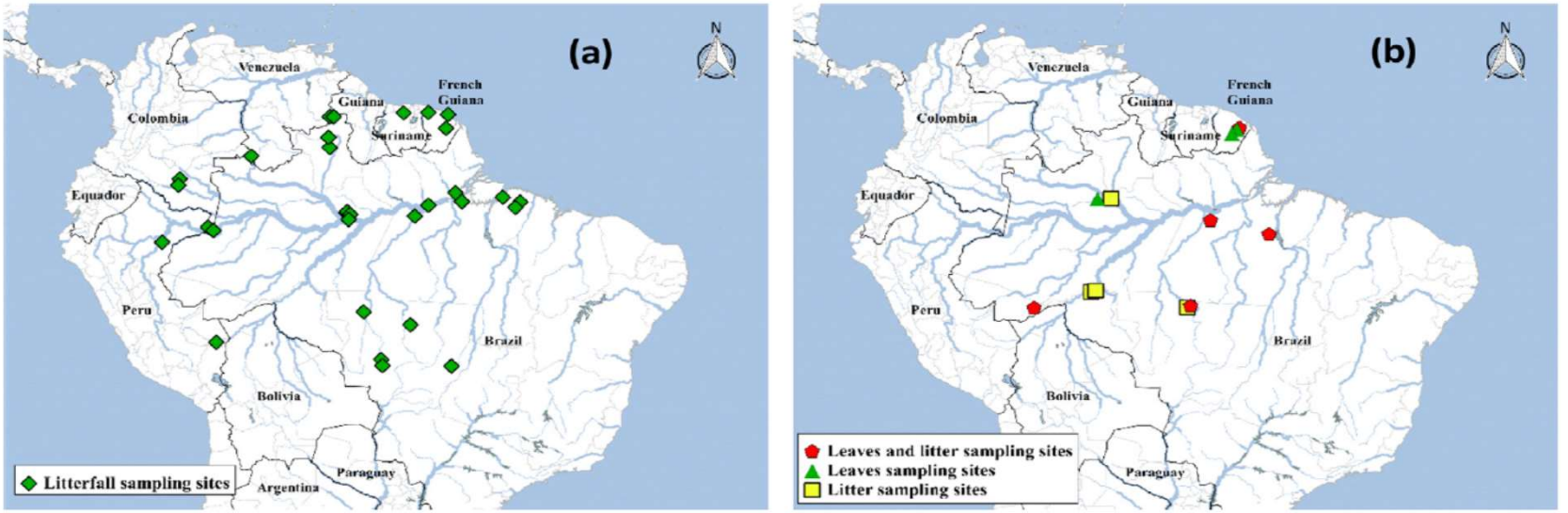
journal homepage: www.elsevier.com/locate/envpol

Litter mercury deposition in the Amazonian rainforest

Anne Hélène Fostier*, José Javier Melendez-Perez, Larissa Richter

Institute of Chemistry, University of Campinas, UNICAMP, P.O. Box 6154, 13083-970 Campinas, SP, Brazil

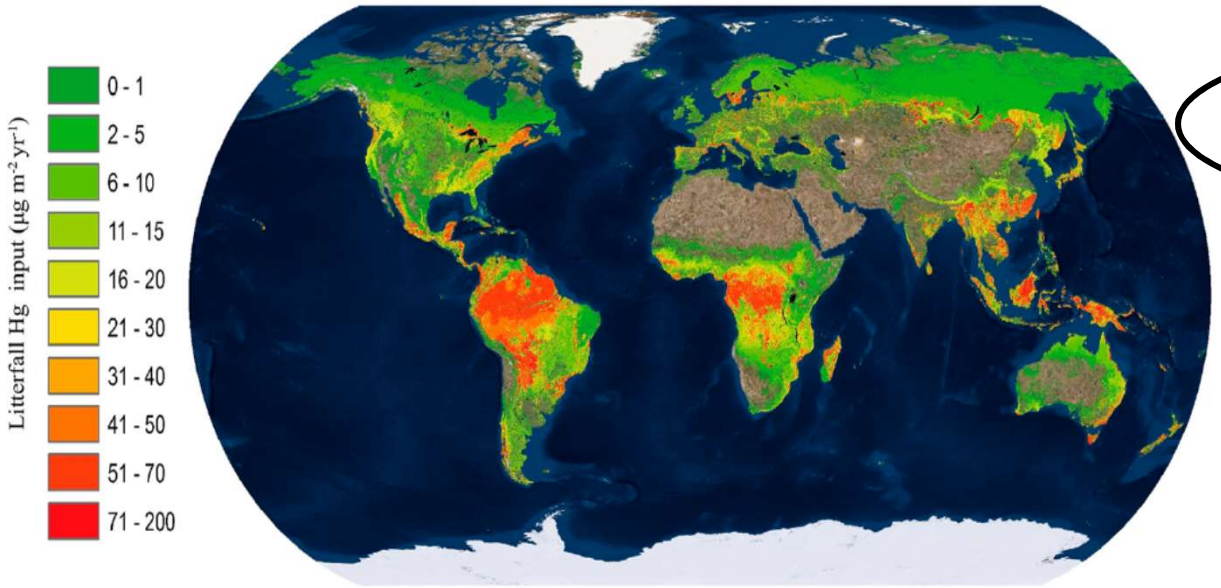
First assessment of litter Hg deposition in a tropical forest



Litter Hg deposition : 49 ± 14 µg m^{-2} yr

Litter Hg deposition in the Amazon rainforest: 268±77 Mg/yr

Assessment of Global Mercury Deposition through Litterfall (2016)



Global Hg deposition through litterfall :1180±710 Mg/yr

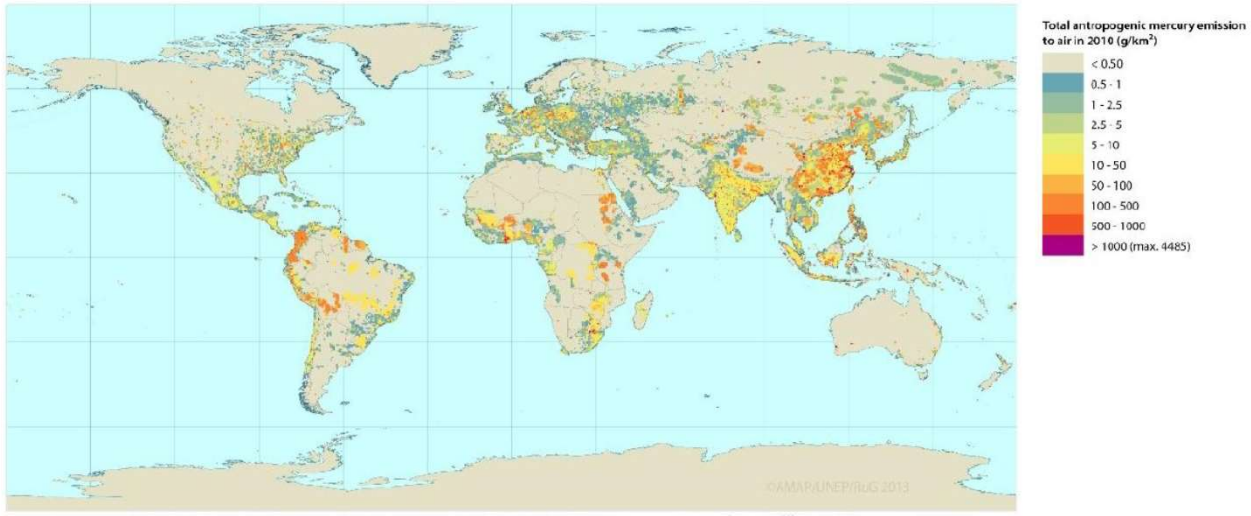
Amazon rainforest: 268±77 Mg/yr

23% of the global Hg deposition through litterfall

Wang et al. , Environ. Sci. Technol., 2016, 50

Geospatial distribution of global anthropogenic mercury emissions to air (2010)

Global anthropogenic Hg emissions: 2500 Mg/yr



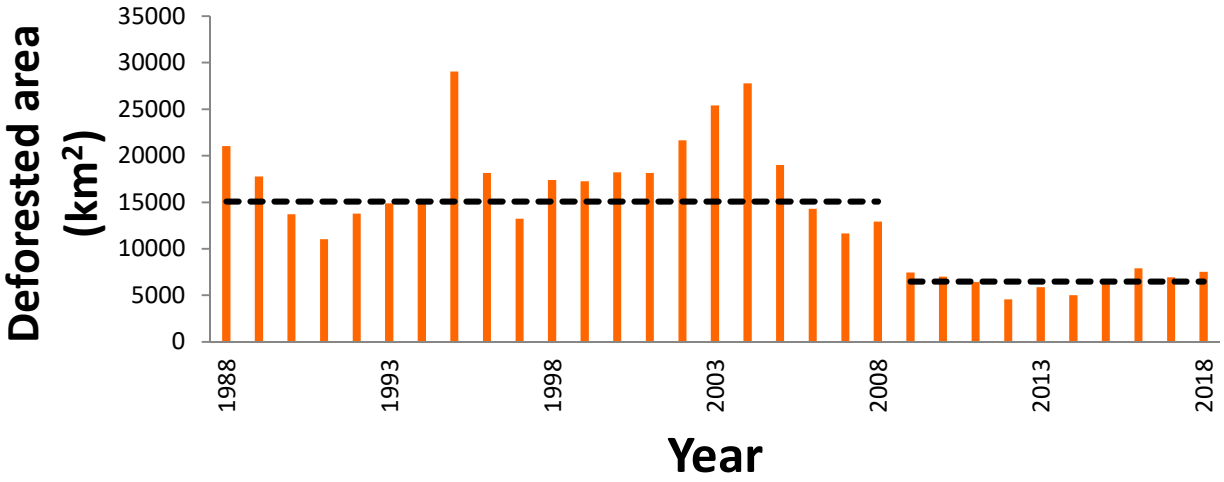
Wilson et al., Technical background report for the global mercury assessment, 2013

Mercury emissions due to forest fires in the Amazon forest

- **In the Amazon, forest fires are closely linked to deforestation processes, through the so called "slash and burn" method**

Photographs of "slash and burn" processes in the Amazon

- **In the last 10 years (2009-2018), annual average of deforestation was 6494 ± 1095 km² yr^{-1}**



Mercury emissions due to forest fires in the Amazon forest

Author	Hg emissions due to forest fires in the Amazon forest (Mg yr^{-1})
Veiga et al., (1994)	88
Lacerda (1995)	8
Roulet et al. (1999)	6 e 9

From 2004 to 2014: Study of biomass combustion, GHG and Hg emissions

- Large-scale controlled fire experiments (2 to 4 ha) according the **"slash and burn" method**
- Small controlled fire experiment (4 m^2)

GEOPHYSICAL RESEARCH LETTERS, VOL. 37, L09809, doi:10.1029/2009GL042220, 2010

Click Here for Full Article

Mercury emissions from forest burning in southern Amazon

Paula Albernaz Machado Michelazzo,[1] Anne Hélène Fostier,[1] Gabriella Magarelli,[2] José Carlos Santos,[3] and João Andrade de Carvalho Jr.[4]

Atmospheric Environment 96 (2014) 415–422

Contents lists available at ScienceDirect

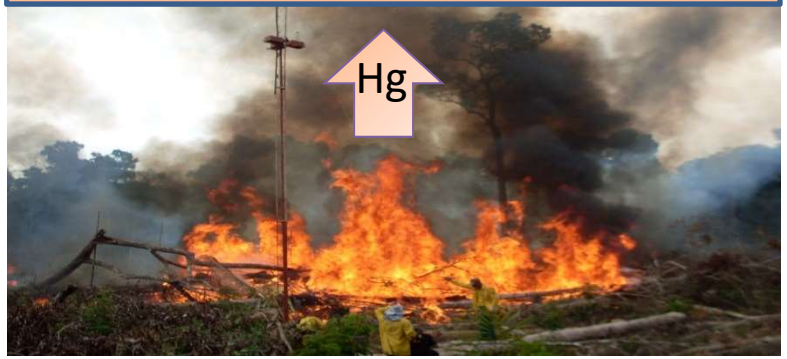
Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

Soil and biomass mercury emissions during a prescribed fire in the Amazonian rain forest

Jose J. Melendez-Perez [a], Anne H. Fostier [a, *], João A. Carvalho Jr. [b], Claudia C. Windmöller [c], José C. Santos [d], Anthony Carpi [e]

Emissions from vegetation and superficial soil: 4 to 6 Mg/yr



Emission factor: 47 g Hg/kg

Atmospheric Environment 96 (2014) 423–429

Contents lists available at ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

Gaseous mercury emissions from soil following forest loss and land use changes: Field experiments in the United States and Brazil

Anthony Carpi [a, b, *], Anne H. Fostier [c], Olivia R. Orta [a, d], Jose Carlos dos Santos [e], Michael Gittings [a]

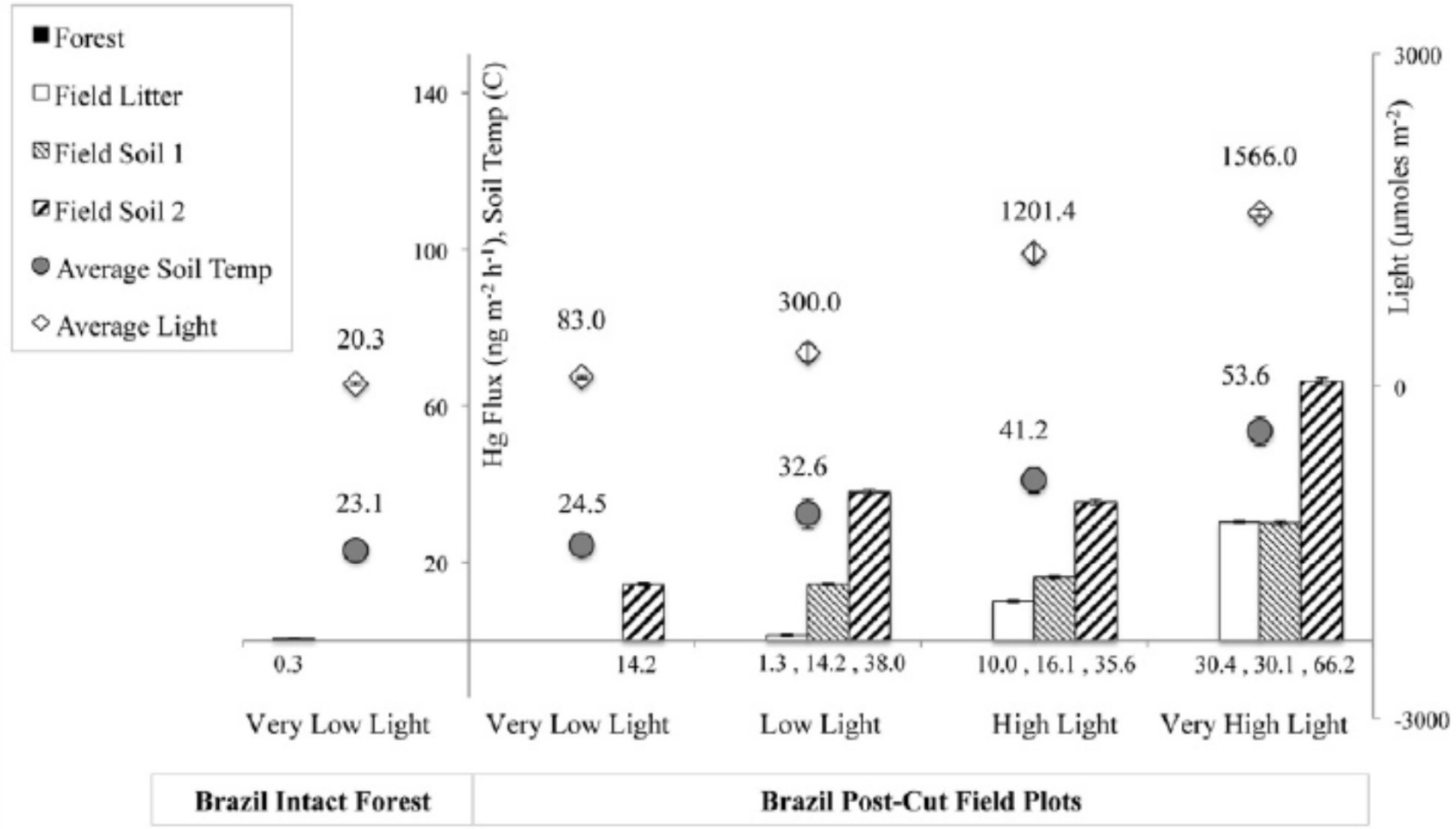
Annual Projected Hg Emission (g ha^{-1})

Soil emissions, Intact Forest (yr^{-1})

Soil emissions, Deforested Soils (yr^{-1})

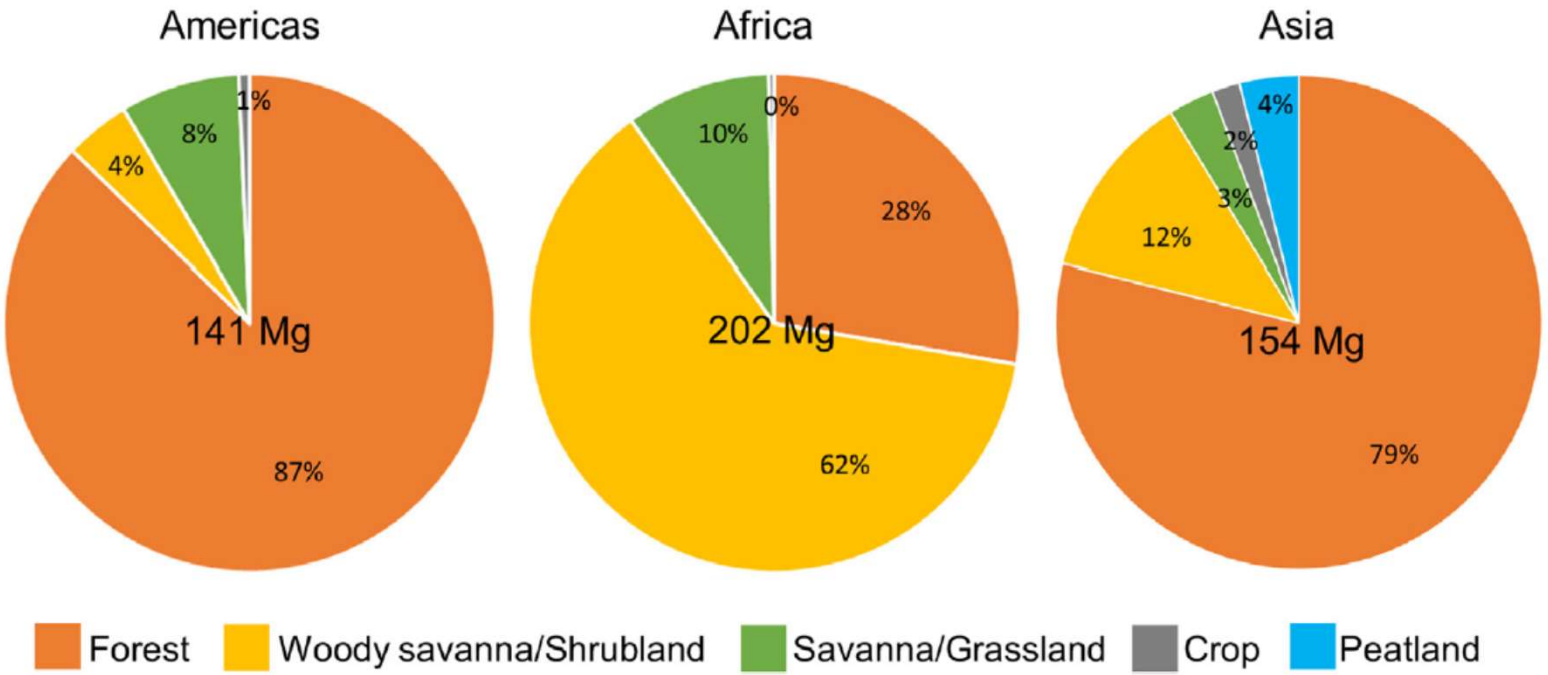
FAPESP Visiting Resecher Grant for Prof. Anthony Carpi (CUNY, USA)

Light intensity as the main driver of mercury soils emissions



Carpi et al. (2014) Atmos. Environ., 96

Mercury Emissions from biomass burning in tropical continents (2001-2017)



Total emissions: 497 Mg yr^{-1} (289 – 681 Mg yr^{-1})

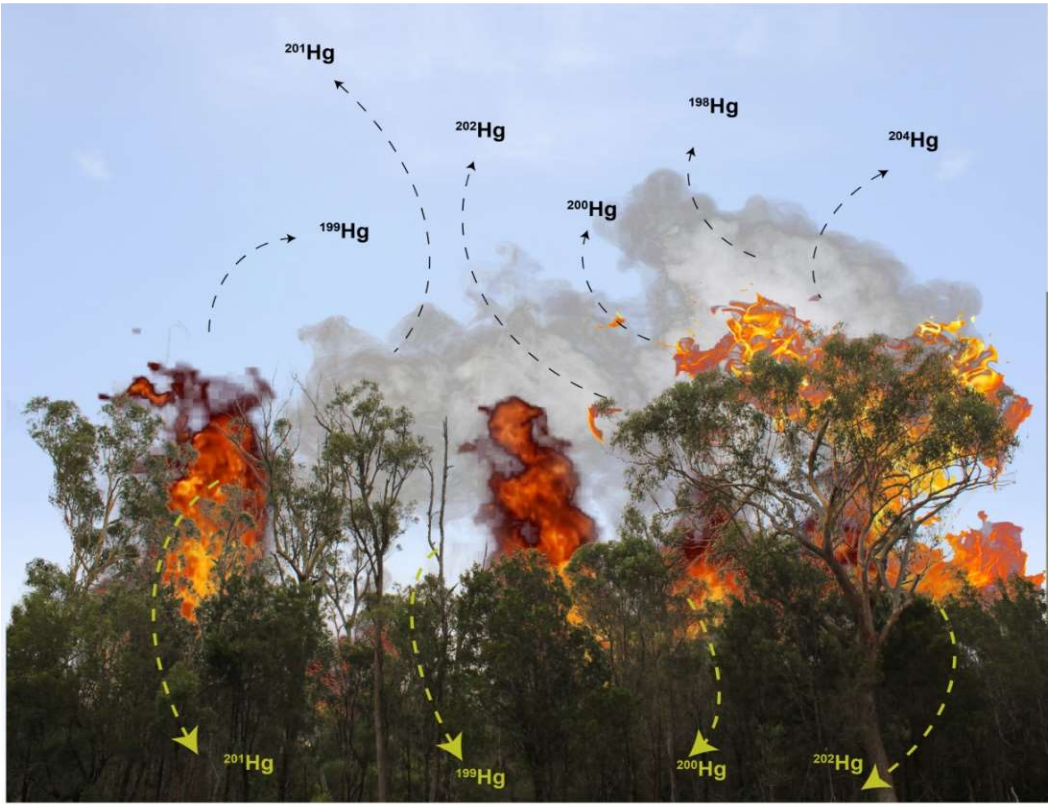
The Hg emission factor (122 g Hg/kg) for tropical forests is an average of the only two available data:

- **47 g Hg/kg** (*Melendez-Perez et al. (2014) Atmos. Environ., 96)*
- **198 g Hg/kg** (*Friedli et al. (2009) Environ. Sci. Technol., 43)*

Shi et al. (2019), Sci. Total. Environ., 653

Mercury isotopic fractionation

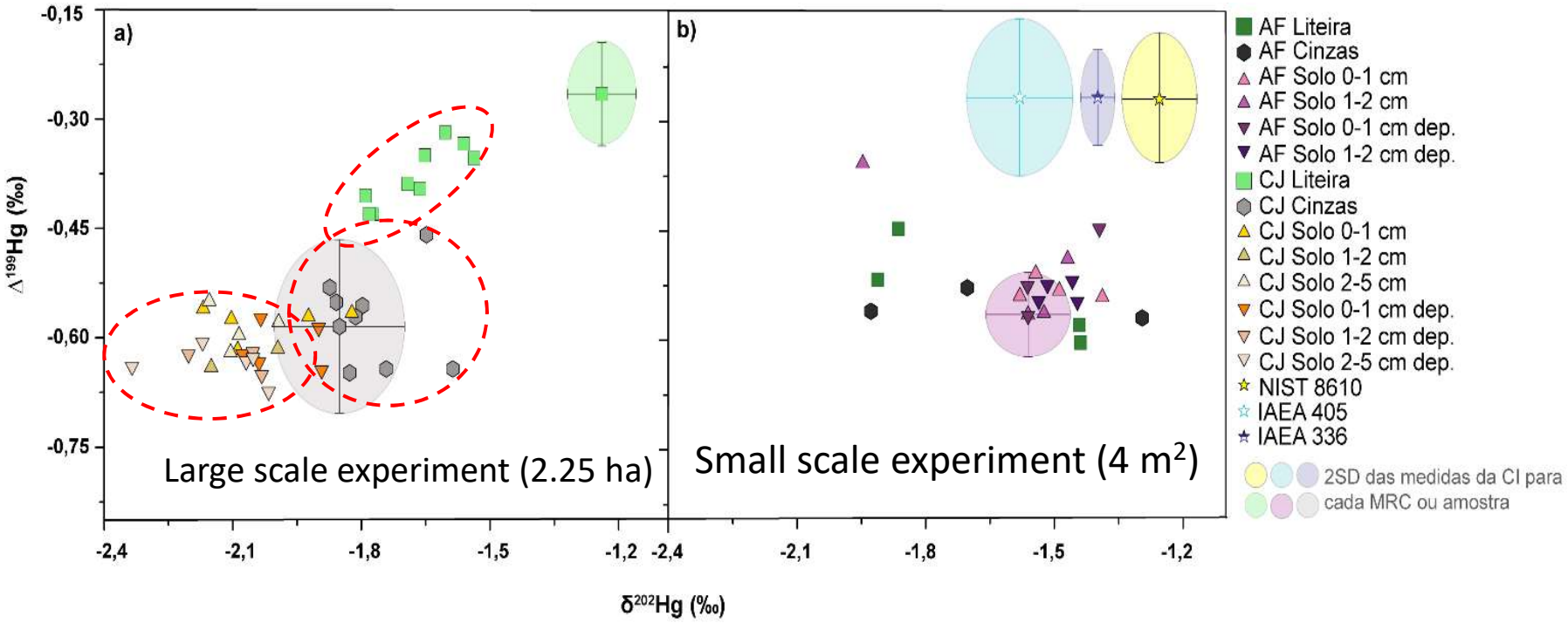
Is it possible to use the mercury isotopic composition as a tracer of forest burning mercury emissions ?



- This area of research has grown rapidely along the last decad due to modern mass spectrometry methods with high sensitivity MS equipments (MC-ICP-MS)

➢ **Analyze of samples (soil, litter, ashes) previously collected in burning experiments**

Is it possible to use the mercury isotopic composition as a tracer of forest burning mercury emissions ?



Burning in large scale experiment provided enough energy to induce Hg isotopic fractionation

On going project in collaboration with Prof. David Amouroux (Univ. Pau et des Pays de l' Adour) (Co-tutalled Doctorate Thesis, CAPESP scholarship)

Mercury emissions and Climate Changes

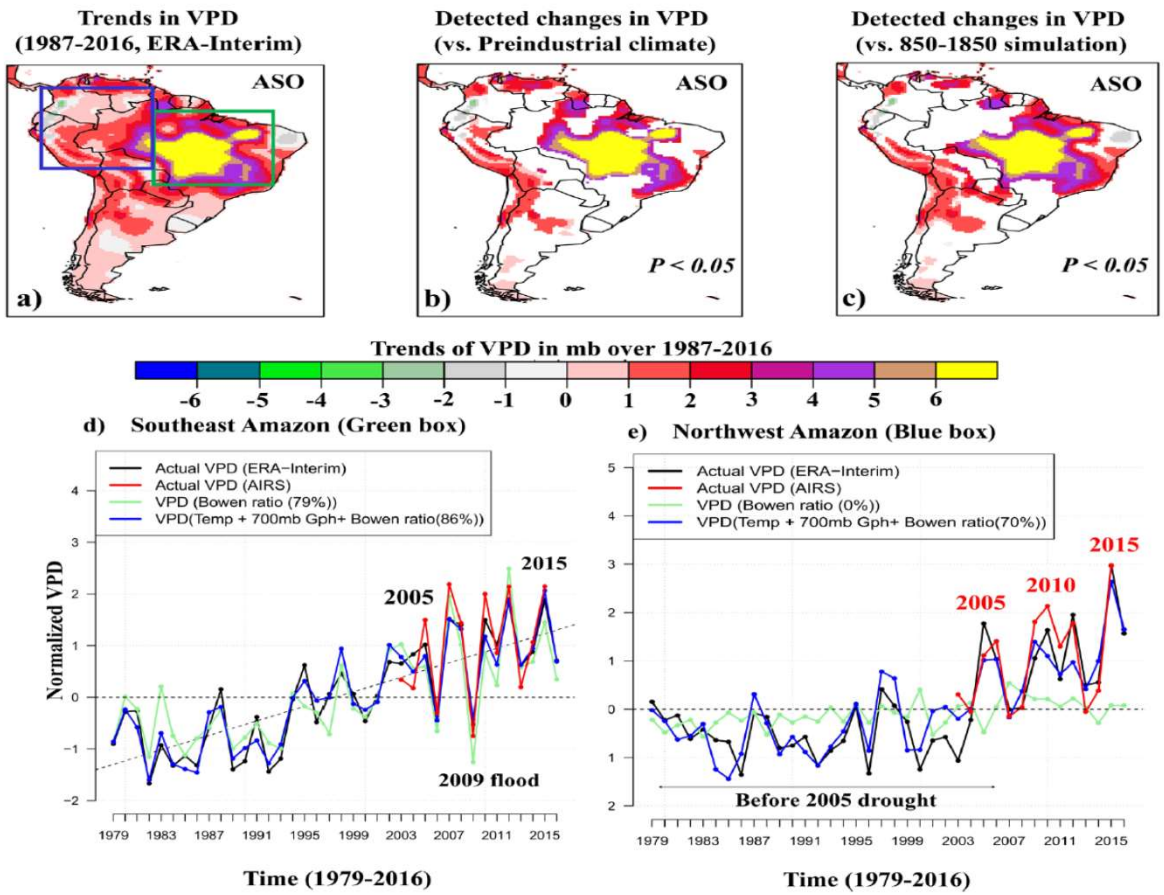
Biogeochemistry (2019) 146:1–16
https://doi.org/10.1007/s10533-019-00605-1

Check for updates

Climate change may alter mercury fluxes in northern hardwood forests

Yang Yang · Linghui Meng · Ruth D. Yanai · Mario Montesdeoca · Pamela H. Templer · Heidi Asbjornsen · Lindsey E. Rustad · Charles T. Driscoll

Mercury emissions and Climate Changes in the Amazonian forest



Human activities (increasing GHG concentrations, changes in land uses) are drying out the Amazon, leaving the ecosystem more vulnerable to fire and extreme drought

Barkhordarian et al. (2019) - "A recent systematic increase in Vapor Pressure Deficit over Tropical South America" – Nature Scientific Report, 9.

CONCLUSIONS

- The Amazon forest is very efficient in removing atmospheric mercury and forest fires could be responsible for large Hg emissions
- The Amazon rainforest significantly contributed to the Global Mercury Cycle
- Datasets are still to limited for the region, which generates large uncertainties
  - Too few data on atmospheric Hg concentrations
  - Only 2 data on Hg concentration in wet deposition
  - No data are available for other types of forest in the Amazon
- Many processes have never been studied in this ecosystem (e.g. atmosphere-plant exchanges, biomethylation in soil)
- Impact of climate changes on the Hg cycle in the Amazon forest???


Janei

AKNOLEDGMENTS

MERCI DE VOTRE ATTENTION !

MUITO OBRIGADO !