A spatially explicit visualization of global GHGs for the AFOLU sector

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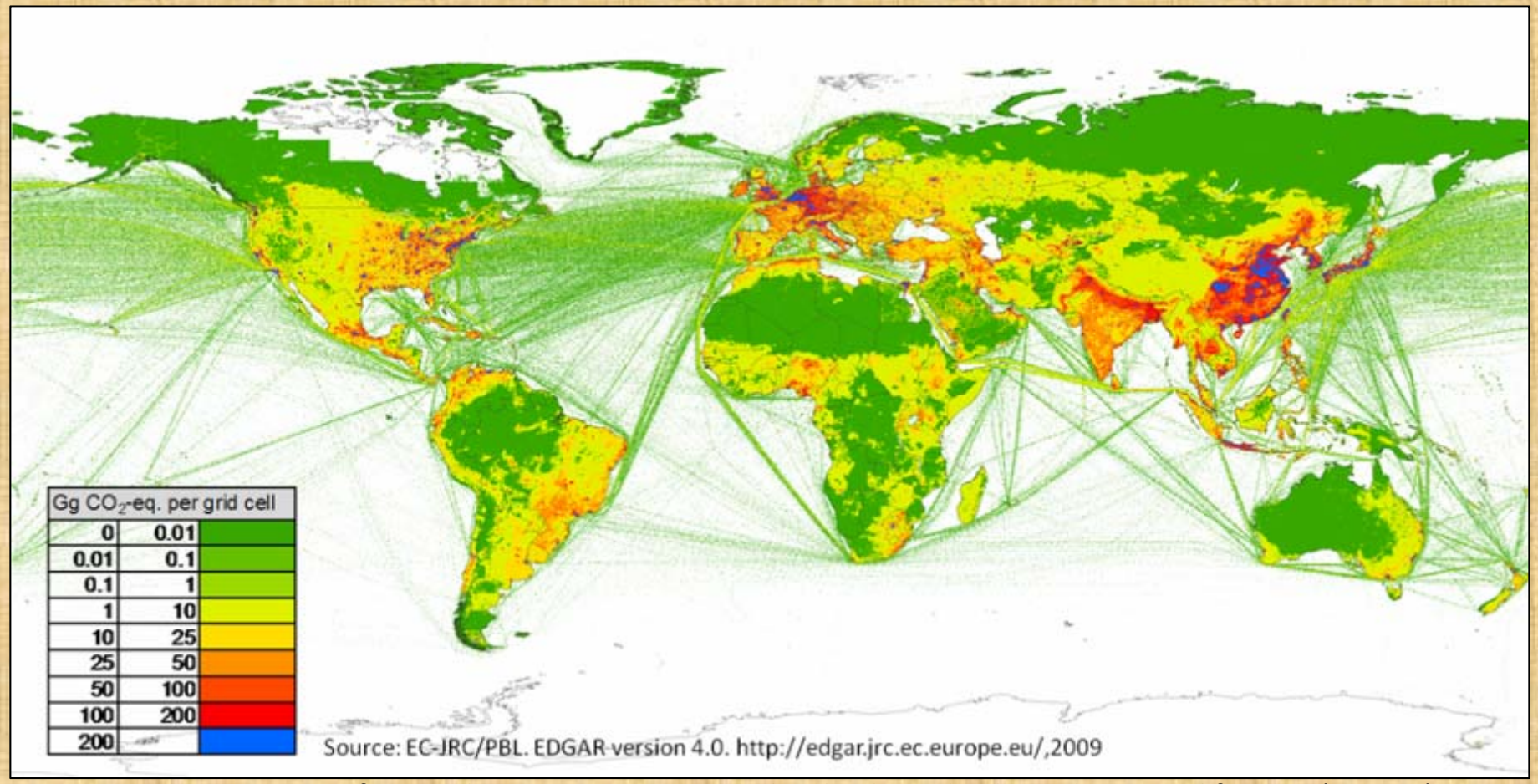

Fig 1: GHG Emissions from anthropogenic origin excluding land-use, land use change and forestry (LULUCF). Source: edgar.jrc.ec.europe.eu

Project background

Main goal: Identifying regions where mitigation of anthropogenic AFOLU GHG emissions might be most promising in terms of **reduction of gross GHG fluxes**, reductions of GHG trends, maximized returns on mitigation investments.

CGIAR-led SAMPLES Project: Focuses on Mitigation Potential from Agricultural Landscapes and aims to better understand livelihoods and climate in agricultural systems, to support pro-poor climate change mitigation options.

Collaborative initiative between University of Wageningen, CIFOR, ICRAF, and the Karlsruhe Institute of Technology (KIT)

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For quality of life

KIT
Karlsruhe Institute of Technology

World Agroforestry Centre

Project activities

1. To produce an **spatially explicit hotspot emission map for the AFOLU sector.**

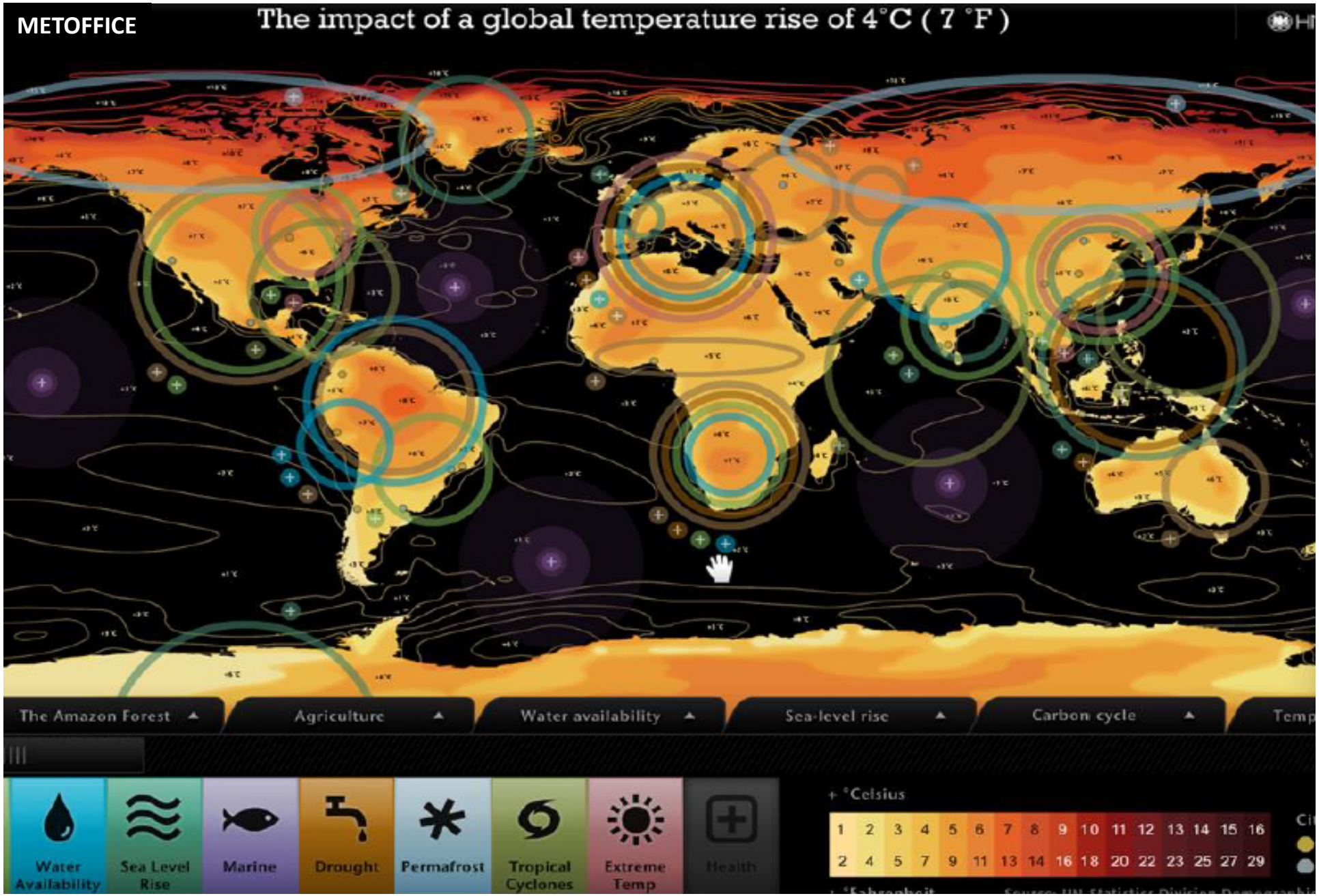
   Components: IPCC categories, pools, and selected gases (CO_2, CO, CH4, N_2O).
   Scales: Pantropical, averaged mean fluxes for the largest period available.
   Audience: Policy makers + researchers.
   Products: disaggregated maps for key sources and gases (CO2 eq) + policy brief for COP this year.

2. To **identify data caveats and data aggregation issues** and to **work towards an improved AFOLU emission map**.

3. To **assess and visualize spatially explicit emission uncertainties.**

4. To **identify plausible regional mitigation potentials and actions**.

Why are integrated AFOLU assessments important?



Identifying AFOLU emission sources, categories, and gases.

IPCC 2006 GPG summary of AFOLU activities: major contributing GHGs

IPCC categories	Activity	Management categories	CO2	CH4	CO	N2O	AGB	Soil	I	A
Forest remaining Forest	Degradation-Harvesting		X				X		y	y
	Degradation-Fuelwood		X				X		?	y
	Biomass burning (degradation fires)		X	X	X	X	X	X	y	y
Forest to Cropland	Deforestation-Harvesting	Including shifting cultivation	X			*	X	X	y	?
	Biomass burning		X	X	X	X	X	X	y	y
Forest to Grassland	Deforestation-Harvesting		X			*	X	X	y	?
	Biomass burning		X	X	X	X	X	X	y	?
Cropland remaining cropland	Long-term cultivated	Management regime: Full tillage, reduced tillage, no-till Input of organic amendment: Low input, medium input, high input with/wo manure	X			*		X	?	y
	Perennial woody crops (agroforestry)		X			*	X	X	?	?
	Fallow <20 yr							X	?	n
	Rice cultivation[1]	Irrigated, Rain fed, upland Input of organic amendment		X		*		X	y	y
	Biomass burning (crop residue management)			X	X	X	X	X	y	y
Grasslands remaining Grasslands	Grasslands under different management and disturbance regimes.	Management practices: Nominally managed (not degraded); moderately degraded; severely degraded; Improved grasslands. Input of organic amendment: Medium input, high input (only for improved grasslands)	X				X	X	?	?
	Biomass burning (savanna burning)			X	X	X	X	X	y	y
Wetlands remaining wetlands	Peatlands under peat extraction (managed peatlands under any phase of peat production, Tier 1)	On-site, off-site (horticultural use) CO2 emissions due to AGB biomass clearing and soil respiration due to drainage. Includes deforestation (?). On site N2O for nutrient rich peats only CH4 emissions only > Tier 1 (drained peats)	X			X	X	X	y	?
	Peat biomass burning		X	X	X	X		X	y	y
Wetlands to Cropland	Peatlands converted to agriculture		X			X		X	y	?
	Peat biomass burning		X	X	X	X		X	y	y
Livestock	Enteric Fermentation	Rumiants, non-rumiants,monogastric		X					y	y
	Manure management	Management regime (liquid, solid)		X		X			y	y
Managed soils (CL, FL, GL)	N2O Managed soils emissions	Human induced net N additions: Organic and synthetic fertilisers; manure deposition; crop residues; sewage sludge. Mineralization of soil N: drainage; management of organic soils; Cultivation/land use change of mineral soils (FL, GL to CL)				X		X	y	y
	CO2 emissions from amendments (lime, urea)		X					X	?	?

Identify key global source categories for the different AFOLU sectors

Major contributors of GHG emissions from the AFOLU sector AR5-WGIII

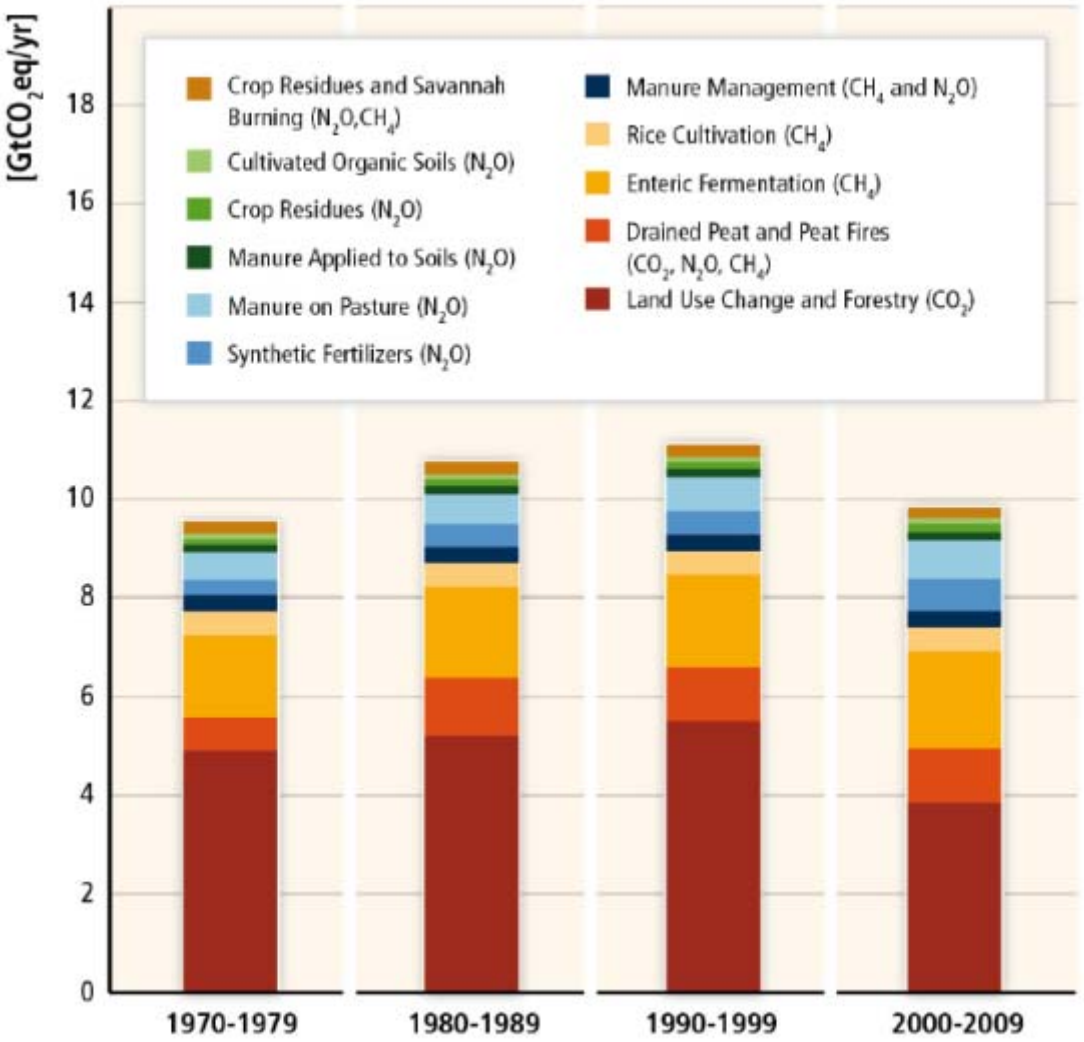


Figure 11.2. AFOLU emissions and subcategories for the last four decades.

AFOLU

24% emissions 2010
50% agriculture
50% forestry

Sources

Agriculture
FAOSTAT (2013)

FOLU
Houghton et al., (2012)

Drained peat and peat fires
JRC/PBL (2012)
Hooijer et al. (2010)
van der Werf et al. (2006)
FAOSTAT 2013

Agricultural contribution: The agricultural sector is the largest contributor of global anthropogenic **non-CO2 GHGs** accounting for 10-12% of the global anthropogenic emissions in 2010.

IPCC categories	Activity	Management categories	CO2	CH4	CO	N2O	AGB	Soil	I	A
Forest remaining Forest	Degradation-Harvesting		X				X		y	y
	Degradation-Fuelwood		X				X		?	y
	Biomass burning (degradation fires)		X	X	X	X	X	X	y	y
Forest to Cropland	Deforestation-Harvesting	Including shifting cultivation						X	y	?
	Biomass burning							X	y	y
Forest to Grassland	Deforestation-Harvesting							X	y	?
	Biomass burning							X	y	?
Crop	g-term cultivated	Management regime: Full tillage, reduced tillage	X			*		X	?	y
	nial woody crops estry)		X			*	X	X	?	?
	20 yr	Input of organic amendment: low input, medium input, high input with/wo manure						X	?	n
	e cultivation[1]	Irrigated, Rain fed, upland Input of organic amendment		X				X	y	y
	Biomass burning (crop residue management)			X	X	X	X	X	y	y
remaining slands	Grasslands under different management and disturbance regimes.	Management practices: Nominally managed (not degraded); moderately degraded; severely degraded; Improved grasslands. Input of organic amendment: Medium input, high input (only for improved grasslands)	X				X	X	?	?
	Biomass burning (savanna burning)			X	X	X	X	X	y	y
remaining nds	Peatlands under peat extraction (managed peatlands under any phase of peat production, Tier 1)	On-site, off-site (horticultural use) CO2 emissions due to AGB biomass clearing and soil respiration due to drainage. Includes deforestation (?). On site N2O for nutrient rich peats only CH4 emissions only > Tier 1 (drained peats)	X			X	X	X	y	?
	Peat biomass burning		X	X	X	X		X	y	y
Wetlands t nd	Peatlands converted to agriculture		X			X		X	y	?
	Peat biomass burning		X	X	X	X		X	y	y
Livestock	Enteric Fermentation	Rumiants, non-rumiants,monogastric		X					y	y
	Manure management	agement regime (liquid, solid)		X		X			y	y
Managed soils (CL, FL, GL)	N2O Managed soils emissions	Hu duced net N additions: Organic and synthetic fertilise e deposition; crop residues; sewage sludge. Mineralization age; management of organic soils; Cultivation/la f mineral soils (FL, GL to CL)				X		X	y	y
	O2 emissions from amendments me, urea)							X	?	?

Enteric fermentation + agricultural soils (70% of agricultural emissions)

Paddy rice (9-11%) emissions

Manure management (7-8%)

Biomass burning (6-12%)

FOLU contribution: The FOLU sector mainly contributes to global anthropogenic **CO2 GHGs** accounting for 12% of the global anthropogenic emissions in 2000-2009. The sector is a net sink

Deforestation and degradation (most of FOLU emissions)

IPCC categories	Activity	M	CO2	CH4	CO	N2O	AGB	Soil	I	A
Forest remaining Forest	Degradation-Harvesting		X				X		y	y
	Degradation-Fuelwood						X		?	y
	Biomass burning (degradation fires)				X	X	X	X	y	y
Forest to Cropland	Deforestation-Harvesting	Including shifting cultiv					X	X	y	?
	Biomass burning							X	y	y
Forest to Grassland	Deforestation-Harvesting							X	y	?
	Biomass burning							X	y	?
Cropland remaining cropland	Long-term cultivated	Management regime: Full tillage, reduced tillage, no-till Input of organic amendment: Low input, medium input, high input with/wo manure						X	?	y
	Perennial woody crops (agroforestry)		X					X	?	?
	Fallow <20 yr							X	?	n
	Rice cultivation[1]	Irrigated, Rain fed, upland Input of organic amendment		X		*		X	y	y
	Biomass burning (crop residue management)			X	X	X	X	X	y	y
Grasslands remaining Grasslands	Grasslands under different management and disturbance regimes.	Management practices: Nominally managed (not degraded); moderately degraded; severely degraded; Improved grasslands. Input of organic amendment: Medium input, high input (only for improved grasslands)	X				X	X	?	?
	Biomass burning (savanna burning)			X	X	X	X	X	y	y
Wetlands remaining wetlands	Peatlands under peat extraction (managed peatlands under any phase of peat production, Tier 1)	On-site, off-site (horticultural use) CO2 emissions due to AGB biomass clearing and soil respiration due to drainage. Includes deforestation (?). On site N2O for nutrient rich peats only CH4 emissions only > Tier 1 (drained peats)	X			X	X	X	y	?
	Peat biomass burning		X	X	X	X		X	y	y
Wetlands to Cropland	Peatlands converted to agriculture		X			X		X	y	?
	Peat biomass burning		X	X	X	X		X	y	y
Livestock	Enteric Fermentation	Rumiants, non-rumiants,monogastric		X					y	y
	Manure management	Management regime (liquid, solid)		X		X			y	y
Managed soils (CL, FL, GL)	N2O Managed soils emissions	Human induced net N additions: Organic and synthetic fertilisers; manure deposition; crop residues; sewage sludge. Mineralization of soil N: drainage; management of organic soils; Cultivation/land use change of mineral soils (FL, GL to CL)				X		X	y	y
	CO2 emissions from amendments (lime, urea)		X					X	?	?

DATABASES ON DISAGGREGATED AFOLU EMISSIONS ON MANAGED LAND AT A GLOBAL SCALE

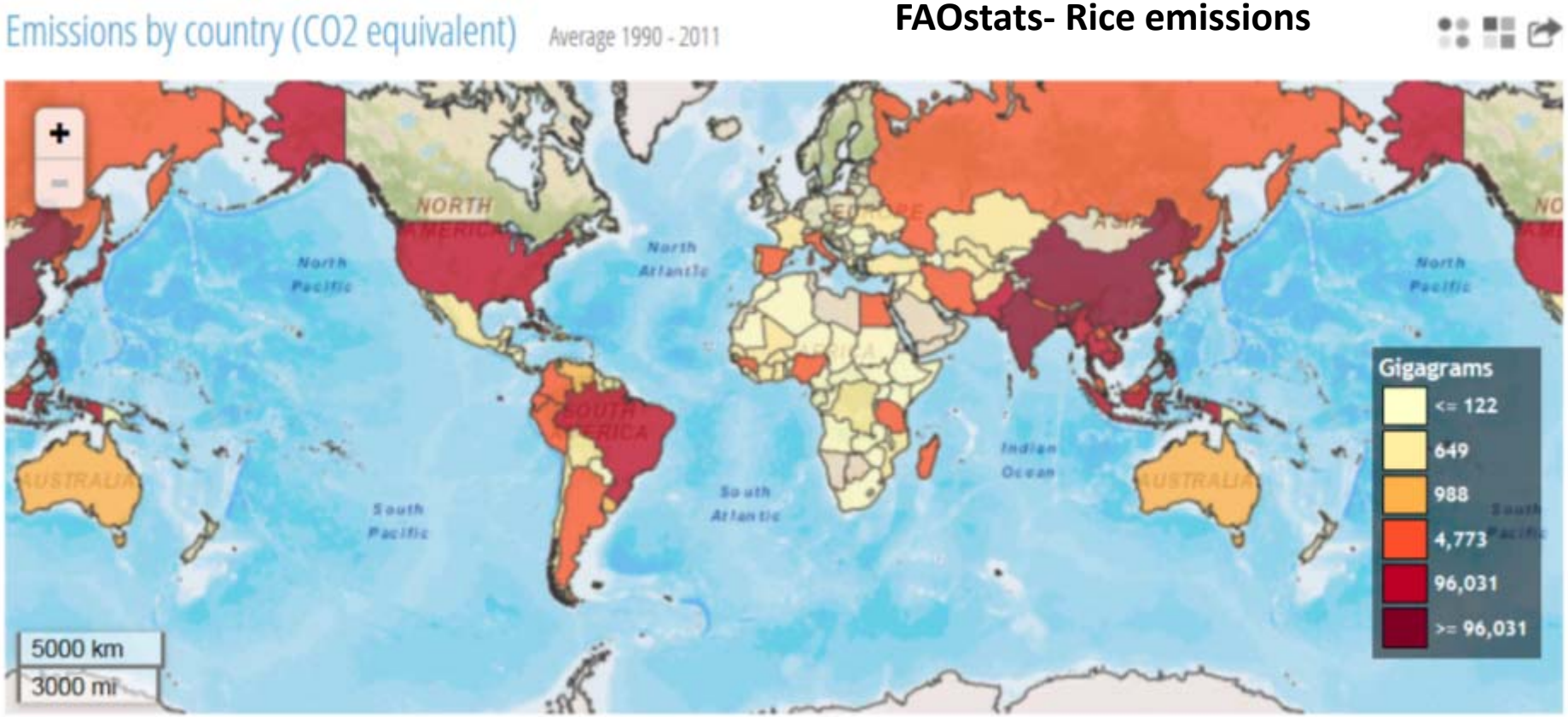
IPCC categories	Activity	CO2	CH4	CO	N2O	AGB	Soil	I	Source	Available-Notes	Available
Forest remaining Forest	Degradation-Harvesting/logging	X				X		Y	1. Ben Poulter-GEOCARBON 2. Hurtt et al. (2006), (2011) 3. Pearson et al. (2014) 4. Hansen et al. (2013)	1. Yes, with GEOCARBON data sharing restrictions. 2. No, Poulter is based in Hurtt. Could be requested. 3. Yes, country statistics available from text. 4. Yes, publicly available	Y
	Degradation-Fuelwood	X				X		?	1. Ben Poulter-GEOCARBON	1. Yes, with GEOCARBON data sharing restrictions.	Y
	Biomass burning (degradation fires)	X	X	X	X	X	X	Y	1.Van der Werf et al. (2010)	1. Degradation fires.	Y
Forest to Cropland	Deforestation-Harvesting/logging	X			*	X	X	Y	1. Harris et al. (2012) 2. Hansen et al. (2013) 3. Baccini et al. (2012) 4. Don et al. (2011)	1. Yes, within Martin group (emissions). 2. Yes, publicly available (forest cover fraction). 3. Yes, within Martin group (emissions) 4. Statistics from meta-analyses in tropics.	Y
	Biomass burning	X	X	X	X	X	X	Y	1.Van der Werf et al. (2010)	1. Deforestation fire, probably not disaggregated.	N (partially)
Forest to Grassland	Deforestation-Harvesting/logging	X			*	X	X	Y	1. Ben Poulter-GEOCARBON 2. Don et al. (2011)	1. Data not disaggregated into final land uses. 2. Statistics from meta-analyses in tropics.	1.N (partially) 2. Y
	Biomass burning	X	X	X	X	X	X	Y	1.Van der Werf et al. (2010)	1. Deforestation fire, probably not disaggregated.	N (partially)
Cropland remaining Cropland	Long-term cultivated	X			*		X	Y?	1. Ogle for EPA report (2014) for C changes in soils.	1. Available in June 2014. Yes, statistics from meta-analysis	Y
	Perennial woody crops (agroforestry)	X			*	X	X	N?		Missing soil contribution and woody AGB to CO2 emissions agroforestry systems. Important?	N
	Fallow <20 yr						X	N?		Missing soil contribution to CO2 emissions. Since they are temporally unmanaged they probably are sinks	N
	Rice cultivation		X		*		X	Y	1. Li for EPA report (2014) 2. Havlik et al. (2014)	1. Requested 12/5/2014 2. GLOBIOM modelling (data not requested yet)	P
	Biomass burning (crop residue management)		X	X	X	X	X	Y	1.Van der Werf et al. (2010)	1. Agricultural waste burning.	Y
Wetlands remaining Wetlands	Peatlands under peat extraction (managed peatlands under any phase of peat production, Tier 1)	X			X	X	X	Y		Data needs to focus on C changes in soils and natural N20 emissions. CH4 is not considered a human induced emission in managed wetlands and not accounted for under the IPCC.	N
	Peat biomass burning	X	X	X	X		X	Y	1.Van der Werf et al. (2010)	1. Tropical peat fires, probably not disaggregated.	N (partially)
Wetlands to Cropland	Peatlands converted to agriculture	X			X		X	Y		Drained peatlands	N
	Peat biomass burning	X	X	X	X		X	Y	1.Van der Werf et al. (2010)	1. Tropical peat fires, probably not disaggregated.	N (partially)

Collect and add available disaggregated global AFOLU datasets (spatially explicit) for key sectors and sub-categories and GHGs.

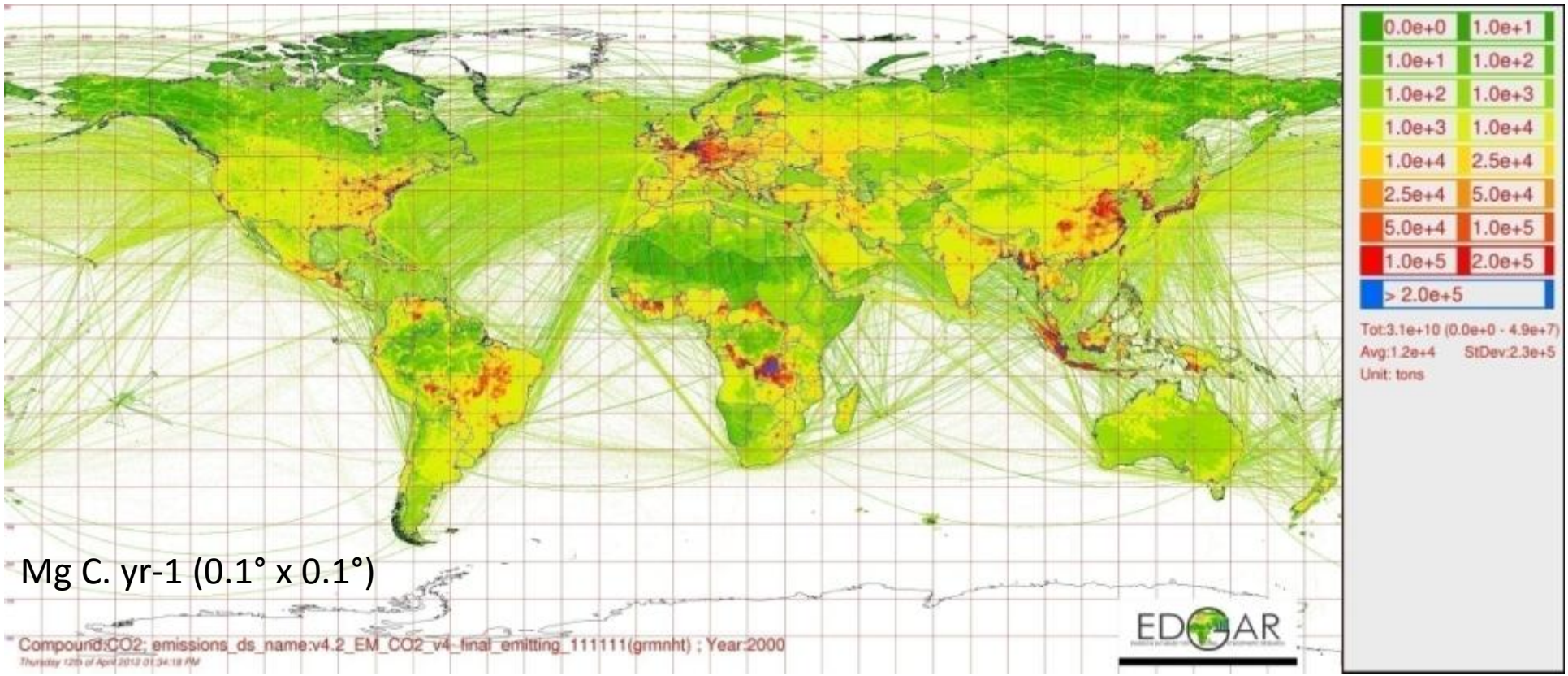
IPCC Tier 1- FAOSTATS- Agricultural total emissions

FAOstats-Agricultural soil emissions

FAOstats- Rice emissions



EDGAR Database: Global total CO2e emissions (Mg C. yr^{-1}) (0.1° x 0.1°), excluding land use change and forestry (IPCC Tier 1/2)



Source: European Commission, Joint Research Centre (JRC)/PBL Netherlands Environmental Assessment Agency. Emission Database for Global Atmospheric Research (EDGAR), version 4.2. http://edgar.jrc.ec.europe.eu, 2011

Enteric fermentation and soil management: CH_4 and N_2O emissions Herrero et al. (2013)

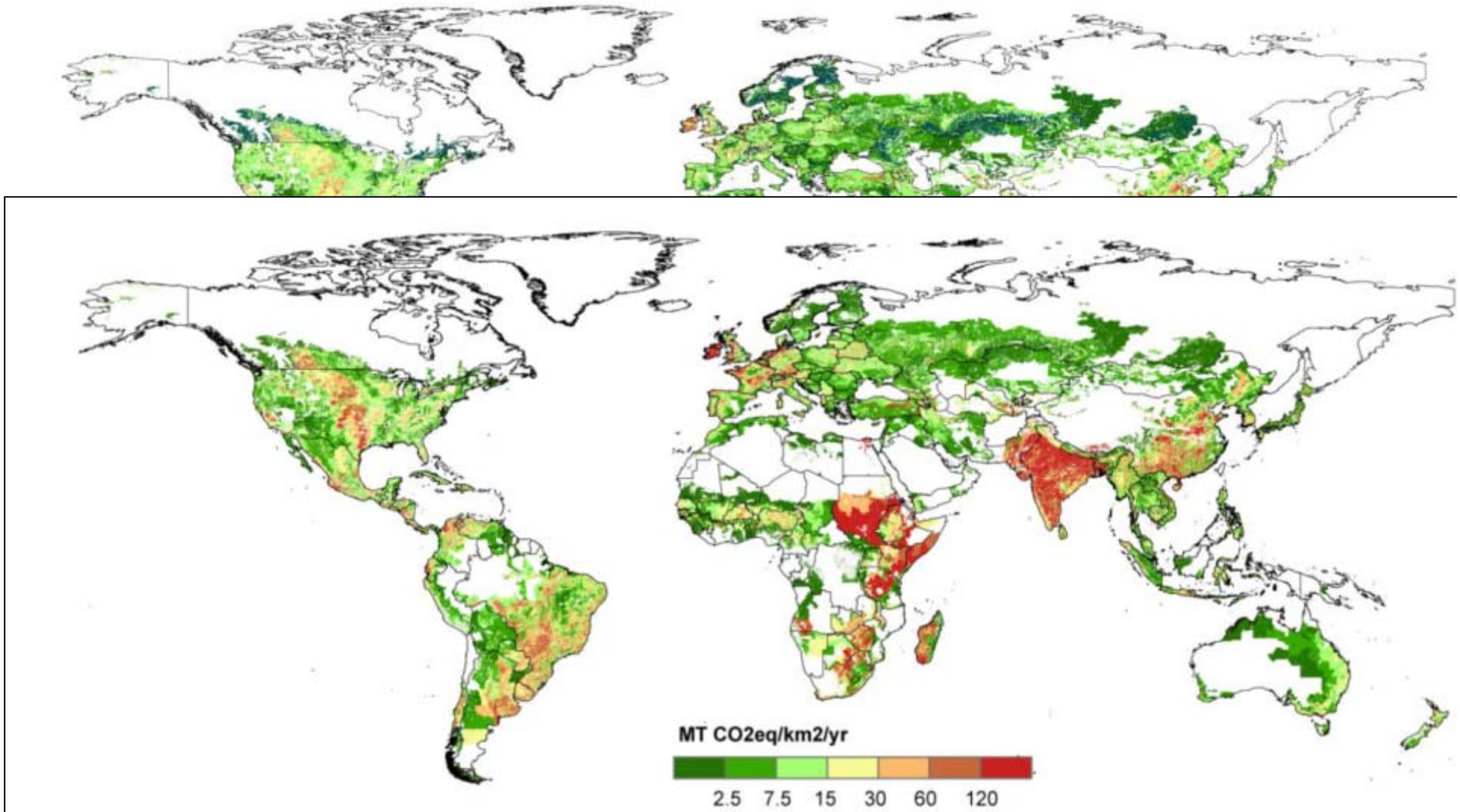
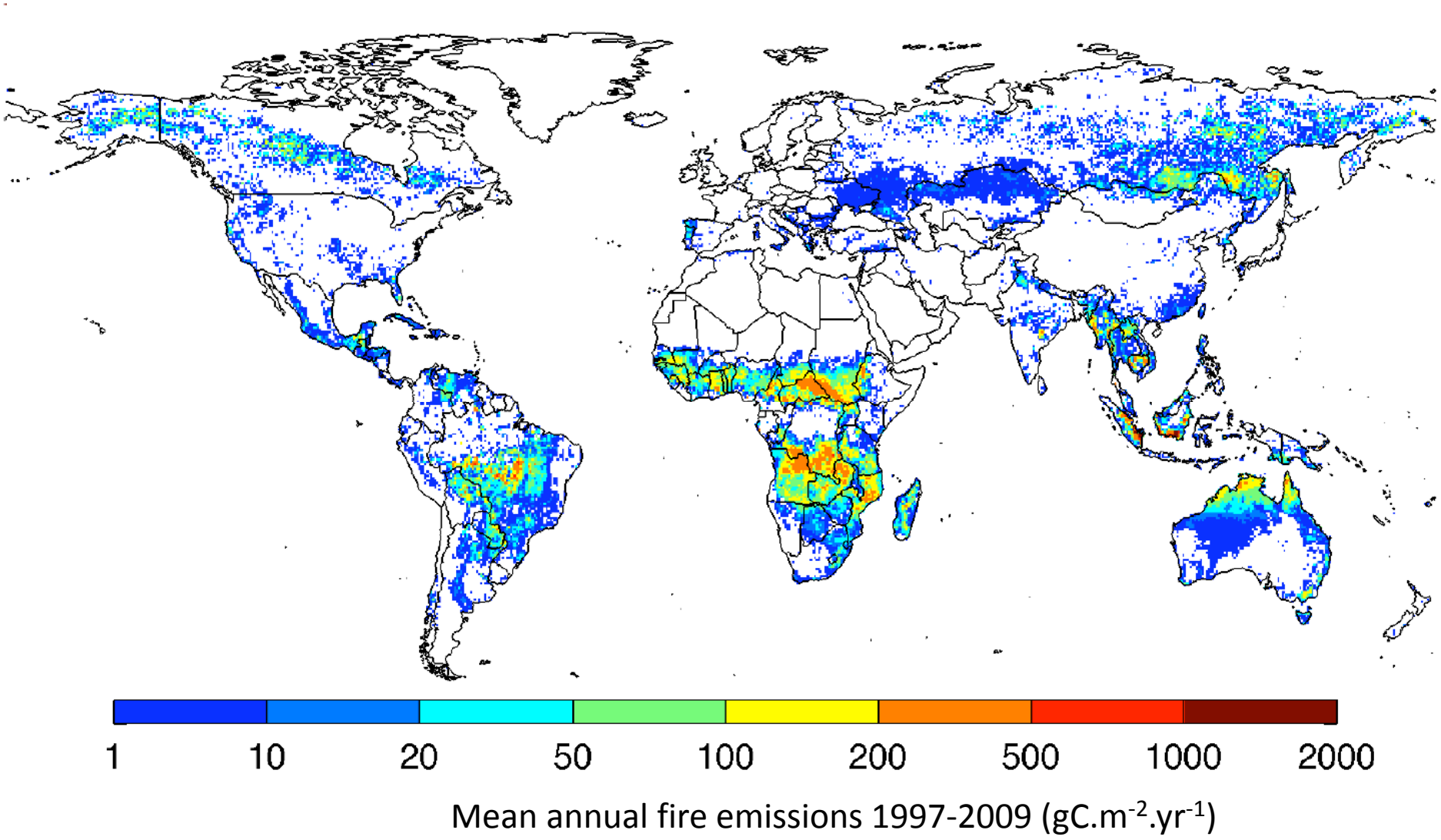
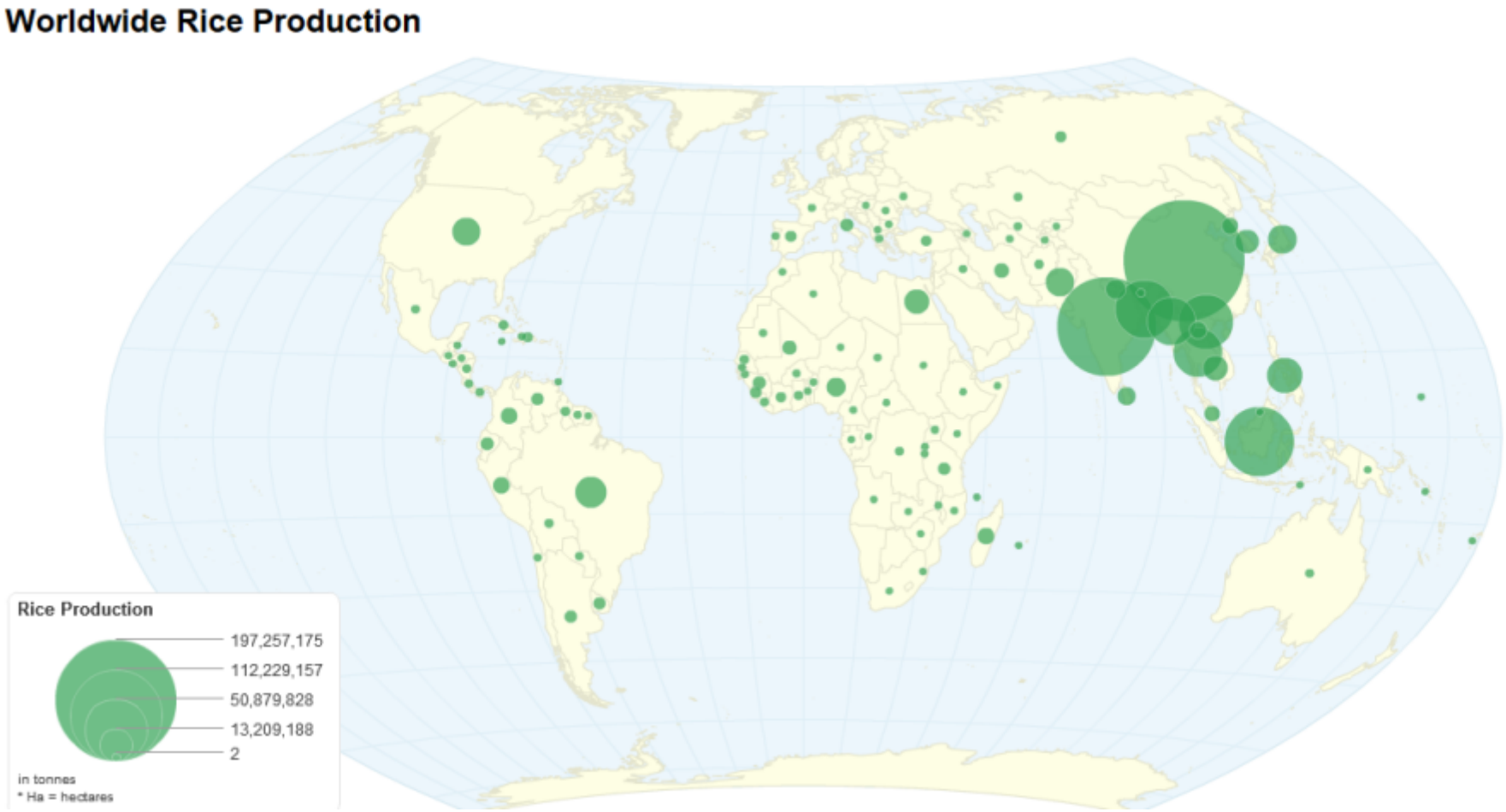


Figure S 41. Methane emission associated with bovine meat production in the year 2000

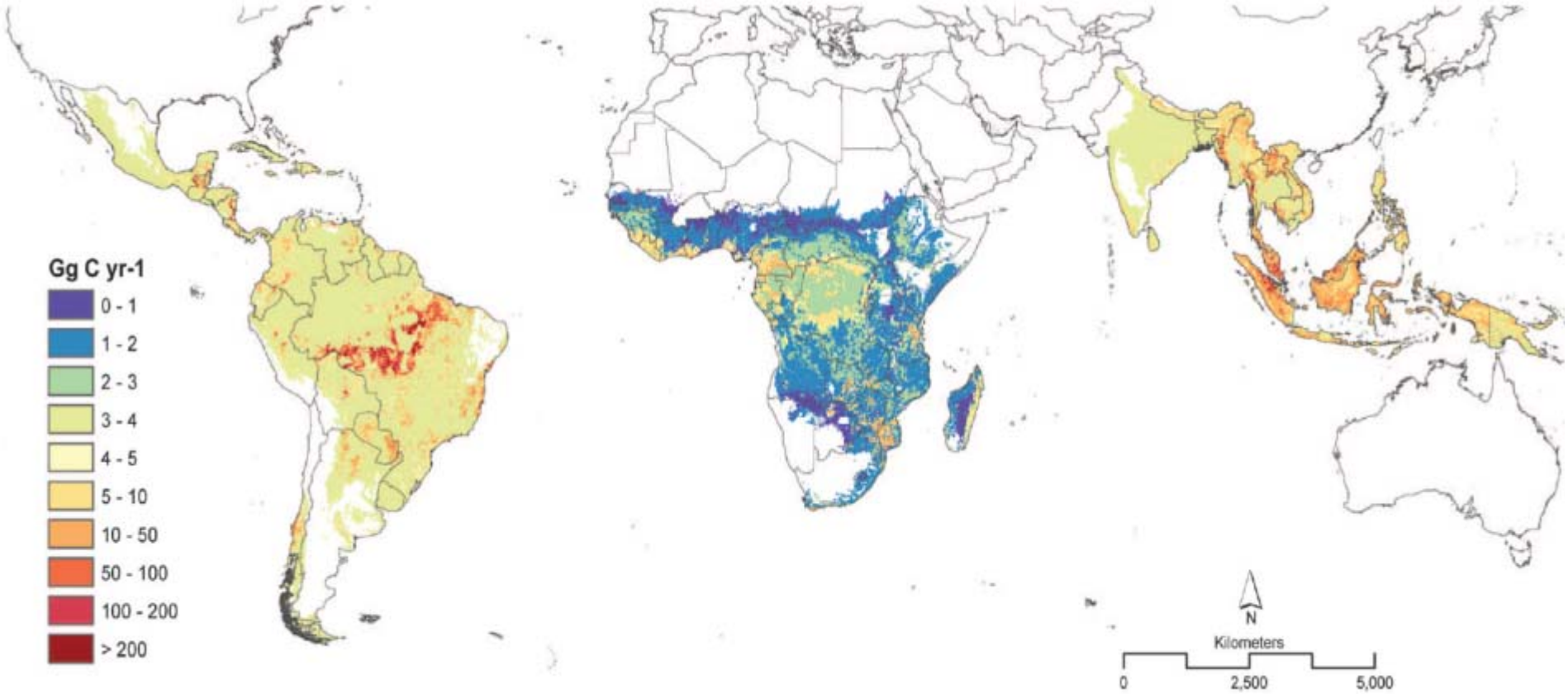
Biomass burning emissions: CO_2eq from global fires Van der Werf et al. (2010)



Paddy Rice: global CH_4 emissions (EPA report, Changsheng Li)

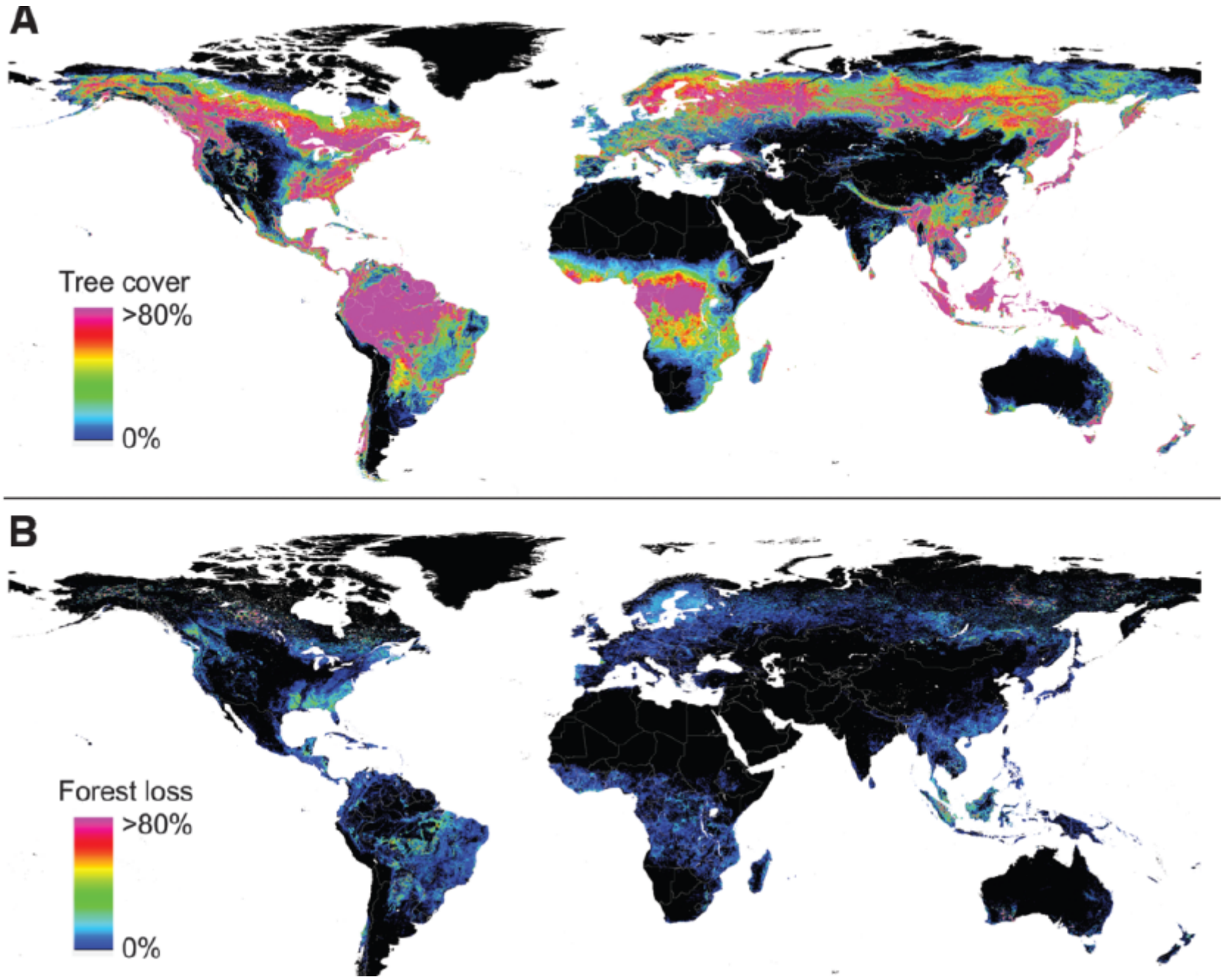


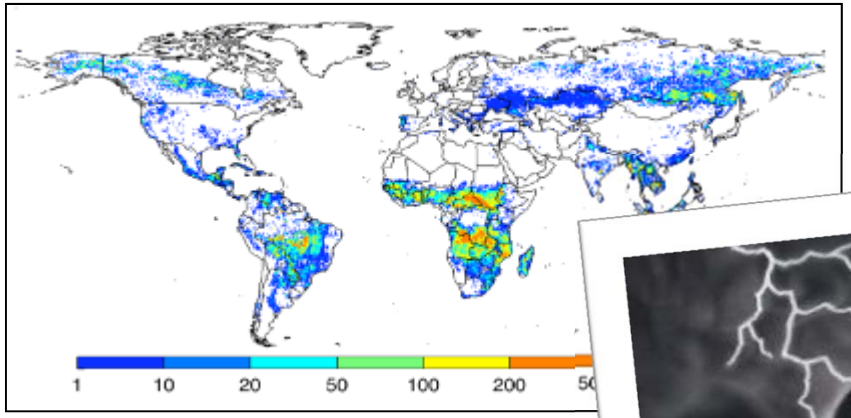
Global deforestation emissions: CO_2eq Harris et al. (2012)

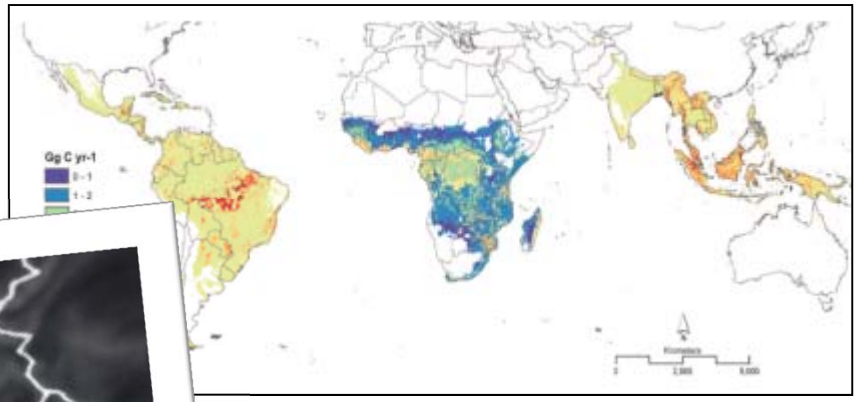


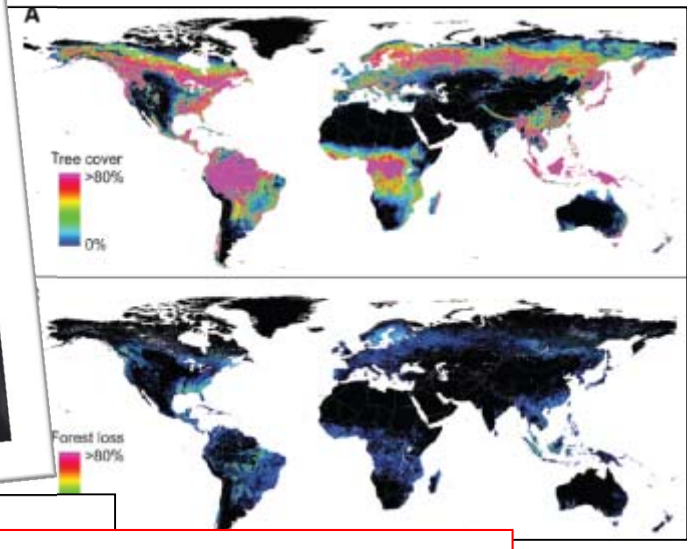
Mean gross carbon emissions ($GgC.km^{-1}.yr^{-1}$)

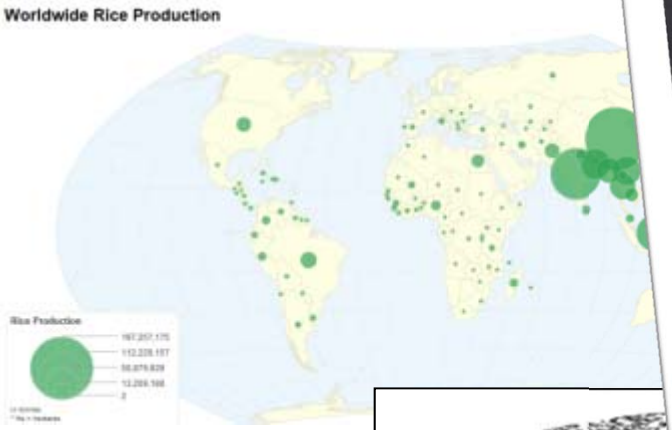
Global degradation emissions: CO_2eq Hansen et al. (2014)

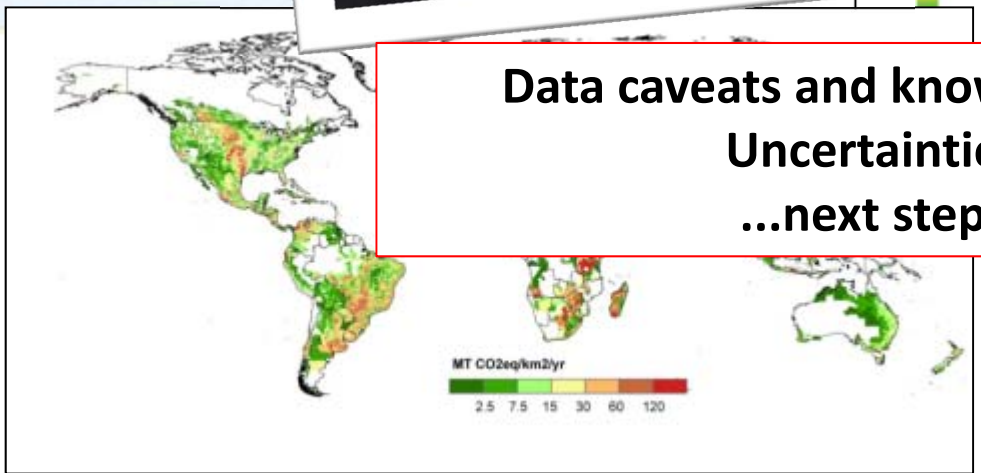












Data caveats and knowledge gaps
Uncertainties
...next steps

Using IPCC 2006 AFOLU GPG

Benefits of using the IPCC 2006-GPG

- Coherent conceptual framework to quickly identify key sources of emissions for the land sector, and guided search for available datasets.

- Useful framework to focus on human-derived emissions only (e.g. CH4 of wetlands not accounted for)
  - Human activities/management vs ecosystem approaches.
  - Guided effort towards mitigation initiatives.

- An improved understanding of drivers of emissions and interactions in different land sectors (e.g. agriculture-forestry relation).

- Useful to contrast data reported at different Tiers and assessing emission uncertainties.

Difficulties using the IPCC 2006-GPG

- No data difficulties------plenty of data for Tier 1 reporting (but uncertainties are large).

- Some land uses are regionally focused in the IPCC 2006 GPG, and difficult to extrapolate to pantropical analyses (e.g. wetlands (definition, human activities in managed wetlands (hortocultural activities?, biofuel consumption?, etc)

Difficulties with AFOLU in general

- It is not always possible to separate anthropogenic from natural GHG fluxes in the land sector.

- The input data needed to estimate AFOLU GHG emissions globally and regionally are highly uncertain, and often based on country level statistics or remote sensing information (spatio-temporal resolution, definition, methodological issues, data quality, data access, data consistency, etc).

QUESTIONS?