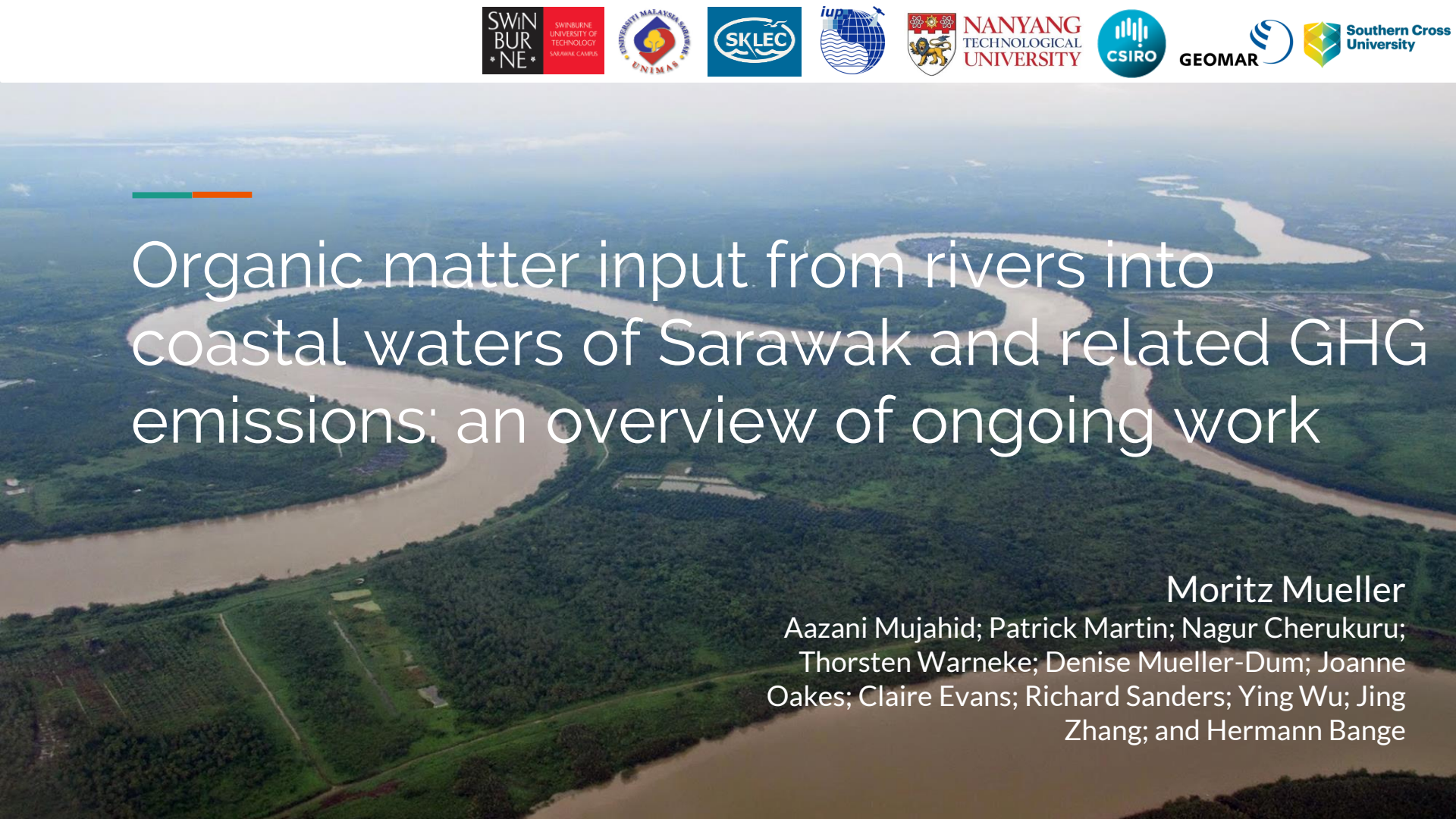


Organic matter input from rivers into coastal waters of Sarawak and related GHG emissions: an overview of ongoing work

Moritz Mueller
Aazani Mujahid; Patrick Martin; Nagur Cherukuru; Thorsten Warneke; Denise Mueller-Dum; Joanne Oakes; Claire Evans; Richard Sanders; Ying Wu; Jing Zhang; and Hermann Bange

TALK OUTLINE

- **Introduction**
  - The role of rivers and estuaries in the global carbon cycle
- **Carbon dioxide**
  - Southeast Asia as a hotspot of aquatic CO_2 fluxes
- **Methane and Nitrous Oxide**
- **Transfer of tDOC** to ocean and its processing
- Conclusions (and advertisement)

Introduction

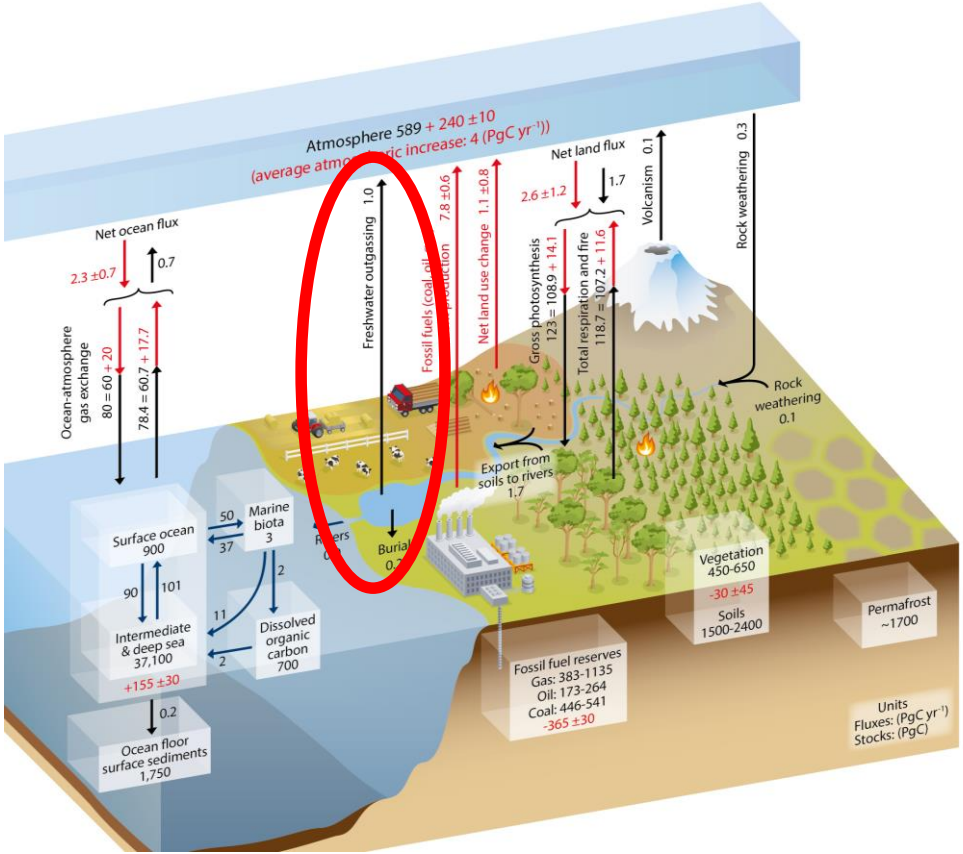
- Southeast Asian peat soils are a globally important carbon pool
- 3% of the land area, but 1/3 of the global soil carbon
- Tropical peatlands are the most efficient terrestrial carbon stores [Dommain et al., 2011]

- Undergoing severe disturbance due to anthropogenic activities, i.e. oil palm.
- Increased carbon loss through direct emissions to the atmosphere and via riverine export.

Distribution of peatlands along the coastlines of Sumatra and Borneo as of FAO (2009). Taken from Müller et al. 2015

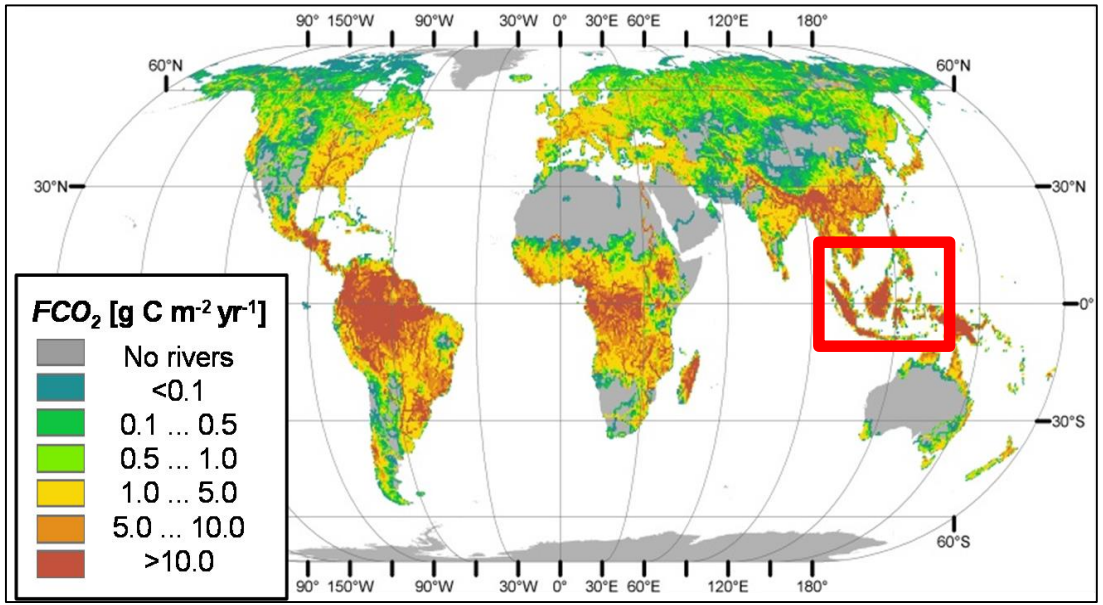
Rivers and C cycle

- Cole et al. 2007: **0.3** PgC yr^{-1}
- Aufdenkampe et al. 2011: **0.6** PgC yr^{-1}
- Raymond et al. 2013: **1.8** PgC yr^{-1}
- Lauerwald et al. 2015: **0.7** PgC yr^{-1}



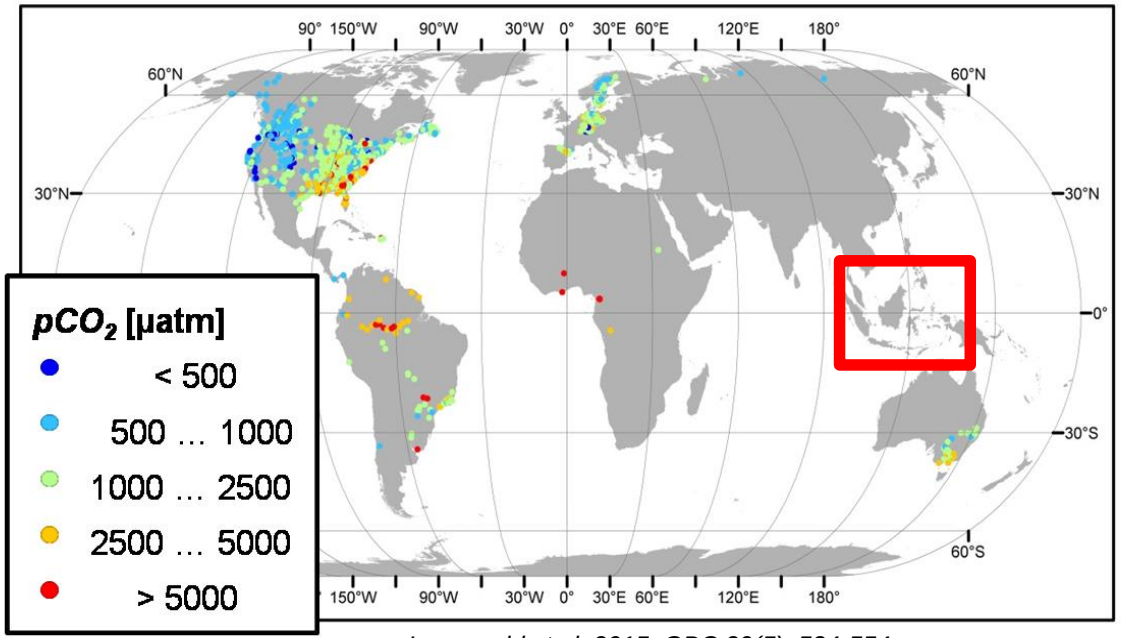
Ciais et al., 2013. IPCC AR5

RIVERS AND GLOBAL CO_2 FLUXES



Lauerwald et al. 2015, GBC 29(5), 534-554

DATA BASIS FOR GLOBAL CO_2 FLUXES



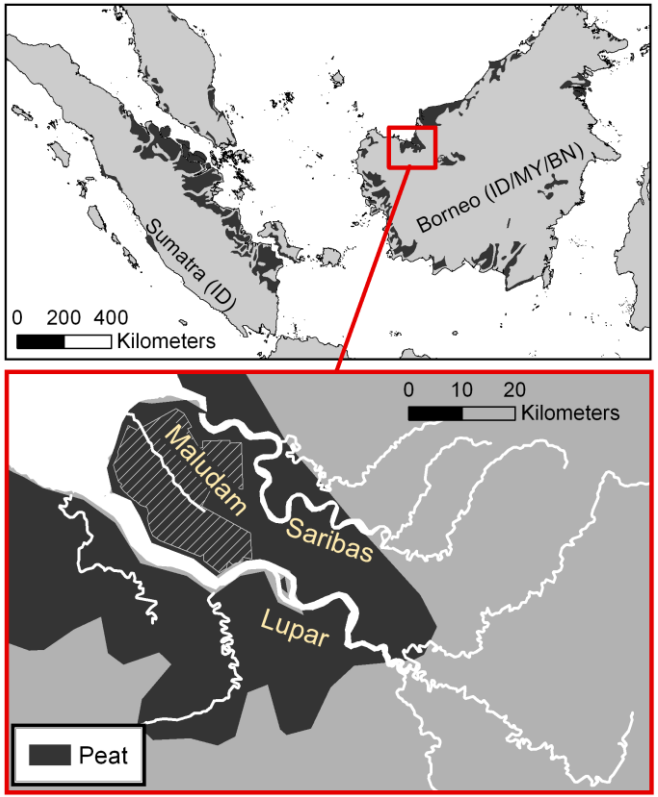
Lauerwald et al. 2015, GBC 29(5), 534-554

Information on tropical river systems is lacking.

CO_2 emissions from tropical peat-draining rivers are poorly quantified and hence their **response to anthropogenic change is unclear.**

Baseline studies

- **Aim:** Quantification of CO_2 outgassing from an undisturbed tropical peat-draining river
- Maludam river; National Park
  - Catchment covered by protected peat swamp forest, without any influence from tributaries
- Lupar & Saribas rivers and estuaries



DOC, TOC, and CO2 (outgassing)

Biogeosciences, 13, 691–705, 2016
www.biogeosciences.net/13/691/2016/
doi:10.5194/bg-13-691-2016

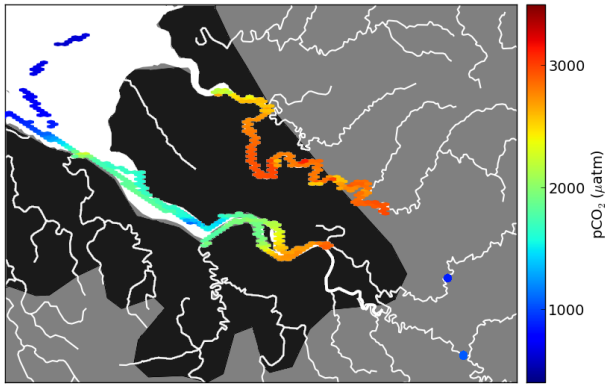
Biogeosciences

Fate of terrestrial organic carbon and associated CO_2 and CO emissions from two Southeast Asian estuaries

D. Müller[1,2], T. Warneke[1], T. Rixen[2,3], M. Müller[4], A. Mujahid[5], H. W. Bange[6], and J. Notholt[1,7]

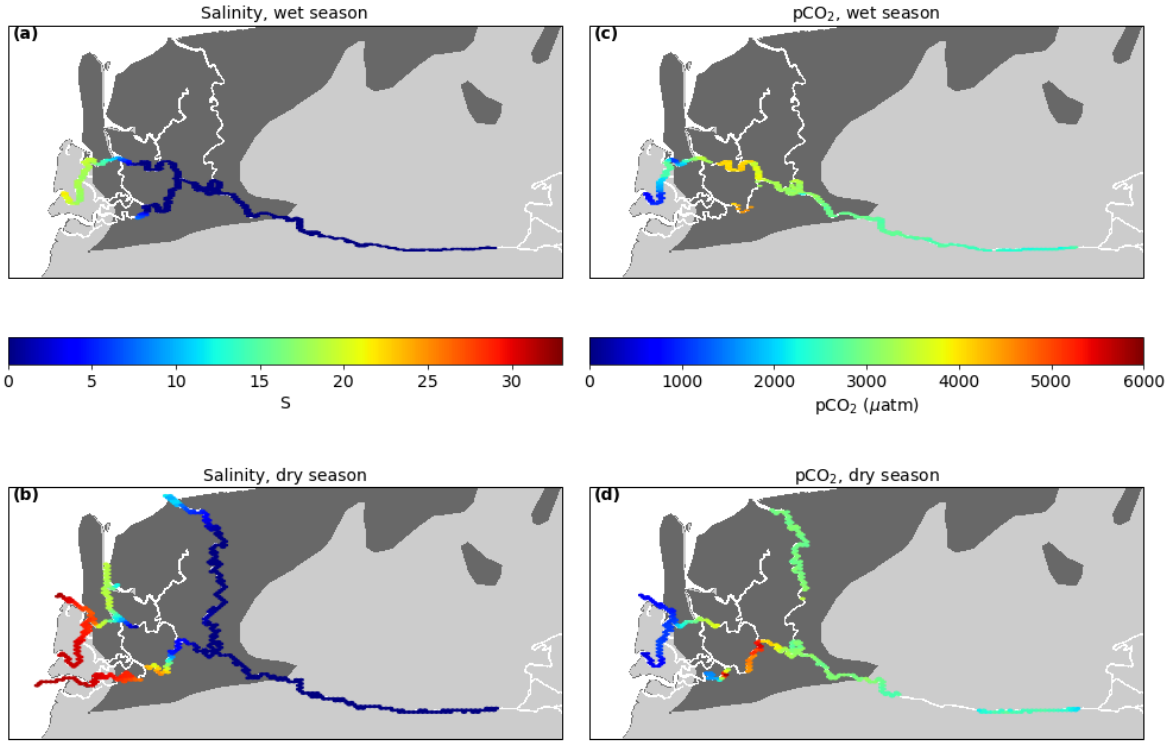
- Maludam NP: Among highest DOC concentrations recorded worldwide
- Only 26 ± 15 % of the carbon was evaded to the atmosphere as CO_2, the rest was transported downstream.

	Maludam
DOC (µmol L^{-1})	3690 ± 504
DO (%)	15 ± 3
pH	3.8 ± 0.2
pCO_2 (µatm)	8100 ± 520

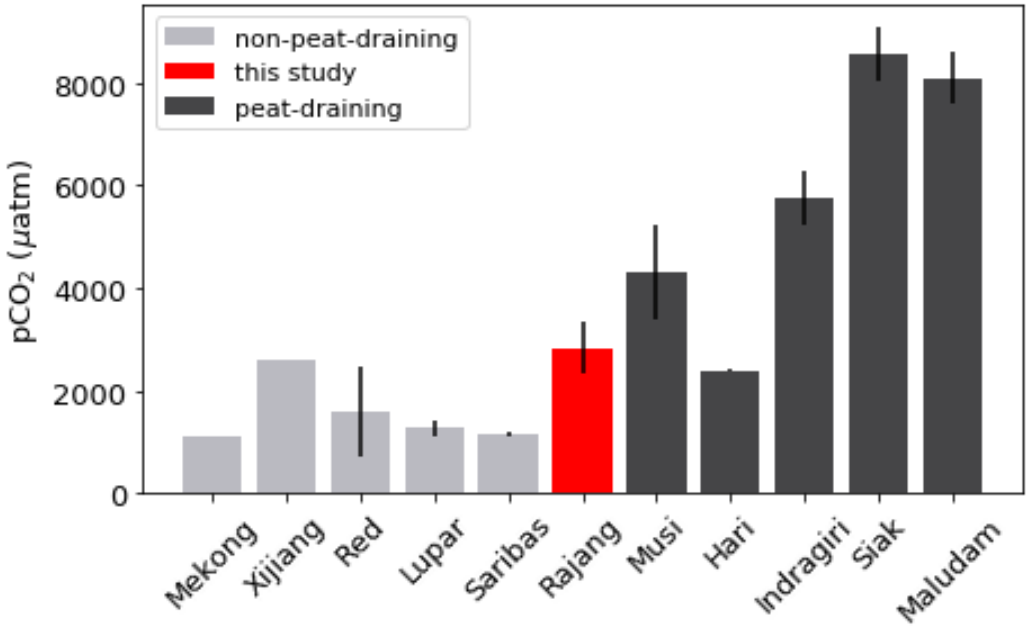


Expansion...

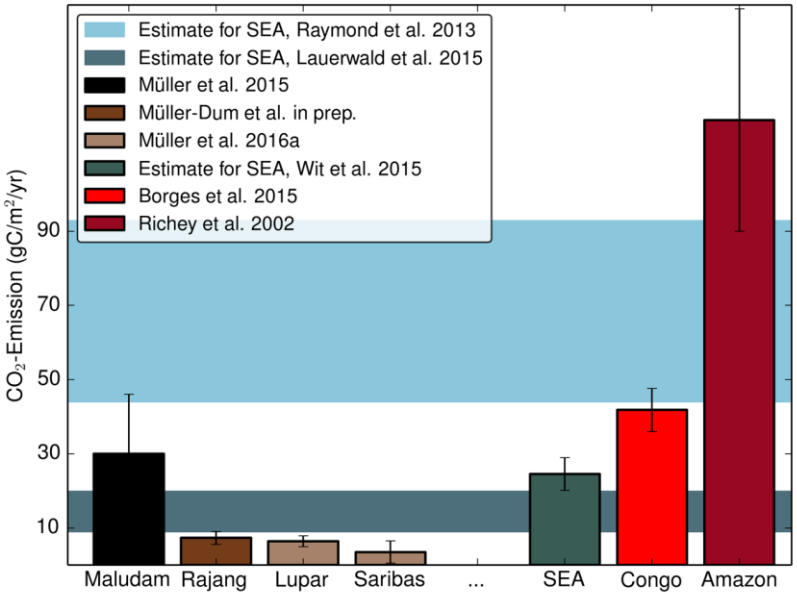
- Rajang river; longest river in Malaysia
- Carbon load and impact of peatlands on CO_2 emissions (Müller-Dum et al., in rev., 2018)
- Tidal limit is equivalent to peat limit => difficult to discern which driver is more important



Peat or No Peat



SEA not a river CO_2 hotspot



nature COMMUNICATIONS

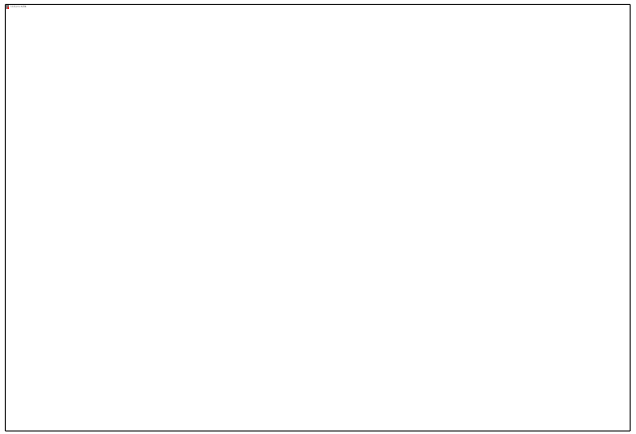
ARTICLE

Received 1 Apr 2015 | Accepted 8 Nov 2015 | Published 16 Dec 2015

DOI: 10.1038/ncomms10155 OPEN

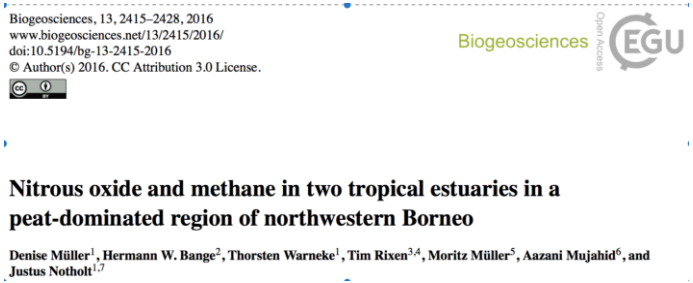
The impact of disturbed peatlands on river outgassing in Southeast Asia

Francisca Wit[1], Denise Müller[1,2], Antje Baum[1], Thorsten Warneke[2], Widodo Setiyo Pranowo[3], Moritz Müller[4] & Tim Rixen[1,5]



Distribution of peatlands along coastlines of Sumatra and Borneo (FAO, 2009).

Methane and Nitrous oxide



Biogeosciences, 13, 2415–2428, 2016
www.biogeosciences.net/13/2415/2016/
doi:10.5194/bg-13-2415-2016

Biogeosciences
Open Access
EGU

Nitrous oxide and methane in two tropical estuaries in a peat-dominated region of northwestern Borneo

Denise Müller[1], Hermann W. Bange[2], Thorsten Warneke[1], Tim Rixen[3,4], Moritz Müller[5], Aazani Mujahid[6], and Justus Notholt[1,7]

- N_2O was negatively correlated with salinity during the dry season, which suggests a riverine source.
- In contrast, N_2O concentrations during the wet season were not correlated with salinity but locally enhanced within the estuaries, implying that there were additional estuarine sources during the wet (monsoon) season.

- Wet season dominated the variability of both N2O and CH4 concentrations and subsequent emissions from tropical estuaries.
- **Changes in the Southeast Asian monsoon system will lead to changes in the N2O and CH4 emissions from these systems.**

Methane and Nitrous oxide

- Localized elevation of N_2O concentrations suggested that estuarine N2O concentrations might be impacted by local anthropogenic sources.
- N2O emissions from peat soils depend on land use and that cultivated sites generally exhibit higher N2O fluxes to the atmosphere (Hadi et al., 2000).
- **Possible that this behaviour is mirrored in the aquatic systems as well ?!?!**

- **Seasonally-resolved**
- **Disturbed vs. Undisturbed**
- **Currently calculating budgets for all rivers**

Fluxes, Budgets

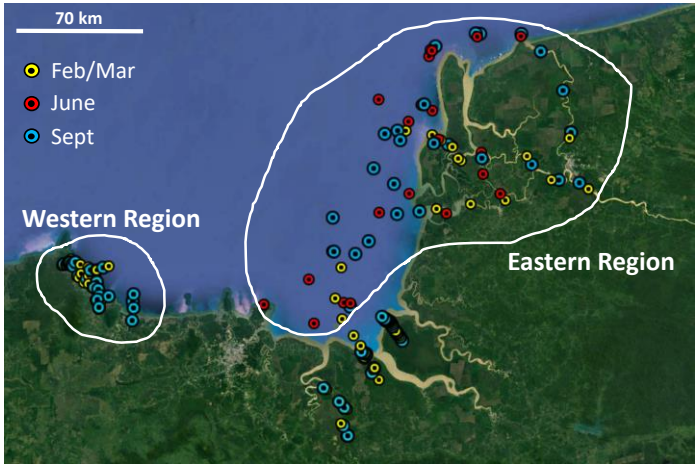
- Undisturbed rivers are possibly sinks for N_2O; whereas disturbed rivers are sources.

Rivers	Sampling Month	Average CH_4 concentration, nM	Average N_2O concentration, nM	Average saturation CH_4, %	Average saturation N_2O, %
Rajang River	Mar 17	175.58	13.99	425.45	136.57
	Sept 17	35.42	21.86	75.51	171.42
Maludam River	Mar 17	508.78	5.45	665.71	37.91
	Sept 17	*10.78	19.79	*19.23	145.66
Sebuyau River	Mar 17	471.98	5.58	1354.35	42.24
	Sept 17	20.79	19.62	32.66	144.39
Simunjan River	Mar 17	2980.42	15.19	3921.60	113.76
	Sept 17	14.66	16.58	19.57	123.91

What happens to all the tDOC?

- Fate of terrigenous DOC in ocean remains poorly understood
- **South-East Asia = 5–10% of global land–sea tDOC flux**

- Seasonally-resolved measurements of DOC concentration and chromophoric dissolved organic matter (CDOM) spectra for peatland-draining rivers and coastal waters



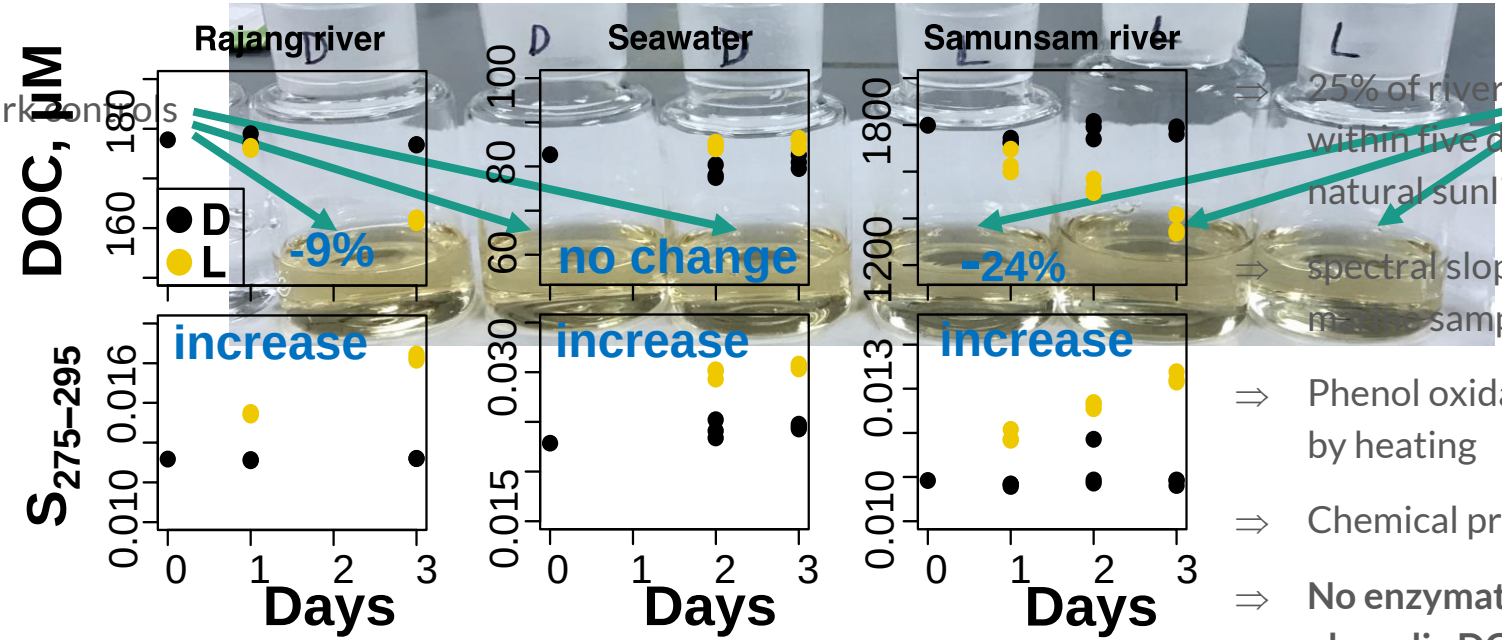
Eastern Region

- No seasonality
- Large DOC input from delta peatlands
- Increase in CDOM slope: adsorption to sediment?

Western Region

- Higher DOC in September, but more tDOC reaches sea in March
- Conservative mixing

Photo-degradation ?? Bacteria ??



Dark controls

⇒ 25% of riverine DOC lost within five days of exposure to natural sunlight

Blackwater **after sunlight exposure**

⇒ spectral slopes resembled marine samples

⇒ Phenol oxidase not impacted by heating

⇒ Chemical process

⇒ **No enzymatic break-down of phenolic DOM?**

Take home messages

- Coastal waters of Sarawak receive large inputs of terrigenous DOC; mostly conservative mixing with seawater
- Photo-labile; microbial degradation after initial photo-degradation ?? [Priming?]
- CO_2 emissions from rivers “low”
- Undisturbed rivers potential sinks for N_2O, in contrast to disturbed rivers

Many parameters more measured

1. CTD, Conductivity, DO, pH, Temp
2. Nutrients
3. PP; chl-a
4. Trace metals, Isotopes
5. Picoplankton; Phyto pigments
6. Microbes, particles and free living
7. GHG [CO2, CH4, CO, N2O]
8. POC/N, C-13, N-15
9. DOC, CDOM; DIC; d13C isotopes
10. OM composition
11. Microplastics




Special Issue in Biogeosciences

- Biogeochemical processes in highly dynamic peat-draining rivers and estuaries in Borneo
- Guest editors: T. Jennerjahn, P. Shanmugam, P. Ford, and S. Bouillon
- 21 Aug 2018–31 Jan 2019
- **Please consider submitting relevant work ☺**

Acknowledgments

Newton Fund

SKLEC State Key Laboratory of Estuarine and Coastal Research

Ministry of Education
moulding the future of our nation

KEMENTERIAN PENDIDIKAN MALAYSIA

ansto

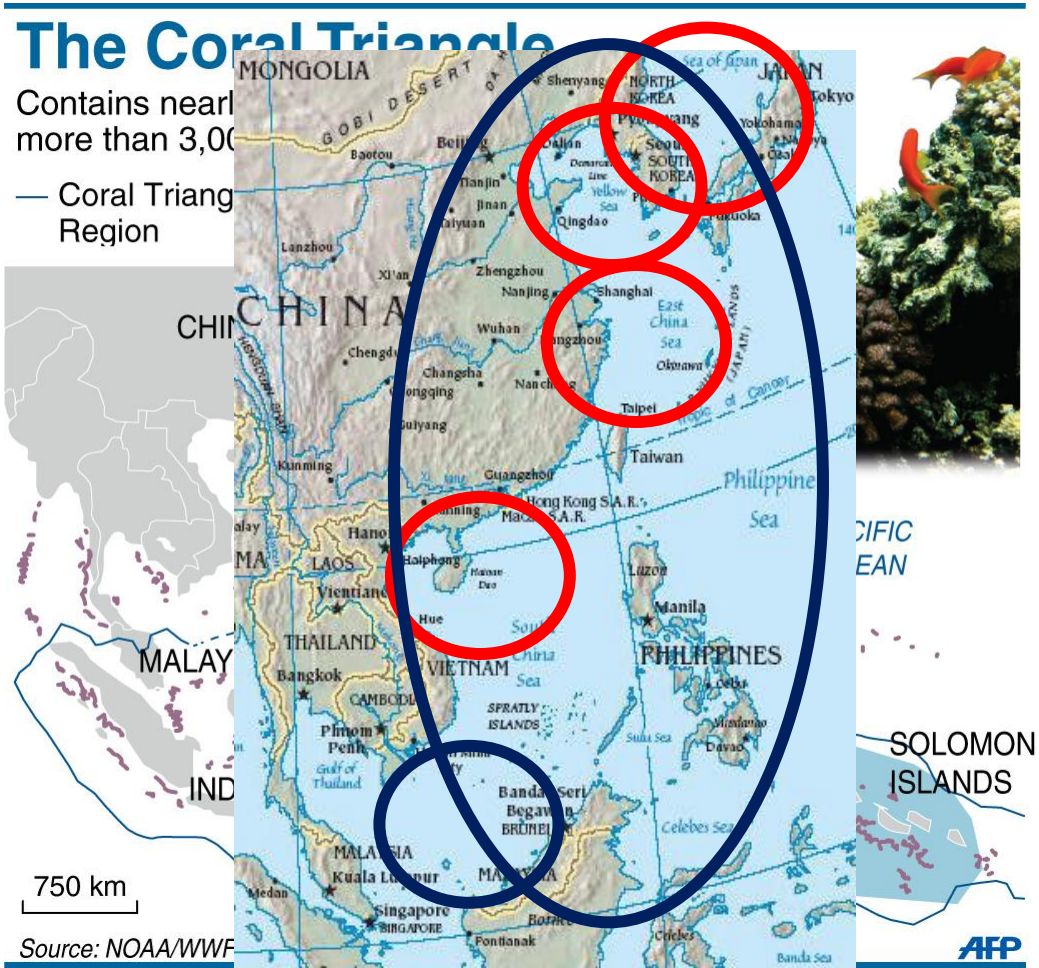
DFG

RISE project

- Writing a proposal with EU and Coral Triangle Initiative colleagues

- Riverine input to coastal waters → DOC → OA → Reefs
- CTI algorithm for DOC
- Prof. Yoo → include PP ?

- CJK-T-M-V-P



Thank you.

Aquatic and Environmental Sciences (AqUES)

- Culture collection (~1000 bacteria and endophytic fungi)
- Next Generation Sequencing; DGGE

- Peat environments (N, and S)
- Corals (diseases)
- Coral cores, micro-atolls (CC, seawater level)
- Shrimp aquaculture (EMS; Probiotic, Biofilm)
- Natural Products (Anticancer)
- Bioremediation (Heavy metals, Plastic; Proteomics)
- Microplastics