# Biogeochemistry of the Congo River: annual transport fluxes and sources of carbon in the upper Congo River (Kisangani, DRC Congo)

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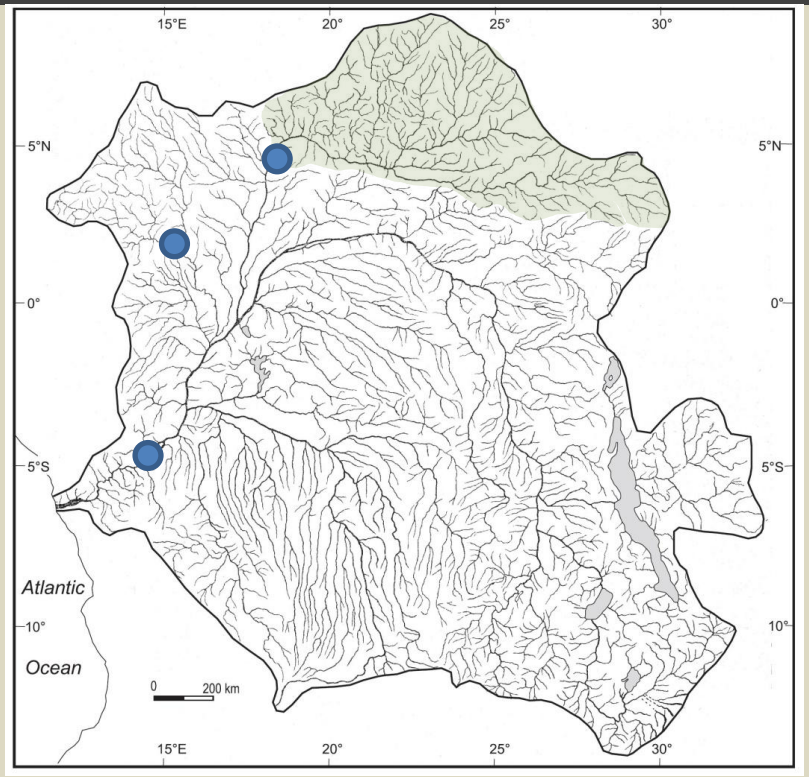
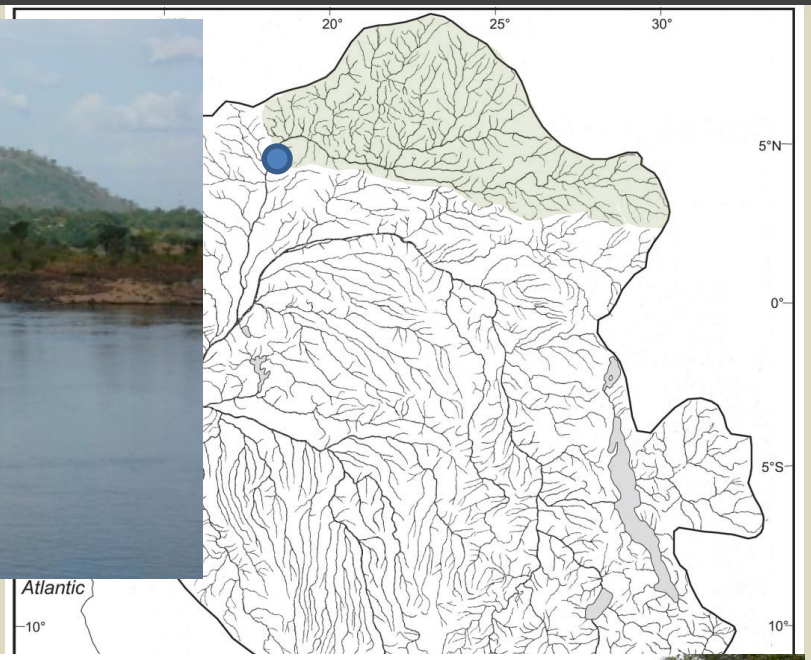
# Congo Basin

2nd largest river basin in the world
2nd in terms of total annual discharge

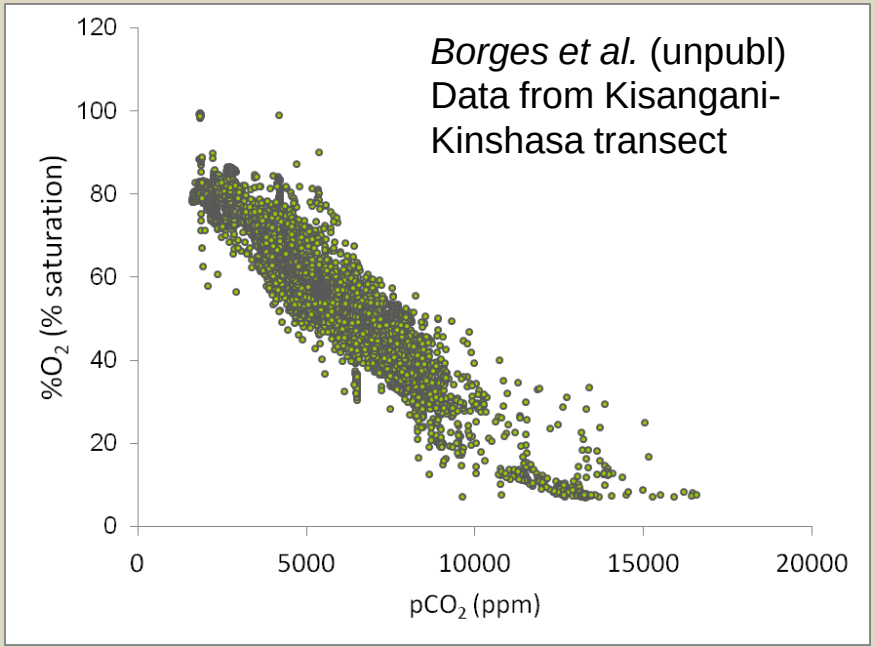
▸ Laraque et al. (2009): most recent synthesis of material fluxes in the basin. Highlights lack of data: regular sampling has been restricted to Kinshasa/Brazzaville (lower mainstem), Bangui (Oubangui), and some rivers in the smaller right bank tributaries (e.g. Sangha), much of the data from 1980's & 1990's.



# Congo Basin




▸ High variability in river characteristics across the basin.

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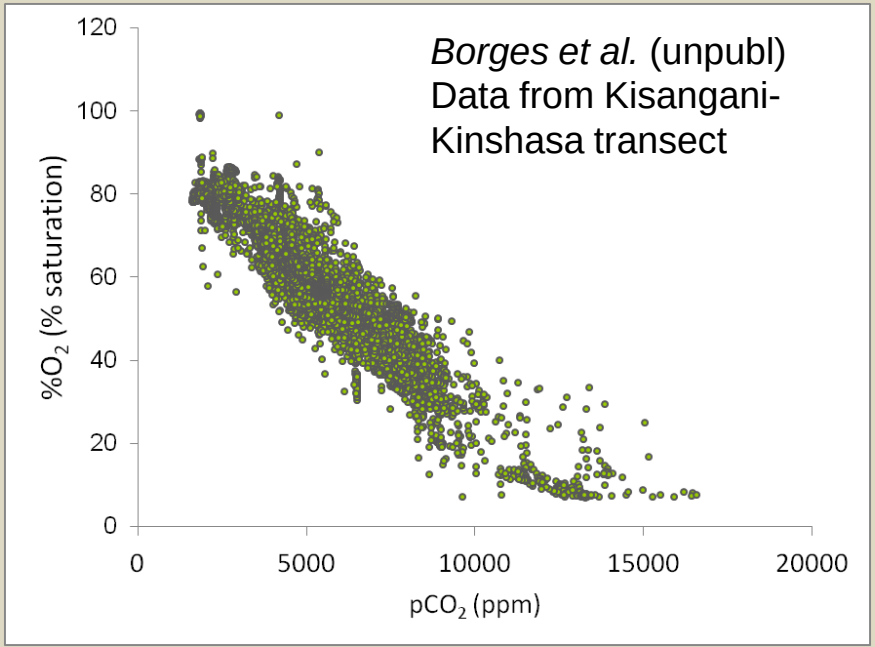
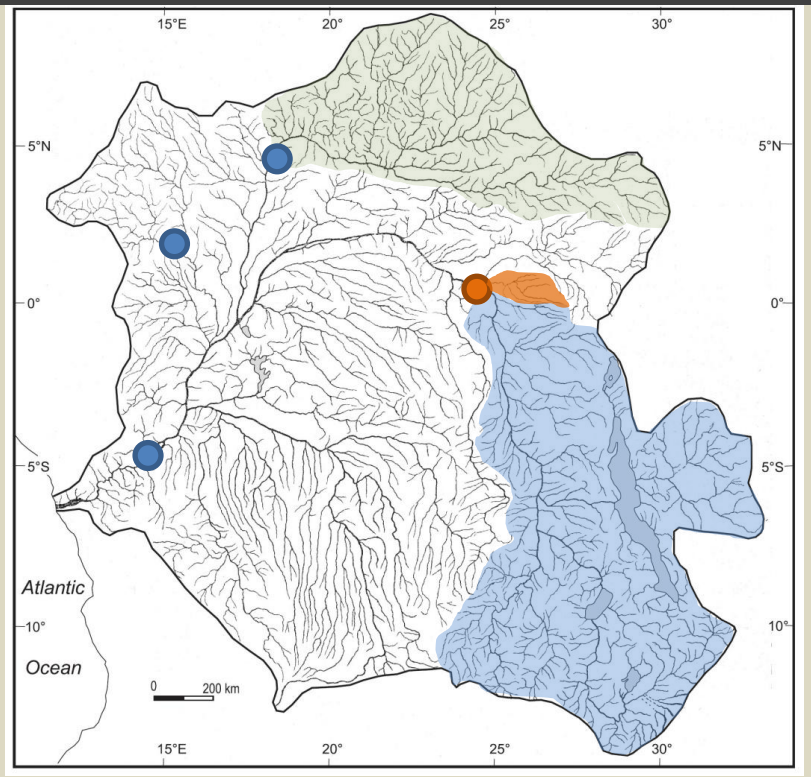



▸ New data collected every two weeks (since Dec. 2012, ongoing)

-mainstem Congo River at Kisangani
-Tshopo River at Kisangani

Catchment areas:

Congo Basin: 3,500,000 km²
Upstream of Kisangani: 972,000 km²
Tshopo: 58,000 km²

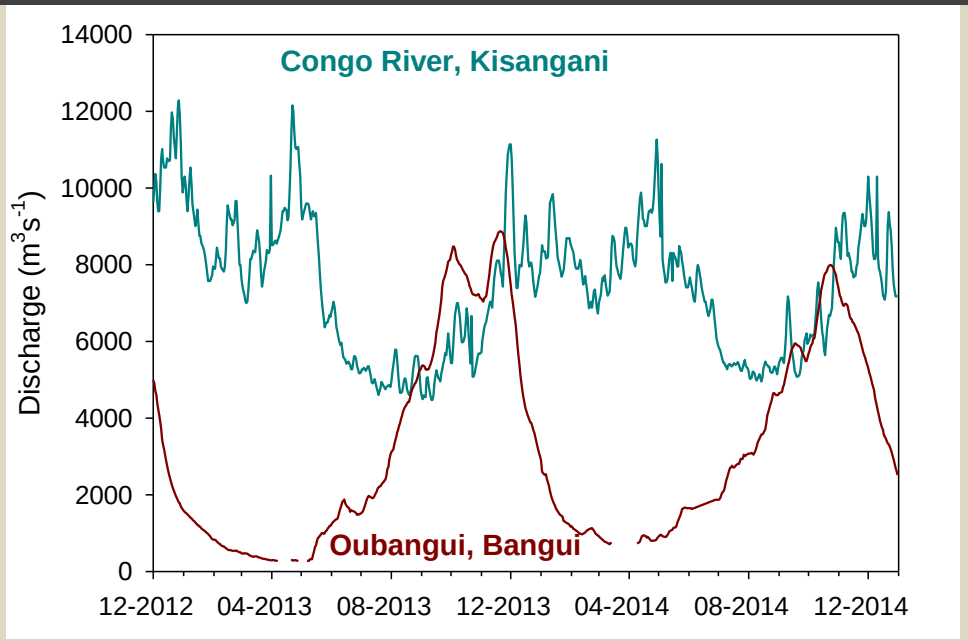
# Discharge at Kisangani

Average annual discharge (2005-2014):
**6800 $m^3$ $s^{-1}$**

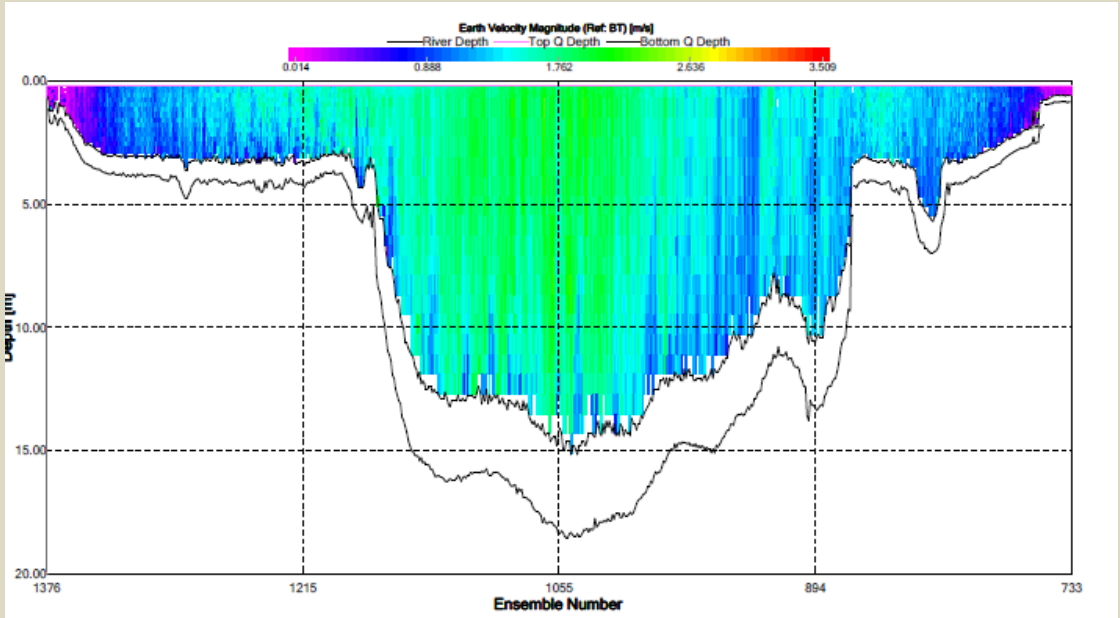
**~17.5 % of the total basin flow**
(39200 $m^3s^{-1}$ for 2008-2012)

$Q_{max}/Q_{min}$ is moderate (2.6)

High flows: November-June
Low flows: July-October




Verification/establishment of discharge rating curve



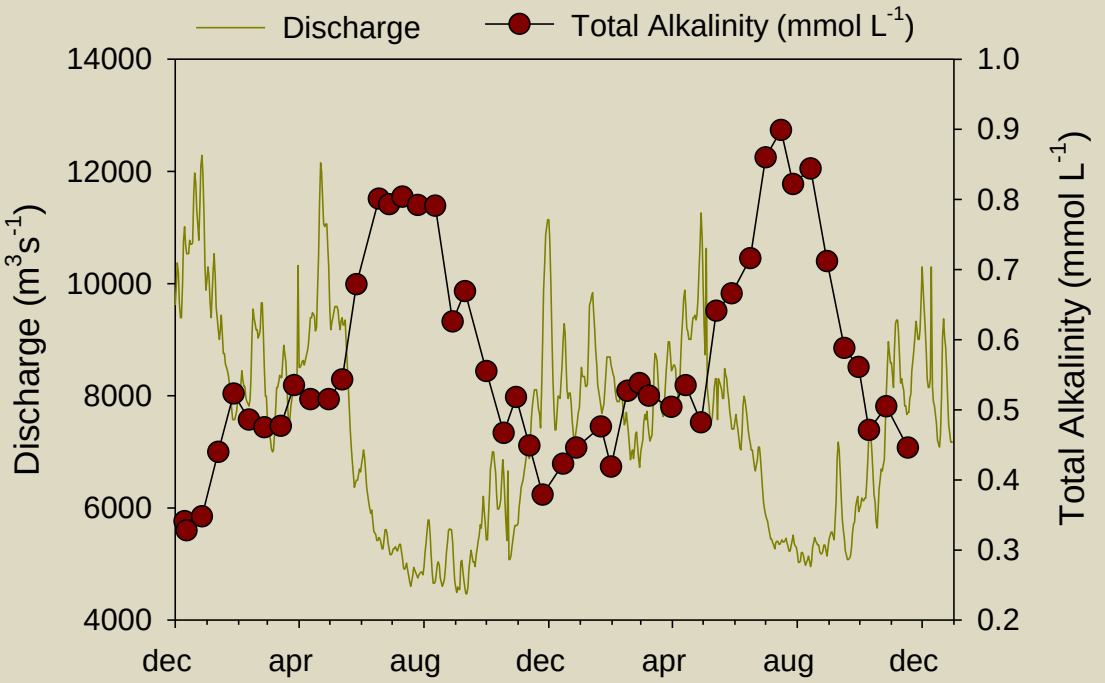
# Total Alkalinity, $\delta^{13}$C-DIC

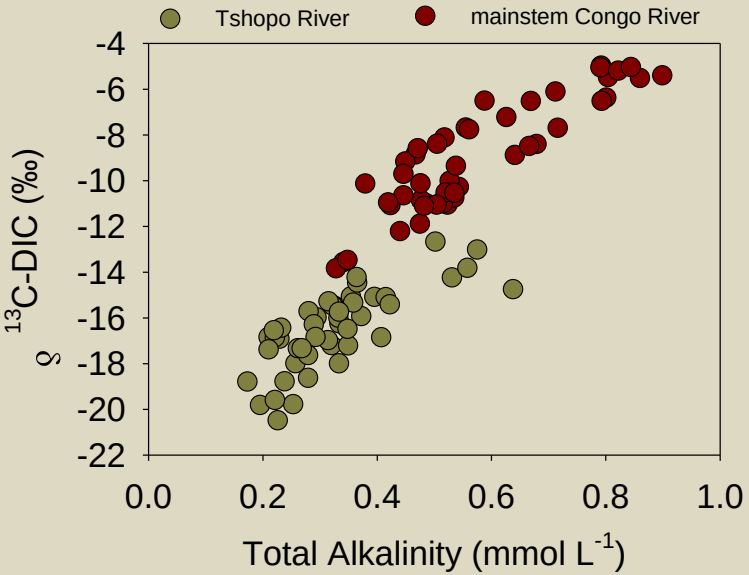
- Higher TA at low discharge
- Hysteresis
- Correlation with $\delta^{13}$C-DIC
  Influence of weathering
  Much lower $\delta^{13}$C-DIC in Tshopo R.

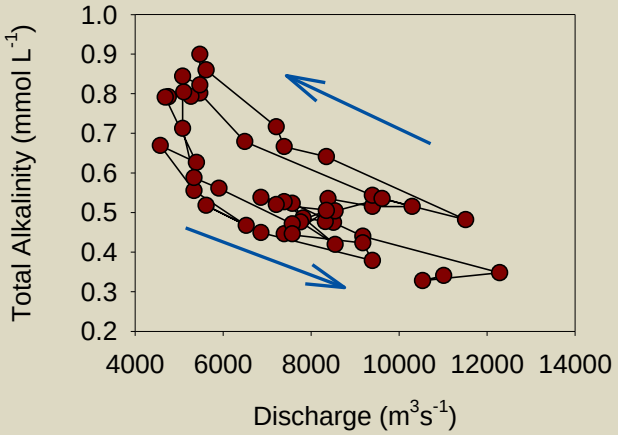
- If we take TA ≈ DIC (…)

**annual DIC flux: 1500-1600 Tg C $y^{-1}$**

Compare with estimate for Kinshasa:
3700 Tg C $y^{-1}$ (Wang et al. 2014)

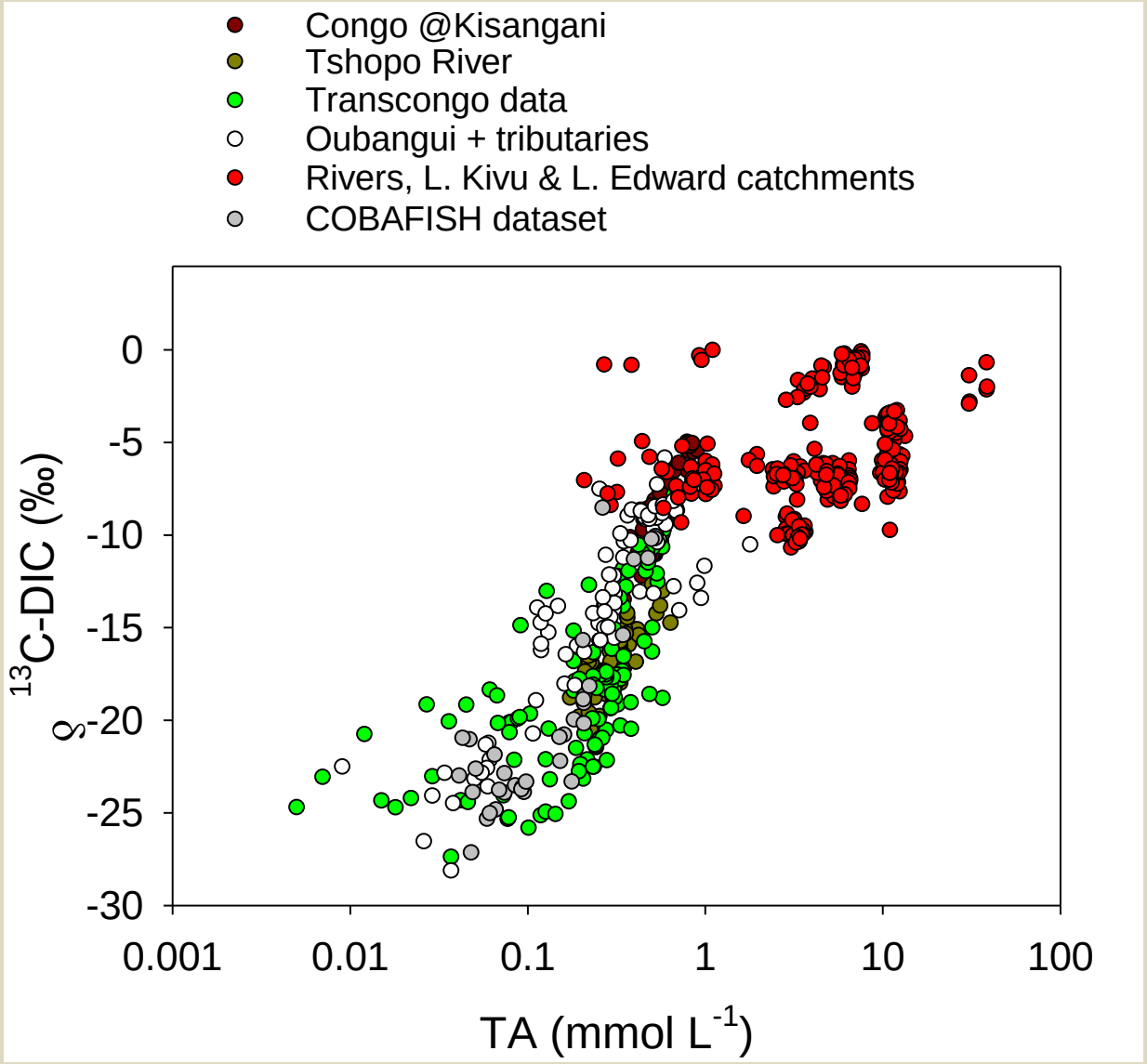


# Total Alkalinity, $\delta^{13}$C-DIC

- Data compiled from across the Congo Basin (>600 paired measurements)




# Suspended sediment and POC

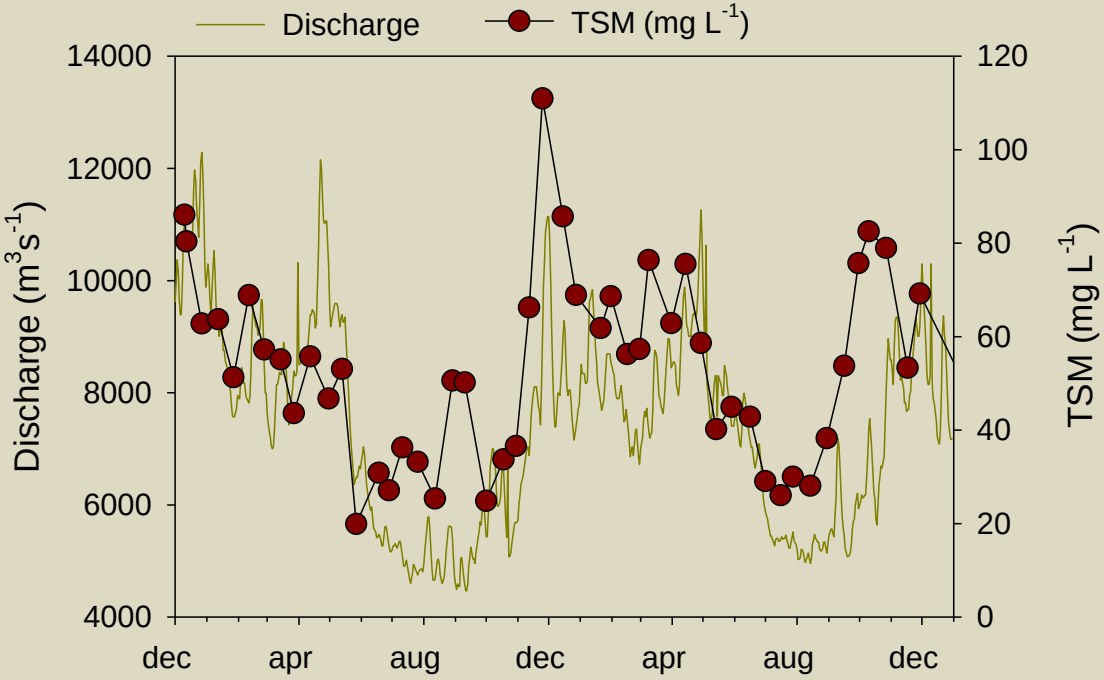
- Much higher supended sediment loads than most other studied sites in the Congo Basin (20-120 mg $L^{-1}$)

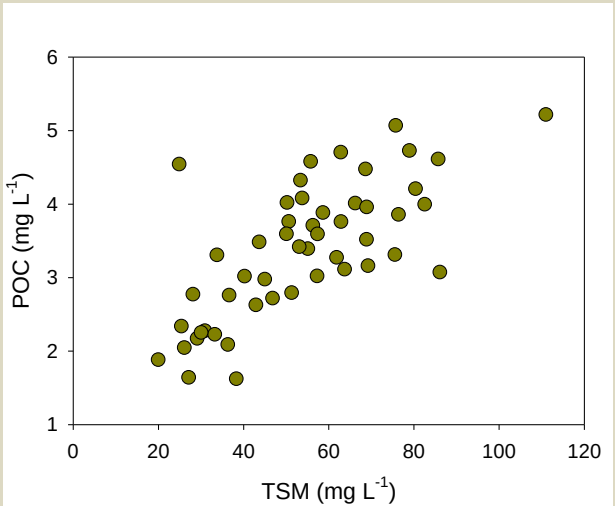
- Complex hysteresis, but general increase with Q

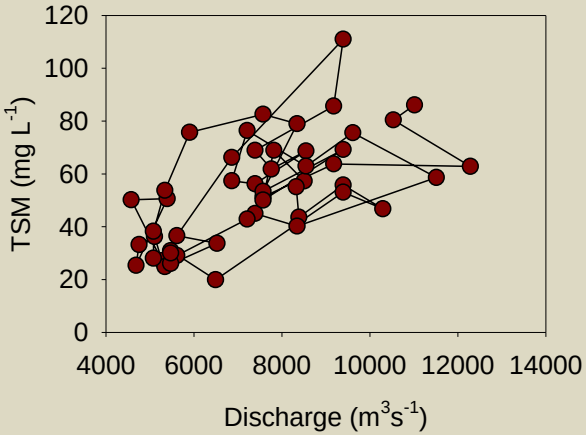
**annual TSM flux: 12.3 – 13.8 Pg $y^{-1}$**

**Basin area: 972,000 $km^2$**
**TSM yield: 12.7 – 14.2 T $km^{-2}$ $y^{-1}$**

**annual POC flux: 813 Tg C $y^{-1}$**
**POC yield: 0.837 T C $km^{-2}$ $y^{-1}$**



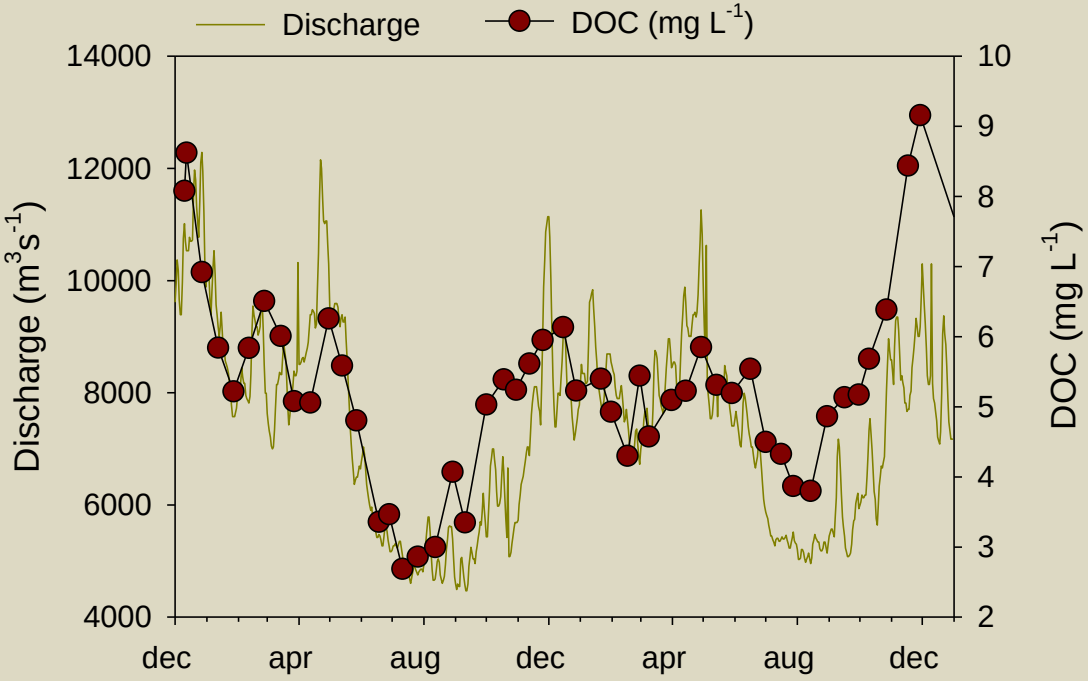



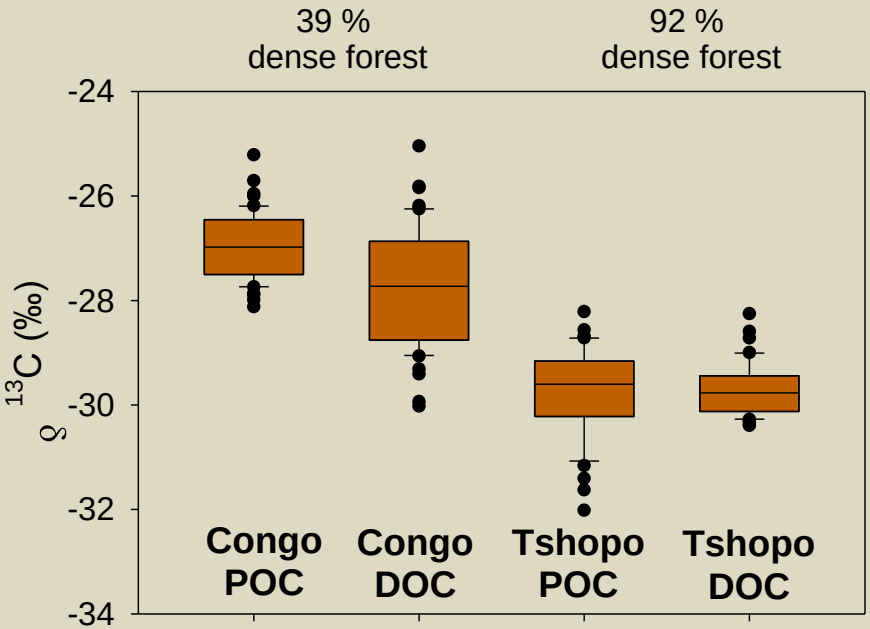



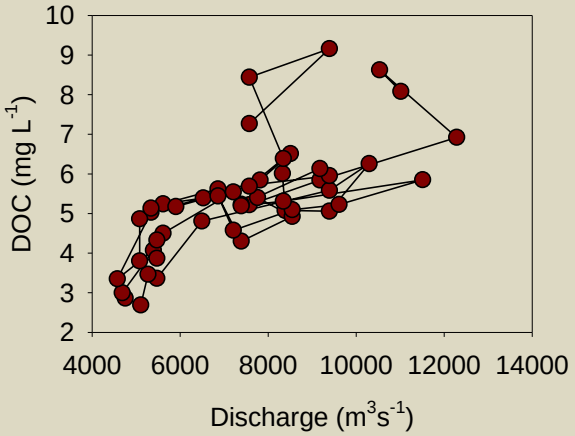
# Dissolved organic C

- DOC concentrations vary substantially (3-9 mg C $L^{-1}$) with discharge

**annual DOC flux: 1271 Tg C $y^{-1}$**
**DOC yield: 1.308 T C $km^{-2}$ $y^{-1}$**

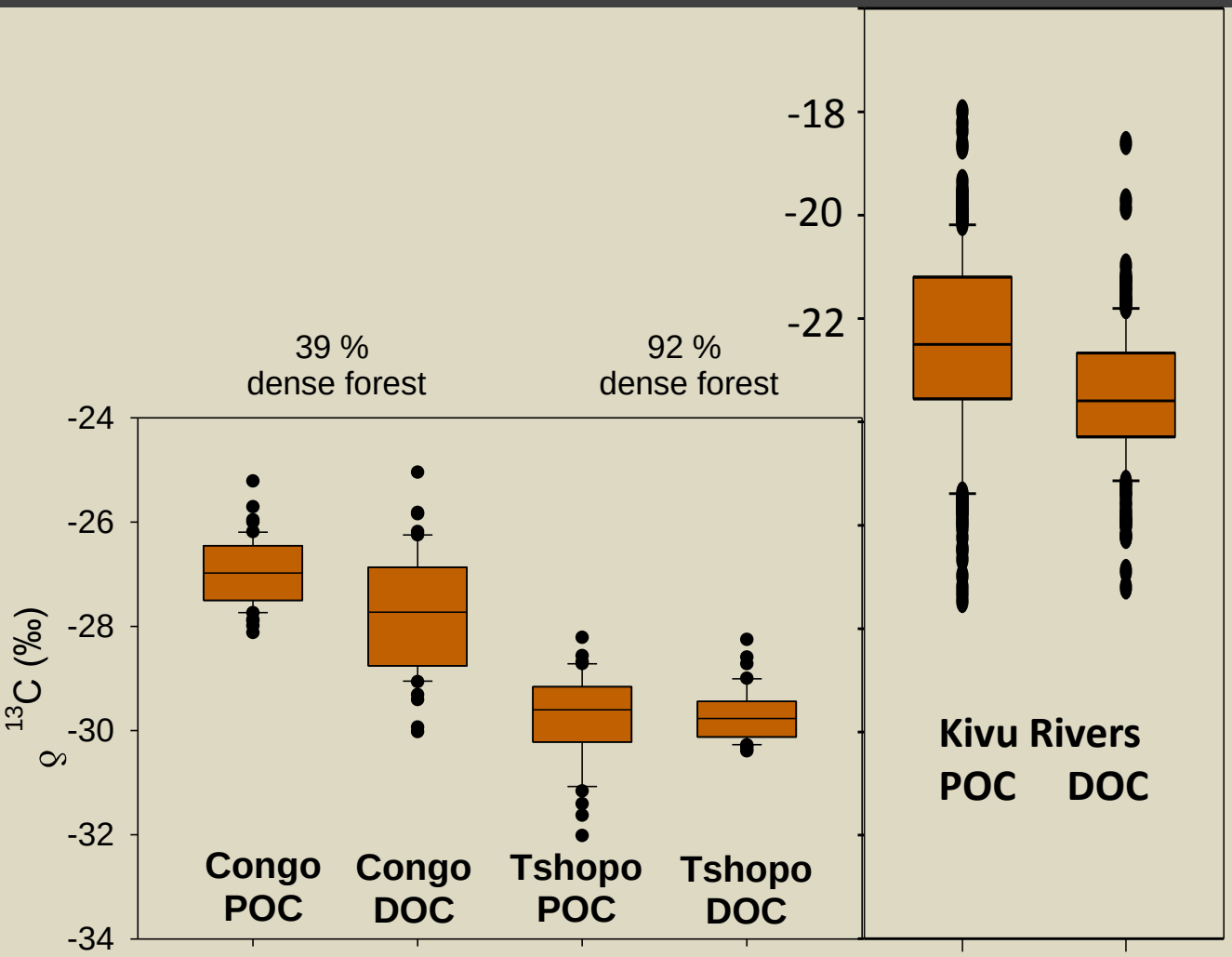


# Seasonality in biogeochemical pools & proxies

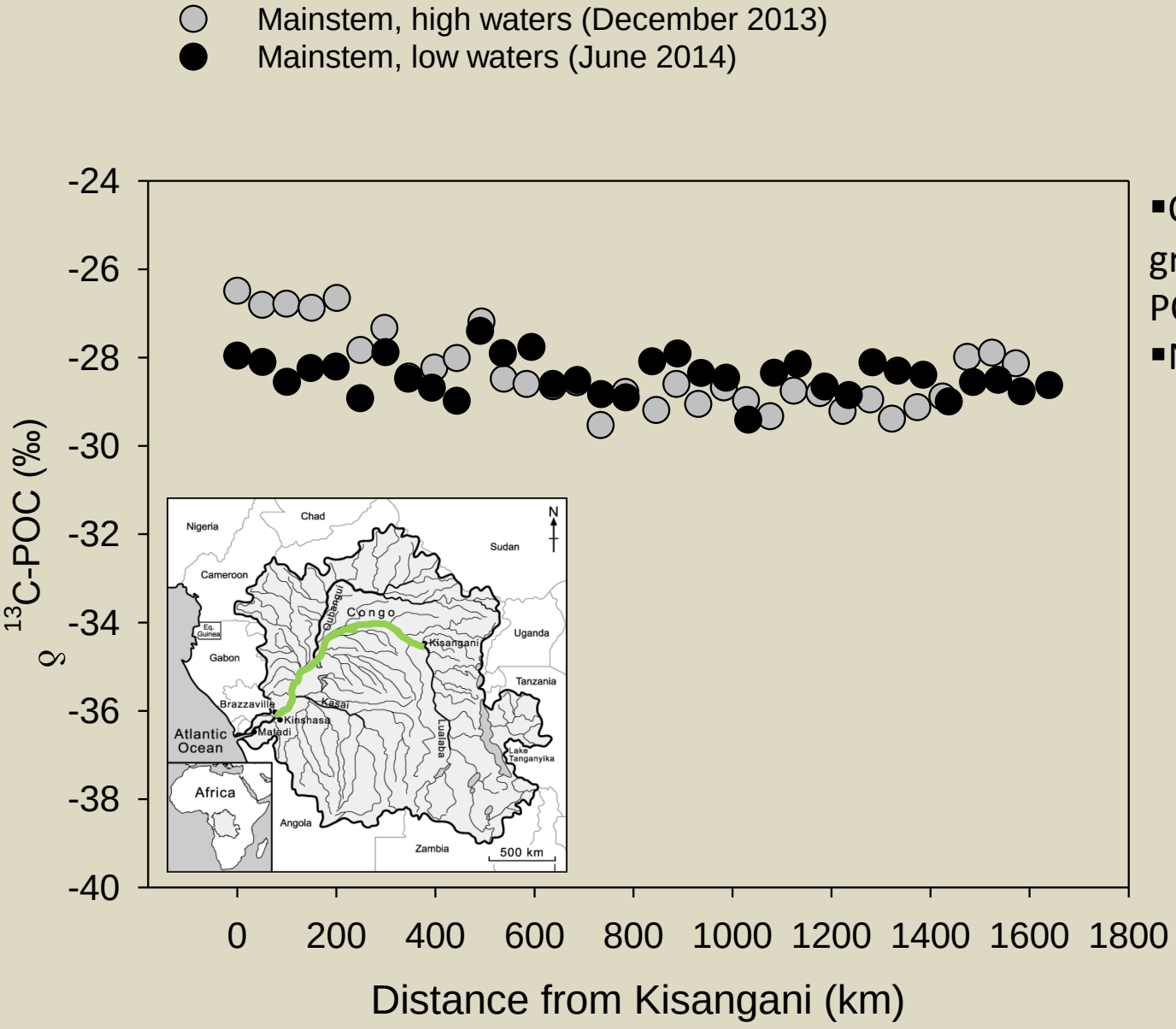
# OC sources in Congo Basin



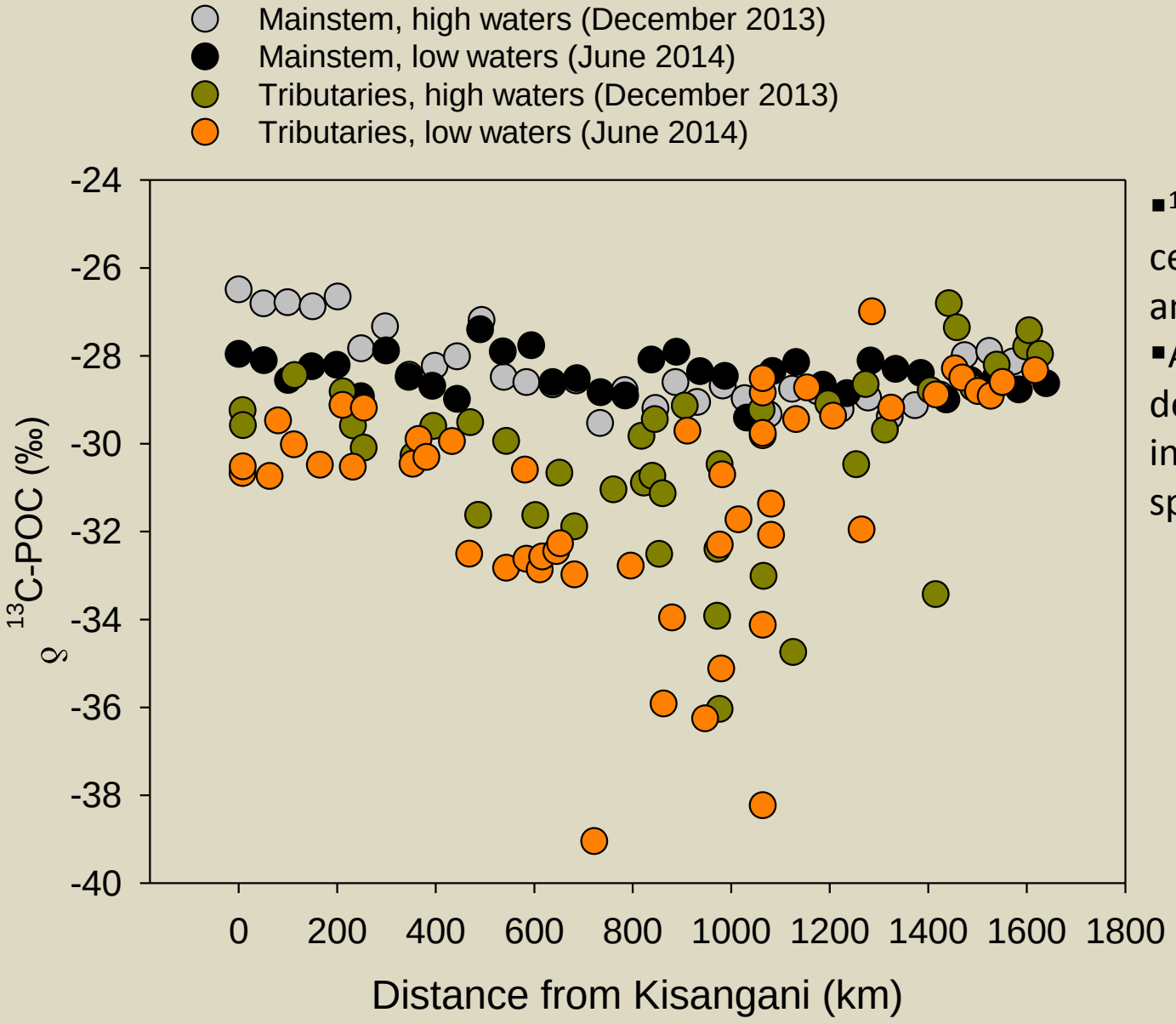


**Similar range as observed in other mainstem sites and large tributaries (e.g., downstream section/Kinshasa, and Oubangui River), but:**

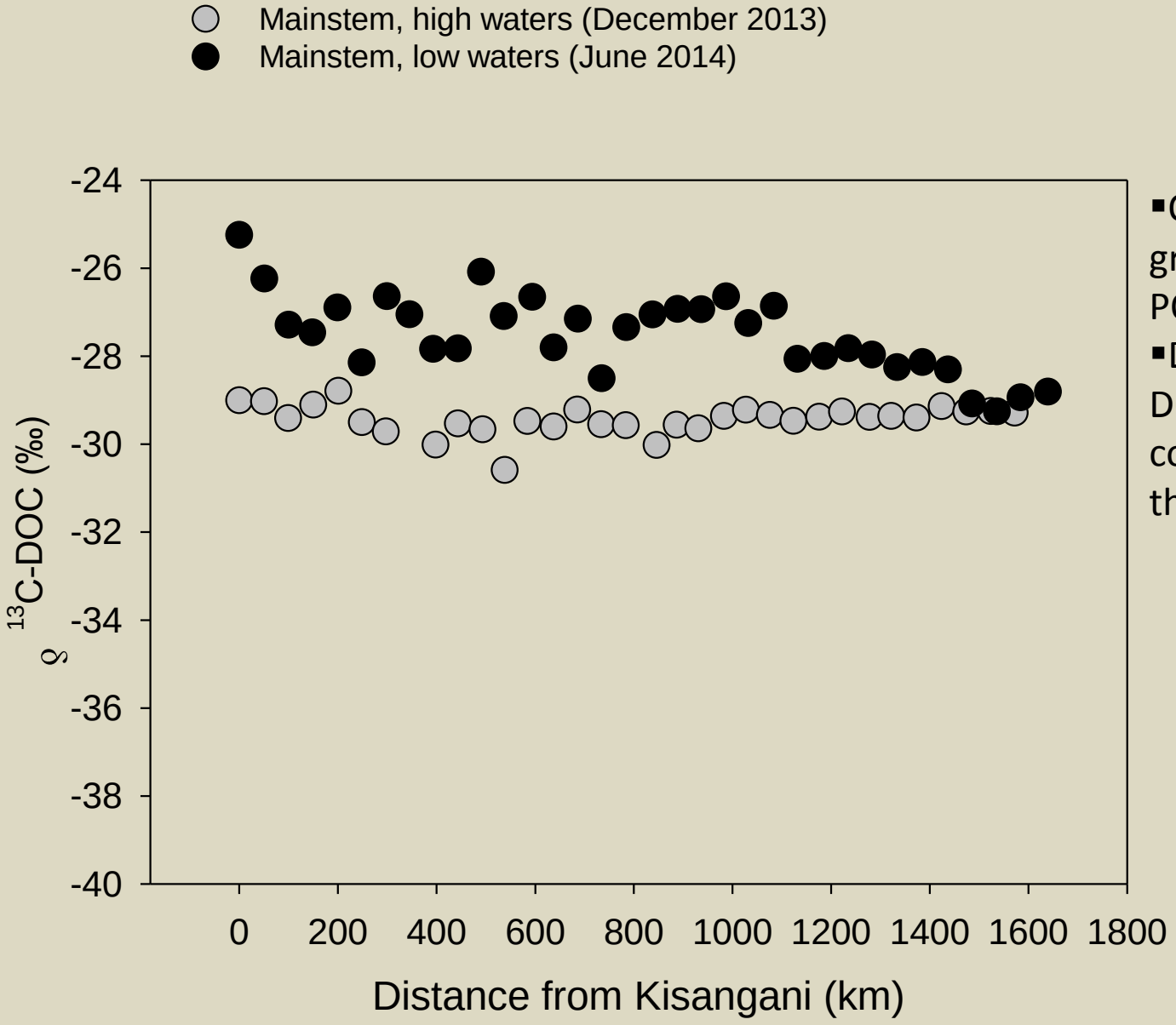
**C4 inputs in Kivu Highlands**



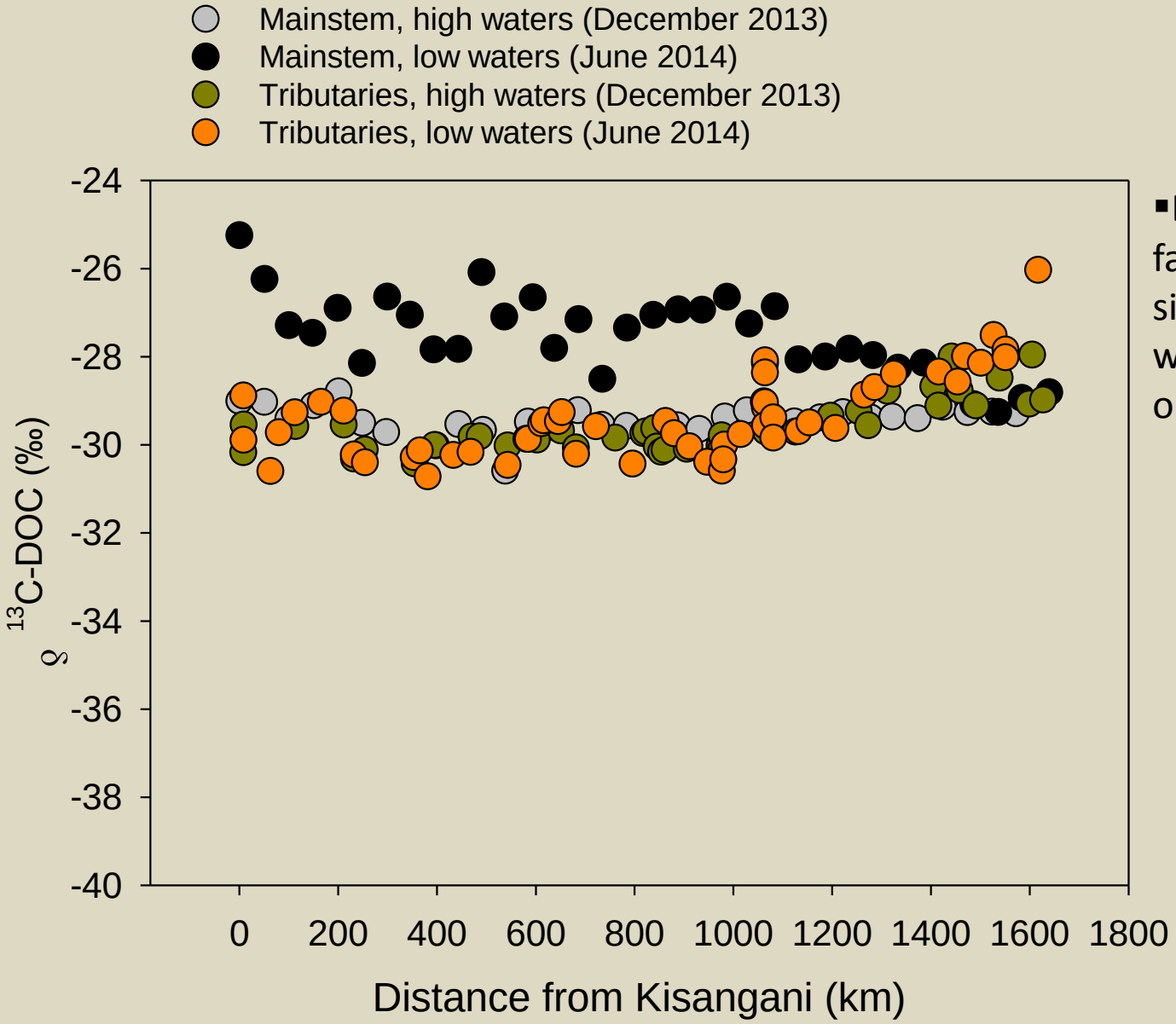

- Only minor downstream gradient in mainstem $\delta^{13}$C-POC
- No strong seasonality



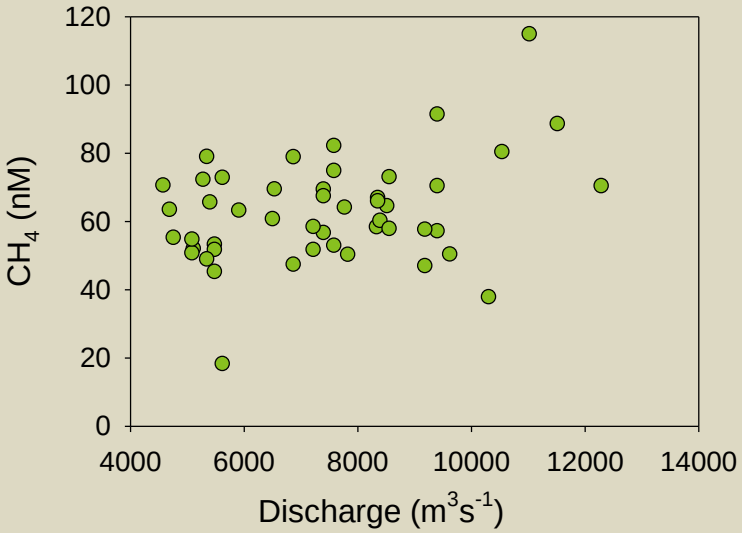

- $^{13}$C-depleted POC in central tributaries: phyto- and/or $CH_4$oxidizers
- Also evidence for $CH_4$-derived C in some invertebrates and fish species



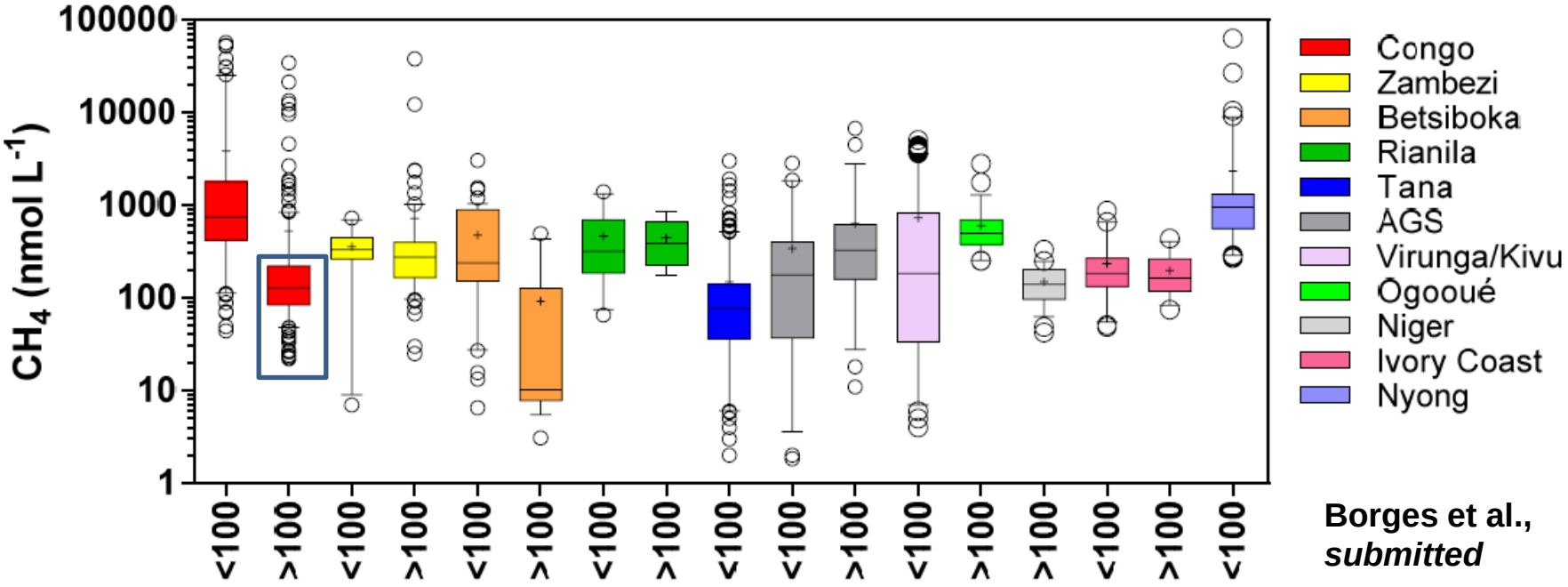

- Only minor downstream gradient in mainstem $\delta^{13}$C-POC
- Distinctly $^{13}$C-enriched DOC during low flow conditions over most of the transect.



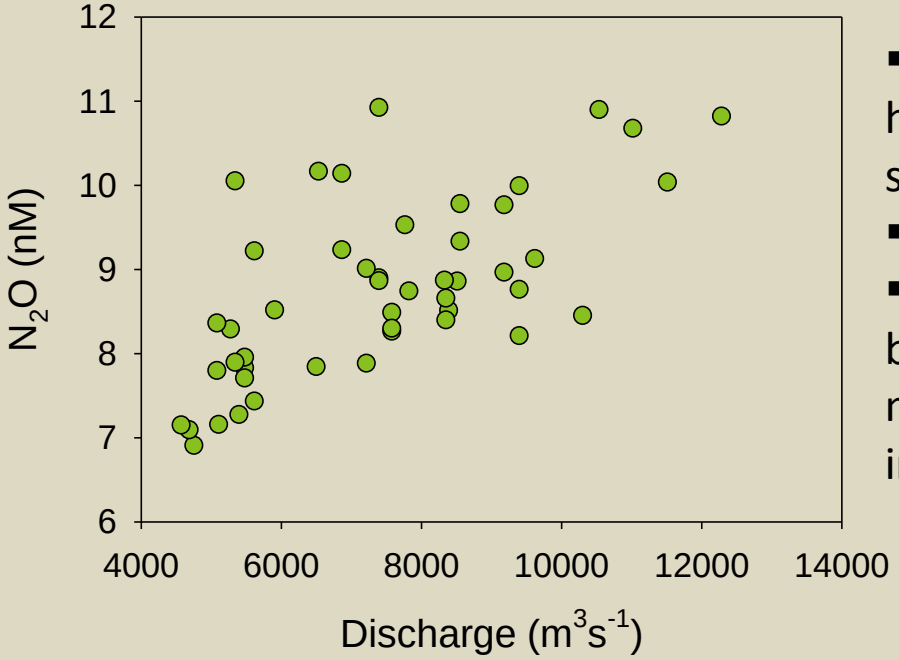

- DOC in tributaries has fairly constant $\delta^{13}C$ signatures – constrasts with strong $^{13}C$-depletion observed in POC.



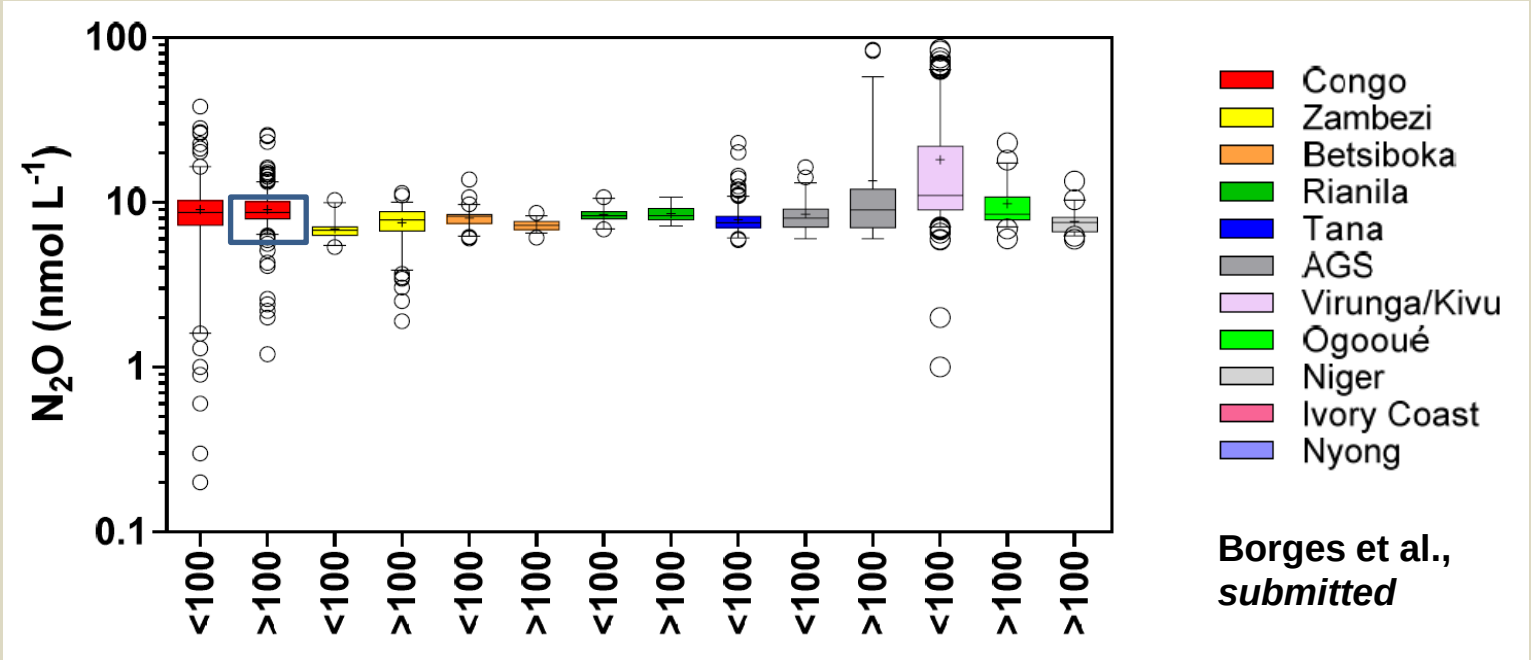

- Relatively modest $CH_4$ concentrations (and hence, diffusive fluxes)
- No strong seasonality
- Data from rest of the basin and other African basins show variations covering 5 orders of magnitude.




**Borges et al., *submitted***




- Relatively modest $N_2O$ concentrations (and hence, diffusive fluxes), only slightly above saturation.
- Increases with discharge
- Data from rest of the basin and other African basins show variations covering 3 orders of magnitude, high levels only in anthropogenically impacted systems.

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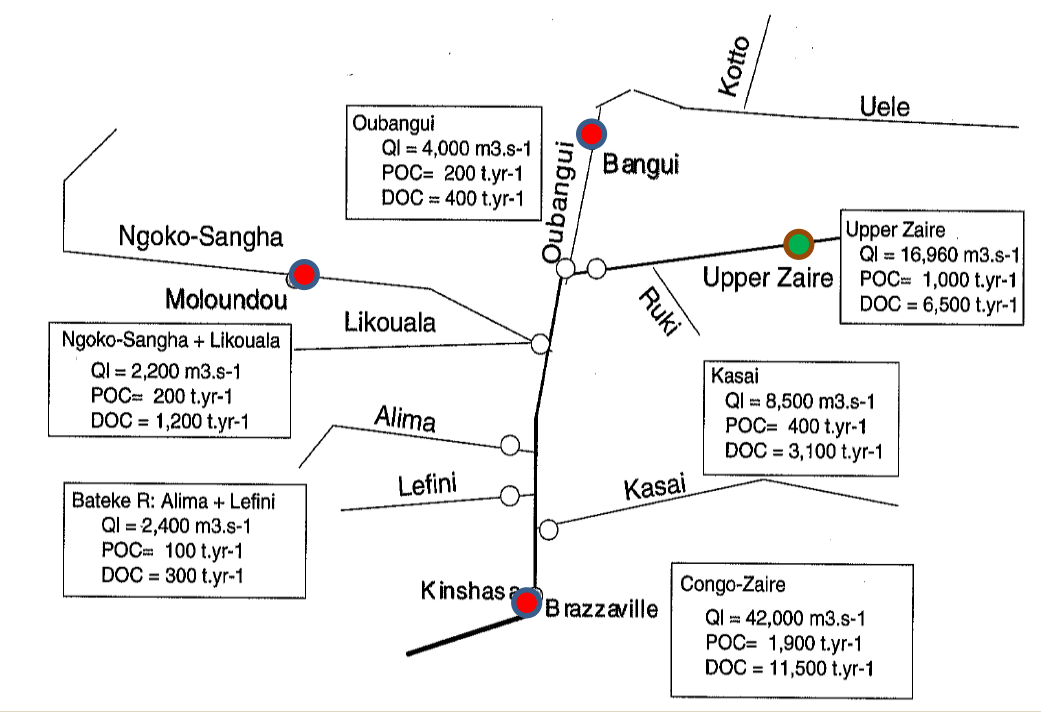
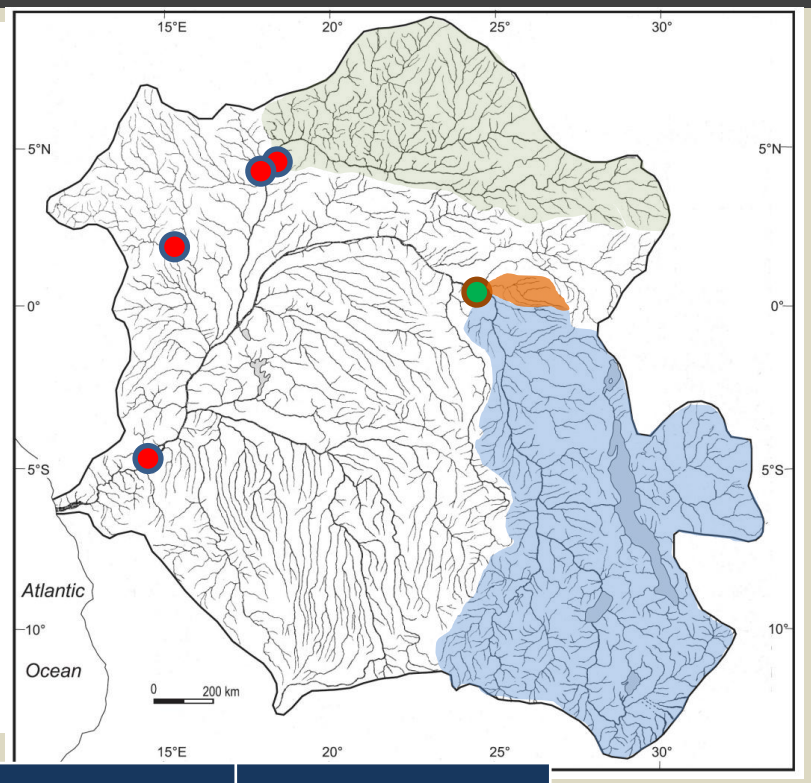
# Congo Basin C fluxes: what do we know ?

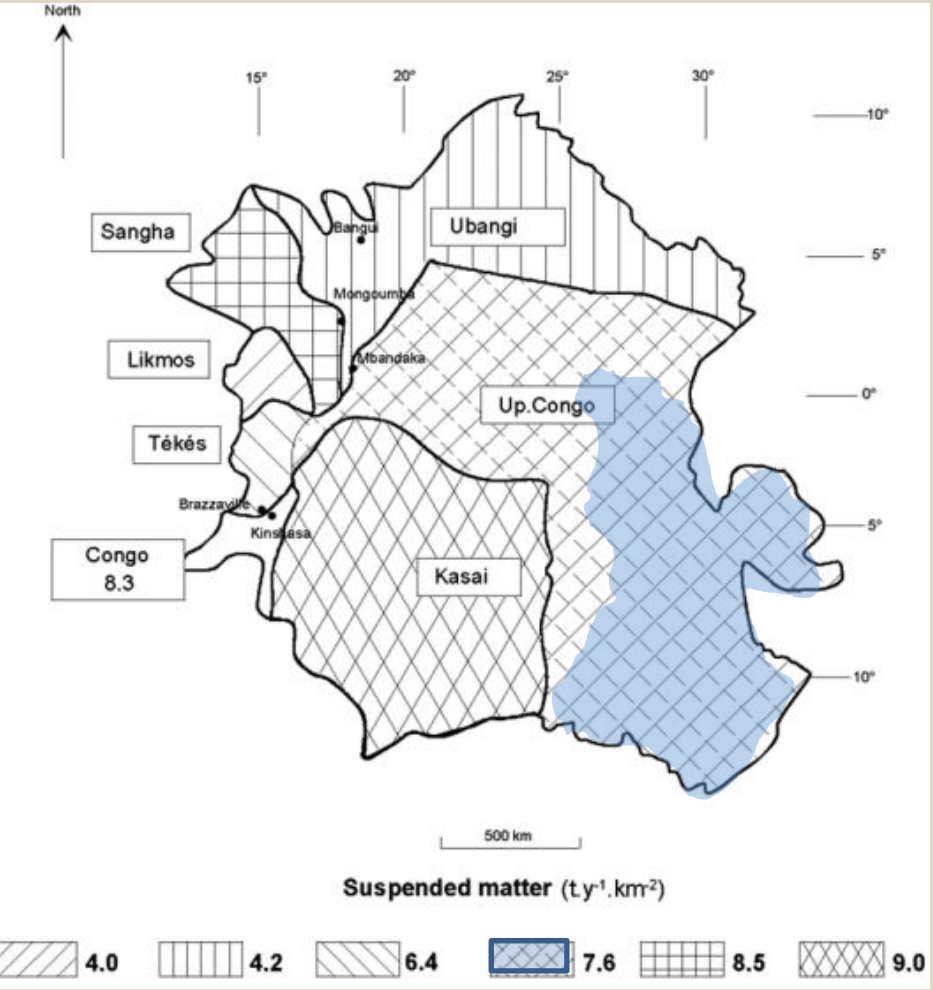



| | DIC yield (kg km$^{-2}$ y$^{-1}$) | POC yield (kg km$^{-2}$ y$^{-1}$) | DOC yield (kg km$^{-2}$ y$^{-1}$) | TSM yield (T km$^{-2}$ y$^{-1}$) |
|---|---|---|---|---|
| Kinshasa | 1060 | 600 | 3500 | 8.8 |
| Oubangui | 873 | 189 | 1072 | 3.3-5.0 |
| Mpoko | | 300 | 900 | 7.7 |
| Ngoko | | 900 | 3900 | 15.3 |
| **Kisangani** | **1595** | **837** | **1308** | **12.7-14.2** |

Seyler et al. (2006), Coynel et al. (2005), Wang et al. (2014) + our work on Oubangui and Congo @Kisangani

# Congo Basin C fluxes: how well do we know them ?




**Sediment yields according to Laraque et al. (2009) synthesis**

Measured $Y_{sediment}$ in Kisangani (12.7-14.2 T $km^{-2}$ $y^{-1}$) much higher than those predicted (7.6 T $km^{-2}$ $y^{-1}$)

- Transport fluxes are only available for a very limited # of sites, inter-annual variability insufficiently covered - long-term datasets lacking.
- Poor network of hydrological gauging stations.
- Sampling across gradients of catchment characteristics reveals huge variability in aquatic biogeochemical functioning, C sources, and GHG sink/source strength.

# Acknowledgements