An integrated approach to tracking paleohydrological changes along the Amazon Basin

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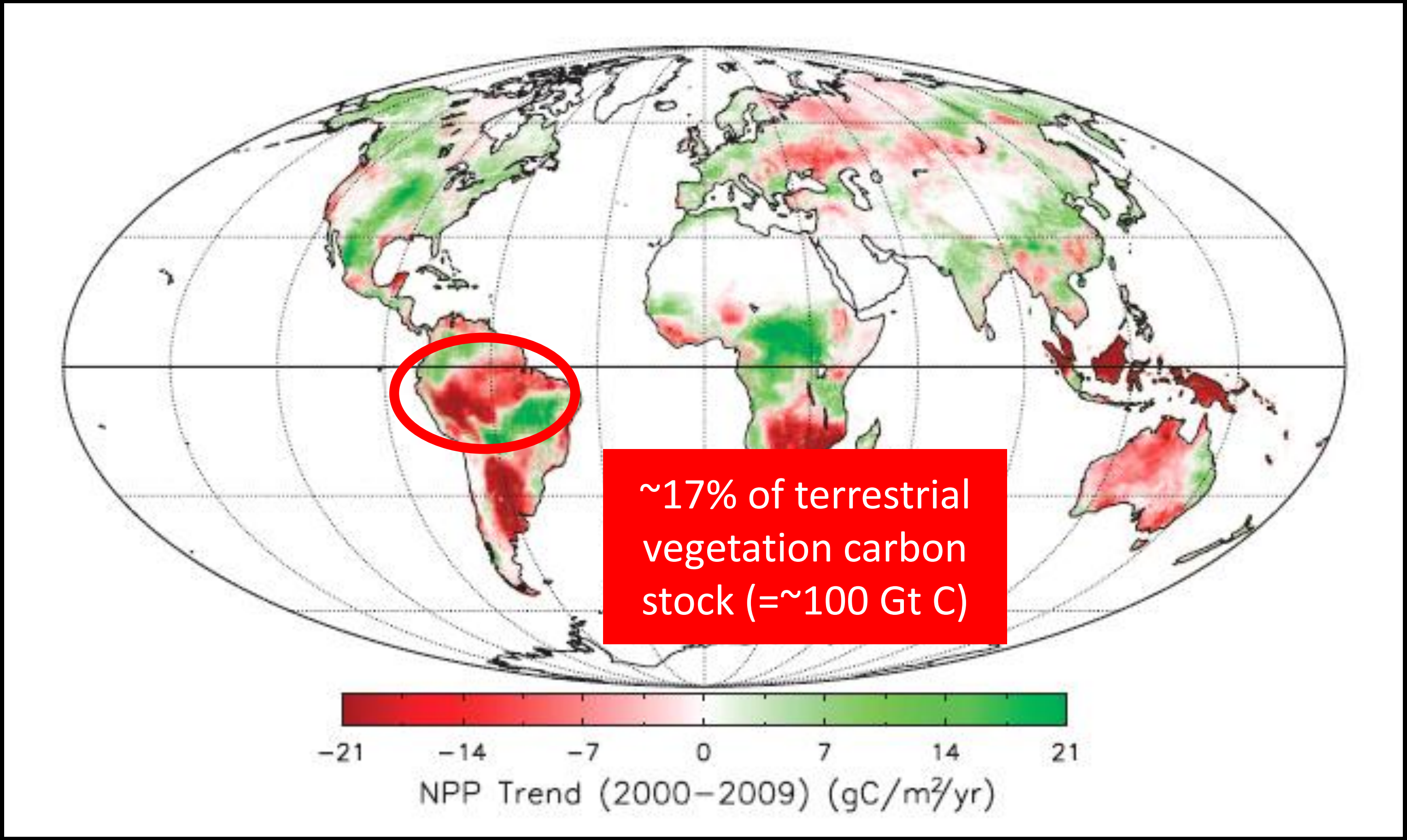
UNIVERSIDADE FEDERAL DO AMAZONAS IN UNIVERSA SCIENTIA VERITAS UFAM

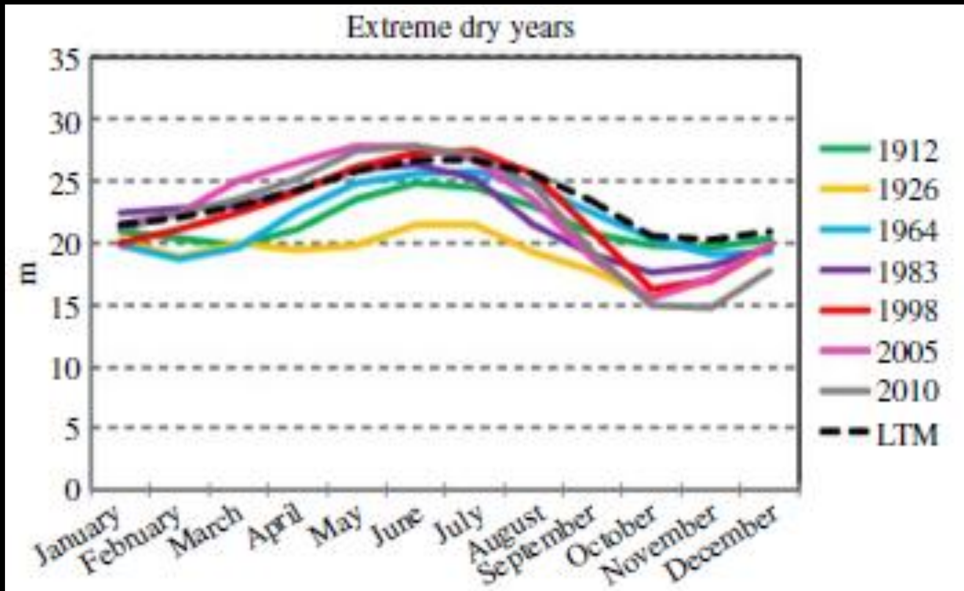
Moreira, L.S.; Moreira-Turcq, P.; Cordeiro, R.C.; Turcq, B.; Aniceto, K.C.; Moreira-Ramírez, M; Soares Cruz, A.P.; Caquineau, S.; Silva, V.C

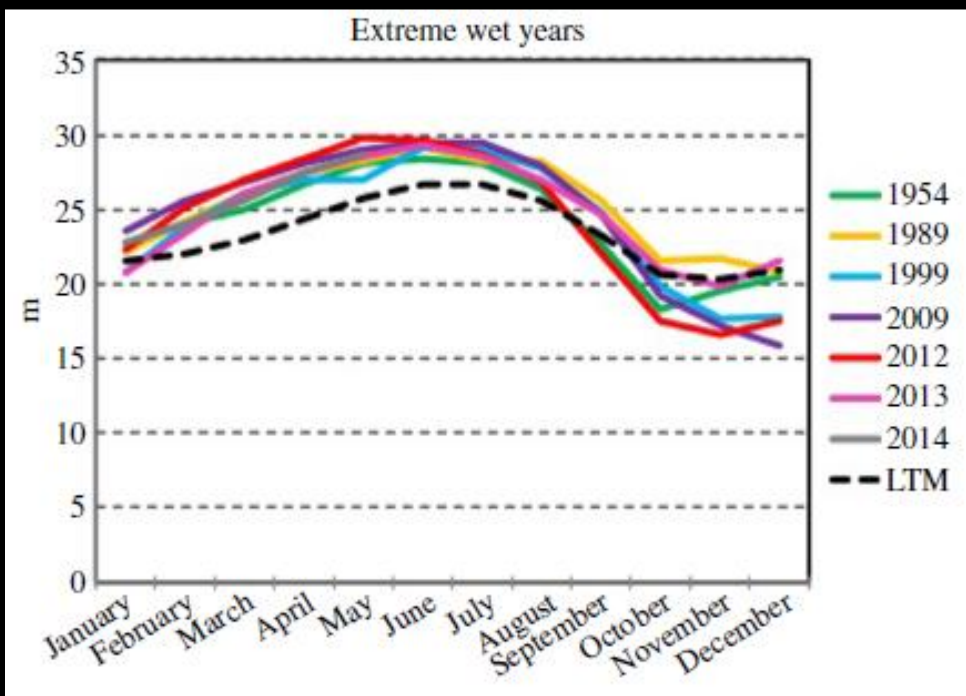
- The Amazon Basin is an important key component for modulating climate due to its role on hydrological cycle

- in addition to the carbon storage amenable to fast release to the atmosphere throughout land use change or drought-induced feedbacks.



Terrestrial NPP – Zhao et al., 2010





In the last decade, extreme events increased in frequency and intensity (extreme droughts in 2005, 2010 and 2016 and extreme floods in 2009, 2012,2014

Marengo & Espinoza, 2016

nature COMMUNICATIONS

ARTICLE

DOI: 10.1038/s41467-018-05668-6 OPEN

Post-drought decline of the Amazon carbon sink

Yan Yang[1,2,3], Sassan S. Saatchi[1,3], Liang Xu[1,3], Yifan Yu[3], Sungho Choi[2], Nathan Phillips[2], Robert Kennedy[4], Michael Keller[3,5], Yuri Knyazikhin[2] & Ranga B. Myneni[2]

LETTER

doi:10.1038/nature14213

Drought impact on forest carbon dynamics and fluxes in Amazonia

Christopher E. Doughty[1], D. B. Metcalfe[2], C. A. J. Girardin[1], F. Farfán Amézquita[3], D. Galiano Cabrera[3], W. Huaraca Huasco[3], J. E. Silva-Espejo[3], A. Araujo-Murakami[4], M. C. da Costa[5], W. Rocha[6], T. R. Feldpausch[7], A. L. M. Mendoza[3], A. C. L. da Costa[5], P. Meir[8,9], O. L. Phillips[10] & Y. Malhi[1]

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https://doi.org/10.5194/bg-15-4833-2018

Biogeosciences Open Access EGU

GLOBAL CLIMATE CHANGE
Vital Signs of the Planet

FEATURES | August 9, 2018

NASA finds Amazon drought leaves long legacy of damage

By Carol Rasmussen,
NASA's Earth Science News Team

Carbon exchange in an Amazon forest: from hours to years

Matthew N. Hayek[1], Marcos Longo[2], Jin Wu[3], Marielle N. Smith[4], Natalia Restrepo-Coupe[5], Raphael Tapajós[6], Rodrigo da Silva[6], David R. Fitzjarrald[7], Plinio B. Camargo[8], Lucy R. Hutyra[9], Luciana F. Alves[10], Bruce Daube[11], J. William Munger[11], Kenia T. Wiedemann[11], Scott R. Saleska[12], and Steven C. Wofsy[11]

PNAS

Persistent effects of a severe drought on Amazonian forest canopy

Sassan Saatchi[a,b,1], Salvi Asefi-Najafabady[b], Yadvinder Malhi[c], Luiz E. O. C. Aragão[d], Liana O. Anderson[c,e], Ranga B. Myneni[f], and Ramakrishna Nemani[g]

[a]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109; [b]Institute of Environment, University of California, Los Angeles, CA 9 [c]Environmental Change Institute, School of Geography and the Environment, University of Oxford, Oxford OX1 3QY, United Kingdom; [d]College of Lif Environmental Sciences, University of Exeter, Devon EX4 4RJ, United Kingdom; [e]Remote Sensing Division, National Institute for Space Research (INPE Jose dos Campos, Sao Paulo 12227-010, Brazil; [f]Department of Geography and Environment, Boston University, Boston, MA 02215; and [g]Biospheric Sciences Branch, National Aeronautics and Space Administration/Ames Research Center, Moffett Field, CA 94035

Water Resour Manage (2012) 26:4553–4568
DOI 10.1007/s11269-012-0166-2

Evaluation of Vulnerability to Extreme Climatic Events in the Brazilian Amazonia: Methodological Proposal to the Rio Acre Basin

José Antônio Sena · Marcos Aurélio V. Freitas · Daniel de Berrêdo · Lazaro Costa Fernandes

SCIENTIFIC REPORTS

OPEN

Record-breaking warming and extreme drought in the Amazon rainforest during the course of El Niño 2015–2016

Received: 10 May 2016
Accepted: 23 August 2016
Published: 08 September 2016

Juan C. Jiménez-Muñoz[1], Cristian Mattar[2], Jonathan Barichivich[3,4,5,6], Andrés Santamarí Artigas[7], Ken Takahashi[8], Yadvinder Malhi[9], José A. Sobrino[1] & Gerard van der Schrier[10]

... have drawn attention to the vulnerability of tropical forests to climate perturbations

to predict the impacts of future climate changes on amazonian ecosystems
we must to look to the past….

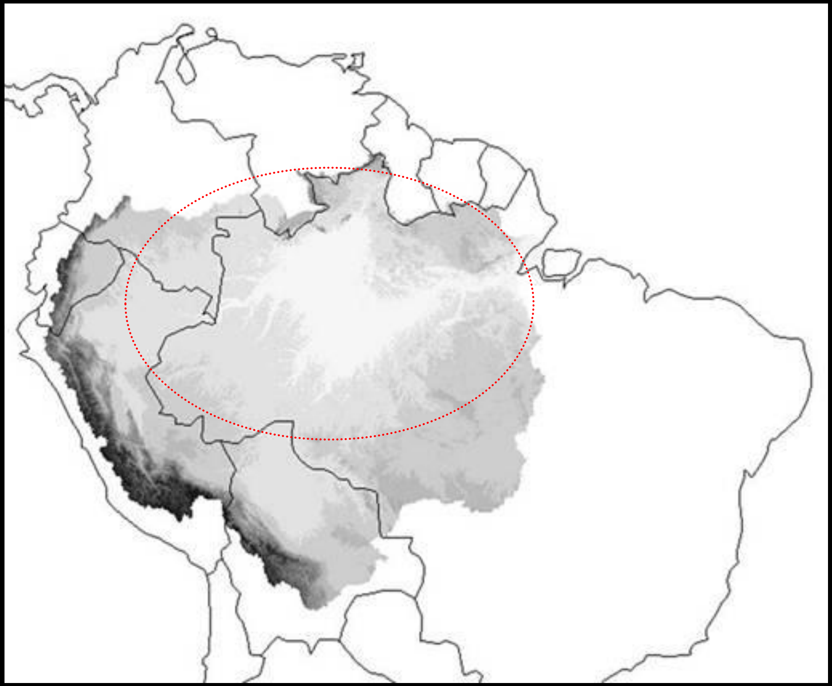
PURPOSE

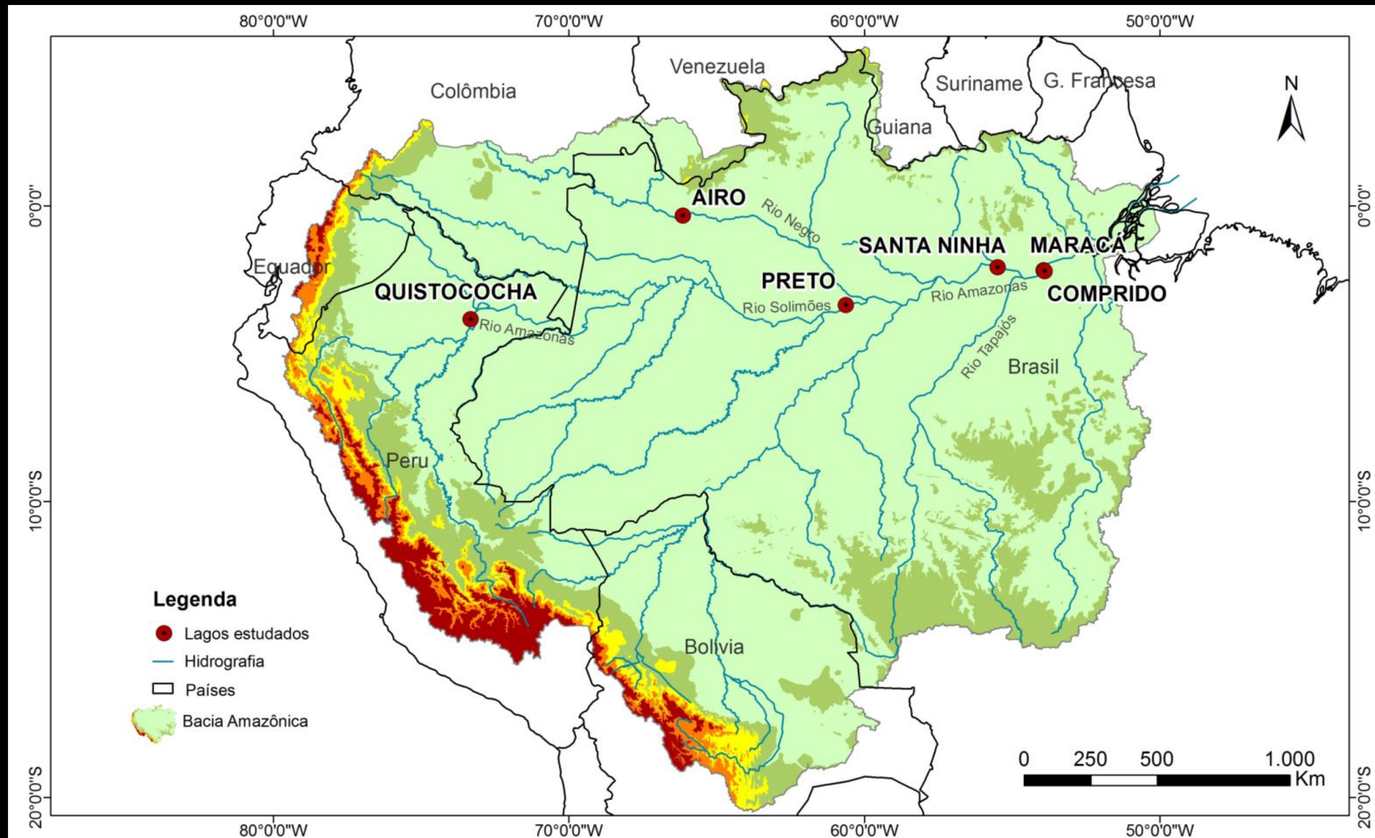
Paleohydrological and paleoclimate changes and its impacts on carbon accumulation in amazonian floodplain lakes

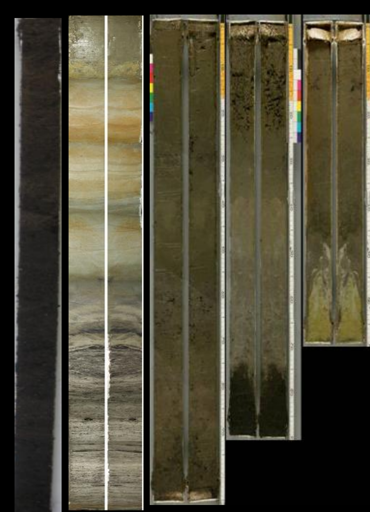
Study area

- The Amazonian floodplain domain covers 44% of the entire basin;

- However paleohydrological reconstructions of Amazonian floodplain lakes are lacking for very large areas instead the high density of floodplain lakes




80°0'0"W
70°0'0"W
60°0'0"W
50°0'0"W
0°0'0"
10°0'0"S
20°0'0"S
Venezuela
Colômbia
Suriname
G. Francesa
Guiana
Equador
Peru
Bolivia
Brasil
N
AIRO
Rio Negro
SANTA NINHA
MARACÁ
PRETO
COMPRIDO
QUISTOCOCHA
Rio Solimões
Rio Amazonas
Rio Tapajós
Legenda
Lagos estudados
Hidrografia
Países
Bacia Amazônica
0 250 500 1.000
Km



- During the Holocene we observed a strong fluvial impact on the floodplain lakes sedimentary process

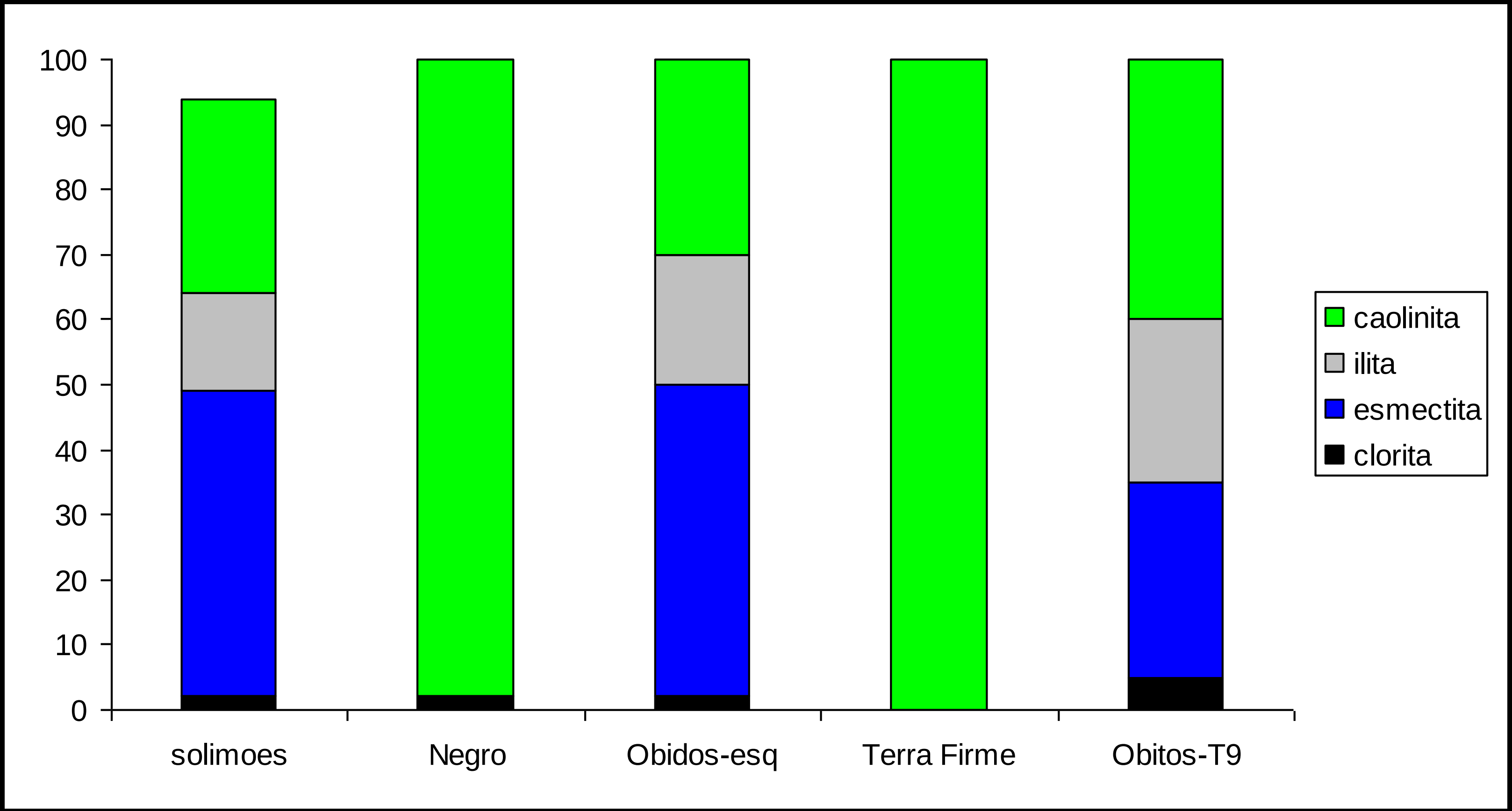
How to track these changes?

A promising tool to identify the periods with high and low fluvial influence on floodplain lakes is **clay composition**

Amazonas/Solimões – suspended sediments presents high smectite content

Drainage basin “Terra Firme” forest - 100% composed of kaolinite

sediment supply: Fluvial x drainage basin



Amorim, 2010

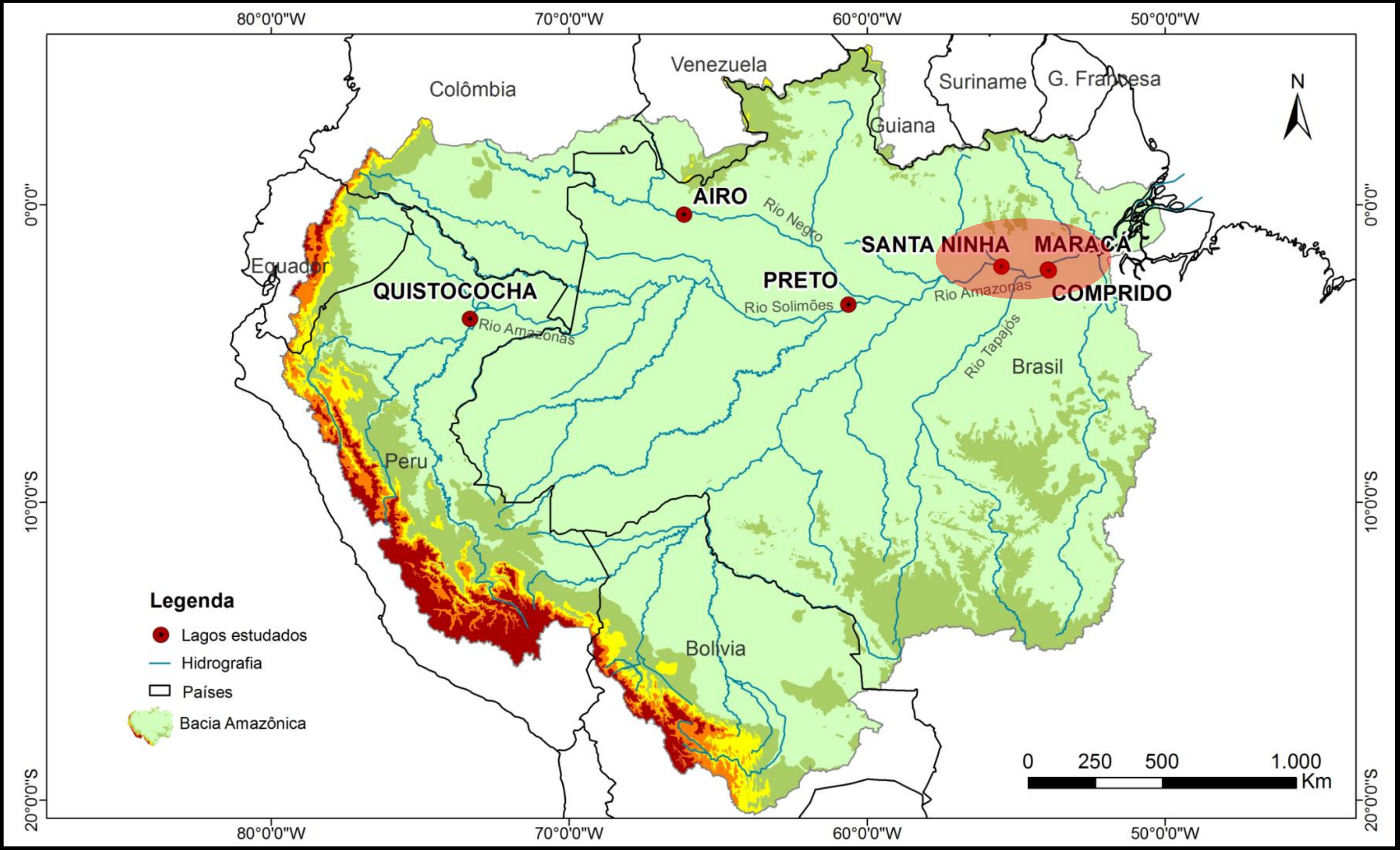
And to track the impacts of the paleohydrogical changes...

Organic geochemical signatures help to identify the source of the organic matter

1 - Paleoclimatic influences on sedimentary process

Transition from a dry to a wet climate across the Holocene

- Santa ninha and Maraca



The mid-Holocene dry event

- Many amazonian lacustrine records have shown a severe mid-Holocene drought (between 7000 and 3000 cal years BP)

- (Absy, 1979; Behling and Hooghiemstra, 1999; Behling et al., 2001; Bush et al., 2007; Cordeiro et al., 1997, 2008; De Freitas et al., 2001; Desjardins et al., 1996; Irion et al., 2006; Mayle and Power, 2008; Mayle et al., 2000; Moreira et al., 2012; Sifeddine et al., 1994, 2001; Soubies, 1980; Turcq et al., 1998; Weng et al., 2002).

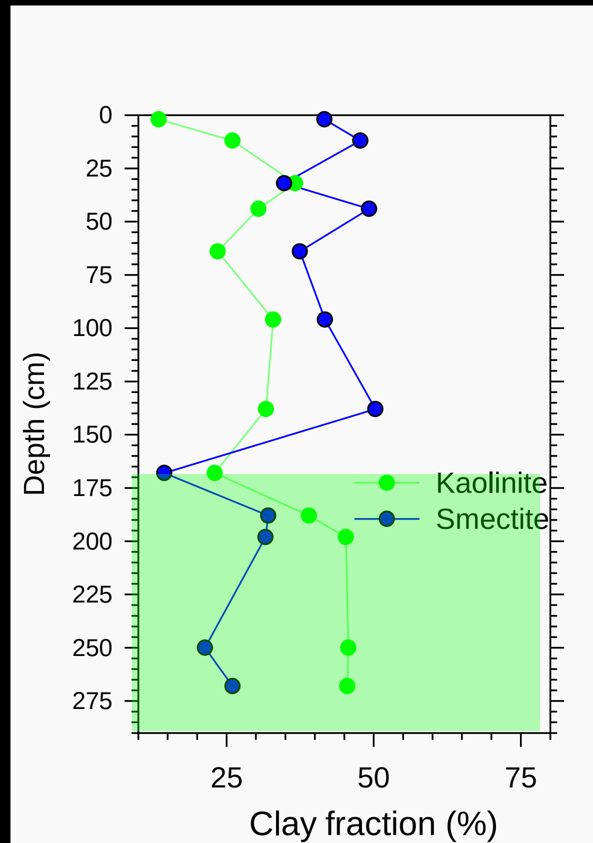
The mid-Holocene dry event

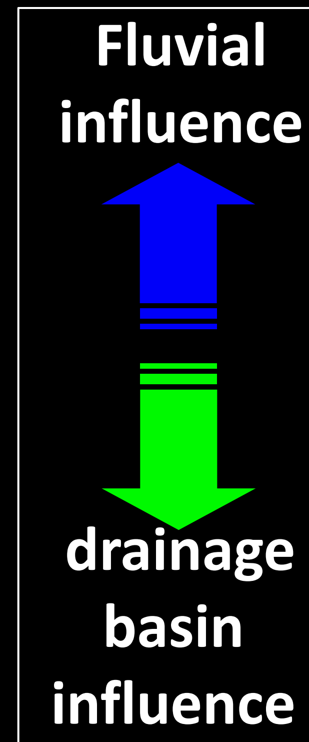
- The mid-Holocene dry event can be tracked from north to south in both the Andes and the Amazon lowlands (Bush et al., 2007).

The mid-Holocene dry event

And was also recorded in Santa Ninha and Maracá Lake

Lago Santa Ninha – dry period during the Middle Holocene (5600 – 3000 cal years BP)

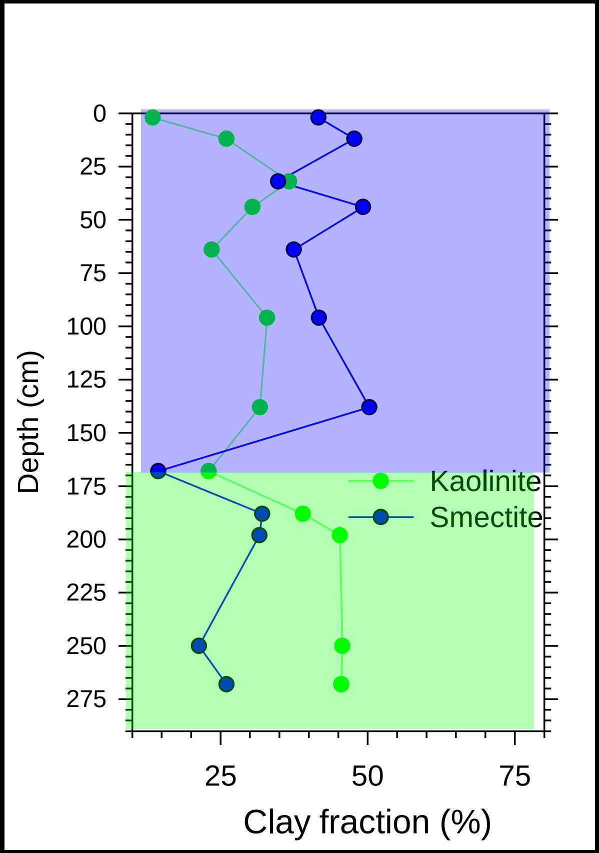


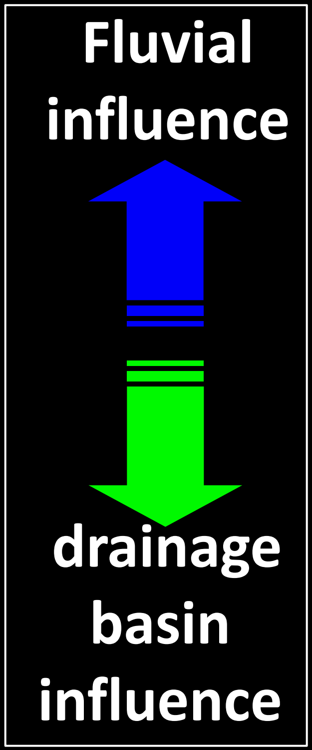


↓ smectite + ↑ Kaolinite

Santa Ninha lake –a reduced Amazon River inflow into this lake was evident

Lago Santa Ninha – humid phase during the Late Holocene (the last 3000 years cal BP)



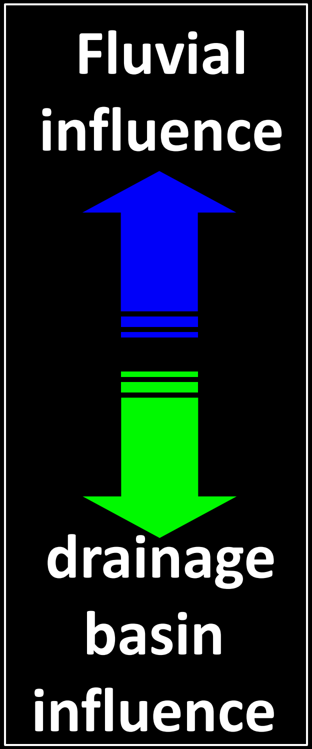


↓ Kaolinite; ↑ smectite

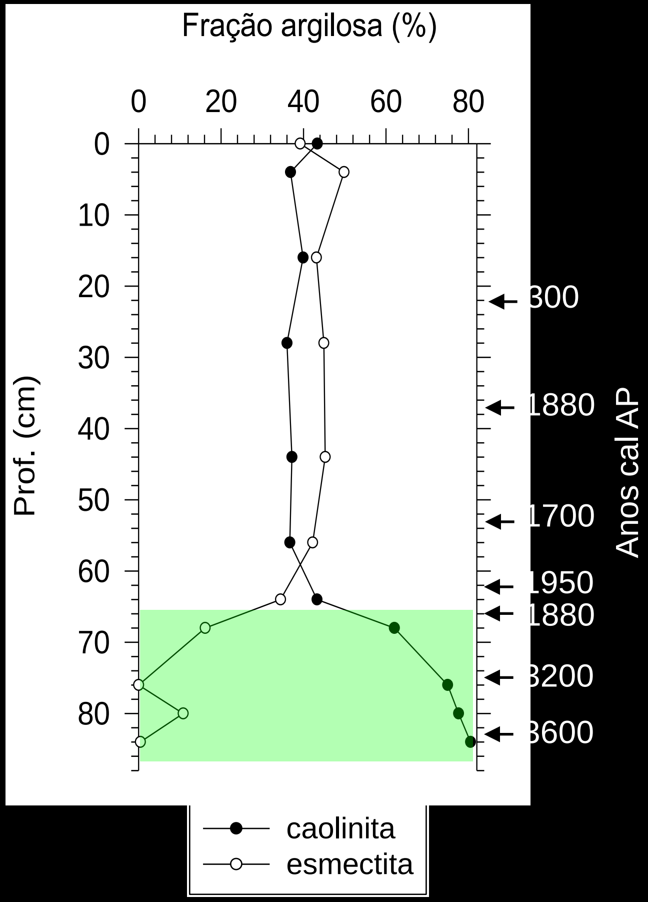
➡ an increase in Amazon River inflow

Lago Maracá – dry period in the Middle Holocene

3.600 a 2.700 cal years BP– kaolinite-rich sediments

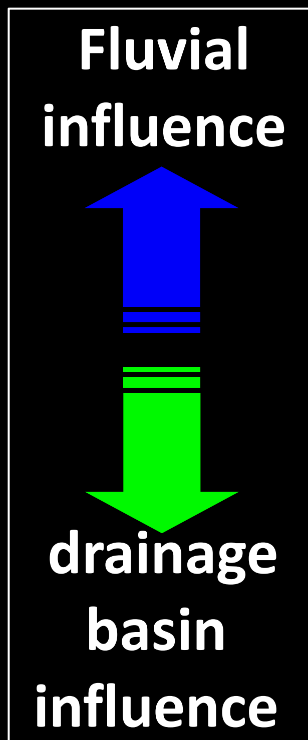


MAR2

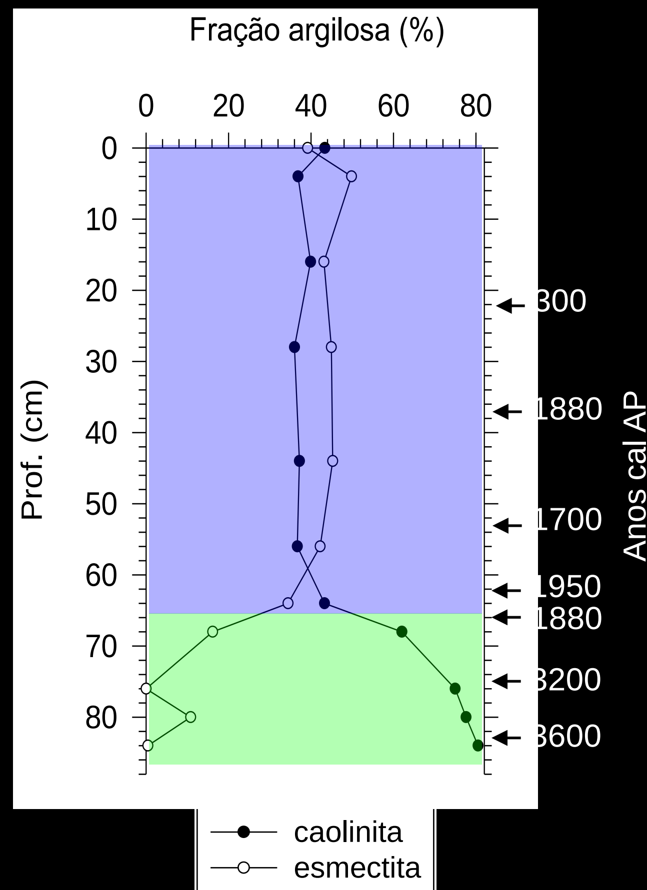


Lago Maracá – wet-Late Holocene

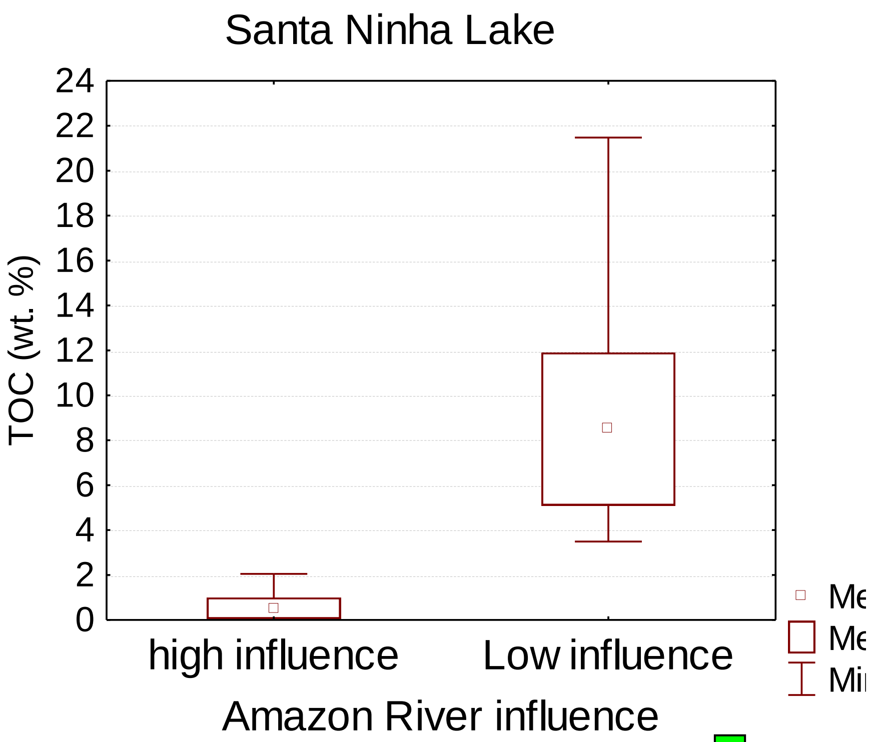
2.700 to present cal years BP– increased smectite content

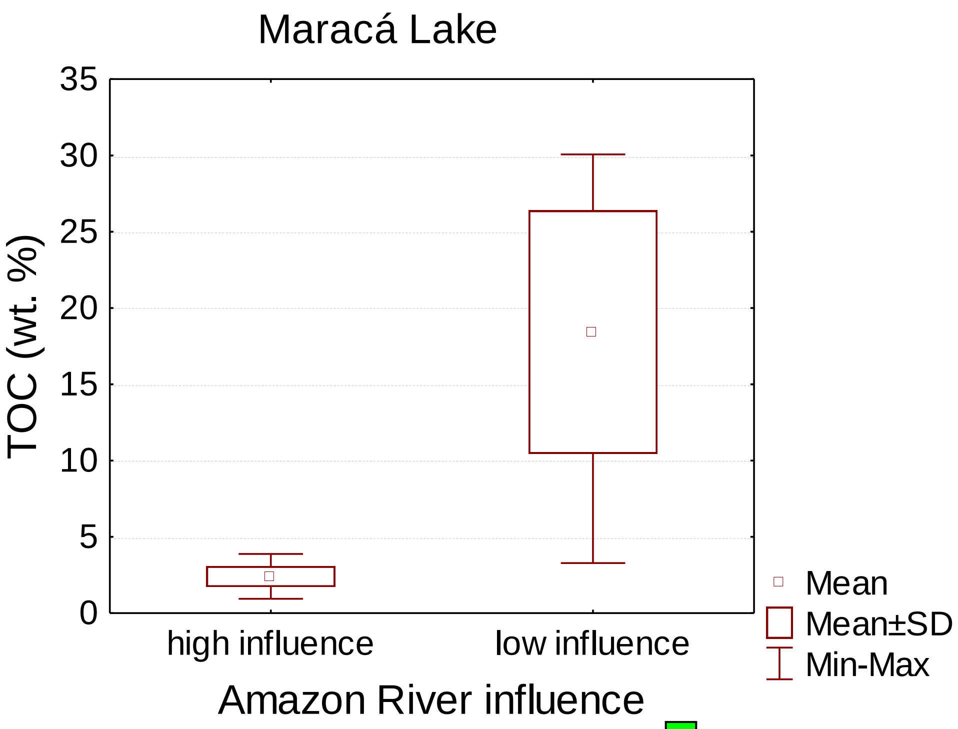


MAR2



What happens with the organic carbon content?

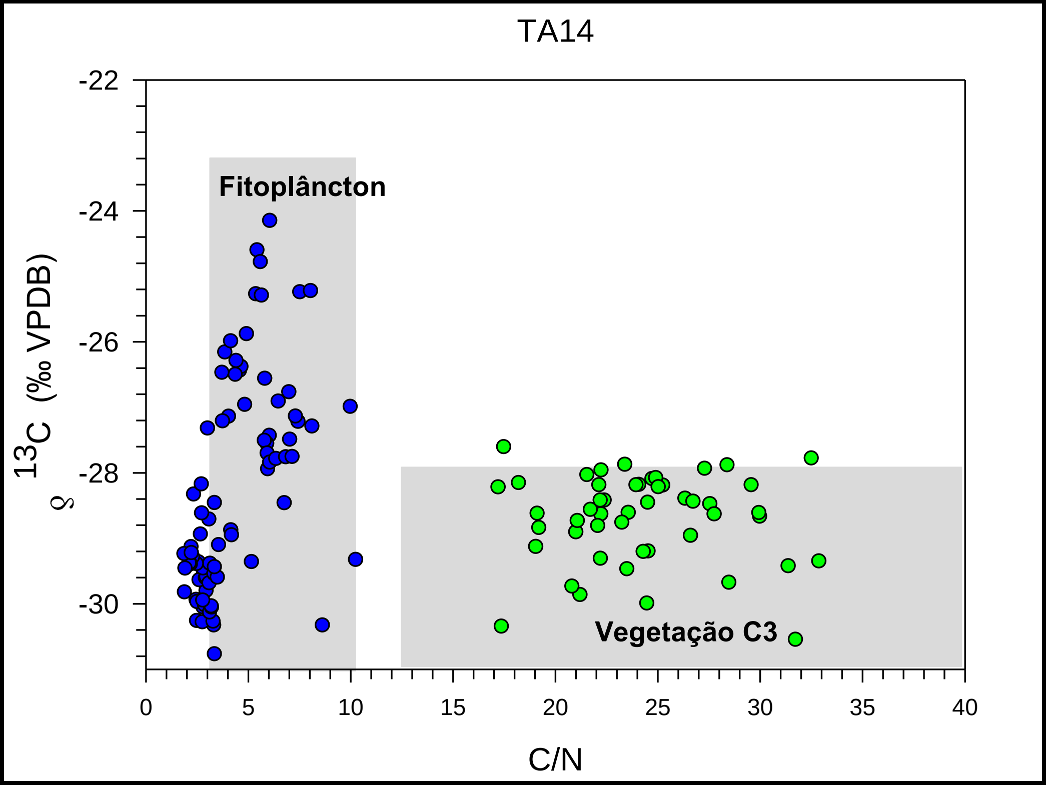




Due to a lesser contribution of clastic input that could dilute the organic matter produced in the lake

Source of the sedimentary organic matter

High river influence ⟵ ⟶ **low river influence**



A higher proportion of phytoplankton was observed during high river flows

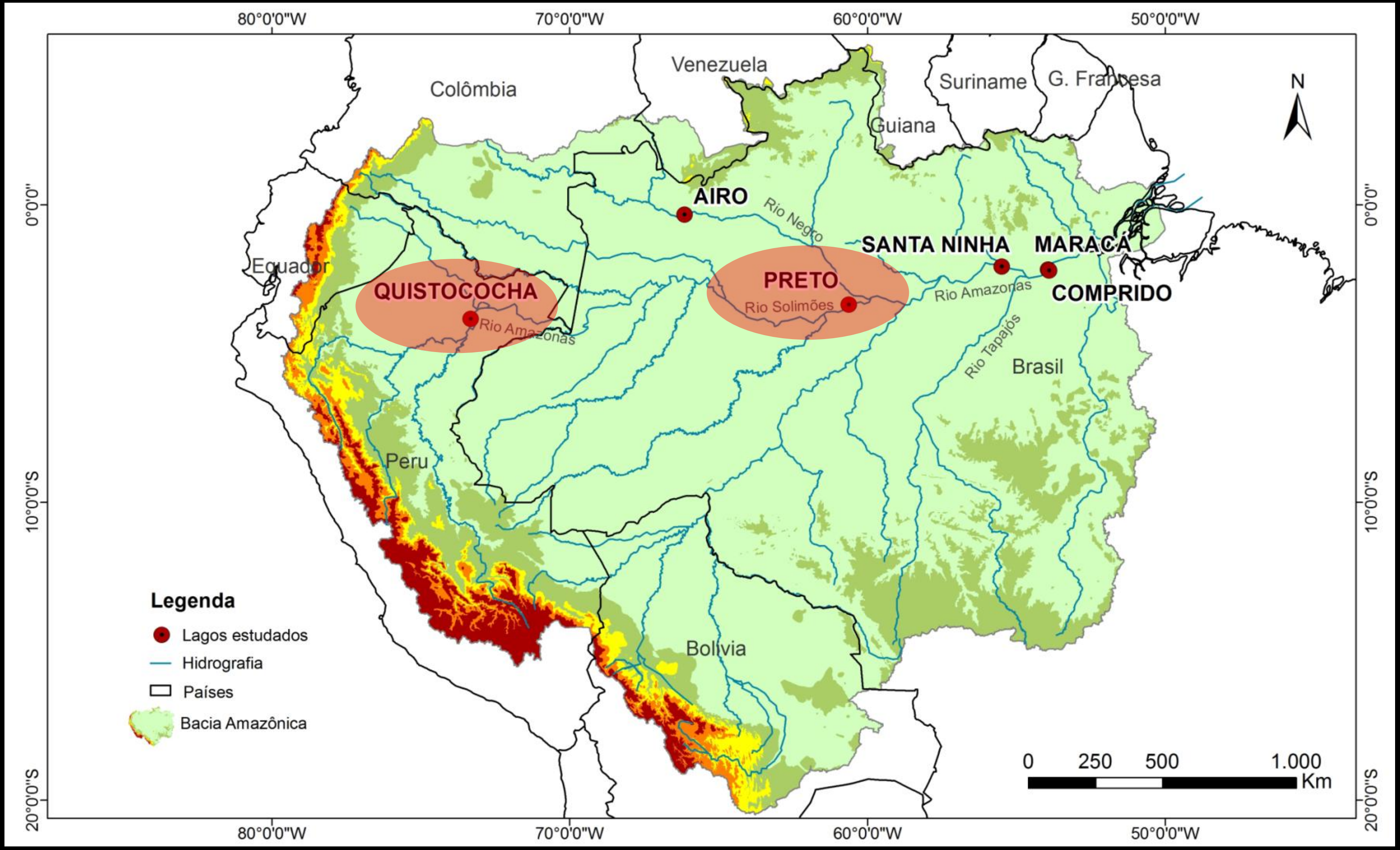
High contribution of C3-land plants carried from the drainage basin

the Santa Ninha and Maracá records show a consistent overall pattern of change to wetter climatic conditions from the middle to the late Holocene, in agreement with others paleoclimatic studies in the Amazon Basin

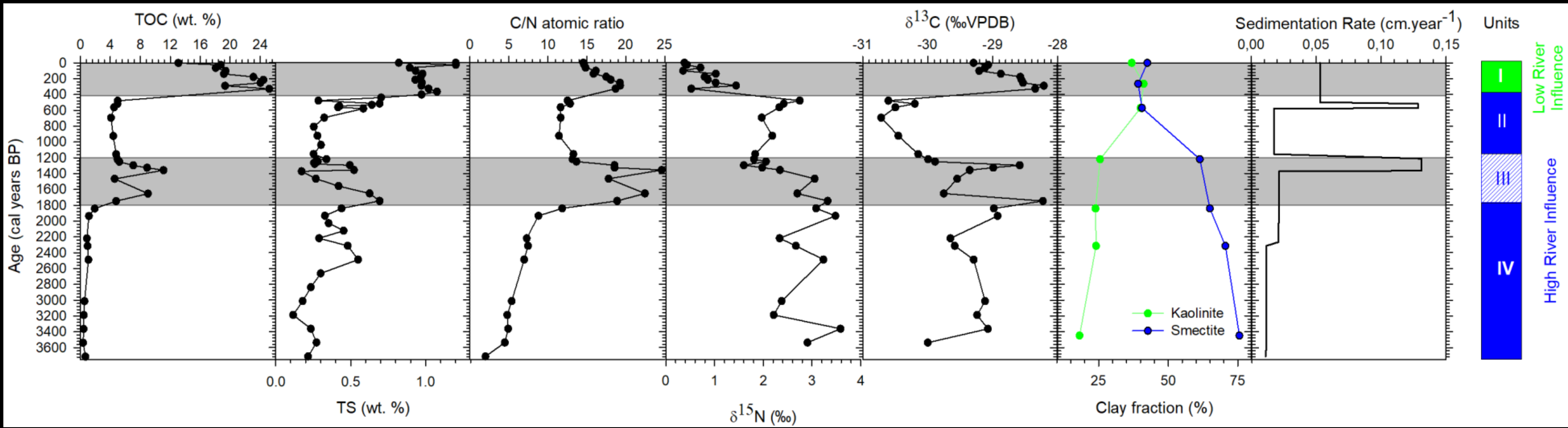
But in others floodplain lakes **the river influence** was not linked to paleoclimatic changes...

2- TOC content trend out of phase with paleoclimatic conditions

- Lago Preto and Quistococha



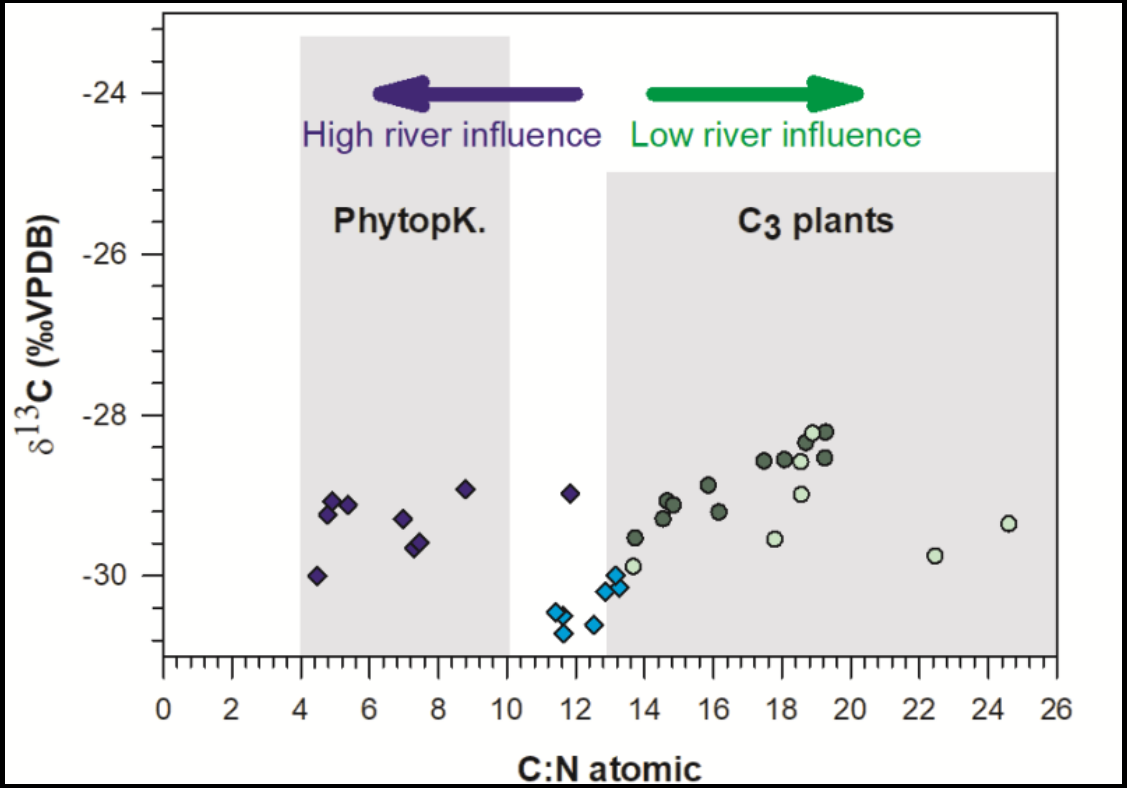
Preto lake



A reduced river inflow was observed in the **Late Holocene wet phase**

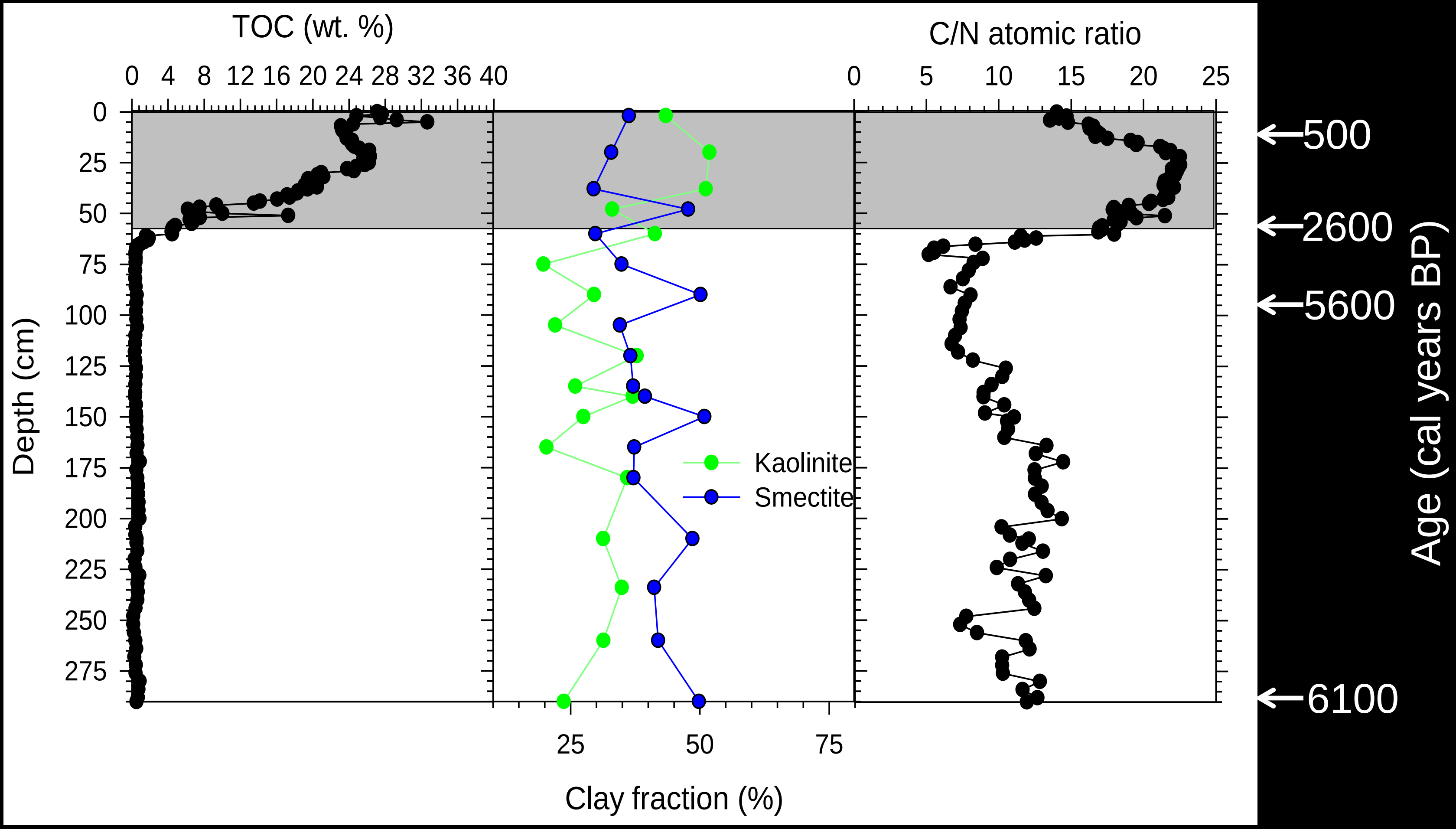
This reduced river inflow was also accompained by increased organic carbon content

A higher proportion of phytoplankton was observed during high river flows



High contribution of C3-land plants carried from the drainage basin

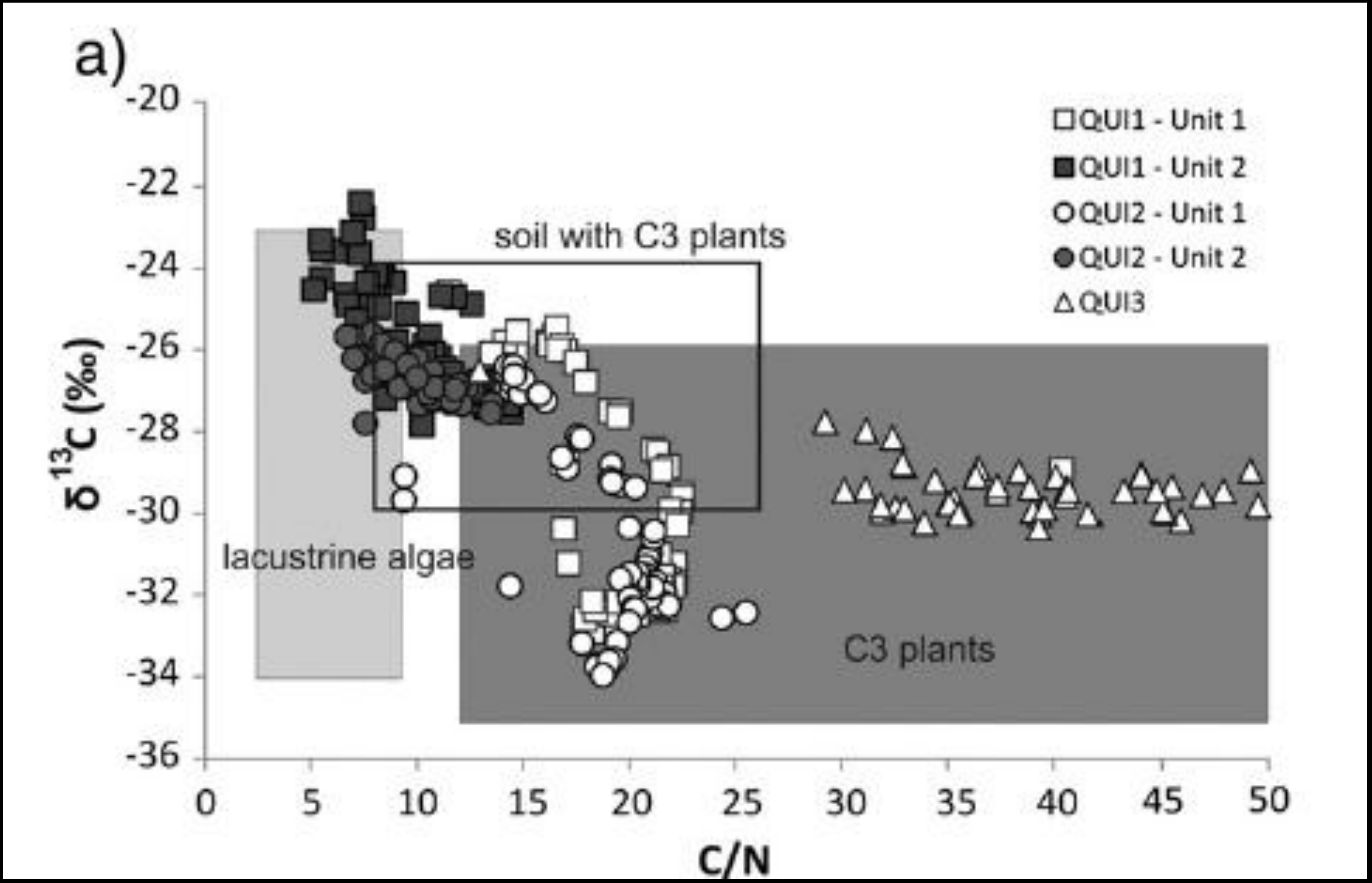
Quistococha lake

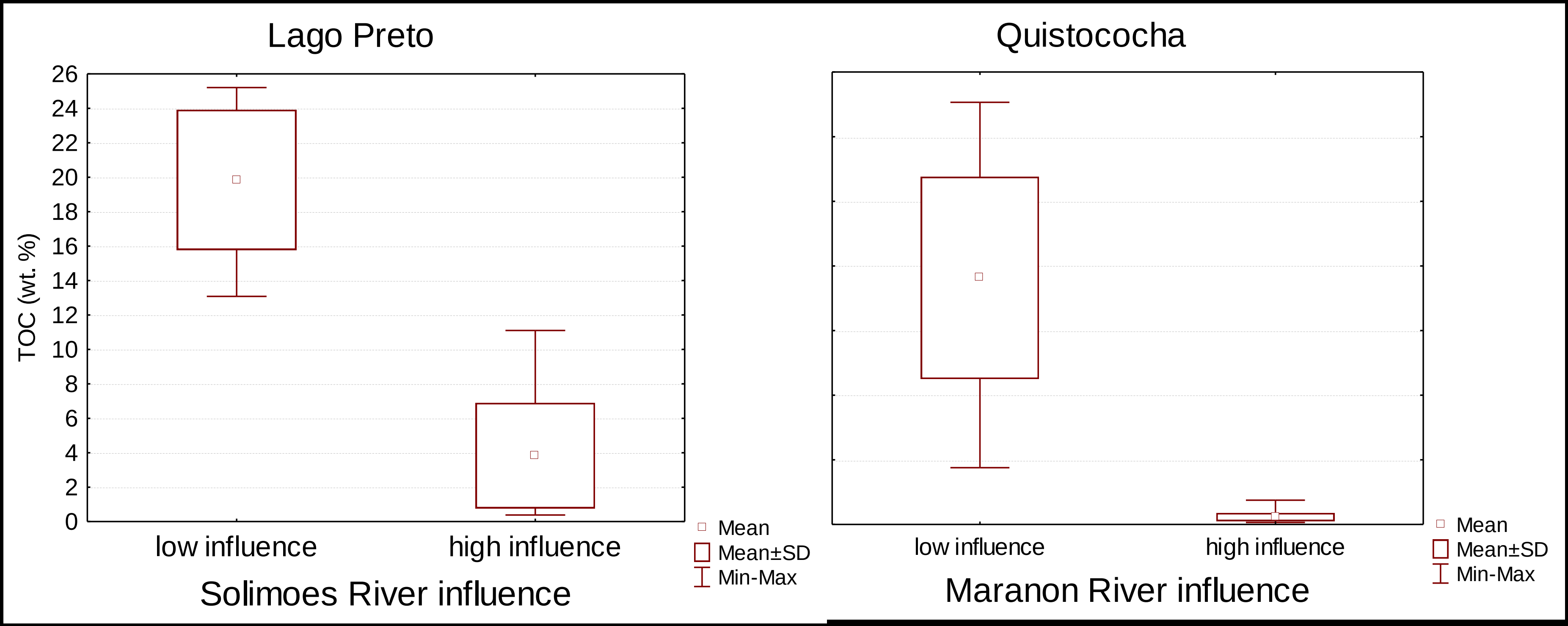


A kaolinite-rich sediment corresponds to a high organic carbon content

High river influence

low river influence



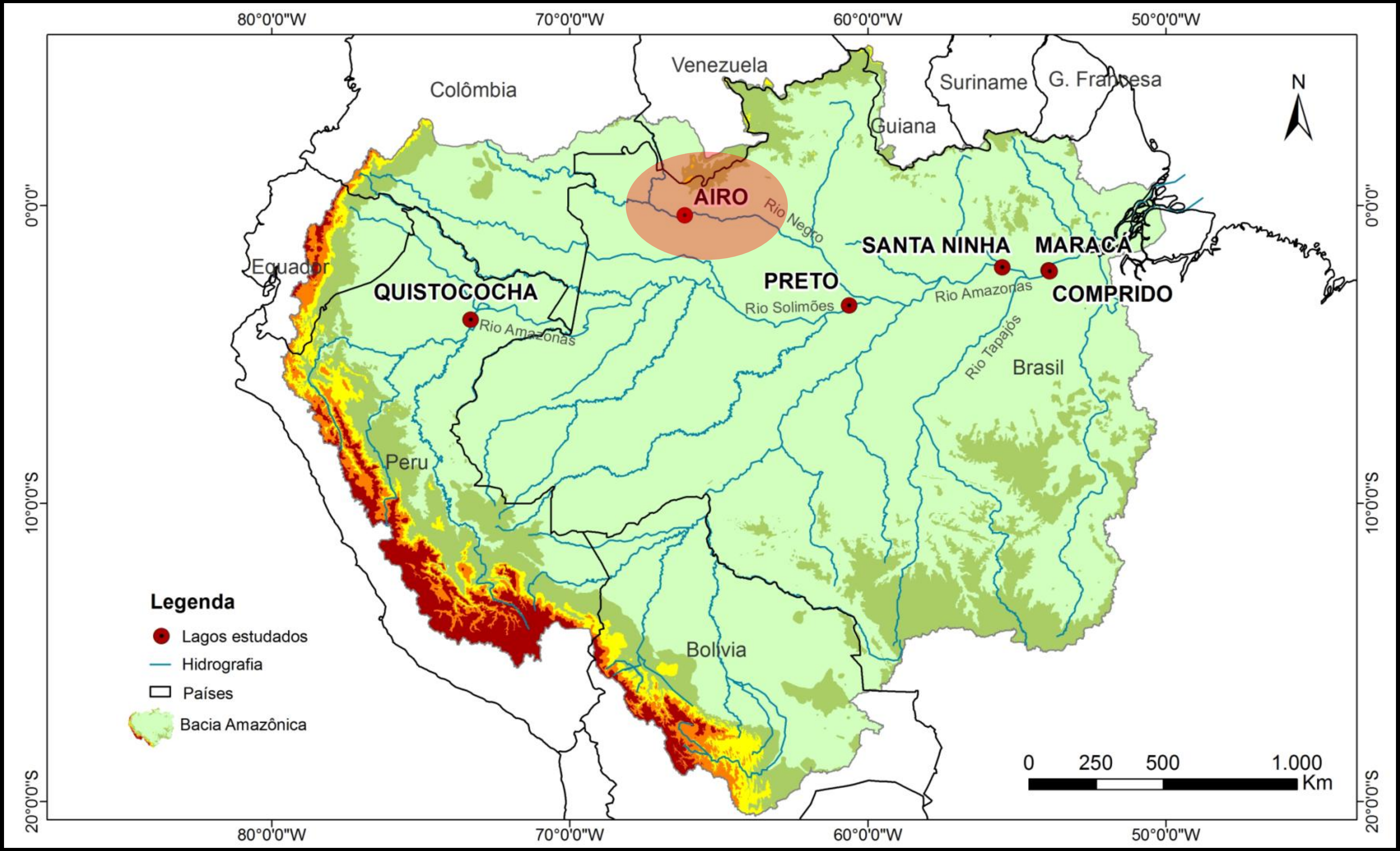

Lago Preto
TOC (wt. %)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
low influence
high influence
Solimoes River influence
Mean
Mean±SD
Min-Max
Quistococha
low influence
high influence
Maranon River influence
Mean
Mean±SD
Min-Max

Preto and Quistococha lakes

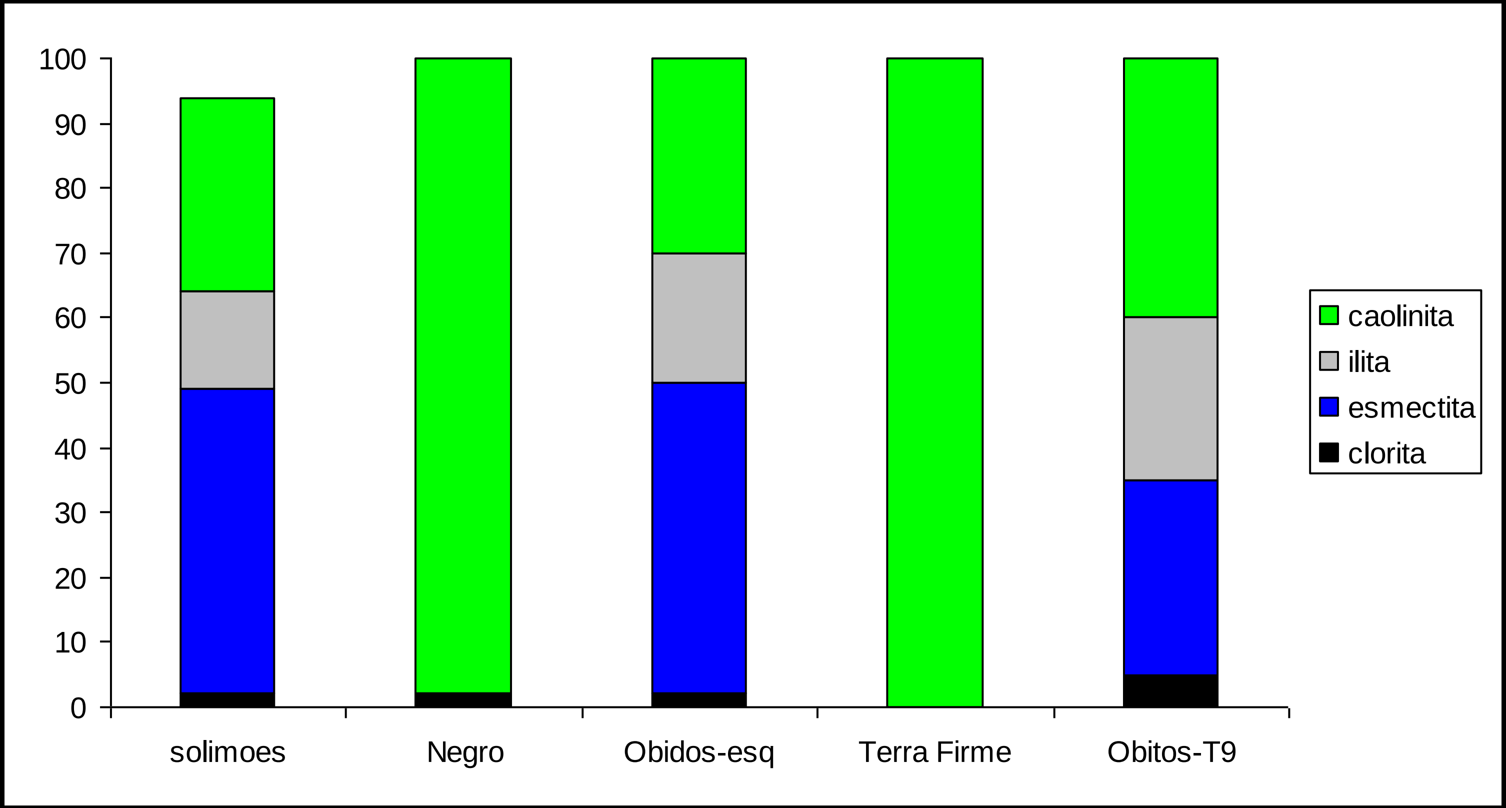
Process that influenced the transition from a high fluvial influence to a low river inflow?

Neotectonism?
Avulsion of the river?

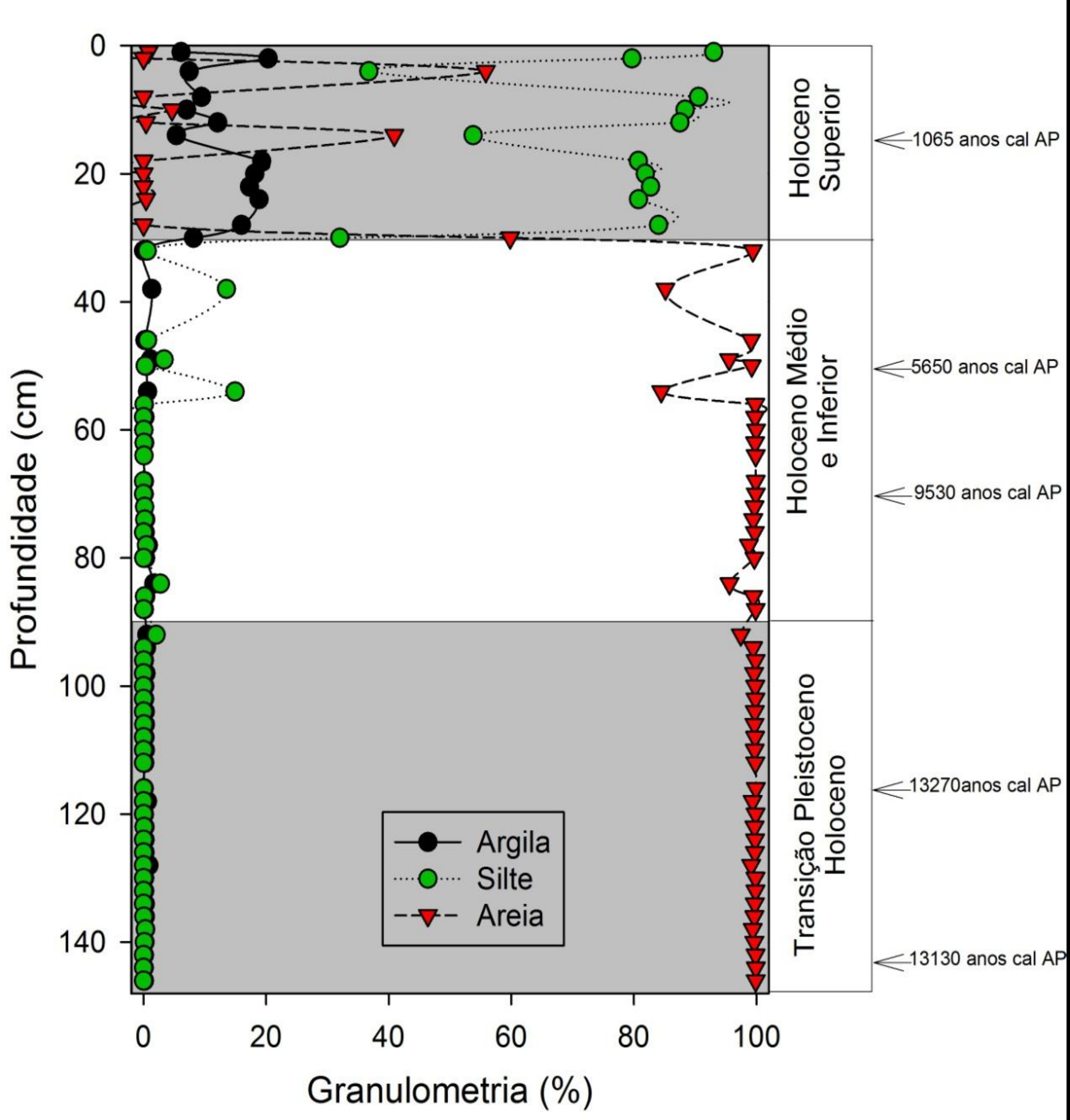
Negro River Basin – Airo Lake



- The main clay mineralogy of Negro River basin is kaolinite – smectite was not detected in our sediment core – *but this analysis is not finished...*



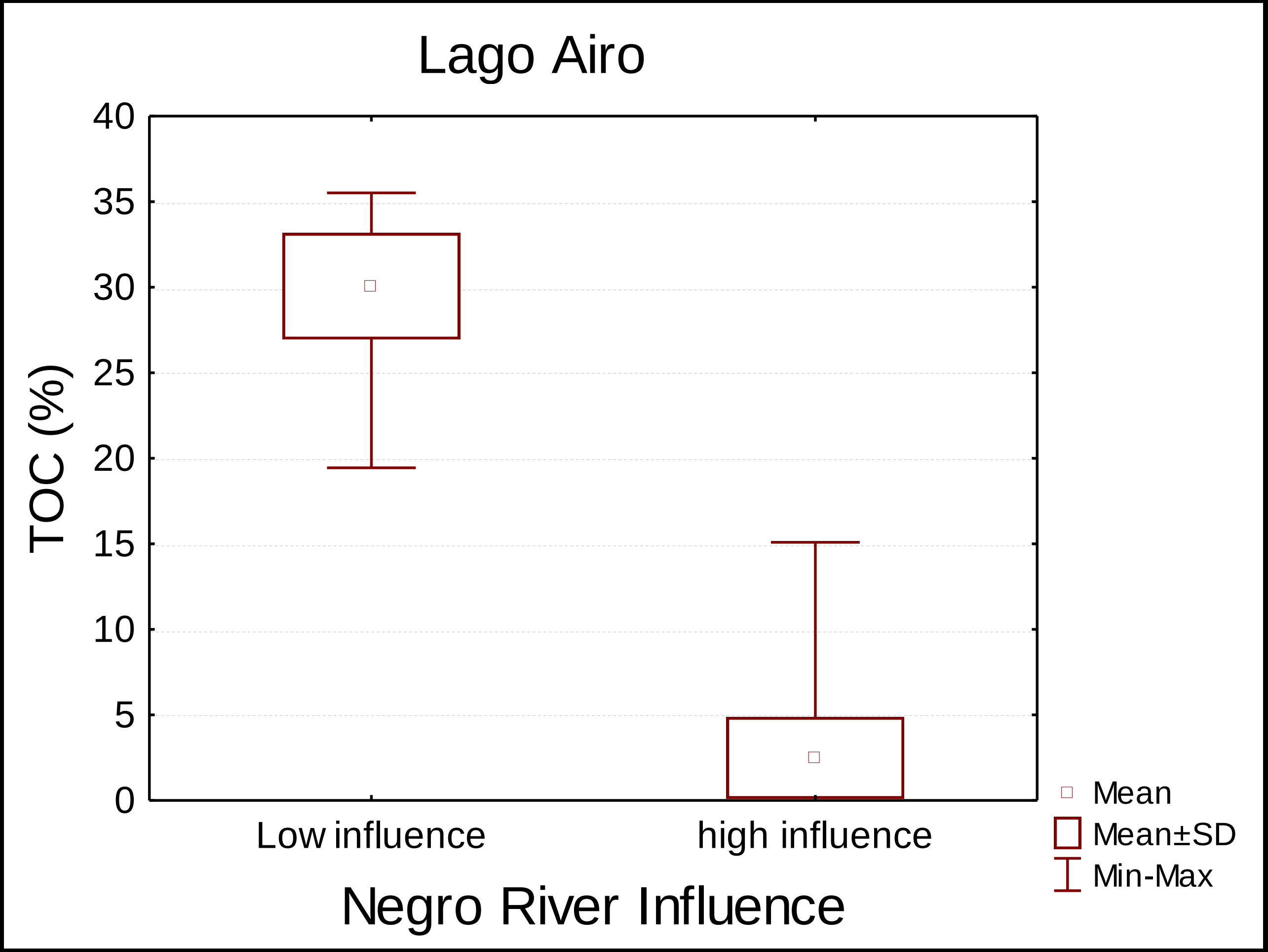
Grain-size fractions can also help to identify the river influence



Reduced river inflow

Substantical reduction in the coarser sediments

Strong fluvial influence marked by the deposition of coarser sediments



Lago Airo
40
35
30
25
20
15
10
5
0
TOC (%)
Low influence
high influence
Negro River Influence
Mean
Mean±SD
Min-Max

Conclusions

- The paleohydrological changes of the Solimoes, Amazon and Negro river strongly affect the floodplain lakes sedimentary process;

- The sedimentary organic carbon content was strongly affected by the variations in the fluvial sediment supply to the floodplain lakes:

    - high fluvial sediment supply – low organic carbon contents due to a clastic dilution of the organic matter produced in the lake

    - low fluvial influence – high carbon content

Conclusions

The source of sedimentary OM was also influenced by the river hydrodinamic changes

- high fluvial sediment supply – high contribution of phytoplancton to the sedimentary organic matter pool

- low fluvial influence – large proportion of C3-land plants

Thanks
merci
obrigada