Nutrient dynamics in nested catchments at nested time scales:

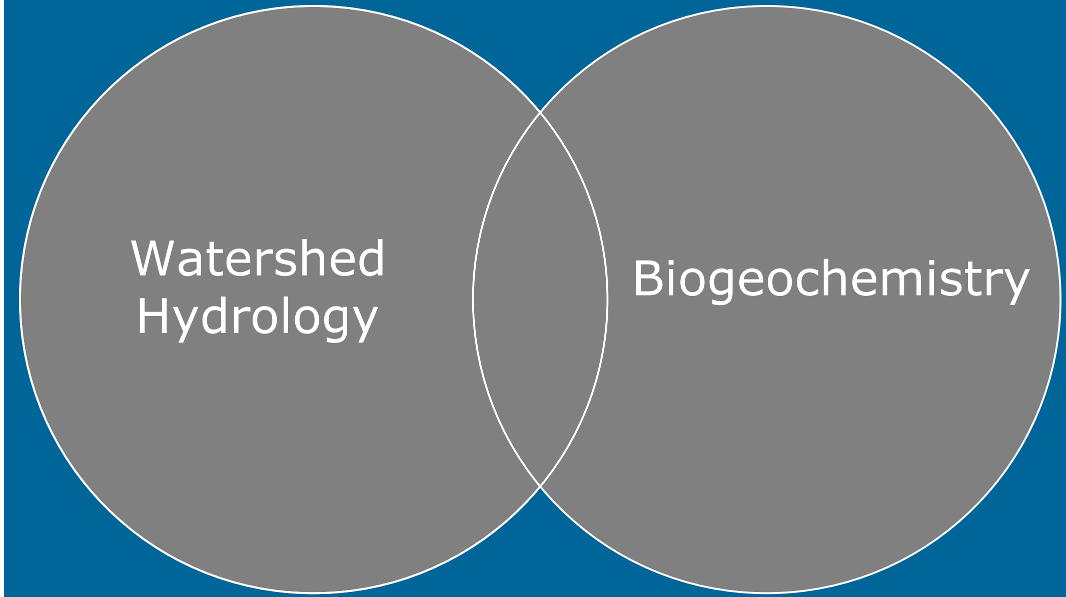
Trends from 1st and 2nd order watersheds in the seasonally dry Southern Amazon

Mark S Johnson (Cornell University)
msj8@cornell.edu
Eduardo Guimarães Couto (UFMT)
Johannes Lehmann (Cornell University)
Susan J Riha (Cornell University)

10th LBA-ECO Science Team Meeting, Brasilia
October 4, 2006

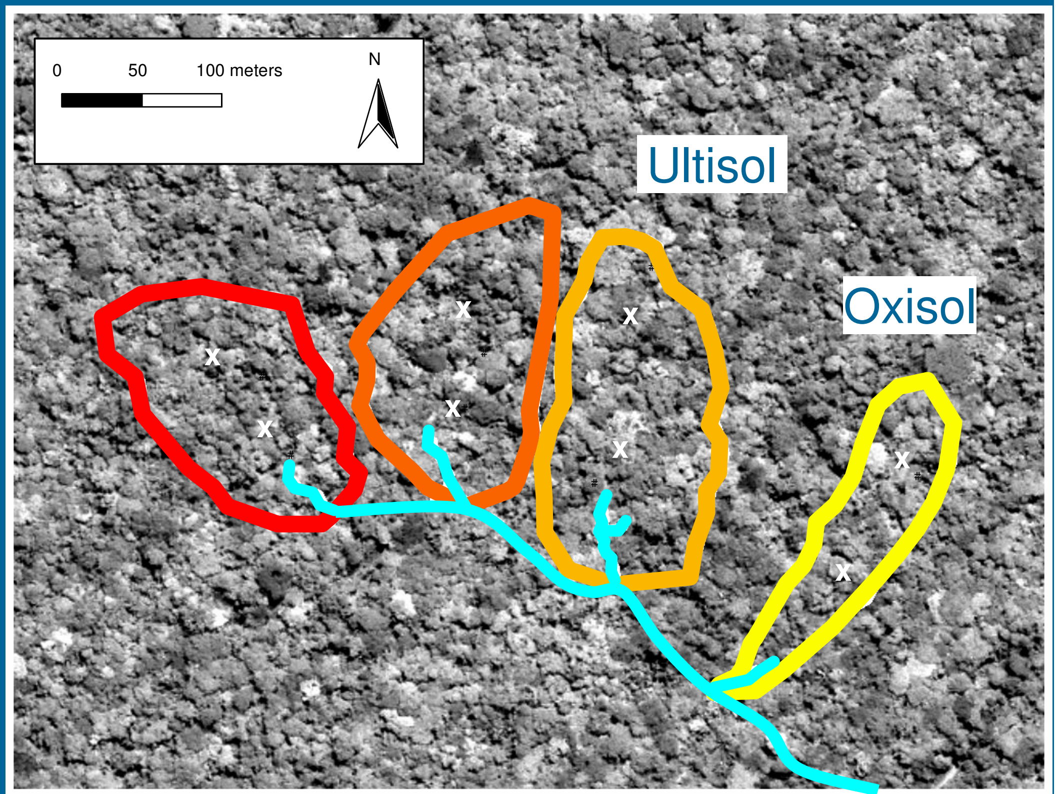
Thematic research area

- Terrestrial-aquatic interface



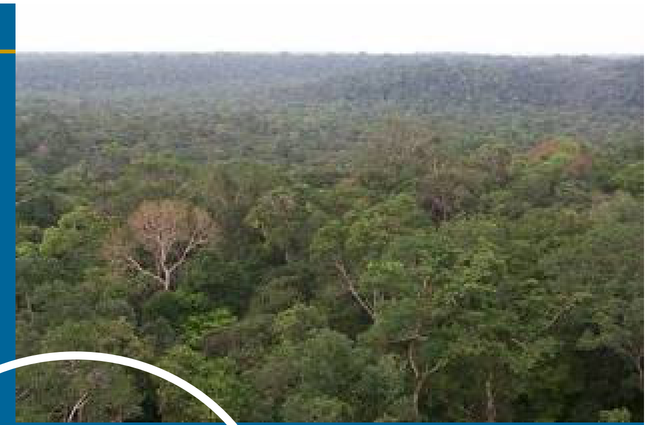
Site Description

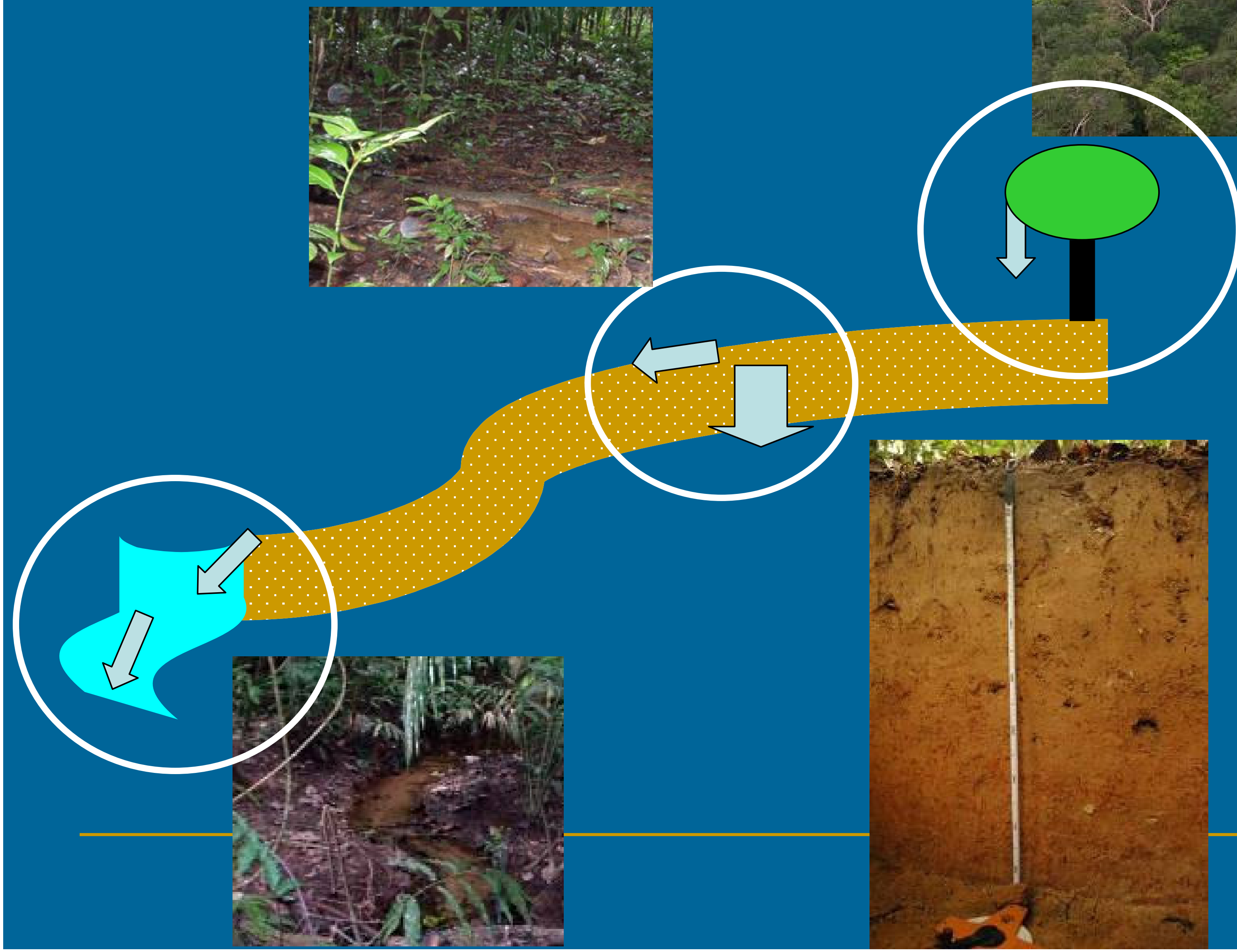
Juruena, Mato Grosso



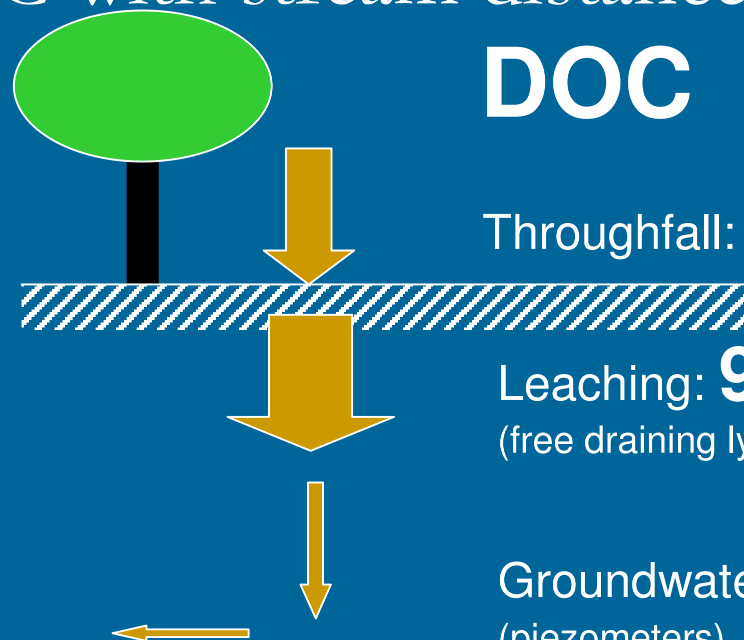
IKONOS Panchromatic Image
(Courtesy EOS-Webster)

Flowpaths and transformations





Decreasing DOC with soil depth
Increasing DOC with stream distance



DOC

Throughfall: **13.8** ±1.5 mg L^{-1} (N=187

Leaching: **9.2** ±0.6 mg L^{-1} (N=64)
(free draining lysimeters at 0.1m depth)

Groundwater: **1.4** ±0.2 mg L^{-1} (N=64
(piezometers)

Springs: **0.5** ±0.03 mg L^{-1} (N=172)
(grab samples)

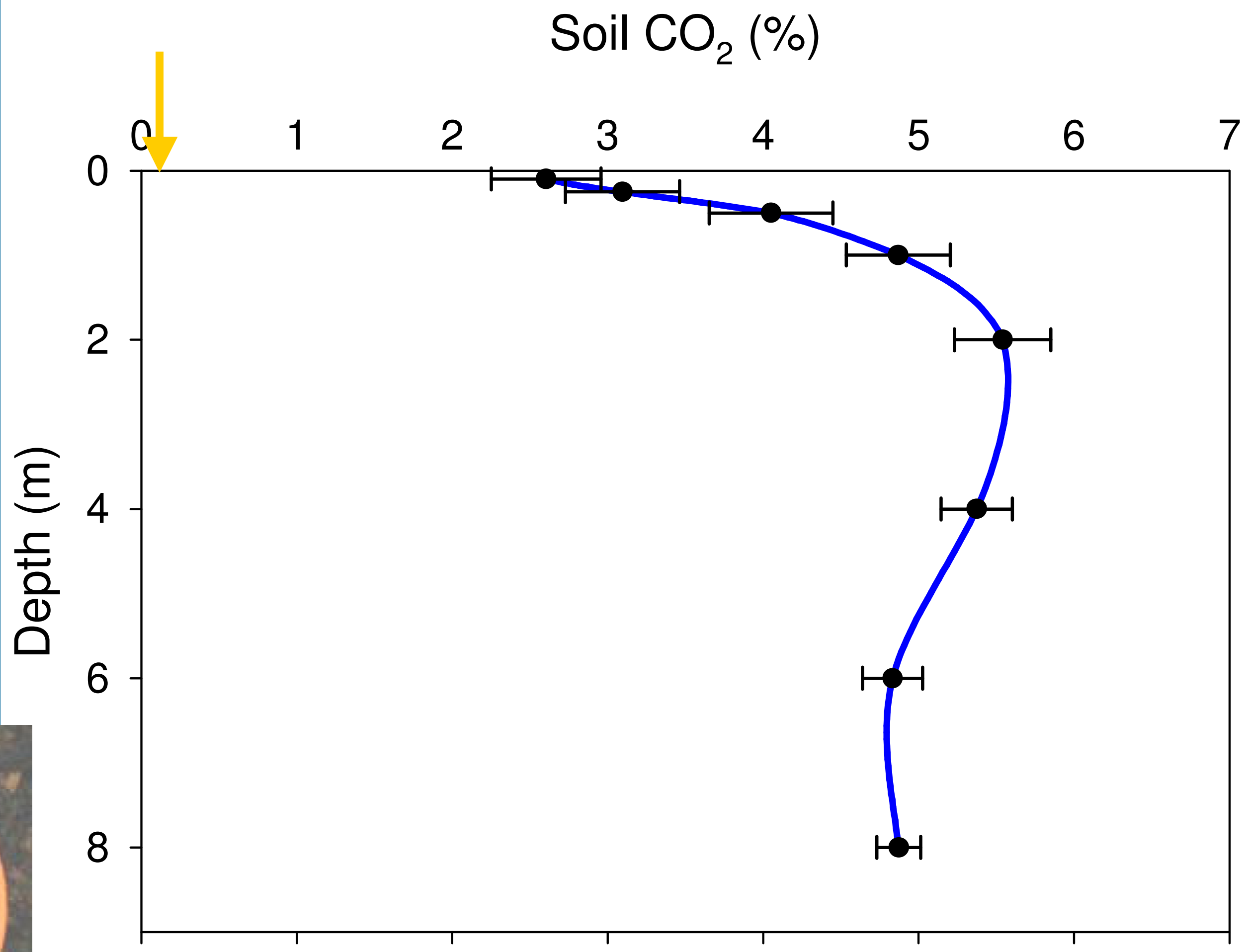
1st order streams:
2.3 ±0.1 mg L^{-1} (N=311)
(grab samples, 50m from spring)

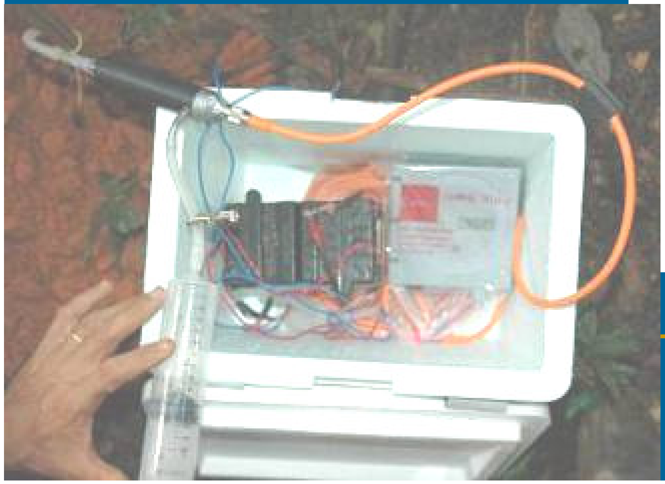
2nd order stream:
3.7 ±0.3 mg L^{-1} (N=75)
(grab samples, 2500m from spring)

Johnson et al.,
Hydrological Processes,
Biogeochemistry

Soil CO_2 profile

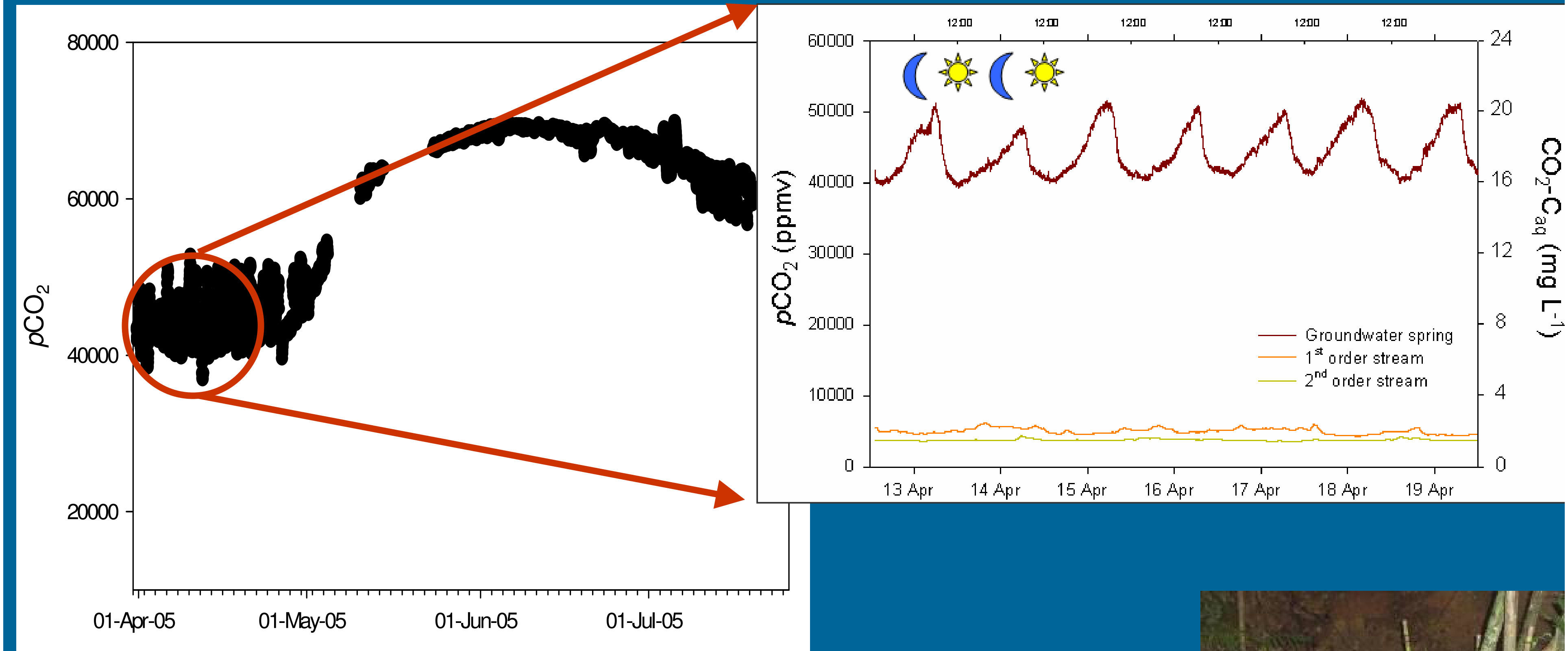
Atmospheric CO_2
(~400 ppm = 0.04%)



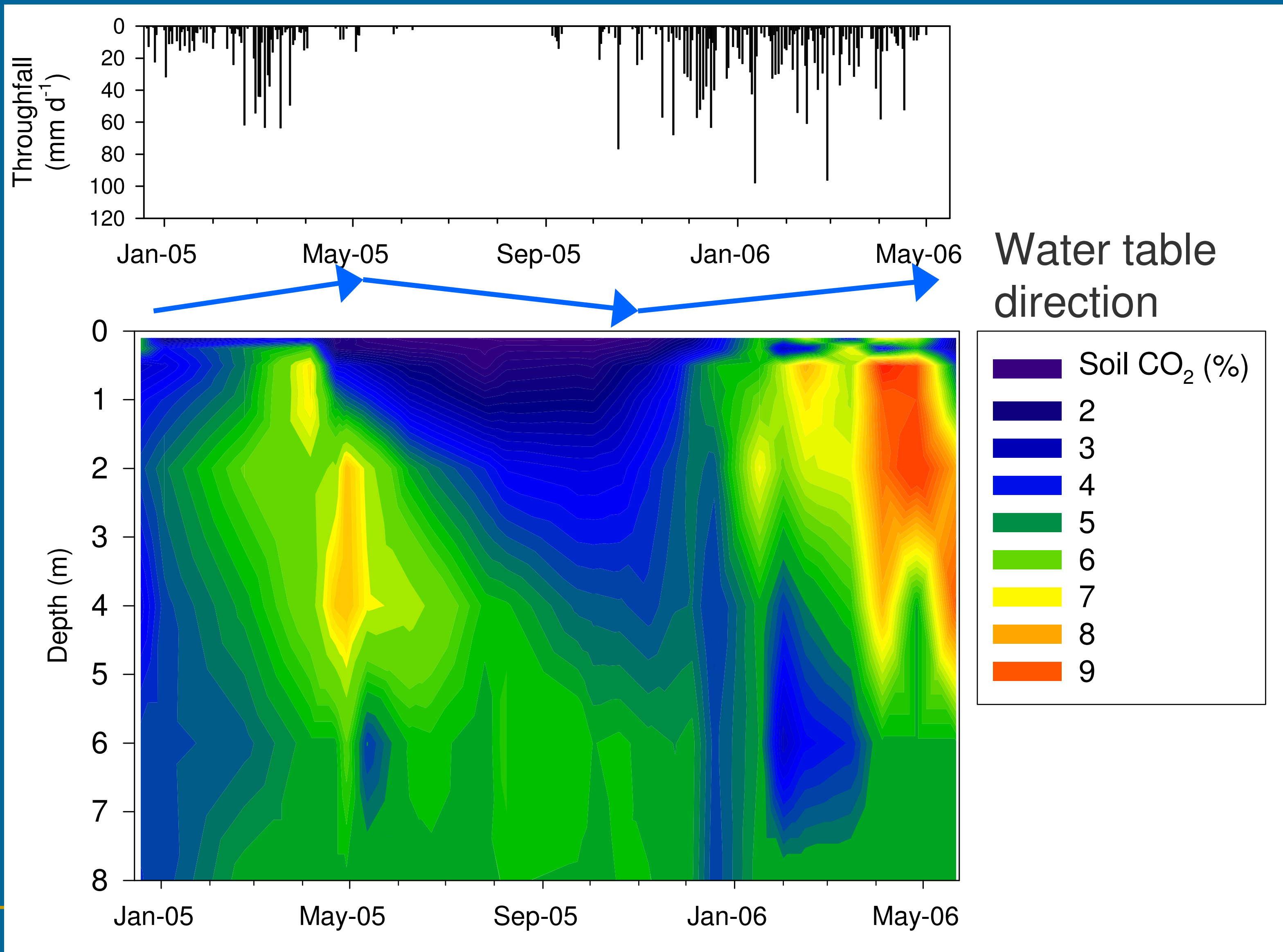


mean ± 1 SE
(N = 35 readings per depth)

CO_2 Fluxo do sistema terrestre à aquática

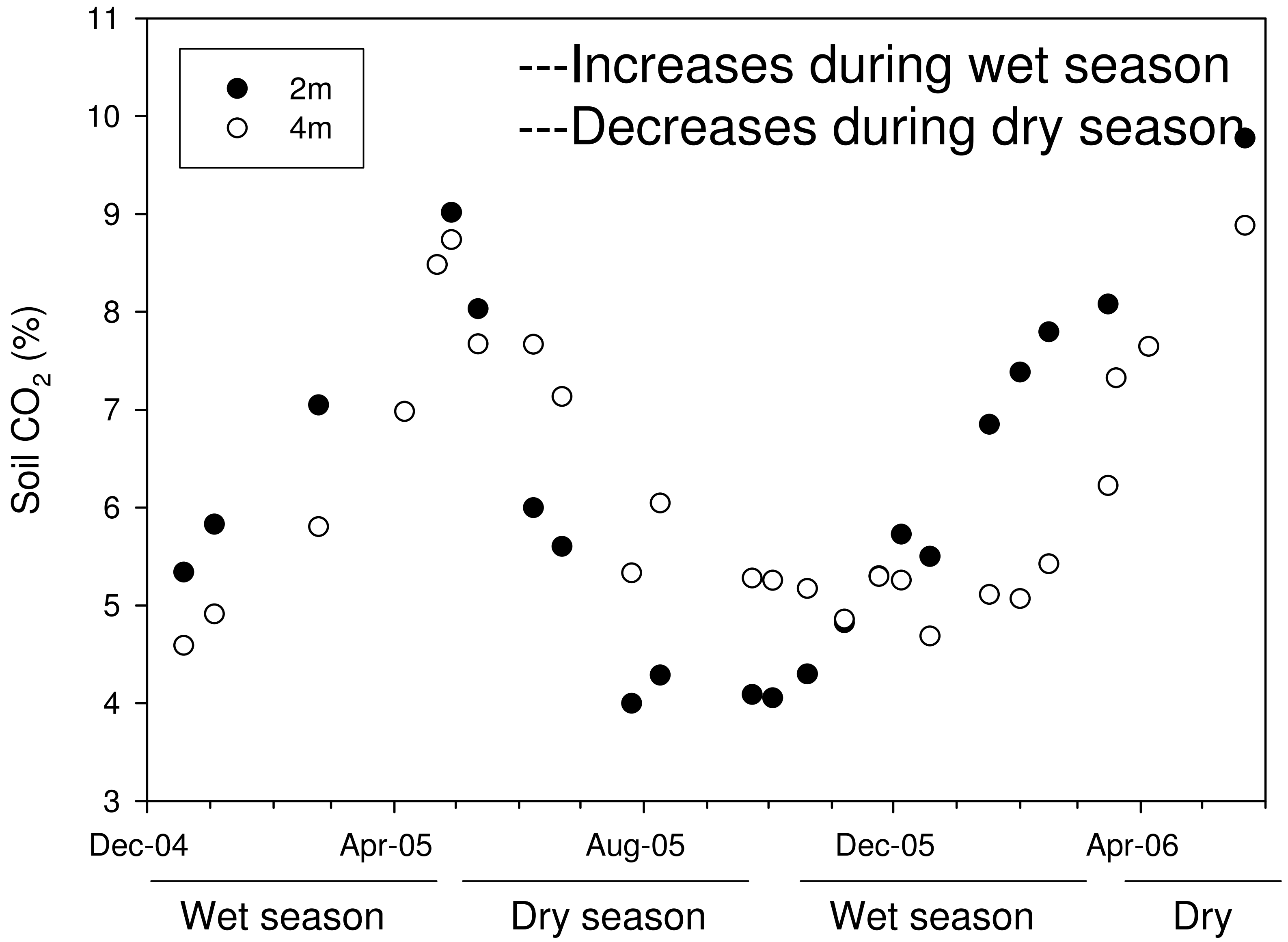


Soil CO_2 responds at seasonal scale

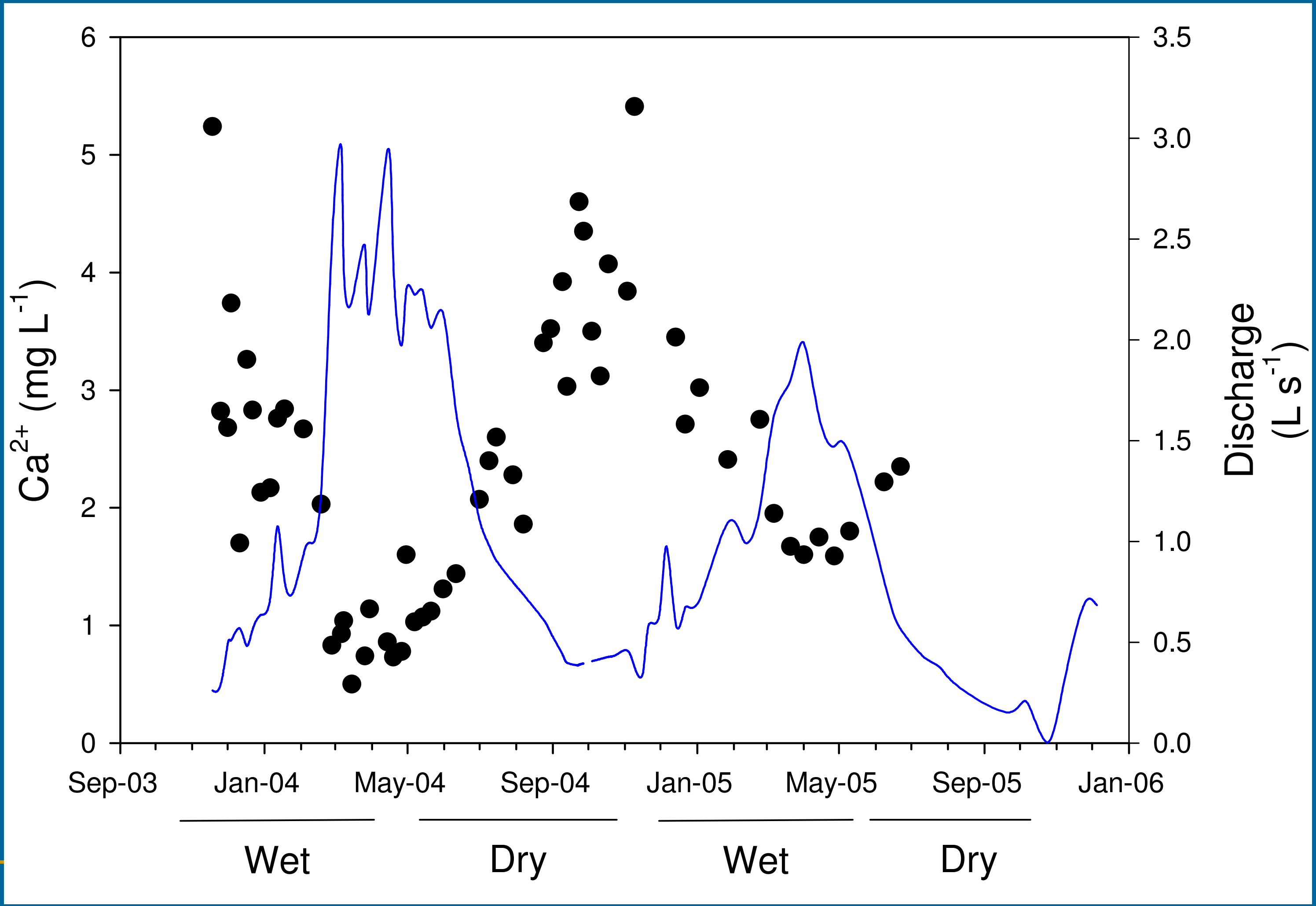


Data is mean of two profiles

CO_2 dyamics in deep soil profile



Cations in streamwater inversely related to discharge (*and* to soil CO_2)

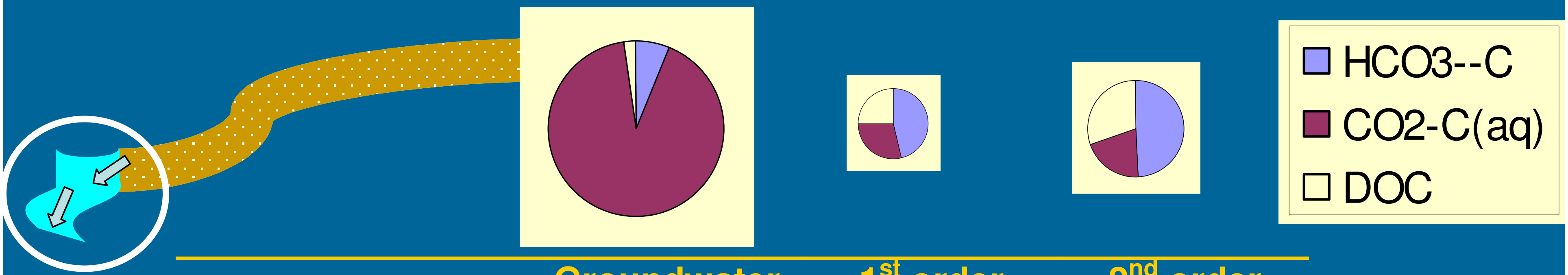


Aggregating and disaggregating the data

- surface water at nested spatial scales
- water quality parameters at various temporal scales

- What are the interactions and trends?

In-stream processes at baseflow: C cycle



	Groundwater springs	1st order streams	2nd order stream
pH	**4.65** ± 0.02 (142)	**6.05** ± 0.03 (296)	**6.41** ± 0.06 (61)
CO_2-C(aq) (mg L^{-1})	**20.65** ± 0.61 (52)	**2.58** ± 0.16 (85)	**2.50** ± 0.20 (21)
HCO_3^--C (mg L^{-1})	**1.47** ± 0.06 (144)	**4.13** ± 0.29 (237)	**6.00** ± 0.31 (57)
DOC (mg L^{-1})	**0.48** ± 0.03 (172)	**2.25** ± 0.14 (311)	**3.72** ± 0.28 (75)

mean ± 1 SE
(N=number of samples)

Pooled data from four springs, four 1st order streams, and one 2nd order stream

In-stream processes at baseflow

	Groundwater springs	1^{st} order streams	2^{nd} order stream
EC (µS cm^{-1})	**18.74** ± 1.04 (164)	**48.83** ± 1.65 (298)	**72.28** ± 3.54 (67)
Na (mg L^{-1})	**0.93** ± 0.04 (136)	**2.21** ± 0.08 (236)	**4.53** ± 0.47 (57)
K (mg L^{-1})	**1.51** ± 0.03 (133)	**2.51** ± 0.09 (236)	**4.87** ± 0.65 (57)
Mg (mg L^{-1})	**0.59** ± 0.02 (134)	**1.30** ± 0.04 (236)	**2.97** ± 0.29 (57)
Ca (mg L^{-1})	**0.46** ± 0.03 (134)	**2.01** ± 0.08 (236)	**4.40** ± 0.35 (57)
SiO_2 (mg L^{-1})	**6.01** ± 0.34 (127)	**16.82** ± 0.66 (213)	**26.79** ± 1.59 (51)

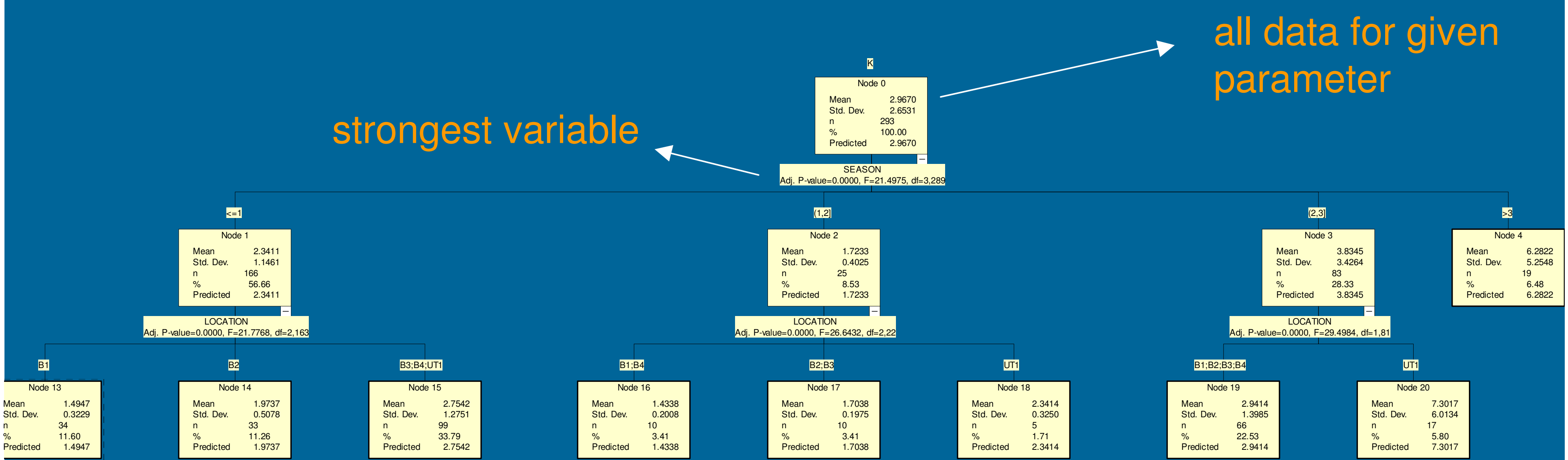
mean ± 1 SE
(N=number of samples)

Pooled data from four springs, four 1^{st} order streams, and one 2^{nd} order stream

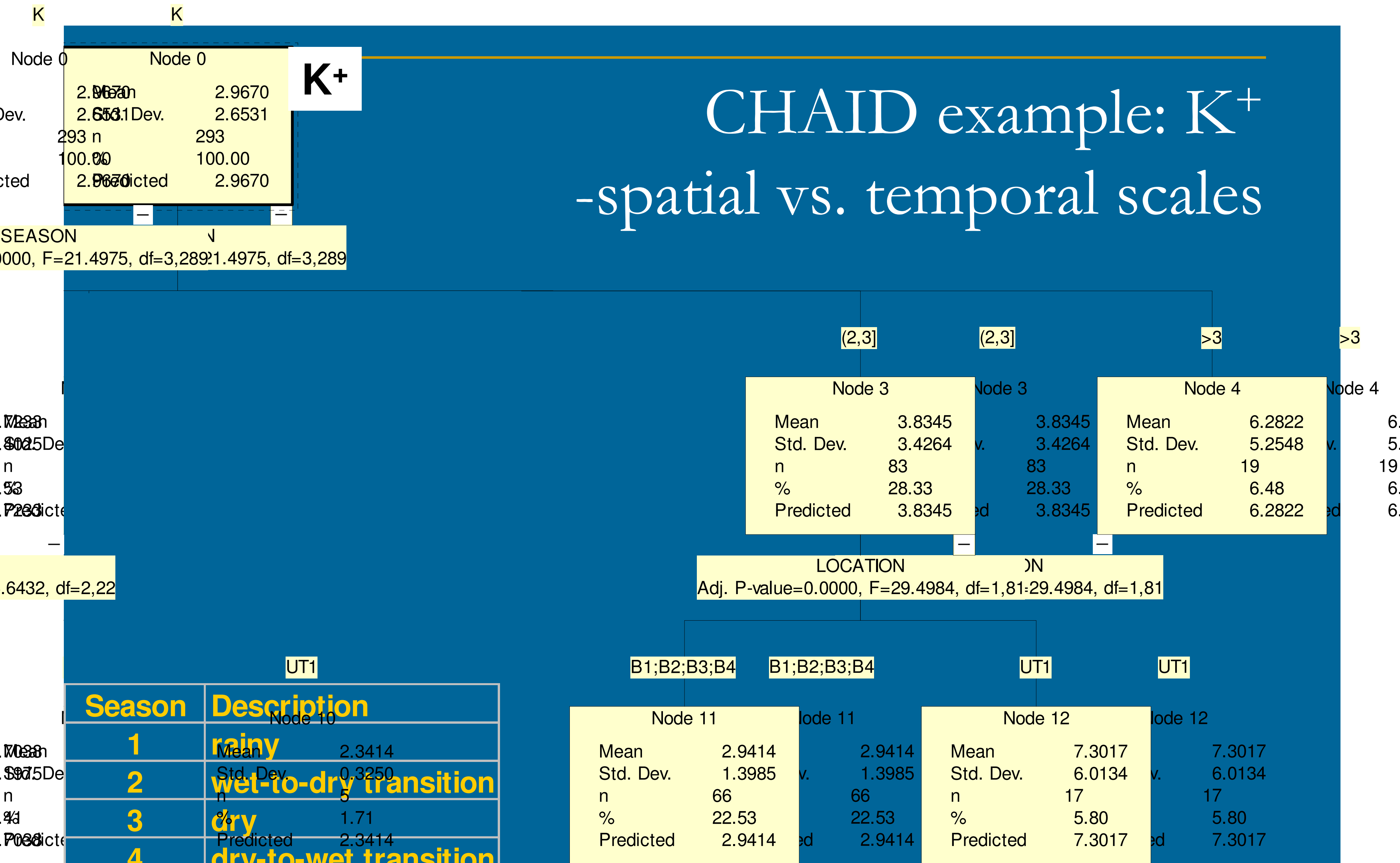
Data exploration in CHAID

(Chi-squared Automatic Interaction Detection)

- Useful for swimming through data at multiple and/or nested spatial and temporal scales



CHAID example: K^+ -spatial vs. temporal scales

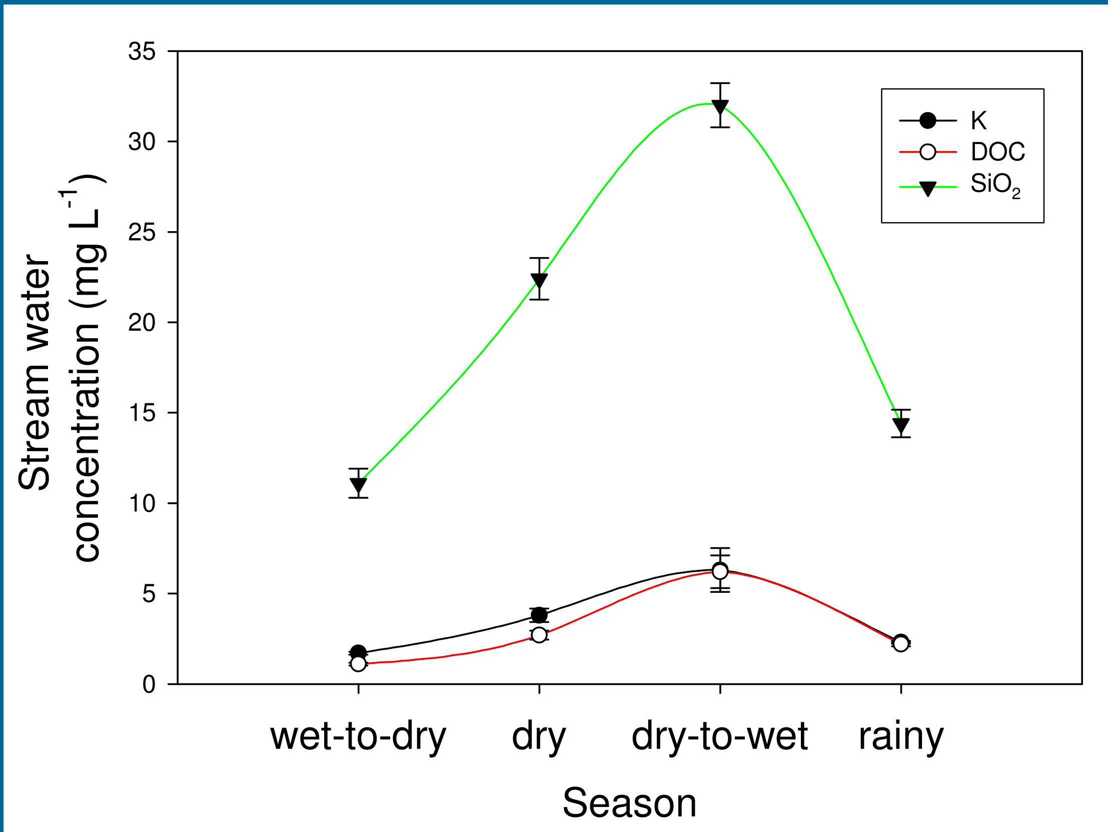


Season	Description
1	rainy
2	wet-to-dry transition
3	dry
4	dry-to-wet transition

CHAID analysis:

Biogeochemical cycles with significant biogenic *component*

- More strongly season-dependent than location-dependent
- Similar seasonal patterns exhibited
- only DOC and K positively related to discharge in storm flow

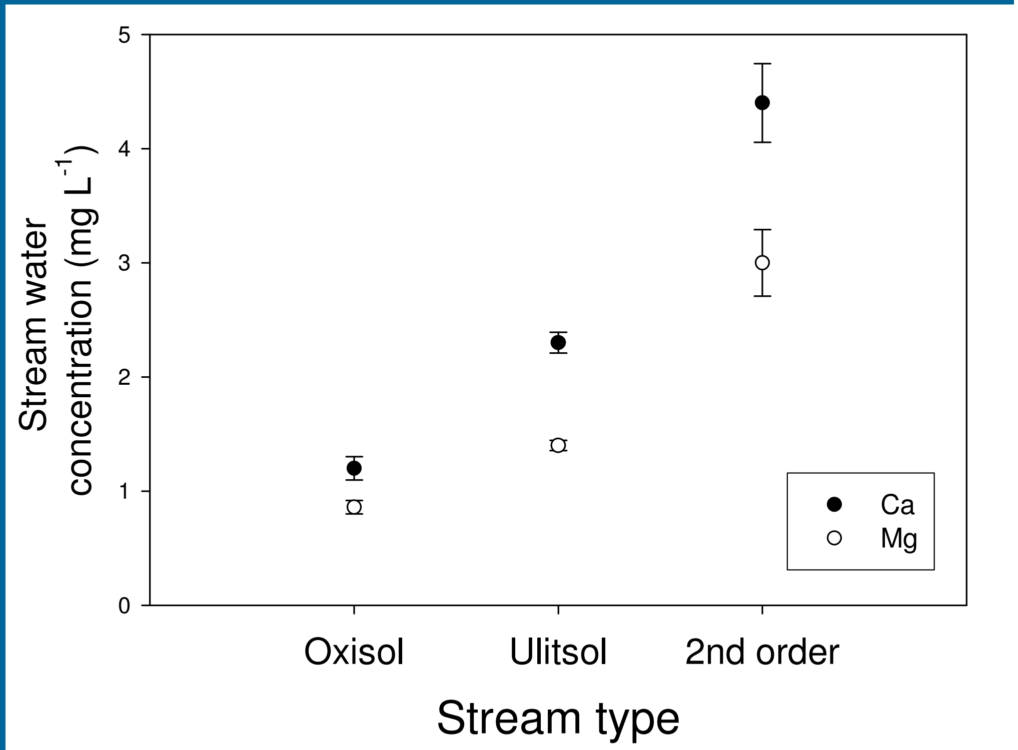


mean ± 1SE of n=5 streams (1st and 2nd order pooled)

CHAID analysis:

Biogeochemical cycles with predominantly geogenic *component*

- More strongly differs between locations rather than between seasons
- Higher concentrations for Ultisol than Oxisol in 1st order streams
- Concentrations increase longitudinally
  - 2nd order > 1st order streams > groundwater springs (not shown)



Summary

- Soil and vegetative processes linked to watershed fluxes
  - DOC mineralization + root respiration = CO_2 production and export
    - associated with seasonal trends in cation exports
- Transformations within streams occur at different spatial and temporal scales
  - CHAID useful for “investigating” data
    - Nutrient cycles with biogenic component varied by season
    - Other nutrients showed differences by soil type and stream order

Agradecimentos

- MCT pela liderança do LBA
  - equipe de LBA (no Brasil e nos EUA)
- Rohden Lígnea Ltda.
  - Apolinário Stuhler e todos os funcionários colaboradores
- Equipe do campo
  - Benedito Silveira de A.
  - Elielton A. da Souza
- O povo Juruenense

Cornell University

UFMT

UNIVERSIDADE FEDERAL DE MATO GROSSO

Thank you! Questions?

Extra slides

Stream Flow Response to Storms