Isotopic Estimation of Water Balance and Groundwater-Surface Water Interactions of Tropical Wetland Lakes in the Pantanal, Brazil

UNI FREIBURG

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HYDROLOGY

1. INTRODUCTION

The Pantanal is one of the largest and most pristine freshwater wetland in the world. During the rainy season, the floodplain is usually covered continuously with water, and the wetland acts like a large reservoir by storing surface and subsurface water for up to several years. During the dry season, smaller rivers and lakes dry up completely or are transformed to lentic water bodies. From this riverine floodplain system a large amount of potential runoff is evaporated due to the very mild relief and tropical climate. For the quantification of such water losses, water balance studies of lakes are fundamental.

2. OBJECTIVES

The objectives of this study were to identify the hydrological behaviour of different water bodies in the Pantanal dry season and to understand the hydrological functioning of tropical floodplain lakes. The components of the water balance of different lakes were determined on the basis of stable water isotopes and chloride concentrations in order to assess the whole water budget and to contribute to the knowledge about groundwater-surface water interactions in the Pantanal.

3. METHODS

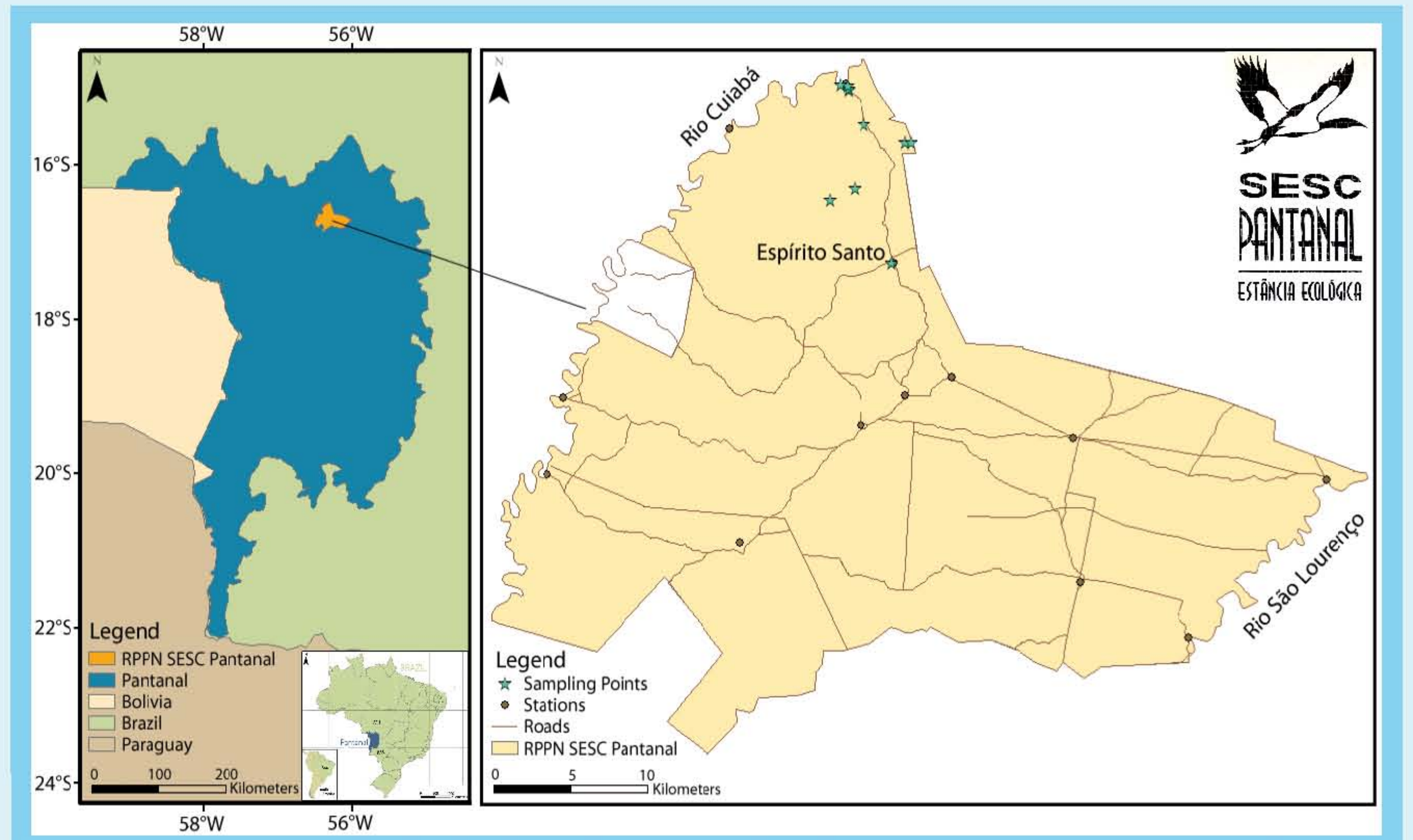

Figure 1: Pantanal wetland and sampling points within the nature reserve RPPN SESC Pantanal

a) For determination of stable water isotopes ($\delta^{18}O$, $\delta^{2}H$) and chloride (Cl^-) concentrations, a total of 70 water samples were collected between August and October 2008 in the RPPN SESC Pantanal (Figure 1). Samples were taken from two rivers and seven shallow lakes as well as from groundwater and rainfall. The morphometric parameters of the lakes were estimated on site.

b) Meteorological data was used to estimate daily evaporation from the water surface with an implementation of the Penman-Monteith Equation (Shuttleworth, 1993).

c) A chloride mass balance served to evaluate whether Cl^- enrichment took place due to evaporation only or whether the system has significant inflow and/or outflow rates.

d) The mass balance model MINA TrêS was developed to estimate inflow rates and their specific concentrations ($\delta^{18}O$, $\delta^{2}H$ and Cl^-) in daily time steps (Figure 2). The output was calibrated to observed data using an inverse modeling approach.

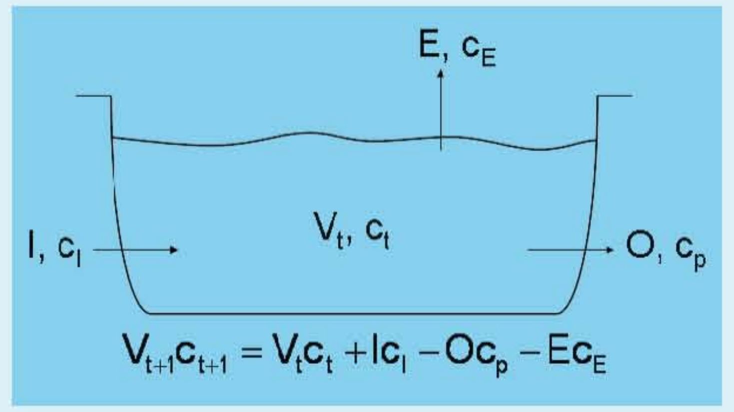

Figure 2: Water balance equation used by MINA TrêS

4. RESULTS

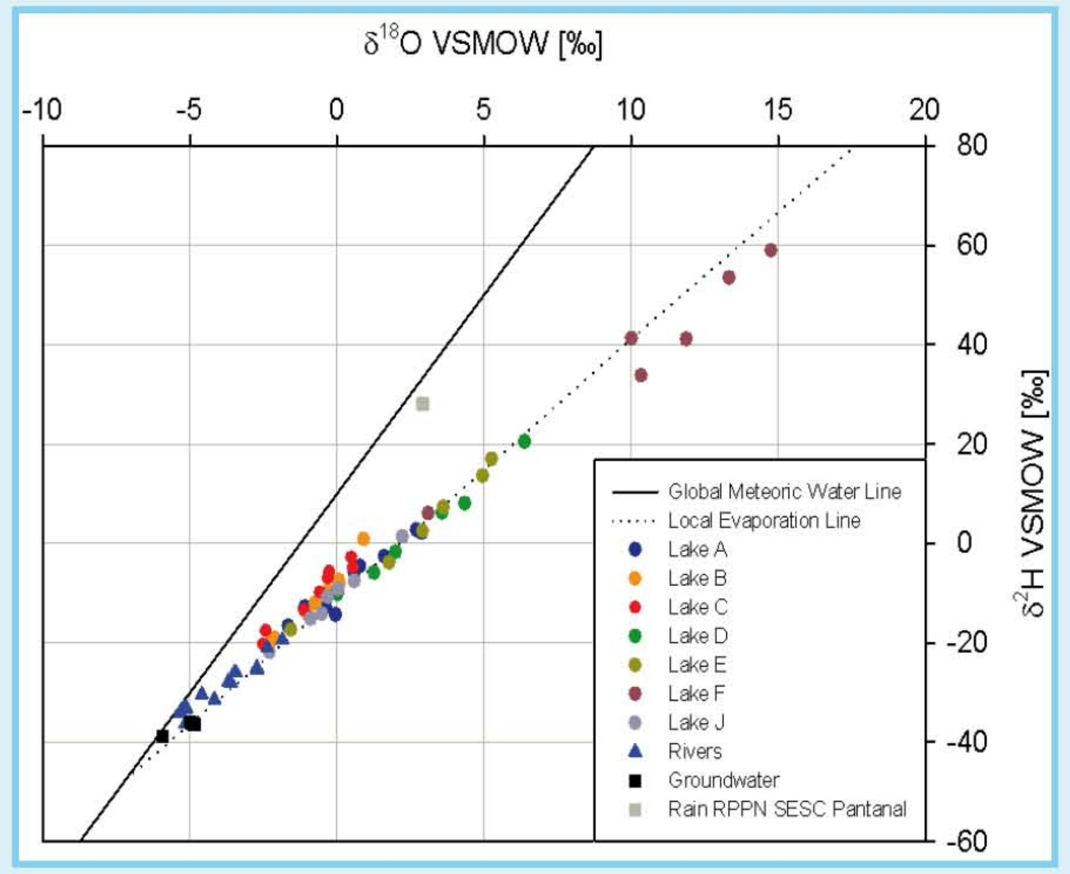

Figure 3: $\delta^{18}O$- $\delta^{2}H$ relationship for water samples collected from the RPPN SESC Pantanal

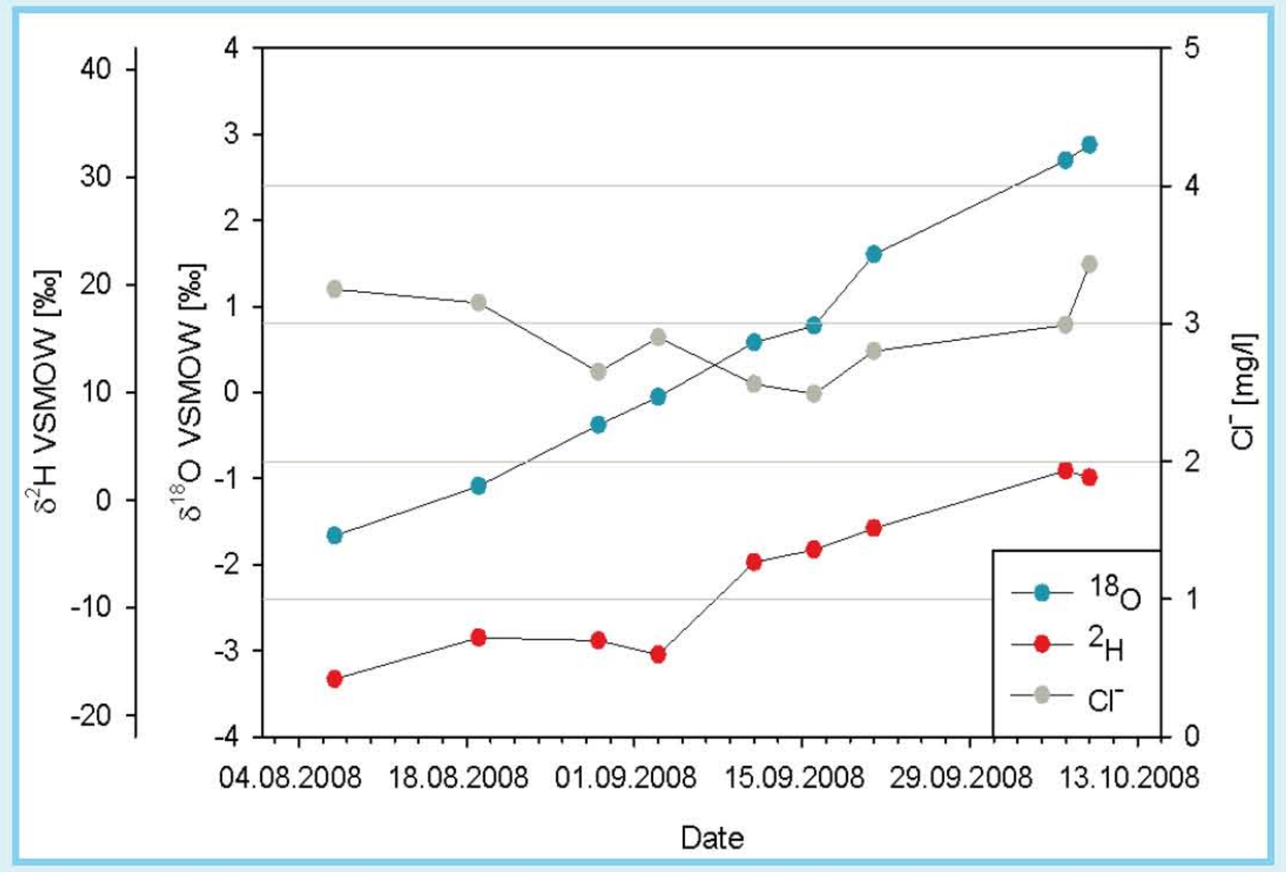

Figure 4: Evolution of $\delta^{18}O$, $\delta^{2}H$ and Cl^- concentration of lake A over the time period of field study

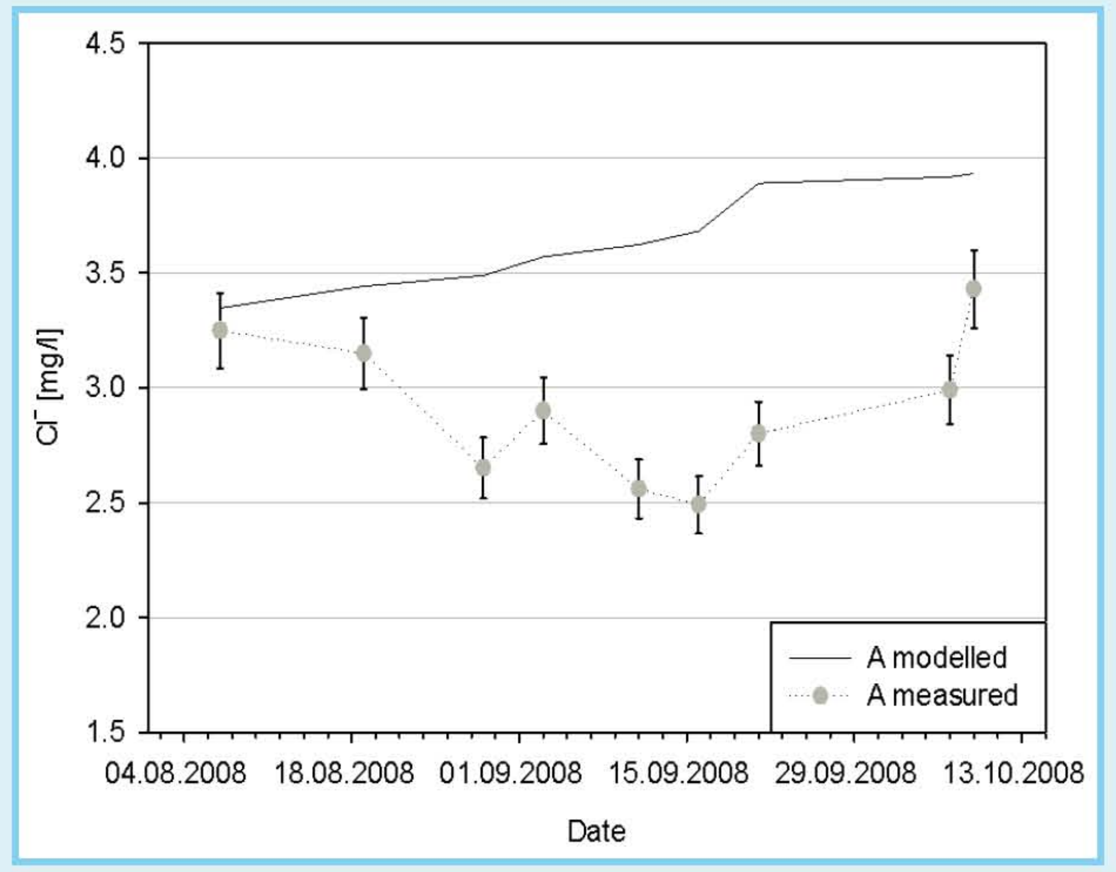

Figure 5: Modelled and measured Cl^- concentrations of lake A obtained from the chloride mass balance

All water bodies underwent strong evaporation effects (Figure 3). By way of example for lake A, both stable isotopes show an increasing tendency with respect to their sampling date and the Cl^- concentrations remain more or less stable (Figure 4). The results showed for all lakes that Cl^- enrichment does not take place due to evaporation only (Figure 5). Output was controlled by strong evaporation while significant inflow rates were also apparent.

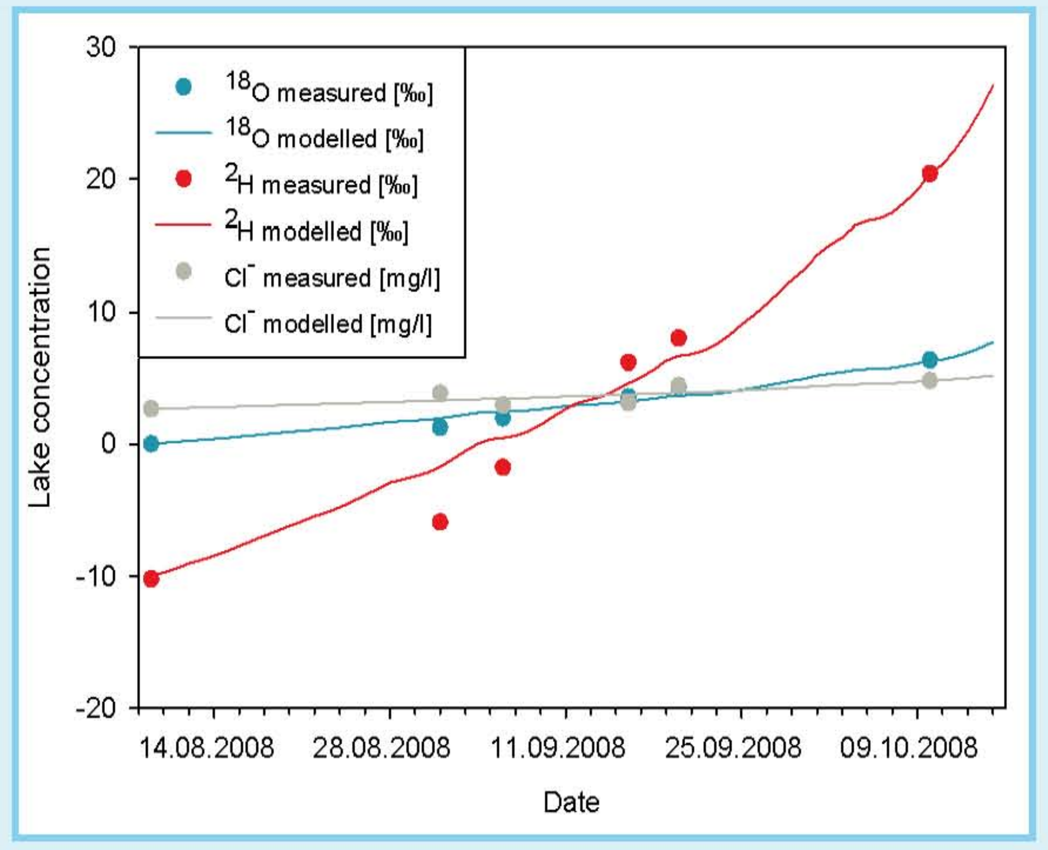

Figure 6: Measured and modelled lake concentrations of lake D

From the application of MINA TrêS estimates of inflow rates for all lakes, with their isotopic compositions and Cl^- concentrations, were derived (Figure 6). With the results of MINA TrêS it is finally possible to establish the water balance of the different lakes (Table 1).

Table 1: Inflow rates and concentrations as well as final water balance for the time period of field study between August and October 2008 modelled by MINA TrêS for all lakes

Lake	Inflow rate [mm/d]	c_p $\delta^{18}O$ [‰]	c_p $\delta^{2}H$ [‰]	c_p Cl^- [mg/l]	$V_{initial}$ [mm]	V_{final} [mm]	I [mm]	E [mm]	O [mm]
A	11.1	1.4	21.1	1.0	1800	1412	776	388	776
B	13.7	-5.5	-34.2	1.4	550	167	950	383	950
C	18.5	-4.8	-28.3	23.9	400	17	1278	383	1278
D	9.7	-4.9	-29.2	2.6	500	122	662	378	662
E	11.2	-4.2	-23.6	1.7	500	122	761	378	761
F	16.2	0.8	16.7	2.8	383	5	1104	378	1104
J	2.3	20.3	172.5	1.0	1994	1550	152	374	223

5. CONCLUSION

The analysis of stable isotopes and Cl^- concentrations served to study hydrological questions concerning the water budget of water bodies in the Pantanal dry season. Modelling inflow rates with its specific concentrations of $\delta^{18}O$, $\delta^{2}H$ and Cl^- by the mass balance model MINA TrêS led to satisfying results for all lakes. This approach enabled us to calculate the water balance for the lakes as well as providing information on source water flowing into the lakes. Considering the simplicity of MINA TrêS it is capable to deliver promising results for an area with limited data availability and little previous knowledge.

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