

Water exchange between estuarine lagoon and sea through a narrow strait: case study of two Brazilian lagoons

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Water exchange regime is determined by the lagoon morphology, fresh runoff into the lagoon, local atmospheric circulation, etc.

How to estimate role of every factor?
How to see, how water exchange forms?
Multiple regression!

Two extreme cases:

Patos



S
10 360 km²
Mean depth
5 m
Width of the strait
1 km
Mean discharge
2500 m³/c
No tides

Todos os Santos

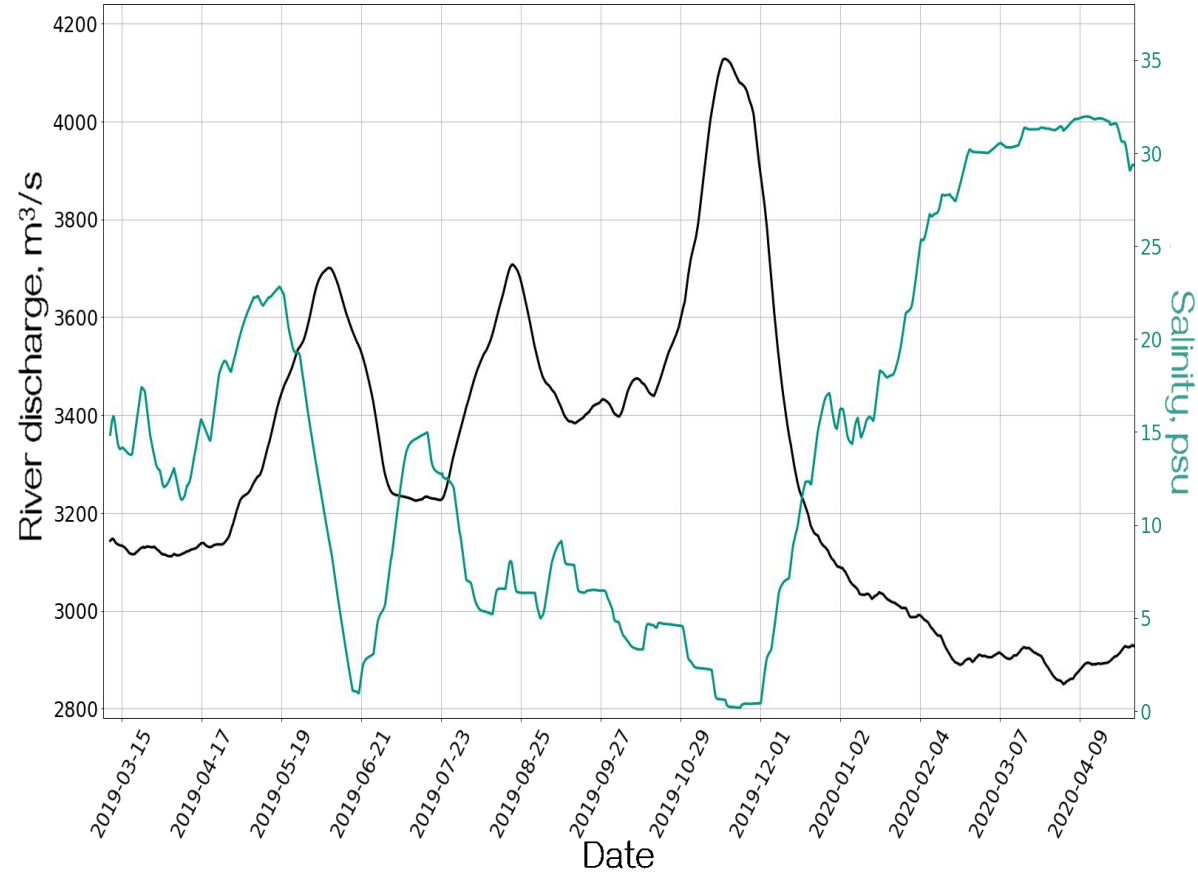


S
1223 km²
Mean depth
9,8 m
Width of the strait
9 km
Mean discharge
162 m³/c
Strong tides

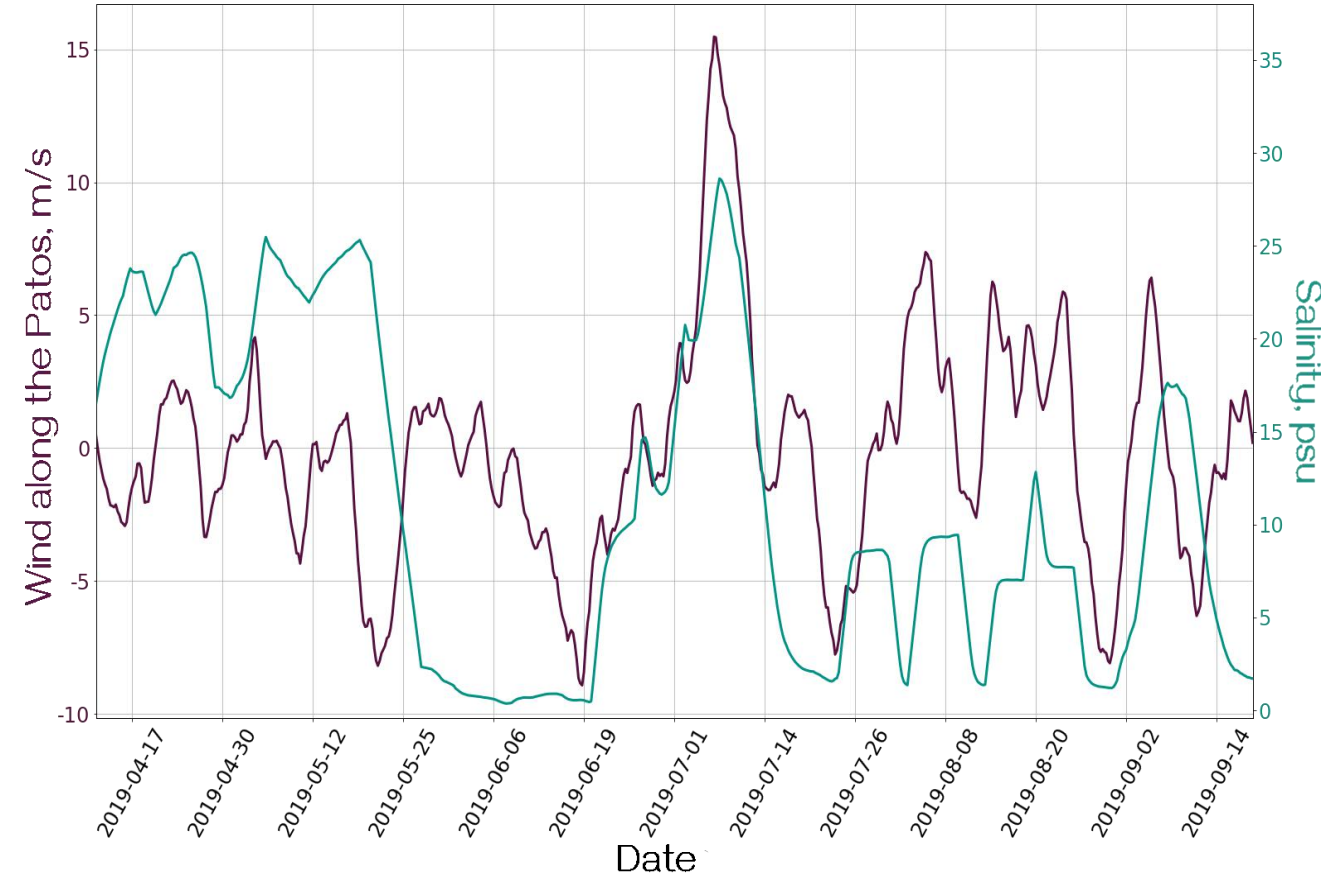


Patos

Month variability of river discharge and salinity in the strait



14-days variability of wind and salinity in the strait



Let's take into account it's interaction

Multiple regression for Patos

$salinity = b_0 + b_1u + b_2v + b_3q$,
u, v - wind velocities; q - discharge

On the scale of month

River runoff	South wind	West wind	R ²
-4.97	0.10	0.03	0.86

R² is high enough for coefficients to be trusted.

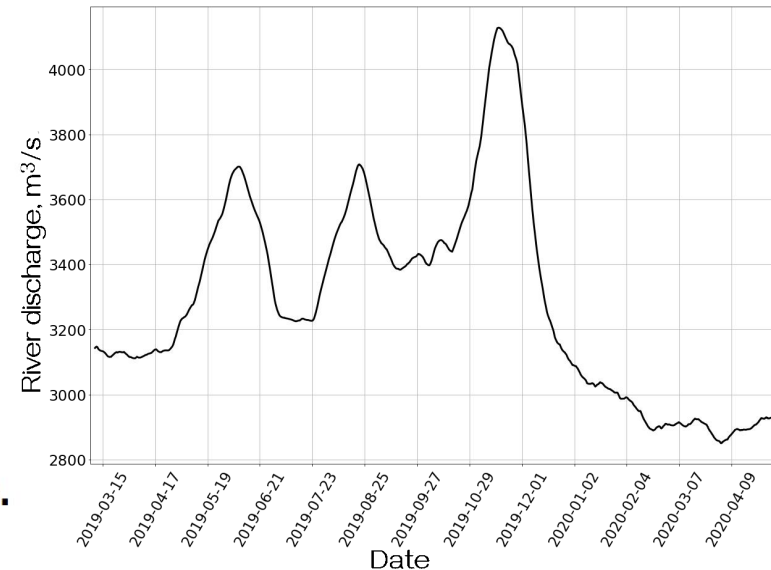
So, variability of salinity on the scale of month is determined by variability of river runoff.

On the scale of 2 days

River runoff	South wind	West wind	R ²
-0.36	0.21	0.03	0.35

Why is R² so low?

Perhaps, there are different types of water exchange in different seasons: during strong and weak river discharge.



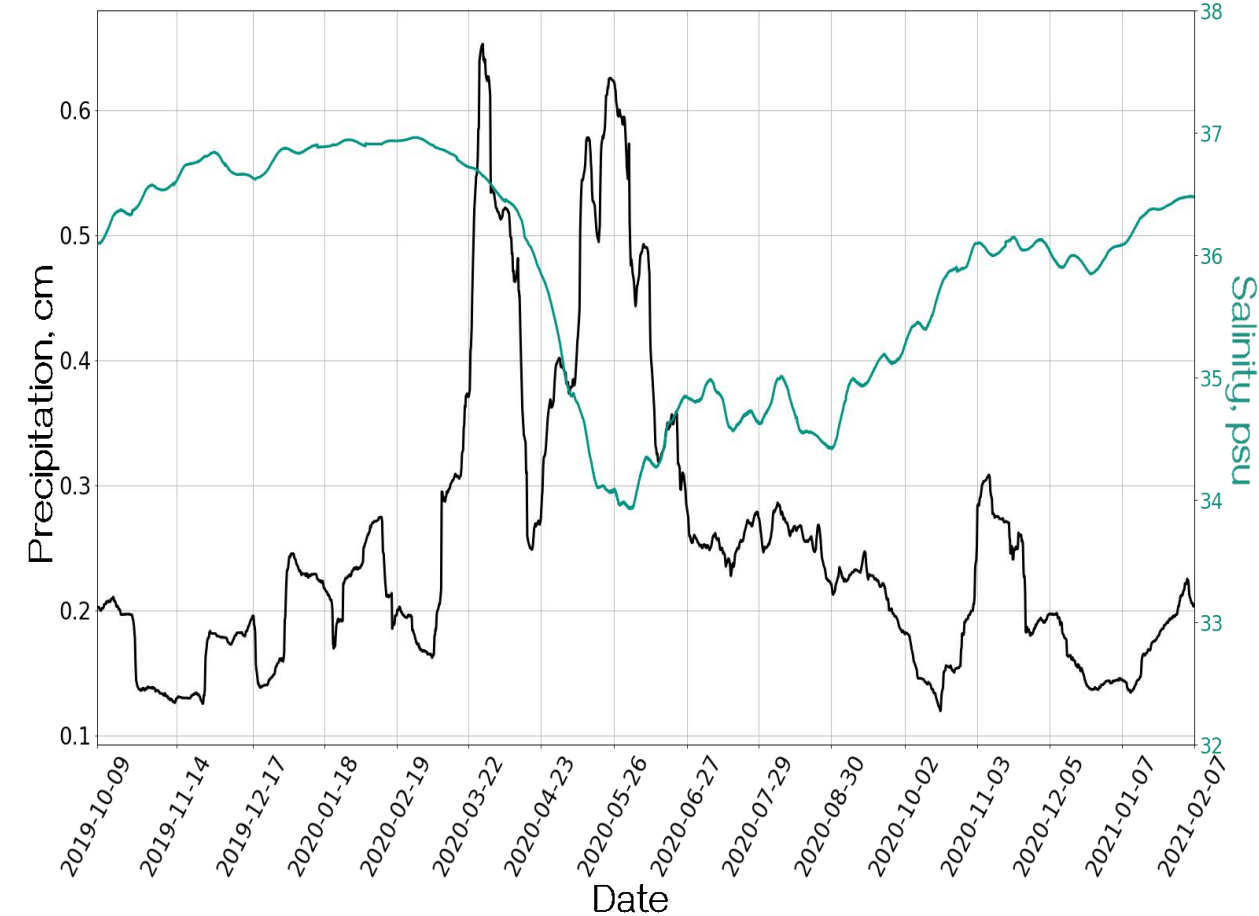
Runoff into the lagoon	River discharge	Wind along the Patos	Wind across the Patos	R ²
Intensive	-1.32	0.46	0.02	0.55
Weak	-5.27	0.27	0.14	0.68

Thus, we can see what and how forms inflows into the Patos and outflows from it! Specifically:

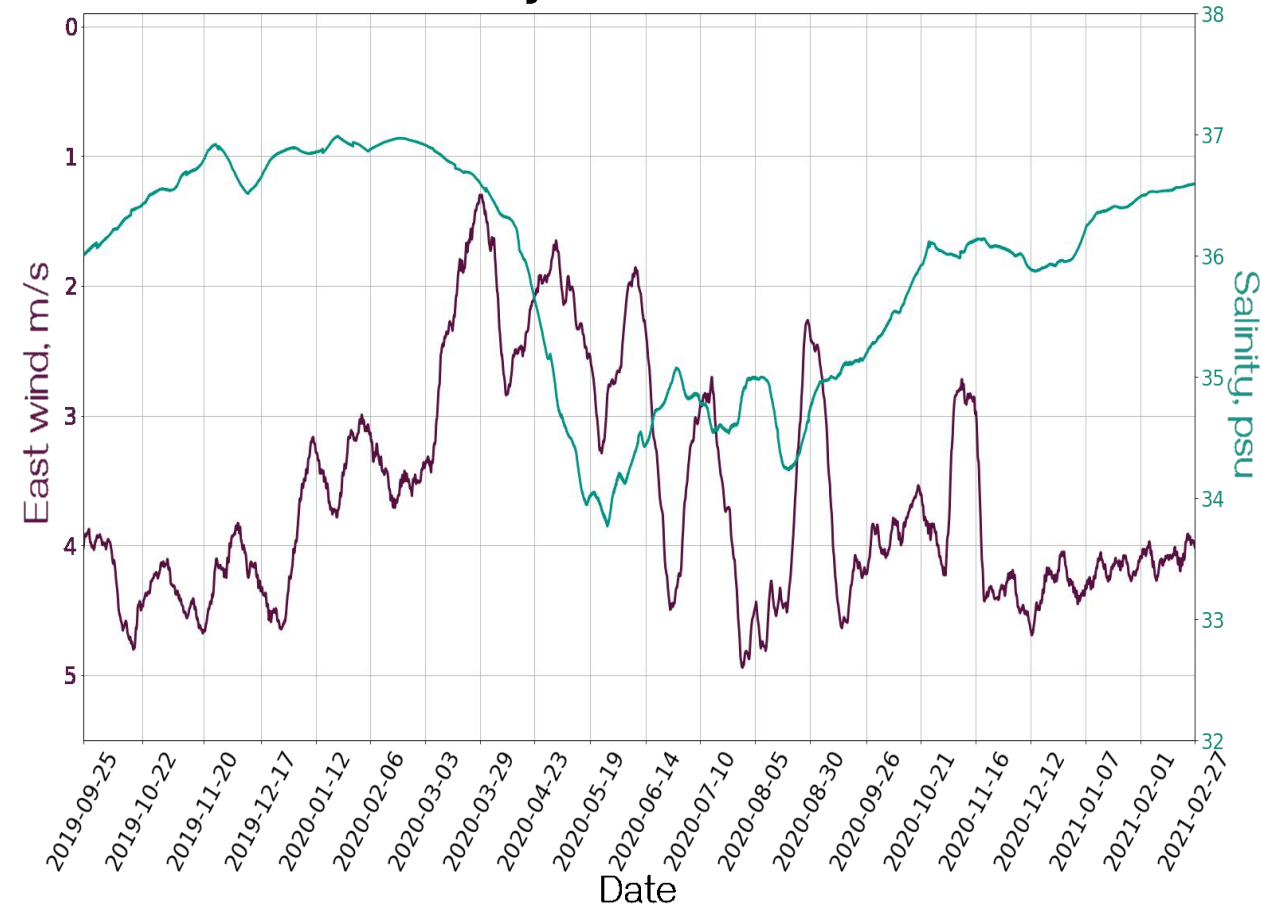
- 2 regimes of water exchange found, depending on the intensity of the river runoff
- under the weak runoff the inflow into the lagoon is usually observed, while changes in hydrological regime are mostly defined by variability of the river runoff
- under the intensive runoff the lagoon waters typically outflow into the ocean, however local atmospherical circulation greatly influence on the water exchange (which is brand new result!). The wind along the Patos, blowing to it's inner area, causes lowering of level in the strait. Due to this surge, rare inflows occur.

Todos os Santos

Month variability of precipitation and salinity in the strait

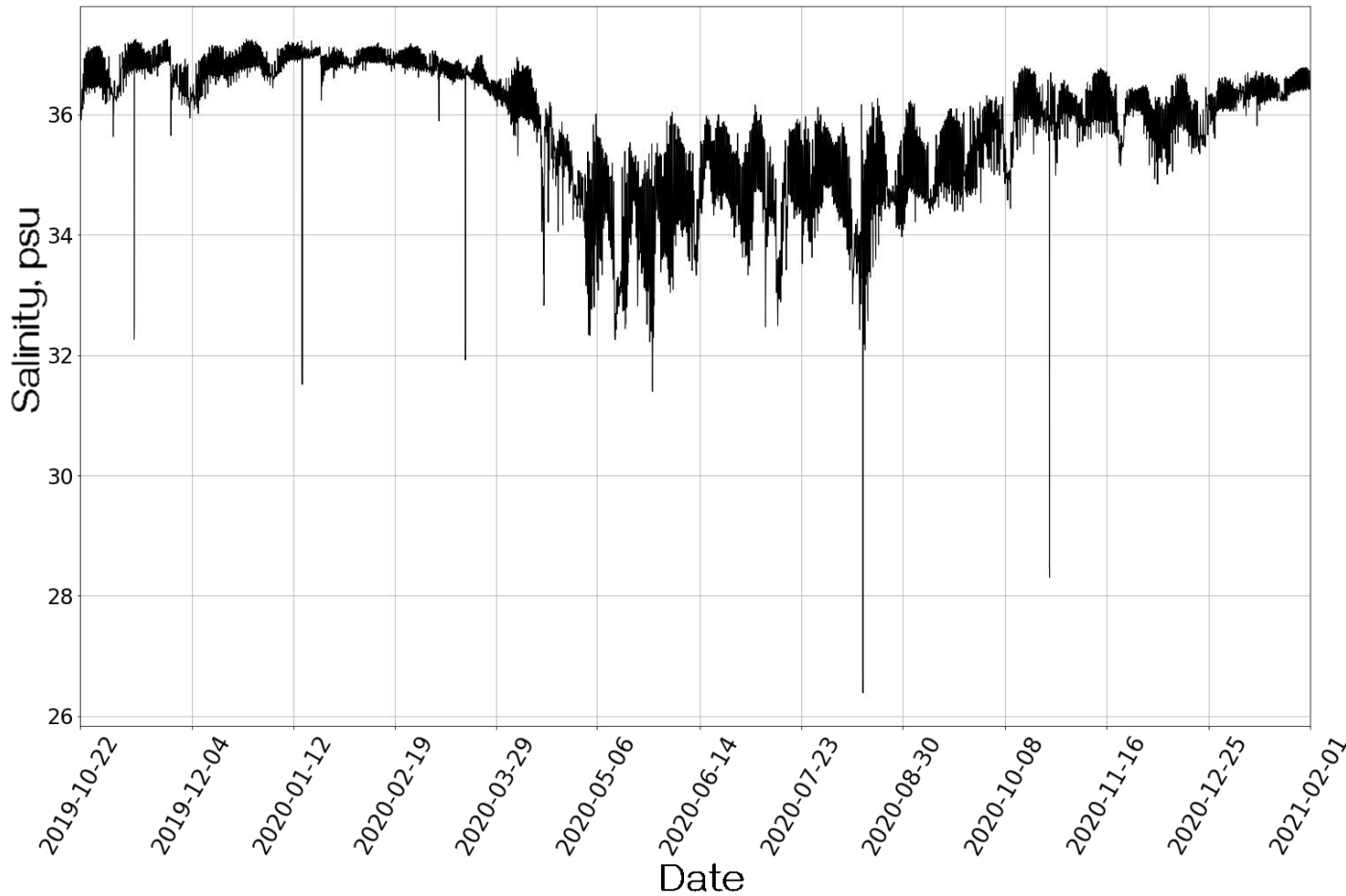


14-days variability of east wind and salinity in the strait



Again, let's consider their interaction! But first...

Strong tides



High amplitude tides:

semidiurnal	37 cm
fortnightly	26 cm

Monthly, semi-annual and annual tides are weak (less than 10 cm).

Therefore, synoptical variability is mostly formed by the tides.

Multiple regression for Todos-os-Santos

$salinity = b_0 + b_1u + b_2v + b_3p,$
u, v - wind velocities; p - precipitation

Precipitation	South wind	East wind	R ²
-0.02	0.00	0.03	0.82

Which gives the next understanding of water exchange mechanisms:

- seasonal variability of salinity in the strait is determined by variability of east wind. That reveals the mechanism of water exchange: east wind causes Ekman transport of ocean waters into the Todos-os-Santos, thus, from March till July, when it weakens, inflow of the ocean waters reduces. Therefore, the border between the lagoon and the sea water masses moves into the strait towards the ocean, meanwhile Todos-os-Santos freshens.
- seasonal precipitations also influence on hydrological regime: during freshet (March-May) river runoff into the lagoon increases, that freshens the Todos-os-Santos.