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Empirical linear model for base flow forecast as a function of the rainfall moving average

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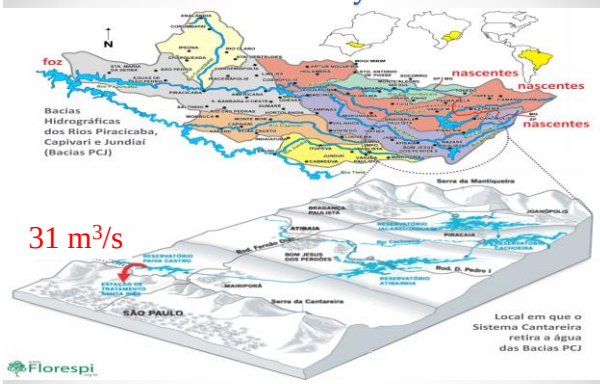
2017 NGWA Groundwater Summit
Nashville, TN
December 5, 2017

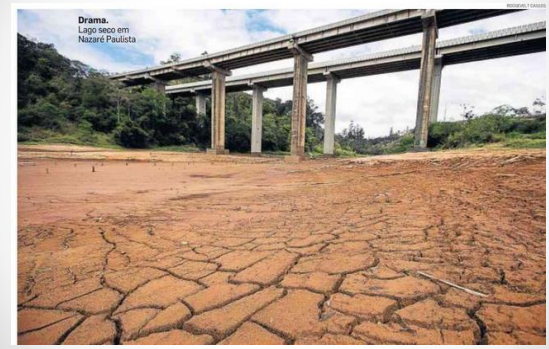
Motivation – São Paulo

12 Million inhabitant – 1500 km²

Cantareira system



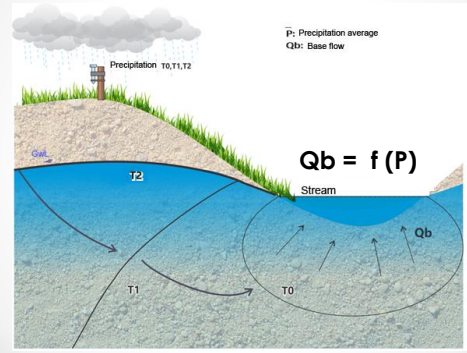
Dry lake - Drought 09/2014



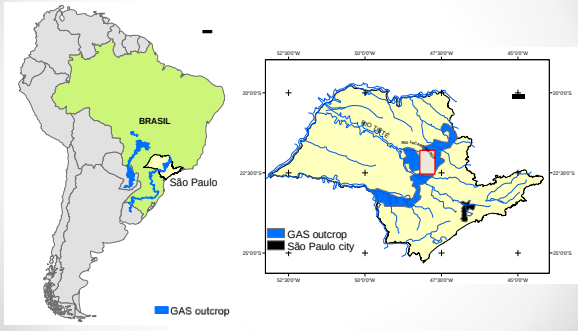
Questions

- **Was it possible to foresee the drought ?**
- **Is it possible to preview the future base flow discharge ?**
- **What are the control parameters ?**

Hypothesis

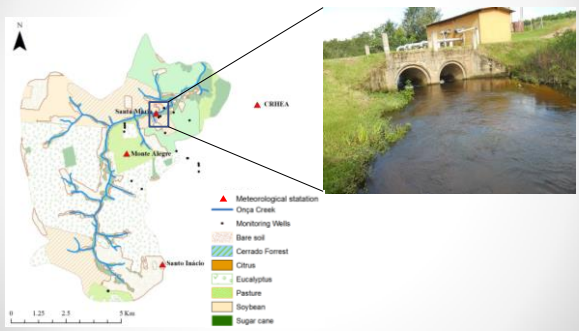


The Onça Creek Basin (OCB)

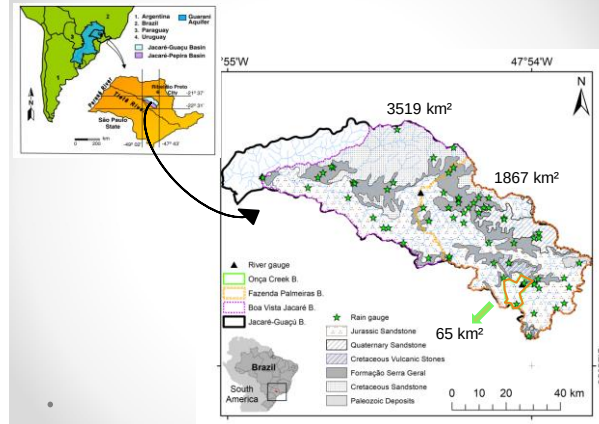


Guarani Aquifer System outcrop

Data monitoring at OCB



Nested basin

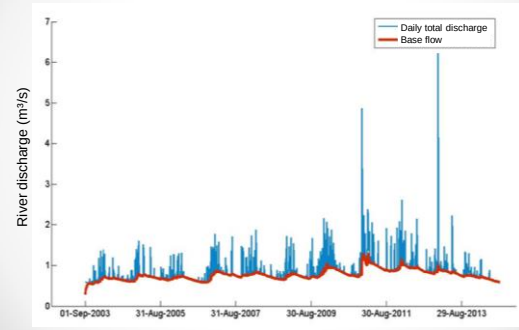


Methodology

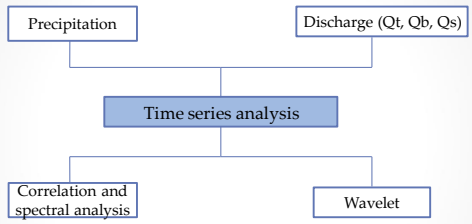
- Hydrograph separation
  - Q_b – base flow
  - Q_s – runoff
- Aquifer response time
  - Tr – base flow
- Empirical model
  - Qb = $f(P_{Tr})$

Hydrograph separation

Nathan and McMahon (1990) filter



Response time



Response time

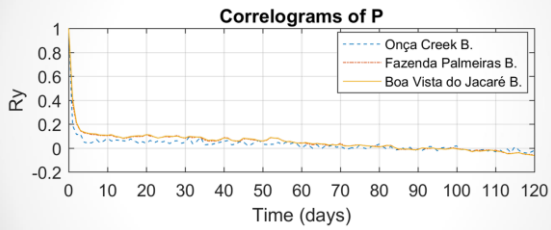
Correlation analysis

$$C_{xy}(k) = \frac{1}{n} \times \sum_{t=1}^{n-k} (x_t - \bar{x}) * (y_{t+k} - \bar{y})$$

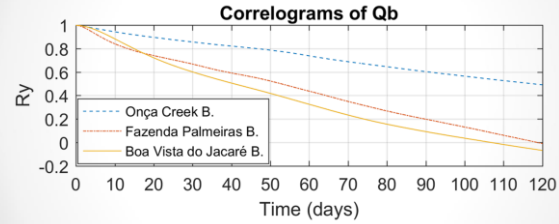
$$R_{xy}(k) = \frac{C_{xy}(k)}{\sigma_x \sigma_y}$$

- Memory effect
- Aquifer regulation time

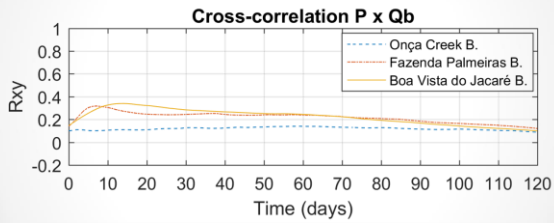
Autocorrelation Precipitation (P)



Autocorrelation Base flow(Qb)



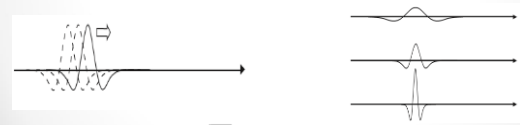
Cross-correlation Precipitation (P) x Base flow (Qb)



Response time

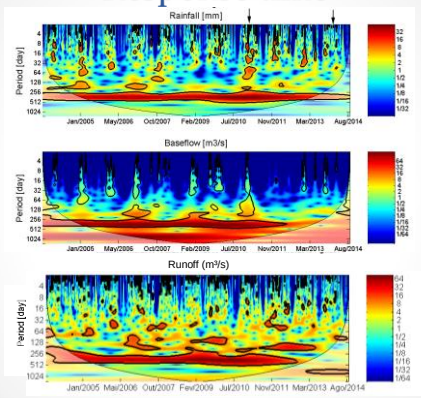
Wavelet convolution

- Translation
- Dilatation

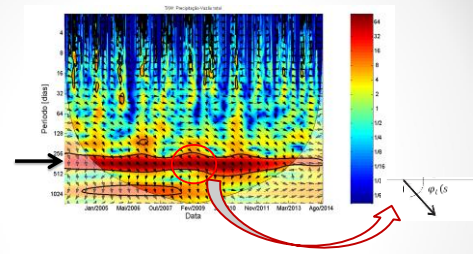


$$DWT = \sqrt{\frac{\Delta t}{S}} \sum_{t=1}^{N} x_{t'} \psi_0 \left(\frac{(t' - t)\Delta t}{S} \right)$$

Response time



Response time – Cross wavelet



$$T = T(s) * \frac{\varphi_t(s)}{2\pi} = 365 * \frac{\mathbf{61,88°}}{360°} = 62,74 \cong \mathbf{63}\ \text{days}$$

Empirical model

Hydrograph separation

- Q_b – base flow
- Q_s – runoff

Aquifer response time

- Tr – base flow = 24 months
- tr2 – subsurf. = 2 months

Empirical model

$$D(\zeta) = \alpha_\kappa * \overline{P_{TR}}(\zeta)$$

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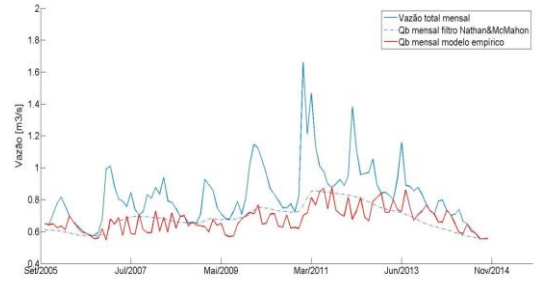
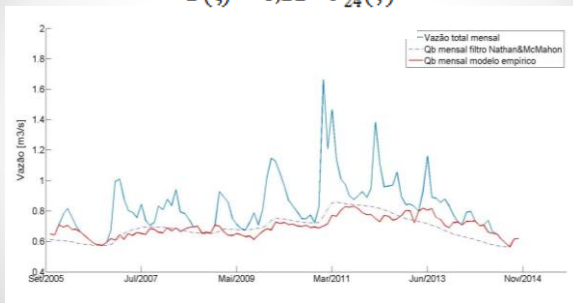
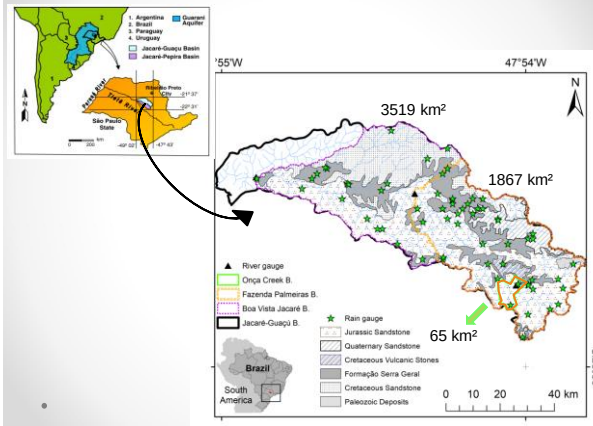


Empirical model – 65 km²

$$D(\zeta) = 0,22 * \overline{P_{24}}(\zeta)$$

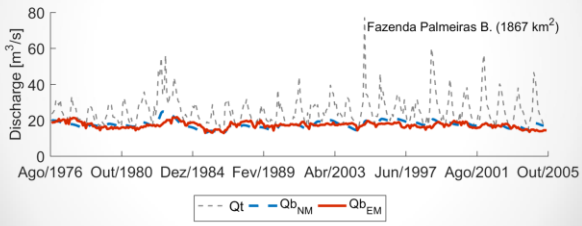


Nested basin



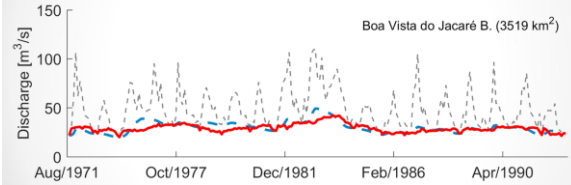
Empirical model – 1867 km²

$$D(\zeta) = 0{,}19 * \overline{P_{24}}(\zeta)$$



Empirical model

$$D(\zeta) = 0{,}2 * \overline{P_{36}}(\zeta)$$



Matlab tool

Conclusions

- **Annual cycle of precipitation was identified**
- **Aquifer response time was estimated**
- **Hypothesis seems to work**
- **Future work: Determine response time based on aquifer parameters**

Thank you

- Questions ?
- Suggestions ?

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