

# Measuring Complexity in data associated with COVID-19

*Márcio Luis Lanfredi Viola<sup>1</sup>, Graziela de Fatima Valero Minezildo<sup>1</sup>*

<sup>1</sup> Federal University of São Carlos

**Abbreviated abstract:** Complex thinking has contributed to model problems related to the emergence of unexpected events and complexity measures are used to model complex problems. Piqueira and Mortoza used the traditional complex measures due to Lopez-Mancini-Calbet (LMC) and to Shiner-Davison-Landsberg (SDL) for a temporal series. In this work, we used the LMC and SDL measures on COVID-19 data to identify changes in behavior over time. Specifically, we used the number of daily cases in Brazil and in the city of Araraquara, located in the state of São Paulo.

## Related publications:

- J. R. Piqueira and L. P. Mortoza, Brazilian exchange rate complexity: Financial crisis effects, *Commun Nonlinear Sci Numer Simulat* 17, 1690–1695 (2012) .
- L. P. Mortoza and J. R. Piqueira, Measuring complexity in Brazilian economic crises, *Plos one* 12 (3), e0173280 (2017)



# Problem, Data, Previous Works

The fight against COVID-19 has been a challenge in several countries. In particular, it has not been done a coordinated movement of actions to fight against the COVID-19 in Brazil. Additionally, the vaccination of its population started late.

Some cities implemented highly restrictive actions. For example, the city of Araraquara, located in the state of São Paulo, adopted a short lockdown in the months of February and June.

In this work, we used the LMC and SDL measures on the number of daily cases in Brazil and Araraquara from 25/02/2020 to 03/10/2021 to identify changes in the behavior over time.

Mortoza and Piqueira applied the LMC and SDL measures to analyze Brazilian economic crises.



# Methods

First the temporal series is divided into  $N$  discrete parts. The relative frequency of occurrence of each interval is considered to be its individual probability ( $p_i$ ). We used  $N=32$ .

The instantaneous disorder for the  $i$ th interval is

$$\Delta_i = p_i \frac{(-\log_2 p_i)}{\log_2 N}.$$

The instantaneous SDL complexity measure is given by

$$(\text{SDL})_i = \Delta_i (1 - \Delta_i)$$

and instantaneous LMC is

$$(\text{LMC})_i = \Delta_i D_i \text{ where } D_i = \left( p_i - \frac{1}{N} \right)^2.$$

# Results and Conclusions

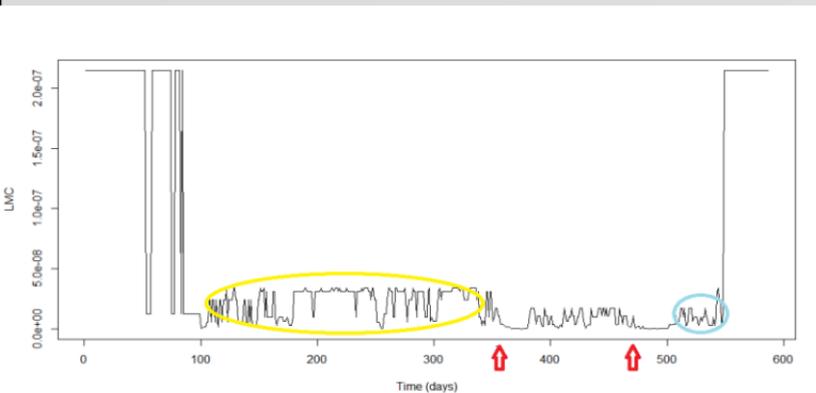


Figure 1: LMC over time for the number of cases in Araraquara.

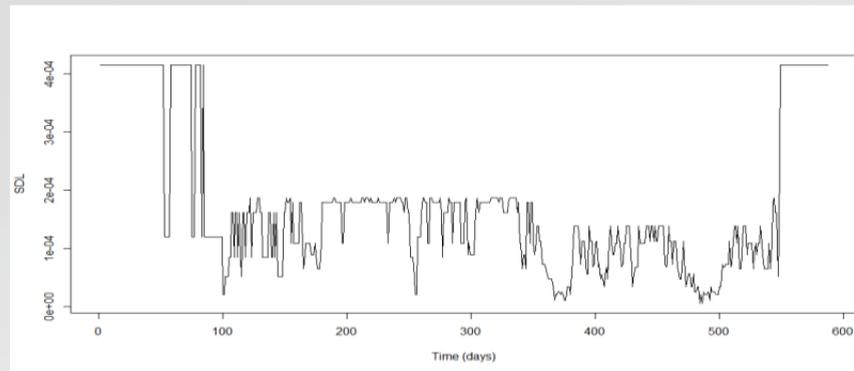


Figure 2: SDL over time for the number of cases in Araraquara.

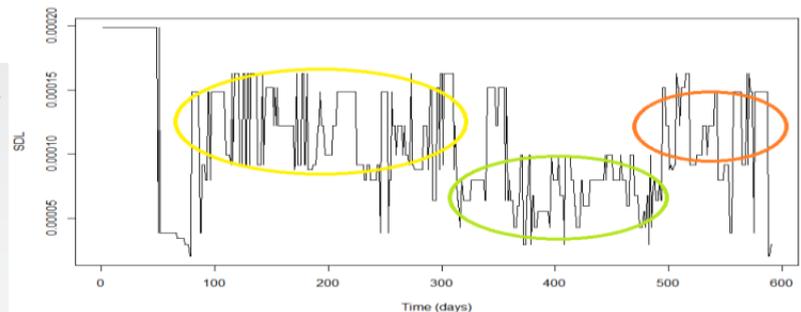


Figure 3: LMC over time for the number of cases in Brazil.