Spatial Sensitivity of Complex Network Communities in the Amazon Basin in Relation to the Minimum Link Value

Sanchez Pena Cesar Arturo[1], Peixoto Calheiros Alan James[1], Pereira Almeida Adriano[1], and Bezerra Leal Neto Helvecio[1]

[1]National Institute for Space Research

November 16, 2022

Abstract

The complex network is a method with a high flexibility and easy application. Complex Network allows extracting relevant information from the system, like its organization and dynamics, as well as different indices that allow obtaining particular characteristics. This work studies the communities present on the rain network in the Amazon basin for the austral summer. Summer was used due to the presence of the South American monsoon system (SAMS), since this is the greatest mechanism for modulating precipitation over South America. Once the communities were obtained, the minimum correlation value (MCV) was varied in order to verify the spatial variations of the communities. Where it was verified how certain communities are composed of subcommunities while others simply disappear. Finally, it is shown how the spatial distribution of the subcommunities shows a relationship with the presence of SAMS. However, more detailed analyzes are needed for each of these communities.

Spatial Sensitivity of Complex Network Communities in the Amazon Basin in Relation to the Minimum Link Value

SANCHEZ, C. A.[1]; CALHEIROS, A. J. P.[1]; ALMEIDA, A.[1]; LEAL NETO, H. B.[1]

[1] Applied Computing – National Institute for Space Research (INPE)

Email: {arturo.sanchez, alan.calheiros, adriano.almeida, helvecio.neto}@inpe.br

INTRODUCTION

The Amazon Basin has the characteristic of being the largest rainforest and the water system in the world. This region is highly important as it plays a vital role in different aspects such as water purification, carbon dioxide absorption, and regional climate regulation [1]. The Amazon Basin acts as an indispensable source in the exchange of heat with the atmosphere, mainly due to the high contribution of evapotranspiration, causing favorable conditions for the formation of tropical and extratropical convective systems thus being of high importance in regional circulation [2], [3].

STUDY AREA AND DATA

We are interested in recognizing rainfall communities in Amazon basin. For this purpose was used the product GPM IMERG Final Precipitation L3 [4]. In this dataset, the rainfall rate is represented in millimeters per day (mm/day) from December 2000 to February 2021. The original spatial resolution is 0.1°x0.1° but for computational reasons this resolution was downgraded to 0.5°x0.5°. Finally, in this study was used only the Austral summer months (December, january and february).

METHODOLOGY

A network can be understood to be a complex network if it has certain non-trivial topological and statistical properties [5]. This method allow extracting key information from the system of interest, such as connectivity, information transport, response to disturbances, regions of predominance or similar behaviors, among other information.

We defined an undirected rainfall network composed of a total of 4071 nodes. Each node represents a rainfall time series referring to its geographical position and forming a regular grid network. Spearman's rank correlation coefficient was used to represent a link (edge). Once the network is created, only 2% of all possible connections were used [6], obtaining the minimum correlation value (MCV) equal to 0.6. Finally, the communities were found using the Greedy modularity maximization. To verify the sensitivity of the spatial distribution of the communities, different MCV values were used to create three other networks and in that way compare the four results. These MCV are 0.7, 0.74 and 0.78.

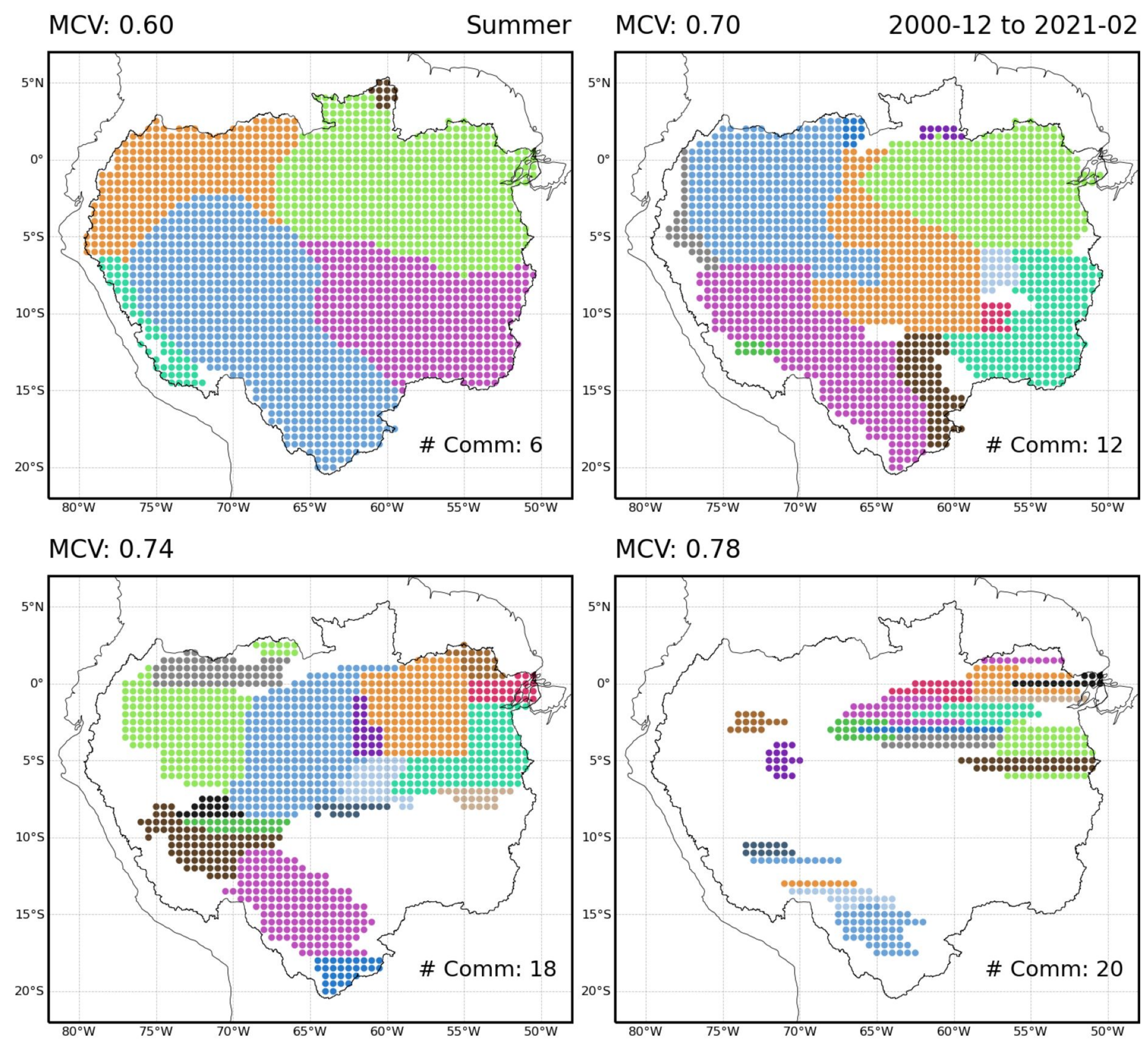

Figure 1. Communities for four rainfall summer networks with same characteristics but differents minimum correlation value (MCV). i.e. minimum value to define a link between two nodes.

RESULTS

The main results are presented in figure 1. Where, for the case of the network with the MCV of 0.6, were found 6 large communities, which cover the entire Amazon Basin. Possibly the more relevant communities are the green and blue, since these two are located on areas associated with the predominant directions of entry and exit of transport over the region (trade winds) [7]. In addition, the dark green community in the middle Andes (West to the blue community), representing precipitating systems on the high Andes, note how this community is disappearing with the increase of the MCV. For the blue community case, which becomes thinner (MCV 0.7) to later break into smaller communities (MCV 0.74 and 0.78). This is mainly due to the fact that most of the precipitating events in the blue community are modulated by an orographic forcing, being the area with the highest rainfall intensity in the region, presenting areas with similar precipitation regimes. It can be easily noted that as the MCV increases, how the communities are defined towards the north and west of the Amazon Basin (MCV 0.74 and 0.78), this is due to associated with the spatial pattern of the South American Monsoon System (SAMS). As expected by increasing the correlation minimum, that is, more intense links, the communities are broken into smaller or more specialized communities (in the case of MCV 0.78), until reaching a point where the network will be completely broken. This shows the importance of define a specific MCV.

CONCLUSIONS

The complex network is a method with high flexibility and easy application. It allows extracting relevant information from the system. In this work was analyzed, the summer precipitation system in the Amazon Basin. The communities that were found, presented a high sensitivity to the variations of the MCV. However, this change in the spatial distribution show a strong association with SAMS as the network becomes more specialized (increase the MCV). This means that for very low values of MCV the network shows generalized communities (bigger) while for very high values too small communities will be obtained (broken network). Now, about the rain in each community, Does these present differences/similarities from a statistical and physical point of view or really be a suitable grouping? In general terms these communities presents correct patterns, but is necessary more studies. These analyzes will be performed in future works.

References:
[1] FISCH, G.; MARENGO, J. A.; NOBRE, C. A. Uma revisão geral sobre o clima da amazônia. Acta amazônica, SciELO Brasil, p. 101–101, 1998.
[2] MARENGO, J. A. et al. Climatology of the low-level jet east of the andes as derived from the ncep–ncar reanalyses: Characteristics and temporal variability. Journal of climate, v. 17, n. 12, p. 2261–2280, 2004.
[3] ELTAHIR, E. A.; BRAS, R. L. Precipitation recycling. Reviews of geophysics, Wiley Online Library, v. 34, n. 3, p. 367–378, 1996.
[4] HUFFMAN, G. J. et al. Nasa global precipitation measurement (gpm) integrated multi-satellite retrievals for gpm (imerg). Algorithm Theoretical Basis Document (ATBD) Version, v. 4, n. 26, 2015.
[5] BARABASI, A.-L. Linked: How Everything Is Connected to Everything Else and What It Means. [S.l.]: Plume, 2003.
[6] BOERS, N. et al. Prediction of extreme floods in the eastern central andes based on a complex networks approach. Nature communications, Nature Publishing Group, v. 5, n. 1, p. 1–7, 2014.
[7] MARENGO, J. et al. Recent developments on the south american monsoon system. International Journal of Climatology, Wiley Online Library, v. 32, n. 1, p. 1–21, 2012.

Acknowledgements:
The authors wish to thank the *Conselho Nacional de Desenvolvimento Científico e Tecnológico* (CNPq) and *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* - Brasil (CAPES) for their financial support.

Author affiliations:
Arturo Sanchez (INPE, BR); Alan Calheiros (INPE, BR); Adriano Almeida (INPE, BR); Helvecio Neto (INPE, BR)