

From Networks to Flows

Using Flow Maps to Better Understand Mobility Patterns in Cattle Trade

Sima Farokhnejad, Eraldo Ribeiro, Ronaldo Menezes

NetSciX 2023, Buenos Aires, Argentina

February 7-10, 2023

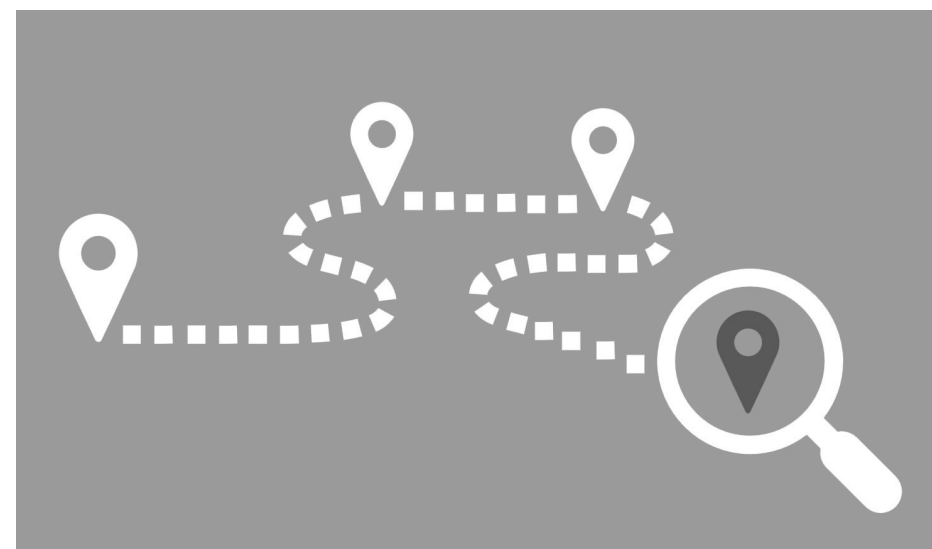
Understanding Mobility Patterns

- Lot of things move around: people, goods, birds, livestock, etc.
 - Mobility can be generally represented using origin-destination data
- Direct impact on policymaking (e.g., urban systems, immigration)
- Disease spreading analyses and control of epidemics benefit from the modelling of human mobility

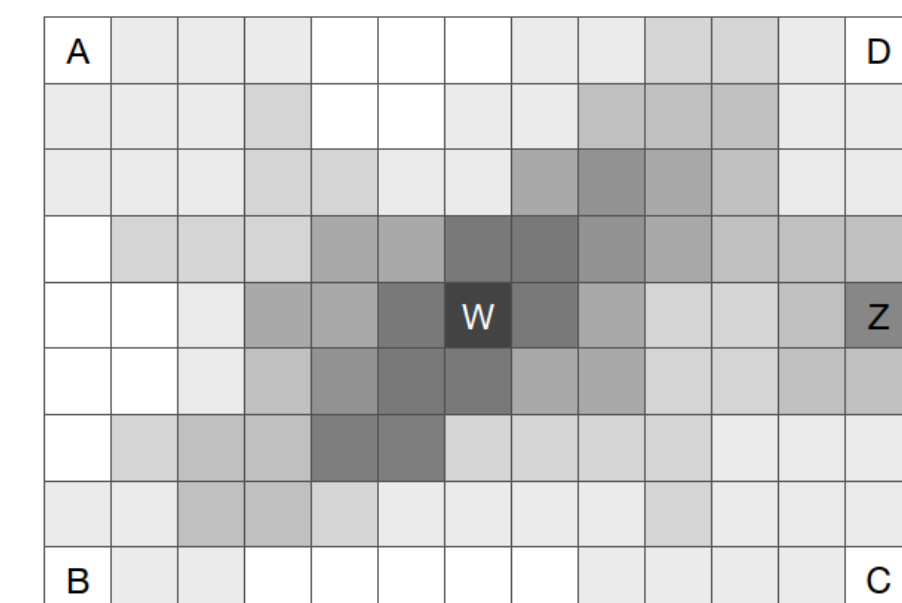
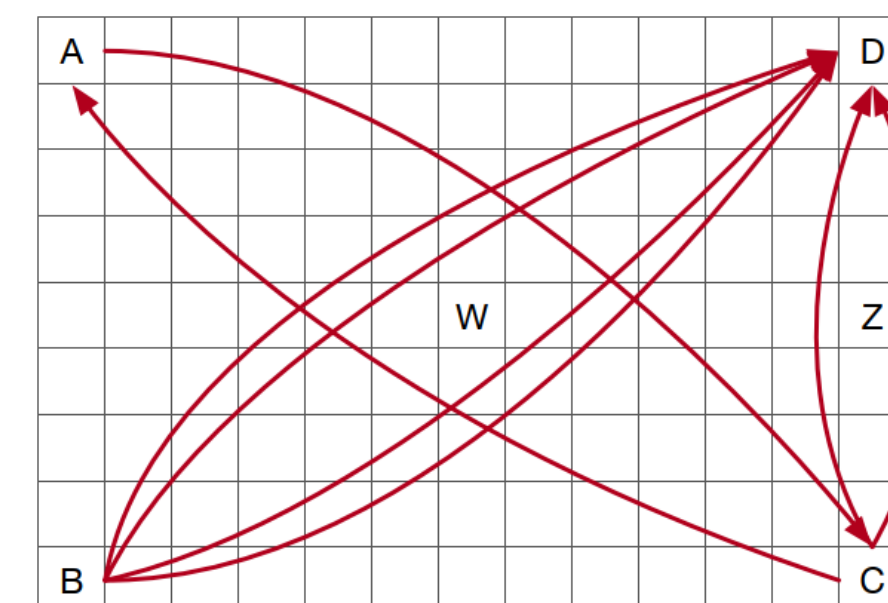


Network Analysis

- Generally networks are applicable to somewhat small datasets
 - Many algorithms are expensive
- Very few approaches on cattle movement used large datasets such as the ones available in Brazil or in the USA.
 - There is a need to look beyond microscopic details
- (Mobility) datasets are often subject to uncertainty

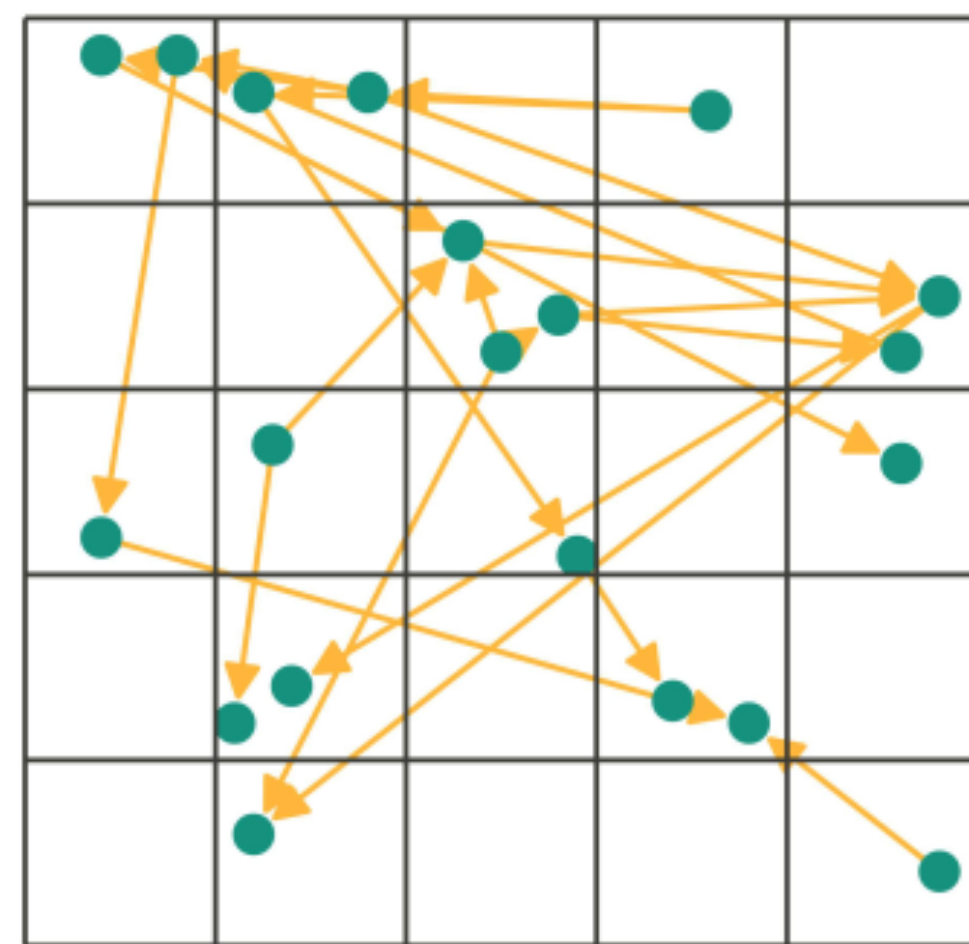


- Network-based approaches often ignore relevant spatial information (e.g., origins or destinations not represented but important nevertheless)
- In cattle mobility, ground transportation is used
 - Networks may miss important "in-between" locations

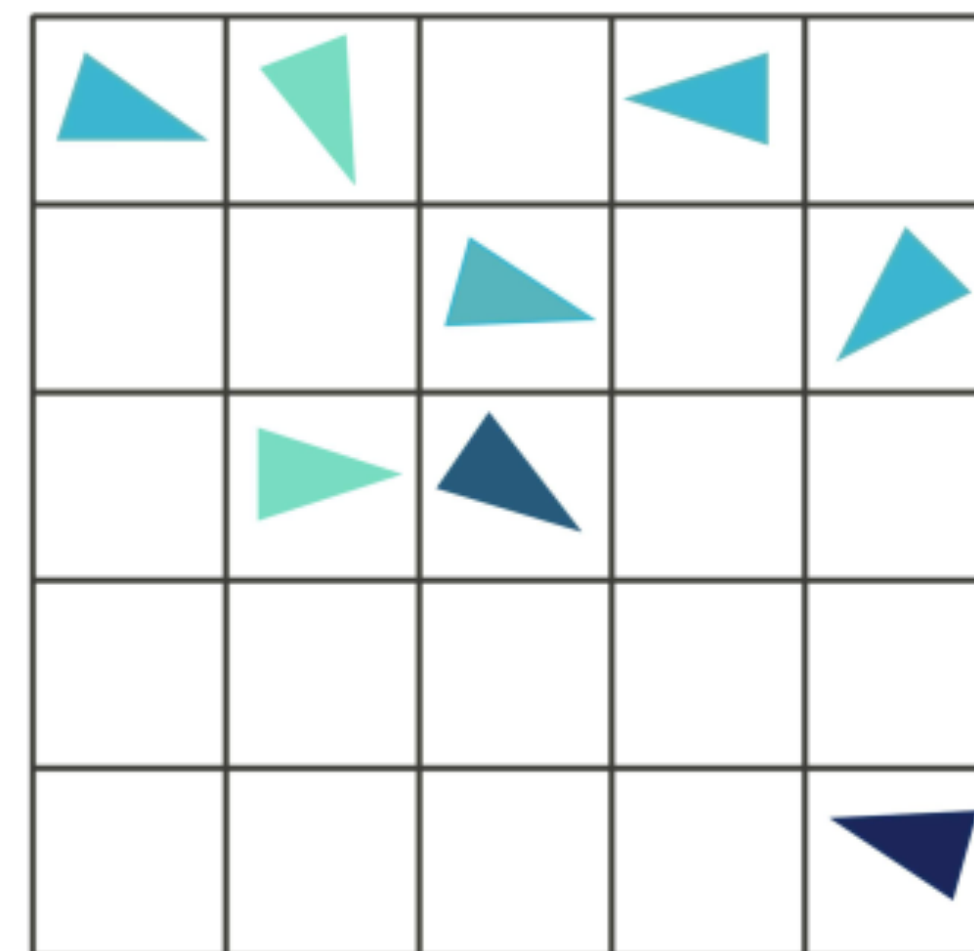


- Farokhnejad, S., Cardoso, D., Rocha, C., da Mata, A.S., Menezes, R.: A data-driven approach to cattle epidemic modelling under uncertainty. In: CompleNet. Springer Nature (2022)
- Y. Zheng, "Trajectory data mining: an overview," ACM Transactions on Intelligent Systems and Technology (TIST), 2015
- The laundering of cattle (in Portuguese). <https://piaui.folha.uol.com.br/materia/lavagem-da-boiada/> (2022)

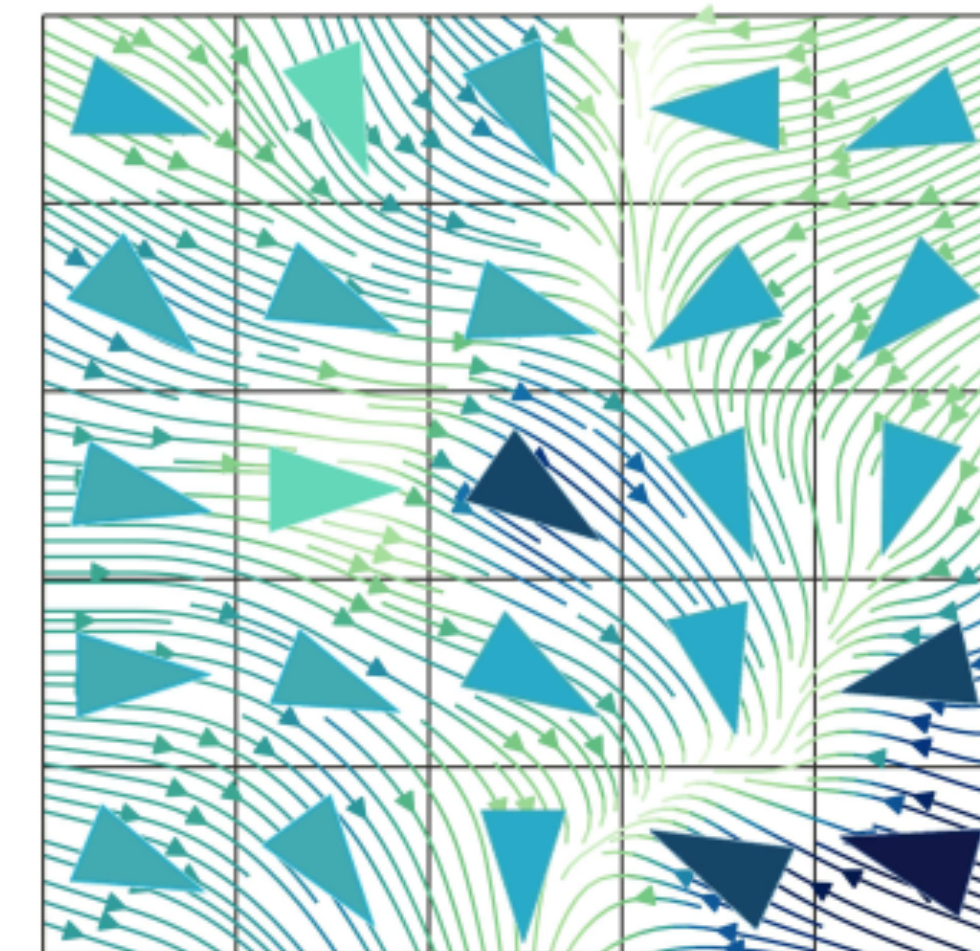
Going Beyond Spatial Networks



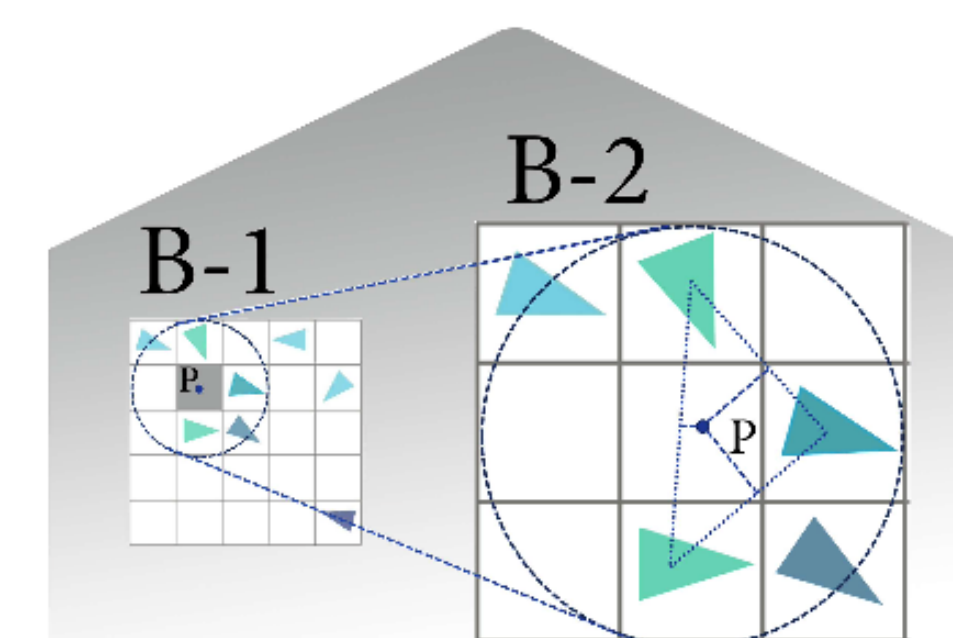
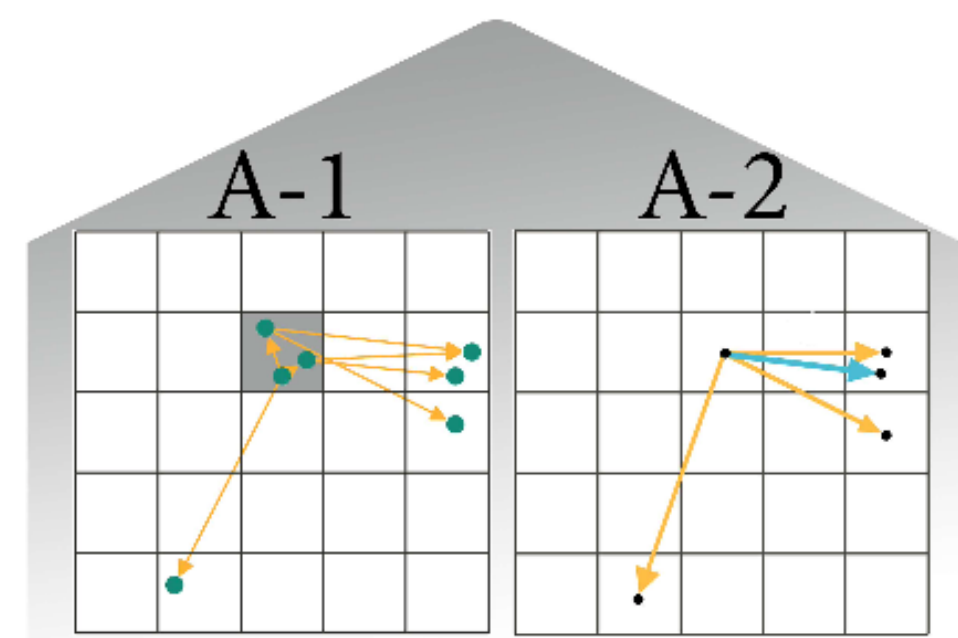
Network



Vectors

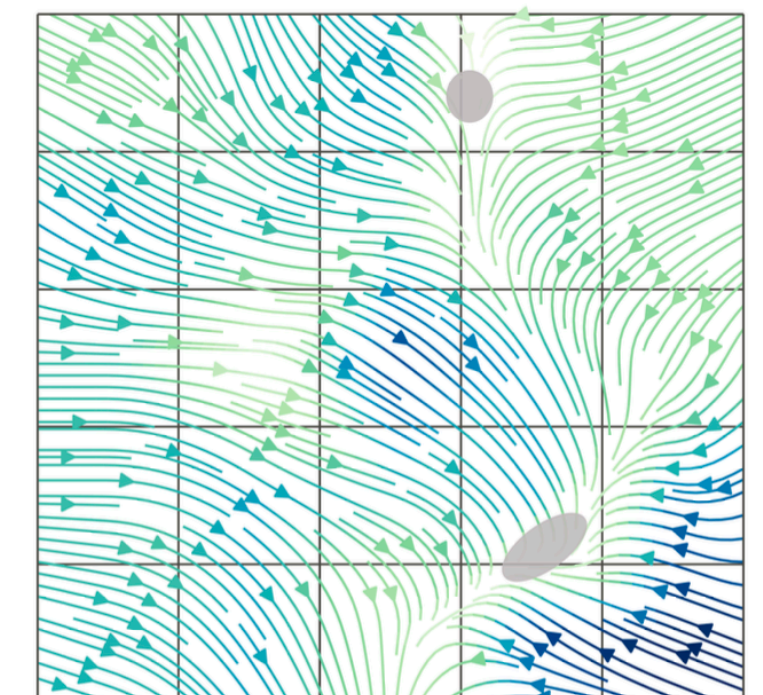
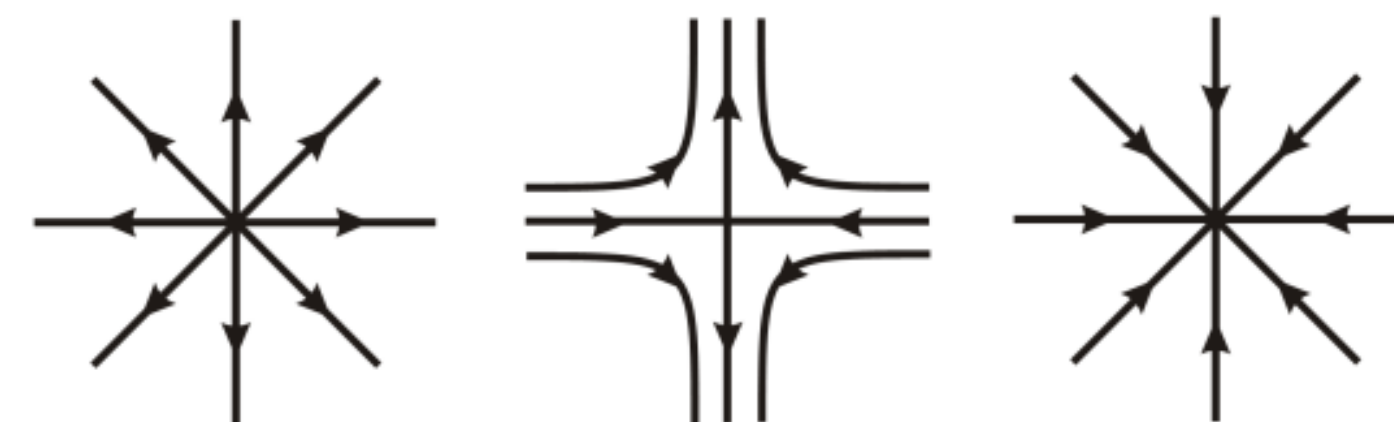
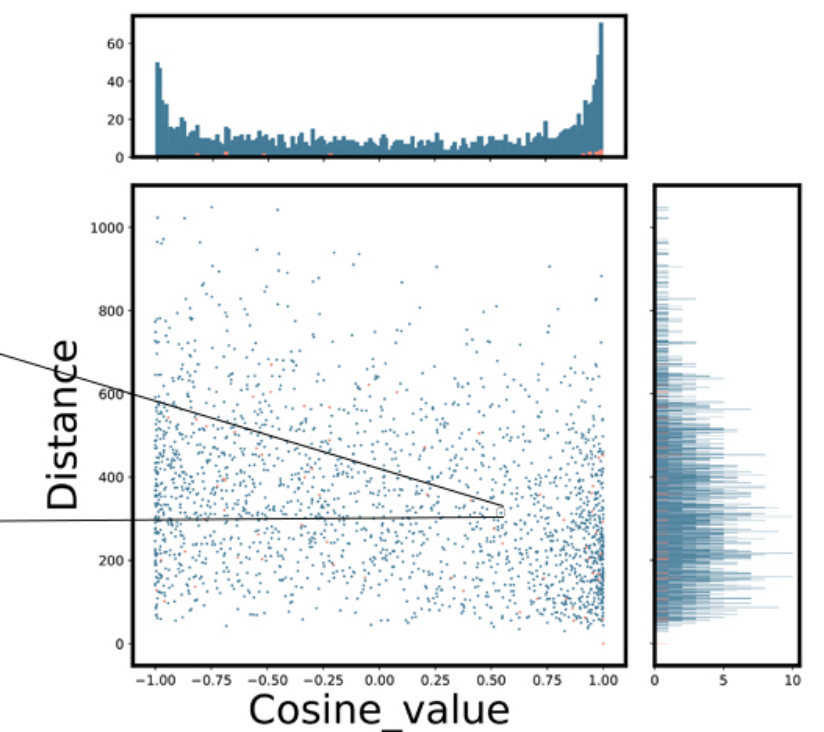
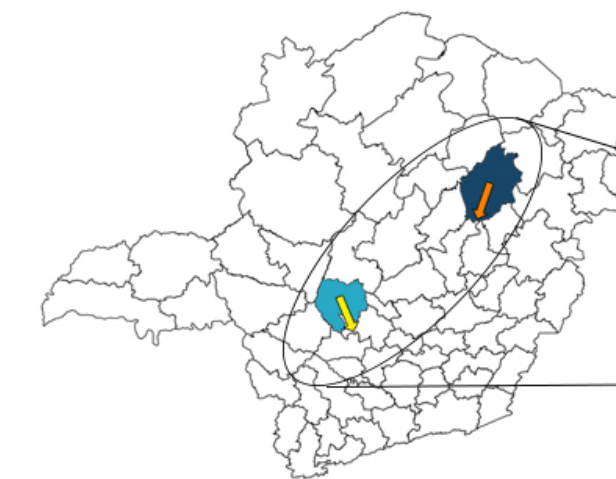
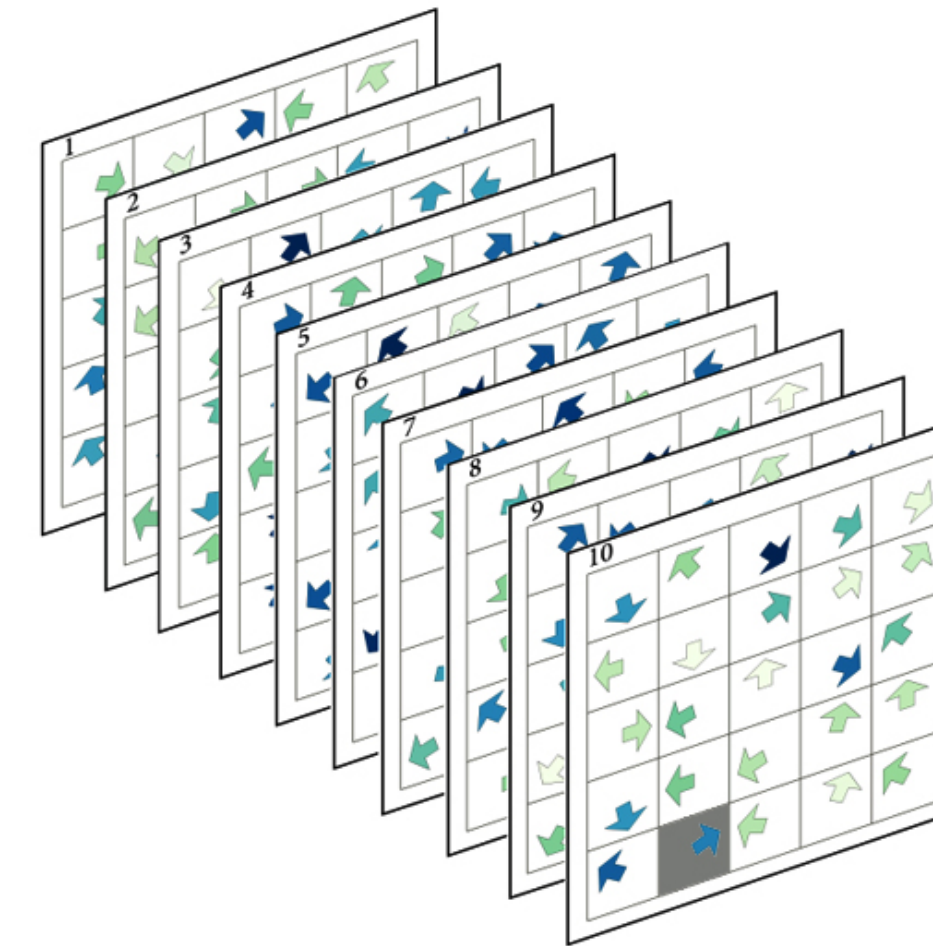


Complete
Vector Field



What Can we do with Fields?

- Autocorrelation behaviour of each part during the time
- Correlation behaviour between different parts
- Global pattern (critical point)



Importance of Livestock Movement



2001 FMD epidemic
3 million animals

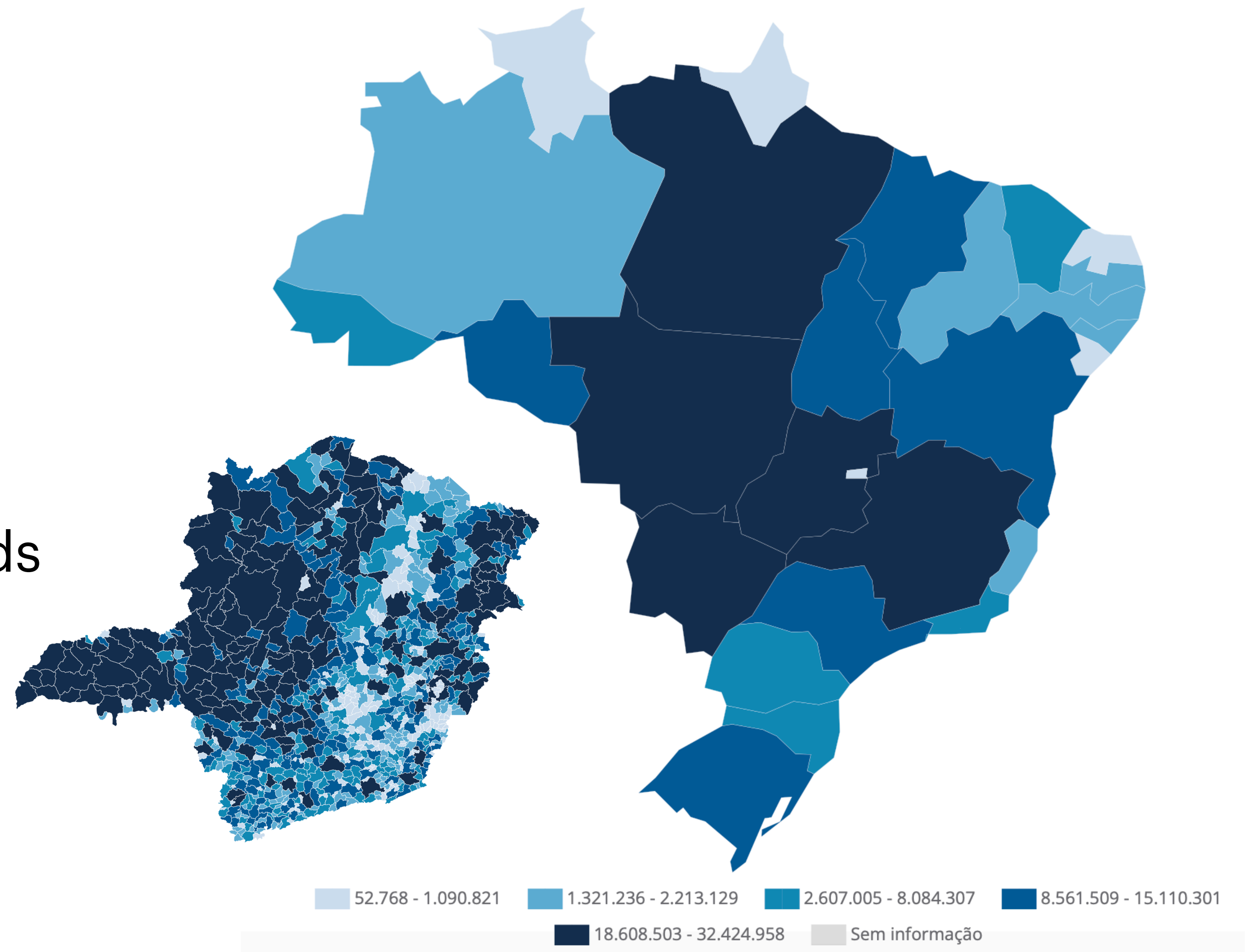


zoonotic swine flu

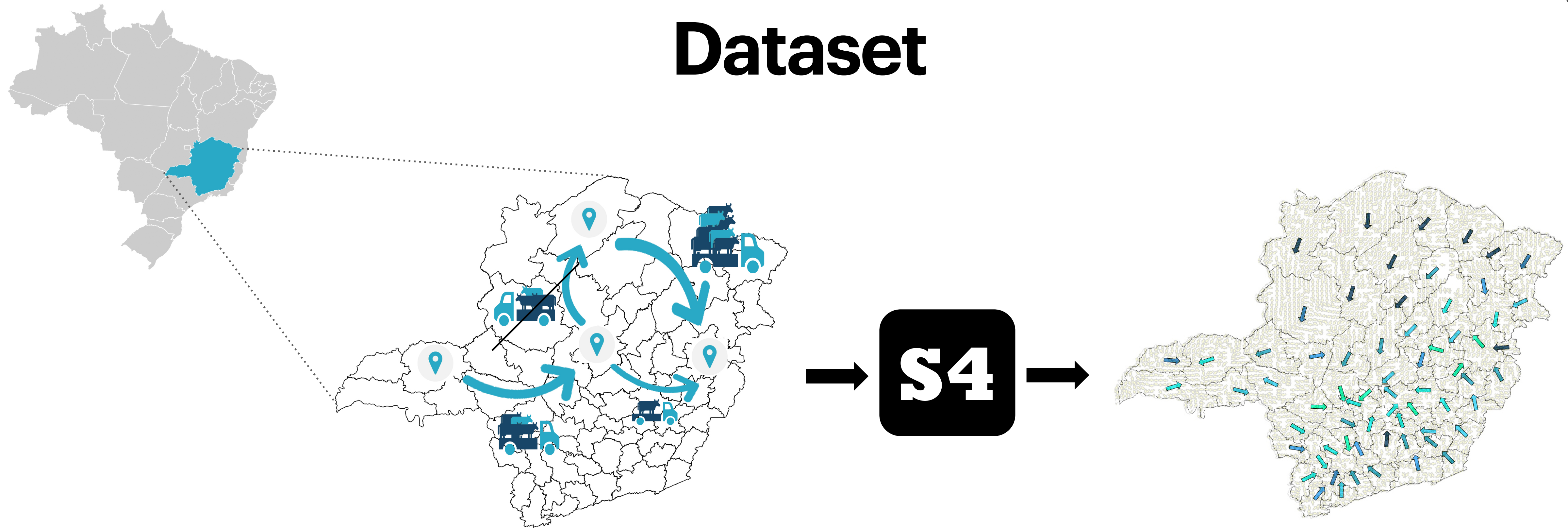


Size of Cattle (Bovine) Production

- Size of Production (as of 2021)
 - Brazil: 224M heads
 - Europe: 77M heads
 - USA: 91.9M heads
 - Minas Gerais (Brazil): 22.8M heads
 - 6.9M (Spain)
 - 11.5M (Germany)



Dataset



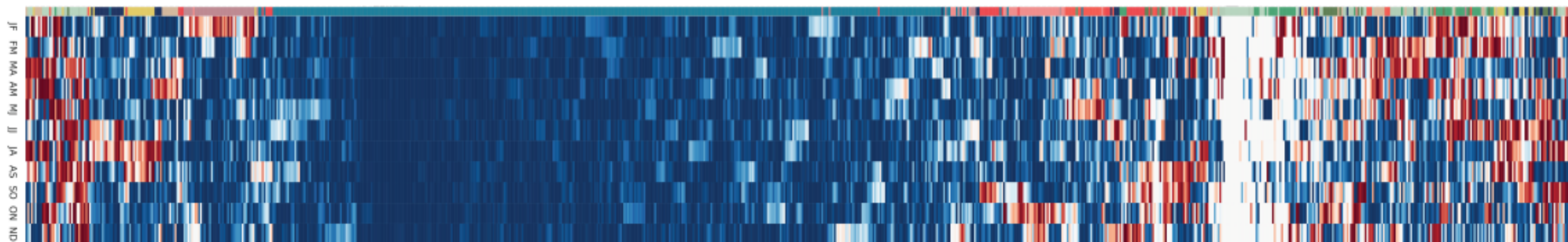
Minas Gerais, Brazil
 Cities: 853
 Micro-regions: 66
 2013 to 2016
 Premises: 362,598
 Movements: 3,865,036
 Animals: 65,128,202 trades during 4 years

Free parameter
 Trade's features included
 Combination method
 Granularity
 Interpolation method

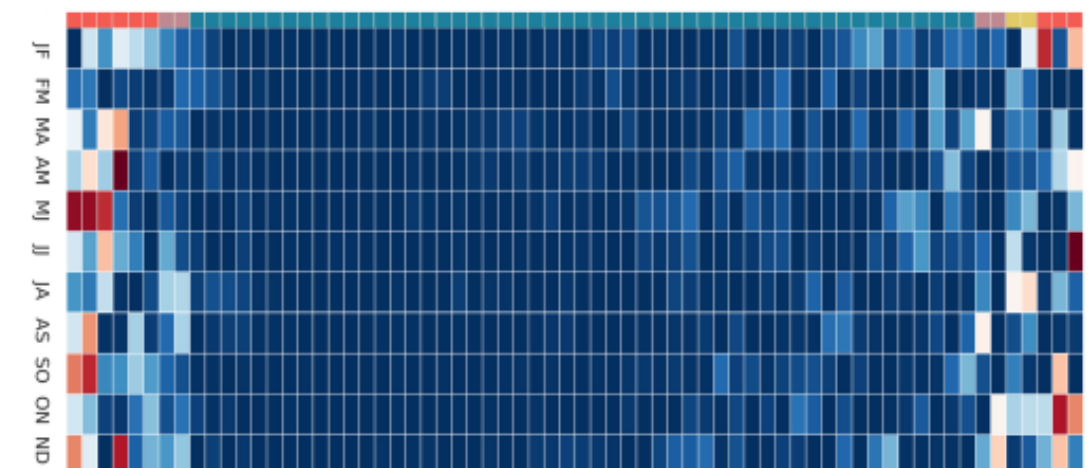
Cosine Similarity

- Division of larger spatial areas into predictable and unpredictable regions

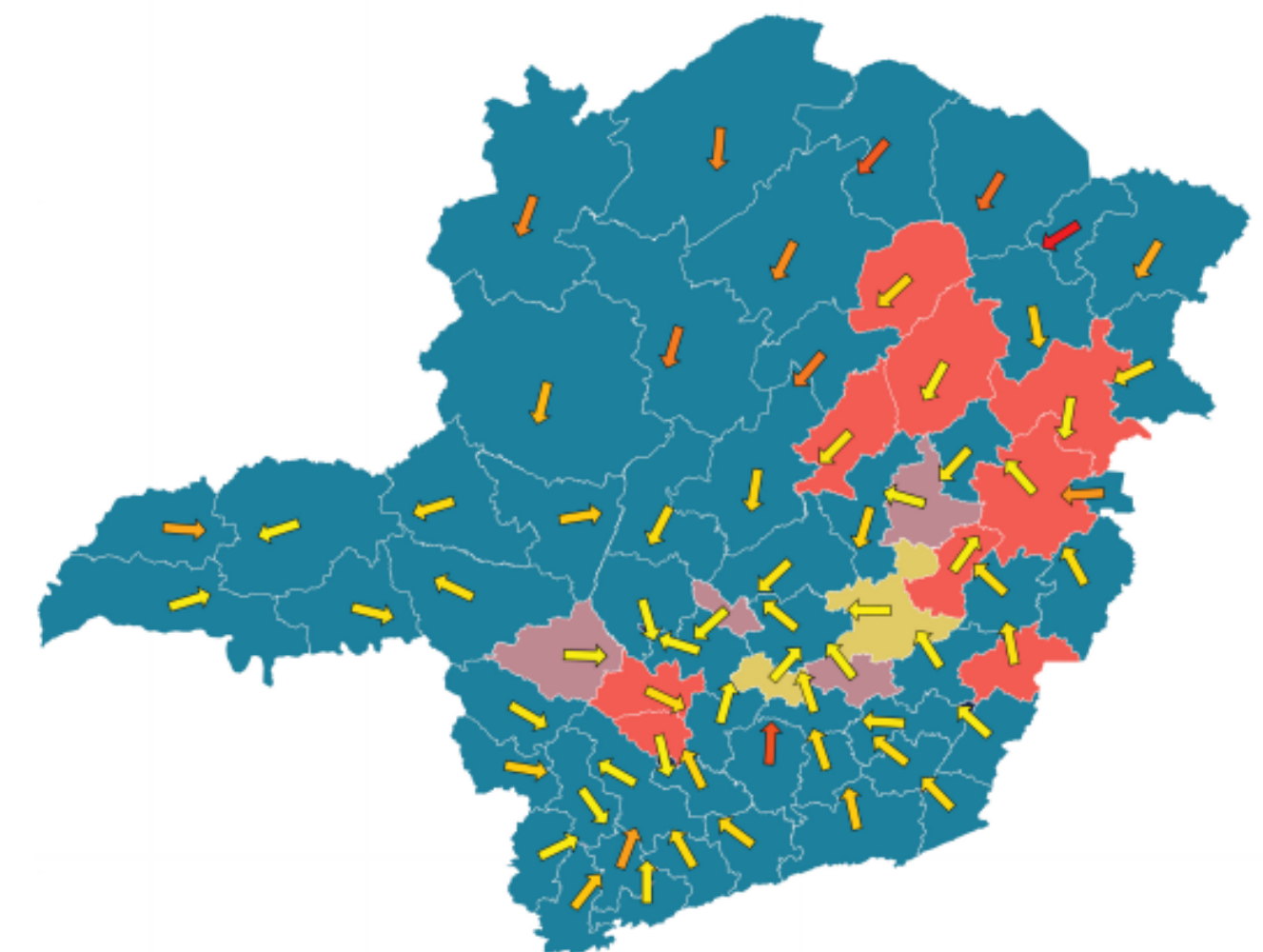
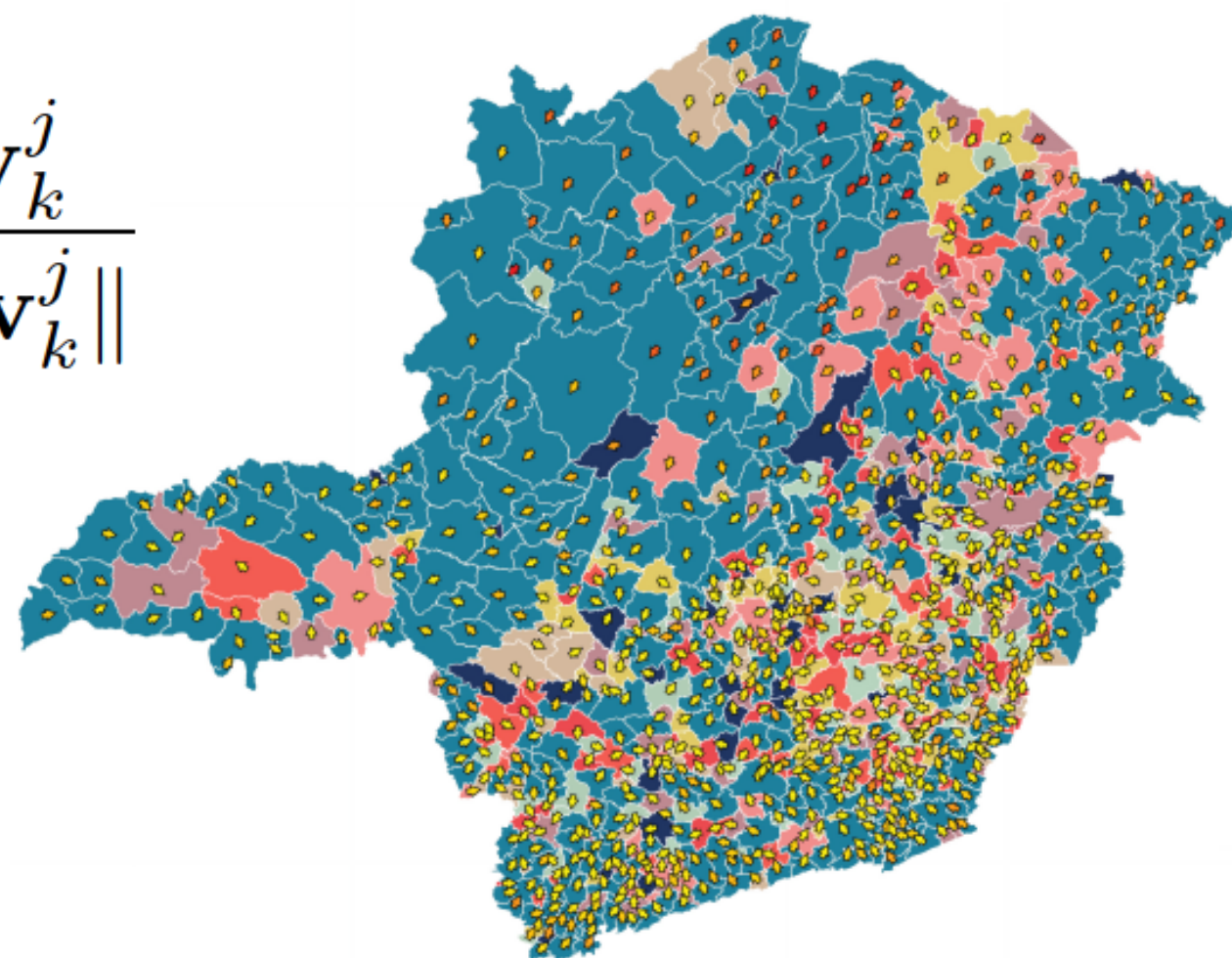
Cities



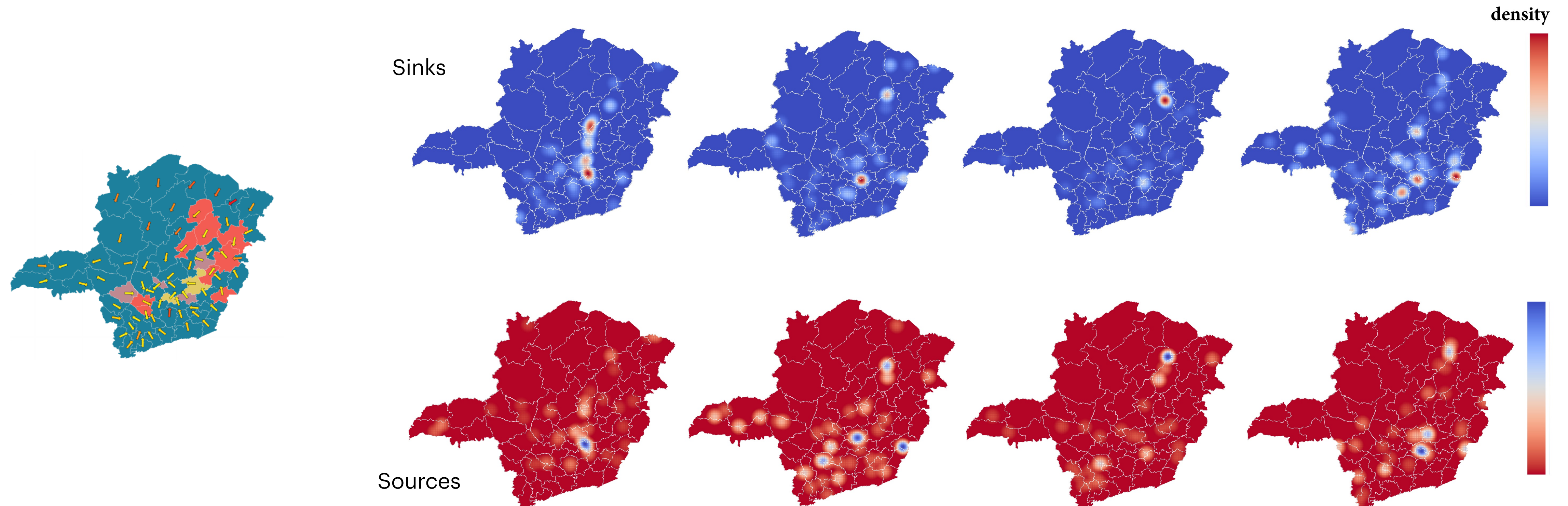
Microregions



$$S_C(\mathbf{v}_k^i, \mathbf{v}_k^j) = \frac{\mathbf{v}_k^i \cdot \mathbf{v}_k^j}{\|\mathbf{v}_k^i\| \|\mathbf{v}_k^j\|}$$



Critical points



Take home messages

- Network-based approaches often ignore some relevant spatial information
- Moving from networks to flow may be beneficial to the understanding of predictability, risk areas, and critical points
- An alternative/complementary tool to network methods for analysing the dynamic patterns of mobility
- We believe this could be a general approach that can be applied to other types of mobility datasets
 - The approach can be used to generate incoming edges also although the semantic of what these fields would represent needs to be carefully defined

Team Involved in this Work



Sima Farokhnejad



Ronaldo Menezes



Marcos Oliveira



Eraldo Ribeiro



Angélica da Mata



Christiane Rocha



Denis Cardoso

Paper: Using Vector Fields in the Modelling of Movements as Flows: A Case Study with Cattle Trade Networks. In: CompleNet. Springer Nature (2023). to Appear

¹Computer Science, University of Exeter, Exeter, England, UK

²Computer Science, Florida Institute of Technology, Melbourne, Florida, USA

³Computer Science, Federal University of Ceará, Fortaleza, Brazil



Sima Farokhnejad¹



Ronaldo Menezes^{1,3}



Marcos Oliveira¹



Eraldo Ribeiro²



University
of Exeter

