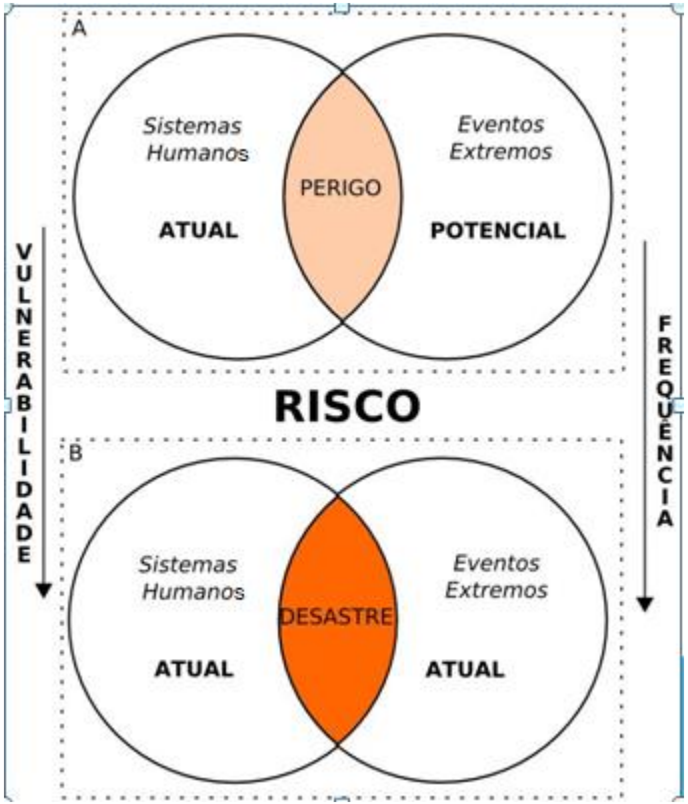
Disaster Risk Reduction - Working Group

Disaster Risk Reduction

RISK is the (measurable) probability that a hazard turns into a disaster.

RISK can not be eliminated, but it can be managed.

International goals adress the priorization of management of RISK instead of management of disasters.



Research areas

Epidemiology
Precipitation Modeling
Climate dynamics (multi-scale)
Extreme events
Risk modeling (measurement scales, multidimensionality, economy)
Hydrological models
Urban mobility

Areas (Maths):

Statistics

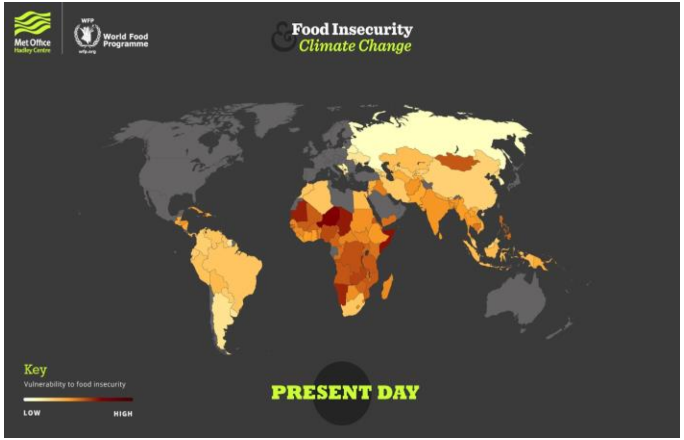
Complex networks

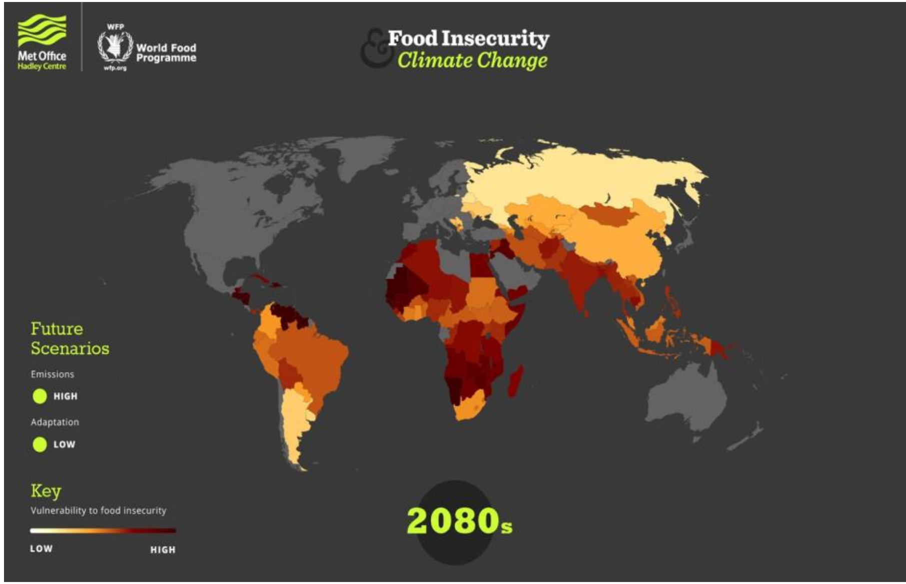
Econometrics

Ordinary differential equations

Partial differential equations

Project 1: Modelling rainfall with applications to flood risk and food insecurity:



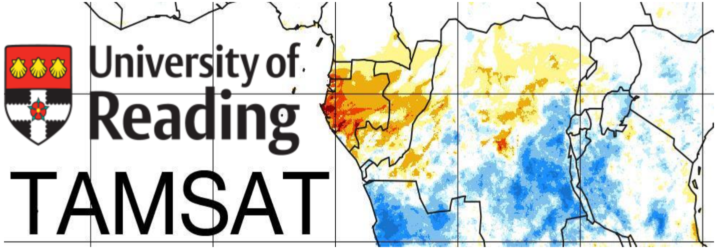


- ❑ Need of a global index for flooding
- ❑ Latest climate models work at 0.5º resolution
- ❑ Impossibility to use hydrological information
- ❑ We still want to include soil information

$$P_i = \sum_{j=0}^{364} w_{ij} \, p_{i-j}$$

Autoregressive structure as weighting scheme:
Effective quantity of retained rainfall

Question: how to calibrate the weights?



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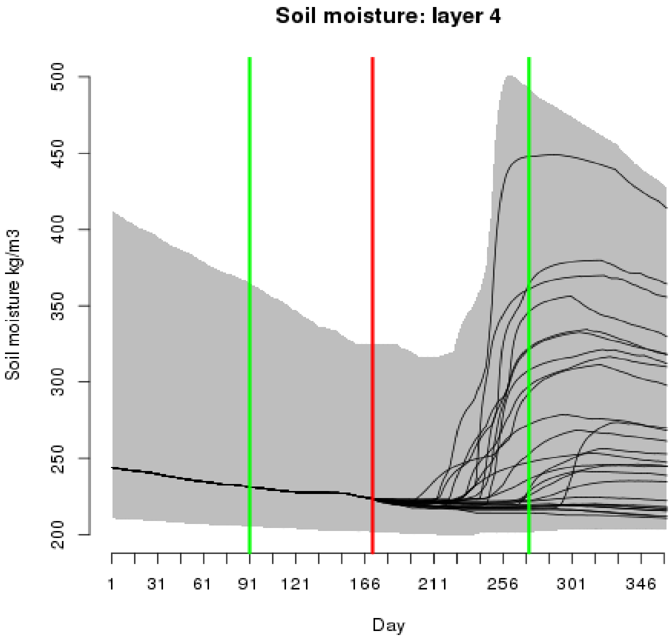
Cemaden

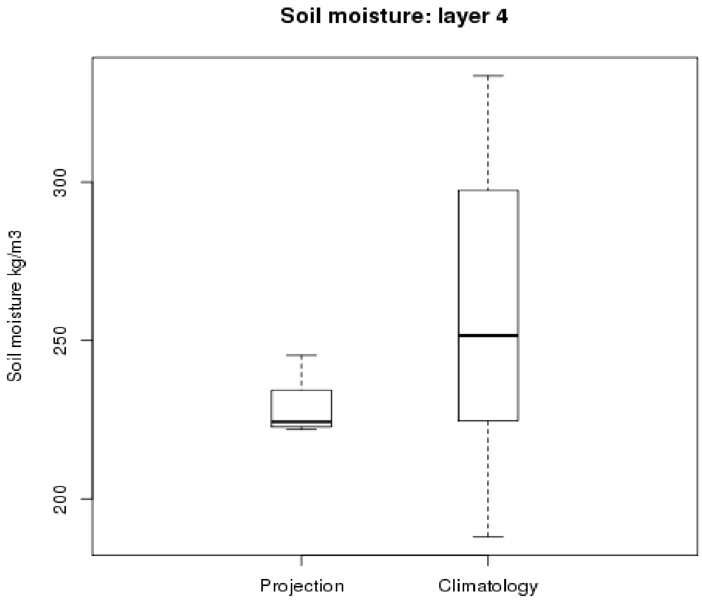
Centro Nacional de Monitoramento e Alertas de Desastres Naturais

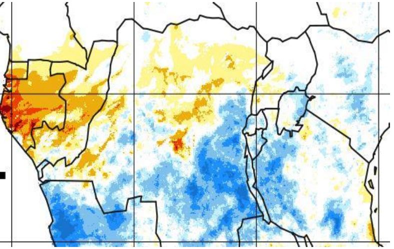
= ?

TAMSAT-CEMADEN collaboration



TAMSAT Example





TAMSAT-CEMADEN potential collaboration

Examples

TAMSAT can be applied at individual locations or country-wide, but needs accurate information on soil and crop types

TAMSAT does not make use of predictive meteorological/crop models and CEMADEN does not use soil moisture persistence

TAMSAT has only been trialled in Africa

CEMADEN have an app where local people can submit this type of information. Or something like this could be developed

We could share our expertise in these different areas to move both products forward

CEMADEN can help apply it in Brazil, in conjunction with their existing products

Project 2: Leptospirosis phylodynamics in an outbreak after flood

(Luciana, Luiz, Leo, Alice, Jair)

Question: Can we associate some hydrological properties with the time-axis in a phylodynamic tree for leptospirosis?

Leptospirosis cases

Londe et al. (2016). Flood-related leptospirosis outbreaks in Brazil: perspectives for a joint monitoring by health services and disaster monitoring centers. Natural Hazards (Dordrecht. Online), v. 84, p. 1419-1435.

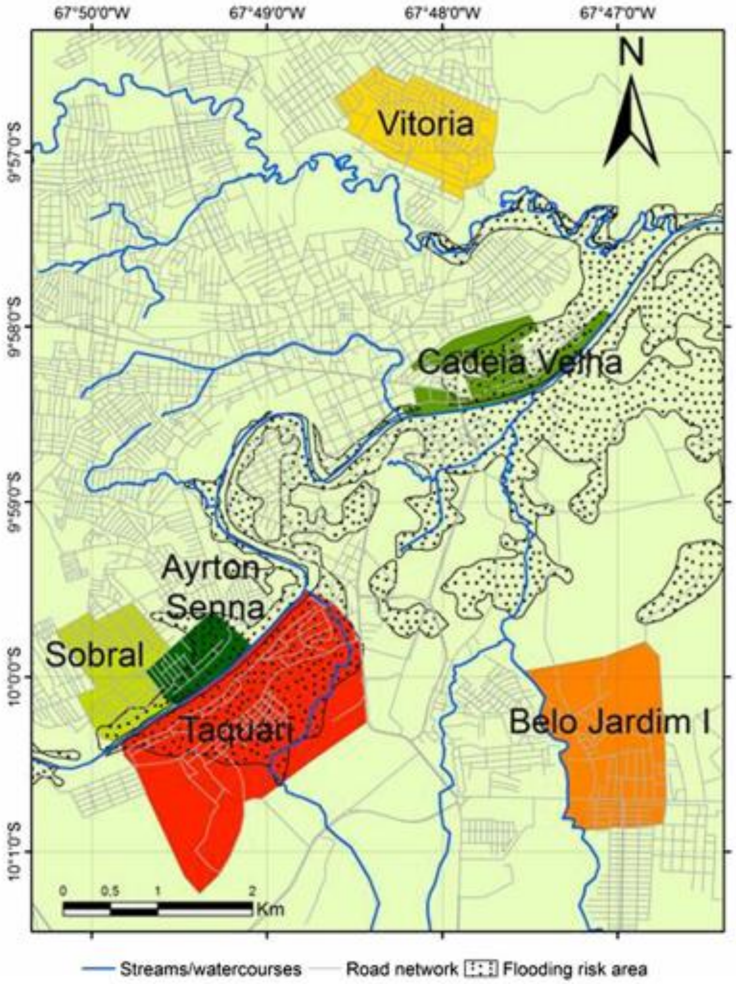


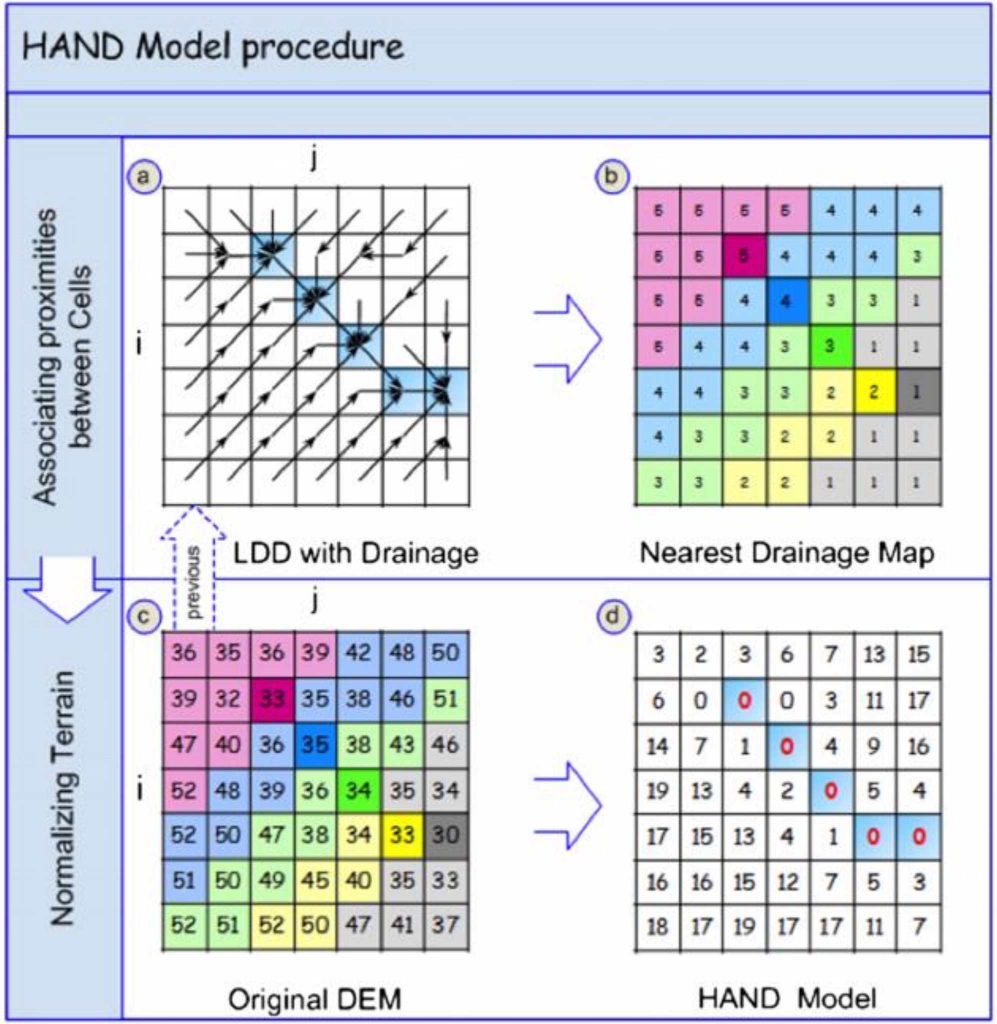
Fig. 7 Rio Branco's neighborhoods which registered high numbers of leptospirosis cases and flooding risk areas. *Source*: risk areas data from CPRM—Brazilian Geological Survey

HAND INDEX

Height Above Nearest Drainage

Static: Nobre et al. (2016) HAND contour: a new proxy predictor of inundation extent. Hydrol. Process., 30: 320–333.

Dynamic: Lima et al. (2016). An operational dynamical neuro forecasting model for hydrological disasters. Modeling Earth Systems and Environment, v. 2, p. 94.



PHYLODYNAMIC TREE

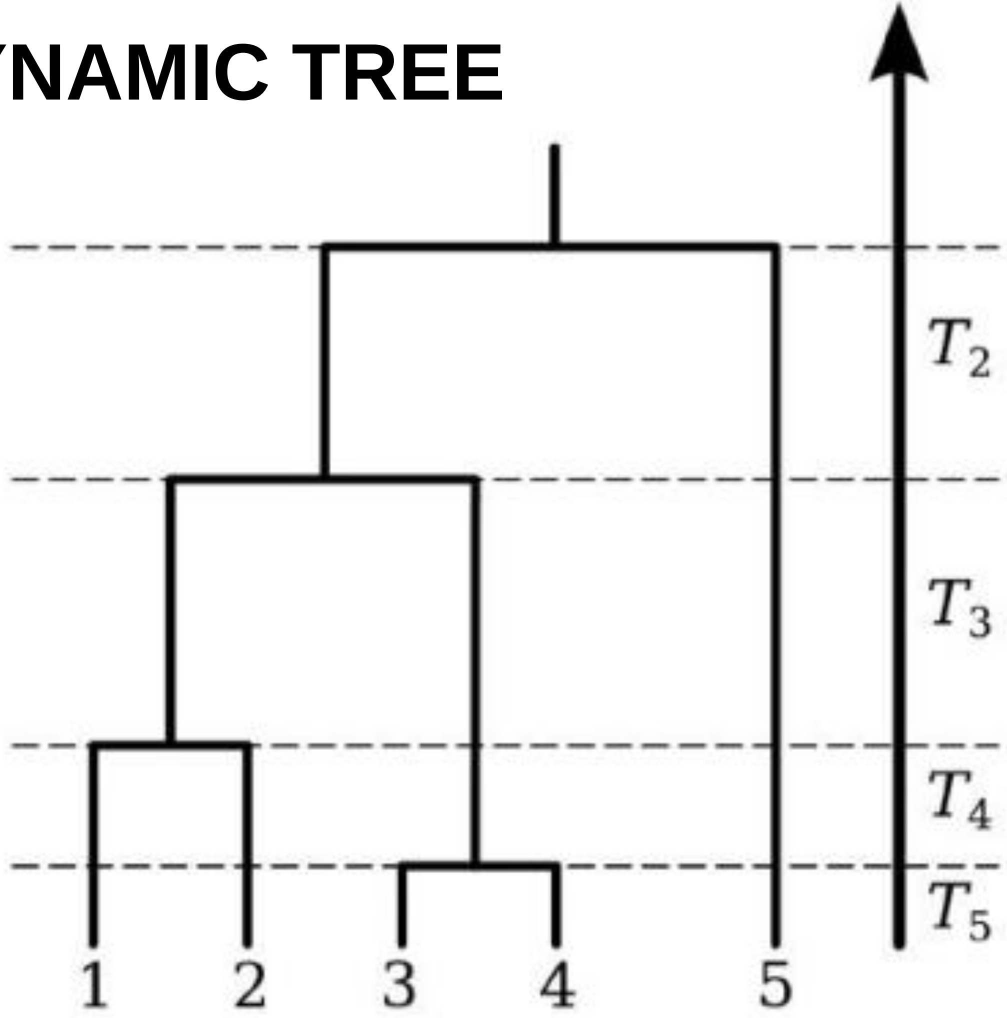
Let T_n denote the time for n lineages to *coalesce*, i.e., merge into one ancestral lineage, in a population of size N_e. Then:

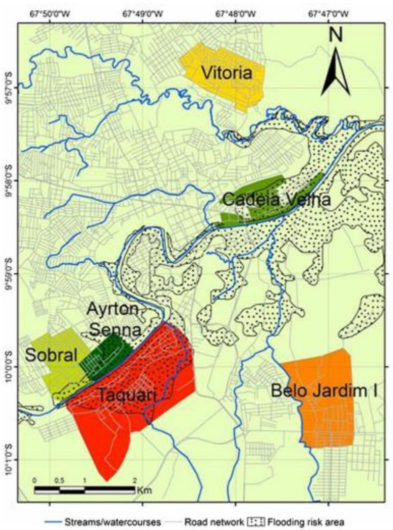
$$Pr(T_n = t) = \lambda_n e^{-\lambda_n t}$$

$$\lambda_n = \binom{n}{2}\frac{1}{N_e} = \binom{n}{2}\frac{1}{N_e \tau}$$

where N_e is the effective population size and τ is the generation time. Let T_{mrca} denote the age of the most recent common ancestor:

$$\begin{aligned}\mathbb{E}[T_{\text{mrca}}] &= \mathbb{E}[T_n] + \mathbb{E}[T_{n-1}] + \ldots + \mathbb{E}[T_2] \\ &= 1/\lambda_n + 1/\lambda_{n-1} + \ldots + 1/\lambda_2 \\ &= 2N_e(1 - \frac{1}{n})\end{aligned}$$





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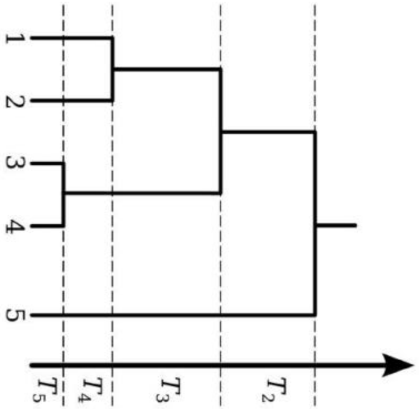

Santos et al. (2017). A RS-GIS-based Comprehensive Impact Assessment of Floods - a Case Study in Madeira River, Western Brazilian Amazon. IEEE Geoscience and Remote Sensing Letters Special Stream, v. 14, n. 9

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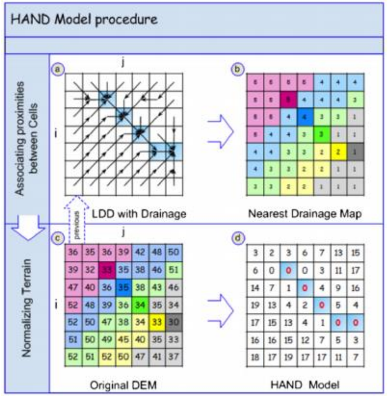


Time scales:

Flooding (Amazon region): 3 months

Bacteria evolution: ???

or any similar proximity matrix

Project 3: Flooding damage estimation using urban mobility data, Geographical Complex Networks and Nash Equilibrium approach - (Leonardo, Andres, Luciana, Selma, Viviana, Guillermo);

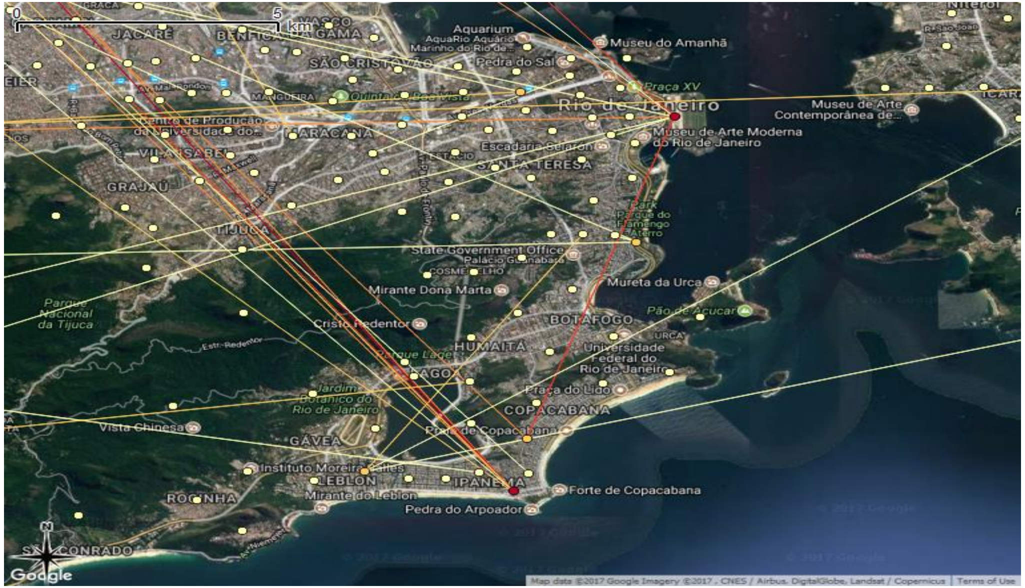
Questions:

1. How to assess the different economic risks in floods?
2. Is there any geographical Complex Networks index able to estimate flood's impacts on urban mobility?
3. Could be possible to analyse the urbanization - disasters relationship under a Nash Equilibrium approach?

First approach:

Santos et al. (2015): based on an ODD from the Rio de Janeiro and using a Google Maps based script, was estimated the amount of people directly and indirectly affected in their mobility in a potential flood episode.

There is a economic impact related to floods that must to be studied in order to understand where the most vulnerable region are. A (geographical) Complex Network approach could be applied to this task.



Second approach:

Challenges of climate change (and natural disasters) and globalization occur simultaneously: "games in the sense of Nash's theory"

Others projects

An early warning indicator for arboviroses in urban environment

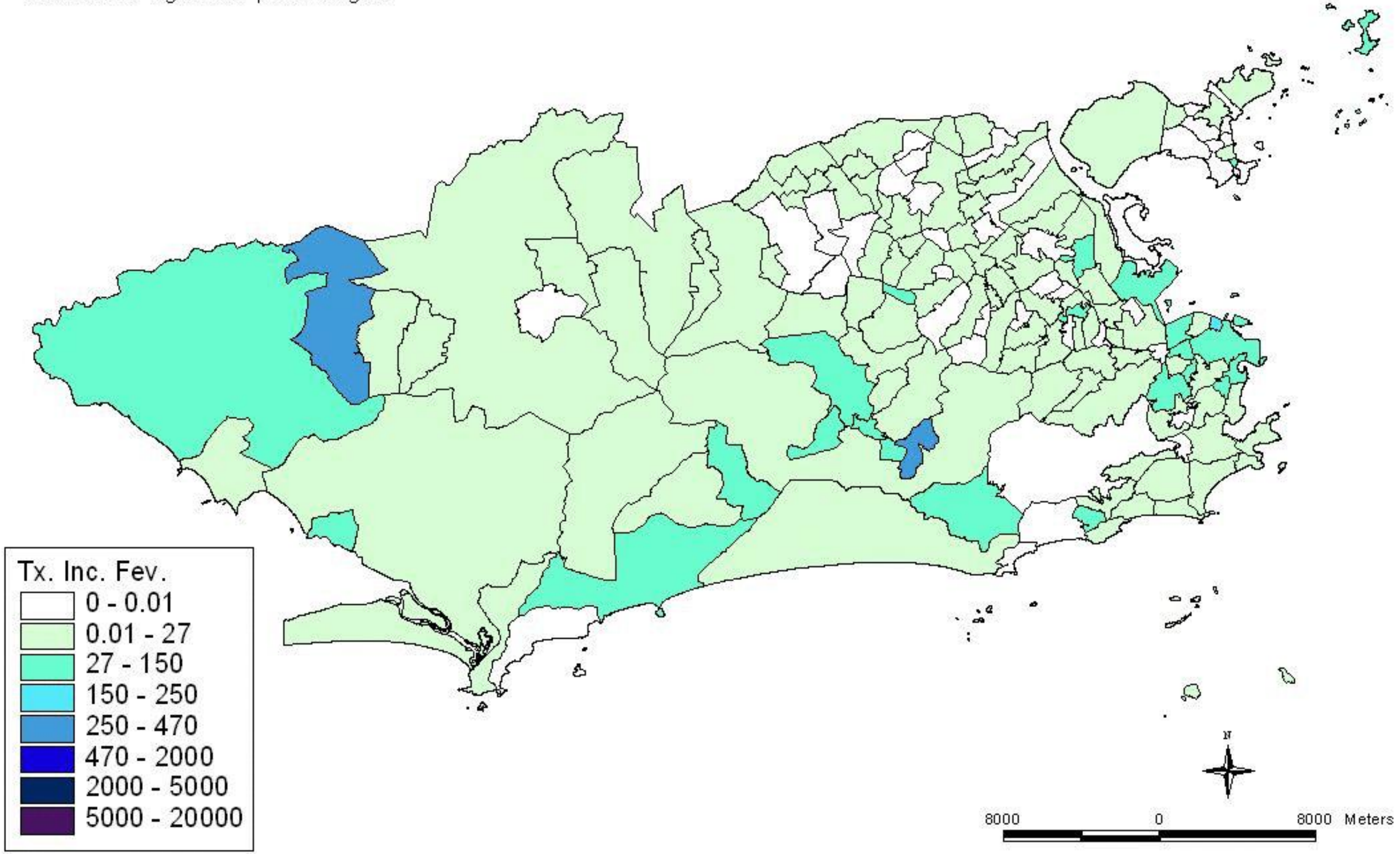
- Arboviroses (dengue, yellow fever, zika, etc) are major health threats in Brazil and other developing tropical countries. Early warning systems give policy makers and health authorities time to prepare.
- The final goal of the project would be to provide a complementary tool to early warning systems already in use (https://info.dengue.mat.br/).
- INFO-DENGUE already uses real-time meteorological data provided by Cemaden
- Disease notifications are assigned to the residence areas; however, many of the infections may have happened in other nodes (city sections) of the graph formed by the city districts (mobility complex networks)
- Can the inverse problem be addressed, namely finding the amount of real infections occurring on a given place?

RIO PREFEITURA
SAÚDE

Superintendência de Vigilância em Saúde
Gerência de Vigilância Epidemiológica

Dengue - Taxa de Incidência por Bairro - MRJ Janeiro 2007

Taxa de Incidência por 100.000 habitantes
Mapa Atualizado em 22-02-2008



WG overview

The **risk** of disasters can be understood as indices based on **spatial-temporal models**, with the difficult objective to preview their scales of magnitude and intensities. For **floods**, for instance, it is possible to adjust prediction systems using observational data, such as rainfall, soil moisture, vegetation and geology. We can also compare the cost/benefit of preventive measures with the **economic and social costs** for remediation of impacts. One of our challenges is to link models on a **global scale** and those on **local scales**. **Infectious diseases** often happen in sequence of an impact (floods, earthquakes, spills, ...). <u>**Innovative research must be done**</u> in a way that links mathematics and the different themes related to the study of disasters, to develop improved risk models.