

# V ComplexNet

V Workshop and School on  
Dynamics, Transport and Control  
in Complex Networks -  
ComplexNet

Cachoeira Paulista, August 26th to September 1th of 2018



## Participant Institutions



Universidade de São Paulo



Humboldt-Universität  
zu Berlin



Instituto Nacional de  
Pesquisas Espaciais



Potsdam-Institut für  
Klimafolgenforschung



Universidade Federal  
de São Paulo



Universität Potsdam



Centro Nacional de Monitoramento e  
Alertas de Desastres Naturais.



Technische Universität  
Berlin



Universidade Federal  
do ABC



Universidade Estadual  
de Campinas

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## ComplexNet - Introduction

The V ComplexNet - Workshop and School on Dynamics, Transport and Control in Complex Networks - ComplexNet - is a multidisciplinary event that aims to bring undergraduate and graduate students, postdocs and researchers interested a systemic view of the area, and covering fundamentals and applications. During the last decade, networks with complex topology have become a very powerful approach for understanding elaborate systems involving a very large number of agents that interact with each other. This approach has been used in various fields, from neuroscience and engineering, to sociology and economics. During this School, in the context of short courses, thematic lectures and panels the basic principles of complex networks will be presented as well as the methodologies that allow them to be used for the understanding of the dynamics in systems related to a broad range of areas, including interaction between neurons, Earth system complexity, autonomous mobile robots, systems energy distribution.

## Organizing Committee

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São José dos Campos - SP

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## Scientific Committee

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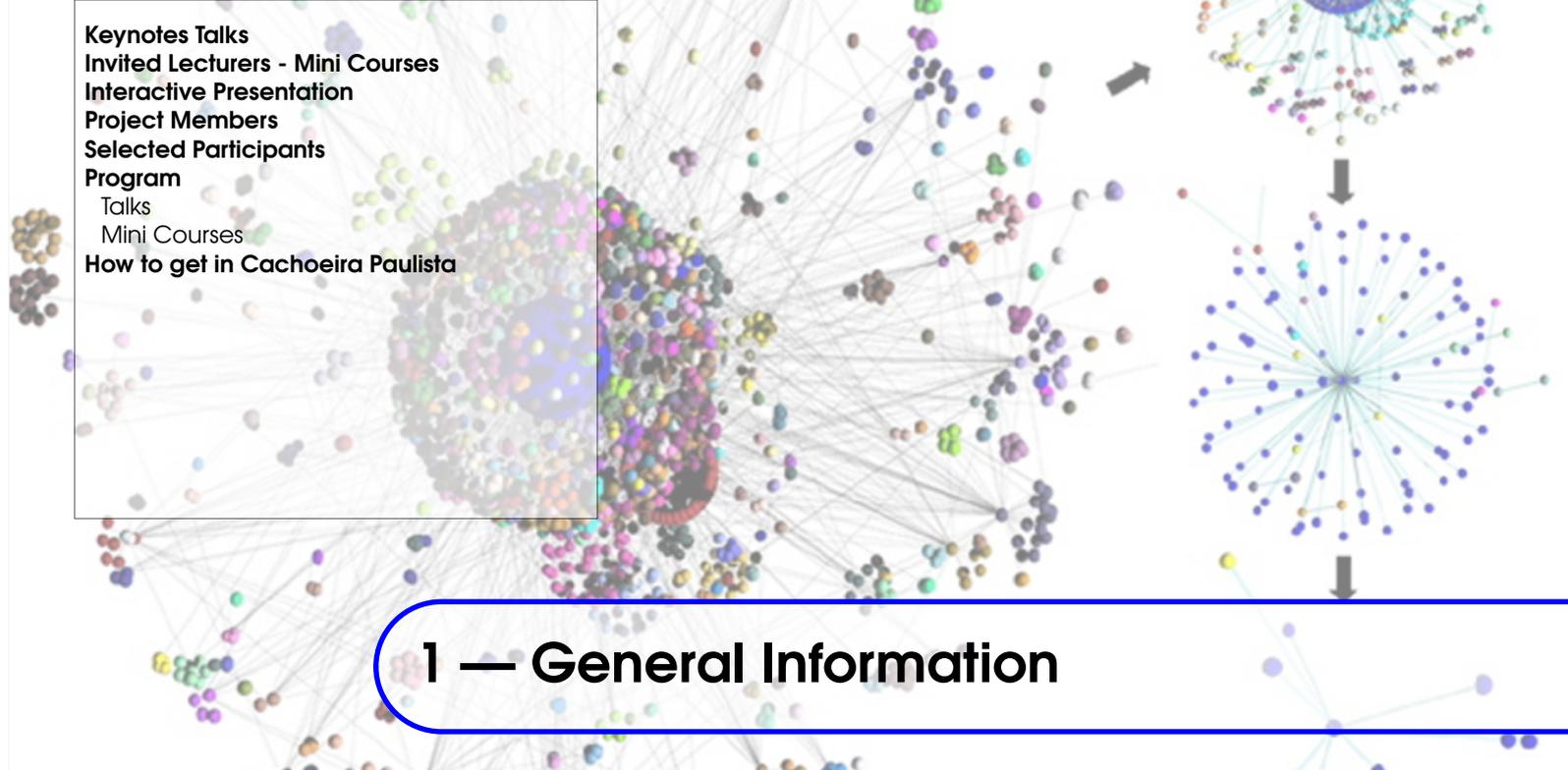
**Zhao Liang**

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Keynotes Talks  
Invited Lecturers - Mini Courses  
Interactive Presentation  
Project Members  
Selected Participants  
Program  
Talks  
Mini Courses  
How to get in Cachoeira Paulista

# 1 — General Information

## 1.1 Keynotes Talks

### **KT-1 - Nonlinear Interactions in meteorological models**

Pedro Leite da Silva Dias

IAG/USP – São Paulo

*The main objective is present the nonlinear interactions in simplified meteorological models and show how the sign of the diurnal variation can propagate to upscale intraseasonal variability and in other time scales, with the ocean interaction, to decadal/multidecadal variability.*

### **KT-2 - Emergence of hierarchical clusters in adaptive networks**

Serhiy Yanchuk

Technische Universität Berlin, Germany

*We report the phenomenon of self-organized emergence of hierarchical multilayered structures in dynamical networks with adaptive couplings. This process is characterized by a sequential formation of subnetworks (layers) of densely coupled elements, the size of which is ordered in a hierarchical way, and which are weakly coupled between each other. We show that the hierarchical structure causes the decoupling of the subnetworks. Each layer can exhibit either a two-cluster state, a periodic traveling wave, or an incoherent state, and these states can coexist on different scales of subnetwork sizes.*

### **KT-3 - First passage in transient conditions**

Victor Nicolai Friedhoff<sup>1</sup>, Martin Falcke<sup>2</sup>

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*First-passage times in random walks have a vast number of diverse applications in physics, chemistry, biology, and finance. In general, environmental conditions for a stochastic process are not constant on the time scale of the average first-passage time or control might be applied to reduce noise. We investigate moments of the first-passage time distribution under an exponential transient describing relaxation of environmental conditions. We solve the Laplace-transformed (generalized) master equation analytically using a novel method that is applicable to general state schemes. The first-passage time from one end to the other of a linear chain of states is our application for the solutions. The dependence of its average on the relaxation rate obeys a power law for slow transients. The exponent depends on the chain length  $N$  like  $-N/(N+1)$  to leading order. Slow transients substantially reduce the noise of first-passage times expressed as the coefficient of variation (CV), even if the average first-passage time is much longer than the transient. The CV has a pronounced minimum for some lengths, which we call resonant lengths. These results also suggest a simple and efficient noise control strategy and are closely related to the timing of repetitive excitations, coherence resonance, and information transmission by noisy excitable systems. A resonant number of steps from the inhibited state to the excitation threshold and slow recovery from negative feedback provide optimal timing noise reduction and information*

transmission.

#### **KT-4 - First passage under resetting**

A. Chechkin<sup>1</sup>, I. M. Sokolov<sup>2</sup>

<sup>1</sup> Institute of Physics and Astronomy, Potsdam University, Karl-Liebknecht-Strasse 24/25, 14476 Potsdam-Golm, Germany / Akhiezer Institute for Theoretical Physics, Akademicheskaya Street 1, 61108 Kharkow, Ukraine, aleksei.chechkin@gmail.com

<sup>2</sup> Institut für Physik and IRIS Adlershof, Humboldt Universität zu Berlin, Newtonstraße 15, 12489 Berlin, Germany, sokolov@physik.hu-berlin.de

*We provide a unified renewal approach to the problem of random search for several targets under resetting. This framework does not rely on specific properties of the search process and resetting procedure, allows for simpler derivation of known results, and leads to new ones. Concentrating on minimizing the mean hitting time, we show that resetting at a constant pace is the best possible option if resetting helps at all, and derive the equation for the optimal resetting pace. No resetting may be a better strategy if without resetting the probability of not finding a target decays with time to zero exponentially or faster. We also calculate splitting probabilities between the targets, and define the limits in which these can be manipulated by changing the resetting procedure. We moreover show that the number of moments of the hitting time distribution under resetting is not less than the sum of the numbers of moments of the resetting time distribution and the hitting time distribution without resetting.*

#### **KT-5 - Network Unfolding Map by Vertex-Edge Dynamics Modeling**

Zhao Liang

Universidade de São Paulo-Ribeirão Preto

*The emergence of collective dynamics in neural networks is a mechanism of the animal and human brain for information processing. In this paper, we develop a computational technique using distributed processing elements in a complex network, which are called particles, to solve semisupervised learning problems. Three actions govern the particles' dynamics: generation, walking, and absorption. Labeled vertices generate new particles that compete against rival particles for edge domination. Active particles randomly walk in the network until they are absorbed by either a rival vertex or an edge currently dominated by rival particles. The result from the model evolution consists of sets of edges arranged by the label dominance. Each set tends to form a connected subnetwork to represent a data class. Although the intrinsic dynamics of the model is a stochastic one, we prove that there exists a deterministic version with largely reduced computational complexity; specifically, with linear growth. Furthermore, the edge domination process corresponds to an unfolding map in such way that edges "stretch" and "shrink" according to the vertex-edge dynamics. Consequently, the unfolding effect summarizes the relevant relationships between vertices and the uncovered data classes. The proposed model captures important details of connectivity patterns over the vertex-edge dynamics evolution, in contrast to the previous approaches, which focused on only vertex or only edge dynamics. Computer simulations reveal that the new model can identify nonlinear features in both real and artificial data, including boundaries between distinct classes and overlapping structures of data.*

#### **KT-6 - INCREASED RISK OF DROUGHT IN THE SEMIARID LANDS OF NORTH-EAST BRAZIL DUE TO REGIONAL WARMING OF 4°C**

Jose A. Marengo<sup>1</sup>, Ana Paula Cunha<sup>1</sup>, Wagner R. Soares<sup>1</sup>, Lincoln M. Alves<sup>2</sup>, Sheila S. de Barros Brito<sup>1</sup>, Luz A. Cuartas<sup>1</sup>, Karinne Leal<sup>1</sup>, Gustavo Ribeiro-Neto<sup>1</sup>, Regina C. S. Alvalá<sup>1</sup>, Antonio R. Magalhaes<sup>3</sup>

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*Historically, during periods of extreme drought, food security for the most vulnerable communities in the drylands of North-east Brazil (NEB) is under severe risk due to reduced subsistence production, reduced income and increased pricing of agricultural products. The recent drought events in the region (2012-2017) continue to highlight the vulnerability of this region and confirm the risk of major impacts due to climate change. Arid conditions are projected to increase significantly by 2100 for climate change scenarios that increase the likelihood of warming above 4 °C by the middle of this century. During the last 10 years, aridification has been already observed in the region. Recurrent droughts conditions in semiarid regions can produce a progressive loss of*

resilience that affects negatively the ability of recovering the initial state, rendering plants to be more vulnerable to a recurring disturbance. Although semiarid vegetation is usually resistant and highly resilient to water deficits, vegetation activity in semi-arid region of Northeast Brazil (NEB) is highly controlled by interannual variations in water availability and decrease in water availability may trigger land degradation and desertification. Recurrent droughts conditions in semiarid regions, such as NEB, can produce a progressive loss of resilience that affects negatively vulnerable populations living from small-scale agriculture. The drought affecting this region continuously during the last 7 years shows an intensity and impact not seen in several decades in the regional economy and society, and represents an example of what could happen in NEB in the future. In sum, regional warming above 4 °C is likely to increase the drought risk in Northeast Brazil, with increase temperature and decrease precipitation resulting in lower vegetal productivity and more unpredictable harvests. In municipalities, where smallholder livelihoods are not very diversified and are dominated by subsistence agriculture, even a moderate drought (as in 2012-13) can cause a decline in harvests; and, with an increased drought risk (as the future projections), the harvest scenario can still be worse and devastating for regional and national food security and economy. Therefore, there is an urgent need for proactive drought management and preparedness strategies as well as integrated assessments considering the synergy of impacts and limits to adaptation in multiple sectors and regions in a 4° C warming for NEB

### **KT-7 - Stochastic Equations with Geodesic Jumps: properties and applications**

Paulo Régis Ruffino

UNICAMP, Campinas, SP

*So far, the main approach of semimartingale with jumps in submanifolds of Euclidean spaces has been the so called Marcus equation since the paper by Kurtz, Pardoux and Protter. Essentially what we propose here is a model where the jumps, instead of following the flow of a vector field, it follows the geodesic pointed by the vector field assigned at the point of jump. This corresponds to the appropriate generalization to Riemannian manifolds of the Itô integral for semimartingales with jumps in Euclidean spaces. We intend to prove an Itô-Kunita generalized formula and use in dynamical applications.*

## **1.2 Invited Lecturers - Mini Courses**

### **MC-1 - Network analytics: Traditional vs modern approaches**

Ernesto Estrada,

Department of Mathematics and Statistics University of Strathclyde Glasgow, ernesto.estrada@strath.ac.uk

*I will introduce several problems in the traditional network analysis. They are: degree distributions, degree-degree correlation, clustering coefficients, assortativity and shortest path communication. I will discuss the problems that emerge when we try to use these traditional approaches due to the constraints of the data available, the lack of interpretation of the existing indices or wrong initial assumptions about the hypothesis behind the methods. For each case I will show alternative, modern methods, which are based on rigorous mathematical analysis using algebraic, topological and combinatorial methods. All the cases are based on real-world examples and I will make emphasis in the understanding of the methods proposed more than in their technicalities. The students do not require any previous knowledge of network theory and only undergraduate level of mathematics is needed.*

### **MC-2 - Complex network approaches for nonlinear time series analysis**

Yong Zhou

East China Normal University, Shanghai, China, yzhou@phy.ecnu.edu.cn

*In the last about 10 years, there has been a growing body of literature aiming at the utilization of complex network methods for the characterization of dynamical systems based on time series. While both nonlinear time series analysis and complex network theory are widely considered to be established fields of complex systems sciences with strong links to Nonlinear Dynamics and Statistical Physics, the thorough combination of both approaches has become an active field of research during the last decade, which has allowed addressing fundamental questions regarding the structural organization of nonlinear dynamics as well as the successful treatment of a variety of applications from a broad range of disciplines. In this talk, I will focus on three main concepts, phase space / recurrence networks, visibility graphs and transition / Markov chain networks, which have made their way from abstract concepts to widely used methodologies. These three concepts, as well as several variants thereof, have been studied in great detail regarding their specific properties, potentials and limitations and provided fundamental new insights into the dynamics of complex systems. In addition, I will show that these approaches have already found a wide range of applications from such diverse fields as climatology, neurophysiology and economics, demonstrating the great potentials of time series networks to tackling real-world contemporary scientific problems.*

**MC-3 - Synchronization in Nonlinear Science**

Arkady Pikovsky

University of Potsdam, Germany,  
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*The emergence of synchronization in a network of coupled oscillators is a fascinating topic in various scientific disciplines. A widely adopted model of a coupled oscillator network is characterized by a population of heterogeneous phase oscillators, a graph describing the interaction among them, and diffusive and sinusoidal coupling. It is known that a strongly coupled and sufficiently homogeneous network synchronizes, but the exact threshold from incoherence to synchrony is unknown. Here, we present a unique, concise, and closed-form condition for synchronization of the fully nonlinear, nonequilibrium, and dynamic network. The topics to be address are the following: Synchronization of periodic oscillators: basic experiments and theory; Synchronization of chaotic systems; Dynamics of large oscillator populations: the Kuramoto model, Watanabe-Strogatz/Ott-Antonsen theory, partial synchrony, chimera states; Network reconstruction from data.*

**MC-4 - Complex systems methods for analyzing climate time series**

Reik Donner

Potsdam Institute for Climate Research Impact (PIK), Germany, redonner@pik-potsdam.de

*Real-world time series from many fields, including climate and neurosciences, are typically reflecting inherently nonlinear processes determining the underlying system's structure and dynamics. Therefore, it is usually not possible to infer sufficiently holistic information on the temporal behavior of observations from time series data when considering only classical linear concepts of statistics like correlation or spectral analysis. As an alternative, a variety of dynamical systems based approaches for analyzing nonlinear time series have been developed over the last decades, the foundations of which originate in the theory of complex (nonlinear) dynamical systems. In this lecture series, I will introduce some prominent examples of contemporary analysis frameworks highlighting the methodological variety of nonlinear time series analysis.*

**MC-5 - Statistical Techniques applied to climatic variability: South American Monsoon**

Samia Regina Garcia Calheiros

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*The study of the climatic variability is important for social and economic issues. In this context, it is known that the South American monsoon system (SAMS) is responsible for a considerable proportion of continental summer precipitation, presenting a marked seasonal rain cycle characterized by dry winters and wet summers. An overview will be done about the main precipitation systems that are related to the SMAS. One aspect of South American climatic variability which has been extensively investigated and which is related to the SAMS is the low frequency variability modes. For this, Empirical Orthogonal Functions (EOF) is one technique that can be applied to the variables anomalies. The EOF technique will be presented with detail, as well as their application in climatic variability studies. Another relevant topic for policymakers is the detection of onset and demise dates of SMAS rainy season. Several papers have focused on the methods to determine these dates. Thus, the findings from these works will be discussed. As the method based on antisymmetric outgoing longwave radiation has a great potential for monitoring purposes, it will be presented and analyzed.*

**MC-6 - Stability and resilience in power grids**

Luis F. C. Alberto

Universidade de São Paulo em São Carlos, lfcaberto@usp.br

*Power grid stability and resilience is already a highly relevant area of complex systems science and becomes even more so in view of an increasing share of variable renewable energy production, ever closer interactions between the physical power grid dynamics and socio-economic systems such as markets and smart-grid components, corresponding shifts in electricity production and consumption, and the projected increases in extreme weather events due to climate change. I will present an overview of related challenges and areas of application for nonlinear dynamics and networks science, and recent related results from our own research regarding the influence of certain network motifs on frequency stability, the role of local and global redundancy in the trade-off between dynamic stability and the resilience against cascading failures, and the application of novel nonlinear measures of transient stability.*

**I-Talk-1 - Community Detection in Temporal Networks**

Marcos G. Quiles<sup>1</sup>, Alessandra Marli<sup>2</sup>, Elbert E. N. Macau<sup>3</sup>

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*The study of real systems via complex networks has been a very active area in recent years. However, much of the progress made during this period is related to the study of the properties of networks with fixed topology (static). Commonly, the investigation and synthesis of complex networks make use of measures to characterize their main topological attributes. The characterization of the network is useful both in understanding and recognition of real systems and in modeling and simulation of synthetic systems. In the dynamic scenario, the topological structure may vary over time and may even result in the change of system functions and properties under study. Thus, the definition of measures to characterize the structural properties of dynamic networks and their modifications over time are essential in many non-stationary scenarios. Among several measurements that can be extracted from a network, the community, or modular structure, is an essential one. Communities are groups of densely connected nodes within a network, while connections between nodes belonging to different communities are proportionally sparser. The detection of communities is not a trivial task, and this problem becomes even more challenging in temporal networks. In this talk, we will introduce temporal networks; revisit how traditional community detection methods can be applied to temporal networks; their limitations; and, finally, we will present a dynamic model that, intrinsically, can deal with these networks.*

### **I-Talk-2 - Information Spreading and Social Curiosity in a nutshell**

Didier Vega-Oliveros<sup>1</sup>, Francisco A. Rodrigues<sup>2</sup>, Zhao Liang<sup>3</sup>

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*Most information spreading models consider that all individuals are identical psychologically. They ignore, for instance, the curiosity level of people, which may indicate that they can be influenced to seek information given their interest. For example, the game Pokémon GO spread rapidly because of the aroused curiosity among users. In this talk, we present an information propagation model that considers the curiosity level of each individual, which is a dynamical parameter that evolves over time. We evaluate the efficiency of considering curiosity in contrast to homogeneous information propagation models, like SIR or IC, and perform analysis on different types of artificial and real-world networks, like Google+, Facebook, and the United States roads map. The proposed mean-field approach also reproduced with a good accuracy the evolution of macroscopic quantities for the system's behavior with the curiosity. The results indicate that the curiosity enhances the spreading of information more notably in spatial networks than in social networks. However, when the curiosity is taken into account, the most significant increase of informed individuals is reached close to the transition point. Since the curious people are more open to new products, concepts, and news, this is an important factor to be considered in propagation modeling. Our results contribute to the understanding of the interplay between diffusion process and dynamical heterogeneous transmission in social networks.*

### **I-Talk-3 - COMPLEX NETWORKS ADDRESSED TO NATURAL HAZARDS AND DISASTERS**

Luciana R. Londe<sup>1</sup>, Leonardo Bacelar Lima Santos<sup>2</sup>

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*Disaster Risk Reduction is a multidisciplinary task, which depends on different tools, techniques and management planning. When combined with other sectors, such as infrastructure, public health, and urban mobility, there are unlimited possibilities for applications of Complex Network studies. Among the different strategies to prevent damages and promote preparedness, Complex Networks can support managers in several approaches. Nevertheless, it demands a conceptual discussion on hazard-prone areas, communities' vulnerability and monitoring. People, societies or physical infrastructure at risk may be exposed to a same hazard under different ways. The hazard is not exclusively related to economical conditions, but also to cultural, social and environmental conditions. Also specific approaches match different conditions of vulnerability to fit the study and management for risk reduction. Complex Networks are useful to understand the problems and make projections.*

### **I-Talk-4 - Exploring the complex network of South America's flying rivers**

Henrique Barbosa

Instituto de Física da USP, São Paulo, SP

*The Amazon rainforest is a tipping element of the earth system. Reduced rainfall and increased temperatures, expected occur with climate change and deforestation, might induce its dieback, while in turn forest loss is expected to intensify regional droughts. The consequences of this vegetation-atmosphere feedback would go beyond the forest boundaries, as large-scale moisture transport from tropical Atlantic to sub-tropical South America depends on the moisture recycling over the forest. In this talk I will discuss how Complex Networks can be used to investigate this problem and what we've learned by doing so.*

### **I-Talk-5 - POTENTIAL IMPACTS OF CLIMATE CHANGE IN BRAZIL**

Lincoln Alves<sup>1</sup>, Naurinete Barreto<sup>1</sup>, Katherine Heath<sup>2</sup>, Jose A. Marengo<sup>3</sup>

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3 CEMADEN, São José dos Campos, Brazil

*In addition to the challenge of reducing greenhouse gas emissions, there is an increasing need to prepare and adapt for the changes in climate and weather that are already locked in. But its inherently complex nature makes it less clear what the impacts will be including when and where they'll happen, or to what degree. To address the need for better information on future climate we used observational and GCMs data from the CMIP5 and examined climate change impacts and their implications for infrastructure and health in Brazil.*

### **I-Talk-6 - Mathematical Models in Neuroscience: from neurons to networks**

Antonio C. Roque

Department of Physics, School of Philosophy, Sciences and Letters of Ribeirão Preto, University of São Paulo, Ribeirão Preto, SP, Brazil, antonior@usp.br

*This talk will give a brief overview of mathematical models of individual neurons and neural networks. It will cover simplified and biophysically detailed spiking neuron models and examples of their use in network models studied by the group of the presenter.*

## **1.3 Interactive Presentation**

### **T-01: Reservoir Computing meets Complex Networks Theory**

Didier A. Vega-Oliveros

University of São Paulo at Ribeirão Preto and INPE at São José dos Campos

*Complex Networks is a powerful mathematical framework for predicting and understanding dynamical and non-linear behavior in complex systems. The Internet, the propagation of information/virus in Social Networks, prediction and management of disaster risk, protein interaction, and many other areas have been benefited with the advances of complex networks theory. On the other hand, Artificial Neural Networks are computational networks that simulate learning processes, like animal neurons, in which the structure of the embedded network can improve the learning curve and computational efficiency. In particular, reservoir computing is a Neural Network approach where the training is based on the structure and connections of the reservoir layer, with lower computational cost compared with the back-propagation methods. In this talk, we present an initial study of reservoir computing and the straightforward advantage provided by the complex network theory.*

### **T-02: Intermittent Bursts in the Texas Helimak**

Felipe A. C. Pereira

Instituto de Física da USP, São Paulo

*The Texas Helimak is a toroidal plasma device with one-dimensional equilibrium, magnetic curvature and shear, resembling closely the border and scrape-off layer of a Tokamak. The Helimak typical regime turbulence presents intermittent density bursts that are responsible for an asymmetrical PDF with heavy-tails. This machine has 16 bias plates, where a large set of Langmuir probes is mounted and from where is possible to impose an external electrical bias. This electrical bias can change the turbulence regime, suppressing or enhancing the intermittent bursts. In this work, we study the intermittent bursts regime and show that the turbulence properties are reproduced by a shot noise model.*

### **T-03: Dynamical Behavior of Neural Networks Considering Synaptic Plasticity**

Kelly C. Iarosz

Instituto de Física da USP, São Paulo

*One of the most important properties of the mammalian brain is synaptic plasticity and it is the changing of the structure, function organization of neurons, in response to new experiences and is also related to processes of learning and memory. We have been studying the capacity of a neuronal network to change temporarily or permanently their connections and behavior, the plasticity, as a function of their synchronous behavior. We showed that the final state of networks evolved by depends on the initial network configuration. Moreover, external perturbations can induce coexistence of clusters, those whose neurons are synchronous and those whose neurons are.*

#### **T-04: Geographical Networks**

Leonardo Santos

Centro Nacional de Monitoramento e Alertas de Desastres Naturais (Cemaden), Sao Jose dos Campos, SP

*Spatial dependency and spatial embedding are basic physical properties of many phenomena modeled by networks. The most indicated computational environment to deal with spatial information is to use Georeferenced Information System (GIS) and Geographical Database Management Systems (GDBMS). Several models have been proposed in this direction, however there is a gap in the literature in generic frameworks for working with Complex Networks in GIS/GDBMS environments. Here we introduce the concept of (geo)graphs: graphs in which the nodes have a known geographical location and the edges have spatial dependence. We present case studies and two open source softwares (GIS4GRAPH and GeoCNet) that indicate how to retrieve networks from GIS data and how to represent networks over GIS data by using (geo)graphs.*

#### **T-05: The Influence of Time Series Distance Functions on Climate Network**

Leonardo N. Ferreira

INPE, São José dos Campos, SP

*In this work, we study the influence of time series distance functions on climate network construction. We use 29 distance functions to construct climate networks using global temperature data. The majority of climate network papers in the literature use the Pearson correlation coefficient with or without lag to measure the similarity between time series. These measures generate similar networks in general. Interestingly, we found that some distance functions generate very different networks and exhibit different teleconnection patterns.*

#### **T-07: Unrevealing Nonlinear Information Flow Between ENSO and PDO**

Lucas Massaroppe

IAG, USP, São Paulo

*A connectivity inference method is used to infer the directionality of information flow between terrestrial atmospheric regions, taking into account possible nonlinear characteristic interactions. To overcome the limitations of the linear technics, this work directly applies kernel-nonlinear-Partial Directed Coherence between Niño 3.4 and the Pacific Decadal Oscillation (PDO) robustly unraveling the nonlinear causality and a coupling model between the central and north Pacific regions. The former (data-driven) statistically inferred results are concordant with the theory: Niño 3.4 influences POD, thus describing a good approach for inferring causality among climate indices.*

#### **T-08: Features of land-cover change derived from satellite images and transition matrices**

Manoel Cardoso

INPE, São José dos Campos, SP

*Important features of the land-cover change in Amazonia can be derived only from remote-sensing data. They include, for example, type and amount of change, and similar transitions between different regions. In this study, the land-cover product TerraClass was analyzed with transitions matrices and similarity networks, enabling quantifying recent change between types of land cover in Amazonia. TerraClass is provided by the INPE/CRA (Centro Regional da Amazônia), and produced recent maps of the land surface of the region, subdivided into major classes of land cover. From these data, transition matrices can be calculated comparing maps for different years. Comparing transition matrices for different sub-regions can also enable to estimate similarities and differences between these regions. Within the features determined with this methodology, it was possible to estimate that deforestation mostly led to areas with pastures, secondary vegetation, and under regeneration, in agreement with ground-based estimates. Also it was possible to reproduce spatial patterns that resemble the sub-region normally referred to as "Arc of Deforestation". In addition to help analyze and model land dynamics in the study region, these results present the advantage of being produced only from an objective analysis of satellite-based land-cover maps, and not from ground-based observations, which are generally expensive and difficult to perform for large regions.*

**T-09: Embedding of relational data via particle dynamics**

Marcos G. Quiles

Universidade Federal de São Paulo, São José dos Campos, SP

*Data can be modeled in several manners, varying from simple feature vectors to complex relational representation. A graph, which commonly represents relational data, can deliver valuable information regarding the problem in analysis. However, a spatial (or dimensional) representation of the samples might be essential in some tasks, for instance in data visualization. Some techniques, such as the non-metric Multidimensional Scaling (NMDS) algorithm, have been developed for this purpose, albeit, these methods cannot be directly applied to non-stationary environments. Recently, a new dynamic community detection model was proposed by Quiles et al. In this model, nodes are represented by particles in a Euclidean space, named Particle Space. Following a simple motion equation, particles converge to readily detected clusters, which represent the communities of the network. Besides delivering state-of-the-art results, this model has introduced the particle space, which is a new way to interpret a graph in a metric space. Here, we explore this model and its dynamic features as a new method for embedding time-varying relational data. Following the derived dynamics, the particle's system evolves to an equilibrium in which the similarity between pairs of particles resembles the real similarity between input samples. In the equilibrium state, the coordinates of the particles represent the dimension (features) of the examples. In contrast to existent methods, our approach responds to changes in the environment without demanding a re-execution of the technique.*

**T-11: Lightning forecasting and storm characterization during to SOS-CHUVA**

Alan James P. Calheiros

INPE, São José dos Campos, SP

*Storm nowcasting is extremely important in the risk management strategy, mainly in regions with high vulnerability to the occurrence of severe weather events. Moreover, the development of nowcasting products and the determination of predictors variables can often be affected by local conditions and the different types of systems. This study characterized some severe systems by analyzing the spatial-temporal structure during to their life cycle. The aims were to determine some local predictors of severity and to create an automatic system of lightning nowcasting. The main dataset is based on the SOS-CHUVA project field campaign: polarimetric radar; weather satellite; disdrometers; high spatial raingauge distribution; radiosondes, lightning network; and microwave radiometer. The ForTraCC, forecasting and tracking of cloud cluster, was adapted to assimilate lightning and radar data too, giving the tracking information about the thunderstorms. The development of this lightning nowcasting model was necessary to know the statistical behavior of the flash rate structure during to the thunderstorm lifecycle. Moreover, different techniques were used to monitoring and predict the lightning occurrence. Furthermore, with the results from the tracking of the lightning structures was possible to study the storm propagation and its relationship with the thermodynamics parameters and the macrophysics and microphysics proprieties. Future application of the complex network on nowcasting studies is discussed.*

**T-12: Simulation of the Holocene climate over South America**

Gilvan Sampaio

INPE, Cachoeira Paulista, SP

*One of the main drivers of the climate system is the total amount of solar radiation that reaches the Earth's surface, known as insolation. There are several factors that influence insolation, such as length of the day, transparency of the atmosphere, solar variations, topographical variations and orbital parameters. Low frequency variations of the orbital parameters comprise the Milankovitch cycles (Berger, 1988), which modulate the insolation and are potential drivers of the climate changes. Atmospheric General Circulation Models (AGCMs) can be used to investigate the impact of insolation changes on the climate. Past climate simulations can be validated through paleoclimate proxies, ensuring that climate models are able to be used in future climate projections. The last past climate change occurred during the Holocene, geological epoch that began at approximately 11,700 years ago. In the Holocene, the insolation was significantly different from today, due to variations on orbital parameters. Holocene climate over South America has been studied through numerical simulations and paleoclimate proxies. However, temporal and spatial coverages of these studies are limited in general to the Last Millennium and 6 ka for the numerical simulations, and few locations for the proxies. The main objective of this study is to simulate the climate and vegetation variations of several Holocene periods (8 ka, 6 ka, 4 ka, 2 ka and present 0 ka) using the Center for Weather Prediction and Climate Studies (CPTEC) AGCM forced with orbital parameters and CO<sub>2</sub> concentration of these periods. For the Mid-Holocene, AGCM experiments were also forced by the oceanic conditions of this period. Simulations were compared with South American paleoclimate proxies and Mid-Holocene simulations with ESMs to analyze the reliability of the CPTEC-AGCM model in simulate climatic features of the*

*Holocene. This study is related with project C5: interaction of tipping elements in the climate system. In this project, a particular focus will be on understanding the role of large-scale inter-hemispheric SST gradient on the ITCZ position and how well the CMIP5 models can simulate it.*

### **T-13: Evaluating the atmospheric origins of current and future drought events in South America using complex networks**

Henrique Barbosa

Instituto de Física da USP, São Paulo, SP

*Brazil experienced several drought events during the last decade. Tropical forest ecosystems, as the Amazon, serve as an atmospheric moisture pump by taking up water from the soil and re-evaporating moisture, which is transported over long distances. Reduced forest cover from drought mortality in addition to forest loss from deforestation activities may lead to a significant change in atmospheric moisture transport. In our research, the atmospheric mechanisms leading to drought events will be investigated. The focus will be developing and applying complex network measures for atmospheric moisture transport patterns.*

### **T-14: Computational modeling of structure and function in neuronal intracellular signaling networks**

Fabio M. Simões de Souza

UFABC, São Bernardo, SP

*A fundamental challenge in Neuroscience is finding causal relationships between cognitive functions and the architecture and dynamics of the nervous system. A powerful approach to solve this problem is constructing computational models of brain structures to study its functional capabilities. Here, we will describe the conceptualization of computational models to investigate the structure and function of large scale stochastic intracellular signaling networks controlling synaptic plasticity in neurons. Particularly, we will focus on the molecular mechanisms of detection and discrimination of dynamic signals, such as calcium ions, underlying the induction of synaptic plasticity. We will present computational modeling applications of synaptic plasticity implied with learning and memory to study mirror neurons and autism spectrum disorder.*

### **T-16: Exact dynamical solution of the Kuramoto–Sakaguchi Model for finite networks of identical oscillators**

Rene O. Medrano-T.

UNIFESP, Diadema, SP

*We study the Kuramoto–Sakaguchi (KS) model composed by any  $N$  identical phase oscillators symmetrically coupled. Ranging from local (one-to-one,  $R = 1$ ) to global (all-to-all,  $R = N/2$ ) couplings, we derive the general solution that describes the network dynamics next to equilibrium. Therewith we build stability diagrams according to  $N$  and  $R$  bringing to the light a rich scenery of attractors, repellers, saddles, and non-hyperbolic equilibriums. Our results also uncover the obscure repulsive regime of the KS model through bifurcation analysis. Moreover, we present numerical evolutions of the network showing the great accordance with our analytical one. The exact knowledge of the behavior close equilibriums is a fundamental step to investigate phenomena about synchronization in networks. As an example, at the end we discuss the dynamics behind chimera states from the point of view of our results.*

### **T-17: Multistability and Transitions in Climate Systems**

Ricardo S. Oyarzabal

INPE, São José dos Campos, SP

*We propose a slightly modified van der Pol oscillator model to illustrate the dynamics of rain in the Amazon forest. In climate terms,  $x$  may be interpreted as a glaciation index, which slowly accumulates the effects of the astronomical forcing  $F(t)$ , while  $y$  might be interpreted as some representation of the ocean or carbon cycle dynamics. The investigation of the proposed model detects the occurrence of multistability and the prediction of the occurrence of possible transition points for other dynamic regimes (tipping point). As an application, this study will be used to better understand the dynamics of drought evolution in the Amazon.*

### **T-18: Reconstruction of Complex Networks Dynamics from Data**

Tiago Pereira

USP at São Carlos, SP

*We consider the problem of recovering the structure and dynamics of a complex network of interacting units from time series of observations. We focus on typical networks which exhibit heterogeneous degrees, i.e. where the number of connections varies widely across the network, and the coupling strength for a single interaction is small. This is the case in many applications ranging*

from neuroscience to physics. We show how to construct effective networks from data - based on blending rigorous mathematical proofs and machine learning - to forecast the original system's behaviour and predict its critical transitions. The reconstruction only requires relatively short time-series on the state variable of most nodes to determine the distribution of the nodes' degrees in the network, the underlying dynamics and the community structure of the network. We present applications to the reconstruction of probabilistic models of heterogeneous networks, as well as to real-world networks. Finally, we show how to use these results to predict critical transitions in networks with community motifs such as those in the brain.

### **T-19: Synchronous behavior in neural networks**

Antonio M. Batista

State University of Ponta Grossa, Ponta Grossa, Brazil;

*Synchronised rhythms have been observed for many years in electroencephalograph recordings of electrical brain activity, and are thought to be an important mechanism for neural information processing. Such synchronised rhythms reflect the hierarchical organisation of the connectome since they occur over a wide range of both spatial and temporal scales. We have studied neuronal synchronisation in a random network of adaptive exponential integrate-and-fire neurons. We study how spiking or bursting synchronous behaviour appears as a function of the coupling strength and the probability of connections, by constructing parameter spaces that identify these synchronous behaviours from measurements of the inter-spike interval and the calculation of the order parameter. Networks can simultaneously exhibit one synchronous and other desynchronous domain, known as chimera states. This way, we also study the existence of chimera-like states in a network considering the connectivity matrix based on the cat cerebral cortex.*

### **T-19: Detecting causal relations from real experimental data**

Elbert E. N. Macau

INPE, São José dos Campos, SP

*In this work, we present the Recurrence Measure of Conditional Dependence (RMCD), a recent data-driven causality inference method using the framework of recurrence plots. The RMCD incorporates the recurrence behavior into the transfer entropy theory. We apply this methodology to some paradigmatic models and to investigate the possible influence of the Pacific Ocean temperatures on the South West Amazon for the 2010 and 2005 droughts. The results reveal that for the 2005 drought there is not a significant signal of dependence from the Pacific Ocean and that for 2010 there is a signal of dependence of around 200 days. These outcomes are confirmed by the traditional climatological analysis of these episodes available in the literature and show the accuracy of RMCD inferring causal relations in climate systems.*

### **T-20: Optimal Control in Stochastic Systems.**

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*We consider the problem of optimal control in stochastic inventory model with deteriorating item. The cost includes the sum of the holding cost of inventory and the production cost. The solution of the related optimal stochastic control problem will be carried out using the stochastic dynamic programming principle. Our methodology is based on the general stochastic optimal control theory developed by Leão, Ohashi and Souza. The optimal stochastic control problem is discretized in such way that a near optimal control for the discretized problem is also a near optimal control for the original problem. By applying this result, we derive near optimal controls for the stochastic inventory with deteriorating item.*

### **T-21 - Spontaneous spiking activity in random networks of excitatory and inhibitory neurons with synaptic noise**

Antonio C. Roque

USP em Ribeirão Preto

*The main purpose of this work is to study spontaneous spiking activity patterns in random networks of excitatory and inhibitory Izhikevich neurons with synaptic noise. The activity patterns are localized on the parameter diagram spanned by relative inhibitory synaptic strength and synaptic noise magnitude. In the inhibition-dominated and moderate noise magnitude region of the diagram, networks feature intermittent switches between oscillatory and quiescent states. In the oscillatory state neuronal voltages oscillate between hyperpolarized and depolarized values, and in the quiescent state they fluctuate around resting state. Increase in noise intensity favors transitions from quiescent to oscillatory state. These patterns and their transitions are explained through*

local descriptions of individual neurons in their partial phase spaces combined with a phenomenological global description of the network state.

### **T-22 – Dynamics of noisy oscillator populations beyond the Ott-Antonsen ansatz**

Arkady Pikovsky

Institute for Physics and Astronomy, University of Potsdam, Karl-Liebknecht-Strasse 24/25, 14476 Potsdam-Golm, Germany

*We develop an approach for the description of the dynamics of large populations of phase oscillators based on “circular cumulants” instead of the Kuramoto-Diado order parameters. In the thermodynamic limit, these variables yield a simple representation of the Ott-Antonsen invariant solution [E. Ott and T. M. Antonsen, CHAOS 18, 037113 (2008)] and appear appropriate for constructing the perturbation theory on top of the Ott-Antonsen ansatz. We employ this approach to study the impact of small intrinsic noise on the dynamics. As a result, a closed system of equations for the two leading cumulants, describing the dynamics of noisy ensembles, is derived. We exemplify the general theory by presenting the effect of noise on the Kuramoto system and on a chimera state in two symmetrically coupled Kuramoto ensembles..*

### **T-23 – Historical warming has at least tripled global population annually exposed to extreme events**

Jan Volkholz

Potsdam Institute for Climate Research Impact (PIK), Germany

*Weather induced extreme events such as crop failure, river floods, tropical cyclones, heatwaves and droughts represent an immediate threat to communities. In spite of their different characteristics they all have a joint potential to cause (long-term) economic losses, displacement, persistence of poverty, or social destabilization. However, the detection of a climate signal in these social dynamics is difficult due to limited availability of observational records and the complex interplay of bio-physical and direct human drivers. However, according to newly released synchronized climate impact simulations, climate change from pre-industrial conditions to today’s IC of global warming alone has at least tripled the number of people exposed to extreme events. In comparison while changes in population distribution, land use and - to a limited extent - other direct human drivers as represented in the model simulations would only have led to an XX fold increase of the number of exposed people under preindustrial climate conditions. Assuming fixed year 2005 socio-economic conditions the population exposed to spatially confined events (river floods, tropical cyclones, wildfires, and crop failures) shows a purely climate change-driven increase of 67 mio people at 1.5C, and 95 mio people at 2C global warming compared to pre-industrial climate conditions. The population exposed to spatially extensive events (droughts and heatwaves) increases by 455 mio people at 1.5C and 781 mio people at 2C. The new repository of harmonized multi-impact model data is intended to evolve in parallel to the climate modelling exercise CMIP and provide the basis for new event-based approaches to estimate the societal impacts of climate change.*

### **T-25 – Inference of oscillator properties by phase dynamics modeling**

Michael Rosenblum

Potsdam University, Germany

*Reconstruction of oscillator models from observations represents a problem that is important for applications in various fields. For example, this approach allows us to recover connectivity of an oscillator network and, in certain cases, to estimate such important characteristics of units as their natural frequencies and phase response curves (PRCs). Here we consider two related particular tasks, when both the input and output of the oscillator can be recorded. Suppose it is driven by a periodic force with given amplitude and frequency. Traditional approach to determination of synchronization domains implies that frequency of the oscillator is computed for many different values of the amplitude and frequency of the drive and the synchronization domain is obtained as a region where both frequencies coincide (or, generally, relate as  $n:m$ , where  $n,m$  are integers). We develop an approach that allows reconstruction of the synchronization region from several measurements only; the requirement is that the oscillator remains in a quasiperiodic state. Namely, parameters of the force are chosen to be outside of the synchronization region but close to it. The approach implies reconstruction of the phase dynamics model from data. Next, this model is used to reveal synchronization properties.*

### **T-26 – Mind-to-Mind Heteroclinic Coordination: Model of Sequential Episodic Memory Initiation**

Michael Zaks

Humboldt University, Berlin, Germany

Retrieval of episodic memory is a dynamical process in the large scale brain networks. In social groups, the neural patterns, associated to specific events directly experienced by single members, are encoded, recalled and shared by all participants. We present the dynamical model for the formation and maintaining of episodic memory in small ensembles of interacting minds. The unconventional dynamical attractor of this process - the nonsmooth heteroclinic torus - is structurally stable within the Lotka-Volterra-like sets of equations. Dynamics on this torus combines absence of chaos with asymptotic instability of every separate trajectory; its adequate quantitative characteristics are length-related Lyapunov exponents. Variation of the coupling strength between the participants results in different types of sequential switching between metastable states; we interpret them as stages in formation and modification of the episodic memory.

### **T-27 – Mapping and discrimination of networks in the complexity-entropy plane**

Reik V. Donner

Potsdam Institute for Climate Research Impact (PIK), Germany

Complex networks are usually characterized in terms of their topological, spatial, or information-theoretic properties and combinations of the associated metrics are used to discriminate networks into different classes or categories. However, even with the present variety of characteristics at hand it still remains a subject of current research to appropriately quantify a network's complexity and correspondingly discriminate between different types of complex networks, like infrastructure or social networks, on such a basis. Here we explore the possibility to classify complex networks by means of a statistical complexity measure that has formerly been successfully applied to distinguish different types of chaotic and stochastic time series. It is composed of a network's averaged per-node entropic measure characterizing the network's information content and the associated Jensen-Shannon divergence as a measure of disequilibrium. We study 29 real-world networks and show that networks of the same category tend to cluster in distinct areas of the resulting complexity-entropy plane. We demonstrate that within our framework, connectome networks exhibit among the highest complexity while, e.g., transportation and infrastructure networks display significantly lower values. Furthermore, we demonstrate the utility of our framework by applying it to families of random scale-free and Watts-Strogatz model networks. We then show in a second application that the proposed framework is useful to objectively construct threshold-based networks, such as functional climate networks or recurrence networks, by choosing the threshold such that the statistical network complexity is maximized.

### **T-28 – Noise induced synchronization in phase oscillators coupled indirectly through a central hub**

Ralf Toenjes

Potsdam University, Germany

The star graph, where a central node is connected to a possibly large number of peripheral nodes is a frequent motif in certain hierarchical or scale free networks. The dynamics of oscillators in the peripheral nodes subjected to the signal of an oscillator in the hub has been proposed to capture some of the aspects of the synchronization transition in these networks. Using the Kuramoto-Sakaguchi model we analyze remote synchronization in this system and the opposing influence of synchronizing noise in the central node, desynchronizing noise or frequency heterogeneity in the peripheral nodes and positive or negative nonisochronicity. We tackle the analytical description of the noisy system employing exact methods like the Ott-Antonsen ansatz and the continued fraction method for the noisy Adler equation, or approximations like phase averaging and a recently developed small noise perturbation extension of the Ott-Antonsen method.

### **T-29 – The far reach of ice-shelf thinning in Antarctica**

Ricarda Winkelmann

Potsdam Institute for Climate Research Impact (PIK), Germany

Floating ice shelves, which fringe most of Antarctica's coastline, regulate ice flow into the Southern Ocean. Their thinning or disintegration can cause upstream acceleration of grounded ice and raise global sea levels. So far the effect has not been quantified in a comprehensive and spatially explicit manner. Here, using a finite-element model, we diagnose the immediate, continent-wide flux response to different spatial patterns of ice-shelf mass loss. We show that highly localized ice-shelf thinning can reach across the entire shelf and accelerate ice flow in regions far from the initial perturbation. As an example, this 'tele-buttrressing' enhances outflow from Bindschadler Ice Stream in response to thinning near Ross Island more than 900 km away. We further find that the integrated flux response across all grounding lines is highly dependent on the location of imposed changes: the strongest response is caused not only near ice streams and ice rises, but also by thinning, for instance, well-within the Filchner-Ronne and Ross Ice Shelves. The most critical regions in all major ice shelves are often located in regions easily accessible to the intrusion of warm

*ocean waters, stressing Antarctica's vulnerability to changes in its surrounding ocean.*

### **T-30 – Observations and Regional Climate Model simulations of Extreme Precipitation events over Southeastern Brazil**

Lincoln Muniz Alves

CCST/INPE – São José dos Campos – Brazil

*Research in extreme precipitation is fundamentally motivated by their impacts on society, which are considerable. For instance, since the austral summer of 2014 Southeastern Brazil has been experiencing one of the most severe droughts in decades. This rainfall deficiency has generated water shortages and a water crisis that have affected population and local economies in the metropolitan region of Sao Paulo (MRSP), the largest megacity in South America. Based on that, the aim of this study is to analyse the changes in extremes precipitation events (frequency and intensity) over the MRSP during the present climate. Also a non-hydrostatic version of RegCM.4.6.1 at very high resolution (5 km) coupled with the CLM4.5 is employed to simulate the regional impacts on climate under the two scenarios: without and with the underlying surface changes due to urbanization over MRSP. Two experiments were performed from 1981 to 2010. Finally, this work is expected to provide technical-scientific knowledge to support decision-makers in different policy options for adaptation and mitigation of environmental changes.*

### **T-31 – Effects of network symmetries on the Kuramoto oscillators dynamics**

Helder L. Casa Grande

LAC/INPE – São José dos Campos - Brasil

*We study how the symmetries of a complex network can affects the dynamics of Kuramoto oscillators. We focus on the clusters formed by nodes with the same symmetry, introducing perturbations following the clusters structure. We find that such perturbations change the global dynamics properties as all nodes inside a cluster act as one when synchronized, causing some remarkable impacts in synchronization patterns observed. Furthermore, we discuss how to build random networks with a designed symmetry, in order to achieved a certain desired asymptotic phase locking configuration.*

### **T-32 - A non-autonomous meteorological-driven epidemiological model**

Felipe Hikari Kawahama<sup>1</sup>, Leonardo Bacelar Lima Santos<sup>2</sup>, Elbert Einsten Nehrer Macau<sup>3</sup>, Patricia Romano Cirilo<sup>4</sup>

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*The threat of an infectious disease's outbreak, which may cause severe consequences around the globe, is a cause for concern to the whole world. In Brazil, for instance, the country is trying to deal with the risk of the Yellow Fever. According to the World Health Organization (WHO) in the most recent outbreak, dating back to 2017, about 200 deaths caused by the disease were registered in Brazil's southeast region alone. This situation brings into question if it's possible to get relevant mathematical models that could help to predict the infection's dissemination in a given population. Mathematical Epidemiology and its compartmental models are useful tools to understand epidemic outbreaks. An Ordinary Differential Equations System is used to represent the varying rate of all the system's compartments in a time series. The study of the system's linear and structural stability has a major importance in understanding the infection's behavior. Therefore, the goal of this work is to build a simple model of a Yellow Fever epidemic process and analyze its stability and bifurcation points, including a non-autonomous meteorological-driven model version.*

### **T-33 - Inference of topology and the nature of synapses in neuronal networks**

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*The characterization of neuronal connectivity is one of the most important matters in neuroscience. In this work, we show that a recently proposed informational quantity, the causal mutual information, employed with an appropriate methodology, can be used not only to correctly infer the direction of the underlying physical synapses, but also to identify their excitatory or inhibitory nature, considering easy to handle and measure bivariate time series. Our work reveals a surprising phenomenon in neural networks, in which a pre-synaptic neuron (a neuron that has an adjacent connection to the post-synaptic one) not only exchange information (positive mutual information), but is also capable of using information to cause an effect in a post-synaptic neuron (positive transfer entropy). Non-adjacent neurons only exchange information. This phenomenon can provide an explanation why informational-based inference methods recently been proposed in the literature do work. We also demonstrate that our methodology can be used to correctly infer directionality of synapses even in the presence of dynamic and observational Gaussian noise, and is also successful in providing the effective directionality of inter-modular connectivity, when only mean fields can be measured.*

### **T-34 - Neuronal Synchronisation**

Kelly C. Iarosz<sup>1,2,3</sup>, Paulo R. Protachevicz<sup>4</sup>, Rafael R. Borges<sup>5</sup>, Adriane S. Reis<sup>6</sup>, Fernando S. Borges<sup>7</sup>, Iberê L. Caldas<sup>1</sup>, Ewandson L. Lameu<sup>2,8</sup>, Chun-Yi Z. Lo<sup>9</sup>, Yong He<sup>10</sup>, Ching P. Lin<sup>11</sup>, Elbert E. N. Macau<sup>8,12</sup>, Ricardo L. Viana<sup>6</sup>, Igor M. Sokolov<sup>2</sup>, Fabiano A. S. Ferrari<sup>13</sup>, Antonio M. Batista<sup>3,4,12</sup>, Jürgen Kurths<sup>2,3</sup>

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*The human brain controls many body functions, receives and interprets information obtained by the five senses. The brain manages our thoughts, memory, speech, movement and all the organs of our body. It is estimated that the human brain contains about 1011 neurons, and each neuron is connected to approximately 104 other neurons. One of the most important properties of the mammalian brain, is synaptic plasticity and it is the changing of the structure, function and organisation of neurons, in response to new experiences. In addition, the synaptic plasticity is also related to processes of learning and memory. This adjustment of the intensities of chemical synapses can be correlated with phenomena of synchronisation of neuronal firing. The occurrence of synchronisation in some specific areas of the brain may be associated with some diseases, such as epilepsy, lesions, Alzheimer and Parkinsons disease. On the other hand, it is also responsible for some vital brain functions, such as processing of sensory information and motor function. With this in mind, We will present a network topology according to the cortico-cortical connection network of the human brain, where each cortical area is composed of a random network of adaptive exponential integrate-and-fire neurons. Depending on the parameters, this neuron model can exhibit spike or burst patterns. As a diagnostic tool to identify spike and burst patterns we utilise the coefficient of variation of the neuronal inter-spike interval. In our neuronal network, we verify the existence of spike and burst synchronisation in different cortical areas. Our simulations show that the network arrangement, i.e., its rich-club organisation, plays an important role in the transition of the areas from desynchronous to synchronous behaviours.*

### **T-35 - Seasonal forecasting of precipitation extremes using complex network and ma-**

### chine learning approaches

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*The quantification of spatio-temporal hydroclimatic extreme events is a key variable in water resources planning and disaster mitigation. Exploiting spatio-temporal covariance structure of fields of relevant climate variables by complex networks and causal discovery approaches has shown potentials for identifying characteristic patterns associated with an elevated risk of some incipient extreme event and unveiling typical mechanisms associated with the preparatory phase of extremes. This study presents comparative results of complex network constructed using Tropical Rainfall Measurement Mission (TRMM) product TRMM<sub>3</sub>B42 and CPC Global Unified Gauge-Based Analysis to study precipitation extremes.*

### T-36 - Synchronization and Dynamic Phenomena in Second Order Phase Oscillator Networks

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*Networks of phase oscillators, where the coupling is nonlinear, represent a model that has been used to capture the dynamics that are found in several real interest situations, especially involving autonomous agents that interact with each other according to the most diverse mechanisms. These are the cases of automotive vehicles in displacement training, satellites in flight training, power distribution networks, information storage, information spread, social phenomena. These networks present a rich and complex dynamics, where, according to the variation of the values of their parameters, there are situations of total disorder, up to the total order, represented by the synchronization of the dynamics of the oscillators. From one extreme to another, there are complex scenarios, represented by subgroups of synchronization and coexistence between subpopulations with dynamics synchronized with other subpopulations of disorder, which is called chimera. The objective of this project is to investigate the dynamic phenomena arising from nonlinear network interactions considering a second order phase oscillator. Note that until the present, the works in the literature practically only explore first-order phase oscillators in the context of the so-called Kuramoto Model, extended to network configurations. When considering second order oscillators, it is possible to take into account the dissipation or damping effects, which are characteristic of the real world. However, the addition of an extra dimension should lead to the appearance of a range of phenomena, which are not found in first-order models, which, if on the one hand imply an increase in intrinsic "complexity", on the other may offer extra potentialities to be exploited in the control of joint behavior. From the present work, it is expected not only to understand the dynamics of networks of second order oscillators with non-linear interactions, but also to create strategies aimed at determining stability and control that may be applicable to systems of technological interest such as vehicles autonomous in training displacement, satellites in training flight and power distribution networks.*

### T-37 - INFLUENCE OF CLASSIC NETWORK MEASURES AND NEIGHBORHOOD SIMILARITY ON SYNCHRONIZATION OF COMPLEX NETWORKS OF NON-IDENTICAL OSCILLATORS

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*In this work, we study how the structure of complex networks of non-identical oscillators influences global synchronization in the context of the Kuramoto model. It is employed here the total dissonance metric for neighborhood similarity, which generalizes to networks the standard concept of dissonance between two non-identical coupled oscillators. Based on this quantifier and on a genetic algorithm, we generate Similar, Dissimilar and Neutral patterns, which correspond to small, large and intermediate values of total dissonance, respectively. Afterwards, the emergency of synchronization is numerically studied considering these three types of networks patterns. The main contribution of this study is to analyze the synchronization behavior using other classic network measures like assortativity, which measures the linear correlation between the nodes of the network, in association with*

such network patterns based on total dissonance.

### **T-38 - From spatio-temporal events to complex networks**

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*In this work, we explore a method to characterize spatio-temporal data to networks by following a chronological linking process. Considering a geographical area, where several events are happening along time, the region is divided into cells to create a grid, and then, each cell is represented as a node and each pair of successive events is connected, by creating a link between the cells where the two events are located. Based on this approach, we use it to study the Amazon Basin fire activity in order to show a real use-case. Finally, we discuss the main advantages and limitations.*

### **T-39 - EVALUATING THE ATMOSPHERIC ORIGINS OF CURRENT AND FUTURE DROUGHT EVENTS IN SOUTH AMERICA USING COMPLEX NETWORKS**

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*Brazil experienced several drought events during the last decade. Tropical forest ecosystems, as the Amazon, serve as an atmospheric moisture pump by taking up water from the soil and re-evaporating moisture, which is transported over long distances. Reduced forest cover from drought mortality in addition to forest loss from deforestation activities may lead to a significant change in atmospheric moisture transport. In our research, the atmospheric mechanisms leading to drought events will be investigated. The focus will be developing and applying complex network measures for atmospheric moisture transport patterns.*

### **T-40 - An Averaging Principle Along Foliated Lévy Diffusions With a Jump Component**

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*Consider an Stochastic Differential Equation (SDE) on a foliated manifold whose trajectories lay on compact leaves. We investigate the effective behavior of a small transversal perturbation. An average principle is shown to hold such that the component transversal to the leaves converges to the solution of a deterministic ODE. An estimate of the rate of convergence is given. After that, we generalize the principle established for continuous semimartingales to Lévy diffusions containing a jump component. We give upper bounds for the rates of convergence and illustrate these results for the random rotations on the circle.*

### **T-41 - Fermi acceleration in a FU-model with a structured particle**

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*We studied the Fermi-Ulam model replacing the point particle with a structured particle consisting of two point particles connected by a harmonic or a quartic spring. When both walls are fixed the total energy of the particles determines the general behavior of the system, which is chaotic at low energies but has a rich phase space structure at high energies. When one wall is put into motion there is an initial transient for the energy gain as a function of the number of collision. This later stabilizes in a regime of a constant growth with the same rate of energy growth for all the types and strengths of springs we used. Fermi Acceleration was achieved for all the situations studied.*

### **T-41 - Characterizing Temporal Networks: A bibliographic review**

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*The study of systems through complex networks has shown to be a plenty active area. Such study is commonly carried out based on measures able to characterize the main topological attributes of the network. Knowing the network topology structure is fundamental to understand and recognize real systems, as well as to model and simulate synthetic ones. Most of the researchers have focused on the study of networks with fixed topology (static). However, real systems are not necessarily static. In the dynamic scenario, the topological structure may vary. Thus, developing measures which are able to characterize the structural properties of networks, and their respective changes over time, are essential in many scenarios. Currently, some authors have dealt with networks whose topology changes over time, called temporal networks. Nevertheless, the deficit of theories and methods in this research field is still evident. This work scrutinizes the issues and challenges faced in characterizing network which include temporal information within the model, as well as it highlights the state-of-art of temporal network studies.*

#### **T-42 - Diffusion phenomena in a mixed phase space**

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*In this study, we investigate statistical properties of some dynamical systems described by discrete mappings near two types of transitions: (i) integrability to non-integrability; (ii) limited to unlimited diffusion in energy (Fermi acceleration). The main goal is to describe the behaviour of the probability density of the velocity/energy for a set of particles moving in a chaotic dynamics. The break of symmetry in the probability distribution leads to an additional scaling to those are already known in the literature and, with this study, we believe that the symmetry break might also explain a well-known phenomenon observed for discrete mappings. This phenomenon, it has been reported so far phenomenologically. A first observation in an area-preserving mapping was in a letter published in Phys. Rev. Let. 93, 014101 (2004), authored by Edson D. Leonel, Peter V. E. McClintock and Jafferson K. L. Silva. Our contribution to the problem is on the development of an analytical approach and numerical verifications, based essentially on a systematic study of the diffusive behaviour of chaotic trajectories on the phase space of dynamical systems of interest.*

#### **T-43 - Escaping basins for an open oval billiard**

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*The investigation of particles transport in different systems has attracted a lot of attention from the scientific community in the last years. Specifically in the billiards theory, there are several problems involving billiards with questions that remain open problems. In this work we discuss maximization and minimization of the particle escape in chaotic billiard. We investigate statistical properties for recurrent and non recurrent escaping particles in an oval billiard with holes in the boundary. We determine where to place the holes and where to launch particles in order to maximize or minimize the escape measurement. Initially, we introduce a fixed hole in the billiard boundary, injecting particles through the hole and analyzing the survival probability of the particles inside of the billiard. We show there are preferential regions to observe the escape of particles. Next, with two holes in the boundary, we obtain the escape basins of the particles and show the influence of the stickiness and the small chains of islands along the phase space in the escape of particles. Finally, we discuss the relation between the escape basins boundary and the uncertainty about the boundary points.*

#### **T-44 - Sync basin and the eigenvalues of Kuramoto model**

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*Basin of attraction is an intricate and fundamental concept in dynamics and hard to study in high-dimensional systems. Other important concept is the basin stability of a state which is quantified essentially by the basin's volume. On the other hand the Kuramoto model is the paradigmatic model for the study of synchronization in networks of coupled oscillators. In this context some important questions to be addressed are: "How likely is the system to synchronize, starting from a random initial condition? And how does the probability of synchronization depend on the way the network is connected?". To answer such questions it is necessary to obtain the volume of the basin of attraction for a synchronized state, the so-called "sync basin". Numerical studies of the Kuramoto model with identical oscillators revealed that the volumes of sync basin obey a simple statistical law: the probability*

that the final state has  $q$  twists follows a Gaussian distribution  $\exp[q^2/(22)]$ , with standard deviation  $\sigma$ , for a network with  $N$  oscillators and each oscillator interacting equally with its  $R$  nearest neighbors on either side. In a recent work we performed a linear stability analysis of the Kuramoto model for finite networks of identical phase oscillators. We obtained explicit expressions for the perturbation eigenvalues of a  $q$ -twisted state and with those we found a rich scenario of attractors, repellers, saddles and non-hyperbolic twisted states. We present in this Workshop the possible relation between the perturbation eigenvalues and the sync basin. We show that size properties of such basin, previously discussed in, seem to be strong related to the eigenvalues of all possible stable synchronized states. Numerical and analytical approaches are presented to support our result.

#### **T-45 - The Application of Fractional Calculus in Army Race Models**

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The application of dynamical systems in the areas of Biology, Economics, Sociology and others branchings of the natural sciences, has gained a special highlight in these last decades. The description of nonlinear effects subject to long-range temporal correlations is itself a great window of opportunity to be explored in modern mathematics. Here, we will use the Fractional Calculus approach to incorporate the inherent memory effects in Army Race models. In particular, we will analyze the discrete-time versions of these models (fractional maps) and the topological effects induced by interactions in complex networks.

#### **T-46 - A Tourist Walk Approach for Outlier Detection**

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Outlier detection is a fundamental task for knowledge discovery in data mining. It aims to detect data items that deviate from the general pattern of a given data set. In this work, we present a new outlier detection technique using tourist walks starting from each data sample and varying the memory size. Specifically, a data sample gets a higher outlier score if it participates in few tourist walk attractors, while it gets a low score if it participates in a large number of attractors. Experimental results on artificial and real data sets show good performance of the proposed method. In comparison to classical methods, the proposed one shows the following salient features: 1) It finds out outliers by identifying the structure of the input data set instead of considering only physical features, such as distance, similarity or density. 2) It can detect not only external outliers as classical methods do, but also internal outliers staying among various normal data groups. 3) By varying the memory size, the tourist walks can characterize both local and global structures of the data set. 4) The proposed method is a deterministic technique. Therefore, only one run is sufficient, in contrast to stochastic techniques, which require many runs. Moreover, in this work, we find, for the first time, that tourist walks can generate complex attractors in various crossing shapes. Such complex attractors reveal data structures in more details. Consequently, it can improve the outlier detection performance.

#### **T-47 - Study of firing patterns in neural network models with hierarchical and modular structure**

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It is believed that the dynamic patterns that occur in the environment are represented and processed in the brain by neuronal action potentials. The attempt to interpret the environmental representation by the analysis of the neuronal population firing patterns is a very complex and expensive task since it involves the recording of a large number of time series. An alternative is the use of analytical and computational methods to reduce complexity, such as the study of spike-trains generated by a single neuron with statistical characteristics similar to the ones it would produce if it were immersed in a network. This recently proposed complexity reduction technique allows an understanding of how different patterns of input stimuli that are presented to a population of neurons relate to their output patterns. Here, we aim to study different individual patterns of activity in neurons immersed in networks and to determine how these patterns may be related to dynamic events in the input stimuli presented to the networks. The patterns will be related to structural characteristics of the network. In the cortex a faithful topological representation is a hierarchical and modular network. In this regard, neurons are chosen to belong to a particular module of the network. In addition, the intrinsic characteristics of the neurons may be of a specific electrophysiological class. The results will be based on simulations of large networks from which second-order statistics (autocorrelations and cross-correlations) will be extracted, and used for the

analysis of the firing patterns of the neurons. The complexity reduction technique will be used to relate the results to models of individual neurons that reproduce the same second-order statistics. Aiming to study situations compatible with those observed experimentally, the patterns of activity generated by the simulated networks will be compared with those of records in the cerebral cortex. This work has the potential to improve understanding of how the cerebral cortex processes patterns of dynamic input stimuli and produces response patterns that allow inferences to be made about these stimuli.

#### **T-48 - Activity patterns in networks of excitatory and inhibitory spiking neurons with synaptic noise**

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*The dynamics of spontaneous population activity patterns in random networks of excitatory and inhibitory two-dimensional integrate-and-fire neurons with synaptic noise is studied. The observed activity pattern types are localized on the parameter diagram spanned by the relative inhibitory synaptic strength and the magnitude of synaptic noise. In the absence of noise, networks display transient activity, either oscillatory or asynchronous non-oscillatory, and noise generates persistent patterns. For weak noise, activity patterns are asynchronous non-oscillatory independently of synaptic strengths. For stronger noise, patterns have oscillatory and synchrony characteristics which depend on the relative inhibitory synaptic strength. In the inhibition-dominated region of parameter space and for moderate noise magnitudes, networks disclose intermittent switches between oscillatory and low activity (quiescent) states. In the oscillatory state the neuronal voltages alternate between hyperpolarized and depolarized values (in a similar fashion to up-down oscillations observed in cortical networks), and in the quiescent state they fluctuate around the resting state (as low activity versions of asynchronous irregular activity modes observed in network models of integrate-and-fire neurons). Increase in noise intensity favors transitions from quiescent to the oscillatory state and hampers the reverse transitions. The oscillatory and quiescent patterns and transitions between them are explained by using local descriptions of individual neurons in their single-neuron phase spaces combined with a phenomenological global description of the network state.*

#### **T-49 - The influence of the oceanic temperature variability on rainfall regimes of the Brazilian Southeast region: A Complex Networks approach**

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*Networks are present everywhere. Communication networks composed of landlines phones and smartphones, the Power Grid network, computer and airline networks, are examples that can be easily found daily. Complex Networks have been applied to represent data from a variety of domains. In order to unravel properties and characteristics of the system, they only take into account the intricate form in which the data is generally present. The climate system is an example of having geographically intricate datasets. This inherent complexity of the climate system made with, recently, researchers turned their attention into its representation under the framework of Complex Networks. Given a climate variable, the related data are normally disposed into time series which express, numerically, the system dynamics for each and every spatial grid point. Willing to comprehend the meanders of the climate dynamics, in such a way that would be possible to track and predict, the occurrence of certain climate events, Complex Networks are used to analyze the already known influence of the temperature variabilities, of determined oceanic portions, on the rainfall regime of the Brazilian Southeast region. By the temporal evolution of the network, derived from the sea level temperature variable, patterns that are common during dry and wet austral summer periods are revealed. Particularly, the oceanic network is composed of nodes highly correlated with an averaged precipitation time series, obtained from the anomalies of the interested continental grid points. The aforementioned correlation takes into account possible temporal lags, and is mathematically achieved by applying the concept of Transfer Entropy. At the end, the major objective is to stress which network metrics are more susceptible to reveal unexpected dry-wet seasons, comparing to its behavior during the expected wet-wet seasons, in order to draw better pathways for the prediction of precipitation-related extreme events, such as the Brazilian Southeast droughts for the summers 2014-2017.*

#### **T-50 - Finite networks of interacting Kuramoto systems**

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*Events in nature are manifestation of interacting networks. For example, the neuronal system depends on the synchronization of interacting subpopulations of neurons to execute an action or function. In the unihemispheric sleep the brain is splitted into two subpopulations: while one synchronizes, the other one behaves irregularly (Chimera state). We study such phenomena considering networks of interacting Kuramoto systems focusing on the stability analysis of synchronization and Chimera states.*

### **T-51 - PARAMETRIC PERTURBATION IN THE RULKOV MAP**

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*The Rulkov mapping is a phenomenological model that simulates the changes in the neuronal membrane potential. In this work, we introduce a parametric perturbation in the Rulkov map, that can be related to an unexpected behavior, such as a malfunction of the neuronal membrane due to pathologies. The perturbed system still keeps its main characteristics, which includes periodic behavior followed by chaotic bursts.*

### **T-52 - The Chimera phenomenon in complex systems**

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*Chimera is a monster in Greek mythology described as a fire-breathing which has a lion's head, goat's body and serpent's tail. Colloquially, the word refers to something composed of parts of different natures or incongruent. In 1665, Huygens noted that regardless of the initial conditions of the pendulums of two clocks they ended oscillating synchronously with opposite phases. He explained that this self-emergent behavior was mediated by vibrations traveling along the wooden beam that supported the clocks. Since then, a series of experiments led to believe that networks composed by the same oscillators, identically coupled, naturally converge to a common synchronized state. In 2002, Kuramoto and Battogtokh showed that states of synchronous and asynchronous behavior could coexist simultaneously in the evolution of the network. This phenomenon was called chimera, opening a new front of research in dynamical systems. Despite of the intense studies and advances made in the last ten years on the chimera states, several fundamental questions still remain opened. For example, it is not known what conditions are enough for a chimera state arises, or when this state become stable or even what kind of networks a chimera state can develop. In this project we propose to address these issues focusing in the bifurcation theory by performing theoretical studies supported by numerical simulations.*

### **T-53 - Wavelet recurrence analysis for multiscale quantification of heart rate variability**

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*The Heart Rate Variability (HRV) quantifies the variation between RR intervals. It can be used to distinguish different clinical groups because its value depends on biological modulators, such as the activity of the sympathetic and parasympathetic systems. In this paper, we propose a nonlinear data analysis approach, called Wavelet Recurrence Analysis (WRA), to analyze 198 tachograms divided into four clinical groups: 23 full-term newborns, 53 premature newborns, 61 healthy young adults and 61 adults undergoing preoperative coronary artery bypass grafting for severe coronary artery disease.*

### **T-54 - Mathematical modeling of the Role of Imitation in Crime Dynamics**

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*In this project, we propose a system of non-linear ordinary differential equations to model crime dynamics in the presence of*

imitation. The model consists of four independent compartments and is analyzed in terms of the basic reproduction number ( $R_0$ ). The analysis shows that the system has a locally asymptotically stable crime-free equilibrium when  $R_0 < 1$ . The model is shown to exhibit a backward bifurcation in which two endemic equilibrium coexist with the crime-free equilibrium. When  $R_0 > 1$ , the system has a locally asymptotically stable endemic equilibrium and the crime-free becomes unstable. The sensitivity analysis shows that the relapse rate has a high influence on  $R_0$ . This shows that in order to minimize crime, the proportion of individuals leaving the prisons and becoming criminals should be minimized.

### **T-55 - A CAUSAL APPROACH TO RECOVER NETWORKS FROM DATA**

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*Inferring large-scale networks from time series data extracted from dynamical processes remains to be a relatively open problem. In contrast, causality often appears as an axiom in the formulation of dynamical equations, typically as the assumption that effects cannot precede their causes. However, what is often left unclear is which general principles should be used to define causal relations. By modelling rigorously causal relationships one has a powerful set of tools for identifying network structure from observed data, a field known as causal inference. We pretend to apply these techniques in the complex network scenario, by using resources of information theory to construct causal quantifiers. These will be used as regressors for algorithms which has time series as inputs allowing to recover the network topology behind a data.*

### **T-56 - Network reconstruction from Data**

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*The project aims at predicting sudden changes of behaviour in the complex systems. We plan to reconstruct the dynamical model of these complex networks from a data set. From a multivariate we first analyse the problem in terms a latent variable model to determine which data sets are independent. The next, in this new data we perform a pre-processing to extract relevant dynamical features such as phase and amplitude. The phases variables the can be written as a network of phase oscillators. In our project, we aim at using Dynamical Bayesian Inference to extract the coupling function along with the adjacency matrix and a factorisation of the noise covariance matrix.*

### **T-57 - Discontinuous transitions to collective dynamics in star motifs of coupled oscillators**

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*Abstract: We studied discontinuous transitions in star graphs of coupled phase oscillators. We considered the setting where the frequency of the leaves is identical and the hub has a higher frequency when isolated. This captures the effect of positive correlation between the hub high number of connections and its high natural frequency. Hub higher frequency turns out to be the key feature for discontinuity in the transition from incoherent to synchronous behavior. We prove that this transition is indeed discontinuous for a certain set of initial conditions.*

### **T-58 - A model of urban scaling laws based on distance-dependent interactions**

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*Socio-economic related properties of a city grow faster than a linear relationship with the population, in a log-log plot, the so-called superlinear scaling. Conversely, the larger a city, the more efficient it is in the use of its infrastructure, leading to a*

sublinear scaling on these variables. In this work, we addressed a simple explanation for those scaling laws in cities based on the interaction range between the citizens and on the fractal properties of the cities. To this purpose, we introduced a measure of social potential which captured the influence of social interaction on the economic performance and the benefits of amenities in the case of infrastructure offered by the city. We assumed that the population density depends on the fractal dimension and on the distance-dependent interactions between individuals. The model suggests that when the city interacts as a whole, and not just as a set of isolated parts, there is improvement of the socio-economic indicators. Moreover, the bigger the interaction range between citizens and amenities, the bigger the improvement of the socio-economic indicators and the lower the infrastructure costs of the city. We addressed how public policies could take advantage of these properties to improve cities development, minimizing negative effects. Furthermore, the model predicts that the sum of the scaling exponents of social-economic and infrastructure variables are 2, as observed in the literature. Simulations with an agent-based model are confronted with the theoretical approach and they are compatible with the empirical evidences.

### **T-59: Critical dynamics in whole-brain systems**

Rodrigo Pereira Rocha

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Understanding the relationship between structural and functional connectivity remains a crucial issue in modern neuroscience. Here we investigate such relationship through a stochastic neural whole-brain model, using as input the structural connectivity matrix defined by the human connectome. We show that equalization of the nodes excitatory input improves the simulated neural patterns of the model with respect to various brain functional data.

### **T-60: Temporal Analysis of expansion the fern species in PNCD-BA**

Cândida Caroline Souza de Santana Leite

Instituto Nacional de Pesquisa Espaciais

In order to analyze the areas occupied by the invasive fern species *Dicranopteris flexuosa* between 2002 and 2014 in the Pati Valley (Brazil) multispectral satellite image classification techniques were used from the supervised classification algorithms Neural Networks and Maximum Likelihood. The results show that the species tends to spread rapidly, blocking the regeneration of native flora. The algorithm with the highest reliability for this was the Neural Networks.

### **T-61: Geo-referenced weather forecast for brazilian territory**

Alexandre Augusto D'Avila de Oliveira

Centro Universitário Salesiano de São Paulo

With the advancement of computing, meteorology has also evolved, thus increasing the interest of the population. Currently the CPTEC meteorologists provide the weather forecast, considering the same meteorological condition for the entire area of the municipality. In order to refine this forecast, this product was developed, which through the current location of the user, it is possible to determine the weather condition with greater accuracy.

### **T-62: Impact of network randomness on multiple opinion dynamics**

Vivian de Araujo Dornelas Nunes

PUC-Rio

People often face the challenge of choosing among different options with similar attractiveness. To study the distribution of preferences that emerge in such situations, we simulate two different dynamics rules (the one proposed by Travieso-Fontoura and the plurality rule) in WS network, which possess the small-world property. We are interested in understand how properties of the network, such as average connectivity and proportion of random shortcuts, affect the final distribution of opinions.

### **T-63: Semi-empirical determination of optimum fragmentation point**

Carolina de Abreu Pereira

Universidade Federal do Rio Grande do Sul

In this contribution we perform all possible combinatorial attacks of a small number of nodes deletions on networks of size  $N=100$ , and we analyze the attacks according to the damage they produce measured by the size of the remaining largest component. We perform this in a series of networks of different and controlled modularities. Following, we compare the resulting statistics with state of the art targetted attacks.

### **T-64: Cooperation risk and Nash equilibrium**

Guilherme Contesini dos Santos

Universidade de São Paulo

*In Game Theory, the solution concept of a game is the Nash Equilibrium (NE). It infers that players adopt the best strategy available. The potential games formalism provides an analytical model that describe the strategy dynamics. We address the NE in the potential games formalism, using the Public Goods Game (PGG) and provide an analytical result for the cooperation risks. Both are necessary to provide a correct description of the game.*

### **T-65: Griffiths phases in non-hierarchical modular networks**

Wesley Cota

Universidade Federal de Viçosa (UFV)

*Griffiths phases (GPs), generated by the heterogeneities on modular networks, have recently been suggested to provide a mechanism to explain the critical behavior of complex systems. We observe that loosely coupled modules act as effective rare-regions, slowing down the extinction of activation. We find extended control parameter regions with continuously changing dynamical exponents. The avalanche size distributions also exhibit robust power-law tails.*

### **T-66: Use of complex networks in predicting epileptic seizures**

Gustavo Henrique Tomanik

Universidade estadual paulista "Júlio de mesquita filho"

*Epilepsy is a brain disorder characterized by convulsions. This disease can be accessed by the technique of electroencephalography (EEG). Studies that relate time series to the theory of complex networks have gained great importance, showing that it is possible to map a time series in a complex network without great loss of information. In this sense, the objective of this work is to apply the theory of complex networks in the analysis of EEG time series of epileptic patients to predict seizures.*

### **T-67: Investigating brain links with the Causal Mutual Information**

Arthur Lopes da Silva Valencio

Universidade Estadual de Campinas (Unicamp)

*The identification of links between brain regions is a challenging task. EEG data provide good temporal resolution on the cortical activity. Granger causality is often applied to identify such links, but it assumes linearisable dynamics on the brain activity. Transfer Entropy (TE) is an information-theory alternative that doesn't require such hypothesis, but is computationally costly. Instead, we describe how to apply the Causal Mutual Information (CaMI), which recovers TE with low cost.*

### **T-68: Avalanches and oscillations coexisting in neuronal networks**

Ariadne de Andrade Costa

IC-UNICAMP

*Adaptive mechanisms have been proposed as explanations for self-organized criticality. Although they present stochastic oscillations, the origin of this behavior is unclear. We analyze the stability of the mean-field fixed points of a fully-connected network of stochastic integrate-and-fire neurons with dynamic gains. We observe that finite-size fluctuations can cause simultaneous stochastic oscillations and avalanches. The coexistence of these activities is supported by recent experiments.*

### **T-69: MATHEMATICAL MODEL FOR EPIDEMIC PROPAGATION**

Eduardo Ribeiro Pinto

UNESP

*The purpose of this work is to analyze the spread of infectious diseases through the computational implementation and visualization of three complex network models (random, small world and modular), in each model will be analyzed the topological properties available in the literature for the characterization (degree connectivity, smallest path length, clustering coefficient, Modularity and mean jump length), for a better understanding and to develop interventions to control the epidemic.*

### **T-70: Inflation Targeting, Heterogeneous Expectation and Networks**

Hector de Moura Luz

FEA/USP

*This work explores the impact of heterogeneity in expectations in a macroeconomic context represented by a 3-equation model (IS curve, Phillips curve and interest rate rule). Using ABM, it explores a diverse heterogeneity between the agents' strategies on how they form their expectations. Furthermore, the work analyses the impact of the network on the stability of the model. Results are not trivial: in some cases, network diffusion and homogeneous expectations can lead to instability.*

### **T-71: Distinction of Aging and Alzheimer's through complex network**

Aruane Mello Pineda

Universidade Estadual Paulista "Julio de Mesquita Filho" UNESP/IBB

*Alzheimer's disease (AD) can be understood as a degenerative and progressive dementia of the Central Nervous System, irreversible and of unknown cause. Studies have been developed for the detection and diagnosis of AD based on electroencephalogram (EEG) data. In this work the theory of complex networks will be used in the differentiation of healthy individuals and with AD.*

### **T-72: Population dynamics in heterogeneous domains**

Renato Antunes Costa de Andrade

UNESP

*My project is about population dynamics with a view to application to ecology and epidemiology. it concerns the spatial dynamics in non-homogeneous habitats. This leads to the study of equation of the reaction-diffusion and integro-difference types with either spatially varying coefficients or, otherwise, to boundary value problems. We indented to study how the dynamics of more than two species is affected by spatial non-homogeneities.*

### **T-73: CHARACTERIZATION OF DELAY TIMES IN BRAIN SYNCHRONIZATION**

Eslaine Santos e Santos

Universidade Federal da Bahia

*Motifs Synchronization (MS) is a method that, combined with Time-Varying Graphs (TVG), can characterize functional brain networks taking into account their inherent dynamics. This approach provides the analysis of delay times of the communication between the various brain regions. Thus, the purpose of this work is to do a dynamic analysis by generating delay time indexes and to use them as a new way to characterizing functional brain networks.*

### **T-74: USE OF COMPLEXITY THEORY FOR THE STUDY OF BRAIN DYNAMICS**

Thais Costa Brunelli

Universidade Federal de Mato Grosso

*In this work, it was investigated the brain dynamics using the theory of complexity end Near Infrared Spectroscopy-NIRS data. The time lag method was used to reconstruct phase space for each of the 64 NIRS channels. We obtained that four channels presented atractors with a defined pattern of the cerebral dynamics. It was observed that the theory of complex systems describes well the cerebral dynamics, with a correlation between the findings and the experimental neuroscience paradigm.*

### **T-75: Synchronization of Layers of Multi-layered Networks Variants**

Rosana de Andrade Sousa

UFBA

*In this work, we try to develop a method to measure the synchronization between the layers of a multilayer network that varies with time, according to the time-varying graphs. For this, it starts from networks with two layers without interconnections and  $N$  vertices in each layer. Synchronization involves the concepts of Incidence and Fidelity, defined in the studies of semantic networks. To evaluate the reliability of the results, we intend to adapt a coupled Rössler oscillator.*

### **T-76: Modeling for Analysis of Crime Networks using Public Safety**

Alex Sander de Oliveira Toledo

Centro Universitário Newton Paiva

*Modeling and simulation are presented as interesting alternatives for understanding social network behaviors, helping in the execution of experiments to validate theories about the properties and characteristics of these networks. With the use of tools, such as Python and its libraries, it seeks to model criminal networks, with the objective of identifying these networks, their leaders and their relationships, simulating their evolution, developing computational tools for analysis and study.*

### **T-77: CLIMATE EXTREMES INDEX IN SÃO PAULO STATE: OBSERVATION AND CMIP5 MODEL.**

Naurinete J. C. Barreto<sup>1</sup>, Lincoln M. Alves<sup>2</sup>

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*This study investigates the representation of models CMIP5 Project in relation to the climate pattern associated with extreme precipitation and temperature on the region of the state of São Paulo - Brazil. 21 extreme indexes were used and compared the data observed with the response of 37 CMIP5 models to the historical scenario. It was observed that the models have difficulty in representing the time pattern of these indices, so we selected five models for each variable, so it was possible to apply the GEV and evaluate if the selected models represent the return period of the climatic indexes, for the state of São Paulo.*

**T-78: Transient Stability and Synchronization in Power Systems**Jéssica Glória Jorge Batista<sup>1,2</sup>, Luís Fernando Costa Alberto<sup>3</sup>.

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3 Escola de Engenharia de São Carlos – Universidade de São Paulo, São Carlos, Brasil, lfcaberto@usp.br

*Power Systems (PS) are composed of elements such as synchronous generators and loads, interconnected by transmission lines, forming a high dimension nonlinear complex network. When the system is in steady state, there is a power balance between generation and demand and the power flow through the lines remains constant. However, the system is subjected to faults, which perturb the power balance and might lead the system to instability. In transient stability analysis, the dynamical behavior of a power system subjected to a large perturbation is investigated. In these studies, the synchronization and coherency of generators is essential to stability. PS stability can be studied by a set of algebraic and differential equations, represented in versions of the Kuramoto model. Our interest is to investigate how the topological structure of networks influences synchronization, coherency and stability, as well as the unstable modes of PS. These modes are associated to clusters of coherent generators within the network, which we aim to identify.*

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## 1.5 Selected Participants

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**OBS:** *All the selected participants will be asked to do a short presentation ( 5 + 3 min) about their accepted work during the Poster Section.*

## 1.6 Program

### 1.6.1 Talks

Time	26/08 – Sun	27/08 - Mon	28/08 - Tue	29/08 - Wed
08h30-09h30		8:00 General Remarks Parallel Session-1	Key Note Talk-4	Key Note Talk-6
09h30-10h00		Coffee	Coffee	Coffee
10h00-12h30		Parallel Session-2	Parallel Session-4	Key Note Talk-7
12h30-14h00		Lunch	Lunch	Lunch
14h00-16h30	Open (15:30)	Parallel Session-3	Parallel Session-5	
16h30-17h30	Key Note Talk-1	Coffee and Posters	Coffee and Posters	
17h30-18h30	Key Note Talk-2	Key Note Talk-3	Key Note Talk-5	

KT-1: Pedro Leite da Silva Dias – Nonlinear Interactions in meteorological models

KT-2: Serhiy Yanchuk - Emergence of hierarchical clusters in adaptive networks

KT-3: Martin Falcke – First passage in transient conditions

KT-4: Igor Sokolov- First passage under resetting

KT-5: Paulo Ruffino – Stochastic Equations with Geodesic Jumps: properties and applications

KT-6: José A. Marengo - Risk of drought in the drylands of northeast of Brazil under regional warming exceeding 4°C.

KT-7: Zhao Liang - Network Unfolding Map by Vertex-Edge Dynamics Modeling

Parallel Session-1: General Aspects of Network Dynamics; Earth Systems and Networks

Parallel Session-2: Stochastic Dynamics and transport; Neuronal Networks

Parallel Session-3: General Aspects of Network Dynamics; Neuronal Networks

Parallel Session-4: Stochastic Dynamics and Transport; Earth Systems and Networks

Parallel Session-5: General Aspects of Networks Dynamics; Stochastic Dynamics and Transport

### 1.6.2 Mini Courses

Time	29/08 -Wed	30/08 - Thur	31/08 - Frid	01/09 - Sat
08h20-08h50		I-Talk-2	I-Talk-4	I-Talk-6
09h00-10h30		MC-3a	MC-2c	MC-4c/MC-6a
10h30-11h00		Coffee	Coffee	Coffee
11h00-12h30		MC-3b	MC-1c/MC-5a	MC-5b/MC-6b
12h30-14h00		Lunch	Lunch	Lunch
14h00-15h30	MC-1a	MC-2a	MC-4a	
15h30-16h00	Coffee & Poster	Coffee & Poster	Coffee & Poster	
16h00-17h30	MC-1b	MC-2b	MC-4b	
17h30-18h00	I-Talk-1	I-Talk-3	I-Talk-5	

MC-1: Ernesto Estrada – Network analytics: Traditional vs modern approaches

MC-2: Yong Zhou – Complex network approaches for nonlinear time series analysis

MC-3: Arkady Pikovsky – Synchronization in Nonlinear Science

MC-4: Reik Donner – Complex systems methods for analyzing climate time series

MC-5: Sâmia Regina Garcia – Statistical Techniques applied to climatic variability: South American Monsoon

MC-6: Luis Alberto – Stability and resilience in power grids

I-Talk-1: Marco Quiles – Community detection in temporal networks

I-Talk-2: Didier Vega-Oliveros – Information spreading and social curiosity in a nutshell

I-Talk-3: Luciana Londe – Complex networks addressed to natural hazards and disasters

I-Talk-4: Henrique Barbosa – Exploring the complex network of South America’s flying rivers

I-Talk-5: Lincoln Muniz Alvez – Potencial impacts of climate changes in Brazil

I-Talk-6: Antônio C. Roque – Mathematical models in neuroscience: from neurons to networks

## 1.7 How to get in Cachoeira Paulista

Foreign participants should plan to arrive GRU Airport (Guarulhos city). São Paulo Bus/Coach Station is called Terminal Tietê. To get to Cachoeira Paulista (Workshop) from GRU: Take the Airport Bus Service ([www.airportbusservice.com.br/br/linhas](http://www.airportbusservice.com.br/br/linhas)) to Terminal Tietê. There is a bus every 50 minutes and the cost is about R\$ 50. The journey will take between 25min and 2h (depending on the traffic). Once at Tietê, there is a company called Pássaro Marron to travel to Cachoeira Paulista ([www.passaromarron.com.br/](http://www.passaromarron.com.br/)). There are six buses per day, the price is around R\$57 and it takes about 2h50min.

To get to Lorena (Hotel) from GRU: Take the Airport Bus Service ([www.airportbusservice.com.br/br/linhas](http://www.airportbusservice.com.br/br/linhas)) to Terminal Tietê. There is a bus every 50 minutes and the cost is about R\$ 50. The journey will take between 25min and 2h (depending on the traffic). Once at Tietê, there is a company called Comêta to travel to Lorena (<http://www.viacaocometa.com.br/>). There are several buses per day, the price is around R\$53 and it takes about 3h10min.

### **Important addresses:**

IBIS Lorena (Hotel)

Address: Estrada Chiquito De Aquino 46 Loja Externa 1, SP, 12612-550

Phone: +55 (12) 3042-1100

CPTEC - INPE Centro de Previsão de Tempo e Estudos Climáticos

Address: Rodovia Presidente Dutra, Km 40, SP-RJ CEP: 12630-000, Cachoeira Paulista, SP

Phone: +55 (12) 3186-8400

# V ComplexNet

Workshop and School on Dynamics,  
Transport and Control in Complex Networks

August 26th - September 1st, 2018 - Cachoeira Paulista/SP

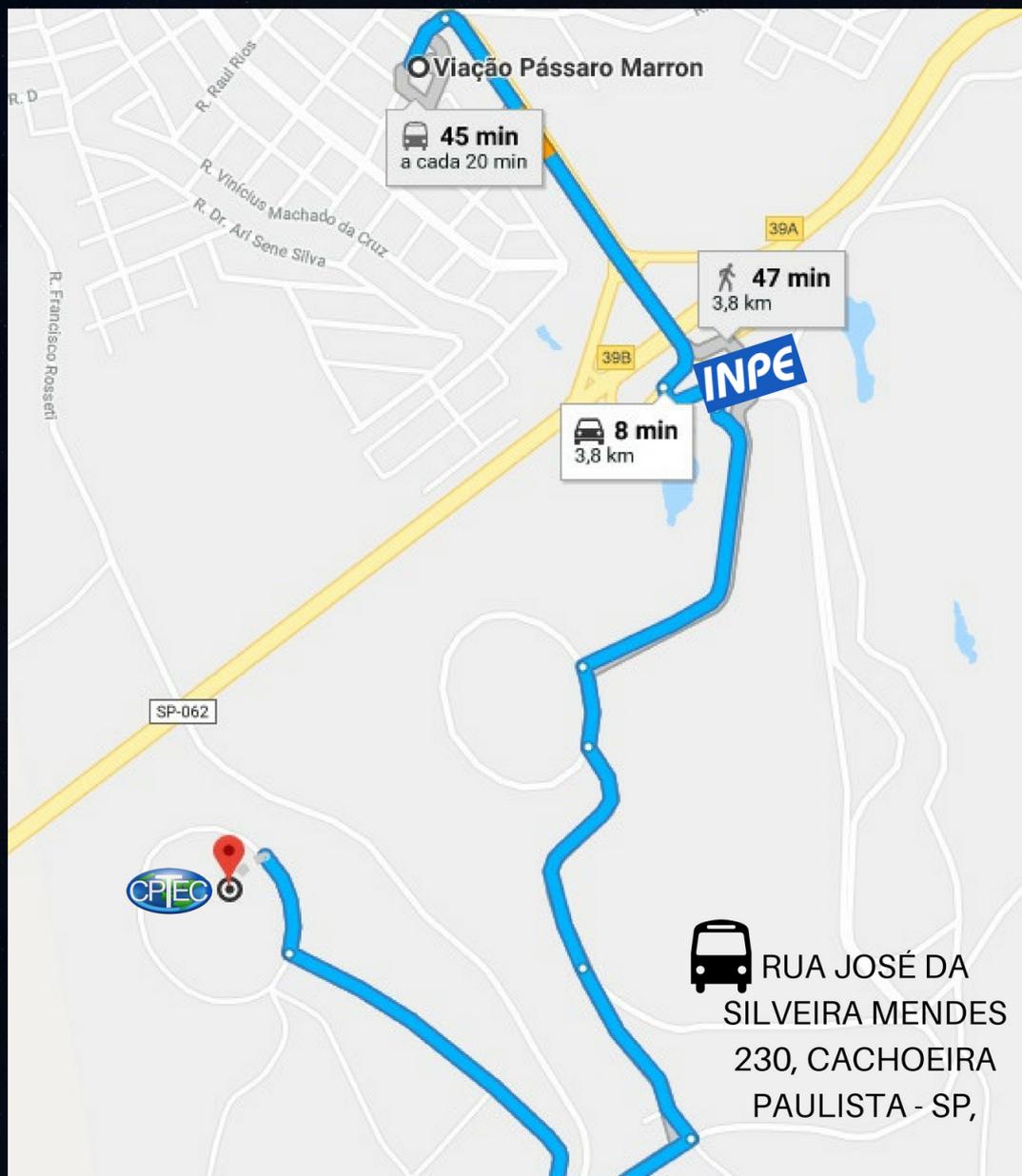


ESTRADA CHIQUITO DE AQUINO 46 LOJA EXTERNA 1, SP

# V ComplexNet

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# V ComplexNet

Workshop and School on Dynamics,  
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## INTERNAL TRANSPORT

**07:30** - GATEWAY x CPTEC

**11:10** - CPTEC x GATEWAY

**13:00** - GATEWAY x CPTEC

**16:30** - CPTEC x GATEWAY

## TAXI

 (12) 3101-2764

 (12) 3101-1554

 (12) 3101-1861



**Annotations**

**Annotations**

**Annotations**

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