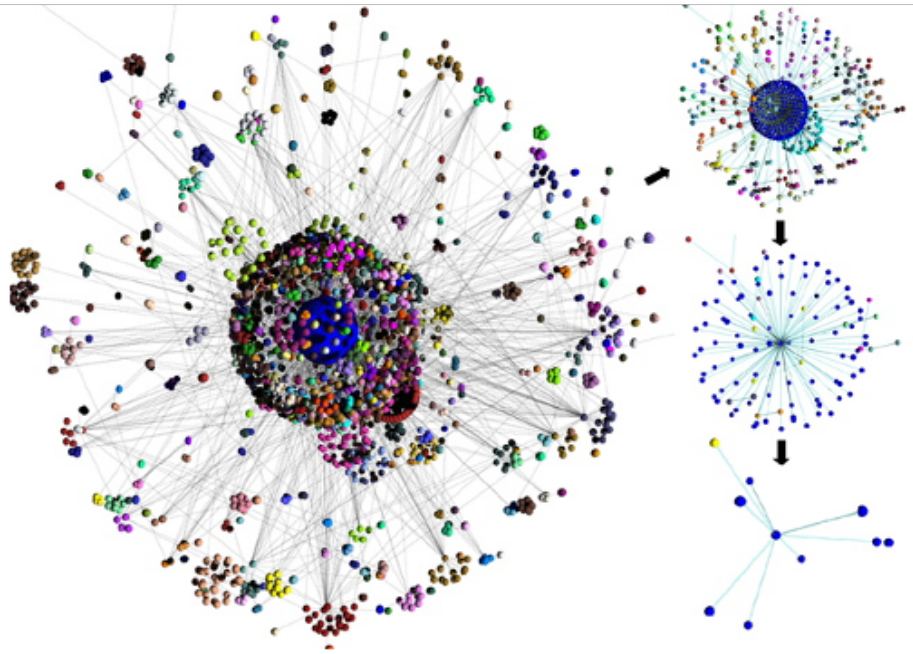

IV ComplexNet

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

São Carlos, September 28th to October 6th of 2016

FAPESP

DFG

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

ComplexNet - Introduction

The IV 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 lasers, interaction between neurons, Earth system complexity, autonomous mobile robots, systems energy distribution.

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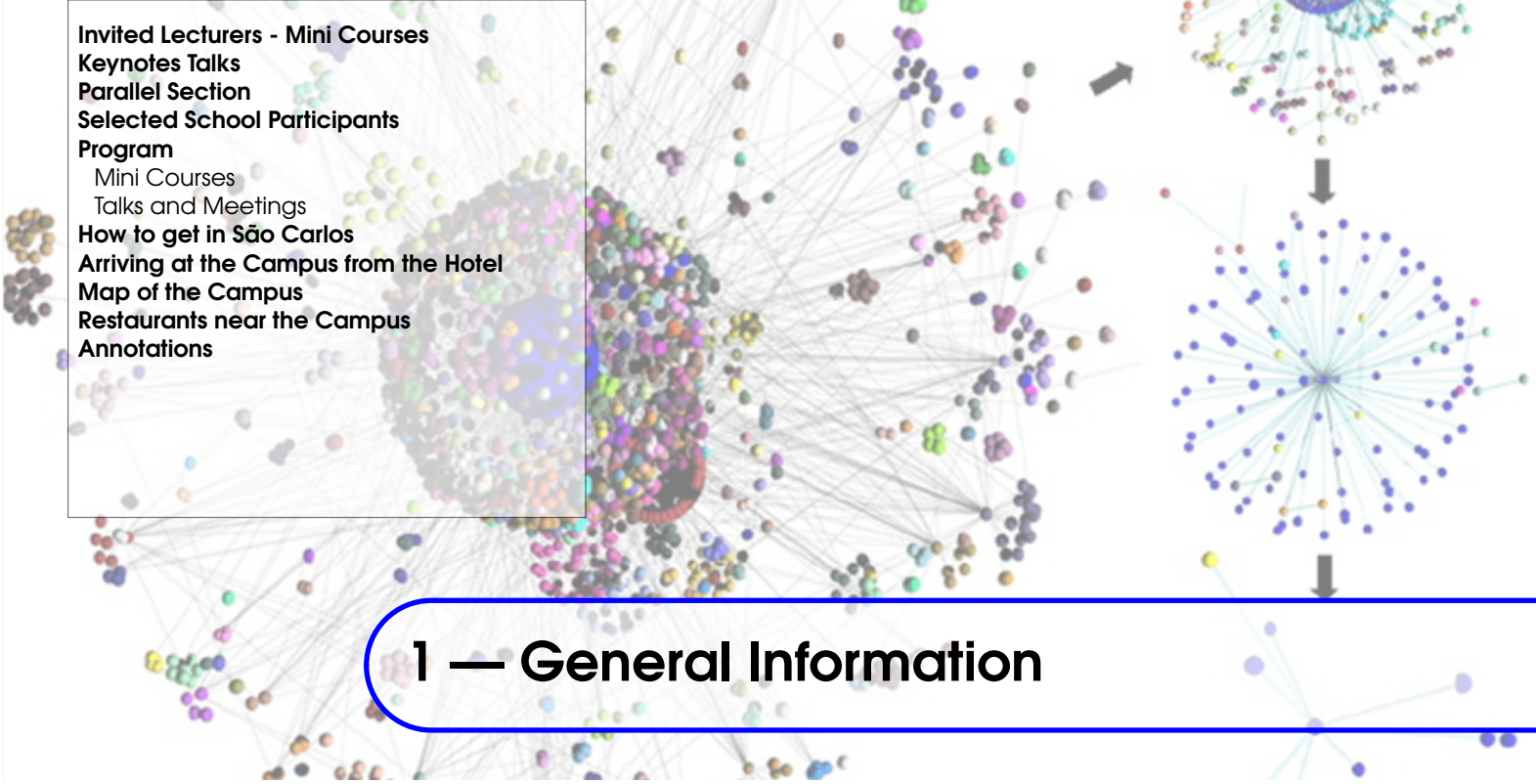

1 — General Information

1.1 Invited Lecturers - Mini Courses

MC-1 - Traditional vs. non-traditional methods in network theory

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

Introduction to degree distributions, assortativity, communication by shortest paths, etc. Difficulties for their application, implementation and applications. Non-traditional methods based on algebraic, graph-theoretic and topological approaches. Answering questions about: How to compare degree heterogeneities in the presence of scarce data? What is the structural meaning of degree assortativity? How can you navigate a network without knowing the shortest paths?, How many topological classes of networks do exist? How to quantify the bipartivity of a network?

MC-2 - Dynamical Phenomena in Complex Networks

Michael Small
CSIRO-UWA Chair of Complex Engineering Systems, michael.small@uwa.edu.au

This course will discuss several dualities between complex networks and nonlinear dynamical systems. After a brief overview of delay reconstruction and time delay embedding, we will examine methods to represent states of dynamical systems as nodes on a network. We will show that certain properties of interest from the perspective of dynamical systems theory are present and can be easily estimated from the network. The second portion of the course will address a variety of alternative network constructions that have been proposed for time series and we will focus, in particular, on ordinal partition networks. In the third part of the course, we go in the reverse direction - constructing time series from networks and observing structural and topological properties of the network manifest in the dynamics of the corresponding time series.

MC-3 - Complex network methods for data analysis in climate and neurosciences

Reik Donner
Potsdam Institute for Climate Impact Research

Both Earth climate and human brain are complex systems governed by inherently nonlinear processes determining the "macroscopic" dynamics as well as the "microscopic" structural organization of the systems. In such cases, classical concepts of multivariate statistics are commonly not sufficient to fully characterize the observed spatio-temporal dynamical patterns and deduce information on the spatial structure of the underlying physical processes. As an alternative, complex networks provide a versatile toolbox for inferring functional connectivity relationships from spatio-temporal data sets and characterize spatial structures in a way that is commonly hidden to other long established analysis techniques. This course provides an introduction into the use of complex network theory to understand the dynamics of spatio-temporal systems like the Earth's climate or the human brain. The tentative agenda of the course is as follows: 1. Complex networks and their characteristics structural 2. Functional network anal-

ysis 3. Similarity measures for constructing functional networks from data 4. Examples of functional climate and brain networks 5. Spatial effects on network structures 6. Coupled networks and networks of networks 7. Network analysis of univariate time series 8. Functional and time series network analysis in practice: The pyunicorn package

MC-4 - Synchronization and collective motion

Ralf Toenjes

Synchronization and Collective Dynamics (I) Many Faces of Synchronization - an Introduction (II) Dynamical Systems - Modeling, Analysis and Case Studies (III) Data Analysis

MC-5 - Climatology and climate change

Gilvan Sampaio

National Institute of Space Research (INPE), São José dos Campos, Brazil, gilvan.sampaio@inpe.br

This course will discuss the main topics related to natural climate change and those caused by human actions. It will approach the consequences of these changes and address the consequences of these changes with respect to the stability of the Earth System. It will address issues relating to modelling and observations of the global climate change. The course aims to introduce the basic concepts of climate modelling and an overview of the various components of the climate system: atmosphere, biosphere, cryosphere, and hydrology. Also, it will be presented the future projections of climate change, with emphasis on Brazil. Part 1: Earth's atmosphere and the location of major biomes; solar radiation and the Earth-atmosphere system, the greenhouse effect; greenhouse gases and the evolution of their concentrations in the atmosphere; anthropogenic greenhouse effect. Part 2: Scientific principles of climate change; natural and anthropogenic climate change; evolution of the concentration of greenhouse gases emissions in the atmosphere; global warming; climate change in different parts of the Earth. Part 3: Climate modelling; scenarios of greenhouse gases; IPCC Earth System Models; future IPCC climate projections; global environmental changes and Brazil: main impacts and future projections of the IPCC; uncertainties of future climate projections; main impacts of climate change on Brazilian biomes; land use changes and impacts on climate.

MC-6 - Smart grids and power distribution

Eduardo Lorenzetti Pellini[1], Giovanni Manassero Junior[1]

[1]Escola Politécnica (POLI) USP

I) Electrification of western society; II) Smartgrid concepts and characteristics; II.1) Electric automation and control; II.2) Advanced measurement infrastructure; II.3) Generation, transmission and distribution automation; II.4) Generation control; III) Smartgrid technology; III.1) Communication; III.2) Sensing; III.3) Components; III.4) Interfaces and control

MC-7 - Stochastic models of neural activity

Benjamin Lindner

Humboldt-Universität zu Berlin, Berlin, Germany, benjamin.lindner@physik.hu-berlin.de

I will review the statistical properties of spike trains generated by various variants of the popular integrate-and-fire model. I will show how equations from stochastic theory (Fokker-Planck equation) are related to the spike train statistics of the spontaneous activity (firing rate, CV, ISI histogram, and ISI correlation coefficients) and to information transmission (rate modulation, signal-to-noise ratio, spectral coherence, and mutual information). Special emphasis will be on multi-dimensional models (e.g. with adaptation currents or collored noise) that can capture non-renewal behavior, i.e. generate spike trains with correlated interspike-intervals. Finally, I will illustrate how analytical approaches and results can be used to (i) gain insights into the mechanisms responsible for specific statistical aspects, as for instance, interval correlations; (ii) estimate physiological parameters from spike train data of real cells; (iii) understand functional relations between properties of the spontaneous activity and neural signal transmission capabilities

1.2 Keynotes Talks

KT-0 - Jittering of spiking oscillators with delayed feedback

Serhiy Yanchuk

Institute of Mathematics, Technische Universität Berlin, yanchuk@math.tu-berlin.de

Oscillatory systems with time-delayed pulsatile feedback appear in various applied and theoretical research areas, including neuroscience. For such systems, we report a remarkable scenario of destabilization of a periodic regular spiking regime. At the bifurcation point numerous regimes with nonequal interspike intervals emerge. We show that the number of the emerging, so-called "jittering" regimes grows exponentially with the delay value. Although this appears as highly degenerate from a dynamical systems

viewpoint, the "multijitter" bifurcation occurs robustly in a large class of systems. We observe it not only in a paradigmatic phase-reduced model, but also in a simulated Hodgkin-Huxley neuron model and in an experiment with an electronic circuit. Main reference: Klinshov et al., Multistable jittering in oscillators with pulsatile delayed feedback, Phys. Rev. Lett. 114, 178103 (2015).

KT-1 - Randomness and variability in Ca2+ signalling and non-markovian modelling

Martin Falcke

Max Delbrück Center for Molecular Medicine, Berlin, martin.falcke@mdc-berlin.de

Ca2+ is a ubiquitous intracellular messenger that regulates diverse cellular activities. Extracellular stimuli often evoke sequences of intracellular Ca2+ spikes, and spike frequency may encode stimulus intensity. However, the timing of spikes within a cell is random because each interspike interval has a large stochastic component (in addition to a fixed absolute refractory period). In human embryonic kidney 293 cells and rat primary hepatocytes, we also found that the average interspike interval varied between individual cells. Hence, each cell responds differently to stimuli and a relation between stimulus and response applying to all cells does not exist. In the face of temporal randomness and variability, what does transmit the information on extracellular agonist concentration to intracellular targets? To evaluate how individual cells reliably encoded stimuli when Ca2+ spikes exhibited such unpredictability, we combined Ca2+ imaging of single cells with mathematical analyses of the Ca2+ spikes evoked by receptors that stimulate formation of inositol 1,4,5-trisphosphate (IP3). This analysis revealed that signal-to-noise ratios were improved by slow recovery from feedback inhibition of Ca2+ spiking operating at the whole-cell level, and they were robust against perturbations of the signalling pathway. Despite variability in the frequency of Ca2+ spikes between cells, steps in stimulus intensity caused the stochastic period of the interspike interval to change by the same factor in all cells. These fold changes reliably encoded changes in stimulus intensity, and they result inevitably in an exponential dependence of average interspike interval on stimulation strength. Hence, not the absolute value of spike frequency is strongly related to stimulation, but the factor by which all individual values change upon a stimulation step is. This encoding rule reconciles large cell variability with the needs of information transmission. I will also present some ideas of modelling these experimental results. In order to circumvent state space explosion, non-markovian formulations of the probability dynamics have been chosen. I will present the state of modelling and will discuss open problems.

KT-2 - Onset of time-dependence in ensembles of excitable units with global repulsive coupling

Michael Zaks[1], Petar Tomov[2]

[1]Potsdam University, mzaks@uni-potsdam.de, [2]Humboldt University of Berlin

We consider effect of global repulsive coupling on an ensemble of identical excitable elements. Increase of the coupling strength destabilizes the synchronous state of equilibrium and replaces it by the multitude of attracting oscillatory states, born from the transcritical heteroclinic bifurcation. The number of stable oscillatory orbits exponentially grows with the size of the ensemble. The period of oscillations is inversely proportional to the distance from the critical parameter value. If the elements are identical and interact with the global field via the first Fourier harmonics of their phases, the stable equilibrium is in one step replaced by the attracting continuum of periodic motions.

KT-3 - Moisture transport from the Amazon and rainfall extremes in western Amazonia and Southeastern Brazil during the extreme drought in Sao Paulo in 2014-15

Jose A. Marengo[1], Carlos A. Nobre [1]

[1]CEMADEN, Sao Jose dos Campos, jose.marengo@cemaden.gov.br, cnobre.res@gmail.com

From austral summer of 2014 to January 2016 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, the largest megacity in South America. The meteorological causes of the drought situation were linked to changes in the regional circulation, characterized by a mid-troposphere blocking high that lasted 45 days during the summer of 2014 over southeastern Brazil, something not seen in five decades. In the context of rain producing mechanisms in the southeastern Brazil region, the Amazon tropical rainforest plays an important role as one of the sources of moisture for rainfall in Southern and Southeastern Brazil during summer. However, during January and February 2014 the atmospheric blocking did not allow for the cold fronts coming from the South to reach Sao Paulo and the Cantareira region, as well as prevented the moist air coming from Amazonia to reach this region. As a consequence, increased moisture flux was detected on western Amazonia in with unprecedented wet conditions are reported in the 2014 summer (December-March) over South-western Amazon, and with rainfall about 100% above normal. Discharge in the Madeira River (the main southern Amazon

tributary) has been 74% higher than normal. In Sao Paulo, the water crisis was aggravated by a combination of lack of rainfall and higher temperatures, the summer of 2014 being the warmest and driest over the Cantareira reservoir system since 1951. Increasing population and water consumption increased vulnerability in the region, and while human-induced warming may not have generated the atmospheric conditions behind the 2014 and 2015 summer droughts in Southeast Brazil, it is more likely that the warm temperatures have affected the severity of the drought and exacerbated the impacts on the population.

KT-4 - Stability and Resilience of Power Grids

Jobst Heitzig

Potsdam Institute for Climate Impact Research, heitzig@pik-potsdam.de

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. This is joint work with S. Auer, C. Grabow, F. Hellmann, M. Jarolin, P. Ji, K. Kleis., M. Krause, J. Kurths, P. Menck, J. Nitzbon, A. Plietzsch, C. Roos, B. Schäfer, H.-J. Schellnhuber and P. Schultz.

KT-5 - Nonliner interactions in simplified meteorological models

Pedro Leite da Silva Dias

University of São Paulo-IAG/USP, São Paulo, Brazil, pldsdias@gmail.com

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-6 - Atmospheric origins and ECOLOGICAL IMPACTS OF drought events: A complex networks APPROACH

Kirsten Thonick[1,2], Susanne Rolinski[3], Henrique Barbosa[4], Gilvan Sampaio[5]

[1]Technical University of Munich, Freising, Germany, Anja.Rammig@tum.de; [2]Potsdam Institute for Climate Impact Research, Potsdam, Germany, Anja.Rammig@pik-potsdam.de; [3]Potsdam Institute for Climate Impact Research, Potsdam, Germany, rolinski@pik-potsdam.de; [4]University of São Paolo (USP), São Paolo, Brazil, hmjbarbosa@gmail.com; [5]National Institute of Space Research (INPE), São José dos Campos, Brazil, gilvan.sampaio@inpe.br

Brazil experienced several drought events during the last decade but some of them, e.g. the recent drought in the São Paulo region in 2014, do not have a clear explanation yet in the literature. Tropical forest ecosystems, particularly in the Amazon basin, serve as an atmospheric moisture pump by taking up water from the soil and re-evaporating moisture, which is in this way transported over long distances. In this project, we will investigate the potential of reduced forest cover from drought mortality and forest loss from deforestation activities to enhance drought events by changing atmospheric moisture transport.

1.3 Parallel Section

Plan for parallel sessions IRTG/TP meeting 2016, Brazil, São Carlos

Within the the annual IRTG/TP meeting 2016, we will have workshops in groups to consolidate and to spark further collaboration. The designated hours are currently called "parallel sessions". We will divide into small groups and will start a draft of a joint work. Each joint work will be presented in its parallel session at the end of the meeting.

- **1) Project meeting**
  1. Students and PIs meet to discuss the status of their existing projects
- **2) Research area meeting 1**
  2. All students and PIs of a research area meet
     - A - General aspects of network dynamics
     - B - Stochastic dynamics and transport
     - C - Earth system and networks
     - D - Neuroscience and networks
  3. Students give a short presentation (10min) about methods they have learned.
  4. PIs pitch (10min) a problem related to topics of the Students.
  5. Students join (group of) PI's for a project. Optimally groups of up to 5 people.
  6. Groups decide on individual tasks for group members
- **3) Work in groups 1**
  Introduction paragraph to the problem and set references
- **4) Work in groups 2**
  Draft with a detailed description of the proposed project and methods
- **5) Work in groups 3**
  prepare presentation
- **6) Research area meeting 2**
  Students present (10-15min) project ideas for feedback of other IRTG members. Short talks to state the problem and a proposed method in a suitable fashion for an interdisciplinary audience.

A1.1 - Spatial Representation of Urban Mobility Complex Networks

Jéssica Domingues Santos[1], Beatriz Marques Moreira da Silva[2],[3], Leonardo B. L. Santos[4],
[1]Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, Brasil, jessica.dominguess@gmail.com,
[2]Centro Nacional de Monitoramento e Alertas de Desastres Naturais (Cemaden/MCTI), São José dos Campos, Brasil,
[3]Faculdade de Tecnologia Prof. Jessen Vidal (FATEC), São José dos Campos, Brasil, beatriz.mm.silva@gmail.com,
[4]Centro Nacional de Monitoramento e Alertas de Desastres Naturais (Cemaden/MCTI), São José dos Campos/SP, Brasil, santoslbl@gmail.com

Spatial representation is a important tool for several analysis, especially in the case of transport and mobility networks. In this work, actual origin-destination data from Rio de Janeiro/RJ and São José dos Campos/SP are used to test an geographical database management system-based approach. It is shown the conceptual diagram, tables and relationships related to nodes and edges representation. Each node is the traffic zone's centroid, and a pair of nodes are connected in accord of people flow in a typical day (origin-destination survey).

A1.2 - Synchronization in Finite-Size Networks: Fluctuations of the Global Phase

Franziska Peter[1], Arkady Pikovsky[2], Elbert E. N. Macau[3]
[1]Universität Potsdam, Germany, frpeter (at) uni-potsdam.de; [2]Universität Potsdam, Germany, pikovsky (at) uni-potsdam.de; [3]INPE, São José dos Campos, Brazil, elbert.macau (at) inpe.br

We investigate the time evolution of the global phase in partially synchronized finite all-to-all networks. Despite the simple network structure, the interplay of nonlinear coupling and small ensemble sizes generates very complex dynamics. In the Kuramoto model, a global phase is defined only above a certain coupling strength. Depending on network size and natural frequency distribution, this mean phase fluctuates. We analyze these fluctuations by constructing diffusion bridges and the transition to the regime where a mean phase is defined.

A1.3 - Temporal Networks of earthquakes

Nastaram Lofti[1],[2], Luciano da Fontoura Costa[3], Amir Hossein Darooneh[1] and Francisco A. Rodrigues[4]
[1]Instituto de Ciências Matemáticas e de Computação, Universidade de São Paulo, São Carlos, SP, Brazil; [2]University of Zanjan, Zanjan, Iran; [3]Instituto de Física de São Carlos, Universidade de São Paulo, São Carlos, SP, Brazil; [4]Departamento de Matemática Aplicada e Estatística, Instituto de Ciências Matemáticas e de Computação, Universidade de São Paulo - Campus de São Carlos, Brazil.

Network studying plays a crucial role in investigating the structure, dynamics, and function of a wide variety of complex systems in different disciplines. One of these systems is earthquakes network which gets a growing interest, recently. Despite the success of traditional earthquake network analysis, standard networks provide a limit representation of this system. In the standard networks, different types of rela- tionships among the constituent components and/or multiple interacting subsystems are not considered which has a significant effect on both dynamics and function. Multilayer approach for modeling net- worked systems allows the incorporation of features of realistic networked systems. This new approach allows one to couple different structural relationships by encoding them in a convenient mathematical object and to couple different dynamical processes of interconnected structures. Results of such consideration help one to achieve a thorough and accurate understanding of complex systems. In this paper, we study the centrality measurement of multilayer earthquakes network which could reveal the importance of considering earthquakes network as a multilayer network rather than a single-layer.

B1.1 - Monge meets Kolmogorov

Christian S. Rodrigues
IMECC - Unicamp, Campinas, Brazil, rodrigues@ime.unicamp.br

Amongst the main concerns of Dynamics, one usually wants to decide whether asymptotic states of a given class of systems or model are robust under small random fluctuations. The concept of random dynamical systems is relatively recent, although the interest in random perturbation of dynamical systems goes back to Kolmogorov. Such randomness, corresponding to natural fluctuations in physical processes, are represented by either a Markov chain model with localised transition or by a sequence of random maps. In this talk, we shall see how Optimal Transport Theory, initially proposed as a logistic optimisation technique by G. Monge in 1781, can shed some light on the understanding of stability of dynamical systems. In particular, we will see how several issues are deeply connected through beautiful mathematical structures. This refers to joint works with Jost, Kell, Matveev, Portegies.

B1.2 - Particle Transport Barriers in Plasmas

Iberê L. Caldas

Instituto de Física, Universidade de São Paulo, Brasil

In magnetic confined plasmas, the chaotic particle transport is described by symplectic maps [1]. This transport is limited by the onset of shearless transport barriers. We present examples of such barriers for plasmas with non monotonic velocity profiles in tokamaks [2] and helimaks [3]. [1] J. S. E. Portela, I. L. Caldas, R. L. Viana. Europ. J. Phys., 165, 195 (2008).[2] K. Rossalem, M. Roberto, I. L. Caldas, Phys. Plasmas, aceito para publicação (2016). [3] R. Ferro, I. L. Caldas. Phys. Plasmas, submetido para publicação.

B1.3 - Rotation Numbers for Discrete Random Dynamics on the Circle

Christian S Rodrigues[1], Paulo R Ruffino[2]

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We revisit the problem of well-defining rotation numbers (RN) for discrete random dynamical systems on S1. We show that, contrasting with deterministic systems, the topological approach (based on Poincarè lifts) does depend on the choice of lifts. Furthermore, the winding orbit RN does not agree with the topological RN. Existence and conversion formulae between these distinct numbers are presented. Finally, we prove a sampling in time theorem which recover the rotation number of continuous Stratonovich stochastic dynamical systems on S1 out of its time discretisation of the flow.

A2.1 - Impact of isolation on endemic diseases

Stefan Ruschel[1], Tiago Pereira[2], Serhiy Yanchuk[3], Lai-Sang Young[4]

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Infectious diseases are among the most prominent threats to mankind. The final severity of such an initially small infection is sigificantly decided upon by the infectous period. The authors investigated the effect of this periods deliberate truncation to prevent epidemic spread on networks via no de isolatin after delay time τ. Here, we present our mean field analysis.

A2.2 - Dynamical detection of network communities

Marcos G. Quiles[1], Elbert E. N. Macau[2], and Nicolás Rubido[3]

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A prominent feature of complex networks is the appearance of communities, also known as modular structures. Specifically, communities are groups of nodes that are densely connected among each other but connect sparsely with others. However, detecting communities in networks is so far a major challenge, in particular, when networks evolve in time. Here, we propose a change in the community detection approach. It underlies in defining an intrinsic dynamic for the nodes of the network as interacting particles (based on diffusive equations of motion and on the topological properties of the network) that results in a fast convergence of the particle system into clustered patterns. The resulting patterns correspond to the communities of the network. Since our detection of communities is constructed from a dynamical process, it is able to analyse time-varying networks straightforwardly. Moreover, for static networks, our numerical experiments show that our approach achieves similar results as the methodologies currently recognized as the most efficient ones. Also, since our approach defines an N-body problem, it allows for efficient numerical implementations using parallel computations that increase its speed performance.

A2.3 - Active particles with angular driving

Jörg Nötel[1], Prof. Lutz Schimansky-Geier[2], Prof. Elbert E. Macau[3]

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The concept of active particles is used to describe the spatial movement of a variety of organisms such as ameba, plankton, fish and birds. Of special interest is the influence of noise on the motion of the particle. Fluctuation of the motion might arise through the internal or external circumstances like the propulsion engine, the medium, food supply, chemical gradients. Here we look at active particles with constant velocitiy and angular driving through α-stable noise and an Ornstein-Uhlenbeck process

with Cauchy noise. We determine the mean square displacement and the effective diffusion coefficient and discuss the displacement distribution.

B2.1 - Nonlocal Conservation laws from Stochastic Particle Systems

Christian H. Olivera

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We consider an interacting particle system modeled as a system of N stochastic differential equations driven by Levy process. The limiting behavior as the size N grows to infinity is achieved as a law of large numbers for the empirical process associated with the interacting particle system.

B2.2 - Multiresolution in Graphs And Markov Chains

Ian Dick de Paula[1], Pedro Catuogno[2]

[1]State University of Campinas, Campinas, Brazil, iandkdp@gmail.com; [2]State University of Campinas, Campinas, Brazil, pedrojc@ime.unicamp.br

We present some ideas of composition and decomposition of graphs in the context of multiresolution analysis and scaling. We show some applications to the study of Markov chains and invariant measures.

A3.1 - Modeling internal fluctuations in the description of sparse networks of dynamical systems

Ralf Toenjes[1], Chris Gong[2], Tiago Pereira[3]

[1]Potsdam University, Potsdam, Germany, ralf.toenjes@uni-potsdam.de; [2]Potsdam University, Potsdam, Germany, cchrisgong@gmail.com; [3]Universidade de São Paulo, São Carlos, Brazil, tiago@icmc.usp.br

In sparse networks of dynamical units each sub-system couples to a finite number of neighbors even in the limit of an infinite network size. Deviations of the local fields from the global mean field can be viewed as internal dynamical fluctuations perturbing the evolution given by mean field equations. The properties of these internal fluctuations and their dependence on the mean field itself determine the collective dynamics in the network, in particular the stability of incoherent and partially synchronized states. Since the amplitude of the fluctuations scales with the square root of the number of neighbors the topologically induced transition to synchronization in sparse networks is a general phenomenon. Subject of this project are the properties of the internal fluctuations in non-equilibrium steady states and the synchronization transition in large, sparse random networks.

A3.2 - Finding global organization of complex sets in the parameter space with extreme orbits

D.R. da Costa[1], M. Hansen[1], G. Gaurise[1], R.O. Medrano-T[2], E.D. Leonel[1]

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We present the extreme orbits, trajectories that connect local maximum and minimum values of one dimensional maps, and show that they play a fundamental role in the parameter space of dissipative systems dictating the organization for the windows of periodicity, hence producing sets of Arnold tongues and shrimp-like structures. As applications, we solve three fundamental problems regarding the distribution of these sets for the circle and perturbed logistic maps and give: (i) their precise localization in the parameter space, even for sets of very high periods; (ii) their local and global distributions along cascades and; (iii) the association of these cascades to complicate sets of periodicity. The extreme orbits are proved to be a powerful indicator to investigate the organization of windows of periodicity in parameter planes and its formalism can be extended to many other different nonlinear and dissipative systems.

D1.1 - Stochastic models of neural activity

Benjamin Lindner

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I will review the statistical properties of spike trains generated by various variants of the popular integrate-and-fire model. I will show how equations from stochastic theory (Fokker-Planck equation) are related to the spike train statistics of the spontaneous activity (firing rate, CV, ISI histogram, and ISI correlation coefficients) and to information transmission (rate modulation, signal-to-noise ratio, spectral coherence, and mutual information). Special emphasis will be on multi-dimensional models (e.g. with adaptation currents or collored noise) that can capture non-renewal behavior, i.e. generate spike trains with correlated interspike-

intervals. Finally, I will illustrate how analytical approaches and results can be used to (i) gain insights into the mechanisms responsible for specific statistical aspects, as for instance, interval correlations; (ii) estimate physiological parameters from spike train data of real cells; (iii) understand functional relations between properties of the spontaneous activity and neural signal transmission capabilities.

D1.2 - Stochastic Induction of Cerebellar Long-Term Potentiation And Long-Term Depression

Gabriela Antunes[1], A. Carlos Roque[2], Fábio M. Simoes-de-Souza[3]

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Long-term depression (LTD) and long-term potentiation (LTP) of granule-Purkinje cell synapses are persistent synaptic alterations induced by high and low rises of the intracellular calcium ion concentration ([Ca2+]), respectively. The occurrence of cerebellar LTD involves the activation of a positive feedback loop formed by protein kinase C, phospholipase A2, and the extracellular signal-regulated protein kinase pathway, and its expression comprises the reduction of the population of synaptic AMPA receptors (AMPARs). Recently, a large-scale stochastic computational model of these signalling processes demonstrated that, in single synapses, LTD is probabilistic and bistable. Here, we expanded this model to include other molecules implicated with LTD and to simulate LTP, which requires several protein phosphatases and the increase in the population of synaptic AMPARs. Our results indicated that, in single synapses, while LTD is bistable, LTP is gradual. Ca2+ induced both processes stochastically. The magnitudes of the Ca2+ signals and the states of the signalling network regulated the likelihood of LTP and LTD and defined dynamic macroscopic Ca2+ thresholds for the synaptic modifications in populations of synapses according to an inverse Bienenstock, Cooper and Munro (BCM) rule or a sigmoidal function. In conclusion, our model presents a unifying mechanism that explains the macroscopic properties of LTP and LTD from their dynamics in single synapses.

D1.3 - Optimizing information processing in neuronal networks beyond critical states

Mariana Ayres Sacrini Ferraz, Hiago Lucas Cardeal de Melo Silva, Alexandre Hiroaki Kihara*,

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Critical dynamics have been postulated as the ideal regimen for neuronal networks in the brain, considering optimal dynamical range and information processing. However, few studies aimed to approach how information might be embedded in the phase transition observed in critical states. Herein, we focused on how information entropy coded in spatiotemporal activity patterns may vary in critical networks. Surprisingly, we were able to determine that information capacity of critical networks with same number of nodes might vary enormously by the manipulation of microscopic parameters. In fact, we were able to determine that information capacity of a network set within the limits of critical dynamics might be even lower when compared to a network with the same number of nodes in a subcritical regimen. These findings are compatible with real neuronal networks observed in specific brain circuitries, where critical behaviour is necessary for the optimal dynamical range response, but uncertainty as coded by spatiotemporal patterns is not required.

A4.1 - Using State Networks for Efficient Computation of Viability Sets and the TSM Partition

Tim Kittel,[1], [2] Jobst Heitzig[1] and Juergen Kurths[1], [2], [3]

[1]Potsdam Institute for Climate Impact Research Potsdam, Germany; [2]Institut fuer Physik; Humboldt-Universitaet zu Berlin Germany; [3]Institute for Complex Systems and Mathematical Biology, University of Aberdeen, United Kingdom

We use state networks, i.e. networks in state space due to different dynamics, in order to develop novel formulations of viability kernels and capture basin. Due to the constructive nature of these new kinds of networks, they can be used for efficient computational estimation of these sets by reducing the problem to the calculation of network partitions. This approach proves to be particular useful for repetitive viability calculations with changing constraints and different but overlapping dynamics. A particular case where this is necessary is within the framework of Topology of Sustainable Management by Heitzig et al. [1].

While this framework has been analyzed in mathematical detail, the first developed algorithms for this frame- work prove to have a high computational demands even for low dimensions [2]. In order to improve the computations, this approach provides two fundamental advantages that reduce the calculations: (i) overlapping calculations for different parts of the partition are naturally omitted / reduced; (ii) multiple recalculations for the capture basin can be reduced.

A4.2 - Efective Distance for Epidemic Spreading on Complex Networks

Flavio Iannelli, Igor Sokolov

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We show that the recently introduced logarithmic metrics to used predict disease arrival times on complex networks are approximations of more general network-based measures derived from random walks theory. Using the daily air-trac transportation data we perform numerical experiments to compare the infection arrival time with this alternative metric that is obtained by accounting for multiple walks instead of only the most probable path. The main difference with respect to previously introduced distances is that also looped trajectories are allowed in the disease propagation. The comparison with direct simulations of arrival times reveals a higher correlation compared to the shortest path approach used previously. In addition our method allows to connect fundamental observables in epidemic spreading with the cumulant generating function of the hitting time for a Markov chain. Our results provides a general and effective computational approach to the problem using only algebraic methods.

C1.1 - Dynamics of land-use and land-cover change in regions of deforestation

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In this study, we explore methods to better understand the dynamics of land-use and land-cover change in regions of deforestation that are crucial for global sustainability. The basis of the analysis are subregional transition probabilities between different land-cover types that are obtained from land-cover maps of the Brazilian Amazon (TerraClass) derived from satellite imagery. We apply clustering analysis and community detection algorithms on similarity networks to identify patterns in these transition probabilities reflecting major subregional differences in land-cover dynamics.

C1.2 - Broad-scale dynamics of land cover in Amazonia

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Using data from the land-cover product TerraClass and analyses with transitions matrices and similarity networks, we were able to determine patterns of broad-scale change on the land surface that occurred in recent years in Amazonia. TerraClass, provided by the INPE/CRA (Centro Regional da Amazônia), produced maps of the land surface in Amazonia subdivided into major classes of land cover and use in the region, based on satellite images for the years 2008, 2010, and 2012. For any sub-region of interest, transition matrices can be calculated comparing information of two maps from different years, by adding up all the areas that have a specific land-cover/use type in the first year and changed to another type in the second year. These numbers are combined in a matrix, in which the lines represent the first year and the columns represent the second year. Each element represents the amount of some specific type of land cover that changed to the same (no change) or to another land-cover type. Comparing transition matrices for different sub-regions, we are also able to estimate simple statistics and determine similarity networks, in which a connection between two points, representing two sub-regions, indicates that the transitions occurring between two years resemble each other in the two sub-regions. The method has been producing interesting results by helping to summarize and visualize broad-scale patterns of change. It is possible to visualize, for example, that between 2010 and 2012 deforestation mostly leaded to areas with pastures, secondary vegetation, and under regeneration. Also it is possible to visualize sub-regions in Amazonia that present similar transition dynamics. Other important aspects of these results include the fact that they do not derive from specific knowledge of experts that have worked on the ground, but only from an objective analysis of the land-cover maps. In addition, they show a great potential for helping build models of land dynamics for any region with similar datasets.

C1.3 - What are the atmospheric mechanisms that leading to changes in the dry season length and drought events in Brazil?

Gilvan Sampaio[1], H. Barbosa (USP)[2], A. Rammig (TUM/PIK)[3], S. Rolinski (PIK)[4]

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Brazil experienced several drought events during the last decade, e.g. the severe droughts in the Amazon basin in 2005 and 2010, the Xingu drought in 2007 and the recent drought in the Sao Paulo region in 2014 and 2015. Some of theses drought events were partly caused by increasing Pacific sea surface temperatures (SSTs) which reinforce the El Niño Southern Oscillation events or were associated with increased Atlantic SSTs and a northwest displacement of the intertropical convergence zone. However, the recent drought in the São Paulo region does not have a clear explanation. The objective of this study is therefore to better understand the atmospheric mechanisms leading to changes in the dry season length and drought events.

A5.1 - The Interplay between Degree Correlations and Stable Activity in Complex Networks

Mate Kähne[1], Sten Rüdiger[1], Alexandre Kihara[2]
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Information processing and storing in the brain is assumed to crucially depend on the structural properties of the neuronal networks. Recurrent connectivity within these networks has been hypothesized to allow cortical networks to store information. Attractor states of the system is one popular theory for the underlying principle of information storage. We consider a networks with nontrivial degree correlations and investigate its stable recurrent activity based on populations in the space of node degree. For simple degree distributions and correlations, our analytical calculations of stable and unstable fixed points of the system are well recovered by simulation results of a system of binary neurons. We further study the influence of the assortativity and the rich club coefficient on the stable activity.

A5.2 - Reactive agent-based model for convergence of autonomous vehicles to parallel formations heading to predefined directions of motion

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Collective motion is everywhere, from colonies of bacteria to flocks of birds. Understanding the local rules of interaction that trigger the collective behaviors is of great interest, since they can be applied in artificial agents like mobile robots, unmanned aerial vehicles, unmanned subaquatic vehicles, and others. In this work we introduce a reactive agent-based model for convergence of autonomous vehicle to parallel formations heading to predefined directions of motion. They interact via rules of repulsion, alignment and attraction. There is also an abstraction of the desired path of motion, represented by a guiding vehicle, which shows all the time the desired direction to be followed by the formation. We performed experiments in parameter space and evaluate the resulting formations under three quantifiers, and also simulate the occurrence of communication failure among agents.

C2.1 - Analysis of rainfall patterns under global change using complex networks

Ricarda Winkelmann[1], Henrique Barbosa[2], Gilvan Sampaio[3], Anja Rammig[4] , Catrin Ciemer[5]
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The South American climate exhibits strong changes between wet and dry seasons, accompanied by specific synoptic events: changes in the location of the South American Low Level Jet and the establishment of the South American Convergence Zone (SACZ). To identify large-scale synoptic events like the SACZ onset, detecting changes to correlation over time between certain regions is of significant relevance. Therefore, we develop modifications to Pearson's correlation coefficient to construct spatial correlation networks of precipitation. In a next step, we examine the dependency of precipitation on sea surface temperatures to investigate how they influence precipitation patterns and thus vegetation.

C2.2 - What we've learn from applying complex networks to South America's flying

rivers and precipitation

Henrique Barbosa[1], Niklas Boers[2], Delphine Zemp[3], Catrin Ciemer[4], Anja Ramming[5], José Marengo[6], Jurgen Kurths[7]

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In this presentation we intend to give an overview of our research during the first 4 years of our joint-project, where we applied complex networks to understand the distribution of water vapor and precipitation over South America. By constructing a directional network to represent events of extreme precipitation in the subtropics, we have shown that these are associated with the northward propagation of complex convective systems from the La Plata Basin to central Andes. We developed a prediction algorithm able to forecast 90southern slopes of the Andes. Furthermore, we were able to identify the dynamical mechanism responsible for this northward propagation, which happens in opposite direction to the moisture flux from the Amazon forest, and to disentangle the role of the South American Low Level Jet. We also build a complex network based on the transport of moisture by the atmospheric winds. For the first time, we quantified the contribution of non-local moisture recycling (cascading) to the total moisture transport and to the precipitation downwind of the moisture source. We showed that about 20subtropical South America comes directly from the Amazon, and that another 6added to that amount when considering cascading. Finally, we have built simple dynamical models to represent the atmosphere-vegetation interactions to study the effect of increasing deforestation on moisture transport and precipitation. We have found that the systems present a non-linear response only when we consider the feedback between the evapotranspiration and the circulation. We also found that the heterogeneity of the vegetation increases the forest resilience to deforestation-induced savanization. Finally, we argue that it is crucial to protect the entire tropical forest as a connected entity in order to maintain the stability of the complex vegetation-rainfall system with changing climate and sustain its valuable ecosystem services.

C2.3 - Analysis of rainfall patterns under global change using complex networks

Ricarda Winkelmann[1], Henrique Barbosa[2], Gilvan Sampaio[3], Anja Rammig[4] , Catrin Ciemer[5]

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The South American climate exhibits strong changes between wet and dry seasons, accompanied by specific synoptic events: changes in the location of the South American Low Level Jet and the establishment of the South American Convergence Zone (SACZ). To identify large-scale synoptic events like the SACZ onset, detecting changes to correlation over time between certain regions is of significant relevance. Therefore, we develop modifications to Pearson's correlation coefficient to construct spatial correlation networks of precipitation. In a next step, we examine the dependency of precipitation on sea surface temperatures to investigate how they influence precipitation patterns and thus vegetation.

D2.1 - Effects of Synaptic Plasticity on Neural Activity of A Primary Visual Cortex Local Circuit Model

Shimoura, R. O., Roque, A. C.

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The primary visual cortex (V1), which is the first region that receives visual stimuli in the cortex, plays essential role in processing visual information. V1 is anatomically divided into six layers, where each layer has different types and numbers of neurons. A computational model of the V1 local circuit was built considering excitatory (regular spiking – RS) and inhibitory (fast and low-threshold spiking – FS and LTS) neurons, which were described by the Izhikevich model. Synapses were modeled by spike-timing synaptic plasticity (STDP) rules, one for connections between excitatory neurons (eSTDP) and one for connections from inhibitory neurons to excitatory neurons (iSTDP). The model was used to study network activity patterns with different combinations of excitatory/inhibitory neurons and STDP rules under different stimulation protocols. Simulation results showed that

LTS neurons lead to excessive synchronization of network activity and this effect is controlled by the presence of FS neurons. The network activity patterns more similar to those observed under normal conditions in vivo were observed in the model configuration with the three cell types and the two STDP rules together.

D2.2 - Self-consistent determination of the second-order correlation statistics in a single-neuron scheme

Rodrigo F.O. Pena[1], D. Bernardi[2], A.C. Roque[3] and B. Lindner[4]

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In a recurrent network with sparse connectivity we assume that the major source of noise that a single neuron receives comes from the quasi-random input from other cells. In such scenario, we encounter the following problem of self-consistency: for any two neurons randomly picked in the network, the input spike-trains should have the same second-order statistics of the output. We investigate this self-consistency problem by using an extended version of an iterative scheme proposed by Lerchner et al. [1] and extended by Dummer et al. [2]: instead of simulating a network, we simulate two single neurons for several generations injecting surrogate noise input with the same correlation statistics of the output of the previous generation. We show that the second-order statistics, the cross- and power-spectra, converge to a self-consistent result. The model uses leaky integrate-and-fire neurons [3]. We compare our results with large random sparsely connected networks [4]. [1] Lerchner, A., Ursta, C, Hertz, J., Ahmadi, M., Ruffiot, P. and Enemark S. (2006). Response variability in balanced cortical networks. Neural Comput. 18:634–659.; [2] Dummer, B., Wieland, S., and Lindner, B. (2014). Self-consistent determination of the spike-train power spectrum in a neural network with sparse connectivity. Front. Comput. Neurosci. 8:104.; [3] Gerstner, W., Kistler, W. M., Naud, R. And Paninski, L. (2014). Neuronal Dynamics: from single neurons to networks and models of cognition. Cambridge: Cambridge University Press.; [4] Brunel, N. (2000). Dynamics of sparsely connected networks of excitatory and inhibitory spiking neurons. J. Comput. Neurosci. 8:183–208.

C3.1 - Long-Term Variability in Amazonia: Regional Characteristics.

Guillermo O. Obregón

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The climate variability over the Amazon Basin is addresses using empirical decomposition method. The Standardized Precipitation Index of monthly rainfall time series (1951-2010) of four rainfall stations, representatives of the West, Central, East and South regions of Amazonia were used to calculate the trends and oscillations of the rainfall. The main results are the following: a) The trends in the East and West Regions are opposite, and the in the Central and South Amazonia it oscillates around the mean value without any trend; b) A strongly antiphase multi-decadal Oscillation (35-45 years) are observed in the West and East regions, but in the South Region this oscillation is absent. The results presented here deserve further analysis trying to find, if it is possible, the underlying mechanism of the long-term variability on Amazonia related to the large scale ocean/atmospheric circulation. The next step is try to find large scale patterns, associated to each one of the rainfall regions, applying the idea of the structure and dynamics of complex networks to the large scale circulation

C3.2 - Influence of the Lake Sobradinho Reservoir on the Atmospheric Dynamics Over Ne Brazil

Reik V. Donner[1], Jan Volkhol[1], Nikoo Ekhtiari[2]

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We study the effects of the artificial Lake Sobradinho on the local near-surface and boundary layer atmospheric conditions in NE Brazil. Using 3-month simulations of the regional climate model CCLM (i) with the lake and (ii) with the native vegetation cover as replacement, the model outputs are compared with both surface and satellite data. The resulting spatial patterns of surface air temperature correlations are studied using climate networks, revealing spatially coherent differences in local network characteristics that reflect the reservoir's impact on the regional atmospheric dynamics.

C3.3 - Statistical Analysis of Seasonality And Trends in Rainy And Dry Season in the Amazon: Present Climate And Future Projections

Lincoln M. Alves

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One of the major impacts in the Amazon region in present and future climate are possible changes in the rainy and dry seasons in terms of duration (onset and demise), intensity and spatial and temporal rainfall variability, which have impacts on forest composition, structure, and function. Therefore, the aim of this study is: to assess the possible changes in the present-day climate and long-term trends in seasonal rainfall; to identify possible future climate changes across Amazônia using regional climate dynamic downscaling; and to evaluate the impact of land surface changes on the climate of Amazon basin, particularly on the seasonal rainfall variability. To achieve these goals, we analyzed the observed rainfall data in the period 1979-2014, climate projections generated by regional climate model HadRM3P, nested in a subset of four HadCM3 global model simulations which are obtained by Perturbed Physics Ensembles method (PPEs) in A1B emission scenario. The regional model simulations were carried out in the period 1961-2010, with the implementation of deforestation scenarios in the HadRM3P. Finally, the study has an impact on biodiversity, agriculture, water resources and therefore with significant environmental and socioeconomic implications.

1.4 Selected School Participants

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OBS: *All the selected participants will be asked to a short presentation about their accepted work during the Poster Section.*

1.5 Program

1.5.1 Mini Courses

Time	28/09 - Wed	29/09 - Thu	30/09 - Fri	01/10 - Sat	02/10 - Sun
09h00-10h30		MC-1b	MC-1lab	MC-6a/MC-7a	MC-6c/5c
10h30-11h00		Coffee	Coffee	Coffee	Coffee
11h00-12h30		MC-2a	MC-3a	MC-4b/MC-5b	MC-4c/7c
12h30-14h00		Lunch	Lunch	Lunch	Closing
14h00-15h30		MC-2b	MC-4a/MC-5a	MC-3-lab	
15h30-16h30	Open	Coffee & Poster	Coffee & Poster	Coffee & Poster	
16h30-18h00	MC-1a	MC-2c	MC-3b	MC-6b/MC-7b	

MC-1: Ernesto Estrada, Traditional vs. non-traditional methods in network theory

MC-2: Michael Small - Dynamical Phenomena in Complex Networks

MC-3: Reik Donner - Complex network methods for data analysis in climate and neurosciences

MC-4: Ralf Toenjes - Synchronization and collective motion

MC-5: Gilvan Sampaio - Climatology and climate change

MC-6: Giovanni Manassero and Eduardo Lorenzatti - Smart grids and power distribution

MC-7: Benjamin Lindner - Stochastic models of neural activity

1.5.2 Talks and Meetings

Time	02/10 - Sun	03/10 - Mon	04/10 - Tue	05/10 - Wed
08h30-09h30		KT-2	KT-4	KT-6
09h30-10h00		Coffee	Coffee	Coffee
10h00-10h30		Parallel Sessions-1	Parallel Sessions-3	Parallel Sessions-5
		A1.1 // B1.1	A3.1 // D1.1	A5.1 // C2.1
		A1.2 // B1.2	A3.2 // D1.2	A5.2 // C2.2
		A1.3 // B1.3	D1.3	C2.3
10h30-12h30		Student-PI meeting	Work in Groups 1	Work in Groups 3
12h30-14h00		Lunch	Lunch	Lunch
14h00-14h30		Parallel Sessions-2	Parallel Sessions-4	Parallel Sessions-6
		A2.1 // B2.1	A4.1 // C1.1	C3.1 // D2.1
		A2.2 // B2.2	A4.2 // C1.2	C3.2 // D2.2
		A2.3	C1.3	C3.3
14h30-16h30	Openning(**15h**)/KT-0	Research meeting 1	Work in Groups 2	Research meeting 2
16h30-17h00	Coffee	Coffee	Coffee	Coffee
17h00-18h00	KT-1	KT-3	KT-5	Selected Student Talks

KT-0: Serhiy Yanchuk - Jittering of spiking oscillators with delayed feedback

KT-1: Martin Falcke - Randomness and variability in Ca2+ signalling and non-markovian modelling

KT-2: Michael Zaks -Onset of time-dependence in ensembles of excitable units with global repulsive coupling.

KT-3: José Marengo - Moisture transport from the Amazon and rainfall

KT-4: Jobst Heitzig - Stability and Resilience of Power Grids

KT-5: Pedro Leite da Silva Dias - Nonlinear Interactions in simplified meteorological models

KT-6: Anja Ramming - Atmospheric origins and ecological impacts of drought events

1.6 How to get in São Carlos

Foreign participants should plan to arrive GRU or Viracopos Airport (in Campinas city).

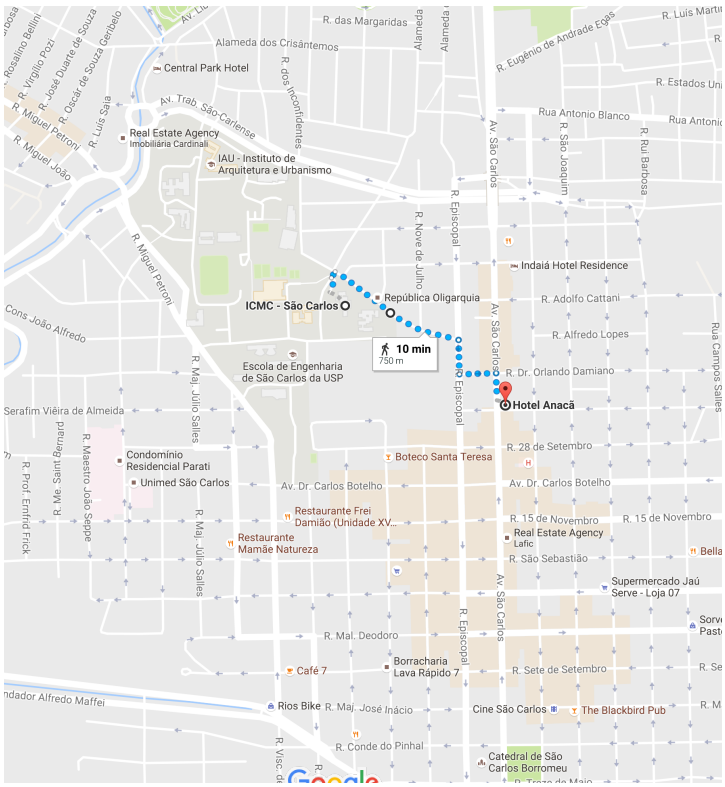
São Paulo Bus/Coach Station is called Terminal Tietê. To get to São Carlos from GRU:

Option 1: Take the Airport Bus Service (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 about 30 mins (depends on the traffic). Once at Tietê, there are two companies to São Carlos: Empresa Cruz (http://www.empresacruz.com.br/) and Cometa (http://www.viacaocometa.com.br/pt/). There are many buses per day, the price is around R$70 and it takes about 3h30min.

Option 2: Take a bus Lirabus (http://www.lirabus.com.br/lira/traslados.php) from GRU to Campinas Bus Station ("Rodoviária de Campinas" in Portuguese). You can buy the ticket in the Lirabus booth at Terminal 2. At Campinas Bus Station take a bus to São Carlos with either Empresa Cruz or Cometa (see links above). This option might be faster if you get a good combination of buses - however, if you don't, it might take much longer since there are less buses to São Carlos from Campinas than from Terminal Tietê. To get to São Carlos from Viracopos:

Take a bus Lirabus (http://www.lirabus.com.br/lira/traslados.php) from Viracopos to Campinas Bus Station. From Campinas Bus Station take a bus to São Carlos with either Empresa Cruz or Cometa (see links above).

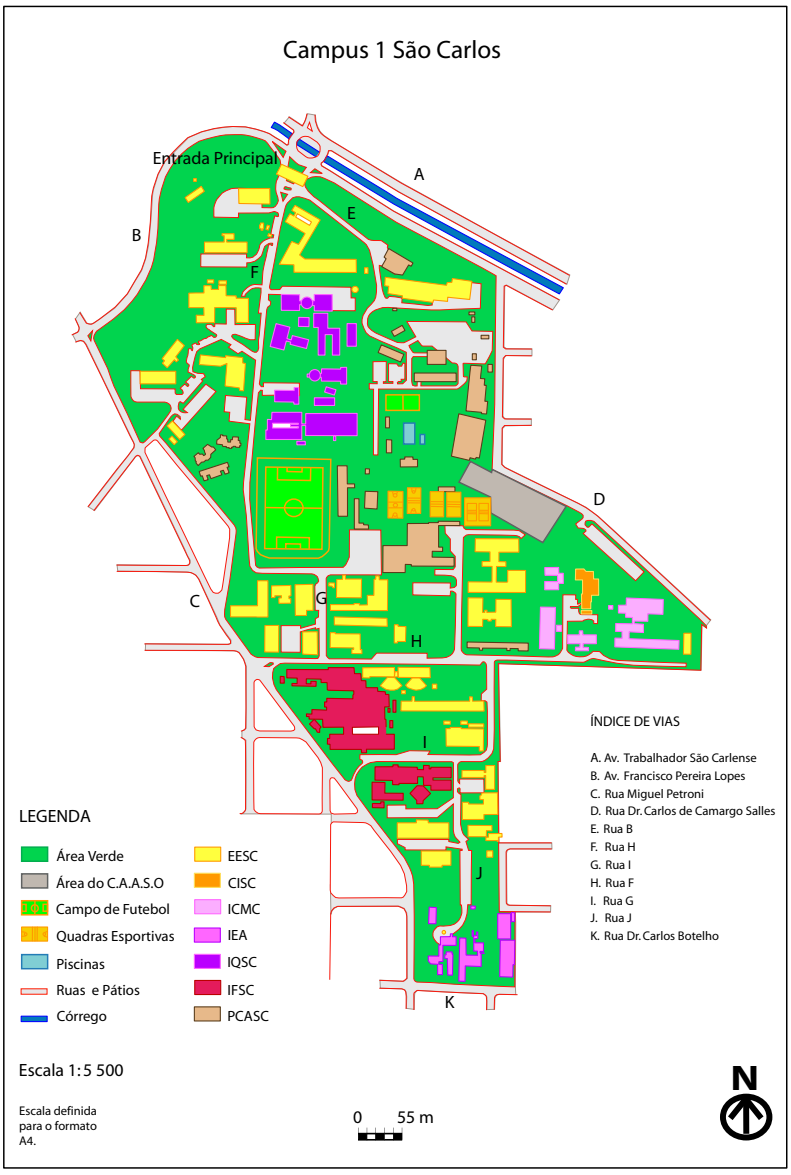
1.7 Arriving at the Campus from the Hotel



1.8 Map of the Campus

The meeting will be held in the following address:
UNIVERSIDADE DE SÃO PAULO
INSTITUTO DE CIÊNCIAS MATEMÁTICAS E DE COMPUTAÇÃO - ICMC
Avenida Trabalhador São-carlense, 400 - Centro
CEP: 13566-590 - São Carlos - SP

The ICMC is in the pink area in the map. Our activities will be held at the auditorium Professor Ferdinand Stella 6-001 ICMC Block 6. During the parallel short courses we will also use Room 3-010 in ICMC Block 3.



1.9 Restaurants near the Campus

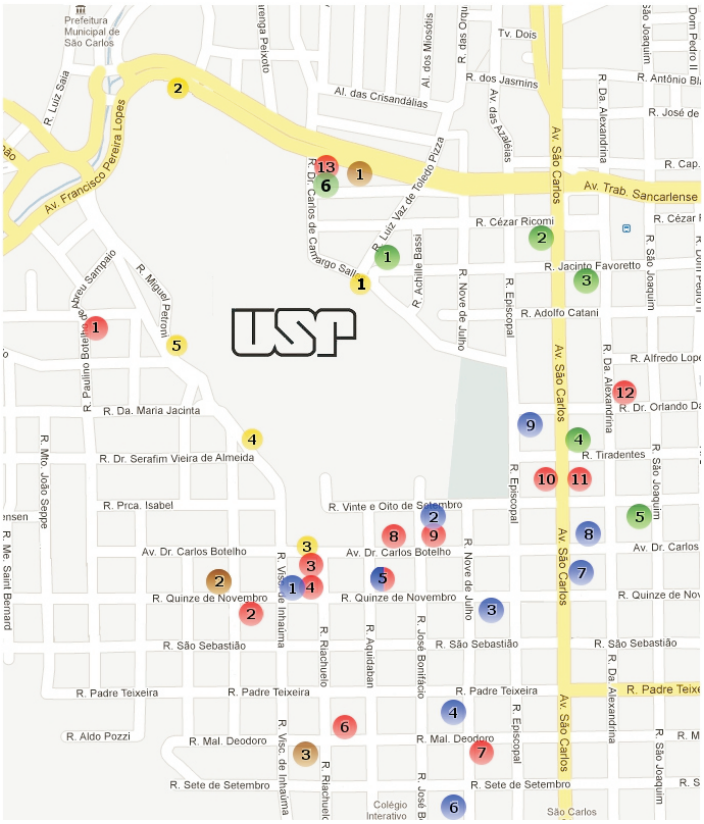
Entrances an Exits of the Campus
1. ICMC entrance
2. Main entrance
3. Observatório's entrance
4. Physics institute's entrance
5. Physics institute's exit

Hotels
1. Hotel Indaiá Residence
2. Parisi Hotel
3. Hotel Indaiá
4. Hotel Anacã
5. San Ciro Apart Hotel
6. Atlantic Inn Residence

Bars
1. Tio Joaquim
2. Boteco Santa Teresa
3. Vila Brasil Botequim
4. Donna Léo Choperia
5. Mosaico Bar e Restaurante
6. Cachaçaria Água Doce
7. Almanach Café e Restaurante
8. Pimentas Bar
9. Seo Gera

Restaurants
1. Restaurante La Salute (lunch only)
2. Restaurante La Villa
3. Casa do Café
4. Cantina Ciao Bello
5. Mosaico Bar e Restaurante
6. Sabor Oriental
7. Restaurante Mamãe Natureza (lunch only)

Pizzerias (dinner only)
1. Pizzaria Bom Pedaço
2. Pizzaria Amici
3. Pizzaria Don Raffaele



1.10 Annotations