WILHELM UND ELSE HERAEUS-STIFTUNG

577. WE-Heraeus-Seminar

Health, Energy & Extreme Events in a Changing Climate

6 – 9 December, 2014
at the Physikzentrum Bad Honnef (Germany)

Subject to alterations!

Introduction

The Wilhelm und Else Heraeus-Stiftung is a private foundation which supports research and education in science, especially in physics. A major activity is the organization of seminars. To German physicists the foundation is recognized as the most important private funding institution in their field. Some activities of the foundation are carried out in cooperation with the German Physical Society (Deutsche Physikalische Gesellschaft).

Aims and Scope of the 577. WE-Heraeus Seminar:

The World Health Organisation estimates that the warming and precipitation trends due to anthropogenic climate change of the past 30 years already claim over 150,000 lives annually. Projections indicate a further increase in many diseases and other health problems. Climate change affects health also through changes in infrastructure, especially energy supply and use, and the latter in turn drives climate change via greenhouse gas emissions and is affected by climate change via raising frequency and strength of extreme-events potentially causing black-outs, thus forming several feedback loops.
These complex relationships between health, energy, and extreme events in a changing climate form a prime example of a global complex dynamical system containing several network-like structures including infrastructure networks such as the regional and global power grids, functional networks such as the interaction network of climate dynamics, and socio-economic networks such as the contact network involved in the spreading of diseases. Modern theoretical physics and complex systems science have developed a number of cutting-edge modeling and data analysis methods to infer the individual components' interactions and mechanisms of such systems from data and model their emergent effects.

The goal of the 577. Wilhelm und Else Heraeus Seminar on Health, Energy & Extreme Events in a Changing Climate (HEEECC) is to bring together theoretical physicists and complex systems scientists with distinguished researchers from the named fields of application to (i) learn about the complex interactions between these global systems, (ii) provide young physicists with an opportunity to explore fields of application of great societal importance, (iii) discuss in an interdisciplinary way the potentials and perspectives of cutting-edge modeling and data analysis methods from theoretical physics for studying both the individual subsystems as well as the whole complex, (iv) show that the language of theoretical physics and complex systems science is a natural and fruitful framework for this transdisciplinary field, and (v) initiate new promising scientific studies and projects in this context. We expect a successful interchange that will lead to many synergies and concrete research opportunities.

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Introduction

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Registration:

Martina Albert (WE Heraeus Foundation)
at the Physikzentrum, reception office
Saturday (15 – 19 h) and Sunday morning

Door Codes:

C 2 5 7 7 For entering the Physikzentrum during the whole seminar

Internet Access:

WLAN SSID **PBH**

password **0 1 1 2 3 5 8 1 3**

encryption **WPA-2 personal**

Computer room in the ground floor:

no password needed

Program

Program

Saturday, 6th December 2014

15:00 – 19:00	Registration	
From 18:00	*BUFFET DINNER*	
19:00 – 19:15	Jobst Heitzig Jürgen Kurths Henry Abarbanel	**Welcome and opening**
19:15 – 20:30	Rainer Sauerborn	**Interrelations between energy supply, climate and health using the example of cooking with biomass**
20:30	Informal Reception with Poster Session 1	

Program

Sunday, 7th December 2014

08:00	*BREAKFAST*	

Extreme events and climate change

09:00 – 10:00	Leonard A. Smith	**Weather as a changing climate**
10:00 – 10:15	Anna Deluca	**Inference of statistical patterns in complex geosystems: Fitting power-law distributions**
10:15 – 10:30	Valerie Livina	**Tipping point analysis of atmospheric oxygen concentration**
10:30 – 11:00	*COFFEE BREAK*	
11:00 – 11:30	Petra Friederichs	**Meteorological extremes in a changing climate**
11:30 – 12:00	Revati Phalkey	**Prepare or react?: Aligning health systems to climate driven extreme weather events**
12:00 – 12:30	Valentin Aich	**Major floods - After the game is before the game**
12:30 – 12:40	**Conference Photo** (in the front of the Physikzentrum)	
12:40	*LUNCH*	

Program

Sunday, 7th December 2014

Energy supply

14:00 – 15:00	Ljupco Kocarev	**Plug-in vehicles and power grids: Economic costs, emissions benefits, and stability concerns**
15:00 – 15:15	Mehrnaz Anvari	**Synchronization in wind farm**
15:15 – 15:30	Benjamin Schäfer	**Decentral smart grid control**
15:30 – 16:00	*COFFEE BREAK*	
16:00 – 16:30	Katrin Schmietendorf	**Synchronization in electrical power grids described by Kuramoto-like models Models**
16:30 – 17:00	Michael Hiete	**Impacts of power outages on the healthcare sector**
17:00 – 17:30	Heidi Heinrichs	**Long-term impacts of electric mobility on the German energy system**
17:30 – 19:00	Free time	
19:00	*HERAEUS DINNER* *(cold & warm buffet, free beverages)*	

Program

Monday, 8th December 2014

08:00	*BREAKFAST*	

Health issues

09:00 – 10:00	Keynote talk by a representative of the World Health Organization	
10:00 – 10:15	Walter Dragoni	**Considerations on climate change, hydrological cycle and groundwater**
10:15 – 10:30	Yoshito Hirata	**Time series prediction for electric power systems: Confidence and credibility**
10:30 – 11:00	*COFFEE BREAK*	
11:00 – 11:30	Gordon McCord	**Malaria ecology and climate change**
11:30 – 12:00	Chris Barker	**Climate and West Nile virus risk in the United States**
12:00 – 12:30	Solomon Hsiang	**Recent advances in research on climate and violence**

12:30 ***Deadline for proposing ignite talks for the wrap-up session****

*Independently of your other contributions, you may apply for one of the six 5-minute slots on Tuesday morning reserved for so-called "ignite talks" (see http://igniteshow.com) on ideas for future research.

To prepare your slides for this format and rehearse, please make your 20 slides advance automatically every 15 sec., as described here:

Powerpoint: http://office.microsoft.com/en-au/powerpoint-help/create-a-self-running-presentation-HA010338348.aspx#Toc264467057

Acrobat Reader: http://grok.lsu.edu/Article.aspx?articleId=8764

12:40 *LUNCH*

Program

Monday, 8th December 2014

Cutting-edge modeling and data analysis methods

14:00 – 15:00	Anne-Ly Do	**Network approaches to complex systems**
15:00 – 15:15	Maria Caterina Bramati	**Modeling conflict insurgence in coastal areas: Climate change and human interactions in a fragile environment**
15:15 – 15:30	Valerio Lucarini	**Towards a general theory of extremes for observables of chaotic dynamical systems**
15:30 – 16:00	*COFFEE BREAK (with announcement of selected ignite talks for wrap-up session)*	
16:00 – 16:30	Aneta Koseska	**Nano-scale organization of proteins within assembling focal adhesions**
16:30 – 17:00	Holger Kantz	**Statistical analysis of extreme weather events in a changing climate**
17:00 – 17:30	Jonathan Donges	**Climate extremes and civil conflicts - a troubled relationship**
17:30 – 19:00	*Free time*	
19:00	*DINNER*	
20:00	Informal Reception with Poster Session 2	

Program

Tuesday, 9th December 2014

08:00	*BREAKFAST*	

Wrap-up Session

09:00 – 09:30	Ignite talks on possible research projects (see above, will be selected after deadline on Mon. noon 12:30 and announced Mon. afternoon 15:30)	
09:30 – 10:30	Discussion in small groups	
10:30 – 11:00	*COFFEE BREAK*	
11:00 – 11:30	Joshua S. Graff Zivin	**Key areas for future research on climate and health: A social sciences perspective**
11:30– 12:00	Henry D. I. Abarbanel	**Insights from the seminar from a climate scientist's viewpoint**
12:00 – 12:30	Jürgen Kurths	**Using complex systems science to study the interrelationship of energy systems, health, and climate**
12:30– 12:40	Jobst Heitzig Jürgen Kurths Henry Abarbanel	**Closing remarks and best poster prize**
12:40	*LUNCH*	

End of the seminar and departure

NO DINNER for participants leaving on Wednesday morning

Posters

Posters

Mauricio Cattaneo + Johannes Titz	**Graphical models for detecting statistical relationships between climatic variability and social conflicts**
Adrien Deliège	**ENSO forecast using a wavelet-based mode decomposition**
Timo Dewenter	**Large-deviation properties of resilience of power grids**
Cornelia Petrovic	**Spiking neural networks: Pattern formation and plasticity**
Thiago Prado	**Synchronization transitions on Hodgkin-Huxley-type neurons in clustered networks**
Martin Rohden	**Dynamical models of power grids: Identifying and curing weak links**
Paul Schultz	**Detours around basin stability in power networks**

More posters will follow and also a best poster prize will be awarded at the end of the seminar

Abstracts of Lectures

chronological order

Interrelations between energy supply, climate and health using the example of cooking with biomass

Rainer Sauerborn

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Weather as a Changing Climate

Leonard A Smith[1,2]

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The potential for significantly more information on future climates given cutting-edge modeling and data analysis methods from theoretical physics (and across the sciences) is challenged. Two primary hurdles are noted: (1) a lack of computational power to resolve physical processes of known importance (faster than real-time) [1,2,4] and as that hurdle is cleared (2) the inability to interpret the simulations with confidence in extrapolation without a strong assumption of structural stability [2,3].

Given imperfection in the mathematical structure of climate models and an irreducible diversity of relevant initial states and parameter values, climate model forecasts will be probabilistic even if the system is deterministic. Models can be useful for insight (understanding the dynamics of a system), even when they admit large (relative to the expected signal) zeroth-order systematic errors which limit their quantitative interpretation. If it is deemed unreasonable to extract future weather from these models, how might progress be made in preparing society for what the future holds[4]? How might the limits of (a given generation of) models to supply information be defined and determined? Where do these limits stand today [1]? And what pathway of model development is more-likely to extend these limits most effectively?

Exploring these questions suggests a less frantic race for model complexity. The relevance of "best available" models is in question when those models are believed not to have sufficient fidelity to prove adequate for purpose quantitatively. Risk management is not hampered by the appeal to reliable, low-resolution information closer to the basic science in this case, indeed it is strengthened. It is suggested that the simultaneous use of today's highest resolution weather models, seasonal models, climate models, and physical insight, might be of use in identifying the lead-times at which we can no longer foresee future weather impacts on a particular spatial scale.

References

[1] Suckling, E.B. and Smith, L.A. (2013) 'An evaluation of decadal probability forecasts', Journal of Climate, 26 (23): 9334.

[2] Smith, L.A. (2002) 'What might we learn from climate forecasts?', Proc. National Acad. Sci. USA, 4 (99): 2487.

[3] E. L. Thompson. (2013) Modelling North Atlantic storms in a changing climate. PhD thesis, Imperial College, London, 2013.

[4] W. Hazeleger et al (2014) "Tales of Future Weather", Nature CC, (to appear)

Inference of Statistical Patterns in Complex Geosystems: Fitting Power-law Distributions

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Power-law distributions contain precious information about a large variety of physical processes. Although there are sound theoretical grounds for these distributions, the empirical evidence giving support to power laws has been traditionally weak. Recently, Clauset et al. have proposed a systematic method to find over which range (if any) a certain distribution behaves as a power law. However, their method fails to recognise true (simulated) power-law tails in some instances, rejecting the power-law hypothesis. Moreover, the method does not perform well when it is extended to power-law distributions with an upper truncation. We present an alternative procedure, valid for truncated as well as for non-truncated power-law distributions, based in maximum likelihood estimation, the Kolmogorov-Smirnov goodness-of-fit test, and Monte Carlo simulations. We will test the performance of our method on several empirical data which were previously analysed with less systematic approaches.

References

1. Clauset, A., Shalizi, C. R., and Newman, M. E. J., Power-law distributions in empirical data, SIAM Rev., **51**, 661–703, (2009).
2. Deluca, A. and Corral, A.: Fitting and goodness-of-fit test of non-truncated and truncated power-law distributions, Acta Geophys., **61**, 1351–1394, (2013).

Tipping point analysis of atmospheric oxygen concentration

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We apply tipping point analysis to nine observational oxygen concentration records around the globe, analyse their dynamics and perform projections under possible future scenarios leading to oxygen deficiency in the atmosphere. The analysis is based on statistical physics framework with stochastic modelling, where we represent the observed data as a composition of deterministic and stochastic components estimated from the observed data using Bayesian and wavelet techniques.

References

[1] V.Livina and T.Lenton, Geophys. Res. Letters, 34, L03712 (2007)
[2] V.Livina et al, Climate of the Past, 6, 77-82 (2010)
[3] V.Livina et al, Climate Dynamics 37 (11-12), 2437-2453 (2011)
[4] V.Livina et al, Physica A 391 (3), 485-496 (2012)
[5] V.Livina et al, Physica A 392 (18), 3891-3902 (2013)
[6] V.Livina et al, Journal of Civil Structural Health Monitoring 4, 91-98 (2014)
[7] V.Livina et al, Chaos (in revision)

Meteorological Extremes in a Changing Climate

Petra Friederichs

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University of Bonn

Predictions on extremes in a changing climate heavily rely on climate projections using complex numerical models of the general circulation (GCM). While the GCM projections widely agree on tendencies with respect to large scale temperature changes, conclusions are much less reliable for other variables such as precipitation, and even worse for extreme events such as winter storms or tropical cyclones. Reliable predictions of extremal behavior of the atmosphere in a changing climate thus fundamentally call for a better theoretical understanding of how extremes are generated within the climate system, and what may cause fundamental change in extremes other than just a shift in the distributions of climate parameters.

The presentation will first give an overview of detection and attribution studies for extremes, and will then discuss aspects towards a more fundamental understanding of extremes in climate system.

Prepare or React?: Aligning Health Systems to Climate Driven Extreme Weather Events

Revati Phalkey

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Major floods - After the game is before the game

V. Aich[1] and F. Hattermann[1]

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Recent research on flooding shows that traditional concepts and methods to describe and explain extreme events are no longer adequate, for example the classification of record flooding as a "once-in-a-century" flood. The lecture gives an introduction to the subject and presents some of the highlights of current research.

Following a general overview on flooding worldwide, two case studies are discussed in more detail: flood development in Germany, where recent trends in flood generation can rather be attributed to climate change and variability and not to changes in land use and water management. For Germany, scenario projections show a strong increase in flood related damages.

The second case study is the Niger basin, where the occurrence of extensive flooding has increased drastically during the last two decades. However, in the face of the dominant water scarcity in the region “the other Sahelian hazard” only few studies on flooding have been conducted in this basin. First results in attribution show a major influence of climate variability but also a regional heterogeneous influence of land use changes.

Plug-in vehicles and power grids: economic costs, emissions benefits, and stability concerns

Ljupco Kocarev

Macedonian Academy of Sciences and Arts

During the last century, two large and separate systems for energy conversion and management were developed: the electric utility system and the light vehicle fleet. The electric power grid and light vehicle fleet are exceptionally complementary as systems for converting and managing energy and power. The electric utility system has essentially no storage, and therefore, energy/power generation and transmission must be continuously managed to match fluctuating customer load. The light vehicle fleet, however, inherently has storage, since both the vehicle and its fuel must be mobile. The high capital cost of large generators motivates high use (average 57% capacity factor). On the other hand, personal vehicles are cheap per unit of power and are utilized only 4% of the time for transportation, making them potentially available the remaining 96% of time for a secondary function.

Recently there has been increased concern on environmental and climate change issues, rising energy costs, and energy security and fossil energy reserves, which, in turn, has triggered worldwide interest for plug-in electric and hybrid vehicles (PEVs). Plug-in vehicles can behave either as loads, which is usually referred as grid-to-vehicle (G2V) connection, or as a distributed energy and power resource in a concept known as vehicle-to-grid (V2G) connection. In this talk I will review economic costs, emissions benefits, and distribution/transmission system impacts of PEVs. In particular methods for improving power grid efficiency, stability, and reliability by considering V2G concept will be suggested.

Synchronization in wind farm

Mehrnaz Anvari[1] **and Joachim Peinke**[2]

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The renewable sources and their share in electricity production have been increased constantly in recent years. The renewable sources, such as wind energy, are influenced by atmospheric turbulence, which causes frequent extreme fluctuations in power output of wind turbines. Such events can influence the stability of power grids and especially may cause frequency variations in very short-term scales. Therefore, understanding and characterization of stochastic behavior of output has great scientific and practical importance. Our aim is to show that such extreme events are intelligible from interactions between wind turbines in different time intervals. For this purpose, we consider the synchronization in wind farm. Therefore, synchronization, i.e. constant phase difference between turbines in specific time intervals, can explain the origin of extreme events in this complex system. This means that higher synchronized turbines will produce higher intermittent power output.

References

[1] Mehrnaz Anvari et al. Eur. Phys. J. Special Topics 223, 2637-2644 (2014)

Decentral Smart Grid Control

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Stable operation of complex flow and transportation networks requires balanced supply and demand. For the operation of electric power grids – due to their increasing fraction of renewable energy sources – a pressing challenge is to fit the fluctuations in decentralized supply to the distributed and temporally varying demands. To achieve this goal, common *smart grid* concepts suggest to collect consumer demand data, centrally evaluate them given current supply and send price information back to customers for them to decide about usage. Besides restrictions regarding cyber security, privacy protection and large required investments, it remains unclear how such central smart grid options guarantee overall stability.

Here we propose a Decentral Smart Grid Control, where the price is directly linked to the local grid frequency at each customer. The grid frequency provides all necessary information about the current power balance such that it is su□cient to match supply and demand without the need for a centralized IT infrastructure. We analyze the performance and the dynamical stability of the power grid with such a control system. Our results suggest that the proposed Decentral Smart Grid Control is feasible independent of e□ective measurement delays, if frequencies are averaged over su□ciently large time intervals.

References

[1] B. Schäfer, M. Matthiae, M. Timme and D. Witthaut, *Decentral Smart Grid Control*, New Journal of Physics, 2014 (submitted, reference: NJP-101664)

Synchronization in Electrical Power Grids Described by Kuramoto-like Models

<u>K. Schmietendorf</u>[1], J. Peinke[1], and O. Kamps[2]

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Synchronization plays a crucial role in electrical power grid operation. A few years ago, a relationship between power system dynamics and synchronization phenomena in nonlinear dynamics was uncovered [1], as the dynamical equations of a reduced power grid model were shown to correspond to a modified version of the Kuramoto model (KM). The KM is a canonical model from the field of nonlinear dynamics of coupled oscillators, that describes a population of oscillators displaying a phase transition from incoherence to (partially) synchronized states at a critical coupling strength value [2].
Within the resultant approach, the power grid is represented by a network of synchronous machines as prototypes of units converting mechanical power into electrical power and vice versa. The corresponding coupled dynamical equations are modified second-order versions of the original KM, which can optionally be completed e. g. by noise terms mimicking feed-in or load fluctuations, specific network topologies featuring power grid characteristics, or more extensive dynamical models including voltage dynamics and angle-voltage stability interplay.
The approach aims to address basic questions of power system stability and topology, in particular those arising from progressive grid decentralization and feed-in fluctuations by renewables in the course of the energy transition. During the last years, a couple of studies based on this approach started to investigate different aspects of power system modeling, stability and the interplay between grid stability and topology [3,4,5,6,7].
In this talk, we present the essential KM modifications with regard to the scope of power systems, we discuss potentialities and advisability of further model extensions and the synthetic generation of more realistic grid topologies.

References

[1] G. Filatrella et al., Eur. Phys. J. B **61**, 485-491 (2008)
[2] Strogatz, Physica D **143**, 1-20 (2000)
[3] M. Rohden et al., Phys. Rev. Lett. **109** , 064101 (2012)
[4] F. Dörfler and F. Bullo, American Control Conference, 930-937 (2010)
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Impacts of power outages on the healthcare sector

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Critical infrastructures (CI) such as electricity and water supply, transport or the healthcare sector show complex network structures. CI can be severely damaged, destroyed or disrupted by technical failure, human failure, natural disasters, criminal activity or acts of terrorism. Strong interdependencies between the CI provide the potential for cascading failure across the mutually dependent systems in the event of system failures and network breakdowns. As most CI depend on a secured electricity supply, power outages take an exceptional role among CI failures. In the health care sector, for example, power outages cause direct impacts such as the breakdown of medical devices but also of building services such as elevators and cooling systems as well as a reduced availability of pharmaceuticals [1]. Indirect impacts result from other CI breakdown such as a disruption of water, heat and food supply. The event underlying a power outage may also increase the number of patients needing healthcare putting an additional strain on the system. A differentiated view on the different parts of the healthcare system is necessary. Whereas in Germany hospitals are in general well prepared with respect to shorter electricity outages due to obligatory emergency power units, outpatient medical care, nursing homes and in particular home-care nursing are early affected by power supply disruptions. The type and severity of the impacts strongly depend on the duration of the power outage [2].

References

[1] M. Hiete, M. Merz, Ch. Trinks, W. Grambs, T. Thiede, Krisenhandbuch Stromausfall Baden Württemberg, Innenministerium Baden-Württemberg, Stuttgart, Bundesamt für Bevölkerungsschutz und Katastrophenhilfe (BBK) (2010)

[2] M. Hiete, M. Merz, F. Schultmann, Scenario-based impact analysis of a power outage on healthcare facilities in Germany, International Journal of Disaster Resilience in the Built Environment, **2**, 222-244 (2011)

Long-term impacts of electric mobility on the German energy system

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The emerging market for electric vehicles gives rise to an additional electricity demand. This new electricity demand will certainly affect the energy system. It seems very likely that those impacts will correlate with the market share of electric vehicles. However, to quantify those impacts for decision makers in the energy system a model-based approach is needed. This approach has to cover a long-term time horizon due to the typical rate of change in energy systems as well as the restrained market development of electric mobility. Therefore I apply a bottom-up electricity system model across two regional scales (Europe and Germany) with a time horizon until 2030 [1]. This model is based on a linear optimization which minimizes the discounted costs of the electricity system. With this model approach different development paths of electric mobility are analyzed. One major result turns out to be that electric vehicles can be integrated in the energy system without increasing the system costs. While a load control is needed to accomplish that, this load control does not have to incorporate a reinjection of electricity from the battery into the grid. In addition, the power plant portfolio is only moderately affected by electric vehicles. In contrast the European electricity exchange as well as the development of renewable energy sources gain in importance over the next decades and can superpose the effects of electric vehicles. Another important side effect of electric vehicles is their substantial contribution to decreasing the CO_2 intensity of our transport sector. Taken together, electric mobility can be an integral part of the transformation of energy systems towards more sustainable ones.

References

[1] H. U. Heinrichs, Analyse der langfristigen Auswirkungen von Elektromobilität auf das deutsche Energiesystem im europäischen Energieverbund, Dissertation, Karlsruher Institut für Technologie (KIT), in Produktion und Energie, Band 5, KIT Scientific Publishing, Karlsruhe (2013).

CONSIDERATIONS ON CLIMATE CHANGE, HYDROLOGICAL CYCLE AND GROUNDWATER

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No matter how much the present warming of the atmosphere is due to anthropogenic or to natural causes, the point is that most studies indicate that the atmosphere will keep warming [1], [2]. This will bring numerous problems, including alterations to the hydrological cycle, which is already heavily influenced both by climatic change and by anthropogenic activity, the latter being, at the moment, more important than the first [3]. In general it is expected that regions at present having water scarcity will get less rain. Considering only the issue "scarcity of water", and neglecting other related water issues like floods and sea level rising, it is clear that the situation is dramatic. Indeed, even in the case that the warming stops, the present rate of increasing population and water demand imply that a water crisis is unavoidable. Actually, the world is already *now* in a water crisis: just for instance, at present about 2.5 billion people do not have access to clean water and adequate sanitation, with obvious consequences on *present* death rates [4]. Furthermore, during the last century millions of people were killed by drought [3], [4]. Such a situation requires immediate actions, which cannot be restricted to try to control the warming, but should include political and social agreements. Groundwater will be vital to alleviate some of the worst drought situations, as it is today. However, groundwater can be an efficient tool only if properly managed and if reliable future climatic scenarios are available, so that appropriate management plans and concrete actions can be taken at the regional level as soon as possible. The main problem with the building of future scenarios of the water yield of groundwater systems is the uncertainty about future rainfall: the present Climate Models are unable to give a narrow range of scenarios. Indeed, the warming and its impacts will depend, at least in part, on unpredictable future anthropic activity, such as actions taken to reduce CO_2 emissions, changing of agricultural practice, population etc.. This, coupled to the approximations of the climatic models and to the input data they use, indicates that future scenarios will continue to be rather uncertain. In this framework, the talk considers the main areas in which hydrogeological research should focus to mitigate the water crisis.

References

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Time series prediction for electric power systems: confidence and credibility

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Time series prediction is useful for electric power systems because it can forecast natural fluctuations of renewable energy outputs as well as electricity demands. In this presentation, we propose some methods [1-4] of time series prediction, extensions of Kwasniok and Smith [5], that can run online, span multi-steps ahead, and show its confidence intervals and credibility given multivariate time series data. The proposed methods of time series predictions can be combined with control and/or optimization so that we can keep the stability of electric power systems even if we introduce more renewable energy into the grids.

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Malaria Ecology and Climate Change

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Malaria has afflicted human society for over 2 million years , and remains one of the great killer diseases today. The disease is the fourth leading cause of death for children under five in low income countries (after neonatal disorders, diarrhea, and pneumonia) and is responsible for at least one in every five child deaths in sub-Saharan Africa. For decades, it killed up to 3 million people a year, though in recent years scale up of anti-malaria efforts in Africa has brought deaths to below 1 million. Malaria is highly conditioned by ecology, because of which climate change is likely to change the local dynamics of the disease through changes in ambient temperature and precipitation. To assess the potential implications of climate change for the malaria burden, this paper employs a Malaria Ecology Index from the epidemiology literature, relates it to malaria incidence and mortality using 20th century data, and then draws implications for 2050 and 2099 by extrapolating the index using general circulation models (GCMs) predictions of temperature and precipitation. It then cites best available evidence from the literature to estimate the economic and social costs of climate change via changes in the ecology of malaria.

References

Climate and West Nile virus risk in the United States

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West Nile virus (WNV) is a mosquitoborne pathogen that has emerged as a significant cause of human disease in the U.S. and Europe over the last two decades. The virus is transmitted in complex, enzootic transmission cycles between several species of mosquitoes and birds, and transmission spills over to cause human disease during periods of intense amplification. Climate is the most important exogenous driver of the system, with effects over a range of spatio-temporal scales that result in strong heterogeneities in human health risks. In this presentation, I will review evidence for the mechanisms by which climate impacts WNV transmission and discuss our emerging body of research in California on the changes in population-level risk in response to key climatic drivers such as temperature and drought.

Recent advances in research on climate and violence

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A rapidly growing body of empirical, quantitative research examines whether rates of human conflict can be systematically altered by climatic changes. We discuss recent advances in this field, including Bayesian meta-analyses of the effect of temperature and rainfall on current and future large-scale conflicts, the impact of climate variables on gang violence and suicides in Mexico, and probabilistic projections of personal violence and property crime in the United States under RCP scenarios. Criticisms of this research field will also be explained and addressed.

Network approaches to Complex Systems

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Among the biggest obstacles for the prediction and control of social and environmental systems are indirect cause and effect relations: perturbing the system here has effects over there because the individual parts are interdependent.

Network descriptions provide an ideal framework to capture these interdependencies, and are, as a result, widely used in complex systems science, be it in modeling or in data analysis.

In models, the nodes of a network usually represent individual dynamical units, while the links between nodes represent inter-unit interactions. Network models can often predict system-level dynamics much more accurately than corresponding mean-field models [1]. Moreover, they can provide a key to control by revealing dynamical implications of structural properties of the interaction net [2].

In data analysis, the nodes of a network usually represent individual data points. The links between them are defined by a metric, which is chosen depending on the particular question under consideration. Analyzing the structure of such networks helps to determine dynamically relevant higher-order statistical properties of time series [3] or to define clusters in high-dimensional data sets [4].

This talk aims to give a short overview over different ways, in which networks are used in complex systems science. Moreover, it shall review some of the powerful tools the network framework provides.

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Modeling conflict insurgence in coastal areas: climate change and human interactions in a fragile environment

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Competing interests in land-use change trigger conflicts between institutional bodies, local residents, land developers and environmental NGOs. This is even more dramatic in fragile areas such as coastal regions, which are characterized by intense human and environmental activity.

This results in a conflicting coastal environment characterized by minimal urban planning, sprawl, pollution due to industrial expansion, climate change and land use competition between residential and recreational development and cultural heritage conservation interests.

The econometric analysis carried out in this study has the main objective of linking human activities in coastal metropolitan areas to land-use management and climate change. To this aim, a statistical model is estimated employing the case study data and used for simulating conflict scenarios according to changes in the environmental, demographic and socio-economic dimensions. Not only are environmental risks and sustainability taken into account in the model equations, but variables related to human mobility, employment, land for housing, agriculture and land in pristine state are also considered. Uniquely, simultaneous equation modeling is used to study how both human and environmental pressures combine in driving conflicts. The empirical results show that environmental sustainability and housing land use are key determinants in mitigating conflicts in areas experiencing demographic, economic and climatic pressures.

Towards a General Theory of Extremes for Observables of Chaotic Dynamical Systems

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In this paper we provide a connection between the geometrical properties of a chaotic dynamical system and the distribution of extreme values. We show that the extremes of so-called physical observables are distributed according to the classical generalised Pareto distribution and derive explicit expressions for the scaling and the shape parameter. In particular, we derive that the shape parameter does not depend on the chosen observables, but only on the partial dimensions of the invariant measure on the stable, unstable, and neutral manifolds. The shape parameter is negative and is close to zero when high-dimensional systems are considered. This result agrees with what was derived recently using the generalized extreme value approach. Combining the results obtained using such physical observables and the properties of the extremes of distance observables, it is possible to derive estimates of the partial dimensions of the attractor along the stable and the unstable directions of the flow. Moreover, by writing the shape parameter in terms of moments of the extremes of the considered observable and by using linear response theory, we relate the sensitivity to perturbations of the shape parameter to the sensitivity of the moments, of the partial dimensions, and of the Kaplan-Yorke dimension of the attractor. Preliminary numerical investigations provide encouraging results on the applicability of the theory presented here. The results presented here do not apply for all combinations of Axiom A systems and observables, but the breakdown seems to be related to very special geometrical configurations.

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Nano-scale organization of proteins within assembling focal adhesions

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Cellular movement is a highly dynamic process regulated by large protein accumulations known as focal adhesions (FAs). The FAs are functional units composed of multiple proteins that serve as anchors of the cell, and integrate the extracellular cues in order to mediate signaling events crucial for migration. To investigate whether a specific nano-structure of focal adhesions maintains their adhesive function, the spatial organization of the major FA components was quantified using photo-activated localization microscopy (PALM). We present here a novel graph theory approach to analyze super-resolution microscopy data, independent of the protein expression levels. In particular, by quantifying the spatial organization of the investigated proteins using network measures, we found that the adhesion sites consisted of areas with different protein densities, culminating in several high-density areas which we term as dense domains. The analysis also captured the transition points at which focal adhesions are formed. The results suggest that the dense domains are formed in early stages of focal adhesion assembly, and the formation process is centered around them, since they most probably serve as signaling centers. The complexity of adhesion assembly therefore suggests a highly-organized formation mechanism, ensuring functional anchoring and sensing of the mature focal adhesions.

Statistical analysis of extreme weather events in a changing climate

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It is often claimed and from the perspective of atmospheric physics also plausible, that extreme weather conditions might occur more frequently in a warmer climate. We discuss statistical approaches to the characterization of the intensity and the frequency of extreme weather conditions on moving time windows. We present analysis results from the analysis of instrumental weather data from the past 100 years in central Europe. Temperature extremes, precipitation extremes, and wind speed extremes have different properties, whereas some very distructive extremes such as hailstorms have not been sufficiently recorded. Based on these data, we are unable to proof the existence of a systematic trend in extreme weather in Germany, although there are signatures which are consistent with a trend towards warming.

Climate extremes and civil conflicts - a troubled relationship

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The roots of civil conflicts are multi-dimensional and context specific. While in individual cases climate related events may contribute to civil conflict outbreak, it is unclear wether this is a statistically robust global phenomenon. Here we performed a coincidence analysis of civil conflicts and extreme events for the 1980-2012 period. We report no significant coincidences of extreme events and civil conflicts on the global scale. However, coincidence is significant for Asian (and African) countries alone, where about 20% (6%) of all conflict outbreaks for countries in this group coincide with an extreme event causing a damage of at least 0.01% of annual national GDP. We furthermore find evidence for an increased long-term risk of conflict outbreak up to 10 month after a severe extreme event for African and least-developed countries.

Our results indicate that climatic extremes contribute to civil conflict risk in regions that are particularly vulnerable and conflict-prone, although no causal attribution is possible based on our analysis. Thus, while climatic extremes may not directly cause civil conflict outbreak, they could contribute to increased societal pressure and thus increased conflict outbreak risk. Given the still high number of conflict prone regions globally and the observed and projected increase in severe climatic extremes due to anthropogenic climate change, this interlink, although not dominant, represents a serious risk to societies globally.

Abstracts of Posters

(in alphabetical order)

Graphical models for detecting statistical relationships between climatic variability and social conflicts

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Recently the debate whether climate change leads to social conflicts has been fueled by several publications[1-6]. Often disagreement results from methodological issues. In our opinion one problem lies in dealing with time series: One has to consider autocorrelation and the time lag of effects. We apply a new statistical method developed by Runge et al.[7-9] to the context of climate change and social conflicts. This method is based on graphical models and is probably better suited to answer the question whether there is a relationship between climate change and social conflicts than classical statistics. Specifically the method should lead to more accurate estimates of effect sizes and time lags of effects. Furthermore, potential causal pathways between climate change and social conflicts can be tested. We reanalyze crime data from Jacob et al.[10] to explore whether this new method can contribute to the discussion of climate change and social conflicts.

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ENSO forecast using a wavelet-based mode decomposition

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We introduce a new method for forecasting major El Niño/ La Niña events based on a wavelet mode decomposition. This methodology allows us to approximate the ENSO time series with a superposition of three periodic signals corresponding to periods of about 31, 41 and 61 months respectively with time-varying amplitudes. This pseudo-periodic approximation is then extrapolated to give several years predictions. While this last one only resolves the large variations in the ENSO time series, three years hindcast, as retroactive prediction, allows to recover most of the El Niño/ La Niña events of the last 60 years.

Large-deviation properties of resilience of power grids

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We study numerically the fixed points of a Kuramoto-like model [1,2], which is used to describe the dynamical behavior of coupled synchronous machines on different mean-field and spatial random graph ensembles. For comparison, we also consider the British transmission power grid. A synchronous machine is represented by a node in the graph, whereas edges stand for transmission lines. A machine can either produce (generator) or consume (motor) power. Here, we investigate the resilience of such networks against transmission line failures, i.e., removal of edges. By using a large-deviation approach [3] we obtain the low-probability tails of the distribution of resilience, which allows us to gain insight in the topology of extreme robust and extreme vulnerable networks. We try to find design principles for very resilient networks by investigating two observables based on the network structure: the diameter of the network and the power sign ratio.

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Spiking Neural Networks: Pattern Formation and Plasticity

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We will present recent studies on spiking neural networks populated by pulse-coupled oscillators. The underlying single neuron model has been introduced by H. Haken as the lighthouse model [1]. It is a model that falls between spiking neuron models and firing rate descriptions [1,4] and thus may combine the "best of both worlds". In the limit of very slow synaptic interactions, it can be reduced to the classical Wilson-Cowan and Amari type firing rate models [2,3,4]; for fast synaptic dynamics, it shows some of the complex properties of real spiking neural networks. Here, we present two aspects of our work. On the one hand, we show some findings on pattern formation in these kind of spiking networks. We concentrate on the formation of spatially localized states of persistent high neuronal activity – often referred to as "bumps" – which have been associated with working memory, i.e., the ability of temporary storage of information over the time-scale of a few seconds. On the other hand, we discuss the influence of spike timing dependent plasticity (STDP) [5], which is considered to be linked to learning and evolution effects.

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Synchronization transitions on Hodgkin-Huxley-type neurons in clustered networks.

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We considered a clustered network of bursting neurons described by the Huber-Braun model [1]. In the upper level of the network we used the connectivity matrix of the cat cerebral cortex network [2], and in the lower level each cortex area (or cluster) is modelled as a small-world network. There are two different coupling strengths related to inter [3] and intra-cluster dynamics. Each bursting cycle is composed of a quiescent period followed by a rapid chaotic sequence of spikes, and we defined a geometric phase which enables us to investigate the onset of synchronized bursting, as the state in which the neuron start bursting at the same time, whereas their spikes may remain uncorrelated. The bursting synchronization of a clustered network has been investigated using order parameter and the average field of the network, in order to identify regimes in which each cluster may display synchronized behavior, whereas the overall network does not. We show some synchronization transitions from small variations in the couplings. Our main finding is that we typically observe in the clustered network not a complete phase synchronized regime, but instead a complex pattern of partial phase synchronization, in which different cortical areas may be internally synchronized at distinct phase values, hence they are not externally synchronized.

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Dynamical models of power grids: Identifying and curing weak links

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The inclusion of more and more renewable energy sources into modern power grids leads inevitably to drastic changes of the topology of power grids[1]. Nevertheless it is not known to date what an optimal network topology for power transport and robustness could be. Here we use the recently introduced novel criteria of redundant capacities to identify weak links in power grids. We propose new strategies to cure these critical links and show their advantages over possible alternatives. Our results may serve as a step towards optimal network topologies in real-world power grids.

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Detours around basin stability in power networks

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To analyse the relationship between stability against (large) perturbations and topological properties of a power transmission grid, we employ a statistical analysis of a large ensemble of synthetic power grids [2], looking for significant statistical relationships between the single-node basin stability measure [3] and classical as well as tailor-made weighted network characteristics. Especially, we propose a strategy to directly estimate a power grid's stability - even on short time scales - to omit the need of costly simulations. The focus lies on the identification of grid nodes that appear critical for stability, using for example a version of Newman's current flow betweenness [4]. This method enables us to predict poor values of single-node basin stability for a large extent of the nodes, offering a node-wise stability estimation at low computational cost.

Further, we analyse the particular function of certain network motifs to promote or degrade the stability of the system. Here we uncover the impact of so-called detour motifs on the appearance of nodes with a poor stability score and discuss implications for power grid design.

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Notes