PSC Summer School 2017
Understanding Risks and Resilience in Plant Systems

May 29 – June 2, 2017, Einsiedeln

Organization:
Melanie Paschke, PhD, Zurich-Basel Plant Science Center (PSC)
Luisa Last, PhD (PSC)
Carole Rapo, PhD (PSC)

For any organisational questions regarding the summer school, please don't hesitate to contact Carole: carole.rapo@usys.ethz.ch

1 Content

With humankind leaving the planetary boundaries and the safe operating space systemic risks have become frequent: our climate system is approaching a new state, biodiversity losses are endangering ecosystem services, pests are globally spreading and threatening our food security. Complex systems are characterized by inter-connections between species, agents, individuals and multiple stable states whereas regime shifts can be triggered after periods of stability towards non-linear behavior, i.e. path dependance, sustained oscillation, contagion and synchrony. Systemic risks arise from the potential for unpredictable changes of the system to another state. While we cannot predict when tipping points will arise, we can stabilize the system in the current equilibrium through increasing or restoring resilience and diversity.

We will discuss modeling of variable to be considered in complex systems and their threshold effects as well as some interaction at the socio-ecological interface, the so-called complex adaptive systems. The range of topics spans from plant sciences to economy with a focus on modeling from the mathematical background to complex ecological models. Research and case studies are from climate change, ecosystem research, epidemiology, agriculture and economics with strong links to plant sciences.

Invited speakers will make presentations on the topic of their research, give insight into their research field, conduct interactive workshops and take part in plenary discussions. They will act as mentors in the case studies group work. The outcome of the group work will be available in the proceedings.

Since 2010 the Zurich-Basel Plant Science Center is organizing summer schools on the big challenges of the 21st century – food security, tackling with wicked problems, transitions in agriculture, resilience in ecosystems - to name just a few.

2 Didactical concept

Learning objectives

Participants will:

- Understand features of complex systems with non-linear behavior and non-linear feedback.
- Understand key features for stabilizing systems: diversity and resilience.
- Learn about fast and slow variables and their contribution to the modeling of systemic risks.
- Learn about systemic risks arising from socio-ecological interactions: complex adaptive systems.

Number of Participants: 24

Number of ECTS: 2

Individual Performance and Assessment:

- Session Summary
- Group Work on Best Practice
- Presentation of group work
- Best Practice report which will be published in proceedings
- Evaluating trends and concepts of a sustainable agriculture production

Organization of Student Work

Before summer school:

- Application includes description of motivation and background.
- Preparatory reading: Students will need to read the assigned literature before the summer school.

During summer school:

- Sessions are composed as lectures, discussions and case study work.
- Group work will be done on case studies, individual working time on this group work is expected to be about 10h
- Presentation and integration: at the end of each afternoon, 1 group presents their experiences and insights. Open Format.
- Case study presentation on day 5. 30 min per group.

After summer school:

- Groups hand in a finalized version of their case study for inclusion in the proceedings.

Group Enrolment

- Based on preferred best practice (enrolment at learning platform)

3 Sessions

<u>Monday 29.05.17</u> Session 1: Systemic Risks: Overview

- **Welcome:** Dr. Melanie Paschke, PSC,
  <u>Title:</u> Introduction to the summer school

- **Presentation 1:** Dr. Melanie Paschke, PSC,
  <u>Title:</u> Principles for risk management

- **Presentation 2:** Dr. Pia-Johanna Schweizer, Institute for Advanced Sustainability Studies (IASS), Berlin, GE
  <u>Title</u>: Governance of systemic risks: Challenges for decision and policy making

Examples for systemic risks in the climate system

- **Presentation 3:** [Case study related]
  Dr. Andrea Downing, Stockholm Resilience Center, Sweden
  <u>Title:</u> Resilience and the resilience of socio-ecological systems

<u>Tuesday 30.05.17</u> Session 2: Modeling of variable to be considered in complex systems

Workshop 1: Prof. Mary Lou Zeeman, Bowdoin College, Brunswick, ME, US
<u>Title:</u> Mathematics of slow variable modeling: Tipping points and resilience

- **Workshop 2:** [Case study related]
  Adam Clark, University of Minnesota, US
  <u>Title:</u> Empirical Dynamic Modeling: Time series analysis for predicting future dynamics and testing causal links

<u>Wednesday 31.05.17</u> Session 3: Examples for systemic risks from plant epidemology and from plant ecology

- **Presentation 4:** [Case study related]
  Prof. Christopher Gilligan, University of Cambridge, UK
  <u>Title:</u> Emerging pathogens that threaten global food security

- **Workshop 3:** [Case study related]
  Prof. Christopher Gilligan, University of Cambridge, UK
  <u>Title:</u> Introduction to epidemiological modelling to inform plant disease management in agricultural and natural environments using Webidemics

- **Presentation 5:** [Case study related]
  Dr. Christophe Randin, University of Lausanne, CH
  <u>Title:</u> Persistence without moving under climate change

<u>Thursday 01.06.17</u> Session 4: Examples for systemic risks from economy

- **Presentation 6:** [Case study related]
  Prof. Robert Finger, ETH Zurich, CH
  <u>Title:</u> The role of risk and risk management for agricultural production

- **Presentation 7:** [Case study related]
  Dr. Matthew Barbour, University of Zurich, Department of Evolutionary Biology and Environmental Studies, CH
  <u>Title:</u> Genetic specificity of a plant-insect food web: Implications for linking genetic variation to network structure

4 Speakers (Biography, Description Talk & Workshop Content)

Monday 29.05.17

Dr. Melanie Paschke, Zurich-Basel Plant Science Center (PSC) in Zurich (CH)
Melanie Paschke is director for education at the Zurich-Basel Plant Science Center. She has a PhD in ecology and environmental sciences, has led and supervised the development of higher education programs there for more than ten years. She has a record of accomplishment as educator in several areas of academic professional conduct and transferable skill development with more than 30 training workshops, summer schools and seminars taught in previous years. Her focus is on ethics in the plant sciences and on research integrity.

Talk: Principles for risk management
A prominent principle that has been implemented to control systemic risks is the precautionary principle. Ongoing controversy about this principle will be illustrated. The overview will introduce you to the risk/ethics boundary and will explore ethical principles can help to reduce systemic risks.

Literature:
Sunstein, CR (2003) Beyond the Precautionary Principle. University of Pennsylvania Law Review, Vol. 151, No. 3 (Jan., 2003), pp. 1003-1058.

Dr. Pia-Johanna Schweizer, Institute for Advanced Sustainability Studies (IASS) in Potsdam (DE)
Pia-Johanna Schweizer is a project leader at the IASS. She holds a Ph.D. in Sociology from the University of Stuttgart where she was a senior researcher at the Stuttgart Research Center for Interdisciplinary Risk and Innovation Studies (ZIRIUS). Pia-Johanna Schweizer's research interests include stakeholder involvement and public participation, energy policy, risk governance and climate change governance. She received the Chauncey Starr Distinguished Young Risk Analyst Award from the Society for Risk Analysis in 2015.

Talk: Governance of systemic risks: Challenges for decision and policy making
Modern pluralistic societies face many challenges. Human life and the environment are especially challenged by large, systemic risks such as climate change, epidemics, financial breakdown and social inequality. Systemic risks can be characterized by four major properties. First, systemic risks are characterized by scientific complexity and epistemological uncertainty. Science cannot identify exact hazard probabilities. Instead, science utilizes models of scenario building to sketch out the stochastic nature of systemic risks. Second, systemic risks are transboundary and global in nature. They transgress nation states and call for international cooperation. Third, although systemic risks originate in one subsystem of society or the environment, the ripple effects of these risks affect all social subsystems, such as the economy, politics, and civil society. Fourth, future technological and societal developments are non-linear. Science struggles to identify tipping points of technological and social trends.

Nevertheless, political decision makers call for scientific advice to govern our emergent future. Systemic risks pose great challenges to governance because they are highly interconnected and complex, stochastic and non-linear in their cause-effect relationships. Furthermore, they are often underestimated in public policy arenas and public perception. Consequentially, systemic risks demand cooperative management efforts of experts, corporate sector, civil society and regulators. Effective risk management must strike a balance between efficiency and resilience, and the solutions devised must be fair to all people affected. Effective, inclusive governance strategies are necessary to pursue the goals of resilience and sustainable development.

Another complicating factor is the fact that we have to deal with the challenges of complexity, uncertainty and ambiguity when governing systemic risks. These challenges are inherent to the risk itself and limit our understanding - analysis and assessment - of risk. Furthermore, complexity, uncertainty and ambiguity influence approaches towards risk management and consequentially risk management options.

While a lot of data is available, there is still a lack of structures and processes that allow meaningful integration towards decision-making and policy processes. The meta-theoretical concept of inclusive governance therefore serves as a guiding framework to tackle the challenges of systemic risks, because it aims to merge all relevant types of knowledge – both within and outside science – in order to jointly among stakeholders find solutions that help us initiate, support and scientifically accompany the transformation to sustainable development.

The lecture will pay special attention to the ways in which complexity, uncertainty and ambiguity pose challenges to governance of systemic risks.

Literature:

International Risk Governance Council (IRGC) (2005). Risk Governance. Towards an Integrative Approach. White Paper. Reprinted 2006.

OECD 2003. Emerging Systemic Risks. Final Report to the OECD Futures Project. Paris. OECD.

Renn, O. (2016): Systemic Risks: The New Kid on the Block, Environment: Science and Policy for Sustainable Development, 58:2 (2016), pp. 26-36, doi:10.1080/00139157.2016.1134019

Dr. Andrea Downing, Stockholm Resilience Centre, SWE

Andrea Downing is a researcher at the Stockholm Resilience Centre of Stockholm University, working in the GRAID project (Guidance for Resilience in the Anthropocene: Investments for Development). Her main research focus is to translate resilience science for sustainable development. Andrea holds a PhD in Environmental Sciences from Wageningen University (Netherlands). The subject of her doctoral research was the complex socio-ecological system that surrounds Lake Victoria's fisheries (East Africa), identifying different drivers of change and sources and threats to the system's resilience. This research, along with subsequent postdoctoral research on phytoplankton in the Baltic Sea and work on the Planetary Boundaries project – analysing dynamics that underlie essential Earth system processes as well as interactions within and between environmental and social processes – has broadened and strengthened Andrea's expertise in the field of socio-ecological systems' resilience. Andrea has a background in resilience thinking, socio-ecological systems, ecological modelling, limnology and marine biology, theoretical ecology and time series analysis.
Talk: Resilience and the Resilience of Socio-Ecological Systems

Talk: Resilience and the Resilience of Socio-Ecological Systems

Resilience is a term used in many different fields, sometimes supported by a definition, oftentimes not. We first look into some of the more basic definitions of resilience, to see how they shape resilience as a tool with which to analyse two-dimensional systems and discuss what assumptions they carry. We then describe properties of socio-ecological systems (SES) – as examples of complex, multidimensional adaptive systems – and explore what resilience thinking can bring to their analysis. We look into trade-offs and opportunities that the analysis of SES can reveal, and discuss risk and management implications.

Literature:

Downing, A. S., E. H. Van Nes, J. S. Balirwa, J. Beuving, P. Bwathondi, L. J. Chapman, I. J. M. Cornelissen, I. G. Cowx, et al. 2014. Coupled human and natural system dynamics as key to the sustainability of Lake Victoria's Ecosystem services. Ecology and Society 19. doi:10.5751/ES-06965-190431

Folke, C. 2016. Resilience (Republished). Ecology and Society 21. The Resilience Alliance: 44. doi:10.5751/ES-09088-210444

Ostrom, E. 2009. A general framework for analyzing sustainability of social-ecological systems. Science 325: 419-22. doi:10.1126/science.1172133

Scheffer, M., S. Carpenter, J. a Foley, C. Folke, and B. Walker. 2001. Catastrophic shifts in ecosystems. Nature 413: 591-596. doi:10.1038/35098000

<u>Case Study:</u> Can the Sustainable Development Goals provide a framework with which to address risks and stresses in a complex socio-ecological system?

We will here carry out a theoretical analysis of the SDG framework, using Lake Victoria's socio-ecological system as an example.

Lake Victoria is a perfect example of a deeply intertwined complex social-ecological system (SES), where society and nature have very strong influences on one-another, and where process dynamics have effects across multiple scales (Downing et al. 2014). Many argue that the introduction of an invasive species – Nile perch – though deleterious to the lake's ecosystem, has done more for the development of the wider region than donor aid. However, even though Nile perch export brings in a lot of foreign investment, social inequity and inequalities are rife and lakeshore societies remain poor, with poor access to health care, education, clean water and more. Furthermore, the lake's ecosystem is degrading, threatening to stop providing services that societies depend on. We need to explore sustainable futures for Lake Victoria.

We here aim to test whether the Sustainable Development Goals can provide a framework with which to tackle the multiple connected social and environmental stresses it faces, and how such a framework can influence the resilience of the SES.

As a first approach, I suggest selecting a handful of SDGs (United Nations 2015) that are relevant to Lake Victoria's social-ecological system. The idea would then be to see how these SDGs connect. This can very likely be done in a number of ways, an example that can be used is presented in Nilsson et al. (ICSU 2016; Nilsson et al. 2016). By connecting SDGs, we can identify tradeoffs, opportunities and risks in tackling the different goals. You can assess whether and how well a connected vision of the SDGs addresses the development needs of Lake Victoria's connected SES. Finally, you can overlay the connected SDG map with the Social-ecological systems map from Downing et al. (2014), and investigate pathways to addressing the SDGs.

Potential outputs from this study include (a) an assessment of the possibilities and pitfalls of connecting SDGs, (b) a theoretical evaluation of risks, opportunities and trade-offs in tackling multiple concurrent goals (c) a map of SDGs relevant to Lake Victoria's SES. Discussions can tackle temporal, spatial or cross-scale contexts, governance, ethics…

It is important to emphasize that this exercise has not been carried out before, it is therefore important for the students to push through connecting the SDGs as well as possible and evaluate and document the challenges involved in this exercise.

<u>Suggested Reading:</u>

Downing, A. S., E. H. Van Nes, J. S. Balirwa, J. Beuving, P. O. J. Bwathondi, L. J. Chapman, and J. M. Ilse. 2014. Coupled human and natural system dynamics as key to the sustainability of Lake Victoria's ecosystem services. Ecology And Society 19: 31. doi: 10.5751/ES-06965-190431

ICSU. 2016. A draft framework for understanding SDG interactions. Paris: International Council for Science (ICSU).

Nilsson, M., D. Griggs, and M. Visbeck. 2016. Map the interactions between Sustainable Development Goals. Nature 534: 320–322. doi:10.1038/534320a

United Nations. 2015. Transforming our world: the 2030 Agenda for Sustainable Development. Vol. A/RES/70/1.

<u>Tuesday 30.05.17</u>

Prof. Mary Lou Zeeman, Mathematics department, Bowdoin College, Brunswick, ME, USC.
Mary Lou Zeeman holds a B.A. & M.A. from University of Oxford, UK and a Ph.D. from University of California, Berkeley. Her research interests are geometric dynamical systems, mathematical biology, population dynamics, neuroendocrinology and hormone oscillations, climate modeling, sustainability and resilience.

<u>Talk:</u> Mathematics of slow variable modeling: Tipping points and resilience.

In this talk we will explore a dynamical systems framework for modeling slow variables, tipping and resilience in conceptual models in which feedback can drive a system to alternative stable states (e.g. species competition, lake eutrophication, climate, etc.). The approach is particularly accessible because it harnesses our visual intuition without needing any mathematics beyond the idea of a derivative. We will see how the same approach can be applied in a wide variety of contexts.

<u>Workshop Description:</u>
In the hands-on workshop, we will work with conceptual models that translate biological assumptions into systems of two or three (or more) coupled ordinary differential equations. We will use the differential equations simulation software XPP to discover and visualize the behavior of the systems. The goal is to help you develop independence to develop and explore your own models of your biological system of interest, if you choose.

<u>Prerequisites for the workshop:</u>
Software: XPP (also known as XPP-AUT) by Bard Ermentrout.

Freely available from http://www.math.pitt.edu/~bard/xpp/xpp.html.

All software has pros and cons. We have chosen XPP because it has a good balance of computational power, user friendliness, and modeling freedom. It is also freely available, widely used in the computational biology community, and works on many platforms, including mac, windows and linux machines, all with the same menu system and graphical user interface.

There are instructions on how to download and use XPP in the tutorial “Bridging Between Experiments and Equations: A Tutorial on Modeling Excitability” (from Computational Neuroendocrinology, Wiley-INF Masterclass in Neuroendocrinology Series, Editors D.J. MacGregor and G. Leng). Here are links to the tutorial and associated “ode file”.

https://dl.dropboxusercontent.com/u/22165371/MorrisLecarTutorial-2015.pdf
https://dl.dropboxusercontent.com/u/22165371/BridgingTutorial-MLecar.txt

To prepare for the workshop, download XPP ahead of time, and use the tutorial to get some familiarity with XPP. Sections 1.1 - 1.5 introduce the action potential, modeling and XPP. You will be in very good shape for the workshop if you have worked through sections 1.1-1.5 before arriving.

In case, you are inspired to go on: sections 1.6-1.10 introduce bifurcations, leading to a model of bursting. Section 1.11 introduces the idea of eigenvalues and relates it to stability.

Literature for the workshop:

Brian Walker David Salt (2006) Resilience Thinking - Sustaining Ecosystems and People in a Changing World. IslandPress. **Read Chapter 1 and 2**

Further Readings/Information:

Brian Walker David Salt (2006) Resilience Thinking - Sustaining Ecosystems and People in a Changing World. IslandPress. **Chapter 3**

Another excellent introduction to these ideas is in the 1978 BBC Christmas Lecture by Sir Christopher Zeeman on Catastrophe and Psychology.
http://www.richannel.org/christmas-lectures/1978/1978-christopher-zeeman#/christmas-lectures-1978-christopher-zeeman--catastrophe-and-psychology

Adam Clark, Dept. Ecology, Evolution, and Behavior, University of Minnesota, Twin Cities, USA, adam.tclark@gmail.com, www.adamclarktheecologist.com

Adam is a PhD student working under Dr. David Tilman in the University of Minnesota's Department of Ecology Evolution, and Behavior. He is broadly interested in how ecological communities persist across space and time. To address this topic, he works across many kinds of ecological communities, though he is particularly familiar with tallgrass prairies in the US Midwest, and ant communities in the US North East and the Caribbean. His main focus is on synthesizing existing data and theory in order to build predictive models of community assembly for real-world systems. Starting in October 2017, he will begin work as a post-doc with Stan Harpole and Helmut Hillebrand at the Synthesis Centre of the German Centre for Integrative Biodiversity Research (sDiv) in Leipzig, Germany.

Talk: Empirical Dynamic Modeling: Time Series Analysis for Predicting Future Dynamics and Testing Causal Links

Ecological systems are generally complex, with many coupled components. Moreover, in most cases we lack sufficient experimental data from these systems to determine the direction and strength of associations among these components. Making predictions about future dynamics of these systems can therefore be very difficult. “Empirical Dynamic Modeling” describes a class of algorithms developed by George Sugihara and his colleagues over the past three decades to help address these problems. These methods allow powerful mathematical concepts rooted in state space reconstruction to be applied to empirically observed time series data. This results in very accurate predictions of future behavior of systems even when observations are only available for a subset of the components that make up the whole system. These predictions can be further used to identify chaotic systems, distinguish between correlations and causal links, estimate the interaction strength among system components, and much more.

Workshop Description:

The goal of this workshop is to introduce the basic theory behind Empirical Dynamical Modeling (EDM), and teach basic proficiency in the “rEDM” software package, which implements the algorithms that make up EDM in the R programming language. While some past experience in R will certainly be helpful, this workshop will not assume that everyone already knows how to program, nor does it require an extensive background in mathematics.

In the first component of the workshop (~45 minutes), we will discuss the mathematical concepts that underlie EDM. The primary predictive algorithms in EDM (“simplex projection” and “s-mapping”) are effectively simple implementations of local autoregressive smoothers, which average across past states of a system, weighted by their similarity to the current state. However, a major advantage of these methods is that they are mathematically rooted in Takens’ Theorem, which shows that historical trends of a single variable can often be used to predict the full dynamics of a complex system. This means that we may not need to measure every component of a system in order to make accurate predictions about it.

In the second component of the workshop (~1 hour), we will use the rEDM package to analyze some example analyses using a few simulated and real-world data sets. This will include the basic methods behind training the fitting algorithms, examples of the computer code needed to run these algorithms, and a discussion of how to interpret the results from these predictions. Lastly, we will go over some examples using “convergent cross mapping”, a numerical method that can be used to test for causal links in complex coupled systems.

Finally, in the third section (all remaining time, plus optionally during the case study work time), we can try to apply these methods to the case study work, or even independent projects. While EDM can theoretically be applied to any time series data, it will work best for longer time series (e.g. where there are at least 30 sequential observations of each system variable, with equal time steps between observations). However, shorter time series can still be analyzed, particularly if measurements are spatially replicated (e.g. 5 sequential measurements from each of 50 plots, even if measurement intervals are somewhat irregular).

Prerequisites:

Most of the workshop will be conducted using a programming package called “rEDM” in the R programming language. You will probably get the most out of this workshop if you follow along on your own computer.

If you do not already have a copy of R on your computer, you can download it for free here: https://cran.r-project.org/

Many people prefer using R through a user interface called “RStudio”. To use RStudio, you need to install R first. Once you’ve done that, you can download RStudio for free here: https://www.rstudio.com/products/RStudio/#Desktop

You can automatically download and install the rEDM package by opening R and typing the following code into the console: `install.packages("rEDM")`

Literature for the Workshop:

This paper and these three short videos (< 2 minutes each) introduce empirical dynamic modeling, a powerful nonparametric tool for making predictions about future dynamics in complex systems, and convergent cross mapping, a statistical method for testing causal links among variables in dynamic systems using observational time series data.

Sugihara, G., May, R., Ye, H., Hsieh, C. H., Deyle, E., Fogarty, M., & Munch, S. (2012). Detecting causality in complex ecosystems. Science, 338, 496-500. DOI: 10.1126/science.1227079

Introduction to Empirical Dynamic Modeling: https://www.youtube.com/watch?v=8DikuwwPWsY

Constructing Empirical Dynamic Models: Taken' Theorem: https://www.youtube.com/watch?v=QQwtrWBwxQg

State Space Reconstruction: Convergent Cross Mapping: https://www.youtube.com/watch?v=iSttQwb-_5Y

Suggested Reading:

This user guide describes the basic concepts and computer code needed for implementing convergent cross mapping and empirical dynamical modeling in the rEDM package in the R programming language. This reading will probably be most useful for anyone who would like to try applying these methods on their own.

Ye, H., Clark, A., Deyle, E., & Sugihara, G. (2016). rEDM: an R package for Empirical Dynamic Modeling and Convergent Cross-Mapping. https://cran.r-project.org/web/packages/rEDM/vignettes/rEDM_tutorial.html.

Further Readings:

Other useful sources for these methods – not directly related to material in this workshop, and certainly not required reading. Clark et al. 2015 tests the circumstances under which we can substitute spatial replication for time series length in analyses. Ye & Sugihara 2016 shows how to incorporate additional variables in order to improve predictive power. Deyle et al. 2016 shows how to extract estimates of interaction strengths among variables.

Clark, A. T., Ye, H., Isbell, F., Deyle, E. R., Cowles, J., Tilman, G. D., & Sugihara, G. (2015). Spatial convergent cross mapping to detect causal relationships from short time series. Ecology, 96, 1174-1181. DOI: 10.1890/14-1479.1

Ye, H., & Sugihara, G. (2016). Information leverage in interconnected ecosystems: Overcoming the curse of dimensionality. Science, 353, 922-925. DOI: 10.1126/science.aag0863

Deyle, E. R., May, R. M., Munch, S. B., & Sugihara, G. (2016). Tracking and forecasting ecosystem interactions in real time. Proc. R. Soc. B, 20152258. DOI: 10.1098/rspb.2015.2258

Wednesday 31.05.17

Prof. Christopher Gilligan, University of Cambridge, UK.
Chris Gilligan is Professor at the Department of Plant Sciences at the University of Cambridge. His research is focused on developing and testing a theoretical framework to understand the mechanisms that control invasion, persistence, scaling and variability of epidemics within changing agricultural and natural landscapes. Their models are used to predict the spread of disease and to identify and optimise economically and ecologically sustainable strategies for disease management, encompassing genetical, chemical, biological and cultural methods. The research involves a synthesis of epidemiological theory, population and evolutionary genetics, landscape ecology and economic modelling. The models are tested using data from laboratory microcosms and extensive field and regional data-sets.

Talk: Emerging Pathogens that Threaten Global Food Security
I shall consider emerging pathogens from an epidemiological perspective designed to advise government and other agencies on risk assessment and effective deployment of control measures. We briefly discuss the extent to which prevention and mitigation of crop loss from disease and food waste is considered in short, medium and long-term planning for global food security. Then, drawing on examples of emerging pathogens of wheat, cassava, citrus and sugar-beet that threaten crop production in Africa, India, US and UK, we show how to assess the risk of pathogens arriving, what the impacts are likely to be, where to survey, when, where and how to deploy control. Particular challenges arise in estimating dispersal parameters, allowing for uncertainty including cryptic infection and in coupling epidemiological with economic models. We consider control at the regional and country-wide scales and show that success involves matching the scale of control with the intrinsic spatial and temporal scales of epidemic spread. Grower behavior is also important and we show how a small change in compliance can undermine the effectiveness of control strategies such as the introduction of clean seed schemes. The intention is to show that instead of starting afresh each time, there is an emerging epidemiological framework and a set of epidemiological tools that can adapted for each new pathogen.

Literature:
Boyd, I.L., Freer-Smith, P.H., Gilligan, C.A., Godfray, H. C. J. (2014) The consequence of tree pests and diseases for ecosystem services. Science 342: 1235773-1-8. doi:10.1126/science.1235773

Cunniffe, N.J, Stutt, R.O.J.H., DeSimone, R.E., Gottwald, T.R., Gilligan, C.A. (2015) Optimising and communicating options for the control of invasive plant disease when there is epidemiological uncertainty. PLoS Computational Biology 11(4): e1004211. doi:10.1371/journal.pcbi.1004211.

Workshop Description:

Building upon the principles introduced in the preceding lecture, we propose to use a user-friendly web-based version of a stochastic, spatially-explicit, individual-based model to explore different aspects of disease management for emerging epidemics in agricultural and natural environments. The underlying model has been used to analyse a range of plant pathogens, which include sudden oak death in California and the related ramorum disease in the UK, citrus canker and citrus greening in Florida, oriental chestnut gall wasp and oak processionary moth in the UK. The web-based interface was originally developed to assist interactions with stakeholders about disease control for citrus diseases which encompass infection of trees in urban environments and plantations. The model can be adapted for a wide variety of pathogens. Further details are given in Cunniffe et al. (2015).

We shall use the model to explore some of the ways in which epidemiological models can be used to predict and understand spread and to compare different disease control scenarios, while allowing for natural variability in epidemic spread as well as uncertainties in current knowledge and understanding of an emerging epidemic together with logistical constrains, for example in mobilising resources for control.

By way of an example, we shall consider citrus canker, a bacterial infection that is spread by rain splash as well as by human activity. These effects are parameterised within a dispersal kernel and a transmission rate. The model can address the spread of disease in groves and for trees in urban environments, which constitute an important source for bulking up of inoculum and spread into commercial groves.

Prerequisites:

1) Access the relevant webpage by clicking here Webidemics (www.webidemics.com)
2) Note that Webidemics uses Adobe Flash Player and can therefore only be used on a PC.

The “Introduction to Webidemics” will be available on OLAT.

Suggested Readings:

Cunniffe, N.J, Stutt, R.O.J.H., DeSimone, R.E., Gottwald, T.R., Gilligan, C.A. (2015) Optimising and communicating options for the control of invasive plant disease when there is epidemiological uncertainty. PLoS Computational Biology 11(4): e1004211. doi:10.1371/journal.pcbi.1004211.

Further Readings:

Cunniffe, N.J., Cobb, R.C. Meentemeyer, R.K., Rizzo, D.M., Gilligan, C.A. (2016). Modelling when, where and how to manage a forest epidemic, motivated by sudden oak death in California. Proceedings of the National Academy of Science USA 113: 5640-5645. doi 10.1073/pnas.1602153113

Gilligan, C.A. (2008) Sustainable agriculture and plant disease: an epidemiological perspective. Philosophical Transactions of the Royal Society, Series B. 363: 741-759. doi: 10.1098/rstb.2007.2181

Gilligan CA, Truscott JE. & Stacey AJ (2007). Impact of scale on the effectiveness of disease control strategies for epidemics with cryptic infection in a dynamical landscape: an example for a crop disease. Journal of the Royal Society Interface 16: 925-934. doi:10.1098/rsif.2007.1019.

Neri, F., Cook, A.R., Gibson, G.J., Gottwald, T.R., Gilligan, C.A. (2014) Bayesian analysis for inference of an emerging epidemic: citrus canker in urban landscapes. PLoS Computational Biology 10(4): e1003587. doi:10.1371/journal.pcbi.1003587.

Parry, M.F., Gibson, G.J., Parnell, S. Gottwald, T.R., Irey, M.E., Gast, T.E., Gilligan, C.A. (2014) Bayesian inference for an emerging arboreal epidemic in the presence of control

Proceedings of the National Academy of Science USA 117: 6258-6262, doi: 10.1073/pnas.1310997111

Dr. Christophe Randin, Faculty of Biology and Medicine, Department of Ecology and Evolution, University of Lausanne, CH

Christophe Randin is associated researcher and privat docent at the University of Lausanne. Moreover, he is the curator of the Musée et Jardins botaniques cantonaux in Lausanne. Over the last five years, Christophe was working on projects that aimed at finding functional and mechanistic explanations of species' range limits. For instance, he assessed the relationships between phenology and the cold limits of broad-leaved tree species in the ERC TREELIM project and how topo-climatic buffering can have assisted the persistence of alpine plant species during quaternary climate oscillations. How species are distributed in space and time, what are the underlying mechanisms that explain their past and current distribution and how can we best predict their future distribution in a rapidly changing environment, are the broad questions that he aims to answer in his research.

Talk: Persistence without moving under climate change

Mountain regions enclose half of the 34 biodiversity hotspots worldwide, are important refugial areas and are considered amongst the most fragile environments in the world. In these mountain regions, ongoing rapid climate change is predicted to either shift upward in elevation plants that are able to track their climate envelope or cause local extinctions of unsuccessful species. However, some plant species have been able to persist during Quaternary climate oscillations without shifting their range.

He will present a novel paradigm to explain plant persistence by highlighting the importance of microrefugia as climatic islands when forecasting the fate of plant species under climate change. For this, he will use the rare arcto-tertiary and endemic alpine plant Saxifraga florulenta as a model organism. Although micro-climatic refugia may mitigate the effects of a changing climate for alpine plants and plants living in other types of extreme habitats, the climate conditions and the mechanisms occurring within such microhabitats remain poorly described and understood. He will thus present candidate mechanisms potentially allowing climate decoupling in microrefugia.

Moreover, he will show to which extent mountain plants, and in particular tree species, can react and adapt to climate warming trough a shift of their spring phenological phases. On one hand, such shifts allow plant species to quickly respond to climate change. On the other hand, climate warming can also have paradoxical effects on spring phenology by delaying phases instead of advancing them. He will illustrate this paradox and the its associated risk on plant species distribution with 10 years of phenological observations collected in the Alps by the citizen program Phenoclim.

Literature:

Suggested Reading:

Körner C, Basler D, Hoch G, Kollas C, Lenz A, Randin CF, Vitasse Y & Zimmermann NE (2016) Where, why and how? Explaining the low temperature range limits of temperate tree species. Journal of Ecology 104: 1076-1088. doi: 10.1111/1365-2745.12574

Patsiou TS, Conti E, Theodoridis S, Randin CF (2017) The contribution of cold air pooling to the distribution of a rare and endemic plant of the Alps Plant Ecology & Diversity doi:10.1080/17550874.2017.1302997

Patsiou TS, Theodoridis S, Conti E and Randin CF. 2014. Topo-climatic microrefugia explain the persistence of a rare endemic plant in the Alps during the last 21 millennia. Global Change Biology. 20 (7): 2286-2300. doi: 10.1111/gcb.12515

Further Readings:

Kollas C, Körner C and Randin CF. 2014b. Spring frost and growing season length co-control the cold range limits of broad-leaved trees. Journal of Biogeography. 41 (4): 773-783. doi: 10.1111/jbi.12238

Pellerin, M., Delestrade, A. & Yoccoz, N.G., 2012. Spring tree phenology in the Alps: Effects of air temperature, altitude and local topography. pp.1957-1965. doi 10.1007/s10342-012-0646-1

Vitasse Y, Hoch G, Randin CF, Scheepens JF, Kollas C, Lenz A, and Körner C. 2013. Elevational adaptation and plasticity of leaf unfolding and budset timing of seedlings of temperate deciduous tree species in the Swiss Alps. Oecologia 171:663-678. doi:10.1007/s00442-012-2580-9

Student Case Study 1: Mechanisms and their limitations for persistence and resilience of plant biodiversity in mountain regions under climate change

Task Description: The goal of this case study will be to write an opinion/perspectives paper that addresses the following question: what are the main key mechanisms and alternatives to distribution shift that can alleviate the effect climate change on mountain plants? The limits of such mechanisms should be discussed in the light of the rapid ongoing climate change.

Suggested Reading:

Dobrowski SZ (2011) A climatic basis for microrefugia: the influence of terrain on climate. *Global Change Biology* 17 2, 1022-1035. doi: 10.1111/j.1365-2486.2010.02263.x

Crimmins SM, Dobrowski SZ, Greenberg JA, Abatzoglou JT, Mynsberge AR (2011) Changes in climatic water balance drive downhill shifts in plant species' optimum elevations. *Science* 331. doi: 10.1126/science.1199040

Curtis JA, Flint LE, Flint AL, *et al*. (2014) Incorporating Cold-Air Pooling into Downscaled Climate Models Increases Potential Refugia for Snow-Dependent Species within the Sierra Nevada Ecoregion, CA. *PLoS ONE*, 9 :9. doi: 10.1371/journal.pone.0106984

Further Readings:

de Witte, LC; Armbruster, GFJ; Gielly, L; Taberlet, P; Stöcklin, J (2012) AFLP markers reveal high clonal diversity and extreme longevity in four key arctic-alpine species, in: Molecular ecology 21, 2012, H. 5, S. 1081-97. doi: 10.1111/j.1365-294X.2011.05326.x.

Lundquist JD, Pepin N and Rochford C (2008) Automated algorithm for mapping regions of cold-air pooling in complex terrain. Journal of Geophysical Research 113. doi: 10.1029/2008JD009879

Scherrer, D and Körner, C (2010) Infra-red thermometry of alpine landscapes challenges climatic warming projections. *Global Change Biology* 16: 2602-2613. doi: 10.1111/j.1365-2486.2009.02122.x

Scherrer D and Körner C (2011) Topographically controlled thermal-habitat differentiation buffers alpine plant diversity against climate warming. *Journal of Biogeography* 38 :2, 406-416. doi: 10.1111/j.1365-2699.2010.02407.x

Wipf S, Stoeckli V, Bebi P (2009) Winter climate change in alpine tundra: Plant responses to changes in snow depth and snowmelt timing. *Climatic Change* 94: 105-121. doi: 10.1007/s10584-009-9546-x

Student Case Study 2: Paradoxical effects of climate change on species and their feedbacks at the global scale

Task Description: The goal of this case study will be to write a review paper providing a comprehensive list of paradoxical effects of climate change on the biodiversity and the (sometimes unexpected) feedbacks of biodiversity on the trophic and climate systems.

Suggested Reading:

Fu, Y.H. et al., 2015. Declining global warming effects on the phenology of spring leaf unfolding. Nature, 526, pp.104-107. doi:10.1038/nature15402

Ims, Rolf Anker; Fuglei, Eva. Trophic Interaction Cycles in Tundra Ecosystems and the Impact of Climate Change. BioScience 2005; Volum 55.

Chapin, F.S., Sturm, M., Serreze, M.C., McFadden, J.P., Key, J.R., Lloyd, A.H., McGuire, A.D., Rupp, T.S., Lynch, A.H., Schimel, J.P., Beringer, J., Chapman, W.L., Epstein, H.E., Euskirchen, E.S., Hinzman, L.D., Jia, G., Ping, C.L., Tape, K.D., Thompson, C.D.C., Walker, D.A. & Welker, J.M. (2005) Role of Land-Surface Changes in Arctic Summer Warming. Science, 310, 657-660.

Further Readings:

Fu, Y.H. et al., 2014. Recent spring phenology shifts in western Central Europe based on multiscale observations. Global Ecology and Biogeography, 23(11), pp.1255-1263. doi: 10.1111/geb.12210

Kurz, W. A., C. C. Dymond, G. Stinson, G. J. Rampley, E. T. Neilson, A. L. Carroll, T. Ebata, and L. Safranyik (2008), Mountain pine beetle and forest carbon feedback to climate change, Nature, 452, 987-990. doi:10.1038/nature06777

Thursday 01.06.17

Prof. Robert Finger, Agricultural Economics and Policy, ETH Zurich

Studied Economics at the European University Viadrina in Frankfurt an der Oder, received a PhD in Agricultural Economics from ETH Zurich in 2009 and was PostDoc in the Agri-food and Agri-environmental Economics Group of ETH Zurich until 2011. Since 2016, Robert Finger is Professor for Agricultural Economics and Policy at ETH Zurich. Before returning to ETH Zurich, he was Assistant Professor in the Agricultural Economics and Rural Policy Group at Wageningen University (2012-2013) and Head of the Production Economics Group at the Rheinische Friedrich-Wilhelms-Universität of Bonn (2014-2015).

The research focus of Robert Finger is on risks and risk management in agriculture, evaluation and design of agricultural policies, sustainable farm-environment interactions and agri-environmental measures. The main objective of his Agricultural Economics and Policy (AECP) Group is to improve the understanding of linkages between policies and production and risk management decisions taken in the agricultural and food sector. The mission of AECP is i) to better understand the decisions taken by farmers and firms in the agribusiness and ii) to contribute to evaluation and design of agricultural policies and risk management instruments. The research activities cover a wide range of topics related to agricultural production, sustainable resource use, agricultural policy and the food industry. Building upon microeconomic theory, research conducted in AECP is quantitatively oriented and highly interdisciplinary.

<u>Talk:</u> The role of risk and risk management for agricultural production

Agricultural production is exposed to various risks which are important for decisions taken by farmers and other actors in the agri-food sector. More specifically, these risks arise from three main components. First, production risks reflect that stochastic environmental conditions influence quantity and quality of production (e.g. crop yields). Second, agricultural in- and output prices are usually volatile, causing market risks. Third, institutional risks summarize uncertainty due to a high level of governmental intervention and frequent policy changes. All these risks are highly interrelated, e.g. price volatility can be caused by highly variable production levels. Farmers react to these risks by choosing various risk management strategies. More specifically, two important ways of reactions to the exposure to high risks are observed. Farmers mitigate risks, e.g. by adjusting the choice of the production program (e.g. crop choice), adjustment of intensity of production (e.g. input use), the control of environment (e.g. using hail nets) or diversification activities on- or off- the farm. Moreover, farmers can transfer risks to third parties, e.g. using price futures or forwards to cope with market risks or using insurances to cope with production risks. These choices made by farmers are highly subjective and farm- and farmer-specific, depending on the structure of the farm but also on the perception and preferences of the farmer. These decisions made by farmers are decisive for various dimensions of societal goals as these, a) affect environmental impacts of agricultural production (e.g. if the use of inputs such as pesticides and irrigation is affected), ii) affect food production and food security (e.g. if farmers decide to rather work off-farm or reduce production intensities), iii) affect farm income and rural development as risk reduction often comes with some price in form of lower profits. Thus, understanding these processes is of large relevance to understand how different risks affect agricultural and food systems and how policy processes can support sustainable agricultural development.

In this lecture, I will give an overview on important risks in agricultural production and will introduce modern economic and psychological concepts on decision making under risk. The important role of individual risk preferences will be illustrated in a classroom experiment. Based on that background, I will derive the importance of risk and risk preferences for production and diversification decisions at the field-, farm- and household-level and outline recent developments in risk management in agriculture.

<u>Literature:</u>

Hardaker, J. B., Huirne, R. B. M., Anderson, J. R., & Lien, G. (2004). Coping with risk in agriculture. Coping with risk in agriculture. (Ed. 2). *(No pdf available)*

Dalhaus, T., Finger, R. (2016). Can Gridded Precipitation Data and Phenological Observations Reduce Basis Risk of Weather Index-based Insurance? Weather, Climate and Society 8, 409-419. doi: 10.1175/WCAS-D-16-0020.1

Finger, R., Buchmann, N. (2015). An ecological economic assessment of risk-reducing effects of species diversity in managed grasslands. Ecological Economics 110: 89-97. doi: 10.1016/j.ecolecon.2014.12.019

Lehmann, N., Briner, S., Finger, R. (2013). The impact of climate and price risks on agricultural land use and crop management decisions. Land Use Policy 35: 119-130. doi: 10.1016/j.landusepol.2013.05.008

Dr. Matthew Barbour, University of Zurich, Department of Evolutionary Biology and Environmental Studies, CH

Matt was born and raised in San Diego, California. He earned his MS from San Diego State University (2012) under the supervision of Dr. Rulon Clark. He then moved to Vancouver, Canada where he earned his PhD at the University of British Columbia (2016) under the supervision of Dr. Greg Crutsinger. Currently, he is a postdoctoral researcher at the University of Zurich in Dr. Jordi Bascompte's lab. Matt's research integrates eco-evolutionary dynamics into a food-web approach in order to answer the question: how do eco-evolutionary processes affect the stability of ecological communities? He primarily uses field and lab experiments to address this question, but complements this empirical work with mathematical modelling and analyses of global datasets on species interactions. He uses these approaches to study networks of interactions between plants, herbivorous insects, and their parasitoids, whose feeding interactions regulate much of Earth's biodiversity.

Talk: Genetic specificity of a plant-insect food web: Implications for linking genetic variation to network structure

Theory predicts that intraspecific genetic variation can increase the complexity of an ecological network. To date, however, we are lacking empirical knowledge of the extent to which genetic variation determines the assembly of ecological networks, as well as how the gain or loss of genetic variation will affect network structure. To address this knowledge gap, I used a common garden experiment to quantify the extent to which heritable trait variation in a host plant determines the assembly of its associated insect food web (network of trophic interactions). I then used a resampling procedure to simulate the additive effects of genetic variation on overall food-web complexity. I found that trait variation among host-plant genotypes was associated with resistance to insect herbivores, which indirectly affected interactions between herbivores and their insect parasitoids. Direct and indirect genetic effects resulted in distinct compositions of trophic interactions associated with each host-plant genotype. Moreover, my simulations suggest that food-web complexity would increase by 20% over the range of genetic variation in the experimental population of host plants. Taken together, my results indicate that intraspecific genetic variation can play a key role in structuring ecological networks, which may in turn affect network persistence.

Student Case Study: How does plant biodiversity affect the structure and dynamics of plant-animal interaction networks?

Task Description: The ultimate goal of this case study will be to write an opinion/perspectives paper that attempts to answer the question: how does plant biodiversity affect the structure and dynamics of plant-animal interaction networks? Here, biodiversity refers to diversity at both the genetic- and species-level, while plant-animal interaction networks refer to both food webs (e.g. plant-herbivore-parasitoid) and mutualistic interactions (e.g. plant-pollinator).

During the summer school session, the immediate goal is to: (1) identify a list of theoretical mechanisms by which plant biodiversity affects the structure and dynamics of plant-animal interaction networks; and (2) identify empirical examples (and knowledge gaps) of these mechanisms from the literature. Using the literature below as a starting point, participants should read papers and begin identifying theoretical mechanisms and empirical examples. We will then have an active discussion where we tabulate these mechanisms and examples, identify knowledge gaps, and resolve confusing concepts.

Literature:

Barbour, M.A., Fortuna, M.A., Bascompte, J., Nicholson, J.R., Julkunen-Tiitto, R., Jules, E.S., et al. (2016). Genetic specificity of a plant-insect food web: Implications for linking genetic variation to network complexity. Proc. Natl. Acad. Sci. U. S. A., 113, 2128-2133. doi: 10.1073/pnas.1513633113

McCann, K.S. (2000). The diversity-stability debate. Nature, 405, 228-233. doi:10.1038/35012234

Thébault, E. & Fontaine, C. (2010). Stability of ecological communities and the architecture of mutualistic and trophic networks. Science, 329, 853-856. doi: 10.1126/science.1188321

5 General Information

Accommodation

Venue: 28 May – 2 June 2017, Study week in Einsiedeln (Canton Schwyz):

We are staying at the Hotel Allegro in Einsiedeln, close to the beautiful Sihlsee (Central Switzerland). The hotel provides meals of well-balanced nutrition, and wherever possible using produce from the region. Breakfast is buffet continental style. The surroundings provide you with beautiful views on the surrounding mountains and on the nearby lake Sihlsee; there are lots of hiking tracks within the area of the hotel.

Hotel website: www.sjbz.ch/

Contact information:

Hotel Allegro – Schweizer Jugend- und Bildungszentrum

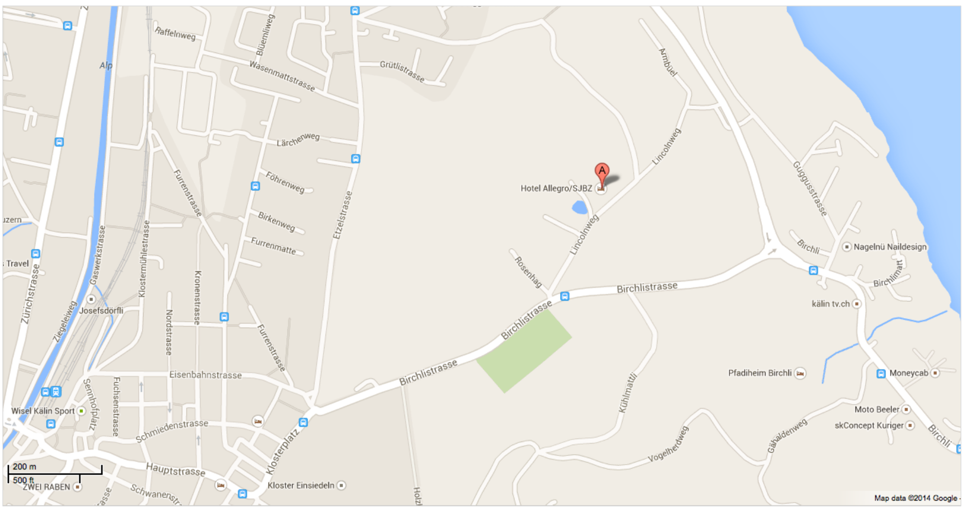
Lincolnweg 23

8840 Einsiedeln

Tel. +41 (0)55 418 88 88

http://www.hotel-allegro.ch/home/

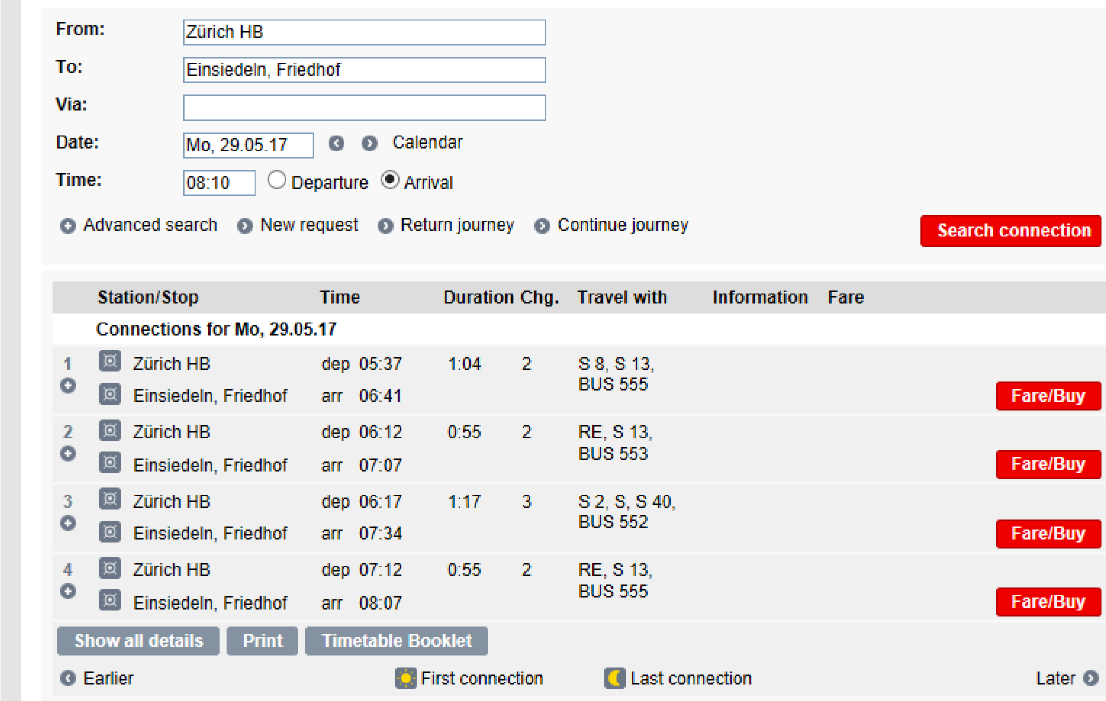
Location plan for Hotel Allegro (http://goo.gl/maps/cIFxA):



How to get to the venue in Einsiedeln

There is a bus stop close (approx. 250 m) to Hotel Allegro in Einsiedeln, this bus stop is called „Friedhof“. Check the SBB online timetable for your detailed connections:
http://fahrplan.sbb.ch/bin/query.exe/en
Buy a single train ticket to Einsiedeln, Friedhof

Example: Travel plan for **Sunday, May 28, 2017** from Zurich (Main station) to Einsiedeln (Bus stop: Friedhof):



From: Zürich HB
To: Einsiedeln, Friedhof
Via:
Date: Mo, 29.05.17 Calendar
Time: 08:10 Departure Arrival
Advanced search | New request | Return journey | Continue journey | Search connection

	Station/Stop	Time	Duration	Chg.	Travel with	Information	Fare
	Connections for Mo, 29.05.17						
1	Zürich HB	dep 05:37	1:04	2	S 8, S 13, BUS 555		
	Einsiedeln, Friedhof	arr 06:41					Fare/Buy
2	Zürich HB	dep 06:12	0:55	2	RE, S 13, BUS 553		
	Einsiedeln, Friedhof	arr 07:07					Fare/Buy
3	Zürich HB	dep 06:17	1:17	3	S 2, S, S 40, BUS 552		
	Einsiedeln, Friedhof	arr 07:34					Fare/Buy
4	Zürich HB	dep 07:12	0:55	2	RE, S 13, BUS 555		
	Einsiedeln, Friedhof	arr 08:07					Fare/Buy

Show all details | Print | Timetable Booklet
Earlier | First connection | Last connection | Later

In Einsiedeln, take the postal bus in the direction of “Hoch-Ybrig” (or Studen), and get off at the stop “Friedhof”. From here, the Hotel Allegro is just a three-minute walk. Upon arrival at the Hotel, go to the main desk and ask for Carole Rapo.

Region

The area is geographically interesting and beautiful with several high mountains. Einsiedeln is located up a plateau (ca. 880 m (2,890 ft) above sea level) and situated near the artificial mountain lake Sihlsee. The dam, which retains the lake, produces electricity for the trains and protects the city of Zurich further down the valley from the flood of the Sihl. The village is a popular tourist destination in central Switzerland. The Benedictine Einsiedeln Abbey, located within the village, is considered one of the most important Roman Catholic pilgrimage sites in Europe. Since the Middle Ages the Graces Chapel and a statue of the Black Madonna have been the centerpiece of the pilgrimage. Einsiedeln is also a popular destination for sports year round.

For more information:

http://www.einsiedeln-tourismus.ch/en/index.cfm

Questions about this summer school? Please contact:

Carole Rapo
E-mail: carole.rapo@usys.ethz.ch
Phone: +41 (0)44 632 89 50