IIASA Summer School for Systems Modeling 2024

Program overview and abstracts

International Institute for Applied Systems Analysis
IIASA www.iiasa.ac.at

IIASA Summer School for Systems Modeling

Welcome to IIASA!

As you read the news on an average day you are confronted with the world's big challenges that lie ahead of us and are already with us: climate change, biodiversity loss, conflicts over territory, the soft underbelly of AI, the growing inequality, the threat of disinformation – you name it. Reading further and digging deeper, you will find that we are also drowning in data and information of which we need to make sense in order to understand what can be done to avoid at least the grimmest of future scenarios.

More data does not necessarily mean more insight. We can use models to give structure to the phenomena, to understand what's going on, to play out possible pathways, to find sweet spots between the trade-offs. Starting from simple "mental models" and heuristics, we often need to migrate to more formal approaches, computer models, to be able to handle the amount of information and data. A model is not an oracle, but a tool to think through a complex situation.

In this summer school we will provide you with opportunities to explore different methods that are being used in modeling of systems, with the express purpose of helping decision makers take better decisions. Our experts here at IIASA use these methods in their everyday research.

Yet we are also acutely aware that good research is not necessarily taken up in policy circles, and this is also true for model results. We therefore embrace the co-production approach to modeling, in which developers and users of models co-design the modeling framework, by agreeing for example on the questions the model should be expected to answer and the method by which the answers are found, by listening very carefully to each other's needs and constraints, and by making the development process transparent. Such an approach may be unintuitive to you but has turned out to be effective in the long run. Thus, we encourage you to stay open to alternative perspectives of what the real challenges are, how they can be analyzed and how solutions can be identified.
Wishing you an exciting and productive time!

Fabian Wagner
Dean of Capacity Development and Academic Training

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Contents

Summer School Agenda

		Mo, 15 IACA building, Seminar Room 5	**Tue, 16** IACA building, Seminar Room 5	**Wed, 17** IACA building: Seminar Room 5, Meeting Room 3 and Blue Room	**Thu, 18** IACA building: Seminar Room 5, Meeting Room 3 and Blue Room	**Fri, 19** IACA building: Seminar Room 5, Meeting Room 3 and Blue Room
Week 1	9:00 AM to 12:30 PM	08:30 AM Arrival of participants at IACA to collect IACA badge 9:00 Welcome **M1 A** Systems Thinking/ Systems Analysis (Fath)	**M1 C** Models: A tasting menu (Fefferman)	**M2 – A: Elective module 1** 1.System Dynamics (Eker) 2.Decision making under uncertainty (Hochrainer-Stiegler) 3.Network Analysis (Fath & Gerber)	**M2 - Elective module 2** 1.Data science (Omodei) 2.Agent-based models (Colon) 3.Complex systems (Fefferman)	**M2 - Elective module 3** 1.Optimization (Khabarov (Part 1) and Satu (Part 2)) 2.Deep learning (Orduña-Cabrera & Sandoval-Gastelum) 3.Justice and Games: A.M.: Advancing Different Justice Considerations in Modeling (Zimm and Brutschin) + P.M. Game Theory (Fefferman) **5-6pm (All, Seminar room 5): Team formation for Week 2**
	2:00 PM to 5:30 PM	**M1 B** Why model/How to model (Rovenskaya)	**M1 D** Transdisciplinary research design (Irshaid, 2hrs) 4:30 pm Jointly with YSSP (Wodak) • OpenModels/Open Science (Hackstock. Kirwan) • Mingling with YSSPs			
	Evening 6-8 PM	Welcome Dinner Glacis Beisl, 1070 Wien **Transportation: Bus meeting point 5pm in front of Laxenburg pharmacy "Apotheke. Bus leaves at 5.15pm**				
		Mo, 22 IIASA, various rooms	**Tue, 23** IIASA, various rooms	**Wed, 24** IIASA, various rooms	**Thu, 25** IIASA, various rooms	**Fri, 26** IIASA, various rooms
Week 2	9:00 AM to 12:30 PM	9 AM Plenary IIASA Gvishiani Room: Project kick-off for all teams Project time – Break Out Groups (BOGs)	Project time (BOGs)	Project time (BOGs)	Project time (BOGs)	Project time (BOGs)
	2:00 PM to 5:30 PM	Project time 4pm Flashtalks (9 x 5 minutes each, final Q&A, Gvishiani Room) (~60min)	Project time (BOGs) 4pm IIASA Tools: Energy Systems (Kishimoto, Gvishiani Room)	Project time (BOGs) 4pm IIASA Tools Modeling for Air Quality Management (Wagner, Gvishiani Room)	Project time (BOGs) 4pm IIASA Tools (tbc, Gvishiani Room)	How to upload to Zenodo (Hackstock) Presentation of project results Reflections and feedback
	Evening			**YSSP Movie night**		Certificates Ceremony/Farewell dinner at Kaiserbahnhof Laxenburg, 6-8 PM

Where will the summer school take place?

The summer school is organized and hosted by IIASA. Due to a meeting room shortage at IIASA, however, activities during Week 1 and also all lunches during Week 2 will actually be happening on the premises of the nearby International Anti-Corruption Agency (IACA, see maps below). To get access to the IACA premises you will need a key card, which you will obtain upon your arrival in the morning of Monday 15 July.

In the second week at IIASA, the following meeting rooms are available for the Breakout Group (BOG) Sessions: Gvishiani Room, Holling Room, Club Room (IIASA restaurant), the Library, the Belvedere (lower platform, maximum 5 people) – the decision which group will go where will be made together.

Week 1 – 15 to 19 July at IACA building. Address: Münchendorfer Str. 2, 2361 Laxenburg
Week 2 – 22 to 26 July at IIASA building. Address: Schloßplatz 1, 2361 Laxenburg

Coffee and Lunch Breaks

Lunch will always be served in the IACA building, also in week 2.
A typical day, in terms of coffee and lunch breaks, will look like this:

Coffee Break at IACA (week 1) will be in the Cafeteria/Coffee Break area.
Coffee Break at IIASA (week 2) will be next to the Wodak Room.

09:00-10:35	Session 1
10:35-10:55	Coffee break
10:55-12:30	Session 2
12:30-14:00	Lunch break
14:00-15:35	Session 3
15:35-15:55	Coffee break
15:55-17:30	Session 4

Abstracts of Sessions

Day 1 & 2: Plenary

Introduction to Systems Thinking and Systems Analysis

Brian Fath

Following a brief history of the role and position of IIASA, this session provides an overview of topics relevant to systems analysis and modeling. To think in systems and understand context is the first step of modelling. Key principles, processes, and outcomes of systems thinking are gathered in a team brainstorming session building a framework that will be key to implementation later.

Some key questions addressed in this session are:
What is IIASA?
What is a system?
What is environment?
What is systems analysis?
What are key concepts and principles of systems analysis?
How are these used to conceptualize and construct models?

Why model? How to model?

Elena Rovenskaya

In this three-hour module we will discuss major approaches to modelling complex socio-environmental systems, their epistemological foundations, as well as their opportunities and limitations. Furthermore, we will discuss how different kinds of research questions and societal challenges require different modelling approaches, and ultimately how a more holistic understanding of the world can emerge from the application of a combination of multiple modelling approaches. Lastly, we will discuss good practices in modelling including sensitivity analysis and model validation.

Transdisciplinary research for sustainable systems transformation

Jenan Irshaid, Susanne Hanger-Kopp

Sustainable systems transformations – to be successful and just – require thoroughly designed science-society interactions. The knowledge necessary to inform transformative action cannot solely be created in disciplinary and strictly scientific contexts. Transdisciplinary research offers an approach that includes society (or societal perspectives) directly into the research process to address complexities associated with sustainable transformation of social-ecological systems. Transdisciplinarity as a research design concept is therefore increasingly sought after and requested by climate and sustainability research funders. This module will offer an introduction into key concepts of transdisciplinarity. Students will explore project phases and key aspects of transdisciplinary research processes such as equal partnerships, stakeholder identification, method selection, knowledge co-production, and reflexive learning vis a vis their own methods and methods discussed in the summer school. We will use their insights to discuss aspects of procedural justice and fairness in designing salient, relevant, and legitimate research processes. In this module students will receive a comprehensive introduction in transdisciplinarity and co-production that shall assist them in the practical exercise within the summer school program.

Day 3, 4, 5: Parallel Sessions

Network Analysis
Brian Fath and Gemma Gerber

Network analysis as a tool in systems research is an immensely growing field. Many of the analyses types are based on foundations accumulated over the past decades, and new approaches are continuously emerging in the different fields. We aim to provide course participants with several aspects and hands-on experience of network analyses as applied to ecosystems and socio-economic systems.

Decision making under uncertainty
Stefan Hochrainer-Stigler

Starting with probabilistic concepts, decision making under uncertainty will be discussed using various risk metrics. Afterwards, based on Expected Utility Theory the concept of certainty equivalents will be introduced which leads to the notion of risk aversion and possible applications, including how to calculate actuarially fair premiums for insurance systems. This will lead to the concept of systemic risk and a systems perspective will be introduced and various metrics of dependencies discussed, including copula approaches, eventually leading to methods how to manage risks from bottom-up as well as top-down approaches. Based on this discussion, modelling applications and tools for assessing and managing direct and indirect risks will be presented on various scales. Through the course various examples based on natural disaster risk will be given and solved by the participants in an interactive mode. Special focus will be on public sector related risks and how the government can act as insurer of last resort, provide incentives for risk reduction and how to select risk instruments to decrease or finance natural hazard induced disaster related risks.

Complex Systems
Nina Fefferman

In this module, we will consider the idea of complex systems: systems in which the basic components are simply defined, but the interactions among the components lead to emergent properties that cannot be readily anticipated or described as an aggregate outcome. We will look at examples of complex systems that both arise from and shape socio-environmental systems and explore some of the common methods for exploration and analysis, including differential equations, cellular automata, dynamic networks, statistical mechanics, and descriptive power law/dimensional distributions. We will discuss a few examples of results that have been obtained using each of these tools/perspectives. We will then conclude by looking at special cases of self-organization and adaptation that add yet another layer of challenges in studying complex systems.

Game Theory
Nina Fefferman

In this module, we will introduce concepts from mathematical game theory: the study of scenarios in which individuals can formulate strategies make decisions about behaviors that lead to (and affect each other's) payoffs. We will begin with a quick introduction of decision theory, then introduce uncertainty, and construct games as scenarios in which the uncertainty comes from other players, who are making their own decisions. We will cover concepts of competitive vs cooperative games, zero-sum games, and iterative games. We will discuss Nash equilibria and evolutionarily stable strategies (as a means by which to understand stable, suboptimal outcomes) in the contexts of diplomacy and public goods. We will also take a brief look at voting theory, a subdiscipline within game theory that focuses on quantifying how much power or influence an individual has within a group-decision making system. Depending on time, we will discuss some applications of coordination games in socio-environmental systems and look at some of the overlaps between game theory and complex systems in these contexts.

Optimization
Part 1
Nikolay Khabarov

In this module, split in two parts of 90 minutes (one and a half hours) each, we will first introduce the optimization concept and start with a simple example of estimating the global land allocation potential for agricultural production (a linear static problem). In this step we will learn how to use the General Algebraic Modeling System (GAMS). We will also carry out experiments with a few parameters of the model to explore the impact that they have on the solution. This part is a simplified version of the research published in the Nature journal.

In the second part of the module, we will use a more advanced optimization example and explore DICE - the Dynamic Integrated Climate-Economy model (a non-linear dynamic problem). DICE is an integrated assessment model developed by the 2018 Nobel Laureate William Nordhaus and is suitable for educational purposes regarding systems modeling. The model was also applied earlier to help policy formulation.

The two models employed in the module provide a flavor of data-slim (DICE) and data-rich (land allocation) problems.

Optimization
Part 2
Reetik Kumar Sahu

This module continues to focus on the optimization techniques with special attention to hydro-economic models for effective water management. It delves into the Water Security research group Hydroeconomic Optimization ECHO model, which integrates economic objectives with physical and institutional constraints to optimize water use across sectors and regions. The course covers the development of a watershed system schematic, including physical structures and water diversion points. It explains the objective function that minimizes total system costs while satisfying environmental flow requirements and supply-demand balance. Various constraints, such as mass balance equations and technology capacity limits, are discussed.

Participants will explore diverse water management strategies, including supply enhancement (e.g., building dams, groundwater pumping) and demand management (e.g., efficient irrigation technologies). Practical applications of the ECHO model to real-world scenarios, such as the Zambezi and Ebro river basins, will be examined. This includes analyzing water availability, demand, and trade-offs under different socio-economic and climatic scenarios to achieve sustainable and efficient water management.

System Dynamics
Sibel Eker

System dynamics (SD) is a complex systems modelling methodology that emphasizes the importance of endogenous dynamics arising from a system structure, represented by stocks, flows and feedback loops. In this module, we will introduce system dynamics modeling, its building blocks, and selected applications. Hence, the overarching objective of this module is to expand participants' knowledge of core system dynamics concepts and their application in simulation models to support decision-making. The module content will follow the system dynamics modeling cycle, comprised of conceptualization of a dynamic hypothesis using causal loop diagrams, formal modeling using stock and flow equations, model validation, testing and use in policy and scenario analyses. Through hands-on exercises and demonstrations, the module will enable participants to gain practical skills for system dynamics modelling.

Data science methods for mapping vulnerability
Elisa Omodei

In the morning, we will introduce the key steps in the data science process, focusing on exploratory data analysis and on modeling, i.e. using the understood data to build machine learning (ML) models. This will be done through an initial theoretical class, followed by a hands-on beginner tutorial in Python.

In the afternoon, we will discuss how data science is being used as a tool to map vulnerability and predict socioeconomic inequalities. We will first provide an overview of the field and then deep dive, again through a hands-on session in Python, on a case study: mapping socioeconomic indicators using social media advertising data.

Students who are already familiar with Python and its data science modules (i.e., pandas and scikit-learn) but would like to learn about their application in vulnerability mapping, are welcome to skip the morning session and join us for the afternoon only.

Agent-based modelling
Celian Colon

Agent-based modeling (ABM) approaches complex systems from the bottom-up: how the behavior of systems' component affects the whole. Their applications range from toy models aiming at qualitative insights to large data-rich models providing forecasts. We will review the basics of complex system modeling, compare ABM with other approaches, discuss their pros and cons. We will discuss the model building process, the analysis, and the role of data. We will review some use cases of ABMs from a variety of contexts, from socioeconomics to ecology. Participants will be given the chance to play with several ABMs using the low-code software NetLogo, and will be exposed to advanced techniques.

Advancing Different Justice Considerations in Modelling
Caroline Zimm & Elina Brutschin

In this module, we will discuss different justice considerations coming up in climate change research and policy discussions. We will share insights on how IIASA colleagues have been trying to advance their climate mitigation pathway modelling efforts, foremost with regards to distributional and procedural justice. We will discuss emerging research avenues and frontiers connected to what models and scenarios can contribute to the justice discourse. We will use a new stakeholder engagement tool to collect insights on perceptions of fairness on different distributional patterns of justice for a range of different indicators.

Deep Learning
Fernando Orduña-Cabrera & Marcial Sandoval-Gastelum

Deep learning (DL) is becoming the most used technique for image and object classification. In this module, we will dive into the significance of pixels in images and their utilization and interpretation using DL. We will work through a Step-by-step exercise aiming to apply DL for image classification and explore the use of DL for Crop-type recognition.

Game Theory
Nina Fefferman

In this module, we will introduce concepts from mathematical game theory: the study of scenarios in which individuals can formulate strategies make decisions about behaviors that lead to (and affect each other's) payoffs. We will begin with a quick introduction of decision theory, then introduce uncertainty, and construct games as scenarios in which the uncertainty comes from other players, who are making their own decisions. We will cover concepts of competitive vs cooperative games, zero-sum games, and iterative games. We will discuss Nash equilibria and evolutionarily stable strategies (as a means by which to understand stable, suboptimal outcomes) in the contexts of diplomacy and public goods. We will also take a brief look at voting theory, a subdiscipline within game theory that focuses on quantifying how much power or influence an individual has within a group-decision making system. Depending on time, we will discuss some applications of coordination games in socio-environmental systems and look at some of the overlaps between game theory and complex systems in these contexts.

Biographies of Lecturers

Elina Brutschin

Elina Brutschin joined IIASA as a research scholar in 2019, and works with the IIASA Energy, Climate, and Environment (ECE) Program, with a research focus on bridging insights from the political economy and modeling studies of energy. In her most recent line of work she has focused on developing tools to evaluate feasibility of ambitious climate scenarios from different perspectives. In her past research she has for example, analyzed political drivers and constraints of investments in renewable energy, the role of international cooperation in the diffusion of nuclear energy and the conditions for a successful coordination of regional gas policies. Dr. Brutschin has published in journals such as Environmental Research Letters, Energy Policy and Energy Economics, and with publishers such as Oxford University Press and Palgrave.

Prior to joining IIASA, Dr. Brutschin was Assistant Professor of International Relations at Webster Vienna Private University (WVPU). After completion of her PhD in political science on the liberalization of the European gas market at Konstanz University, Germany, she devoted her post-doctoral research to investigating the political economy of energy. She completed her undergraduate studies at the same university and she also holds a post-graduate degree in EU Multi-Level Governance from the Institute for Advanced Studies, located in Vienna, Austria.

Celian Colon

Celian Colon is a postdoctoral research scholar in the Exploratory Modeling of Human-Natural Systems (EM) Research Group, within the IIASA Advancing Systems Analysis (ASA) Program. His research focuses on the modeling of systemic risks, resilience and tipping points in ecological and economical systems, using system dynamics, agent-based modeling, and complex networks.

One of Dr. Colon's recent achievements is the development of a tool that analyzes the criticality of a country's transport system to extreme events. The originality of this model is to integrate socioeconomic and supply chain data to fully evaluate the importance of transport links. This tool has been applied for the World Bank to Tanzania and Cambodia to prioritize investment.

Dr. Colon completed his PhD in Applied Mathematics with Prof. Michael Ghil at Ecole Normale Superieure Paris (2016), for a thesis entitled Modeling Economic Resilience. He holds an MSc in Environmental Technology and Policy from Imperial College London (2011), and graduated from the Ecole Polytechnique Paris, a multidisciplinary engineering school, in 2010. Dr. Colon participated in the IIASA Young Scientists Summer Program (YSSP) in 2015, with the former Ecology and Evolution and Advanced Systems Analysis Programs. He is associated with the World Bank and is chief data advisor for Lemon Tri, a startup company in the recycling business.

Sibel Eker

Sibel Eker is a senior research scholar in the Sustainable Service Systems Research Group of the IIASA Energy, Climate, and Environment Program. Her interdisciplinary research profile combines systems analysis and engineering, decision sciences, and social sciences. Her work brings a systems thinking and uncertainty focus to climate change and sustainability problems with model-based approaches. Complementing her academic experience, she has worked with several stakeholders and policy actors such as the UK Department for Business, Energy, and Industrial Strategy, the World Bank, the European Institute of Innovation and Technology (EIT)-Climate Knowledge and Innovation Community (KIC), as well as other governmental and private organizations.

Her current research interests center around the drivers and implications of demand-side climate change mitigation, sustainable diets, and co-production of mitigation and sustainability scenarios through simple integrated assessment models, such as the FeliX model. Eker has had leading roles in related European research consortia, including the ongoing WorldTrans and CHOICE projects, and she is the PI of LOW-AI.

Eker is a selected member of the Global Young Academy where she co-leads the Scientific Excellence Working Group. She is also a Lead Author in the United Nations Environment Programme (UNEP) Global Environment Outlook (GEO-7), as well as an editorial board member of Humanities and Social Sciences Communications and Mitigation and Adaptation Strategies for Global Change. She teaches system dynamics modeling at Nijmegen School of Management and as part of the European Master in System Dynamics.

Eker obtained her PhD degree in 2016, from Delft University of Technology in The Netherlands, with a focus on dealing with uncertainties in the Dutch natural gas sector. Prior to joining IIASA in 2017, she worked at University College London on integrated decision making in housing, energy, and wellbeing; and at Delft University of Technology on the resilience of the transport network in Bangladesh.

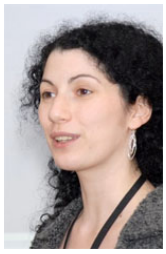
Brian Fath

Brian D. Fath is a professor in the Department of Biological Sciences at Towson University, Maryland, USA. He teaches courses in ecosystem ecology, environmental biology, networks, and human ecology and sustainability. He has also taught courses on ecological networks and modeling in Austria, China, Croatia, Czech Republic, Denmark, Finland, France, Germany, Italy, Portugal, and Russia. He held Fulbright Distinguished Chair positions at Parthenope University of Naples, Italy (2012) and Masaryk University in Brno, Czech Republic (2019).

Fath is also a Principal Research Scholar in IIASA's Systemic Risk and Resilience Research Group of the Advancing Systems Analysis (ASA) Program. His work at IIASA contributes to ASA activities in environmental systems modeling, specifically in the area of network analysis of social-ecological systems. In addition, he has been serving as YSSP scientific coordinator since 2011.

He has published over 200 research papers, reports, and book chapters and has co-authored the books *Explaining Technology* (2023); *A New Ecology: Systems perspective* (2020); *Foundations for sustainability* (2018); *Flourishing within limits to growth* (2015); and *Ecological Modelling* 4th ed. (2011). He is also the editor-in-chief for both the four-volume *Encyclopedia of Ecology* 2nd ed. (2018) and the six-volume *Environmental Management Handbook* 2nd ed. (2021). Furthermore, he serves as editor-in-chief for *Frontiers in Sustainable Resource Management*, and he is the past editor of the journal, *Ecological Modelling.* Fath was also the 2016 recipient of the Prigogine Medal for outstanding work in systems ecology.

Nina Fefferman

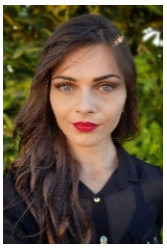


I am interested in the application of mathematical and computational models to biological systems, especially those systems created and governed by the voluntary collaboration of many independent individuals. In my research, I work on a broad variety of systems, both in my own lab and in collaboration with others at many different institutions.

My research usually falls into one or all of three categories: Epidemiology, Evolutionary & Behavioral Ecology, and Conservation Biology. I am interested in the effects of animal behavior, ecology and infectious disease epidemiology on one another. I model disease in both human and animal populations, and am interested in how disease and disease-related behavioral ecology can affect the short-term survival and long-term evolutionary success of a population. Some of my current projects focus on the modeling of endangered populations of tortoises to determine effective courses of management, social insect populations and their susceptibility to pathogens based on their behavior and nesting ecology, the effects of stress on populations in fluctuating environments, and how best to maintain human societal infrastructure in the face of pandemic disease.

Mathematically, I am interested in Complex Systems: the mathematics of studying the conclusions or outputs of systems where each component is relatively simple (governed by a small set of logical rules), but when you put a lot of them together they react to each other and create highly organized systems and incredibly complex behaviors. Not only are these systems fascinating and beautiful by themselves, but they have direct applications to the types of biological problems mentioned above. For example, in social insect biology, individual honey bees forage for nectar and communicate information about their foraging success to foraging sister bees, but each bee decides independently for herself where to go to next and somehow, as a whole, the nest forages very (mathematically) efficiently!

Gemma Gerber



Gemma Gerber first joined IIASA as a participant in the 2022 Young Scientists Summer Program (Advancing Systems Analysis Program), and is currently a research scholar in the Biodiversity, Ecology, and Conservation Research Group of the Biodiversity and Natural Resources Program. She is strongly involved with the Assessing Climate Change Risk in EUrope (ACCREU) project addressing the impacts of projected climate change and land use on biodiversity and ecosystem services.

She holds a PhD, a master's, and a bachelor's with honors degree in Biological Sciences from the University of KwaZulu-Natal, South Africa. Gerber has extensive experience with applied ecosystem network modeling and ecological network analysis, with a particular focus on characterizing model uncertainties introduced by real-world data variability. She is well-versed in current ecological network modelling methodologies, and is the author and maintainer of R-package 'autoLIMR' – a comprehensive workflow for incorporation and evaluation of data uncertainty in ecological networks.

Susanne Hanger-Kopp

Susanne Hanger-Kopp is a researcher in the Equity and Justice Research Group of the IIASA Population and Just Societies Program. She first joined IIASA as a researcher in the former Risk and Resilience Program in 2010. Her work focuses on decision-making, governance, and risk management in the context of climate and societal changes, while her methodological focus is soft systems approaches using co-production methods, text analysis, expert elicitation, and the survey method, for which discourse analysis and cultural theory often provide a useful background.

She holds a doctoral degree from the Department of Environmental Systems Science at ETH Zurich in Switzerland and is also currently employed as a scientist and lecturer (Lehrauftrag) in the Climate Policy Group of this department. At IIASA, she leads the fairSTREAM project - an IIASA strategic initiative exploring fairness issues at the food-water-biodiversity nexus. In addition, she is the principal investigator of the WaterStressAT project, which explores climate change induced water stress through participatory modeling and contributes to

the Pathways Project to design adaptation pathways in the context of flood risk management. She is actively involved in the development of a Systems Analysis Course as part of the IIASA Capacity Development and Academic Training (CDAT) Unit, and is a chapter lead author for the Global Assessment Report for Disaster Risk Reduction 20222. Hanger-Kopp's interdisciplinary background stems from her graduate training in theoretical and applied geography at the University of Vienna in Austria where she specialized in regional development and EU policy with an emphasis on Central and Eastern Europe. She also studied romance languages at the University of Vienna and was actively involved in the foundation and running of a European Youth Media NGO for a number of years.

Stefan Hochrainer-Stigler

Stefan Hochrainer-Stigler is a senior research scholar with the Systemic Risk and Resilience (SYRR) research group at IIASA, and the leader of the Systemic Risk Analysis and Modeling theme. He is a member of the board of directors of the Integrated Disaster Risk Management (IDRiM) Society and the board of directors for the Global Alliance of Disaster Research Institutes (GADRI). Dr. Hochrainer-Stigler studied statistics with a focus on mathematical statistics at the Department of Statistics and Decision Support Systems and Sociology, empirical branch, at the Department of Sociology, University of Vienna.

His main research interests include risk management of systemic risk and extreme events such as natural disasters in developing countries, statistical (stochastic) modeling of rare and systemic events, extreme value theory, dependency of risks using copula approaches, econometrics, and multivariate analysis. He has published widely, including a number of books, book chapters and articles in major peer-reviewed journals such as Nature and Global Environmental Change. Dr. Hochrainer-Stigler is a regularly invited speaker at major scientific conferences and insurance meetings and has also facilitated and participated in high-level workshops in the Caribbean, Madagascar, Turkey, the Philippines, India and Mexico.

Jenan Irshaid

Jenan Irshaid joined the IIASA Risk and Resilience (RISK) Program as a Research Assistant in September 2015. She previously worked on the MENA Sustainable Electricity Trajectories (MENA SELECT) project that aims to provide policy makers in the MENA region with alternative options to fossil fuels. She is particularly interested in climate change mitigation and adaptation schemes in the context of sustainable socio-economic development. She worked on the coDesign (Addressing Energy Transition Gaps in Climate and Energy Model Regions of Austria Through Policy Co-Design) project exploring causes and innovative solutions for the policy implementation gap in Austrian climate and energy model regions. Ms. Irshaid further worked as a predoctoral researcher at the Institute of Science and Technology at the Alpen Adria University in Klagenfurt, where she is collaborating on the project Reflexive Governance in a Changing Climate: How to Address Uncertainties in Transformation Strategies (RefGovCC.AT), while also writing her dissertation.

Currently, Ms. Irshaid is working on conducting a Political Economy Analysis within the ScaleWays project focusing on the scaling of sustainable intensification practices in rice and fodder crop production in East African countries. Ms. Irshaid holds an MSc in Environmental Policy and Management from the University of Bristol (UK), where she specialized in statistical modeling of development indicators, the effects of resources on peace, conflict and prosperity and the implementation and management of renewable resources.

Prior to joining IIASA, Ms. Irshaid worked at the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) in Vienna and the International Climate Initiative of the Federal German Ministry for the Environment.

Nikolay Khabarov

Nikolay Khabarov joined IIASA as a research scholar in January 2007, to strengthen the team in charge of quantifying the benefits of improved Earth observations. Since then, Dr. Khabarov has been a principal investigator and contributor to a range of IIASA research projects with a particular focus on crop growth modeling, natural disasters (e.g. forest fires), assessment of climate change impacts and adaptation options, economics of adaptation, estimation of the value of information including environmental aspects, risk-optimal portfolios (e.g. technological portfolios for power generation), modeling carbon risk reduction through innovative financial tools, asset-level economic modeling and optimal land allocation for agricultural production.

Dr. Khabarov's expertise is in mathematical modeling, programming, and optimization under uncertainty. With his technical skills, Dr. Khabarov is contributing to improving the methods, tools, and technologies used by IIASA for biophysical and economic modeling at regional and global scales.

In the course of his professional activities prior to joining IIASA, Dr. Khabarov gained extensive business experience while working for private companies covering a range of industries including news and media, financial services and investment banking, legal services, marketing and trading, and information technologies.

Dr. Khabarov studied applied mathematics at the Moscow State University, Faculty of Computational Mathematics and Cybernetics, and received his Master of Science degree in 1998 and his PhD in mathematics in 2004. In his PhD thesis, Dr. Khabarov developed new efficient methods providing global fast convergence to a solution of an optimal control problem.
Dr. Khabarov has been involved in over 20 international research projects including Global Earth Observation - Benefit Estimation: Now, Next and Emerging, (GEO-BENE), Methodology for Effective Decision-making on Impacts and Adaptation (MEDIATION), the Agricultural Model Intercomparison and Improvement project (AgMIP/GGCMI), and the Economics of Climate Change Adaptation project (econadapt.eu). Dr. Khabarov is an author of more than 100 scientific publications including book chapters and reports.

Paul Kishimoto

Paul Natsuo Kishimoto is an IIASA Postdoctoral Research Scholar in the Energy (ENE) and Transitions to New Technologies (TNT) programs, with a research focus on transportation demand growth in emerging economies; consequent energy demand and environmental impacts; and technology and policy for sustainable mobility.

He joined IIASA in August 2018, after completing his PhD in Engineering Systems and SM in Technology and Policy at the Institute for Data, Systems, and Society and the Joint Program on the Science & Policy of Global Change at the Massachusetts Institute of Technology. His dissertation work focused on freight and passenger transport in China, developing and applying computable general equilibrium and econometric methods to characterize and project transport demand, energy use, and emissions of greenhouse gases and local air pollutants.

Dr. Kishimoto is interested in data, methods, and models that can be used to understand uncertain trends, emerging technologies, and new policies in transport. At IIASA, he is involved in improving the treatment of travel behavior and consumer decisions in the MESSAGEix global integrated assessment model, and in using household-level microdata from national-level social services to better characterize individual mobility and its relationship to urban and transport-system context.

He previously studied aerospace engineering at the University of Toronto, and in 2013, was a visiting scholar at the Institute of Energy, Environment and Economy at Tsinghua University.

Elisa Omodei

Elisa Omodei is an Assistant Professor at the Department of Network and Data Science at the Central European University. She holds a BSc and a MSc in Physics from the University of Padua and Bologna, respectively, and a PhD in Applied Mathematics for the Social Sciences from the École Normale Supérieure (ENS) of Paris. She carried out her postdoctoral training at the Rovira and Virgili University in Tarragona, Spain. She then spent over four years at the United Nations, first at UNICEF's Office of Innovation in New York and then at the UN World Food Programme in Rome. In her research, she explores how complexity and data science can help us address the needs of the most vulnerable populations and monitor the UN Sustainable Development Goals. She also served as Vice-President Secretary of the Complex Systems Society from 2018 to 2021.

Fernando Orduña-Cabrera

Fernando Orduna-Cabrera is a research scholar jointly associated with the Novel Data Ecosystems for Sustainability and the Exploratory Modeling of Human-Natural Systems research groups of the IIASA Advancing Systems Analysis Program. He studied Computer Science Engineering and obtained a Master of Science in Computer Science at the National Technological Institute of Mexico (NTI) and a PhD in Artificial Intelligence at the Polytechnic University of Catalunya, Spain. He was a titular professor at the NTI campus in Cajeme, Mexico, for 15 years. He was the coordinator of the Advanced Research Center and a member of the postgraduate council board. The General Direction University Education awarded him a researcher and teaching profile in Mexico.

He has experience developing machine learning algorithms and is collaborating with the Food, Agriculture, Biodiversity, Land-Use and Energy (FABLE) Consortium, developing tools to manage, analyze, and improve the FABLE tools, including the Scenathon and FABLE Calculator. He is also collaborating on the development of SmartLinker Architecture to harmonize commodities trade in the FABLE Consortium. The new developments are in the field of deep learning. He recently introduced deep learning methods in remote sensing for crop-type recognition. His research interests include machine learning, clustering, deep learning, multi-agent systems, and decision support systems.

Elena Rovenskaya

Elena Rovenskaya is the IIASA Advancing Systems Analysis (ASA) Program Director. She is also a research scholar at the Optimal Control Department of the Faculty of Computational Mathematics and Cybernetics, Lomonosov Moscow State University, Russia (on-leave). Her scientific interests lie in the fields of optimization, decision science, and mathematical modeling of complex socio-environmental systems.

Dr. Rovenskaya graduated in 2003 from the Faculty of Physics, Lomonosov Moscow State University, Russia. She received her PhD in 2006 at the Faculty of Computational Mathematics and Cybernetics, Lomonosov Moscow State University, Russia. In her PhD dissertation, Dr. Rovenskaya developed a new numerical method for solving a broad class of non-convex optimization problems.

In 2005, Dr. Rovenskaya participated in the IIASA Young Scientists Summer Program (YSSP). She continued to collaborate with the former Dynamic Systems (DYN) Program from 2006 to 2010, and later, from 2011 to 2012 with its successor, the Advanced Systems Analysis (ASA) Program at IIASA. From 2013 to 2020, Dr. Rovenskaya served as ASA Program Director and from 2019 to 2020, she was also appointed in the capacity of Acting IIASA Evolution and Ecology Program Director.

Dr. Rovenskaya was appointed Advancing Systems Analysis (ASA) Program Director from January 2021 as the institute moved to a new program structure. Currently, the new ASA Program includes 85+ scientists and aims to identify, develop, and deploy new systems-analytical methods, tools, and data that address the most pressing global sustainability challenges with greater agility, and help find solutions to those challenges that are both realistic and appropriate.

Marcial Sandoval-Gastelum

Marcial Sandoval Gastelum is a researcher in the Exploratory Modeling of Human-Natural Systems (EM) group at the International Institute for Applied Systems Analysis (IIASA). His primary research interest lies in advancing artificial intelligence, with a focus on developing and applying state-of-the-art deep learning architectures for addressing climate change.

He has over six years of experience in the artificial intelligence field and holds a Master's degree in Computer Science from the Universidad Autónoma de Baja California in Mexico. Additionally, he has specialized in deep learning and natural language processing through certifications from DeepLearning.ai.

Marcial has accumulated extensive expertise in various deep learning architectures applied across multiple domains. During his master's degree studies, his research journey included contributions to human action recognition using inertial data and classical artificial intelligence techniques. As a guest researcher at IIASA during his master's degree studies in 2019, he contributed to developing a crop type image recognition system using convolutional neural networks. After completing his master's degree, he collaborated with University College London (UCL) on research related to human action recognition using graph convolutional neural networks.

Currently, he is involved in developing SmartLinker, a multi-agent, multi-objective reinforcement learning algorithm for land use modeling within the FABLE consortium. His current research focuses on applying state-of-the-art deep learning architectures such as Deep Q-Learning, Transformers, and large language models to address climate change.

Fabian Wagner

Fabian Wagner is the Dean of Capacity Development and Academic Training (CDAT) at IIASA, and a principal research scholar in the Energy, Climate, and Environment Program. In addition to being associate faculty at the Complexity Science Hub, he is also editor-in-chief of the journal *npj Clean Energy*, an open access journal of the Nature Portfolio.

His research interests include the socioeconomic and environmental implications of mitigation technologies, including energy savings, renewables, and district heating, but also generally public health co-benefits and interactions of the Sustainable Development Goals (SDGs). Wagner is experienced in science policy, strategic planning, and research evaluation, and serves in a variety of advisory roles with national and international organizations.

Between the years of 2014 and 2016, Wagner was the Gerhard R. Andlinger '52 Professor for Energy and the Environment at Princeton University's Andlinger Center for Energy and the Environment, and the Princeton School of Public and International Affairs. Before joining IIASA in 2004, he was a researcher with the Intergovernmental Panel on Climate Change (IPCC) located at the Institute for Global Environmental Strategies (IGES) in Hayama, Japan. Prior to that, he was a postdoc with the International Energy Analysis Group at the Lawrence Berkeley National Laboratory (LBNL). From 2020 to 2024 he served as editor-in-chief of the journal *Mitigation and Adaptation Strategies for Global Change* (Springer Nature).

Wagner received both his PhD (theoretical physics) and two master's degrees (mathematics, history, and philosophy of science) from Cambridge University, UK. In 1998, he won the J.T. Knight's Prize in mathematics from Cambridge University.

Caroline Zimm

Caroline Zimm is a research scholar jointly associated with the Transformative Institutional and Social Solutions (TISS) Research Group of the IIASA Energy, Climate, and Environment (ECE) Program and the Equity and Justice (EQU) Research Group of the Population and Just Societies (POPJUS) Program.

She currently works on the international research initiatives of the Earth Commission of the Global Commons Alliance, and leads the IIASA Strategic Initiative, Just Transitions to Net-zero Carbon Emissions for All (JustTrans4ALL). Her research is concerned with the diffusion of technologies and policies for sustainable development, inequalities across countries, and transformative development pathways for humanity within a stable Earth system.

Prior to joining IIASA in 2014, she worked in development cooperation and on consulting projects in the field of rural energy supply, energy access, and climate change. She held positions with the United Nations Industrial Development Organization (UNIDO), a private consulting firm, and the German Development Agency (GIZ) where she was based in Cambodia and India.

Zimm received her PhD from the University of Technology in Vienna, Austria (Energy Economics Group), focusing on the early stage of electric vehicle diffusion. She holds a master's degree in environmental and resource management from the University of Applied Life Sciences Vienna, where she majored in renewable energies, a diploma (MBA. equiv.) in international business administration from the University for Economics and Business Administration Vienna, and a bachelor's degree in political science from the University of Vienna.

Venues and logistics

Austrian public transportation

Within Vienna, you will need to buy a public transportation ticket from "Wiener Linien". We recommend to download the Wien Mobil app https://www.wienerlinien.at/web/wl-en/wienmobil-features. The price for a weekly pass is 19.70€ (digital ticket)/22.60€ (paper ticket, transferable). The weekly tickets will be valid as of time of purchase. To go to Laxenburg, you will need to buy another ticket for the bus/train. In order to purchase a ticket valid for both Vienna and Laxenburg we recommend to either do so at one of the information points at Vienna Central Train station or via the ÖBB Scotty App: https://www.oebb.at/en/fahrplan/fahrplanauskunft/scottymobil. A weekly ticket for both the Vienna and Laxenburg journey costs around 38€.

Sim card

You may wish to purchase a SIM Card upon arrival to have internet access on the go. Some supermarkets and other providers also have cheap options: Hofer, Spar S-budget, Yesss!

Important to note about Austria

Every Sunday and on official holidays, all stores/banks, etc, in Austria are closed!
On Sundays, only some grocery stores such as at the airport or train stations Westbahnhof, Hauptbahnhof, Franz-Josefs Bahnhof are open (with a limited selection of what you can buy). So you will have to do your shopping during the week or Saturdays. Stores are also not open 24/7, be sure to google their opening hours! https://www.visitingvienna.com/shopping/opening-hours/. Furthermore, depending on where you're coming from in the world, please don't forget to pack a travel adapter [with voltage converter if needed] for your electronic devices. You may wish to bring an extension cord with multiple outlets from your home country – then you can plug it into the Austrian outlet/socket with your adaptor and charge multiple devices at once.

Getting to Laxenburg

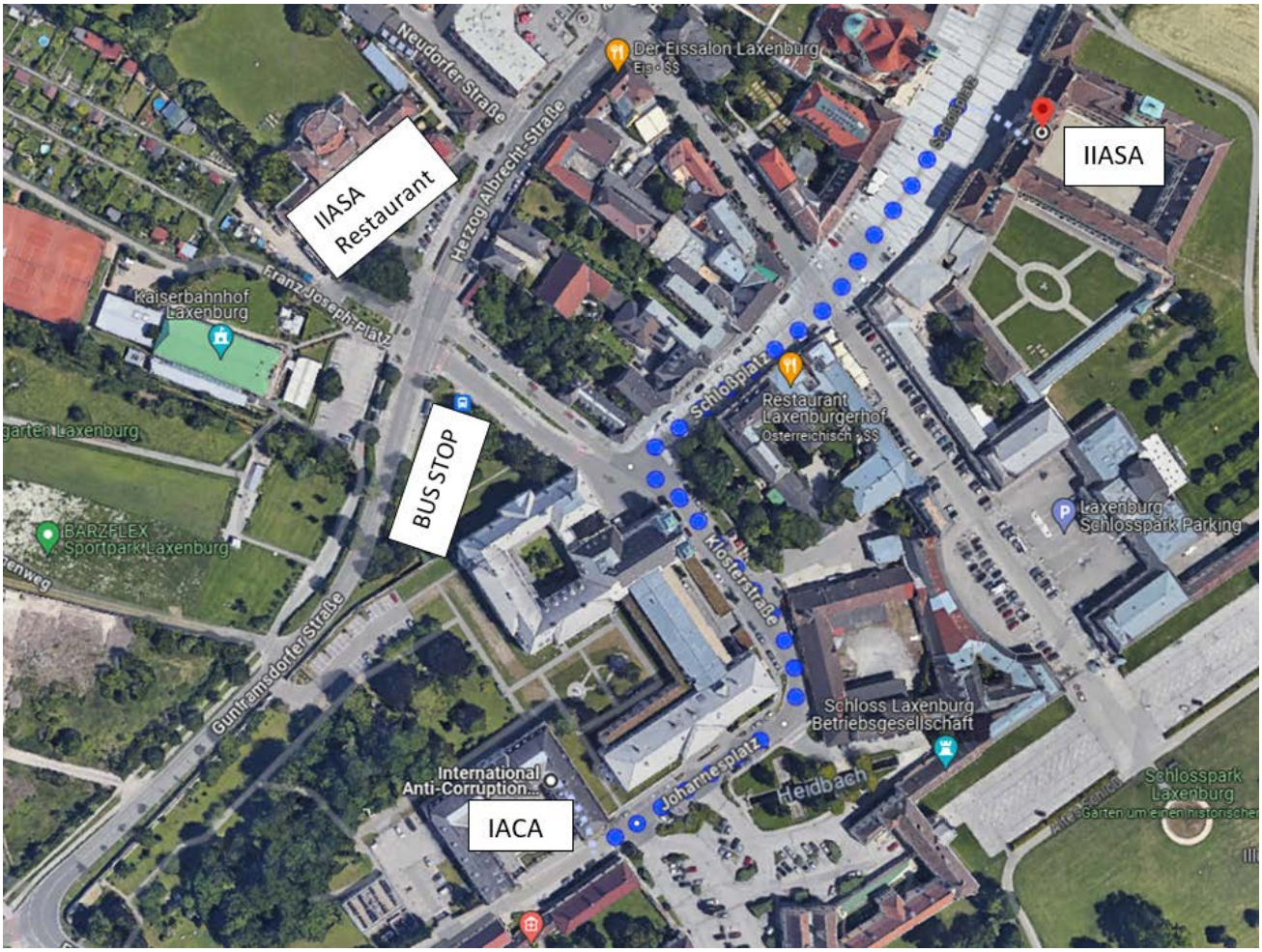
Vienna and its surroundings are well served by public transport. Many apps can help you navigate: Google Maps, Citymapper, ÖBB, ÖBB Scotty, VOR AnachB, WienMobil. Do not hesitate to use them to find your way!

There are two main ways to reach IIASA/IACA with public transport from Vienna. The most convenient for newcomers is the 200/210 bus lines, which depart from the central train station Wien Hauptbahnhof every 30 min at H:00 and H:30. For example, if you take the bus at 8:00 AM, you arrive in Laxenburg at 8:34 AM. The stop for IIASA and IACA is Laxenburg Franz Josef Platz, which is about 5 min walking distance to the institutes. In Wien Hauptbahnhof, the bus departs from platform N2 located outside of (and underneath) the train station. If you arrive to Wien Hauptbahnhof by subway (U-Bahn) or local train (S-Bahn), follow the bus signs to reach the regional Bus Terminal.

Another way is the regional train R95 with destination Traiskirchen Aspangbahn Bahnhof. It runs every hour at H:24 and stops at Laxenburg-Biedermannsdorf Bahnhof, which is 15 min walking from IIASA
You can find more information here: https://iiasa.ac.at/how-to-find-us

BUS STATION AT VIENNA CENTRAL TRAIN STATION

VENUES IN LAXENBURG



The walk from IACA to IIASA takes approximately 5 mins

Venue 1: IACA Information

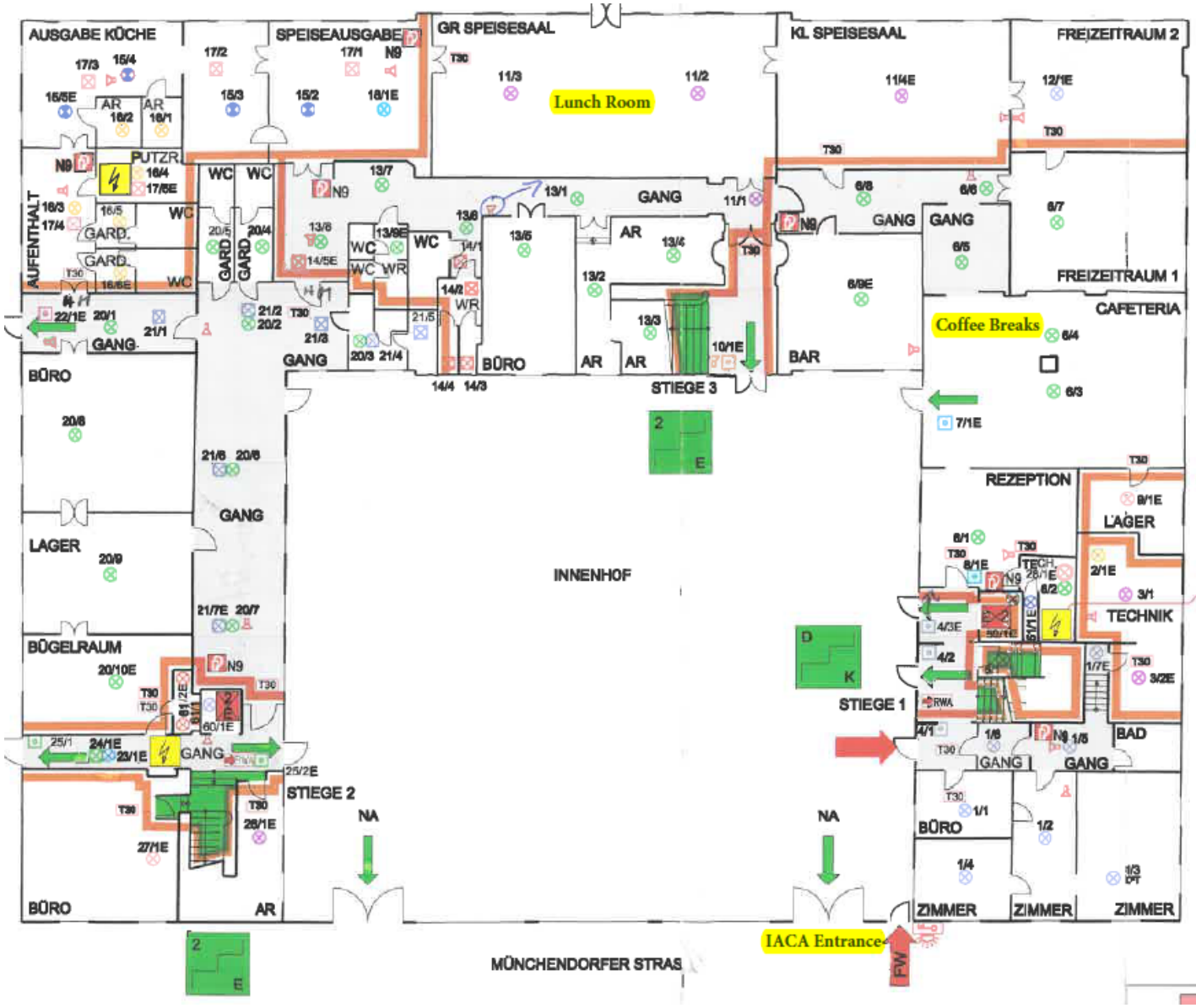
Wifi Information:

Name: IACA_Guest

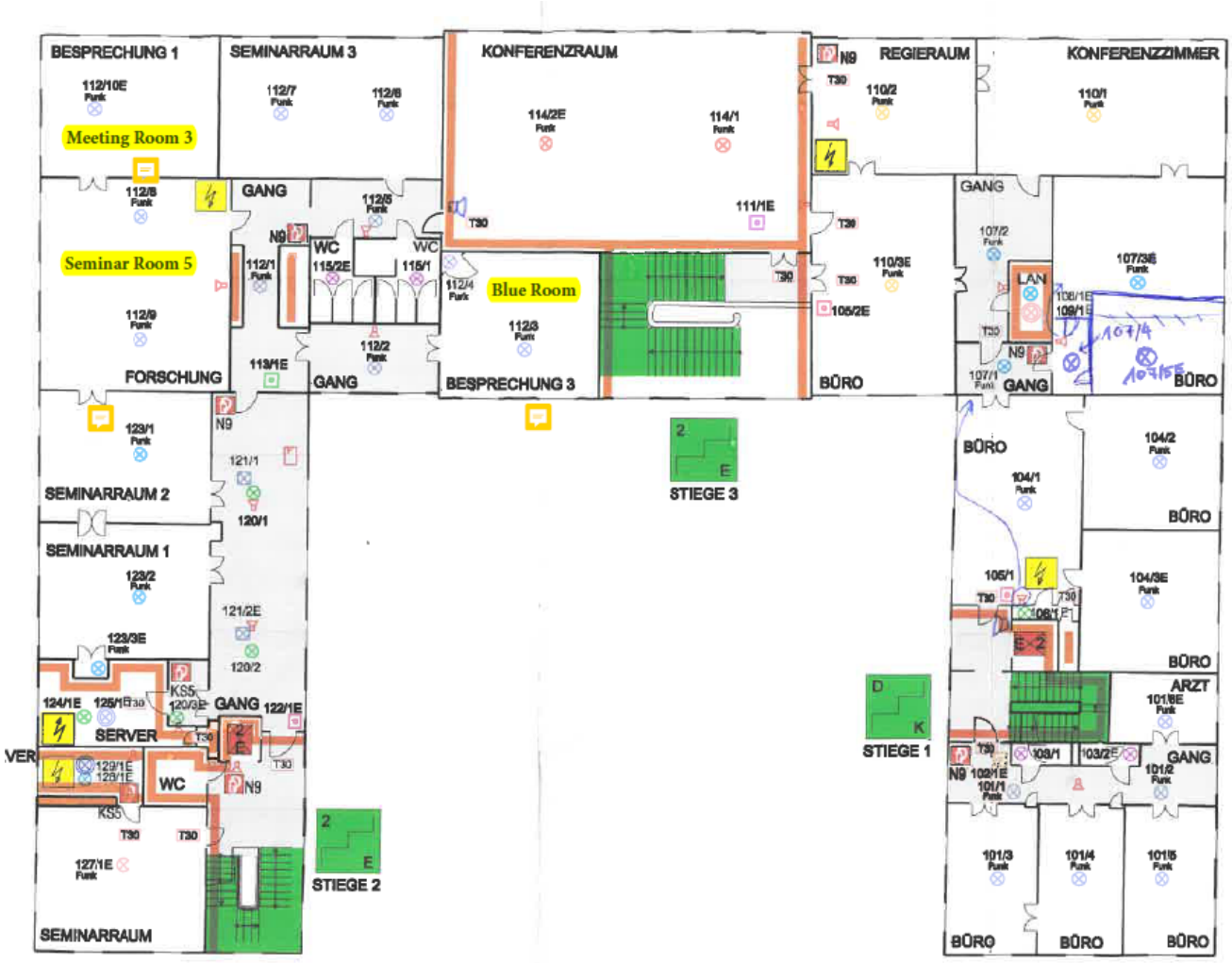
Password: Iaca_2021

Coffee breaks and lunch will be served in the marked rooms on the ground floor. The summer school classroom is located on the first floor – main room is “Seminar Room 5” with breakout group hosted in Meeting Room 3 and Blue Room. All relevant rooms are highlighted in yellow.

IACA Floorplan Ground Floor



IACA Floorplan – First Floor

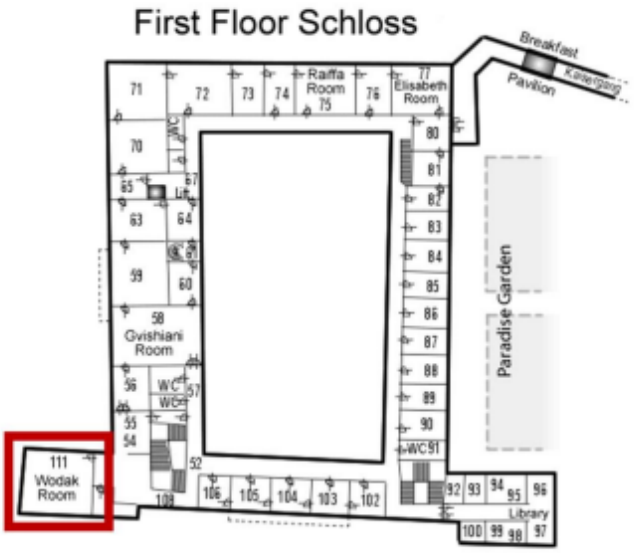


Venue 2: IIASA

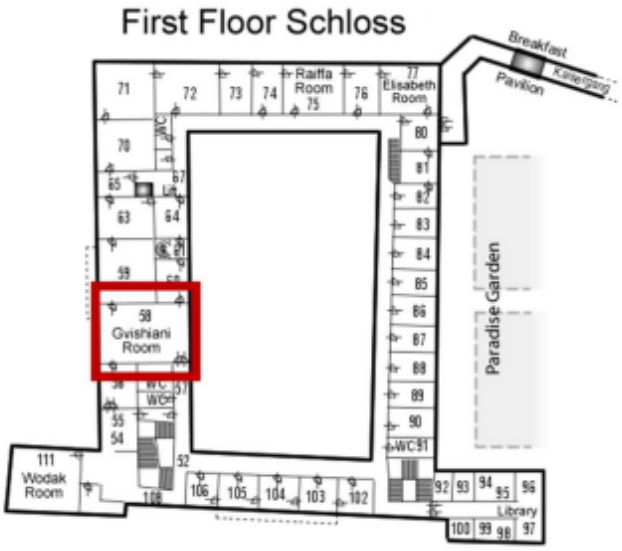
If you have an *eduroam* account, feel free to use the Wireless SSID "eduroam". Otherwise[1] choose the **IIASAguest** network and click the Connect button. Your device should automatically start your favorite browser. You should get the Login window instead of your configured home page. If you did not get it, please enter the URL https://iiasa.ac.at/ or http://1.1.1.1/. **Username: summerschool, Password: July2024**

Location of IIASA Meeting Rooms

Wodak Room – S111

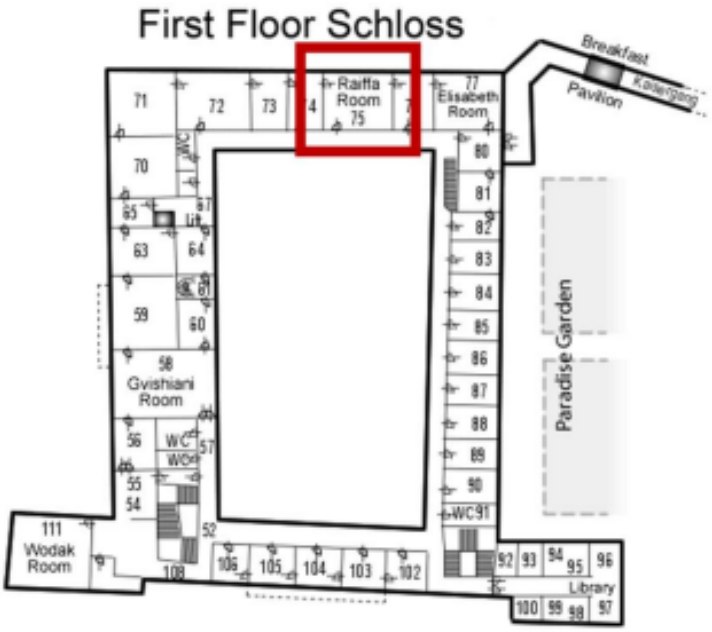


Gvishiani Room – S58

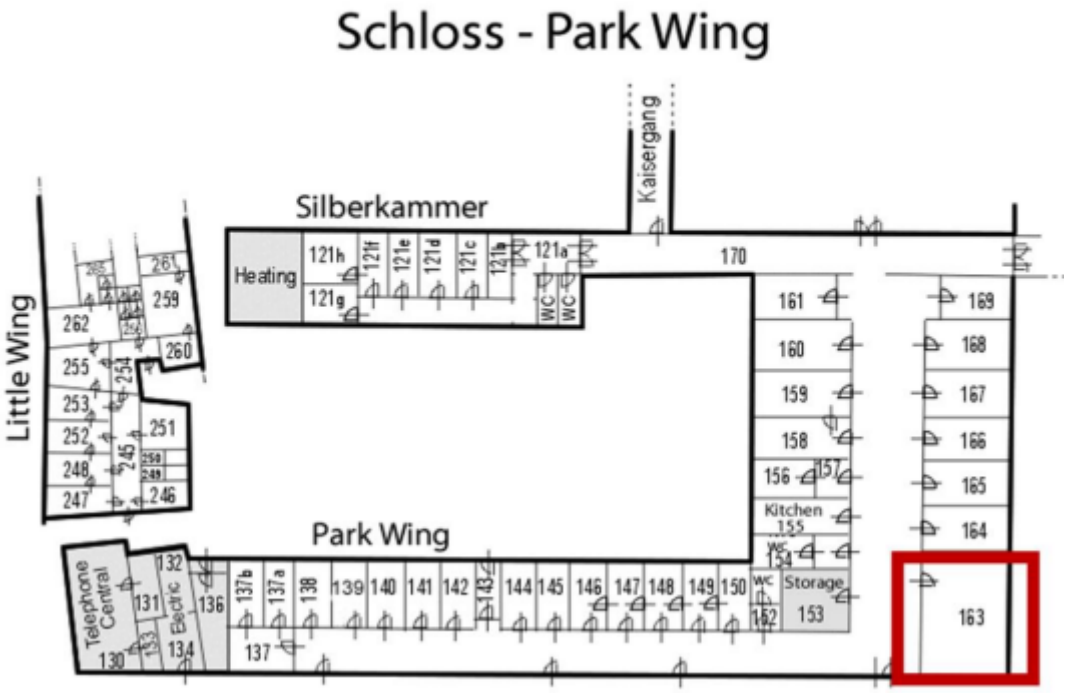


[1] The settings of the IIASAguest wireless network connection has to be: Network Authentication: Open Data Encryption: Disabled. The IIASAguest SSID is behind our firewall and provides controlled access to the Internet/

Raiffa Room – S75



Holling Room (former Environment Room) – S163



Levien Room (former SLBG Room) – S8