Workshop HETEROCLIM

'The response of organisms to climate change in heterogeneous environments.'

June 10-14, 2014
Loches, France

contact : heteroclim@univ-tours.fr

AGENCE NATIONALE DE LA RECHERCHE ANR
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Fire service : 18
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Program

	Time	Event
Tuesday 10	PM	Arrivals & Registrations
	20:00	Welcome drink at Luccotel
	20:30	Dinner at Luccotel
Wednesday 11	08:45	**Welcome and general presentation of the workshop** *Sylvain Pincebourde*
	09:00	**Introductory talk** The new thermal biology: building a predictive theory for real problems – *Michael Angilletta*
		Session S1 opening **Connecting global and local climate change**
	10:00	**S1.T1** The 'true' climate that acts on plant species and their range limit – *Christian Körner*
	10:40	Coffee break
	11:10	**S1.T2** Ecological implications of the mismatch between macro- and micro-climates in ectotherms – *Sylvain Pincebourde*
	11:50	**S1.T3** Thermal socio-ecology? Insights from pest management in agricultural landscapes – *Olivier Dangles*
	12:30	**S1.T4** A global model of leaf microclimates during climate change: implications for insect performance – *Arthur Woods*
	13:10	Lunch at Luccotel
	14:40	**S1.T5** Climate refugia and scale: How complex terrain and microclimatic variation shape the velocity of climate change – *Solomon Dobrowski*
	15:20	**S1.T6** Combining large-scale vegetation plot databases with a plant-community-based approach to assess fine-grained thermal variability within 1-km2 spatial units across Northern Europe – *Jonathan Lenoir*
	16:00	**S1.T7** Statistical downscaling models: Why? How? & What's next? – *Mathieu Vrac*
	16:40	**S1.T8** Stochastic weather generators: what are they good for? – *Dennis Allard*
	17:20	Coffee break

Wed. 11	17:50	**Training** Presentation of a global microclimate dataset – *Michael Kearney*
	20:00	Dinner at Luccotel

Thursday 12		**Session S2 opening** **Modeling distributions and processes**
	09:00	**S2.T1** Dealing with uncertainty in the era of climate change: when do "the details" matter? – *Brian Helmuth*
	09:40	**S2.T2** Climatic constraints and the thermodynamic niches of organisms – *Michael Kearney*
	10:20	Coffee break
	10:50	**S2.T3** Macroscale modelling of ecosystem function - *Colin Prentice*
	11:30	**S2.T4** Impacts of global change on different facets of biodiversity - from static to dynamic modeling of biodiversity - *Wilfried Thuiller*
	12:10	**S2.T5** Understanding species distributions across scales: where biogeography meets community ecology – *Miguel Araújo*
	12:50	Lunch at Luccotel
		Session S3 opening **Thermal performance of organisms in fluctuating environments**
	14:20	**S3.T1** Amphibian body temperature along tropical altitudinal gradients: climatic heterogeneity at individual scale – *Carlos Navas*
	15:00	**S3.T2** Energetic fitness: linking metabolic effort with Darwinian fitness in birds exposed to climate change – *David Grémillet*
	15:40	Coffee break in poster room
	16:00	**Poster session**
	20:00	Dinner at Luccotel

Friday 13	**Session S3 continuing Thermal performance of organisms in fluctuating environments**	
	09:00	**S3.T3** Ecological responses to environmental fluctuations: means, variances and extremes – *Lisandro Benedetti-Cecchi*
	09:40	**S3.T4** Cycles, chance, and scale-dependent noise: challenges to defining the nature of thermal variations – *Mark Denny*
	10:20	Coffee break
	10:50	**S3.T5** The distribution implications of local adaptation in current and future environments – *Lauren Buckley*
	11:30	**S3.T6** Phenotypic plasticity in fluctuating and unpredictable environments: adding ecological relevence to the experimental study of life history traits – *Volker Loeschcke*
	12:10	**S3.T7** Evolutionary responses of insects to climate variability and climate change – *Joel Kingsolver*
	12:50	Lunch at Luccotel
	14:20	**Workshops: sub-group discussion on topics**
	15:50	Coffee break
	16:30	**General discussion and synthesis** Discussing new challenges in global change ecology.
	18:00	End of the workshop
	Evening	Dinner at the Luccotel and drinks in town
Sat. 14	AM	Departure

Global Aim of the Conference

Global aim of the conference

Our general aim is to bring together leading scientists from various key disciplines to promote interconnections between their different expertise and skills, with the ambition to stimulate the emergence of new developments related to scale issues in thermal ecology. Such advances are necessary to anticipate and attenuate the impacts of global warming on ecological systems and societies.

Keywords: Microclimate; Spatial scaling; Thermal heterogeneity; Variance; Thermal sensitivity; Species distribution models; biophysical ecology; Climate change; Biological conservation; Agronomy.

General context of the conference

Past and ongoing global warming has dramatic impacts on ecological systems, including species distributions, extinction of populations and species and biodiversity. The societal and economical consequences of these climate-related ecological shifts are also documented. The urgent need to accurately forecast, qualitatively and quantitatively, the ecological impacts of global change is now obvious if we are to anticipate the consequences for land use, management of pests and invasive species, as well as conservation and agriculture. This need has led researchers to develop various conceptual and technical methods that aim at linking environmental variables such as temperature with biological characteristics of organisms like growth and mortality as well as species interaction strength. Overall, these methods involve multidisciplinary approaches to integrate atmospheric sciences, bioclimatology, physics, organismal eco-physiology, population dynamics and food web functioning, all based on important mathematical and computer sciences developments. Our predictive power to accurately anticipate the climate change effects depends therefore on our ability to integrate these multiple disciplines.

Very recently, scientists working on climate change biology realized that the environmental heterogeneity could be an important ecological driver because, theoretically, organisms can move within local/regional spatial scales to find suitable micro-habitats as climate is changing, buffering thereby the amplitude of global warming. Thermal environments are not only quite heterogeneous in the natural habitat for most - if not all - species, but they are also extremely variable through time. The workshop proposes to establish a state-of-the-art on both concepts and methods developed today by researchers to connect the thermal variations at various spatial scales, from global circulation models (GCM) down to organism body, and to identify and predict the ecological consequences of climate change based on the performance of organisms in fluctuating climates. Such approach should incorporate knowledge from diverse fields, including atmospheric sciences, thermal biology, animal and plant eco-physiology, as well as species distribution modeling and organisms' energy budgets. Such methods can be used to forecast the direction and the amplitude of climate change impacts on any biological system. *By bringing together a broad panel of scientists from different disciplines, this conference aims at promoting the development of global change biology.* The conference structure involves 3 interconnected sessions.

Session 1 - Connecting global and local climate change

This session will focus on the level of climatic heterogeneity at various spatial scales, from the large scale corresponding to the grid size of a GCM down to the local and microhabitat scale in which species are living. The microclimate of species will appear central in this session. This session will cover the latest development on computational modeling of multidimensional climatic models that attempt to interconnect the spatial heterogeneities at several spatial scales down to the scale at which organisms are living. The aim is to stimulate the use of such models by ecologists to downscale climatic variables to the scale of the organisms.

Session 2 – Modeling processes in space and time

Forecasting ecological impacts of climate change necessitates that we develop predictive tools. Currently, two kinds of approaches are used: statistical and mechanistic methods. These models usually are mixing concepts from various disciplines such as ecology, physiology, the physics of thermal transfer, statistics, programming, etc. There is an urgent need to increase our knowledge on the mechanics by which climatic stresses affect interconnected populations, communities, and ecosystem processes and to try to incorporate this knowledge into the predictive framework of climate change. The conference will bring together scientists from the two fields (statistical vs. mechanistic modeling) with the aim to stimulate a debate on the possibility to develop mixed models that could provide innovative predictive framework of species assemblage response to climate variability and open-up new exciting avenues in this field of research.

Session 3 - Thermal performance of organisms in fluctuating environments

In their natural habitat, organisms experience fluctuating rather than constant environmental conditions. Fluctuations can occur at different spatial and temporal scales. There are at least two challenges to identifying the ecological effects of climate-induced thermal stress. First, the impact of stress on the physiological ecology of organisms is often estimated via experiments conducted under constant conditions. There is concern – and debate – about the pertinence of using thermally constant treatments to estimate the influence of fluctuating temperature on ecological processes. Second, organisms are exposed to multiple stresses in their natural habitat. Nevertheless, the level of stress for each environmental variable fluctuates in time and space, and different stresses are correlated with each other to varying degrees. Very recent studies offer promising advancements in how we can incorporate such temporal dimension into climate change models. This session will provide attendants with the latest advancements on the ecological and physiological responses of organisms to fluctuating conditions. How are thermal sensitivities of organisms pre-determined by environmental fluctuations? This question is central to global change biology and the conference will attempt to give latest insights into it.

Scientific committee:

Dr. Sylvain PINCEBOURDE (CR CNRS) [organizer[1]],
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Prof. Jérôme CASAS (IRBI, Université de Tours, 37200 TOURS)[3],
Prof. Brian HELMUTH (Northeastern University, Nahant, Boston, USA)[4].

Organizing committee:

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Plenary & talks

Wednesday 11 June 09:00 – Plenary talk

Prof. Angilletta Michael

School of Life Sciences,
Arizona State University,
Tempe, AZ, USA.

The new thermal biology: building a predictive theory for real problems

***Michael J. Angilletta Jr.*[1]**, *Lauren B, Buckley[2], Tim H. Keitt[3], Adam Leache[2], Ofir Levy[1], and Michael W. Sears[4]*

The growing interest in economic and environmental impacts of global warming has thrust thermal biologists into the spotlight. As if explaining thermal adaptation in past climates wasn't hard enough, policy makers, lay people, and other scientists would like us to tell them how warming will affect biodiversity decades from now. My talk addresses three major challenges to forecasting the impacts of climate change. First, we must scale from the macroclimates derived from global circulation models to the microclimates experienced by organisms. This challenge requires us to downscale climatic data from a resolution of 1000 km to a resolution of 1m (or less). Then, we must use these microclimates to infer acute and chronic effects on organismal performance. This second challenge requires us to design experiments in which thermal conditions correspond to likely ecological scenarios. Finally, we must aggregate performances of organisms to predict the dynamics of metapopulations, communities, and ecosystems. This third challenge requires us to formulate individual-based models and parameterize these models with data from many sources. To meet these challenges, I unwittingly journeyed between two points in my career - from a researcher who studies the thermal ecology of lizards to a member of an interdisciplinary team that integrates climate modeling, organismal biology, and landscape ecology. This talk tells the story of that journey, highlighting the research that my collaborators and I are currently pursuing.

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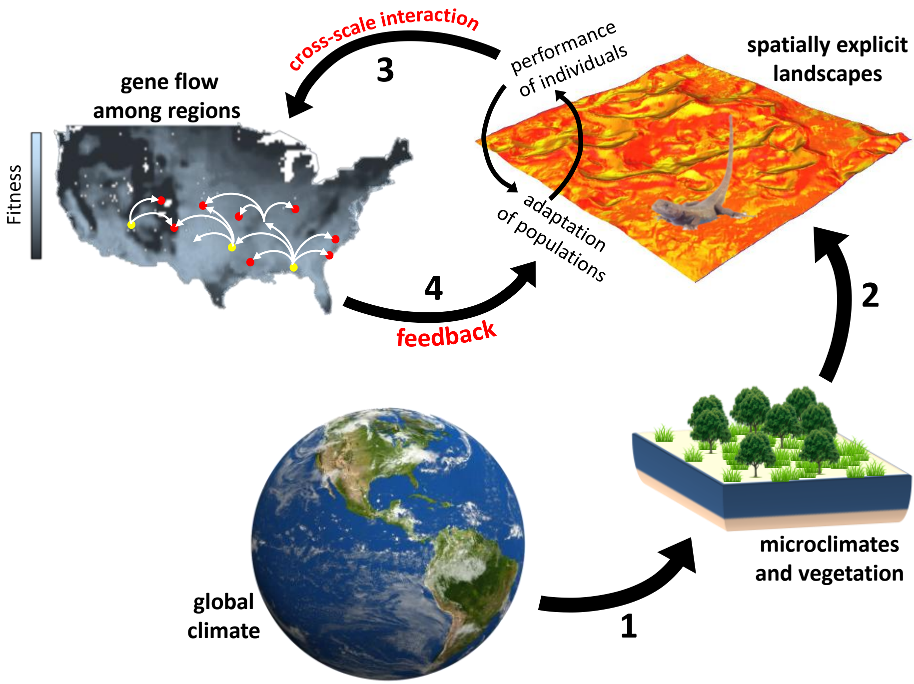


Angilletta and his collaborators are studying the impacts of climate warming on terrestrial ectotherms. This work involves downscaling global climate to microclimates (1), modeling the performance of organisms (2), inferring sources and sinks of regional gene flow (3), and projecting adaptation to local conditions (4). This macrosystems approach enables one to consider interactions and feedbacks across scales, mediated by gene flow from source to sink populations that affects adaptation to local climates.

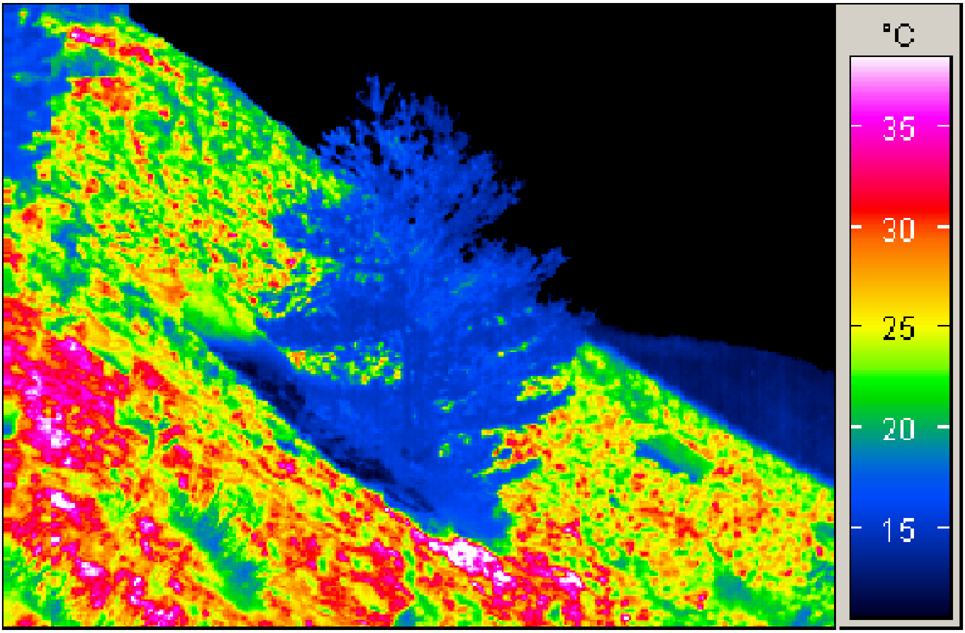
Wednesday 11 June 10:00 – Session 1 Talk 1

Prof. Körner Christian

Institute of Botany,
University of Basel,
Basel, Switzerland.

The 'true' climate that acts on plant species and their range limit

Most plants, small animals and microbes are living in a world not well described by conventional meteorological data and they reach range limits most commonly set by climate conditions not really known. In order to explain species distribution, the true life condition need to be assessed at the spatial and temporal scale at which the crucial biological processes take place. In this presentation, I will focus on thermal limitations. When temperature comes into play, the biologically relevant time scale is at least an hour or less. The single coldest hour in a century may be decisive for the presence or absence of a species. Ecologist should refrain from using monthly or annual data and a clear distinction is to be made between the action of extremes and means or thermal sums. Similar with space, the decisive processes occur at the scale of meters rather than square kilometers or larger. In this presentation I will illustrate the critical role of topography and plant stature on microclimate. Examples will include alpine and arctic environments, the climatic treeline and the low temperature range limits of deciduous tree taxa.



No question, organisms do in large not experience the climate weather stations report. Thermal imaging permits mapping the heterogeneity of climatic conditions in the landscape. This image was taken on a steep slope in central Switzerland on a bright day in summer and illustrates a broad spectrum of temperatures experienced by vegetation that would never be captured by weather station data. This departure of microclimate from macroclimate is not only topography related but is strongly affected by plant morphology and plant density.

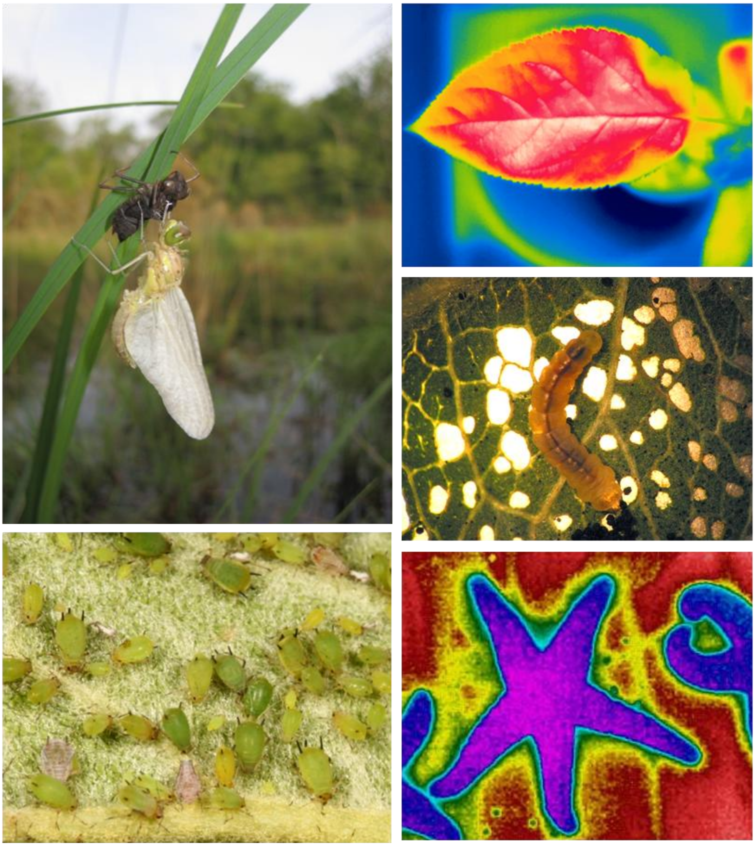
Wednesday 11 June 11:10 – Session 1 Talk 2

Dr. Pincebourde Sylvain

Institut de Recherche sur la
Biologie de l'Insecte,
UMR 7261, CNRS,
Tours, France.

Ecological implications of the mismatch between macro- and micro-climates in ectotherms

Organisms do not necessarily experience climatic conditions as measured at global scale by our meteorological stations. Instead, they live in microhabitats with specific climatic conditions—the microclimates. For most species, microclimates can deviate substantially from global weather. Despite the complexity of the multiple interacting factors that determine those microclimates, the tools necessary to comprehend and model them are available today. The aim of this presentation is to show the necessity for integrating microclimates into ecological frameworks to increase our ability to forecast climate change impacts on ecological processes. I use a combination of examples from our lab to highlight several key processes that are driven by microclimates. (i) Experienced microclimates directly determine the warming tolerance of insects. (ii) Microclimate heterogeneity interact with the body size of organisms to define their thermoregulatory space across spatial scales, from the scale of a single leaf surface for spider mites to the scale of a local landscape for tropical ectotherms. (iii) The temporal coincidence of multiple microclimatic factors affects biotic interactions as much as the variance and the mean of each factor. Along those examples taken from the marine, freshwater and terrestrial biota, we suggest that the huge variability of microclimates in space and time can potentially be a lever for species to buffer part or all of the amplitude of climate change just by moving within the smallest spatial scales. This effect would make species more resilient to global warming than previously expected.



Integrating microclimates and thermal ecology of ectotherms. We study the microclimate of various species, including dragonfly larvae, aphids on apple leaves, endophageous insects such as a leaf miner, and the ochre sea star in North America. Our aim is to determine to what extent the microclimate of species allows them to buffer the amplitude of global change. Our approach is purely mechanistic, by integrating biophysical models of heat transfers, thermographic measurements and eco-physiological recordings. The comparison of multiple biomes (freshwater, intertidal, plant leaves) allows us to classify microhabitats from the best buffer of global climatic change to the ones with the smallest inertia. From a microclimate point of view, the microclimate of an intertidal sea star resembles more the microclimate of a leaf mine than that of a dragonfly larvae in a pond!

Wednesday 11 June 11:50 – Session 1 Talk 3

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Dr. Dangles Olivier

Biodiversity and evolution plant/insect-pest/antagonist complexes, UR 072, IRD, Gif-sur-Yvette, France.

Thermal socio-ecology? Insights from pest management in agricultural landscapes

Olivier Dangles[1,2], François Rebaudo[1], Émile Faye[1], and Verónica Crespo-Pérez[2]

Despite increasing inputs of pesticides, current figures for global crop losses still show that agricultural pests are reducing food availability and security considerably. Pests globally consume the amount of food sufficient to feed more than 1 billion people. Worldwide, uncertainty related to temperature heterogeneity, variability, and extremes, is a key obstacle to the development of efficient agricultural pest control strategies. Thermal characteristics of agricultural landscapes are influenced by both environmental and human activities (e.g., density of crop storages) so that a sound understanding of the relationship between pest dynamics and thermal landscape heterogeneity needs integrating both ecological and social dynamics in a common approach. Over the last decade, our team has developed a multi-tool framework for the study of the "thermal socio-ecology" of agricultural pests. Our approach combines several fields of research that have emerged independently during the last decade to face the challenge of predicting responses of social and ecological systems to global changes: the ecology of thermal landscapes, the development of variable temperature-dependent population dynamics, and the adaptive management in pest control. Our methodological framework includes a wide array of methods from continental-scale participatory monitoring of pests to field measurements using broad-scale temperature metrology (thermo-radiography fixed on unmanned automated vehicle) to modeling (individual-based models and agent-based models). Overall, our approach gathers into the same framework scientists, resource managers, and farmers, so that a truly integrated approach of pest management in thermally uncertain and fluctuant socio-ecosystems could emerge.

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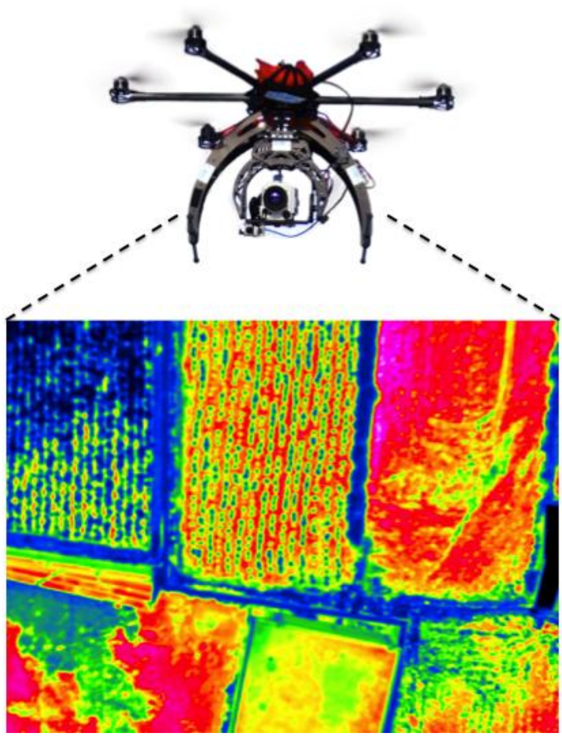

Worldwide, uncertainty related to temperature heterogeneity, variability, and extremes, is a key obstacle to the development of efficient agricultural pest control strategies. Our team develops a multi-tool framework of adaptive management in insect pest control in the context of climate change and variability in the tropical Andes. As one of this tool, we fly an unmanned aerial vehicle equipped with a thermal camera over agricultural fields to measure the spatial heterogeneity in crop canopy temperatures, which we then relate with pest abundance at a local scale. High-resolution airborne thermal imagery enables the assessment of discontinuous canopies as plant crowns can be targeted, thus eliminating the background effects.

Wednesday 11 June 12:30 – Session 1 Talk 4

Prof. Woods Arthur

Division of Biological Sciences,
University of Montana,
Missoula, MT, USA.

A global model of leaf microclimates during climate change: implications for insect performance

H. Arthur Woods[1] and Sylvain Pincebourde[2]

This talk examines the physical and physiological effects of climate change on herbivorous insects. Insect herbivores do not live in the macro-environments studied by climate scientists. Rather, they live in conditions produced at scales over much smaller spatial and temporal extents; they live in microclimates. The microclimates of herbivorous insects are strongly linked to the structure and physiology of their host plants. For example, leaf temperatures can be up to 10°C warmer or colder than ambient air depending on other climatic variables and the physiology of the leaf. We illustrate the magnitude of these effects with a series of studies of a hawkmoth caterpillar, *Manduca sexta*, on one of its host plants, *Datura wrightii*, in the southwestern deserts of the US. Understanding the effects of climate change on herbivorous insects, however, will require models that generalize beyond the details of individual case studies. To this end, we present preliminary results from a numerical model, currently under construction, that integrates global environmental data with broad-scale patterns in physiological traits of tree leaves to predict equilibrium leaf temperatures across the globe. These predictions are then coupled to patterns of insect thermal performance to predict how shifting leaf microclimates will affect insect herbivores.

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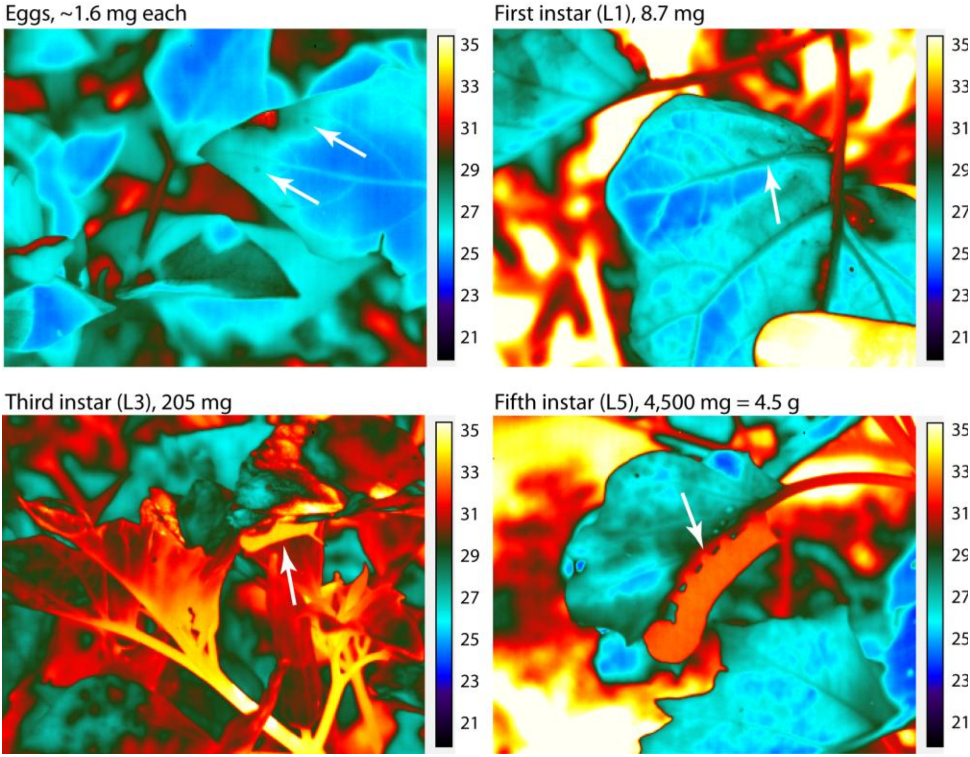


As caterpillars grow, they emerge from their leaf microclimates, with potentially large consequences for body temperature. This pattern is illustrated by these thermal images of the ontogeny of the sphingid caterpillar *Manduca sexta* (indicated by white arrows) on *Datura wrightii*, its primary host plant in the Chihuahuan Desert (US). The earlier, smaller life stages have temperatures similar to those of their host leaves, which generally are colder than air temperature. The later, larger stages, which outgrow the leaf boundary layer, are hotter, reflecting relatively stronger contributions of air temperature and solar radiation to the heat balance.

Images from Woods HA (2013) Ontogenetic changes in the body temperature of an insect herbivore. *Functional Ecology* 27, 1322 – 1331.

Wednesday 11 June 14:40 – Session 1 Talk 5

Prof. Dobrowski Solomon

Department of Forest Management, University of Montana, Missoula, MT, USA.

Climate refugia and scale:
How complex terrain and microclimatic variation shape the velocity of climate change

A concern for species conservation is whether the rate of climate change will exceed the rate at which species can adapt or move to suitable environments. There is also increasing awareness that climatic heterogeneity driven by complex terrain and microclimatic variation may spatially buffer the effects of rapid climate changes. This has prompted the use of climate change velocity as a metric for estimating the rate of climate change given that it accounts for regional changes in climate through time and the ability of spatial climatic heterogeneity to buffer biota against these changes. Here we assess the climate change velocity (both climate displacement rate and direction) for minimum temperature, actual evapotranspiration, and climatic water deficit over the contiguous US during the 20th century (1916–2005). Climate change velocity for these variables demonstrate complex patterns that vary spatially and temporally and are dependent on the spatial resolution of input climate data. Climate change velocity increases as the spatial resolution of climate data is coarsened. This is due to the fact that coarsely grained data underestimate the spatial heterogeneity of climate in areas of complex terrain. The sensitivity of climate change velocity to climate data resolution is largest at fine grain sizes highlighting the importance of topoclimatic and microclimatic variability for assessing the capacity of organisms to keep pace with changing climate. It also suggests that we may be overestimating the rate at which species will need to move in order to keep pace with ongoing climate changes.

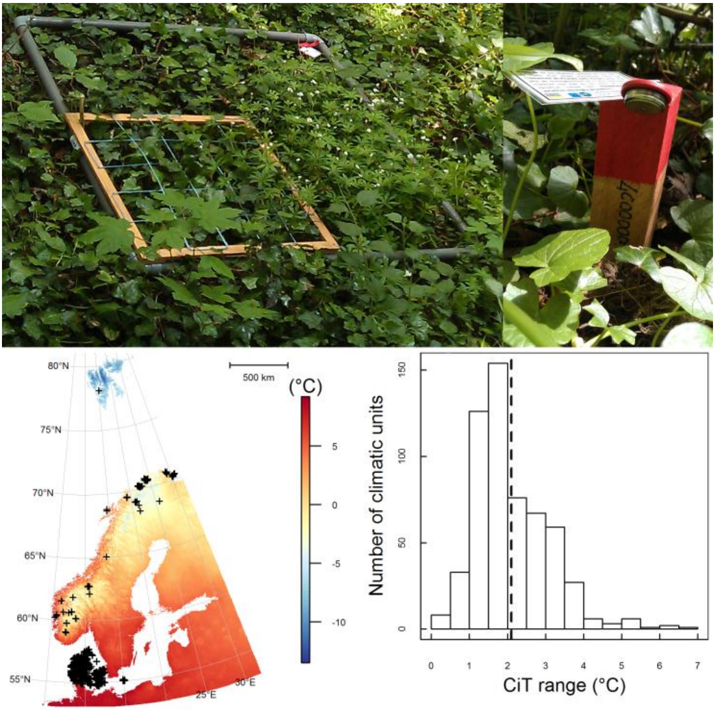
Wednesday 11 June 15:20 – Session 1 Talk 6

Dr. Lenoir Jonathan

Ecologie et Dynamique des
Systèmes Anthropisés,
FRE 3498, CNRS,
Amiens, France.

Combining large-scale vegetation plot databases with a plant-community-based approach to assess fine-grained thermal variability within 1-km^2 climatic units across Northern Europe

Temperature variability over tens or hundreds of metres may mitigate climate-change impacts on species distribution. However, we know little about such fine-grained thermal variability across large geographical extents. Is this local spatial buffering restricted to topographically complex terrains? Combining an exceptional, large, high-quality database on vascular plant communities across a 2,500-km wide latitudinal gradient in Northern Europe (42,117 vegetation plots) with a plant-community-based approach, we first inferred temperature conditions within plant communities of less than 1000 m^2 (community-inferred temperatures: CiT). Based on CiT, we assessed fine-grained thermal variability (CiT range) within 1-km^2 climatic units along a wide gradient of topographic complexity from flat to rough terrains. Our plant-community-based approach performed best to predict CiT during the growing season (June, July, August). During the growing-season, CiT range within 1-km^2 climatic units peaked at intermediates latitudes and increased with terrain roughness, averaging 1.97°C (SD = 0.84°C) and 2.68°C (SD = 1.26°C) within the flattest and roughest 1-km^2 units, respectively. Complex interactions between topography-related variables and latitude explained 35% of variation in growing-season CiT range when accounting for sampling effort and residual spatial autocorrelation. We conclude that even flat terrains may provide microrefugia for species to cope with rapid climate change, thus challenging predictions from coarse-resolution models of species distribution.



Fine-grained thermal variability within 1-km^2 climatic units inferred from plant communities suggest strong spatial buffering of climate warming across Northern Europe[*]. The two pictures illustrate an example of co-occurring plant species within a 1-m^2 quadrat for which locally measured temperatures are available from a miniature data-logger (iButton). Biologically relevant temperature conditions (hereafter community-inferred temperatures: CiT) were inferred by combining, in a modelling framework, plant community composition data with Ellenberg temperature indicator values, local temperature data from miniature data-loggers and global temperature data from WorldClim (http://www.worldclim.org/). The map shows the geographic distribution across Northern Europe of 569 1-km^2 climatic units used to assess the range of values for CiT. The histogram shows the frequency distribution of the thermal variability (CiT range) computed for each of these 569 1-km^2 climatic units. Background temperatures are 1-km^2 annual mean temperature from WorldClim. The dashed vertical line shows the mean.

[*]Lenoir J. *et al.* (2013). Local temperatures inferred from plant communities suggest strong spatial buffering of climate warming across Northern Europe. *Global Change Biology*, 19: 1470-1481

Wednesday 11 June 16:00 – Session 1 Talk 7

Dr. Vrac Mathieu

Laboratoire des Sciences du Climat et de l'Environnement
UMR 8212, CNRS,
Gif-sur-Yvette, France.

Statistical downscaling models: Why? How? & What's next?

Coupled Ocean-Atmosphere General Circulation Models (AOGCMs) are the key modelling tools to try to understand the climate, and its past and potential future evolutions. Nevertheless, the coarse spatial resolution (~ 2.5°x2.5°) of their climate simulations (e.g., precipitation, temperature) is generally not adapted to conduct (societal, environmental, human) impacts studies of climate changes. Indeed, those studies often need to be driven by local-scale (i.e., high-resolution) climate simulations. "Downscaling" models and methods are then required to go from low-resolution AOGCM outputs to high-resolution simulations adapted to impacts models. If the "dynamical" approach for downscaling is now well known among climate modellers through the use of Regional Climate Models (RCMs), statistical downscaling models (SDMs) are alternatives that are more and more employed. Those two complementary approaches present both strengths and drawbacks, which justifies the modelling efforts made in their developments.

In this talk, the main statistical downscaling approaches will be presented. The goal is not to detail all models, methodologies and variants but to discuss the philosophy of the different possible statistical approaches. Some recent personal works will serve as illustrations.

Wednesday 11 June 16h40 – Session 1 Talk 8

Dr. Allard Denis

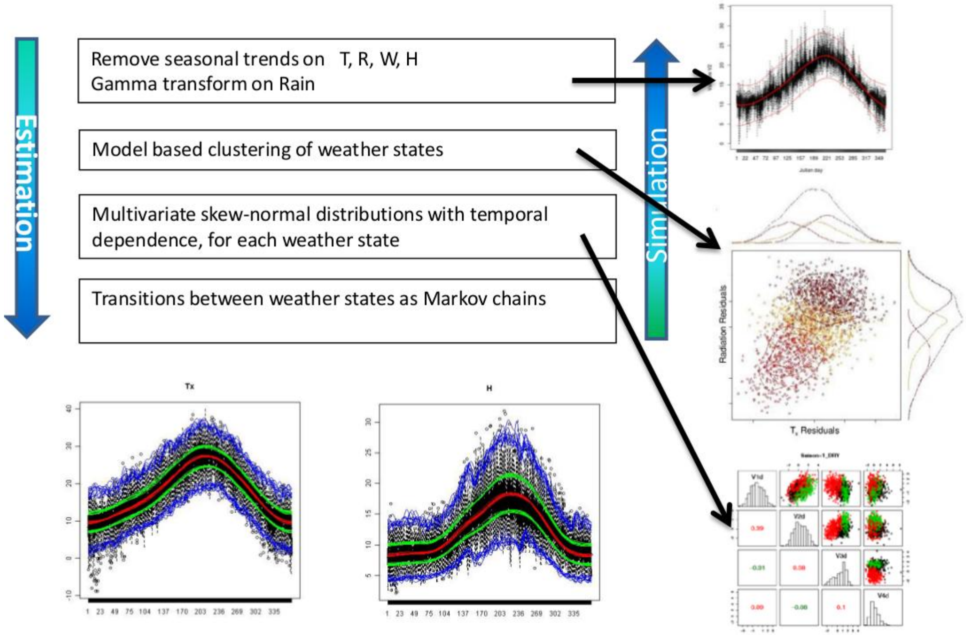
Biostatistics and Spatial Processes,
INRA PACA,
Avignon, France.

Stochastic weather generators: what are they good for?

Many environmental, ecological or agricultural impact studies need daily climate variables, such as temperature, precipitation, total radiation and wind speed as inputs. For example, crop models or forest stands models need daily climatic series as inputs to asses past, present and future variability for yields. Modelling coherently the variability of several climatic variables together for better reproducing high-impact weather events is thus of primary importance in any impact study. This could be done with the use of recorded climatic series but, in many situations they are too short for a proper assessment of the probability of these kinds of events.

Weather generators (WG) are statistical simulators that produce daily time series of atmospheric variables with properties resembling those of observed ones, including their dependence structure and temporal persistence. They have been adopted in impact studies as an inexpensive tool to generate synthetic climatic time series of climatic variables required by process-based models. For example, assessing the variability of agricultural yields in the future cannot be assessed without the use of WGs, because of the complex interaction between sowing date, temperature, drought and growth.

We will first make a short review of stochastic weather generator models, highlighting their key properties but also their limits. We will describe the multivariate daily weather generator WACSgen. Some research contexts in which WACSgen will be used in a very near future are shown. Application of WACSgen will be illustrated on a pine forest on the Ventoux mountain.



Schematic representation of the Stochastic Weather Generator 'WACSgen'. The first step consists in estimating the parameters of the statistical model; it includes removing seasonal trends, clustering daily values into weather states and estimating the parameters of the multivariate model.

The second step is a simulation step: given a set of parameters, time series are simulated according to the statistical model. Results on a series of multi-simulations are displayed for two variables: Tmax and Humidity.

Wednesday 11 June 17:50 – Session 1 Training

Prof. Kearney Michael

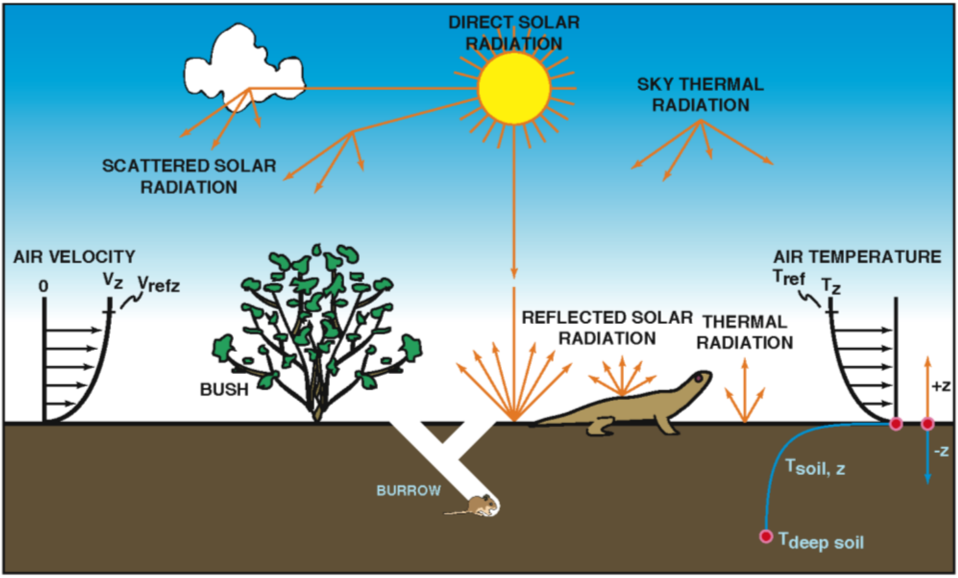
Department of Zoology,
The University of Melbourne,
Victoria, Australia.

Presentation of a global microclimate dataset

Microclimates are the critical link between physiology and climate. Most modelling approaches that use climate data do not explicitly include known aspects of an animal's physiological sensitivity to climate because the available data are at the wrong scale. To facilitate the development of physiologically explicit models of the role of climate in limiting distribution, abundance and behaviour, we published a global microclimate dataset in the new journal Scientific Data. You can find it here.

This data set comprises gridded hourly estimates of typical microclimatic conditions (air temperature, wind speed, relative humidity, solar radiation, sky radiation and substrate temperatures from the surface to 1 m depth) at high resolution (~15 km) for all terrestrial landmasses except Antarctica. The estimates are for the middle day of each month, based on long-term average macroclimates, and include six shade levels and three generic substrates (soil, rock and sand) per pixel.

These data can be used as inputs for biophysical models of heat and water exchange of plants and animals. The dataset can also be used to develop more 'proximal' layers for correlative species distribution modelling methods. During the workshop I will provide an overview of these layers and step through an R script for interacting with the data set.



© Warren Porter and Bill Feeny

My research is focused on integrating spatially-explicit environmental data with measured behavioural, morphological and physiological traits to infer constraints on behaviour, distribution and abundance. The aim is to make the inference based on the thermodynamic processes of heat, water and nutritional exchange, i.e. to infer the 'thermodynamic niche'. For terrestrial organisms especially, a major challenge is to convert the spatial data into the appropriate form with which to drive the thermodynamic models, i.e. to determine microclimates. This figure illustrates some of the key microclimatic processes driving heat and water exchange in animals and plants and how they vary with height above or below the ground. Most recently I have invested time in developing and testing a microclimate model originally developed by Porter and colleagues. We have produced generic global microclimate layers (the 'microclim' dataset) and have adapted the model to simulate snow and its effects on soil temperatures. We use this microclimate model to drive an animal model that integrates the biophysics of heat and water exchange with a Dynamic Energy Budget model of food uptake and allocation across the whole life cycle.

Thursday 12 June 09:00 – Session 2 Talk 1

Prof. Helmuth Brian

Northeastern University,
Marine Science Center,
Nahant, MA USA.

Dealing with uncertainty in the era of climate change: when do “the details” matter?

Generalized predictions of the biological impacts of climate change such as poleward migrations of species range boundaries have served as a useful heuristic framework. However, recent evidence suggests that these simplifications may be violated in nature more often than has previously been appreciated, and that the “details” of how organisms interact with their environment can have dramatic influences on how environmental change affects ecosystems. Ecological forecasting approaches that build on a mechanistic understanding of how organisms interact with their environment can provide spatially explicit estimates of where, when and with what magnitude climate-influenced impacts are likely to occur. Specifically, coupled biophysical-energetic models estimate spatial and temporal patterns of growth, reproduction, and maximum body size in coastal invertebrates, and can serve as a potentially effective means of providing decision makers with relevant, useful indicators. However, these approaches also show that because of nonlinearities in how the environment affects organismal physiology, and in how such individual impacts scale to ecosystem-level processes, these methods must be embedded within a probabilistic framework. As scientists we thus face the quandary of communicating complex processes in “sound bites” while recognizing that we can never truly predict the exact, detailed impacts of climate change with a high degree of certainty. Instead, we may be better off focusing on what aspects of climate signaling drive the likelihood of “surprises” such as ecological thresholds (tipping points) – i.e., a focus on weather rather than climate- may serve as a more effective means of communication than focusing on generalizations.

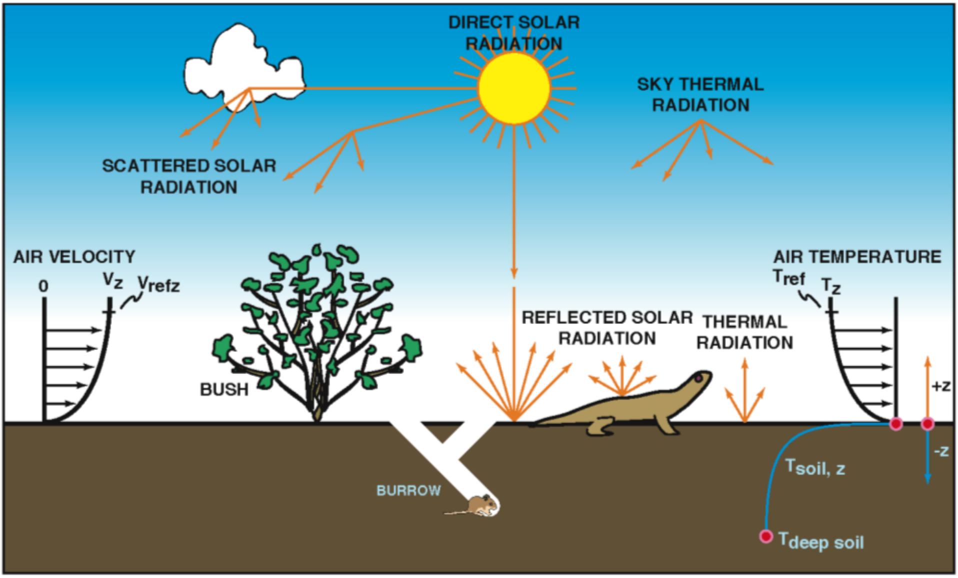
Thursday 12 June 09:40 – Session 2 Talk 2

Prof. Kearney Michael

Department of Zoology,
The University of Melbourne,
Victoria, Australia.

Climatic constraints and the thermodynamic niches of organisms

Climate influences the distribution and abundance of terrestrial animals in a rich variety of ways. Most directly, however, it imposes thermodynamic constraints on heat, water and nutritional balances. The sum of these constraints can be thought of as defining the 'thermodynamic niche'. I will discuss how the thermodynamic niche can be characterized using integrated models of the biophysics of animals and their microclimates, together with metabolic theory. I will show how the models can be coupled to weather and climate databases to predict constraints on animal survival, behaviour, phenology, growth, development and reproduction, and ultimately distribution limits.



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Imperial College London

Prof. Prentice Colin

Imperial College London,
London, UK.

Macroscale modelling of ecosystem function

I. Colin Prentice[1,2], Han Wang[2], Tyler W. Davis[1]

Acclimation, environmental heterogeneity and biodiversity are often seen as complications for modelling ecosystem processes. The opposite is true. Acclimation allows physiological properties to track environmental variation so that individual plant performance is optimized. Environmental selection allows plant species collectively to occupy available niche space so that primary production approaches theoretical capacities at the community level. Modelling the emergent behaviour of ecosystems can thus paradoxically be simplified by implicitly taking these key biological processes into account. However, current models represent diverse communities quite unrealistically as consisting of one or few Plant Functional Types (PFTs) with fixed physiological properties. This approach can lead to artefacts (when PFT properties are mismatched to environment). It has also concealed over-fitting of models, and arguably encouraged spurious accuracy at the expense of genuine predictive power. The consequences can be seen in the disastrous performance of “state-of-the-art” climate-carbon cycle models. Fortunately there is an alternative way forward, assisted by major improvements in the availability of global observations at various scales from leaf to atmosphere. A deceptively simple theoretical framework, based on minimizing the combined unit costs of maintaining photosynthetic and transpiration capacities, will be shown to lead to accurate predictions of plant CO_2 drawdown (indexed by the c_i/c_a ratio) as a function of temperature, aridity and elevation. This theory makes correct predictions about the latitudinal and seasonal patterns of gross primary production, and offers the possibility of a ‘next-generation’ global vegetation model that will be both simpler and more realistic than those of today.

[1]*Imperial College London, UK.*
[2]*Macquarie University, Sydney, Australia.*

c_i/c_a minimizes $aE/A + bV_{cmax}/A$

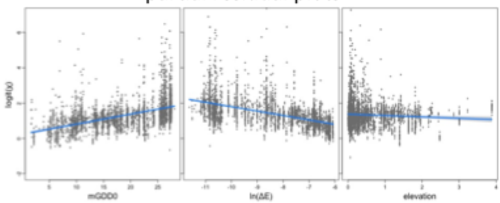
- χ_o = optimal $c_i/c_a = \xi/(\xi + \sqrt{D})$ for *Rubisco* limited photosynthesis, where:
- $\xi = \sqrt{(bK/1.6a)}$
- $K = K_C(1 + O/K_O)$
- $a = r_s h \rho_s \eta / 2\Delta\Psi k_s \rho_w$

Derivation: Prentice *et al.* (2013) *Ecology Letters*

- Dependencies of ln $[\chi/(1 - \chi)]$:

	Predicted	*Fitted*
T	0.055	0.050 ± 0.004
ln D	– 0.250	– 0.226 ± 0.012
z	– 0.082	– 0.093 ± 0.030

partial residual plots



Data: Will Cornwell *et al.*
Analyses: Han Wang

The relationship between ci/ca ratios in C3 plant leaves (from δ13C measurements) and environment is universal and predictable. High ci/ca ratios are associated with warm, wet conditions and low elevations. Low ci/ca ratios are associated with cold, dry conditions and high elevations. The quantitative prediction involves minimizing the sum of the unit costs of maintaining a transpiration pathway, and maintaining photosynthetic capacity. The aridity effect arises because of the greater evaporative potential of dry air. The temperature effect arises because of (a) the declining affinity of Rubisco for CO2 and (b) the reduction in the viscosity of water with increasing temperature. The elevation effect arises because of the declining partial pressure of O2, which increases the affinity of Rubisco for CO2.

This example illustrates a more general principle that key plant functions conform to optimality criteria that are enforced by natural selection. According to this view, biodiversity plays a key role in maintaining ecosystem function under spatial and temporal heterogeneity simply because of the limits to any one species' plasticity, i.e. its capacity to achieve optimal outcomes under a range of environmental conditions.

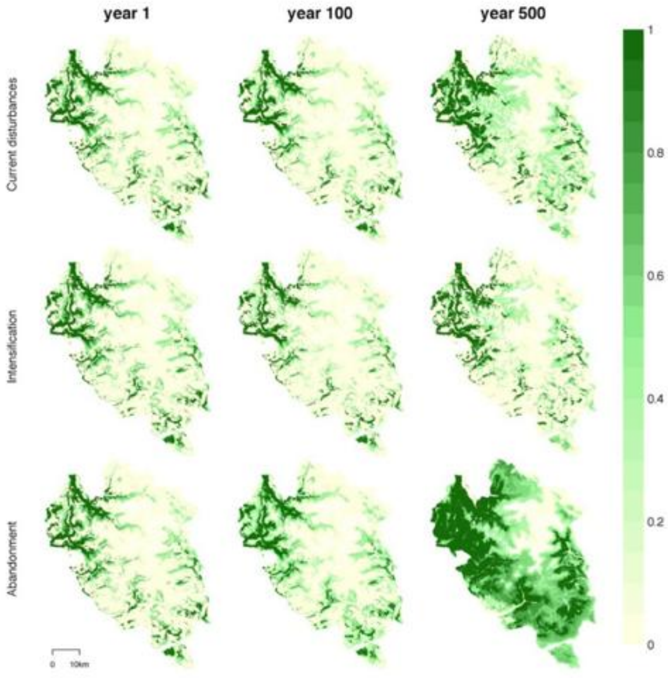
Thursday 12 June 11:30 – Session 2 Talk 4

Dr. Thuiller Wilfried

Evolution, Modelling
and Analysis of Biodiversity,
Laboratoire d'Ecologie Alpine,
UMR 5553, CNRS,
Grenoble, France.

Macroscale modelling of ecosystem function

The demand for scenarios of future biodiversity dynamics has triggered an upsurge of biodiversity models projecting changes in species distributions under future states of the world. The common assessment of these biodiversity models is that they typically incorporate too little of established ecological theory. In this presentation, I quickly review in detail several modelling approaches that successfully pioneered the integration of multiple eco- evolutionary processes into biodiversity scenarios. I finally present a potential way of integrating ecological understanding into dynamic vegetation models using well-defined plant functional groups and a newly developed integrated modelling platform.



Sequence of forest dynamics in the Ecrins National Park in the French Alps simulated with a spatially and temporally explicit model under climate change and various management scenarios. For each scenario, the tree cover (strata above 1.5m) is shown for the initial simulation state (end of initialization, year 1) and years 10 and 500. Tree cover varies from 0 (no vegetation above 1.5m) to 1 (closed forest).

Thursday 12 June 12:10 – Session 2 Talk 5

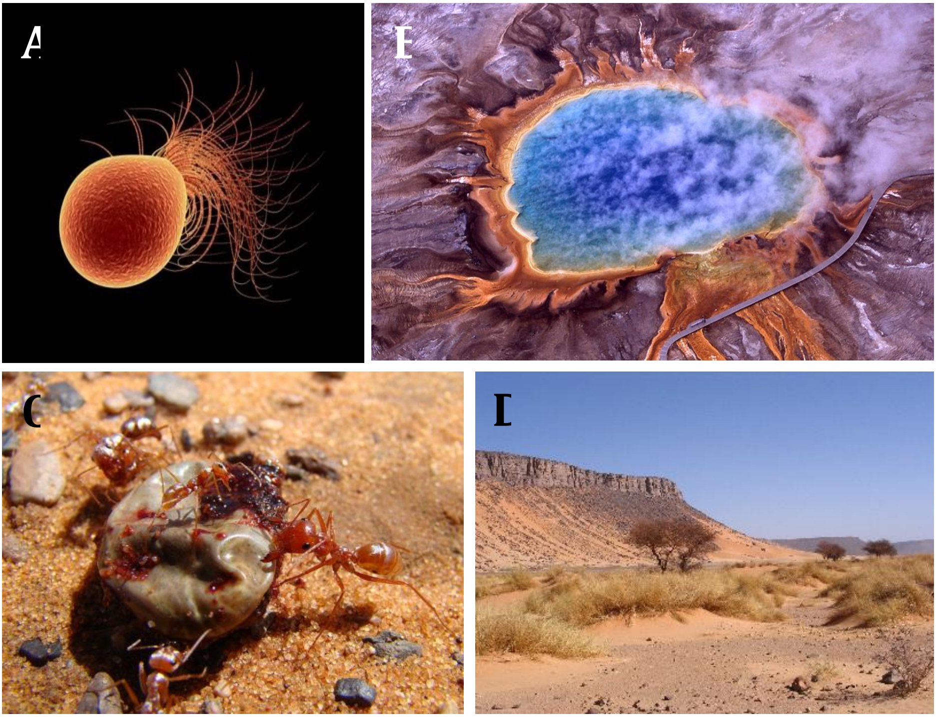
Imperial College London

Prof. Araújo Miguel

Imperial College London,
London, UK.

Understanding species distributions across scales:
Where biogeography meets community ecology

Simple questions often require complex answers. Although consensus exists that species distributions are determined by a combination of biotic interactions (B), physiological tolerances to abiotic factors (A), and movement (M), debate still exists regarding the relative importance of each of these factors. Understanding of relative contributions of B, A, and M is critical for the development of theoretical ecology and biogeography but also for predicting climate change effects on biodiversity. In this talk I will summarise some of recent findings from my group in understanding the contributions of B and A to shape distributions of species across scales. I will argue that further progress involves greater interdisciplinary connections between otherwise disconnected disciplines in life sciences.



Few organisms on earth are adapted to extreme temperatures. (A) The Archaea Pyrococcus furiosus found in the hot pools of the Italian island of “Vulcano” thrives best at 100°C (Photo: Roberto Alamino). (B) The Grand Prismatic hot spring in Yellowstone National Park with mats of orange depicting extremophilic algae and bacteria (Photo: Jim Peaco). (C) Saharan silver ant Cataglyphis bombycina foragers in few minutes per day during the hottest midday period to avoid predators (Photo: Bjørn Christian Tørrissen); (D) Typical habitat of the Saharan silver ant in the Sahara desert (Photo: Florence Devouard).

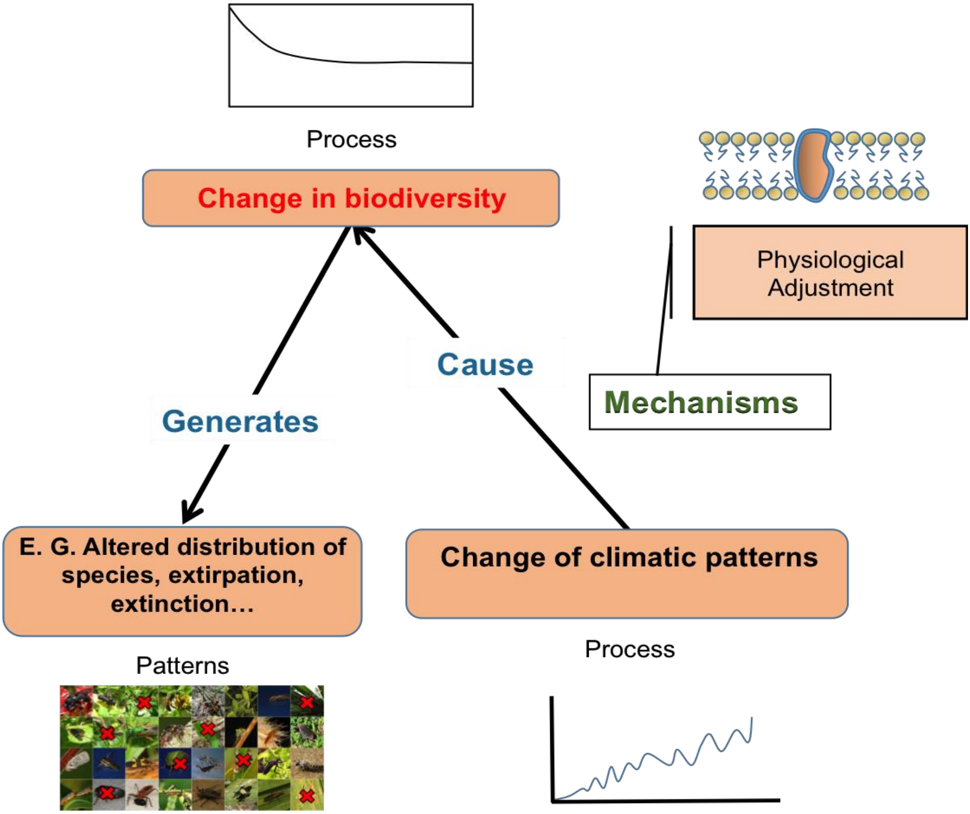
Thursday 12 June 14:20 – Session 3 Talk 1

Prof. Navas Carlos

Department of Physiology,
Biosciences Institute,
University of São Paulo,
São Paulo, Brazil.

Amphibian body temperature along tropical altitudinal gradients: climatic heterogeneity at individual scale

The problem how climate change affects the fauna involves patterns, ecological processes leading to such patterns, and the links between climate and the ecological performance of individuals (mechanisms). These mechanisms are typically weakened physical condition or arrested reproductive output, both related to physiological function. Enhanced climatic extremes may be consequential in biogeographic zones characterized by high levels of climatic variance, for example, high-elevation tropical settings (e.g. elevations above 3000 m). These environments involve considerable diel variation in temperatures, and a fraction of the fauna may be already exposed to thermal fluctuation near physiological tolerances. However, understanding the impact of enhanced thermal variation in high tropical elevations is difficult because significant thermal heterogeneity exists within and across microhabitats that is not easily perceived with broad climatic databases. Key questions include: 1) What is the thermal heterogeneity across high-elevation habitats?; 2) How thermal heterogeneity, across habitats, varies with elevation?; and 3) Do animals use habitat heterogeneity to decrease physiological challenges through behavior?. I address these questions from the perspective of the thermal biology of anurans in the Colombian paramos using data collected over the past 20 years. I show that significant variation exist in the thermal variance across high elevation microhabitats; that thermal variance varies in complex manners with elevation and is influenced by biome structure; and that behavioral buffering may be available for some taxa, but not other. Overall, I highlight the relevance of thermal variance as a key aspect of ecological climate change research focused on ectothermic animals.



Our current proposal aims to integrate patterns, processes and mechanisms to understand the impact of climate change on the fauna. One important component in this equation is the capacity that animals have to adjust their physiology as a response to changes in the environment. This issue has received increasing attention because of cumulative evidence supporting physiological function, and the impact of physiological function on behavioral performance, as a mechanistic link between climatic change and shifts in biodiversity. When facing climate change, individuals may respond physiologically, but the type and extent of possible adjustments vary among species. Therefore, changes in the in the scope, nature and time course of extreme climatic events are consequential for the fauna, particularly in environments that are already variable. One example are high tropical elevation, an environment in which increase freezing spells have potential to disrupt the current composition of animal communities representing diverse taxa.

Thursday 12 June 15:00 – Session 3 Talk 2

Dr. Grémillet David

Centre d'Ecologie Fonctionnelle et Evolutive, UMR 5175, CNRS, Montpellier, France

Energetic fitness: linking metabolic effort with Darwinian fitness in birds exposed to climate change

David Grémillet[1,2], Amélie Lescroël[1], Grant Ballard[3], Melanie Massaro[4], David Ainley[5]

Evaluating the fitness of organisms exposed to heterogeneous environments is an essential step towards understanding their responses to climate change. Linkages between energy expenditure and Darwinian fitness are suggested in the scientific literature across the last century (Lotka *PNAS* 1922, Brown et al. *Ecology* 2004). However, testing this premise in the natural world is constrained by difficulties in measuring energy expenditure of wild animals while monitoring conventional fitness metrics such as survival and reproductive output. We addressed this issue conceptually and empirically by (1) refining the definition of metabolic effort so that it can be routinely measured in free-ranging animals (2) exploring the functional links between metabolic effort, body condition and reproductive performance in a wild population. To this aim we deployed 3-axis accelerometry data loggers on 75 Adélie penguins (*Pygoscelis adeliae*) across three breeding seasons at their breeding site on Ross Island, Antarctica. This population has been the subject of demographic monitoring for the past 18 years, and accelerometry data were collected for birds of known age and breeding history. We determined Overall Dynamic Body Acceleration as a proxy for energy expenditure, and derived metabolic effort from ODBA levels. We then explored the links between metabolic effort, body condition and multi-year reproductive performance. This allows us to propose using metabolic effort as a Darwinian fitness component, complementary to more conventional fitness metrics.

[1]Centre d'Ecologie Fonctionnelle et Evolutive, CNRS, Montpellier, France.
[2]FitzPatrick Institute, DST/NRF Centre of Excellence at the University of Cape Town, South Africa.
[3]Point Blue Conservation Science, Petaluma, California, USA.
[4]Charles Sturt University, Albury, Australia.
[5]H.T. Harvey & Associates, Los Gatos, California, USA.

Adélie penguins (Pygoscelis adeliae) from Ross Island, Antarctica, breed at their southernmost location on the planet (77°S) where they used to face extreme, yet relatively stable, environmental conditions. These climatic conditions are now changing, also in this remote and pristine marine ecosystem, and it is essential to evaluate the short term adaptive potential of long-lived penguins to rapid changes in sea-ice conditions. Long-term demographic studies providing classical fitness indicators such as lifetime reproductive success are useful in this context, but are of little use in the shorter term. Within the framework of a research programme funded by the US National Science Foundation and with the support of the French Polar Institute (IPEV), we are therefore developing short-term indicators of fitness, using the metabolic effort of individuals assessed via their three-dimensional movements. These movements are recorded 20 times per second by miniature electronic tags attached to the birds, during series of 24h periods, while birds forage at sea and attend their chicks on land. Metabolic effort as an immediate fitness proxi is confronted with more conventional fitness indicators such as longevity and reproductive success, which are determined for the study population via a long term Capture-Mark-Recapture study.

Friday 13 June 09:00 – Session 3 Talk 3

Prof. Benedetti-Cecchi Lisandro

Department of Biology,
University of Pisa,
Pisa, Italy.

Ecological responses to environmental fluctuations: means, variances and extremes.

Ecology has long been a science of means and trends, seeking causal links between average changes in ecological response variables (e.g., species abundance, productivity etc.) and mean changes in abiotic or biological environmental conditions. In the last decade there has been a dramatic increase in studies focusing on variance, autocorrelation and environmental extremes as drivers or as indicators of ecological change. This is in large part a consequence of the increasing need to understand global change effects, which involve variations along multiple dimensions of environmental envelopes (e.g., changes in the magnitude, frequency, timing, duration and extent of climate and non-climate drivers of ecological change). The systematic analysis of environmental heterogeneity can provide insights into ecological patterns and processes beyond those disclosed by focusing solely on means and trends. I will give two examples: the first is a test of catastrophe theory and uses variance and autocorrelation as early warning indicators of an impending regime shift. The second is a test of the compounded effects of multiple extreme perturbations on primary productivity on microbial films. These examples come from my research on rocky intertidal assemblages of algae and invertebrates in the Mediterranean and are based on manipulative field experiments.

Friday 13 June 11:40 – Session 3 Talk 4

STANFORD
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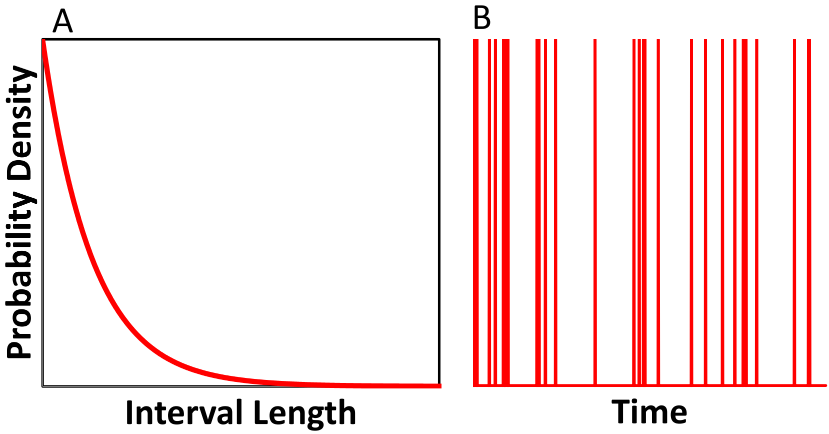
Prof. Denny Mark

Hopkins Marine Station,
Stanford University,
Pacific Grove, CA, USA.

Cycles, chance, and scale-dependent noise:
challenges to defining the nature of thermal variation

Plants' and animals' response to their physical environment depends on the organisms' average conditions, the variation around that average, and the spatial or temporal pattern of that variation. Until we can accurately describe each of these factors, physiologists and ecologists will not be able to account for their effects. Therein lie substantial problems. Wave-swept rocky shores provide illustrative examples of these difficulties: (1) Apparent trends in short-term measurements may actually be part of unidentified long-term cycles. For instance, decade-long declines in seaweed abundance are actually due to the 18.6 year periodicity of lunar declination, which modulates seaweeds' exposure at low tide. Identifying cycles in other systems - where celestial mechanics don't apply - can be problematic. (2) Extremes in body temperature are often caused by the chance alignment of environmental factors (solar irradiance, wind, speed, etc.). As a result, the interval between stressful events follows a Poisson distribution in which common short intervals are interspersed with rare long intervals. Physiological, evolutionary, and ecological responses to this pattern of stress have not been thoroughly explored. (3) For many environmental factors, both the mean and variance are scale dependent: the larger the area or the longer the time over which a measurement is conducted, the higher the mean and the greater the variance one encounters. Careful assessment of the spatial or temporal spectrum of fluctuations is required before accurate means and variances can be determined, but measuring spectra is fraught with practical difficulties. I look forward to discussing solutions to these problems.

Poisson Time Series



A mechanistic niche-modelling framework allows scaling from environmental and phenotypic data to organismal physiology, performance, fitness, demography, and distribution. A thermal image demonstrates the importance of using a biophysical model to estimate how the body temperature of a grasshopper (°C) differs from its environment. The framework enables considering how local adaptation will influence responses to climate change.

Friday 13 June 10:50 – Session 3 Talk 5

Prof. Buckley Lauren

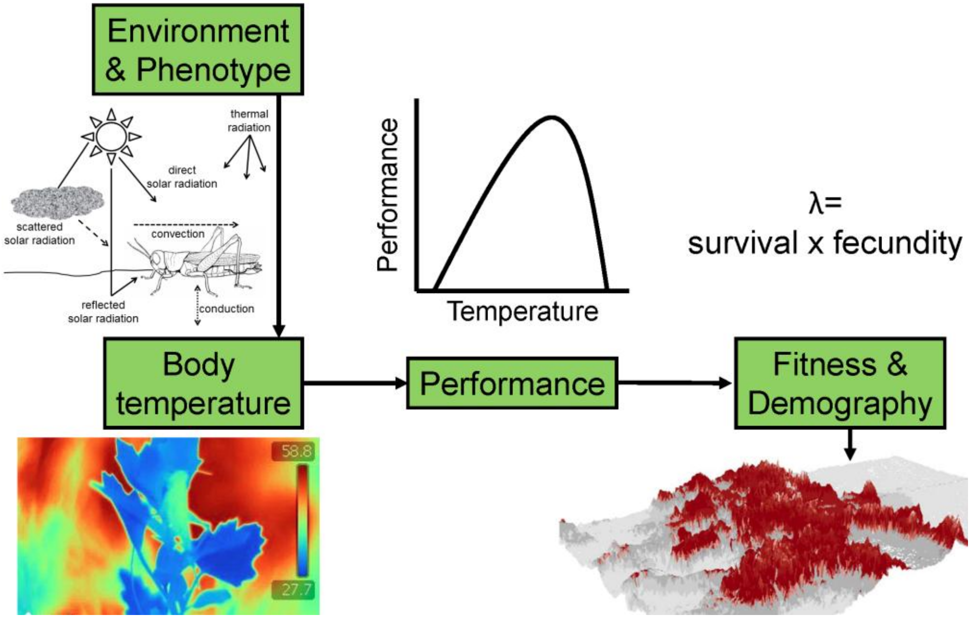
Department of Biology,
University of Washington,
Seattle, USA.

The distribution implications of local adaptation in current and future environments

Lauren B. Buckley[1] and Michael J. Angilletta[2]

What phenotypic traits can account for individualistic responses to past climate change and how can this knowledge be used to predict future responses? I will present research demonstrating how local adaptation influences responses to both chronic and acute thermal stress. This research has enabled developing a phenotype-based forecasting framework, which integrates models at physiological, performance, and fitness levels to better predict responses to climate change. I will focus on examining how thermal tolerance and thermoregulatory behavior interact to determine the susceptibility of a widespread group of lizards, the *Sceloporus undulatus* complex, to climate change. Thermoregulation buffers environmental variation, which can weaken selective pressures and ultimately hinder adaptation to climate change. We used a model of optimal thermal physiology to demonstrate how thermoregulatory behavior limits local adaptation of thermal physiology. We empirically confirmed the predicted conservatism of the thermal niche for seven populations across the distribution. In an eighth population, from the warmest region of the range, we observed the higher heat tolerance and lower cold tolerance as predicted by our model. The effectiveness of thermoregulation can decline abruptly with climate warming, precluding adaptation to reduce thermal stress. Our analyses bolster concerns that behavioral plasticity, while beneficial in the short term, ultimately limits the physiological adaptation required to endure a warming climate in the long term.

[1] *Department of Biology, University of Washington, Seattle, WA 98195, USA.*
[2] *School of Life Sciences, Arizona State University, Tempe, AZ 85287, USA.*



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Prof. Loeschcke Volker

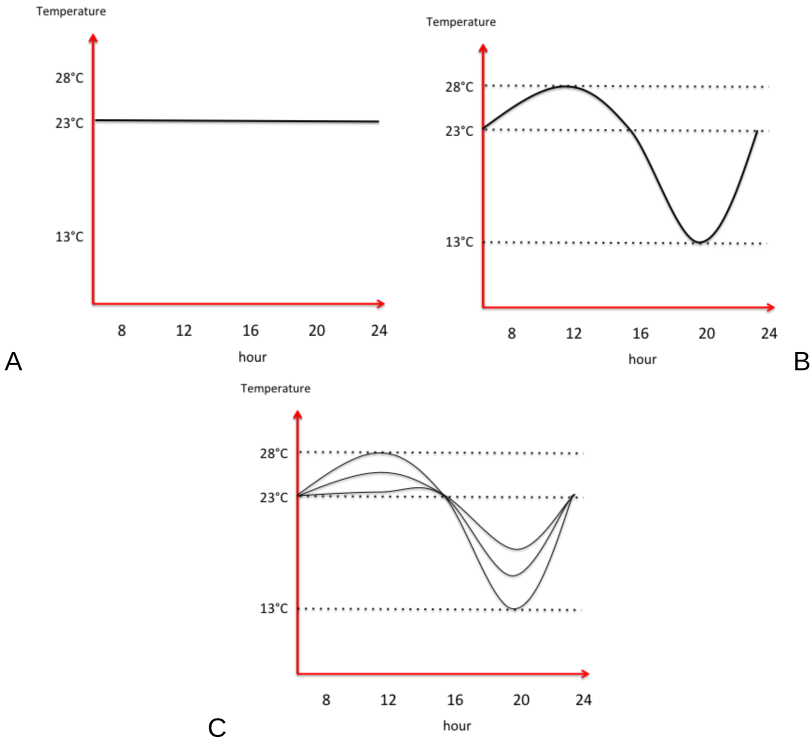
AARHUS UNIVERSITY

Department of Bioscience,
Genetics, Ecology and Evolution,
Aarhus University,
Aarhus C, Denmark.

Phenotypic plasticity in fluctuating and unpredictable environments: adding ecological relevance to the experimental study of life history traits

T. Manenti, J. G. Sørensen, N. N. Moghadam and V. Loeschcke

For most organisms natural thermal conditions fluctuate across days and among seasons. Current laboratory studies on adaptation to changing environments however use commonly different constant temperatures when studying effects of temperature on life history traits. We try to overcome these limitations and add ecological relevance to such experiments by exposing organisms to either constant, predictable or unpredictable fluctuating temperatures. We compare the plastic responses in life history and stress resistance traits to the different thermal regimes. We found that the three environments induced a clear-cut plastic response in all the traits investigated, which suggests a strong impact of predictability and temperature variations on flies. Flies from the unpredictable fluctuating environment apparently experienced the most stressful environment and their plastic response was more different than that from the other two environments. The decreased fitness in unpredictable fluctuating environments may be the consequence of maladaptive phenotypic plasticity in this setting. However, the differences between predictable and unpredictable environments indicate that plasticity might be a beneficial mechanism when the environmental conditions change in a predictable way.



The main types of thermal environments in our experiment: constant (A, top left), predictable fluctuating (B, top right) and unpredictable fluctuating temperatures (C, bottom middle) experienced as larvae and young adults.

Using variation in temperature we are going to address the following questions, contrasting constant, predictable and unpredictable fluctuating thermal conditions and aiming for ecological relevance:

- Are stress resistance and other fitness related traits depending on if flies are reared at constant, predictable or unpredictable fluctuating temperatures (without selection)?

- Does laboratory natural selection under constant, predictable and unpredictable fluctuating thermal conditions reduces the extent of plastic responses to these conditions, i.e. is there a trade-off between phenotypic plasticity and evolutionary adaptation?

Friday 13 June 12:10 – Session 3 Talk 7

Prof. Kingsolver Joel

Department of Biology,
University of North Carolina,
Seattle, USA.

Evolutionary responses of insects to climate variability and climate change

Joel G. Kingsolver[1], Lauren B. Buckley[2], H. Arthur Woods[3]

Under what conditions will insects evolve in response to rapid climate change? We explore two aspects of this question that highlight the roles of thermal fluctuations and climate variability. First, we use historical data on larval thermal performance curves (TPCs) and adult wing melanin in *Colias* butterflies to document potential evolutionary responses to recent climate change in the western USA. We also describe an integrated set of models that predict selection and evolution of wing melanin in *Colias* in the Rocky Mountains in response to recent climate change. These studies suggest that evolutionary changes in TPCs are associated with increases in the frequency of high temperatures during the past 60 years, and that climate variability between years can reduce potential evolutionary responses to climate warming. Second, we use data on *Manduca* and *Pieris* larvae to demonstrate the importance of transient effects of temperature change on larval growth and survival, even at temperatures that are not ‘stressful’. For example, temperatures that maximize growth rates at short time scales can be sub-optimal or even lethal at longer time scales. Such transient thermal effects make it challenging to connect thermal performance curves measured at different time scales, and to relate thermal performance at longer time scales (e.g. fitness over a generation) to climate variability at shorter time scales. The lack of a theoretical framework for understanding and quantifying transient effects strongly limits our ability to predict the performance and fitness consequences of climate change for ectotherms.

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[2]*Department of Biology, University of Washington, Seattle WA 98195, USA.*
[3]*Division of Biological Sciences, University of Montana, Missoula MT 59812, USA.*

Colias meadii, an alpine butterfly found at higher elevations in the Rocky Mountains in western North America. We use lab and field experiments, historical records and models to evaluate the evolutionary and plastic responses to *Colias* larvae and adults to recent and future climate changes.

Poster Sessions

Session 1 - Connecting global and local climate change
Session 2 - Modeling distributions and processes
Session 3 - Thermal performance of organisms in fluctuating environments

Thu 12 June 16:30 – Session 1 Poster 1

Dr. Ayllon Daniel

Department of Ecological Modelling, Helmholtz Centre for Environmental Research-UFZ, Leipzig, Germany

Danial Aylion is a fish ecologist with a PhD in conservation biology. He holds a Marie Curie post-doc fellowship at the Helmholtz Centre for Environmental Research-UFZ (Germany). His research focuses on predicting the demographic and evolutionary dynamics of marginal populations of cold-freshwater fish species under global warming, using eco-genetic individual-based approaches.

Interactive effects of temperature and anthropogenic disturbance hasten ecological change in Mediterranean trout streams under global warming

Daniel Ayllón[1,2], *Graciela G. Nicola*[3], *Benigno Elvira*[2], *Irene Parra*[2], *Volker Grimm*[1], *Steven F. Railsback*[4,5], *Simone Vincenzi*[6], *Ana Almodóvar*[2]

Recent research indicates that species are shifting their ranges significantly faster than previously reported, especially freshwater fish, which are responding to global warming at higher rates than terrestrial organisms. However, significant population declines may occur before any reduction in the range of a species is observed, so accurately modelling the factors driving population size and trends is critical to predict their future extinction risk. We tracked over 12 years 51 populations of a thermally-sensitive fish species, brown trout, living along both temperature and anthropogenic disturbance gradients at the warmest thermal edge of its range. We observed an overall decline in population abundance concurrent with a long-term warming trend across the region. Population performance was markedly driven by temperature and limiting temperature effects were increasingly stronger with increasing anthropogenic disturbance. There was however a critical threshold, matching the incipient thermal limit for survival, beyond which realized density was always below potential numbers irrespective of disturbance intensity. We additionally found a lower threshold, matching the thermal limit for feeding, beyond which even unaltered populations started to decline.

We detected complex synergies among temperature and multiple anthropogenic stressors, which have facilitated the upward movement of warm-water fish species previously limited in their altitudinal distribution by temperature. Synergies among stressors form amplifying feedbacks that hasten the dynamics of species replacement along altitudinal gradients under global warming. Consequently, interactive effects of key anthropogenic drivers should be explicitly accounted for by mechanistic eco-genetic simulation models deployed for predicting trajectories of change under future climate change.

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[3]*Department of Environmental Sciences, University of Castilla-La Mancha, Toledo, Spain.*
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Thu 12 June 16:30 – Session 1 Poster 2

Dr. Bellard Céline

Department of Ecology, Systematic & Evolution, University Paris-Sud, Orsay, France

Céline Bellard works on the effects of global changes such as climate change, invasive alien species, land-use changes, and sea-level rise on the future of biodiversity at a global scale using species distribution models, climate analog analyses, and cumulative impacts approaches.

Future threats across the United States of America

***Céline Bellard**, C. Leclerc, & F. Courchamp*

Human modifications to the planet have greatly accelerated the rate at which extinctions occur. In general, species extinctions involve multiple threats, such as habitat loss, biological invasions, overexploitation, pollution, and climate change. Consequently, to infer the effects of future global changes on biodiversity, it is important to investigate the cumulative impact of these threats. Yet, most studies focus on single threat. In response to this need, Halpern et al., (2008) developed a methodology to quantify and map cumulative impacts, and applied them to marine and freshwater systems for current stressors of biodiversity.We adapted this approach to investigate the future impacts of global changes (i.e., climate change, sea-level rise, biological invasions, and land use changes) across the United States of America, for amphibians, birds, mammals, and reptiles. We predict that large areas of moderate to high cumulative impact scores (with at least two to three threats) will be concentrated in the eastern part of the United States by 2050 and 2080. In contrast, half of the western areas should experience relatively low stress, for all the taxa considered. We highlighted that high cumulative impacts are mainly due to the predicted presence of alien invasive species, and land use changes (i.e., cropland and pasture areas), but also because a significant proportion of species richness are predicted to be sensitive to these threats. Ultimately, identifying spatial distribution of future threats and determining their cumulative influence on biodiversity will allow the implementation of optimal conservation strategy.

Halpern, B. S., Walbridge, S., Selkoe, K. A., Kappel, C. V, Micheli, F., D'Agrosa, C., Watson, R. (2008). A global map of human impact on marine ecosystems. *Science (New York, N.Y.)*, *319*(5865), 948–52. doi:10.1126/science.1149345.

Thu 12 June 16:30 – Session 1 Poster 3

Dr. Bonnaud Elsa

Department of Ecology, Systematics & Evolution, University Paris-Sud, Orsay, France

Elsa Bonnaud is a Lecturer in Paris south University since 2011. Her main research areas are focused on invasive species, disturbed ecosystems, biotic interactions and biological conservation. She is currently working on the impact of predators both in insular ecosystems and peri-urban areas to understand how global changes can induce disturbances in predator-prey interactions.

How altitudinal gradients can be useful to study predator-prey interactions according to climate change?

Currently, it is largely admitted that climate would alter species distribution. However, climate change will also modify the web of interactions and accounting for biotic interactions is urgently needed to better understand how communities are going to respond to climate change. In order to experimentally mimic potential climate change, we will use an altitudinal gradient of 1,200 meters in New Caledonia where data of temperature, precipitations and humidity are available. To avoid confounding effect of spatial differences we will ensure that this survey will be conducted through homogeneous soil and habitat all along this gradient. We plan to study cat diet, population structure and movement, by collecting and individualizing cat scats all along this gradient. Meanwhile targeted prey abundances of cats will be survey by live-traps and transect lines at each 100m of elevation to account for change in climate conditions. We will aim to focus only on particular prey groups: (i) reptiles, highly vulnerable to climate change, being at high conservation priority with species highly threatened and endemic of New Caledonia and, (ii) rodents, staple prey for cats, to understand potential changes in cat trophic behavior along this elevation gradient and its impact. We also plan to complete this reptile abundance data by modeling reptile distribution area through species distribution models according to climatic variables. So we expected to observe differences in structure and abundance of reptile community according to altitude and climatic variables that will certainly influence cat predation on this group according to rodent abundance.

Malhi et al. 2011 Introduction: Elevation gradients in the tropics: laboratories for ecosystem ecology and global change research. Global Change Biology,16, 3171-3175

Sundqvist et al. Community and ecosystem responses to elevational gradients: processes, mechanisms and insights for global change. In review.

Thu 12 June 16:30 – Session 1 Poster 4

Caillon Robin (PhD)

Research Institute on Insect Biology,
UMR CNRS 7261,
Tours, France.

Robin Caillon is a third year PhD at the CNRS studying the biogeography of the leaf microclimate. His studies focus on the impact of climate on both leaf temperature and performance along a latitudinal gradient, and its consequences on leaf-dwelling arthropods.

Linking leaf microclimate to leaf performance along a latitudinal gradient

Organisms may not experience climatic conditions measured at global scales. Rather, most ectotherms live in microclimates characterized by their microhabitat physical properties. Microclimates are extremely important features in the context of global change because they can buffer or enhance climatic variability and its consequences on organisms.
Leaf surfaces provide highly relevant models to study interactions between macro- and microclimate and its consequences on ectotherms. Indeed, the leaf microclimate concerns a great diversity of organisms. It involves physical and physiological properties of the plant that actively senses and responds to macroclimatic variability to reach or maintain optimal levels of photosynthesis. In this context, do plants have a constant thermal optimum for photosynthesis, and regulate leaf temperatures to maintain it, or are plants thermally adapted to reach optimal levels of photosynthesis under different macroclimatic conditions?
We conducted the first field study that combines direct measurements of (i) leaf temperature, with (ii) conductance and (iii) photosynthesis response curves to test for a thermal adaptation of the photosynthesis optimum. Measurements were conducted on five orchards of the apple tree *Malus domestica* spread over a 10° latitudinal gradient from south of France (Montpellier) to Belgium (Namur). Data on the thermal resistance of organisms collected in the same locations must later complete this analysis to add another layer to these complex interactions and test for the consequences of the microclimatic latitudinal gradient on the thermal resistance of leaf-dwelling arthropods.

Thu 12 June 16:30 – Session 1 Poster 5

Dr. Chuine Isabelle

Department of Functional and Evolutionary Ecology, UMR CNRS 5175, Montpellier, France.

Her main research topic concerns the ecological niche that she explores with a process-based species distribution model named PHENOFIT in which phenology is a key stone. Her goals are to identify key traits allowing species to adapt to their environment and how their genetic evolution is constrained.

Fitness consequences of phenological plasticity of temperate tree species

*Anne Duputié[1,2], Alexis Rutschmann[1,3], Ophélie Ronce[4] & **Isabelle Chuine[1]***

Phenotypic plasticity is often put forward as a mechanism helping species to cope with changing environments. Phenology is intimately linked to fitness in temperate trees, and is plastic with respect to temperature and photoperiod. Plasticity in phenology may represent an adaptive response to adjust the life cycle to climatic variation in seasonal environments. However, it could also reflect physiological constraints on growth, which make organ development dependant on climatic conditions. Furthermore, there is concern that adaptive plasticity having evolved under a given regime of environmental variation may become maladaptive when the environment changes, in particular when cues mediating change in phenotype become unreliable. Distinguishing between adaptive and non-adaptive plastic responses to climate change is thus an important challenge in the context of climate change. Using a process-based model describing tree fitness as a function of phenology and resistance to abiotic stresses, we assess the contribution of plasticity in phenological traits to fitness, species range and niche breadth in three common European tree species. We investigate this contribution by artificially altering phenotypic plasticity in the model and its expression through space and time. We examine the predicted contribution of plasticity in current and projected future climate at the scale of Europe. Surprisingly, for the 3 species, plastic variation in phenology has a weak effect on fitness in a large part of the range, but strong effects in marginal conditions. In warm and cold margins, plasticity can have either a positive or a negative effect, with patterns varying among species.

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Thu 12 June 16:30 – Session 1 Poster 6

Prof. Henry Pierre-Yves

Department of Ecology and Biodiversity Management, UMR 7179 CNRS-MNHN, Paris, France.

Pierre-Yves Henry is interested in the functional, ecological and evolutionary consequences of changes in climatic variability on vertebrates and biodiversity dynamics. His current main models are a heterothermic primate for functional experimental in situ and ex situ approaches, and capture-recapture songbird monitoring by volunteer bird ringers for large-scale demographic patterns.

Which are the individuals with the most resilient metabolism to climatic constraints?

***Pierre-Yves Henry**, Cindy I. Canale, Pauline Vuarin*

Climatic fluctuations impose two constraints to endotherms: unfavorable temperatures increase the allocation of energy and time to thermoregulation, but they also reduce food availability by inhibiting primary (vegetation) and secondary (invertebrate) productions. Phenotypically flexible genotypes should cope better with this fine-grained environmental heterogeneity. We investigate the efficiency of an energy saving mechanism (torpor) at plastically compensating fluctuating environmental constraints.
Which are the individuals with the greatest flexibility of torpor use? Using a heterothermic primate that evolved under the 'hyper variable' Malagasy climate, we showed that individuals acclimated to food shortage had a more flexible use of torpor than individuals with *ad libitum* access to food. This corresponds to what naturally occurs when animals gradually enter the dry, cold season. Indeed, individuals with experimentally increased food availability on their territory postponed the seasonal launching of their winter phenotype (torpor), independently of temperature and daylength. Individuals with the largest energy stores (body condition) were also more flexible in their use of torpor than lean individuals. Additionally, immune challenged individuals were temporarily forced to reduce their use of torpor. Overall, individuals in good condition (health, fat, territory) had the most flexible use of torpor, what should help them to be resilient to climatic disturbances.
Which are the individuals with the best chances to survive climatic anomalies? Two starting PhD projects will assess the spatial scale (local – national) at which

climate forcing operates on demography (M. Ghislain), and test if hot anomalies favor the survival of smaller individuals, using the French songbirds' capture-recapture database.

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Canale, C. I., & Henry, P.-Y. (2011). Energetic costs of the immune response and torpor use in a primate. Functional Ecology, 25, 557–565.
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Vuarin, P., Dammhahn, M., & Henry, P.-Y. (2013). Individual flexibility in energy saving: body size and condition constrain torpor use. Functional Ecology, 27, 793–799.

Thu 12 June 16:30 – Session 1 Poster 7

Dr. Hines Jessica

German Centre for Integrative Biodiversity Research, University Leipzig, Leipzig, Germany.

The overall goal of her research program is to inform responsible stewardship of natural resources. She is intrigued by the causes of broad, general patterns in food web dynamics and ecosystem processes, and in ways to assure ecological and societal sustainability in the face of increasing human influences on ecosystems.

Density-dependent phenotypic plasticity of consumer body size determines the influence of global change on ecosystem functioning

Jes Hines[1,2,3]*, Marta Reyes*[1]*, Mark O. Gessner*[1,2]

Predicting the influence of environmental change on ecosystem functioning depends, in part, on our ability to predict changes in the strength and plasticity of consumer-resource interactions. We evaluated the direct and interactive effects of climate warming and increased nitrogen deposition on the plasticity of caddisfly-leaf litter interactions in an outdoor global change experiment. We found that phenotypic plasticity in caddisfly body size was density dependent. That is, when density of conspecifics was low, caddisflies grew rapidly, and their resource consumption was highly plastic in response to global change. For example, by consuming leaf litter and fungal biomass, caddisflies accelerated decomposition by 20-30% in warmed compared to ambient conditions. Increased density of conspecifics, however, resulted in reduced growth rate, smaller maximum body size, and loss of plasticity in response to environmental conditions. This demonstrates that the impact of global change on ecosystem functioning may depend not only on the magnitude of climate warming, but also upon density-dependent interactions among consumers.

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Thu 12 June 16:30 – Session 1 Poster 8

Karakoç Canan (PhD)

Department of Environmental Microbiology,
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for Environmental Research–UFZ,
Leipzig, Germany

Canan Karakoç Studied Biology and Molecular Biology & Genetics in Turkey. She earned Master's degree in Global Change Ecology at the University of Bayreuth, Germany. In January 2013, she joined to the PhD program at the Helmholtz Centre for Environmental Research, Germany. She is Interested in response of ecological interaction networks to fluctuating environments.

Transient dynamics of trophically interacting species after disturbance

***Canan Karakoç**[1], Alexander Singer[2], Karin Johst[2], Antonis Chatzinotas[1]*

Interspecific interactions shape community dynamics. Disturbances intervene in these dynamics causing unpredictable consequences. Theory is essential to gain immediate answers of urgent ecological questions related to disturbances. However, the biological interface is also needed for model creation, modification and validation. Obtaining mechanistic understanding is difficult by the way of macro-ecological experiments alone; highly controlled microbial experimental systems can complement these experiments and provide new theoretical insights.

In our study, we constructed spatially implicit populations of two trophically interacting species (prey bacteria/ predatory protists). The communities were exposed to disturbances by diluting the solutions in the batch cultures, which effectively simulated removal of parts of the populations. We tested the effect of disturbance regimes that differed in duration and intensity and observed transient population size of the species during and after disturbance events. Results show that prey recovery starts immediately after disturbance and population size is even higher than before disturbance, regardless of its duration/intensity. However, predator recovery depends on the disturbance duration. After a press disturbance which allows populations to reach disturbance equilibrium size, predator recovery starts immediately. In contrast, after a pulse disturbance predator population size continues to decline for a substantial period until prey population reaches the pre-disturbance equilibrium density.

Our experimental results confirm ecological theory and theoretical predictions on prey release and delayed predator recovery. We believe that our microbial system correctly mimics prey-predator processes under disturbance, and thus can serve as an important model system to tackle macro-ecological questions in, for instance, epidemiology and conservation biology.

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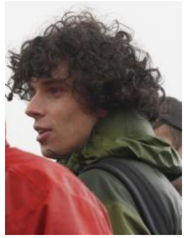
Thu 12 June 16:30 – Session 1 Poster 9

Dr. Laparie Mathieu

Forest Zoology Research Unit,
INRA, Orléans, France.



Mathieu is a Research Asssociate recently hired at INRA, Forest Zoology Research Unit. His research interests lie in the relationship between durable success of invasive/expanding species and the way they fit novel selection regimes encountered as they expand and disturb colonized habitats. He mainly uses tools in ecophysiology, metabolomics and morphometrics.

The success of the pine processionary moth in a changing world research directions on the responses to climate heterogeneity in an insect expanding its range

Climate warming is assumed as the main factor driving rapid expansion of the pine processionary moth in Europe, by broadening habitat suitability during its winter development. Nonetheless, the way this insect deals with climate heterogeneity at the range edge has not been fully untangled. Yet, this is critical to understand its sustained expansion despite conditions close to developmental limits during uneven years or stochastic extreme events. Mitigating responses range from gregarious life in sheltering silk tents to prolonged diapause, which ensures recruitment of individuals even following years of extreme larval mortality (uneven winter near distribution margins). It may also include physiological plasticity and its evolution across the expansion succession due to positive selection on thermal tolerance.

The ecological relevance of such responses directly depends on local conditions and their predictability, which vary along altitudinal and latitudinal gradients, or from oceanic to continental climates. The heterogeneity of climate through space and time therefore appears as a critical selective pressure on pine processionary moth's life histories. Its rapid expansion may consequently promote differentiation of populations throughout its range. This poster will detail research directions of a new project aiming at investigating the mechanisms of such responses and associated variability. It should ultimately allow testing the spatio-temporal structuration of the variation observed within and among populations.

Untangling how pine processionary moth's life histories are impacted by climate heterogeneity and expansion history may prove being crucial for (1) understanding success or failure under challenging conditions, and (2) improving predictive models of phenology and expansion.

Thu 12 June 16:30 – Session 1 Poster 10

Lourenco Carla (PhD)

Department of Zoology and Entomology, Rhodes University, Grahamstown, South Africa.

Carla Lourenço is a PhD student at the Rhodes University, South Africa, working together with CCMAR in Portugal. She earned her undergraduate and Master degree in Marine Biology at the University of Algarve, Portugal, investigating range distributional shifts of the brown mussel *Perna perna* and its relationship to climate change.

Upwelling areas as refugia from rising sea surface temperatures along the contracting southern range edge of the macroalga *Fucus guiryi*

***Carla R. Lourenço*[1,2]**, *Gerardo I. Zardi[1,2], Christopher D. McQuaid[2], Rita Jacinto[1], Ester A. Serrão[1], Gareth Pearson[1], Katy R. Nicastro[1]*

Climate change is having profound and diverse effects on biological diversity. Identifying present-day climatic refugia is an increasingly recognized research strategy that underpins the management of biodiversity loss. These refugia are seen as safe havens that enhance environmental diversity by buffering the effects of large scale change, thereby facilitating species persistence at regional scales.

Numerous studies have examined the diverse functional roles played by upwelled waters, but their potential as refugia in a scenario of global warming has only recently been hypothesized, and remains largely unexplored. Using integrated molecular genetic and ecological approaches, we found that upwelling areas act as refugia for the macroalga *Fucus guiryi* in a region affected by global warming, and characterized by rising sea surface temperatures (SSTs) and extensive shifts in species distributions. The ecological and evolutionary implications of these refugia are discussed.

Nicastro, K.R., G.I. Zardi, S. Teixeira, J. Neiva, E.A. Serrão, and G.A. Pearson, Shift happens: trailing edge contraction associated with recent warming trends threatens a distinct genetic lineage in the marine macroalga Fucus vesiculosus. BMC Biol, 2013. 11: p. 6.

Ashcroft, M.B., Identifying refugia from climate change. Journal of Biogeography, 2010. 37: p. 1407-1413.

Keppel, G., K.P. Van Niel, G.W. Wardell-Johnson, C.J. Yates, M. Byrne, L. Mucina, A.G.T. Schut, S.D. Hopper, and S.E. Franklin, Refugia: identifying and understanding safe havens for biodiversity under climate change. Global Ecology and Biogeography, 2012. 21(4): p. 393-404.

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Thu 12 June 16:30 – Session 1 Poster 11

Dr. Mieszkowska Nova

Marine Biological Association of the UK, Citadel Hill, Plymouth, United Kingdom.

Nova is a Research Fellow at the Marine Biological Association of the UK. She leads the MarClim Project, including the most spatio-temporally extensive time-series for rocky intertidal ecosystems globally, centered around the UK and extending from Norway to Portugal. Her research integrates molecular, physiological and ecological experimental approaches to determine mechanisms underpinning species responses to climate, OA and anthropogenic stressors.

MarClim: a molecular to ecosystems approach for determining mechanistic responses of intertidal species to climate change, ocean acidification and multiple stressors

The MarClim intertidal time-series documents the annual abundance and distributions of rocky intertidal species of Boreal, Lusitanian and Invasive origins around the UK and wider Europe. Some of the fastest biogeographic responses to climate change in any system globally have been recorded by MarClim for invertebrates along the coastline of the UK. Shifts in range limits have been accompanied by directional shifts in population dynamics and relative dominance of co-occurring congeneric species from different biogeographic origins, driven primarily by changes in recruitment success. Long-term mesocosm experiments are being run to determine the biological mechanisms by which species of differing thermal evolutionary origins respond to chronic changes in temperature, ocean pH and localized anthropogenic stressors including microplastics and nutrient loading of coastal waters. Studies into the transcriptional response of invertebrates are revealing the genes and pathways by which ectothermic species are impacted by, and respond to alterations in the marine climate and ocean carbonate chemistry.

Mieszkowska et al. 2014 J. Mar. Syst. 133: 70–76; Mieszkowska et al. 2013. Phil. Trans. Roy. Soc. A. in press; Mieszkowska et al. 2013 J. An. Ecol. 82 : 1215-1226 ; Russell et al. Phil. Trans. Roy. Soc. B. 368 : 20120438 ; Mieszkowska et al. 2013 Marine Climate Change Impacts Report Card 2013. http://www.mccip.org.uk/media/18758/mccip-arc2013.pdf; Spencer, Mieszkowska et. al. 2012 Glob. Change Biol. 18: 1270-1281; Mieszkowska et al. 2006 Hydrobiologia 555: 241-251.

Thu 12 June 16:30 – Session 2 Poster 1

Dr. Bernard Frédéric

AgroParisTech, Paris, France.

Frédéric is an assistant professor on plant physiology and agronomy at the Paris Institute of Technology for Life, Food and Environmental Sciences (AgroParisTech), France. His research aims at reconsidering the use of temperature for the study of the development of foliar fungal pathogens, focusing on the pathosystem *Mycosphaerella graminicola* / wheat, and developing a general approach based on the complementary scales describing climate (meso-, micro-, phyllo- climate).

The development of a fungal pathogen is affected by daily fluctuations of leaf temperature

***Frédéric Bernard**[1,2], Ons Riahi el Kamel[2], Sylvain Pincebourde[3], Michaël Chelle[2], Ivan Sache[1,4], Frédéric Suffert[4]*

In thermal ecology, studying the response of an organism to temperature is based on two paradigms: the use of the body temperature, instead of the environmental temperature, and the consideration of not only the mean, but also the variance of the temperature. These paradigms together have been largely applied to macro-invertebrates but very little to microorganisms. For foliar fungal pathogens, this requires considering variations in the leaf temperature, rather than in air temperature. We experimented the impact of two patterns of leaf temperature of equal mean, but differing in their daily amplitude (± 2°C and ± 5°C), on the development of *Mycosphaerella graminicola*, a fungus infecting wheat leaves. The highest daily thermal amplitude increased the length of the generation time (latent period) and decreased the density of fruiting bodies (pycnidia). The amplitude of these two detrimental effects depended on the considered variable. More precisely, while increasing the daily thermal amplitude did not affect the growth of the necrotic area, it dramatically affected the growth of the sporulating area and the three studied components of fitness: the incubation and latent periods, and the density of pycnidia. In all cases, the highest amplitude resulted in lower pathogen performance. The growth of the sporulating area was slowed down and the final area was reduced, the incubation period and the latent period were lengthened and, more strikingly, the

density of pycnidia was reduced. We conclude on the need to consider daily leaf temperature amplitudes, in addition to the mean leaf temperature, when studying the development of foliar fungal pathogens and other foliar microorganisms.

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Thu 12 June 16:30 – Session 2 Poster 2

Dr. Chapperon Coraline

Laboratoire des Sciences de l'Environnement Marin, CNRS UMR 6539, Institut Universitaire Européen de la Mer, Plouzané, France.

Coraline Chapperon, Ph.D., is a postdoctoral researcher (LabexMer international fellow) at the Institut Universitaire Européen de la Mer (IUEM) in the Laboratoire des Sciences de l'Environnement Marin, LEMAR (Plouzané, France). Her research focuses upon the behavioural, metabolic and physiological responses of intertidal ectotherms to environmental stressors especially thermal stress.

Differential microhabitat use in morphologically different intertidal snails: importance of behaviour and microscale thermal heterogeneity and implications in an era of global warming

Coraline Chapperon[1,2,*], *Laurent Seuront*[1,3,4]

Predicting whether ectothermic species will adapt to future environmental conditions and how they will distribute in the warming climate has become a main priority in the recent decades. Climate change models have, however, shown their limitations *e.g*. they do not take into account high thermal heterogeneity identified at scales relevant to the biology of individual organisms. Body temperature of intertidal ectotherms is, however, strongly related to the temperature of their microclimate and determined by biological factors such as morphology and colour. Thermal imaging is used to examine the distribution and body temperature of two intertidal grazers that differ in shape and colour, but coexist on a thermally stressful rock platform in South Australia. The two species differ in their pattern of space occupation: the light and conical species (*B. nanum*) was mostly solitary, and occurred on surfaces directly exposed to solar radiations that were warmer than those occupied by the dark and rounded species (*N. atramentosa*), mainly found in aggregations under rocks. Snail colour and shape, and thermal selection behaviour associated with the high microscale heterogeneity in substrate temperature (variations as great as 17°C over a few cm), highly contributed to the observed distribution patterns. We finally stress the importance of coupling different approaches (physiology, morphology and behaviour) to increase our understanding of the determinism of microscale

distribution of ectotherms, hence improve predictions about future species distribution at larger spatial scales and help implementing conservation and management plans that may decrease their vulnerability in the warming climate.

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Faye Emile (PhD)

Biodiversity and evolution plant/insect-pest/antagonist complexes, UR 072, IRD, Gif-Sur-Yvette, France.

Emile Faye is a second year PhD at the French Research Institute for Development studying thermal landscape dynamics and related insect pest performance in complex agrosystems in the Andes. He works on microclimates experienced by agricultural pest using high resolution U.A.V. thermal imagery.

Distance makes the difference in thermography for ecological studies

***Emile Faye**[1, 2], Olivier Dangles[1], and Sylvain Pincebourde[3]*

Infrared cameras are widely used in thermal ecology research. While many studies in thermal spatial ecology (studying microhabitat in complex landscapes for instance) were confined to point measurements, modern infrared imagery currently allows spatially continuous and instantaneous measurements of surface temperatures with a much broader spatial coverage and at high spatial and thermal resolution (i.e. few centimeters / pixel). Thermal images captured with these cameras are usually analyzed by landscape ecologists for featuring thermal landscape with metrics of heterogeneity, composition and configuration. Thermal ecologists, however, use these cameras in a range of smaller spatial scales. This is despite varying the distance between an object and the camera at such small scales can strongly bias the thermal metrics. Herein, we investigate the effect of the distance between the studied object and the infrared-camera on thermal information provided. To help understand how distance affects the metrics, we used synchronized shots of the same surface from two thermal cameras at different distances (one fixed at 2 m and the other ranging from 2 to 100 m). Our results revealed that thermal metrics are strongly influenced by distance. Mean temperature, standard deviation and patch richness strongly decrease in the first 20 m from the studying object (i.e. less than 2°C for mean temperatures) while the aggregation index increases. Beyond 20m, metrics are slowly decreasing with the distance. These findings clearly point out that care should be taken regarding distance when using thermography in ecological studies.

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Thu 12 June 16:30 – Session 2 Poster 4

Dr. Gibert Patricia

Biometry & Evolutionary Biology laboratory, UMR CNRS 5558, Lyon, France.

Patricia Gibert is a researcher at the French CNRS. She is interesting in the adaptive responses of insects to environmental changes and on the evolution of thermal reaction norms. Her favorite biological model is Drosophila and associated parasitoids.

Can we predict the effect of thermal fluctuations on specialist and generalist reaction norms?

*Vincent Foray[1,2], Emmanuel Desouhant[1], **Patricia Gibert**[1]*

Reaction norms depict the environmental effects on phenotypic traits and are used to predict the global change consequences on organisms. However, studies performed at constant temperatures have limited ecological significance because expressed phenotypes depend on the range and frequency of environmental states. By using the Jensen's Inequality (a mathematical property of nonlinear functions), we predict that the effect of thermal fluctuations on the phenotype depends on the shape of the reaction norm: a negative effect of the thermal fluctuations when the reaction norm is convex and a positive effect when the reaction norm is concave. This study measures the impact of diel fluctuations in developmental temperature on phenotypic expression of traits related to fitness and energetic resources in two strains of the parasitoid wasp *Venturia canescens* differing in their thermal sensitivity. We compare the effect of a constant versus a fluctuating thermal regime having the same means (20, 25 and 30 °C) on reaction norms of life history traits and of energetic reserves. As predicted, our results show that the shape of the reaction norm defines the phenotypic changes induced by the development under fluctuating thermal conditions. Moreover, our results emphasize the significance of taking into account several phenotypic life history traits to study the adaptive value of phenotypic plasticity. This is the first experimental study demonstrating that Jensen's Inequality can quantitatively predict the effect of thermal fluctuations on life-history traits of an ectotherm species.

Foray V, Desouhant E, Gibert P 2014 The impact of fluctuations on reaction norms in specialist and

generalist parasitic wasps *Funct Ecology* 28 : 411-423.

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Thu 12 June 16:30 – Session 2 Poster 5

Prof. Marshall David

Biometry & Evolutionary Biology laboratory, University of Brunei Darussalam, Brunei Darussalam.

His current research focuses on physiological and behavioural adaptations of tropical gastropod molluscs. I have particular interests in the evolution of metabolic depression in gastropods, an energy conserving mechanism that seemingly underlies their diversity and success in all of Earth's major domains, and that should influence the way they respond to future environmental change.

Activity-constrained gastropods: considering alternative physiological models in ectothermic climate vulnerability predictions?

David J. Marshall[1], Christopher D. McQuaid[2], Gray A. Williams[3]

Gastropod lineages uniquely span diverse habitats in Earth's three major domains (marine, terrestrial and freshwater). However, gastropods are poorly equipped to control evaporative water loss when active in air. Consequently, they become inactive and reduce interaction with the environment when evaporative rates rise in tandem with daily rising temperatures. The resulting narrowing of the thermal range for activity, along with an intrinsic limitation on movement (muscular foot), potentially restrict thermal adaptation of locomotor performance. The adaptive and acclimatory mechanisms of gastropods for maintaining energy homeostasis and for tolerating heat stress in thermally variable environments thus differ vastly from those of ectotherms typically used to model climatic responses (insects, lizards). To overcome activity and thermally constrained energy gain in highly fluctuating thermal environments, gastropods have evolved mechanisms to lower energetic costs when quiescent, including temperature-insensitive metabolic rate depression ($Q_{10} \leq 1$). Unlike many ectotherms, their heat tolerance (lethality) is not determined by a precise limit to locomotor performance (CTmax), but varies over a broad thermal range of inactivity (often 10^{o}C), dependent on the duration of stressful exposure (hours). Heat tolerance seemingly relates to energy-conserving mechanisms being compromised above the temperature that limits muscular activity, when a costly heat shock response is induced. Because intrinsic dehydration factors (not thermal factors) are also likely to control activity under rising temperatures in other lesser-studied terrestrial invertebrate taxa (and phyla), there is a need for greater consideration

of humidity regime change in models exploring the full scope of ectothermic climate warming vulnerability.

Foray V, Desouhant E, Gibert P 2014 The impact of fluctuations on reaction norms in specialist and generalist parasitic wasps *Funct Ecology* 28: 411-423.

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Dr. Milbau Ann

Climate Impacts Research Centre, Umea University, Umea, Sweden.

Ann Milbau is a plant ecologist, mainly working along natural gradients in arctic and alpine ecosystems. Her research focuses on three topics: (1) Plant recruitment and colonization, (2) Plant invasion, (3) Fine-root dynamics. She especially likes the combination of observing processes under natural conditions and testing specific hypotheses under more controlled conditions.

The hidden season – arctic growing season 50% longer in roots than shoots

Gesche Blume-Werry[1], Scott D. Wilson[2], Juergen Kreyling[3], **Ann Milbau[1]**

There is compelling evidence from experiments and observations that climate warming prolongs the growing season in arctic regions. Start, peak and end of the growing season are used to model vegetation influences on biogeochemical cycles and have thus far been quantified solely aboveground. Yet, paradoxically, over 80% of the plant biomass in the Arctic consists of roots, and root growth phenology considerably affects biogeochemical processes by influencing plant water and nutrient uptake, soil carbon input and microbial activity. Whether or how arctic root phenology is coupled with aboveground phenology is still unclear. Here, we use in situ measurements to show that production does not peak simultaneously in shoots and roots in arctic plant communities. Moreover, the growing season continues around 50% longer belowground than aboveground. These results strongly suggest that in arctic regions traditional aboveground estimates of phenology, including remotely sensed information, cannot be used to infer root production intensity or duration, nor associated processes. We thus argue for the inclusion of seasonal root growth into future scenarios of how arctic ecosystems will respond to climate warming.

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Nati Julie (PhD)

Institute of biodiversity, animal health and comparative medicine, University of Glasgow, Glasgow, Scotland.

Julie is a second year PhD student at the University of Glasgow in the Institute of Biodiversity, Animal Health and Comparative Medicine working on the effect of temperature on the physiology and behaviour in invasive and native freshwater fish species in Great Britain.

Links between metabolic traits and latitudinal distribution across fish species

Julie J.H. Nati[1], Paul Johnson[1], Jan Lindstrom[1], Shaun S. Killen[1]

A range of biotic and abiotic factors may affect the geographical distribution of species. For example, recent work has shown that latitude range in ectothermic species might be governed by thermal tolerance limits. Still unknown, however, are the proximate physiological mechanisms that allow certain species to have wider thermal limits and possibly a broader geographic range. Here we examined how metabolic and life-history traits might affect latitudinal range and position in fish. Our comparative analysis of the existing data from literature revealed a positive correlation between aerobic scope and latitude range across 65 fish species and species with higher baseline metabolic rate were found at higher latitudinal positions. These findings suggest that geographical distribution and capacity to colonise new habitats of fishes are tightly linked with their metabolic physiology. In this regard, we are currently investigating how the physiological traits of invasive fish species may differ from of native fish species.

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Quenta Estefania (Msc)

Institute of Ecology, animal health and comparative medicine, University Mayor San Andrés, La Paz, Bolivia.

Estefanía Quenta Herrera (La Paz, Bolivia). She is Master in Ecology and Conservation of the *Universidad Mayor de San Andrés*. Now, she is conducting her research on the structure of zooplankton communities in high altitude wetlands of the *Cordillera Real*, and her research in tropical thermal rivers of high altitude.

Effects of warming on geothermal stream biota in the high Bolivian Andes

Estefanía Quenta[1], Antonio Daza[1], Jorge Molina[1], Sophie Cauvy[1,2], Xavier Lazarro[3], Dean Jacobsen[4], and Olivier Dangles[1,2]

Identifying terrestrial and aquatic *sentinel species and ecosystems* is a major issue to deal with the effects of climate change as it allows early detection and prediction of ecological responses. Geothermal streams are one of these ecosystems as they represent natural experimental systems allowing capturing the ecosystem complexity in the face of rapid warming. These systems have been investigated at high latitudes, but they are also present in other location highly sensitive to climate change, the tropical high Andes. High altitude geothermal streams represent unique ecosystems to assess the effects of warming on aquatic biota as they are also subjected to other environmental stresses that currently interact with temperature (e.g. oxygen deficiency). The aim of the study was to examine the form of the relationship between temperature and different metrics depicting the structure and function of aquatic biota in a geothermal stream. We selected 26 stream sites along a gradient of temperature (12-36 ºC) where we quantified macroinvertebrate community structure and fish abundance and body sizes. Benthic chlorophyll *a* was measured using a portable fluoro-probe, and cellulose decomposition was assessed using plastic bags of different mesh size. Our results revealed that macroinvertebrate community similarity among stream sites rapidly decreased with small difference in temperature while body size fish differences increased constantly with increasing temperature. Primary producers showed a unimodal relationship with temperature and there was a linear increase in decomposition rate of cellulose as temperature increased. These results suggest that event

small amount of warming have important effect on the aquatic biota but that these effects strongly differ depending on the metrics considered.

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Prof. Sears Michael

Department of Biological Sciences, Clemson University, Clemson, SC, USA.

Michael Sears studies ecological physiology and thermal adaptation to better understand the responses of organisms to changing environments. Specifically, he seeks to explain landscape-level patterns of the abundances and distributions of animals by understanding the basic physiologies and behaviors of individuals within a spatial context using computational approaches.

Thermal heterogeneity of landscapes drives potential activity of ectotherms

Michael W. Sears[1], Ofir Levy[2], Michael J. Angilletta[2]

Understanding the ecological responses to global climate change represents one of the greatest challenges of the 21st century. To forecast these responses, we must develop computer-intensive models that leverage detailed climatic and biological data. Current approaches to forecasting have focused on driving factors of geographic distributions such as climate, topography, and land use. In particular, mechanistic models have successfully integrated principles of biophysical ecology with GIS to predict species' ranges. While this approach is quite powerful, integrating behavior and physiology to predict the potential for organismal activities—a central component of many mechanistic models—remains challenging. The problem is worsened by the mismatch between the spatiotemporal scales of environmental data versus the scale at which organisms experience environmental heterogeneity. Here, we extend a framework that explicitly incorporates fine-scale processes to predict the activity, dispersal, and energetics of animals[1]. Earlier findings suggested that either increased elevational relief or increased fractal dimension of a landscape can increase the potential duration of activity. To examine the robustness of this result, we generated randomly configured landscapes that differed over a range of elevation, percent vegetation, and their fractal dimensions. With these artificial landscapes, we used an individual-based model to predict spatial and temporal patterns of activity, not just the potential for activity. Two insights emerged from these simulations: 1) features of landscapes that increased thermal

heterogeneity tended to increase the potential for activity, and 2) environments with the highest potential for activity did not necessarily have the highest potential energetic expenditures. These results illustrate the importance of incorporating fine scale interactions between organisms and their environments for a better understanding of ecological dynamics related to climate.

[1]Sears MW, E Raskin, MJ. Angilletta. 2011. The world is not flat: defining relevant thermal landscapes in the context of climate change. Integrative and Comparative Biology 51: 666-675.

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Thu 12 June 16:30 – Session 2 Poster 10

Dr. Seuront Laurent

Laboratory of Oceanology and Geosiences, UMR 81187, CNRS, Wilmereux, France.

Laurent Seuront, Ph.D., is a Research Professor at the Centre National de la Recherche Scientifique (CNRS, France) and a Professor of Oceanography at Flinders University (Adelaide, Australia). His research concerns biological-physical coupling in marine environments, with a special focus on the behavioural response of individual organisms to anthropogenic and climatic stressors.

Behavioural flexibility as an adaptation to thermal stress in an era of global warming

Laurent Seuront[1,2], Coraline Chapperon[2,3]

There is now ample evidence of the ecological impact of recent climate change, from polar terrestrial to tropical marine environments. The responses of both flora and fauna span an array of ecosystems and organizational hierarchies, from the species to the community levels. Organisms, populations and ecological communities do not, however, respond to approximated global averages. Instead, regional changes, which are highly spatially heterogeneous, are more relevant in the context of ecological response to climatic change. More specifically, the variability in thermal stress observed on wave-swept rocky intertidal ecosystems at scales pertinent to individual organisms in rocky intertidal ecosystems is increasingly shown to be greater than along latitudinal gradients. As a consequence, the physiological and behavioral abilities of intertidal organisms to dampen temperature fluctuations are potentially a critical adaptive and evolutionary force to face the increasingly stressful conditions they experience in an era of global change. In this context, we explore both *in situ* and *ex situ* a range of behavioral adaptations that are shown to decrease the impact of thermal and/or desiccation stress in intertidal gastropods. These questions have been assessed through measurements of body temperature and water content in a range of gastropod species from environments under various levels of thermal and desiccation stress such as Australia, Hawaii, Portugal and France. These adaptations include shell standing, cooling towers, aggregation,

habitat selection, and appear to vary with specimen size and color. The implications of these observations are discussed in the general context of the scenarios predicting future climate conditions.

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Thu 12 June 16:30 – Session 2 Poster 11

Dr. Sheldon Kimberly

Department of Zoology and Physiology and Program in Ecology, University of Wyoming, Laramie, WY, USA.

Kimberly is an NSF Postdoctoral Fellow at the University of Wyoming. She works across broad latitudinal and elevational gradients to answer questions at the interface of ecology, physiology, and evolution. She has particular interests in thermal physiology, biogeography, natural history, and the impacts of climate change.

Beyond the mean: biological impacts of cryptic temperature change

Kimberly S. Sheldon & Michael E. Dillon

Studies on the biotic impacts of climate warming have overwhelmingly focused on the potential impacts of shifts in mean temperatures. Though changes in mean temperatures correlate with shifts in, for example, phenology and geographic ranges, other "cryptic" changes in temperature may be equally important. Yet, these cryptic changes have received relatively little attention, in part because the organism-appropriate temperature metric is often elusive. As an alternative to defining arbitrary temperature metrics, we evaluated the biotic impacts of cryptic temperature changes by viewing organisms as physiological filters. Thus, we filtered global hourly temperature data through three classes of cryptic temperature effects: 1) non-linear thermal responses using thermal performance curves of insect fitness, 2) hysteresis of thermal effects using degree-day models for corn development, and 3) threshold temperature effects using critical thermal maxima and minima for diverse ectotherms. We contrast biotic impacts based on mean temperatures with estimates from this physiological filter approach to evaluate the effects of cryptic temperature change.

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Dr. Suffert Frédéric

Biology & Management of Agricultural Threats-Fungal Plants Pathogens, INRA, Thivernal-Grignon, France.

Frédéric Suffert is a plant disease epidemiologist. He leads the group "Epidemiology" in a research unit specialized in fungal plant pathology (BIOGER, INRA Versailles-Grignon). He works on the quantitative epidemiology of leaf blotch of wheat (*Mycosphaerella graminicola*) with particular reference to the role of primary inoculum in the dynamic of epidemics and to response and adaption of pathogen populations to temperature (seasonal changes, geographical heterogeneity).

Is the annual amplitude of temperatures a driving force for fungal pathogen population adaptation?

Frédéric Bernard[1,2], Ons El Kamel[3], Alain Fortineau[2], Ivan Sache[1,3], Michaël Chelle[2], **Frédéric Suffert[3]**

Annual mean temperature is known to drive local adaptation of fungal pathogen populations. Our objective was to assess whether annual temperature amplitude is also a significant driver. To this end, we selected two French areas (West and East) characterized by an annual air temperature of similar mean but contrasted amplitude. In each area, nine isolates of *Mycosphaerella graminicola* (the fungus causing septoria tritici blotch disease on wheat leaves) were collected from field plots. The thermal performance curve (TPC) for two aggressiveness components (latent period and maximum diseased area) was established for each isolate on adult wheat plants, using five mean temperatures (greenhouse/growth chamber experiments). TPCs were obtained by fitting a quadratic relationship, characterized by three parameters: T_{opt} (optimal temperature), Val_{opt} (value at T_{opt}), and *Curv* (curvature), to the five values of aggressiveness components. The analyses of Val_{opt} for both the latent period and the maximum diseased area demonstrated a significantly higher aggressiveness for the population originated from the area with a higher annual amplitude of temperature (East); this difference, not necessary related to temperature, could be explained by adaptation to local wheat cultivars. The means of T_{opt} and *Curv* did not differ between populations for both aggressiveness components. However, differences

in the variance of T_{opt} between populations showed that intra-population polymorphism in TPC is reduced in the area with low annual amplitude of temperatures (West). This result suggests that the annual amplitude of temperature may be a driving force for the adaptation of *M. graminicola* populations to climatic conditions.

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Thu 12 June 16:30 – Session 2 Poster 13

Prof. Vasseur David

Department of Ecology and Evolutionary Biology, Yale University, New Haven, CT, USA.

David Vasseur is a theoretical ecologist addressing fundamental questions in community ecology by means of developing of new mathematical theory, conducting simple lab-based experiments, and analyzing long-term data. The questions he addresses are motivated by a desire to mechanistically define the processes underlying population and community dynamics in aquatic systems.

Increased temperature variation poses a greater risk to species than climate warming

***David A. Vasseur*[1]*,** *John P. DeLong*[2]*, Benjamin Gilbert*[3]*, Hamish S. Greig*[4,5]*, Christopher D.G. Harley*[6]*, Kevin S. McCann*[7]*, Van Savage*[8,9]*, Tyler D. Tunney*[7]*, and Mary I. O'Connor*[6]

Increases in the frequency, severity and duration of temperature extremes are anticipated in the near future. Although recent work suggests that changes in temperature variation will have disproportionately greater effects on species than changes in mean, much of climate change research in ecology has focused on the impacts of mean temperature change. Here we couple fine-grained climate projections (2050-2059) to thermal performance data from 38 ectothermic invertebrate species and contrast projections with those of a simple model. We show that projections based on mean temperature change alone differ substantially from those incorporating changes to the variation, and to the mean and variation in concert. Although most species show increases in performance at greater mean temperatures, the effect of mean and variance change together yield a range of responses, with temperate species at greatest risk of performance declines.

These (and most other) projected changes in performance do not include estimates of how evolutionary change might mediate species responses. I will describe how we are currently thinking about this problem and how it changes our estimates of climate change impacts.

Vasseur, D.A., et al. 2014. Increased temperature variation poses a greater risk to species than climate warming. Proc. Roy. Soc. B. 281(1779).

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Thu 12 June 16:30 – Session 3 Poster 1

Dr. Bertrand Romain

Centre for Biodiversity,
Theory & Modelling, CNRS,
Moulis, France.

Romain Bertrand is a post-doctorate at the Centre for Biodiversity Theory and Modelling (Loreau laboratory, CNRS). He is particularly interested by understanding how the global changes affect species' distribution, community composition and ecosystem functioning, and by developing and testing new approaches in this topic.

Projected species distribution models over the time: a risky business?

***Romain Bertrand*[1], *Xavier Morin*[2], *Michel Loreau*[1]**

Since the 90s correlative species distribution models (SDMs) are increasingly used to predict changes in species habitat sustainability under future climate conditions. However, only few studies had focus on the temporal transferability of SDMs. Here, we tested the ability of SDMs to match environmental conditions that tree species occupied from ~20,000 years before present to present. SDMs were fitted by linking the species presence/absence from their known current species distribution (EUFORGEN data) to the averaged climate conditions over the period 1961-2000 through a GLM regression. Then, SDMs were projected over the past using the climate conditions predicted by the GCM CCSM3, and predictions were transformed from probability of presence to presence/absence. Finally, environmental conditions of some species presences in the past (assessed from the European Pollen database) were sampled at different time periods and compared to the environmental conditions of predicted species presences by computing and testing Schoener's *D* (an index of overlap). We repeated the analysis 1,000 times for each time frame to account for the stochasticity of presence/absence predictions. Preliminary results for *Abies alba* showed high values of Schoener's *D* with low variation since 20,000 years before present (*D* average varies from 0.87 to 0.92), although the SDM was projected under no-analog climate conditions. This demonstrates that the SDM is able to predict species presence whatever the time frame. However, as this result may be specific to *Abies alba* and GLM regression, we will extend our study to more species and models.

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Thu 12 June 16:30 – Session 3 Poster 2

Carolan Kevin (PhD)

Maladies Infectieuses et Vecteurs : Écologie, Génétique, Evolution, et Contrôle, IRD, Montpellier, France.

Kevin Carolan is a third year of PhD with IRD and CIRAD at Montpellier, studying the environmentally acquired pathogen *Mycobacterium ulcerans*, and how its ecological niche changes across different regions and scales.

How to compare niche models on different spatial scales

Kevin Carolan[1,2]*, Danny Lo-Seen*[2]*, Jean-François Guégan*[1]

Ecological niche models are widely used to describe the ecological distribution of macro-organisms, such as birds or mammals, and in the last decade their use has increased considerably for the study of vector-borne diseases. Here we explore the sample size needed for good model performance, and how this changes depending on the species studied.

We create several virtual species and model their ecological niches with the software Maxent. We generate presence data to be used for niche modelling in Maxent, and also use absence data, often unknown or unavailable, to explore the ability of a commonly used metric, the area under the curve of the receiver operating characteristic (AUC), to judge model performance.

We find that the sample size needed for good performance of a niche model changes according to the species and scale studied. We also find that the ability of the AUC to indicate model performance changes according to the species and scale studied.

These results highlight the need to appropriately limit the spatial extent of the study. Which can limit the utility of historical data, or provide a guideline for future studies. AUC is found to be unsuitable for evaluation of niche models.

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Thu 12 June 16:30 – Session 3 Poster 3

INRA SCIENCE & IMPACT

Dr. Hampe Arndt

UMR 1202 Genes & Communities Biodiversity, INRA, Bordeaux, France.

Arndt Hampe has a background in plant population ecology and evolutionary biology. His research spans local to large geographical scales and combines field and molecular ecological approaches. He is particularly interested in the ecology and evolution of climate relict populations residing at the rear edge of species ranges.

Modelling effects of the fine-scale mating environment on gene flow in a relictual riparian tree

Rocío Rodríguez[1*], *Pedro Jordano*[1] & ***Arndt Hampe***[2]

Understanding how spatial patterns of mating and gene flow respond to habitat loss and geographical isolation is a crucial task of forest fragmentation genetics. Here, we investigate patterns of mating and pollen-mediated gene flow in four populations of the tree *Frangula alnus baetica* (Rhamnaceae) that have persisted in isolation through an extended period in small riparian forests in southern Spain. For this we used paternity analyses and a Bayesian modelling approach. Results indicate that a few trees within each population are disproportionately fecund while most trees sire only few seeds. This pattern is not related with intrinsic factors such as plant size or age. A predominance of short-distance pollination events generates local mating clusters within each population. However, we also detected numerous pollination events over hundreds of meters and a remarkably high fraction (15-42%) of pollen immigration. We tested different ecological correlates of mating patterns and found consistent evidence that 1) tree size influences the female function markedly more than the male function, 2) the fine-scale mating environment is the main driver of kinship relationships, being closely related to spacing and clumping patterns of the adult trees, and 3) distances of pollen movement respond to drivers at various scales, with longer distances associated to larger tree size, sparser mating neighbourhoods, and overall population size. Our results demonstrate that seemingly isolated relict tree populations can persist and remain functionally connected over very long periods even in peculiar environments that constrain mating patterns and pollen-mediated gene flow.

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Thu 12 June 16:30 – Session 3 Poster 4

Dr. Leroy Boris

UMR 8079 Ecology,
Systematic & Evolution,
University of Paris-Sud,
Orsay, France.

Boris Leroy is doing a post-doc on the impacts of climate change on economically important invasive insects. He is particularly interested in conservation biogeography and climate change issues. He is also interested in improving methodological tools such as species distribution models.

Virtualspecies: an R package to generate virtual species distributions

Boris Leroy*[1]*, *Christine N. Meynard*[2]*, Céline Bellard*[1]*, Franck Courchamp*[1]

Species distribution models have become a central tool in estimating the impacts of environmental changes on species distributions, and are thus subject to constant methodological improvements regarding new techniques, protocols, or evaluation methods. These methodological improvements need testing and validation. The use of empirical data during this validation phase is many times problematic because each dataset has many confounding factors which preclude generalisation. The use of simulation of virtual species distributions is a valuable alternative because underlying mechanisms that generate such distribution patterns are known and can be manipulated independently. This approach allows comparing the known 'true' distribution with the output from the models, and to test independently the effects of each confounding factor. Although the simulation of virtual species distributions is increasingly applied and advocated, there are surprisingly few articles on the methods to generate adequate virtual species distributions, and there is no software for generating virtual species. Here we present a new R package called 'virtualspecies', designed to readily generate virtual species distributions with appropriate methodologies. The package covers the simulation of probabilities of occurrence for virtual species, their conversion into presence-absence and the sampling of occurrences, with the possibility of simulating different biases in the process (species not at the equilibrium, sampling bias, etc.). These simulations are achieved by a range of functions, including visualisation functions, and can be completely parameterised or randomised. The package is based on spatial data of 'raster' format, and is thus compatible with most software of species distribution model, such as the BIOMOD and dismo R packages.

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Thu 12 June 16:30 – Session 3 Poster 5

UNIVERSITÀ DEGLI STUDI DI PALERMO

Prof. Sarà Gianluca

Department of Earth and Marine Science, University of Palermo, Palermo, Italy.

Gianluca Sarà (Ph.D. 1994) is Associate Professor of Ecology and leads the Integrative & Experimental Ecology Lab at University of Palermo (Italy). His current research focuses on the mechanistic and ecological responses of marine organisms to anthropogenic-induced changes ranging from functional level up population processes, species interactions, and biodiversity.

Functional traits, mechanistic bioenergetics and microclimatic downscaling of marine ectotherms

Sarà Gianluca, *Giomi Folco, Montalto Valeria, Rinaldi Alessandro*

In the last decades the great concern toward the rapidly anthropogenic climate change has raised the interest toward the pervasive effect of climatic features on ecological processes. In this context, the Laboratory of Integrative & Experimental Ecology at University of Palermo studies how climate- and anthropogenic-induced changes drive the loss of biodiversity by adopting an accurate bottom-up mechanistic-based approach. It starts from the available energy at functional level and transversally involves the whole ecological hierarchy. The approach relies on the mechanistic basis of the Dynamic Energy Budget (DEB) theory and represent a pioneering solution to quantitatively predict change of species abundance in a rapidly changing world. We adopt it ranging from invasive marine species worldwide distributed to local communities and from the intertidal belt to the upper infralittoral habitats that we integrate with large projections of climatic trends down to the characterization of microclimatic niche. At large geographical scale, we combine experimental approaches and mechanistic DEB modeling to determine the acclimation capacity and the resilience of natural communities to heterogeneous environmental correlates, over species' biogeographic ranges. A more recent challenge is linking environmental features (and its natural or human-induced variance) with functional and life history traits of marine species in order to feed population models. Here, we built predictive models to draw the consequences for population dynamics of changes in species functional traits in order to mechanistically explore the role of species inside communities. Finally, down-scaling our focus on microclimatic heterogeneity, we investigate to which extent the rich biodiversity of infauna inhabiting structured communities is sustained not only by the quantity and quality of the sedimentary food entrapped but also by the thermal heterogeneity provided by these ecosystem engineers.

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Dr. Saudreau Marc

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After a PhD and Postdoctoral research work in Fluid Dymanics (unsteady flow, turbulence, mixing, combustion, modeling).
Current position: full time research scientist at UMR PIAF - INRA (France). Research topics: leaf and fruit temperature dynamics in relation with tree structure and within canopy microclimate. Application: within pest development and fruit quality.

Modelling Spatial and Temporal Leaf Temperature Dynamics at leaf and canopy scales.

Marc Saudreau [1,2,*]**,** Boris Adam [1,2] and Sylvain Pincebourde [3]

Leaf temperature is an important factor involved in many biological processes such as leaf transpiration and photosynthesis, leaf – pathogen interactions or insect development rates. Within a plant canopy, leaves can exhibit a wide variety of temperature dynamics (frequency, amplitude, spatial gradients) related to the leaf position within the canopy (sunlit vs shaded leaf), the leaf shape and orientation (small vs large, downward vs upward), the leaf physiology (stomatal regulation), and the variability in microclimatic conditions (wind, light, air temperature and air relative humidity). Thus high spatial variability in leaf temperature at canopy scale (shaded leaf versus sunlit leaf for instance) and at leaf scale (edge effect for instance) is observed. Such variability provides heterogeneous thermal conditions which could greatly impact the development of organisms. Such variability in leaf temperature dynamics results from changes in heat energy exchanges between the leaf and its local environment. The underlying physics is well known and the temperature dynamics can be inferred by solving a heat balance equation where microclimate and leaf physiology are taken into account through radiation (R), convection (C), evapotranspiration (λE) and diffusion (G) terms.

Based upon the MicroClimite project (funded by the French National Research Agency – PI: S. Pincebourde), a modelling work was developed by IRBI and PIAF labs to predict leaf temperature heterogeneity at the leaf scale (a 3D leaf model) and at the canopy scale (a 3D tree model). This poster presents part of this work, focuses on the validation of the models and highlights some interesting outputs.

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Dr. Serra-Diaz Josep

School of Geographical Sciences and Urban Planning, Arizona State University, AZ, USA.

JM Serra Diaz (Pep). PhD in Environmental Sciences by the Universitat Autonoma de Barcelona and Advanced studies in Botany. He works with different modelling approaches to better understand spatial patterns of species distribution to obtain robust global predictions across spatial and temporal resolutions.

micro2MACRO: Connecting micro environments to macro ecology: California forests under climate change

Josep M Serra-Diaz[1], Janet Franklin[1], Frank W Davis[2], Alexandra D Syphard[3], Helen M Regan[4], Lynn Sweet[2], Ian McCullough[2], John Dingman[5] , Alan L Flint[5] , Lorraine E Flint[5], Alex Hall[6] , Lee Hannah[7] , Max Moritz[8], Kelly Redmond [9], Malcolm North[10].

The aim of this research is to measure and model microenvironment controls on tree species establishment and population dynamics in order to predict regional range dynamics under projected future climate for five dominant tree species across four study sites in the Sierra Nevada and Coast Ranges of California, USA. In a novel combination of site trials, physical models, distribution models and population models, our design incorporates measured (rather than inferred) species' tolerances of microenvironments at spatial scales that vary over five orders of magnitude (30m-3000km). We perform species trait-based distribution models, population models, landscape models and biogeographic models of climate change that explicitly incorporate microclimatic information from reciprocal transplant experiments, measurements of microclimate and soil factors related to temperature and moisture regimes.

Our approach is an integrated multi-scale and multi-modeling framework that allows us to bridge scales from micro- to macro-. The advantages of such a system in climate change analyses have long been recognized (Root and Schneider 1995). The preliminary results of this project point out the effects of microclimates on species persistence and migration, and the shortcomings of the use of coarse resolution data to assess certain ecological processes. All in all, our results improve our understanding of microenvironment effects on macroecology.

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Information

Loches
Lucottel
Restaurant

Loches, Touraine

You will find all the information you need on Loches, its castle and the region in the booklets you received from the tourism office on your arrival at the Luccotel hotel.

Nights

Loches, Touraine – Luccotel Hotel

Situated in a quiet green park in Loches en Touraine, medieval town of the Loire Valley, the Luccotel hotel restaurant offers an ideal setting to enjoy your stay in the Loire Valley. Situated near the Loire castles, with your family, couple of friends, you will discover the charm of our Touraine, while enjoying the activities and the relaxation space offered by our establishment.

Restaurant

Tuesday 10 June

Dinner

Entrée

Quiche tourangelle aux rillons

Plat

Suprême de volaille farci à la duxelles de champignons, riz aux petits légumes

Dessert

Tarte fine aux pommes et au caramel beurre salé

Wednesday 11 June

Lunch

Entrée

Terrine de campagne maison, à la confiture d'oignon

Plat

Filets de rouget au beurre blanc, flan de légumes à la royale

Dessert

Moelleux au chocolat noir, à la crème pistache

Dinner

Entrée

Croustillant de Sainte Maure au miel sur lit de jeunes pousses

Plat

Cœur de quasi de veau rôti, jus à l'ail, risotto au parmesan

Dessert

Poire pochée au vin rouge et épices

Thursday 12 June

Lunch

Entrée

Brochettes de crevettes, caviar d'aubergine, coulis de poivron

Plat

Sauté de canard à l'orange, écrasée de pomme de terre

Dessert

Canotier à la noix de coco au coulis de fruits exotiques

Dinner

Entrée

Croustade d'œufs brouillés au saumon fumé

Plat

Filet mignon porc à la tourangelle (vin rouge, Ste Maure), gratin pomme de terre

Dessert

Nougat glacé, coulis de fruits rouges

Friday 13 June

Lunch

Entrée

Melon au jambon sec

Plat

Dos de cabillaud à la crème safranée, printanière de légumes

Dessert

Vacherin à la vanille et cassis

Dinner

Entrée

Assiette de crudités

Plat

Daube de bœuf aux lardons marinés au marc, fenouil et purée à l'ail

Dessert

Bavarois aux fruits exotiques

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HETEROCLIM