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DIPARTIMENTO DI INGEGNERIA CIVILE, EDILE E AMBIENTALE - I C E A
DEPARTMENT OF CIVIL, ENVIRONMENTAL AND ARCHITECTURAL ENGINEERING

Via F. Marzolo, 9 - I 35131 Padova
tel +39 049 8275424 fax +39 049 8275446

C.F 80006480281 - P.IVA 00742430283

Winter school “Patterns of vegetation in water controlled ecosystems”

General purpose and topics

The aim of the School is to offer to a group of 20-30 Ph.D students and early stage Researchers the opportunity get a deep and multidisciplinary knowledge of vegetation patterns of self-organization in arid and semi-arid environments, vegetation resilience to drought and desertification, and possible advances in land use sustainability.

Scenarios of land use change, climate change, and natural resources commercialization at a global scale are threatening the most unstable and fragile ecosystems, such as the wide arid and semi-arid areas of Earth. Understanding the eco hydrological equilibra that allow survival in such habitats helps us predict and prevent irreversible shifts, that could possibly affect microclimate and water balance in the adjacent areas with a knock-on effect. Monitoring these areas through remote sensing and digital images analysis allows us to assess the health status and reveal the first symptoms of change. Observing soil-vegetation-atmosphere mechanisms that allow vegetation growth and persistance even in water scarcity conditions gives quantitative indications on possible sustainable agricultural practices in water limited conditions.

We aim at establishing a shared platform, through the participation of expert international lecturers coming from various research fields, that will commit to teaching non only by traditional lectures but also by proposing scientific questions to be developed by small groups of students during the stay in San Servolo.

Research themes the lecturers are focusing on include:

Experimental analysis of soil and vegetation,
Satellite images and data processing,
Stability analysis of dynamical systems,
Biological and mathematical modelling of ecosystems.

Features of the Winter School

General schedule of the activities:
Arrival, Opening ceremony and Participants Registration: 03 January 2016
Winter School Activities: 04-09 January 2016
End of the Activities and Departures: 10 January 2016

Participants:
20-50 selected Ph.D Students or Early Stage Researchers coming from international Universities and Institutions.

Location:
San Servolo island, with its unique position in the heart of Venice but at the same time isolated from the touristic flow, will provide a peaceful and inspiring environment and allow participants to discuss and exchange ideas even after the Activities time.

Lecturers and topics:

Ehud Meron Ben Gurion University, Boqer, Israel

[Non-linear dynamics and pattern formation, non-linear ecosystem physics]

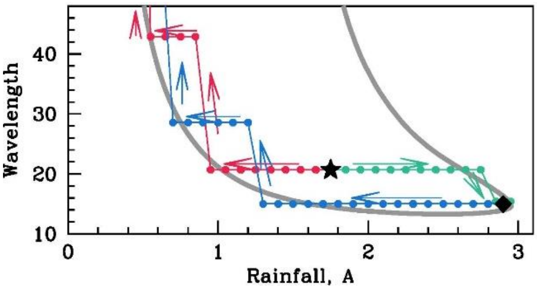
Pattern formation - a missing link in the study of ecosystem response to environmental changes

Environmental changes can affect the functioning of an ecosystem directly, through the response of individual life forms, or indirectly, through interspecific interactions and community dynamics. The feasibility of a community-level response has motivated numerous studies aimed at understanding the mutual relationships between three elements of ecosystem dynamics: the abiotic environment, biodiversity and ecosystem function. Since ecosystems are inherently nonlinear and spatially extended, environmental changes can also induce pattern-forming instabilities that result in spatial self-organization of life forms and resources. This, in turn, can affect the relationships between these three elements, and make the response of ecosystems to environmental changes far more complex. Responses of this kind can be expected in dryland ecosystems, which show a variety of self-organizing vegetation patterns along the rainfall gradient. In these lectures I will describe the progress that has been made in understanding vegetation patterning in dryland ecosystems, and the roles it plays in ecosystem response to environmental variability. The progress to be described has been achieved by modeling pattern-forming feedbacks at small spatial scales and up-scaling their effects to large scales through model studies. This approach sets the basis for integrating pattern formation theory into the study of ecosystem dynamics and addressing ecologically significant questions such as the dynamics of desertification, restoration of degraded landscapes, biodiversity changes along environmental gradients, and shrubland-grassland transitions.

Jonathan Sherratt Heriot-Watt University, Edimburgh, Great Bretain

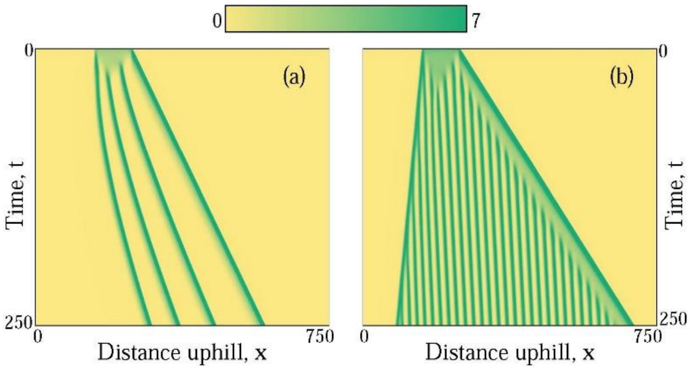
[Mathematical biology]

Simple mathematical models of semi-arid vegetation are able to provide important and often surprising insights into spatial patterning. Coexistence of multiple pattern wavelengths: wavelength prediction requires the solution of a pattern selection problem. Mathematical and computational methods.



Changes in wavelength of striped vegetation patterns as rainfall is varied, in simulations. The hysteretic behavior shows that wavelength depends on rainfall history as well as current rainfall level.

Simulations: vegetation colonising a hillslope and forming spatial patterns.



Vincent Deblauwe Institute of Research for Development, Yaounde, Cameroon

[Vegetation Science, Climate Change]

Testing association between spatially autocorrelated variables: a new approach using surrogate lattice data

Hubert Savenije Delft University of Technology, Netherlands
[Hydrology, Water Resources Management]

How ecosystems buffer against climate variability

The moisture storage capacity in the root zone of ecosystems acts as a buffer against climatic variability and is a critical factor controlling many physical, biogeochemical and biological processes including land-atmosphere exchanges, rainfall-runoff generation, carbon cycling and nutrient dynamics. Notwithstanding its importance this storage capacity cannot be directly observed at catchment scale. Approaching this problem from a different angle, we can try to understand how adaptive systems cope with the variability of essential inputs through the creation of buffers. Surprisingly, there appears to be a strong correspondence between how societies and ecosystems try to safeguard their water supply. People build reservoirs to buffer against periods of water shortage; ecosystems essentially do the same by creating sufficient moisture storage in their root zone. Both try to do this at minimum expense: people by optimizing the amount of storage at minimum costs; and ecosystems by creating an optimum root zone buffer at minimum biomass investment. At the start of the Anthropocene, human societies first created means to tap water directly from the natural system: designing wells, diverting river water, harvesting rainwater, tapping groundwater by underground tunnels (qanats), and building canals and aquaducts to convey the water to where it was needed. Although sometimes highly complex engineering works, this was only a first step towards manipulating the natural system. In guaranteeing access to water, people soon realized that it was necessary to create sufficient storage to offset the high variability of hydrological fluxes in the natural system. The building of reservoirs dates back as early as 5000 ago, when the first reservoir was built in the Middle East, not surprisingly in an area with high hydrological variability. A classical engineering way for designing the size of a reservoir is the Rippl (1883) diagram, where tangents to the accumulated inflow determine the required storage. It is a logical method for people to size the storage required to satisfy the long-term water demand. Using this principle, over time, many societies have tried to regulate their rivers, leveling out the natural dynamics of the system. But are people unique in trying to even out unwanted fluctuations or to bridge periods of water shortage? Like societies, ecosystems adjust their storage buffer to climatic variability. Similar to the way in which engineers design reservoirs, we can estimate the root zone storage capacity at catchment scale on the basis of observed climate and hydrological data. This approach was proven to be remarkably accurate not only in 11 catchments of the Ping River in Thailand but also in 413 catchments across the USA, with diverse climate and land surface conditions. The results illustrate that ecosystems adjust their root zone storage to periods of drought or wetness, and that the maximum root zone storage is essentially a function of climate and land cover. In contrast to a mechanistic description of the hydrological world, where the maximum storage in the unsaturated (root) zone is simulated by a fixed parameter (often identified by Sumax), we have to realize the root zone is actually part of a living ecosystem, which adjusts itself to climatic variability. This so crucial hydrological parameter is alive! Ecosystems adjust their root zone storage gradually to periods of drought or wetness, and the maximum root zone storage parameter is essentially a function of climate and land cover and much less of soil characteristics.

Reference: Gao, H., M. Hrachowitz, S.J. Schymanski, F. Fenicia, N. Sriwongsitanon, H.H.G. Savenije, 2014. Climate controls how ecosystems size the root zone storage capacity at catchment scale, Geophysical Research Letters, 41, 7916-7923, doi: 10.1002/2014GL061668.

Dan Malkinson University of Haifa, Israel
[Landscape Ecology]

Interaction between plants and their effect on the patterns emergence. A case study in the Negev desert.

Several approaches have been proposed to explain the emergence of vegetation spatial patterns, particularly in water limited environments. One of the possible mechanisms generating these patterns are the interrelations between individual plants at various spatial scales. Intra and inter-specific facilitation and competition processes may be important drivers dictating the properties in such ecosystems. Equilibrium, feedback processes, and the role of disturbances will be discussed, alongside with presentation of a case study of sand-dune ecosystems in the Negev desert.

Mara Baudena Utrecht University, Netherlands
[Plant ecology, stochasticity, modelling, networks, dryland, savanna, ecohydrology]

Plant communities, networks and species richness

Possible Schedule

Sunday 03/01/2016: participants arrival and registration.

Monday morning 04/01/2016	**Tuesday morning 05/01/2016**	**Wednesday morning 06/01/2016**	**Thursday morning 07/01/2016**	**Friday morning 08/01/2016**	**Saturday morning 09/01/2016**
Modelling vegetation growth and collaboration [Meron]	Modelling vegetation spatial interactions [Couteron]	Stability analysis of dynamic systems [Sherratt]	Modelling vegetation growth and collaboration [Meron]	Group work on the scientific question, under the supervision of lecturers.	Group work on the scientific question, under the supervision of lecturers.
Global-scale socio-economical implications of man-soil-vegetation interaction in climate change scenarios [Savenjie]	Soil-vegetation-atmosphere interactions in arid environments [Malkinson]	Modelling vegetation spatial interactions [Baudena]	Methods for data analysis of spatial patterns in natural landscapes [Deblauwe]		
Lunch pause					
Monday afternoon 04/01/2016	**Tuesday afternoon 05/01/2016**	**Wednesday afternoon 06/01/2016**	**Thursday afternoon 07/01/2016**	**Friday afternoon 08/01/2016**	**Saturday afternoon 09/01/2016**
Methods for data analysis of spatial patterns in natural landscapes [Deblauwe]	Stability analysis of dynamic systems [Sherratt]	Workshops and exercises on themes suggested by the lecturers	Modelling vegetation spatial interactions [Couteron]	Group work on the scientific question, under the supervision of lecturers.	Group work on the scientific question, under the supervision of lecturers.
Global-scale socio-economical implications of man-soil-vegetation interaction in climate change scenarios [Savenjie]	Modelling vegetation spatial interactions [Baudena]		Soil-vegetation-atmosphere interactions in arid environments [Malkinson]		