Project proposal form

Project title: Drought Sensitivity of Terrestrial Ecosystems in Europe and North America
Project code:
Host institution: University of Birmingham
Theme:
Key words: Drought, ecosystems
Supervisory team (including institution & email address): Dr. Anne Van Loon (University of Birmingham; a.f.vanloon@bham.ac.uk), Dr. Samuel Zipper (McGill University, Canada; samuelczipper@gmail.com), Dr. Claudia Teutschbein (Uppsala University, Sweden; claudia.teutschbein@geo.uu.se), Dr. Laurent Pfister (Luxembourg Institute of Science and Technology; laurent.pfister@list.lu), Dr. Nick Kettridge (University of Birmingham; N.Kettridge@bham.ac.uk)

Project Highlights:

- Exciting new research field studying both drought sensitivity of river flow and terrestrial ecosystems
- Unique field observatories: combining data from experimental catchments in Europe and North-America
- Interdisciplinary, international supervisory team of experts in drought, ecohydrology, climate change.

Overview:

Drought frequency and severity are expected to increase globally under projected climate change, with unknown consequences for hydrological and terrestrial ecosystems, while the terrestrial hydrological cycle is strongly linked to changing ecosystem processes. Current management tools, however, are based on the assumption of stationarity. To solve complex questions related to drought and ecosystems in a non-stationary world we need new hypotheses and new tools. Traditionally, the effects of drought on hydrology and vegetation are considered separately, despite the integral role of the terrestrial hydrological cycle in determining streamflow. This exciting PhD project proposes to answer the questions: (1) what are the driving meteorological conditions for streamflow drought and ecosystem impacts, (2) what is the relationship between terrestrial and hydrological drought sensitivity, and (3) how does this relationship vary among vegetation types (grassland, forest, agriculture) and climates (precipitation/temperature gradient)? Using a novel methodology, we propose to directly compare hydrological drought sensitivity (measured by streamflow) and terrestrial drought sensitivity (measured by aboveground net primary productivity, ANPP) via synthetic analysis of a number of experimental catchments where this data is available. This PhD project will work in Europe and North America by analysing and comparing various sites. The prospective sites in Europe are the Birmingham Institute of Forest Research site in the UK (BIFOR, www.birmingham. ac.uk/research/activity/ bifor/index.aspx), the Krycklan catchment in Sweden (www.slu.se/Krycklan; Figure 1), the Alzette River basin in Luxembourg, and the TERENO network in Germany (teodoor.icg.kfa-juelich.de). For the North American sites we will make use of the LTER network. The goal is to investigate a large number of sites in order to quantitatively assess tradeoffs and synergies between hydrological and terrestrial drought sensitivity across a climatic and ecosystem gradient. In a unique collaborative action, the results of this PhD project will then be compared between the European and North-American dataset with the aim to predict complex relationships between the ecosystem and (lack of) water under future climate change and vegetation changes (a non-stationary world).

Figure 1: *Rivers and streams in ecosystems in the study sites.*

Methodology:

The methodology for this project will be developed in conjunction with our international partners and will draw from the experience of the supervisory team. For all of the sites, drought indices and hydrological and ecological drought sensitivity metrics will be calculated from generally available datasets of meteorological conditions (precipitation and potential evapotranspiration), streamflow observations and terrestrial ecosystem variables (net primary production). Terrestrial and hydrological drought sensitivity will be assessed separately; the relationship between the drought indices and the hydrological and ecological drought sensitivity metrics indicates how much of the interannual variability is explained by drought severity. Hydrological and terrestrial sensitivity will then be considered in tandem to assess the relationship between streamflow and ecosystem productivity.

Training and skills:

CENTA students are required to complete 45 days training throughout their PhD including a 10 day placement. In the first year, students will be trained as a single cohort on environmental science, research methods and core skills. Throughout the PhD, training will progress from core skills sets to master classes specific to the student's projects and themes.

This PhD offers unique opportunities to learn about different drought methods, novel data analysis techniques and ecohydrological processes. The PhD student will be embedded in the Drought Research Group at the University of Birmingham, which provides training in R-programming, abstract and paper writing, presenting your scientific results, etc. The PhD student will have the possibility to exchange and interact with other PhD students in the framework of the recently launched doctoral training unit in hydrological sciences at the Luxembourg Institute of Science and Technology (www.list.lu/en/project/hydro-csi/). Additionally, the student is encouraged to attend the annual Krycklan summer school and symposium in Sweden. The link to our partners in North-America offers opportunities to visit dedicated workshops and conferences on the topic.

Partners and collaboration (including CASE):

The PhD project benefits from supervision by the world's leading catchment-based ecohydrology and drought research groups. The School of Geography, Earth and Environmental Sciences at the University of Birmingham has a strong background in hydrological drought and ecohydrology, especially linked to the Birmingham Institute of Forest Research (BIFOR). McGill University (Canada), Uppsala University (Sweden), and the Luxembourg Institute of Science and Technology (Luxembourg) are top-level institutes with expertise in terrestrial ecosystems, effects of climate change and hydrological extremes.

Possible timeline:

Year 1: The 1st year of the project will be devoted to getting to know the experimental catchments and collecting data from the study areas. Also the methodology developed in North America will be tested on the European data and possibly adapted.
Year 2: During the 2nd year of the project the data analysis will be performed on all sites and hypotheses will be tested.
Year 3: The 3rd year of the project focusses on combining and comparing the European results with the North-American dataset and writing research papers.

Further reading:

- Laudon, H., I. Taberman, A. Ågren, M. Futter, M. Ottosson-Löfvenius, and K. Bishop (2013), The Krycklan CatchmentStudy—A flagship infrastructure for hydrology, biogeochemistry, and climate research in the boreal landscape, Water Resour. Res., 49,7154–7158, doi:10.1002/wrcr.20520.
- Teutschbein, C., Grabs, T., Karlsen, R.H., Laudon, H., Bishop, K. (2015) Hydrological Response to Changing Climate Conditions: Spatial Streamflow Variability in the Boreal Region, Water Resour Res, doi: 10.1002/2015WR017337.
- Tydecks, L., Bremerich, V., Jentschke, I., Likens, G. E., & Tockner, K. (2016). Biological Field Stations: A Global Infrastructure for Research, Education, and Public Engagement. BioScience, 66(2), 164-171. doi:10.1093/biosci/biv174.
- Van Loon, A. F. (2015), Hydrological drought explained. WIREs Water, 2: 359–392. doi:10.1002/wat2.1085.
- Wrede, S, Fenicia, F, Martínez-Carreras, N, Juilleret, J, Hissler, C, Krein, A, Savenije, HHG, Uhlenbrook, S, Kavetski, D, and Pfister, L (2015), Towards more systematic perceptual model development: a case study using 3 Luxembourgish catchments. Hydrol. Process., 29, 2731–2750. doi: 10.1002/hyp.10393.
- Zipper, S.C., Qiu, J., Kucharik, C.J., 2016. Drought effects on US maize and soybean production: spatiotemporal patterns and historical changes. Environ. Res. Lett. 11, 94021. doi:10.1088/1748-9326/11/9/094021

Further details:

Applicants should have a background in a related field such as hydrology, ecology, earth sciences, meteorology, geography. Good process understanding and programming experience are essential. Working experience with R would be beneficial. For further details please contact Anne Van Loon (a.f.vanloon@bham.ac.uk).