HYDRO-CSI

CLUSTER 4 – HYDROLOGICAL FORECASTS AND PROJECTIONS UNDER GLOBAL CHANGE

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Summary of Hydro-CSI research clusters

INTRODUCTION

The Doctoral Education Unit in Hydrological Sciences (Hydro-CSI) is contributing to the exploration of new and interdisciplinary research avenues to overcome limitations in our current understanding of catchment functioning.

Hydro-CSI is led by LIST in partnership with the University of Luxembourg (LU), Vienna University of Technology (AT), Wageningen UR (NL), Karlsruher Institute of Technology (DE) and is supported by the FNR.

Hydro-CSI is composed of four research clusters:

- Cluster 1 – Innovative field-deployable instruments for high-frequency monitoring
- Cluster 2 – New tracers and approaches for investigating hydrological processes
- Cluster 3 – Remote sensing applied to hydrology
- **Cluster 4 – Hydrological forecasts and projections under global change**

In this document, please find the presentation of Cluster 4.

4.1 PHD PROJECT OF CONCETTA DI MAURO

Topic: Hydraulic modelling

Project objectives:

The main goal of Concetta di Mauro's PhD project is to improve flood forecasts in terms of water depth, streamflow and flood extent. The improvement of flood predictions is intended to be achieved with the enhancement of the data assimilation framework developed by Hostache et al. (2018). The methodology consists in the assimilation of flood maps derived from satellite observations into flood forecasting models.

Abstract:

Hydrological extremes such as floods have enormous environmental and socio-economic consequences. It is expected that climate change effects combined with a growing global population in flood-prone areas will increase their impacts in the future. Central to mitigating inundation risk are high-resolution information on how floodplains inundate in response to river discharge dynamics. Anticipating floods enhances the ability of flood managers to address the risk.

Within this framework, it is important to define numerical models capable of simulating floods, thereby improving flood warning and risk assessment. The most commonly used techniques to calibrate, validate and control these models consist in using ground measurements. However, such measurement instruments are sparse and not always available. That is why there is an increasing expectation that Earth Observation (EO) data may support flooding-related disaster risk reduction at global scale, for example through the periodical assimilation of EO data.

The main goal of the PhD project is to contribute to the improvement of flood model predictions via the assimilation of flood extent maps derived from satellite images. In the still rare scientific studies in which EO-derived flood extent maps are assimilated into such models, for convenience rainfall is often the main source of model uncertainty. However, in complex hydrological systems sources of uncertainties are numerous and not well understood: model parameters, boundary conditions, observation, inputs. In this regard, we will use synthetically generated data sets to investigate how different sources of uncertainties affect the efficiency of established DA approaches. The following step will be the gradual improvement of existing DA methods for a more effective and reliable assimilation of EO-derived flood extent maps into the model. Among the widely acknowledged weak points in similar studies, one may mention the absence of adequate bias detection and ensemble generation techniques. Finally, we will apply and evaluate the enhanced techniques in a real case study to conclude on the benefit of satellite data for better prediction at large scale.

4.2 PHD PROJECT OF NN (UNIVERSITY OF LUXEMBOURG)

4.3 PHD PROJECT OF NICOLAUS VAN ZWEEL

Topic: **Hydro-geochemical modelling** Project objectives: to be defined	

4.4 PHD PROJECT OF JUDITH MEYER

Topic: **Flashflood mechanistics and modelling** Project objectives: In a first step, the pattern of the local flash flood events is going be analysed in a meta-analysis, including events that occurred in the neighbouring countries. Based on data availability, analyses are going to be conducted to compare the atmospheric conditions during the event, discharge properties, pre-event soil moisture conditions, catchment properties, the spatial extent of the flooding and the timing within a year and over a longer time period. These analyses are likely to provide information, which may help to detect certain threshold values or trends in space and time. To gain better process understanding of the flash floods, a major approach is going to be the testing of different hydrological models and executing virtual experiments5	

Abstract:

Since 2016, flash floods have been observed to an increasing degree in central eastern Luxembourg[1,2]. The area lies within a corridor, in which extreme precipitation events occur regularly[3]. In the PhD project, the underlying driving factors and mechanisms of the flash floods are going to be investigated considering the European context and using a series of virtual experiments. The outcomes of the project could help to improve flash flood forecasting or to identify trends.
Therefore, in a first step, the pattern of the local flash flood events is going be analysed in a meta-analysis[4], including events that occurred in the neighbouring countries Belgium, northern France, Germany and the Netherlands. Based on data availability, analyses are going to be conducted to compare the atmospheric conditions during the event, discharge properties, pre-event soil moisture conditions, catchment properties, the spatial extent of the flooding and the timing within a year and over a longer time period. These analyses are likely to provide information, which may help to detect certain threshold values or trends in space and time.
To gain better process understanding of the flash floods, a major approach is going to be the testing of different hydrological models and executing virtual experiments[5]. Knowledge about catchment properties is

going to be used in physically based hydrological models. By changing input parameters such as the pre-event soil moisture or precipitation characteristics, different scenarios can be simulated, through which key processes and possible thresholds might be validated.

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[1] : Pfister, L., Faber, O., Hostache, R., Iffly, J. F., Matgen, P., Minette, F., Trabs, I., Bastian, C., Göhlhausen, D., Meisch, C., Patz, N. (2018): Crue éclair du 22 juillet 2016 dans la region de Larochette, report, p. 1-16.

[2] : Source Flash flood 2018

[3] : Pfister, L., Douinot, A., Meisch, C., Bastian, C., Tamez-Melendez, C. (2019): Recent extreme hydro-meteorological events in North-Western Central Europe (Luxembourg): extreme hydrological features, meteorological factors and atmospheric conditions. Geophysical Research Abstracts, Vol. 21, EGU2019-13457.

[4] : Evaristo, J., McDonnell, J. (2017): A role for meta-analysis in hydrology. Hydrological Processes, Vol. 87, p. 1-4.

[5] : Weiler, M., McDonnell, J. (2004): Virtual experiments: a new approach for improving process conceptualization in hillslope hydrology. Journal of Hydrology, Vol. 285, p. 3-8.

4.5 PHD PROJECT OF ADNAN MOUSSA

Topic: **Isotope hydrology**

Project objectives:

The main objective of Adnan Moussa's PhD is to determine the travel time distribution and SAS functions of different output fluxes (discharge, transpiration and evaporation) in the Weierbach catchment, using the ParFLOW-CLM model with different land covers and different atmospheric forcings. The calibration and evaluation of the model is to be done by comparing the fluxes and isotopic composition measured from the discharge, soil evaporation and tree water uptake.