GRADUATION RESEARCH PROJECTS 2023

within the programme

EARTH SURFACE AND WATER

offered by the staff of the
Department of Physical Geography
Faculty of Geosciences
Utrecht University

Note that:
- some topics also fit in the programmes of *Earth Life or Climate* or *Marine Sciences* or *Applied Data Science (ADS)*
- additional ESW topics are available from the department of Earth Sciences, and
- you can also bring in your own research topic.

OFFERED PROJECTS BY TRACK

HYDR = Hydrology (Earth Surface and Water)
CDFS = Coastal Dynamics and Fluvial Systems (Earth Surface and Water)
GHEO = Geohazards and Earth Observation (Earth Surface and Water)

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GHEO = Geohazards and Earth Observation (Earth Surface and Water)
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Earth Surface and Water	Hydrology

Water-soil-vegetation interactions in an Alpine catchment

Supervision:	Esther Brakkee, Jana Eichel, Philip Kraaijenbrink
In cooperation with:	-

Description:

The high-elevation ecosystems of the Alps are a crucial water source for millions of people downstream, while also forming an important biodiversity hotspot. However, these high-mountain ecosystems are changing fast. Snow is disappearing from many slopes, while vegetation is increasingly expanding upwards. These changes may feed back on the water flows, potentially affecting future water resources on a small and larger scale.

A recently started research project is studying how current and future mountain 'greening' may affect the hydrological dynamics of these areas. We are working in a small catchment in Valais, Switzerland. Within this project there is an opportunity for an MSc research project with the aim to better understand how surface hydrology and/or soil characteristics in the catchment relate to local topography and vegetation. This forms an important step in understanding how the water flows in mountain systems like this may change towards the future.

You will collect hydrological and soil data during fieldwork and subsequently analyze these data in the lab. You will measure and sample hydrological and/or soil properties in plots distributed across vegetation types in the study catchment. There is room to choose your own focus depending on your interests and own ideas. The project will be part of ongoing research and there are many opportunities to connect with other data. With that the project forms a nice opportunity to get field and/or lab research experience, while gaining insights into (future) mountain water resources.

Location:	Utrecht University + fieldwork Switzerland
Period:	Fieldwork in summer (July) 2023, analysis autumn 2023
Number of students:	1 or 2
MSc programme:	Earth Surface and Water
Fits in track 1:	Hydrology (HYDR)
Fits in track 2:	Geohazards and earth observation (GHEO)
Prerequisites:	Interest in surface hydrology, soils and/or eco(hydro)logy; Interest in fieldwork in Switzerland (~2 weeks) and lab work. Basic physical fitness to work in a high mountain environment.
Contact / info:	e.a.brakkee@uu.nl

Earth Surface and Water	Hydrology

Using machine learning to improve hydrological streamflow predictions at the global extent

Supervision:	prof. dr. Derek Karssenberg; dr. ir. Edwin H. Sutanudjaja; Youchen Shen, MSc.
In cooperation with:	-

Description:

To improve hydrological streamflow predictions, researchers have implemented updating procedures that correct predictions from a simulation model using machine learning methods, in which simulated streamflow and meteorological data are used as predictors. Few studies however have included an extensive set of meteorological and hydrological state variables simulated by the simulation model. Shen et al. (2022; https://doi.org/10.1016/j.cageo.2021.105019) developed a Random Forests (RF)-based approach to correct predictions from the global hydrological model PCR-GLOBWB (Sutanudjaja et al., 2018; https://doi.org/10.5194/gmd-11-2429-2018). From PCR-GLOBWB, meteorological input as well as its simulated hydrological state variables were used as predictors in the RF to estimate errors of PCR-GLOBWB streamflow predictions, which were then applied to correct simulated hydrographs. The RF was trained and applied separately at three streamflow gauging stations in the Rhine basin with different physiographic characteristics.

This master thesis topic aims to expand the success of this study of Shen et al. (2022) to the global extent (and possibly to higher resolutions, from 50 km to 100 m). Together with us, you will apply and if needed modify the established machine learning method of Shen et al. (2022) for a number of discharge observation stations in the entire world. This requires addition of more predictor variables in the error correction procedure such that the method can be applied across catchments with different characteristics. You will be involved in writing scientific publications resulting from this work. We will also explore the opportunity for you to present this work on scientific conferences (subject to funding). This is an interesting project for students who like to combine data science research with hydrological research.

Location:	Utrecht University / home
Period:	as early as possible
Number of students:	1-2
MSc programme:	Earth Surface and Water
Fits in track 1:	Hydrology (HYDR)
Fits in track 2:	Geohazards and earth observation (GHEO)
Prerequisites:	Background in hydrology at MSc level, knowledge of data science methods (preferably machine learning but this could be learned during the project), capability of basic programming in R and/or Python
Contact / info:	d.karssenberg@uu.nl; e.h.sutanudjaja@uu.nl

Earth Surface and Water	Hydrology

Mapping the requirements for water, food, and energy resources and their trade-offs to meet Sustainable Development Goals in the transboundary Indus river basin

Supervision:	Arthur Lutz, Walter Immerzeel
In cooperation with:	

Description:

The Indus river basin is a global climate change hotspot, characterized by a rapidly growing population and strong economic development. This is associated with an exponential increase in water, energy, and food demands. Presently, 250 million people live in the Indus basin. The densely populated plains are home to the world's largest irrigation scheme, fed primarily by melt water from the upstream mountain ranges. These mountain ranges also have a vast hydropower potential, which is largely untapped, even though the basin faces energy deficits since decades. In this water-stressed basin, water is used conjunctively for irrigation, for industrial and domestic purposes, and for energy generation. These water demands compete in this transboundary river basin, causing strong geopolitical tensions between the riparian countries. A combination of population and economic growth will likely result in a strong increase in the demand for water, food and energy, which are strongly interlinked in the water-energy-food nexus.

Given this context, the road towards achieving the Sustainable Development Goals (SDGs) 6, 7, and 2, for water, energy and food in the basin is extremely challenging. In this project you will use a resource accounting framework to explore the resources required to meet food, energy and water security in the river basin under different climate change and socioeconomic future scenarios, and you will explore synergies and trade-offs in pursuing resource security for each of the three resources.

In this project you will do spatial hands-on analysis with the resource accounting framework by analysing sets of scenarios. In this framework you will integrate existing hydrological and crop-hydrological model output, high resolution spatial socioeconomic projections, hydropower development projections and other GIS datasets.

Location:	Utrecht University
Period:	2023
Number of students:	1
MSc programme:	Earth Surface and Water
Fits in track 1:	Hydrology (HYDR)
Fits in track 2:	None
Prerequisites:	Experience with R (or Python/Matlab) and GIS tools (QGIS/ArcGIS) preferred
Contact / info:	a.f.lutz@uu.nl; w.w.immerzeel@uu.nl

Earth Surface and Water	Hydrology

Evaluating crop regeneration rates after droughts

Supervision:	Niko Wanders, Jennie C. Steyaert
In cooperation with:	-

Description:

Population growth and economic development are projected to increase global water demands by 2050. These water stressors are directly related to changes in physical scarcity (mainly in arid nations), economic development, and increased consumptive demand which is categorized into four sectors: livestock, industry, irrigation, and municipal. Of these sources, irrigation consume most of the renewable water resources and therefore large scale models, such as PCR-GLOBWB 2.0, focus on improving the model accuracy in simulating this sector.

Currently, PCR-GLOBWB 2.0 simulates irrigation by calculating the amount of irrigable land and allocating water based on if the land use is paddy (e.g. wet rice) or non-paddy (e.g. wheat) crops. Using these land cover distinctions, generalized equations are formed to ensure that both crop categories receive the correct amount of water under typically climatic conditions. In the case of an extreme weather event such as a drought, the crop dies, and water is no longer provided to these cells. Upon the next sufficient rain event, the crop's water demand automatically turns back on, and water is routed to these cells. This simplification is useful in calculating water demand; however, studies have shown that vegetation needs time to recover and regrow after a drought resulting in a post drought period with reduced water demand.

Therefore, the goal of this project is to develop an understanding of the magnitude and duration of drought impacts on vegetation growth. This will be done using remotely sensed crop data acquired from current research to derive relationships between extreme weather events and crop regeneration rates. The results of this analysis will be implemented in PCR-GLOBWB 2.0 at the 1km resolution. The work will consist of 1) a literature review of existing drought impacts on crop growth and regeneration post extreme events, 2) deriving relationships for crop regeneration via remote sensing data and methods, 3) implement these relationships in the PCR-GLOBWB model using the Rhine Meuse basin as a case study, and 4) evaluate if these equations are more computationally efficient than direct coupling to a crop model. All work related to this master's project will be done at Utrecht University and will have the potential to be included in multiple scientific papers with student authorship.

Location:	Utrecht University
Period:	Autumn 2023 or earlier in mutual consent
Number of students:	1
MSc programme:	Earth Surface and Water
Fits in track 1:	Hydrology (HYDR)
Fits in track 2:	Geohazards and earth observation (GHEO)
Prerequisites:	Experience in remote sensing and programming are recommended.
Contact / info:	j.c.steyaert@uu.nl; n.wanders@uu.nl

Earth Surface and Water	Hydrology

Best-fit relations between discharge and species richness in groundwater-dependent rivers basins and wetlands

Supervision:	Nicole Gyakowah Otoo, Dr. Michelle van Vliet, Dr Marc Bierkens, Dr. Edwin Sutanudjaja
In cooperation with:	

Description:

The increase in global population has led to the expansion of water demands increasing the dependency on groundwater resources. An increase in water demand alongside a decrease in recharge rates can lead to reductions in groundwater levels and groundwater discharge (Bierkens & Wada, 2019). This in the long term leads to alterations in flow regimes and water volume, which are major drivers of maintaining groundwater-dependent ecosystems (GDEs). These hydrological alterations of rivers and streams affect the unique biodiversity and ecosystem services and will hinder achieving the UN Sustainable Development Goal 14 which seeks to 'protect life below' water. Plant and fish species communities are adapted to specific flow regimes and water volumes and slight alterations may lead to the loss of certain species (Barbarossa et al., 2021; Schipper & Barbarossa, 2022).

This Master's thesis focuses on exploring the relationships between species richness (either plant or fish species) and groundwater discharge into river and wetland GDEs and the extent of the GDEs. This study will include a comprehensive literature review and analyses of large-scale data sets on discharge, extent and species richness for the entire continent. The strength of the discharge-species richness relationship will be quantified using data sets from field monitoring and existing models using scaling relationships.

- Barbarossa, V., Bosmans, J., Wanders, N., King, H., Bierkens, M. F., Huijbregts, M. A., & Schipper, A. M. (2021). Threats of global warming to the world's freshwater fishes. Nature communications, 12(1), 1-10.
- Bierkens, M. F., & Wada, Y. (2019). Non-renewable groundwater use and groundwater depletion: a review. Environmental Research Letters, 14(6), 063002.
- Schipper, A. M., & Barbarossa, V. (2022). Global congruence of riverine fish species richness and human presence. Global Ecology and Biogeography.

Location:	Utrecht University
Period:	Autumn 2023 or earlier in mutual consent
Number of students:	1
MSc programme:	Earth Surface and Water
Fits in track 1:	Hydrology (HYDR)
Fits in track 2:	None
Prerequisites:	Affinity with data analyses (e.g. excel, R or Python) and working with large datasets (GIS)
Contact / info:	n.g.otoo@uu.nl

Earth Surface and Water	Hydrology

Global assessment of prioritisation rules of water use during droughts and heatwave

Supervision:	Gabriel Cárdenas MSc., Dr. Michelle van Vliet
In cooperation with:	Not applicable

Description:

Increasing water demand due to population growth coupled with increasing occurrence of extreme events (e.g. droughts and heatwaves) pose a threat to global water security (van Vliet et al., 2017), implying unmet sectoral water demands (i.e., irrigation, livestock, domestic use, thermoelectric and manufacturing) (Schewe et al., 2014). To cope with water scarcity, this freshwater is allocated to satisfy sectoral water demands following prioritisation rules that vary around the world due to different factors (e.g. socio-economic, policy-based, etc.). Moreover, extreme events are expected to affect the normal behaviour of sectoral water uses (Wada et al., 2011), as well as the quality of water resources, thus altering the water allocation rules.

This MSc thesis focuses on assessing how different water use sectors prioritise freshwater use of suitable quality on a global scale and on identifying possible responses during droughts and heatwaves. To this end, the student will collect and evaluate information on the prioritisation of water use around the world during normal periods and during the occurrence of droughts and heatwaves (e.g. EurEau, 2020; OECD, 2015). The analysis will be extended to the global scale by understanding regional patterns. For this, the student will assess possible socio-economic and environmental factors (e.g., population density, gross domestic product, air temperature) and their influence on prioritisation patterns. The result will form the basis for the development of the water allocation scheme of a global sectoral water use model. This work is part of an NWO Vidi project on water scarcity under droughts and heatwaves.

van Vliet, M. T. H., Florke, M., & Wada, Y. (2017). Quality matters for water scarcity. Nature Geoscience, 10(11), 800–802. https://doi.org/10.1038/NGEO3047

Schewe, J., Heinke, J., Gerten, D., Haddeland, I., Arnell, N. W., Clark, D. B., Dankers, R., Eisner, S., Fekete, B. M., Colón-González, F. J., Gosling, S. N., Kim, H., Liu, X., Masaki, Y., Portmann, F. T., Satoh, Y., Stacke, T., Tang, Q., Wada, Y., … Kabat, P. (2014). Multimodel assessment of water scarcity under climate change. Proceedings of the National Academy of Sciences of the United States of America, 111(9), 3245–3250. https://doi.org/10.1073/pnas.1222460110

Wada, Y., van Beek, L. P. H., & Bierkens, M. F. P. (2011). "Modelling global water stress of the recent past: on the relative importance of trends in water demand and climate variability". Hydrology and Earth System Sciences, 15, 3785–3808. https://doi.org/10.5194/hess-15-3785-2011

EurEau. (2020). The impact of drought on drinking water Summary. www.eureau.org

OECD. (2015). Water Resources Allocation - Sharing risks and opportunities. https://doi.org/https://doi.org/10.1787/9789264229631-en

Location:	Utrecht University
Period:	Autumn 2023
Number of students:	1
MSc programme:	Earth Surface and Water
Fits in track 1:	Hydrology (HYDR)
Fits in track 2:	None
Prerequisites:	Affinity with data analyses (e.g. excel, Python) and working with large datasets (GIS)
Contact / info:	g.a.cardenasbelleza@uu.nl; m.t.h.vanvliet@uu.nl

Earth Surface and Water	Hydrology

Reconstruction of drying over Europe using PCR-GLOBWB

Supervision:	prof. dr. ir. Marc F. P. Bierkens; dr. ir. Edwin H. Sutanudjaja
In cooperation with:	-

Description:

During the last years, the GRACE satellite signal indicates Europe is currently drying up (see e.g. Fig. 15 of the WMO report "State of Global Water Resources 2021", https://library.wmo.int/doc_num.php?explnum_id=11435). This may be due to slow recovery from drought years that become more frequent. Another possible reason is that this may be due to increased groundwater pumping.

This work aims to reconstruct this drying condition with the hydrological model simulation of PCR-GLOBWB (Sutanudjaja et al., 2018, https://doi.org/10.5194/gmd-11-2429-2018) that is coupled to the groundwater model GLOBGM (Verkaik et al., 2022, https://doi.org/10.5194/gmd-2022-226). Multiple possible scenarios will be developed for this modeling study, including scenarios with increased groundwater abstraction in areas where the standard PCR-GLOBWB is failed to match the depleting trends according to GRACE.

This is an interesting project for students who like to do computer modelling. You will be involved in writing scientific publications resulting from this work. We will also explore the opportunity for you to present this work on scientific conferences (subject to funding).

This master thesis topic is also suitable for a guided research project.

Location:	Utrecht University / home
Period:	as early as possible
Number of students:	1-2
MSc programme:	Earth Surface and Water
Fits in track 1:	Hydrology (HYDR)
Fits in track 2:	Geohazards and earth observation (GHEO)
Prerequisites:	Background in hydrology at MSc level, capability of basic scientific programming, e.g. Python, R, or Matlab. Knowledge of GLOBGM PCR-GLOBWB, or PCRaster is NOT a prerequisite.
Contact / info:	m.f.p.bierkens@uu.nl; e.h.sutanudjaja@uu.nl

Earth Surface and Water	Hydrology

Towards high resolution (~1 km) global surface water quality modelling: Developing test beds for some small river basins in the world

Supervision:	dr. Michelle van Vliet; prof. dr. ir. Marc F. P. Bierkens; dr. ir. Edwin H. Sutanudjaja
In cooperation with:	-

Description:

DynQual is a newly developed large scale DYNamical surface water QUALity model for simulating surface water temperature and salinity, pathogen and organic pollution levels (Jones et al, 2022, https://doi.org/10.5194/gmd-2022-222). The current version of DynQual is already available for the global extent at 5 arc-minute (~10 km at the equator) spatial resolution. In this work, we aim to further develop the DynQual model at a much more locally relevant resolution of 1 km grid cell size. While running DynQual at such high resolution may not yet be feasible for the global extent (e.g. due to limited computational power), we intend to develop some test beds for relatively small river basins (i.e. < 20,000 km2) to explore the potential of DynQual for simulating surface water quality at more locally relevant scale. For such tests beds, we intend to focus on river basins in the United Kingdom, Japan, and Java island of Indonesia.

The main activities of this project are split into two phases. The first part is to prepare the 1 km model input data for the test beds. We will prepare such input data in two ways, by collecting the local data at the test bed river basins and by downscaling the global datasets that are often only available at the resolution coarser than 1 km. The second part of the project is to use both input datasets (local and downscaled global-based) for running the DynQual model for the period 1980-2019. Here we will investigate the following research questions, which are relevant from both the hydrological and water quality perspective, 1) What are the advantages and challenges of running DynQual at 1 km compared to its original 10 km resolution model?; 2) To what extent will the model results improve if locally-specific input data are used (compared to the downscaled input data from coarser resolution global datasets)?

The project is mainly study desk for doing computer modelling. You will be involved in writing scientific publications resulting from this work. We will also explore the opportunity for you to present this work at scientific conferences (subject to funding).

This master thesis topic is also suitable for a guided research project.

Location:	Utrecht University / home
Period:	as early as possible
Number of students:	1-2
MSc programme:	Earth Surface and Water
Fits in track 1:	Hydrology (HYDR)
Fits in track 2:	Geohazards and earth observation (GHEO)
Prerequisites:	Background in hydrology at MSc level, capability of basic scientific programming, e.g. Python, R, or Matlab. Knowledge of GLOBGM PCR-GLOBWB, or PCRaster is NOT a prerequisite.
Contact / info:	m.t.h.vanvliet@uu.nl; e.h.sutanudjaja@uu.nl

Earth Surface and Water	Hydrology

Impact of climate change on Roman food security

Supervision:	Rens van Beek, Brian Dermody
In cooperation with:	-

Description:

The onset of the Dark Ages Cold period is contemporaneous with the fall of the Western Roman Empire. However, the impact climate cooling on Roman food security has until now not being examined. In this project, you will analyse how the change in climate from the Roman Warm Period to the Dark Ages Cold Period impacted the production of the triad of crops grown in the Roman empire: grain, olives and grapes.

The objective of this study is to evaluate how yields in these crops were affected by these climate changes throughout the Roman Empire, using PCR-GLOBWB. You will explore the relative importance of factors such as labour availability, urbanisation, agricultural practices to evaluate the impact of climate change on Roman food security.

To do so,

- You will carry out sensitivity analyses using prepared python scripts to examine how different assumptions affect the model outcomes
- You will statistically analyse the model output in the form of Net CDF files which capture spatial and temporal information in a matrix format
- Depending on interest, you can also extend the analysis to answer specific research questions you may have.

The outcome of the project will serve as input for a paper on the topic of climate change and its impact on Roman food security.

Location:	Utrecht University
Period:	Autumn 2023 or earlier in mutual consent
Number of students:	1
MSc Programme	Earth Surface and Water
Fits in track 1:	Hydrology (HYDR)
Fits in track 2:	None
Prerequisites:	Hands on GIS; Land Surface Process Modelling or similar
Contact / info:	r.vanbeek@uu.nl; b.dermody@uu.nl

Earth Surface and Water	Hydrology

Impact of reservoir operation on river flow

Supervision:	Rens van Beek, Marc Bierkens, Michelle van Vliet
In cooperation with:	Planbureau voor de Leefomgeving (PBL)

Description:

There are currently more than 30,000 large reservoirs in operation globally. These reservoirs serve several purposes (hydropower, water supply, flood control etc). The operation of those reservoirs typically 'flattens' the incoming hydrograph, which has a number of effects on river temperatures, and biogeochemical processes in the river stream. The operation rules of reservoirs itself generally depend on the main purpose of the reservoir (hydropower, water supply, flood control etc), the variability of inflow, and a number of site-specific characteristics that are not know for most reservoirs globally.

The objective of this study is to characterize the impacts of reservoir operation on continental and global scale discharge using a newly developed time varying data set of reservoirs on a high spatial resolution and projected into the future.

Implemented in our hydrological model PCR-GLOBWB, the changing reservoir operations and their impacts on river discharge under present and future conditions can be assessed. This analysis can be expanded to cover also the potential of hydropower generation in the future. In detail, activities can comprise:

- Collection of a set of observed inflow and release hydrographs of major reservoirs from publicly available databases (~30-50 globally) to tune and validate the reservoir scheme.
- Characterization of reservoirs by inflow regime, purpose, residence time etc.
- Quantification of reservoir impact on discharge at large scales using the global hydrological model PCR-GLOBWB for contemporary conditions and into the future.

The outcome of this project is of direct interest of the Netherlands Environmental Assessment Agency (PBL) with possible applications in the fields of aquatic biodiversity and riverine nutrient transport.

Location:	Utrecht University
Period:	Autumn 2023 or earlier in mutual consent
Number of students:	1
MSc Programme	Earth Surface and Water
Fits in track 2:	Hydrology (HYDR)
Fits in track 2:	None
Prerequisites:	Land Surface Hydrology, Hydrology and Climate/Fluvial Systems and Climate Change.
Contact / info:	r.vanbeek@uu.nl

Earth Surface and Water	Hydrology

Pathways and patterns in co-evolving hydrological system

Supervision:	Rens van Beek, Marc Bierkens
In cooperation with:	-

Description:

Existing catchments reflect the close geohydroecological interactions in the patterns of soil, vegetation and topography that underlie the hydrological response. These patterns have evolved over long time scales resulting in landscapes that may be stable in light of (climate) variability and resilient in light of external disturbances. This implies that different pathways may have led to similar landscapes and that landscapes will adapt differently to future changes. Understanding these principles is essential to evaluate the performance of existing hydrological models at the catchment scale and the transition of geohydroecological systems.

The objective of this study is to identify key processes that affect the organization of a landscape and to define and test different measures that may help to explain how these systems will adapt to changes imposed upon them. This will be done by means of computer simulations and the evaluation of the results in terms of existing measures of landscape organization. These computer simulations can be performed with the meso-scale landscape dynamics model, CALEROS, which has been developed to simulate the interactions between climate, soil production and erosion, vegetation and land use on geomorphological to human time scales in Mediterranean environments.

- More in detail and in consultation with the student, activities will comprise:
- Literature review of existing theories of landscape organization and optimization;
- Simulating the development of dynamically stable landscapes from similar but varying initial landscapes under stationary conditions;
- Quantification of the organization of landscape and energy, water and sediment flows in light of co-evolution and optimization;
- Classification of resulting stable landscapes and comparison with existing landscapes, either natural or human-impacted;
- Evaluation of shifts (trends, disturbance) and landscape adaptation in response to change in terms of a landscape resilience.

Location:	Utrecht University
Period:	Autumn 2023 or earlier in mutual consent
Number of students:	1
MSc Programme	Earth Surface and Water
Fits in track 2:	Hydrology (HYDR)
Fits in track 2:	Geohazards and earth observation (GHEO)
Prerequisites:	Land Surface Hydrology, .Land Surface Process Modelling
Contact / info:	r.vanbeek@uu.nl

Earth Surface and Water	Hydrology

Muddy waters: the impact of global change on sediment sources and sinks along rivers

Supervision:	Rens van Beek, Hans Middelkoop
In cooperation with:	-

Description:

Rivers are crucial pathways along which water and sediment are transported. These fluxes are essential to man, having both beneficial (e.g., water availability, delta growth) as negative effects (e.g., siltation and pollution). At the same time, these fluxes change over time, not only as a result of natural trends and variability, but also as the result of human-induced changes that affect the climate (GHG emissions) or the sediment supply (deforestation, trapping by reservoirs and river engineering). Such changes eventually have consequences for the long-term stability of river and delta systems. To sustainably manage these systems it is therefore crucial to know the provenance of sediment and to understand the impact of human interventions.

The objective of this study is to define the rate of change that affect river and delta systems in relation to global change. Its outcome will help to bridge gaps in our present understanding of these systems and help to explain observed trends. To this end, this study will evaluate observational records over time in conjunction with model results and reconstructions.

Specific topics that can be addressed during this study include:

- Evaluation of the changing deposition of fine sediment behind weirs in light of the observed decrease in suspended sediment for the River Rhine;
- Assessment of any changes in sediment production along the River Rhine due to reconstructed changes in land cover / land use and the observed sediment concentrations at gauging stations;
- Estimation of sediment volumes mobilized along the unstable river banks along large, monsoon-dominated rivers (Brahmaputra, Mekong or Amazon) using satellite information on river course alterations, observed cross-sections and empirical/mechanistic models.

Location:	Utrecht University
Period:	Autumn 2023 or earlier in mutual consent
Number of students:	1
MSc Programme	Earth Surface and Water
Fits in track 2:	Hydrology (HYDR)
Fits in track 2:	Coastal dynamics and fluvial systems (CDFS)
Prerequisites:	Land Surface Hydrology, .Land Surface Process Modelling
Contact / info:	r.vanbeek@uu.nl; h.middelkoop@uu.nl

Earth Surface and Water	Hydrology

Deriving groundwater recharge from the soil moisture budget in the Langtang valley, Himalaya

Supervision:	Caroline Aubry-Wake, Walter Immerzeel, Philip Kraaijenbrink
In cooperation with:	

Description:

The Himalaya are at the source of river systems supplying critical freshwater to millions of people. A large proportion of the precipitation, snow and ice melt occurring in the mountains reaches the stream network as groundwater. Quantifying how much of the precipitation and meltwater reaches the subsurface is critical to better predict shift in timing and volume of river streamflow, and improve water availability assessments in the region.

Using a combination of *in-situ* measurements of soil moisture, shallow groundwater level and meteorological observations, you will use the soil moisture balance approach to estimate groundwater recharge along an elevation gradient in the Langtang Basin, Nepal Himalaya. By comparing the components of the soil moisture balance at the sites, you will identify the spatial and temporal controls of groundwater recharge. Secondly, you will perform a sensitivity analysis of the variables and parameters of the soil moisture balance to determine the largest uncertainties, assess the limitations of this approach and explore approaches to address these uncertainties and limitations. Finally, you will compare your groundwater recharge estimates and field-data driven estimate of the soil moisture balance component with existing simulations from the SPHY hydrological model.

This knowledge is essential to guide the application and parametrization of soil processes in hydrological model simulation, which often have simplified representation of sub-surface hydrology in mountain regions.

Location:	Utrecht University
Period:	Fall 2023
Number of students:	1
MSc programme:	Earth Surface and Water
Fits in track 1:	Hydrology (HYDR)
Fits in track 2:	Geohazards and earth observation (GHEO)
Prerequisites:	Experience in programming is recommended
Contact / info:	c.aubry-wake@uu.nl; w.w.immerzeel@uu.nl

Earth Surface and Water	Hydrology

Comparison of 2D and 3D groundwater flow model estimations in deltaic regions

Supervision:	Daniel Zamrsky, Marc Bierkens, Gualbert Oude Essink
In cooperation with:	Deltares

Description:

Groundwater flow models are an essential tool in water management, often relied upon by regional and national administrations to create policies and assess fresh groundwater resources. Recent advancements in computer technology and computation power lead to increased complexity of computer models. While local, regional and national scale 3D groundwater models are becoming a norm, coastal groundwater models are still widely built as transactional (2D) schematizations. Groundwater models in coastal zones need to account for variable density modelling (salinization) which brings additional computational demands. Nevertheless, in recent years, 3D groundwater models of deltaic regions are becoming the norm as water management decision making tool. One major drawback is that due to the increased computation demands these 3D groundwater models often have coarser grid discretization and shorter time extents than common 2D groundwater models. A comprehensive comparison between 2D and 3D groundwater models in deltaic areas is the main purpose of this research topic. The student will quantify the differences in estimated coastal groundwater salinity levels in a set of 2D and 3D groundwater models in several deltaic areas. This will include collecting available 3D groundwater models, building a set of 2D groundwater models in selected deltaic areas (based on input from the aforementioned 3D groundwater models) and lastly also create a 3D interpolation based on the 2D groundwater results. This 3D interpolation will also be compared to the previously collected 3D groundwater models to assess the possibility of using 2D groundwater model interpolation as an additional tool for water management strategies.

Location:	Utrecht University
Period:	Spring/Summer 2023 or earlier in mutual consent
Number of students:	1
MSc programme:	Earth Surface and Water
Fits in track 1:	Hydrology (HYDR)
Fits in track 2:	None
Prerequisites:	Groundwater modelling and Python knowledge desirable
Contact / info:	d.zamrsky@uu.nl

Earth Surface and Water	Hydrology

Economical and technical feasibility of offshore groundwater pumping

Supervision:	Daniel Zamrsky, Marc Bierkens, Gualbert Oude Essink
In cooperation with:	Deltares

Description:

In recent years offshore fresh groundwater reserves have been identified in numerous regions worldwide. It has also been suggested that these reserves could provide an additional source of fresh (and brackish) water for coastal communities that often find themselves in increasing water stress situations. The exploration of these offshore fresh groundwater resources faces several obstacles before it can be accepted as a reliable source of fresh water. The economic feasibility of extracting groundwater offshore has to be studied. The costs of infrastructure need to be examined and compared with current (and future predictions of) fresh water prices. The infrastructure costs can potentially be brought down by using abandoned oil drilling facilities (e.g., offshore wells) for extracting the offshore fresh groundwater. The offshore groundwater can be brackish and therefore not directly usable for human consumption. However, due to its lower salinity level than seawater it can bring down energy costs in desalination plants if it is used as feed water. The costs that would be thus saved can provide an economic incentive for exploring the offshore groundwater reserves. A crucial part of this research will be to assess the potential impacts of offshore drilling on inland groundwater conditions (e.g., dropdowns in groundwater heads). It is therefore desirable that the student who is interested in this study has some basic knowledge in groundwater modelling.

Location:	Utrecht University
Period:	Spring/Summer 2023 or earlier in mutual consent
Number of students:	1
MSc programme:	Earth Surface and Water
Fits in track 1:	Hydrology (HYDR)
Fits in track 2:	None
Prerequisites:	Groundwater modelling and coding experience desirable
Contact / info:	d.zamrsky@uu.nl

Earth Surface and Water	Coastal Dynamics and Fluvial Systems

Barrier island evolution by plants, wind and water

Supervision:	Maarten van der Vegt and Valerie Reijers
In cooperation with:	Name of external organisation

Description:

Barrier islands form a protective barrier around one-tenth of the world's shorelines, sustain a rich and unique biodiversity and accommodate a great number of people and economical value. These dynamic landscapes are shaped by the effects of water, wind, sediment and plants. Plants strongly determine the evolution of dunes, that serve as a protective barrier against flooding. On the other hand, storms can remove standing vegetation, erode (small) dunes with cause island erosion or may even induce drowning. Typically models either focus on aeolian transport and dune growth, influenced by plants, or focus on what happens during storms. In this project you will develop a simple, process-based model that includes effects of wind, storms and plants. Parts of the model already exists, but they need to be combined. Using the model, you can, for example study, under which conditions the tail of islands develop from unvegetated, low-lying areas to self-organized dune systems interrupted by wash over gaps or even fully closed dune barriers. You will test your model against existing systems like the barrier islands of the Wadden Sea or the US east coast.

Location:	Utrecht University
Period:	Summer/Autumn 2023
Number of students:	1 -2
MSc programme:	Earth Surface and Water
Fits in track 1:	Coastal dynamics and fluvial systems (CDFS)
Fits in track 2:	None
Prerequisites:	Modelling experience is required.
Contact / info:	m.vandervegt@uu.nl; v.c.reijers@uu.nl

Earth Surface and Water	Coastal Dynamics and Fluvial Systems

What determines the shape of tide-influenced deltas?

Supervision:	Maarten van der Vegt, Maarten Kleinhans
In cooperation with:	-

Description:

Deltas have multiple channels in which tides and river discharge drive sediment transport and morphological evolution. But how do deltas respond to changes in forcing, like reduced sediment supply or SLR?

In this project the student will analyse field of deltas and use our 1D morphodynamic delta model to systematically investigate the parameters and conditions that influence development of tide-influenced deltas. Topics to be studied could for example be:

1. How fast will the morphology of delta's respond to changes in upstream sediment supply, sand mining or sea-level rise?
2. Analysing the role of different bifurcations and channels in tidal deltas. Inspired by existing delta's, analyse how the different bifurcations and channels influence the morphological evolution by reducing or increasing the complexity of the delta channel network. How do # bifurcations and cross-cut channels influence evolution of the delta? Deltas to be studied can be the Mahakam, Brahmaputra, Rhine-Meuse delta, to mention a few
3. Does typical channel width, e-folding length scale, depth and stability of delta depend on river vs tidal forcing, number of bifurcations? Gather field data and combine with our 1D model with dynamics bed and width!
4. Do delta's have multiple stable equilibria? Preliminary tests with the 1D model suggest no unique channel depth exists, but that the actual depth of the channels depend on the past.

This subject is closely related to cutting-edge research themes of enthusiastic supervisors and, as successfully done in the past, we aim for publication in a journal. There is plenty of space to fit the interests and ideas of the student.

Location:	Utrecht University
Period:	Summer/Autumn 2023
Number of students:	1-4
MSc programme:	Earth Surface and Water
Fits in track 1:	Coastal dynamics and fluvial systems (CDFS)
Fits in track 2:	None
Prerequisites:	River and Delta Systems GEO4-4436 and Morphodynamics of Tidal Systems GEO4-4435 Modelling experience is required
Contact / info:	m.vandervegt@uu.nl; m.g.kleinhans@uu.nl

Earth Surface and Water	Coastal Dynamics and Fluvial Systems

Interaction of storm surges and tides shelf seas

Supervision:	Maarten van der Vegt
In cooperation with:	-

Description:
During storms water levels are elevated and can cause flooding. The peak water levels are determined by the tides and the storm surge, but also by a so-called surge-tide interaction. For example, due to the storm surge the water depths are larger and thereby influence the tidal propagation. On the other hand, water depths change due to tides and thereby effect the height of the surge by the wind. In this study we use the worldwide GESLA data base for observed time series of water levels and together with astronomical tides we determine the spatial and temporal pattern of the tide-surge interaction and relate it to time, position in the shelf sea and storm type. This can be used to develop simple prediction models for peak water levels and to look for long-term changes in storm surge dynamics cause by climate change, SLR or local morphological changes.

Location:	Utrecht University
Period:	Summer/Autumn 2023
Number of students:	1-2
MSc programme:	Earth Surface and Water
Fits in track 1:	Coastal dynamics and fluvial systems (CDFS)
Fits in track 2:	None
Prerequisites:	Morphodynamics of Tidal Systems GEO4-4435 Modelling experience is required
Contact / info:	m.vandervegt@uu.nl

Earth Surface and Water	Coastal Dynamics and Fluvial Systems

Projecting global delta area under relative sea-level rise scenarios

Supervision:	Frances E. Dunn, Jaap H. Nienhuis
In cooperation with:	

Description:

Coastal river deltas are low-lying environments vulnerable to changes in land elevation and sea level, which is concerning given relative sea-level rise (RSLR) projections for the coming decades and the hundreds of millions of people that currently live and rely on coastal deltas. Recent work (Nienhuis and van de Wal 2021) has modelled delta land area change over the 21st century under scenarios of RSLR, and here we will take the work further by combining their model with projections of fluvial sediment delivery (Dunn et al. 2019). Sediment deposition and retention is the primary driver of land elevation gain in deltas, and therefore the key counterbalance to subsidence and global sea-level rise. The proposed methodology allows for the inclusion of varying influences of dams and other human activities on sediment delivery to deltas, and therefore analysis of the effect of these drivers on delta land area change.

The student will undertake the modelling with advice from the supervisors, using existing available code and datasets. The analysis will focus on a selection of deltas based both on the best modelled data and processes, and broader academic and practical interest. The direction of the research may also be determined considering the student's interests. For example, the student can make a webpage showcasing land area projections of future deltas, or be involved in writing a publication based on the modelling work and analysis. As all research activities for this project are computer based, there should be no disruption to the work in case of further homeworking advice. Fortnightly meetings with the supervisors can be online or in person.

Location:	Utrecht University
Period:	Autumn 2023 or earlier
Number of students:	1
MSc programme:	Earth Surface and Water
Fits in track 1:	Coastal dynamics and fluvial systems (CDFS)
Fits in track 2:	None
Prerequisites:	Experience with Matlab or Python and working with spatial data would be advantageous, as would knowledge of coastal river delta geomorphology.
Contact / info:	f.e.dunn@uu.nl; j.h.nienhuis@uu.nl

Earth Surface and Water	Coastal Dynamics and Fluvial Systems

A new benchmark for flooding in river deltas: From nuisance flooding to permanent land loss

Supervision:	Frances E. Dunn, Jaap H. Nienhuis
In cooperation with:	

Description:

Coastal river deltas are low-lying environments vulnerable to changes in land elevation and sea level, which is concerning given relative sea-level rise (RSLR) projections for the coming decades and the hundreds of millions of people that currently live and rely on coastal deltas. One of the key consequences of RSLR is flooding, both temporary and permanent, but it remains unknown how long typical floods last, and how RSLR may increase flooding durations.

In this project we will use high resolution satellite data from 2016 - 2022 for the 50 largest river deltas, assessing flooding and analysing patterns, seasonally, interannually, spatially, and between deltas. We will quantify the effect of RSLR on permanent flooding and land loss in delta coastal zones, and consider the long-term implications for delta sustainability.

The dissemination of the research may be determined considering the student's interests. For example, the student can make a webpage showcasing the results, or be involved in writing a publication based on the work. As all research activities for this project are computer based, there should be no disruption to the work in case of further homeworking advice. Fortnightly meetings with the supervisors can be online or in person.

Location:	Utrecht University
Period:	Autumn 2023 or earlier
Number of students:	1
MSc programme:	Earth Surface and Water
Fits in track 1:	Coastal dynamics and fluvial systems (CDFS)
Fits in track 2:	Geohazards and earth observation (GHEO)
Prerequisites:	Also appropriate for the Hydrology track. Experience with GIS and working with satellite data would be advantageous, as would knowledge of coastal river delta geomorphology.
Contact / info:	f.e.dunn@uu.nl, j.h.nienhuis@uu.nl

Earth Surface and Water	Coastal Dynamics and Fluvial Systems

Numerical modelling of storm erosion in laboratory estuaries

Supervision:	Maarten Kleinhans, Eise Nota
In cooperation with:	Deltares?

Description:

Estuaries are beautiful systems of dynamic networks of channels and bars, showing a unique and complex morphology influenced by river flow, tides and storm waves. Worldwide, many estuaries are pivotal for hosting vulnerable ecosystems as well as providing important shipping fairways for human communities and industry. Yet, estuary systems are also vulnerable to climate change-induced sea level rise and more frequent storms, as well as undesirable effects from human engineering (i.e. dredging and dike construction).

In the www.uu.nl/Metronome at the Earth Simulation Laboratory, we succeeded in emulating the dynamics of different kinds of estuaries and their responses to climatic and human factors. Conducting laboratory experiments is important for understanding the processes in estuary dynamics, as it can be used to study the effects of changing a single boundary condition in a controlled environment. This lab data can be compared to real life estuaries, but can also contribute to validating numerical models.

In this study, you will work on validating the numerical model XBeach using a number of laboratory experiments conducted in the Metronome. This model was developed specifically to simulate the impact of extreme storms on sandy coastal areas, incorporating wave propagation, long waves, mean flow and morphological changes. Validating this model to lab experiments can contribute to improving the model for real estuaries, such as the Western Scheldt. Moreover, this study can enable us to run numerous scenarios for calculating and analyzing morphodynamic responses within estuaries of various bank geometries.

Additionally, it is possible to design and conduct your own experiment in the Metronome, where you can determine your own boundary conditions for modelling in XBeach and gain experience in laboratory research.

This subject is closely related to cutting-edge research themes of enthusiastic supervisors and, as successfully done in the past, we aim for publication in a journal. There is plenty of space to fit the interests and ideas of the student.

Location:	Utrecht University
Period:	Flexible
Number of students:	1
MSc programme:	Earth Surface and Water
Fits in track 1:	Coastal dynamics and fluvial systems (CDFS)
Fits in track 2:	None
Prerequisites:	Something computational would be convenient.
Contact / info:	m.g.kleinhans@uu.nl and e.w.nota@uu.nl

Earth Surface and Water	Coastal Dynamics and Fluvial Systems

Topographic forcing effects on local dynamics and global equilibrium of estuaries

Supervision:	Maarten Kleinhans, Eise Nota
In cooperation with:	Possibly computer scientists in Eindhoven

Description:

Estuaries are beautiful systems of dynamic networks of channels and bars, showing a unique and complex morphology influenced by river flow, tides and storm waves. Worldwide, many estuaries are pivotal for hosting vulnerable ecosystems as well as providing important shipping fairways for human communities and industry. Yet, estuary systems are also vulnerable to climate change-induced sea level rise and more frequent storms, as well as undesirable effects from human engineering (i.e. dredging and dike construction). In many estuaries around the world, this human engineering has profoundly affected estuary morphodynamics, where fixed banks and shipping channels have influenced tidal prisms and sediment budgets. The extent of these effects are however not completely understood and we are still unable to predict the ecomorphodynamic response of estuary systems to planned human engineering measures in real estuaries such as the Western Scheldt.

In the www.uu.nl/Metronome at the Earth Simulation Laboratory, we succeeded in emulating the dynamics of different kinds of estuaries and their responses to dredging and dike construction. It was found that an estuary completely confined by dikes results in a system with enhanced flow velocity, where the networks of main channels and bars are stable, whereas locations of barb channels, bifurcations and confluences locally migrate in a repeating pattern. It is however uncertain how the outline of dikes affects this global equilibrium with local dynamics.

In this study, you will conduct a number of experiments in the Metronome to develop statistics that characterize the effects of topographic forcing on these dynamics and equilibria with different configurations of dikes. Additionally, we can study the effects of local perturbations (e.g. dredging) or sea level rise in the entire system. This study can be extended by using a network tool capturing these changes over time.

This subject is closely related to cutting-edge research themes of enthusiastic supervisors and, as successfully done in the past, we aim for publication in a journal. There is plenty of space to fit the interests and ideas of the student.

Location:	Utrecht University
Period:	Flexible
Number of students:	1 or 2
MSc programme:	Earth Surface and Water
Fits in track 1:	Coastal dynamics and fluvial systems (CDFS)
Fits in track 2:	None
Prerequisites:	Something computational would be convenient.
Contact / info:	m.g.kleinhans@uu.nl and e.w.nota@uu.nl

Earth Surface and Water	Coastal Dynamics and Fluvial Systems

Improving the experimental method: remote sensing on a laboratory scale

Supervision:	Maarten Kleinhans, Eise Nota
In cooperation with:	

Description:

Estuaries are beautiful systems of dynamic networks of channels and bars, showing a unique and complex morphology influenced by river flow, tides and storm waves. Worldwide, many estuaries are pivotal for hosting vulnerable ecosystems as well as providing important shipping fairways for human communities and industry. Yet, estuary systems are also vulnerable to climate change-induced sea level rise and more frequent storms, as well as undesirable effects from human engineering (i.e. dredging and dike construction). This requires constant monitoring of estuaries around the world in order to sustain crucial infrastructure, urban areas and nature. However, such monitoring is costly and it is still unclear how often this should be conducted. Remote sensing is a tool that is increasingly applied to assist here, where the saturation and intensity of water colour can be used as proxies for determining water depth.

Similarly, in the www.uu.nl/Metronome at the Earth Simulation Laboratory, we apply blue dye to the water, where locally increased blueness of the water indicates increased estuary depth. However, we are still unable to directly link blueness to exact water depth in the Metronome. Moreover, we require a protocol for a standard application of dye into the Metronome water, to maintain a reasonably constant dye concentration.

In this study, you will work on the development of a Python tool to assess estuary depth in the Metronome through blueness of the water captured by overhead cameras. Moreover, you will use state-of-the-art laser scanner equipment to obtain high definition digital elevation models (DEMs) for tool validation. Besides, you will compare the depth distributions of Metronome estuary cross-sections to a recently developed empirical model for natural estuaries (Leuven et al., 2018). Additionally, you can explore beyond the field of physical geography into hands-on applied chemistry of solutes to work on the dye application protocol, as well as conducting your own experiment in the Metronome under various dye concentrations.

This subject is closely related to cutting-edge research themes of enthusiastic supervisors and, as successfully done in the past, we aim for publication in a journal. There is plenty of space to fit the interests and ideas of the student.

Location:	Utrecht University
Period:	Flexible
Number of students:	1
MSc programme:	Earth Surface and Water
Fits in track 1:	Coastal dynamics and fluvial systems (CDFS)
Fits in track 2:	Geohazards and earth observation (GHEO)
Prerequisites:	Computational skills in Python and/or Matlab.
Contact / info:	m.g.kleinhans@uu.nl and e.w.nota@uu.nl

Earth Surface and Water	Coastal Dynamics and Fluvial Systems

Cryo-morphodynamics on the Alaskan Coast

Supervision:	Jaap Nienhuis
In cooperation with:	Emily Eidam (Oregon State), Nina Stark (Virginia Tech)

Description:

The Beaufort Sea in Alaska is frozen for 8 months every year. What happens to the seafloor during this time?

You will be part of an international project that aims to understand sediment transport and coastal change in the Arctic Ocean. We have obtained high-resolution bathymetric data where we see ice-generated keel scours across the seafloor. In this project you will analyze these data and investigate keel scours patterns (directions, density, depth). These keel scour patterns can offer great insight into ice dynamics, rates, and volumes of ice-driven sediment transport, and cryo-morphodynamics broadly.

Location:	Utrecht University, OSU (Oregon), VT (Virginia)
Period:	Anytime
Number of students:	1
MSc programme:	Earth Surface and Water
Fits in track 1:	Coastal dynamics and fluvial systems (CDFS)
Fits in track 2:	Geohazards and earth observation (GHEO)
Prerequisites:	Matlab or Python, interest in image processing
Contact / info:	j.h.nienhuis@uu.nl

Earth Surface and Water	Coastal Dynamics and Fluvial Systems

Restoration of coastal dynamics on Terschelling

Supervision:	Jaap Nienhuis & Maarten vd Vegt
In cooperation with:	Gerben Ruessink & Valerie Reijers

Description:

The natural dynamics that once governed our barrier islands has been subdued. Levees restrict natural sediment flows and lower island resilience and biodiversity.

Plans are underway to restore natural dynamics on Terschelling (https://www.boschplaatvisie.nl/) but long-term effects of the restoration remain uncertain.

In this project you will join a team of geomorphologists and ecologists, and use Delft3D, a coupled hydro- and morphodynamic model, to simulate the effect of the Terschelling restoration over the coming decades. Outcomes can help guide restoration design but also restoration expectations.

Location:	Utrecht University, Terschelling
Period:	Anytime
Number of students:	1
MSc programme:	Earth Surface and Water
Fits in track 1:	Coastal dynamics and fluvial systems (CDFS)
Fits in track 2:	Geohazards and earth observation (GHEO)
Prerequisites:	Interest in numerical modelling and sediment dynamics
Contact / info:	j.h.nienhuis@uu.nl

Earth Surface and Water	Coastal Dynamics and Fluvial Systems

Adaptation pathways toward global delta sustainability

Supervision:	Jaap Nienhuis & Marjolijn Haasnoot
In cooperation with:	Deltares

Description:

Global deltas will lose land from sea-level rise, putting remaining land under great pressure from expanding population. Adaptation pathways are needed to investigate when measures need to be taken to make deltas sustainable.

In this project you will develop adaptation pathways for 1,000 deltas globally. The first step is to use available projections for sea-level rise, land loss, existing flood defenses, and population growth to investigate which potential futures exist. The second step is to decide what optimal delta futures are for different deltas globally that would allow them to be sustainable and support their population.

Location:	Utrecht University
Period:	Anytime
Number of students:	1
MSc programme:	Earth Surface and Water
Fits in track 1:	Coastal dynamics and fluvial systems (CDFS)
Fits in track 2:	Geohazards and earth observation (GHEO)
Prerequisites:	Coastal Zone and River Management (GEO4-4403) preferred
Contact / info:	j.h.nienhuis@uu.nl

Earth Surface and Water	Coastal Dynamics and Fluvial Systems

Stuck on an island: land area during Holocene sea-level rise and implications for species evolution

Supervision:	Jaap Nienhuis, Maarten Kleinhans, Roderik vd Wal
In cooperation with:	Kenneth Rijsdijk (UvA), Johannes De Groeve (UvA)

Description:

To be stuck on an island has important consequences for the evolution of a species. Island reconstructions are therefore important for biogeography and our understanding of genetic diversification. But, existing reconstructions do not take into account morphodynamics such as delta evolution, with potentially large, though uncertain, implications.

In this project you will collaborate with evolutionary ecologists from the University of Amsterdam and add delta land loss and land gain to the paleo-geographic reconstructions of Southeast Asia. (1) you will use literature and synthesize drainage patterns, sediment thickness, and expected delta locations through time from the last glacial maximum to the present. (2) You will use a delta model (available in Excel, Matlab, and Python) to compute delta thickness through time. (3) You will place the delta thickness onto the paleo drainage pattern map and find paleo biogeographical implications.

Location:	Utrecht University
Period:	Anytime
Number of students:	2
MSc programme:	Earth Surface and Water
Fits in track 1:	Coastal dynamics and fluvial systems (CDFS)
Fits in track 2:	Geohazards and earth observation (GHEO)
Prerequisites:	
Contact / info:	j.h.nienhuis@uu.nl

Earth Surface and Water	Coastal Dynamics and Fluvial Systems

Numerical modelling of dune erosion for different storm sequences on the Dutch coast

Supervision:	Timothy Price, Bart Grasmeijer
In cooperation with:	Ellen Quataert (Deltares)

Description:

Along wave-dominated coasts, sandy beach-dune systems can erode severely during storms. On the Dutch coast, dune erosion is most common during heavy storms from the north-west, characterised by large waves and high surge levels. After such storms, sand slowly returns to the beach-dune system during prolonged periods of lower wave energy, until the next storm arrives. If storms follow each other up without sufficient time for the beach-dune system to recover, the effect of a single storm within such a sequence may be larger than when it occurs as an isolated storm. Although much effort is dedicated to predicting impacts of single large storm, the effect of storm sequences for the (long-term) development of sandy coasts remains less well understood. The objective of this project is to study the effect of storm sequences on dune erosion, using a numerical model.

This project provides an opportunity for a student to work on erosion of a beach-dune system, using the numerical model XBeach (https://oss.deltares.nl/web/xbeach/). This model was developed specifically to simulate the impact of extreme storms on sandy coasts. For this study, you will apply a version of the model especially calibrated for use on the Dutch coast, to reproduce a number of different storms. Field observations may be used to initialize the model, or as a reference for setting up idealized boundary conditions. You will also have access to field measurements of waves, and pre- and post-storm bed levels obtained at Egmond aan Zee, for possible assessment of model agreement. The model output will allow you to study morphological change during different storms, and the responsible drivers (currents, infragravity waves, sediment transport fluxes) from the surf zone up to the dune.

Depending on the occurrence of storm conditions during the thesis period, you will have the possibility to spend several days in the field to assist with measurements during storms. This topic requires a background in coastal dynamics and good programming skills (in Matlab) are a must.

Location:	Utrecht University
Period:	Autumn 2023 or earlier in mutual consent
Number of students:	1
MSc programme:	Earth Surface and Water
Fits in track 1:	Coastal dynamics and fluvial systems (CDFS)
Fits in track 2:	Geohazards and earth observation (GHEO)
Prerequisites:	- GEO4-4434 Morphodynamics of wave-dominated coasts - Experience with or a keen interest for programming in Matlab
Contact / info:	t.d.price@uu.nl

Earth Surface and Water	Coastal Dynamics and Fluvial Systems

Swimmer safety at Dutch beaches

Supervision:	Timothy Price Tina Venema (Dept. Sustainable Development); Margot Peeters (Fac. of Social and Behavioural Sciences, Dept. of Interdisciplinary Social Sciences);
In cooperation with:	Reddingsbrigade Nederland

Description:

Coastal drowning is a global public health issue, and it is well-established that rip currents are the leading cause of both fatal and non-fatal drowning incidents on surf beaches worldwide. Rip currents, or rips, are strong, narrow currents that originate in the shallow waters near the beach and flow into deeper water beyond the breaking waves 50 – 100 m seaward. They commonly flow through channels incised through nearshore sandbars and therefore their distribution is intertwined with the morphodynamics of the seabed. The existence and activity of such rip channels is primarily controlled by offshore wave conditions and tidal elevation.

At Dutch beaches alone, over 100 people are rescued from life-threatening situations each year while swimming. Rescue reports do not distinguish rip-related incidents and terminology across data sources is inconsistent. Little is known about (1) the physical conditions (e.g. waves, tides, weather) under which swimmers are most at risk, and (2) the risk perceptions and behaviour regarding rip current hazard and warnings, such as beach flags and warning signage put in place by lifeguards. Recent surveys in Australia, New Zealand, the US, and the UK, for example have shown poor ability of beachgoers to identify potential rip currents, and a disconnect between the risk perceptions of beach safety practitioners and beachgoers.

The aim of this project is to collect the available data on rescues and demographics along the Dutch coast and analyse these in terms of the physical boundary conditions (waves, tides, weather, rip presence). This will allow for the compilation of a database of existing rip-related swimming incidents. Depending on your interest, research steps could focus on, for example, statistical analysis and interpretations of incidents (see https://doi.org/10.5194/nhess-19-2183-2019) or the analysis of incidents at a single site (such as Egmond aan Zee). Another alternative would be to conduct surveys among beachgoers and beach safety practitioners on rip identification and risk perception of drowning.

This project would form a first step in a new collaboration between the departments of Physical Geography, Sustainable Development, the Faculty of Social and Behavioural Sciences and the Dutch beach safety practioners (Reddingsbrigade). The outcomes are expected to provide insight into risk behaviour in relation to demographic and cultural variability, oceanographic conditions, and rip presence. Ideally, this will help reduce drowning rates at beaches on the Dutch coast.

Location:	Utrecht University
Period:	Autumn 2023 or earlier in mutual consent
Number of students:	1
MSc programme:	Earth Surface and Water
Fits in track 1:	Coastal dynamics and fluvial systems (CDFS)
Fits in track 2:	Geohazards and earth observation (GHEO)
Prerequisites:	- GEO4-4434 Morphodynamics of wave-dominated coasts - Experience with or a keen interest for programming in Matlab or Python - A keen interest for social aspects of swimmer safety
Contact / info:	t.d.price@uu.nl

Earth Surface and Water	Coastal Dynamics and Fluvial Systems

Do birds boost or block ecosystem engineering in sandy systems

Supervision:	Floris van Rees; Valérie Reijers
In cooperation with:	NIOZ

Description:

The presence of coastal birds on hard-substrate islands fosters ecosystem productivity; bird excrements boost the local plant community. Yet, how birds impact plant development on nutrient deprived sandy islands through guano deposition, remains unknown. However, plant-sediment feedbacks are key in shaping these bio-geomorphodynamic landscapes. These plants, so called ecosystem engineers, can trap sand by their above-ground biomass and withstand erosion by anchorage through their roots and rhizomes. Over time these plant-sediment feedbacks can lead to the generation of landscape element such as dunes or salt marshes. However, to which extent plants execute their ecosystem engineering ability, is a function of their plant traits such as shoot organization, shoot density and root density. Therefore, to quantify how bird presence influences island morphodynamics, we first have to understand how bird presence affects plants traits.

In this master thesis you will set-up a lab/greenhouse experiment in which you will grow different dune-building plant species under varying guano deposition regimes. You will monitor plant growth and trait expression over time and link plant performance to soil biogeochemistry. Using this set-up you will be able to assess how guano affects species-specific plant growth and the competitive outcome between species. Plant selection can be discussed but also depends on the commercial availability of seeds.

Additionally, depending on your research interests and in consultation with your supervisors there will be (1) opportunities to link the experiment to the field situation by collecting additional samples and analysing remote sensing data or (2) opportunities to evaluate the implications of your findings using simple numerical models in which vegetation and landscape development will be assessed as a function of guano deposition.

Location:	Utrecht University or NIOZ Yerseke
Period:	Spring 2023
Number of students:	1
MSc programme:	Earth Surface and Water
Fits in track 1:	Coastal dynamics and fluvial systems (CDFS)
Fits in track 2:	Geohazards and earth observation (GHEO)
Prerequisites:	Coastal Ecology; Morphodynamics of Wave-dominated Coasts
Contact / info:	f.vanrees@uu.nl; v.c.reijers@uu.nl

Earth Surface and Water	Coastal Dynamics and Fluvial Systems

Shoreline dynamics of nourished and nearby non-nourished beaches

Supervision:	Gerben Ruessink
In cooperation with:	Timothy Price

Description:

Global change is likely to exacerbate beach erosion. This poses a clear need to quantify present-day dynamics of the shoreline, understand the drivers of change (e.g., natural wave forcing versus anthropogenic activities) and to calibrate, validate and improve shoreline evolution models for future use with climate-change scenarios. The focus in the present work will be on high-energy (storm-dominated) low-sloping beaches along the Dutch coast that are nourished regularly.

The aim of the present MSc Research topic is to quantify shore dynamics and to unravel its underlying drivers for an ≈20-km stretch of nourished and non-nourished beaches along the northern part of the Dutch Holland coast (Castricum-Egmond-Bergen). You will use the CoastSat (Python) software package to extract shorelines from Landsat and Sentinel satellite imagery (1985 – present). Based on the acquired time series you can subsequently explore a range of topics to investigate drivers of change, including:

(i) the importance of cross-shore (on/offshore) versus alongshore change,
(ii) the relative importance of time scales of change (storm, seasons, long-term trends),
(iii) the impact of nourishments on nearby non-nourished beaches, and
(iv) the impact of alongshore variability in subtidal morphology (e.g., sandbars) on shoreline dynamics.

The candidate should have a strong interest in beach dynamics, drivers of change and remote sensing. Python programming skills are a must; affinity with analysing time series data is highly advantageous. We plan to publish the results of this project in a peer-reviewed journal article, on which the student will be one of the authors. There is also the opportunity to present research findings at the annual conference of the Netherlands Centre for Coastal Research.

Location:	Utrecht University
Period:	Spring 2023 or in mutual consent
Number of students:	1
MSc programme:	Earth Surface and Water; Marine Sciences
Fits in track 1:	Coastal dynamics and fluvial systems (CDFS)
Fits in track 2:	Geohazards and earth observation (GHEO)
Prerequisites:	GEO4-4434 – Morphodynamics of wave-dominated coasts; GEO4-4408 – Remote Sensing is advised.
Contact / info:	b.g.ruessink@uu.nl

Earth Surface and Water	Coastal Dynamics and Fluvial Systems

Shifting sands and growing plants in restored coastal dune ecosystems

Supervision:	Gerben Ruessink
In cooperation with:	Jaap Nienhuis

Description:

Coastal dunes are created when loose sand is blown inland by the wind and is subsequently captured by vegetation. The interaction between vegetation and sand supply often leads to dynamic dunes, with heterogenous landscapes that are rich in plant and animal species. Human interventions to improve the dunes' role as sea defence have for a long time focused on minimizing dune dynamics by planting vegetation (e.g., marram grass). This has stabilized many dune systems into rather artificial sand dikes. It is increasingly realized that such anthropogenically modified dunes are unlikely to be adaptive to global change (e.g., sea-level rise) and possess strongly declining biodiversity.

To counteract these adverse trends, current dune management aims to re-vitalize coastal dunes by imposing measures that make the stabilized dunes dynamic again. An example of such measures is the construction of so-called notches, gaps in the most seaward dune that resemble natural trough blowouts. The idea is that these gaps act as efficient corridors for inland transport of wind-blown sand, where the imported sand will allow the dunes to grow with sea-level rise and create the right conditions to regain a wide variety in species.

The rapidly increasing interest in foredune notching worldwide creates an urgent need to unravel and quantify the physical-ecological relations that shape the evolution of restored coastal dune ecosystems. In this MSc study you will study the dynamics of the oldest (> 25 years) and largest (about 5 km) dune restoration project in The Netherlands, on the barrier island of Terschelling, using satellite imagery (Google Earth Engine) and digital elevation models. Based on the data you can explore questions such as:

(i) How and at what time scales did the notches develop? Was their geomorphological evolution gradual or abrupt?

(ii) How did the vegetation respond to the implementation of the notches and their subsequent evolution?

(iii) What were the feedbacks between the geomorphological evolution and the vegetation dynamics, and how did these change over time?

Your study will contribute to the understanding of the restoration of coastal dune systems. In the near future, other parts of the island of Terschelling will be re-vitalized (such as the Boschplaat). Your study will thus also contribute to providing coastal managers on Terschelling with the much-needed insight in how these new interventions might develop in the future. Visits to the study site and interaction with these managers during this MSc project will be encouraged.

Location:	Utrecht University
Period:	Spring 2023 or in mutual consent
Number of students:	1
MSc programme:	Earth Surface and Water; Marine Sciences
Fits in track 1:	Coastal dynamics and fluvial systems (CDFS)
Fits in track 2:	Geohazards and earth observation (GHEO)
Prerequisites:	GEO4-4434 – Morphodynamics of wave-dominated coasts; GEO4-4408 – Remote Sensing is advised.
Contact / info:	b.g.ruessink@uu.nl

Earth Surface and Water	Coastal Dynamics and Fluvial Systems

Suspended sediment characteristics in the Rhine River

Supervision:	Dr Marcel van der Perk, Prof. Hans Middelkoop
In cooperation with:	-

Description:
Sediment characteristics, such particle size distribution, organic matter content, settling velocity distribution, control for a large part the transport and fate of suspended sediments in river systems. Furthermore, their chemical composition can reveal the origin of the sediment. However, data on these sediment characteristics is scarce for most large rivers, including the Rhine and Meuse rivers. This study aims to determine the sediment characteristics and their spatial and temporal variability in the Rhine River. This information will be used to assess the origin, transport pathways, and fate of suspended sediment in the Rhine River.

Location:	Rhine River basin, The Netherlands or Germany / UU
Period:	from September 2023
Number of students:	1
MSc programme:	Earth Surface and Water
Fits in track 1:	Coastal dynamics and fluvial systems (CDFS)
Fits in track 2:	Hydrology (HYDR)
Prerequisites:	GEO4-4436 River and Delta Systems
Contact / info:	m.vanderperk@uu.nl

Earth Surface and Water	Coastal Dynamics and Fluvial Systems

Transfer and travel times of fine sediment in Geul River, The Netherlands

Supervision:	Dr. Marcel van der Perk
In cooperation with:	Stichting Visstandbeheercommissie Geul en Zijbeken (VBC) Waterschap Limburg

Description:
The infiltration of fine sediments in gravel bed rivers may adversely impact the spawning success of various fish species including trout and salmonids. Moreover, intermittent sedimentation and subsequent resuspension cause considerable delays in the source-to-sink transport of fine sediment and associated contaminants through rivers systems. This study will quantify the storage and release rates and the accompanying sediment residence time of fine sediment in the Geul River. This will be achieved by means of a combination of field mapping, measurements of sedimentation storage and release rates in various sediment storage compartments (channel bed, channel banks and floodplains) using sediment traps and erosion pins and measurements of the metal content of the sediments. The field data will be used to develop a mathematical model of fine sediment transfer in small gravel-bed streams.

Location:	Geul River Valley, The Netherlands
Period:	4-8 weeks fieldwork in the period from September 2023
Number of students:	1-2
MSc programme:	Earth Surface and Water
Fits in track 1:	Coastal dynamics and fluvial systems (CDFS)
Fits in track 2:	Hydrology (HYDR)
Prerequisites:	GEO4-4436 River and Delta Systems
Contact / info:	m.vanderperk@uu.nl

Earth Surface and Water	Geohazards and Earth Observation

Permafrost, climate change and the debris flow hazard in High Mountain Asia

Supervision:	Varvara Bazilova, Walter Immerzeel
In cooperation with:	Léo Martin (Aix Marseille University)

Description:

Debris flows are masses of soil, rock and water which frequently occur in extreme, mountainous terrain. These events pose great risks to settlements located downstream from the headwaters of the Alpine basins. Population expansion and socioeconomic development has altered the exposure of people to these hazards. At the same time, these hazards may increase in both frequency and magnitude due to the glacier, snow and permafrost decline as result of global climate change and the following destabilization of mountain slopes.

The aim of the project is to test, how the changes in the glacier extent and the permafrost thaw affect the magnitude and frequency of the debris flows across High Mountain Asia.

Student will use the SedCas (sediment cascade) model (lumped model that follows a hillslope-channel cascade approach) or machine learning techniques to test to test how sensitive the high mountain hazards (e.g. debris flows) are to different scenarios of climate warming, glacier retreat, and permafrost thaw.

The student will have a potential of further developing the SedCas model to include the permafrost parameters and physical processes related to that affecting the water balance and sediment budget into the model.

Location:	Utrecht University
Period:	Autumn or earlier in mutual consent
Number of students:	1
MSc programme:	Earth Surface and Water
Fits in track 1:	Geohazards and earth observation (GHEO)
Fits in track 2:	None
Prerequisites:	Programming skills are preferred
Contact / info:	v.bazilova@uu.nl

Earth Surface and Water	Geohazards and Earth Observation

Parallel algorithms for environmental modelling

Supervision:	Prof. Dr. Derek Karssenberg, Dr. Oliver Schmitz, Dr. Kor de Jong
In cooperation with:	-

Description:

Algorithms for environmental modelling are at the heart of any raster-based environment model. The environmental modeler combines these core model building blocks to build a unique model. There are many different environmental modelling algorithms, some of which are also found in geographic information systems (GIS).
Until around 2005, CPU cores found in computers doubled in clock speed about every two years. Environmental modelers who wanted to use more complex modelling rules and/or larger data sets, just had to buy a new computer to decrease the increased model run times. That is not the case anymore and so model run times keep increasing with added model complexity and data. Because CPU cores are not getting much faster anymore, hardware vendors have been adding additional CPU cores to their CPU's. One obvious way to solve the issue of increasing model run times is to make models use the multiple CPU cores. This requires a reimplementation of the above-mentioned environmental modelling algorithms. This project is about parallelizing one or more environmental modelling algorithms. Some of these algorithms are very easy to parallelize, and some are not. In this project you will investigate parallelize one or more algorithms from the latter category. You will design one or more approaches to parallelize the algorithm and, depending on your interest and background, test these approaches by implementing them. This work is highly relevant, because the results may be used in a new implementation of our own library of modelling algorithms. Faster algorithms will have obvious benefits for the modellers, and you can make a very concrete contribution to this. Supervision: You will be supervised by a team of experienced modelers and software engineers. They will provide you with a description of the sequential version of each algorithm and help you getting up to speed quickly.

Location:	Utrecht University
Period:	To be determined
Number of students:	1-3
MSc programme:	Earth Surface and Water
Fits in track 1:	Geohazards and earth observation (GHEO)
Fits in track 2:	Hydrology (HYDR)
Fits in track 3:	Coastal dynamics and fluvial systems (CDFS)
Prerequisites:	Preferably courses in spatio-temporal modelling, geo-informatics, computer science
Contact / info:	d.karssenberg@uu.nl; k.dejong1@uu.nl

Earth Surface and Water	Geohazards and Earth Observation

Coupled field-agent modelling: an algebra for fields and objects

Supervision:	Prof. Dr. Derek Karssenberg, Dr. Oliver Schmitz, Dr. Kor de Jong
In cooperation with:	-

Description:

In our view, a modelling language is a language for expressing environmental models, by modelers. Modelers are domain experts who are not necessarily knowledgeable or interested in software development. They need an environment with a high level of abstraction. A modelling language, like a script language or a graphical language for example, provides the means for the domain expert to express his ideas about the phenomena being modelled. Most domain experts are not able to express such ideas in lower-level languages like C++, C#, Java or even Python. The use of these languages requires the domain expert to know things that are not directly related to expressing a model, like managing computer memory, managing files, handling errors. Another reason to provide a modelling environment directly to the domain expert, instead of asking a software developer to develop models for the domain expert, is that important decisions that have to be made during the development of the model get taken by the domain expert, instead of the developer. Like software development, model development is a highly iterative process, and decisions about the implementation need to be made continuously during the development of a model. Only for the most trivial models can the domain expert provide the software developer with the full specification of the model beforehand. In most cases the requirements of the model get adjusted continuously, based on the model's performance. Modellers mostly construct models along one of two modelling paradigms: field-based, or agent-based. In the field-based approach, phenomena are considered as spatially continuous, and spatial variation is represented by changes in the attribute value. Examples of fields are air temperature or elevation. In the agent-based approach (also individual based, feature based, or object-based approach), phenomena are represented as bounded objects that can be mobile. Spatial variation is represented by the distribution of objects in space. Although many landscape systems require to combine the field and agent-based approaches, it is notably hard to do so in a model. This is mainly due to modelling languages being monolithic: they are either build around the field based or agent-based paradigm. Integrating the two approaches requires coupling different modelling frameworks, which can be error prone, difficult, and time consuming. To overcome this problem, this study aims at developing a modelling language that integrates the two approaches. The envisioned language should provide functions that operate on fields and/or agents, in a similar fashion. This will allow modelers to construct heterogeneous models consisting of agents and fields, in one single modelling language. Depending on your background, you can focus on designing concepts of such a language (e.g. the syntax), implementing a prototype (in your preferred programming language), or implementing a case study model that can be used to benchmark such a language. This is an interesting study if you like to combine your knowledge in spatio-temporal modelling and computer science or GIS. It gives you the opportunity to work in a multi-disciplinary team consisting of environmental scientists and (PCRaster) software engineers.

Location:	Utrecht University
Period:	To be determined
Number of students:	1-2
MSc programme:	Earth Surface and Water
Fits in track 1:	Geohazards and earth observation (GHEO)
Fits in track 2:	Hydrology (HYDR)
Fits in track 3:	Coastal dynamics and fluvial systems (CDFS)
Prerequisites:	Courses in spatio-temporal modelling, geo-statistics, remote sensing, hydrology, geomorphology, and/or natural hazards. Content of project can be adjusted to your background.
Contact / info:	d.karssenberg@uu.nl

Earth Surface and Water	Geohazards and Earth Observation

Novel air pollution exposure modelling - Evaluating spatial-temporal aggregation as substitute for uncertain activity patterns

Supervision:	Prof. Dr. Derek Karssenberg, Dr. Oliver Schmitz
In cooperation with:	Partners from the Risk Assessment Institute (Veterinary Science, UU)

Description:

Air pollution shows a high spatio-temporal variability and pollution can be influenced by land use, road traffic intensity, building height, meteorological conditions, and industrial use. To assess the severity of air pollution, human exposure to air pollution needs to be determined. Conventional air pollution exposure assessment methods often measure air pollution exposure at front door locations. This approach, however, does not take human activity patterns into account, which consequently may lead to over- or under-estimation of air pollution exposure.

Assessing air pollution exposure considering activity patterns of individual persons remains to be a challenge as 1) the detailed working location information and detailed activity pattern of the residents are commonly unknown when large numbers of individuals need to be considered, 2) the modelling of air pollution exposure using a combination of process- and agent-based models across a large population (e.g. at country scale) may be computationally infeasible.

This study aims at developing a novel method to assess air pollution exposure of different human activity patterns. The human activity patterns will be modelled by spatial (and temporal) aggregation using windows of various shapes and different buffer sizes. The window shapes are suitable to represent a series of activity patterns and optimized for computation. The methodology will be tested and evaluated for a Dutch municipality. This study is highly related to our on-going project of improving air pollution exposure modelling using a combined field and agent-based modelling.

Location:	Utrecht University
Period:	Any period
Number of students:	1-3
MSc programme:	Earth Surface and Water
Fits in track 1:	Geohazards and earth observation (GHEO)
Fits in track 2:	None
Prerequisites:	Earth observation, basic spatio-temporal data analysis Content of project can be adjusted to your background.
Contact / info:	d.karssenberg@uu.nl

Earth Surface and Water	Geohazards and Earth Observation

Assessing spatio-temporal surface water patterns for improved vector-borne diseases mapping

Supervision:	Prof. Dr. Derek Karssenberg, Dr. Oliver Schmitz
In cooperation with:	

Description:

Open surface water plays an important role in the epidemiology of vector-borne diseases such as Malaria and Dengue as the vectors of these diseases (Mosquitos) rely on open water for reproduction. In this project you will contribute to improved prediction in space and time of these diseases by mapping, at a high resolution, the occurrence and dynamics of open surface water. This can be done by using earth observation satellite imagery, which potentially enables quantifying the proportion of the land surface that is covered by open water, and how this changes over time. However, this does not enable forecasting of open surface water under climate change, which requires process-based modelling of the hydrological system, with an emphasis on the hydrological processes that steer the occurrence of land surface water. The idea is to use process-based modelling with high-resolution climate forcing combined with high-resolution land surface data such as surface topography and vegetation. This can be combined with observations of land surface water to validate outputs of the process-based modelling. There is also an option to associate land surface water occurrence to observed incidence of a disease. Data sets are available (and have been analysed by our team) on Malaria incidence over Africa, for instance.

Location:	Utrecht University
Period:	Any period
Number of students:	1-3
MSc programme:	Earth Surface and Water
Fits in track 1:	Hydrology (HYDR)
Fits in track 2:	None
Prerequisites:	Hydrology (e.g. land surface hydrology at MSc level), spatial simulation modelling (e.g. land surface process modelling MSc course), and/or data science methods.
Contact / info:	d.karssenberg@uu.nl

Earth Surface and Water	Geohazards and Earth Observation

Emulation of Simulation Models with Machine Learning

Supervision:	Prof. Dr. Derek Karssenberg, Oriol Pomarol Moya (MSc)
In cooperation with:	

Description:

The availability of spatio-temporal data is increasing exponentially leading to information at higher spatio-temporal resolution. This has resulted in a considerable increase in spatio-temporal detail of simulation models. However, to run such very high-resolution models over large areas leads to long run times requiring hardware resources often well above currently available computer clusters. One approach to overcome this issue is the use of surrogate model components, also referred to as model emulation. A surrogate model component is a fast running model component that replaces the original, detailed, slow model component. This comes with a certain loss of precision, as the surrogate model provides approximate model states. However, it may reduce run time, which allows for running very detailed model conceptualisations even over very large areas (e.g. global scale). In this very challenging project, you will identify and test such a surrogate model. One domain to apply this approach would be global hydrological modelling; the research group has ample experience and codes for simulation models. Of course, you can also apply this concept to other domains, for instance erosion modelling, agent-based simulation of large populations (e.g. disease dispersal), or vegetation modelling. You can define the focus area in consultation with the supervisor. This topic requires interest in integrating techniques from statistical learning (statistics, machine learning) and numerical modelling. Preferably you have experience with building machine learning models, for instance tree-based techniques. But if you lack this background you could study these techniques in the first phase of the project.

Location:	Utrecht University
Period:	Any
Number of students:	1-2
MSc programme:	Earth Surface and Water
Fits in track 1:	Geohazards and earth observation (GHEO)
Fits in track 2:	Hydrology (HYDR)
Prerequisites:	Data Science knowledge and experience: statistics, spatio-temporal simulation modelling, Python / R, GIS.
Contact / info:	d.karssenberg@uu.nl

Earth Surface and Water	Geohazards and Earth Observation

Human environmental exposures at global scale

Supervision:	Prof. Dr. Derek Karssenberg, Dr. Oliver Schmitz
In cooperation with:	Institute for Risk Assessment Sciences (Utrecht University)

Description:
Human exposure to environmental factors is an important determinant of health and disease. Examples include exposure to air pollution increasing the risk of cardio-vascular disease, exposure to green space contributing to mental health, and exposure to surface water increasing the risk for vector-borne diseases such as malaria or dengue. An important concept is personal human exposure, which is the exposure to environmental factors of an individual person. This is the exposure to the environmental factor aggregated along the space-time path visited by an individual. For global health studies, it is important to quantify personal environmental exposures across the world population. This is a massive challenge, as it requires both mapping the environmental factor (e.g. surface water, air pollution) as well as estimating how persons move in their surroundings, as this influences the exposure to the environmental factor. For the latter, relatively simple methods exist that can be applied over large populations. In this topic you will focus on one or two environmental factors (for instance, but not limited to, air pollution, water, green space, noise, mass movements) and assess long-term human exposures in principle at global scale, but focus can be at one or two countries, or for instance a number of large cities. This project requires good skills in modelling, programming GIS operations, e.g. using Python and/or PCRaster, ArcGIS. It is interesting if you like to link environmental research with risk assessment or health research.

Location:	Utrecht University, cooperation possible with Institute for Risk Assessment Sciences, University Medical Centre Utrecht
Period:	Any period is possible.
Number of students:	1-2 students
MSc programme:	Earth Surface and Water
Fits in track 1:	Geohazards and earth observation (GHEO)
Fits in track 2:	Hydrology (HYDR)
Prerequisites:	Experience with programming (scripting, e.g. Python), background in GIS, spatio-temporal modelling, (geo-statistics).
Contact / info:	d.karssenberg@uu.nl

Earth Surface and Water	Geohazards and Earth Observation

Improving assessment of green environments with a focus on green visibility

Supervision:	Prof Dr. Derek Karssenberg, Dr. Oliver Schmitz
In cooperation with:	IRAS, Veterinary Science

Description:

Natural ("green") environments around homes have been consistently linked to better health. But: What is green and how exactly does it improve health? One of the open questions are centered on the question if people can actually see (and appreciate) green environments from their homes. An approach to measure such "visible green" is to use geodata to calculate it. Recently, several methods have been developed, based on 3D geodata or on google Street view photos. These "visible green models" can then be validated with camera pictures. Aim of the thesis is to compare and validate the models that have been developed recently, and to do so in a meaningful way. For this aim, 360-degree pictures have to be taken at specific geographical points, segmentation algorithms applied to the photos, and a validation strategy developed. Final product is a validated model that can be applied for health studies to assess in how far residential natural environments contribute to better human health.

Location:	Utrecht University
Period:	Autumn 2023 or earlier in mutual consent
Number of students:	1-2
MSc programme:	Earth Surface and Water
Fits in track 1:	Geohazards and earth observation (GHEO)
Fits in track 2:	None
Prerequisites:	Spatial Data Analysis, Data Science, and/or Geographical Information Science expertise required at MSc level
Contact / info:	d.karssenberg@uu.nl

Earth Surface and Water	Geohazards and Earth Observation

Can we use plants to prevent debris-flow hazards? Laboratory experiments on the effects of vegetation on debris-flow erosion

Supervision:	Dr. Tjalling de Haas; Dr. Jana Eichel; Prof. Maarten Kleinhans
In cooperation with:	-

Description:

Debris flows are masses of soil, rock and water that rush down mountainsides and spill onto valley floors, where they can devastate people and property. The number of casualties and the amount of damage caused by a debris flow depends on its volume. Flow volume depends on how much sediment is eroded while flow traverses from mountainside to valley. Therefore, to minimize the hazardous impact of debris flows erosion needs to be minimized.

At present, debris-flow hazards are often mitigated by minimizing erosion through concrete structures such as check dams. However, bioengineering techniques, such as growing vegetation in the debris-flow path, may also inhibit erosion. However, at present we lack understanding of how vegetation affects the erosion process, and to what extent it can limit debris-flow erosion.

The goal of this project is to unravel how vegetation affects debris-flow erosion, and to assess to what extent bioengineering can be used for mitigation debris-flow hazards. For this project you will perform experiments in a large debris-flow flume in the Earth Science Simulation Lab (ESL), equipped with modern measurement devices such as load cells, geophones, and laser scanners. Furthermore, you will develop and test new methods to grow vegetated channel beds in laboratory settings.

We envision that this project will form the first steps in exploring the potential of bioengineering for debris-flow hazard mitigation, which we hope will evolve in the implementation of bioengineering approaches in real-life debris-flow torrents in the future.

Location:	Utrecht University
Period:	Autumn 2023 or earlier in mutual consent
Number of students:	1-2
MSc programme:	Earth Surface and Water
Fits in track 1:	Geohazards and earth observation (GHEO)
Fits in track 2:	Coastal dynamics and fluvial systems (CDFS)
Prerequisites:	-
Contact / info:	t.dehaas@uu.nl

Earth Surface and Water	Geohazards and Earth Observation

Evaluating debris-flow erosion equations in numerical models: case study of the Illgraben torrent (Swiss Alps)

Supervision:	Dr. Tjalling de Haas
In cooperation with:	ITC Faculty Geo-Information Science and Earth Observation, University of Twente

Description:

Debris flows are masses of soil, rock and water that rush down mountainsides and spill onto valley floors, where they can annihilate thousands of people and wreck property. Expansion of human population into mountainous regions and the effects of global warming have increased the hazardous effects of debris flows over the last decades.

Debris flows may grow greatly in size and hazardous potential by eroding bed material. However, the processes of bed erosion remain very poorly understood, and are therefore often ignored in numerical models. As a result, debris-flow volumes are underestimated by models used for hazard assessment and mitigation, potentially leading to catastrophic effect.

A number of equations have been developed for predicting erosion by debris flows, but because of the lack of understanding of the erosion processes they use very different approaches leading to a disparity of outcomes.

In this project you will use the OpenLISEM Hazard model to simulate bed erosion by debris flows in the Illgraben torrent in the Swiss Alps, testing the performance and applicability of a wide variety of available erosion equations. Model results will be compared to measured flow characteristics and bed erosion in the Illgraben torrent, in order to test the validity of the erosion modules in these numerical models and to suggest potential improvements. This is a timely and urgent project, and any improvements to the erosion modules in these models will greatly benefit future hazard assessment and mitigation in Alpine areas.

Location:	Utrecht University
Period:	Autumn 2023 or earlier in mutual consent
Number of students:	1
MSc programme:	Earth Surface and Water
Fits in track 1:	Geohazards and earth observation (GHEO)
Fits in track 2:	Coastal dynamics and fluvial systems (CDFS)
Prerequisites:	-
Contact / info:	t.dehaas@uu.nl

Earth Surface and Water	Geohazards and Earth Observation

Quantification of rockwall sediment supply and channel erosion and sedimentation in the Illgraben catchment (Swiss Alps)

Supervision:	Dr. Daniel Draebing; Dr. Tjalling de Haas; Dr. Wiebe Nijland
In cooperation with:	Swiss Federal Institute for Forest, Snow and Landscape Research (WSL)

Description:

Debris flows are mixtures of soil, rock and water that rush down mountains onto valley floors, which can have devastating consequences for humans and infrastructure. The frequency and magnitude of debris flows is controlled or limited by weather such as frequency of thunderstorms or by material supply from rock slopes due to weathering and landsliding. The Illgraben is the most active debris flow catchment in the world suggesting that sediment supply is unlimited resulting in high debris flow frequency following thunderstorms.

The goal of the project is to unravel sediment supply by landslide processes from rock slopes in the Illgraben, sediment connectivity to the channel, and erosion and deposition within the channel during debris flows. Candidates can participate in fieldwork collecting UAV data in the Illgraben from Spring to Autumn 2023. Based on existing UAV data from WSL and newly collected data, the candidate will for the first time quantify sediment dynamics in an entire debris flow catchment in high temporal resolution to find the missing puzzle piece in the understanding of debris flows.

Location:	Utrecht University
Period:	Spring to Autumn 2023 or in mutual consent
Number of students:	1-2
MSc programme:	Earth Surface and Water
Fits in track 1:	Geohazards and earth observation (GHEO)
Fits in track 2:	Coastal dynamics and fluvial systems (CDFS)
Prerequisites:	-
Contact / info:	t.dehaas@uu.nl or d.draebing@uu.nl

Earth Surface and Water	Geohazards and Earth Observation

BEYONd the bathtub: deciphering SEA-level rise control on coastal change (BEYONSEA)

Supervision:	Jaap Nienhuis & Mathieu Gravey
In cooperation with:	

Description:

Relative sea-level rise (SLR) induced coastal erosion and drowning is one of the most consequential effects of climate change and a global threat to coastal populations and ecosystems. Despite its importance, the effect of SLR on present-day coastal change is mostly unknown.

Perhaps the single biggest reason why we have not been able to observe the impact of SLR on coastal change, is that most global coastlines have experienced roughly the same SLR over the instrumental record, on the order of 2-3 mm/yr in the past decades. Without spatial variability it is difficult to extract a signature of SLR between other factors that drive coastal change.

This project involves a robust 4-step data science approach to detect the influence of SLR on coastal change, including (1) clipping, cloud-masking, and filtering available NASA Landsat data to fit within available outlines of coastal systems (beaches, salt marshes, mangroves), (2) reduce image to morphometric statistics, (3) obtain sea-level elevation per image, (4) investigate statistics trends between (2) and (3).

Location:	Utrecht University
Period:	Autumn or earlier in mutual consent
Number of students:	1
MSc programme:	Earth Surface and Water
Fits in track 1:	Geohazards and earth observation (GHEO)
Fits in track 2:	Coastal dynamics and fluvial systems (CDFS)
Prerequisites:	List of required courses and/or experience
Contact / info:	j.h.nienhuis@uu.nl