Socio-Hydrology on the global scale in the Anthropocene

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There are several motivations and rationales why socio-hydrology is emerging. Even though the responses of water on the earth to human activity are those the discipline of hydrology covers as UNESCO defined in 1964, hydrologists mainly pursued to observe and understand water cycles on the earth from natural scientific point of view. Typically, "naturalized flow" was estimated and simulated even for practical prediction of stream flow into reservoirs.
In the 21st century, the recognition of the Anthropocene prevailed that "real" environment is modified by human influences and differs substantially from "natural" environment, mainly because the changes and the impacts of climate due to the increase of greenhouse gas emissions by human beings became apparent. Real land use and land cover, instead of potential or natural land cover and land use, should be given as boundary conditions for realistic simulation of climate system, and plausible future predictions of land use and land cover including the changes of vegetation should be given for reliable predictions of future climate.
It was not apparent whether human activities, such as reservoir operations and water withdrawals for human needs, have significant impacts on the global hydrological cycles and feedbacks for climate systems, realistic consideration of human interventions have been required for realistic estimates of the impacts of climate change.
These have been the major drivers to promote socio-hydrology on the global scale, and the human interventions on water cycle, such as reservoir operations and human water withdrawals from rivers and ground water, have been included in hydrological and water resources modeling. Owing to the development of socio-hydrologic modeling on the global scale, it was prevailed, for example, storing water in man-made reservoirs should have been suppressing the sea level rise with comparative rate with other causes such as glacier melt in Greenland and Antarctica, ground water in several regions in the world has been depleting substantially and pushing up the mean sea level as a result of mass balance of water in the hydrosphere, and the impacts of climate change on the water resources management would be less significant with autonomous adaptation by changing crop calendar and reservoir operations.
Such a socio-hydrologic development in global hydrology is promising to promote scientifically relevant, socially expected, and personally dedicated studies. In the 20th century, hydrological science was expected to be objective and value-neutral, however, in the Anthropocene in the 21st century, it is expected to propose possible alternative options how to respond to natural and anthropogenic changes in hydrologic cycles even on the global scale. Overview on the socio-hydrologic modeling on the global scale will be presented.

Keywords: human interventions, hydrological cycle, water resources

Modeling the river discharge responses to climate variation and vegetation change in the Loess Plateau

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Simulation of the mutual interaction between hydrological processes and vegetation dynamics is important for understanding and predicting regional hydrological change caused by the climate variability and local land use/cover change. Traditional hydrological models simulate the impact of vegetation change using a simple parameterization scheme. Land surface models emphasize the vertical transfer of energy, water and carbon dioxide in the soil-vegetation-atmosphere continuum, however, some important hydrological processes are over simplified in these models. To fill these gaps, this study chose the Community Land Model version 4 (CLM4) and the Geomorphology Based Hydrological Model version 2 (GBHM2), and replaced the runoff generation and flow routing schemes of CLM4 by the schemes used in GBHM2. The new eco-hydrological model was developed in a study basin with semi-arid climate, the Wudinghe River basin (WRB), which located in the middle reach of the Yellow River with a drainage area of 28706 km^2. After a comprehensive calibration and validation, the model was applied for simulation of the eco-hydrological changes in the past five decades. Changes in regional hydrology and ecosystem were analyzed using the simulated results, with a special focus on the understanding of the river discharge responses to climate variation and vegetation change in the Loess Plateau during the recent 30 years.

Keywords: eco-hydrological modeling, land use/cover change, climate change, regional hydrological change

Global River Flood Exposure Assessment under Climate and Socioeconomic Scenarios: How Many People Are Affected In Future?

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Floods are the most common natural disaster due to the frequency and intensity of heavy rainfall. In particular, human exposure to floods has been increasing to a greater extent in South Asia, East Asia, and Europe as well. This is likely to expand exposure of assets at risk and magnify flood risk, resulting in more human and economic damage, if population growth is sustained and valuable assets are continuously accumulated in river deltas. For global flood risk assessment, it is important to identify and characterize flood areas, locations, and durations. Thus, global flood mapping is an imperative process for risk management, as well as an effective tool for solving trans-boundary water issues at both national and international levels.
Although advanced hydrological inundation models have been developed and suggested that flood hazard, exposure, vulnerability, and risk are well revealed at the river basin to national levels, it is obviously hard to identify the distribution and locations of flood risk on the continent scale. The main concern is which parts in the Eurasian region can be found as high-risk areas in terms of population vulnerable to probabilistic 50-year cyclic flood events under the conditions of climate change and socio-economic scenarios, based on MRI-AGCM3.2S with the Representative Concentration Pathways (RCP8.5) emissions scenario.
In these regards, the purpose of this study is to propose an assessment method for flood exposure between the two periods, i.e., for Present (daily data from 1980 to 2004), and Future (daily data from 2075 to 2099), over the Eurasian region with a special interest in long-term changes due to climate change and socio-economic effects. We propose a methodological possibility to be used as a rapid flood exposure assessment despite low data availability. The method is designed to effectively simplify complexities caused by hydrological and topographical variables in a flood risk-prone area and then visually evaluate hazard occurrences and exposure under the condition of annual maximum daily river discharge with a 1/50 probability of occurrence.
The preliminary results show that inundation areas in Asia and Europe were identified as upward trends in both Present and Future by using GFID2M (global flood inundation depth 2-dimension model) that uses a rapid and straightforward method based on topographic calculation, and that the possible number of affected population may increase in the future by calculating with population change ratio from a distributed data of global population (Landscan 2009 by the Oak Ridge National Laboratory). As a result of the physical exposure assessment from Present and Future, potential hazards area and affected population are projected to occupy approximately 228,646 km^2 and approximately 305 million people respectively, because the population of Asia may increase by about 43% while that of Europe may decrease slightly in Future. Moreover, the results show that the cropland is likely to account for the largest proportion among the increased risk areas in Future in terms of socioeconomic impacts by probabilistic 50-year cyclic flood events.

Keywords: Global river flood, Flood exposure, Flood inundation depth, Affected population

Incorporation of advanced water abstraction schemes into the H08 global hydrological model

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Water is indispensable resources for the society. However, due to increasing water demand, overexploitation of groundwater, and acceleration of anthropogenic climatic change, it is largely concerned about the sustainability of global water resources in this century. In order to quantitatively analyze such global water resources issues, global hydrological models have been developed and made much success in climate change impact assessments and others. The H08 model is one of such models. H08 consists of six sub-models, namely land surface hydrology, river routing, crop growth, water abstraction, reservoir operation, and environmental flow estimation. It enables us to simulate both natural hydrological cycle and major human activities in an integrated manner. To conduct further advanced analyses including adaptation measures to climatic change, six additional schemes on water abstraction have been developed and incorporated into H08. They include the processes of groundwater recharge, groundwater abstraction, inter-cell water diversion through canals, return-flow and delivery loss, improved reservoir representation, and sea water desalination. This presentation introduces the effects of incorporation of these new schemes on global hydrological simulations and implications for global water resources assessments.

Keywords: Global Hydrological Model

High-resolution modeling of human and climate impacts on global water resources

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The number of global hydrological models (GHMs) have been developed in recent decades in order to understand the impacts of climate variability and human activities on water resources availability. The spatial resolution of GHMs is mostly constrained at a 0.5° by 0.5° grid (~50km by ~50km at the equator). However, for many of the water-related problems facing society, the current spatial scale of GHMs is insufficient to provide locally relevant information. Here, using the PCR-GLOBWB model we present for the first time the analysis of human and climate impacts on global water resources at a 0.1° by 0.1° grid (~10km by ~10km at the equator) in order to depict more precisely regional variability in water availability and use. Most model input data (topography, vegetation, soil properties, routing, human water use) have been parameterized at a 0.1° global grid and feature a distinctively higher resolution. Distinct from many other GHMs, PCR-GLOBWB includes groundwater representation and simulates groundwater heads and lateral groundwater flows based on MODFLOW with existing geohydrological information. This study shows that global hydrological simulations at higher spatial resolutions are feasible for multi-decadal to century periods.

Keywords: Global water resources, Human impacts, Climate variability, Groundwater dynamics, High-resolution modeling

Development of future water use scenarios: Water Futures and Solutions (WFaS) initiative's approaches

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Long-term and efficient strategies for water security have become increasingly important to achieve sustainable development. In order to explore practical development goals and pathways, a scenario-base approach provides valuable insights, since it can identify our challenges. However, still only few water resource assessments have considered "Shared Socioeconomic Pathways (SSPs)". It is expected that water demand will increase in conjunction with population and economic growth. On the other hand, economic and technological progress have potential to improve water use efficiency leading to a reduction in water use. Water Future and Solutions (WFaS) aims to establish a comprehensive water assessment framework which covers agricultural-industrial-domestic sectors. The purpose of this study is to develop and analyze a set of consistent global water scenarios, especially about agricultural sector.
As a fast track, WFaS chose three sets of SSPs and Representative Concentration Pathway (RCPs), then developed global water narratives.
For agriculture sector, future trajectories of two key drivers were assumed; crop and irrigation area, and irrigation efficiency (*IE*) (Yearly, 2010-2099). It is expected that crop area and the area equipped for irrigation will expand over time. Irrigation area change reflects structural socioeconomic change such as food demand and land use. The Global Agro-ecological Zones (GAEZ) system provided a series of projection of spatial distribution of crop and irrigation area. GAEZ encompasses climate scenarios, demographic and socio-economic drivers, and production, consumption and world food trade dynamics.
WFaS provides dynamical scenarios of *IE* with a hypothesis that *IE* improves along with socio-economic growth, considering possible combinations of five crop types and three irrigation systems; gravity, sprinkler and drip irrigation. Each system has specific range of *IE*. The projection of *IE* was aggregated at country level to meet specification of existing global hydrological models. The country level *IE* will improves when an existing irrigation system is replaced with an innovated same irrigation system or another higher efficiency system, or an irrigation area expands with a higher efficiency system. Thus this study formulates the improvement of *IE* as a function of country/scenario-specific or system-specific parameters of replacement speed and a function of irrigation area. To define country/scenario-specific parameters, a country classification which is based on its socioeconomic condition and hydrological condition was applied. For instance, a country who has less water resource and higher financial power shows more rapid improvement of *IE*.
Forced the three scenarios, three global water models (H08, PCR-GLOBWB, WaterGAP) projected and estimated future water supply and demand. As results of the projection, two water resource assessments which covers agricultural, industrial and domestic sectors will be presented. The first assessment is about imbalances between supply and demand, then hot spots of water scarcity is highlighted. For example in Asia, potential population under severe water scarcity will increase throughout all scenarios considered, in the range of 1.7 to 2.1 billion, which represents

approximately 40% of Asia's total population in the 2050s. The second assessment is a country classification from the view point of their cooping capacity and hydrological challenge. Our result suggests that Pakistan, Afghanistan, and Azerbaijan will remain the most vulnerable countries in Asia because they will be highly water stressed with low adaptive capacity under all scenarios. The number of people living in these three countries will total between 323 and 450 million people in the 2050s.

Keywords: Global water scenarios, Water demand, Shared Socioeconomic Pathways (SSPs), Global water model

Real and virtual water transfers in a Coupled Human-Water System Dynamics

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In China, a large amount of water is transferred among regions to mitigate regional water scarcity. Water can be relocated through water transfer projects and virtually, embodied water for the production of traded products. Here, we explore whether such water redistributions can help mitigate water stress in China. In this talk, a full inventory is investigated for physical and virtual water transfers at a provincial level in China. Our results show that, at the national level, physical water flows because of the major water transfer projects amounted to 4.5% of national water supply, whereas virtual water flows accounted for 35% (varies between 11% and 65%at the provincial level). Furthermore, our analysis shows that these transfers help mitigate water scarcity in several water-receiving regions, but they exacerbate water stress for the water-exporting regions of China. Future water stress in the main water-exporting provinces is likely to increase further based on our analysis of the historical trajectory of the major governing socioeconomic and technical factors and the full implementation of policy initiatives relating to water use and economic development. Improving water use efficiency is key to mitigating water stress, but the efficiency gains will be largely offset by the water demand increase caused by continued economic development. We conclude that much greater attention needs to be paid to water demand management rather than the current focus on supply-oriented management. In a coupled human-water system, human should rely on not only built water infrastructure (“grey” infrastructure), but also ecosystem-based “green” infrastructure to mitigate water scarcity.

Keywords: Water transfer, Virtual water, Water scarcity, Green infrastructure

Evolution of societal value on water for economic development and environmental sustainability in Australia during 1843-2011

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The stress on freshwater resources around the world cast by the human activities now as well as in future requires a radical paradigm shift in approaches to water resources management. Changes in values are seen as leading to changes in decisions and thus to changes in behaviour. However, societal value has not been addressed adequately in current water management studies.
This paper aims to understand the evolution of societal value on water resources for economic development and environmental sustainability in Australia. The Sydney Morning Herald was used as the data sources to track the changes of societal values on water resource between 1843 and 2011. Specifically, this paper will address the following three research questions:
1) How did the societal value on water for economic development verse environmental sustainability in Australia evolve over timescale of 169 years?
2) What was the transition pattern of the societal value?
3) In what context such transition occurs, and what factors possibly trigger such transition?
Three methods were used in this study include: 1) describing evolution of the societal value on water for economic development and environmental sustainability in Australia with the content analysis of newspaper; 2) determining the pattern of evolution of the societal value with both regression analysis and transition theory; 3) understanding the pattern of evolution of the societal value with co-evolutionary framework.
Overall, the importance of economic development has been declining with the arising attention given to environment. The vision for environmental sustainability were kept at a minimal level at the beginning, and stayed as a relatively low voice in the society until it took off at around 1960s and overweigh the voice of economic development in the last decade. The fitted sigmoid curve for societal value on economic development and societal value on environmental sustainability were regressed. According to the derivatives of these two equations, three stages were identified. The predevelopment stage of societal value on environmental sustainability when changes occurred only marginally was identified as the period during 1843-1961. The take-off stage was considered between 1962-1980. The take-off point was when the rate of change speed is maximized. The acceleration stage was identified during1981-2011. It is a period of the absolute value of societal value is still increasing, the acceleration rate is negative and the rate of change is decreasing. Around 2000 a new process of the acceleration rate increase started. The stabilization stage did not appear because the rate of change of societal value has not come to zero.
The societal value on water resources in Australia has co-evolved with the variability of rainfall, and management policies and practice reforms. The co-evolutionary processes are explained according to the stages of societal value transition identified above. They include the predevelopment (1900s-1960s)- societal value on water resources was dominated by economic development; take-off (1962-1980), societal value on water resources reflected increasing awareness of the environment due to outbreak of pollution events; 1980-2011: environment oriented societal value on water resources and the Millennium Drought triggered a package of policy initiatives and management practice towards sustainable water resource use.
This study developed a new method in combination of qualitative and quantitative approach to measure the change of societal value on water, a "less tangible" variable, and its transition pattern with time. Our study provided an understanding of the dynamical mechanism of transitions

which can assist policy makers to identify management practices that require improvement by understanding how today's conditions and problems were created in the past.

Keywords: Societal value change, Water resources managmeent, Content analysis of news paper, Social-hydrology, Social-ecological co-evolution

Understanding of feedback mechanisms of the introduction of new technology in rice farming from ecohydrological and social perspectives in heterogeneous farm households in Korea

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The agricultural institutes in Korea promote a new rice farming technology, so-called "wet-hill-direct-seeding". This technology would reduce the production costs as well as labor and prevent ear of rice from collapsing, resulting in better initial growth and rooting. However, the new method may result in uncertain consequences in term of ecohydrology and biogeochemical cycling. It also requires the application of herbicides, which may not be suitable for organic-farming. The younger generation of farmers are prone to adopt this new technology whereas the older prefer the conventional approach. The objective of this study is 1) to develop a model framework for the assessment of the feedback mechanisms of the introduction of new technology from ecohydrological and social perspectives and 2) to simulate the potential economic and environmental impacts of this technology over time in a community with heterogeneous farm-households. In this presentation, the framework of multi agent systems simulator is introduced, which include social systems defining specific behavioral processes of farm households, agricultural systems characterizing different management and ecohydrological conditions, and the interactions between two systems. In the context of climate-smart agriculture, various factors are considered such as decision-making, diffusion of technology, and environmental modules such as carbon-calculator, biotic and thermodynamic indicators. The expected outcome from this study is to better understand how new technology, market dynamics, environmental change and policy intervention affect a heterogeneous population of a local farm-households and the resources they command.

Keywords: climate smart agriculture, ecohydrological and social effects, multi agent systems modleing, rice farming , new technology

Unintended consequence of managing coupled humans and water in an arid landscape: irrigation efficiency paradox

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In the arid landscapes like northwestern China, water shortage is one of the most influencing factors to restrict the socio-economic development during its long history. Since 1990s, agricultural water-saving technology has been adopted as an effective long-term solution for severe water shortages. However, during 1998-2010, the irrigation water consumption experienced significant rising while irrigation efficiency increased evidently, which indicates the occurrence of so-called irrigation efficiency paradox (IEP). There exist a lot of studies which explore its economic side using theory of rebound effect. However, other sides like policy or institution, which could be more important to understand the interactions between humans and water, have not yet been explored. In this study, a long-term (1950-2010) agriculture development in Bayingolin is firstly analyzed to provide a general context of IEP occurring during 1998-2010 and to identity the key feedback loops between human and water. A conceptual socio-hydrological model has been developed aiming to capture the rebound effect of technology and adaptation effect of society. The model can be used to identify potentially sustainable policy for agricultural development and water management in arid landscapes.

Keywords: humans, irrigation efficiency, paradox, arid landscape

Finding a Sustainable Balance in the Water-Food-Environment Nexus: Socio-economic Transformation of an Agricultural Basin

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Freshwater security poses one of the major challenges of the 21st century, with future supplies uncertain due to climate change and increasing demands on water as populations grow and ecosystem services become increasingly valued. Increasing water use in agriculture inevitably reduces the share available for ecosystems, leading to its degradation, and in places where ecosystem services are valued by humans, community sentiment turns adverse. Water management decisions made that favour ecosystem sustainability can, however, impact a region's economy, employment, and population, especially in agriculture centred economies. The competition for water threatens the viability of agricultural communities. The potential for conflict is self-evident as different users of water attempt to maximize their benefits at the expense of others. This paper focused on this water-food-environment nexus in the Murrumbidgee River Basin, Australia, and how it contributed to the evolution of the regional economy and changing demographic patterns. In the Murrumbidgee water management policies favouring the environment were implemented in the mid-1990s. Paradoxically, against expectations, unemployment in the region fell and there was an increase in average regional income, despite a decline in agriculture. To understand this, and to explore how the competition for water played out in the Murrumbidgee Basin, we developed and used a socio-hydrologic model that explicitly considers bi-directional feedbacks between human and water systems. The modelling simulated the change in community sentiment in response to widespread ecosystem degradation, and forced water management that favoured ecosystems which led to the inevitable decline in agriculture production. The model translated the impact of this decline to the remainder of the economy. The modelling showed how the basin economy reorganized through sectoral transformation to the manufacturing and service sectors, improved agricultural practices, and out-migration of basin residents. The sectoral transformation was facilitated by capital available for investment in manufacturing and service sectors with knock-on impacts on population dynamics and unemployment. The composite impact of sectoral transformation, out-migration and agriculture diversification cushioned the basin economy which adapted to cope with cuts to agricultural water allocations and collectively these contributed to a sustainable transformation of the basin economy. The dynamics outlined here highlight the adaptive capacity of people and movement of capital in a free economy, supported by appropriate strategies and funding, to cope with water stress. These findings are counter-intuitive and not self-evident without the use of the socio-hydrology analysis present in this paper. This type of modelling can be useful to assist the debate in other agriculture communities and beneficially inform how communities could transform and open up adaptation pathways. In a world where fresh water crisis is imminent it can further the understanding of why water management in some basins fail (Aral Sea, Unina Lake), while other basins like the Murrumbidgee are transforming and can help define the role of economic transformation in water management.

Keywords: ecosystem, economy, sectoral transformation, water allocation

Extracting Triggers of Design Flood Revisions to Capture Feedbacks between Physical and Social Processes in Technological Society

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In the era of the emergent Anthropocene, it is important to capture the feedbacks between physical and social processes [Savenije et al., 2014; Sivapalan, 2015]. In technological society [Di Baldassarre et al. 2015], flood mitigations and managements in a river basin are conducted based on a design flood (m^3/s) set by hydrological technologies: observations and modeling so on, and river structures (levees, dam reservoirs etc.) are designed based on the design flood.
In Japan, one of the typical technological society, modern hydrological technologies were imported by Dutch engineers in Meiji era (1868-1912), and modern flood prevention projects were started. The design floods of these projects were set based on the observed historical floods discharge, and the return periods of the design floods were about 20-30 years. However, after the era, the design floods have been revised many times and increased, and the flood prevention projects were also enhanced with increasing levees height and constructing dam reservoirs. Now, the return periods of design flood in Japanese main rivers are set as 150-200 years. The increasing tendency of design floods and enhancements of flood preventions have caused “levee effects” [Montz and Tobin, 2008]: enhancement of land use changes (increasing vulnerability for flooding), and increasing flood intensity [Takahashi, 1964].
As described above history, we hypothesize that the feedbacks in the technological society have been caused via design flood revisions, and conduct a survey for historical sources related Japanese flood prevention plans and design floods to extract the triggers of design flood revisions [Nakamura, S. and T. Oki, 2011]. In this presentation, we show a classification and historical transition of triggers of design flood revisions in Japan, in addition, discuss the mechanism of design flood revisions to capture feedbacks between physical and social processes in technological societies based on the survey result and other socio-hydrological data.
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Keywords: technological society, design flood, Anthropocene

Evolutions of spatial structures in hydrology through the interactuions between water, soil, and forest

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Hydrological processes depend on the geographical differences on the earth. In a huge continent like Eurasia, the water recycle between land and the atmosphere governs the local precipitation amount (Numaguti, JGR,1999), and constantly large evapotranspiration from forest contributes to a sustainable humid climate in the inland area (Yasunari, JMSJ, 2007; Kumagai et al., HP, 2013). In an tectonically active region, heavy rainfall works as a trigger of landslide (Tsukamoto and Ohta, JoH, 1988), and a close relationship exists between water and soil movements by strong erosional forces. The root-system mediation of forest contributes to the soil stability on a steep hillslope (Abe and Ziemer, USDA, 1991).
Although the geographical conditions are different, it should be noted that a spatial structure engaging each of the hydrological processes is created by the evolution at a long timescale based on matryoshka (nesting) doll interactions between the inherent earth activities and terrestrial ecosystems. A pollen analysis in Lake Baikal (Shichi et al., Palaeogeogr. Palaeoclimatol. Palaeoecol., 2013) demonstrated that forests covering Siberia had a dynamic glacial-interglacial spatial cycle, suggesting the spatial expansion/shrinkage fluctuation of water recycle system there has been accompanied with the vapor supply from the boreal forest. Therefore, we should pay a special attention to anthropogenic impacts on the destruction of interaction system between forest and the atmosphere. The deforestation at a huge spatial scale as well as the climate change may cause unexpected environmental devastations in the Anthropocene.
In an tectonically active region, the spatial structure of rainwater flow processes is created by geomorphological and soil-layer evolutions, and the heterogeneities including preferential pathways composed of connected macropores are developed with them (Tani, HESS, 2013). Such long timescale co-evolutions may account for a contrast between the complexity of flow processes and the simplicity involved in rainfall-runoff responses (Sivapalan, HP, 2003). The nonlinearity shown in the responses that hydrologists have studied for several decades (Takagi and Matsubayashi, 1979; Harman and Sivapalan, WRR, 2009) may also be produced by the co-evolutions.
My presentation here will focus on how the long timescale co-evolutions play roles in the flow processes and rainfall-runoff responses. A remarkable contrast in the hydrogeomorphological process between forested and denuded hillslopes will provide clear evidences not only for the role of co-evolutions but also the mitigation effect of forest on the stormflow responses.

Keywords: Hydrogeomorphological evolution, Interactions between Earth and Ecosystems, Water recycle system

Investigation of geotechnical properties and erosion characteristic of reservoir bed sediments

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In recent years, capacities of reservoirs in Taiwan have decreased due to the input of sediments from upstream watersheds, caused by the soil loss of slopeland under construction and during flood events. The lifetime of reservoirs is therefore reducing rapidly; thus dredging of reservoir bed sediments has become one of the major issues relating to soil conservation, water resources, and human society. Hydraulic desilting is one of the commonly applied measures for dredging of reservoir bed sediments in Taiwan. Accordingly, the hydraulic condition at which desilting of sediments initiates becomes a key factor for maintaining the features of targets and extending the lifetime of a reservoir.
This study focus on the fundamental geotechnical properties and erosion characteristic of bed sediments in Agongdian Reservoir, which locates in Kaohsiung City, Taiwan. First, we carried out geotechnical experiments to identify physical properties of the bed sediments. Then erosion experiments were carried out using a recirculating hydraulic flume under different flow conditions, created by adjusting different flow rates and slopes. Afterwards, we applied the modified Shields diagram to analyze the experimental data and determined the critical condition that the erosion of bed sediments initiates. With these results, we are expected to find out the appropriate hydraulic conditions for the bed sediments to be agitated and re-suspend, and provide operating strategies that promotes the efficiency of hydraulic desilting, in order to extend the lifetime of Agongdian Reservoir.

Keywords: geotechnical properties, hydraulic desilting, Shields parameter

Natural and Human-induced Changes in Terrestrial Water Storage over the Indian Subcontinent

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Terrestrial Water Storage (TWS), which is composed of water stored above and underneath the land surface, influences the water cycle through multiple pathways. Near the surface, soil water controls evapotranspiration (ET) and hence water-energy exchange between the land surface and the atmosphere, directly affecting the physical climate; by limiting ET, soil water availability affects land ecosystem dynamics, indirectly affecting the climate; immediately below, the shallow phreatic groundwater feeds streams, lakes and wetlands; further down, groundwater storage in the aquifers provides vital support for water and food (via irrigation) security in societies on arid and semi-arid lands. Thus, understanding the changes in TWS is the key to understanding the dynamics of groundwater systems, especially in highly managed agro-ecosystems, toward identifying and solving groundwater related problems. In this study, we use a global land surface model (LSM) called the HiGW-MAT, which simulates both natural and human-induced changes in the terrestrial water cycle, to explore the changes in various TWS components over the Indian subcontinent. The model explicitly simulates the changes in different TWS components caused by both natural climate variability and human land-water management. We combine model results of TWS change with the data derived from the Gravity Recovery and Climate Experiment (GRACE) satellite mission to understand how groundwater systems are responding to climatic drivers and human land-water management in the region. Results indicate a rapid decline of groundwater resources in part of the region; these results are in line with previous findings but provide further insights on the changes and interactions between different TWS components which are explicitly simulated by the model. Finally, we compare the results from the simulations with and without human impacts to attribute the changes in TWS components to natural and human-induced causes.

Keywords: Hydrological cycle, terrestrial water storage, groundwater, GRACE

Conservation and Restoration of Wells in Ogaki City

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1. Research Purpose and Background
Flowing wells, which naturally supply an abundance of quality groundwater, have been utilized in Ogaki City since the Edo Period. Wells survived as a connecting factor among the people in each local community. The purpose of this research is to clarify the history of the restoration of wells in Ogaki City and their current conditions.
2. Study Methods
Bibliographical research and field research were conducted in order to understand the history of restoration of wells in Ogaki City. Field research was organized after studying the current conditions of the wells, to uncover utilization and their design methods.
3. History of Conservation and Restoration of Wells in Ogaki City
The land of Ogaki City was formed by sedimentation of a river, and this enabled the formation of flowing wells, which naturally supplied an abundance of quality groundwater from the Edo Period. In the late 1960's, during the period of high economic growth, most flowing wells disappeared due to groundwater utilization for factories, which caused a severe drop of the groundwater level. In recent years, factories have been shut down in the consequence economic stagnation and the fall of the textile industry. This resulted in a rise of the groundwater level, and the government together with citizens and volunteer organizations started cooperating to utilize water for city planning.
4. Conservation and Restoration of Wells
(1) Environmental Development by Equipping Wells
Restoration of wells was initiated mainly in the castle town around Ogaki Castle, which has always supplied ample amount of groundwater since the Edo Period. The newly equipped wells had a classic design which imitated a natural pond as well as other unique ones. The surrounding environment around the wells became naturally with planting, and now serves as a recreational area for citizens. The wells and their surrounding environment are managed through the cooperation between the government and the local residents. Due to sharing water and cleaning wells, wells are contributing to energize local community, serving as a central point for the citizens to exchange information.
(2) Environmental Educational by Utilizing Wells
There are pond and water ways derived from the well of Kagano Hachiman Shrine in Ogaki City; and Smallhead Sticleback, fresh water fish which is designated as an endangered species, inhabits in this pond and water ways. Environmental education has been implemented so that the community would feel attachment to nature. An annual program has been developed for the primary and middle schools in the city, with which students observe the wells, ponds, surrounding environment of the water ways, and Smallhead Stickleback. They also conduct water quality survey and learn how Ogaki City manages its environment.
(3) Earth Thermal Energy Generation by Well Water
Ogaki City has been discussing earth thermal energy utilization since 2013, in the course of energy efficiency measures. The temperature of well water is stable throughout the year; therefore, it can be utilized as an energy source for air conditioning and water heating. As a result, since June 2015, the city has been distributing subsidies to offices, corporations, and organizations, which would install earth thermal energy heat pump facilities. This is, as mentioned above, one of the energy efficiency measures.

5. Conclusion
In Ogaki City, wells created a city environment which incorporates nature. At the same time, they are also utilized for the promotion of environmental education and for energy efficiency measures. Wells made the nature and life of the city rich, and contributed to energize local communities. Participation and cooperation among the diverse stakeholders, including local residents, in conservation and restoration of groundwater would be expected for the future.

Keywords: Ogaki, Wells, Conservation, Restoration

①	加賀野八幡神社井戸 1874年	⑧	大垣女子短期大学「みずきの森水」 2007年
②	春日神社「春日の宮湧き出ずる名水」 1962年	⑨	高屋稲荷神社 2008年
③	西之川ハリヨの池広場 1965年	⑩	弘法の井戸広場 2009年
④	大手いこ井の泉緑地 2003年	⑪	三城公園 2011年
⑤	八幡神社「大垣の湧水」 2003年	⑫	むすびの泉 2012年
⑥	栗屋公園 2004年		
⑦	金蝶園総本家大垣東店「菓生の泉」 2005年		

注：赤字は大垣城城下町以内の井戸を示す

Airborne pathogenic bacteria risk related to a storm water retention basin

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Stormwater management is a major concern for urban areas, especially within the context of increasing urban development and climate change. The Greater Lyon (France) is engaged into a sustainable water management. The Django Reinhardt infiltration basin is part of it. Its catchment area is a 185 ha industrial zone, highly impervious, drained by a stormwater separate system. Only stormwater are managed by the basin and, intermittency, some waters, which come from cooling of industrial process and considered as clean, can be injected in rain pipe networks. Django Reinhardt basin is composed by two compartments: one for sedimentation, to get rids of suspend pollutants, and one to infiltrate decanted water. A recent sedimentological study has shown the presence of pathogens bacteria (Sebastian et al., 2014), which can be aerosolized and disseminated into the local environment. This situation exposes surrounding population to a bacterial contamination risk, no yet qualified nor quantified (Lipeme Kouyi, 2014). This study aims to measure this aerosolization, examines extend of the potentially generated plume and its impact on the surrounding population. The final objective is to improve the knowledge and management of this risk. To ensure this objective, the project is highly multidisciplinary and associates skills of life sciences (microbiology) and social and humans sciences (anthropology and geography). The interactions between hazard and vulnerabilities of assets are taken into accounts to get a global vision of this risk. Spatial hazard characterisation is considered as a crossing between dispersion climatic factors, particularly the wind, and abilities of bacteria to survive under local environment. The area considered for exposure is a 1 km buffer zone around the basin, in accordance to previous studies (Dugan, 2014; Kazmierczuk and Bojanowicz-Bablok, 2014). However, to achieve spatial and pathogenicity plume extend (figure 1), inactivation bacteria during airborne must be include. To get a better consideration of local diversity land uses, a visual interpretation is conducted on aerial pictures (10 cm resolution). It allows to improve vulnerability characterisation by considering physical activities or temporality occupation of identified land parcels. First results indicate that the potential plume generated may extend on a N/S transect and affect three different areas: an industrial zone; a residential zone where some sport fields are locted; and an international conference hall (Eurexpo).

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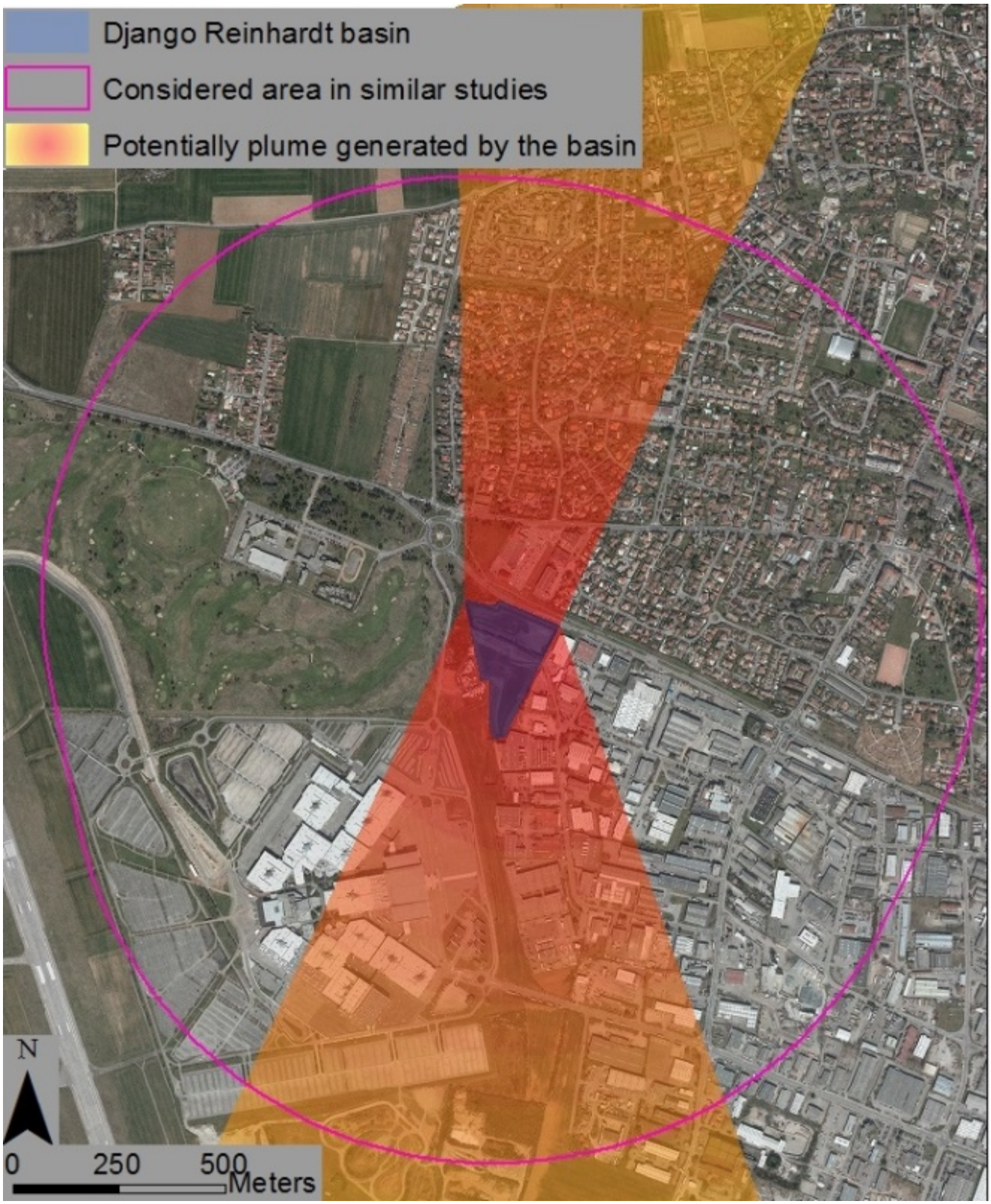
Keywords: water, hazard, bacteria, Lyon (France)



Application of the geothermal snow melting system at the campus of Seoul National University

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Seoul, the capital city of South Korea, has four distinct seasons and the snowfall causes some problems in winter. Especially the campus of Seoul National University located in Mt. Gwanak is high-altitude area with lower temperature than downtown. Therefore, the roads are frozen frequently and it may cause significant problems to pedestrians and cars. However, occasional snow removal works by snow-plough vehicles or human powers cannot meet the immediate needs. In this study, geothermal snow melting system is designed and applied to the road from the bus stop to the buildings of the engineering college for enhanced safety of students and faculties. Mt. Gwanak comprises a basement of granite so that geothermal snow melting system depends on just the geothermal gradient due to lack of other magmatic heat sources. A borehole was drilled to a depth of 500 meters from ground level and three other boreholes were 140 -170 meters for further monitoring. The weathering grades of the rocks are mostly classified from moderately weathered to fresh. Therefore, this area is estimated to be suitable for the heat exchange with groundwater using geothermal heat pump. The heat pump system of 30 RT (Ton of Refrigeration) was installed and 8 lines of pipes were employed to the 155 meters road with 1.45 meters width for water circulation. As a result of recent operations on January 26, 2016, a few cm of snowfall was melted instantly.

Keywords: geothermal, snow melting system, water circulation, heat pump, borehole

Geometry Of Aquifer Based On Geophysics and Hydrogeology Data in Jatinangor, Sumedang, West Java

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Water is one of the essential requirements for society nowadays. Jatinangor is an education area that has rapid development. Rapid development has many impacts to water demand which is increasing year by year. The main issue is about the situation of groundwater in Jatinangor is growing crisis. Therefore, Jatinangor is feasible to do the research to know the causes and the suggestion for groundwater resources.
This study aimed is to find out the position of the aquifer at a certain depth and determine the condition of the subsurface based on geophysics and hydrogeology data. After that, geophysical and hydrogeology data are correlated that could be a model geometry of aquifer. Based on the geophysics data, there are 60 points geoelectric around campus University of Padjadjaran which is have three classifications of the resistivity range such as low resistivity (0-60 Ohm-meter) for tuff, medium resistivity (61-100 Ohm-meter) for pyroclastic flow breccias, and high resistivity (101-571 Ohm-meter) for pyroclastic fall breccias. These rocks are distributed on 0 meter until 125 meter. Schlumberger method is used for this research.
Based on the hydogeological data include hydrogeology mapping and 4 wells, the research area have four system aquifer are aquifer 1, aquifer 2, aquiclud, and aquitard. The analysis from 4 wells correlation showed that the Self-Potential (SP) Logs can be seen that the Self-Potential value of tuff is 0-10 mV and Self-Potential value of breccia is -10 to 0 mV. Overall, geometry of aquifer is divided into three packages of aquifer system based on the similarities of the resistivity at different depths, Package 1 on 90-180 meters has pyroclastic flow breccias and the thickness is 100m as an aquifer 2, Package 2 on 10-90 meters has pyroclastic fall breccias and the thickness is 70m as an aquiclud, Package 3 on 0-10 meters has clay soil and the thickness is 10m as an aquitard. From the analysis, it is known that the research area still have good potential for groundwater resources but the government must have rules for the urban planning and do reforestation to increase the quality of groundwater resources.

Keywords: aquifer, geometry, Jatinangor

