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Editorial

Editorial for Special Issue: "Integrated Surface Water and Groundwater Analysis"

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Comprehensive understanding of groundwater—surface water (GW–SW) interaction is essential for effective water resources management. Groundwater (GW) and surface water (SW) are closely connected components that constantly interact with each other within the earth's hydrologic cycle. Many studies utilized observations to explain the GW–SW interactions by carefully analyzing the behavior of surface water features (streams, lakes, reservoirs, wetlands, and estuaries) and the related aquifer environments. Surface water bodies gain water and solutes from groundwater systems, and in other cases surface water bodies recharge groundwater, which causes changes in groundwater quality. The interfaces between GW and SW environments, such as hyporheic—benthic zones and riparian corridors, often function as biogeochemical hotspots and can have significant influences on the entire stream ecology. Furthermore, groundwater is a major source of drinking water supply and irrigation, and hence critical to global food security. Groundwater needs to be wisely managed, protected, and especially sustainably used. However, the aforementioned tasks have become challenging to many hydrologic systems in various areas from arid to even humid regions because of added stress caused by changing environment, climate, land use, and population. The aim of the Special Issue "Integrated Surface Water and Groundwater Analysis" was to elevate integrated understanding of the science in GW–SW systems through healthy discussions in the relevant research communities.

In this Special Issue, researchers have contributed to the study of groundwater–surface water interactions on a variety of subjects and methods, such as analytical and explicit numerical approaches [1], groundwater level prediction via a long short-term memory (LSTM) network [2], the impact of hydraulic fracturing and climate change [3], modification of the SWAT+ watershed model [4], water management in small islands [5], fluctuation of induced aquifer recharge [6,7], response of river to the 2016 seismic sequence [8], hydrological connectivity in permafrost regions [9], groundwater and streamflow interactions during floods [10], heat transport in managed aquifer recharge (MAR) [11], isotope analysis for distinguishing different types of water [12], digital platform to support decision-making [13], and deep percolation in irrigated fields [14,15].

When evaluating SW–GW interactions, the accuracy of calibration or prediction has been demonstrated by new techniques or multidisciplinary techniques applied in site-specific regional studies. The hydrodynamic surface water module of the STRIVE package (stream river ecosystem) of FEMME (flexible environment for mathematically modelling the environment), combined with analytical/explicit numerical solutions for groundwater flows, successfully investigated the hydraulic GW–SW interaction [1]. Machine learning techniques predicted the groundwater level, revealing that the LSTM (long short-term memory) network approach can be very useful for one-day forecasting of groundwater fluctuations in Jeju Island, Korea [2]. Bailey [4] developed a new module called 'gwflow' for the SWAT+ modeling code and applied this module to simulate both land surface and subsurface hydrological processes of Little River Experimental Watershed (LREW) (327 km^2) in southern Georgia, USA. There was also a valuable case study that simultaneously employed water isotopes, dissolved organic carbon, and electrical resistivity tomography to analyze the hydrological connectivity in a permafrost region [9]. Oxygen and hydrogen isotope ($\delta^{18}O$–$\delta^{2}H$) relationships were characterized by means of various statistical approaches on the Northern Italian Apennines [12].

Important investigations were presented regarding the effects of natural and anthropogenic stress on GW–SW interactions. An integrated hydrologic model (MIKE-SHE and MIKE-11 models) and a cumulative effects landscape simulator (ALCES) were used to assess the impact of hydraulic fracturing on GW–SW interactions in a shale gas and oil play area (23,984.9 km^2) of northwestern Alberta, Canada during 2021–2036 under future climate change scenarios [3]. The impact of a 2016 seismic sequence was analyzed with stream discharge data and recession curves in Nera River Basin, Italy [8]. The hydrological–ecological integrated watershed-scale flow model (HEIFLOW) was tested to verify interactions between the groundwater and streamflow during flood events in 2013 in the Miho catchment, Korea [10].

The interaction of GW–SW was also understood by observing or assessing quantitative/qualitative changes in major hydrologic components. First, in the process of managed aquifer recharging (MAR), GW–SW interactions occur as a mechanism of induced recharge. Hydrodynamics, hydrochemical, and numerical modeling methods were used to analyze an induced aquifer recharge in riverbank filtration (RBF) at Serchio River in Italy [6]. Integrated MODFLOW and SWAT modeling quantitatively assessed induced aquifer recharge due to nearby rivers during the seasonal exploitation of groundwater water curtain cultivation sites in Korea, and it predicted that the aquifers were being depleted every year [7]. Groundwater heat and temperature were monitored in shallow aquifers in the alluvial plain of the Cornia River, Italy to detect the mechanism development of recharge in MAR operations [11]. Second, in addition to recharge, the SW–GW interaction can be explained by another component such as deep percolation (DP) from water balance analysis. In addition to recharge as a direct indicator, the SW–GW interaction can be explained by deep percolation. A two-year study on Willamette Valley in western Oregon, USA assessed DP and recharge into the aquifer [14]. Estimation of DP into shallow aquifers characterized the practice of water management of two flood-irrigated fields in northern New Mexico [15].

Development of tools for the decision-making process was also presented. White [5] found large water supply differences between small islands vulnerable to various natural disasters and climate change. The author compared the national Tonga Strategic Development Framework, 2015–2025 (TSDFII) and local community development plans (CDPs) with census and limited hydrological data in the study. Rojas et al. [13] focused on early involvement of stakeholders, and therefore developed a digital platform (SimCopiapo) that combined integrated modelling and participatory modelling to support decision making for water management in the Copiapó River Basin, northern Chile.

We believe that the insights from the latest research outcomes in the areas of SW–GW interaction observations, modeling calibration/analyses, and decision-making support systems presented in the articles published in this Special Issue can serve as a foundation for an integrated water resource management (IWRM) approach in the future.

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References

1. El-Rawy, M.; Batelaan, O.; Buis, K.; Anibas, C.; Mohammed, G.; Zijl, W.; Salem, A. Analytical and Numerical Groundwater Flow Solutions for the FEMME-Modeling Environment. *Hydrology* **2020**, *7*, 27. [CrossRef]
2. Shin, M.; Moon, S.; Kang, K.; Moon, D.; Koh, H. Analysis of Groundwater Level Variations Caused by the Changes in Groundwater Withdrawals Using Long Short-Term Memory Network. *Hydrology* **2020**, *7*, 64. [CrossRef]
3. Saha, G.; Quinn, M. Integrated Surface Water and Groundwater Analysis under the Effects of Climate Change, Hydraulic Fracturing and its Associated Activities: A Case Study from Northwestern Alberta, Canada. *Hydrology* **2020**, *7*, 70. [CrossRef]
4. Bailey, R.; Bieger, K.; Arnold, J.; Bosch, D. A New Physically-Based Spatially-Distributed Groundwater Flow Module for SWAT+. *Hydrology* **2020**, *7*, 75. [CrossRef]
5. White, I.; Falkland, T.; Kula, T. Meeting SDG6 in the Kingdom of Tonga: The Mismatch between National and Local Sustainable Development Planning for Water Supply. *Hydrology* **2020**, *7*, 81. [CrossRef]
6. Rossetto, R.; Barbagli, A.; De Filippis, G.; Marchina, C.; Vienken, T.; Mazzanti, G. Importance of the Induced Recharge Term in Riverbank Filtration: Hydrodynamics, Hydrochemical, and Numerical Modelling Investigations. *Hydrology* **2020**, *7*, 96. [CrossRef]
7. Chang, S.; Chung, I. Water Budget Analysis Considering Surface Water–Groundwater Interactions in the Exploitation of Seasonally Varying Agricultural Groundwater. *Hydrology* **2021**, *8*, 60. [CrossRef]
8. Di Matteo, L.; Capoccioni, A.; Porreca, M.; Pauselli, C. Groundwater-Surface Water Interaction in the Nera River Basin (Central Italy): New Insights after the 2016 Seismic Sequence. *Hydrology* **2021**, *8*, 97. [CrossRef]
9. Tananaev, N.; Isaev, V.; Sergeev, D.; Kotov, P.; Komarov, O. Hydrological Connectivity in a Permafrost Tundra Landscape near Vorkuta, North-European Arctic Russia. *Hydrology* **2021**, *8*, 106. [CrossRef]
10. Joo, J.; Tian, Y. Impact of Stream-Groundwater Interactions on Peak Streamflow in the Floods. *Hydrology* **2021**, *8*, 141. [CrossRef]
11. Caligaris, E.; Agostini, M.; Rossetto, R. Using Heat as a Tracer to Detect the Development of the Recharge Bulb in Managed Aquifer Recharge Schemes. *Hydrology* **2022**, *9*, 14. [CrossRef]
12. Cervi, F.; Tazioli, A. Inferring Hydrological Information at the Regional Scale by Means of δ18O–δ2H Relationships: Insights from the Northern Italian Apennines. *Hydrology* **2022**, *9*, 41. [CrossRef]
13. Rojas, R.; Castilla-Rho, J.; Bennison, G.; Bridgart, R.; Prats, C.; Claro, E. Participatory and Integrated Modelling under Contentious Water Use in Semiarid Basins. *Hydrology* **2022**, *9*, 49. [CrossRef]
14. Gómez, D.; Ochoa, C.; Godwin, D.; Tomasek, A.; Zamora Re, M. Soil Water Balance and Shallow Aquifer Recharge in an Irrigated Pasture Field with Clay Soils in the Willamette Valley, Oregon, USA. *Hydrology* **2022**, *9*, 60. [CrossRef]
15. Conrad, L.; Fernald, A.; Guldan, S.; Ochoa, C. A Water Balancing Act: Water Balances Highlight the Benefits of Community-Based Adaptive Management in Northern New Mexico, USA. *Hydrology* **2022**, *9*, 64. [CrossRef]