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3D groundwater salinity mapping of the global coastal zone

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Accessible and reliable freshwater sources are essential for human communities and freshwater ecosystems worldwide. In coastal regions, groundwater is the main freshwater sources for drinking water thanks to its high quality, easy accessibility and relatively constant supply. Both anthropogenic (e.g. poor water management and rising population numbers) and natural (e.g. climate change related sea-level rise and storm surges) create additional pressure on coastal freshwater resources. This pressure can lead to declines in fresh groundwater availability caused by salinization and over-exploitation, especially in densely populated areas with intensive agricultural production that already have a high freshwater demand. Groundwater salinization can have severe negative impacts on environmental, economic and human health conditions in these areas. Understanding of current and future threats to fresh groundwater availability by salinization allows coastal communities to better adapt to these risks. Groundwater salinity models are typically applied to study groundwater salinization in local and regional settings and thus provide information for water management bodies to improve their mitigation and adaptation measures. The added value of a global 3D coastal groundwater salinity map would be that it provides important insights into the most threatened regions worldwide, while also identifying coastal regions with similar groundwater salinization risks and similar suitable mitigation and adaptation measures to tackle them. The global 3D groundwater salinity map can also be used as a starting point to evaluate future groundwater salinity developments under multiple climate change and socio-economic scenarios. Hitherto, there were several key obstacles preventing us from building a global 3D groundwater salinity map; the most important ones being the lack of standardized global hydrogeochemical, geological and geophysical datasets and inadequate computational resources and numerical codes. Recent developments in code parallelization (e.g. iMOD-WQ and in due time MODFLOW6) and access to high performance computing allows us to simulate global 3D groundwater salinity by splitting the world into smaller regional scale 3D groundwater salinity models and simulating these in parallel. Moreover, the advancement in available global datasets and creation of a unified global hydrogeological database and schematization allow us to better estimate regional subsurface conditions. Here, we demonstrate the process of building the global 3D groundwater salinity map and show its potential applications. Ultimately, identifying the most threatened regions in near future can lead to better water management strategies to limit the negative impacts of groundwater salinization

on fresh groundwater resources, and/or to come up with strategies to explore additional new ones.