Premature peak of fresh submarine groundwater discharge linked with climate change and its potential impact on coastal environment

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Recent studies have recognized submarine groundwater discharge (SGD) as an important component of the hydrological cycle and chemical budgets in the coastal zone. While it is clear that many coastal systems are affected by SGD, however, its variation and impact in decadal time scale under climate change is largely unknown, particularly in complex coastal system influenced both by river and SGD. Toyama Bay (TB) is such an ideal study area, a semi-enclosed bay in the Sea of Japan at mid latitude zone, which receives huge amounts of nutrients from runoff and fresh SGD. The river basin near the TB, snowmelt runoff timing is sensitive to temperature change in winter. In this study, hydrographic parameters in the TB were measured monthly from 2004 to 2013. We constructed salt and water budget in the inner TB and calculated monthly fresh SGD flux. SGD peak occurred in spring and summer in recent decade, consistent with seasonal change of groundwater table. However, during another decade from 1978-1987, SGD flux reaches to maximum only in summer. Based on historial dataset of precipitation and river flux from 1978 to 2013, across ~40 years, snowfall significantly decreased in winter time, in contrast, rainfall increased in winter and spring. Response with these precipitation variations, total flux of five main rivers in Toyama was on the increase in spring and winter, growth rate in spring was greatly faster than that in winter. Moreover, the river flux peak shifted from July to May in recent three decades. Therefore, SGD peak moving forward toward spring in the last decade may be interpreted by the increase of rainfall and river flux in spring with climate change. Being as a significant nutrients source to TB in summer, fresh SGD has particularly important impact on the shallow oligotrophic baywater during stratification in summer when slight nutrients were supported by vertical mixing. However, SGD peak shifting toward spring would lead to nutrients deficiency and may cause reduction of primary production, as well as negative effect on the ecosystem of TB in the summer time.