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Numerical modeling for evaluation of SGD fluxes constrained by radon-derived assessments

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It has been recognized that submarine groundwater discharge (SGD) may be one of the principal mechanisms for delivering nutrients to surface water bodies. A multifaceted study of the coastal aquifer system of Gulf Shores, Alabama was conducted to assess SGD fluxes and associated nutrient loading to coastal areas. A three-dimensional density-dependent numerical groundwater model was utilized and combined with field-based radon (^{222}Rn, $t_{1/2}$=3.82 d) isotopic tracer techniques. Two model-based SGD estimation approaches were developed to determine localized and entire-shoreline SGD fluxes. Both model estimations for the surficial aquifer system were calibrated using ^{222}Rn-derived groundwater seepages to Lake Shelby, a groundwater-fed lake located within the study area. To constrain the groundwater end-member in the model estimations, 50 groundwater samples from 32 wells in the study area representing all three aquifer units were collected. The radon concentrations in groundwater from the uppermost two regional aquifer units (A1 and A2) were statistically identical, an indication for direct connection between these two aquifer units. Groundwater seepage calculated through the radon mass-balance model resulted in a maximum groundwater flux to Lake Shelby of 18.3 cm/day for these units, which was used to calibrate the numerical model for the surficial aquifer system. Final shoreline seepage fluxes of 6.4 and 8.6-cm/day were obtained from the multi-cell and shoreface numerical model approaches, respectively. The two model-based SGD estimation approaches displayed a reasonable agreement with the radon-derived methods and provided an effective approximation technique that can be inexpensively applied in other similar shoreline areas.