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Lake Peipsi's eutrophication issue: new insights into large scale water quality modeling

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The large and shallow European Lake Peipsi was polluted with phosphorus loadings from different point and diffuse sources over decades. The lake's trophic state changed from mesotrophic to eutrophic and hypertrophic. In the 1990s phosphorus pollution dropped significantly. However, more than twenty years later the lake is still eutrophic (L. Peipsi s.s.) and hypertrophic (L. Pihkva). It has been determined that internal loadings from a large nutrient pool in the lake's sediments play an important role in the actual phosphorus balance. For a pursuing and comprehensive understanding, there is a need for detailed and integrated water quality data. This is necessary to assess the current state as well as the younger lake nutrient history. However, in-situ data are scarce and difficult to access. To overcome this data sparse situation the global integrated modeling framework WaterGAP3 was applied (i) to test the applicability of a global scale (5 arc minutes resolution) water quality model in a local scale eutrophication study, and (ii) to provide a detailed local analysis of the eutrophication issue for Lake Peipsi. In this setting WaterGAP3 provides a detailed description of phosphorus sources, loadings and concentrations. Furthermore the newly implemented two box eutrophication module provides a long term description of total phosphorus (TP) concentrations in lakes, the consequent potential for toxic algae blooms, and the TP balance components such as the sediment storage. The WaterGAP3 global results such as river discharge, TP loads from different sectors, TP concentration in the lake and in the catchments river system cover a period of 1990-2010. Our model results indicate that the agricultural sector (diffuse source) is the primary source of TP pollution in the Lake Peipsi catchment (45%) followed by background sources (diffuse sources) such as atmospheric deposition and weathering (33%), and domestic point sources (19%). The model results confirm the reported phosphorus reduction of 84% since 1992 for the Estonian part of the lake river basin. The TP concentrations in Lake Peipsi and the eutrophic state were well reproduced by the newly developed lake eutrophication module. While actual (post-Soviet Union) loadings from the catchment are low, internal phosphorus loadings from the sediment are the major cause of the actual eutrophic state. However, the poor data situation inhibits a comprehensive model validation. To conclude (i) the global integrated water model WaterGAP3 performed well in providing general and spatial average values for the lake and its catchment. (ii) The model indicates that Lake Peipsi's high phosphorus concentrations and the related water quality issues are primary caused by a huge nutrient pool accumulated in the sediment but which were carried into the lake decades ago.