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An approach to simulation of large lake-aquifer-systems: Semi-arid Nebraska Sandhills, USA

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In many regions of the world, large systems of shallow water bodies include hundreds and thousands of lakes and wetlands, integrated with climate- and human-controlled groundwater. In some cases, like in China and Mongolia, a dramatic reduction of areas and numbers of such lakes is observed. Disparity between spatial-temporal scales of each surface-water body and the entire system presents grand challenge to their modeling, and practical approaches are needed.

We explore feasibility of modeling for the Nebraska Sand Hills (48,000 sq. km), a large, grass-stabilized dune region containing thousands of small closed-basin lakes and wetlands in hydraulic connection with the Northern High Plains aquifer. Groundwater recharge (GR), critical to the existence of lakes and wetlands in the semi-arid climate, was assessed using projected changes in decadal averages of the difference between precipitation and evapotranspiration under the 21st century GR scenarios. Sixteen downscaled Global Circulation Models (ran through the Variable Infiltration Capacity Land Surface Model) and three greenhouse emission scenarios produced median, wet, and dry GR scenarios, accounting for uncertainty in forecasts.

Instead of tracking lakes individually, we propose to identify lakes as areas where the simulated regional water table exceeds land surface elevation DEM, and wetlands as areas where the water table is within 3 m from the land surface. Baseflow, the area, and numbers of lakes and wetlands were simulated using a calibrated groundwater flow model. Results indicate mild increase of lake and wetland numbers and total areas for median GR scenario by the end of century. More dramatic changes can be expected, if wet or dry GR scenarios will be realized. At intermediate times, some inversions between different scenarios are possible. Results are consistent with studies of the future GR in the High Plains and indicate feasibility of the proposed approach.