Climate Change Effects on Water Pollution and Crop Production in the Upper Mississippi River Basin

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Introduction

NONPOINT SOURCE pollution is the main source of Nitrogen (N) and Phosphorus (P) in the intensely row-cropped Upper Mississippi River Basin (UMRB)–which are the pollutants responsible for the Northern Gulf of Mexico hypoxic zone.

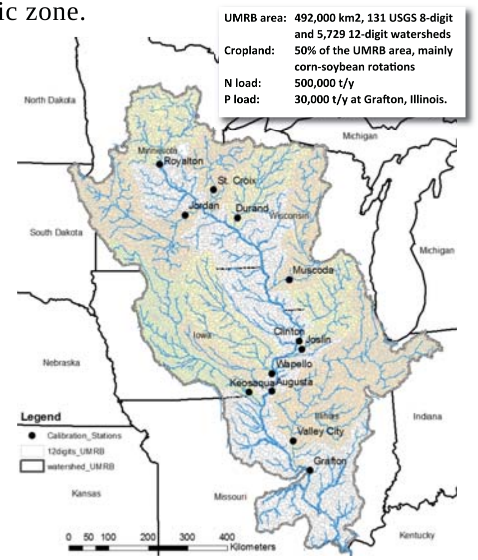

Figure 1: The 12-digit UMRB and the calibration points along the Mississippi river and its tributaries.

The Soil and Water Assessment Tool (SWAT) was delineated using 12-digit watersheds for the UMRB and configured as follows:

- **Tile drains:** Assigned to the agricultural land with slopes lower than 2% and poorly drained soils. http://www.wri.org/publication/assessing-u-s-farm-drainage-can-gis-lead-better-estimates-subsurface-drainage-exten.
- **Tillage types (conventional, reduced, mulch, no-till):** Incorporated based on data compiled by N. Baker. (http://pubs.usgs.gov/ds/ds573/)
- **Existing conservation practices:** A proxy approach based on information provided in the CEAP UMRB study (reductions of USLE P factor and slope length). (http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1042093.pdf)
- **Fertilizer (including manure).** Statewide averages: 117-156 kgN/ha/y and 25-34 kgP/ha/y. Calculated based on NuGIS. (http://www.ipni.net/nugis)

Agricultural Management Scenarios

FOUR AGRICULTURAL management scenarios were tested under the present climatic conditions and a future climate scenario: 1) Continuous corn rotation (C-C), 2) No-tillage (NT), 3) Extended (5-y) rotation of corn-soybean with alfalfa (C-S-A-A-A), and 4) A winter cover crop (COC) within the existing rotations.

General Circulation Model (GCM) and Predicted Mid-Century Climate

- Projected future mid-century (2046-2065) climate were used from the medium-resolution version of the Model for Interdisciplinary Research on Climate, version 3.2 (MIROC 3.2) Global Circulation Model (GCM). The downscaling method used was bias corrected with spatial disaggregation (BCSD).
- The departures from climatology for any given monthly time step are interpolated to a 1/8 degree latitude-longitude grid and superimposed on the observed climatology, which included percentage changes in precipitation and absolute changes in temperatures.

Water Balance Under the Historical and Future Climate

- Mean annual precipitation decreased to 829 mm from the baseline value of 884 mm. Significant reductions (up to 150 mm) in the most intensely cultivated areas (Illinois, Iowa) mainly occurred during the growth stages of the crops (May-Oct).
- Mean annual temperature in the UMRB increased by 4º C for the mid-century period. Changes were consistent across the entire basin.

Water Pollution and Crop Production under the Historical and Future Climate

- All scenarios behaved similarly under the current and future climate resulting in reduced erosion and nutrient loadings to surface water bodies.
- Increased N pollution was only predicted for the C-C scenario due to increased N fertilization (50 kg/ha).

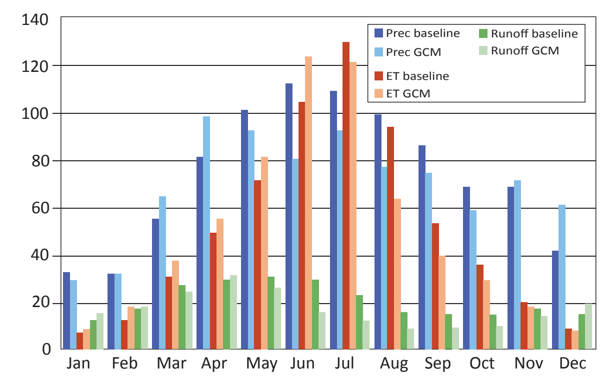

Figure 2: Mean monthly precipitation, evapotranspiration and runoff in UMRB caused with baseline (1981-2000) and future (2046-2065) climate.

- The replacement of soybean with corn in the C-C scenario leaves higher residue amounts on the ground reducing its erosion susceptibility, sediment transport, and P losses.
- No-till was the most environmentally effective scenario with the greatest pollution reduction sustaining crop production levels.
- The extended 5-year rotation with alfalfa is highly effective in reducing pollution; but corn and soybean production is reduced within the 5-y period.
- The establishment of rye as a cover crop to protect soil within the fallow period reduced erosion, and sediment-bound and soluble forms of nutrients due to uptake, with a small sacrifice in crop yields.
- The trend of the simulated effects of all the scenarios tested are in agreement with findings from several experiments that were recently reported: http://www.nutrientstrategy.iastate.edu/documents.
- Future climate resulted in reduced water pollution.
- On the other hand, reduced precipitation during the crop-growth period causes reduced water availability with a negative impact on crops.
- The results underscore the potential SWAT contribution in developing a general decision support system for Corn Belt agricultural systems.

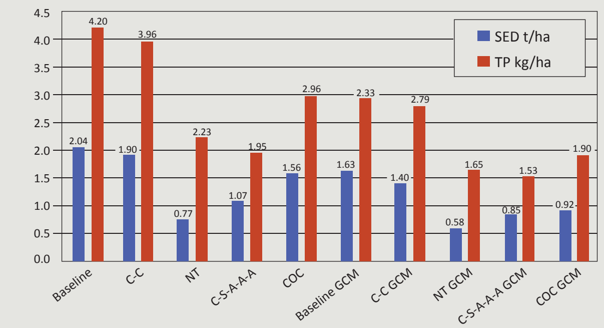

Figure 3: Average annual sediment and TP losses from the cropland of the UMRB with the historical and future climate under the baseline and 4 agricultural management scenarios.

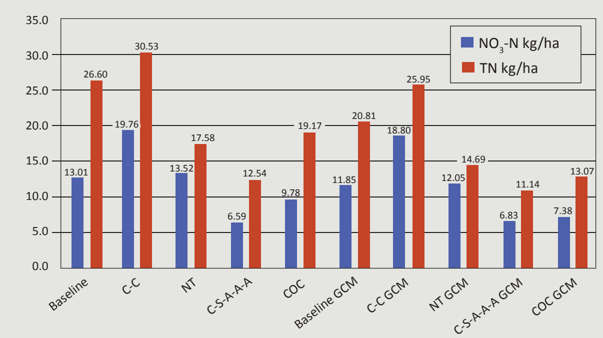

Figure 4: Average annual NO3-N and TN losses from the cropland of the UMRB with the historical and future climate under the baseline and 4 agricultural management scenarios.

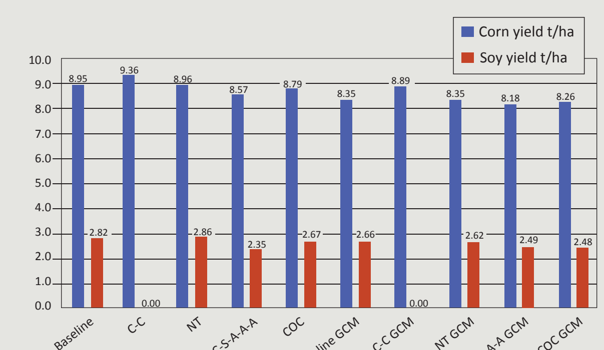

Figure 5: Average annual corn and soybean yields for the years when the crops are growing in UMRB with the historical and future climate under the baseline and 4 agricultural management scenarios.

Acknowledgments

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