Assessing Water Quality Sensitivity to Decadal Climate Variability in the Missouri River Basin based on SWAT Simulations

Amita Mehta[1], Katherin Mendoza[2], Prasad Daggupati[3], Raghavan Srinivasan[3]
Vikram Mehta[2] , Norman J. Rosenberg[2], and Debjani Deb[3]

[1]NASA-UMBC-Joint Center for Earth Systems Technology (JCET)
[2]The Center for Research on the Changing Earth System (CRCES)
[3]Texas A & M University (Texas A&M)

amita.v.mehta@nasa.gov

Outline

- Overview of decadal climate variability impacts project focusing on the Missouri River Basin (MRB)
- Preliminary analysis of decadal variability impacts on nutrient (Nitrogen and Phosphorous) transport over MRB that can potentially influence water quality in the MRB region

Decadal Climate Variability
(Variability with 8-12 year time scale)

Interactions between ocean and atmosphere give rise to natural decadal climate variability (DCV)

Well-known DVC phenomena are:

- Pacific Decadal Oscillation (PDO)
- Tropical Atlantic sea-surface temperature (SST) gradient variability (TAG)
- West Pacific warm pool (WPWP) SST variability

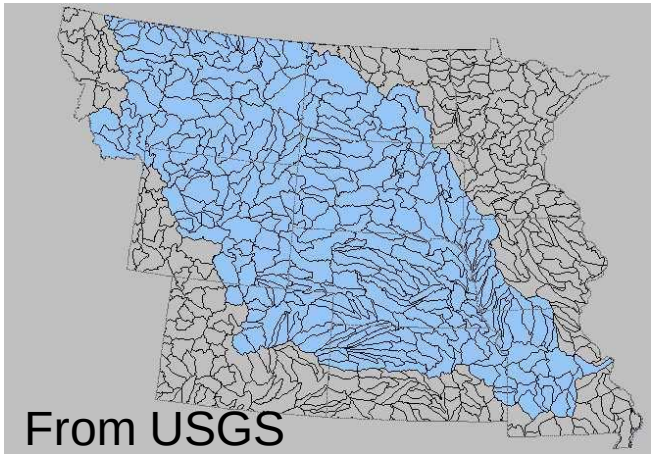
Observations have shown that DCV impacts regional hydrologic conditions in many parts of the world

DCV Impacts Study over the Missouri River Basin

The Center for Research on the Changing Earth System (CRCES), in collaboration with Texas A & M University (Texas A&M) and NASA-UMBC-Joint Center for Earth Systems Technology (JCET), is leading a project to assess impacts of natural decadal climate variability on water and crop yields in the Missouri River Basin (MRB)

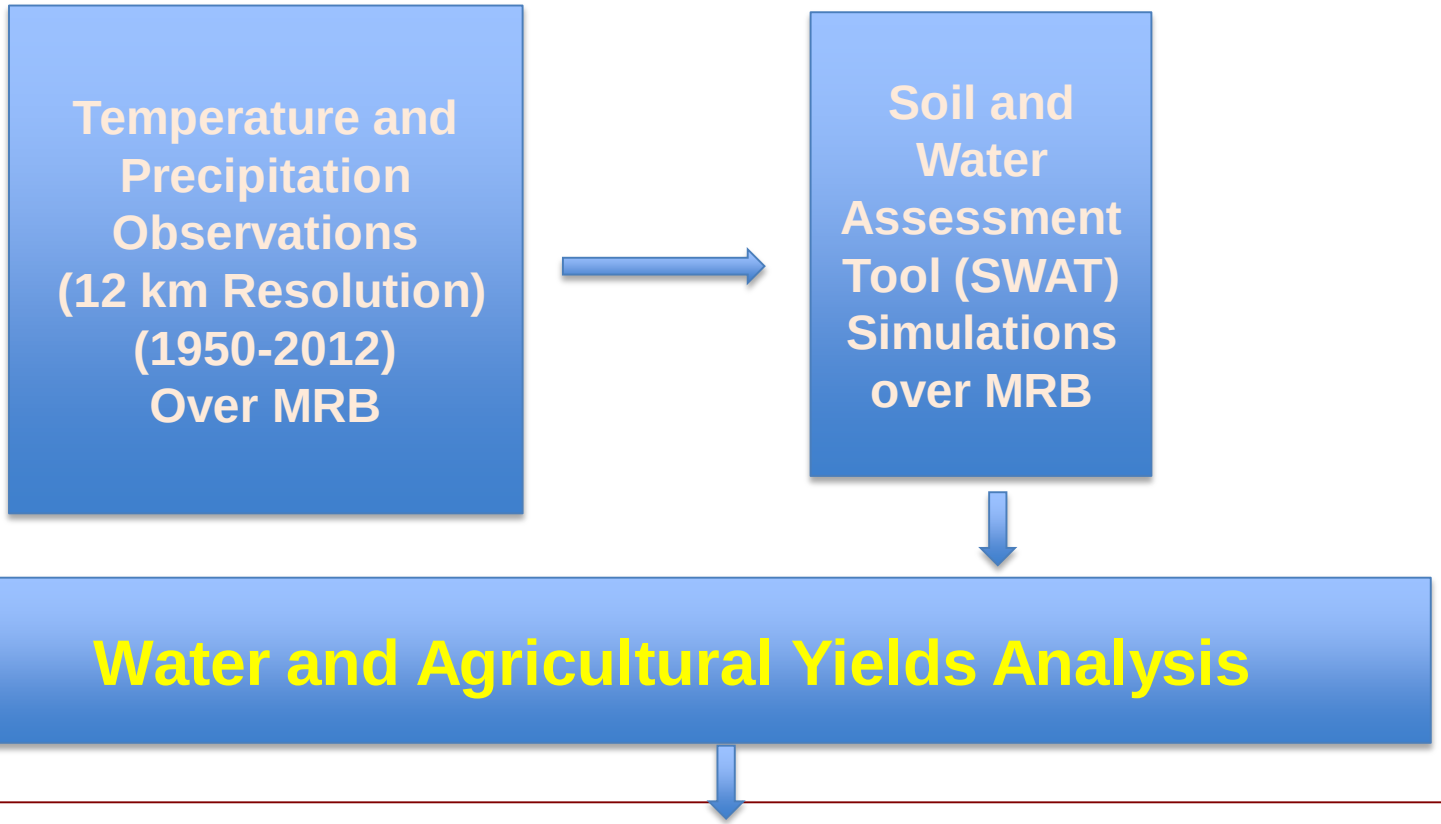
Major River Basins and Watersheds of US

MRB is the largest river basin in the US, covers more than 500,000 square miles (~1,280,000 sq. km), a major crop producing region, dependent mostly in seasonal precipitation (non-irrigated agricultural practice), vulnerable to climate variability and change



Missouri River Basin Watersheds

Impacts Assessment of Decadal Climate Variability on Water and Crop Yields in the Missouri River Basin (MRB)



Economic impact assessment over MRB
Development of management strategy over MRB

SWAT Simulations for DCV Impacts Study

SWAT was calibrated over 14,000 sub-basins covering MRB

SWAT simulations were conducted over these sub-basins using observed temperature and precipitation from 1950-2012

SWAT simulations were also conducted for various DCV scenarios (PDO, TAG, and WPWP in positive and negative phases)

SWAT simulations used auto-fertilization practice based on nitrogen and phosphorous stress conditions

SWAT Simulations for DCV Impacts Study

Analysis of the multi-decadal SWAT simulations show that overall water yield and streamflow in MRB increase by 80% during the positive phase of PDO and negative phase of TAG compared to average condition (Similar deficit was found during the opposite phases of PDO and TAG)

SWAT simulations also showed significant DCV impact on winter and spring wheat

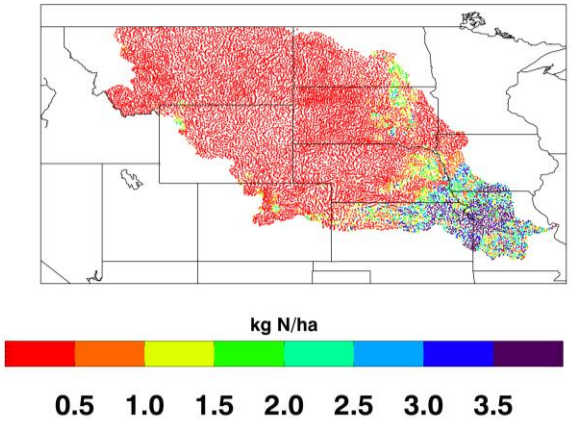
Nutrient Transport over MRB

Our hypothesis is that the DCV impact on water yield, subsequent impact on total sediments, and crop yields would result in DCV of nutrient transport (N and P) with potential of significant impact on water quality (e.g. algal bloom, dissolved oxygen) in the MRB region

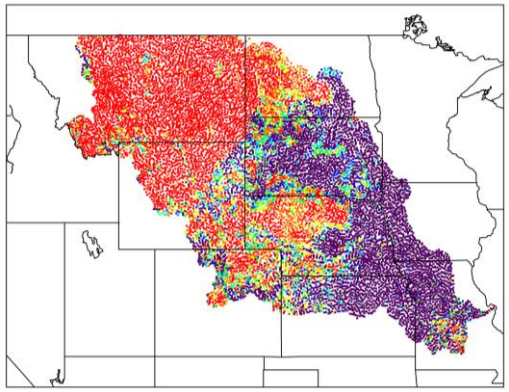
SWAT Simulations of N and P Transport over MRB

10-year Climatology

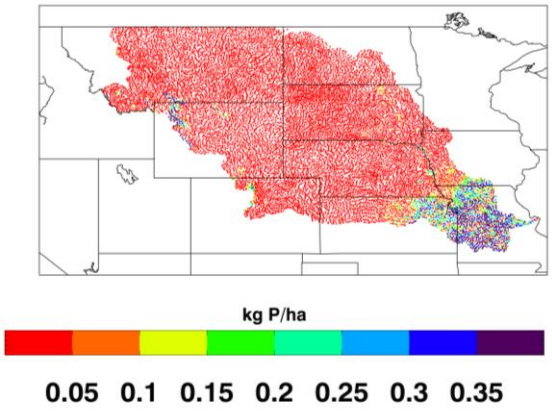
Nitrate



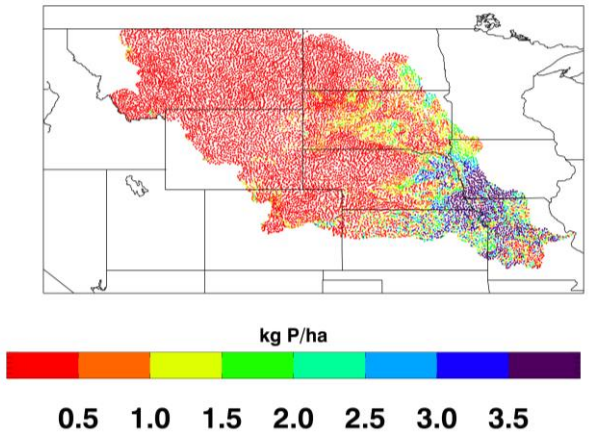
Organic Nitrogen



Soluble Phosphorus

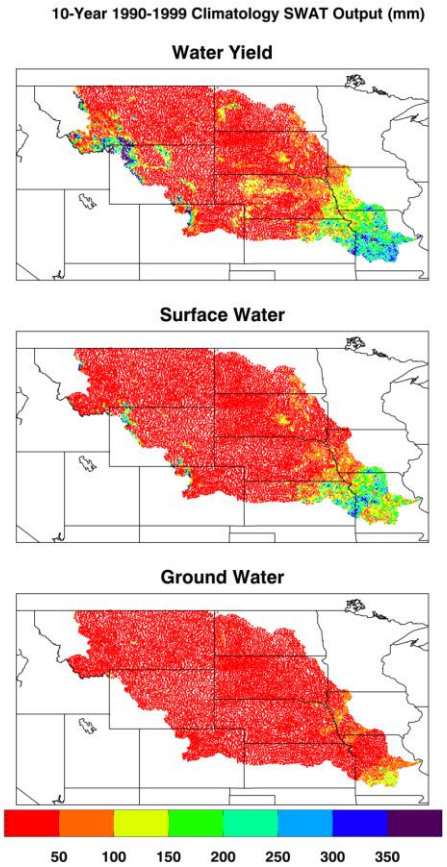


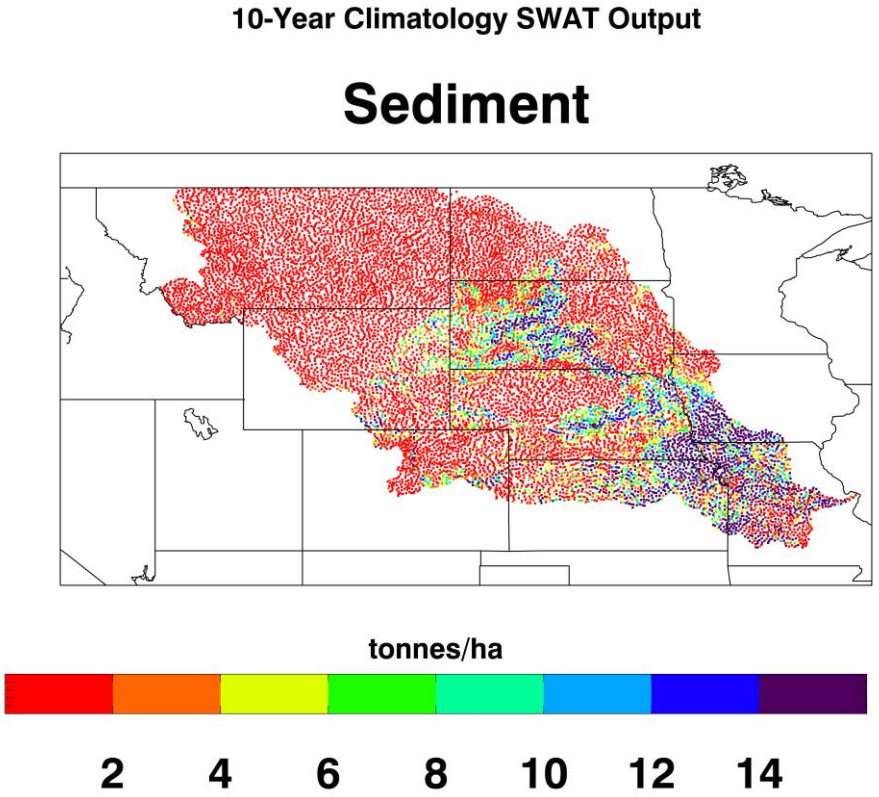
Organic Phosphorus



SWAT Simulation of Water and Sediment Yields over MRB

Water Yield

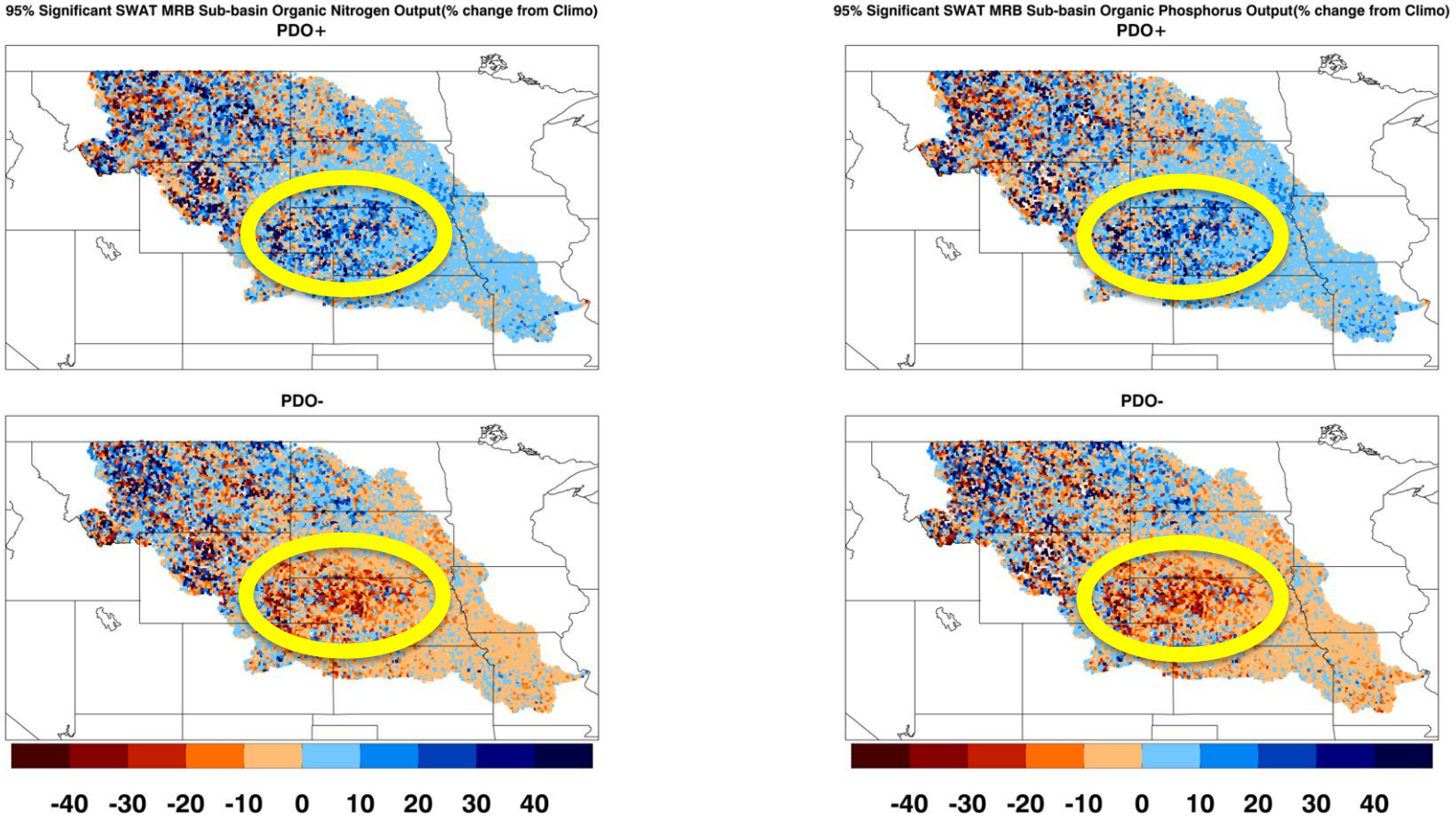




SWAT-Simulated DCV of N and P Associated with PDO

Per Cent Change from Climatology

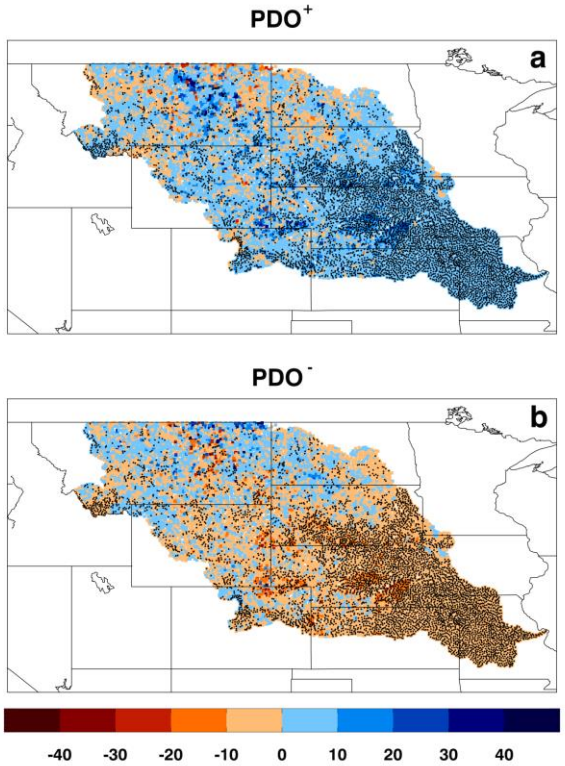
Spatially coherent impact over southern South Dakota and central/northern Nebraska



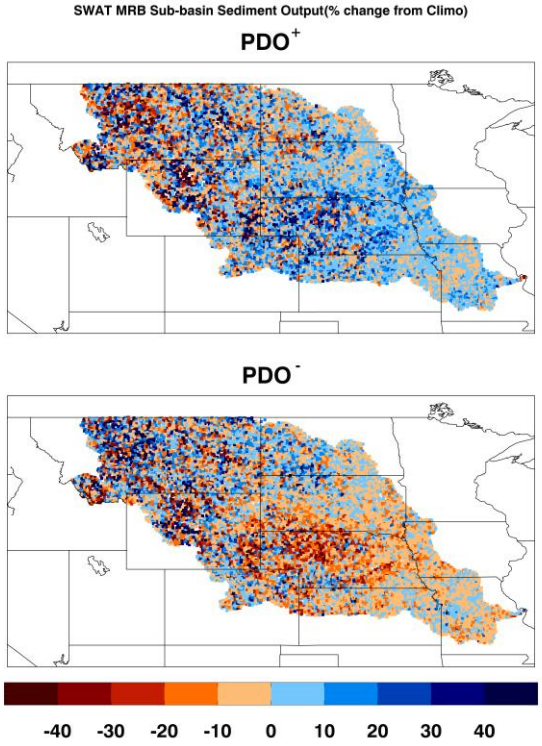
SWAT-Simulated DCV of Water Yield and Sediment Associated with PDO

Per Cent Change from Climatology

Water Yield

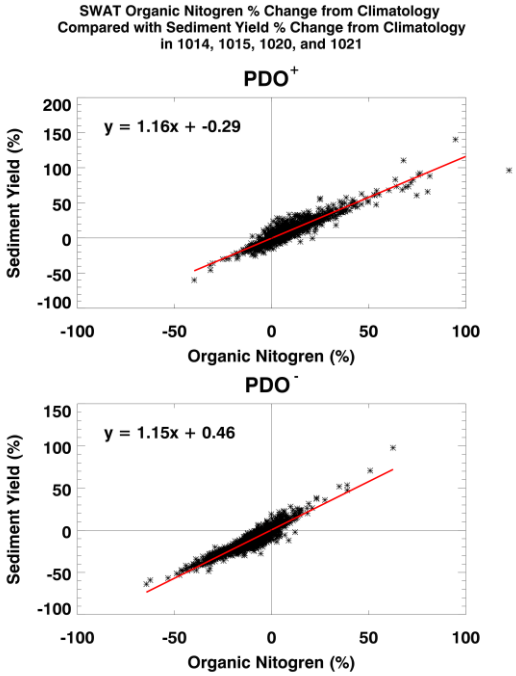


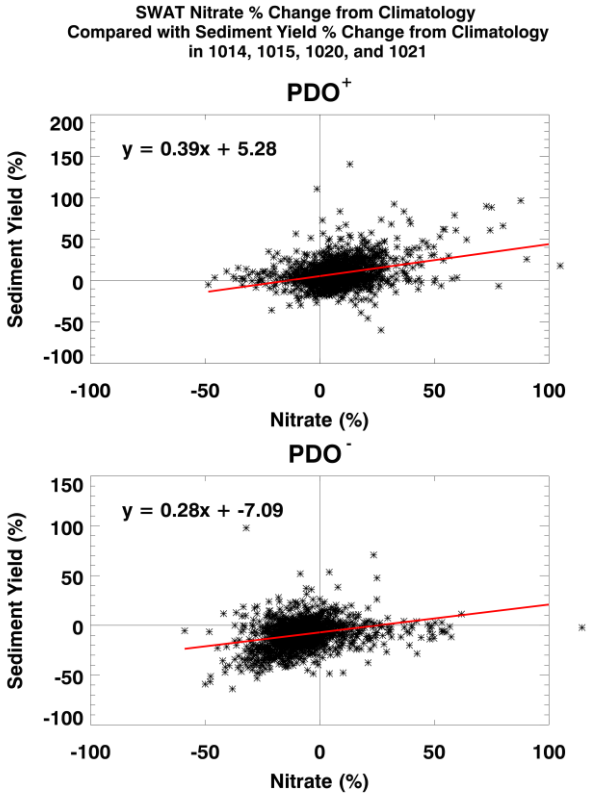
Sediment



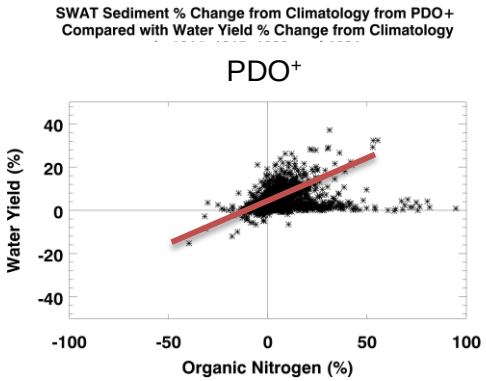
amita.v.mehta@nasa.gov

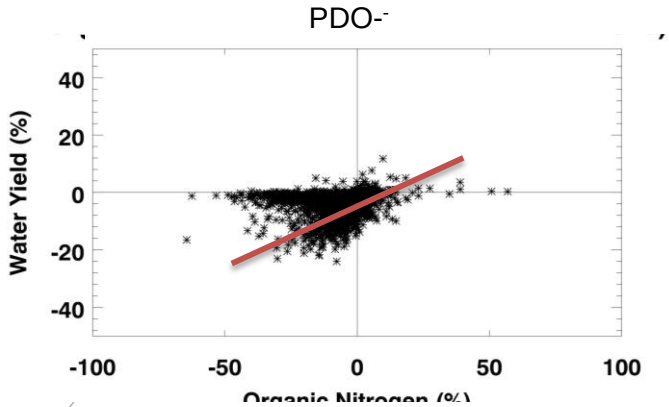
SWAT-Simulated DCV of N and P Associated with PDO

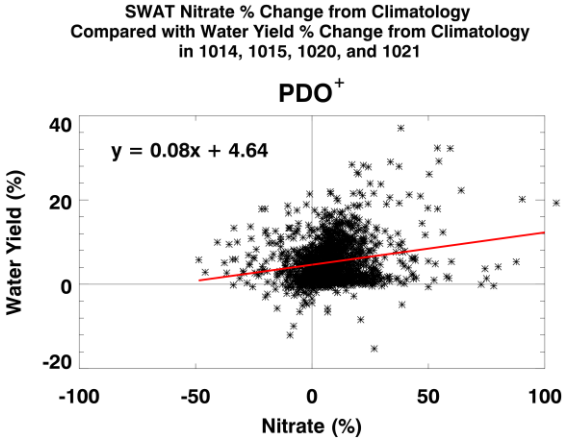


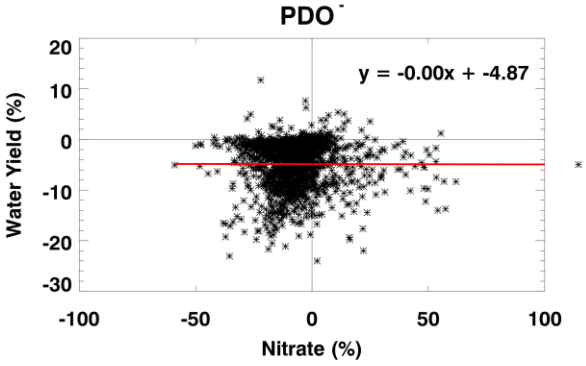


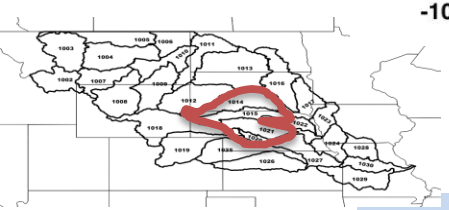
SWAT-Simulated DCV of N and P Associated with PDO











Summary

Many SWAT-based studies focus on nutrient transport and water quality issues, the present study focuses on sensitivity of nutrient transports associated with natural DCV over such a large river basin

Mean N and P transports are much larger in the lower MRB where water yields and sediment output are also large

Decadal variability of N and P is primarily influenced by PDO phases and show spatially coherent variability in Nebraska and South Dakota – 40-60% change from PDO^+ to PDO^-

Larger variability is found in organic N and P components and appear to be related primarily to sediment variability -- positive (negative) anomaly during PDO^+ (PDO^-)

On-going Analysis

- Detailed analysis of: i) land use and crop simulations and ii) water stress and nutrient stress
- Focus on upper and middle MRB to understand spatial pattern of DCV variability

Thank You!