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Nitrate in the Mississippi River and Its Tributaries, 1980 to 2008: Are We Making Progress?

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Supporting Information

ABSTRACT: Changes in nitrate concentration and flux between 1980 and 2008 at eight sites in the Mississippi River basin were determined using a new statistical method that accommodates evolving nitrate behavior over time and produces flow-normalized estimates of nitrate concentration and flux that are independent of random variations in streamflow. The results show that little consistent progress has been made in reducing riverine nitrate since 1980, and that flow-normalized concentration and flux are increasing in some areas. Flow-normalized nitrate concentration and flux increased between 9 and 76% at four sites on the Mississippi River and a tributary site on the Missouri River, but changed very little at tributary sites on the Ohio, Iowa, and Illinois Rivers. Increases in flow-normalized concentration and flux at the Mississippi River at Clinton and Missouri River at Hermann were more than three times larger than at any other site. The increases at these two sites contributed much of the 9% increase in flow-normalized nitrate flux leaving the Mississippi River basin. At most sites, concentrations increased more at low and moderate streamflows than at high streamflows, suggesting that increasing groundwater concentrations are having an effect on river concentrations.

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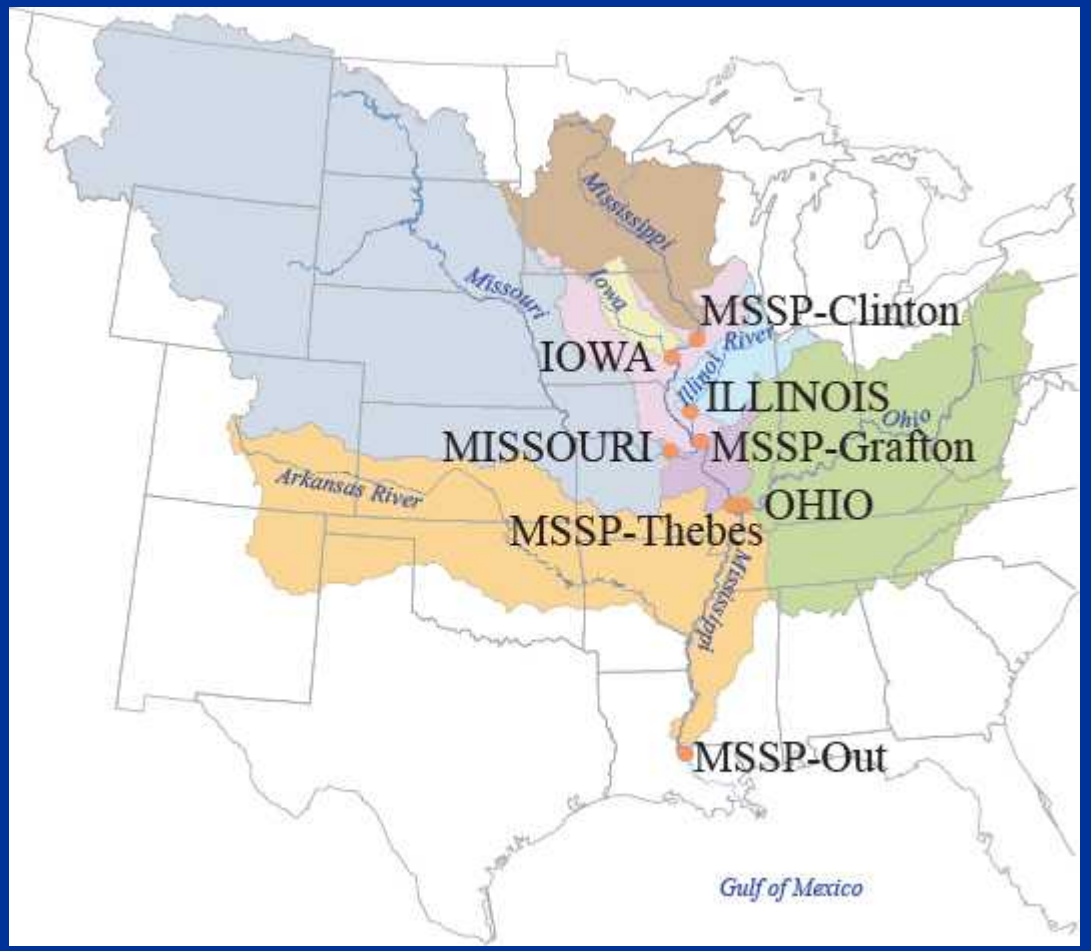
Applies WRTDS to nitrate data from 8 sites on the mainstem and tributaries: 3,368 chemical measurements, 110,732 daily streamflow values, 29 years.

USGS

Mississippi River Basin study

Data requirements

- Sample size > 200
- Record length > 20 yr
- Complete flow record
- Data censoring <1%
- Data gaps < 4 years



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Flow-normalized flux

Net change 1980-2008

Site	Total annual flow-normalized yield (flux per unit area) in 1980 ($kg/km^2/yr$)
MSSP-Clinton	297
IOWA	1,813
ILLINOIS	1,433
MSSP-Grafton	751
MISSOURI	67
MSSP-Thebes	257
OHIO	590
MSSP-Out	278

USGS

Flow-normalized flux

Net change 1980-2008

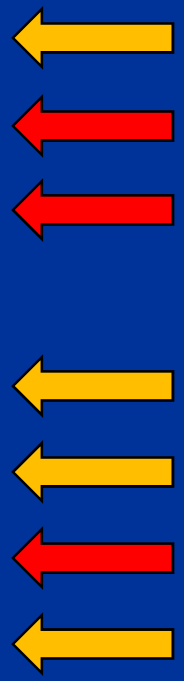
Site	Total annual flow-normalized yield (flux per unit area) in 1980 ($kg/km^2/yr$)	Net change, 1980-2008 (%)
MSSP-Clinton	297	67
IOWA	1,813	-3
ILLINOIS	1,433	-1
MSSP-Grafton	751	14
MISSOURI	67	57
MSSP-Thebes	257	9
OHIO	590	-1
MSSP-Out	278	9

USGS

Flow-normalized flux

Comparison of rates of change 1980-2000 and 2000-2008

Site	Rate of change, in %/yr	
	1980-2000	2000-2008
MSSP-Clinton	1.4	3.7
IOWA	0.1	-0.6
ILLINOIS	0.7	-1.7
MSSP-Grafton	0.5	0.4
MISSOURI	1.0	3.9
MSSP-Thebes	0.1	0.9
OHIO	0.1	-0.3
MSSP-Out	0.2	0.5



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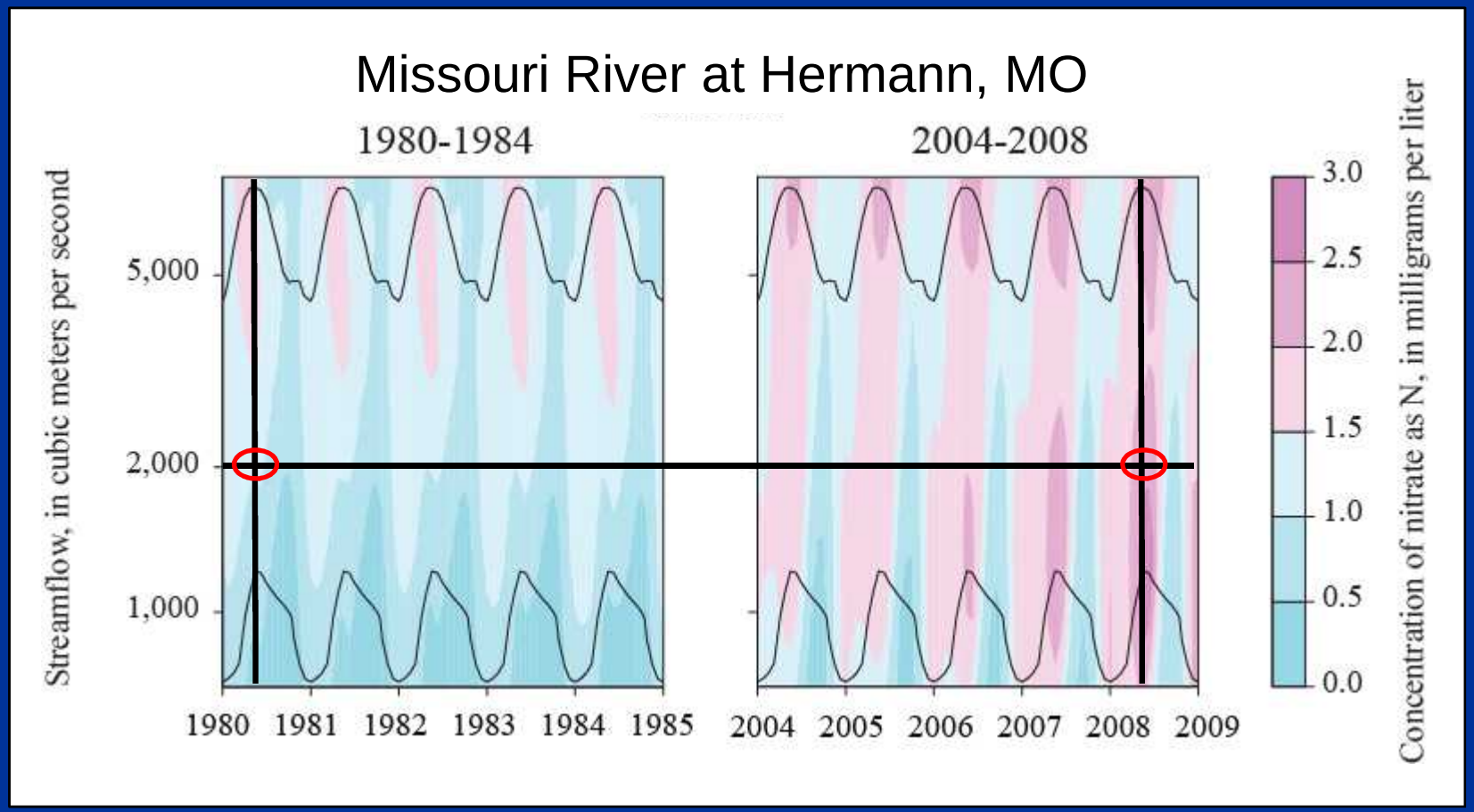
Expected concentration

by streamflow and season



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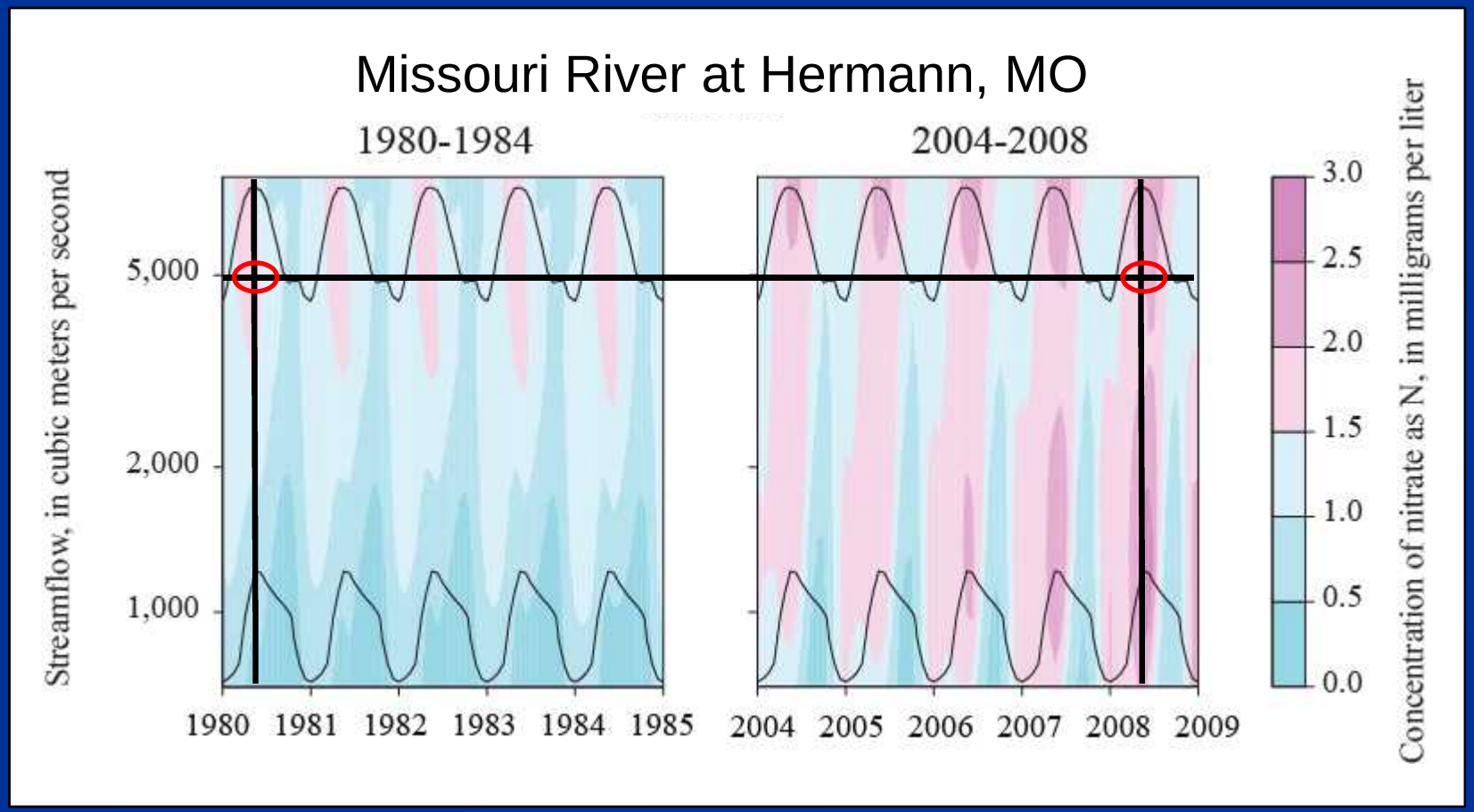
Expected concentration

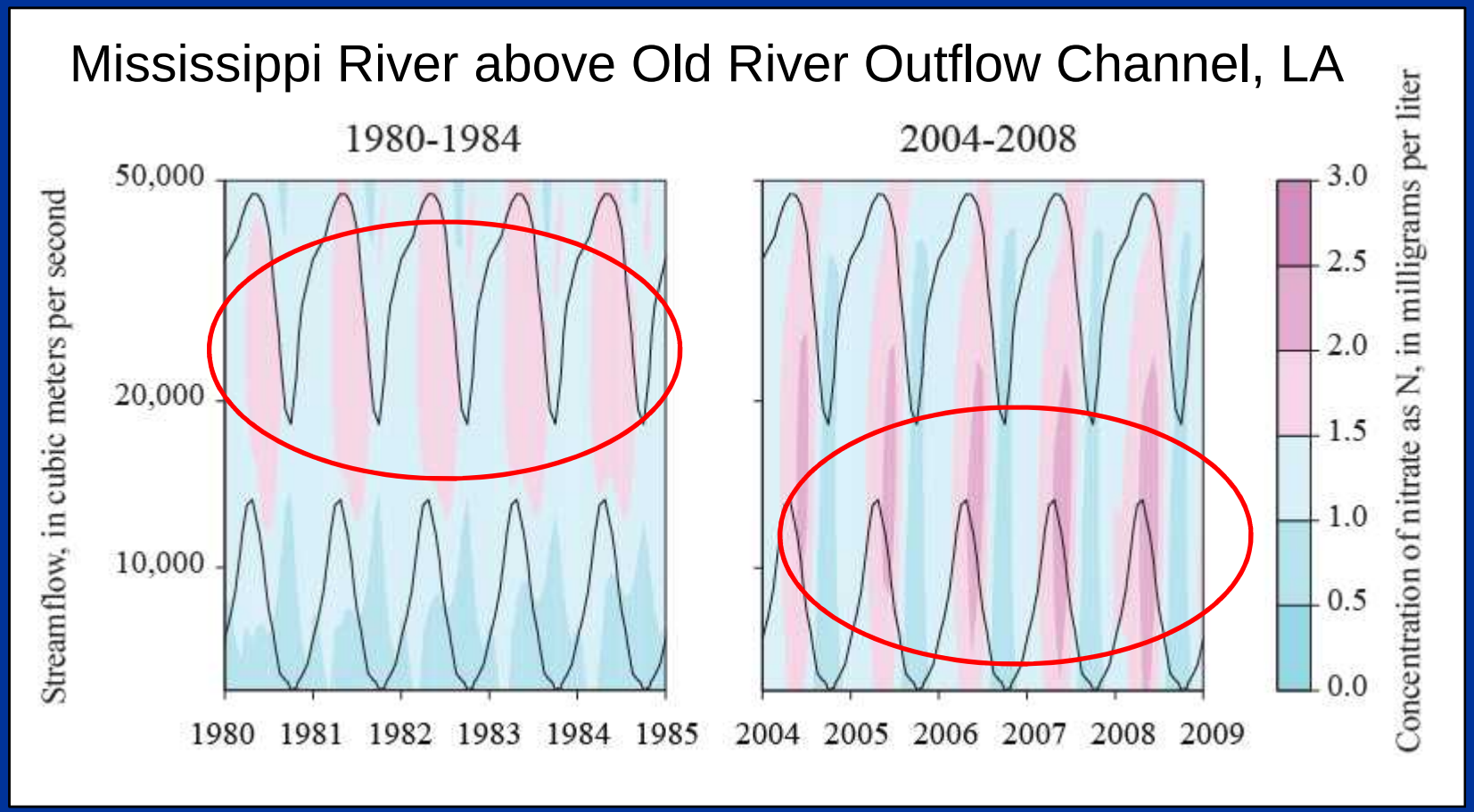
by streamflow and season



USGS

Expected concentration

by streamflow and season



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Conclusions

1. **Flow-normalized concentration and flux of nitrate increased at MISSOURI and the mainstem sites since 1980. No substantial decreases at any other sites.**

   - ***Increases at MISSOURI and MSSP-Clinton were over three times larger than at any other site***

2. **Concentrations decreased in the spring at high flows at MSSP-Thebes, OHIO, and MSSP-Out.**

   - ***Some progress has been made in reducing nitrate transport in spring runoff***

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Conclusions

3. **At MSSP-Out, the highest concentrations occurred at high flows in 1980 but at low to moderate flows in 2008.**

   - ***Flux during high flow years has been declining but it has been increasing during low flow years***

4. **Increases in concentration at low to moderate flows were greater than or comparable to changes at high flows.**

   - ***Increasing nitrate concentrations in groundwater may be having an effect on river concentrations***

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