Improving estimates of phosphorus loads from tile-drained landscapes using Kriging techniques

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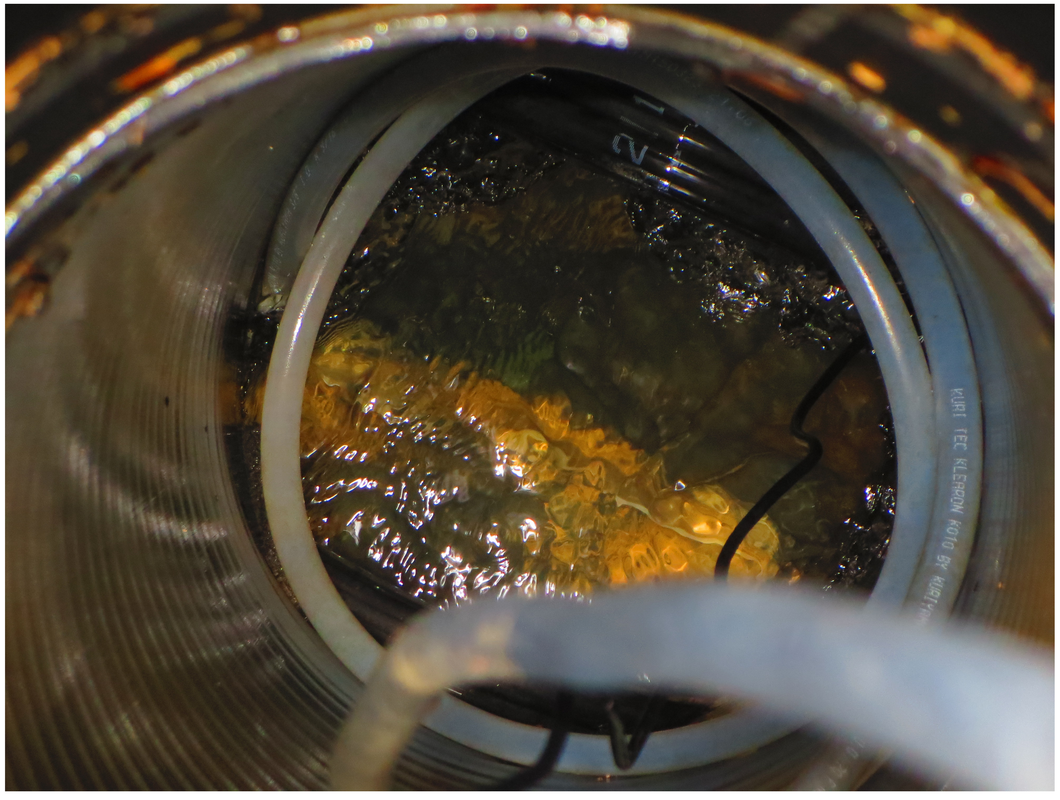
Introduction

Excessive transport of phosphorus from agricultural lands to downstream water bodies and lakes has led to the proliferation of algal blooms in the Great Lakes region.

Introduction

Efficient modelling and management of phosphorus transport needs accurate assessment of the amount and timing of phosphorus loads in surface runoff and subsurface tile drainage.



Objectives

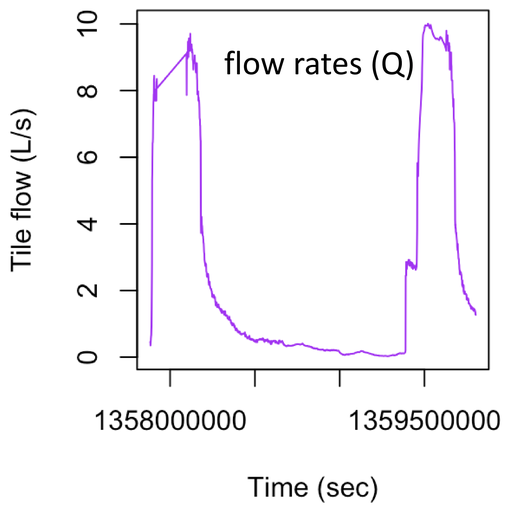
- Use novel interpolation technique to more precisely estimate dissolved and total phosphorus concentrations and loads in continuous time-series data for surface runoff and tile drainage from farmlands

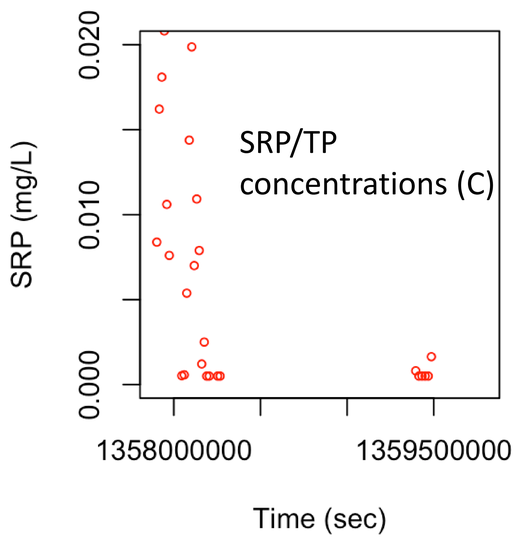
- Assess total and temporal uncertainties in the estimated phosphorus loads

Previous Work on Interpolation

- Period/Time Weighted Means(PWMC/TWMC) (Preston et al., 1989)
- Flow weighted Means (FWMC)
- Interpolation of flow and/or concentrations (Phillips et al., 1999; Williams et al., 2015)
- Regression between flow and concentrations (Walker, 1999; Hirsch, 2014)
- Composite method (Huntington et al., 1994; Appling et al., 2015)
  - Regression (Deterministic)
  - Interpolation (Stochastic)

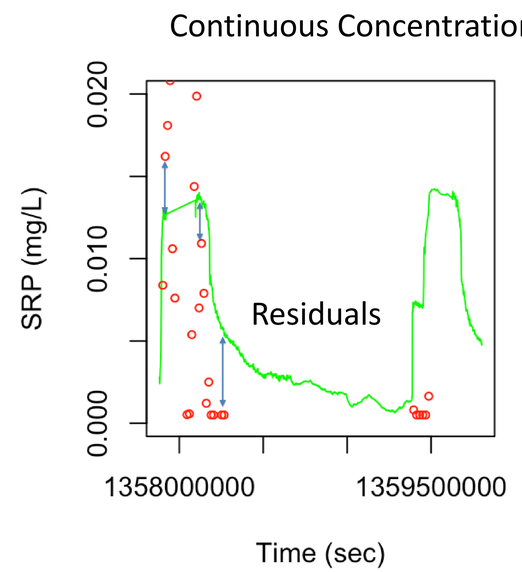
Calculation steps





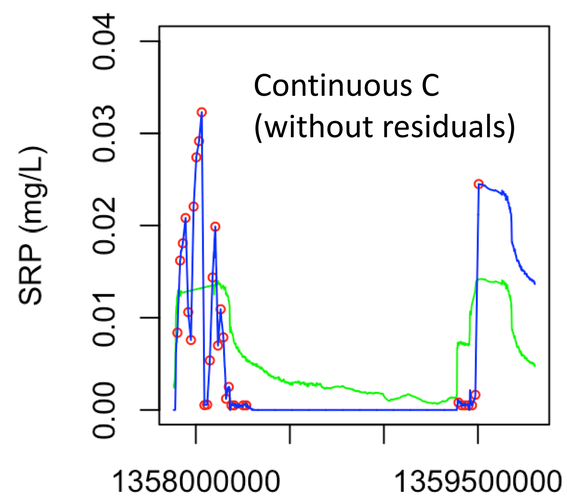
Linear log-log relationship between Q and C

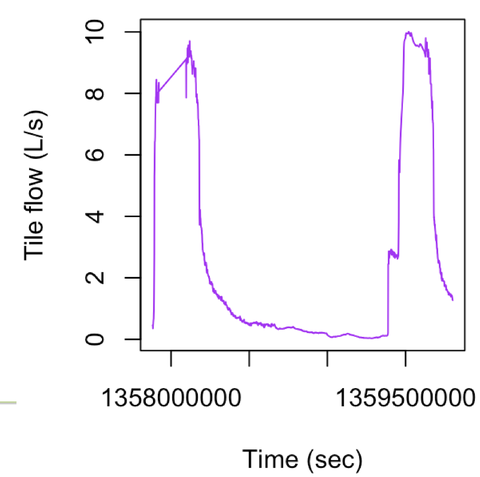
Deterministic

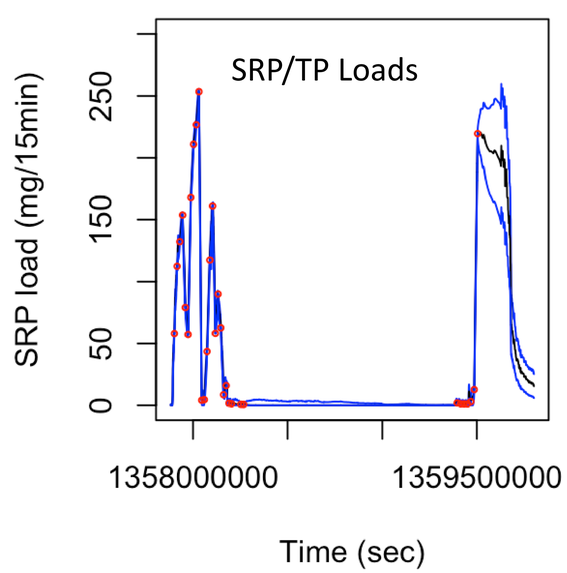


Stochastic

Interpolating the residuals by Kriging

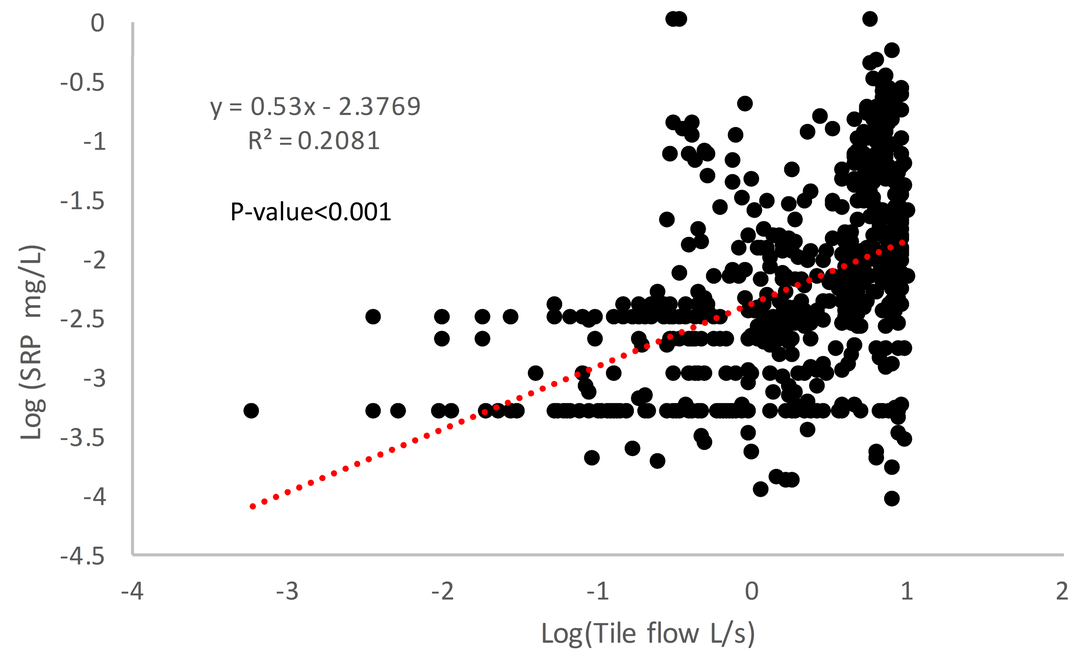


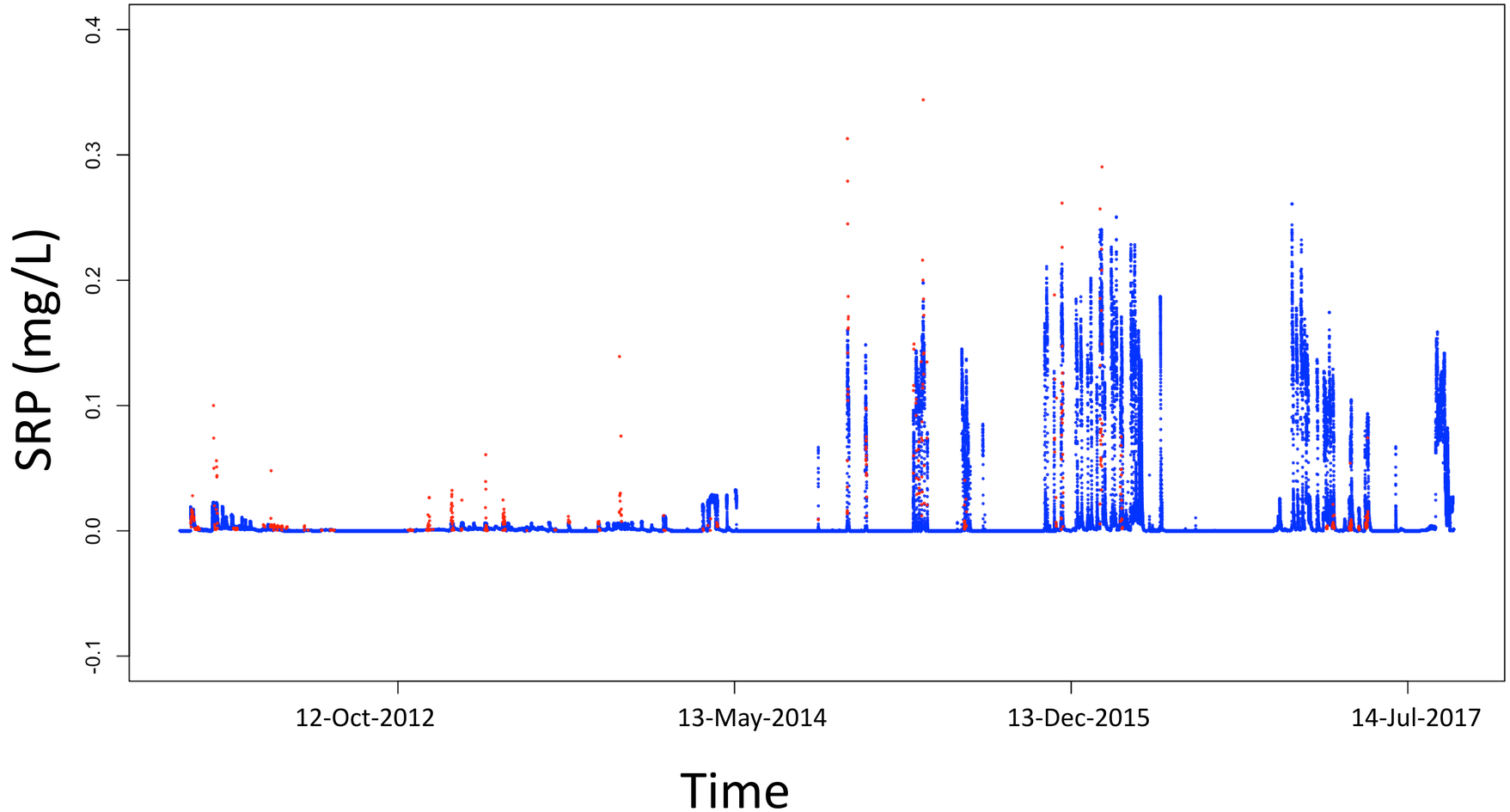




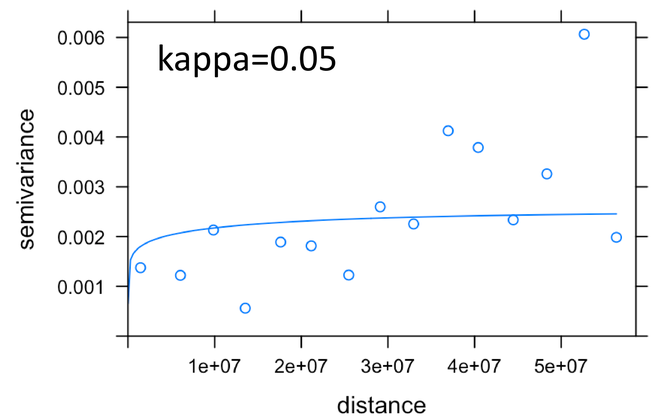
Log-Log linear relationships between flow and SRP

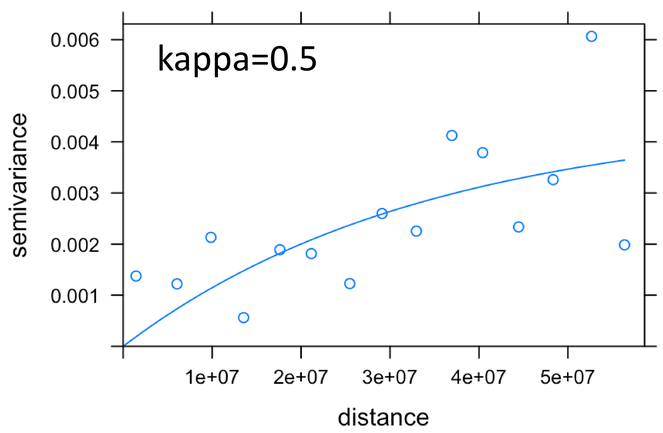
In 50% of cases at our study sites, the p-values are less than 0.005

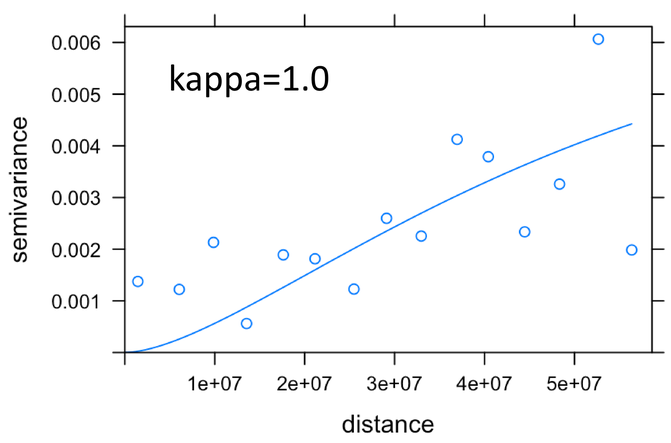


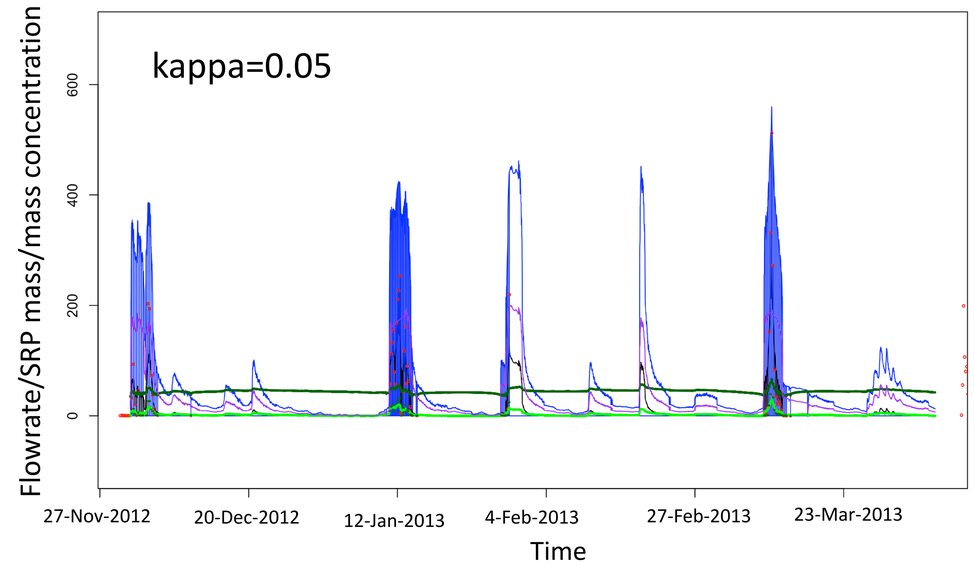


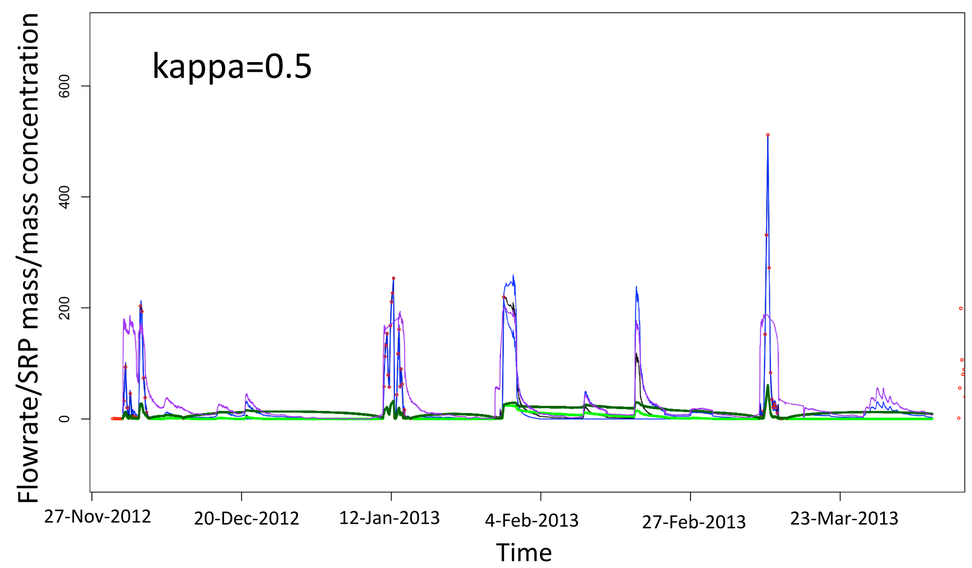
Interpolation of SRP residuals by kriging

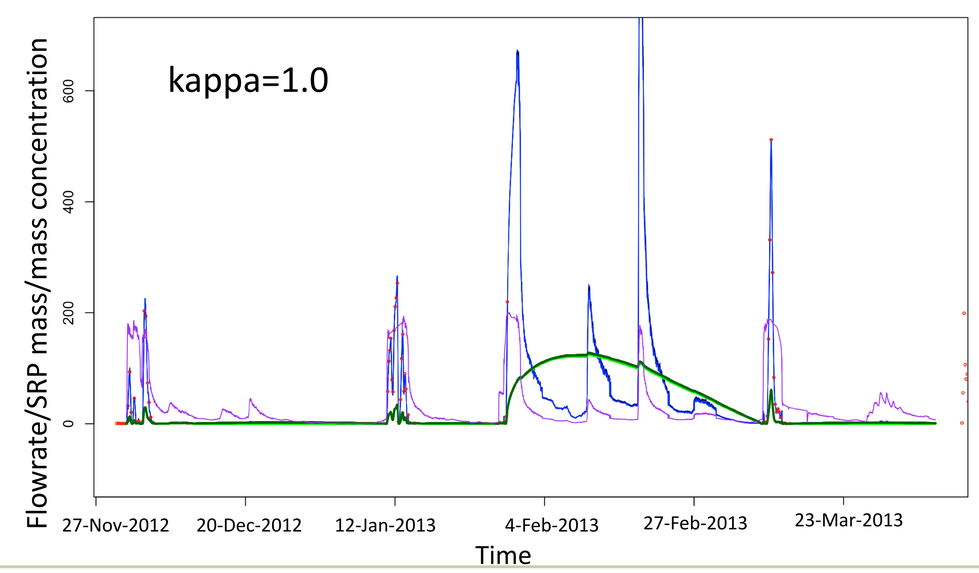


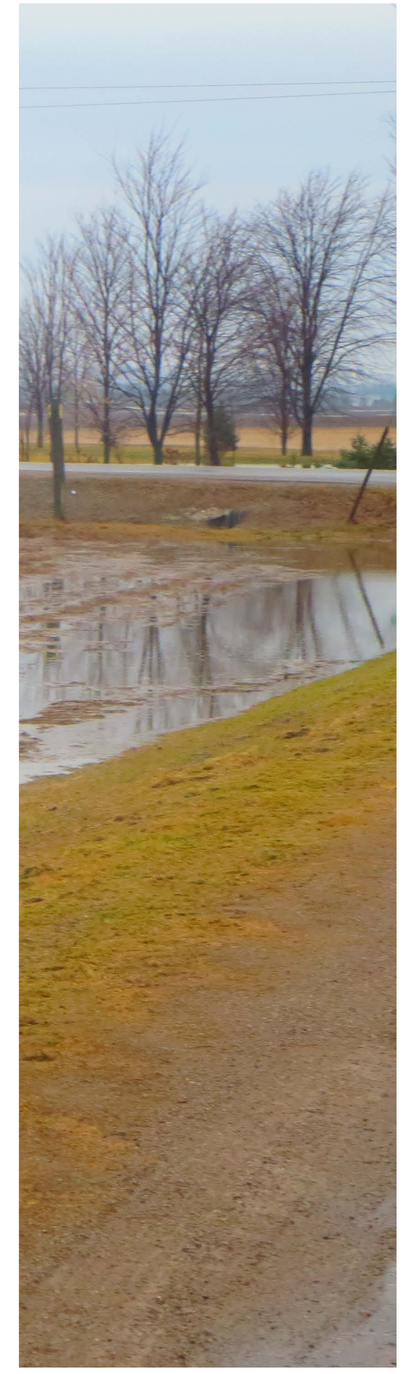




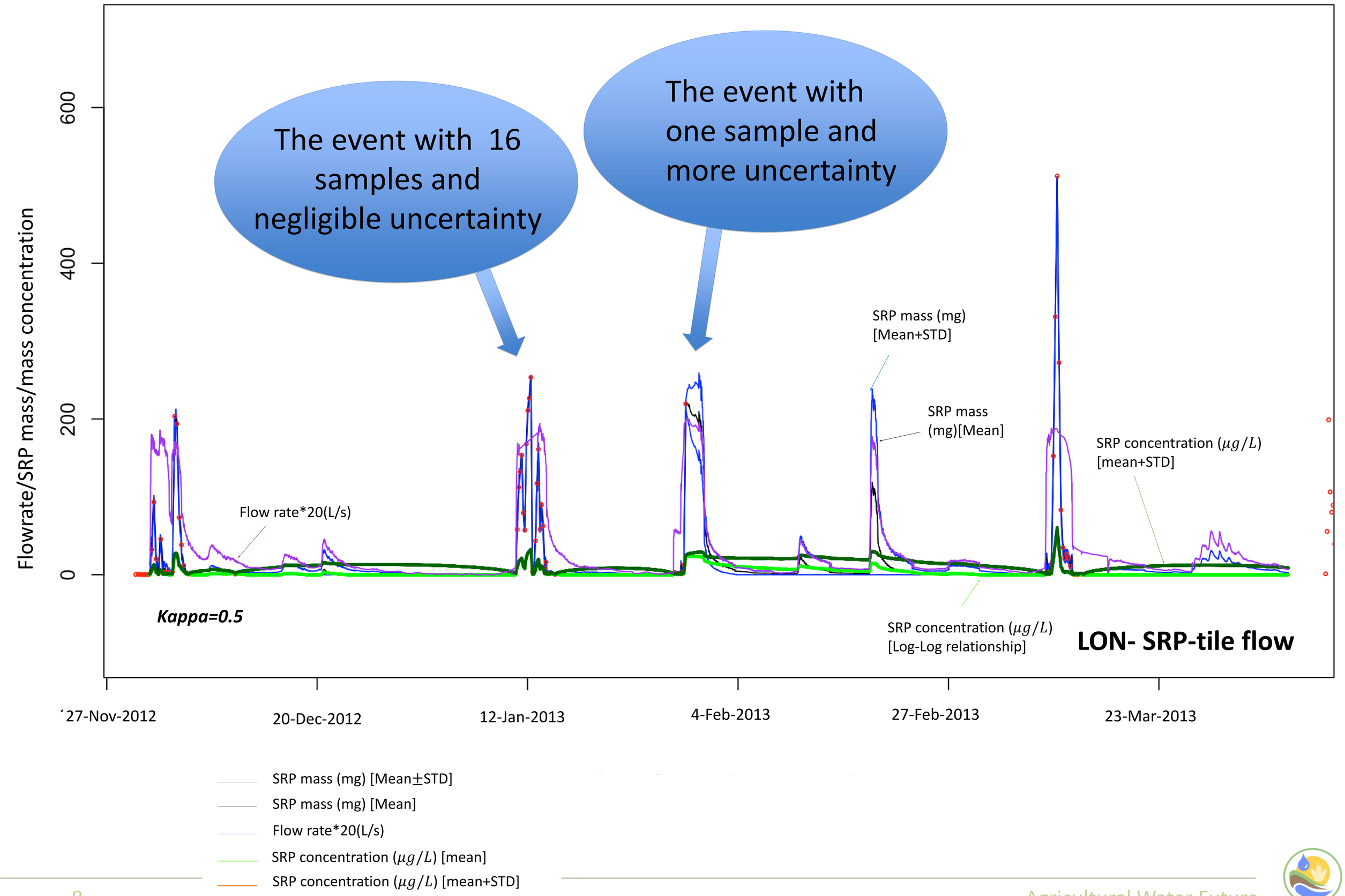








SRP mass (mg) [Mean±STD]
SRP mass (mg) [Mean]
Flow rate*20(L/s)
SRP concentration ($\mu g/L$) [mean]
SRP concentration ($\mu g/L$) [mean+STD]

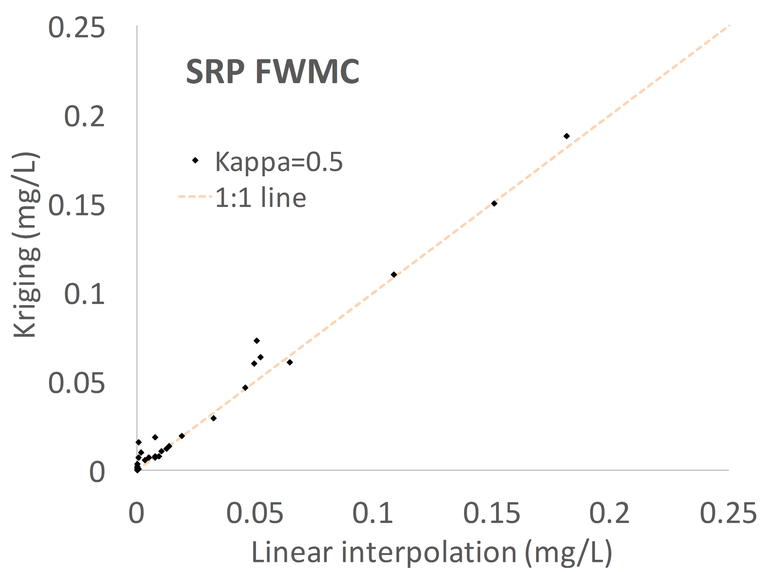

The event with 16 samples and negligible uncertainty
The event with one sample and more uncertainty
Flowrate/SRP mass/mass concentration
0
200
400
600
SRP mass (mg) [Mean+STD]
SRP mass (mg)[Mean]
SRP concentration ($\mu g/L$) [mean+STD]
Flow rate*20(L/s)
Kappa=0.5
SRP concentration ($\mu g/L$) [Log-Log relationship]
LON- SRP-tile flow
´27-Nov-2012
20-Dec-2012
12-Jan-2013
4-Feb-2013
27-Feb-2013
23-Mar-2013
SRP mass (mg) [Mean±STD]
SRP mass (mg) [Mean]
Flow rate*20(L/s)
SRP concentration ($\mu g/L$) [mean]
SRP concentration ($\mu g/L$) [mean+STD]

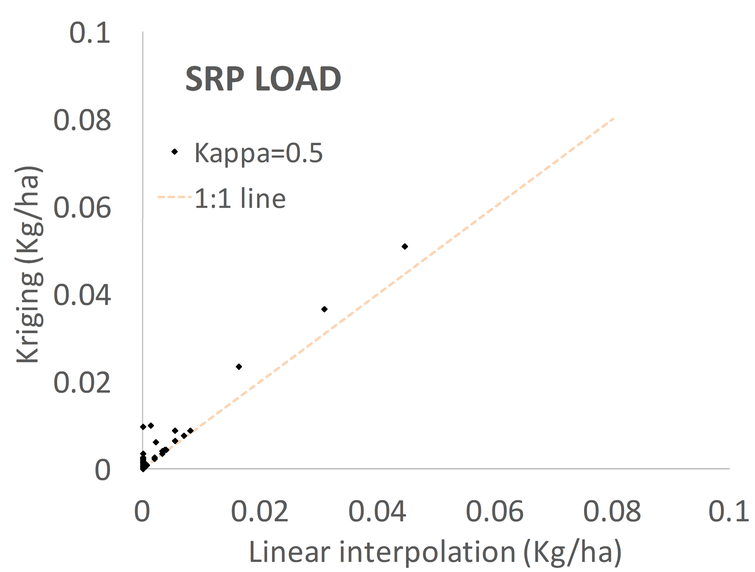
Comparison of Concentration Data Estimated Using Kriging and Linear Interpolation

FWMC

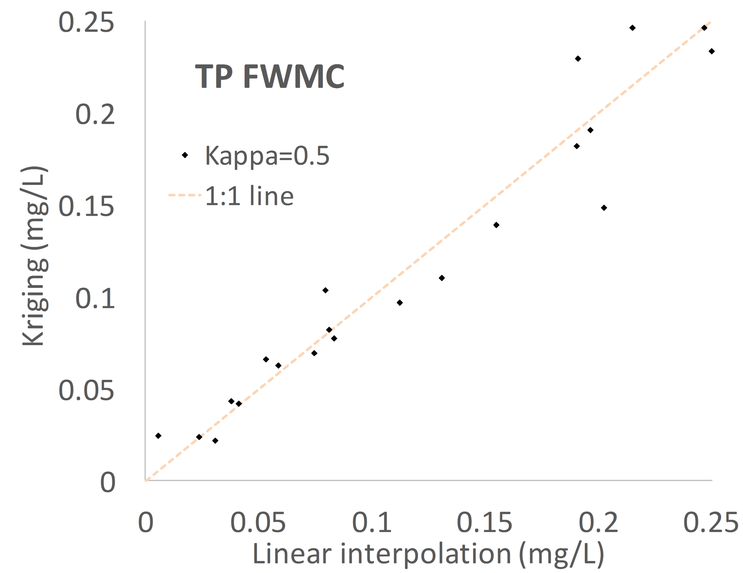
Load

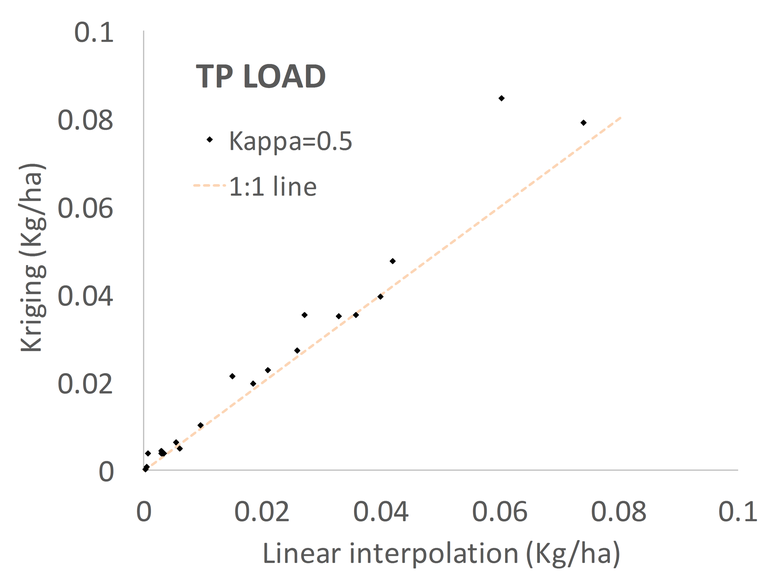
SRP





TP





Conclusion

- The Kriging method can help us to more precisely interpolate phosphorus loads and the uncertainties associated with these estimates when missing data are gap filled to generate load estimates

- Between 2011-2017, across our sites:
  - SRP (FWMC=0.11 $\begin{bmatrix} +0.07 \\ -0.06 \end{bmatrix}$ mg/L, Load= 0.62 $\begin{bmatrix} +0.41 \\ -0.34 \end{bmatrix}$ kg/ha),
  - TP (FWMC = 0.28 $\begin{bmatrix} +0.18 \\ -0.13 \end{bmatrix}$ mg/L, Load= 2.1 $\begin{bmatrix} +1.30 \\ -1.07 \end{bmatrix}$ kg/ha).

- The uncertainties in estimates depend on the degree of fit in the regression (linear Log-Log) function between P concentrations and flows. [For example, p-value<0.001 resulted in ~30% uncertainty (standard deviation)].

Acknowledgements

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