Controls on greenhouse gas production in streams across a land use gradient

NEW HAMPSHIRE Water Quality Analysis Lab

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Background

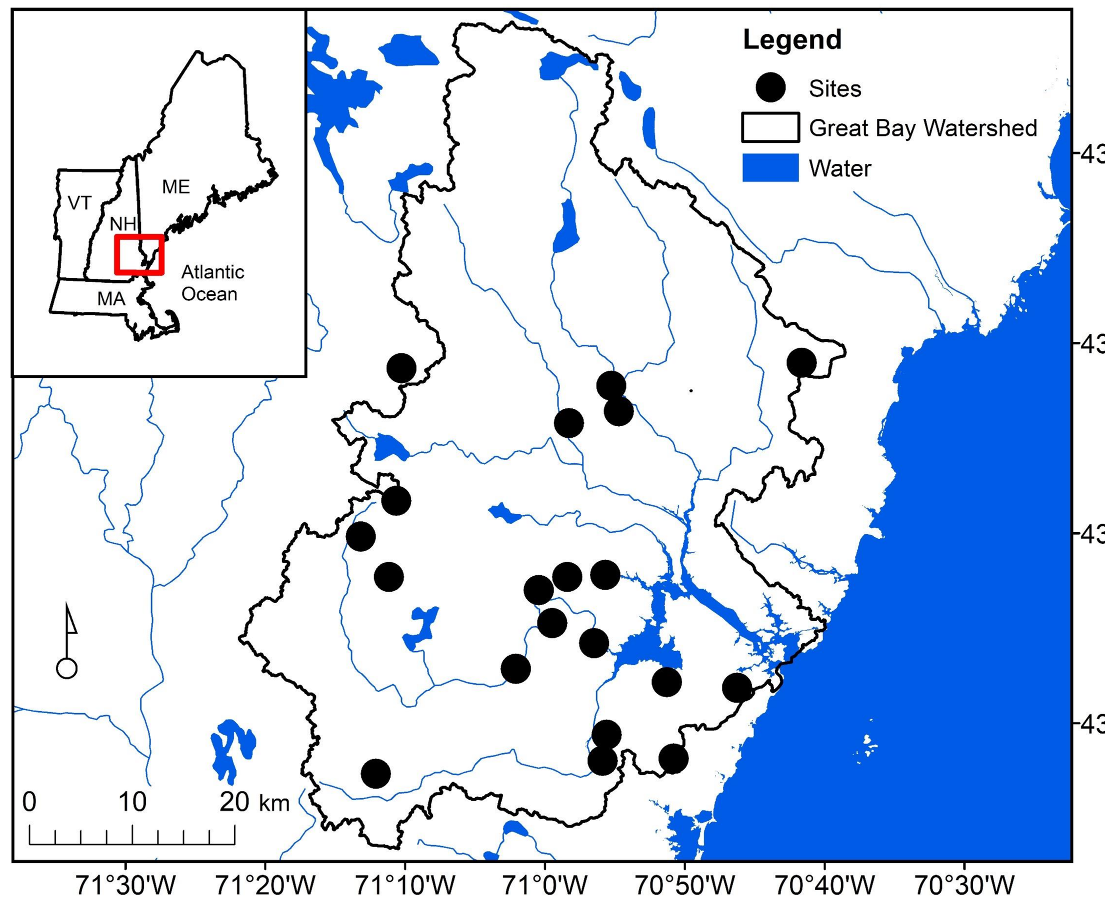
- Fluvial ecosystems can be quantitatively significant sources of CH_4 and N_2O
- Collective emissions may offset terrestrial carbon sink
- Considerable uncertainty remains in regional and global estimates of greenhouse gas (GHG) emissions from streams
- Controls on GHG concentrations (water chemistry, sediment characteristics) are poorly understood

- **What controls spatial and temporal variability in CH_4 and N_2O across streams of varying land use?**

Methods

Monthly sampling at 20 sites

- Surface water
  - DOC, TDN, NO_3^-, NH_4^+, PO_4^{3-}, cations & anions
- Dissolved gas
  - CH_4, N_2O



Results

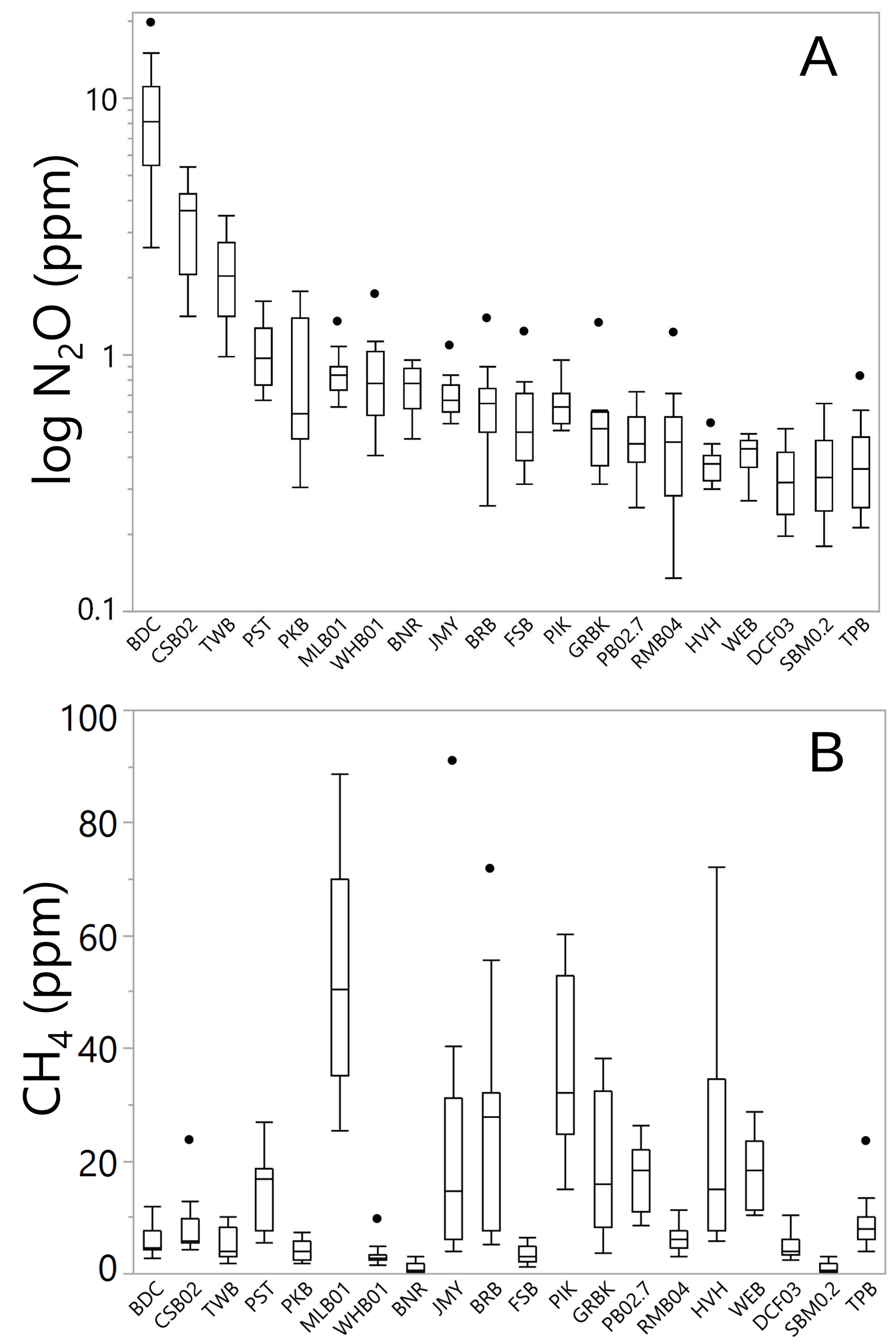


Figure 1. Boxplot panels represent N_2O (A) and CH_4 (B) concentrations across 12 months at 20 sites. Ordered by decreasing N_2O concentration.

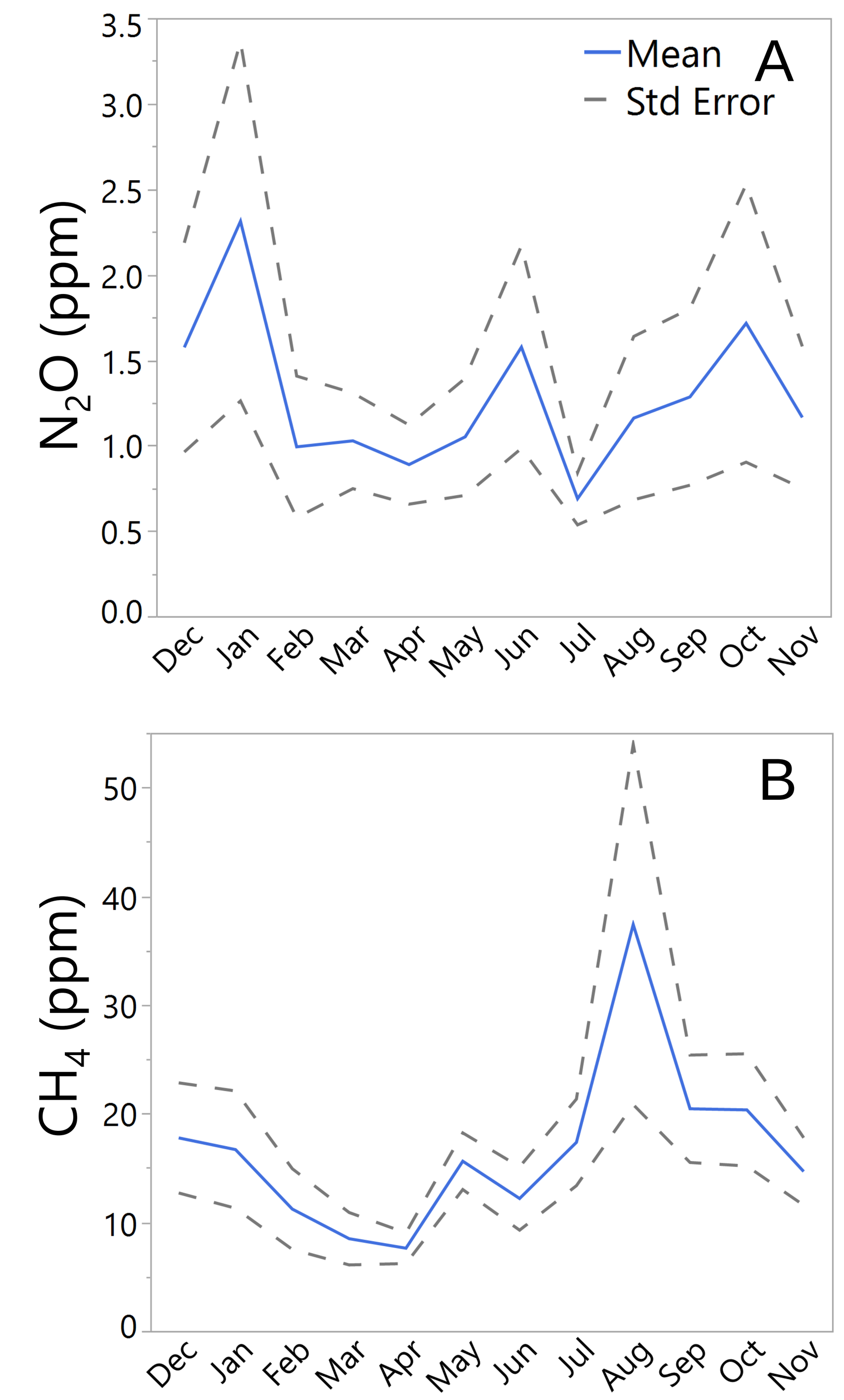


Figure 2. Mean N_2O (A) and CH_4 (B) concentrations across 20 sites over time. The dashed line represents standard error.

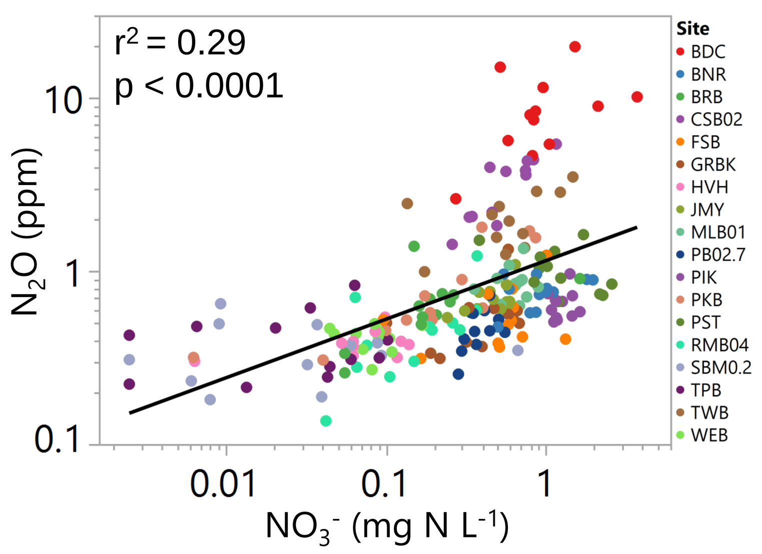


Figure 3. Linear regression between N_2O and NO_3^- concentrations across sites.

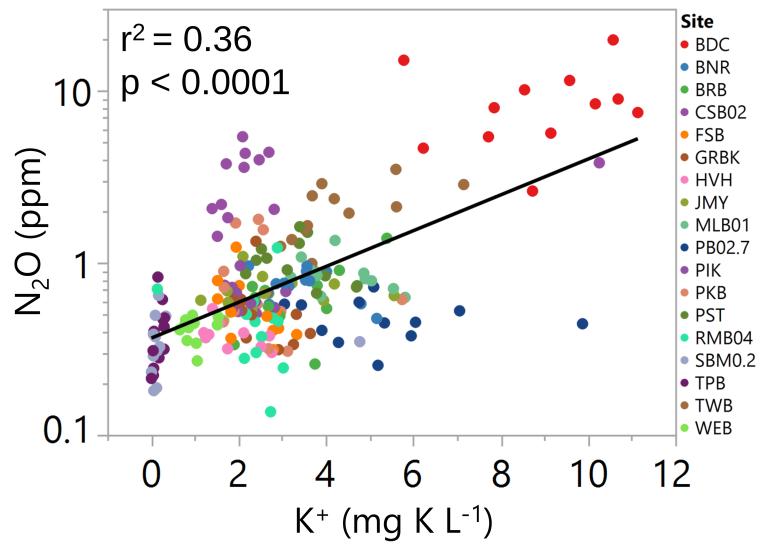
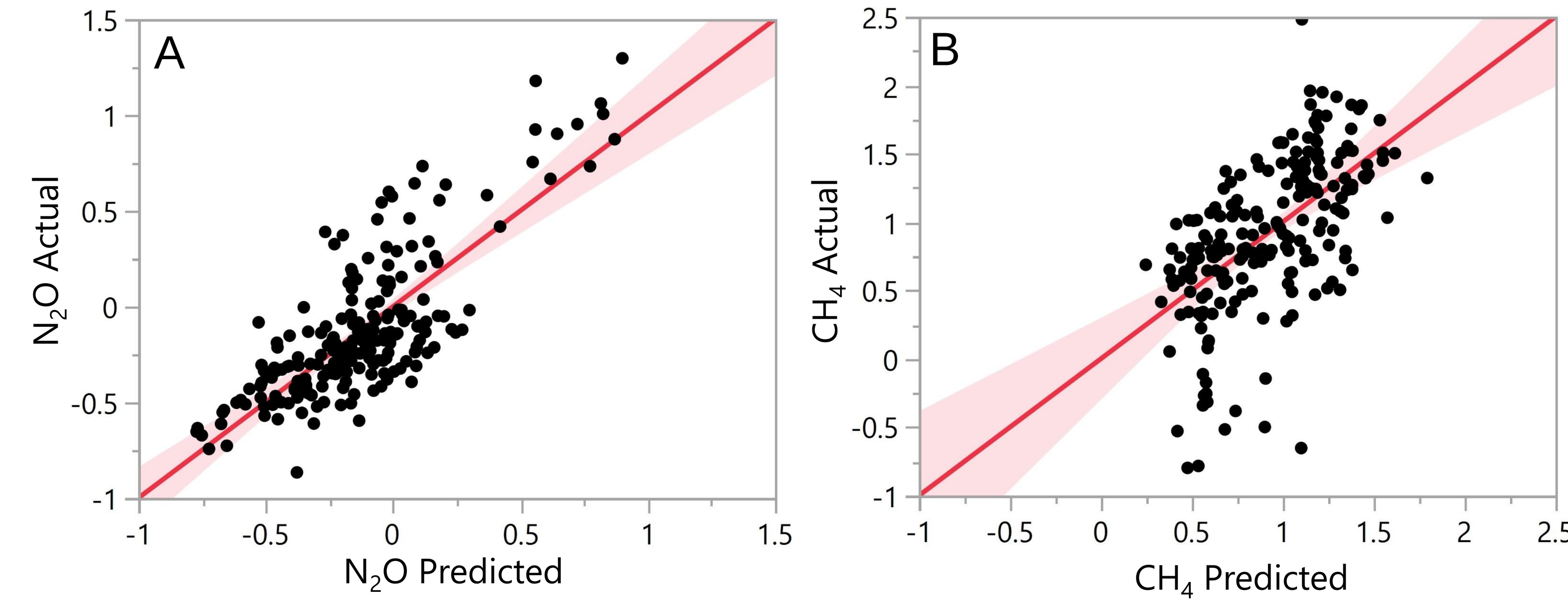


Figure 4. Linear regression between N_2O and K^+ concentrations across sites.

Table 1. Variable importance on projection (VIP) scores (≥ 0.8) of predictor variables in methane (CH_4) and nitrous oxide (N_2O) partial least squares (PLS) models. Higher VIP scores represent a greater influence on the model.

Predictor	CH_4	N_2O
% Agriculture	**1.96***	**1.87***
Spec Cond	**1.73***	—
% Developed	**1.68***	0.93
DO	**1.50***	—
NH_4^+	**1.15***	1.00
NO_3^-	1.09	**1.63***
Temp	1.08	**1.19***
FI	1.06	—
SO_4^{2-}	1.00	0.94
% C	0.92	0.81
% Wetland	0.86	—
DON	0.80	0.89
% Forest	—	1.11
PO_4^{3-}	—	**1.38***
K^+	—	**1.59***
C:N	—	1.04
% N	—	0.91

***Asterisk** denotes top five VIPs for each model (see Figure 5).



Predictor	β	p value
% Agriculture	0.41	< 0.0001
K^+ (mg K L^{-1})	0.26	0.0012
NO_3^- (mg L^{-1})	0.24	< 0.0001
Temp (ºC)	-0.26	< 0.0001
PO_4^{3-} (mg P L^{-1})	NS	NS
Overall model fit: $R^2 = 0.63$, $p < 0.0001$		

Predictor	β	p value
NH_4^+ (µg N L^{-1})	0.30	< 0.0001
% Agriculture	-0.25	0.0003
DO	-0.19	0.0010
% Developed	NS	NS
Spec Cond	NS	NS
Overall model fit: $R^2 = 0.35$, $p < 0.0001$		

Figure 5. Plots of log actual vs. log predicted N_2O (A) and CH_4 (B) concentrations using multiple linear regression models with the top five predictors identified through PLS (Table 1). Tables show predictors and corresponding β values which provide a measure of how strongly each predictor influences the model.

Conclusions

- Differences in seasonal and spatial patterns of CH_4 and N_2O concentrations
- Variability of CH_4 concentrations unexplained by a single predictor variable
- N_2O driven by elevated NO_3^- and K^+ concentrations
- N_2O concentrations more predictable than CH_4
- Primary drivers differ between CH_4 and N_2O concentrations
  - Agriculture is an influential driver for both CH_4 and N_2O, but effects are in opposite directions for the two GHGs

Acknowledgements

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