Supplements for
Spatio-temporal controls of C-N-P dynamics across headwater catchments of a temperate agricultural region from public data analysis

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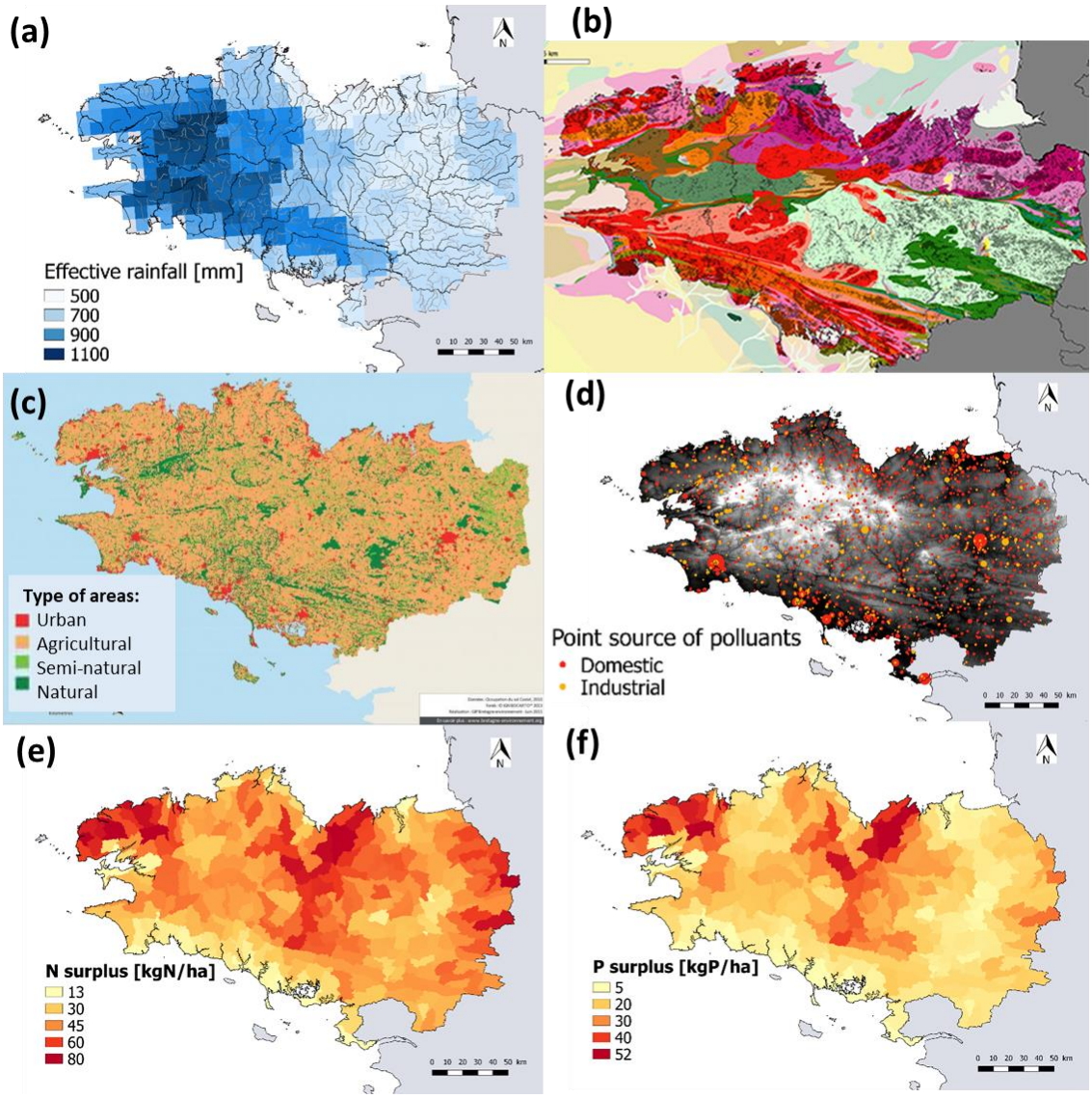

15 **Figure S1. General characteristics of the Brittany region: (a) effective rainfall (SAFRAN database 2010), (b) geology (Sols de Bretagne database), (c) land use (OSO database), (d) nitrogen (N) and phosphorus (P) point sources (Agence de l'Eau Loire Bretagne database), (e) N surplus (NOPOLU model 2010), and (f) P surplus (NOPOLU model 2010).**

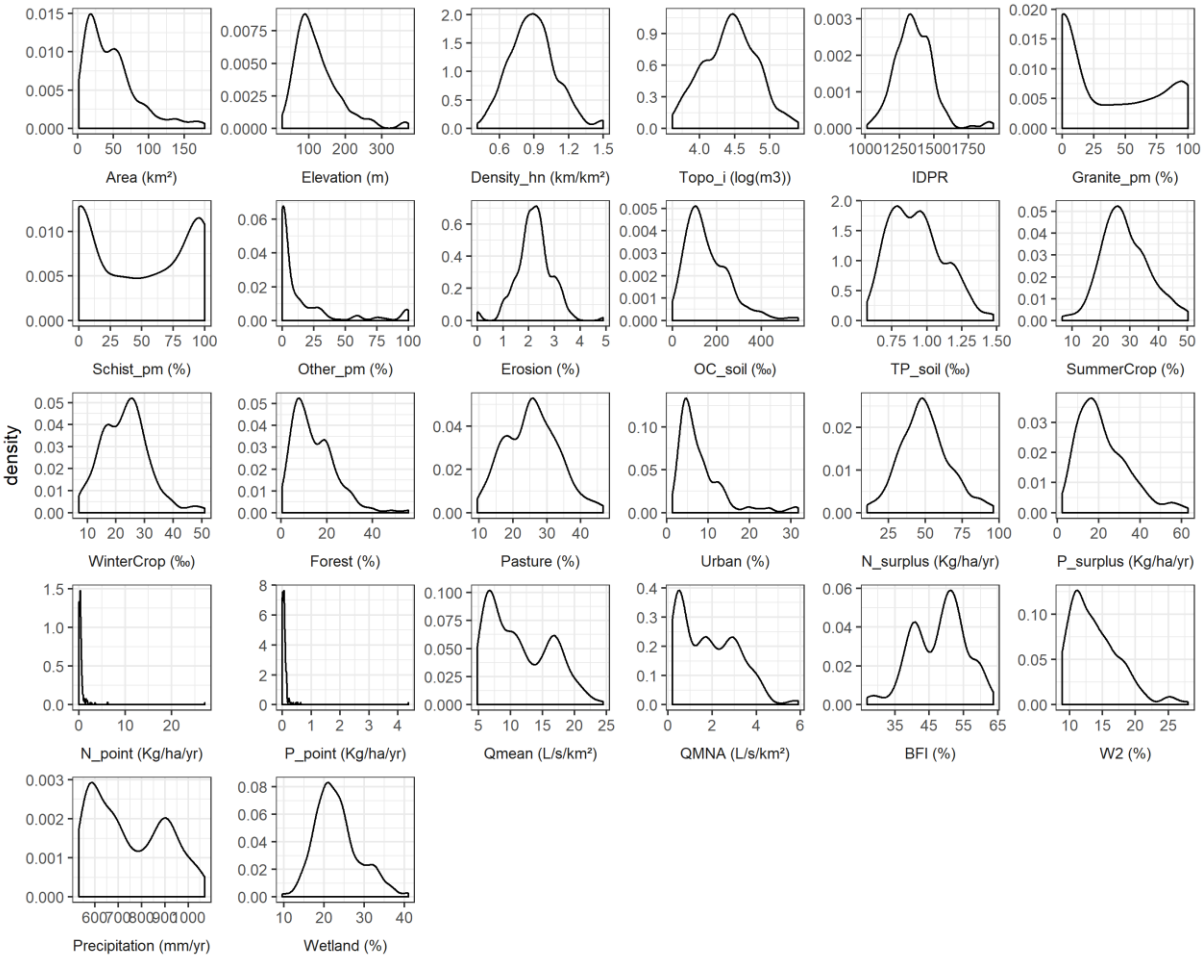

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Figure S2. Density histograms of each catchment descriptor. See Table 1 for definitions, units, and sources.

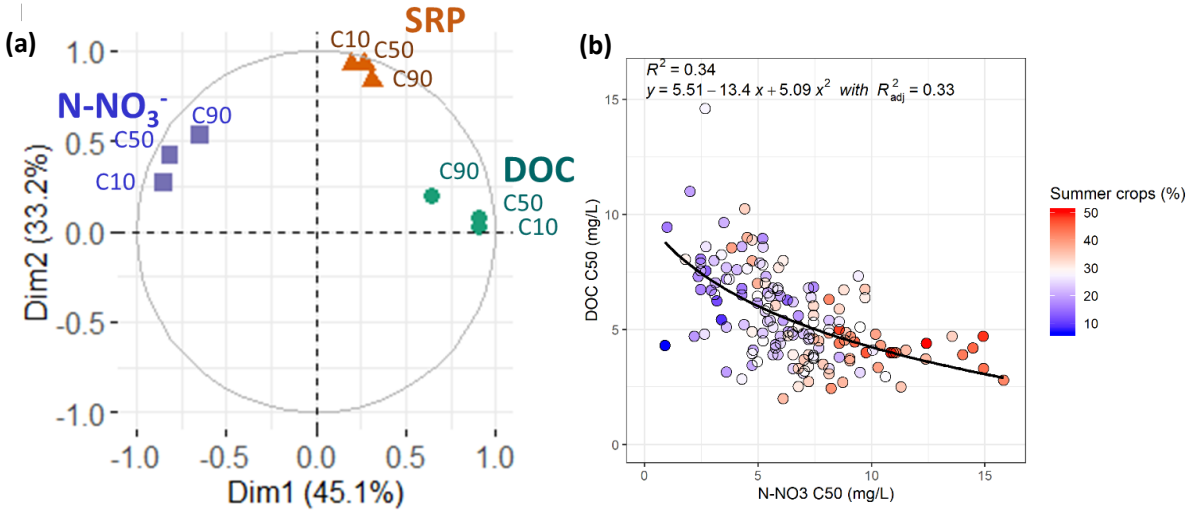


Figure S3. (a) Principal component analysis of 10th, 50th, and 90th percentiles (C10, C50 and C90) of nitrate (N-NO_3), dissolved organic carbon (DOC), and soluble reactive phosphorus (SRP) concentrations for the 185 headwater catchments analyzed; (b) Correlation between the medians (C50) of DOC and N-NO_3 concentrations for the 159 catchments in which DOC and NO_3 were monitored from 2007-2017. The color gradient indicates the percentage of catchment area covered by summer crops.

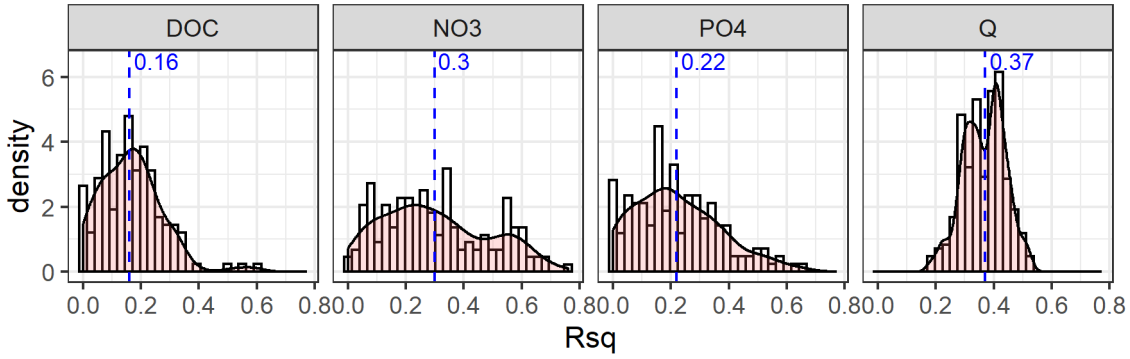
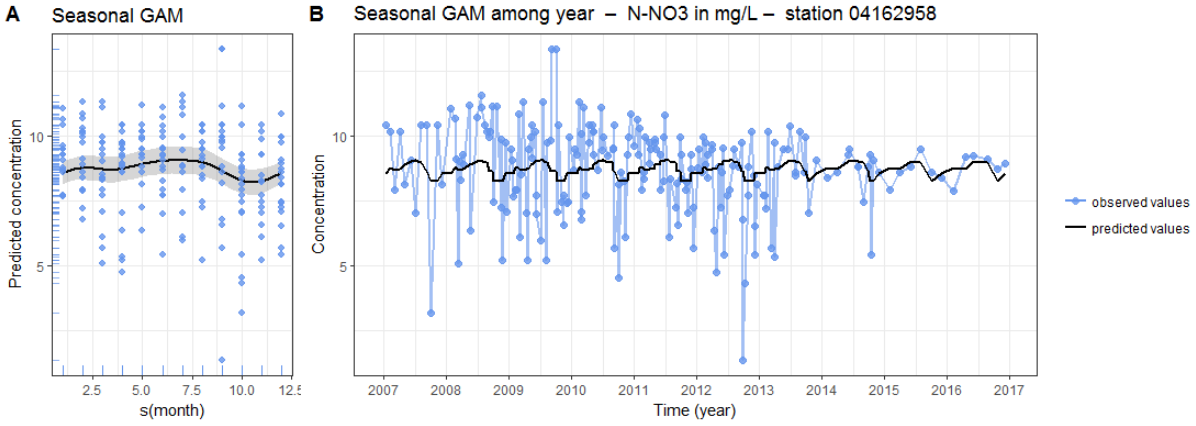
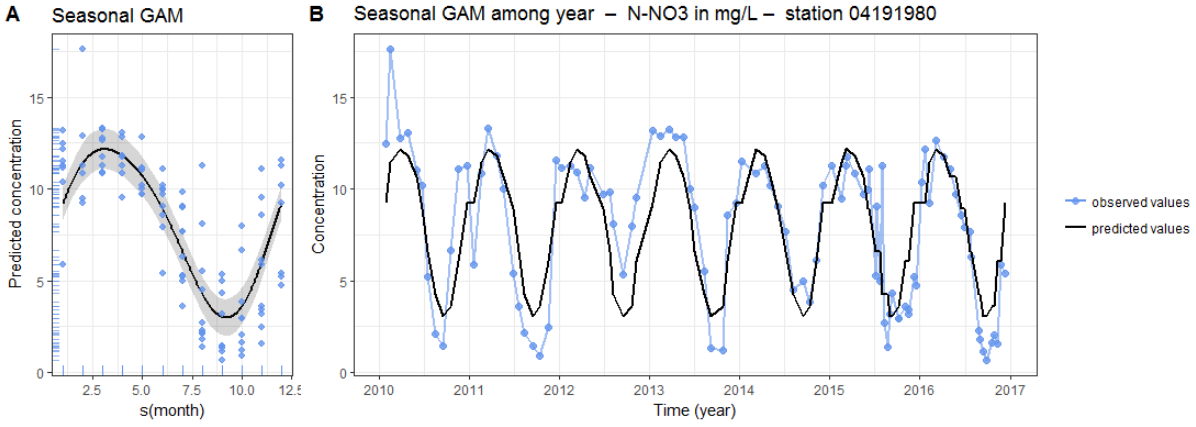


Figure S4. Density histogram of variance in the seasonal component explained by the Generalized Additive Models (GAMs) among headwater catchments for dissolved organic carbon (DOC), nitrate (NO_3), soluble reactive phosphorus (noted PO4 here), and discharge (Q). Rsq is the coefficient of determination between observed concentrations and values calculated by the GAM. Dashed lines identify mean values.



(1)



(2)

Figure S5. Two examples of Generalized Additive Model adjustments to nitrate (N-NO_3) time series: (1) La Loisance River (station no. 04162958 in the OSUR database) illustrates poor adjustment quality (Rsq=0.02). (2) Saint Niel River/ tributary of the Blavet (station no. 04191980 in the OSUR database) illustrates good adjustment quality (Rsq=0.66).

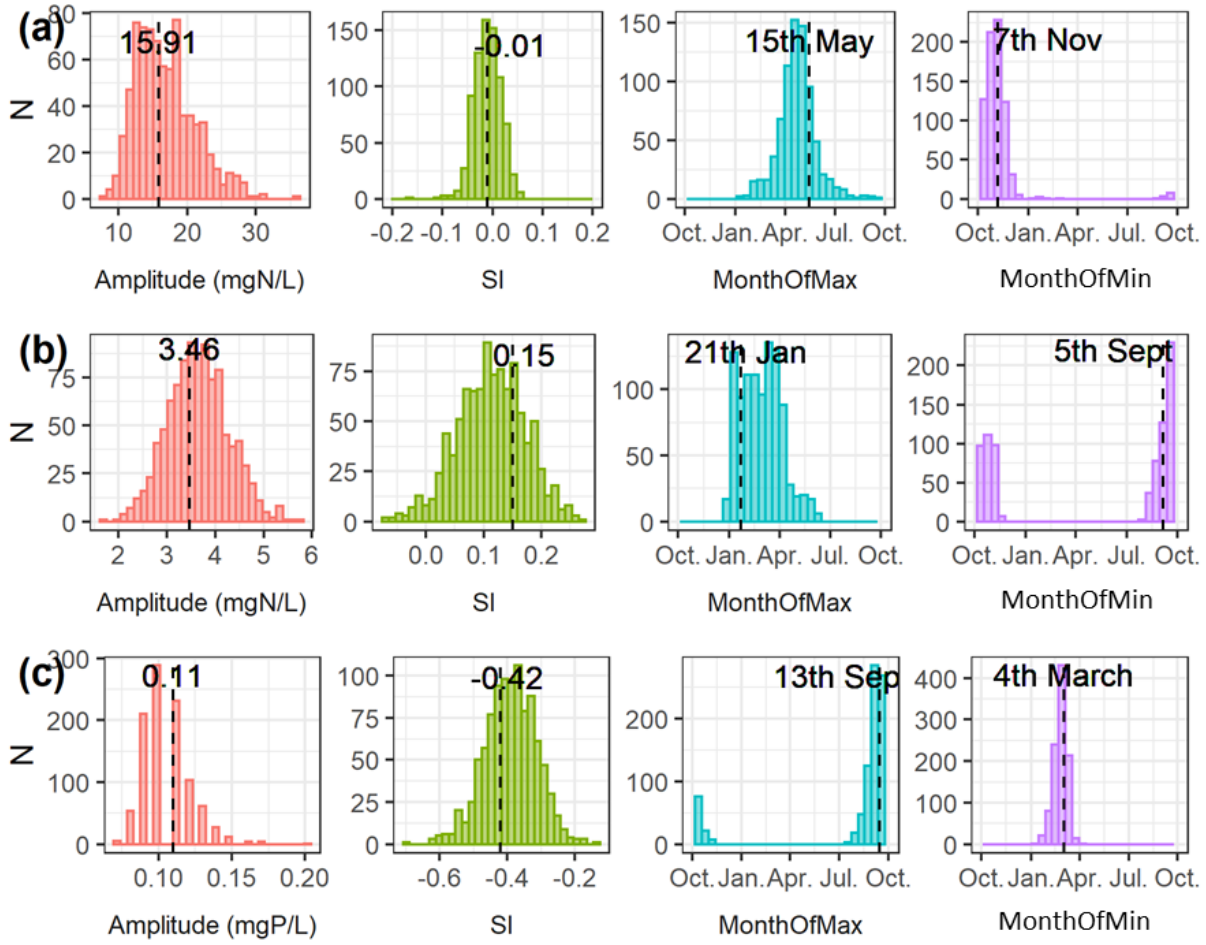
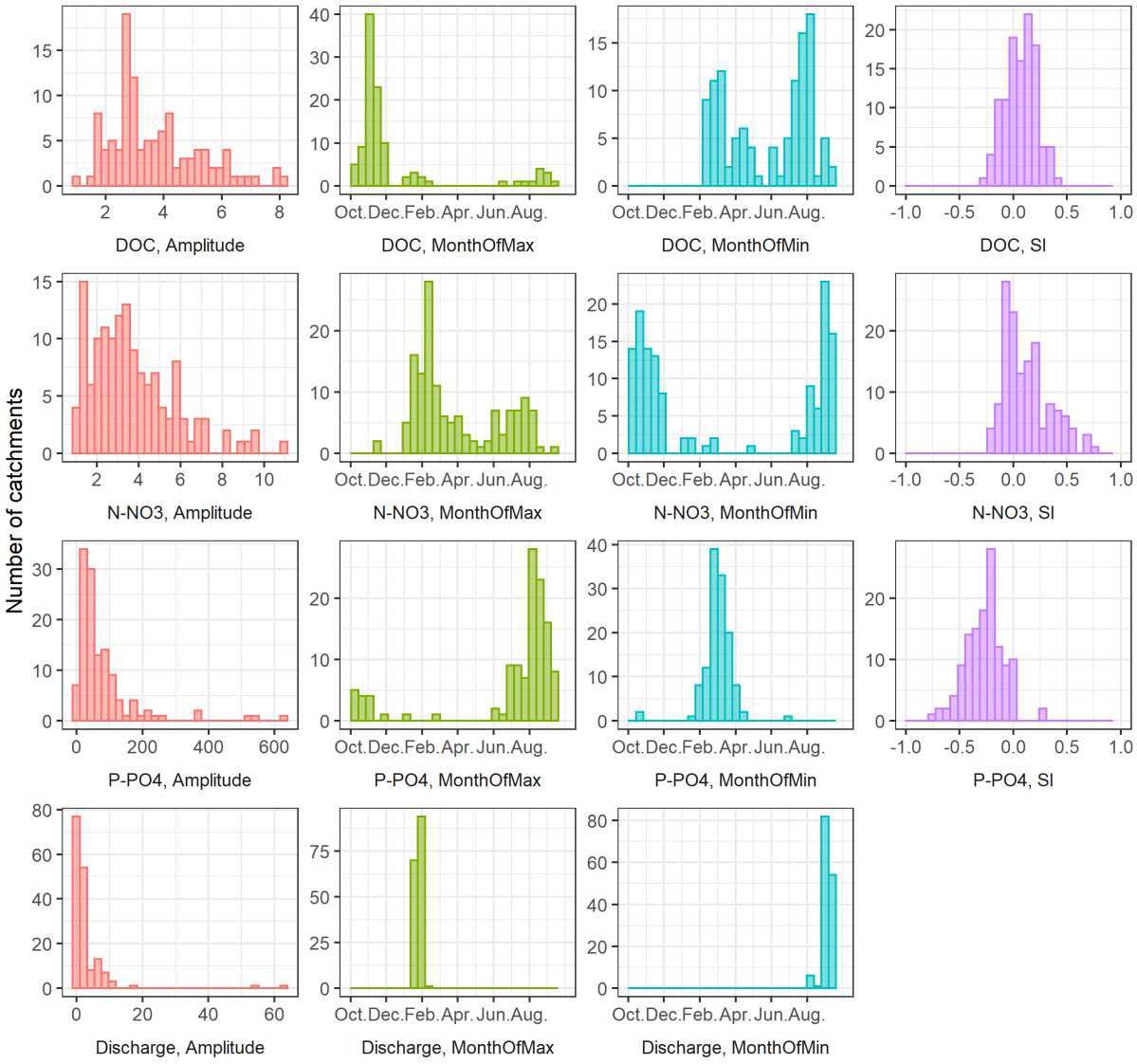


Figure S6. On average, the Generalized Additive Model (GAM) seasonal components were fitted to time series of monthly data, which is a low frequency for investigating intra-annual variations. We assumed that aggregating the 10 years would allow a relatively robust average seasonal pattern to be extracted. To verify this assumption, we analyzed how much the relatively low-frequency sampling influenced the seasonal metrics. We calculated differences between the seasonal indices calculated from GAMs adjusted to high-frequency data and those calculated from GAMs adjusted to monthly data, generated by random Monte Carlo draws (n=1000) from the high-frequency time series. This analysis was performed for three catchments Brittany for which NO_3 and SRP concentration data were available at higher frequency (not available for DOC data) from 2007-2016. The figure summarizes the variability in the seasonality indices (Ampli, seasonality index (SI), MaxPhase and MinPhase) calculated from the 1000 GAM models that were fitted to monthly concentration time series for (a) nitrate (NO_3) in the Kervidy-Naizin catchment, (b) NO_3 in the Néal catchment, and (c) soluble reactive phosphorus (SRP) in the Le Queffeuth catchment. Only significant GAM models (Rsq ≥ 0.10) are shown. Dashed lines indicate the value obtained by the GAM with the original daily (Kervidy-Naizin, AgrHyS observatory) or weekly (Néal and Le Queffeuth catchments) time series. The y-axis corresponds to the number of catchments (N). The comparisons show that the distribution of seasonality metrics obtained from lower-frequency time series were centered on the values obtained from the original time series. Despite some delay in phases, minimum and maximum concentrations were identified during the same season by both types of time series. For NO_3, the mean errors in seasonal metrics obtained from the monthly time series were -4.5% and 6.7% for amplitude, 21.0% and -7.2% for SI for the Kervidy-Naizin and Néal catchments respectively. PhaseMax was delayed by -1.0 to -1.5 months, and PhaseMin by 0 to 1 months. For SRP (Le Queffeuth catchment), the mean error was -4.0% for amplitude, -7.0% for SI, ±18 days for PhaseMax, and ±12 days for PhaseMin.



65 **Figure S7. Histograms of water quality metrics and discharge, from left to right: absolute annual amplitude (mg.l^{-1}), annual minimum and maximum concentration phases (in months), and the seasonal index (only for concentrations). From top to bottom: for dissolved organic carbon (DOC) (n=113), nitrate (N-NO_3) (n=142), soluble reactive phosphorus (SRP) (n= 126), and discharge (Q) (n=124). Non-significant amplitudes (Rsq<0.1) are not shown.**