Hydro-Climatological Influences on Multi-Decadal Trends of Dissolved Organic Carbon Concentration and Export in a Headwater Stream of the Southern Appalachians

Introduction
Studies have reported long-term (>10 yr) increases in dissolved organic carbon (DOC), and variously attributed the patterns to rising air temperature, hydrological change, and recovery from acid deposition.

No clear consensus on either the direction of the trend or its potential drivers for headwater streams in the United States.

Objectives
Explores the long-term DOC concentration and flux for a forested headwater stream in the Southern Appalachian from 1988 to 2012.
Identify the potential drivers responsible for the multi-decadal DOC trends observed at Coweeta Hydrologic Laboratory (CHL).

Methods
Trend analysis was performed on time series records of stream flow, [DOC] and climate for Watershed 27, a deciduous forested catchment at CHL studied since 1950 (Fig 1).

Volume weighted DOC (DOC$_{vw}$) was computed:

$$\text{DOC}_{vw} = \frac{\sum_{j=1}^{m} c_j \cdot Q_j}{\sum_{j=1}^{m} Q_j}$$

where $c_j$ is the DOC concentration of a bimonthly sample (mg L$^{-1}$) and $Q_j$ is the instantaneous runoff (L sec$^{-1}$) at the time of sampling.

Flux was computed at monthly scale using monthly DOC$_{vw}$ and discharge.

Break-point analysis was conducted to identify the transition period, when the direction of trends for DOC concentration changed.

Results
Decade of decline (1988-2001) in DOC concentration (DOC$_{vw}$) and annual DOC flux followed by decade of increase (1997-2012)

Results Contd. Monthly DOC: Significant change in monthly DOC$_{vw}$ in growing seasons

Fig 3. Mean Monthly a) DOC$_{vw}$ and b) Fluxes for pre (black circles) and post (green circles) periods. Error bar represents (±1 SE) for monthly time series.

Air Temperature: Strong warming trends

Fig 4. Trends in a) Mean and b) Max Annual Air Temperatures for long term (LT-open circle) and study period (SP-filled circle). Solid lines (Sen slopes) and dash line (95%CI).

Hydrological Fluxes: Precipitation and discharge decreased

Fig 5. Annual Trends in a) Precipitation and b) Discharge for the study period. Solid lines (Sen slopes) and dash line (95%CI).

Results Contd. Stormier September ?:

September, only growing season month to show significant decrease followed by increase in DOC$_{vw}$: significant decline in discharge, increase in number of high intensity storms for the post period

Fig 6. a) Mean DOC$_{vw}$, b) % of storms >17 mm and c) Discharge, for the month of September.

Conclusions

- Significant decreasing followed by increasing trends in annual mean DOC$_{vw}$ and fluxes for 25 years of the record.
- Decreasing annual DOC concentrations from 1988 to 2001 corresponded to declining growing season runoff, which may affect DOC mobilization from uplands to the stream.
- Increasing DOC concentrations (1997-2012) corresponded to an increase in the number of high intensity storms for September, which may flush DOC accreted in the forest floor and soil profile.
- Rising air temperature may contribute to increasing DOC during growing season months.
- Period of record chosen for analysis affects observed trends.

References and Acknowledgements

Data analysis and travel were funded by a Global Change Fellowship from the University of North Carolina, Department of Interior's Southeast Climate Science Center, Raleigh, NC.