Impacts of streambed dynamics on nutrient and fine sediment transport in mountain rivers

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Summary

- The armor layer protects the finer bed subsurface from erosion, but when dislodged during high flow events it can release fine sediment enriched in Phosphorus (P) and Organic Carbon (OC).
- **Hysteresis and seasonal variations** in particulate and soluble reactive phosphorus (PP and SRP) and in particulate and dissolved organic carbon (POC and DOC) could be **controlled by armor layer motion**
- Particulate constituents such as POC and suspended sediment (SS) often show clockwise hysteresis, whereas DOC showed different hysteresis for different seasons, suggesting they are **coming from different sources.**
- We are currently investigating these sources and constraining the exact timing of armor layer motion in each event.

Methods

1. Capturing Hysteresis:

Study Site: La Jara Creek, Valles Caldera National Preserve, NM

Turbidity and fDOM*
Collected using a YSI EXO2 Sonde

Water samples (SS, SRP, PP, DOC & POC)
Stage-triggered portable ISCO samplers

Flow depth and Discharge
Pressure transducers in stilling wells

* Fluorescent dissolved organic matter – a reliable proxy for DOC

Laboratory Procedures
SS – Laser diffraction method (LISST portable XR)
POC – Eurovector elemental analyzer coupled to an Isoprime IRMS
DOC – OI Analytical Aurora 1030 TOC Analyzer
SRP & PP – SpectraMax M2e

2. Fine Sediment Deposition

Sediment traps with open and closed bottoms were installed next to subsurface temperature probes during the spring of 2023
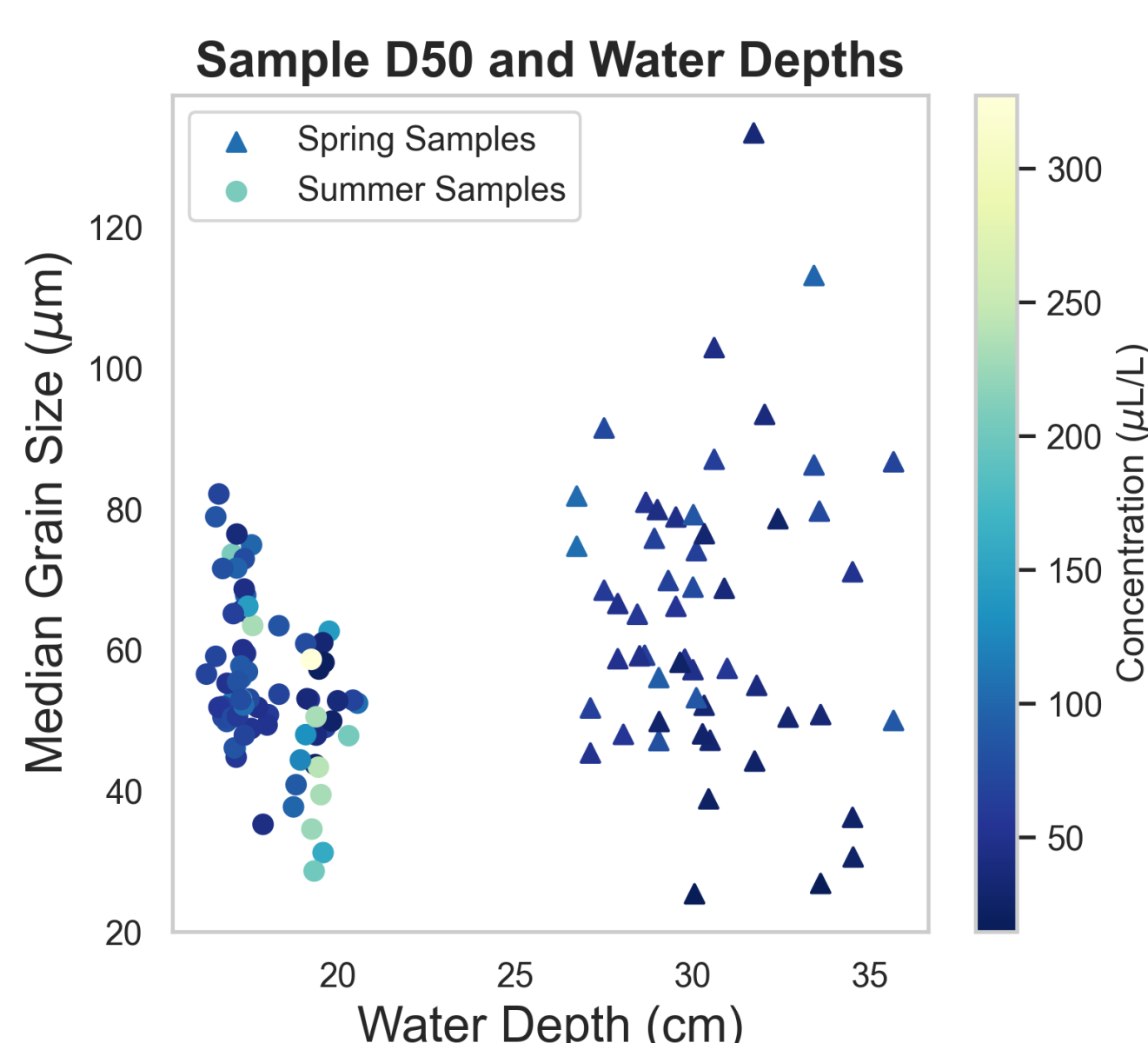

Downwelling Conditions / Upwelling Conditions
Flux + Other effects / Just other effects
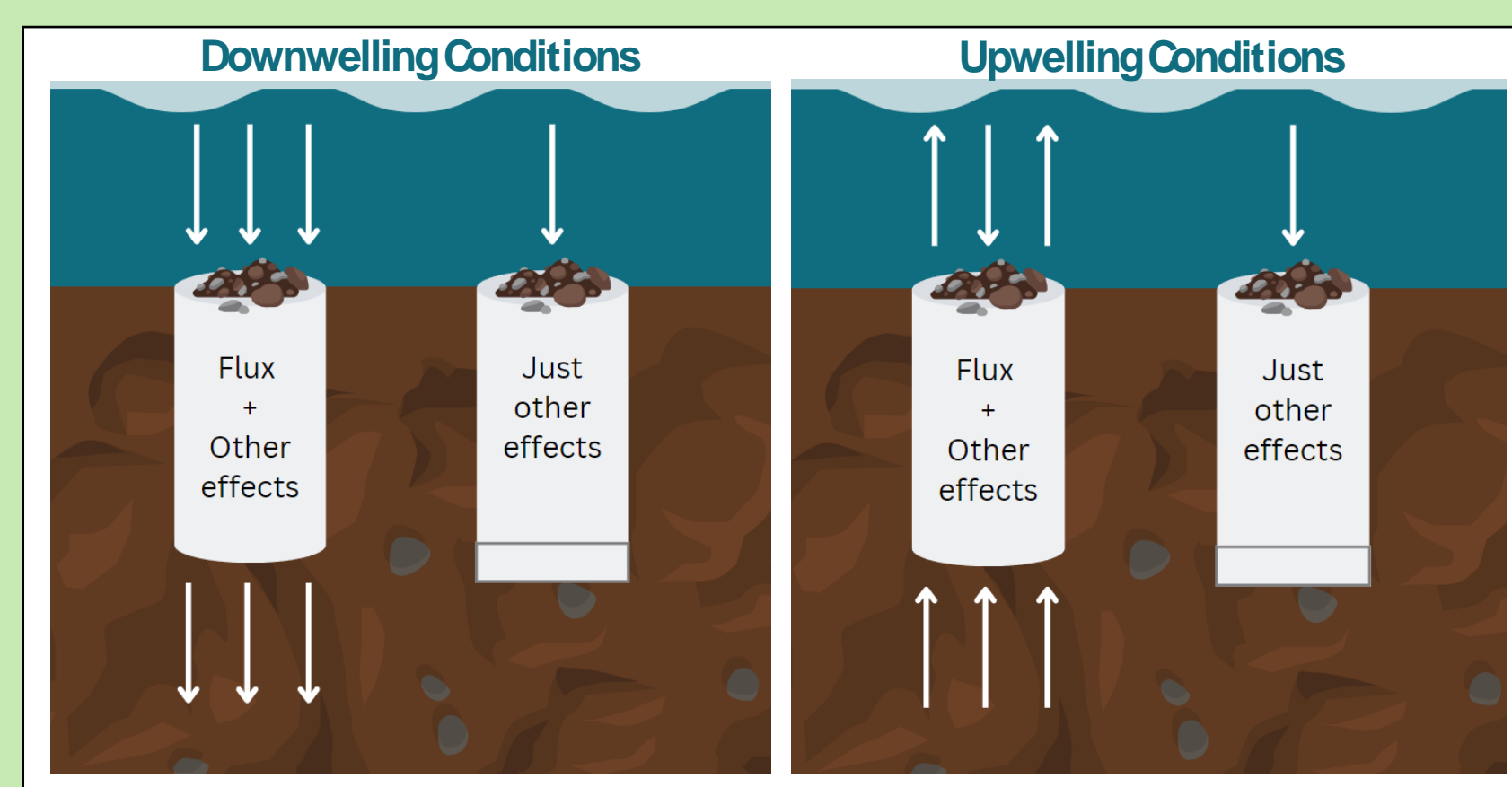
Other deposition effects:
- settling velocity
- stream turbulence effects

3. Computing Hyporheic Flux

Through diel substrate water temperature fluctuations, we can solve the vertical flux from the 1D advection-diffusion equation using ΔA and $\Delta \Phi$. Temperature-monitoring probes were installed at the locations of each basket group to estimate local hyporheic flux.

ΔA: Amplitude Ratio - $\Delta \Phi$: Phase Shift
0 cm, 30 cm, 45 cm, 60 cm
T° sensors
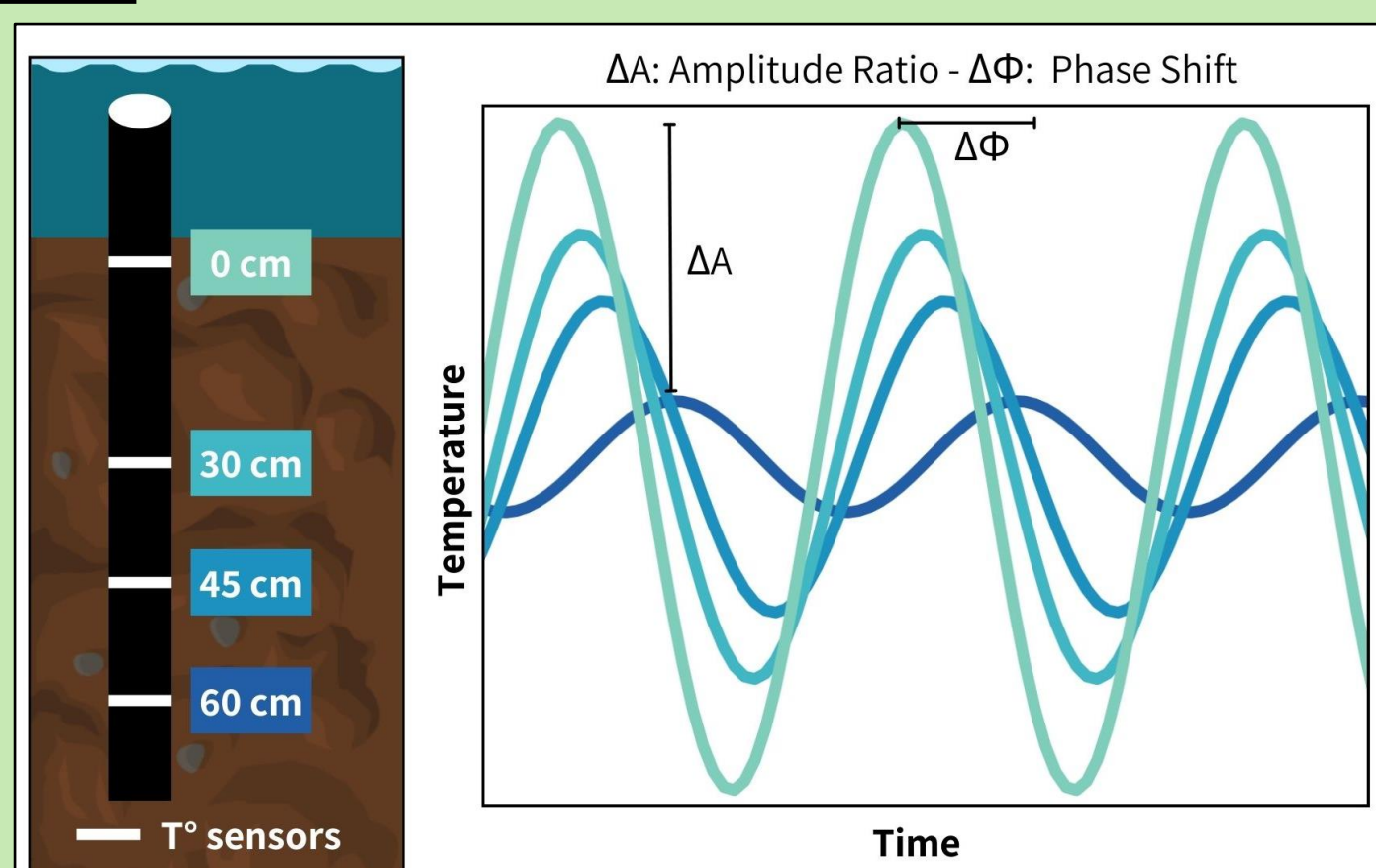
Results — Water Column Fine Sediment Concentrations and D_{50}

Sample D50 and Water Depths
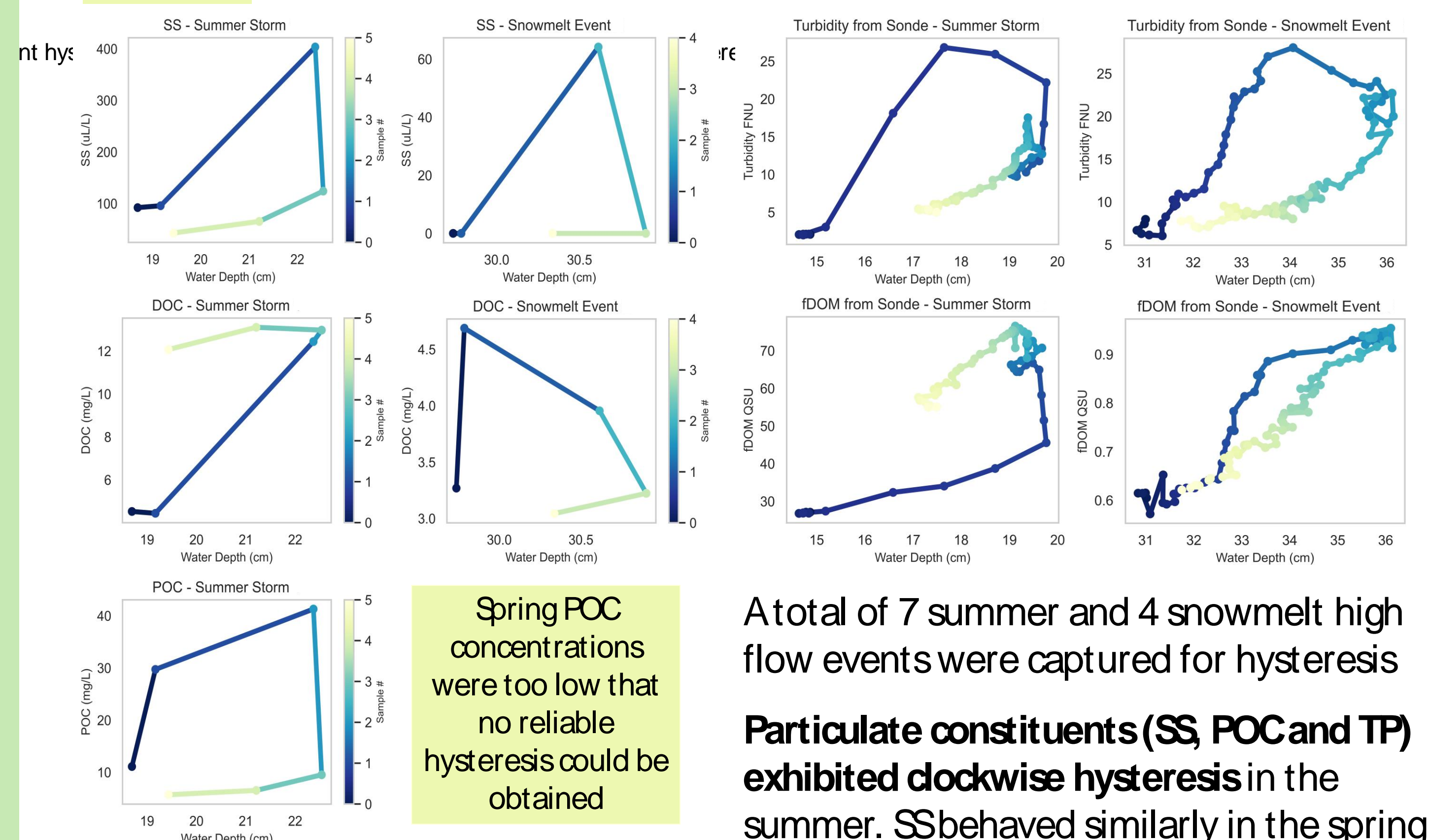- Spring Samples
- Summer Samples

Summer high flow events displayed a wider range of concentrations and **higher peak concentrations on average** than the spring event concentrations.

Spring high flow events have a wider range of D50's and a **coarser grain size distribution on average** compared to the summer samples.

Average:	Spring	Summer
Concentration (µL/L)	53.76	95.00
Median Grain Size (µm) (µm)	65.74	54.65

Results — Spring and Summer Fine Sediment Deposition

Results — Seasonal Constituent Hysteresis

SS – Summer Storm / SS – Snowmelt Event / Turbidity from Sonde - Summer Storm / Turbidity from Sonde - Snowmelt Event
DOC – Summer Storm / DOC – Snowmelt Event / fDOM from Sonde - Summer Storm / fDOM from Sonde - Snowmelt Event
POC – Summer Storm

Spring POC concentrations were too low that no reliable hysteresis could be obtained

A total of 7 summer and 4 snowmelt high flow events were captured for hysteresis

Particulate constituents (SS, POC and TP) exhibited clockwise hysteresis in the summer. SS behaved similarly in the spring

Dissolved constituents (DOC and SRP) differed in their behavior. Hysteresis for SRP changed for different summer storms. Hysteresis for DOC was consistently counter-clockwise in the summer and consistently clockwise in the spring. This suggests that these constituents might come from different sources

Discussion and Further Work

- Coarser deposited grain sizes in the spring traps might be due to the transport of larger particle sizes and higher deposited sediment volume could be due to constant exposure to high flows compared to the summer storms.
- Settling velocities for water column suspended sediment samples are yet to be calculated. A more comprehensive analysis of the sediment trap deposition of each grain size class (sand, silt and clay) with hyporheic flux is in development.
- Different summer hysteresis patterns for DOC and particulate constituents suggest they are coming from different sources.
- The different degree of hysteresis for particulates could be explained by the timing of armor layer motion. This timing is currently being explored to better understand our results

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