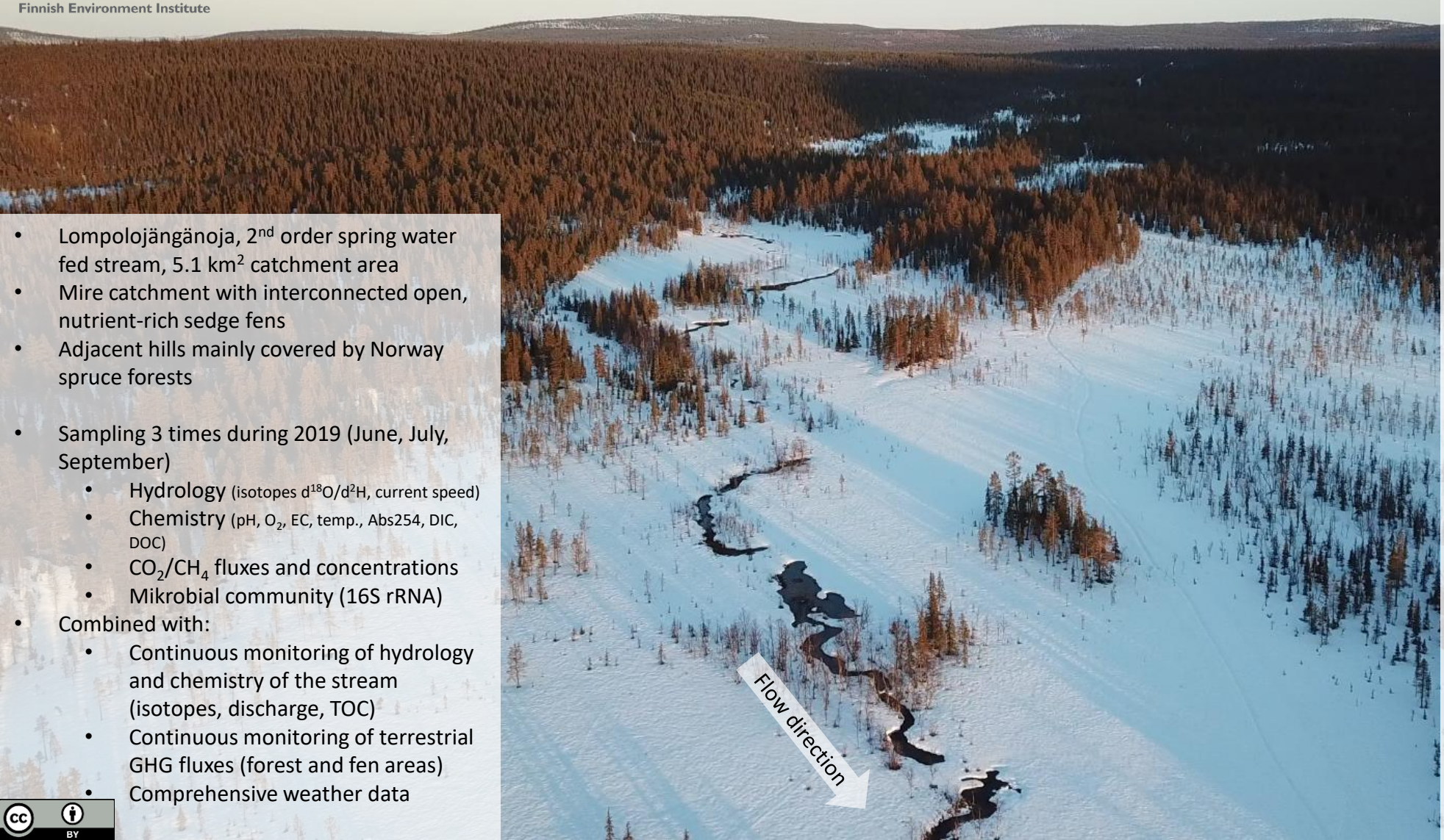
Understanding interacting dynamics of hydrology, carbon cycle and greenhouse gas fluxes in Arctic watersheds

Kaisa-Riikka Mustonen[1], Hannu Marttila[2], Kaisa Lehosmaa[1], Iina Koivunen[1], Jeffrey Welker[1,3,6], Annalea Lohila[4,5], Jussi Jyväsjärvi[1]

[1]Ecology and Genetics Research Unit, University of Oulu, Finland; [2]Water Resources and Environmental Engineering Research Unit, University of Oulu, Finland; [3]Department of Biological Sciences, University of Alaska Anchorage, USA; [4]INAR Institute for Atmospheric and Earth System Research, University of Helsinki, Finland; [5]Finnish Meteorological Institute, Climate System Research, Helsinki, Finland; [6]The University of the Arctic (UArctic).

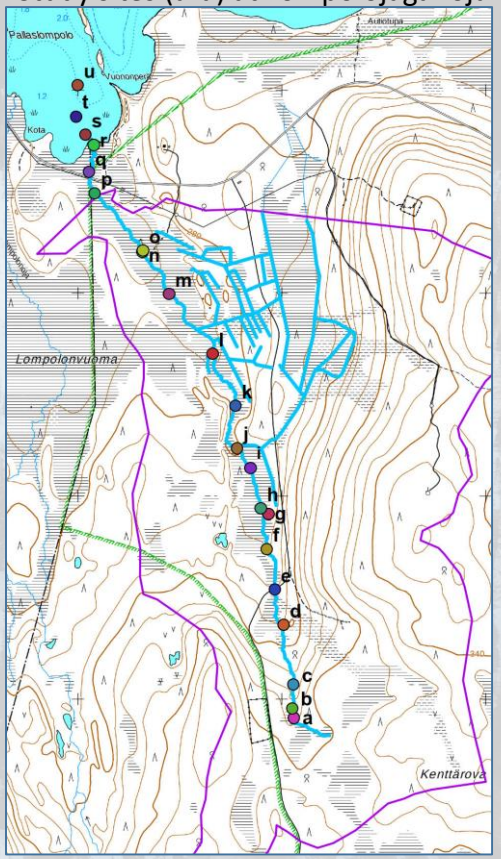


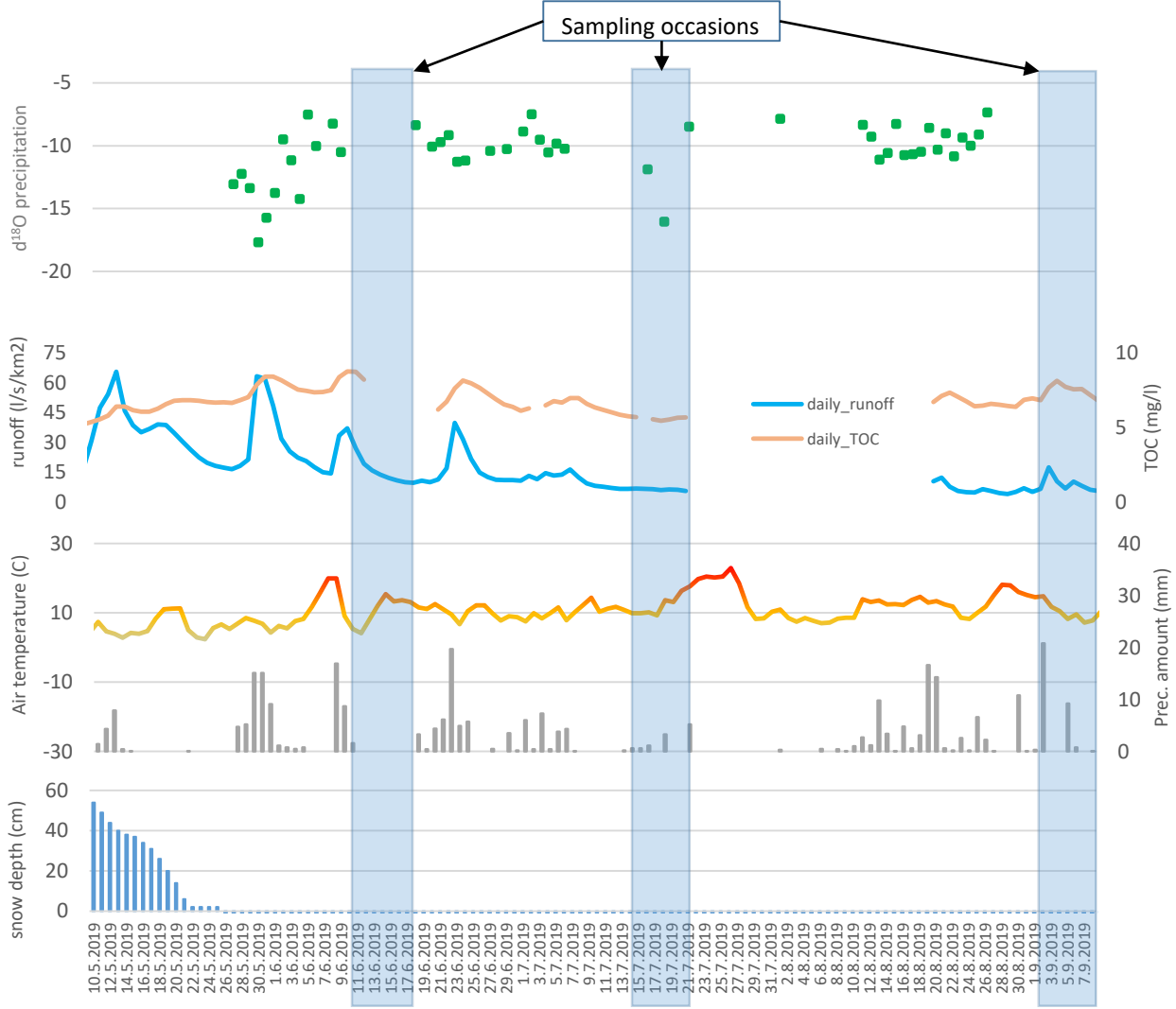
- Lompolojängänoja, 2nd order spring water fed stream, 5.1 km^2 catchment area
- Mire catchment with interconnected open, nutrient-rich sedge fens
- Adjacent hills mainly covered by Norway spruce forests

- Sampling 3 times during 2019 (June, July, September)
  - Hydrology (isotopes d^{18}O/d^{2}H, current speed)
  - Chemistry (pH, O_2, EC, temp., Abs254, DIC, DOC)
  - CO_2/CH_4 fluxes and concentrations
  - Mikrobial community (16S rRNA)
- Combined with:
  - Continuous monitoring of hydrology and chemistry of the stream (isotopes, discharge, TOC)
  - Continuous monitoring of terrestrial GHG fluxes (forest and fen areas)
  - Comprehensive weather data

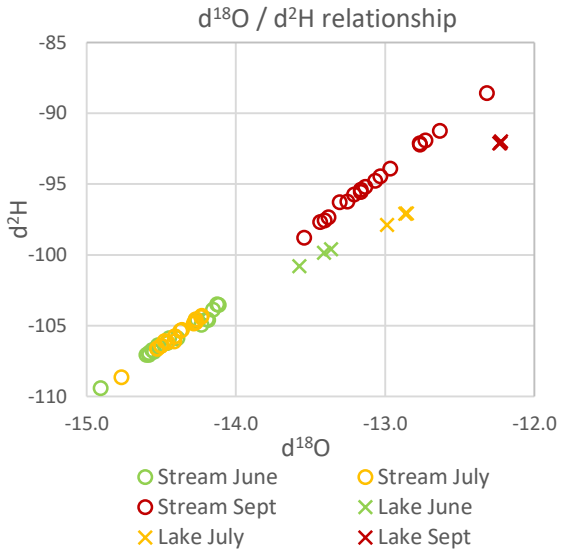
Pallas research site location

Study sites (a-u) at Lompolojägänoja

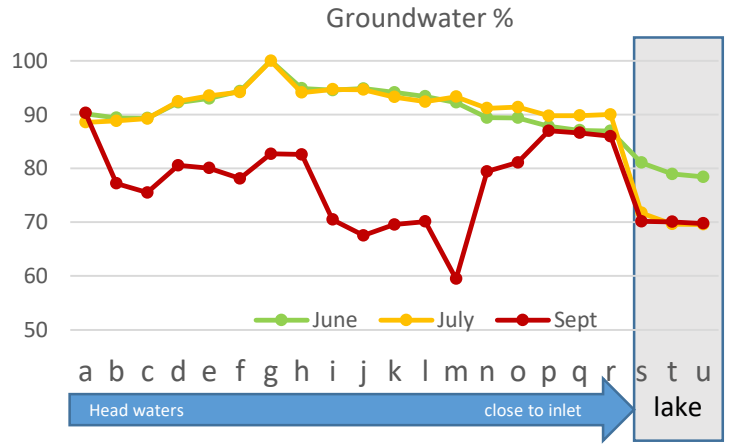




- First sampling not that far from snowy days, and right after few days of heavy rainfall and high discharge. Precipitation isotopes before June sampling are also showing relatively depleted values → snow/sleet events → mixed GW and snow signal in water source
- Second sampling during baseflow conditions. GW% high, no more snowmelt signal, pure baseflow conditions. Too minor rain events to have an effect on water source in the stream.
- Third sampling right after a heavy rain event. Also heavy rain events one month prior to sampling.

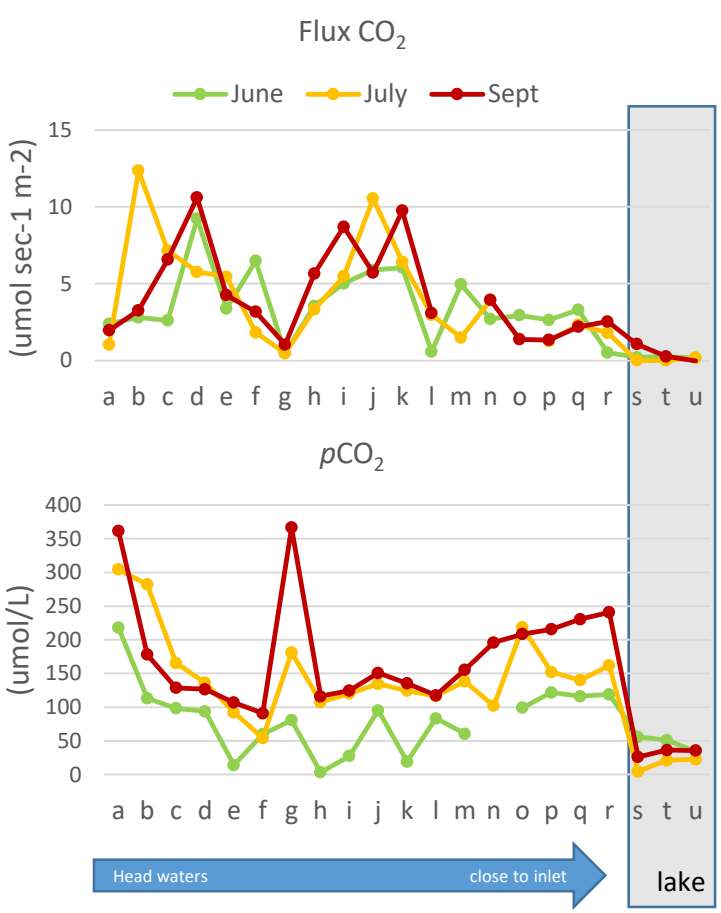


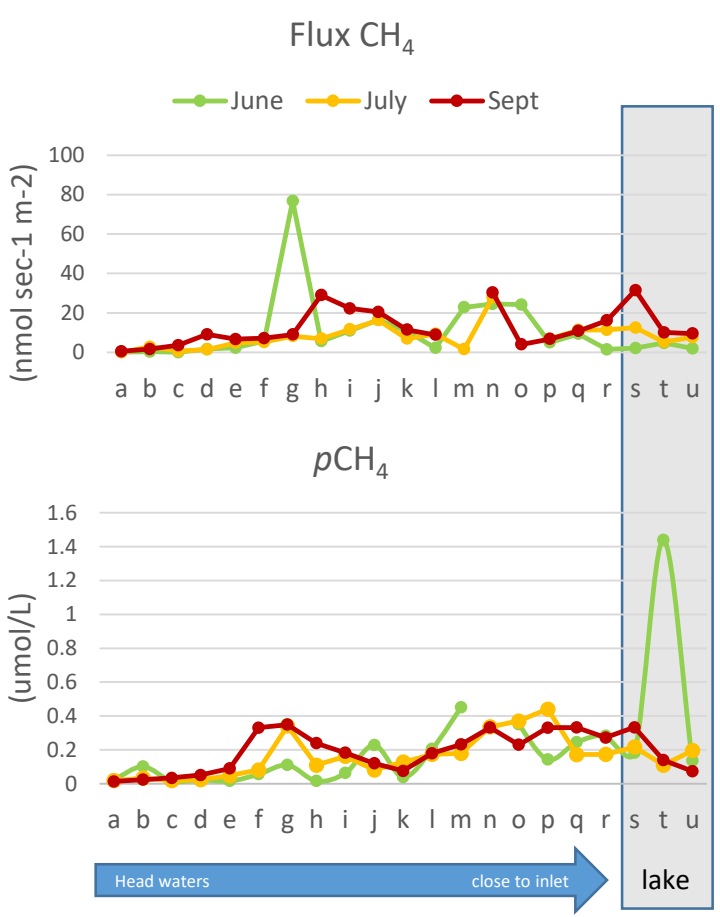
- Stream isotopes in June and July do not differ much, however larger variance and a bit more depleted values in June also support the still remaining snowmelt influence. More enriched isotope values in September indicate water origin from precipitation.
- Consistent enrichment of lake isotope values over summer indicate clear evaporation effect in the lake.

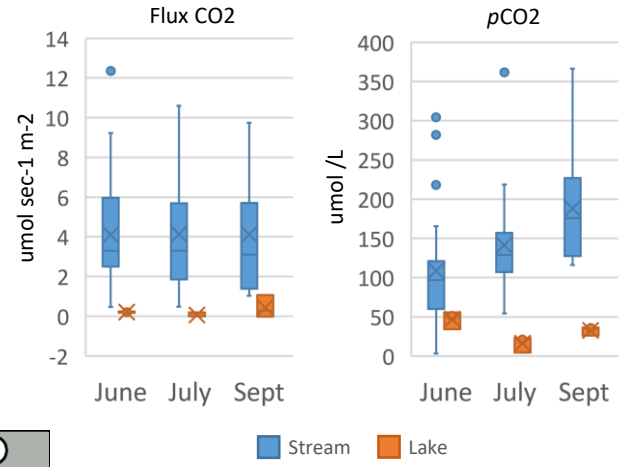


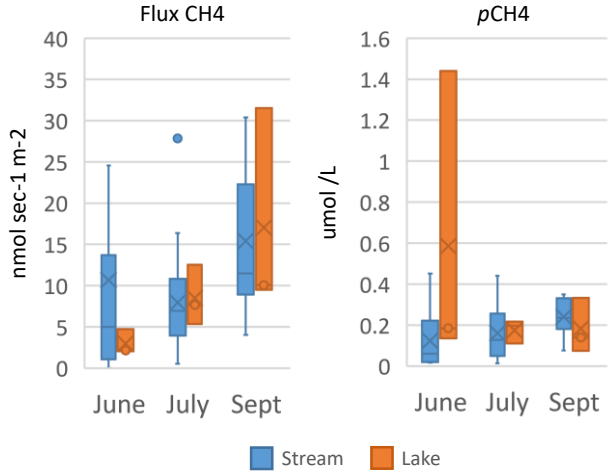
- GW% calculations based on a mixing model approach using long term average isotope values for GW (measured regularly from groundwater pipes in the catchment) as a GW signal, and volume weighted summer precipitation isotope value for the month prior to each sampling time as the precipitation signal.

- September more enriched isotope values + lower GW% indicate water origin from precipitation → Terrestrial areas of catchment saturated with water → high surface runoff flow into the stream.
- September conditions reveal the most groundwater influenced sites (a, g, p, q, r). High GW% despite high surface runoff.
- Sites i-m have lowest GW% in September. These sites are also influenced by additional runoff from upper reach ditches → more surface runoff into the stream.
- Sites p, q, r are close to inlet with no springs nearby, yet heavily influenced by GW → GW seepage from surrounding wetland areas. Also sites n and o (wetland sites) indicate relatively high GW influence and hence seepage through the wetland.









- CO_2 and CH_4 fluxes were measured at site using a Licor (Li-7810) CH4/CO2/H2O Trace Gas Analyzer attached to a floating aluminum chamber build for the purpose.
- Flux measurements were based on the concentration change within the sealed chamber over time (5 minutes).
- CO_2 and CH_4 concentrations were measured from 50ml water samples using a headspace equilibrium technique, where 50ml of reference air is shaken for 2mins with the 50ml water sample. pCO_2/pCH_4 in the headspace were then analyzed using an infrared gas analyzer and normalized to the reference air sample by using Henry's law.
- pCO_2/pCH_4 values = Cw-Ca where Cw is concentration in water and Ca is concentration in water assuming the concentration of water is in equilibrium with the atmosphere.

- All stream and lake sites were constant sources of CO_2 and CH_4 to the atmosphere as they were always supersaturated with respect to the atmosphere (pCO_2/pCH_4 values positive).

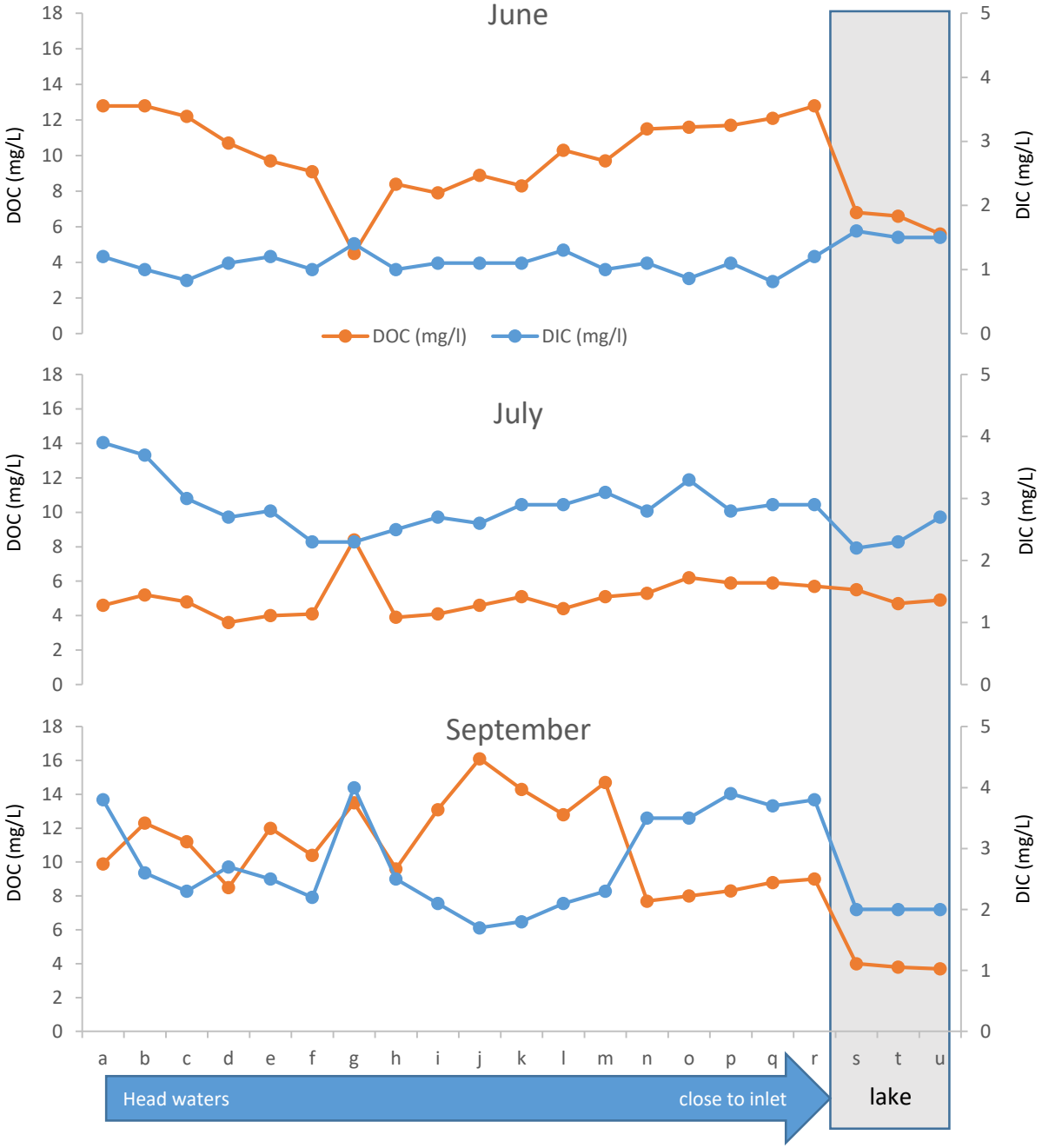
- Lowest CO_2 flux at most groundwater influenced sites, but highest CO_2 concentrations.
  → Lower current speed at most GW influenced sites
  → CO_2 input from GW or other processes → Emitted to the atmosphere when moving downstream to more turbulent locations.

- CH_4 fluxes behave differently. No significant relationship with current speed. E.g. Groundwater hotspot site g: very high CH_4 flux.
  → anaerobic/hypoxic microbial activity?

- Overall stream CO_2 flux staying constant throughout the summer, but the concentrations do increase → water sources and microbial activity playing a role here.

- Stream and lake CH_4 fluxes increasing consistently over summer, but concentrations showing a slight inverse relationship.

- Stream sites seem to be contributing more to CO_2 emissions overall than lakes. Stream turbulence plays a role here, however also concentration higher. Difference between stream and lake site CH_4 values depend on the sampling occasion.

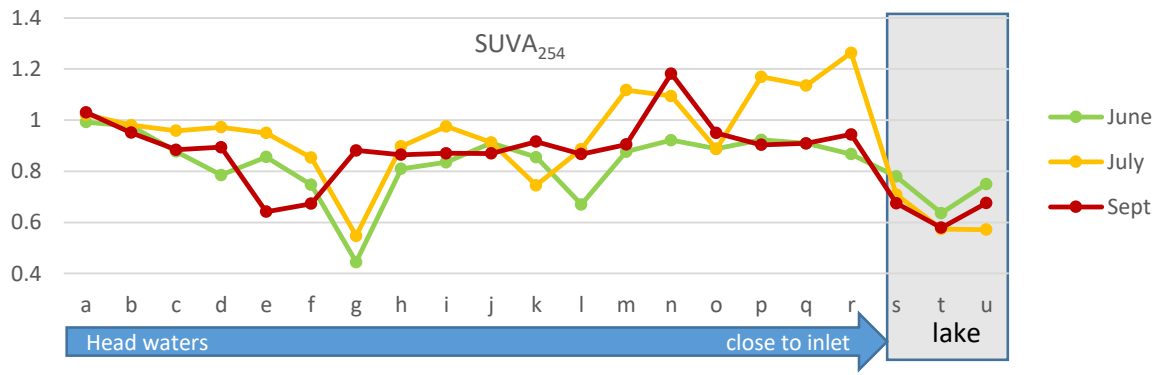


- High DOC amounts in June (except GW site g). DOC has been delivered to the stream via still snowmelt influenced surface runoff (based on depleted isotope values and heavy prior rain events). DOC relatively easily released from surrounding terrestrial areas with not much vegetation → Microbes not consuming DOC that efficiently yet?

- In July: Baseflow conditions. DOC is being efficiently mineralized by mirobes. GW input highest, no new DOC sources → DIC values increase throughout the stream.

- In september: Lots of rain before and discharge higher. Groundwater percentage low compared to other times = surface runoff from surrounding terrestrial landscape → high DOC values again, but now very efficiently mineralized which can be seen from the inverse DOC/DIC relationship.

- $SUVA_{254}$ –index (Specific UV Absorbance) correlates positively with the DOC aromaticity and molecular mass. Heavier and more aromatic combounds are thought to be unfavorable for microbes.
  → Some of the GW hotspots seem to be producing more favourable C for microbes at least in June and July.



- Water sources in the stream change spatially (along stream continuum) and temporally (throughout the open water season) influencing the CO_2 and CH_4 fluxes and concentrations.

- Water sources, hydrological conditions and connected terrestrial landscape are controlling the spatial and temporal variability of DOC amount and quality within the stream.

- Still missing microbial community data will give us answers to many previously mentioned microbe related questions. Which goups are presents and active during which sampling occasion? Is community structure dependent on water source spatially or temporally or both? What role do microbes play in C-cycling and resulted GHG emissions?

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