



Groundwater bacterial communities evolve over time, exhibiting oscillating similarity patterns in response to recharge

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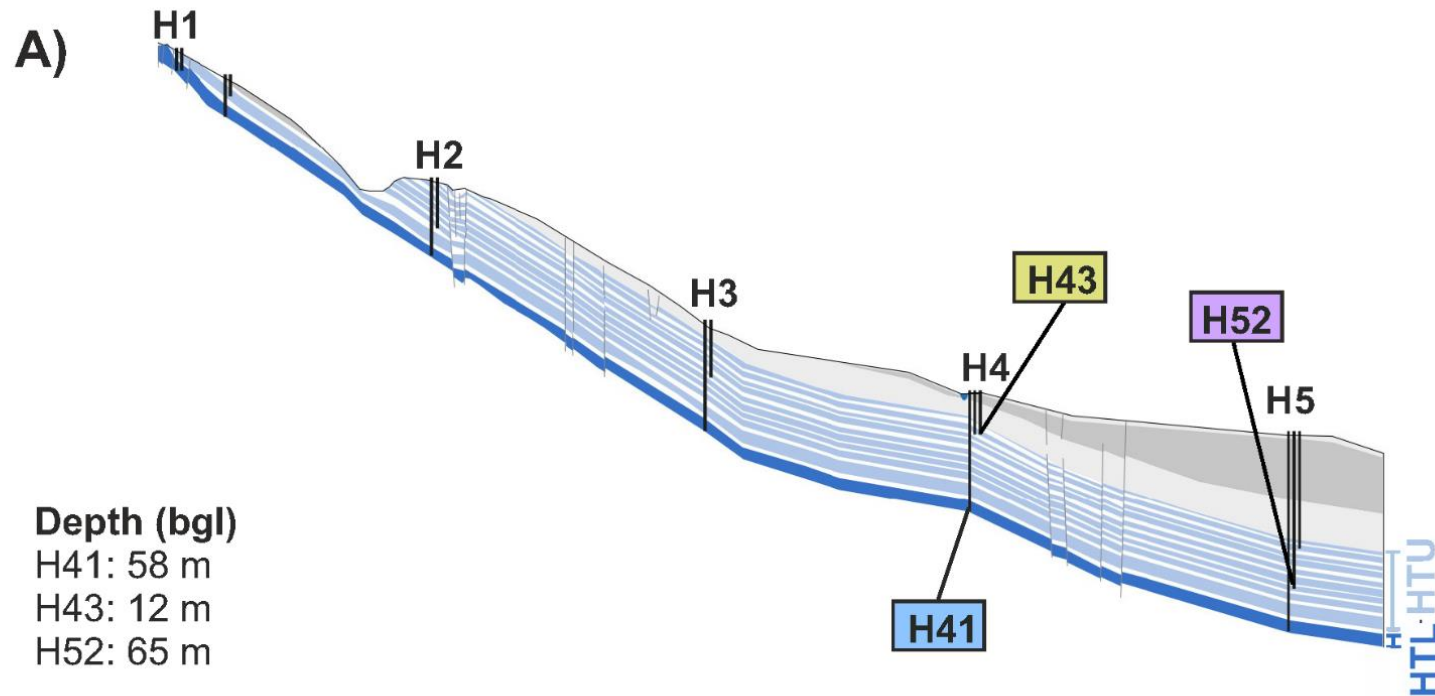


Temporal patterns in groundwater microbiomes

Subsurface waters are unique ecosystems, especially compared to surface aquatic environments. However, groundwater microbial communities have not been comprehensively studied for temporal patterns

OUR AIM: To disentangle the long-term temporal changes in surface-near groundwater bacterial communities and identify the drivers of the observed patterns.

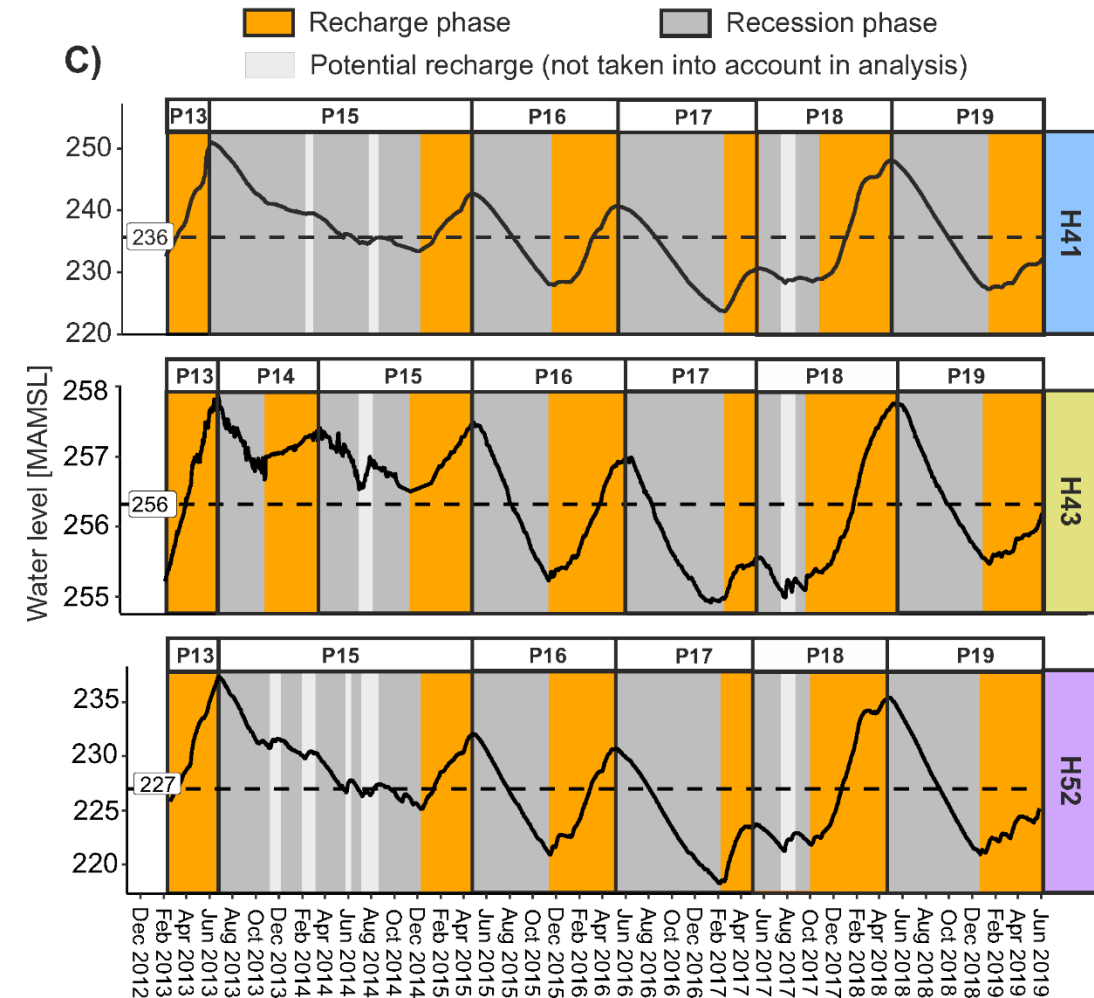
Methods: Long-term groundwater sampling of the Hainich Critical Zone Exploratory (CZE)



- Three wells from the Hainich CZE were sampled monthly from Feb 2013 to May 2019
- Bacterial community composition was determined using amplicon sequencing (V3-V4 region of the bacterial 16S rRNA gene)

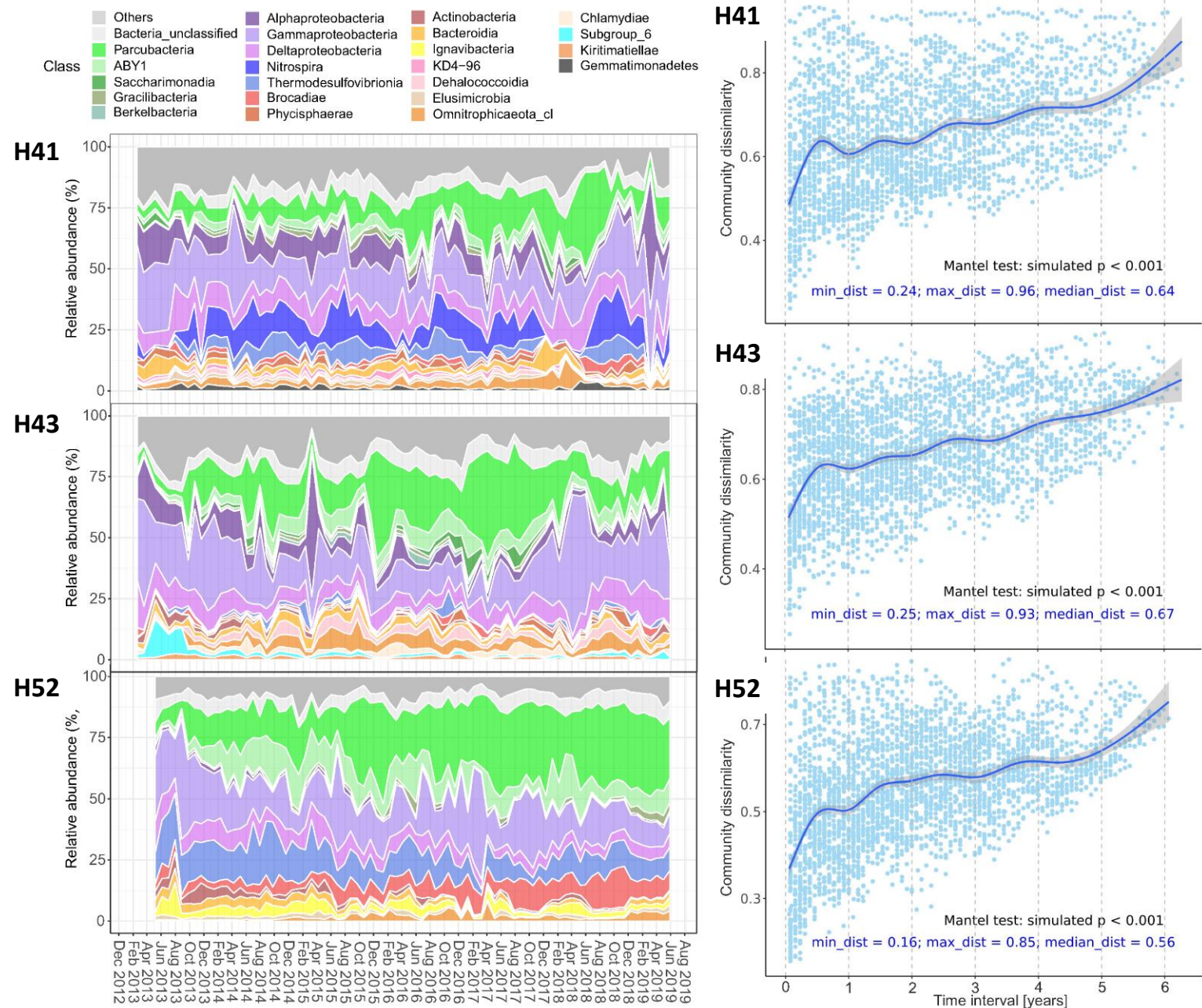
Methods: Recharge/recession phases

- Recharge phase: Water levels increasing, mostly surface derived
- Recession phases: falling water levels, generally due to limited surface-recharge
- Six 'periods' were identified during the sampling campaign, each consisting of one recession phase and one recharge phase.
 - For P13 only the recharge phase was sampled



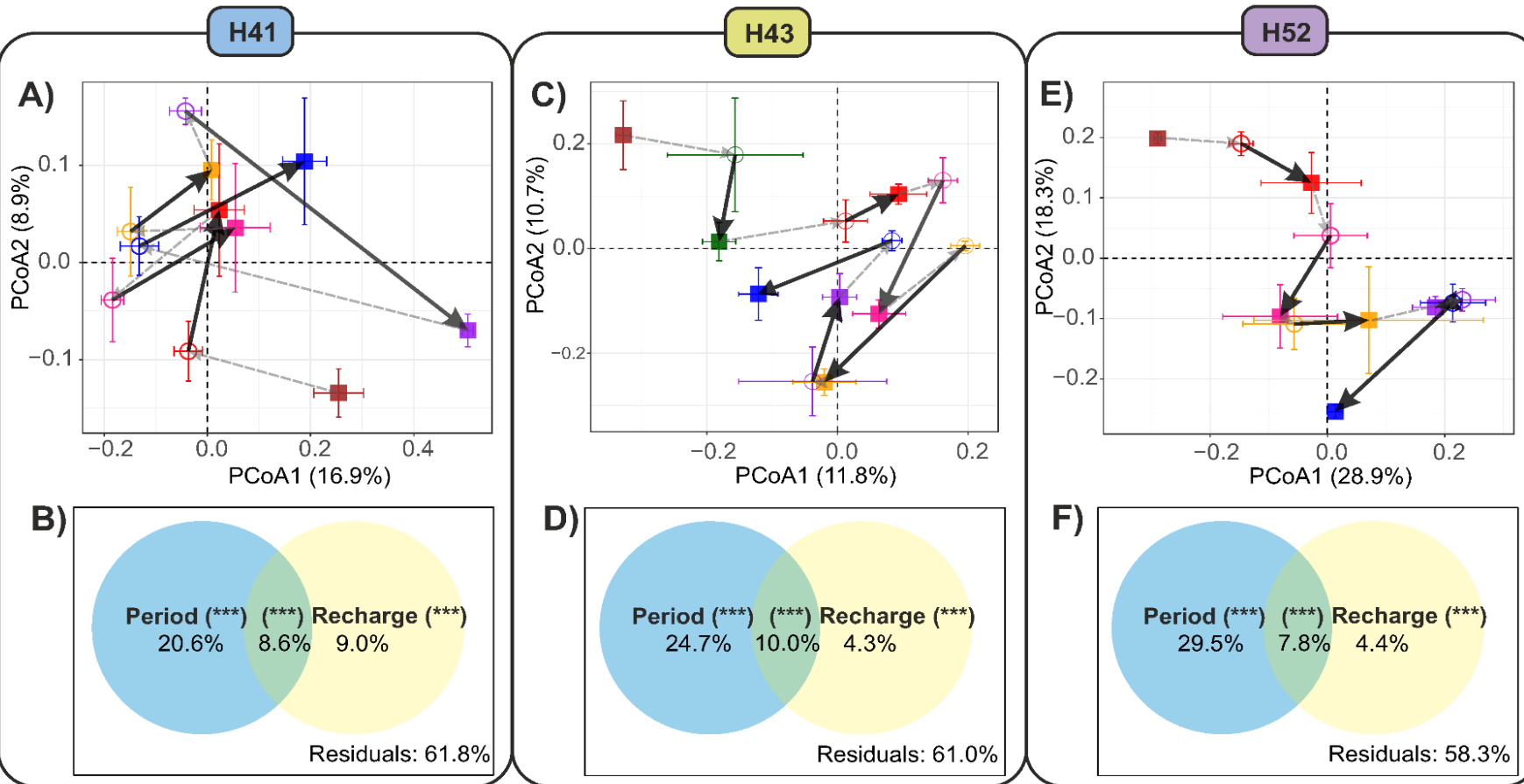
Above: Changes in groundwater level for the sampled wells. The mean water level across the timeseries for each well was indicated with a value box and a dashed line. MAMSL: meters above mean sea level.

Result 1: Bacterial community compositional changes over time, showing an 'oscillating' pattern at intervals < 3 years, followed by a steep increase in dissimilarity over time

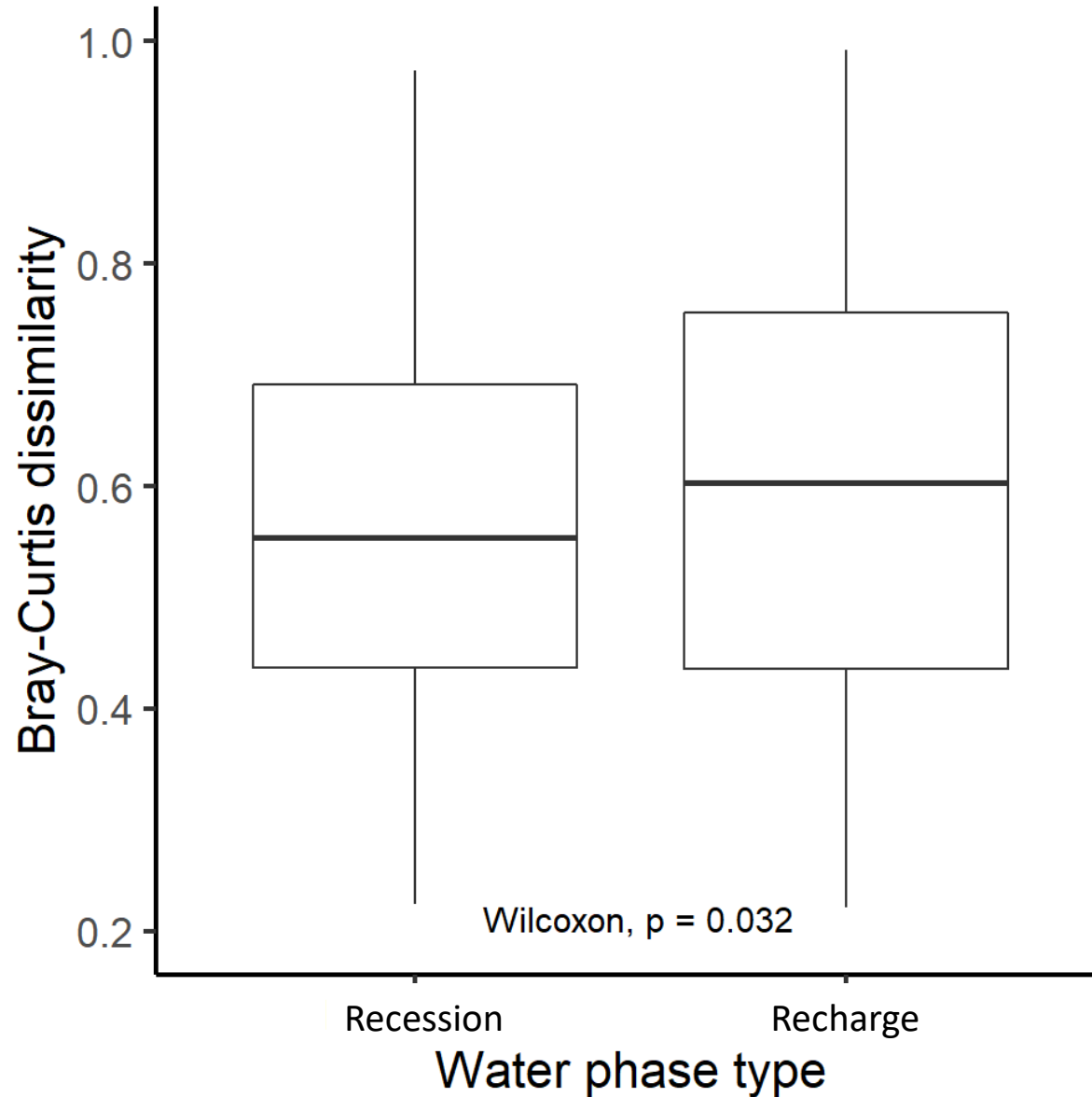


Above: Taxonomic composition of at the class level and the changes in community dissimilarity (Bray-Curtis distance) over time.

Result 2: Bacterial community compositional changes are driven by recharge and recession phases, which accounted for 39-42% of variation in microbiome composition



Left: PCoA showing the changes in bacterial community composition between recharge and recession phases and among different time periods and variance partitioning analysis results

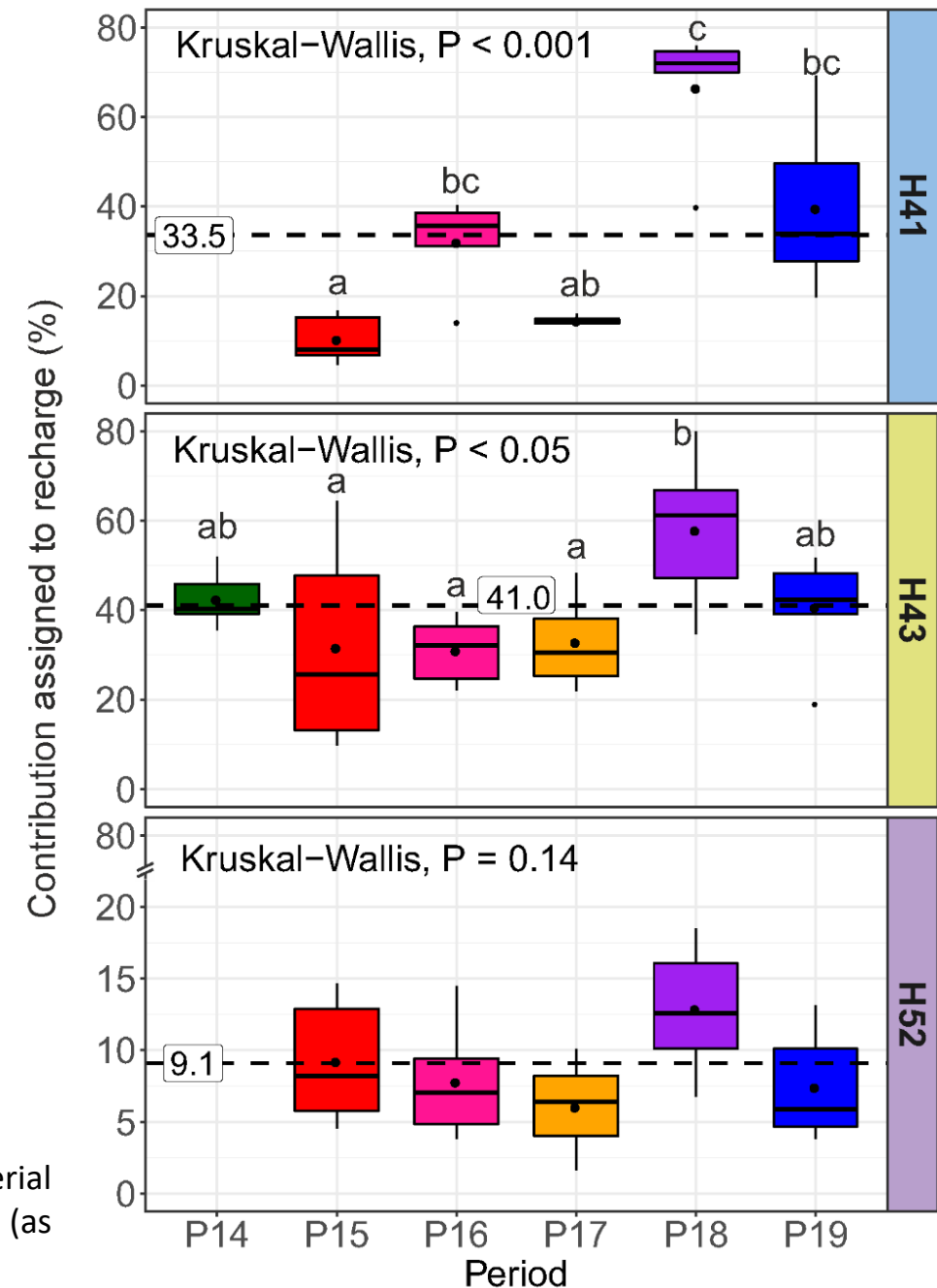


Result 3: Bacterial community composition changes more over the course of a single recharge phase than a recession phase

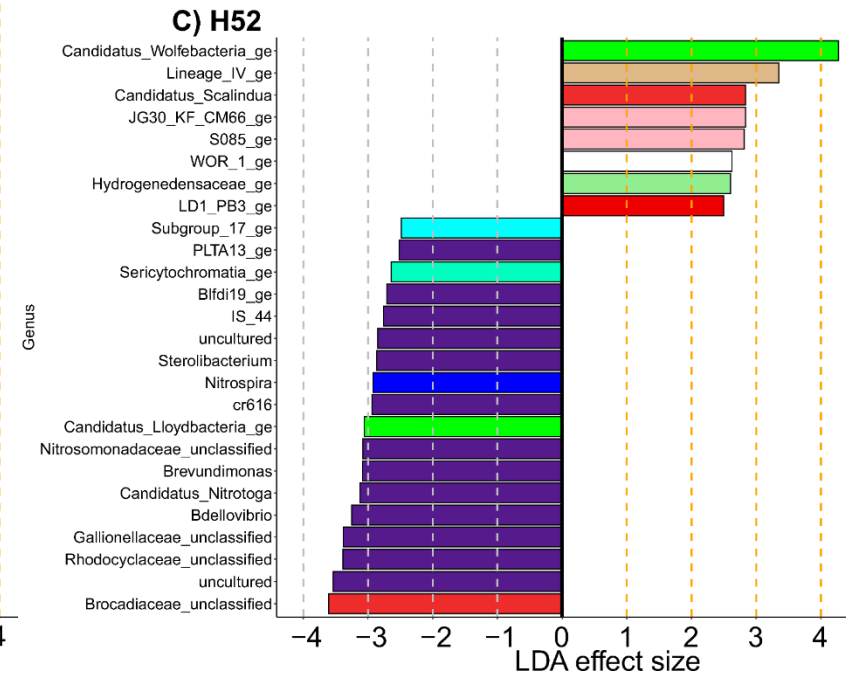
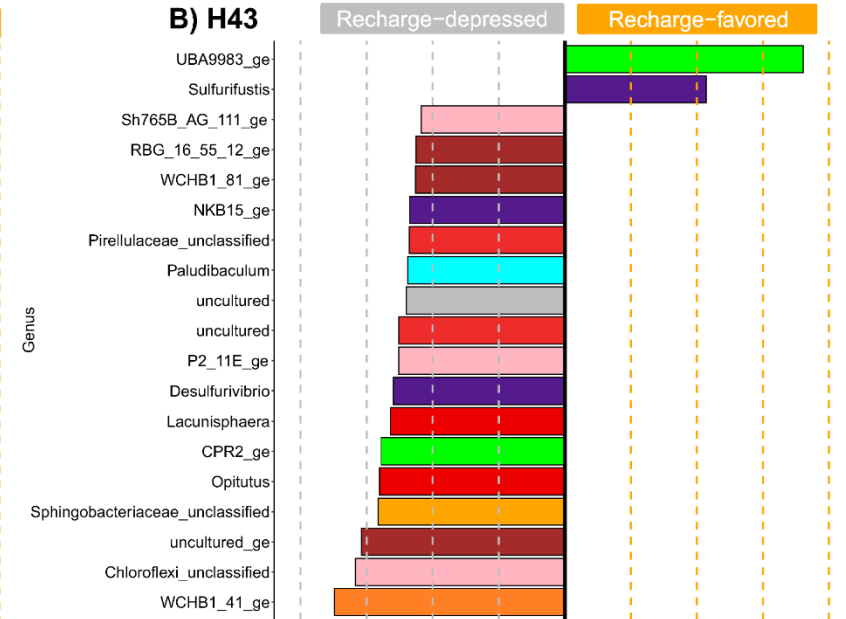
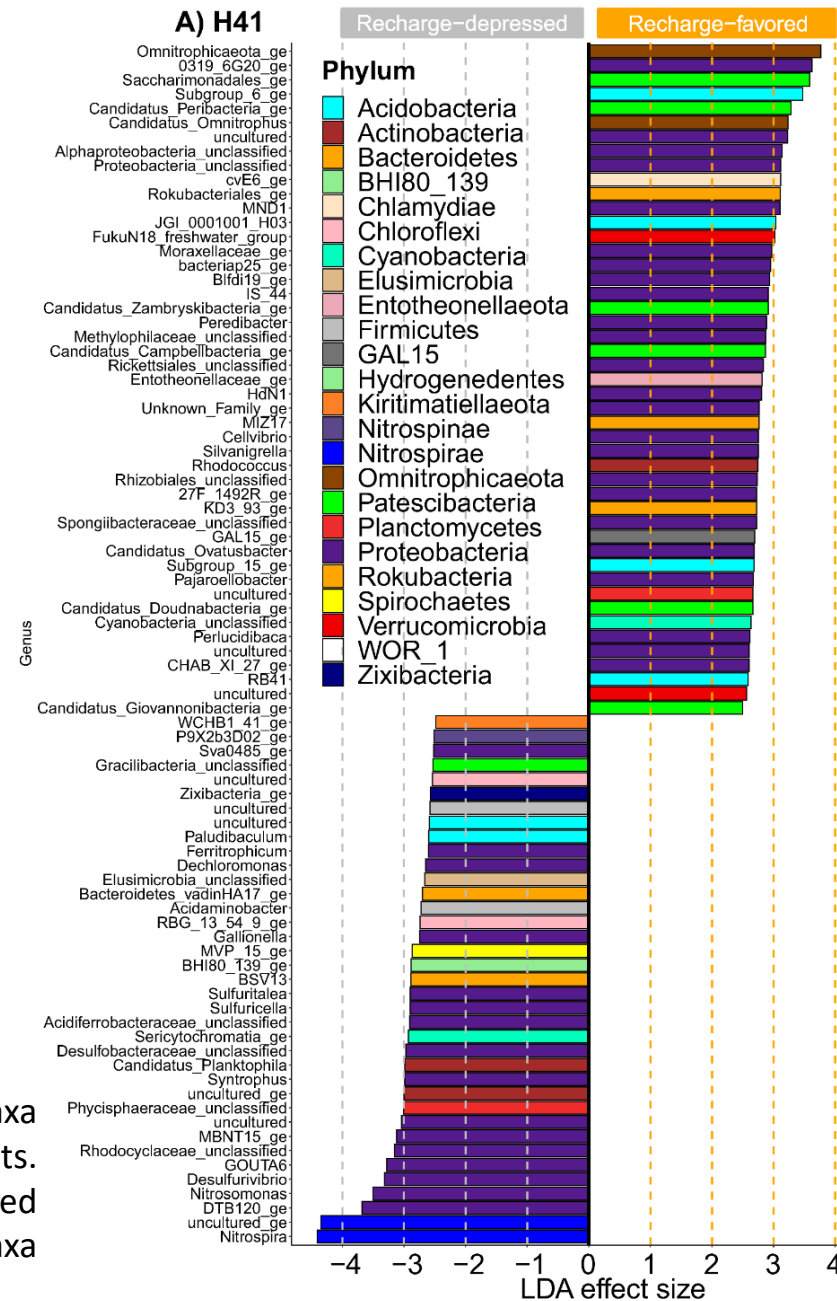
Left: The community dissimilarity between samples from the same recession or recharge event

Result 4: Recharge introduces new taxa into groundwater microbial communities. This was well dependent, and generally more taxa were introduced when water level changes were greater

Right: The proportion of taxa contributed to the bacterial communities during recharge in each defined period (as determined using FEAST analysis).



Result 5: Specific taxa are associated with recharge events



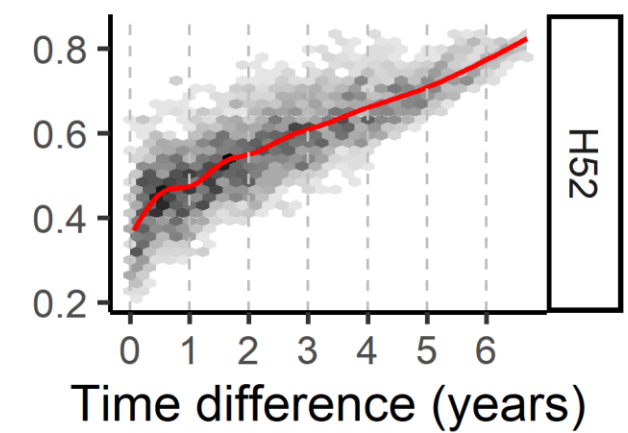
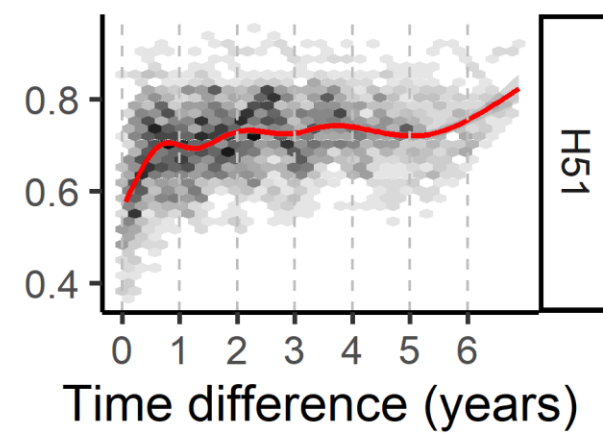
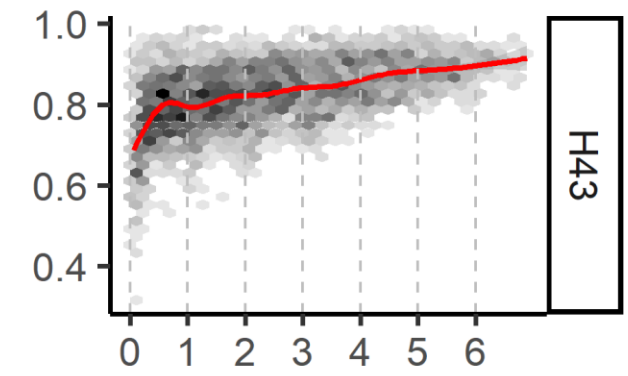
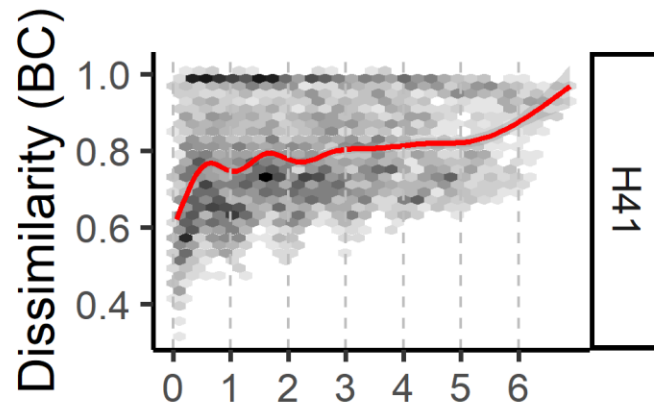
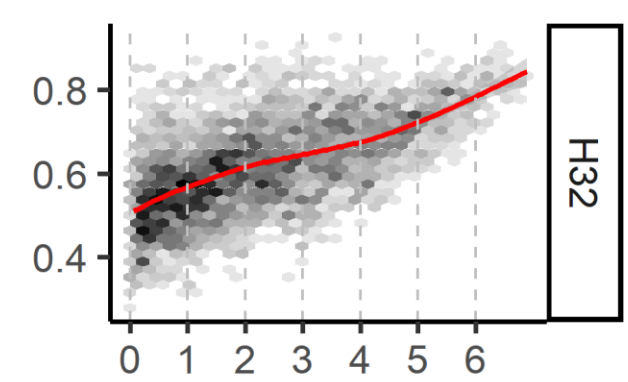
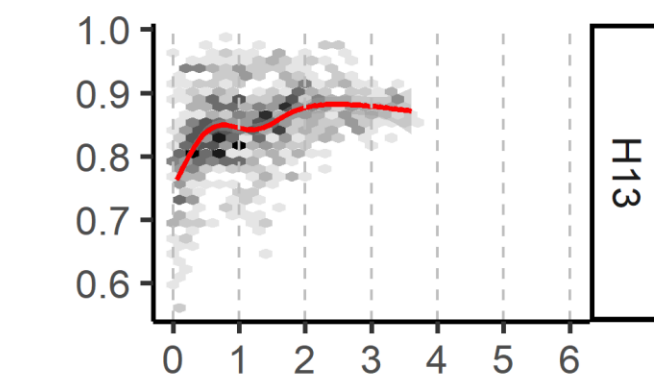
Right: Results from LefSe analyses showing which taxa were consistently associated with recharge events. 'Recharge-depressed' taxa were under-represented during recharge events, while 'recharge-favoured' taxa were over-represented.

Conclusions

- The discrete but recurring disturbances, in the form of groundwater recharge, are an intrinsic system property of near-surface groundwater microbiomes
- The oscillating patterns in community similarity was only observed when comparing bacterial communities sampled within three years of each other.
 - After this the temporal variation between samples was too great to observe the oscillating patterns, leading to decreased similarity to the initial state over time suggesting that community succession is occurring.
- Temporal patterns in groundwater microbiomes are driven largely by disturbance, in the form of recharge events which impose ‘shocks’ on the aquifer communities
 - Recharge events introduce surface derived taxa to the groundwater and result in a greater exchange with these rock surface attached communities

“To be continued...”

Preliminary investigations of additional wells in the Hainich CZE indicates consistent patterns overall, but with each well’s characteristics resulting in slight differences





New Results

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