Harmonizing Multiple Information Sources to Predict River Corridor Respiration at the Watershed Scale

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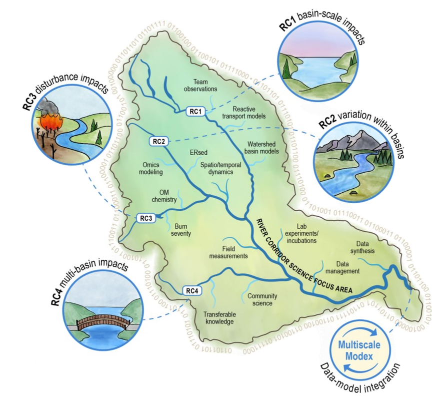
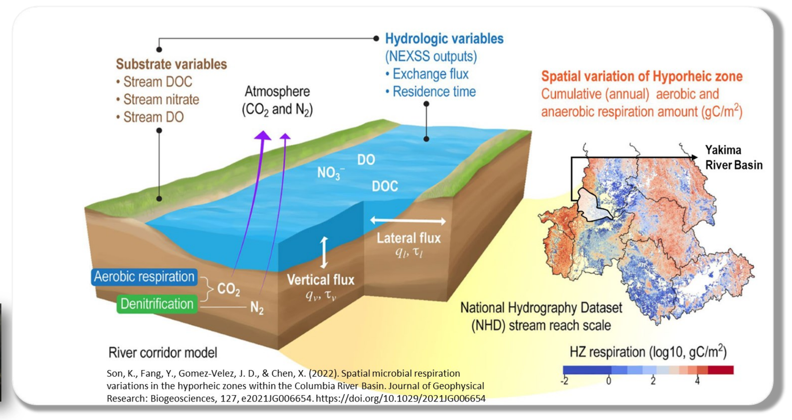


River corridors' metabolism

Rivers respire. Fluvial corridors continuously metabolize terrestrial and aquatic organic matter inputs and release CO_2 into the atmosphere. When observed at the reach scale, our respiration rate measurements directly indicate **biological activity**. Our data speak about watershed function when integrated across multiple spatial scales within a watershed.

Heterogeneous Information Sources: Data & Models



To better understand biological metabolic activity in streams and rivers we collect data in our *field campaigns*. We build *hydro-biogeochemical models* to better understand metabolic function at the watershed scale.

Harmonizing information sources to predict watershed function

While **ModEx 1.0** guides **data-model integration** through model calibration, sensitivity analysis, and experimental design, among other steps. **ModEx 2.0** broaden the integration scope toward the implementation of the **scientific method** via an iterative process of **testable hypothesis** formulation. Here, we use the Allometric Scaling Framework[1], to integrate data and model predictions at the level of organization principles of watershed function.

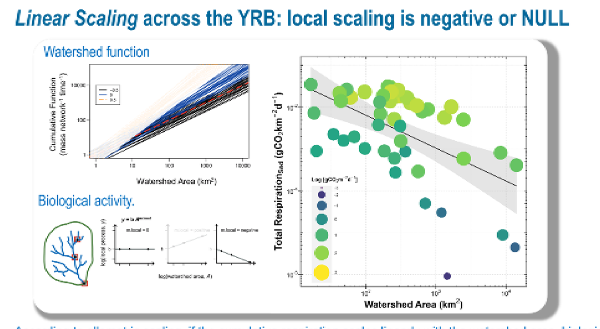
Both field data and model predictions suggest overarching control of physical processes on watershed scale respiration

The ModEx 2.0 Framework: Implementation of the Scientific Method

We formulate hypotheses about local scaling relationships that can be tested against data from the spatial study

Testable Hypotheses

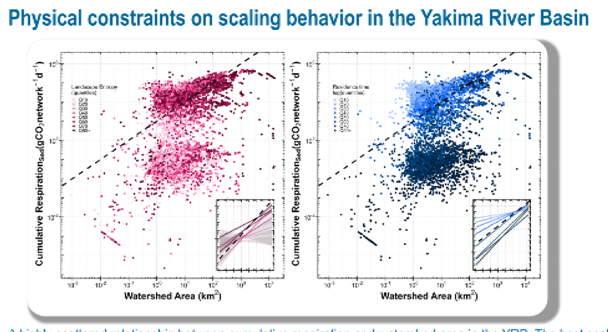
Linear Scaling across the YRB: local scaling is negative or NULL



According to allometric scaling, if the cumulative respiration scales linearly with the watershed area, biological activity rates could only have slopes = < 0. As it is shown by predicted respiration at local sampling sites.

Since our best prediction for the YRB would be linear scaling, that implies that **local scaling** relationships can **only be null (no slope) or negative**, as shown for predicted values for local respiration rates at the **spatial study locations**.

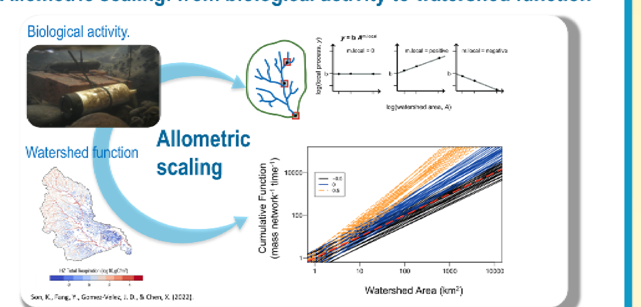
Physical constraints on scaling behavior in the Yakima River Basin



A highly scattered relationship between cumulative respiration and watershed area in the YRB. The best scaling relationships can only be found within data grouped by residence time, corresponding to linear scaling.

We use **predictions from the RCM** to calculate cumulative respiration across the watershed and explore scaling relationships. At best, **scaling would be linear**, suggesting **overarching control of physical processes** on metabolism.

Allometric scaling: from biological activity to watershed function



Allometric scaling provides a conceptual framework to formulate hypotheses linking local measurements of stream metabolic activity with model predictions for watershed scale metabolic function.

According to allometric scaling theory, if **physical processes exert overarching control** on metabolism, cumulative respiration rates would increase **linearly** with watershed area. Alternatively, **biological dominance** over respiration rates results in **superlinear scaling**

We interpret River Corridor Model's predictions using allometric scaling to formulate new hypotheses about Watershed function

Spatial Study

Field study measuring whole ecosystem respiration at 48 sites across the Yakima River Basin. A great deal of potentially explanatory contextual data was also collected.Field

ModEx 1.0

Mechanics of Data-Model Integration

River Corridor Model

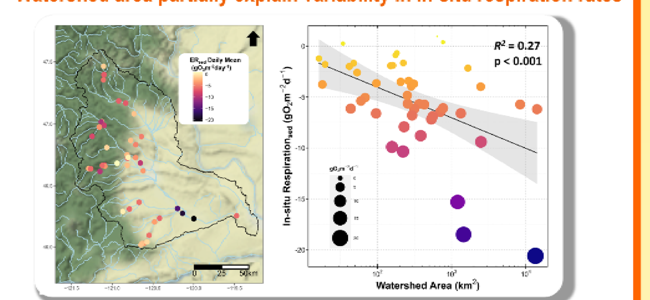
The RCM combines empirical substrate models derived from observations and three microbially driven reactions to compute the respiration of the HZ. In the YRB, the water exchange rate between the channel and riverbed can explain the spatial variation of CO2 emissions over other physical variables.

We use observations from the spatial study to explore local scaling relationships across the Yakima River Basin

Testable Hypotheses

An **apparent local scaling** between respiration rates and watershed area. The slope will be positive if respiration rates are expressed as positive O2 consumption, suggesting **potential superlinear scaling of watershed function.**

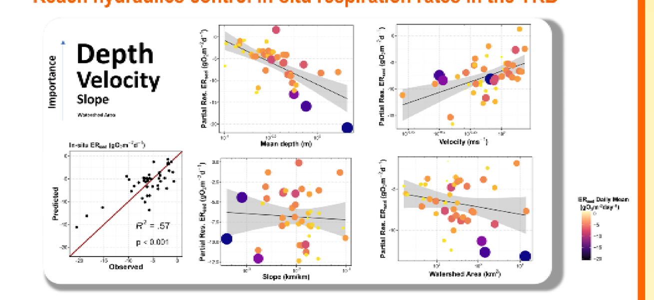
Watershed area partially explain variability in in-situ respiration rates



In situ respiration rates (measured as **negative** oxygen consumption) seem to increase with watershed area across sampling locations for the spatial study.

However, regression analysis indicates that the **apparent effects of watershed scale** on respiration rates are **mostly due to** physical changes in **water depth and velocity.**

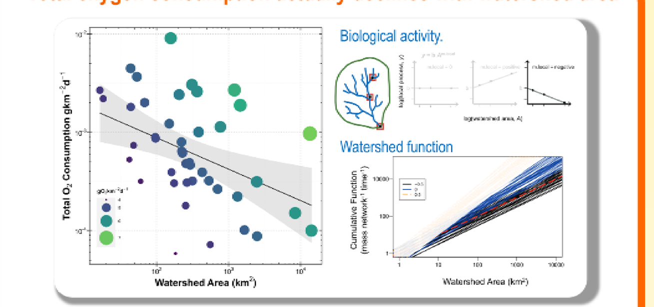
Reach hydraulics control in-situ respiration rates in the YRB



In-situ respiration rates are strongly influenced by water depth and velocity. Larger scale variables like slope and watershed area may play a lesser role after accounting for hydraulic variables.

After normalizing total oxygen consumption rates (positive) by watershed area, **the local scaling slope** becomes **negative**, indicating that the **expected scaling** of watershed function would **be linear**, as predicted by the RCM.

Total oxygen consumption actually declines with watershed area



In situ respiration rates (measured as **positive** oxygen consumption) decrease with watershed area, suggesting that the expected scaling behavior for cumulative respiration rates would be linear.

We formulate a new hypothesis about the scaling of watershed function in the YRB from local scaling relationships

Important Findings

Running a ModEx 2.0 example cycle within the context of Allometric Scaling, we found agreements (in the form of testable hypotheses) between predictions from the River Corridor Model (RCM) and the field data from the sampling campaign across the Yakima River Basin. The common working hypothesis is that channel hydraulics is one of the most important drivers of the entire ecosystem's respiration. This finding highlights the importance of building robust products to physically characterize stream reaches across the watershed.

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