Modelling ecosystem metabolism at the scale of entire river networks

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Why model metabolism at the network scale?

- Ecosystem metabolism (EM), the sum of gross primary production and ecosystem respiration is a key ecosystem function in rivers
- In situ measurements of light, temperature, and dissolved oxygen are needed to study EM in the field
- Existing single and two-station models integrate EM for relatively short stream segments
- Thus, although sensor prices are dropping, data requirements for measuring EM at all points in a river network remain prohibitive

Objective: **develop a model estimating EM at all points in a river network, calibrated from a reasonable number (n < 100) of sampling stations dispersed through the network**

A multiscale ecosystem metabolism model

Local Scale

Diel dissolved oxygen varies as a result of three processes, which are in turn affected by local conditions:

-Gross primary productivity (GPP)

-Ecosystem respiration (ER)

-Reaeration

Reach Scale

Parameters influencing the local processes vary according to

-The ecological community (total biomass, community composition, diversity)

-Stream physical properties (e.g., velocity, slope)

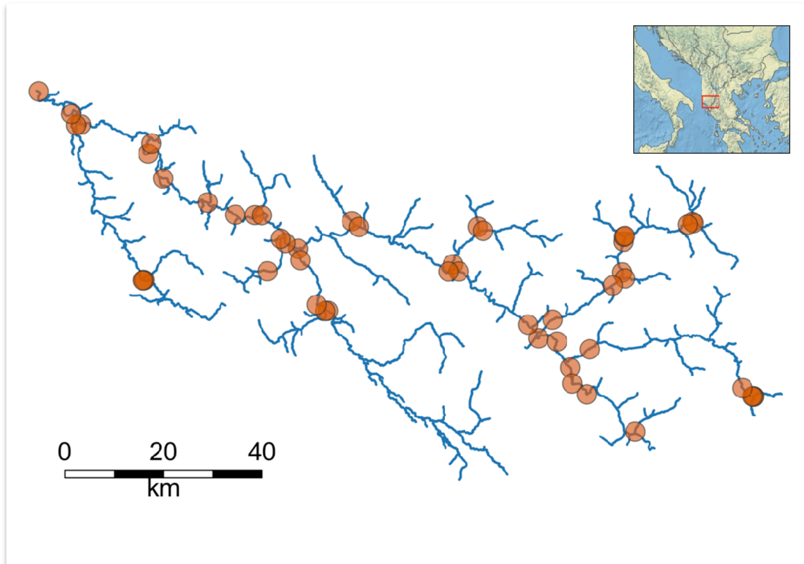
Subcatchment Scale

At broader scales, we can allow for landscape context, including geology, land use, and other spatial variables to influence local-scale parameters

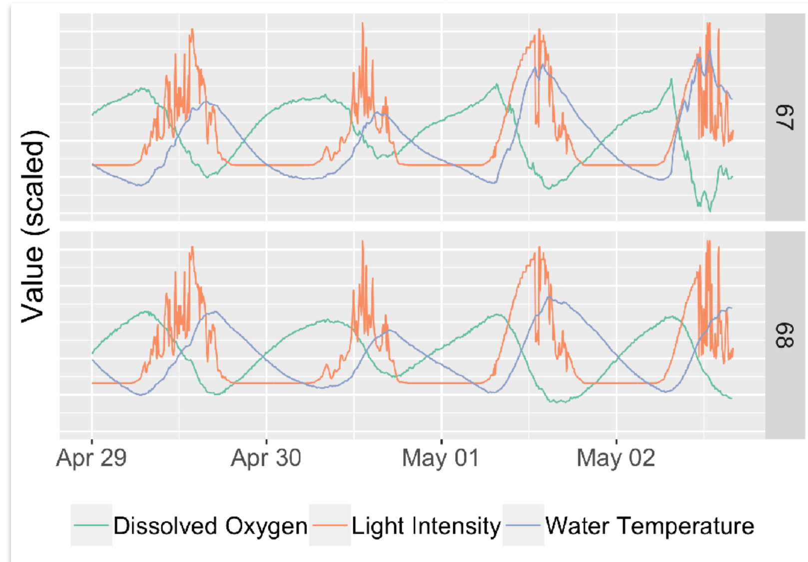
Whole-catchment Scale

Whole-catchment primary production and respiration (in units of mg O_2 m^{-2} day^{-1}) is computed as the average of the local estimates

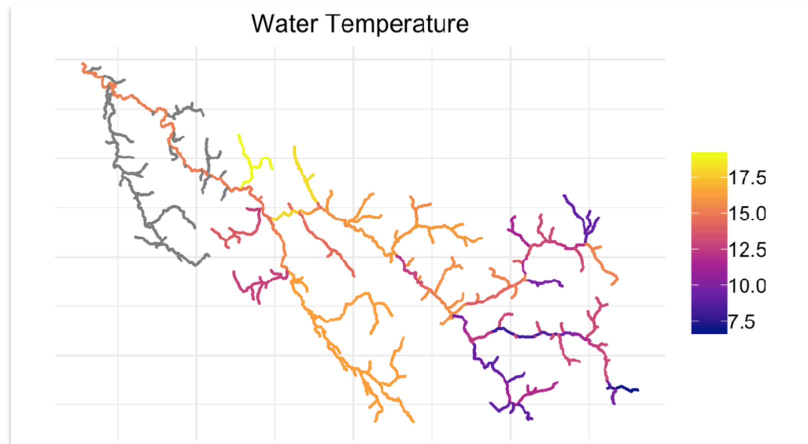
Data flow

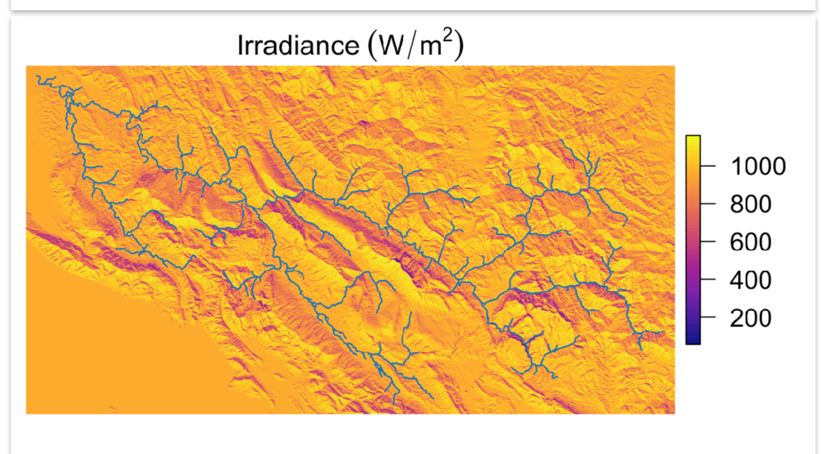


- A catchment-wide network of sampling stations, with sensors at each station



- Stations produce local measurements of light, dissolved oxygen, and water temperature





- Upscaling and interpolation then produce catchment-wide models for water temperature and light
- Dissolved oxygen is inferred by transport-reaction model

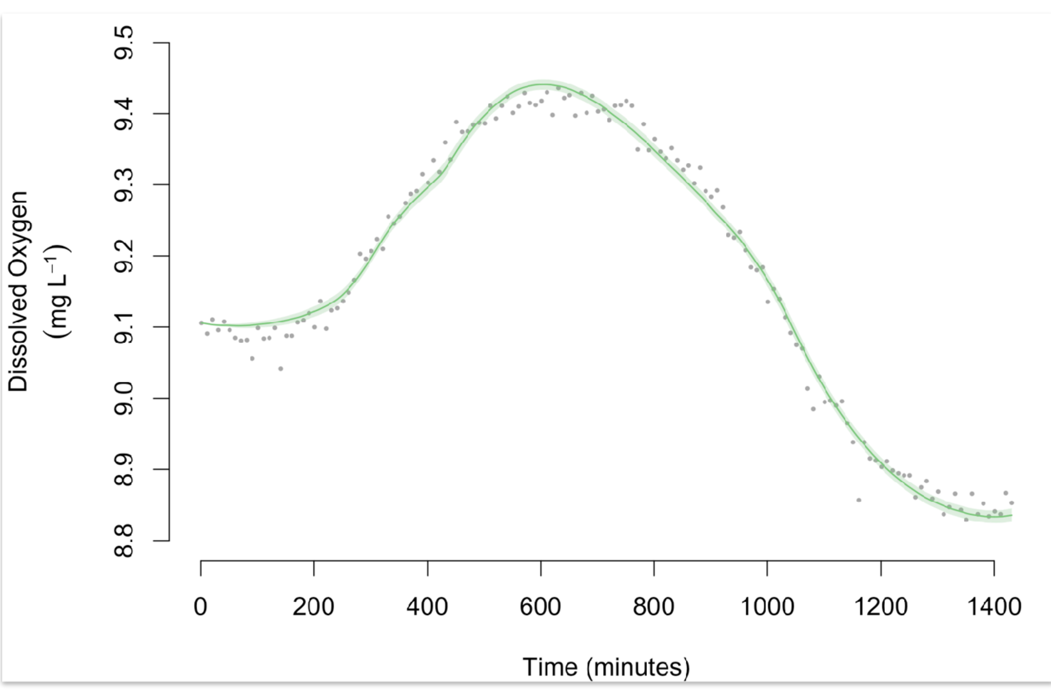
Output

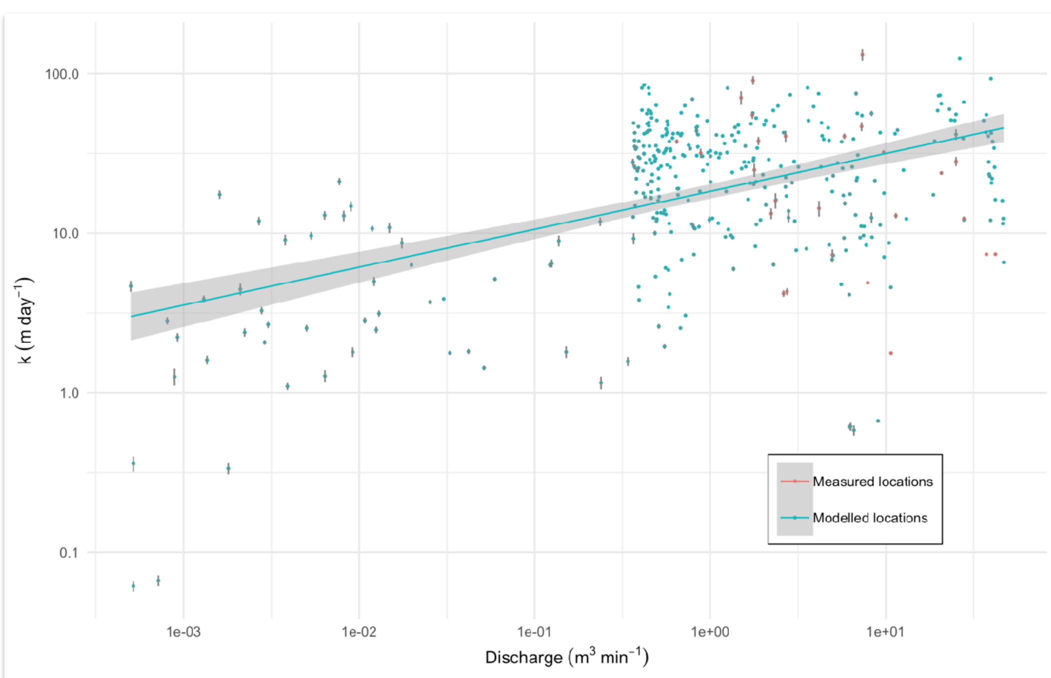
LOCAL
Diel estimated dissolved oxygen concentration at all points in the catchment

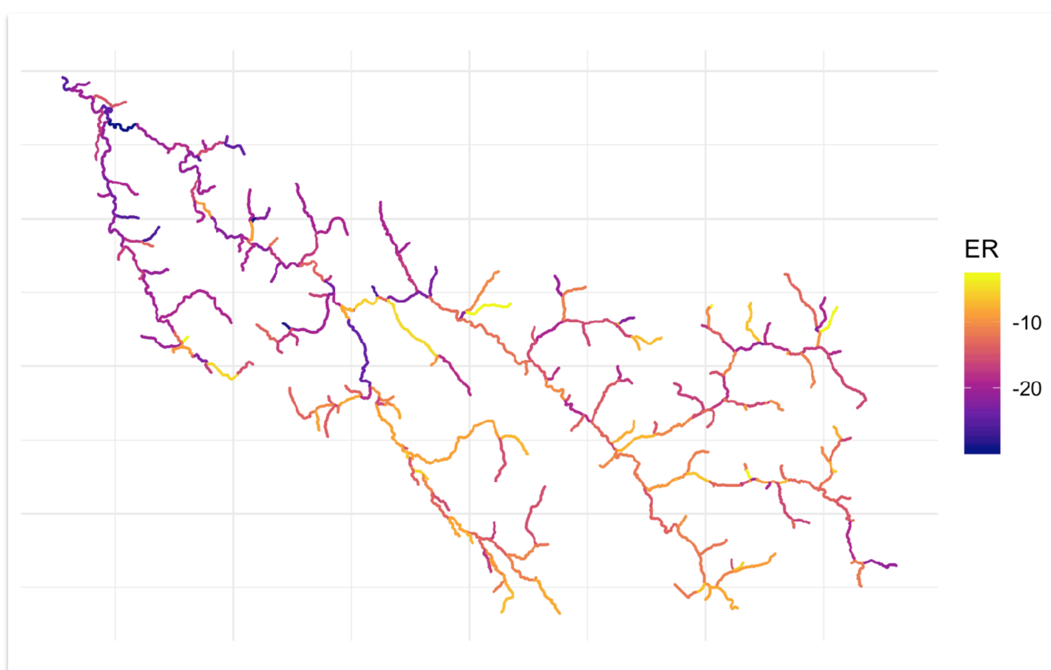
REACH
Relationships between environment and GPP, respiration, and reaeration parameters

WHOLE CATCHMENT
Spatial variation in primary production and ecosystem respiration (in mg O_2 m^{-2} day^{-1})

Whole-catchment estimates (in kg O_2 day^{-1})







Software

WatershedTools: An R-package for managing the data flow and spatial representation

NSmetabolism: For calibration of the whole-catchment (i.e., n-station) ecosystem metabolism model

Model Status

- ☑ Design
- ☑ Data Flow
- ☑ Prototyping
- ☐ Fast implementation
- ☐ Release

About

The Fluvial Ecosystem Ecology Group @IGB
We study spatial relationships among the environment, biodiversity, and ecosystem function in fluvial ecosystems

Matthew V. Talluto
I am a macroecological modeller; I combine statistical and process-based models to better understand biodiversity at large spatial scales.

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GEFÖRDERT VOM Bundesministerium für Bildung und Forschung

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