The Influence of Climate Change Scenario Formulation on Sediment Load Projections

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Precipitation-Driven Catchment Dynamics: Why Climate Models Define the Outcomes

Core question: How do different climate model projections shape rainfall patterns used in hydrological modeling, and what is their effect on predicted sediment transport?

Why it matters:
Precipitation is the main driver of surface runoff and sediment transport, especially under erosion-prone mountainous conditions.
Model resolution and projection frameworks significantly **influence predictive accuracy** and environmental planning.

Wypych, A., Wilk, P., Szalińska, E., & Orlińska-Woźniak, P. (2023, May). **Precipitation driven river catchment changes-how the climate models determine the results (the example from Polish Carpathians).** In *EGU General Assembly Conference Abstracts* (Vienna, Austria).

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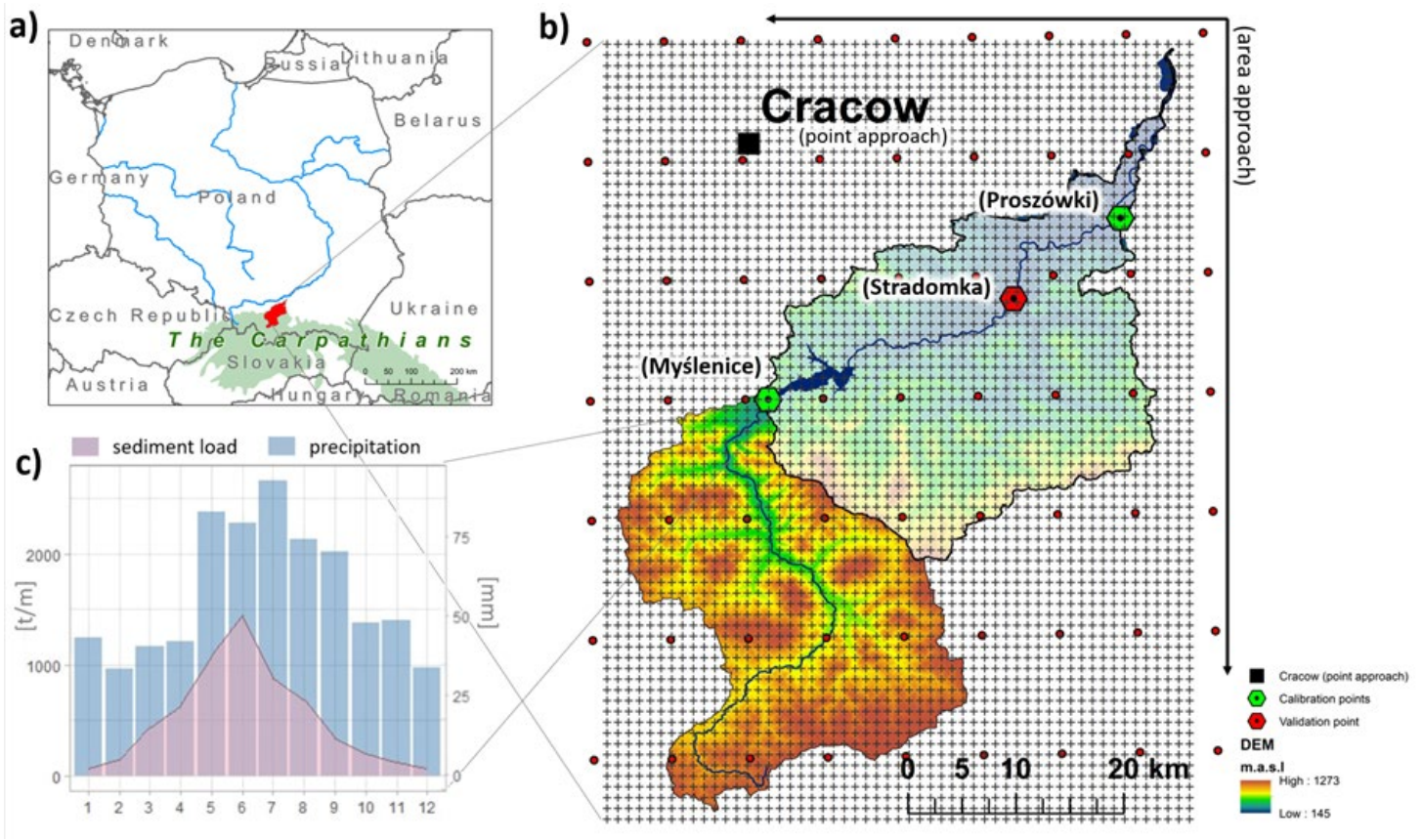
- Here we present a set of sediment load assessments for a catchment in the Carpathian Mountains representing the specificity of Central European climate, where the variability of weather and climate conditions is significant, dependent on prevalence and intensity of maritime or continental factors.



How Much Do We Really Know About Future Erosion?

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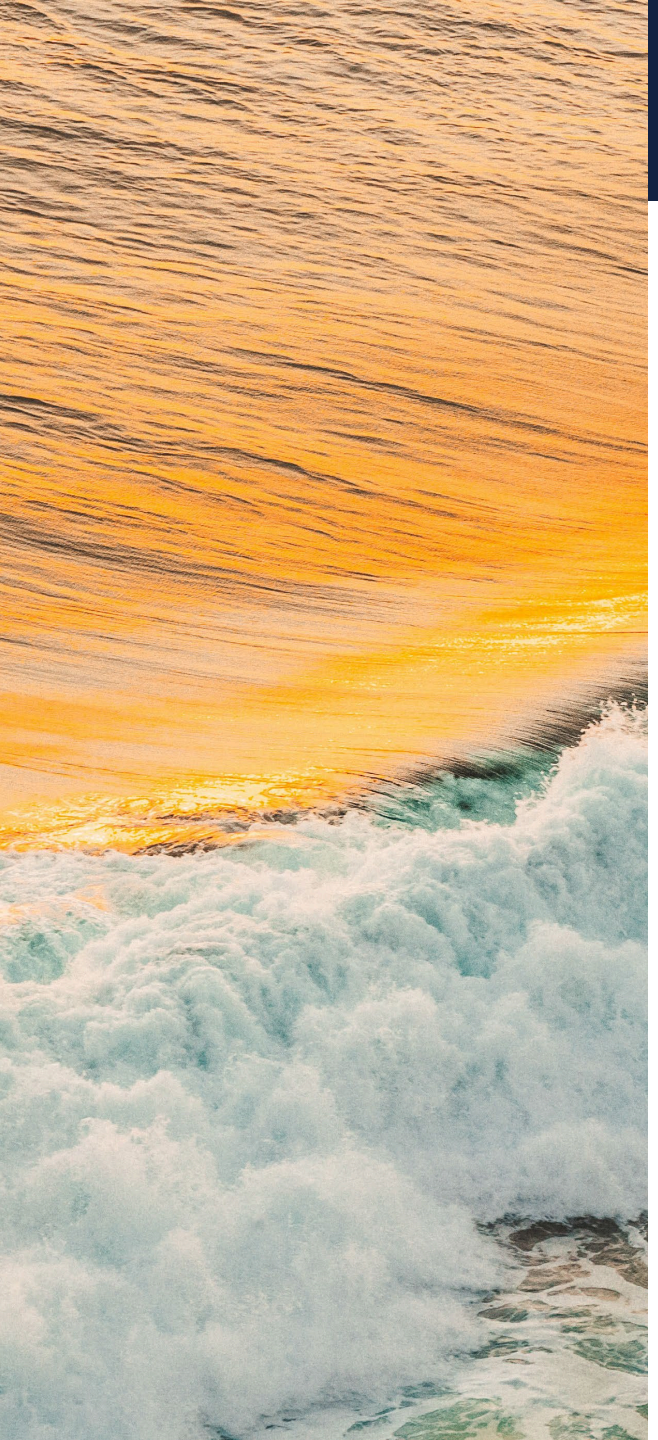
- Study Context

Catchment: Upper Raba River (Western Carpathians, Poland)
Area: 768 km²
Elevation: 780 m to 265 m
Highly responsive to rainfall
Problem: sediment yields vary greatly with climate input
Goal: quantify how scenario selection impacts sediment load predictions

- Baseline Simulation Results

Average annual sediment load: ~6,000 tons/year
Monthly variability: 64 to 1,444 tons/month
Peak loads in May–July with >70 mm precipitation
Implication: rainfall variability = sediment yield variability



Climate Change Scenario Formulation

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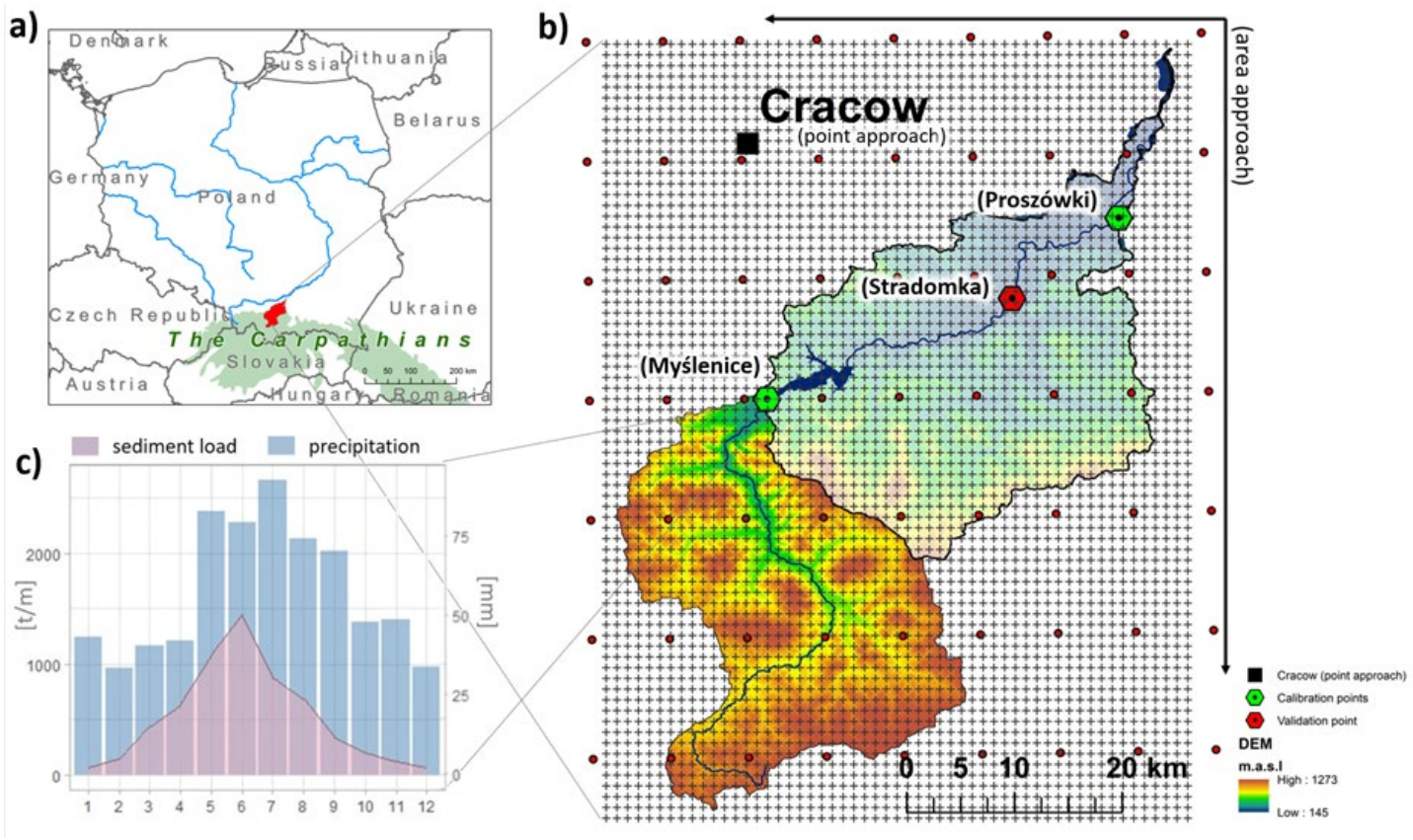
1. Precipitation data source (point vs. grid)
2. Reference period length (10 vs. 30 years)
3. Climate model ensemble (wet vs. dry biases)

→ Each introduces significant uncertainty in sediment load projections

The Influence of Climate Change Scenario Formulation on Sediment Load Projections

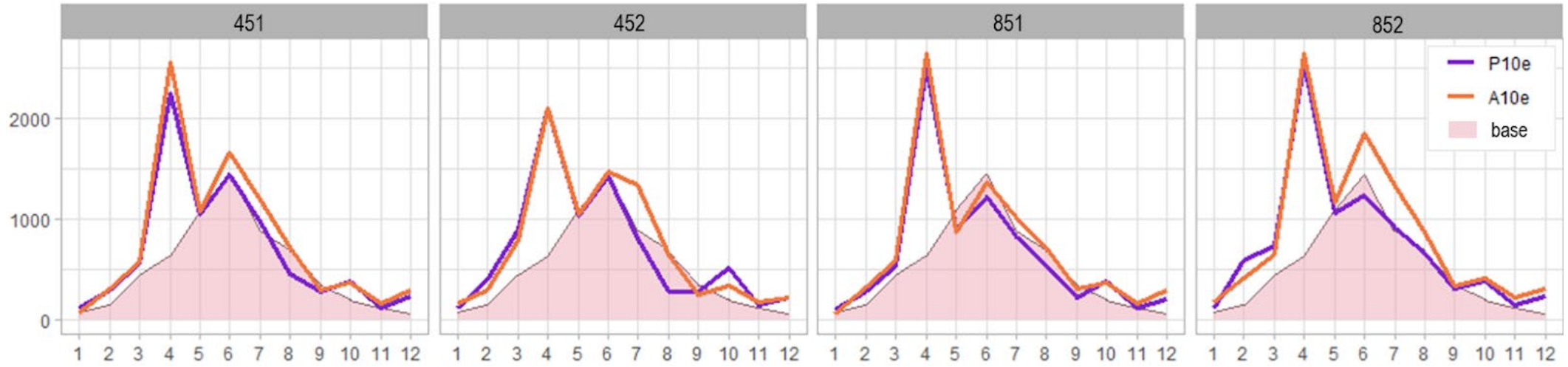
Team:



Pitfalls:

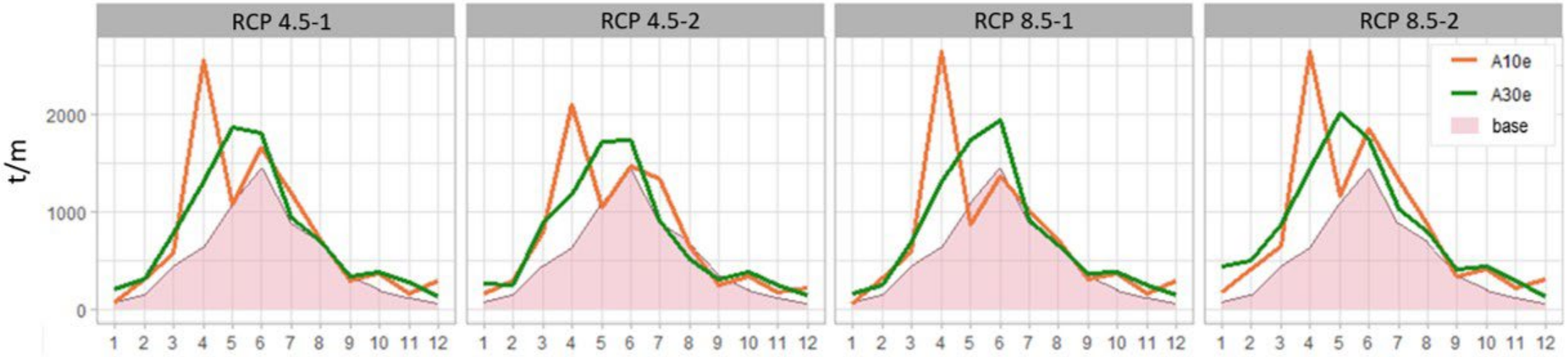
- the issue of climate change data source based on comparison of future loads on forecasts prepared for a single meteorological station (point approach), and for grid points over the catchment area (areal approach);
- impact of reference periods (10- vs. 30-year long) applied in both approaches;
- rainfall performance in particular models constituting the model ensemble to depict a possible range of simulated sediment loads during dry and wet conditions.

- Point-based: single meteorological station
  - Station outside of the modeled catchment, the distance to the model simulation cross-section and elevation difference were in between the World Meteorological Organization's (WMO) guidelines.
- Areal-based: gridded data over catchment
- 10 years reference period
- April peaks

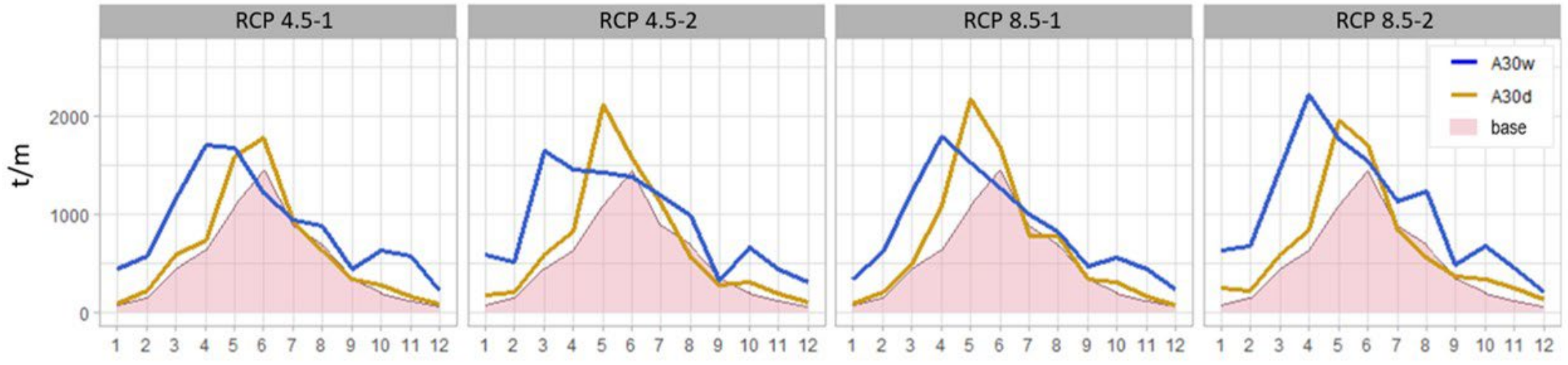


Standard: 30 years (WMO guidelines)
Shorter periods (10–20 yrs) used due to data limitations
Result: inconsistent baseline, exaggerated anomalies

- both scenarios approx 4,000 t - differed from each other only by approx. 2%
- the monthly distribution of sediment loads turned out to be distinctly different
- the average precipitation for the month of April in the period of 2006-2015 was lower by almost 42% when compared to 1981-2010.
- the delta change rates of sediment reached 90% and 35% in the near and far future projections, respectively



Identified dry vs. wet sub-ensembles
Difference in sediment loads: >3,000 tons/year
Moisture bias largely ignored in many hydrologic impact studies



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Scenario-Induced Range of Sediment Loads

- Near Future (2026–2035) vs. Far Future (2046–2055)
- RCP 4.5 vs. RCP 8.5
- Resulting load differences: 3,000–6,000 tons/year
- large differences in monthly loads (up to 2,000 tons) are also visible in selected months.
- All rainfall-driven parameters affected

Why This Matters

- Sediment load affects reservoir capacity and flood risk
- Inaccurate predictions → misinformed water management policies
- Integration of reliable climate data is essential

Conclusion –> integration steps?

It is generally accepted that current changes in the climate system and those expected in the future will increasingly have significant impacts on ecosystems.

Since adaptation plays a key role in reducing risks and vulnerability from these changes, the need for reliable assessments of their impacts on the environment is drastically growing.

The results of climate, and consequently of catchment models, are increasingly becoming the basis for shaping water policy and management for the upcoming decades.

Take-home message

- Small changes in climate input = big differences in outputs
- Data source, reference period, and ensemble choice all matter
- Toward more transparent and integrated erosion modeling practices

A Call for Integration

- Climate scientists and environmental modelers must collaborate
- Regional-specific climate impact ensembles needed
- Shared standards

The influence of climate change scenarios selection on sediment load variability simulation in the Carpathian mountain catchment

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Sediment load assessments under climate change scenarios and a lack of integration between climatologists and environmental modelers

Ewa Szalińska ✉, Paulina Orlińska-Woźniak, Paweł Wilk, Ewa Jakusik, Petr Skalák, Agnieszka Wypych & Jeff Arnold

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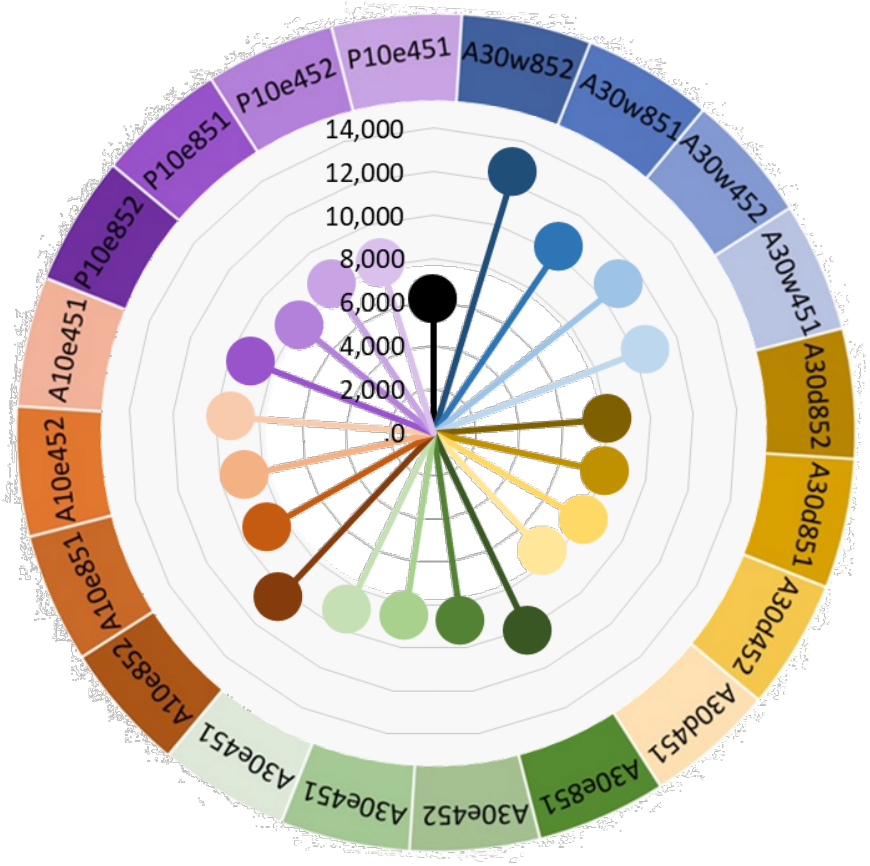

Thank you

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