The implications of soil erosion model conceptualization, bias correction methods and climate model ensembles on soil erosion projections under climate change

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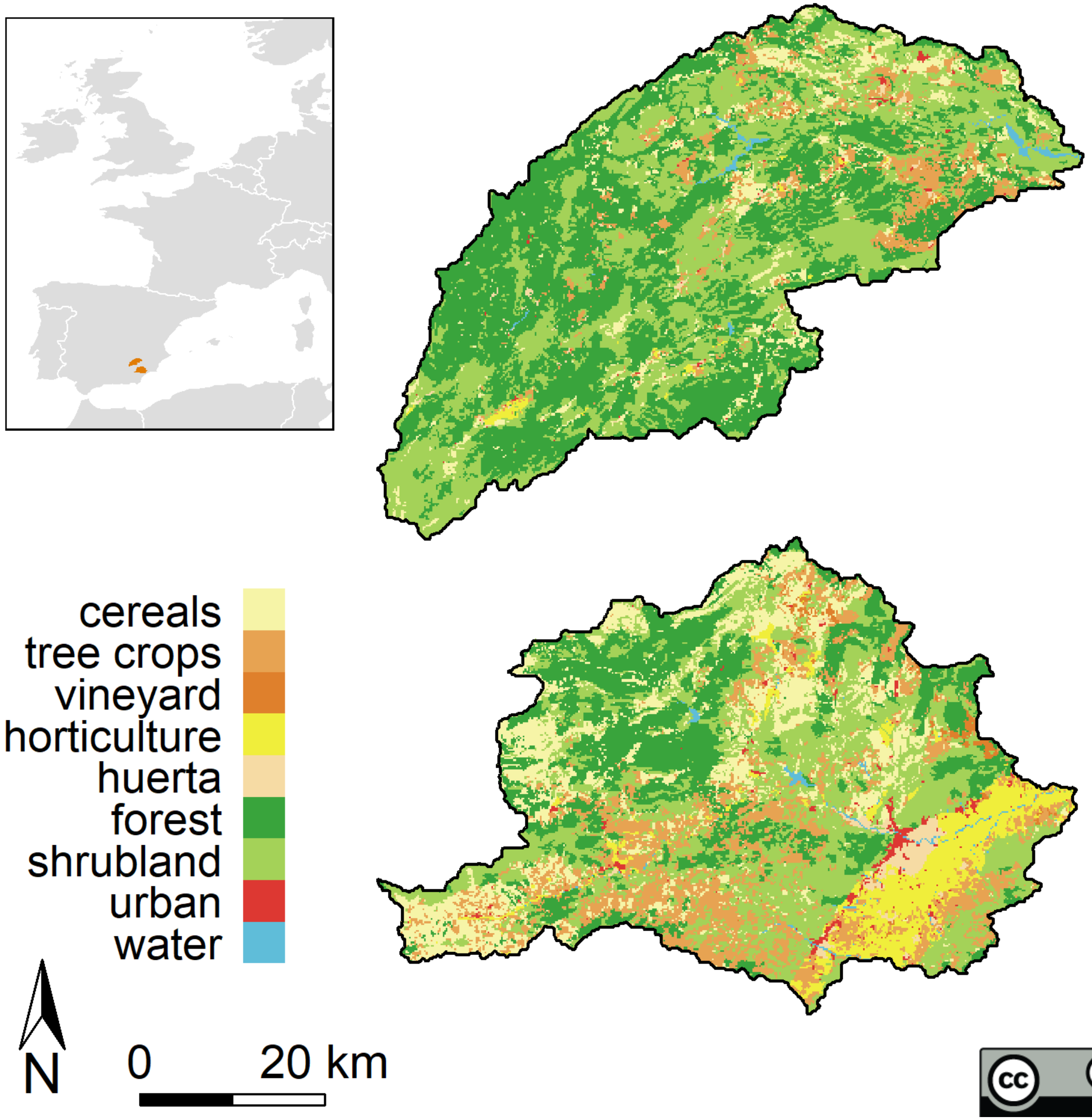
We performed a **literature review** on catchment-scale (> 10 km^2) soil erosion projections under climate change:

- **94 articles** were published on this subject since 1995
- Assessments were performed in **32 countries**, covering all continents
- From small to large catchments (up to 2300000 km^2)

This presentation focusses on the results and implications of three important sources of uncertainty: **soil erosion model concepts**, **bias-correction methods** and **size of climate model ensembles**.

The implications of these aspects were tested in two equally sized catchments that differ in **climate** (Mediterranean vs. semi-arid) and **land cover** (natural vs. agricultural).

Climate change in these two catchments is expected to lead to a **decrease in annual precipitation**, but an **increase in extreme precipitation**, based on the raw climate model output.



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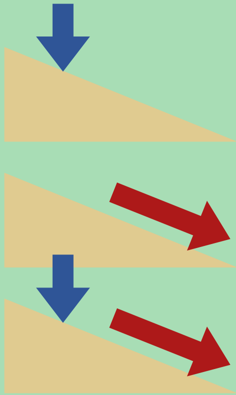
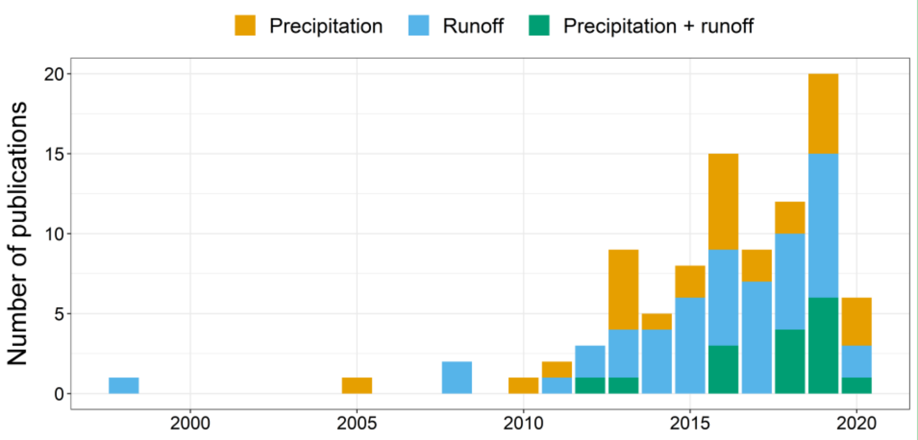
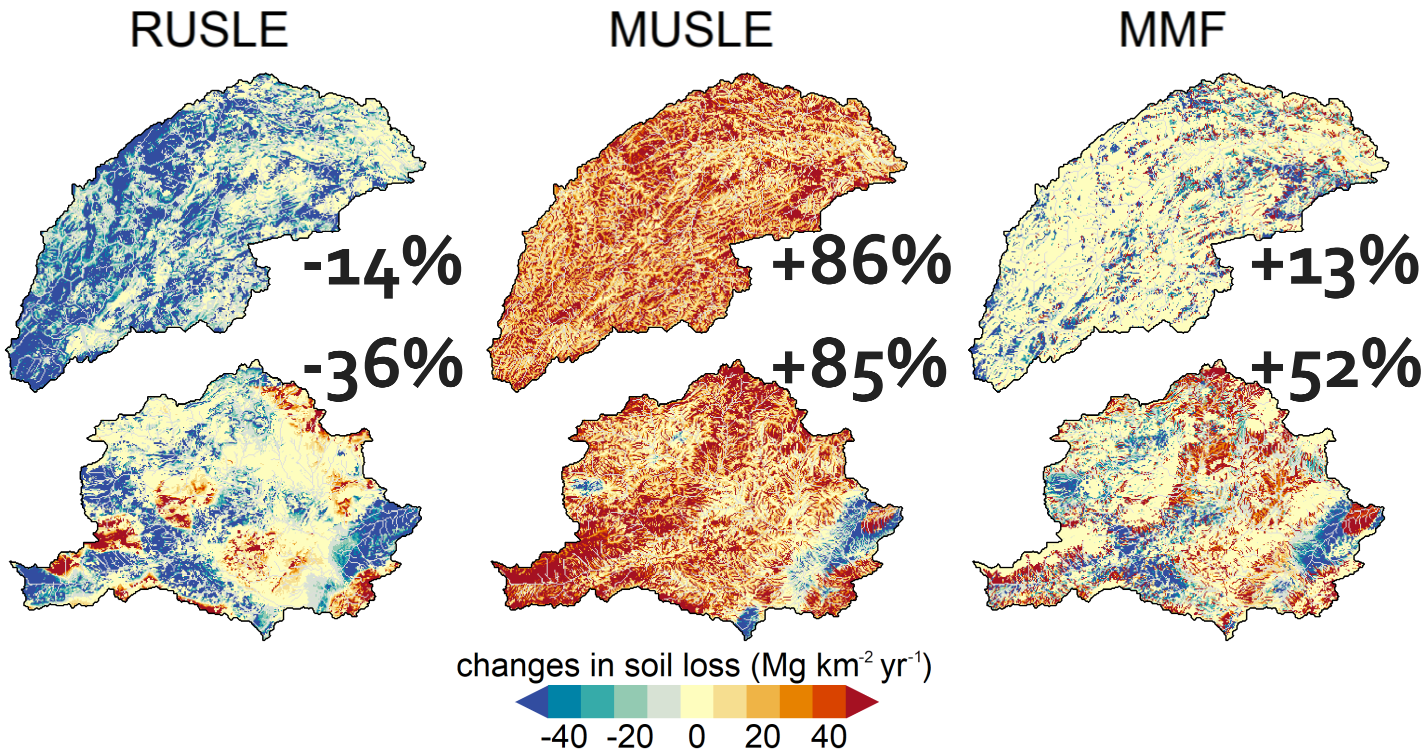
Soil erosion model conceptualization

We identified 3 main soil erosion model concepts:

- Forced by **precipitation** in 29 studies (e.g. USLE, **RUSLE**, EPM)
- Forced by **runoff** in 49 studies (e.g. CAESAR, PESERA, STREAM, SWAT (**MUSLE**), TETIS)
- Forced by **precipitation and runoff** in 16 studies (e.g. EUROSEM, MEFIDIS, SHETRAN, **SPHY-MMF**, WEPP)







Eekhout & de Vente (2020), Prog. Phys. Geogr., 44 (2): 212-232 (doi: 10.1177/0309133319871937)

We selected **three models**, each representing a model concept, which were applied to the two catchments under the **RCP8.5** scenario for the period **2081-2100**.

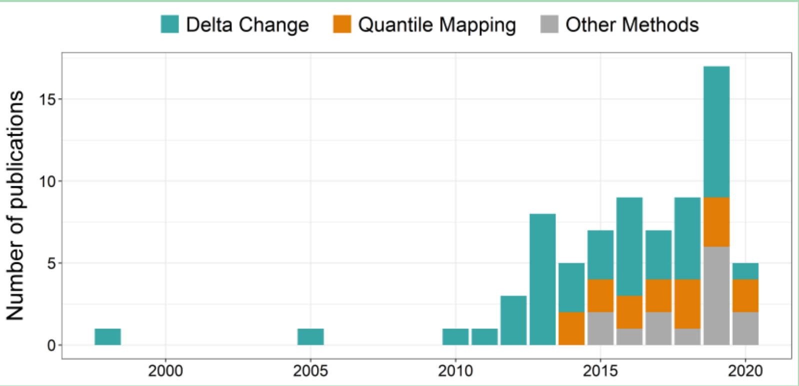
- RUSLE projects a **decrease** of soil loss, which is a result of the decrease of precipitation sum
- MUSLE projects a large **increase** of soil loss
- MMF projects a **mixed** result, where **detachment by raindrop impact** show large similarities with RUSLE and **detachment by runoff** with MUSLE

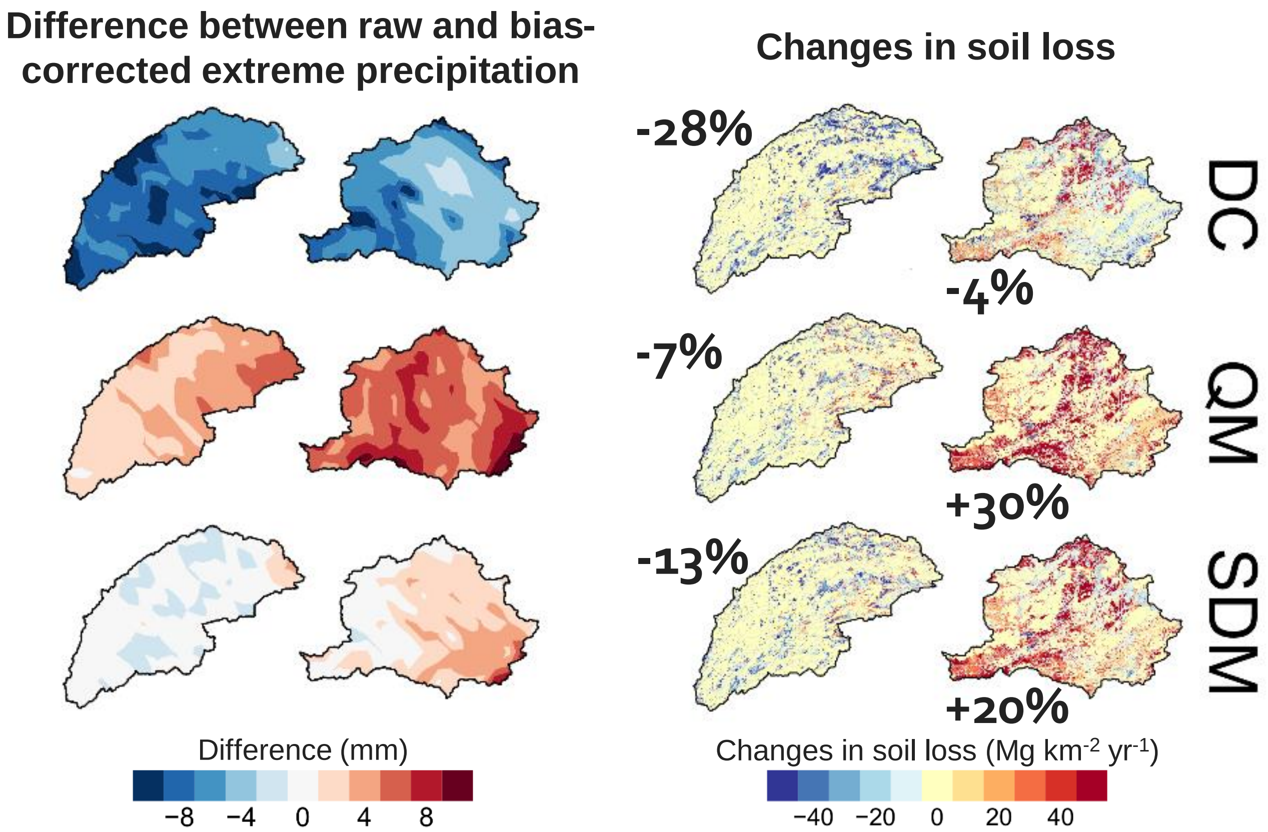
We conclude that in case of **opposing** changes in precipitation sum and extreme precipitation, soil erosion is **best** assessed with a soil erosion model that if forced by both **precipitation and runoff.**

Bias correction methods

Climate models produce a bias between the historical model output and observations, which can be corrected by applying bias correction methods. We identified the 3 main bias correction methods used in the literature:

- **Delta change (DC)** in 44 studies
- **Quantile mapping (QM)** in 16 studies
- **Other methods** in 15 studies, including **scaled distribution mapping (SDM)**, detrended quantile mapping, distribution mapping





Eekhout & de Vente (2019), Earth Surf. Process. Landf., 44 (5): 1137-1147 (doi: 10.1002/esp.4563)

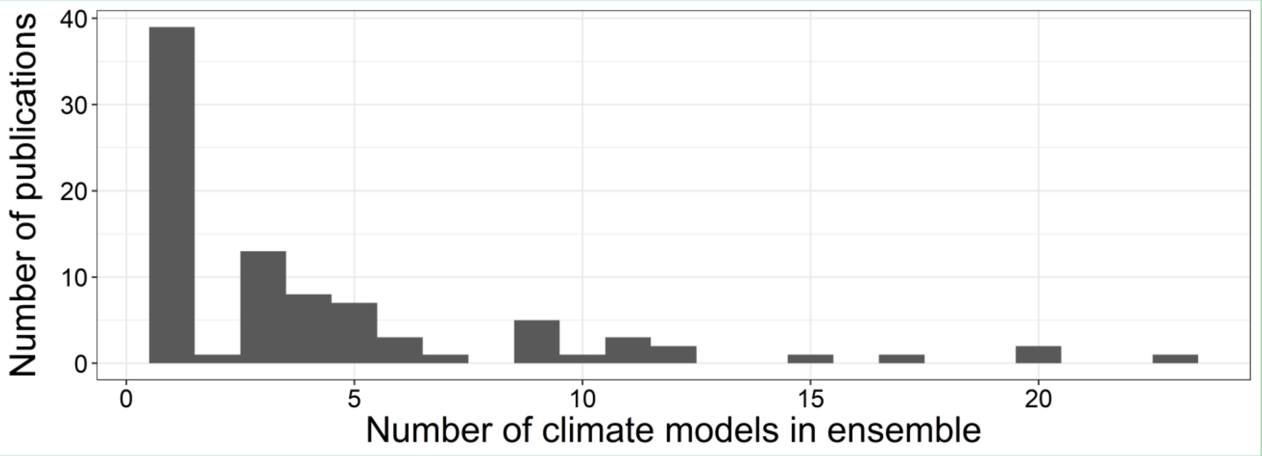
We selected **three bias correction methods**, which were applied to the two catchments under the **RCP8.5** scenario for the period **2081-2100**.

- DC leads to an **underestimation** of extreme precipitation and subsequently to a decrease in soil loss
- QM leads to an **overestimation** of extreme precipitation and an strong increase in soil loss in one of the catchments
- SDM is shows the **smallest deviation** from the raw climate projections, leading to a **mixed** result with respect to the other two bias correction methods

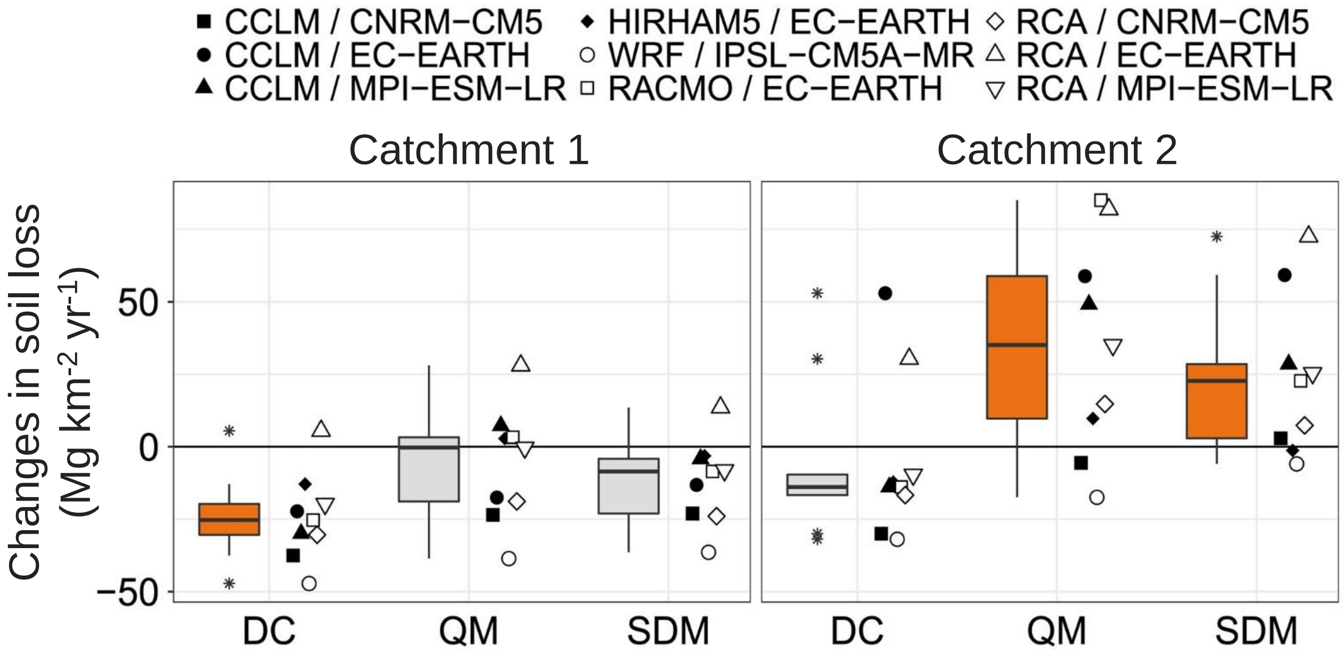
We conclude that the impact of climate change on soil erosion can only **accurately** be assessed with a bias correction method that **best** reproduces the **projected climate change signal**.

Climate model ensembles

- Climate model output is a **source of uncertainty** in climate change impact studies.
- Many climate change assessments on soil erosion apply only **one climate model** and, therefore, most likely do not sufficiently account for **climate model uncertainty**.



Uncertainty among climate models and bias-correction methods



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We included an ensemble of **9 climate models** (GCM/RCM combinations from EURO-CORDEX), to account for differences in projected changes in the climate variables. The orange fill in the box plots indicates a significant change ($p < 0.05$).

Even when projected changes in soil loss were classified as **significant**, individual climate models projected a change **opposite** to the ensemble average.

We conclude that **climate model ensemble** predictions consisting of **sufficient** climate models are needed to assess the impact of climate change on soil erosion.