Calibration of a semi-distributed hydrological model adding constrains from remotely sensed snow cover and soil moisture products

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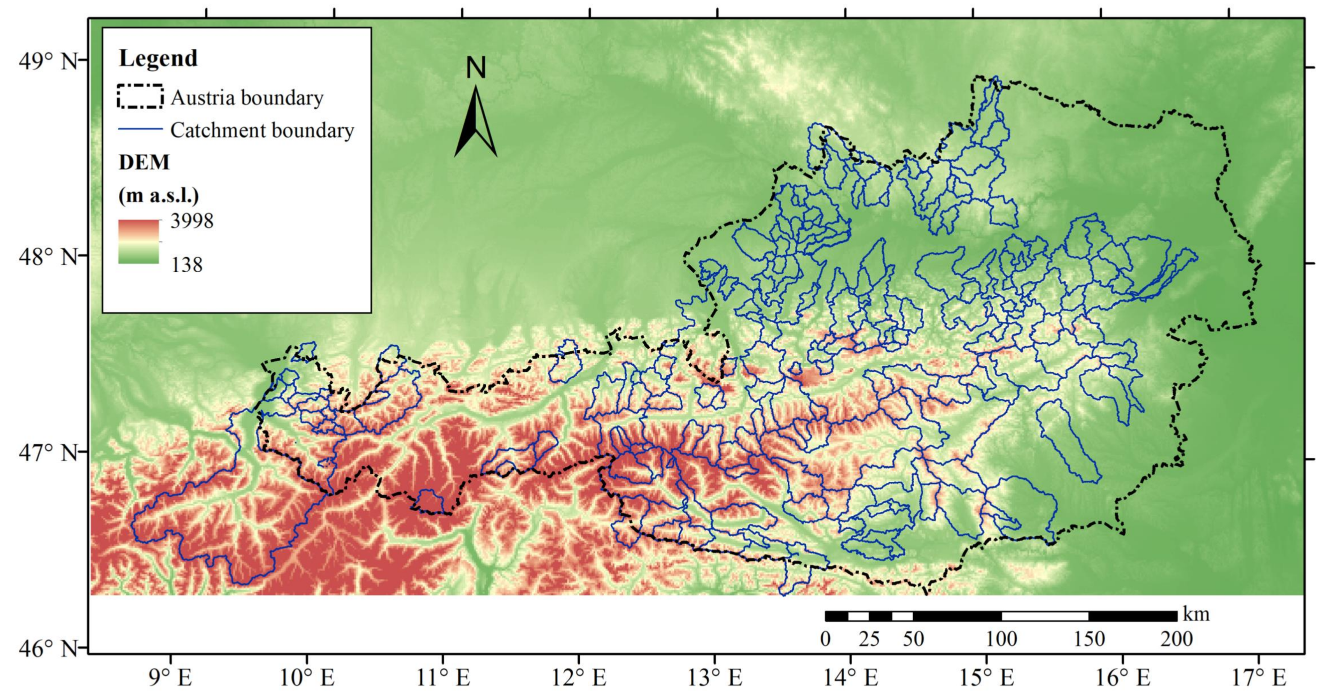
INTRODUCTION

Objectives of the work

- ✓ to investigate what is the potential of new S1ASCAT soil moisture for calibration of conceptual hydrologic model
- ✓ to compare the model performance with multi-objective calibration using satellite MODIS snow cover and combined satellite soil moisture and MODIS snow cover

STUDY AREA AND MODEL



Austria is located in the eastern part of the Alps, with elevation ranging from 115 to 3797 m a.s.l. from flat or undulating eastern and northern area to the mountainous western and southern alpines regions. The territory is about 84,000 km^2. Mean annual precipitation varying less than 500 mm/a in the East and almost 3000 mm/a in the West. This study is carried on 213 catchments, mostly in Austria, within which the hydrological processes are not obviously changed by anthropogenic influence. The area of the catchments varies from 13.7 to 6214 km2. The 213 catchments locate in both Alpine mountainous regions and flat land area, mean elevation ranges from 353 to 2940 m a.s.l..

TUWMODEL

A semi-distributed conceptual hydrological model

Details in: Parajka et al. (2007) DOI:10.1002/hyp.6253;

R package available: https://cran.r-project.org/web/packages/TUWmodel/.)

METHODS

OBJECTIVE METRICS

Streamflow

$$NSE = 1 - \frac{\sum_{i=1}^{n}\left(Q_{obs,i} - Q_{sim,i}\right)^2}{\sum_{i=1}^{n}\left(Q_{obs,i} - \overline{Q_{obs}}\right)^2} \qquad (1)$$

$$NSE_{\log} = 1 - \frac{\sum_{i=1}^{n}\left(\log(Q_{obs,i}) - \log(Q_{sim,i})\right)^2}{\sum_{i=1}^{n}\left(\log(Q_{obs,i}) - \overline{\log(Q_{obs})}\right)^2} \qquad (2)$$

$$ME_Q = w \cdot NSE + (1-w) \cdot NSE_{\log} \qquad (3)$$

Soil moisture

$$R_{soil} = \frac{\sum_{i=1}^{n}\left((\theta_{sim,i} - \overline{\theta_{sim}})(\theta_{obs,i} - \overline{\theta_{obs}})\right)}{\sqrt{\sum_{i=1}^{n}\left((\theta_{sim,i} - \overline{\theta_{sim}})^2(\theta_{obs,i} - \overline{\theta_{obs}})^2\right)}} \qquad (8)$$

Snow

$$A_t = \sum_{i=1}^{N_{days}}\sum_{j=1}^{N_{zones}} p_{i,j} \cap (SCA_{i,j} >= 0) \qquad (4)$$

$$OE = \frac{1}{A_t}\sum_{i=1}^{N_{days}}\sum_{j=1}^{N_{zones}} A_{i,j} \cap (SWE_{i,j} > \xi_{SWE}) \cap (SCA_{i,j} = 0) \qquad (5)$$

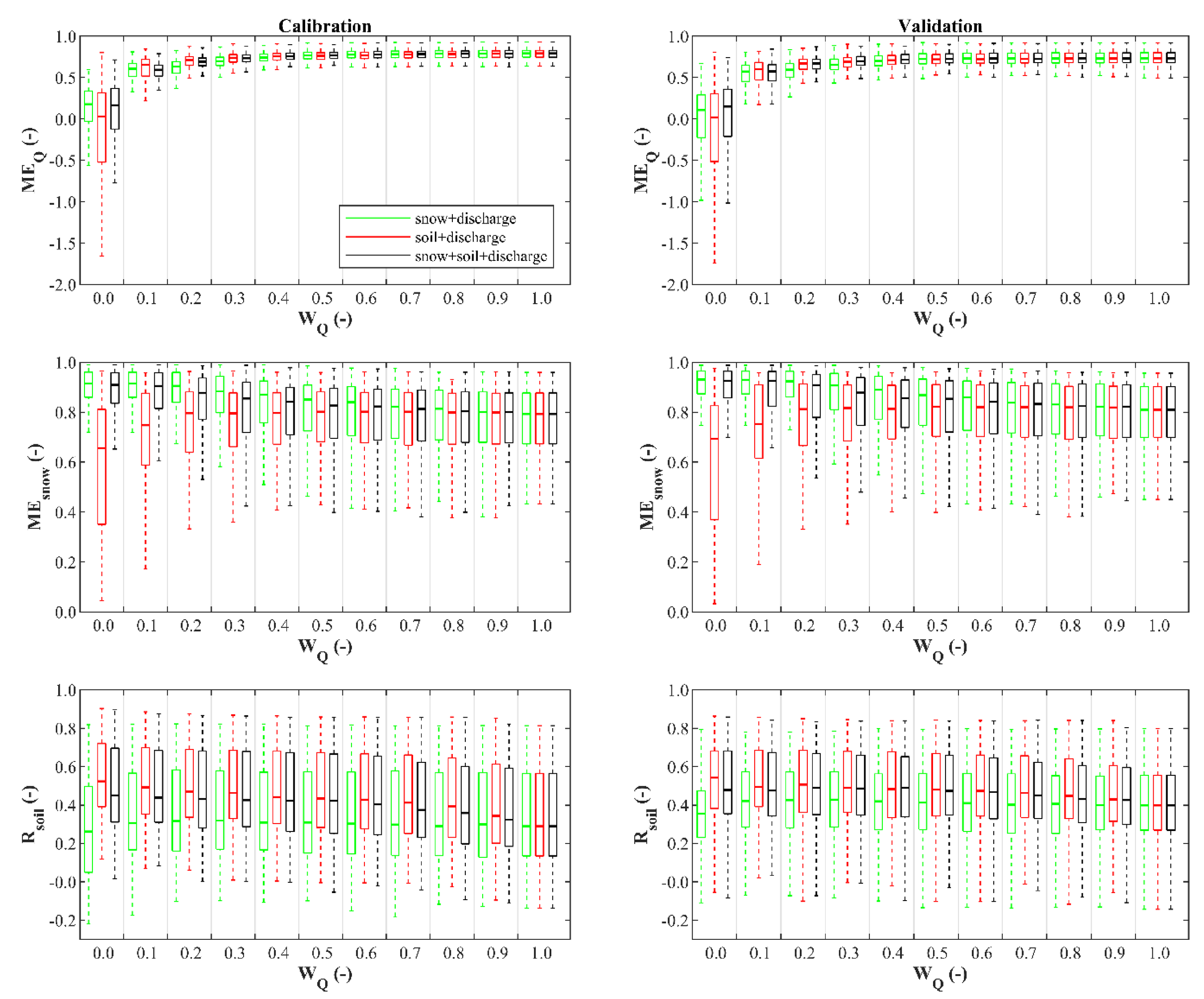
$$UE = \frac{1}{A_t}\sum_{i=1}^{N_{days}}\sum_{j=1}^{N_{zones}} A_{i,j} \cap (SWE_{i,j} = 0) \cap (SCA_{i,j} > \xi_{SCA}) \qquad (6)$$

$$ME_{snow} = 1 - (OE + UE) \qquad (7)$$

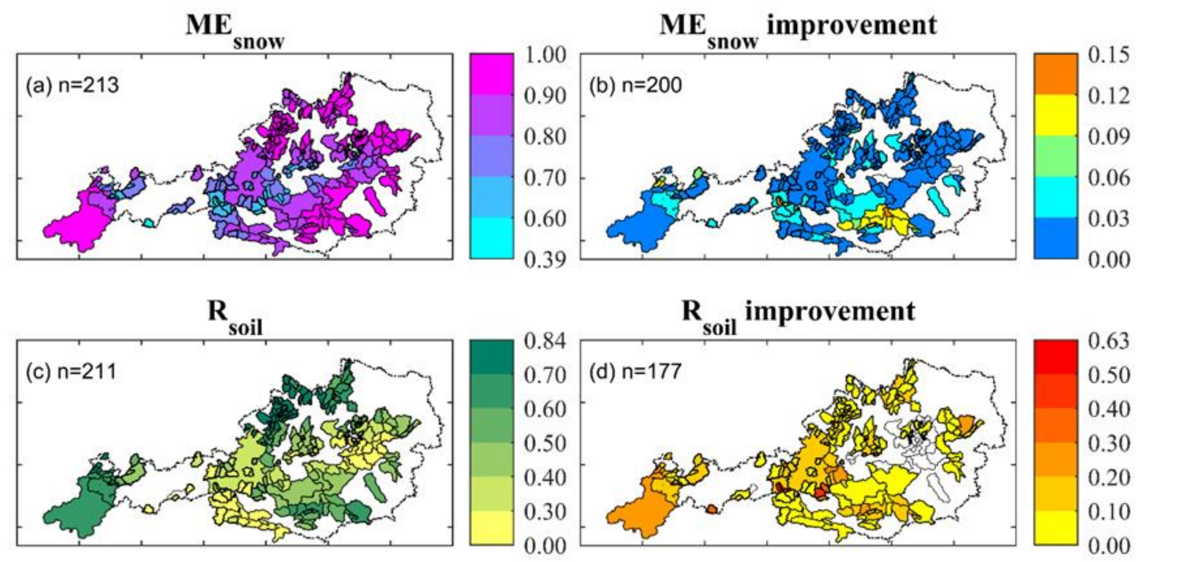
Multiple objective function

$$F_{multi} = w_Q \cdot ME_Q + w_{snow} \cdot ME_{snow} + w_{soil} \cdot R_{soil} \qquad (9)$$
$$w_Q + w_{snow} + w_{soil} = 1$$

RESULTS



Model efficiency of runoff (ME_Q, upper panel), snow cover (MEsnow, middle panel) and soil moisture correlation (Rsoil, lower panel) from multiple objective calibration to snow cover plus discharge (green boxes), soil moisture plus discharge (red boxes) and combined snow and soil moisture plus discharge (black boxes) in the calibration and validation periods



The spatial distribution of model efficiency of snow (MEsnow, a) and the correlation coefficient of soil moisture (Rsoil, c) by calibration with combined snow, soil and discharge (W_Q=0.5) from validation period. Improvement of MEsnow (b) and Rsoil (d) from calibration with runoff only to combined multiple objective methods for W_Q=0.5 in validation period. Values under 0.0 were not displayed, n shows the number of catchments that have a positive value.

CONCLUSIONS

- ➢ S1ASCAT soil moisture improves hydrologic model calibration.
- ➢ Runoff model efficiency for calibration to soil moisture is very similar as calibration to snow cover in both calibration and validation periods.
- ➢ Combined calibration to soil moisture and snow cover is even better, it improves snow (median about 5%) and soil moisture (median 20%) model efficiency and improvement is found in more than 80% of catchments compared to traditional calibration to runoff only.

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