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Calibrating a Hydrological Model Based on TOPEX/Poseidon Radar Altimetry Observation: A Case Study in Upper Mississippi Basin

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This study proposes a new orientation to utilizing remote sensing data to solve the problem of hydrological model calibration in ungauged basin. Satellite radar altimetric observations of river water level at basin outlet are used to calibrate the model, as a surrogate of streamflow data. To shift the calibration objective, the hydrological model is coupled with a hydraulic model describing the relation between streamflow and water stage. The methodology is illustrated by a case study in the Upper Mississippi Basin using TOPEX/Poseidon (T/P) satellite data. The generalized likelihood uncertainty estimation (GLUE) is employed for model calibration and uncertainty analysis. We found that the model could be fairly well calibrated using remote sensing data, indicating that this approach can be effective for solving the calibration problem of hydrological models in ungauged basins. Comparison with traditional calibration using streamflow data shows that for the new calibration method, the uncertainty in the modeling process is higher, and the parameter space is less constrained. It is in accordance with our understanding that potentials of the radar altimetric data only exists for the cases of that streamflow data are unavailable. The posterior distributions of hydrological parameters derived from calibration using T/P data with fixed hydraulic parameters are very similar to the ones derived from the calibration based on streamflow data, which means that the parameter uncertainty rather than the error in remote sensing data makes the biggest contribution to the extra uncertainty associated with the shift of calibration objective. Still the uncertainty associated with remote sensing product is always a major concern for the integration between the hydrological model and satellite observations. The discussion in this study indicates that eliminating data with high errors is feasible, as long as the number of remaining observations is enough to identifying the temporal dynamics of the hydrological system. Under this precondition, using less but more accurate satellite observations can eliminate some unrealistic parameters sets. The study may contribute to improve streamflow estimation in ungauged basin and evaluate the value of remote sensing in hydrological modeling.