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Computationally efficient stochastic optimization of deficit irrigation systems

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The scarcity of water constitutes the main drawback within agricultural production. Besides the improvement of irrigation technique a task of primary importance is solving the problem of intra-seasonal irrigation scheduling under limited seasonal water supply and different sources of uncertainty (e.g. climate, soil conditions and management). To treat this uncertainty within a simulation optimization framework for irrigation management it is necessary to formulate a tractable probabilistic framework which avoids the considerable computational effort of Monte Carlo simulations. This is even more the case for ensuring food security since higher quantiles (90% and above), which for achieving convergence require large evaluation sets, are of interest. This study demonstrates the high efficiency of a stack-ordering technique for generating stochastic crop water production functions which are based on a statistically appropriate sample sizes and a reliable optimal management. It is shown that this procedure works well in combination with evolutionary optimization algorithms, which are to some extent robust against noisy objective functions. More precisely, differential evolution (DE), the Covariance Matrix Adaptation Evolution Strategy (CMA-ES) and the tailor-made irrigation scheduling algorithm GET-OPTIS are applied. Stack ordering is comprehensively investigated for an agricultural area in the Batinah region of Sultanate of Oman. In comparison to an always exhaustive evaluation of the realizations set the stack ordering procedure yields considerable computational savings by identifying critical solutions which define the user chosen reliability quantile in the course of the overlying optimization process.