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Performance comparison of knowledge-based and data-driven approaches for seasonal meteo-hydrological forecasts in the central Mediterranean

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Water scarcity and drought, worsened by climate change, are growing threats to both the economy and society, particularly in hotspots like the Mediterranean Basin. Effective water resources management requires timely forecasting to implement appropriate countermeasures. Seasonal forecasts, based on knowledge-based models, are essential for managing water scarcity and drought risks. These forecasts have become more reliable with advancements in weather modeling systems. Currently, global seasonal forecasts are provided by various centers, such as the Copernicus Climate Change Service (C3S). However, the success of Artificial Intelligence encourages a shift towards a data-driven approach, which moves away from traditional knowledge-based models, relying instead on machine learning to improve forecast accuracy.

This study compares two advanced seasonal forecast models, one knowledge-based and the other data-driven, for the Calabrian peninsula in southern Italy. The knowledge-based, process-based model uses the SEAS5 ensemble forecasts from the ECMWF, with precipitation predictions disaggregated to a higher resolution (around 9 km) and bias-corrected according to the ERA5-Land product for improved accuracy. The data-driven approach predicts future precipitation using time series from 134 local rain gauges, employing methods like Gaussian process regression (GPR), support vector machines (SVM), and feed-forward neural networks (FFNN). The models' performance is evaluated for the 2021-2023 period using indices such as bias, RMSE, and Pearson correlation coefficient across different spatial areas. Furthermore, the output of both approaches is used for further hydrological modeling.

The results show a high level of consistency between the two techniques and their respective reference datasets, emphasizing the significant potential of combining both approaches. This integration allows for the utilization of their individual strengths, such as probabilistic forecasting

and physical consistency with other variables in knowledge-based methods, as well as flexibility and computational efficiency in data-driven models.

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