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Nonparametric Statistical Process Control for Monitoring Structural Changes in Regional Drought Dynamics

This study develops a statistical process control framework for monitoring drought as a stochastic process characterized by frequency, duration, and severity. The analysis focuses on the Emilia-Romagna region (Italy) and relies on a spatially weighted SPEI-12 index, ensuring a robust and representative aggregation of regional climatic conditions. The main contribution from a statistical process control perspective is the adoption of nonparametric Time-Between-Event and Amplitude (TBEA) control charts, which jointly monitor inter-event times (frequency) and event magnitudes (severity). Two complementary monitoring schemes are implemented: (i) a distribution-free EWMA control chart, designed to detect small and persistent shifts, and (ii) a change-point control chart based on the Kolmogorov–Smirnov statistic, aimed at identifying abrupt distributional changes. A classical Phase I and Phase II structure is employed to estimate in-control parameters and subsequently detect out-of-control signals. The empirical results highlight significant out-of-control sequences in recent years (2017–2018 and 2022–2023) and multiple structural breakpoints, with a clear deterioration in drought conditions starting in the early 2000s. Methodologically, the integration of EWMA and change-point charts enhances diagnostic capability: the former captures gradual trends and persistence, while the latter identifies discrete regime shifts. Overall, the proposed framework extends SPC methodologies to environmental and climate applications, providing an effective tool for continuous monitoring and evidence-based decision-making in drought risk management.

Special/ Invited session

Classification

Mainly application

Keywords

Change Point Detection; Non-Parametric Methods; Regional Cli-mate Analysis; Time-Between-Event and Amplitude

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