EMS Annual Meeting Abstracts
Vol. 21, EMS2024-372, 2024, updated on 22 Jul 2024
https://doi.org/10.5194/ems2024-372
EMS Annual Meeting 2024

TeWA: A new approach to predict the seasonal and subseasonal anomalies

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It is widely understood from analyzing energy balances that the global oceans play a crucial role in shaping atmospheric seasonal variations through interconnected mechanisms. Despite advances, numerical weather prediction models still face significant challenges in accurately predicting long-term trends due to their nonlinear response to initial deep ocean conditions. Given the inherently erratic nature of the Mediterranean climate, we have formulated an alternative approach based on several underlying assumptions: (1) recognizing that delayed teleconnection patterns offer valuable insights into the complex interactions between the ocean and atmosphere, particularly on shorter timescales, (2) noting the presence of predictable cyclic oscillations, and (3) leveraging the discernible predictive signals by isolating them from the surrounding noise over a continuous time frame. To empirically test these theoretical underpinnings, we conducted an extensive analysis of the subseasonal predictability of temperature and precipitation at 11 reference points in the Mediterranean region spanning the period from 1993 to 2021. Our innovative method involves integrating lag-correlated teleconnections (comprising 15 indices) with self-predictive techniques for residual quasi-oscillations, utilizing both Wavelet (cyclic) and ARIMA (linear) analyses. The predictive performance of this Teleconnection-Wavelet-ARIMA (TeWA) method was cross-validated and benchmarked against the SEAS5-ECMWF model (3 months ahead). The results clearly demonstrate that the TeWA method significantly enhances the predictability of temperature and precipitation anomalies for the first month by an impressive margin of 50–70% compared to the SEAS5 forecast. Furthermore, on a daily moving-average basis, we identified optimal prediction windows of 30 days for temperature and 16 days for precipitation. Particularly, these predictable intervals exhibit strong alignment with atmospheric connections observed in teleconnection patterns (e.g., ULMO) and are further corroborated by spatial correlations with sea surface temperatures (SST). Finally, our findings underscore the potential of integrating the TeWA approach with existing numerical models to unlock new frontiers in subseasonal-to-seasonal forecasting research.