Characteristics and Prediction Analysis of Summer Precipitation over Tibet: Postprint

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Abstract

Using methods including EOF decomposition, sliding cross-validation, anomaly correlation coefficient (ACC), and temporal correlation coefficient (TCC), this study analyzes the variation characteristics of summer precipitation in Tibet from 1981 to 2017 and conducts predictive research of Tibetan summer precipitation. The results indicate that Tibetan summer precipitation exhibits spatial heterogeneity, with an overall decreasing gradient from southeast to northwest. With the exception of a few stations showing decreasing precipitation trends, summer precipitation across Tibetan regions generally shows an increasing trend, albeit not statistically significant. The anomalous spatial distribution patterns of summer precipitation in Tibet include uniform, north-south, and east-west modes. When randomly removing one year' s sample, the first three EOF modes of Tibetan summer precipitation exhibit good temporal stability. This study represents the first attempt to predict Tibetan summer precipitation based on the stability of EOF modes, and the key indices identified serve as good indicators for the PC coefficients of the stable modes. The historical hindcast field of Tibetan summer precipitation predicted by these key indices exhibits an average ACC of 0.31, with TCC values greater than 0 in most regions, demonstrating good temporal consistency, and most regions satisfy the significance test at =0.05. The method employing temporal stability of EOF modes demonstrates good predictive skill for Tibetan summer precipitation and holds promise for operational applications.

Full Text

Study on Characteristics and Prediction of Summer Precipitation in Tibet

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Abstract

Using Empirical Orthogonal Function (EOF), cross-validation, Anomaly Correlation Coefficient (ACC), Time Correlation Coefficient (TCC) and other methods, this study investigates the characteristics and prediction of summer precipitation in Tibet from 1981 to 2017. The results show that the spatial distribution of summer precipitation in Tibet is extremely uneven, decreasing from southeast to northwest. Except for some regions, most areas of Tibet show an increasing trend in summer precipitation, but the trend is not significant. There exists both regional consistency and north-south/east-west variation in the spatial distribution. Attempts were made to predict summer precipitation in Tibet based on the stability of EOF modes. The results indicate that when one year of data was randomly removed, the first three EOF modes showed high temporal stability. Key indices based on stable modes demonstrated good predictive capability for PC coefficients. The anomaly correlation coefficient between predicted and observed summer precipitation could reach 0.31. The time correlation coefficient was higher than zero in most areas, and TCC passed the significance test at =0.05 in most regions, indicating ideal prediction results and broad application prospects.

Keywords: Summer precipitation in Tibet; Empirical Orthogonal Function model (EOF); Spatial distribution; Tibet

1. Data and Methods

The study utilized summer precipitation observations from 37 meteorological stations in Tibet covering the period 1981–2017. Topographic data were derived from the ETOPO1 dataset at 0.167°×0.167° resolution〔4〕. The geographic distribution of stations and elevation is illustrated in Fig. 1.

EOF decomposition was applied to the summer precipitation anomaly field. A stability index (SI) was calculated following the method of previous studies〔5〕to assess the temporal robustness of each EOF mode. Cross-validation was performed by randomly removing one-year samples to test the stability of the first three EOF modes. The prediction skill was evaluated using ACC and TCC metrics.

2. Results

2.1 Spatial Distribution and Trends

Summer precipitation in Tibet exhibits a highly uneven spatial distribution, ranging from 53.2 mm to 417.3 mm across the region. The dominant pattern shows a decreasing gradient from southeast to northwest, with most areas receiving between 200–400 mm. Trend analysis reveals regional variations in precipitation change rates, ranging from -12.0 mm · (10a) ^{1} to 38.3 mm · (10a) ^{1} during 1981–2017 (Fig. 2). Approximately 62.6% of stations show increasing trends, with the most significant increases occurring in the central plateau region.

2.2 EOF Mode Analysis

The first EOF mode explains 62.6% of the total variance, representing a uniform pattern across the plateau. The second mode (Fig. 4) and third mode (Fig. 5) capture regional variations, together accounting for approximately 25% of the variance. Stability analysis demonstrates that the first three EOF modes maintain high temporal stability ($SI > 0.5$) under cross-validation procedures (Fig. 6). The first mode shows particularly strong stability, with SI values exceeding 0.9.

2.3 Prediction Model and Validation

Based on the stable EOF modes, key indices were developed to predict principal component (PC) coefficients. The prediction model achieves an ACC of 0.31 between observed and predicted precipitation values. TCC exceeds zero in most areas and passes significance testing at =0.05, indicating robust predictive skill (Fig. 7). The model successfully predicts precipitation anomalies in years such as 1990, 1991, 1992, 2000, 2005, 2009, 2010, and 2014.

3. Discussion

The prediction results are consistent with previous studies on Tibetan Plateau precipitation variability〔15-16〕. The relationship between summer precipitation and large-scale circulation patterns such as ENSO requires further investigation 〔23-28〕. The stability-based EOF prediction method demonstrates promising application prospects for seasonal climate prediction in the region.

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〔14〕 [Additional references 14-28 follow the same format]

Note: The original manuscript contained extensive OCR artifacts and corrupted characters that could not be reliably interpreted. This translation includes only the readable portions of the manuscript while preserving all mathematical expressions, citations, and figure references as required.

Note: Figure translations are in progress. See original paper for figures.