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Inter-annual variability of winter convective precipitation in south-eastern Europe and its connection to middle tropospheric circulation

C. J. Lolis
University of Ioannina, Department of Physics, Ioannina, Greece (chlolis@cc.uoi.gr)

The inter-annual variability of convective precipitation rate in the Italian and Balkan peninsulas and their surrounding areas and its connection to 500hPa geopotential height over Europe during winter is examined by using the multivariate statistical methods Factor Analysis and Canonical Correlation Analysis.

The data used are monthly values of: 1) convective precipitation rate (CPR) at 126 grid points (1.875˚x1.905˚) in the area of south-eastern Europe (5.625˚E to 30˚E and 33.333˚N to 48.570˚N) and 2) 500hPa geopotential height (GPH) at 375 grid points (2.5˚x2.5˚) in the area of central and southern Europe and north Africa (20˚W to 40˚E and 25˚N to 60˚N) for the winter months December, January and February and for the period 1950-2009 (60 years), obtained from the NCEP/NCAR Reanalysis data sets. The seasonal (winter) values are calculated from the monthly ones and two matrices are constructed: one 60x126 matrix for CPR and one 60x375 matrix for GPH. The rows and the columns refer to time (years) and space (grid points) respectively.

At first, S-mode Factor Analysis is applied to each one of the above data matrices, as a data reduction tool, leading to 7 factors for CPR (80% of the total variance) and 6 factors for GPH (93% of the total variance). Then, Canonical Correlation Analysis is applied to the factor scores time series of both parameters, leading to two statistically significant (95% confidence level) canonical pairs and the patterns of the correlation coefficients between the canonical variates and the corresponding parameter time series are constructed.

The 1^{st} canonical pair (W_1,V_1) (canonical correlation r_1= 0.90) is associated with the typical winter depression activity regime over the Mediterranean Sea. In 500hPa geopotential height field, the canonical variate W_1 is highly correlated (high negative correlation coefficients) with GPH over Italy and the Tyrrhenian Sea, while in convective precipitation field, V_1 is highly correlated with CPR over a broad area comprising Sardinia, the Tyrrhenian, Ionian and Aegean Seas and the southern parts of the Italian and Balkan peninsulas. Thus, when cyclonic activity over Italy is intense and/or frequent, convective precipitation over central and southern Italy, the southern Balkans and the adjacent sea areas is high. On the contrary, when cyclonic activity over Italy is weak and/or not frequent or anticyclonic activity persists, convective precipitation over the above regions is low. The inter-annual variations of W_1 and V_1 scores are characterized by negative trends (statistically significant at 95% confidence level), implying a GPH increase over Italy and a synchronous CPR decrease over the northern Mediterranean Sea.

The 2^{nd} canonical pair (W_2,V_2) (canonical correlation r_2= 0.82) is associated with blocking activity over western Europe. In 500hPa geopotential height field, W_2 is highly correlated with GPH over the area of Ireland and Britain, while in precipitation field, V_2 corresponds to a north-south seesaw teleconnection between the central Mediterranean Sea south of Sicily (high positive correlation coefficients) and the northern continental areas of Italy, the Alps and the northern Balkans (high negative correlation coefficients). Intense and/or frequent blocking activity over western Europe is accompanied with high CPR over the south part of the central Mediterranean Sea and low CPR over the northern continental areas of the Italian and Balkan peninsulas. On the contrary, the absence of blocking activity and the intense depression activity over western Europe imply high (relatively to the normal values) CPR over the aforementioned northern continental areas and low CPR over the southern part of the central Mediterranean Sea. The inter-annual variations of W_2 and V_2 scores are characterized by positive trends (statistically significant at 95% confidence level), implying a GPH increase over western Europe, a CPR increase over the south part of the central Mediterranean Sea and a CPR decrease over northern Italy, the Alps and the northern Balkans.

Finally, the mean GPH and CPR anomaly patterns are constructed for the 6 years (10% of the total number of years) characterized by the highest and the lowest values of W_1 and W_2. In this way, a validation of the results is performed, confirming the above conclusions regarding the centers of high correlation coefficients between the canonical variates and the original GPH and CPR time series.