



## **Is it possible to distinguish an ENSO-related signal from NAO in European climate anomalies?**

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Impact of wintertime El Niño Southern-Oscillation (ENSO) on the climate variability of North Atlantic and Europe (NAE) in the context of simultaneous effect of dominant North Atlantic Oscillation (NAO) is examined. The presented work points to a possible modulation of ENSO signal with NAO. Composite analysis, empirical orthogonal function (EOF) analysis and signal-to-noise ratio approach are used to identify ENSO-related signal in European climate anomalies.

Probability distributions of relative occurrence of observed NAO and ENSO events reveal that if the whole 120-year time period is considered, El Niño (La Niña) ENSO is more frequently accompanied with negative (positive) NAO. However, the distribution is non-stationary. Dividing the time period into 30-year long sub-periods showed that the incidence of ENSO-NAO phases has changed with El Niño being more frequently accompanied with positive NAO in last three sub-periods. To perform composite analysis, each individual dataset is divided into subsets according to the value and sign of Niño3.4 and NAO indices. ENSO composites are constructed in two ways. Firstly, ENSO events are defined as those associated with an ENSO, but without taking into account the value and sign of the NAO. Secondly, “pure” ENSO events are defined as those associated with years when NAO was detected as neutral. Results indicate that NAO is so powerful that even a weak NAO imposes its own characteristics to the ENSO composite. Additionally, EOF analysis shows that the variance associated with “pure” ENSO signal appears as a second mode of MSLP total variance (EOF2). However, when only “pure” ENSO events are subjected to the EOF analysis, the same pattern appears as in the first mode (EOF1). The impact of NAO is also recognized in signal-to-noise analysis in such way that NAO is interpreted as noise when the whole ensemble of simulations is used. On the other hand, the signal associated with ENSO events projects onto NAO pattern, while the signal of “pure” ENSO events is different, resembling the signal of the overall dataset.

Applied procedures indicate that ENSO has a weak impact on the NAE climate, but the effect can be disguised with NAO. Consequently, not only ENSO signal can be modulated with NAO, but also the associated spatial and temporal properties of the ENSO–NAE connection (like stationarity, linearity and variability on different time-scales).