



## **ENSO variability, Southern Hemisphere teleconnection changes and the relationship with SAM during the past millennium**

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The El Niño-Southern Oscillation (ENSO) and the Southern Annular Mode (SAM) are important modes of climate variability with a strong impact on the Earth's climate, particularly in the Southern Hemisphere. The short instrumental period significantly limits our understanding of these two key modes and their potential interplay. Here we use palaeo-proxy records and climate model simulations to reconstruct and analyse the variability and relationship of ENSO and SAM back in time.

We provide new ENSO reconstructions using a large collection of proxy records and apply a novel reconstruction approach based on principal component analysis. Comparisons with ENSO reconstructions obtained by classical reconstruction methods allows us to identify periods of disagreement where teleconnections are likely to have changed. We show that quantifications of ENSO are most robust from 1580 until the end of the 17th century and from 1825 to present. In contrast, we find five short phases in the 18th century where there is low agreement among our new and existing reconstructions. During these four phases a distinct spatial pattern of proxy covariance differing from the instrumental period is identified, pointing towards changes in teleconnections in the west Pacific/Australasian region.

Instrumental ENSO and SAM indices show a negative correlation over the most recent decades. We show that this relationship can be seen in palaeoproxy-based reconstructions back to around 1400 CE. Model simulations confirm this pattern with a very stable ensemble mean correlation of about -0.3. We use pseudo-proxy experiments to show that the tropical-extratropical teleconnection pattern can be reproduced by currently available proxy records back to 1600 CE. Individual model runs as well as the proxy-based reconstructions show intermittent periods of positive and particularly strong negative correlations. These periods are then used for a spatial pattern analysis of gridded temperature and sea level pressure data.