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Differences between temporal (S-Mode) and spatial (T-Mode) principal component analysis of Antarctic sea ice monthly concentration anomalies: relationship with climate variables.

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Monthly sea ice concentration anomalies over the period 1979-2009 around Antarctica derived from satellite information generated by NASA Team algorithm and acquired from the National Snow and Ice Data Center were analyzed by means of principal components analysis (PCA) in S-Mode (correlation between temporal series) and in T-Mode (correlation between fields). These two different kinds of analysis show how these approaches conduct to different interesting results. The temporal variability of sea ice (S-Mode) is useful to perform spatial clusters of sea ice series. Therefore, the results correspond only to patterns of series that can represent the temporal behaviour of sea ice in some regions of Antarctica. These series can be correlated with different atmospheric or oceanographic variables to generate the associated teleconnection patterns between the atmosphere and sea ice. The spatial variability of sea ice around Antarctica (T-Mode) is used to obtain temporal clusters of fields of sea ice. With this kind of temporal clusters, it is easy to establish the relationships between sea ice concentration anomaly (SICA) spatial structure and atmospheric circulation characteristics together with the frequency of occurrence for the different sea ice/atmosphere coupled patterns. T-Mode is the appropriate method if the goal of the analysis is to find spatial synoptic patterns and when they happen in time. T-Mode scores for correlation must be interpreted as standardized spatial patterns or 'snapshots', while the principal component loadings indicate at what time the patterns occur.

For S-Mode, six principal components time series scores (TPC) that represented the 37% of the variance were obtained. The first TPC characterized the Antarctic Dipole Oscillation between the northern region of the Weddell-Bellingshausen Seas and the Amundsen Sea. This pattern relates an increase of temperatures over in the Pacific Ocean with low sea ice concentration in the Amundsen Sea. The second TPC represented another temporal dipole between 0-60° E and 150-180°E which may associate increased sea ice at 0-60°E with a heating of the western region of the Pacific Ocean. The third TPC corresponds to a dipole between the eastern Weddell Sea and the southern Amundsen areas and appears to link a decrease of sea ice concentration over Amundsen with a warm El Niño-Southern Oscillation event. The fourth, fifth and sixth TPC represented the temporal behaviour of three dipolar regions: the seas around the Antarctic Peninsula and the region located at 0-90° E (4th TPC), 90-150°E and 30-90°E (5th TPC) and, 120-180°W and 120-150°E (6th TPC).

Using T-Mode PCA, the principal spatial structure of SICA for both summer-autumn and winter-spring months were obtained together with their associated atmospheric circulation patterns. Eight principal component score fields (SPC) (five for winter-spring and three for summer-autumn months) represented almost the 70% of the variance. The sea-ice patterns in positive (negative) phase were obtained from SICA composite for the months with component loadings over (below) the threshold of 0.3. The first spatial summer-autumn pattern shows a positive (negative) sea ice concentration anomaly centre over the Bellingshausen and Amundsen Seas in positive (negative) phase and two big opposite sign centres of anomalies over the Weddell and the West Ross Sea. This pattern is accompanying by a strong positive (negative) 850-hPa height anomaly that covers most of the Antarctic Continent with three centres extended over the Atlantic, Pacific and Indian Oceans. The first spatial winter-spring pattern in positive (negative) phase shows two positive (negative) sea-ice concentration anomalies, one over the North Bellingshausen and Northeast Weddell Seas and the other between 120°W and 180°W. Two strong opposite sign centres are located over the Indian Ocean and the Amundsen Sea. For this pattern a strong positive (negative) 850-hPa height anomaly covers the Antarctic Continent centred over the Bellingshausen Sea accompanied by three negative (positive) height anomalies in middle-latitudes (Atlantic, Pacific and Indian Oceans).