



## Decadal variability and metastability in the Southern Hemisphere

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An examination of systematic changes in the metastability of the southern hemisphere 500hPa circulation is performed using both cluster analysis techniques and split flow blocking indices. The cluster methodology is a purely data-driven approach for parametrisation whereby a multi-scale approximation to non-stationary dynamical processes is achieved through optimal sequences of locally stationary fast Vector Auto-Regressive Factor (VARX) processes and some slow (or persistent) hidden process switching between them. Comparison is made with blocking indices commonly used in weather forecasting and climate analysis to identify dynamically relevant metastable regimes in the 500hPa circulation in both reanalysis and AMIP model data sets. Our analysis characterises the metastable regime in both reanalysis and model data sets prior to 1978 as positive and negative phases of a hemispheric mid-latitude blocking state with the Southern Annular Mode (SAM) associated with a transition state. Post 1978, SAM emerges as a true metastable state replacing the negative phase of the hemispheric blocking pattern. The hidden state frequency of occurrences exhibits strong trends. The blocking pattern dominates in the early 1980s then gradually decreases. There is a corresponding increase in the SAM frequency of occurrence. This trend is largely evident in the reanalysis summer and spring but was not evident in the AMIP data set. Non-stationary cluster analysis was then further used to identify the Southern Oceans response to the systematic changes in the mid-latitude atmospheric circulation and identify dynamical regimes associated with subsurface thermocline anomalies which were found to teleconnect the Pacific and Atlantic regions of the Antarctic Circumpolar Current (ACC).