Geophysical Research Abstracts
Vol. 16, EGU2014-1140, 2014
EGU General Assembly 2014

Decadal Variability in an OGCM Southern Ocean: intrinsic modes, forced modes and metastable states

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An Ocean General Circulation Model (OGCM) is used to identify a Southern Ocean southeast Pacific intrinsic mode of low frequency variability. Using CORE data a comprehensive suite of experiments were carried out to elucidate excitation and amplification responses of this intrinsic mode to low frequency forcing (ENSO, SAM) and stochastic forcing due to high frequency winds. Subsurface anomalies were found to teleconnect the Pacific and Atlantic regions of the Antarctic Circumpolar Current (ACC) thermocline. The Pacific region of the ACC is characterised by intrinsic baroclinic disturbances that respond to both SAM and ENSO, while the Atlantic sector of the ACC is sensitive to higher frequency winds that act to amplify thermocline anomalies propagating downstream from the Pacific. Non-stationary cluster analysis was used to identify the system's dynamical regimes and characterise meta-stability, persistence and transitions between the respective states. This analysis reveals significant trends, indicating fundamental changes to the meta-stability of the ocean dynamics in response to changes in atmospheric forcing. Intrinsic variability in sea-ice concentration was found to be coupled to thermocline processes. Sea-ice variability localised in the Atlantic was most closely associated with high frequency weather forcing. The SAM was associated with a circumpolar sea-ice response whereas ENSO was found to be a major driver of sea-ice variability only in the Pacific. This simulation study identifies plausible mechanisms that determine the predictability of the Southern Ocean climate on multi-decadal timescales.