Geophysical Research Abstracts
Vol. 20, EGU2018-106, 2018
EGU General Assembly 2018
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Seasonality of the Agulhas Current with respect to near- and far-field winds

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The Agulhas Current plays a critical role in both local and global ocean circulation and climate regulation, yet the mechanisms that determine the seasonal cycle of the current remain poorly understood. Model studies predict an austral winter-spring maximum in volume transport, whilst observations reveal an austral summertime (February-March) maximum. In this study, the role of winds on Agulhas Current seasonality is investigated using shallow water models, satellite measurements, and a 24-year transport proxy based on observations. A reduced gravity first baroclinic model is shown to successfully reproduce the seasonal phasing of the current. This seasonality is found to be highly sensitive to the propagation speed of Rossby waves, which determines the arrival time of the wind stress signal at the western boundary. By matching Rossby wave speeds to those observed using altimetry, an Agulhas Current with a maximum flow in January-February-March and a minimum flow in July is simulated, agreeing well with observations. Near-field winds, to the west of 35E, are found to dominate this seasonality, as signals from more remote wind forcing dissipate due to destructive interference while crossing the Indian Ocean basin. Local winds driving coastal upwelling/downwelling directly over the Agulhas cannot, alone, explain the observed seasonal phasing, as they force a November-December maximum and June minimum in flow. In addition, the seasonal response to Indian Ocean winds is investigated using a barotropic model with realistic topography, as theory suggests the barotropic response dominates at seasonal timescales. The barotropic model is, however, unable to correctly capture the seasonal cycle of the Agulhas Current, predicting a wintertime maximum in transport. The results from the barotropic simulation are similar to previous model studies, showing seasonality dominated by a southward propagation of signals via the Mozambique Channel, and suggest these models are too barotopic in their response to the winds. Findings from this study elucidate the role of near-fields winds and baroclinic processes in determining the seasonality of the Agulhas Current.