Session: C40 Poster: Th116B

Antarctic sea ice climatology, variability and late 20th- Century change in CCSM4

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A preindustrial control run and an ensemble of 20th-Century integrations of the Community Climate System Model version 4 (CCSM4) are evaluated for Antarctic sea ice climatology, modes of variability, trends and covariance with related physical variables such as surface temperature and sea level pressure. Compared to observations, the mean ice cover is too extensive in all months. This is in part related to excessively strong westerly winds over ~50oS-60oS, which drive a large equatorward meridional ice transport and enhanced ice growth near the continent. In spite of these biases in the climatology, the model's sea ice variability compares well to observations. The leading mode of austral winter sea ice concentration exhibits a dipole structure with anomalies of opposite sign in the Atlantic and Pacific sectors. These anomalies are related to the timing of ice advance and retreat, are transported eastward with the mean ocean currents, and reoccur over subsequent years due to an imprint of the seasonal ice anomalies on surface ocean conditions. Both the El Niño-Southern Oscillation and the Southern Annular Mode (SAM) project onto the leading mode of sea ice variability and contribute to a significant spectral peak at about four years. In 20th-Century integrations, Antarctic sea ice area exhibits significant decreasing annual trends in all ensemble members from the mid-20th-Century through the end of the simulation. While this long-term trend is in apparent contrast to observations, which show a modest ice area increase since 1979, some ensemble members do not show significant changes in Antarctic sea ice area since 1979. The ensemble mean shows a significant increase in the austral summer SAM index over 1960-2005 that compares well to the observed SAM trend, associated with an increase in zonal wind stress and equatorward Ekman transport over the Southern Ocean. Although this process could lead to further increased sea ice extent, it is apparently overwhelmed by other changes in the coupled climate system.