Geophysical Research Abstracts
Vol. 13, EGU2011-9544, 2011
EGU General Assembly 2011

Projections of 21st Century Winter Wave Climate in the North Pacific under the SRES A2 Scenario using a Numerical Wave Model

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Mid-latitude ocean wave climate is a critical consideration for coastal processes and littoral and maritime activities of all sorts, and one that responds strongly to relatively subtle changes in cyclone activity, emphasizing how changes in storminess can impact other elements of the climate system. Previous studies have demonstrated generally good agreement between the character mid-latitude cyclone activity as seen in observations and climate models, a result that has stimulated investigations into changes in mid-latitude cyclone activity in model projections of 21st century climate. One consensus of these studies is that anthropogenic warming will lead to a poleward shift in winter cyclone activity. For the North Pacific, the most consistent result of this shift is decreased cyclone activity south of ∼35-40N, especially in the western ocean where meridional gradients in cyclone activity are strongest. North of ∼40N, patterns of projected change are more varied, but tend to show increasing activity. Such changes would have important effects on winter wave climate.

The character and causes of low frequency variability mid-latitude wave climate during the 20th century, and its relationships to changes in cyclone activity, have been addressed in numerous studies using observations, statistical methods and numerical wave models. While a number of studies have addressed projected 21st changes in winter wave heights over the North Atlantic, very few have treated North Pacific

We present results from long (at least 110 years) simulations of the North Pacific using a numerical ocean wave model (Wavewatch III) driven with 6-hourly near-surface wind data from three different coupled global climate models (CGCMs) transitioning from late 20th century conditions into an aggressive scenario for future greenhouse gas emissions (IPCC SRES A2). Aside from showing excellent agreement with reanalysis-derived products for late 20th century wave climate, the wave model simulations remarkably similar patterns and magnitudes of projected 21st century changes in extreme wave heights. These are marked most conspicuously by major decreases wave heights over the western and central mid-latitude North Pacific, a feature clearly related northward shifts in cyclone activity.

We also use the climate and wave model results to examine the performance of a statistical methodology for projecting 21st century changes in wave climate on the basis of large-scale winter average circulation fields. In this application, the statistical models have only limited qualitative success in estimating the magnitude and character of simulated future changes in wave climate, emphasizing the utility of numerical wave models for such studies.