Model projected winds, pressure, and temperature in upwelling systems derived from the Coupled Model Intercomparison Project Phase 5 (CMIP5)

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Project
» Climate Change and Upwelling -- Comparative Analysis of Current and Future Responses of the California and Benguela Ecosystems (CalBenJI)

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Dataset Description

Model projected winds, pressure, and temperature in upwelling systems; data are derived from the Coupled Model Intercomparison Project Phase 5 (CMIP5). Data include surface wind stress (N md^{-2}), air-surface temperatures (degrees C), and sea-level pressures (hPa). Robustness of changes through time are denoted by the "signal-to-noise" ratio, which is defined here as the mean multi-model change divided by the inter-model standard deviation.

The "Get Data" button above opens an Excel file containing data on seasonal wind changes, summer wind changes, summer surface temperature changes, and summer PSL changes for the areas of interest in a lat/lon grid.

See a complete description of the data and initial interpretation in the following manuscript:
Rykaczewski, RR, JP Dunne, WJ Sydeman, M García-Reyes, BA Black, and SJ Bograd. 2015. Poleward displacement of coastal upwelling-favorable winds in the ocean's eastern boundary currents through the 21st century. Geophysical Research Letters 42:6424–6431, doi:10.1002/2015GL064694.

Methods & Sampling

Here we utilize output from 21 AOGCMs to investigate the proposed mechanism of upwelling intensification with climate change following RCP 8.5, a high radiative forcing scenario (Riahi et al., 2011). Model projections of oceanic and atmospheric properties during the 2071–2100 period are compared to an 1861–1890 base period. Monthly fields of air-surface temperature, sea-level pressure, and meridional wind stress are obtained from AOGCM output contributed to the Coupled Model Intercomparison Project Phase 5 (CMIP5) database. Criteria for model selection include availability of monthly output for the 1861–2005 period parameterized with estimates of historical greenhouse gas concentrations (i.e., the CMIP5 "historical" experiment) and for the 2006–2100 period parameterized as specified by RCP 8.5. Selected models and their horizontal resolutions are listed in Table S1 of Rykaczewski et al (2015; doi:10.1002/2015GL064694).

Model data are subset to regions relevant for the four major coastal upwelling ecosystems. For each region, wind stresses are examined from the coast to 600 km offshore, broadly representative of the area of upwelling-favorable winds (Jacox et al., 2014). To represent the major oceanic sea-level pressure and surface temperature fields relevant to forcing of the upwelling process (Schroeder et al., 2013), these properties are extracted from 600 km offshore to a meridian about 2500 km offshore (155 deg W for the California, 45 deg W for the Canary, 130 deg W for the Humboldt, and 15 deg W for the Benguela Current systems). For representation of sea-level pressure and air-surface temperature over western portions of the continents, properties are examined from the coastline to 600 km inland. Latitudinal domains are chosen to include eastern boundary current regions of seasonal upwelling and are 26 deg N to 49 deg N for the California, 26 deg N to 44 deg N for the Canary, 16 deg S to 44 deg S for the Humboldt, and 16 deg S to 34 deg S for the Benguela Current systems. The summer season is defined as May–July (January–March) in the Northern (Southern) Hemisphere. Positive values of surface wind stress correspond to northerly (southerly) wind stress for the Northern (Southern) Hemisphere.

To estimate model means and intermodel standard deviation for data plotted spatially, variables are interpolated onto a common 1 degree × 1 degree grid. Significance of projected changes are defined relative to the intermodel spread and are considered robust where the multimodel mean change exceeds the intermodel standard deviation.

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Parameters

Parameters for this dataset have not yet been identified

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Project Information

Climate Change and Upwelling -- Comparative Analysis of Current and Future Responses of the California and Benguela Ecosystems (CalBenJI)

Coverage: California Current Ecosystem and Benguela Current Ecosystem

Desciption from NSF award abstract:
Along the west coasts of North and South America, Africa, and Iberia, alongshore equatorward winds bring nutrient-rich waters to the sunlit surface of the ocean, stimulating phytoplankton blooms that support robust, rich and diverse ecosystems. This process is known as "upwelling". Because upwelling is driven by winds, and winds are related to atmospheric conditions, upwelling is highly vulnerable to the effects of climate change. However, the potential impacts of climate change on upwelling and biology remain largely uncertain. In earlier work in the California Current upwelling system, off the west coast of the United States, researchers found that upwelling occurs in distinct winter and summer "modes" that have different impacts on biology. In this project, oceanographic and atmospheric data from the Benguela Current system, off South Africa and Namibia, will be analyzed for similar seasonal patterns and relationships with the ecosystem. Comparisons between these two upwelling systems will allow researchers to investigate if previous findings of regional climate impacts on biology are applicable at a global scale and consider how these systems may change in the future. The project will facilitate collaboration between researchers from South Africa, Namibia, and the United States, integrating a team of young and senior scientists from the three countries and providing them with opportunities for broad-scale scientific synthesis early in their careers.

This project will be a comparative analyses of climate forcing and biological responses in the California Current (CCS) and Benguela Current systems (BCS), the two upwelling systems with the most similar time series of atmospheric and oceanographic conditions, seabird demography, and lower (chlorophyll) and mid (forage fish) trophic data. The project will determine whether changes in the ecosystems can be attributed to regional or global climate processes. Growth-increment chronologies from fish in the BCS (deep-water hake) will be developed as indicators of upper-trophic fish growth, and compared to rockfish growth chronologies developed in the CCS. Mid-trophic level fish abundance will be modeled as indices of prey availability for integration between climate and upper-trophic-level parameters. Oceanographic and atmospheric data will be analyzed from global observational and reanalysis data sets, as well as from earth system model projections of climate change. The project will address the following questions:
1) are seasonal upwelling modes (winter and summer) discernible in the BCS as they are in the CCS?
2) are upwelling modes forced by similar or contrasting atmospheric forcing mechanisms?
3) is there evidence of coherence/covariance among mid-trophic fish, upper-trophic fish, and seabirds (and at which lags) within and between the CCS and BCS?
4) will the positioning and amplitude of the atmospheric pressure systems that result in upwelling-favorable winds change coherently between ecosystems under various climate-change scenarios? and
5) what are the fisheries and wildlife management implications for variability in the seasonality and spatial distribution of upwelling in a changing climate?

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Funding

Funding Source	Award
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