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North Pacific attractors: the evolution of low frequency internal variability in a shallow water model

R. Hester (U.S. NOAA/FOCI & UW), H. Dijkstra (CSU), F. Primeau (UCI), P. Stabeno (U.S. NOAA/FOCI)

(1) Fisheries Oceanography Coordinated Investigations (FOCI), U.S. NOAA/PMEL/OERD [richard.e.hester@noaa.gov] (2) University of Washington, Department of Physics

We use the dynamical systems approach to better understand the wind-driven circulation of the North Pacific and its low-frequency variability. Our methods and strategies are similar to those used in Simonnet, et al (2003), Schmeits & Dijkstra (2001), and Primeau (2002) in the Journal of Physical Oceanography, which extended the approach to ocean models with more realistic configurations. Our model has 1.5 layers in a spherical geometry, is run at low resolution (50 km) with realistic continental boundaries, and includes the Pacific north of Hawaii, but none of the marginal seas. Numerical continuation techniques combined with explicit forward integrations are used to locate multiple stable equilibria, and then to follow their development through local, then global bifurcations as the strength of the wind stress is increased to more and more realistic levels. As the energy of the system increases, individual equilibria typically change from constant to periodic, to a-periodic in character, and eventually connect into one attractor exhibiting irregular “regime” transitions on decadal time scales. The impact of model regime transitions on transport and circulation patterns are briefly addressed for the west coast of North America and Alaska. Preliminary comparisons are made to previous studies, to output from more advanced ocean models, to published analyses of sea surface temperature variability, and to satellite altimetry.

Finally, a simple theoretical scheme (using physically intuitive concepts), is presented to interpret the behavior of the double-gyre models referenced above. We describe the next set of challenges for the dynamical systems approach to the North Pacific, and offer speculation on the operational identification and use of dynamical circulation regimes in the real ocean.