ICES Theme M Report 2013

Identifying mechanisms linking physical climate & ecosystem change

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Theme Session M at ICES Annual Meeting 2013 (Iceland)

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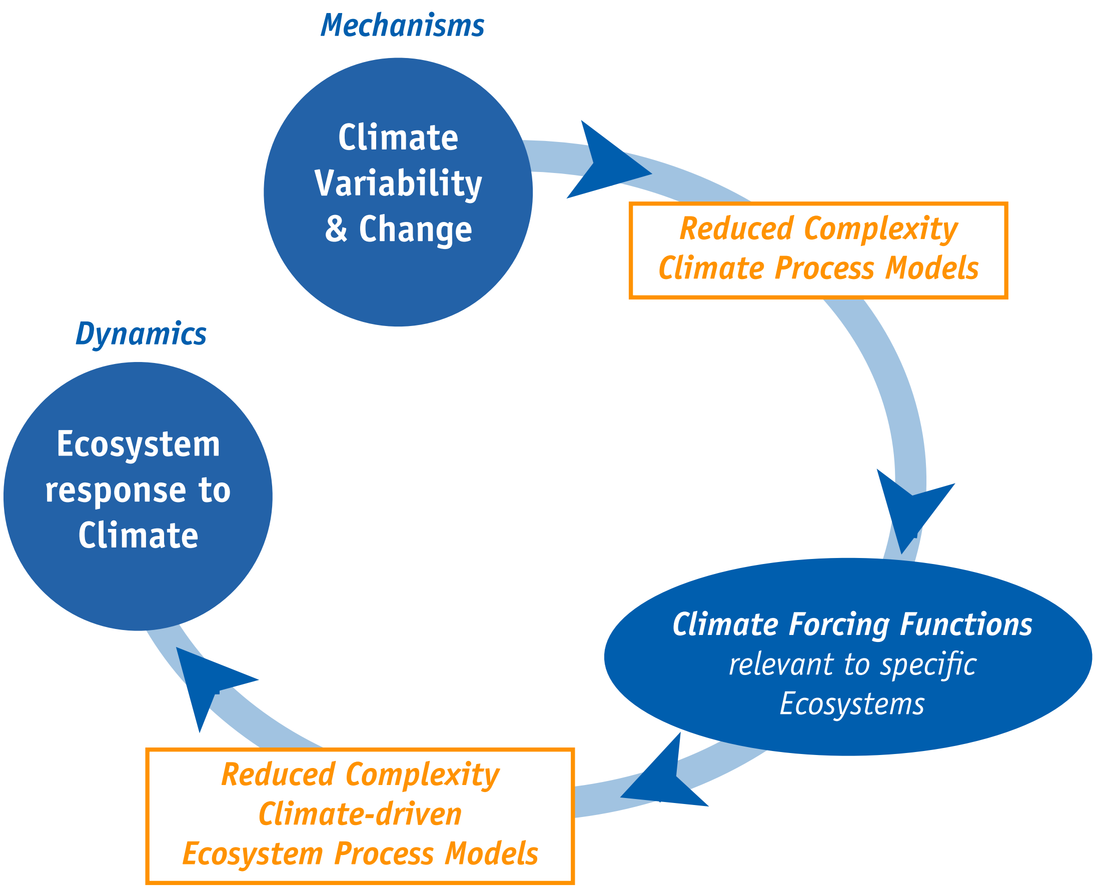
Session description

Climate variability and change in the ocean is now recognized as a significant driver of marine ecosystem response, from primary production to zooplankton composition, and through the trophic chain to fish, marine mammals and other top predators. Past studies have often relied upon existing datasets to draw correlative conclusions (associated with indices and discovered time-lags in the system) regarding the possible mechanisms that may control these linkages. In this workshop, we seek to identify and model key processes that enable us to succinctly and quantifiably explain the mechanisms underlying the correlative relationships in physical-biological datasets, both in the North Pacific and North Atlantic. The description and modeling of these key processes may (a) involve few or several variables (but not full complexity), (b) use dynamical (e.g., eddy-resolving ocean models, NPZ, IBM, etc.) or statistically based methods (e.g., Bayesian, linear inverse models, etc.), (c) explain variability in low or high tropic levels (although we seek to emphasize secondary and higher producers), and (d) include uncertainty estimation. We also solicit ideas and hypotheses concerning new mechanisms of physical-biological linkages that can only be tested by establishing novel long-term observational strategies, where the harvest of understanding will eventually be reaped by future generations of ocean scientists, as well as by developing creative modeling datasets, where ecosystem complexities can be effectively unraveled. The workshop format will be a mixture of talks and group discussions that aim at enriching the exchange of ideas and concepts between physical and biological ocean scientists. The ultimate goal is to deliver: (1) a set of new hypotheses of the mechanisms of marine ecosystem response to climate forcing, and (2) a description of the observational and modeling datasets required to test these hypotheses using process models.

The main goal of the PICES/ICES sessions was to (1) identify mechanisms controlling the marine ecosystem response to climate forcing, (2) isolate the climate forcing functions that are relevant to the specific ecosystem that are studied, and (3) link these climate forcing functions to the dynamics of large and regional scale climate variability. Furthermore, in this session we were seeking talks that would allow to synthesize the complex interaction dynamics between climate and marine ecosystem by providing reduced complexity models or understanding of the dynamics. This concept is illustrated in the digram below.



This session was conducted both the ICES and PICES annual meetings. The sessions were very well attended with about 100-200 participants. Several talks were able to target different aspects of diagram (see above) and provided important insight on the nature of the climate forcing to which ecosystem are sensitive too and the dynamics of ecosystem response to environmental perturbations. Below is a synthesis of the main findings.

1. Sensitivity of ecosystem to physical drivers changes with season

During different months of the season different physical drivers become important in driving ecosystem variability. Therefore using regional indices that tracks the seasonal sensitivity of the ecosystem leads to better predictions than using climate indices. In future studies it is critical to examine if IPCC class models can resolve the dynamics of the regional forcing functions.

2. Lower-trophic levels variability tracks regional and local physical forcing

Ecosystem properties of lower trophic level (e.g. nutrient fluxes and primary productivity) are typically sensitive to few environmental driver and often track indices of climate variability that are regional or locally defined. These regionally defined indices allow to capture both the local-scale environmental variability as well as the impacts of large-scale climate variability.

3. Higher-trophic levels integrate multiple forcing and track large-scale climate modes

Ecosystem functions of higher trophic levels (e.g. sardine) are typically sensitive to multiple stressors. Hence higher trophic levels have the ability to integrate multiple sources of environmental variability and exhibit the tendency to align their variability with that of the large-scale climate modes, which capture the shared low-frequency variance among the different environmental forcing.

4. Changes in large-scale and regional scale circulation play a dominant role in driving ecosystem variability

Changes in large-scale and regional scale circulation play a dominant role in driving ecosystem variability both at the lower and higher trophic levels. Resolving the circulation dynamics with regional climate model is key to allow a proper understanding of how coastal ecosystem respond to climate forcing. It will be important in the future to develop adequate data archives of ocean currents and advection pathways that can be used by ecosystem scientists to test hypothesis on the ecosystem response to environmental oceanic forcing. These data archives will likely be assemble using the output of regional scale model hindcast. It was also pointed out the resolving eddies at the regional scale is critical, but it also introduces a random component in the variability associated with the degree of intrinsic nature of the eddy-scale circulation. Future eddy resolving models will need to perform an ensemble hindcast in order to separate the fraction of variance that is deterministically forced vs. the internal variance.

5. Spatial dimension is key for understanding the links between physical variability and ecosystem response

As we develop reduced complexity models of the marine ecosystem response to climate forcing it will be critical to incorporate the spatial dimension (e.g. associated with fish distributions). This topic has already emerged from the section on Climate Change impacts on Marine Ecosystem (S-CCME) and is currently an important topics research/ discussion. Although several talks showed example of how the spatial dimension plays an important role, no systematic approach was presented to incorporate the spatial dimension in reduced complexity models. During the discussion a Linear Inverse Model methodology was suggested as one approach to model the spatial dimension of fish distribution in the context of a changing climate.