08-06

Project Title: Developing Statistically Robust IPCC Climate Model Products for Estuarine-dependent and Anadromous Fish Stock Assessments

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Goals:

To develop objective methods for combining the outputs of the AR4 models at the regional scale for selected output variables to construct (probabilistic) indicators of future climate change, and to use these indicators in existing stock assessment models to project abundances for the next several decades

Approach:

The project has two principal tasks: (1) develop a set of rules for objectively evaluating and averaging climate model projections, and use them to develop probabilistic estimates of the future state of the CCLME; and (2) produce leading indicators of fishery-relevant climate parameters, and incorporate these indicators into selected stock assessment models to project future abundance tendencies under realistic climate scenarios.

Work Completed:

Climate model output produced as part of the IPCC AR4 provide a basis to produce (probabilistic) indicator series that can be used in ecosystem models to examine the possible effects of climate change on marine related ecosystems. There are some 15-20 IPCC models that produce relevant output over grids of differing resolution, and the problem is how to combine the information from the different models in a probabilistic fashion, to reduce the dimensionality of the results and provide indices that are usable in ecosystem models.

State-space, hierarchical Bayesian and EOF analyses were performed on IPCC AR4 model output from 20th century runs in order to find the "best' models or combination of models to produce {probabilistic) forecasts. These results will then be used with the results from model runs of various future climate scenarios to produce indices that can be used to project the ecosystem consequences of those climate scenarios, in particular with regard to salmon.

For a first pass at the data, the model output were converted to a resolution of 5◦ over the coordinates 22.5◦ - 62.5◦ North and 112.5◦ − 247.5◦ East, consisted with grids used in previous analyses of SST over the North Pacific ocean. Monthly decadal averages were then calculated over the 100-year period from 1900-2000 for both the model output as well as for the observed data.

The first approach to analyzing the data was to fit univariate state-space models to the model output, and then calculate common underlying structure in the results. A univariate state-space decomposition separates the observed series into a nonparametric (in time) trend term, a non-stationary seasonal term, a stochastic but stationary cycle and an error term. Subspace identification methods are then used to calculate lower-dimension "common trends", 'common seasonals", and "common cycles".

“Common trends” were calculated for each model and for the observed data, and then those results were combined into a joint common trend analysis (Figure 1).

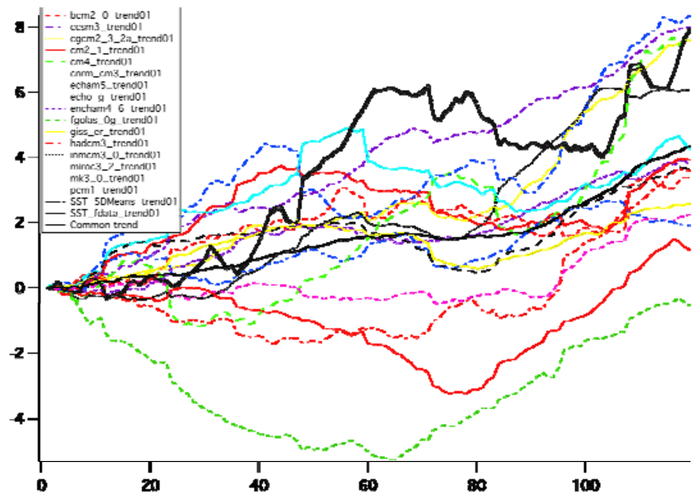

Figure 1 - The first common trend from each model (colored lines), from the data (dashed black lines), and the common trend (solid black line).

It can be seen that the first common trend of some of the models are similar to that from the observed SST, but many are not. Moreover, when analyzed this way, since no extra weight is given to the observed data, all results are treated equally and the models that misfit the data pull the joint common trend away from the data common trend.

A way to remedy this is to first project the model results onto the observed data common trend spatial pattern, and then use results from subspace identification methods to calculate the system matrices of the state-space model (Figure 2). This reproduces the observed data first common trend. However, only a few of the models significantly weight in the reconstruction, and some of those weight negatively. This makes it problematic using these weightings in future projections. Moreover, there is no guarantee that runs from the future climate scenarios will have the same results. We are in the midst of analyzing the runs from several of the future projections, as well at looking at sparse versions of the subspace methods that will force some of the weights to zero.

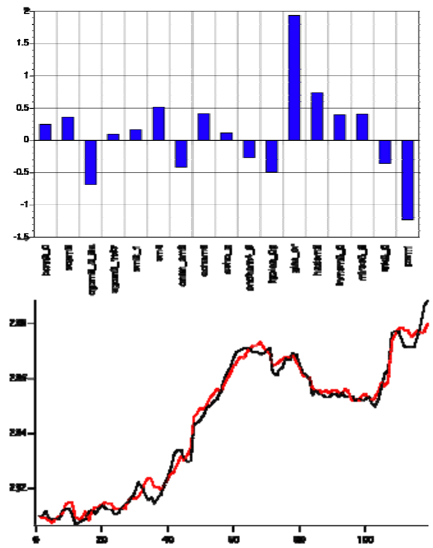

Figure 2 - Reconstruction of the data common trend (bottom) from projecting the model common trends onto the data common trends. The top graph shows the relative weight given each model in the projection.

A second approach starts with calculating the EOF's of the model output anomalies as well as for the observed data. As with the common trends, this produced inconsistent results. Instead the model output where projected onto the observed data first EOF (Figure 3). Then a hierarchical Bayesian model was fit to these results. This model assumes there is a common trend in the observed data and the projected model output, "local" time-dependent discrepancy in each model, and model specific error. The same can be done for output from future projections and produce forecasts into the future with probability distributions. This procedure produces reasonable results (Figures 4-5) and provides a basis for developing useful probabilistic indices for ecosystem model input.

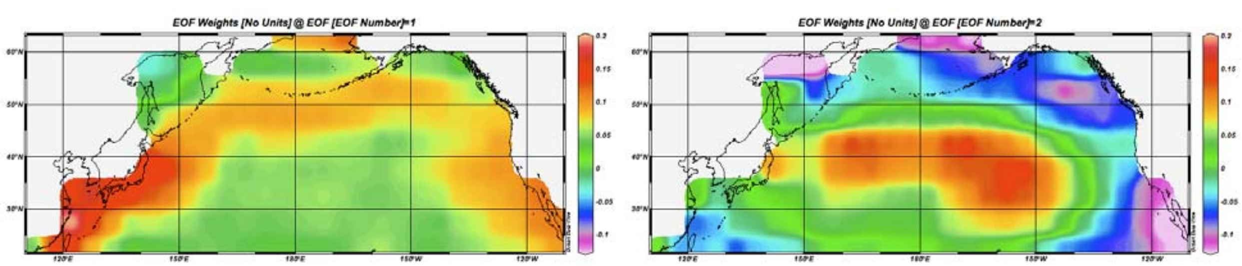

Figure 3 – First two observational data EOFs.

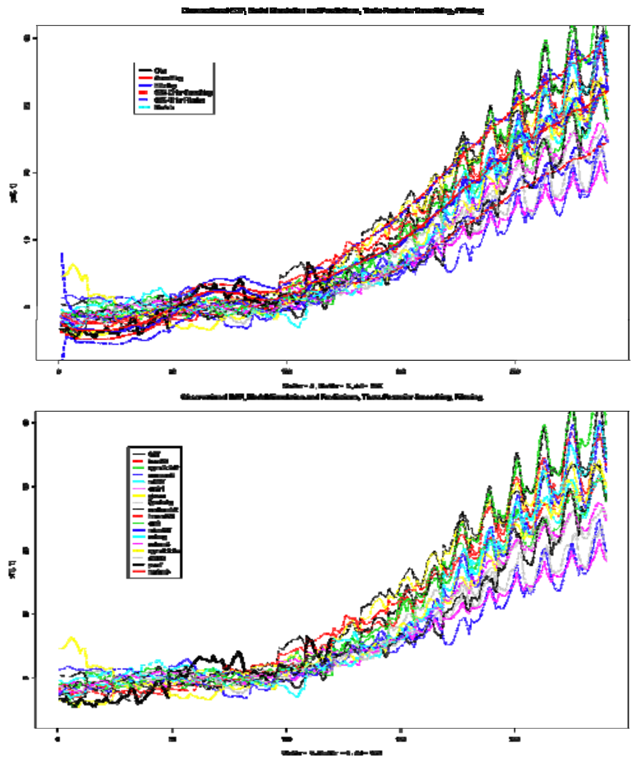

Figure 4 - Common trends of the projected model anomalies EOFs and forecast into the future.

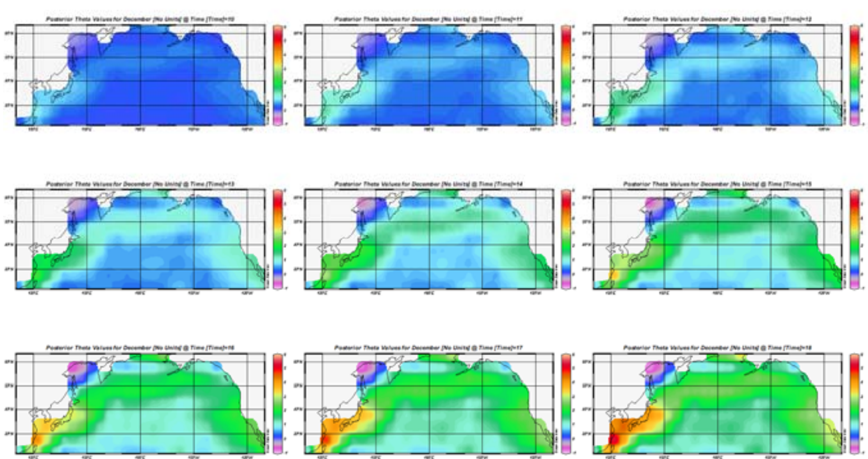

Figure 5 - Posterior mode forecast for selected time periods from the common trend model for the projected EOFs.

Applications:

The results of the analyses of the climate models will be applied to stock assessment models as part of the Year 2 effort of this project.

Publications/Presentations/Webpages:

"Joint Projections of North Pacific Sea Surface Temperature from Different Global Climate Models" by Francisco M Beltran, Ricardo T. Lemos, Bruno Sanso, and Roy Mendelssohn – Presented at Graduate Session at UCSC.

"Joint Projections of North Pacific Sea Surface Temperature from Different Global Climate Models" by Francisco M Beltran, Ricardo T. Lemos, Bruno Sanso, and Roy Mendelssohn – Presented at "Applying IPCC-class Models of Global Warming to Fisheries Prediction" at GFDL in Princeton, NJ.