Evaluation of a numerical model and application of results to understanding modes of variability in the Bering Sea ice/ocean/ecosystem

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Outline

- Assessing model skill: philosophy & approach
- Examples of Bering Sea model/data comparisons
- Variability in thermohaline fields over the Bering Sea shelf via EOF and correlation analyses
- Bio-physical co-variates

Numerical 3-d circulation models generate vast quantities of information.

How much of the output can we trust?

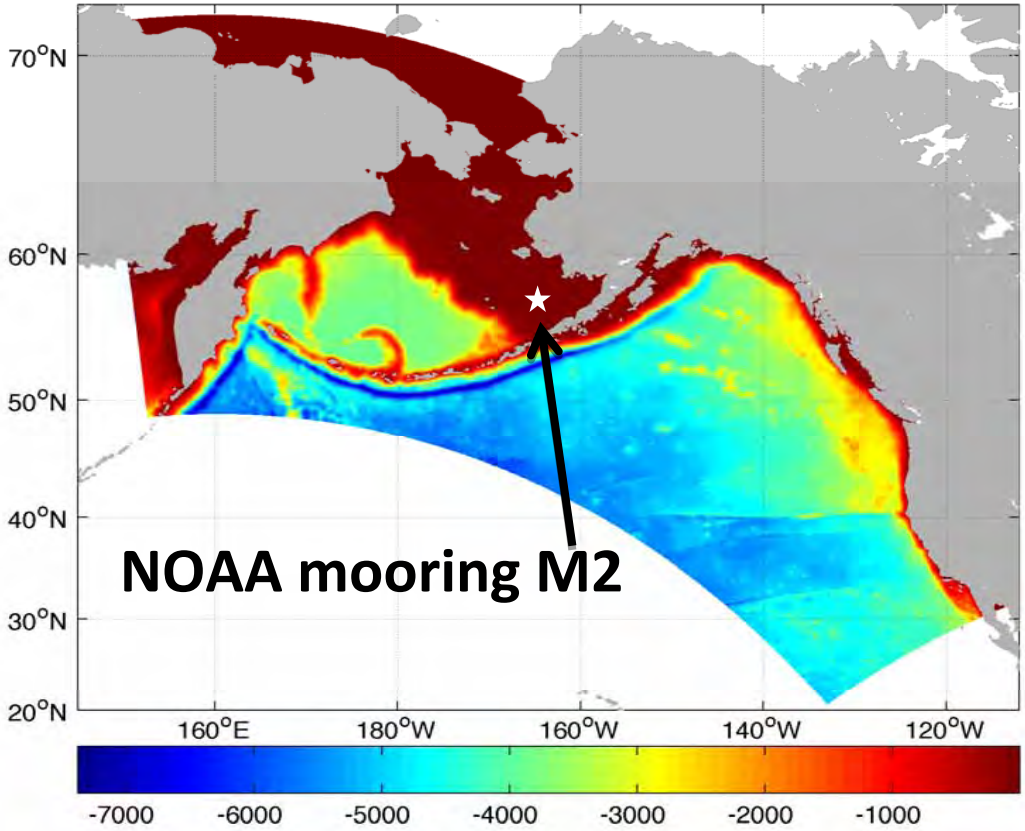
How accurately do model hind-casts reflect “reality”?
What are appropriate applications of model results?

Approach to assessing model skill

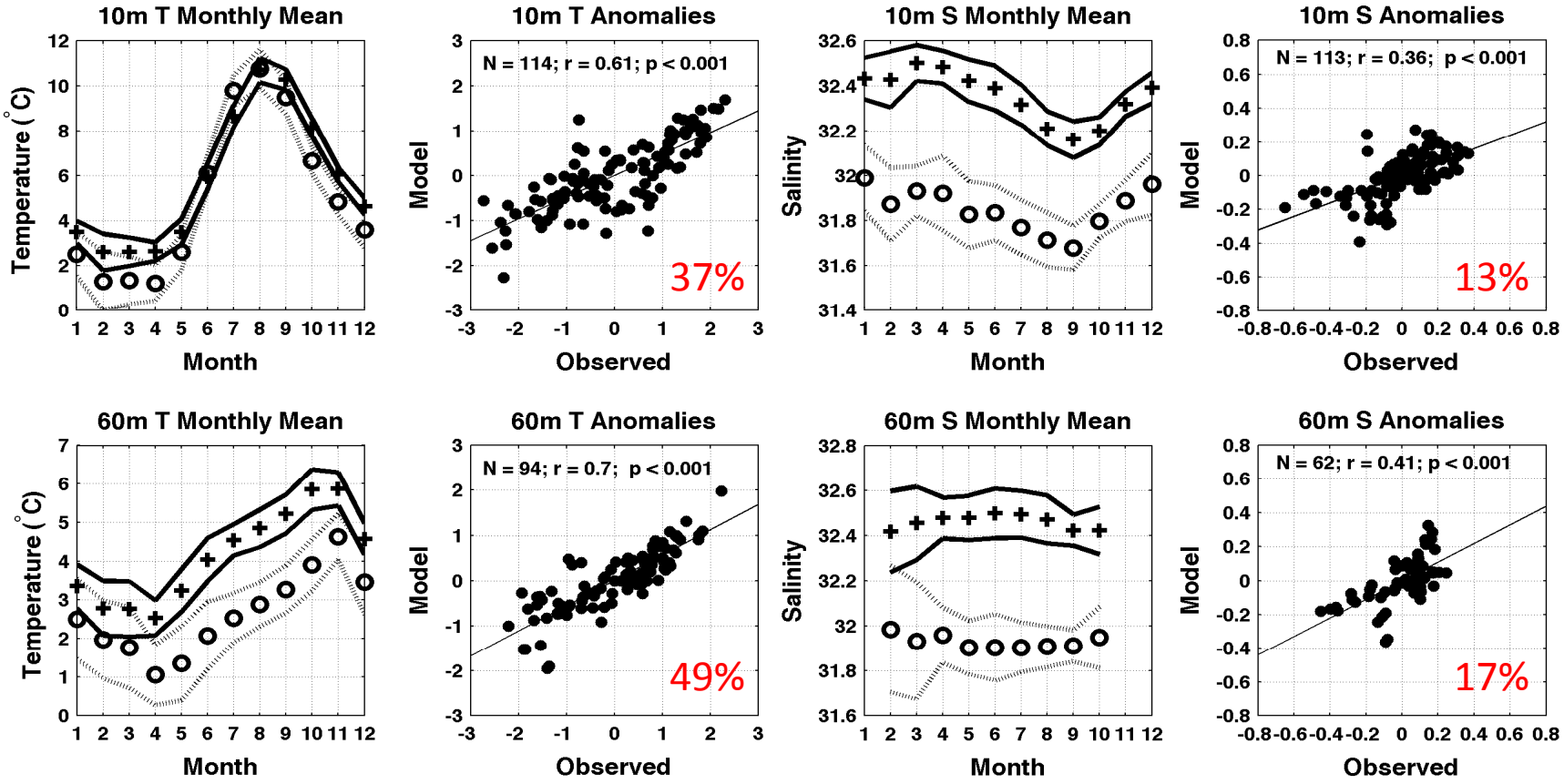
- Identify datasets
- To the extent possible, decompose different processes & signals for separate analyses
- Strive for consistency in handling data & model output
- Quantification of statistical measures
  - Mean, RMSD, variance, confidence limits, cross-correlation

The Northeast Pacific Model (NEP5)

- ROMS
- 10 km horizontal resolution
- 60 vertical levels
- 1970-2005 integration
- Ice-ocean coupled model



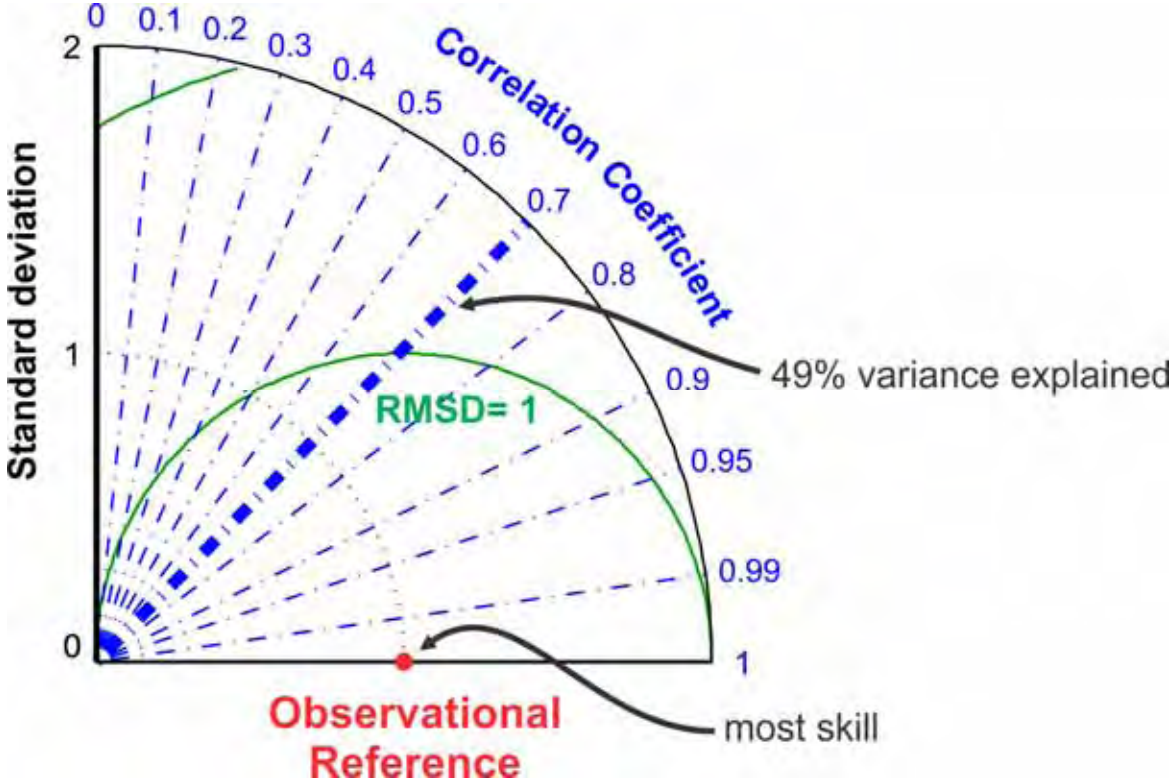
NEP5 at mooring M2



1995-2005 M2 data at 10m depth and 60m depth
o= observation; + = model
Lines depict 95% confidence limits

[Mooring data courtesy P. Stabeno & EcoFOCI program]

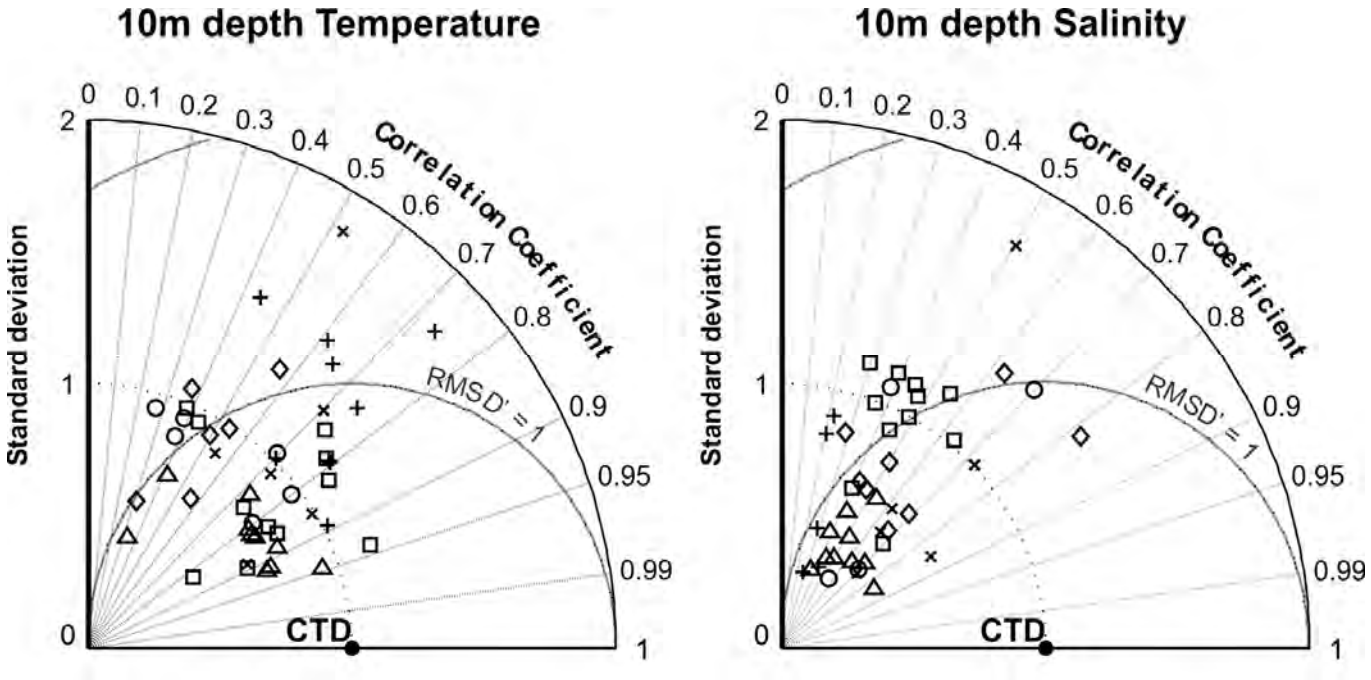
Taylor diagrams



$$RMSD = \sqrt{\sigma_M^2 + \sigma_O^2 - 2\sigma_M \sigma_O r}$$

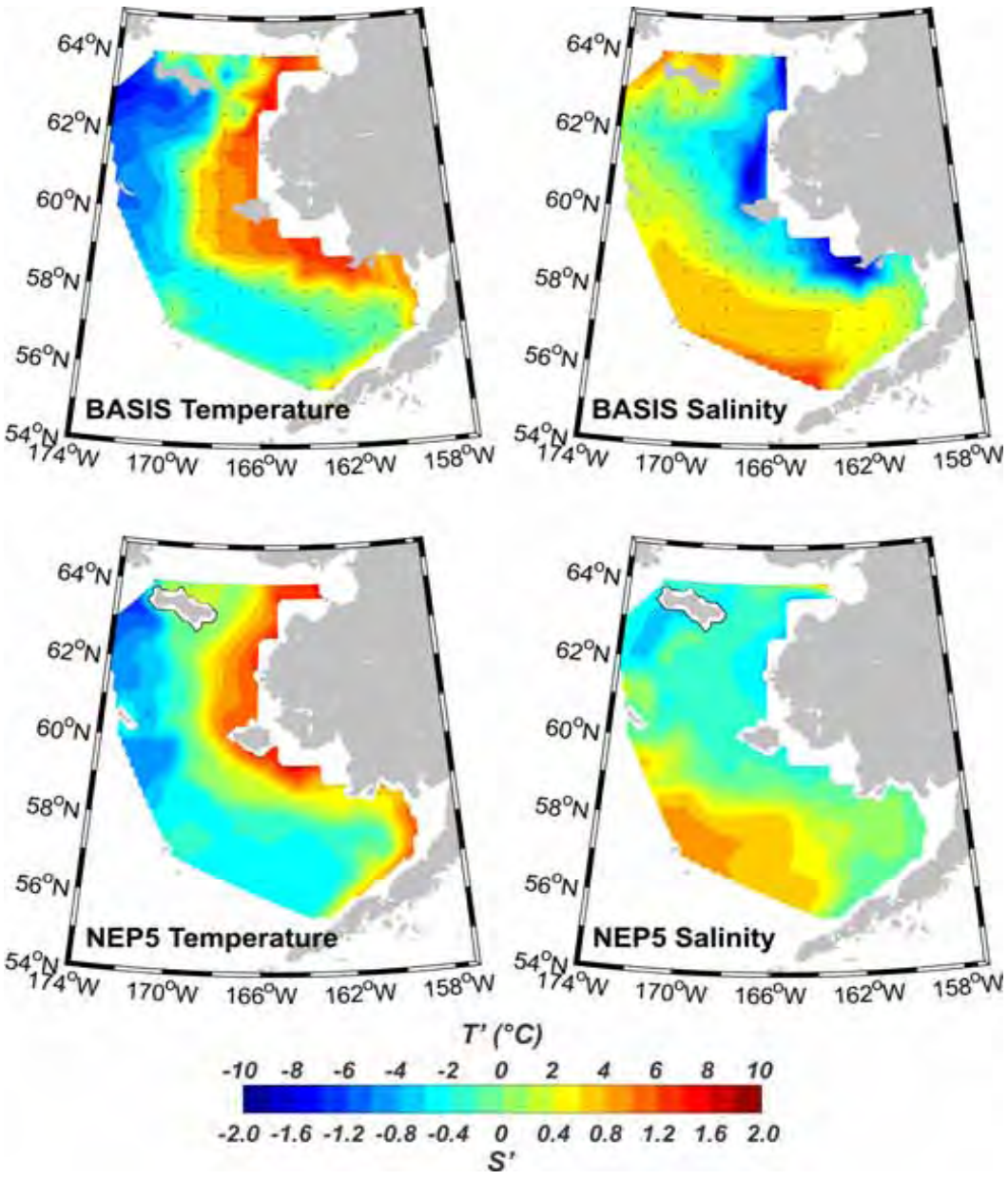
[Taylor, 2000 & 2001]

NEP5:CTD Taylor diagram analysis



- 11,500 historical CTD casts over Bering shelf
- Bering Sea shelf subdivided into 6 regions
- Calendar months considered individually
- Model output conforms to day, latitude, longitude & depth of CTD cast

[CTD data extracted from NODC WOD-09]



2004 late summer near-bottom hydrography

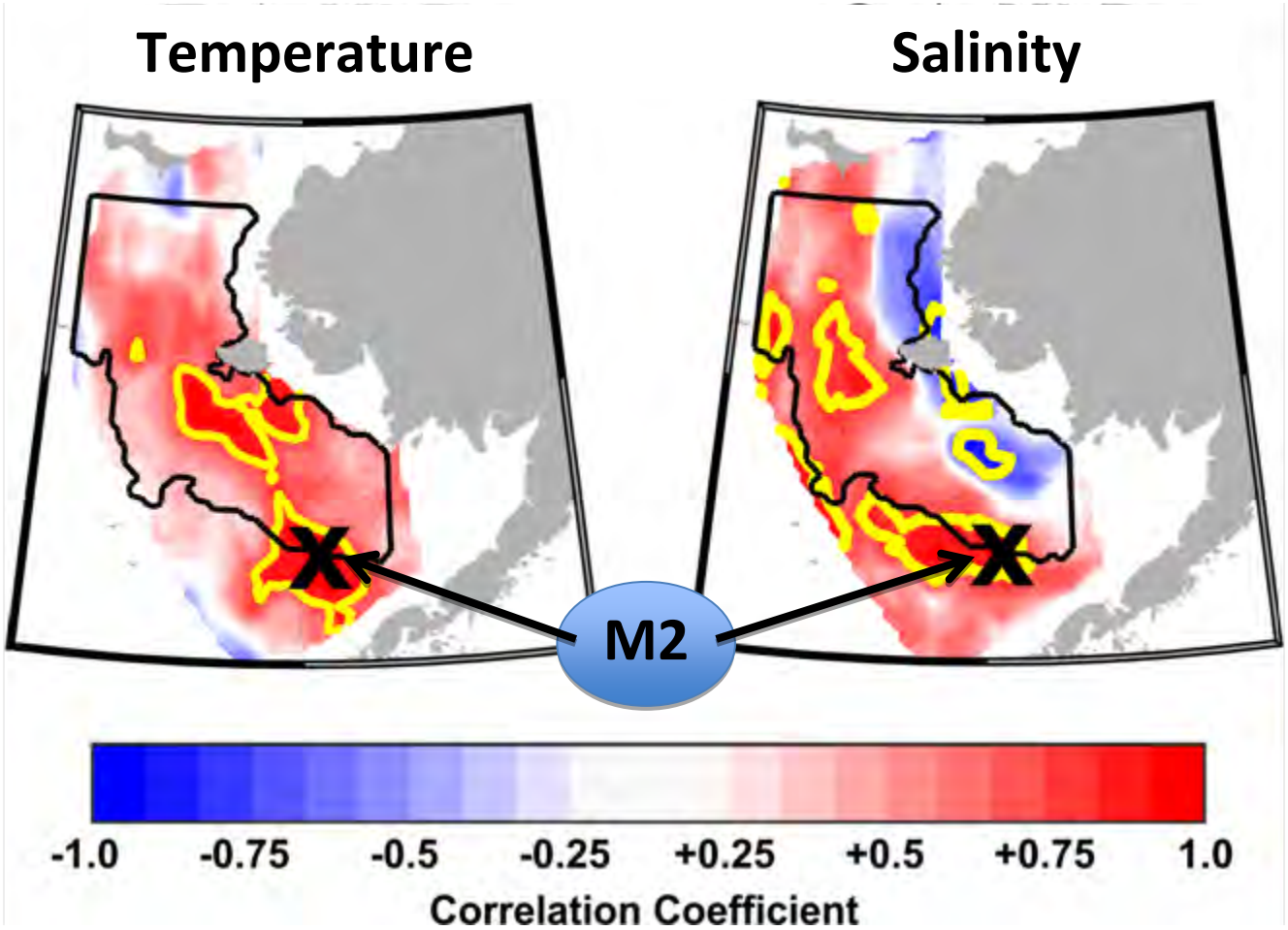
Model output has been re-gridded to match observational data grid

- $T' = T - T_{mean}$
- $S' = S - S_{mean}$

[CTD data courtesy L. Eisner & BASIS program]

Now, on to some applications…

BASIS CTD Data Correlation Map

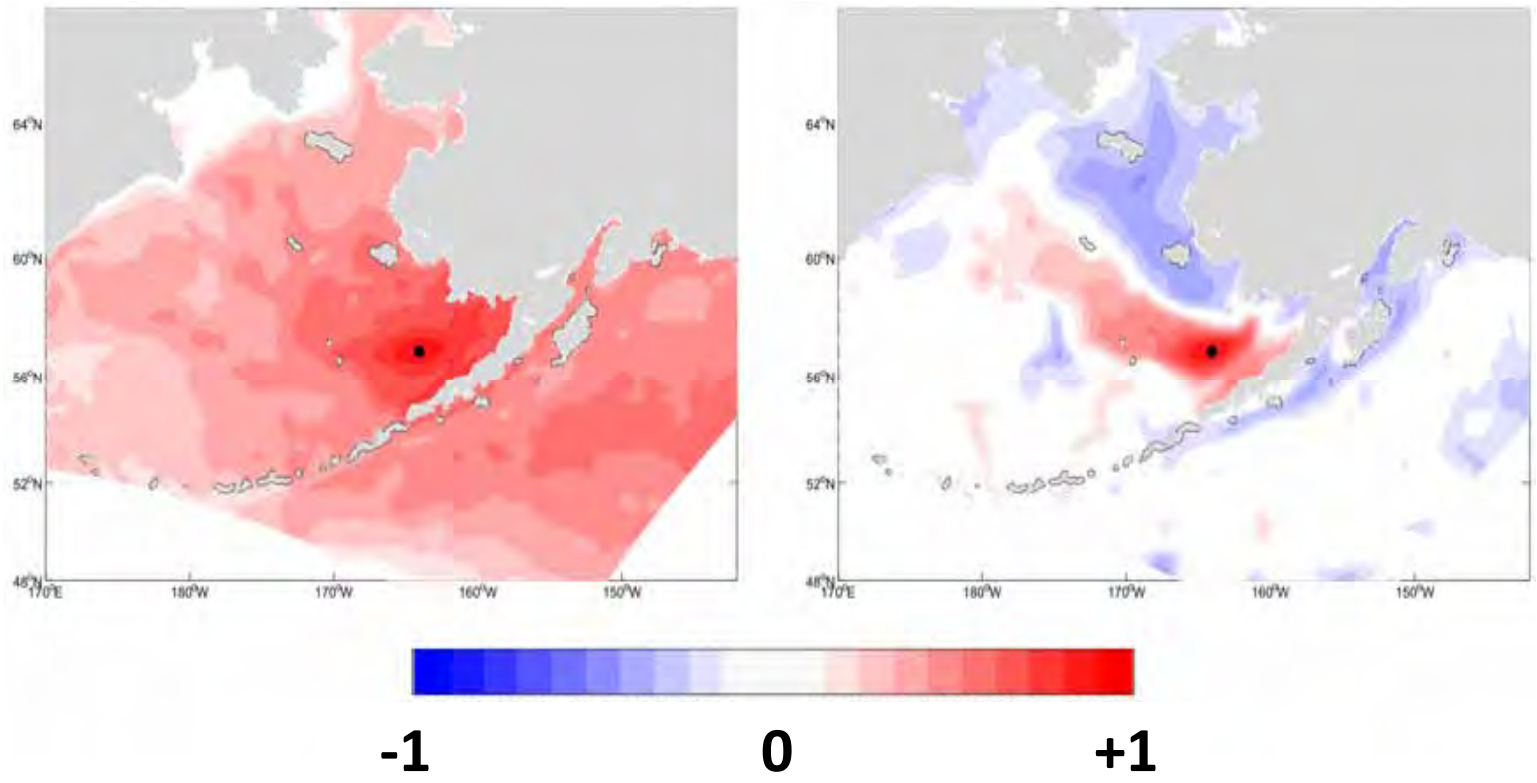


[Danielson et al., 2011]

0-20m Layer NEP5 Correlation Map (reference at M2)

Temperature

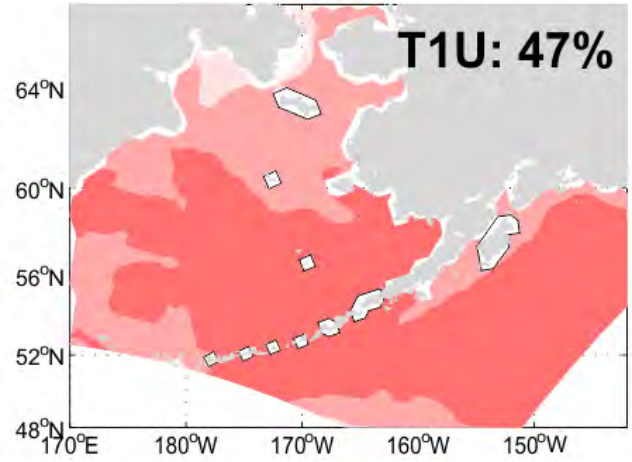
Salinity

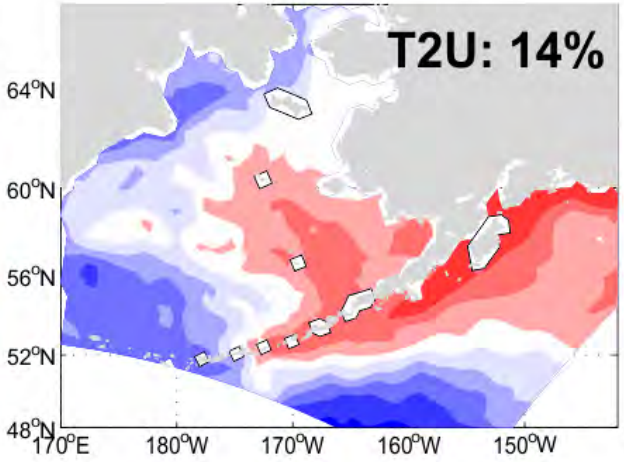


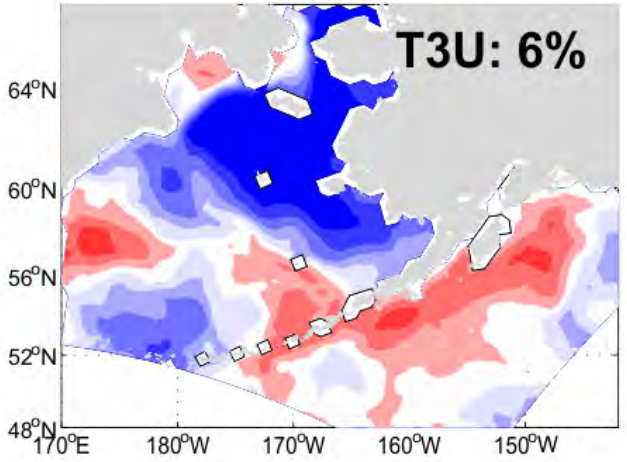
EOF Analysis

- Annual means of monthly T & S anomalies
- 0-20 m and 40-100 m Layers
- Correlated principal components with various climate & ecosystem indicator time series
- Correlation significance:
  - Significant temporal trends removed
  - Account for autocorrelation via Pyper & Peterman [1998]

0-20m Temperature EOFs







PDO & Ice Area

- Walleye Pollock & Pacific Cod condition indices

NPGO

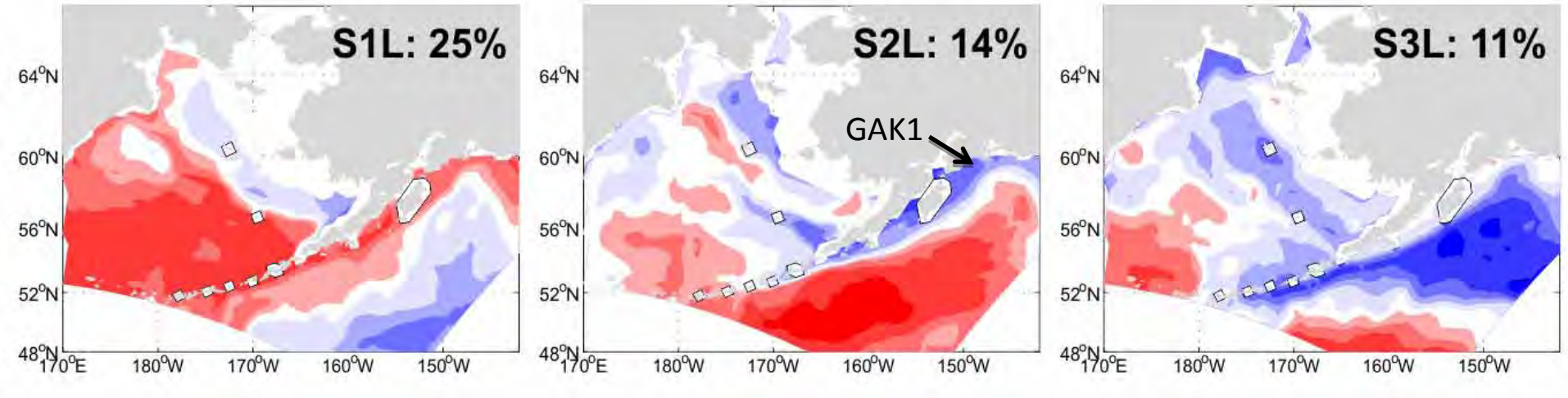
- Snow Crab spawner-recruitment relationship

Anomaly of the mean Winter Wind Direction

- Togiak stock of mature Pacific Herring biomass
- Female spawing stock biomass of Rock Sole

[Ecosystem indicator indices courtesy F. Mueter]

40-100m Salinity EOFs



PDO

- Yellowfin Sole Biomass
- Phenology of St. Paul Island Common Murres

GAK1 near-bottom temperature

- Pollock age-1 recruitment & spawner-recruitment residuals

NPGO

- Onset of spring bloom over SE Bering Shelf based on SeaWifs

[Ecosystem indicator indices courtesy F. Mueter]

Summary

- Quantitative evaluations of model skill provide insight to model strengths and weaknesses and guide applications of model results
- NEP5 shows appreciable skill hind-casting the temperature & ice fields; less skill with the salinity field.
- NEP5 appears to reproduce some fundamental structures manifest within the thermohaline fields. Spatial patterns generally conform to that of the identified mechanistic drivers.
- Correlation analyses suggest bio-physical connections that span multiple trophic levels.

  Do these relations reflect bottom-up forcing?

  Do these relations reflect stationary processes?