The Skill of North American Multi-Model Ensemble (NMME) SST forecasts for US coastal ecosystems

Michael Alexander
NOAA/Earth System Research Lab

Gaelle Hervieux, Michael Jacox, Charles Stock, Desiree Tommasi and Kathleen Pegion
Global Climate Models (GCMs)

- Developed to study Climate variability and change
- GCM Forecast system developed – mainly to predict ENSO
- Now being used to make seasonal to decadal forecasts of global SSTs and other climate variables

Here we evaluate SST forecast skill of GCMS for Large Marine Ecosystems (LMEs) in US waters

GCM – ocean, atmosphere, land, and sea ice

Figure courtesy of D. Tommasi
Large Marine Ecosystems (LMEs)

LMEs 1: East Bering Sea (EBS), 2: Gulf of Alaska (GoA), 3: California Current (CC), 5: Gulf of Mexico (GoM), 6: Southeast U.S. Continental Shelf (SEUS), 7: Northeast U.S. Continental Shelf (NEUS), 8: Scotian Shelf (SS), 9: Newfoundland-Labrador Shelf (NL), 10: Insular Pacific Hawaiian (IPH), 65: Aleutian Islands
Monthly SST Anomaly Forecast Skill in LMEs

Based on the Anomaly correlation coefficient (ACC) for SST anomalies (bias corrected) from hindcasts during 1982-2009.

Stock et al., Progress in Oceanography, 2015
Multi-Model Forecasts

• Many studies have found that forecasts from multiple models are better than those from any single model

• Here we examine the skill of SST hindcasts from the North American Multi-Model Ensemble (NMME), phase 1
  – Kirtman et al. 2014, BAMS

• Monthly Hindcasts during 1982-2002 from 14 models
  – All output on a 1° lat x 1° lon grid

• Skill estimated by:
  – First average ensembles from individual models
  – Average models to create a multi-model mean hindcast
  – Bias correct hindcasts by removing drift (initialization month, lead)
  – Skill of SST hindcasts evaluated relative to ¼° Reynolds OI SST data set
Anomaly Correlation Coefficients (ACC) for Ensemble mean SST NMME Forecasts for US LME regions (all NMME models averaged together)
Average of ACCs over all initialized months as a function of forecast lead time for each model, persistence and the multi-model mean.
Overall Skill Estimates of SST hindcasts

Mean ACC

Model
- ENSEMBLE
- CanCM3
- CanCM4
- CCSM3
- CCSM4
- CM2p1
- CM2p1-aer04
- CM2p5-FLOR-A06
- CM2p5-FLOR-B01
- AnomalyCoupled
- DirectCoupled
- GMAO-062012
- GMAO
- CFSv1
- CFSv2
- PERSISTENCE

LME

Mean RMSE

Model
Hindcast skill (ACC) for 3-sub regions in the California Current LME from CanCM4

Anomaly correlation coefficients:
- above 0 at 5% level
- above persistence at 10% level with ACC > 0.5
- above persistence at 10% level with ACC < 0.5.
Processes that influence predictability

Correlation of Pacific basin wide SST with CCS regionally averaged SST 0, 3, 6, and 9 months prior

- **ENSO**
  - Lead 0
  - Lead 3
  - Lead 6
  - Lead 9

- **Persistence**

- **ENSO + Persistence**
Forecast Skill in the CC LME for:
- a) initialization,
- b) lead time
- c) forecast month

Persistence + Nino3.4 forecast a from a simple multiple linear regression model
Application of SST forecasts to Pacific Sardines

- Sardine population simulated using an age-structured model
  - Recruitment dependent on parents biomass and SST
- Current harvest guideline (HG) dependent on previous year’s SST and biomass in CC LME (HG2)
- Use late winter/early spring SST forecast from an NMME model
  - Use in Hg (controls fishing rate) to get predicted biomass (HG3)
- Use the predicted Biomass to inform the following years biomass (HG4)
Summary

• GCMs have skill in predicting SSTs but varies widely by region, e.g.
  – Gulf of Alaska & California Current reasonably good
  – Southeast and northeast US not so much

• Skill in LME subregions
  – Decreases from north to south in the 3 California Current subregions

• Multi-model mean generally the best forecast though not necessarily for all regions at all time
  – Perhaps could be improved by weighting models by skill but non-trivial
  – Can use models to understand processes that contribute to predictability
  – Use this information to improve climate forecast systems (including statistical models)