

Projected sea surface temperatures over the 21st century: changes in the mean, variability and extremes for large marine ecosystem regions of Northern Oceans.

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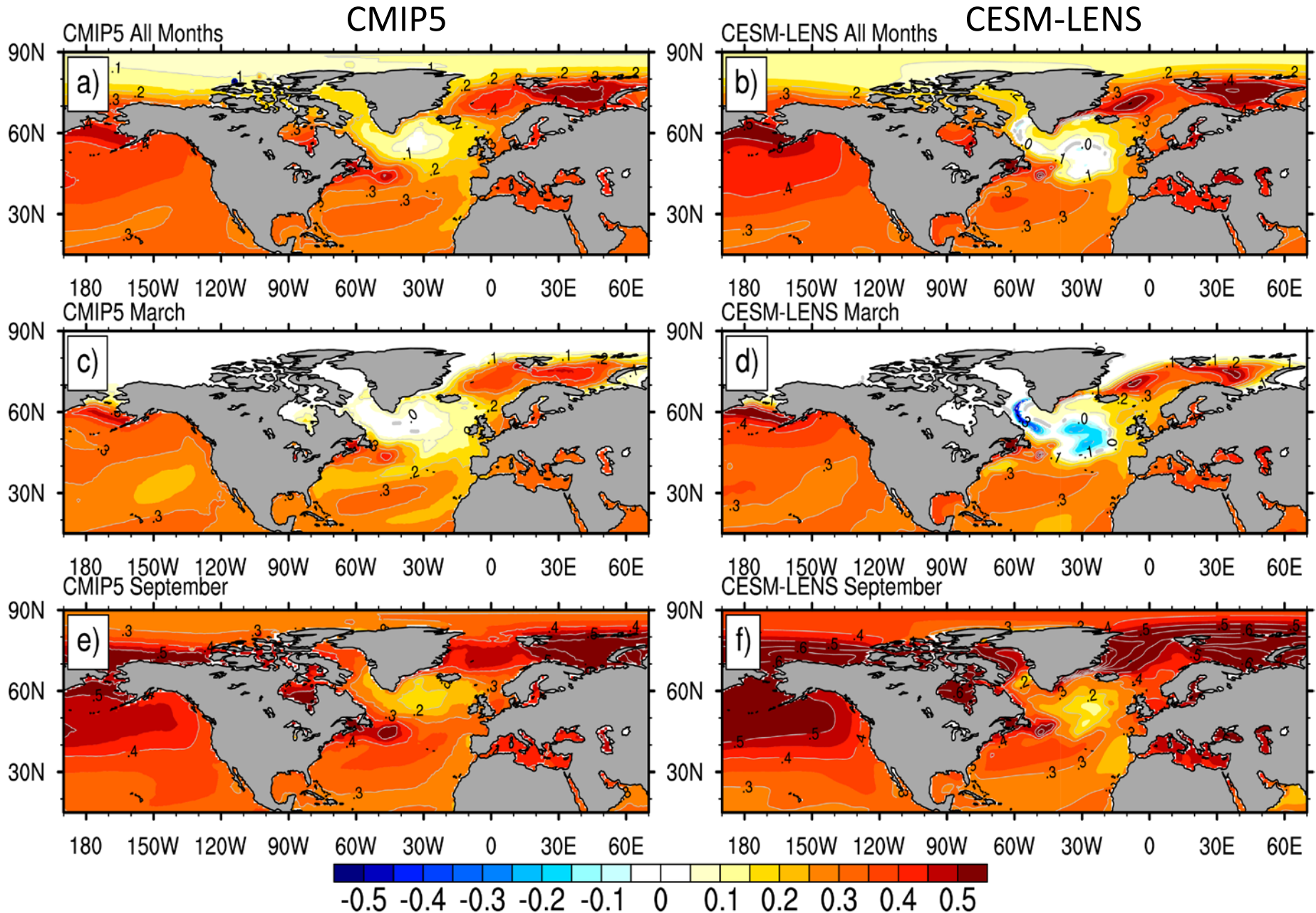
Motivation

- Strong interest in SST variability and change among marine ecologist & fishery scientists in addition to climate scientists.
 - Example: Poleward movement of fish populations along the US east coast.
 - Concern now extends beyond just the change in the mean.
 - Extremes could be as or more important
 - e.g. thermal thresholds reached - Coral bleaching
 - Notion: “All extremes are getting more extreme”, true?
- Examine change in mean and the variability of SSTs
- Focus on Large Marine Ecosystems (LMEs)
 - Ocean areas along continental margins whose ecology is characterized by similar in bathymetry, hydrography, and biological productivity”

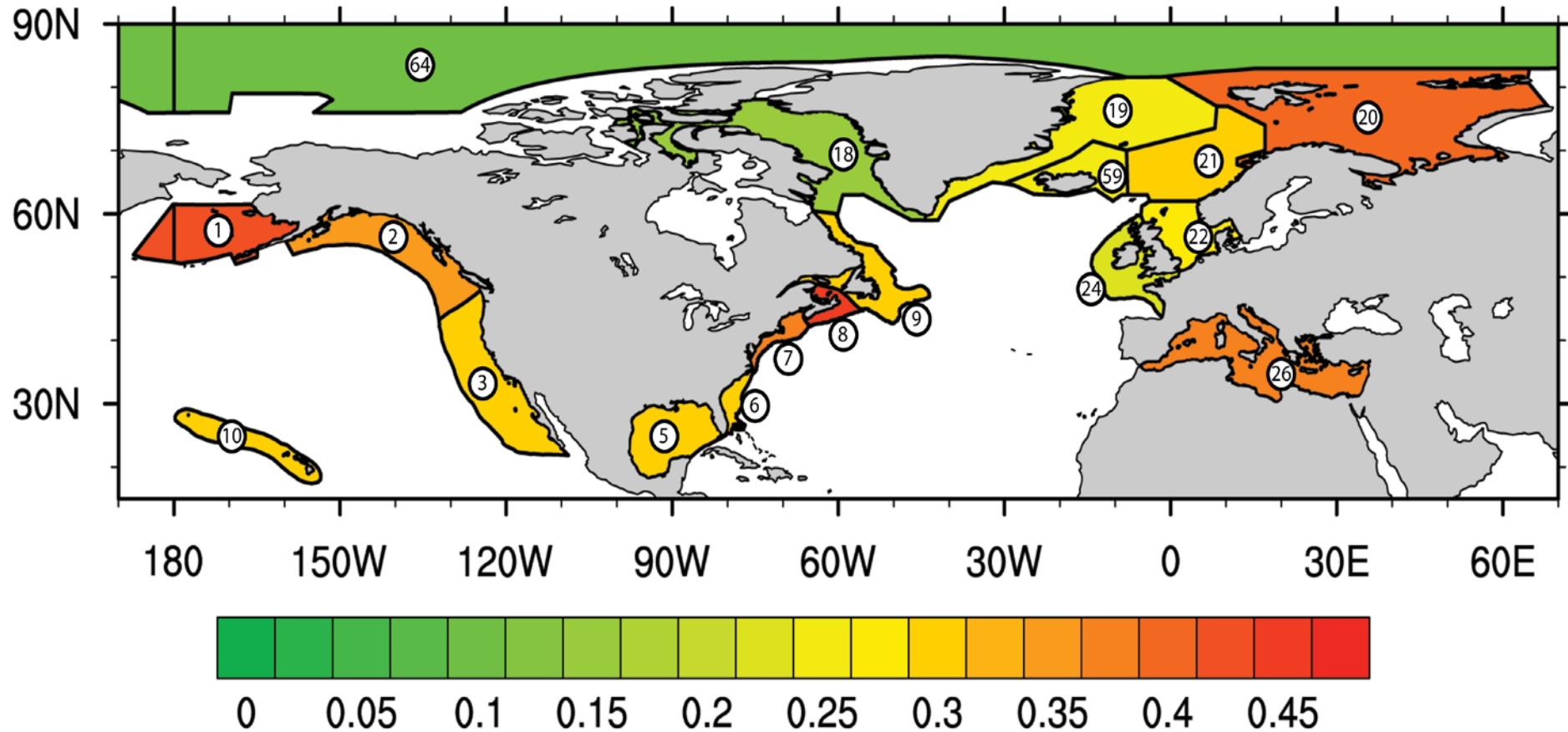
Methods

- Climate change
 - RCP8.5 scenario after 2005, examine 1976-2099
- 26 CMIP5 Climate Models
- 30 simulations NCAR CESM Large-Ensemble
 - Only very small perturbations in the initial conditions
 - Differences only due to internal variability
- Monthly SSTs and also Mixed Layer Depth (MLD)

SST trends 1976-2099 ($^{\circ}\text{C}/\text{decade}$)



CMIP5 Median SST trends ($^{\circ}\text{C}/\text{decade}$) in Large Marine Ecosystem (LME) regions



N. America

SST Trends

CMIP5 &
CESM-LENS

1976-2099

°C/decade

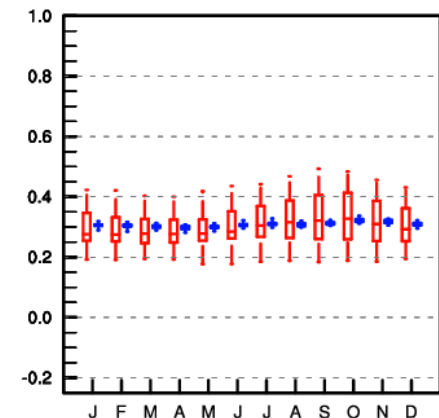
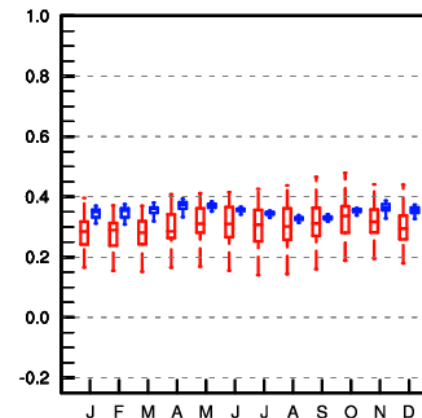
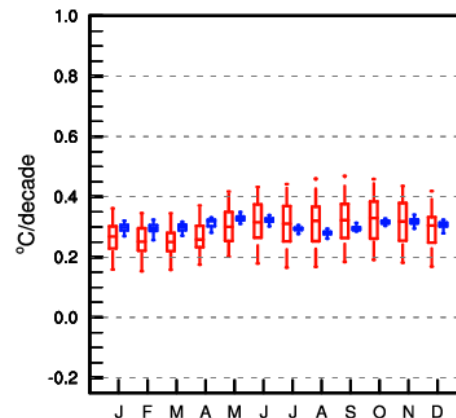
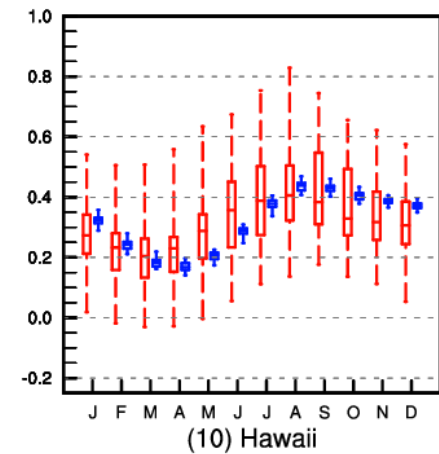
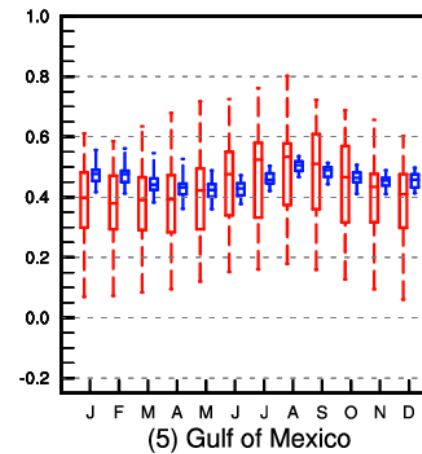
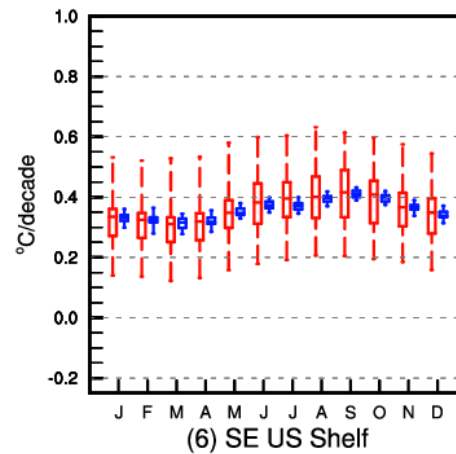
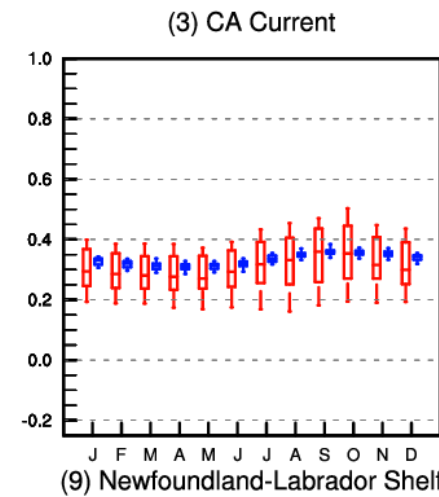
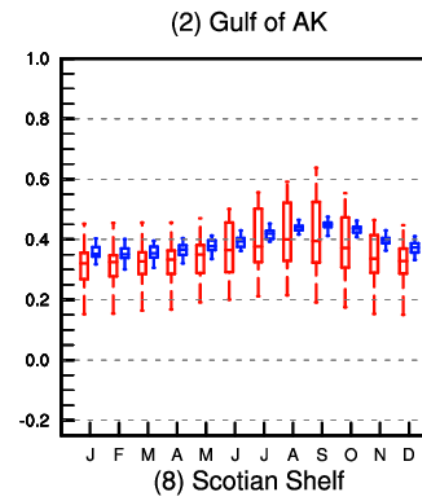
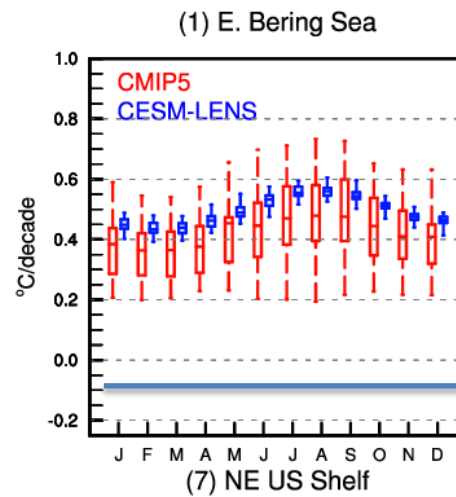
Box &

Whisker

low, 25%,

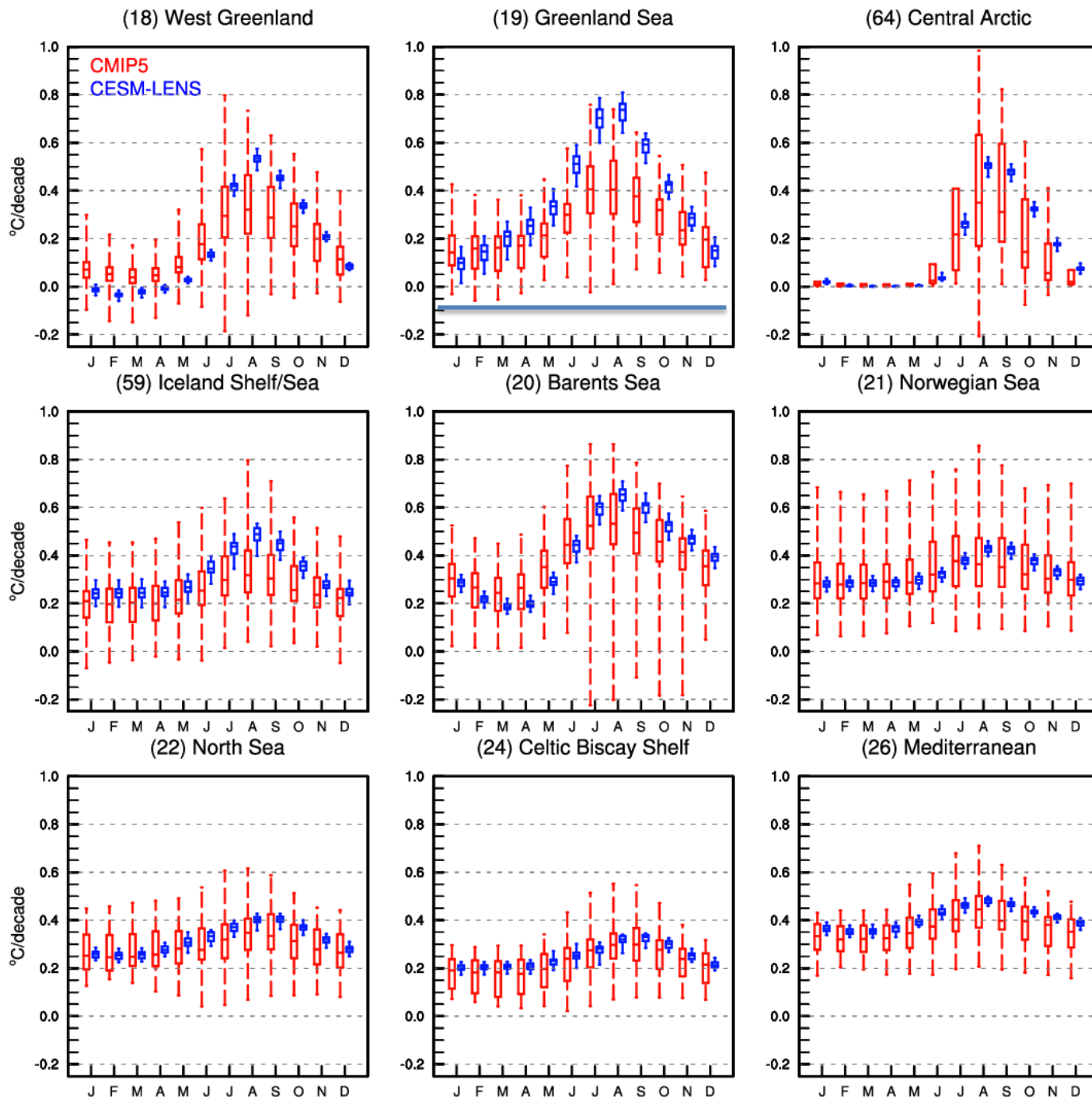
50%, 75%,

high

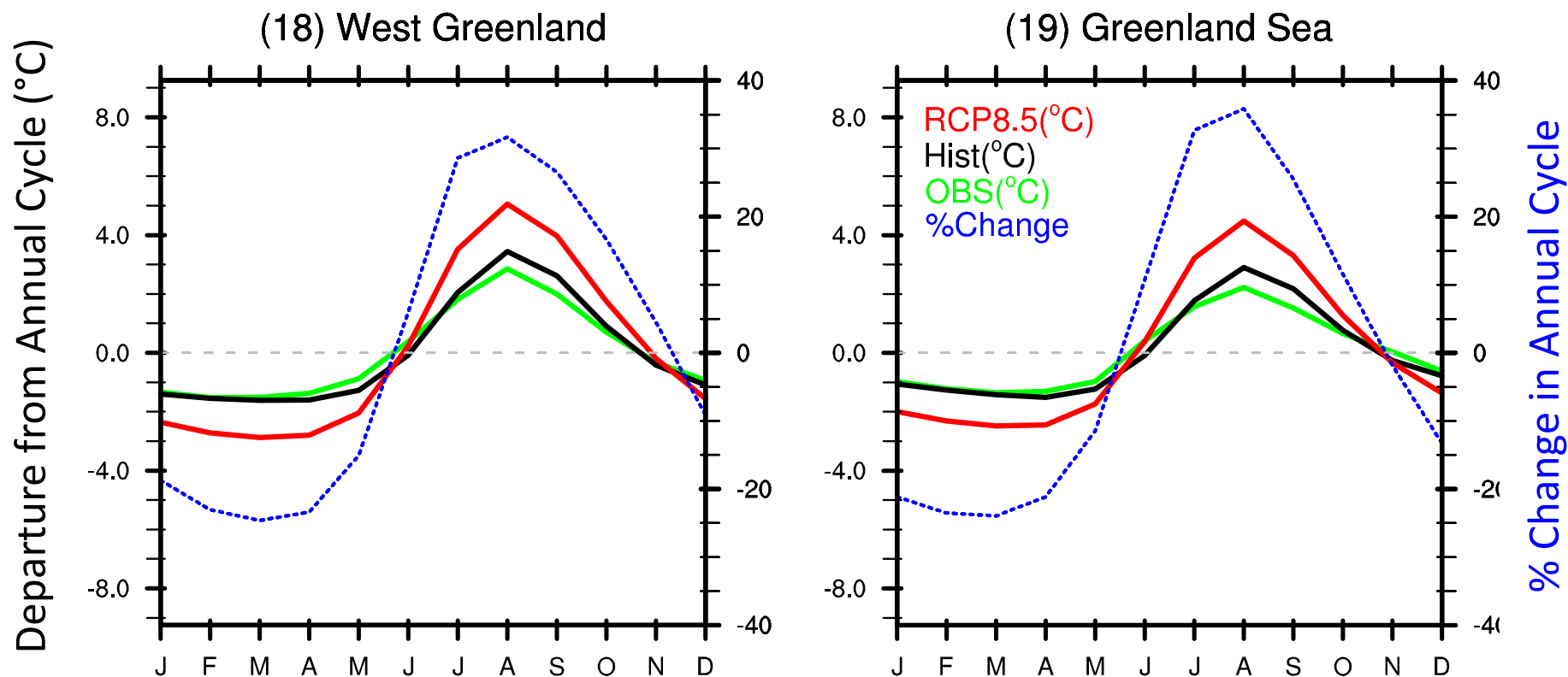


N Atlantic SST Trends CMIP5 & CESM-LENS 1976-2099 °C/decade

Box &
Whiskers
low, 25%,
50%, 75%,
high



CMIP5 SST Seasonal Cycle, Annual Mean Removed

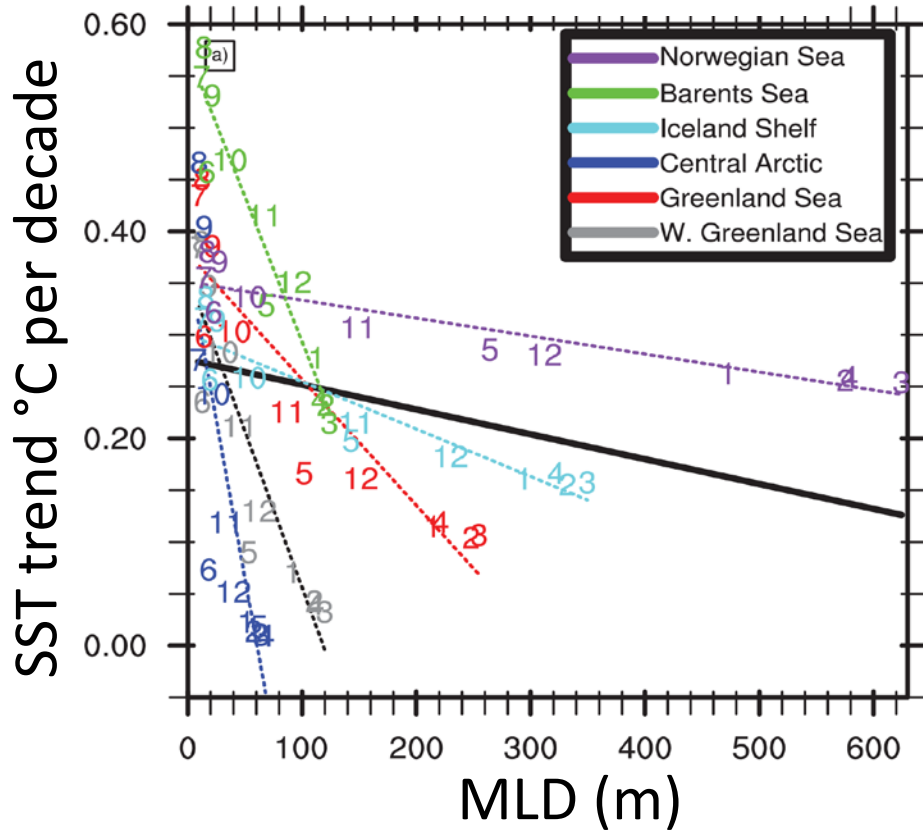


Obs – green; CMIP5: 1977-2005 black; 2070-2099 red; % change blue

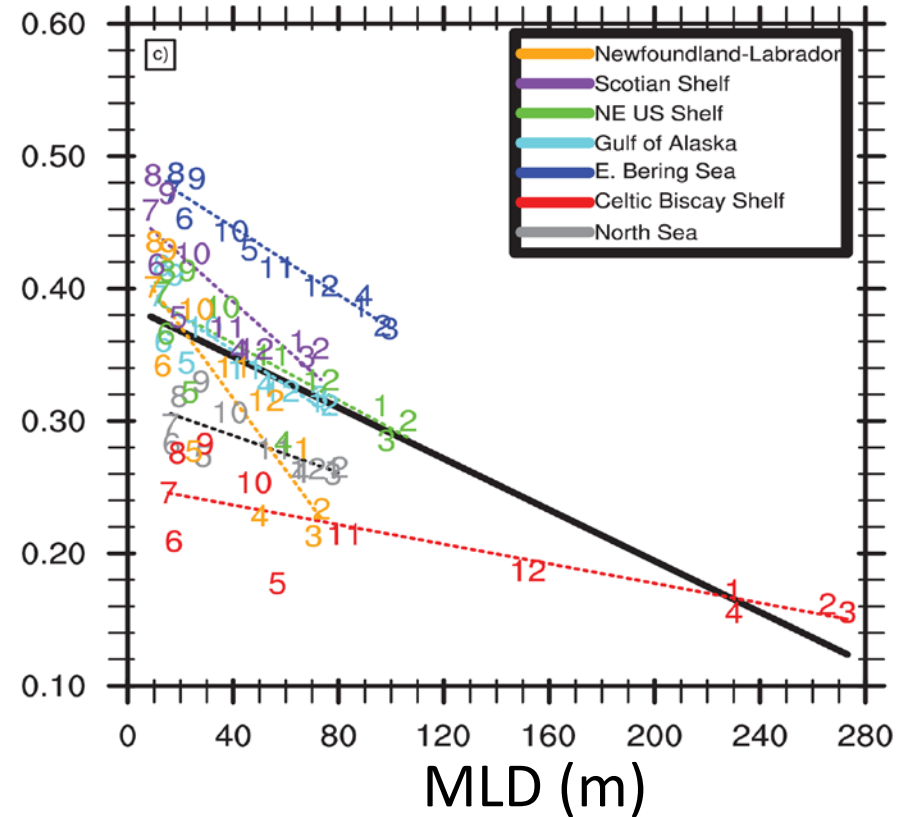
Subtropical & Midlatitude regions 4%-8%;
high latitudes > 20% increase in seasonal cycle

CMIP5 LME SST trends in each calendar month (#s) as a function of mean MLD

High latitude LMEs



Midlatitude LMEs



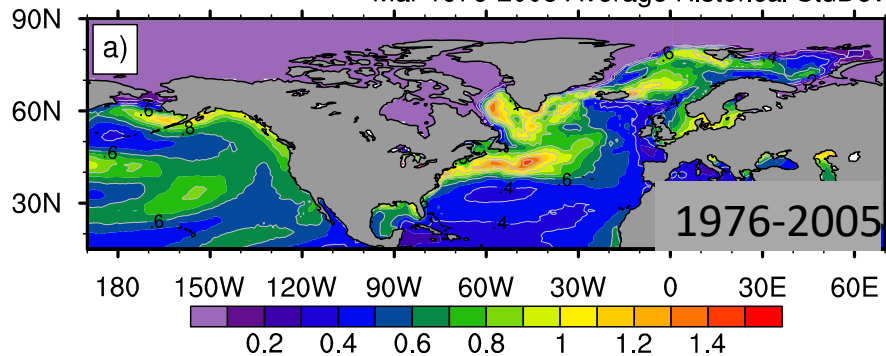
Subtropical LMEs similar but with less seasonal MLD variation

CMIP5 SST Variability (σ)

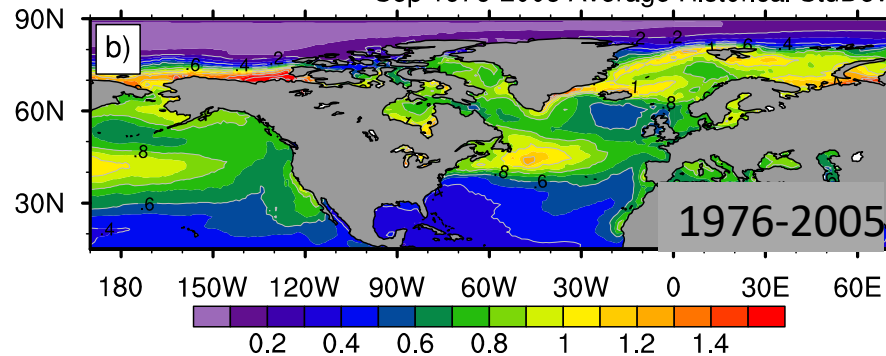
March

September

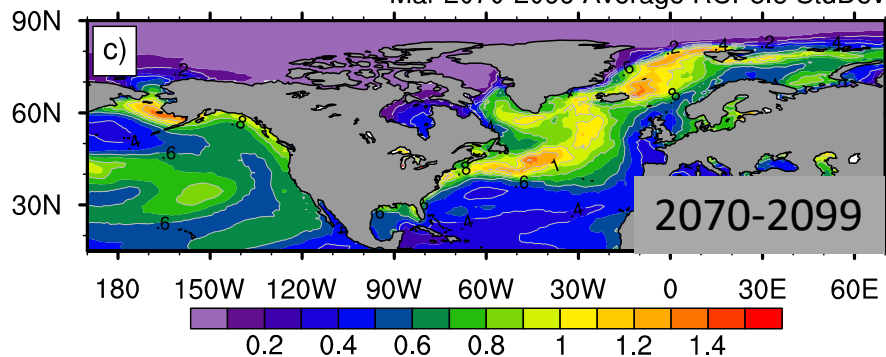
Mar 1976-2005 Average Historical StdDev



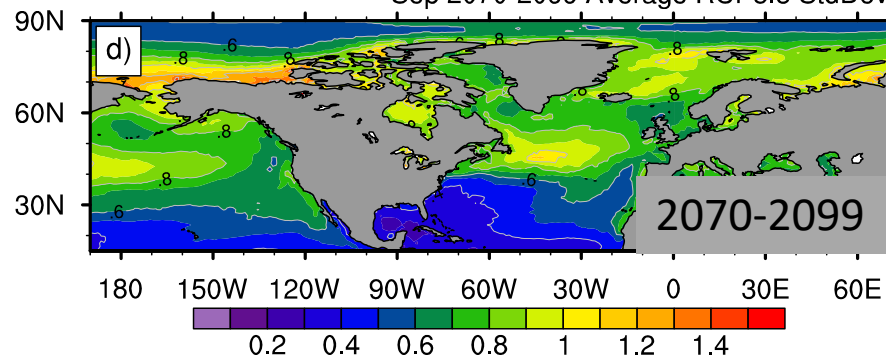
Sep 1976-2005 Average Historical StdDev



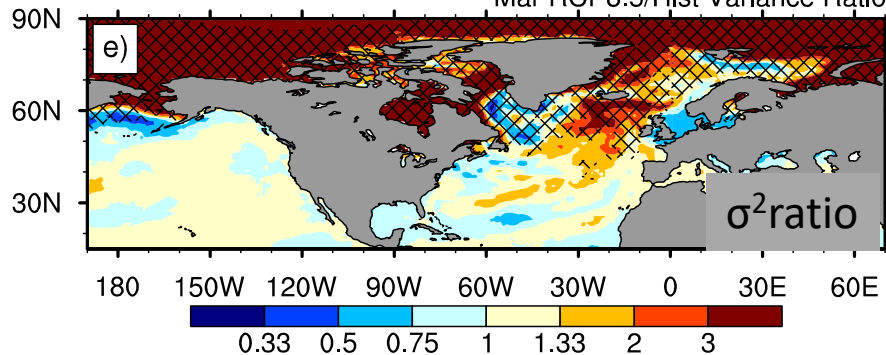
Mar 2070-2099 Average RCP8.5 StdDev



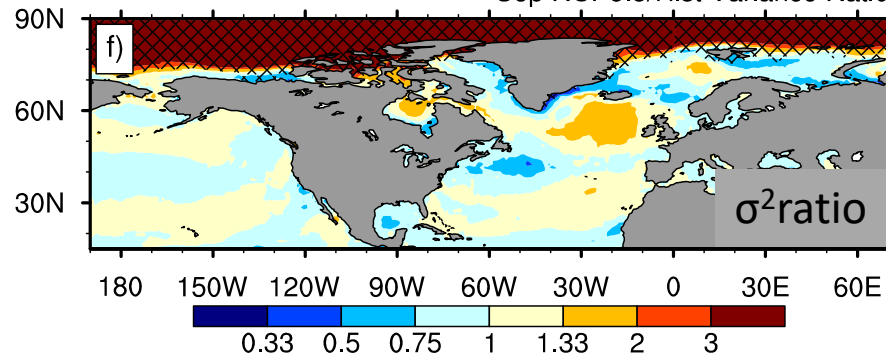
Sep 2070-2099 Average RCP8.5 StdDev



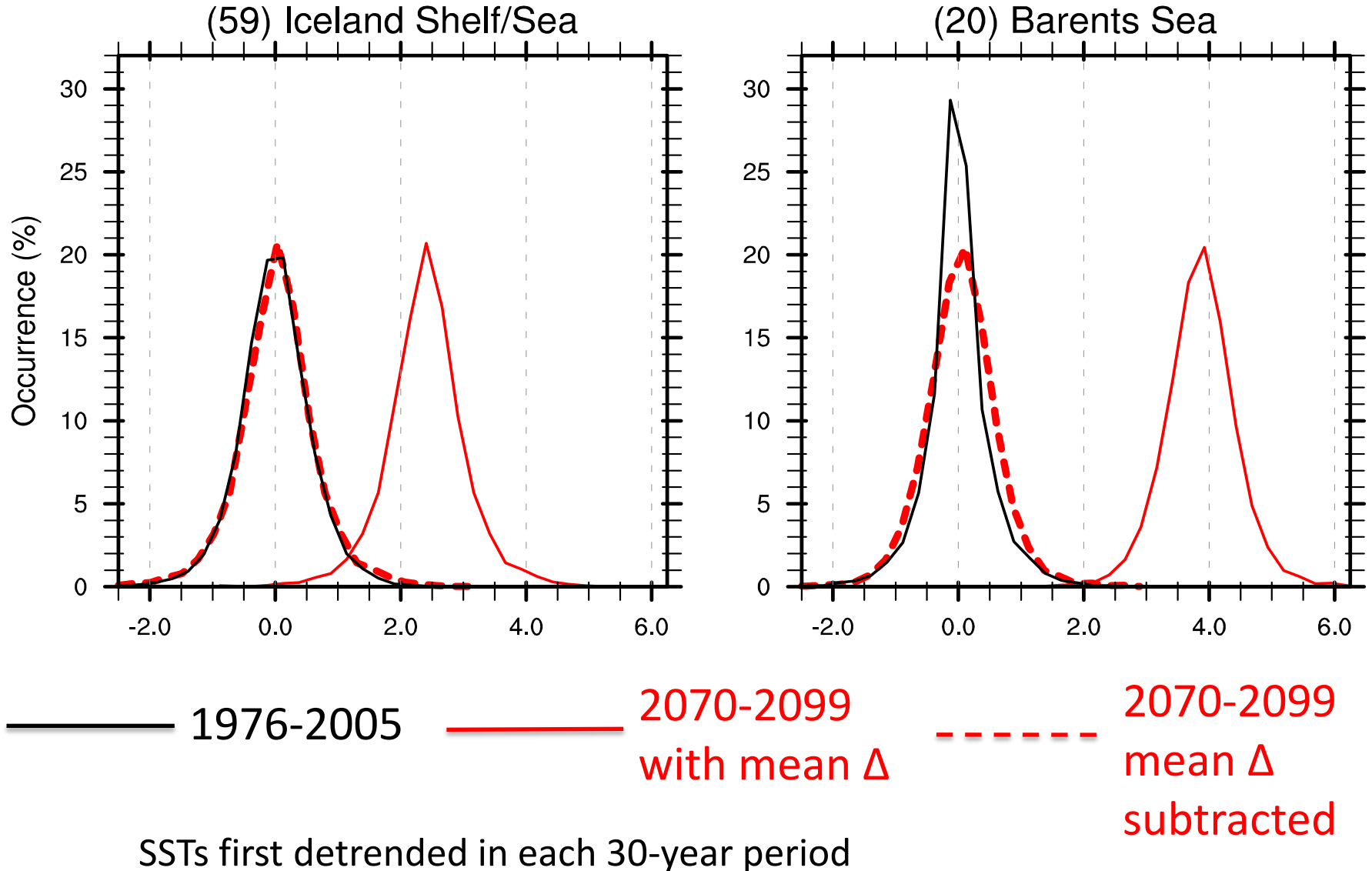
Mar RCP8.5/Hist Variance Ratio



Sep RCP8.5/Hist Variance Ratio



Example CMIP5 SSTA PDFs (Histograms) relative to 1976-2005

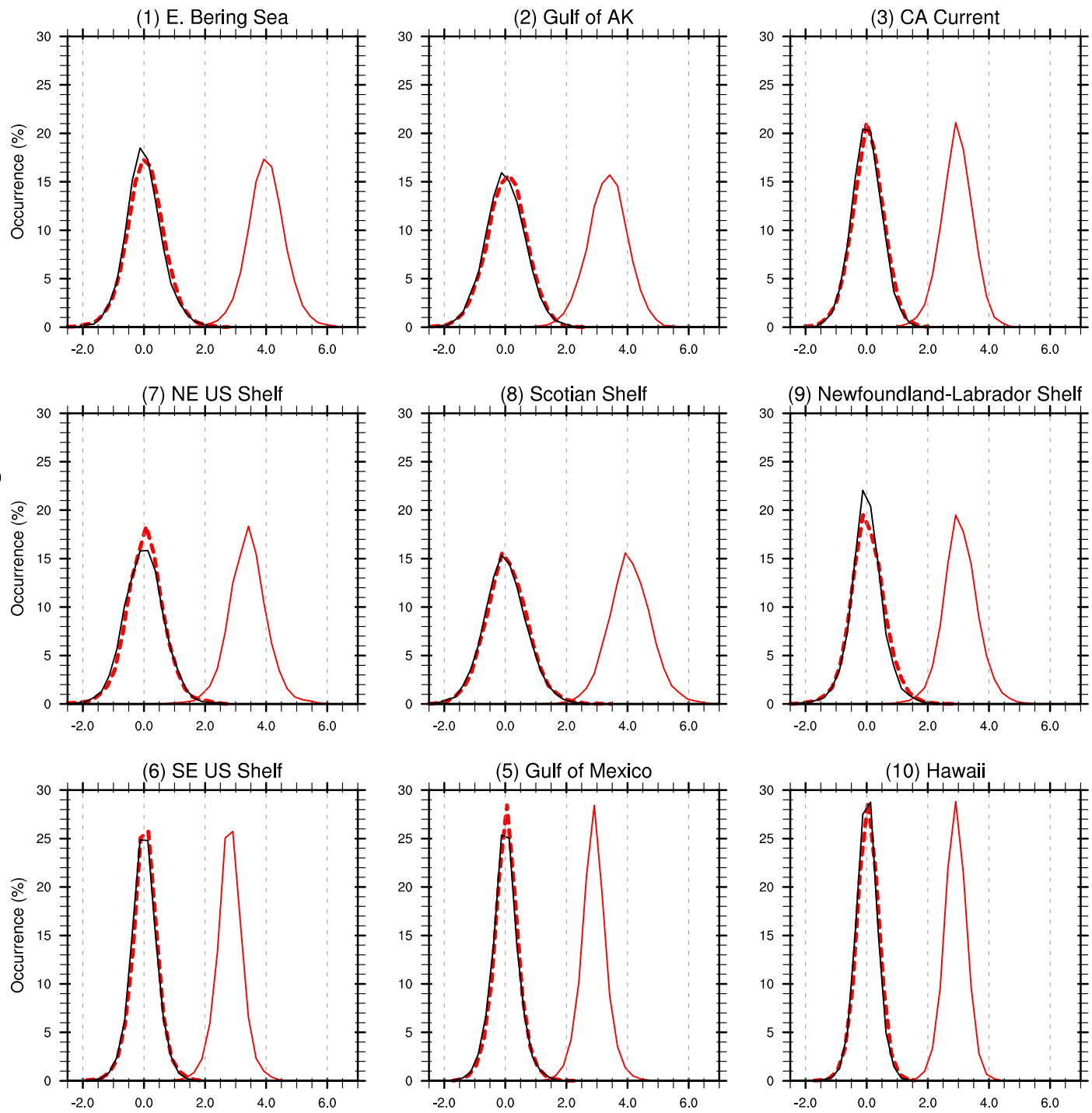


Monthly SSTA PDFs All CMIP5 Models

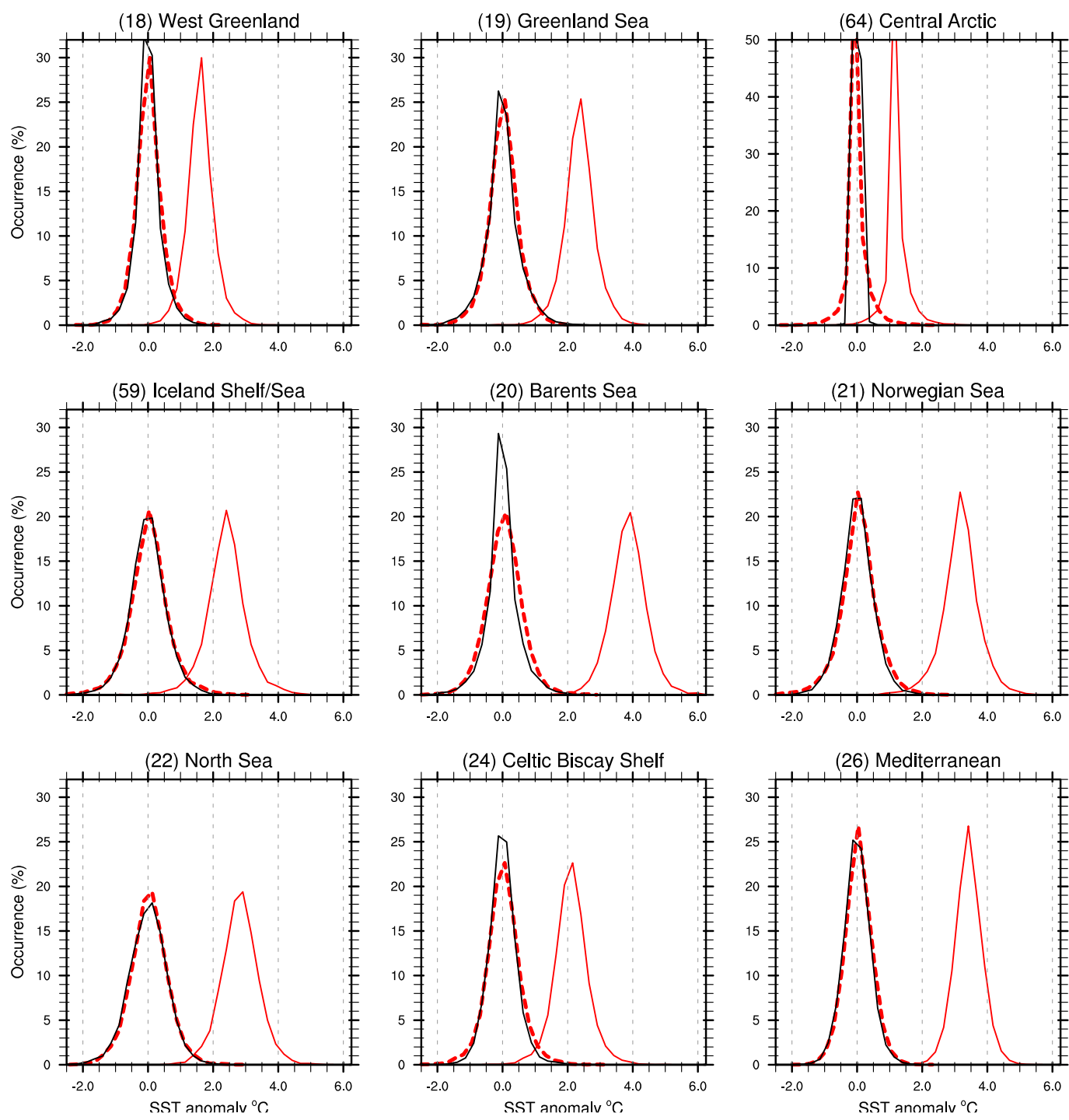
Black:1976-2005

Red Solid 2076-
2099
with mean Δ

Red dashed
2076-2099
with mean
 Δ removed



Monthly SSTA PDFs All CMIP5 Models



Summary

- Upward SST trends over the 21st century
 - Spread in trends much greater in CMIP5 than in CESM-LENS: physics > natural variability for generating SST variability
 - Trends greater in summer than in winter especially mid and high latitudes => amplifies the Seasonal cycle of SST
 - Due in part to the mean seasonal cycle of MLD
- Modest changes in variability
 - Large mean shift, small changes in PDF
 - *All extremes not more extreme*
 - Except where sea ice disappears and portions of N. Atlantic