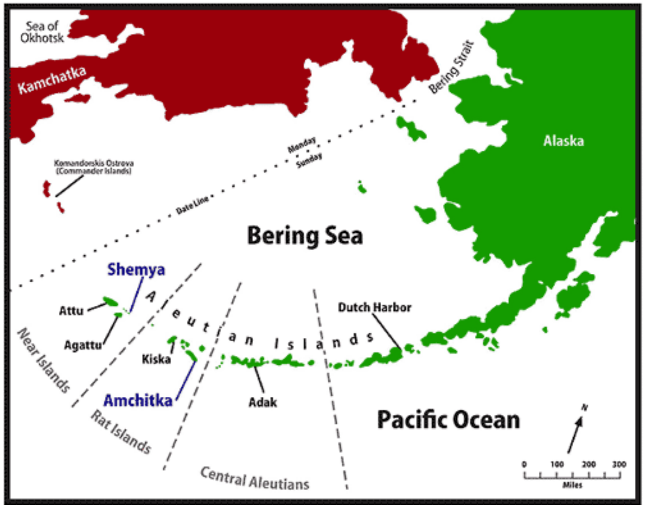
CESM simulations of Bering Sea climate and marine production

John Walsh, Georgina Gibson and Josh Walston

University of Alaska Fairbanks



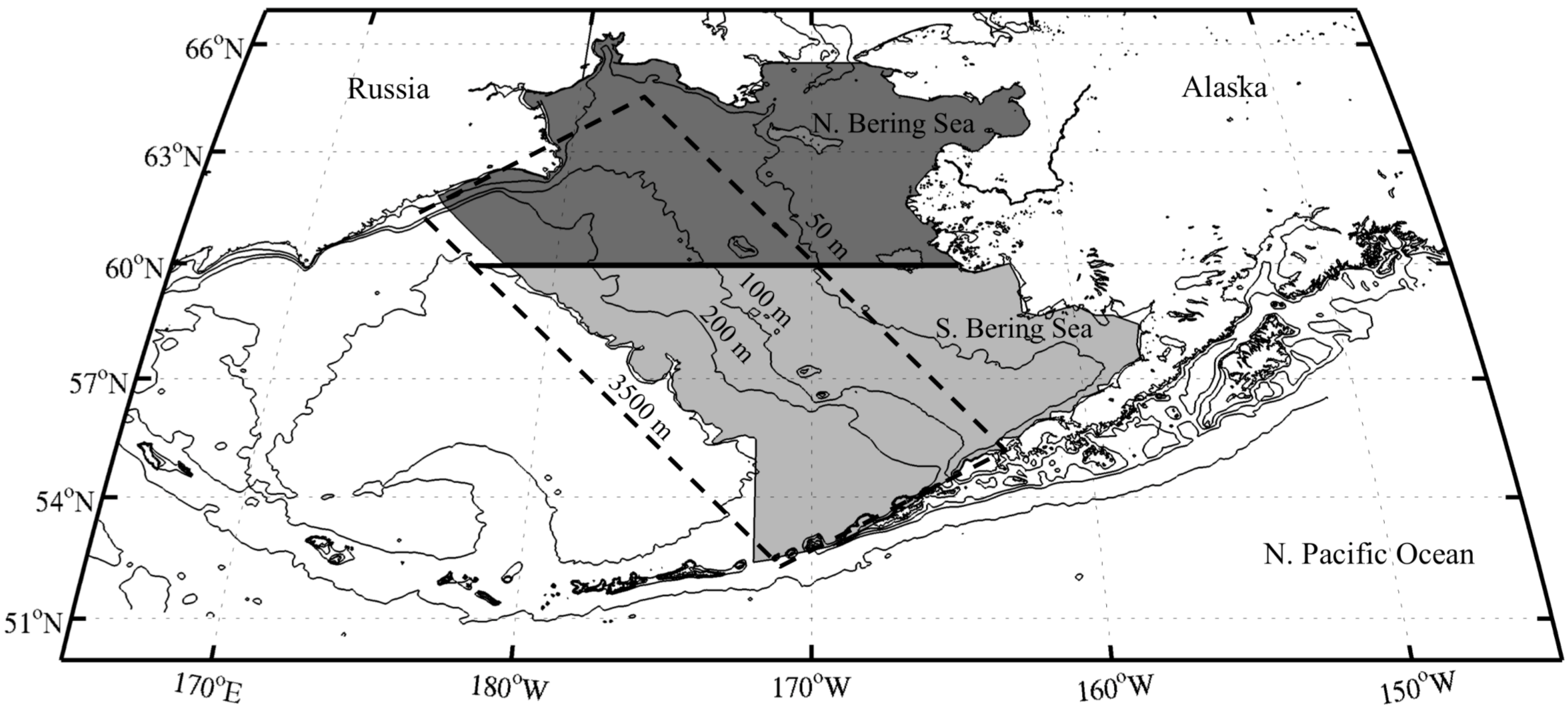
Motivation: The Bering Sea is a key oceanic pathway and an economically important marine ecosystem that appears to be changing.

Focus: Primary production (the base of the marine food chain)

-- How well do models such as CESM simulate this region?

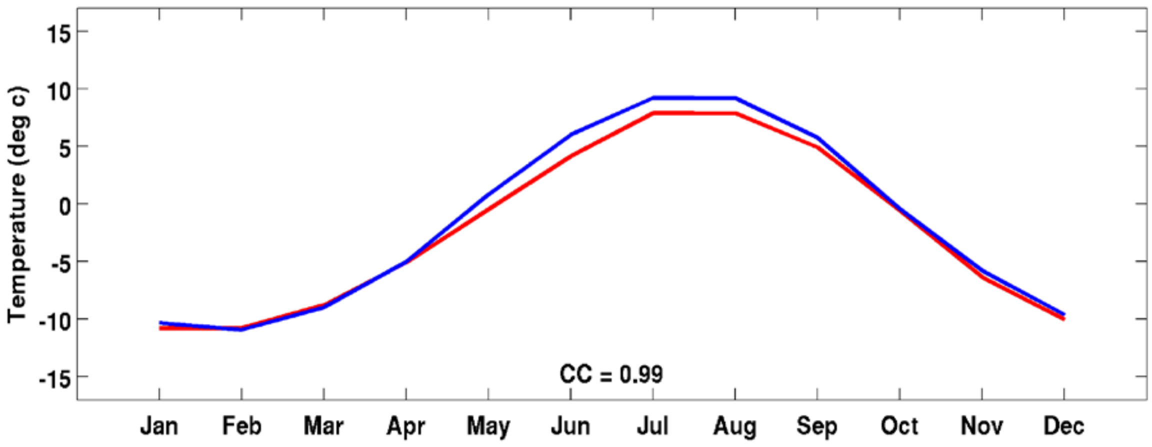
-- Are the relationships between physical drivers and primary production captured by system models such as CESM?

Bering Sea analysis domain, North and South

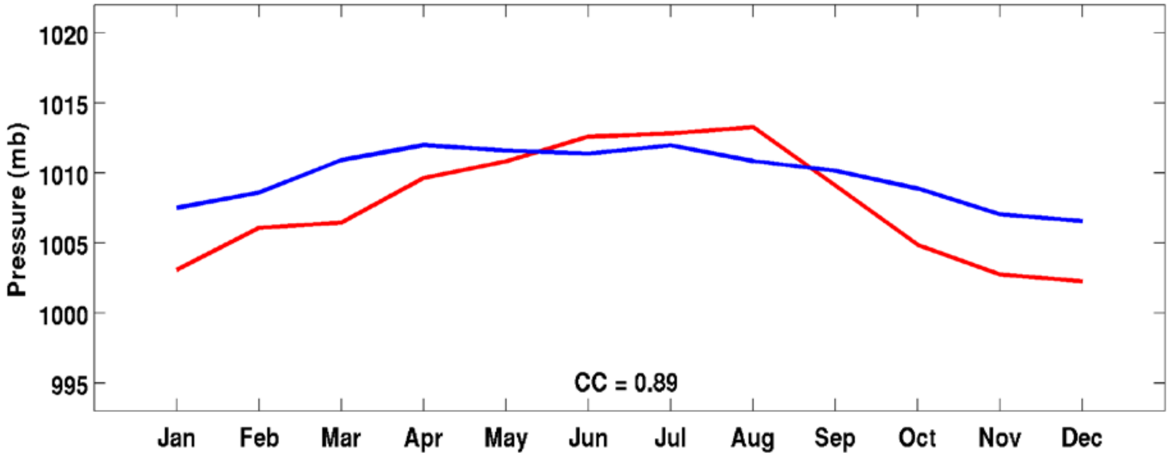


Climatological seasonal cycles over Bering Sea, 1955-2005

CESM vs. NCEP/NCAR Reanalysis



T_{air}

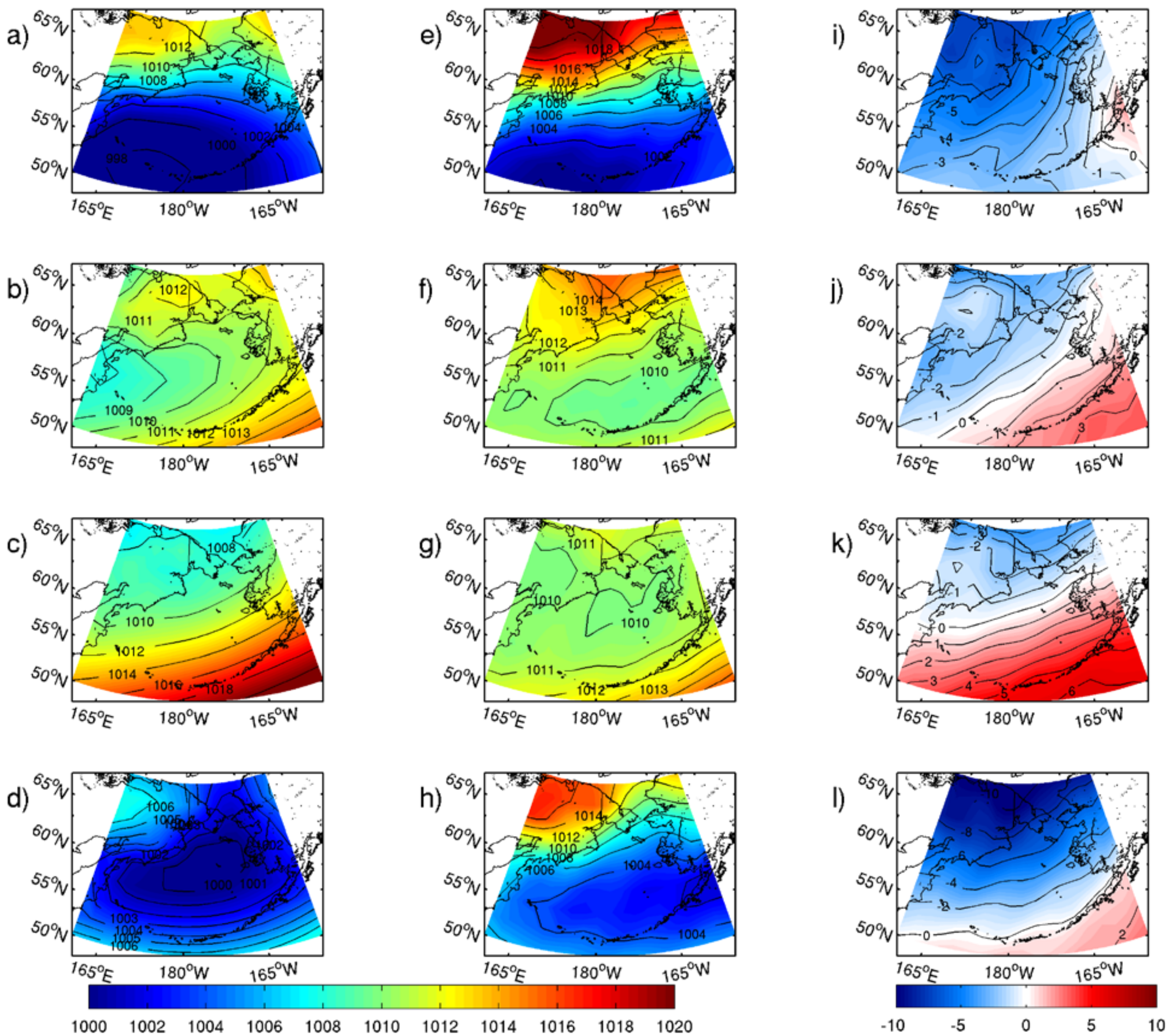


SLP

Spatial pattern of climatological SLP, 1955-2005

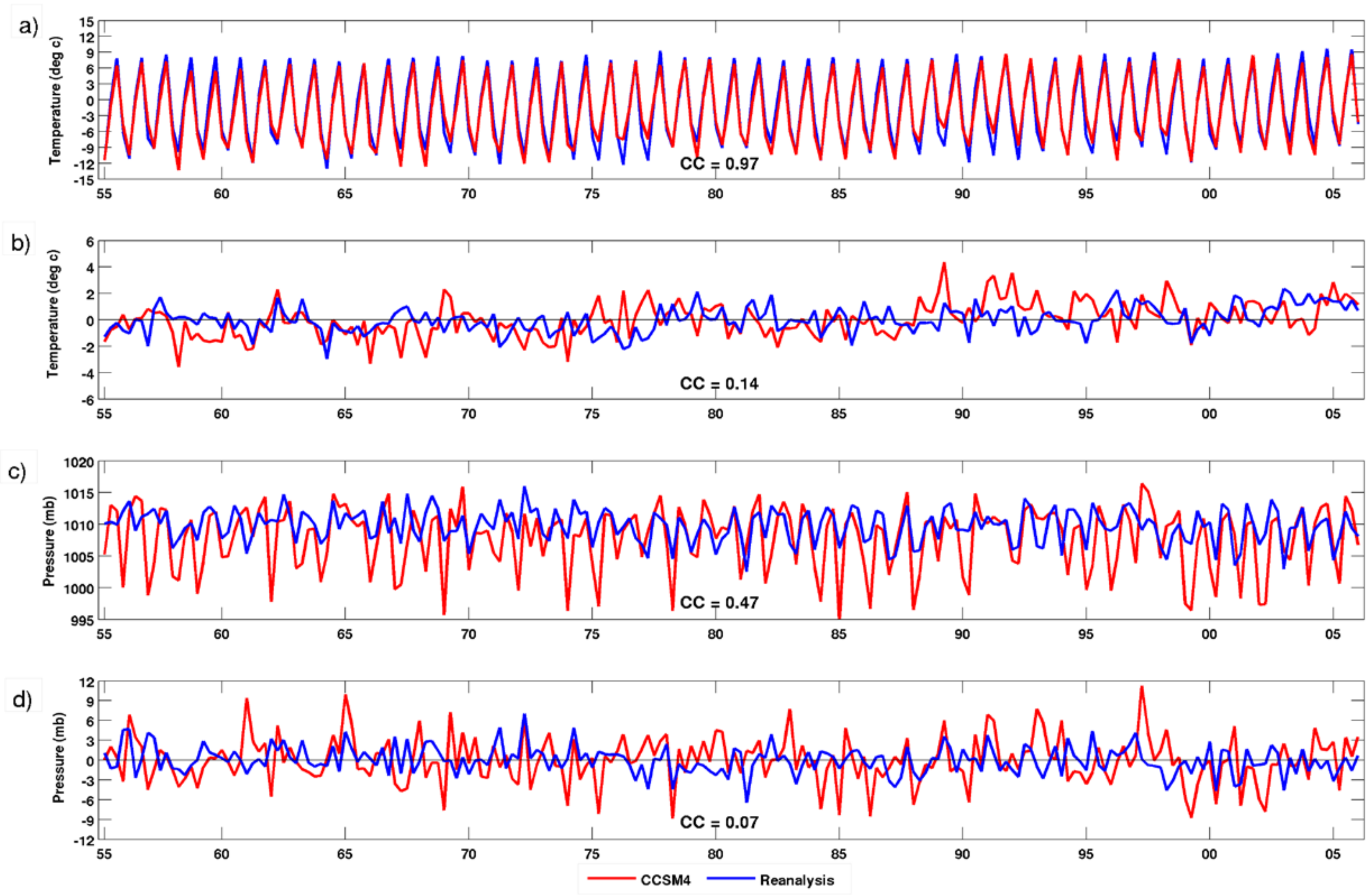
CESM | **reanalysis** | **difference**

winter | **spring** | **summer** | **autumn**



Variance of T_{air} is comparable in CCSM4 and Reanalysis;

Variance of SLP is 2x larger in CCSM4 (vs. Reanalysis)



T_{air}

SLP

The model: BEC within POP2 within CESM

BEC = Biogeochemical Elemental Cycling

-- a marine ecosystem module

-- a nutrient-phytoplankton-zooplankton-detritus structure

-- explicitly represents the distribution of biological components and their response to physical drivers

-- three phytoplankton functional groups

- ***diatoms***
- ***diazotrophs***
- ***small phytoplankton***

Primary production in the Bering Sea

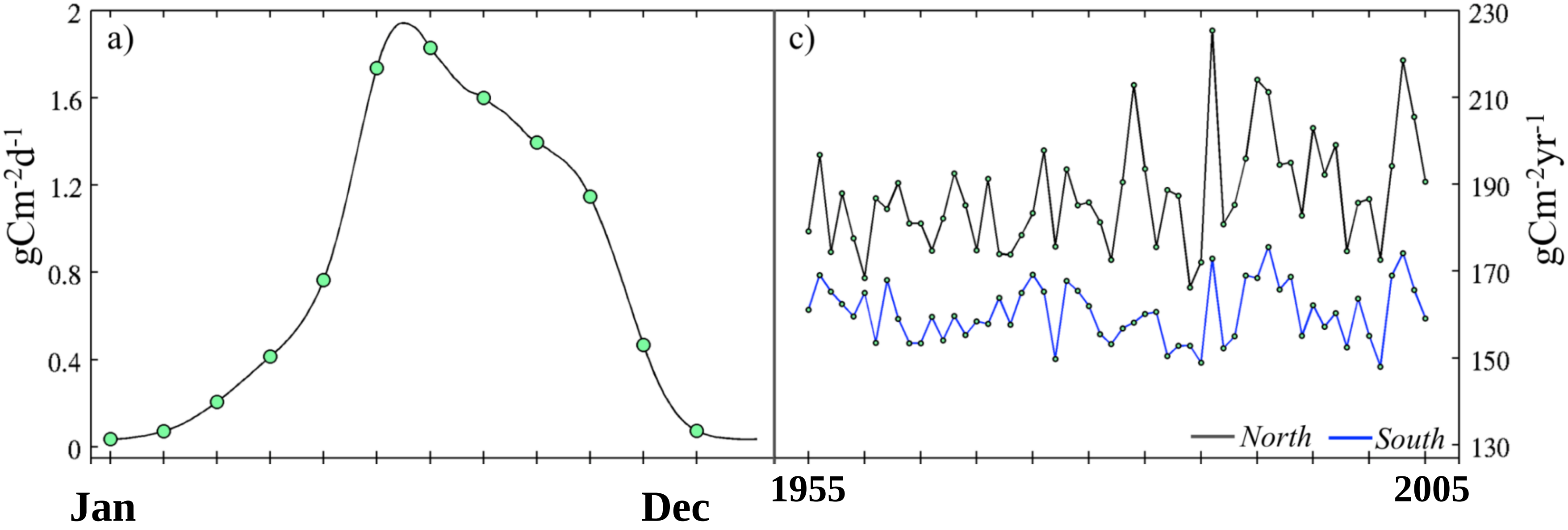
-- small phytoplankton (~15%), diatoms (>80%), diazotrophs

Hypotheses concerning the drivers of primary production:

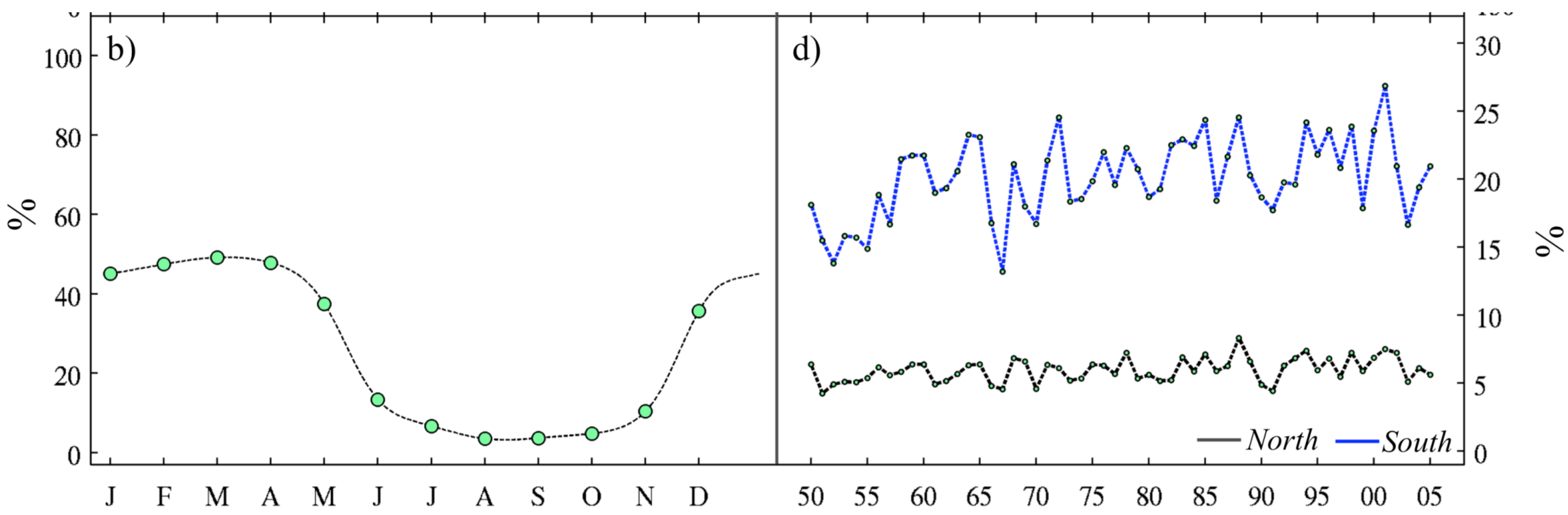
H1: Primary production in the Bering Sea increases as temperature increases, as the wind forcing increases, and as sea ice decreases.

H2: Extremes of seasonal production coincide with extremes of atmospheric forcing and sea ice.

Seasonal cycle and annual time series of CESM-simulated primary production in Bering Sea



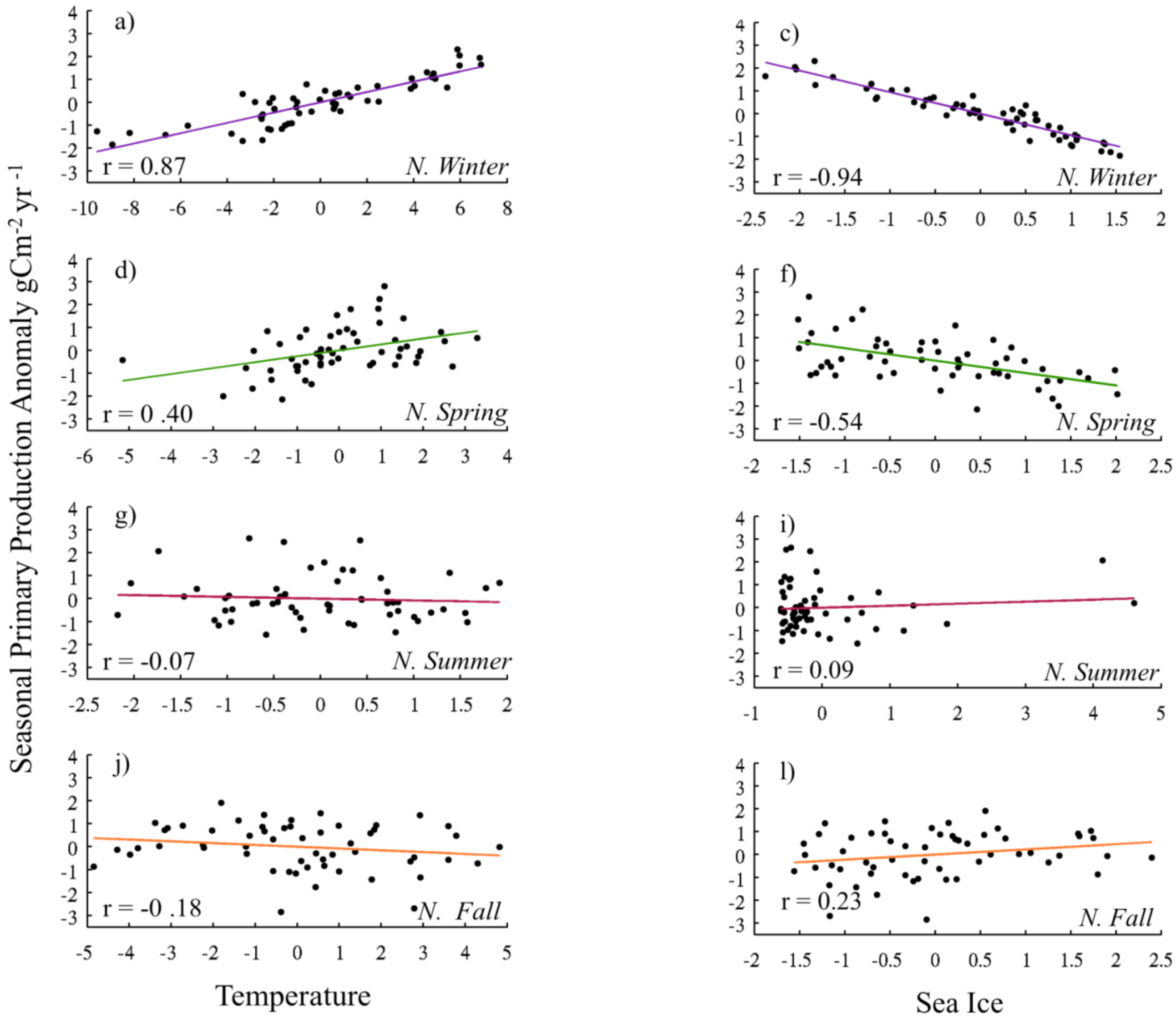
Contribution (%) of small phytoplankton to total primary production (CESM)



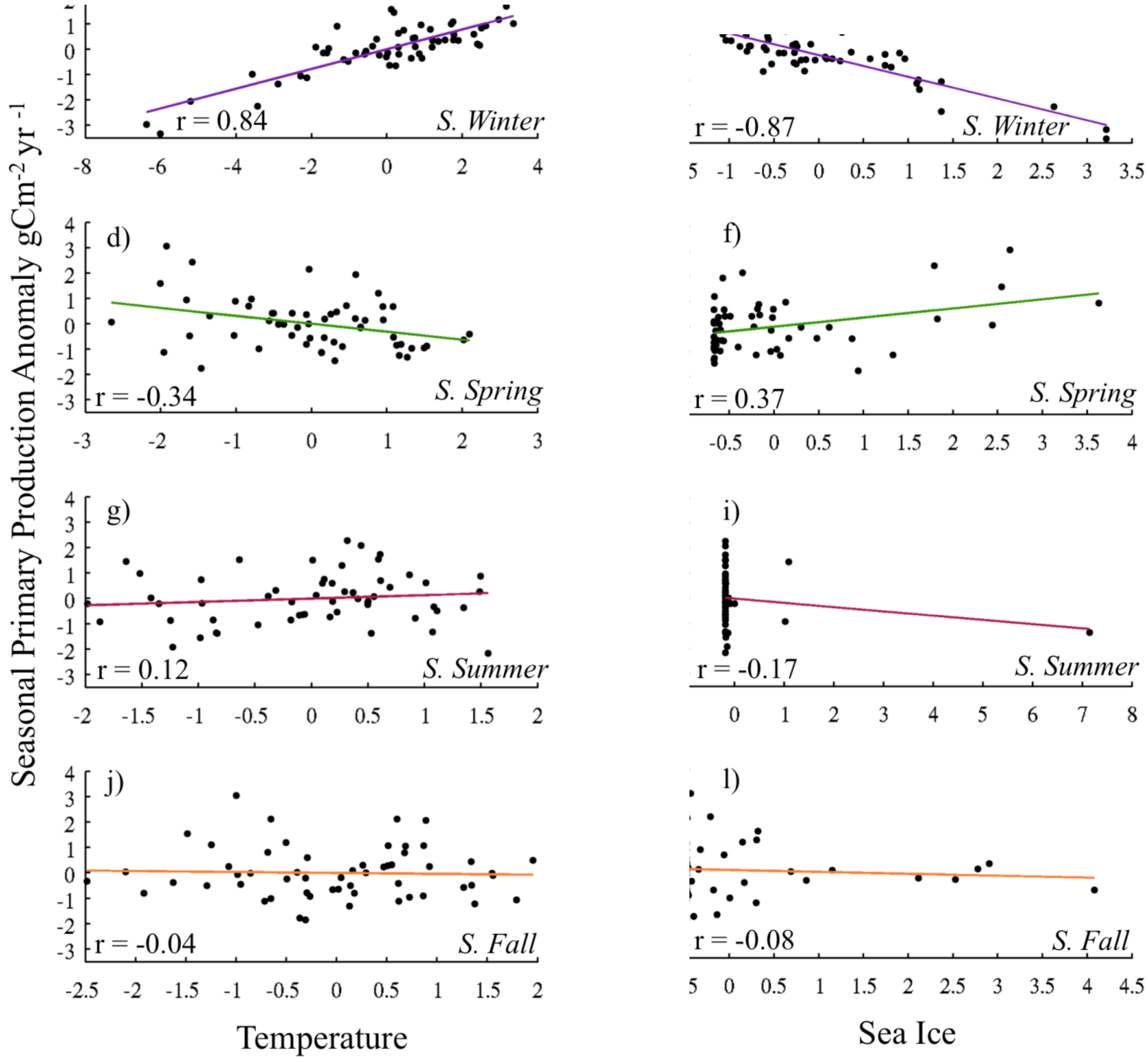
Seasonal primary production in N domain varies by year with:

temperature

sea ice



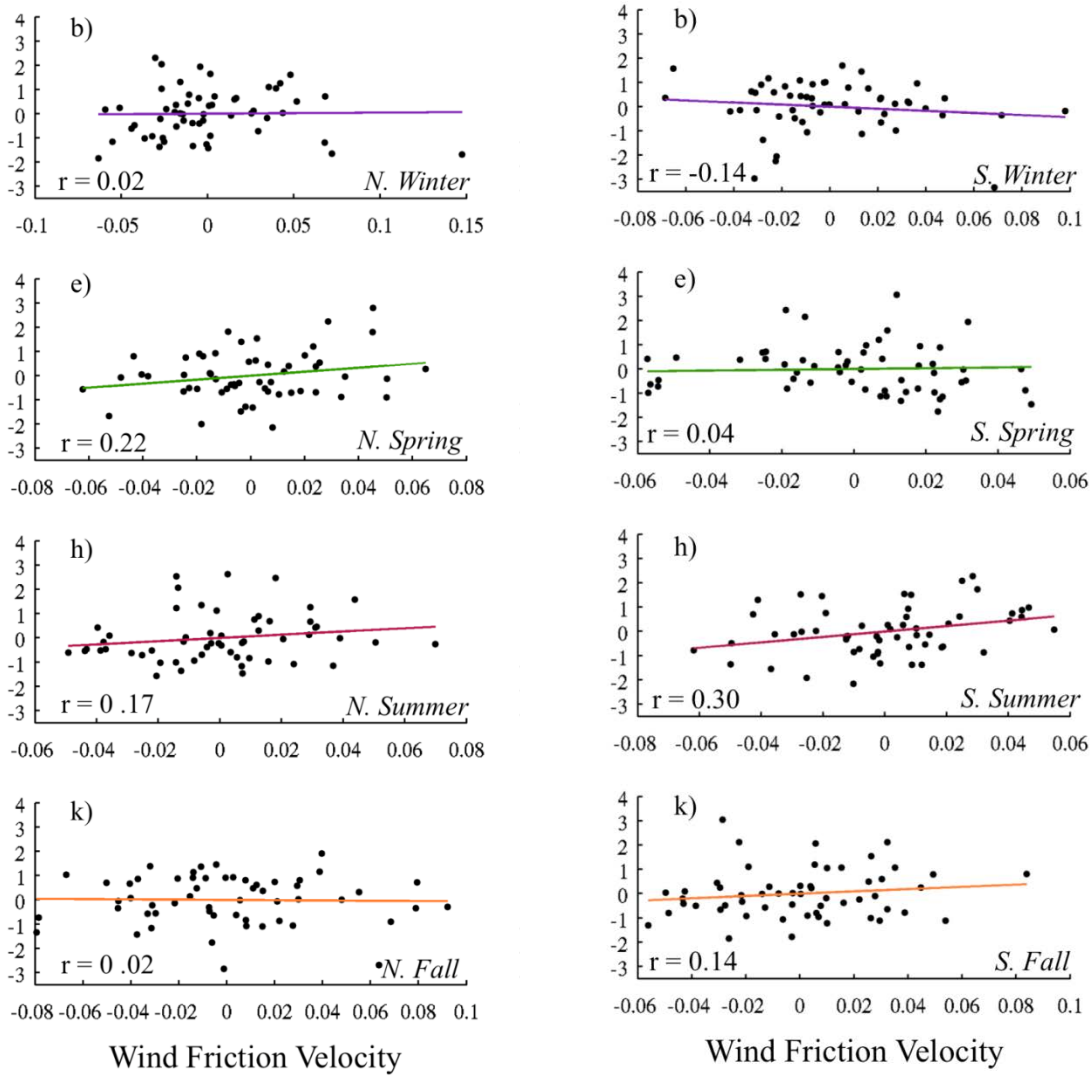
Temperature, sea ice dependence similar in S domain -- except for spring



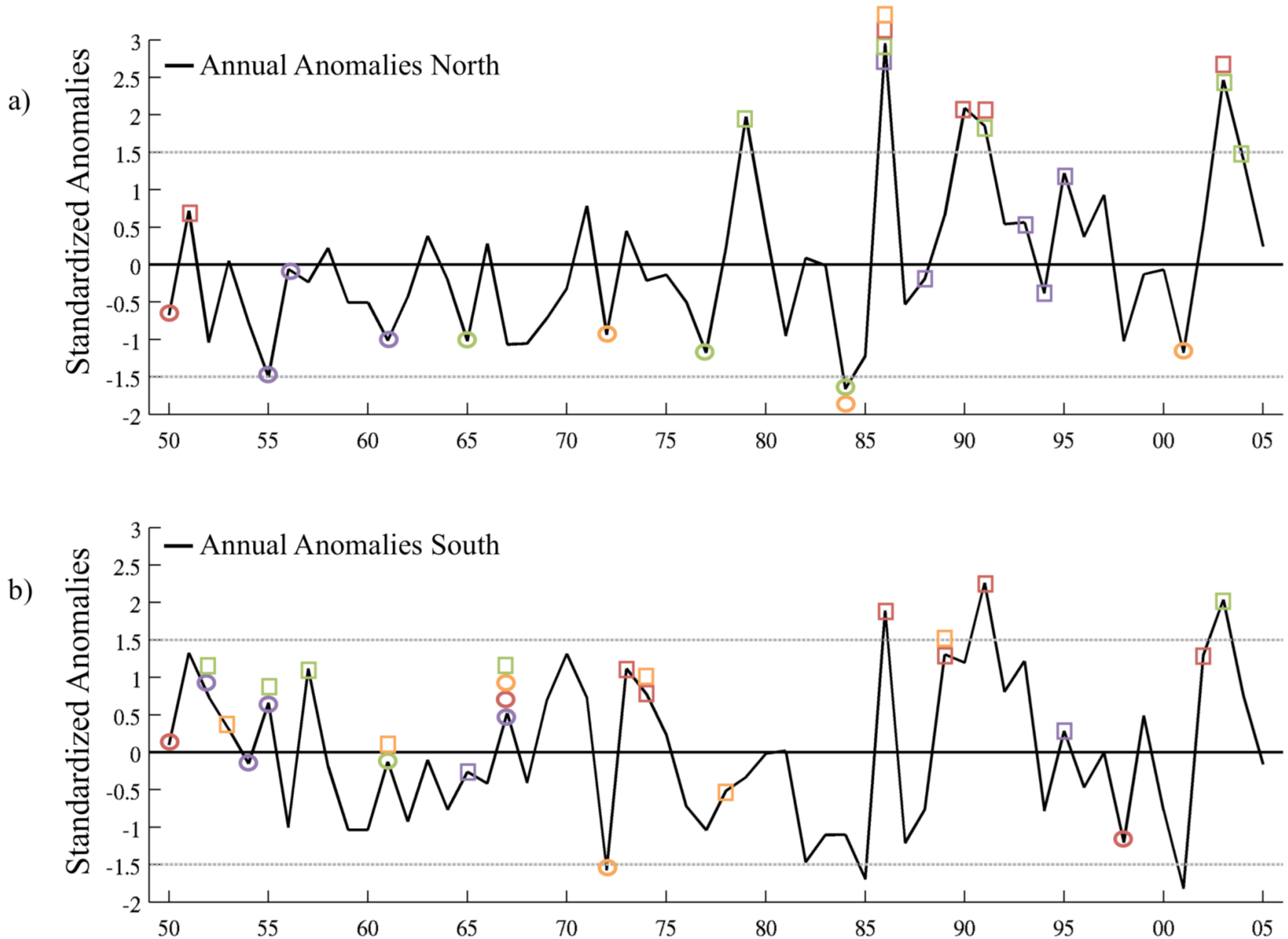
Seasonal production shows little dependence on wind-mixing (integrated over season)

N domain

S domain



Annual extremes of PP are determined mainly by extremes of PP in spring and summer

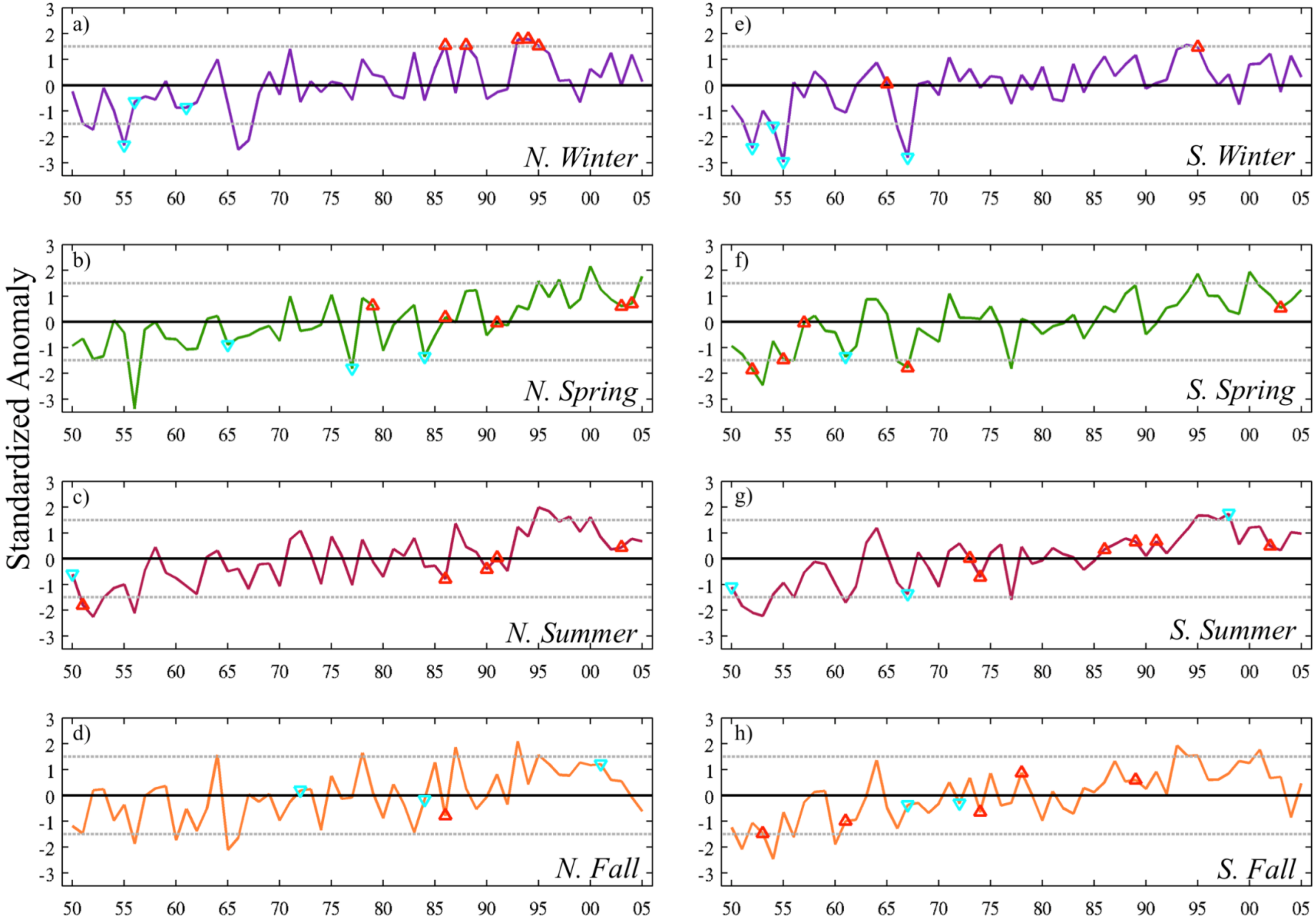


Squares- positive, Circles- negative

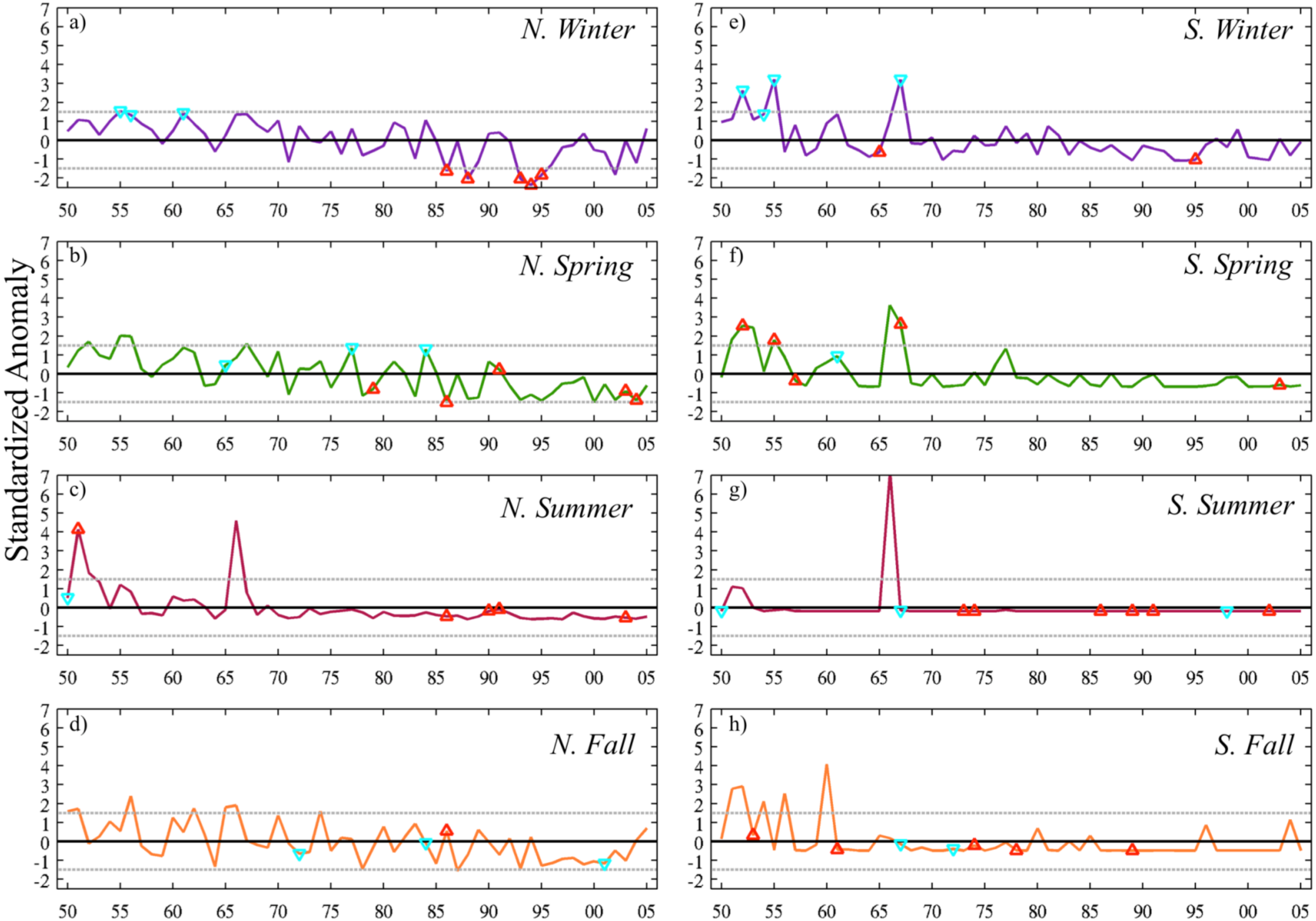
Winter- purple, Spring- green, Summer- red, Fall- orange

Time series of seasonal temperature anomalies;

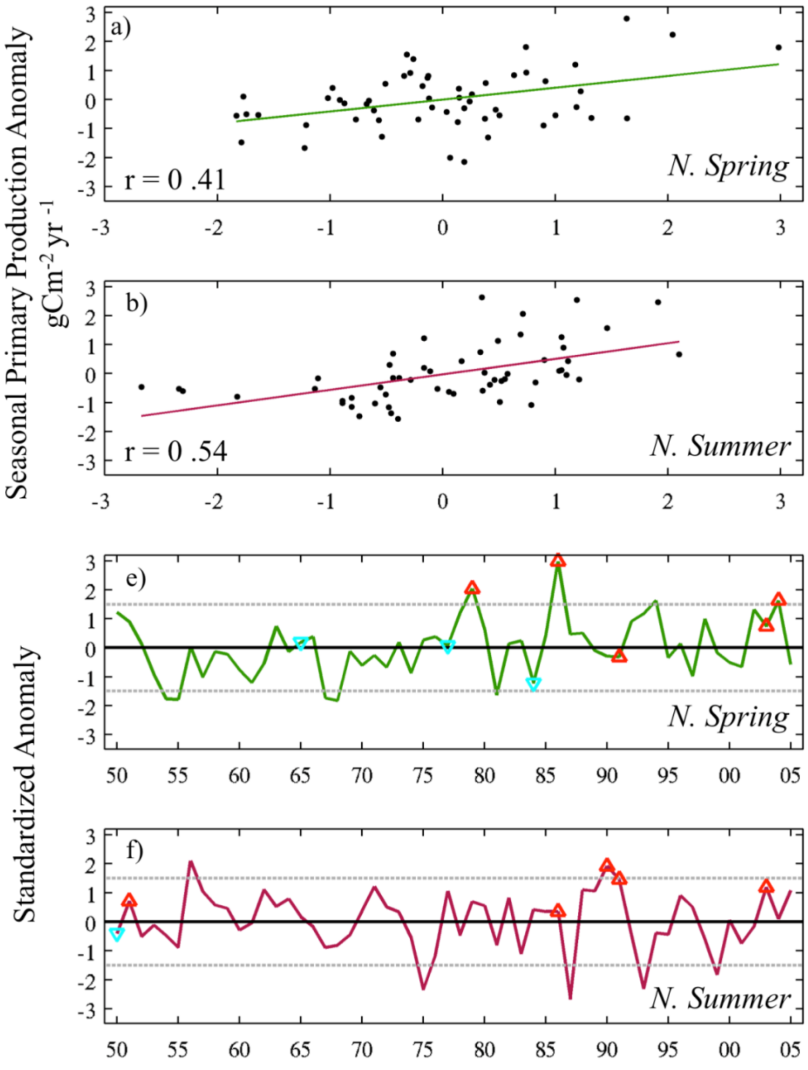
Δ = *extreme of primary production*



Time series of seasonal sea ice anomalies;
Δ = *extreme of primary production*



Primary production vs. mixed layer depth anomalies (N domain, spring and summer)



Conclusions

H1: Partially supported: Primary production in the Bering Sea increases as air temperature increases and as sea ice decreases, but the relationships vary by season and Bering Sea subregion

-- mixed-layer depth in spring/summer appears to be important

H2: Some extremes of drivers (temperature, sea ice) coincide with extremes of primary production, but not significantly

-- optimum timescale for definition of extremes of drivers?

Underlying issue: Variance of Bering Sea drivers in CESM