

Upwelling Intensity, Stratification, and Nutrient Supply Trends in the California Current System

Mike Jacox

March 21, 2015

Collaborators

Steven Bograd, Elliott Hazen (NOAA)

Jerome Fiechter (UCSC)

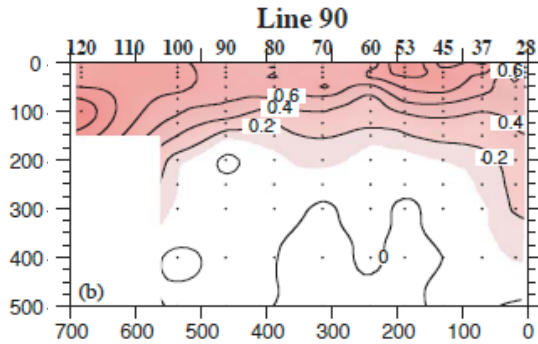


UC SANTA CRUZ

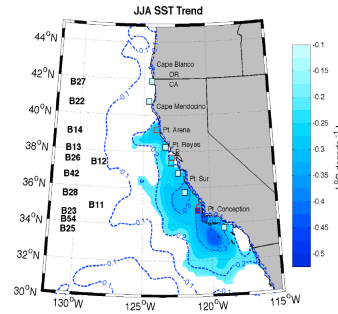


Trends in Upwelling Systems

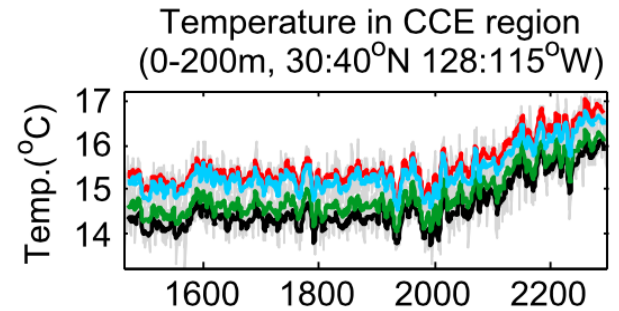
Temperature



1950-1999
(Bograd and Lynn 2003)

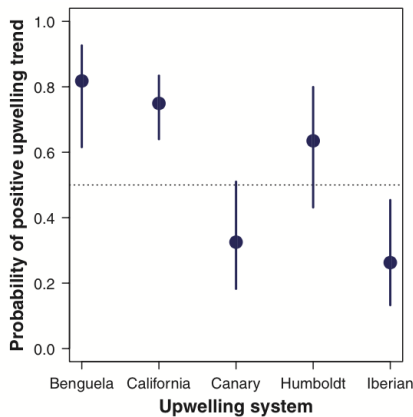


1982-2010
(Seo et al. 2012)

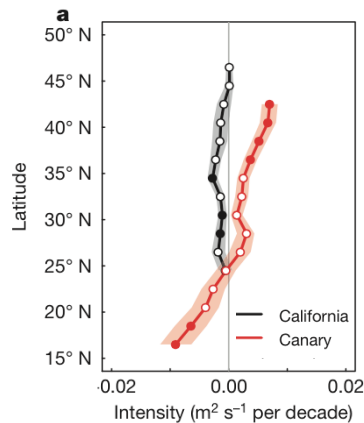


Projected
(Rykaczewski and Dunne 2010)

Upwelling

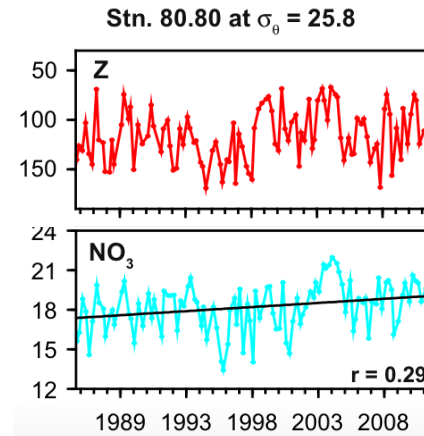


1950-2012
(Sydeman et al. 2014)

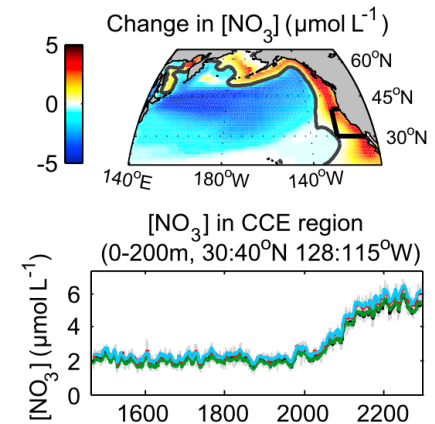


Projected
(Wang et al. 2015)

Nitrate in Source Waters

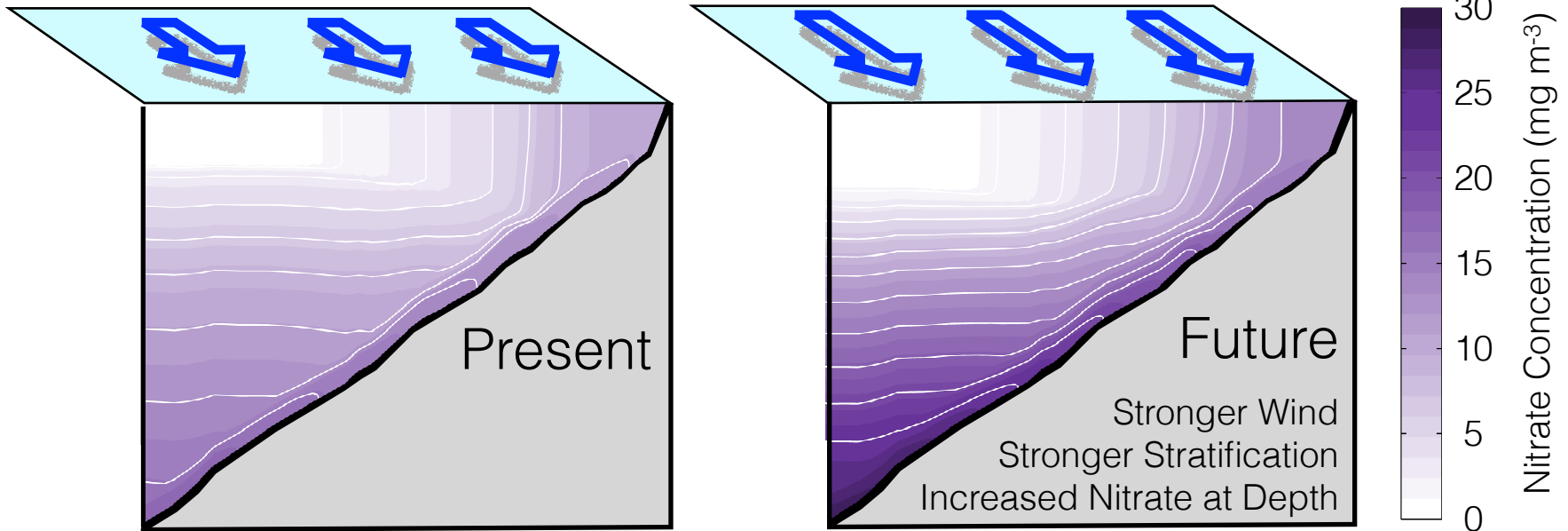


1985-2011
(Bograd et al. 2015)



Projected
(Rykaczewski and Dunne 2010)

Trends in Upwelling Systems



Nitrate Supply

Stratification > Wind



Di Lorenzo et al. (2005)

Wind > Stratification



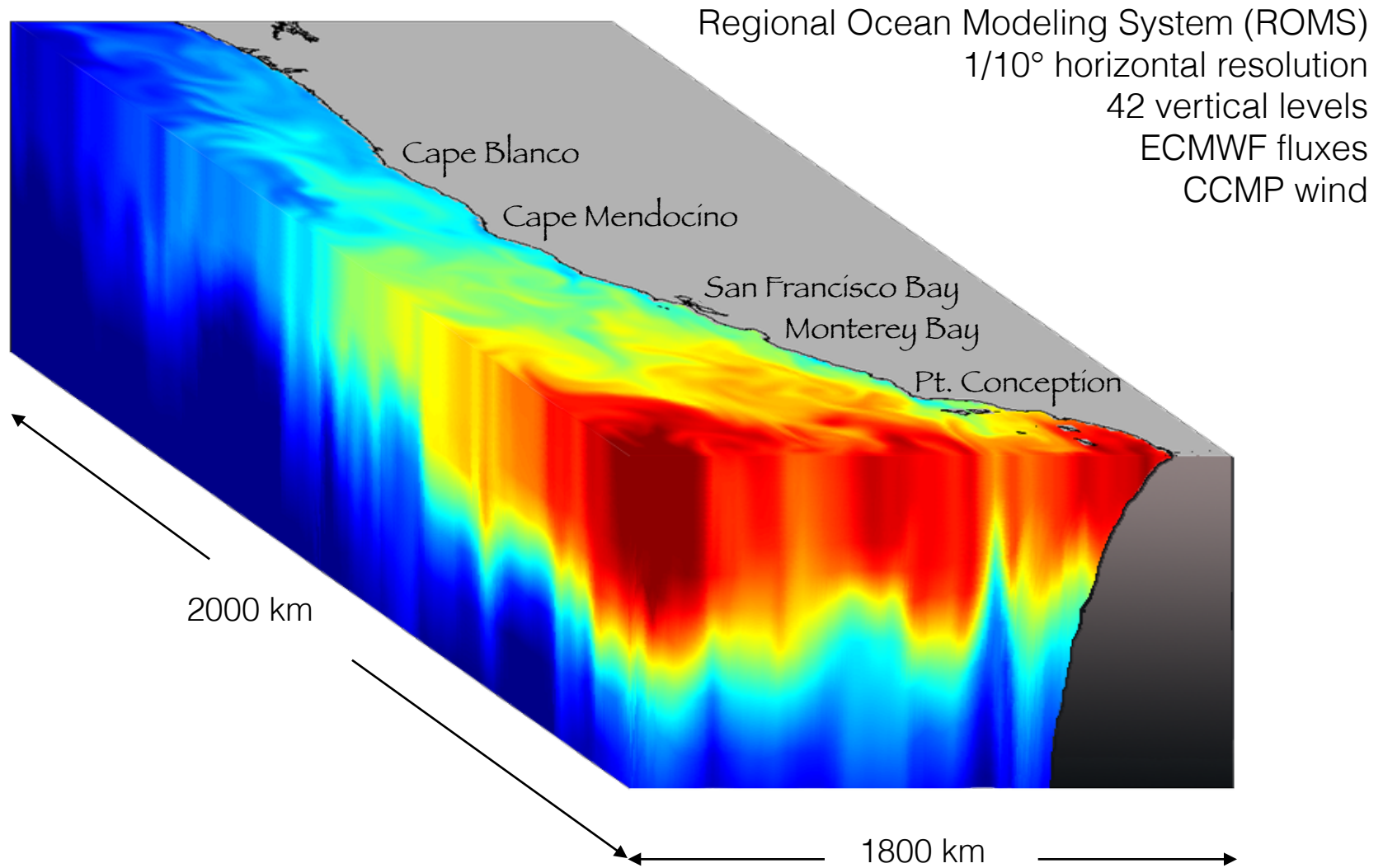
Auad et al. (2006)

$[\text{NO}_3]_{\text{source}} > \text{Stratification}$



Rykaczewski and Dunne (2010)

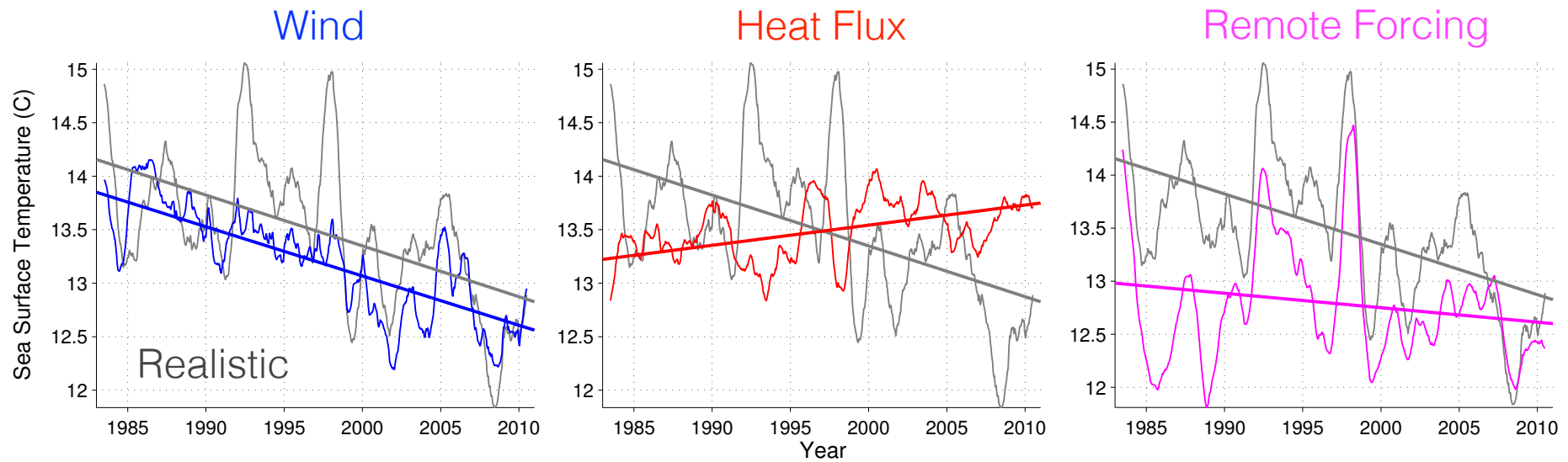
Model Configuration



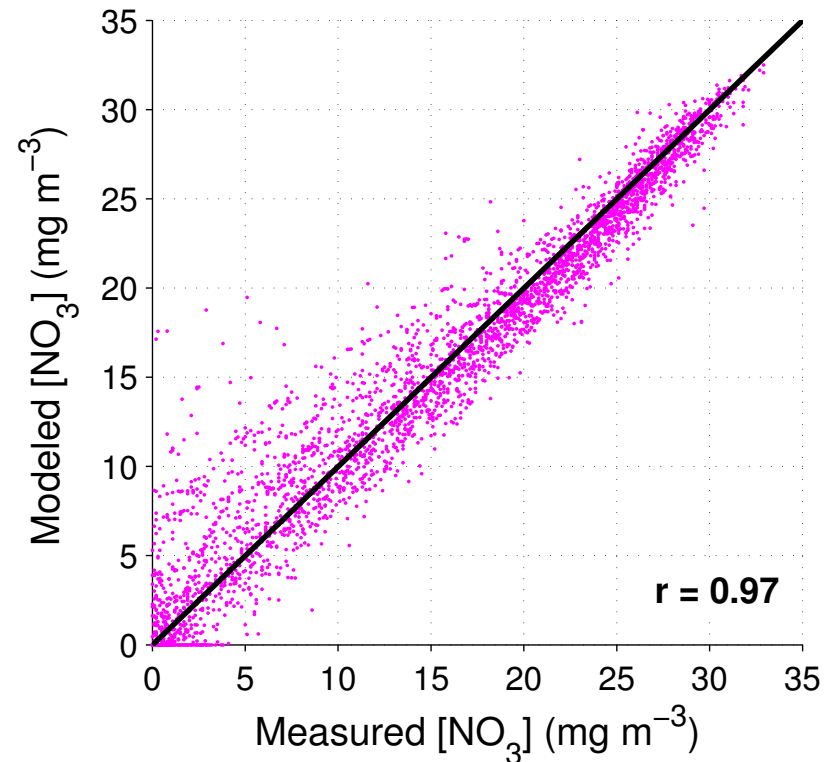
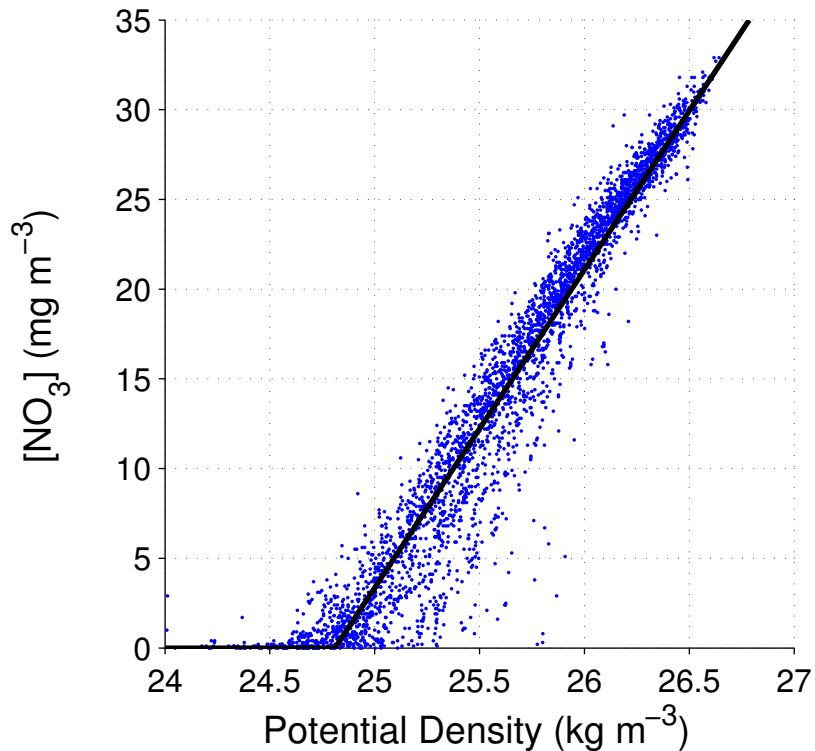
Model Configuration

Model	Wind Stress	Heat/Freshwater Flux	Boundary Conditions
Climatology	Climatology	Climatology	Climatology
Wind	ECMWF/CCMP	Climatology	Climatology
Heat Flux	Climatology	ECMWF	Climatology
Remote Forcing	Climatology	Climatology	SODA
Realistic	ECMWF/CCMP	ECMWF	SODA

Drivers of Temperature in the CCS



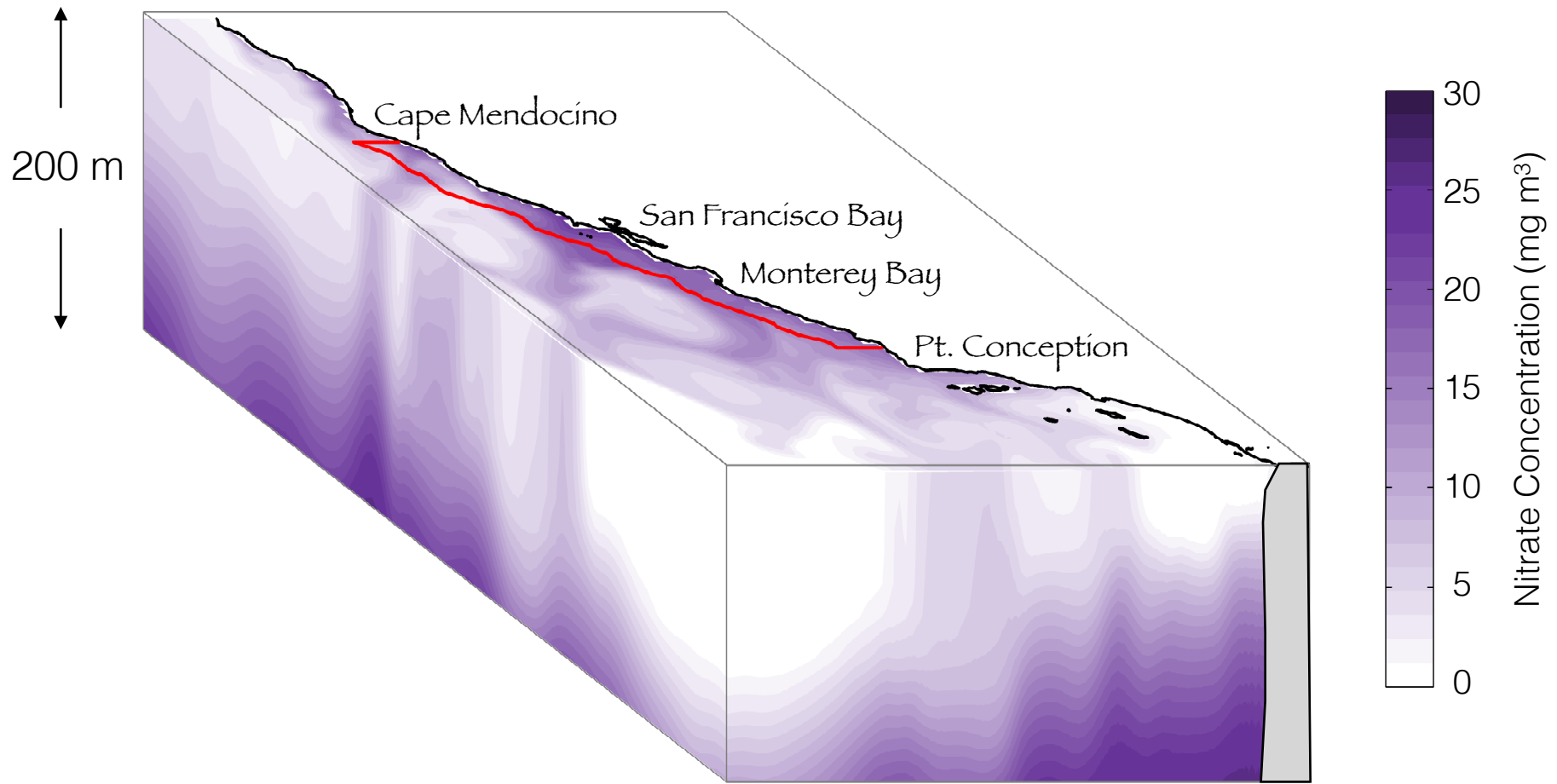
Modeling Nitrate Concentration in the CCS



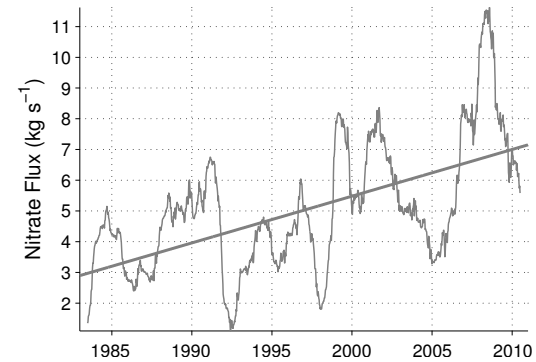
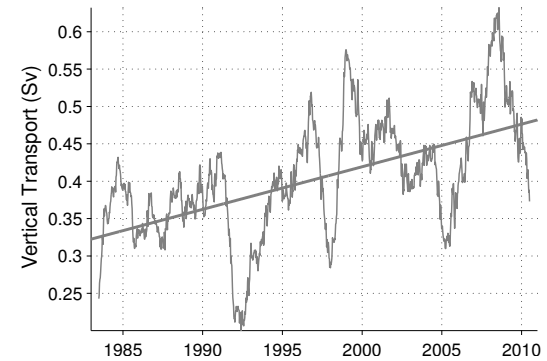
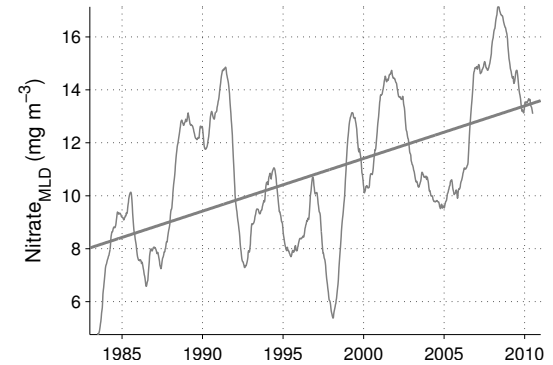
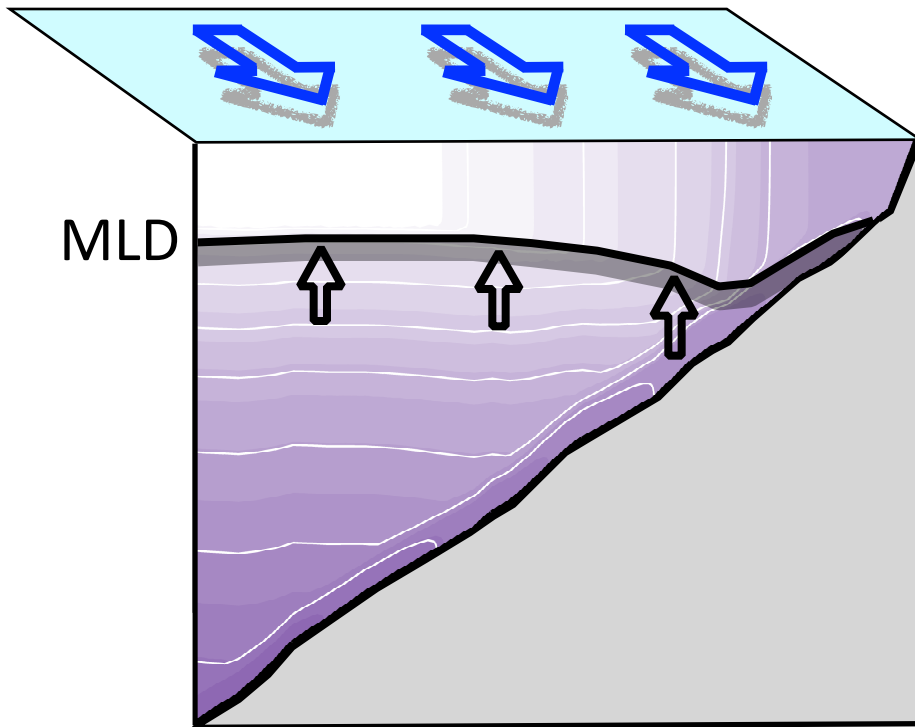
World Ocean Database: All available nitrate data in study region (1980-2010)

389 Casts, 3548 Data Points (Mostly CalCOFI)

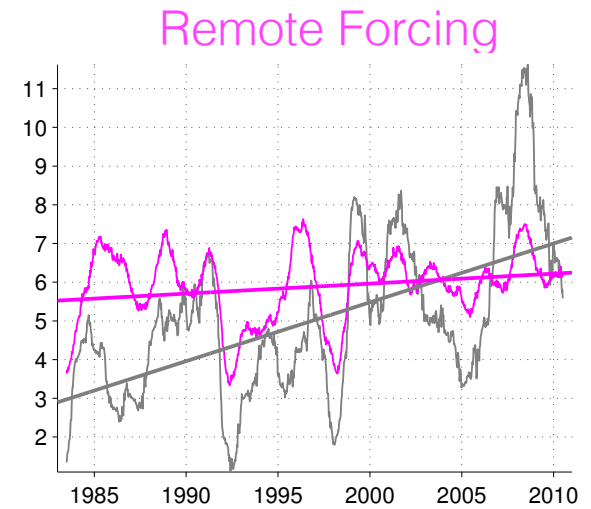
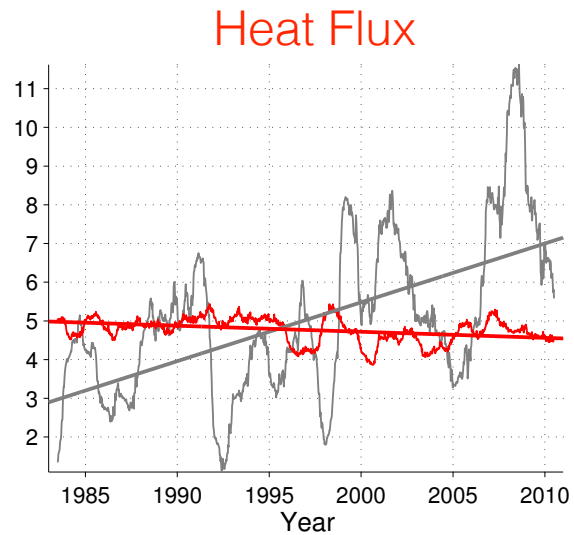
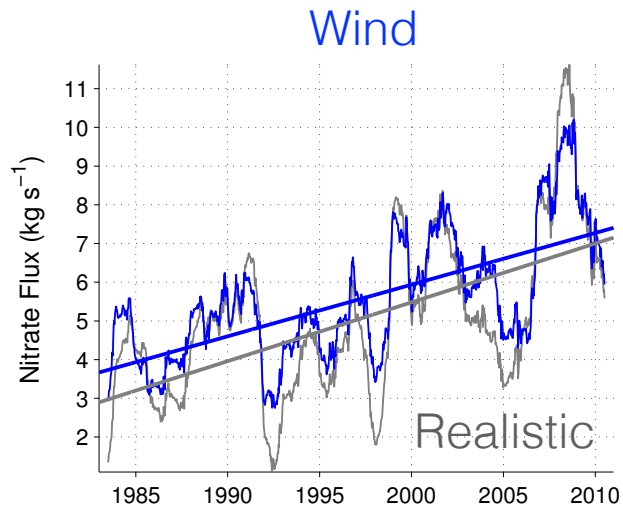
The Study Region



Nitrate Flux Calculation

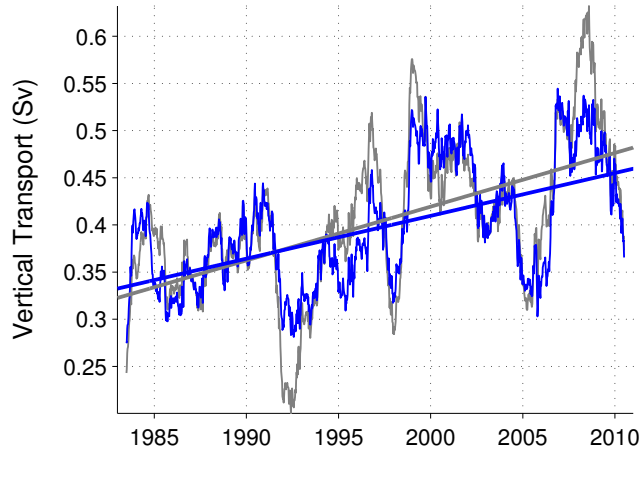


Drivers of Nitrate Flux in the CCS

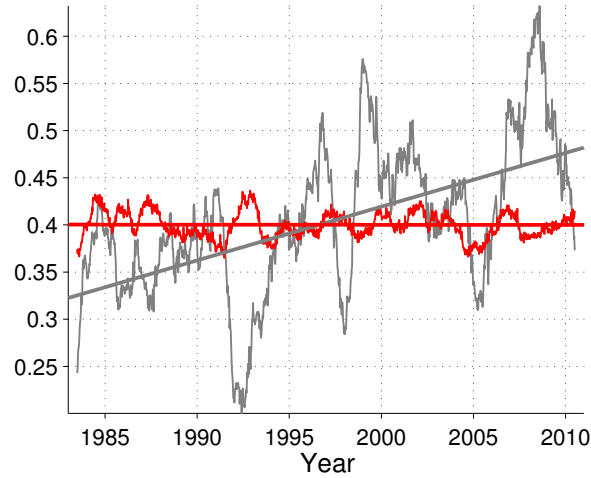


Drivers of Nitrate Flux in the CCS

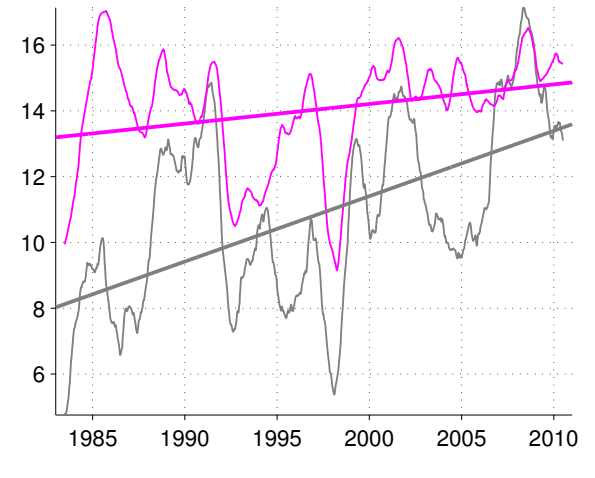
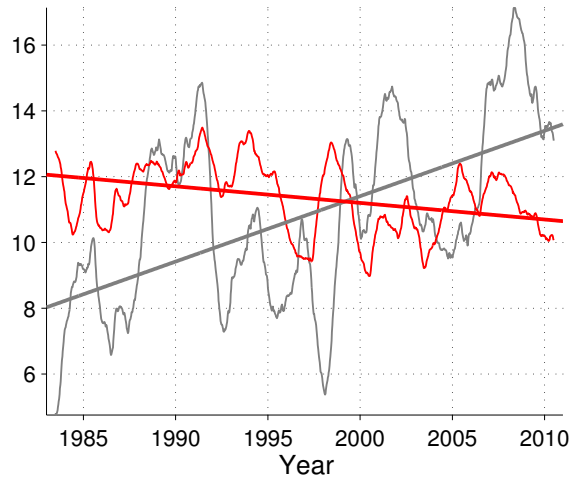
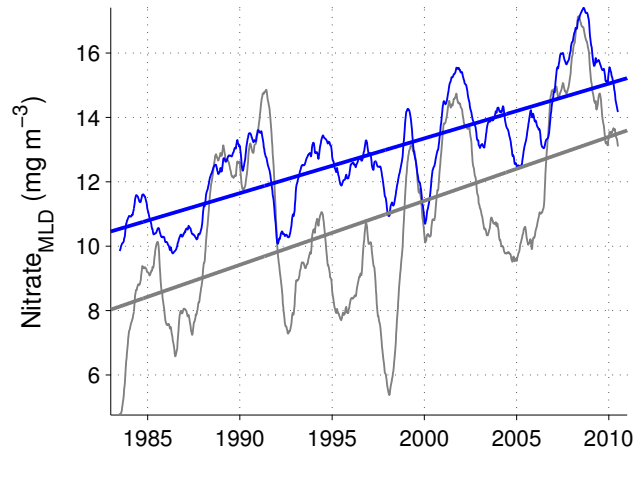
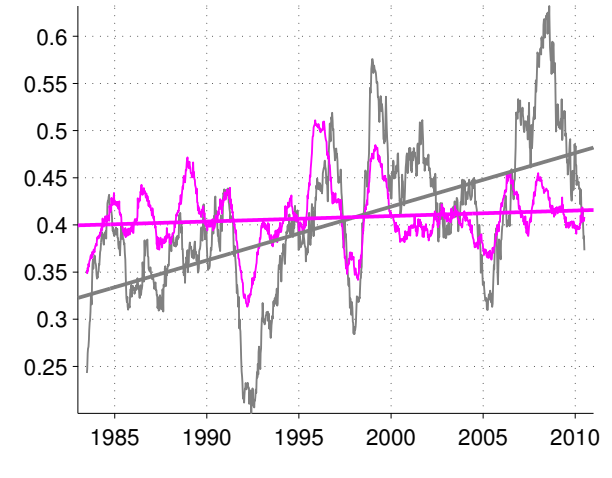
Wind



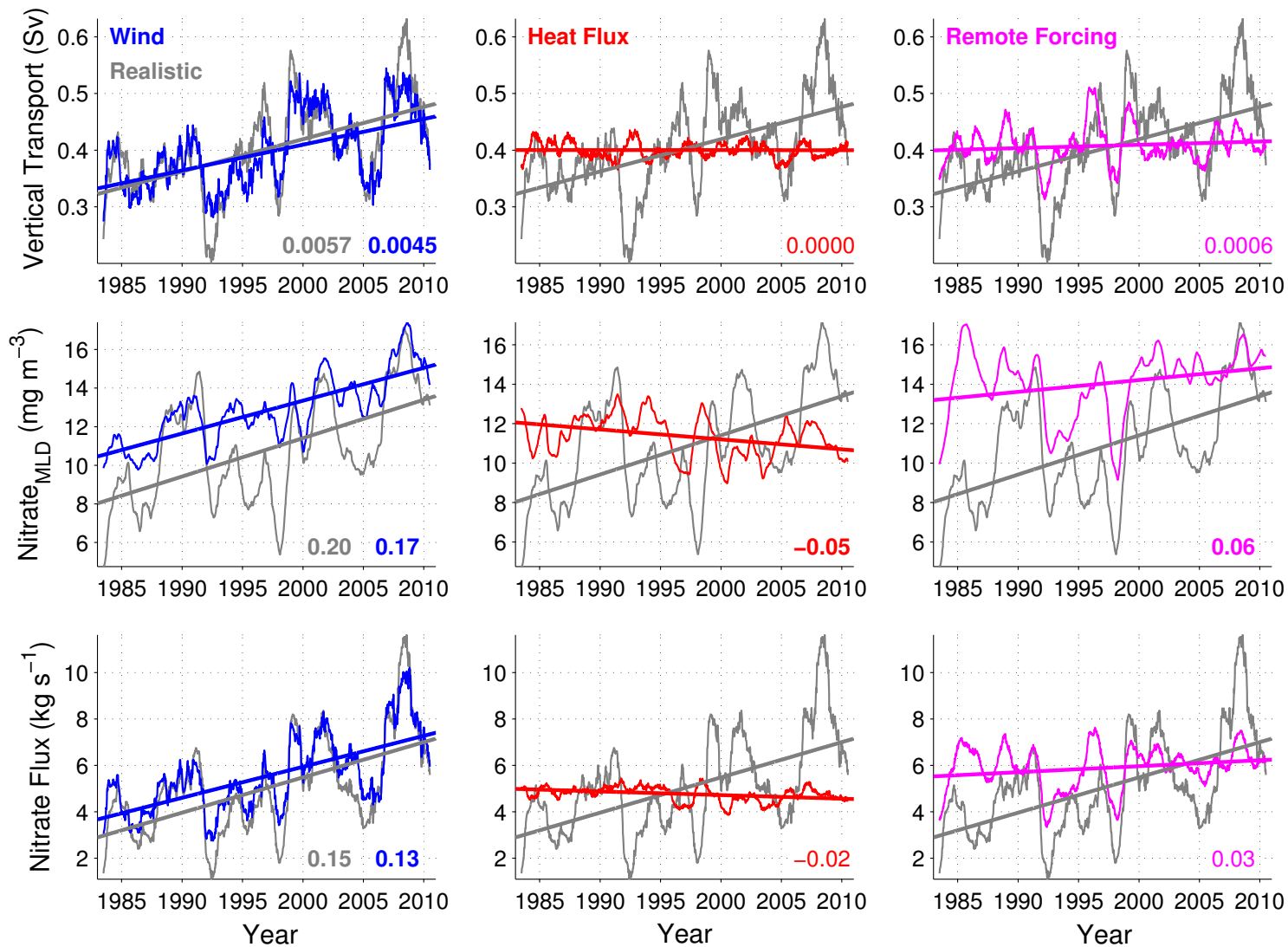
Heat Flux



Remote Forcing

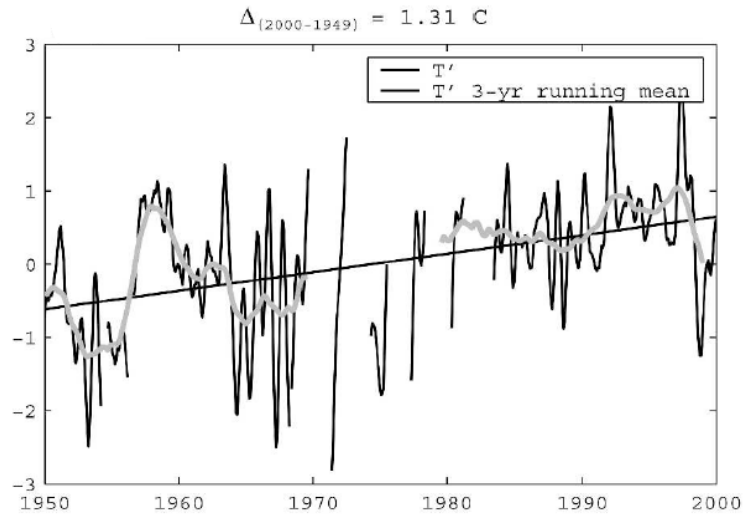


Drivers of Nitrate Flux in the CCS

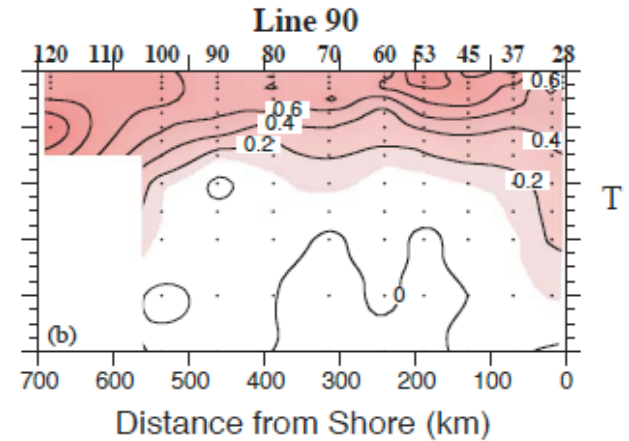


Timescales of Variability

1950-1999:

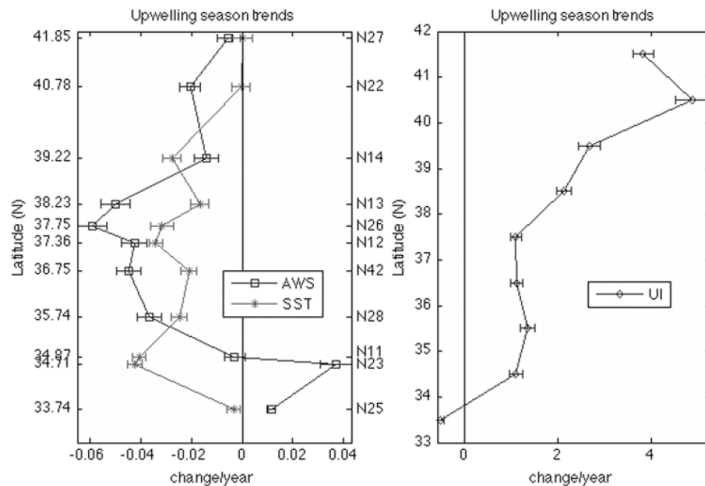


Di Lorenzo et al. (2005)

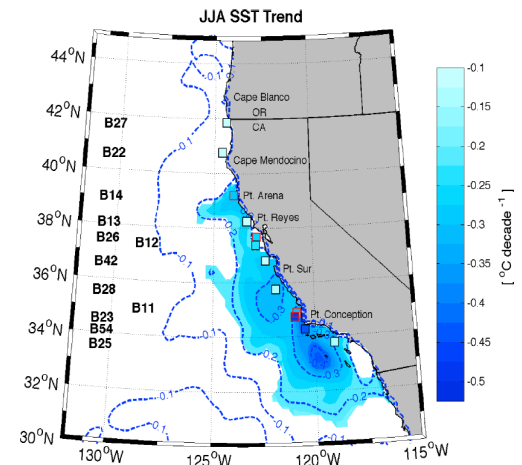


Bograd and Lynn (2003)

1980-2010:



García-Reyes and Largier (2010)

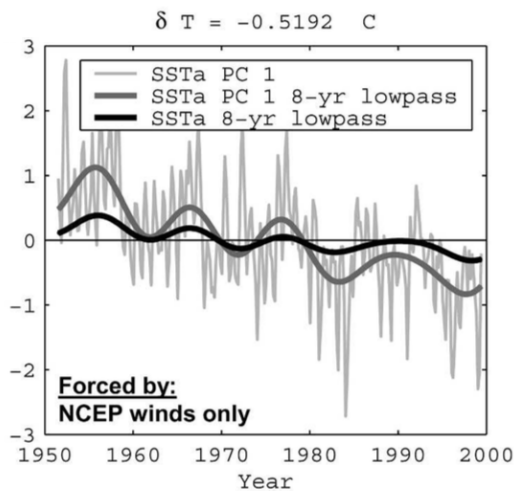


Seo et al. (2012)

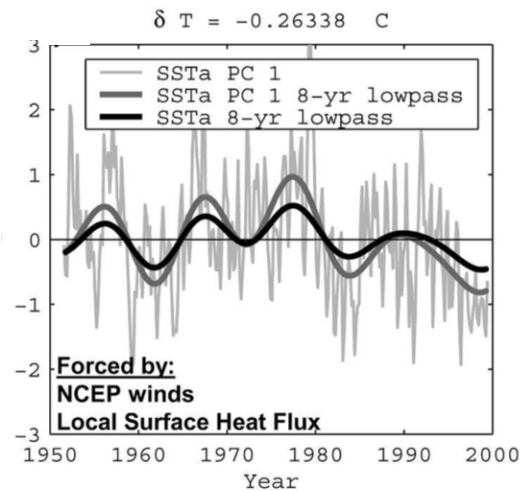
Timescales of Variability

Di Lorenzo et al. (2005):

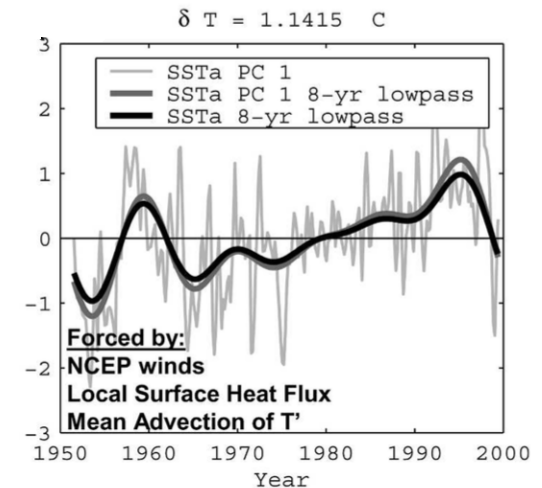
Model	Wind Stress	Heat/Freshwater Flux	Boundary Conditions
A	Climatology	Climatology	Climatology
B	NCEP	Climatology	Climatology
C	NCEP	COADS	Climatology
D	NCEP	COADS	CalCOFI



B (cooling)



C (cooling)



D (warming)

Timescales of Variability

Di Lorenzo et al. (2005) Jacox et al., submitted

	1950-1999	1980-2010
Upwelling	+	+
Local Heat Flux	—	—
Remote Forcing	—	+

Upwelling intensity and local heat flux trends are consistent over 60 years

Upwelling intensity is the stronger driver of nitrate supply

Remote forcing is related to basin-scale climate variability, and is decoupled from local heat flux

