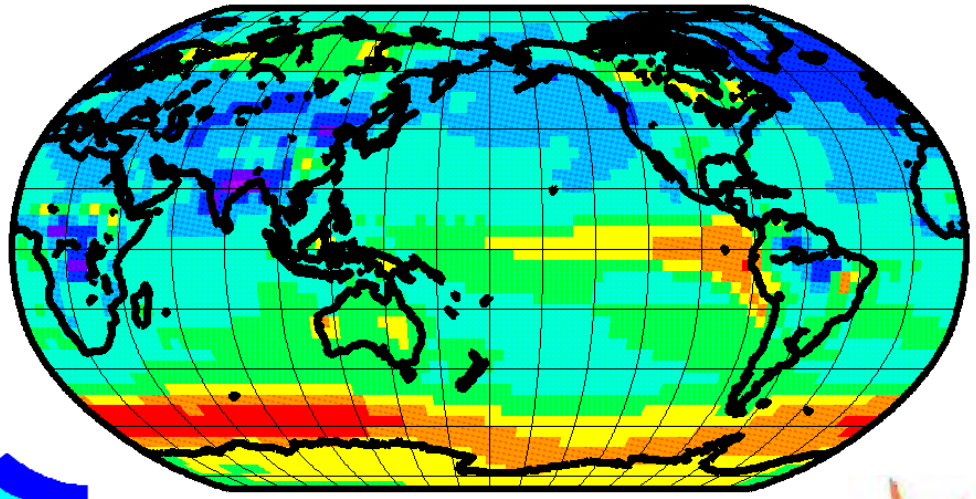
Effects of natural variability on biogeochemical processes in climate models

Fisheries and Oceans Canada
Pêches et Océans Canada



IOS

CCCma

James Christian
Fisheries and Oceans Canada / Canadian Centre for Climate Modelling and Analysis
Victoria, BC

What do we (can we) expect of climate models?

- climate models increasingly reproduce the natural modes of internal variability of the climate system (ENSO, PDO, SAM), but not as well as we would like

- whether the total magnitude of internal variability is adequate is difficult to verify because data records are short and much of the variability is low-frequency

- biogeochemical fields are particularly poorly observed

AR5 models now online!

Models:

CanESM v.2

HadGEM v.2

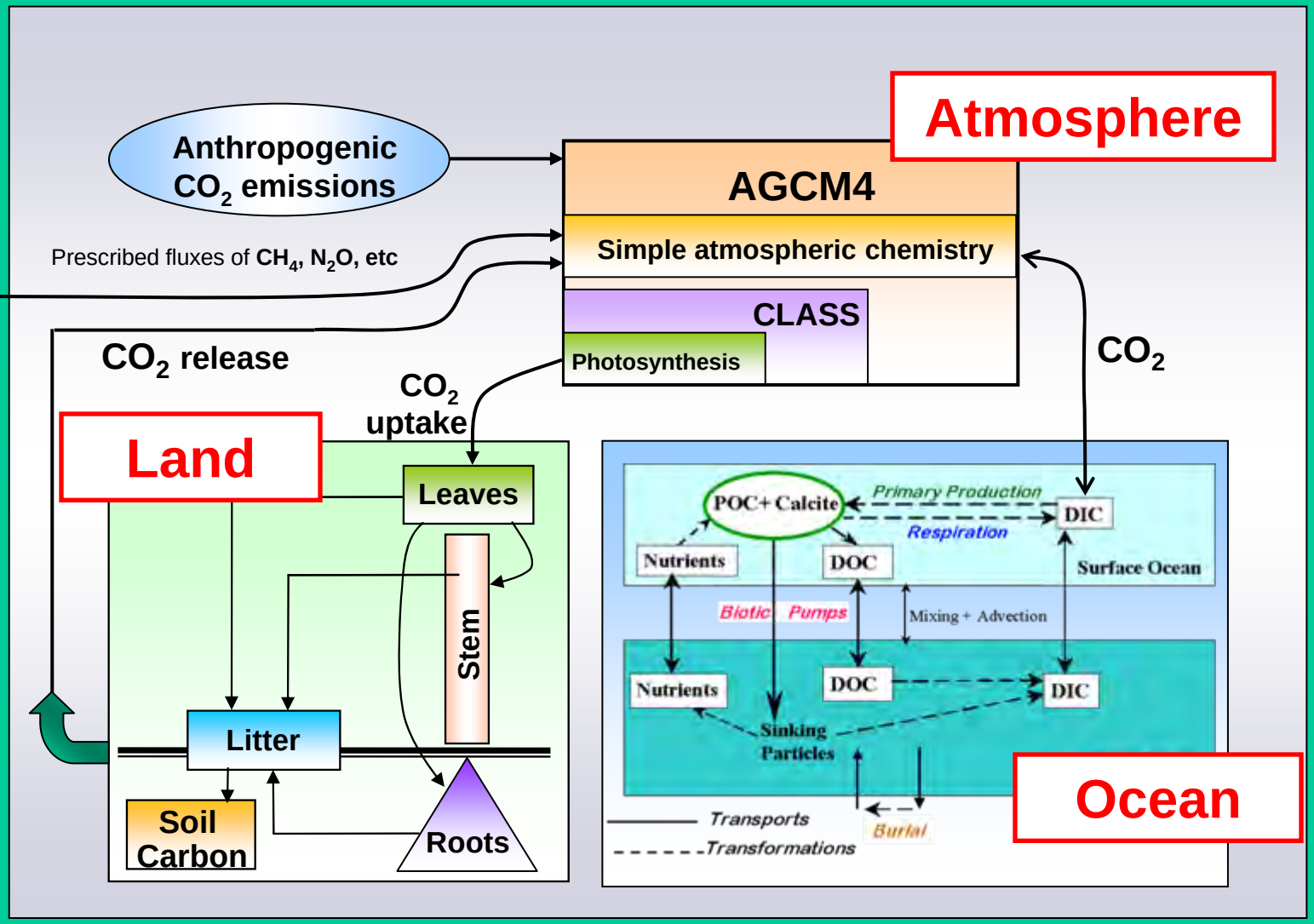
1960-2005

Data:

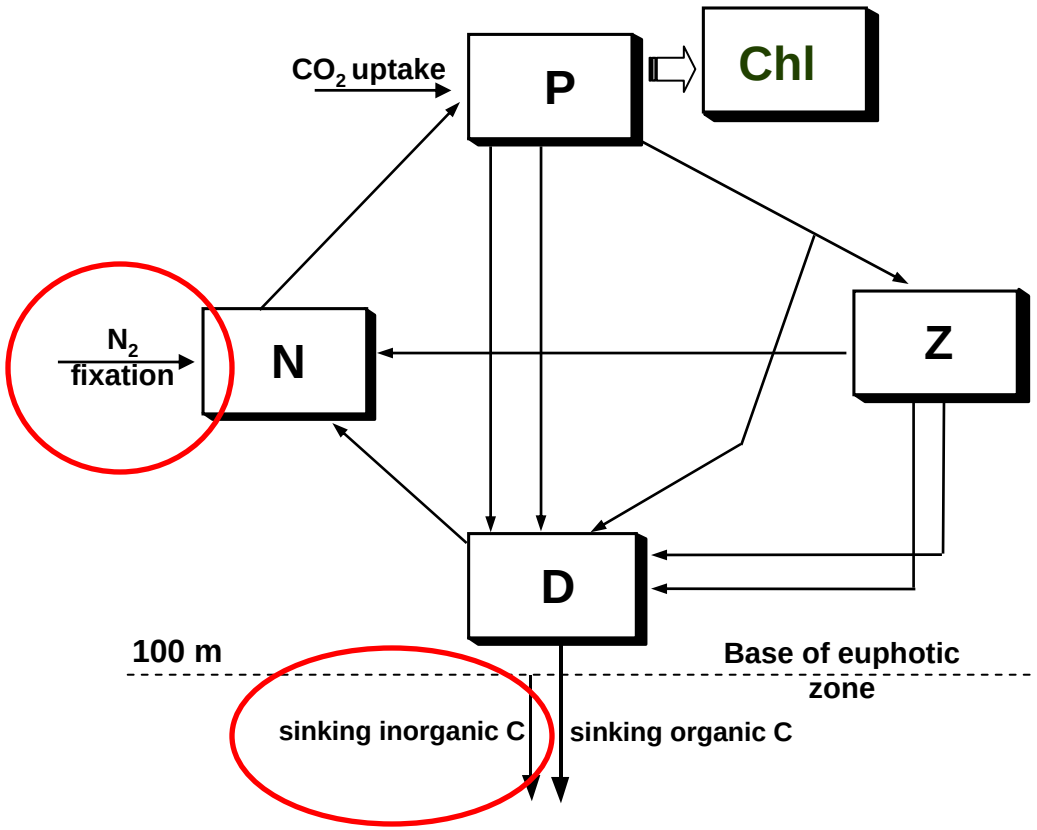
1982-2007

IGOSS SST (Reynolds and Smith 1990)

The Canadian Earth System Model (CanESM)

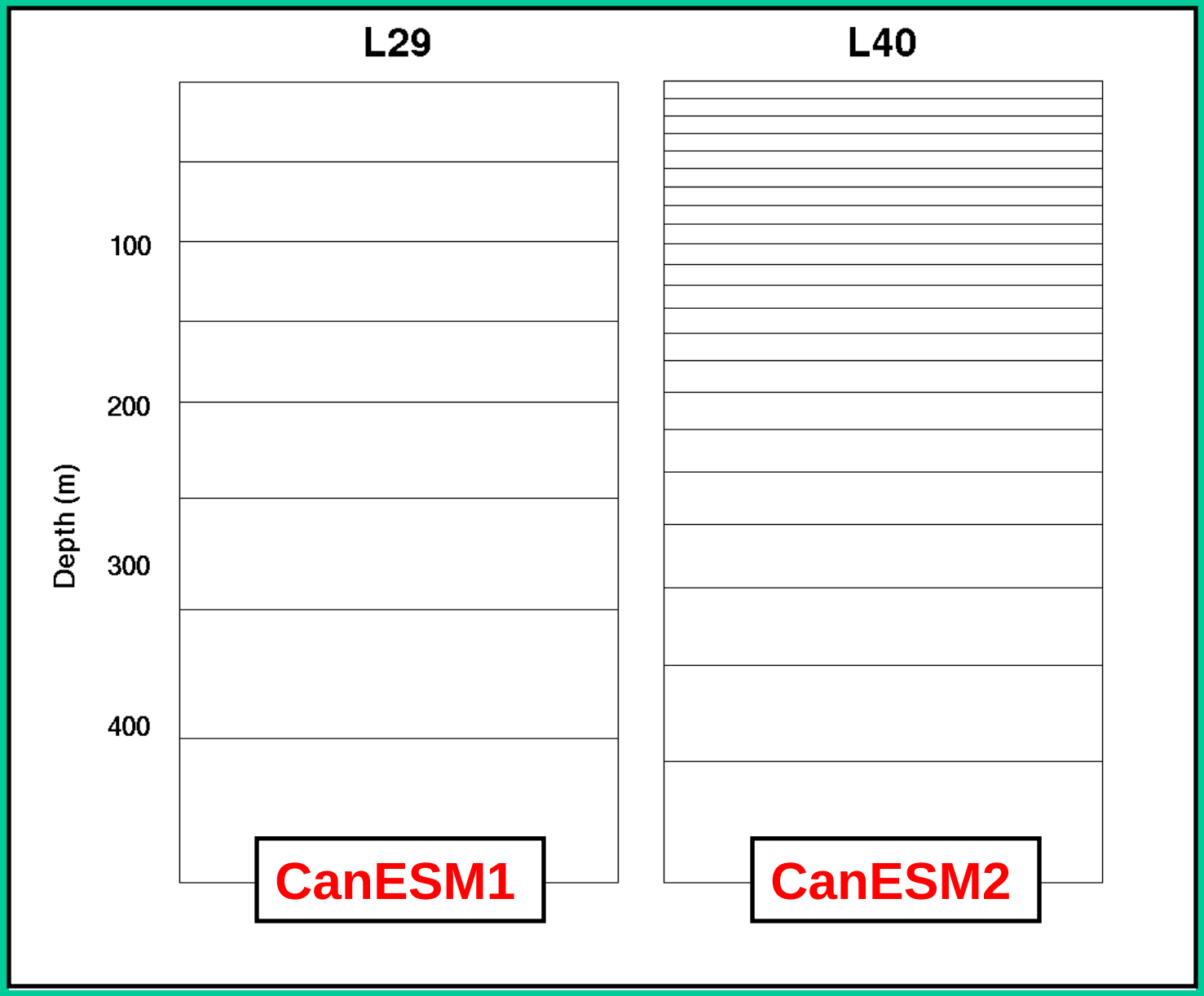


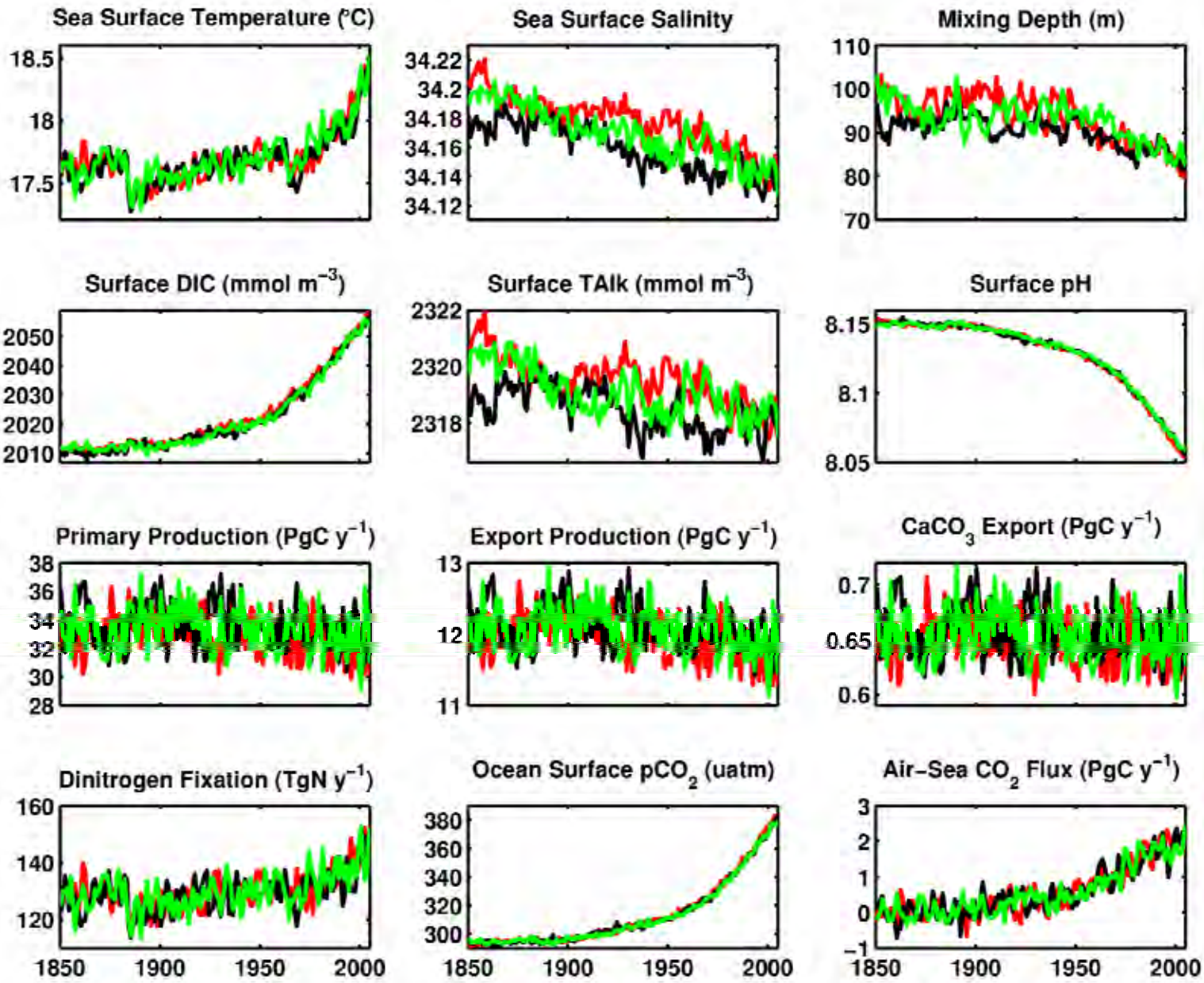
CanESM ocean ecosystem model



NPZD with simple parameterizations of N_2 fixation and calcification

Increased vertical resolution particularly in upper 200 m




Sea Surface Temperature (°C)
18.5
18
17.5
Sea Surface Salinity
34.22
34.2
34.18
34.16
34.14
34.12
Mixing Depth (m)
110
100
90
80
70
Surface DIC (mmol m^{-3})
2050
2040
2030
2020
2010
Surface TAlk (mmol m^{-3})
2322
2320
2318
Surface pH
8.15
8.1
8.05
Primary Production (PgC y^{-1})
38
36
34
32
30
28
Export Production (PgC y^{-1})
13
12
11
CaCO$_3$ Export (PgC y^{-1})
0.7
0.65
0.6
Dinitrogen Fixation (TgN y^{-1})
160
140
120
Ocean Surface pCO$_2$ (uatm)
380
360
340
320
300
Air–Sea CO$_2$ Flux (PgC y^{-1})
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1850
1900
1950
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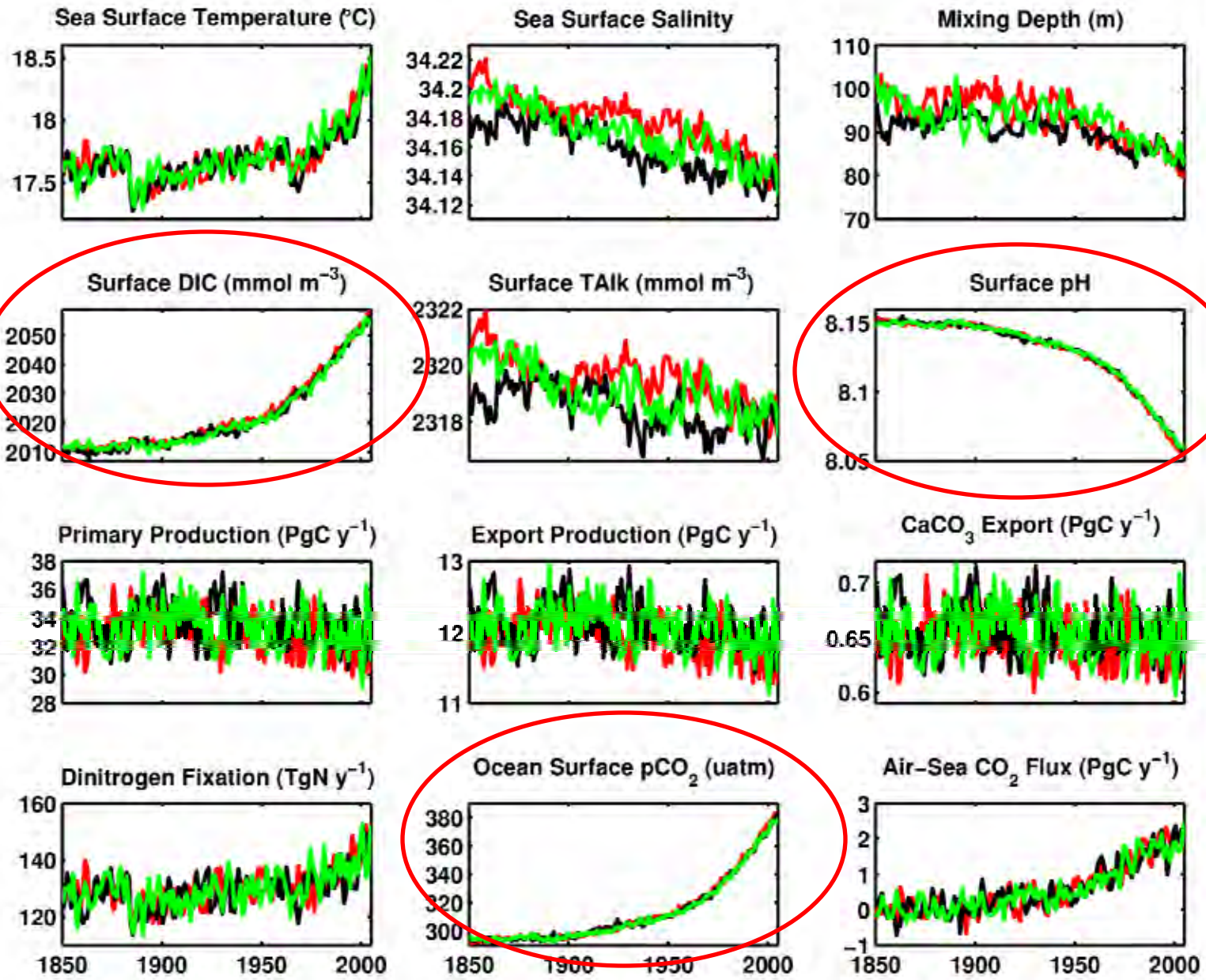
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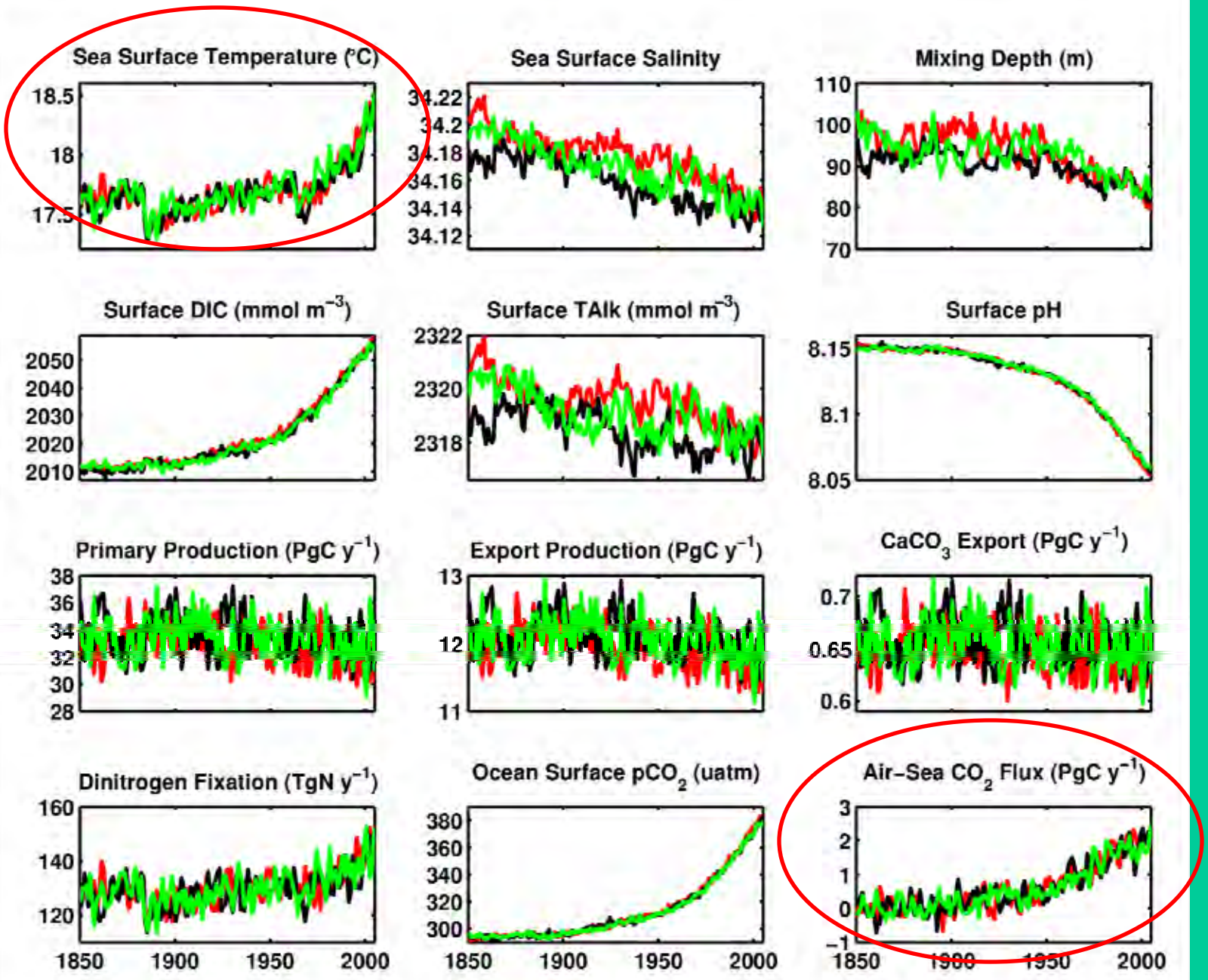
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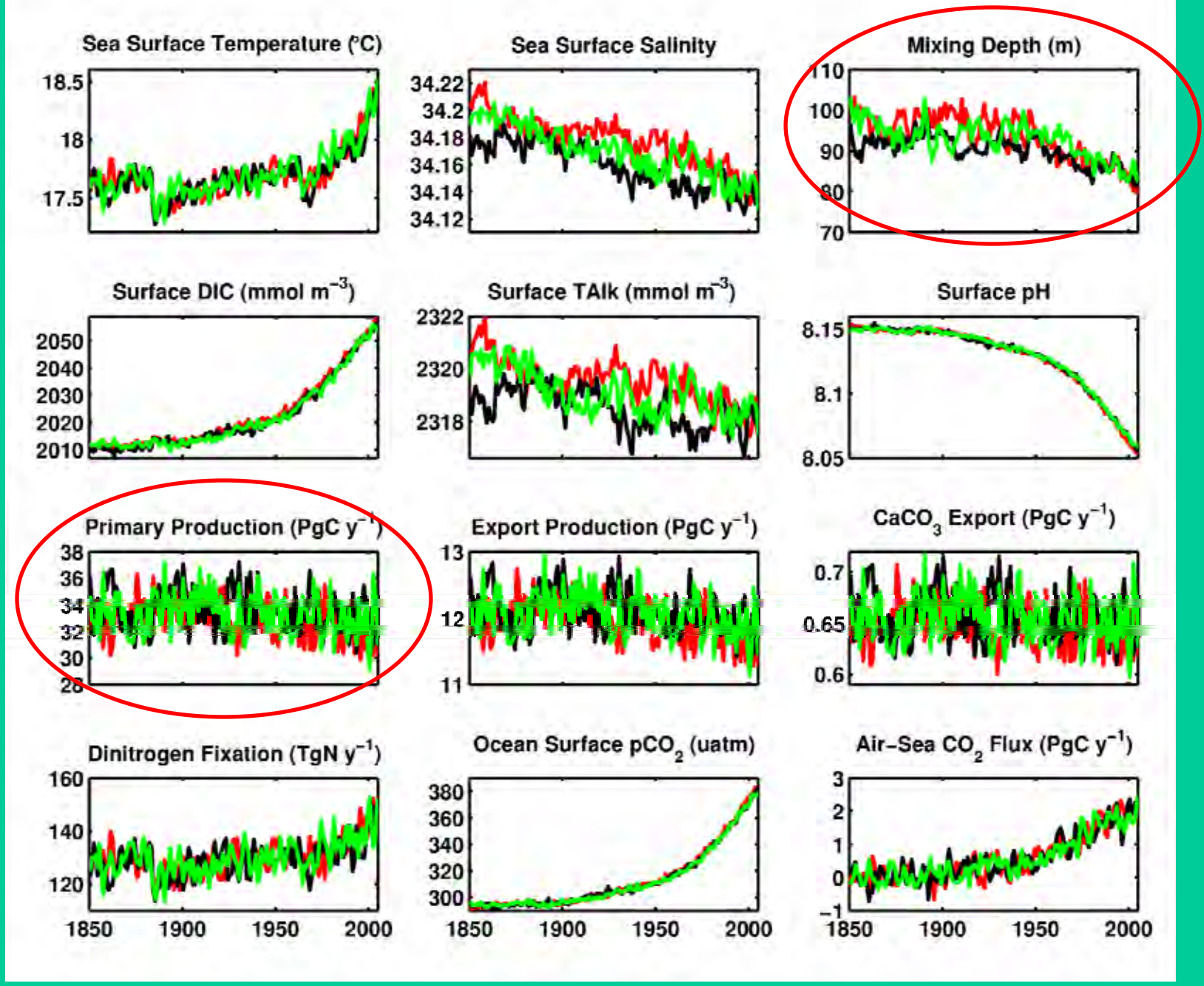
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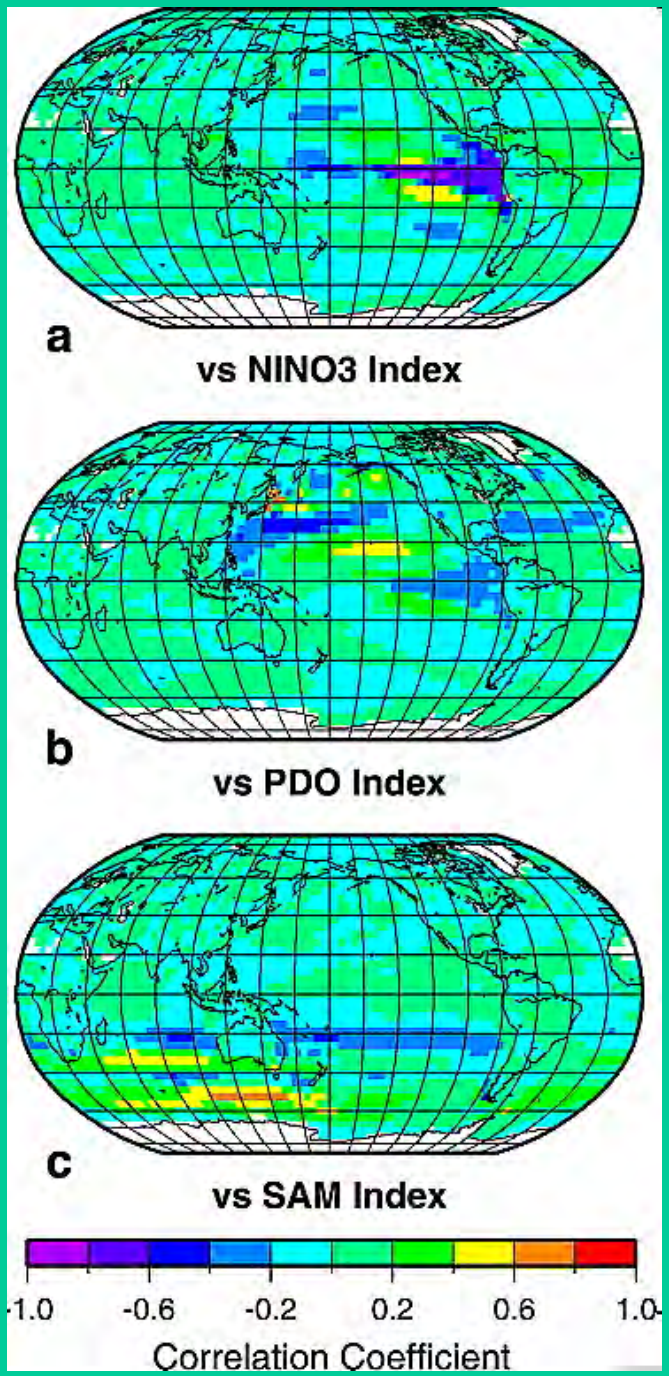
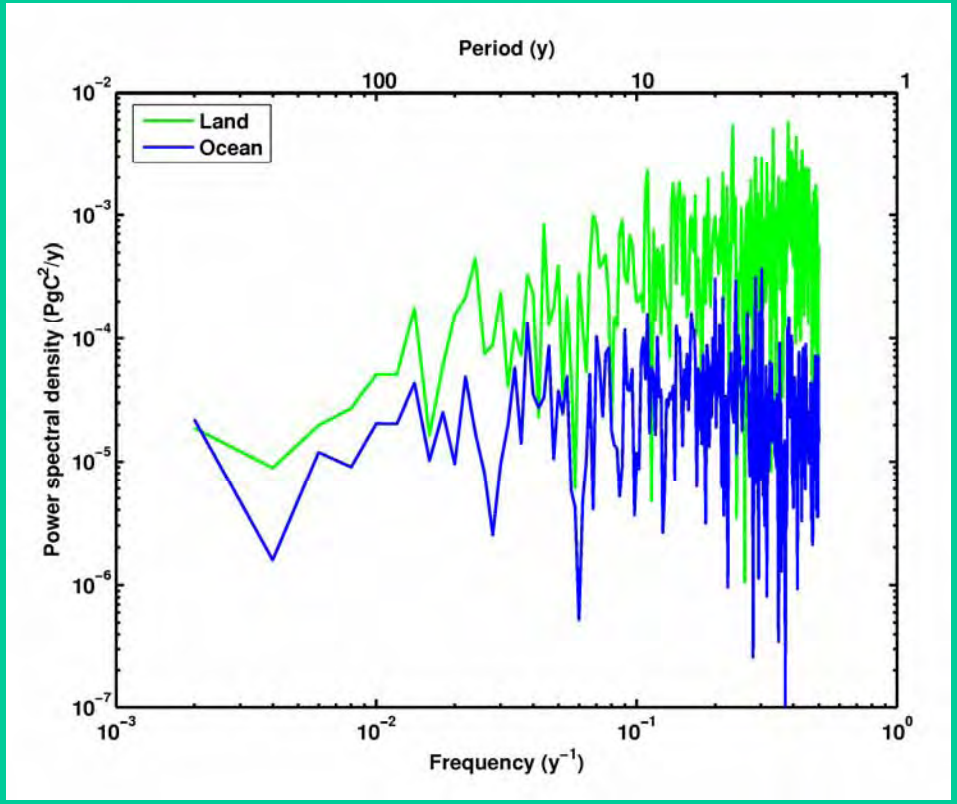
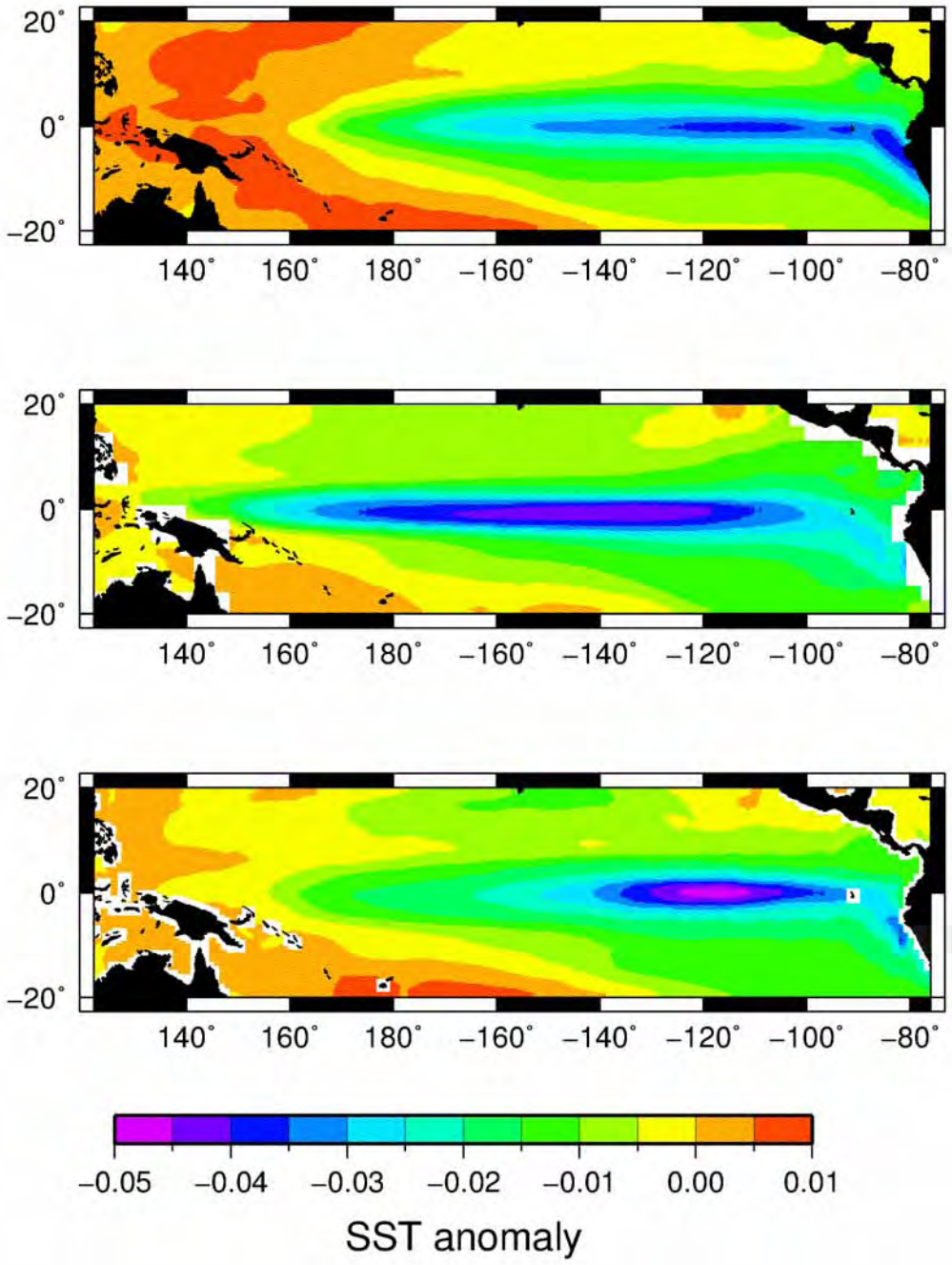
Correlation of surface CO_2 flux with climate indices





Christian et al 2010 JGR

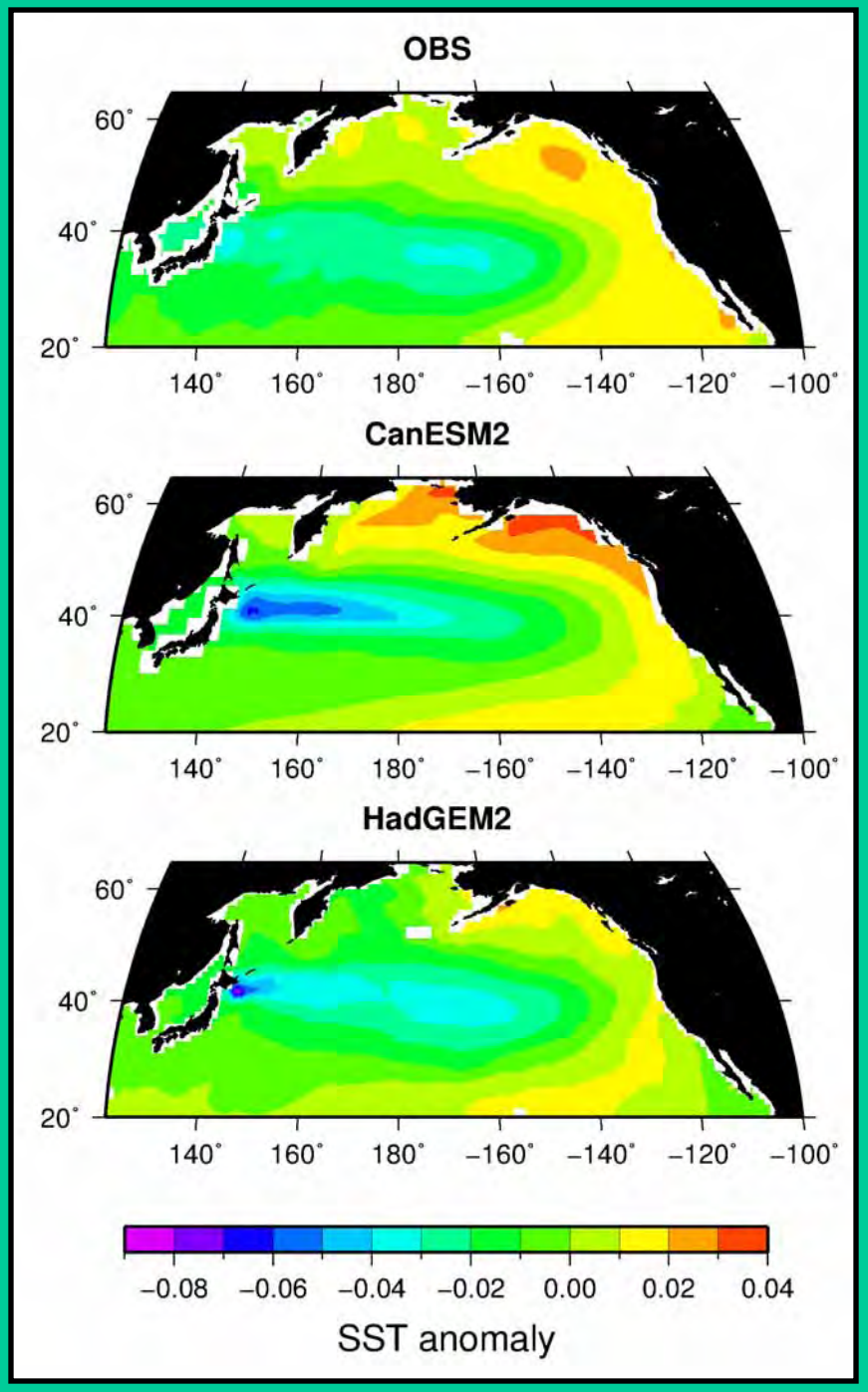


OBS

CanESM

HadGEM

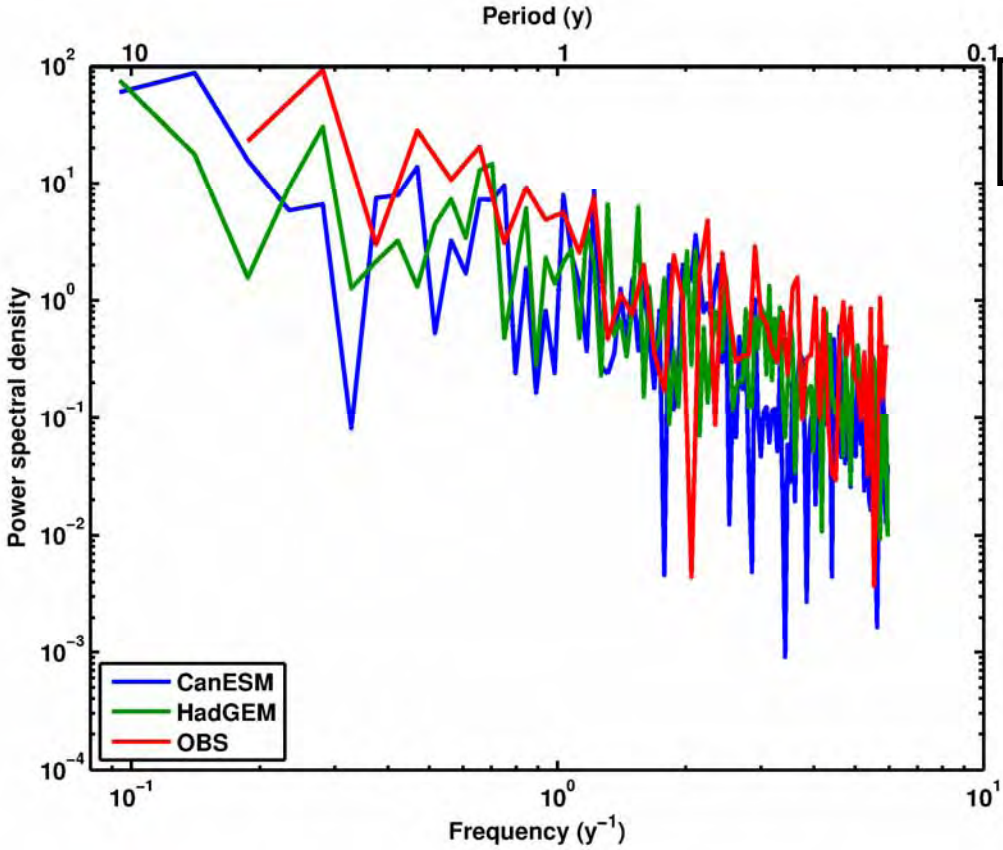
SST EOF 1
Tropical Pacific



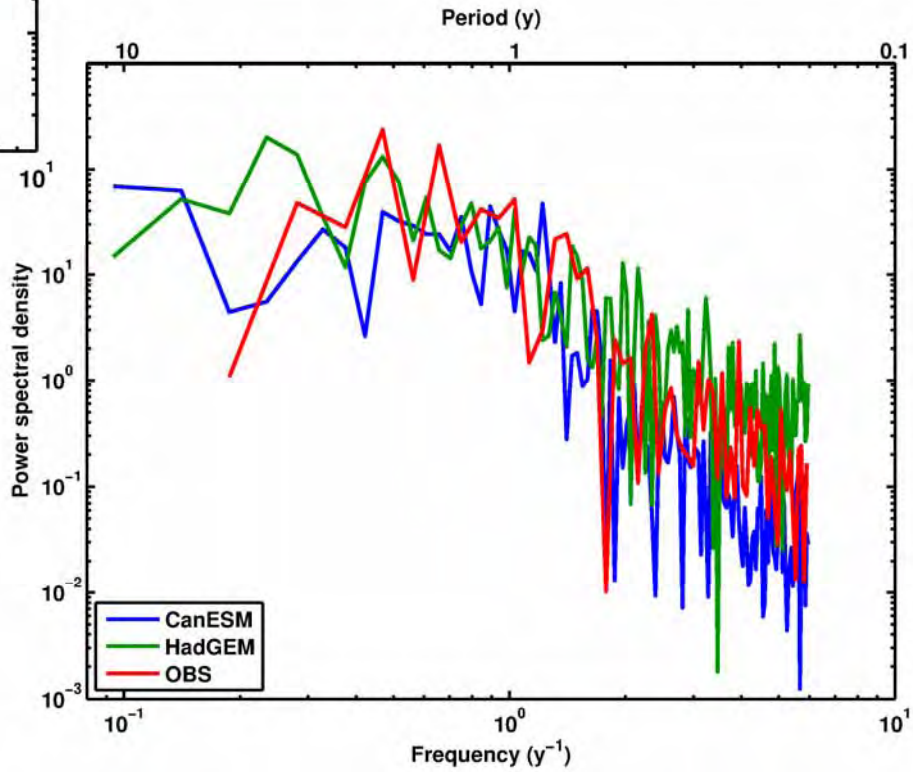
SST EOF 1
North Pacific

Power spectra: SST principal components

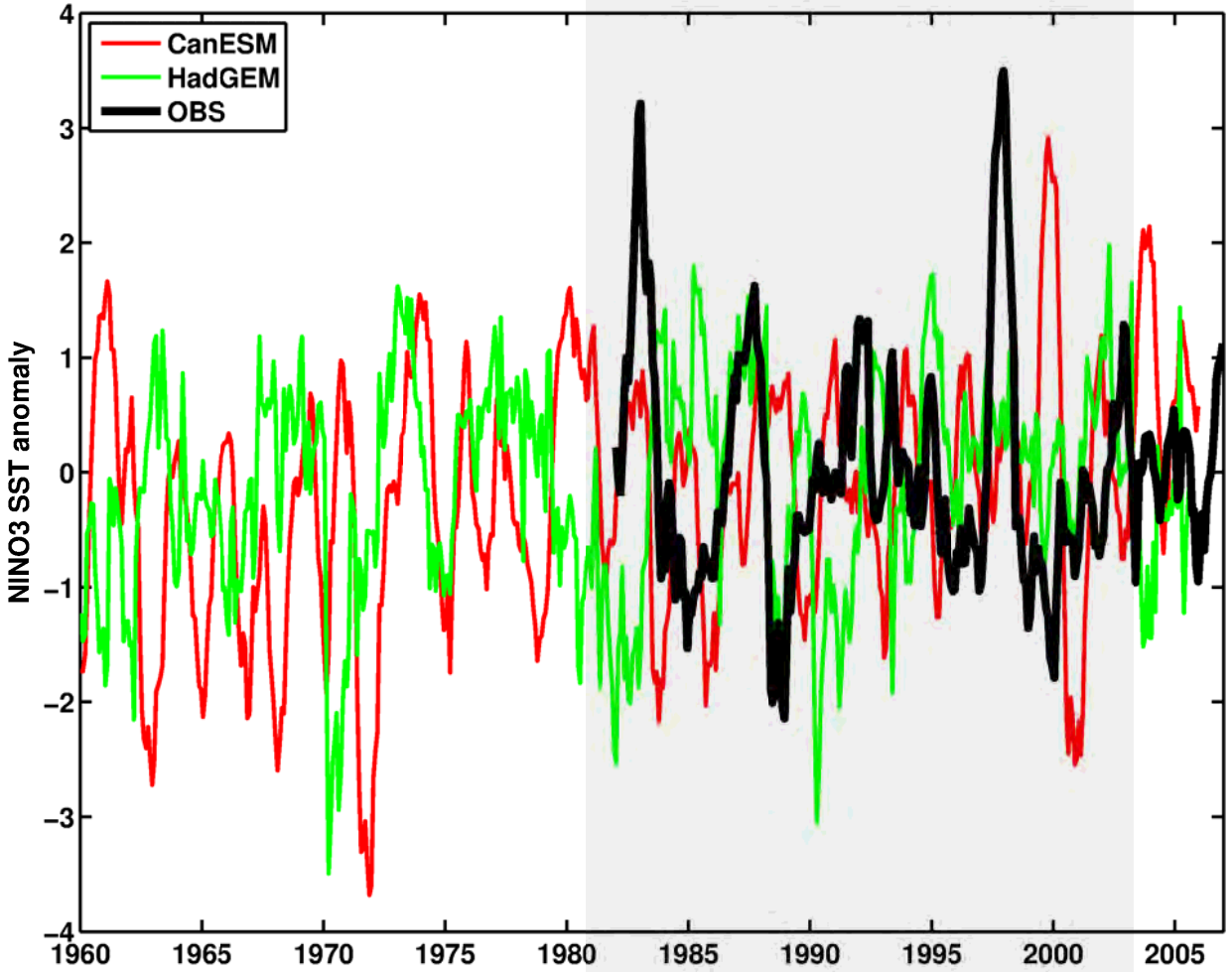
PDO

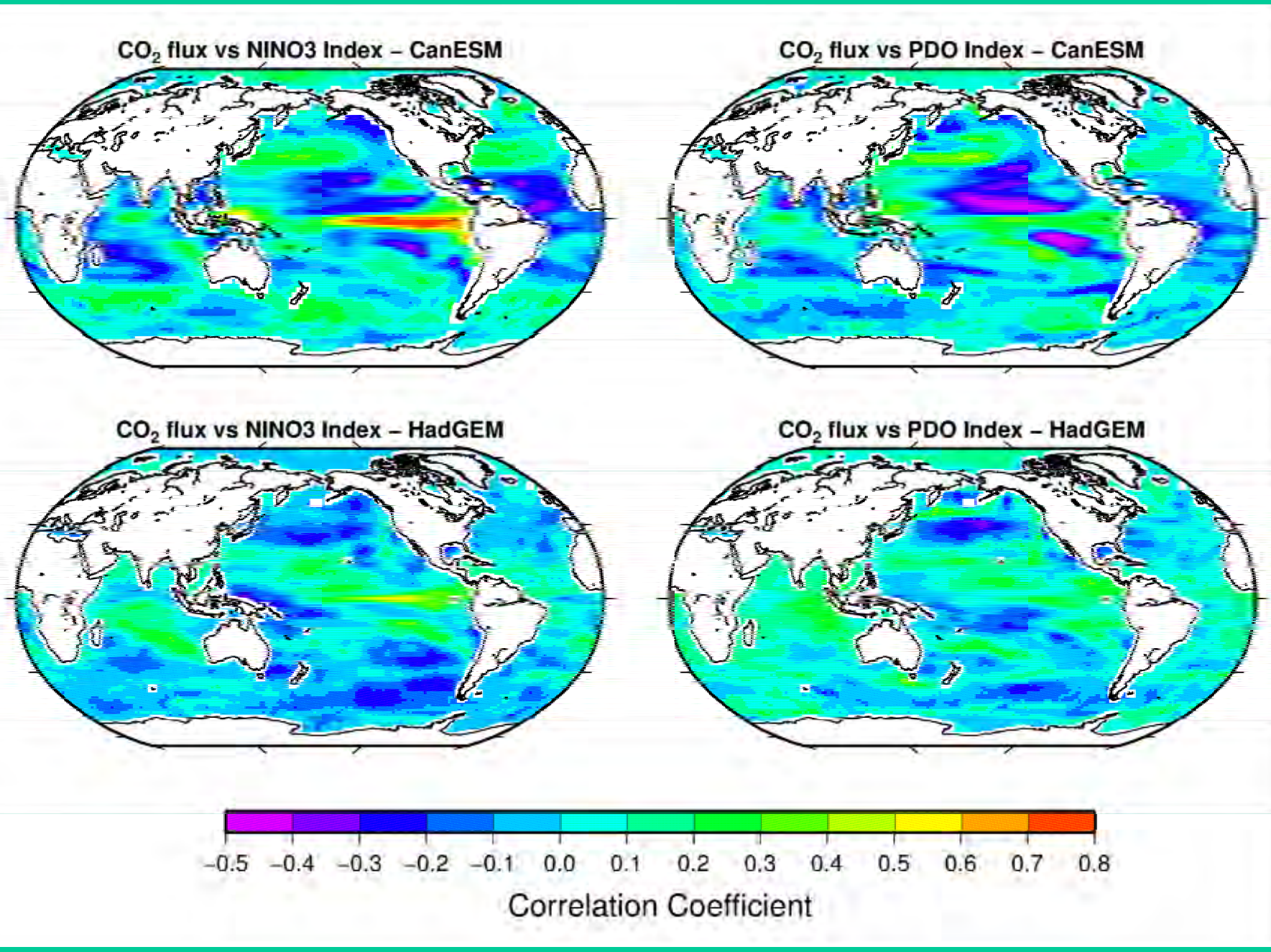


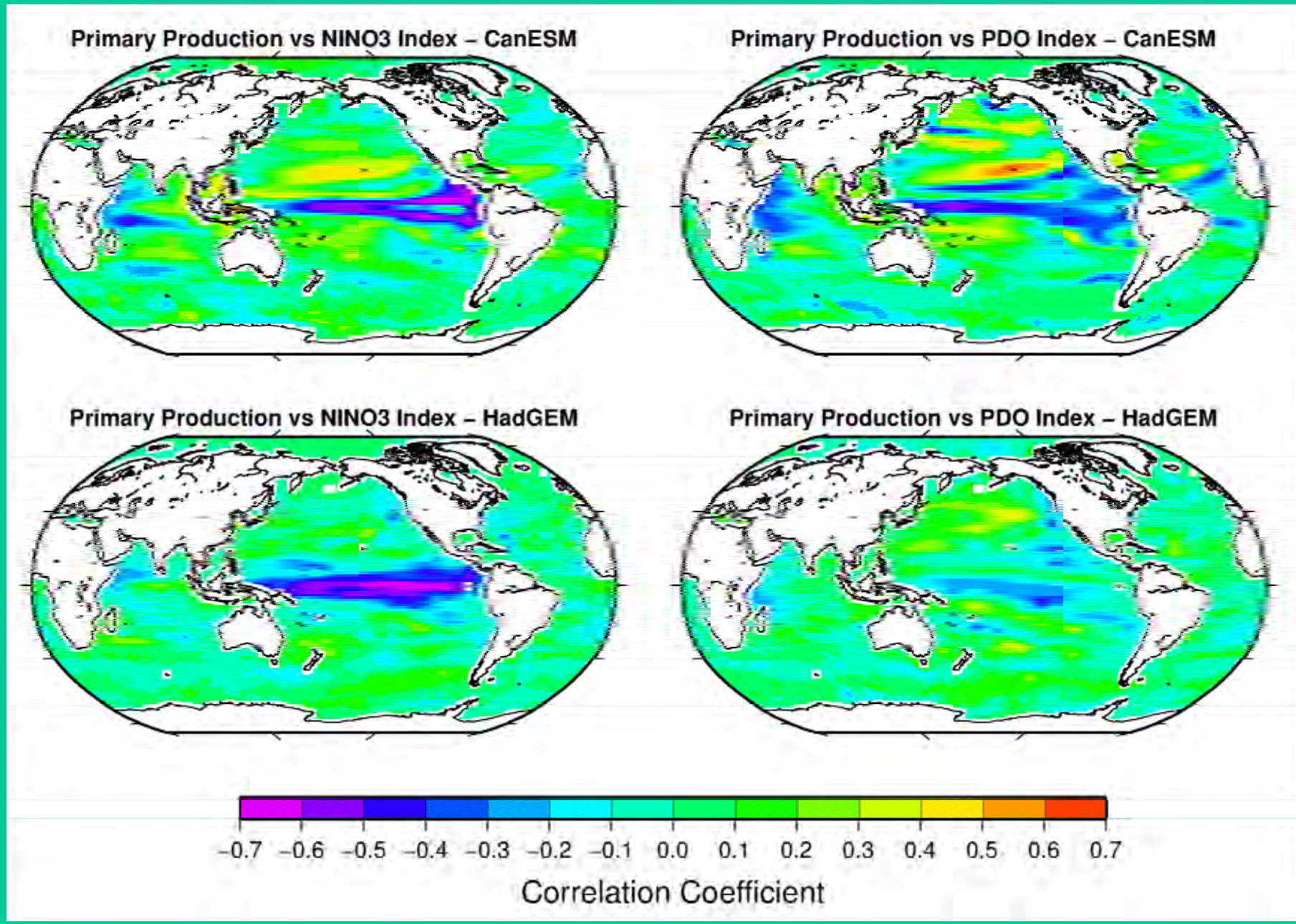
ENSO



NINO3 SST anomaly




CO_2 flux vs NINO3 Index – CanESM
CO_2 flux vs PDO Index – CanESM
CO_2 flux vs NINO3 Index – HadGEM
CO_2 flux vs PDO Index – HadGEM
−0.5 −0.4 −0.3 −0.2 −0.1 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8
Correlation Coefficient


Primary Production vs NINO3 Index – CanESM
Primary Production vs PDO Index – CanESM
Primary Production vs NINO3 Index – HadGEM
Primary Production vs PDO Index – HadGEM
−0.7 −0.6 −0.5 −0.4 −0.3 −0.2 −0.1 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
Correlation Coefficient

Conclusions

- climate models such as CanESM and HadGEM are getting better at simulating ‘modes’ of natural variability in the Pacific
- HadGEM does a better job of tropical SST anomaly pattern; amplitude and overall variability are similar
- global patterns of correlation of biogeochemical processes with climate indices are similar; difficult to test vs observations but SOCAT should help
- coherence of biogeochemical processes with ENSO and PDO modes is stronger in CanESM, particularly in the extratropics