Detecting Saturation in the Ocean Carbon Sink

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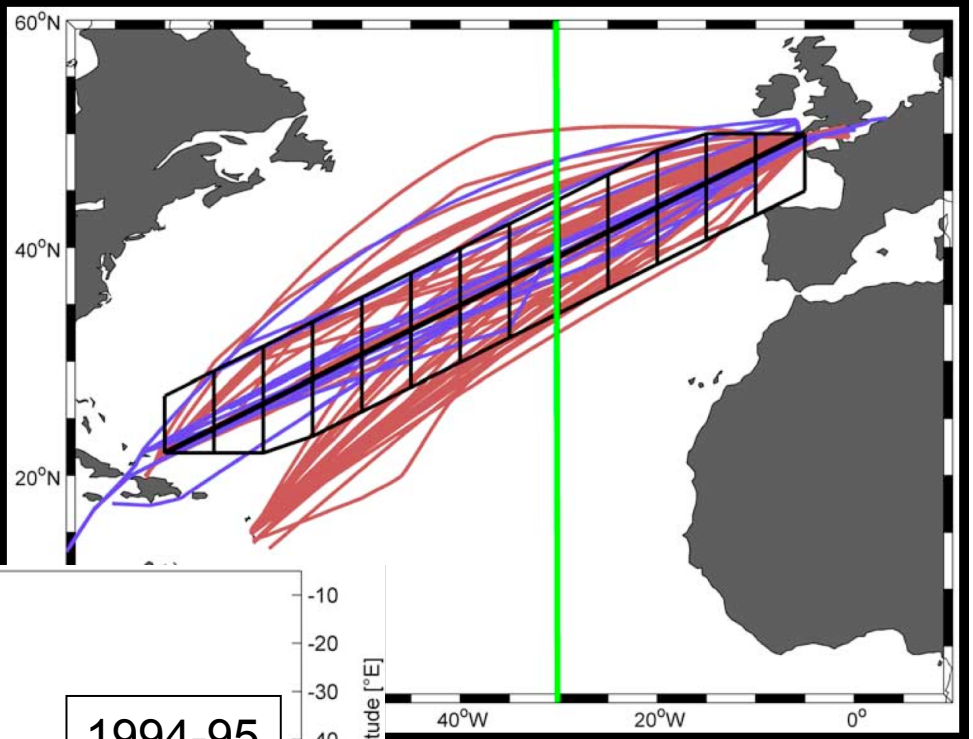
Motivations

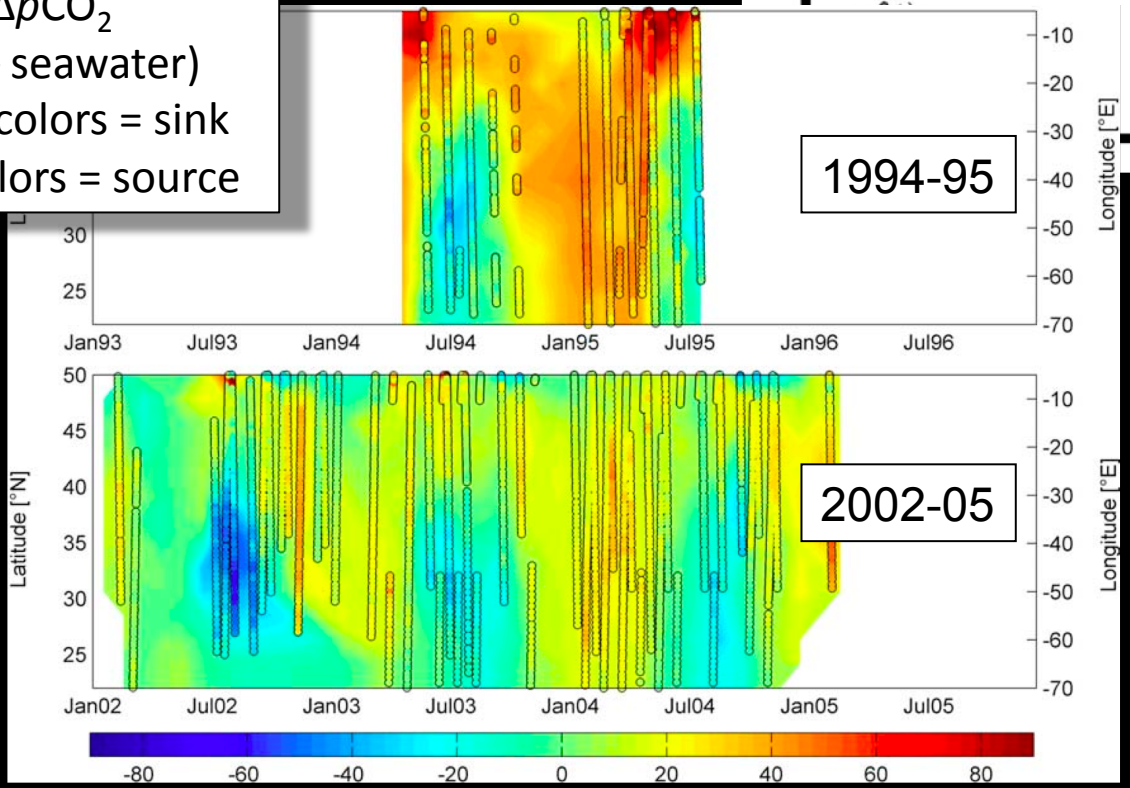
1. Suggestions of saturation
2. Public availability of the pCO_2 data
3. Better IAV prior for CarbonTracker air-sea flux

Schuster & Watson (2007)

decrease of 0.24 PgC yr^{-1} in subtropical North Atlantic CO_2 sink over about 10 years



ΔpCO_2
(air – seawater)
warm colors = sink
cool colors = source



sampling?
interannual variability?

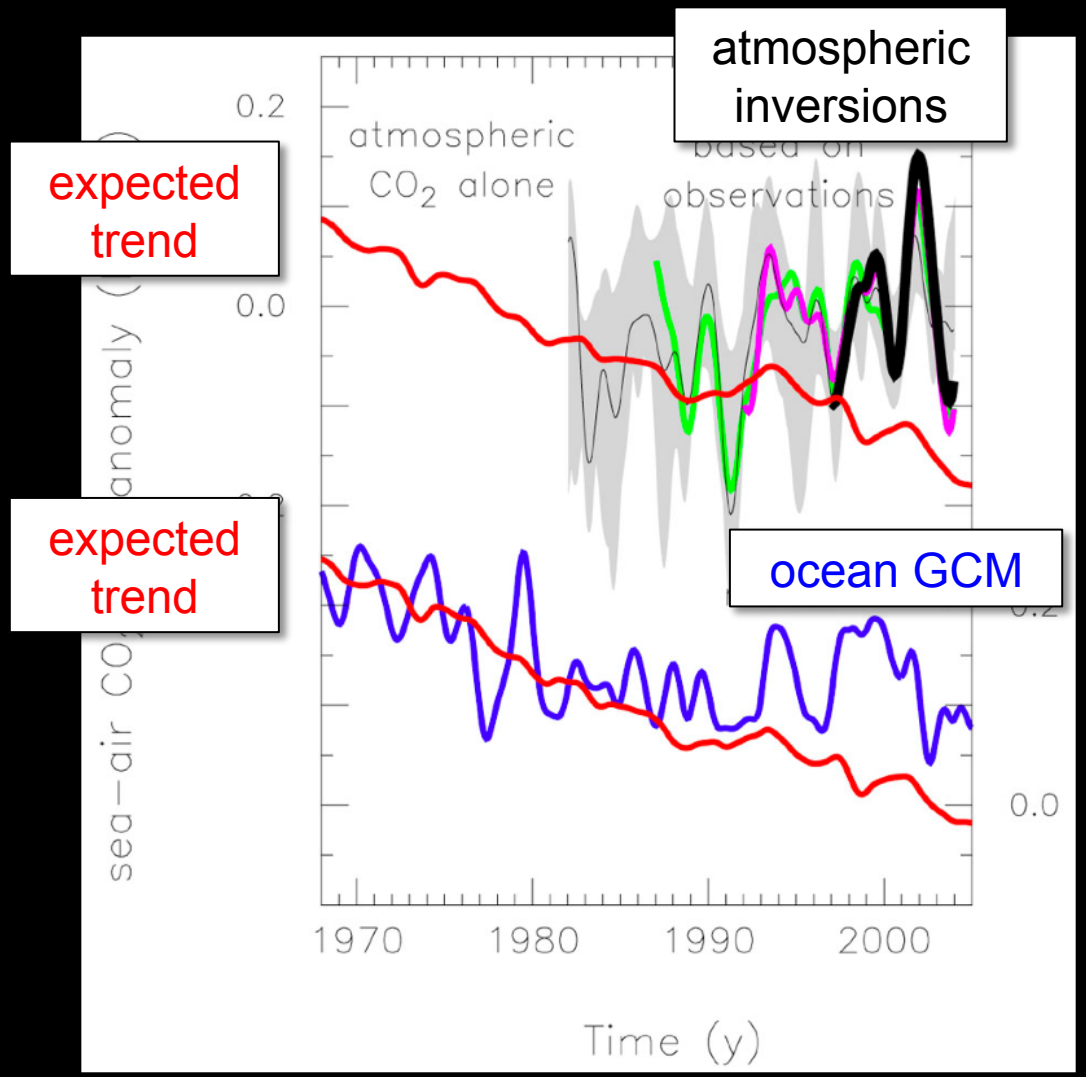
Figure 2. Hovmüller plots of ΔpCO_2 (μatm) (defined as the atmosphere minus sea surface), for (top) 1994/1995 and (bottom) 2002/2005, calculated as described in the text.

Le Quéré *et al.* (2007)

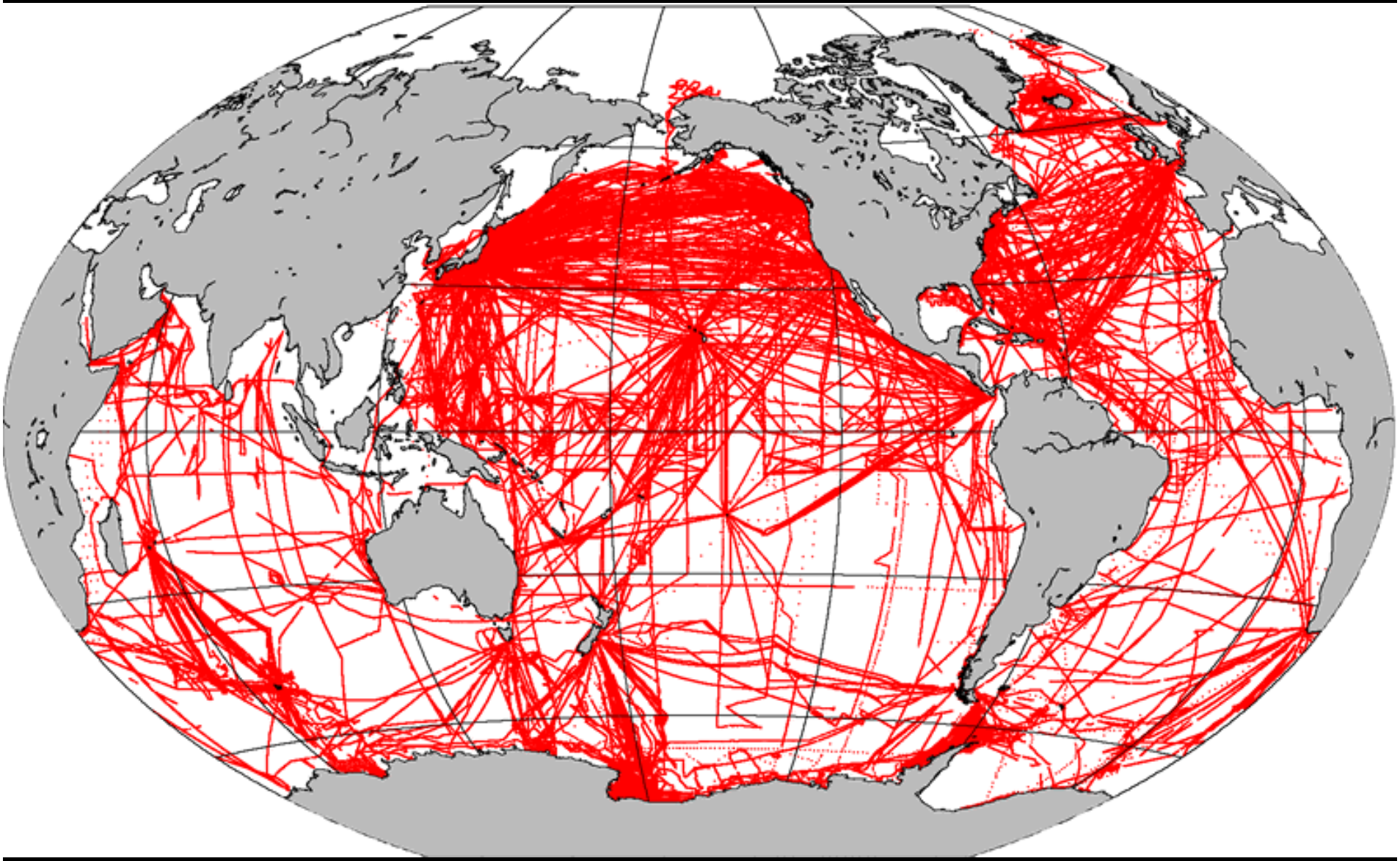
decrease of ~0.07 PgC yr^{-1} $decade^{-1}$ in Southern Ocean CO_2 sink

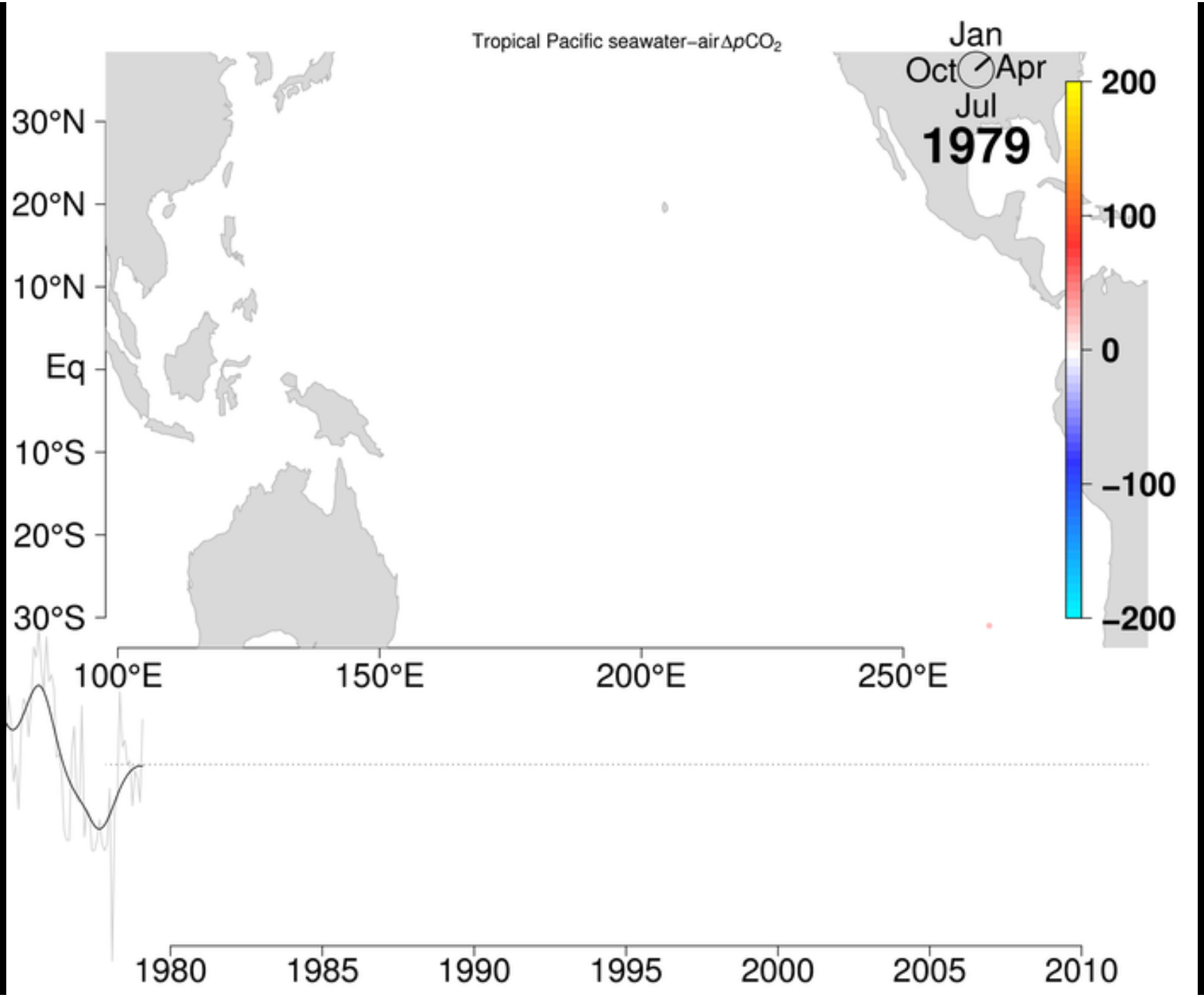
ocean GCM and atmospheric inversion

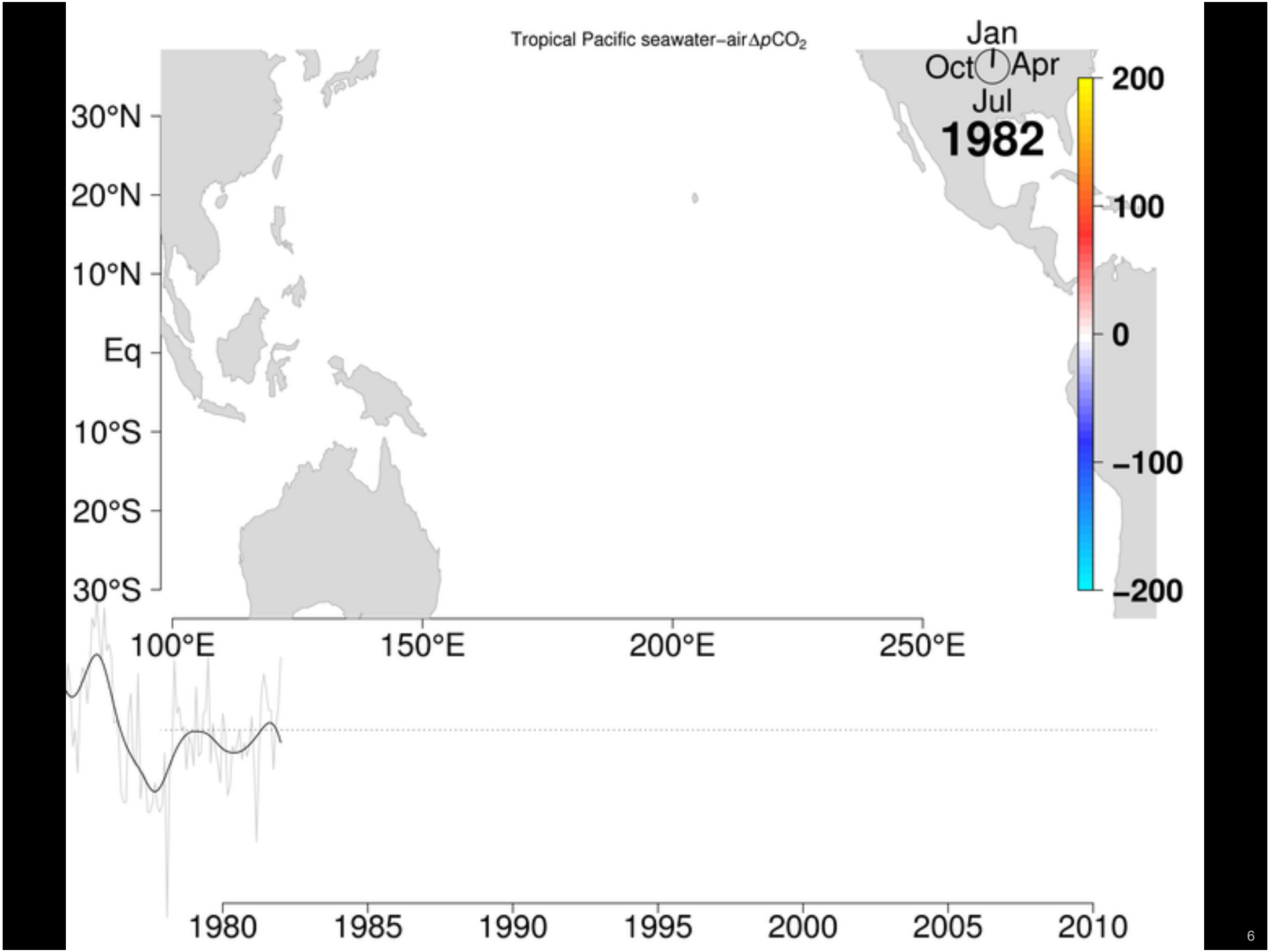
NCEP forcing overexpresses SAM inversions questionable in SH



Takahashi *et al.* (2009) observations – 4.5M, 1979-2008




Tropical Pacific seawater–air ΔpCO2
Jan
Oct
Apr
Jul
1979
200
100
0
−100
−200
30°N
20°N
10°N
Eq
10°S
20°S
30°S
100°E
150°E
200°E
250°E
1980
1985
1990
1995
2000
2005
2010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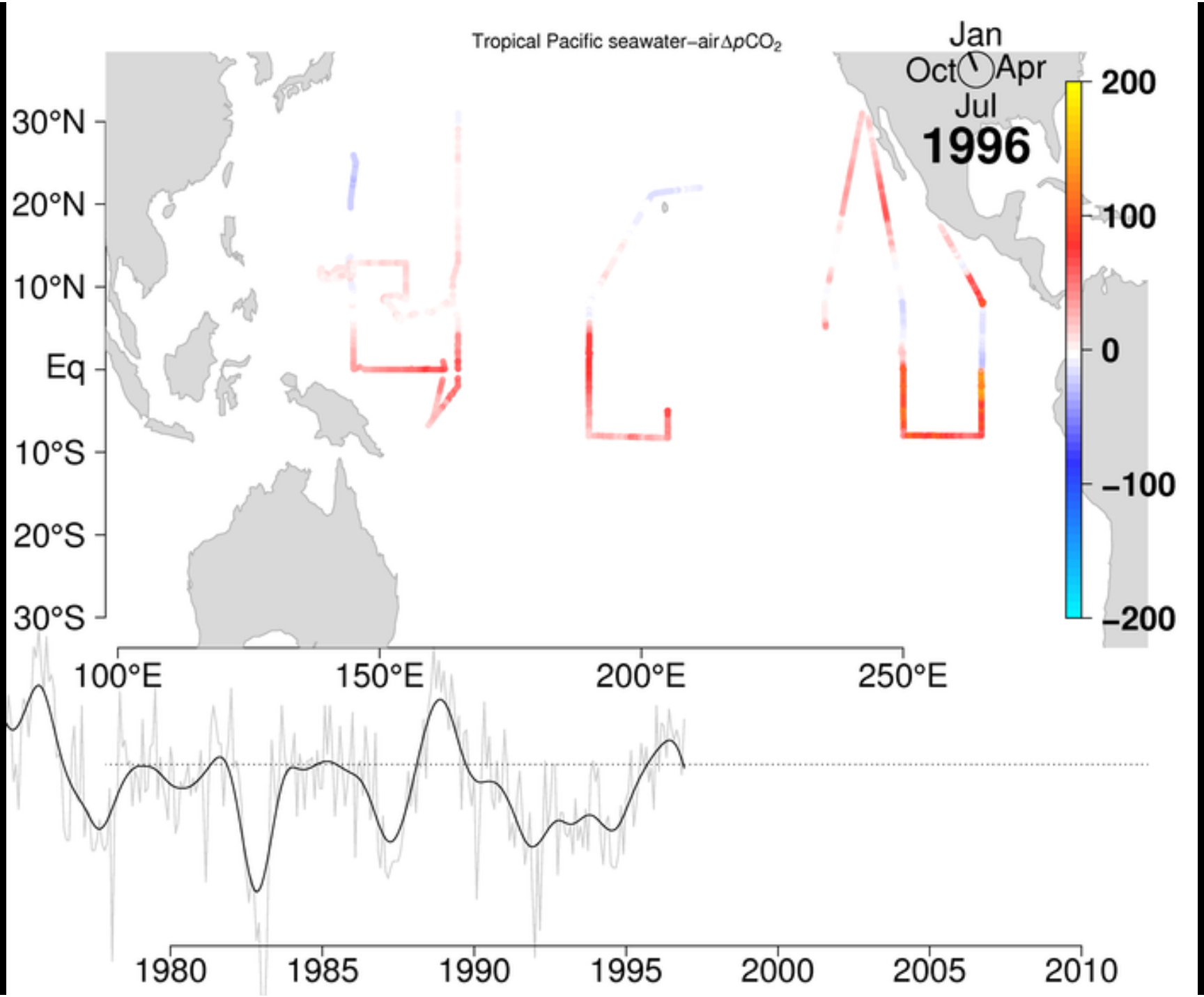
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Surface pCO_2 observations	Ocean interior carbon measurements
4.5 million 1980-2008, surface	67,000 in the 1990s, vertical profiles
seasonal and geographical sampling biases	carefully designed sampling grid
gas transfer, winds, climatology	biological transformations, ocean GCMs
intense variability	almost time invariant

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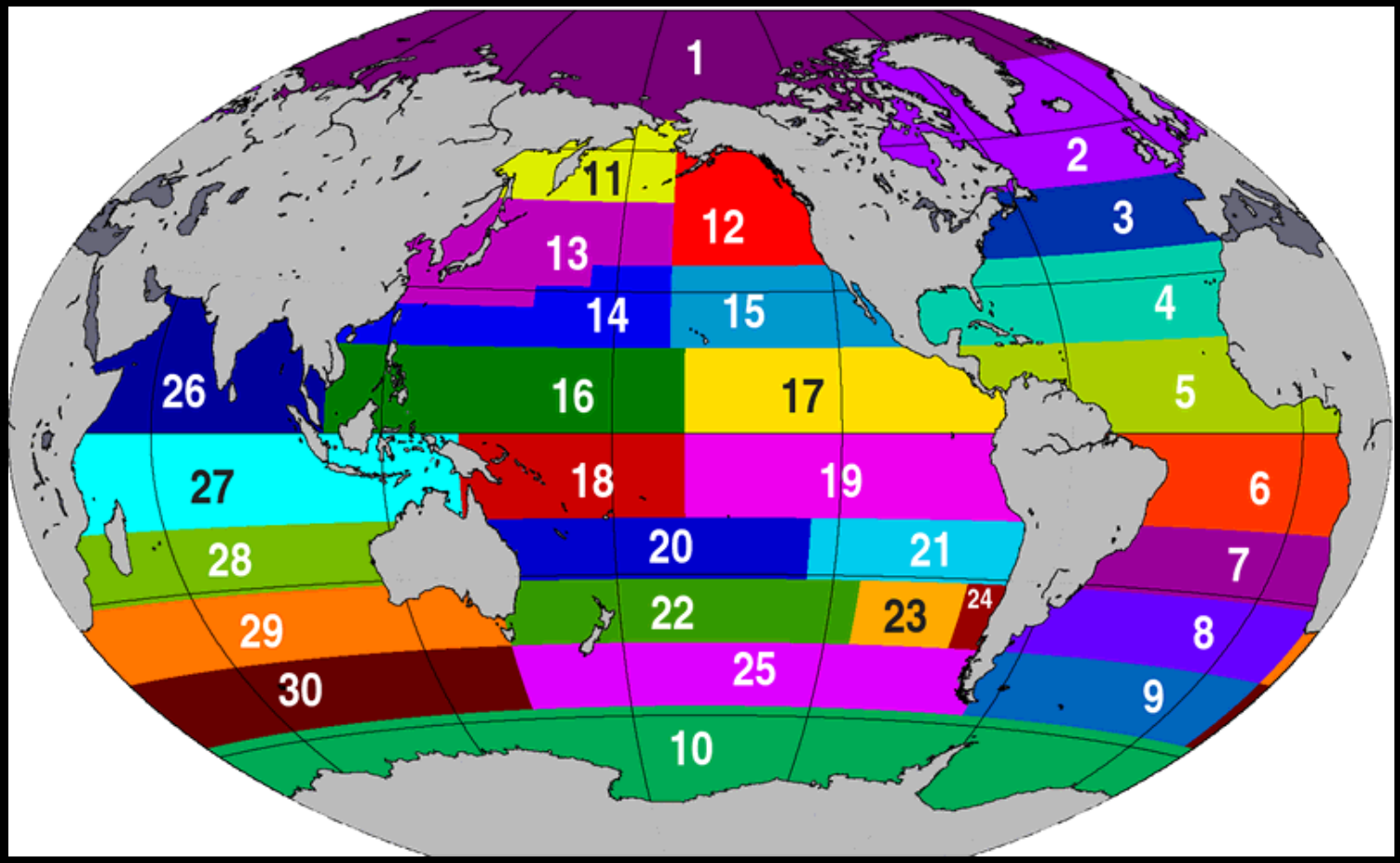
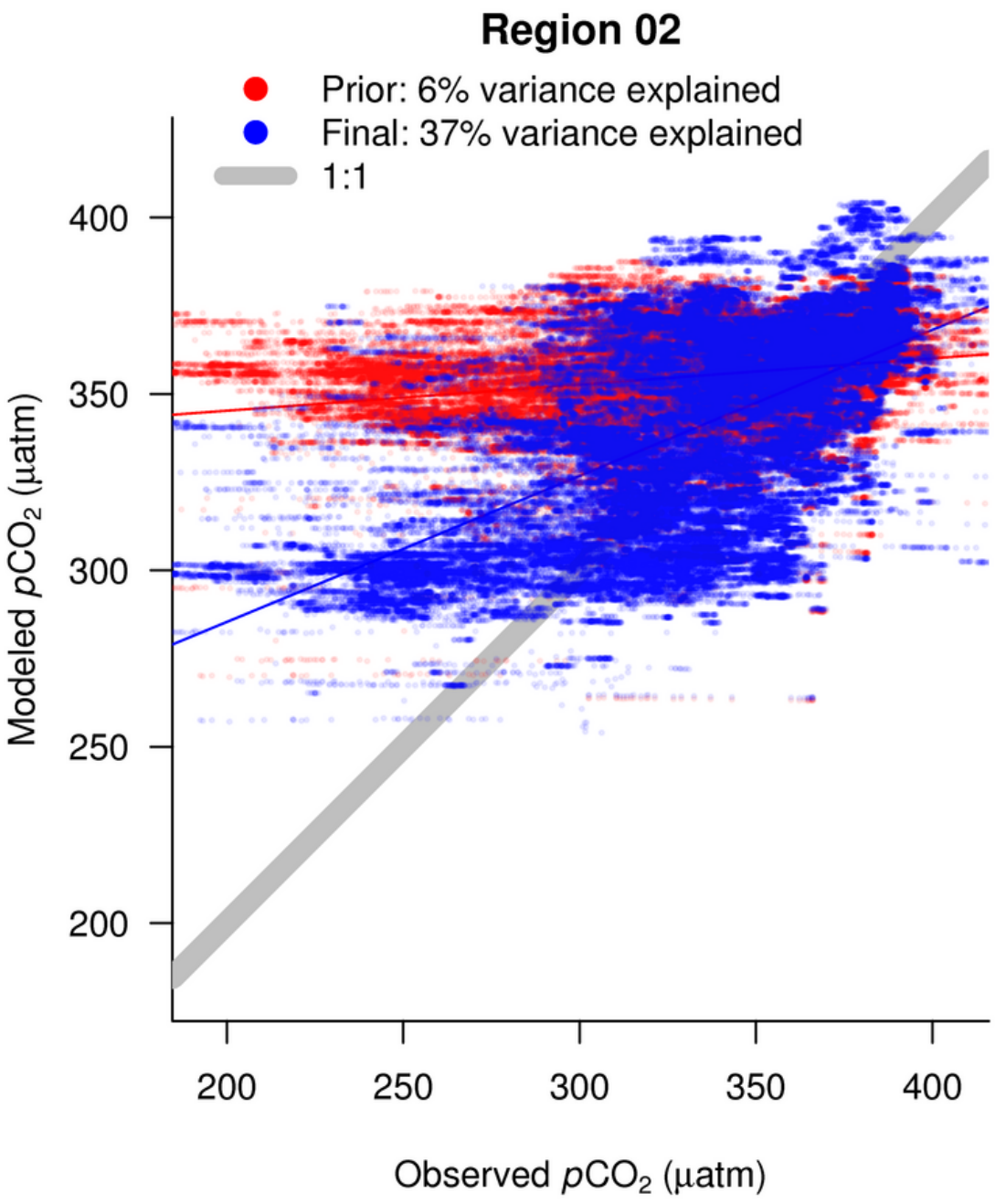
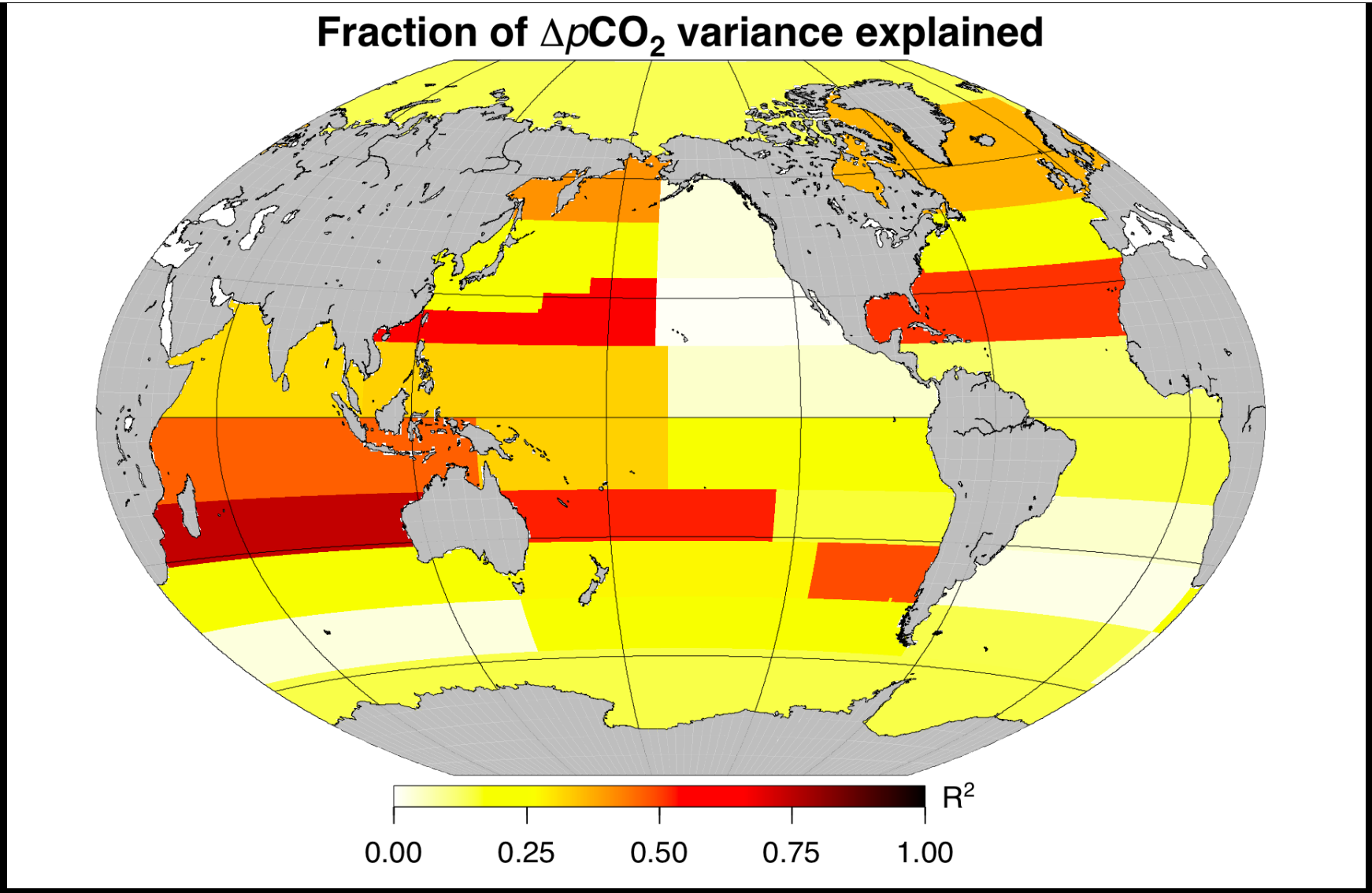
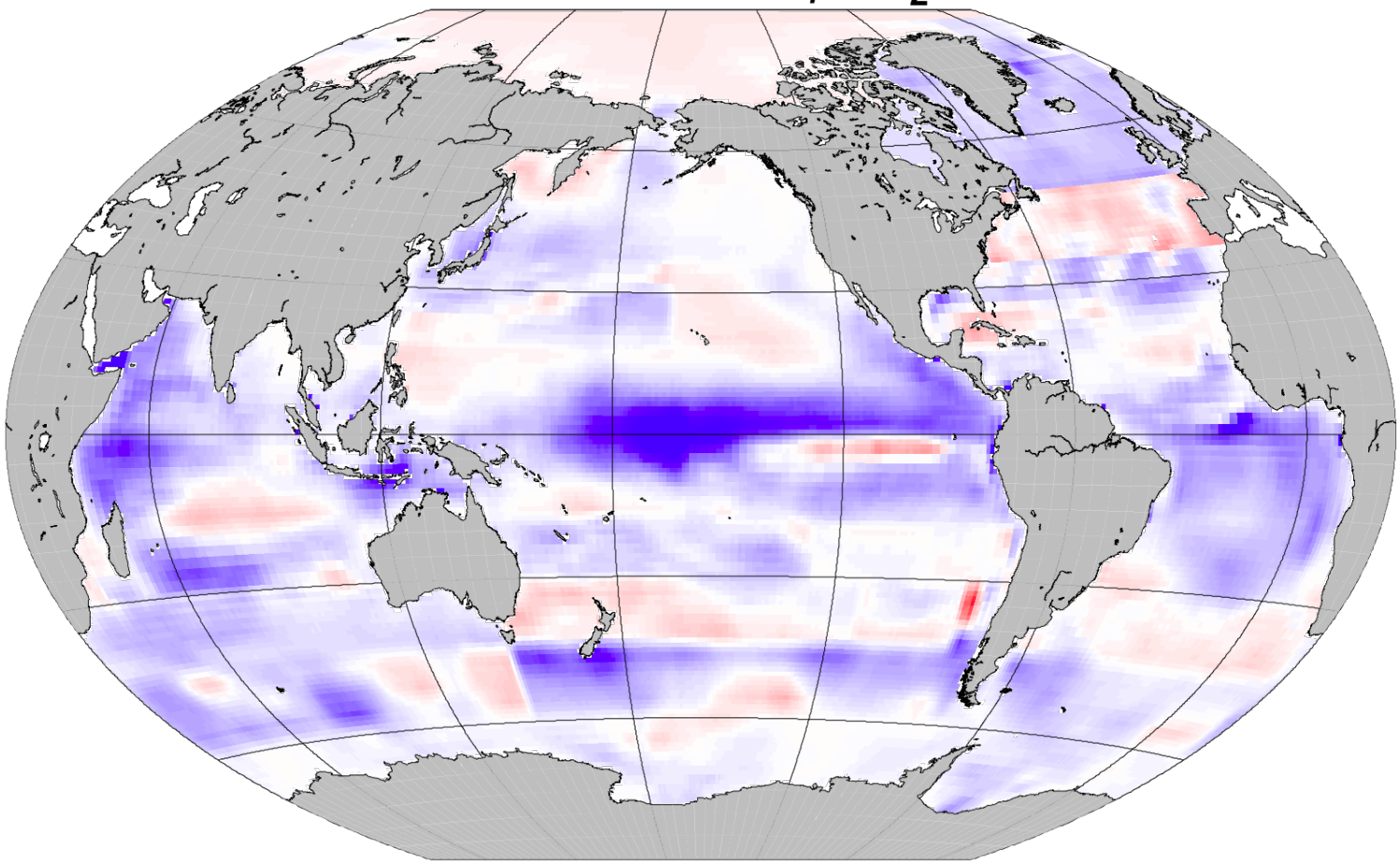
$$pCO_{2,obs} = pCO_{2,OIF} +$$
$$\text{bias} + \text{trend} + \text{seasonal harmonics} +$$
$$f(\text{climate indices, SST})$$

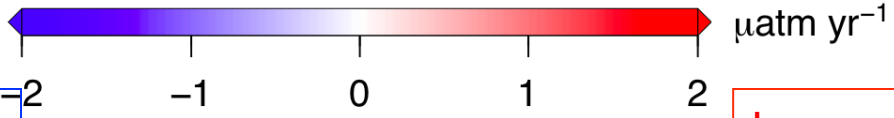



Region 02
Prior: 6% variance explained
Final: 37% variance explained
1:1
400
350
300
250
200
Modeled pCO_2 (µatm)
200
250
300
350
400
Observed pCO_2 (µatm)


Fraction of ΔpCO2 variance explained
R2
0.00
0.25
0.50
0.75
1.00

1982–2008 sea–air ΔpCO_2 trend

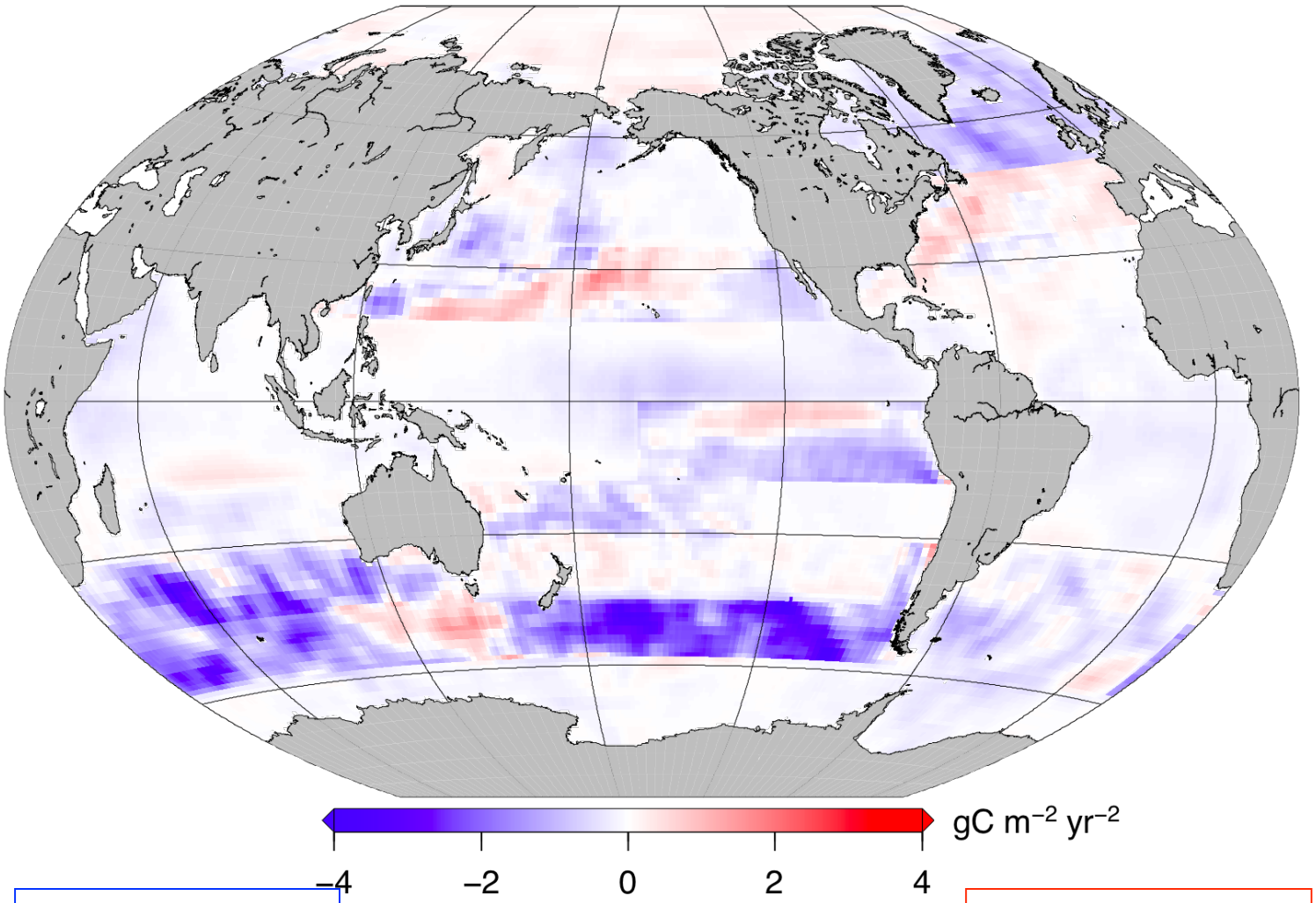




more uptake
less outgassing

less uptake
more outgassing

1982–2008 flux trend



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Conclusions

Modest evidence of less uptake in N. Atlantic;
more uptake in S. Ocean.

This model supports Schuster & Watson,
but throws an arrow at results of Le Quéré *et al.*

Next steps

Better error estimate using cross-validation
Start with inversions using new North Atlantic data
Try shorter period with altimetry & ocean color
Can atmosphere help?