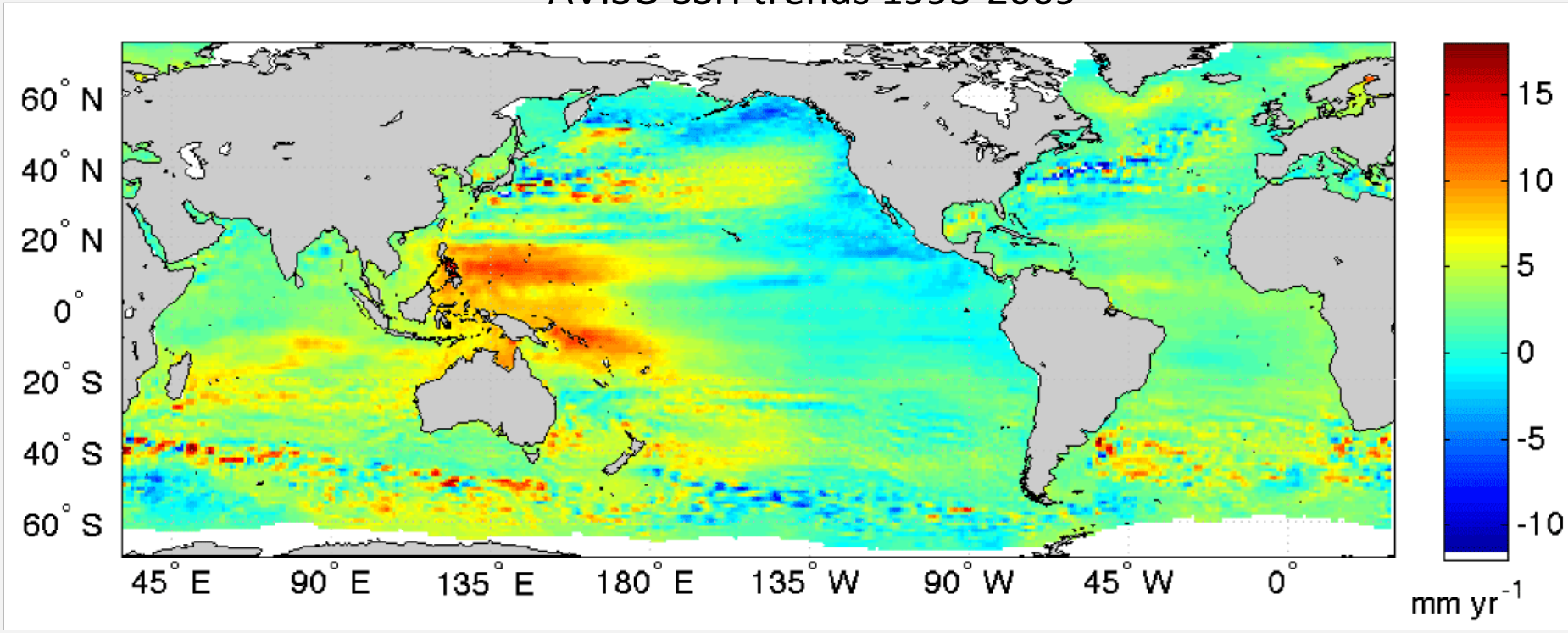
Western Pacific Sea Level and Winds

Mark Merrifield and Phil Thompson
University of Hawai'i Sea Level Center

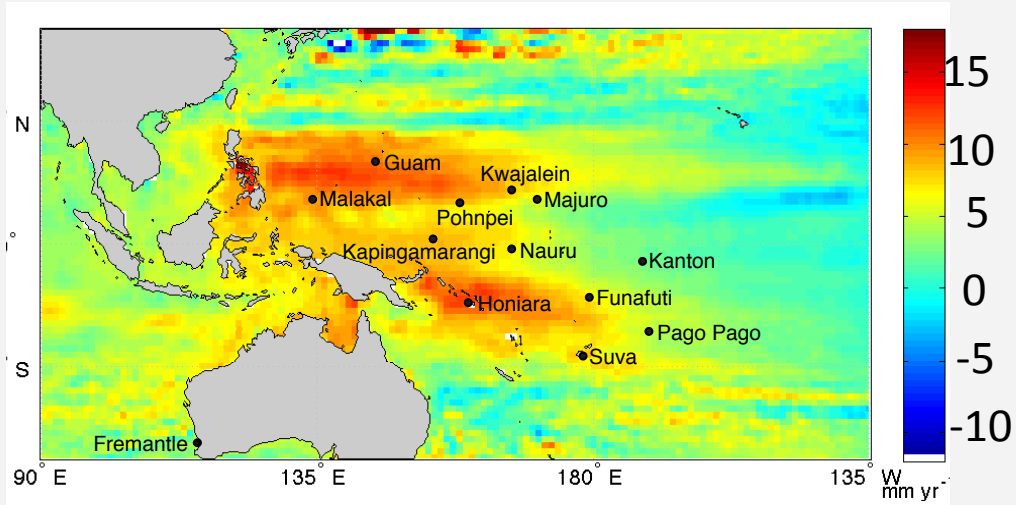
PSMSL 80th Anniversary Workshop
29 October 2013

AVISO SSH trends 1993-2009

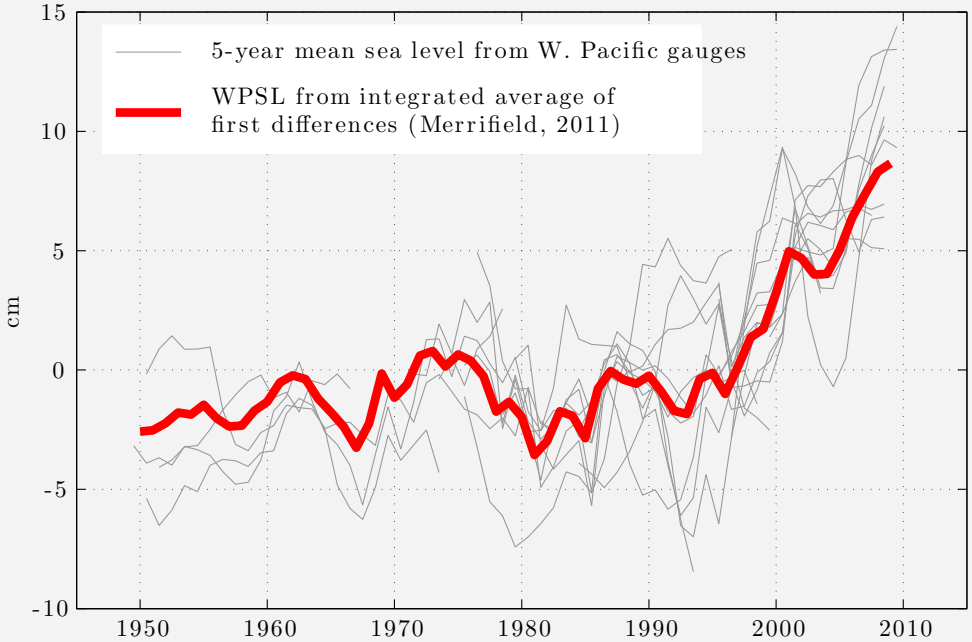


- What drives recent positive sea level trends in the western tropical Pacific and near zero trends along the N. American coast?
- How are these changes related to Pacific climate indices?

W. Pacific Sea Level from Tide Gauges

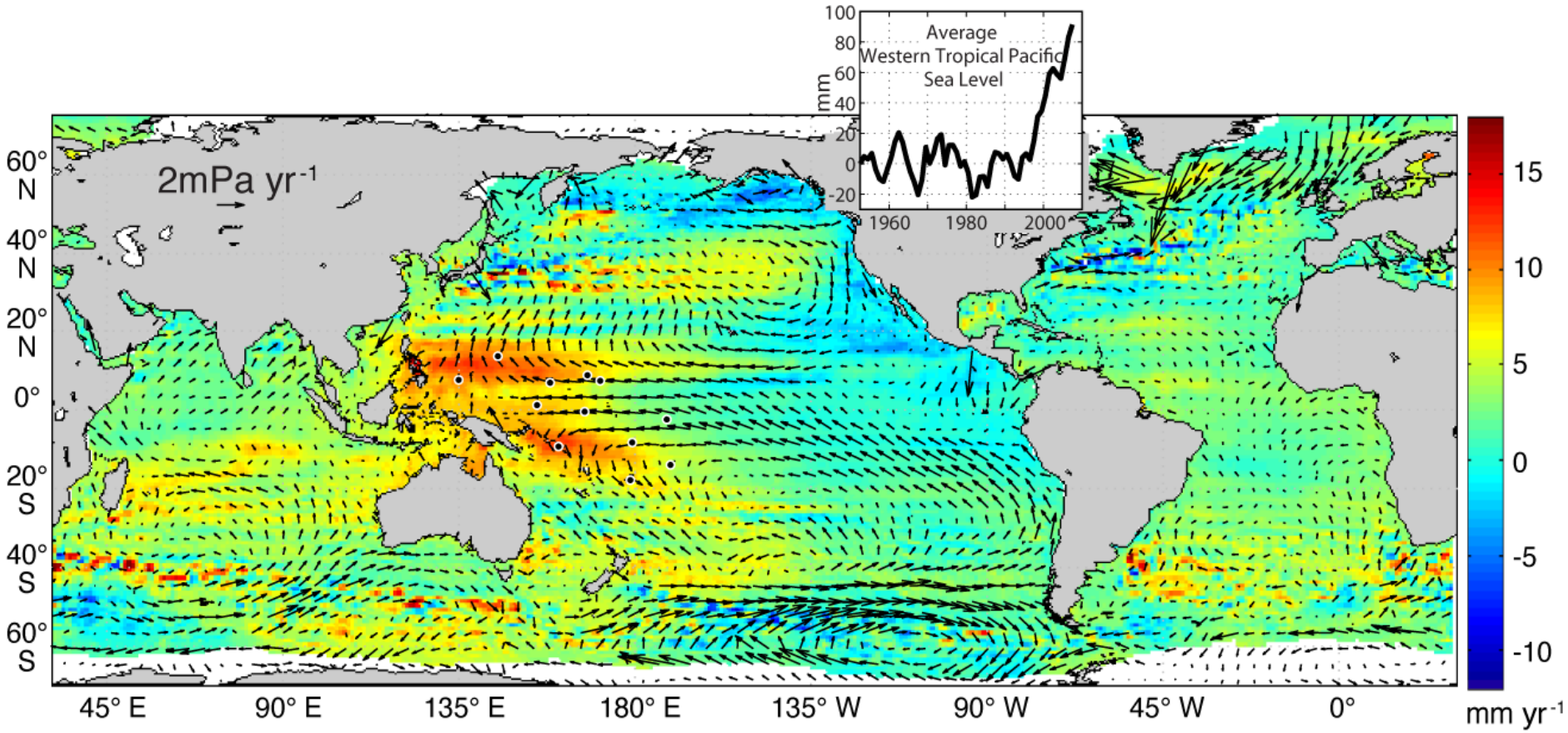


12 island tide gauge stations, 3 with records dating back to mid-20th century



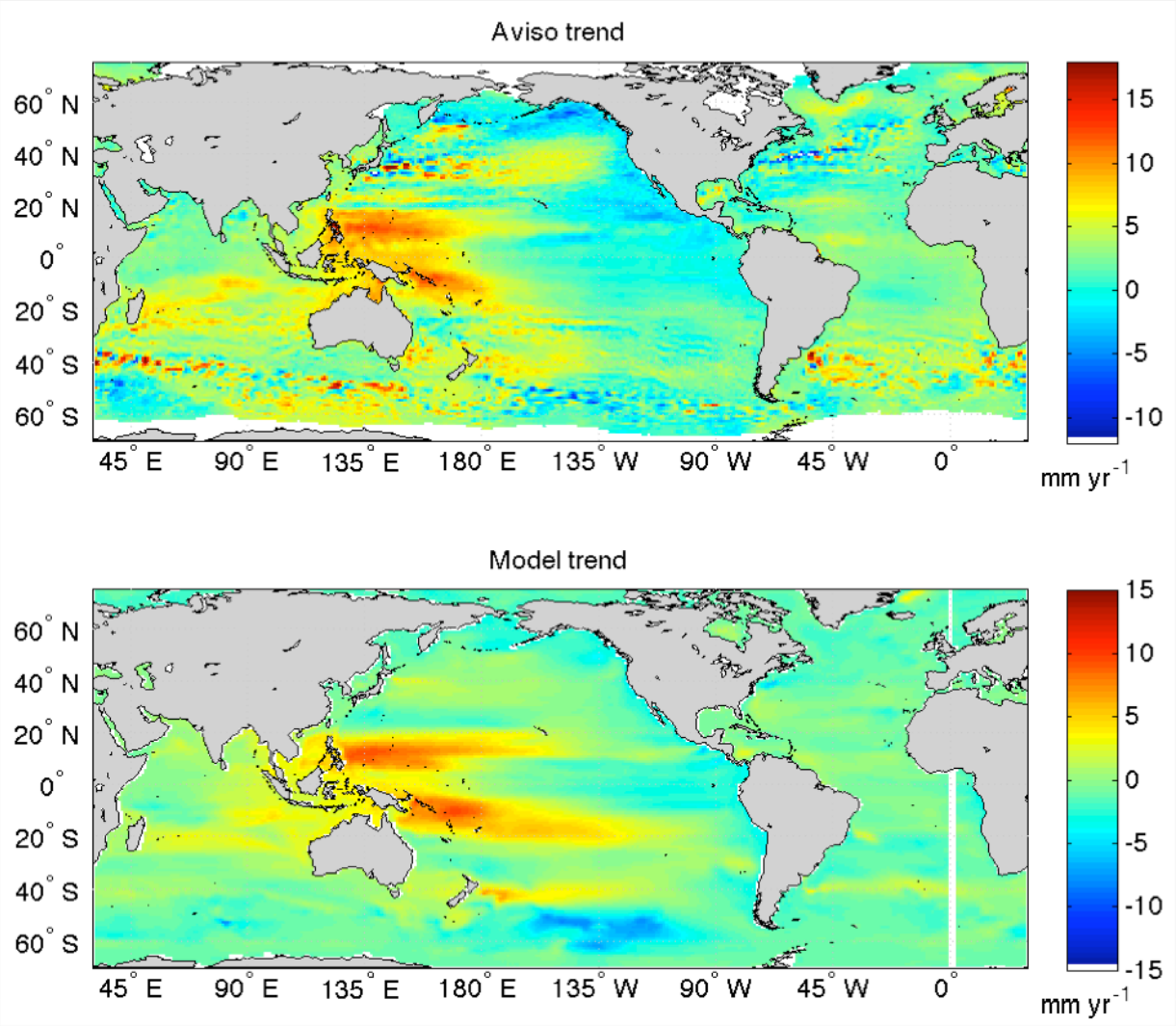
Near zero trend prior to early 1990s, ~7 mm/yr since then

Increase in Pacific Trade Winds



ECMWF ORA-S3

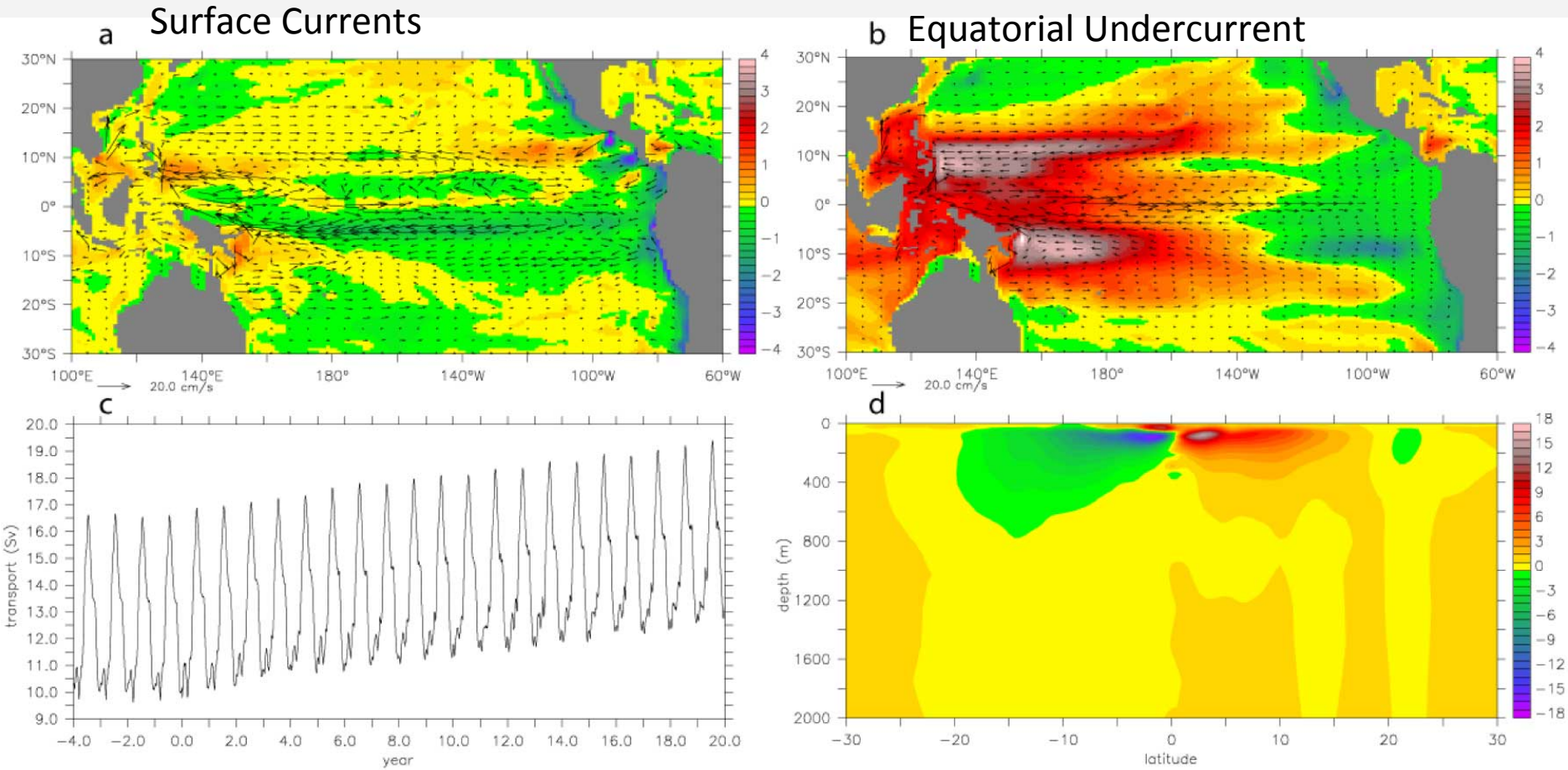
POP model simulation forced by ORA-S3 wind stress trend pattern



Merrifield and Maltrud, 2011

Carton et al. (2005), Kohl et al. (2007), Timmermann et al. (2010), Becker et al. (2012)

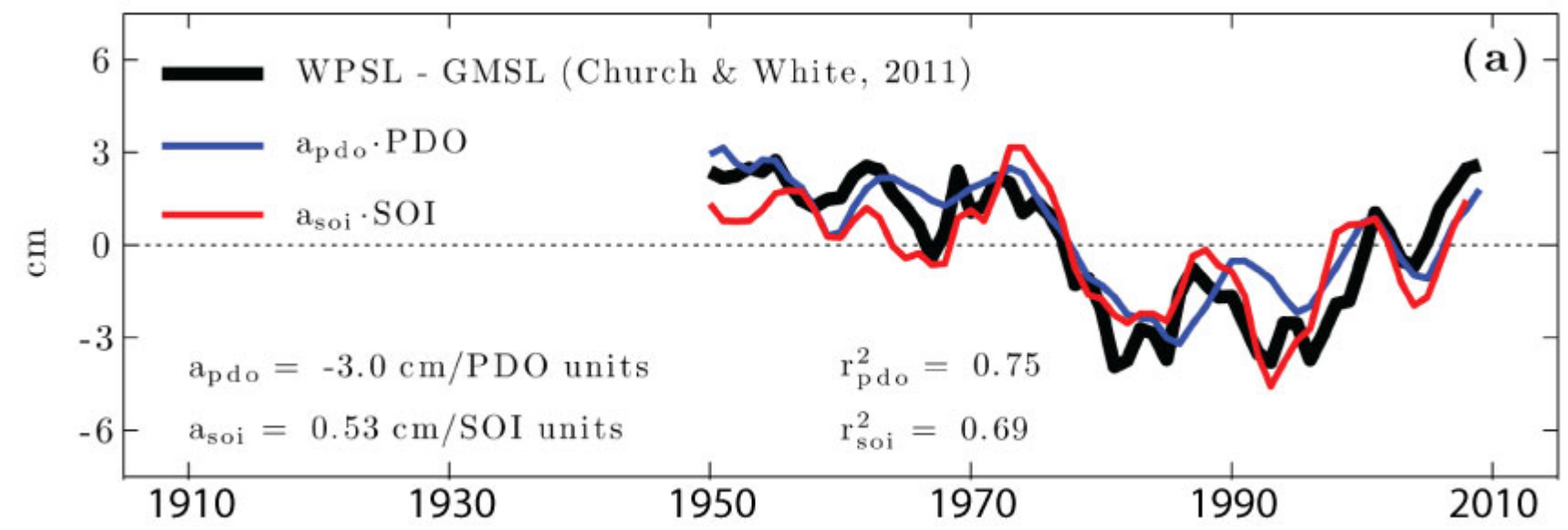
Associated trends in other model fields



Indonesian Throughflow

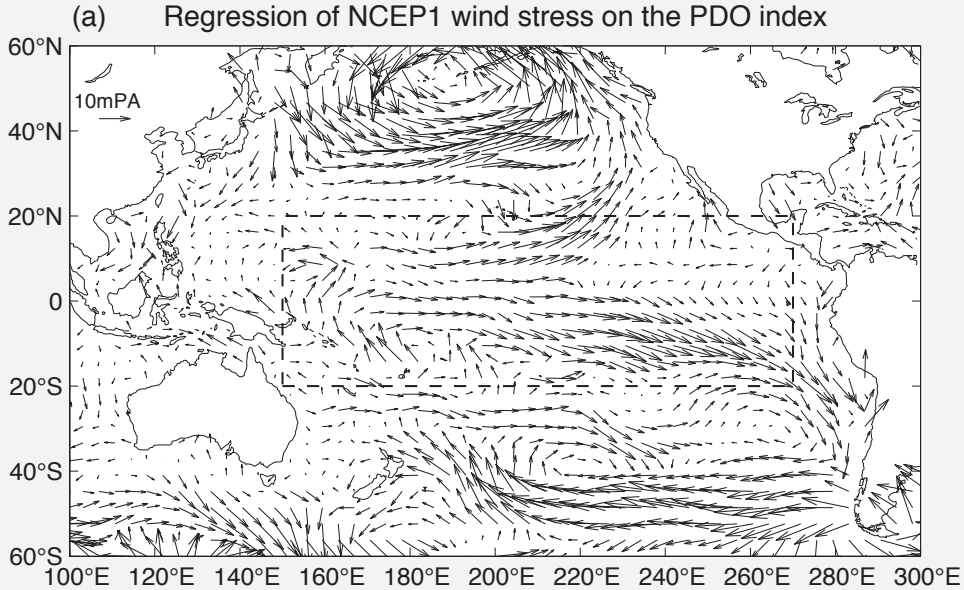
Pacific Meridional Overturning Circulation

Relationship to Pacific Climate Indices

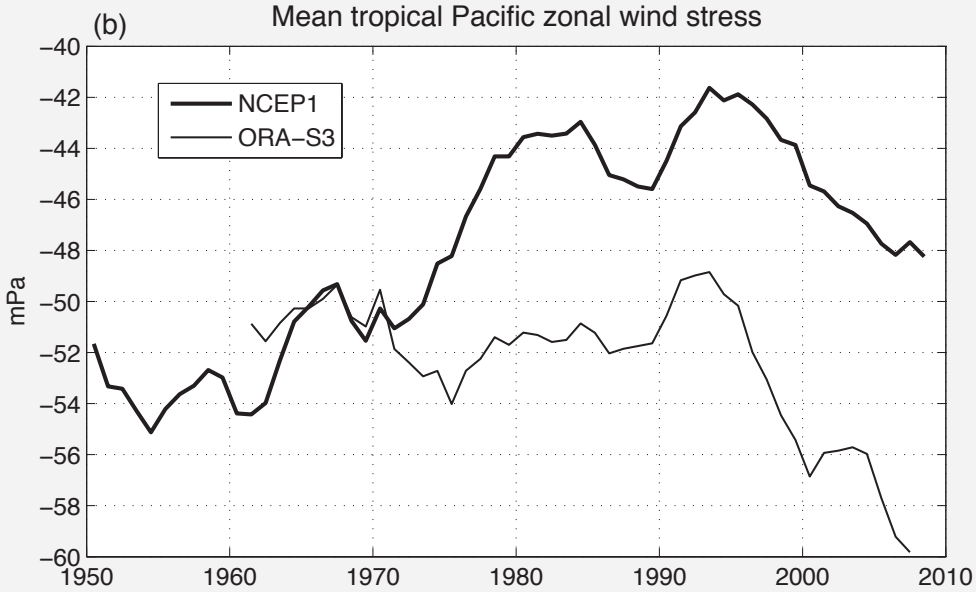


Merrifield et al. (2012), Corrections to Merrifield (2011) regarding importance of PDO/SOI

Feng et al. (2004), Feng et al. (2010), Meyssignac et al. (2012)

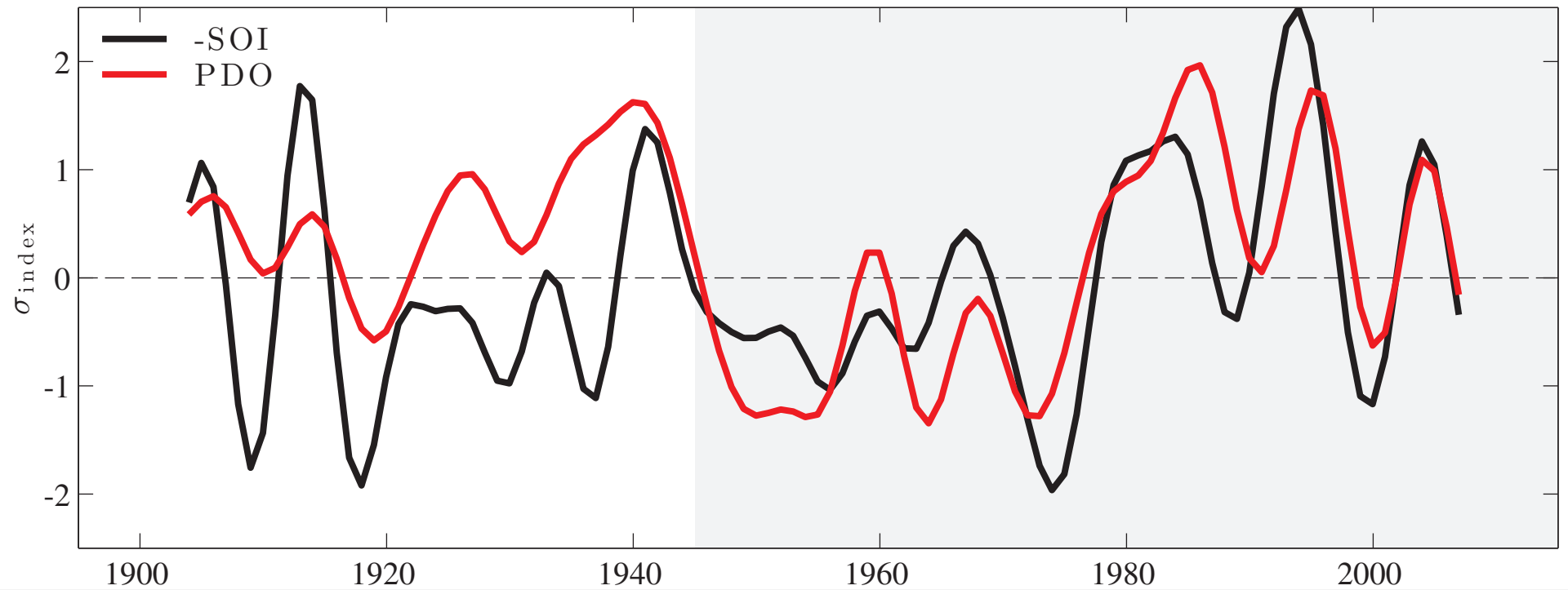


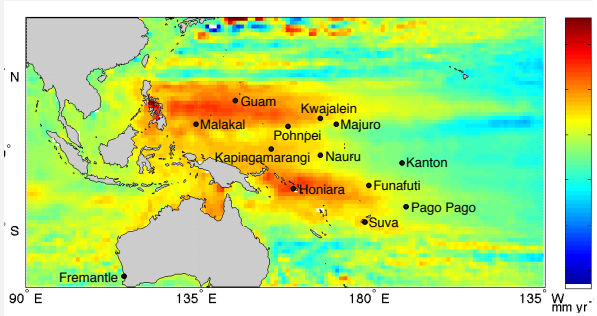
PDO related wind stress (NCEP1)

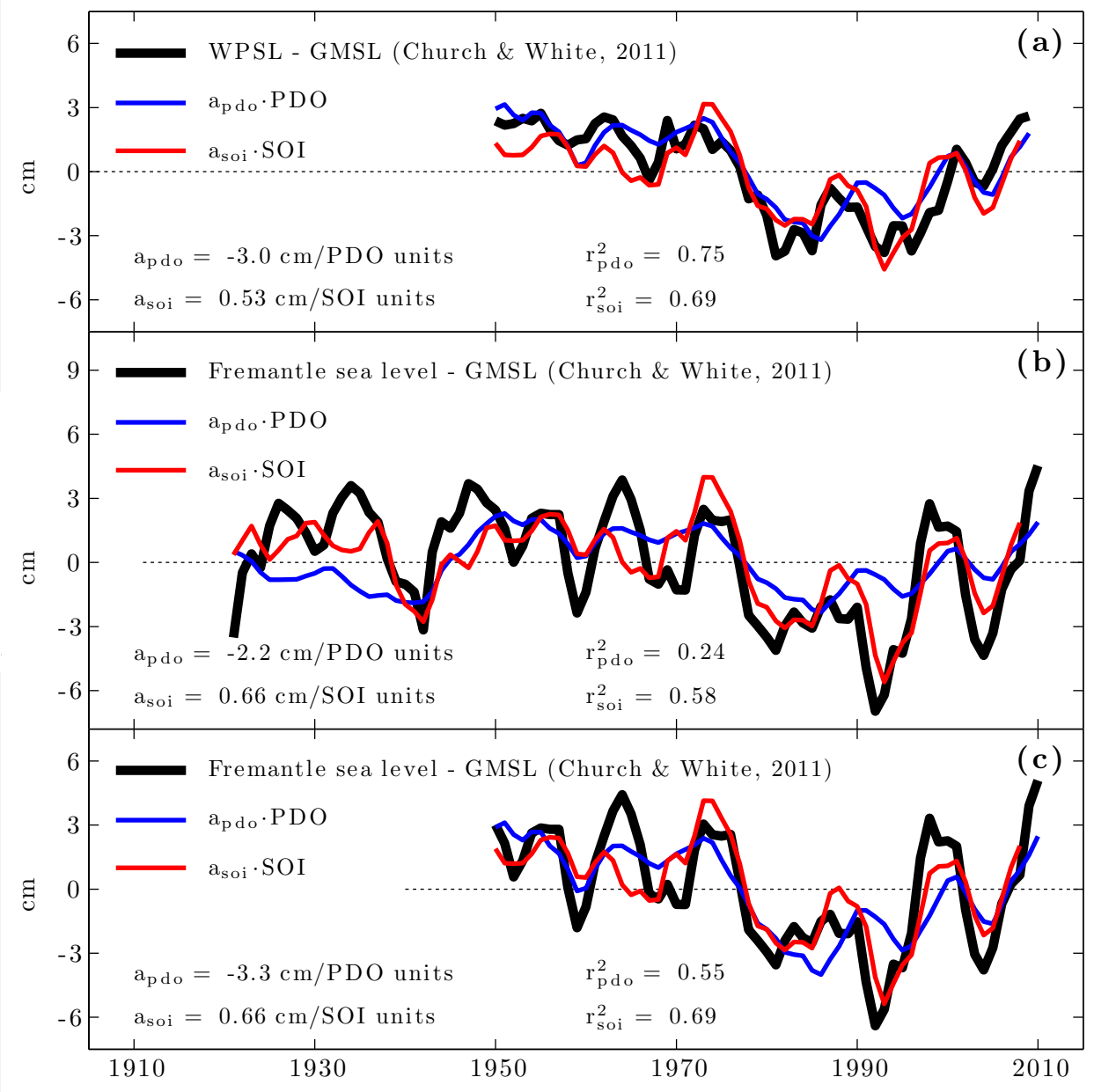


Zonal trades vary with reanalysis product, see McGregor et al. (2012)

PDO vs SOI




Guam
Kwajalein
Malakal
Majuro
Pohnpei
Kapingamarangi
Nauru
Kanton
Honiara
Funafuti
Pago Pago
Suva
Fremantle
N
S
90° E
135° E
180° E
135° W
mm yr⁻¹

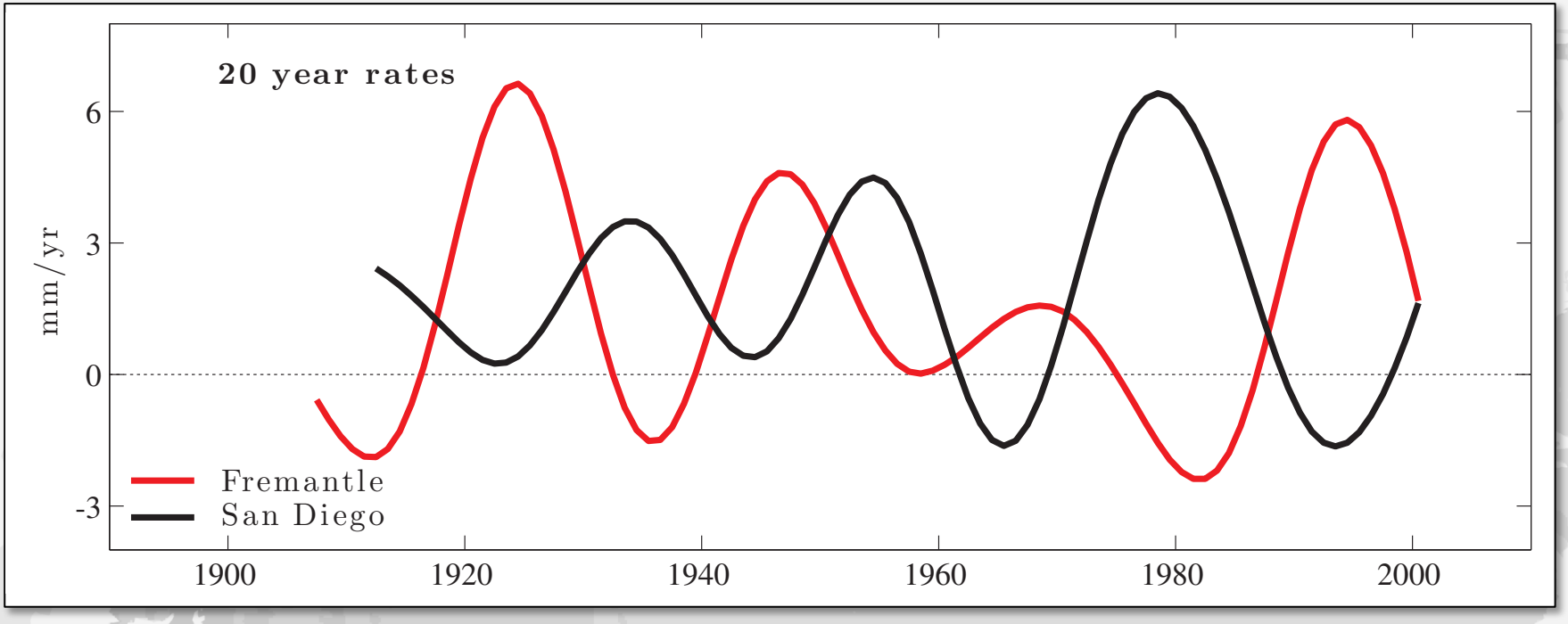

(a)
WPSL - GMSL (Church & White, 2011)
a_{pdo}·PDO
a_{soi}·SOI
a_{pdo} = -3.0 cm/PDO units
r^2_{pdo} = 0.75
a_{soi} = 0.53 cm/SOI units
r^2_{soi} = 0.69
(b)
Fremantle sea level - GMSL (Church & White, 2011)
a_{pdo}·PDO
a_{soi}·SOI
a_{pdo} = -2.2 cm/PDO units
r^2_{pdo} = 0.24
a_{soi} = 0.66 cm/SOI units
r^2_{soi} = 0.58
(c)
Fremantle sea level - GMSL (Church & White, 2011)
a_{pdo}·PDO
a_{soi}·SOI
a_{pdo} = -3.3 cm/PDO units
r^2_{pdo} = 0.55
a_{soi} = 0.66 cm/SOI units
r^2_{soi} = 0.69
cm
6
3
0
-3
-6
9
1910
1930
1950
1970
1990
2010

Recent rates of coastal sea level change in the Northeast Pacific

Phil Thompson and Mark Merrifield
University of Hawai'i Sea Level Center

PSMSL 80th Anniversary Workshop
29 October 2013

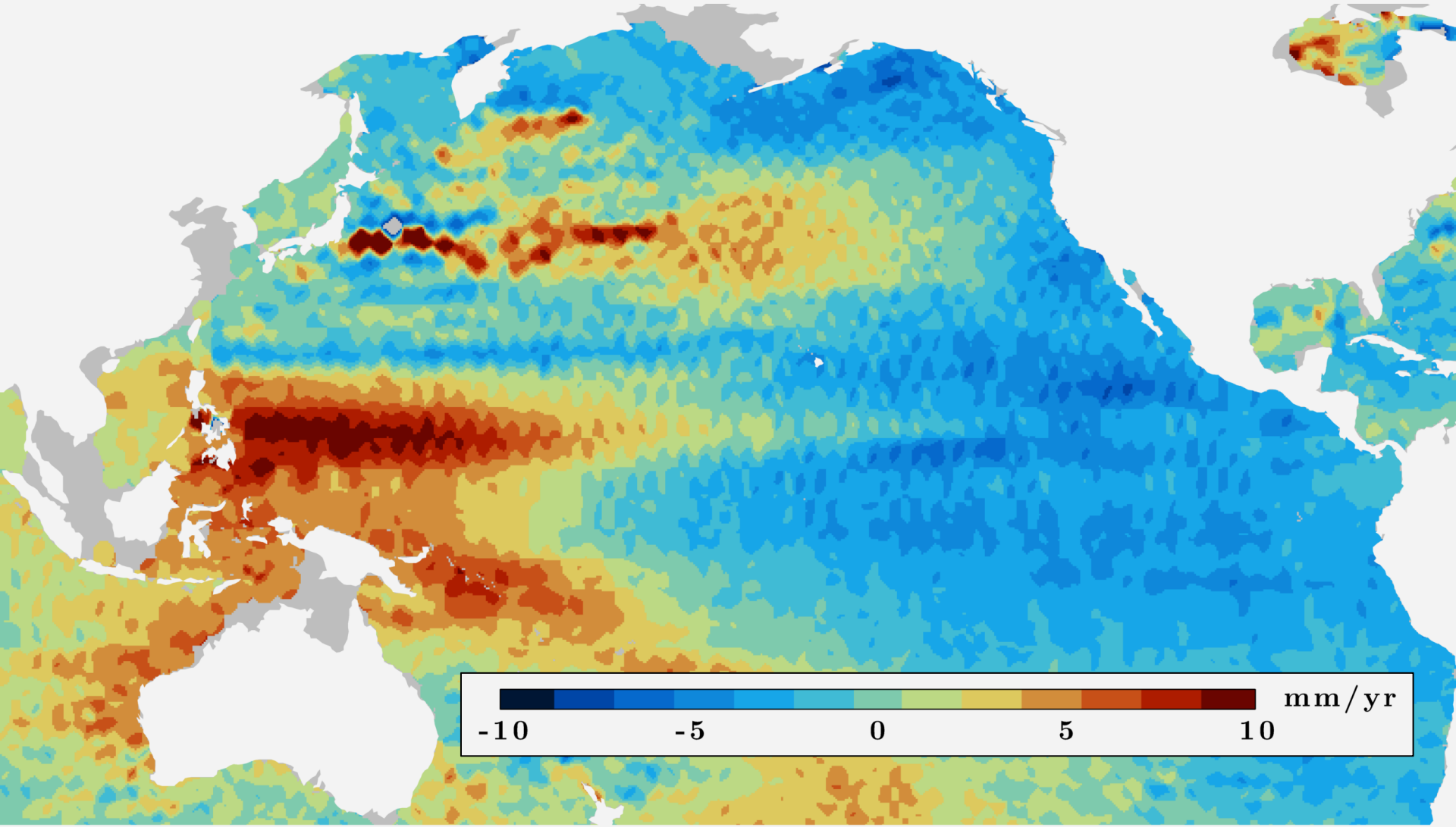
East-West connection



- Relationship suggests zonal volume redistribution and a common forcing.

North Pacific SSH trends (1993-2012)

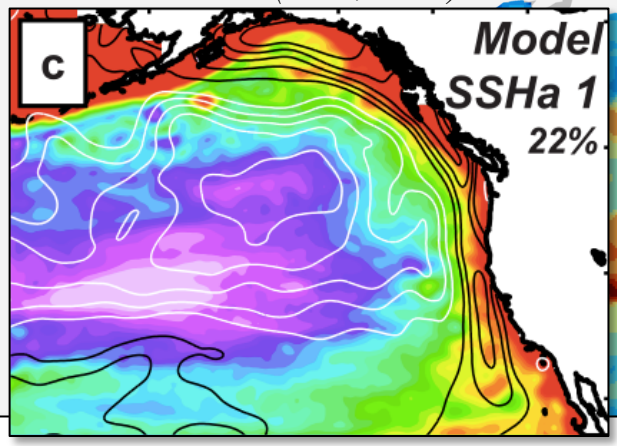
The global mean trend (3.2 mm/yr) is subtracted.

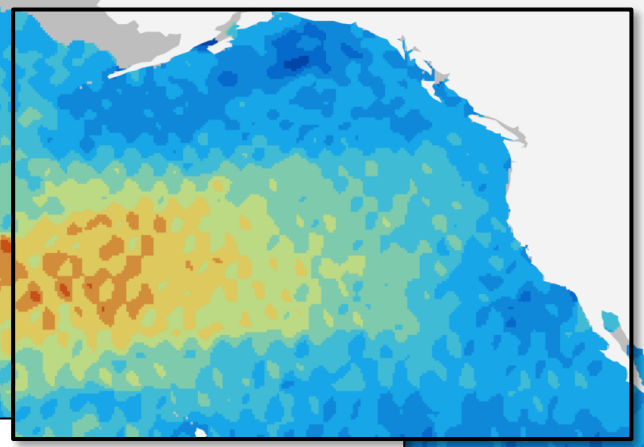


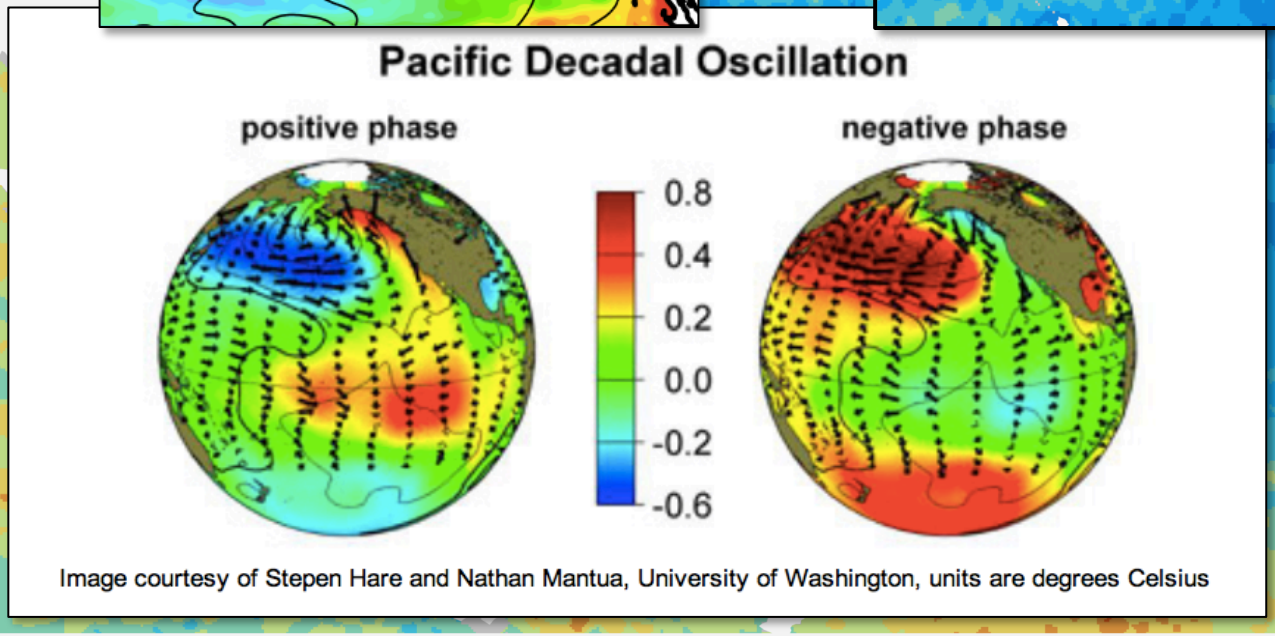
North Pacific SSH trends (1993-2011)

The global mean trend (3.2 mm/yr) is subtracted.

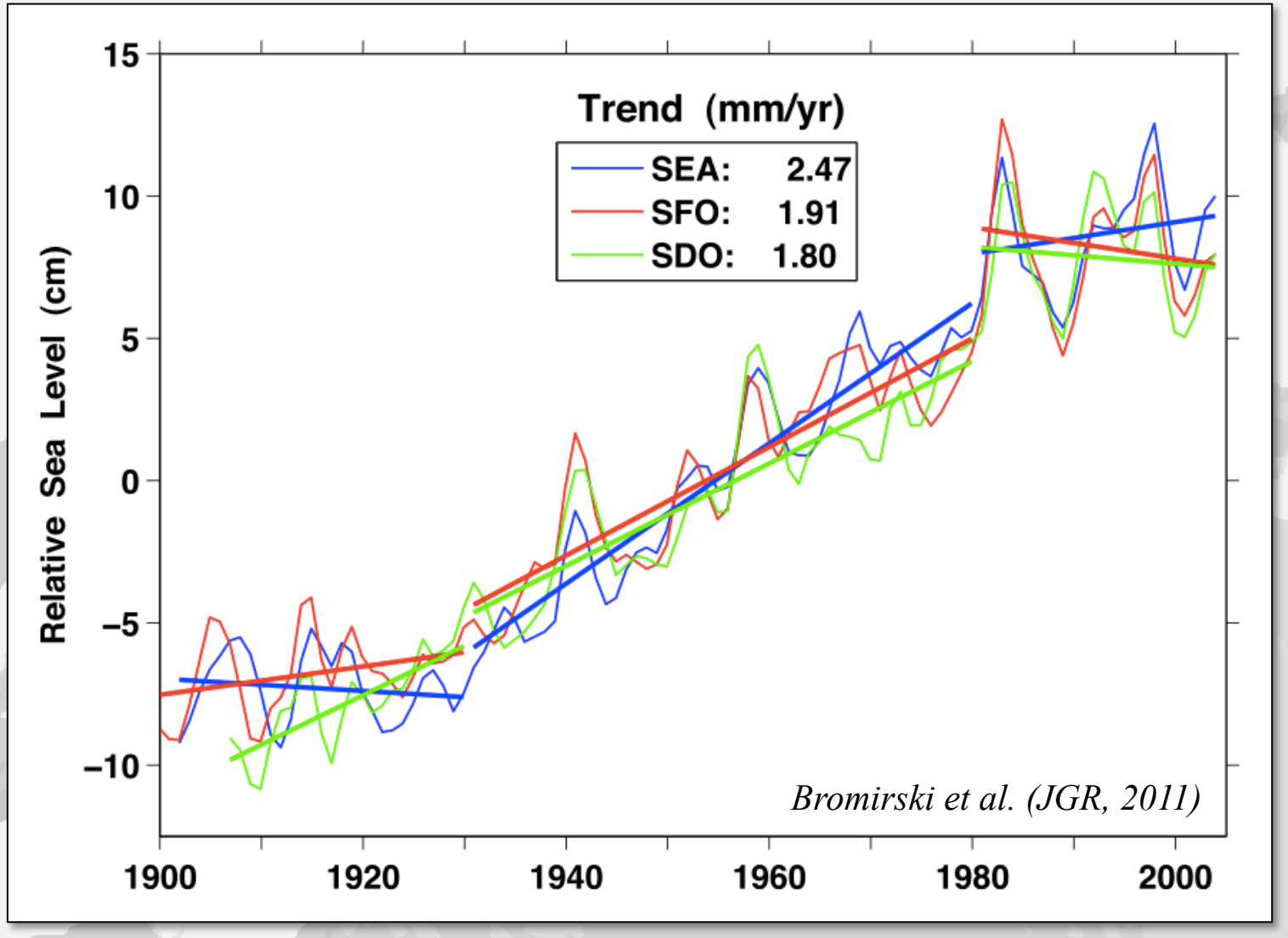
Di Lorenzo et al. (GRL, 2008)





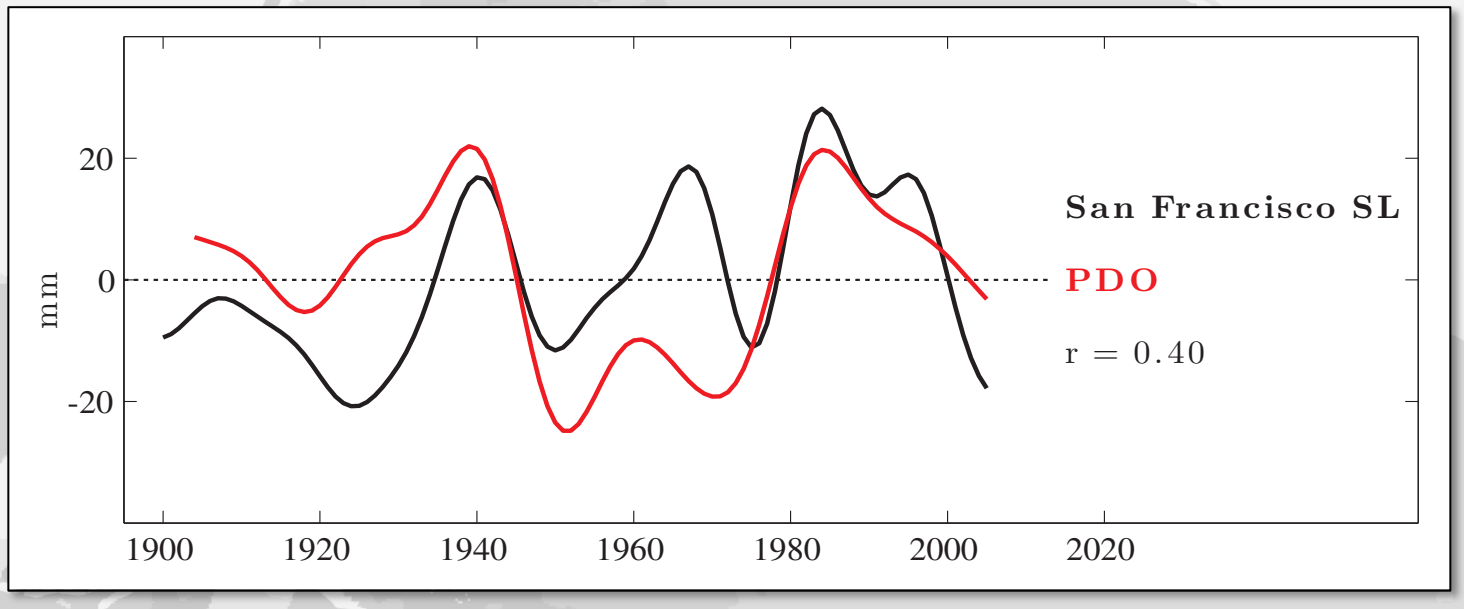


Long NE Pacific sea level records



PDO & NE Pacific coastal sea level

- NE Pacific sea level does not correlate highly over the 20th century with the PDO.



- If not PDO, then what?

Wind-forcing mechanisms

1) Remote equatorial forcing (τ_{eq})

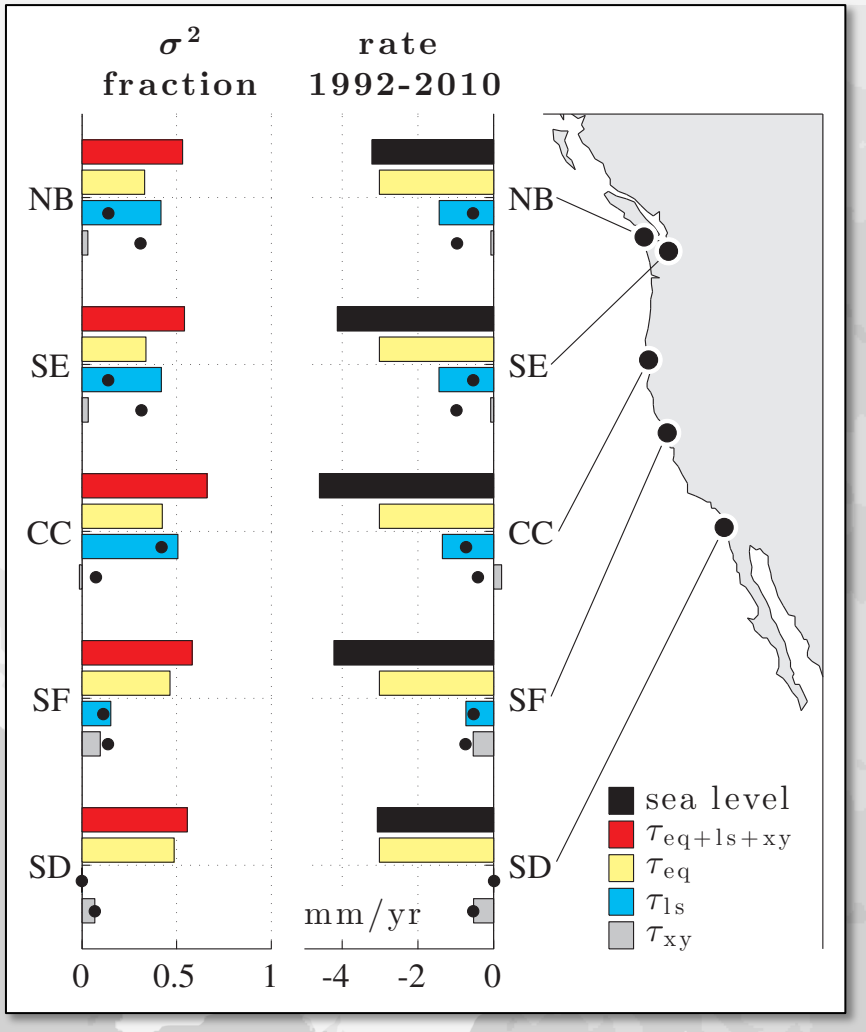
2) Local longshore wind-stress (τ_{ls})

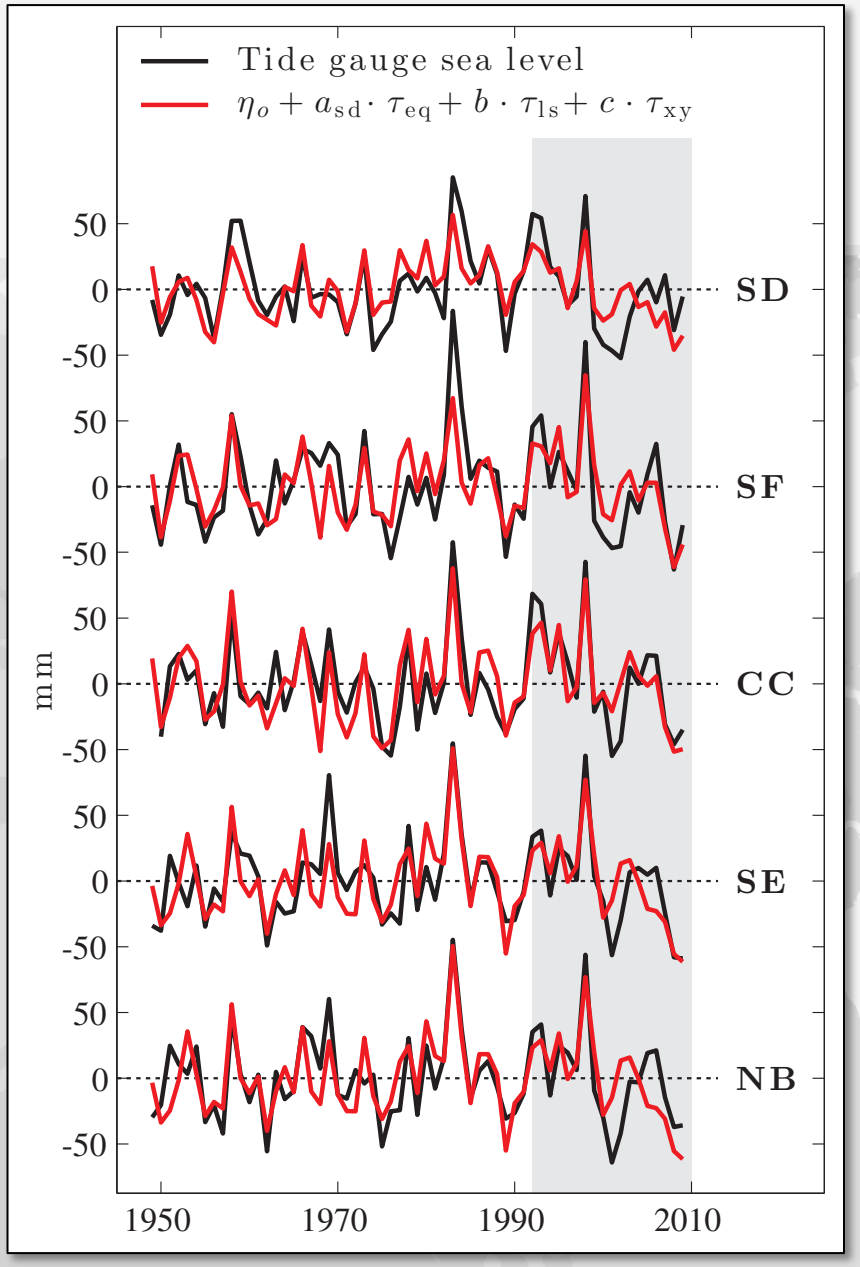
3) Local wind-stress curl (τ_{xy})

The role of these mechanisms in interannual variations of NE Pacific sea level was discussed by Enfield & Allen (*JPO*, 1980) and Chelton & Davis (*JPO*, 1982).

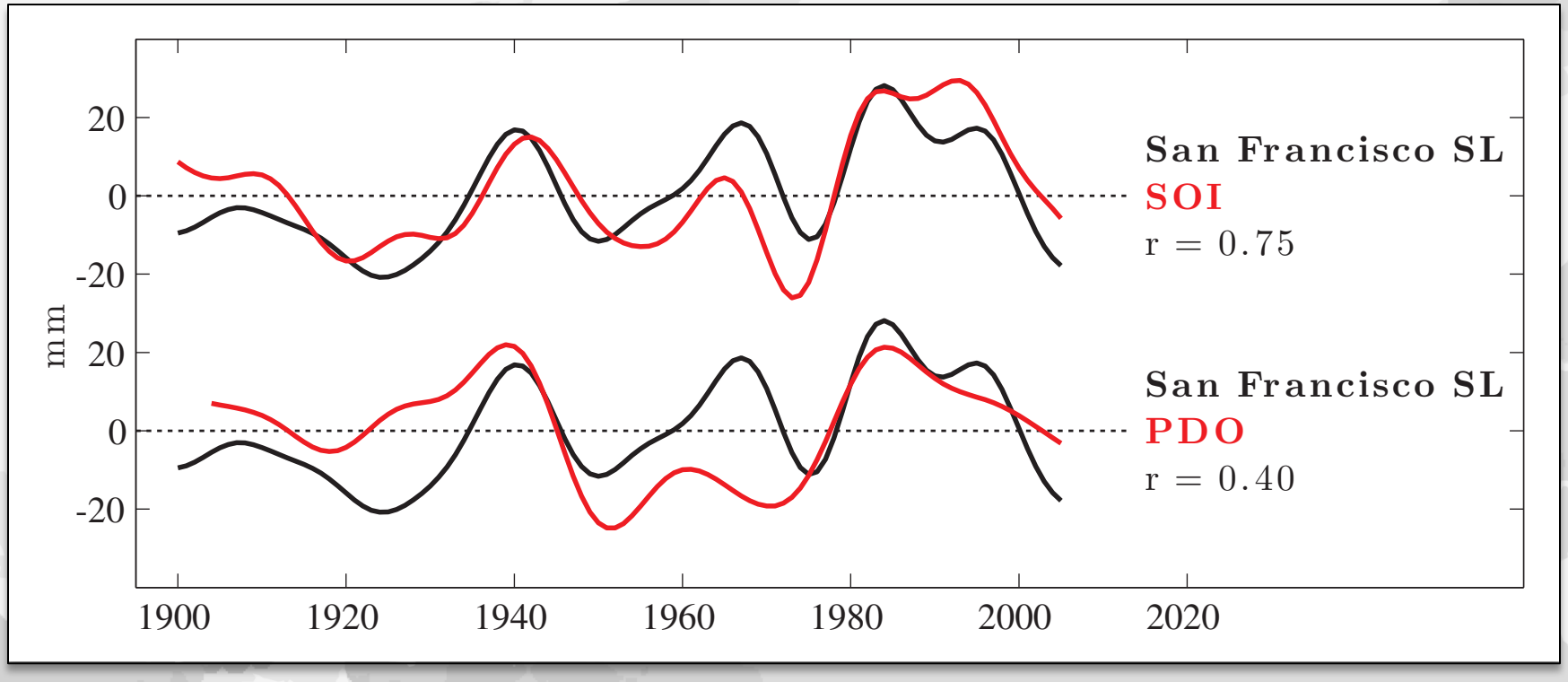
What about recent long-term trends?

Results


σ^2 fraction
rate 1992-2010
NB
SE
CC
SF
SD
mm/yr
0
0.5
1
-4
-2
0
sea level
$\tau_{eq+ls+xy}$
τ_{eq}
τ_{ls}
τ_{xy}


Tide gauge sea level
$\eta_o + a_{sd} \cdot \tau_{eq} + b \cdot \tau_{ls} + c \cdot \tau_{xy}$
mm
50
0
-50
SD
SF
CC
SE
NB
1950
1970
1990
2010

SOI vs. PDO


20
0
-20
mm
20
0
-20
1900
1920
1940
1960
1980
2000
2020
San Francisco SL
SOI
r = 0.75
San Francisco SL
PDO
r = 0.40

Summary

- Decadal variations in the trades are the dominant driver of long-term sea level change along the equatorial and coastal waveguides.

- Local wind forcing can be an important driver of interannual variability north of San Francisco.

- The PDO can be a useful predictor of sea level along the waveguide during the period when SOI and PDO are similar. Over the whole 20th century, however, the SOI is a better indicator.