Slow changes in ocean vector wind: Evidence of the Walker circulation slowdown over the past six decades

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Tokinaga, H., S.-P. Xie, A. Timmermann, S. McGregor, T. Ogata, H. Kubota, & Y. M. Okumura, 2012: ***J. Climate***

Long-term changes in ocean vector wind

- Sea surface temperature
- Ocean & atmospheric circulation
- Sea level height
- Atmospheric convection… etc.

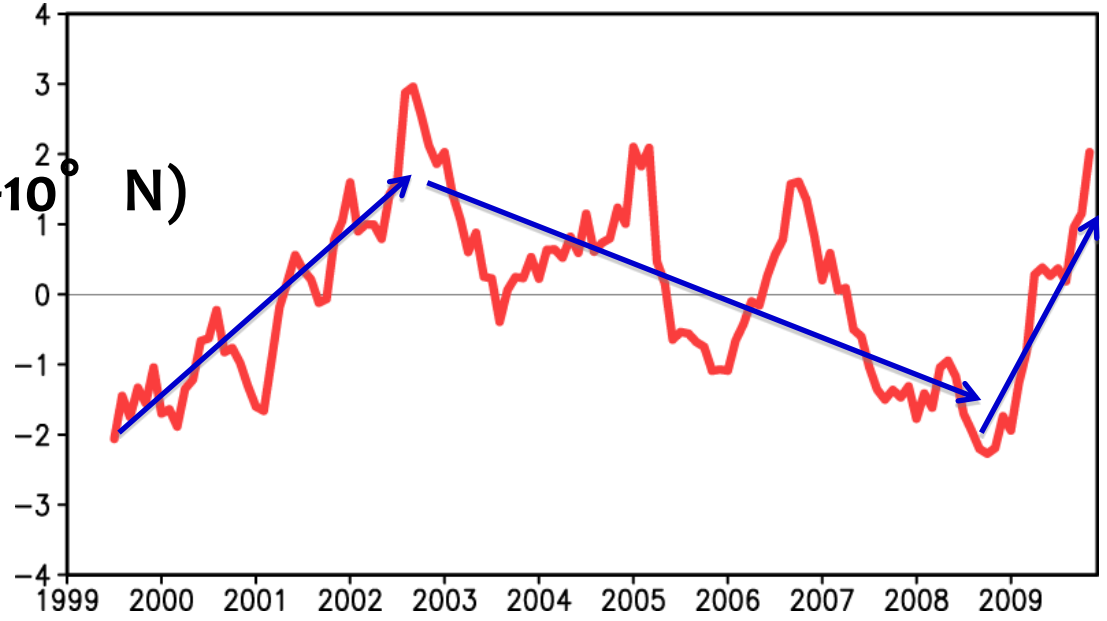
Long-term wind changes are important. But…

Detecting observed long-term changes in ocean vector wind is still challenging…

Recent changes in the tropical Pacific zonal wind (QuikSCAT)

- Large interannual variations
- The 10-year record is too short to characterize interdecadal trends in the Walker circulation

Time series of U_{eq} wind anomaly (150° E-70° W, 10° S-10° N)



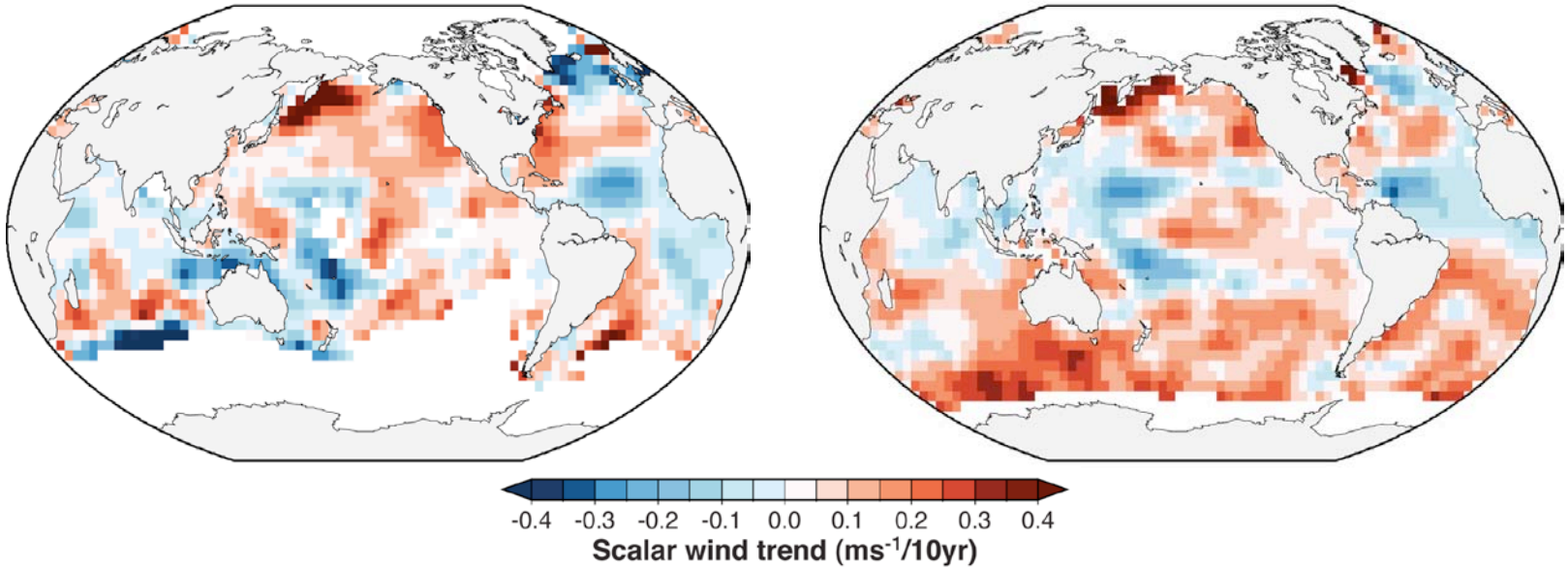
WASWind

Wave and **A**nemometer-based **S**ea-surface **Wind**

- Bias corrections with anemometer height & wind-wave height from ship observations
- Similar trend patterns of SSM/I wind
- 60 years from 1950 to 2009

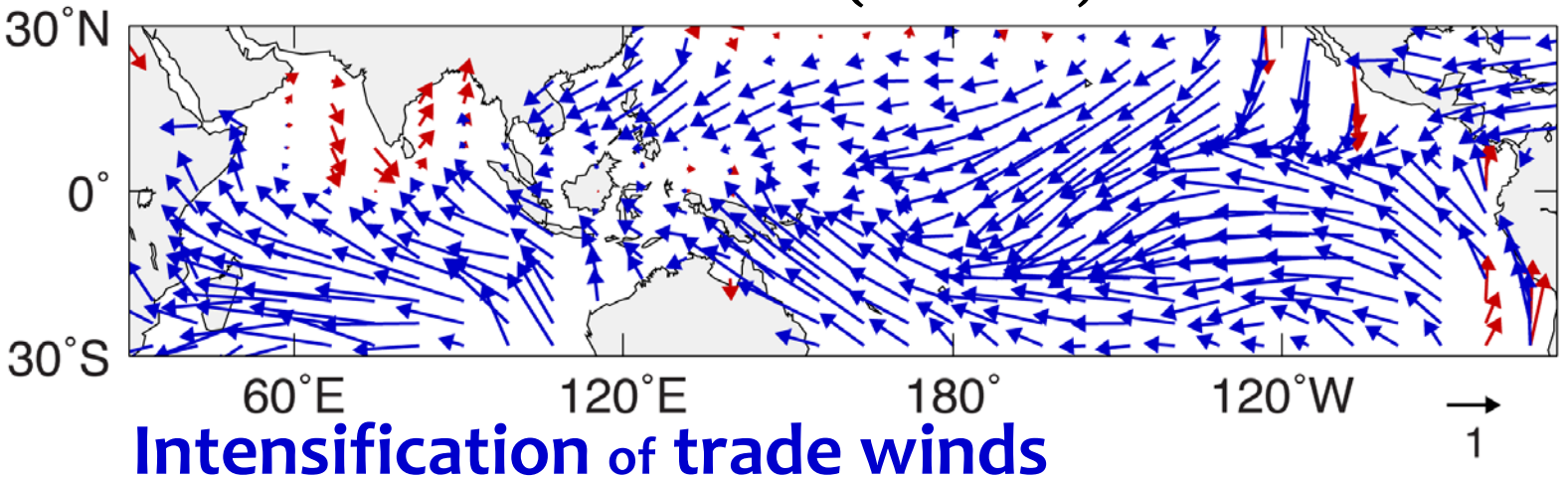
20-year trend

WASWind | **SSM/I**



Annual mean trend (1950–2009)

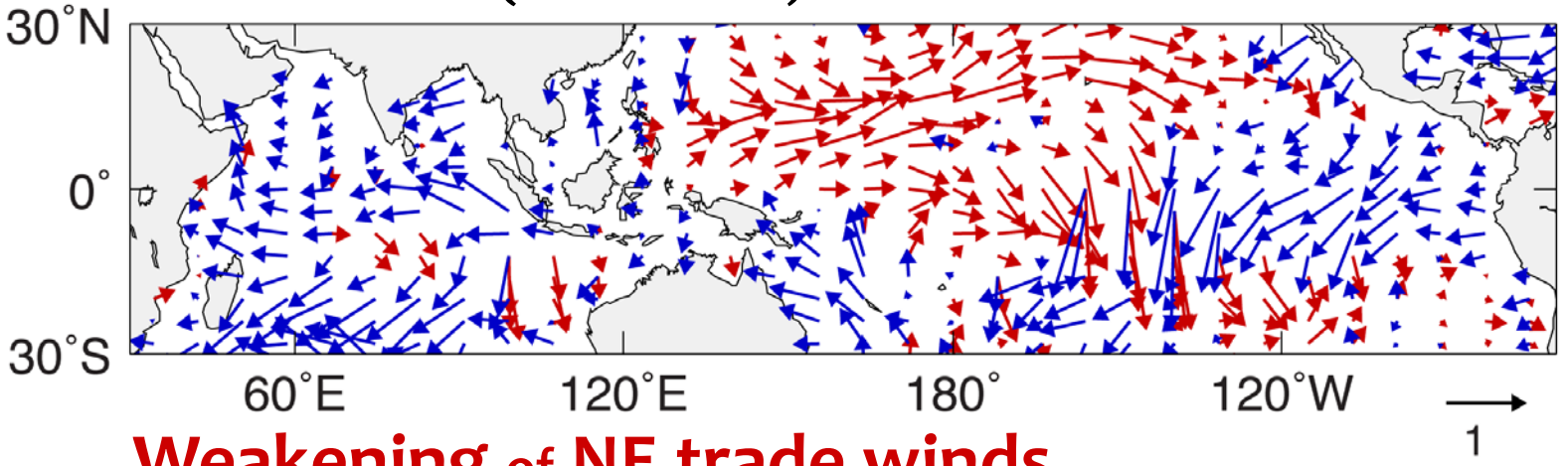
Uncorrected surface wind (ICOADS)



Intensification of trade winds

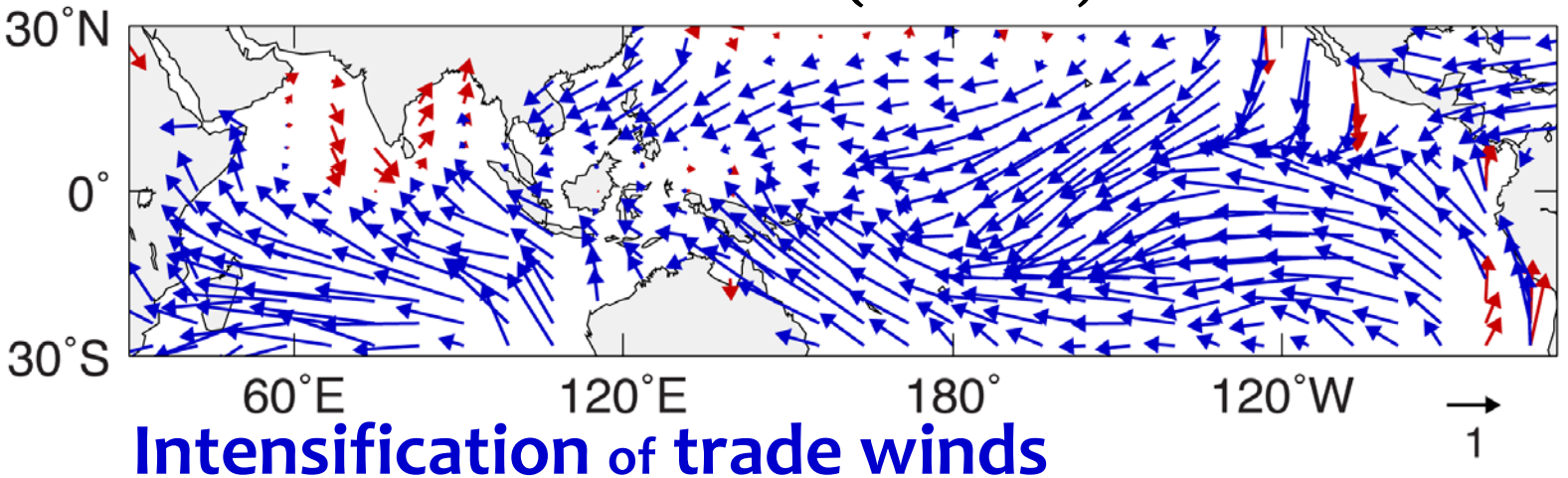
Annual mean trend (1950–2009)

Surface wind (WASWind)



Weakening of NE trade winds

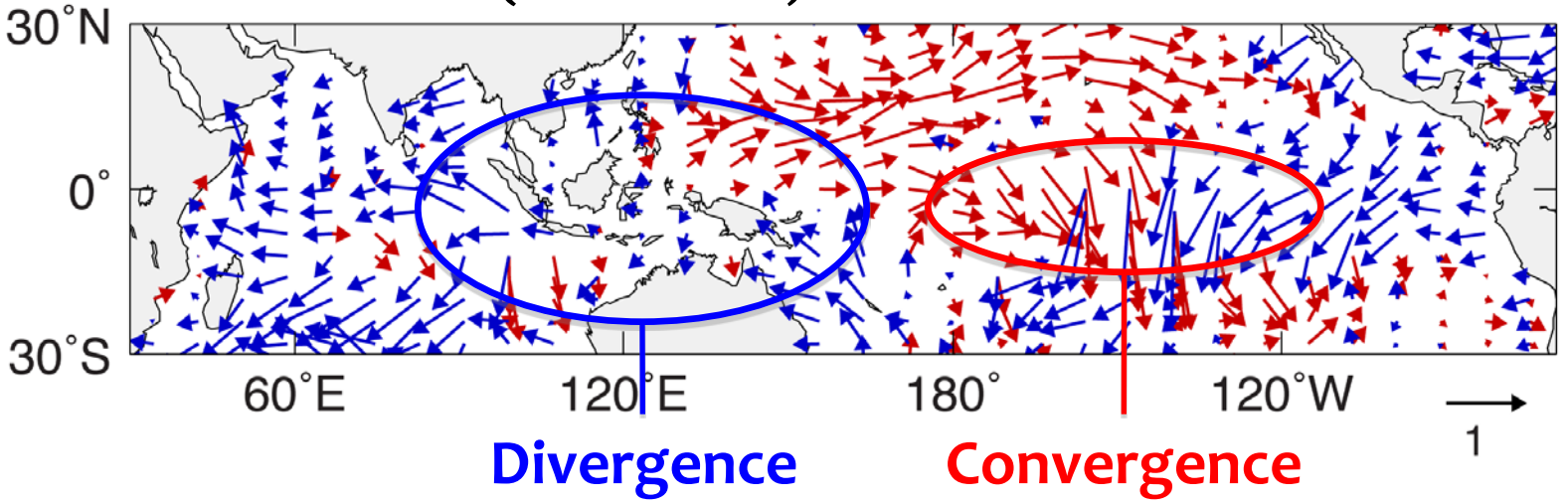
Uncorrected surface wind (ICOADS)



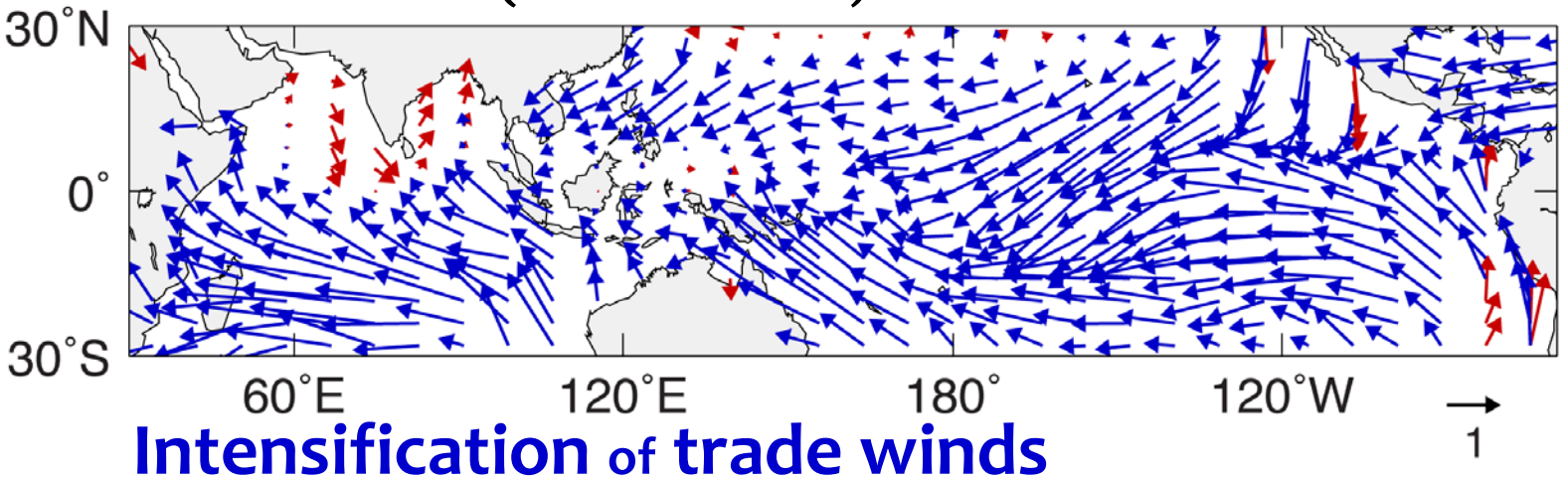
Intensification of trade winds

Annual mean trend (1950–2009)

Surface wind (WASWind)



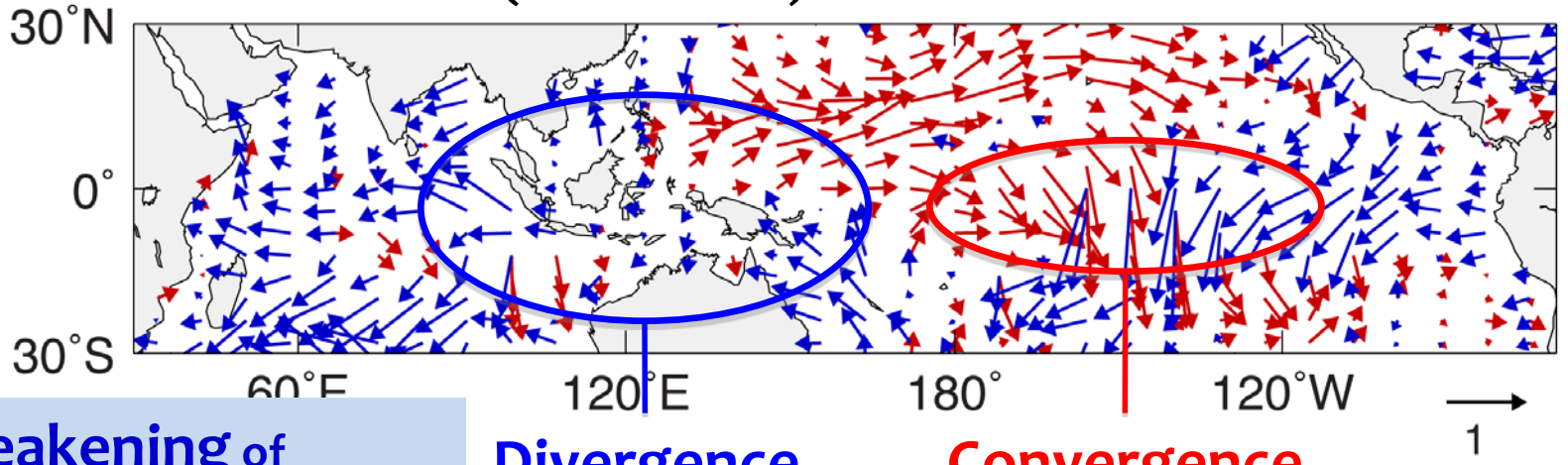
Surface wind (uncorrected)



Intensification of trade winds

Annual mean trend (1950–2009)

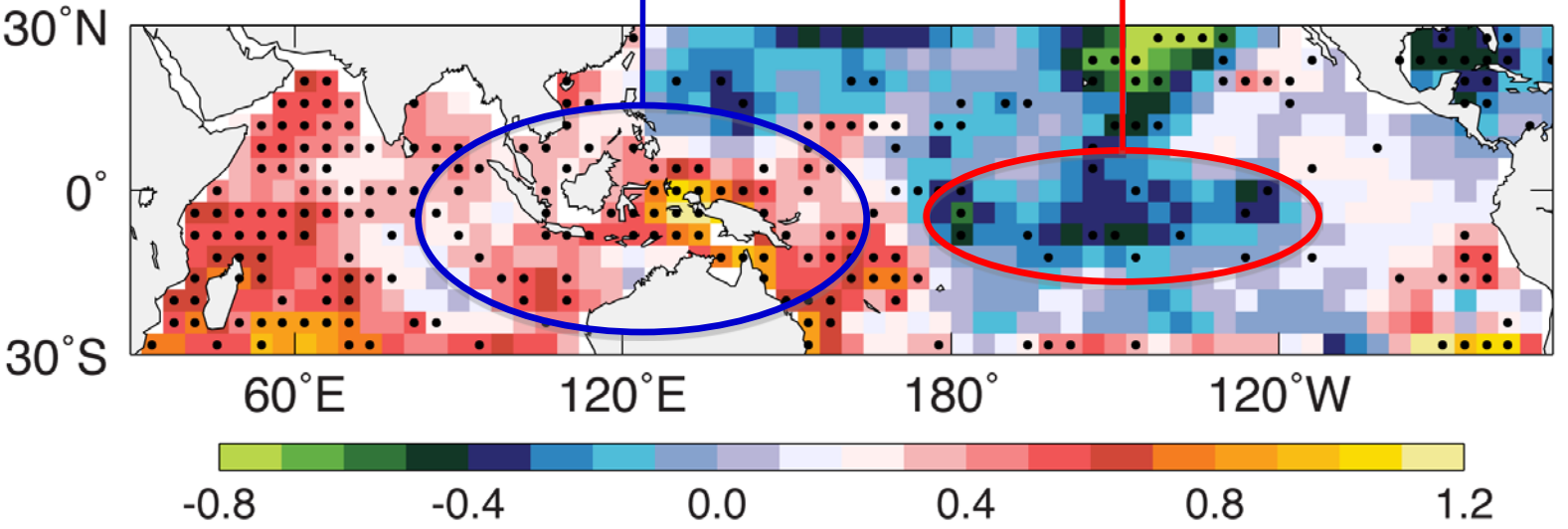
Surface wind (WASWind)



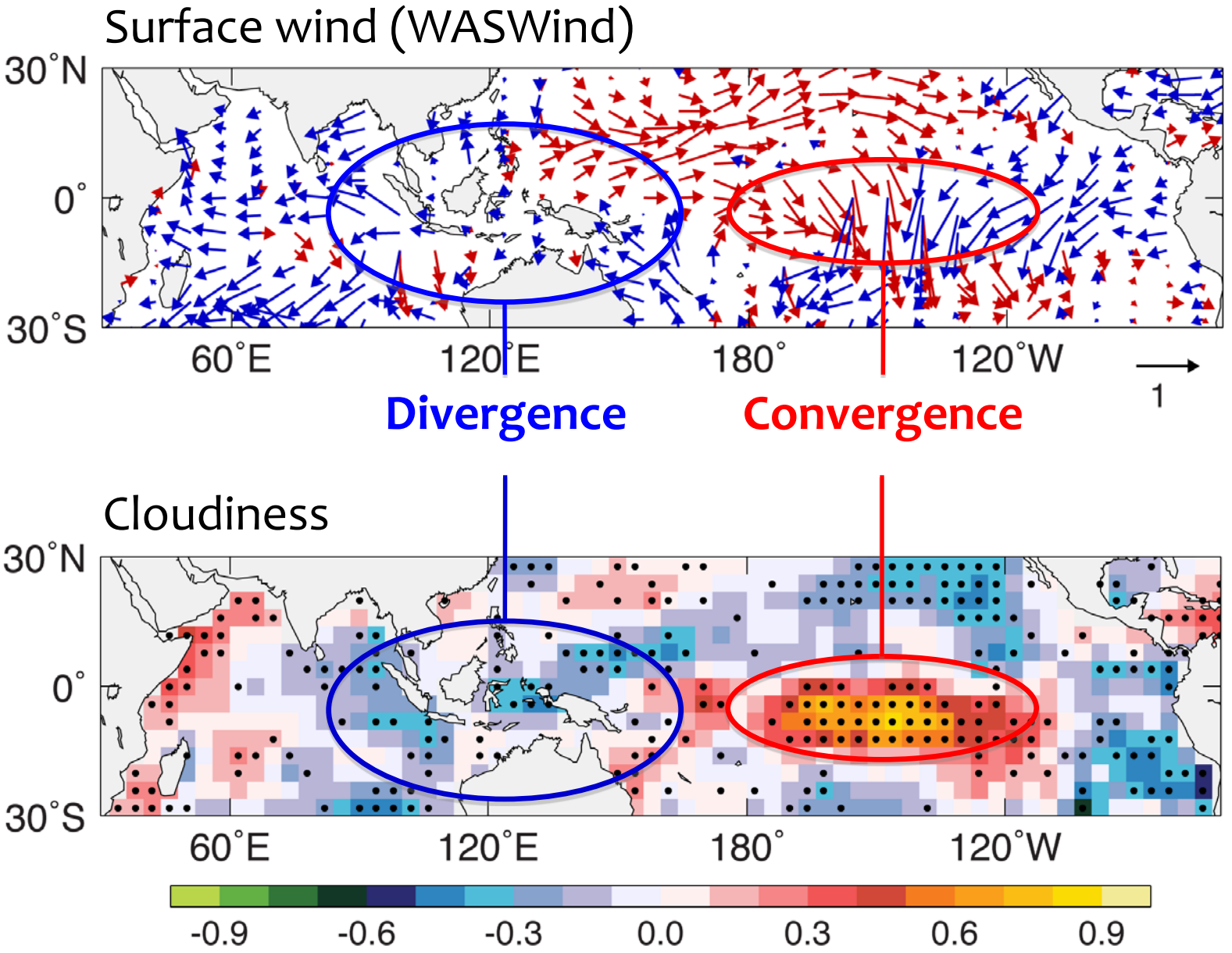
Weakening of the Walker circulation

Divergence **Convergence**

SLP

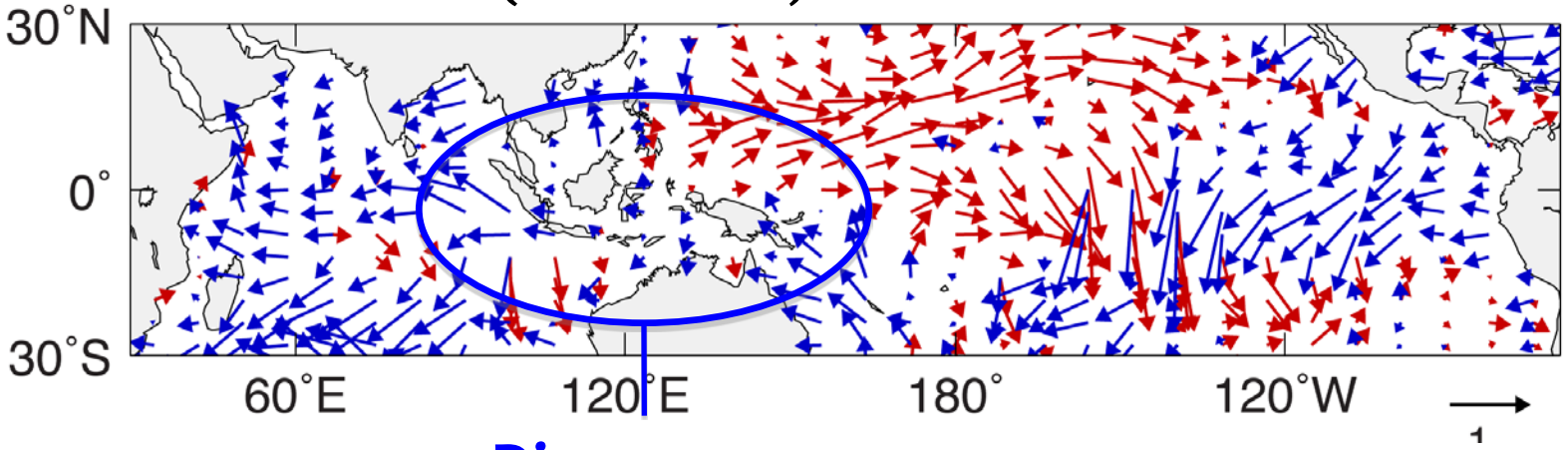


Annual mean trend (1950–2009)



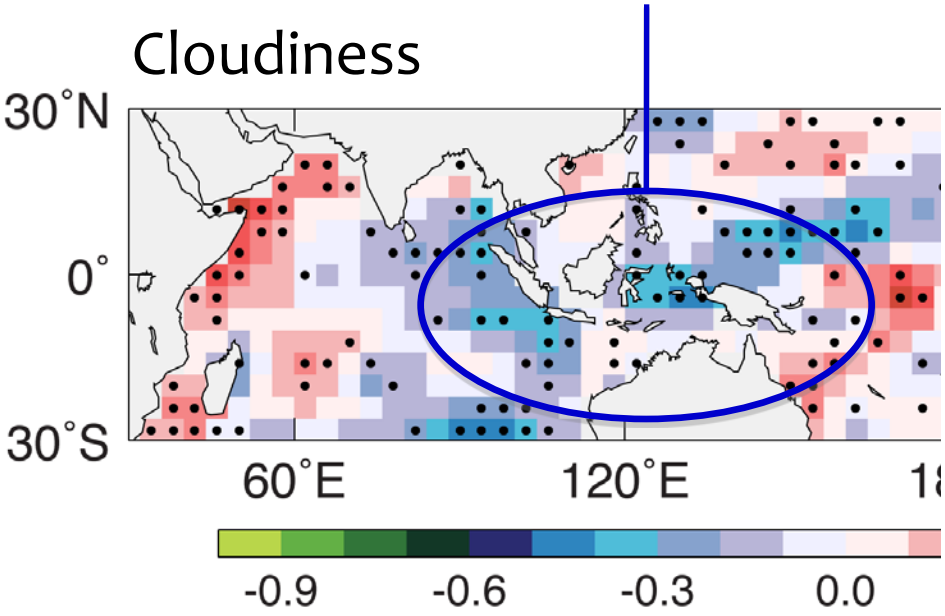
Annual mean trend (1950–2009)

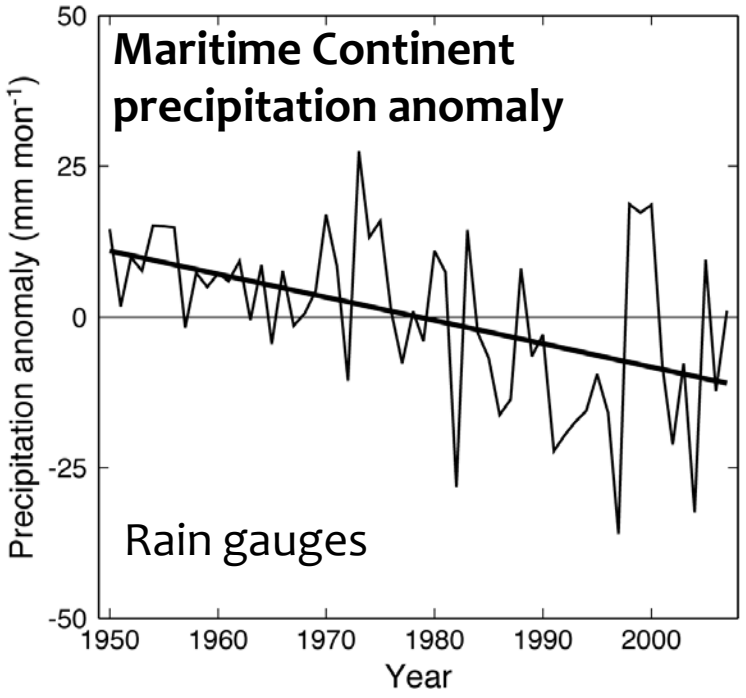
Surface wind (WASWind)



Divergence

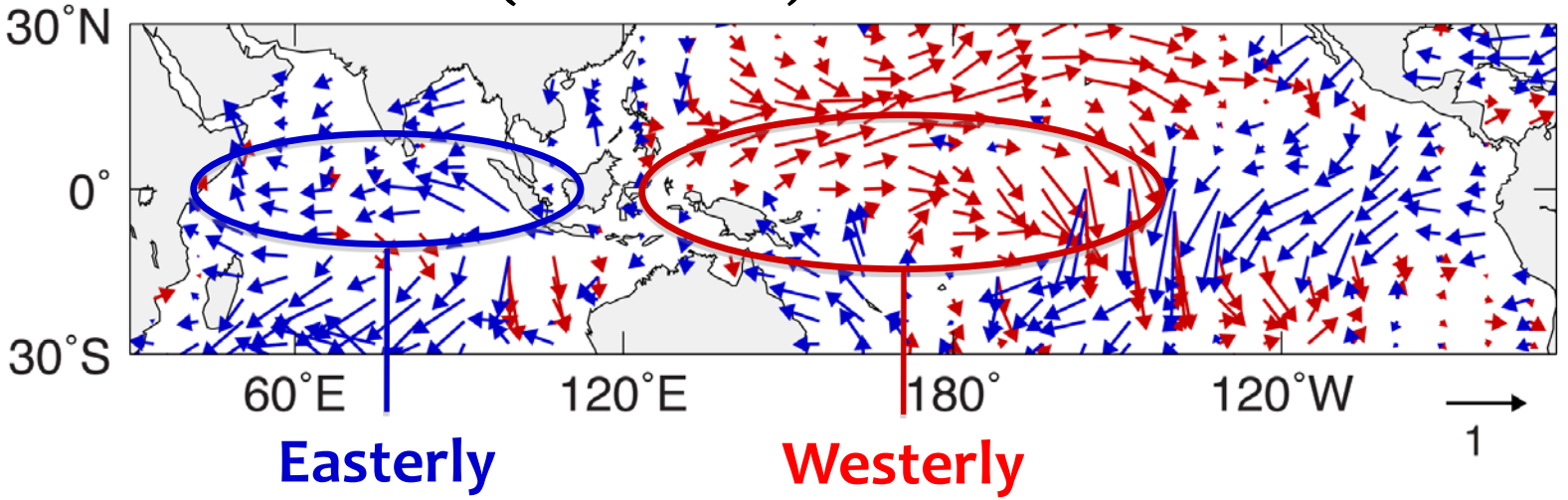
Cloudiness



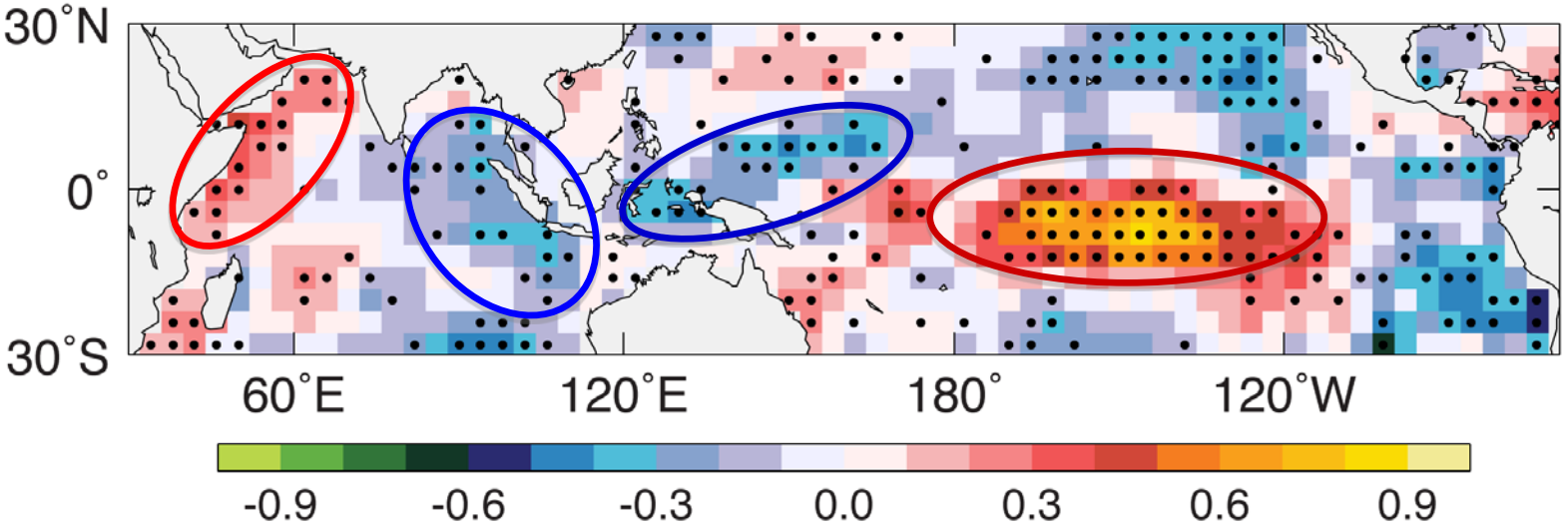


Annual mean trend (1950–2009)

Surface wind (WASWind)

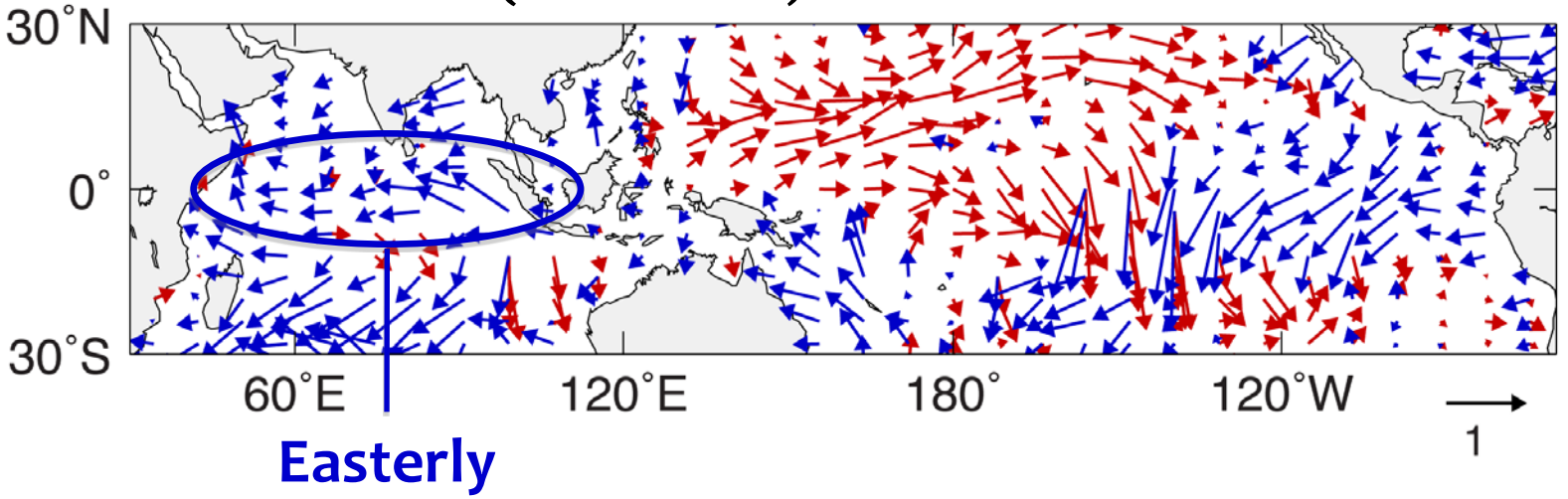


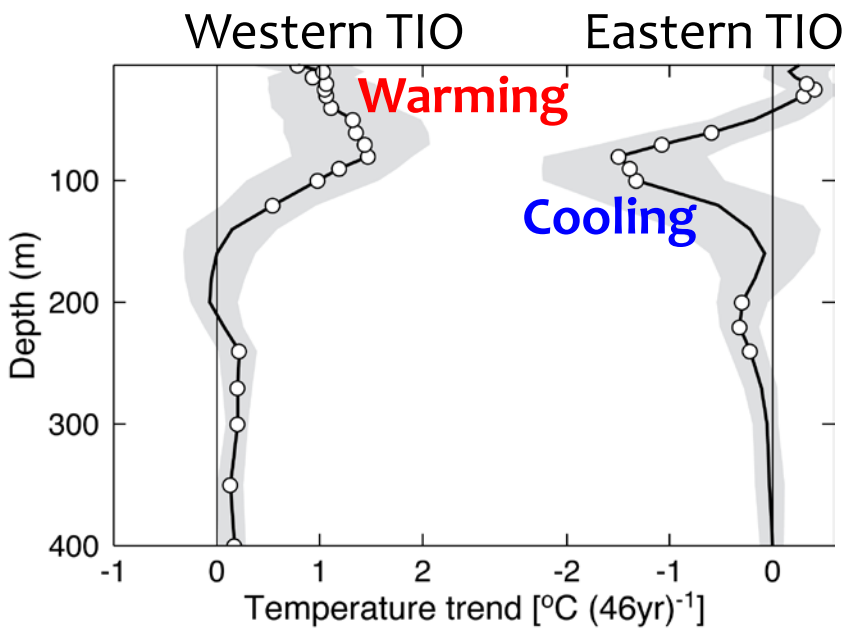
Cloudiness



Annual mean trend (1950–2009)

Surface wind (WASWind)

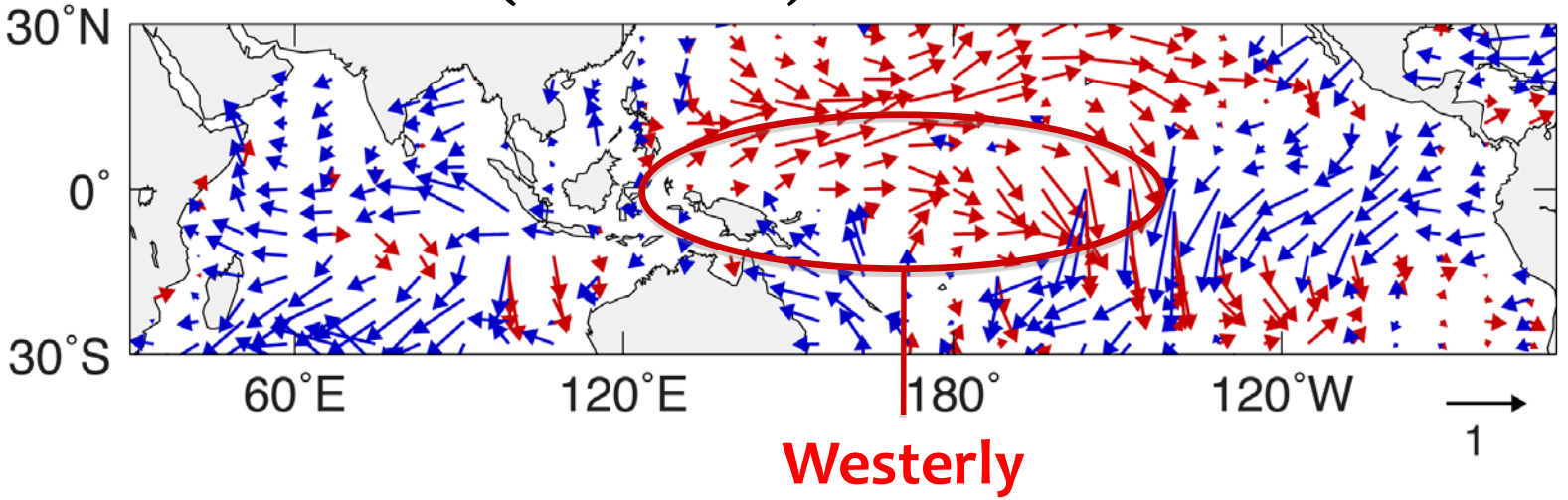




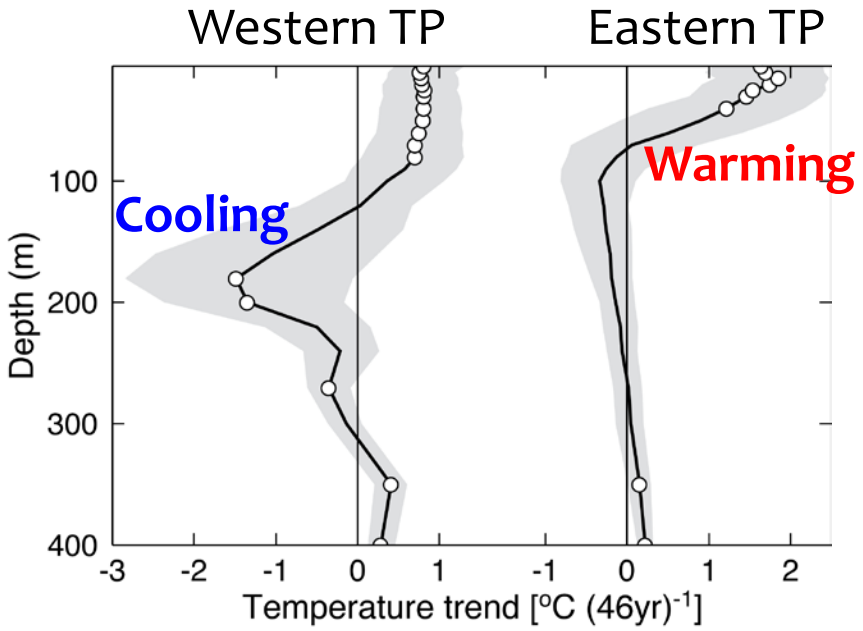
Subsurface temp. trend
in the **tropical Indian Ocean**
(Bias-corrected XBT, 1963–2009)

Annual mean trend (1950–2009)

Surface wind (WASWind)



Westerly



Subsurface temp. trend
in the **tropical Pacific**
(Bias-corrected XBT, 1963–2009)

Findings

- Weakening of the Walker circulation
- Eastward shift of atmospheric convection
  from the Maritime continent to central equatorial Pacific
- Reduced zonal gradient of subsurface ocean temperature

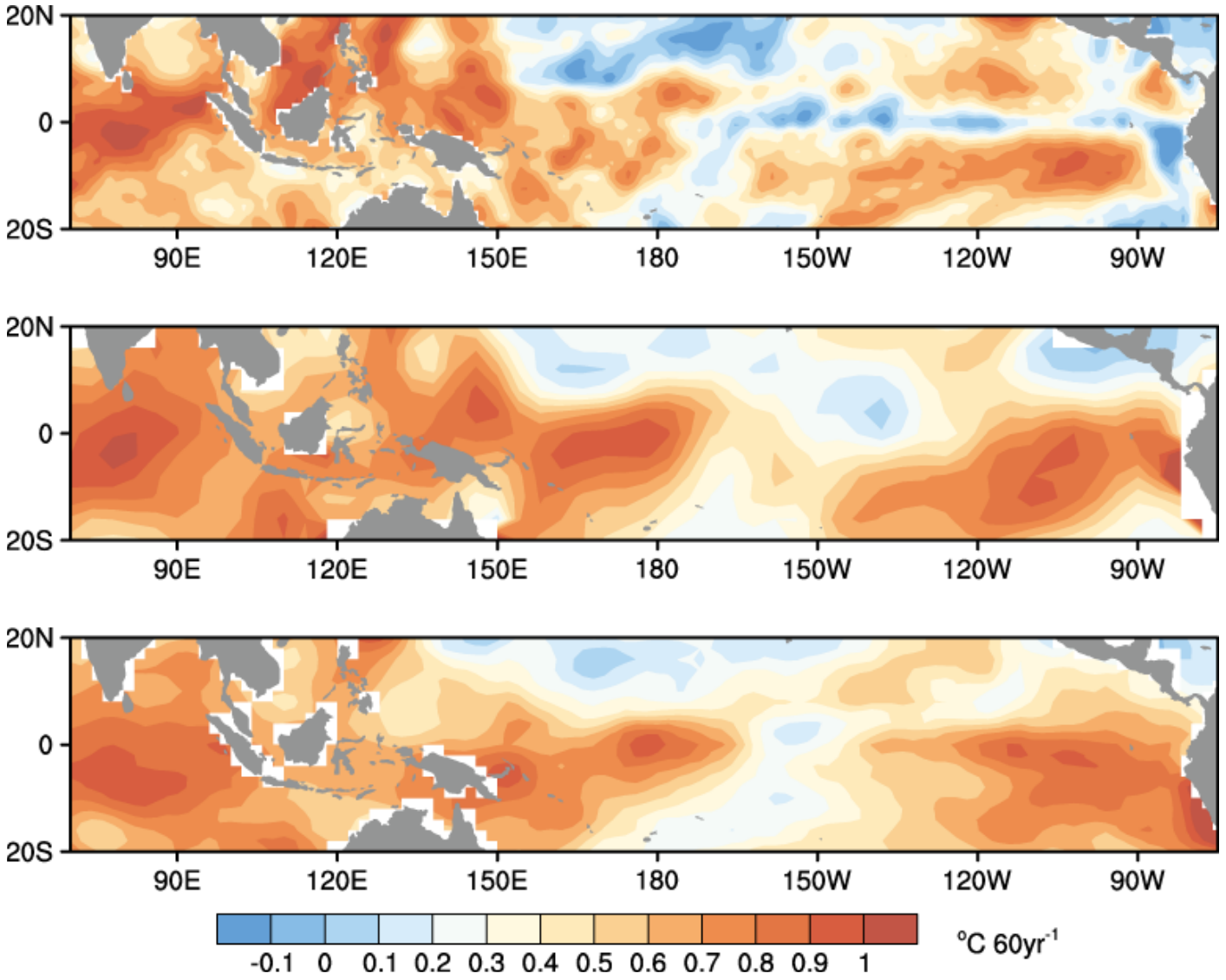
Bjerknes feedback

SST trend (1950–2009)

HadISST1

ICOADS

ERSST3b

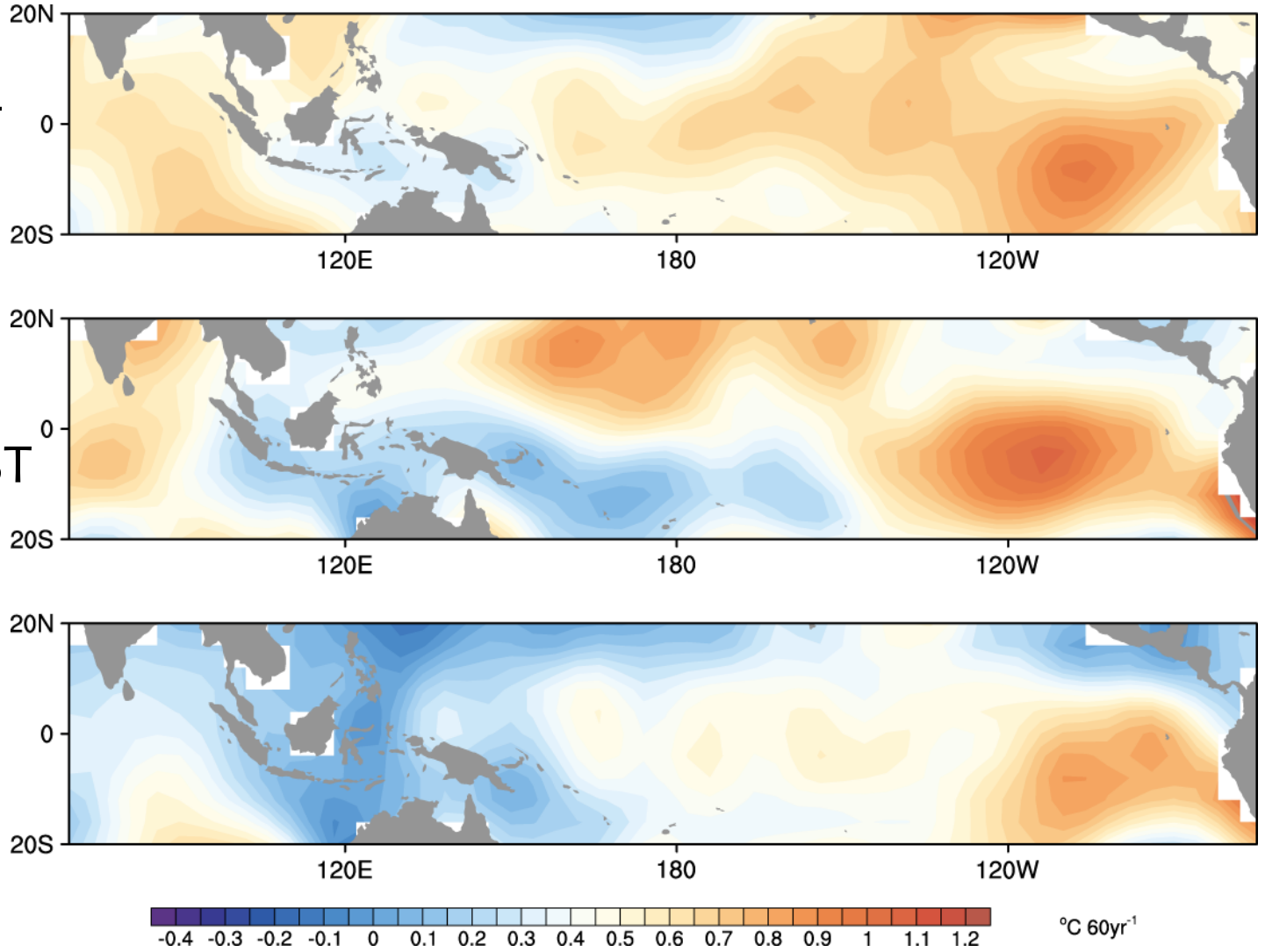


Surface air temp. & Bucket SST trend (1950–2009)

MOHMAT

ICOADS Bucket SST

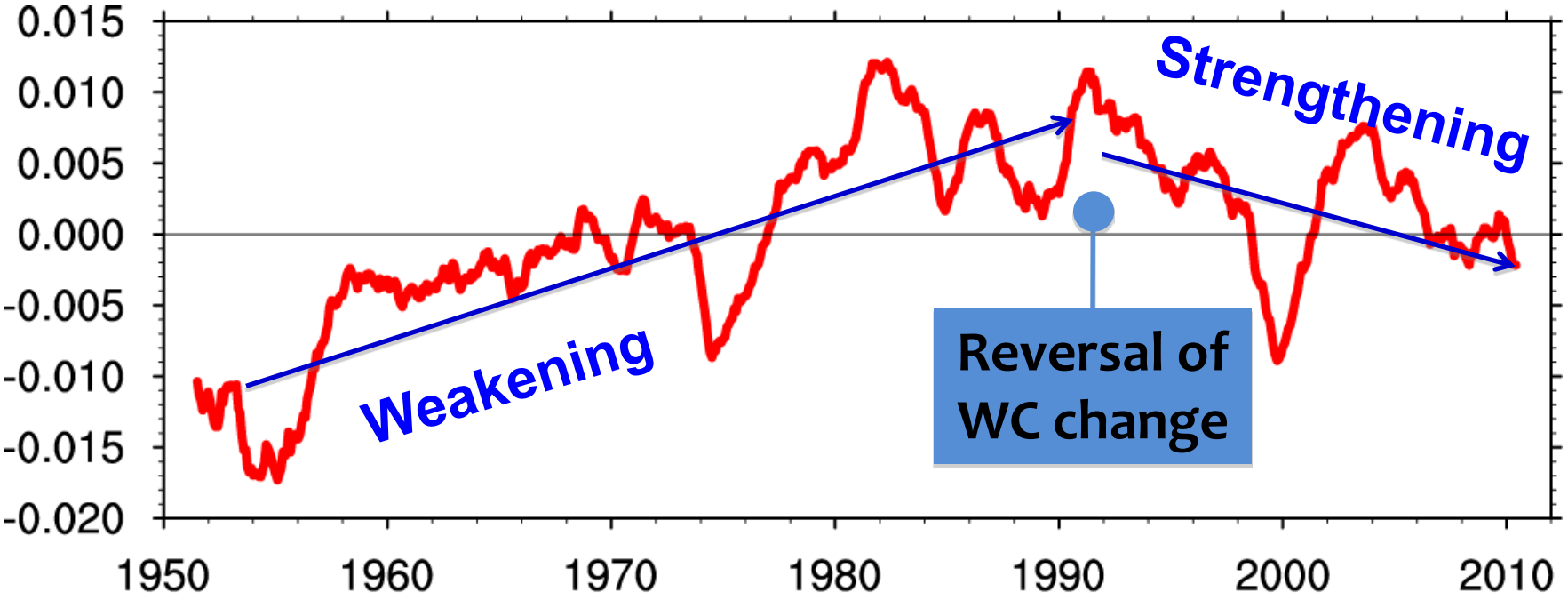
ICOADS NMAT



Time series of zonal wind stress

over the tropical Pacific (1950–2009)

Weakening of the Walker circulation is **NOT steady !!**



Summary

- WASWind indicates
  a **weakening trend** in the **Walker Circulation**
  over the past 60 years

- Patterns of surface wind change are **consistent** with those of **cloudiness**, **SLP**, **precipitation** and **subsurface ocean temperature**

- **Bucket SST and surface air temp. trends** suggest a **reduced zonal SST gradient** in the tropical Pacific **(Bjerknes feedback)**

- The Walker circulation weakening is **not steady** (**reversal in 1990s**).

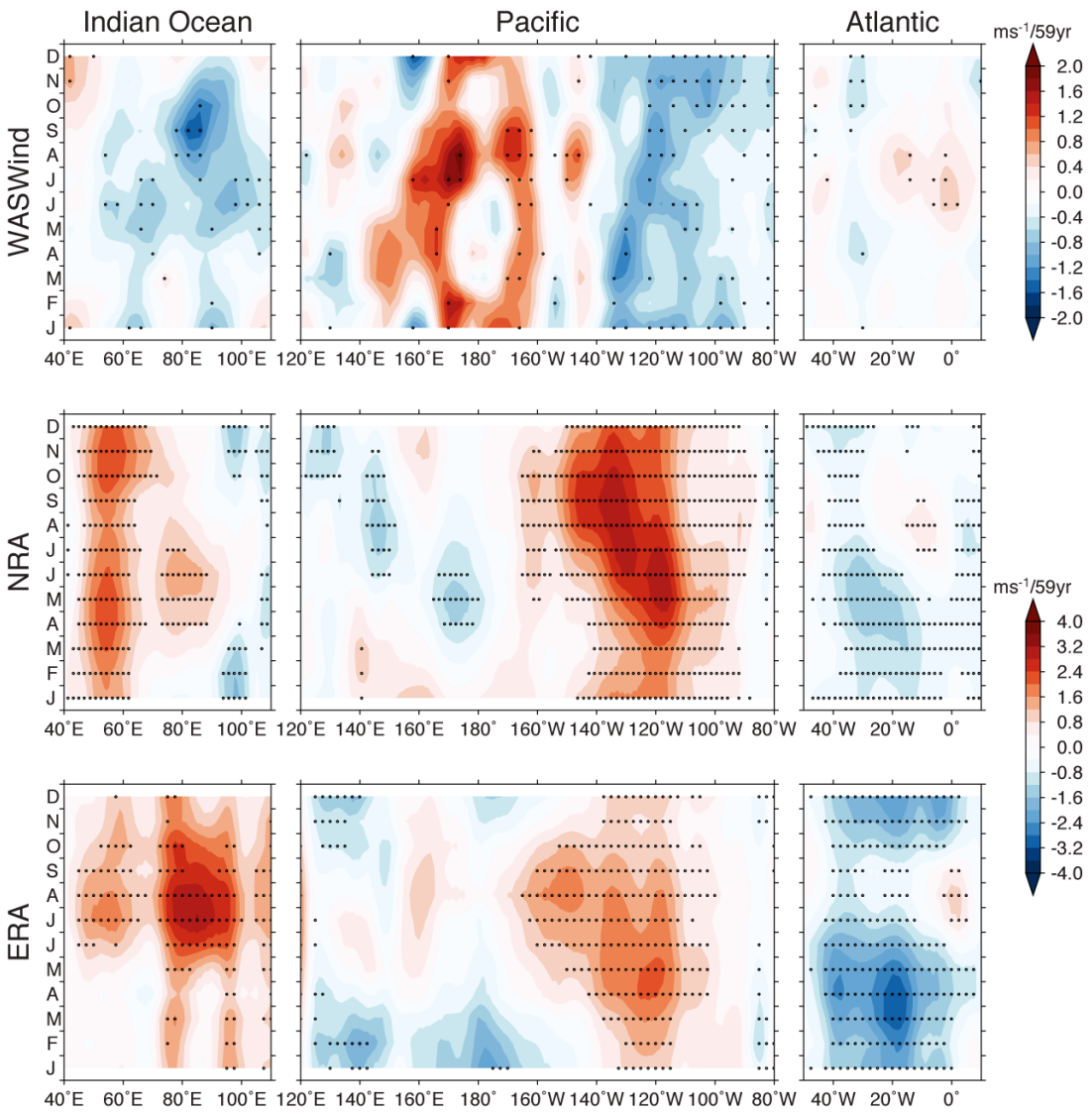
Equatorial zonal wind trend

(4°S–4°N, 1950–2009)

WASWind

NCEP/NCARR

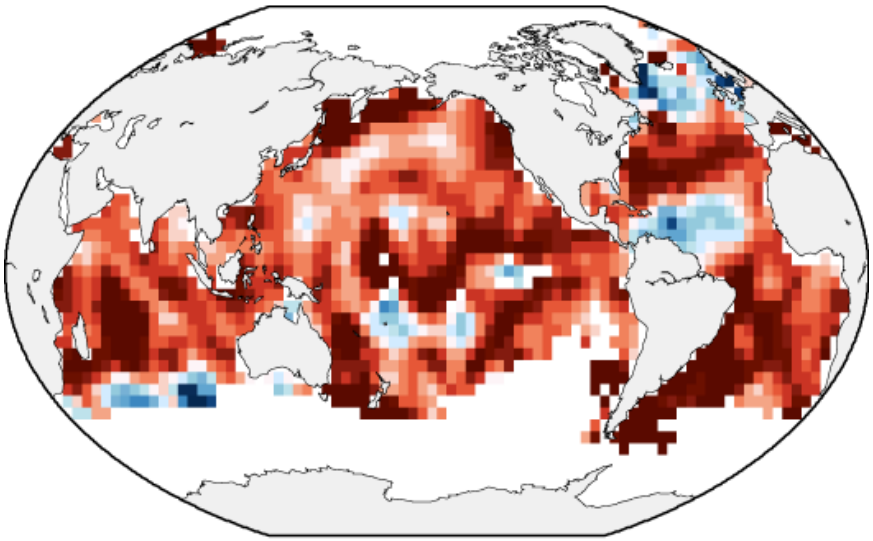
ERA40



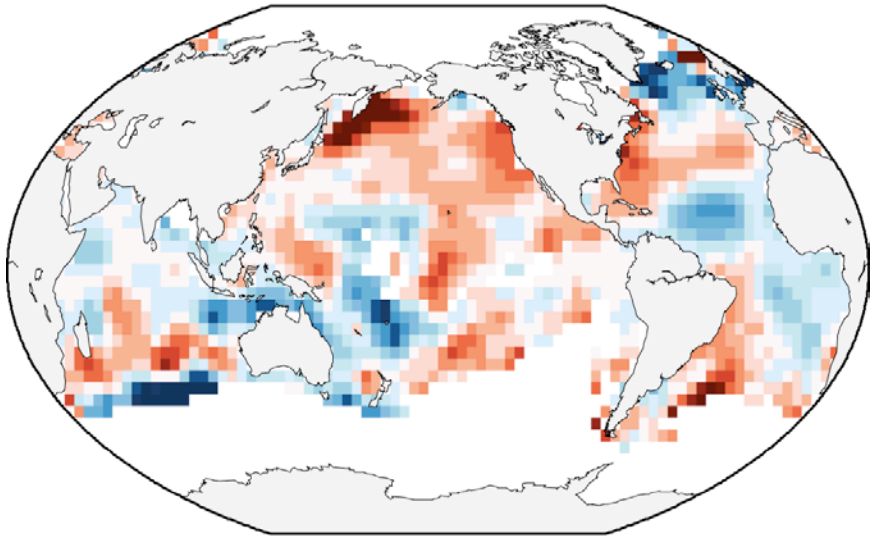
Comparison of wind trend patterns

for recent 20 years

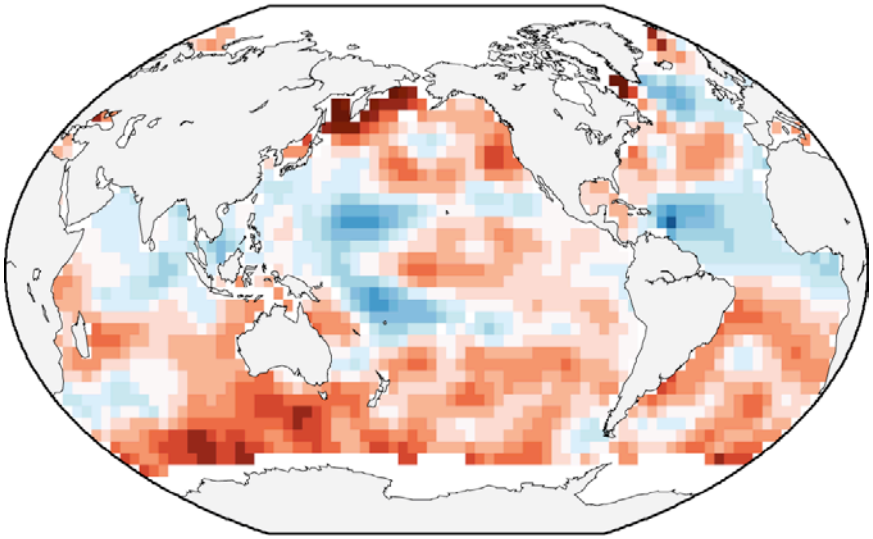
Ship (Uncorrected)



Corrected

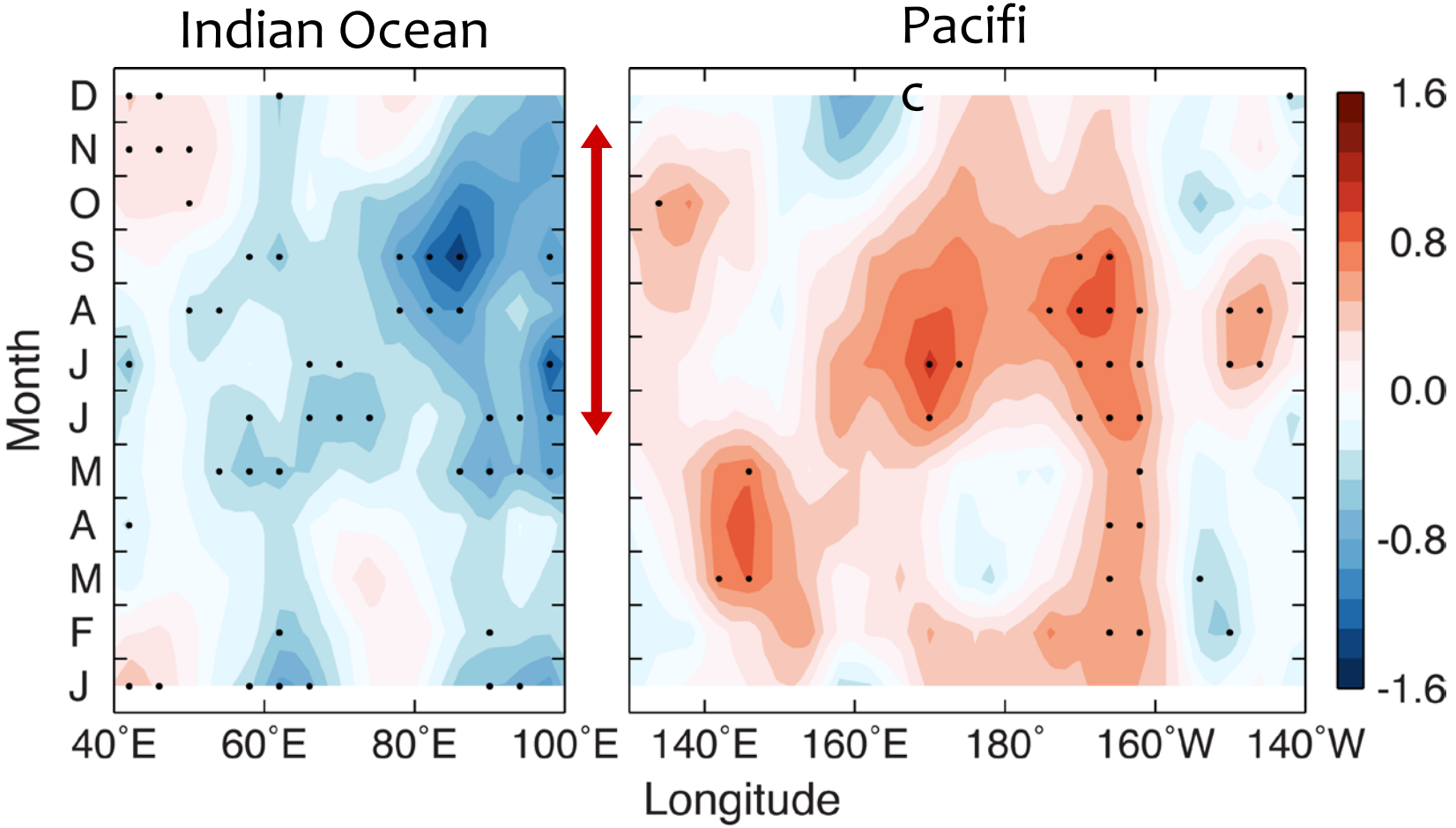


Satellite (SSM/I)



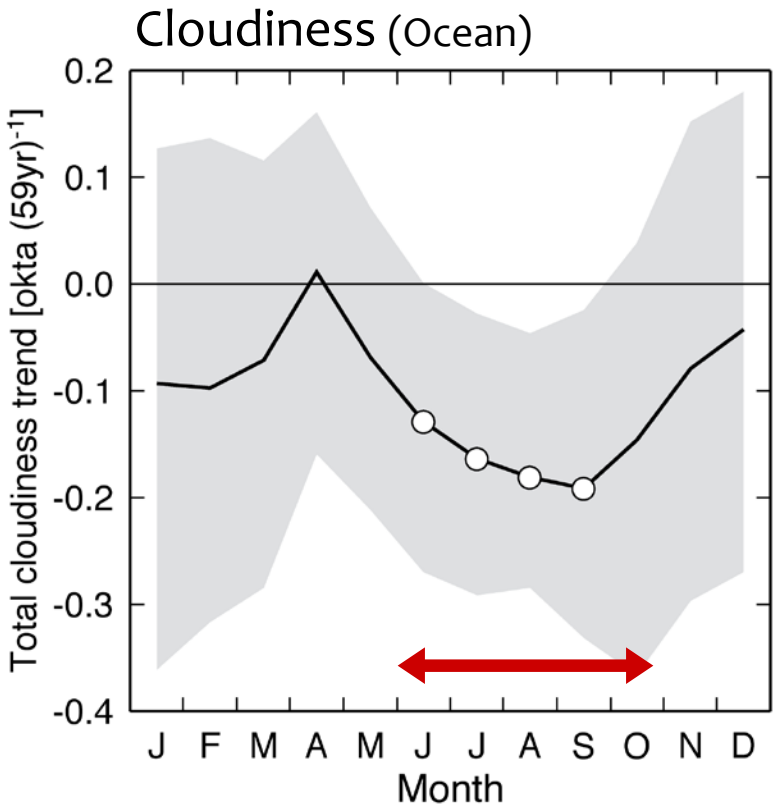
Equatorial zonal wind trend

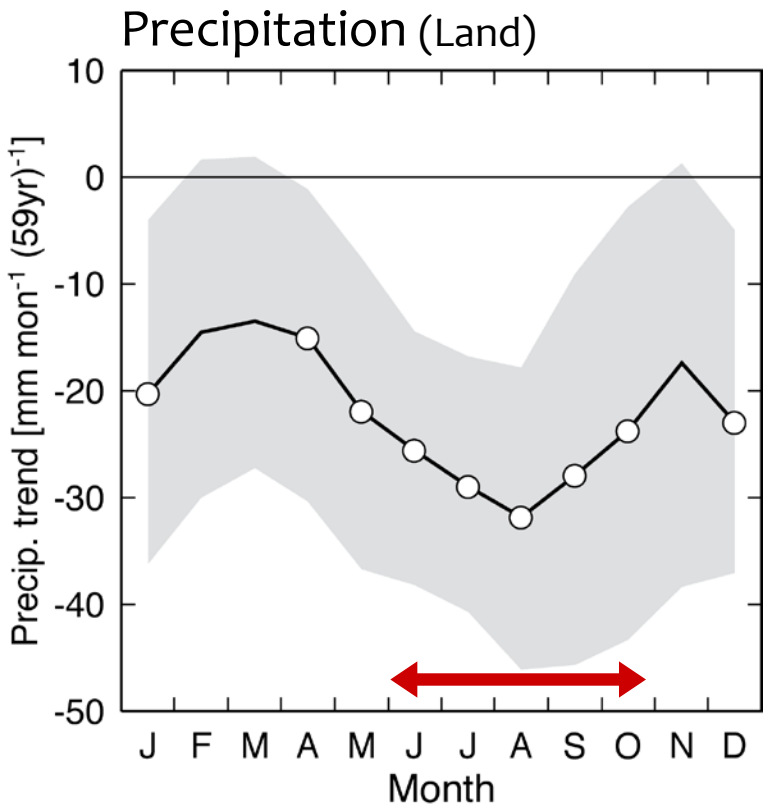
(4°S–4°N, 1950–2009)



Cloud & Precip. trends over Maritime Continent

(80°-150°E, 20°S-20°N, 1950–2009)



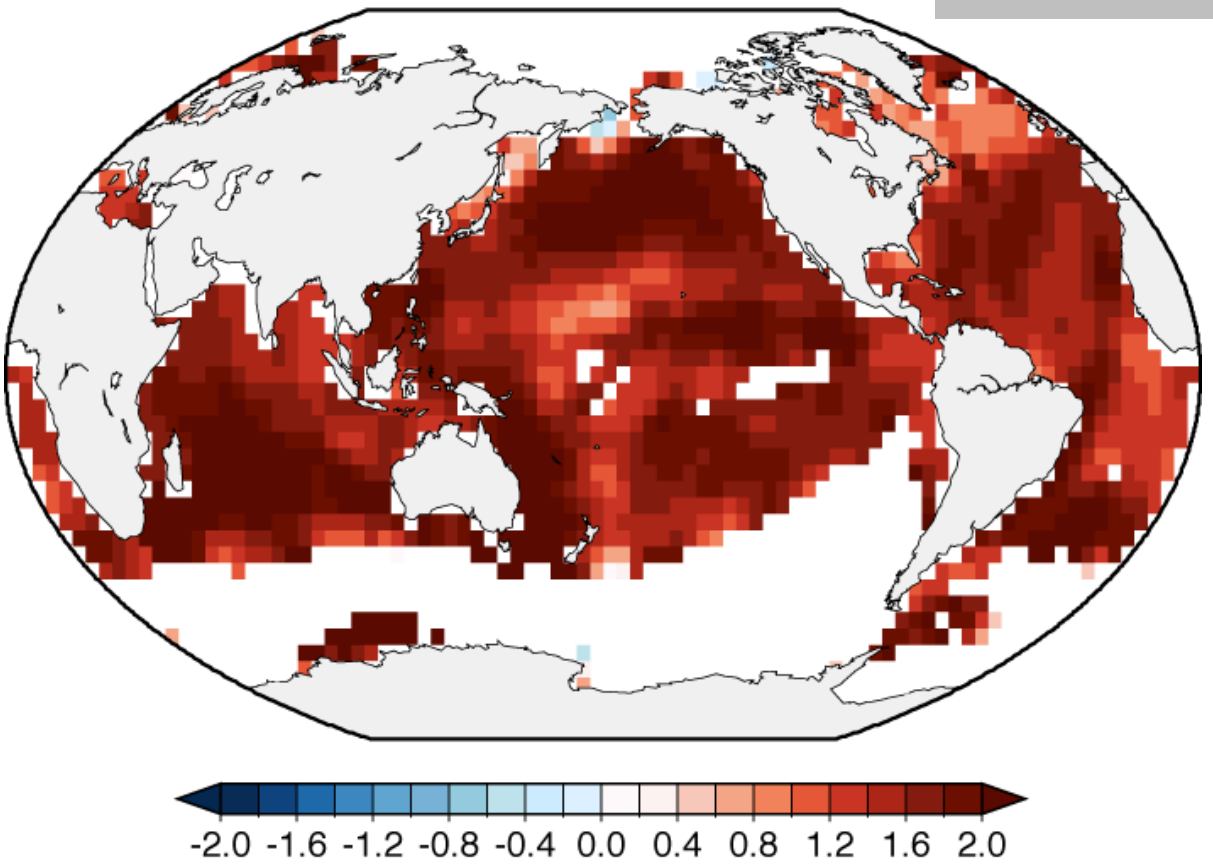


Consistent with **surface divergence trend**

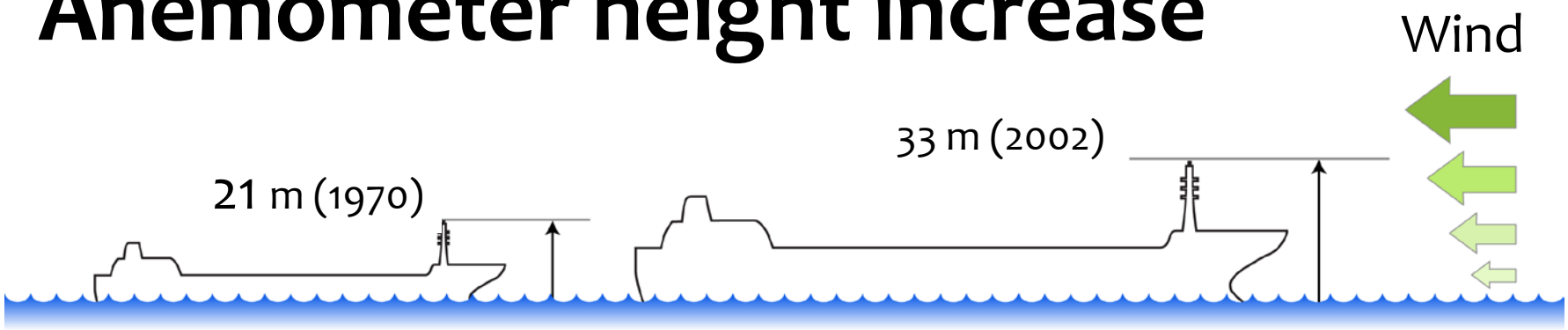
Upward wind trends?

Scalar wind trend
(Ships, 1950-2008)

+1.8 ms^{-1}/ 59yr



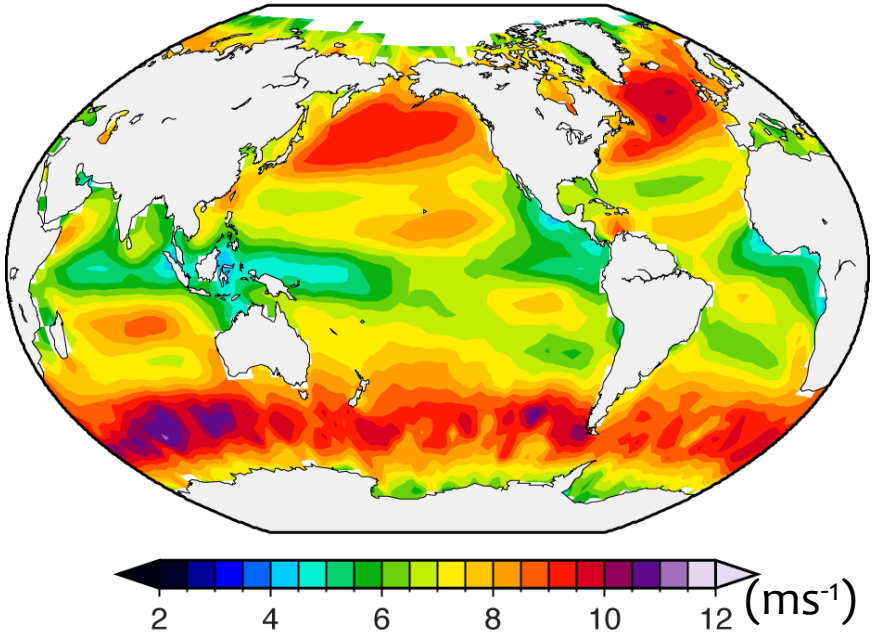
Wind bias due to Anemometer height increase



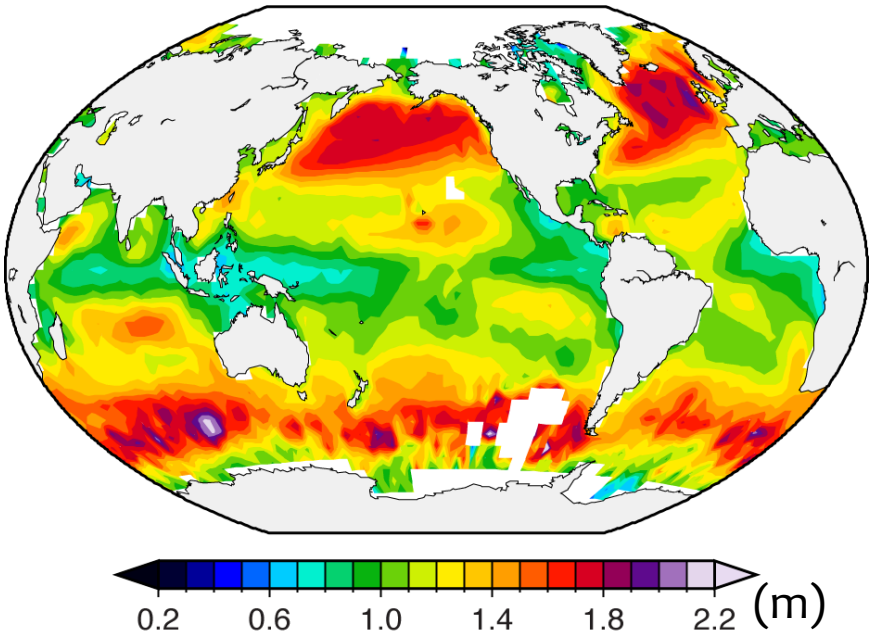
Increase in ship size

Wind estimate from wind-wave height

Scalar wind



Wind-wave height



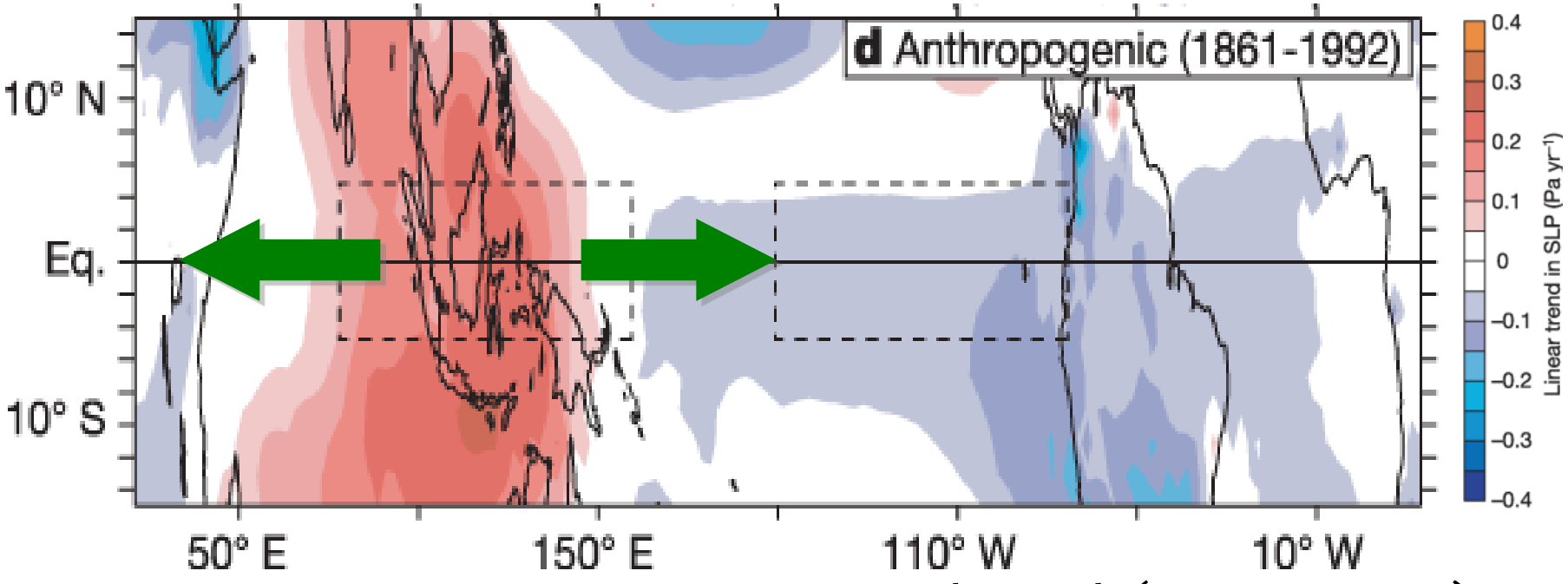
$$(10\text{m wind speed}) = a \bullet (\text{Wind-wave height})^{b} + c$$

$b \sim 0.5$

Long-term changes in ocean vector wind

- **The Walker circulation**

Simulated SLP response (model)



Vecchi et al. (2006, *Nature*)