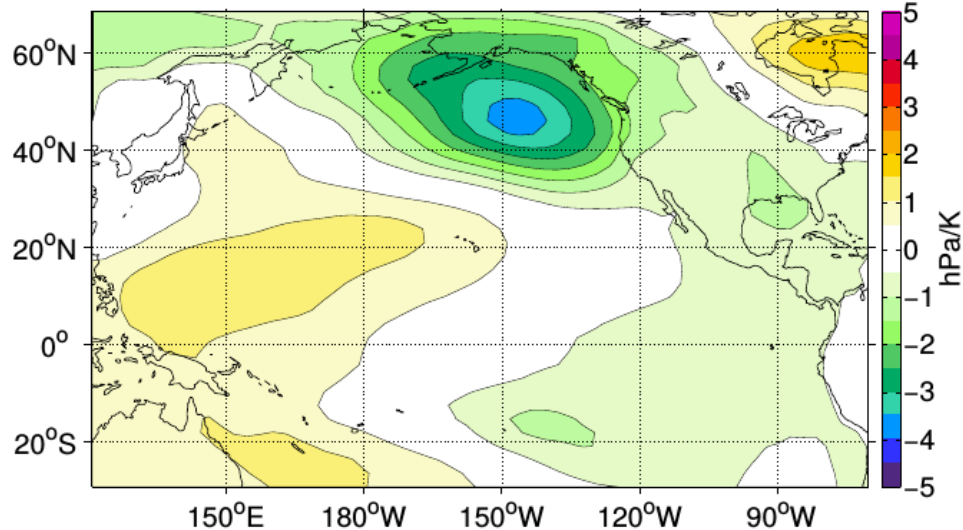


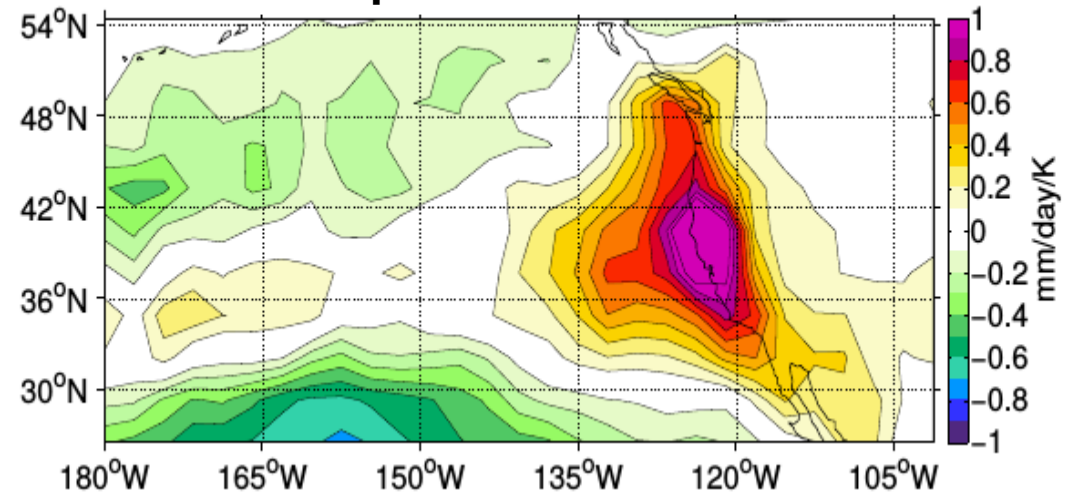
# How linear is the ENSO Teleconnection to the North Pacific?

## The Role of ENSO Atmospheric Feedbacks for Rainfall in California

SLP EP El Nino



Precipitation EP El Nino

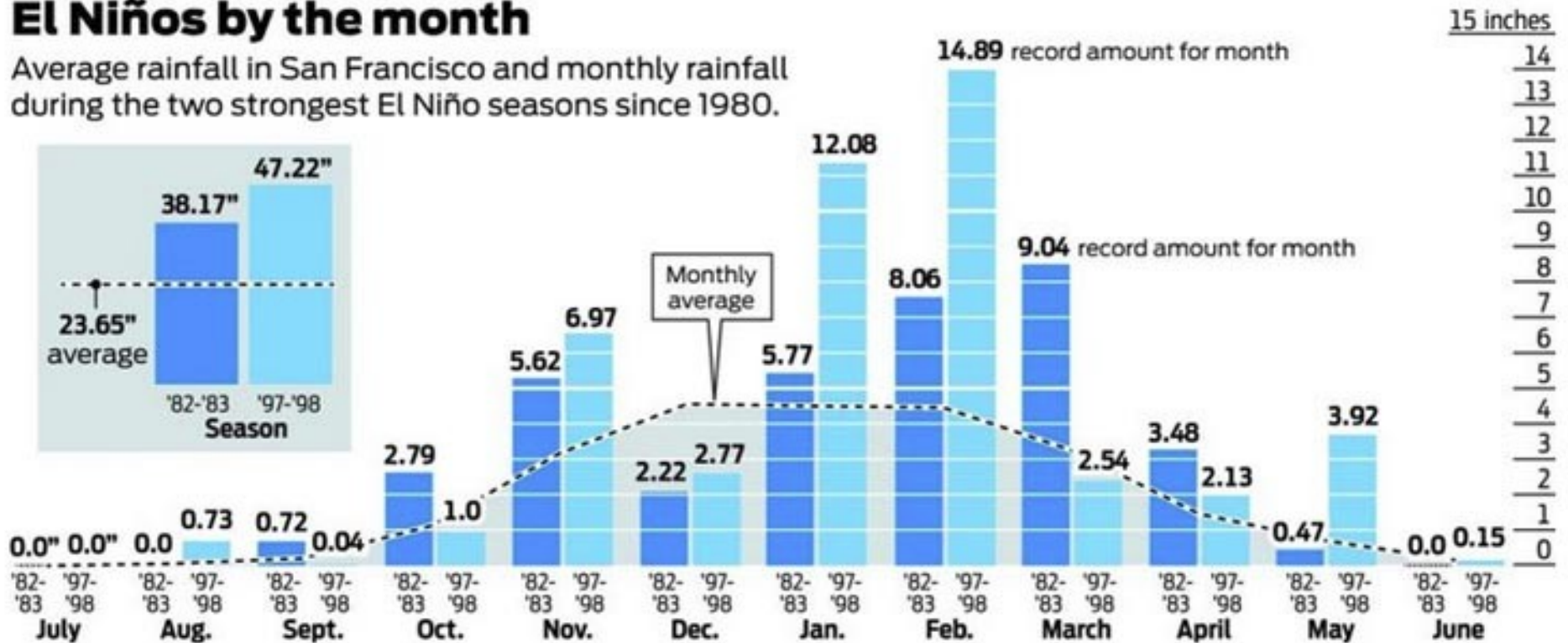


Daniela Domeisen, Tobias Bayr and Christian Wengel

# Motivation: EP El Niño has an strong impact on Californian rainfall

## El Niños by the month

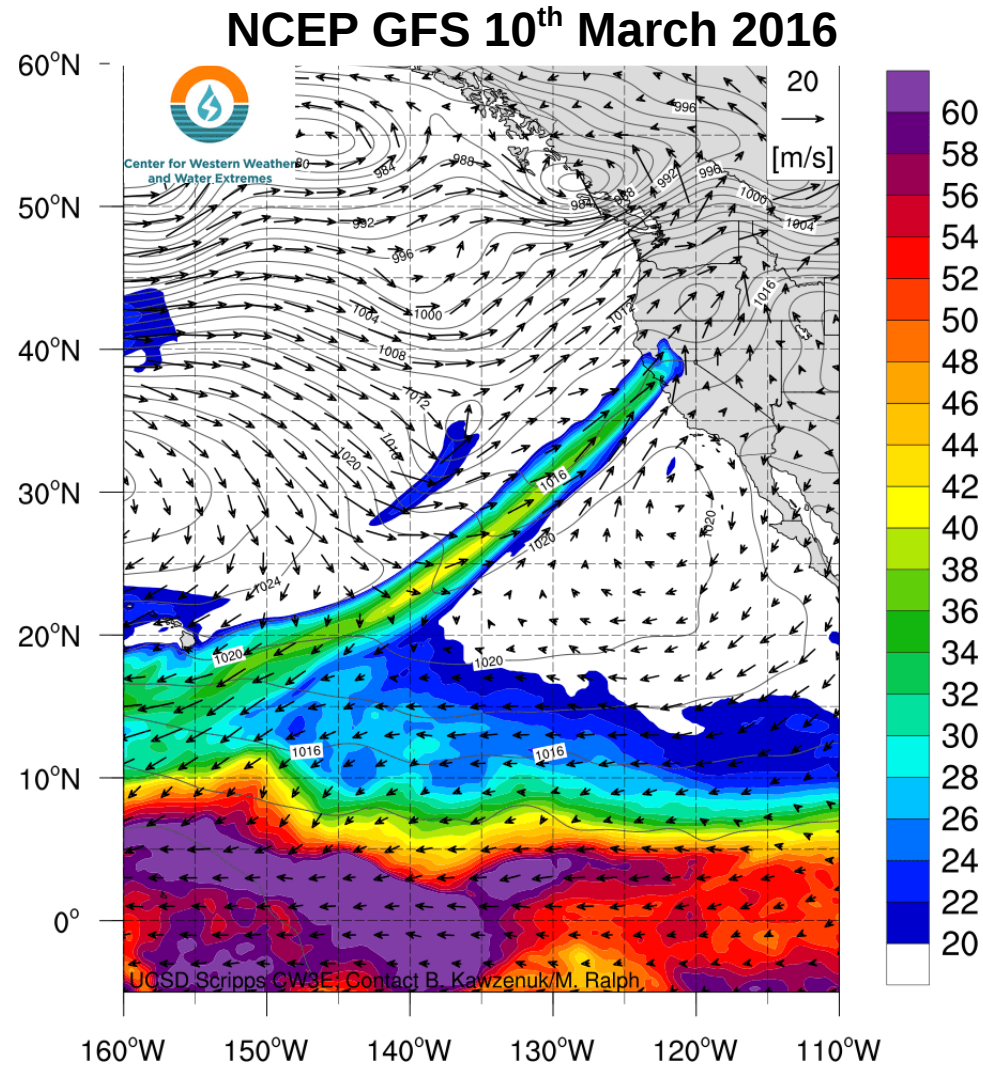
Average rainfall in San Francisco and monthly rainfall during the two strongest El Niño seasons since 1980.



Source: Golden Gate Weather Services

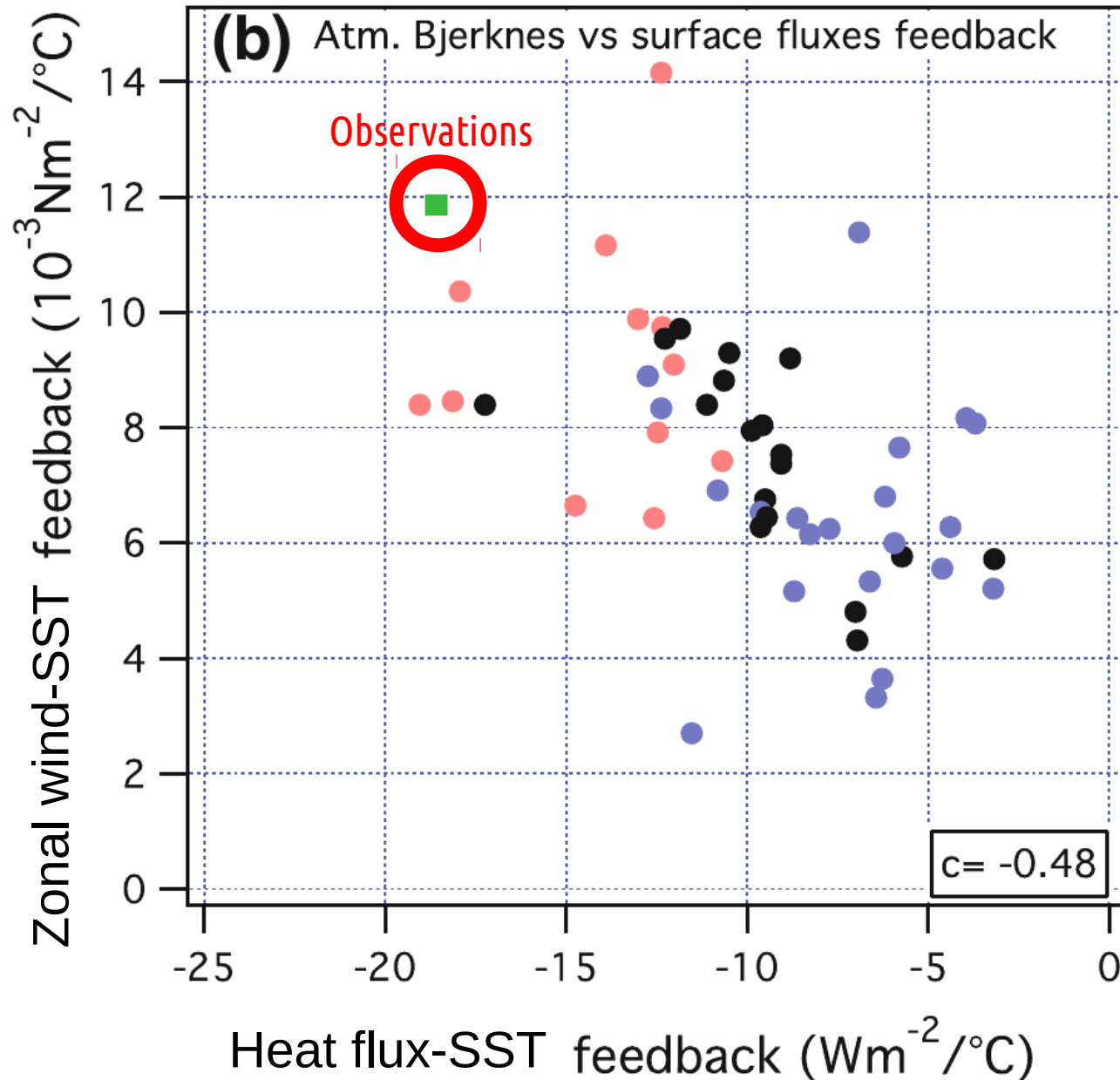
John Blanchard / The Chronicle

# Atmospheric rivers are more likely during El Niño



Integrated water vapour (shaded), 850 hPa winds (vectors), SLP (contours)

# Motivation: Underestimated ENSO Atmospheric Feedbacks in CMIP3 and CMIP5

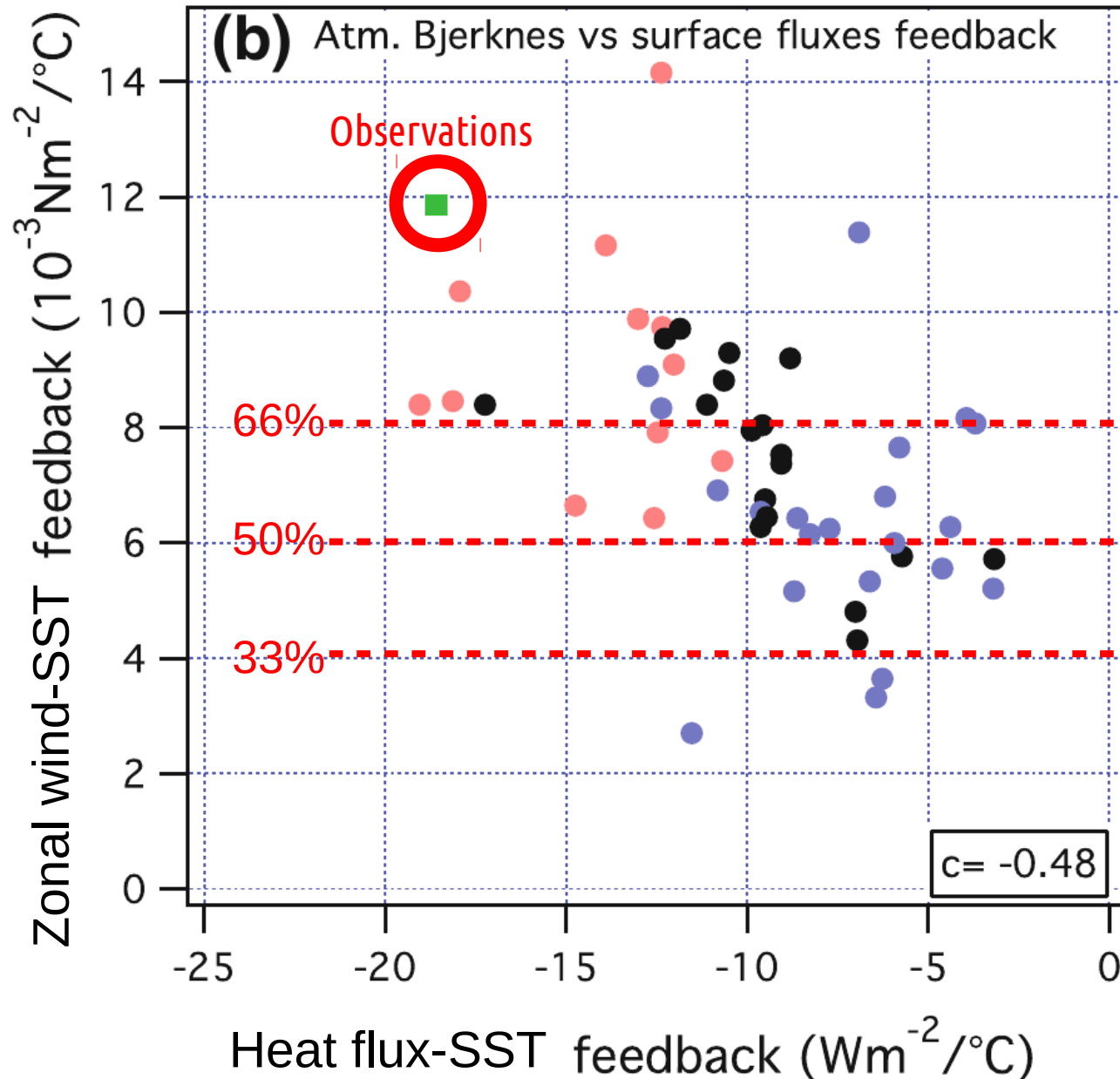


Most CMIP3 and CMIP5 models underestimate Wind-SST feedback and Heat flux-SST feedback  
=> Compensating Error!

Red: convective in Nino3  
Black: conv./sub. in Nino3  
Blue: subsiding in Nino3

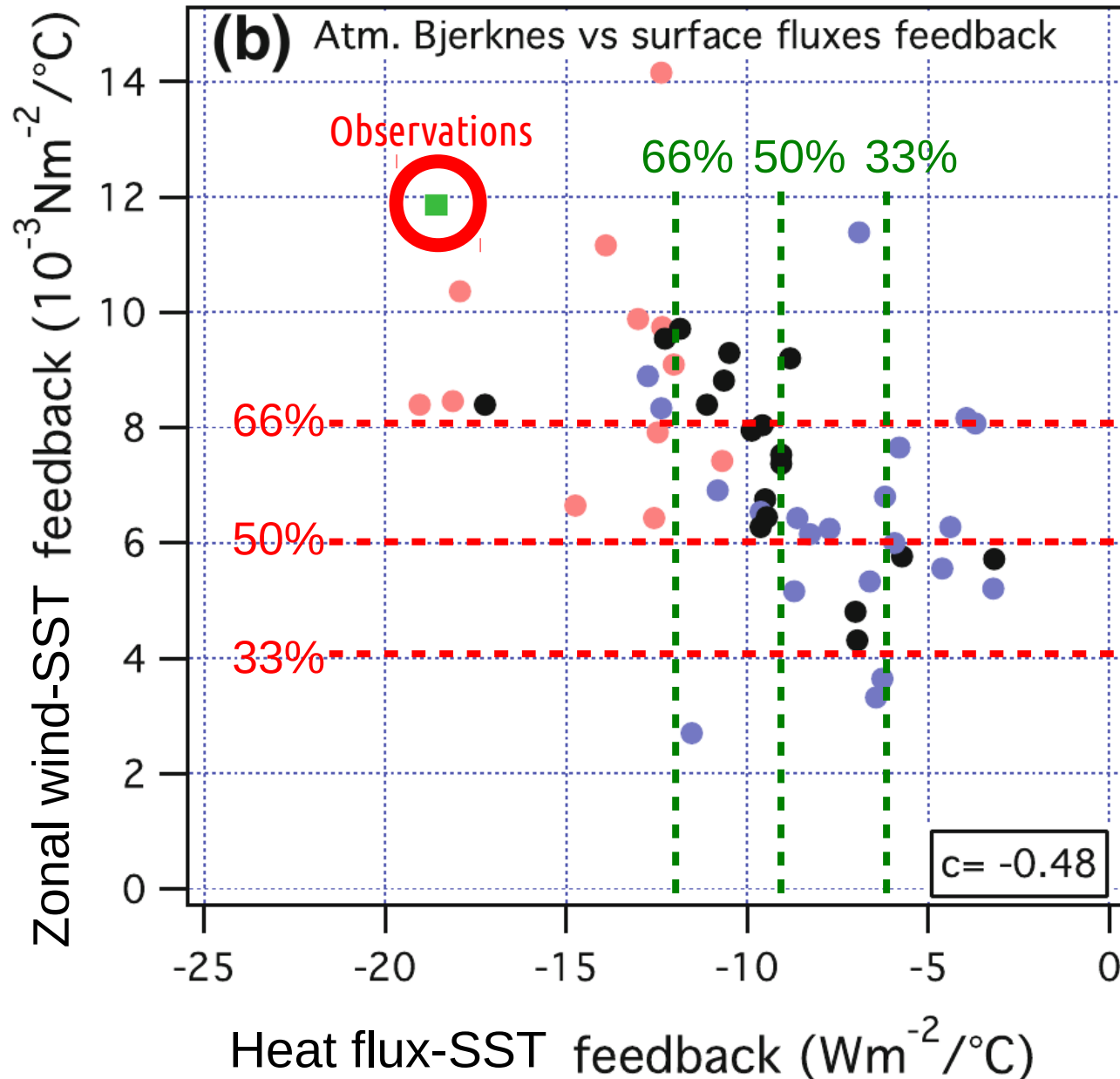
Bellenger et al. (2014)

# Motivation: Underestimated ENSO Atmospheric Feedbacks in CMIP3 and CMIP5



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# Motivation: Underestimated ENSO Atmospheric Feedbacks in CMIP3 and CMIP5

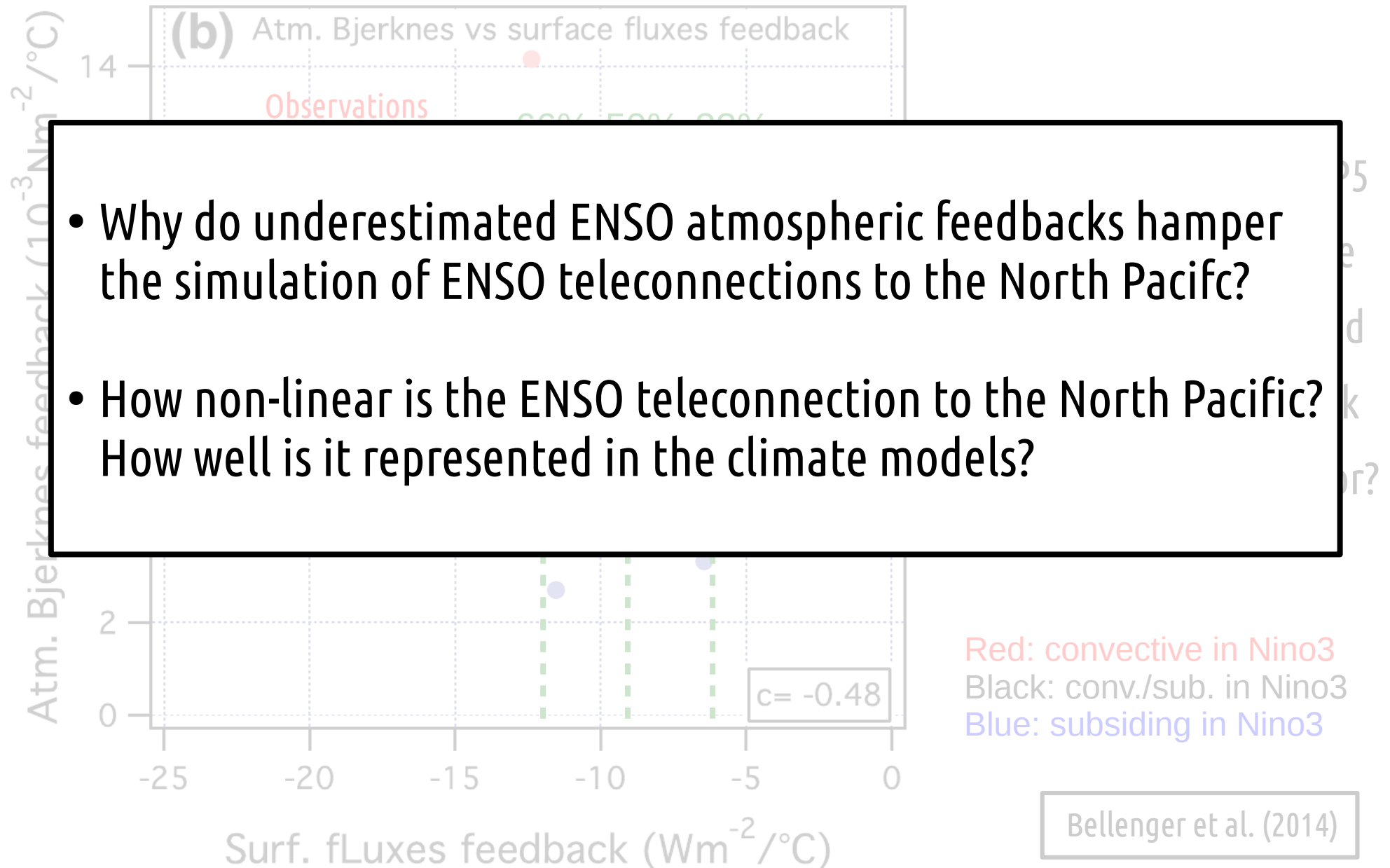


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Bellenger et al. (2014)

# Motivation: Underestimated Atmospheric Feedbacks in CMIP3 and CMIP5



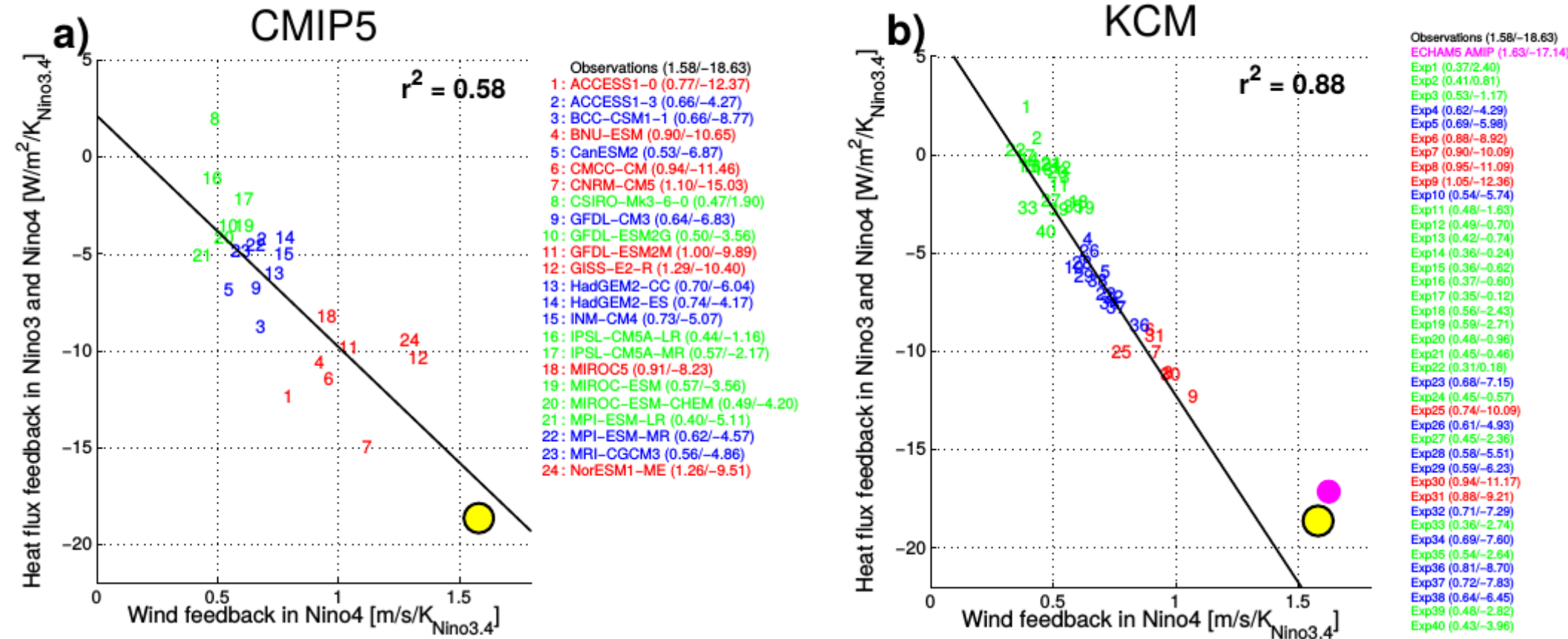
# Data of Obs and KCM

- Observations and reanalysis data:  
HadISST, ERA40, ERA Interim and CMAP
- Perturbed physics ensemble of the Kiel Climate Model (KCM) 1.4.0 with
  - ECHAM5 with T42 ( $2.8^\circ \times 2.8^\circ$ )
  - Nemo Orca2 ( $\sim 2^\circ \times 2^\circ$ )
  - 40 different sets of convection parameters (= tuning parameters) based on Mauritsen et al. (2012) => 40 different mean states
- “AMIP-type” experiments with KCM
  - forced by observed daily SST from NOAA OISST for period 1982-2015
  - other boundary conditions fix ( $\text{CO}_2$ , solar radiation, ...)



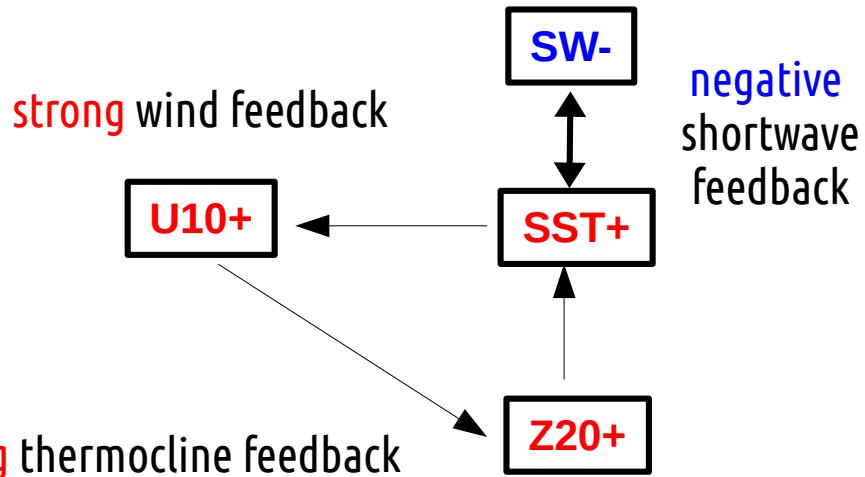
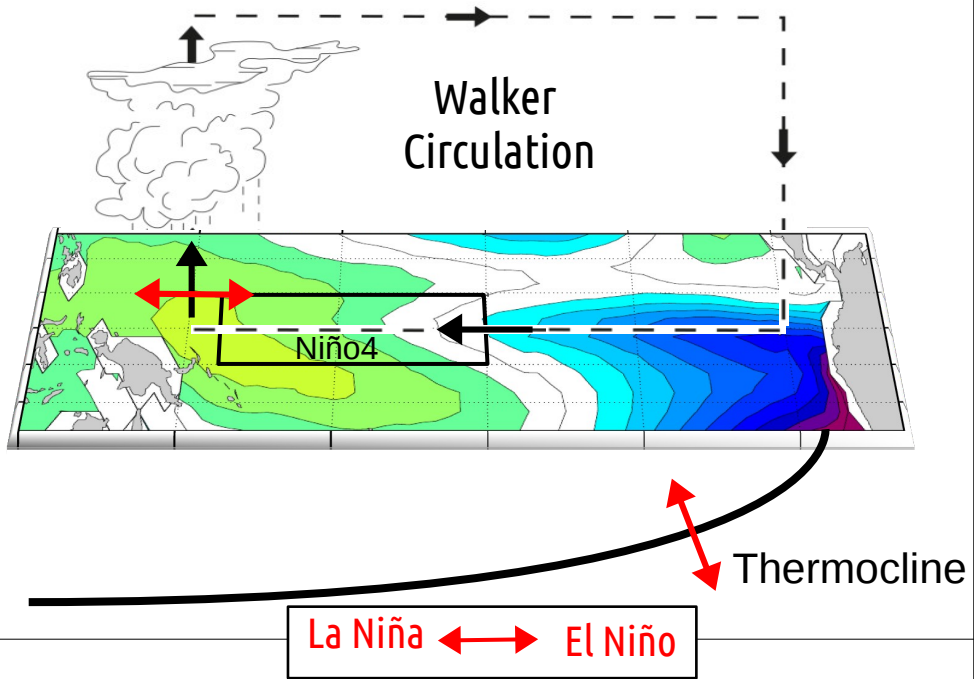
# ENSO atmospheric feedbacks in CMIP5 and KCM

Zonal wind vs. net heat flux feedback in



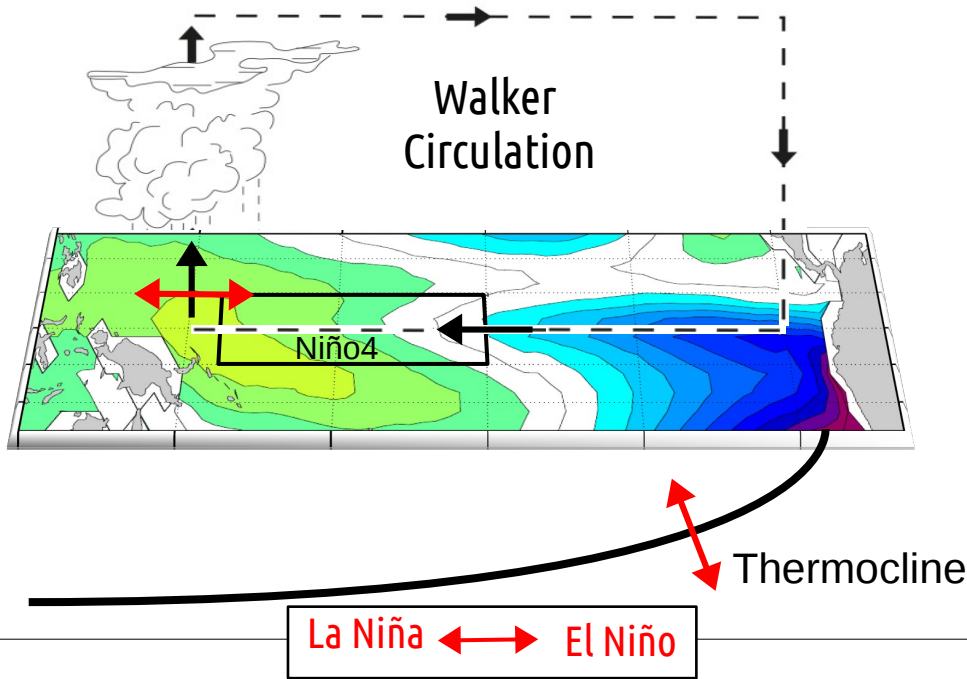
# Equatorial cold SST Bias, the Walker Circulation and ENSO atmospheric feedbacks

No cold SST bias

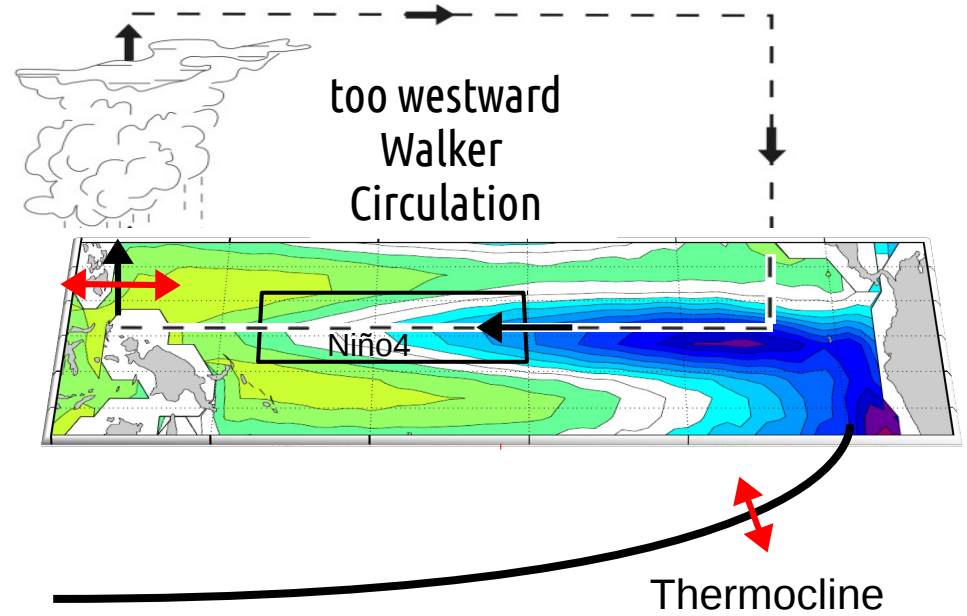


# Equatorial cold SST Bias, the Walker Circulation and ENSO atmospheric feedbacks

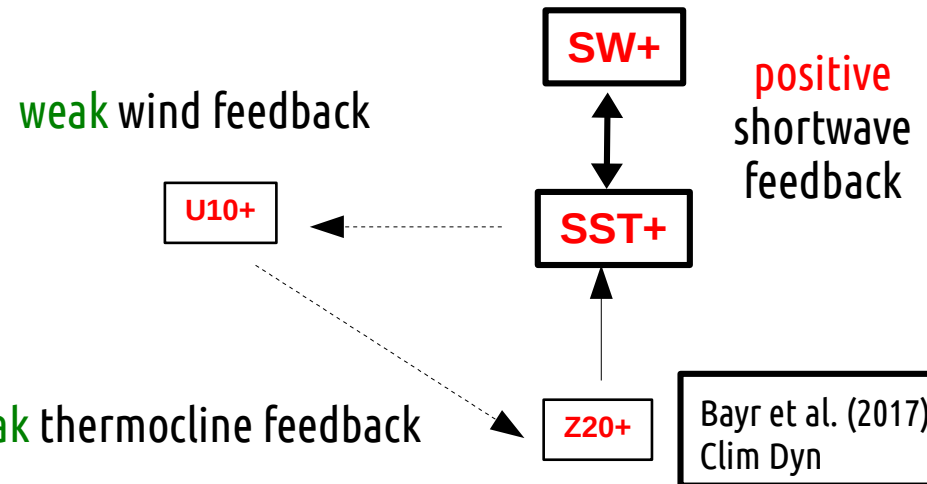
No cold SST bias



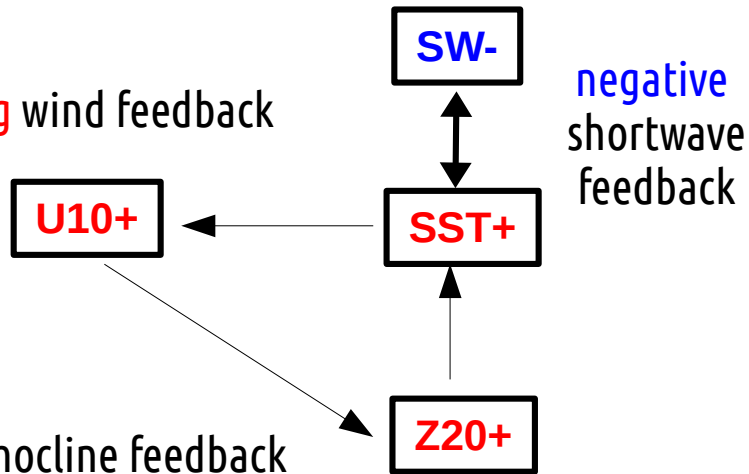
Large cold SST bias



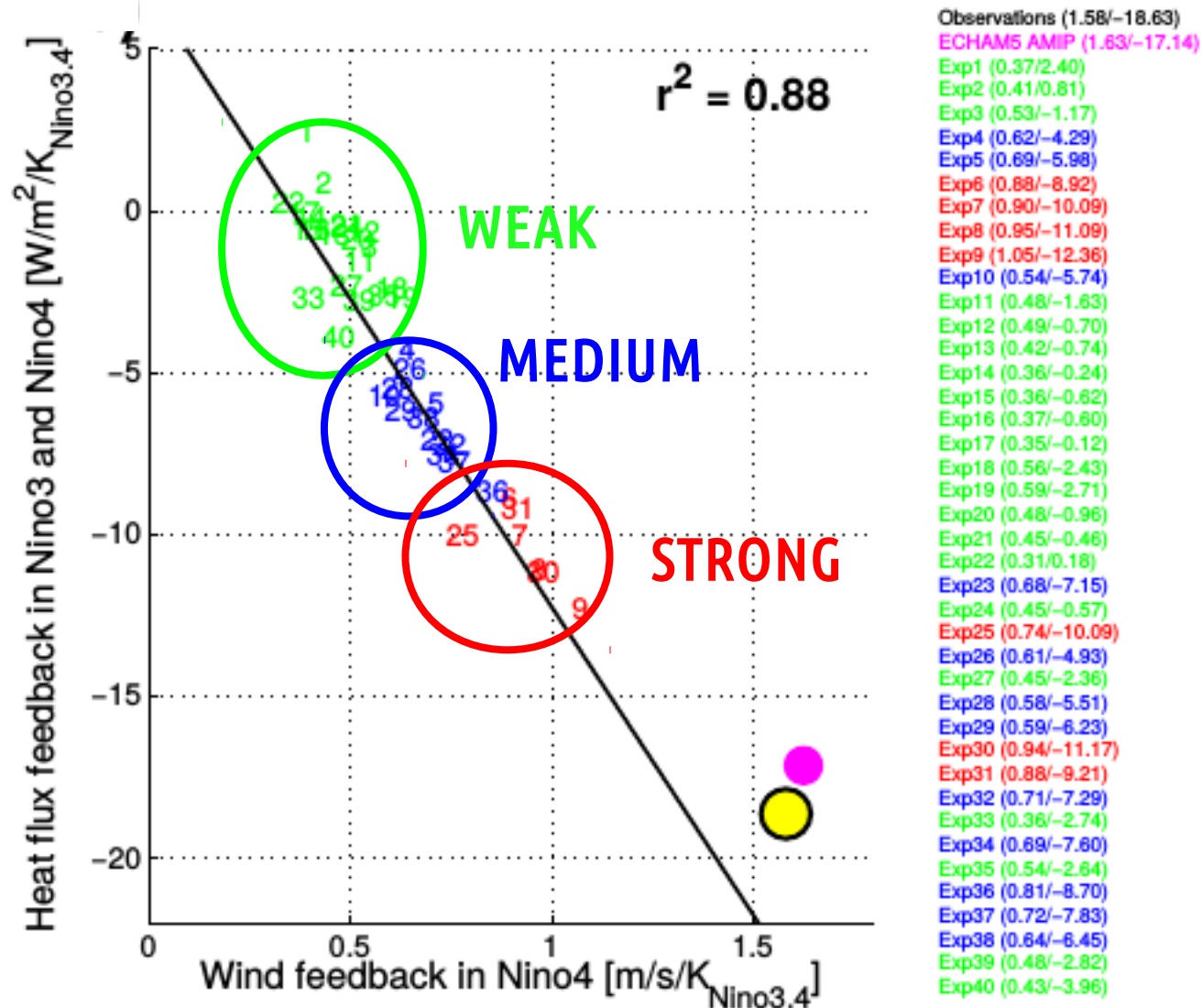
too weak wind feedback is compensated by positive shortwave feedback!



strong wind feedback

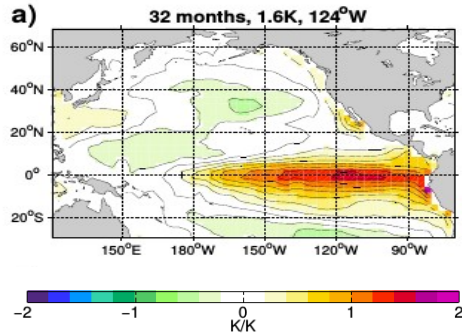


# Perturbed physics ensemble of KCM

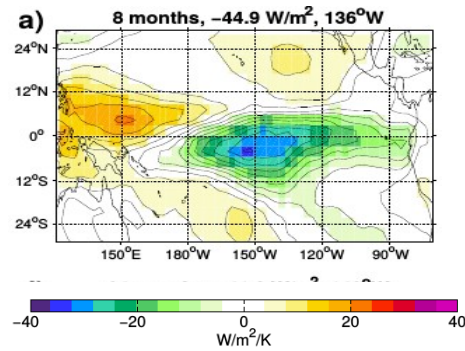


# Composites of EP El Niño events in

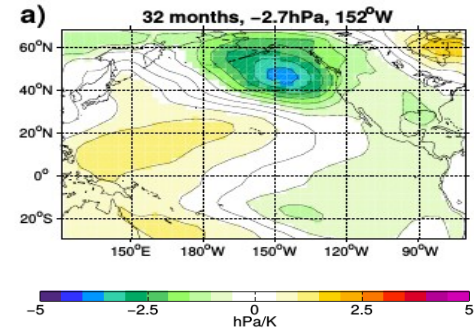
## SST



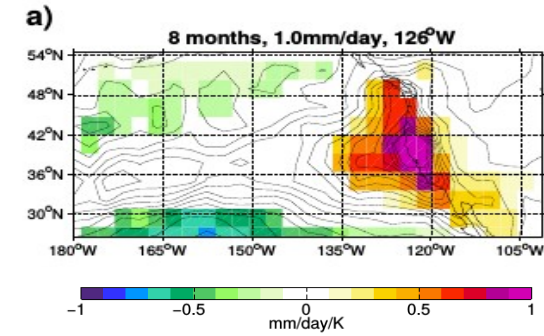
## OLR



## SLP



## Precip



OLR = outgoing longwave radiation  
= measure for convection

# Composites of EP El Niño events in

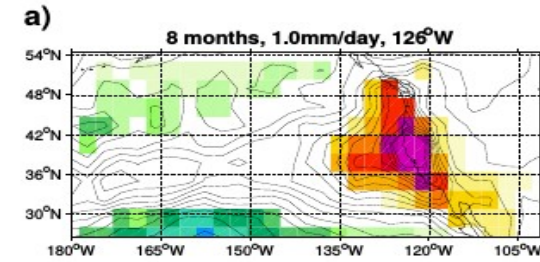
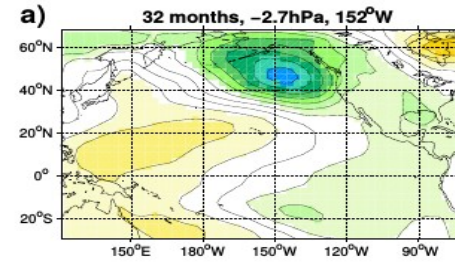
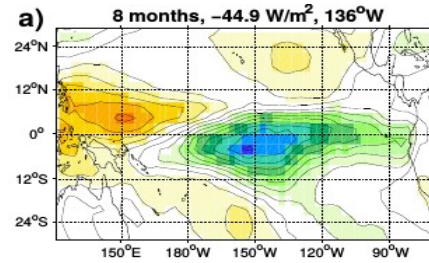
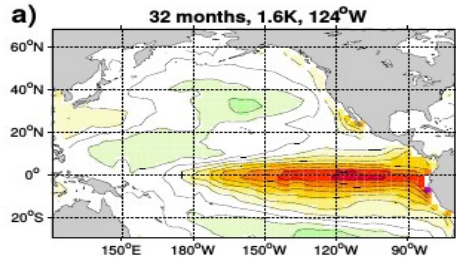
## SST

## OLR

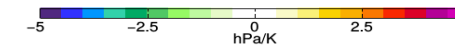
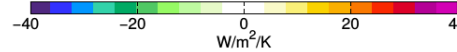
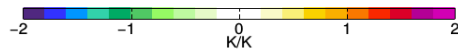
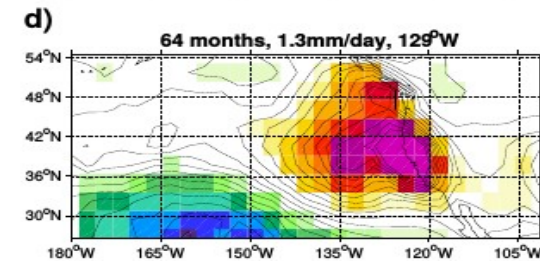
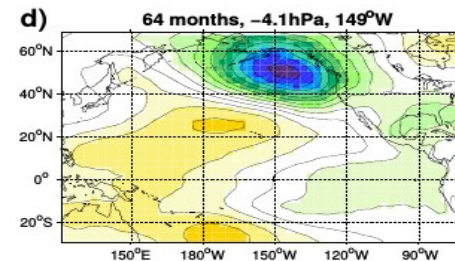
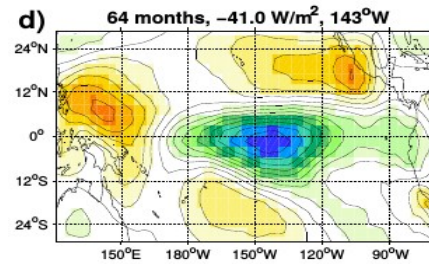
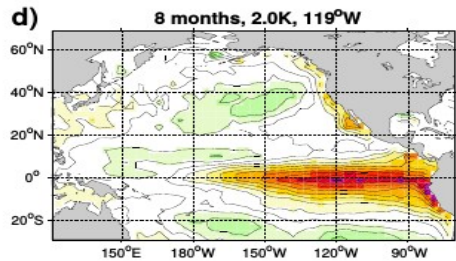
## SLP

## Precip

Obs



AMIP-type



AMIP-type experiments can reproduce Obs quite well!  
(in terms of spatial pattern as well as amplitude)

# Composites of EP El Niño events in

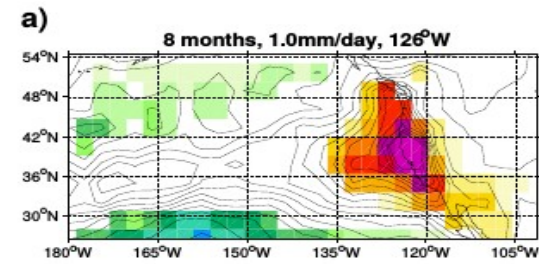
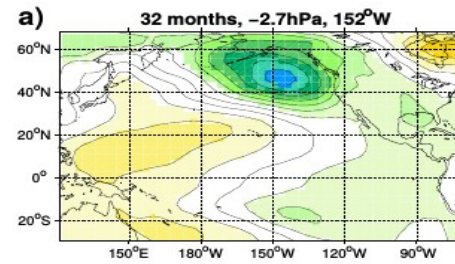
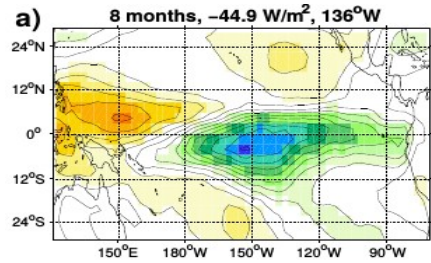
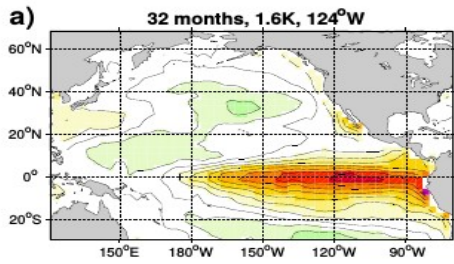
## SST

## OLR

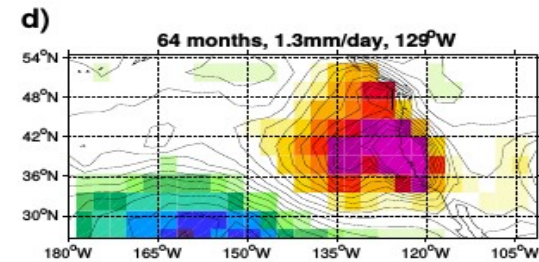
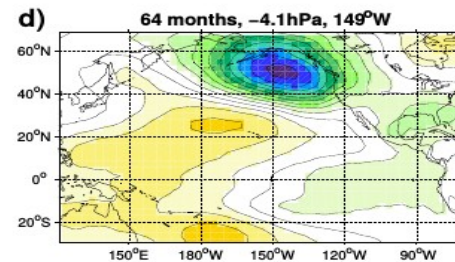
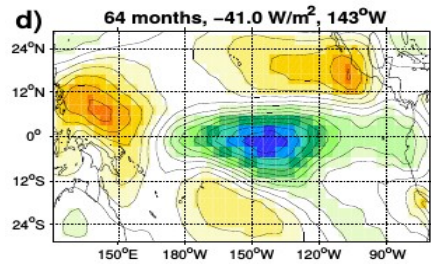
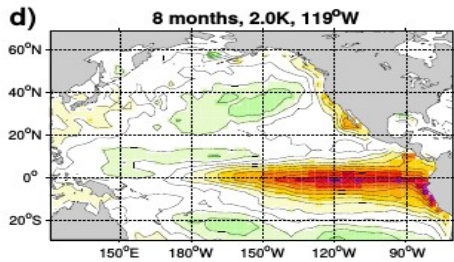
## SLP

## Precip

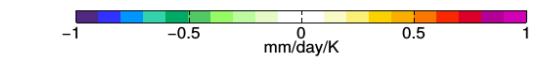
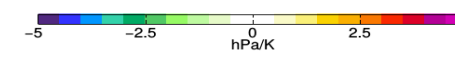
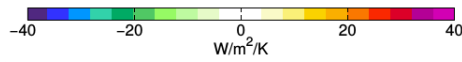
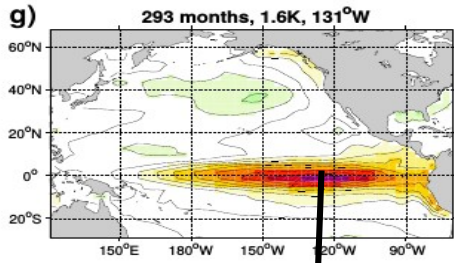
Obs



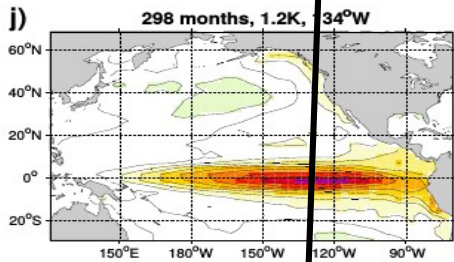
AMIP-type



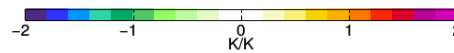
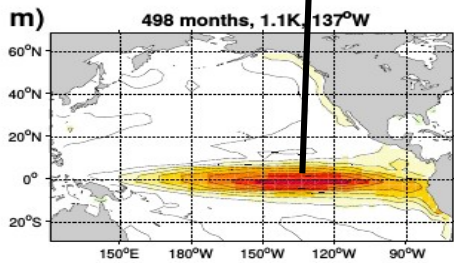
STRONG



MEDIUM



WEAK



Domeisen et al., in prep.

# Composites of EP El Niño events in

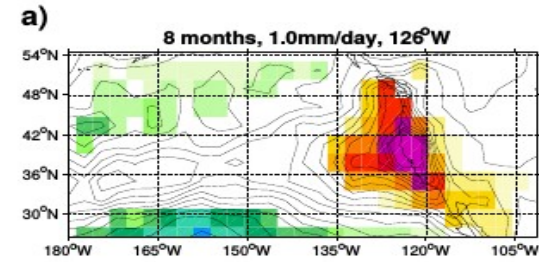
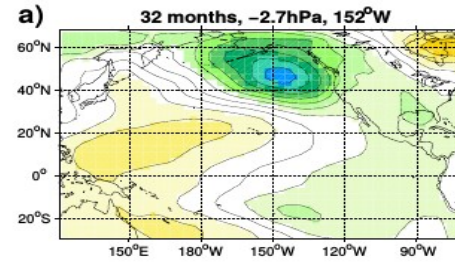
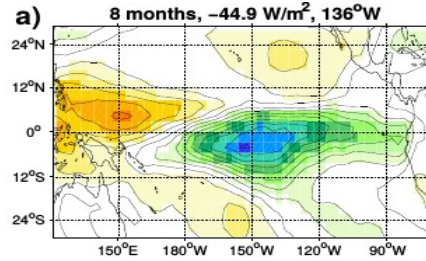
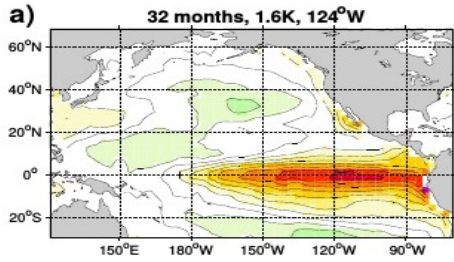
## SST

## OLR

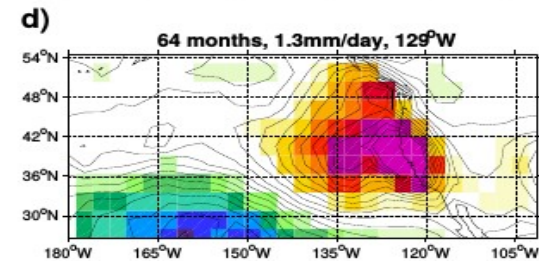
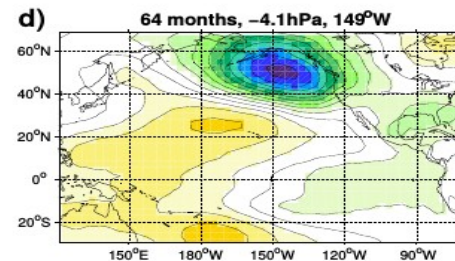
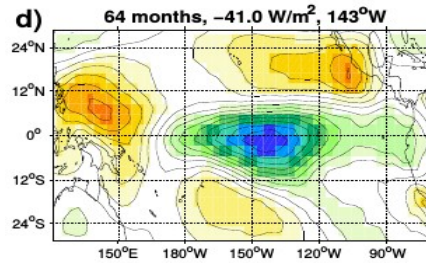
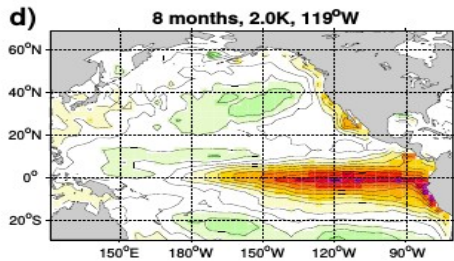
## SLP

## Precip

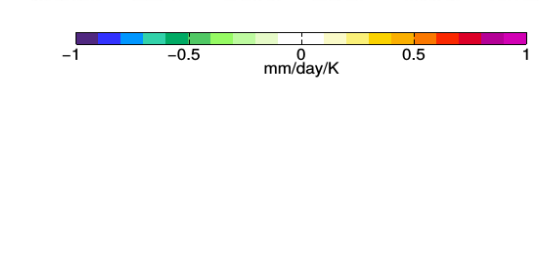
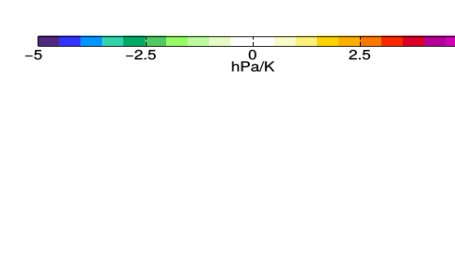
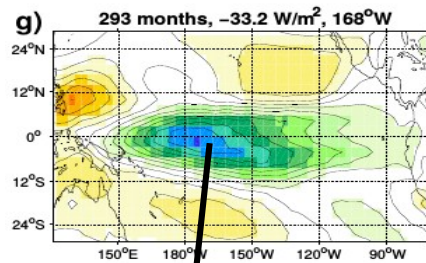
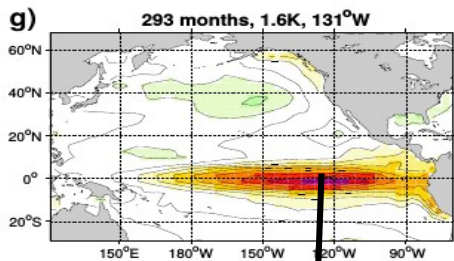
Obs



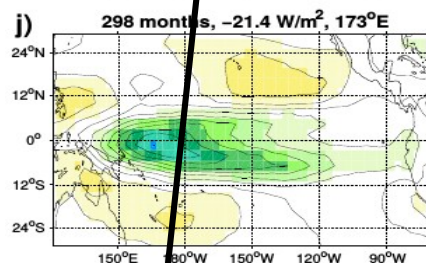
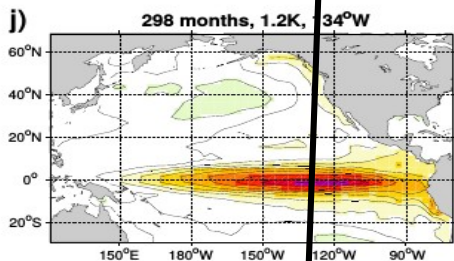
AMIP-type



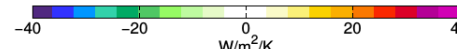
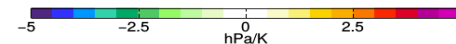
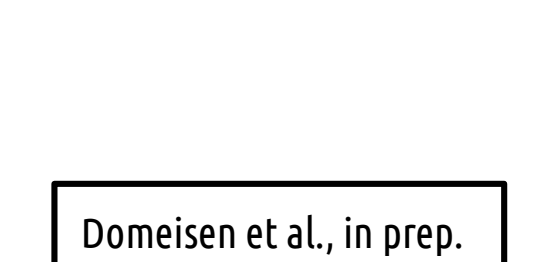
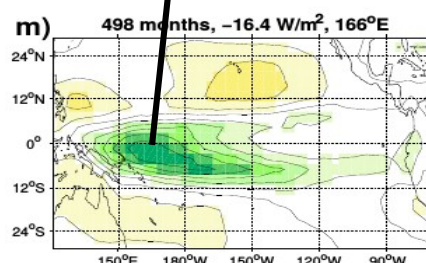
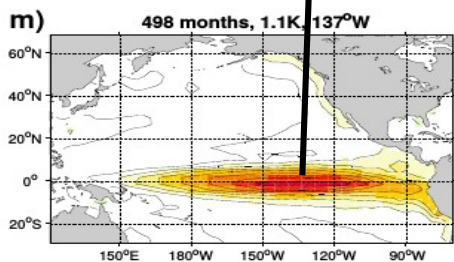
STRONG



MEDIUM



WEAK



Domeisen et al., in prep.



# Composites of EP El Niño events in

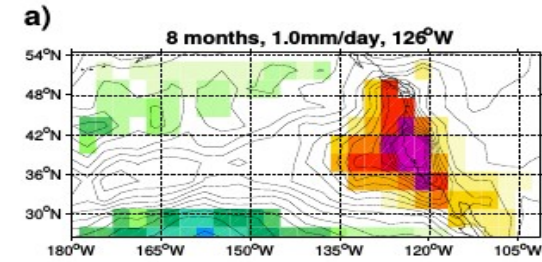
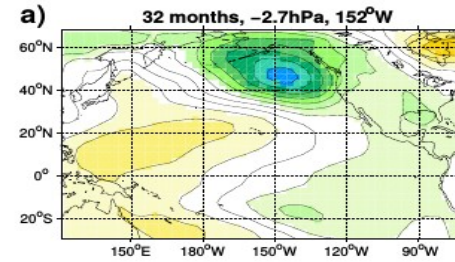
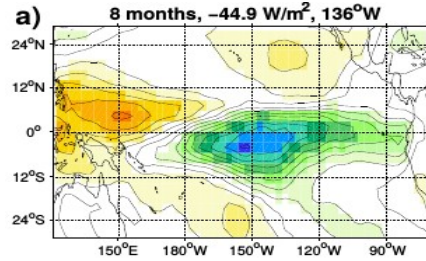
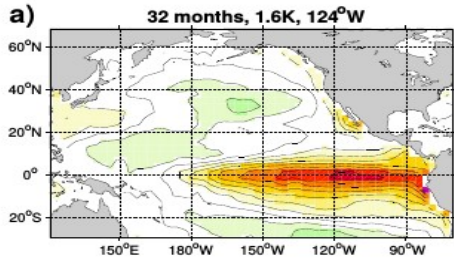
## SST

## OLR

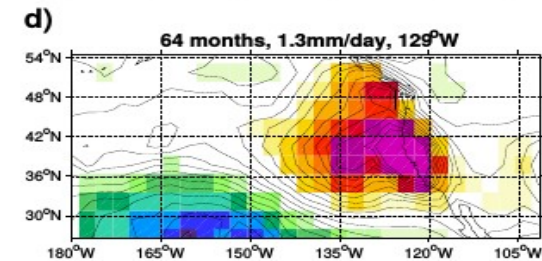
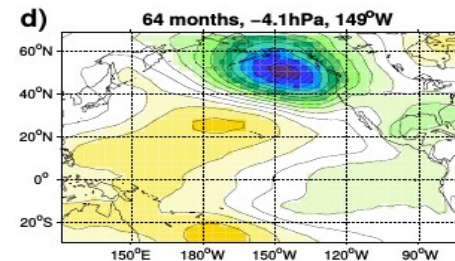
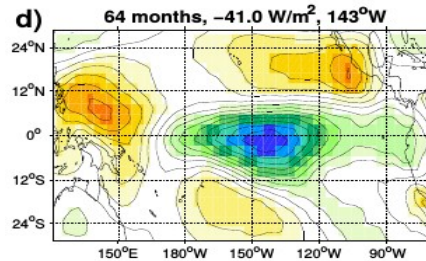
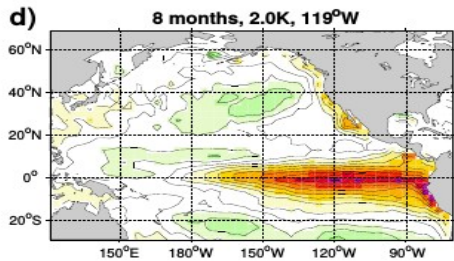
## SLP

## Precip

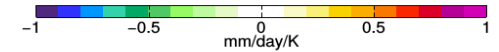
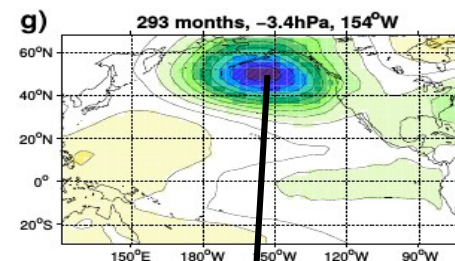
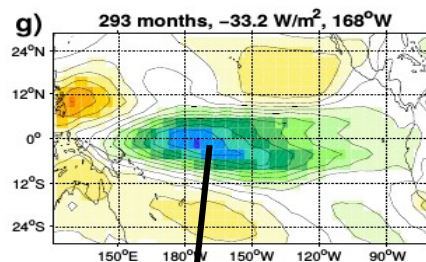
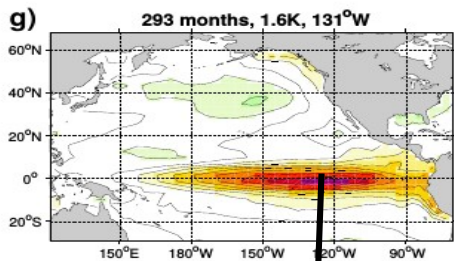
Obs



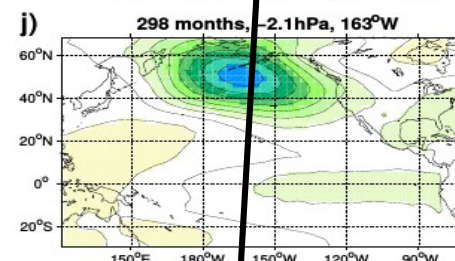
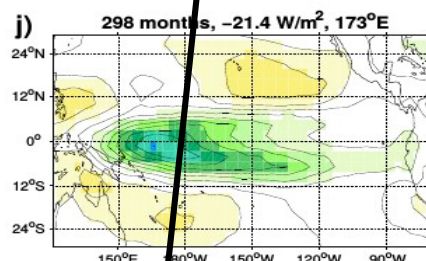
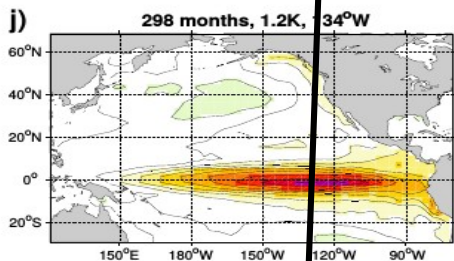
AMIP-type



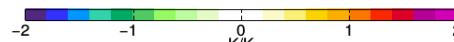
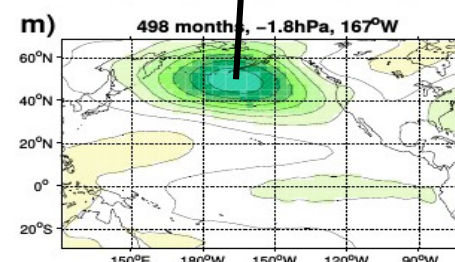
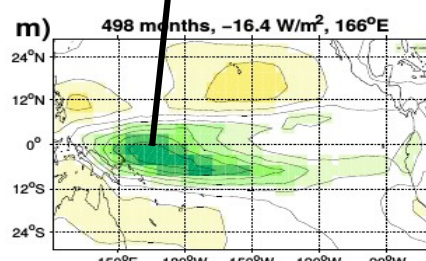
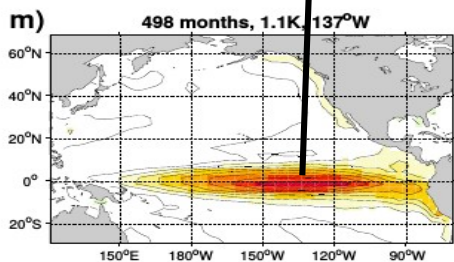
STRONG



MEDIUM



WEAK



Domeisen et al., in prep.

# Composites of EP El Niño events in

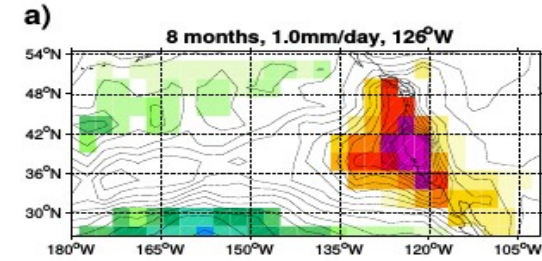
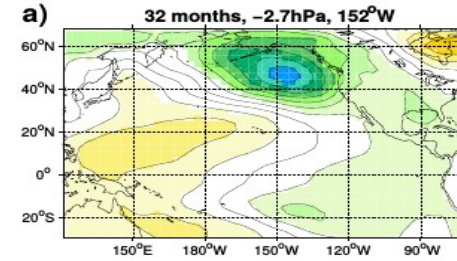
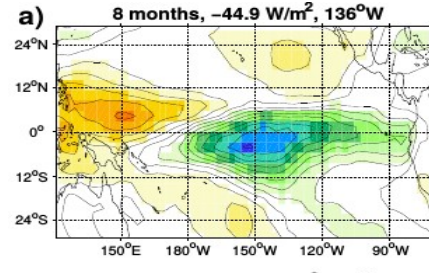
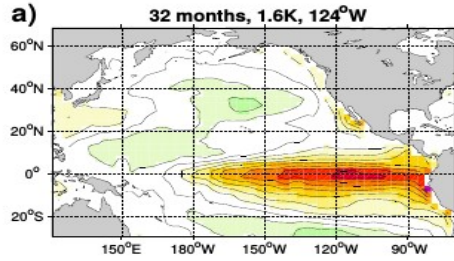
## SST

## OLR

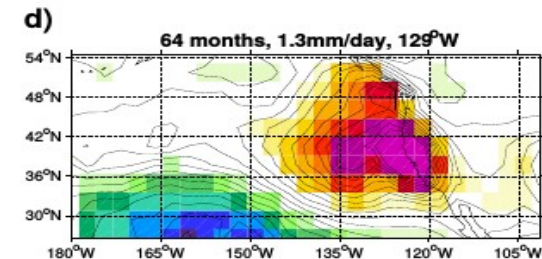
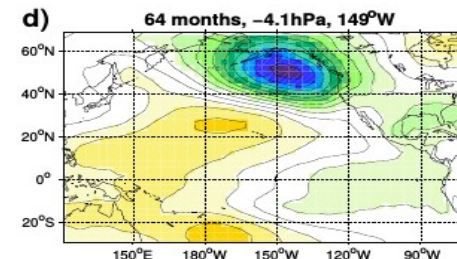
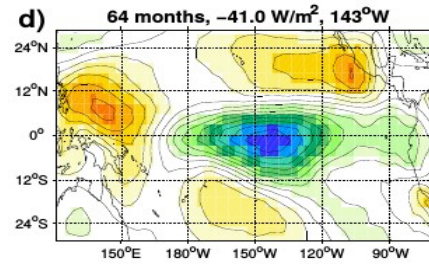
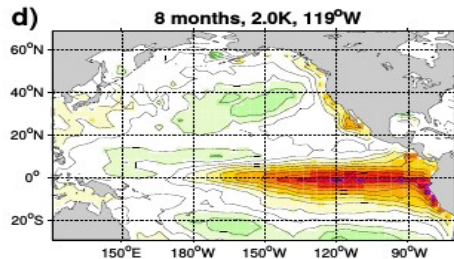
## SLP

## Precip

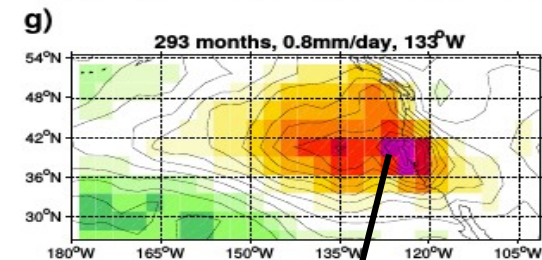
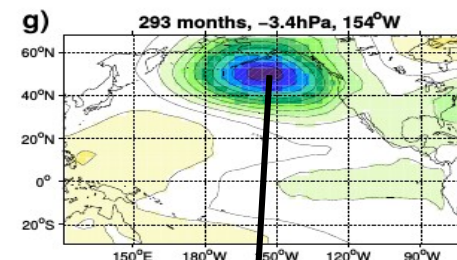
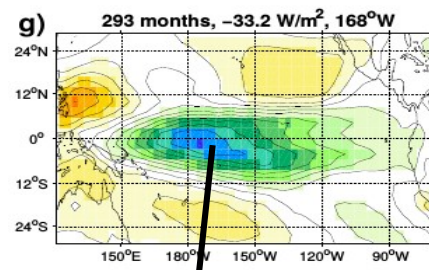
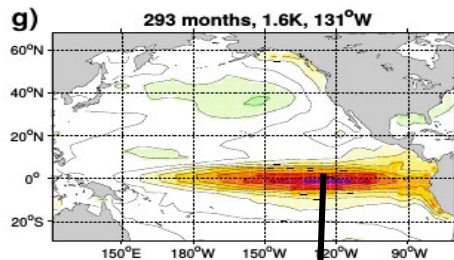
Obs



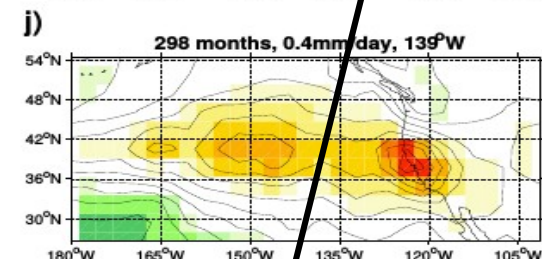
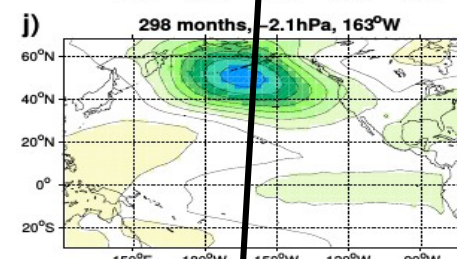
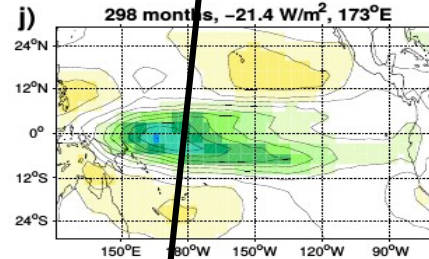
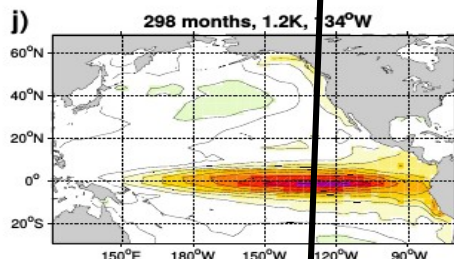
AMIP-type



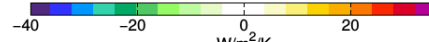
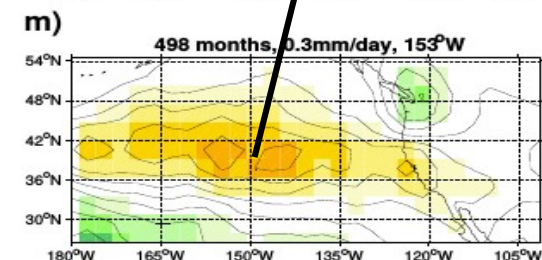
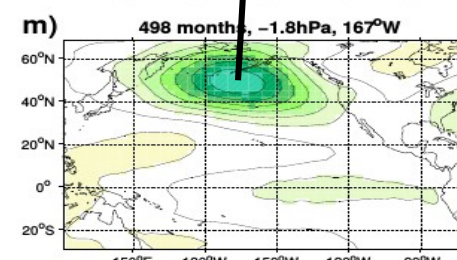
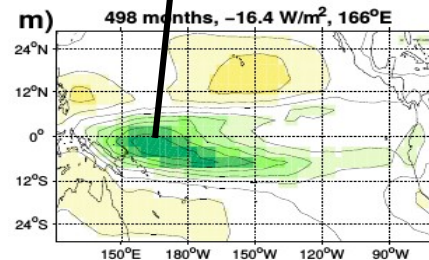
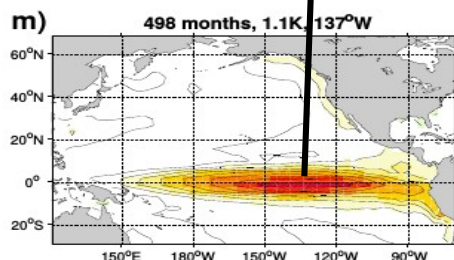
STRONG



MEDIUM

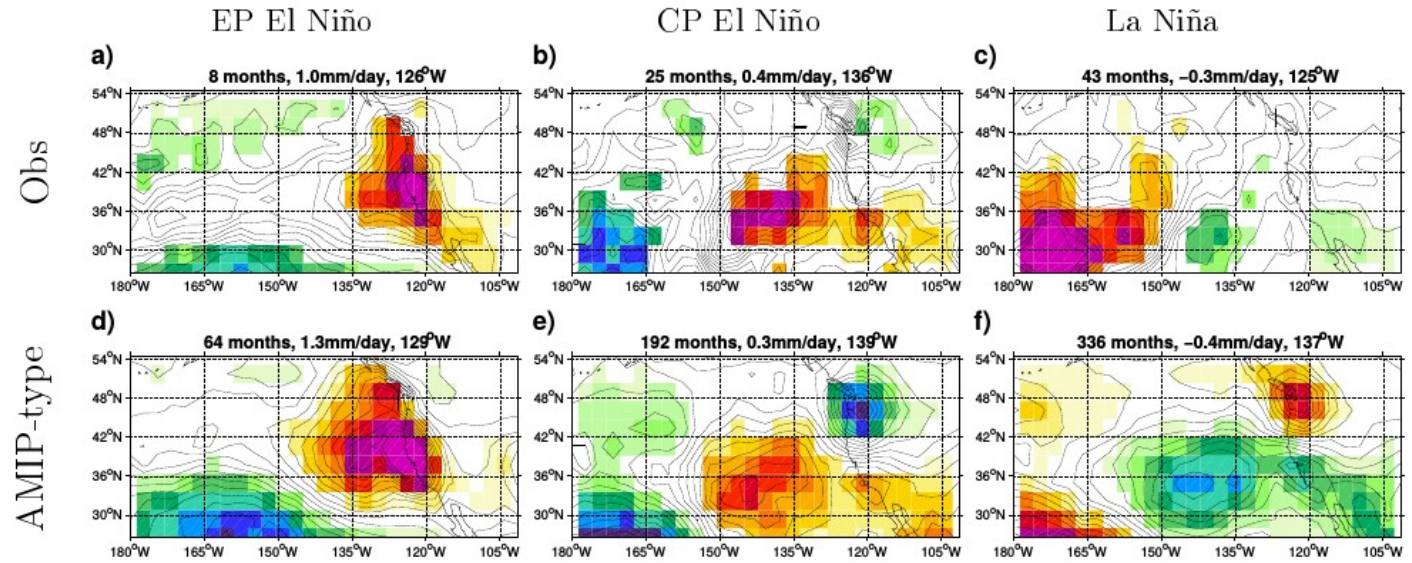


WEAK



How linear is the ENSO teleconnection to the North Pacific?

In Obs and AMIP-type CP El Niño and La Niña are quite linear, while EP El Niño is non-linear.

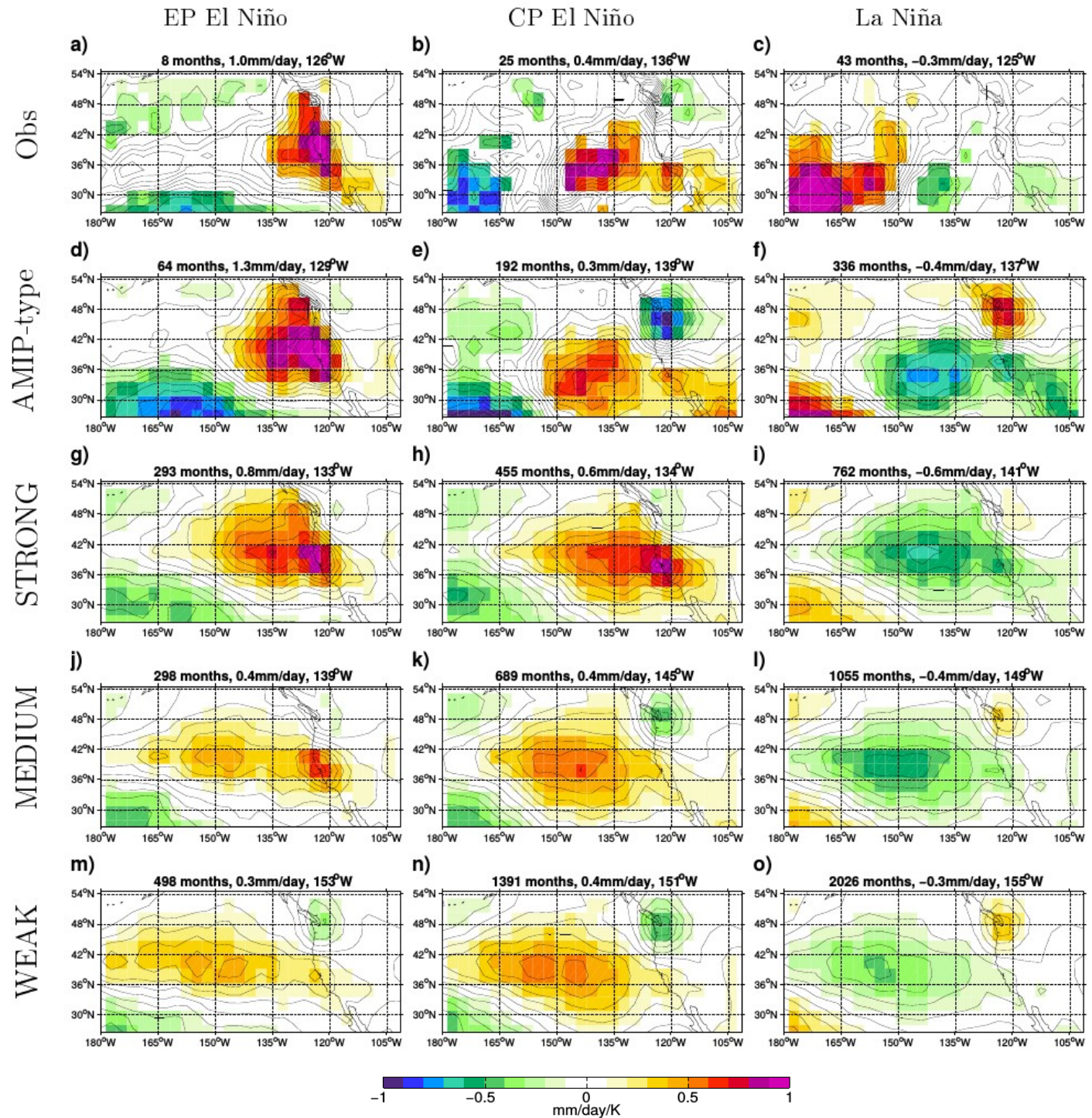


# How linear is the ENSO teleconnection to the North Pacific?

In Obs and AMIP-type CP El Niño and La Niña are quite linear, while EP El Niño is non-linear.

This non-linearity of EP El Ninos is underestimated in all KCM sub-ensembles. => due to underestimated warming in the far eastern Pacific? (Lee et al. (2017), GRL)

Domeisen et al., in prep.



# Summary

- Why do underestimated ENSO atmospheric feedbacks hamper the simulation of ENSO teleconnections to the North Pacific?  
Due to equatorial SST cold bias the rising branch of the Walker Circulation is too far west  
=> Teleconnection is triggered from the “wrong” location
- How non-linear is the ENSO teleconnection to the North Pacific?  
How well is it represented in the climate models?  
CP El Niño and La Niña are quite linear, but EP El Niño is quite non-linear. This non-linearity is poorly represented in KCM

# Thank you for your attention!

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