## How linear is the ENSO Teleconnection to the North Pacific? The Role of ENSO Atmospheric Feedbacks for Rainfall in California



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



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

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# Motivation: Underestimated Atmospheric Feedbacks in CMIP3 and CMIP5

 Why do underestimated ENSO atmospheric feedbacks hamper the simulation of ENSO teleconnections to the North Pacifc?

Atm. Bjerknes vs surface fluxes feedback

 How non-linear is the ENSO teleconnection to the North Pacific? How well is it represented in the climate models?



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# 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°x2.8°)
  - Nemo Orca2 (~2°x2°)
  - 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 (CO<sub>2</sub>, solar radiation, ...)

## ENSO atmospheric feedbacks in CMIP5 and KCM

Zonal wind vs. net heat flux feedback in



Bayr et al. (2017), Clim Dyn

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

No cold SST bias



Bayr et al. (2017), Clim Dyn



## Perturbed physics ensemble of KCM



Observations (1.58/-18.63) ECHAM5 AMIP (1.63/-17.14) Exp1 (0.37/2.40) Exp2 (0.41/0.81) Exp3 (0.53/-1.17) Exp4 (0.62/-4.29) Exp5 (0.69/-5.98 Exp6 (0.88/-8.92) Exp7 (0.90/-10.09 Exp8 (0.95/-11.09 Exp9 (1.05/-12.36 Exp10 (0.54/-5.74) Exp11 (0.48/-1.63 Exp12 (0.49/-0.70 Exp13 (0.42/-0.74) Exp14 (0.36/-0.24) Exp15 (0.36/-0.62 Exp16 (0.37/-0.60 Exp17 (0.35/-0.12) Exp18 (0.56/--2.43) Exp19 (0.59/-2.71) Exp20 (0.48/-0.96 Exp21 (0.45/-0.46 Exp22 (0.31/0.18) Exp23 (0.68/-7.15) Exp24 (0.45/-0.57 Exp25 (0.74/-10.09 Exp26 (0.61/-4.93) Exp27 (0.45/-2.36 Exp28 (0.58/-5.51) Exp29 (0.59/-6.23) Exp30 (0.94/-11.17 Exp31 (0.88/-9.21) Exp32 (0.71/-7.29 Exp33 (0.36/-2.74 Exp34 (0.69/-7.60) Exp35 (0.54/-2.64 Exp36 (0.81/-8.70 Exp37 (0.72/-7.83 Exp38 (0.64/-6.45) Exp39 (0.48/-2.82) Exp40 (0.43/-3.96)

Bayr et al. (2017), Clim Dyn



OLR = outgoing longwave raditon = measure for convection

Domeisen et al., in prep.



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

Domeisen et al., in prep.













0 hPa/K

2.5

-2.5



Ргесір

a)



Domeisen et al., in prep.



-40



20

40

\_5



-1

0 K/K

-2



12ºN

0°

12°S

24°S

150°E

-20

180°W

150°W

0

W/m<sup>2</sup>/K

120°W

20

90°W





0 hPa/K





Domeisen et al., in prep.





-20

0

W/m<sup>2</sup>/K

20









#### Ргесір







Domeisen et al., in prep.





W/m<sup>2</sup>/K



SLP

#### Precip 8 months, 1.0mm/day, 126°W 165 150 120°W 105°W 64 months, 1.3mm/day, 129°W 165°W 150°W 135°W 120°W 105°W 293 months, 0.8mm/day, 133°W 105°W 120°W 165°W 150°W 135 298 months, 0.4mm/day, 139°W 120°W 165°W 150°W 135°W 105°W

180°W

180°W



#### 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 Nino is nonlinear.

#### ENSO Composites of Precip in Obs and KCM



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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)

#### ENSO Composites of Precip in Obs and KCM



# Summary

- Why do underestimated ENSO atmospheric feedbacks hamper the simulation of ENSO teleconnections to the North Pacifc? Due to equatorial SST cold bias the rising branch of the Walker Circulation is too far west
  Teleconnection is triggert 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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