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

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

Observations
50%  66%  33%

Red: convective in Nino3
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Bellenger et al. (2014)
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 (CO₂, solar radiation, ...)
ENSO atmospheric feedbacks in CMIP5 and KCM

Zonal wind vs. net heat flux feedback in

**CMIP5**

- Observations (1.58/-18.63)
- Exp1 (0.377/0.4)
- Exp2 (0.41/0.81)
- Exp3 (0.50/1.17)
- Exp4 (0.62/2.29)
- Exp5 (0.69/-5.98)
- Exp6 (0.88/-6.92)
- Exp7 (0.99/-10.09)
- Exp8 (0.95/-11.09)
- Exp9 (1.05/-12.39)
- Exp10 (0.54/-5.74)
- Exp11 (0.48/-1.63)
- Exp12 (0.48/-0.70)
- Exp13 (0.42/-0.74)
- Exp14 (0.36/-0.24)
- Exp15 (0.36/-0.62)
- Exp16 (0.37/-0.66)
- Exp17 (0.35/-0.12)
- Exp18 (0.56/-2.43)
- Exp19 (0.59/-2.71)
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- Exp21 (0.45/-0.46)
- Exp22 (0.31/0.18)
- Exp23 (0.68/-7.15)
- Exp24 (0.42/-0.27)
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- Exp35 (0.54/-2.94)
- Exp36 (0.81/-6.79)
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**KCM**

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Bayr et al. (2017), Clim Dyn
Equatorial cold SST Bias, the Walker Circulation and ENSO atmospheric feedbacks

No cold SST bias

La Niña  El Niño

strong wind feedback

U10+ SW-

SST+ negative shortwave feedback

Z20+ strong thermocline feedback

strong thermocline feedback

Bayr et al. (2017), Clim Dyn
Equatorial cold SST Bias, the Walker Circulation and ENSO atmospheric feedbacks

No cold SST bias

Large cold SST bias

too westward
Walker
Circulation

too weak wind feedback is compensated by positive shortwave feedback!

Bayr et al. (2017), Clim Dyn
Perturbed physics ensemble of KCM

Bayr et al. (2017), Clim Dyn
Composites of EP El Niño events in

SST

OLR

SLP

Precip

OLR = outgoing longwave radiation
= measure for convection

Domeisen et al., in prep.
Composites of EP El Niño events in SST, OLR, SLP, and Precip. AMIP-type experiments can reproduce Obs quite well! (in terms of spatial pattern as well as amplitude)

Domeisen et al., in prep.

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

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This non-linearity of EP El Niños 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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