# Controls of seasonal ENSO phase locking in the Kiel Climate Model

April 18, 2016, Vienna

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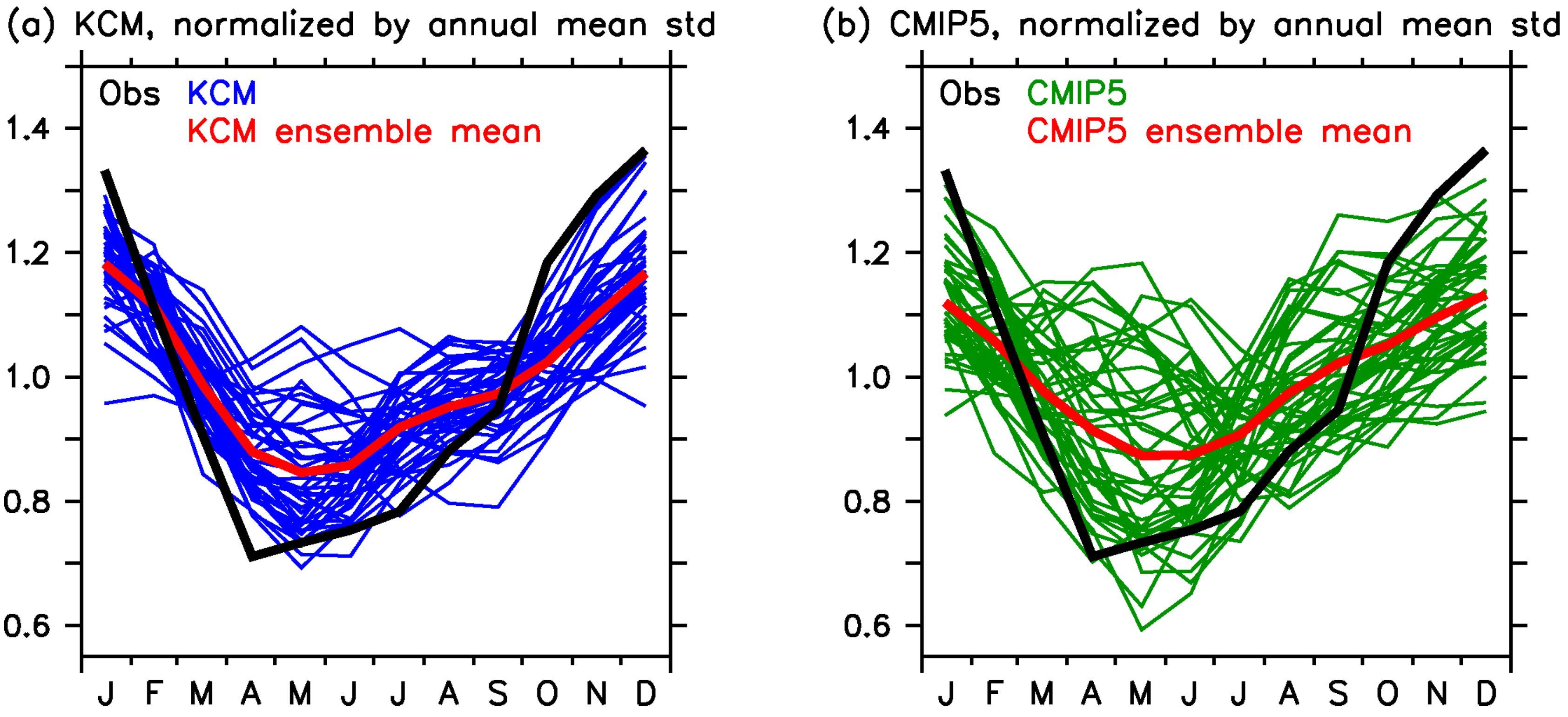
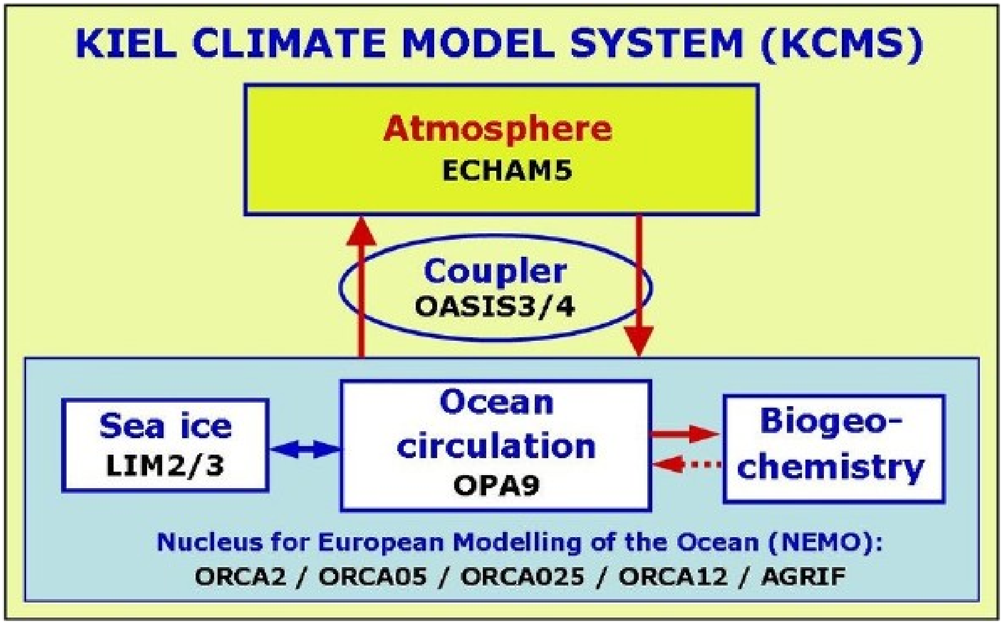
# Seasonal cycle of Nino3.4 SSTa std dev



- Phase well captured by the KCM and CMIP5 ensemble-mean, but annual variation too weak

- Large spread about ensemble-mean



Atmosphere: **ECHAM5** T42 (2.8° x 2.8°)

Ocean: **NEMO** ORCA2 (2° x 2°), latitudinal refinement near equator (0.5°), 31 levels

(Park et al. 2009)

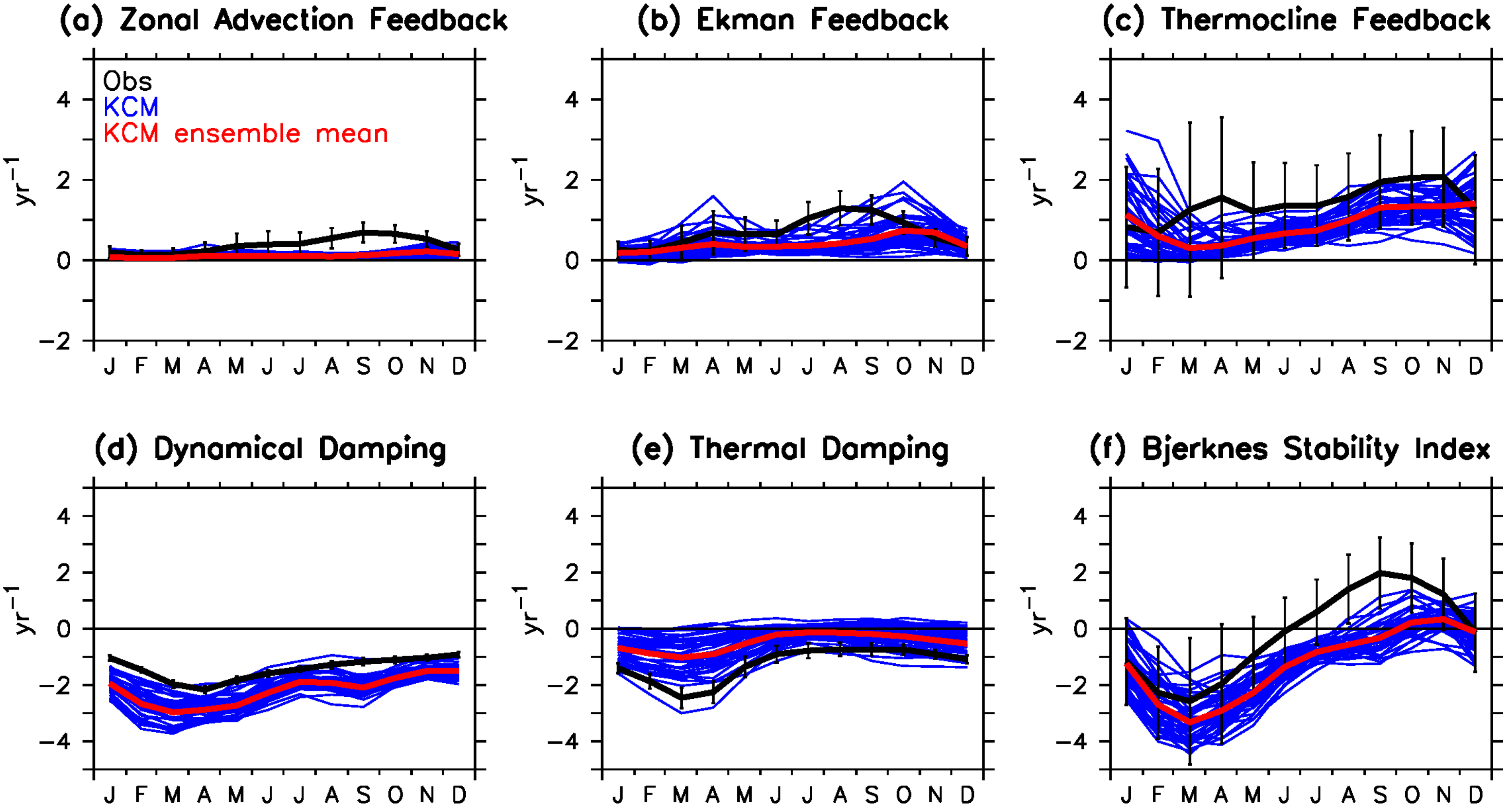
Set of 43 sensitivity experiments:

- different values for atmospheric cloud parameters (determine strength of shallow and deep convective processes)

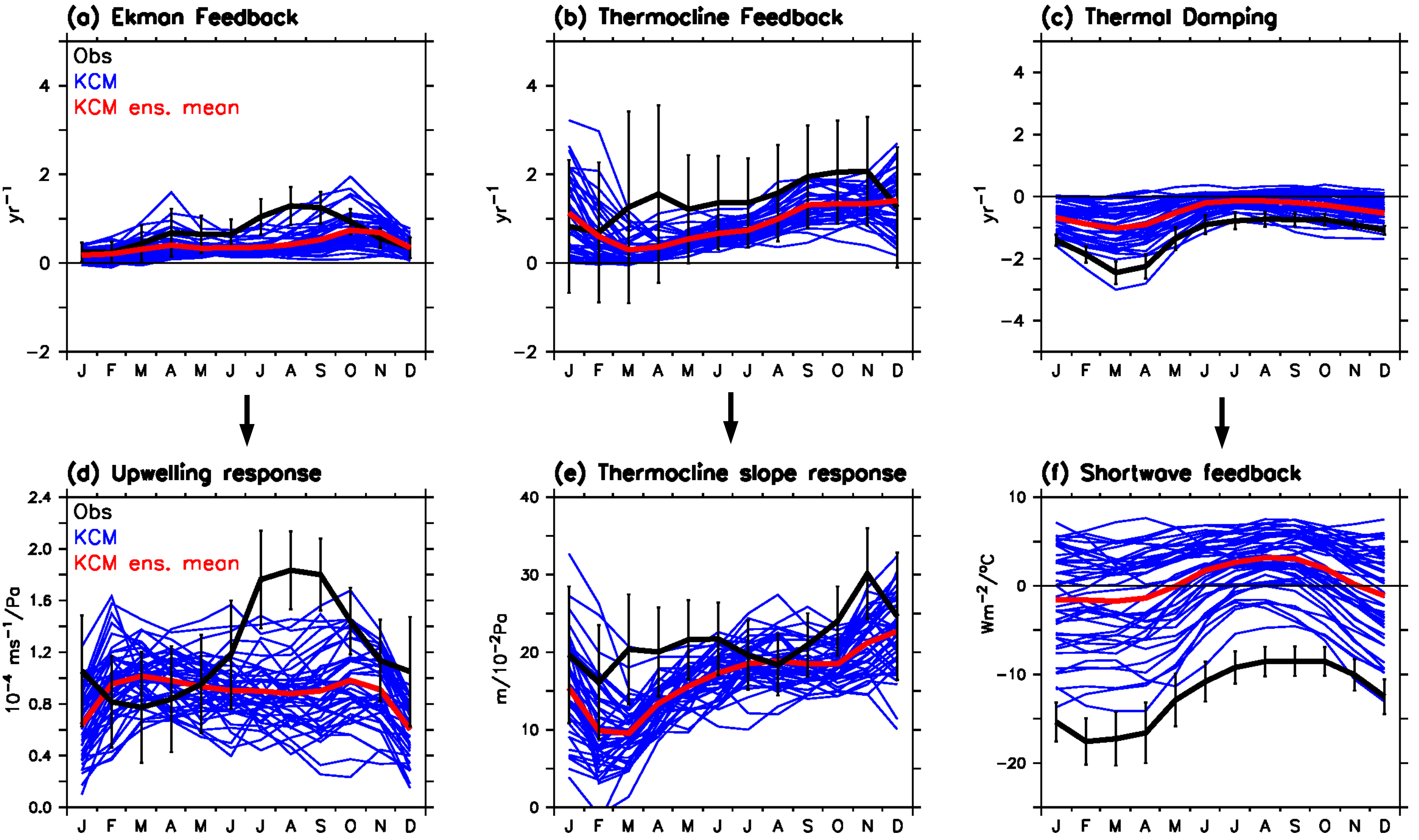
- different number of atmospheric vertical levels (19, 31, 62)

# The Bjerknes stability index: a measure of coupled atmosphere-ocean stability (Jin et al. 2006)

- Formulation based on the linearized SST equation
- Quantifies positive feedbacks and damping processes
- Seasonal variation of the BJ index can be used to explain ENSO phase locking



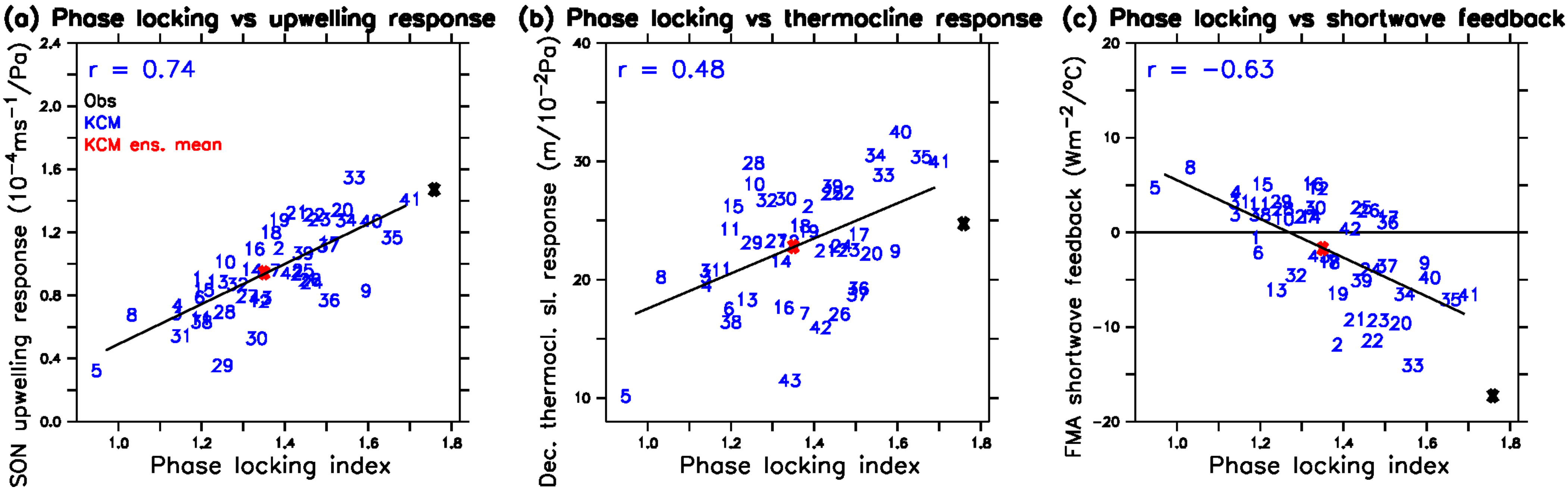
# Decomposition of the Ekman feedback, thermocline feedback and thermal damping into their dominant terms



# Stronger response → stronger phase locking?

$$\text{Phase locking index} = \frac{\text{STD DEV}\left(\text{SSTa}_{\text{Nino3.4}}\right)_{\text{DJF}}}{\text{STD DEV}\left(\text{SSTa}_{\text{Nino3.4}}\right)_{\text{AMJ}}}$$

(Bellenger et al. 2014)

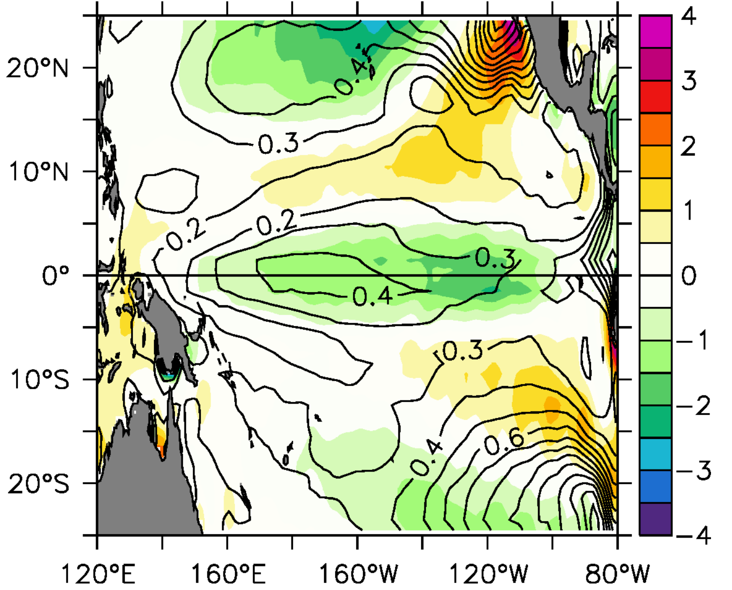


- Increase of upwelling response, thermocline slope response and shortwave feedback lead to stronger phase locking in the KCM

- What influences the strength of these responses?

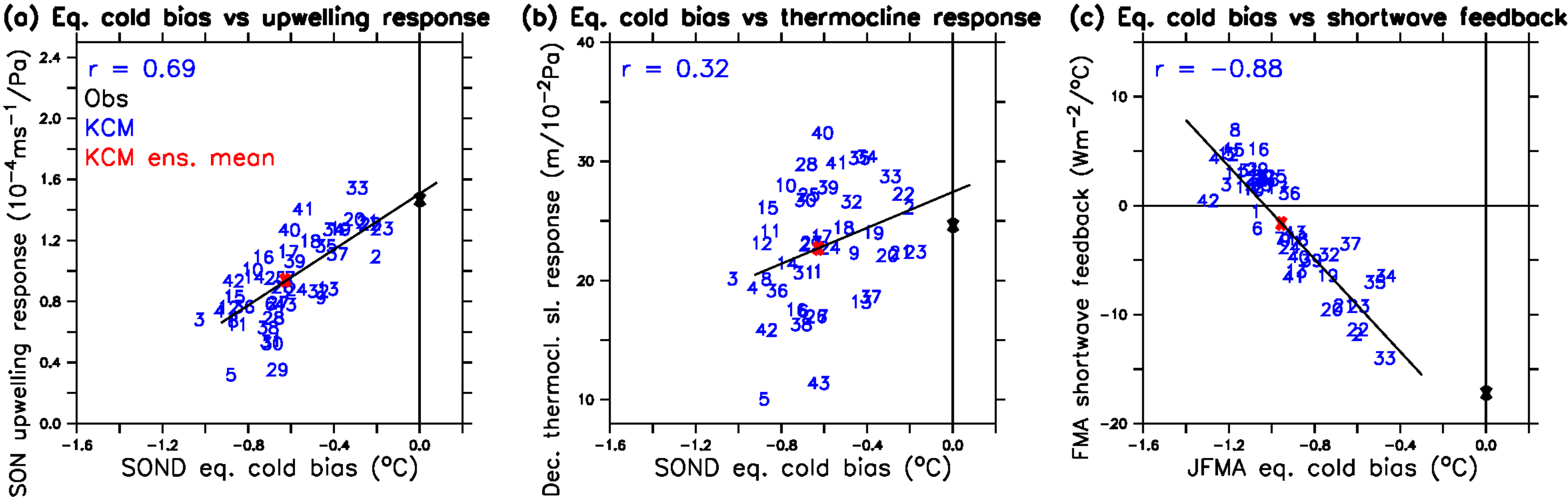
# Effect of the equatorial cold bias

KCM ensemble mean SST bias (°C)



Weaker SST cold bias → stronger response

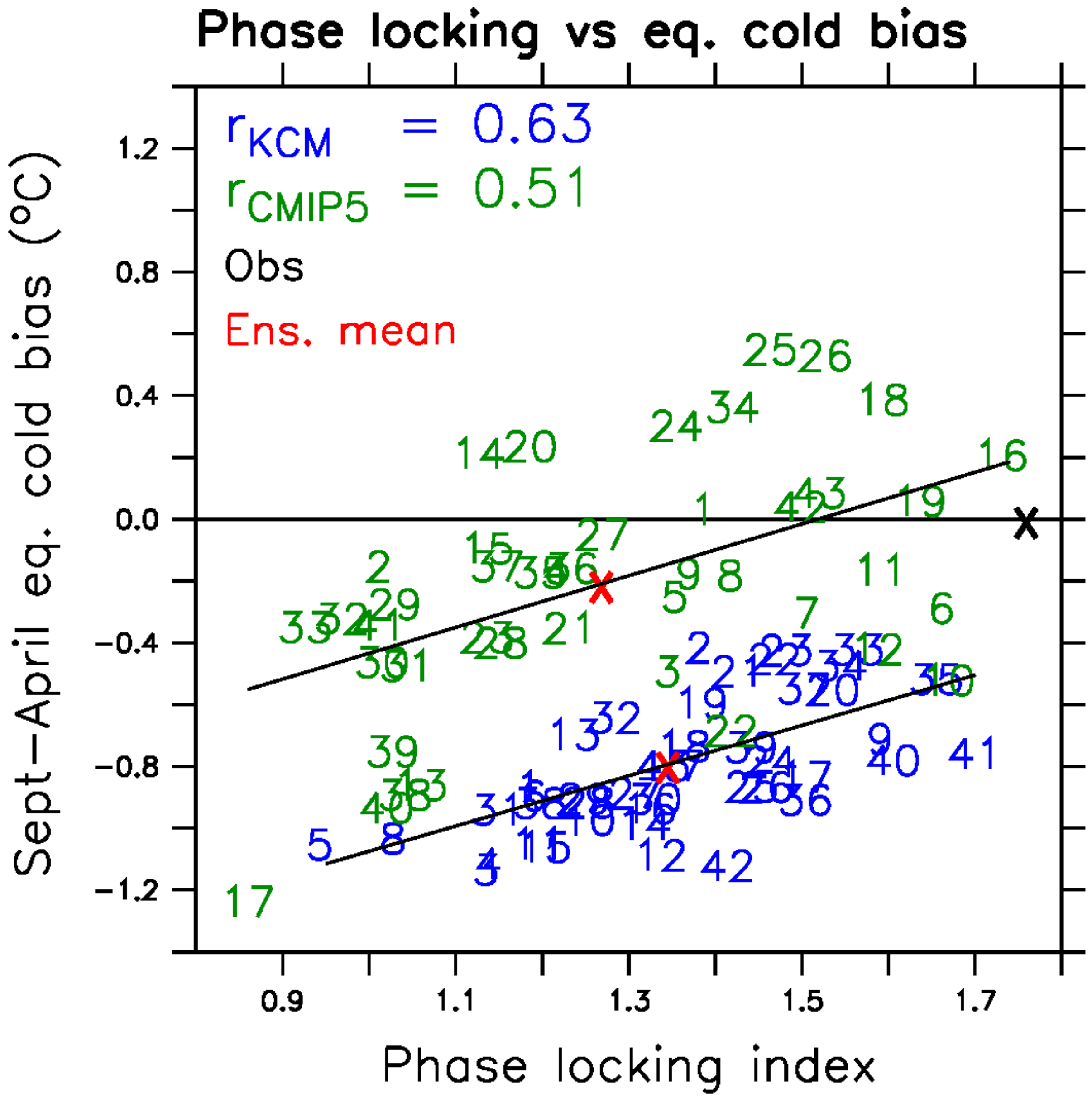
Contour lines: std dev over all KCM experiments


(a) Eq. cold bias vs upwelling response

(b) Eq. cold bias vs thermocline response

(c) Eq. cold bias vs shortwave feedback

# Reducing the equatorial cold bias improves phase locking in the KCM and CMIP5 models



## Conclusion

Warmer sea surface conditions
in the cold tongue region lead to:

Higher convective activity
→ stronger shortwave feedback

Stronger upper ocean vertical stratification (Kim et al. 2013)
→ increases upwelling response to wind forcing
→ Increases thermocline slope response to wind forcing

Increases damping of the coupled system at the beginning of the calendar year
→ Lower variability in boreal spring

More unstable conditions towards the end of the calendar year
→ Higher variability in boreal winter

Stronger phase locking

# References

Bellenger H, Guilyardi E, Leloup J, et al (2014) ENSO representation in climate models: From CMIP3 to CMIP5. Clim Dyn 42:1999–2018. doi: 10.1007/s00382-013-1783-z

Jin F-F, Kim ST, Bejarano L (2006) A coupled-stability index for ENSO. Geophys Res Lett 33:2–5. doi: 10.1029/2006GL027221

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