UTILISATION D'ENSEMBLES PARAMÉTRIQUES FORCÉS/COUPLÉS

What can be learned from waves of tuning AMIP and Coupled simulations using HighTune ?

Brady FERSTER, Juliette MIGNOT, Julie DESHAYES, Guillaume GACHON, Guillaume GASTINEAU

Tuning the Coupled Model

Objectives

- **Can we efficiently use waves of LMDZOR as preconditioning for the IPSL-CM6 model ?**
  - **Should we revisit our metrics for future coupled tuning ?**
  - **Can we identify links between AMIP and Coupled climates in -LR ?**
  - **Can we translate these preconditioning results between model resolutions (-VLR, -LR, -HR)?**

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Parameters

HighTune Name	Min. Parametric Value	Max. Parametric Value	IPSL Model Value	Model Component	Short Description
RNALB	0.	1.	0.50	SICE	facteur multiplicatif pour régler les 4 albédos en même temps
RNCDN	0.10	0.50	0.31	SICE	rn_cnd_s (thermal conductivity of the snow over sea ice, W/m/K)
RNCE	0.06	0.08	0.06	NEMO	rn_ce
RNLC	0.05	0.5	0.15	NEMO	rn_lc
CLC	1E-04	1.00E-03	6.5e-4	LMDZ	seuil d'autoconversion de l'eau nuageuse liquide
FALLV	0.3	2.	0.8	LMDZ	vitesse de chute des cristaux de glace
OMEPMX	0.0003	0.02	0.001	LMDZ	1-epmax
DZ	0.04	0.12	0.07	LMDZ	parametre controlant le detrainement au sommet des thermiques
EVAP	5E-05	5.00E-04	1.00E-04	LMDZ	coefficient sur la réévaporation des pluies
GKDRAG	0.2	2.	0.6	LMDZ	sso_gkdrag
PCENT	0.3	1.	0.8	ORCH	Pcent
ASNOW	5.	15.	10.	ORCH	tcst_snowa

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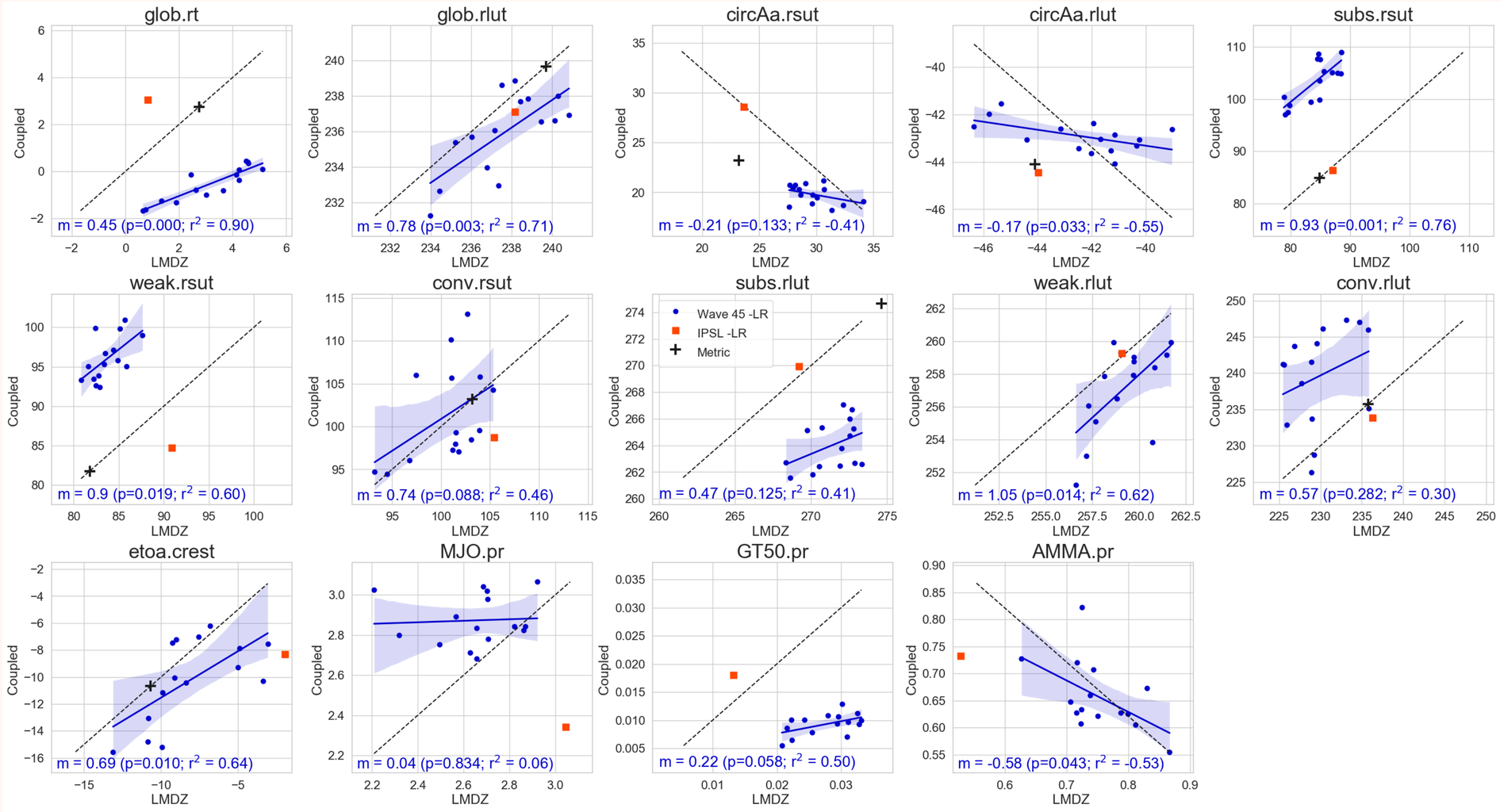
Metrics in Forced vs Coupled



Not all metrics exhibit a similar 1:1 behavior between AMIP and Coupled

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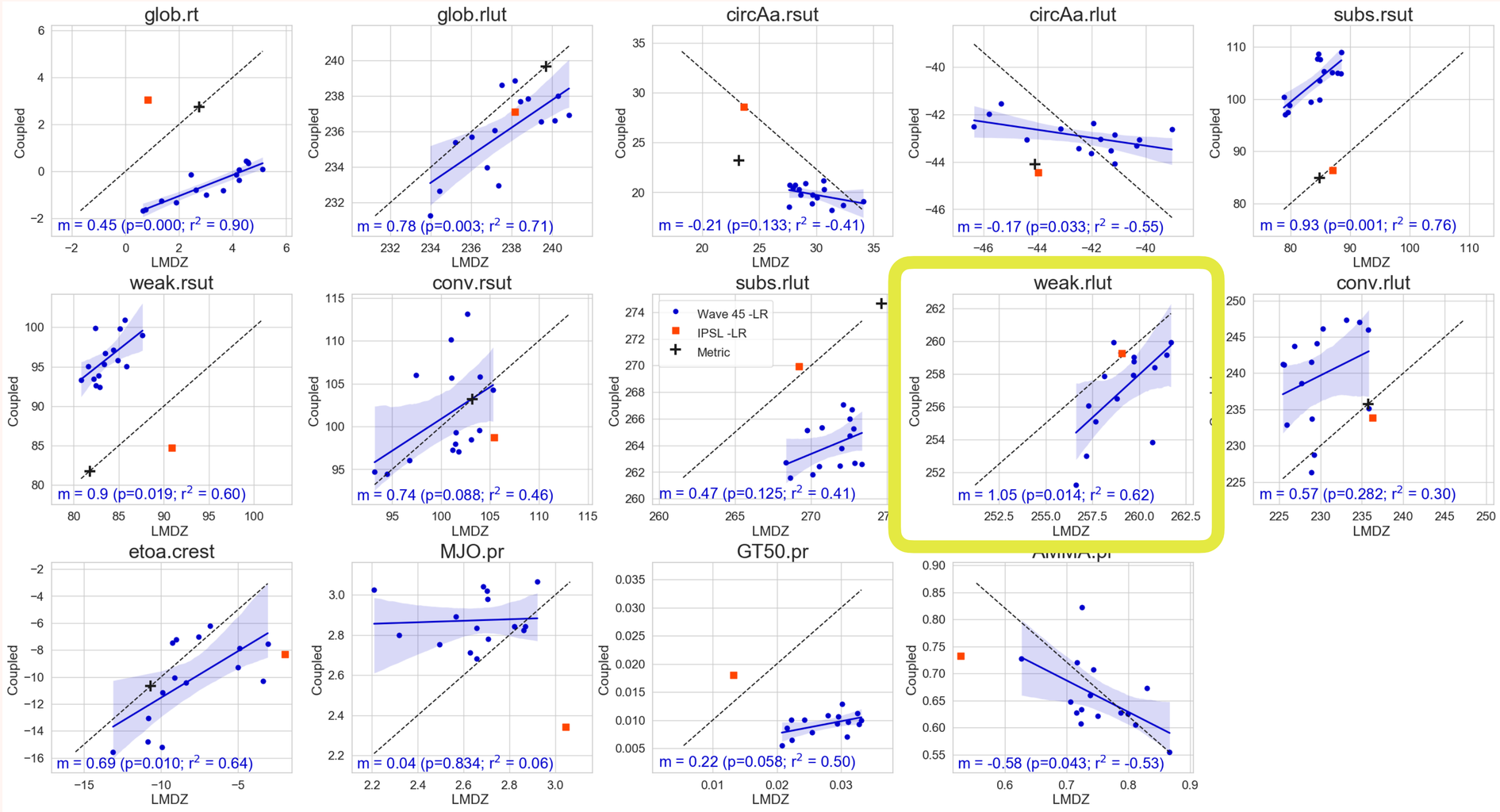

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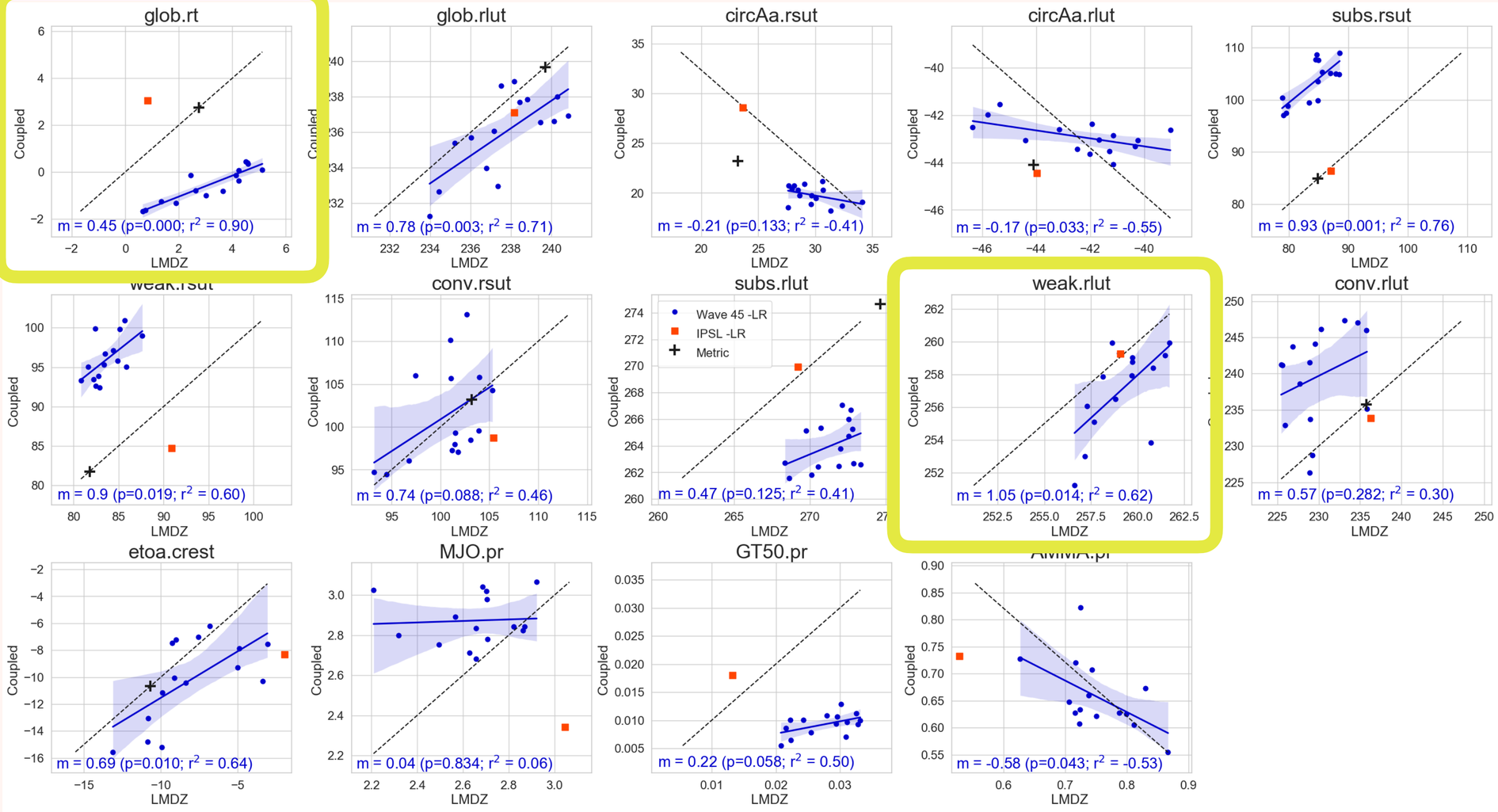

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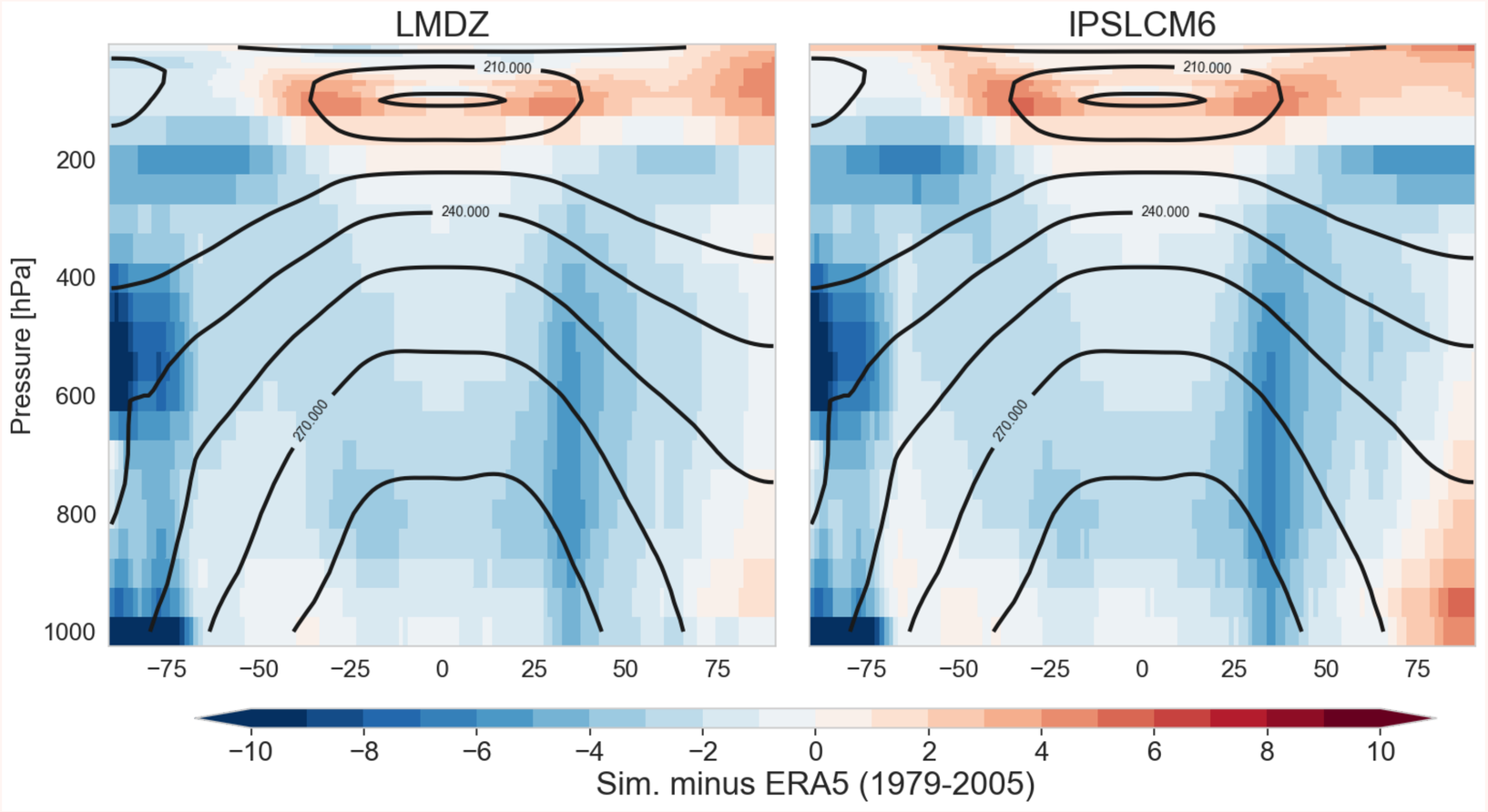
Why is this Important ?

Current version is being tuned too cold at the surface and too warm in the stratosphere



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Difference in Forced vs Coupled

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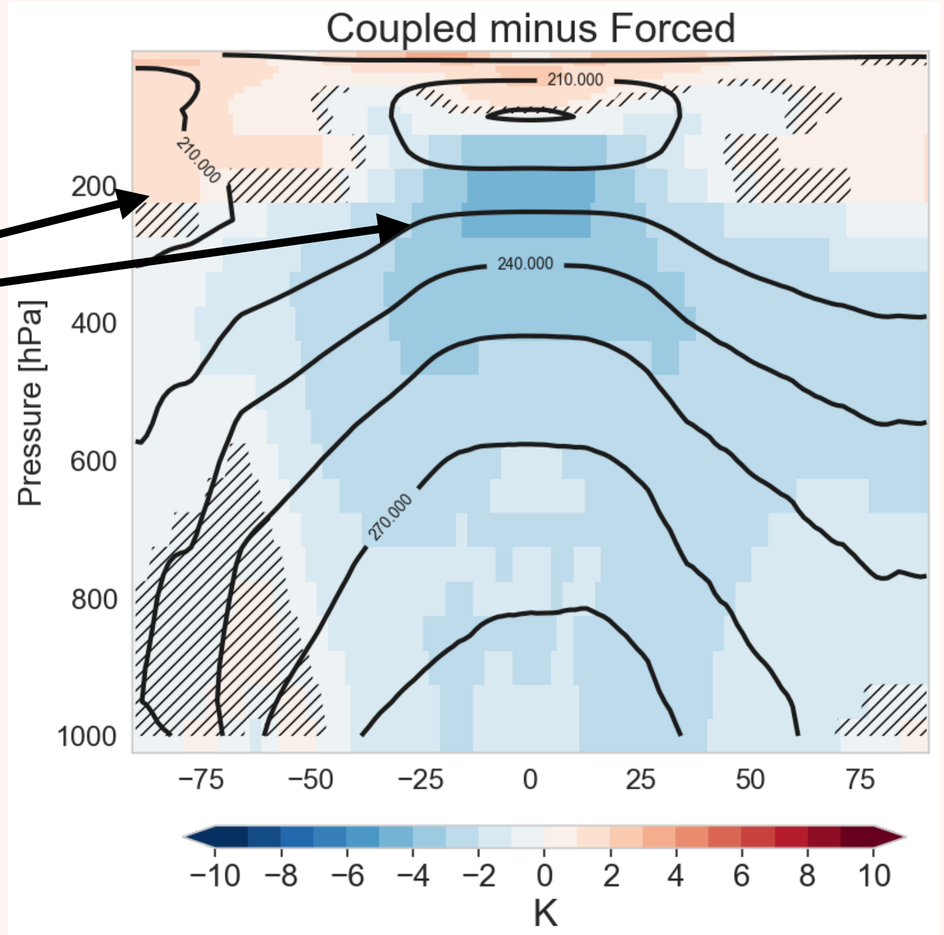
15 Simulations

- **AMIP runs:**
  - **Cooler stratosphere, warmer tropopause**
- **Coupled runs:**
  - **Larger spread between simulations in polar regions (see individual simulations)**
- **Thermal gradient in the mid-latitudes**
  - **Important for structure of zonal winds and reaches the surface**



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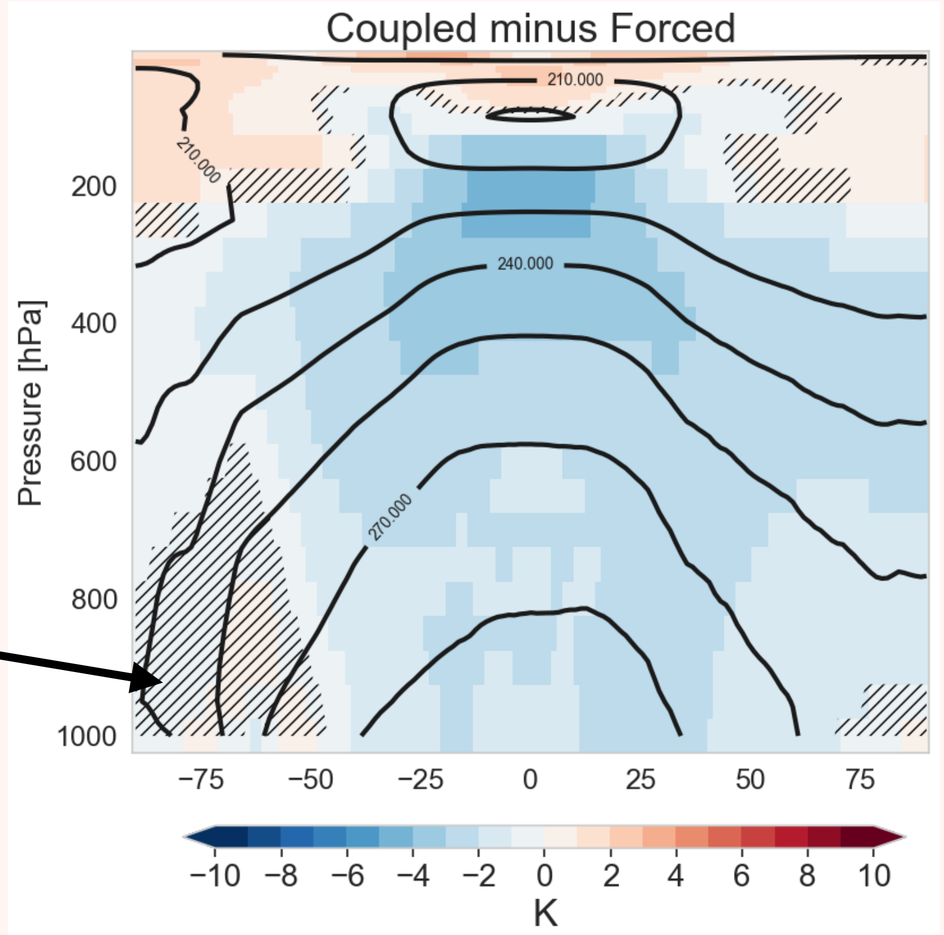

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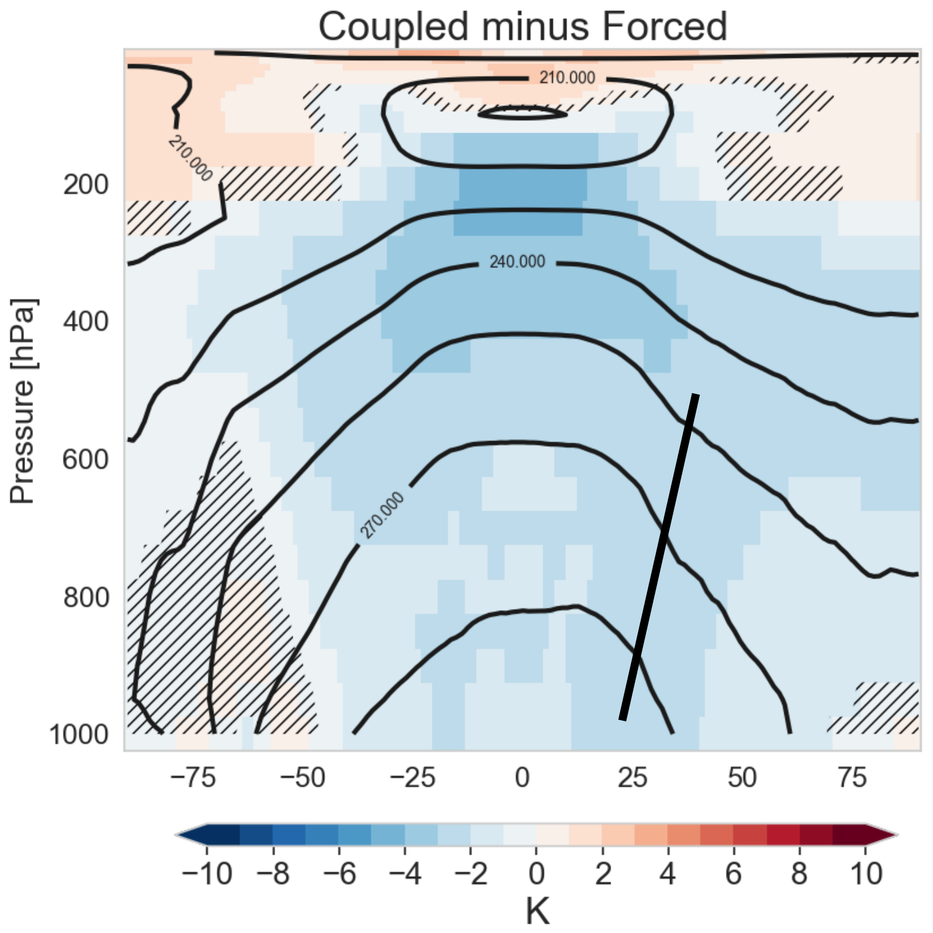

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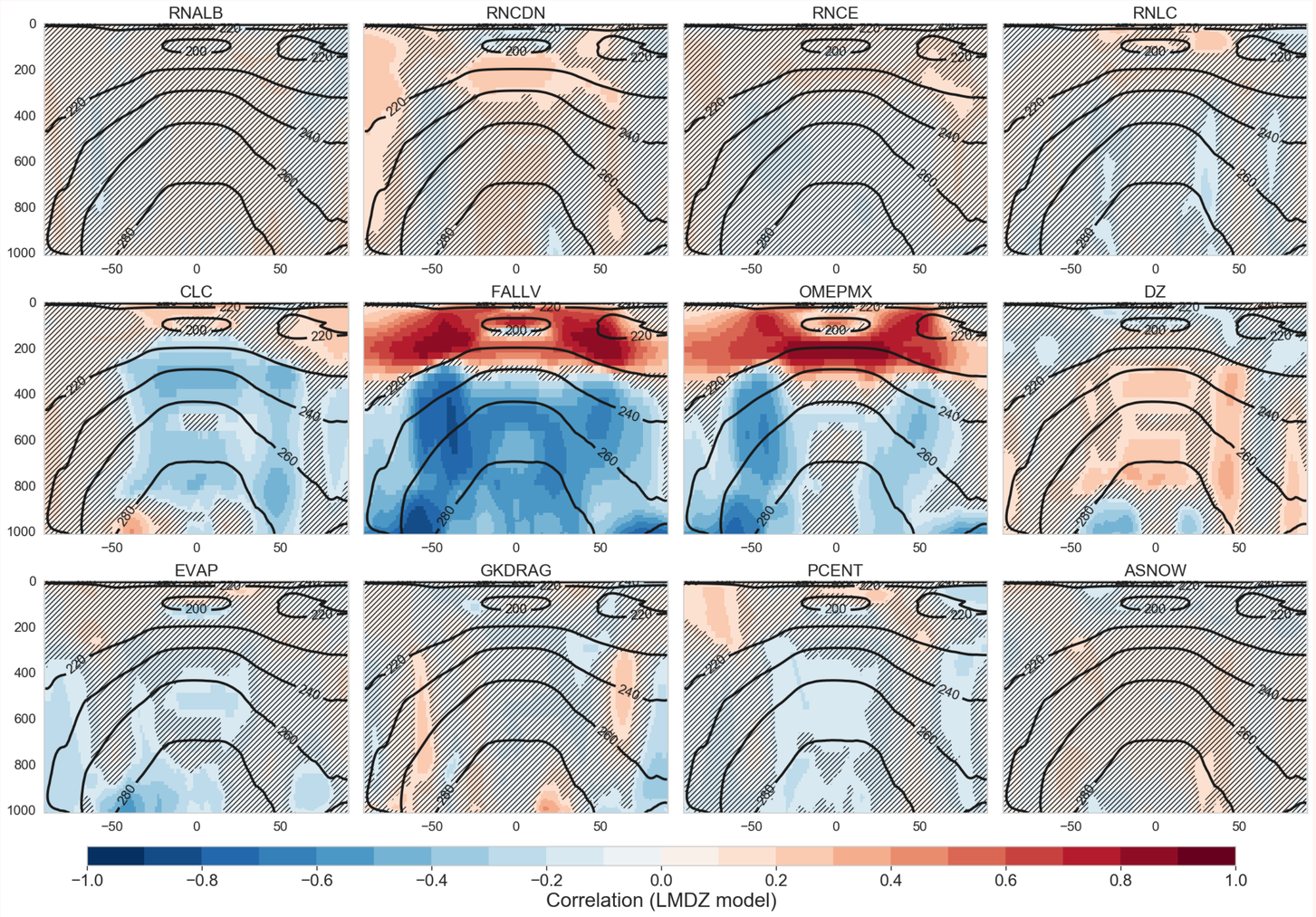
Forced Response to Parameters

- **FALLV & OMEPMX largely constrain vertical temperature gradient between stratosphere and troposphere**
- **CLC, DZ, EVAP, and PCENT also large impacts to tropics and extra-tropics**
- **Is this the same in the Coupled?**



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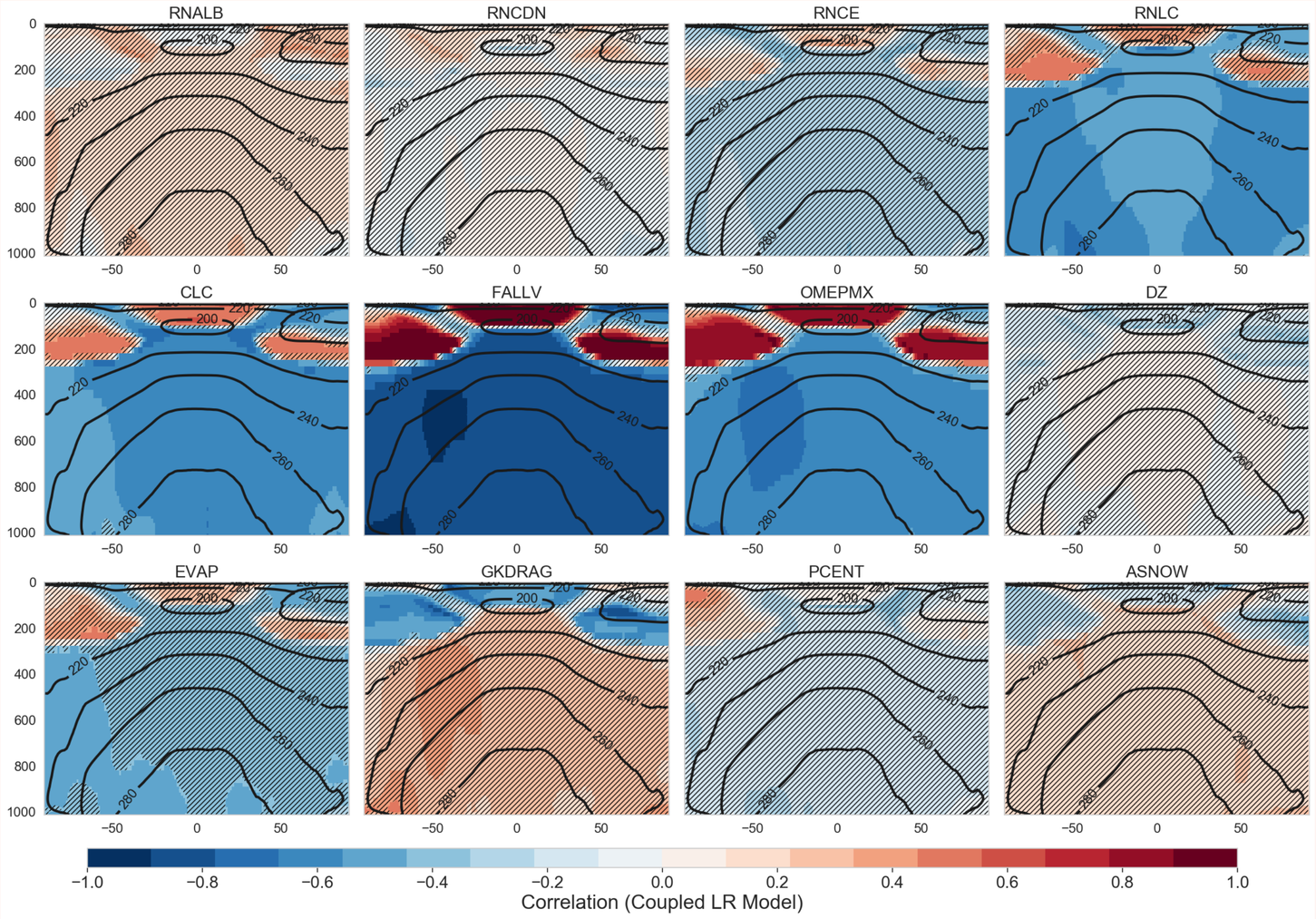
Coupled Response to Parameters

- **FALLV , OMEPMX, CLC, & RNLC constrain global theta**
- **Even larger impacts the Southern Hemisphere (similar to forced)**
- **CLC and RNLC become more important for coupled than forced**



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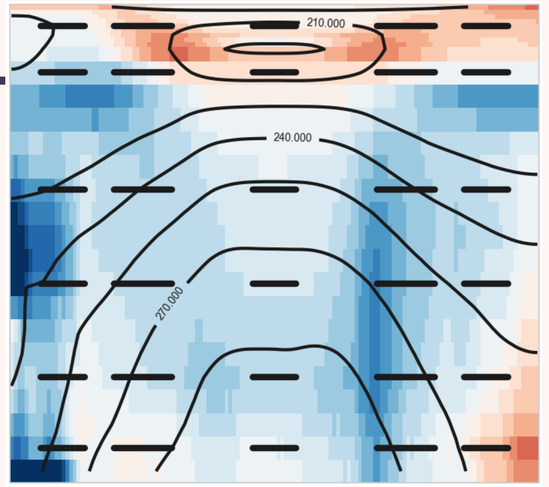
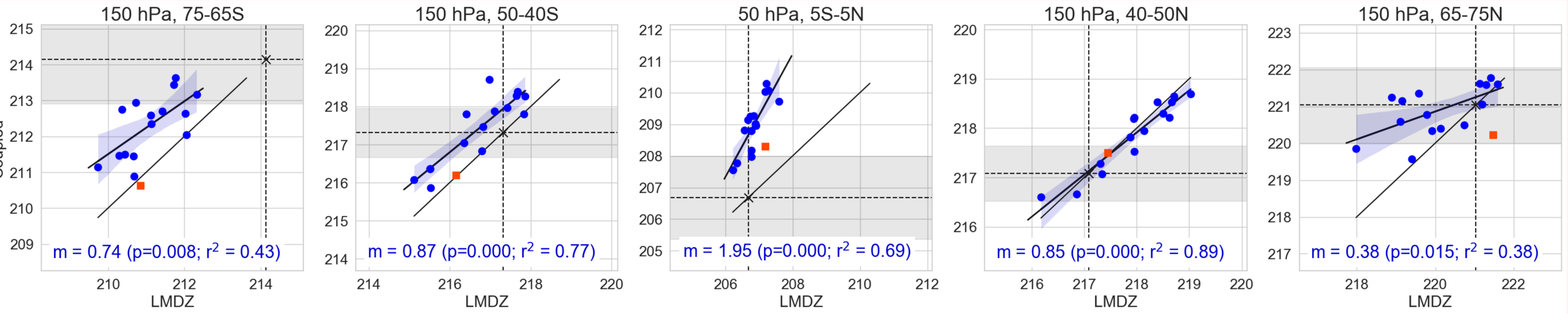


Bias compared to ERA 5

- **Focus on those regions with a significant 1:1 relationship of Forced:Coupled**
- **Upper-tropopause and Stratosphere represent regions of 1:1 relationship in -LR**
  - ***Could this be a useful metric to include for AMIP Preconditioning ?***
  - ***Some metrics already within observations***



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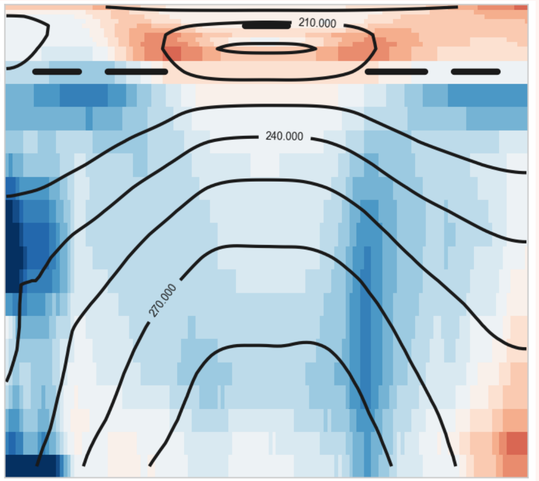

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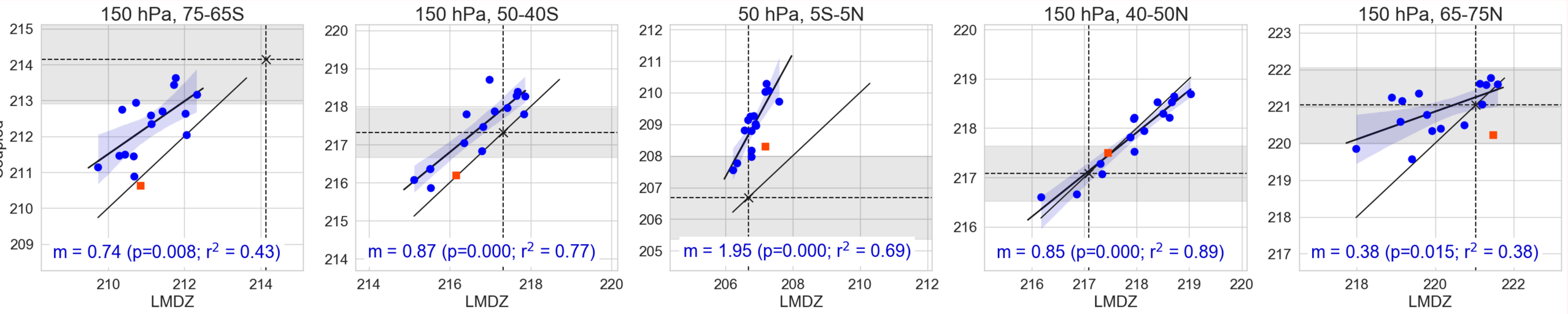

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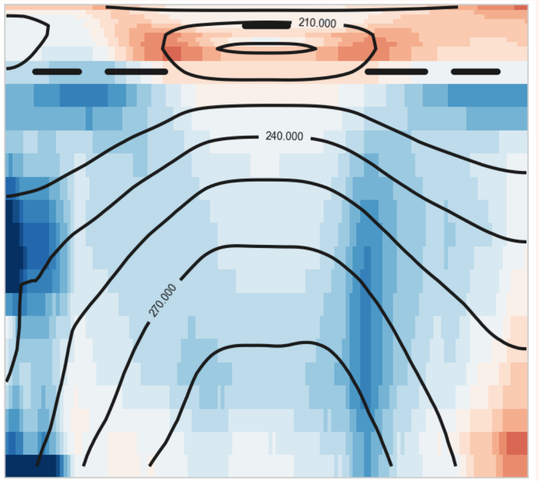

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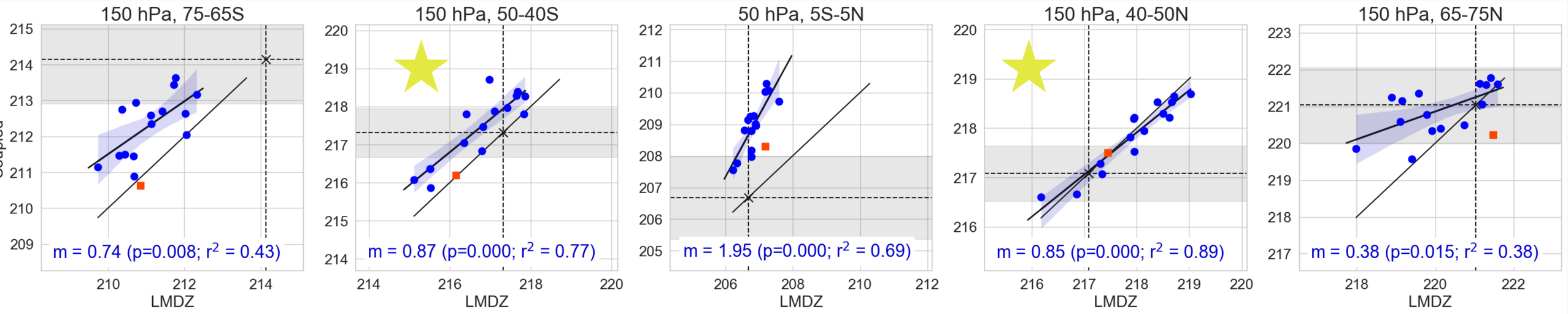

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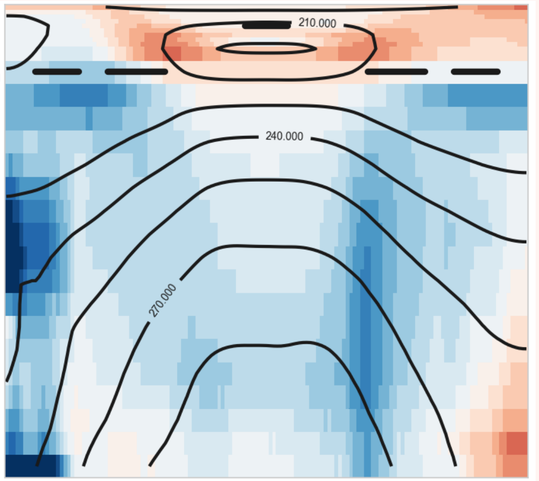

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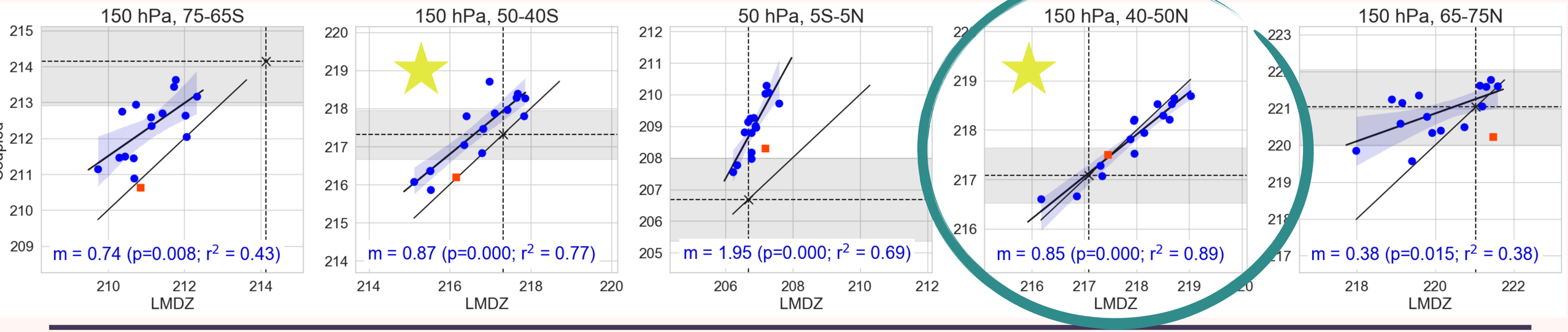

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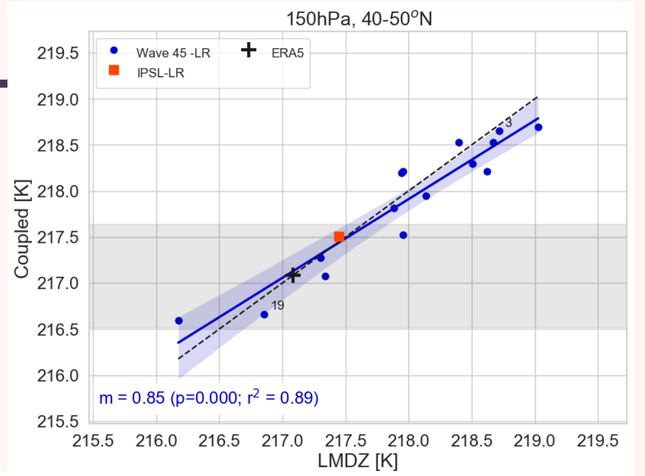
150 hPa Metric

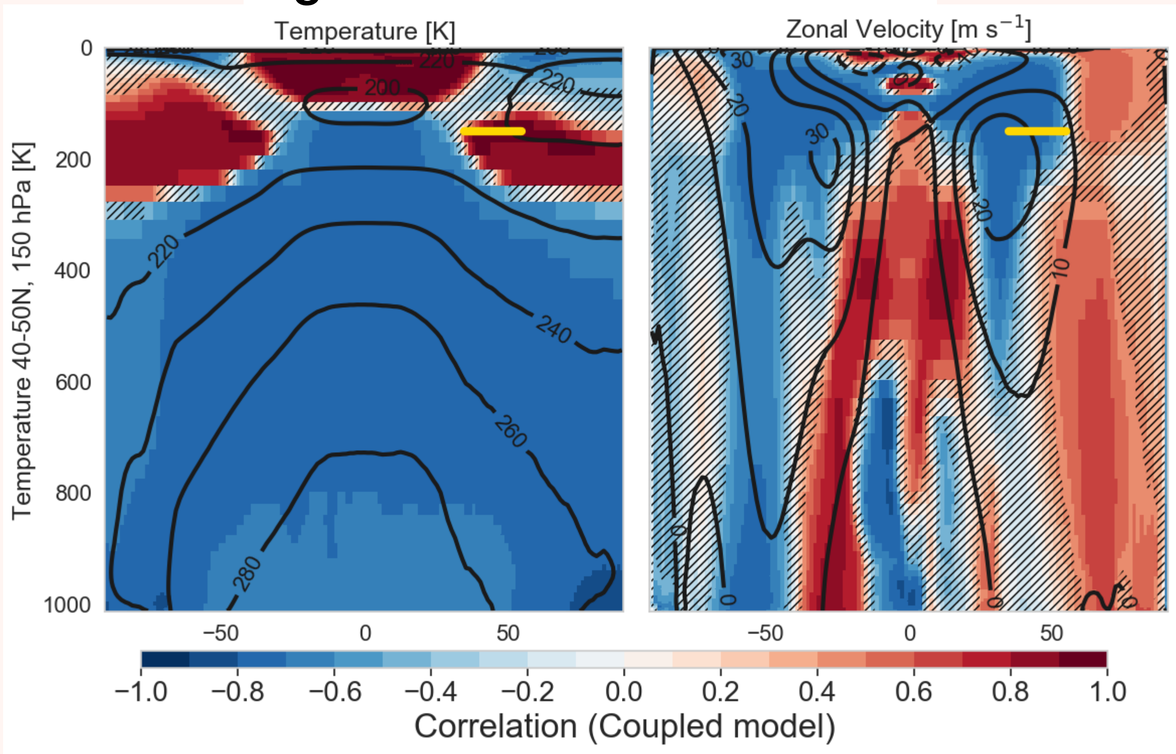


- Stratosphere metrics mostly constrain stratosphere/ tropopause and the surface of the polar regions
- Negative correlation to the N.H. jet

Anomalies of Warm (black) minus Cold (gray) stratospheric metric

- 1 K in the theta metric is approx. 3 K to the polar surface and 2 K equatorial
- Warmer stratosphere leads to reduced jet
  - Reduced polar easterlies

High metric minus Low metric



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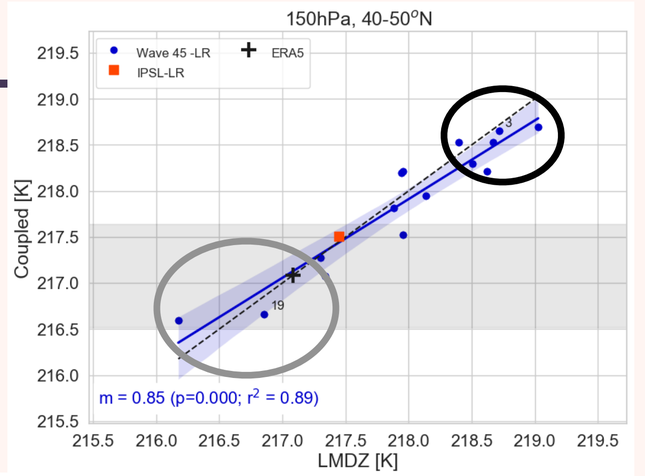

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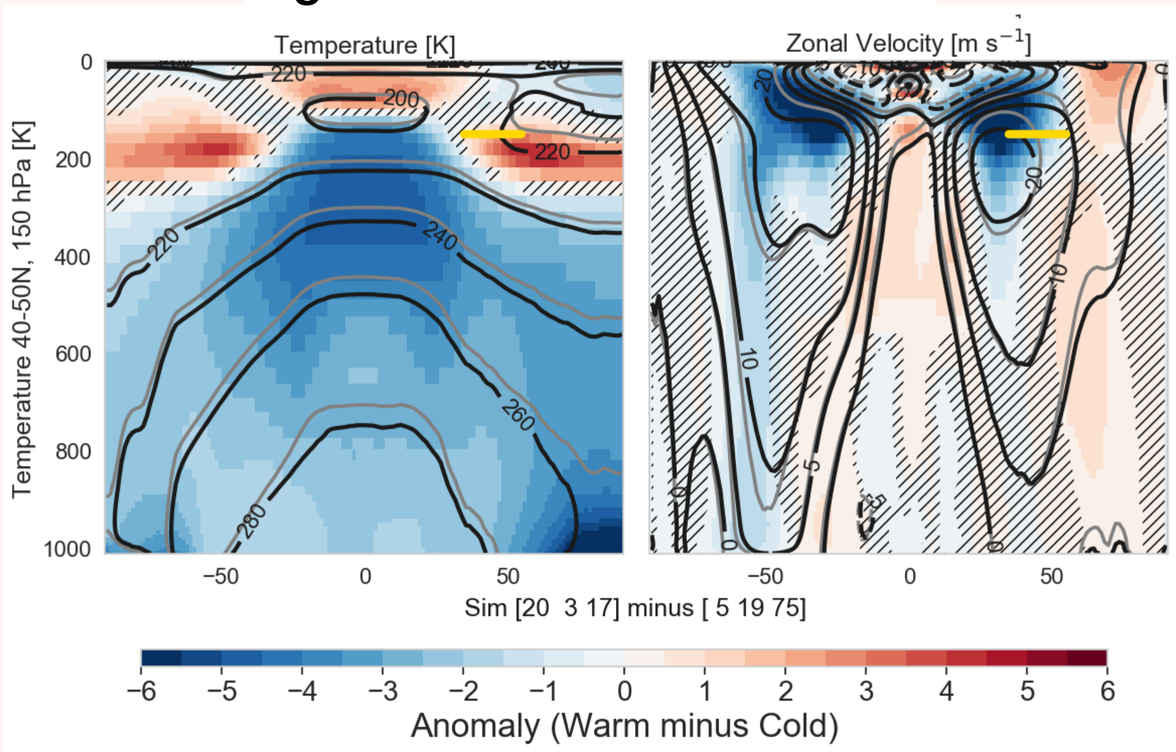

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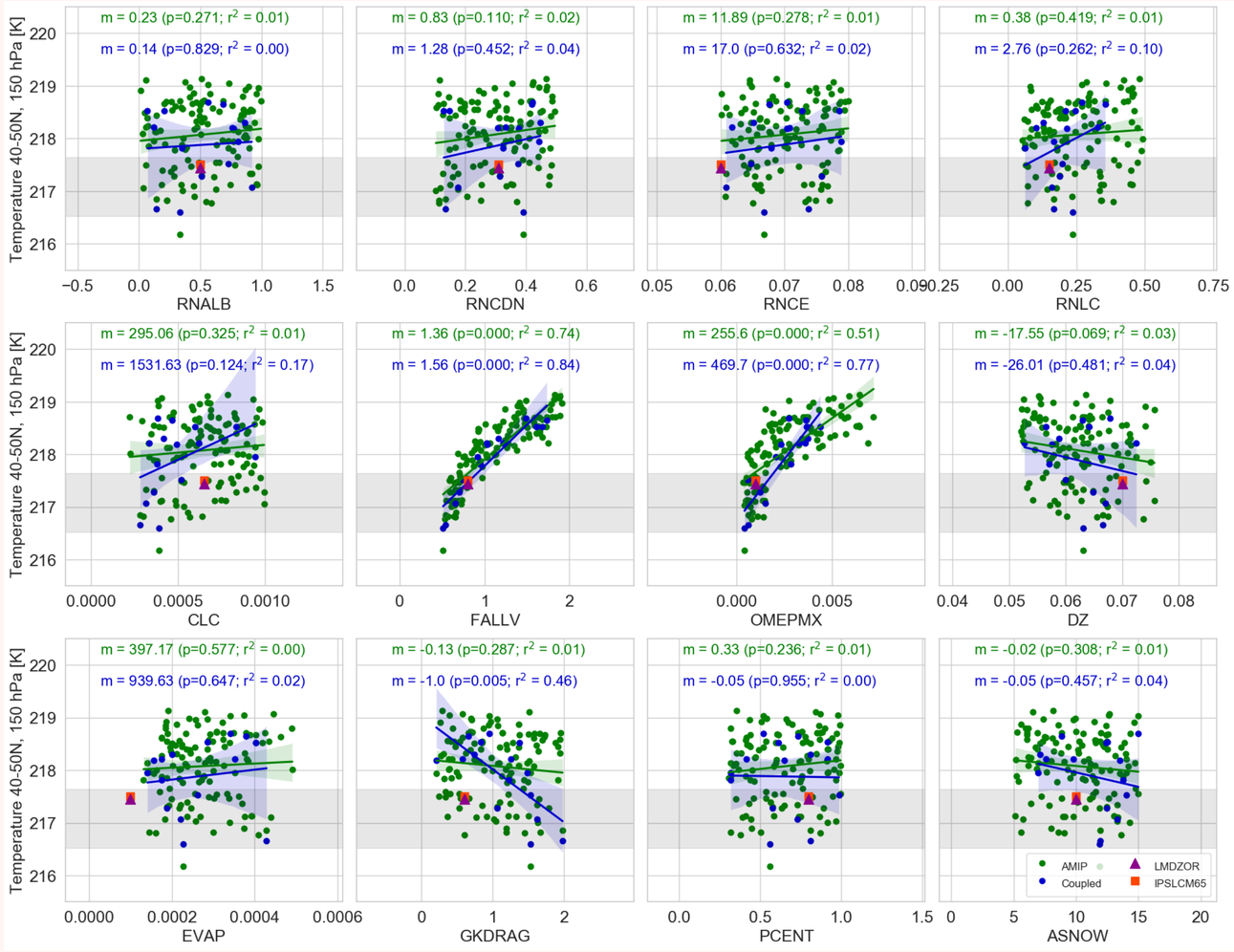
Temperature Metrics vs Parameters

Stratospheric Metric

- **Similar slopes of Forced and Coupled responses in FALLV and OPEMPMX**
  - **Could this metric help reduce uncertainty and constrain temperature?**
- **GKDRAG becomes important for Coupled models**

****Gray shading represents ERA5 from 1979-2004**



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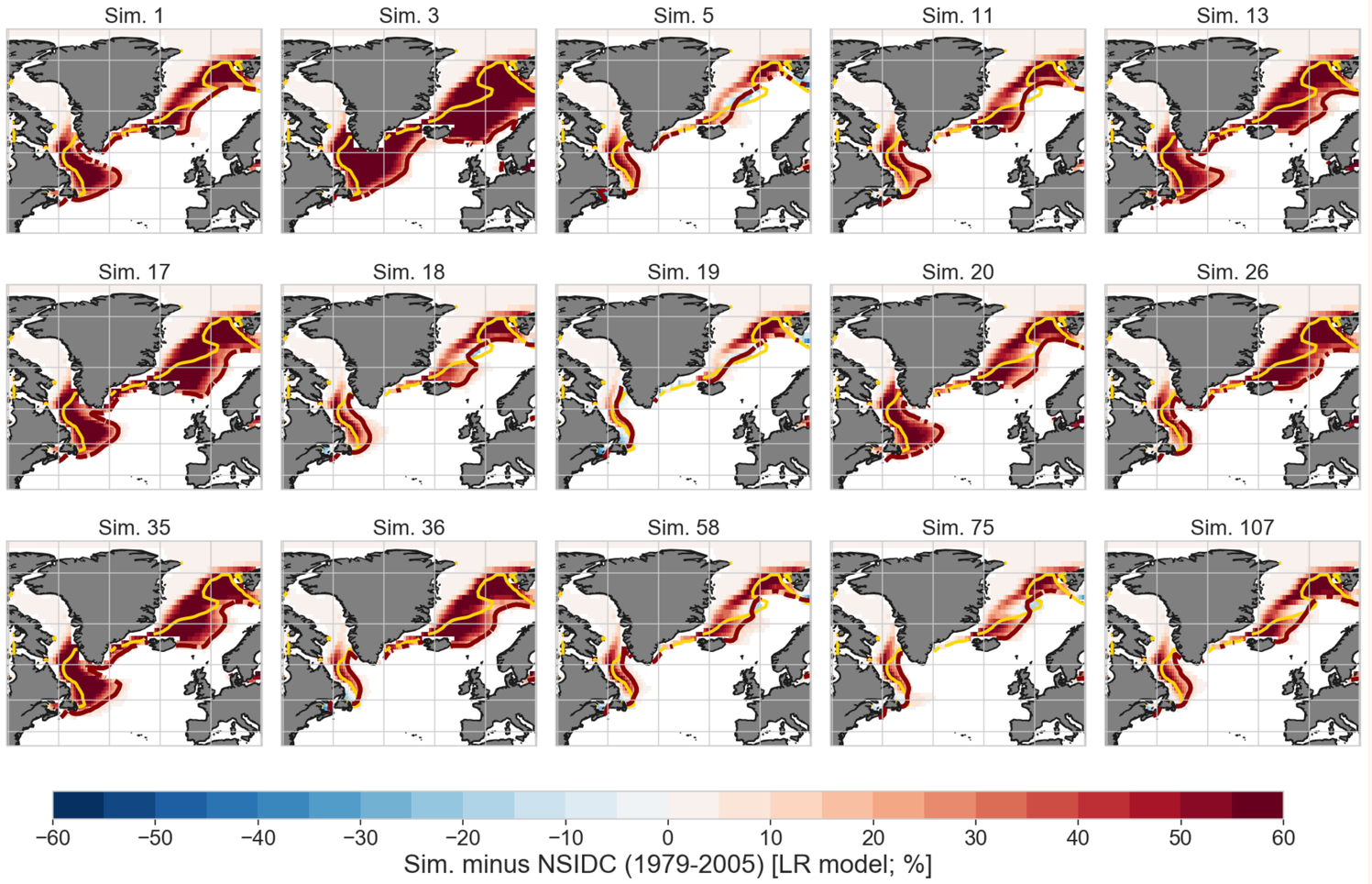
Temperature Metrics Driving Arctic Sea Ice

Coupled Model Simulations

- **Some simulations represent subpolar sea ice better than others**



Can we apply these metrics and parameters to Arctic sea ice extent ?

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Coupled Model Simulations

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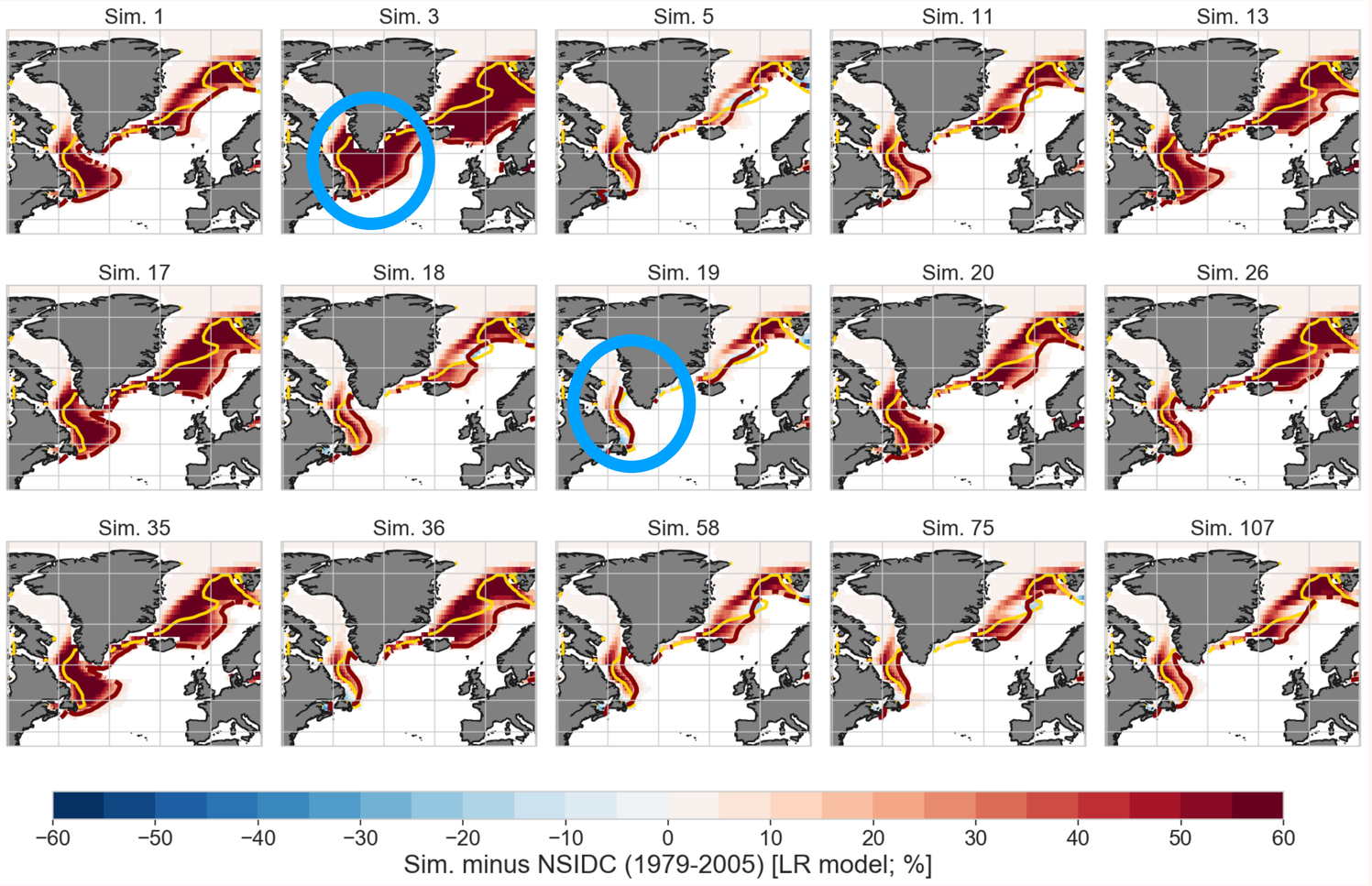
- Simulation 3:
  - High stratospheric metric, low glob.rt
- Simulation 19:
  - Low stratospheric metric, high glob.rt



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- **Coupled model exhibit too much JFM Arctic sea ice compared to NOAA NSIDC (1979-2005; gold line)**
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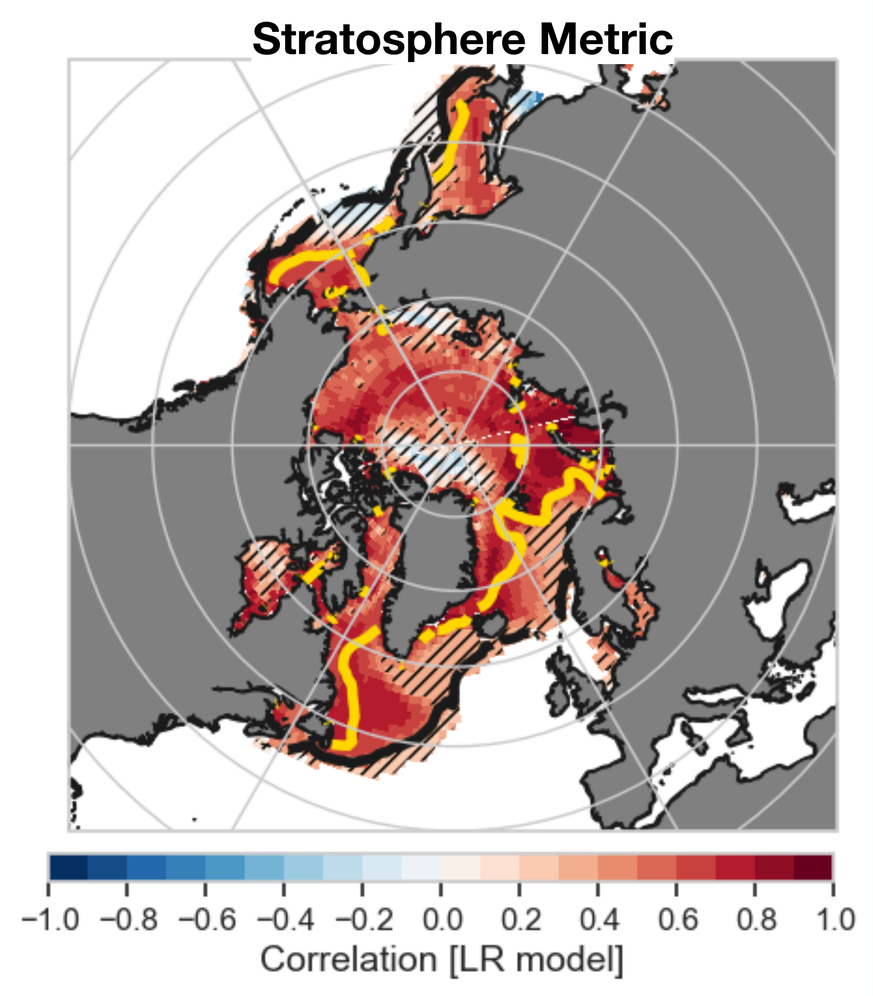
  - **Reducing stratospheric biases (lower metric values) COULD be related to Arctic climate**



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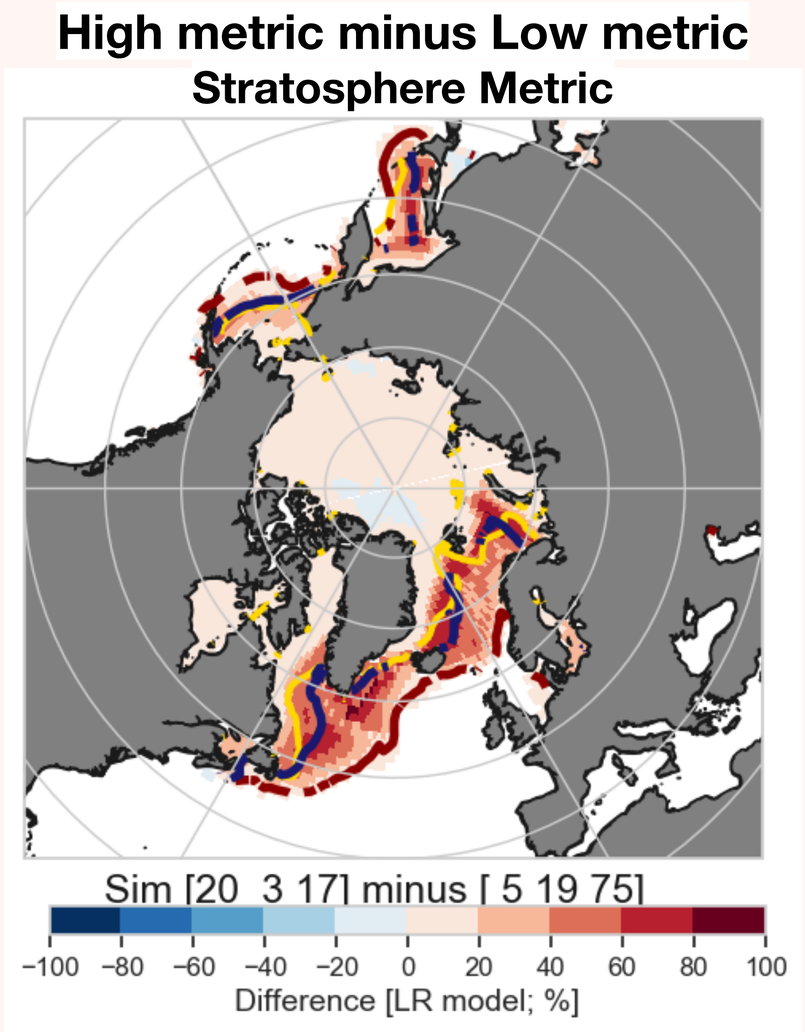
- Models with the low stratospheric metric (dark blue) exhibit Arctic sea ice extent more comparable to NSIDC (1979-2005; gold line)
  - Models with high metric value (red) over-estimate Arctic sea ice



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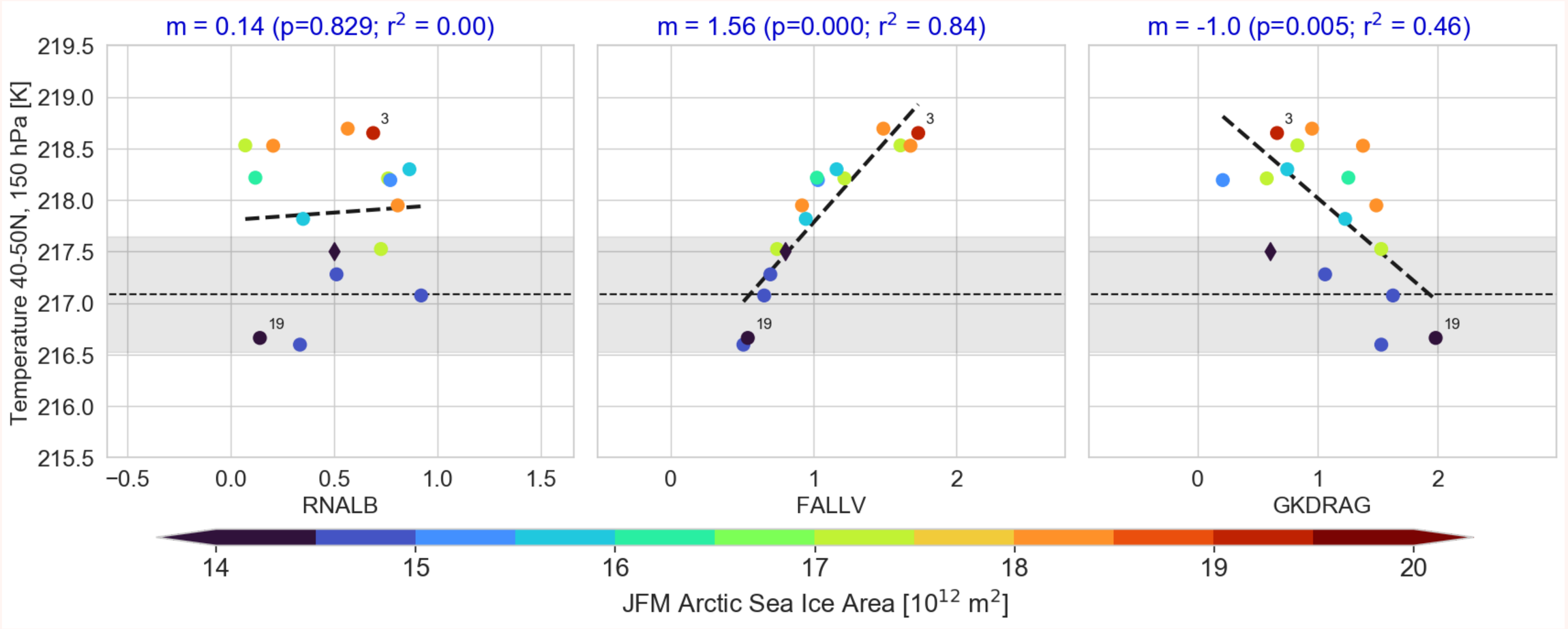
Parameters, Metrics, & Sea Ice

Stratosphere Metric

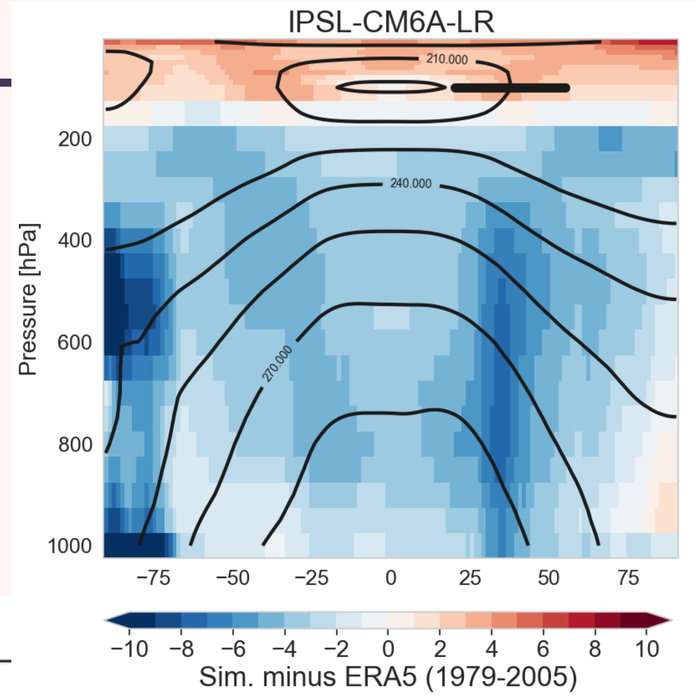


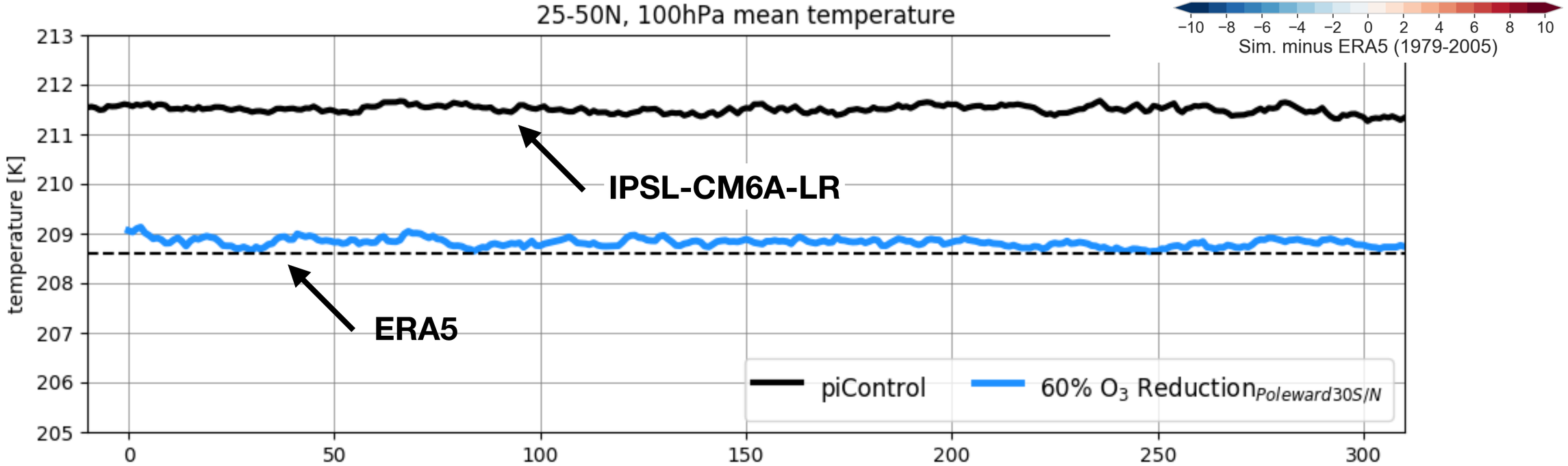
A stratospheric metric can be used to reduce parametric space and constrain Arctic sea ice

Can the parameters, metrics, and sea ice all be related ?

Stratospheric Mechanism

- **Experiment reducing stratospheric temperature bias through O_3 reduction poleward of 30deg latitude in both hemispheres**





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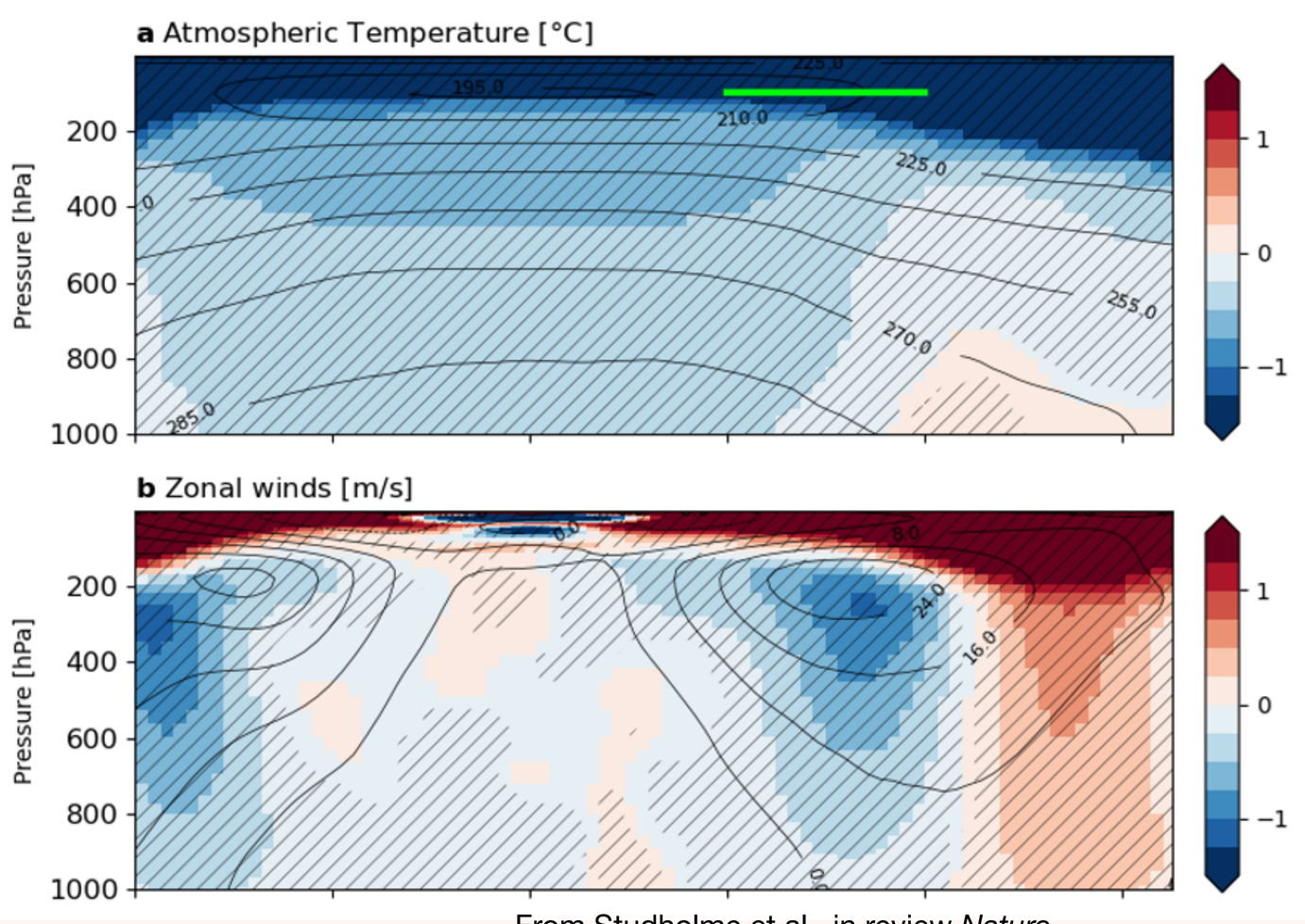

From Studholme et al., in review *Nature*

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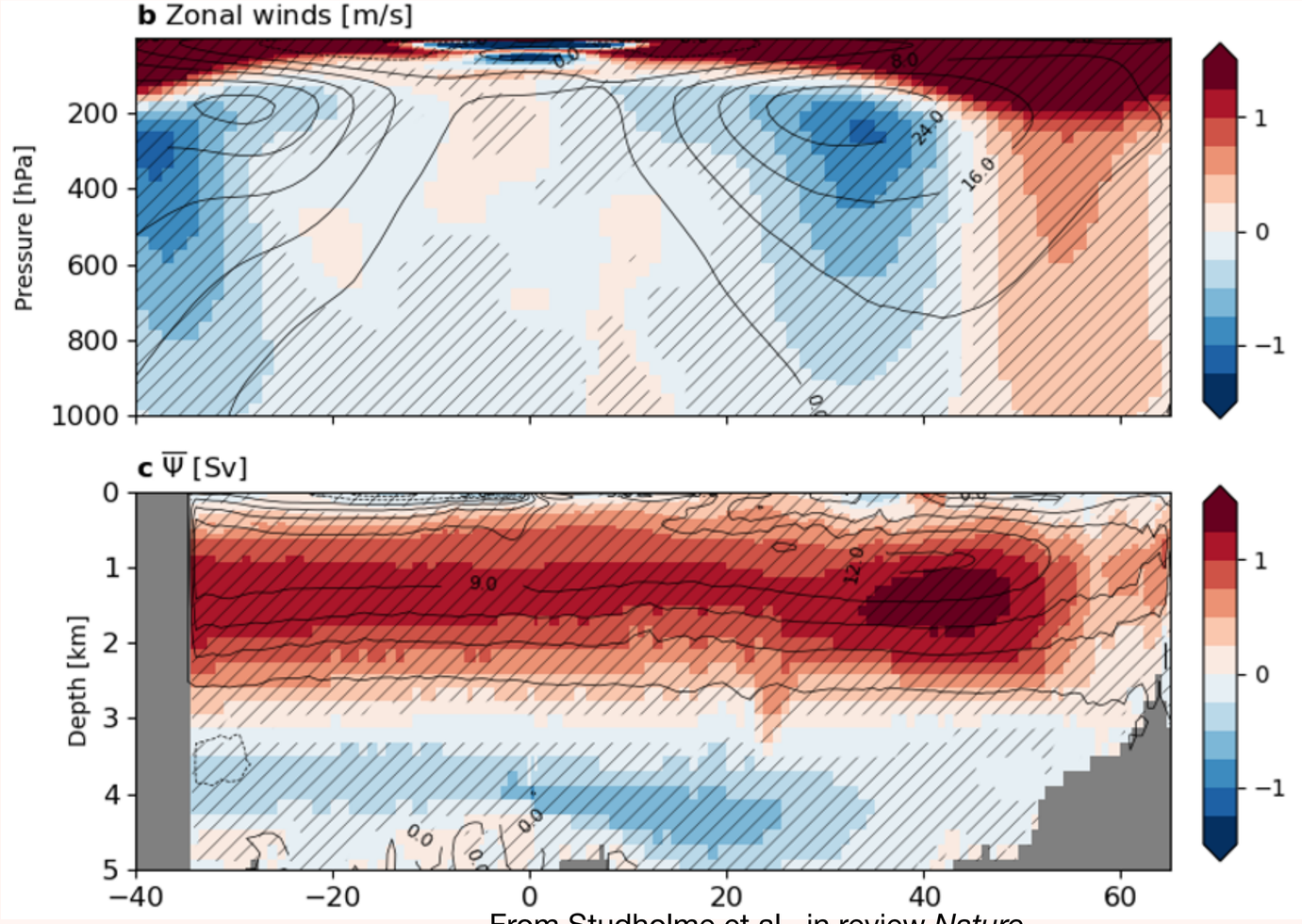
  - **Reduces subpolar Atlantic winter sea ice extent**



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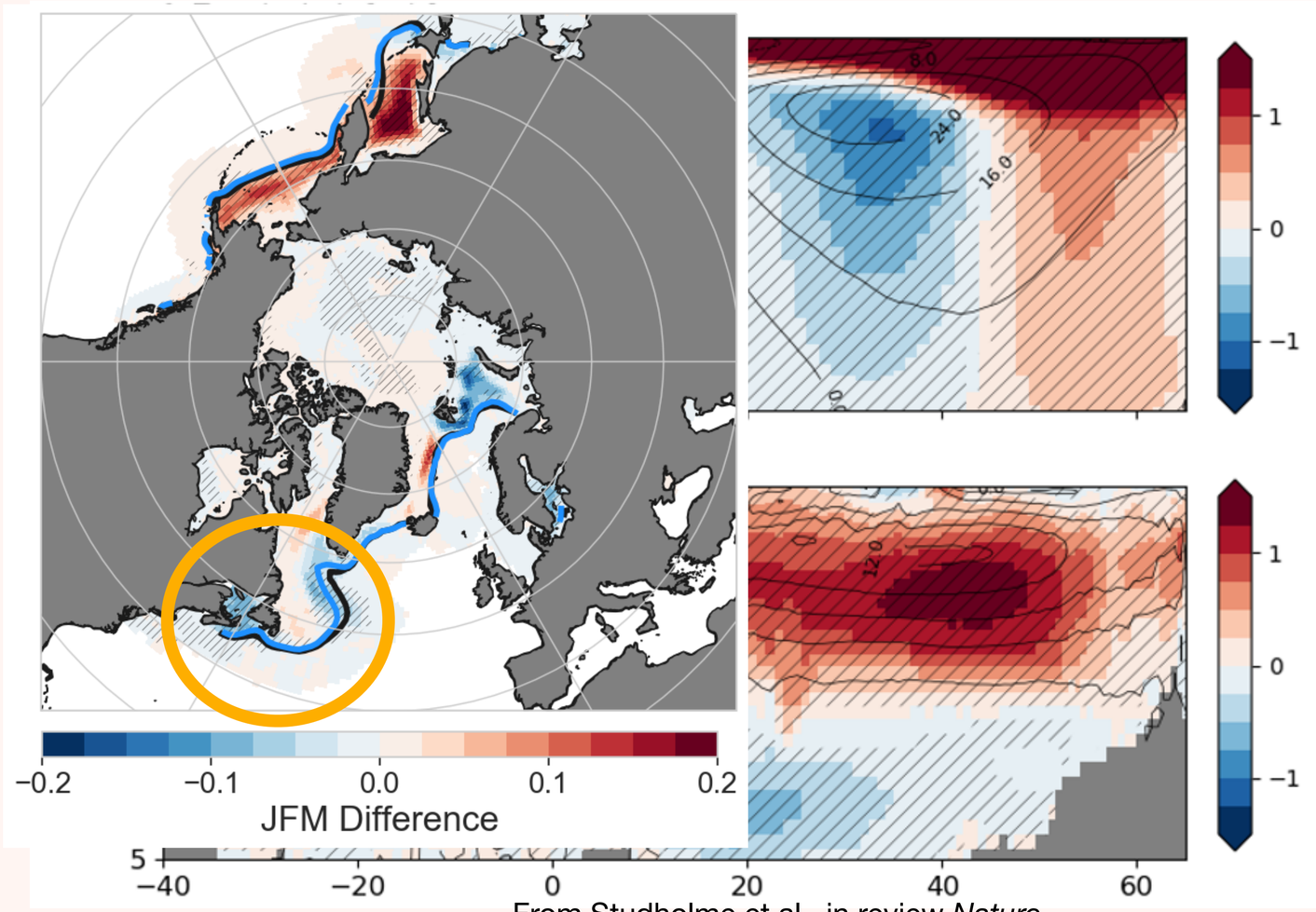

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Lessons Learned

1. We need to adjust the *glob.rt* target metric closer to 6.4 W m^2 to within the 1979-2004 mean

2. Tropopause and Stratosphere offer 1:1 Forced to Coupled relationship
   - Potential to include in AMIP preconditioning as a metric

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   - Coupled model theta is more sensitive to FALLV than AMIP

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3. **Sea ice in the coupled simulations is constrained by atmospheric theta and FALLV parameter**

   - **Coupled model theta is more sensitive to FALLV than AMIP**

By including an upper atmosphere metric, which in part helps with refine parametric space, can work to constrain the mean Arctic sea ice extent in the coupled model

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