

Asian Monsoon Overturning in Large-Ensemble Climate Model Simulations

Jonathon S. Wright & Yuanrui Chen [Department of Earth System Science, Tsinghua University, Beijing]; Franklin Tat-Fan Cheng & Lun Dai [Hong Kong University of Science & Technology]



Objectives

Systematic view of South Asian monsoon overturning and its links to summertime surface climate and extremes

- Compensations vs compounding errors – can root causes be deduced?
- Common features between model biases and model responses to forcing?

Background

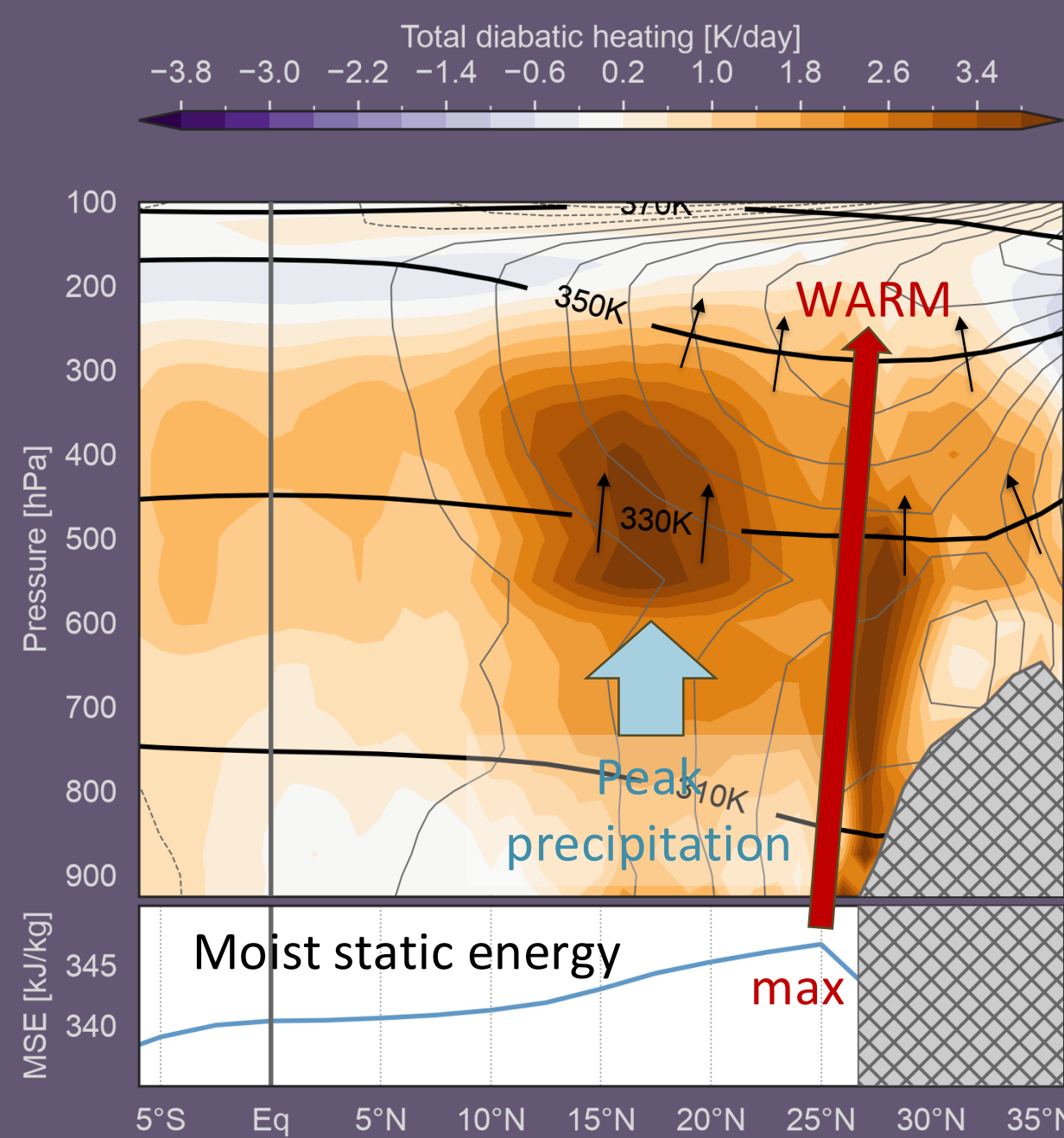
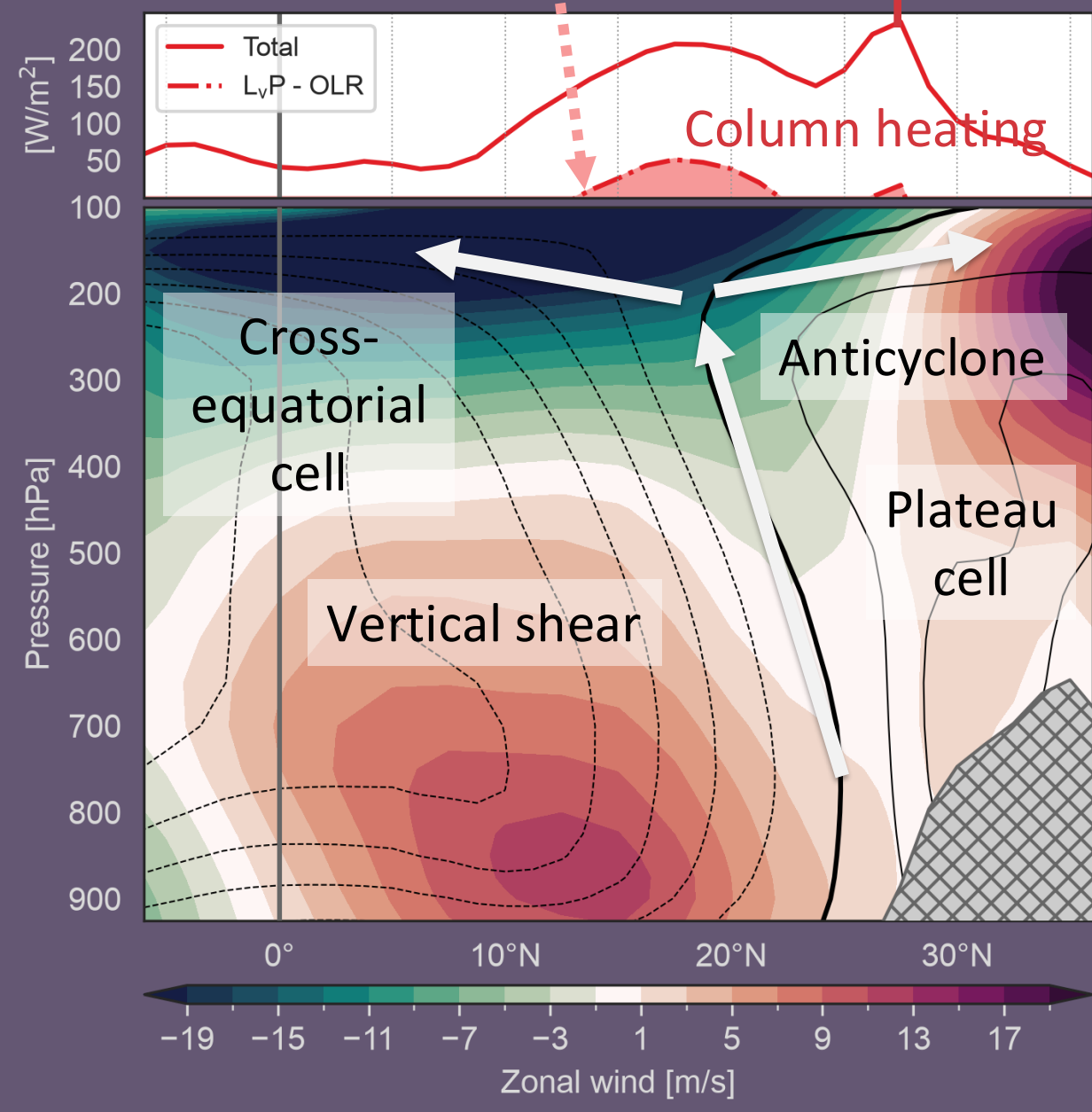
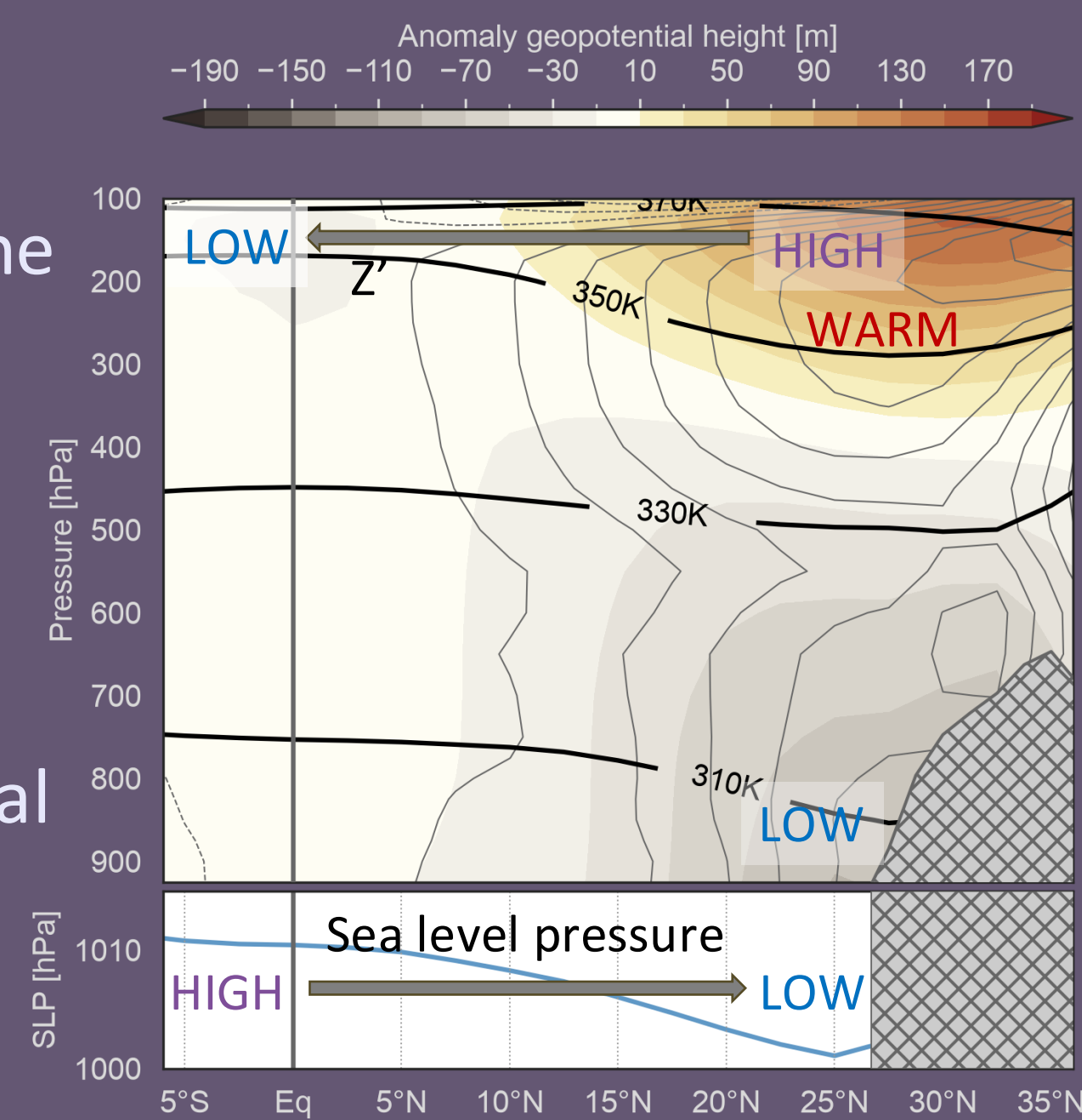
The LEADER monsoons working group is using large ensemble historical and single forcing simulations to study the forced response of the Asian monsoon and associated impacts on surface extremes

Convective balance equation: $c_p \frac{\partial \langle T \rangle}{\partial t} + \nabla_h \cdot \langle v s \rangle \approx L_v P - \text{OLR} + F_{\text{LW}\uparrow}^{\text{sfc}} + Q_{\text{SW}} + H$

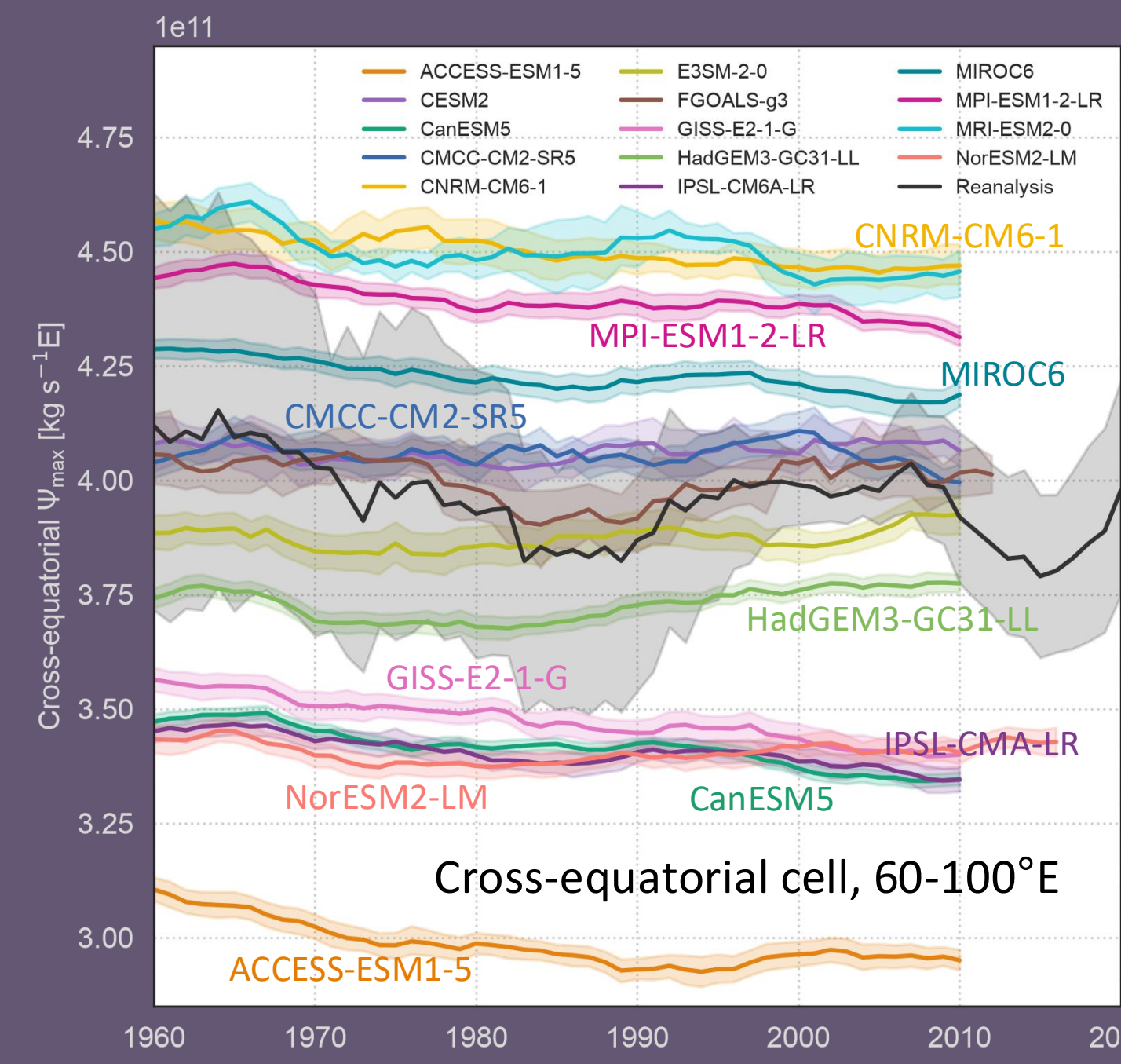
Common issues and outlook:

1. Heating too strong over equator
2. Heating too weak or absent over North India
3. Underestimate vertical shear of zonal wind
4. Moist static energy distributions too flat
5. Most models show weakening overturning
6. Convective column heating is a useful metric
7. Next steps target seasonality and variability

Upper-level anticyclone
Monsoon thermal reversal
SLP minimum



Upper-level warm anomaly (static stability)
Two centers of heating
Peak in 925 hPa MSE



Considerable diversity across models

Benchmarks

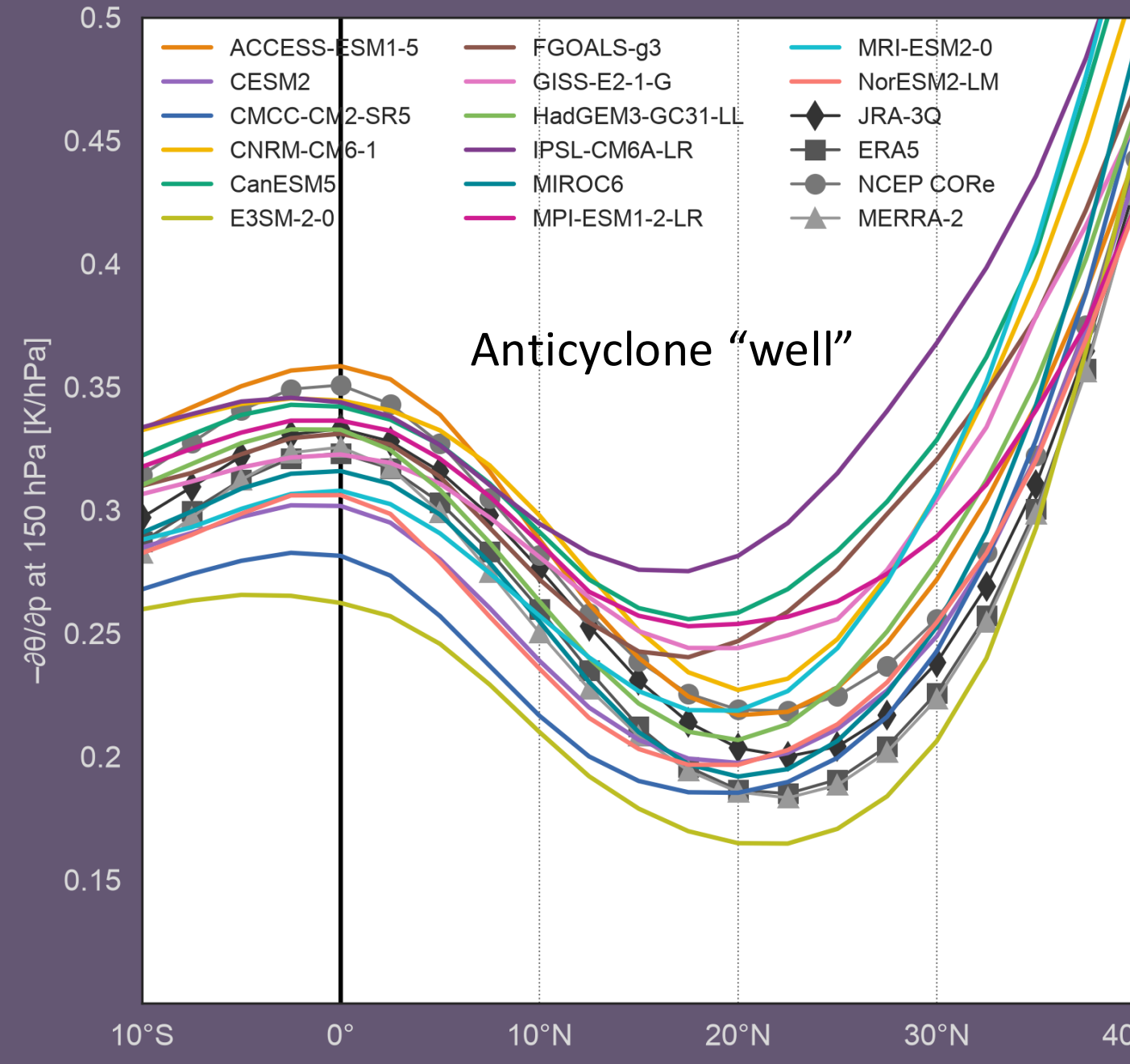
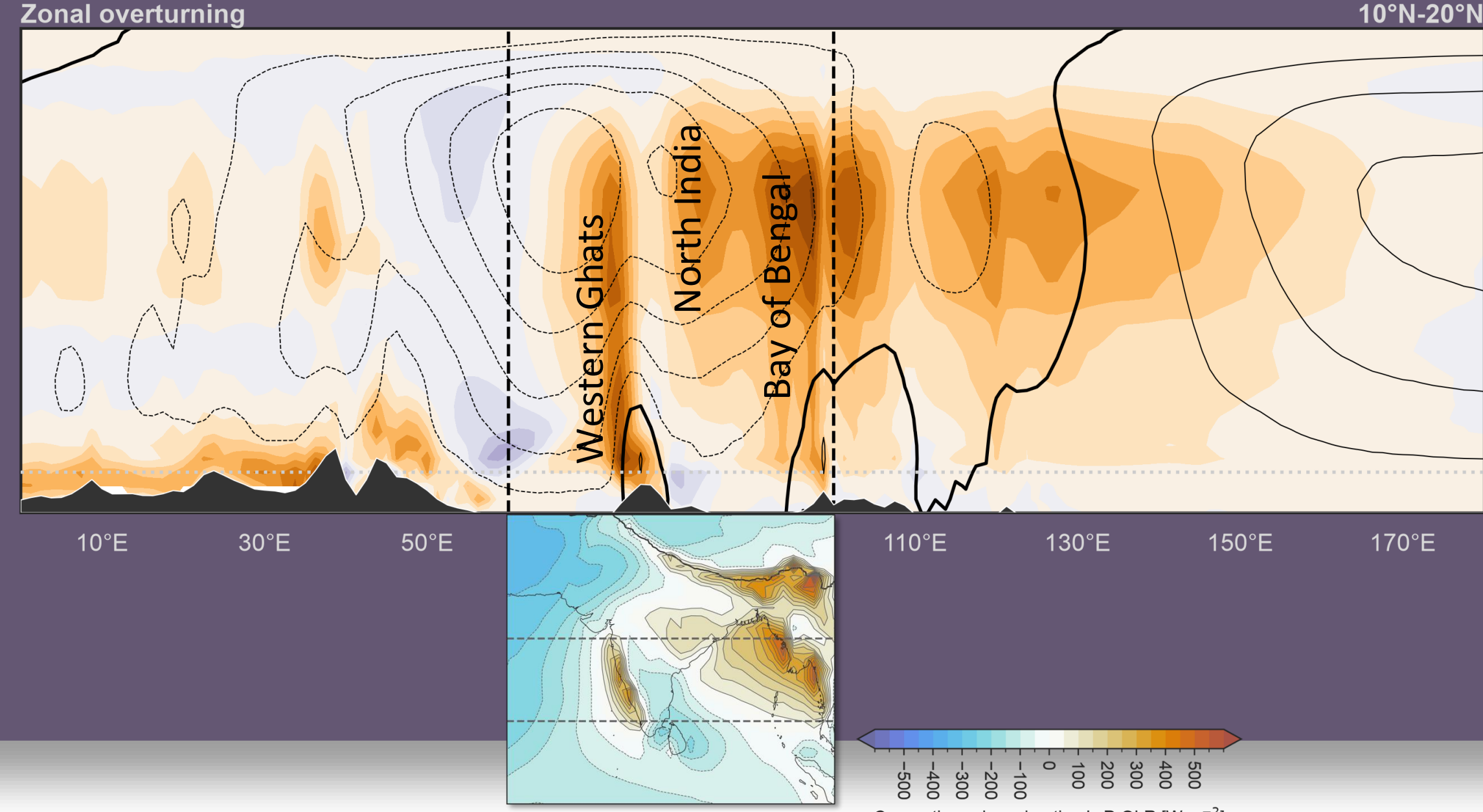
Upper-level
Column
Surface

Mass circulation

ASM anticyclone
Mass streamfunction
Sea level pressure

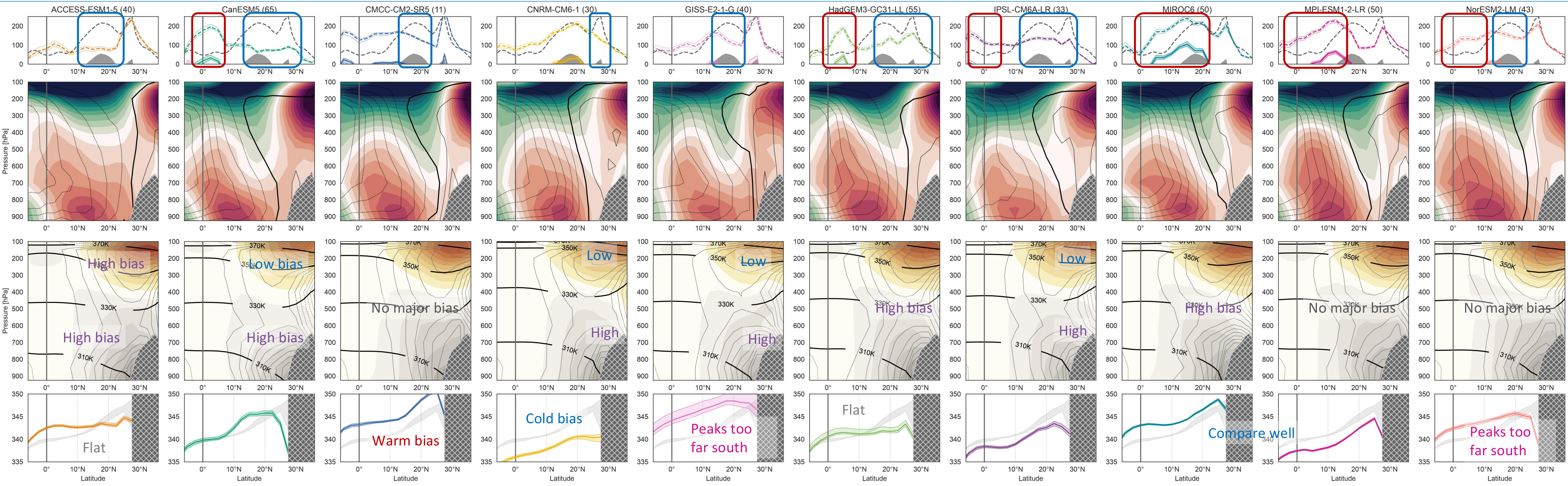
Energetics

UT warm anomaly
Diabatic heating
Low-level MSE

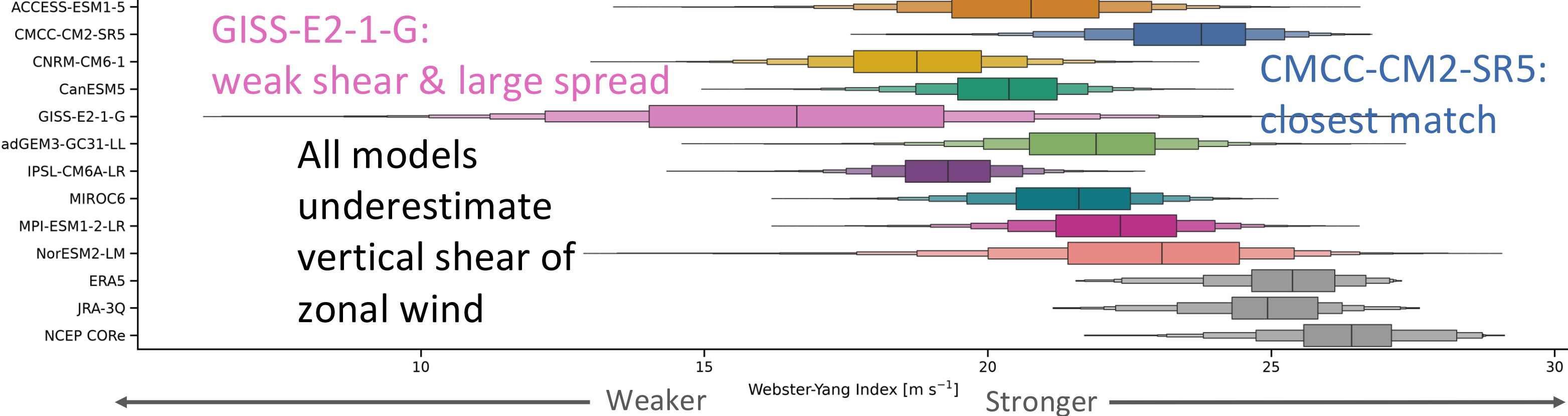


Difficulty representing upper-level monsoon

Model Climatologies (1960-2014): Establish baselines for detailed evaluation of the single-forcing ensembles



U850 – U200, 40°-110°E, 0°-20°N



V850 – V200, 70°-110°E, 10°-30°N

