

Linking stratosphere--troposphere coupling biases to Annular Mode predictability and midlatitude impacts in subseasonal forecast systems

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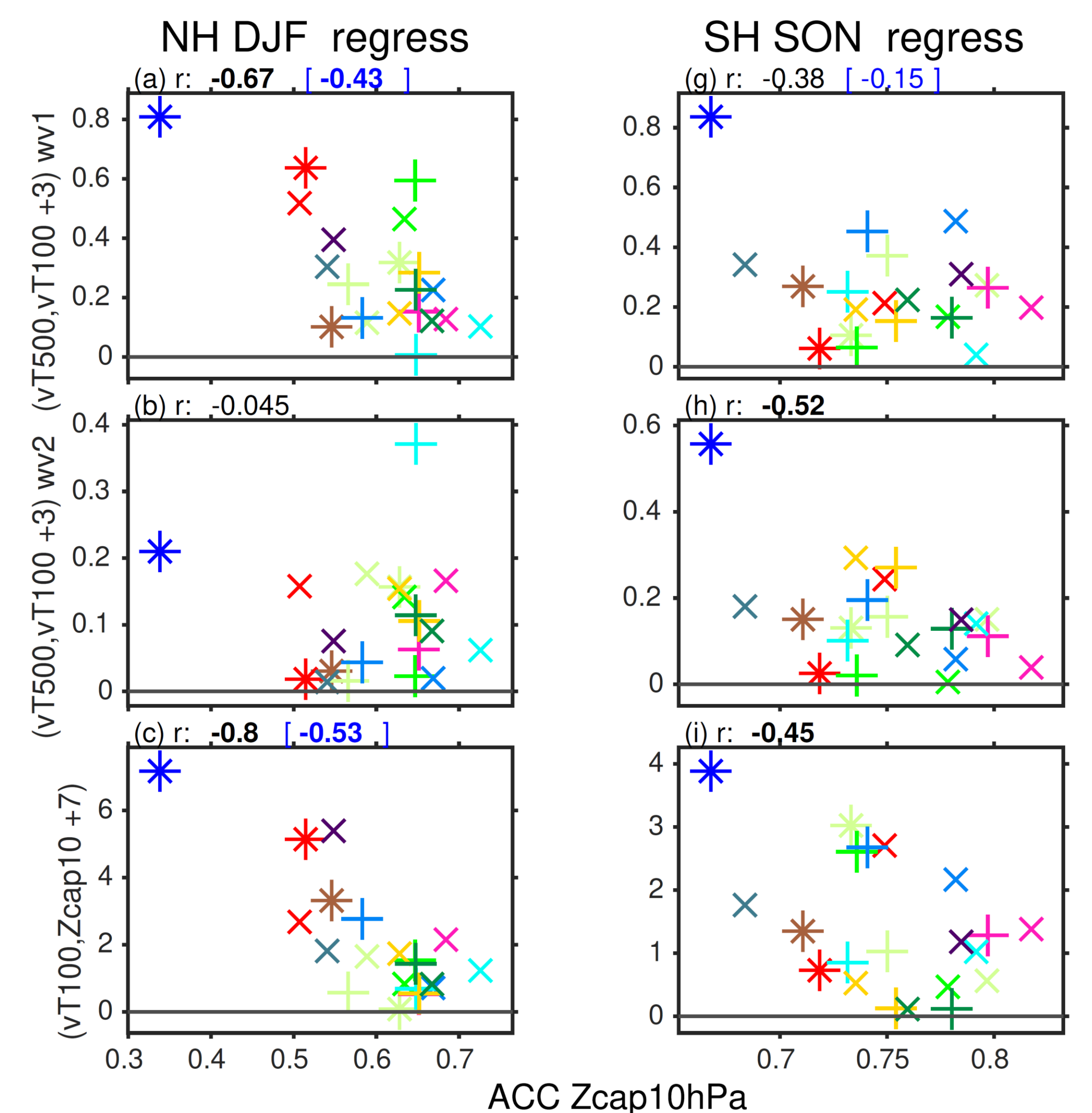
Introduction

- Two-way coupling between the stratosphere and troposphere is recognized as an important source of subseasonal-to-seasonal (S2S) predictability and can provide forecast windows of opportunity.
- SNAP has organized two papers focused on documenting model biases in the mean-state and in coupling processes (Lawrence et al 2022; Garfinkel et al 2025).
- This third paper is aimed at evaluating how these biases impact skill; fourth paper (Lee et al) will focus on signal to noise properties

Conclusions

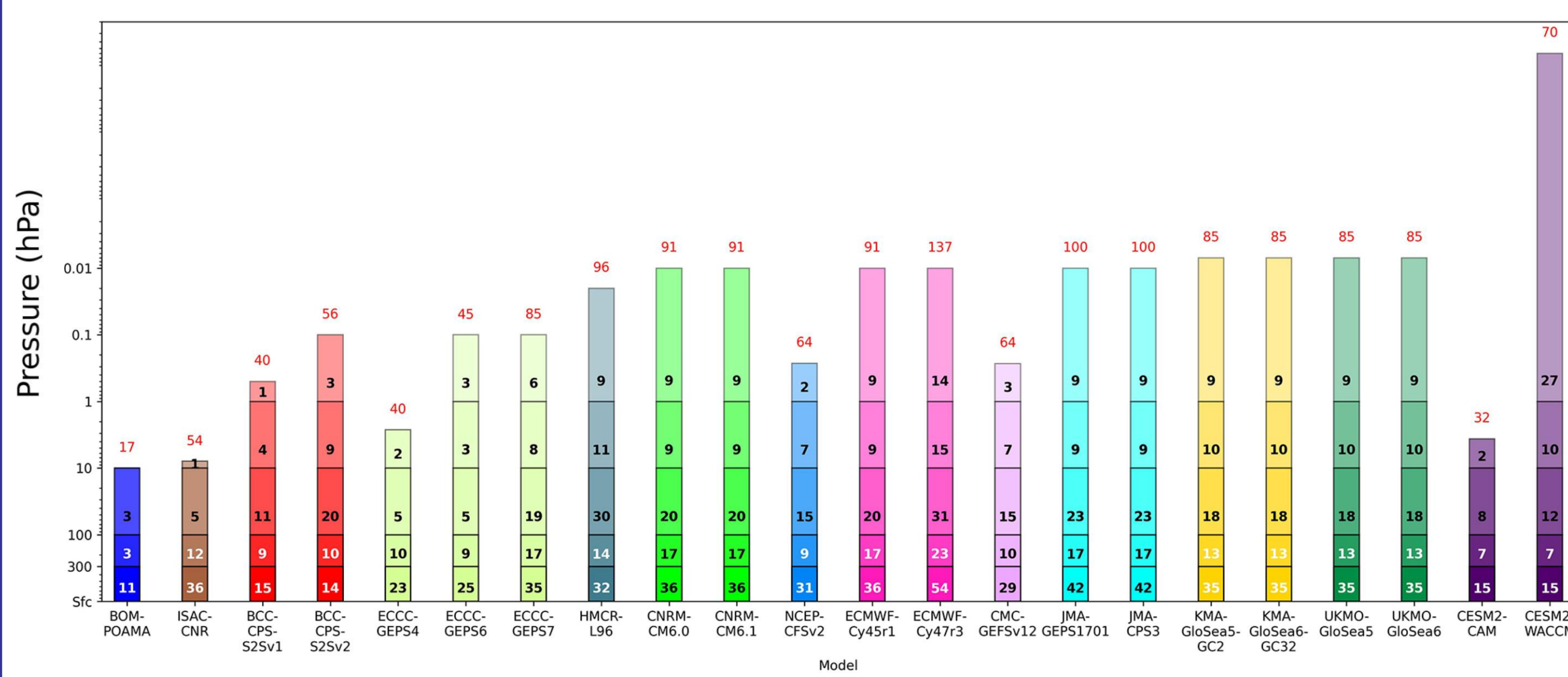
- Newer model version and higher top version tend to have higher skill than older and lower top versions, but with notable exceptions.
- Attempts to identify relationships between skill at different levels or between different metrics led to ambiguous results, as typically the “good” models are better at most things at all leads.
- Models with a better representation of upward coupling processes have higher skill for Zcap10 and other levels. This relationship is much stronger than the corresponding relationship contrasting skill to mean state biases (not shown).
- While there is no clear relationship between bias in downward coupling metrics and ACC for Zcap850 or the NAO, these models certainly capture downward coupling to T850 and to the NAM1000, and skill is higher during weak and strong vortex states than neutral vortex states. But there are systematic too-weak biases throughout the midlatitudes.
- We welcome feedback and community involvement!**

4. Skill in stratosphere better in models with better upward coupling

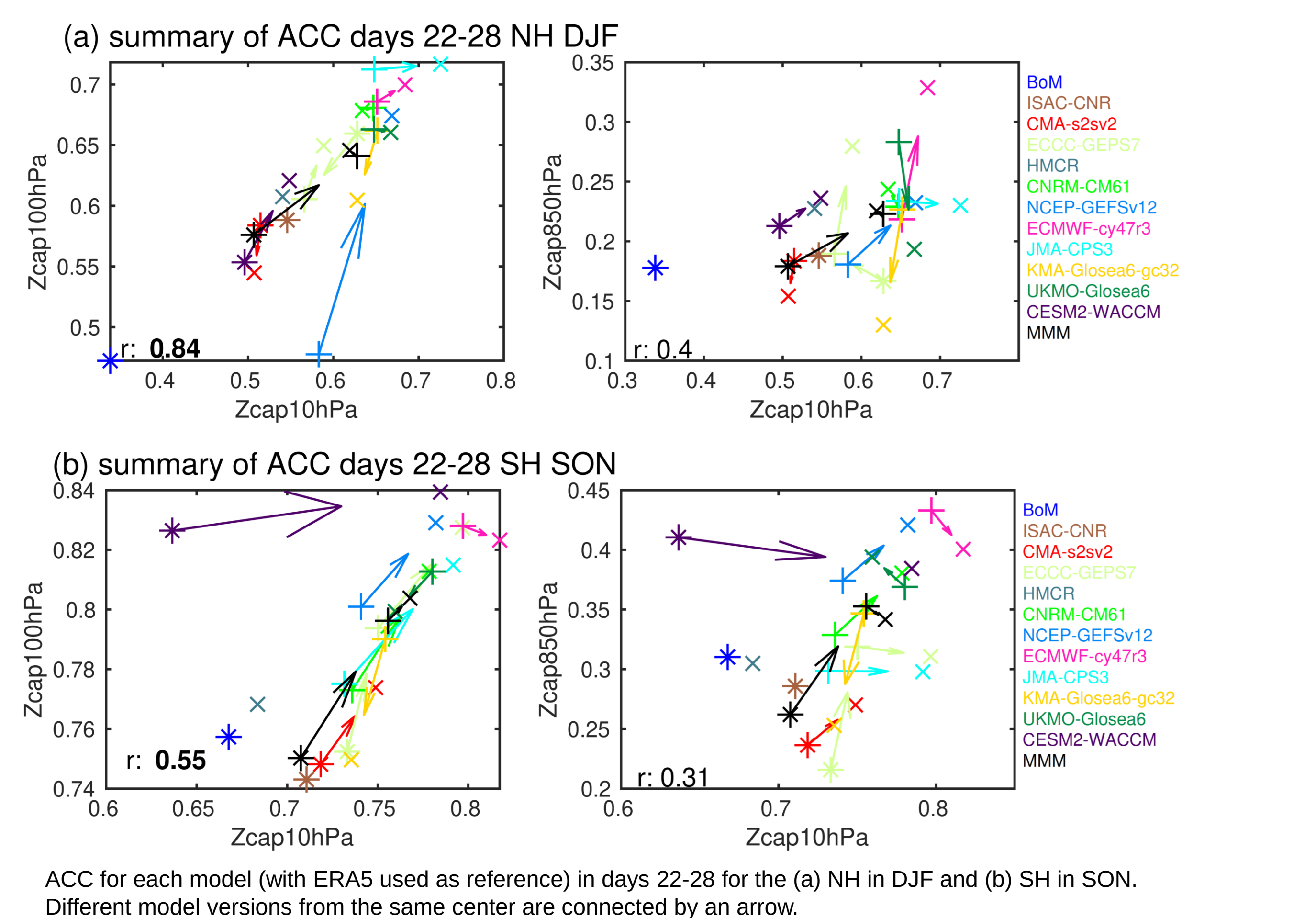


- Models with smaller biases in the regression coefficient of upward flux of wave-1 (top) and wave-2 (middle) from 500hPa to 100hPa have better ACC for Zcap10.
- Models with a more realistic sensitivity of the vortex to heat flux at 100hPa have a better ACC for Zcap10 in the NH.
- Similar figures but for ACC of Zcap850 with downward coupling metrics show limited signal (not shown). Nonetheless, there is a clear imprint of the stratosphere on surface skill as seen in the next two boxes.

2. Models used and their vertical resolutions

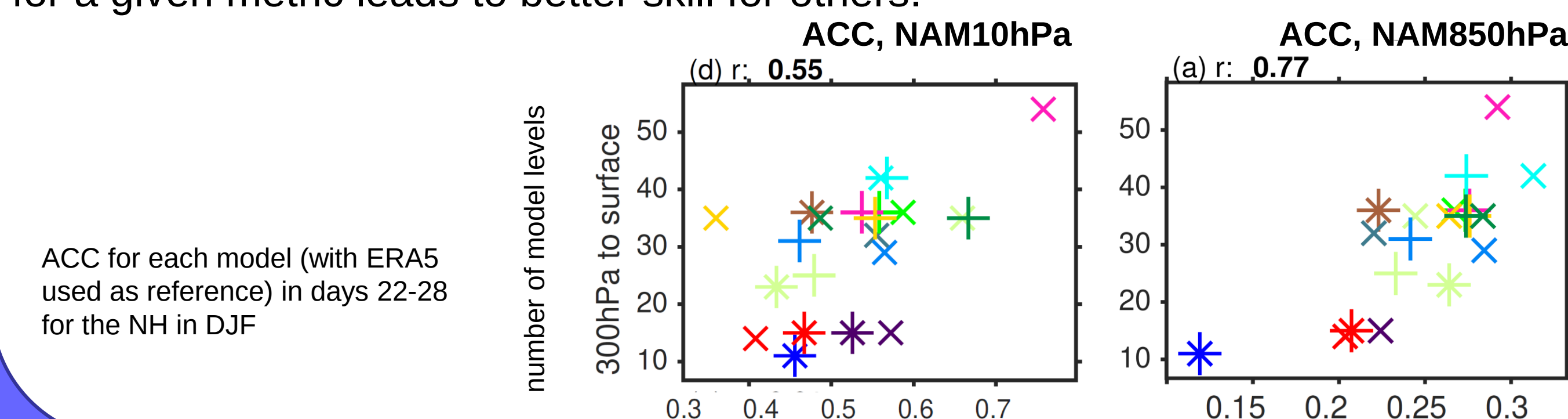


3. Are high-top models more skillful? More recent versions more skillful?



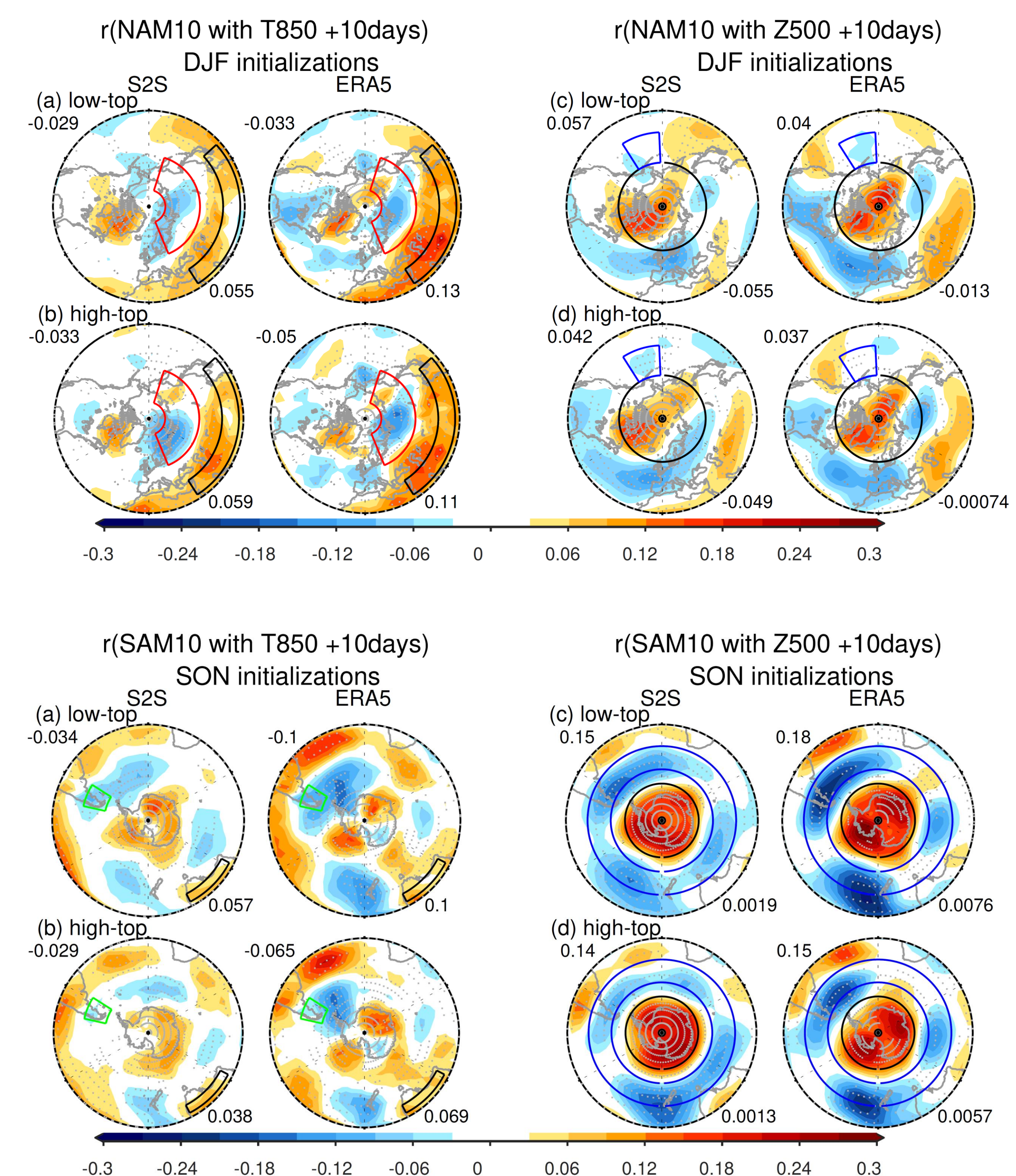
In most cases, high-top models are better than low-top, and newer model versions perform better than older model versions.

The “good” models tend to be better for all metrics (and also for all forecast leads), making it challenging to make causal statements as to whether better skill for a given metric leads to better skill for others.

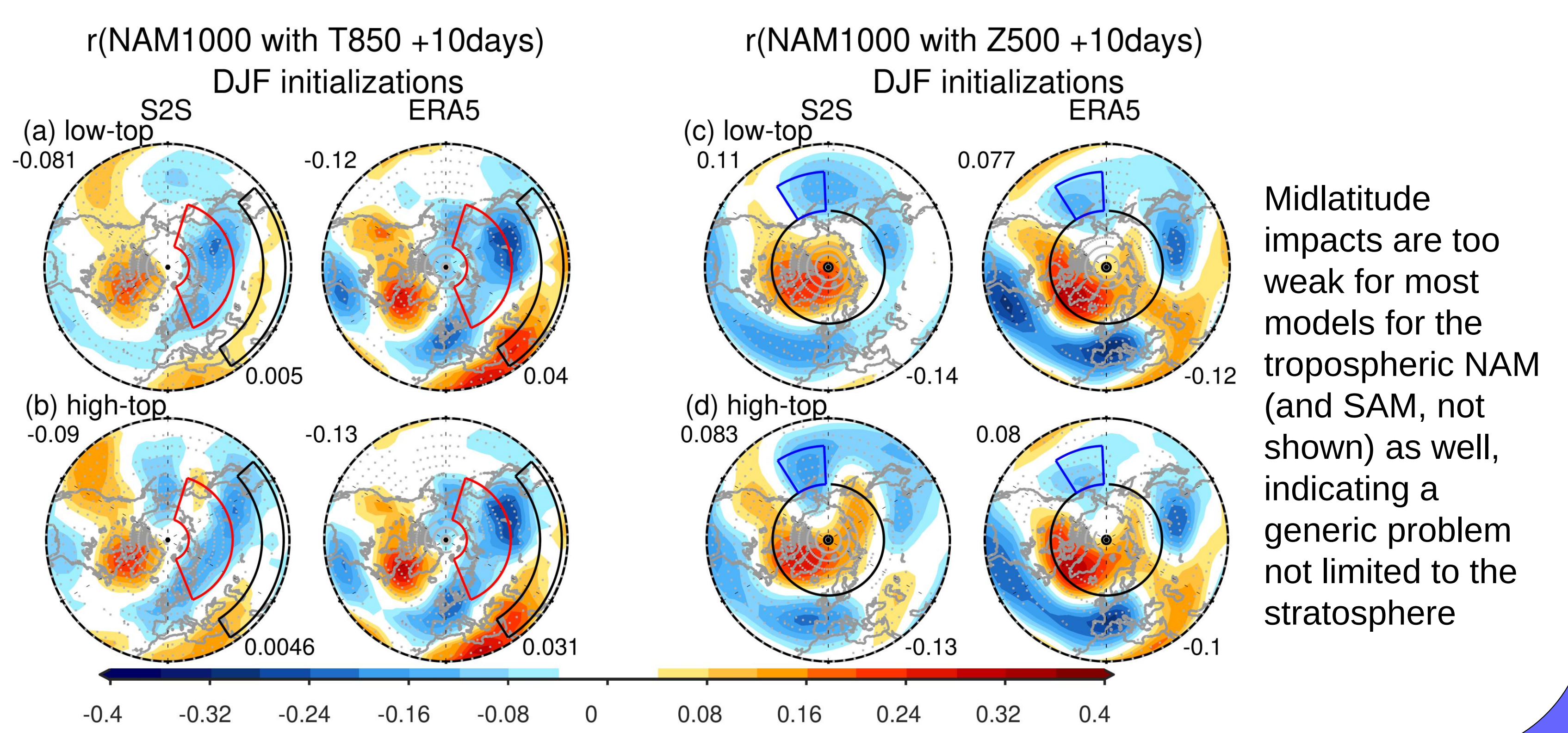


5. Downward coupling: Biased regional structure

Midlatitude impacts are too weak for most models even as the tropospheric polar cap height response to NAM10 is realistic (see Garfinkel et al 2025, Paper #2, for details on polar cap response).



6. Tropospheric AM regional structure



Midlatitude impacts are too weak for most models for the tropospheric NAM (and SAM, not shown) as well, indicating a generic problem not limited to the stratosphere