Weather Clim. Dynam. Discuss., referee comment RC2
https://doi.org/10.5194/wcd-2021-34-RC2, 2021

Review for wcd-2021-34

Anonymous Referee #2

Referee comment on "Future summer warming pattern under climate change is affected by lapse-rate changes" by Roman Brogli et al., Weather Clim. Dynam. Discuss., https://doi.org/10.5194/wcd-2021-34-RC2, 2021

Review for "Future summer warming pattern under climate change is regulated by lapse-rate changes"

In this paper, the authors argue that lapse rate changes are fundamental to understanding the pattern of summertime warming projected in a variety of regional and global climate models. The authors present results from idealized modelling experiments to support their hypothesis that lapse rate changes are fundamental to understanding the pattern of surface warming across the globe and that lapse rate changes are a major factor that generate the pattern of surface warming that manifests across climate models.

The paper is well written and clear, and I think the investigation into the role of the atmosphere's role in generating land surface warming patterns is extremely important. However, in its current state, I don't think this paper provides an adequate explanation of the physics behind the creation of the amplification pattern over the Mediterranean; this makes the global analysis presented later in the paper less insightful. I was left wanting more evidence from the initial simulations to bolster the author's argument that the atmosphere's adjustment is crucial to understanding the warming pattern of summertime surface temperature.

Major Comments

The authors allude (lines 39-40) to the fact that the spatial warming pattern is at least partially driven by energy partitioning between latent and sensible at the land surface. To me, this is a null hypothesis, and the authors must use their experiments to quantify the role of the atmosphere in amplifying the pattern of warming initially generated by the local differences in energy flux partitioning at the land surface. In my mind the authors need to show that convective activity or circulation adjustment to the warming pattern driven by energy flux partitioning near the land surface is amplified by the lapse-rate adjustment

accomplished by the atmosphere for their conclusions to be valid.

To me, the analysis of novel experiment done by the authors (application of a vertically uniform boundary condition) does not prove that lapse rate changes are the ultimate cause of the surface warming pattern because there is no evidence presented about the dynamical adjustment. As a reader, I would like to know how the retribution of energy that amplifies the warming in the Mediterranean is accomplished in the TDLR simulations (and not accomplished in the TD simulations). Could it be that an unrealistic (vertically uniform) boundary condition destabilizes the atmosphere, causing enhanced convection across all of Europe and a large dynamical adjustment that mixes out some component of the summertime warming pattern? Or is it that the realistic lapse rate boundary condition applied to the TDLR simulations induces large scale subsidence over the Mediterranean and amplifies the local warming? In any case, I was left wanting an analysis of the atmospheric motions that give rise to the lapse rate changes shown in Figs. 3d and f. The authors approach this analysis in Fig. 4, but the moist enthalpy changes could also be driven by the surface flux partitioning; without a complementary analysis of the atmospheric adjustment, I think the argument is much less convincing.

In particular, the presentation of Fig. 3e needs to be changed. To my eye, removing the TD simulation domain mean (rather than the FCC domain mean) would reveal a pattern similar (but not exactly the same) as the TDLR experiment, suggesting that energy flux partitioning at the land surface is fundamentally responsible for the warming gradient and only accentuated by the atmospheric response.

Minor Comments:

Suggestion for lines 30-31: Since the dry adiabatic lapse rate is independent of temperature changes, the lapse rate changes driven by global warming are driven by the response of the moist-adiabatic lapse rate that decreases with warming.

Line 44: In summer, however, also

Lines 53-54: Do you really mean this? I think the argument is that lapse-rate changes accentuate the Mediterranean amplification, rather than cause it outright.

Line 71: are covering

Fig. 3c, e: Please remove the experimental mean, rather than the mean from the FCC experiment. This is a particular problem with panel e as I've noted above.

Line 134-135: The Mediterranean amplification is not absent in the TD experiment, it's merely reduced and it's hard to tell because the relevant mean temperature has not been removed.

Line 137-139: This is part of my major comment above and the place for a deeper analysis of the circulation differences between the TD and TDLR experiments. How does this dynamically weakened lapse rate accomplished? I think this is crucial for the argument.

Line 146-148: I'm not sure I understand this sentence. We expect the upper tropospheric warming to be larger than surface warming no matter what due to climate change. I think clarification here would help me understand the argument.

Fig 4: Maybe mask the oceans, the enthalpy changes there are so high it's a bit distracting from the argument you're articulating.

Lines 216-217: This seems at odds with the contention at other points in the paper (Lines 53-54) that lapse-rate changes cause the warming pattern.

Lines 250-251: Again, I don't think the analysis as currently constituted shows that lapse-rate feedbacks are "decisive". Some numerical comparisons between the TD and TDLR warming amplification patterns over Europe could help here.