Reviewer 2 (Anonymous):

Review of "Influence of Lower Tropospheric Moisture on Local Soil Moisture-Precipitation Feedback over the U.S. Southern Great Plains" by Wang et al.

General comments:

This paper examines the role of lower troposphere (LT) moisture in land-atmosphere coupling (LAC) using radiosonde data from the US Southern Great Plains (SGP) site. The analysis focuses on afternoon precipitation events (APEs) in the warm season (May– September). It is found that LT moisture has a greater impact on dry-coupling APEs than on wet-coupling APEs. A higher BLT, which is a vertically integrated LT buoyancy uncoupled with the PBL humidity, tends to increase both the frequency and intensity of dry-coupling APEs. The paper is overall well-structured and easy to follow, and the findings clarify the importance of warm-season LT moisture in dry-coupling conditions in the SGP. I have a few minor suggestions for the authors to consider.

Specific comments:

1. While the Introduction Section provides a detailed review of previous studies of LAC and LT moisture, little is mentioned about the SGP and why this region is selected to study the impact of LT moisture. It is also not clear why ARM SGP radiosonde data were used as the primary data in this work. A brief background information about LAC and LT moisture in the SGP and a clarification of the novelty of the approach would be helpful and informative in the Introduction Section.

We have revised the last paragraph of the introduction section to address this. **Note that all line numbers listed below are referred to the track-change version of the revised manuscript.**

Line 66-74: "The Department of Energy's Atmospheric Radiation Measurement (DOE ARM) project has been pivotal in providing comprehensive datasets for investigating land-atmospheric interactions over the past two decades (e.g., Zhang and Klein, 2010; Santanello et al., 2018). Among the various ARM sites, the Southern Great Plains (SGP) site stands out as the project's inaugural site and one of the most heavily instrumented sites. The SGP region is also widely known as a hotspot of land–atmosphere interactions, as evidenced by numerous past research (e.g., Wakefield et al., 2019; Santanello et al., 2018; Dirmeyer and Koster, 2006; Koster, 2004; Koster et al., 2006; Guo et al., 2006). This study aims to quantify the impact of LT humidity on the SM-P relationship and local LAC at the SGP site by utilizing an entrained parcel buoyancy model (Zhuang et al. 2018) and the correlation between LT humidity and near-surface humidity."

2. The concept of the lower troposphere (LT) was brought up very early in the paper, but it is not clearly defined until section 2.2 (line 135). It would be better to clarify the definition of LT in the earlier part of the paper.

Done! We have defined LT earlier in the introduction (Line 52).

Lines 51-53: "However, the humidity in the lower troposphere (LT) above the PBL, i.e., ~2-4 km above ground level (AGL), is not explicitly included in previous research."

3. It would be nice to have a section to discuss the uncertainties associated with the data and/or methodology. For instance, the coupled LT humidity profile is reconstructed by linear regressions. What's the uncertainty

of the approach? Are all the APEs convective precipitation? In addition, it also would be interesting to briefly discuss to what extent the approach used here and findings in the SGP can be generalized to other regions.

Thank you for pointing out potential limitations/uncertainties in this study. We have revised the last paragraph of the manuscript to reflect these points.

Lines 356-368: "However, there are still limitations in our work. One key concern is the potential uncertainties introduced by constructing the land-coupled LT humidity profile via linear regression. Such uncertainties arise mainly from the linear model's inherent assumptions, including the constancy of relationships under varying conditions and the potential oversight of non-linearity. A more thorough investigation into the model's residuals and additional sensitivity analyses could provide deeper insights into these uncertainties. Furthermore, our categorization of APEs may not be always associated with convective precipitation, given that it relies solely on the region-average precipitation data. Improving the classification of APEs, possibly by integrating convection classification results from radar observations, could lead to more precise interpretations. This study only focuses on a single location, i.e., SGP, thus expanding research to include a variety of climatic zones would be crucial in assessing the broader applicability of our methods and conclusions. Our future work will also involve investigating the primary source of LT humidity and employing both B_{LT} and CTP/HI_{Low} as atmospheric indicators to identify global regions with diverse LT humidity-SM-P relationships, thereby advancing our understanding of LAC on a broader scale."

4. In section 2.1, it would be nice to provide more details about the SGP CF site, such as location (lat, long), data coverage, and why the site was selected.

We added some more details in the introduction (Lines 66-74) and in section 2.1 (Lines 80-82).

Lines 66-74: "The Department of Energy's Atmospheric Radiation Measurement (DOE ARM) project has been pivotal in providing comprehensive datasets for investigating land-atmospheric interactions over the past two decades (e.g., Zhang and Klein, 2010; Santanello et al., 2018). Among the various ARM sites, the Southern Great Plains (SGP) site stands out as the project's inaugural site and one of the most heavily instrumented sites. The SGP region is also widely known as a hotspot of land–atmosphere interactions, as evidenced by numerous past research (e.g., Wakefield et al., 2019; Santanello et al., 2018; Dirmeyer and Koster, 2006; Koster, 2004; Koster et al., 2006; Guo et al., 2006). This study delves into the impact of LT humidity on the SM-P relationship at the SGP site, aiming to determine its influence on the local LAC."

Lines 81-83: "Unless stated otherwise, all measurements are taken at the DOE ARM SGP central facility (CF) in north-central Oklahoma (36.60°N, 97.48°W), and the region within a 50-km radius of the CF for 2001-2018."

5. In sections 2.1.1-2.1.3, please add information about the temporal resolution and coverage of the datasets and variables used in the paper. It also would be informative to discuss the error ranges of the data, if possible.

We have revised the sections accordingly to show the temporal resolution and coverage information.

Section 2.1.1 – Sounding profiles: Line 86-89: "This data is available four times daily at 05:30, 11:30, 17:30, and 23:30 local standard time (LST). We only use the 11:30 LST sounding data as it best represents the precondition of afternoon convection. "

Section 2.1.2 – Soil moisture: Lines 100-104: "we used FWI at 25 cm measurement depth provided by the Oklahoma Mesonet Soil Moisture (OKMSOIL) value-added product (VAP) (available at https://www.arm.gov/capabilities/vaps/okmsoil). This data has a 30-min resolution, and we use the average FWI during 06:00-12:00 LST to represent soil moisture condition before afternoon precipitation at daily scale."

Section 2.1.3 – Precipitation: Lines 108-112: "The Arkansas-Red Basin River Forecast Center (ABRFC) precipitation data is based on WSR-88D Nexrad radar precipitation estimates and rain gauge reports with extensive quality control (Fulton et al., 1998). This is an hourly gridded data product and is available at https://www.arm.gov/capabilities/vaps/abrfc. We used spatially averaged data over the region within a 50 km radius of the SGP CF for this study."

6. Section 2.1.4, can you please provide the equation used to calculate PBL height?

Sorry for the confusion. We did not calculate the PBL, instead, it's an ARM value added product (VAP). We revised the description to better reflect this:

Lines 114-118: "PBL height data are obtained from the ARM's Planetary Boundary Layer Height (PBLHT) value-added products derived from radiosonde data using the algorithm developed by Liu and Liang (2010). This data is available at https://www.arm.gov/capabilities/vaps/pblht."

We did not list the equations used by Liu and Liang (2010) as they involve many steps and it's not the focus of this study.

7. Line 116, how do you determine the height of the mixed layer?

In this study, the mixed layer is simply defined as 0-1km AGL. This information is added at Line 128.

8. Section 2.4, are both dry- and wet-coupling defined on the daily time scale?

Yes, dry-/wet- coupling is defined on daily scale. We have revised Lines 182-183 to clarify this.

"We first calculate CTP and HI_{Low} using sounding data at 11:30 LST, and average FWI during 06:00-12:00 LST. Then dry-coupling cases are defined as days with anomalously high CTP …"

9. I suggest moving Figure S1 to the main text, as it provides useful information and there is sufficient room for one more figure in the main text.

Done. Figure S1 is now Figure 6.

10. Fig. 1, please consider marking the coefficients that are significant at the 95% confidence level. The caption mentioned "…value of 18 years", but 2001-2019 (line 74) is 19 years.

All correlation coefficients in Fig. 1 (0-4 km, all 18 years) are significant at 0.05 level. We have added this information in the caption.

And sorry for the typo, we use 2001-2018 data (18 years in total). We have corrected this throughout the manuscript.

11. Figs. 2-3, consider marking profiles where the composite differences are significant.

Thanks for the suggestions. We have modified Figs. 2-3 to mark significance (by thicker lines).

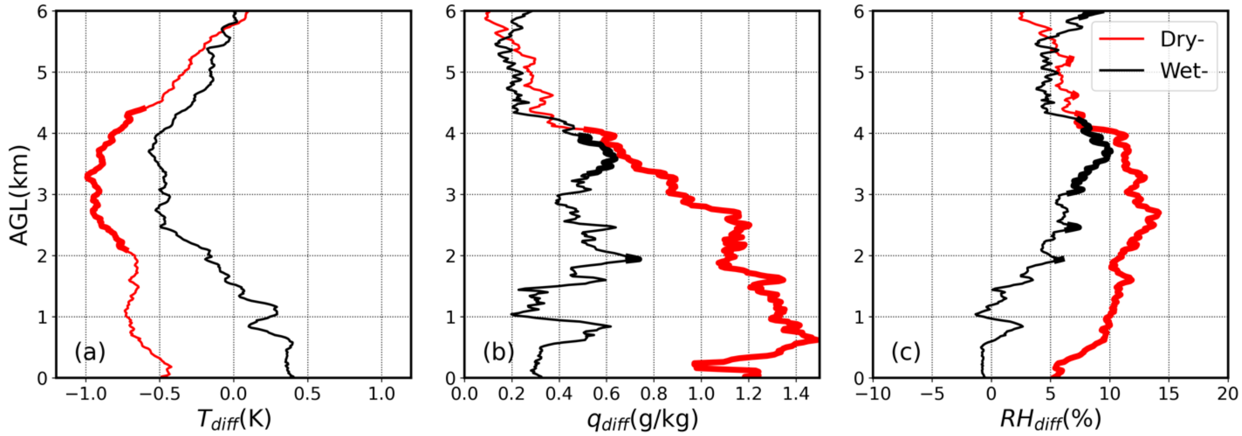

Figure 2: Composite difference of a) temperature ($\boldsymbol{T_{diff}}$), b) specific humidity ($\boldsymbol{q_{diff}}$), and c) relative humidity ($\boldsymbol{RH_{diff}}$) profiles between APEs and non-APEs for dry- (red lines) and wet- (black lines) coupling cases. The thicker portions of the lines indicate where the differences are statistically significant at 0.05 level.

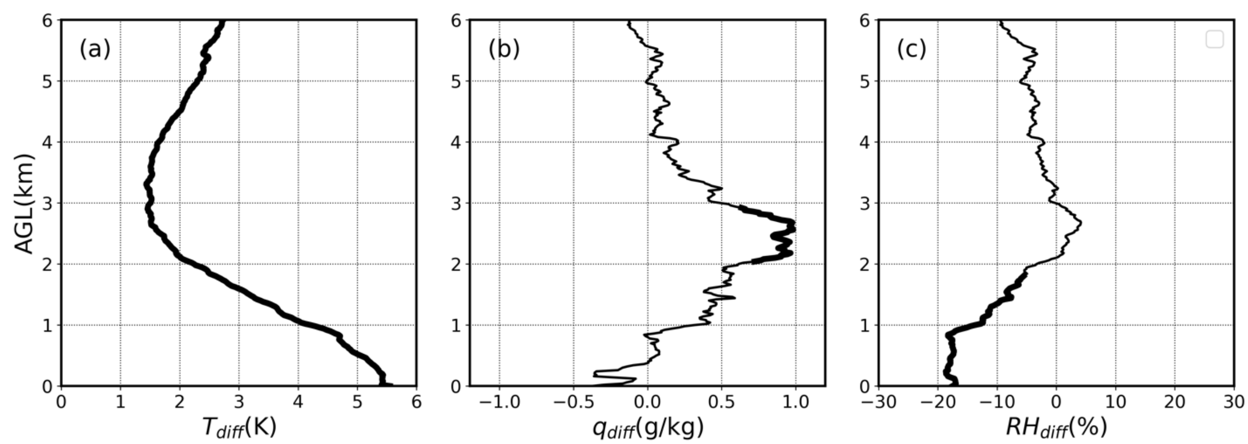

Figure 3: Composite difference of a) temperature (T_{diff}), b) specific humidity(q_{diff}), and c) relative humidity (RH_{diff}) between dry- and wet-coupling APEs (Dry minus Wet). The thicker portions of the lines indicate where the differences are statistically significant at 0.05 level.

12. Fig. 4, why is the data coverage 2001-2018 instead of 2001-2019?

Sorry for the mistake, we actually use 2001-2018 data for this study (18 years in total). We have corrected this in the revised manuscript.

Technical corrections:

1. In lines 216 and 219, there is no "Figure 4a" nor "Figure 4b".

Thanks for pointing this out. Those were referring to an earlier version of that figure which has three panels. We have removed “a”, “b”, “c” in that paragraph.

2. In Figure 5, the last label of the x-axis (“200”) is too close to the first label of the vertical axis of the bar plot (“0”), so it looks like “2000”.

Thanks, we have updated Fig. 5 accordingly.