We thank the reviewer for their useful comments on our manuscript. Below we provide detailed response to your comments. In the following, the comments of the reviewer are presented in *italic blue*. Our responses are in normal black font. Changes to the text are in red.

Comment 1:

The paper presents a hypothesis that deep overshooting convection over the great plains of north America moistens the lower stratosphere and is transported and trapped in the North American anticyclone. they use trajectory calculations to see if water vapor measurements from MLS encountered convection or not. They show that during July and August that the difference between convective and non convective trajectories is nearly 1 ppmv. In June it is much less. The take away message i get from this is that the establishment of the North American anticyclone is the dominant factor for having high lower stratospheric water vapor over North America.

This is not the impression we were trying to get across. Convection is they key reason that water vapor is higher in the monsoon region. Dynamics and the structure of the monsoon can mediate the impact of convection by, for example, regulating the temperature that air in the monsoon experiences. In fact, one should not really separate these phenomena. After all, it is convection that fundamentally causes the anticyclonic monsoonal circulation. Changes like this will be made in the text:

Line 4 - We use a Lagrangian trajectory model to demonstrate that the structure and the location of the NA anticyclone, as well as the tropical upper tropospheric temperature, mediate the moistening impact of convection.

It completely dominates convective activity in the Junes of 2010 and 2011 where the former year is high with low NA convection and low the following year despite having more NA convection. I have difficulty believing that in 2010 before the anticyclone is set up that the convectively moistened air moves to the colder tropics where it gets freeze dried first.

While this might be counterintuitive, we provide evidence in the paper that this is indeed happening. We examine Lagrangian trajectories (e.g., Fig. 6 in the original paper and associated text) and show that parcels are indeed reaching deep into the tropics. If we regard 20°N-20°S as the tropics, then 20% and 44% of the convectively influenced parcels travel into the tropics and back during June 2010 and 2011, respectively, and this difference can lead to significant interannual variability in the monsoon region.

We acknowledge that we should add more numerical information to the paper to make it clear. Changes have been made in the text:

Line 137 - The second reason is also connected to the changing dynamics during June, July, and August. Parcels tend to travel to lower latitudes during June (Fig. 4a). 33% of the convectively moistened parcels travels to the tropics (20°N-20°S) during June, and 13% during July and 9% during August. Traveling to the tropics leads them to experience colder temperatures at 100 hPa (Fig. 4b). As a result, the median of the water vapor mixing ratio of the parcels that stays in the mid-latitudes is 5.98 ppmv, while it is 5.36 ppmv for those parcels that travels to the tropics. This means that convectively moistened air experiences subsequent dehydration more frequently in June than in later months (Randel et al., 2015).

Line 157 - In June 2010, 20% of the convectively influenced parcels travel to the tropics (20◦N-20◦S) in 5 days, while in June 2011, 44% do (Fig. 6a).

It seems from looking at the figure 3 and figure 5 that the horizontal tape recorder signature of water transport is playing a big role here too. i certainly agree that deep convection over the NA plains is adding water but it might be a small perturbation on top of the large scale transport coming up from the tropics that is also becoming more moist during the summer months. I think this could be disentangled with some modelling studies where one could artificially hold the tropical tropopause temperature constant all year thus removing the tape recorder signatures from the tropics and seeing what NA enhancements occur just due to local convection.

There is abundant previously published work that show that the high water vapor found in this region is the result of local convection in the region (Hanisco et al., 2007; Herman et al., 2017; Schwartz et al., 2013; Smith et al., 2017). This can also be seen in Fig. S1, which shows that the water vapor over the monsoon region is a local maximum, meaning that it could not be caused by horizontal transport out of the deep tropics.

To provide further support, Fig. S2 shows the horizontal distribution of parcels initially located in the NA monsoon after 10 day back trajectories. This shows that many of the parcels had been within the NA monsoon for more than 10 days, and those that were not had been transported to the monsoon by westerly winds from the Pacific — not from the tropics.

We will add some discussion to the revised paper discussing how the water vapor maximum in the monsoon is due to local convection:

Line 18 - However, over the Asian monsoon and North American monsoon, higher water vapor mixing ratios, sometimes as high as 12 ppmv, are observed. This value is much higher than the water vapor mixing ratio in the tropics, indicating that the air did not go through the TTL or is moistened further after leaving the TTL (Anderson et al., 2012; Schwartz et al., 2013; Randel et al., 2015; Smith et al., 2017).

Line 80 - We have subtracted the zonal mean value (based on the JJA mean from 70°W to 130°W at each degree of latitude) from NA the 100-hPa water vapor content before normalizing, allowing us to focus on the variability in the NA region relative to the zonal average value and minimize the impact of transportation from the tropics.

Minor recommendation 1:
minor recommendations page 1 line 18 replace sometimes as high as with exceeding ... MLS has seen higher values as has Anderson.

Changes have been made in the text:

Line 18- However, over the Asian monsoon and North American monsoon, higher water vapor mixing ratios, sometimes exceeding 12 ppmv, are observed, indicating that the air did not go through the TTL or is moistened further after leaving the TTL.

Minor recommendation 2:
page 3 line 81 from NA the 100 to from the NA 100...

Changes have been made in the text:
Line 81 - We have subtracted the zonal mean value (based on the JJA mean from 70°W to 130°W at each degree of latitude) from the NA 100-hPa water vapor content before normalizing, allowing us to focus on the variability in the NA region relative to the zonal average value.

Minor recommendation 3:
Throughout the manuscript lower case letters a, b, .. are used to refer to panels in the figures but the figures use upper case letters A, B, ... Please make this consistent.

Changes have been made in the text.

Minor recommendation 4:
page 5 line 135 I would write that sentence as As a result moistening from deep convection becomes less diluted by zonal mean flow later in the summer.

Changes have been made in the text:

As a result, moistening from deep convection becomes less diluted by zonal mean flow later in the summer.

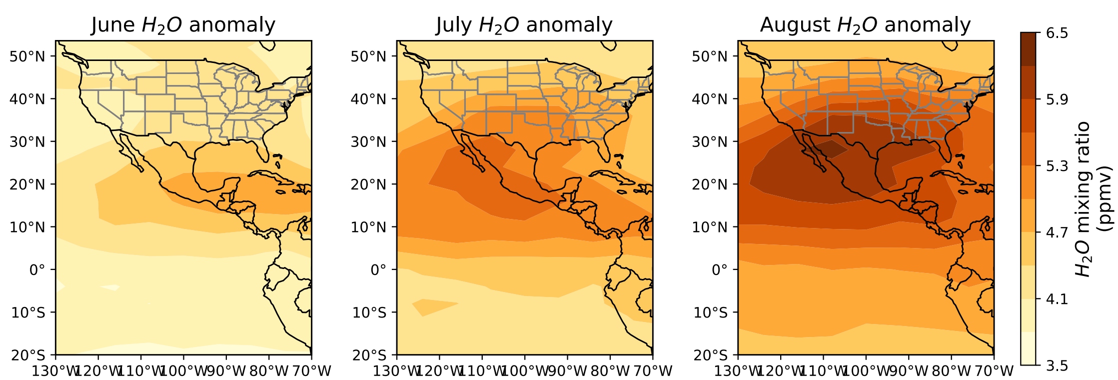

Figure S1. MLS 100-hPa water vapor mixing ratio during 2005-2016 (A) June, (B) July, and (C) August.

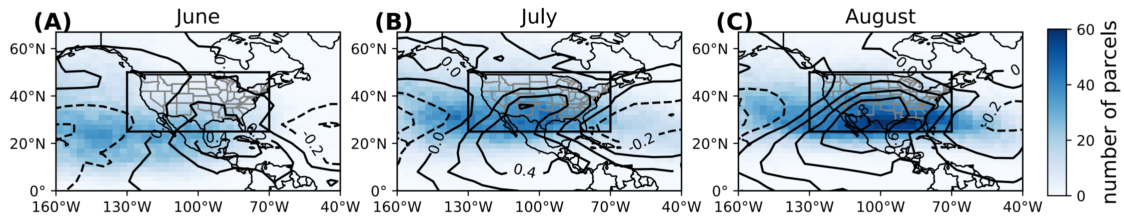

Figure S2. Number of the parcels in each 2°*2° grid box after 10 days in the back trajectory model during 2005-2016 (A) June, (B) July and (C) August. In the back trajectory experiments, we initiate the parcels 1°x1° 1◦x 1◦grid over NA (25°N - 50°N, 70°W- 130°W) every day during each month, and track back their position in 10 days. (Black contour) Geographical distribution of the MLS 100-hPa water vapor anomaly (after removal of the zonal mean).

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