Anonymous Referee #1

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General Comments: East Asian precipitation simulation is one of the great challenges faced by climate scientists due to the complexity of East Asian climate system and topography. The simulation of East Asian precipitation is sensitive to model resolution and air-sea coupling. This paper investigated the moisture sources of East Asian precipitation simulated by MetUM models using WAM-2layers. It provides a novel way to understand model bias. This study shows evidence about the sensitivities of moisture sources of EA precipitation to model horizontal resolution and air-sea coupling. The results are convincing, and helpful for model developers and climate model users. This paper is well structured and written. Thus, I suggest a minor revision.

We thank the reviewer for providing useful comments and discussions to help us improve this manuscript.

Specific Comments:

1. As shown in Fig3d, the moisture source over the tropics in region1 and region2 is underestimated, and more source from mid-latitude is transported to the two regions. Is there any coupling between the biases of the tropical source and mid-latitude source?

We believe that the reviewer meant Figure 4b&d instead of Figure 3d.

If the moisture flux from the tropics is weak as shown in MetUM, then the moisture for precipitation over regions 1 and 2 should come from elsewhere. In the case of region 1, the additional moisture comes from the mid-latitude regions; in the case of region 2, the additional moisture comes from local evaporation regions; the additional moisture comes from local evaporation.

With that being said, there is a positive precipitation anomaly over the tropical Indian Ocean in MetUM simulations (Figure R1a, enclosed with this response). Besides, the subtropical jets at 200hPa in both hemispheres shift southward in MetUM (Figure R1c). The anomalous monsoon westerly in the MetUM between 15°-30°N at 850hPa transports more moisture from the west, which is collocated with the positive moisture source anomaly shown in Figure 4b (Figure R1b). The anomalous circulation is consistent with the anomalous convection; however, it is difficult to separate the cause and effect without carrying out extra experiments.

For the Tibetan Plateau (region 2, Figure 4d), there is a positive mid-latitude moisture source anomaly within the region and to the east, which is collocated with a positive evaporation anomaly in MetUM simulations. Here, we focus our analysis on the summer, as the differences shown in Figure 4 show the patterns of summer monsoon over Asia.

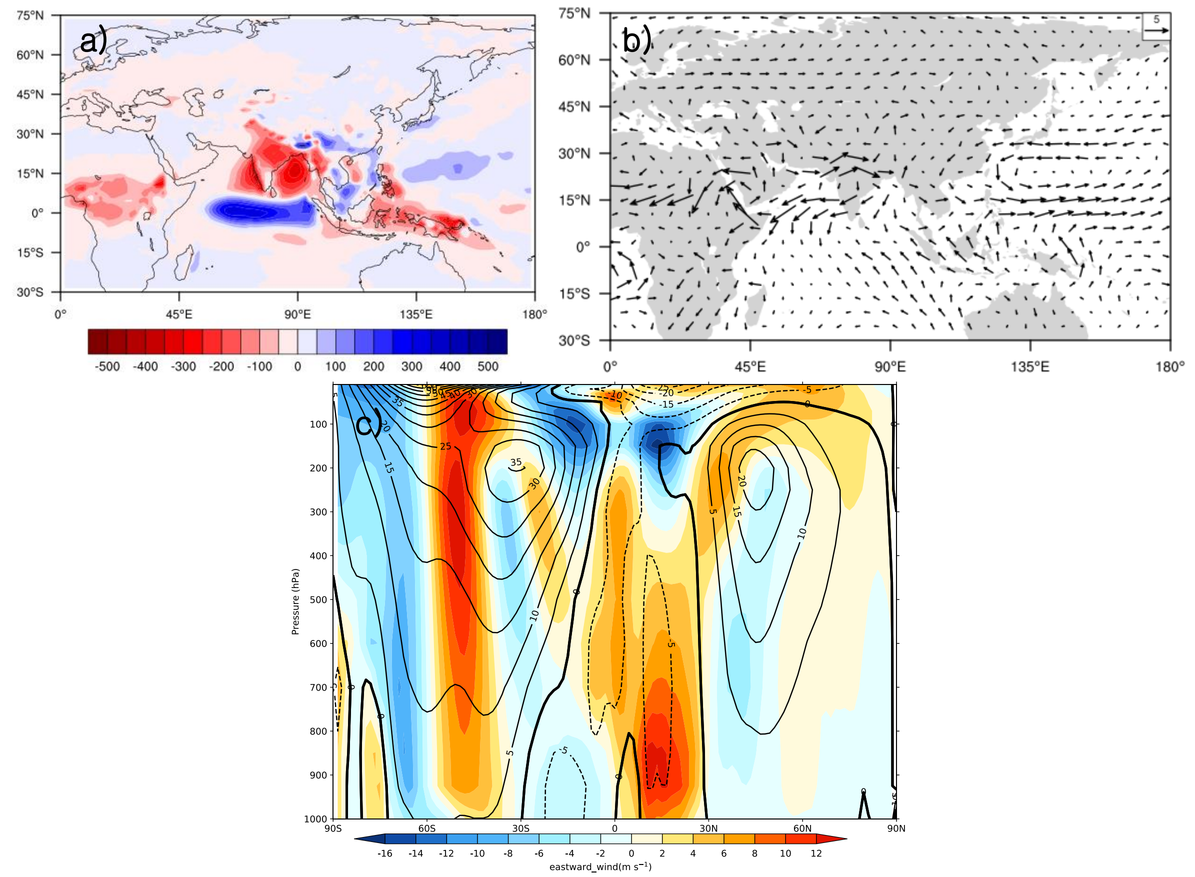

Figure R1. (a) Difference of JJA precipitation between MetUM AN96 and ERA-Interim averaged over 1982-2012 (mm/month). (b) Difference of JJA 850hPa wind between MetUM AN96 and ERA-Interim averaged over 1982-2012 (m/s). (c) Latitude-Pressure plot of the JJA U-wind climatology averaged between 60° and 90°E in ERA-Interim during 1982-2012 (contour, m/s) and the difference between MetUM AN96 and ERA-Interim over the same domain and period (colour, m/s).

2. It would be useful to examine the travelling time and distance of moisture to further check the model biases and sensitivities to resolution and air-sea coupling.

We thank the reviewer for the suggestion. We investigated both the travel time and travel distance of the tracked moisture. However, the results do not show a systematic change with either resolution or coupling. We are investigating the reason: one possible cause could be the delayed monthly mean, since all results shown in this manuscript are obtained from monthly mean outputs. The monthly mean is not simply calculated from the 1st of each month to the last day of the same month, because the moisture transport takes place over timescales of days and weeks. For example, moisture evaporated from the Mediterranean Sea typically takes 15 days to be transported to EA. Therefore, in the backward tracking, any precipitation put back into the WAM-2layers over EA would take 15 days to reach the Mediterranean Sea. Therefore, the monthly mean moisture source for EA precipitation over the Mediterranean Sea starts from the 15th of the month and ends a month later (the exact date depends on the length of the month). We have treated the tracked moisture shown in this manuscript with this method, but we have not treated the travelling time and distance in the same way. We suspect that this causes the inconsistent results between tracked moisture and the travelling time or distance. To confirm this idea, we are re-running all our WAM tracking simulations, but as this process requires a substantial amount of computational time, we will need to report the results in a future study.

3. As for the moisture bias of region5 precipitation in DJF, it shows that less moisture source from the mid-latitude and more moisture source from the Seas of Japan and Okhotsk lead to the eastward shift of the moisture centre. This paper well discussed the positive anomalies of the moisture source from east of region5 with resolution. How about the contribution of mid-latitude circulation or evaporation bias?

As shown in Figure 10, over region 5 in DJF, the major moisture source biases across all MetUM simulations come from the mid-latitude water surfaces, i.e., the Seas of Japan and Okhotsk in the Pacific, the Mediterranean Sea, Caspian Sea, Red Sea and Persian Gulf in western and central Asia, not from the Eurasian land surface. This indicates that the MetUM bias of evaporation over the Eurasian continent is small (due to the frozen soil). The biases in the mid-latitude lower-tropospheric circulation during DJF are also small, as indicated by Figure R2 (below).

Similar to the moisture source bias caused by SST bias over the Seas of Japan and Okhotsk, the reduced moisture sources over the Mediterranean Sea, Caspian Sea, Red Sea and Persian Gulf are linked to the negative SST biases over those water bodies, especially in the low and mid-resolution coupled simulations.

The following revision will be made on Page 8 Lines 30-31: "*In DJF, the land moisture source plays a minor role, due to its frozen soil and therefore small evaporation. The mid-latitude circulation in DJF is also reasonably simulated in all MetUM simulations (figure not shown).*".

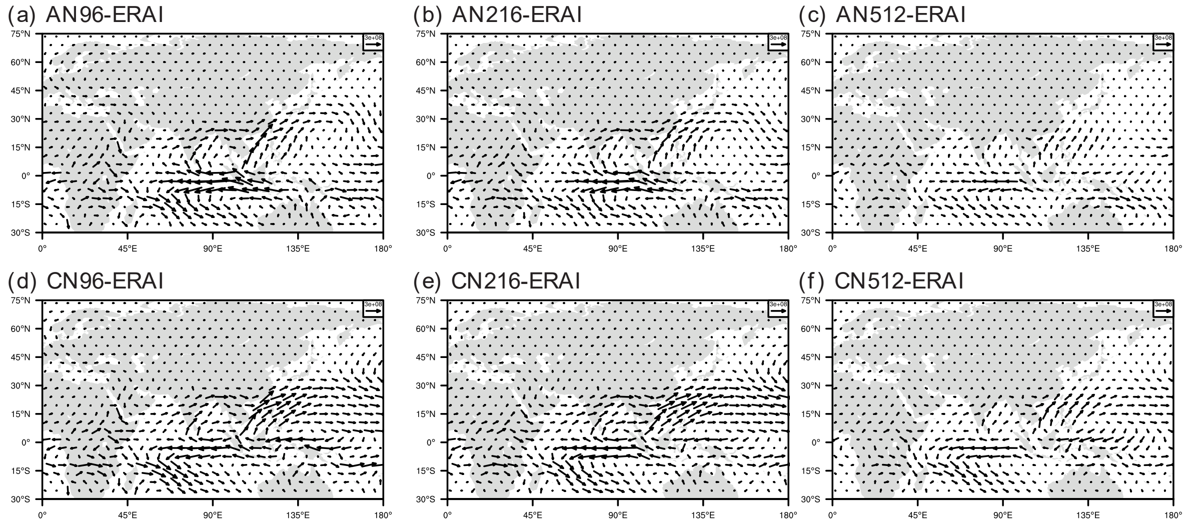

Figure R2. Difference in DJF moisture flux between MetUM simulations and ERA-Interim. Units: m^3/month.

Typing errors

1. Fig.10i, “CN512-CN512”-> “CN512-AN512”

Correction has been done.

2. P8 L229 Seas of Japan ad Okhotsk-> Seas of Japan and Okhotsk. P10 L289 cecessary->necessary.

Corrections have been done.