Reviewer 1:

We sincerely thank the reviewer for taking the time to thorough review our manuscript and for providing the helpful and constructive comments and suggestions for improvement. We hope that we have addressed the Referee's comments. Our responses are in black color font.

General Comments: In this manuscript, the authors study the 'Added value (skill) of high resolution climate models (WRF simulations) in simulating the rainfall and temperature over Himalayan region'. Study of model resolution over complex hilly terrain is indeed important especially over the Himalayan mountain ranges where the rainfall is largely influenced by both the local factors as well as large scale circulations. In addition to that the paper also explains some of the important feature of precipitation over study region such as diurnal variations and spatial variability.

Specific Comments: The authors have selected a year of data with two initialization and compared the results of different horizontal resolution across different seasons viz. winter, pre-monsoon, monsoon, and post-monsoon. The skill of model resolution (25 km, 5km, and 1 km) is compared with observational station dataset at different altitudinal ranges. The description of the model setup and configuration part is nicely written in the manuscript. Although the manuscript is well written and results are properly explained for most of the cases, there are few areas where the explanation is inadequate (see the discussion in the comment section), nevertheless they are acceptable if revised. Therefore, I am suggesting a minor revision of this manuscript. I have some very minor comments provided below.

Minor comments:

1. The biases or spurious influence of the boundaries in the regional climate model can be reduced by nudging. Here authors can provide little more information about the details of the nudging.

Response: We have rephrased and added following text in the revised manuscript (line 21 to 27 page 5)

> Mesoscale climate models may have difficulties in representing the large-scale features (Jones et al., 1995), therefore nudging is often used for longer simulations to prevent the downscaling model from simulating completely different and unrealistic drift from driving model, and to ensure the timings of synoptic disturbances to be in phase with driving model (Von Storch et al., 2000, Pohl and Crétat, 2014). But, the value added by nudging depends on skill of forcing data. Two different types of nudging termed spectral (wave numbers to filter large and small scale features) and grid analysis (in every grid cell) exist. Over Himalaya, the sensitivity study of both types of the techniques by Norris et al. (2016) found no significant quantitative differences in the precipitation distribution. Thus, we have applied grid analysis nudging only to D1 and merely for the horizontal winds, potential temperature, and water vapor mixing ratio in the vertical levels above the planetary boundry layer (PBL) and above the lowest 15 model levels thereby allowing meso-scale forcing in the PBL as the strong nudging even in the PBL where most of the atmospheric phenomena takes place, can prevent the downscaling model from representing meso-scale (small scale features) processes (Alexandru et al., 2008). This strategy is based on previous studies (Otte et al., 2012; Collier and Immerzeel, 2015), which have demonstrated the improved simulation of mean and extremes of surface variables with the application of such mild nudging.

2. In figure 3 'Daily station averaged precipitation' during mid-monsoon season (JulyAugust) is not very well represented by D3, when compared with the observations. Authors need to comment on this finding. Again it will be really interesting to know why authors chose to use 10-day moving average.

Response: We had missed to mention this result, therefore, we have added following lines in the revised manuscript (line 28 page 8) now;

> However, precipitation is consistently overestimated by both high resolutions during the whole two weeks period in mid-monsoon (Jul –Aug), likewise the dry bias in D1 is significantly reduced with its pattern more closer to observation as compared to other monsoon days. Similar overestimation in WRF simulations identified by Raju et al. (2014) is attributed to excessive moisture transport from Bay of Bengal and western pacific towards the monsoon dominated regions due to the strong low level easterly wind bias. Hence, we speculate the similar mechanisms to be responsible for our simulations too.

- As the day to day fluctuation in precipitation is high, we smoothed using 10 days moving average to make the comparison easier to follow.

3. In figure 5 'Diurnal precipitation during monsoon seasons' across D2 and D3 are close to observed in lower valley regions. However, for the remaining cases except for the morning precipitation, the precipitation is either overestimating (after noon) or underestimating (before morning). Authors can provide a little explanation on this.

Response: We agree with the reviewer that particularly in the upper valley stations (with dominancy of Rolwaling stations) where narrow river valley is not resolved even in 1km topography, the pattern differs from observation. But, ridge stations captures the pattern though the magnitude of day time precipitation is overestimated.

Hence, we have rewritten it as (line 22 page 9) ;

> Although D3 shows best performance with closer agreement with observations and a better representation of the spatial and diurnal characteristics, there still is deficiency for the narrow and deep upper valleys like Rolwaling- **reflected with relatively poor performance in upper valley stations -** where mountains and valleys are not fully resolved in the 30 arc second WRF topography.

- In general, overestimated day time peak and underestimated night time peak magnitude are common deficiencies in WRF simulation. The possible reasons for this were discussed in our manuscript line 7 page 15 as

  This may be due to: 1) too much release of moisture at the mountain slopes during the day (anomalously strong convection); 2) underestimation of down valley winds due to smoothed topography.

4. In the explanation of figure 9 the authors have commented on west-east gradient during winter precipitation. However, I do not find a clear west-east precipitation gradient in all the three domains as well as in the observations. In fact I can see a north-south gradient. Authors needs to explain this with more clarity.

Response: Corrected as north south gradient for the Figure 9 case which covers relatively smaller area. Nevertheless, if we see in original supplement Figure 2 for larger area, the gradient from west-east is obvious due to weakening of westerlies towards east (also mentioned in the manuscript).

5. Figure 9: The difference between D2 and D3 is less for the winter season, premonsoon season and the monsoon precipitation.

Response: We agree with the reviewer that essential features are the same between D2 and D3, but there is relative improvement in later. We have also mentioned that in our conclusions, thus the choice of high resolutions depends on available computing resources and time.
When we look it in detail in Figure 9 then the better resolving of topo-climates in D3 (mountain, valley and ridge precipitation contrast) owing to better representation of topography is evident.
For instance, if we follow the precipitation pattern near the outlets of the basins and river valleys between D2 and D3, the relative reduction in overestimated magnitude of precipitation in later is apparent for all of these seasons. Further, the pattern closely follows more realistic topographic features at D3. The overall improvement in D3 can be also seen in error statistics in Table 3.

6. Figure 10: For monsoon season the bias is more over southern region which is comparatively low elevation region... please provide a comment on this?

Response: These texts are added in the revised manuscript (line 34 page 12.

> In contrast to other seasons, the warm biases evident in lower river valley station locations reverses to cold during monsoon season in high resolutions, which can potentially be associated with wet bias in precipitation in those locations with moisture and evaporation feedbacks as discussed earlier.
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> (* our original Figure 10 supports this attribution)

7. The authors argued that the pre-monsoon precipitation over the study region is mostly due the local scale circulations from local moisture source. If possible please provide an explanation with figure.

Response: We rephrased (add some texts too) and added reference to the previous study which had analyzed this;

> In study area section (line 19 page 4):
>
> The season is dominated with strong dry northwesterly winds. However, despite unfavourable synoptic environment, precipitation usually observed in the evening is generated primarily by localized convective instability with heating and is supported by the mountain uplift in the areas of surplus moisture (Shrestha et al., 2012)
>
> In result section (line 15 page 11):
>
> We had explained, and indicated not only local but there is also some contribution of synoptic scale systems in the manuscript. Now reference will be added.
>
> Pre-monsoon precipitation over the study region is primarily generated by localized convective instability (due to local surface heating and uplifting) with moisture supply from local sources

(**Shrestha et al., 2012**) or by the occasional passage of westerly disturbances during early months. However, due to the location of the target area in Eastern Nepal, a substantial amount of precipitation occurs in late pre-monsoon season, when moisture supply from the Bay of Bengal starts to increase

8. I see most of the local scale features in D2 and D3 are closely resemble with each other. How good is D3 compared to D2? The authors can briefly state this in the conclusions.

Response: We have now discussed it in conclusions by adding following lines (at line 23 page 15).

Although the essential features between both 5 and 1 km convection permitting simulation are the same, the later reduces the overestimated magnitude of precipitation and biases in temperature, and especially better reproduces the timing and magnitude of monsoonal diurnal cycle of precipitation, indicating the dominant influence of topography and surface fields (atmospheric dynamics) on resolving the topo-climates.

9. Although, it is not in scope of this manuscript, the authors can briefly comment on interaction between the westerlies and monsoonal circulation.

Response: We have added following lines in the study area section (line 30 page 4)

In general, the northward migration of monsoonal trough (break monsoon in main land India) towards Himalaya increases the rainfall activity and intense precipitation events over the region. When these northward migrated monsoonal system further merge with upper level extra-tropical westerly trough (south ward migrated) then it often provides a highly favorable synoptic situation to converge huge moisture from both Arabian sea and Bay of Bengal resulting in catastrophic extreme precipitation events (Shrestha, 2016).

References:

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