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Interactive comment on "An Assessment of the Impact of ATMS and CrIS Data Assimilation on Precipitation Prediction over the Tibetan Plateau" *by* Tong Xue et al.

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Specific comments 1. Lines 108: the content of section 2.1.1 has to be moved into section 2.2.1 of WRF-ARW regional model. Answer: Thanks for your suggestion. We have followed it in the revised manuscript in lines 195-200.

2. Lines 110: Is 0.5° × 0.5° the finest GFS horizontal resolution available? Answer: Thanks for your question. The NCEP GFS Analysis and Forecast System was upgraded on January 14, 2015 (1200 UTC), providing 0.25° × 0.25° gridded output which is the finest GFS horizontal resolution available. As the finer GFS product, 0.5° × 0.5° gridded output is still available. We have made some experiments comparing the winter and summer forecast over Tibetan Plateau while the 0.25° product was not available in

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the whole January 2015. So we choose the 0.5 degree gridded output at first.

3. Page.7, line 116: change the title of section 2.1.2 in “Data used for the evaluation/verification” (2.1.2) Answer: We have followed your suggestion in the revised manuscript in line 121.

4. Page.8, line 137: change the title of section 2.1.3 in “Data used for the assimilation” (new 2.1.1) Answer: We have followed your suggestion in the revised manuscript in line 104.

5. Page.10, line 171: change the title of section 2.2.1 in “The GSI 3D-VAR system and the Community Radiative Transfer Model”; please give in this paragraph some theory concepts on GSI 3D-Var system Answer: We have followed your suggestion in the revised manuscript in lines 203-221. Instead of the spectral definition of backgrounds errors in the SSI, GSI is constructed in physical space which the background errors can be represented by a non-homogeneous and anistropic gridpoint and used for both global and regional forecasts. GSI utilizes recursive filters and is designed to be a flexible system that is efficient on available parallel computing platforms (Wu et al., 2002; Purser et al., 2003a,b). The GSI 3D-Var system provides an optimal analysis through two outer iterative minimization of a prescribed function as follows: (1) Where is the analysis state can be calculated by minimizing the penalty function , is the first guess that comes from GFS product in this article representing background model state, are the observations including conventional observation, satellite radiance data, radar data, etc. is the transformation operator from the analysis variable to the form of the error. By means of the two sources of priori data: the first guess and the observations , the solution for the penalty function which indicates the posteriori maximum likelihood estimate of the true atmospheric state can be found. While B and are the error estimates of (covariance matrix of the background error) and (covariance matrix of the observation error) respectively which are used to weight the analysis fit to individual observations (Wu et al., 2002). Wu, W., R. Purser, and D. Parrish: Three-Dimensional Variational Analysis with Spatially Inhomogeneous Covariances. Mon. Wea. Rev., 130,

2905–2916, 2002 Purser, R. J., Wu, W. S., Parrish, D. F., and Roberts, N. M: Numerical aspects of the application of recursive filters to variational statistical analysis. Part I: Spatially homogeneous and isotropic Gaussian covariances. Monthly Weather Review, 131(8), 1524-1535, 2003a Purser, R. J., Wu, W. S., Parrish, D. F., and Roberts, N. M: Numerical aspects of the application of recursive filters to variational statistical analysis. Part II: Spatially inhomogeneous and anisotropic general covariances. Monthly Weather Review, 131(8), 1536-1548, 2003b

6. Line 185: In my opinion this paragraph would follow the one on assimilation data becoming 2.1.3 Answer: We have followed your suggestion in the revised manuscript in lines 155-178.

7. Line 210 section 3.1: please indicate in this section which is the best value for each score Answer: We have followed your suggestion in the revised manuscript in lines 239-262.

8. Lines 242-245: the sentences here are not so clear Answer: Following your suggestion, we have added the text in lines 269-273: The CTRL experiment was carried out first with an initial time of 00:00 UTC and made 54 h forecasts. The data assimilation was applied on the D01 region of the output from CTRL at 06:00 UTC. The initial condition of the DA experiments was derived from the CTRL 6 h forecasts and then DA experiments made a 48 h forecast for each day.

9. Pag.15 lines 275-277: the values in brackets are referred to L24h, is it right? If yes, please specify it in the text Answer: Thanks for your question. The values in brackets are referred to L24h. Following your suggestion, we have added the text in lines 309-312: The overall bias statistic in D02 is 0.97 mm (0.86 mm), 0.52 mm (0.70 mm), 1.08 mm (0.97 mm), and 0.98 mm (0.76 mm) CTRL, CONV, ATMS and CRIS respectively. The values in brackets are referred to L24h.

10. Pag.17 lines 313-316: please indicate on figure 8 (for example using circles or arrows) the overestimated and underestimated events Answer: Thanks for your mention,

we have added the grey shadings to indicate the underestimated events in figure 8.

11. Pag. 18 lines 325-326: please add a reference figure Answer: We have followed your suggestion in the revised manuscript in lines 362-367. It is usual to define the amount of 25.0 to 49.9 mm and 50 mm daily precipitation as heavy rain and rainstorm, respectively. However, due to the history data sets of the TP indicating that the days of precipitation exceeding 50 mm are few (only accounting for 0.3% of rain days) (Wei et al., 2003) and referring to previous studies (Wang et al., 2011; Zhao et al., 2015), the heavy rainfall threshold was defined as above 20 mm for the 24 h precipitation in this study. Wei, Z.ïijŇR. H. Huangïij Ň W. J. Dong: Interannual and interdecadal variations of air temperature and precipitation over the Tibetan Plateau. Chinese Journal of Atmospheric Sciences, 27(2), 157-170, 2003. Wang, C. H., S. W. Zhou, X. P. Tang, and P. Wu: Temporal and spatial distribution of heavy precipitation over Tibetan Plateau in recent 48 years. Scientia Geographica Sinica, 31(4), 470-477, 2011. Zhao, X. Y., Y. R. Wang, Q. Zhang, and L. Luo: Climatic characteristics of heavy precipitation events during summer half year over the Eastern Tibetan Plateau in recent 50 years. Arid Land Geography, 4, 004, 2015.

12. It would be useful to consider bootstrap confidence intervals when discussing the results Answer: Thanks for these very thoughtful suggestions. To consider bootstrap confidence intervals may be a useful way to present our results. Actually, we calculate these statistics based on a threshold with the different coefficients, please check Figure 7 and the description in lines 327-341 in section 4.1. If we want to consider bootstrap confidence intervals with the different threshold, the calculation should be very complicated. But we accept your suggestion with the different way discussion.

Technical corrections 13. Line 36: a space has to be added between “hours” and “and” Answer: Thanks for pointing out this issue to us. We have corrected it in the revised manuscript in lines 30-31. For the first 24-hour and last 24-hour accumulated daily precipitation. . . . . .

14. Line 52: “influences” rather than “influence”; “causes” rather than “cause” Answer: Thanks for pointing out this error to us. We have corrected it in the revised manuscript in line 47. The dramatic modification caused by the rugged terrain influences the local atmospheric circulation and causes strong local convection to arise. . .. . .

15ïijŐLine 127: “several” rather than “Several” Answer: Thanks for pointing out this issue to us. We have corrected it in the revised manuscript in line 141. Of the several merged satellite precipitation products. . .. . .

16. Lines 138-141-142-143: please specify the acronyms: GDAS, pibal, SSM/I and TCW Answer: Following your suggestion, we have added the text in lines 105-112. The conventional data which is from the Global Data Assimilation System (GDAS)-prepared BUFR files (gdas1.tCCz.prepbufr.nr) is composed of a global set of surface and upper air reports operationally collected by the National Centers for Environmental Prediction (NCEP). It includes radiosondes, surface ship and buoy observations, surface observations over land, pilot balloon (pibal) winds and aircraft reports from the Global Telecommunications System (GTS), profiler and US radar derived winds, Special Sensor Microwave Imager (SSM/I) oceanic winds and atmospheric total column water (TCW) retrievals, and satellite wind data from the National Environmental Satellite Data and Information Service (NESDIS).

17. Line 201: (Table 1) instead of (Table 2) Answer: Thanks for pointing out this mistake for us, we have changed it in the revised manuscript in line 172.

18. Line 280: “(Table 2)” instead of “(Table 1)” Answer: Thanks for pointing out this mistake for us, we have changed it in the revised manuscript in line 236.

19. Line 313: “It can be seen in the time series of Figure 8a that” Answer: Thanks for pointing out this issue for us, we have added it in the revised manuscript in line 350. It can be seen in the time series of Figure 8a that there are four observed heavy rainfall events. . ..

20. Line 317: “The L24H forecasts (fig.8b) showed a. . ..” Answer: Thanks for pointing out this issue for us, we have added it in the revised manuscript in line 355. The L24H forecasts (fig. 8b) showed a similar pattern.

21. Line 322: “the CONV (blue line) experiment” Answer: Thanks for pointing out this issue for us, we have added it in the revised manuscript in line 360. the CONV (blue line) experiment captured the accumulated amount of precipitation. . ..

22. Line 324:“the ATMS (red line) performed the worst. . ..the 24h precipitation maxima” Answer: Thanks for pointing out errors for us, we have added and corrected them in the revised manuscript in line 361 and line 367. the ATMS (red line) performed the worst. . ...the 24 h precipitation maxima surpassing 20 mm are spread in the main precipitation region

23. Line 349: a space has to be added between“experiments” and“data” Answer: Thanks for pointing out this issue for us, we have added a space it in the revised manuscript in line 393.

24. Line 354:“but the results are not the same. . ..” Answer: Thanks for pointing out this issue for us, we have changed the words in the revised manuscript in line 398. but the results are not the same when different data sets are injected.

25. Line 377:“(bottom left in Fig. 11m)” Answer: Thanks for pointing out this issue for us, we have added the words in the revised manuscript in line 437.

26. Line 408: delete the double comma Answer: Thanks for pointing out this issue for us, we have deleted it in the revised manuscript in line 469.

27. Line 409: a space has to be added between “25” and “July” Answer: Thanks for pointing out this issue for us, we have added a space it in the revised manuscript in line 470.

28. Line 445: “we choose” rather than “we chose” Answer: Thanks for pointing out errors for us, we have added and corrected them in the revised manuscript in line 507.

29. Table 1: New Table 1 will be the one about ATMS and CrIS channels and the caption could be modified as follows: “The channels for ATMS and CrIS data that have been selected for the data assimilation procedure” Answer: Following your suggestion, we have revised the text in the caption of new Table 1 in lines 648-649. Table 1. The channels for ATMS and CrIS data that have been selected for the data assimilation procedure

30. Table 2: New Table 2 will be the one about contingency table; please add also more details in the caption Answer: We have followed your suggestion to add more details in the caption of new Table 2 in lines 651-652. Table 2. Rain contingency table used in the verification studies. As a threshold, 6 mm day-1 is chose to separate rain from no-rain events

31. Figure 1: please add more details into the caption of figure 1a (resolution of the domains for example) Answer: Following your suggestion, we have added more details into the caption of figure 1 in lines 661-665. Figure 1. (a) Simulation domains and topography. Resolutions are at 12 km and 4 km for the outer (coarse grid, D01) and inner (nested grid, D02) boxes, respectively. The shading indicates the terrain elevation (unit: m). (b)–(d) Distribution of (b) conventional data observations, (c) scan coverage of ATMS data after data assimilation, and (d) scan coverage of CrIS data after data assimilation at 06:00 UTC on 1 July 2015.

32. Figure 2: clarify into the caption the difference between “observations kept and used” Answer: Thanks for your suggestion, we have revised the caption in lines 666-670 as follows: Figure 2. Blue bars indicate the total amount of radiance read in the DA system. Red bars present the number of kept radiance after first step of quality control. The used percentage after final quality control is shown as black curves. The right y-axis indicates the ratio of used amount to read amount. Top panel is for ATMS (a) and bottom is for CrIS data (b).

33. Figure 3: in the caption there are no info about the part of the figure at the top;

please also mention into the caption the initial time of each experiment Answer: Thanks for your suggestion, we have revised the caption in lines 671-676 as follows: Top panel shows the schematic of data assimilation configuration with 3D-Var. Bottom panel presents the experiments design. CTRL: control experiment without data assimilation that the initial time is 00:00 UTC from 1 to 31 July; CONV: data assimilation with conventional data only; ATMS: data assimilation with conventional and ATMS data; CRIS: data assimilation with conventional and CrIS data. CONV, ATMS and CRIS experiments all start at 06:00 UTC from 1 to 31 July.

34. Figure 4: put the unit also close to the color bar; "black contours are altitude" Answer: Thanks for your mention, we have put the unit above the color bar now and revised the manuscript in lines 677-678. Figure 4. Daily precipitation averaged (unit: mm) for the month of July 2015. (a), (b) are F24H forecast and (c), (d) are L24H forecast. Black contours are altitude (unit: m).

35. Figure 5: put the unit also close to the color bar Answer: We have put the unit above the color bar now.

36. Figure 7: please list into the caption the validation statistics presented in the figure Answer: The validations statistics is listed into the caption in lines 686-689. Figure 7. Monthly and domain average validation statistics for F24H forecast (a–f) and L24H forecast (g–l). (a) and (g) are Bias Score; (b) and (h) are Fraction skill Score; (c) and (i) are Equitable Threat Score; (d) and (j) are Probability of False Detection; (e) and (k) are Probability of Detection; (f) and (l) are False Alarm ratio.

37. Figure 8: please add more details into the caption Answer: We have added more details in to the caption in lines 690-693: Time series of daily precipitation distribution for F24H forecast (a) and L24H forecast (b). The black, grey, blue, red and green lines indicate observation, CTRL, CONV, ATMS and CRIS, respectively. The unit is mm. The grey shadings indicate the underestimated events.

38. Figure 11: put the unit also close to the color bar Answer: We have put the unit

above the color bar now.

39. Can be figures 4-5-6-10-11 a little bit bigger? Answer: Those figures are bigger now.

Please also note the supplement to this comment:
http://www.atmos-meas-tech-discuss.net/amt-2017-31/amt-2017-31-AC1-supplement.zip

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