**Response to reviewer 1: (MWR-D-11-00367)**

Thank you for your positive review. Your comments on an earlier version of the paper have led to large improvement of our paper.

**Response to reviewer 2: (MWR-D-11-00367)**

Thank you for your insightful and detailed comments. We have made revisions to the paper to address all your five major comments. These are: the diffusion in the models, the eddy transport calculation from reanalysis, the description of the offline radiation calculation, the calculation method of the diagnostic method, and English improvement. We have also revised the paper to take into account of your all your fifty-six detailed comments in the revision. These are described below. To respond to a comment from the third review, we changed the “two atmospheric dynamical cores” to “two atmospheric models” in the title.

**Major Comments:**

1. We have revised the paper to include the description of the diffusion processes in the IAP model by adding Equations (8) – (11). The horizontal diffusion coefficients are described in Equation (9), and the non-dimensional proportionality constant  is set to 0.1 for both the 128x256 and 181x360 grid point configurations. We have now stated that it is the tendencies of  that are filtered via the polar filter. The reference of Umscheid and Sankar-Rao (1971) is added. These are described on page 9 line 14-15 in the revised paper. The order of accuracy in Equation (13) (Equation 9 in the old version) is still second order because both terms on the right hand side of Equation (3) are second order. We have revised the controlling equations of the model (4) to correctly include the diffusion terms which were omitted in the earlier version. The kinetic energy (KE) is therefore damped at the small scales through the diffusion. We have included the explicit diffusion coefficients used in CAM3.1 in Section 2b in the revision. These are m$ ^2$s-1 and  m4s-1 (Line 13-14, page 11).The original incorrect description on polar filter and energy conservation in the CAM has been revised on page 13 line 14 and page 11 line 21, respectively.
2. Thank you for pointing this out. We re-calculated the transient eddy flux by using the ERA-Interim data instead of the NCEP data. The magnitude of the eddy transports is indeed larger in the ERA-Interim than in the NCEP reanalysis. The model simulations agree relatively better with the ERA-Interim data than with the NCEP data. We have therefore replaced the original figures 3 and 4 by using the ERA-Interim calculations, because ERA-Interim has been shown in the literature as more accurate than the NCEP reanalysis (e.g., Decker 2012, JCL). This change does not affect the results, since the simulated eddy transports by the models are still stronger than the calculation from the reanalysis, and the difference between the two models remains the same as seen in the new figures of 3 and 4. We have added a brief discussion on this on page 12 lines 11-16. A reference is added.
3. We have added a more detailed description of the offline radiation calculation on page 20 lines 18-22, and Table 1 in the revision.
4. We have added discussions of the impact of calculation methods on the values of eddy transports (page 14, lines 17-25). The steps of the comparison from the two models are as follows:
5. Interpolate the model data from model levels to pressure levels by linear interpolation using pressure.
6. Calculate time-mean of the vertically interpolated data.
7. Interpolate the time-mean data to T42 resolution.
8. Calculate the zonal-mean of the time-mean data with T42 resolution.

After these four steps, we can compare two model data directly. The interpolation and remapping of the model results can only weaken the model eddy activities, which are stronger in the models than in the reanalysis. Additionally, the same procedure is used for the dry models and for the moist models, whose contrast is the main focus of the present study, and similar results are obtained from using different resolution of the models (CAM T85 and T42). We therefore did not carry out sensitivity calculations on how the interpolations quantitatively affected the eddy transports by mapping reanalysis to the model grids.

1. The English writing of the manuscript has been improved. The undefined symbols have been defined, and some inconsistencies in the figure captions have been corrected. We greatly appreciate your careful review. It has helped us to improve the paper greatly. We have acknowledged this in the paper.

**Detailed Comments:**

1. ‘Eulerian dynamical core’ has been changed to ‘Eulerian spectral transform dynamical core’’.
2. We have stated that CAM was developed at NCAR in the abstract and introduction, and defined the NCAR acronym.
3. The sentence has been rephrased as you suggested.
4. The acronyms IAP and CAM have been defined in the first paragraph of the introduction again, and the modeling centers and references have been provided. Thank you.
5. The original sentence has been revised.
6. The sentence has been rephrased as you suggested.
7. The sentence has been rephrased as you suggested.
8. ‘Tibet’ has been corrected to ‘Tibetan’.
9. The definition of ‘available energy’ has been added on page 7 lines 1-2.
10. The hydrostatic relationship has been added in equation 4. The state equation was been used implicitly in the equation set of (4) which does not contain the air density, so we did not include it here. We have added explicit horizontal diffusion in momentum and therrnodynamic equations and specified them in equation 8. The value of the diffusion coefficient *ksa* has been specified on page 7 line 15. The multiplication sign between  has been omitted. The switch  has been replaced by . The meaning of the switch  has been provided. In the presented calculations,  is used, but the conservation of the total available energy is achieved under .  has been defined on page 7 line 15. We no longer call  the ‘Coriolis parameter’ in the revised paper. The  notation is standardized to  .
11. ‘formulas’ is corrected to ‘formulae’.
12. ‘Reduced grid’ has been replaced by ‘reduction of the physical grid spacing’. ‘±70o’ are used instead of ‘70o’. The filtered quantities are listed on page 9 line 14.
13. The missing ‘j’ index has been added in equation 13. Equation 13 is used to enlarge the grid spacing at high latitudes, so that the time step can be larger.
14. ‘increasing’ has been corrected to ‘increases’.
15. The information on the resolution has been added on page 10 line 5.
16. The sentence has been rephrased as you suggested. We have removed the sentence on better computational stability since this will introduce new discussions that are not essential for the paper.
17. Yes, we use equidistant grid spacings. We have modified ‘the same’ to ‘approximately the same’. The number of vertical levels has been quoted on page 11 line 2. The time step used for the 1x1 degree simulations is 540s.
18. ‘Spectral transform’ has been added in the caption.
19. This has been revised on page 11 line 17-21.
20. ‘Respectively’ has been omitted.
21. The explanation of the acronym NCAR has been moved to the introduction.
22. ‘IAP’ has been added.
23. ‘Student-t test’ has been capitalized and the sentence has been rephrased as you suggested.
24. The sentence has been revised.
25. The sentences have been revised as you suggested.
26. The sentences have been revised as your suggested.
27. Yes, the stationary component was removed.
28. We now use the ERA-Interim data to calculate the eddy activities instead of the NCEP data. The corresponding figures 3 and 4 have been re-plotted.
29. The sentences have been rephrased.
30. Yes, the two models have the same amount of total mass.
31. The Student-t test is specified.
32. Figure 7c has been re-plotted with contour intervals 1 m s-1 instead of 2 m s-1. It can be seen that the westerly jets in IAP is about 3 m s-1 stronger than CAM in southern hemisphere and 1 m s-1 stronger in northern hemisphere.
33. ‘maximum’ has been corrected to ‘maxima’.
34. Yes, it refers to different handling of the topography, because of the subtraction of the standard stratification in the IAP model. We have revised this sentence to make it clearer now.
35. The type of SST distribution has now been described on page 17 line 14-15.
36. The sentence has been rephrased as you suggested.
37. This is now removed in the revision.
38. ‘Pressure’ has been added.
39. This is because the zonal average of the geostrophic meridional wind is zero ( ). We have revised the sentence to clarify this on page18 line 5.
40. The error occurred in the word-to-pdf version during the submission. We have rewritten the equation and now made sure that it is right in the pdf version.
41. Yes, this is any latitude where the eddy flux is smaller in the IAP model than that in the CAM3.1.
42. Revised, on page 19 line 17.
43. Symbols ‘qrl’ and ‘qrs’ have been defined in page 20 line 11-12. We added more detailed discussion of figure 14 on page 20 lines 12-15.
44. A more detailed description of the ‘offline radiation calculations’ has been added on page 20 line 18-22.
45. The sentence has been rephrased.
46. We added the definition on page 21 line 18.
47. The typo has been corrected.
48. The description of table 1 has been revised.
49. The NCEP data has been replaced by the ERA-Interim data.
50. The NCEP data has been replaced by the ERA-Interim data.
51. The typo in ‘Fig. 5’ has been corrected to ‘Fig. 6’.
52. The typo in ‘Fig. 5’ has been corrected to ‘Fig. 6’.
53. The information which you suggested has been added.
54. This is now described in Table 1.
55. The detailed information on the experiments is now added in table 1 and in the first paragraph on page 20.
56. The labels (a) and (b) for Figure 16 are added.

**Response to reviewer 3: (MWR-D-11-00367)**

Thank you for your helpful comments. We have revised the paper to address the two main concerns you raised: resolution dependence of the results, and the impact of the time steps; we have also revised the paper to take all suggestions from your minor comments.

**Major Comments:**

1. About the effective resolution of the two models, we carried out an additional experiment in which a coarser resolution model of the CAM T42 is compared against the 1x1 degree IAP AGCM. The difference in the eddy transport between these two models is very similar to the difference between the 1.4x1.4 degree IAP AGCM and the T85 CAM that we reported in the paper (see Figure 1 below). We therefore think that the numerical formulations of the equations (including the subtraction of standard stratification in the IAP model) and the difference schemes are primarily responsible for the model differences when approximately similar numbers of grids are used. Since we cannot clearly define an “effective resolution” and search for it to seek a comparable solution among the two models, we now explicitly state in the revised paper that the dynamical core in this paper includes the diffusions from numerical and physical terms (page 3 line 14), and that the comparison is made with comparable resolutions. Our focus is really on the differences between dry models and moist models at the reported resolutions. To take account your comment, we have modified the phrase ‘two atmospheric dynamical cores’ to ‘two atmospheric models’ in the title.

Because we do not have a 0.5x0.5 degree version of the IAP model, to check the impact of resolutions on our results, we have run the simulation with CAM3.1 at a coarser T42 resolution. Fig. 1 shows the differences of the eddy transports of heat and momentum between the 1x1 degree IAP model and T42 CAM (360 grids versus 126 grids in the zonal direction). The differences of the eddy strength between the two resolutions are similar to what we reported in the paper for the differences between the 1.4x1.4 degree IAP model and the T85 CAM, which show weaker eddy transports in the IAP model. We revised the paper to add additional discussions on this issue about the resolution dependence in the revision (page 15, lines 8-10).

We have calculated the kinetic energy spectra for the IAP and the CAM model at different resolutions as you suggested. These are shown in Fig. 2. The energy spectra are similar between the IAP 1x1 degree resolution, 1.4x1.4 degree resolution, and CAM T85. CAM T42 has a faster drop off of the energy spectra at large wavenumber due to its coarse resolution. These results suggest to us that the resolution is not the main reason of the model differences given the comparable resolutions.

1. Yes, the IAP model uses a two-level time integration scheme, with 600s time steps for both the dynamics and physics. Thank you for the correction that CAM T85 uses 600s time steps for the dynamics, but 1200s for the physics. This has been corrected in the paper (page 11, lines 16-17). Both the IAP model and the CAM model have been tuned as standard model versions. In this paper, our objective is to show that the difference between these two tuned models is opposite to the difference of the respective dry models, and we explained the cause to be the weaker eddy transports in the IAP model.

**Minor points:**

1. We revised the sentence as you suggested, and added a reference on the filter (page 9 line 15).
2. We have changed ‘quadratic terms’ to ‘nonlinear terms’ in page 11 line 19.
3. The original sentence has been revised. It was meant to refer to all model layers except for the top three layers. A bi-harmonic diffusion operator is used in the CAM except for the top three model layers. This is now more specifically described in the paragraph (page 11, lines 14-20).
4. This has been revised (page 12 line 22 and page 13 lines 1-2).
5. We have modified ‘by 1-2 K’ to ‘more than 1 K’.
6. Thank you for the comment. We have re-calculated the transient eddy statistics from the ERA-Interim reanalysis data. Figures 3 and 4 are re-plotted using the ERA-Interim data, and we added a reference to justify why we used the ERA-Interim data (page 12, lines 11-16). The conclusions are the same.



**Fig. 1**. Differences of zonally averaged 5-year annual mean transient eddy heat flux (a) and momentum flux (b) from the climate simulations between the IAP AGCM4.0 with resolution 1o x 1o and the CAM3.1 with resolution T42 (IAP -CAM). Contour intervals are 1 K m s-1 in (a) and 4 m2 s-2 in (b).

KE

**Fig. 2.** 1000-day mean KE spectra as a function of total horizontal wavenumber for the IAP and the CAM model with different resolutions.