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Journal of Atmospheric and Oceanic Technology

Response to the Reviewer # 1

Dear Reviewer #1,

Thank you for prompt reviewing of this manuscript.

We hired Ms. Mary Golden (was chief editorial assistant of MWR) to help to improve the manuscript.

I changed the title a little bit from “Development of the Upgraded Tangent Linear and Adjoint of the Weather Research and Forecasting (WRF) Modeling System” to “Development of the Upgraded Tangent Linear and Adjoint of the Weather Research and Forecasting (WRF) Model” as this manuscript focus on WRF model, instead of the WRF modeling system, which includes WPS, REAL, WRF, WRFDA etc.

Best Regards,

Xin Zhang

Below is the point –by-point response:

*Reviewer #1: The authors present an interesting introduction of their recent work on the WRFPLUS that include the upgraded tangent linear and adjoint models of WRF's new dynamic core. I am impressed by the innovative technique for parallelizations of tangent linear and adjoint models proposed in this paper. I do believe it is worth accepting this paper for publication on Journal of Atmospheric and Oceanic Technology.*

*However, before it is accepted for publication on this journal, some revisions are required. The detail comments are as follows:*

*1) To show the significance of the new techniqe for parallelizations of tangent linear and adjoint models, the authors should give a description in the section of introduction on how the previous works did to parallelize tangent linear and adjoint models when forward model were upgraded and what difficults were met. Actually, for development of 4DVar system, one of challenging works is to update and parallelize tangent linear and adjoint models following the upgrade of the corresponding forward models. The authors didnot point out this to highlight their innovative work.*

Authors: We add a few sentences to emphasize the difficulty of the parallelization of the WAMS. Please see line 48-51,56-58 page 2-3. We hesitate to emphasize more as we would like to respect the colleagues who worked on WAMS .

*2)The writting should be further improved. Some expressions are not very good logically or not exact in science. The following are some examples:*

Authors: We hired a professional editor (Mary Golden, was chief editorial assistant of MWR) to improve the writing.

*2.1 Line 122 on Page 6: The phrase "general atmospheric model" or "general oceanic model" is scarcely used. In general, it should be "atmospheric general circulation model (AGCM)" or "oceanic general circulation model (OGCM)". In this paper, AGCM or/and OGCM were not considered. Therefore, the phrase "general atmospheric and oceanic models" in this manuscript should be replaced by "atmospheric and oceanic models".*

Authors: The phrases of “general atmospheric model” and “general oceanic model” were corrected to “atmospheric and oceanic models” , see line 132 page 6.

*2.2 Line 123 on Page 6: The phrase "finite differential algorithms" is incorrect, which should be "finite difference algorithms". In mathematics, "differential" is quite different from "difference". They are in continuous space and discrete space, respectively.*

Authors: The phrases of “finite differential algorithms” was corrected to “finite difference algorithms” , see line 133 page 6.

*2.3 Line 161-162 on Page 8: 'Followed by calling "RSL\_LITE\_EXCH\_Y" to finished the packed ghost area data exchanges on south-north direction'. What's meaning of this sentence? Is "to finished ..." correct?*

Authors: To make it more readable, this sentence is modified to “Therefore, one call of ”RSL\_LITE\_EXCH\_Y” is able to complete the data exchanges in the south-north direction ” , see line 171-173 page 8.

*2.4 Line 206-207 on Page 11: What's meaning of "a 15-km domain"? Do the authors mean "a 15km-resolution domain"? What are the range and location of the domain?*

Authors: Add more description of the domain configuration at line 220-222, page 11.

*3) Some improper or incorrect uses, such as:*

*3.1 Line 95-96 on Page 4: A bracket was missing before "Vukicevic (1991)".*

Authors: Bracket was added, see line 105 page 5.

*3.2 Line 136 on Page 6: ".... needs to be revised. the adjoint ...". The first letter of a word after the full stop mark should be capital.*

Authors: Corrected as “…needs to be reversed. The adjoint…”, see line 140 page 6.

*3.3 Line 137 on page 6: "add on". Should it be "add to"?*

Authors: Corrected as “add to”, see line 148 page 6.

*3.4 Line 169 on Page 8: "let Registry to generate ...". Should it be "let Registry generate ..."?*

Authors: corrected as “….there is the possibility of letting the Registry generate “, see line 180 page 8.

*4) Line 252 on Page 12: What coupler was used to couple WRFDA and WRFPLUS? This coupler has never been mentioned in the previous texts. Please give an introduction of it.*

Authors: The use of “coupler” mis-leads the readers. It is not a real coupler and it should be “coupling interfaces”, which are the inline codes/subroutines were developed for couple WRFDA and WRFPLUS together.

We make some correction. See line 265-268 page 13

Response to the Reviewer # 2

Dear Reviewer #2,

Thank you for prompt reviewing of this manuscript.

We hired Ms. Mary Golden (was chief editorial assistant of MWR) to help to improve the manuscript.

I changed the title a little bit from “Development of the Upgraded Tangent Linear and Adjoint of the Weather Research and Forecasting (WRF) Modeling System” to “Development of the Upgraded Tangent Linear and Adjoint of the Weather Research and Forecasting (WRF) Model” as this manuscript focus on WRF model, instead of the WRF modeling system, which includes WPS, REAL, WRF, WRFDA etc.

Best Regards,

Xin Zhang

Below is the point –by-point response:

*The paper describes some very significant improvements to the design of the WRF TL and adjoint codes, making use of the TAPENADE AD tool and the flexible WRF Registry infrastructure. The paper is generally well written, and should be published after minor changes.*

*Improvements to English grammer should be made. Most of my detailed comments below are grammer-related (my proposed text in* ***red****) with a few comments (in* ***blue****) to propose clarifications to help understanding.*

Authors: We hired a professional editor (Mary Golden, was chief editorial assistant of MWR) to improve the writing.

*Only a few figures, generally ok but Fig2b and 3b text could be increased in size – it is hard to read.*

Authors: We re-plotted Fig2b and 3b and the text size was increased.

***Detailed Comments:***

*‘During the past two decades, the use of the adjoint technique in meteorology and oceanography has been rapidly increasing.’*

Authors: We changed to “ the use of adjoint technique”, see line 24, page 2.

*‘The WRF model is designed to be an efficient massively parallel computing code to take advantage of advanced 33  high-performance computing systems.’*

Authors: We corrected, see line 33-34 page 2.

*‘WAMS has failed to follow the rapid development of WRF model and data assimilation system (WRFDA - Barker et al. 2012).’*

Authors: We added the reference of WRFDA paper, see line 54 page 3.

*‘makes WAMS inconvenient to be used with other systems. Furthermore, because WAMS uses disk input/output (I/O) for storing basic states and exchanging data, parallel efficiency is unsatisfactory on modern high performance computers ‘*

Authors: We made suggested changes; see line 58-62, page 3

*‘with the WAMS developed by Xiao et al. (2008) ‘*

Authors: We corrected. See line 65-66, page 3

*‘An innovative approach has been applied to develop the parallel code which dramatically reduces the’*

Authors: Editor suggests using “was” here and also changing “innovative” to “new”. See line 70, page 3

*‘Pascual (2004)) to re-develop the tangent linear and adjoint models of the WRF ARW core’*

Authors: Corrected. See line 84, page 4.

*‘condensation developed by Jimy Dudhia’*

Authors: Corrected. See line 100-101, page 4.

*‘(Vukicevic (1991);’*

Authors: Corrected. See line 105, page 5.

***I didn't understand this sentence****. Reword?: 'Due to the duality between MPI SEND and MPI RECV calls, in ADM, send message to where we receive in FWM and receive message from where we send previously. '*

Authors: After consulting with the editor, we changed this sentence to “Due to the duality between MPI SEND and MPI RECV calls, in transforming FWM to ADM, we replace MPI SEND calls with MPI RECV, and vice versa.”, see line 141-142, page 6. It is illustrated by figure 1.

*“*

*'In* ***the*** *FWM model, the variable U in* ***the*** *ghost region'* ***and subsequent 'ghost' references'***

Authors: Corrected. See line 145-149, page 6-7.

*‘In* ***the*** *WRF model, hundreds of thousands of lines of the code are automatically generated from a user-edited table, called* ***the*** *Registry ’*

Authors: Corrected. See line 150-151, page 7.

*‘The second entry ”HALO EM C” will be used in the model to refer to the communication operation being defined’. Also, explain what this example means i.e. what does \_C signify?*

Authors: Added “the”, see line 162, page 7.

“\_C” doesn’t mean anything, it just a suffix appended to halo entry name following the alphabetic sequence.

This example specifies that 4 points (one cell each in north, south, east, and west directions, respectively) of the stencil be used in updating the state arrays for fields u\_2 and v\_2 across the processors.

*‘During compilation, the WRF Registry ‘ and many following examples…*

Authors: Corrected. See line 166-167, page 7 and all the following .

*‘TLM has exactly the same exchange stencil’*

Authors: Corrected. See line 187, page 9.

*‘same communication latency and amount as in the first stage’*

Authors: Per editor’s suggestion, changed to “same communication overhead and amount as the first”. See line 212-213, page 11.

*‘It is worth mentioning that, with this approach, we completed the parallelization of the serial WRFPLUS model within a week by one person.’ Really? With no preparation? How long do you estimate this took with WAMS?*

Authors: We removed this sentence per editor’s suggestion.

With preparation (the registry is upgraded to be able to generate TLM and ADM of halo exchanges), we can complete in a week. Same estimation for the WAMS.

*‘grid points in the horizontal’*

Authors: Corrected. See line 221, page 11.

*‘that data is ready to be read. ‘*

Authors: Corrected. See line 258, page 12.

*‘and WRFDA fetches the data from the coupler instead of disk files.’*

Authors: Corrected. See line 267-268, page 13.

*‘introduced in a separate paper.’*

Authors: Corrected. See line 281, page 13.

Response to the Reviewer # 3

Dear Reviewer #3,

Thank you for prompt reviewing of this manuscript.

We hired Ms. Mary Golden (was chief editorial assistant of MWR) to help to improve the manuscript.

I changed the title a little bit from “Development of the Upgraded Tangent Linear and Adjoint of the Weather Research and Forecasting (WRF) Modeling System” to “Development of the Upgraded Tangent Linear and Adjoint of the Weather Research and Forecasting (WRF) Model” as this manuscript focus on WRF model, instead of the WRF modeling system, which includes WPS, REAL, WRF, WRFDA etc.

Best Regards,

Xin Zhang

Below is the point –by-point response:

*In this manuscript, the authors present the technical aspects of the re-development of the tangent linear and adjoint models for the Weather Research and Forecasting (WRF) Model with its Advanced Research WRF dynamic core (WRFPLUS). It is especially interesting to see a new approach to deal with the parallel computation of the tangent linear and adjoint codes described in the manuscript. The approach is easier for code-development and is also quite efficient. The manuscript is generally well written. The text is about the right length and the number of diagrams is also about right. I consider the manuscript suitable for publication in the Journal of Atmospheric and Oceanic Technology once the authors make the following minor corrections.*

*Minor Comments:*

1. *Line 23: "the adjoint technique ?" should be "the use of adjoint technique ?"*

Authors: We change to “ the use of adjoint technique”, see line 24 page 2.

1. *Line 336: "1381-1393" should be "1433-1446"*

Authors: We correct this error, see line 355 page 18.