Reply to Interactive comment on "A scale-dependent blending scheme for WRFDA: impact on regional weather forecasting" by H. Wang et al.

Anonymous Referee #1

Received and published: 6 May 2014

Review of the manuscript

A scale-dependent blending scheme for WRFDA: impact on regional weather forecasting

by H. Wang, X.-Y. Huang, D. Xu and J. Liu

General comment

The manuscript describes the utilization of large scale information from global numerical weather prediction (NWP) models in regional NWP models. Regional NWP models has difficulties to handle the large scale information in a proper way, partly due to use of observations within the regional model domain only and partly due to the effects on non-perfect lateral boundary conditions (on the lateral boundaries of the regional model domain). This is a problem that is well known to the NWP community applying regional high resolution models operationally for short range weather forecasting. Various "blending" schemes to mix in large scale information from global NWP models have been invented and are also applied successfully for operational forecasting. These "operational" blending schemes are hardly described in the scientific literature. The blending scheme of the current manuscript by Wang et al. is, for example, very similar to the blending scheme of Yang that has been operationally applied in the HIRLAM forecasting system for many years but only described in a HIRLAM Newsletter article. For this reason, I think that it is worthwhile to publish the current manuscript by Wang et al. since it also has merits by itself with a thorough comparison between "no blending data assimilation", "background blending", "analysis blending" and "downscaling (no data assimilation)".

We thank you very much for your invaluable comments that improved the revised manuscript. Here are our responses.

Detailed comments

Page 2464, lines 28-29: The ECMWF reanalysis data set seems to me to be on a too large scale for verification of WRF forecasts produced by a model with 15 km grid resolution. Preferably, observation verification scores should also be provided for u, v, T and q.

Reply: We agree that 'small' scale information in WRF forecasts can not be well verified by use of the ECMWF reanalysis. Here we only intend to verify 'large' scale component of forecasts that can be presented by ECMWF reanalysis (0.7 degree). We chose ECMWF reanalysis as independent reference because it is well known that the ECMWF reanalysis has high accuracy because it is produced by an advanced 4-dimensional variational data assimilation system that ingests in-site and remote observations. Moreover, it is not used in the experiments in this manuscript.

Following your suggestion, we verified WRF forecasts against conventional data (radiosonde, wind profiler, et al.). In general, the forecast skills are consistent to those compared to the

ECMWF reanalysis. So we do not add the verifications skill against observations in the revised manuscript. Here is an example of 24 h forecast verification, which is same to Fig. 5 in the manuscript but against observations.

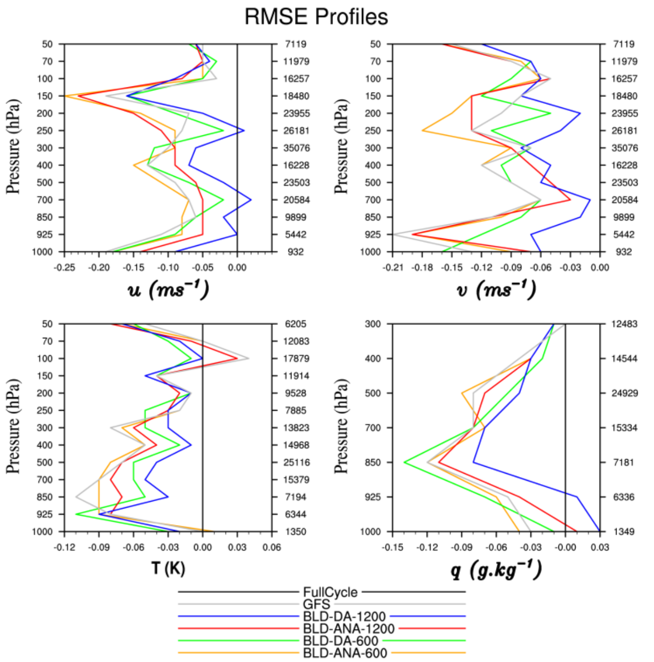

Fig. 1. 24h forecast RMSD reduction compared to FullCyclce. (a) *u*, (b) *v*, (c) T, and (d) q. Number of observations is shown in the right side y-axis.

In the verification of precipitation forecasts, it seems that observations were used, indeed. Please provide a short description of the precipitation observations (Stage IV) that were used.

Reply: The Stage IV precipitation is the regional hourly/6-hourly multi-sensor (radar+gauges) precipitation analyses at NCEP. We added a short description on Stage IV precipitation in the revised manuscript, and reference was added as well.

Lin, Y., and K. E. Mitchell, 2005: The NCEP stage II/IV hourly precipitation analysis: Development and applications. Preprints, 19th Conf. on Hydrology, San Diego, CA, Amer. Meteor.Soc., P1.2.

Language and editorial comments

Page 2457, line 9: .....when a forecast error .....

Accepted.

Page 2457, line 28: .....study of such a method

Accepted.

Page 2458, line 9: ..... took a slightly different ......

Accepted.

Page 2458, line 25: I would prefer “in order to reduce spin-up effects” rather than “this can reduce spin-up issue”.

In the revised manuscript, the statement is change to: is expect to reduce spin-up issue.

Page 2459, line 3: I would prefer “The component of a field x at length scale” rather

than “A field x whose component at length scale”.
Accepted.
Page 2460, line 13: ...... maintained at the National ....
Accepted.
Page 2461, line 2: .... when the wave length is equal to the .....
Accepted.
Page 2462, line 17-18: ..... WRF forecast compared to that .....
Accepted.
Page 2463, line 14: Before performing the blending experiments ....
Accepted.
Page 2464, line 1: ...... to generate a forecast difference ensemble to model the background ....
Accepted.
Page 2464, line 7: ..... from the Global .....
Accepted.
Page 2464, line 24: ..... that were initiated from ......
Accepted.
Page 2468, line 6: .... in the first few hours .....
Accepted.
Page 2468, line 15-16: .... Compared to the GFS.....
Accepted.

Reply to Interactive comment on "A scale-dependent blending scheme for WRFDA: impact on regional weather forecasting" by H. Wang et al.
Anonymous Referee #2
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1. General Comments

Review of the manuscript A scale-dependent blending scheme for WRFDA: impact on regional weather forecast- ing by H. Wang, X.-Y. Huang, D. Xu and J. Liu

In this manuscript, on the base of Yang's preliminary implementation, the authors describe a scale dependent blending technique of re-introducing large-scale features from global analyses and forecasts into regional model, which is supposed to resolve the problem of the obvious large-scale forecast error in regional WRFDA system running in full cycle mode. The results of a 2-week period full cycle assimilation and forecast experiments indicate that the blending scheme does show the merit of improving largescale weather features while keeping the well-developed small-scale signals active in the WRFDA analyses and regional model, and the blending scheme led to reduced analysis and forecast error and better precipitation forecast quality. The results shown in the manuscript are exciting as it provides a practical method to resolve the problem relating to the large scale error due to the inherent deficiency of regional model, especially for the operational regional numerical forecast running in full cycle mode. Therefore, I recommend the manuscript to be published.

We thank you very much for your invaluable and encouraging comments. Here are our responses.

2. Specific Comments

The choice of cut-off length scale determines the amount of information extracted or retained from the host/regional model respectively. As mentioned in page 2463, line 14-15, 'response functions to various cut-off length scales are examined to aid in selecting cut-off length scales', there is on further discussion about the selection of cut-off length scale in the manuscript. It's correct that the response function only reveals the performance of the filter to a certain cut-off length scale, which aids, but can not provide an objective criteria. Actually the selection of 1200 and 600km in the manuscript still looks as an empirical choice. The authors need to emphasize the issue.

Reply: Thank you for your suggestions. We added discussions on choice of cut-off length scale in the revised manuscript. Please see section 3.2 in the revised manuscript.

We agree that there is no a definite objective criteria or standard for selections of the cut-off length scale. However, the size of model domain, and experience on a data assimilation system do help to select the cut-off length scales. It is pointed out that one of reasons is given why the cut-off length scales of 600 and 1200 km are selected in the previous manuscript. The two cut-off length scales of 600 and 1200 km are selected because they can reintroduce the large-scale components in GFS with wavelengths above 3000 km that might not be well presented in the current model domain region of about 6300km×4800 km.

It's mentioned that "The filtered fields become smoother when the cut-off length scale becomes larger (Fig. 2b and c). Those filtered fields represent the large-scale information that is kept in blended fields (Fig. 2g and h) using Eq. (6c) "(page 2462 line 10-11). And “ The differences showed in Fig. 2e and f represent the small-scale information that is kept in blended fields (Fig. 2g and h).”(page 2462 line 14-15) . But we can identify the similar noise-alike(relating to topography) distribution of 500hPa geo-potential height from both the filtered (Fig.2b-c) and the residual (Fig2e-f). If possible, please give some explanations about it.

Reply: It is noted that the filter was implemented over the WRF model ETA level space. The noise-like distributions was caused by interpolation fields from model levels to pressure levels. If figure are drawn exactly on the WRF model level, you will not see the "noise".

3. Technical Comments

Page 2459, line 11: equation (3) not correct

Typo error is fixed.

Page 2461, line 24: should be ‘perturbation potential temperature’

Accepted.

Page 2464, line 20: why ‘next WRF cycle’?

Changed to "this WRF cycle".

Page 2473, Fig.1: I think the labels of GFS and WRF are confusing. In caption of figure1, it is only about the ‘amplitude response’ ,whatever it is for GFS or WRF. I understand the authors are trying to express after blending, most of large-scale part is from GFS and the residuals are from WRF. If so, the caption needs more revision.

Accepted. We added description on GFS and WRF in the Fig. 1 caption. Fig. 1 is also used to explain the idea of blending. Please see section 2.2 for details.