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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Assimilation of stratospheric and mesospheric temperatures from MLS and SABER into a global NWP model" *by* K. W. Hoppel et al.

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We thank referee #1 for the prompt and helpful review comments. The revised paper incorporates the changes as indicated.

General comments:

We added information in section 3.4 about the specification of background and observation error variances. The background temperature variance is a static function of pressure and latitude. Above the 32 hPa level, the temperature variance is in the range of 1.3 to 16.1 K, increasing with altitude and increasing poleward. The observation errors are taken as the precision values in the SABER and MLS retrieval files with two additional constraints: the minimum observation error is set to the larger of 2 K or 30% of the O-F magnitude. This latter constraint prevents the large mesospheric innovations from being rejected by quality control filters in the analysis algorithm. With these choices for the error variance, the analysis is tightly constrained to the SABER and MLS observations, with a global RMS residual difference (A-O) of ˜2 K. The issue of skill raised by the reviewer is addressed in point #8 below.

Specific comments:

1. The text in section 2.1 has been revised to add the following information: The top two model layers constitute the "sponge" and, for the L68 model formulation adopted here, span the pressure range of 0.0005-0.00089 hPa. Two relevant damping processes are each applied spectrally, through a horizontal diffusion coefficient, to the model layers in this sponge region. The first involves a significant increase of the spectral diffusion coefficient from the background values applied lower down. Additional damping is applied to the virtual potential temperature in the sponge layers in a way that relaxes temperatures towards an isothermal state. Since there is no Rayleigh friction in this version of the model either, our scale-selective upper-level damping acts preferentially on small spatial scales and has negligible damping impact on zonal means. Therefore the damping in these layers should not lead to the kinds of spurious circulation responses that can arise when zonal-mean friction is applied to such layers in ways that do not conserve momentum.

2. Corrected

3. Section 3.1 and the caption of Fig. 1 are modified to say that AIRS, SSMIS and GPS-RO data are not assimilated in this study. These 3 data types are the focus of ongoing NAVDAS research and development.

4. See the response to comment #1 above. Since the sponge layer spans 0.0005-0.00089 hPa, it constitutes only a segment of the 0.0005-0.005 hPa range. Parameterized gravity waves can also break in the sponge layer, and indeed deposit all their

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remaining flux in the sponge to conserve column momentum. Section 2.3 has been modified to include this information.

5. We agree that the original text does not adequately characterize Fig. 7. The text has been modified to simply note that the largest O-F values occur near the stratopause and mesopause.

6. There appears to be some confusion about what is being plotted in Fig 7. The "O standard deviation" described in section 4.2 is not the observation error but the geophysical standard deviation of the observation values themselves. The text has been revised to make this point clearer. We would agree with the reviewers comment if the observation errors had been plotted instead. The text has been modified to indicate that there are ˜40-100 profiles in each latitude bin, and that the profiles are generally distributed along 6 tracks, as illustrated in Figure 2.

7. Corrected

8. As you suggested, we have increased the number of forecasts used in Fig. 9 from 12 to 22 (˜1 forecast every 2 days). The updated figure shows no significant changes in the forecast skill relative to the original. The small time span (2 months) is probably the limiting factor for generating additional independent samples. We agree that a two month period is too small for an accurate assessment of upper-atmosphere forecast skill in general. Our results show just an example of the skill during the major warming, a period chosen given the fact that warmings are known to present the greatest middle atmospheric forecasting challenges to NWP systems (e.g., Lahoz, QJRMS, 1999). However, the decrease in forecast skill with increasing altitude and the summer/winter contrast appear to be robust results. Additional text will be added to emphasize that the results cannot be considered definitive given the small sample size.

9. The suggestion is to run forecasts initialized from an analysis that excludes SABER and MLS data, and then to compare the forecasts with those data. This would be an interesting experiment, but the first step would be to simply compare the stratosphere

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and mesosphere analysis with the SABER and MLS data to see how well these regions can be determined from only assimilating operational radiance data in stratosphere. Some our earlier NOGAPS-ALPHA mesospheric forecasting experiments were initialized using assimilation fields containing only tropospheric and stratospheric measurements and they were able to reproduce observed mesospheric circulation features in the winter hemispheres of August, 2002 (Coy et al., GRL, 2005) and February 2005 and 2006 (Siskind et al., GRL, 2007). See also our related responses to Gloria Manney's review comments. Since the scientific focus of this work is the winter hemisphere, we feel a dedicated study of this kind focused on the summer hemisphere is beyond the scope of this paper. Moreover, the companion study of Eckermann et al. [2008] for June-August 2007 focuses on the summer mesosphere. Their results (see their section 3) show that the forecast performance depends very sensitively on the tuning of parameterized nonorographic gravity wave drag. Given our ongoing interest in modeling the summer mesosphere in support of NASA’s AIM mission, we intend to study summer mesospheric predictability in future PMC-related research using NOGAPS-ALPHA and will seriously consider sensitivity experiments of the type proposed by the reviewer. A related study was also reported by Yulia Nezlin and Yves Rochon at the 2008 SPARC data assimilation workshop.

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