#Referee 1

In this work, the authors presented an empirical model, named CH-Therm-2018, of the thermospheric mass density derived from 9-year accelerometer measurements at altitude from 460 to 310 km, from CHAMP satellite. This paper is well written, and well organized. However, the referee did not get the point of this study. In other words, I did not see new findings of this work.

Thanks to your valuable comments on our manuscript angeo-2018-25, that will definitely help to improve our results.

Comments:

1. The authors should be addressed the purpose of this work to develop a new empirical model since there are a few models from CHAMP or GRCAE data. Most of the features were mentioned or reported in the previous works, especially in Liu et al. (2013). See more references attached. For me, it is more and less like a student exercise.

The method we used in this study is indeed similar to that of Liu et al. (2013), but the difference is that they used only the CHAMP dataset from 2002-2005 (high to moderate solar activity) and focused on low- and middle-latitudes. Yamazaki et al. (2015) used also the CHAMP and GRACE thermospheric mass density to build an empirical model, but they have normalized the observations to a common height of 450 km and only used the data from 2002 to 2006 at high latitudes. Therefore, we want to check if different features result during high and low solar activity levels. Another important fact is that we compare our mass density estimates with results from a cannonball satellite, ANDE-Pollux. These spherically shaped spacecraft are considered as density calibration missions. With the help of that our model is scaled to the “absolute” density level.

These advantages will be spelled out clearer in the revised version.

2. The CHAMP thermospheric densities derived from different groups show different biases. If the authors did not evaluate these datasets first, the model could be useless.

For our analysis we used the data set provided by Doornbos (see Doornbos et al., 2010). This is now explicitly stated in the manuscript. From Figure 5, we see that our model predicts are quite consistent with the observations. For correcting any biases of this data set we made the comparison with the SLR results from the cannon ball satellites, see above.

Doornbos, E., J. Van Den Ijssel, H. Lühr, M. Förster, G. Koppenwallner (2010), Neutral density and crosswind determination from arbitrarily, oriented multiaxis accelerometers on satellites. J Spacecraft Rockets, 47, pp. 580-589.

3. The authors mentioned that they used similar equation as Liu et al. (2013) did. Actually, it is totally different. Liu et al. (2013) used multinomial series, so that they got thousands of coefficients.

We should have been clearer. What we mean is we use a similar parameterization. Still we think the multivariable least-square fitting method is quite similar to that of Liu et al. (2013). If you take the coefficients list from our Table 1 and multiply them, you will get a number of $3\times3\times7\times8\times12\times8\times3= 145152$. This is now clarified.

4. Although there are 9 year dataset, the data are very sparse if the authors consider so many factors, including latitude, longitude, solar activity, geomagnetic activity, altitude, and so on. How to avoid the overfitting issue? How can use the constant scale height to fit the altitudinal variations without a large dataset?

We agree that the 9-year dataset is sparse when compared to the thermospheric variations with altitudes, solar activity, season, etc. Therefore the physical meaning of the different parameters is not obvious. An example for that is our constant scale height (see our answer to Dr. Matthias Förster above). Just the combination of all parameters gives a consistent picture. These facts will be discussed in more details in the revised version.

5. The authors developed two models for low and high solar activities. It is odd for me.

Our parameterization is not capable of tracing the full range of variability over the CHAMP mission. For that reason we decided to divide the dataset into two periods. The most important parameters (altitude and solar activity) vary simultaneously in the CHAMP observations and are therefore challenging to separate. Satisfying agreement with observations is achieved when dividing the data into two periods.

In this way we can check the variability of the mass density with respect to certain parameters for both high and low solar activity periods (see Figs 3 and 4).

6. It seems that the CH-Therm has a better performance as compared with MSIS. This is expected. When they compared the SLR data, the CH-Therm is even worse than the JB model.

The CH-Therm-2018 model performs better than NRLMSIS-00 during the years of the deep solar minimum. In the beginning of the CHAMP mission it covers the same epoch as the underlying data for the NRLMSIS-00. Therefore differences are small.

We regard the systematic difference between our model and the ANDE-Pollux calibration data by 1.267 as a scaling factor for increasing all model values. This value fits quite well the difference between CHAMP and GRACE density estimates, as reported earlier by Doornbos (2011). All the model values are now multiplied by that correction factor before plotting the comparisons. We have restructured the manuscript somewhat, presenting the validation with SLR data earlier in the text, in order to show that it is part of the CH-Therm-2018 model.

It is no surprise that the comparison of JB2008 with the ANDE-Pollux results give a smoother curve. These standard models contain less variability.

Doornbos, E. (2011), Thermospheric density and wind determination from satellite dynamics, Ph.D. Dissertation, 188 pp., University of Delft, available at http://repository.tudelft.nl/.

7. “CH-Therm-2018” should be removed from the title.

Accepted.

Ref: Weimer, D. R., Sutton, E. K., Mlynczak, M. G., & Hunt, L. A. (2016). Intercalibration of neutral density measurements for mapping the thermosphere. Journal of Geophysical Research: Space Physics, 121, 5975–5990. https://doi.org/10.1002/2016JA022691.

Calabia, A., & Jin, S. (2016). New modes and mechanisms of thermospheric mass density variations from GRACE accelerometers. Journal of Geophysical Research: Space Physics, 121, 11, 191–11, 212. https://doi.org/10.1002/2016JA022594.

Ruan et al. (2018). An exospheric temperature model based on CHAMP observations and TIEGCM simulations. Space Weather, 16. https://doi.org/10.1002/2017SW001759