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Atmospheric Measurement Techniques Discussions

Interactive comment on "Monitoring Sudden Stratospheric Warmings using radio occultation: a new approach demonstrated based on the 2009 event" *by* Ying Li et al.

Anonymous Referee #3

Received and published: 8 August 2020

This paper proposes a new application of GNSS-RO for detecting stratospheric sudden warming (SSW) events. I appreciate the devoted efforts of the authors for developing an interesting analysis technique with the COSMIC GNSS-RO data and applying it to the major SSW event that occurred in 2009. The results are impressive in visualizing the horizontal distribution as well as the time evolution of the 2009 SSW event. However, I have several concerns about the data analysis procedure and the usefulness of the proposed techniques.

Major comments:

1. This method is successfully applied to the SSW event of January 2009, which

is a well-studied case. I am afraid that Section 3 is too descriptive. For comparing the analyzed results with earlier studies, any new scientific findings on SSW behavior should be reported. The technique should be evaluated, showing any new features of the SSW that can be uniquely resolved by GNSS-RO data.

2. Before proposing this method to monitor major/minor SSW events from long-term records, more cases should be tested to confirm that it is fully robust.

3. SSW is defined by the temperature anomaly in this study, but it is also characterized by zonal wind reversal. As GNSS-RO can provide only the former information, it may not clarify the entire behavior of SSW; therefore, this method may not be considered as primary. (See comment 1.)

4. The analysis procedure is a bit complicated. It employs three anomaly parameters: temperature, density, and bending angle, in four altitude ranges. Out of a total of 12 values, only five parameters listed in Table 1 are used to monitor the SSW characteristics. It is not clear whether the selection of these five parameters will generally be adopted for any SSW event, or this set is used specifically for the 2009 SSW event.

5. Assuming that the COSMIC GNSS-RO data is assimilated into ECMWF, the 2009 SSW naturally appears similar in both GNSS-RO and ECMWF. Therefore, agreement of the SSW characteristics, as shown in Fig. 4, does not necessarily confirm the validity of the proposed GNSS-RO method.

6. The accuracy of the GNSS-RO data in the upper stratosphere and mesosphere (above about 40–50 km) should be tested carefully, because the error in the bending angle due to ionospheric effects could dominate, depending on the ionospheric conditions. Moreover, it is noteworthy that the bending angle profile at high altitudes is heavily optimized by referring to a model atmosphere profile, reducing the deviations from a climatological profile.

7. As the analyzed values are a weighted mean over three days, the time resolution

is longer than one day. Therefore, the time evolution of the SSW event, such as its duration and onset date, cannot be precisely determined at a daily resolution.

8. I would encourage the authors to extend the latitude range below 60°N, as the effects of SSW on the middle latitudes and equatorial regions have been the subject of recent research. I would also suggest the use of ionospheric electron density data with GNSS-RO to identify SSW effects on the upper atmosphere.

Specific comments:

9. P2, L27–30: Show some references on the limitations of other satellite missions.

10. P3, L1–3: Similarly, explain the limitations of the reanalysis data, referring to the relevant papers.

11. P5, L19–25: GNSS-RO data are neither distributed evenly nor regularly, but randomly with a relatively high horizontal density.

12. P6, L23–25: Is the GNSS-RO data assimilated into the ECMWF? If so, the agreement of the climatology is reasonable. (See comment 5.)

13. P6, L32: Remove one of “the”.

14. P7, L9–11: Temporal resolution is lower than one day, which affects the description of the time evolution of SSW, such as its duration and onset date. (See comment 7.)

15. P7, L14–17: For the four altitude regions, the exact height ranges should be provided here, even though they are shown in Table 1.

16. P7, L30–34: Is selection of the thresholds intended to be applicable to any SSW events, or specific to the 2009 case? (See comment 4.)

17. P8, L2: Isn’t 50% of the density deviation reasonable? It seems too large. (See comment 6.)

18. P8, L13: The word “then” can be read as “than”, right?

19. P8, L19–20: “number of days”. (See comment 14.)

20. P8, L22–23: How is the technique adjusted for long-term data? It sounds like this method is not fully robust, and a specific tuning is required for each SSW event. (See comment 4.)

21. P9, L26–28: "differences above 50 km". (See comment 6.)

22. Section 3, P11, L24–26: I encourage the authors to show any new scientific findings obtained with the GNSS-RO data. (See comments 1 and 3.)

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