Referee comments – Chris Watson

Manuscript title: Application of Fengyun 3-C GNSS occultation sounder for assessing global ionospheric response to magnetic storm event

Authors: Bai et al.

General Comments:
This manuscript discusses ionospheric radio occultation measurements of the GNSS receiver (GNOS) onboard the sun-synchronous FY3-C satellite launched Sept. 23, 2013. Validation of GNOS radio occultation (RO) derived NmF2 with ground-based ionosonde measurements is presented for a one year period. Global variations in RO NmF2, hmF2 and ionosonde NmF2 during the March 2015 geomagnetic storm are also presented.

The primary findings are that GNOS provides reliable ionospheric NmF2, and that GNOS measurements can be used to observe the average trend of ionospheric NmF2 and hmF2 associated with a geomagnetic storm at mid to high latitudes. The validation of NmF2 is fine, however I have concerns with the results based on averaging of the occultation-derived NmF2, and the characterization of the ionosphere in localized regions based on this averaging. The concerns along with other specific comments are itemized below.

The ionospheric response to the March 2015 storm has been extensively studied using (e.g. Astafyeva et al. 2015, Nava et al., 2016, etc.. a quick Google search reveals many). Discussion and references to these previous studies should be added, as well as consistencies or inconsistencies between GNOS RO observations and pervious results. Also add discussion on *Habarulema et al.,* 2016, "Long-term analysis between radio occultation and ionosonde peak electron density and height during geomagnetic storms", which is directly related to the analysis attempted in your study.

Also, GNOS occultation measurements are a valuable contribution to existing RO constellations. It would be worthwhile to add some discussion highlighting the uniqueness of GNOS RO measurements in terms of existing RO capabilities, and the specific RO studies that the high elevation, sun-synchronous FY3-C orbit may allow for.

Specific Comments:

1. P2 L30-37 Please specify receiver and antenna models.

2. Figure 2: Individual hardware components shown in the figure should be labelled.

3. P3 L33: Equation 1 does not eliminate differential code biases due to receiver and satellite hardware, as implied in the text. Please discuss the techniques applied to account for these biases.

4. Equation 2: Direct inversion of the TEC is usually sufficient for obtaining F region ionospheric densities. Is there a reason for using the bending angle inversion?

5. Equation 2: Please provide the method used for obtaining bending angle from the excess phase. Also specify how bending angles above satellite altitude are accounted for (since you are integrating to infinity).

6. Please indicate whether ionograms were scaled manually or "auto-scaled". Ionospheric parameters derived from manually scaled ionograms are generally more reliable.

7. State the maximum tangent point – ionosonde separation distance used in NmF2 validations.

8. Since occultation hmf2 is being used for analysis in this study, it should be validated as well. It shouldn't be too difficult to compare occultation and ionosonde hmf2, similar to the Nmf2 validation.

9. The Discussion in Section 3.2 seems to imply that the variations in NmF2 are a geographical effect (e.g. Line 28: "large increases in the South Atlantic region"), however these are observations over a 10 hour period, and thus temporal effects would be large, particularly during a geomagnetic storm. I'm not convinced that a few occultation events over a 10 hour period are sufficient to characterize the ionospheric behavior in a particular geographical region. From Figures 7a-b, the most I would conclude is that equatorial/low latitude NmF2 increases during daytime, and decreases at night. I have the same concerns for the geographical trends are also discussed on Page 7, Lines 17-23.

10. Figure 8 averages NmF2/hmF2 from mid-latitude, trough, and auroral regions. Since the ionospheric structure can vary significantly over these regions, please comment on the potential effects of this averaging, and whether the trends shown in Figure 8 would change if only mid-latitudes or auroral regions were considered.

11. On a related note, please comment on the occurrence magnetospheric substorm activity, which can result in significantly enhanced ionization in the nighttime auroral region. I would strongly suggest analyzing mid-latitude and auroral regions separately, instead of a broad region covering 40 to 80 degrees inclination.

12. The standard deviation for each averaged HmF2 and NmF2 value should be shown in Figures 8 and 12, perhaps as error bars.

13. P6 L8: NmF2 is maximum on March 16 according to Figure 8, as opposed to March 17 as stated in the text.

14. P6 L32: Is there an explanation for the few stations that observed a sustained daytime NmF2 enhancement on March 18?

15. Integrating NmF2 over all local times in the top panel of Figure 12 seems meaningless.

16. P7 L5-6: GNOS observations at 40-80 magnetic inclination extend into the auroral region, well poleward of the northernmost ionosonde station (Moscow) in Figure 9, and thus the averaged ionosonde NmF2 wouldn't include significant auroral region effects. This may help explain discrepancies in Figure 12. For completeness, consider including ionosonde measurements from stations north of Moscow, of which there are several.

17. P7 L6-7: "..indicating significant differences still exist between the two measurement techniques." Please specify the differences this statement is referring to.

18. P7 L13: Spherical homogeneity of ionospheric density is also a very large assumption at high latitudes (trough, auroral, polar cap regions).

19. P8 L7: Instead of "GNOS data", specify that GNOS NmF2 values are reliable, since this was the only parameter validated in the manuscript.

Technical Corrections:

P1 L16: I suggest "space detection" be replaced with "space-based remote sensing" or something along those lines.

P1 L26-28: Unless I'm misinterpreting the intended meaning, this sentence should read something like: "In the zone of 40-80° magnetic inclination, average NmF2 observed by GNOS and 17 ground-based ionosondes showed the same basic trends during the geomagnetic storm.

P2 L4: "The GNSS radio occultation technique uses occultation receivers…"

Figure 1 axis labels are difficult to read.