Review of the manuscript

"On the variability of the semidiurnal solar and lunar tides of the equatorial electrojet during sudden stratospheric warmings".

By Tarique A. Siddiqui et al.

Submitted to Annales Geophysicae [MS angeo-2018-80].

General comments

The work presented in this paper focuses on the variability of the semidiurnal solar (S2) and lunar (L2) tides of the equatorial electrojet during the 2003, 2006, 2009 and 2013 major sudden stratospheric warming (SSW) events. Based on ground-magnetometer measurements at Huancayo and Fuquene the authors implemented a least squares fitting technique to extract information on S2 and L2 from the difference between these two stations of the horizontal component of the terrestrial magnetic field. Then, they proceeded to describe in detail the variations the S2 and L2 tidal components exhibit during the above-specified SSW time periods. Finally, they compared the observed variations of S2 and L2 against the variability of the migrating semidiurnal solar (SW2) and lunar (M2) tides obtained from model simulations during the 2003, 2009 and 2013 SSWs, finding good agreement in the timing of the M2 enhancements between observations and model simulations. This is a very interesting paper. It provides the community with new information on the behavior of the semidiurnal tides of the equatorial electrojet. It is generally well written and very clearly structured. **This reviewer recommends its publication in Annales Geophysicae after minor revision**.

Specific comments

1- In page 5, line 6, the uncertainty level (σ) is mentioned for the first time. It would be helpful if the authors provided the value of σ, since it is very difficult to estimate it from the figures. Furthermore, it seems that the uncertainty level of the phase is larger than that of the amplitudes of the tides. Maybe, it's the type of plotting that confuses me and in reality the uncertainty levels of both amplitude and phase are similar. But, if the phase uncertainty level is indeed larger, do the authors know why? In the case of the phase of S2, it concerns me that the authors can really state there is a shift of 1-2 h given that σ appears to be of 1-1.5 h. I mean, from the figures, except in the case of 2009 and maybe in 2006 around the 10th of January, the

shift in the phase of S2 may be completely embedded within the uncertainty level. Hence, one could say that the phase has not changed. Or, did I overlook something?

2- Plots of the phase of SW2 and M2 are presented in Figs. 6, 7 and 8. However, they are never discussed in the manuscript. Besides, I strongly recommend changing the colorbar to "hsv" or any other cyclic colorbar, and use 0 and 12 (12.4) as lower and upper boundaries, respectively. In that way, one can clearly see if there are (or not) changes in the phase of the simulated tides.

3- To extract the tides from the model simulations, I guess the authors used a similar fitting technique as in the case of the observations. If so, please mention that explicitly in the manuscript. Further, did the authors only fit SW2 and M2 or did they consider more wave numbers as well as other tides such as DW1?

4- Page 9, lines 7-8. Can one really expect that tides in temperature behave in the same way as in the winds? This reviewer has had the opportunity to study thermal tides in different model simulations and has found that they can behave quite differently in temperature and in the winds. Maybe the authors could show some results in the simulated winds to clarify this issue.

5- Page 12, lines 9-10. Please correct me if I am wrong, but when the authors write about the relative amplification of the tides, I understand that they mean relative to pre-SSW conditions. If that is the case then, at least for the eye of this reviewer, it is not clear that the relative amplification of L2 is larger than that of S2 for the 2013 SSW event.

Technical comments

The suggested changes and/or corrections are marked in bold and underlined.

Page 1

Line 1: "lunar tide**s**…"

Line 2: "For this purpose, ~~**the**~~…"

Line 10: "(M2) tide**s**" and "120 km **of** altitude"

Line 14: "winter-time" →"**wintertime**"

Line 17: "SSWs result ~~**due to**~~" → "SSWs result **from**…"

Page 2

Line 11: “evidence of **the** impact…”

Line 12: “low-latitudes ~~**have**~~ been” → “low-latitudes **has** been”

Line 12: “semi-diurnal” → “**semidiurnal**”

Line 17: “sub-periods of **the** solar **and** lunar day**s**…”

Lines 29-30: “counter-electrojets **(CEJ)** are…”

Lines 30-31: “Although Bartels and Johnston (1940) didn’t link the occurrence of ‘big-L days’ to SSWs…”. I would rephrase this, given that SSWs were not observed until the beginning of the 1950s.

Line 34: “could be linked to ~~**the**~~ enhancements…”

Page 3

Lines 9-10: “SSW events using **magnetometers over the Indian sector** by…”

Line 18: “the onset of **the** SSW” and “deceleration of **the** zonal…”

Line 20: “similar variability during ~~**the**~~ SSWs…”

Line 22: “presents the observations**;** ~~**which is**~~ followed…”

Lines 26, 27 and 29: please change “downloaded” to “**available**”.

Line 29: “from the website of **the** German…”

Page 4

Line 10: “For both ~~**the**~~ observatories…”

Line 12: “at both ~~**the**~~ observatories…”

Line 15: “**is** calculated…”

Line 21: “tidal variations, which **are mainly the result of** the lunar…”

Line 22: “typically **one** order…”

Lines 22-23: “amplitude of S**,** but occasionally **it** can become comparable to **that of S.**”

Line 27: “study was **the** determination…”

Line 28: “method, ~~**however**~~, they ~~**have**~~ also described…”

Page 5

Line 1: “the solar **local time** in hours…”

Line 3: “components of **the** S…”

Line 11: “harmonics in **such a way** that **they are** smaller during the night than **during** the day…”

Line 13: “a window ~~**size**~~ of length…”

Line 14: “approach. **In** this study…”

Lines 14-15: “window, **shifted** forward by 1 day, ~~**for the least squares fitting**~~ in order…”

Line 22: “represented by **black** and **white** circles…”

Line 26: “wind is **seen** later in January.”

Page 6

Line 3: “happen**s**”

Line 3: “the more dominant **between** the…”

Line 8: “pattern in **the** EEJ…”

Line 16: “between 6-17 **h of** LT…”

Line 24: “with the occurrence of **the** full…”

Line 27: “with the occurrence of **the** new moon…”

Line 28: “Figure 3e, remain~~s~~ below…”

Line 31: “during the onset of **the** SSW.” And “at these levels **until**…”

Line 33: “the onset of **the** SSW…”

Page 7

Line 1: “the start of **the** SSW…”

Line 4: “the onset of **the** SSW…”

Lines 8-9: “the zonal mean zonal wind ~~**speed**~~ is seen to begin **on** 11th January…”

Line 10: “The zonal mean zonal wind ~~**speed**~~, meanwhile…”

Line 13: “EEJ is again **visible**.”

Line 14: “levels (Fig 4e) **were** extremely low.”

Line 15: “onset of **the** SSW…”

Line 18: “the onset of **the** SSW…”

Line 19: “main phase of **the** SSW…”

Line 20: “the first ~~**peak**~~ enhancement…”

Lines 23-24: “onset of **the** SSW. In the main phase of **the** SSW…”

Line 27: “the change in **the** propagation…”

Line 28: “of the EEJ **are** mainly…”

Line 29: “in the phase of **the** SW2 tide…”

Page 8

Line 2: “temperature shows **an** enhancement…”

Line 4: “the zonal mean zonal wind ~~**amplitude**~~ starts…”

Lines 5-6: “as seen in the **previous** SSWs…” and “11th January start~~**s**~~ to…”

Line 8: “CEJ on 17th Jan**uary** could…”

Line 9: “caused by enhancement**s** of **the** geomagnetic…”

Line 10: “is similar to **that of** the observations…”

Line 16: “is being caused **by** the heating…”

Line 18: “two episodes of ~~**the**~~ L2…”

Line 22: “main phase of **the** SSW…”

Line 24: “the main phase of **the** SSW event.”

Line 28: “moderate to high ~~**levels**~~ between December **and** February…”

Line 29: “main phase of **the** SSW.”

Page 9

Line 6: “120 km **of** altitude…”

Line 8: “A moving window of 21 day**s** ~~**length**~~ is used…”

Line 16: “in both ~~**the**~~ hemispheres…” I have marked this change also in other parts of manuscript. I know that what the authors wrote is not wrong. However, I think that in these cases it is better to omit the article after the word “both”.

Line 17: “January coincide~~s~~”

Line 18: “exactly correspond **with** the reduction…”

Line 19: “variation of S2 amplitude**s**”

Line 20: “SW2 tidal amplitude**s** obtained…”

Line 27: “120 km **of** altitude…” and “A moving window of 21 day**s** ~~**length**~~ is used…”

Line 28: “at mid-latitudes in **the** SH shows…”

Line 31: “asymmetry with the **highest** values…”

Line 32: “its reduction **are** seen…”

Line 33: “in both ~~**the**~~ hemispheres…”

Page 10

Line 6: “120 km **of** altitude…”

Lines 9-10: “in both ~~**the**~~ hemispheres…”

Line 11: “The M2 amplitude~~s~~ get**s** enhanced…”

Line 12: “in both ~~**the**~~ hemispheres.”

Lines 15-16: “the 2013 SSW event **are** comparably larger than **those corresponding to** the other two SSW events and absolute comparison**s** in semidiurnal tidal amplitudes **among** the three…”

Line 17: “simulation output**s**”

Line 21: “tidal enhanc**e**ments”

Line 23: “of SW2 in neutral temperature and **of** S2.”

Line 33: “116 km **of** altitude…”

Line 35: “also cause**s** major…”

Page 11

Line 1: “wavelength**s**” and “smaller than **those of the** symmetric…”

Line 3: “the ionosphere **is** smaller than **in the case of** the symmetrical…”

Line 3: “changes during SSWs **are**”

Line 4: “likely to be caused **by** the variability…”

Line 11: “of SW2 amplitude**s**”

Line 13: “in one of the tide**s** at the expense…”

Line 20: “**A** modeling study…”

Line 23: “Numerical stud**ies** by…”

Line 26: “SW2 tide ~~**have**~~ resulted **from** the increase…”

Line 31: “mechanisms **is** responsible…”

Line 34: “more research **is** needed…”

Page 12

Line 9: “greater than the semidiurnal solar tide **amplitude**.”

Line 10: “to be larger than **that of** the EEJ…”

Line 12: “shows **an** enhancement…”

Line 17: “other. In **the** case of…”

Page 17

Figure 1 caption: “observator**ies** are marked **with** black…”

Page 18

Figure 2 caption; third line: “solar (red) and lunar (blue) tide**s**”

Figures 2a, 3a, 4a and 5a should be modified. Please put the colorbar outside the color map and add its units. And also, it would be nice if the authors used different boundaries (e.g., +/- 170 nT) so the CEJs are seen more clearly.

Figure 4b should also be modified.

Page 23

Figure 7 caption; second line: “the same period **are** presented…”