RC4: 'Reply on AC1', Anonymous Referee #1, 13 Jul 2022

Response to Reviewer 1

Since I have not seen a revised manuscript, I just comment on one of the authors' replies.

Reply 1: *Unfortunately, we have been advised not to upload the revised manuscript with our replies to comments. Here we include at least one part of the revision that is relevant to the Reviewer comments:*

"4 Discussion

The presented multi-instrument observations of polar cap patches in the Canadian Arctic are consistent with previously published results (e.g., Provan et al, 1998) that support the accepted model of polar patch formation (Cowley and Lockwood, 1992). Transient azimuthal flows in the cusp that resulted in the formation of polar cap patches were associated with the IMF B_y fluctuations due to solar wind Alfvén waves. Pulsed ionospheric flows modulated by solar wind Alfvén waves followed by polar cap patches were previously observed (Prikryl et al., 1999; 2002).

The large-amplitude solar wind Alfvén waves in the CIRs at the leading edge of HSSs also modulated the ionospheric currents that were estimated from the ground-based magnetometer data using an inversion technique. The ionospheric currents have been recognized as sources of AGWs causing TIDs. Of course, AGWs/TIDs can be generated by various other sources, including tropospheric weather systems (Bertin et al., 1975, 1978; Waldock and Jones, 1987; Oliver et al., 1997; Nishioka et al. 2013), polar vortex (Frissell et al., 2016), volcanic eruptions, earthquakes, and tsunamis (e.g., Nishitani et al., 2019; Themens et al., 2022), as well as phenomena associated with ion-neutral interactions (Nishitani et al., 2019). However, the case studies of equatorward propagating TIDs observed by SuperDARN and GNSS receivers presented in this paper clearly point to dayside ionospheric currents modulated by solar wind Alfvén waves. This is consistent with the previously published results (Prikryl et al., 2005).

Milan et al. (2017; see, their Fig. 2) reviewed the morphology and dynamics of the electrical current systems of the terrestrial magnetosphere and ionosphere that include DP1, DP2 and DPY currents. The patch formation has been associated with the By-modulated DPY currents (Hall currents associated with FCEs) (Friis-Christensen and Wilhjelm, 1975; Clauer et al., 1995; Stauning et al. 1994, 1995; Prikryl et al. 1999). In the high conductance auroral zone, Hall currents form the eastward and westward auroral electrojets, and the corresponding magnetic perturbations on the ground associated with these Hall currents, are known as the DP1 and DP2 patterns. However, this paper is concerned with the dayside currents, so the TIDs were caused primarily by the DP2 current intensifications."

>We agree that it may not be possible to strictly distinguish between MSTIDs and LSTIDs, because of a continuum of sizes and periods. But we disagree with the statement that LSTIDs with wavelengths greater than 1000 km cannot focus HF radio waves. The electron enhancements, particularly when slanted as in TIDs, would certainly refract the radio waves, and focus them to produce enhanced ground scatter power. Of course, we agree that TIDs can also be observed in the variations of Doppler velocities changes in the ground scatter data as shown and correlated with the GNSS TEC in the quoted paper by Hayashi et al. (2010, their Figs. 4 and 5). However, their equatorward propagating LSTIDs (Events 1 and

2) can also be clearly identified in the ground scatter power (https://cicr.isee.nagoya-u.ac.jp/web1/superdarn/sddata/hokql/gif/hok/2006/bm00/20061215_hok_bm00_ql.gif), although not shown or discussed by the authors. This is in contrast with their poleward propagating LSTID Event 3 that they observed both in TEC and Doppler velocity, but that does not seem to be observed in the ground scatter power.

I agree that LSTIDs can divert the radar waves forth and back owing to the tilted isopycnic surface. However, it does not mean the radar waves are focused or defocused. I can see that the plot the authors showed indicates maximum echo power region moves away and toward the radar in association with the LSTID. Still, it cannot be called focusing / defocusing of the radar wave packets at all because it does not show the propagating structure (just forth and back). It is thus appropriate to use words other than focusing / defocusing, such as diverting the maximum echo power region forth and back. If the authors disagree, they need to show that the focusing / defocusing can modulate the echo power significantly with the gravity waves with a wavelength of more than 1000 km using the HF ray path tracing technique.

Reply 2: *We agree, and we have now clarified this in the revised manuscript:*

"In the case of LSTIDs with a wavelength of more than 1000 km the tilted isopycnic surfaces divert the refracted radio waves back and forth thus modulating the range of the ground scatter."