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Interactive comment on "Satellite observations of middle atmosphere gravity wave activity and dissipation during recent stratospheric warmings" *by* Manfred Ern et al.

Anonymous Referee #1

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The authors present an analysis of gravity wave amplitudes, momentum fluxes, and potential drag during 13 Northern hemisphere as estimated from satellite temperature observations from HIRDLS and SABER instruments. They then focus in detail on the three dimensional evolution of these fields during two major warmings/polar night jet oscillation (PJO) events: a split event in early 2009 and a displacement in early 2006.

While the analysis yields only partial information on the gravity wave field (e.g. no directional information regarding the momentum fluxes, and sensitivity to only some parts of the spectrum), the results are nonetheless clearly informative regarding the interaction of the wave field and the background winds. For instance, there is some indication of enhanced wave activity prior to some major warmings, and the wave activity is clearly

suppressed during the recovery phase of PJO events, while the drag plays a role in the descent of the newly formed elevated stratopause during the same period, consistent with recent modeling work. There is some evidence as well for meridional propagation during this period which is not captured by current parameterizations.

The analysis is thorough, the paper is clearly written, and these observational results are of clear importance to our understanding of the dynamics of polar night-jet variability, so I am happy to recommend publication with minor revisions. I do have some comments outlined below.

I have four main questions, in no particular order of significance:

a) Role of stratospheric sources

In a number of places the authors seem to imply the possible role of stratospheric sources through jet related generation mechanisms; e.g. p14 l4-7, p18 l10-15, p26 l20-21 p31 l30-32 or by breaking planetary waves p19 l28-29, p31 l33-34. Do the authors believe there to be significant sources within the stratosphere? The possibility that these hotspots are related to selective filtering or to jet-related sources at lower altitudes that are colocated with these features is also raised but I was left feeling unsure of exactly what claims were being made. If these are all simply possibilities being raised that's fine but it would be helpful to have that stated a bit more clearly, perhaps earlier in the discussion. If there are stratospheric sources, might that be an alternative explanation for some of the weak gradients in momentum fluxes seen in Fig. 4 or the apparent meridional propagation in Fig. 7c6?

b) Insensitivity of potential drag to background flow field

p15 l31-32: Presumably this statement is referring to the weak winds in the lower stratosphere (that remain weak well after the winds return to their eastward state)? The winds in the upper stratosphere towards the later part of the recovery phase are quite strong. Do the authors have a sense of whether the weakness of the zonal mean

winds is the key point, or whether the fact that the winds are relatively weak at all longitudes is more relevant? The parameterized orographic fluxes shown in Hitchcock and Shepherd 2013 (their Fig. 5c) recover reasonably quickly once the zonal mean winds return to eastward; this is not so obvious in Fig. 4.

p 17, l4-7: I was a bit surprised that the mesospheric potential drag seems to be relatively insensitive to the background wind field; the presence of westward winds throughout the column doesn't seem to affect the values of the drag in Fig. 5. This again seems at odds with Hitchcock and Shepherd 2013 their Fig. 5a) which shows a strong responses of both orographic and non-orographic parameterized drag to the stratospheric wind reversal. Does this suggest a real difference between the observations and the models?

c) Enhancement prior to sudden warmings

p12 l24-p13 l3: This may to some extend be an issue of the color scale, but it's not so clear to me that the quoted episodes really constitude the periods of highest amplitudes between 30 and 40 km - certainly the peak during the period of westward winds in 2012/13 is the single largest episode, but the periods near day 20 in Fig. 3d, day 0 in Fig. 3f, and much of Figs. 3j and 3b all have comparable amplitudes to my eye. Is the case for enhanced wave activity prior to sudden warmings more clearly made from a zonally asymmetric perspective?

p14 l29-30: It isn't obvious to me why enhanced planetary wave activity should lead to enhanced gravity wave activity - certainly the associated wind field will affect the filtering as is clearly shown in Figs. 6 and 8 but is there evidence that the zonal mean fluxes also increase? Why should this be?

d) Timescale of intermittency

The momentum flux features in both Figs. 6 and 8 are highly localized, and as the authors argue clearly, are related in part to expected filtering processes. Can the authors

comment on the timescale of these hotspots in the satellite observations? Do they typically persist for much of the duration of the averaging periods shown, or do they have shorter timescales?

Finally, one minor point in the introduction:

p3 l13-17; the surface impacts of sudden warmings are not confined to high latitudes - see, e.g Figs.1 and 11 of Hitchcock and Simpson (2014).

P. Hitchcock and I. R. Simpson (2014) 'The Downward Influence of Stratospheric Sudden Warmings' J. Atmos. Sci. 71, 3856-3876 DOI: 10.1175/JAS-D-14-0012.1

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