We would like to thank to three reviewers for their valuable comments. Because important comments are similar or related, we thought it would be convenient to respond together to clarify the questions.

Common questions 1. Robustness of the relationship

Reviewer 1 While the links between high latitude stratospheric eddy forcing and tropical temperatures/ upwelling are reasonable (and consistent with well-known behavior),the further relationships with cloud statistics and precipitation are not convincing or shown to be statistically significant. Although the patterns in Figs. 1 and 3 are suggestive of tropospheric variations 10-20 days following the stratospheric cooling events, the arguments are hand-wavy and there are no statistically significant relationships deduced.

Reviewer 2 1. My main general comment concerns the robustness of this connection during other SSW events. The authors themselves acknowledge that not all SSW events have tropical impacts (line 8-10 of 23748). The significance "test" the authors present on page 23750 is dependent on three relationships holding true during two separate events, but if other events exist in which these relationships don't hold, then one could accuse this study of cherry-picking events to match their hypothesis. Clearly there have been more than 2 SSW over the period for which the requisite data is available, and the authors need to discuss these other events. If the relationship they find isn't present in these other events, the authors need to explain why not (e.g. the lower stratospheric tropical upwelling is weak or nonexistent, and thus the feedbacks never are able to develop), or I have trouble believing their results and the significance "test".

Reviewer 3 -My main concern is how robust are the results of this study. The results of this study are based on only two major SSW events. As the authors indicated in the introduction, "not all major SSW events necessarily have large tropical impacts". So what are the results for other major SSW events? Would the difference in the latitude of the wave breaking really results in different tropical impact? If so, does that contradict with current working hypothesis that "lower stratospheric vertical velocity variation is coupled with the tropical convective activity."

As stated in the Summary and Discussion that the results obtained from the present two cases are consistent with the earlier results from an independent composite analysis of the winters from1979 to 2001 (Kodera, 2006), which shows a statistically significant relationship between SSWs and tropical convection.

A problem of the statistical analysis is that by averaging many different events to extract a common feature, detailed structures often become obscure. Therefore, case study on exceptionary large events was chosen for the present investigation. Because all reviewers questioned on the robustness of the results from two cases, the following sentences and Figure are added in the revised version to show a generality of the present result.

"Figure A1a shows the results of the above mentioned composite analysis in Kodera, (2006). Twelve SSWs with average deceleration during 8 days of the polar night jet at 10hPa exceeding 2ms^{-1}/day were selected. The key day is defined as the day of the largest deceleration. Following a deceleration of the polar night jet, statistically significant increase in the upwelling occurs in the tropical stratosphere around day 2, and in the tropospheric equatorial SH around day 4 to 11. Student-*t* values corresponding to a 95% significance level for one- and two-sided tests are 1.8 and 2.2, respectively.

Two SSW events in the present study are juxtaposed in Fig A1b. The top panel shows the zonal-mean zonal wind tendency of winters 2009 and 2010 similar to Fig A1a-top panel. The tropical vertical pressure velocity in the SH (20°S-Eq) is presented in a similar way as the composite analysis by choosing the day of the maximum deceleration as the time origin. We can see that the upwelling in the tropical SH increases in the upper troposphere around day 4 to day 11 similar to the composite mean (rectangles in A1). It is clear that by adding the present two cases, statistical significance further increases. Therefore, we consider that the relationship between the enhancement of tropical convection and SSW shown in the present study is robust enough."

We also added in Introduction the following sentences clarifying why we perform case studies on two SSW events in January 1979 and 2010.

"In a previous study composite analysis of the tropical tropospheric impact of SSW events were made for the winters from 1979 to 2001 (Kodera, 2006). Even though significant responses were found in the tropical troposphere, a problem of the statistical analysis is that by averaging many different events to extract a common feature, detailed structures often become obscure. Therefore, case studies are made in the present paper on two exceptionary large events focusing on the role of overshooting and deep convective clouds in stratosphere–troposphere dynamical coupling in the tropics. The selected two largest SSW events of January 2009 and January 2010 (Harada et al., 2010; Ayarzagüena et al., 2011) have large impact on the tropical upwelling in the lower stratosphere as will be shown later. It should also be noted that not all major SSW events necessarily have such large tropical impacts, as this depends on the latitude of the wave breaking (Taguchi, 2011)."

"It should also be noted that not all major SSW events necessarily have large tropical impacts, as this depends on the latitude of the wave breaking (Taguchi, 2011). The two largest SSW events of January 2009 and January 2010 (Harada et al., 2010; Ayarzagüena et al., 2011) have outstanding impact on the tropical upwelling in the lower stratosphere. Therefore, we made case studies of these events in the present paper focusing on the role of overshooting and deep convective clouds in stratosphere–troposphere dynamical coupling in the tropics."

Common questions 2. Statistical significance of Fig. 2

Reviewer 1 (there are no attempts to evaluate the statistical significance levels in Fig. 2). I expect that demonstrating clear effects of specific stratosphere changes on tropical clouds / precipitation will be difficult because of the large natural variability in tropical clouds; there are relatively few degrees of freedom in the 40 day time series utilized here, so that significant relationships require extremely high correlation levels. (This could be evaluated by sampling longer records of cloud / precipitation statistics to see how often such relationships occur by chance).

Reviewer 2 3. I didn't find figure 2 and the accompanying discussion particularly convincing.

Reviewer 3 -Figure 2: The correlation in this figure is based on 31-day period. What is degree of freedom? Are the correlation coefficients significant?

We calculated correlations between the vertical velocity and indices representing different convective activity such as COV, DC, OLR. Here, we do not address a relationship of individual variable by comparing with a stochastic noise. Instead, physical consistency among the variables is checked by comparing the correlation coefficients according to the inequality expressed by Eq. 1. The result indicates that this happens only in about 1.5% of the cases, as noted in the text.

We added the following sentence to explain the purpose of this analysis.
"Here, we check the physical consistency among the variables by comparing the correlation coefficients among them."

Common questions 3. Possible mechanism of strat-trop connection

Reviewer 1 It is also difficult for me to understand the physical links proposed here, especially a 'direct relationship to lower stratospheric upwelling at around 70-50 hPa', which is well above the height of 99% of tropical clouds.

Reviewer 3 -Please give some possible physical mechanism that is responsible for the occurrence of the convective overshooting clouds during the SSW events.

In order to better explain a possible mechanism, the following discussion was added in the revised text in Summary and Discussion together with the results of additional correlation analysis in Figure 2 (presented as Figure A2 below).

"To get an insight into a possible mechanism of connection between the stratospheric and tropospheric variability, we also calculated correlations between the temperature or vertical temperature gradient (static stability) at each level, and COV or -OLR (Fig A2 bottom). COV shows better relationship with vertical temperature gradient than temperature itself around the tropopause (100 hPa). This means that the COV is sensitive to the stability around the tropopause region, while OLR is related with the static stability in the upper troposphere. This result indicates that COV increases due to a decrease of static stability around the tropopause induced by a cooling in the lower stratospheric associated with the SSW, consistent with the results of Kuang and Bretherton (2004) and Chae and Sherwood (2010).

The result of our previous numerical experiment also shows that when local cooling occurs near the tropopause, upwelling enhances in the lower TTL and the upper troposphere, inducing a warming there (see Figure 4 of Kodera et al., 2011a). A global non-hydrostatic model study (Eguchi et al., 2014) also confirmed the relationship suggested in the present result. Therefore, we consider that although in zonally averaged field cooling effect by stratospheric upwelling is limited in the stratosphere, its effect can further penetrate below through changes in COV and deep convective activity."

Common questions 4. Spatial distribution of convection in Fig. 4

Reviewer 1 I see much less evidence of any coherent variability in Figs. 4-5.

Reviewer 3 -Figure 4: Discussions on ENSO results are unclear. The author argues that the large different in OLR before the onset of the SSW events that are due to the opposite phase of the ENSO, and the small difference after the SSW events indicates the role of the COV-related deep convective activity. However, the similarity in OLR is not evident (second row in Figure 4); the amplitude of OLR for event 2009 is very weak, and localized to the northern Australia; the amplitude of OLR for event 2010 is much stronger and extended eastward to the date line. The argument "The distribution of the regions with low OLR becomes increasingly similar to that of COV during period (ii)" sounds speculative. And thus the conclusion is hand-wavy.

To facilitate the comparison before and after the onset of the event we rearranged Fig. 4 as in Figure A3 and gave the following explanation in revised version. We hope this arrangement facilitates to reveal a common structural change between the 2009 and 2010 events.

"During the period i) low OLR region is concentrated around Maritime continent-Western Pacific region in association with a large-scale convergence in the lower level. While COV are distributed more zonally along the Equator and 15°S latitude spreading over several sectors. During the period ii) low OLR area around the Maritime continent-Western Pacific diminishes together with a low level convergence, and the distribution becomes more zonal in the tropical SH similar to COV."

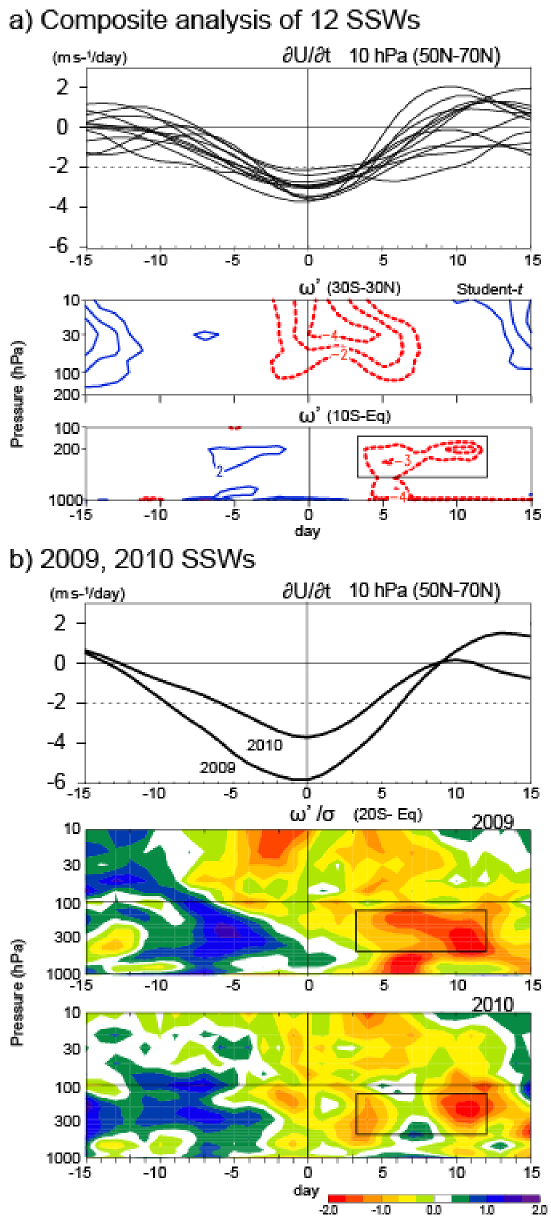

Figure A1

(a) Composite analysis of twelve SSWs during boreal winters from 1979- 2001 from Kodera (2006): Low pass filtered zonal-mean zonal wind tendency at 10 hPa averaged over 50°-70°N of twelve events (top). Student-t values of composited vertical pressure velocity averaged over 30°S-30°N in the stratosphere (middle) and that of 10°S-Equator in the troposphere. (b) Zonal-mean zonal wind tendency in winters 2009 and 2010 similar to Figure 7a (top). Normalized tropical vertical pressure velocity averaged over 20°S-Equator in January 2009 (middle) and January 2010 (bottom). Vertical lines indicate key date (see text). Rectangles indicate a period of enhanced tropospheric upwelling in (a).

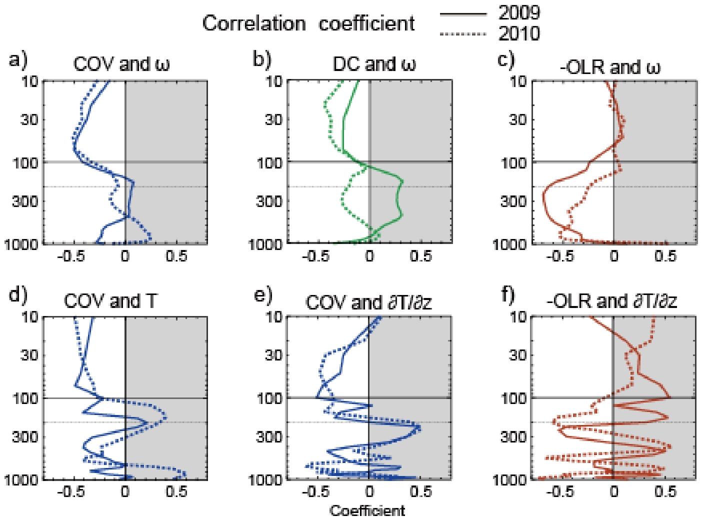

Figure A2

a) Correlation coefficient between the pressure coordinate vertical velocity (ω) at each pressure level and the daily convective overshooting occurrence frequency (COV) averaged over the tropics. b) As for (a), but for deep convection (DC). c) As for (a), but for the correlation coefficient with –OLR. d) Same as in (a), except for COV and temperature at each level. e) Same as in (d) except for COV and vertical temperature gradient at each level, f) Same as in (e) , except for –OLR and vertical temperature gradient. Variables were first averaged over 25°S to 25°N and then the correlation was calculated over 31 days centered at the onset day (16 January in 2009 and 20 January in 2010). Solid and dashed lines indicate 2009 and 2010, respectively.

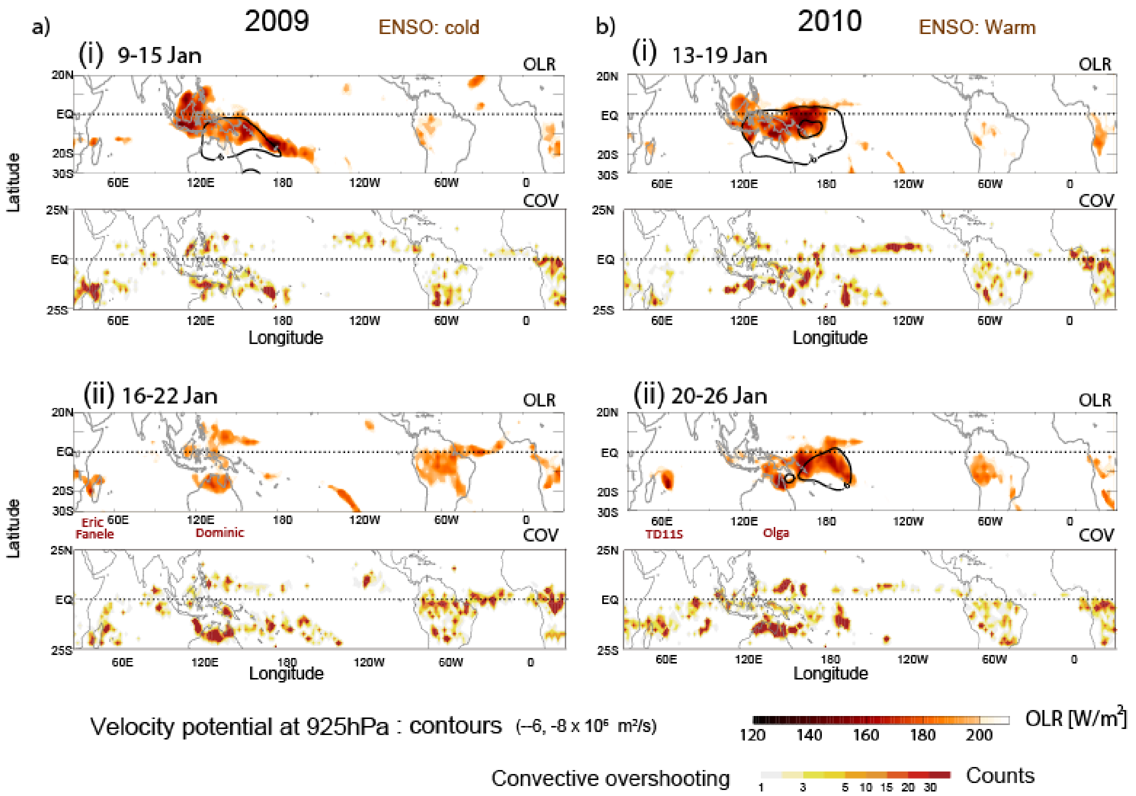

Figure A3.
Seven-day period before (i) and after (ii) the onset of the event in January 2009 (a) and 2010 (b). Top panels in each of (i) and (ii) are seven-day mean OLR (color shadings) with velocity potential at 925 hPa (contours of –6, and -8×10^6 m^2 s^{-1}), and the average number of COV in each 2.5° lat/lon grid box, respectively. Labels below top panels in (ii) indicate the names of tropical cyclones and storms.