Is There Statistical Connection between Stratospheric Sudden Warming and Tropospheric Blocking Events?

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ABSTRACT

Our statistical analysis does not support the long-assumed association between stratospheric sudden warming (SSW) and tropospheric blocking events (BEs) observed for 1957/58-2005/06 in the NH, suggesting that their association is not a dominant mode of ST dynamical coupling.

1. Introduction

◆ Associations of SSWs & BEs
Recurrently discussed topic
☆ BEs →SSWs
   BEs amplify planetary waves (PWs)
☆ SSWs →BEs
   SSWs lead to NAM- anomalies
   in troposphere, ～BEs
⇒ Some case studies exist,
   but still not well understood
◆ This Study
Statistical tests on the associations:
BEs occur more freqntly/last longer
   ☆ for pre-SSW (Hypothesis 1)
   ☆ for post-SSW (Hypothesis 2).

2. Data and Analysis

◆ NCEP/NCAR reanal. (Kalnay et al. 1996)
   September to May for 1957/58-2005/06
◆ Define SSWs (Charlton & Polvani 2007)
Find when [U]@60N, 10hPa gets easterly
→ Used as central days or lag = 0 day
◆ Define BEs (Tibaldi & Molteni 1990)
☆ Z500 grad. reversed between 40 & 60N
☆ Reversal for 5+ days at 3+ lon. grids
☆ Consider PW amplification in Z500
   H1 tested for BEs w/ PW amp. (BEs#)
   H2 tested for all BEs
◆ Fz@100 hPa, 45-75N
   ～PW activity to stratosphere
◆ Daily AO index defined in Z1000

Fig. 1: Frequency of locally blocked days.

Fig. 2: Z500 for (a) clim.&(b,c) two BE# days (CI=200 m). Bottom panels for PWs 1-3 (CI=100 m).

3. Results

◆ Calendar of SSWs & BEs (Figs. 3, 4)
NOT useful to say "Most SSWs preceded
   and/or accompanied by BEs".

◆ Bootstrap test on H1 w/ BEs# for pre-SSW
☆ Find linked cases (see Fig. 5a)
   Frequency: $Nobs^{BEs\#}$=14
   Duration: $\tau obs^{BEs\#}$=14.6 days
☆ Test for significant difference(s)
   ・Randomly replace SSWs in year,
      count $Nind^{BEs\#}$ & $\tau ind^{BEs\#}$
   ・Repeat 10,000 times to get PDFs
   ・Compare obs. to the PDFs (Fig. 6a,b)
⇒ Neither $Nobs^{BEs\#}$ or $\tau obs^{BEs\#}$ different
☆ Compare SSWs & BEs# to Fz (Fig. 7)
   SSWs closely tied to Fz
   BEs# weakly related to Fz

◆ Bootstrap test on H2 w/ all BEs
☆ Find linked cases (see Fig. 5b)
   $Nobs^{BEs}$=97, τobs^{BEs}=11.9 days
☆ Test for significant difference(s) (Fig. 6c,d)
⇒ Neither $Nobs^{BEs}$ or τobs^{BEs} different
☆ Compare SSWs, BEs & AO (Fig. 8)
   AO- bias for post-SSW, but variable
   AO weakly related to BEs
   For AOI<0, 1 BE day vs. 0.8 non-BE day

4. Summary

◆ "Bootstrap" tests on SSW-BE association
◆ NOT supported for either pre- or post-SSW, treating all SSWs & BEs altogether (Fig.9)
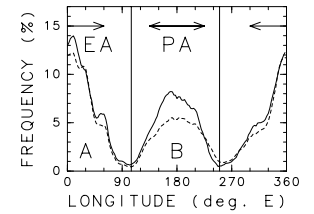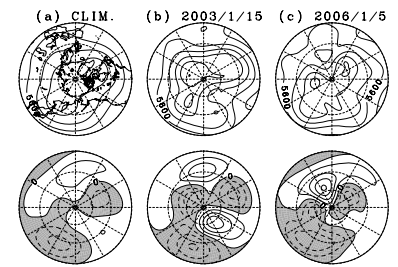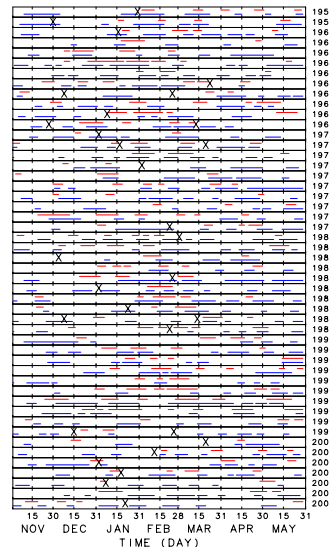◆ NOT dominant mode of ST coupling

Fig. 3: Calendar of SSWs(X) & BEs (bars). Blue for region A, red for region B.
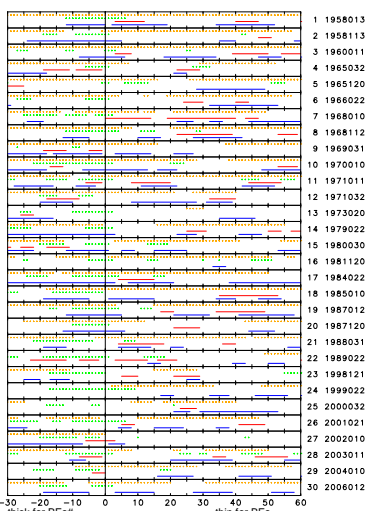

Fig. 4: SSWs (lag=0) compared to BEs (bars), strong Fz (green), & negative AOI (orange).
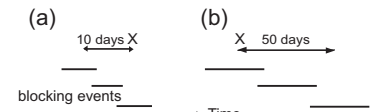

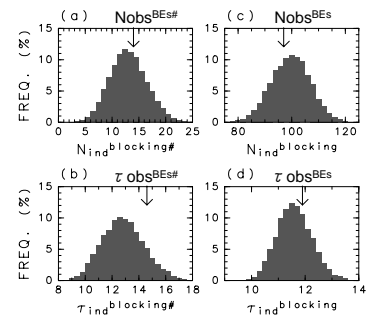Fig. 5: Examples of linked cases for pre-SSW (H1) and post-SSW (H2).

Fig. 6: PDFs obtained in the random shuffling. Observed values marked by arrows.
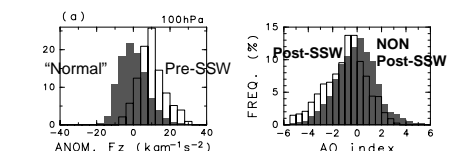

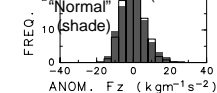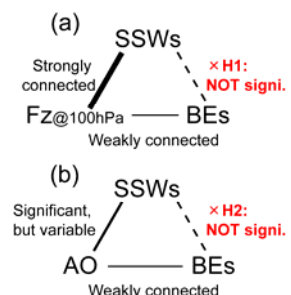Fig. 7: PDFs of Fz anomalies at 100hPa, 45-75N.

Fig. 8: PDFs of AOI.

Fig. 9: Interpretations of non-association between SSWs & BEs. (a) H1 for pre-SSW, (b) H2 for post-SSW.