Accelerated increase in Arctic tropospheric warming surpassing stratospheric warming

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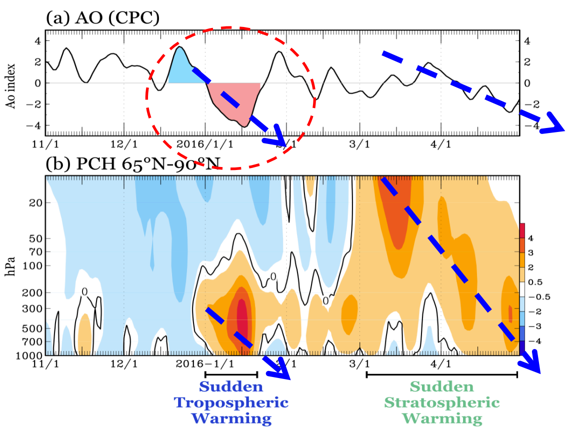
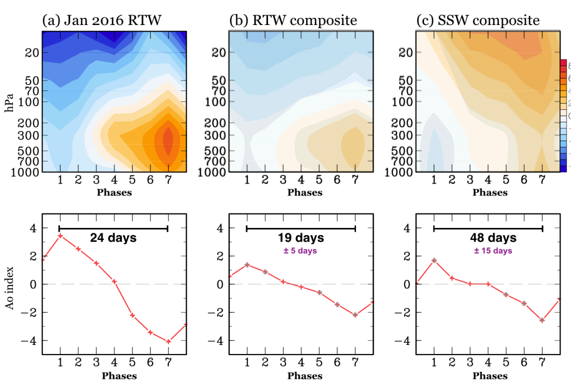
Abstract

In January 2016, a tropospheric warming occurred in the Arctic region associated with a fast, marked phase transition of the Arctic Oscillation (AO); this was followed by a classic sudden stratospheric warming in March. The succession of these two distinct Arctic warming events provides a stimulating opportunity to examine their long-term changes. Historical cases of these two types of Arctic warming were identified based upon previous studies in terms of the dynamics, tropical linkage, phase coincidence of the Madden-Julian Oscillation, and El Niño impacts. Results indicate a recent and accelerated increase in the tropospheric warming type versus a flat trend in stratospheric warming type. Forced simulations with a global atmospheric model suggest the dominant role of reduced sea ice, over that of the global SST modulation, on the circulation anomaly and increased intraseasonal variability in the Arctic region. Given that the AO transition associated with the tropospheric warming type occurs much more quickly than that with the stratospheric warming type, the noted increase in the former implies intensification in the boreal-winter midlatitude weather extremes.

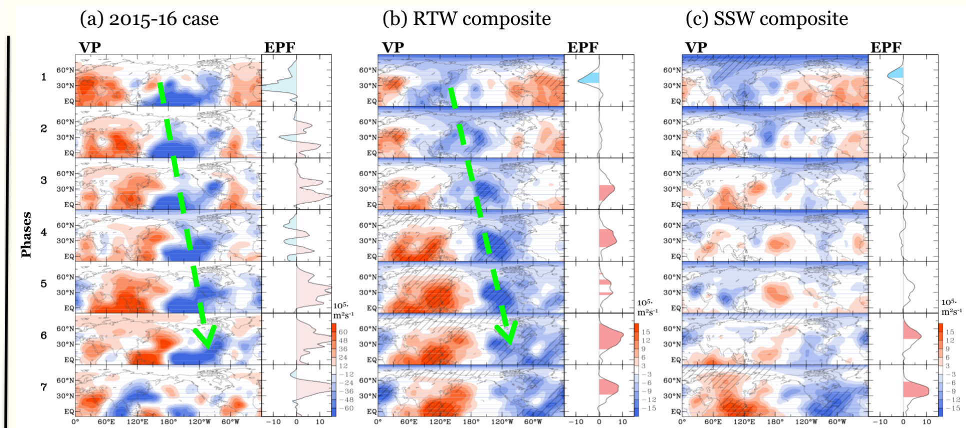
An extreme event: Jan 2016



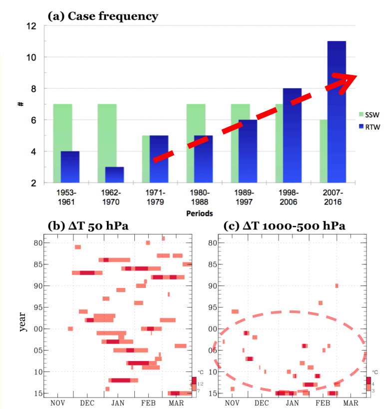
2015-2016 (a) Arctic Oscillation index. (b) Polar Cap Height anomaly; note the succession of tropospheric vs. stratospheric warming events.



Composite PCH spanning the 7 phases of the index cycle averaged north of 65°N (top) and corresponding AO index (bottom) for (a) the January 2016 RTW case, (b) composite RTW with 30 cases, and (c) composite SSW with 28 cases since 1979. Gray shaded areas and gray circles in (b) and (c) are significant at the 95% confidence level.

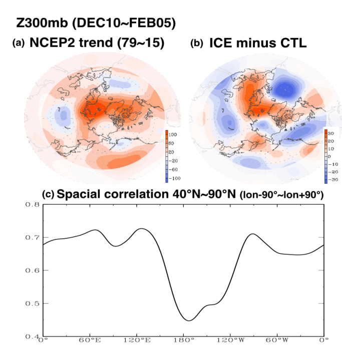


Composite phases of 250-hPa velocity potential (VP) and the eddy momentum component of the E-P flux (EPF) computed from (a) the January 2016 RTW case, (b) historical RTW cases, and (c) historical SSW cases. Hatched areas of VP and shaded areas of EPF in (b) and (c) are significant at the 95% confidence level.

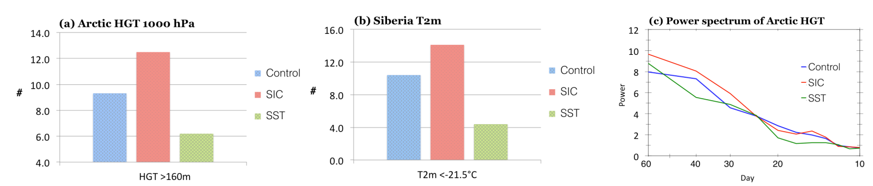


(a) The case frequencies of RTW (blue) and SSW (light green) cases plotted at every 9 years during the November-March period, and occurrence of Arctic temperature anomalies with the daily long-term mean removed at (b) 50 hPa and (c) 1000-500 hPa.

ECHAM5 experiments (Control run, Sea Ice Run, and SST Run: 2015-2016, 30 ensembles)



Wintertime Z300mb (a) Linear trend of NCEP2 (b) ICE run minus CTL run, and (c) the spatial correlation between (a) and (b) over 40°N-90°N and longitude -90° to +90°



The frequencies of (a) 1000-hPa HGT exceeding 160 m over the Arctic region and (b) T2m below -21.5°C over Siberia, and (c) power spectrum of Arctic 1000-hPa HGT, derived from the ensemble means of the three ECHAM5 experiments

Conclusions

- **Arctic warming of January 2016 began with tropospheric processes**
- **Rapid tropospheric warming events have increased in recent decades**
- **Sea Ice decline apparently enhances the rapid tropospheric warming**