Role of solar activity in the troposphere-stratosphere coupling in the northern and southern hemisphere winters

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Outline

1, Observation indicates both winter-mean North Atlantic Oscillation (NAO) (Figure 1) and late-winter/spring Southern Annular Mode (SAM) (Figure 3) show structural modulation with the 11-year solar cycle: The signal extends to higher altitude and more persistent in high solar (HS) years.

2, The source of such structural modulation of the NAO or SAM in winter or late-winter/spring originates from modulation of stratosphere-troposphere coupling with solar activity (Figure 2, 4, 6). Possible origin is from changing UV (Figure 5).

DATA: NAO-index (Hurrell, 1996), NAM-index (Baldwin and Dunkerton, 2001), ERA40 meteorological fields, F10.7-index, Period used is 1958-2000 (NH) or 1968-2001 (SH).

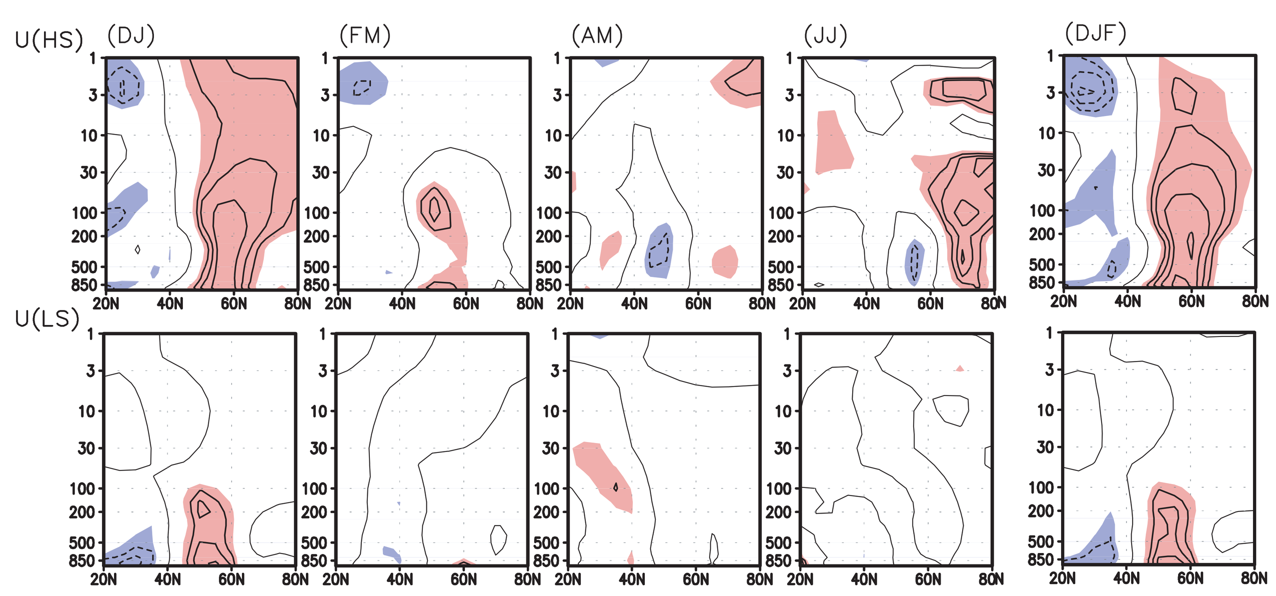

Figure 1, Comparison of the correlation of DJF-mean NAO-index with each grid point of two-month mean zonal wind from December-January (DJ) to June-July (JJ), and DJF-mean zonal wind (right most panels). Calculation is performed for high solar (HS) (upper panels) and low solar (LS) years (lower panels), separately. HS or LS year is determined by DJFM-mean F10.7 index, and 19 HS and 23 LS winters are selected from 43 winters from data of 1958/9 to 1999/2000. Shading is applied to regions where absolute value of the correlation is greater than 0.4 and contour is drawn with the area greater than 0.5 with a contour interval of 0.1. Dashed line indicate negative values.

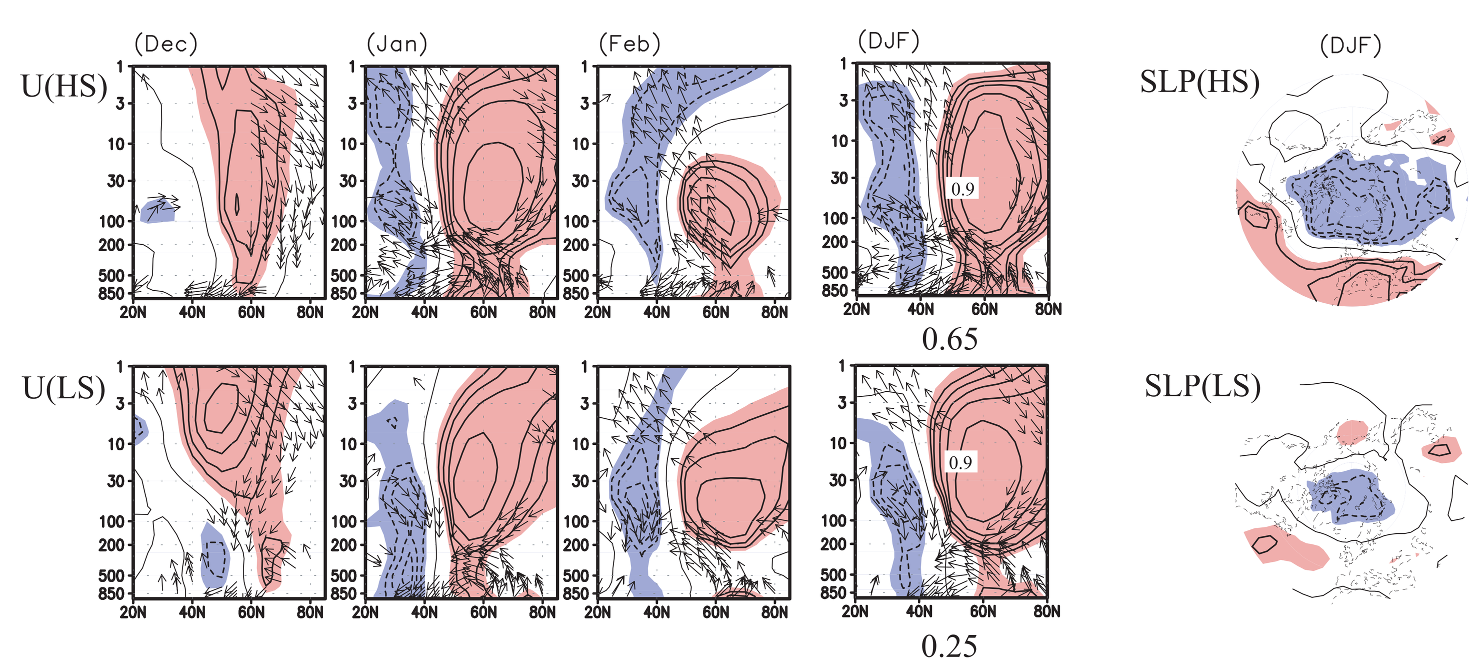

Figure 2, Same as Figure 1, except showing correlation of DJF-mean NAM-index at 30-hPa levels for HS (upper panels) and LS years (lower panels), respectively. Left panels indicate the correlation of monthly zonal wind (contour) and the E-P flux (arrows) from December to February, and DJF-mean fields. Right panels indicate DJF-mean sea level pressure (SLP). Numbers under panels indicate the correlation between DJF-mean NAO-index and NAM-index at 30-hPa levels.

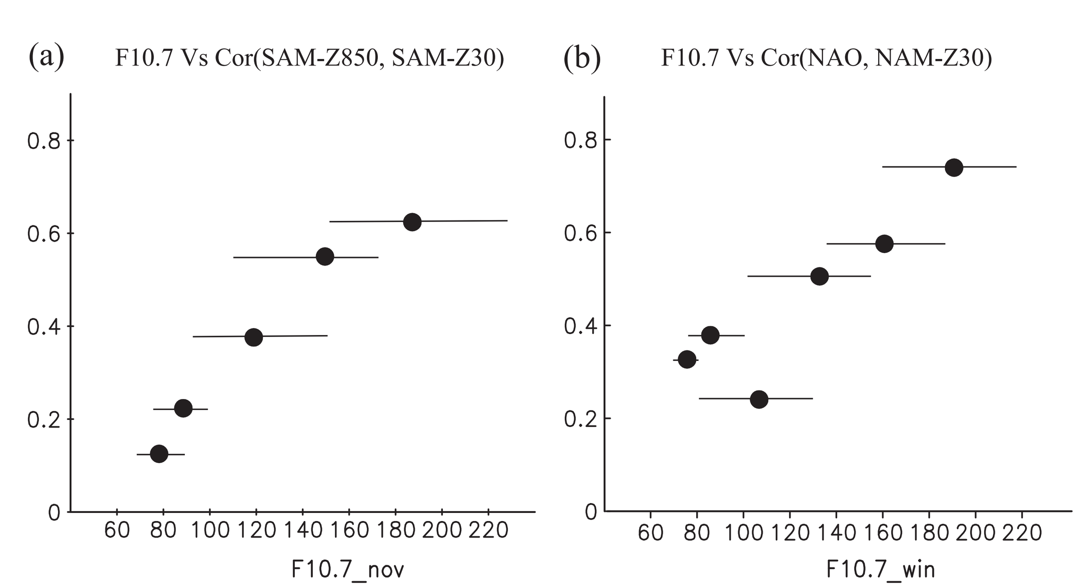

Figure 6, Scatter plots indicating the relationship between (a) the correlation between the November-mean 30-hPa and 850-hPa SAM indices and mean F10.7 index in the SH and (b) the correlation between the DJF-mean 30-hPa NAM and NAO indices and mean F10.7 index in the NH. The horizontal bar indicates the range of F10.7 indices of each winter for the calculation.

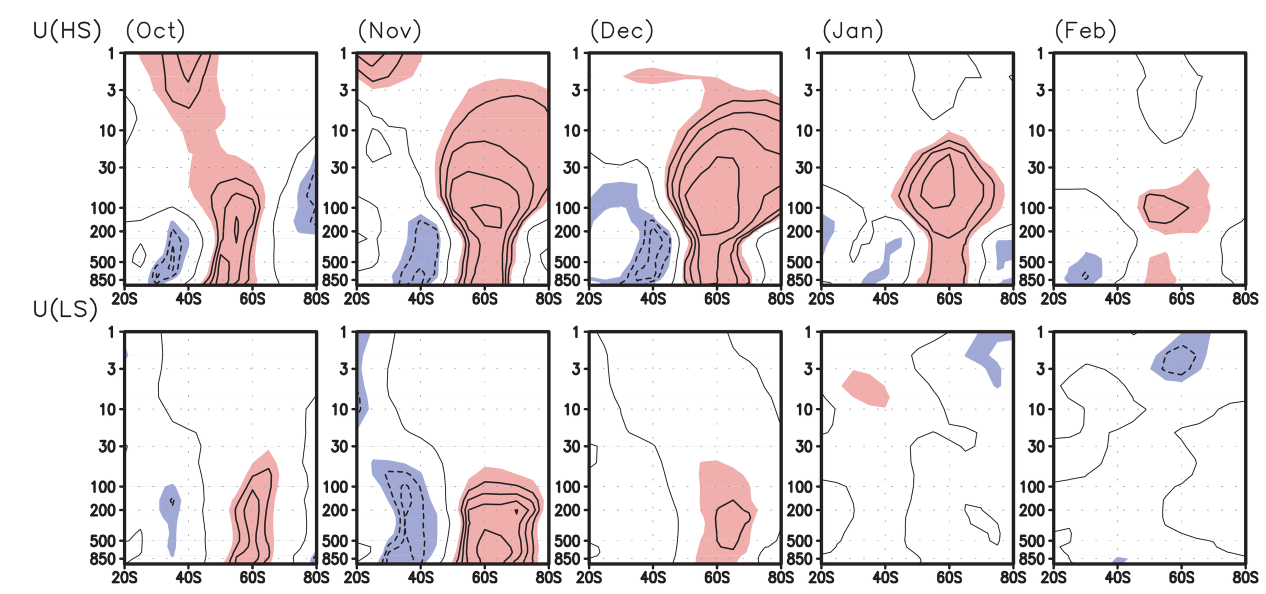

Figure 3, Same as Figure 1, except showing correlation of October-November mean SAM-index with each grid point of monthly mean zonal wind from October to February. 15 HS and 18 LS winters are selected from 34 winters from winters of 1968/9 to 2000/1.

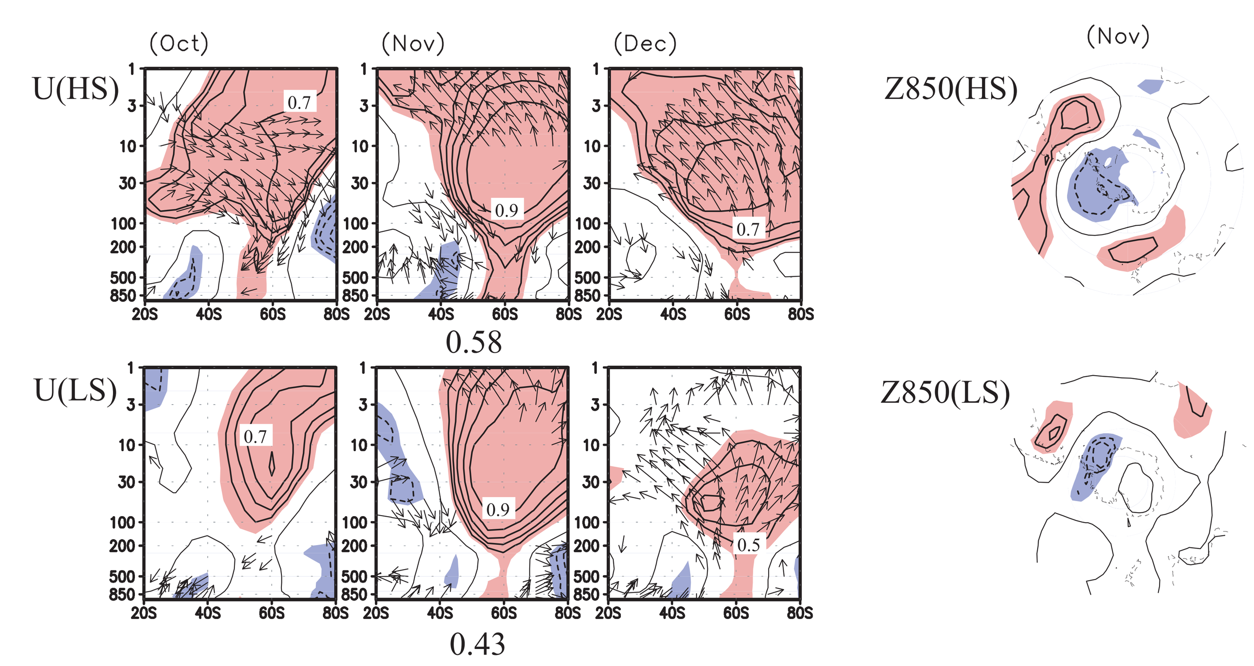

Figure 4, Same as Figure 2, except showing correlation of November SAM-index at 30-hPa levels with each grid point of monthly mean zonal wind (contour or shading) or E-P flux (arrow) (left) from October to December. Right panels indicate November-mean 850-hPa geopotential hight. Numbers under panels indicate the correlation between November-mean 850-hPa and 30-hPa SAM-indices.

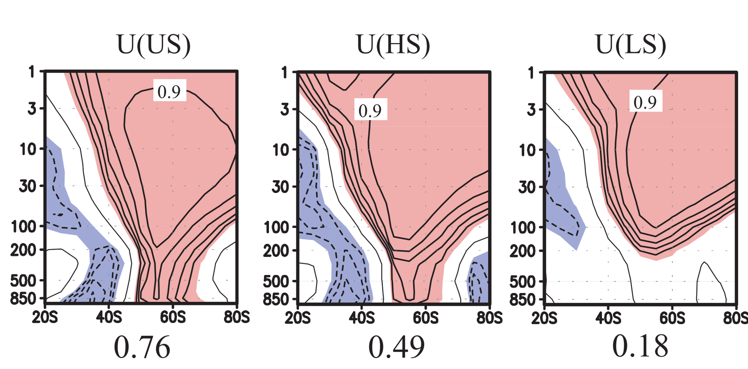

Figure 5, Same as Figure 4 except showing correlation of SAM index at 30-hPa level on the active season (December in the model) from 20-year model-experiments of a chemistry-climate model with changing ultra-violet radiation. From left to right, panels illustrate ultra-solar (US), high-solar (HS), and low-solar (LS) runs.

Conclusion

1, Observation shows that the variability associated with surface Annular Mode (AM) (NAO in the NH, and SAM in the SH) in the active season (mid-winter in the NH and late winter/spring in the SH) commonly tends to indicate structural modulation with the solar cycle: The signal extends to the upper stratosphere and persistent until next summer in high solar (HS) years but it is restricted in the troposphere and disappears very quickly in low solar (LS) years.

2, Such a structural modulation of the AM is originated from modulation of the strength of the stratosphere-troposphere coupling with the solar activity. Experiments with a CCM suggest that it is originated from UV strength.

References

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