The Salience of nonlinearities in the boreal winter response to ENSO

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El Nino and La Nina events in the tropical Pacific have significant and disrupting impacts on the global atmospheric and oceanic circulation.A series of simulations using the NASA Goddard Earth Observing System Chemistry-Climate Model are analyzed in order to assess the prominence of nonlinearities in the response to the El Nino - Southern Oscillation (ENSO). In the Central North Pacific region where the sea level pressure response to ENSO peaks, nonlinearities are relatively muted. In contrast, changes to the east of this region (i.e. the far-Northeastern Pacific) and to the north of this region (over Alaska) in response to different ENSO phases are more clearly nonlinear, and become statistically robust after more than 15 events are considered. The relative prominence of these nonlinearities is related to the zonal wavenumber of the tropical precipitation response. Associated with these nonlinearities over the far-Northeastern Pacific are nonlinearities in precipitation over Southwestern United States and surface temperature over Northwest North America and Midwestern United States. In all regions at least 15 events of each type are necessary before nonlinearities can be identified as statistically significant at the 95% confidence level due to the presence of internal atmospheric variability. As there have only been a similar number of ENSO event of each type since 1920, it is not surprising that it has been difficult to establish statistically significant nonlinearities using observational data.

Nonlinearities in the Arctic stratosphere are even less prominent. However there are significant differences in the zonal wavenumber forced by CP as compared to EP El Nino events, and this leads to a different morphology of sudden stratospheric warmings. In contrast, there is no indication of any nonlinearities in the wave driving between moderate EP EN and extreme EP EN, nor between El Nino and La Nina. However in approximately 10% of the integrations within our ensemble, there is no difference in SSW frequency between EN and LN, suggesting that a similar SSW frequency for both EN and LN, as has occurred over the past 60 years, can occur by chance. The intra-ensemble variability in LN SSW frequency can be related back to intra-ensemble variability in the tropospheric response to LN.

References

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