



## **HTE or no HTE? Investigating the QBO-Northern Hemisphere teleconnection with causal effect networks**

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The Quasi-Biennial Oscillation (QBO), the dominant mode of zonal wind variability in the equatorial stratosphere, is thought to influence the Northern Hemisphere winter stratospheric vortex, and in extension, the North Atlantic Oscillation and European winter weather. This phenomenon, namely the correlation between the zonal winds in the tropical and Northern Hemisphere polar stratosphere in the winter, became known as the Holton-Tan effect (HTE).

However, most studies investigating this teleconnection use correlation or composite analysis, which cannot distinguish between causes and consequences, nor whether there is a third process acting as common driver. Furthermore, the QBO->vortex influence is not well captured in models, which can be either due to model inadequacies, or the Holton-Tan effect being a statistical fluke, and not a real interaction.

A new method based on graphical networks and information theory promises to separate driving and driven processes and hence is applied to investigate the teleconnection between the QBO and the Northern Hemisphere winter circulation in observational data.

Influences which could confound the QBO-Vortex interaction, such as the El Nino Southern Oscillation, varying solar irradiance, and volcanic eruptions can easily be accounted for within this framework. Furthermore, potential interaction routes (via troposphere/stratosphere/both) and their relative importance can be analysed.

A more accurate estimation of the polar vortex modulation by the QBO could improve medium range weather forecasts, as the QBO can be forecasted pretty well due to its long intrinsic period of about 28 months.