Shifts in the Frequency of Atlantic Jet Regimes Following Sudden Stratospheric Warmings

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BACKGROUND

Many previous studies investigating the tropospheric impact induced by sudden stratospheric warmings (SSWs) have focused on the zonal mean geopotential height response. This response is generally regarded as a projection onto the negative phase of the Northern Annular Mode (NAM), analogous to an equatorward shift of the jet stream. However, the NAM is intrinsically tied to variability in the eddy-driven jet over the Atlantic associated with the three preferred jet regimes identified by Woolings et al. (2010). These three jet regimes are each associated with changes in the circulation that alter temperature and precipitation patterns over parts of North America and Europe. With this background in mind, we seek to address the following questions:

1) **Does the documented "equatorward shift" manifest as a southward shift in the whole distribution of jet latitudes, or do we see the three jet maxima in largely the same locations, but with varying frequencies?**
2) **How do the jet latitude changes compare between polar vortex splits and displacements?**
3) **What are possible implications for weather patterns over North America and Europe?**

METHODS

- Utilize a 202-year run of the Whole Atmosphere Community Climate Model (WACCM)
  - 92 SSW central dates (using Butler and Gerber, 2018
  - 72 displacements and 20 splits (using Lindgren et al., 2018)
- Calculate the Atlantic Jet Latitude Index (JLI) (using Woolings et al., 2010 and White et al., 2019)
- Use a kernel density estimate (KDE) derive probability density functions for the JLI
- Use lagged composite analyses to investigate changes in atmospheric variables surrounding SSWs

RESULTS

- A southward shift of the composite 850-hPa zonal winds following SSWs
- Distribution of jet latitudes shows no changes in preferred jet latitudes
- The southern and central jet latitudes occur more frequently following SSWs, while the northern jet latitudes occur less frequently
- Polar vortex splits and displacements show similar frequency changes
  - Splits tend to have more frequent jet maxima in the 45º-50ºN latitude range when compared to displacements
- Cold anomalies (associated with the negative phase of the NAM) follow SSWs over parts of North America and Europe
  - These anomalies tend to show up further north or northwest in WACCM than they do in ERA-Interim reanalysis calculations (not shown, see QR code)
- Upper tropospheric geopotential height anomalies also depict a pattern with a projection onto the negative phase of the NAM

KEY TAKEAWAYS

1) **The "equatorward shift" in the Atlantic jet following SSWs manifests as a change in frequencies of the preferred jet latitudes, not as a shift in those latitudes.**
2) **Splits and displacements show similar patterns of jet latitude frequency changes as compared to SSWs in general.**
3) **The mean impact over North America and Europe is consistent with the negative phase of the NAM, but the pattern of jet latitude frequency changes suggests that the circulation on any given day is more likely to look like the circulation associated with the Central and Southern preferred jet regimes than the composite.**

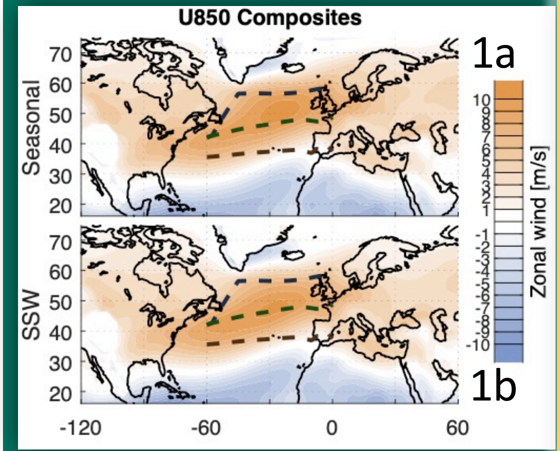


Figure 1: 850-hPa zonal wind composites for a) all Nov-Mar days, and b) 0 to 30 days following central dates of sudden stratospheric warmings. Dashed lines on both plots are latitudinal maxima of zonal winds when the jet is in the Northern (blue), Central (green), and Southern (red) preferred jet latitude regimes.

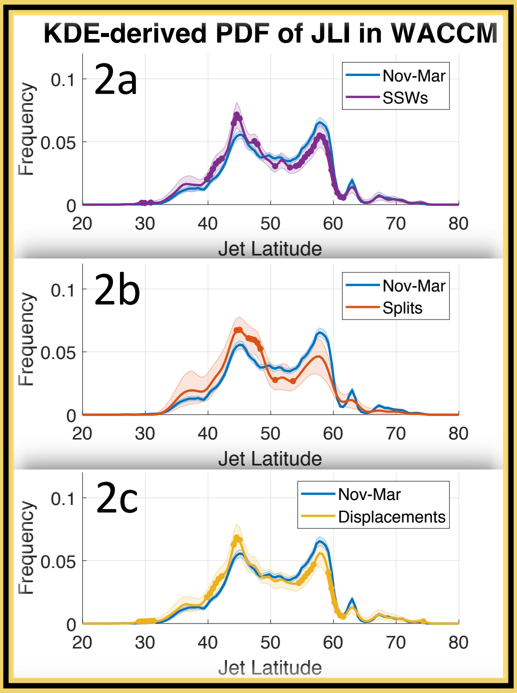
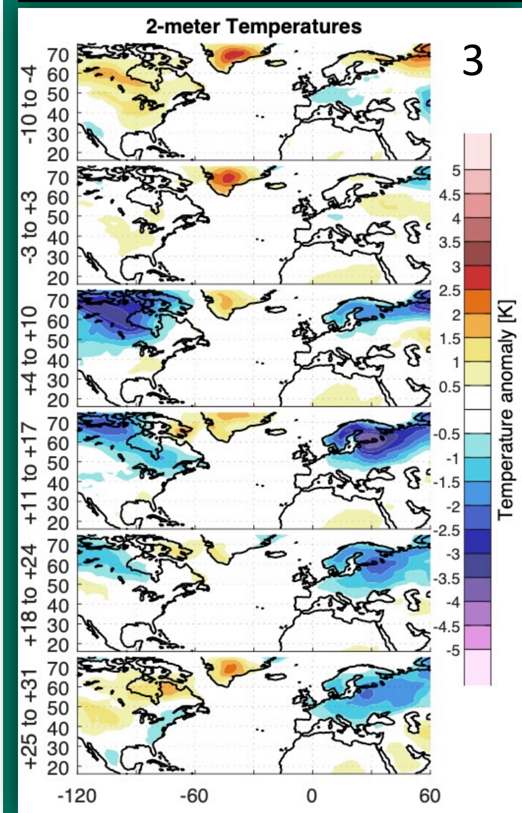


Figure 2: Kernel density estimated probability density functions for the JLI during all Nov-Mar days (blue curves). These estimates are compared to kernel density estimated probability functions for the JLI during a) the 0 to 30 days following all sudden stratospheric warmings (purple), b) the 0 to 30 days following split-type sudden stratospheric warmings (red), and c) the 0 to 30 days following displacement-type sudden stratospheric warmings (yellow).



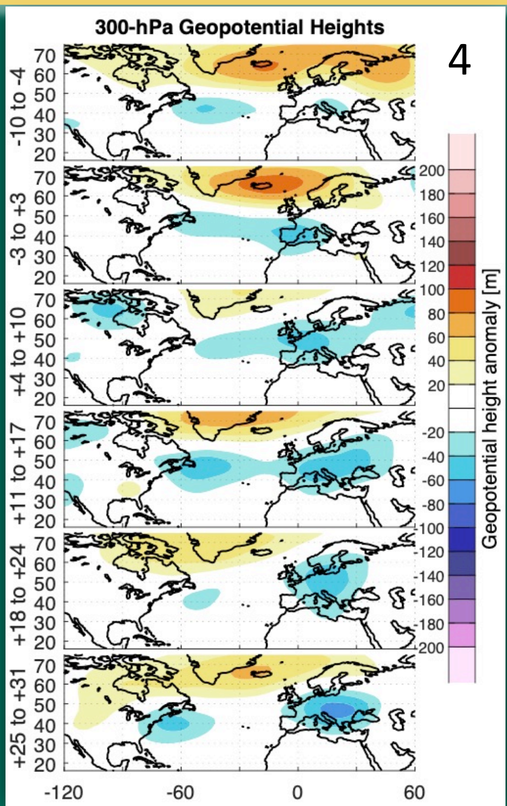


Figure 3: 2-meter temperature anomaly composites at various lag days surrounding sudden stratospheric warming central dates in WACCM.

Figure 4: 300-hPa geopotential height anomaly composites at various lag days surrounding sudden stratospheric warming central dates in WACCM.

For more details about this study, contact me at: goss@stanford.edu

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