How different are Sudden Stratospheric Warmings based on the North Atlantic response?

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MOTIVATION

Sudden stratospheric warmings (SSWs) are extreme disruptions of the wintertime polar circulation, and can **alter the tropospheric weather for over two months**.

IMPORTANCE → Source of **predictability in seasonal** timescales for surface wintertime[1].

Why only some SSWs have tropospheric impact?

Objective: understand the **differences** in the atmospheric circulation for **SSWs with canonical and non-canonical tropospheric impact** in the North Atlantic, where occurs the largest jet stream response after SSWs[2].

DATA & METHODS

ERA5 reanalysis data:
Zonal wind (U)
Geopotential heigth (Z)

Classification of SSWs:
Based on the variability pattern in Figure 1 → latitudinal dipolar shift of the jet.
Two SSWs groups: EQ and POLE, based on the jet stream shift.

→ Composite technique to see common characteristics

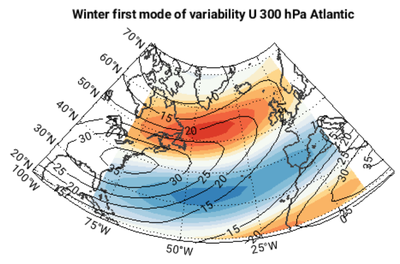


Figure 1. First variability pattern of winter U 300 hPa in the North Atlantic región (shading) and winter jet stream climatology (contours).

Two types of SSWs

- **EQ** (equatorward shift) → 29
- **POLE** (poleward shift) → 12

(~2/3) EQ corresponds to the canonical response

RESULTS

1. Differing Stratospheric conditions for EQ/POLE SSWs

NAM (Northern Annular Mode) composites →

negative == weakened &
positive == strengthened
stratospheric polar circulation

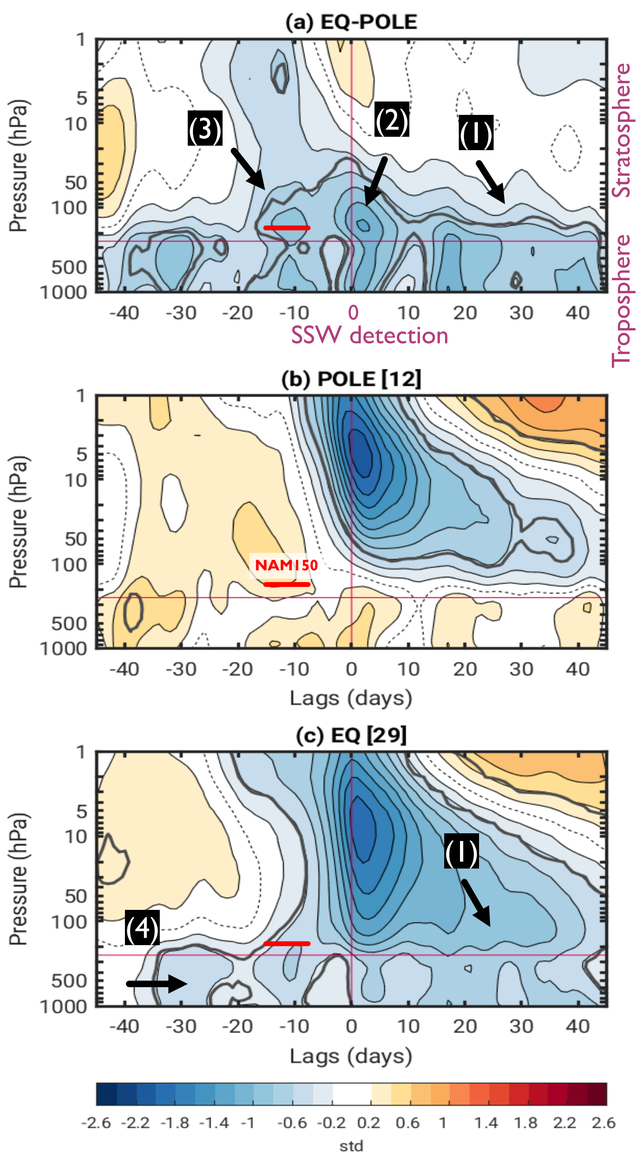


Figure 3. Time-height evolution NAM composites for SSWs based on EQ/POLE classification.

EQ vs POLE

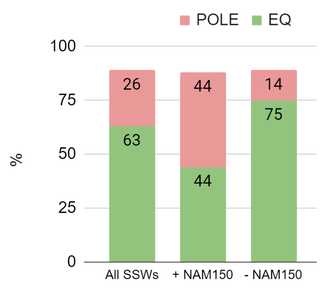
(1) Long-persistent weakened NAM in EQ at the lower stratrosphere.

(2) NAM reach **deeper levels** in EQ at the lower stratosphere the initial days (Karpechko et al. 2017)

(3) Opposite sign NAM in EQ/POLE in the lower-stratosphere **prior** the SSW.

Significantly conditions the probability of having EQ or POLE

PREDICTIVE POWER

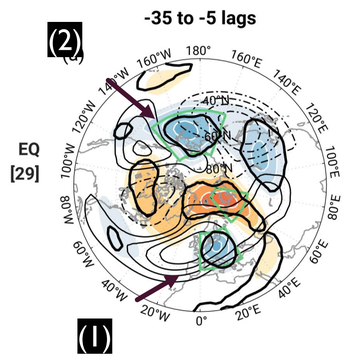


Significant change

(4) Tropospheric NAM is **constanly negative** in EQ, even at negative lags → precursors SSWs

2. Tropospheric precursors to EQ/POLE SSWs response

Geopotential height (Z) anomalies 500 hPa



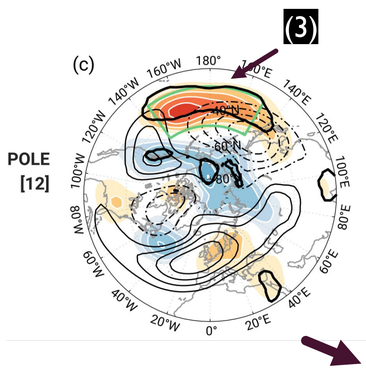
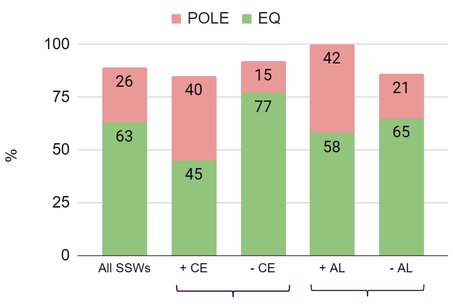


Figure 4. EQ and POLE SSWs composites of Z anomalies at 500 hPa averaged from -35 to -5 lags.

Mix patterns of SSW precursors in EQ.

(1) Central Europe low (CE) significantly increases the probability of EQ

(2) Aleutians low (AL) does not give predictability on the North Atlantic response



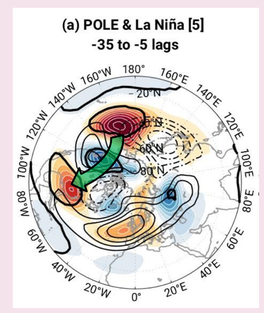
Significant change | Not significant change

(3) Central Pacific high (CP) significantly increase the probabili.

Significant change

Most of POLE SSWs are influenced by La Niña

Pacific high pressure+ strong polar vortex
chanels quasi-stationary wave activity from the Pacific to the Atlantic and affect transient eddies downstream propagation



CONCLUSIONS

- Circulation anomalies in the **lower stratosphere** are important and can give valuable predictive power in determining the jet stream response to SSWs, and hence surface impacts.
- Previous negative tropospheric NAM signal in equatorward shift (EQ) SSWs comes from well-known SSWs precursors. Some also significantly conditioning the subsequent North Atlantic jet response.
- Poleward shift (POLE) SSWs are preceded by high geopotential anomalies over the Pacific. This pattern is enhaced during strong La Niña.

REFERENCES

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