How different are Sudden Stratospheric Warmings with and without a 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 → They provide a 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 and without tropospheric impact**, especially 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

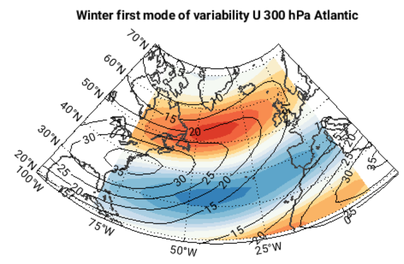


Figure 1. First variability pattern of winter U 300 hPa in the North Atlantic región (shading) and winter jet stream climatology (contours).

Two types of SSWs
- **EQ** (equatorward shift)
- **POLE** (poleward shift)

EQ corresponds to the canonical response

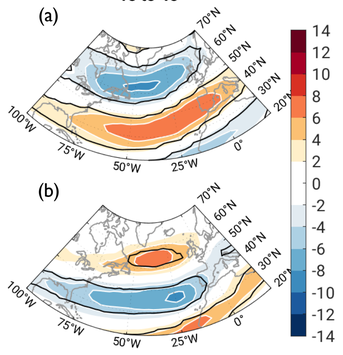


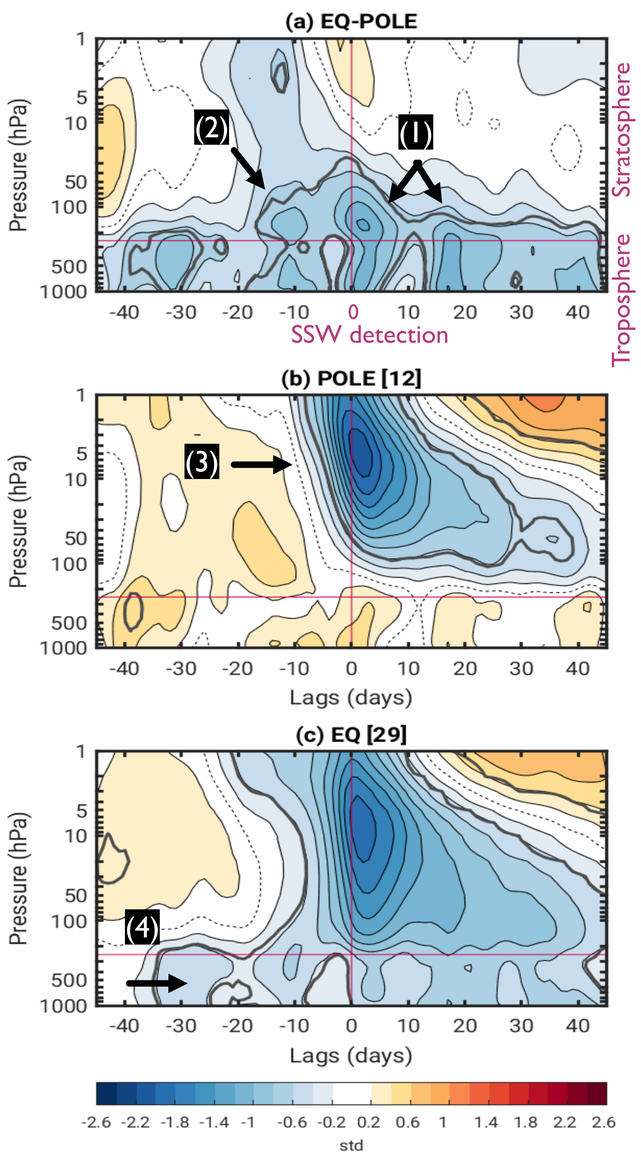
Figure 2. U 300 hPa anomalies for EQ (a) & POLE (b) composites from 15 to 45 lags.

RESULTS

1. Differing tropospheric and stratospheric conditions for EQ/POLE SSWs

NAM (Nothern Annular Mode) composites →

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



EQ vs POLE

(1) In EQ the negative anomalies reach **deeper levels** in the lower-stratosphere and troposphere and **stay** there for 40 days.

(2) Anomalies with **opposite sign** in EQ and POLE in the lower-stratosphere **prior** the SSW.

(3) In the middle stratosphere the weaking of polar cirulation is more **abrupt** in **POLE**.

(4) In the troposphere the NAM is **constanly negative** in the EQ composite. Is this not a response to SSW? → 2

- NAM ≈ - NAO = EQ in the troposphere

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

2. Tropospheric patterns for EQ SSWs

In the EQ composite the troposferic **NAM is constantly negative**, suggesting that the anomalies are not a response to SSW but another mechasim of lower frecuency. But the signal becomes from:

(1) Before: polar cap & Pacific
(2) After: North Atlantic

(3) Anomalies in POLE prior the SSW detection look like La Niña signature.

→ 3

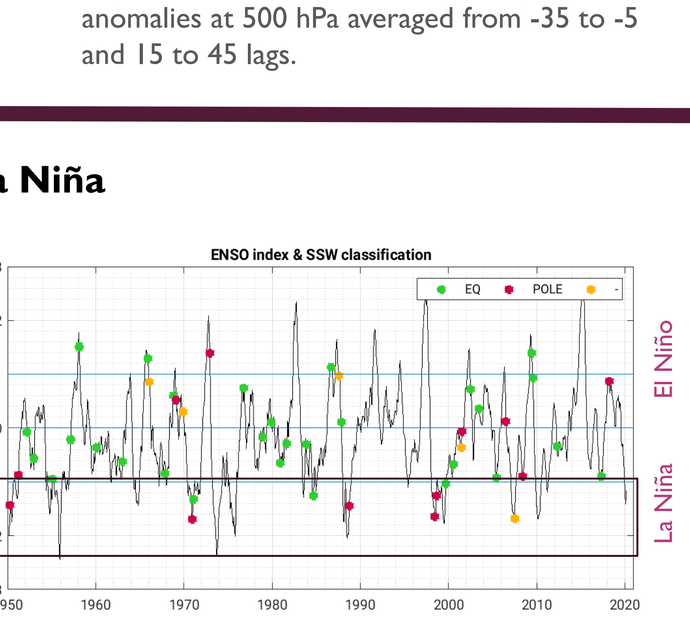


Figure 4. EQ and POLE SSWs composites of Z anomalies at 500 hPa averaged from -35 to -5 and 15 to 45 lags.

3. SSWs during strong La Niña

ENSO is the greatest source of tropospheric interanual variability and La Niña is his cold pase (negative).

More POLE SSWs during strong La Niña →

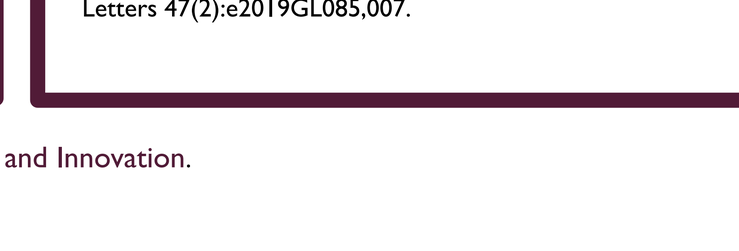


Figure 5. ENSO index with SSWs detection dates in dots.

CONCLUSIONS

- Circulation anomalies in the **lower stratosphere** are important in determining the jet stream response to SSWs, and hence surface impacts.
- Despite the mantained tropospheric NAM signal, there is a response in tropospheric circulation for EQ due to SSWs.
- During **strong La Niña** more SSWs are **POLE**, potentially reducing the subseasonal to seasonal predictability given by SSWs.

REFERENCES

[1] Sigmond M, Scinocca J, Kharin V, Shepherd T (2013) Enhanced seasonal forecast skill following stratospheric sudden warmings. Nature Geoscience 6(2):98–102.

[2] Afargan-Gerstman H, Domeisen DI (2020) Pacific modulation of the north Atlantic storm track response to sudden stratospheric warming events. Geophysical Research Letters 47(2):e2019GL085,007.

Acknowledgements. Predoctoral fellowship PID2019-109107GB-I00 and project PRE2020-091812 from Spanish Ministry of Science and Innovation.