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# ENSO influence on the North Atlantic: Interaction between the stratospheric and the tropospheric pathways

### Bernat Jiménez-Esteve<sup>1</sup> Daniela I.V. Domeisen<sup>1</sup>

<sup>1</sup>Institute for Atmospheric and Climate Science, ETH Zurich, Zurich, Switzerland



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### **Introduction: The ENSO-North Atlantic Teleconnection**



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### **Motivation of the study**

- Asymmetry between El Niño and La Niña are significant in the North Pacific using a sufficient sample size (opposite but weaker response during La Niña). (Garfinkel et al. 2018, Jiménez-Esteve and Domeisen 2019)
- 2. Recent modelling studies show **disagreement on the linearity** of the ENSO teleconnection to the **stratosphere and the North Atlantic.** (Hardiman et al. 2019, Trascasa-Castro et al. 2019, Rao and Ren 2016, Weineberg et al. 2019)
- 3. Separation between the stratospheric and tropospheric pathways is difficult due to interaction and large interannual variability. (Butler et al. 2014, Jiménez-Esteve and Domeisen 2018)

#### JRA-55 Reanalysis





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### Aim of the Study

- **1.** To **quantify the linearity** in the North Atlantic response to ENSO.
- 2. To isolate the tropospheric from the stratospheric pathway.







### Model simulations: the SST forcing

- Atmospheric model with prescribed fixed SSTs following a repeating seasonal cycle
- **1958–2016 monthly SST climatology** NOAA ERSSTv4 (Huang et al., 2015)

- **4 idealized ENSO forcings** of linearly varying strength at a fixed location.
- **Extratropical anomalies** follow climatology.







### To isolate the tropospheric pathway: Nudging

- An extra set of 5 simulations with **identical SST forcing**
- The stratospheric zonal mean winds nudged towards the model climatology.



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### **Defining the Aleutian Low and the NAO indices**

### **SLP Regression**



### **Index definitions**

- based on area weighted SLP average over the North Pacific (AL) and the difference between the northern a a southern box in the North Atlantic (NAO)
- All the simulations with fixed SST (ENSO and climatological forcings, total of 396 years) and with **nudged stratospheric** winds
- Monthly anomalies from December to March

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### Nonlinearity in the North Pacific and North Atlantic

- Nonlinear response in the North Pacific response, mainly for strong forcings. (Jiménez-Esteve and Domeisen, 2019, GRL)
- Weaker but nonlinear response in the North Atlantic, mainly for La Niña (saturation).

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### The combined effect of the North Pacific and the Stratosphere

We use the simulations with <u>free evolving stratosphere</u> (646 years) and average the monthly NAO anomalies for each combination of Aleutian low and Stratospheric anomaly (NAM) indices.

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### The Stratosphere amplifies the tropospheric pathway



- Correlation between the AL and the NAO does not change
- Regression is significantly larger when the stratosphere is freely evolving
- The variance in the NAO index decreases by 40% when winds are nudged

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### Conclusions

- **1.** The **North Atlantic response to the ENSO** forcing changes due to the upstream influence from the North Pacific. The response to ENSO in the North Atlantic projects onto a negative (positive) NAO during EN (LN).
- 2. The ENSO tropospheric pathway to the North Atlantic exhibits significant nonlinearity with respect to the tropical SST forcing.
- **3.** The stratospheric variability contributes to 40% of the interannual variance of the NAO. The regression coefficient between the AL and the NAO increases significantly when the stratosphere interacts with the tropospheric pathway.

#### Paper **under revision** in Journal of Climate:

Jiménez-Esteve, B. and Domeisen, I. V. D. (2019). The ENSO-North Atlantic Teleconnection: Quantifying the nonlinearity and the relative roles of the tropospheric and stratospheric pathways in a simplified model

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