Effects of mean state of climate models on the response to prescribed forcing: Sensitivity experiments with the SPEEDY general circulation model.

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Introduction

State of the art General Circulation Models (**GCM**) show several issues in representing the extratropical circulation:

- The North Atlantic Storm Track is not enough tilted.
- Tri-modality of the North Atlantic eddy-driven jet stream is absent.
- Responses to the same forcing like Atlantic multidecadal variability (**AMV**), El Niño Southern oscillation (**ENSO**) can be widely different.

The response to external forcing is affected by two key features of models:

- the mean state (Climatology/Bias)
- the variability

The mean state might have a major role in the distortion of the response to any kind of forcing.

We investigated the role of the mean state in the response to an idealized El Niño (**NINO3.4**) Sea Surface Temperature (**SST**) anomaly.

The focus is on the modulation of the Rossby wave on the Eastern boundary of the Pacific Ocean.

Methods

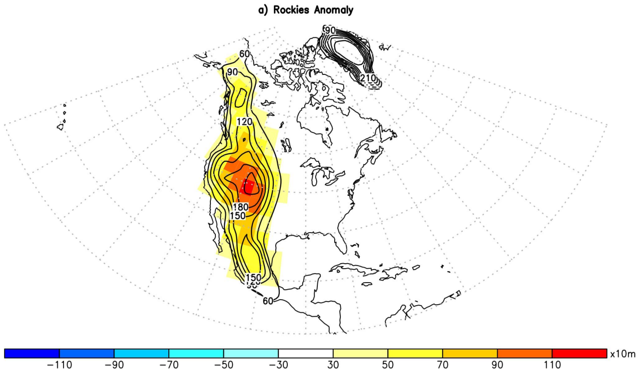
THE MODEL

Simplified Parameterization primitivE-Equations DYnamics (**SPEEDY**)

- Primitive-Equations
- Hydrostatic
- Semi-implicit gravity waves
- T30 Spectral resolution (3.75 X 3.75 degree)
- 8 vertical levels

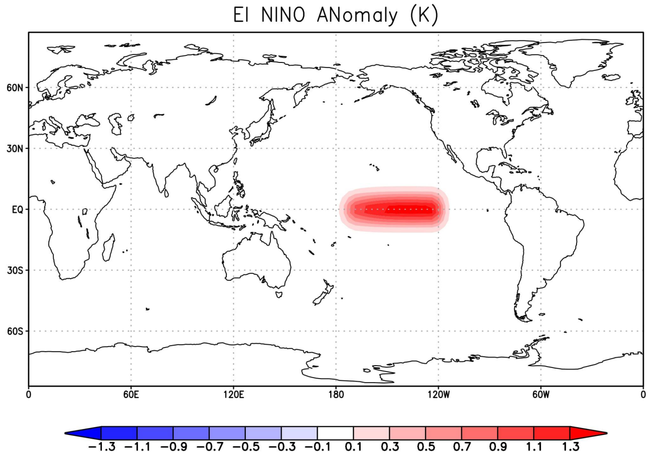
STEP 1
ROCKY MOUNTAINS

We performed six experiment with different heights of the Rocky Mountains (**ROCK**) in order to induce changes in the mean state. A seventh experiment with the default orography is used as control (**CTL**). Each experiment is 200 year long.



STEP 2
IDEALIZED EL NINO

To each of the **ROCK** experiments, an idealized El Niño SST anomaly is applied(**NINO**). The anomaly is obtained from the NOAA daily SST anomalies data and making the composite of all the days with an El Nino index greater than 0.5.

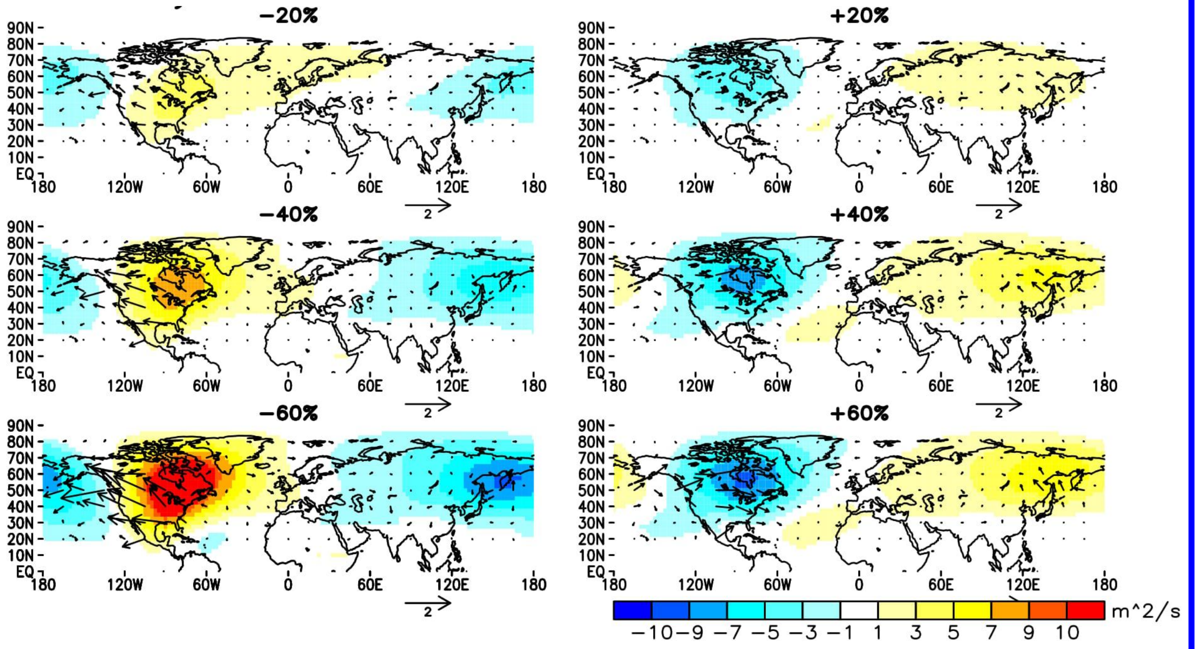


Results:

Effects of orography on the DJF Rossby wave activity flux.

DJF 300 hPa wave activity flux and QG stream-function.
Colors are the differences of the stream-function between the **ROCK** experiments and the control**.** Arrows are the same differences in the wave activity flux.

The effect of the orography to the stream-function is linear.
By **increasing the height of the Rockies**, the **stream-function decreases downstream** of the anomaly and **increases upstream**.
The effect is the opposite when the height is reduced.
The wave activity flux shows that **Rossby wave is “weakened” when Rockies are lower and enhanced when mountains are higher**. The +60% experiment shows a clear meridional component in the wave activity flux associated with a northern minimum in the stream-function.

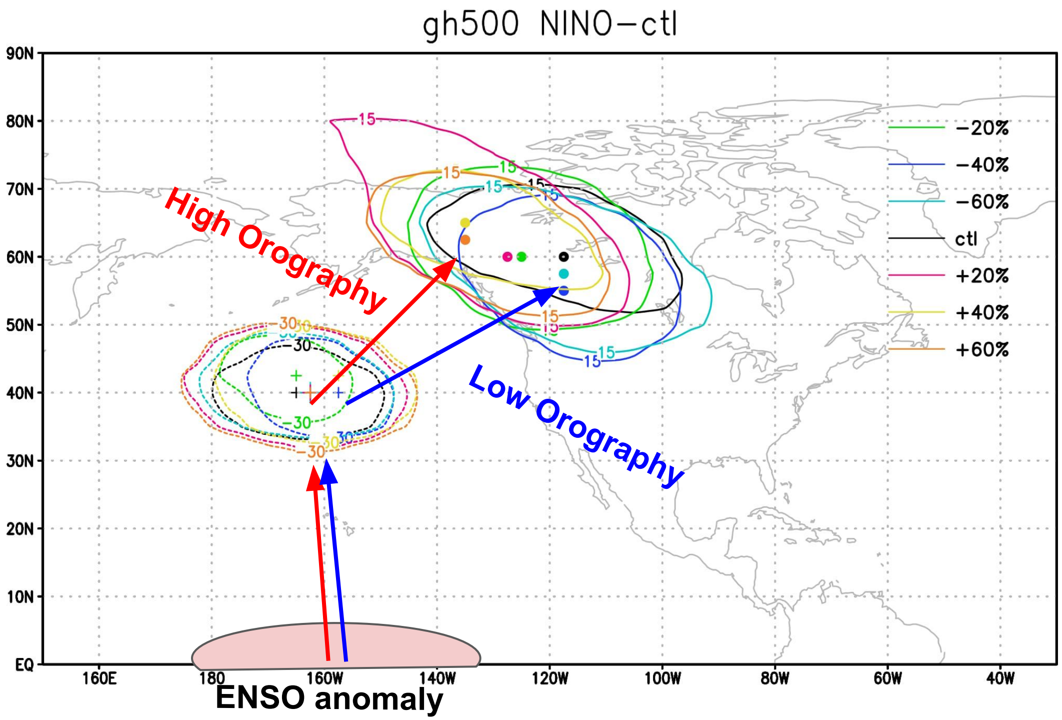


Results:

Effects of orography on the El Niño response.

500 hPa Geopotential height showing the response to El Niño in stationary waves for each ROCK experiment. **The figure shows the dipole generated by El Niño** with **only one contour for the negative pole** over the Pacific Ocean and **only one for the positive pole** over Alaska and Canada are drawn. Dots show the positions of the maximum and crosses show the position of the minimum.

Despite the low pressure pole doesn't move across the different orography, **the high pressure pole is affected by the mean state change**. Higher orography displaces the Rossby wave to higher latitudes. Low orography refracts sooner the Rossby wave back to low latitudes.



Conclusions

- By modifying the orography of the Rocky Mountains it is possible to change the mean state of the model.
- The **height of the Rocky Mountains modulates the propagation of the Rossby wave**.
- NINO experiments show that the response of the model is indeed dependent on the mean state.
- **Higher orography lets the Rossby stationary wave propagate to high latitudes**, while **low orography refracts the waves back to low latitudes**.