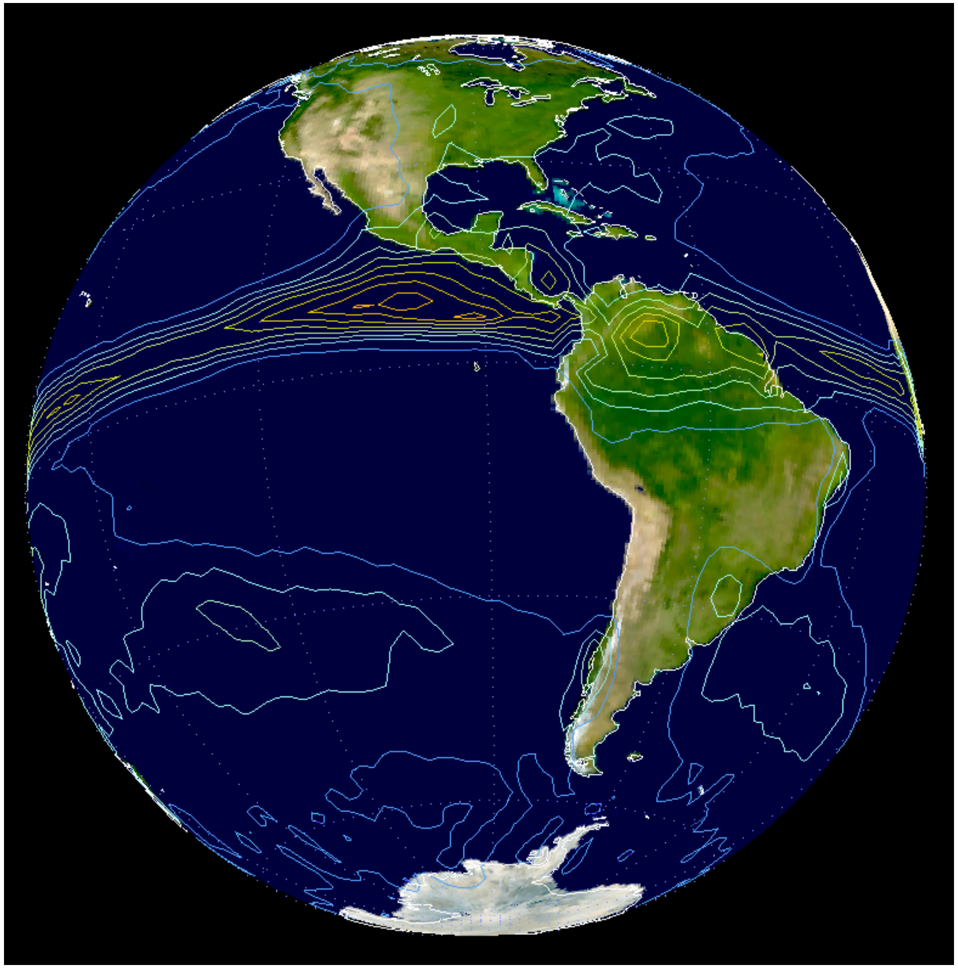

BIZARRO WORLD
BIZARRO
NO. 1

Climas Extraños usando PLASIM

René Garreaud & Alejandra Molina
DGF-UCH



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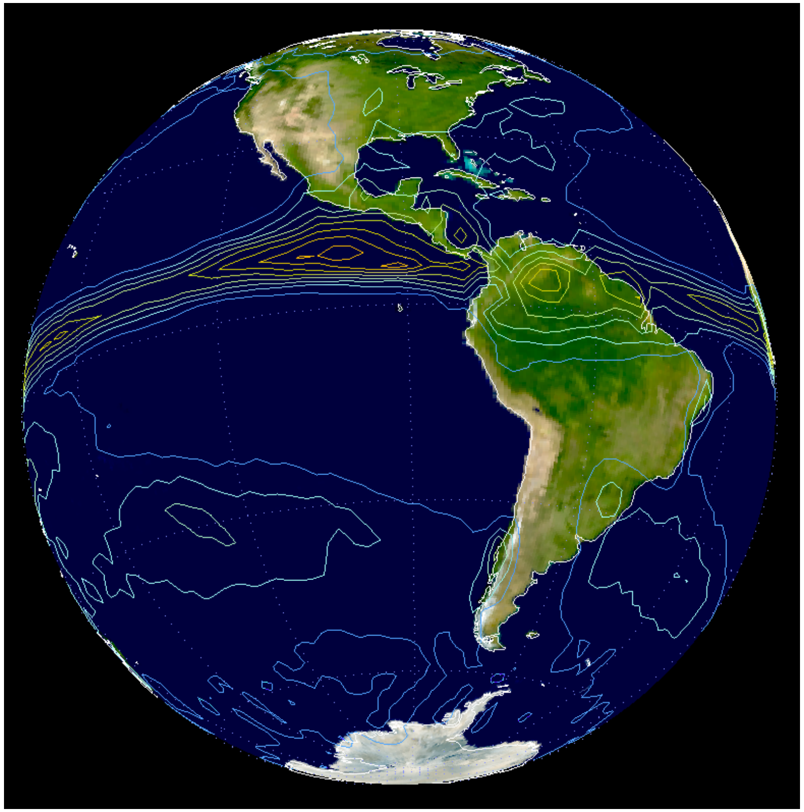
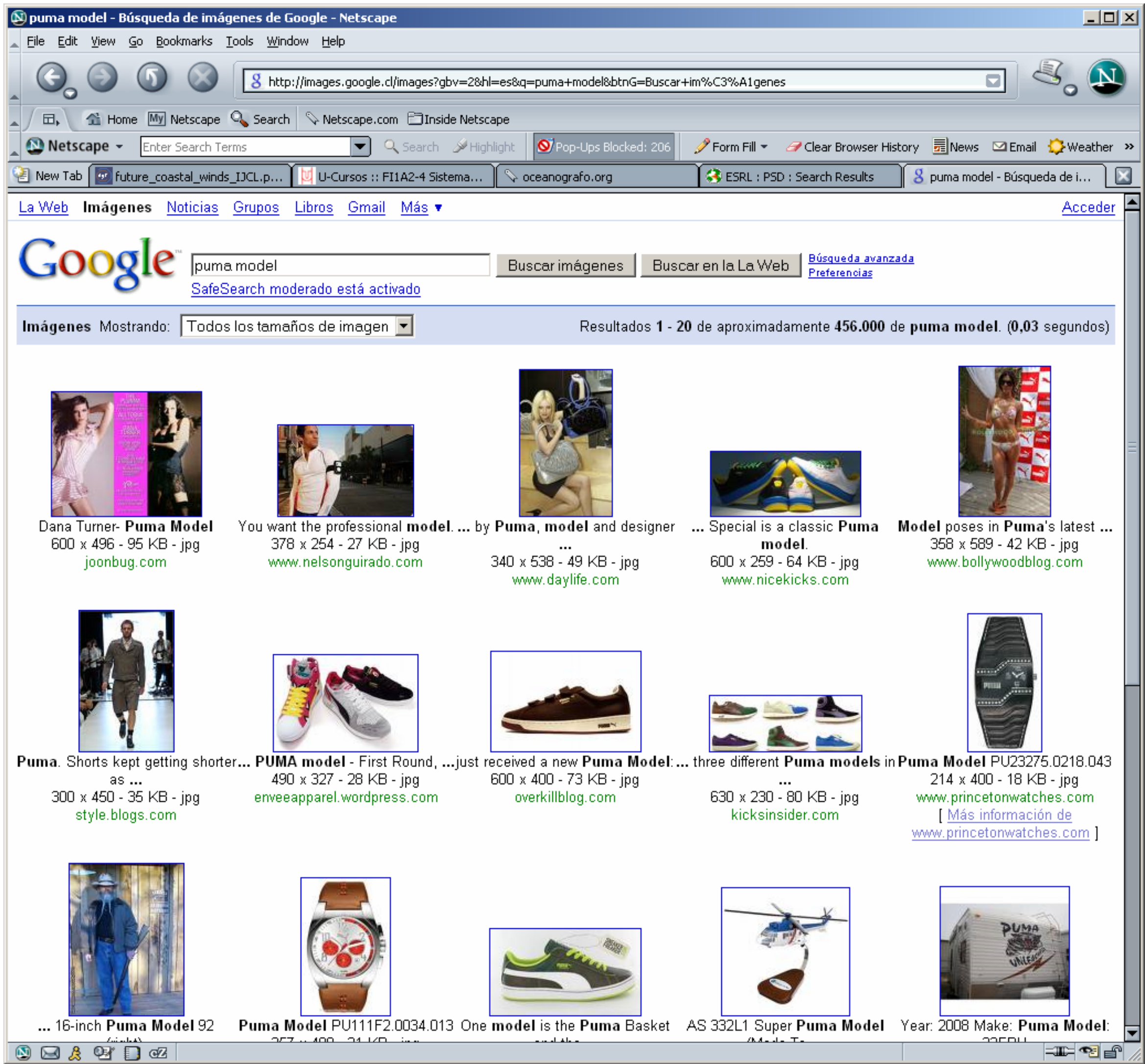


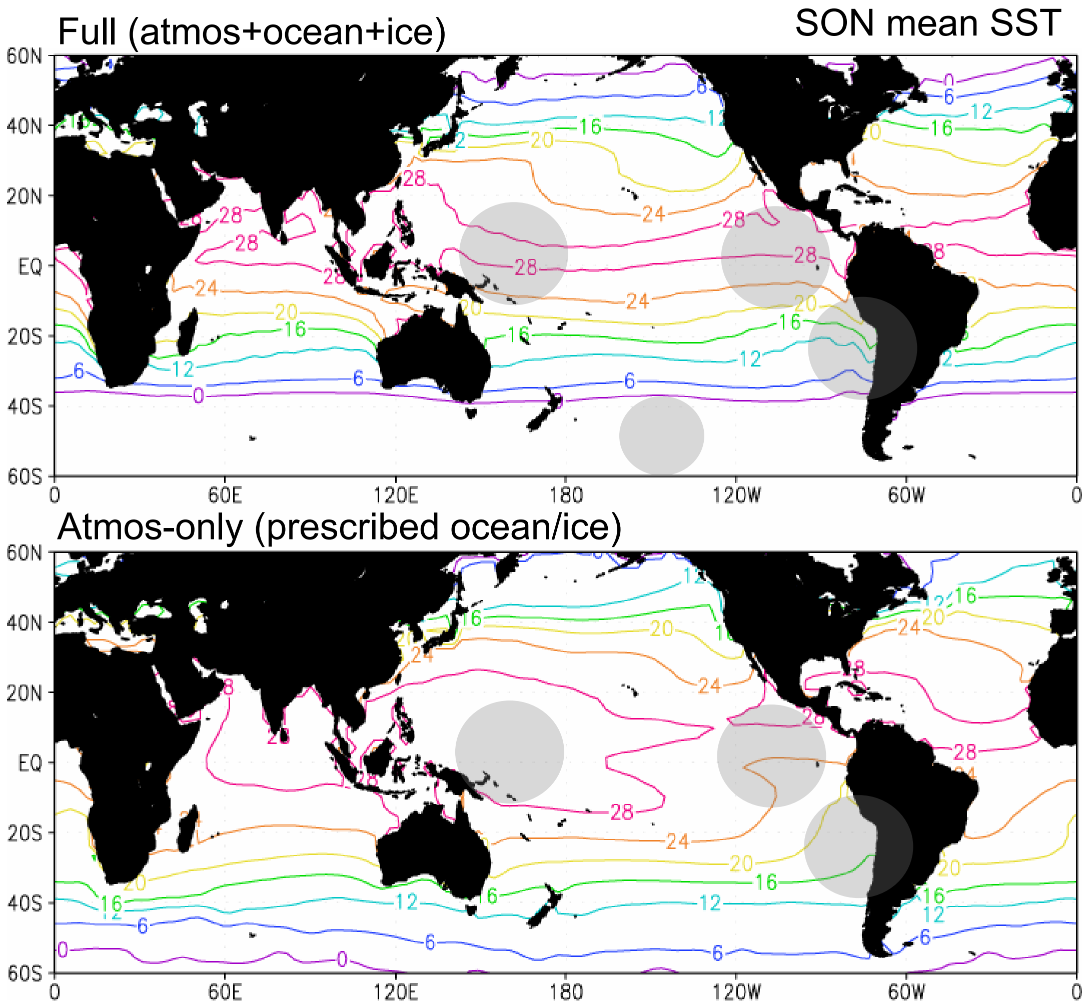
- Model Description
- Model Validation
- Rotation Experiments
- Topography Experiments

RG: Conoces algun modelo climatico “simple” de usar?
SS: Claro che…hay algo llamado Puma Model…

Pero buscar “Puma Model” en Interner puede ser peligroso…

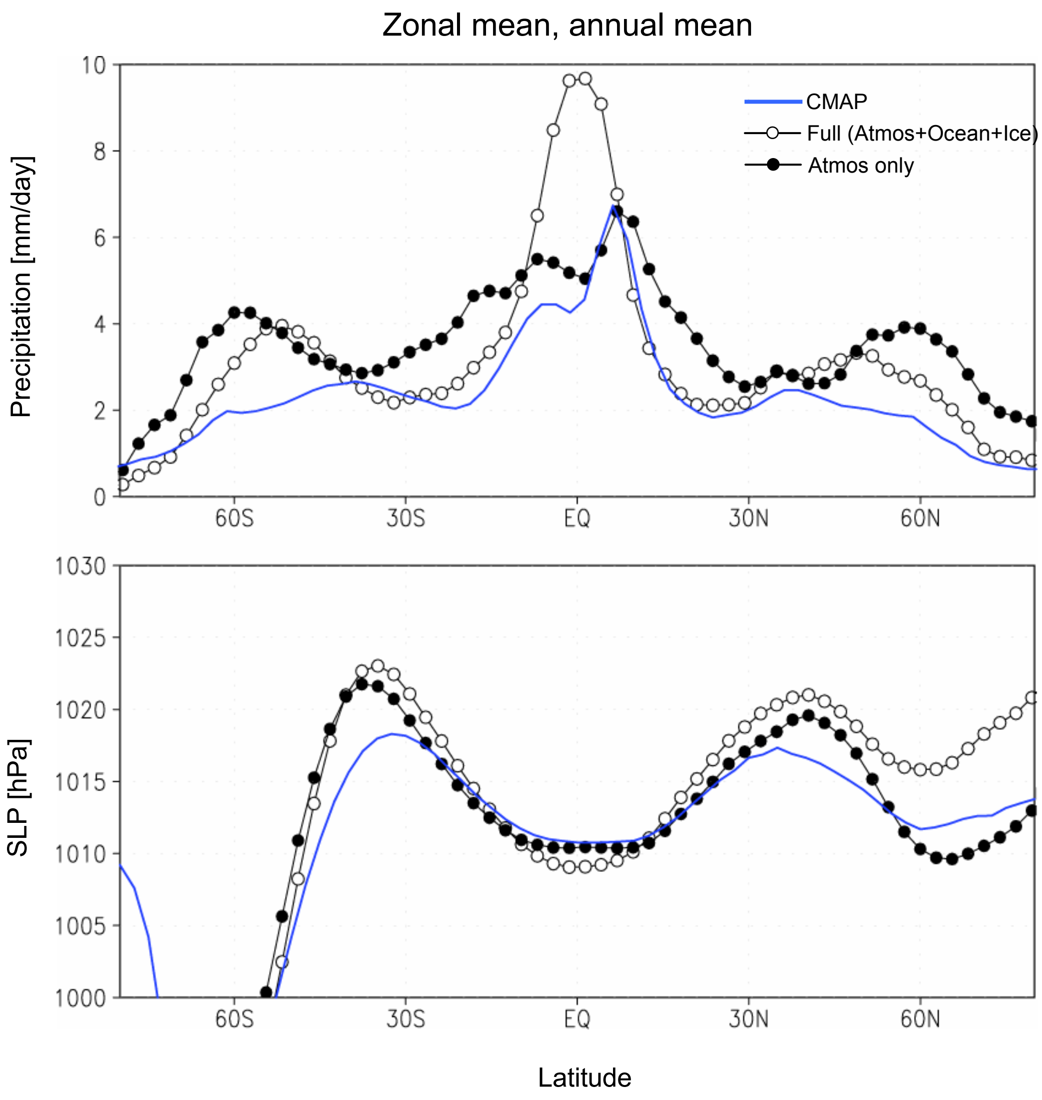


Model Validation



Weak cold tongue, small warm pool, too much ice ☹

Model Validation



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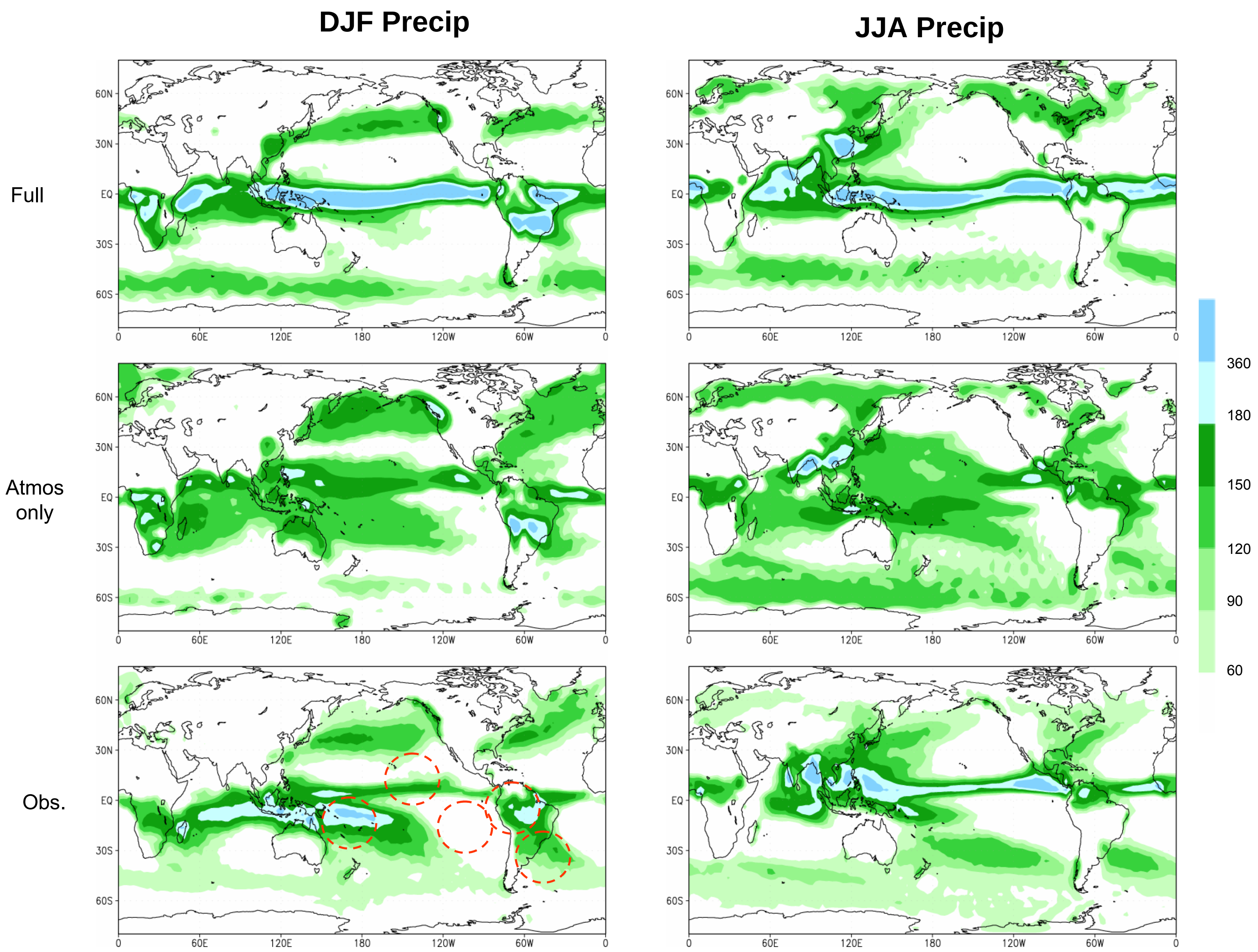
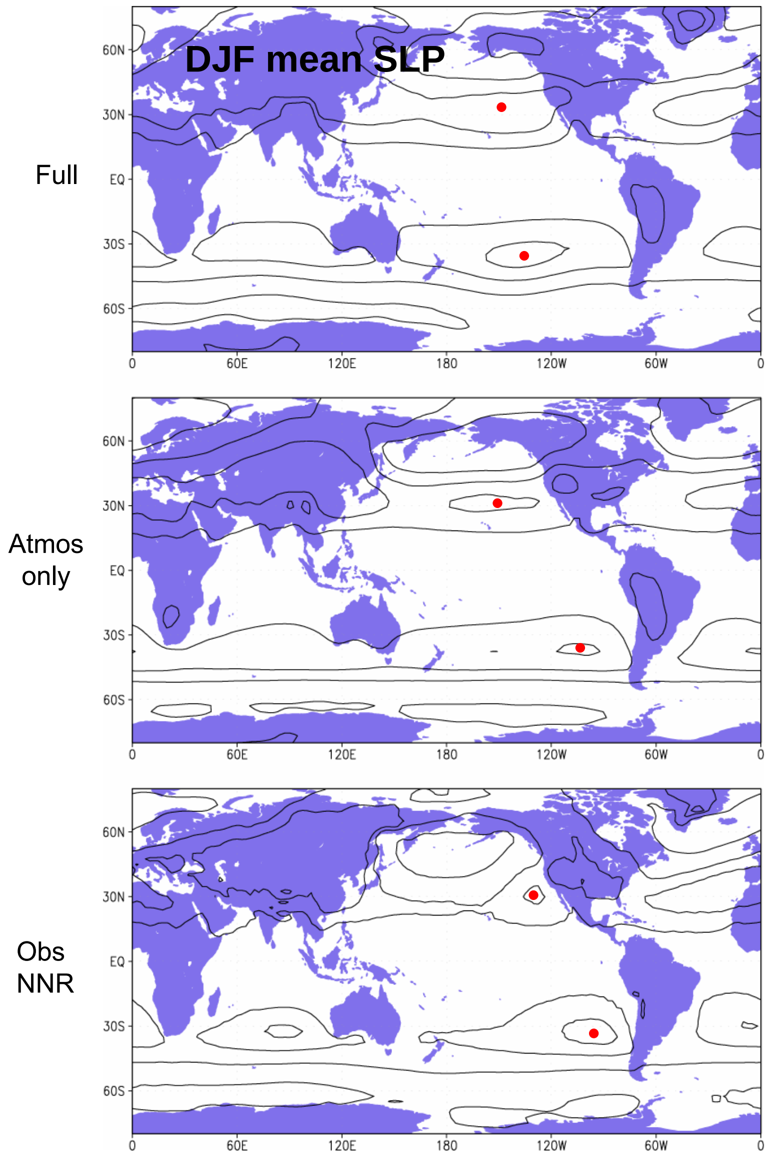
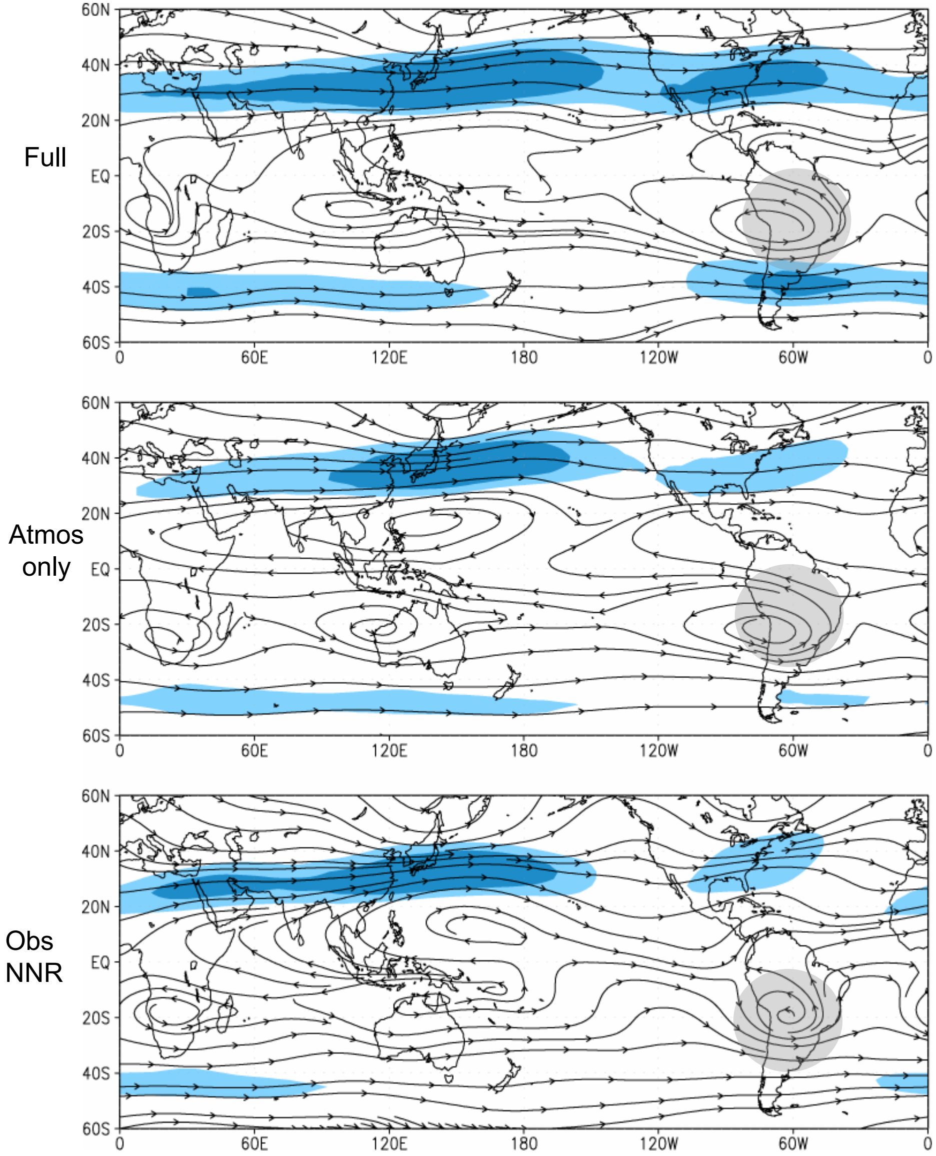


Model Validation



Model Validation

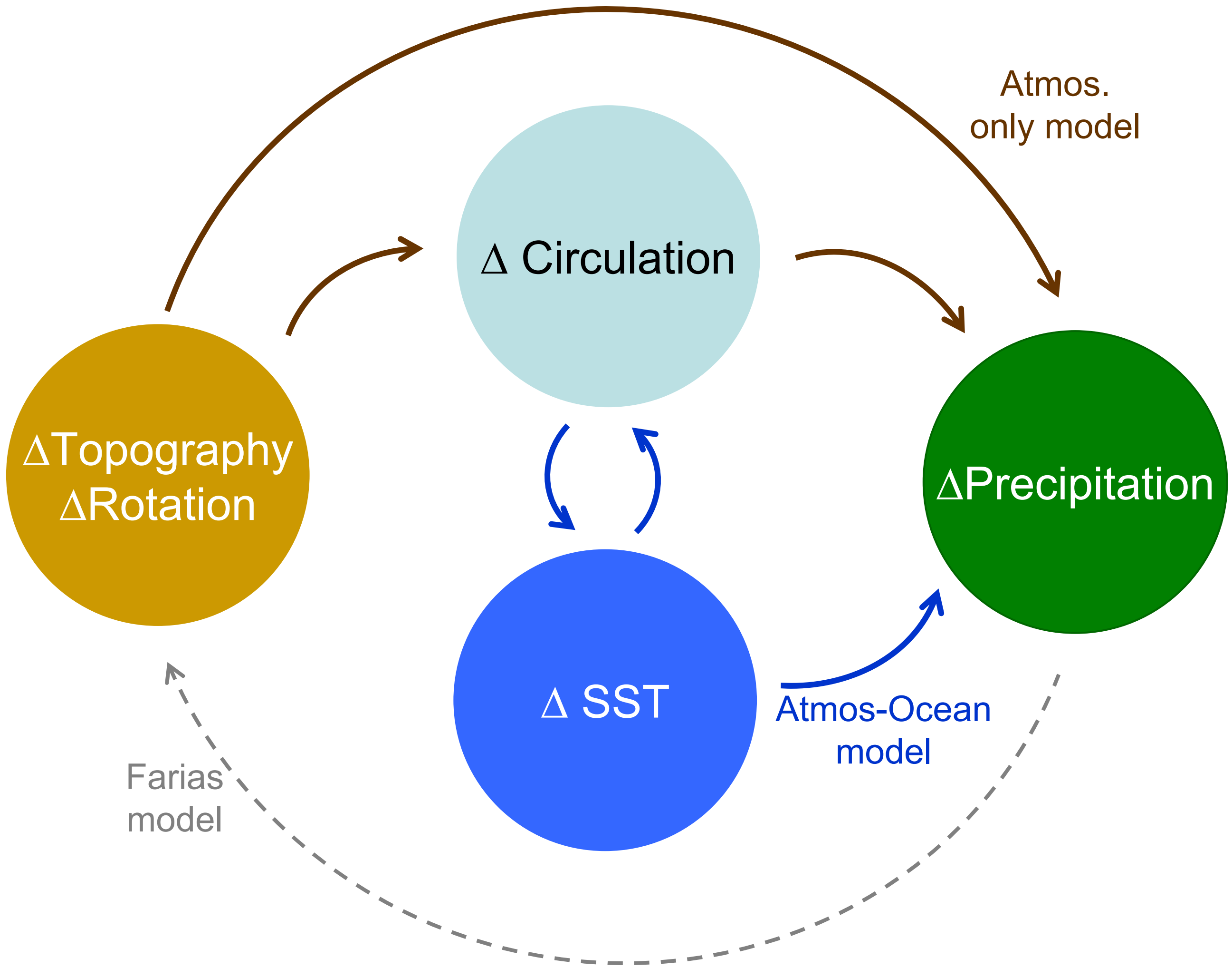
DJF mean 200 hPa winds



Model Validation

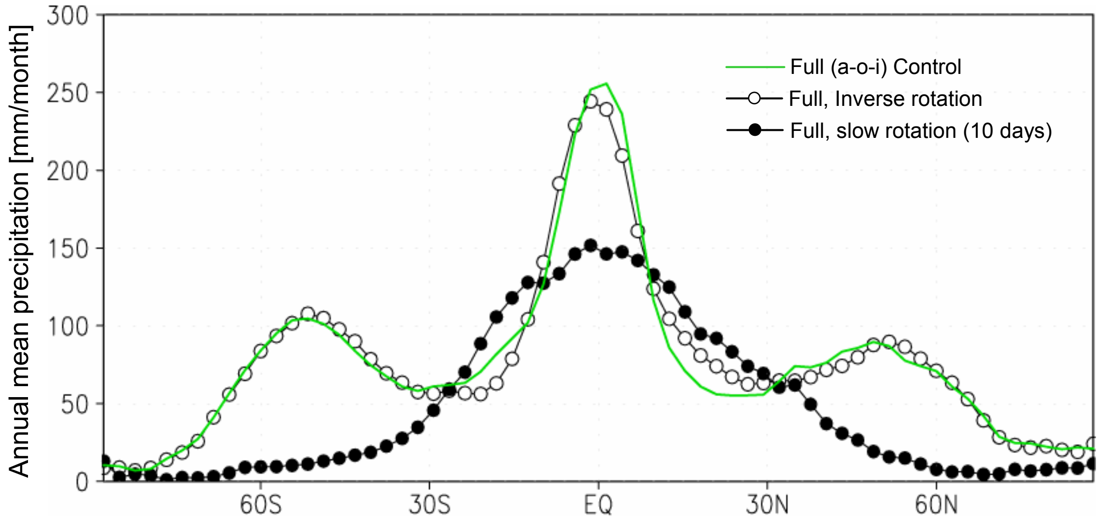
Feature	Atmos-Only	Full
Cold tongue	Of course	weak
Warm pool	Of course	Small
ITCZ	Ok, too wide	Too strong, too zonal
South American Monsoon	Yes	Yes
SH Storm Track	Yes	Yes
Orographic precipitation	Yes	Yes
Subtropical deserts	Yes, but too small	Yes, but too small
Subtropical anticylones	Yes, but too wide	Ok, too wide
SPCZ	Yes	No
SACZ	Ok, but too short	Yes

Model Validation

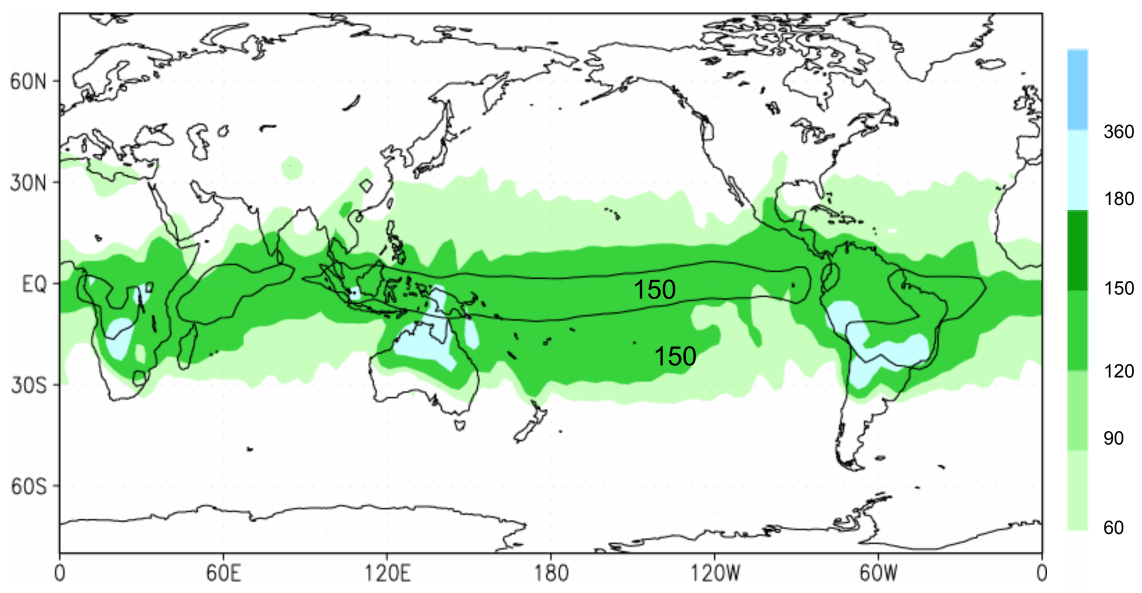


Atmos-Ocean model includes more processes but it has a less realistic representation of the basic state

Rotation Experiments

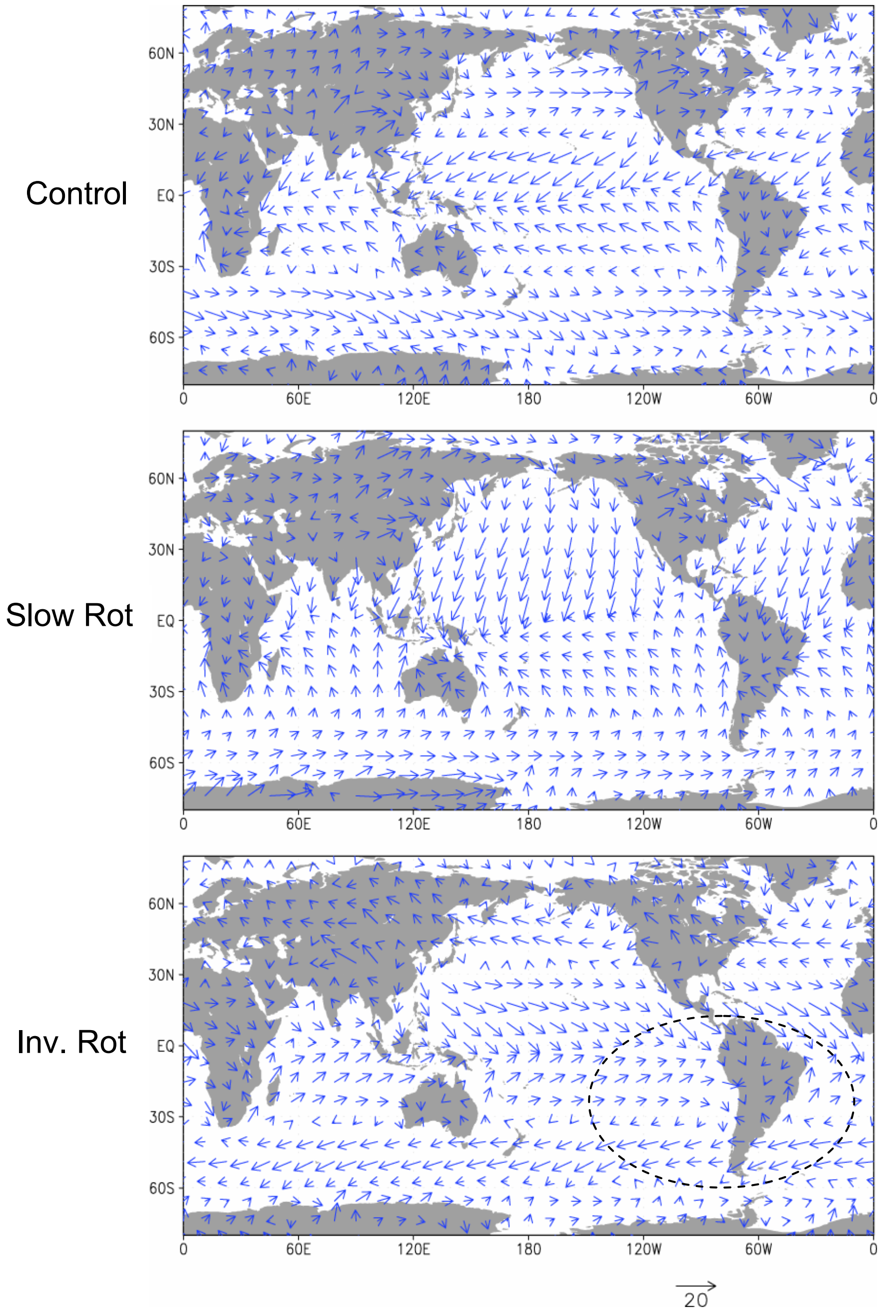


Control (lines) and slow-rot (shaded) annual mean precip [mm/month]



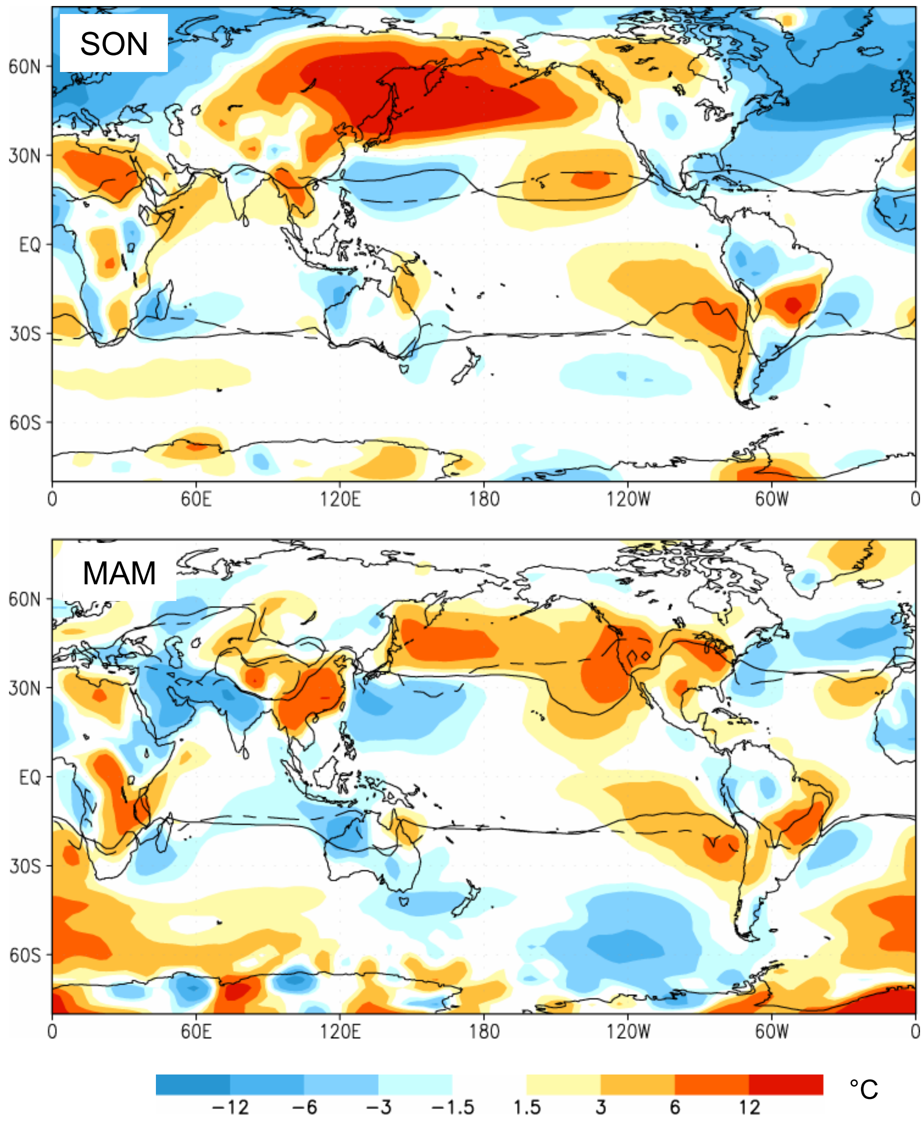
Rotation Experiments

DJF surface winds

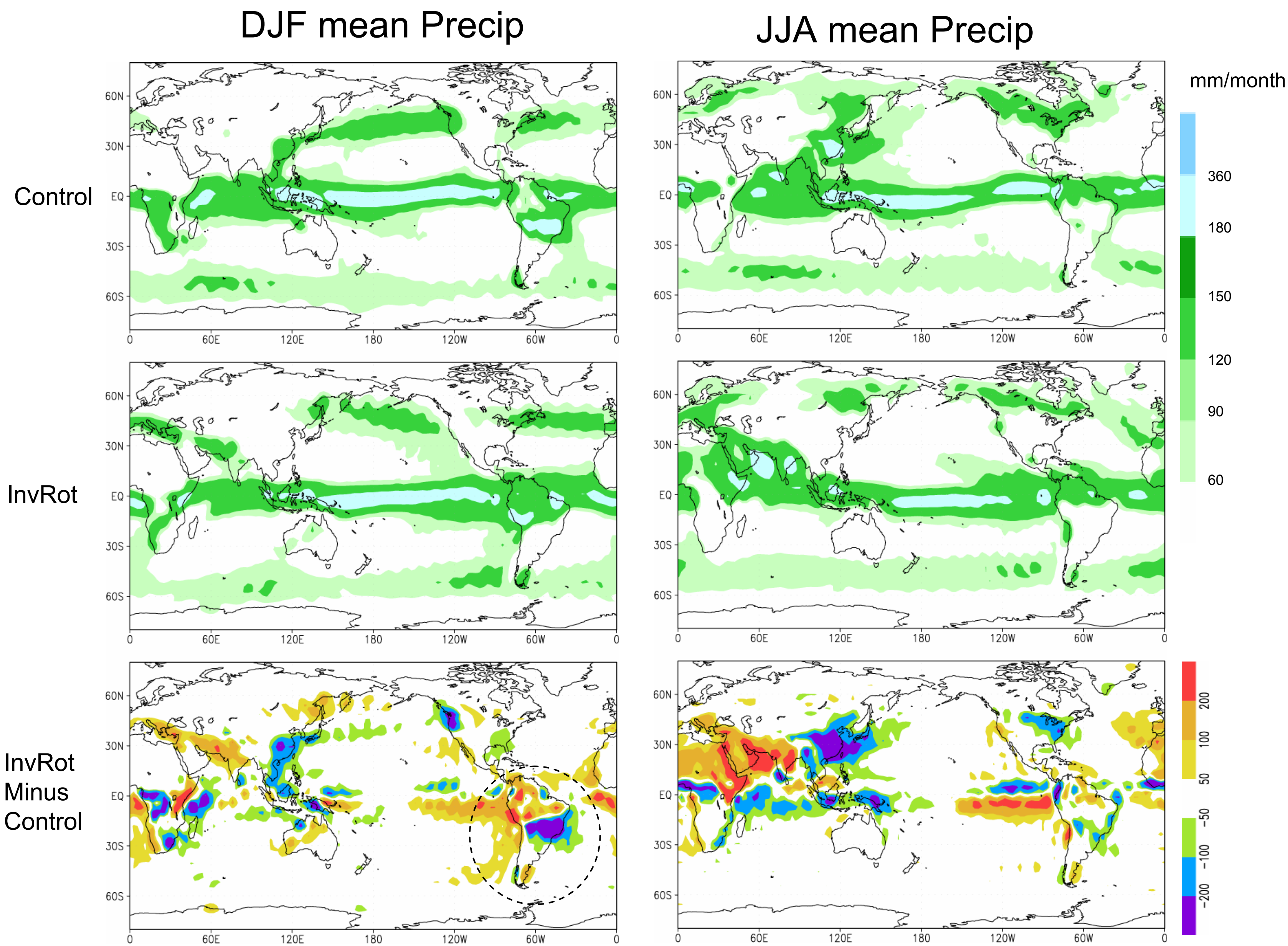


Rotation Experiments

Inverse-Rot minus Control SST/SAT

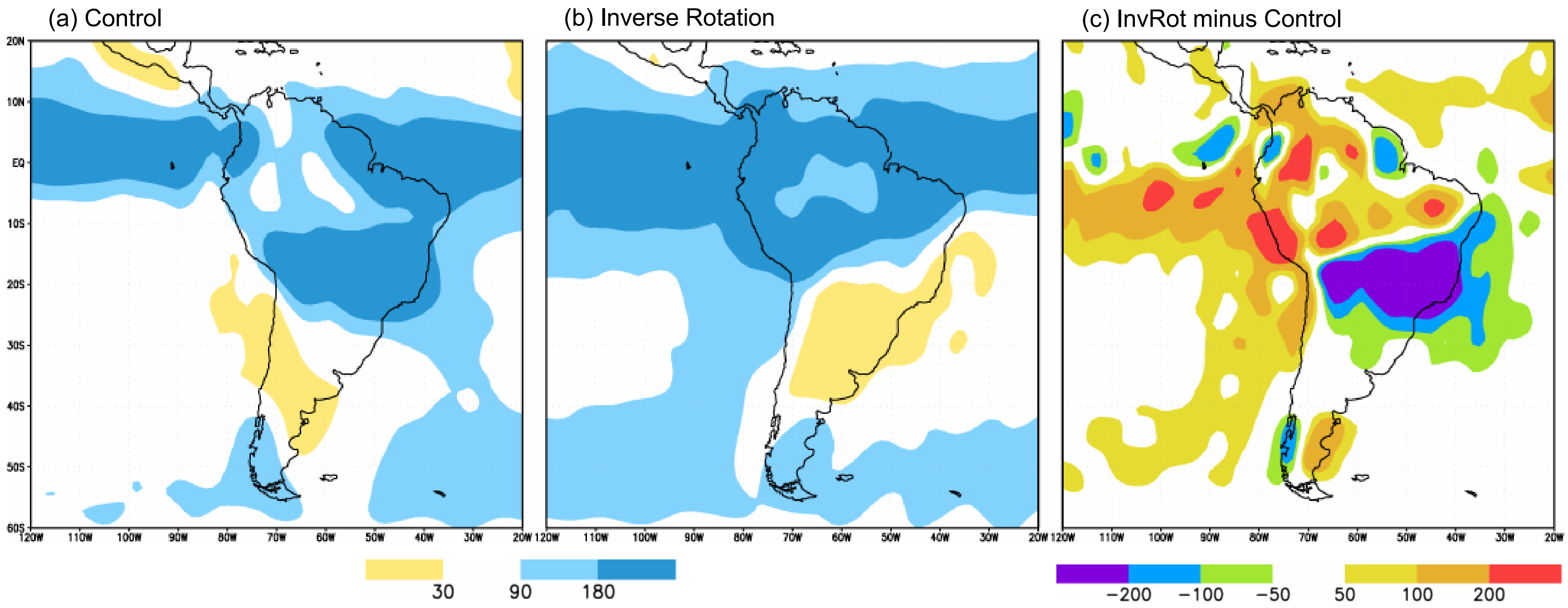


Rotation Experiments



Rotation Experiments

DJF mean Precipitation



Topography Experiments

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THE CENTRAL ANDEAN WEST-SLOPE RAINSHADOW AND ITS POTENTIAL CONTRIBUTION TO THE ORIGIN OF HYPER-ARIDITY IN THE ATACAMA DESERT

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ABSTRACT

The west slope of the central Andes exhibits a pronounced rainshadow effect. Precipitation between 15° and 27 °S is dominated by summer convective activity from Amazonia, and data analysis shows that the increase in precipitation with elevation due to the rainshadow effect best fits an exponential correlation. Coupling with limited data from high elevations suggests that the correlation is accurate to 4500 m above sea level (m a.s.l.) and perhaps to 5500 m a.s.l., suggesting that increased precipitation goes unrecorded over the peaks of the western Cordillera. South of 27 °S the precipitation is dominated by winter frontal sources and shows no well-defined relationship with elevation. The core zone of hyper-aridity in the Atacama Desert extends from 15 to 30 °S at elevations from sea level to 3500 m a.s.l. Although the Atacama Desert has existed since at least 90 Ma, it is considered that the initial onset of hyper-aridity was most likely to have developed progressively with the uplift of the Andes as they reached elevations between 1000 to 2000 m a.s.l. coupled with the intensification of a cold, upwelling Peruvian Current between 15 and 10 Ma. Also apparent in the palaeogeographic record are subsequent fluctuations between (semi-) arid to hyper-arid conditions that were probably largely controlled by changes in orbital and oceanic forcing.

5.3. Elevation forcing

Regional uplifts, such as the Andes, have been shown unequivocally to cause increasing aridity (Manabe and Broccoli, 1990; Ruddiman *et al.*, 1997). At elevations of 1000 m the effects of topographic forcing begin to be felt (Browning, 1980), with increasing effect by the time elevation has reached 2000 m (Hay and Wold, 1998; Otto-Bliesner, 1998), and palaeoclimate modelling of the Himalayas suggests that the impacts on climate may develop progressively and in step with increasing uplift Zhiseng *et al.* (2001).

Topography Experiments

Neogene climate change and uplift in the Atacama Desert, Chile

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ABSTRACT

The relationship between Andean uplift and extreme desiccation of the west coast of South America is important for understanding the interplay between climate and tectonics in the Central Andes, yet it is poorly understood. Here we use soil morphological characteristics, salt chemistry, and mass independent fractionation anomalies ($\Delta^{17}O$ values) in dated paleosols to reconstruct a middle Miocene climatic transition from semiaridity to extreme hyperaridity in the Atacama Desert. Paleosols along the southeastern margin of the Calama Basin change from calcic Vertisols with root traces, slickensides, and gleyed horizons to an extremely mature salic Gypsisol with pedogenic nitrate. We interpret this transition, which occurred between 19 and 13 Ma, to represent a change in precipitation from >200 mm/yr to <20 mm/yr. This drastic reduction in precipitation likely resulted from uplift of the Central Andes to elevations >2 km; the uplift blocked moisture from the South American summer monsoon from entering the Atacama. The mid-Miocene Gypsisol with pedogenic nitrate is located at elevations between 2900 and 3400 m in the Calama Basin, significantly higher than modern nitrate soils, which occur below ~2500 m. Modern and Quaternary soils in this elevation zone contain soil carbonate and lack pedogenic gypsum and nitrate. We infer that >900 m of local surface uplift over the past 10 m.y. displaced these nitrate paleosols relative to modern nitrate soils and caused a return to wetter conditions in the Calama Basin by decreasing local air temperatures and creating an orographic barrier to Pacific air masses.

Keywords: Atacama Desert, Andes, paleosols, Calama Basin, soil nitrate.

INTRODUCTION

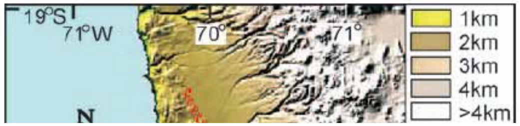
maintained through the existence of a strong

elevations above ~2800 m, but do not cause rainfall in the central Atacama.

The Calama Basin is located on the eastern margin of the Atacama, ~150 km from the Pacific Coast at elevations between 2200 and 3500 m (Fig. 1). Precipitation in the center of the basin (2200 m) is ~4 mm/yr, whereas along the eastern margin (3350 m) precipitation is ~50 mm/yr.

PALEOSOLS IN THE CALAMA BASIN

We examined Miocene strata and Quaternary landforms along the southeastern margin of the Calama Basin for evidence of pedogenesis. Miocene gypcretes were first reported in this region by Hartley and May (1998). We identified Miocene and Quaternary paleosols developed on substrates of alluvial fan and flood-plain deposits, and basement bedrock.



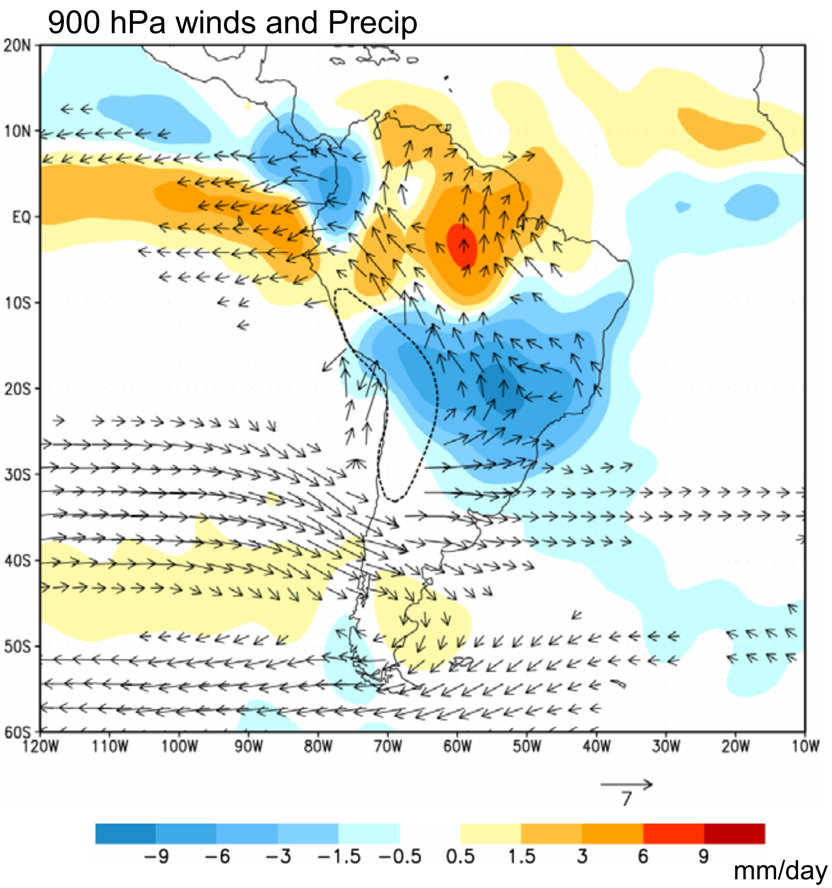
Topography Experiments

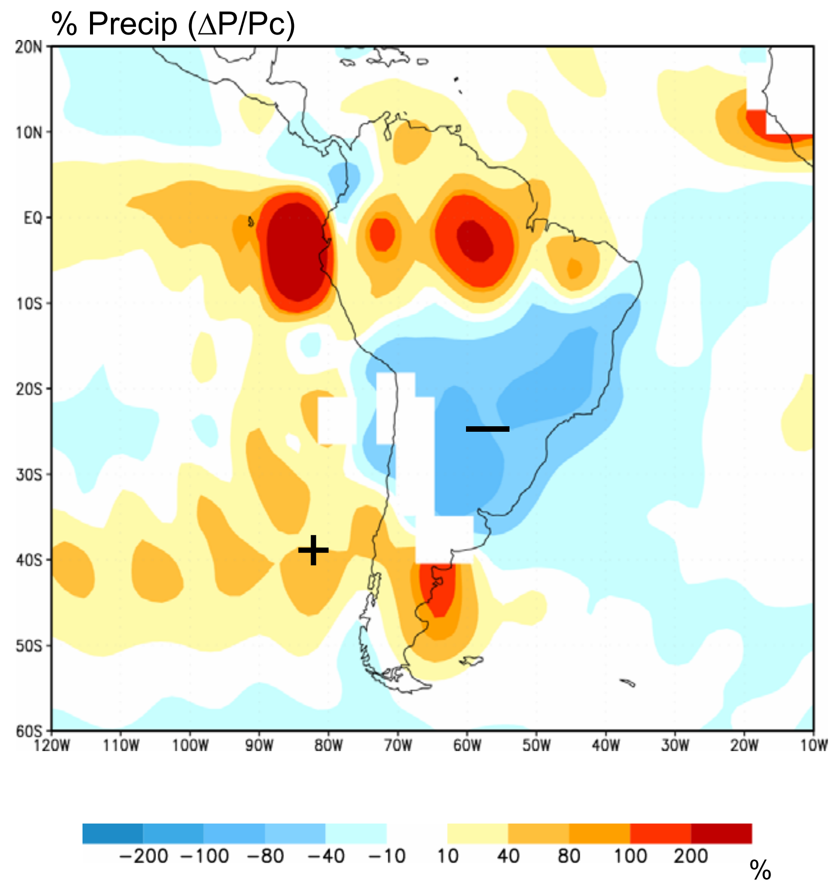
Motivated by the previous wisdoms in the paleo-climate and geological communities, we set up a numerical experiment using PLASIM:

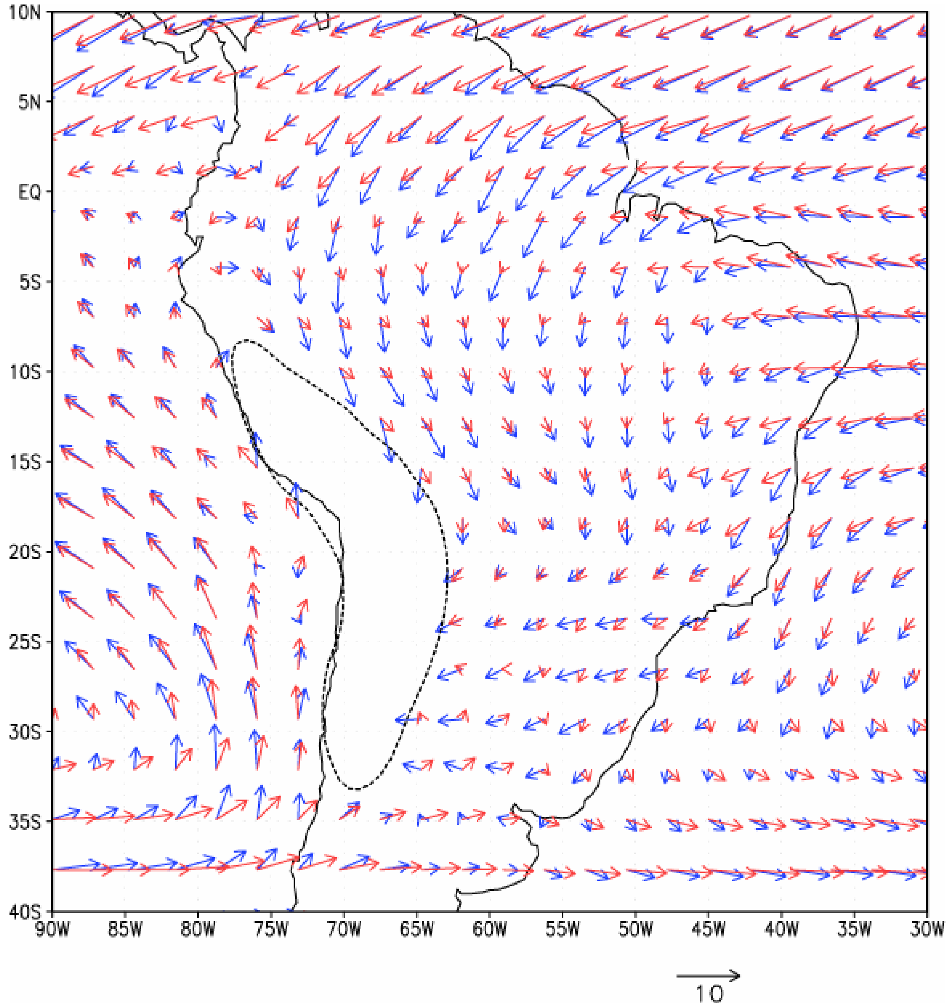
Experiment	Topography	Ocean/Ice model
Control	100%	Yes
Atmos Only	100%	No
0.1Topo-f	10% everywhere	Yes
0.3Topo-f	30% everywhere	Yes
0.5Topo-f	50% everywhere	Yes
0.7Topo-f	70% everywhere	Yes
0.9Topo-f	90% everywhere	Yes
0.3Topo-A	30% everywhere	No
0.3Andes-f	30% South America	Yes
0.3Andes-A	30% South America	No

Topography Experiments

0.3*Topo minus Control (DJF)





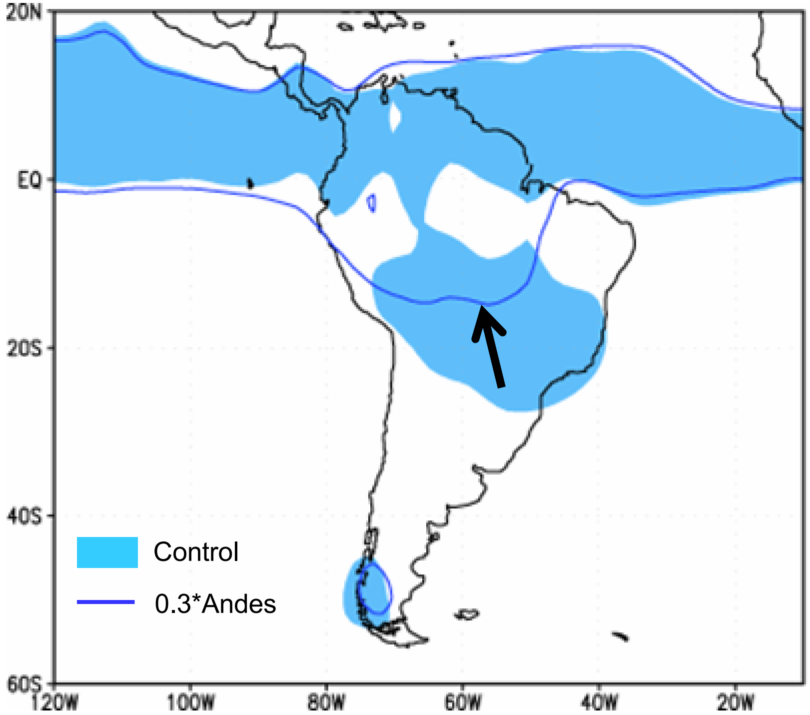


10N
5N
EQ
5S
10S
15S
20S
25S
30S
35S
40S
90W
85W
80W
75W
70W
65W
60W
55W
50W
45W
40W
35W
30W
10

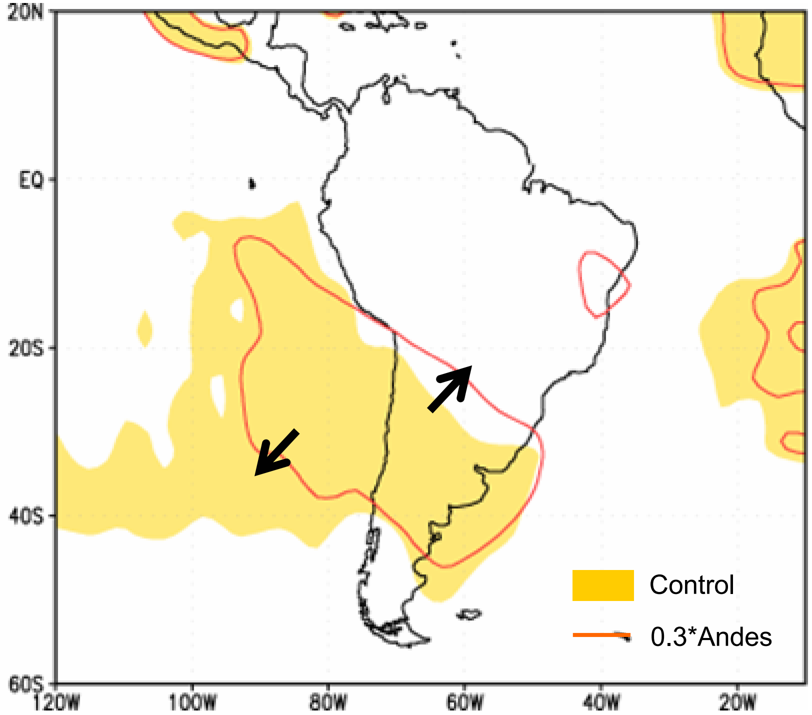
Topography Experiments

DJF Precipitation

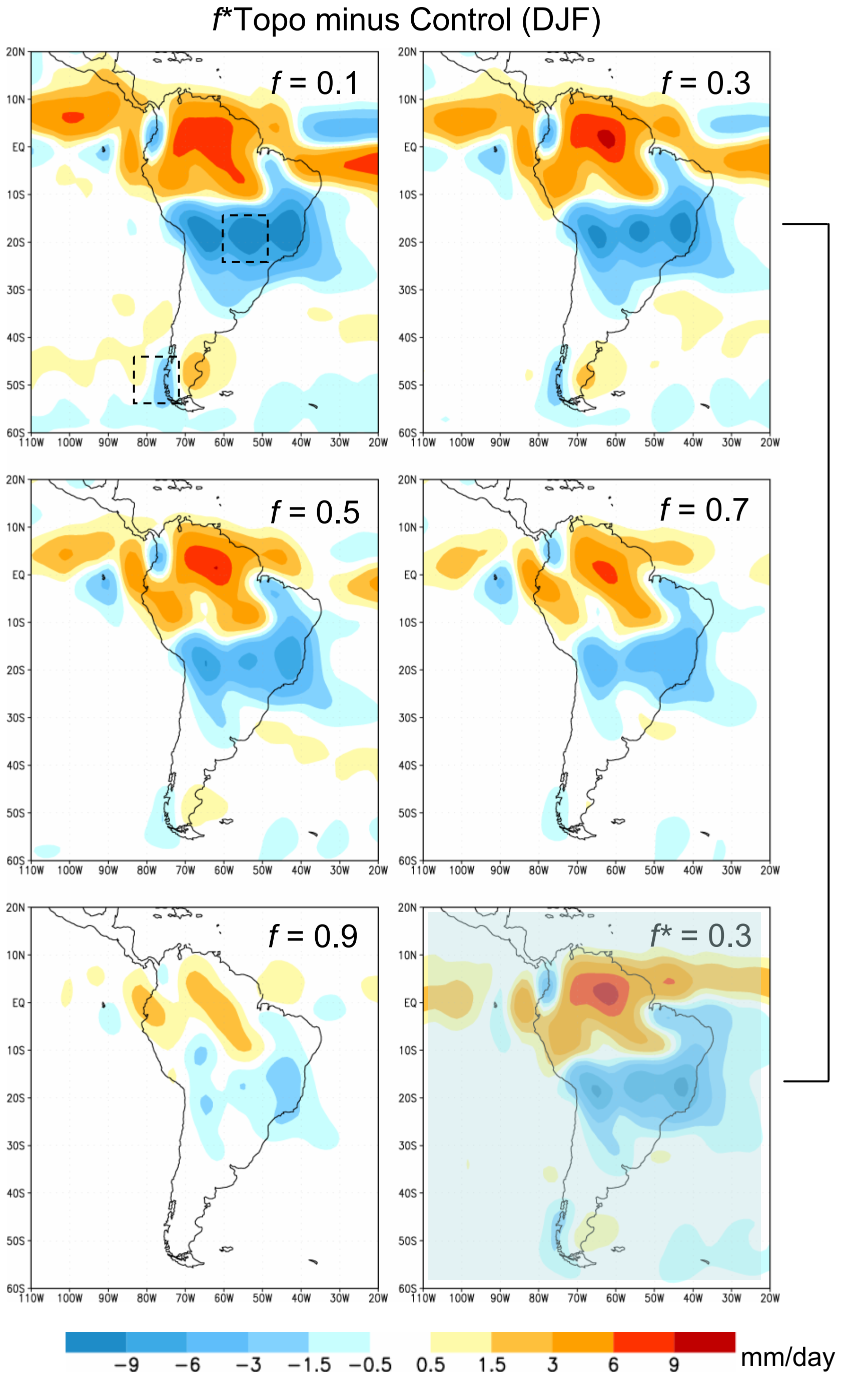
R>100 mm/month



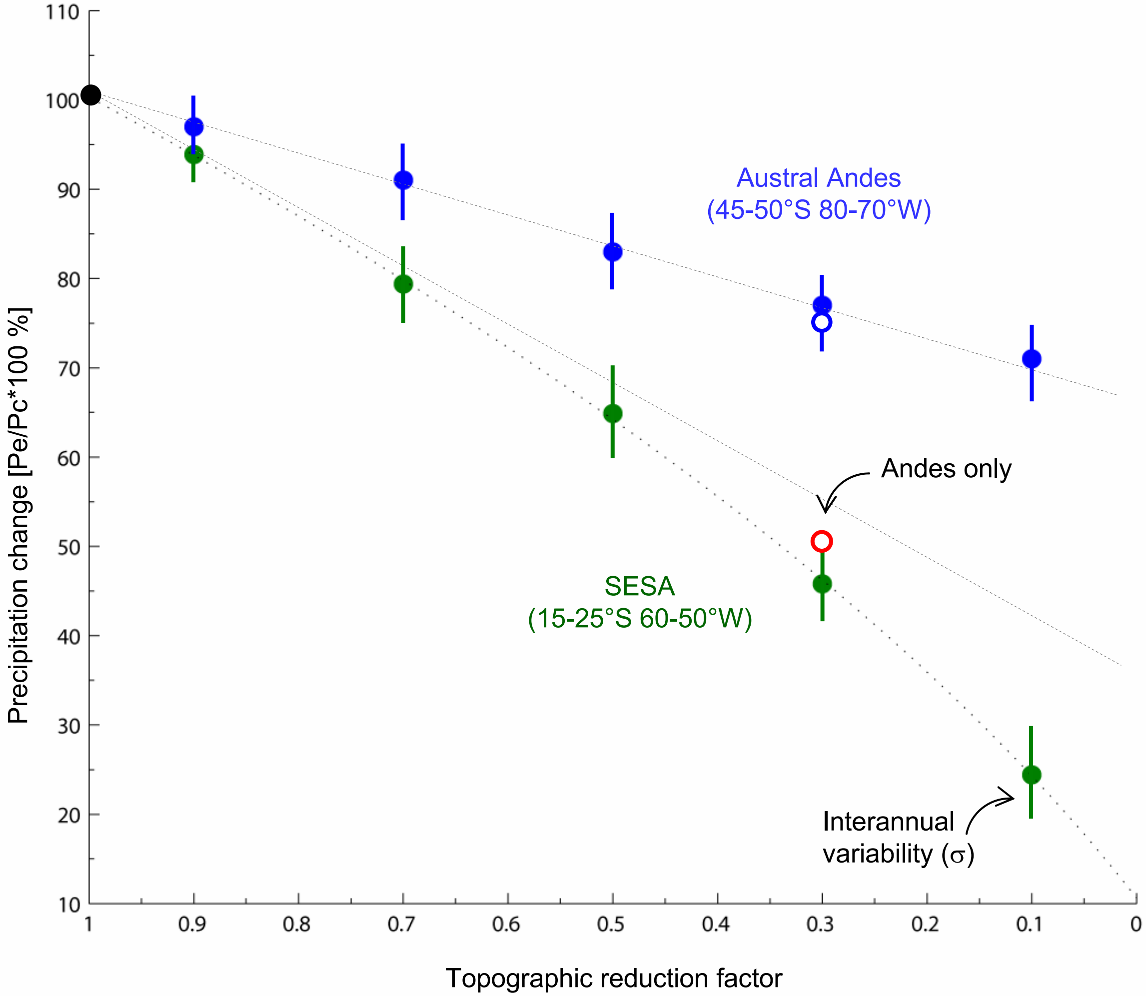
R< 10 mm/month



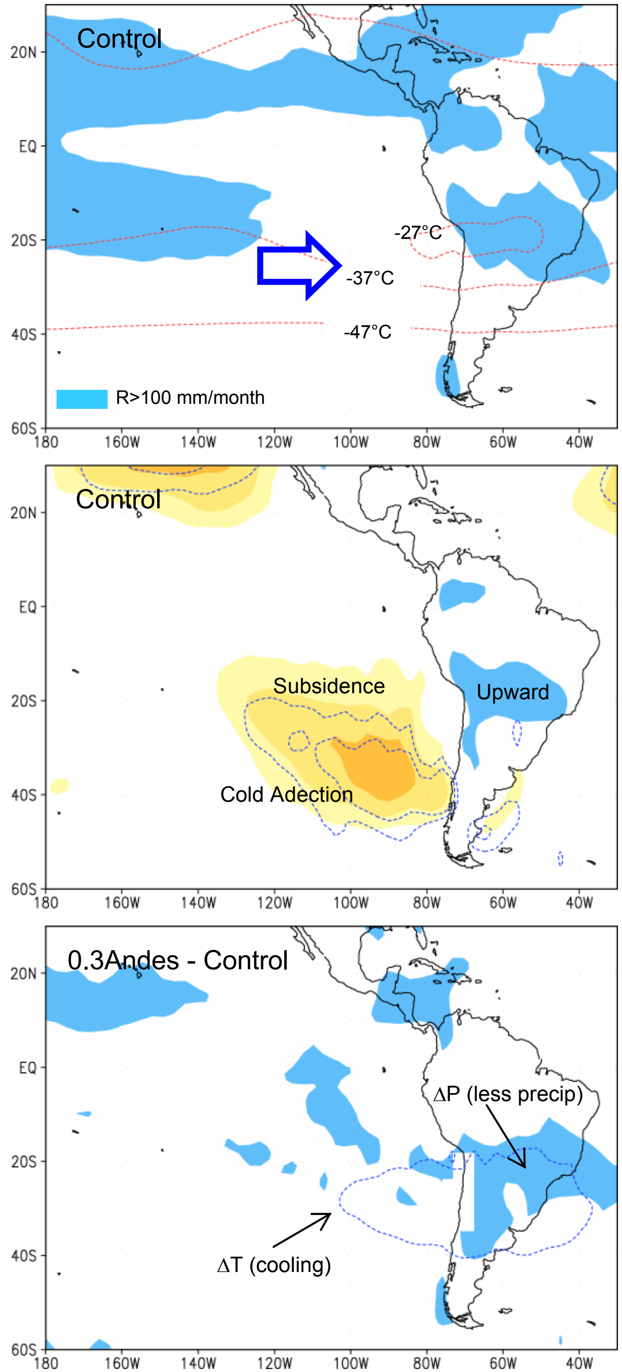
Topography Experiments



Topography Experiments



Topography Experiments



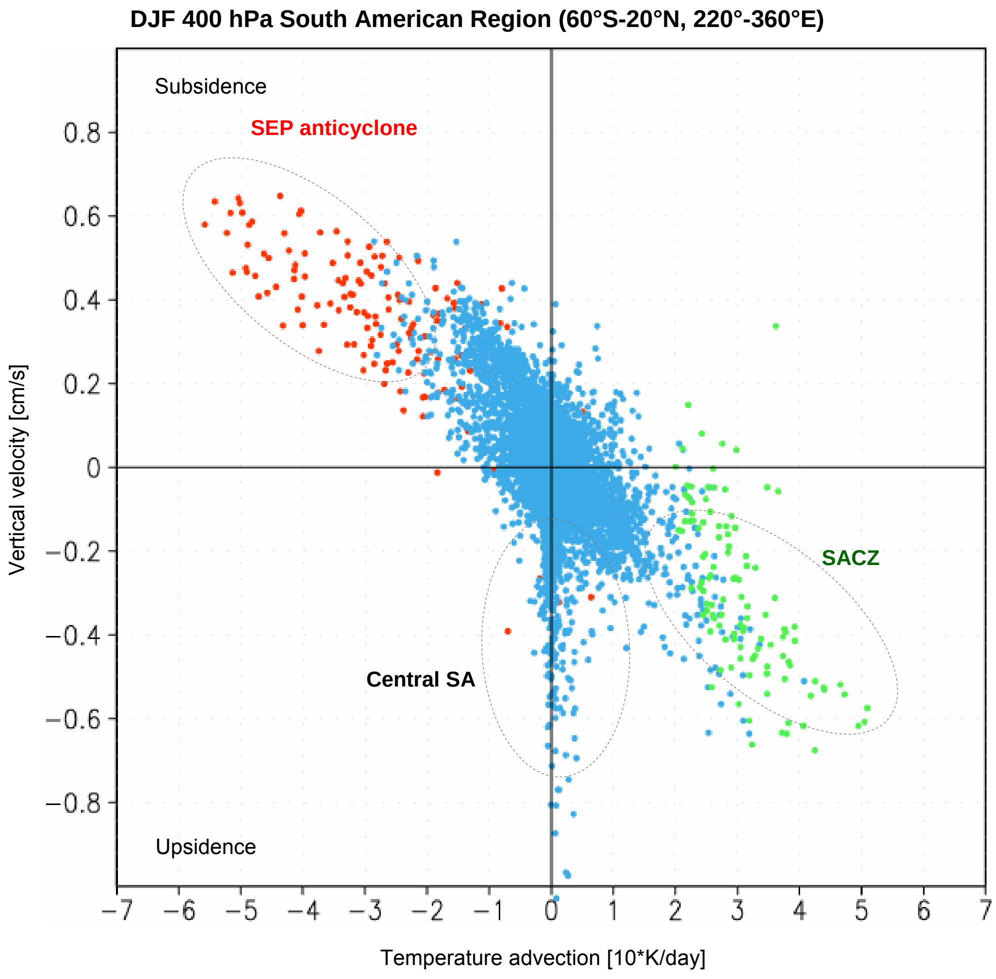
Deep convections warms the tropical / subtropical tropospher, producing a warm-core upper-level anticyclone

Rodwell-Hoskins Mechanism

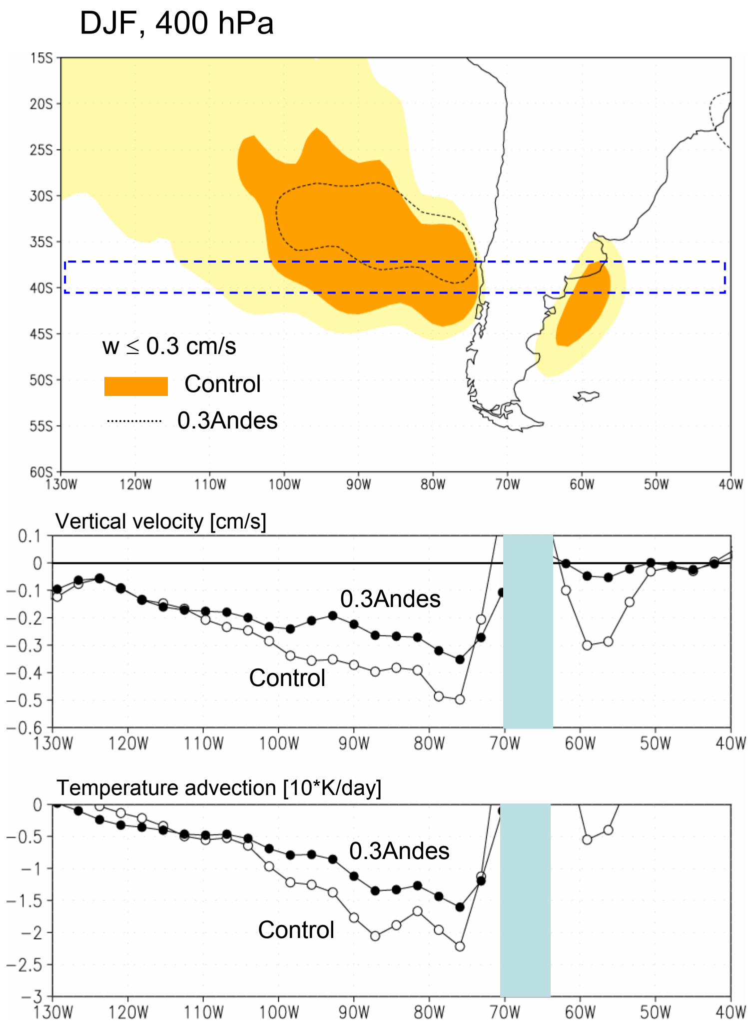
Strong cold advection occurs where the westerly flow "encounters" the upper-level warm region. Thermal balance requires enhanced susbidence, strengthening the SEP subtropical anticyclone

Smaller Andes reduce rainfall over the interior of the continent and thus reduce the warming of the upper-troposphere…
less thermal gradient…
less cold advection….
less subsidence?

Topography Experiments

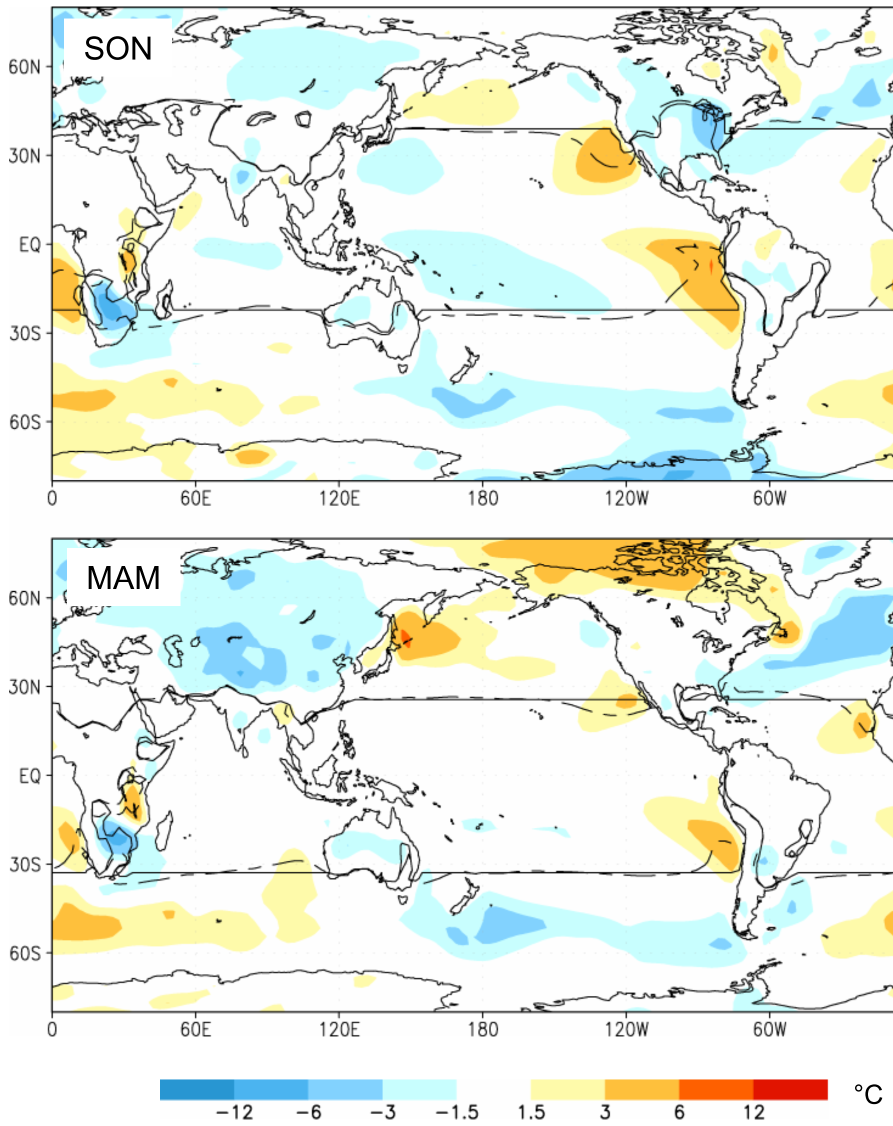


Topography Experiments



Rotation Experiments

Inverse-Rot minus Control SST/SAT



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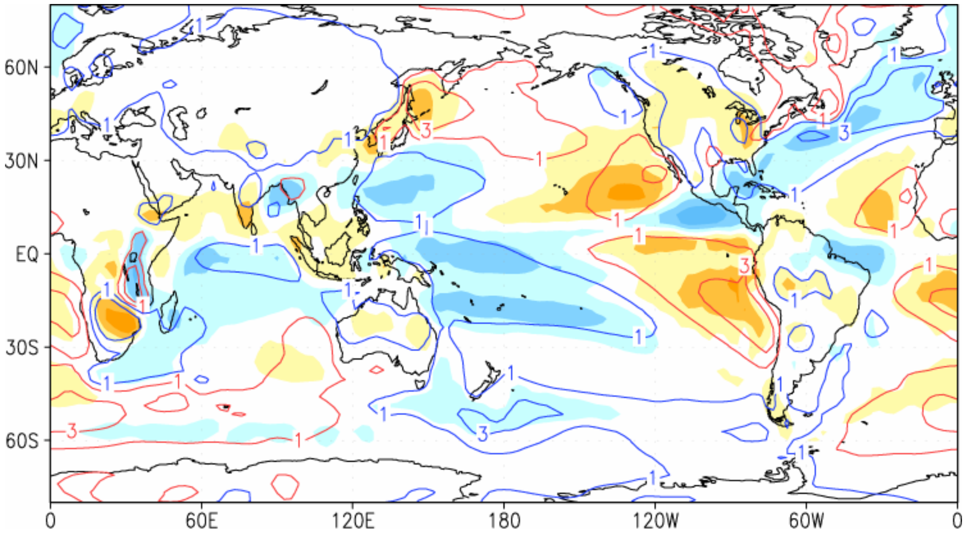
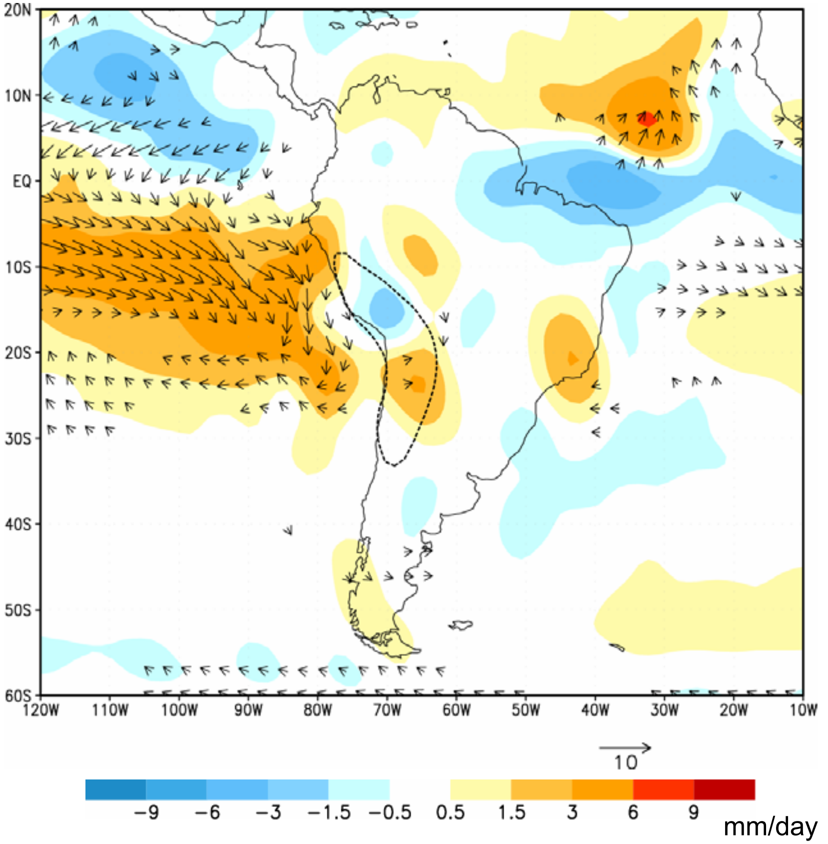


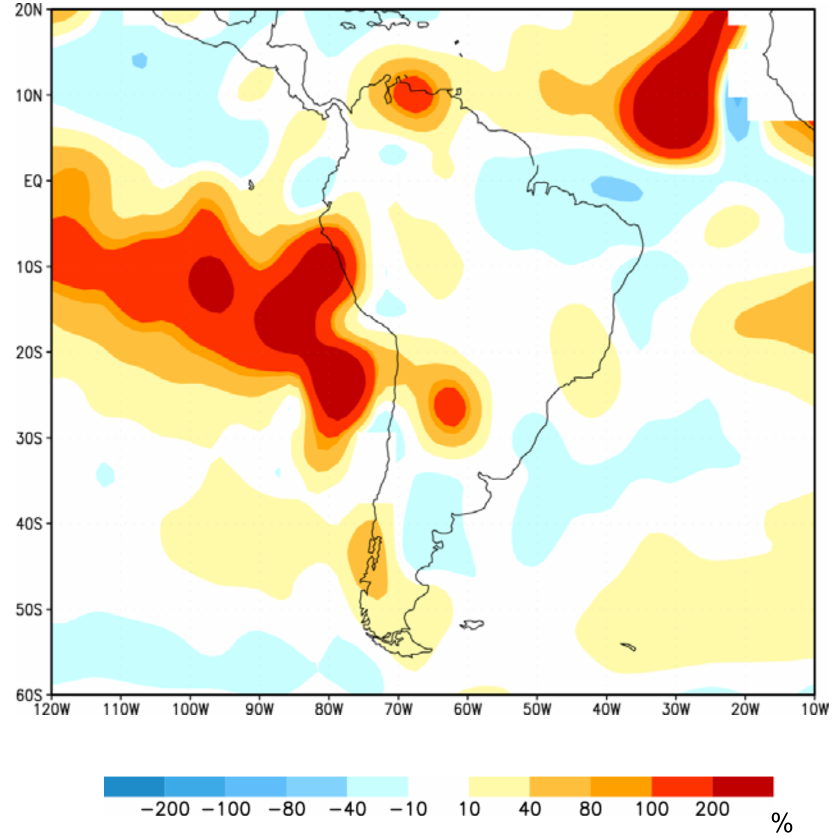
Topography Experiments

0.3*Topo minus Control (DJF)

900 hPa winds and Precip



% Precip (ΔP/Pc)



Topography Experiments

DJF Precipitation