

Global Climate Change: Impacts in Chile

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Outline

The ACT-19 Project (2006-2008)

Observed trends

Future regional climate

ACT-19 Project. Climate Variability in Chile: Evaluation, interpretation and projections 2006-2008

Main scientific questions

- Is the Chilean climate changing?
- Which are the characteristics of this change in the global context? Is there evidence of anthropogenic impacts?
- Which are the leading mechanism behind regional climate variability?
- What is the role of the ocean in driving atmospheric variability?

ACT-19 Project. Climate Variability in Chile: Evaluation, interpretation and projections

PIs

- René Garreaud (Dir)
- Patricio Aceituno
- Jorge Carrasco
- José Rutllant
- Samuel Hormazabal
- Aldo Montecinos
- Oscar Pizarro

CO-Pis

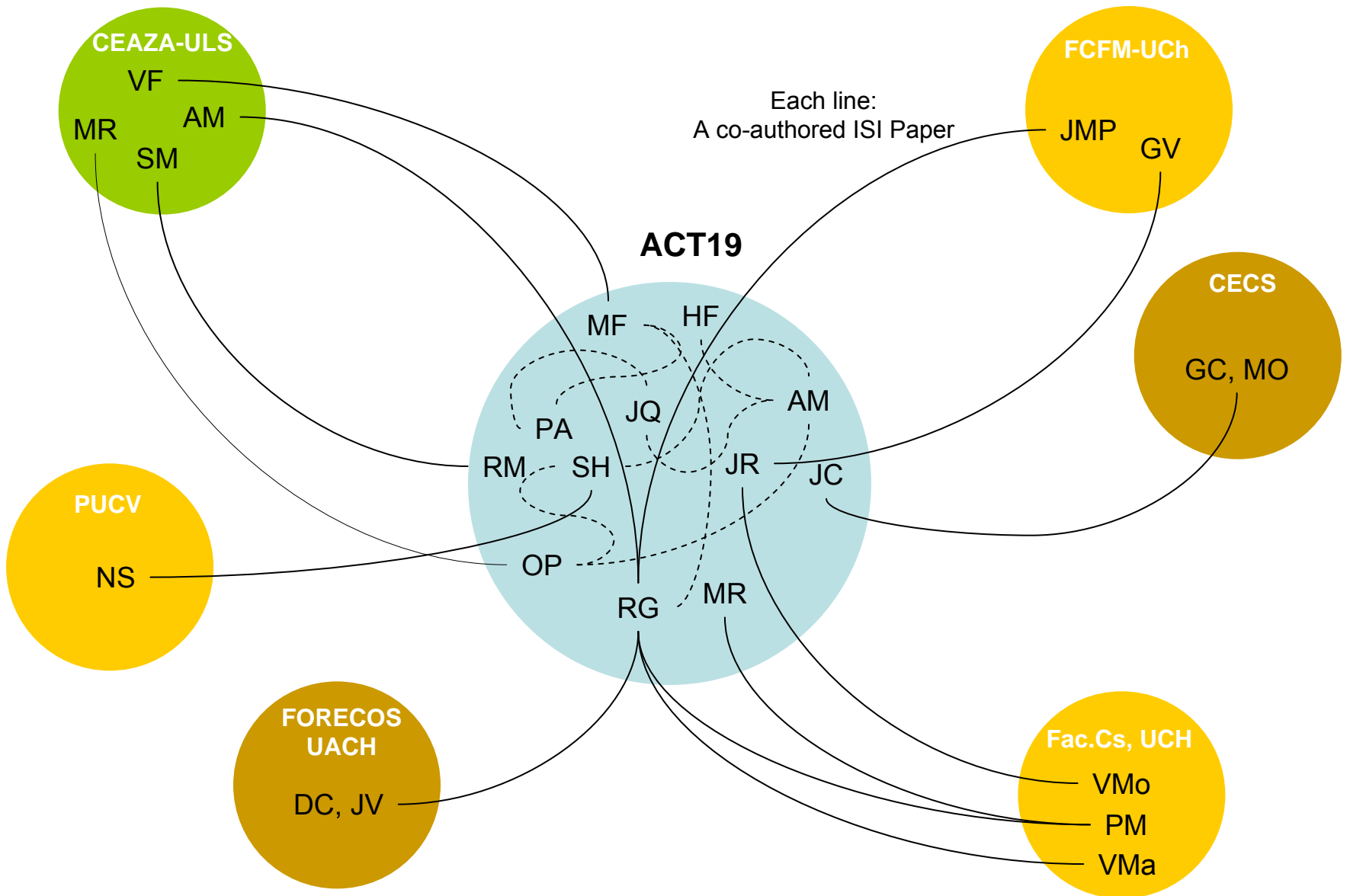
- Ricardo Muñoz
- Humberto Fuenzalida
- Dante Figueroa
- Elias Ovalle
- Juan Quintana
- Mark Falvey (YR)
- Maisa Rojas (YR)
- Brad Barrett (PD)
- Dave Rahn (PD)
- Sebastian Vicuña (PD)
- Rainer Schmitz

Students

- Fabian Gomez
- Claudia Villarroel
- Paola Uribe
- Rosa Zamora
- Martin Jacques
- Ricardo Alcafuz
- Enrique Garrido
- Cristian Henríquez

- German Osses (Pre)
- Ruben Maureira (Pre)
- Michelle Muñoz (Pre)

National Networking



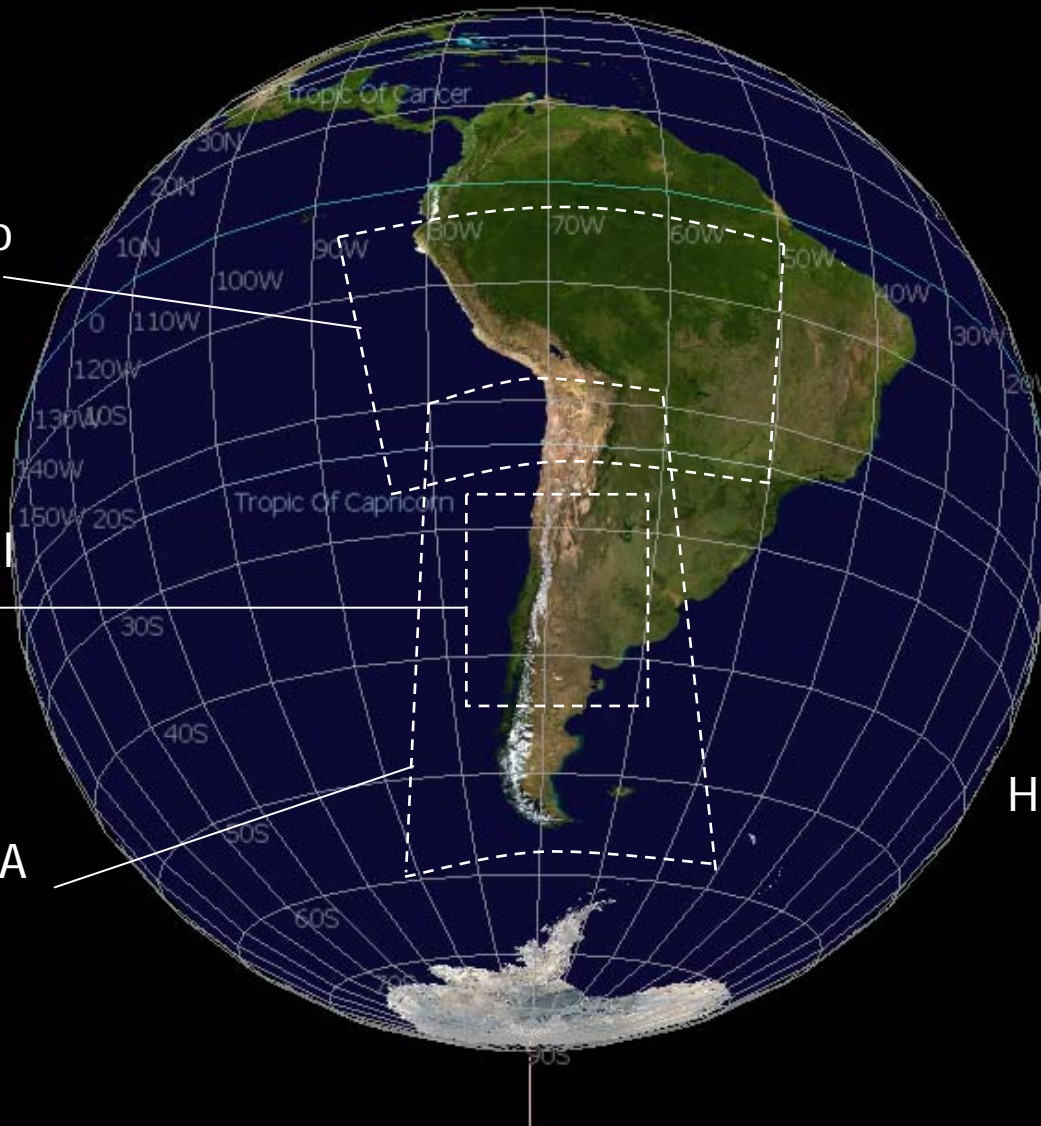
Regional Climate Simulations during ACT-19

All output available via DODs: www.dgf.uchile.cl/ACT19

PRECIS-Altiplano
25 km hor res.

WRF-ChileCentral
15 km hor.res.

PRECIS-CONAMA
25 km hor. Res.



Scenarios:

BL (1960-1990)
A2 (2070-200)
B2 (2070-2100)

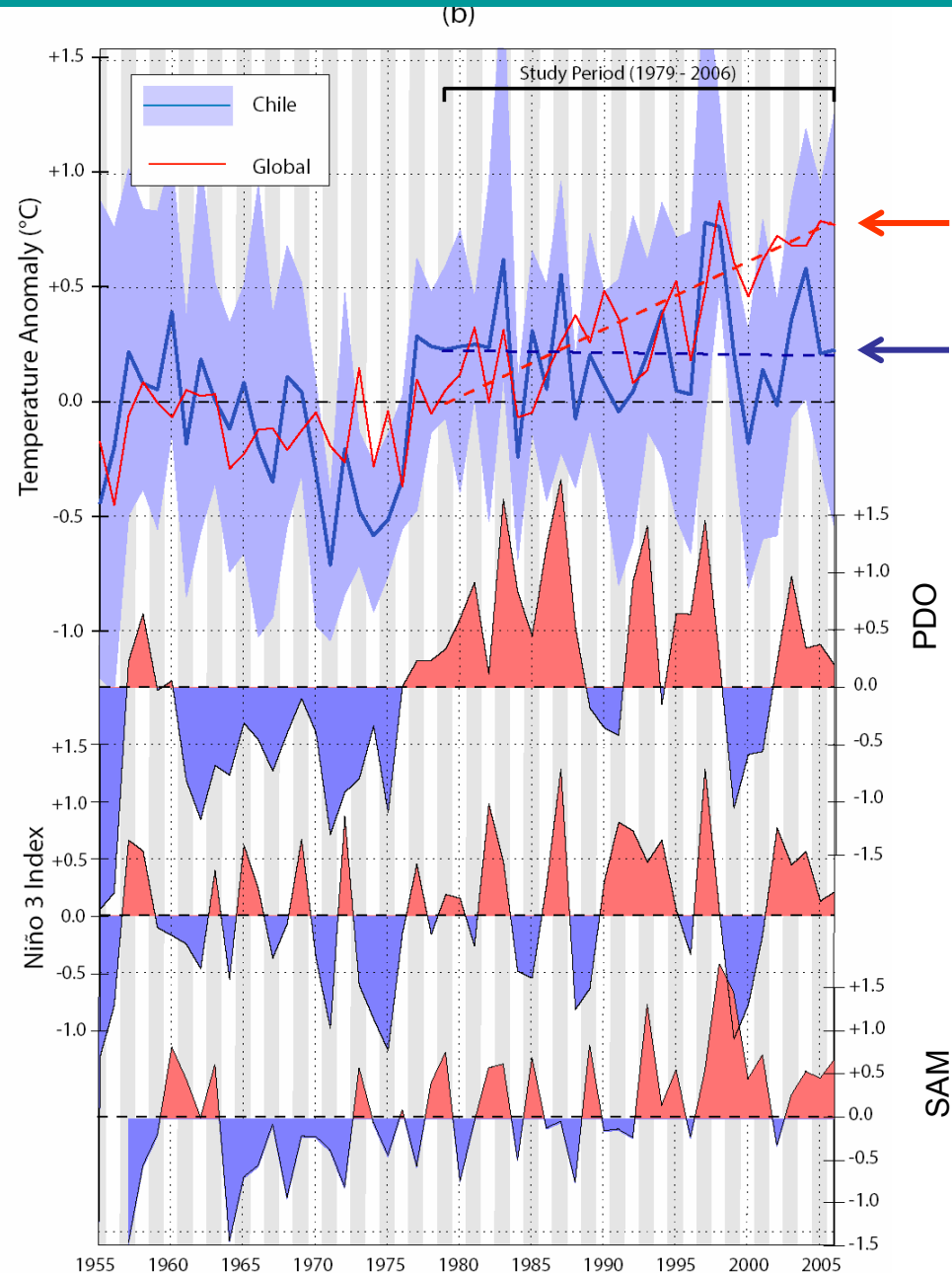
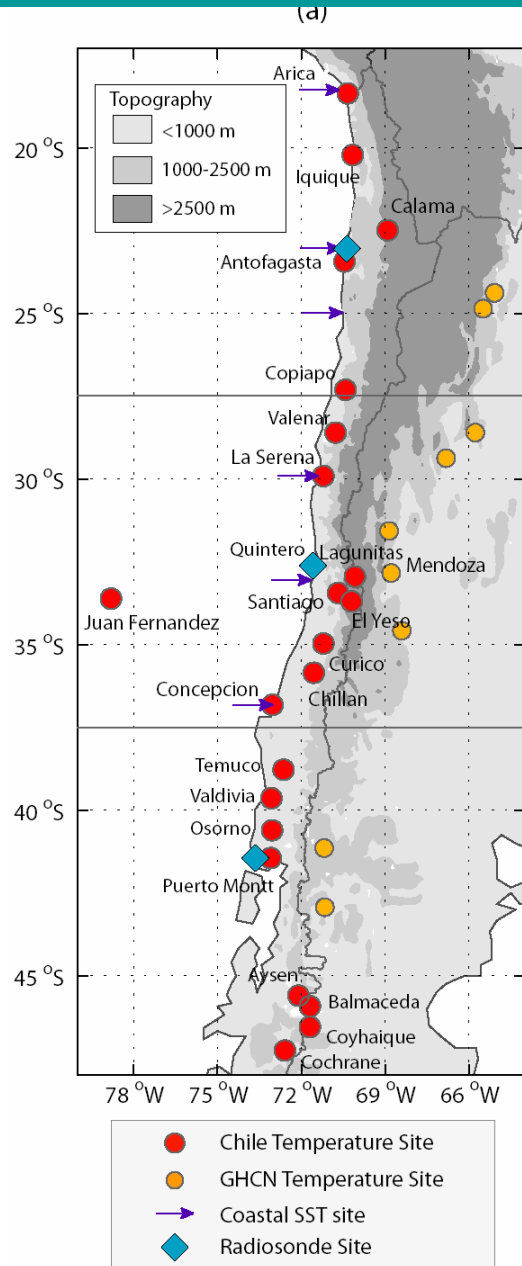
Lateral BC:
HadAM

Surface BC:
HadISST + HadCM3

Outreach Brochure

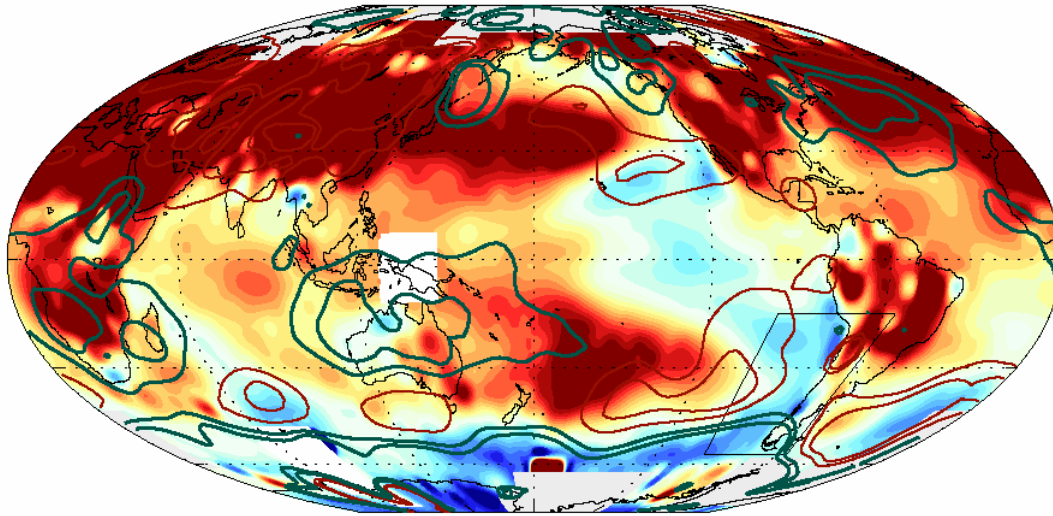


SAT Change: Geographical setting and global context

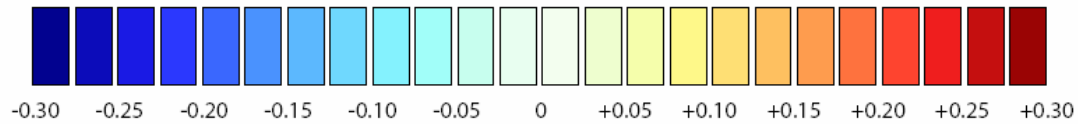
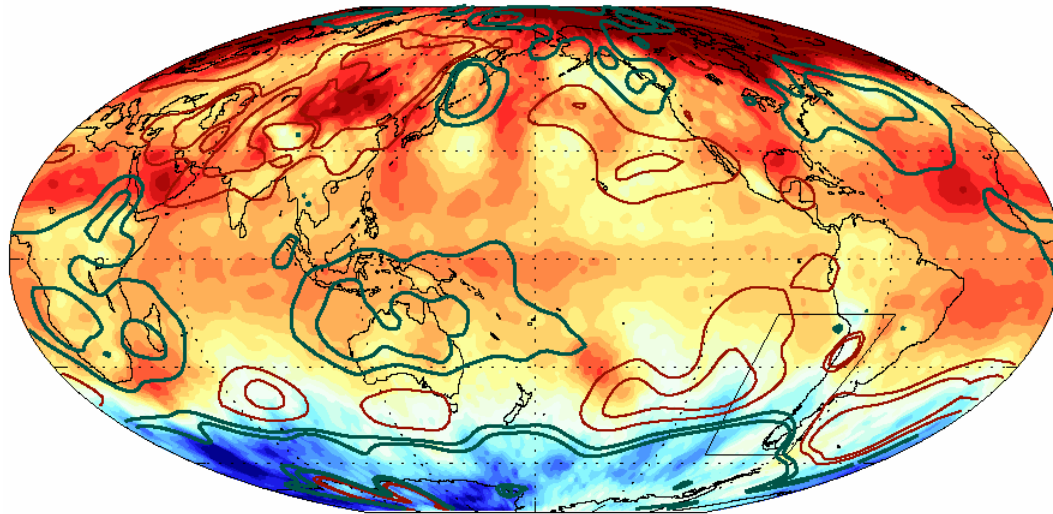


Global Temperature Change 1979-2006

Surface Air Temperature and SST (NCDC)

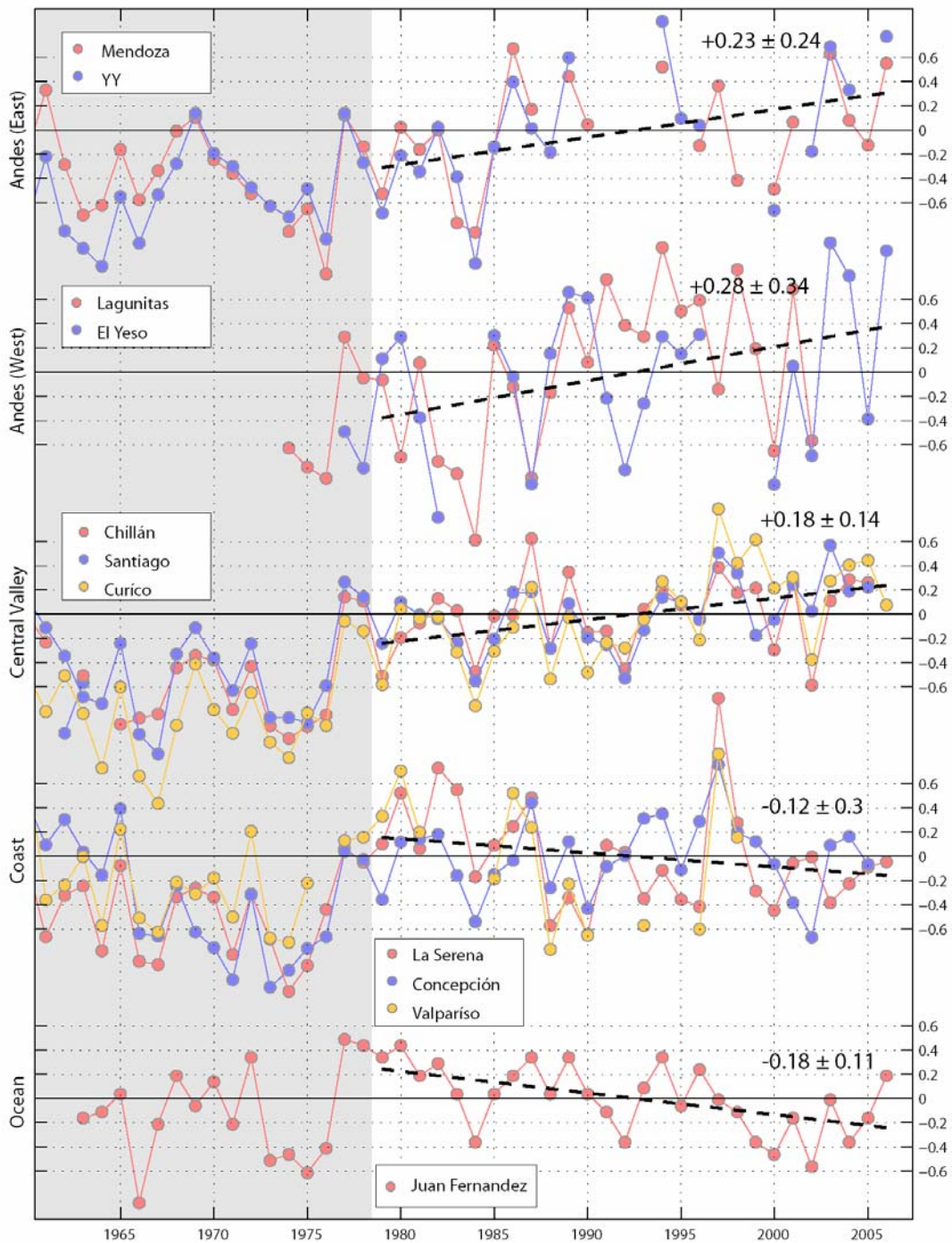


Mid-Troposphere Air Temperature (MSU)

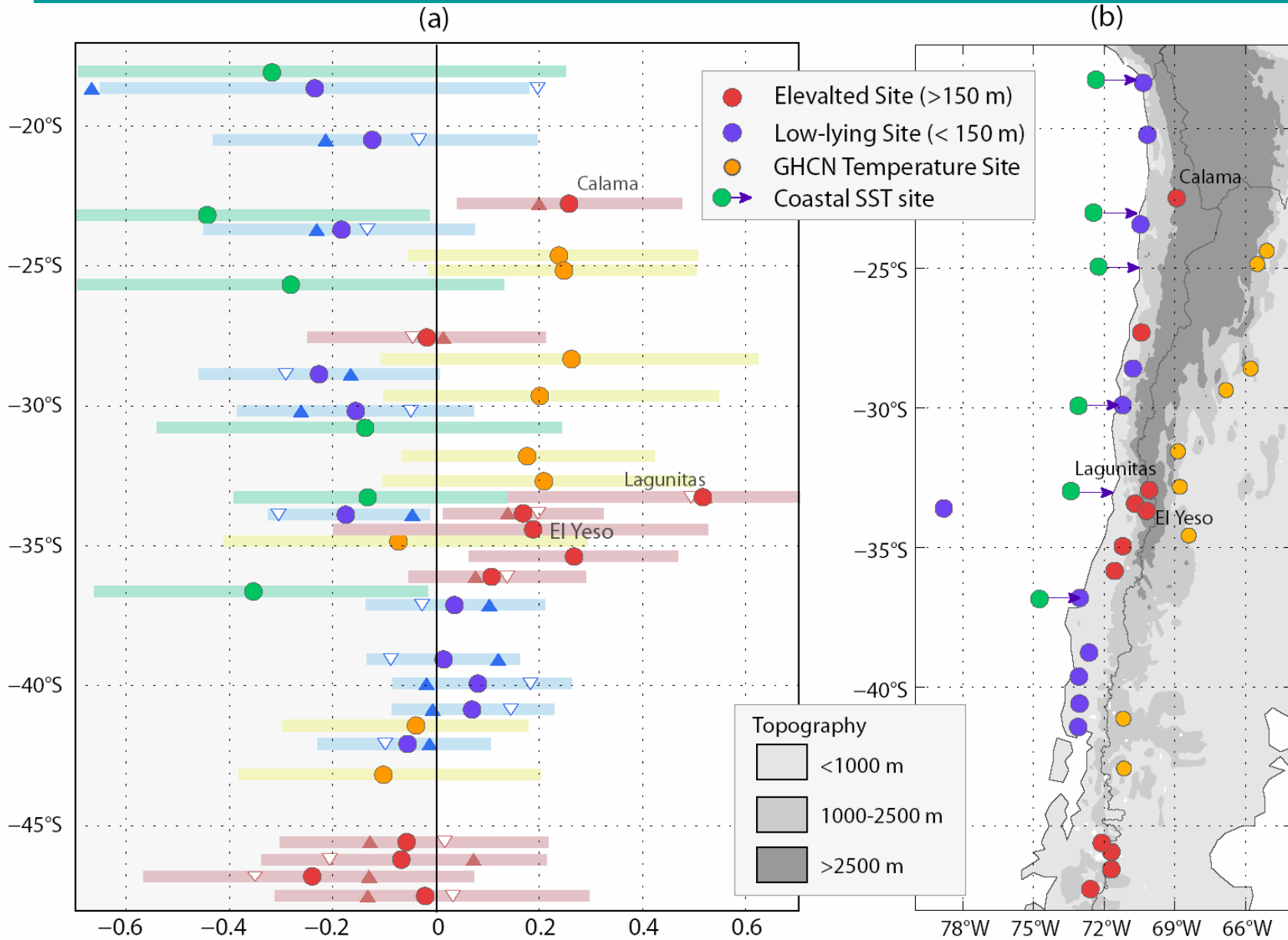


Temperature Tendency 1979-2006 ($^{\circ}$ / decade)

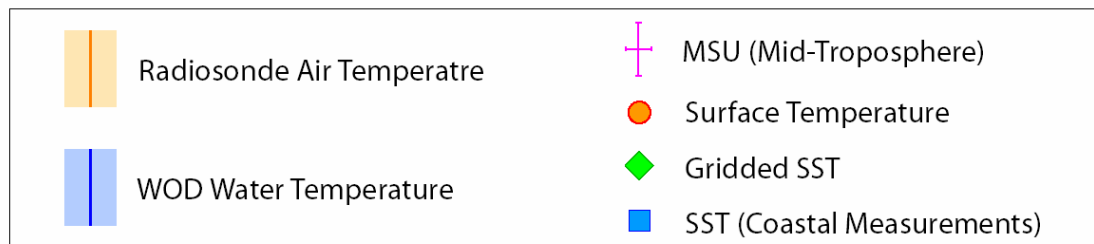
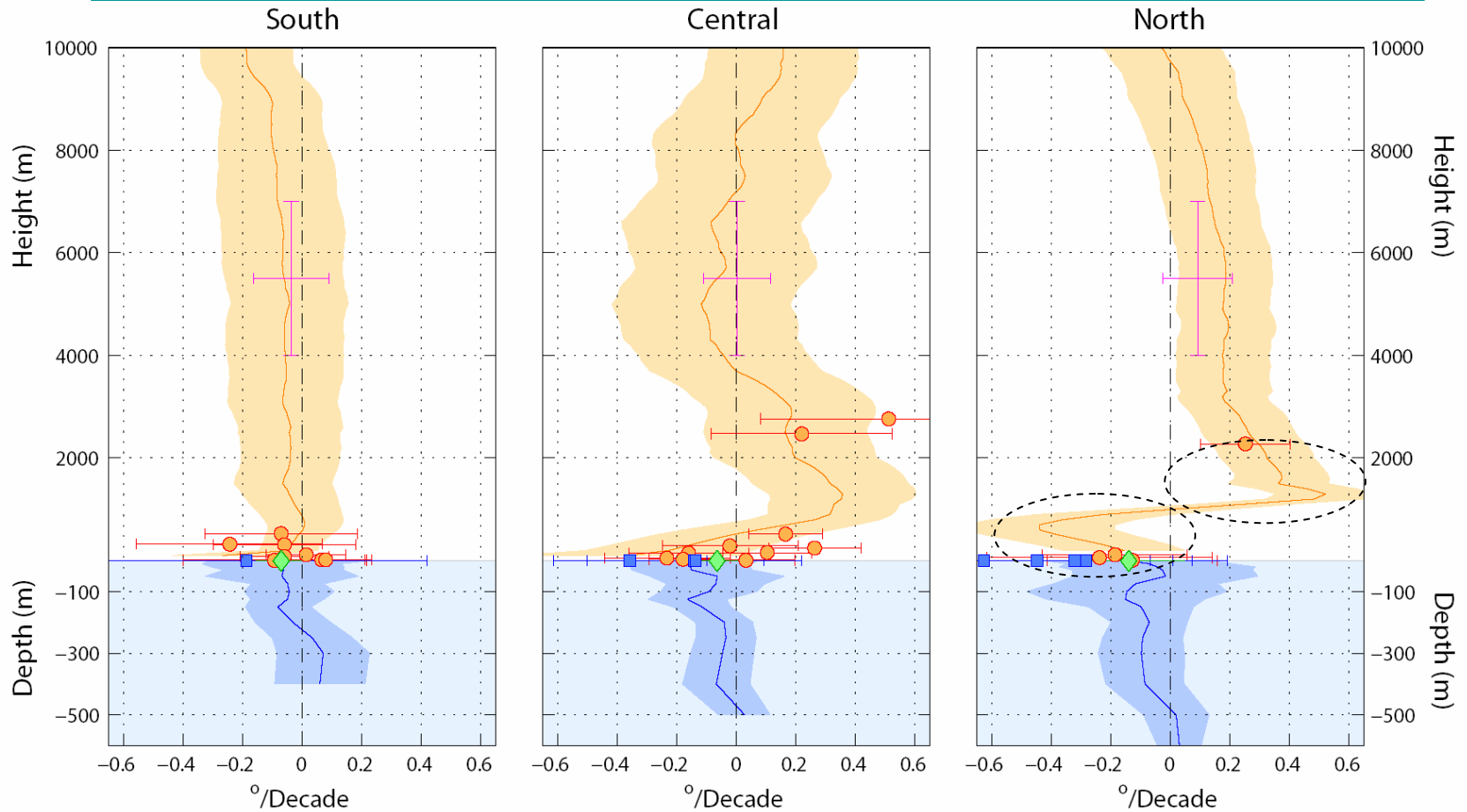
Temperature Changes in Central Chile



Ocean cooling – land warming along north-central Chile. Pattern reverses farther south

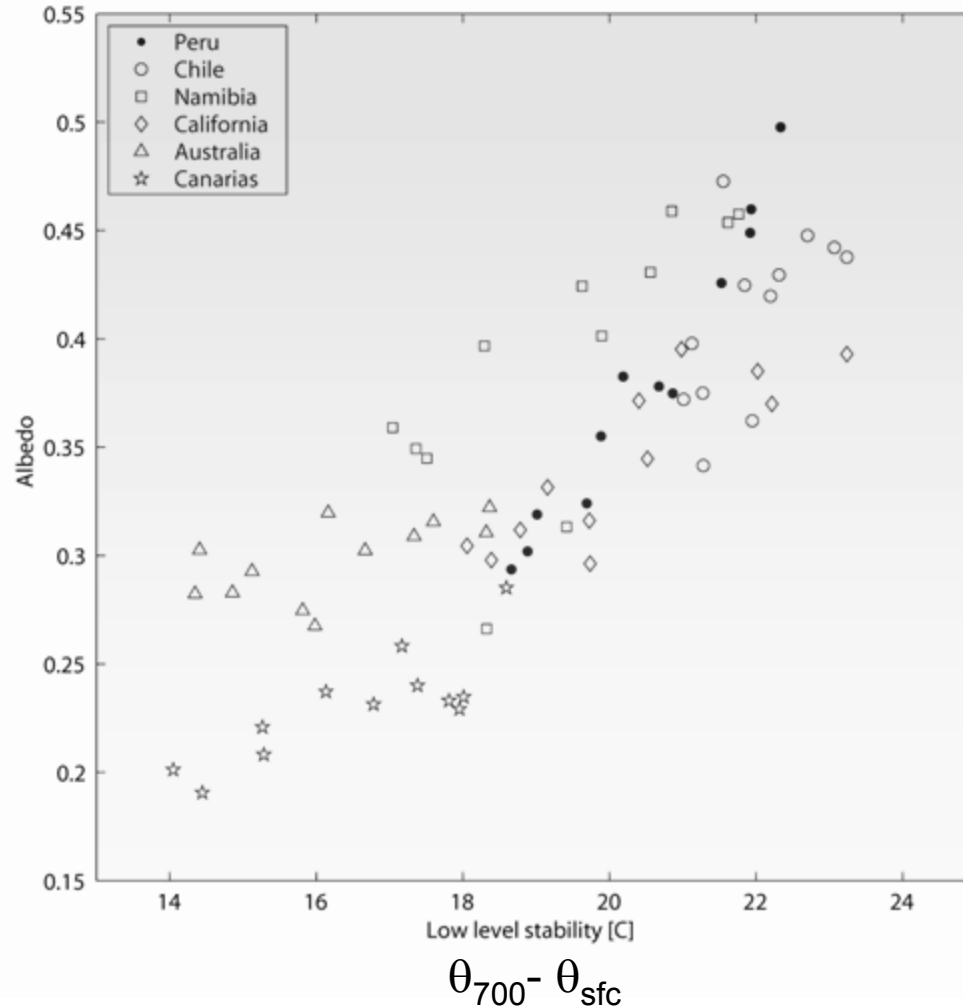


Cooling MBL / warming lower free troposphere → increased lower tropospheric stability ... Sc?



Increase in cloudiness?

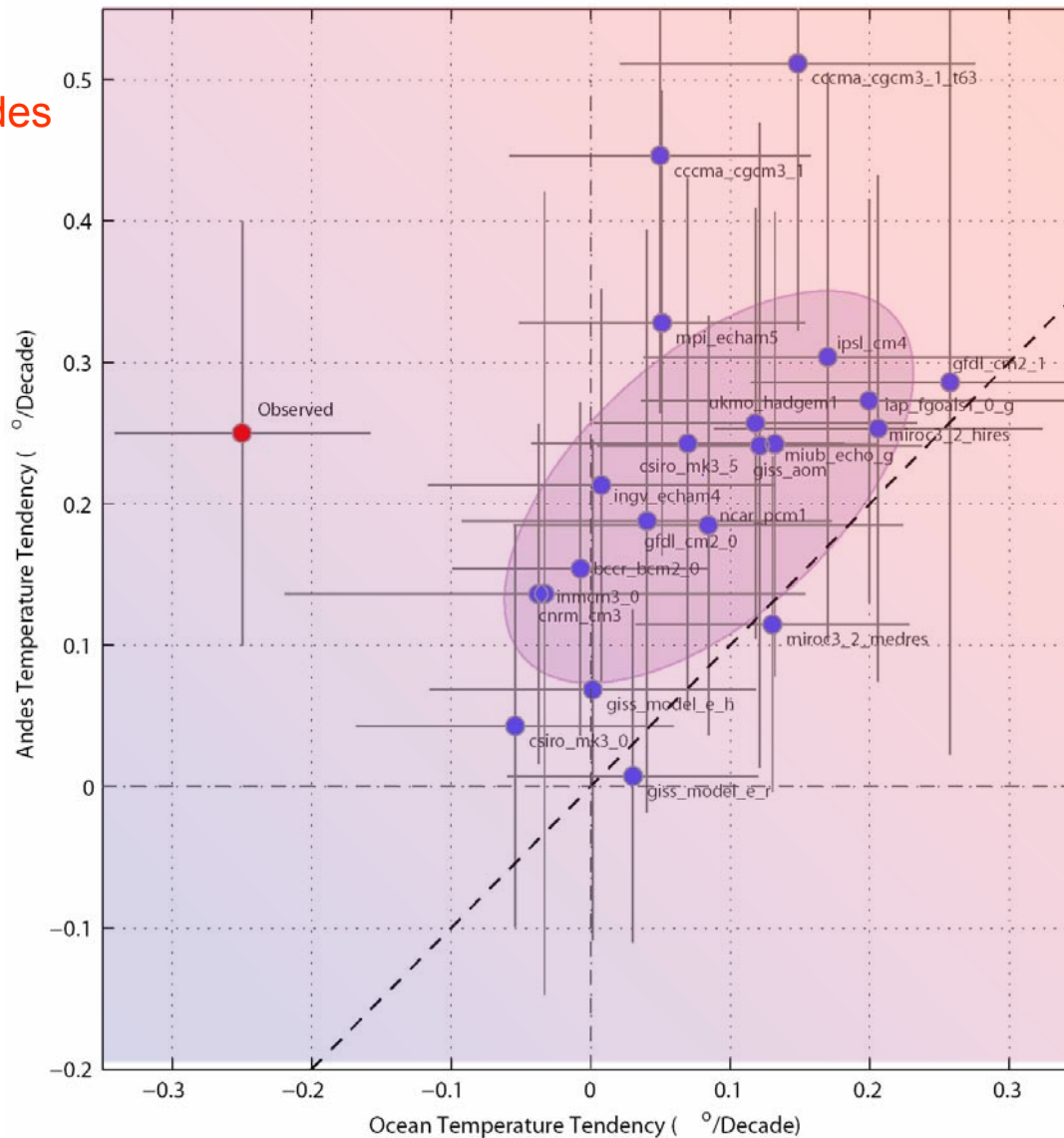
Maybe...hard to test...requires a feedback



Annual cycle of SCu an inter-regional differences largely explained by low level stability: $\theta_{700} - \theta_{sfc}$ (Klein and Hartmann 1993)

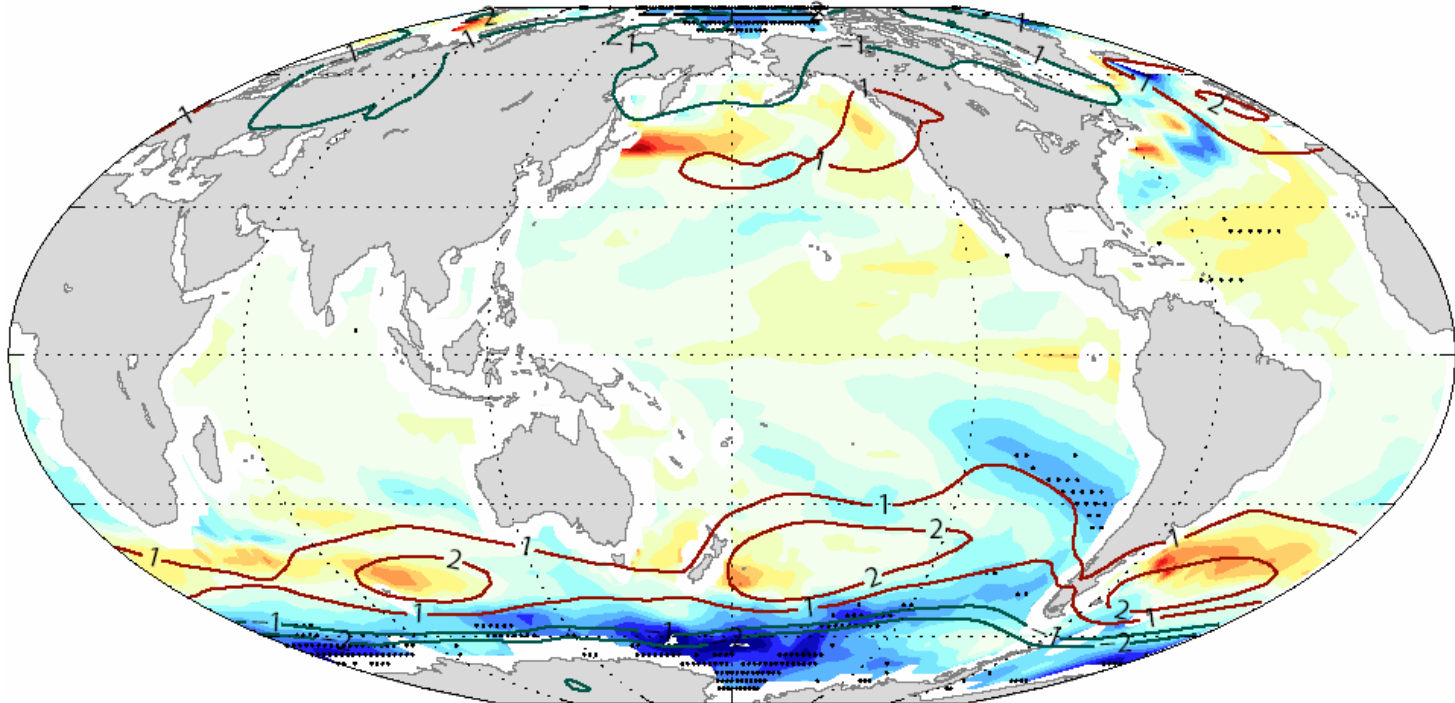
How are the models doing? Not good but no so bad..

$\partial T/\partial t$
central Andes

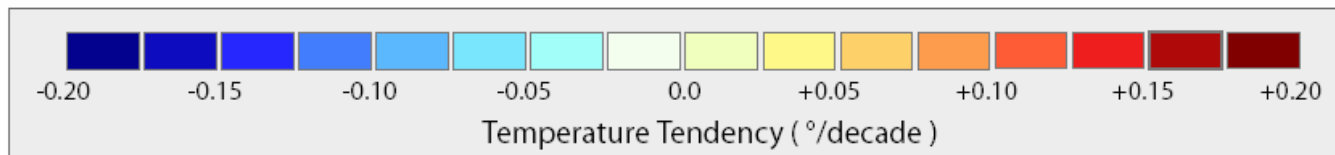


$\partial T/\partial t$
off Central Chile

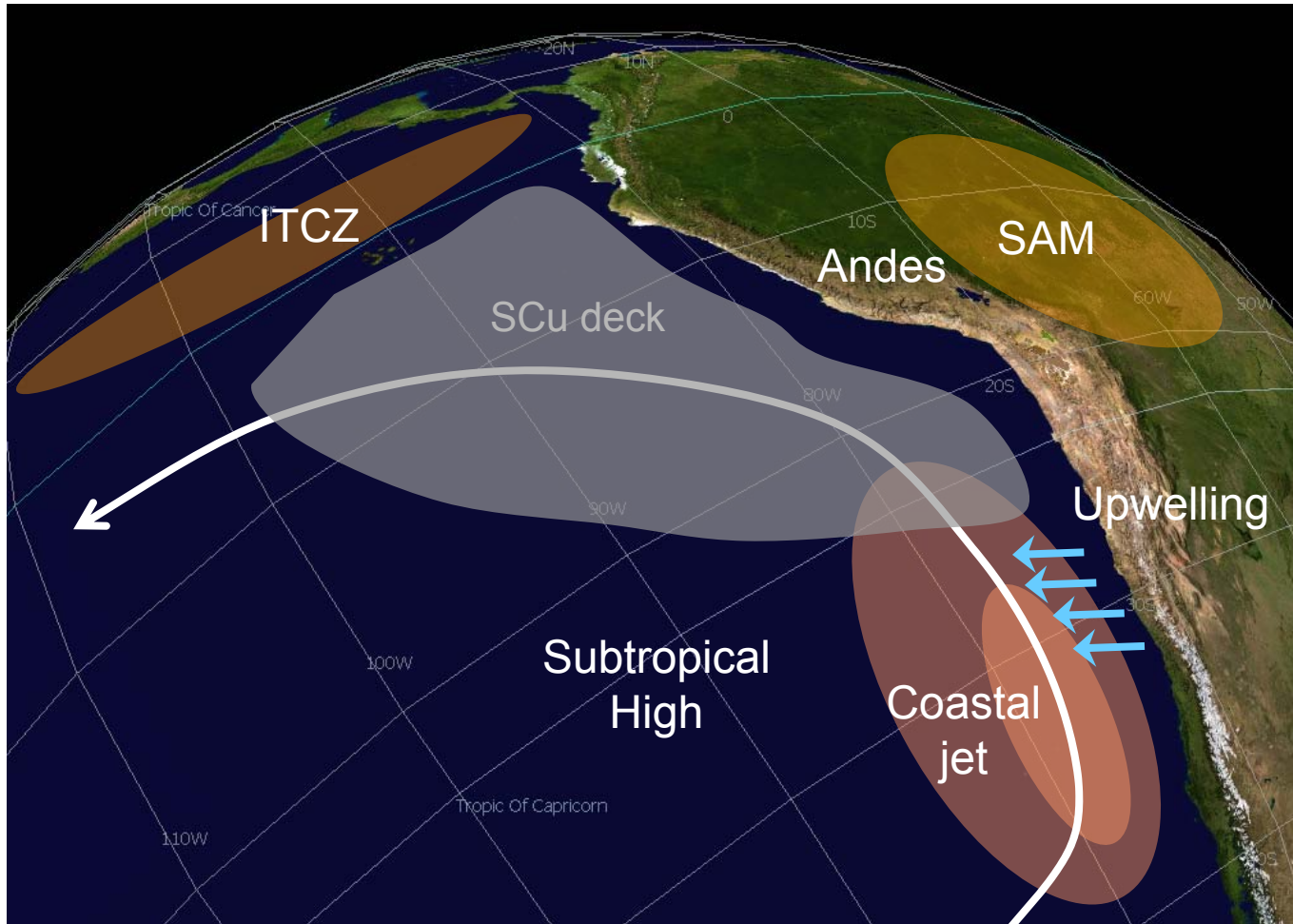
Multimodel mean Regional warming 1970-2000 (SST*). Also shown in contours SLP* trend



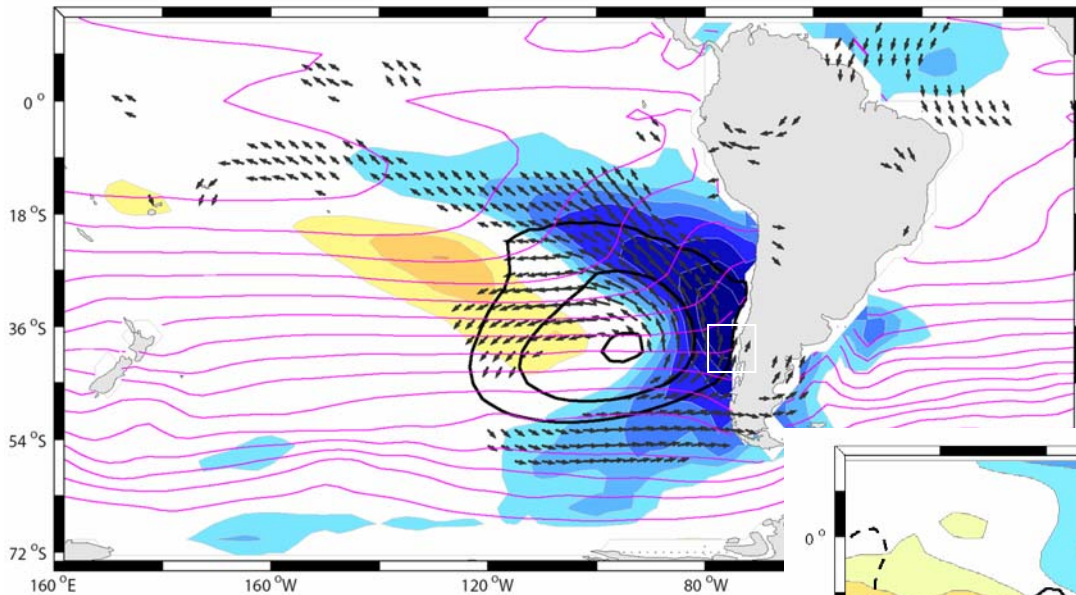
Global mean: +0.2°/dec



Ocean cooling, Possible explanations.... Key atmospheric features over the coastal SEP

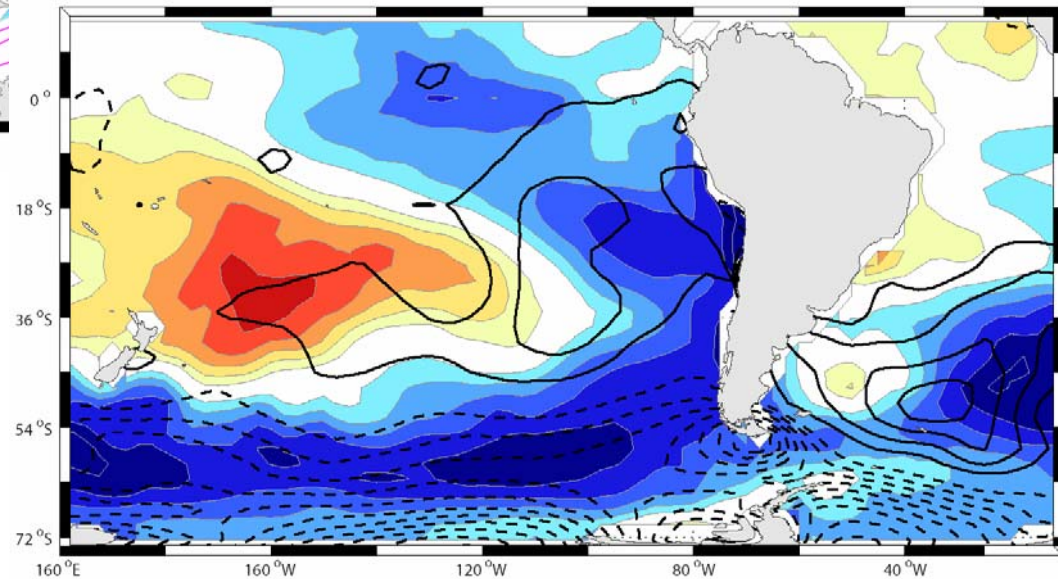


SAT, SST Cold advection

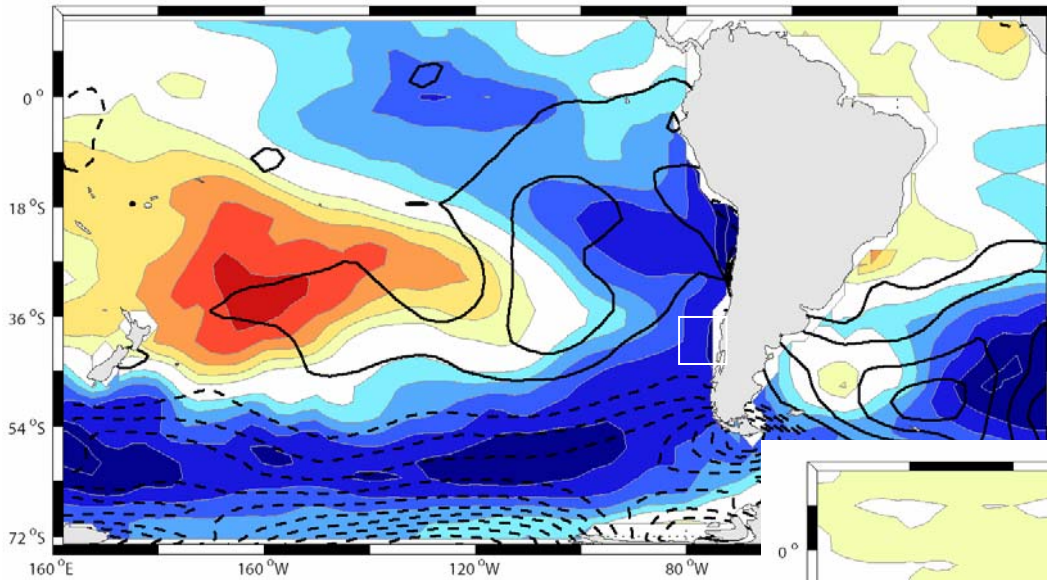


◀ 1-Point correlation map
SST off central Chile, SST,
SLP, sfc. winds. Interannual
variability only.

Observed ERSST and SLP
changes, 1979-2005. SLP
from NCEP/NCAR
reanalysis, supported by ins-
situ observations. ▶

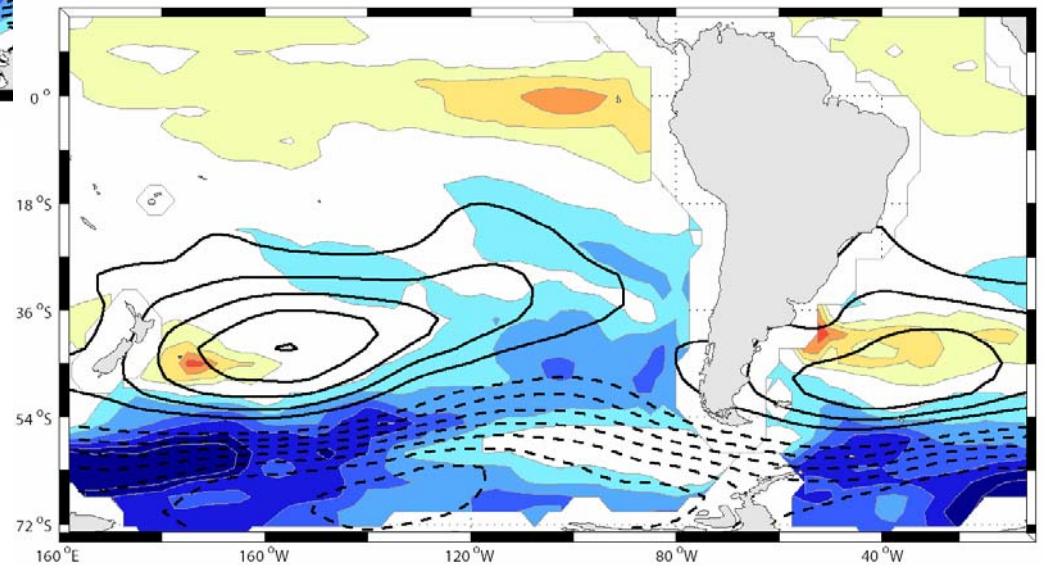


At interannual time scales, cooling off central Chile associated with spin-up of SEP anticyclone (increased cold advection, upwelling and heat fluxes). The same mechanism appears to operate in last decades to produce trends.



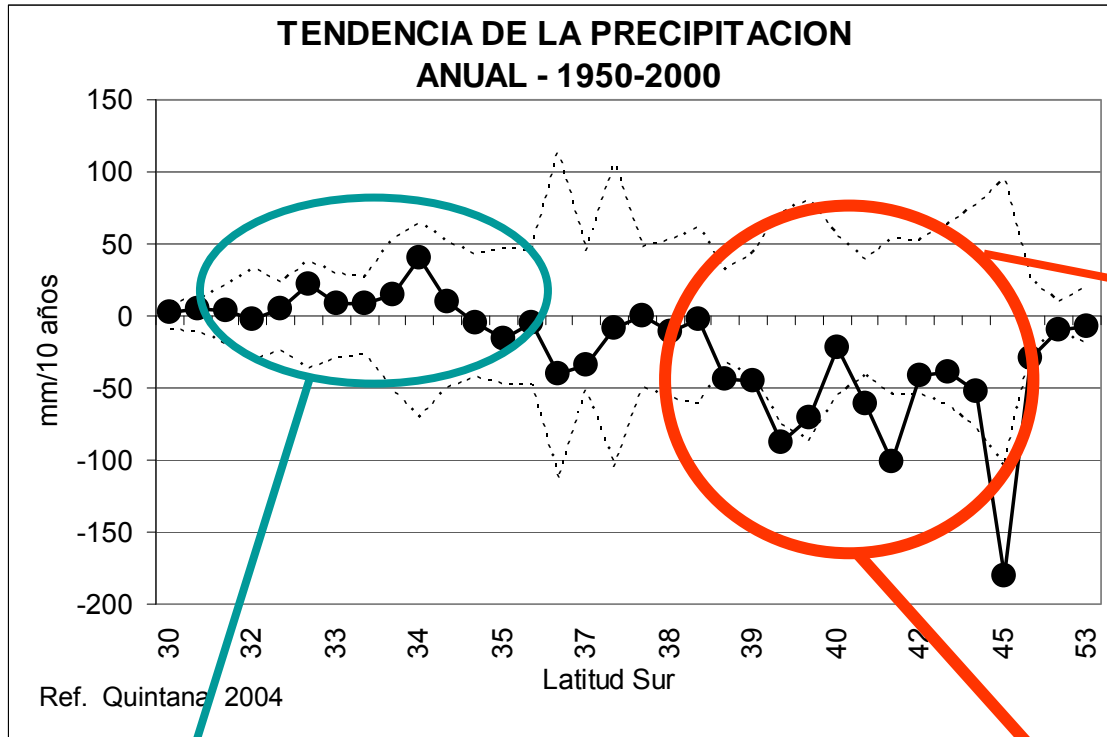
◀ Observed ERSST and SLP changes, 1979-2005. SLP from NCEP/NCAR reanalysis.

Multimodel mean SST* and SLP tendency, 1970-2000



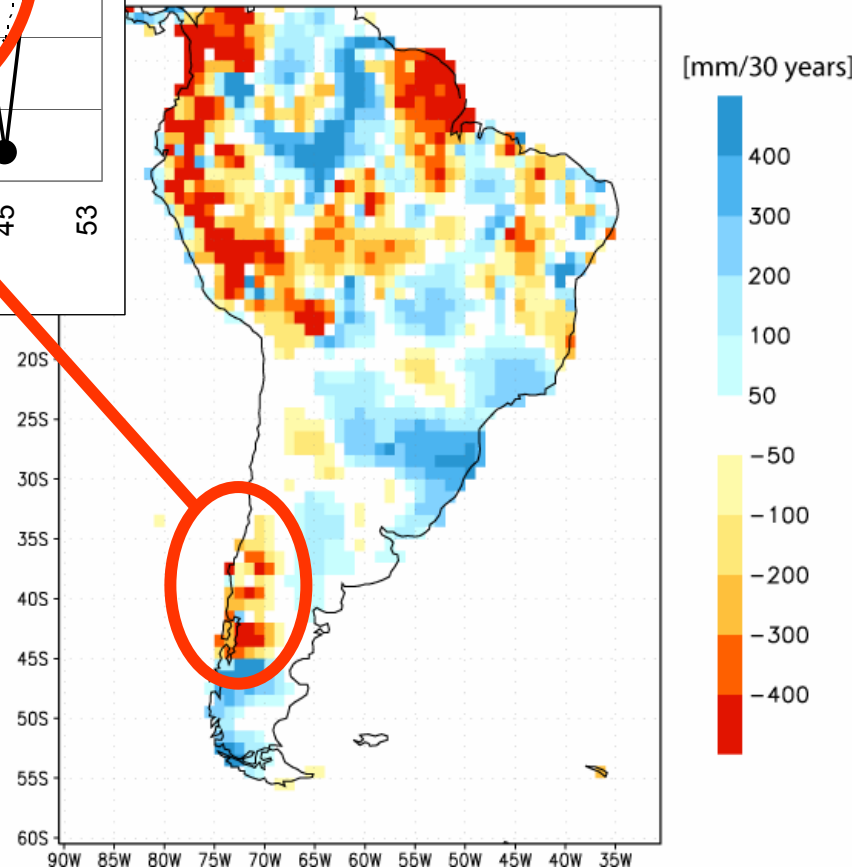
The same mechanism appears to operate in the models during the last decades to produce trends. Thus, observed change is at least partially due to increased GHG (the only common ingredient in GCMs)

Precipitation Changes...warming, drying south

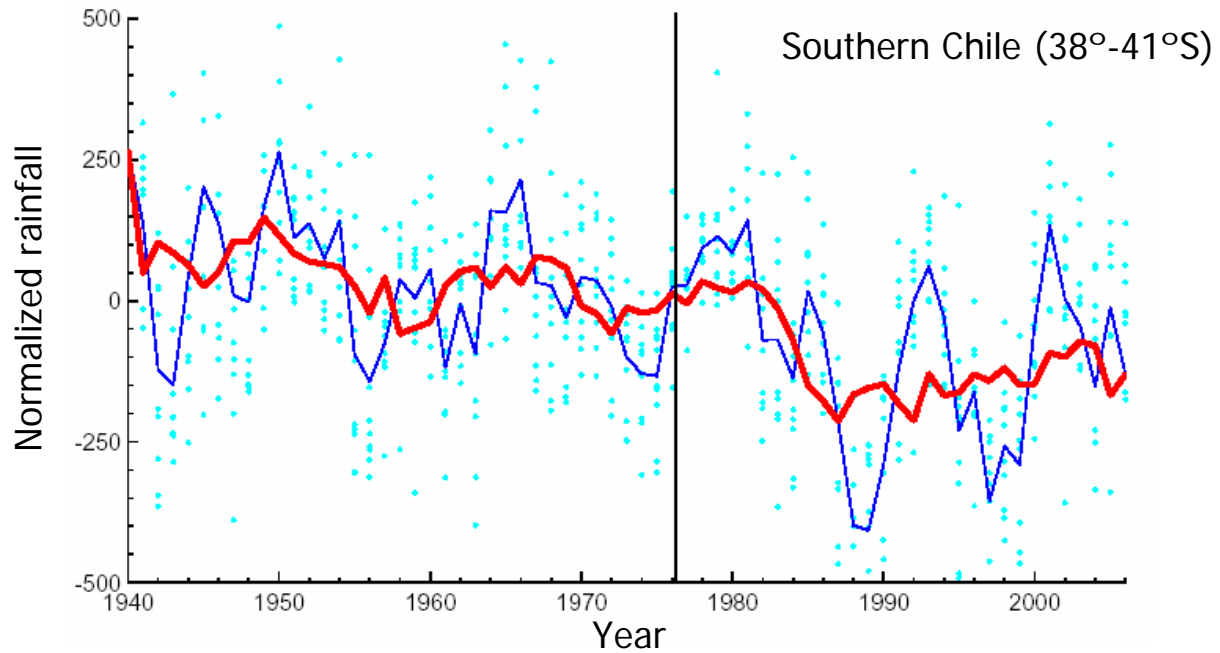
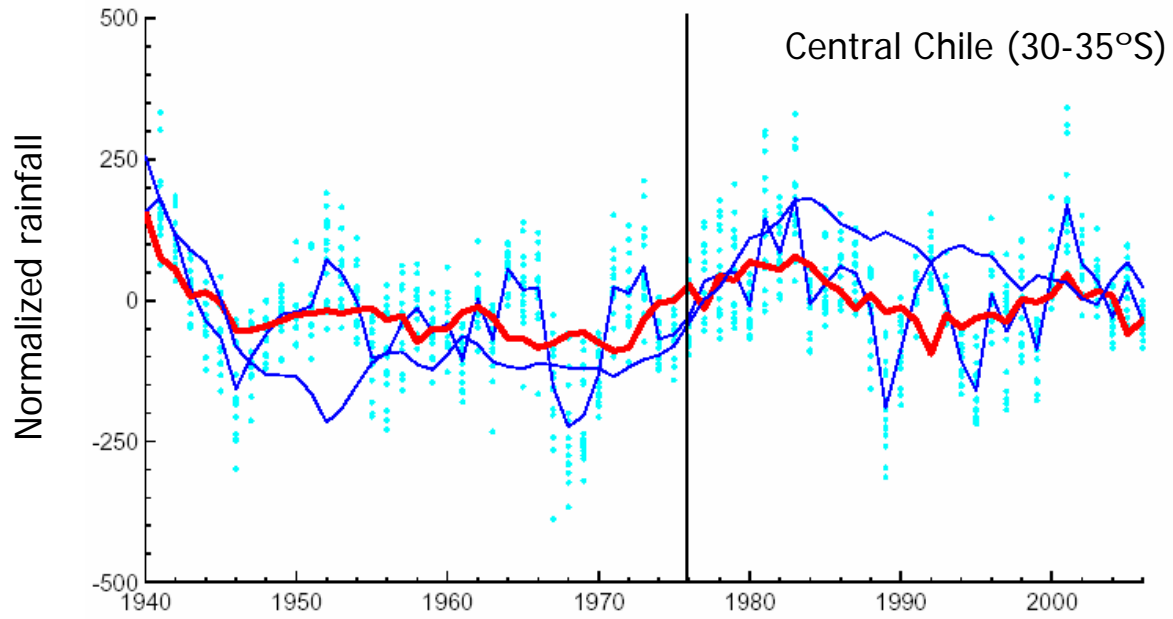


- Rainy climate
- MAP ~ 1000-3000 mm
- $\sigma(IA)/MAP \sim 0.1$
- Weak ENSO Impact
- Significant drying trend

- Semiarid climate
- MAP ~ 30-500 mm
- $\sigma(IA)/MAP \sim 0.3 - 0.5$
- Strong ENSO Impact
- No significant trend

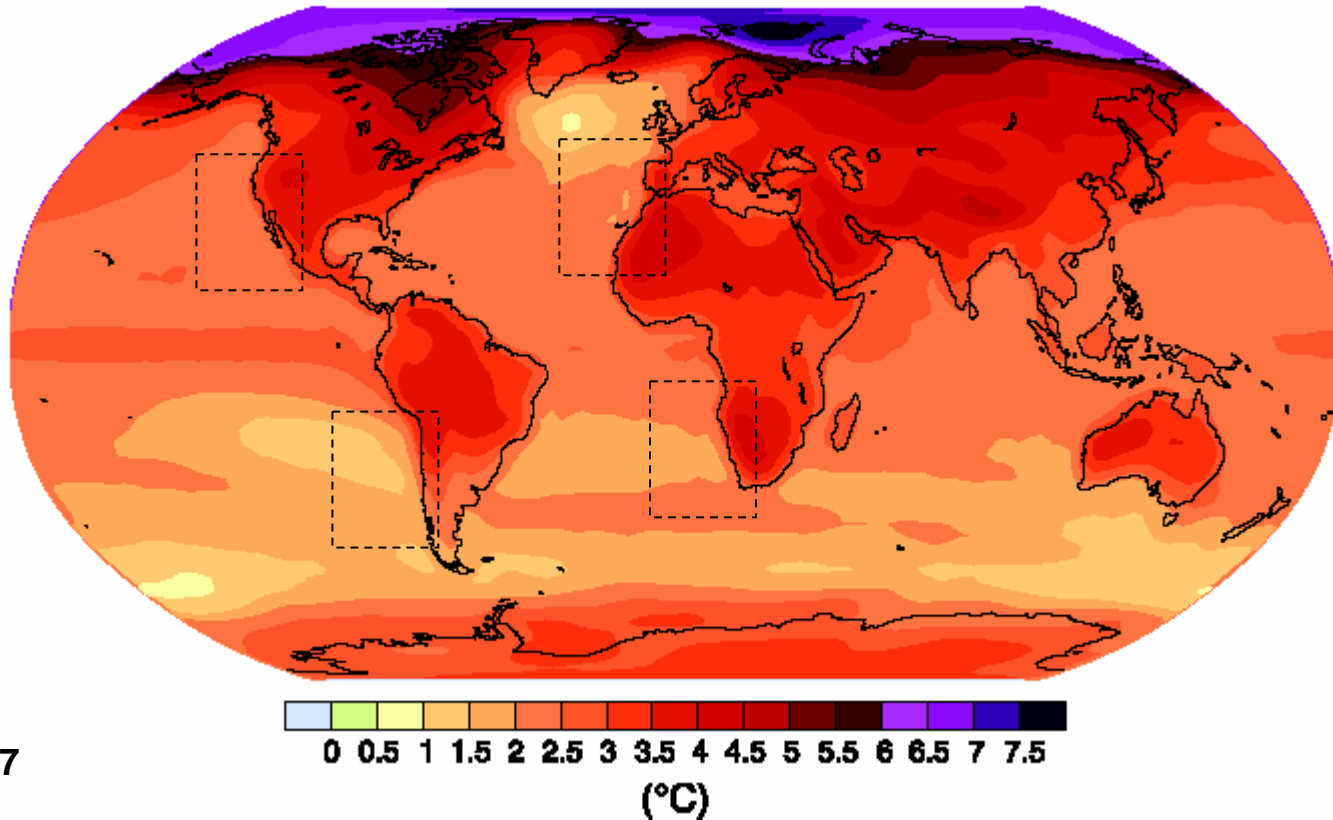


Evolución de las Precipitaciones



Multimodel average surface air warming A2-BL (future-present)

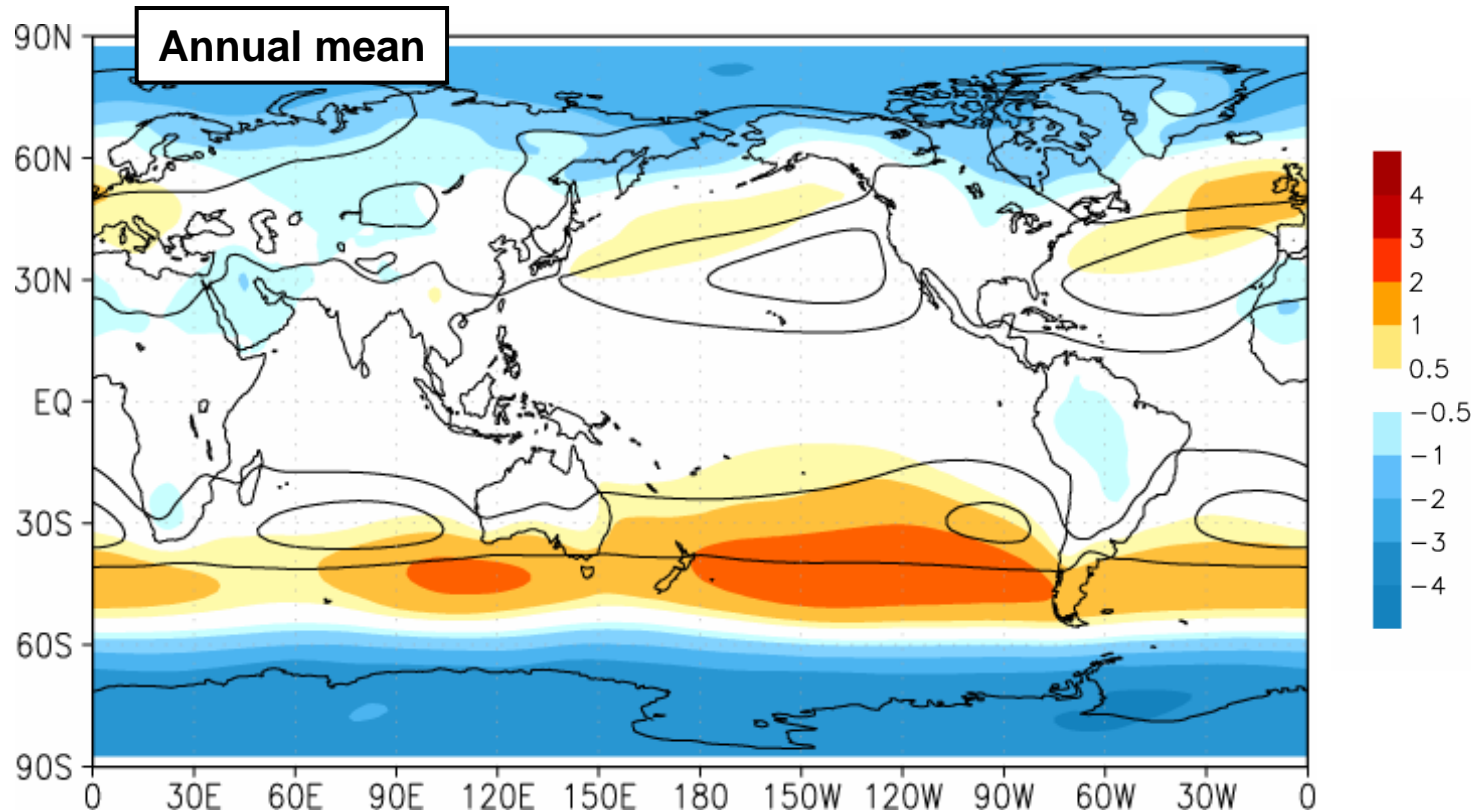
Geographical pattern of surface warming



IPCC 2007

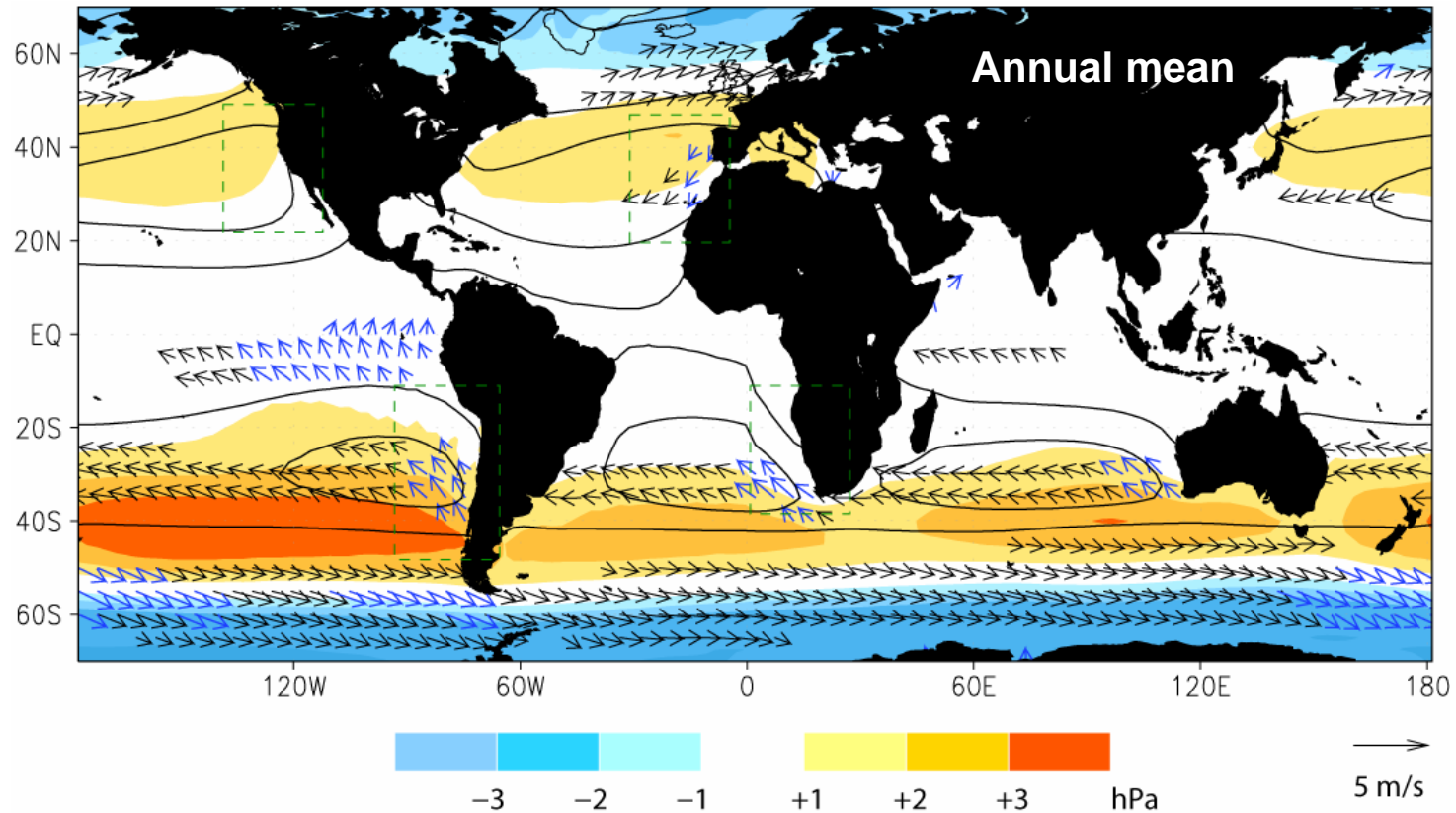
Warming everywhere but with different magnitude
Ocean warming less than land warming, especially on EBUS!

Multimodel average SLP difference between A2 (2070-2100) and BL (1970-2000)



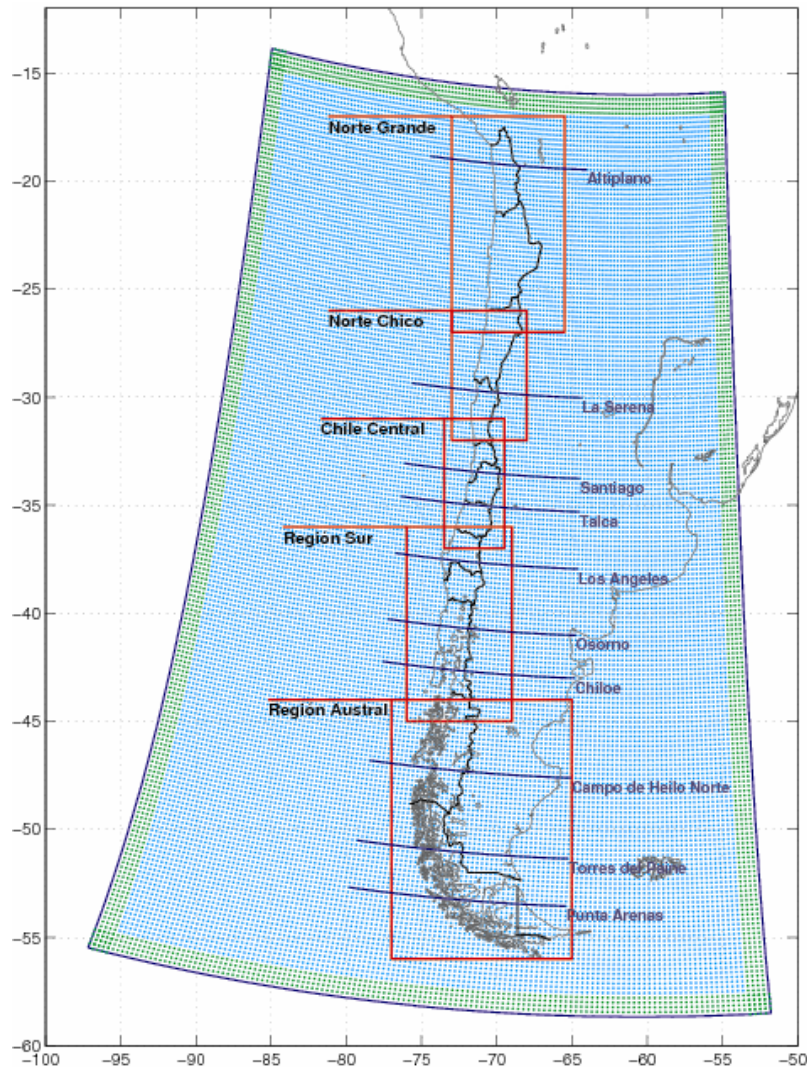
Strengthening of the poleward flank of subtropical anticyclones and poleward shift of the midlatitude storm track is very consistent among GCMs

Multimodel average SLP and sfc wind difference between A2 (2070-2100) and BL (1970-2000)



Over open ocean Δv in geostrophic balance with ΔSLP .
Near the coast Δv more controlled by along-coast ΔSLP

Regional Simulations of the Future



Model:

- PRECIS – UK

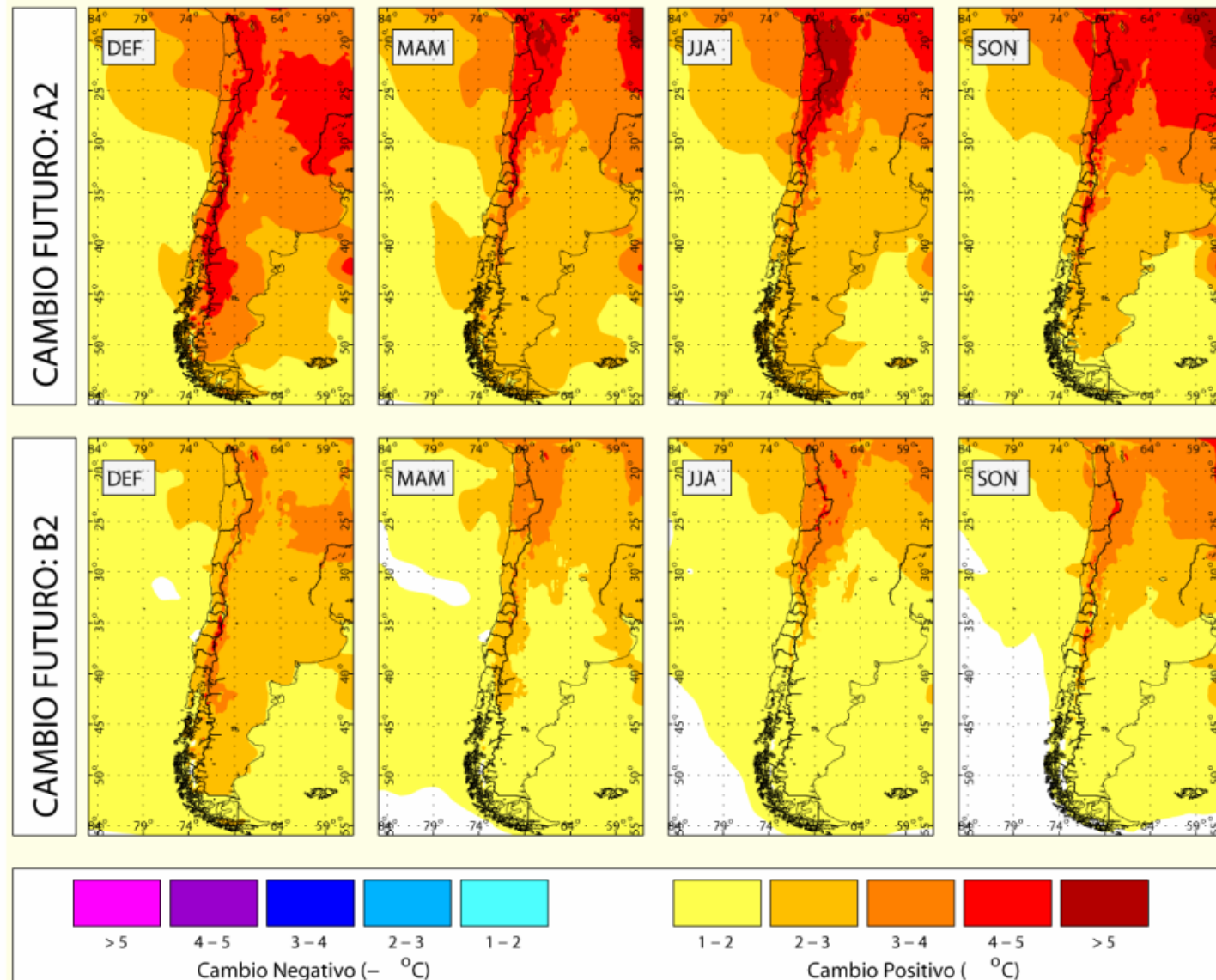
Single domain

- Horiz. grid spacing. 25 km
- 19 vertical levels
- Lateral BC: HadAM every 6h
- Sfc. BC: HadISST1 + Linear trend

Simulations

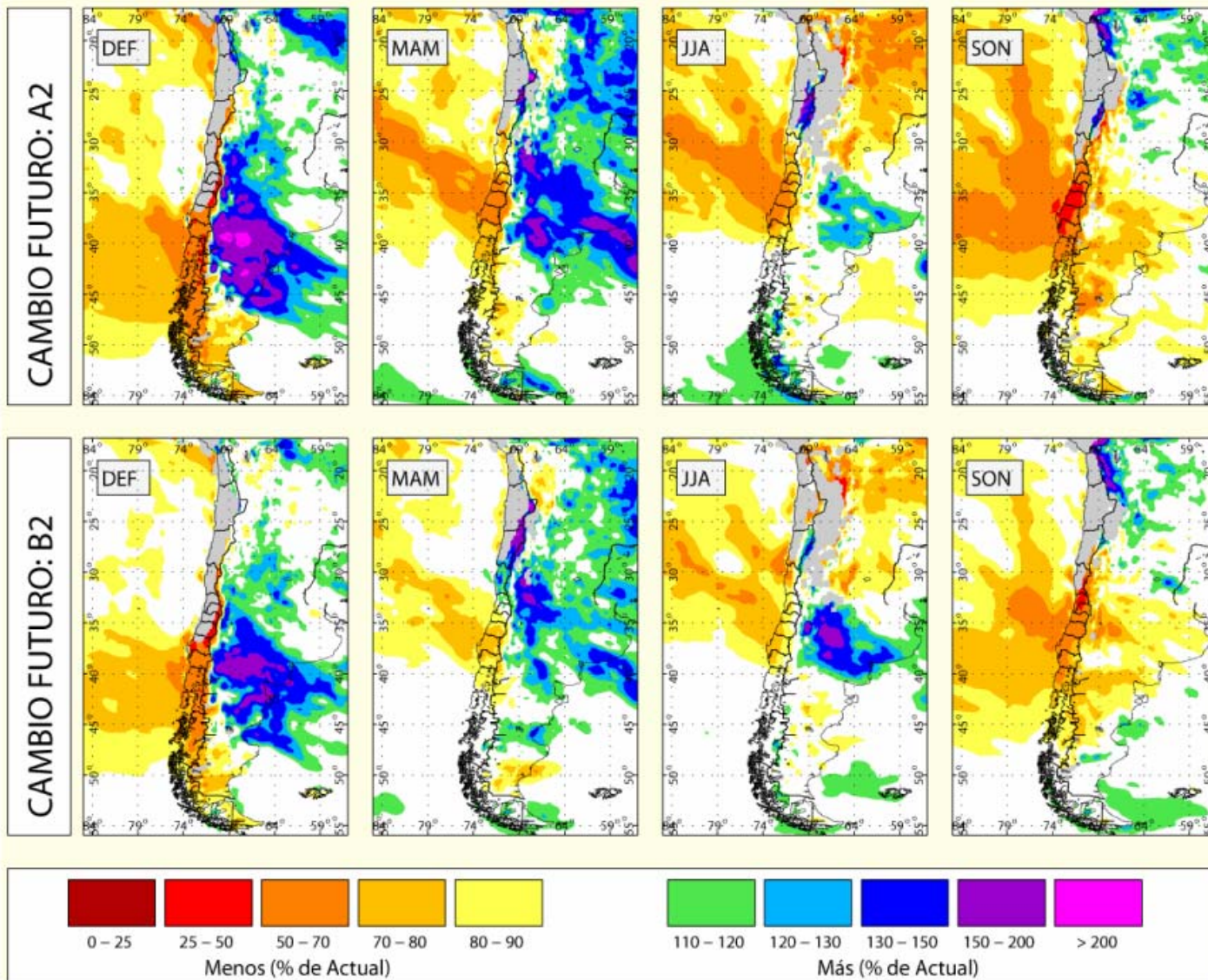
- **1961-1990 Baseline**
- **2071-2100 SRES A2 y B2**
- 30 years @ 3 min → 4 months per simulation in fast PC

PRECIS-DGF $T_{\text{futuro}} - T_{\text{presente}}$



Futuro: 2071-2100 / Presente: 1960-1990

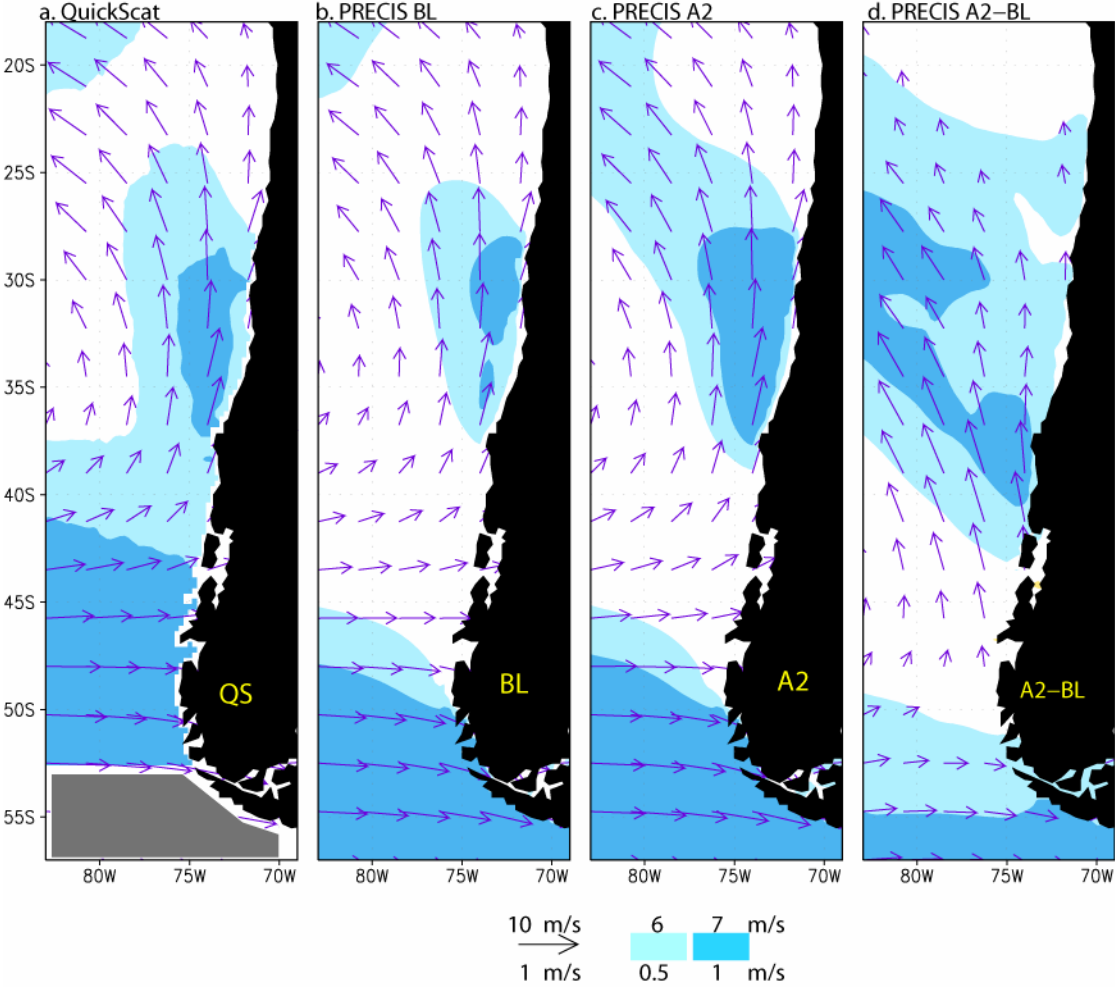
PRECIS-DGF $R_{\text{futuro}} / R_{\text{presente}}$



Futuro: 2071-2100 / Presente: 2071-2100

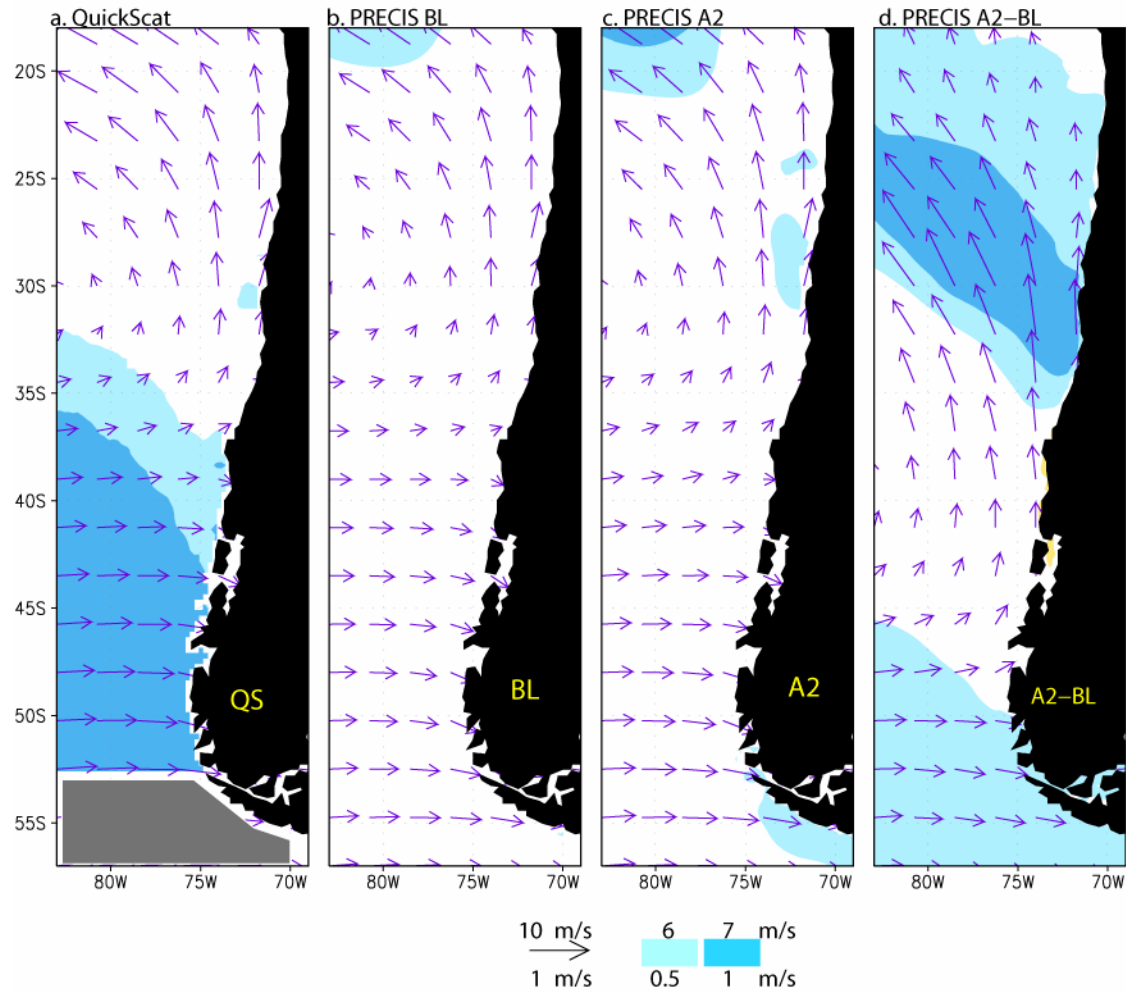
PRECIS Results

Surface Wind – SONDJ



PRECIS Results

Surface Wind – AMJJJ



Conclusions

- Last 30 years in Chile characterized by continental warming and surface ocean cooling ($\pm 0.3^\circ$ /decade). Natural (IPV) or anthropogenic?
- Such pattern is partially detected by CMIP3 IPCC4 global simulations of the 20th century...suggesting an anthropogenic forcing
- Future trends quite similar to the observed in the last 30 years: intensification and poleward extent of the SEP subtropical anticyclone, enhanced southerly winds, ocean cooling.
- It is time now to move into environmental prediction!