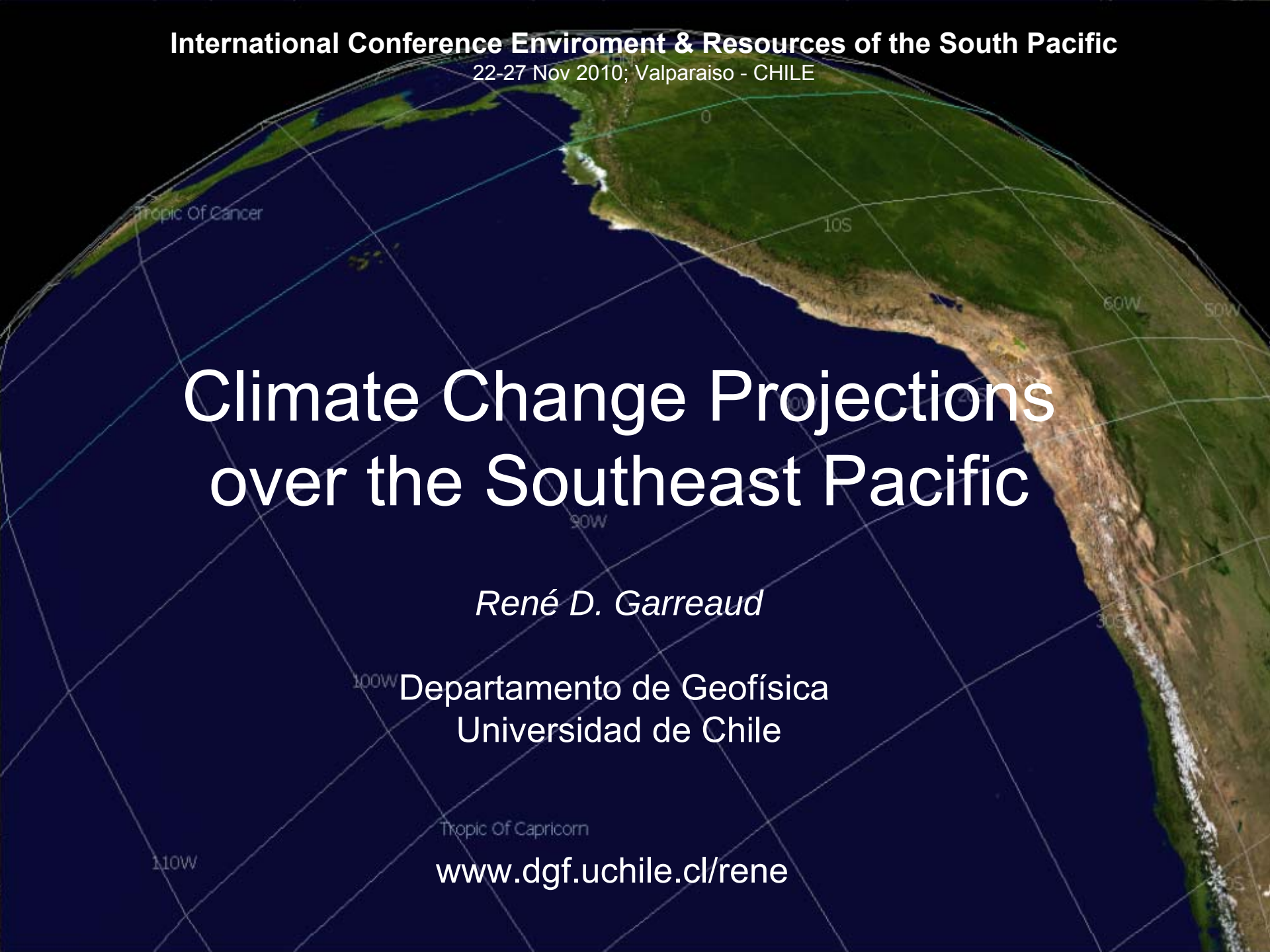
International Conference Enviroment & Resources of the South Pacific
22-27 Nov 2010; Valparaiso - CHILE



Climate Change Projections over the Southeast Pacific

René D. Garreaud

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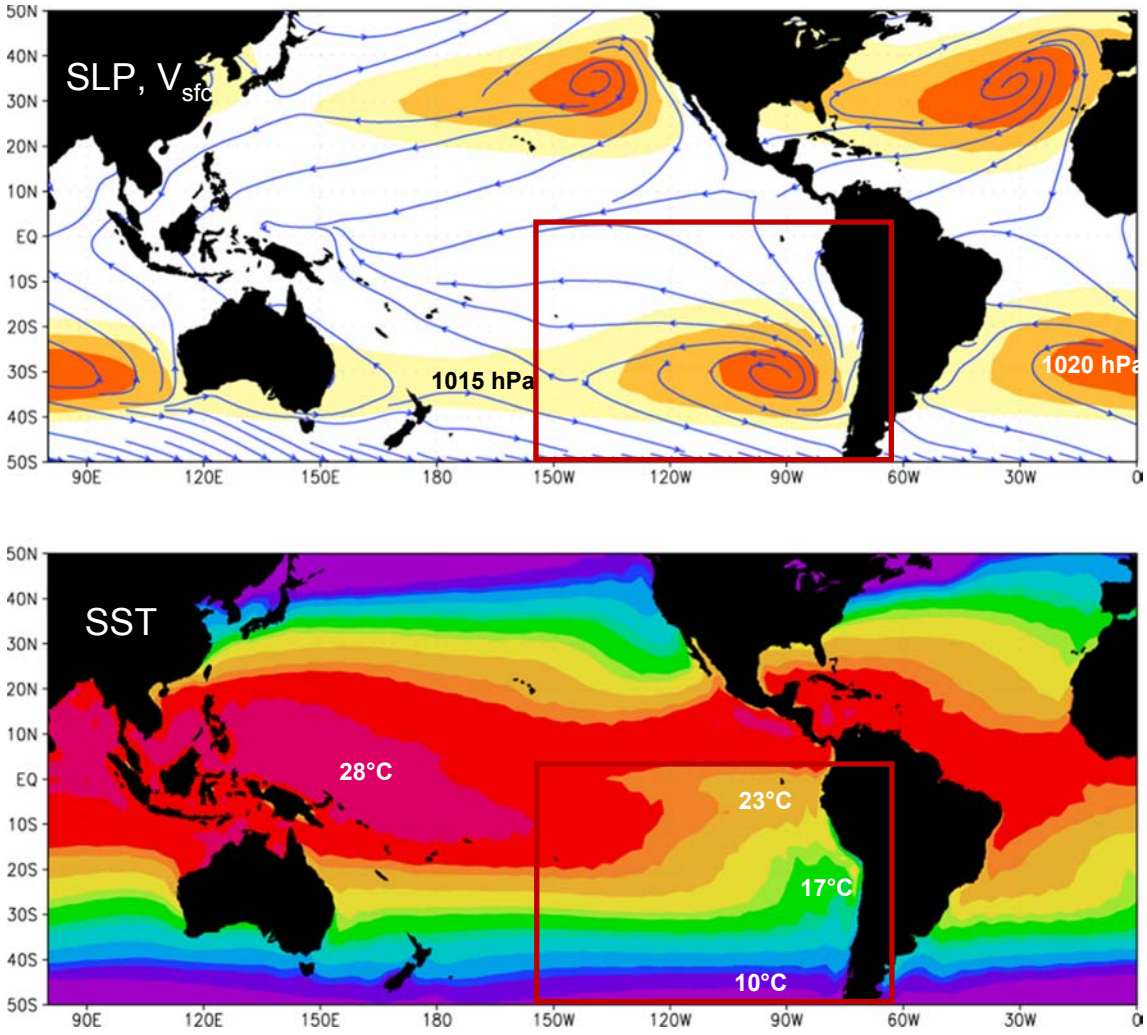
www.dgf.uchile.cl/rene

Outline

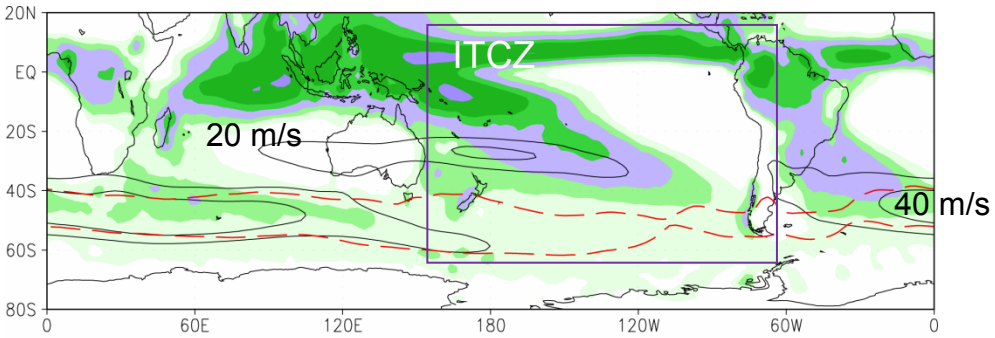
- EBUS Climate background
- Future (end of 21st century) climate from AOGCMs
- Regional details from a Regional Climate Model
- Is the coastal cooling already occurring?

EBUS: Subtropical anticyclones, equatorward flow and cold SST

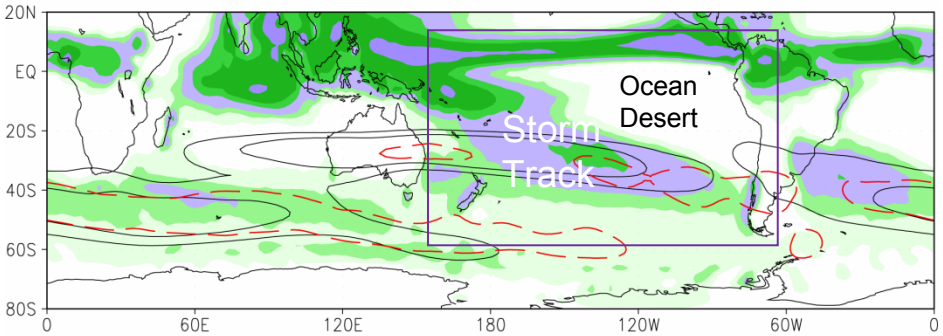


Precipitation and upper level winds

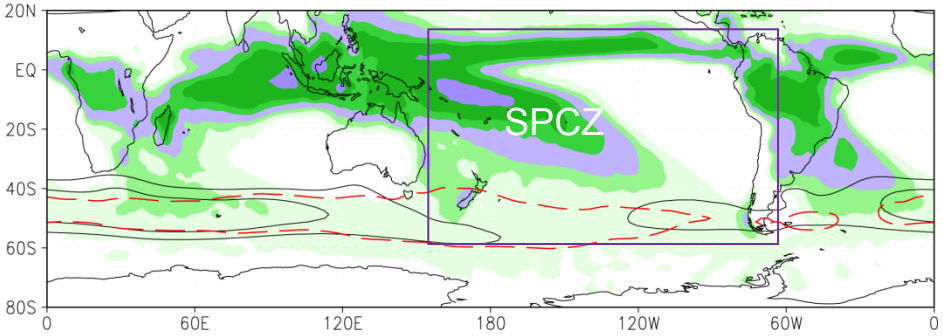
Anual

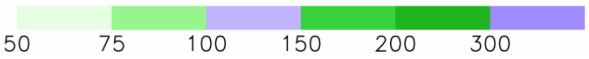


Junio



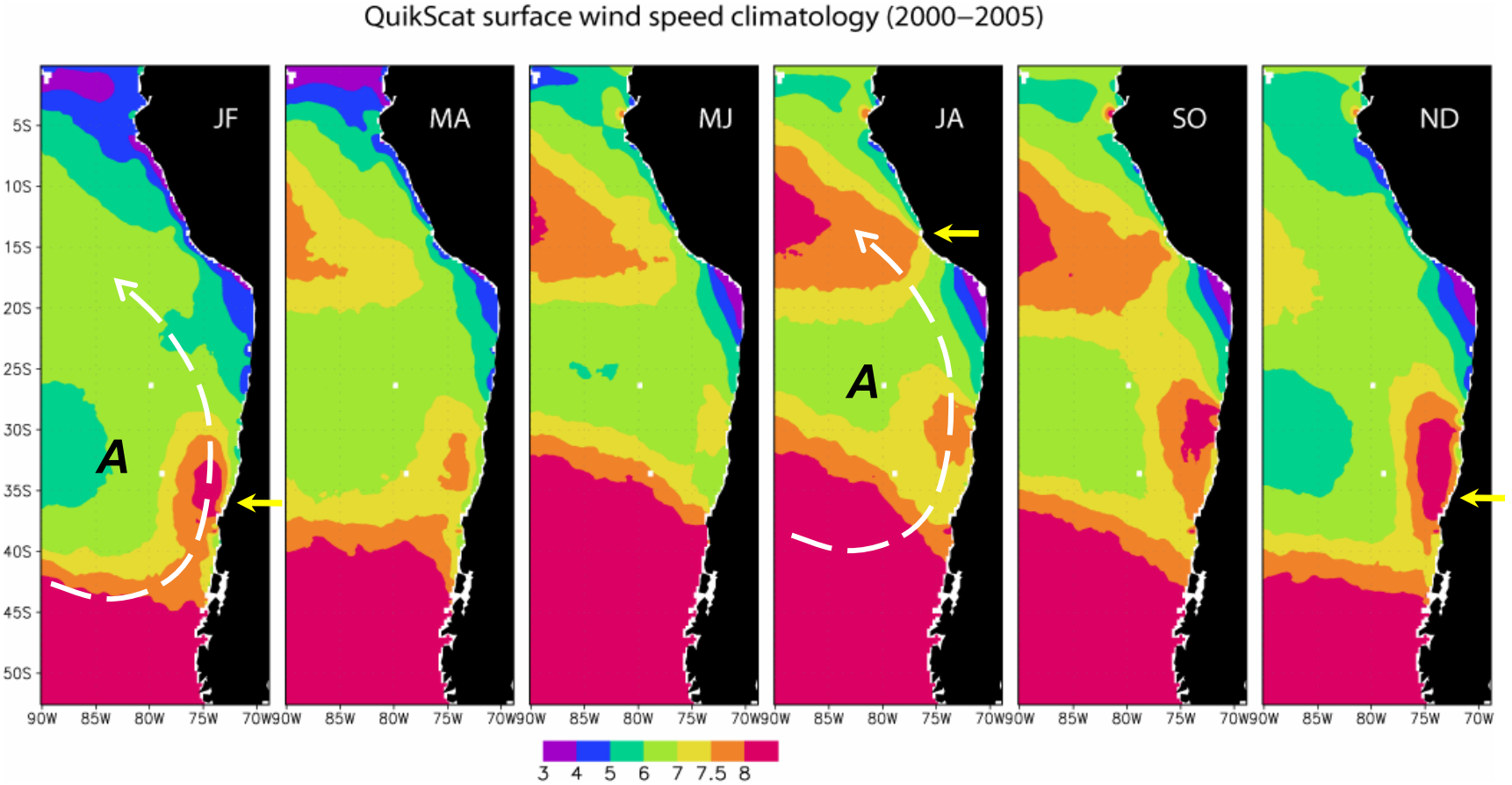
Enero



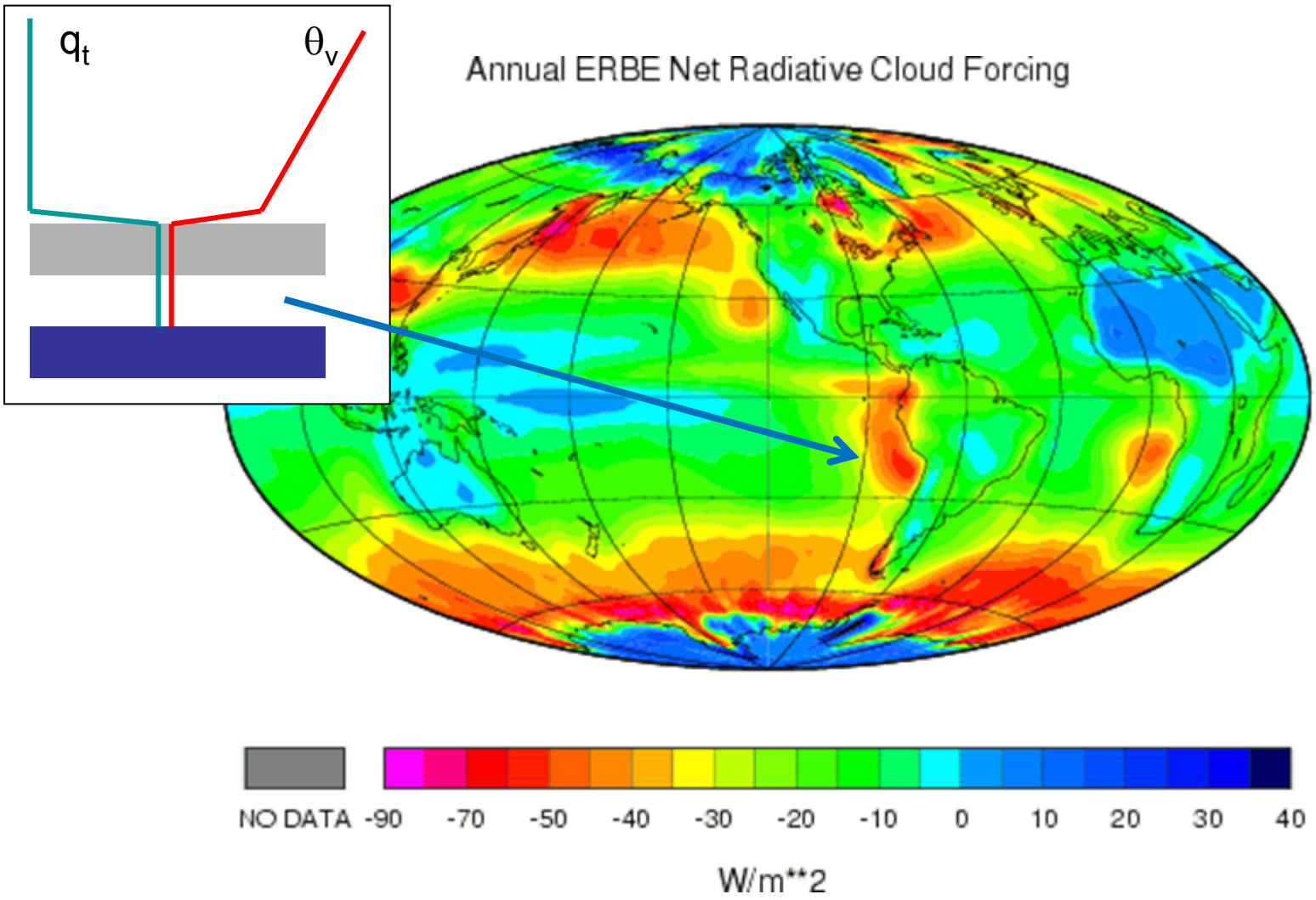


Surface wind speed & coastal jets

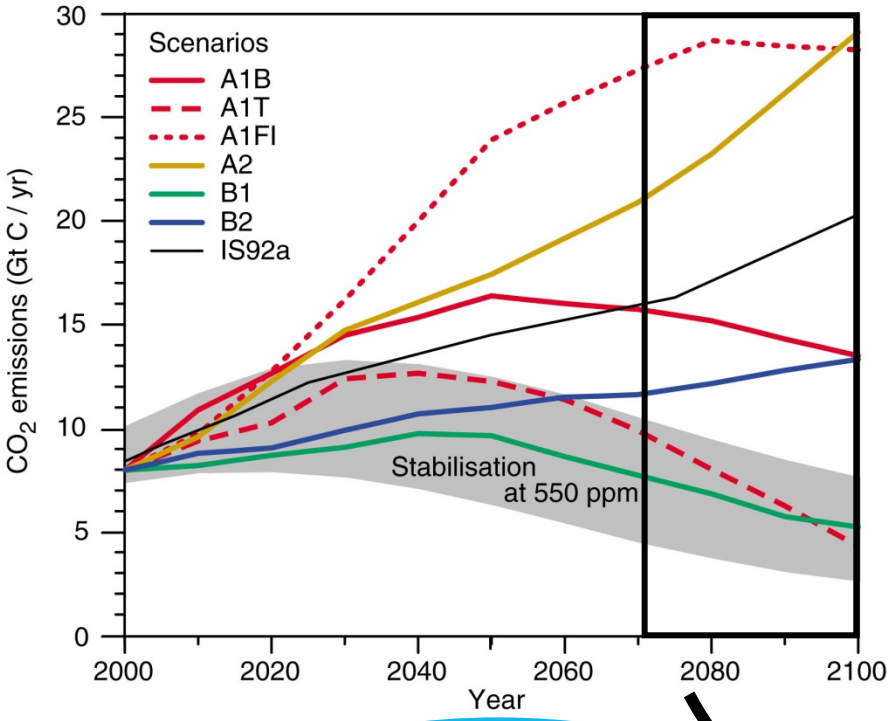
Jet costero (máxima magnitud) a lo largo de la costa
Variabilidad sinóptica y estacional dictada por ∂(SLP) / ∂y



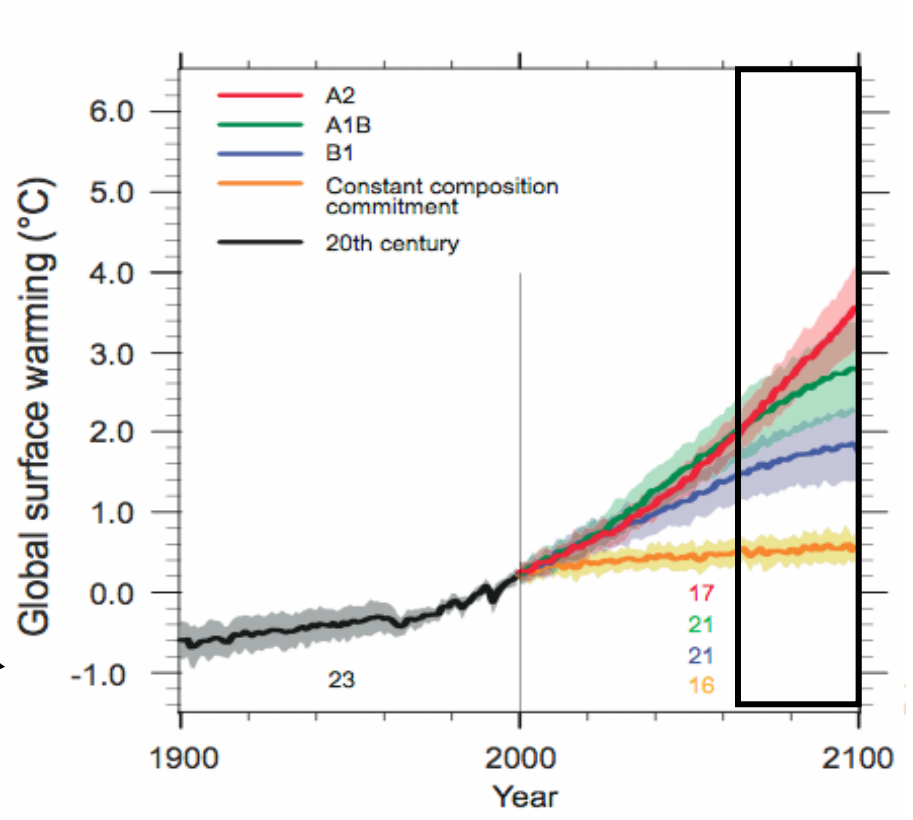
Cloud cover: Persistent cloud deck



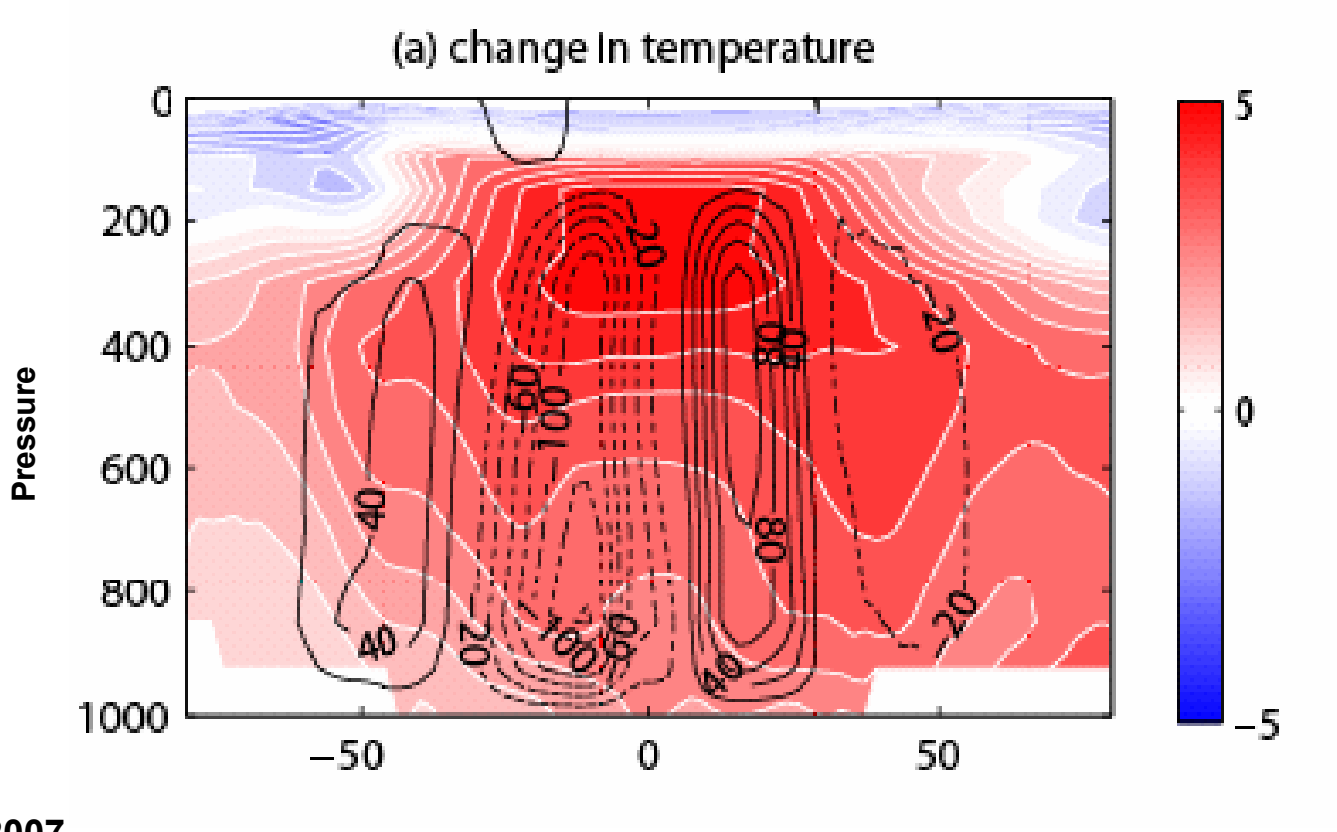
Future Climate Scenarios
GHG (CO2,…) emissions projections + GCMs



20+ GCMs
CMIP3/IPCC AR4



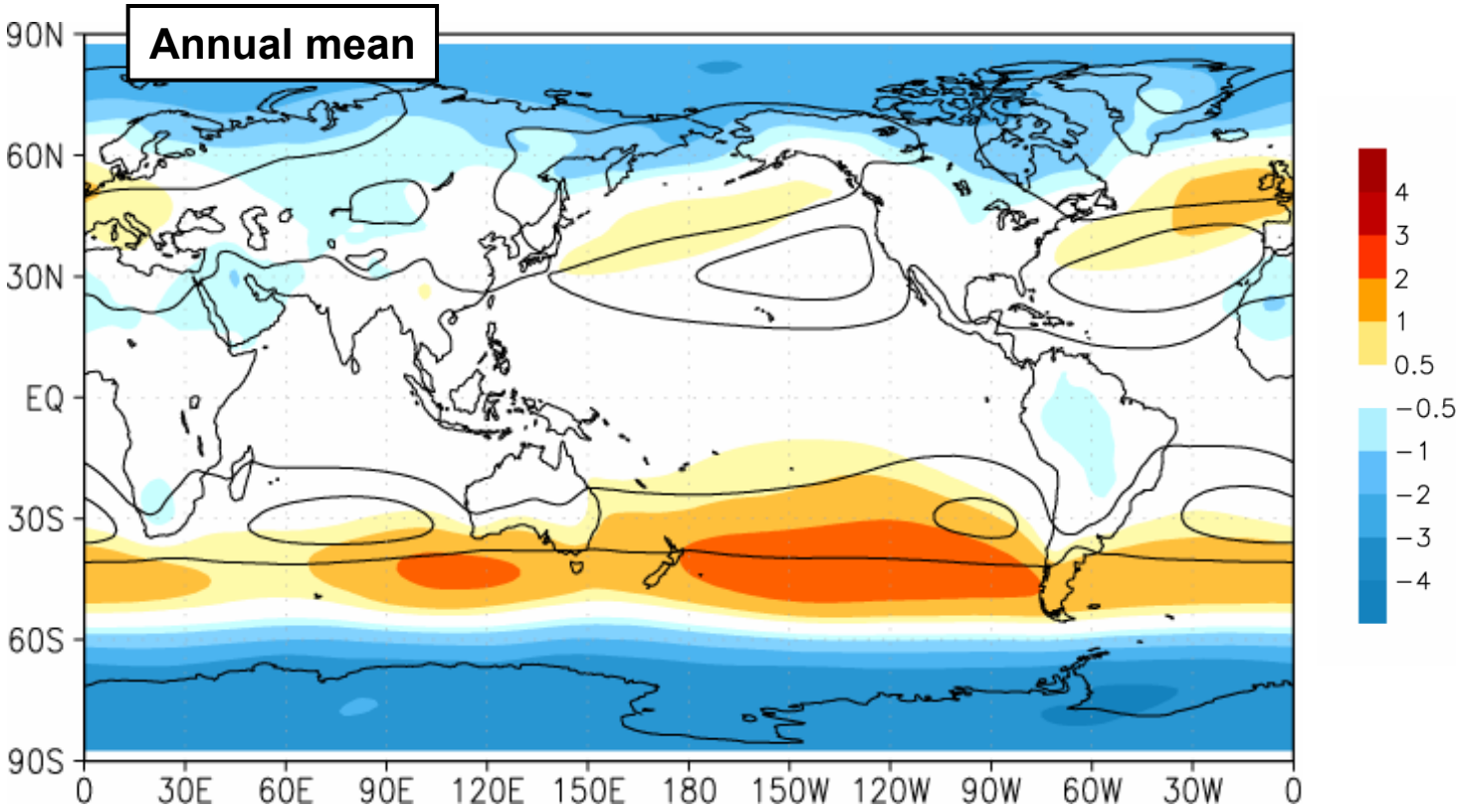
Multimodel average of difference in zonal mean air temperature between A2 and BL



Lu et al. 2007

Warming of the tropical upper troposphere ►Increased static stability at subtropics and midlatitudes ► polerward expansion of the Hadley cell

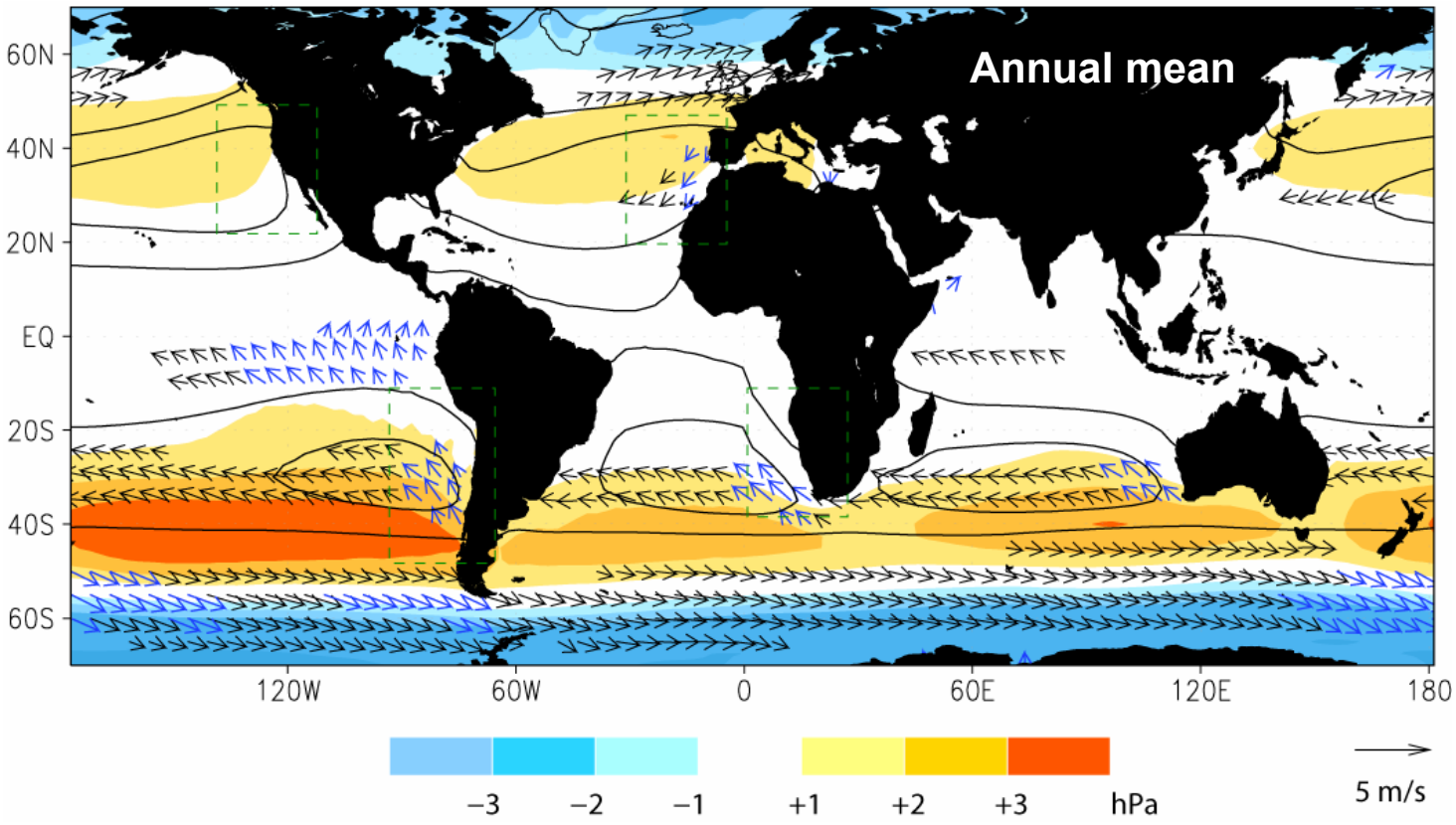
Multimodel average SLP difference between A2 (2070-2100) and BL (1970-2000)



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

Garreaud & Falvey 2007

Multimodel average SLP and sfc wind difference betweenA2 (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

Garreaud & Falvey 2007

Precipitation and surface temperature Changes

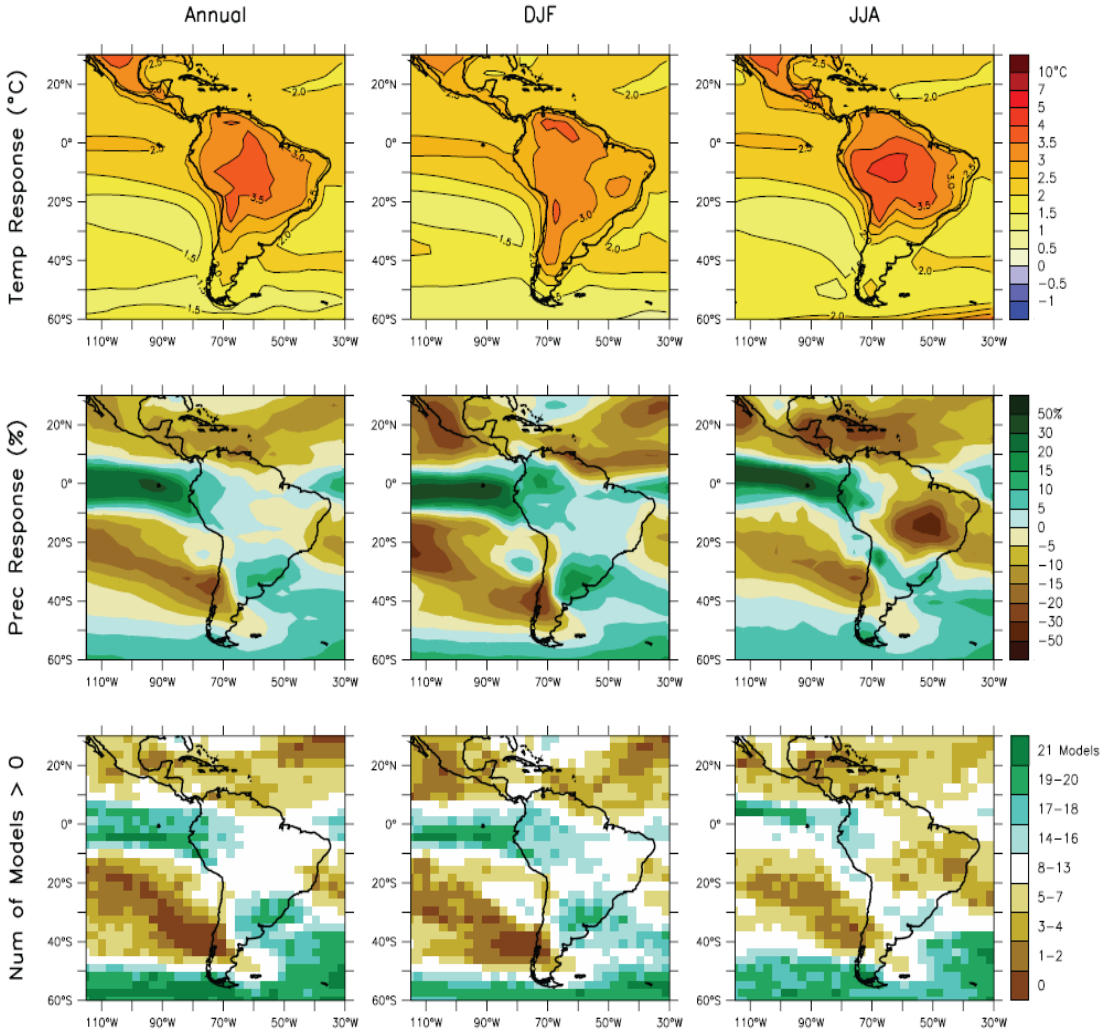
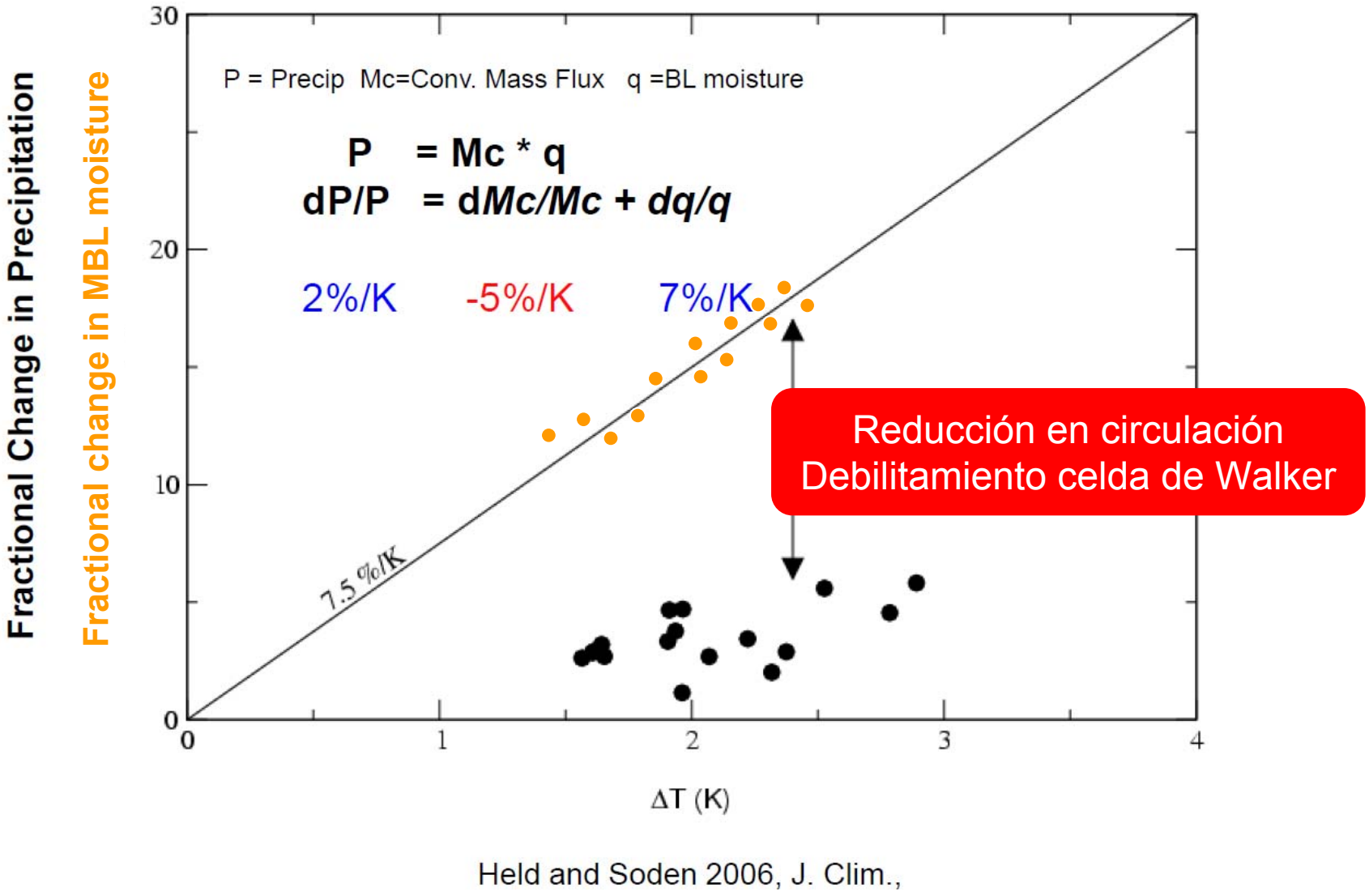


Figure 11.15. *Temperature and precipitation changes over Central and South America from the MMD-A1B simulations. Top row: Annual mean, DJF and JJA temperature change between 1980 to 1999 and 2080 to 2099, averaged over 21 models. Middle row: same as top, but for fractional change in precipitation. Bottom row: number of models out of 21 that project increases in precipitation.*

:C 2007: WG1-AR4 (2007)

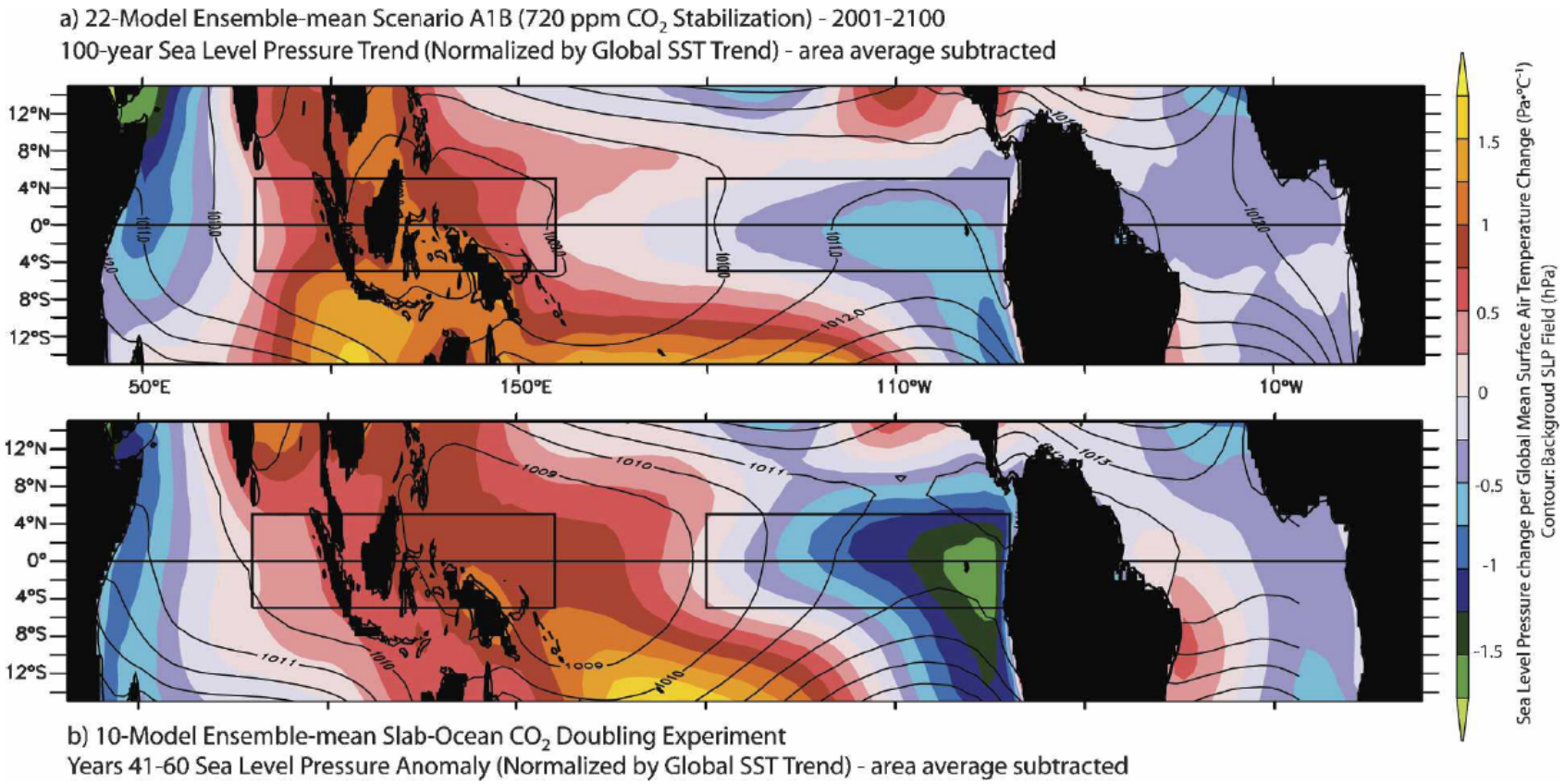
Change in Global Precipitation at 2100

Low latitudes (10°S-10°N)



Held and Soden 2006, J. Clim.,

Multimodel average SLP trend 2000 - 2100 (A1B)



Cambio tipo El Niño en latitudes bajas, pero sin teleconecciones en lat. medias

Vecchi and Sodden 2006

Multimodel average thermocline trend 2000 - 2100 (A1B)

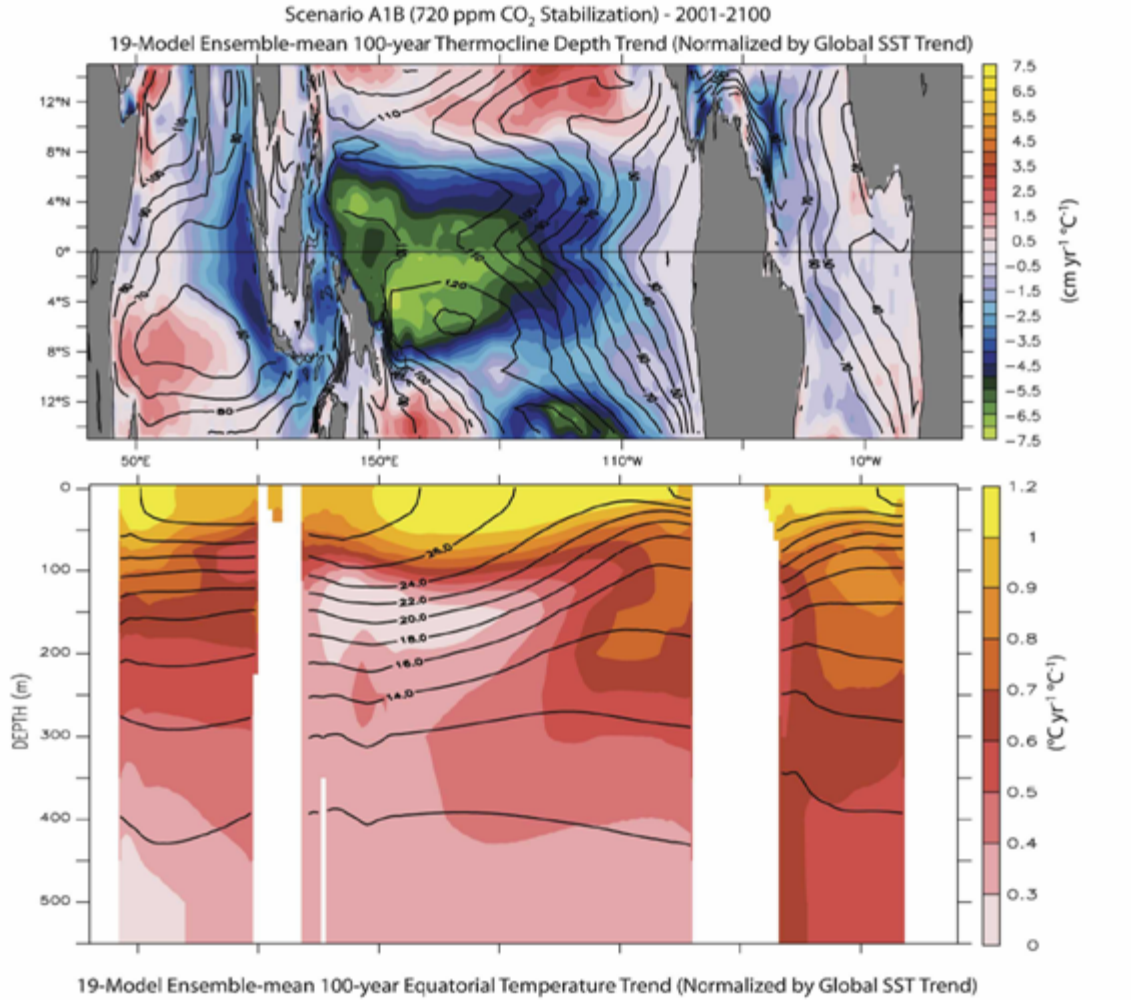
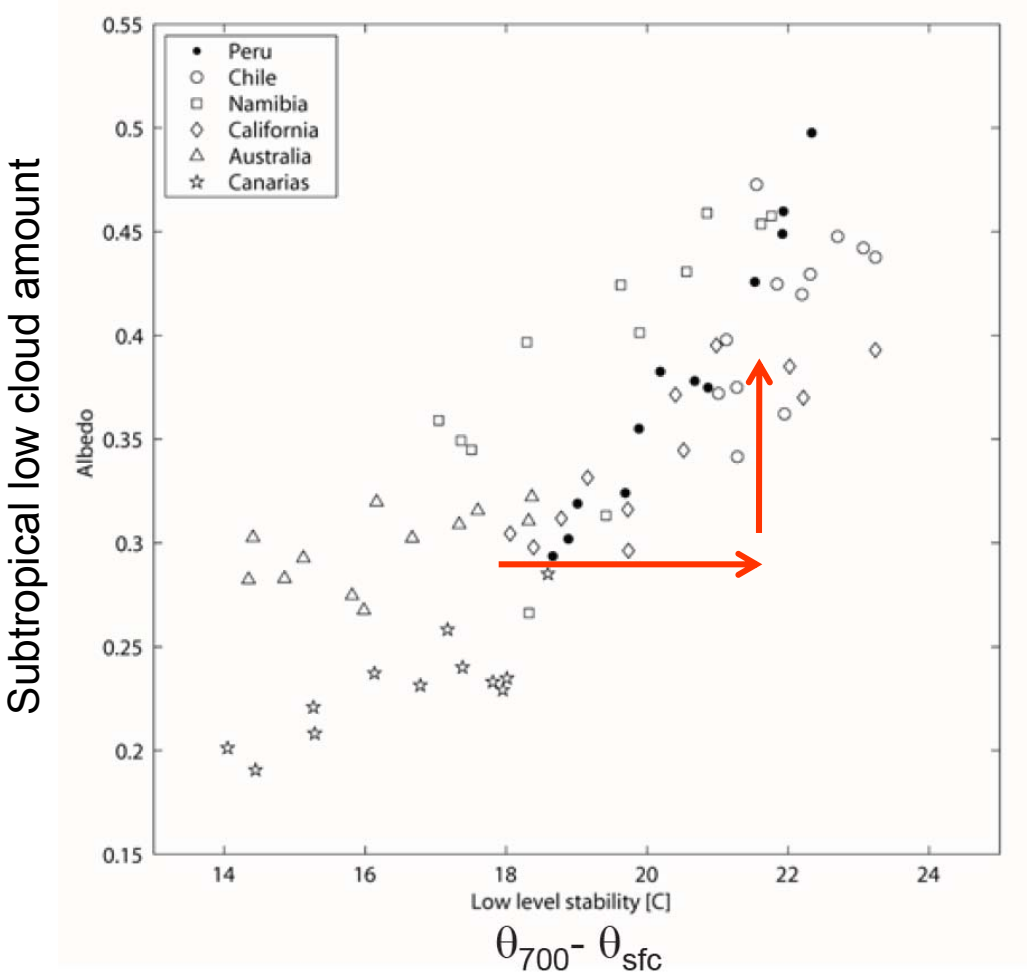


FIG. 12. Multimodel ensemble-mean tropical ocean thermal structure trends forced by increased CO_2 (shading) and reference (contours). (top) The thermocline depth changes. (bottom) The 2°S–2°N averaged temperature changes over the upper 500 m. Trends are the 19-model average of the linear least squares trend of each quantity over 2001–2100 of scenario A1B (see Table 1), with each model normalized by the global-mean surface temperature trend over the same period. The reference is the 2001–20 average of thermocline depth (top, m) and 2°S–2°N temperature (bottom, °C).

Vecchi and Sodden 2006

Changes in subtropical low level cloudiness…most difficult to project

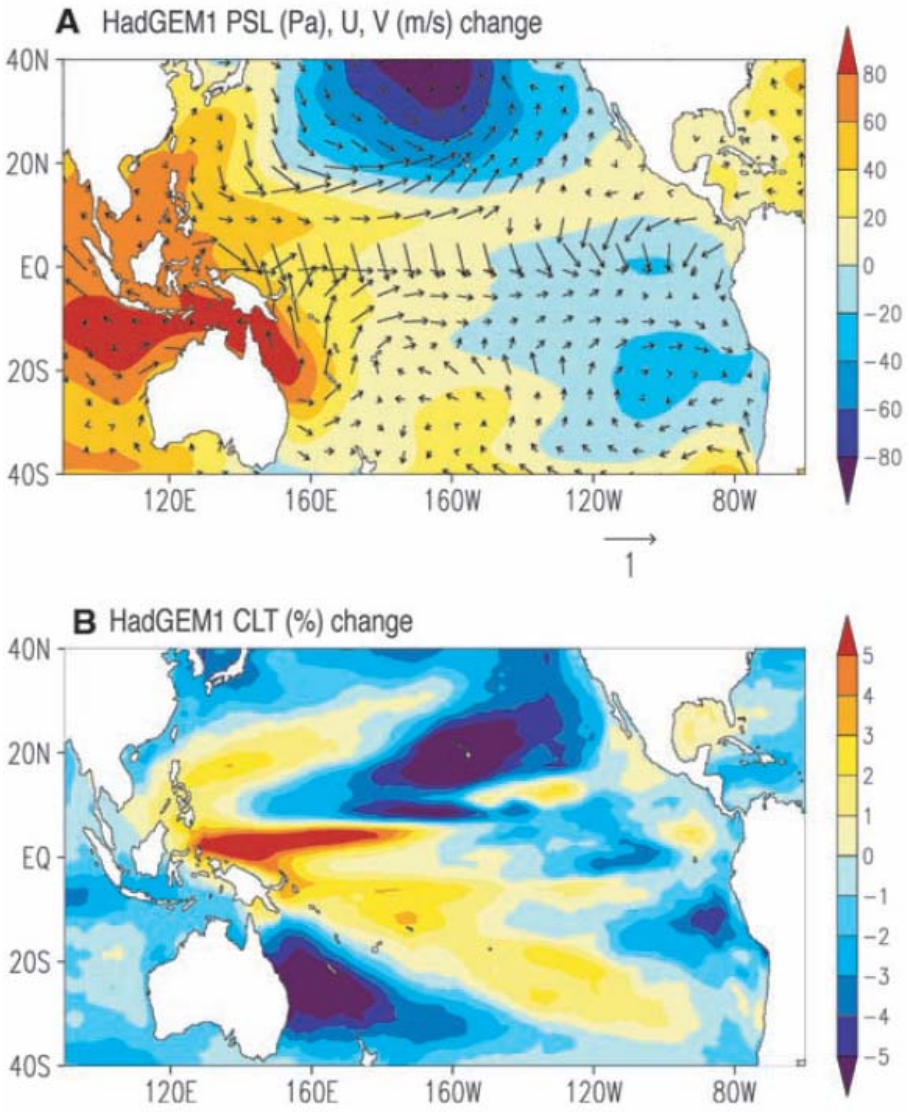
1



Warmer climate…more stable troposphere….more clouds

Changes in subtropical low level cloudiness…most difficult to project

2

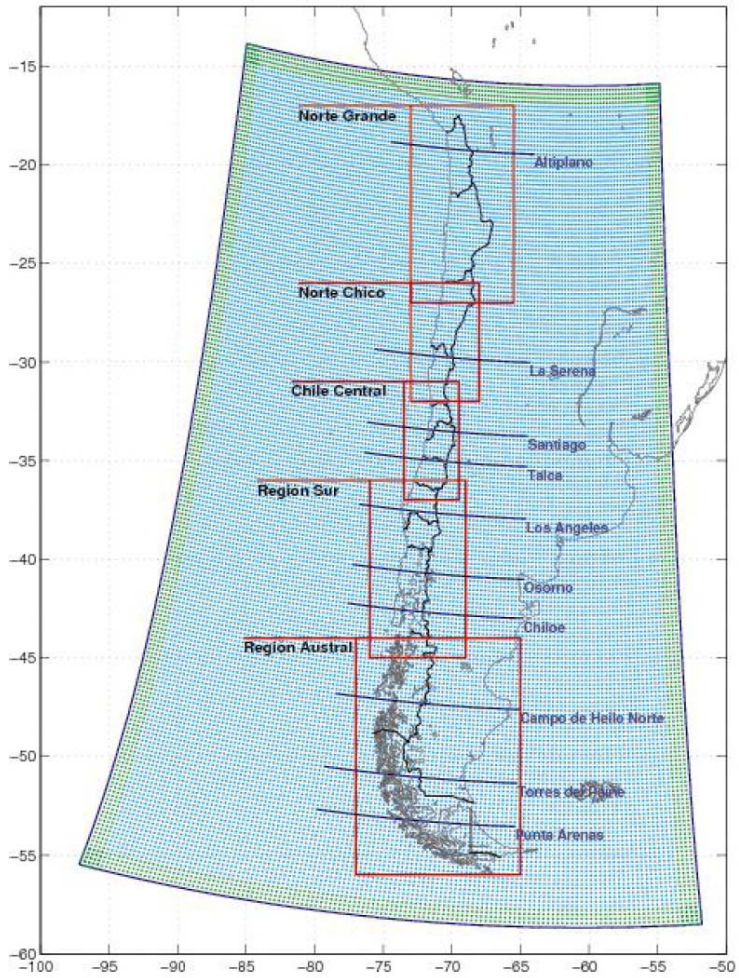


Warmer climate…
less clouds

Clements, Norris and Dovary 2007

PRECIS Results

PRECIS (**P**roviding **RE**gional **C**limates for **I**mpact **S**tudies)
(Hadley Centre UK MetOffice RCM)



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

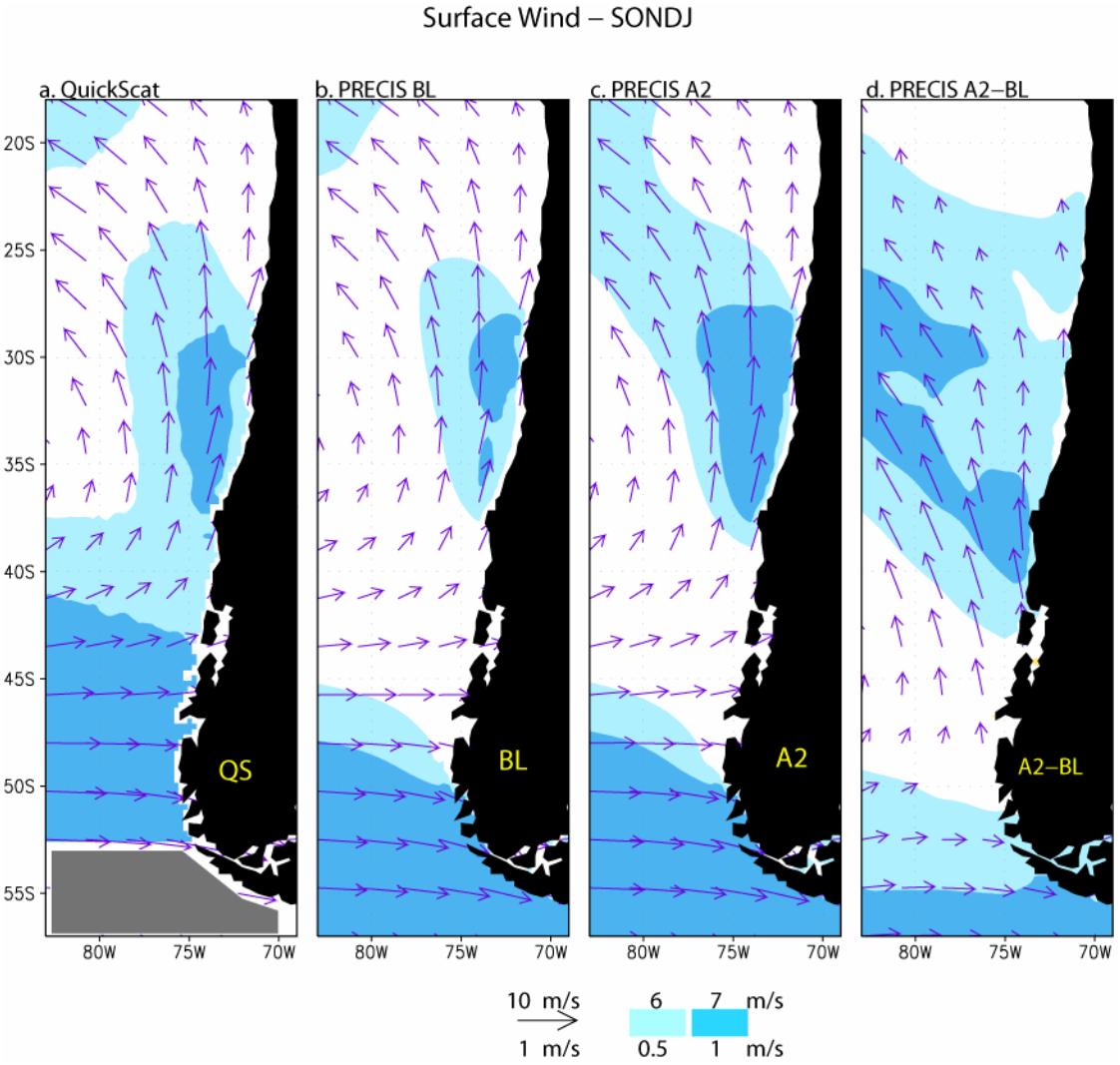
Why?

- CONAMA (Chile) needed results in 9 months

Where?

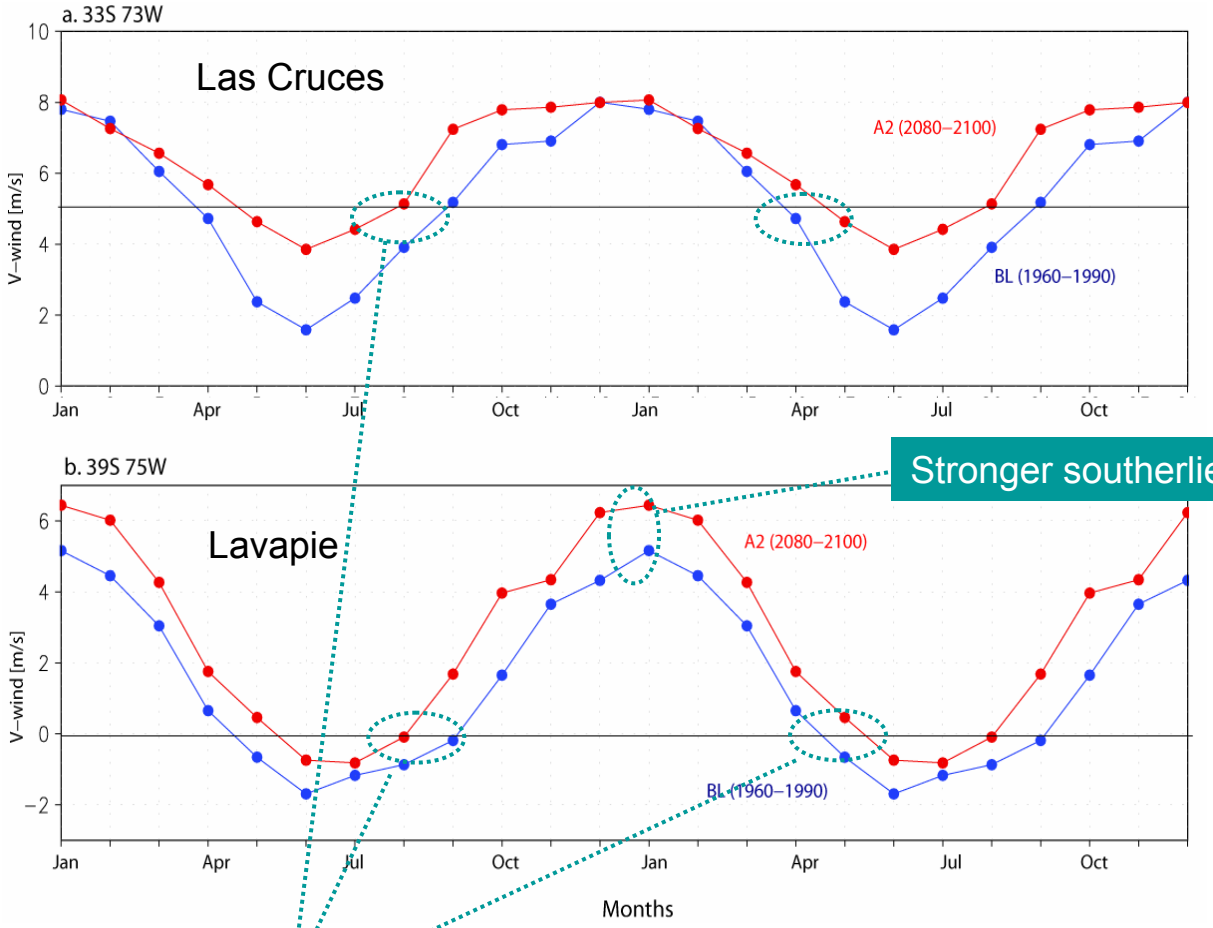
http://www.dgf.uchile.cl/PRECIS

PRECIS Results



Garreaud & Falvey 2007

PRECIS Results



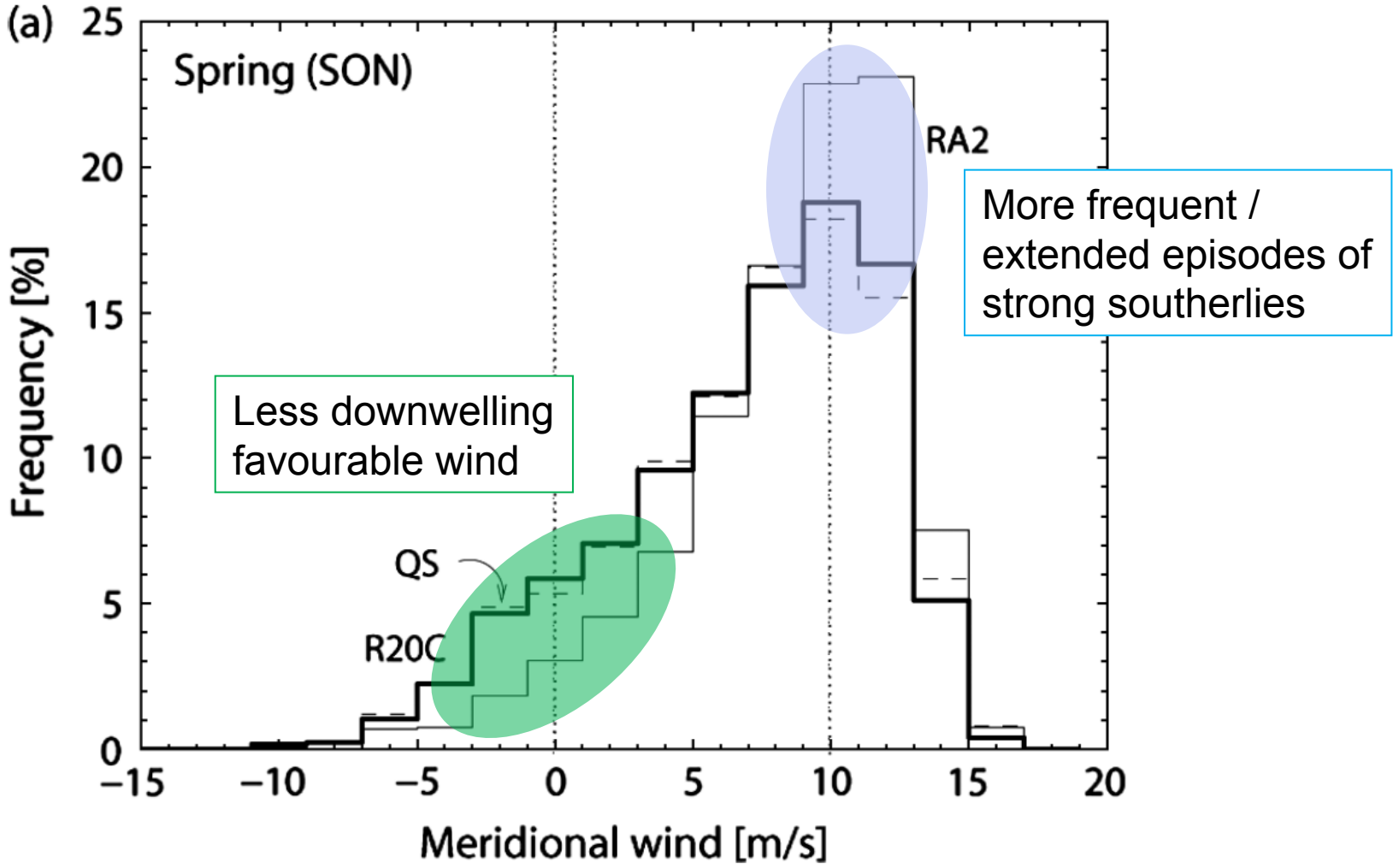
Stronger southerlies

2 month extended upwelling season
(earlier onset, later demise)

Garreaud & Falvey 2007

PRECIS Results

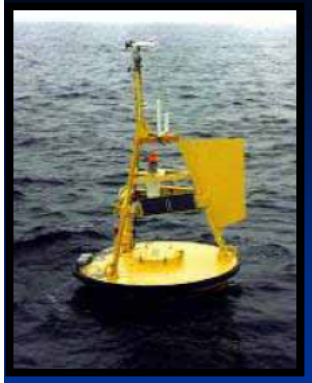
Frequency of surface meridional wind speed at 33°S 74°W



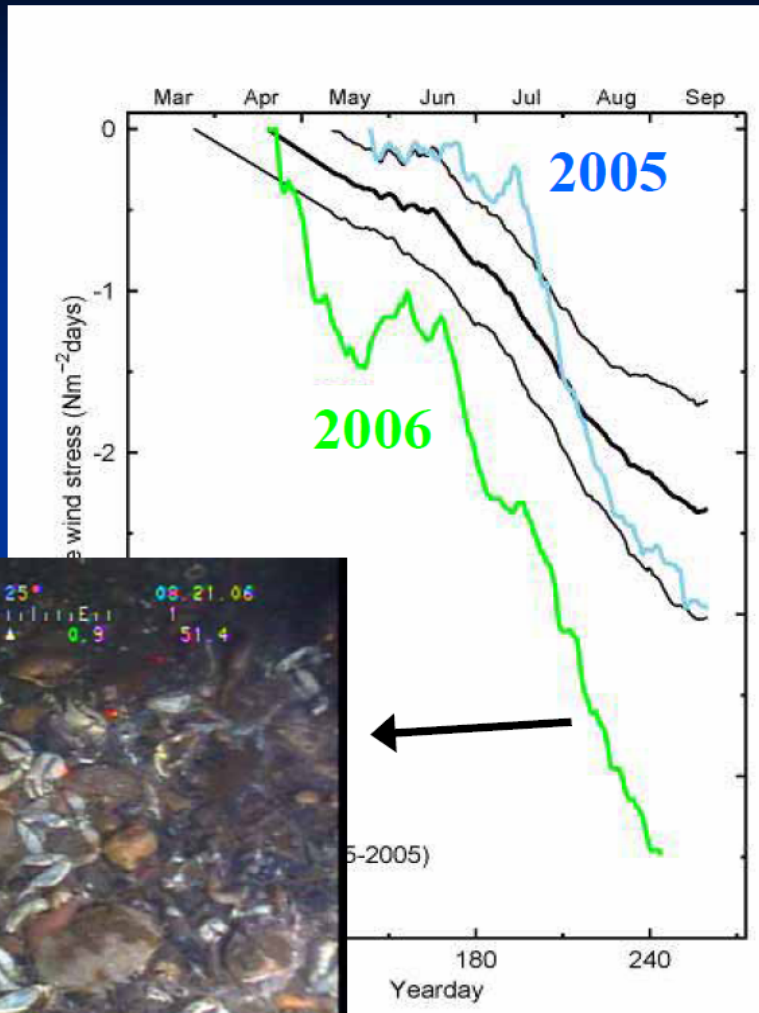
Garreaud & Falvey 2007

PRECIS Results

Local Forcing (2006): Supercharged upwelling



Cumulative wind stress since Spring Transition



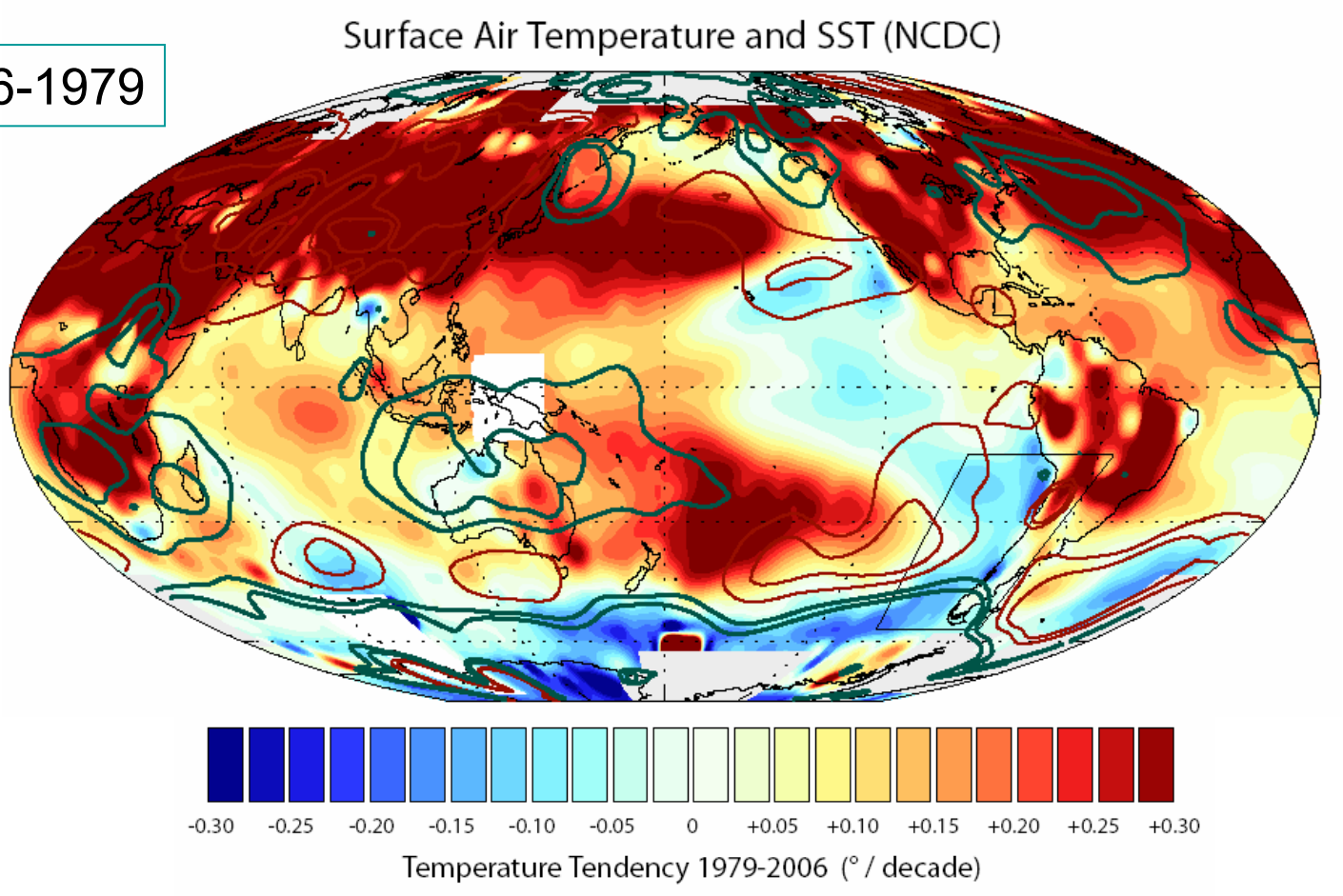
Equatorward, Upwelling favorable

twice as much upwelling as normal

Barth/Pierce (OSU)

Is the regional cooling of the Humboldt EBUS already taking place?

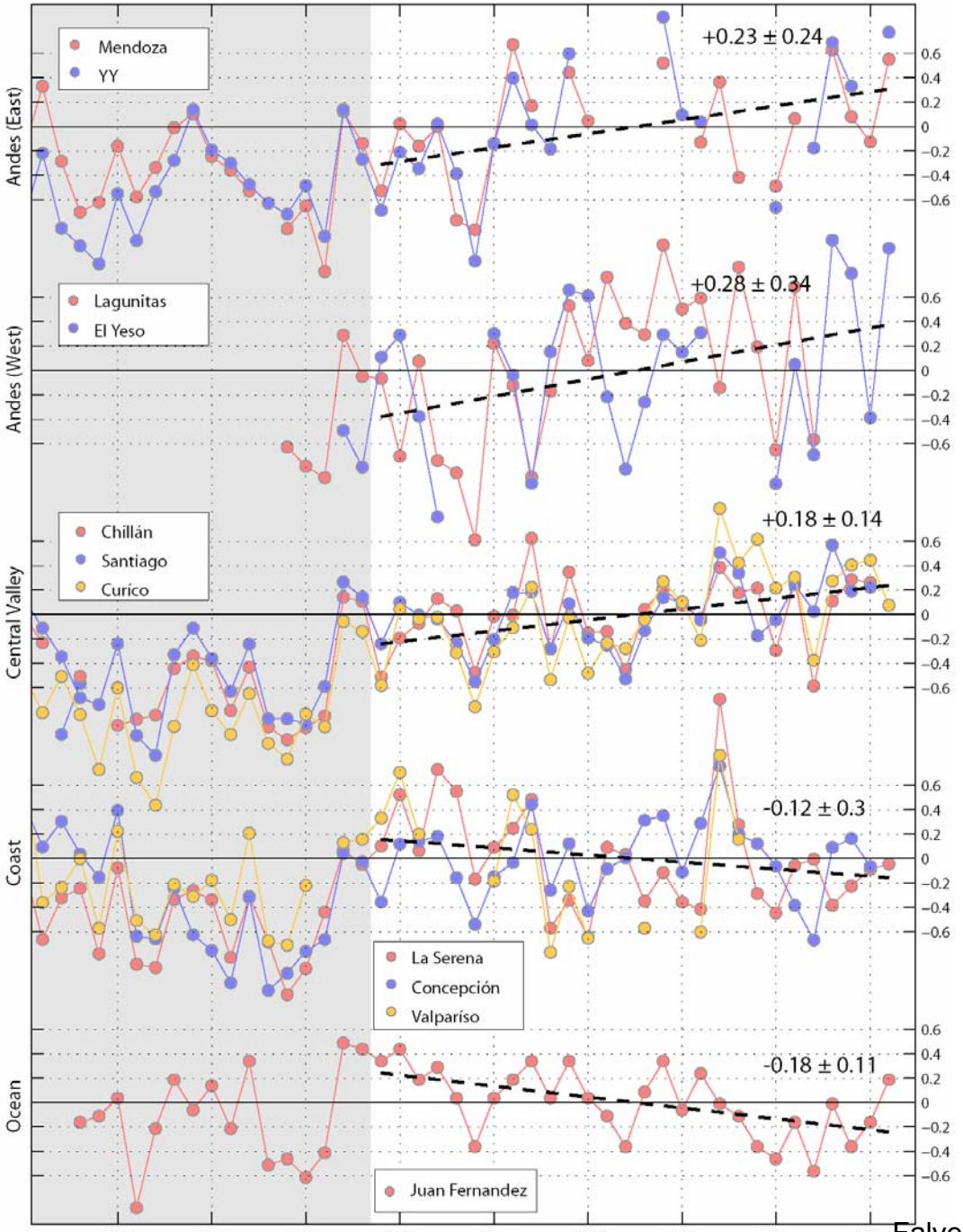
2006-1979



Over the Pacifc SST trend looks very similar to the PDV patter

Falvey & Garreaud 2007

Is the regional cooling of the Humboldt EBUS already taking place?



East Andes

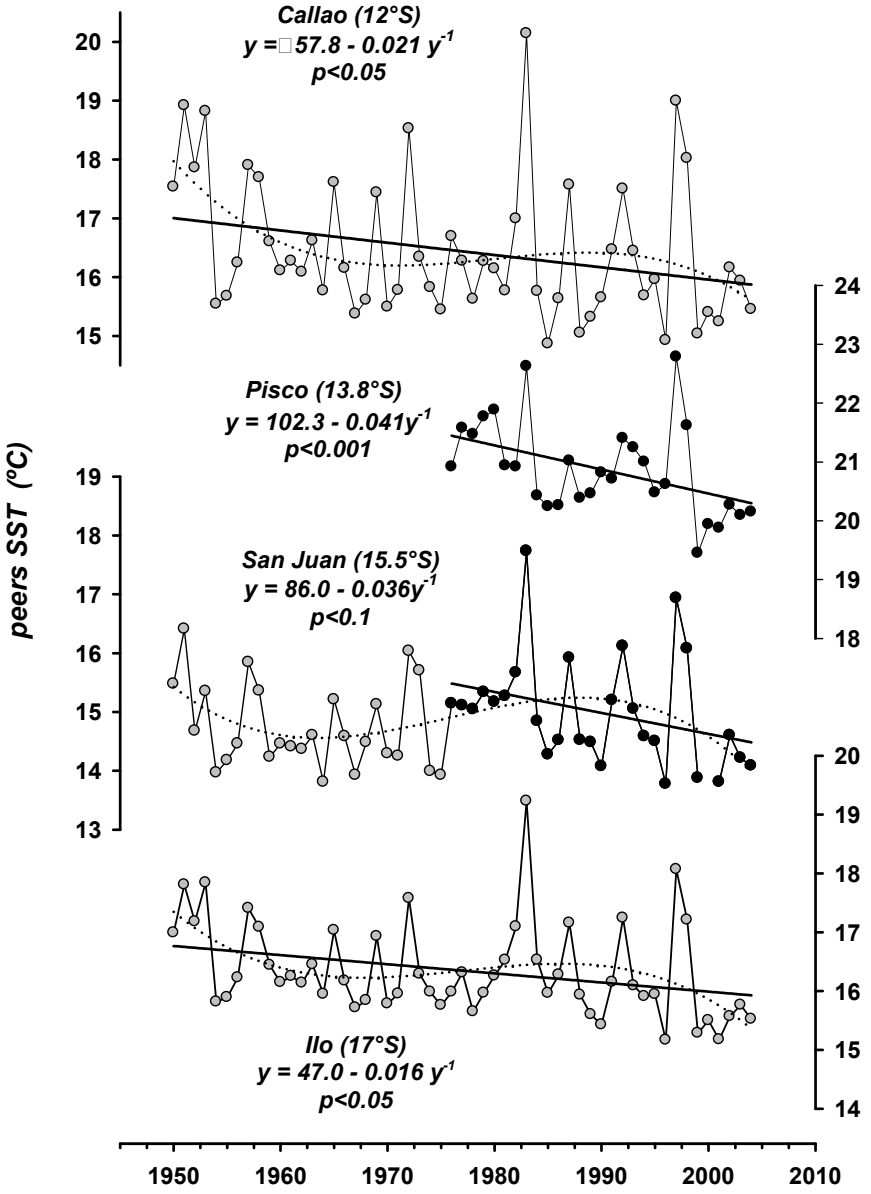
West Andes

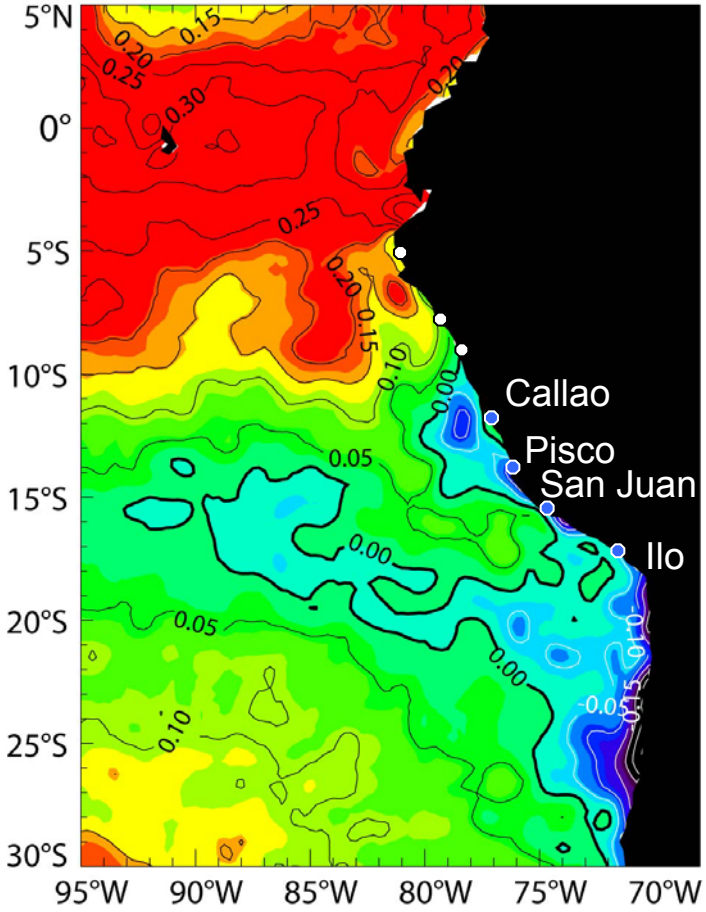
inland

coast

offshore

Falvey & Garreaud 2007



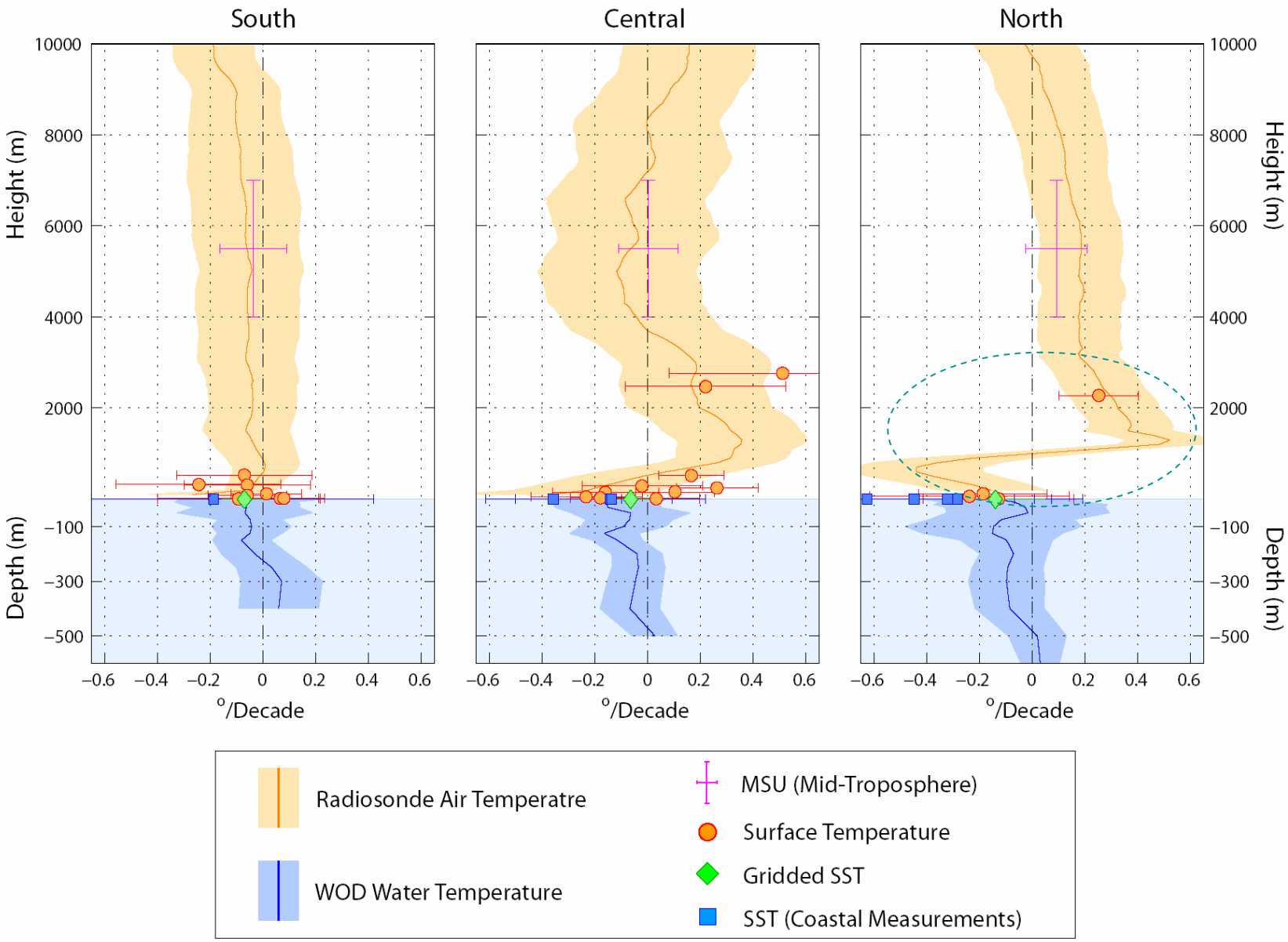


Trends in°C/décade (1984 – 2010), from Reynolds data base (1/4° resolution) *(Gutiérrez et al., RPGA, subm.)*

Gutiérrez, Bouloubassi, et al., GRL, to be submitted

Is the regional cooling of the Humboldt EBUS already taking place?

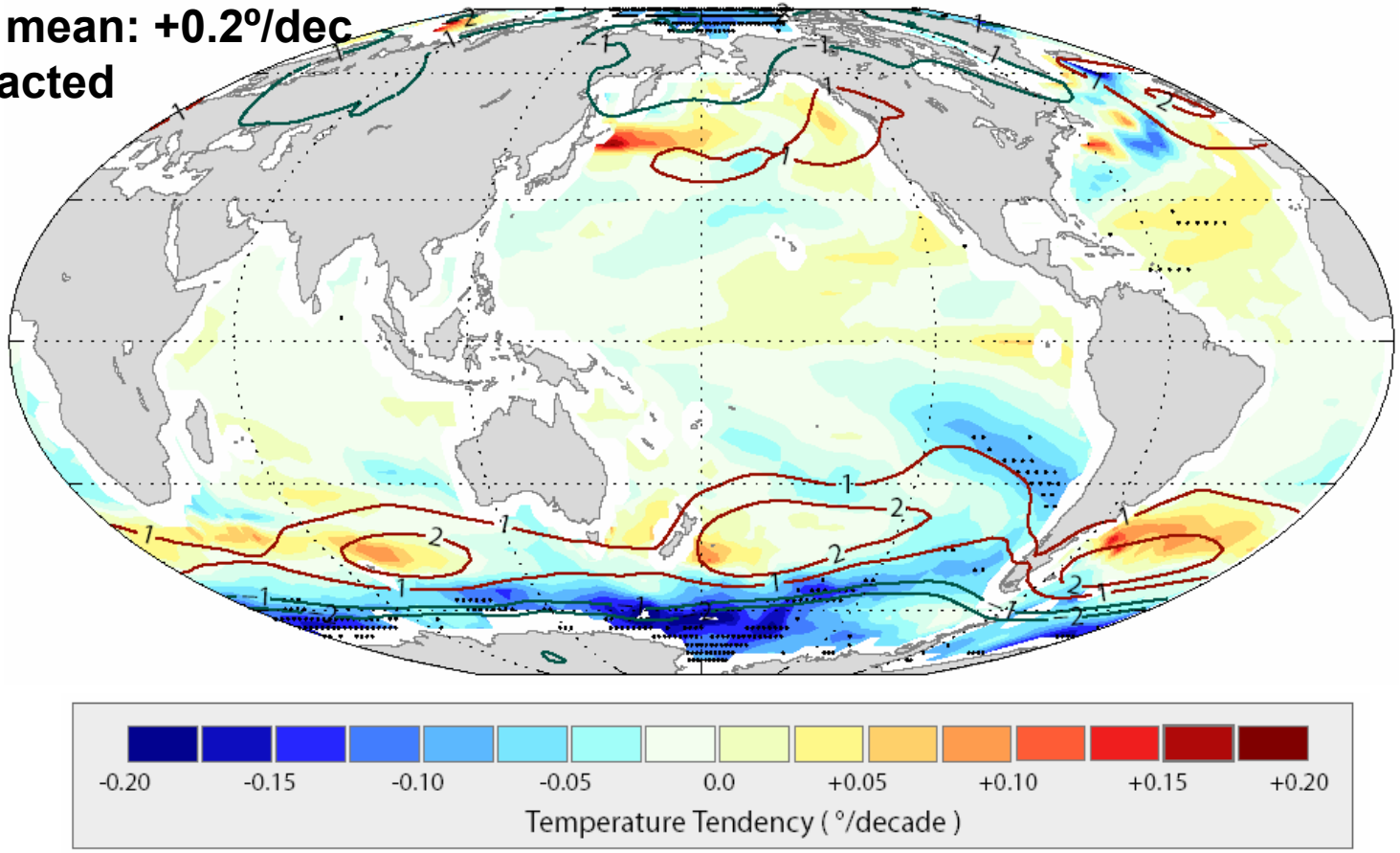
Temperature trends 1979-2006



Falvey & Garreaud 2007

Is the regional cooling of the Humboldt EBUS already taking place?

Global mean: +0.2º/dec
Substracted



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

Falvey & Garreaud 2007

Conclusiones

- Un clima más calido tiende a generar condiciones tipo El Niño en el Pacifico ecuatorial (alisios menos intensos). No hay consenso sobre variabilidad interanual.
- GCMs predicen en forma consistente una expansión de la celda de Hadley resultando en un incremento de persión a lo largo de la costa.
- El incremento de la PNM favorece aumento de vientos del sur a lo largo de la costa de Chile. También explica reducción de precipitaciones (20-30%)

- El modelo PRECIS aporta detalles. Extensión de la estación de surgencia e incremento de los vientos del sur en zona centro-sur.
- Vientos del sur mas estables y eventos mas intensos en zona central.
- Respuesta oceanografica & biologica incierta…modelación acoplada

- Enfriamiento costero en las últimas tres decadas (0.25°C/decada) contrasta con calentamiento continental. Posiblemente debido a factores naturales pero también a efecto de cambio climático debido a incremento de surgencia

References

Falvey, M. and R. Garreaud, 2009: Regional cooling in a warming world: Recent temperature trends in the SE Pacific and along the west coast of subtropical South America (1979-2006). *J. Geophys. Res*., **114**, D04102, doi:10.1029/2008JD010519.

Garreaud, R. and M. Falvey, 2009: The coastal winds off western subtropical South America in future climate scenarios. *Int. J. of Climatology*, **29**, 543-554. doi: 10.1002/joc.1716

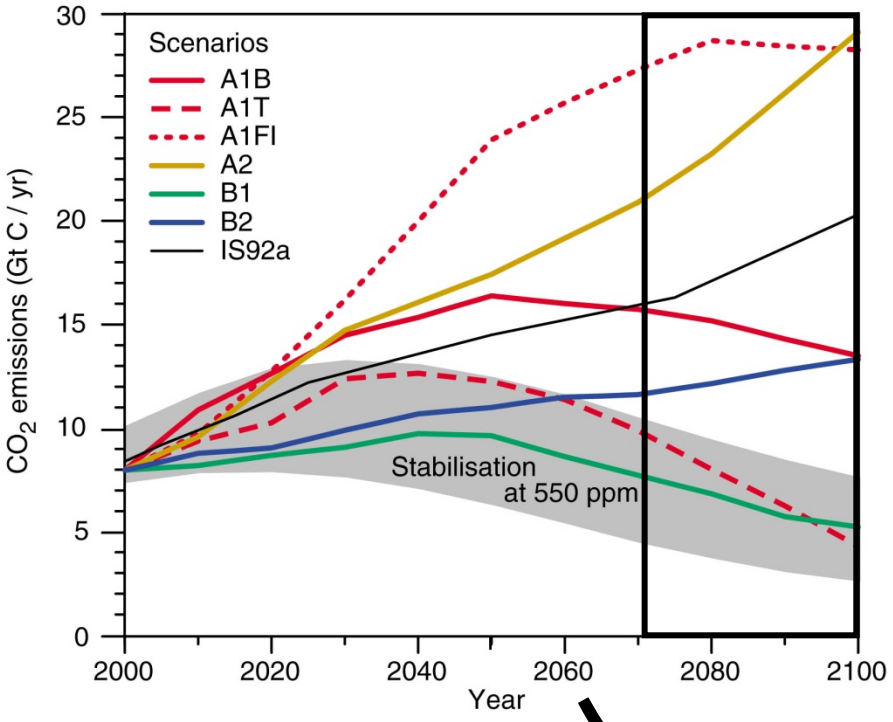
Vecchi, G. and Soden, B.: Global warming and the weakening of the tropical circulation. *Journal of Climate*, **20,** 4316-4340, 2007.

Lu, J., Vecchi, G., and Reichler, T.: Expansion of the Hadley cell under global warming. *Geophys. Res. Lett*, **34**, 2007.

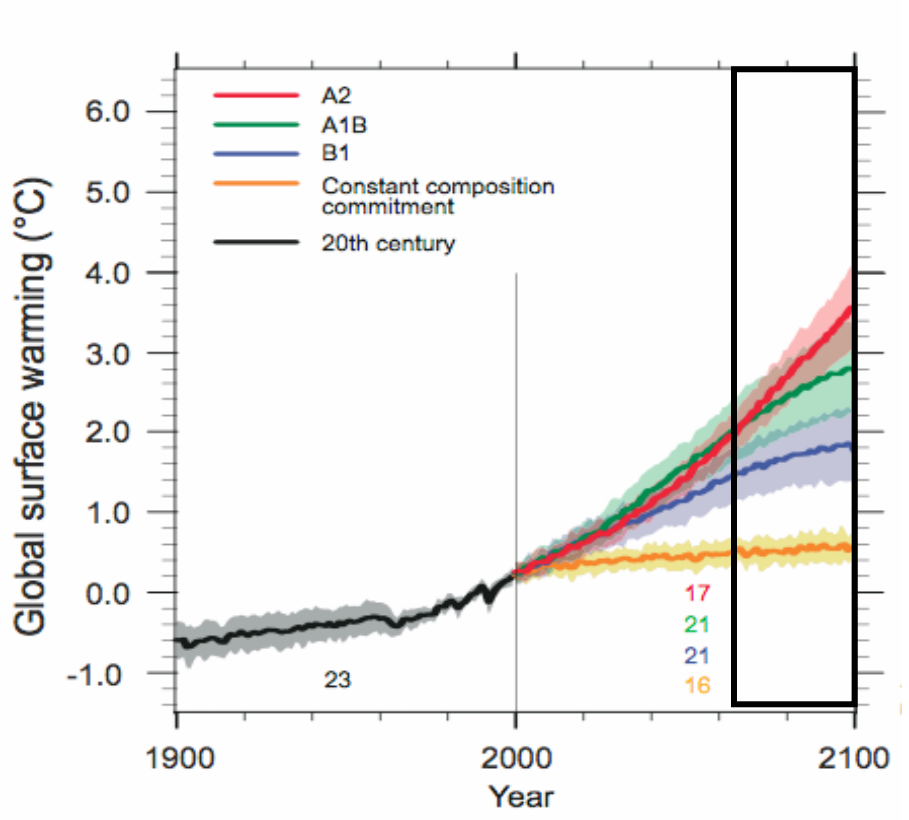
All available on line @ http://www.dgf.uchile.cl/rene

Material de apoyo

Future Climate Scenarios
GHG (CO2,…) emissions projections + GCMs



20+ GCMs
CMIP3/IPCC AR4



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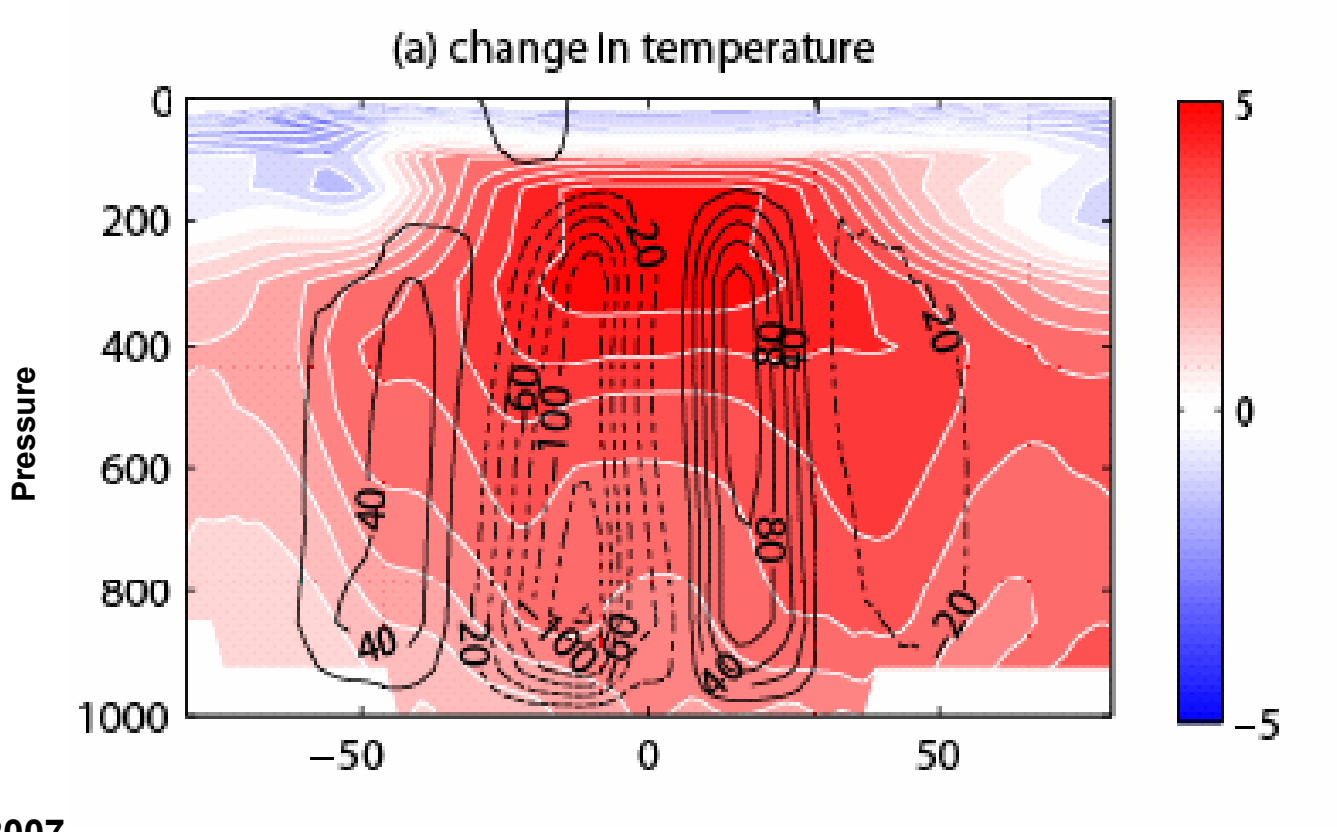

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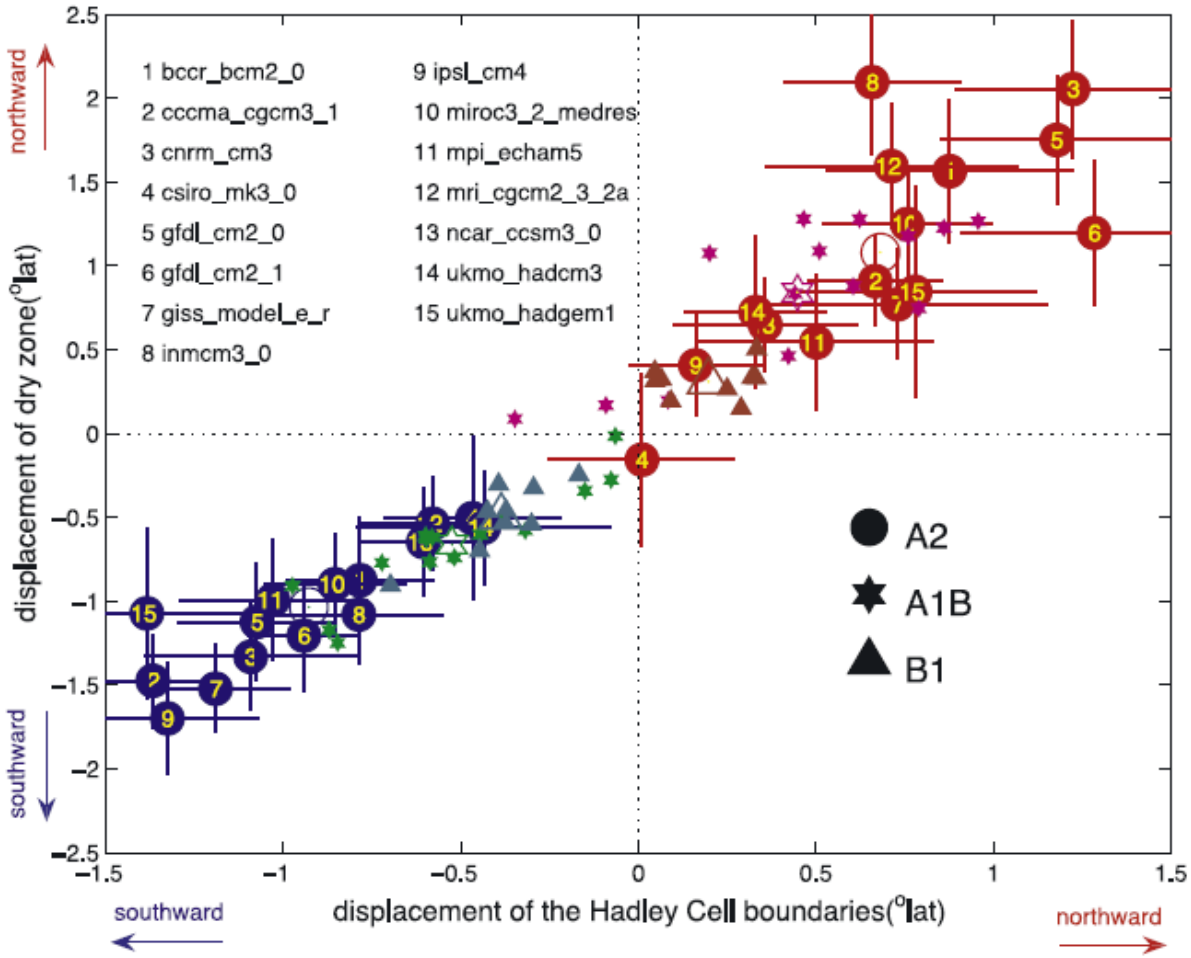
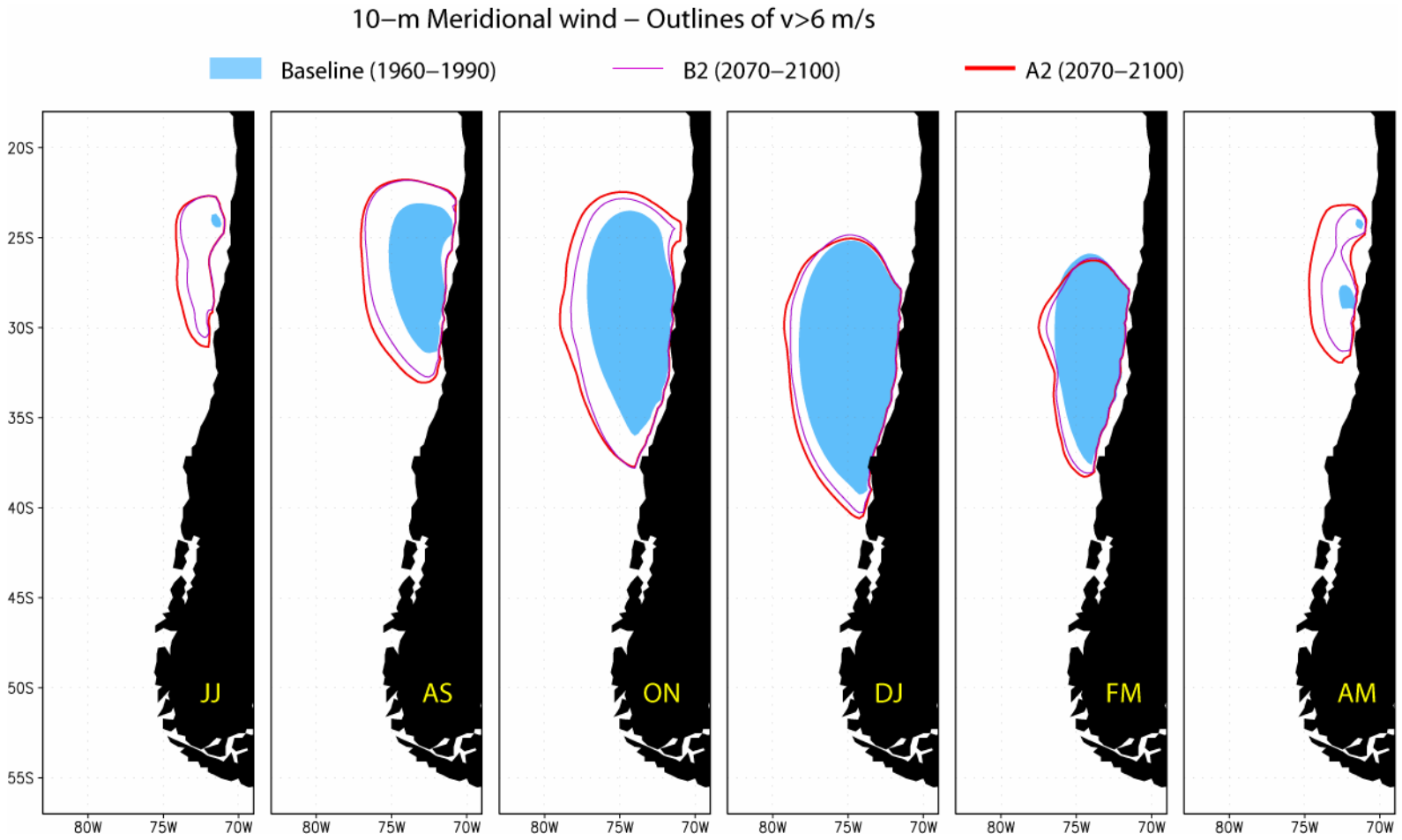
Poleward expansion of the Hadley cell

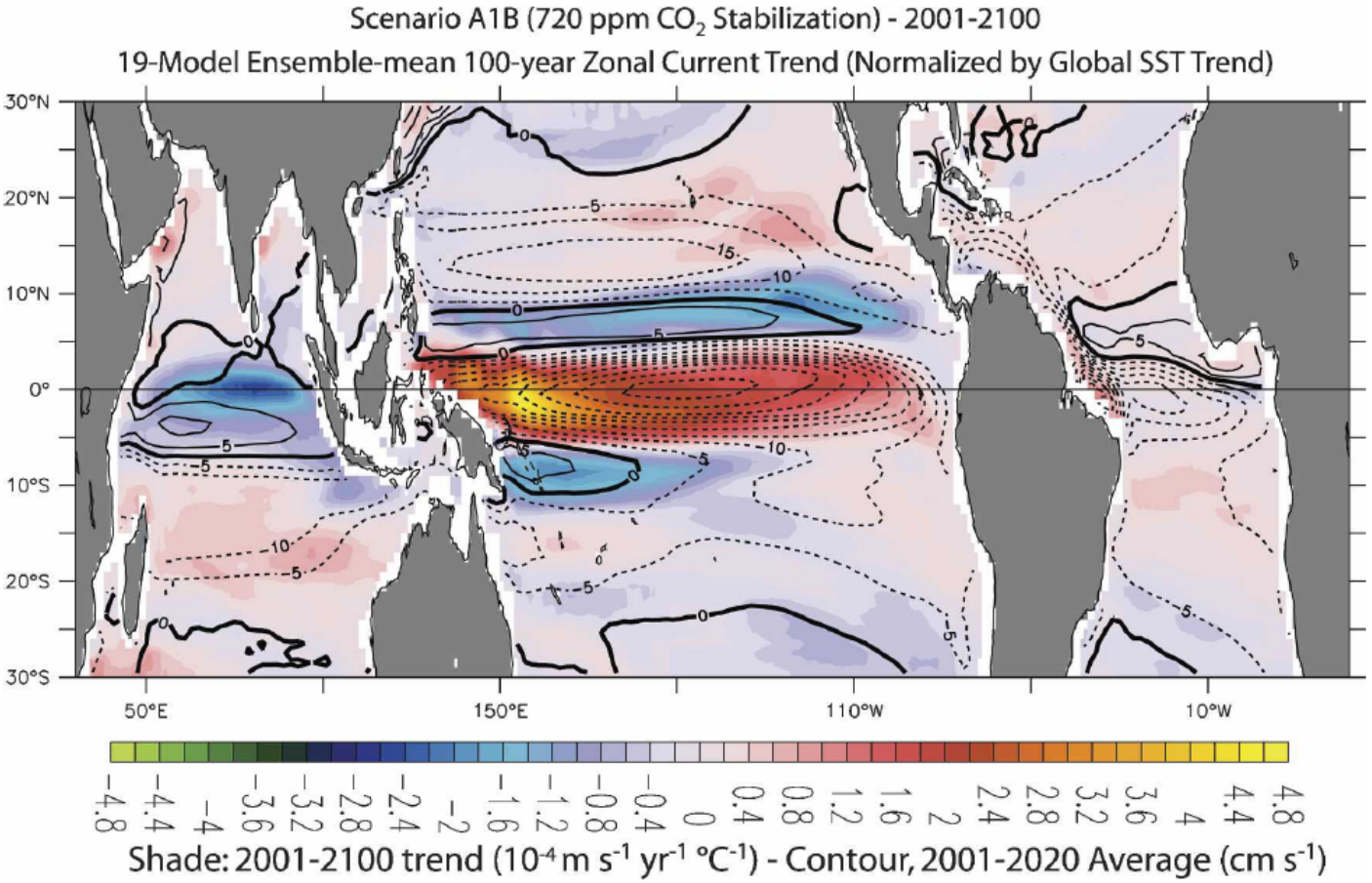


Lu et al. 2007

PRECIS Results

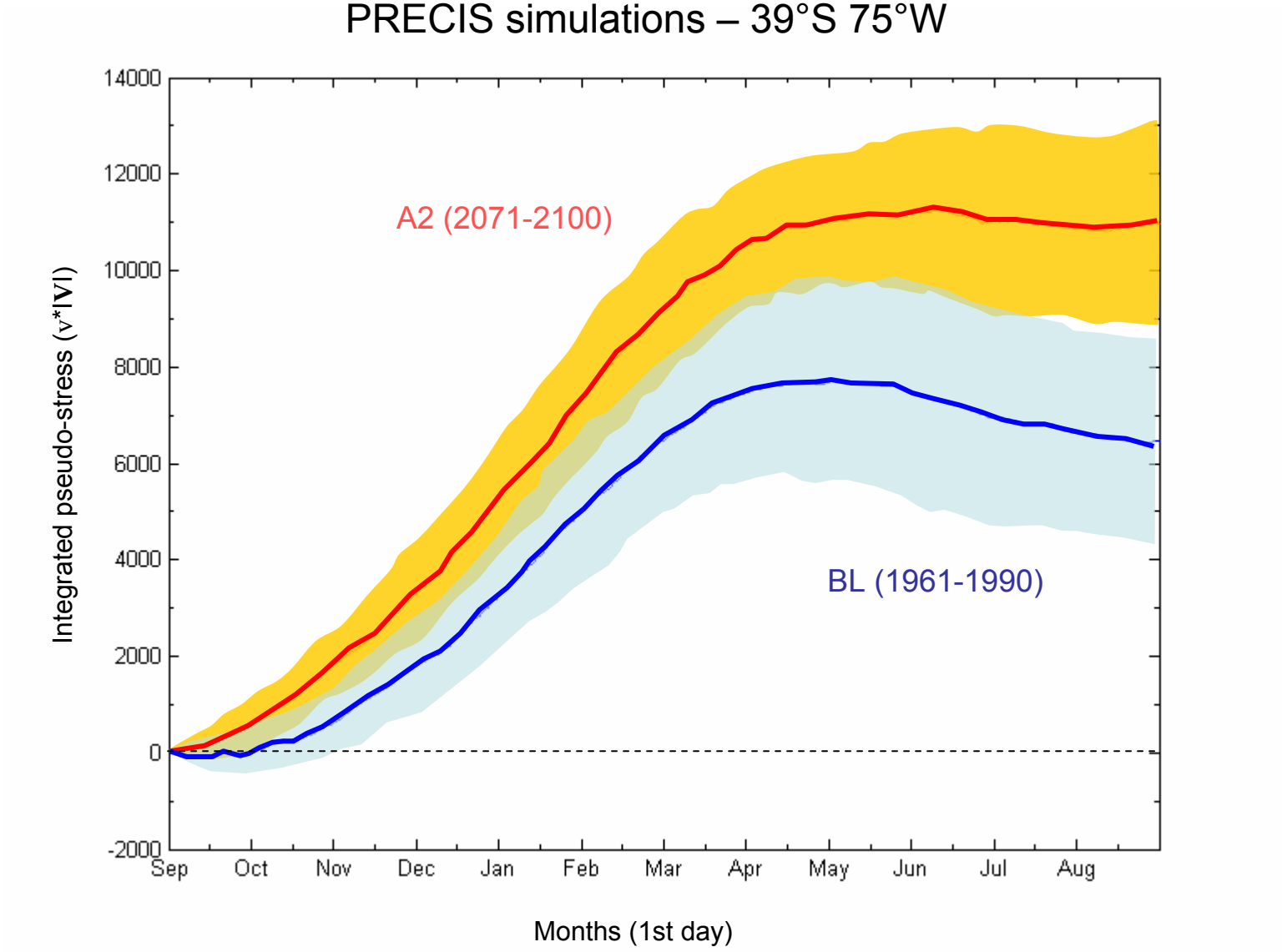


Multimodel average zonal trend 2000 - 2100 (A1B)



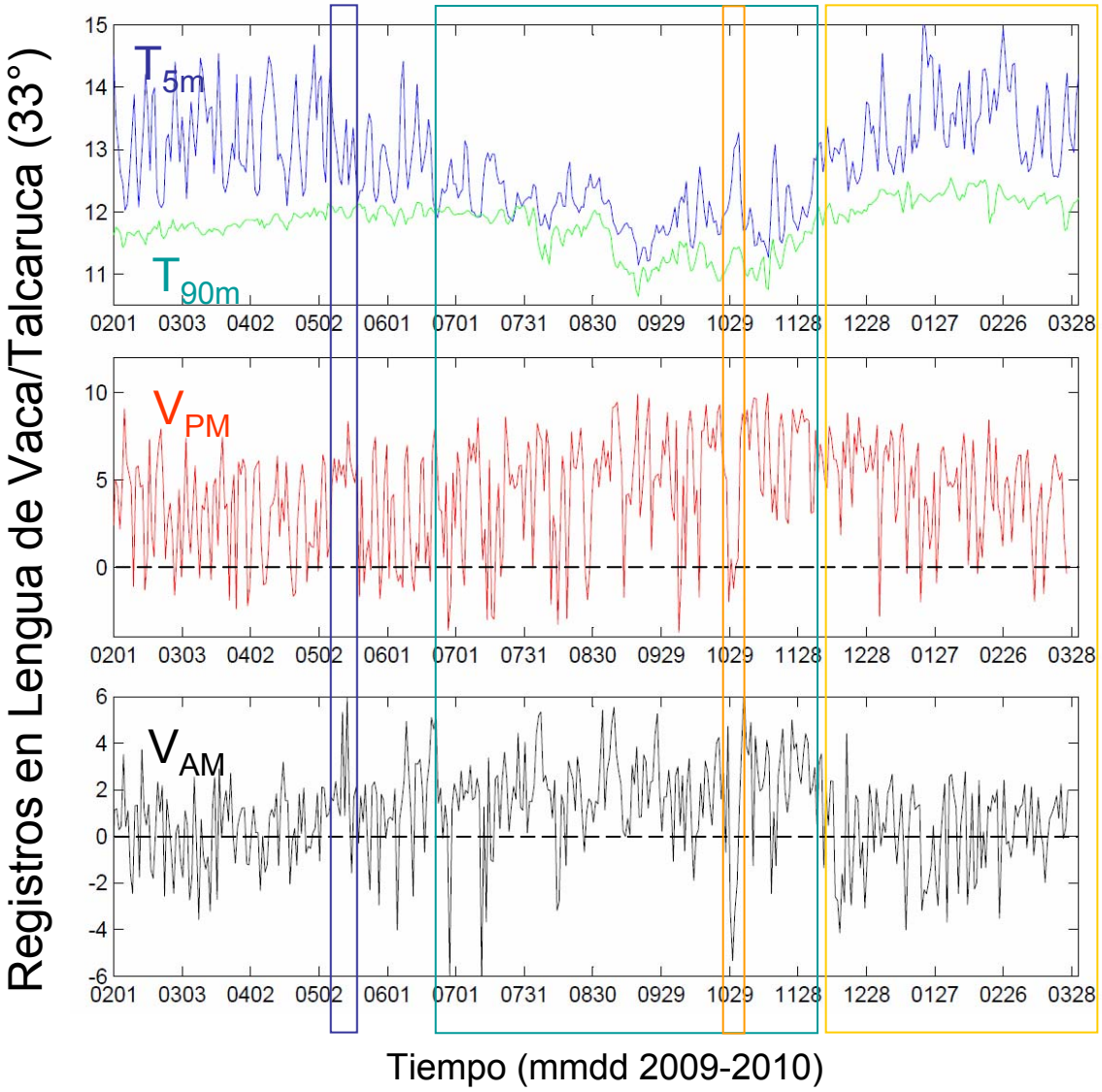
Vecchi and Sodden 2006

PRECIS Results



Garreaud & Falvey 2007

Observaciones: Viento y Surgencia



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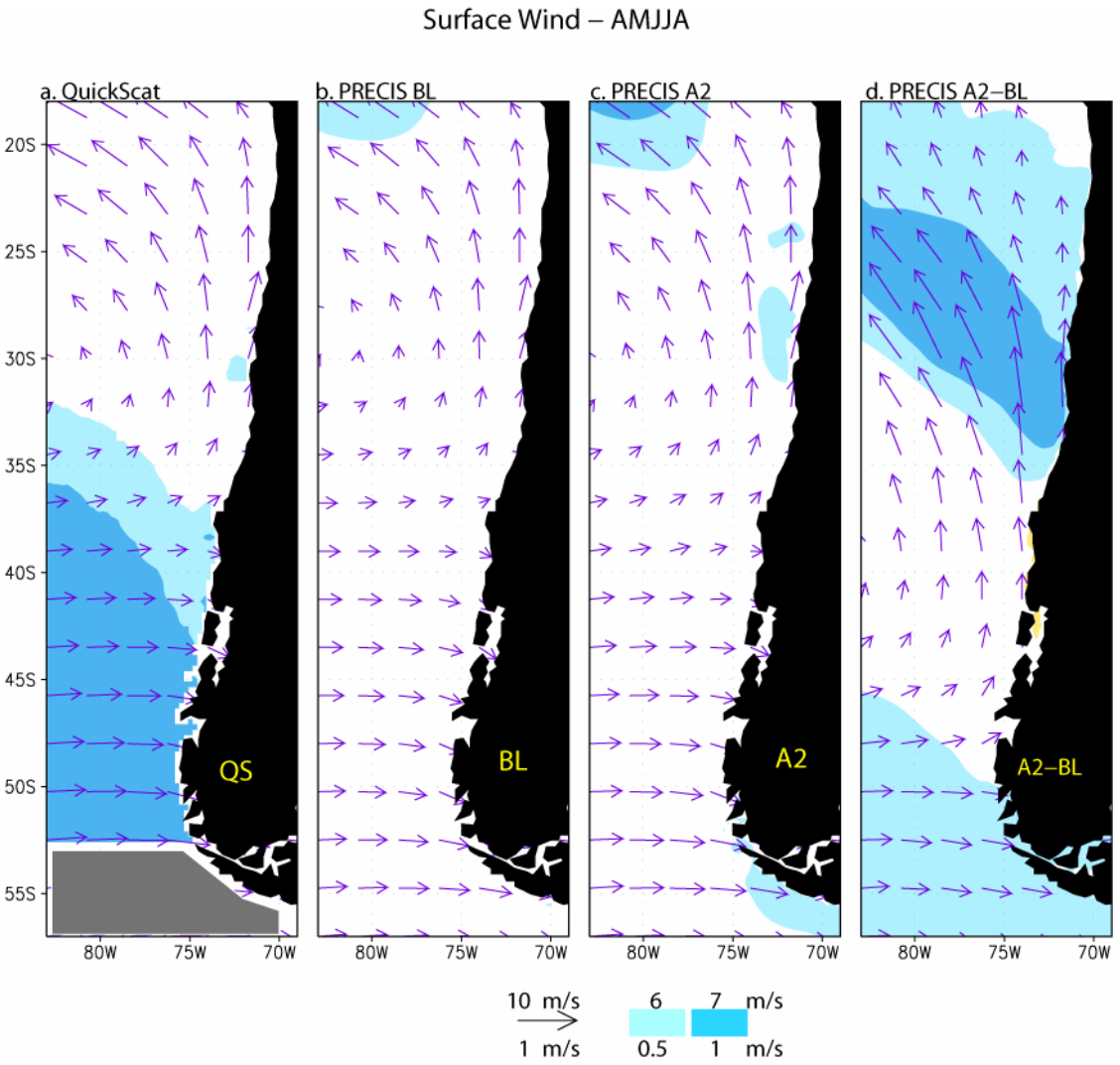

Garreaud & Falvey 2007

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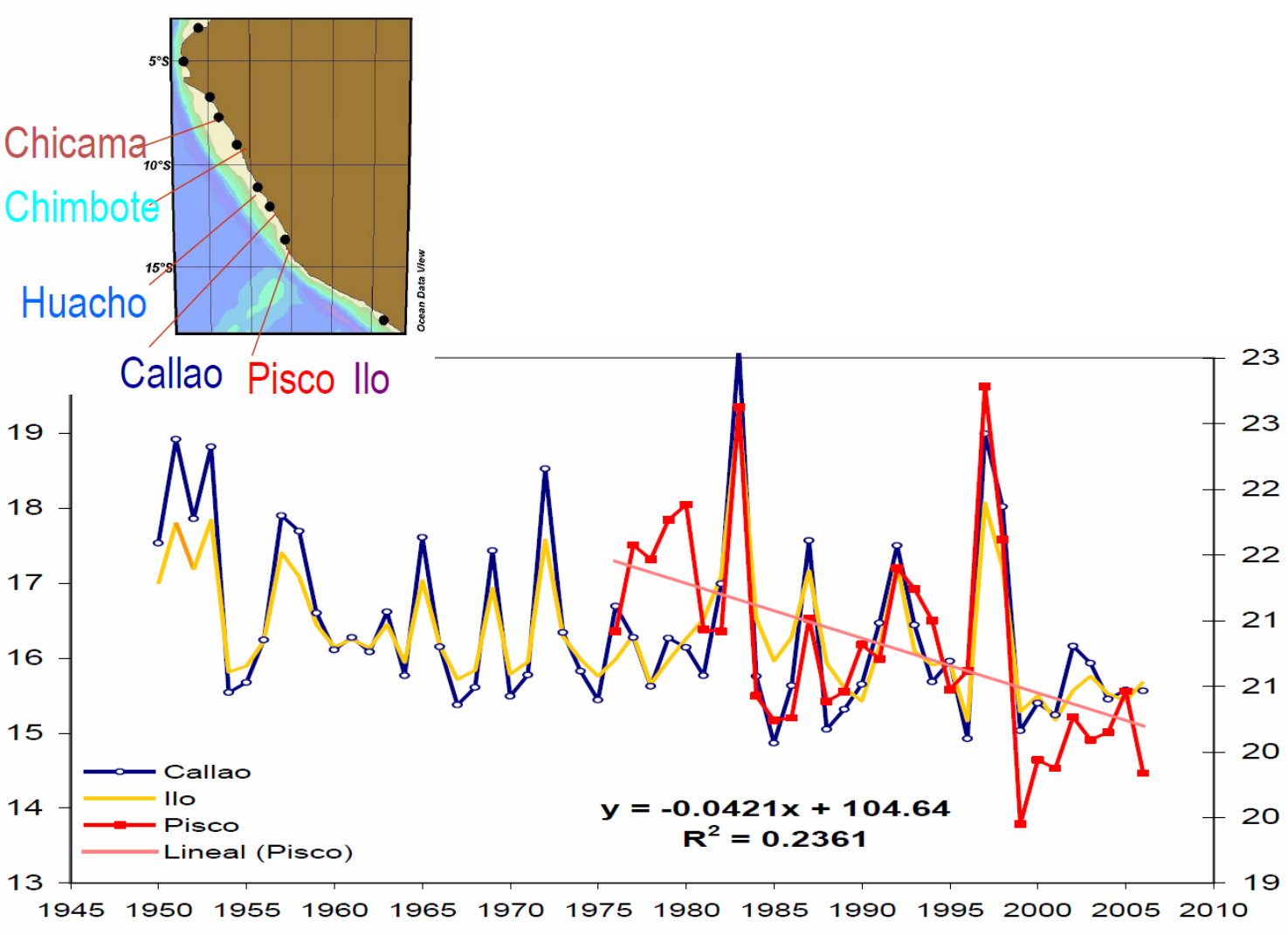

Gentileza Carmen Grados
IMARPE