

Proyecciones Regionales de Cambio Climático en la costa centro sur de Chile

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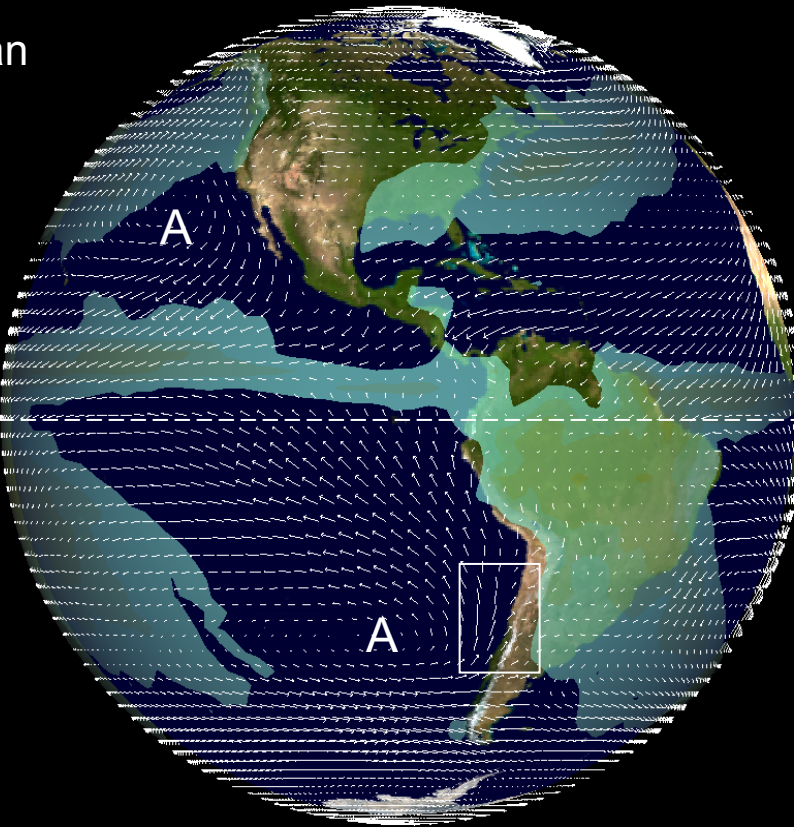
XXX Congreso de Ciencias del Mar
19-22 Octubre 2010, Concepción Chile

Programa

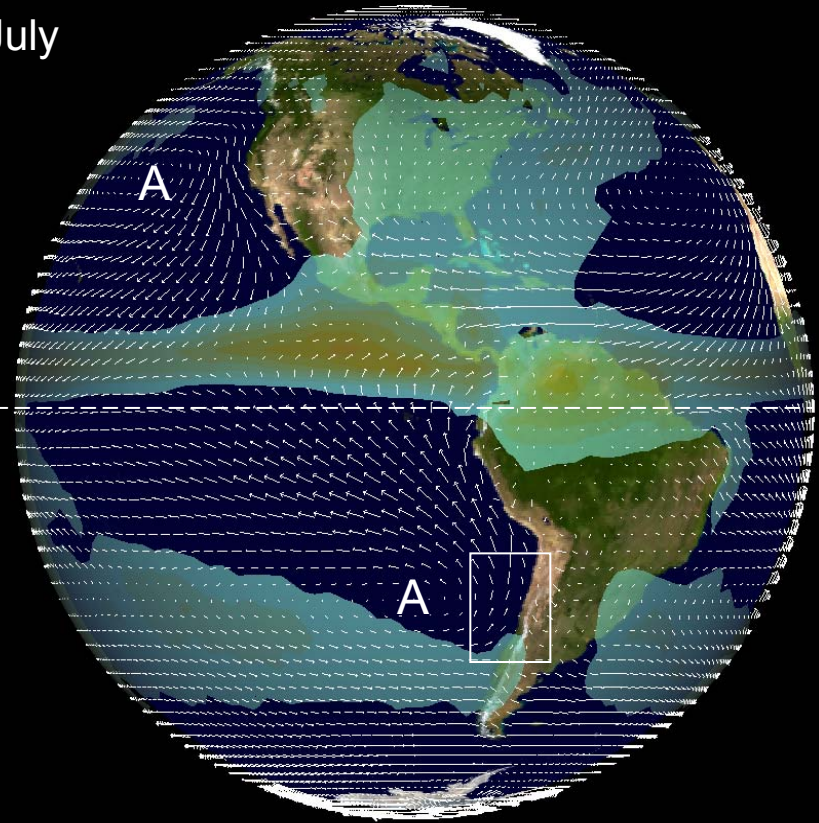
- El clima a lo largo de la costa de Chile
- Clima futuro en base a modelos globales
- Clima futuro en base a PRECIS (modelo regional)
- Esta ocurriendo el cambio de clima costero?

Observaciones: Viento en Sfc y Precipitación

Jan



July

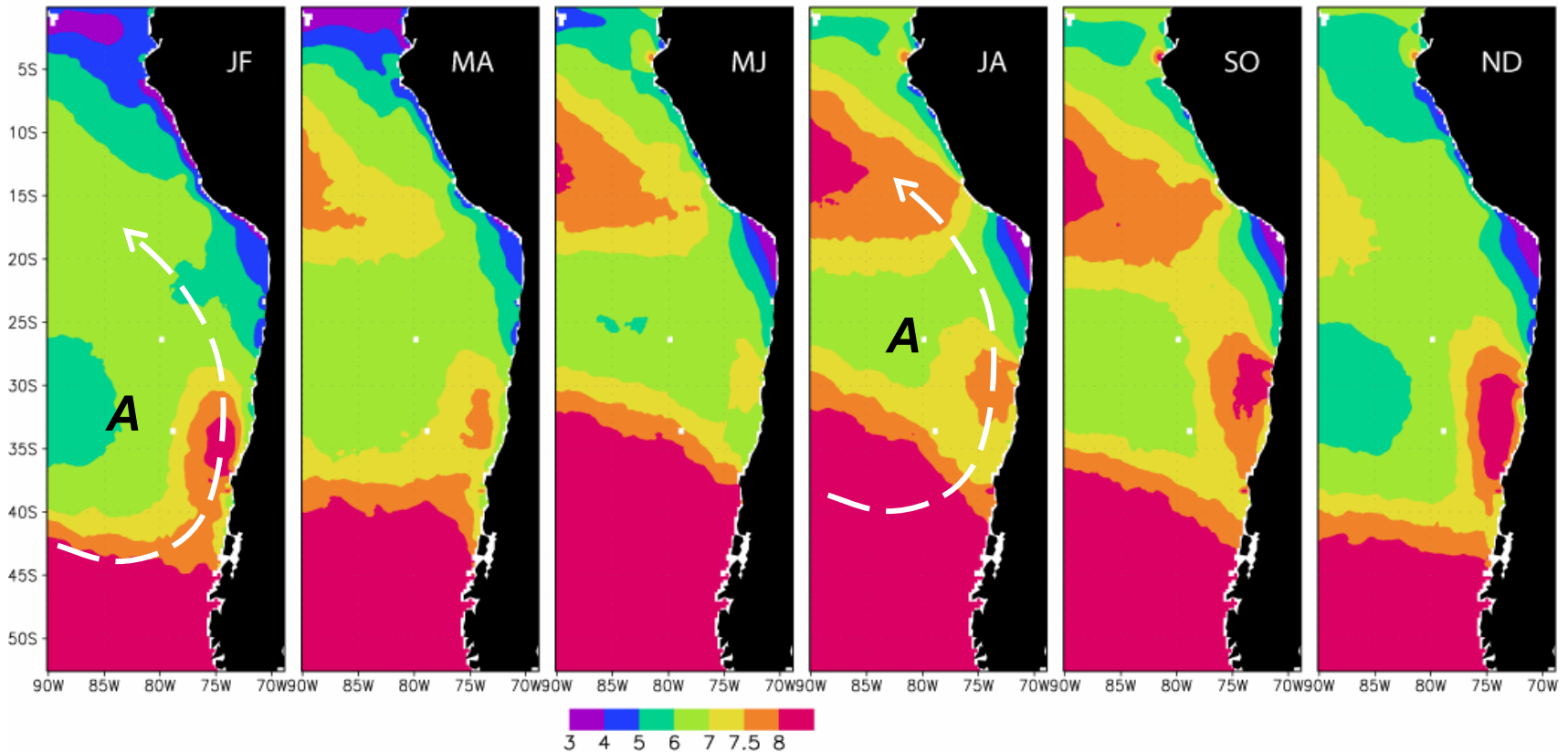


Long term mean rainfall (colors) & surface winds (arrows)

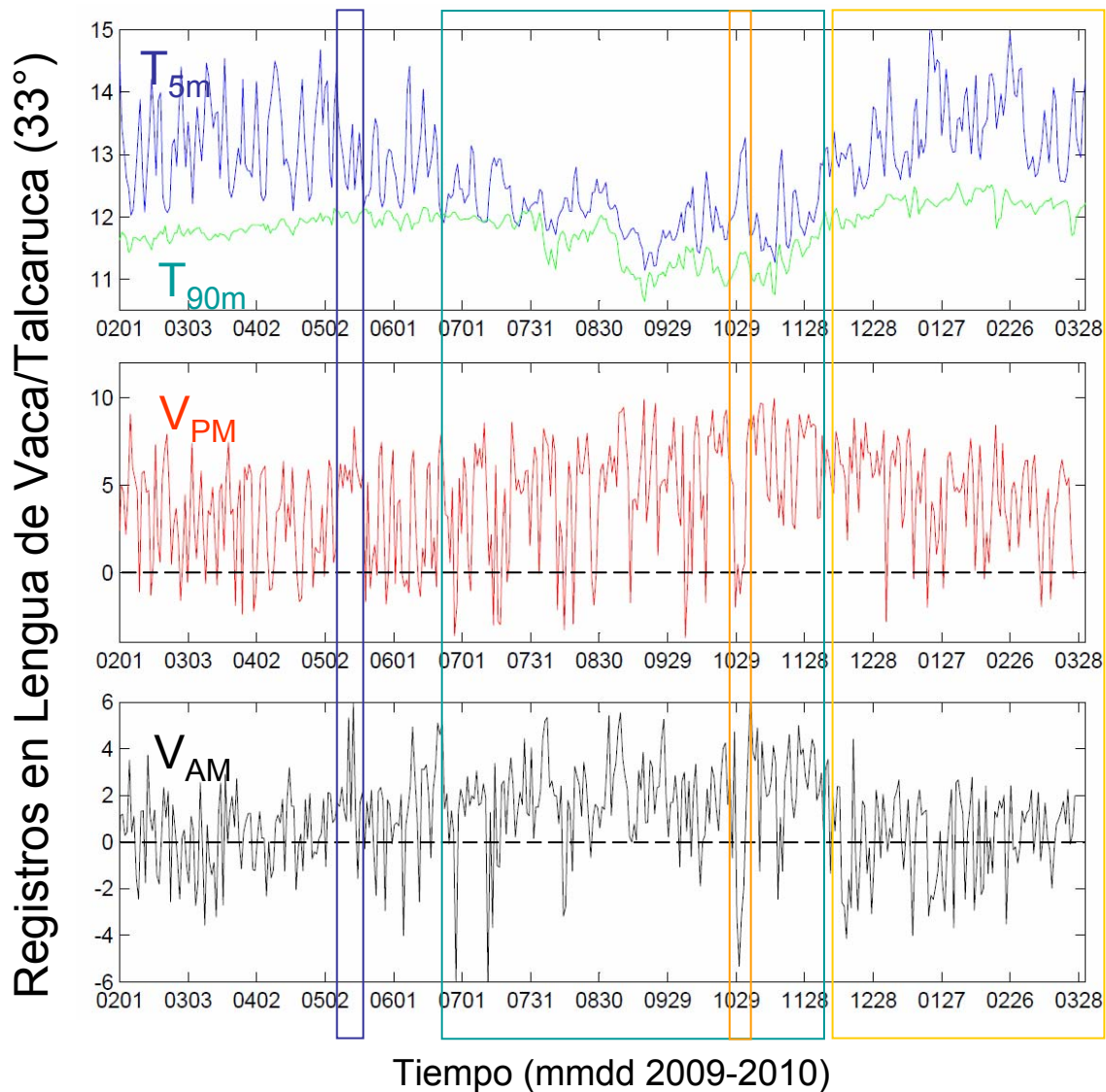
Observaciones: Campo de Viento en Sfc

Jet costero (máxima magnitud) a lo largo de la costa
Variabilidad sinóptica y estacional dictada por $\partial(\text{SLP}) / \partial y$

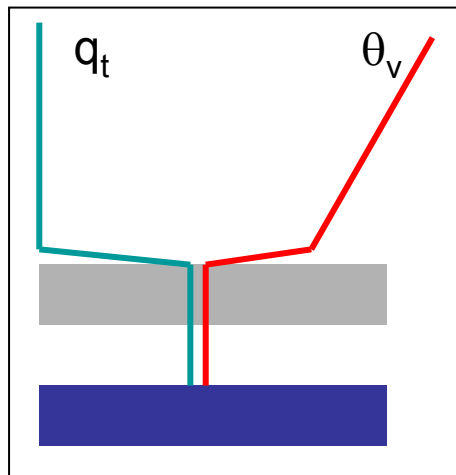
QuikScat surface wind speed climatology (2000–2005)



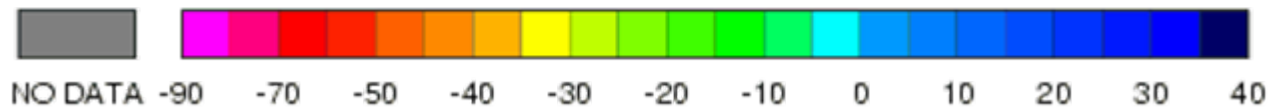
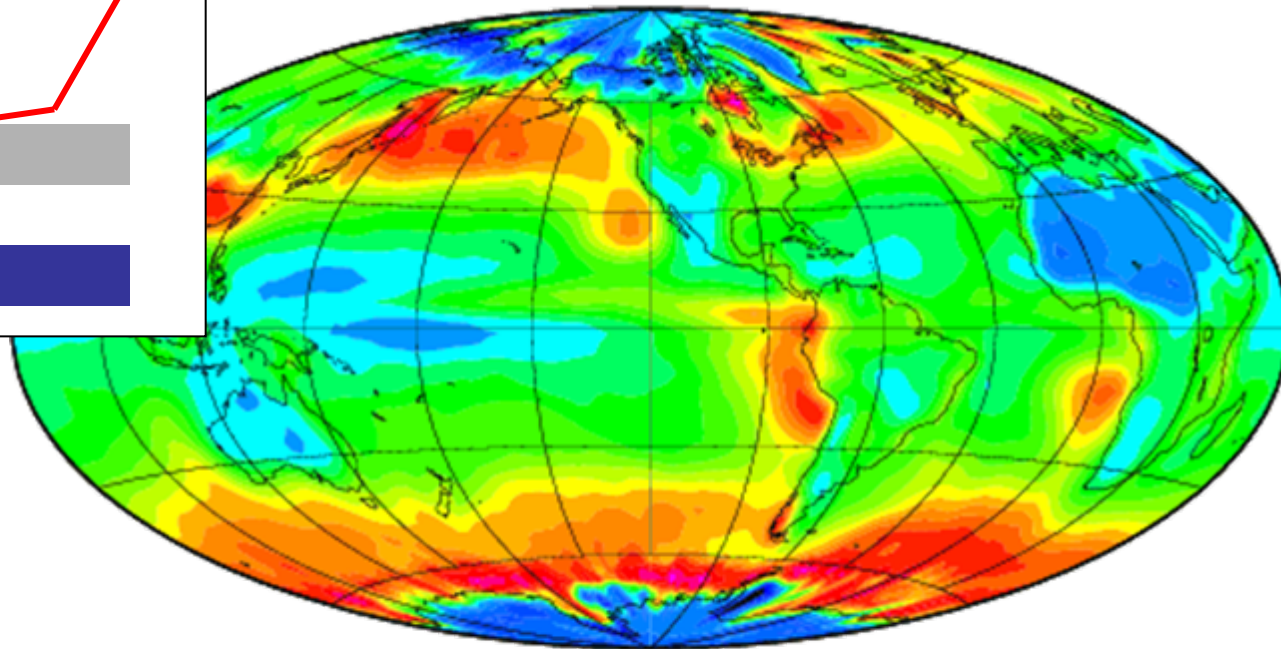
Observaciones: Viento, Temperatura y



Observaciones: Cubierta de nubes bajas



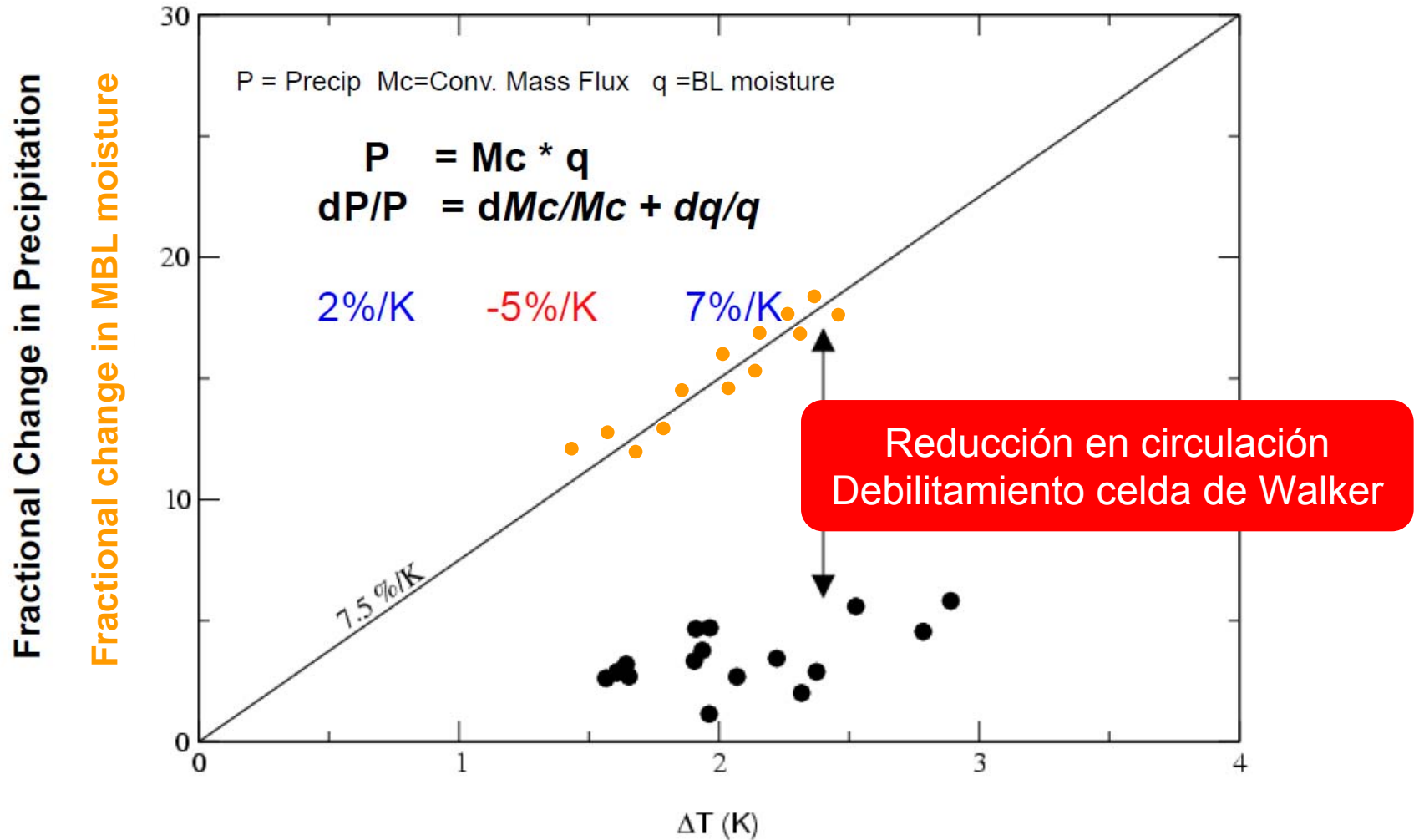
Annual ERBE Net Radiative Cloud Forcing



W/m^2

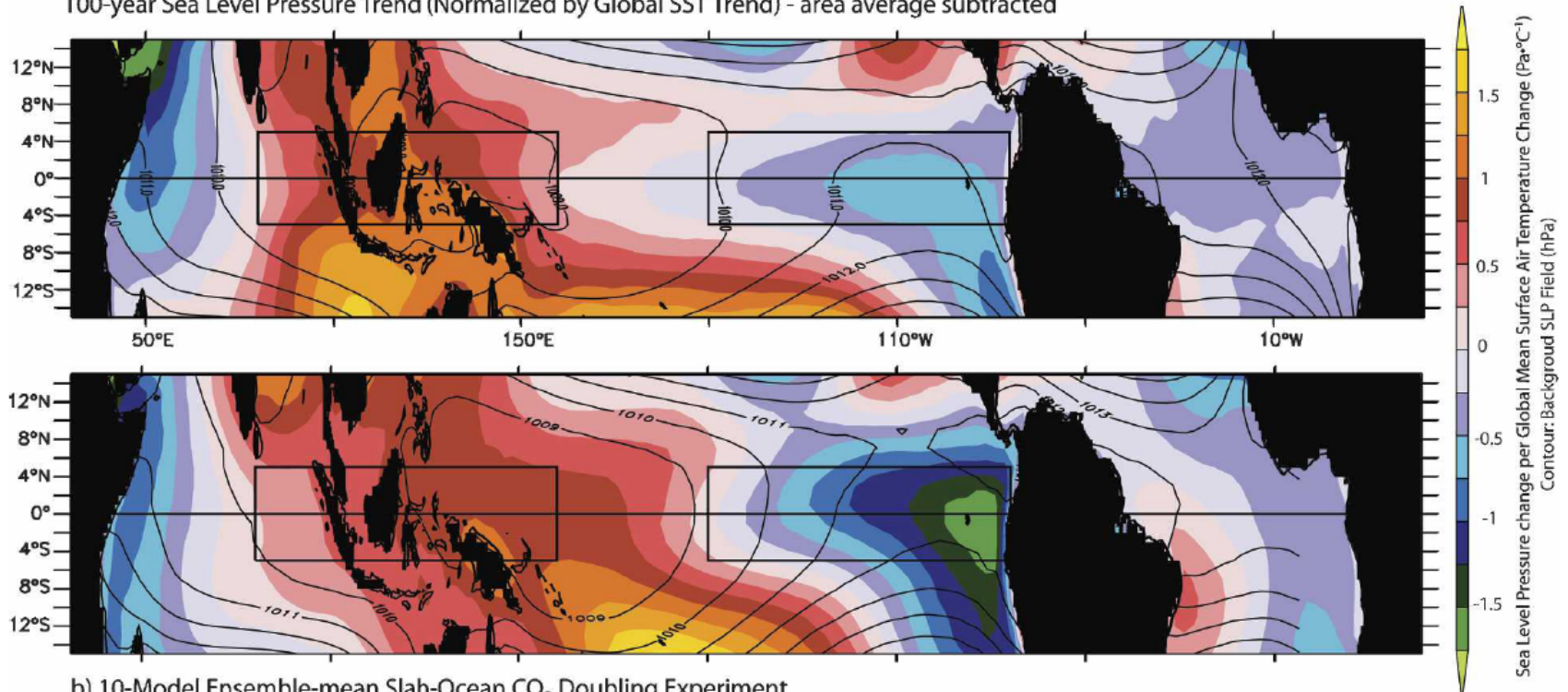
Change in Global Precipitation at 2100

Low latitudes (10°S-10°N)



Multimodel average SLP trend 2000 - 2100 (A1B)

a) 22-Model Ensemble-mean Scenario A1B (720 ppm CO₂ Stabilization) - 2001-2100
100-year Sea Level Pressure Trend (Normalized by Global SST Trend) - area average subtracted



b) 10-Model Ensemble-mean Slab-Ocean CO₂ Doubling Experiment
Years 41-60 Sea Level Pressure Anomaly (Normalized by Global SST Trend) - area average subtracted

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

Multimodel average thermocline trend 2000 - 2100 (A1B)

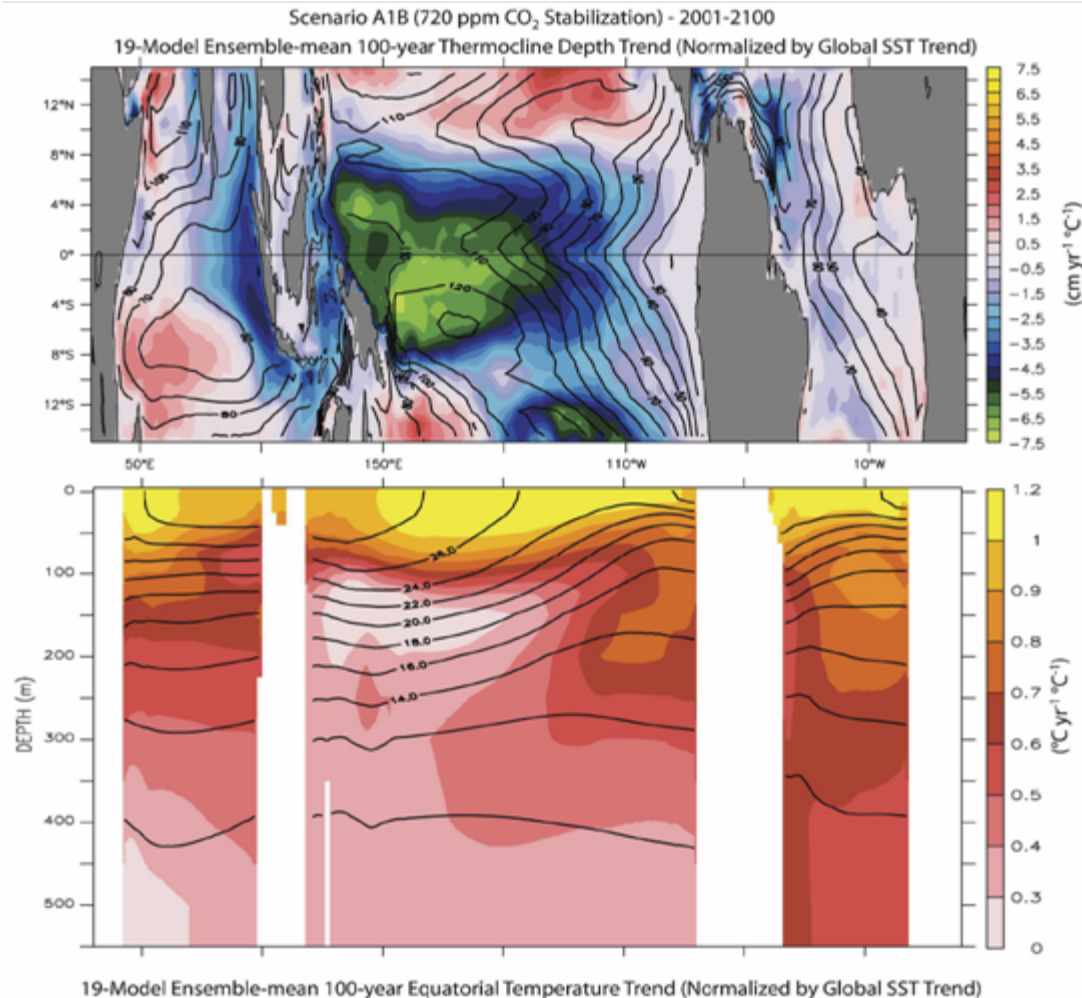
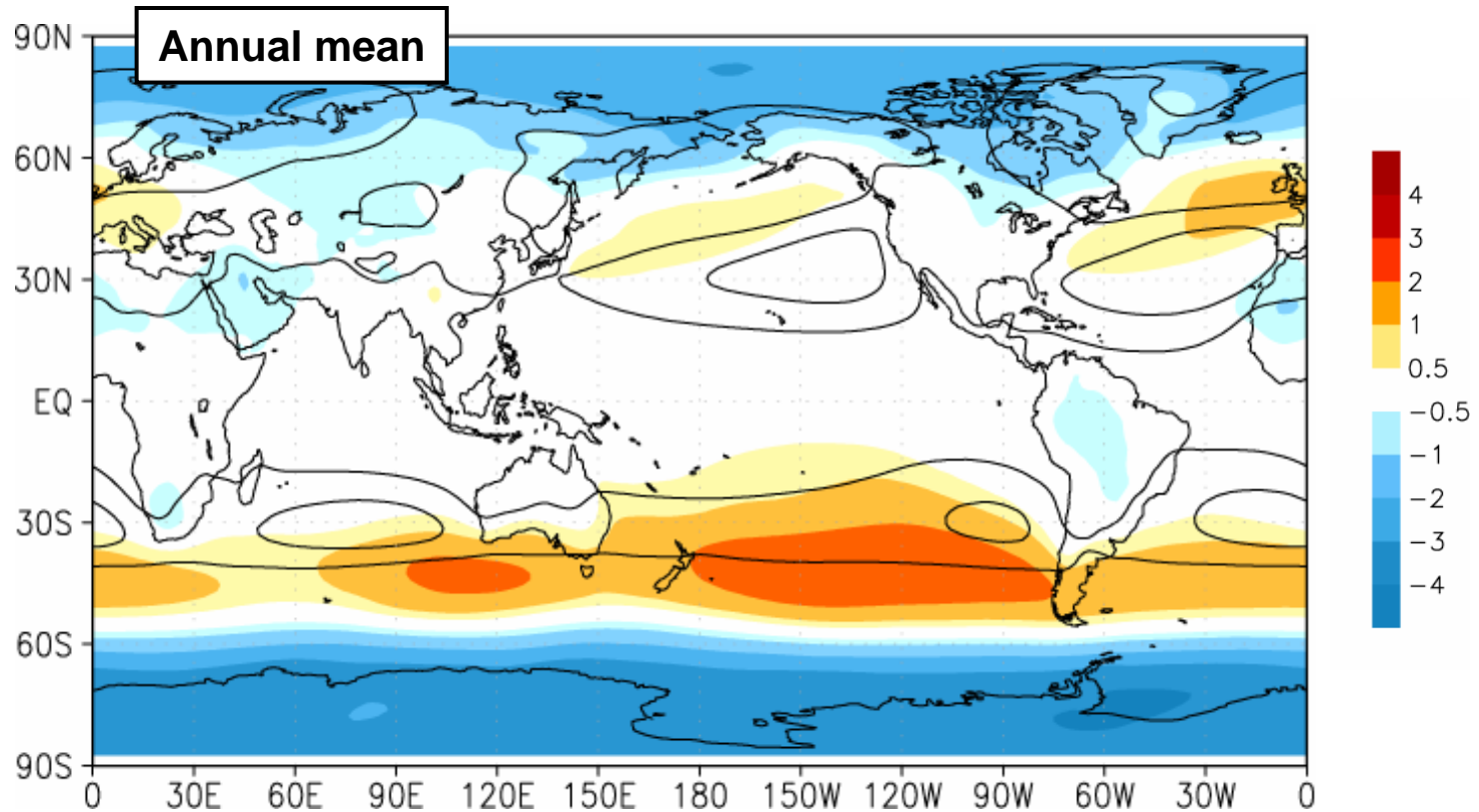


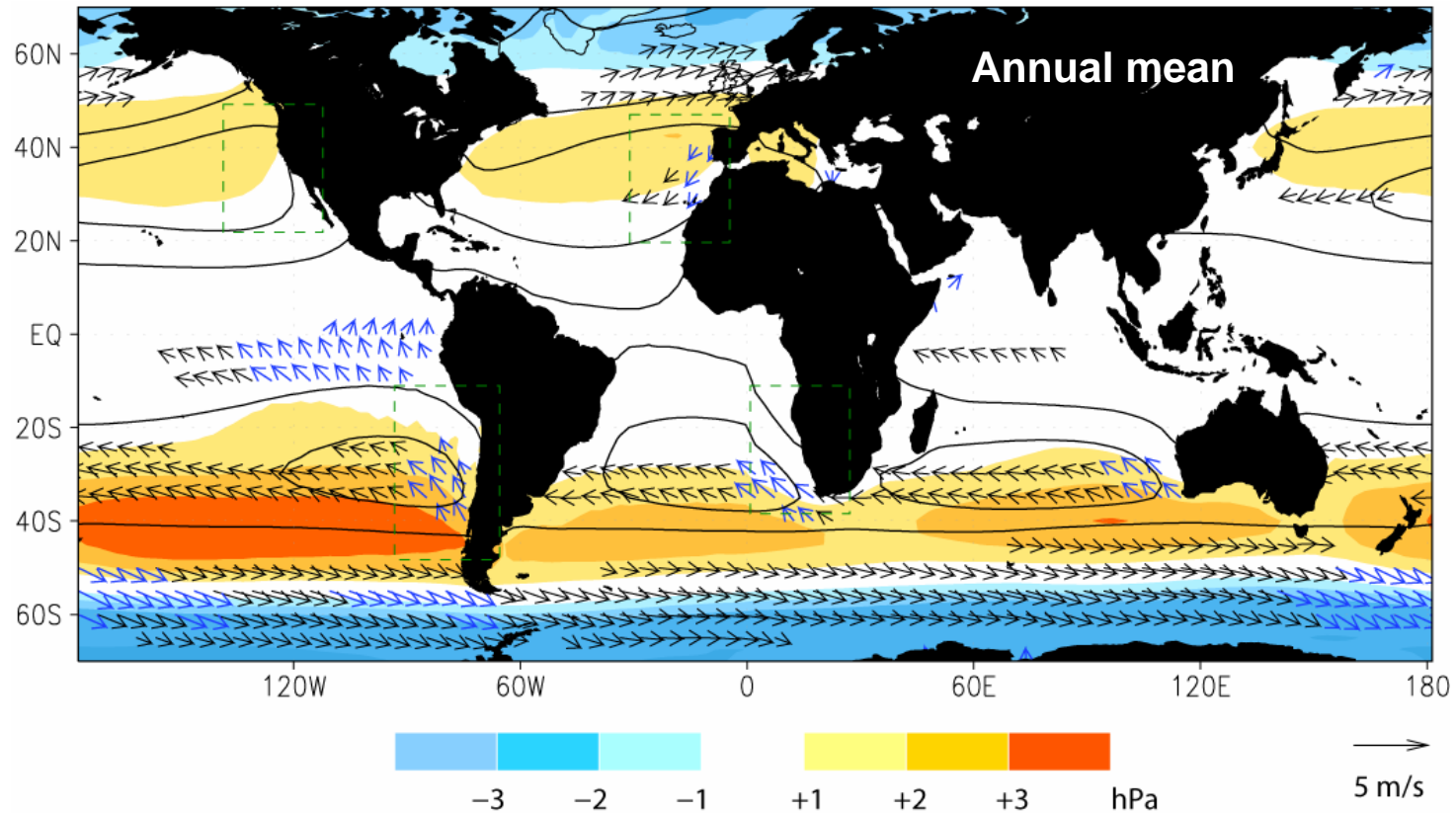
FIG. 12. Multimodel ensemble-mean tropical ocean thermal structure trends forced by increased CO₂ (shading) and reference (contours). (top) The thermocline depth changes. (bottom) The 2°S–2°N averaged temperature changes over the upper 500 m. Trends are the 19-model average of the linear least squares 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).

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

Precipitation and surface temperature Changes

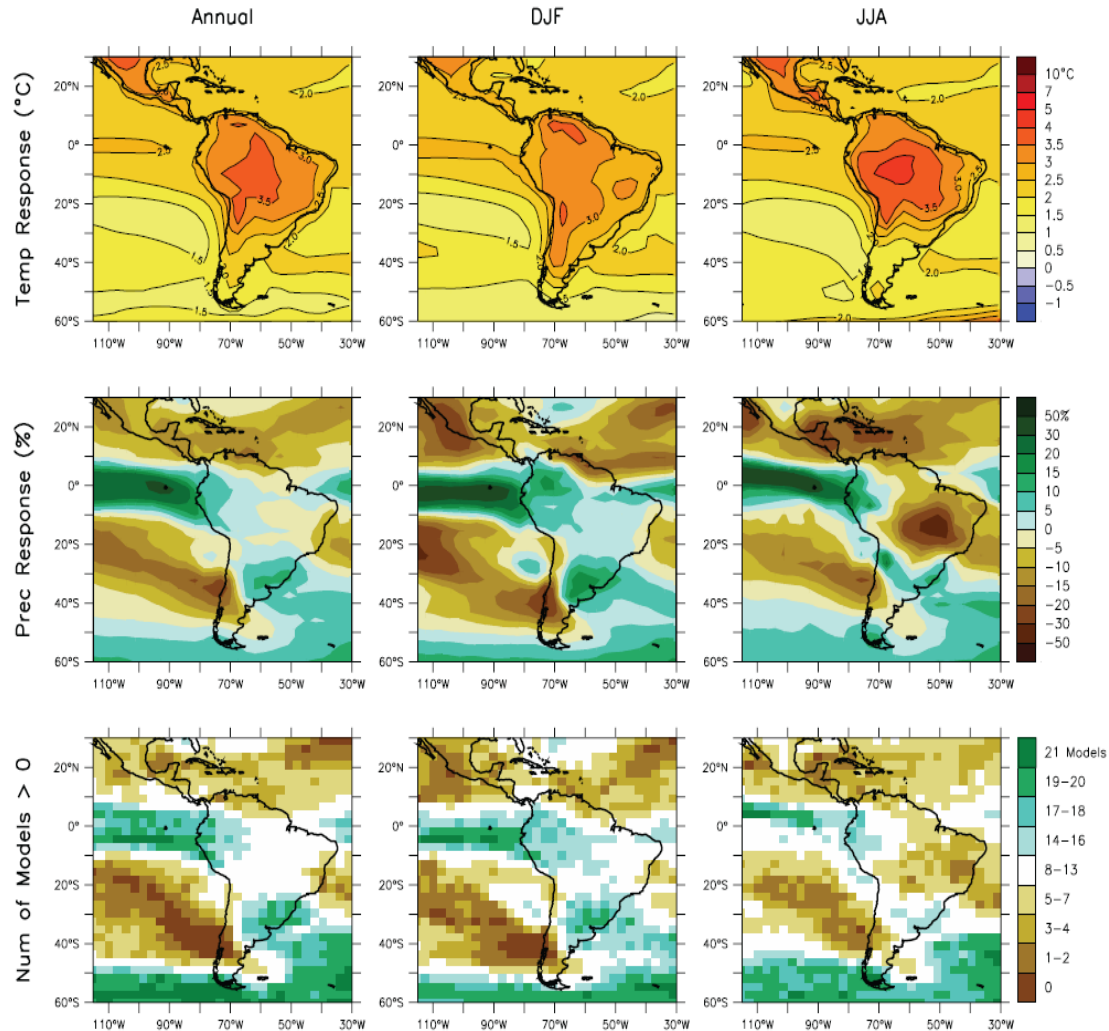
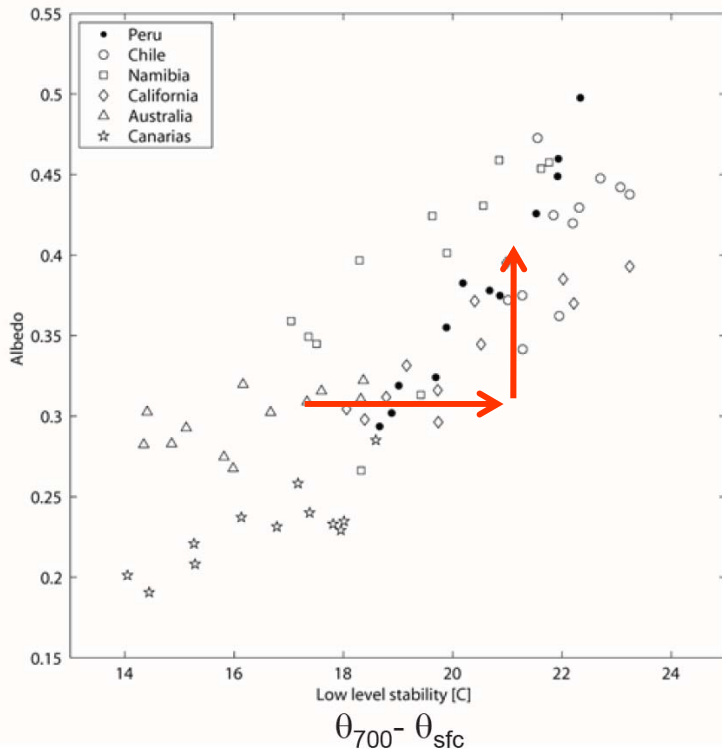


Figure 11.15. Temperature and precipitation changes over Central and South America from the MMD-A1B simulations. Top row: Annual mean, DJF and JJA temperature change between 1980 to 1999 and 2080 to 2099, averaged over 21 models. Middle row: same as top, but for fractional change in precipitation. Bottom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

Changes in subtropical low level cloudiness...most difficult

1

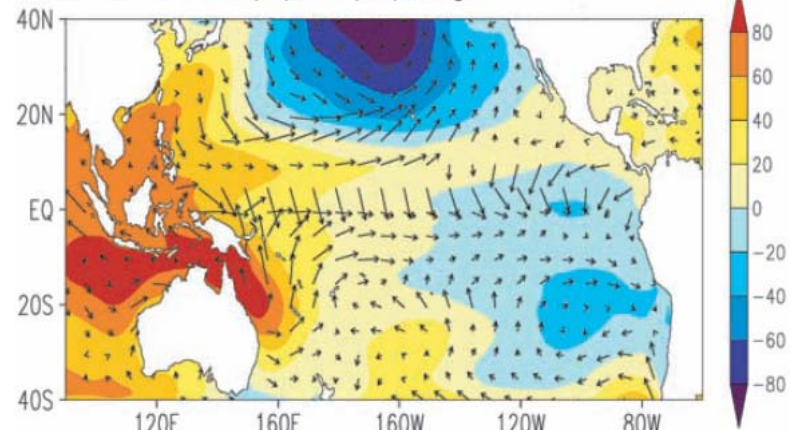
Subtropical low cloud amount



Warmer climate...more clouds

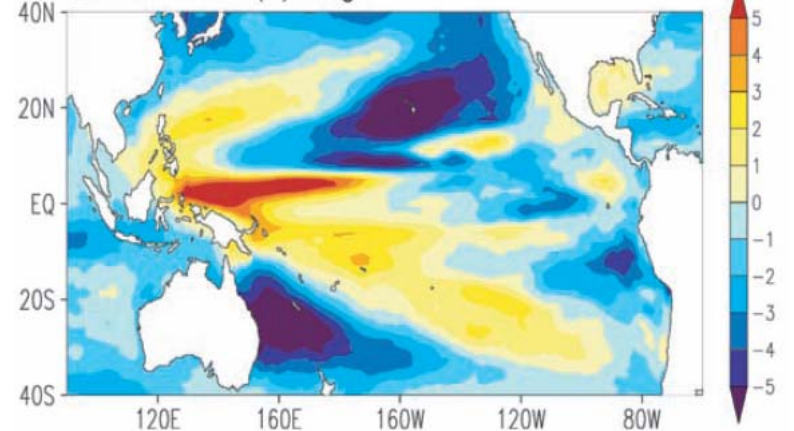
2

A HadGEM1 PSL (Pa), U, V (m/s) change



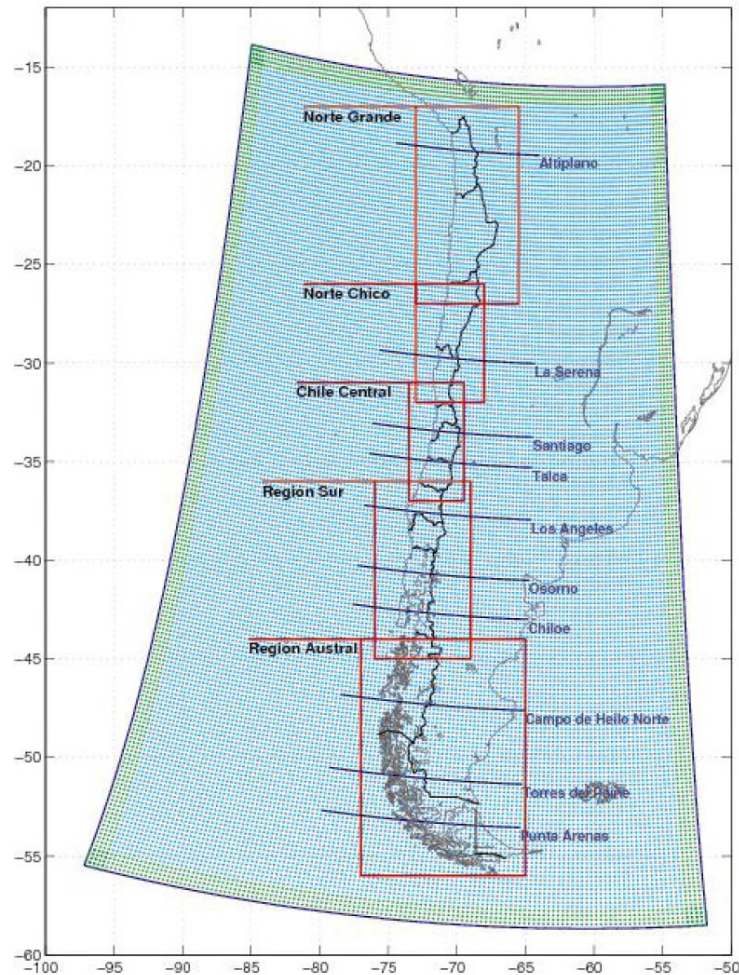
Warmer climate...less clouds

B HadGEM1 CLT (%) change



PRECIS Results

PRECIS (Providing REGIONAL Climates for Impact Studies)
(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?

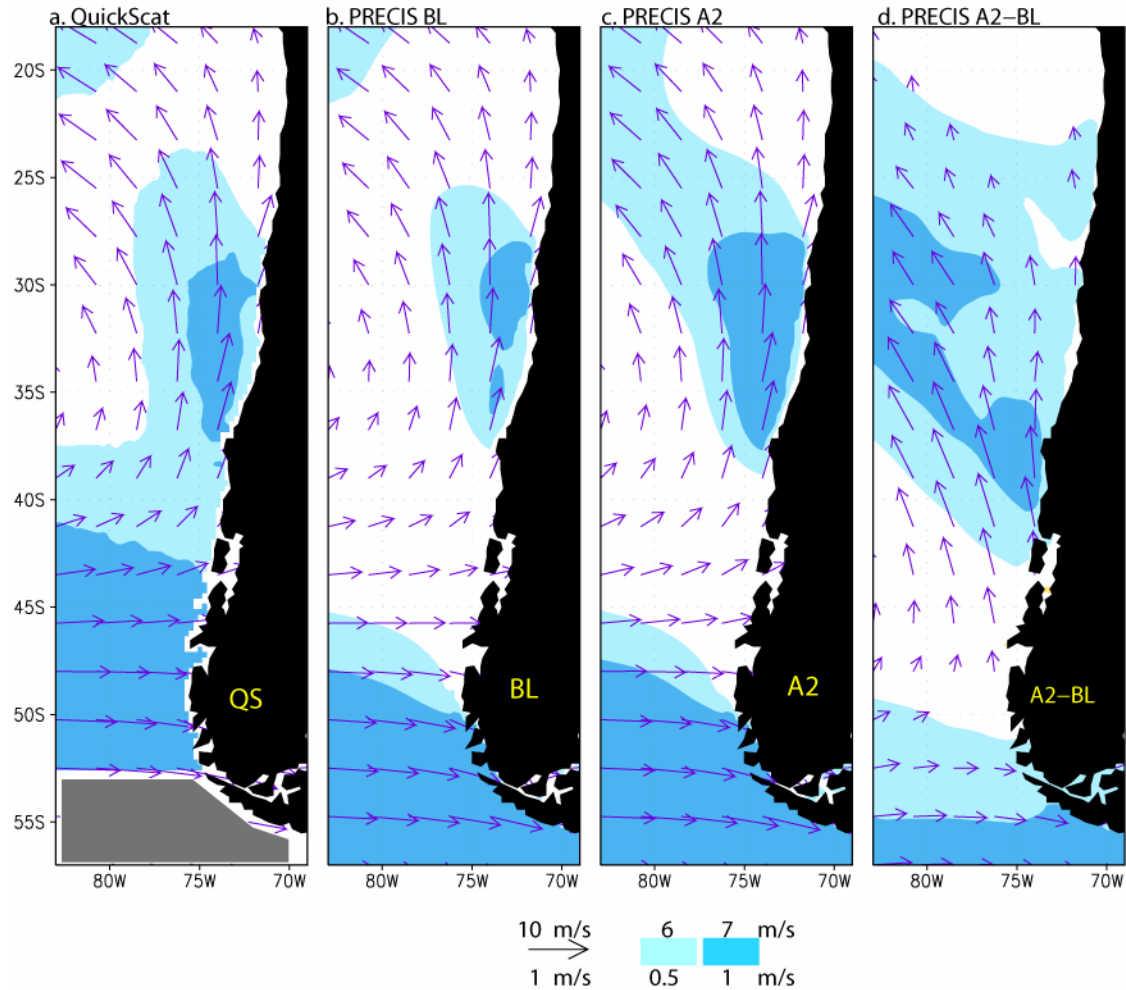
- CONAMA (Chile) needed results in 9 months

Where?

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

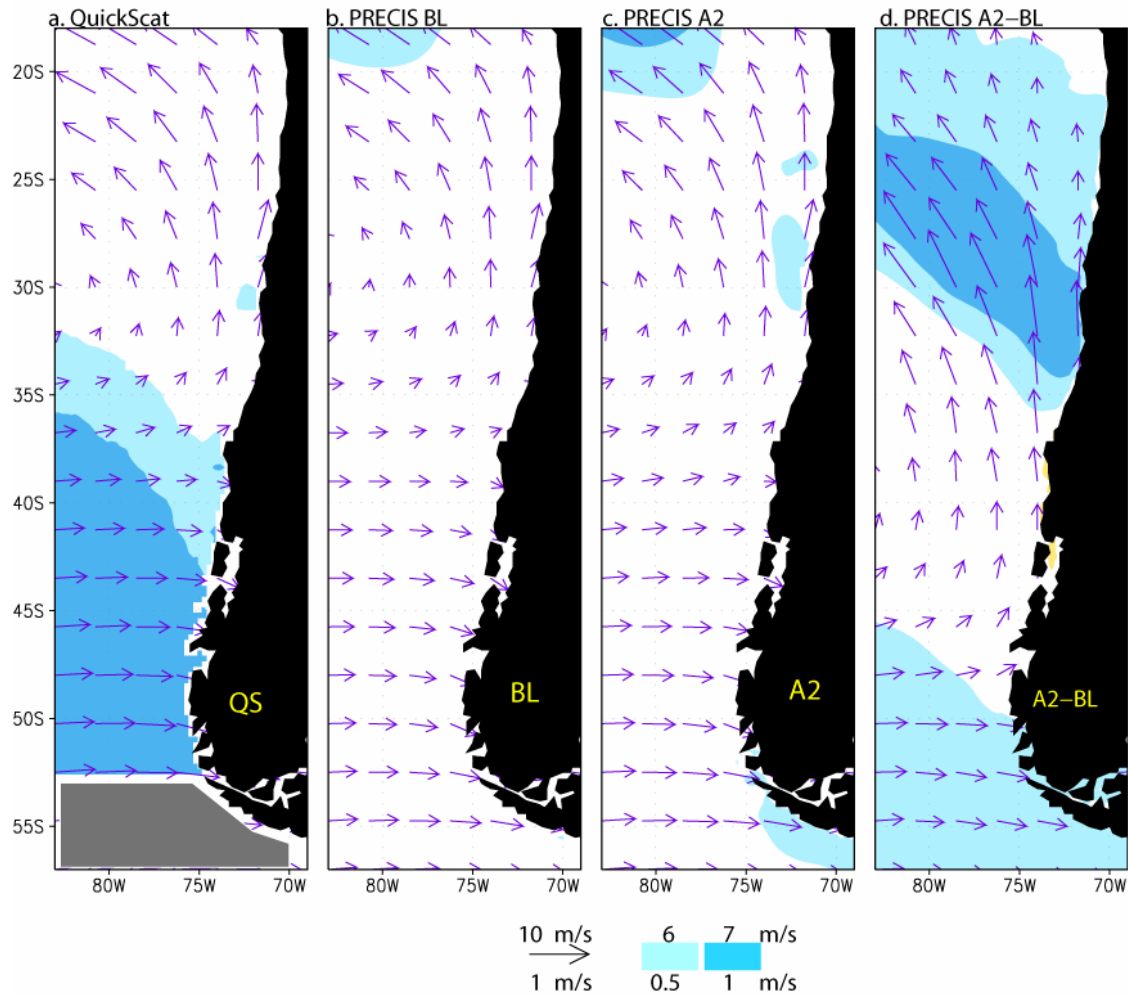
PRECIS Results

Surface Wind – SONDJ

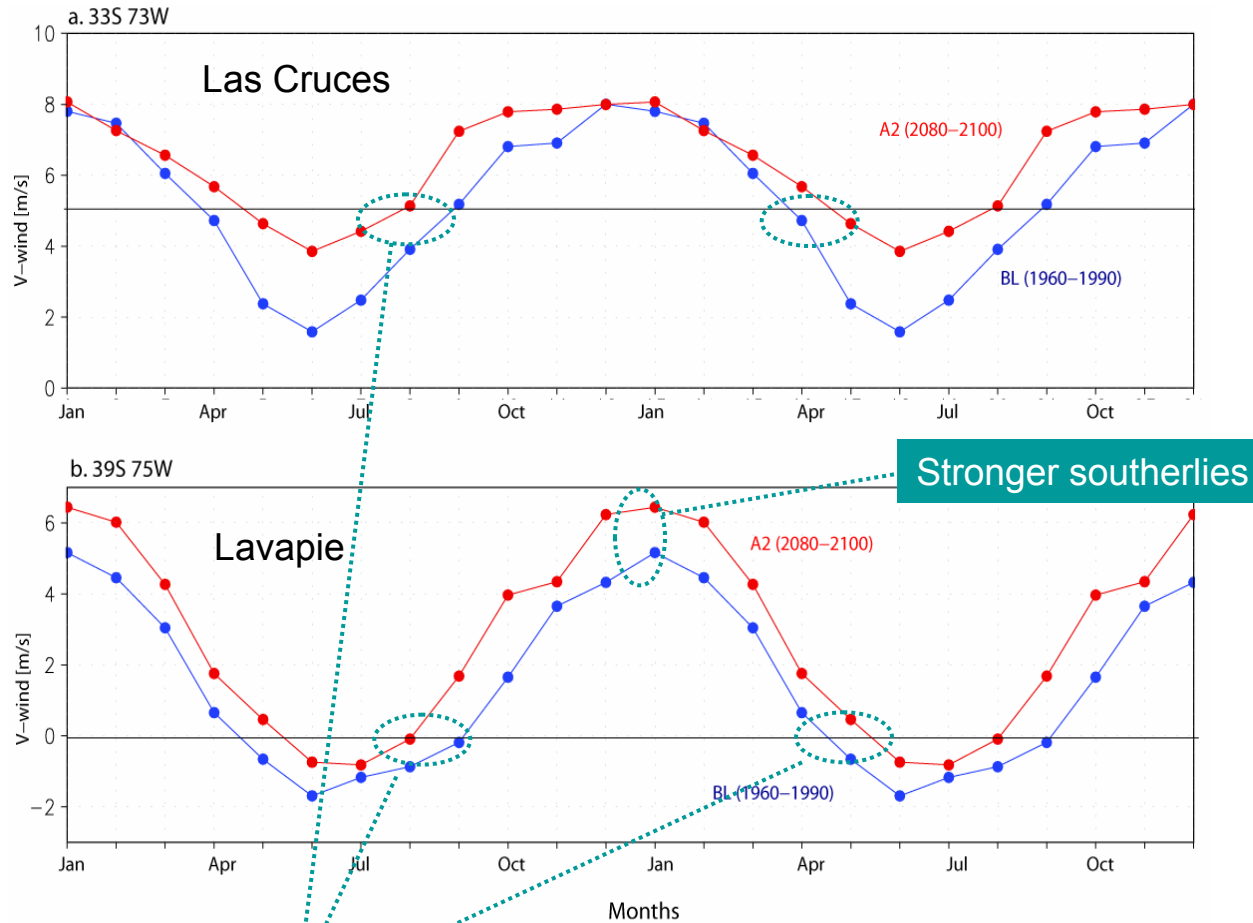


PRECIS Results

Surface Wind – AMJJA

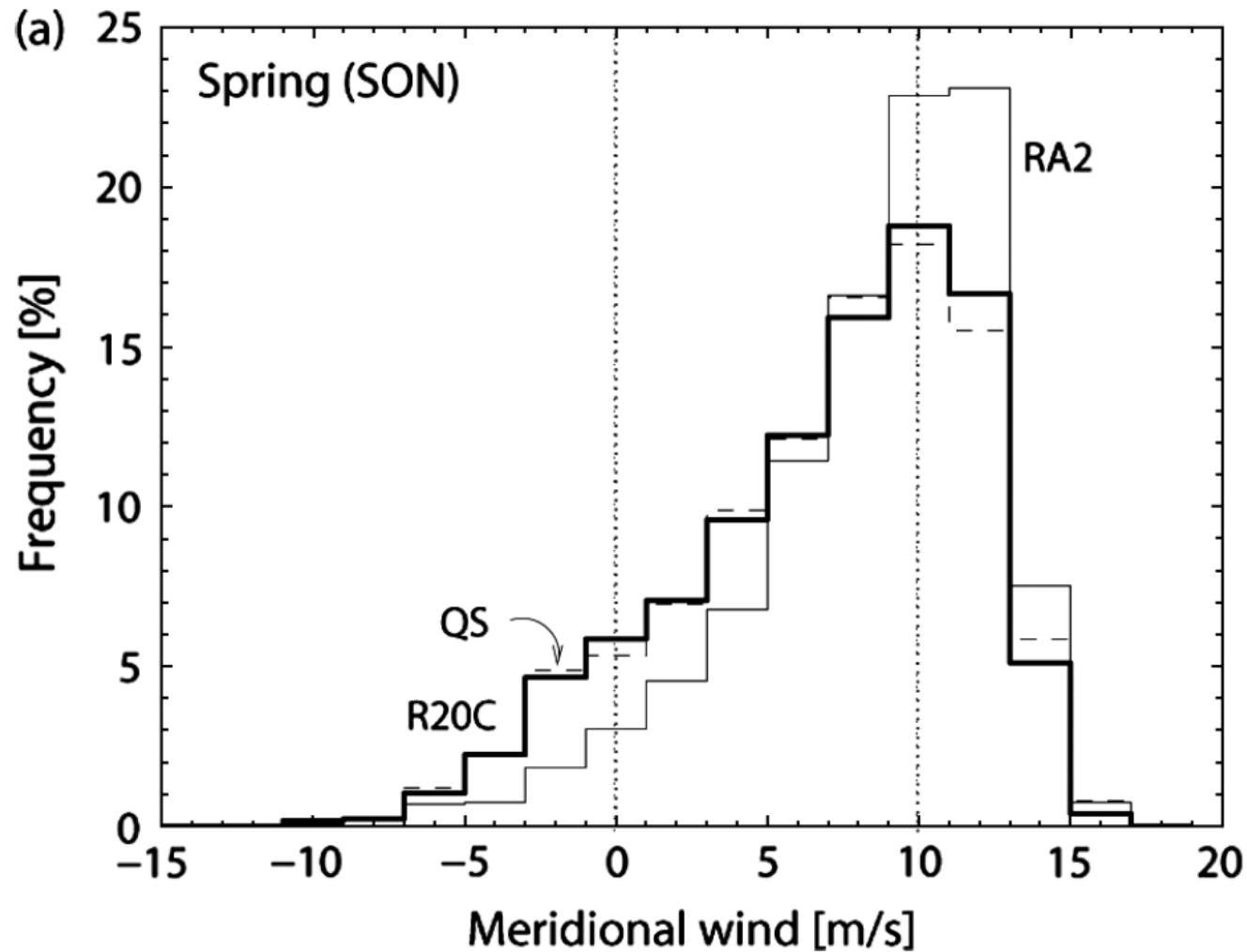


PRECIS Results



PRECIS Results

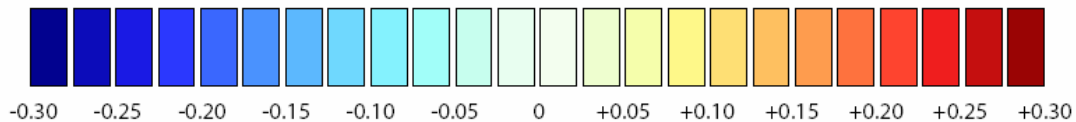
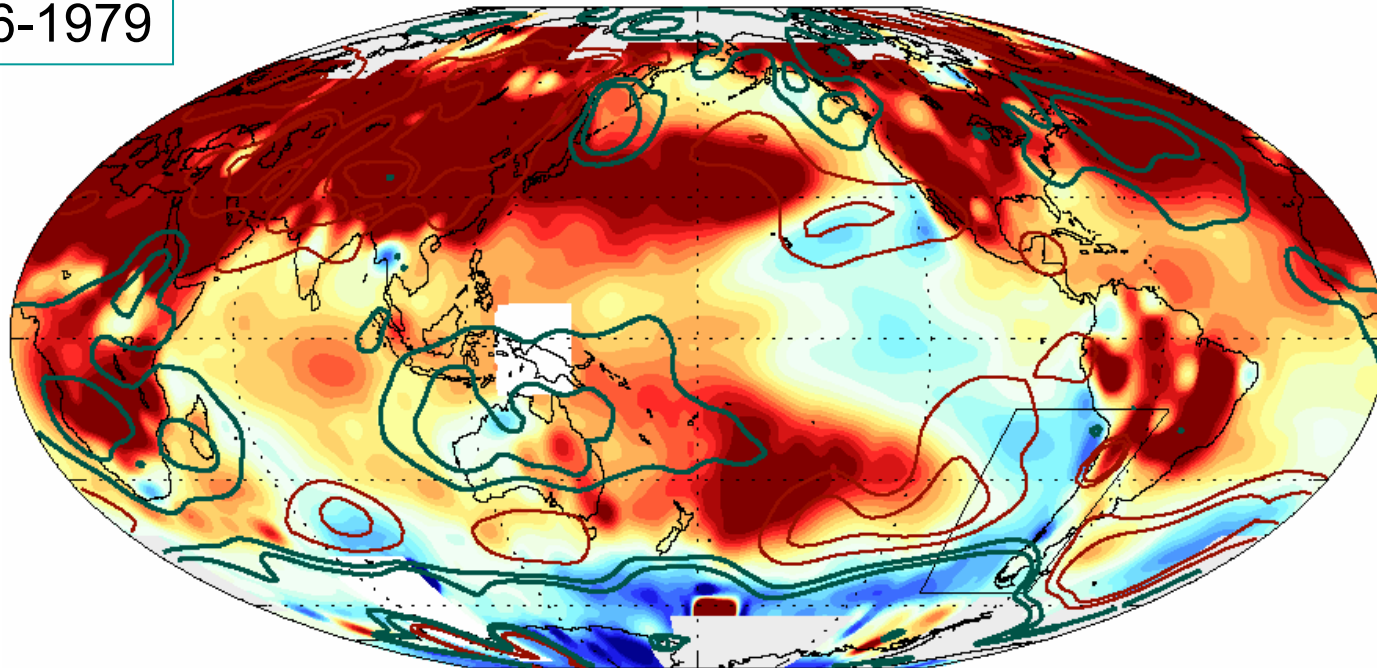
Frequency of surface meridional wind speed at 33°S 74°W



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

2006-1979

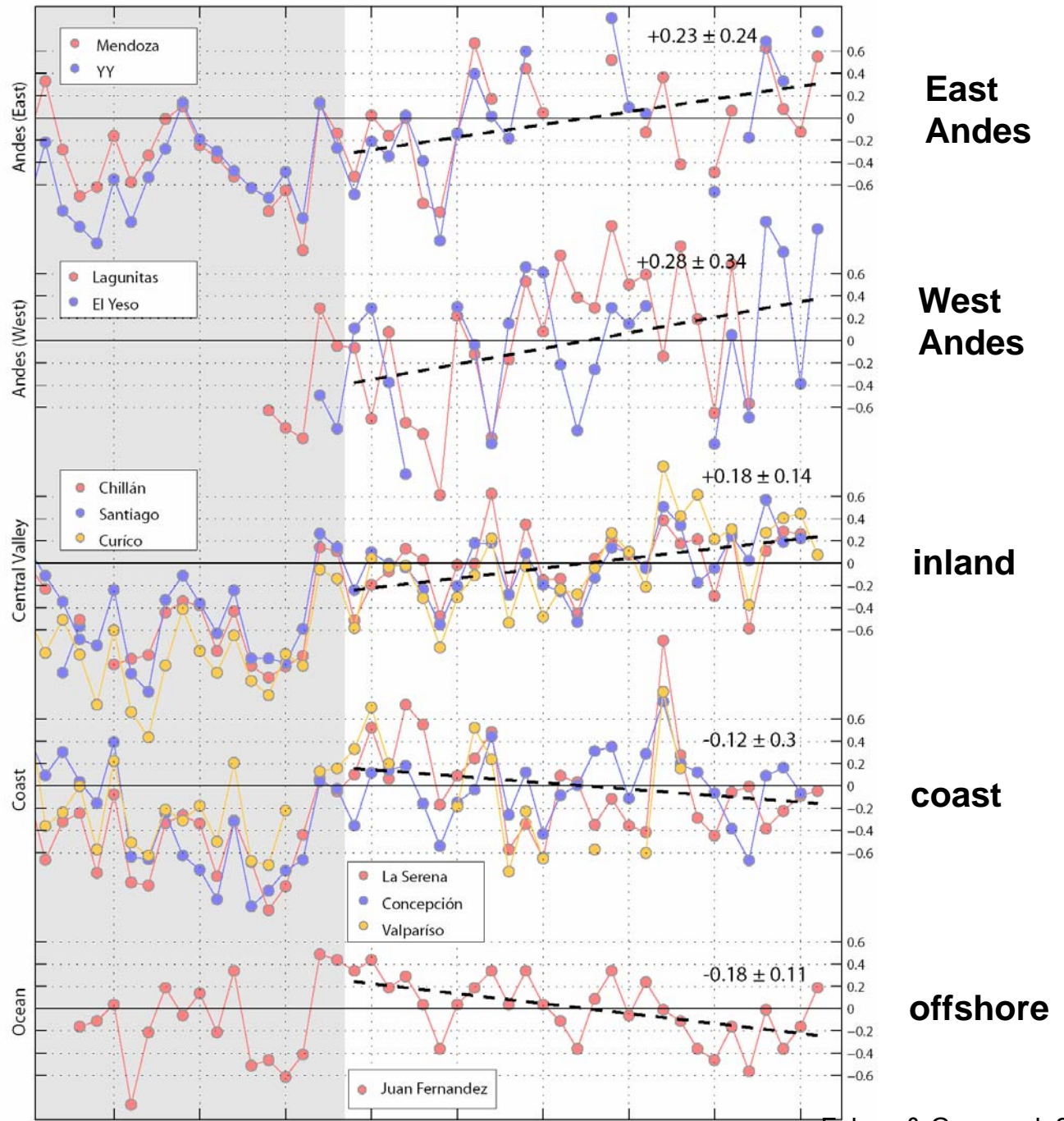
Surface Air Temperature and SST (NCDC)



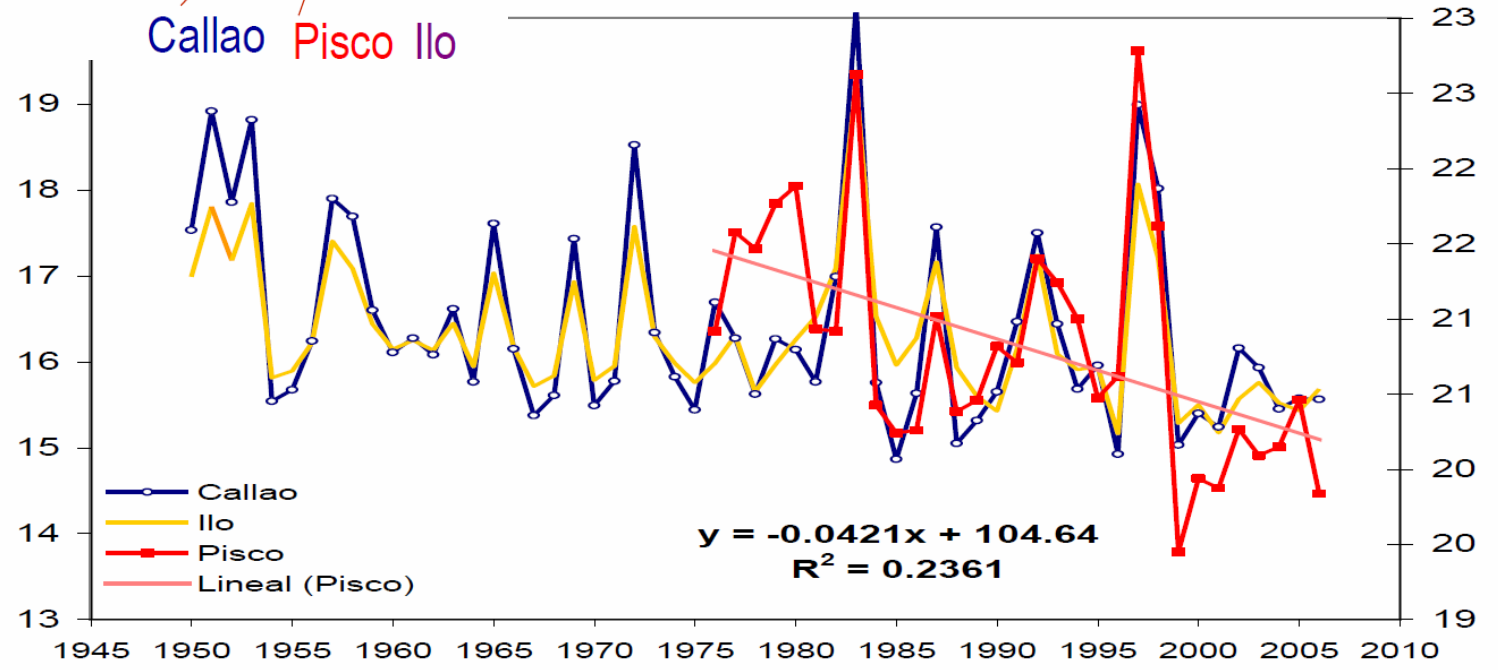
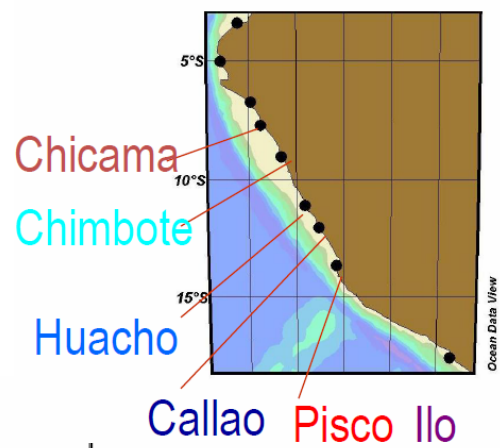
Temperature Tendency 1979-2006 ($^{\circ}$ / decade)

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

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

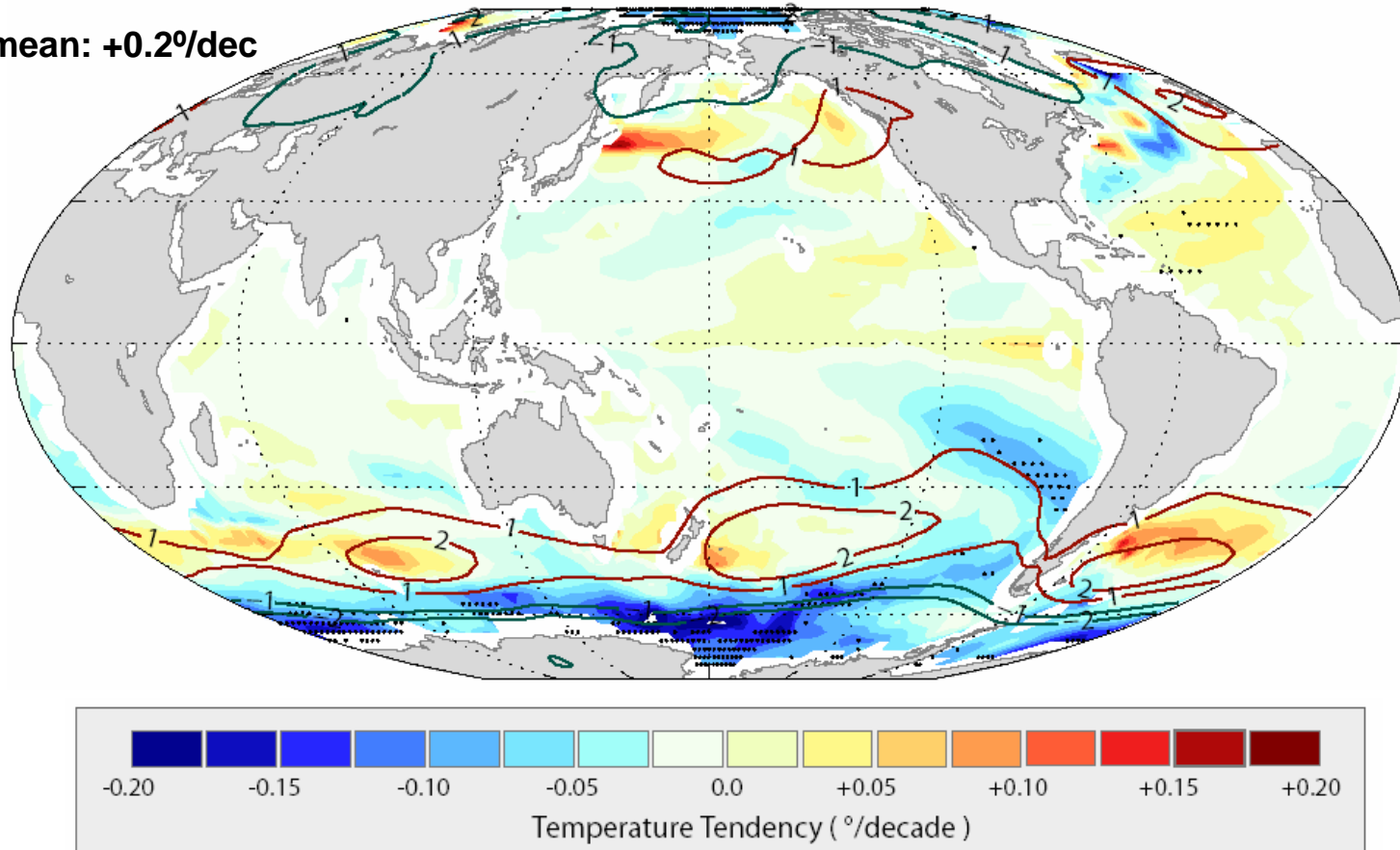


Is the regional cooling of the Humboldt EBUS already taking place?



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

Global mean: $+0.2^\circ/\text{dec}$



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

Conclusiones

- Un clima más cálido tiende a generar condiciones tipo El Niño en el Pacífico 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 presión 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 más estables y eventos más intensos en zona central.
 - Respuesta oceanográfica & biológica incierta...modelación acoplada
- Enfriamiento costero en las últimas tres décadas ($0.25^{\circ}\text{C}/\text{década}$) 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

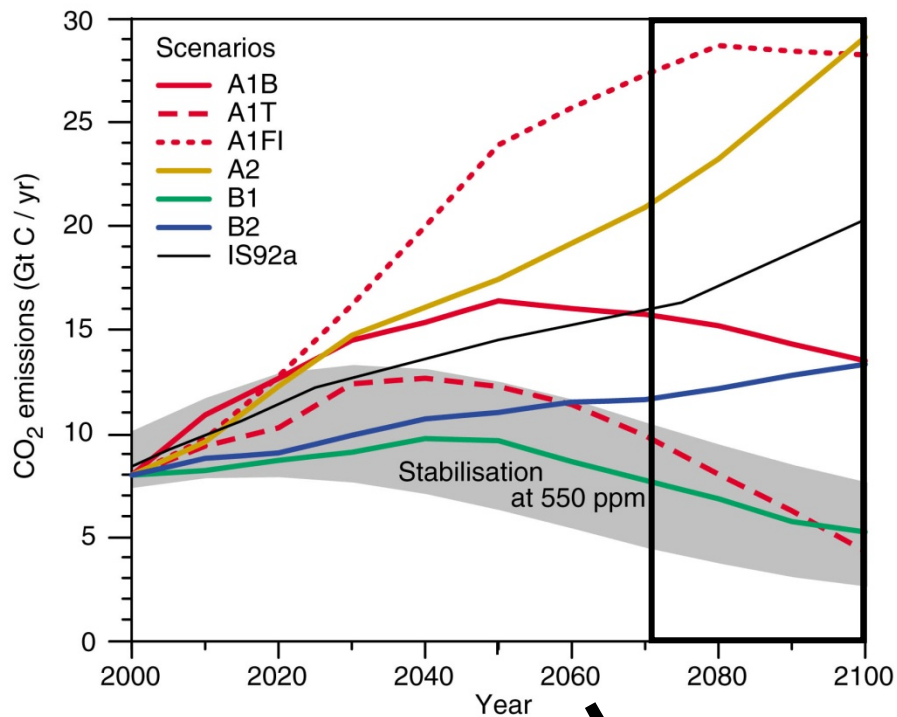
Vecchi, G. and Soden, B.: Global warming and the weakening of the tropical circulation. *Journal of Climate*, **20**, 4316-4340, 2007.

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

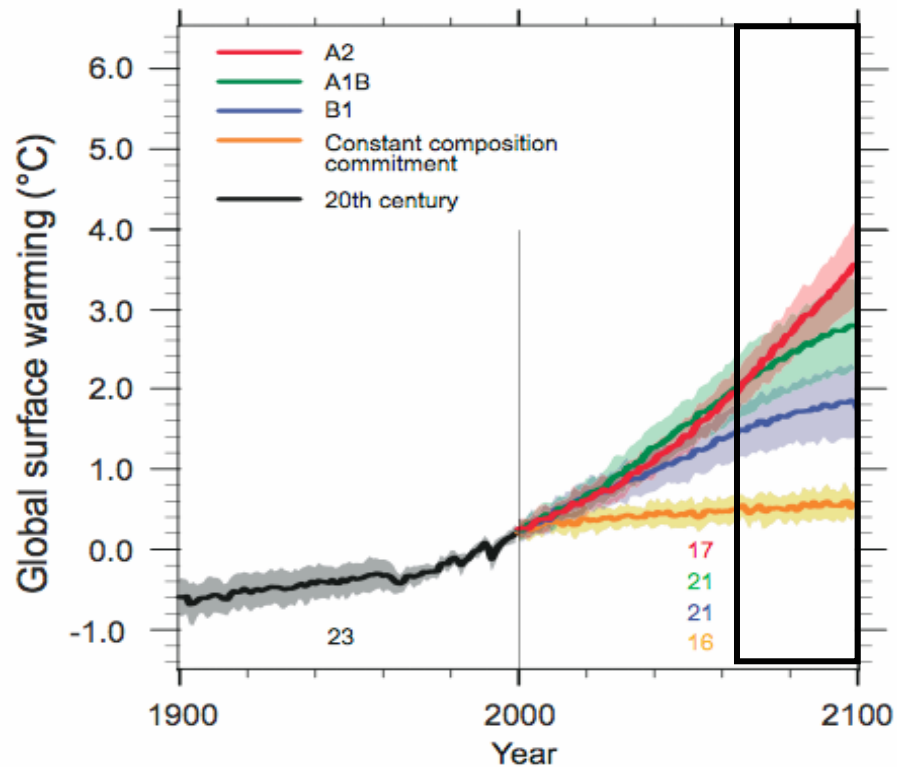
Material de apoyo

Future Climate Scenarios

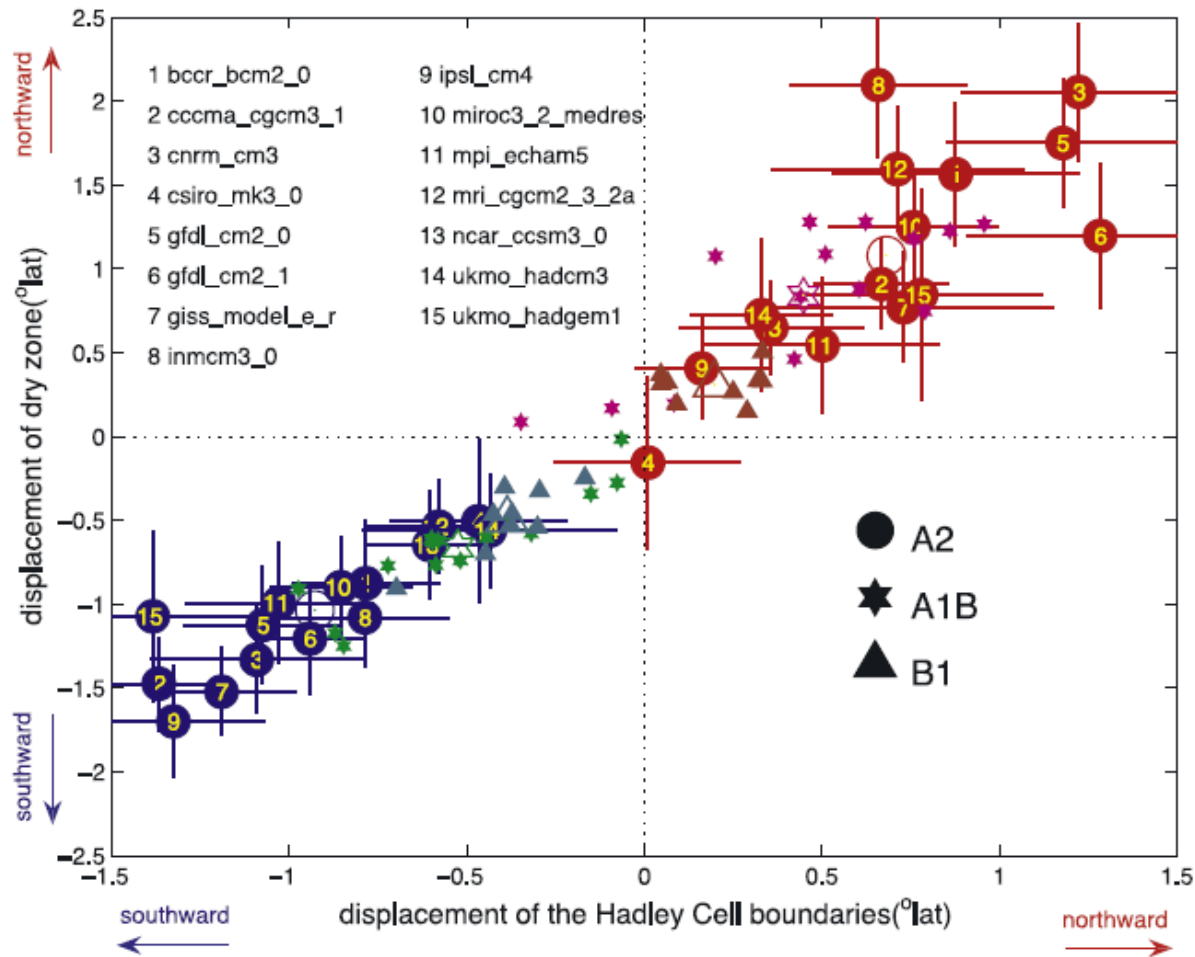
GHG (CO₂,...) emissions projections + GCMs



20+ GCMs
CMIP3/IPCC AR4



Poleward expansion of the Hadley cell



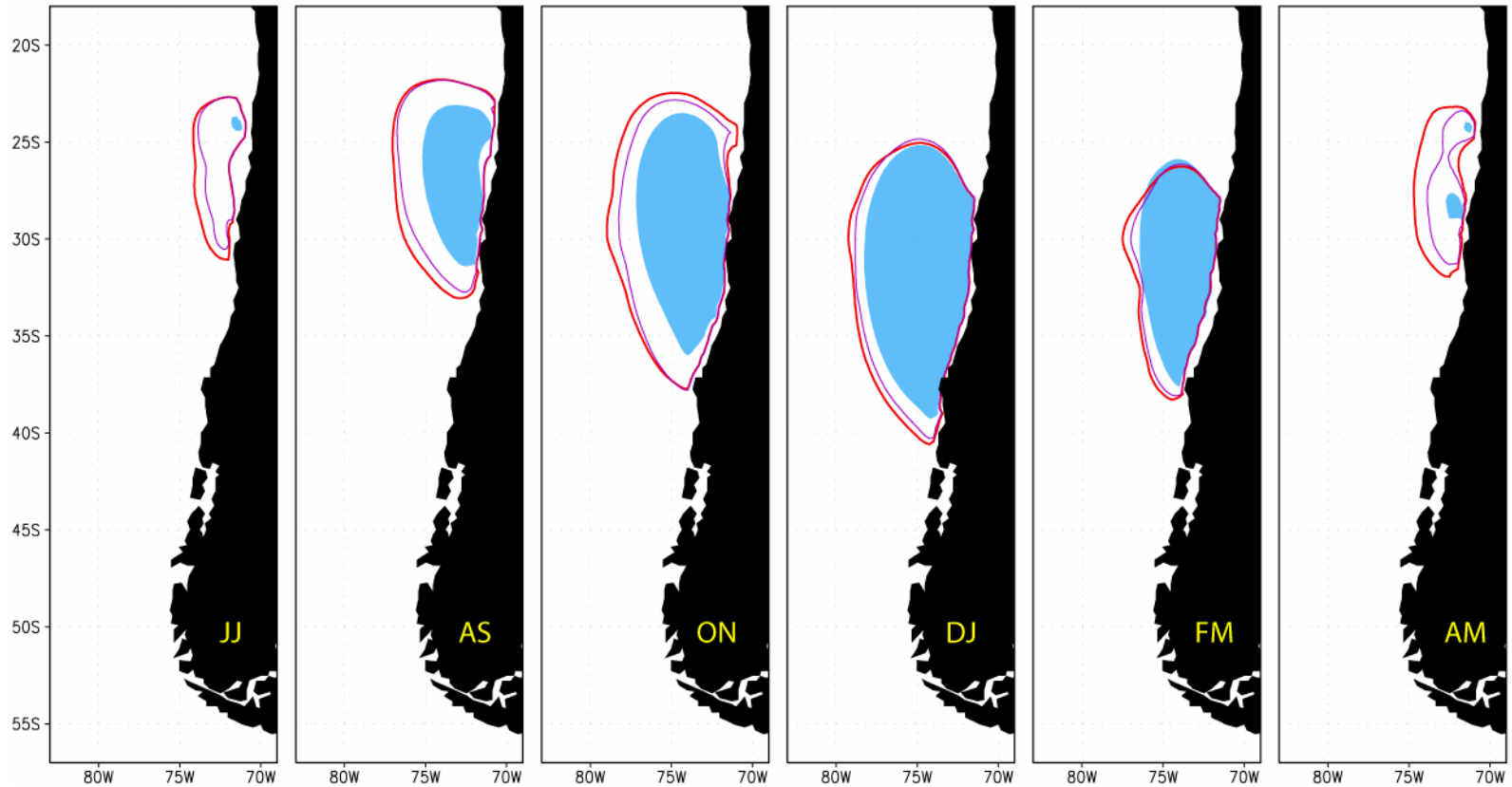
PRECIS Results

10-m Meridional wind – Outlines of $v > 6$ m/s

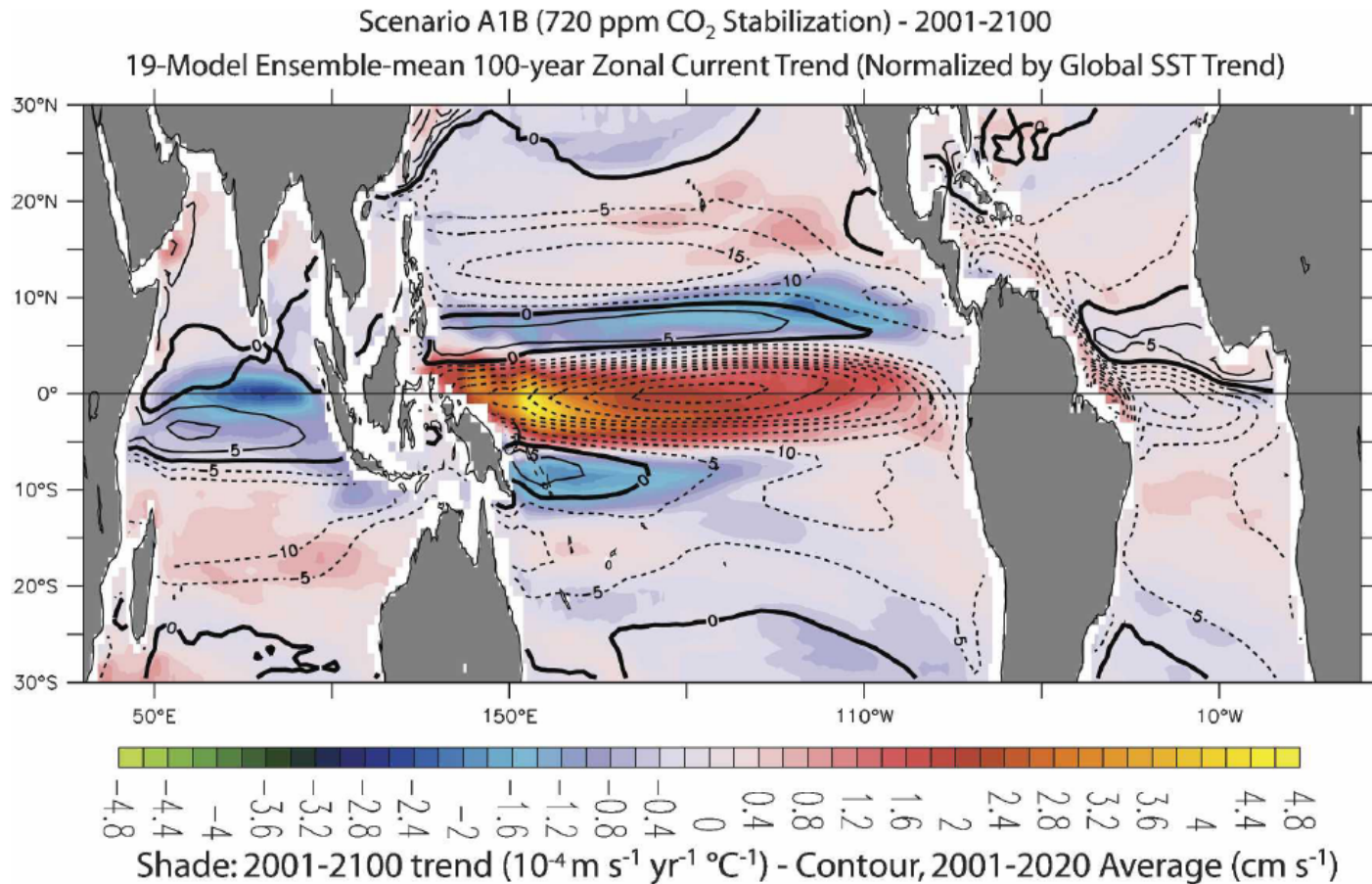
Baseline (1960–1990)

B2 (2070–2100)

A2 (2070–2100)

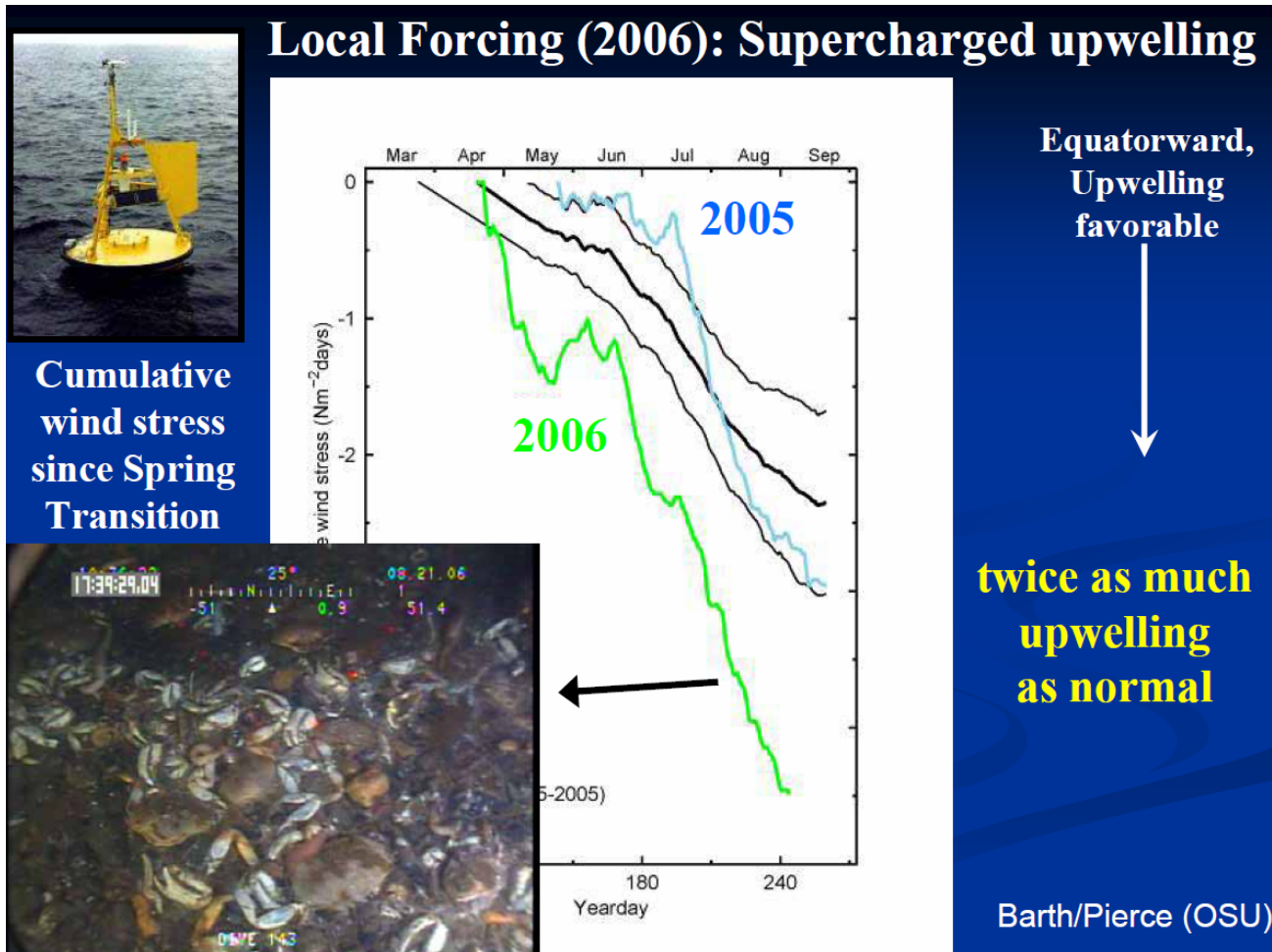


Multimodel average zonal trend 2000 - 2100 (A1B)



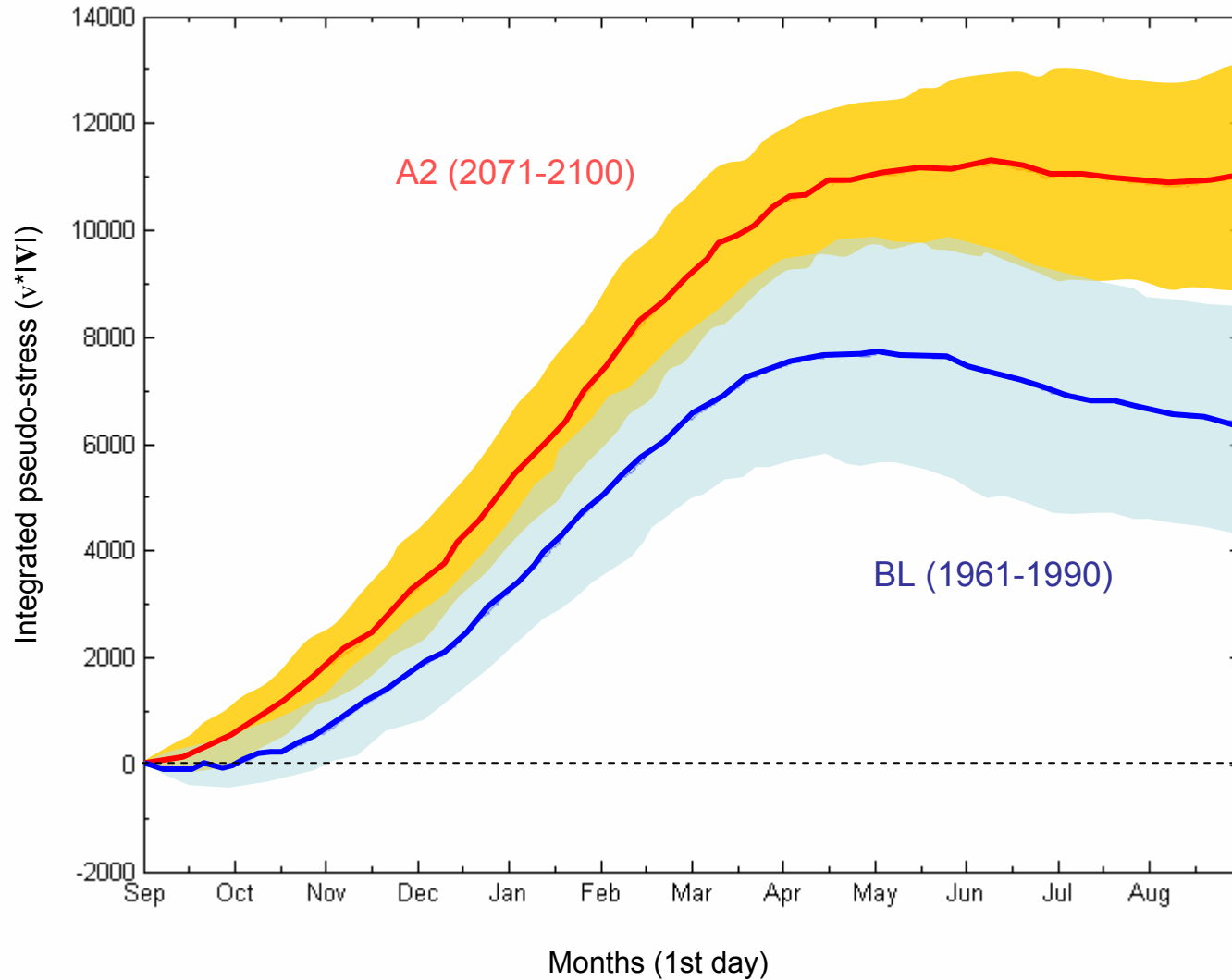
PRECIS Results

Entonces...mas surgencia en el futuro...que bueno!
Parece que no tanto ☹



PRECIS Results

PRECIS simulations – 39°S 75°W



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Temperature trends 1979-2006

