

Cambio Climático Global: Impactos físicos en Chile

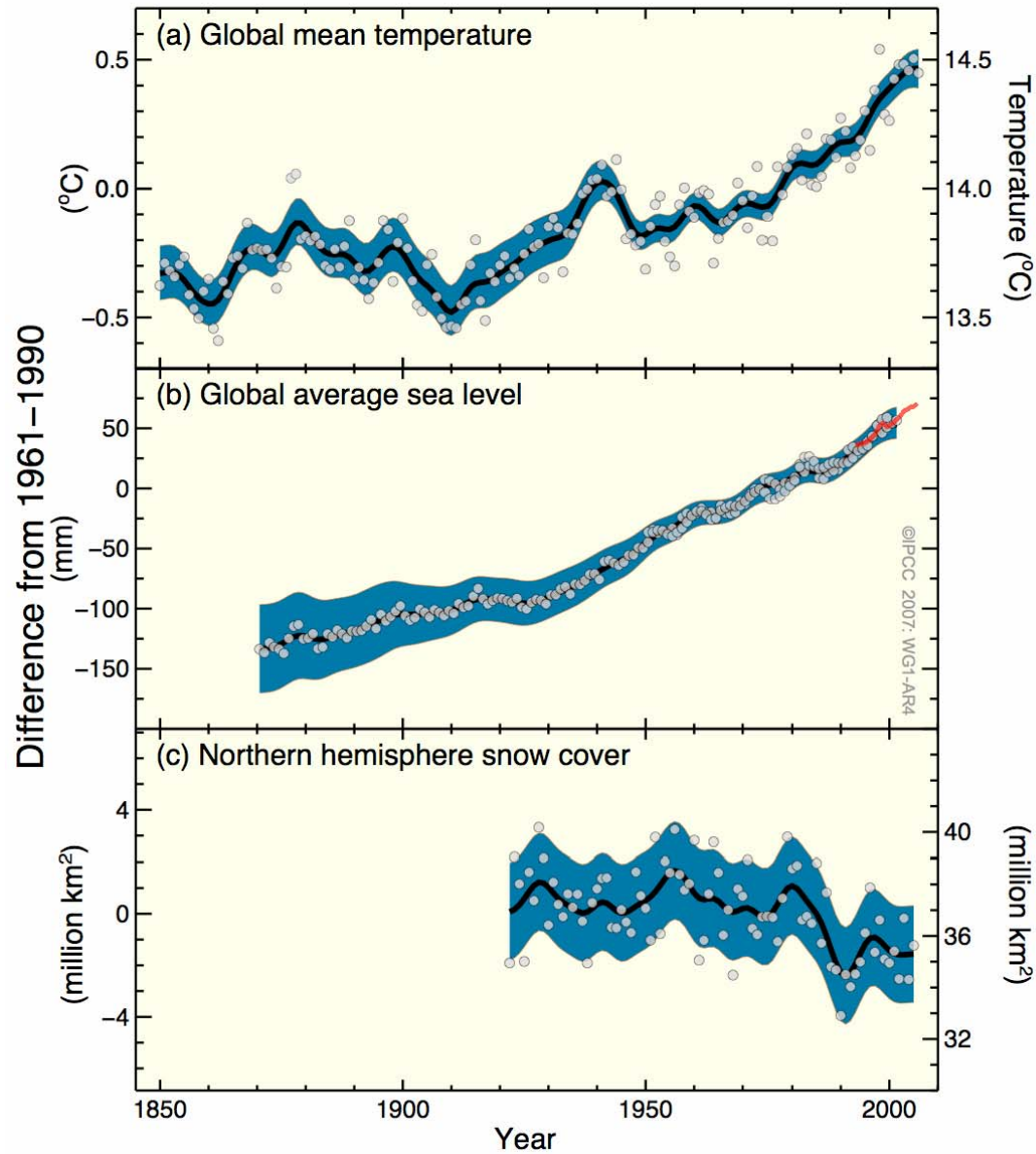
Talleres sectoriales
Fundación PUC-COPEC
Octubre 2007

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Temario

1. Cambios en el siglo XX: Global /Regional
2. Pronóstico para mañana
3. Impactos físicos en algunos sectores

Changes in Temperature , Sea Level and Northern Hemisphere Snow Cover



$$\partial T_{sfc} / \partial t$$

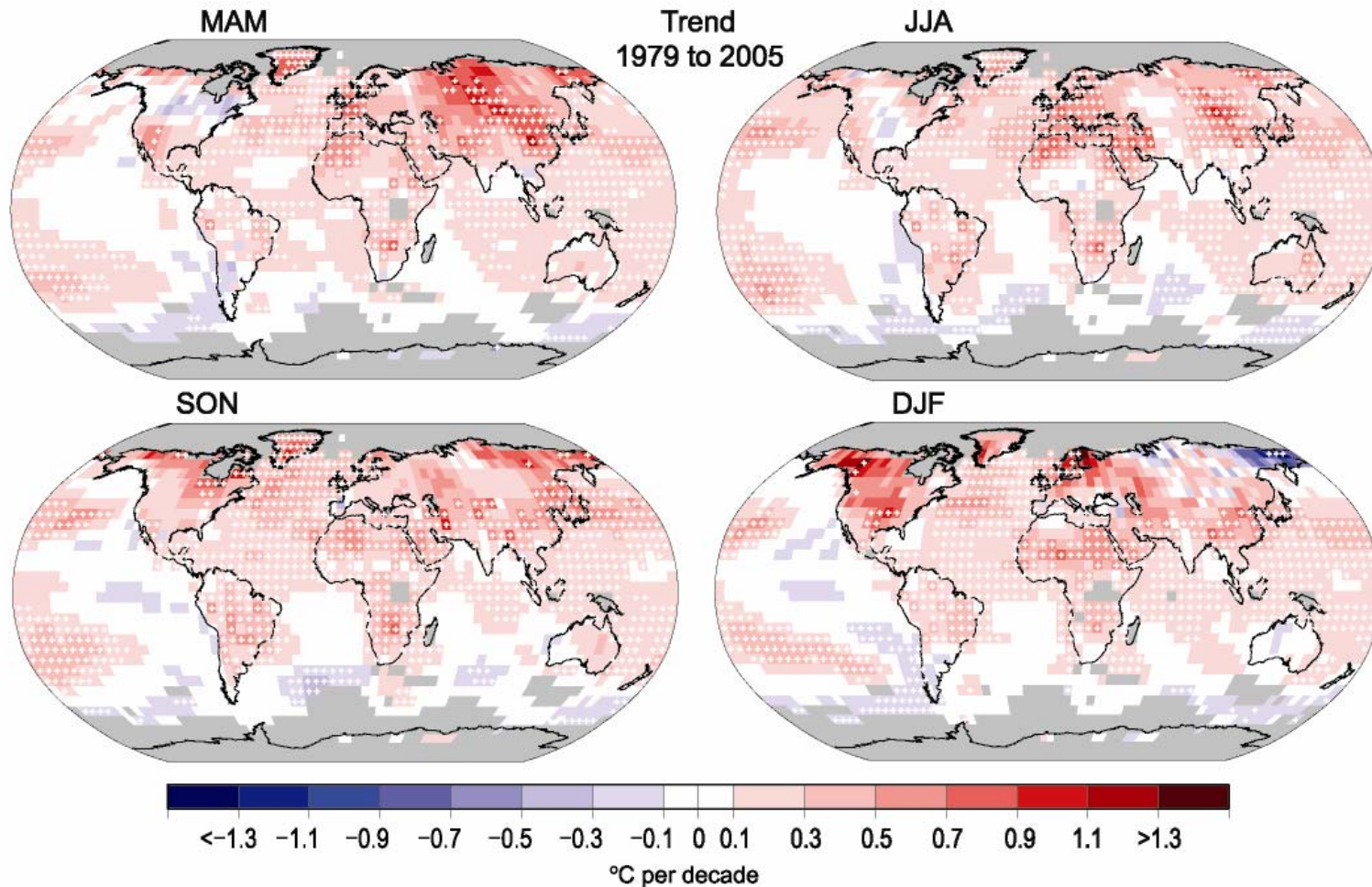
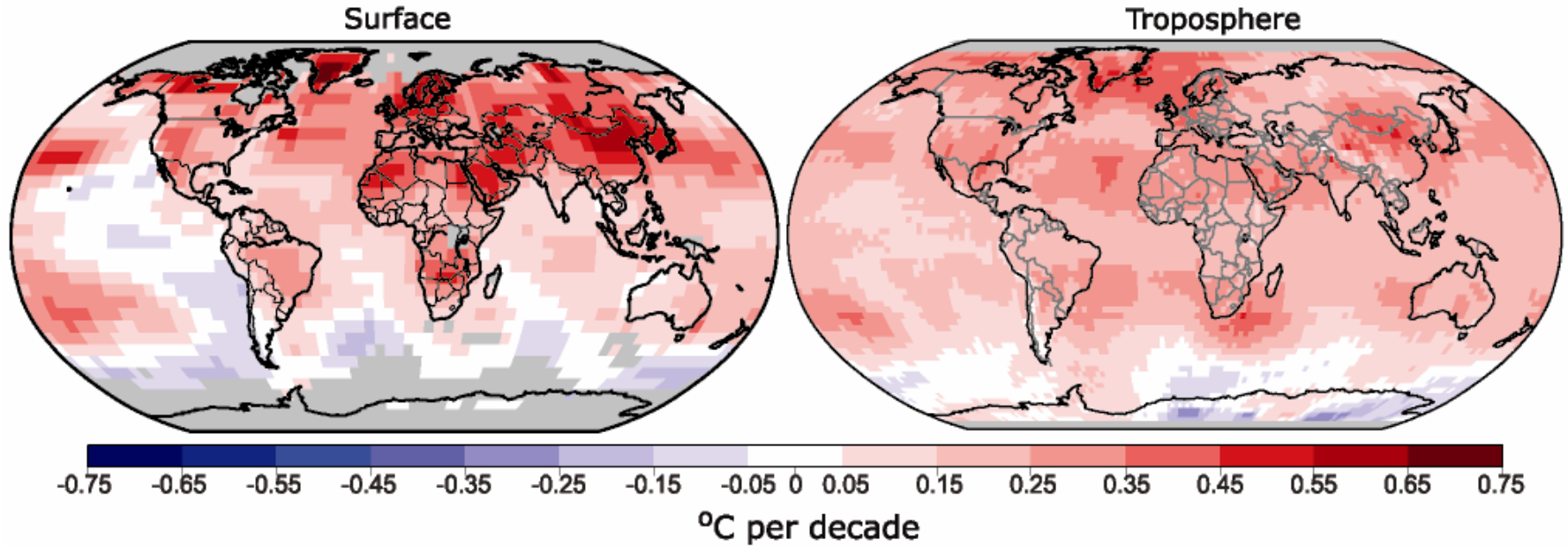


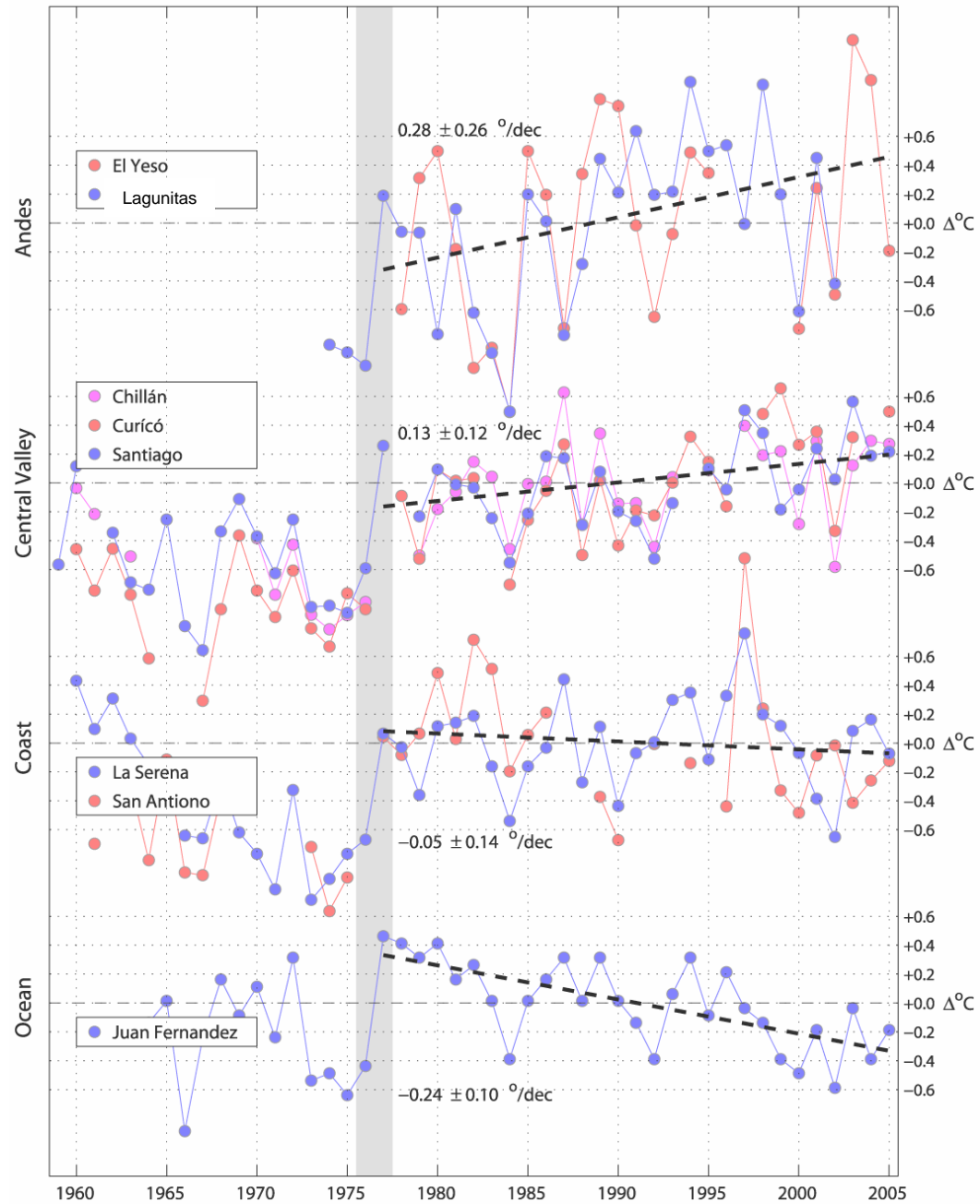
Figure 3.10. Linear trend of seasonal MAM, SON and DJF temperature for 1979 to 2005 (°C per decade). Areas in grey have insufficient data to produce reliable trends. The minimum number of years required to calculate a trend value is 18. A seasonal value is available if there are two valid monthly temperature anomaly values. The data used was produced by NCDC from Smith and Reynolds (2005). Trends significant at the 5% level are indicated by white + marks.

$$\partial T / \partial t \quad 1979-2005$$



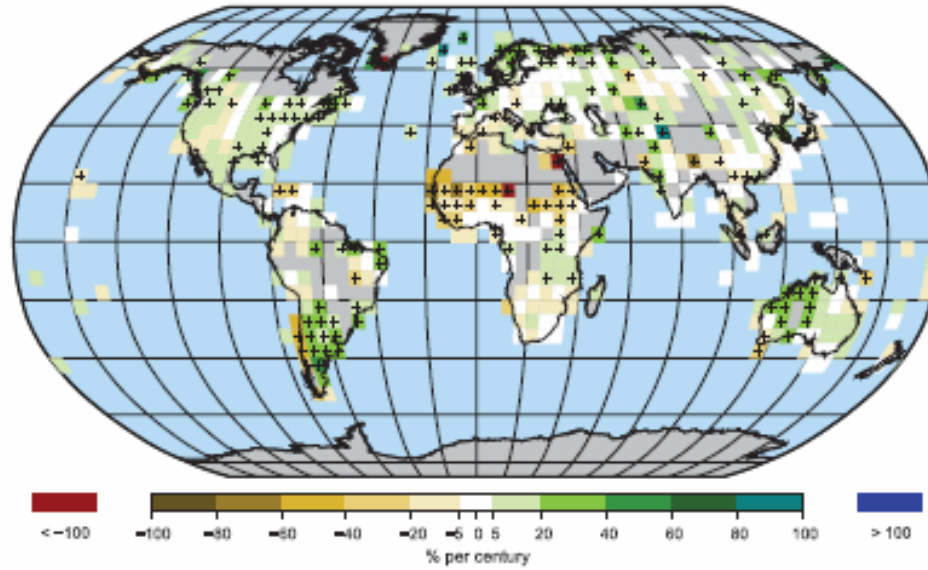
Patterns of linear global temperature trends from 1979-2005 estimated at the surface (left) and for the troposphere (right) from surface to about 10 km altitude, from satellite records.

Central Chile Temperatures

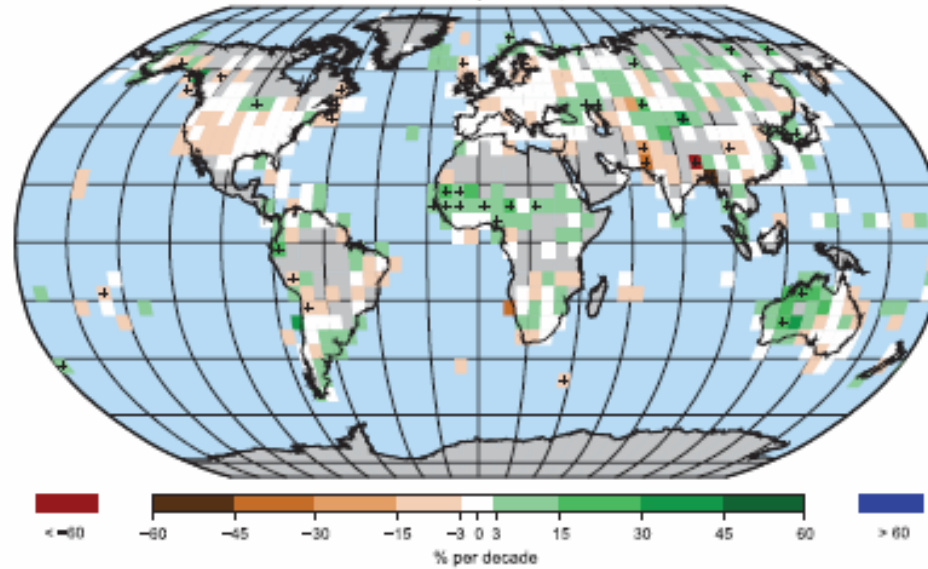


$$\partial R / \partial t$$

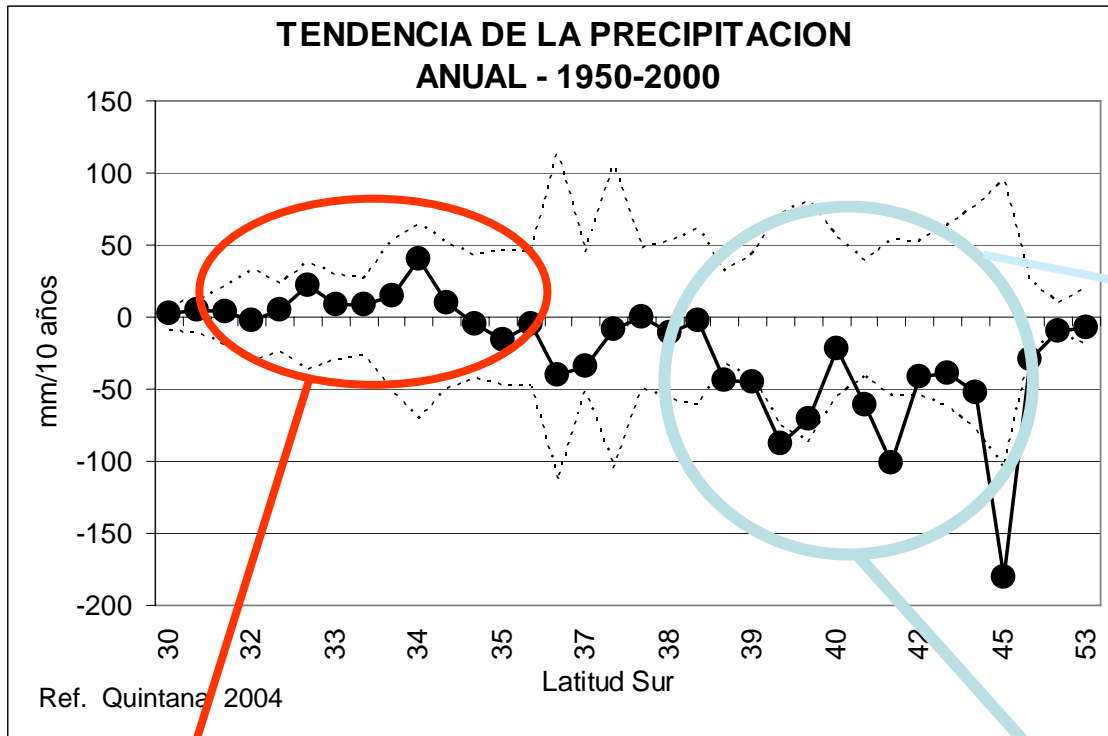
Trend in Annual Precipitation, 1901 to 2005



Trend in Annual Precipitation, 1979 to 2005

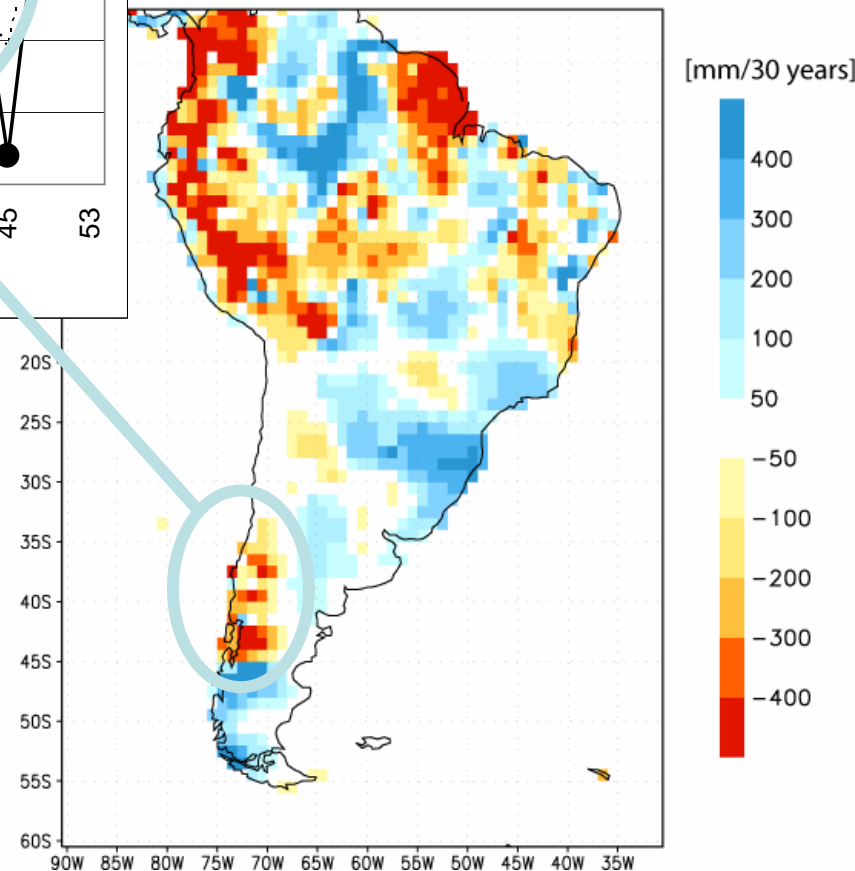


Cambios absolutos en precipitación



- 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



Cambios relativos en precipitación

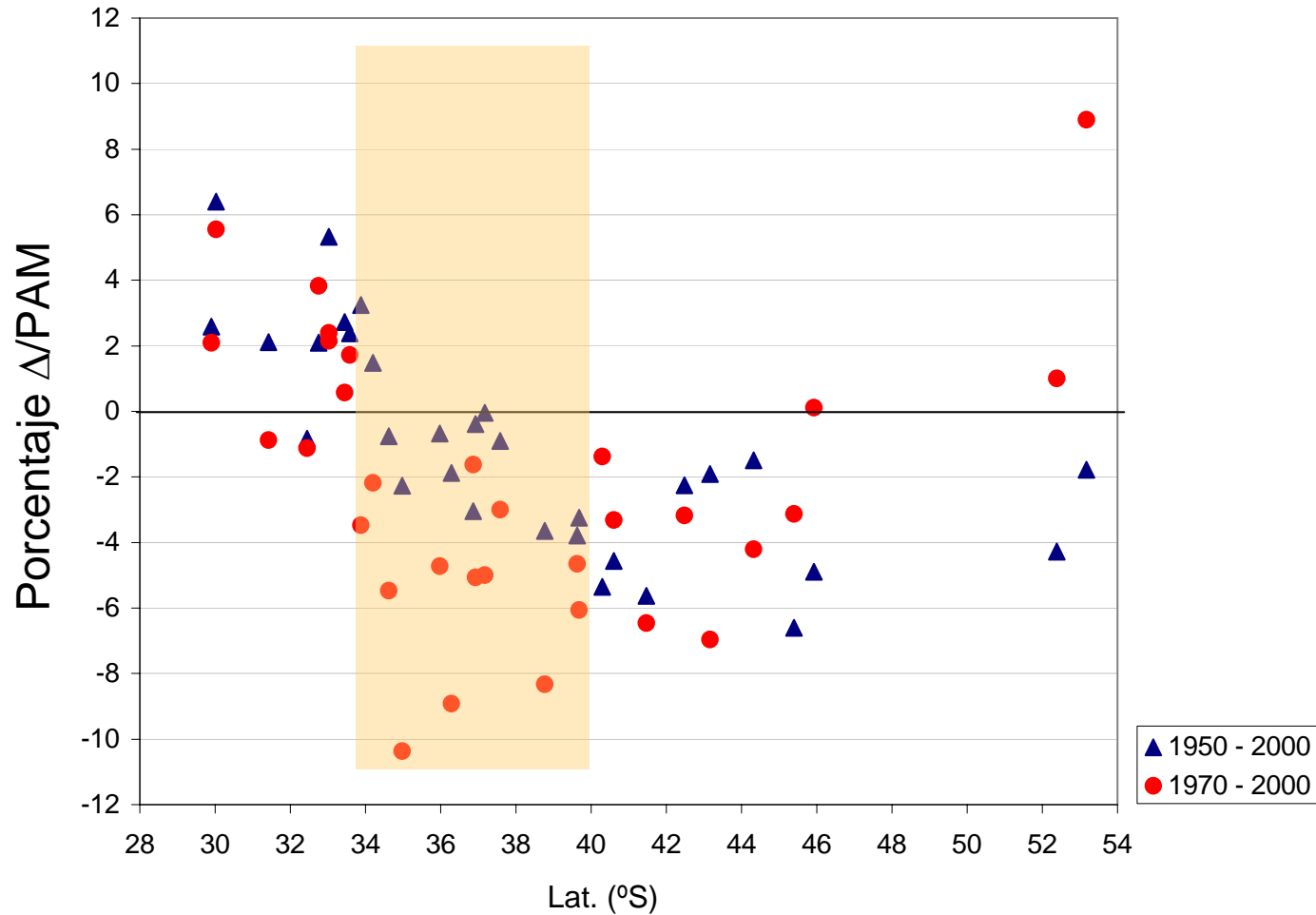


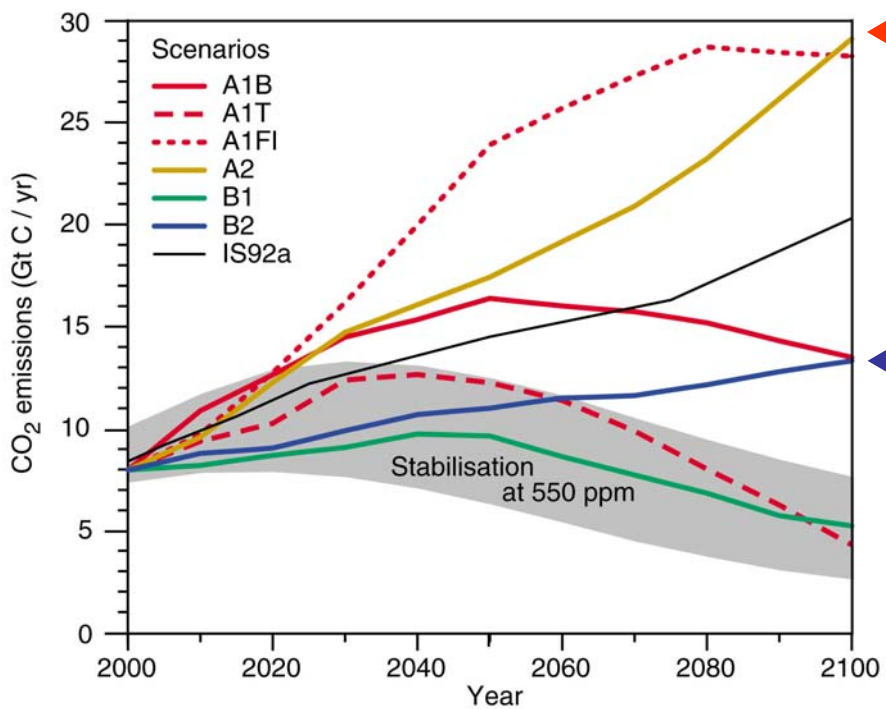
Figura 2. Tendencia de la precipitación anual expresada como el cambio porcentual por década (el porcentaje se evalúa con respecto al promedio de precipitación durante el periodo respectivo).

Proyecciones Climáticas para el siglo XXI

i. Modelos atmosféricos

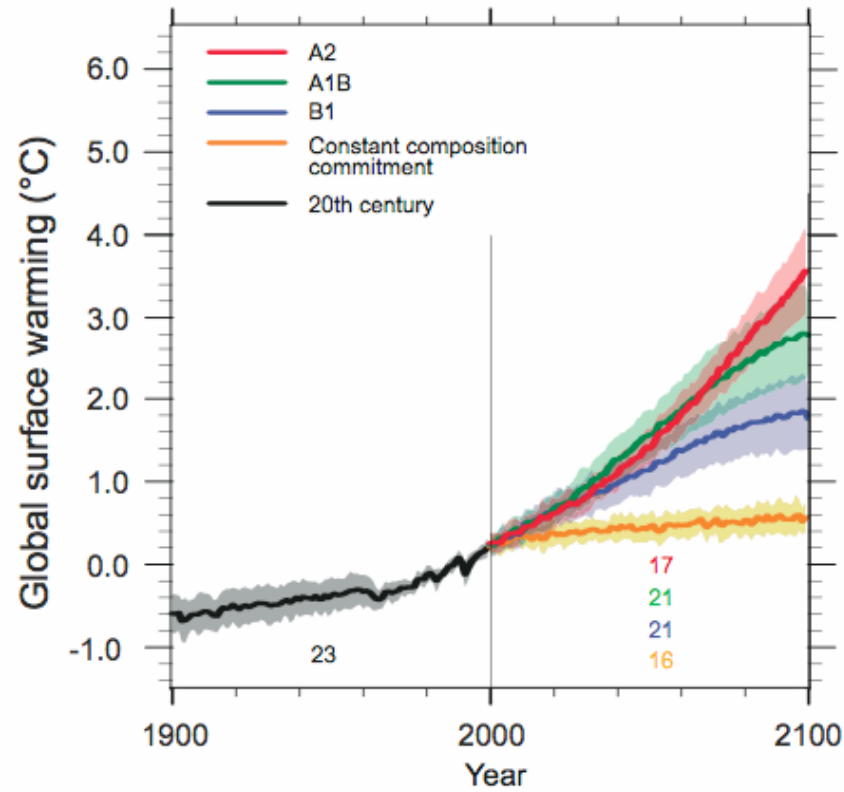
ii. Resultados Globales

iii. Resultados Regionales



Escenarios Desarrollo
Economico-Social

GCMs



Atmospheric circulation is governed by fluid dynamics equation + ideal gas thermodynamics

$$\frac{d\vec{V}}{dt} + f\hat{k} \times \vec{V} = -\frac{1}{\rho} \nabla p - \vec{F}_R + \vec{g}$$

Momentum eqn.

$$\left(\frac{\partial}{\partial t} + \vec{V} \cdot \nabla\right)T - S_p \omega = Q_{RAD} + Q_{Conv} + Q_{Sfc}$$

Energy eqn.

$$\nabla \cdot \vec{V} + \frac{\partial \omega}{\partial p} = 0$$

Mass eqn.

$$\frac{\partial(gz)}{\partial p} = -\frac{RT}{p}$$

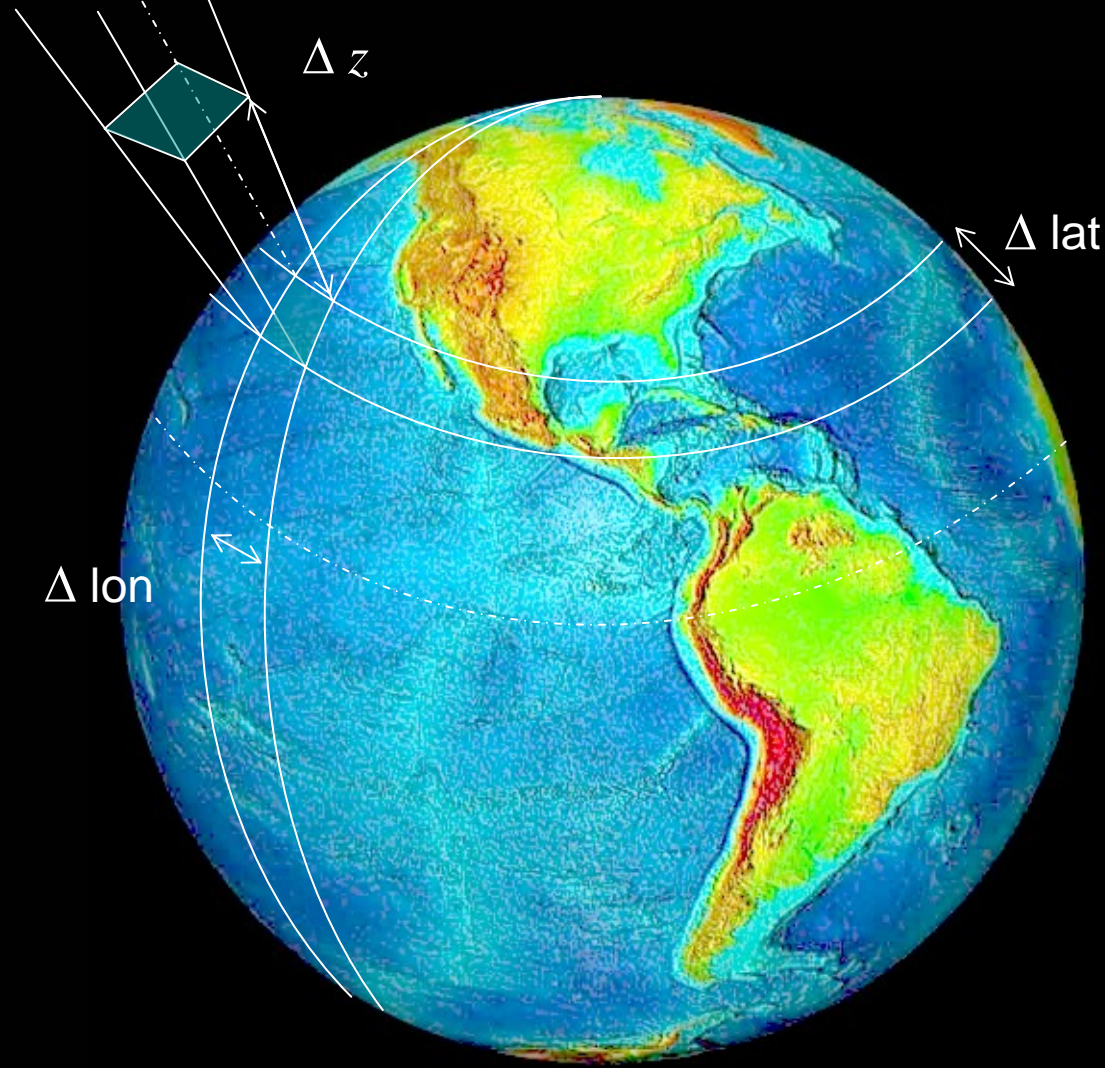
Idea gas law

$$\frac{dq_v}{dt} = -C + E$$

$$\frac{dq_r}{dt} = +C - E + S_r$$

Water substance eqns.

Global Models (GCM)



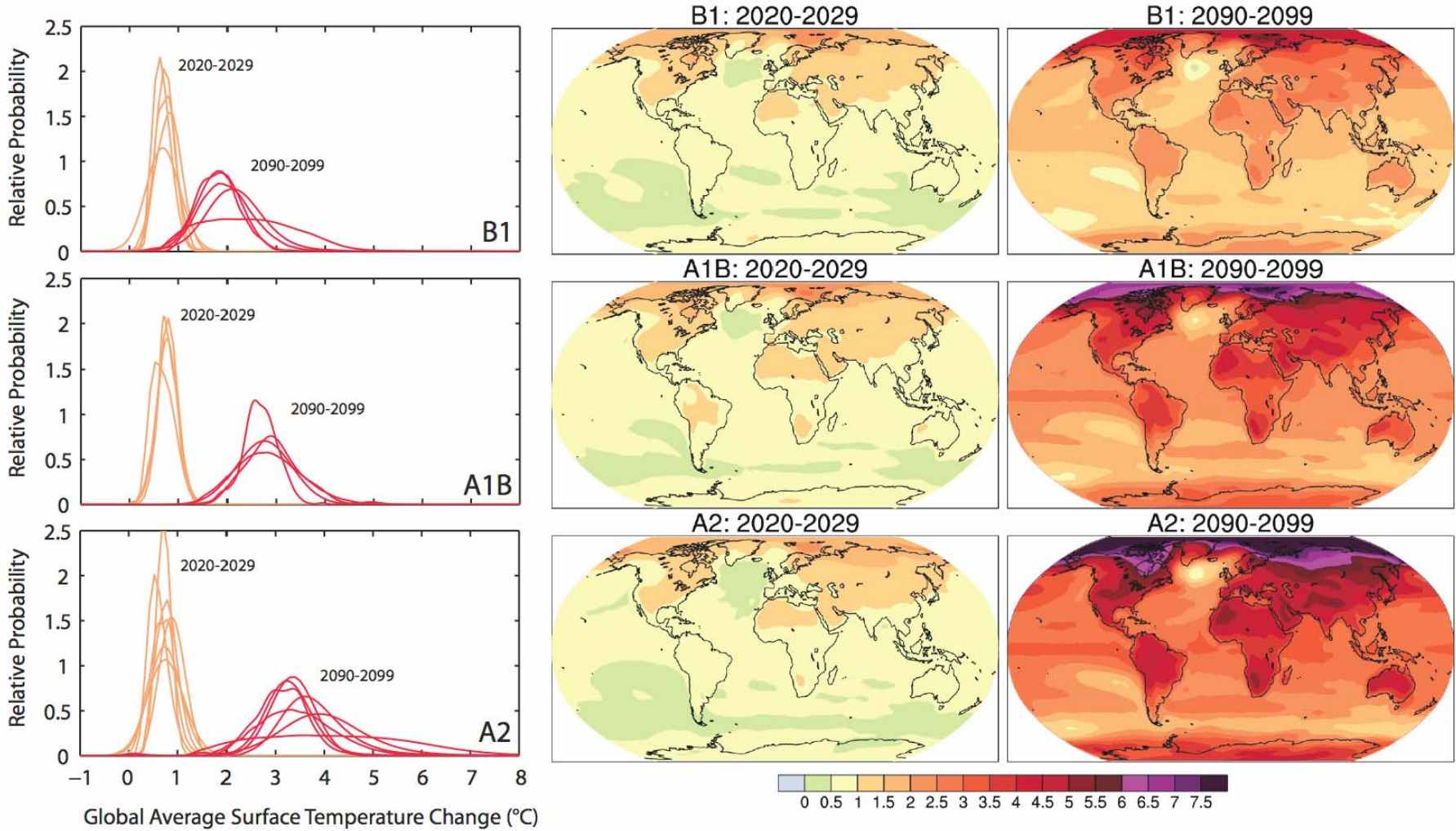
$\Delta \text{lat} \sim \Delta \text{lon} \sim 1^\circ - 3^\circ$

$\Delta z \sim 1 \text{ km}$

$\Delta t \sim \text{minutes-hours}$

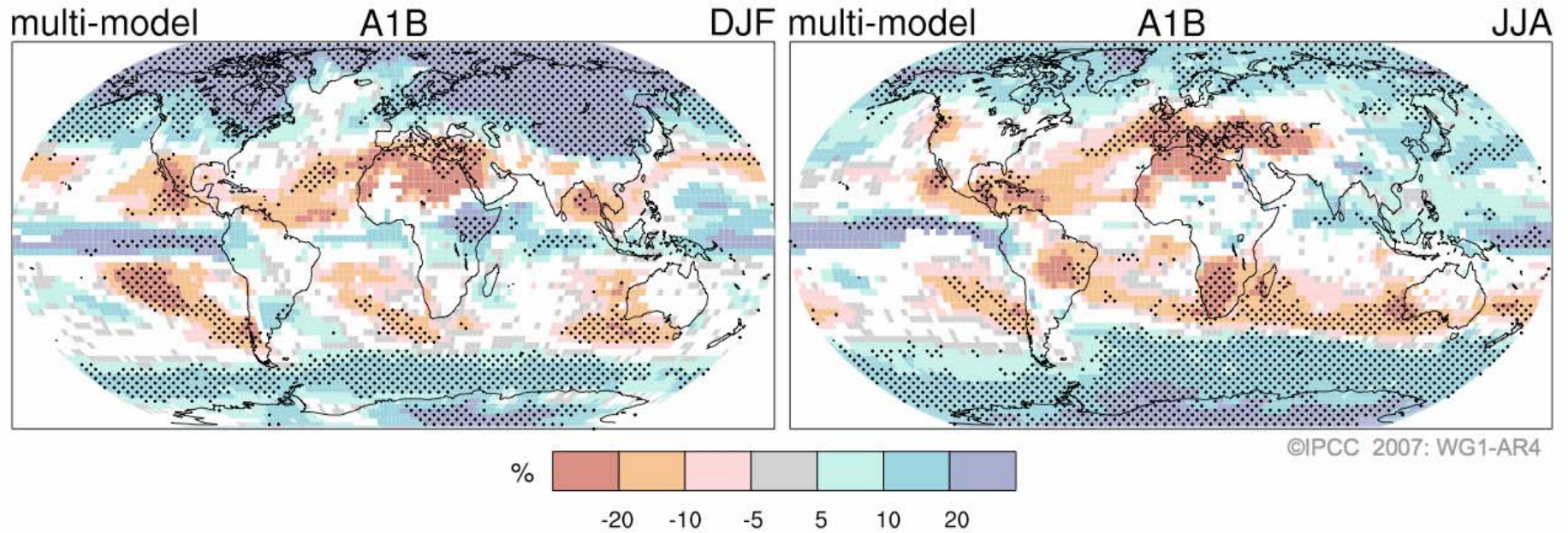
Top of atmosphere: 15-50 km

AOGCM Projections of Surface Temperatures

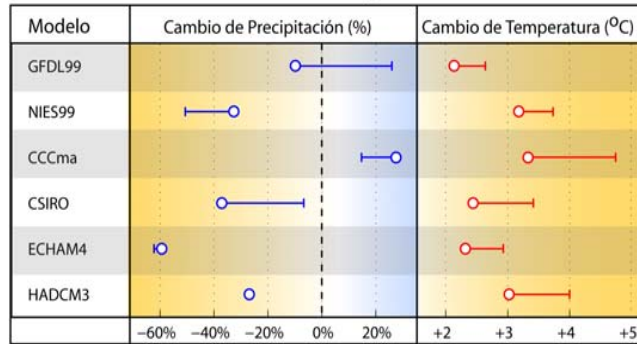


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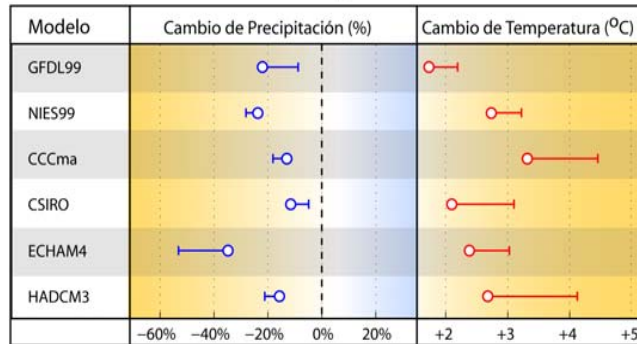
Projected Patterns of Precipitation Changes



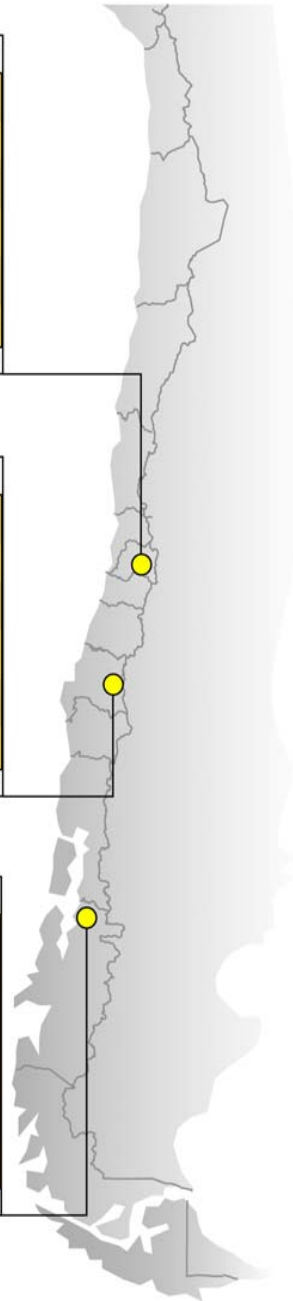
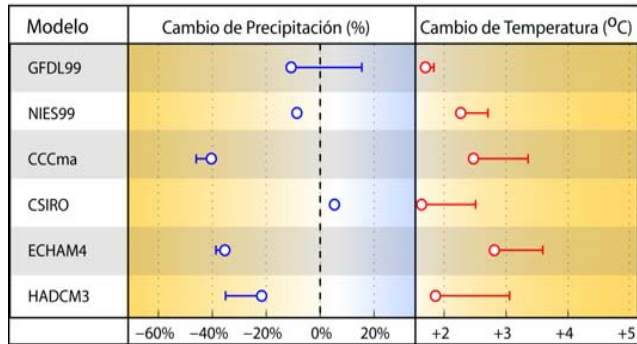
Santiago



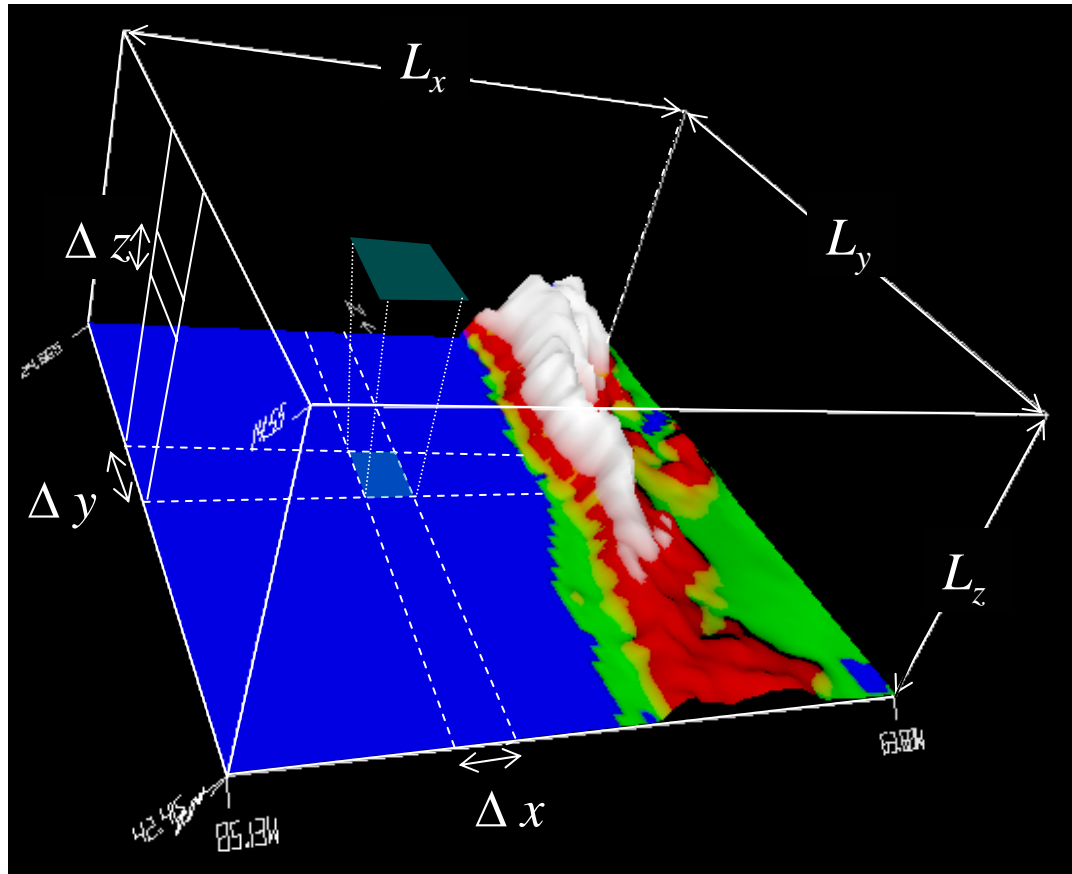
Concepción



Aysén



Regional Models (LAM, Mesoscale Models)

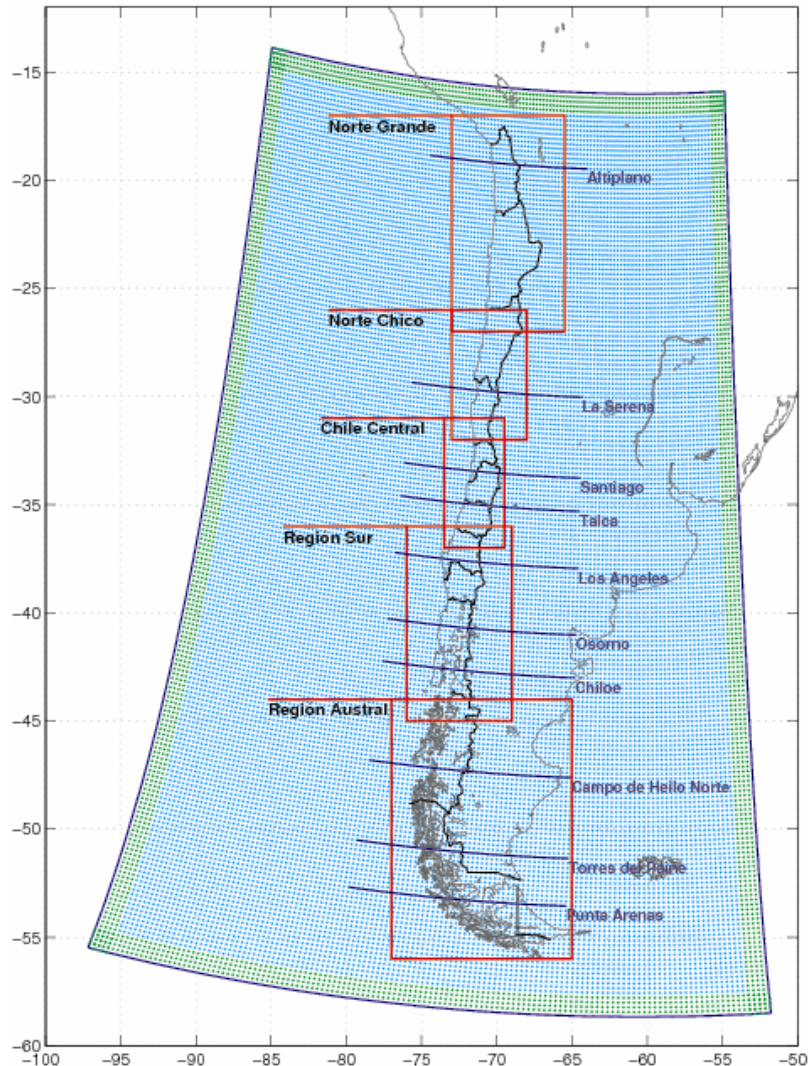


$\Delta x \sim \Delta y \sim 1-50 \text{ km}$ $\Delta z \sim 50-200 \text{ m}$ $\Delta t \sim \text{seconds}$
 $L_x \sim L_y \sim 100-5000 \text{ km}$ $L_z \sim 15 \text{ km}$ LBC from GCMs

Main Problem: Garbage in – Garbage out

Proyecto CONAMA – DGF/UCH

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



Model:

- PRECIS – UK

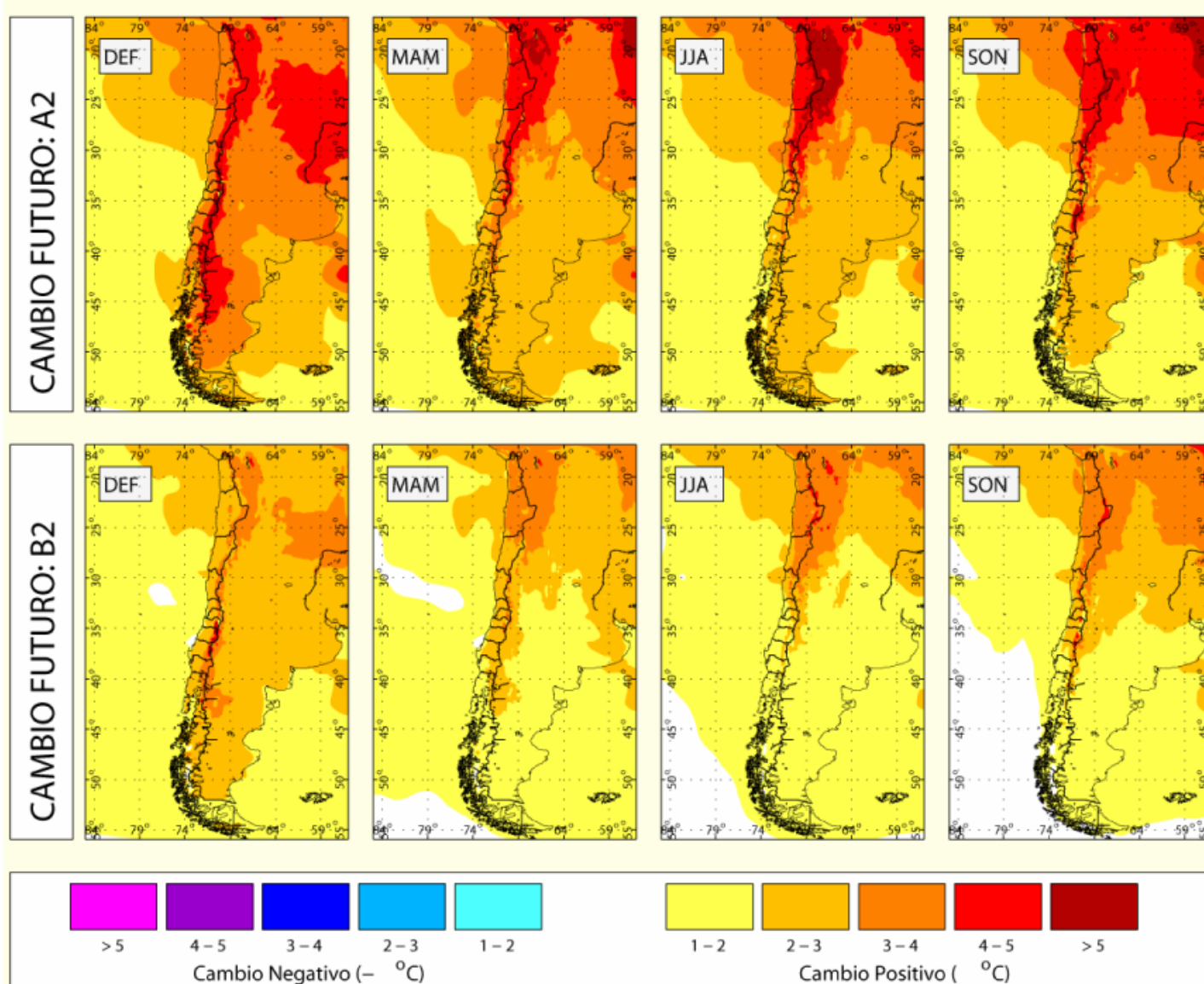
Single domain

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

Simulations

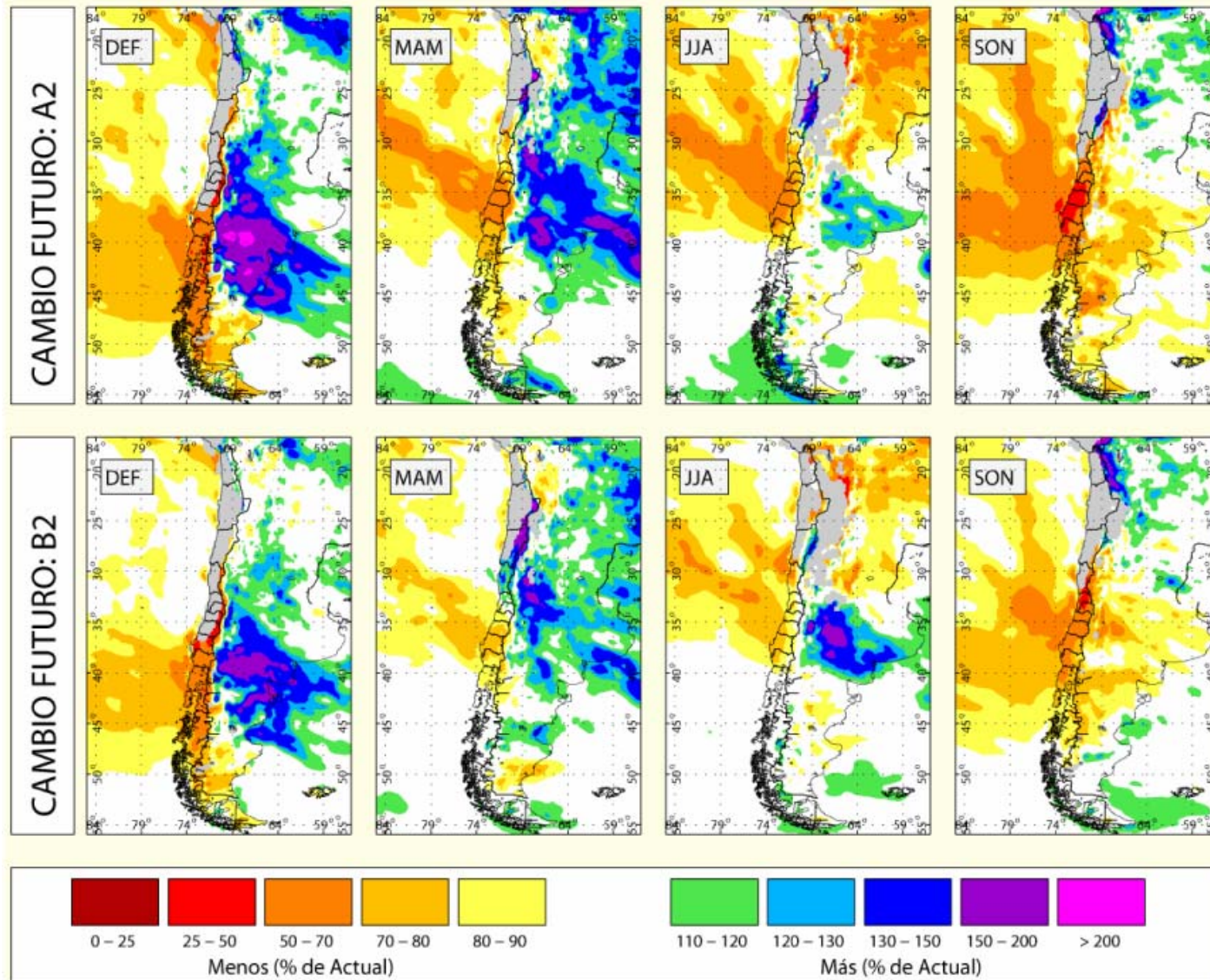
- **1961-1990 Baseline**
- **2071-2100 SRES A2 y B2**
- 30 years @ 3 min → 4 months per simulation in fast PC

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



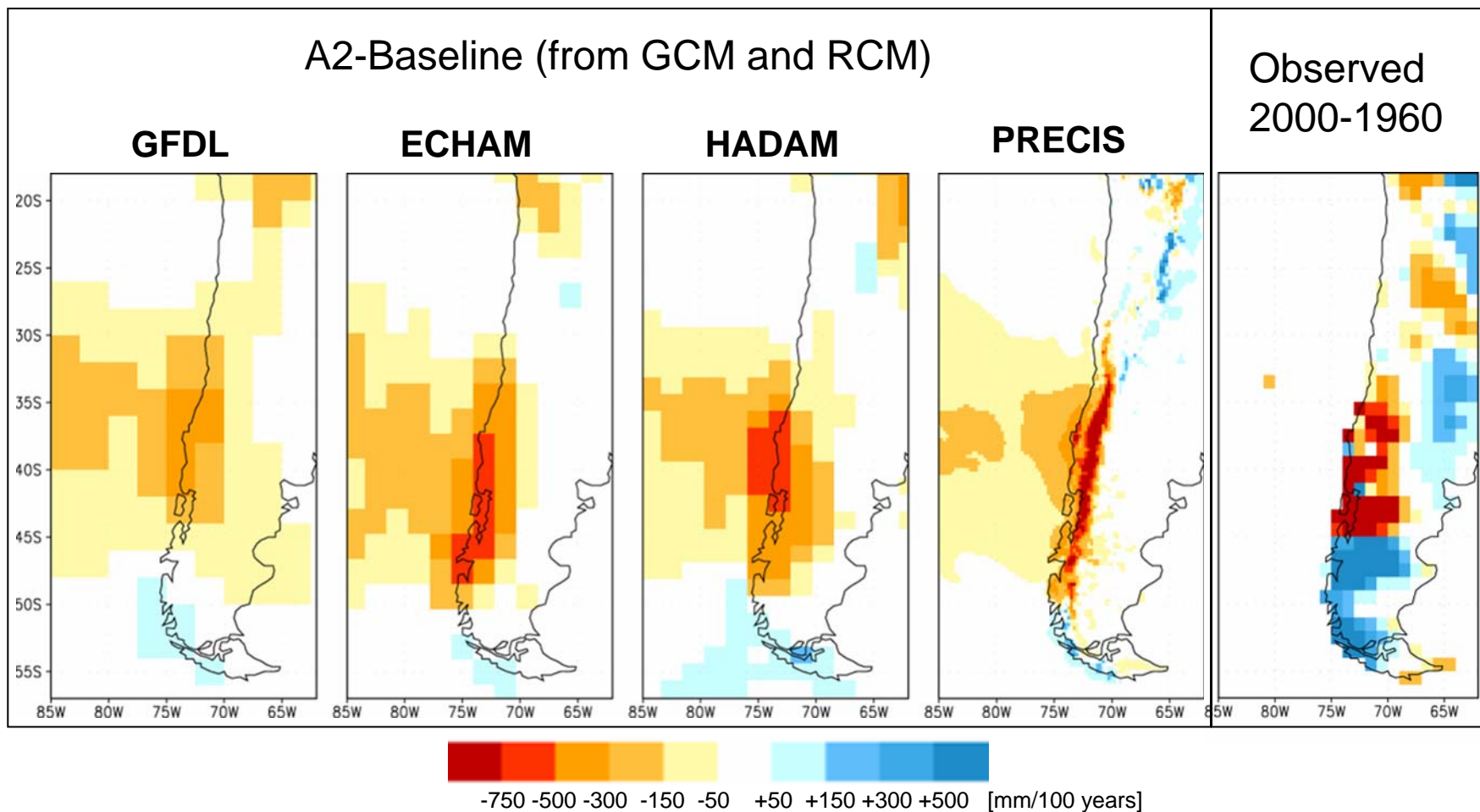
Futuro: 2071-2100 / Presente: 1960-1990

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

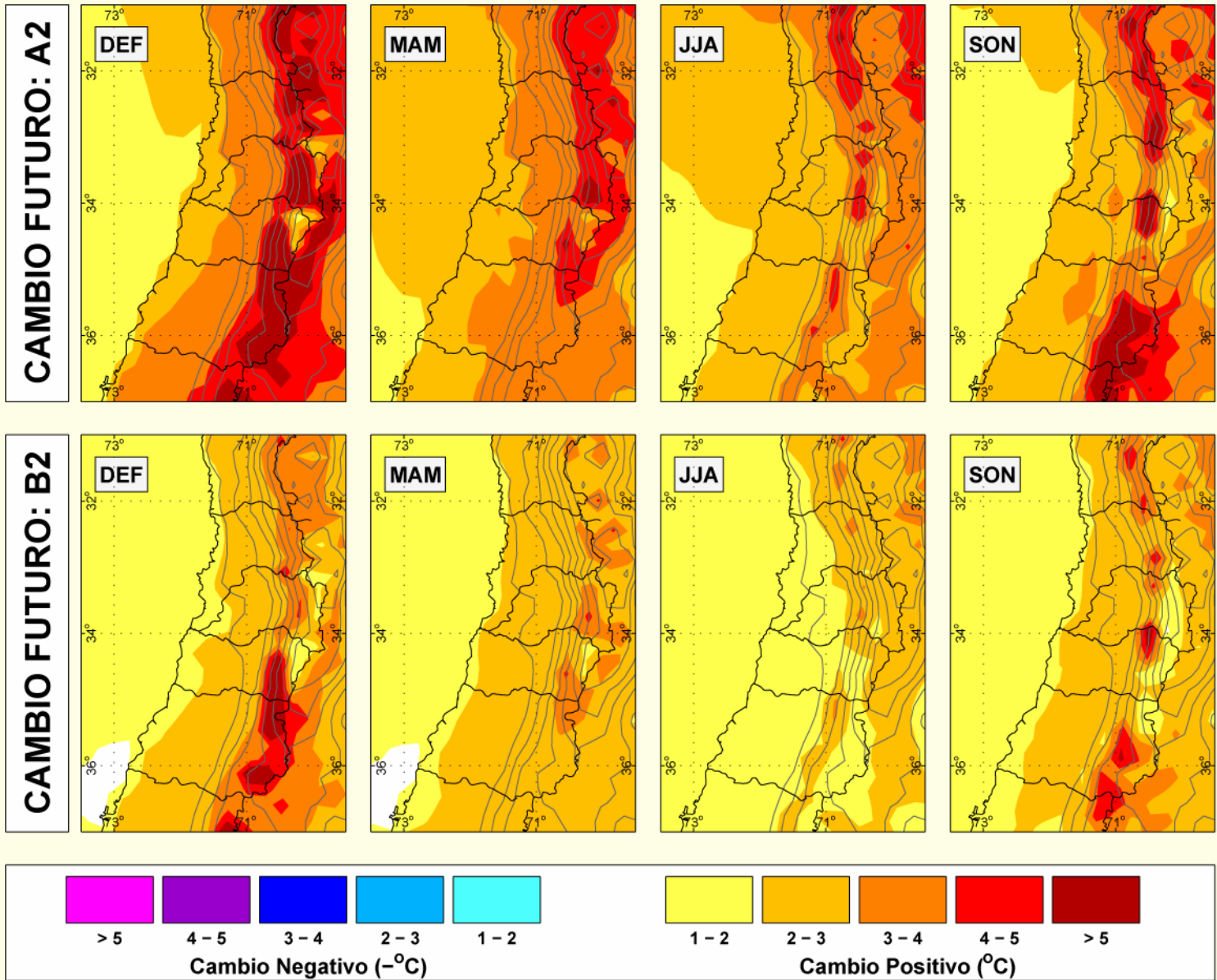


Futuro: 2071-2100 / Presente: 1960-1990

Cambios previstos en R ya parecen estar manifestandose

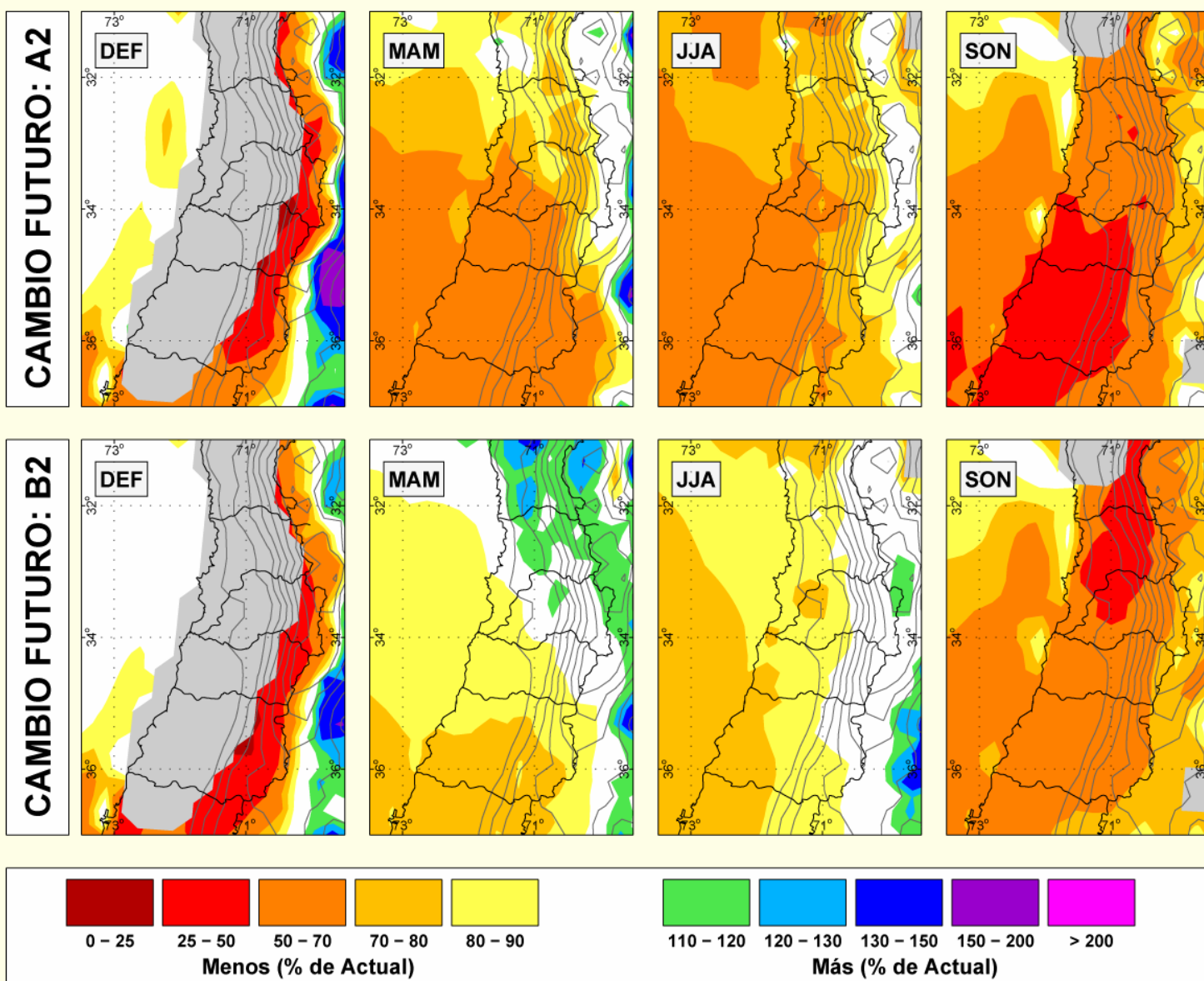


PRECIS-DGF $T_{\text{futuro}} - T_{\text{presente}}$



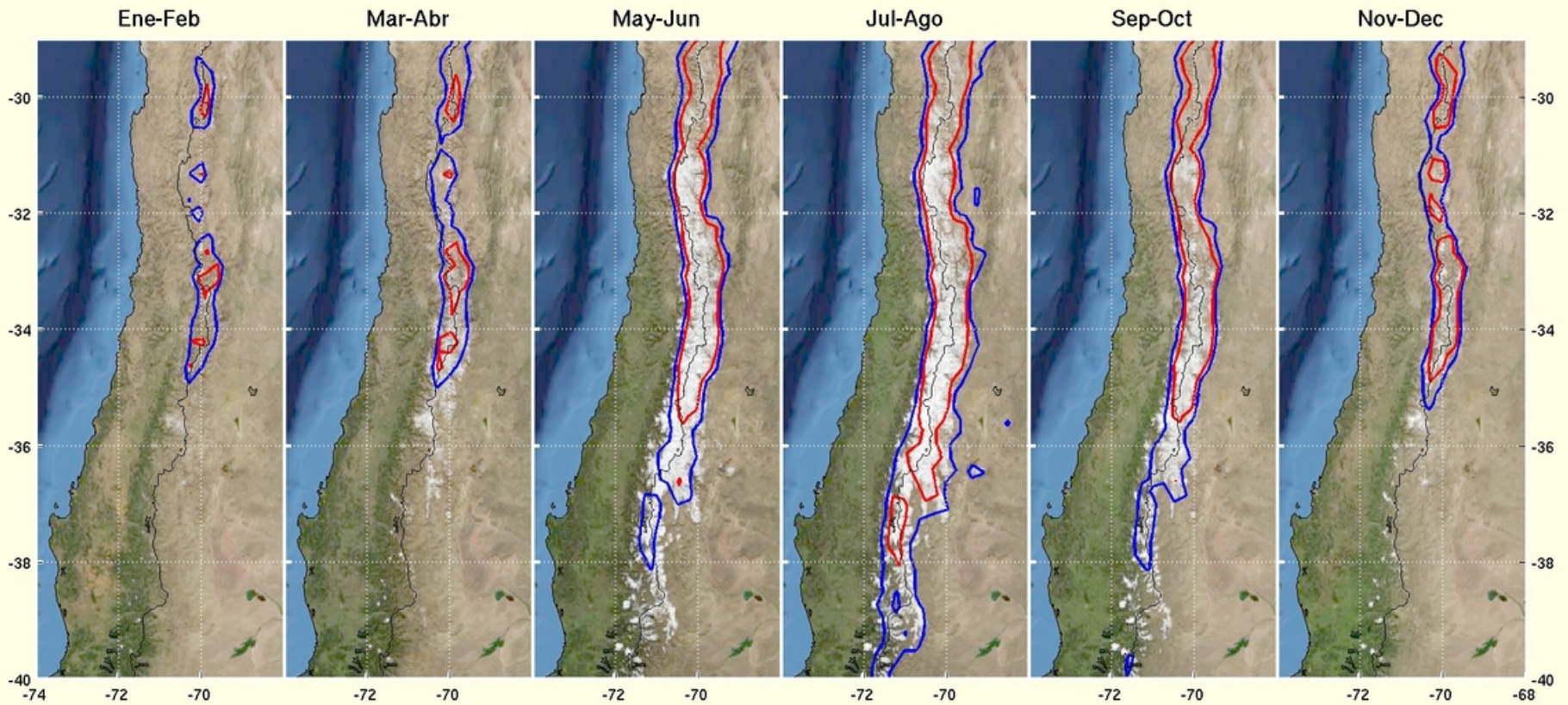
Futuro: 2071-2100 / Presente: 1960-1990

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



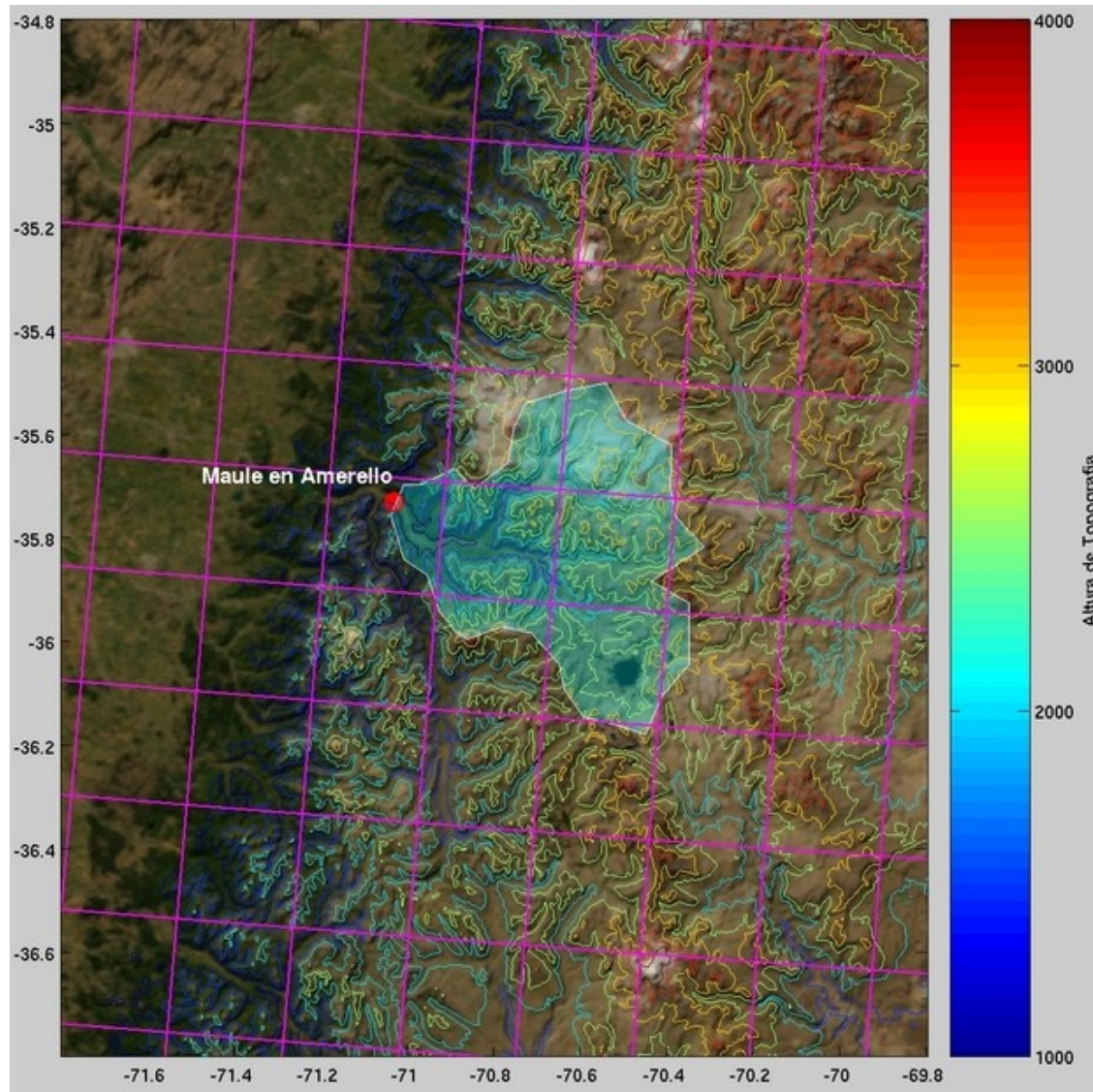
Futuro: 2071-2100 / Presente: 1960-1990

Isoterma cero: **A2** / Actual



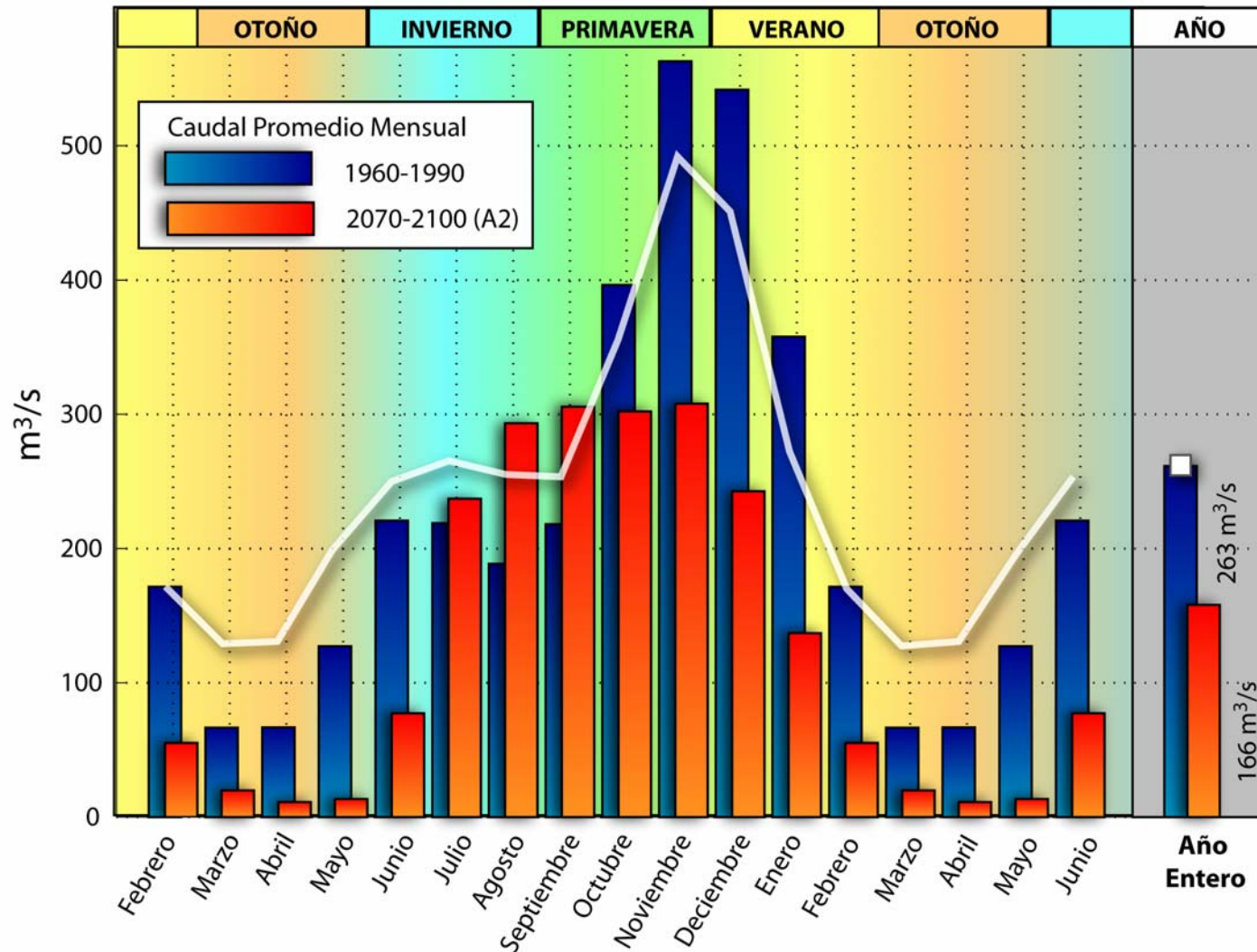
PRECIS-DGF

Acomplamiento con modelos hidrológicos.



PRECIS-DGF Acomplamiento con modelos hidrológicos.

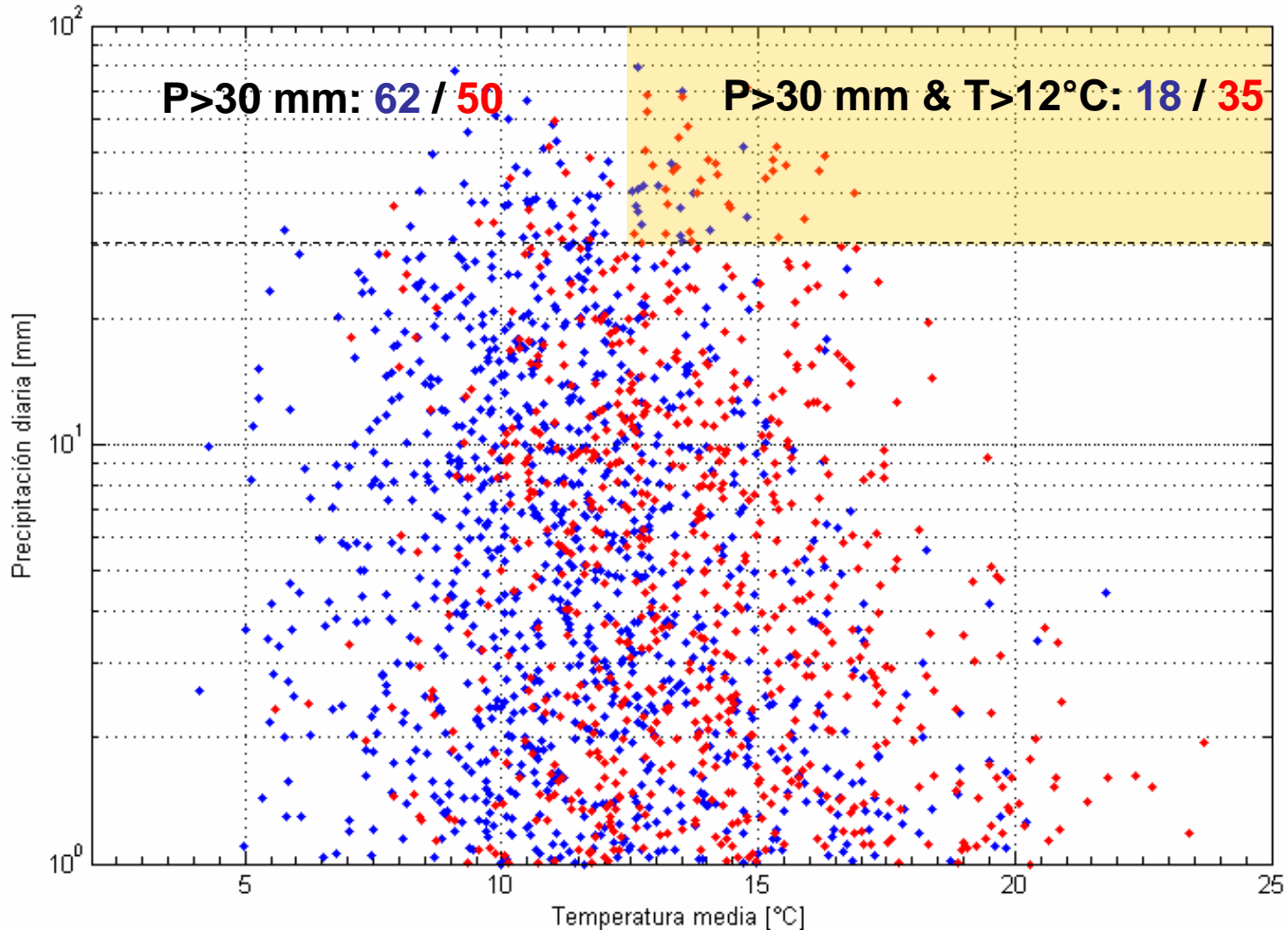
CAUDAL SIMULADO DEL RIO MAULE* - PRESENTE y FUTURO (A2)



* Rio Maule en Armerillo - Pre-Cordillera

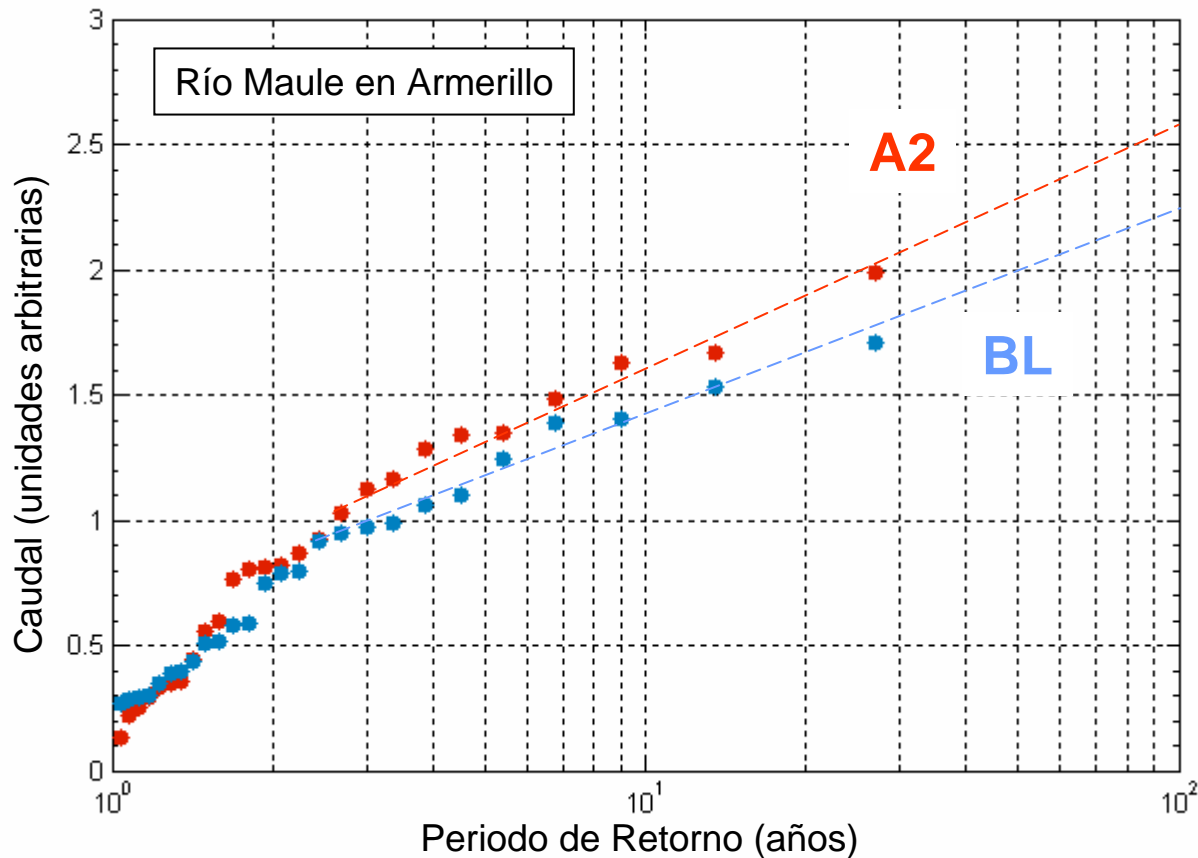
PRECIS-DGF – Eventos Extremos

Sobre Chile central disminuye precipitación media annual, pero **tormentas cálidas** aumentan al doble.



PRECIS-DGF - Eventos Extremos

Modelo hidrológico simple indica cierta disminución de **caudales extremos diarios** con bajo periodo de retorno pero un aumento de caudales extremos diarios con alto periodo de retorno



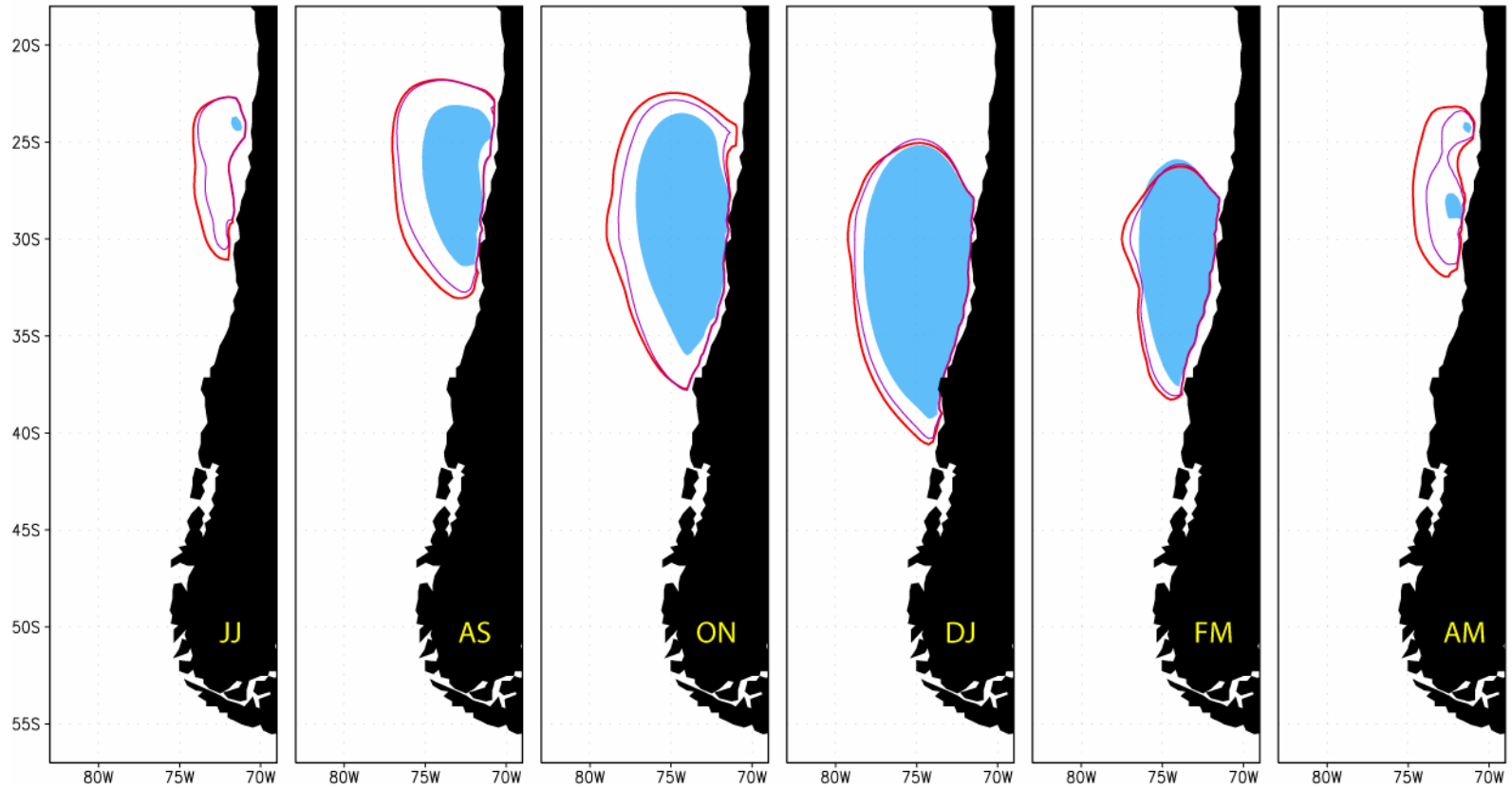
PRECIS Results

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

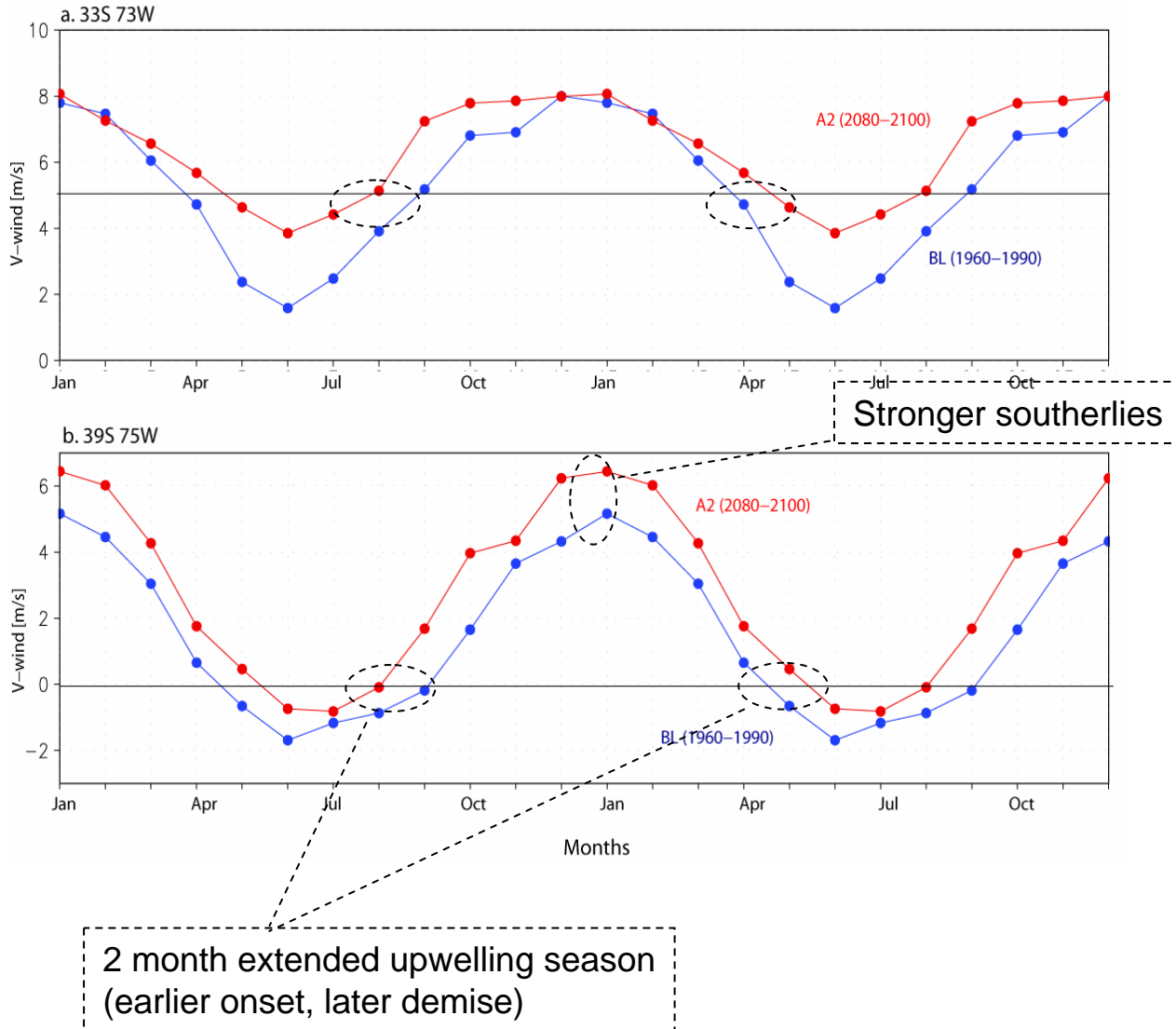
Baseline (1960–1990)

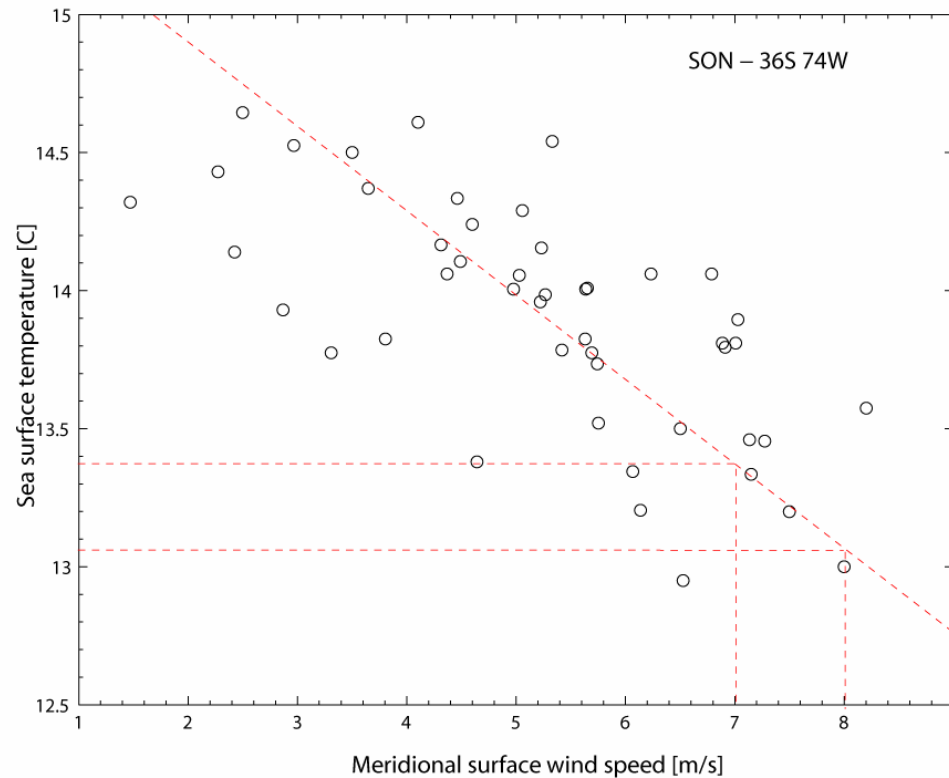
B2 (2070–2100)

A2 (2070–2100)



PRECIS Results





Scatter plot between V_{sfc} and SST off central Chile...SON averages (1958-2002). Springs with stronger (weaker) southerlies associated with colder (warmer) SST. There is, however, significant scatter because seasonal SST is also determined by oceanic, non-local factors (e.g., thermocline depth).

Yet, an increase of, say, 1 m/s, leads to a local cooling of about 0.5°C .

Conclusiones

Existen manifestaciones del cambio climático asociado a los GI en las últimas décadas a lo largo del país.

Cambios proyectados son en algunos casos similares en magnitud y signo a los observados en las últimas décadas.

Recursos hídricos superficiales se verán afectados por disminución de precipitación y aumento de temperatura, tanto en su promedio anual, estacionalidad y eventos extremos. Cambios en régimen de viento costero...

PRECIS-DGF es una buena base de datos para análisis sectoriales, pero solo un comienzo....