

Cambio Climático Global: Bases Físicas e Impactos en Chile

Seminario “Cambio Climático y Huella de Carbono: Desarrollo y Eficiencia en la Agricultura Nacional”

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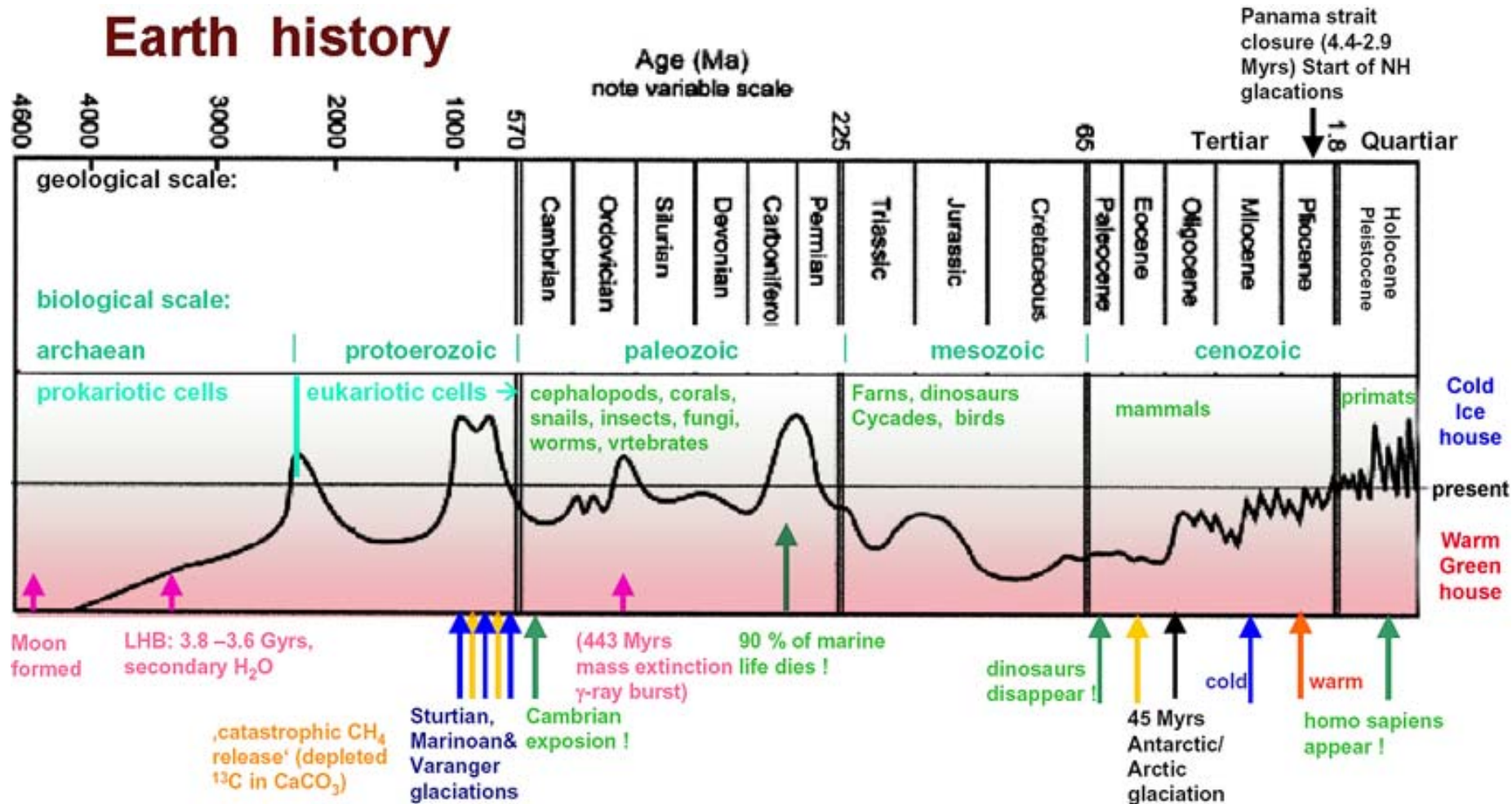
Temario

1. Bases Físicas del Cambio Climático

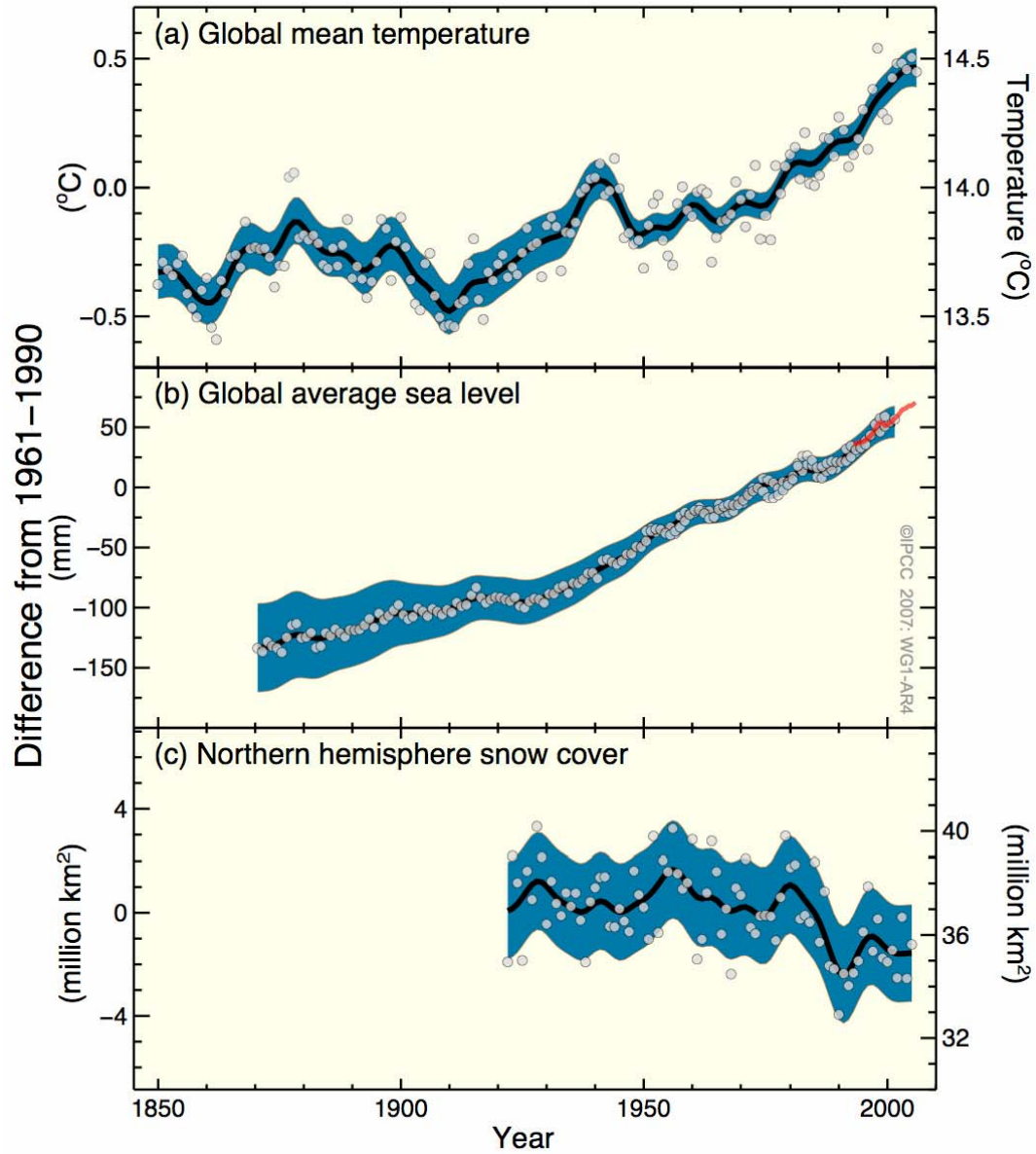
2. Cambios en el siglo XX: Global /Regional

3. Pronóstico para mañana: GCMs / RCMs

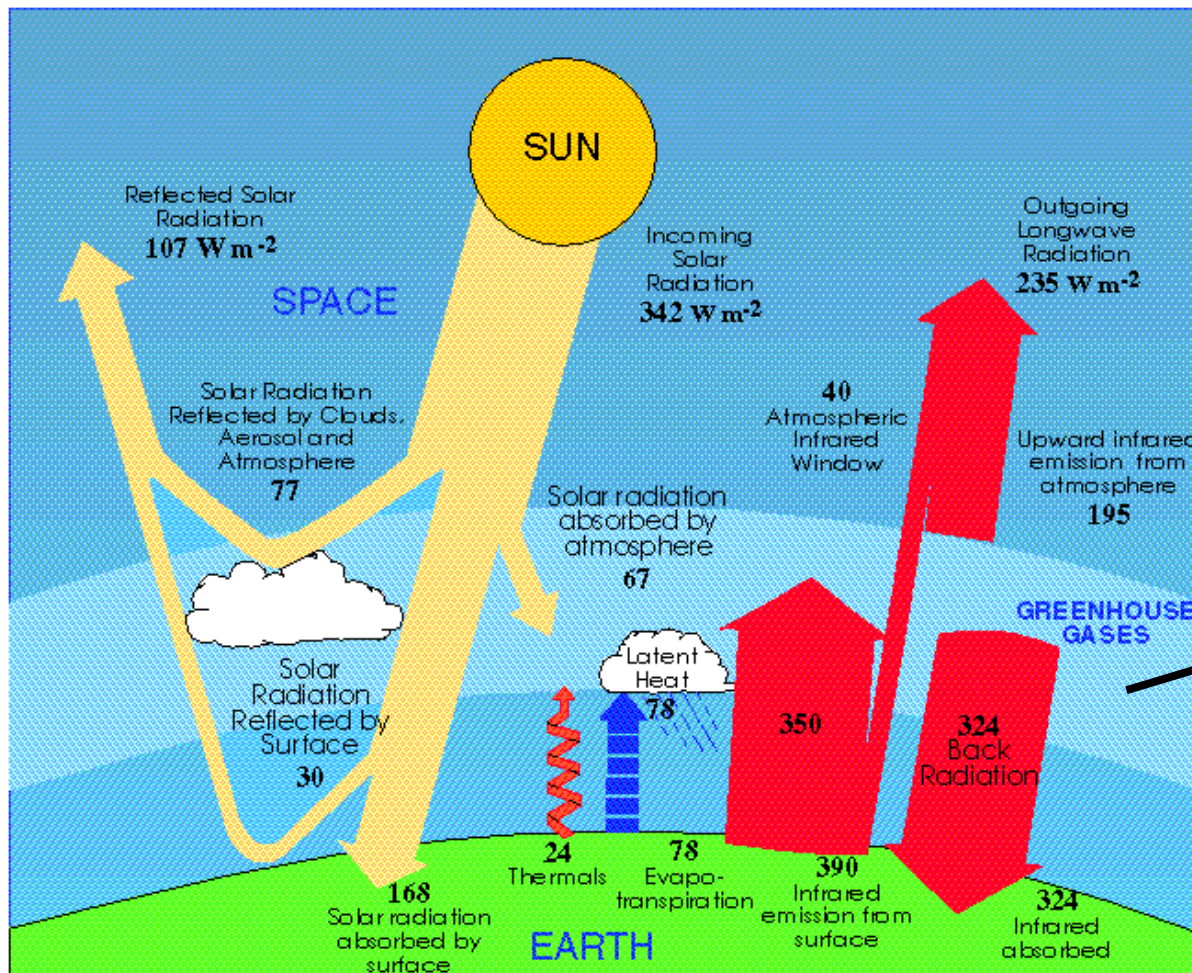
Historia climática del Planeta: Usualmente más calido que las condiciones actuales y en permanente cambio



Changes in Temperature , Sea Level and Northern Hemisphere Snow Cover

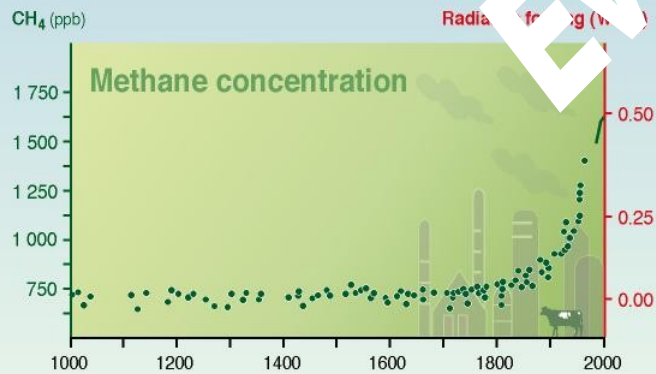
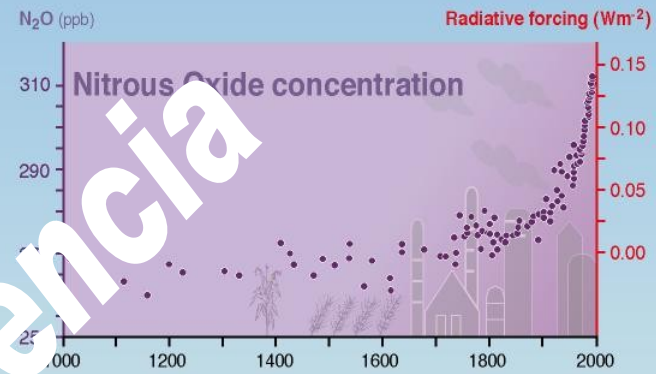
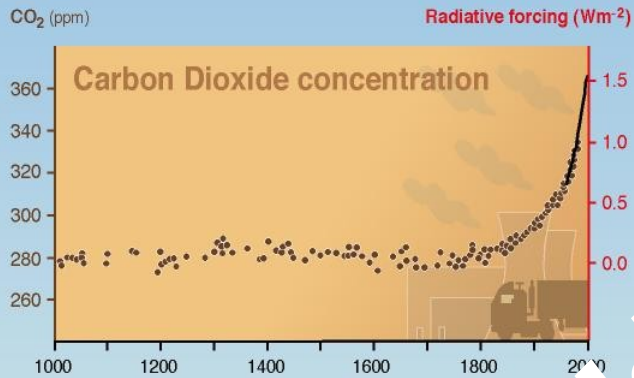


Balance Global de Energía del Planeta Tierra (promedio en latitud y longitud)

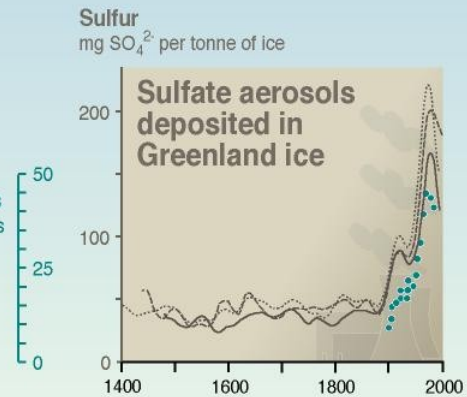


Gases Invernadero
 H_2O , CO_2 , CH_4 , N_2O

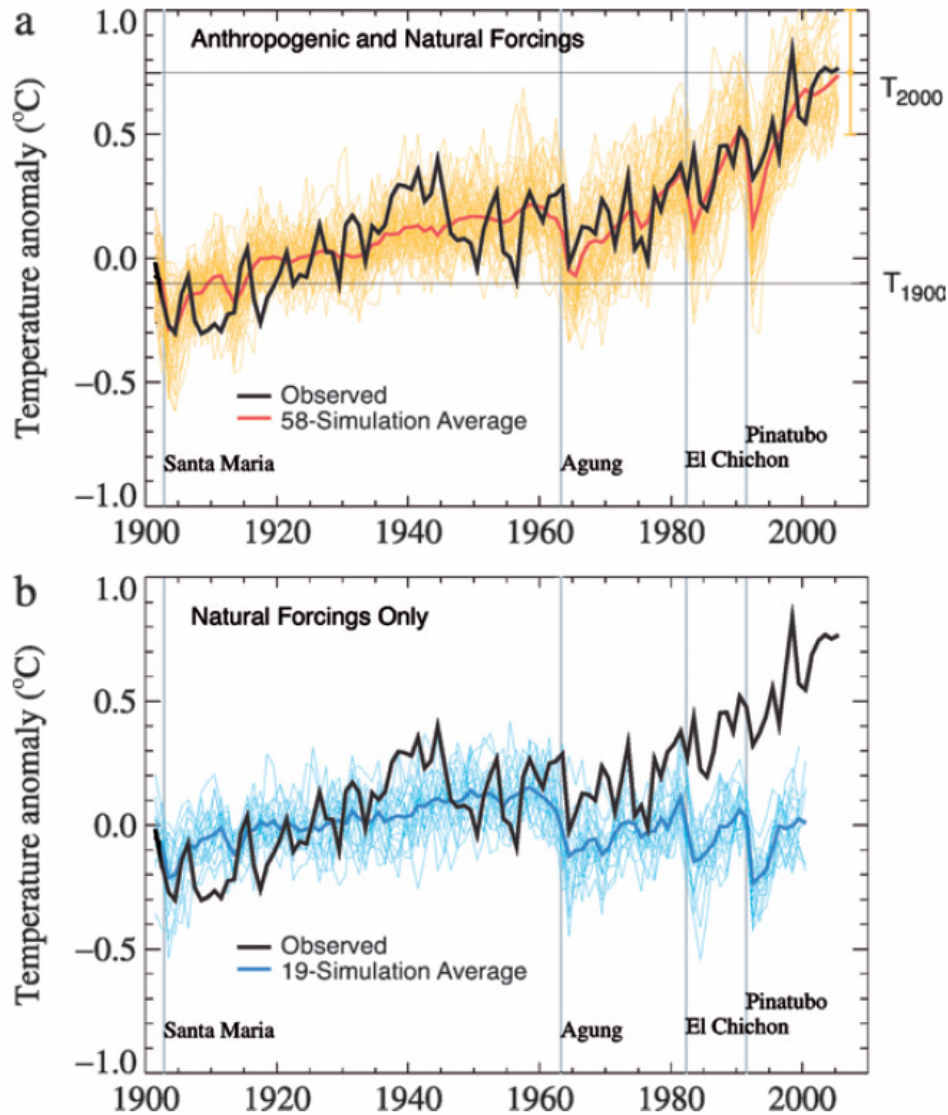
Indicators of the human influence on the atmosphere during the Industrial era



SO₂ emissions from United States and Europe (Mt S yr⁻¹)



Cambios observados y simulados en Tsfc



Evidencia

Cambios observados en Temp. Superficial

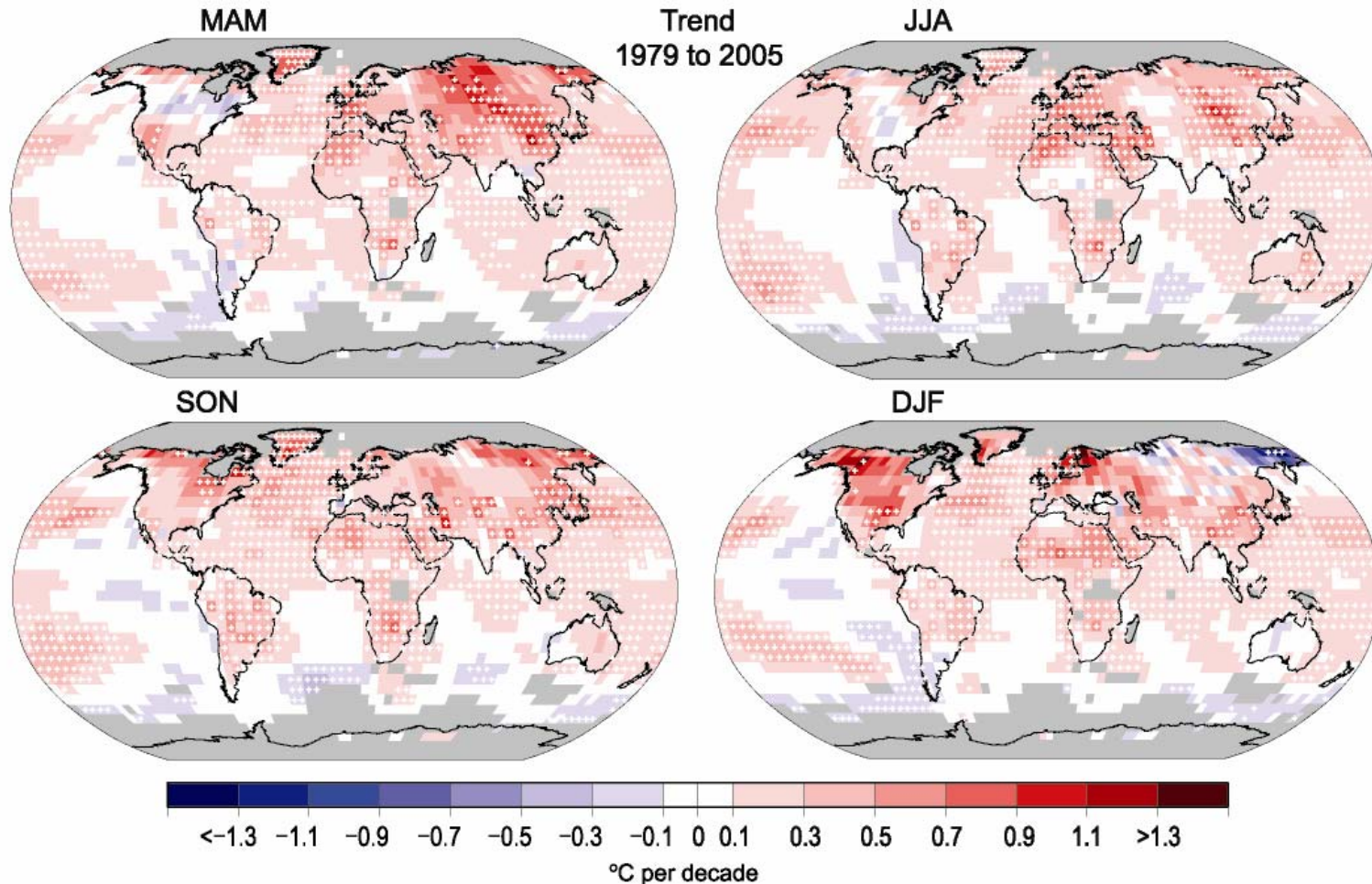
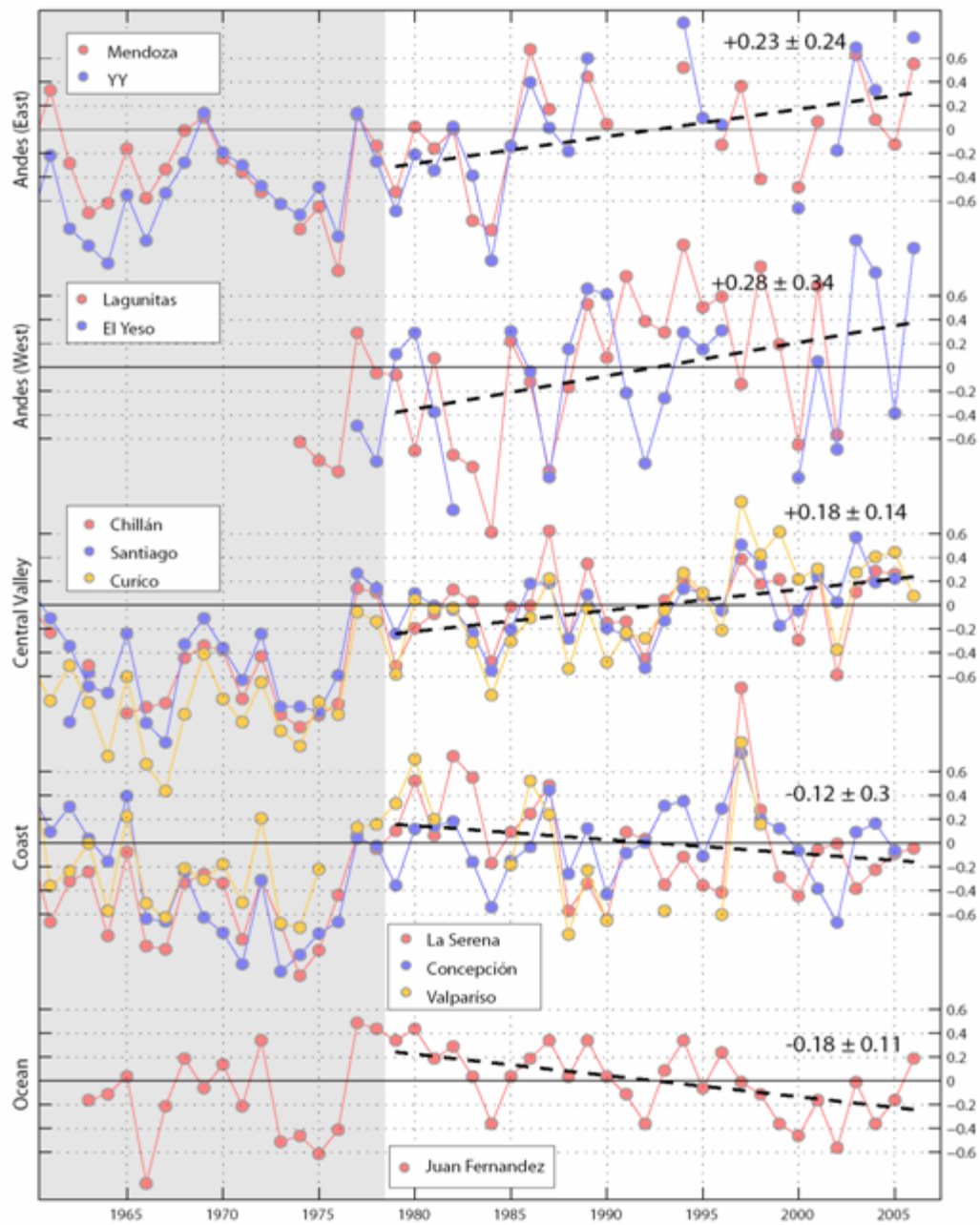
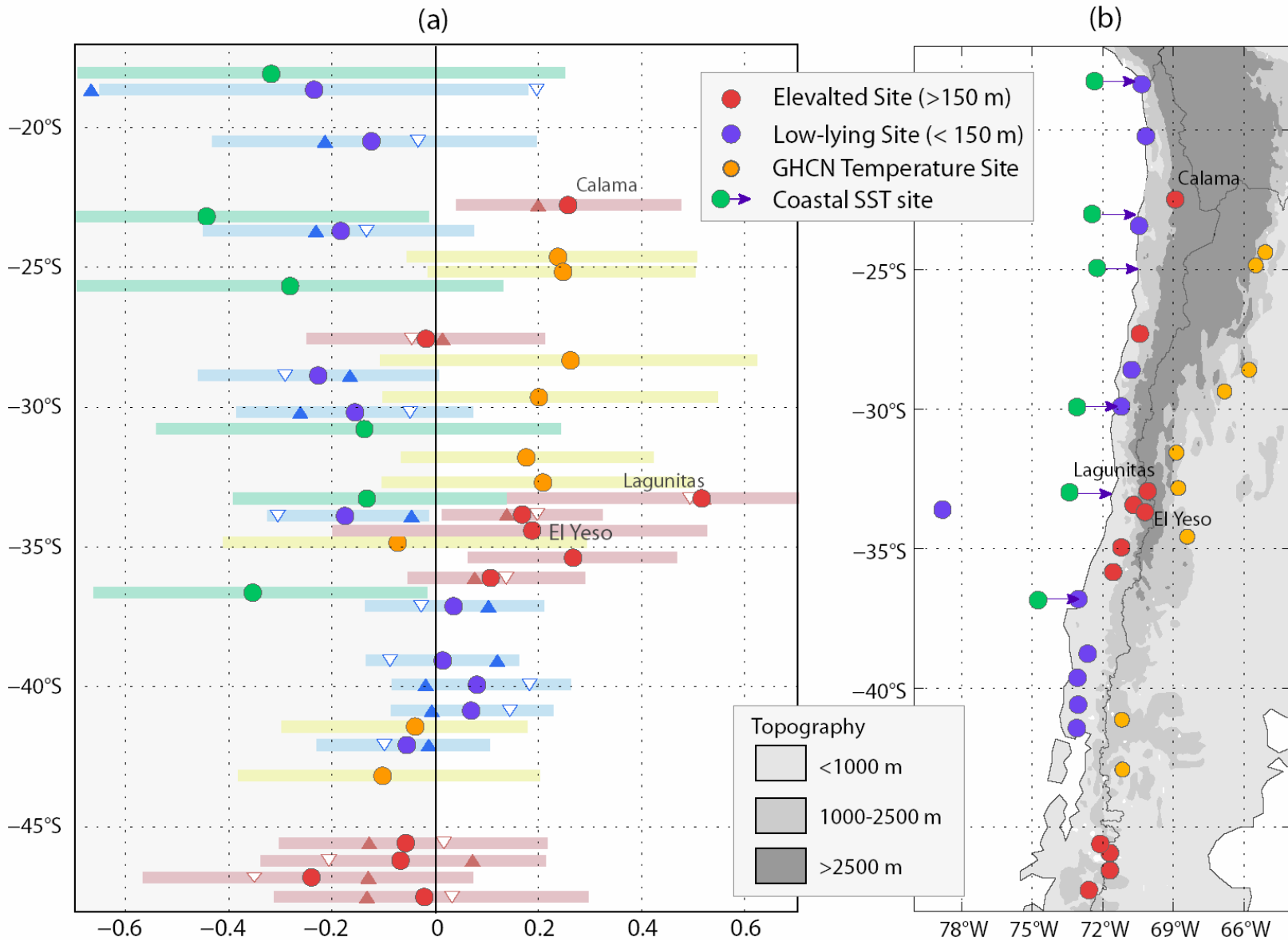


Figure 3.10. Linear trend of seasonal MAM, SON and DJF temperature for 1979 to 2005 (°C per decade). Areas in grey have insufficient data to produce reliable trends. The minimum number of years required to calculate a trend value is 18. A seasonal value is available if there are two valid monthly temperature 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.

Cambios de Temperatura en Chile



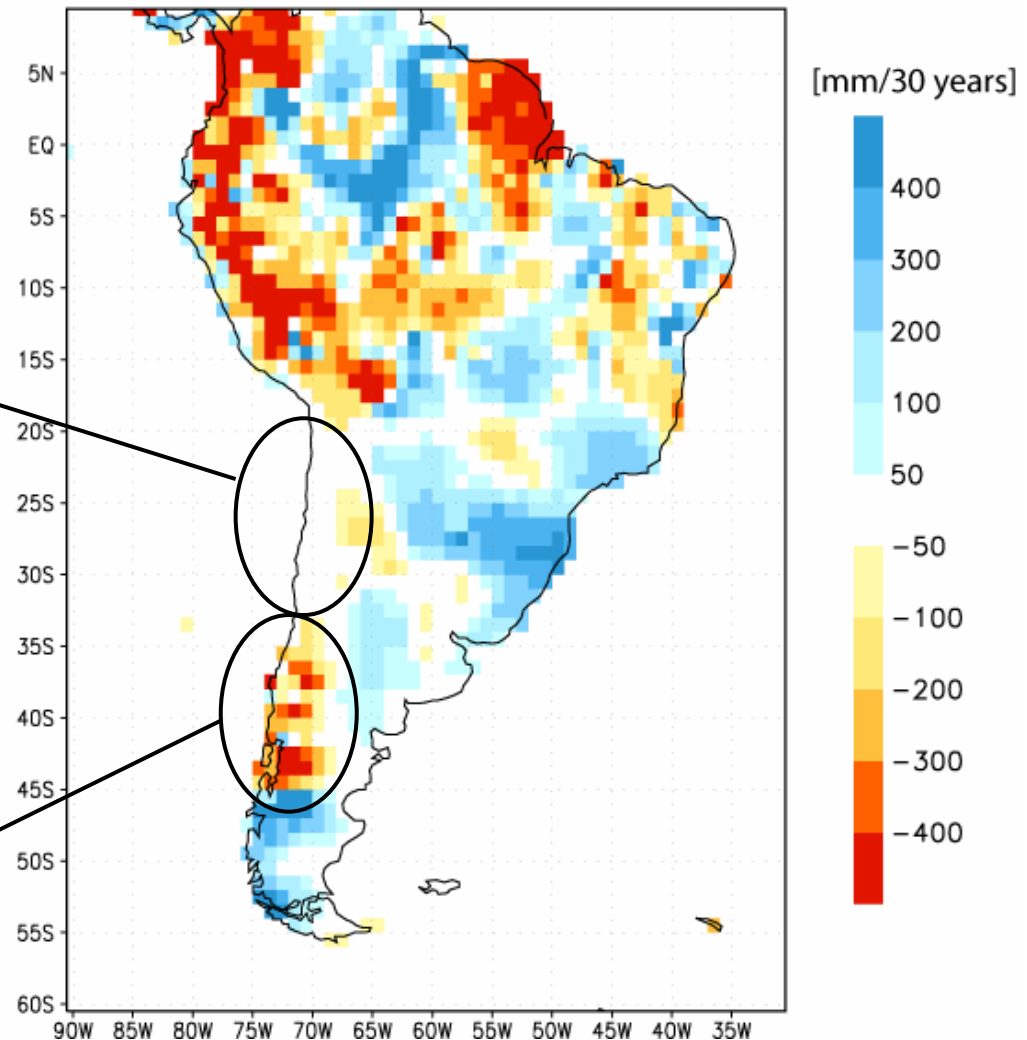
Cambios de Temperatura en Chile



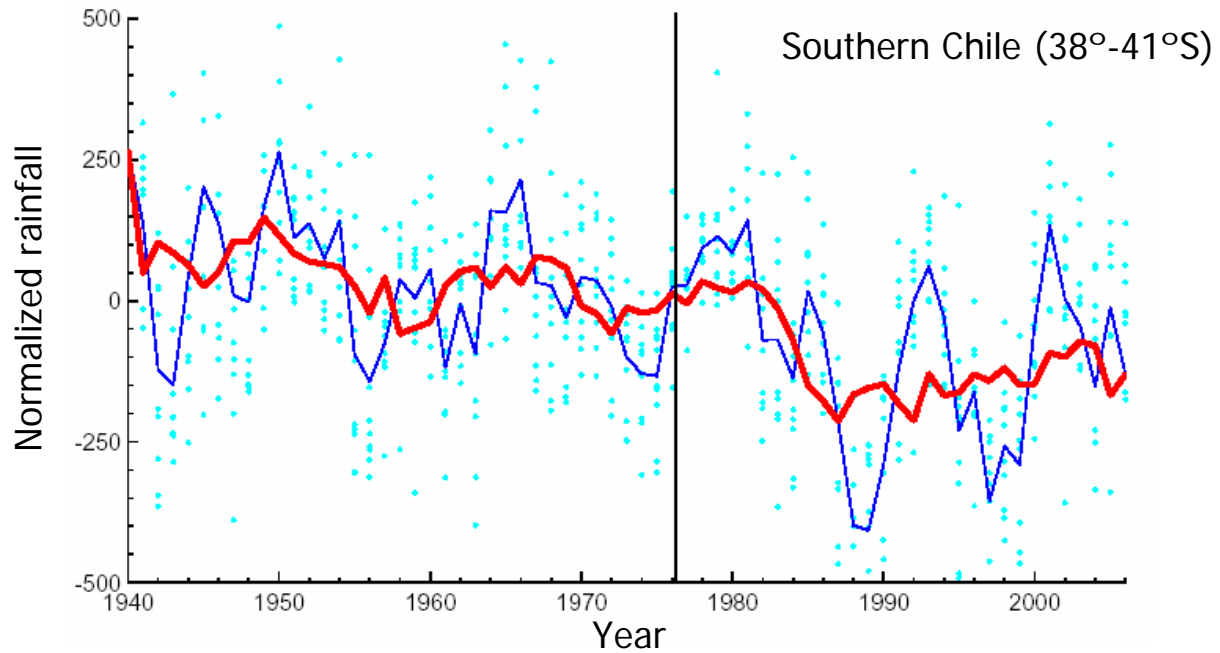
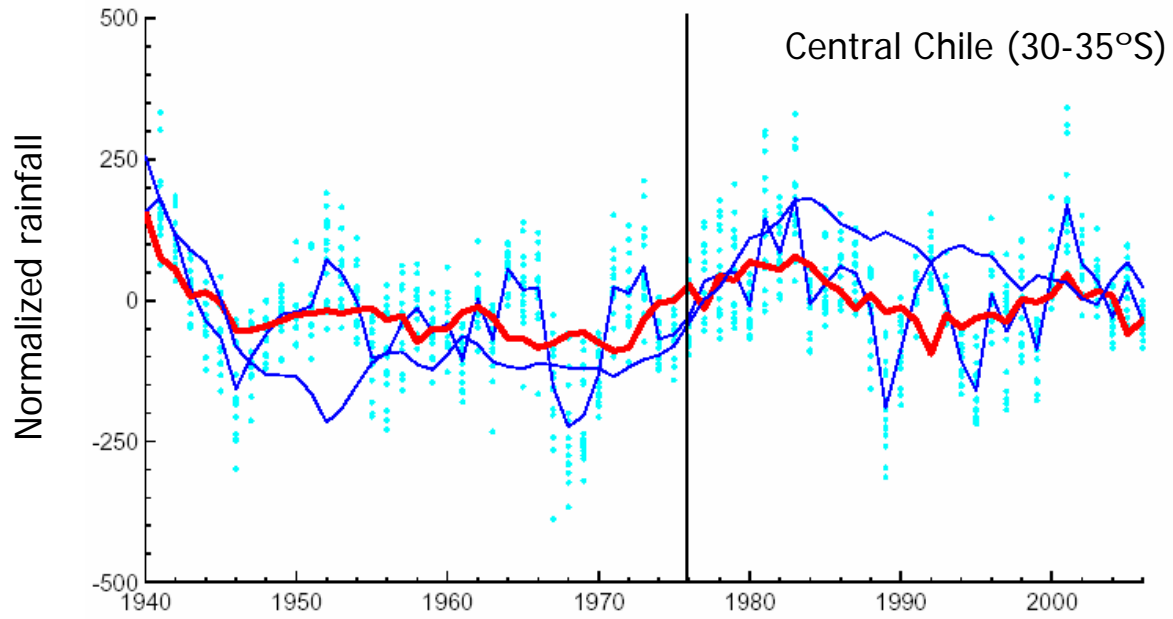
Cambios observados de Precipitación (1960-2000)

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

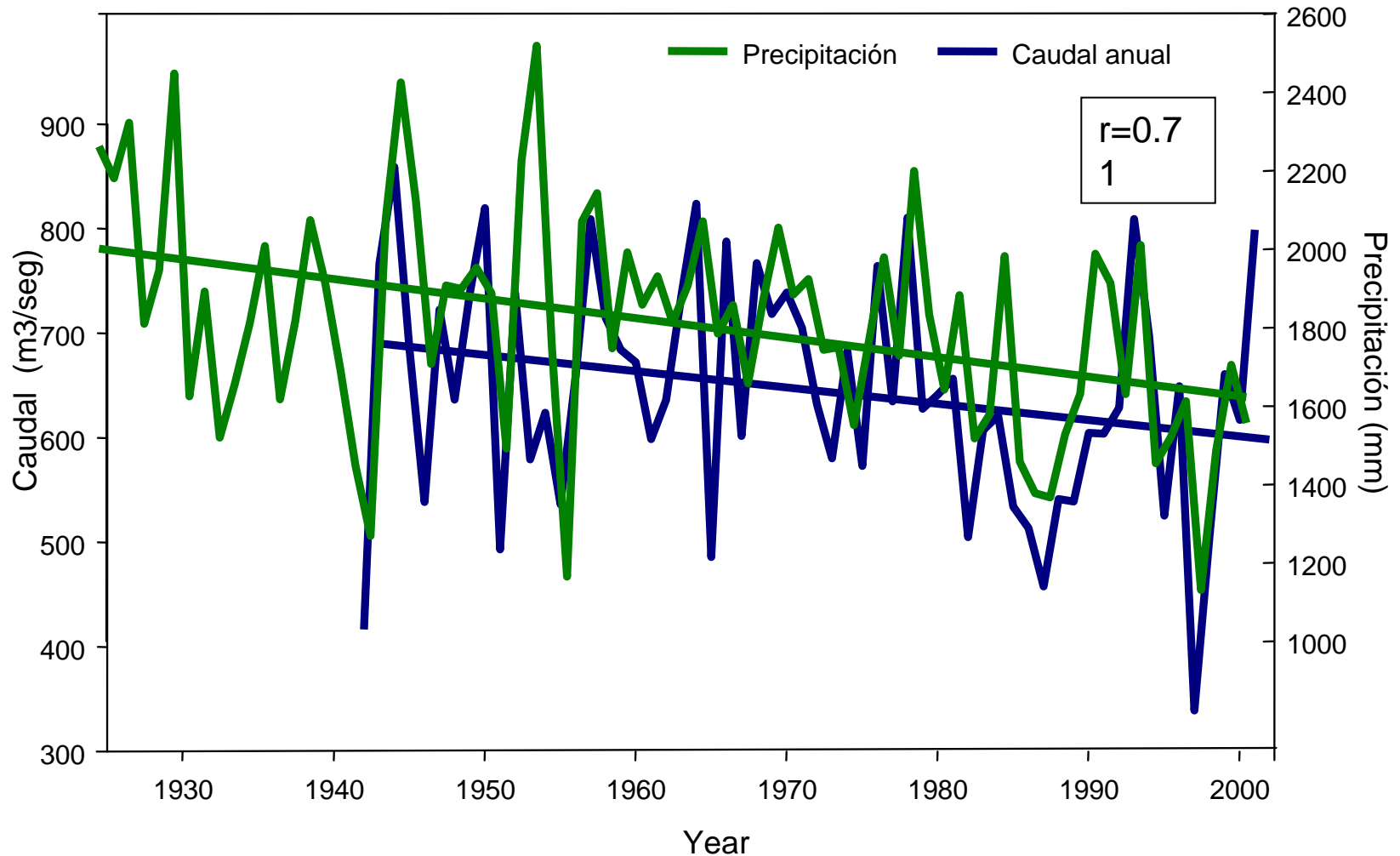
- Rainy climate
- MAP ~ 1000-3000 mm
- $\sigma(\text{IA})/\text{MAP} \sim 0.1$
- Weak ENSO Impact
- Significant drying trend



Evolución de las Precipitaciones



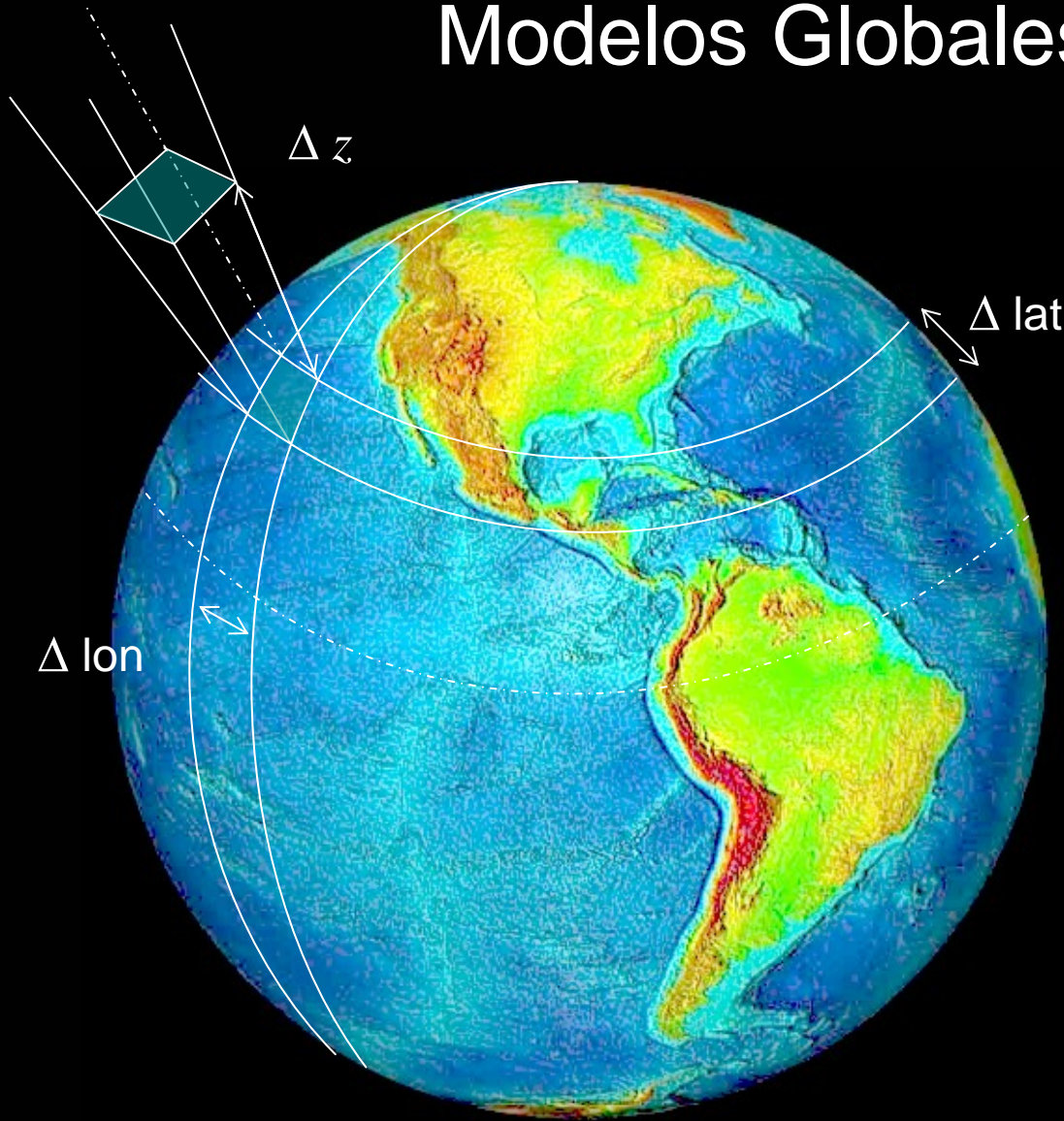
Comparación entre la precipitación de Pto. Montt y el caudal del Río Puelo (Fuente: Antonio Lara, UACH)



Proyecciones Climáticas para el siglo XXI

- i. Resultados Modelos Globales
- ii. Resultados Modelos Regionales

Modelos Globales (GCM)



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

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

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

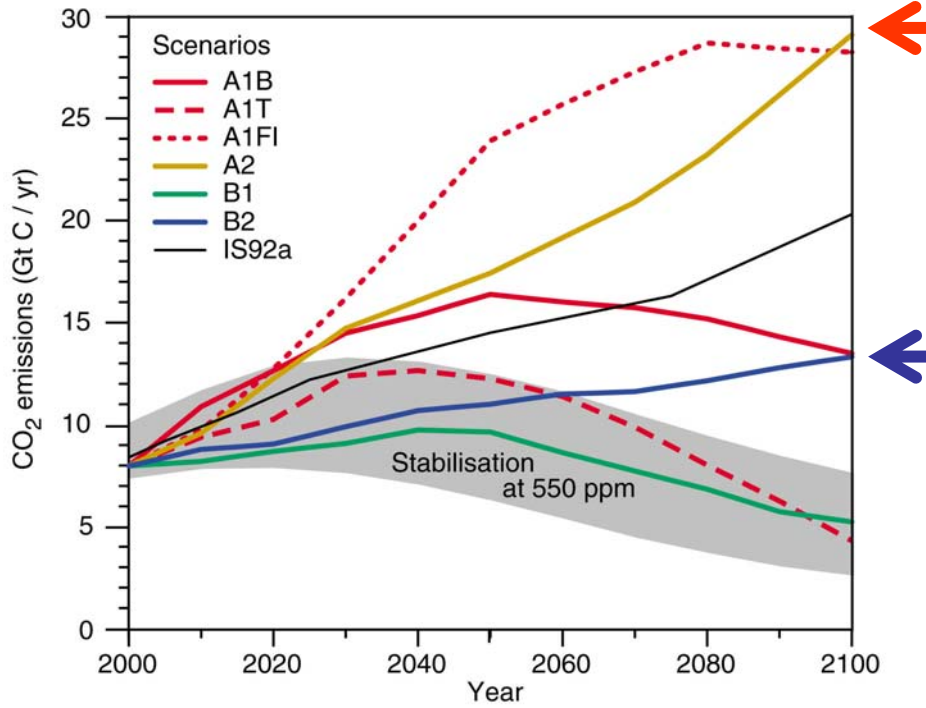
$$\frac{\partial(gz)}{\partial p} = -\frac{RT}{p}$$

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

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

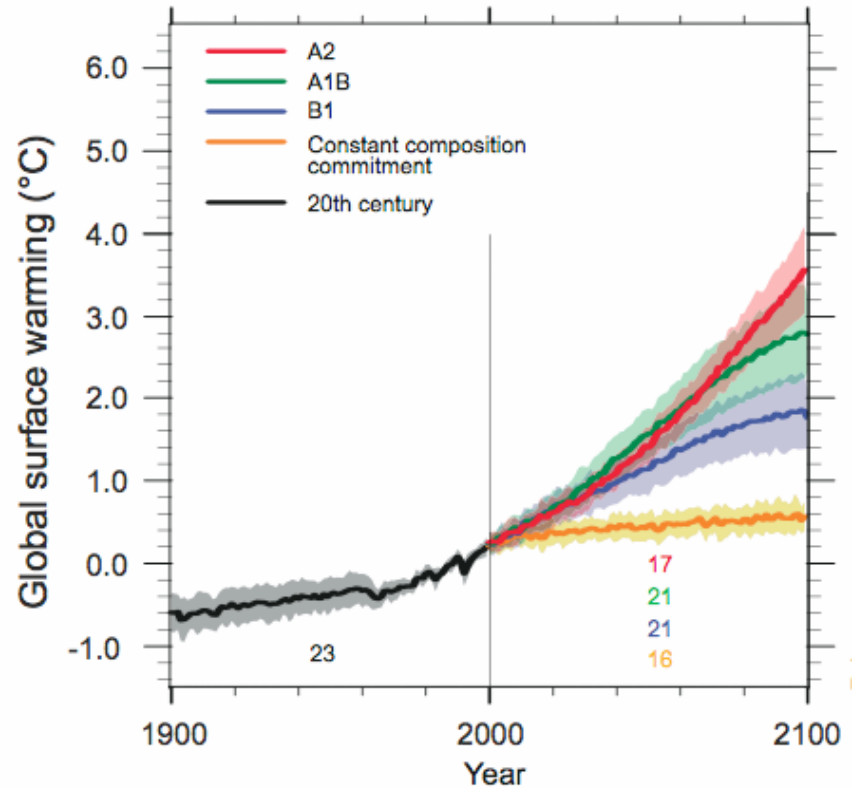
$\Delta t \sim \text{minutes-hours}$

Top of atmosphere: 15-50 km



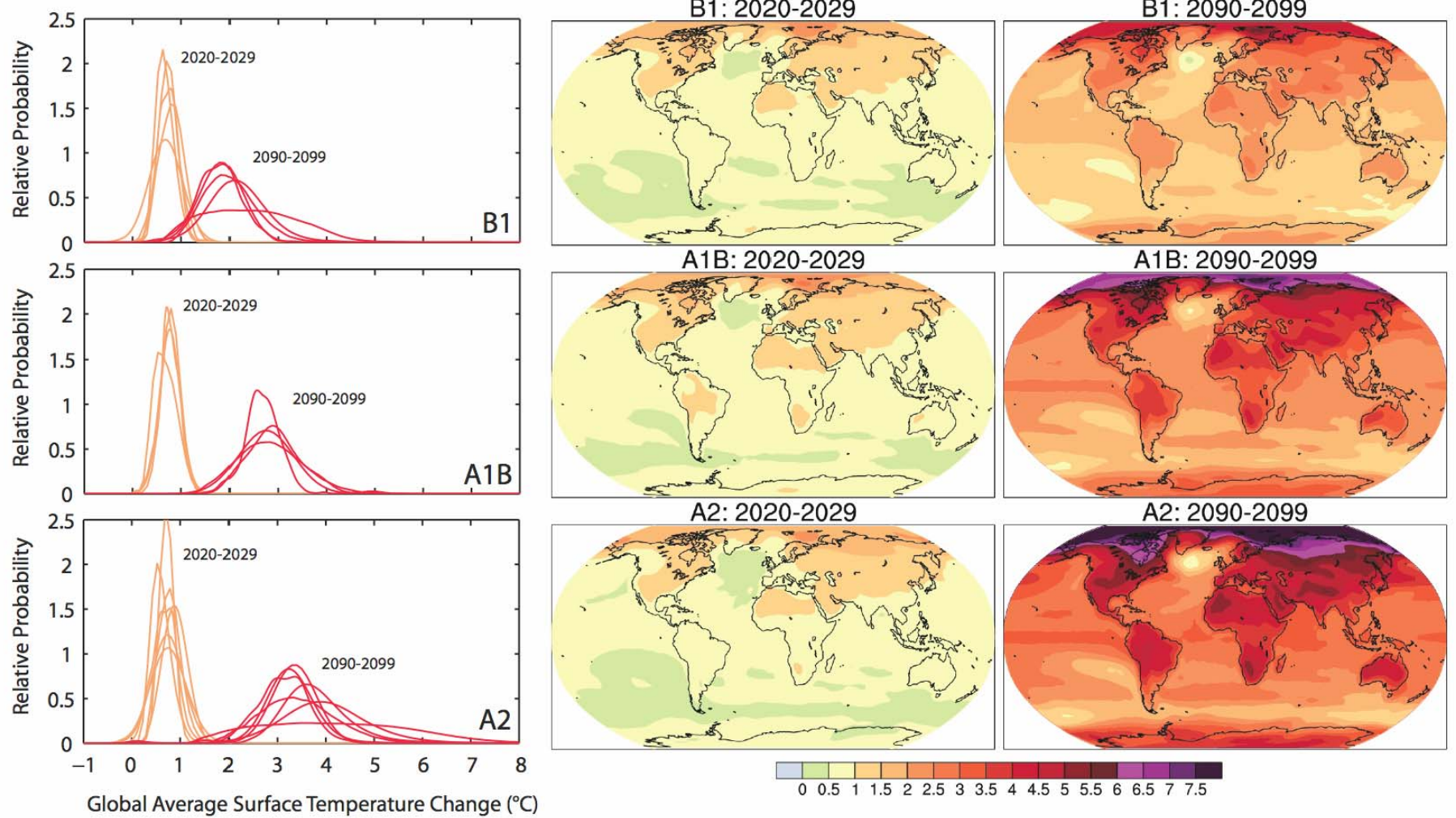
Escenarios Desarrollo
Economico-Social

GCMs



IPCC AR4: 23 GCMs disponibles con simulaciones del siglo XXI

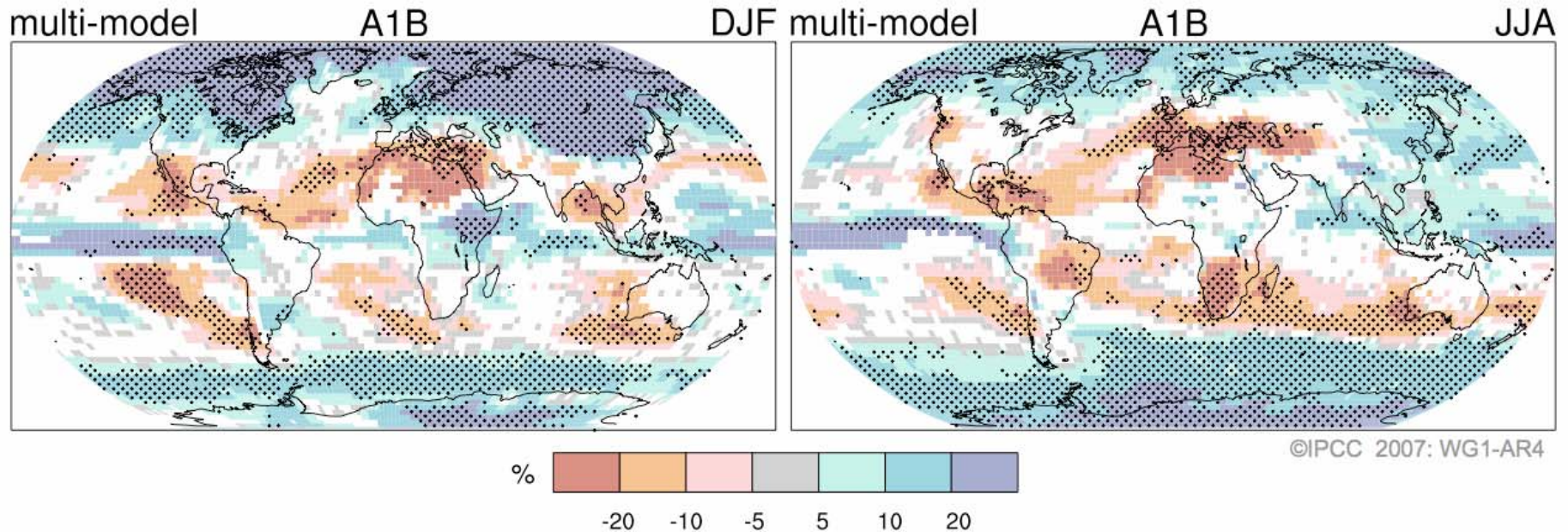
AOGCM Projections of Surface Temperatures



©IPCC 2007: WG1-AR4

IPCC AR4: 23 GCMs disponibles con simulaciones del siglo XXI

Projected Patterns of Precipitation Changes



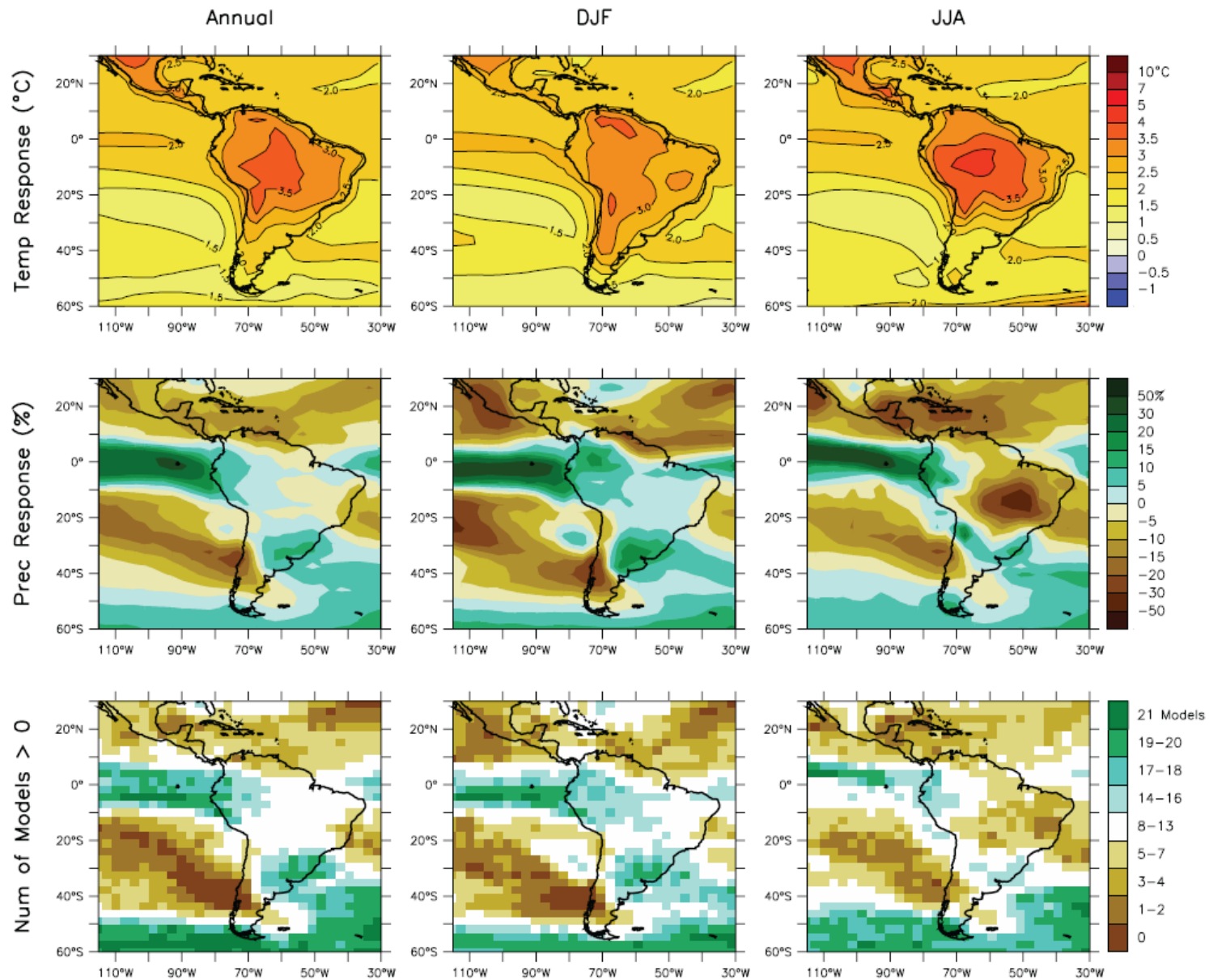
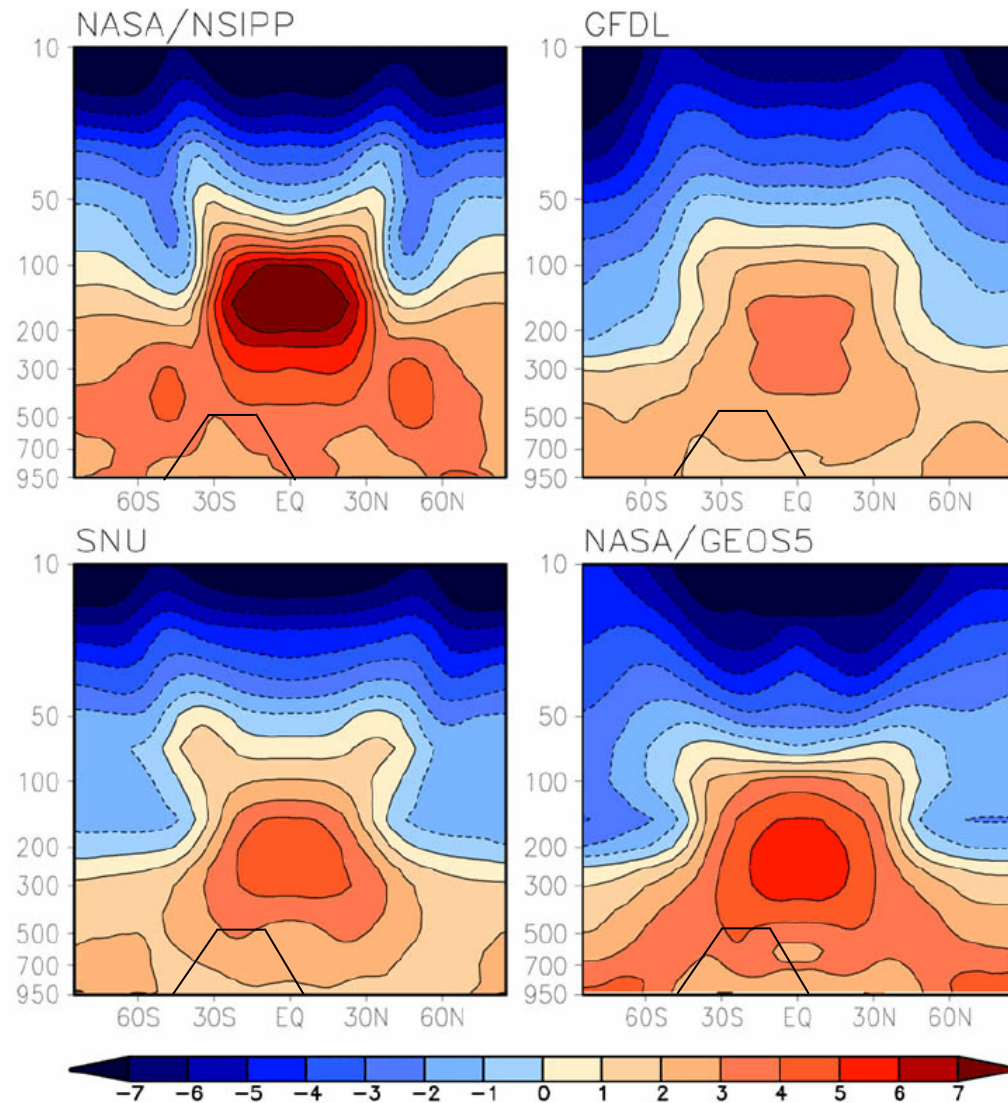


Figure 11.15. Temperature and precipitation changes over Central and South America from the MMD-A1B simulations. Top row: Annual mean, DJF and JJA temperature change between 1980 to 1999 and 2080 to 2099, averaged over 21 models. Middle row: same as top, but for fractional change in precipitation. Bottom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

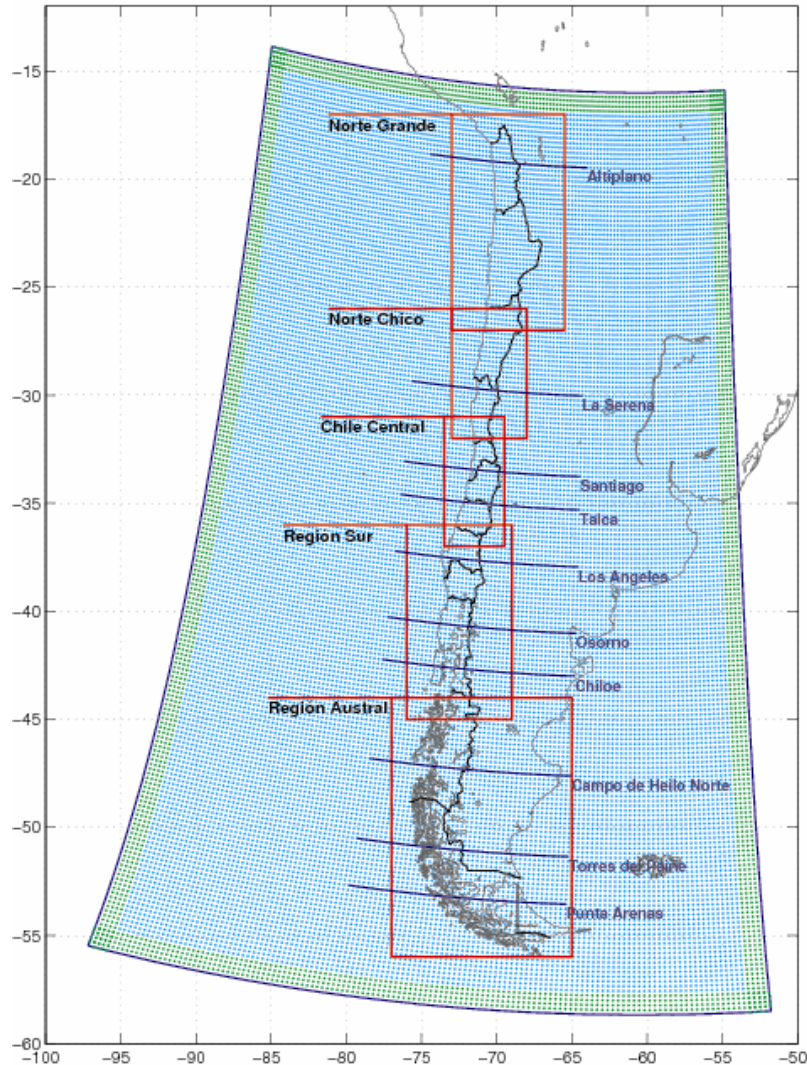
Zonal mean distribution of temperature change (2xCO₂-Ctr)



Zonal mean distributions of temperature change (2xCO₂-Control). Units are Kelvin.

Proyecto CONAMA – DGF/UCH

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



Model:

- PRECIS – UK

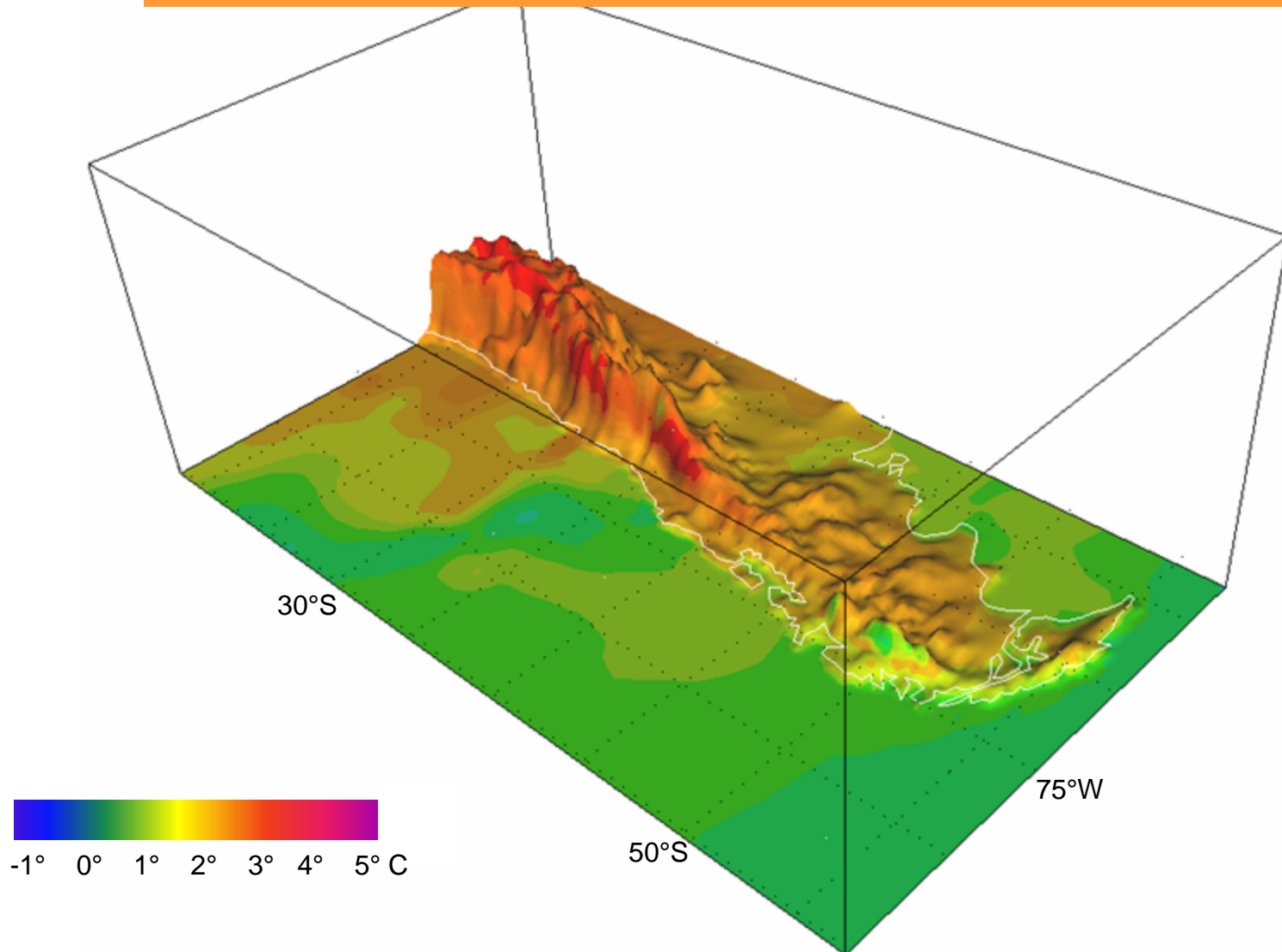
Single domain

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

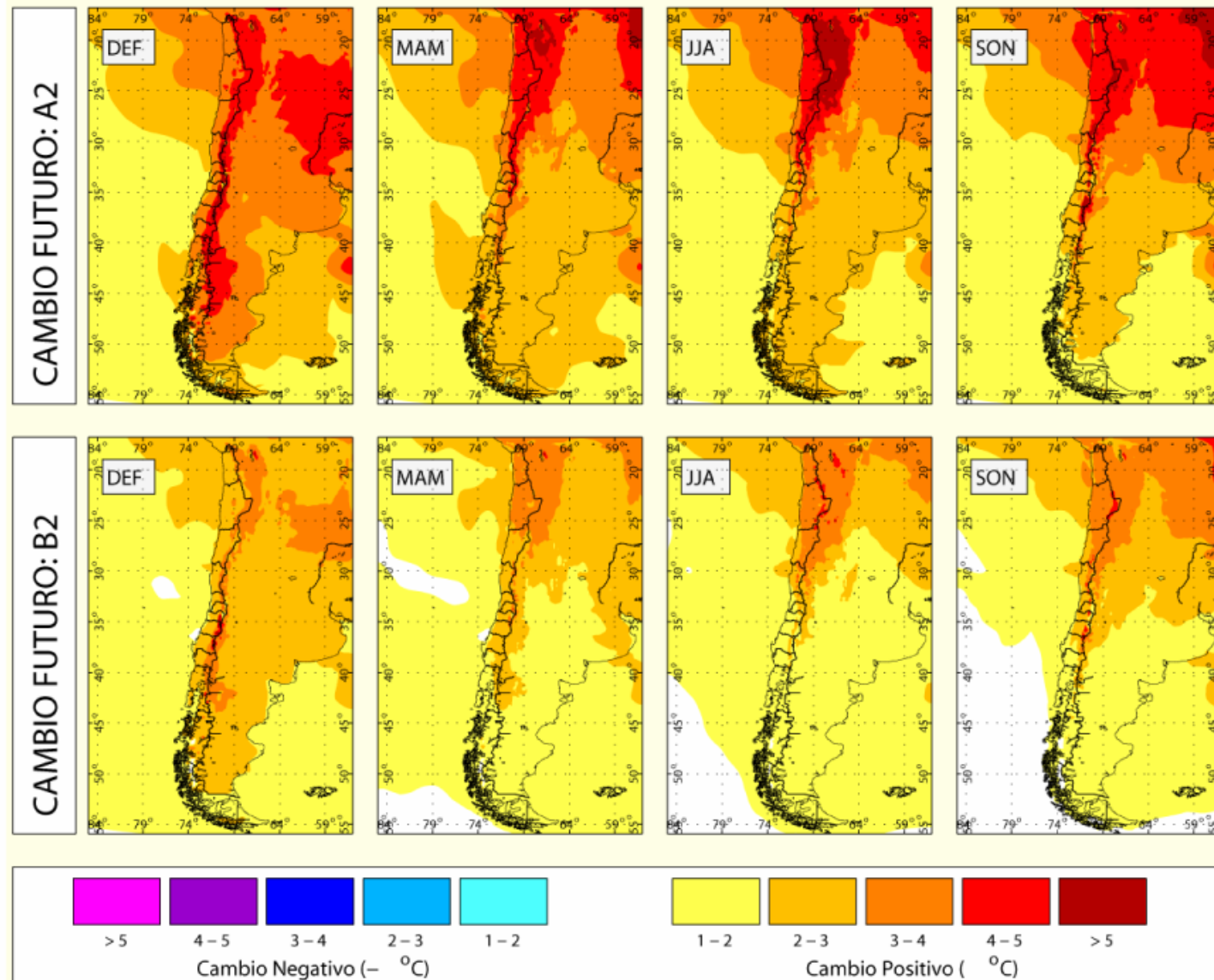
Simulations

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

Diferencia Temperatura 2-m A2-BL

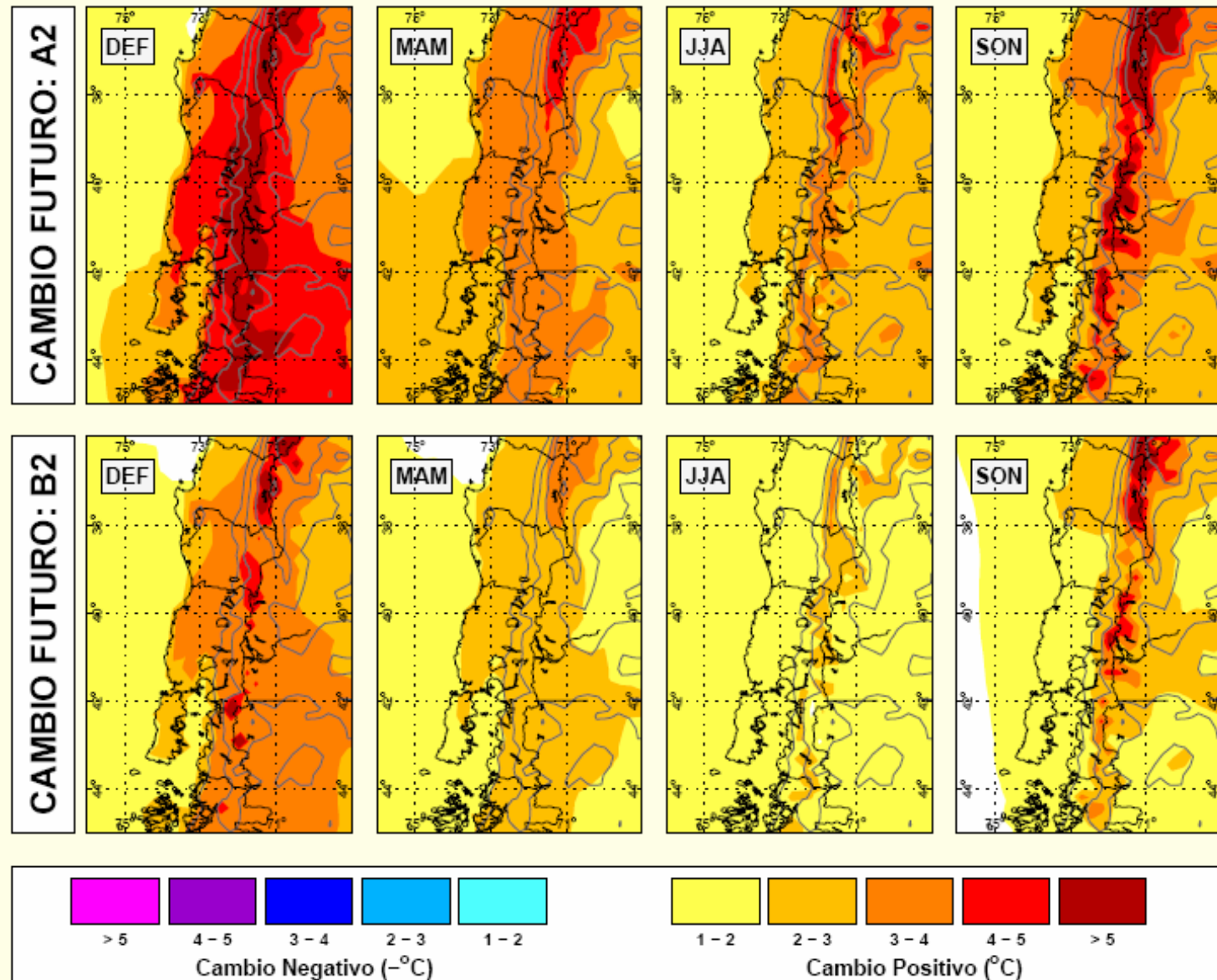


PRECIS-DGF $T_{\text{futuro}} - T_{\text{presente}}$



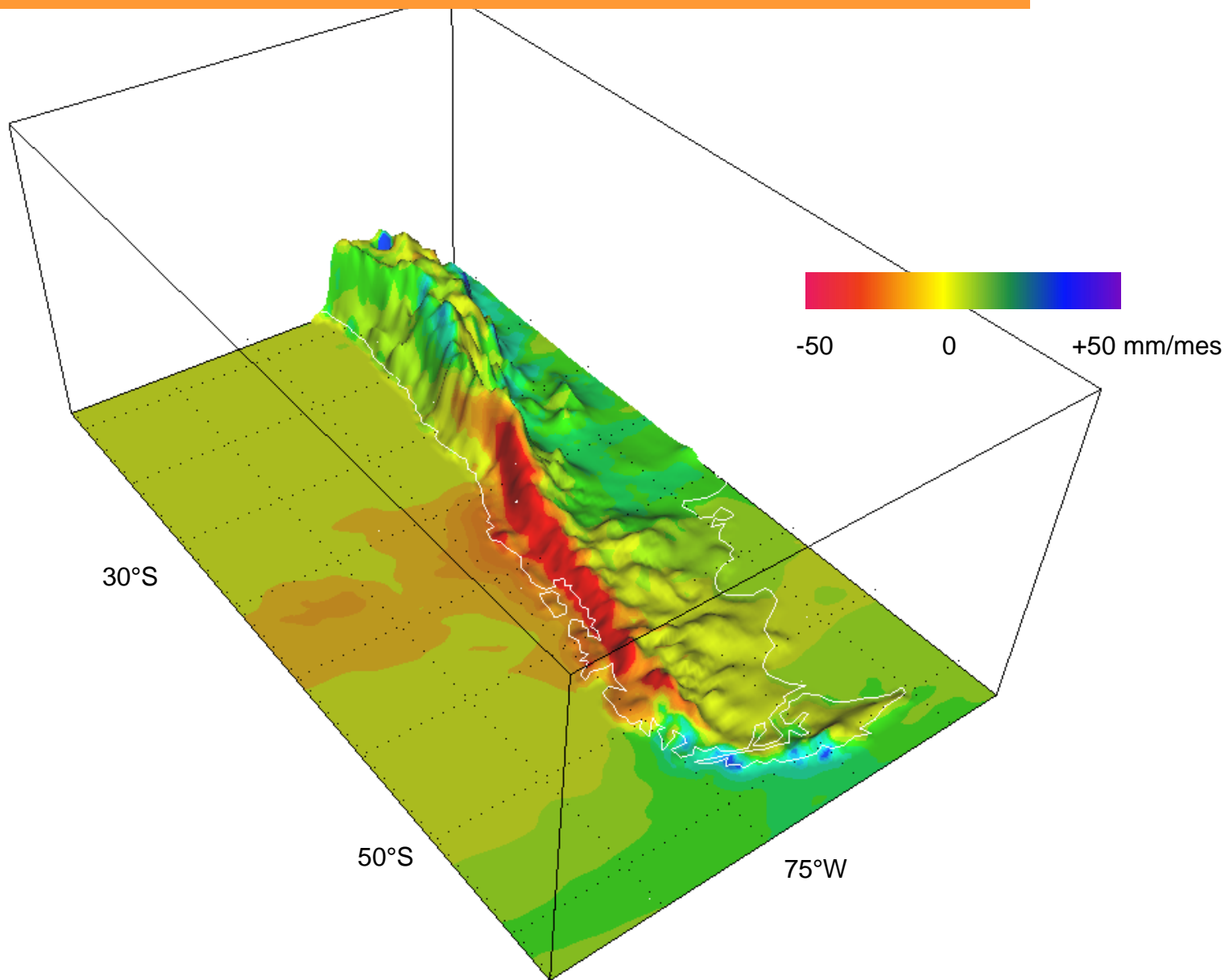
Futuro: 2071-2100 / Presente: 1960-1990

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

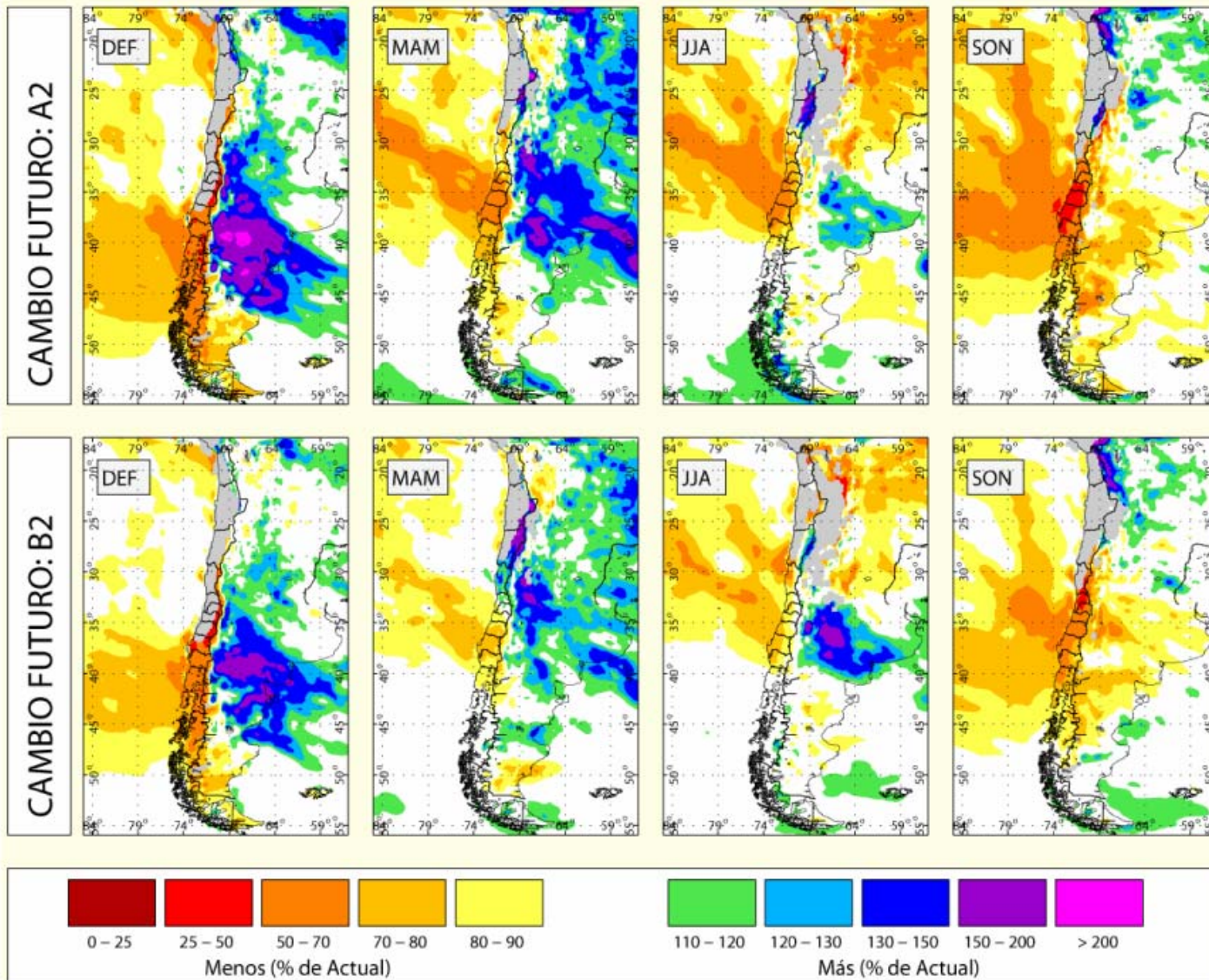


Futuro: 2071-2100 / Presente: 1961-1990

Diferencia de Precipitación A2-BL

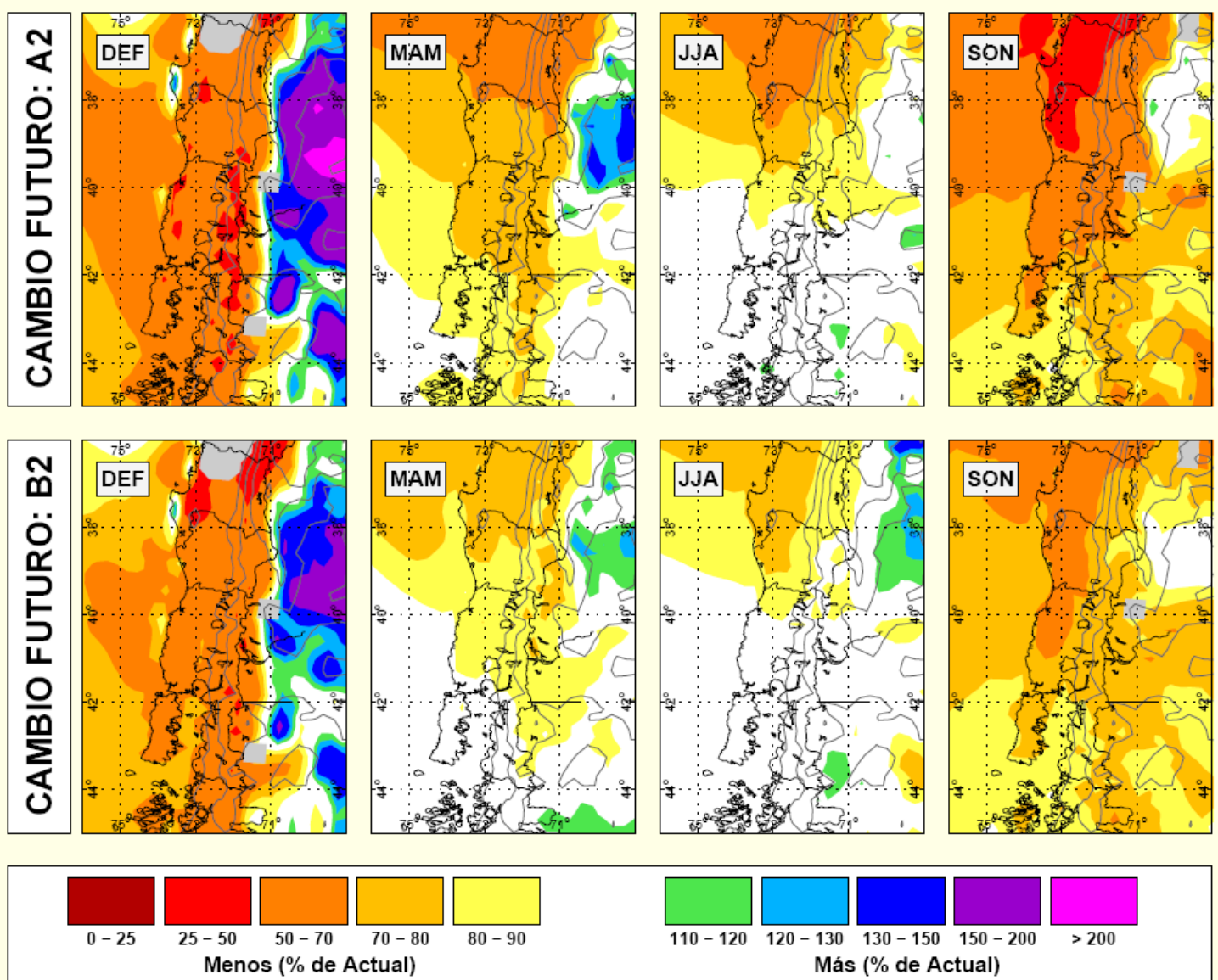


PRECIS-DGF $R_{\text{futuro}} / R_{\text{presente}}$



Futuro: 2071-2100 / Presente: 2071-2100

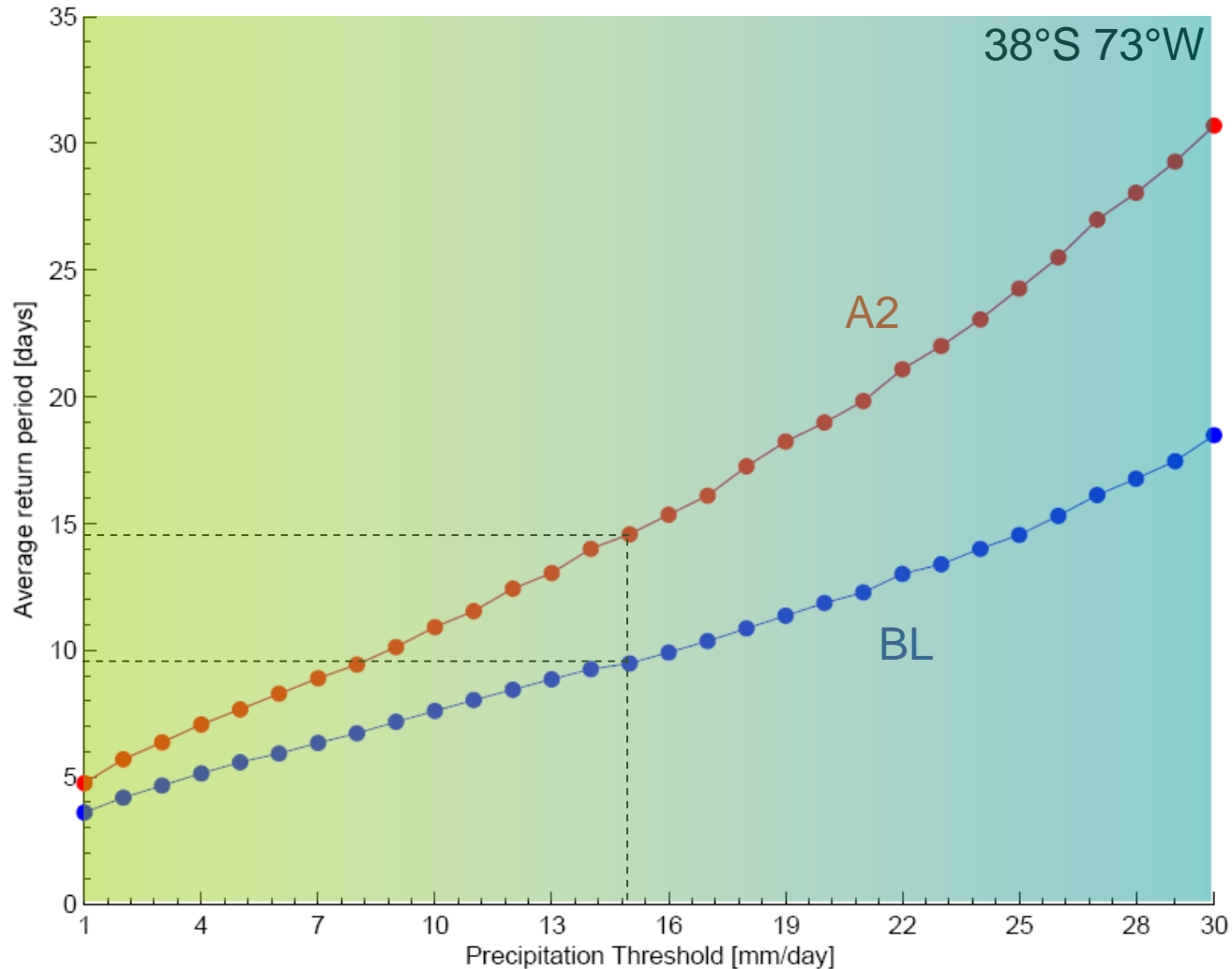
PRECIS-DGF $R_{\text{futuro}} / R_{\text{presente}}$



Futuro: 2071-2100 / Presente: 1961-1990

PRECIS-DGF

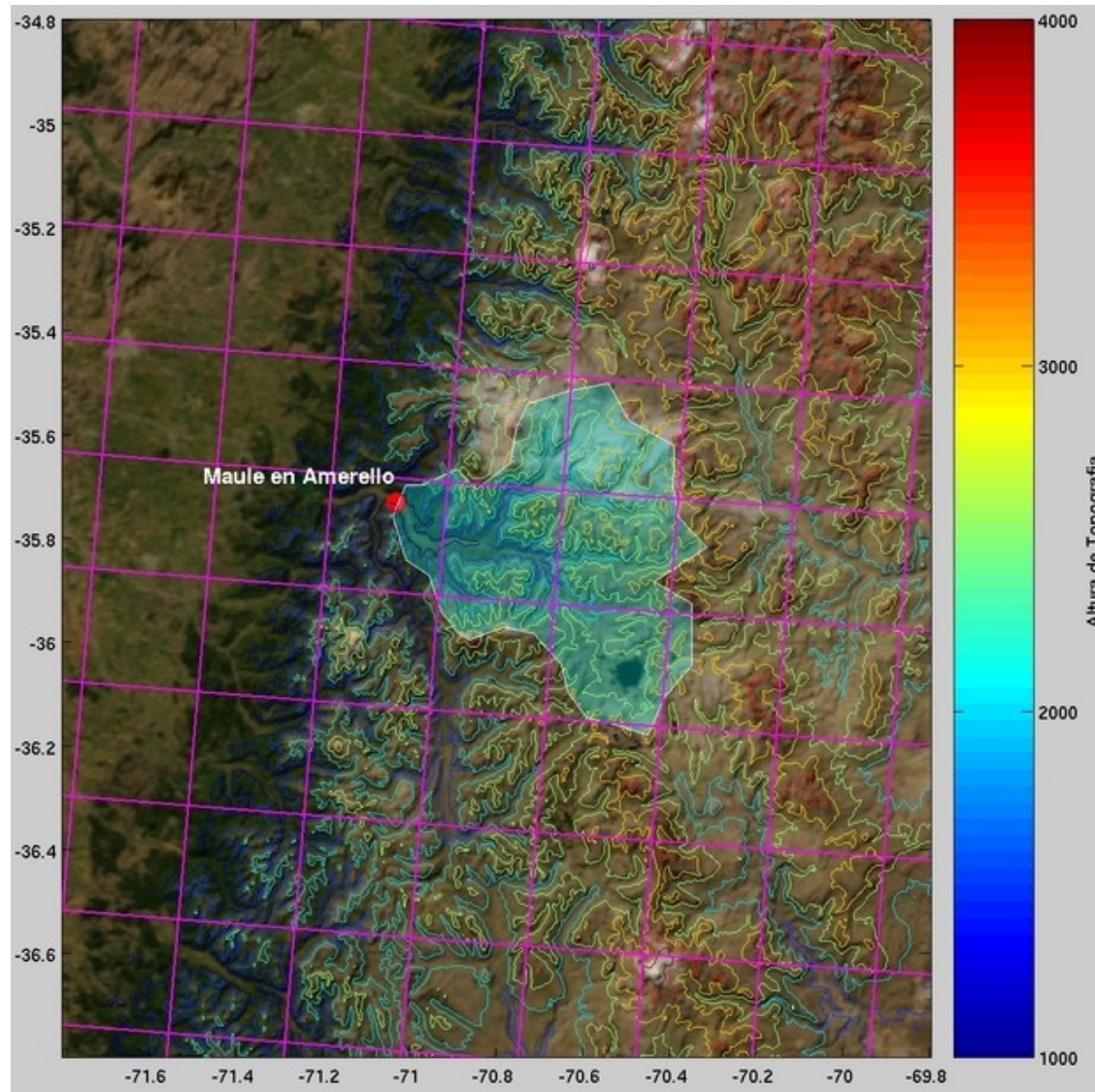
¿Cuanto tiempo transcurre entre episodios de precipitación?
e.g.: PP=15 mm: 9 días clima actual, 15 días clima A2



Futuro: 2071-2100 / Presente: 1961-1990

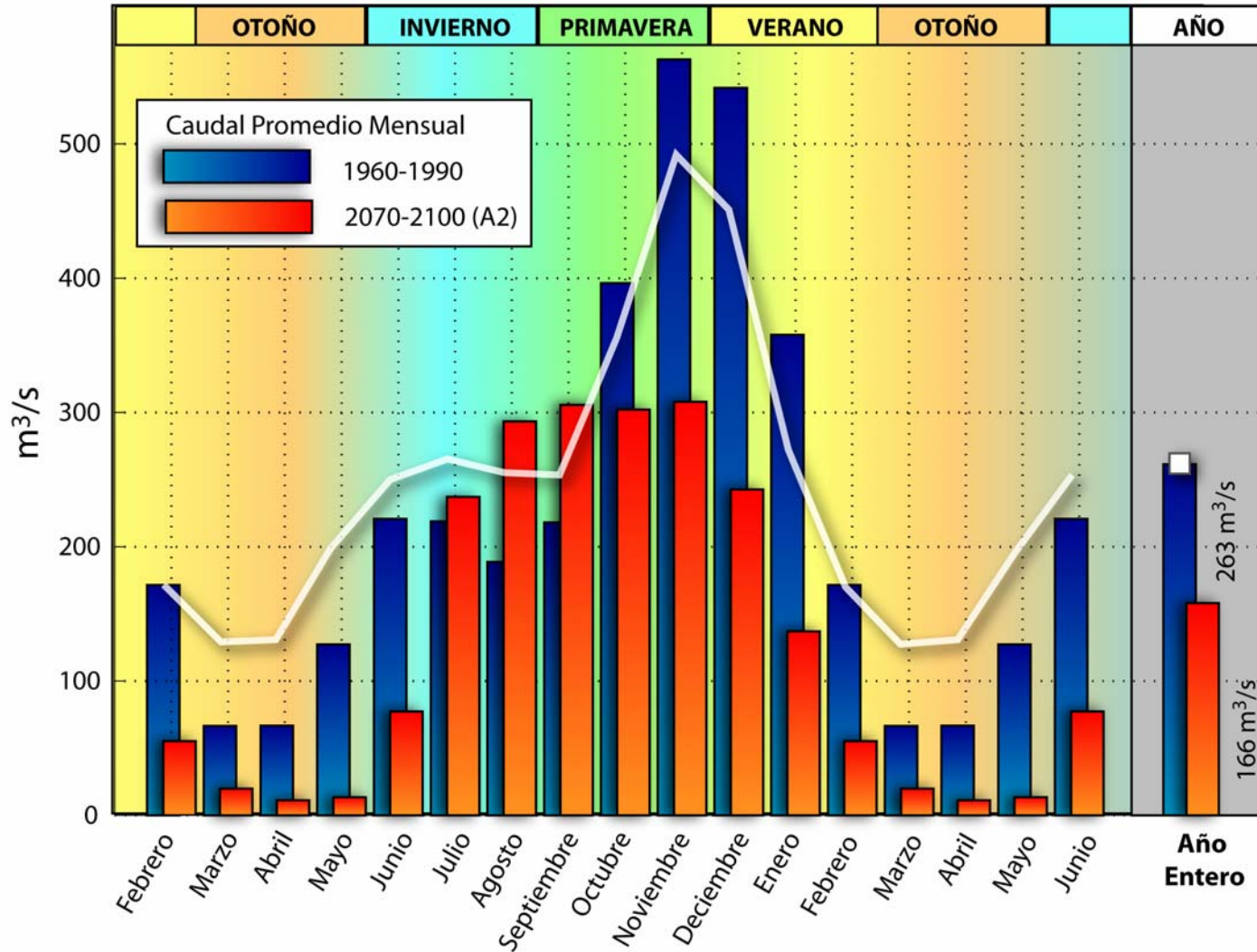
PRECIS-DGF

Acomplamiento con modelos hidrológicos.



PRECIS-DGF Acomplamiento con modelos hidrológicos.

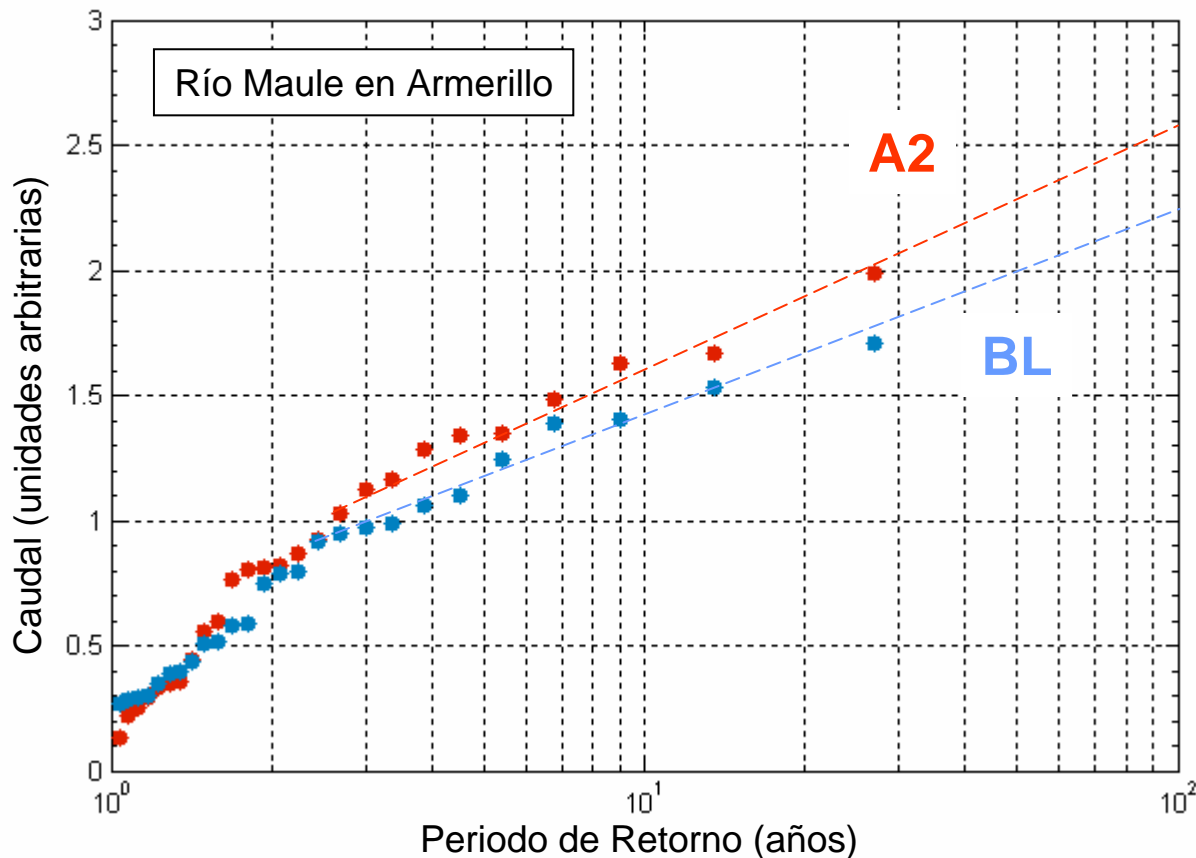
CAUDAL SIMULADO DEL RIO MAULE* - PRESENTE y FUTURO (A2)



* Rio Maule en Armerillo - Pre-Cordillera

PRECIS-DGF - Eventos Extremos

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



Conclusiones

- Existen manifestaciones del cambio climático asociado a los GI en las últimas décadas a nivel global y local.
- Cambios proyectados son en algunos casos similares en magnitud y signo a los cambios observados en las últimas décadas.
- Zona centro sur afectada por disminución de precipitación (especialmente en primavera, $\sim 1/2-3/4$ actual) y aumento de temperatura (especialmente T_x , $\sim + 2-4^\circ\text{C}$)
- PRECIS-DGF es una buena base de datos para análisis sectoriales, pero solo un comienzo....