Regional Climate Change simulations with PRECIS for Chile

Maisa Rojas, R. Garreaud, M.Falvey, H. Fuenzalida

Department of Geophysics

Univ. of Chile

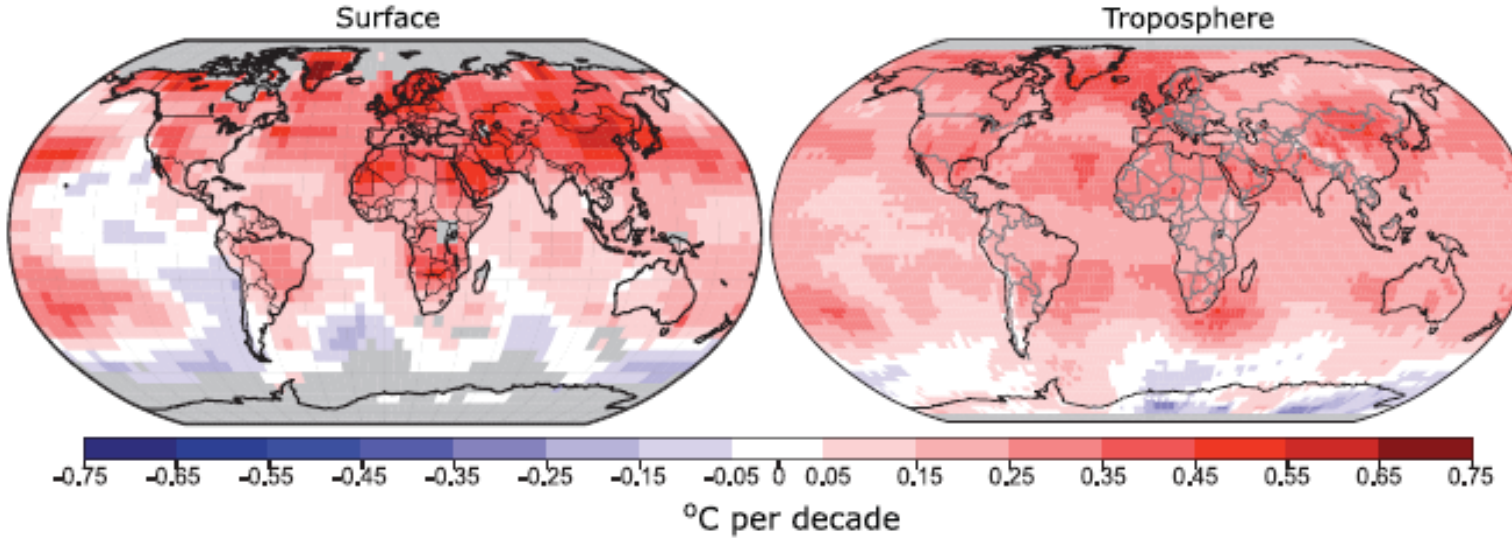
outline

- Observed climate change over Chile
- Validation of global model and RCM
- PRECIS results
- Some applications to water resources

motivation

- Simulations were carried out for the second national communication on climate change.
- Due to the complex topography a higher resolution simulation will be necessary for any impact study.

Global Temperature change



IPCC AR4, 2007

Temperature tendencies:
annual means

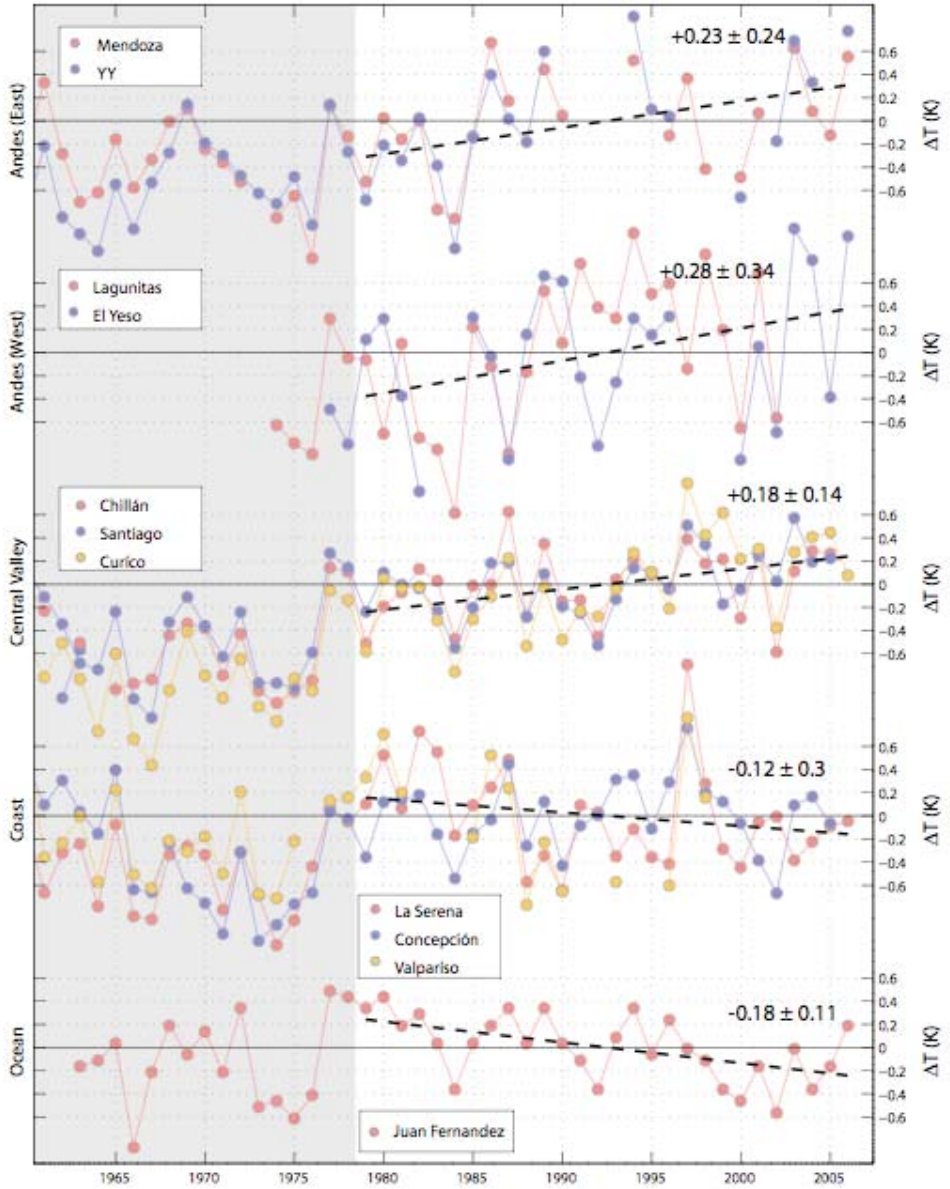
Argentina

Andes

valley

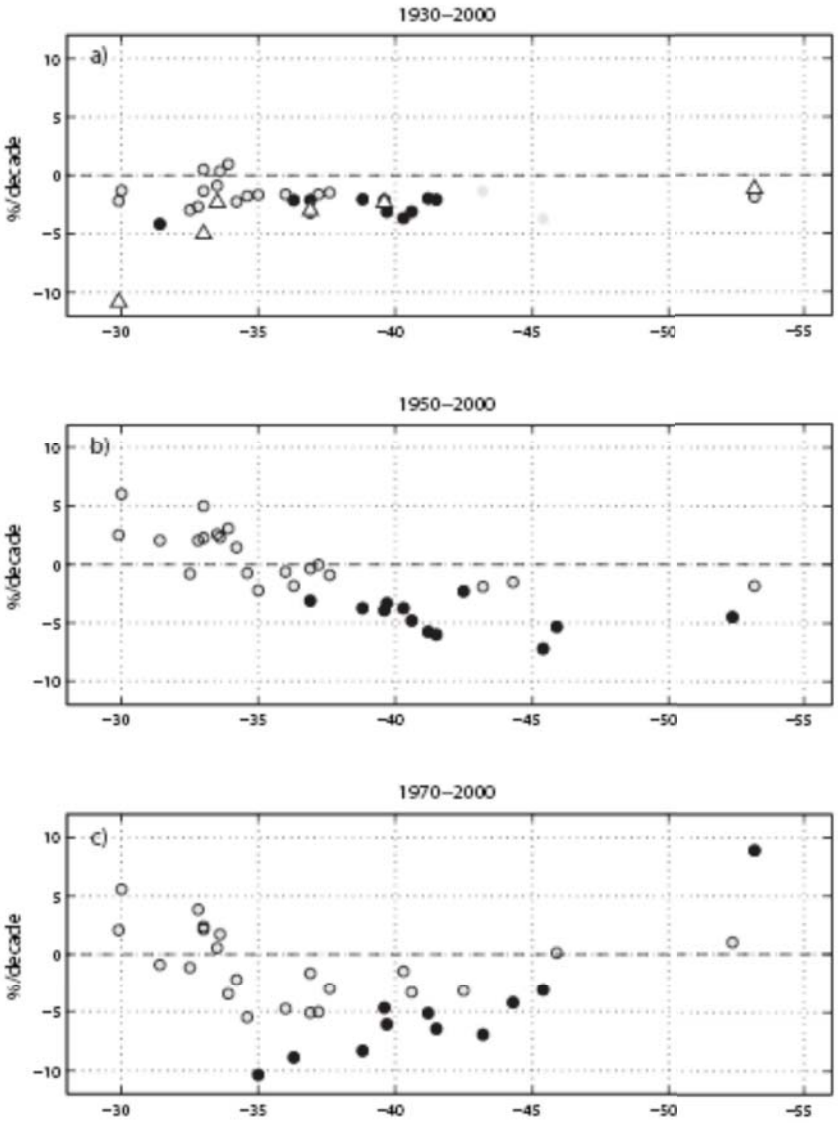
coast

ocean



Falvey and Garreaud, *in prep*

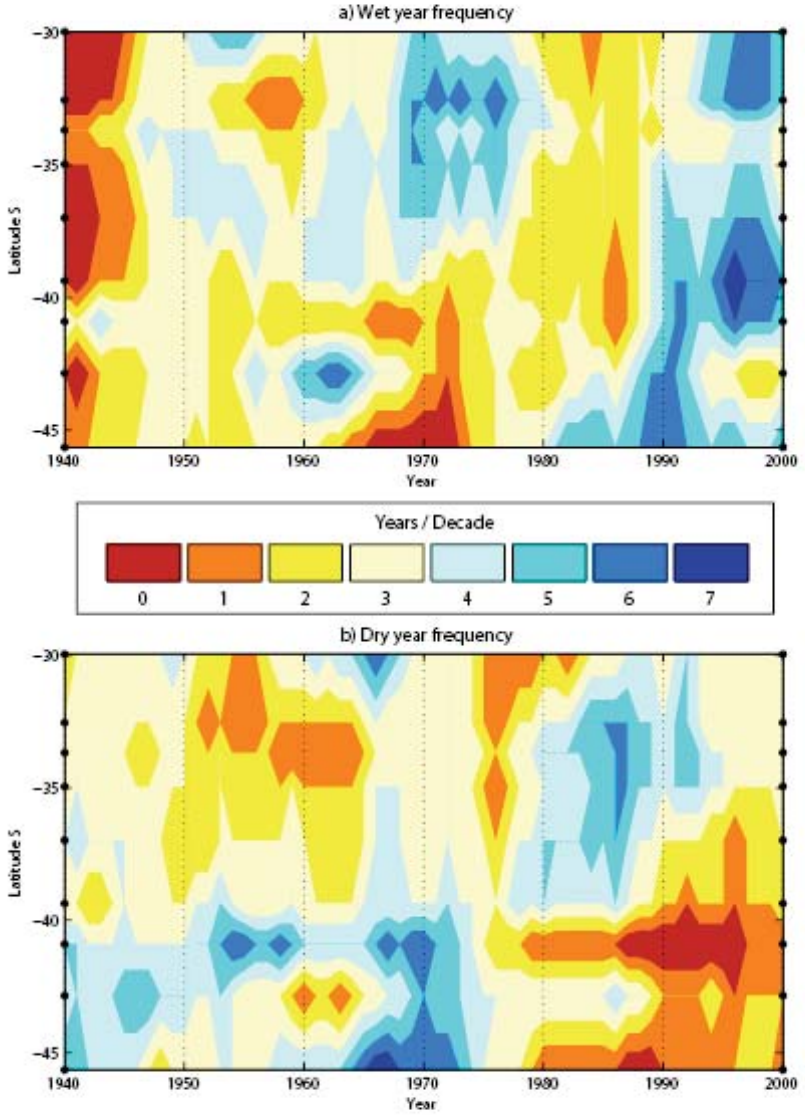
Tendencies in annual Precipitation



Linear trends in annual rainfall for different periods, expressed in %/decade, with the percentage of change is calculated with respect to the 1971-2000 mean value: a) 1930 – 2000. Triangles indicate trend during the period 1900 - 2000; b) 1950 - 2000; c) 1970 - 2000. Close circles indicated trends reaching the 95% significant level, according to a Monte Carlo test.

Quintana y Aceituno, 2008

Frequency of wet and dry years in a decade



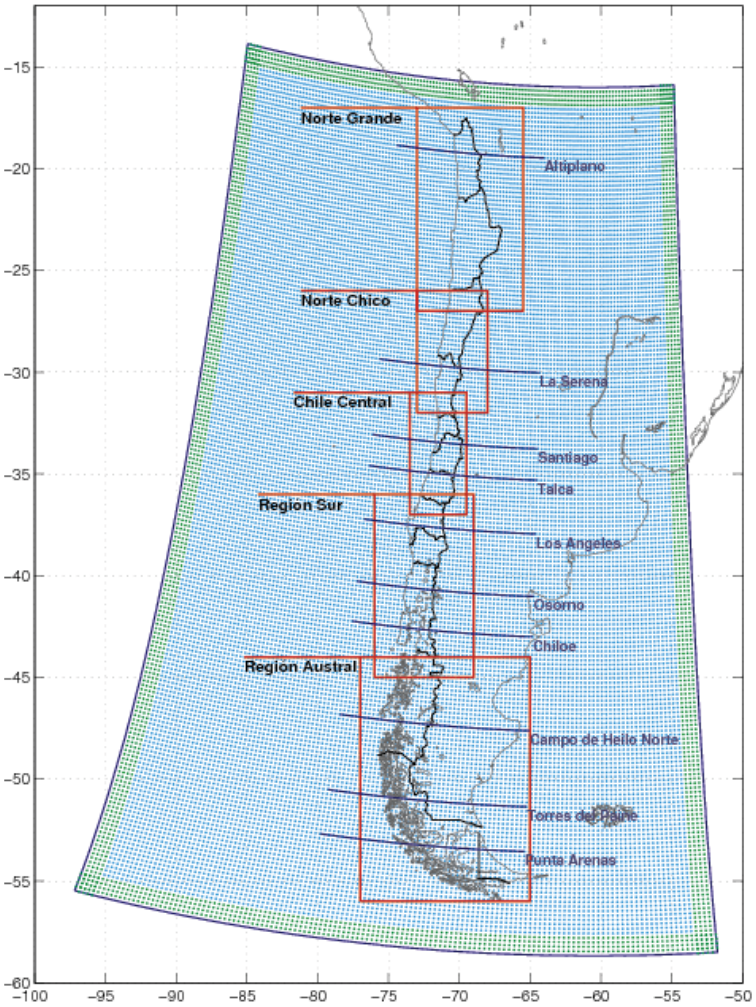
Frequency of wet (a) and dry (b) years for 10-year sliding periods during 1930 - 2000, calculated from regional rainfall indices. Wet and dry years are those with annual rainfall in the 1st tercile and in the 3rd tercile of the distribution, respectively. Frequencies 0, 1, or equal or larger than 5 are statistically significant to the approximately 90% level. X-scale indicates the last year of a 10-year period.

Important interdecadal Variability is observed!

Quintana and Aceituno, 2008

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

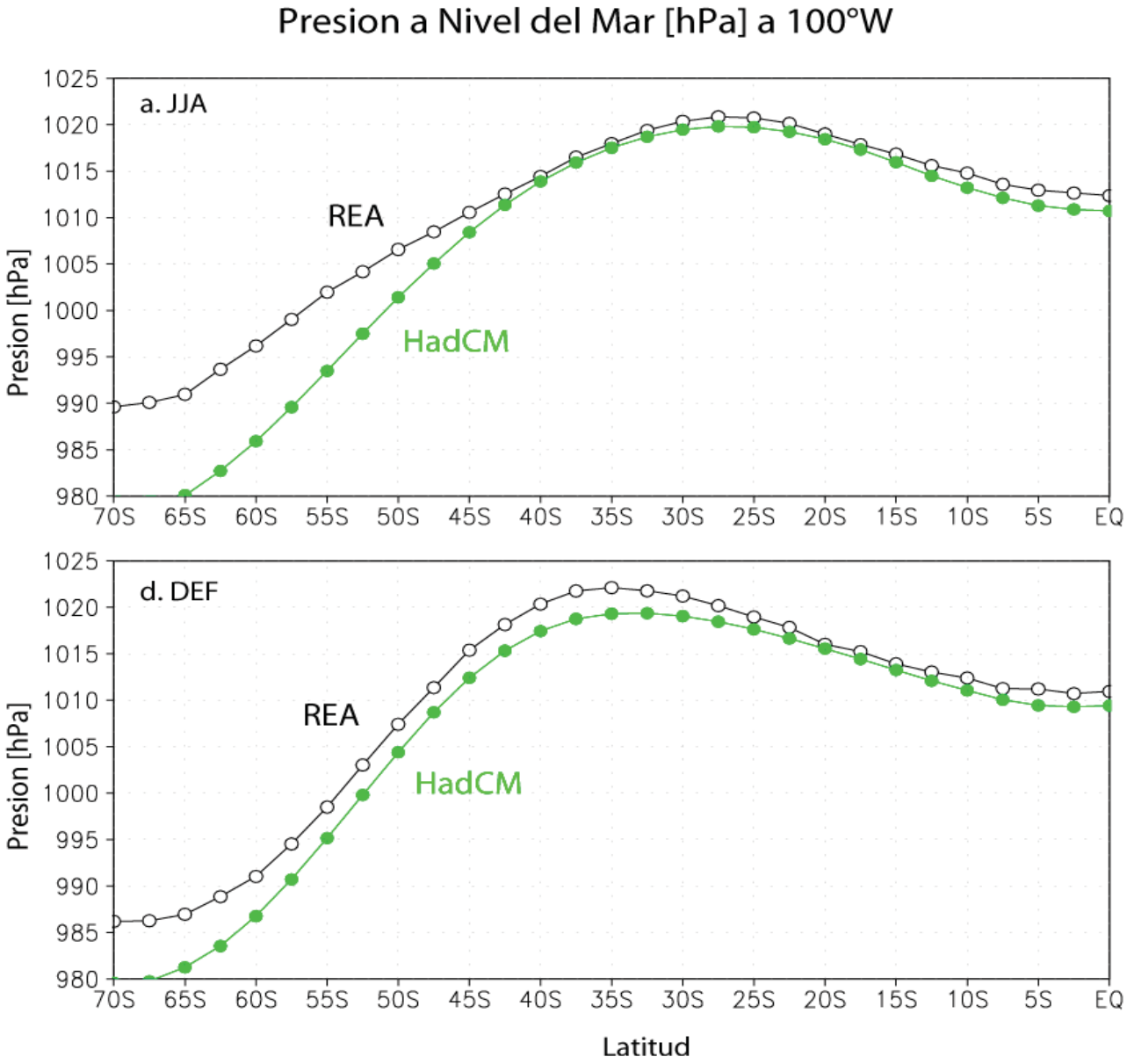
Simulations

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

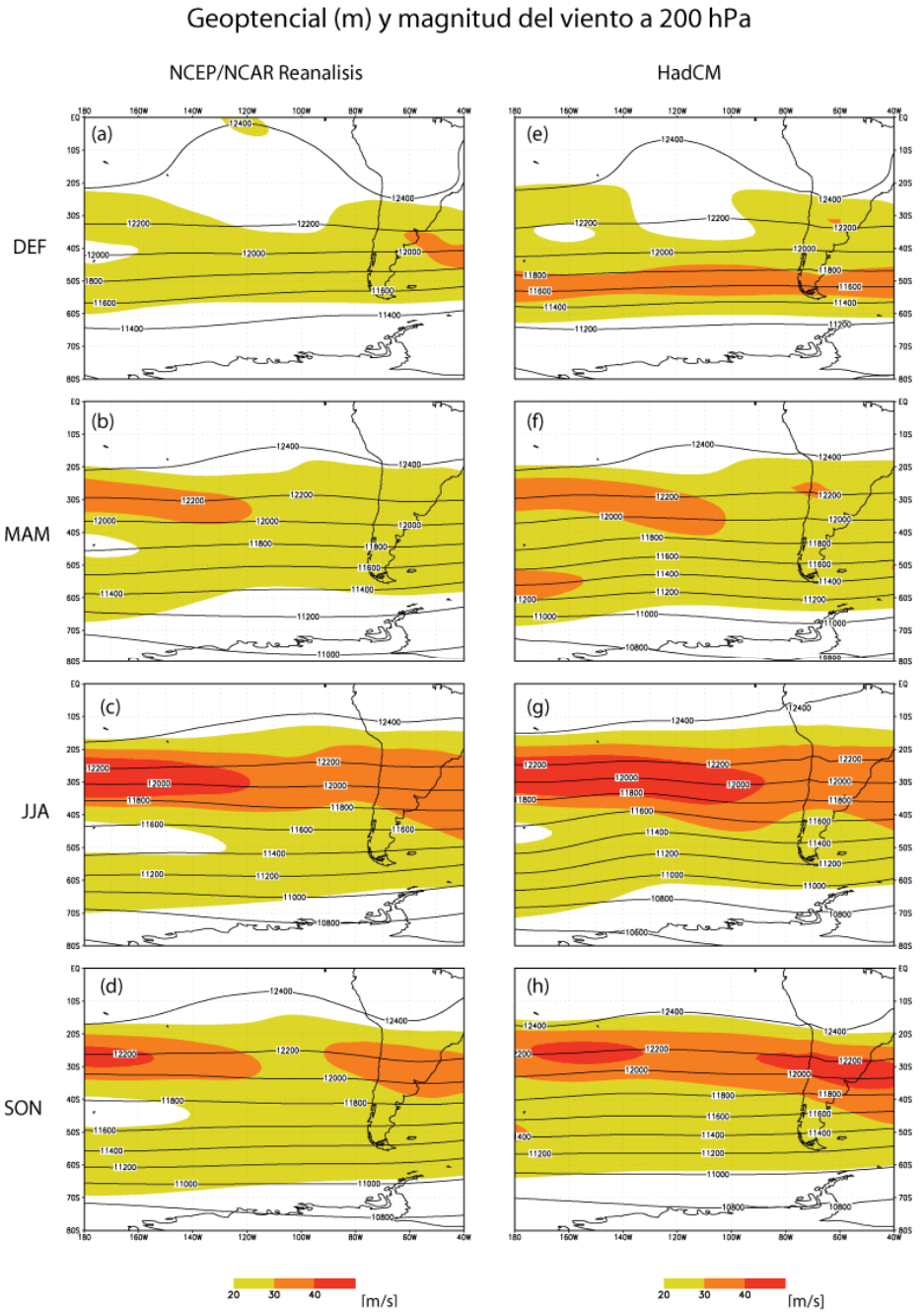
Validation GCM SLP at 100W

WINTER

SUMMER



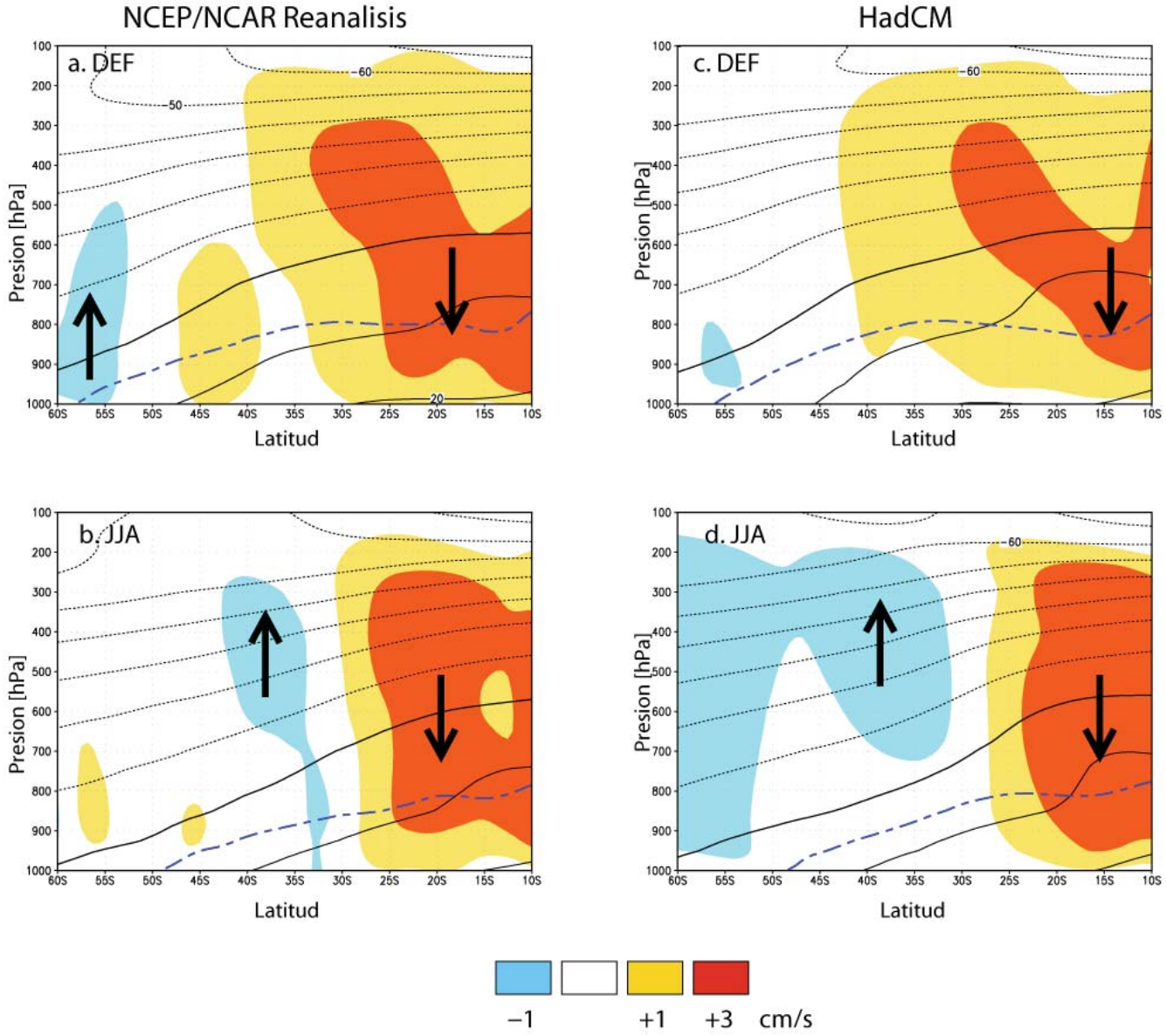
Validation GCM Height and 200hPa wind speed



Validation GCM vertical motion at 100W

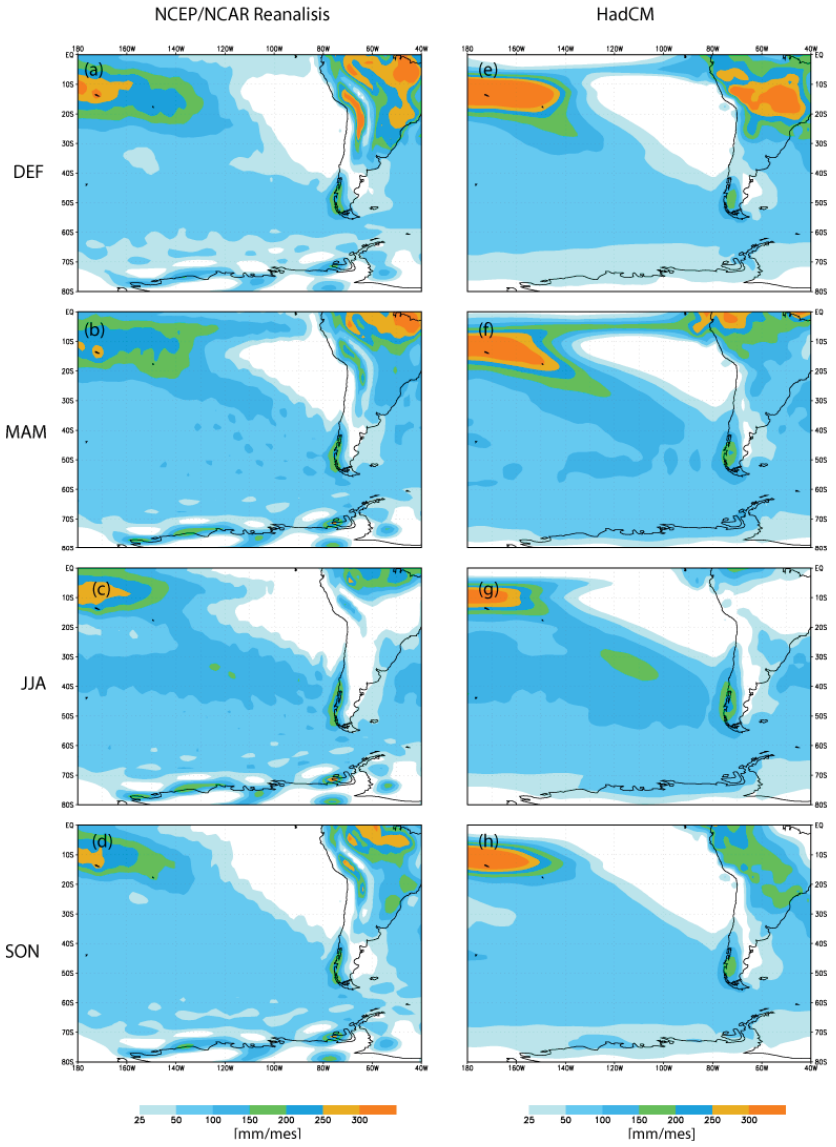
SUMMER

WINTER



Validation GCM

Precipitation



Projections CMIP3

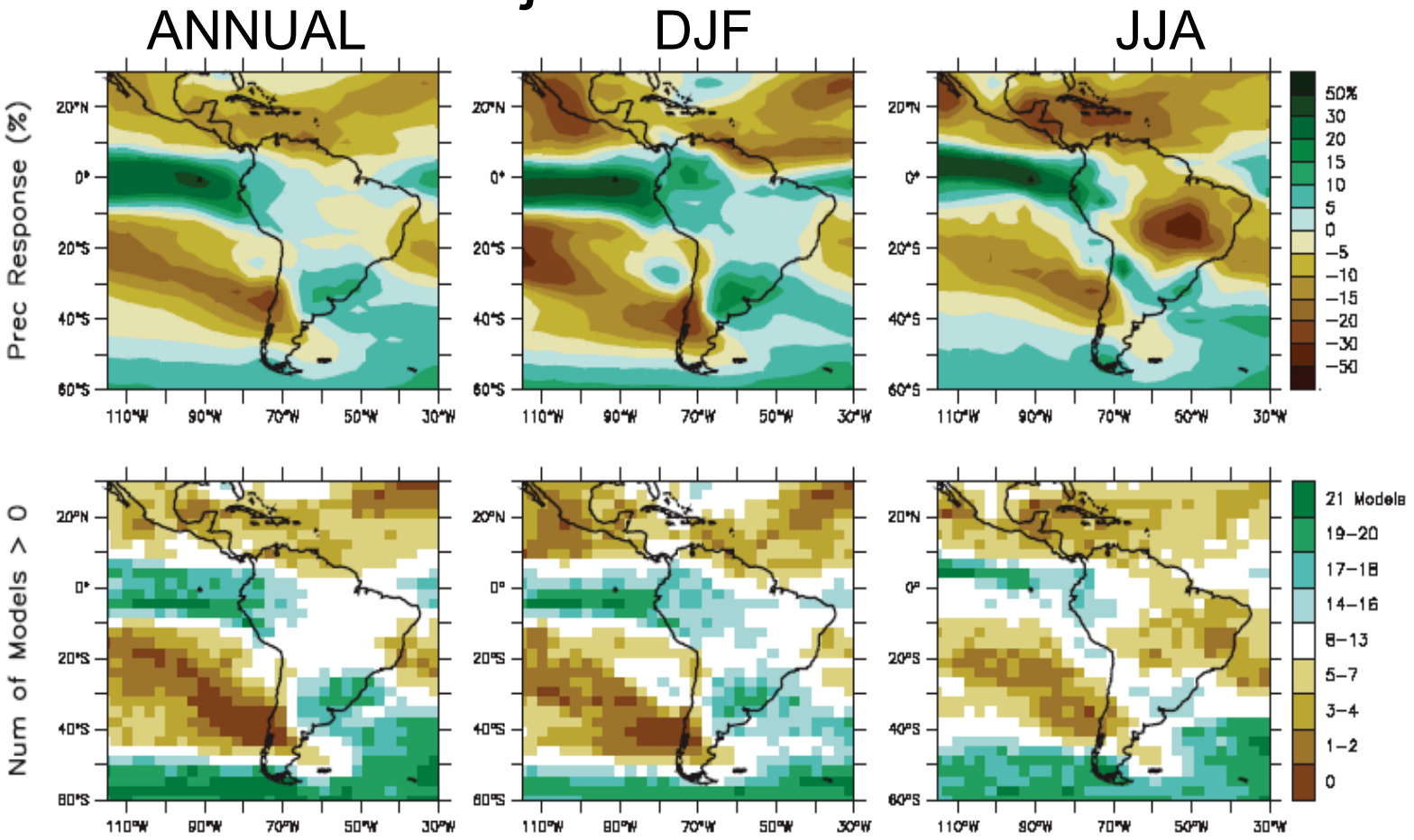


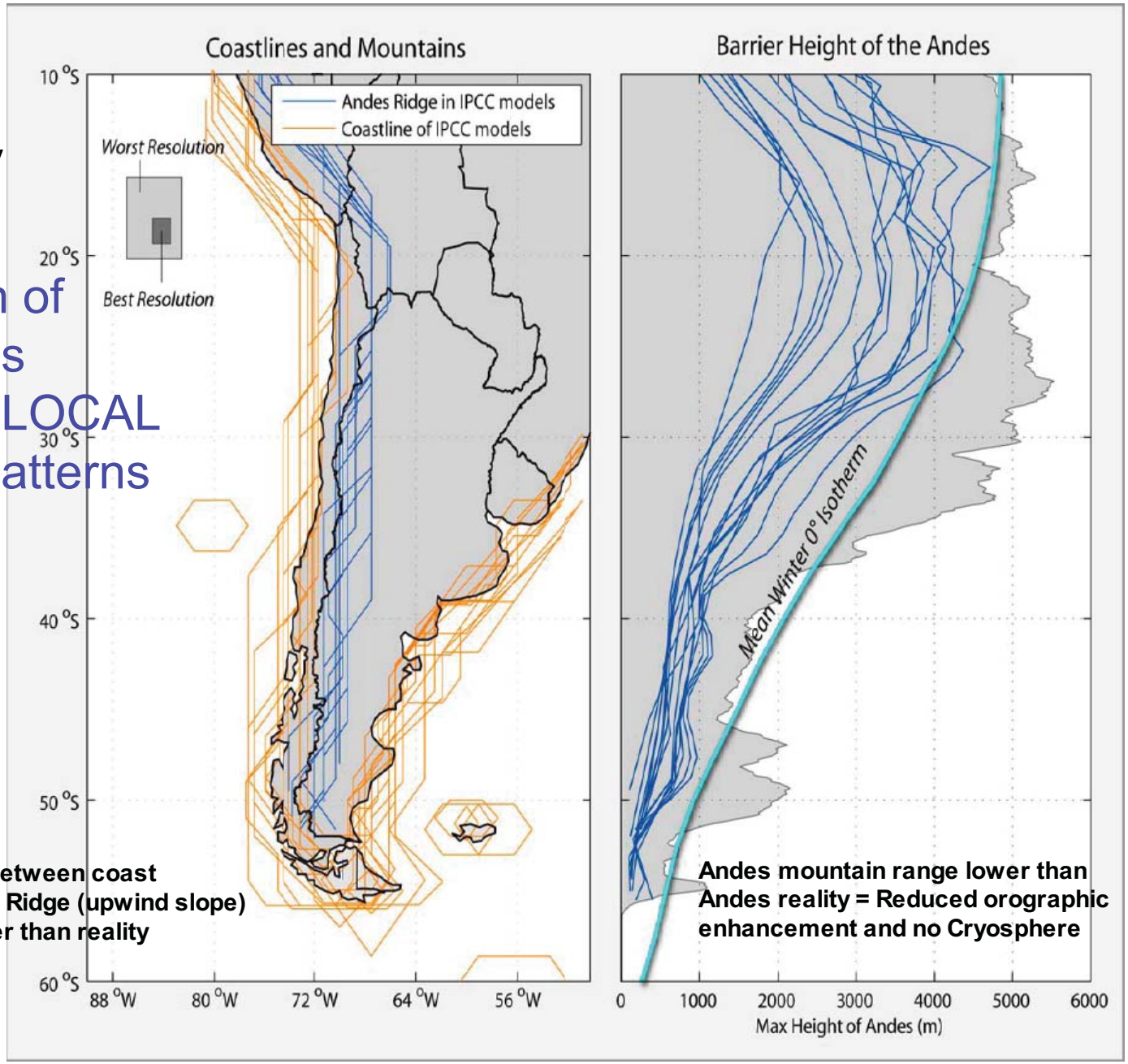
Figure 11.15. *Temperature and precipitation changes over Central and South America from the MMD-A1B simulations. Top row: Annual mean, DJF and JJA temperature change between 1980 to 1999 and 2080 to 2099, averaged over 21 models. Middle row: same as top, but for fractional change in precipitation. Bottom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

IPCC WG1, 2007

Why run a regional model?

CMIP3 topography

representation of terrain features that influence LOCAL precipitation patterns is poor…

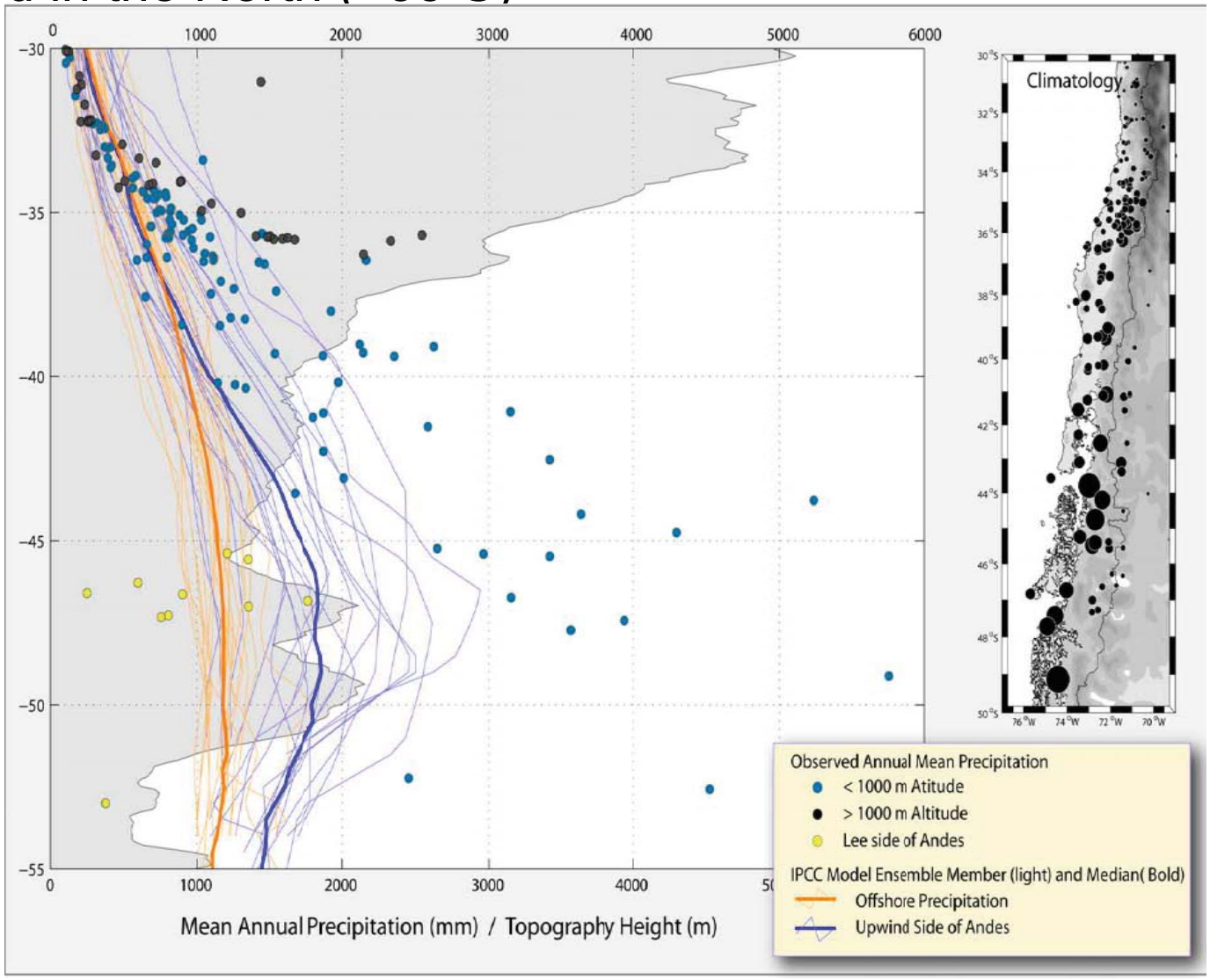


Distance between coast and Andes Ridge (upwind slope) much wider than reality

Andes mountain range lower than Andes reality = Reduced orographic enhancement and no Cryosphere

M. Falvey

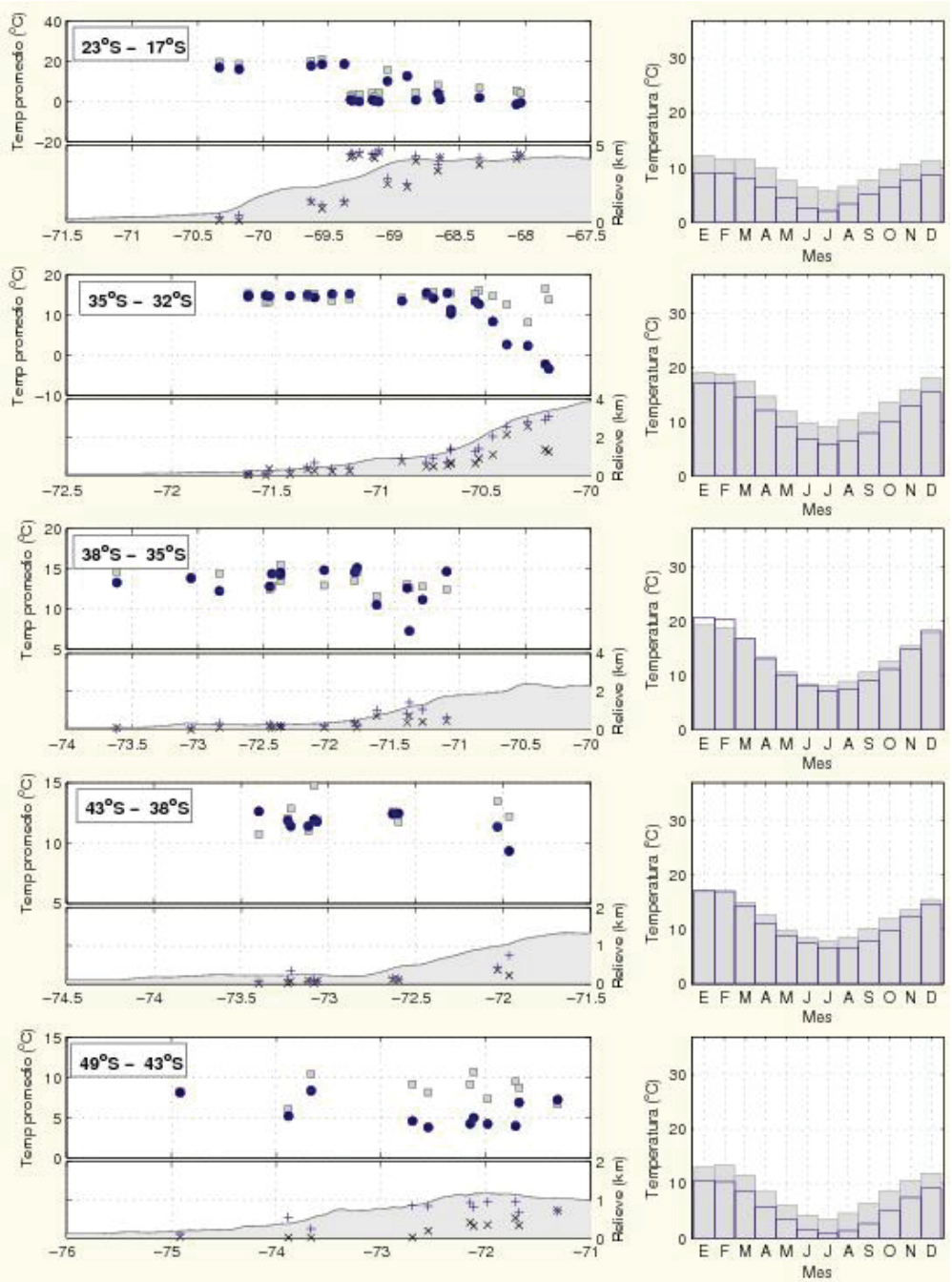
GCM annual precipitation along Chile is underestimated in the South (<35 S) and over estimated in the North (>35 S)



M. Falvey

VALIDATION PRECIS Temp comp with station data

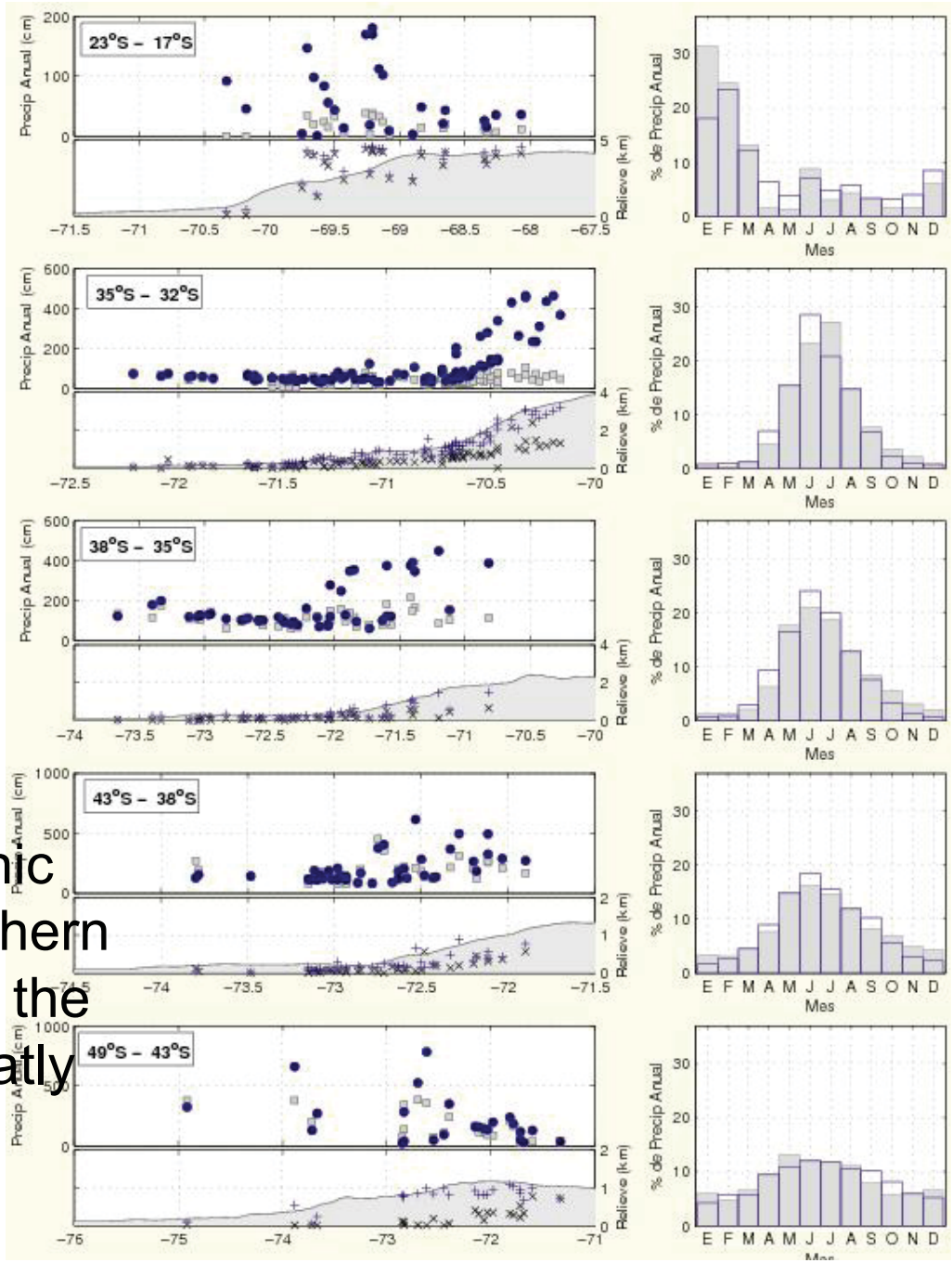
- Station data
- PRECIS
- + PRECIS altitude
- X station altitude



VALIDATION PRECIS
Precipitation comp with station data

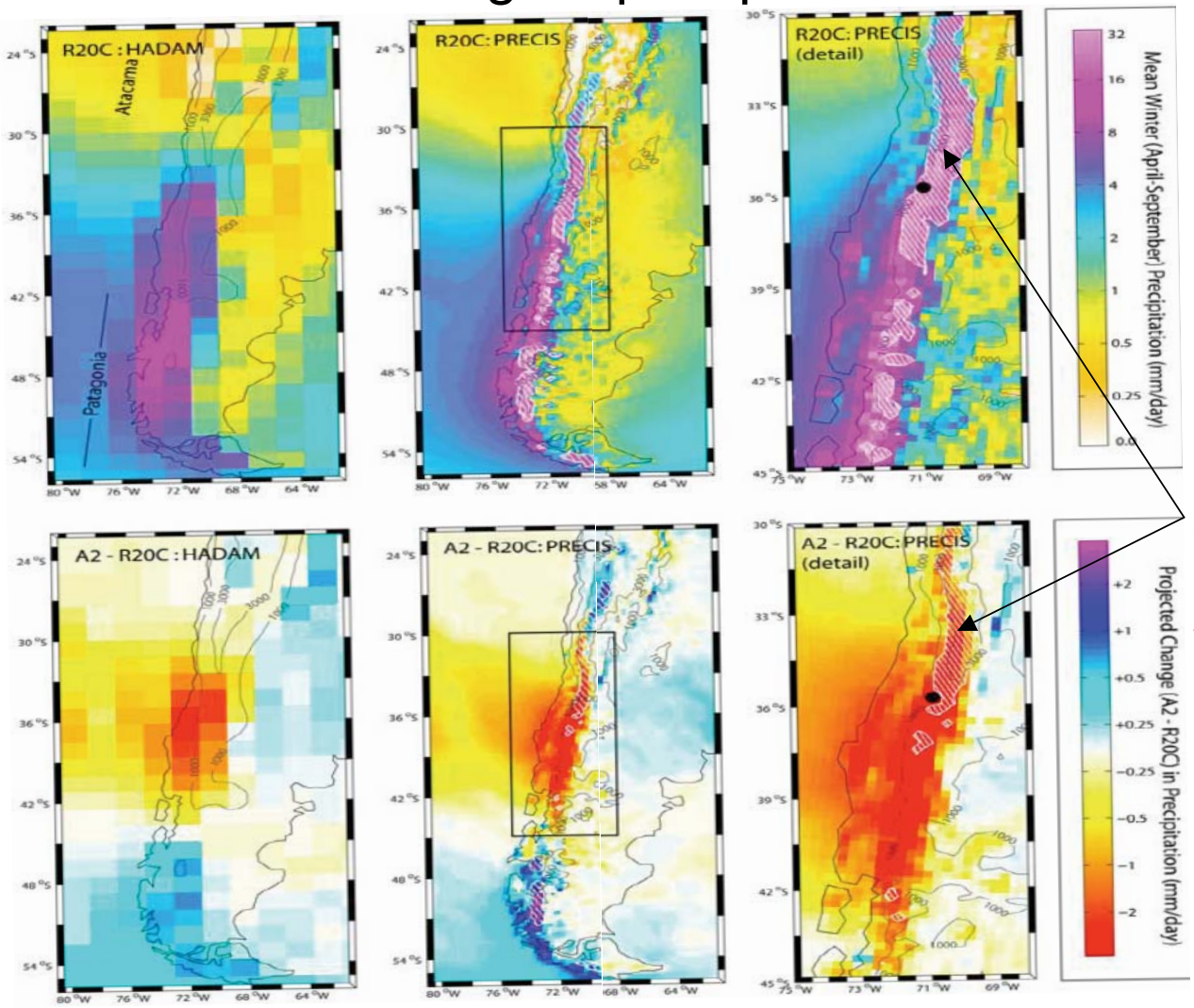
- Station data
- PRECIS
- + PRECIS altitude
- X station altitude

PRECIS simulations show considerably more orographic precipitation. In fact, in Northern and Central Chile (20-40 S) the net precipitation seems greatly overestimated.



PRECIS results

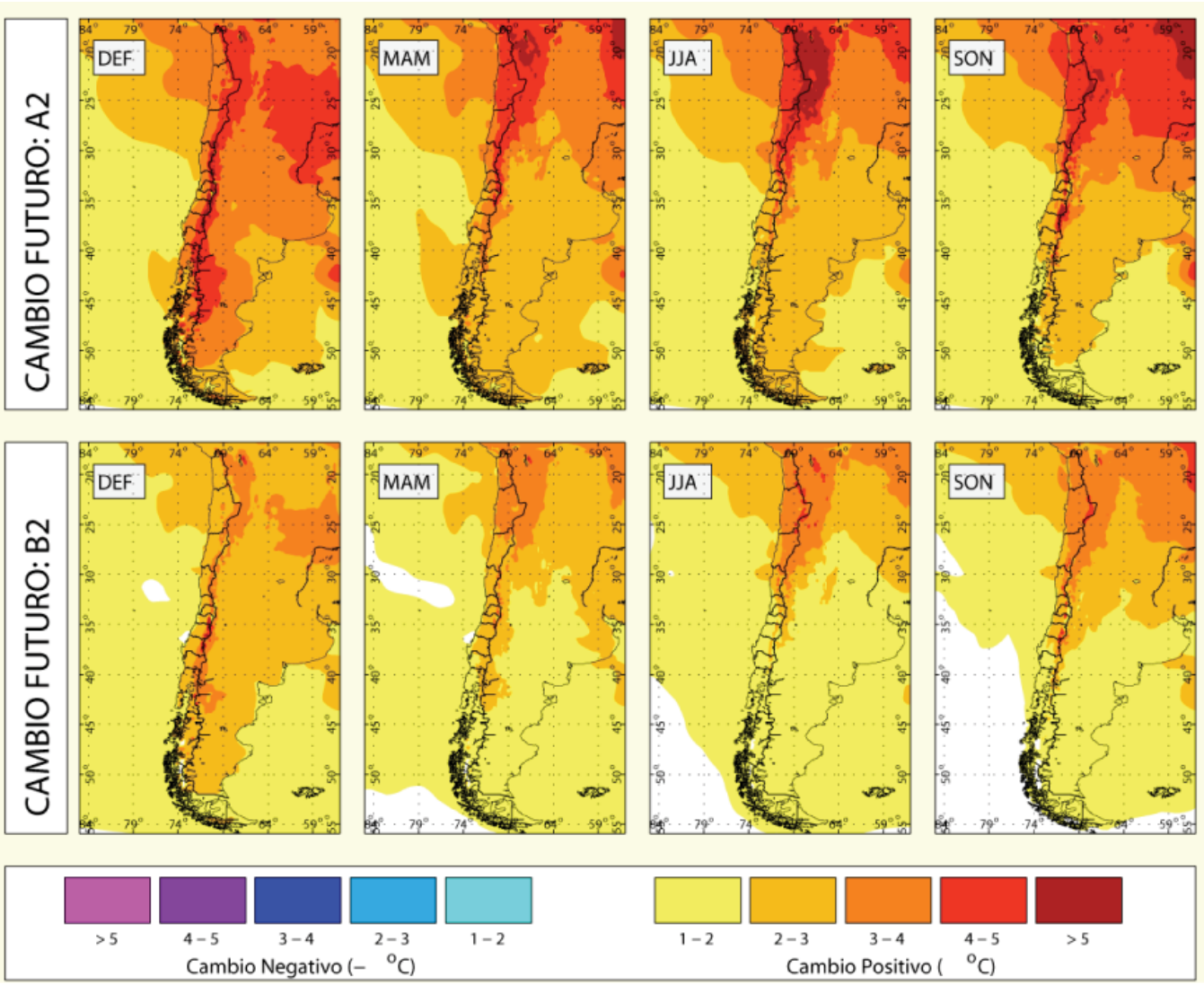
Large scale precipitation fields similar to parent model (HADAM) .
More detail and higher precipitation in the Andes.



Note the significant change in central Chile's winter snow cover between current climate and the A2 scenario

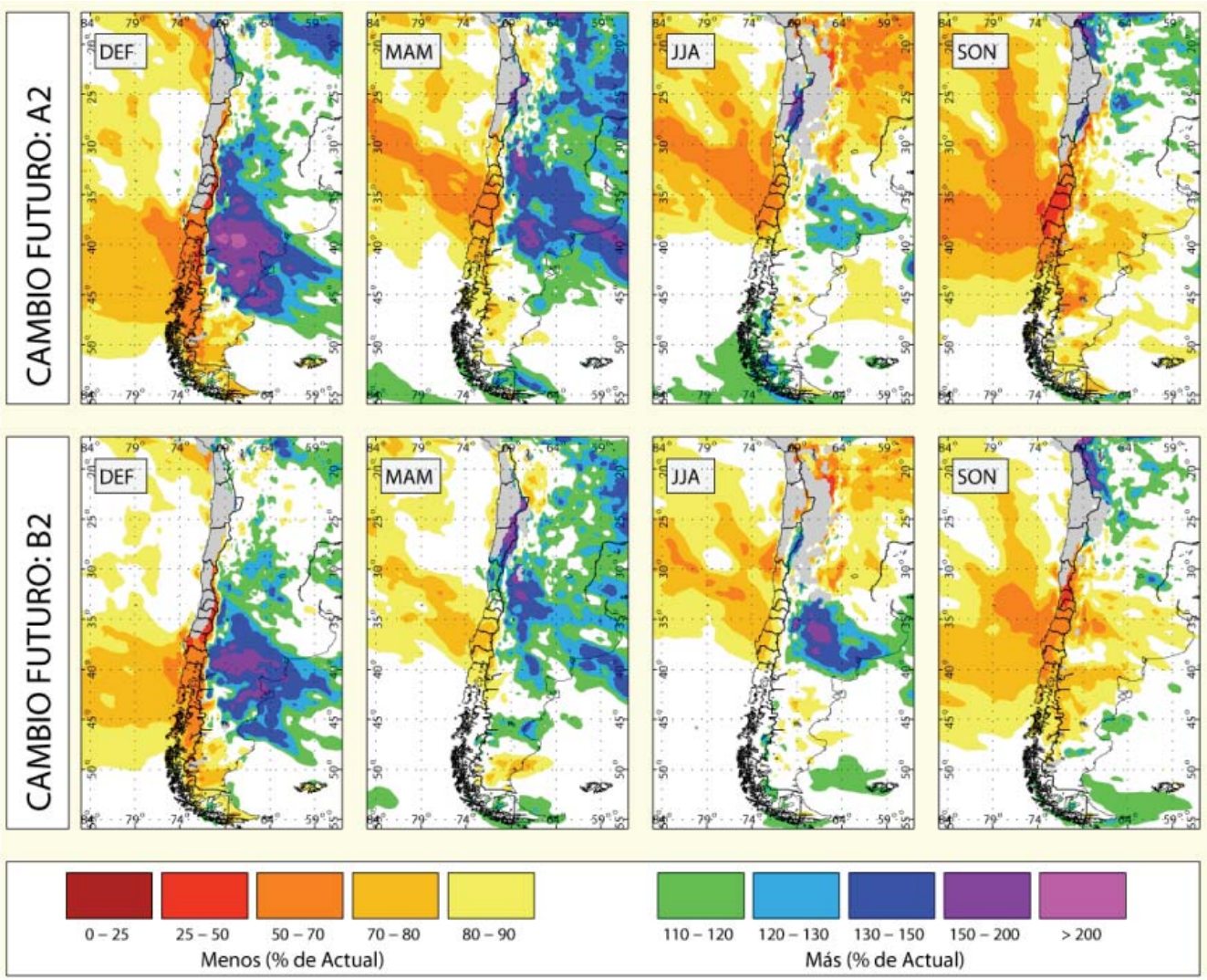
PRECIS-DGF T_{future} - $T_{present}$

Temperature changes between 2 and 5 C, generally higher in the Andes



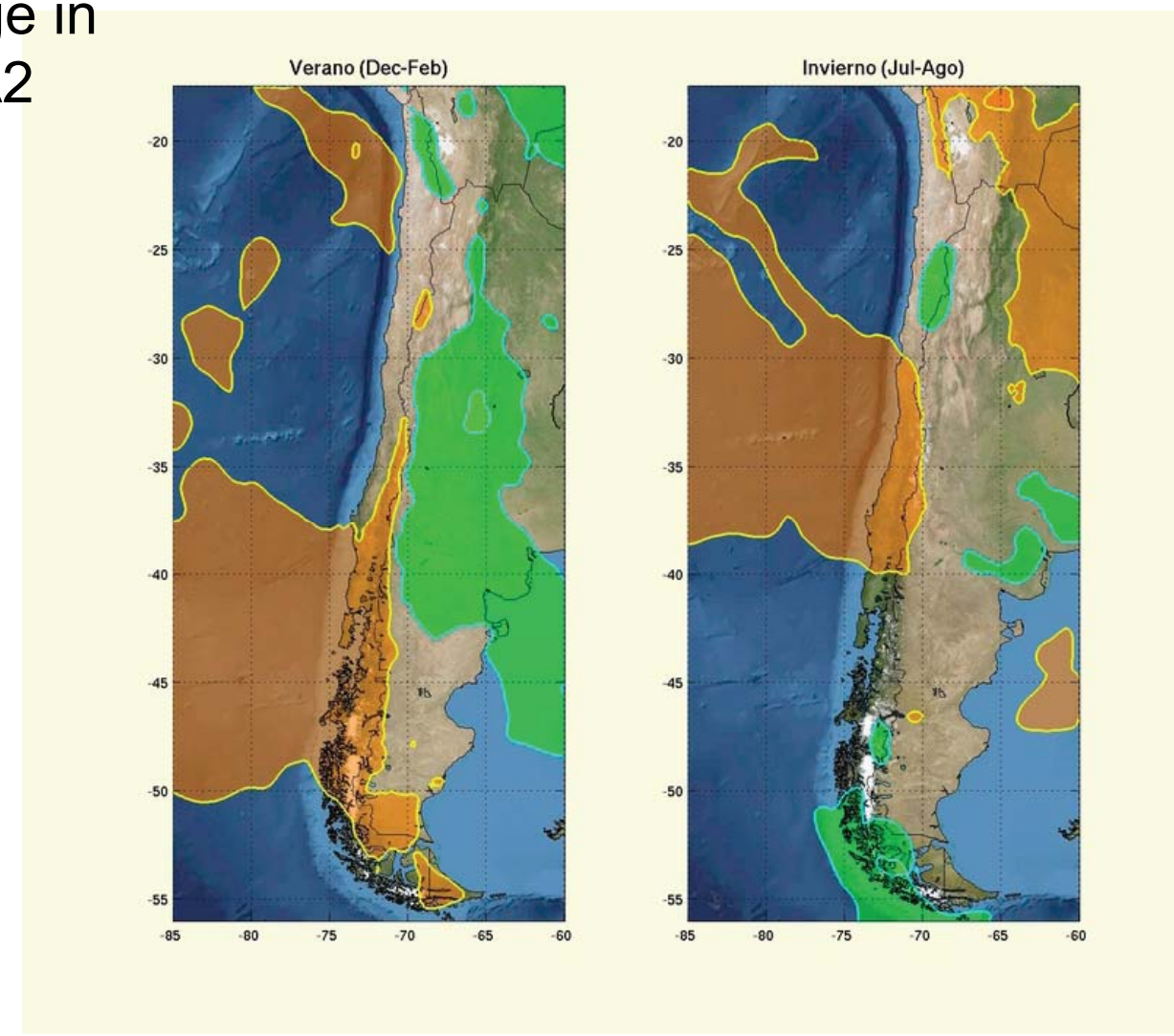
Future: 2071-2100 / Present: 1961-1900

PRECIS-DGF R_{future} / $R_{present}$



Future: 2071-2100 / Present: 1961-1990

PRECIS-DGF Change in precipitation SRES A2

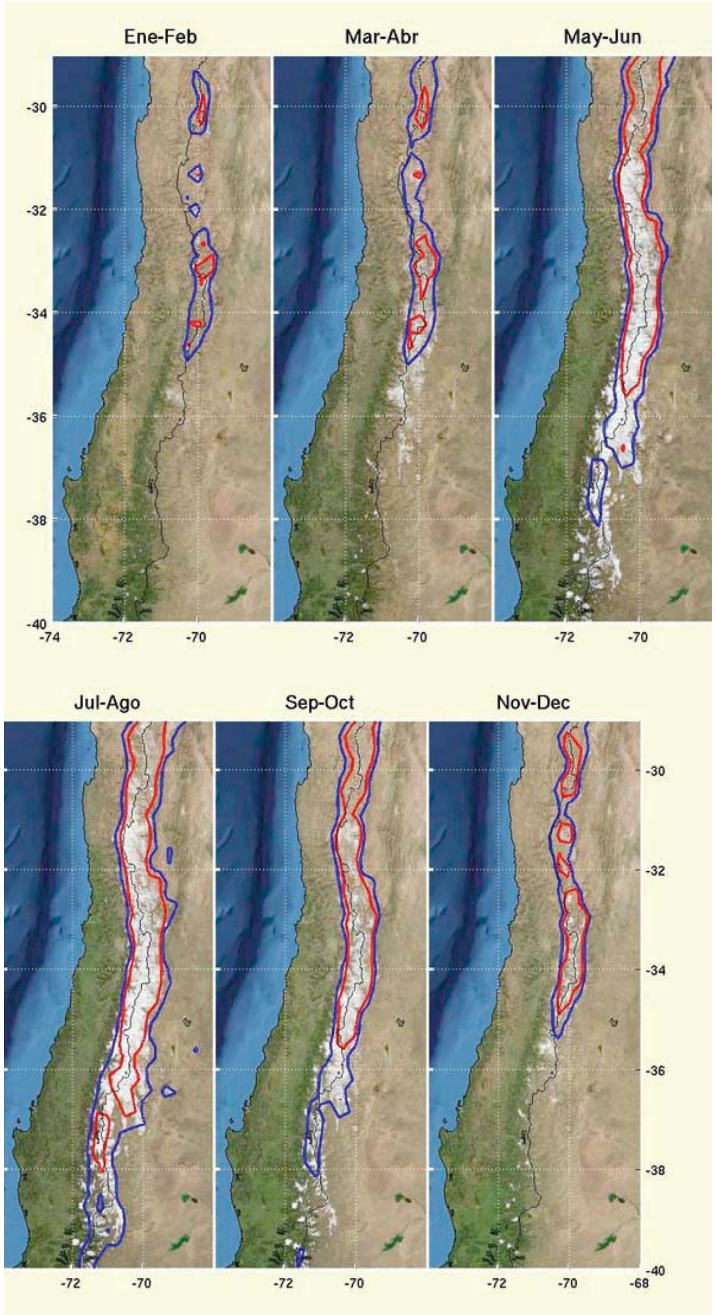


yellow line 20% less precip than present day
green line 20% more precip than present day

PRECIS-DGF change
in the zero isotherm

- Present
- A2

- Decrease in snow!



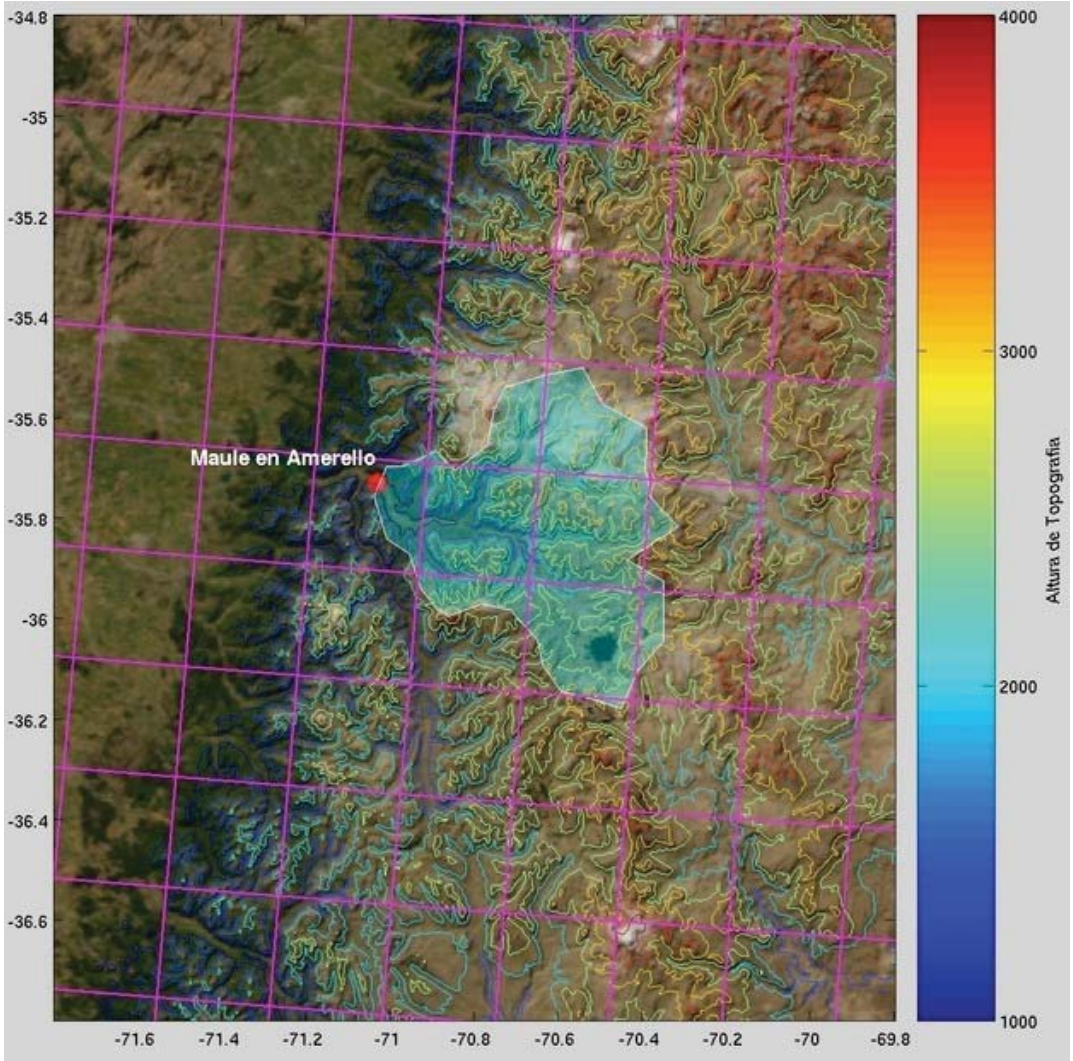
Future: 2071-2100 / Present: 1961-1990

Applications to the water management sector (M.Falvey)

- Changes in the precipitation regime (more or less water?)
- Changes in the seasonality of runoff?
- Changes in extreme events

PRECIS-DGF

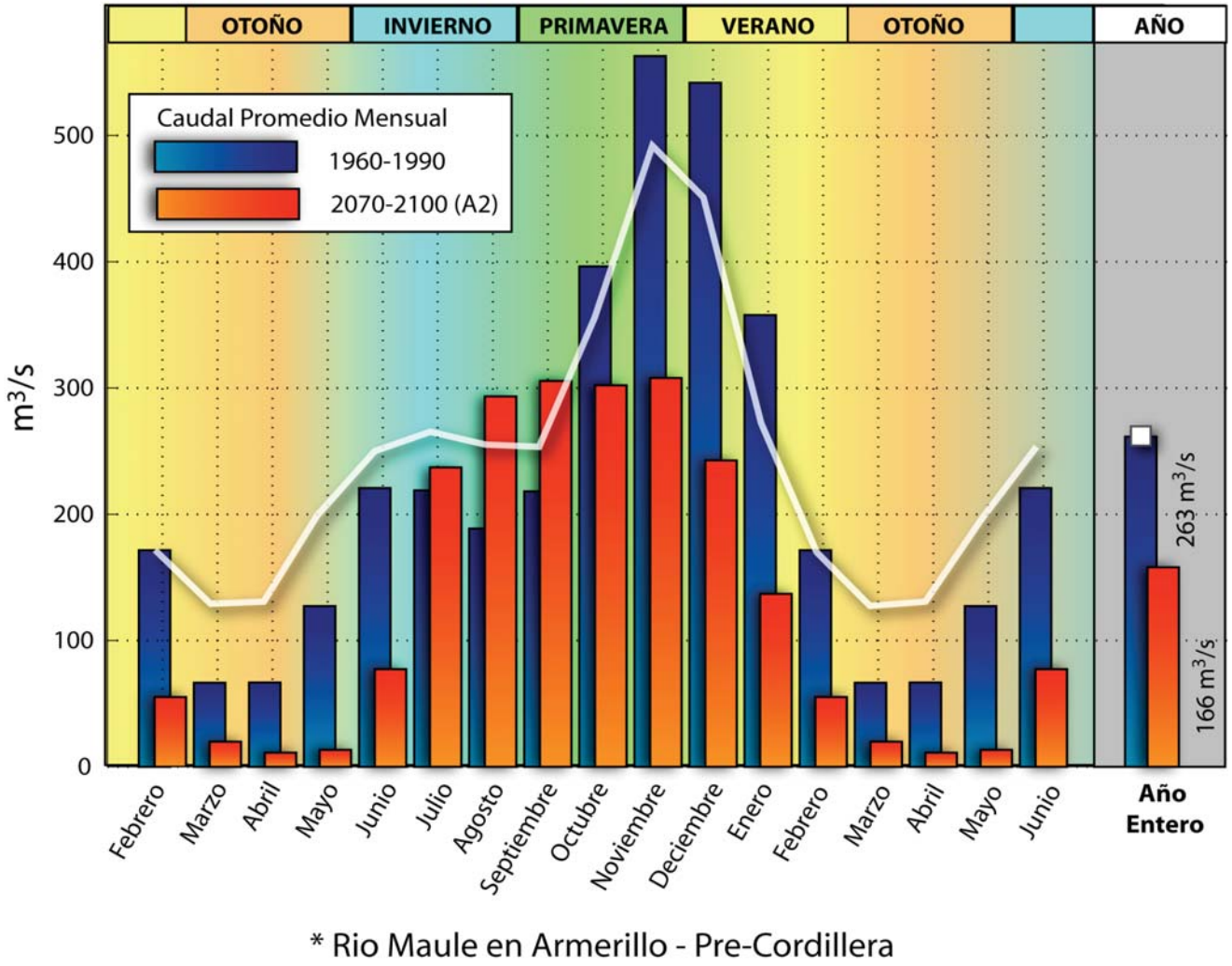
Use the results of the 1D soil scheme (MOSES) to make rough estimates of runoff..



Rio MauleCatchment: Feeds a major hydropower station and used for irrigation.

PRECIS-DGF

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

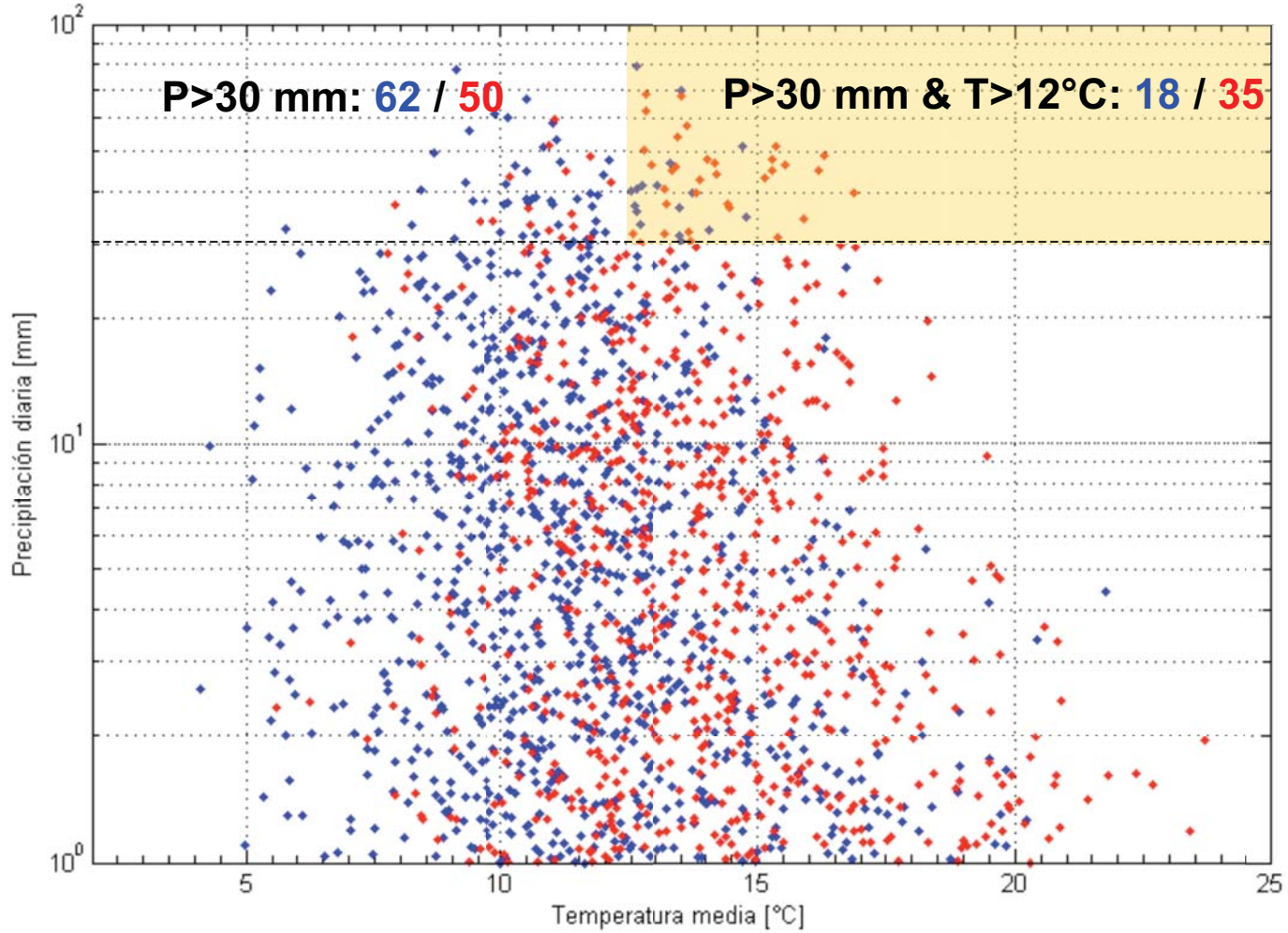


* Rio Maule en Armerillo - Pre-Cordillera

Model predicts major changes in runoff under the A2 scenario. Not just the annual mean, but also in the seasonal cycle as a result of the reduction in snow cover.

PRECIS-DGF – Extreme events

Although the mean annual precipitation decreases, PRECIS suggests that heavy precipitation events will occur nearl as frequently, and WARM events will occur twice as often.



conclusions

- Almost all IPCC models predict significant drying (and warming) in central Chile (30° 45°S) under scenarios of increasing greenhouse gas emissions.
- the representation of Chile's topography in the GCM's is not sufficient for adequate representation of orographic precipitation and associated hydrological/ cryological processes.
- Reduced (~70%) net runoff in alpine watersheds of central Chile, along with marked changes in the seasonal cycle due to reduced snow cover in future climate scenarios.
- Despite the above, flooding events occur just as often and may be stronger in future climates.
- Substantial reduction in snow/ice accumulation predicted in both central Chile and in Southern Patagonia (where glaciers are found).
- Conclusions about the hydrological/cryological response to climate change based on PRECIS are hampered by the models over-prediction of precipitation in the Andes of North/Central Chile, and the simplicity of the hydrological modeling system that was used…
- NOTE: overprediction of rainfall over the Andes is common in all RCM (MM5, PRECIS, WRF, RegCM)!