The current Mega Drought in Central Chile: Is the future now?

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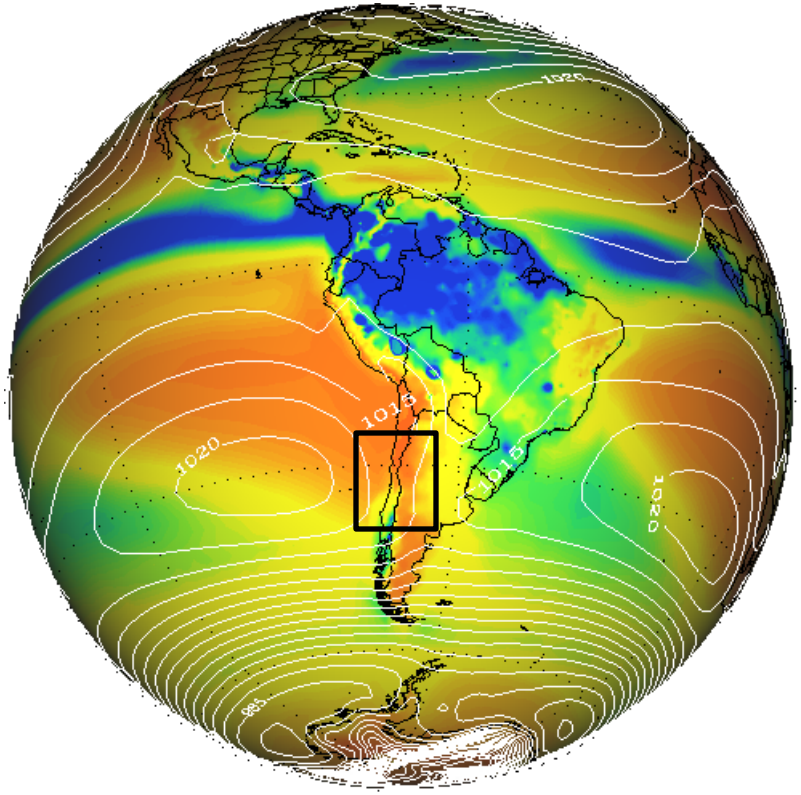
Outline

- Where is Chile?
- Climate projections
- The current Mega drought
- Dynamical analysis

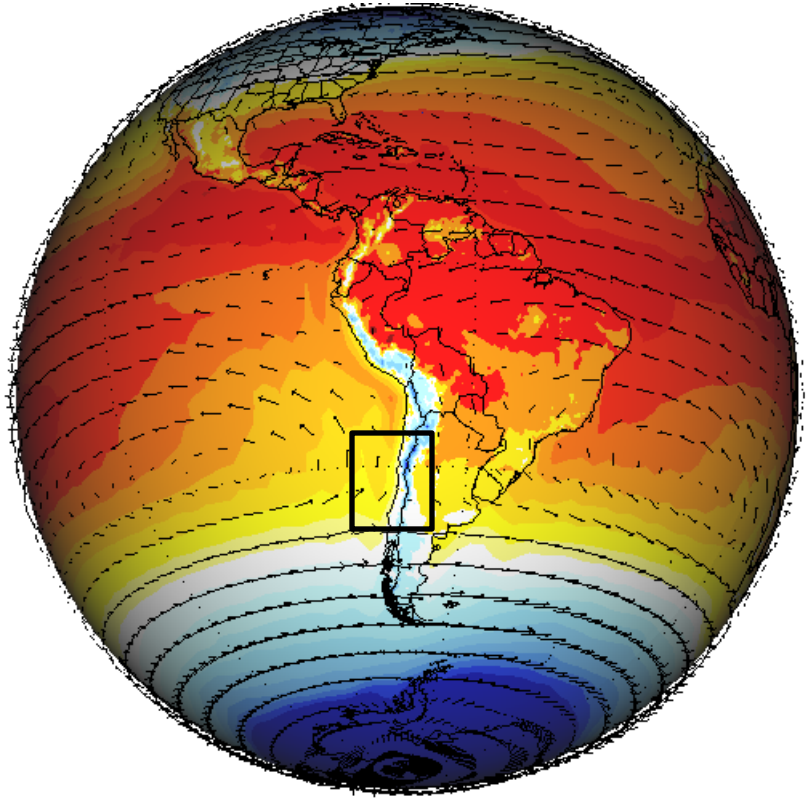
26th General Assembly of the International Union of Geodesy and Geophysics (IUGG)
Praga, July 2015

Central Chile: subtropical (30-40°S) west coast of South America, bounded by the Andes cordillera (3-5 km). MAP from 100 to 1500 mm/year. Strongly impacted by ENSO

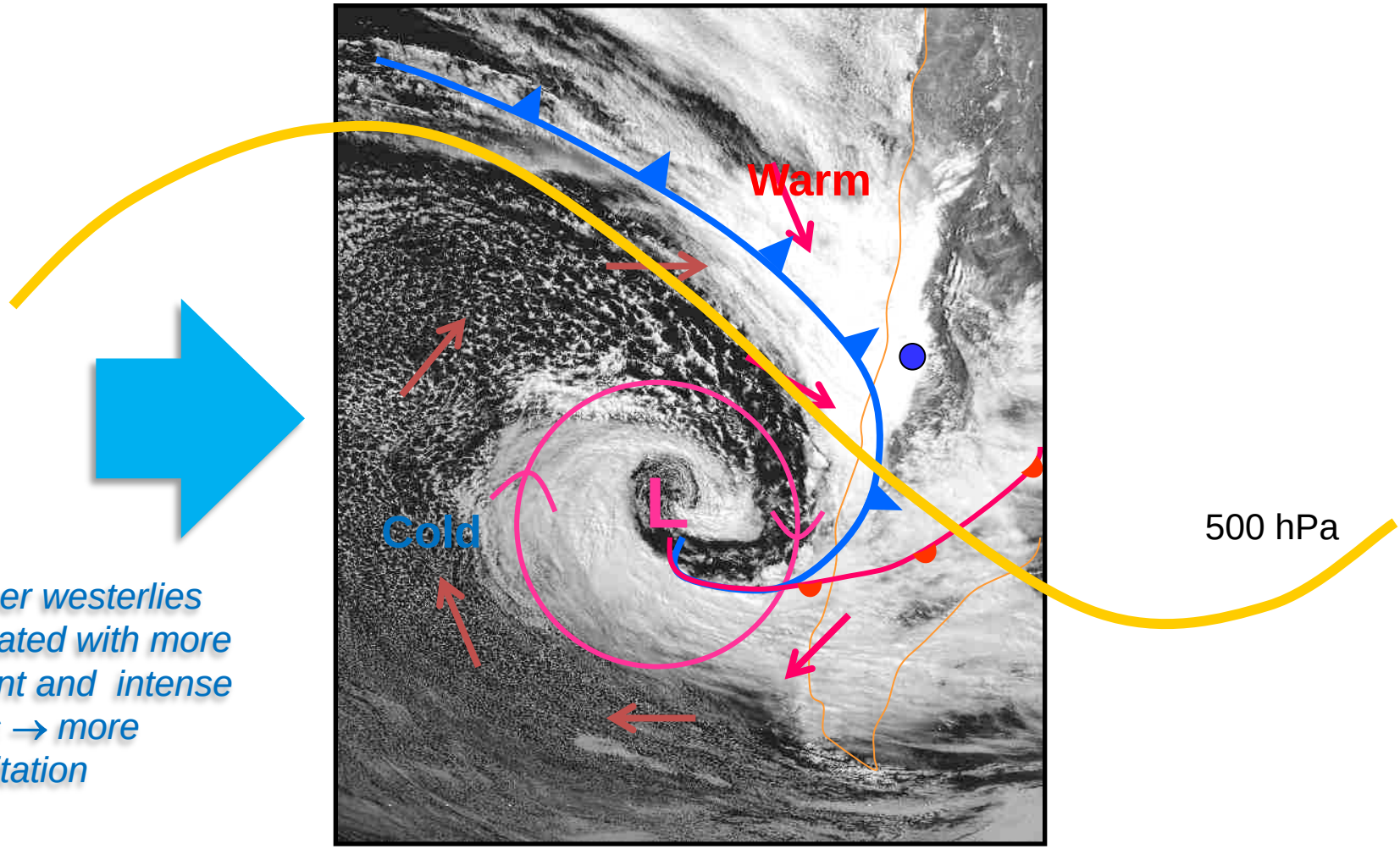
SLP & MAP



850 hPa winds & SAT

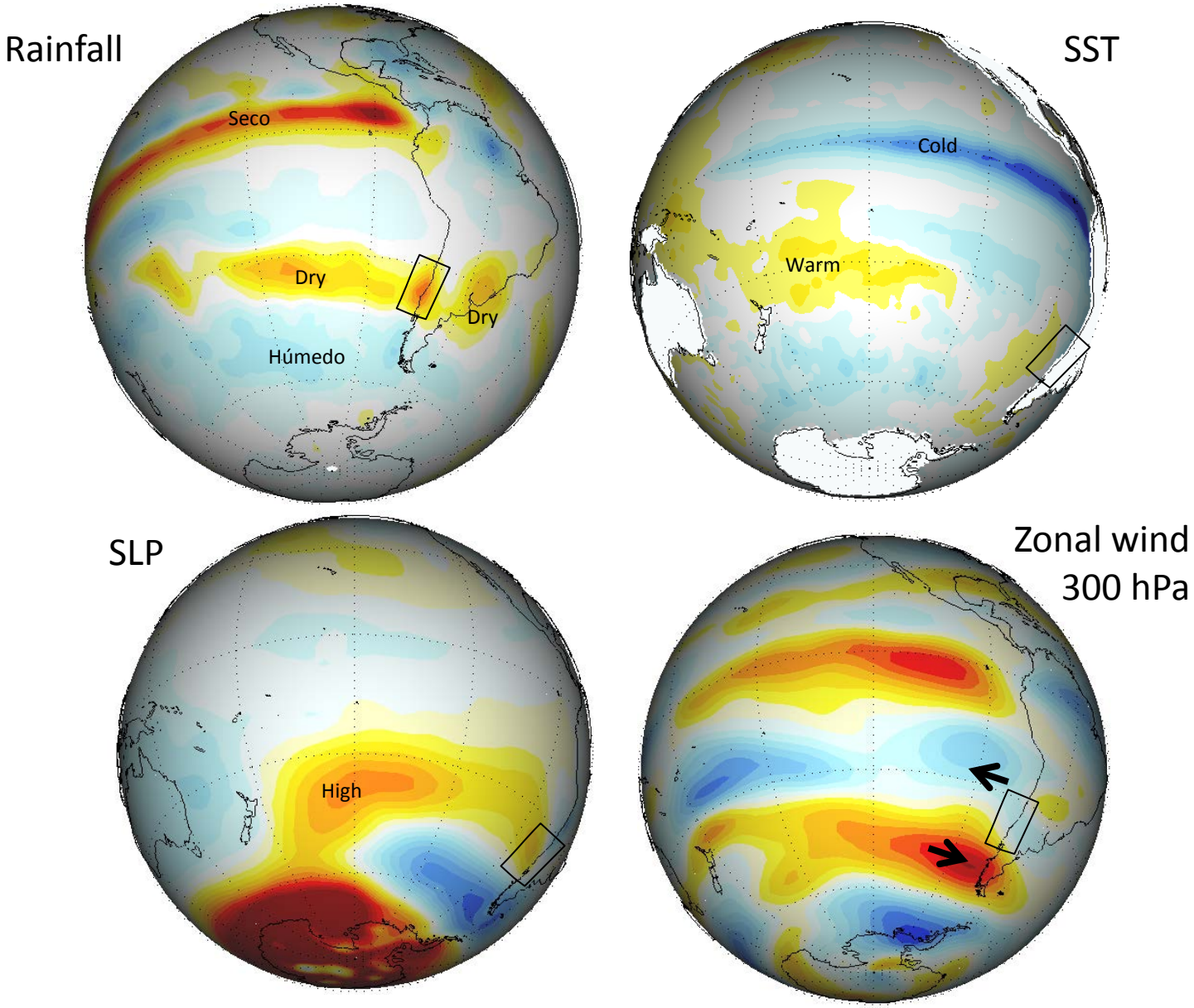


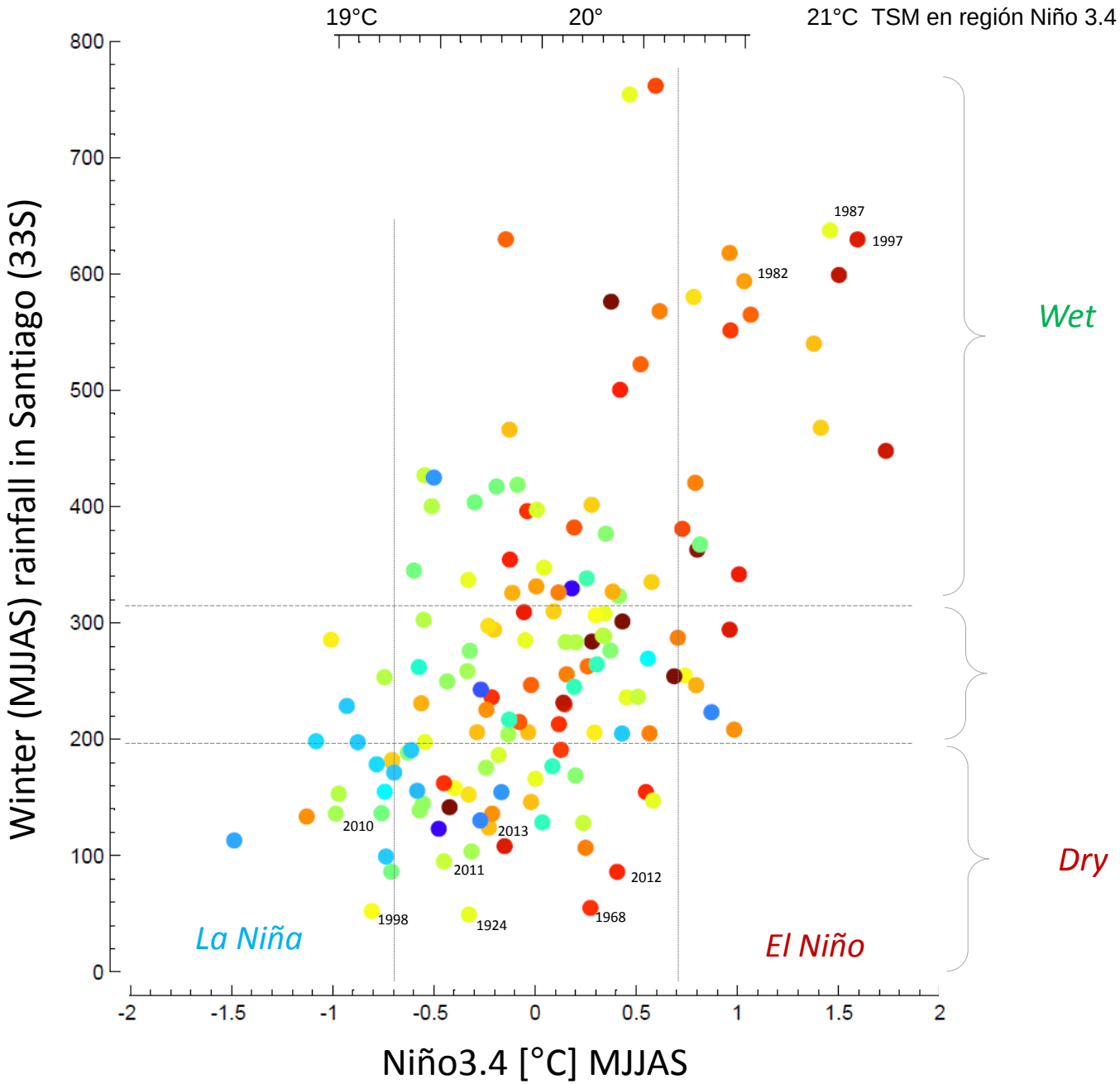
Precipitation in central Chile is largely caused by the passage of frontal systems rooted in extratropical depression embedded in the South Pacific westerly wind belt



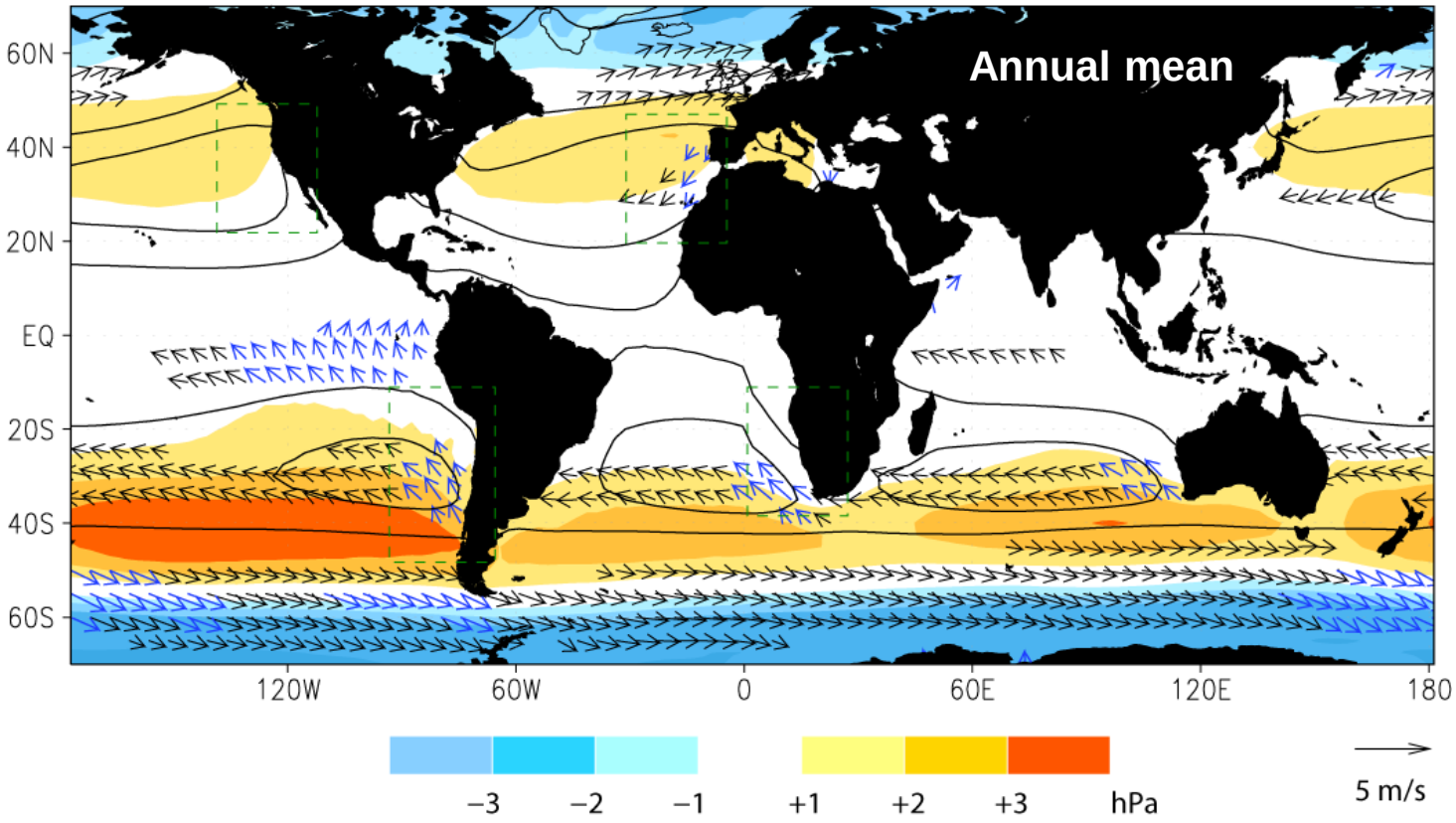
Stronger westerlies associated with more frequent and intense storms → more precipitation

Global context for central Chile droughts




19°C
20°
21°C TSM en región Niño 3.4
Winter (MJJAS) rainfall in Santiago (33S)
800
700
600
500
400
300
200
100
0
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
Niño3.4 [°C] MJJAS
1987
1997
1982
2010
2013
2011
2012
1998
1924
1968
Wet
Dry
La Niña
El Niño

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

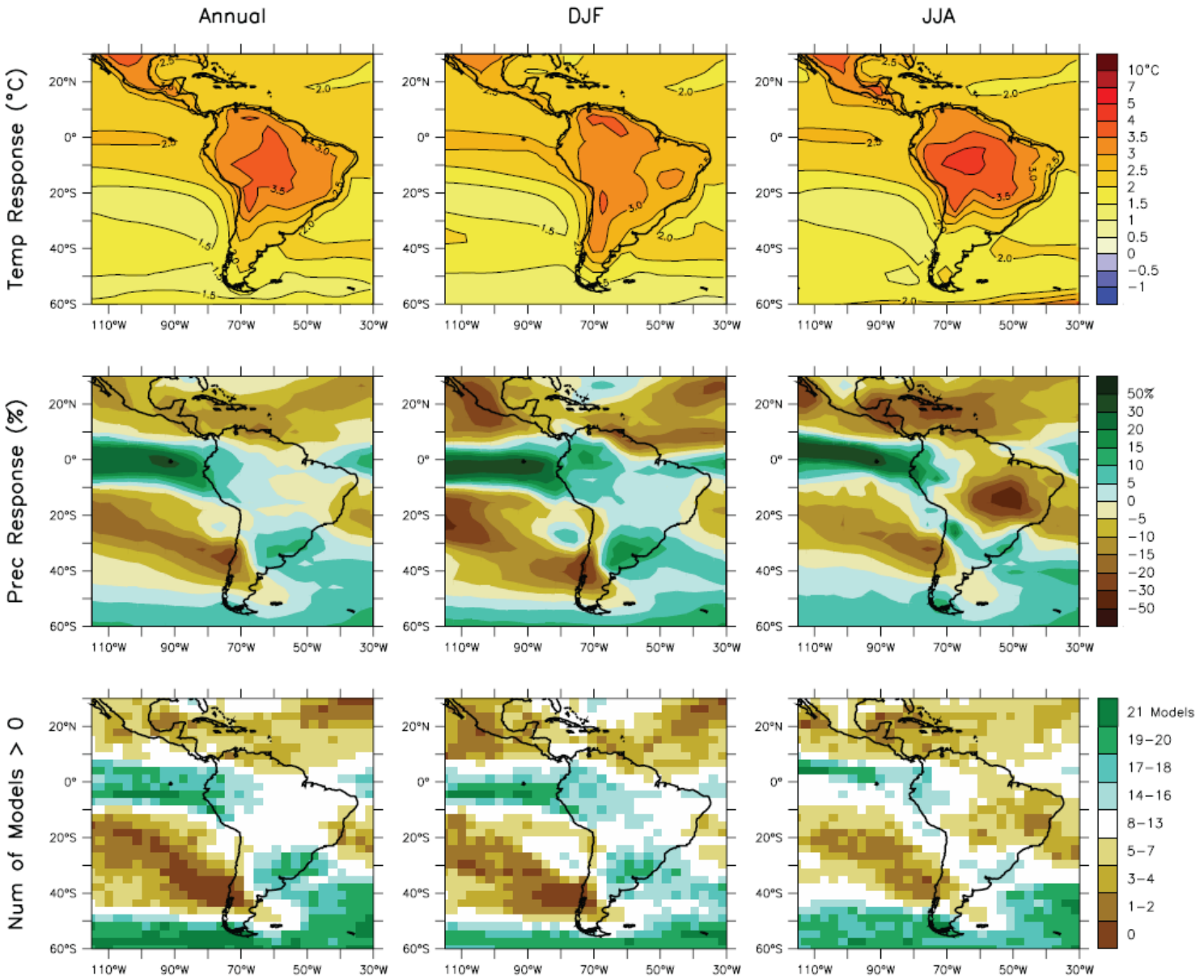
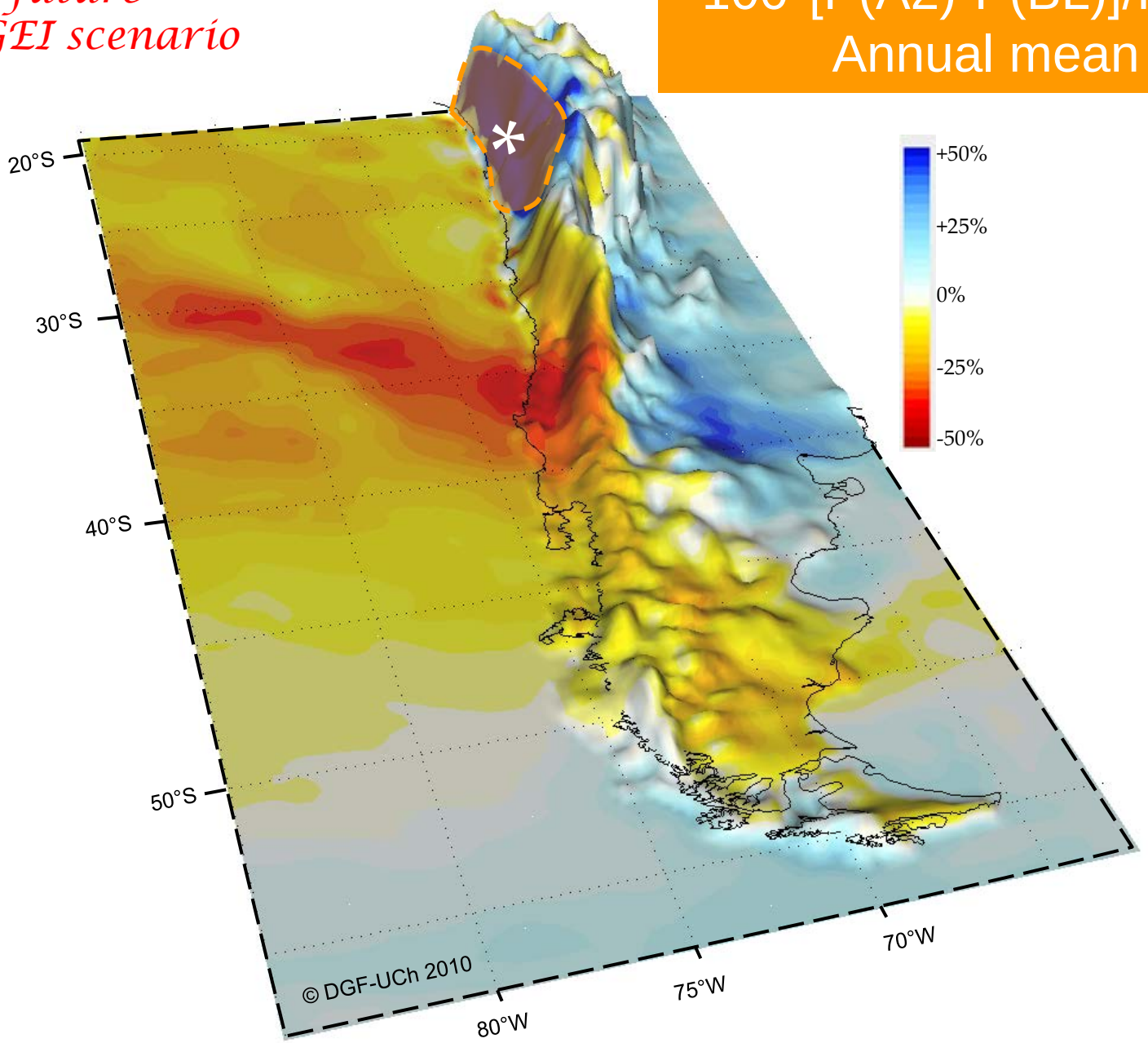


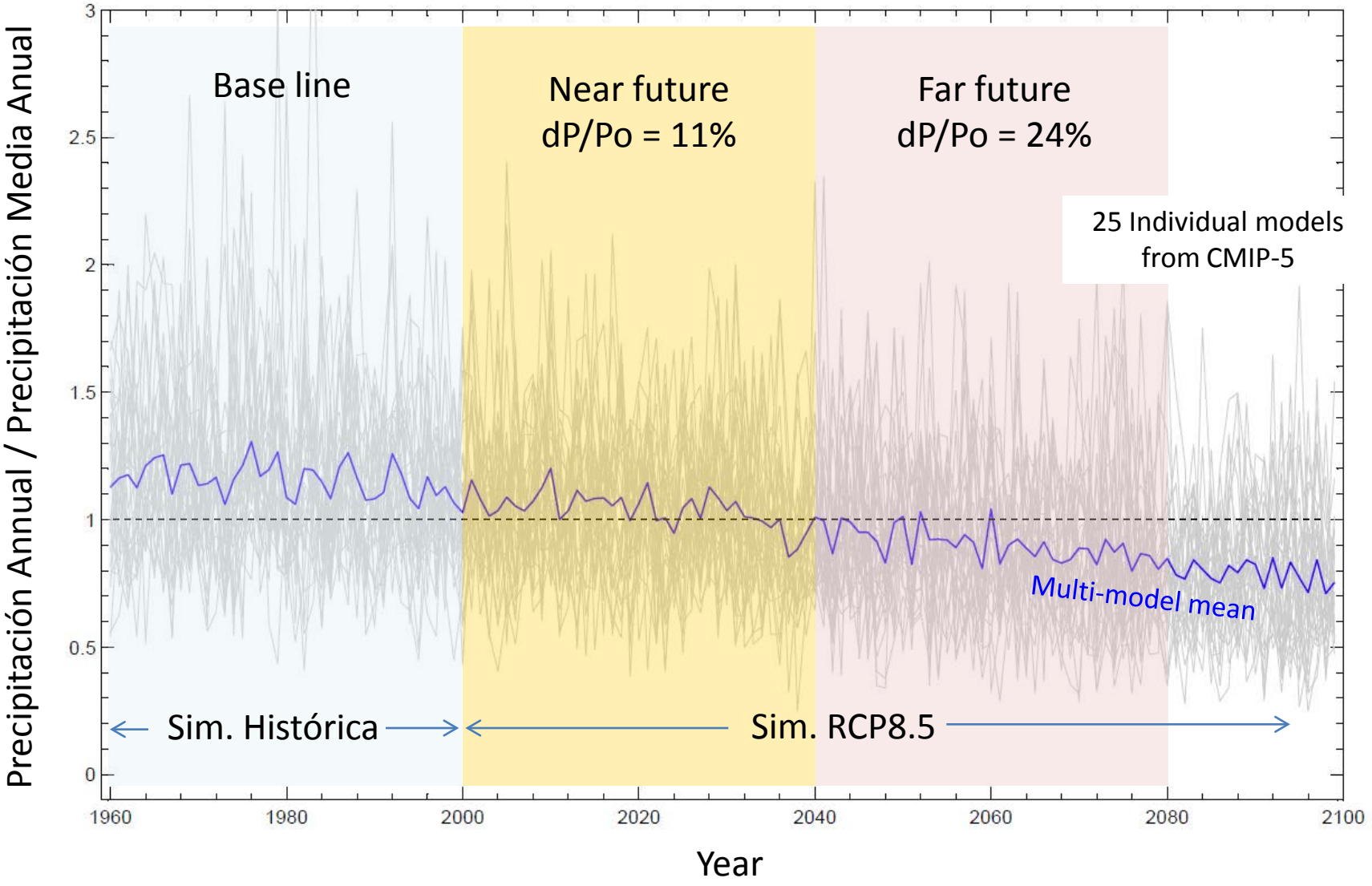
Figure 11.15. *Temperature and precipitation changes over Central and South America from the MMD-A1B simulations. Top row: Annual mean, DJF and JJA temperature change between 1980 to 1999 and 2080 to 2099, averaged over 21 models. Middle row: same as top, but for fractional change in precipitation. Bottom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

Far future
Heavy GEI scenario

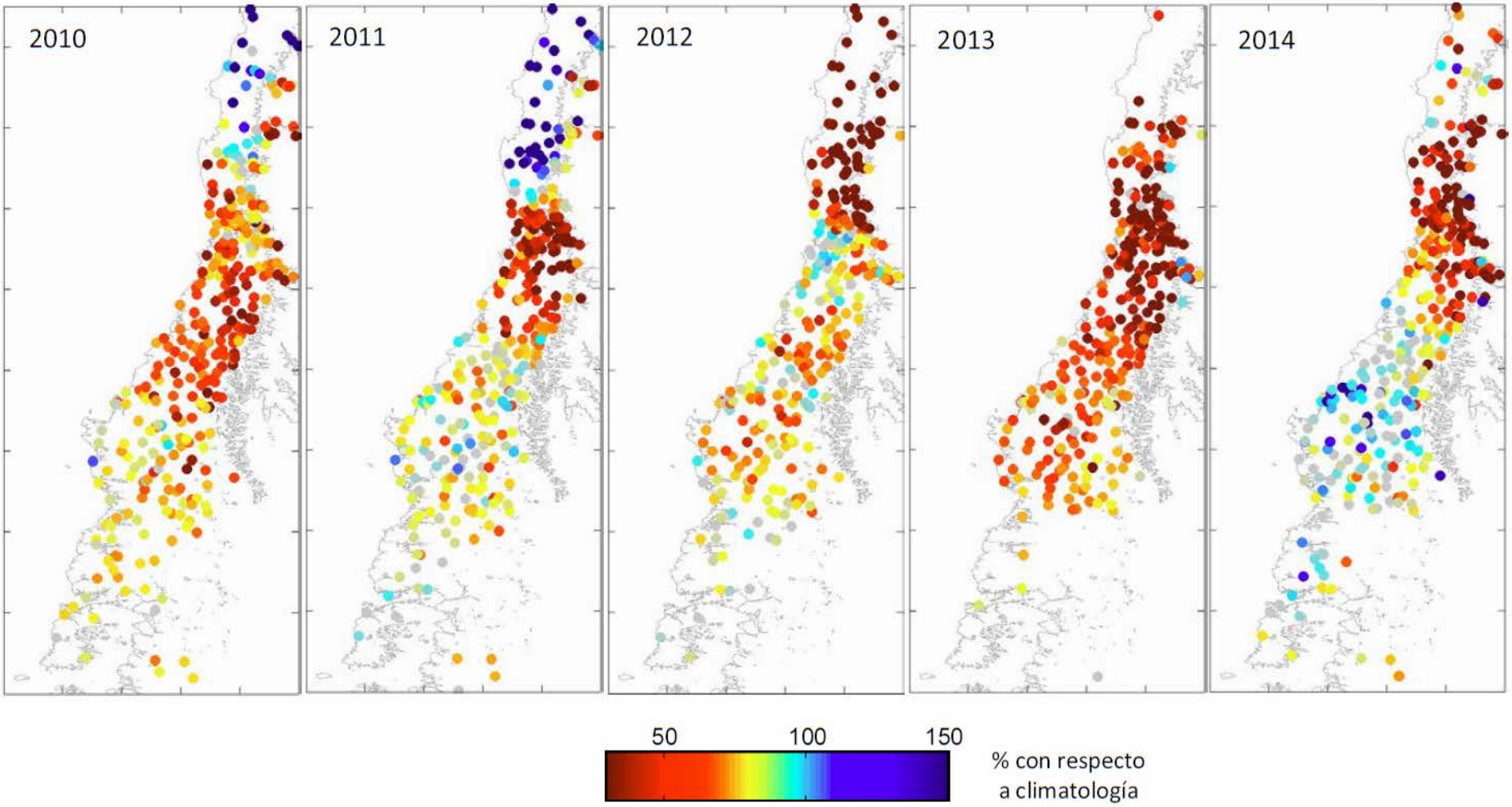
100*[P(A2)-P(BL)]/P(BL)
Annual mean



Annual Precipitation 33°S-71°W



Central Chile current mega-drought (2015 very dry so far)



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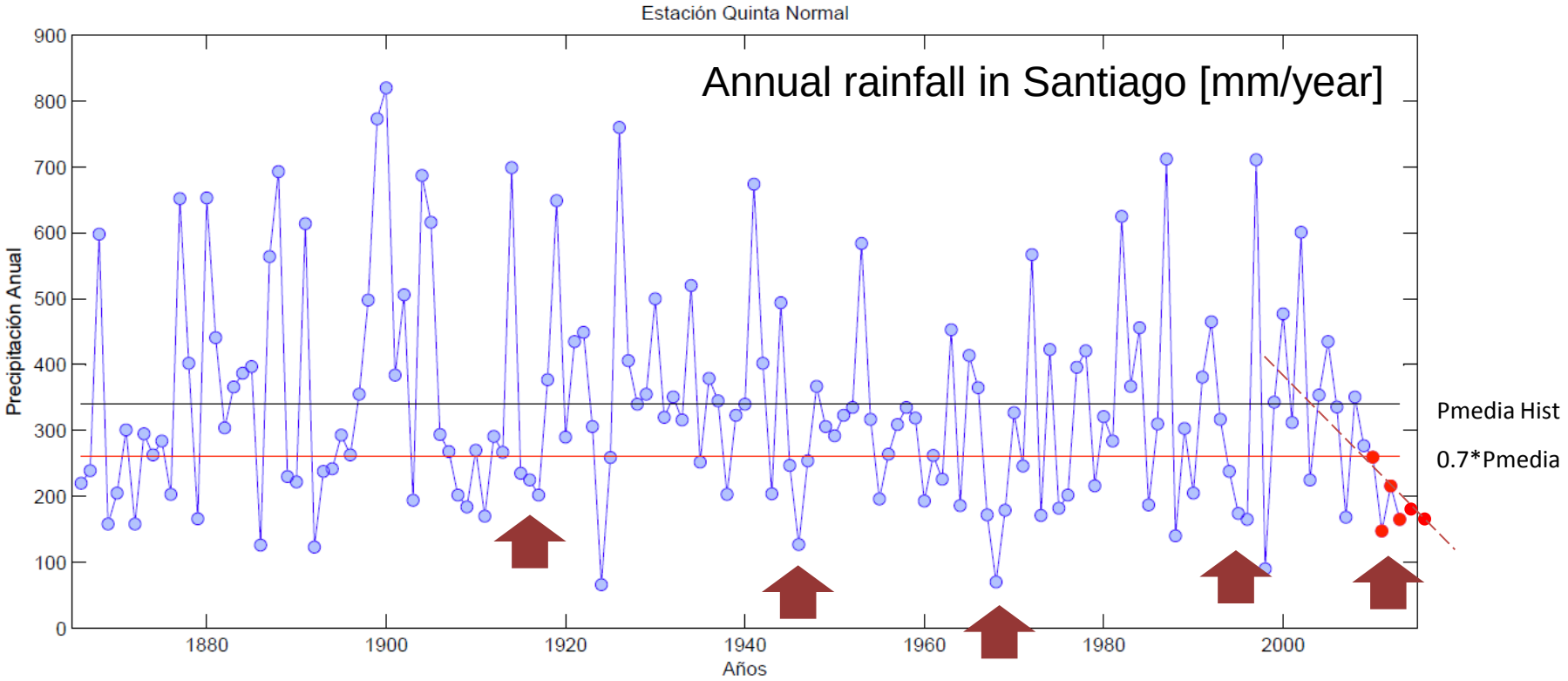
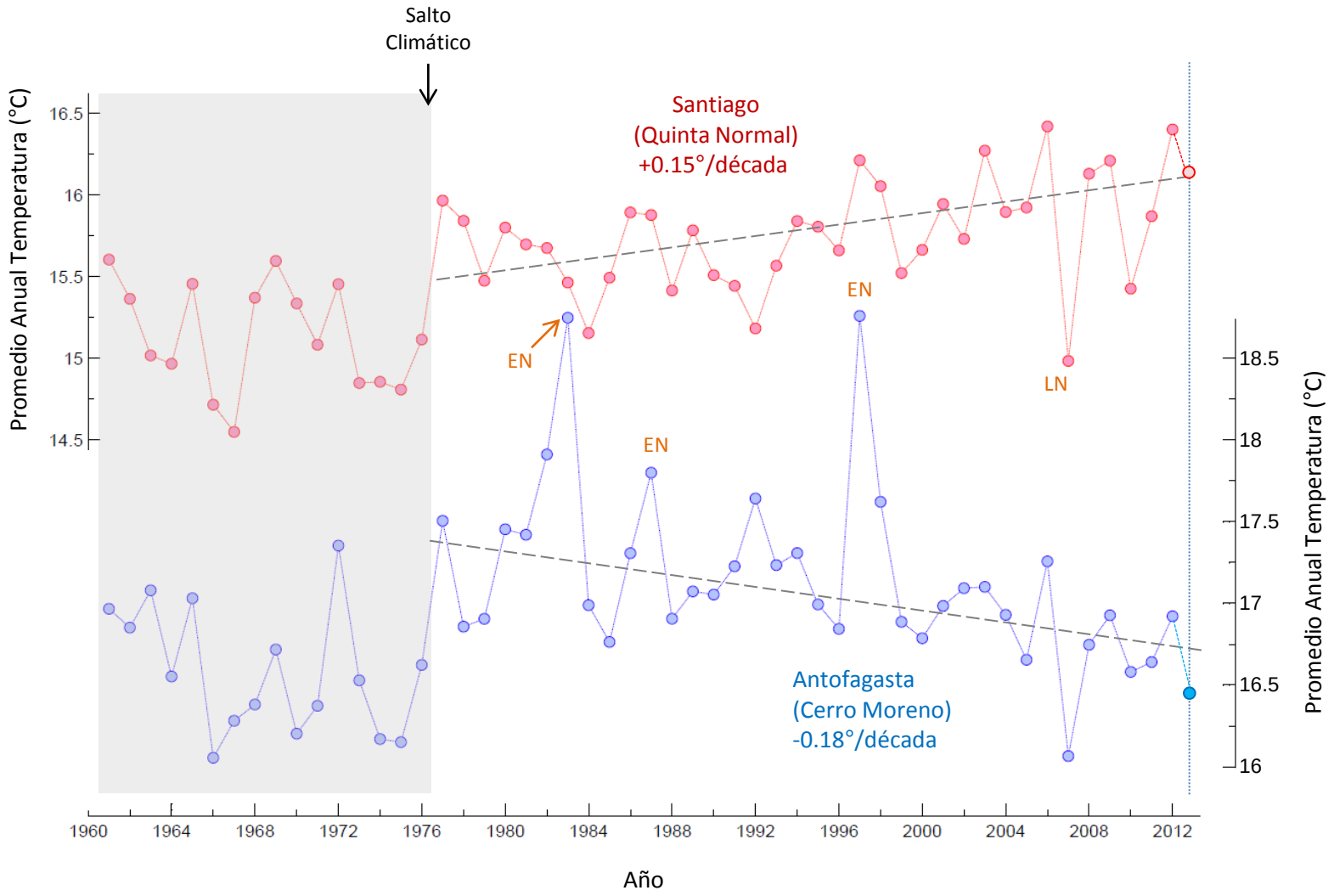


Mega Drought: 2010-2013	Norte Chico	Centro	Centro-sur
Ret. Period driest year within MD (year)	7	15	>30
Recurrence of 4 year drought (per 50 years)	4-6	2-3	1?

Increasing temperatures in central Chile…
Impacts on evapo-transpiración y snow-cover



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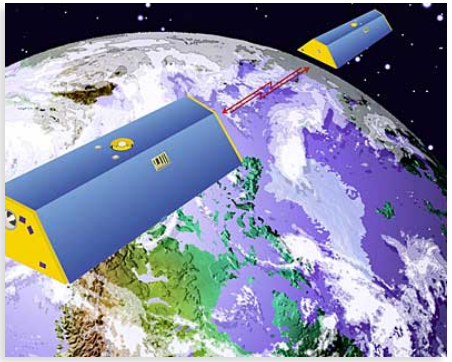
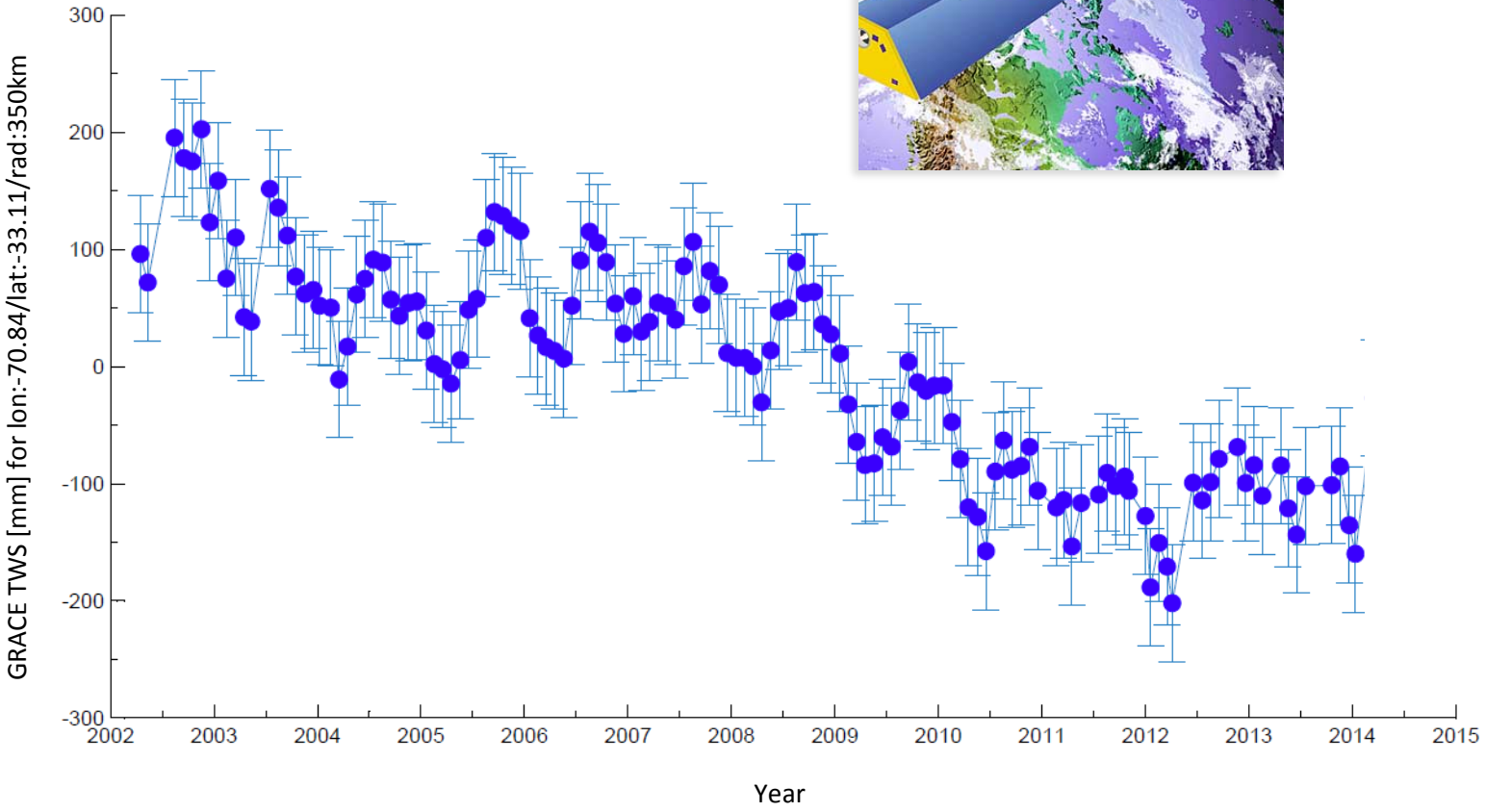


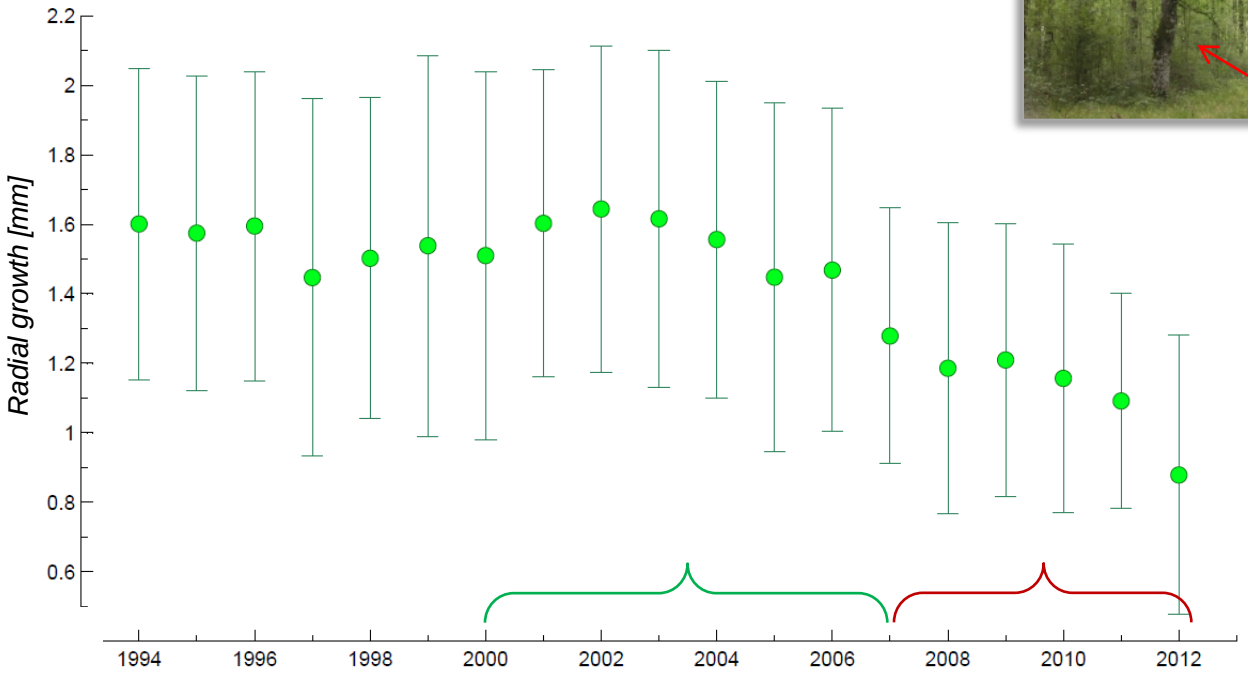


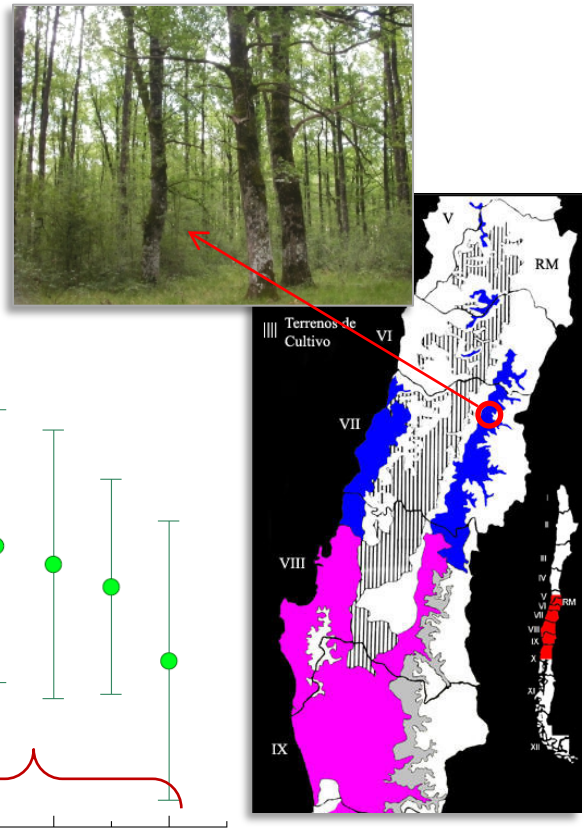
$$TWS_t = SM_t + SNW_t + SW_t + GW_t \approx GW_t$$

Monte Oscuro - Maule foothills

Nothofagus obliqua (Roble)

41 isolated trees + 81 surrounded trees





Wet versus dry periods

- 40% less precipitation (1630 → 1602 mm/yr)
- 25% less radial growth (1.7 → 1.3 mm/yr)
- 11% less volume growth (7.1 → 6.2 m^3/ha) → ΔCO2 Sequestration?

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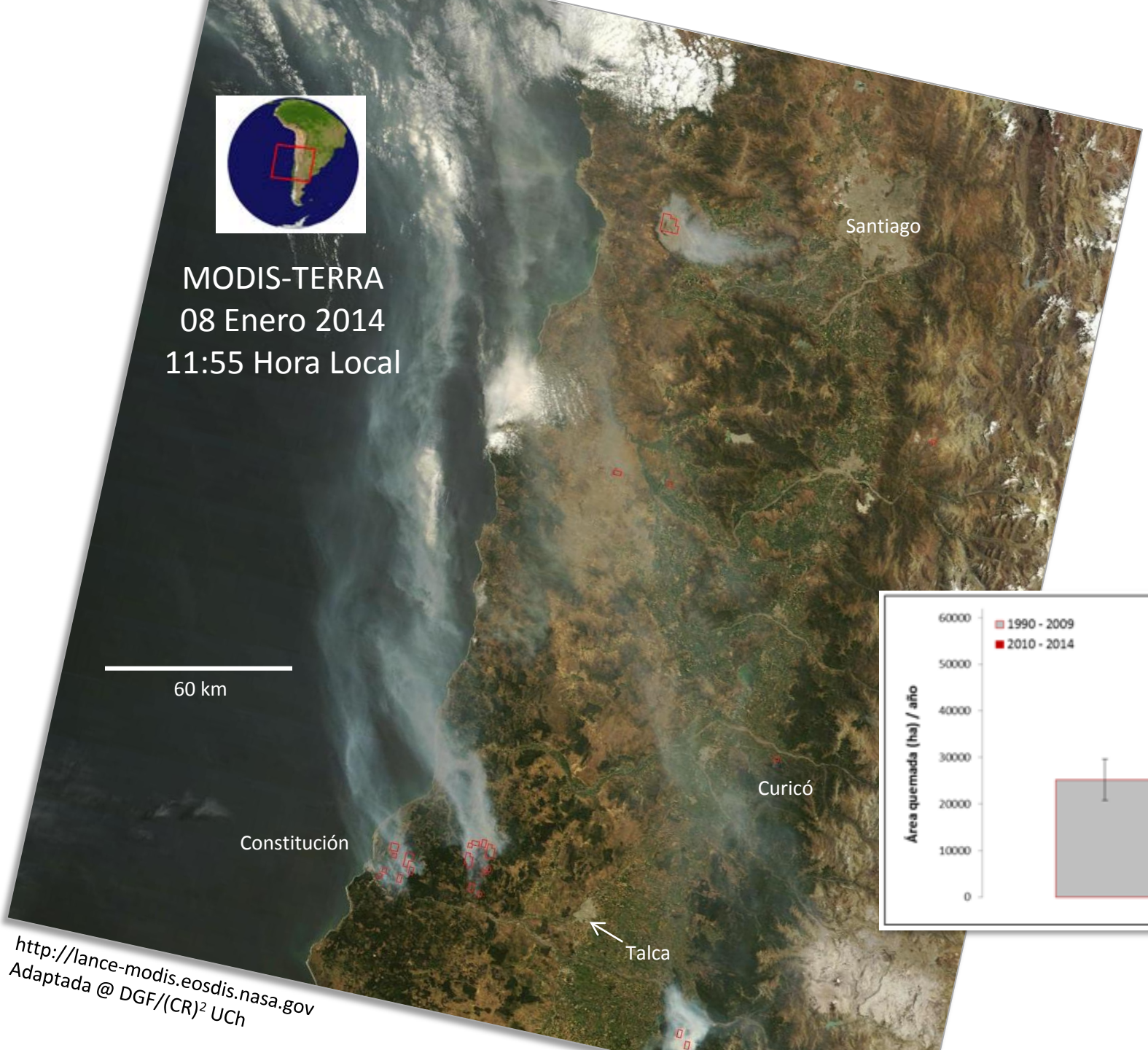
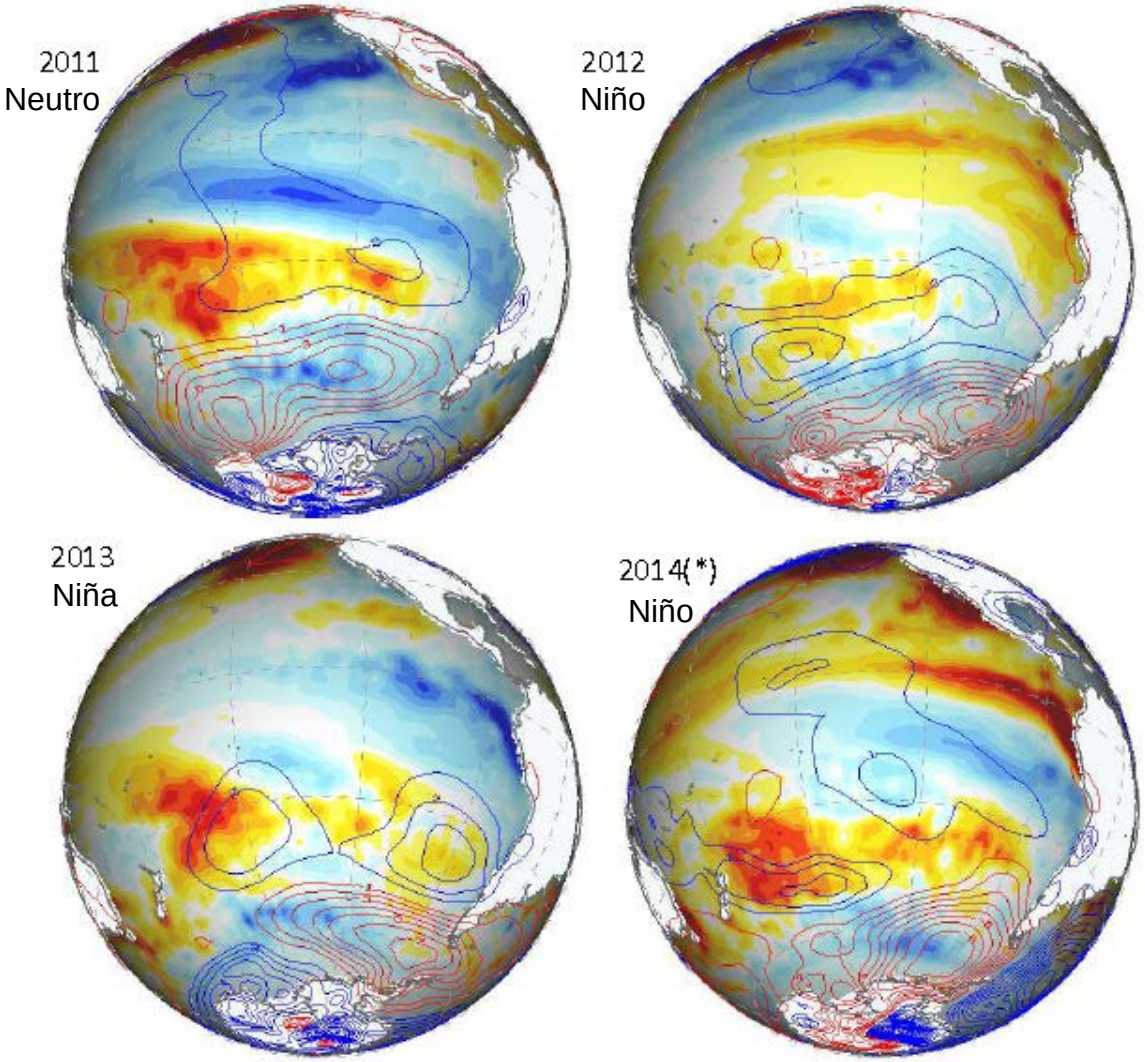

MODIS-TERRA
08 Enero 2014
11:55 Hora Local
Santiago
60 km
Curicó
Constitución
Talca
http://lance-modis.eosdis.nasa.gov
Adaptada @ DGF/(CR)² UCh

60000
50000
40000
30000
20000
10000
0
Área quemada (ha) / año
1990 - 2009
2010 - 2014
69%
D

Central Chile current mega-drought (2015 very dry so far)

SST (colors) and SLP (contours) anomalies



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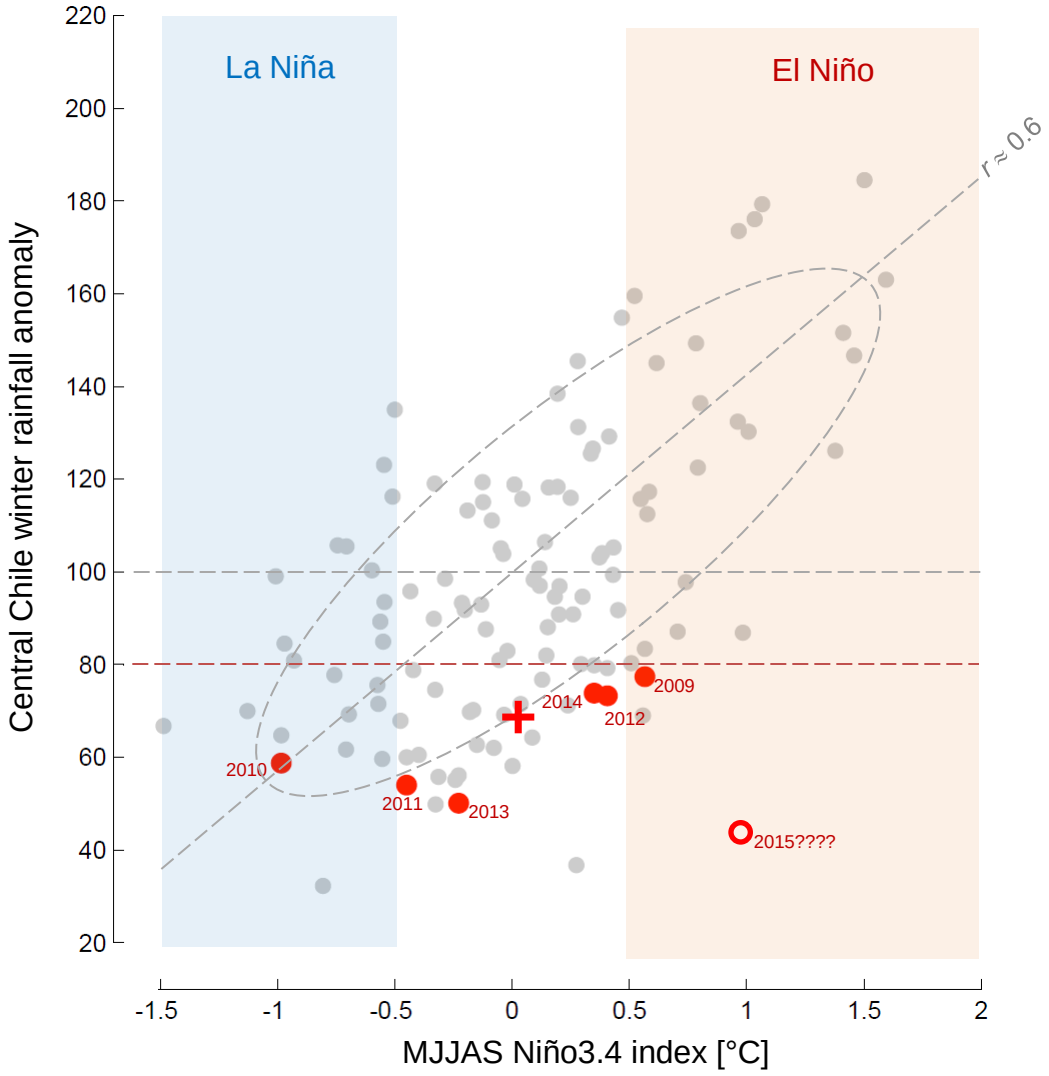
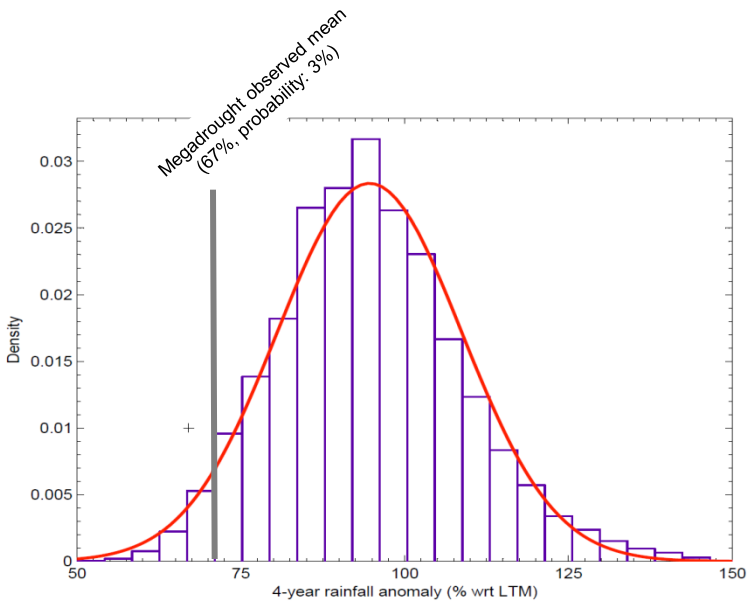
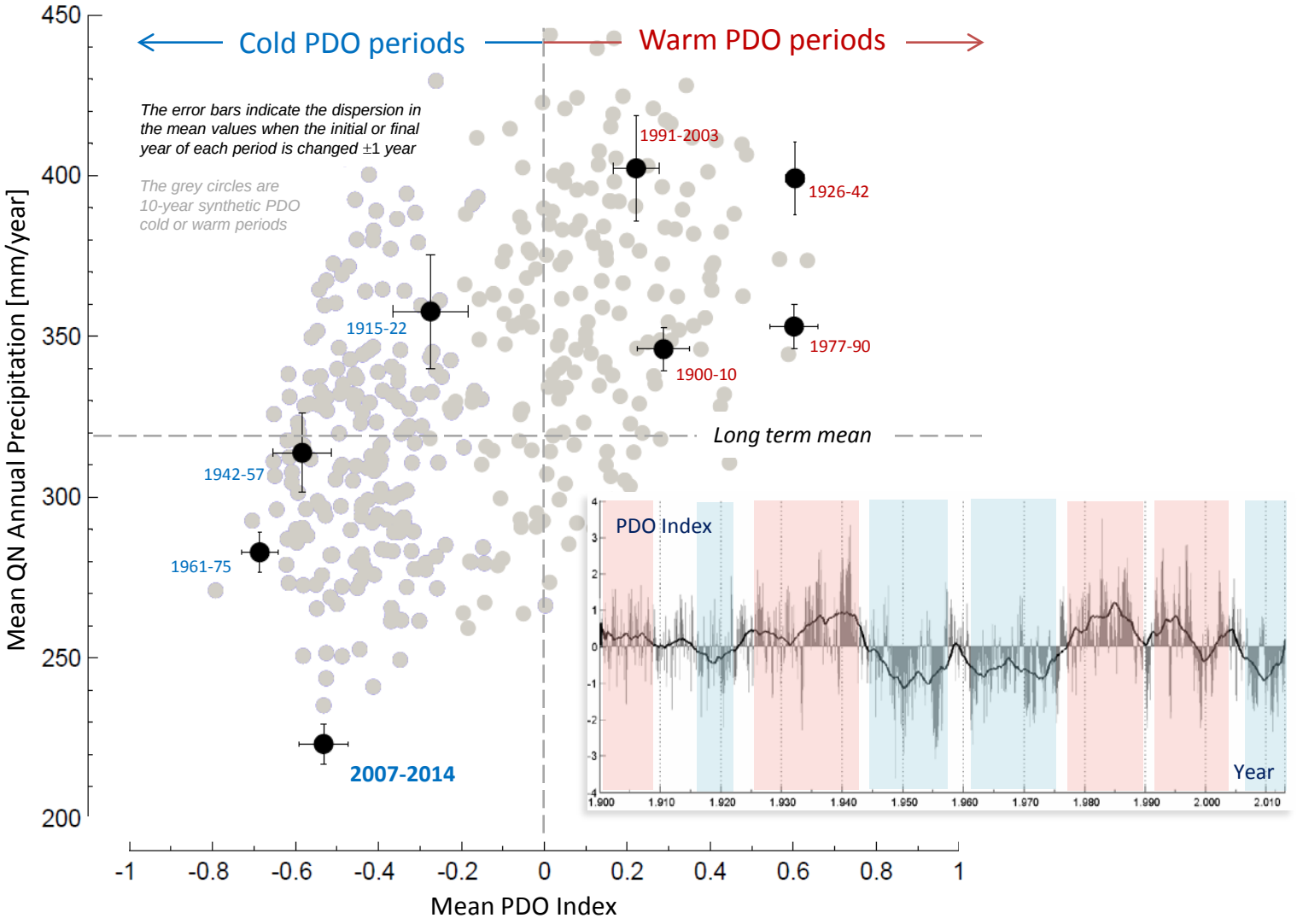


Monte Carlo Experiment:
5000 samples of 4 randomly chosen ENSO-neutral years

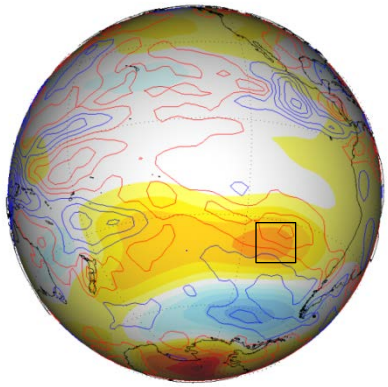


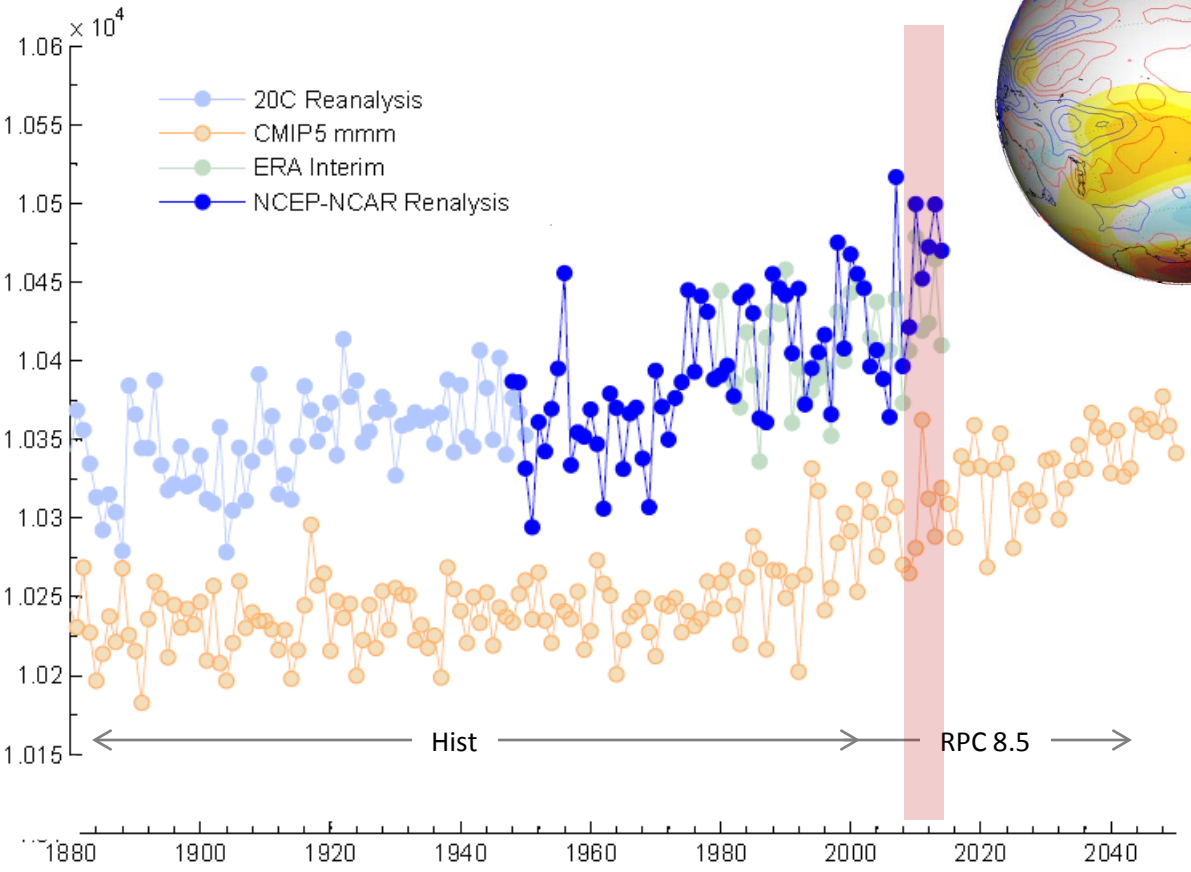
Precipitation distribution in Quinta Normal during cold and warm PDO periods



Evidence for anthropogenic forcing (?)

Altura Geopotencial en
250 hPa, 35S-100W





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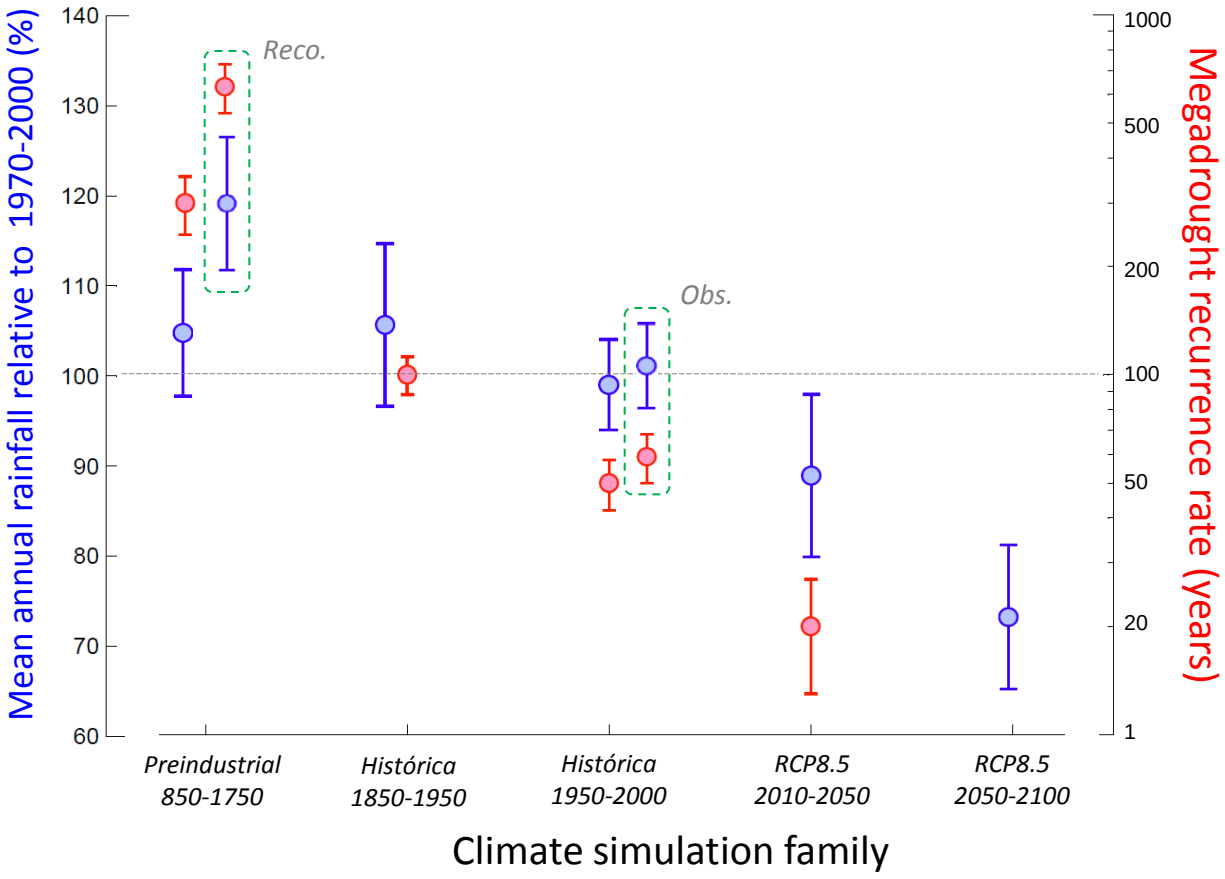

Conclusions

• Current multi-year drought (MD) in central Chile is a very infrequent event in the historical record (100 years) and paleo-record (1000 years). It occurs during the warmest decade on record and much increased water demands.

• The uninterrupted sequence of 5 (6) dry years occurred during mostly ENSO-neutral conditions, a very unlikely situation.

• Roughly speaking, half of the current MD rainfall deficit can be attributed to concurrent cold-phase of PDO (transitioning now?).

• Thus, anthropogenic climate change, mediated by circulation anomalies, is already influencing central Chile hydro-climate.

• So, we are not fully into the “future”, but this is how it will be…warm and dry.