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

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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.
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

Rainfall

SST

SLP

Zonal wind
300 hPa
Winter (MJJAS) rainfall in Santiago (33S)

Niño3.4 [°C] MJJAS

Wet

Dry

La Niña

El Niño

19°C                              20°                                21°C TSM en región Niño 3.4
Multimodel average SLP and sfc wind difference between A2 (2070-2100) and BL (1970-2000)

Over open ocean $\Delta v$ in geostrophic balance with $\Delta$SLP. Near the coast $\Delta v$ more controlled by along-coast $\Delta$SLP.
Figure 11.15. Temperature and precipitation changes over Central and South America from the MMDO1B 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

Annual mean

$100 \times \frac{P(A2) - P(BL)}{P(BL)}$
Annual Precipitation 33°S-71°W

Base line

Near future
dP/Po = 11%

Far future
dP/Po = 24%

25 Individual models from CMIP-5

Sim. Histórica

Sim. RCP8.5

Multi-model mean

Precipitation Annual / Precipitación Media Anual

Year

1960 1980 2000 2020 2040 2060 2080 2100
Central Chile current mega-drought (2015 very dry so far)
Central Chile current mega-drought (2015 very dry so far)

Mega Drought: 2010-2013

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<th>Norte Chico</th>
<th>Centro</th>
<th>Centro-sur</th>
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<tr>
<td>Ret. Period driest year within MD (year)</td>
<td>7</td>
<td>15</td>
<td>&gt;30</td>
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<td>Recurrence of 4 year drought (per 50 years)</td>
<td>4-6</td>
<td>2-3</td>
<td>1?</td>
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Increasing temperatures in central Chile...
Impacts on evapo-transpiración y snow-cover
Central Chile current mega-drought (2015 very dry so far)

\[ \text{TWS}_t = \text{SM}_t + \text{SNW}_t + \text{SW}_t + \text{GW}_t \approx \text{GW}_t \]
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 m³/ha) → ΔCO₂ Sequestration?

P. Corvalán, M. Galleguillos, J. Hernández, R. Garreaud
MODIS-TERRA
08 Enero 2014
11:55 Hora Local
Central Chile current mega-drought (2015 very dry so far)
SST (colors) and SLP (contours) anomalies
Central Chile current mega-drought (2015 very dry so far)

Monte Carlo Experiment: 5000 samples of 4 randomly chosen ENSO-neutral years
Precipitation distribution in Quinta Normal during cold and warm PDO periods

The error bars indicate the dispersion in the mean values when the initial or final year of each period is changed ±1 year.

The grey circles are 10-year synthetic PDO cold or warm periods.
Evidence for anthropogenic forcing (?)

Altura Geopotencial en 250 hPa, 35S-100W
Evidence for anthropogenic forcing (?)
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.