

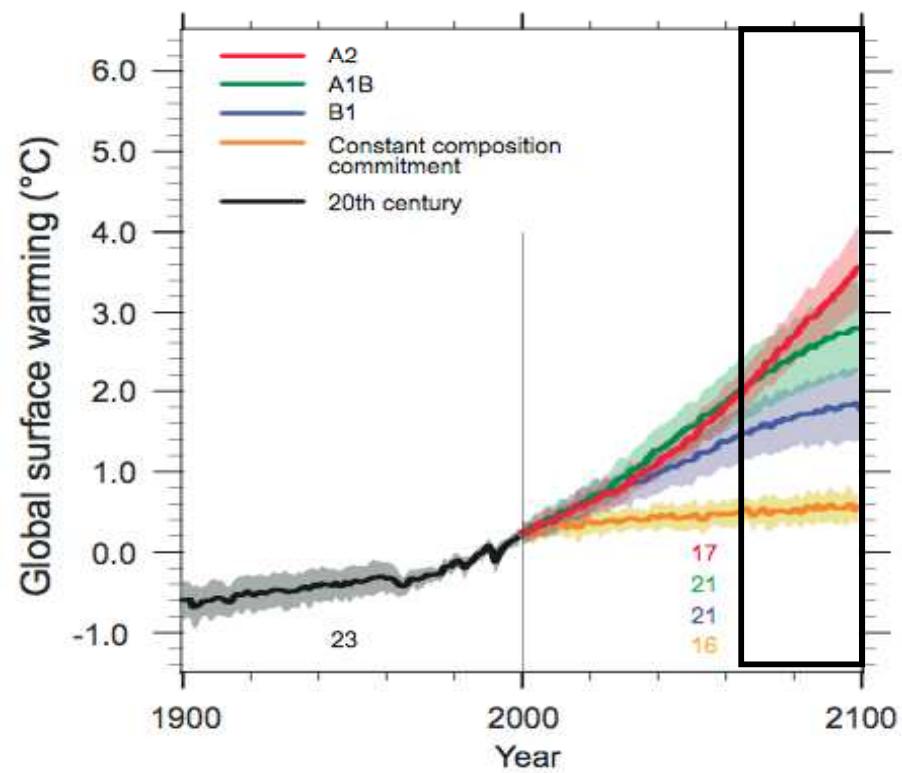
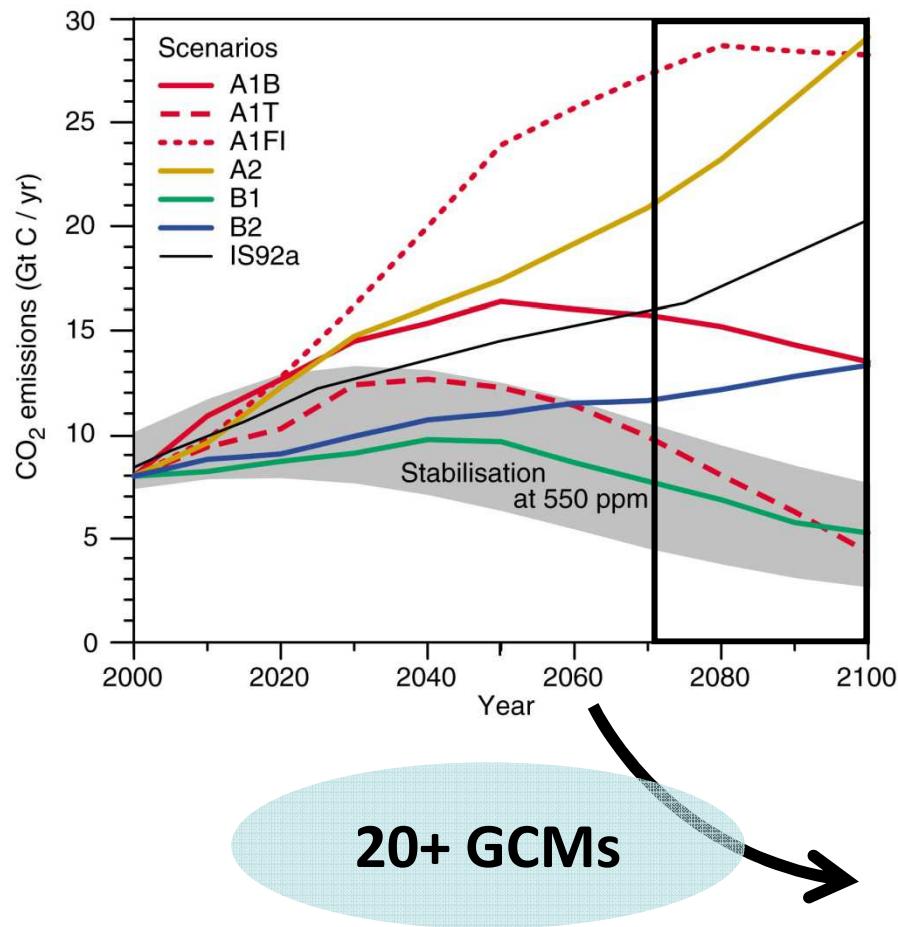
La actual Mega-Sequía en Chile Central: Llegó el futuro?



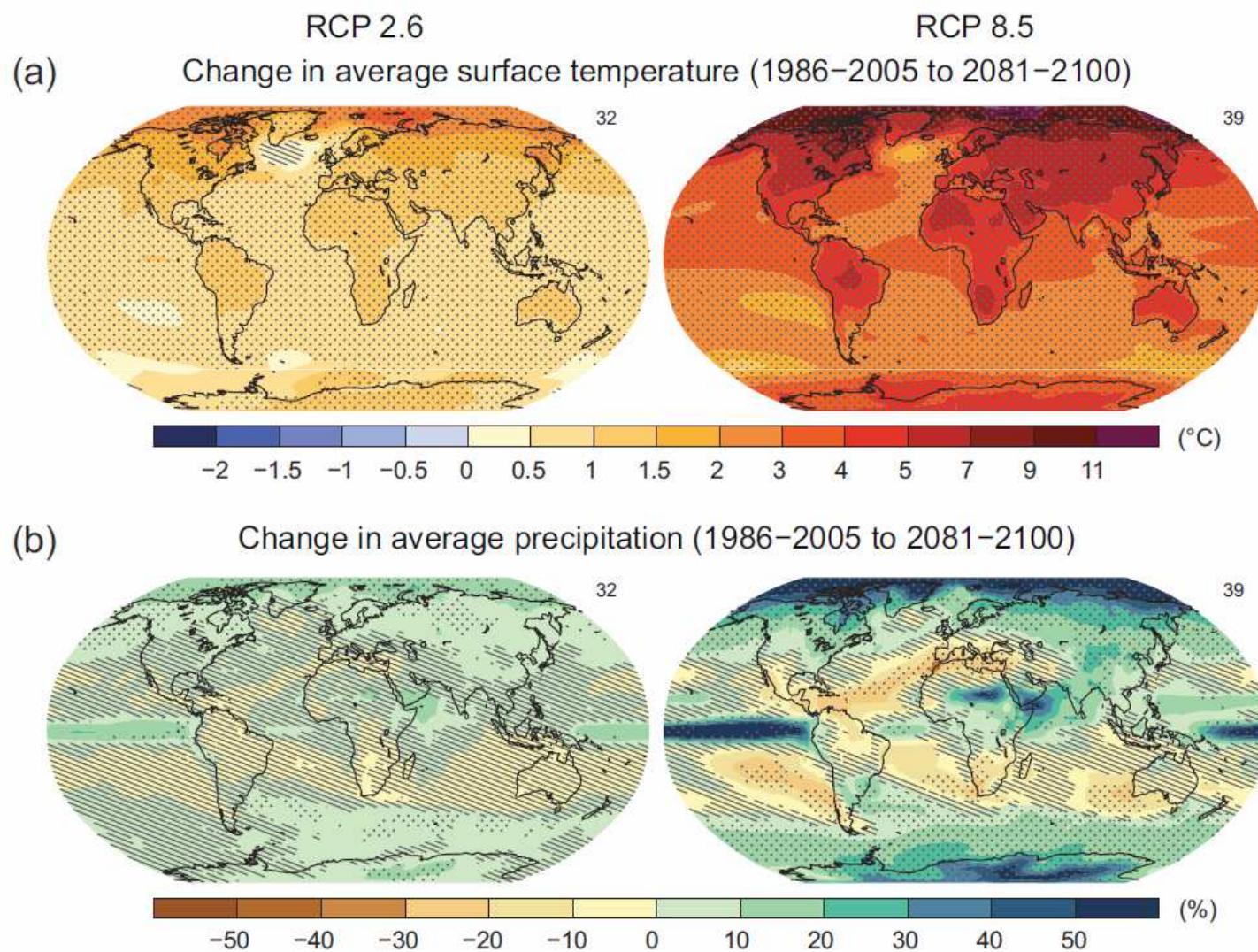
René D. Garreaud + grupo de Sequía CR2
Department of Geophysics, Universidad de Chile
Center for Climate and Resilience Research, CR2

IV Congreso Nacional de Oceanografía Física y Meteorología
PUCV 1u-Noviembre-2015

Mirando el futuro: Escenarios de emisiones (CO₂, etc) + Modelos de Circulación General (Atmos+Ocean)



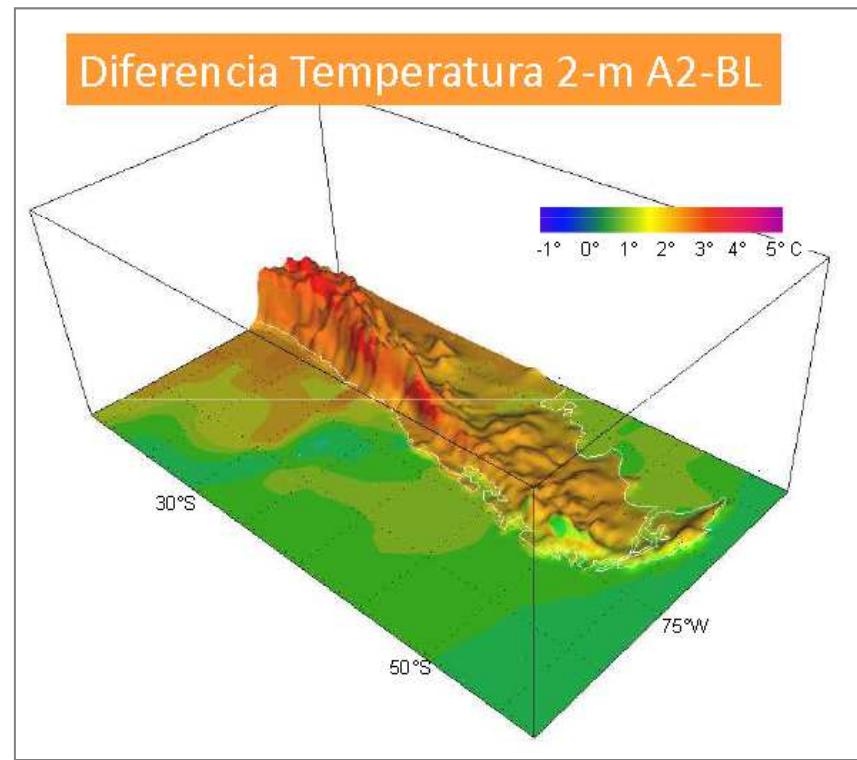
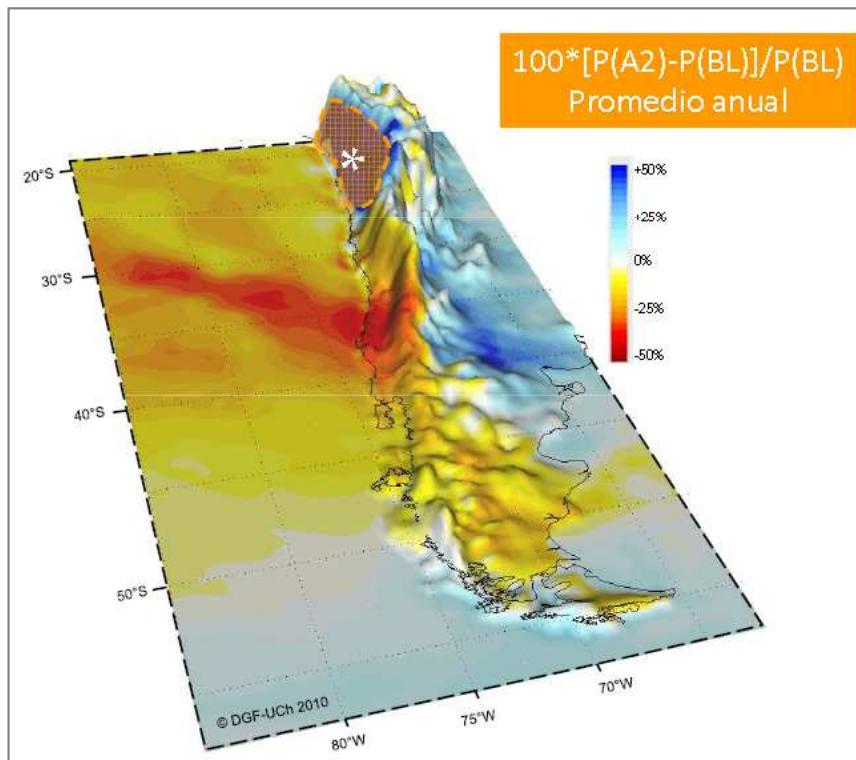
Mirando el futuro: Escenarios de emisiones (CO₂, etc) + Modelos de Circulación General (Atmos+Ocean)



IPCC-AR5

Impactos Regionales del Cambio Climático

- Aumento de temperatura 2.5-3.5°C (*)
 - Disminución de precipitación 25-35% (*)
- (*) Proyección a fin de siglo bajo escenario A2



Estudio DGF/UCh-CONAMA 2007 empleando PRECIS

La megasequía 2010-2015

- Moderada (20-40% déficit anual)
- Larga (5-6 años) e ininterrumpida
- Extensa (30-40°S)
- Cálida (+0.5 – 1°C)
- Alta demanda hídrica

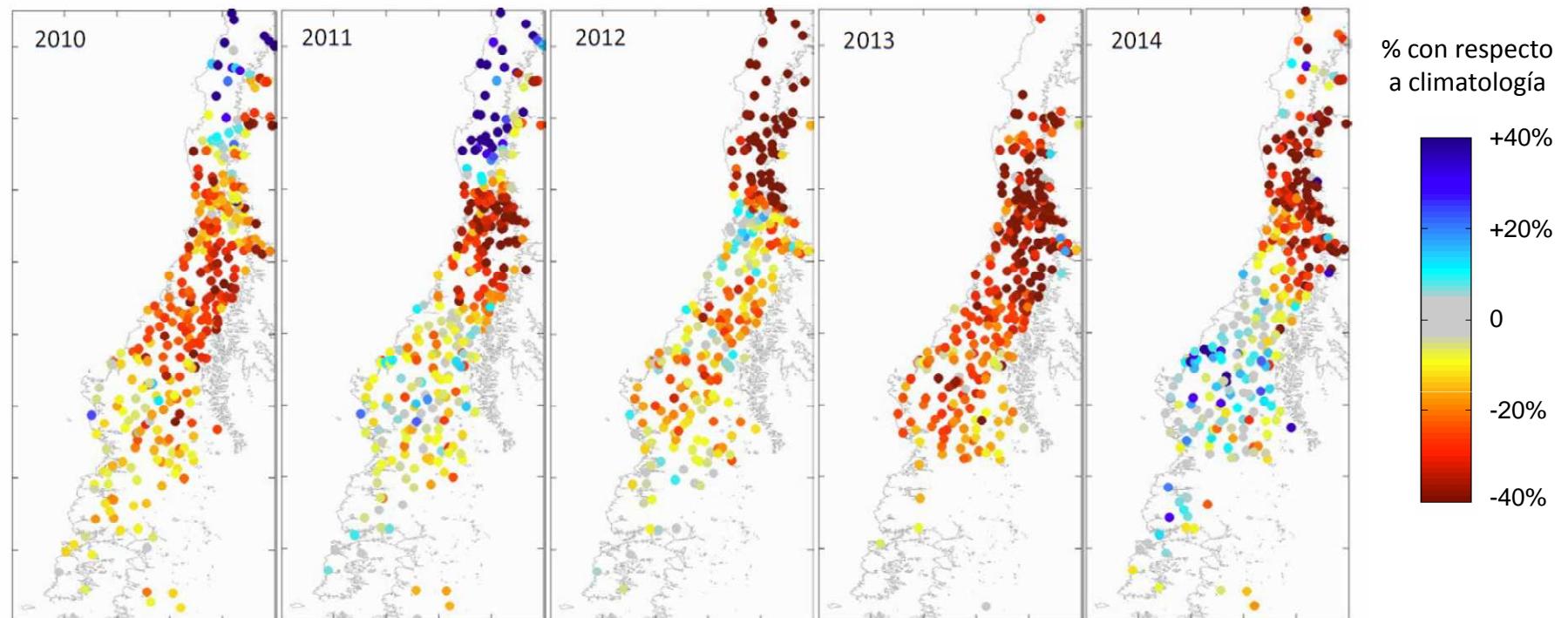
Recurrencia en el siglo XX

- 2-3 casos similares en centro-norte
- <1 caso en centro-sur
- También es inusual en reconstrucción Paleo

Impactos:

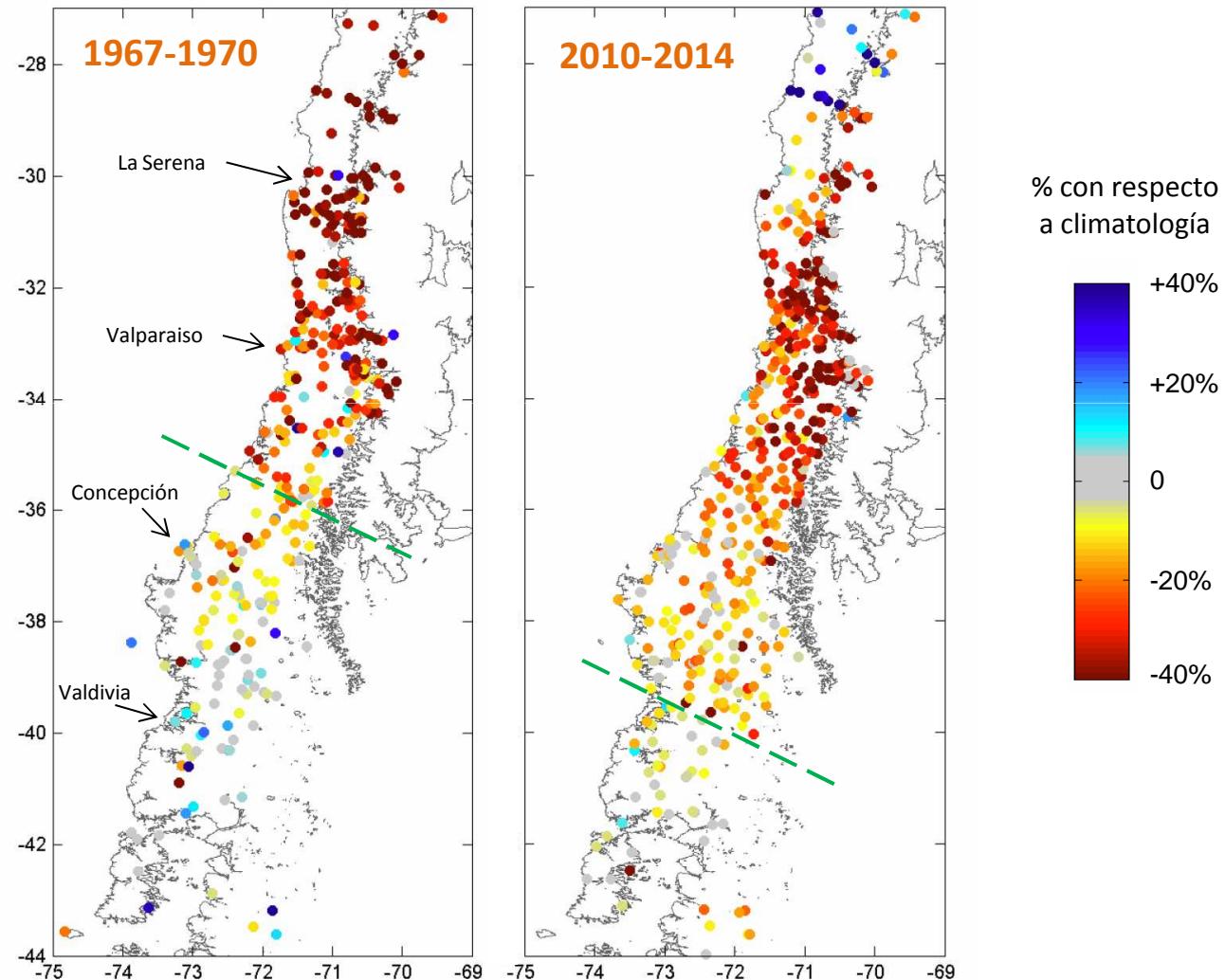
- Hidrología sfc y subterránea
- Vegetación natural
- Regimen de incendios
- Sociales y económicos

La Megasequía 2010-2015

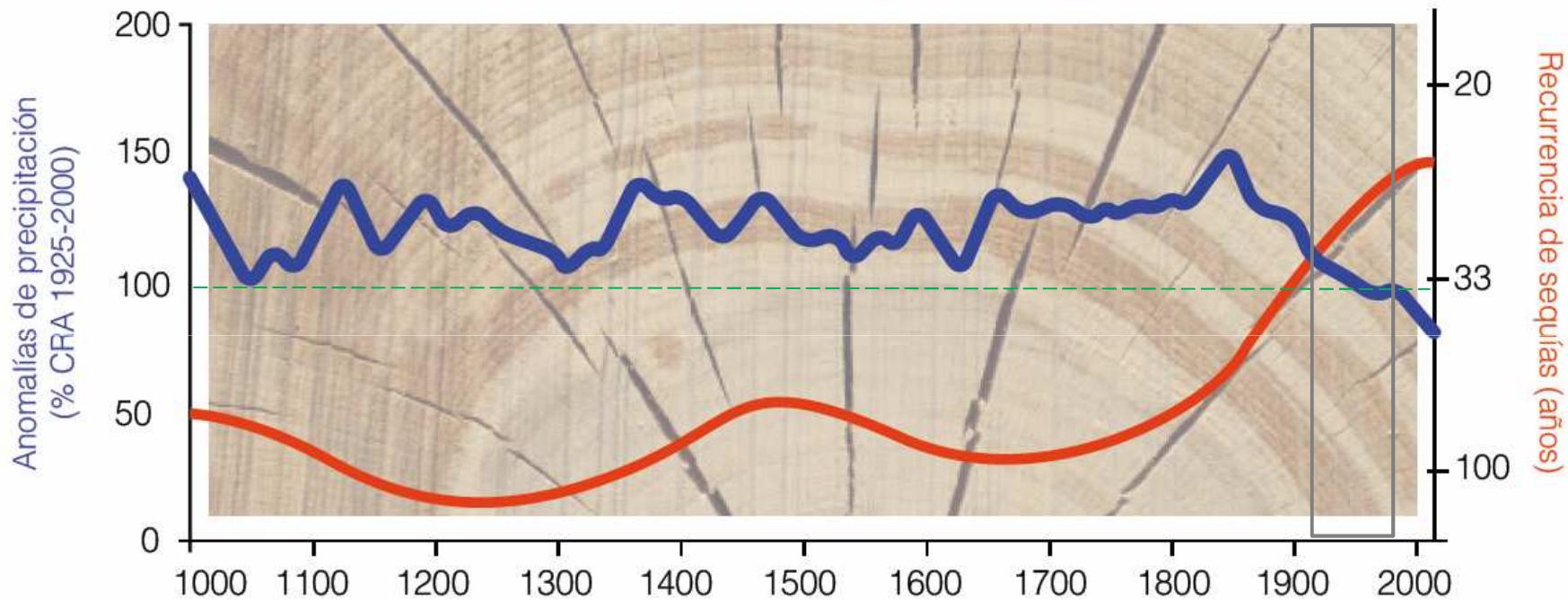


| | Norte Chico | Centro | Centro-sur |
|--|-------------|--------|------------|
| Período de retorno del año más seco durante la MS (años) | 7 | 15 | >30 |
| Recurrencia de eventos secos (>30%) de 4 o mas años | 4-6 | 2-3 | 1? |

Grandes sequías contemporáneas

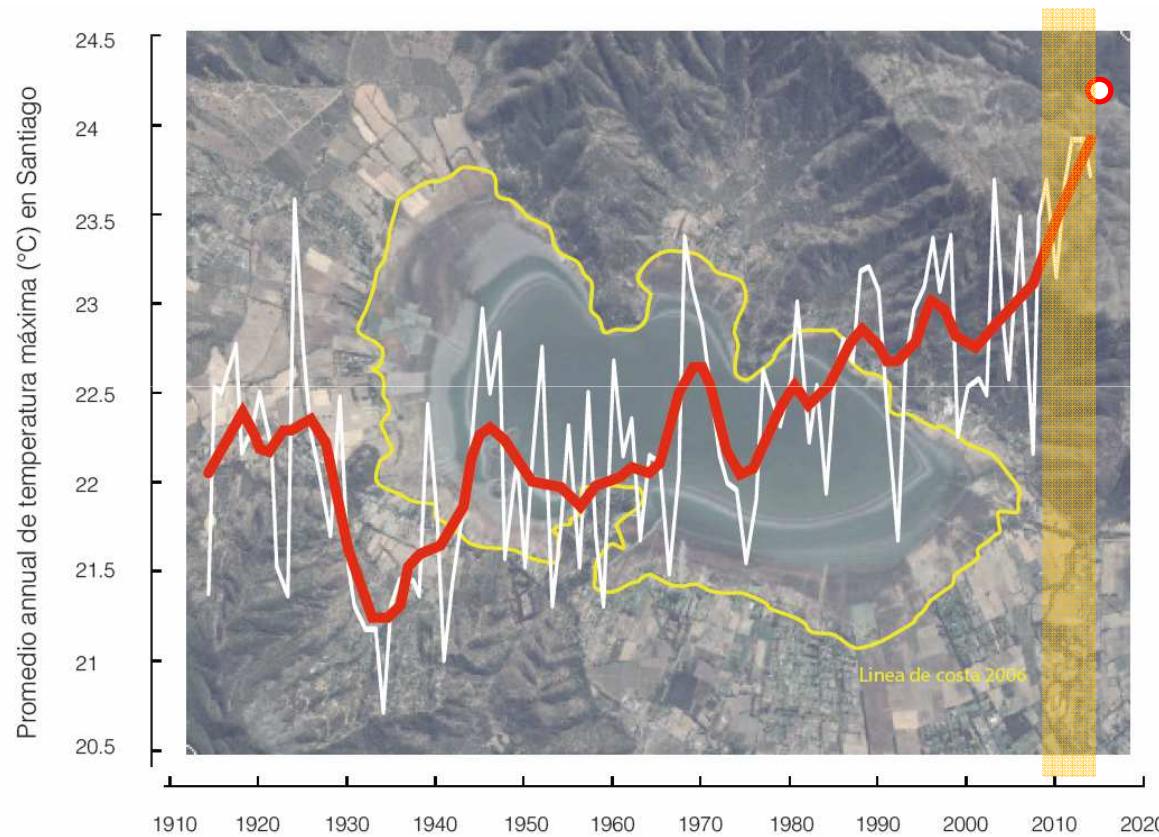


Una mirada al pasado



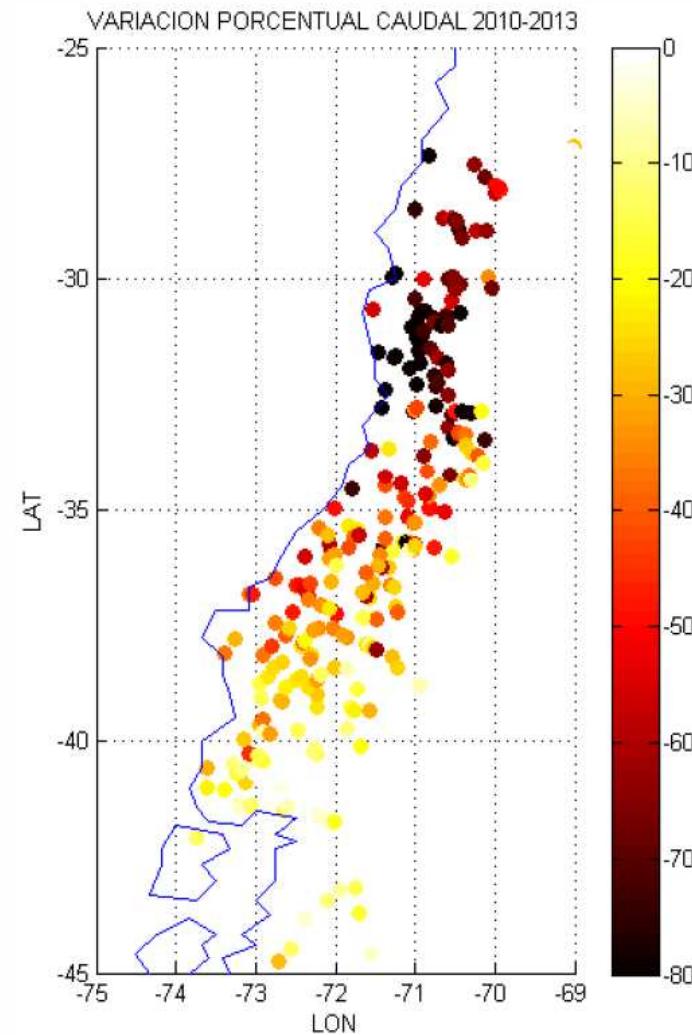
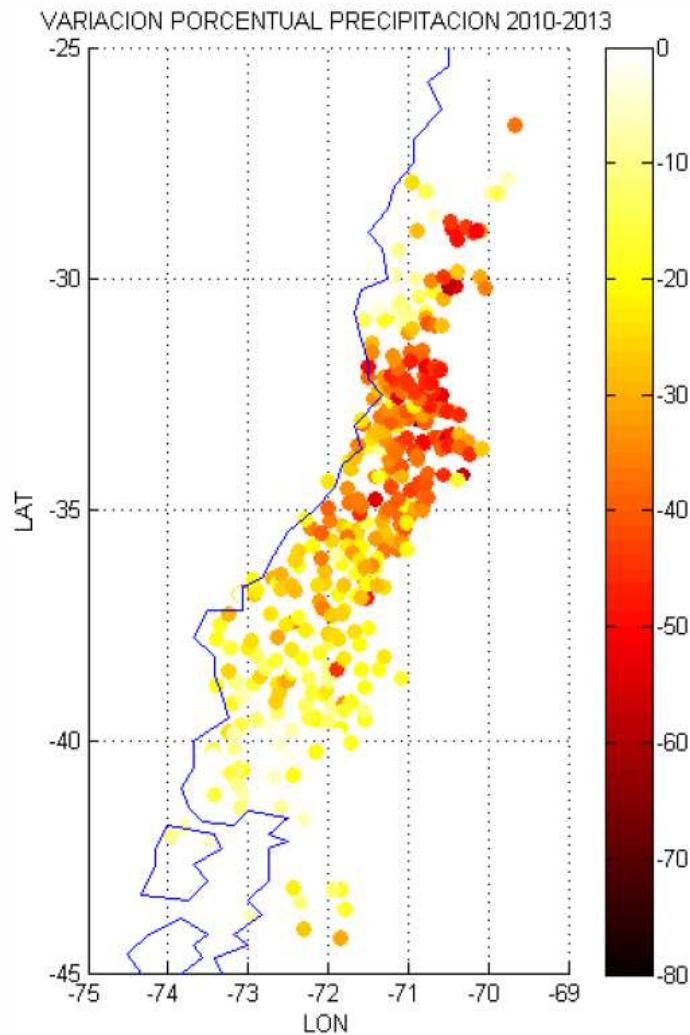
Reconstrucción dendroclimática (1000-2000 años d.C.)
de la precipitación en Chile central

Sequía y calor

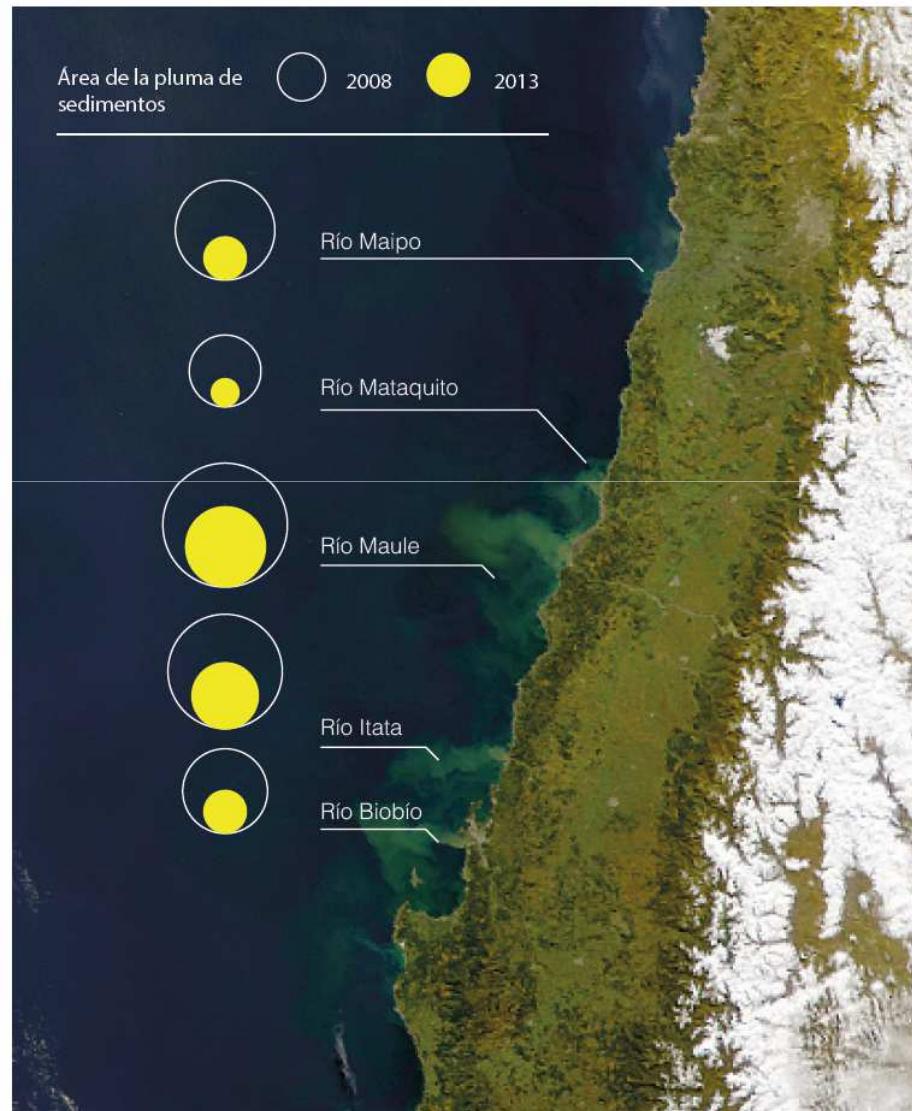


Promedio anual de la temperatura máxima en Santiago (DMC)

Impactos en Hidrología

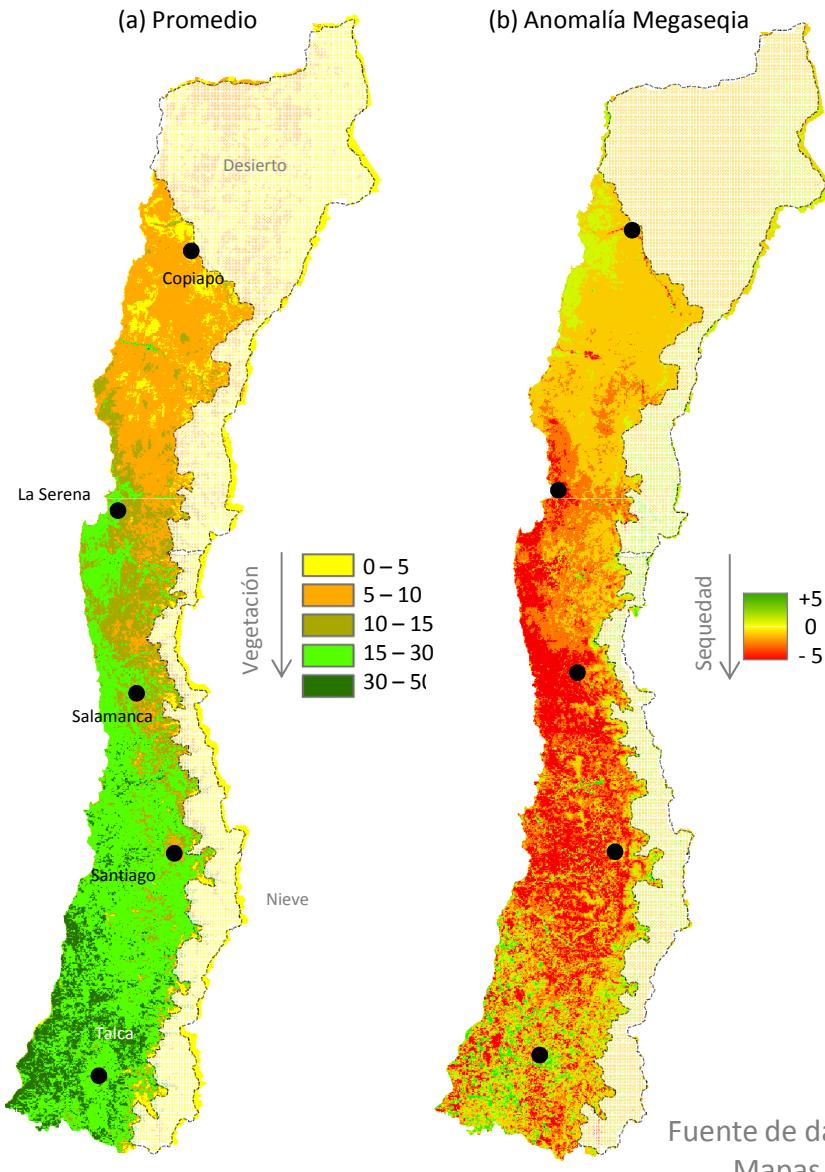


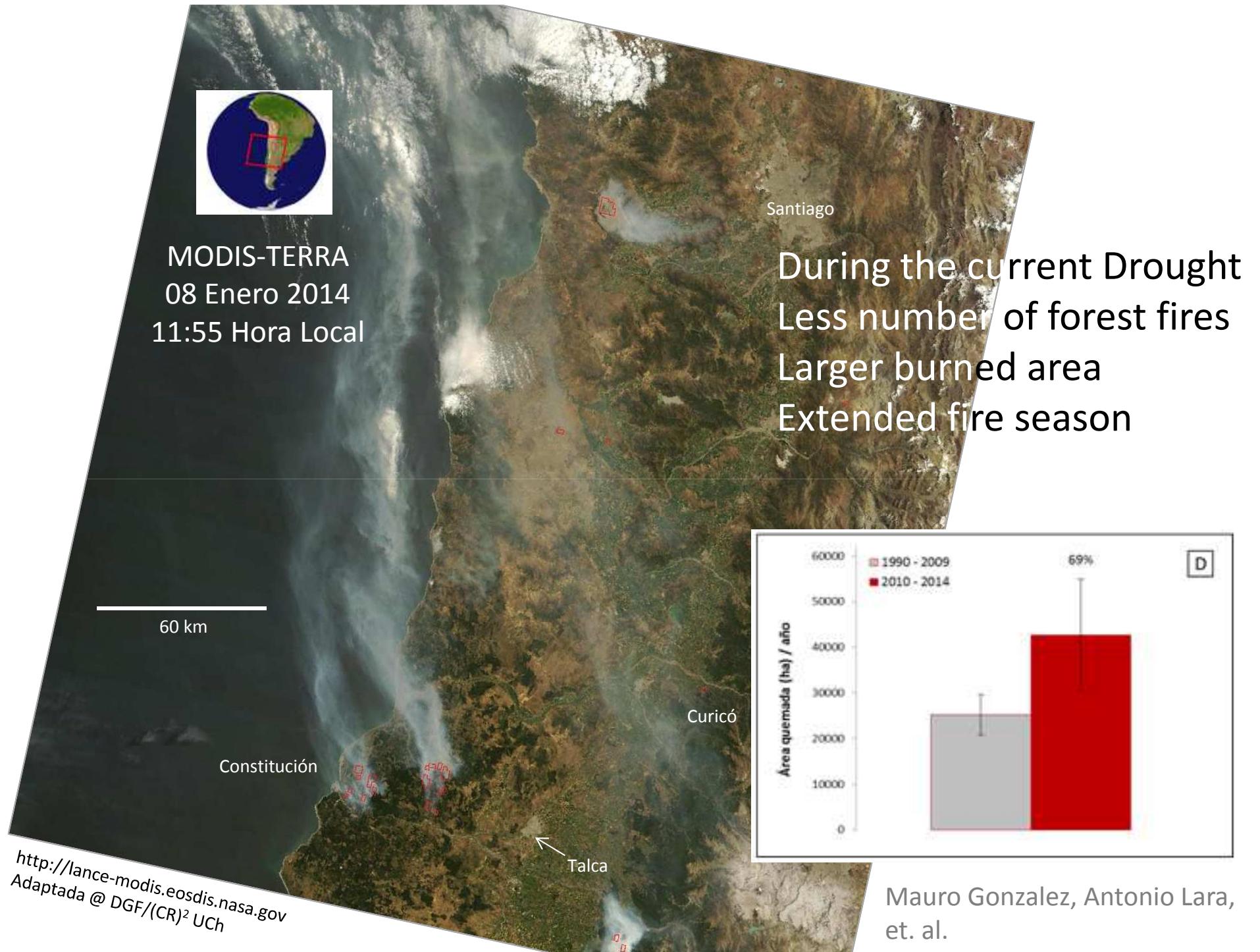
Impactos en Hidrología



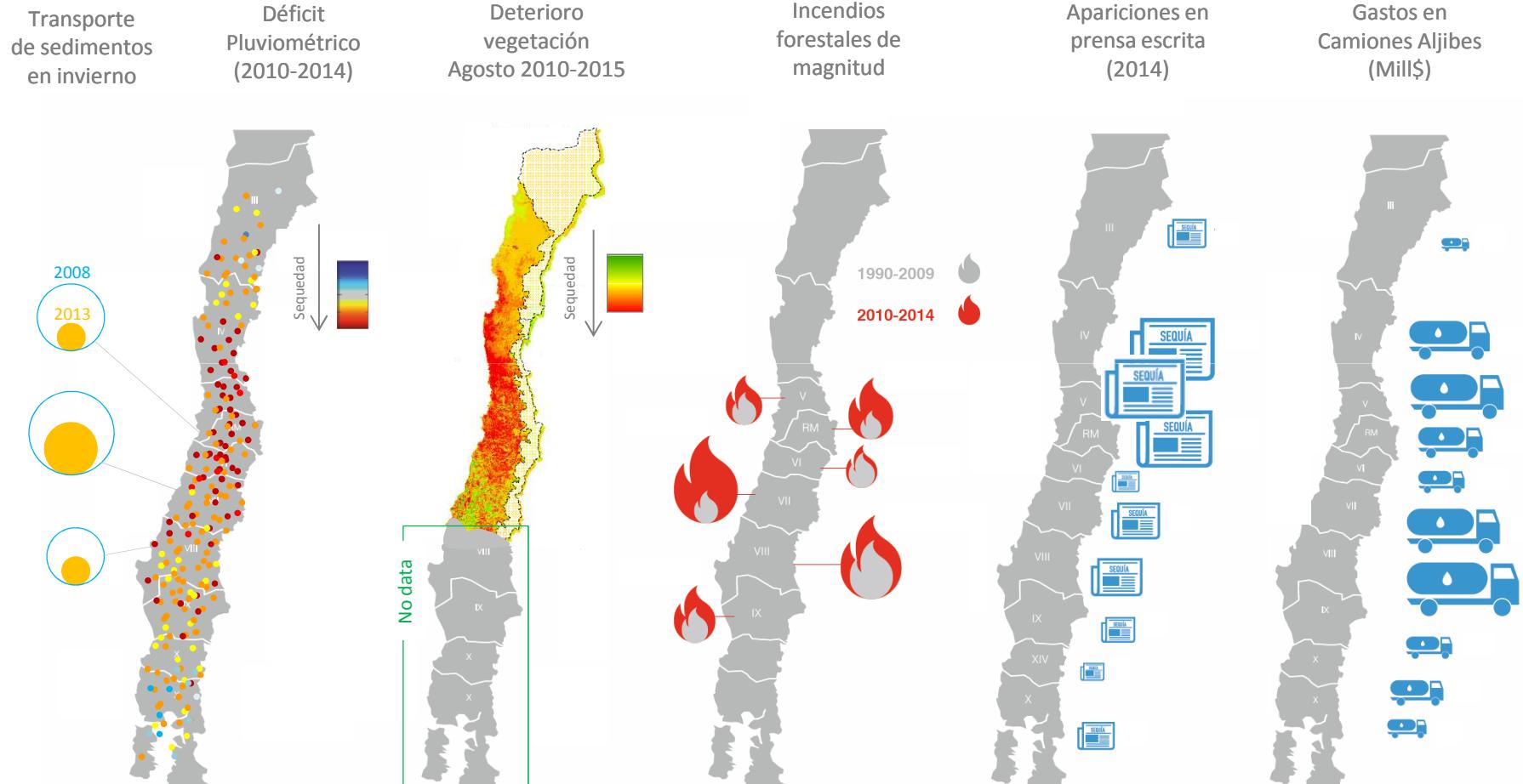
Índice de Vegetación Mejorada (EVI)

Julio-Agosto-Septiembre





La Megasequía 2010-2015



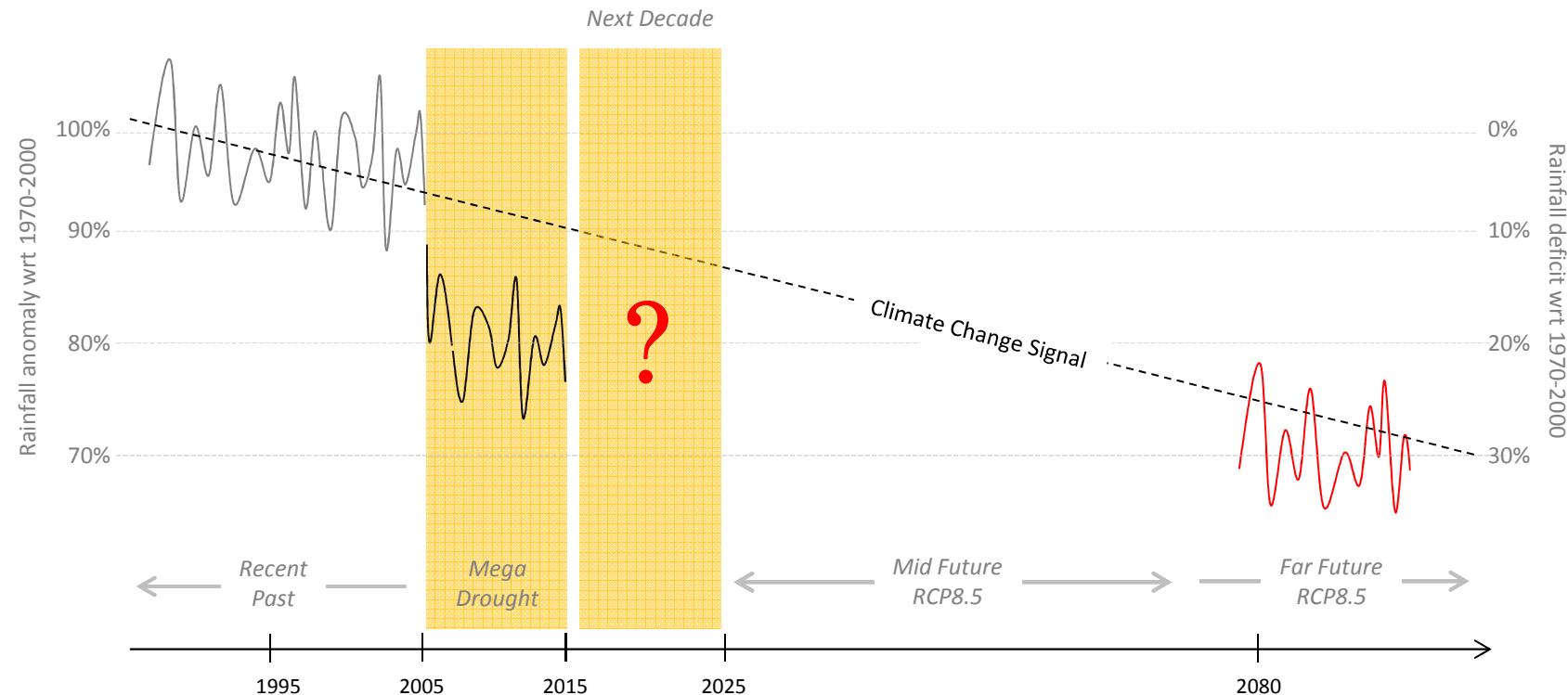
La Megasequía 2010-2015: Una lección para el futuro

www.cr2.cl/megasequia



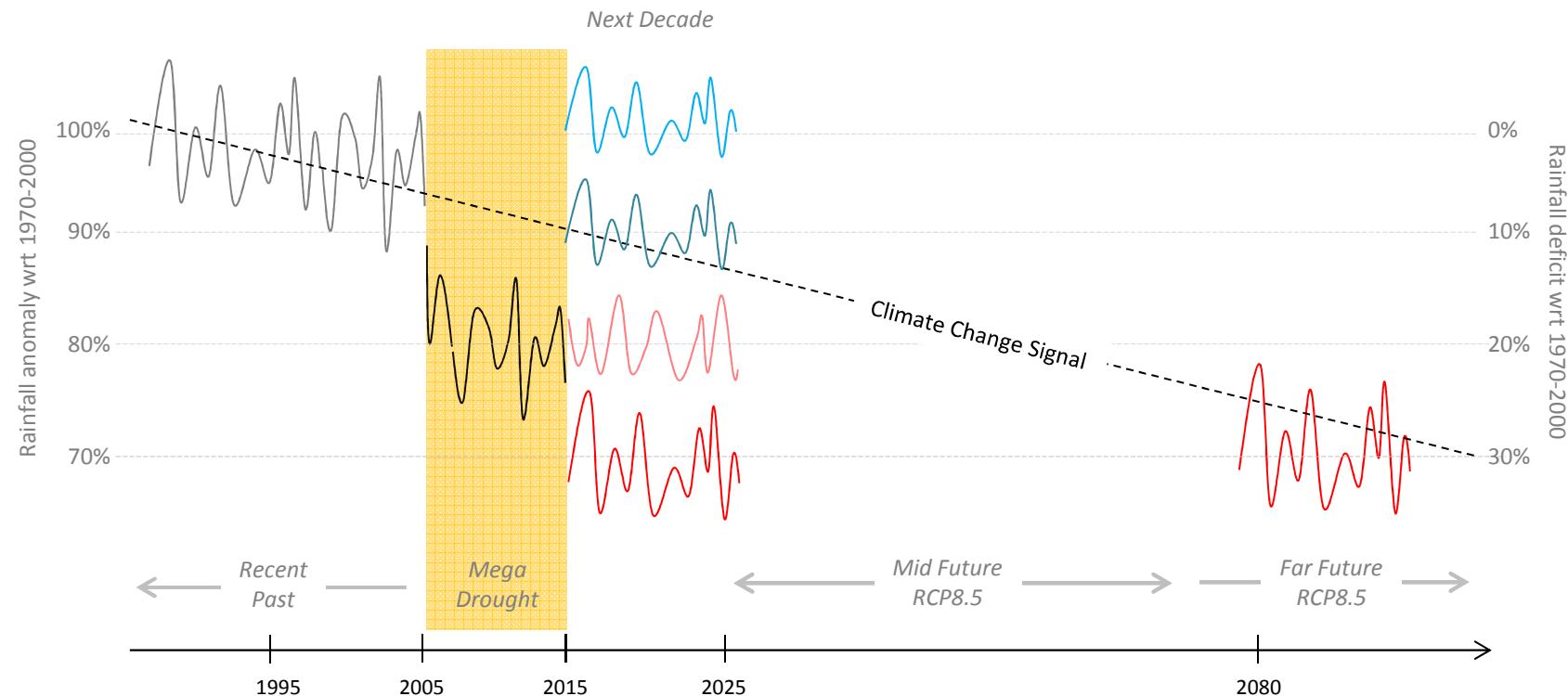
Precipitación en Chile Central

El desafío de la próxima década



Precipitación en Chile Central

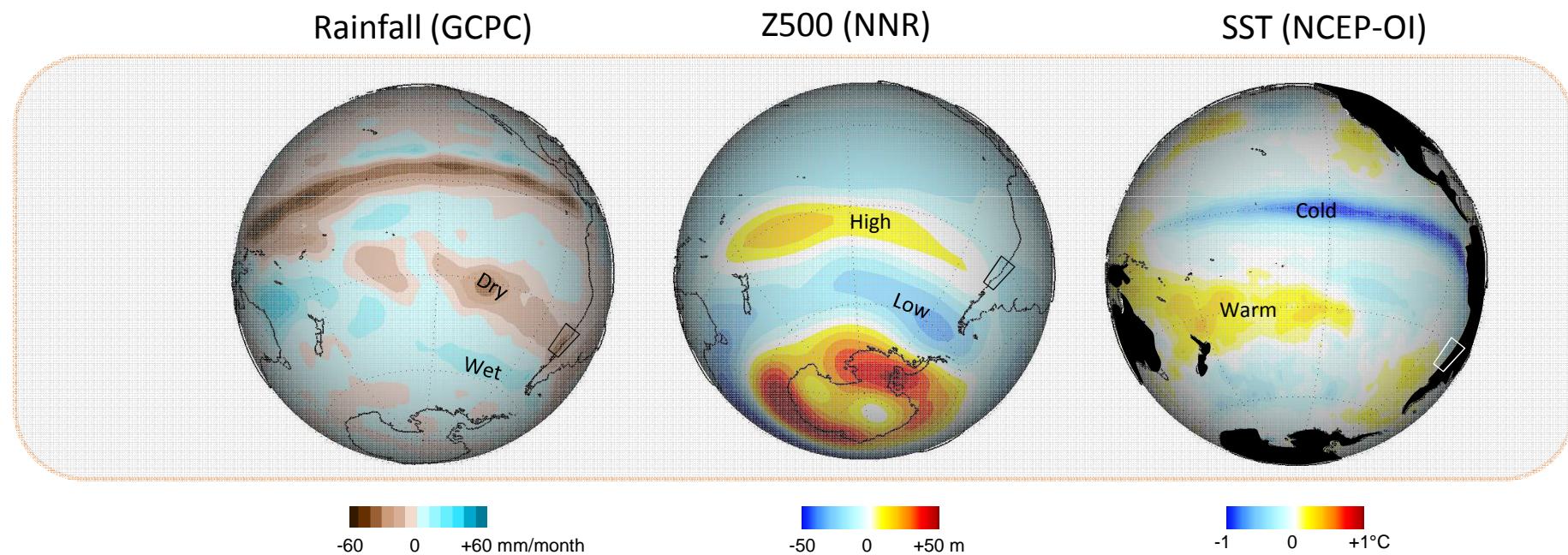
El desafío de la próxima década



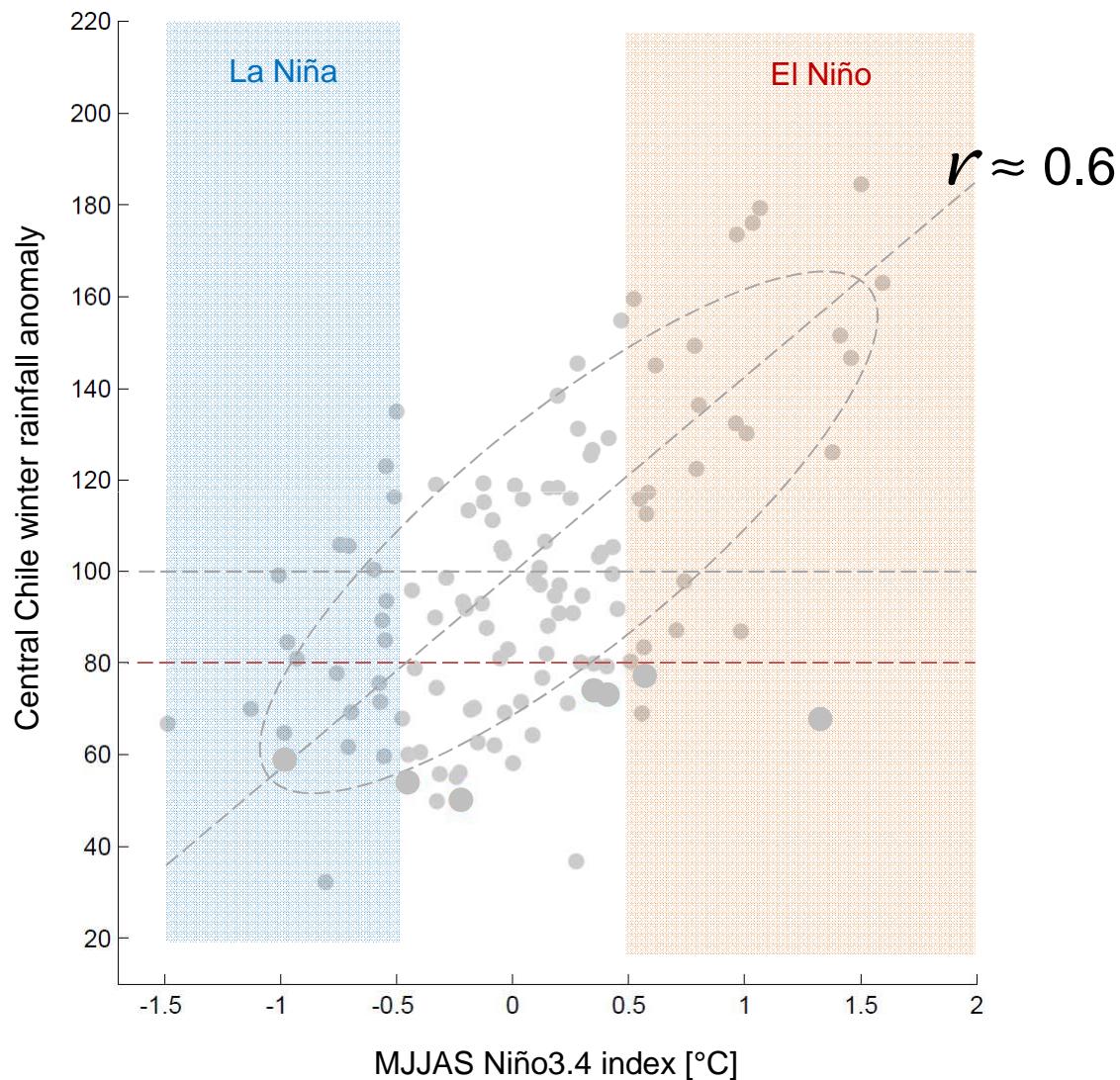
Large-scale context for central Chile droughts

Drought Composite

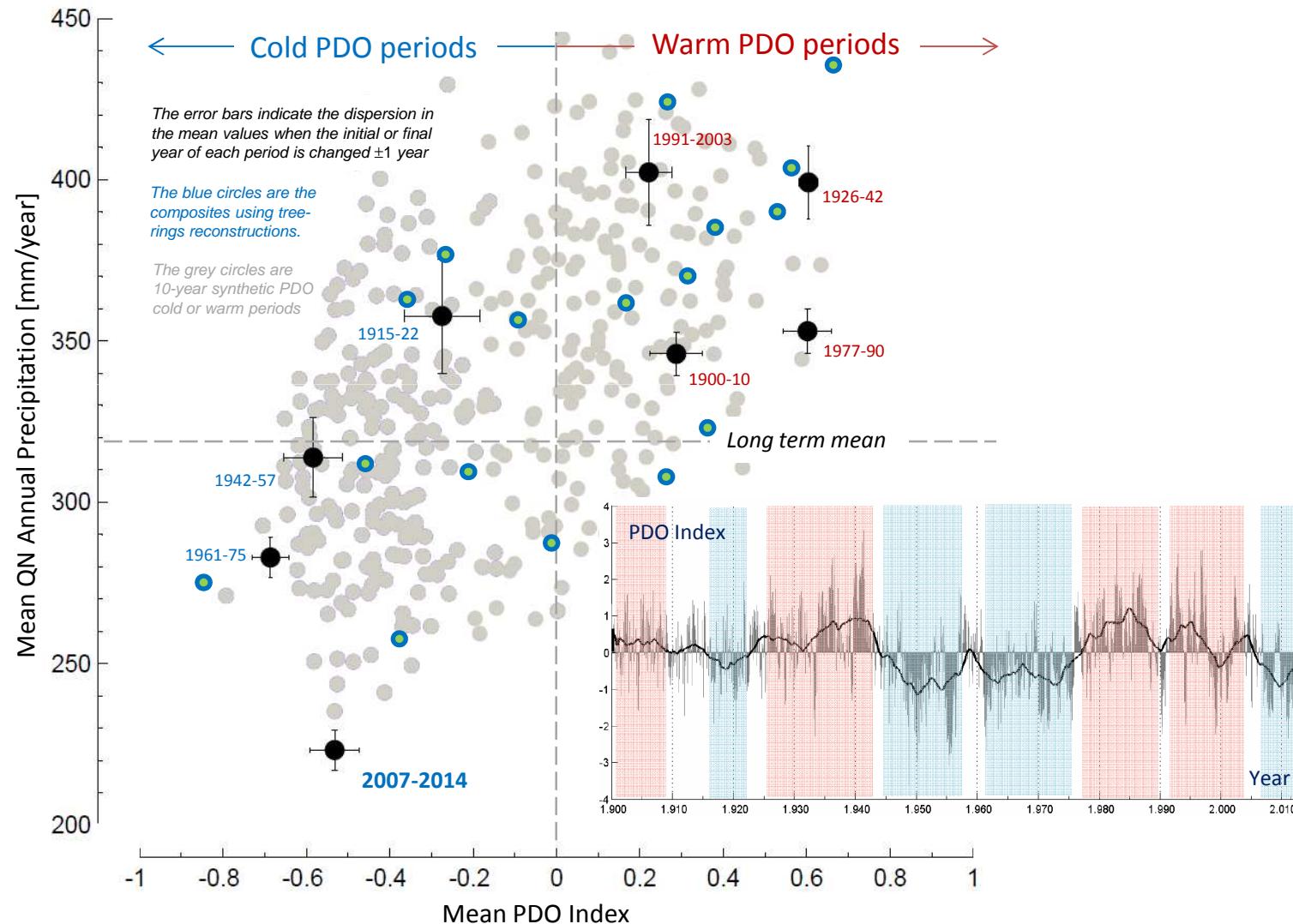
1967,68,64,73,76,85,96,87,03,07



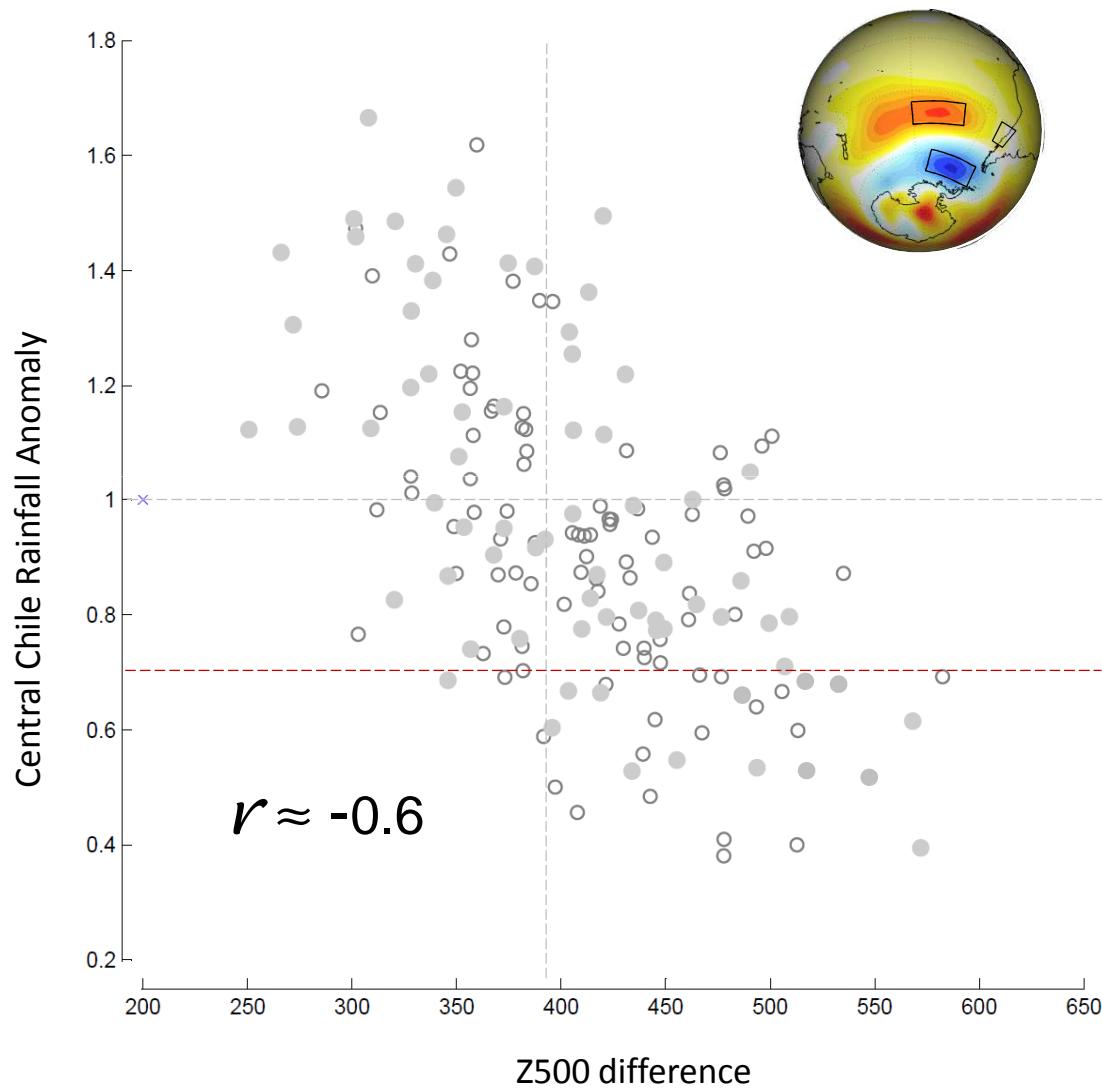
Large-scale context for central Chile droughts



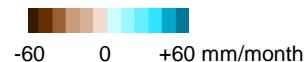
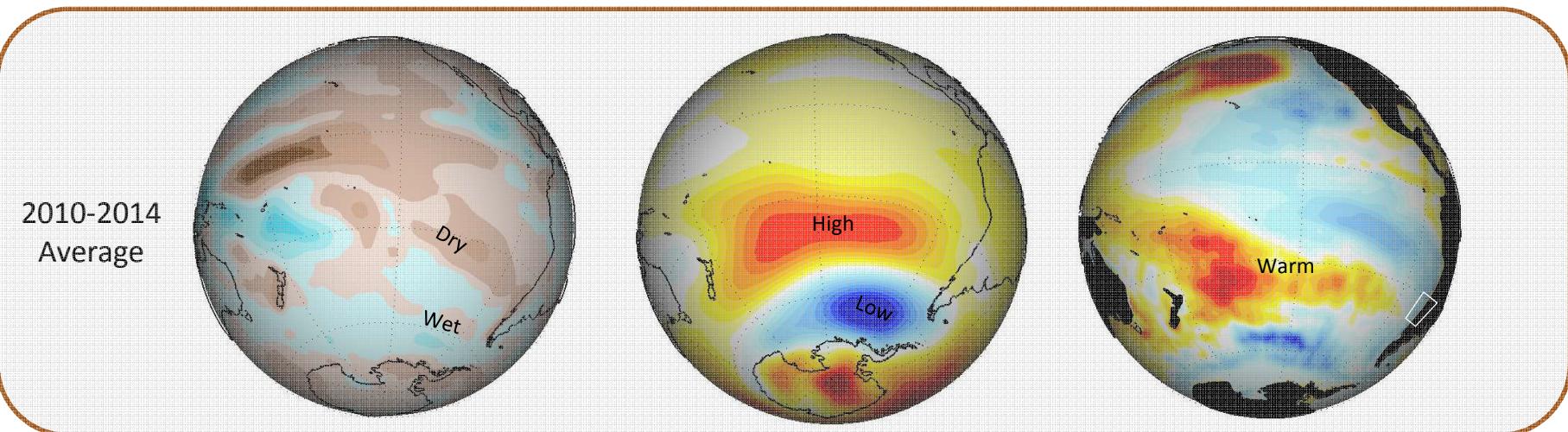
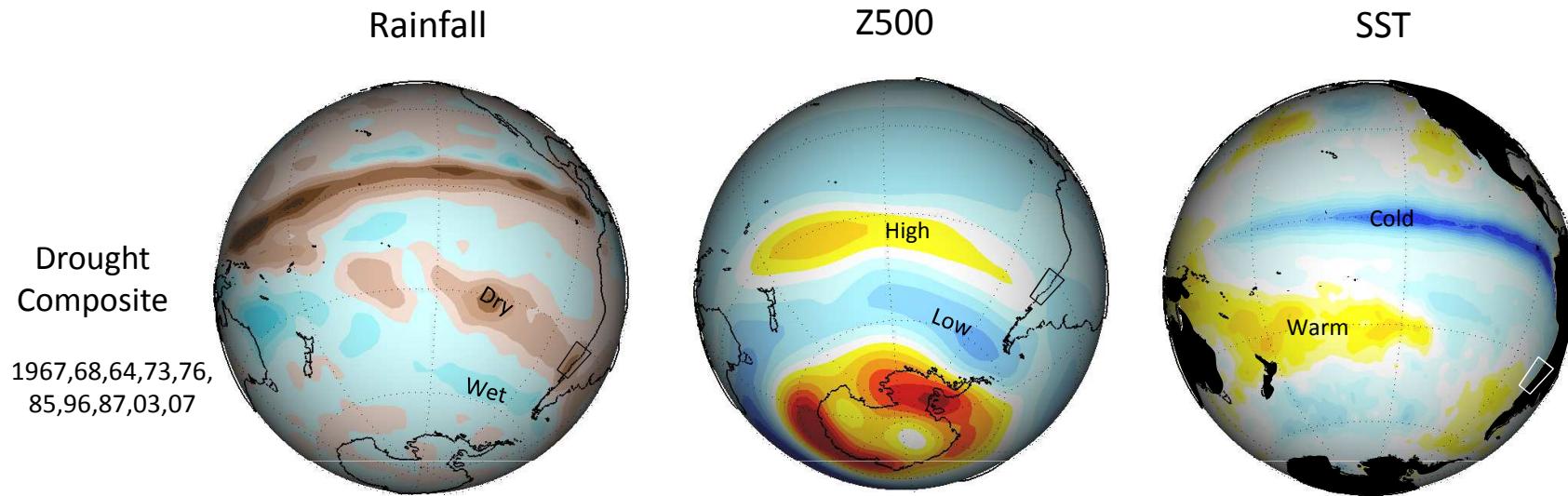
The 2010-2015 drought in Central Chile



Large-scale context for central Chile droughts

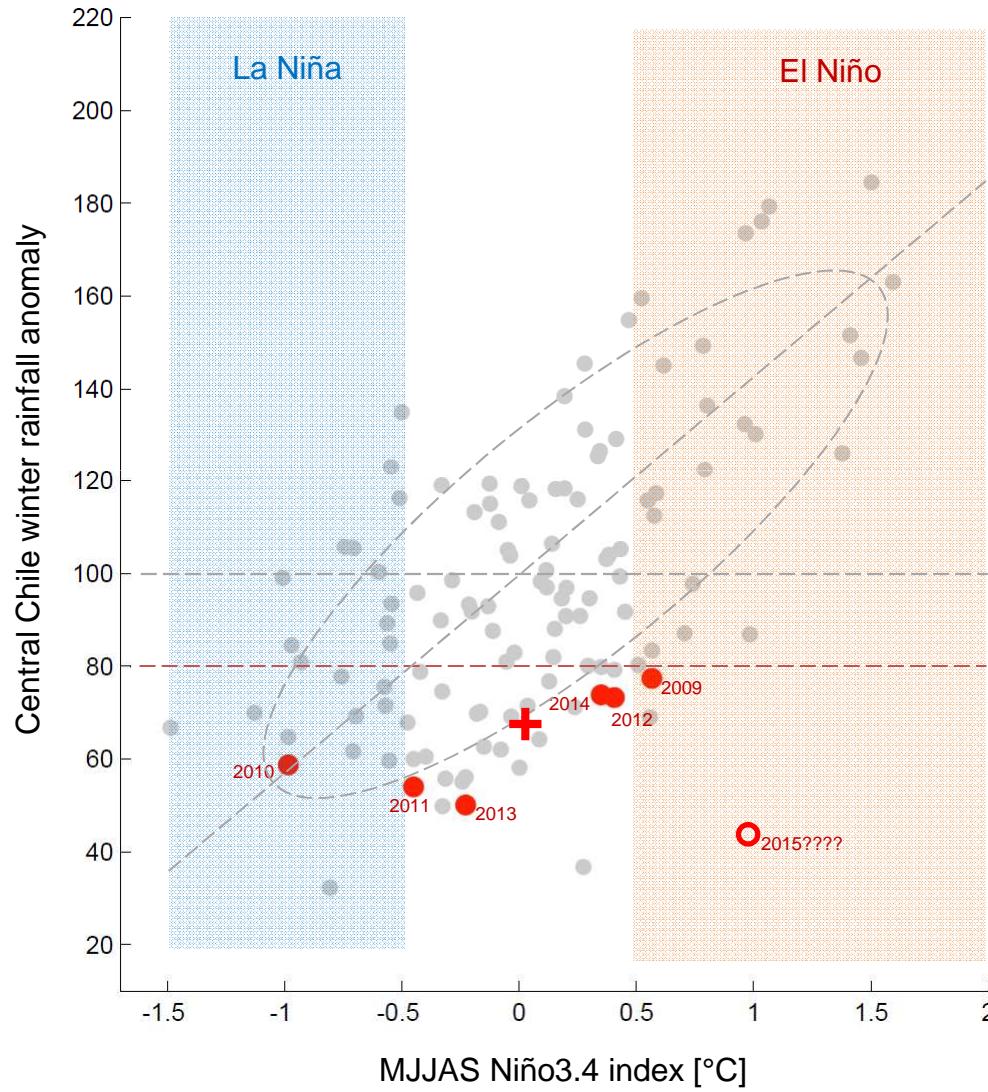
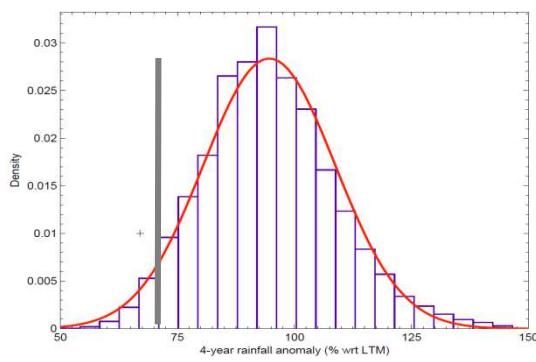


The 2010-2015 drought in Central Chile

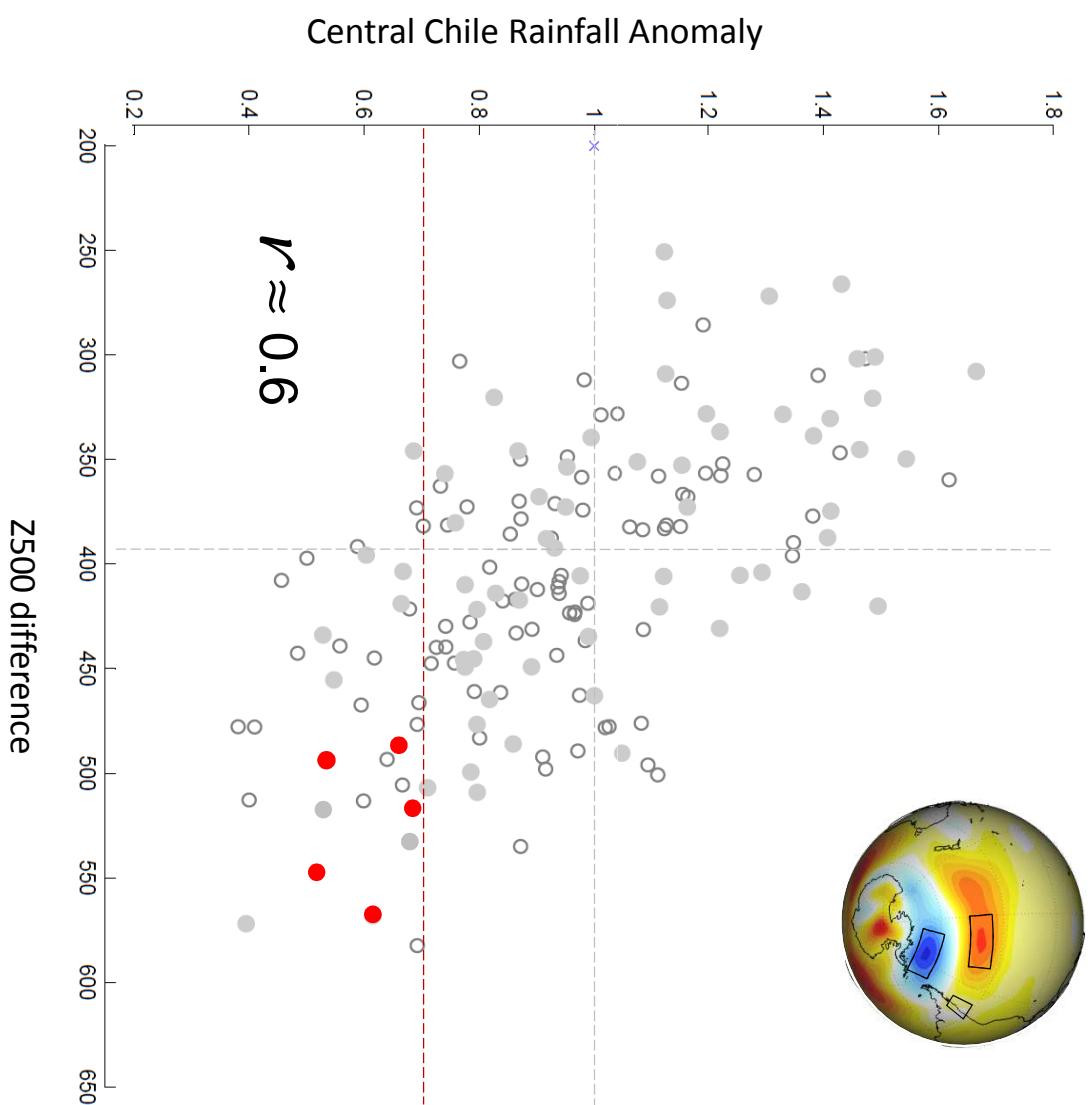


The 2010-2015 drought in Central Chile

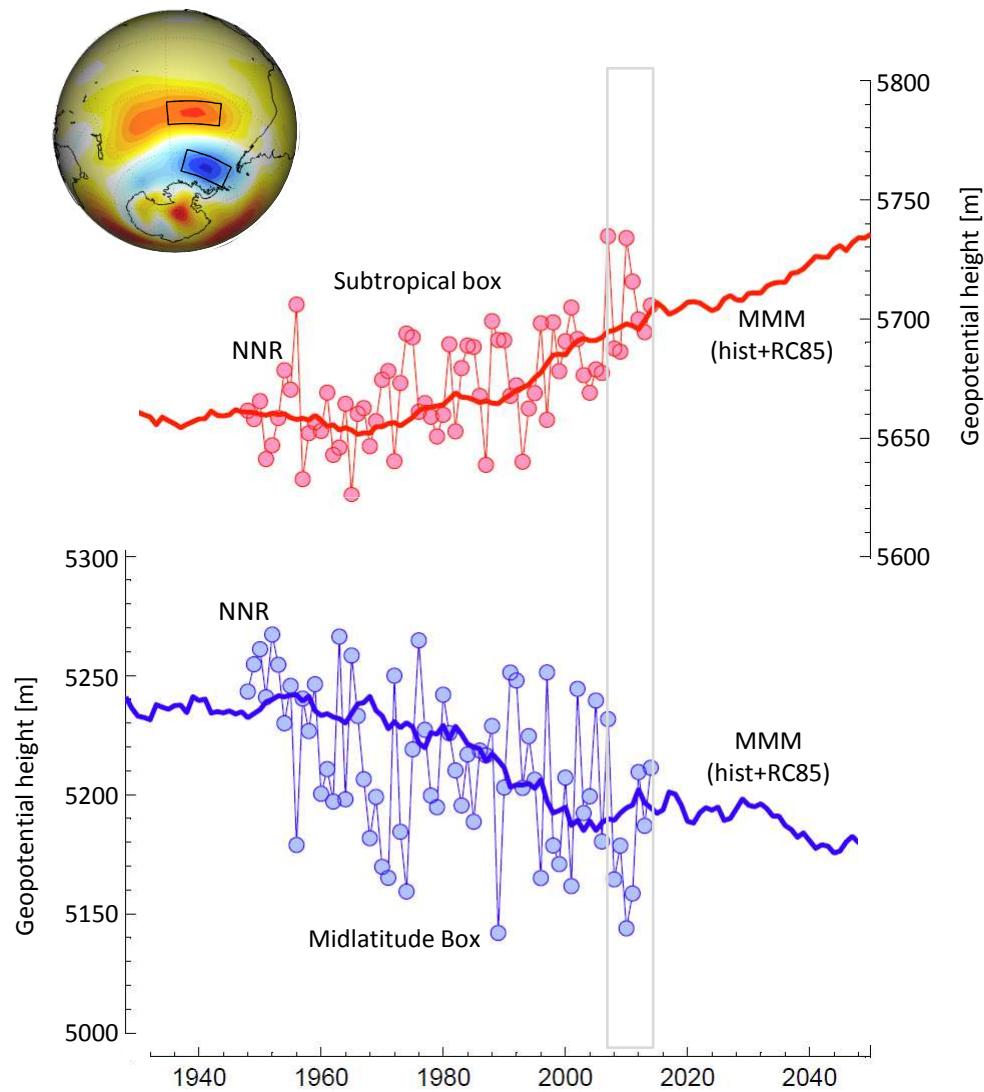
Monte Carlo Experiment:
5000 samples of 4 randomly
chosen ENSO-neutral years



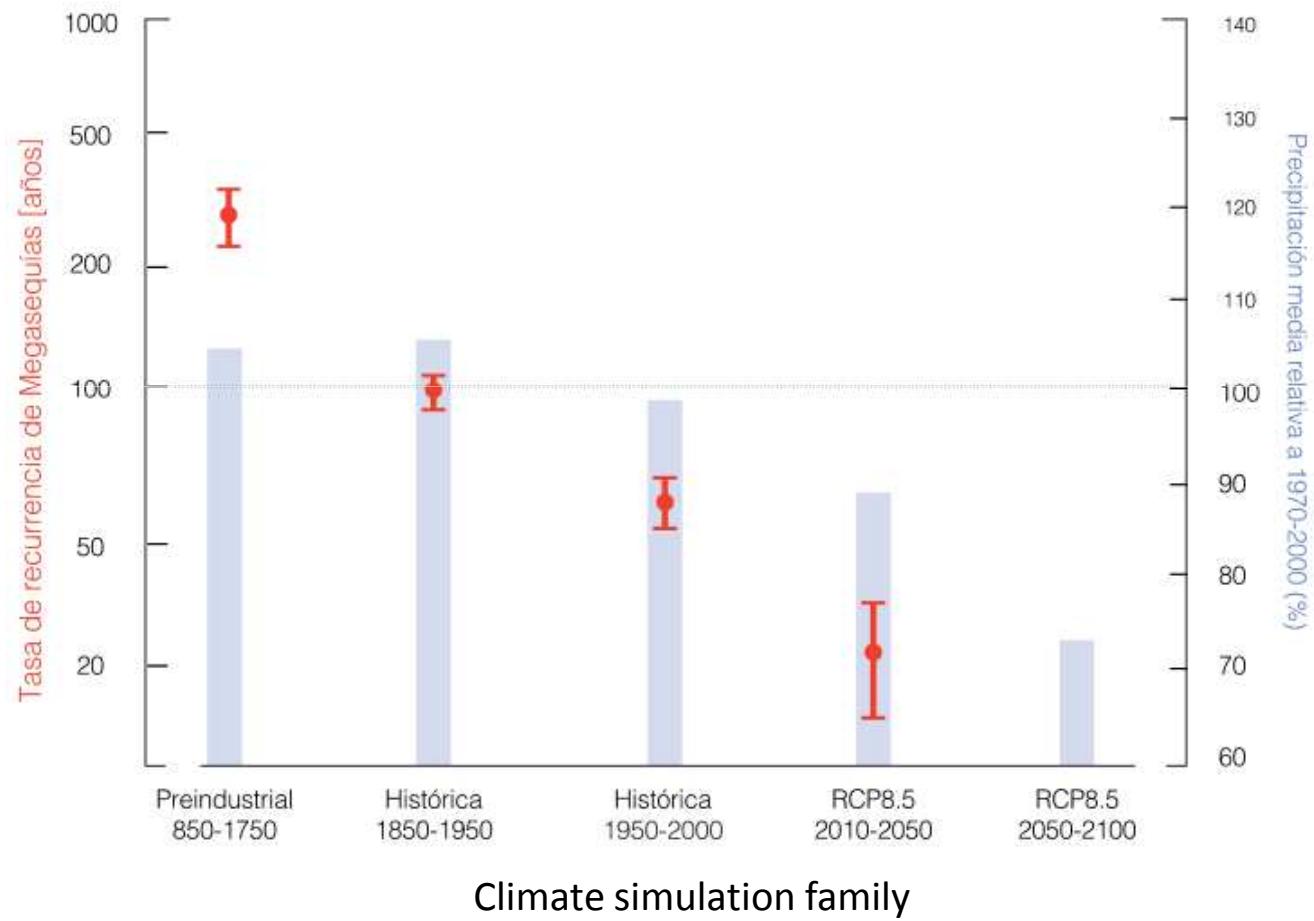
The 2010-2015 drought in Central Chile



The 2010-2015 drought in Central Chile



Evidence for anthropogenic forcing



Attribution of the 2010-2015 mega drought

AMIP simulations: Global Circulation Model (GCM) forced by

- Observed SST
- Observed Sea Ice Distribution
- Observed or past Radiative Forcing (CO₂, aerosols, O₃,...)

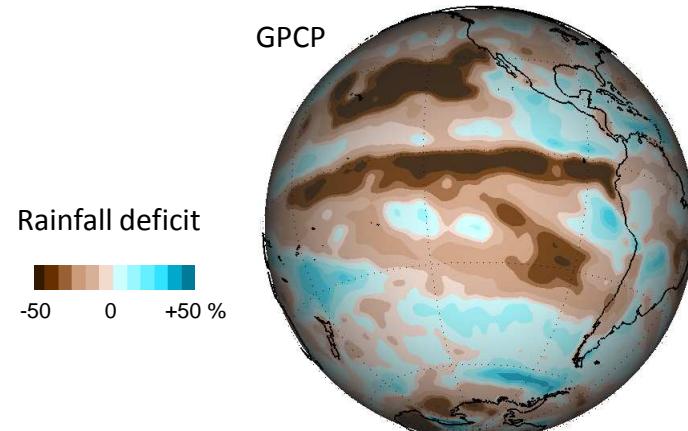
Ensemble AMIP simulations

- 10-30 “runs” of several decades long with slightly different initial conditions
- Ensemble mean reveals the SST forced response
- Ensemble spread reveals impact of internal variability (weather)

SST forcing includes natural variability (e.g., ENSO) but also anthropogenic impact
Ensemble mean with past radiative forcing excludes direct anthropogenic impact

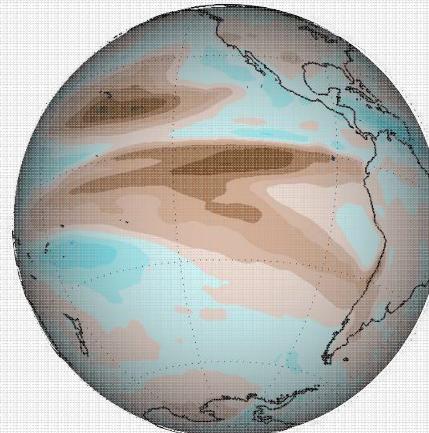
May-September, 2010-2014

Observations

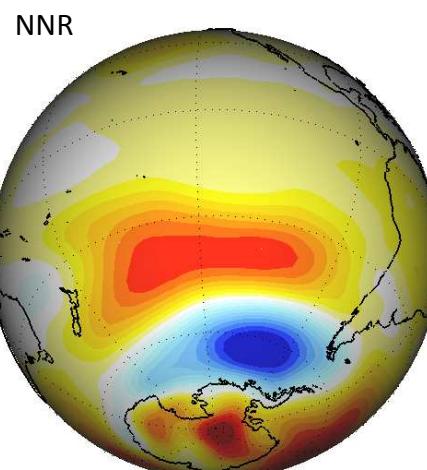
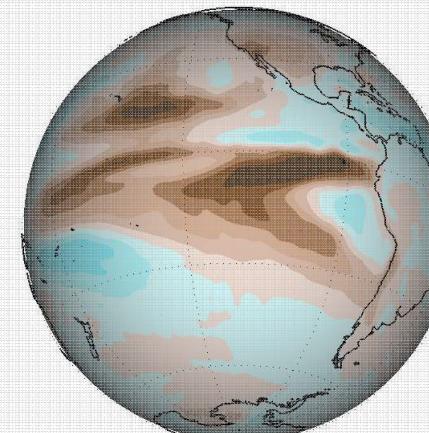


AMIP (Obs .SST, Obs. Rad.Forc.)

CAM4 (20)



ECHAM5 (30)



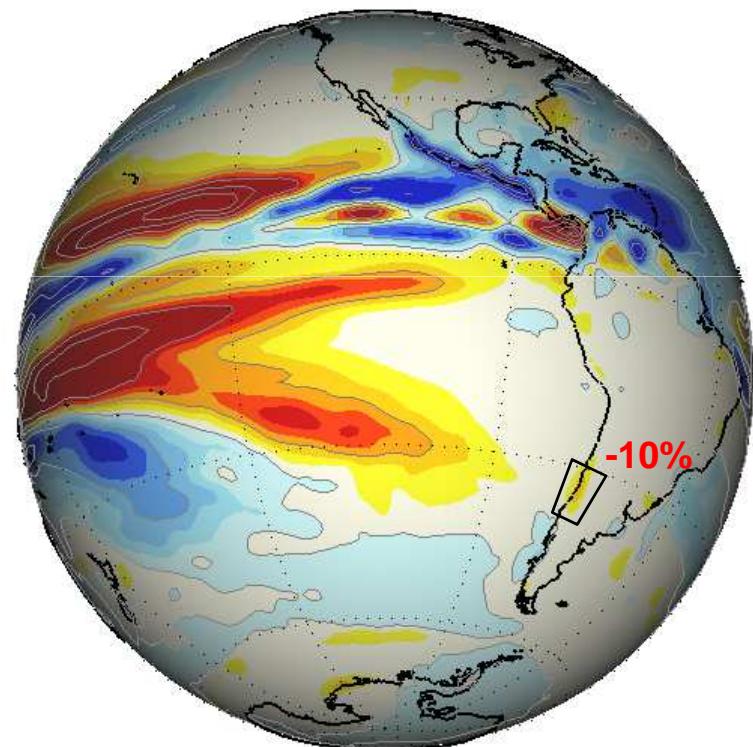
Z500 anomaly



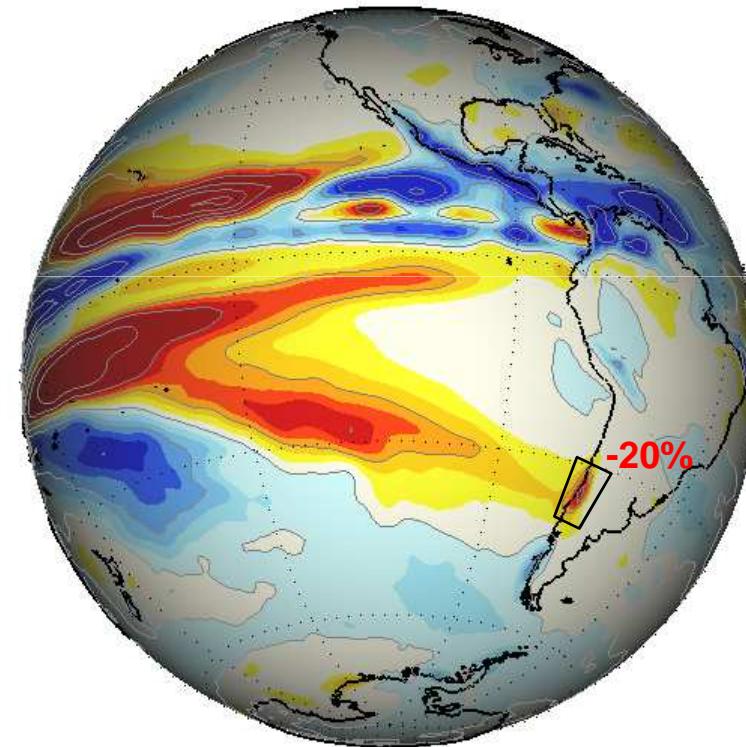
SST variability + Obs. Rad. Forcing during 2010-2014 accounts about half of the observed Z and P anomalies. Remaining anomaly can due to “bad luck”

Winter (MJJAS) rainfall anomaly 2010-2014 LBNL CAM 5.1 AMIP simulations (50 runs)

(a) Nat-Hist forcing / Obs SST

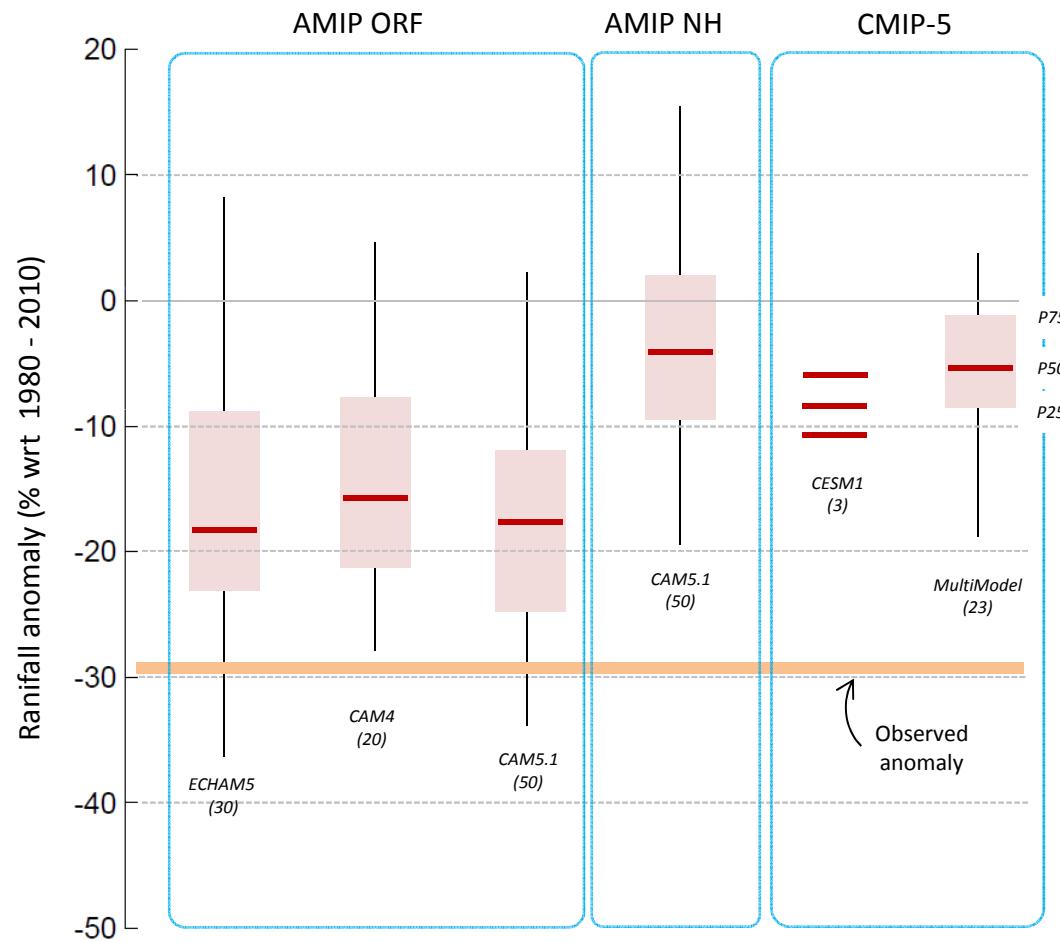


(b) Obs. Rad. Forcing / Obs. SST

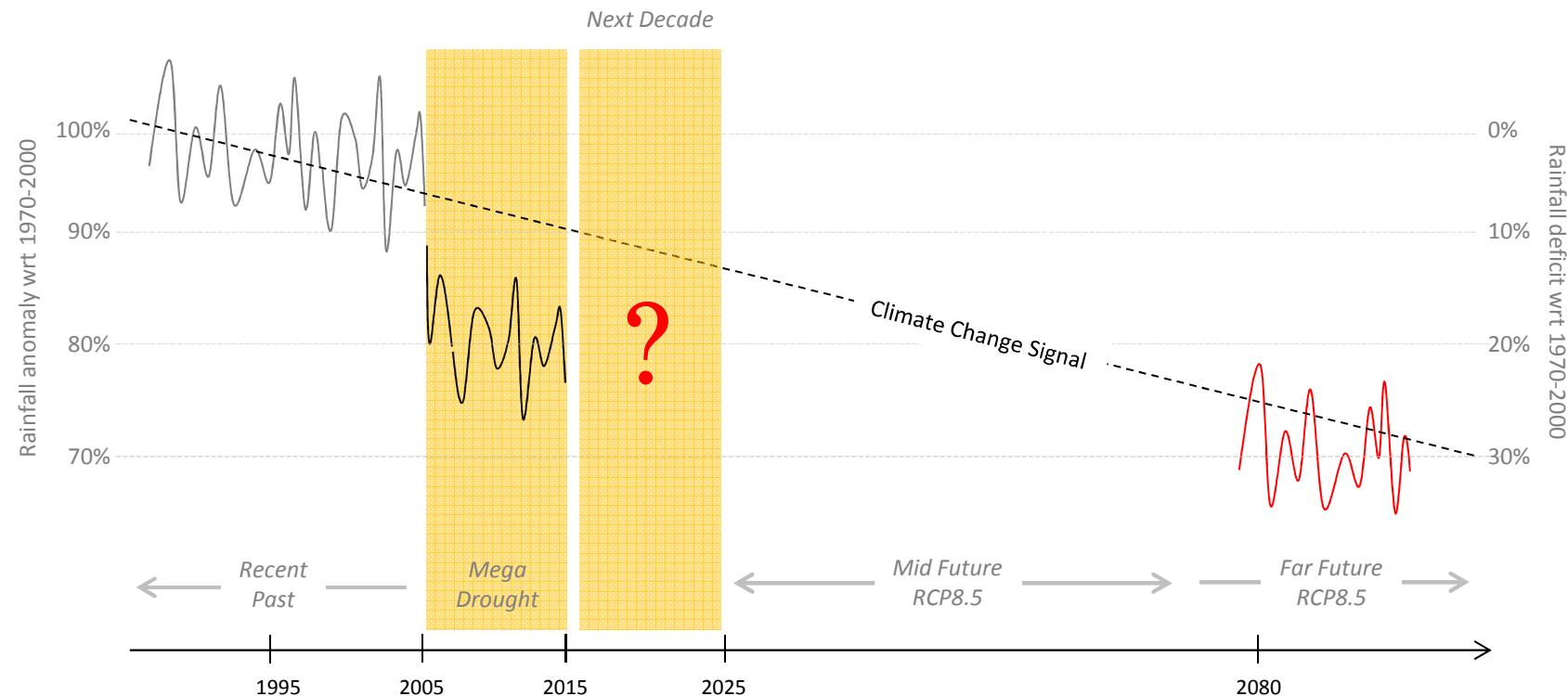


-300 0 300 mm/year

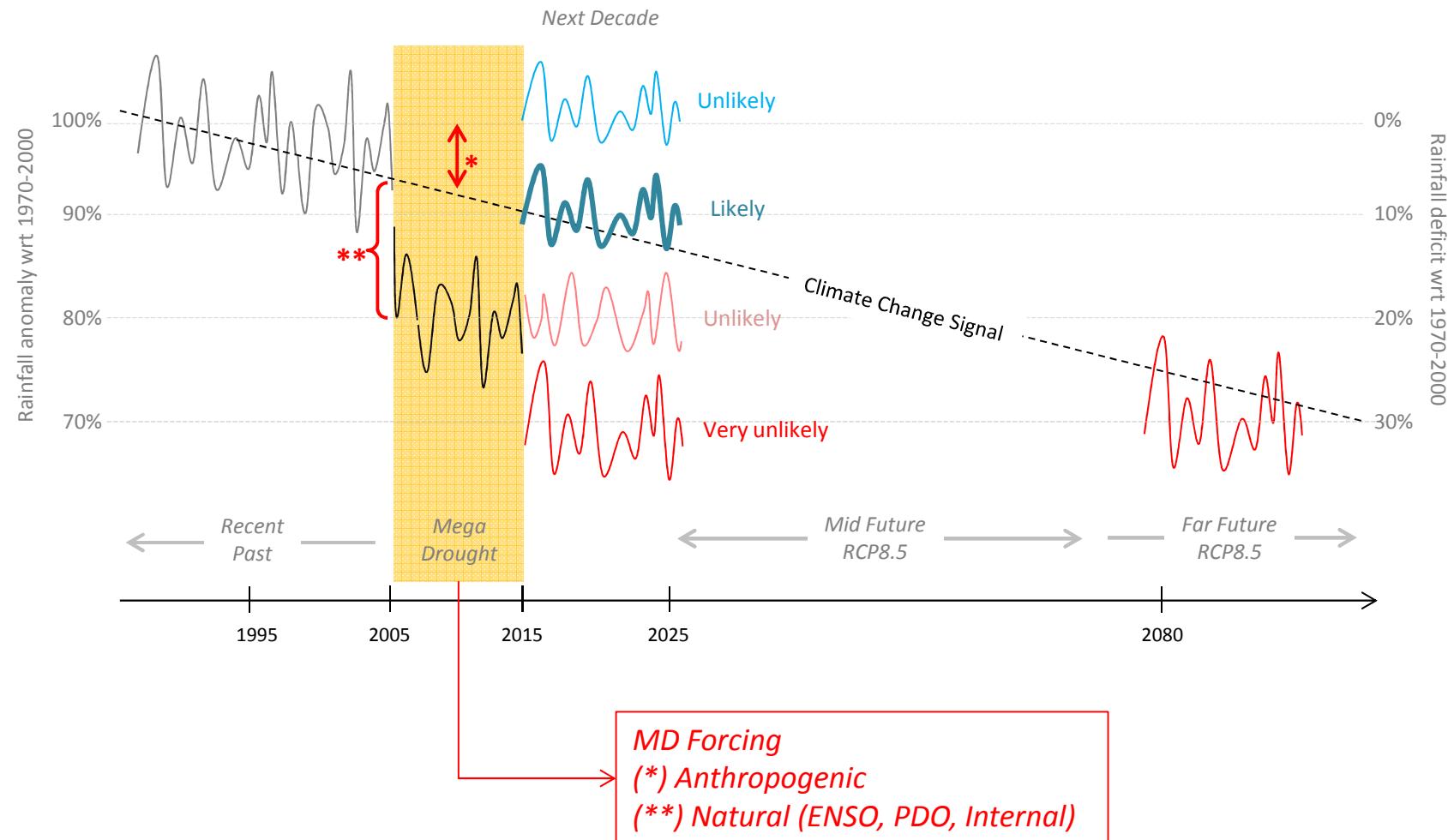
Central Chile (33-36°S) winter (MJJAS) rainfall anomalies during mega drought (2010-2014)



The Next Decade Challenge



The Next Decade Challenge



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 SST state (cold-phase of PDO).
- 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.