

Contribution of temperature to Chilean droughts using ensemble climate projections

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Motivation

- The **year 2016** was the **hottest on record** (since 1880) (NASA, 2017; NOAA 2017).
- During the 21st century, the **annual global temperature record** has been **broken five times** (2005, 2010, 2014, 2015, and 2016) (NASA 2017).
- One of the major consequences of global warming is the **increase in extreme events**
Mishra y Singh, 2010.
- In addition to precipitation deficits, extremely warm and dry conditions might **worsen drought impacts** over vulnerable areas (Diffenbaugh et al., 2015).
- Notwithstanding the total actual renewable water resources of Chile are $57\,640\text{ m}^3/\text{year}$ per capita (FAO, 2005), since 2010 it has been affected by a long-lasting and severe **Megadrought** (Garreaud et al., 2017) → important **societal consequences** on water supply, agriculture and livestock.



Objectives

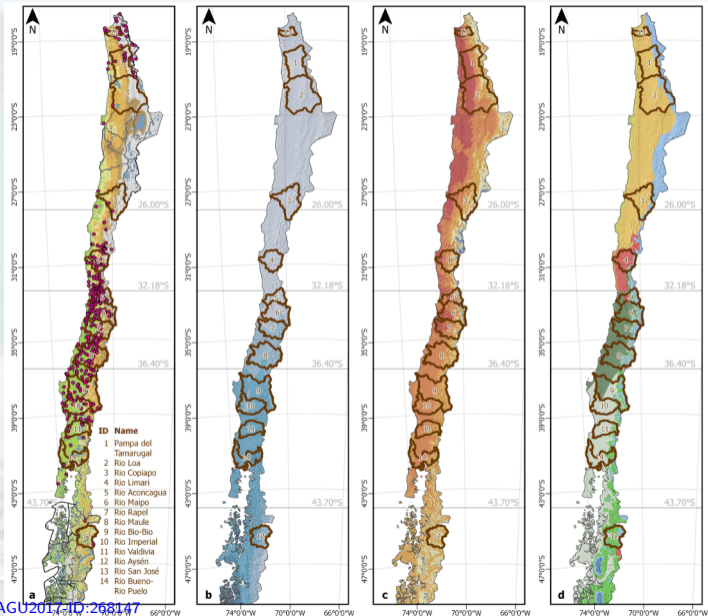
General

To analyze different **climate scenarios** for the XXI century in order to identify if the recent **Chilean Megadrought** (2010-2016) has been an **exceptional event** or it is just a **sample** of more severe events coming up in the near and long-term future.

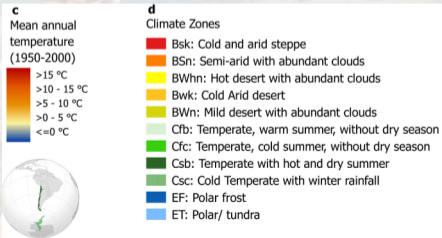
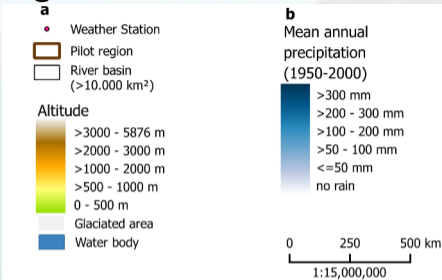
Specific

- To analyze **drought characteristics** (i.e., duration, severity and maximum intensity) during a historical and 3 future **climate scenarios**.
- To assess the impacts of expected **changes in temperature** on **drought characteristics**.





Legend

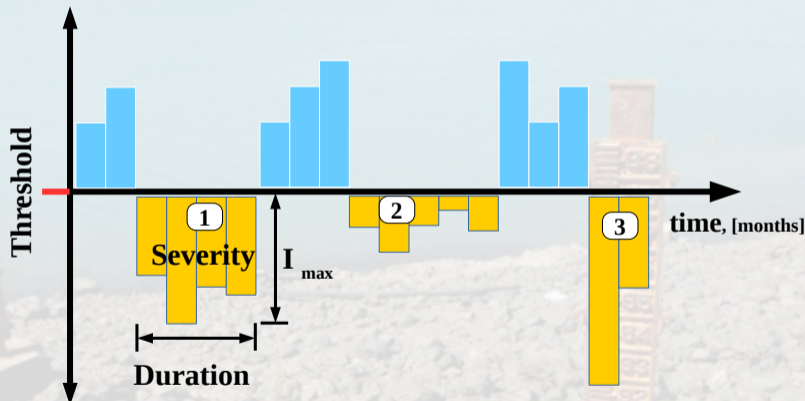


Drought identification

- The **Standardized Precipitation Index (SPI)**, McKee et al. 1993) is used to describe the impact of precipitation deficit on drought conditions.
- The **Standardized Precipitation Evapotranspiration Index (SPEI)**, Vicente-Serrano et al. 2010; Beguería et al. 2014) is used to assess the joint effect of temperature (throughout PET) and precipitation on drought characteristics.
- **12-month time scale:** SPI-12 and SPEI-12 should tend toward zero unless a clear trend is undergoing (DNR, 2016) → **suitable for hydrological drought analyses and applications** (WMO, 2012).
- A **threshold of -0.84** (Agnew, 2000) is used to **identify drought events** for both SPI-12 and SPEI-12 indices, based on the *theory of runs* (Yevjevich, 1967).



Drought characteristics



- 1: Drought event with the highest severity.
- 2: Drought event with the longest duration.
- 3: Drought event with the highest maximum intensity.

Climate scenarios

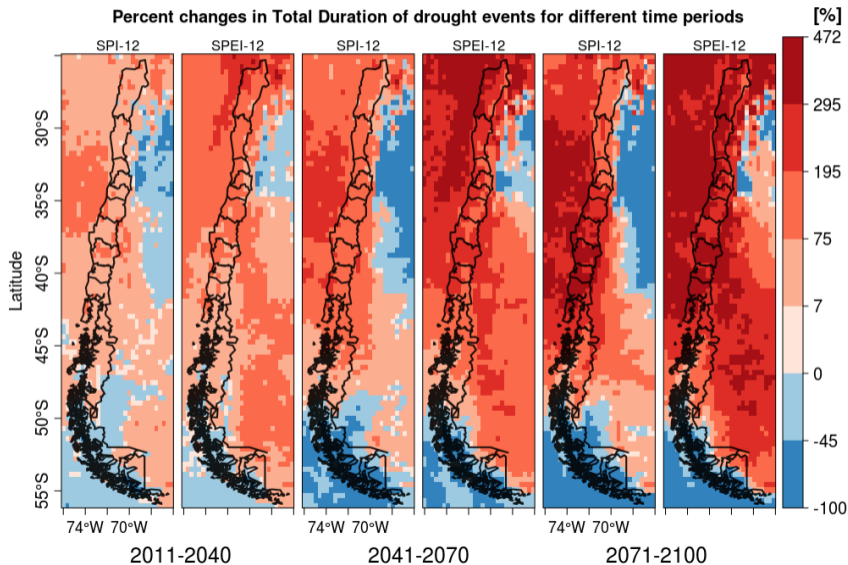
- An ensemble of **7 CMIP5 simulations** forced the Earth System Model **EC-EARTH3-HR v3.1** (Hazeleger et al., 2012) at 0.35° .

Driving GCM	Ensemble member	Data availability
IPSL-CM5A-LR	r1i1p1	1971-2120
GFDL-ESM2M	r1i1p1	1971-2100
HadGEM2-ES	r1i1p1	1971-2125
EC-EARTH	r12i1p1	1971-2100
GISS-E2-H	r1i1p1	1971-2130
IPSL-CM5A-MR	r1i1p1	1971-2100
HadCM3LC	r1i1p1	1971-2100

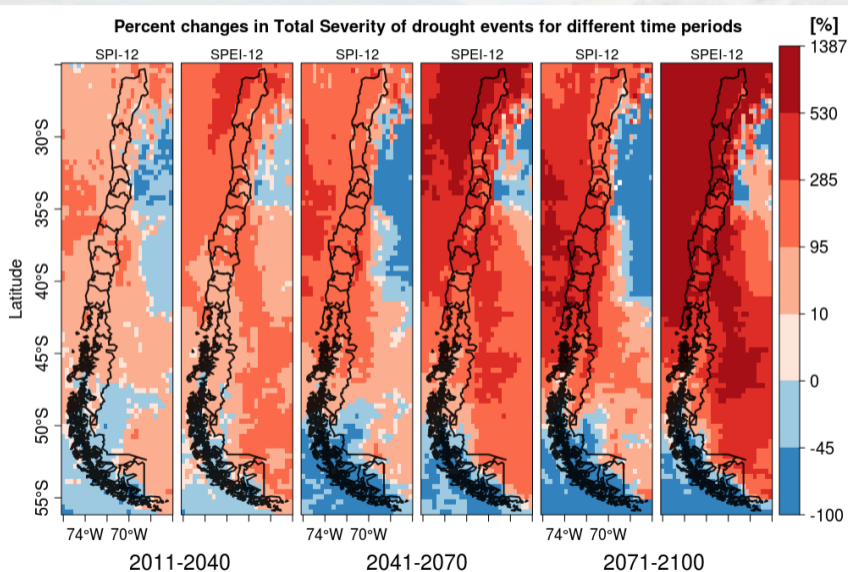
- Temporal periods:** baseline (1976-2005), short (2011-2040), medium (2041-2070), and long term (2071-2100).
- SPI-12 and SPEI-12 were **always computed using the baseline period** (1976-2005) to fit the parameters of the Gamma and log-logistic distributions, respectively.



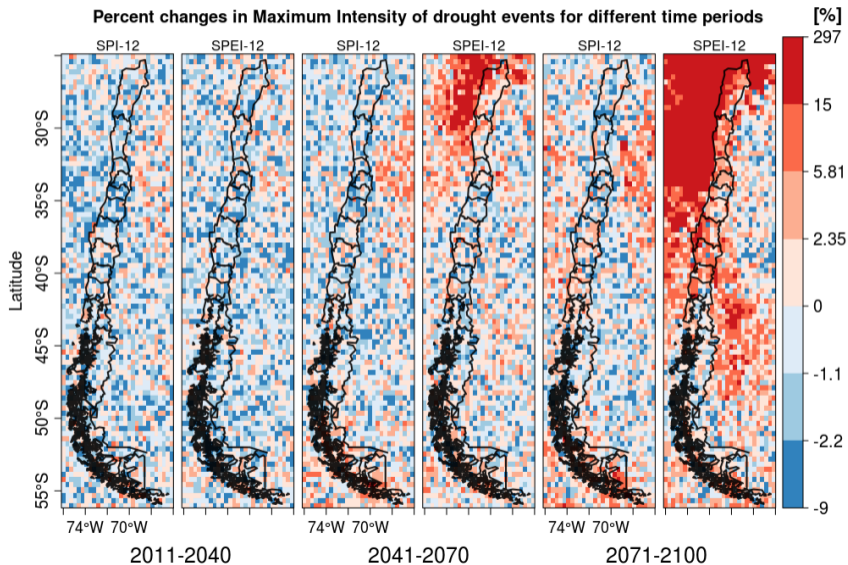
Preliminary results (Total Duration)



Preliminary results (Total Severity)



Preliminary results (Maximum Intensity)



Conclusions

- ① Two drought indices (**SPI-12** and **SPEI-12**) were used to analyze changes in **drought characteristics** based on **seven climate projections** for the **RCP 8.5** scenario at Chilean scale and 0.35° resolution.
- ② Results obtained with **SPI-12** revealed a general **decrease in precipitation** during the XXI century, consistent through all climate models (but different spatial patterns).
- ③ Results obtained with **SPI-12** revealed an important **increase in the duration and severity of drought events** during the XXI century, while changes in maximum intensity do not present a clear spatial pattern.
- ④ Simulations based on **SPEI-12** show that the expected increase in evaporative demand is likely to **exacerbate the severity and duration** of drought events during the XXI century.
- ⑤ Preliminary results of this work should support the **timely preparation** of drought **adaptation** and **mitigation plans** in Central-Southern Chile.



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