Climate Change Impact on Groundwater Resources in Northern Chile

25-29th September 2016
43rd IAH congress
Montpellier, France
CORUM CONFERENCE CENTER

*Claudio Moya[1,2,3], Jazna Rodríguez[1,2], Francisco García[1,2], Benoit Viguier[4], Damián Cordoba[5], Elisabeth Lictevout[6], Eric Sproles[7], Christian Carrasco[7], Cristóbal Juliá[7]

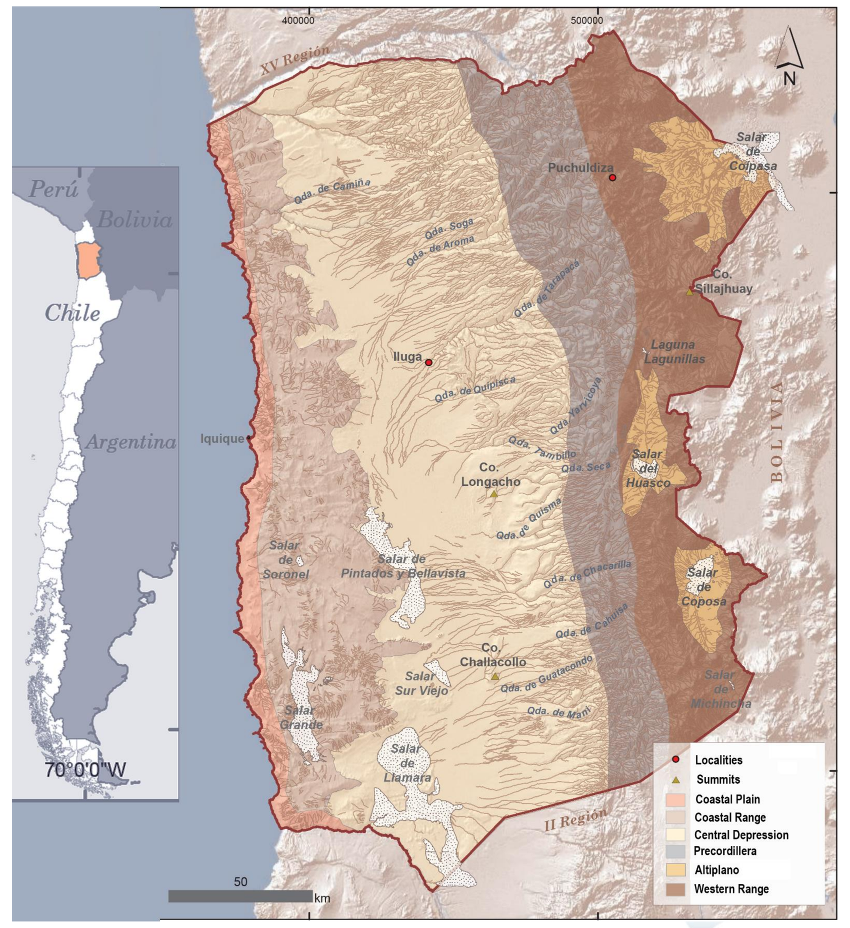
[1] Centro de Investigación y Desarrollo en Recursos Hídricos (CIDERH), Iquique, Chile; [2] Universidad Arturo Prat, Iquique, Chile; [3] Golder Associates S.A., Santiago, Chile, [4] HydroSciences Montpellier, Université de Montpellier, France; [5] Sociedad Química y Minera de Chile (SQM), Santiago, Chile;[6] Facultad de Ciencias Forestales, Universidad de Concepción, Concepción, Chile; [7] Centro de Estudio Avanzados en Zonas Aridas (CEAZA), La Serena, Chile

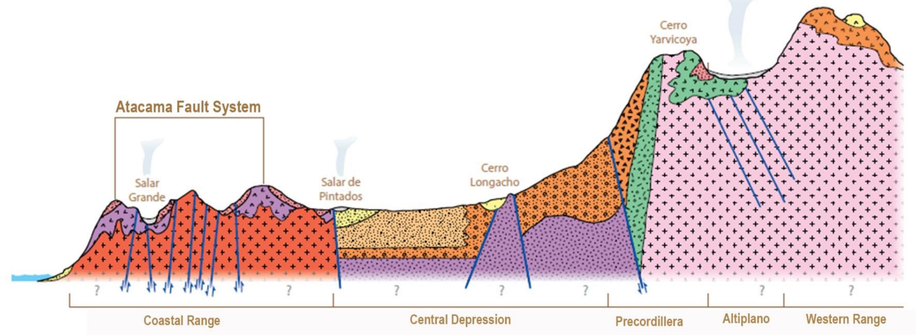
Abstract n°2261

***Corresponding author:** claudio.ms@gmail.com

1) INTRODUCTION & STUDY AREA

Northern Chile is characterized by desert-like climate. Five regions are recognized based on their geomorphological features which are grouped into four areas (Figure below), these are the Coastal Plain and Range (Zone I), the Central Depression (Zone II), the Precordillera (Zone III) and The Western Range (Zone 4; including the Altiplano). Streams are very restricted in the Tarapacá region, distributed mostly in the Altiplano and Precordillera where they flow downward through narrow ravines ("quebradas") until infiltrating when reaching the Central Depression, which concentrates the largest groundwater resources. The study aims to understand how climate change affects water resources by calculating Extreme Climate Indices (ECI).





2) METHODOLOGY

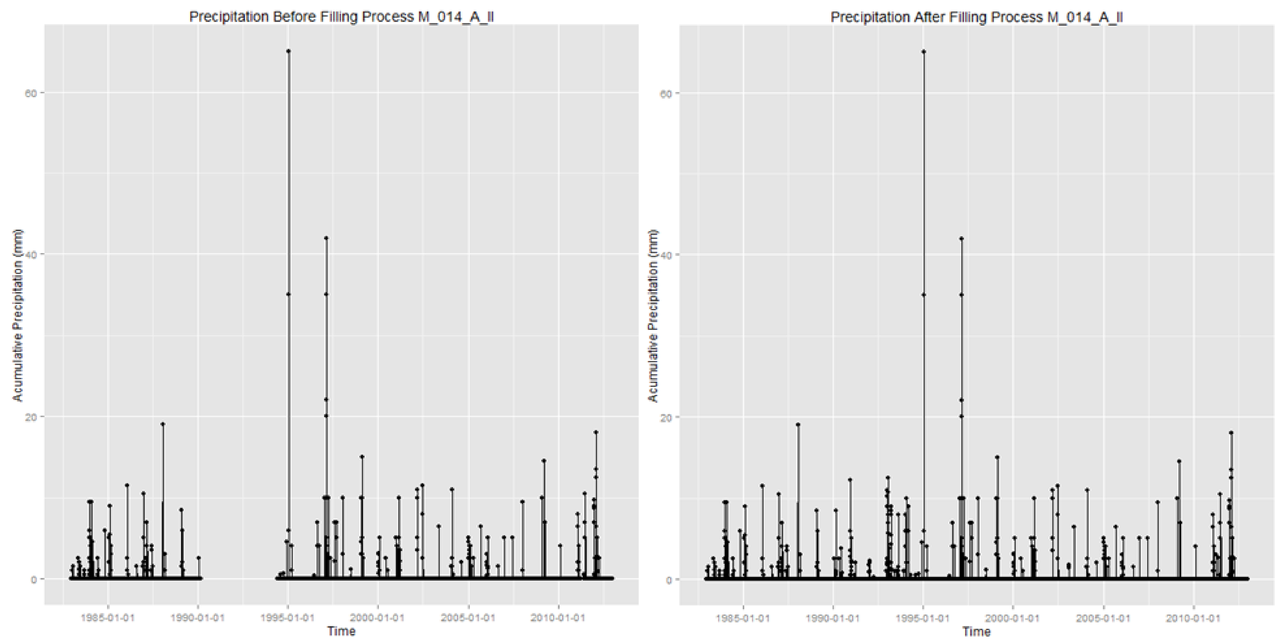
The methodology encompasses the use of precipitation and temperature data from 75 meteorological stations from the XV, I and II regions in Northern Chile, as some neighboring stations in Bolivia and Northern Argentina in the monitored period 1983 to 2012 for the ECI calculation. All the data processing and analysis, as well as, the ECI calculation, was performed through semi-automatic processes designed in the Knime platform and integrated with R software, allowing the use of the RClimdex script.

The data collection process included the identification of 638 meteorological stations in the area being studied. All these stations were included in the data preparation and exploratory analysis carried out in Knime and R packages. This stage considers cleaning and transforming the data in order to standardize the structure from different data sources, along with the temporal series filling to solve the missing data problem, and the exploratory analysis to identify the data quality in each station, permitting to identify the best stations to be used in the ECI calculation process. In our case, only 75 meteorological stations (out of 638) were considered of enough quality.

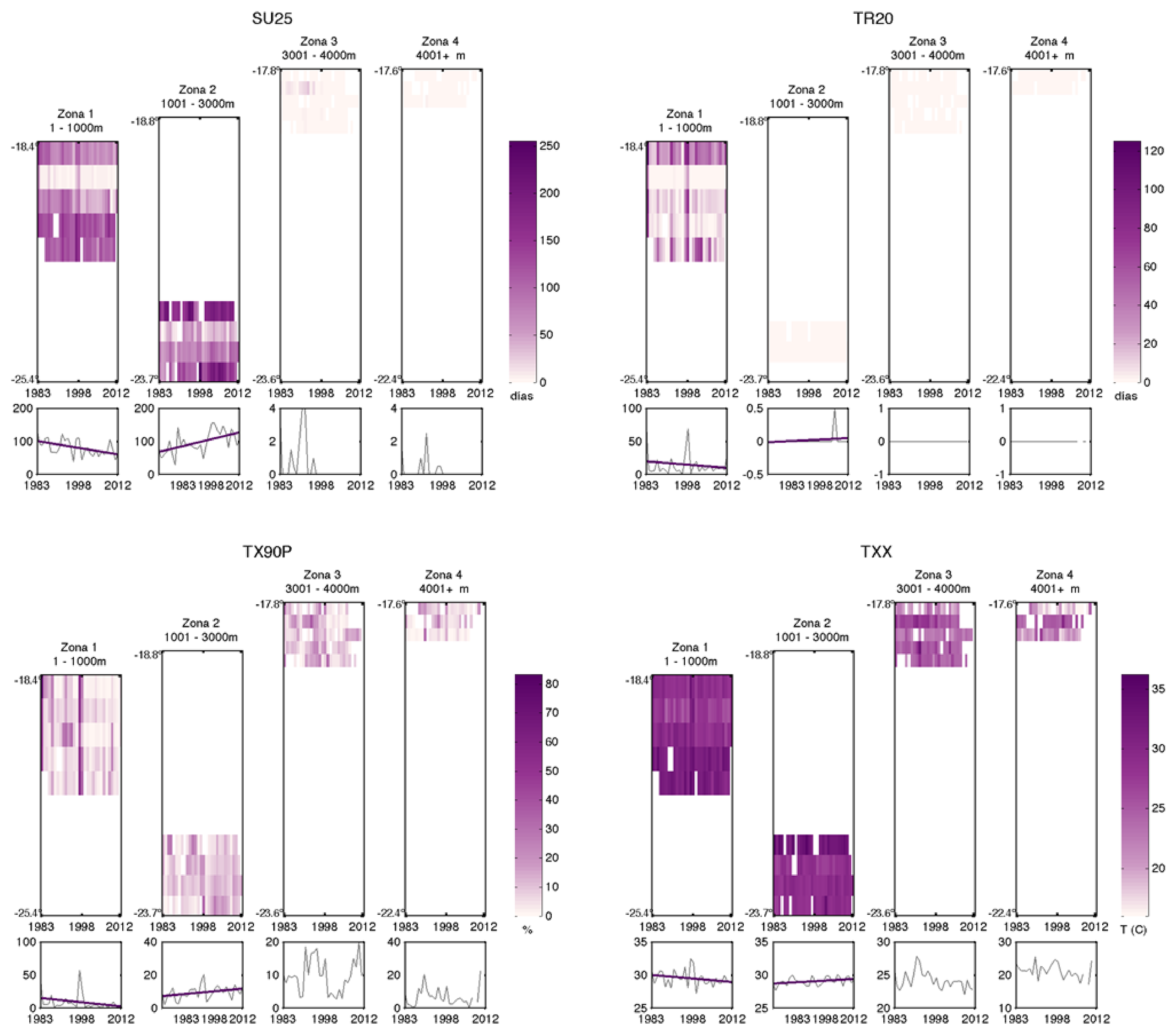
The exploratory analysis was applied twice in the study. Firstly, it was applied after cleaning and transforming the data, and before the temporal series filling process aiming to identify the meteorological station quality. Secondly, it was applied after the temporal series filling process in order to know whether the original data was altered by the filling process. In our study, the last analysis demonstrated that the filling process allowed to increase the data quantity in the case of stations with missing data but without affecting the data homogeneity and distribution.

The method utilized in the temporal series filling process was the Weighted Linear Combination (WLC), which implies the correlation coefficient calculation and analyzing the geographic location (in the ArcGIS platform) among stations before applying the WLC in order to identify well correlated stations (rho >= 0.8). The Spearman correlation coefficient was selected because our data do not follow a normal distribution (in the first exploratory analysis). This method helps to increase the data quantity in stations with missing data in one or more variables during certain period of time. The below figure shows on meteorological station before and after the data filling process.

Finally, after all this processing, the selected meteorological stations in the study used for ECI calculation are homogeneous and present a quality index above 80% for precipitation data and above 70% for temperature data.



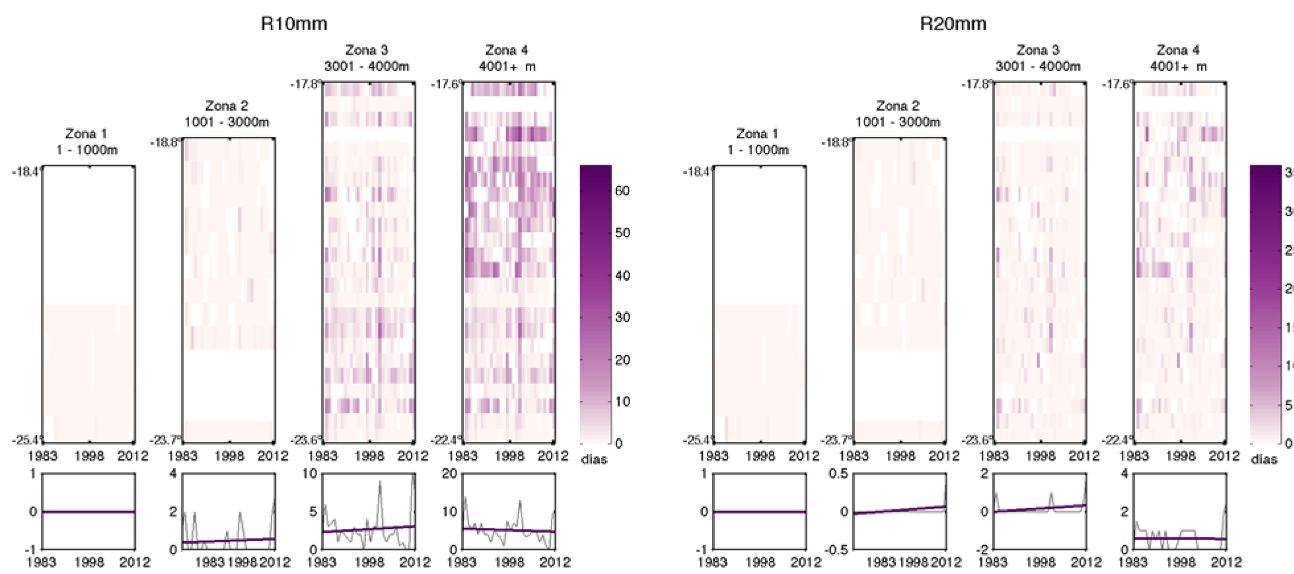
3) ECI VARIABILITY BY AREA



Zone 2) Central Depression

Several temperature related ECI show important trends in this area. For instance, maximum daily temperature (TXx) tends to increase whereas the minimum decreases producing an augmentation in temperature daily oscillation. Number of summer days (SU25; days when temperature rises above 25° C), number of tropical nights (TR20; days when night temperature rises above 20° C) and hot days frequency (Tx90P) also show an increasing trend in the monitored period.

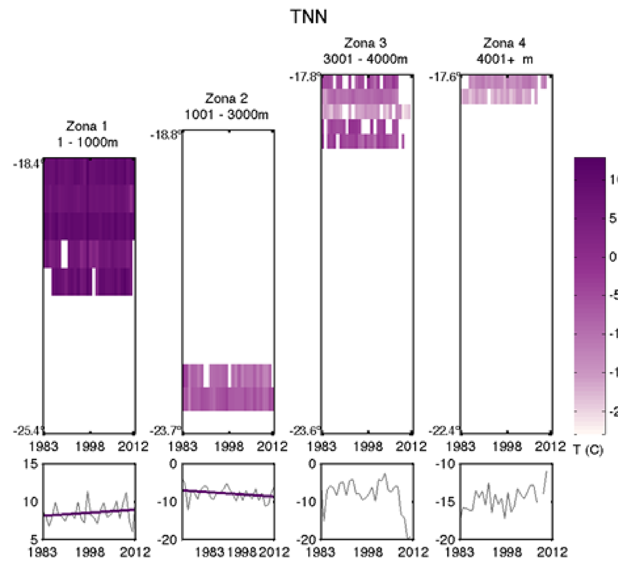
Evaporation is already very high in the Central Depression and this temperature rise evidenced by the ECI may trigger an increased rate in evaporated water during aquifer recharge. Likewise this may also produce an increased rate in Prosopis Tamarugo (broadly present) transpiration causing higher aquifer discharge. Consequently the water budget in Central Depression aquifers may be reduced.



Zone 3) Precordillera

Either the amount of days with precipitation above 10 mm (R10mm) and 20 mm (R20mm) register a positive trend, indicating a larger amount of these type of days compared to previous times. Owe to the low annual precipitation registered in Northern Chile and the steep geomorphology in the Precordillera flush-flooding occurrence may be registered more frequently.

Although flush-flooding pose a risk to the communities living in the Precordillera "quebradas" they also may contribute to aquifer recharge, specially when flooded waters reach the Central Depression.



Zone 1) Coastal Plain and Range

As observed in the temperature related ECI, daily oscillation temperature is reducing in this area evidenced by a decrease in daily maximum (TXx) and an increase in minimum temperature (TNn). Because of this an increase of stratocumulus clouds which is related with fog availability.

Currently, fog is not considered as an usable water source in the Tarapacá region but in other areas of Chile is, using fog catchers. As no major aquifers are recognized in zone I it could be reasonable to think whether fog availability is increasing as an useful resource, specially for local coastal communities with limited access to water supply.

4) CONCLUSIONS

Although there are 27 extreme climate indexes (all of them were assessed), only a few of them showed clear trends in the monitored period but evidencing important effects on water resources, especially in the most important aquifers in the Tarapacá region of Northern Chile. Although the study focuses in the Tarapacá region only, it may be correlated to all Northern Chile as the geomorphological features, and the precipitation and temperatures regime are similar.