

(CR)<sup>2</sup>

Center for Climate  
and Resilience Research  
[www.CR2.cl](http://www.CR2.cl)

---

# 2013 - 2017 REPORT

---



UNIVERSIDAD  
DE CHILE

SPONSORING  
INSTITUTION



UNIVERSIDAD  
DE CONCEPCION

ASSOCIATED INSTITUTIONS



UNIVERSIDAD  
AUSTRAL DE CHILE



CONICYT

FUNDING  
AGENCY



---

# Content

---

<b>Editorial</b> .....	3
<b>What is (CR)2?</b> .....	5
Origins.....	8
<b>Structure</b> .....	9
Organizational Structure.....	12
Researchers .....	13
Publication .....	15
<b>Lines of Research</b> .....	19
Biogeochemistry .....	21
Climate Dynamics .....	22
Ecosystem Services.....	23
Human Dimension .....	24
Modelling and Observing Systems .....	25
<b>Infrastructure</b> .....	27
Instruments .....	29
Observation Platform of the Coupled Ocean-Atmosphere System (Posar) .....	30
Climate Explorer .....	31
Databases .....	32
Computing Resources .....	32
<b>Collaboration Networks</b> .....	33
<b>Research Achievements</b> .....	39
Report to the Nation: The 2010-2015 Mega-drought: A Lesson for the Future.....	41
Proposal for a Legal and Institutional Framework to Address Climate Change in Chile.....	42
Manifestations of the Anthropocene in Chile .....	44
<b>Communications and Relations with the Social Environment</b> .....	45
Presence in the Media .....	47
Scientific Outreach.....	48
<b>(CR)2 Team, 2013-2017</b> .....	51

Editor: Nicole Tondreau  
Copy-editor: Miguelángel Sánchez  
Translator: Helen Conway  
Graphic designer: María Giselle Ogaz





## (CR)2 Director Laura Gallardo: Investigating Climate and Resilience in the Anthropocene

It has been almost four and a half years since the foundation of the Centre for Climate Research and Resilience, also known as (CR)2. In early 2012, a small group of women and men who shared a passion for understanding climate dynamics, but who worked at different locations and had different specialties and career paths, set about the task of convincing others about their competences and the idea of conducting interdisciplinary research on climate change and resilience in Chile. That original group has grown two or three-fold since then—depending on how you count—along with our conviction and desire to do more. Together, we have been creating an *ethos* of disciplinary, interdisciplinary and even transdisciplinary research to address the immense challenges of a changing climate and a social-ecological system that is, in many ways, vulnerable to these changes.

Over and above the Centre's quantifiable achievements in terms of publications, projects, data-collection, research teams, number of theses completed, etc., the journey to this point has doubtless been worthwhile. We have benefitted from the work and the knowledge of others, thereby enriching our own outlooks and perhaps laying the groundwork for a common perspective. At times, we have been overwhelmed by the pressing demand for answers to the many difficult questions that arise on how to face a mega-drought, or by the other challenges posed by an era we call the Anthropocene. Our students and younger colleagues have acted as Guinea pigs, venturing across the tenuous footbridges that link different fields of knowledge, and they've also shared their enthusiasm and their unlimited capacity to dream. More than once, they've forced us to change our paradigms—scientific or otherwise—which is probably a good thing, in these times of the Anthropocene.

We continue to face the challenge of managing people and resources under rules that are not always conducive to good science, but fortunately the spirit of service to our country has always prevailed. In these matters, our support team has played a crucial and enthusiastic role. The same can be said for our communicators who, apart from promoting media coverage of the Centre, have taught us to communicate our knowledge and our concerns more effectively. In short, all these generous people have made an invaluable contribution to the Centre.

An enormous asset of (CR)2 has been the uninterested contribution of outstanding scientists from the five continents who have shared with us their enormous experience and sapiency. In the same way, our national panel has been crucial contextualizing and making our science relevant. We have learned from them about the great challenges of decision making.

This report briefly describes some of the important milestones along the road travelled by (CR)2. We have tried to cover the Centre's achievements in science, outreach, training and impact, and hope it will also help us appraise these achievements and improve the improvable (of which there is plenty!). It lets us share the experience and look ahead.



# What is (CR)<sup>2</sup>?

---

*(CR)<sup>2</sup> is a centre of excellence whose objective is to improve the understanding of the Earth system in a changing climate and evaluate mitigation and adaptation measures in order to strengthen resilience in Chile.*

# What is (CR)2?

- Origins

---

*(CR)2 is a centre of excellence whose objective is to improve the understanding of the Earth system in a changing climate and evaluate mitigation and adaptation measures in order to strengthen resilience in Chile.*

## What is (CR)2?



The Centre for Climate Research and Resilience (CR)2 is a centre of excellence created in 2013 with funding from the Priority Areas Program (Fondap) of Chile's National Commission for Scientific and Technological Research (Conicyt). It is the point of contact and collaboration for researchers from Universidad de Chile (the sponsoring institution), Universidad de Concepción and Universidad Austral de Chile (partner institutions), along with others from Universidad Católica de Chile, Universidad de Valparaíso, Universidad Adolfo Ibáñez and Universidad Diego Portales. Affiliated researchers also contribute to other academic institutions.

(CR)2's leadership, administrative team, scientific computation and communications units work in the Geophysics Department of the Universidad de Chile's Faculty of Physical and Mathematical Sciences.



(CR)2 is a world-class interdisciplinary research centre focused on Earth-system science. Through close collaboration with all stakeholders, the Centre seeks to improve our understanding of the Earth system and help develop resilience in Chile.



Artistic rendering of simulated precipitation trends in Chile by artist Tully Satre completed at the request of (CR)2. Left to right: 1941-1980, 1981-2020, 2021-2060. The red areas represent drought and the blue areas represent increased precipitation. Data obtained from the CESM1 and CAM predictive models.



### Origins

Chile provides a unique setting for the study of the Earth-system because of the sharp biophysical gradients between the Andes and the Pacific Ocean, the diversity of climate regimes, the marked variability of climatic conditions, the country's rapid economic growth and urbanization, and the immense inequalities that characterize our human society.

These conditions called for the interdisciplinary approach adopted by (CR)2 researchers, who also count on the expertise and knowledge of the Chilean State and the private sector. As a result of this collaboration, significant advances have been made in defining strategies for adaptation, mitigation, development and resilience.

All of the research conducted by the Centre deals with three great problem areas related to climate change and variability in Chile, and the accompanying vulnerabilities. The problem areas are:

- » Scarcity and variability of water resources. This area requires better characterization of climate variability and the hydrological cycle in order to orient the formulation of strategies to meet our demand for water.
- » Rapid urbanization. This area requires integrated, trans-sectoral management aimed at maximizing our control over sources of pollution that affect air quality and the climate in general.
- » Rapid changes in land use. These changes have led to conflicts that require solutions based on new perspectives, such as ecological restoration aimed at recovering ecosystem services.

In order to address these problem areas, (CR)2 was organized, in a first stage, around five lines of research: biogeochemistry, climate dynamics, ecosystem services, the human dimension, and modelling and observation systems.



**Biogeochemistry**



**Climate dynamics**



**Ecosystem services**



**The human dimension**



**Modelling and observation systems.**

In a second stage, the Centre will be reorganized around important interdisciplinary questions concerning water shortage, changes in land use, coastal processes, urbanization, and a new area focused on the interface between science and decision making. The existing lines of research will be incorporated into these interdisciplinary models, which will be interconnected in territorial and methodological terms.



# Organizational Structure

*An important and distinctive characteristic of (CR)<sup>2</sup> is the equitable presence of women, who represent 48% of all our researchers and students.*



# Organizational Structure

- Organizational chart
- Researchers
- Scientific publications

---

*An important and distinctive characteristic of (CR)2 is the equitable presence of women, who represent 48% of all our researchers and students.*



## Organizational Structure

The organizational structure of (CR)<sup>2</sup> is determined by its research areas or lines, each of which is headed by a principal researcher. The Director, jointly with the Centre's Assistant Director and each area's principal researcher, are members of an academic governing body which is responsible for the Centre's strategic decisions. This governing body is also advised by a panel of scientific experts and networks of collaborators in Chile and abroad.

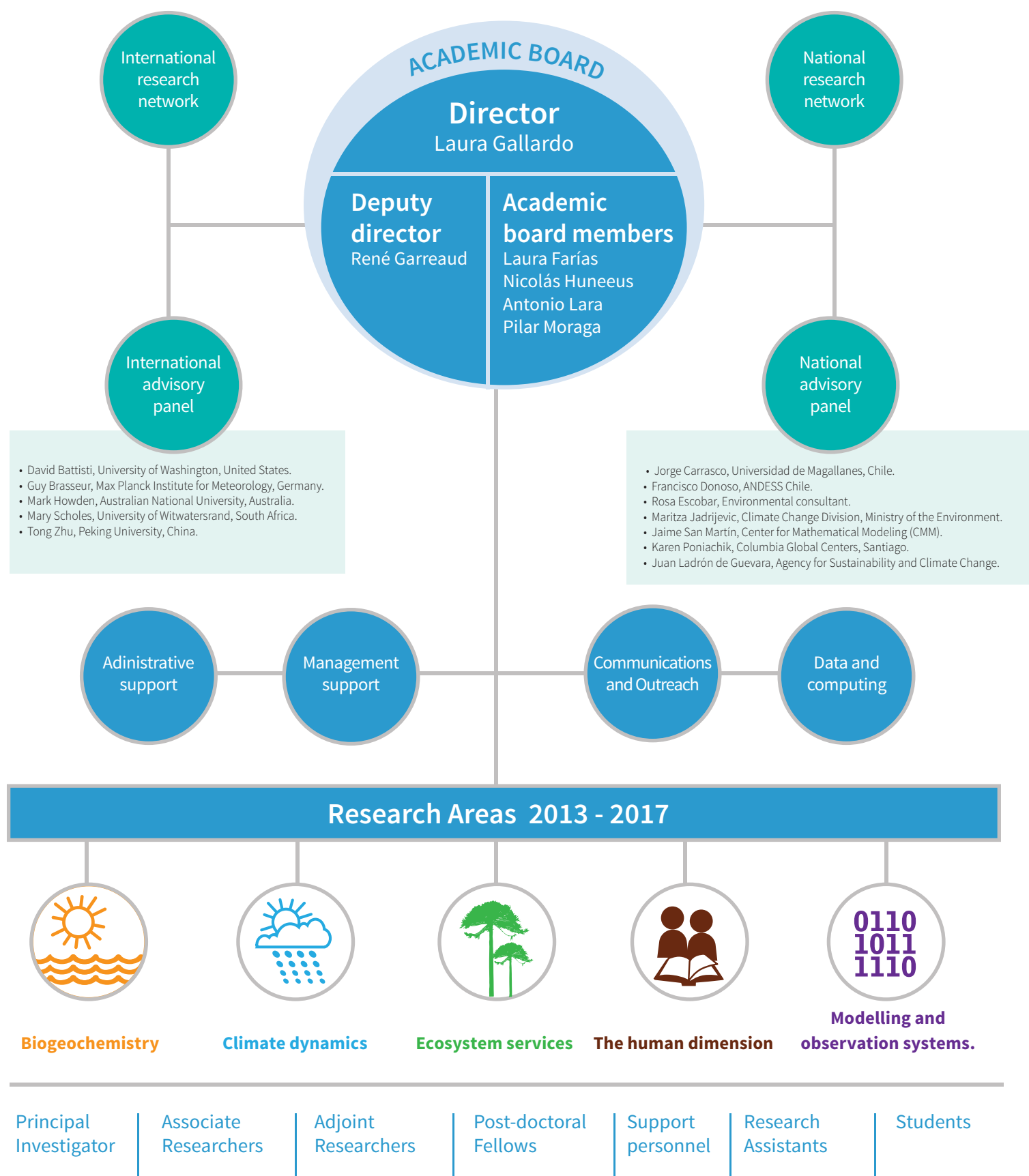


*From left to right: Antonio Lara, Laura Gallardo, Laura Fariás, Nicolás Huneeus, Pilar Moraga and René Garreaud.*



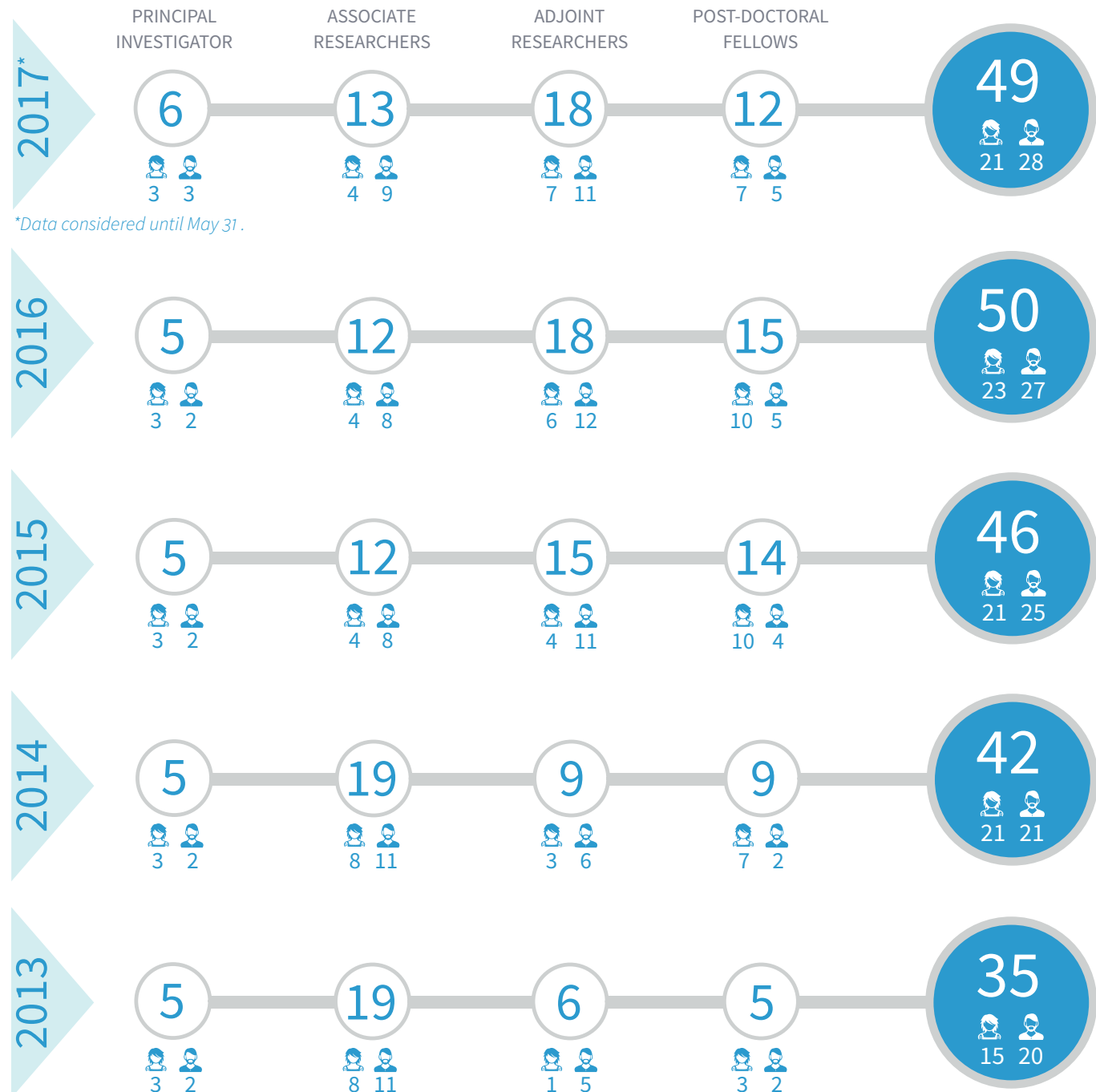
*Expanded meeting / Casablanca – 2016*

## Organizational Structure



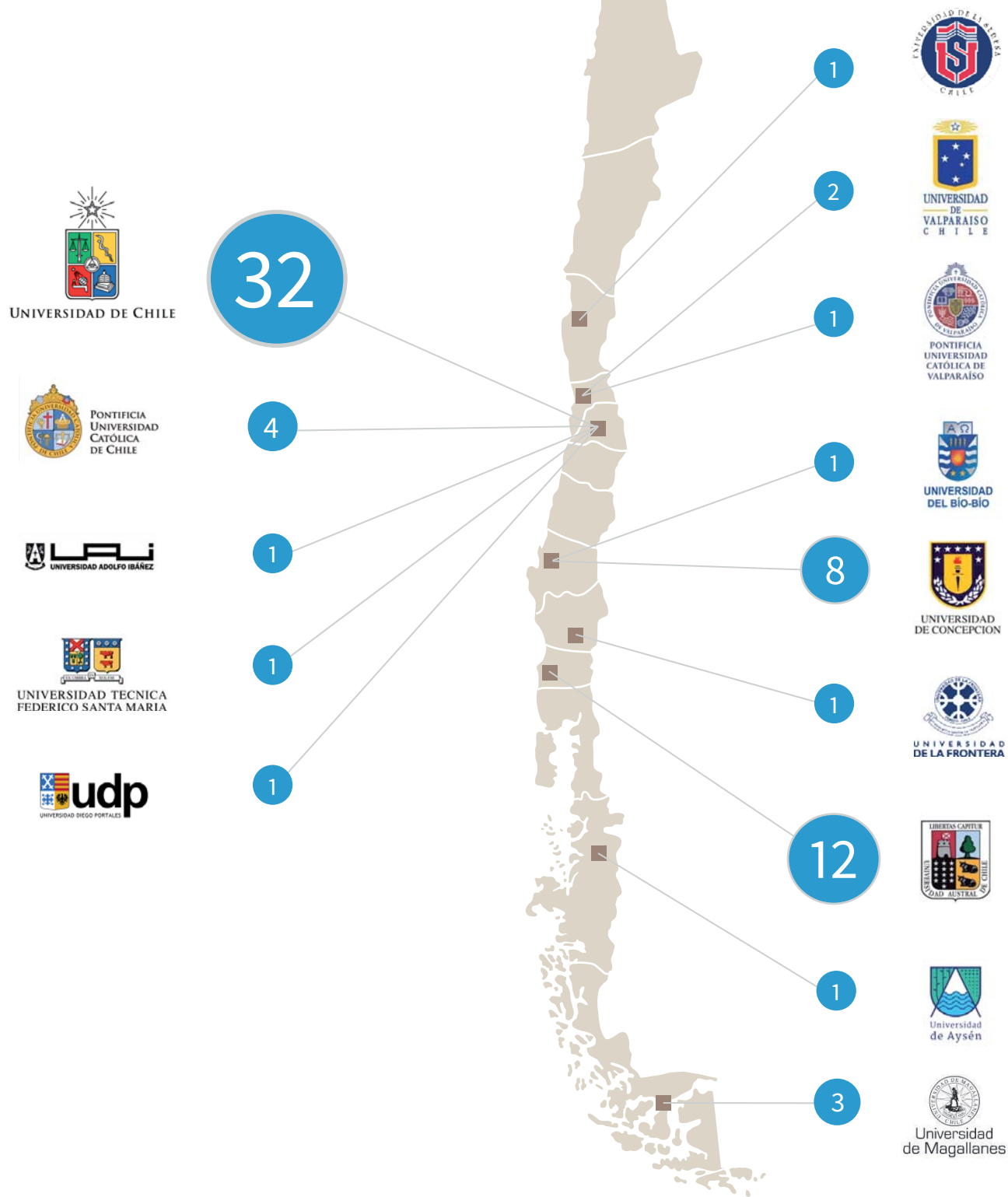
69 Chilean and foreign researchers have been part of the team at (CR)2. Twenty-two of them are postdoctoral researchers from Chile and various other countries. A significant number of students have also been trained at (CR)2 and have completed a total of 47 undergraduate theses, 76 Master's theses, and 26 PhD theses.

An important and distinctive feature of (CR)2 in comparison to other Chilean research centres, is the equal involvement of women: they make up 48% of all researchers. At the senior management level, the role of women is also significant.

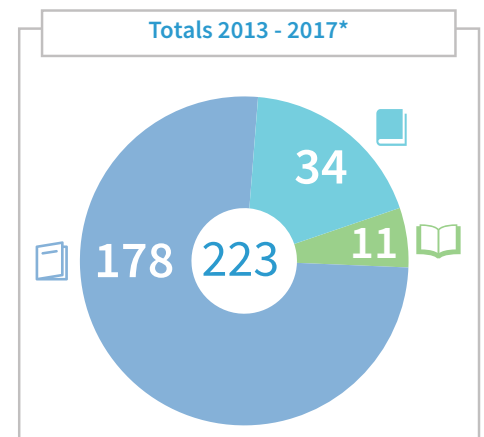
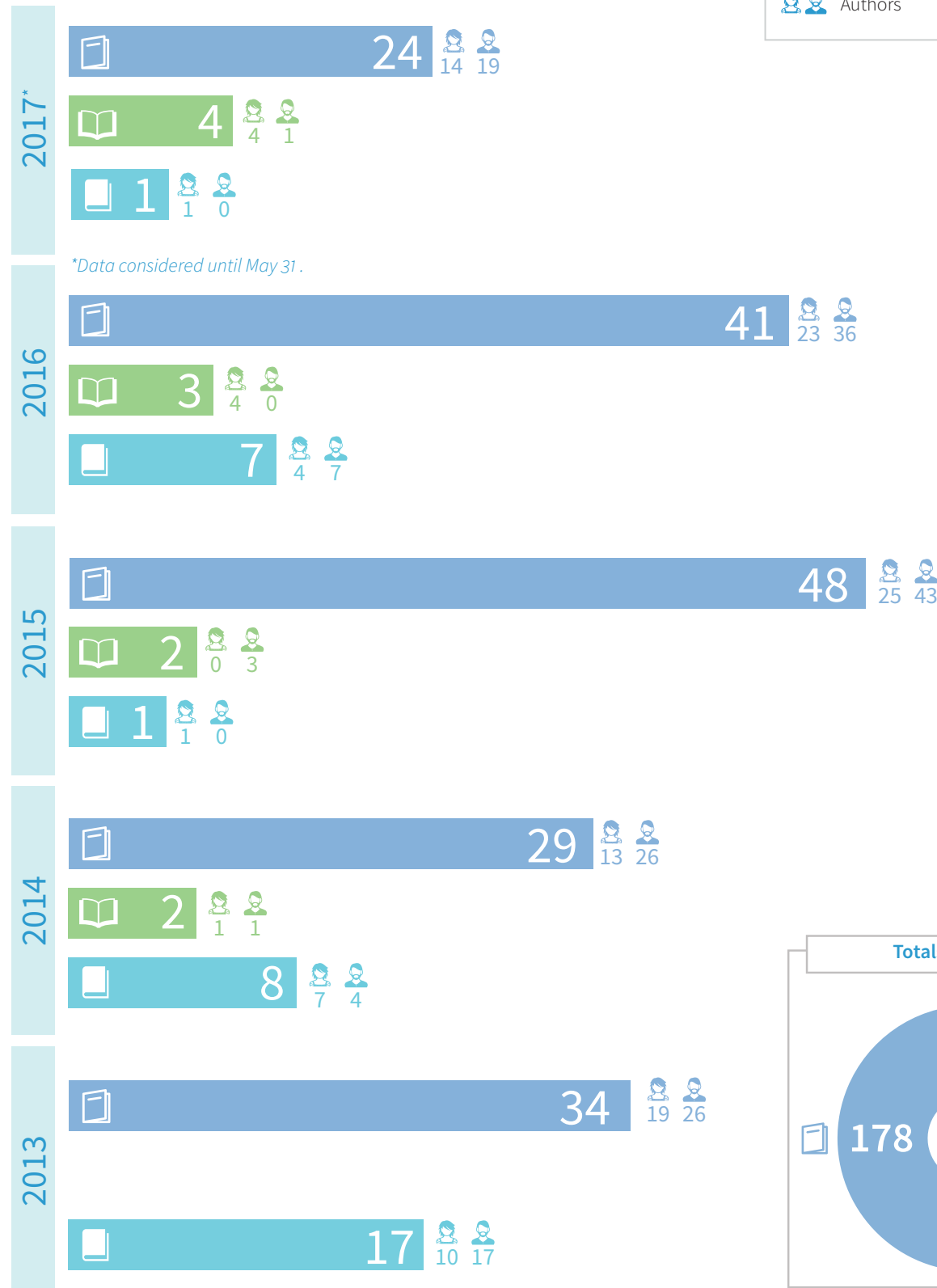
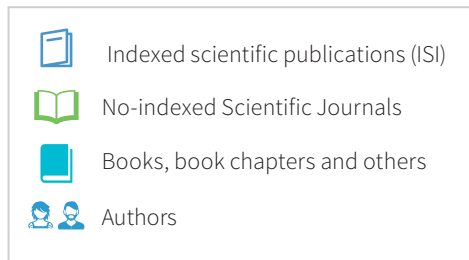


## Organizational Structure

This human team is distributed throughout the country, especially at (CR)2's three venues, which are located at Universidad de Chile in Santiago, Universidad de Concepción in Concepción and Universidad Austral de Chile in Valdivia.



The Centre's scientific production is vast and diverse, including the publication of articles and study results in indexed and non-indexed scientific journals (ISI), authorship of books and book chapters, the Centre's own publications, and numerous presentations in symposia and conferences.

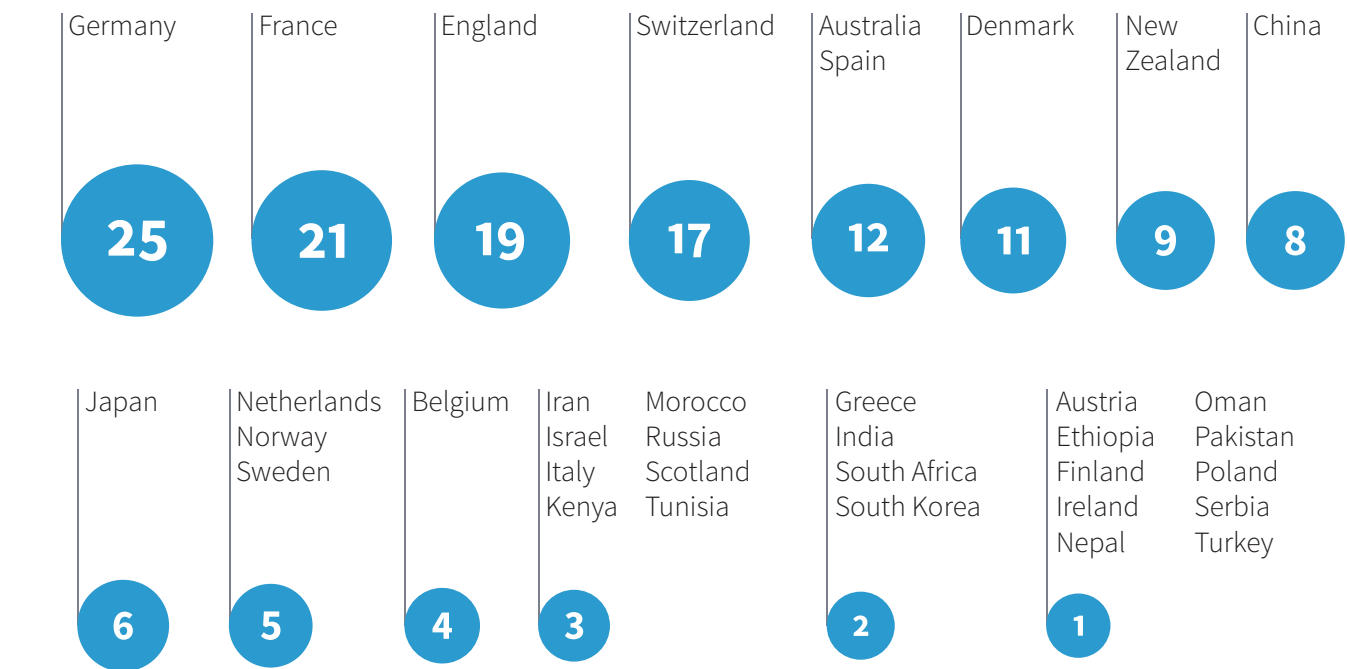
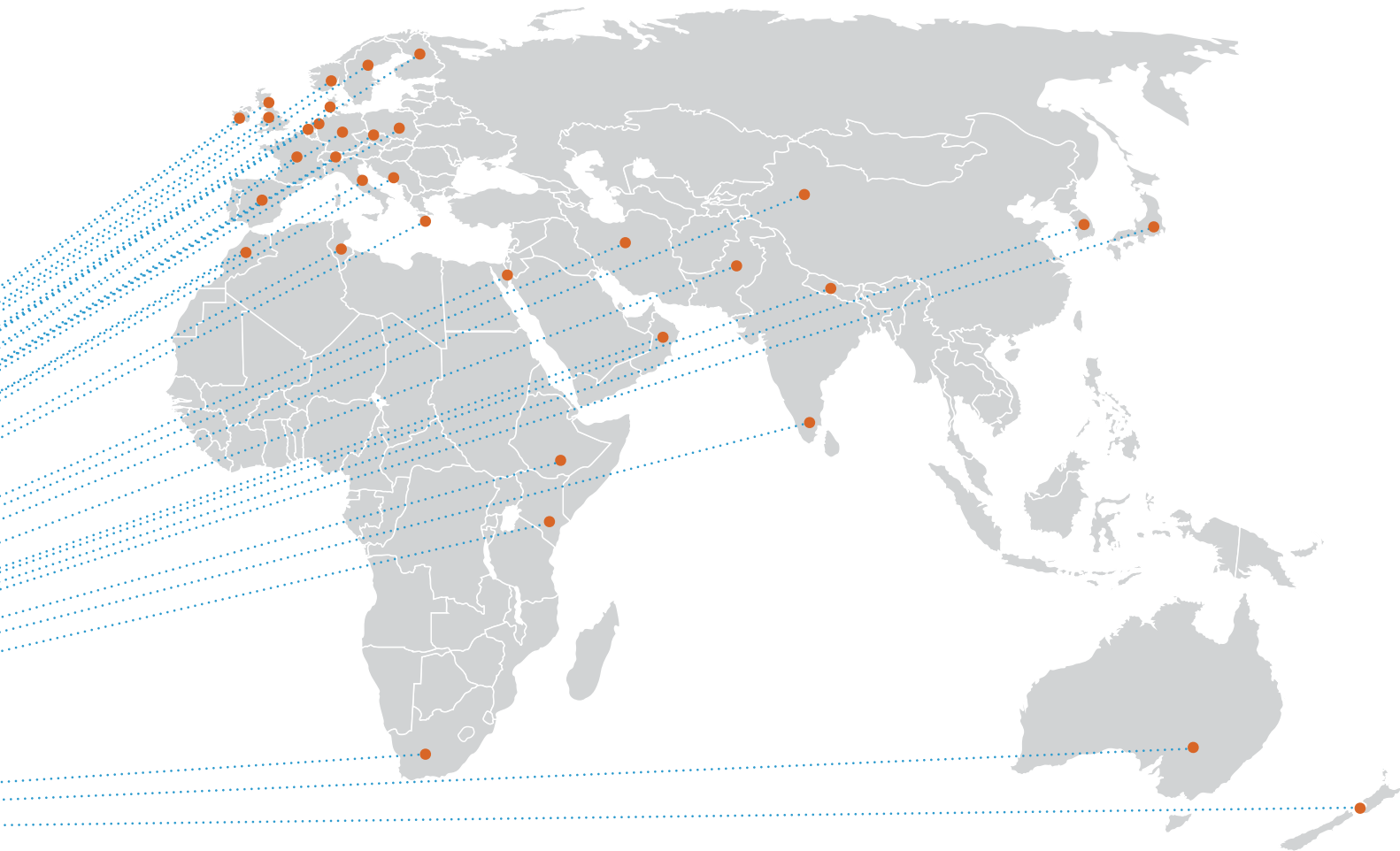




# Organizational Structure

Authors map showing the countries of publication for indexed scientific journal (ISI) publications in which (CR)2 researchers participated. Graphics represent number of collaborations per country.









Art installation by Nele Azevedo,  
Faculty of Law / Universidad de Chile - 2012.



# Lines of Research

*The lines of work coordinate the research performed by natural and social science professionals in order to address priority topics for Chile.*

# Lines of Research

- Biogeochemistry
- Climate Dynamics
- Ecosystem Services
- Human Dimension
- Modelling and Observing Systems

---

*The lines of work coordinate the research performed by natural and social science professionals in order to address priority topics for Chile.*





## Line of Research

# Biogeochemistry

Biogeochemistry research is conducted by a diverse group of oceanographers, geophysicists, biologists, ecologists, microbiologists and other specialists who study the movement and the transformations undergone by compounds and elements such as water, carbon, nutrients and greenhouse gases (carbon dioxide, methane and nitrous oxide), etc., through the Earth system.

### Emission and Recycling of Greenhouse Gases in the Chilean Ocean

After collecting and studying extensive data throughout the Chilean coastal system, the research team observed that the areas of coastal upwelling along northern and central Chile constitute significant sources of greenhouse gases that pass from the ocean to the atmosphere. The team also found that oxygen-poor sub-surface waters favour the accumulation and recycling of nitrous oxide and methane; on the other hand, the fjords and estuaries of central-southern Chile do not emit significant amounts of nitrous oxide, though they are responsible for considerable emissions of methane, which reaches the sea by way of continental run-off.

### New Biogeochemical Processes

The researchers have found evidence of new biogeochemical paths for methane and the consumption of nitrous oxide. This latter process seems to account for the fact that certain areas of the ocean act as nitrous oxide sinks (assimilation zones). Other studies showed that the metabolic rates, as well as the rates of assimilation of carbon and nitrogen by some Antarctic Peninsula microbial communities, are affected by the decrease in salinity of surface waters which results from the melting of glaciers.

### Radiocarbon Dating

The researchers have done radiocarbon tree-ring dating of various tree species throughout Chile in order to increase our knowledge of variations in carbon dioxide concentrations in the Southern Hemisphere since 1800, and also to identify the corresponding anthropic forcing factors.

Radiocarbon dating was also applied to marine organisms, which showed that some 18,000 years ago—during the last glacial period—there existed a significant carbon dioxide sink in the deep

waters of the Pacific Ocean. Over time, said gas began to be released as a result of rising global temperatures. This evidence may help elucidate the possible consequences of the current global warming.

### Transport of Nutrients and Phytoplankton Biomass Along the Coasts of Central-Southern Chile

The long mega-drought that has been affecting central-southern Chile prompted the group of biogeochemistry researchers to study the drought's impact on marine productivity in coastal areas. They were able to determine that the reduction in river flows caused by the extreme drought has led to a decrease in the delivery of nutrients to the sea and a corresponding reduction of phytoplankton biomass, which underpins marine productivity and the fishing sector in these zones.

### Liquid Water Content in the Cloud Forests of Northern Chile

With a view to better understand the development of forests in Chile's semi-arid zones—such as Fray Jorge forest in Coquimbo Region, where precipitation is less than 200 mm per year—the group of researchers studied the liquid water content in the clouds over these areas. This data is crucial for determining the rates of formation of precipitation and the size of water droplets in the clouds, which in turn determine the amounts of solar radiation reflected back to space and that reaching the surface.

### Sensitivity of pre-Hispanic Societies to Environmental Change

The results of the archaeological studies conducted by the biogeochemistry team suggest that the human settlement of the Great North of Chile was aided by an unprecedented increase of natural resources. There is evidence of human settlements in the Pampa del Tamarugal 13,000 years ago—the oldest in the New World—whose existence is linked to the appearance of an oasis with vegetation and fresh water. During events of prolonged drought, local population levels decreased and were redistributed to extreme environments such as the coast of the Atacama Desert, the foothills of the Andes and the Chilean Altiplano.



Line of Research

## Climate Dynamics

The research carried out in the climate dynamics line—which is at the centre of (CR)2’s efforts—is focused on characterizing and understanding the variability of water resources over time—including the underlying physical factors throughout the country and over different time scales.

### Temperature Trends

Over the last few years, Santiago and other Chilean cities have recorded historical temperature maxima. Along the coast of central-northern Chile, these increases have been less marked. This latter fact would seem to be inconsistent with anthropogenic global warming. With this in mind, the climate dynamics research team studied the records of more than 200 weather stations in Ecuador, Peru, Bolivia and Chile, and was able to confirm that there has been a cooling of the coast over the last three decades. In contrast, the weather stations most distant from the coast have recorded increases in temperatures during the last 60 years. The researchers came to the conclusion that temperature trends along the coast are determined to a high degree by conditions in the Pacific Ocean. However, the cooling is also due, in part, to an increase in southerly winds which blow parallel to the coast and cause an upsurge of cooler water. This intensification is consistent with the displacement towards the south of the Pacific anticyclone (a zone of high atmospheric pressure), which is one of the factors behind climate change.

### Recorded and Reconstructed Precipitation Trends

Using climate models, the research team detected a trend towards lower precipitations in Central Chile during the 21st century. They also determined that 25% of this deficit can be attributed to anthropogenic climate change.

The climate reconstructions have also shed light on the behaviour of El Niño. The team detected a significant increase in El Niño variability year after year starting in the 20th century. They also detected the phenomenon of aridification of the South American altiplano starting in the mid-20th century, a trend that will continue to be exacerbated during the current century.

### Extreme Hydrometeorological Events

Landslides, rivers bursting their banks and floods all have a major impact on the population, destroying human lives and infrastructure as witnessed in the Atacama event of March 2015 and the great storms in the Andes in late February 2017. Attributing such events to climate change is becoming commonplace. This might be an obvious connection in tropical climates, but it is not yet so in the case of Chile. (CR)2 researchers are investigating the various factors behind these extreme climate events.

In the case of the Atacama landslides and floods, the research team was able to establish the fundamental role played by moisture coming in from the Pacific Ocean—which is controlled by sea-surface temperatures—in the genesis of storms in Chile’s arid zones. On the contrary, summer and autumn storms over the Andes are mostly associated with moisture coming in from the East. Although these extreme storm events are very difficult to reproduce in climate models, the large-scale conditions that accompany them *can* be modelled, which will make it possible to obtain physically-consistent estimates of changes in these events during the 21st century.

### A Look at the More Distant Past

The research team studied climate fluctuations at a scale of centuries over a period of 3,000 years, including the current global warming. Determining the geographical parameters, the magnitude, and the rate at which these changes take place could help deepen our understanding of the factors and mechanisms behind these climate fluctuations, and also help us identify and evaluate the environmental consequences and the impact of human activity, in the context of natural climate variability.

Through the analysis of lake sediments in the Chilean Patagonia, the researchers have detected the existence of warm and dry events lasting 60 to 200 years, which alternate with cold humid events of 200 to 500 years in duration, over the last 11 millennia. The most recent warm conditions are in synchrony with the medieval climatic anomaly (from 800 to 1100 AD) and the Anthropocene (1950 to the present), separated by a long cold period that is contemporaneous with the Little Ice Age (from 1100 to 1600 AD).



## Line of Research

# Ecosystem Services

This line of research has focused on land use changes, ecological restoration, and forest fires and their relationship with ecosystem services, i.e., the benefits that Nature provides to human society, such as providing water and food, and the regulation of the climate, river flows, etc.

### Changes in Land Use

The research has revealed the rapid rate of native forest loss in Chile. This study, which covers 36% of the area between Valparaíso and Los Lagos Regions, reported the loss of 782,120 ha of native forest between 1973 and 2011, mainly as a result of changes in land use or land cover: the change from forest to scrubland accounts for 45% of the loss, followed by the change from forest to forestry plantations (pine and eucalyptus), agriculture and grasslands.

### Land-use Design for the Combined Production of Goods and Ecosystem Services

Based on the analysis of two watersheds in Maule Region where forestry plantations are predominant, the team modelled the annual production of water and timber in this zone and the relationship between these two ecosystem services.

The researchers considered different scenarios of changes in land use in a 35-year horizon: the restoration of native forest in strips of land next to water courses, and maintaining existing land use practices (no restoration). This analysis considered different climate scenarios with diminishing rainfall. The results of the modelling have contributed to optimizing combined production of water and wood in these watersheds by adjusting the ratio of forestry plantations to native forest, scrubland, and other categories of land, as well as implementing adequate crop management practices.

### Restoration of Native Forest for the Recovery of Biodiversity and Ecosystem Services

The research team also developed a model based on the results of monitoring six experimental watersheds for the purpose of evaluating the effects of changing land use from forestry plantations to native forest, both for recovery of biodiversity and for ecosystem services (provision of water). This methodology is a support instrument for the setting of priorities and decision-making in relation to projects and restoration initiatives.

### Occurrence of Forest Fires in Central-Southern Chile

One of the fundamental conclusions of the research is that there is a direct relationship between the drought and the presence of forestry plantations and the occurrence of forest fires, while native forest has the opposite effect. Similarly, the affected territories evolve differently depending on the type of land use: over the last three decades, the area destroyed by fire in forestry plantation has increased by 140%, while in areas covered by native forest and scrubland the area destroyed by fire has decreased by 10%. The increase of the area destroyed by fire during the 2016-2017 season (over 600,000 ha) is due to three factors: the mega-drought and high temperatures in central Chile; negligence or intentionality as cause of almost all forest fires in the country; and the presence of highly combustible landscapes: pine and eucalyptus plantations are the type of vegetation reporting the greatest burnt surface areas.

Also, the research team studied the relationship between fires and climate variability in the central-southern zones of Chile. The results reveal a correlation between frequency of fires and above-average precipitation during the winter of the previous year (because the increase in rainfall leads to more growth of grasses which become combustible material) as well as dry conditions during the spring and summer of the current season. This latter relationship is more marked towards the south, where rainfall is more abundant and high temperatures can result in the destruction of greater surface areas.

Additionally, the research showed that fire causes evolutionary changes in the seeds of the native grass known as “*Manzanilla del cerro*”. This suggests that the increase in forest fires could also modify the evolutionary path of other native plants which, in accordance with these study results, might be replaced by exotic species, thereby modifying the species composition of Chile’s scrublands.

### Drought Severity Index

The research team used the Palmer Drought Severity Index to quantify the influence of the 2015-2016 El Niño phenomenon on the drought in Chile and worldwide. According to this indicator, the drought in Chile is “extreme”, in spite of the fact that past El Niño events have been usually associated with wet conditions.





Line of Research

## Human Dimension

This line of research has been undertaken mainly from the perspective of national law, the economy, sociology and social psychology. The joint work has focused on a comprehensive analysis of government practice in respect to climate change in Chile, in order to determine the manner in which the various agencies at the national and subnational levels (regional and local governments) relate with communities and individuals when making decisions and constructing knowledge about climate change.

### Governance in Relation to Climate Change in Chile

After studying governance in relation to climate change in Chile as well as the different laws and/or legal frameworks that exist worldwide, along with recommendations made by international organizations, the researchers in this line have stressed the need and the viability of enacting a law on climate change in Chile. Said legislation should envisage the following: institutional reform to place decision making on climate change in the hands of the executive branch; greater citizen participation; implementation of mechanisms to monitor public policy; etc.

### Building Resilience in the Face of Climate Change

The concept of resilience refers to a system's capacity to resist and recover from the effects of threats in a timely and effective way. The researchers worked directly with communities in three of Chile's administrative regions and arrived at the conclusion that education, access to information, citizen participation and decentralized government are some of the essential conditions needed for building resilience to climate change.

### The Role of Local Communities in Developing Resilience to Climate Change

Based on the above, the Human Dimension team undertook new studies about the perception of climate change in two administrative regions in Central Chile. The results indicate that the main perceived impacts are: dryness of the landscape; lowering of the water surface in lakes; decreased snow precipitation; and the impact on agriculture.

A second study identified the various strategies developed by communities to adapt to the drought and climate change. The researchers also organized group sessions with the communities for the purpose of assessing and possibly to improve the effectiveness of these strategies.

### National Survey About Climate Change

In 2016, the Human Dimension researchers and the Ministry of the Environment conducted the first national survey on the perception of climate change. The results show that 84% of Chileans believe climate change is definitely taking place, while 89% are of the opinion that human activity is entirely or partly responsible for the phenomenon.

A majority of respondents have some understanding of climate change, and of its relation to changes in precipitation patterns, the regularity of the seasons, and overall temperatures.

### Vulnerability mapping protocol: the case of family farming

In order to understand the vulnerability to climate change and climate variability, a mapping protocol was developed and applied in the Maule Region. The results indicate that, as a result of the mega-drought, the vulnerability of agriculture has increased in 2013 compared to 1997, both in terms of the availability of water and of food production, especially in the case of maize and wheat. In general, the geographical zone where vulnerability to climate change has increased the most is the Central Valley, where there is a high concentration of small-scale maize farming, as well as a high demand for drinking water in rural areas.



Line of Research

## Modelling and Observing Systems

The research efforts deployed by the modelling and observation systems team have focused mainly on studying climate variability and on estimating the climate caused by humans.

### Climate Variability in Chile

Through the analysis of climate projections, the team calculated that we can expect an increase in the number of extreme precipitation events in Chile's Near North (Norte Chico). The analysis also revealed a trend towards a drying-out of the river flows in the country's central-southern zone during the present century. Based on these simulations, the researchers were able to calculate the moment when the anthropic signal (in terms of precipitation) emerges over the background noise of natural climate variability.

### Ocean Swells and Coastal Upwelling

Through the use of satellite data and mathematical modelling, the team discovered that the height of waves along Central Chile bears a relation to the presence of intense winds during the summer. According to the projections, one of the effects of climate change in the 21st century will be that zones of high atmospheric pressure—which are associated with the occurrence of such winds—will move gradually towards the poles, meaning they will also move along the coasts of Chile. Similarly, it is expected that wind patterns will tend to increase coastal upwelling.

### Sea Level Rise

Future changes in sea level affecting Chile in the context of anthropogenic climate change were analyzed for the 21st century for the representative concentration pathway RCP4.5 and RCP8.5 scenarios. RCP scenarios describe four possible climate futures for the planet, all of which are considered possible depending on how much greenhouse gases are emitted worldwide in the years to come. The total mean sea-level rise along the Chilean coast lies between 34 cm and 52 cm for the RCP4.5 scenario and between 46 cm and 74 cm for the RCP8.5 scenario.

### Atmospheric Pollution

The researchers were able to identify the main sources of atmospheric pollution in Santiago and Temuco. In Temuco, the major polluting factor is the burning of firewood, while in the capital air pollution is due to vehicle traffic and industry. The team also conducted a systematic review and assessment of inventories of emissions, and helped generate data for new inventories such as pollutants having a short half-life.

The team developed evaluation methods aimed at optimizing different observation networks, such as the network of air-quality and aerosol optical depth monitoring stations in Santiago.

Another subject of research has been the atmospheric transport of pollutants from Santiago to the Andes and nearby glaciers. They discovered that air pollution follows an episodic time pattern to enter the interior of the high valleys near Santiago and that the pollutants can reach the glaciers in the Andes northeast of the capital, at elevations of 4,800 m.a.s.l.

The research on modelling and observation systems has also analysed tropospheric ozone trends in Rapa Nui and Cerro Tololo. This has contributed to our understanding of the compositional changes that take place in the upper atmosphere.

### Paleoclimate Studies

Through the study of various databases on the climate of the Earth's past geological ages, (CR)2 researchers have developed a deposition map of mineral dust. This has proved to be an adequate input for estimating the role of mineral dust in the variations of the concentration of carbon dioxide in our planet in glacial and interglacial periods over millions of years.



POSAR Buoy/ Mouth of the Itata River, 2016





# Infrastructure

---

*(CR)2's instruments, databases and computer resources are available for the development of high-level science in Chile and around the world.*

# Infrastructure

- Instruments
- Coupled Ocean-Atmosphere System Observation Platform (Posar)
- Climate Explorer
- Databases
- Computing Resources

---

*(CR)2's instruments, databases and computer resources are available for the development of high-level science in Chile and around the world.*

# Infrastructure

## Instruments

Through the years, (CR)2 has acquired its own infrastructure for the scientific investigation of climate change. The databases developed through the use of these instruments, as well as the computational resources used for climate modelling, are of great importance to the Chilean and international scientific community. For this reason a significant percentage of the data is freely available to be consulted and used.



1



2



3

Universidad de Concepción, Biobío Region.

### 1 ISOTOPE RATIO MASS SPECTROMETER

It measures the isotopic composition of nitrogen ( $\delta^{15}\text{N}$ ), carbon ( $\delta^{13}\text{C}$ ) and oxygen ( $\delta^{18}\text{O}$ ) in solid, liquid and vapor samples.

### 2 WATER ISOTOPES ANALYSER AND NITROUS OXIDE ISOTOPES AND CONCENTRATION ANALYSER

Both instruments measure the isotopic composition of different substances with high sensitivity.

### 3 PRECIPITATION MICRO RADAR

It detects the presence, amount and vertical velocity of raindrops, snow and hail.



### FOG MONITOR

Fray Jorge National Park.  
Coquimbo Region.

It measures the liquid water content in the clouds and the composition of water droplets.



### WIND PROFILER

Carén Lagoon, Universidad de Chile site.  
Metropolitan Region.

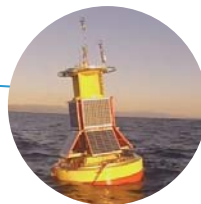
It measures the wind magnitude and direction, vertical velocity and turbulence.



### AUTOMATIC SUNTRACKING PHOTOMETER

Geophysics Department of the Faculty of Physical and Mathematical Sciences, Universidad de Chile, Metropolitan Region.

It allows to study the interaction between solar radiation and aerosols.



### COUPLED OCEAN-ATMOSPHERE SYSTEM OBSERVATION PLATFORM (POSAR)

Mouth of the Itata River, Biobío Region.

Buoy that collects weather and ocean data.



### WEATHER STATION AND RIVER FLOW MONITORING STATION

Nasampulli Reserve, Araucanía Region.

It collects weather data in mountain ecosystems as part of a network of high altitude stations under construction.



### EDDY FLUX TOWER

Alerce Costero National Park, Los Ríos Region.

It allows to estimate the carbon balance in adult forests, using an infrared gas analyzer, meteorological instruments and four chambers that measure soil respiration.



### Observation Platform of the Coupled Ocean-Atmosphere System (Posar)

[www.cr2.cl/posar](http://www.cr2.cl/posar)

The Posar project involves the design, construction, installation, operation and maintenance of an ocean and atmosphere observation system in the coastal Biobío Region. This work was completed by (CR)2 researchers and professionals along with the Chilean firm SeaHorse (Concepción). The project is financed by the Scientific and Technological Equipment Fund (Fondequip), Conicyt and the Faculty of Physical and Mathematical Sciences of the Universidad de Chile.

The Posar platform consists of a coastal buoy that takes meteorological measurements (wind intensity and direction, air temperature, relative humidity, solar radiation, net radiation and atmospheric pressure) as well as oceanographic readings at a depth of approximately 2 meters (water temperature, conductivity, dissolved oxygen, chlorophyll, pH, nitrate concentrations and carbon dioxide partial pressure). The buoy transmits the data hourly

to a receiving station on land, where it is processed for online publication, which is accessible by the entire community. This is the only equipment of its kind on the coast of South America. Posar is sited in front of the mouth of the Itata River, some 30 km north of Talcahuano. This zone is subject to diverse natural phenomena (coastal upwelling, water discharge from rivers, winter storms) and anthropic activities such as fishing, tourism, agriculture, forestry and the cellulose industry. The principal function of Posar is to measure a number of meteorological and oceanographic variables to help monitor conditions in the coastal environment. This data, which is of high quality and is taken at very short time intervals, is freely available to the local and regional community, so that it may be used in various activities and in scientific research.



## Climate Explorer

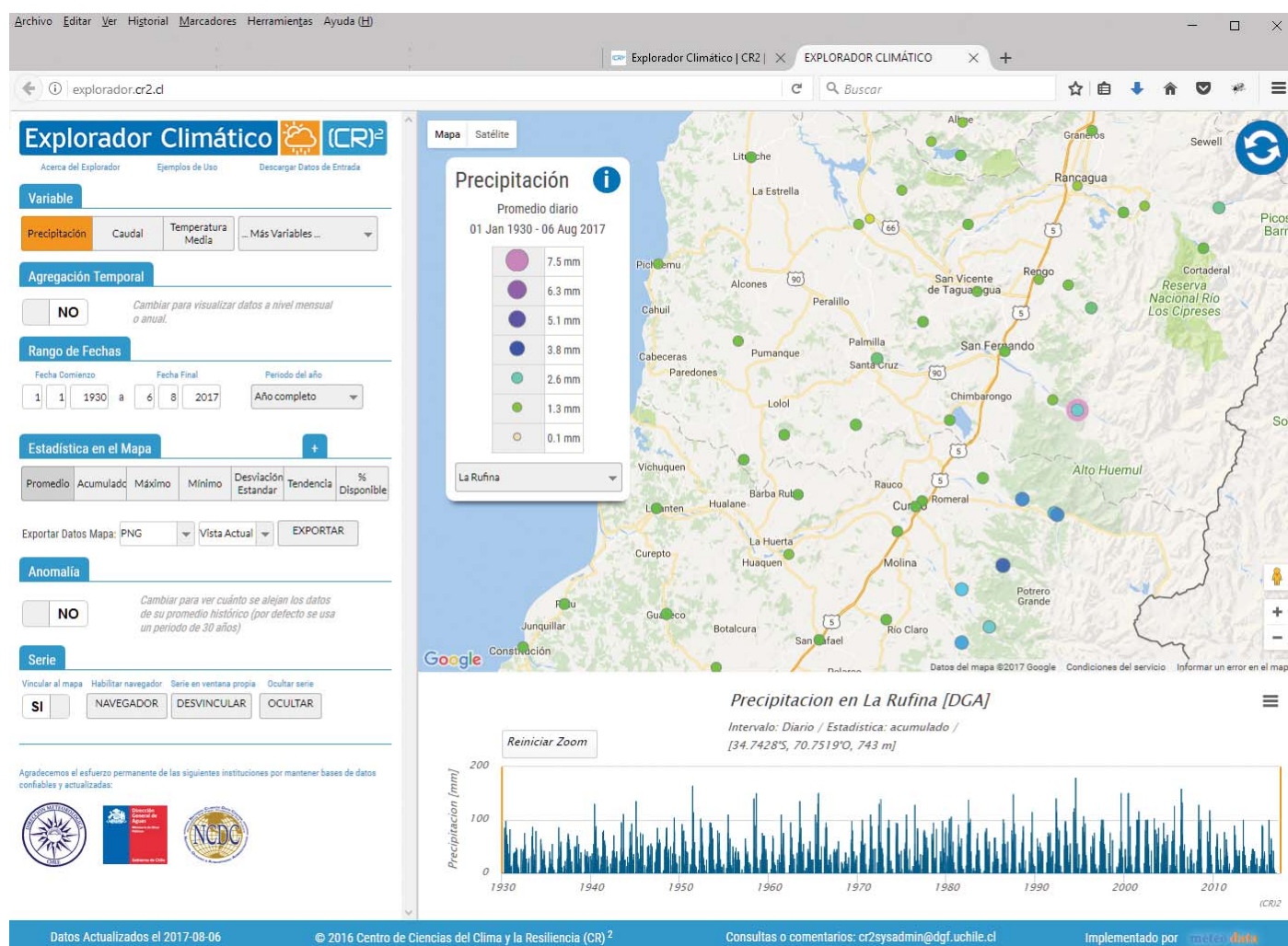
[explorador.cr2.cl](http://explorador.cr2.cl)

The Climate Explorer is an online tool developed by (CR)2 and implemented by the Chilean company Meteodata. The tool makes it possible to visualize, analyse and download climate data. It uses records of observed data compiled by the Centre for academic and research use. The data is obtained from Chile's Meteorological Office, the General Waters Directorate and the Ministry of the Environment. Although this data was generally available, (CR)2 carried out the important task of standardizing and assembling the various databases.

This type of platform belongs to the type of offering commonly known as “climate services”, i.e., climate information processed and transformed into products and applications for a variety of users. The Climate Explorer may be used by the community in

general or by professionals having advanced knowledge of meteorology, making the Explorer a useful tool for decision making in policy planning and development, as well as in daily activities.

The Explorer lets users access extensive databases containing information on the entire Chilean territory since 1940, perform simple calculations, display the results in the form of maps or time series, and export them in various image or text formats. In the menu, users can select different variables (precipitation, river flows, mean temperature, maximum and minimum temperatures), and see the corresponding values for complete years, seasons, or specific months. Also available are standard deviation, data on anomalies and trends, and other statistics.





### Databases

#### Climate Data and Climate Simulations

The data and computing area at (CR)2 has collected data on climate, river flows, and climate simulations from open access platforms in Chile and abroad, and through measurement campaigns and digital simulations performed by researchers at (CR)2 and other sources. These compilations are freely accessible for research and teaching purposes, and are also accessible by the general public. The compilations do not replace the original data provided by the responsible institutions.

The observational data available include precipitation, mean river flows, and mean and extreme temperatures, which are obtained from Chile's Meteorological Office, the General Waters Directorate and the Ministry of the Environment. The data on global climate simulations by the Coupled Model Intercomparison Project (CMIP5) were obtained from the nodes associated with the Earth System Grid Federation, while the data from regional climate simulations are the result of work performed by (CR)2's own researchers, the Geophysics Department at Universidad de Chile, and Chile's Meteorological Office.

#### Rapa Nui Ozone Profiles

(CR)2 grants free access to the data records of 20 years of Rapa Nui ozone profiles, collected by Chile's Meteorological Office under the auspices of Global Atmospheric Watch and the World Meteorological Organisation. The analysis of this data was performed by (CR)2 researchers, Universidad de Magallanes and NASA Goddard Space Flight Center.

#### Databases of Chilean stakeholders and practices of adaptation to climate change

In the framework of (CR)2's interdisciplinary research on the mega-drought in Chile, two databases were compiled. The first is a list of parties concerned about the drought, which includes almost 300 public agencies, private organizations, research entities and civil society groups involved in managing or responding to the drought in Chile. The second is a list of practices adopted by various stakeholders and aimed at adapting to climate change, in the municipalities of Paine and La Pintana (Metropolitan Region), and San Felipe, Santa María, Los Andes and Rinconada (Valparaíso Region).

### Computing Resources

Digital climate simulations require a great deal of high-performance computing resources, as well as data storage capacity. (CR)2 has two different platforms with different distributed processing and storage capacities available for conducting atmospheric science research.

The first platform is located in the area assigned to (CR)2 at Universidad de Chile's Computing Centre. This consists of a high-performance distributed processing cluster capable of performing climate simulations in three nodes (104 cores in total) connected to a 100 TB storage system.

The National Laboratory of High Performance Computing (NLHPC) at Universidad de Chile's Centre for Mathematical Modelling houses Chile's most powerful computer, with 70 teraFlops of calculation power. This facility houses (CR)2's second computing platform and provides 120 cores of computing capacity to each researcher at the Centre.



# Collaboration Networks

*Through its participation on commissions and collaboration with national and international institutions, (CR)2 has contributed to the development of Earth-system science in Chile and to public policies that address climate change in the country.*

# Collaboration Networks

- Public and private Chilean and foreign institutions

---

*Through its participation on commissions and collaboration with national and international institutions, (CR)2 has contributed to the development of Earth-system science in Chile and to public policies that address climate change in the country.*



## Collaboration Networks

(CR)<sup>2</sup> collaborates with public and private sector institutions in Chile and abroad in the different areas of research pursued at the Centre, such as climate modelling, the construction of social resilience, environmental legislation, forestry systems, and monitoring of coastal conditions, among other lines of research.

Some of the collaborative efforts have made important contributions to the formulation of public policy on climate change in Chile.



## Collaboration Networks



### Ministry of the Environment

The Ministry of the Environment (MMA) and (CR)2 have worked in close and permanent collaboration in the implementation of various projects and in the formulation of public policy on climate change. These collaborative efforts include the work done for MAPS Chile, the inter-ministerial and participatory project that defined several options for reducing greenhouse gas emissions in Chile and for moving towards low carbon development.

(CR)2 also prepared a proposal for the structure and the contents of the Climate Change National Action Plan (PANCC), and also drafted the closing evaluation of the initiative. PANCC is the government's highest-level instrument for managing the response to climate change.

The MMA has requested the collaboration of the Centre in developing regional climate simulations as well as methods for evaluating vulnerability to climate change. In this regard, both institutions signed an agreement in 2016, under which (CR)2 is responsible for generating information on climate projections and national vulnerability through climate modelling at a regional scale. The projections will be accessible by way of an interactive platform that will support the design of public policy at a national level.



### Ministry of Foreign Affairs

The Directorate of the Environment and Oceanic Affairs at the Ministry of Foreign Affairs has been a key promoter of the participation of (CR)2 in the Conferences of the Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC). The parties to UNFCCC are national governments, companies, NGO's, and other bodies interested in reaching international agreements on the response to climate change at a global level.

(CR)2's participation in these conferences has become increasingly relevant. In 2016, the Centre worked closely with the Ministry of Foreign Affairs in promoting scientific cooperation in various areas of interest to the Ministry. In the context of this collaboration both institutions, jointly with the Inter-American Development Bank, organized an official event at the Marrakech COP22 Summit. The event dealt with topics related to the financial implementation of the Nationally Determined Contributions (NDC) agreed at the Paris Climate Agreement.



### Ministry of Public Works

In 2016, the Centre for Mathematical Modelling (CMM), the National Laboratory of High Performance Computing (NLHPC), the Ministry of Public Works (MOP) and (CR)2 signed an agreement aimed at establishing collaboration mechanisms in matters related to climate change and the modelling of this phenomenon, in order to contribute to the Ministry's policies and prospective studies.

### Universidad Católica de Chile's Centre for Global Change

(CR)2, jointly with the Centre for Global Change at Pontificia Universidad Católica de Chile, wrote the chapter “Chile’s Vulnerability and Adaptation to Climate Change” in the document *Chile’s Third National Communication on Climate Change to the United Nations Framework Convention on Climate Change*. The document was prepared under the direction of the Ministry of the Environment, and describes the progress made by Chile in adapting to climate change from 2011 to 2016. This report was published and officially delivered to the United Nations in November 2016, during the Marrakech COP22 Summit.

### Andean Geothermal Centre of Excellence and the Institute of Ecology and Biodiversity

(CR)2, jointly with Universidad de Chile’s Andean Geothermal Centre of Excellence (CEGA) and the Institute of Ecology and Biodiversity (IEB) developed the Explora Conicyt Popularization of Science and Technology project titled “Julietta in the Land of Girls”, whose major objective is to motivate girls to become involved in science. The project concluded in September 2016.

### Solar Energy Research Centre

(CR)2 and the Solar Energy Research Centre (SERC) designed the diploma course “Climate Change and Low-Carbon Development”, which aims to provide conceptual and methodological tools for developing a comprehensive understanding of problems related to climate change and low-carbon development.

### Chilean General Directorate of Civil Aviation, Chilean Meteorological Office

In July 2014, the Centre signed a collaboration agreement with Chile’s General Directorate of Civil Aviation (DGAC) and Chile’s Meteorological Office (DMC) aimed at sharing relevant weather information and data analysis methods, and to develop climate services.

### National Council for Innovation and Development (CNID)

The first sessions of the Commission on Research, Development and Innovation (I+D+i) and of the Commission on Resilience to Natural Disasters (Creden) were held in January 2016. The meetings were promoted by the National Council for Innovation and Development (CNID) which proposed an agenda centred on potentially catastrophic natural phenomena in Chile.

(CR)2 was a participant in the central Creden commission as well as in the I+D+i Commission on the Sustainability of Water Resources, whose goal is to define guidelines in support of the country’s strategic agenda on the matter.

In late 2016, both commissions submitted their reports to the President of Chile, Michelle Bachelet, along with a series of recommendations and proposals to improve the management of water resources and preparations for natural disasters in the context of climate change in Chile.

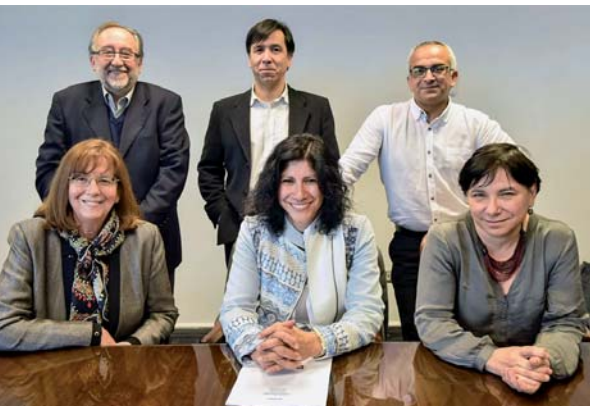






### National Emergency Office at the Ministry of the Interior and Public Safety

(CR)2 is a member of the scientific-technical committee, an advisory body to the National Emergency Office (Onemi). Onemi aims to maximize its understanding of the various threats and develop effective means of managing risk in Chile. (CR)2 is also part of the national platform for the reduction of risk of disasters, which is a multi-sector initiative whose objective is to increase resilience to catastrophes in Chile.



### Ministry of the Economy's Commission on Red Tide

One of (CR)2's principal researchers was a member of the Panel of Independent Experts organized by the Ministry of the Economy, which analysed the red tide phenomenon in Los Lagos and Aysén Regions in the summer of 2016.

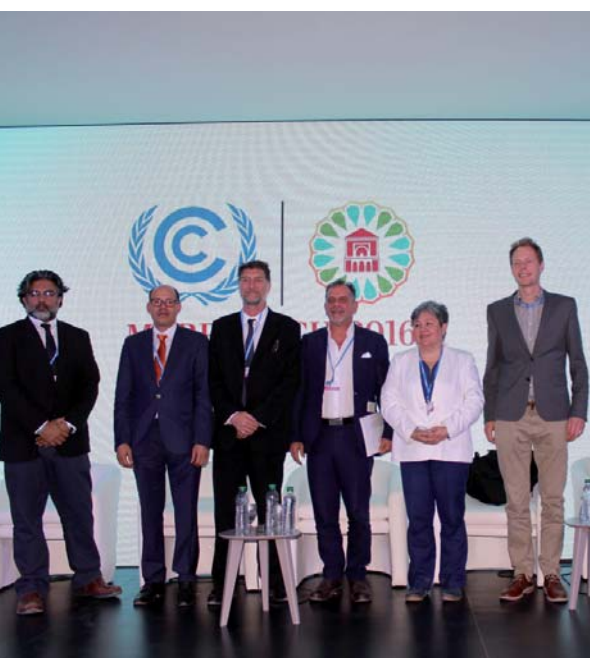
The team included five scientists convened by the Chilean Academy of Sciences. They worked to confirm or rule out a possible causative relationship between the dumping of decaying fish by fish-farm operators and the red-tide phenomenon. The final report of the Commission was delivered in November 2016.



### Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) was created in 1988 through the initiative by the United Nations Environment Programme and the World Meteorological Organisation, for the purpose of defining the scientific view and the state of knowledge regarding climate change and its environmental and socio-economic repercussions.

(CR)2 researchers authored and edited the IPCC's fifth evaluation report, as well as other special reports such as Managing the Risk of Extreme Events due to Climate Change. Researchers at the Centre are currently taking part in the preparatory meetings for the sixth evaluation report to be published in 2022.



### International Network of Climate Change Centres of Excellence and Think Tanks for Capacity Building

In 2016, (CR)2 together with eleven other research centres worldwide created the International Network of Climate Change Centers of Excellence and Think Tanks for Capacity Building (INCCETT), whose mission is to promote the design and implementation of the Nationally Determined Contributions presented in order to comply with the Paris Agreement and increase international collaboration on climate change.

The official launching of the network took place at the Marrakech COP22 Summit. (CR)2 took part in the event, alongside authorities of the United Nations Framework Convention on Climate Change (UNFCCC) and of the Kingdom of Morocco.

INCCETT will focus on defining aspects of financing and initiating joint work, and subsequently on developing concrete proposals to promote capacity building in each country for the implementation of the NDC.



# Research Achievements

*The research carried out at (CR)2 on climate change, climate variability and resilience in Chile has resulted in the creation of relevant products for the national and international scientific community, and also for Chilean society.*

Presentation of the Megadrought Report  
to Chilean President Michelle Bachelet, 2015.

# Research Achievements

- Report to the Nation: The 2010-2015 Mega-drought: A Lesson for the Future
- Manifestations of the Anthropocene in Chile
- Proposal for a Legal and Institutional Framework to Address Climate Change in Chile

---

*The research on climate change, climate variability and resilience in Chile conducted by (CR)2 has generated important products for the national and international scientific community and especially for Chilean society.*

## Research Achievements

### Report to the Nation:

#### ***The 2010-2015 Mega-drought: A Lesson for the Future***

The *2010-2015 Mega-drought Report* is a dissemination report that summarizes the interdisciplinary scientific research conducted by (CR)2 from 2013 to 2016 in relation to the unprecedented conditions of precipitation deficit that have affected many parts of the Chilean territory since 2010.

The term “mega-drought” adequately describes the phenomenon, in view of the extraordinary duration and geographical extent of water-shortage conditions from Coquimbo Region to Araucanía Region. In this zone, precipitation deficits have been on the order of 30%. The severity of the phenomenon is unprecedented in the last millennium according to climate reconstructions based on studies of tree-ring growth. The drought also coincides with the warmest decade of the last century, which has greatly increased water loss from lakes, reservoirs and agricultural land through evaporation.

One of the most obvious consequences of the mega-drought has been its impact on water resources. For example, average river-flow deficits in Coquimbo and Valparaíso Regions have reached maxima of 70% during the period in question. The water level in reservoirs and aquifers has dropped to historic lows, while the snowline has gradually risen.

As a result of reduced river flows during the mega-drought, nutrients such as nitrates and phosphates are reaching the sea in smaller quantities, which may be affecting the biological productivity of coastal zones, including fish stocks such as the Pacific Anchoveta and sardines.

The surface area destroyed by fire each year in the central-southern zone has increased by 70% since the beginning of the mega-drought. Over 600,000 hectares were destroyed in the 2016-2017 season, which is more than 10 times the historic average, an unprecedented event which also resulted in 11 fatalities and over 1,500 homes destroyed.

(CR)2 scientists have noticed that the causes of the mega-drought are not completely attributable to natural phenomena such as La Niña or the cool phase of the Pacific Decadal Oscillation. In fact, the report reached the conclusion that at least 25% of the current mega-drought is attributable to anthropic climate change.

This percentage may well increase over the coming decades. Climate simulations for 2010-2050 based on a pessimistic scenario of greenhouse gas emissions suggest the possibility of a mega-drought every 20 years. As the 21st century progresses, the definition of drought as a transitory phenomenon will become relatively meaningless, as there will be a permanent and substantial decrease of annual precipitations. In other words, average conditions in the future may be similar to those observed during the current mega-drought.

In the report’s recommendations, (CR)2 discussed the urgency of setting up an inter-institutional coordination agency responsible for administering water resources, raising awareness of their finite nature, and promoting Chile’s adaptive capacity. The report also recommended that the Water Code be reformed to explicitly enshrine the preservation of the natural environment and the human right to water.

Emergency and structural measures need to be regularly and participatively reviewed and updated so as to identify obstacles and deficiencies, take into account traditional knowledge, and promote social learning –especially at the local level.



The Centre’s Principal Researchers officially presented (CR)2’s report on the mega-drought to the President of Chile, Michelle Bachelet, in November 2015. The report was also presented to the Chilean Senate’s Special Commission on Water resources, Desertification and Drought, and to various other scientific bodies and agencies of the public and private sectors.



### Proposal for a Legal and Institutional Framework to Address Climate Change in Chile

This project was an initiative of (CR)2 and the NGO Adapt-Chile, which is supported by the 2015 Prosperity Fund of the British Embassy in Chile. The initiative was also sponsored by the Ministry of the Environment. Its objective was to make a diagnosis of the need and the viability of enacting climate change legislation in Chile, as well as suggesting the minimum contents of such a law. This project had a participatory nature, and was guided by a directive committee which included members of the British Embassy and of the Ministry of the Environment, along with a panel of experts, members of civil society, municipalities, academia, Parliament, the executive branch and international agencies.

As a result of the research conducted, the team identified deficiencies in the existing institutional framework associated with climate change, which is mainly a responsibility of the Ministry of the Environment. There are problems with such a model, in terms of the stability and continuity of policies, because the implementation of decisions is subject to the will of various agencies. Furthermore, there are no budget items for climate change matters nor is there any legal definition regarding the jurisdictions of the various state agencies. This diagnosis—along with proposals for solutions—are contained in the three reports published by the panel of experts: *Governance of Climate Change in Chile*; *Comparative Analysis of Climate Change Legislation*; and *Minimum Contents of a Climate Change Law for Chile and Methodological Guidelines for their Evaluation from Economic and Social Perspectives*.

The governance analysis focused on the evolution of public policy on climate change in Chile (from the signing of United Nations Framework Convention on Climate Change–UNFCCC—to the present), and reviewed all documents issued by the State, including strategies, plans, regulations, etc.

The comparative analysis of legislation consisted of a review of legal bodies dealing with climate change in various countries, as well as numerous parliamentary initiatives on the matter in Latin America.

Finally, the document on minimum contents and evaluation proposed two institutional models for climate change legislation in Chile. The first deals with the relationship between climate change and security and risks. From this perspective, the design of climate policy should be a responsibility of one of the departments of the Ministry of the Interior and Public Safety, which would incorporate the Climate Change Office (now Climate Change Division at the Ministry of the Environment), and which would be advised by a scientific-technical committee at the Ministry of Science and Technology and by a joint public sector-private sector committee. The second model is based on the principle of hierarchical superiority, and would house the Climate Change Office at the Presidency of the Republic. This office would be in charge of drafting policy on climate change, and would also be advised by the above-mentioned committees. Said policy proposals would be discussed by the Council of Ministers on Sustainability and Climate Change, in a consultative capacity.



In both scenarios, the objective would be for issues related to climate change to be examined and discussed at higher levels in the State apparatus, and to assure transversality of perspectives and coordination between the various levels of government, as well as permanence of policy decisions over time, in line with international guidelines on the matter.

Finally, the project proposed that a methodological framework be adopted which would ensure adequate evaluation of the impacts of such a climate change law, in economic, environmental and social terms, in view of the fact that—in spite of the abundant scientific evidence on the effects of climate change—there is little consensus on the best way to address the drafting of policy and the undertaking of practical measures to mitigate these effects and change social practices in order to mitigate and adapt to this global climate change.

The second part of the project was implemented in 2016 for the purpose of defining the contents of a legal and institutional framework for adapting to climate change at the regional and municipal level in Chile. The study was commissioned by the Ministry of the Environment, and counted on the technical support of the United Nations Environment Programme (UNEP), as well as funding from the European Union's Euroclima Programme. The results were officially presented during a parallel event to the CMNUCC Conference of the Parties (COP22), held in 2016 in Marrakech.



This proposal for a climate change law in Chile was officially presented to then-Minister of the Environment Pablo Badenier, and was very well received by the so-called “Climate Bloc” of members of parliament, which was informally created to assure materialization of the initiative, and includes Representatives Camila Vallejo, Giorgio Jackson, Andrea Molina, Daniel Melo and Patricio Vallespín, jointly with Senators Alfonso of Urresti, Carolina Goic, Guido Girardi, Antonio Horvath and Ricardo Lagos Weber.





### Manifestations of the Anthropocene in Chile

Since the Industrial Revolution, “progress” made by Humanity has taken place at such a rapid pace and in a manner so dependent on the use of fossil fuels (coal, oil and their derived products) that human activity has become a factor comparable in importance to the natural geological forces that determine Earth’s climate. In fact, some scientists believe we have entered a new geological age that may be called the Anthropocene, replacing the Holocene during which, over a period of 20,000 or 30,000 years humans became masters of the Earth. But regardless of whether we have entered a new geological era, what is being called into question is our way of living on this blue planet of the solar system or, to put it in other words, the paths to progress and development. In a country where social inequalities are so marked, meeting this challenge is of crucial importance and may even be the road to new opportunities.

The Centre has worked hard to understand some of the regional manifestations of the Anthropocene in Chile, in order to identify paths to greater resilience. (CR)<sup>2</sup> has studied the co-evolution of air quality and the mobility of the residents of Santiago over the last 30 years, including the obvious trends and the need for new public policies based not just on adopting technological advances, but rather on changes in behaviour and social transformations. Another (CR)<sup>2</sup> study addressed changes in land use and their

consequences on biodiversity, water resources, carbon capture and storage, and fire regimes, and called for comprehensive sustainable management of native forest and forestry plantations. Other authors have studied the causes of the variability of precipitation in Chile’s central and southern zones. They have also reviewed the uncertainties implicit in climate projections. These aspects are then taken into account when evaluating the best way to allocate water resources under existing legislation. Changes in large-scale climate trends and their effects on coastal biogeochemical processes are discussed in light of climate projections and empirical evidence. Paleo-geo-historical records are used to analyse human influence in Chile’s territory since pre-Hispanic times. Finally, the study of governance in relation to climate change in Chile suggests ways for improvement through greater citizen participation and integration.

These matters are considered to be direct or indirect manifestations of the Anthropocene in Chile. Firstly, they are caused by, and also affect, human activities, in a clearly identifiable manner. Secondly, these phenomena have taken place simultaneously and at a rapid pace, over wide geographical areas. They have been occurring ever more frequently over the last few decades. Finally, they constitute great challenges to society’s institutions, their instruments, governance, and, in general, the way we inhabit a planet with finite resources.





# Communications and Relations with the Social Environment

*The impact on issues of national importance and on the development of public policies is a distinctive characteristic of (CR)2 research and projects, which not only contribute to the development of science in Chile but also serve as a fundamental input for decisions regarding policies that promote social resilience in a country that is highly vulnerable to the effects of a changing climate.*

# Communications and Relations with the Social Environment

- Presence in the media
- Scientific outreach

---

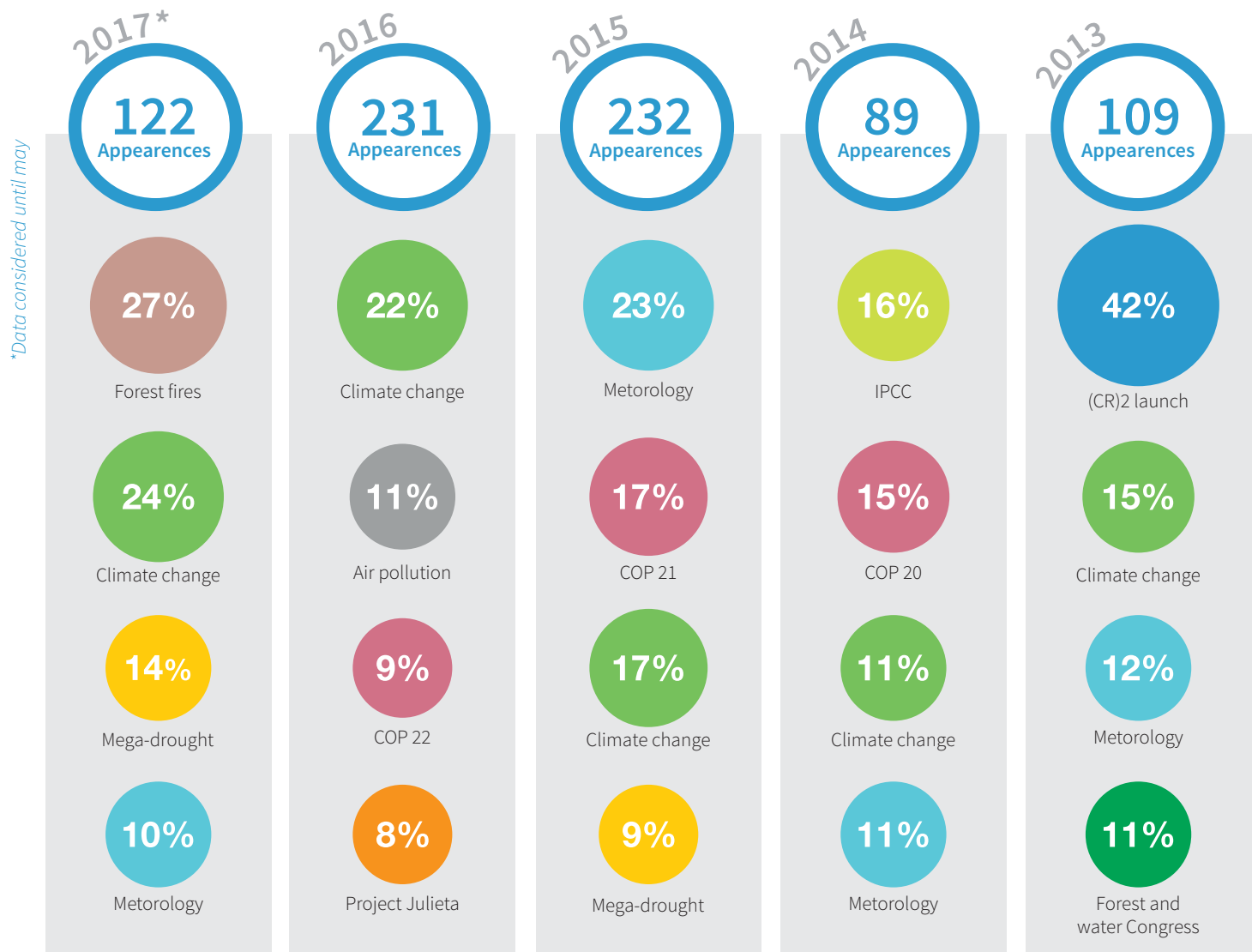
*The impact on issues of national importance and on the development of public policies is a distinctive characteristic of (CR)2 research and projects, which not only contribute to the development of science in Chile but also serve as a fundamental input for decisions regarding policies that promote social resilience in a country that is highly vulnerable to the effects of a changing climate.*

# Communications and Relations with the Social Environment

## Presence in the Media

Along with scientific research, outreach to the non-expert public is a fundamental part of (CR)2's mission and activities, with a view to raising awareness and understanding of the phenomenon of anthropic climate change and its different impacts in Chile.

There has been a noticeable increase in the number of instances in which (CR)2 has been described or mentioned in the Chilean and international press in relation to climate change contingency topics and other matters directly involving the Centre, such as the report on the mega-drought, the proposed contents for climate change legislation in Chile, the Climate Explorer and the Posar Buoy, etc.





### RedLama

With a view to promoting direct contact with local communities, the students and research assistants at (CR)2 have created the Latin American Environmental Educational Network (RedLama), which seeks to communicate knowledge on climate change and environmental science.

Some of the projects implemented by RedLama are: inventory-taking of greenhouse gas emissions, carried out by schoolchildren in Biobío Region; building and maintaining a greenhouse at a school for handicapped children in Valdivia; and a series of presentations for primary and secondary school children in Valparaíso and Santiago.



### Communicate your Science

(CR)2's communications department—jointly with CEGA and IEB (the Millennium Institute on Ecology and Biodiversity)—organize the annual participatory event “Communicate your Science” with the goal of training young scientists in the communication of science.

The initiative is aimed at undergraduate and graduate students, and delivers basic tools for the communication of science, media relations, and for undertaking outreach programmes.





### Julietta in the Land of Girls

Also in collaboration with CEGA and IEB, the Centre developed the initiative “Julietta in the Land of Girls”, an Explora Conicyt Popularization of Science and Technology project. This consists of a game showing a magnifying glass, a rain gauge, a notebook and other items, along with the Chilean animated character “Julietta”. The purpose of the game is to trigger scientific curiosity in girls aged 7 to 11



“Julietta in the Land of Girls” received the 2016 Innovation in Scientific Education prize awarded jointly by Fundación Ciencia Joven and UNESCO to the best informal scientific education project, an acknowledgement of its contribution to narrowing the gender gap in Chilean science.







Expanded meeting / Villa Alegre - 2014





# (CR)<sup>2</sup> Team 2013-2017



Principal Researchers

**Antonio Lara**  
Universidad Austral de Chile  
**Laura Farías**  
Universidad de Concepción  
**Laura Gallardo**  
Universidad de Chile  
**Nicolás Huneeus**  
Universidad de Chile  
**Pilar Moraga**  
Universidad de Chile  
**René Garreaud**  
Universidad de Chile

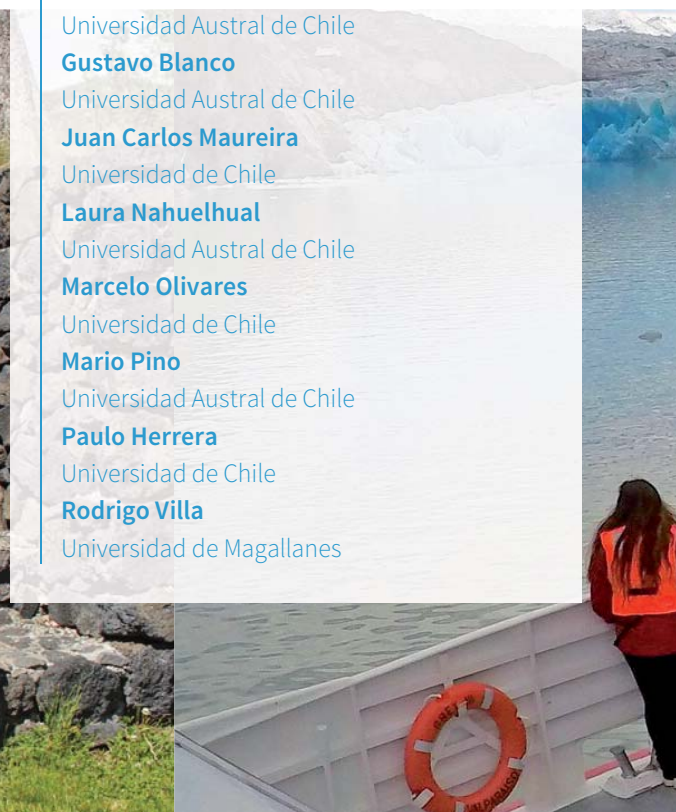
Associate Researchers

**Axel Osses**  
Universidad de Chile  
**Duncan Christie**  
Universidad Austral de Chile  
**Eugenia Gayó**  
Universidad de Concepción  
**Fabrice Lambert**  
Pontificia Universidad Católica de Chile  
**Maisa Rojas**  
Universidad de Chile  
**Mauricio Galleguillos**  
Universidad de Chile  
**Mauro González**  
Universidad Austral de Chile  
**Patricio Moreno**  
Universidad de Chile  
**Paulina Aldunce**  
Universidad de Chile  
**Raúl O’Ryan**  
Universidad Adolfo Ibáñez  
**Ricardo De Pol-Holz**  
Universidad de Magallanes  
**Roberto Rondanelli**  
Universidad de Chile  
**Susana Gómez**  
Universidad del BíoBío  
**Ana Lya Uriarte**  
Universidad de Chile  
**Gary Shaffer**  
Universidad de Concepción  
**Marcela Cornejo**  
Universidad de Concepción  
**Melitta Fiebig**  
Universidad de La Serena

Assistant Researchers

**Anahí Urquiza**  
Universidad de Chile  
**Ariel Muñoz**  
Pontificia Universidad Católica de Valparaíso  
**Armando Sepúlveda**  
Universidad de Magallanes  
**Beatriz Díez**  
Pontificia Universidad Católica de Chile  
**Carlos Zamorano**  
Universidad de Aysén  
**Catalina Aguirre**  
Universidad de Valparaíso  
**Christian Little**  
Universidad Austral de Chile  
**Héctor Zambrano**  
Universidad de La Frontera  
**Italo Massoti**  
Universidad de Valparaíso  
**Karina Véliz**  
Universidad Diego Portales  
**Marcela Munizaga**  
Universidad de Chile  
**Mauricio Osses**  
Universidad Técnica Federico Santa María  
**Nancy Hitschfeld**  
Universidad de Chile  
**Pablo Saide**  
Universidad de Chile / University of Iowa, USA  
**Rodolfo Sapiains**  
Universidad de Chile  
**Rodrigo Arriagada**  
Pontificia Universidad Católica de Chile  
**Carlos Jara**  
Universidad Austral de Chile  
**Gustavo Blanco**  
Universidad Austral de Chile  
**Juan Carlos Maureira**  
Universidad de Chile  
**Laura Nahuelhual**  
Universidad Austral de Chile  
**Marcelo Olivares**  
Universidad de Chile  
**Mario Pino**  
Universidad Austral de Chile  
**Paulo Herrera**  
Universidad de Chile  
**Rodrigo Villa**  
Universidad de Magallanes

● Actives on May 2017





## Postdoctoral Researchers

**Andrea Mazzeo**

Universidad de Chile

**Camila Álvarez**

Universidad Austral de Chile

**Camila Tejo**

Universidad Austral de Chile

**Cecilia Ibarra**

Universidad de Chile

**Deniz Bozkurt**

Universidad de Chile

**Francisco Barraza**

Pontificia Universidad Católica de Chile

**Jonathan Barichivich**

Universidad Austral de Chile

**Juan Pablo Boisier**

Universidad de Chile

**Lucy Belmar**

Universidad de Chile

**Raúl Valenzuela**

Universidad de Chile

**Rocío Urrutia**

Universidad Austral de Chile

**Caitlin Frame**

Universidad de Concepción

**Carola Flores**

Universidad de Concepción

**Carolina Riquelme**

Universidad de Chile

**Catherine Van den Hoof**

Universidad de Chile

**Cintha Ramallo**

Universidad de Chile

**Frauke Albrecht**

Universidad de Concepción

**Jie Chang**

Universidad de Chile

**Kristina Pistone**

Universidad de Chile

**Mariela Yévenes**

Universidad de Concepción

**Nancy Yáñez**

Universidad de Chile

**Paola Arias**

Universidad de Chile

## Communications

**María Giselle Ogaz**

Universidad de Chile

**Michelle Ferrer**

Universidad de Chile

**Nicole Tondreau**

Universidad de Chile

**Cristóbal Bustamante**

Universidad de Chile

**Luz Fariña**

Universidad de Chile

## Management and Projects

**Susana Bustos**

Universidad de Chile

**María Isabel Guerra**

Universidad de Chile

## Data and Computing

**Francisca Muñoz**

Universidad de Chile

**Felipe Saavedra**

Universidad de Chile

**Paloma Pérez**

Universidad de Chile

**Nancy Valdebenito**

Universidad de Chile

**Matías Bravo**

Universidad de Chile

## Administrative Staff

**Cecilia Montecino**

Universidad de Chile

**Jimena Cortés**

Universidad de Chile

**Mabel Torres**

Universidad de Concepción

**Marcia Millas**

Universidad Austral de Chile

**Bellkys Castillo**

Universidad de Chile

**Mauricio Castro**

Universidad de Chile

**Miguel Aróstica**

Universidad de Chile

**Claudia Isla**

Universidad de Chile





Ph.D. Students

**Óscar Pesce**  
Universidad de Chile  
**Mónica Bello**  
Universidad de Chile  
**Federico Flores**  
Universidad de Chile  
**Ignacio Díaz Gálvez**  
Universidad Austral de Chile  
**Marco Aurelio Cortés**  
Universidad Austral de Chile  
**Mario Romero**  
Universidad Austral de Chile  
**Melisa Díaz Resquín**  
Universidad de Buenos Aires, Argentina  
**Priscilla Nowajewski**  
Universidad de Chile  
**Pilar Aparicio**  
Universidad de Valparaíso  
**Roy Mackenzie**  
Universidad Autónoma de Barcelona, España  
**María Estrella Alcamán**  
Pontificia Universidad Católica de Chile  
**Sergio Guajardo**  
Pontificia Universidad Católica de Chile  
**Noémi Kugler**  
Universidad de Chile  
**Gastón Sotes**  
Universidad de Concepción  
**Carolina Jara**  
Universidad Austral de Chile  
**Jose Ignacio Arroyo**  
Pontificia Universidad Católica de Chile  
**Santiago Ancapichún**  
Universidad de Concepción  
**Carla Henríquez**  
Universidad de Chile  
**Ángela Bustos**  
Universidad Austral de Chile  
**Andrea Leiva**  
Universidad Austral de Chile  
**Francisco Tello**  
Universidad Austral de Chile  
**Alejandro Miranda**  
Universidad Austral de Chile  
**Pilar Barría**  
Universidad de Chile  
**Sebastián Ruiz**  
Pontificia Universidad Católica de Chile  
**Marco Billi**  
Universidad de Chile

Master Students

**Cynthia Escares**  
Universidad de Concepción  
**Dharma Reyes-Macaya**  
Universidad de Concepción  
**Inger Daniel**  
Universidad de Concepción  
**Cristina Carrasco**  
Universidad de Concepción  
**Sandra Sanhueza**  
Universidad de Concepción  
**Cyntia Sanhueza**  
Pontificia Universidad Católica  
**Josefa Verdugo**  
Universidad de Concepción  
**Pamela Pizarro**  
Universidad de Chile  
**Javiera Videla**  
Universidad de Chile  
**William Henríquez**  
Universidad de Chile  
**Lucía Gonzaloren**  
Universidad de Chile  
**Carolina Morano**  
Universidad de Magallanes  
**Cristián Muñoz**  
Universidad de Chile  
**Carlos Ardissoni**  
Universidad de Chile  
**Mindy Fuentes**  
Universidad de Chile  
**Julio Hasbún**  
Universidad de Chile  
**Katy Indvik**  
Universidad de Chile  
**Denis Alegría**  
Universidad de Chile  
**Dana Jiménez**  
Universidad Austral de Chile  
**Joaquín Rivera**  
Universidad Austral de Chile  
**Néstor Burgos**  
Universidad Austral de Chile  
**Rodrigo Santander**  
Universidad Austral de Chile  
**Pilar Fierro**  
Universidad Austral de Chile  
**Romina Novoa**  
Universidad Austral de Chile  
**Claudio Bravo**  
Universidad de Chile  
**Andrea Orfanoy**  
Universidad de Chile

**Patricio Velázquez**  
Universidad de Chile  
**Adolfo Henríquez**  
Universidad de Chile  
**Amerindia Jaramillo**  
Universidad Austral de Chile  
**María Lorena Gonzalez**  
Universidad de Concepción  
**María Jesús Galvez**  
Universidad de Concepción  
**Alejandro Rangel**  
Universidad de Concepción  
**Victor Merino**  
Universidad de Concepción  
**Ricardo Konrad**  
Universidad de Chile  
**Fabián Pinto**  
Universidad de Chile  
**Enzo Simi**  
Universidad de Chile  
**Cristián Muñoz**  
Universidad de Chile  
**Sergio González**  
Universidad de Chile  
**Cristián Pino**  
Universidad de Chile  
**Camilo Barahona**  
Universidad de Chile  
**Susana Correa**  
Universidad de Chile  
**Hugo Pizana**  
Universidad de Chile  
**Cristián Parra**  
Universidad Austral de Chile  
**Ignacio Vera**  
Universidad Austral de Chile  
**Rinhard Fitzek**  
Universidad Austral de Chile  
**Matías Bravo**  
Universidad de Chile  
**Giovanni Testa**  
Universidad de Concepción  
**Macarena Troncoso**  
Universidad de Concepción  
**Sebastián García-Loyola**  
Universidad de Concepción  
**Valeria Moreno**  
Universidad de Chile  
**Fabiola Cid**  
Universidad de Chile  
**Juan Pedro Guerrero**  
Universidad de Chile

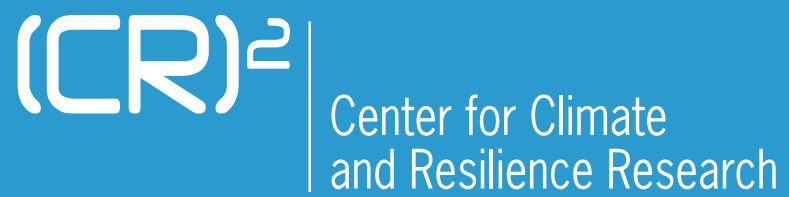
Master Students

**Andrés Ceballos**  
Universidad Austral de Chile  
**Constanza Becerra**  
Universidad Austral de Chile  
**Guillermo Barrientos**  
Universidad Austral de Chile  
**Waldo Iglesias**  
Universidad Austral de Chile  
**Lorenzo Palma**  
Universidad Austral de Chile  
**Humberto Bernasconi**  
Universidad del Biobío  
**Alice Junqueira**  
Universidad de Chile  
**Issa Ramos**  
Universidad de Chile  
**Marco Billi**  
Universidad de Chile  
**María Fernanda Rojas**  
Universidad Austral de Chile  
**Pamela Maldonado**  
Universidad de Chile  
**Benjamín del Favero**  
Universidad de Chile  
**Hernaldo Leyton**  
Universidad de Chile  
**María José Meneses**  
Universidad de Chile  
**Diego Campos**  
Universidad de Chile  
**Francisca Clemo**  
Universidad de Concepción  
**Heidy Correa**  
Universidad Austral de Chile  
**Lizette Bertín**  
Universidad Austral de Chile  
**Jorge Luis Guadalupe**  
Universidad Técnica  
Federico Santa María  
**Benjamín Trehwela**  
Universidad de Chile  
**Tomás Carrasco**  
Universidad de Chile  
**Daniela Latoja**  
Universidad de Chile  
**André Moreau**  
Universidad de Chile  
**Felipe Velden**  
Universidad de Chile

Undergraduate Students


**Valentina Besaoin**  
Pontificia Universidad Católica  
de Valparaíso  
**Lenin San Martín**  
Universidad de Concepción  
**Gustavo Contreras**  
Universidad de Concepción  
**Víctor Merino**  
Universidad de Concepción  
**Gonzalo Duarte**  
Universidad Austral de Chile  
**Paulina Montory**  
Universidad Austral de Chile  
**Miguel Pelayo**  
Universidad de Chile  
**Daniela Rodríguez**  
Universidad Austral de Chile  
**Ignacio Díaz**  
Universidad Austral de Chile  
**Ignacio Vera**  
Universidad Austral de Chile  
**Karla Leal**  
Universidad Austral de Chile  
**Pía Leiva**  
Universidad Austral de Chile  
**Víctor Elgueta**  
Universidad Austral de Chile  
**Mauricio Montiel**  
Universidad Austral de Chile  
**Consuelo Martínez**  
Universidad de Concepción  
**Sebastián García-Loyola**  
Universidad de Concepción  
**Sebastián Espinoza**  
Pontificia Universidad Católica  
de Chile  
**Jaime Alcorta**  
Pontificia Universidad Católica  
de Chile  
**Felipe Flores**  
Universidad Austral de Chile  
**David Jaramillo**  
Universidad Austral de Chile  
**Ivo Balic**  
Universidad de Chile  
**Marcela Vidal**  
Universidad de Chile  
**Camila Carrasco**  
Universidad de Chile  
**Gabriel Araya**  
Universidad de Chile


**Aníbal Acevedo**  
Universidad de Chile  
**Patricia González**  
Universidad de Chile  
**Pilar Muñoz**  
Universidad de Chile  
**Yasna Salazar**  
Universidad Austral de Chile  
**Andrés Palma**  
Universidad Austral de Chile  
**Yalila Aguad**  
Universidad del Biobío  
**Camila Barrientos**  
Universidad del Biobío  
**Camila Espinoza**  
Universidad del Biobío  
**Manuel Jesús Rojas**  
Universidad de Tarapacá  
**Pablo Ugalde**  
Pontificia Universidad Católica  
de Chile  
**Pilar García**  
Pontificia Universidad Católica  
de Chile  
**Cristóbal Puelma**  
Universidad Austral de Chile  
**Andrés Ceballos**  
Universidad Austral de Chile  
**Benjamín Sotomayor**  
Universidad de Chile  
**Marcos Buchi**  
Universidad Austral de Chile  
**Carolina Quijada**  
Universidad Austral de Chile  
**José Alejandro Sobarzo**  
Universidad Austral de Chile  
**Felipe Toledo**  
Universidad de Chile  
**Estrella Bello**  
Universidad de Concepción  
**Thiare Ceballos**  
Universidad Nacional Andrés Bello  
**Carolina Valdés**  
Universidad de Chile  
**Paulina Riquelme**  
Universidad de Chile  
**Marcelo Godoy**  
Universidad de Valparaíso  
**Danilo Cáceres**  
Universidad del Biobío  
**Constanza Mondaca**  
Universidad del Biobío




 [www.cr2.cl](http://www.cr2.cl)

 [@cr2\\_uchile](https://twitter.com/cr2_uchile)

 [/cr2uchile](https://facebook.com/cr2uchile)

 (+56) 22 978 4446

 [comunicaciones.cr2@dgf.uchile.cl](mailto:comunicaciones.cr2@dgf.uchile.cl)

 Blanco Encalada 2002. 4th floor  
FCFM. Universidad de Chile.  
Santiago, Chile.