



PISAC

Pollution and its Impact on the
South American Cryosphere



Andes

The Andes is the longest continental mountain range in the world.

- 7,000 km long, ~ 200 km to 700 km wide, average height of ~ 4,000 m.

- The Andes extend from north to south through seven South American countries: Argentina, Bolivia, Chile, Colombia, Ecuador, Peru, and Venezuela
- Complex topography, covering several climate zones, diversity of ecosystems and communities.
- A variety of sources emitted along the Andes, with varied cultural and behavioral aspects.



**Aconcagua, Argentina
(6962 m)**

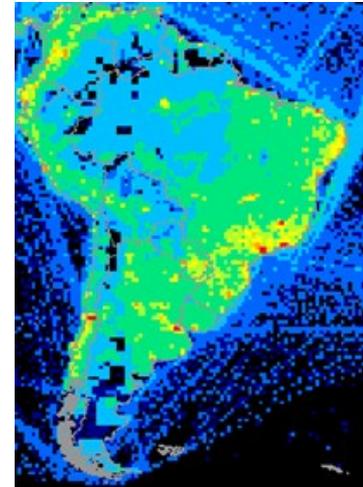
**Andes
composite
satellite Image**

PISAC Objective

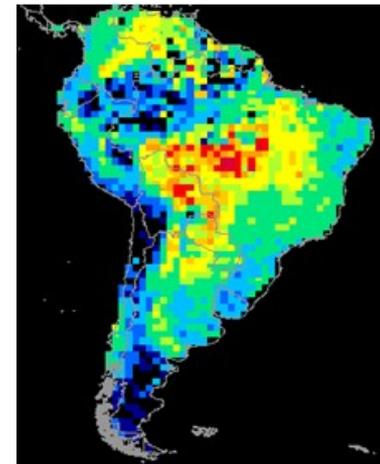
The overall goal of the PISAC initiative is to investigate **key sources and impacts of black carbon** and co-emitted pollutants in the Andean and Patagonian regions aiming at **designing research activities** and observation sites to close knowledge gaps and **policy options** to address **mitigation** for near-term climate protection and air quality improvement.

Motivation

- Water needs to support a growing population in South America
- Andean snow packs and glaciers have been diminishing in the past 50 years
- BC studies in other regions (Himalayas, Arctic) have shown that BC can contribute to the receding of glaciers and snow packs



Anthropogenic BC emissions (ACCMIP, 2000)



Biomass burning BC emissions (ACCMIP, 2000)

Science / Policy Questions

- What are the factors influencing the glacier retreat in the Andean region (Temperature? Precipitation? Aerosols? ...)
- Is there any evidence of anthropogenic sources affecting glacier retreat and snow melt in the Andean cryosphere? May this change over time?
- What sectors contribute to BC and co-pollutants?
- Has the glacier retreat already led to changes in water availability? Which curbing measures are in place?
- What mitigation measures can be implemented in the Andean region?
- Can efforts to reduce BC and co-pollutant emissions influence the future development of Andean glaciers?

Emissions

- Many sources of emissions
 - Wildfires, biomass burning (natural and agriculture)
 - Urban emissions: mobile sources (on-road, off-road, ships, aircrafts)
 - Other sources: volcanoes
- The only information available on BC emission in South America is the global inventories, e.g., Emissions of atmospheric Compounds & Compilation of Ancillary Data (ECCAD)



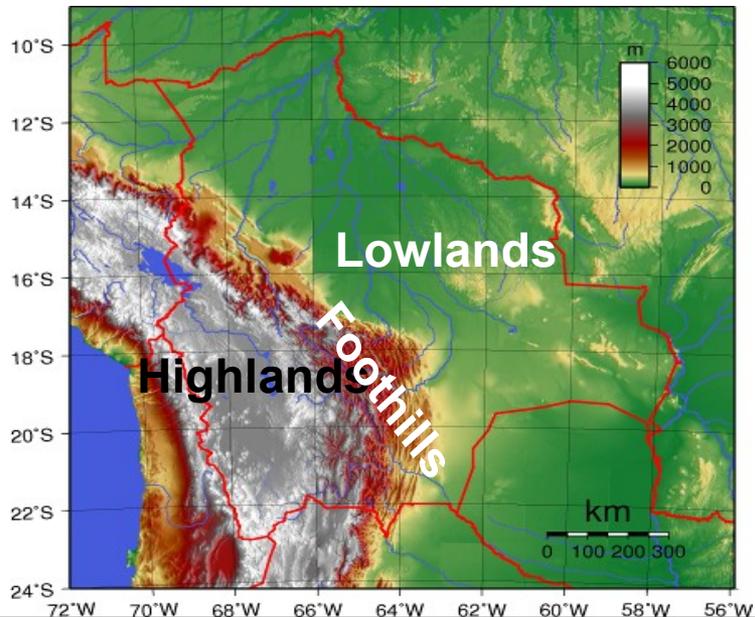
- Need measurements to improve emissions inventory for South America, in particular the regions surrounding the Andes
- Ultimate goal: Emission inventory with spatial and temporal distribution.

Measurement Sites and Monitoring Stations

- Measurements are needed for validation of emissions inventories, atmospheric processes, chemical transport and climate models.
- Set up a central laboratory, but every country should have its own laboratory.
- More sophisticated monitoring stations are necessary. Every country should have a monitoring station such as the Bolivian GAW station with *in-situ* and remote sensors that can measure properties of BC and dust in clouds and cloud-free air.
- Alternative option: Using a lot of cheap stations with good spatial coverage for monitoring trends and transport
- Samples can be taken by volunteers like the American Climber Science Program, after appropriate training, or during field campaigns that target specific regions and time periods.
- Linking measurements of pollutants in the Andean region with population health, water availability and quality, food security.

GAW/CHC Chacaltaya Station, Bolivia

(5240 m asl)



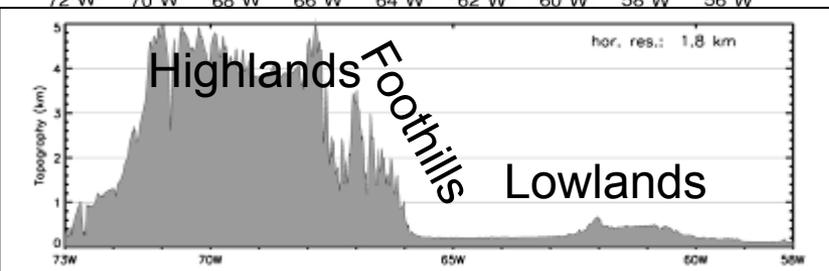
Bolivia

- 10 M inhabitants
- 1 M sq. km
- Complex topography
- Three distinct climate zones



High-altitude GAW station (Dec 2011)

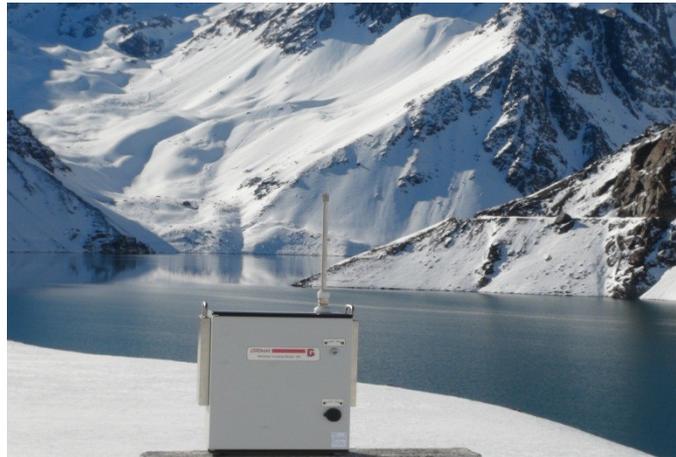
- Aerosols properties as well as gas concentrations are measured .
- Observations show a clear signal during biomass burning season
- In the long term, the LFA expects to maintain a regional station measuring mainly both gases and aerosols



*Credit: Marcos Andrade
Laboratorio de Física de la Atmósfera (LFA)
Universidad Mayor de San Andrés, Bolivia*

Glaciers Monitoring

Objective: to evaluate the impact of pollution transport towards Andes glacier and its influence on climate change and water reserves in Chile through the study of snow and aerosol samples collected in sampling campaigns longitudinally across the Andes.



(Credit: F. Cereceda, USC, Chile)

American Climber Science Program

All volunteer citizen driven science program.
Scientists and non-scientist (climbers) participate in research expeditions.
Climbers help scientists with data collection in the mountains and valleys.
Sampling protocols are designed to be simple so that they can be completed in the field under challenging conditions.
ACSP sampling techniques have been shown to be well correlated with the state of the art instrumentation.

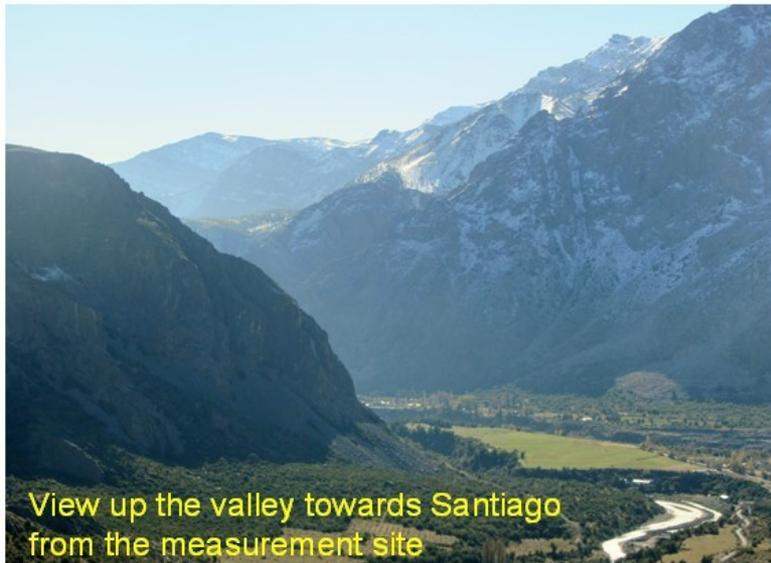


(Credit: C. Schmitt, NCAR, USA)

The Pollution Impact on Snow in the Cordillera-Experiments and Simulations (PISCES)

Goal: to test the hypothesis: “The increase in concentrations of aerosol particles in the atmosphere over the Andes have made a significant contribution to the receding cryosphere in that region.”

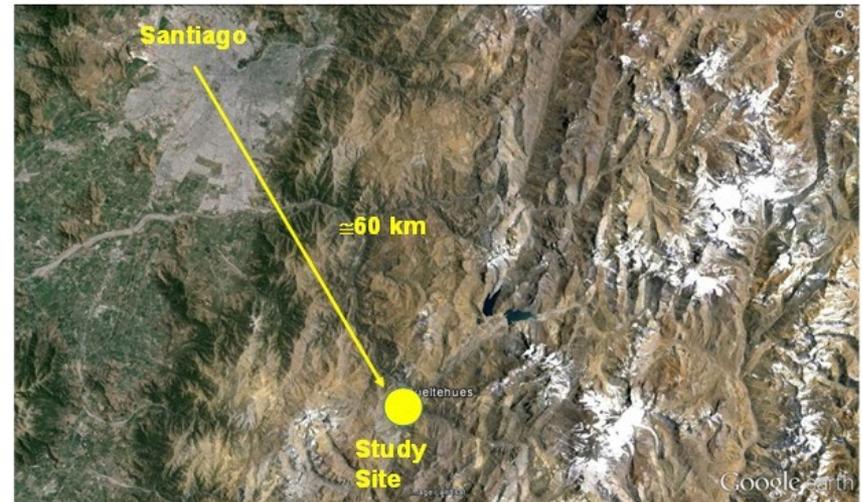
Field Campaign:
from September 8 to October 15, 2014



This photo from the measurement site shows the haze produced by pollution from Santiago.

Location of measurement site:

Up the Maipo Valley at a
hydro-electrical plant at Queltehues
1500 m amsl



This Google map image shows the distance from the measurement site to the city of Santiago and surrounding topography.

Modeling

Modeling objectives

- Better understand the atmospheric processes, pollutant transport and deposition in the Andean region.
- Evaluate land-use changes
- Produce scenarios for decision makers addressing the following:
 - What are the potential impacts of the BC emissions and co-pollutants on the Andean cryosphere?
 - What are the impacts on the population health and the environment as well as economic cost?
- Conduct cost-benefit analysis of potential mitigation measures.

Conclusions

<http://www.mce2.org/activities/pisac>

- White paper on the impact of black carbon and co-pollutants on the Andean cryosphere
 - Also address urban emissions and impacts, SLCPs, water security, health, land use
- Several proposals and measuring campaigns already submitted / initiated
- MoU with WMO/GAW program on measurement standards, data sharing, collaborations
- Challenges:
 - Lack of emissions data
 - Limited monitoring stations
 - Inadequate human resources (technical expertise) in some regions
 - Insufficient financial resources
- Open to ideas and collaborations!
 - Post-docs, PhD theses
 - Sample collection and monitoring methods