Recent studies in Chile

Andrés Rivera and the CECs team

Laboratorio de Glaciología y Cambio Climático
Centro de Estudios Científicos (CECs), Valdivia

Key questions

- Are the observed climatic changes an expression of the natural variability and/or a response to human influence?
- How are the glaciers responding to those climatic changes?
- Could be possible to predict/mitigate/manage the consequences of the glacier responses?
- Are we providing necessary data for decision makers?

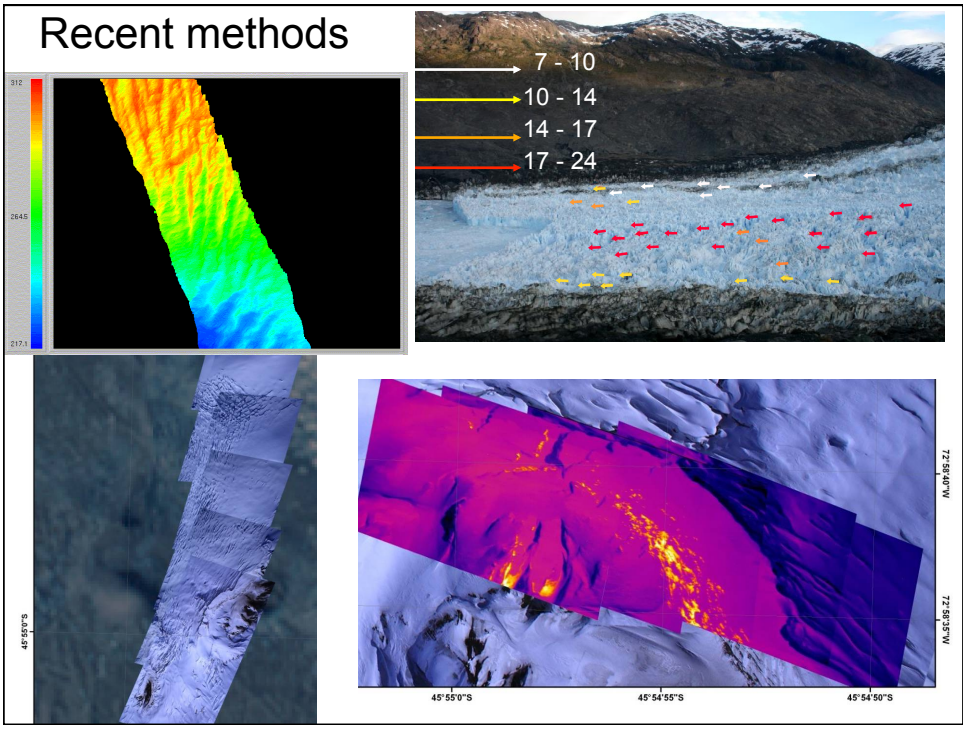
Main glaciological research problems in Chile

- Scarce and poor availability of field data
- Lack of several accurate glacier parameters
- Limited budgets for software/hardware/data/ training/monitoring
- Inefficient and bureaucratic data distribution among national institutions
- Reduced collaboration between scientists and institutions
- Lack of common aims and policy
- Few systematic monitoring programs

State of art

- Glacier inventory
  - A few thousands inventoried glaciers
  - Total inventoried area: near 20000 km^2
  - Estimated non inventoried area: 4000 km^2 mainly in Patagonia
- Frontal and volumetric changes
  - More than 150 studied glaciers. The great majority are retreating and thinning. Only three glaciers advanced in recent years, all in Patagonia
- Applied geophysics
  - LIDAR of more than 30 glaciers.
  - RES (ground and airborne) of more than 50 glaciers
  - Sonar/calving studies of more than 5 glaciers
  - Remote sensing, GPS, Fixed cameras, AWS's, ice coring, modelling, runoff.

Recent methods



Main Chilean glacier zones

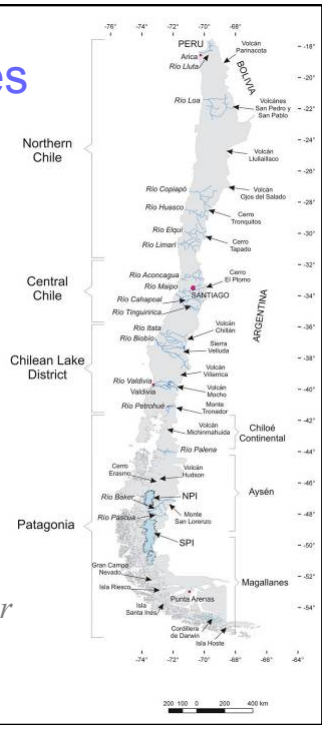
- *North: Retreating and disappearing*

  (mining activities)
- *Central: Retreating and thinning*

  (mining, touristic, water supply and energy activities)
- *Lake District: Retreating and thinning*

  (volcanic related variations)
- *Patagonia: Retreating and thinning with several exceptions (calving glaciers) and an important dynamic component in the behavior of the glaciers*

  (Touristic and energy activities)



Southern Patagonian Icefield

- **350 km N-S & 80-15 km E-W, 48 main basins**
- **40% are tidewater glaciers, all retreating but three (Pío XI, Moreno, Trinidad)**
- **Generalized glacier front retreats and area changes (>800 km^2 1945-2010)**
- **Several glaciers are retreating at very strong rates because they are calving into deep fjords and lakes (Jorge Montt, O'Higgins, Upsala)**
- **Warming at 850 hPa has been 0.5 °C over the 40 years, resulting in:**
    i. **shifted from snow to rain ~5% of the precipitation, the total of which has changed little**
    ii. **increased annual melt in the ablation areas by ~0.5 m w.e. (Rasmussen et al, 2007)**

Chilean contribution to sea level rise 1975-2005:

Chilean glaciers	Area km^2	%	Contribution to sea level rise mm a^{-1}	%	Sources
Patagonian icefields	13612	2.6	(0.032± 0.013)	5.1	Rivera et al 2002
			0.041 ± 0.016		Rivera et al, 2007
Rest of Chile	6547	1.25	(0.009± 0.002)	2.6	Rivera et al 2002
			0.021 ± 0.008		Rivera et al, 2007
Global glacier area	525000	100	0.8 ± 0.2	100	IPCC y UNEP 2007

Chilean glaciers contribution to sea level rise is exceeding higher estimated rates

Conclusions

- Chilean glaciers are severely affected by ongoing global climate change. However, Chilean regional characteristics of temperature and precipitation changes is not necessarily as strong as global rates.
- Most of Chilean glaciers have experienced negative mass balances, frontal retreats and high thinning rates, in response to climatic changes.
- *Not all glaciers are good indicators of climatic changes, since there are several "anomalies" or dynamic responses, especially in Patagonia and in some volcanoes*
- The strong glacier retreat and thinning seems to be accelerating in recent decades
- There is a need of systematic monitoring programs, especially in Patagonia.

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