# Deposition of the 2011 Cordón Caulle tephra (Chile, 40ºS) in lake sediments: Implications for tephrochronology and volcanology

Sebastien Bertrand [1], Romina Daga [2],
Robin Bedert [1], Karen Fontijn [1,3]

[1] Ghent University, Belgium
[2] Centro Atomico Bariloche, Argentina
[3] University of Oxford, UK

UNIVERSITEIT GENT

*Photo: Eduardo Mora - CONAF - Chile*

**Rationale**

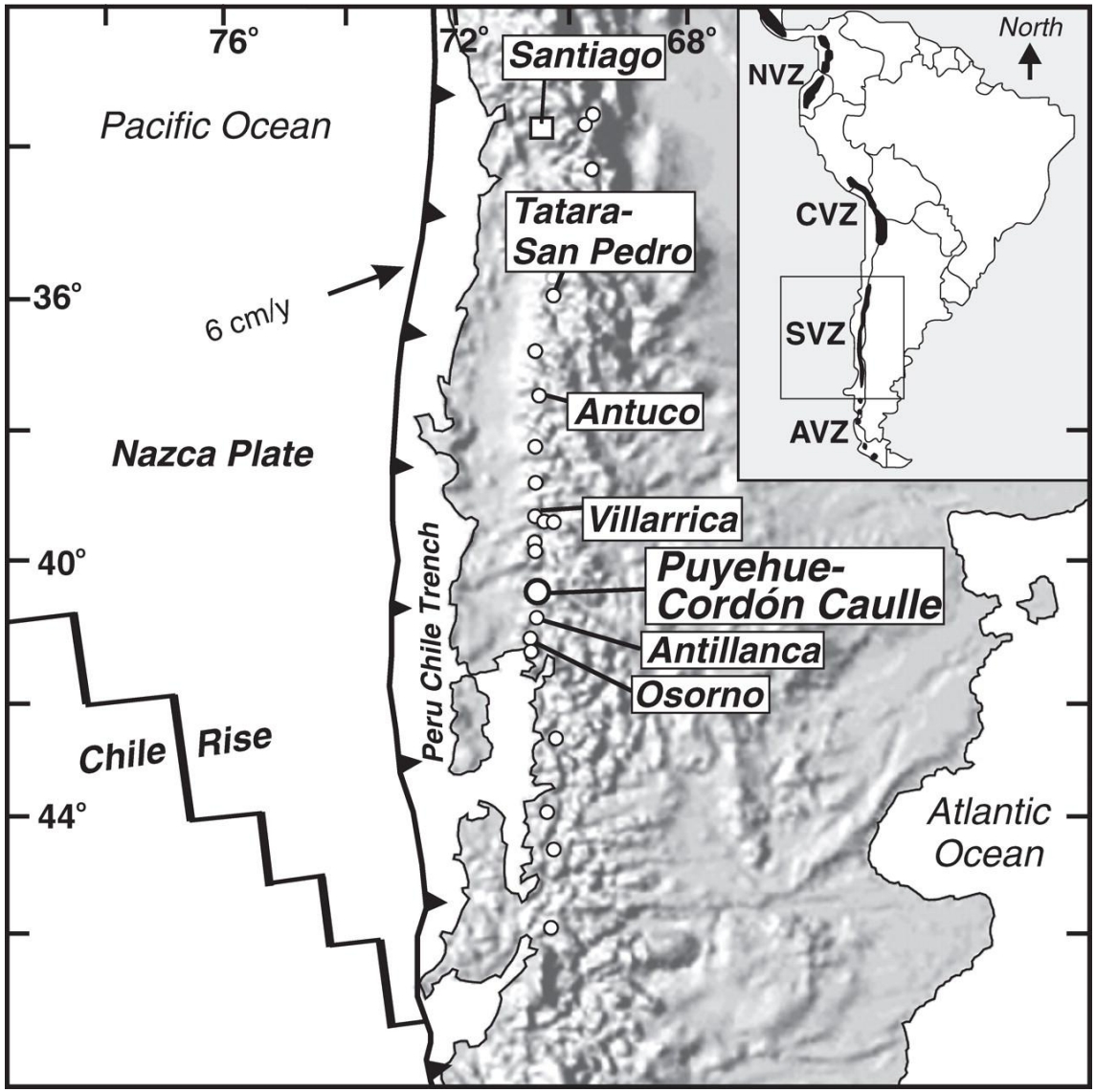
Tephras preserved in lake sediments

- Commonly used to synchronize sedimentary archives of climate and environmental change
- Correlate lake sediment archives with terrestrial environments
- Provide an opportunity to reconstruct explosive volcanic activity, e.g., eruption frequency and tephra dispersal (better preservation than in terrestrial environments)


Lake sediments are generally considered as one of the best archives of tephra stratigraphy but … sedimentary processes may affect the record of tephras in lakes.


The 2011 Cordón Caulle eruption

# The Puyehue-Cordón Caulle Volcanic Complex (PCCVC) – Southern Volcanic Zone of Chile




*Singer et al., 2008*

PCCVC

Numerous explosive eruptions during the Holocene

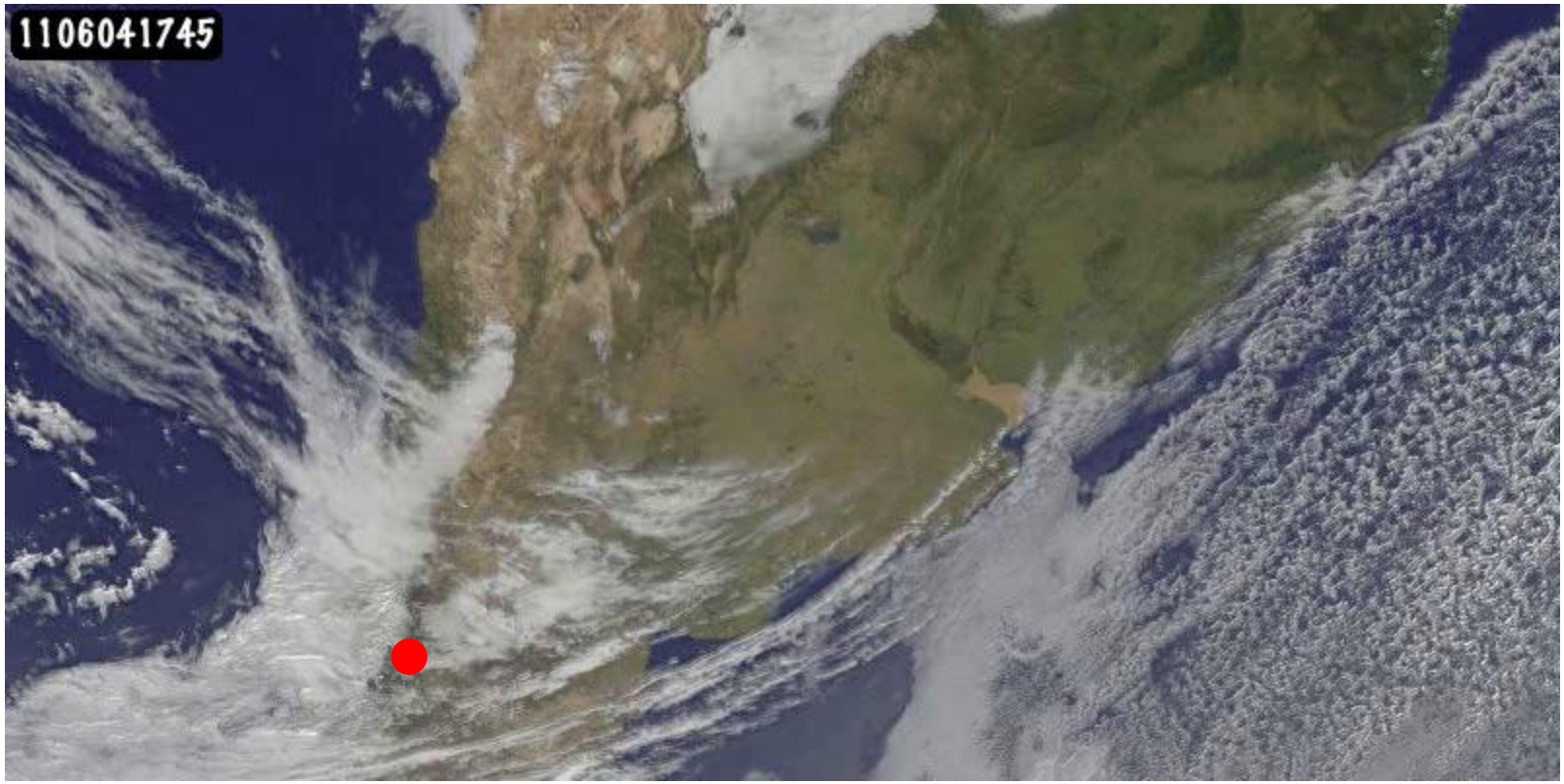
Previous historical eruptions: 1921-22, 1960

Located in a region rich in lakes (Chilean Lake District)

→ Ideal opportunity to investigate how volcanic eruptions are recorded in lake sediments.


Eruption started
on June 4, 2011
Puyehue-Cordón Caulle
N
20 km

# The 2011 CC eruption – June 4-6

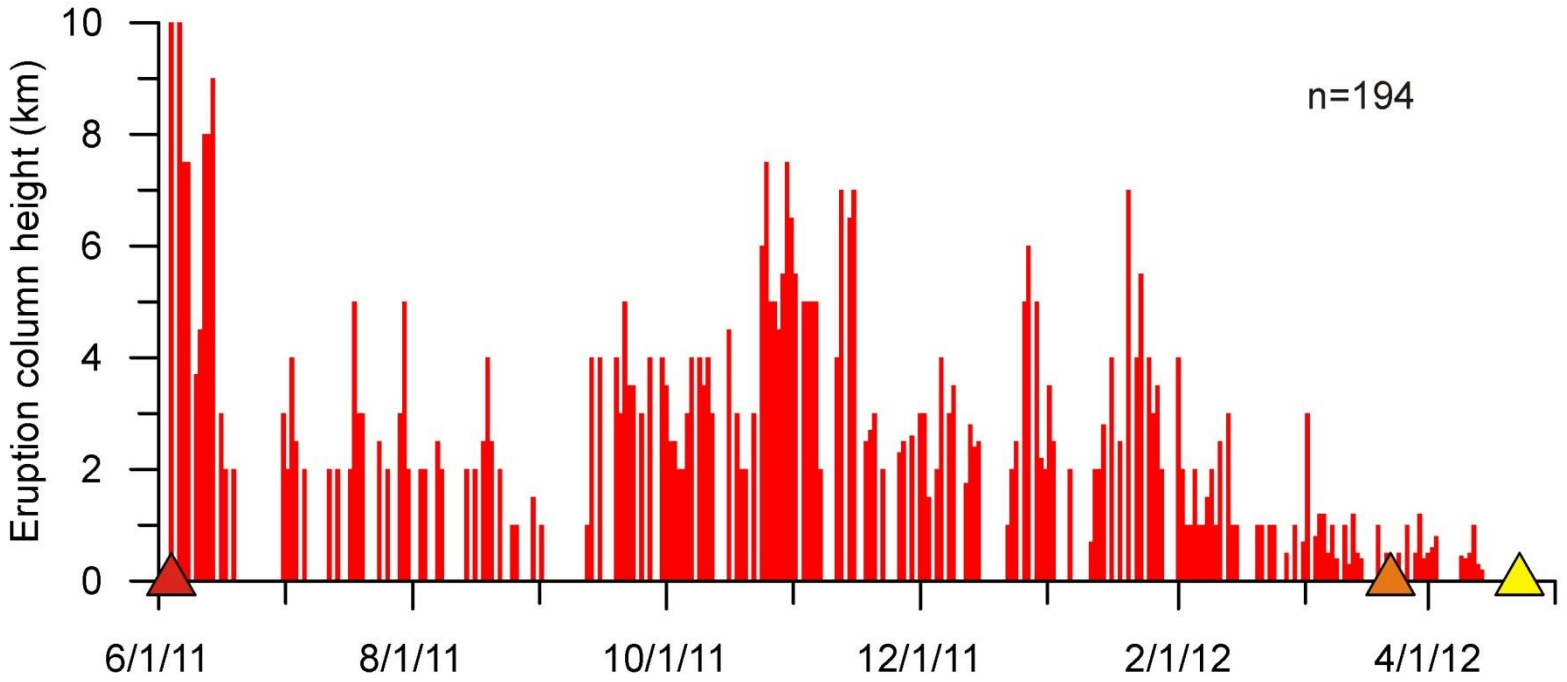



*PCCVC ash plume June 4-6*
*NASA/NOAA GOES and MODIS*

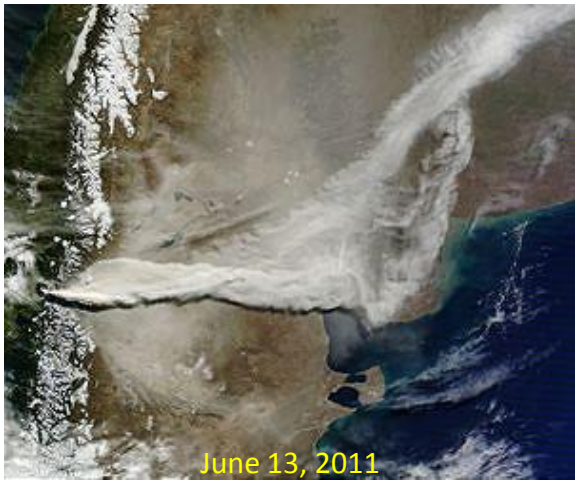
*V. La Angostura, 45 km to the SE of PCCVC*

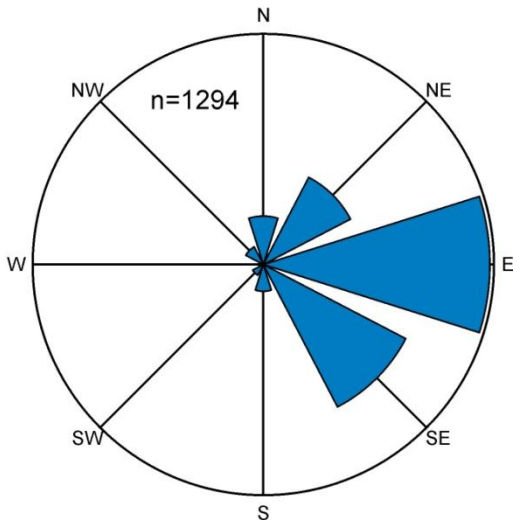

*Paso Cardenal Samore, 20 km to the SE of PCCVC*
*June 6, 2011*

# The 2011 CC eruption – duration and wind direction

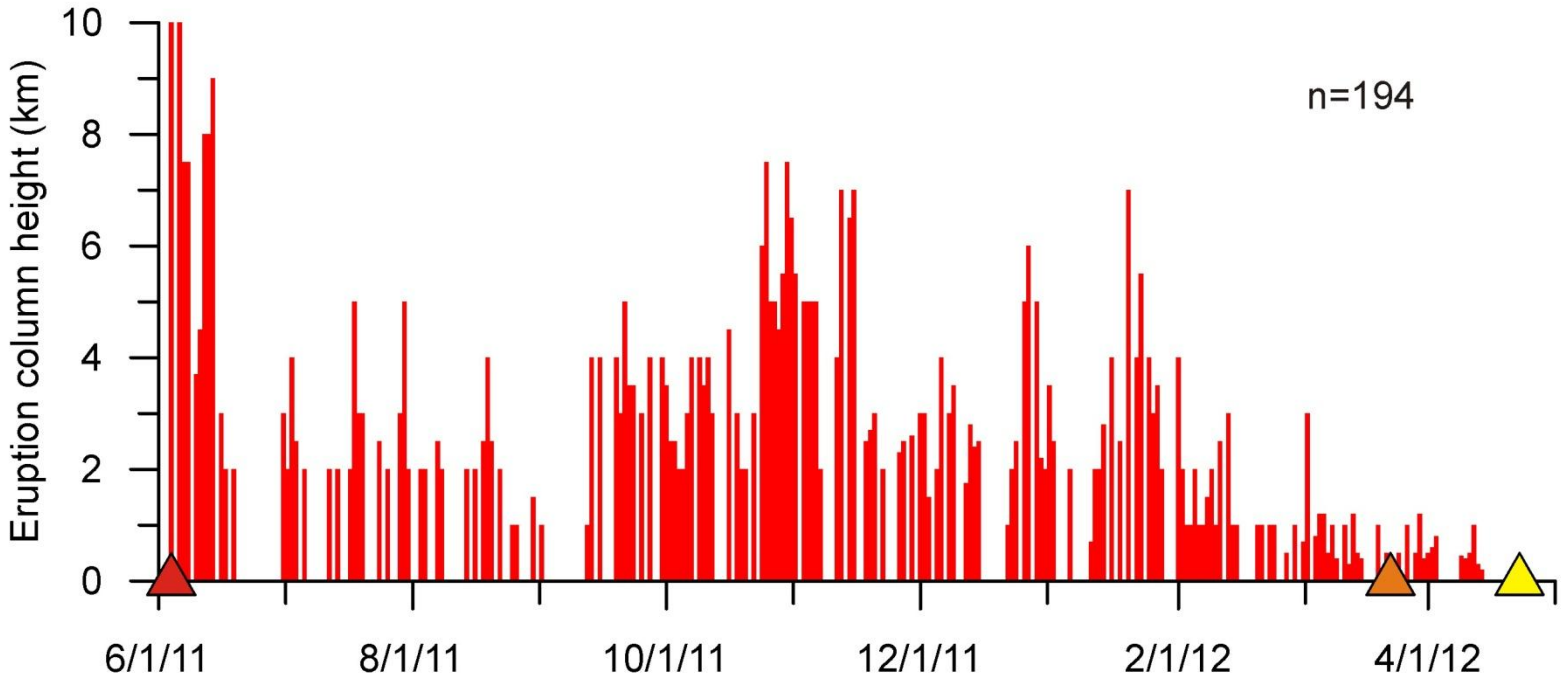


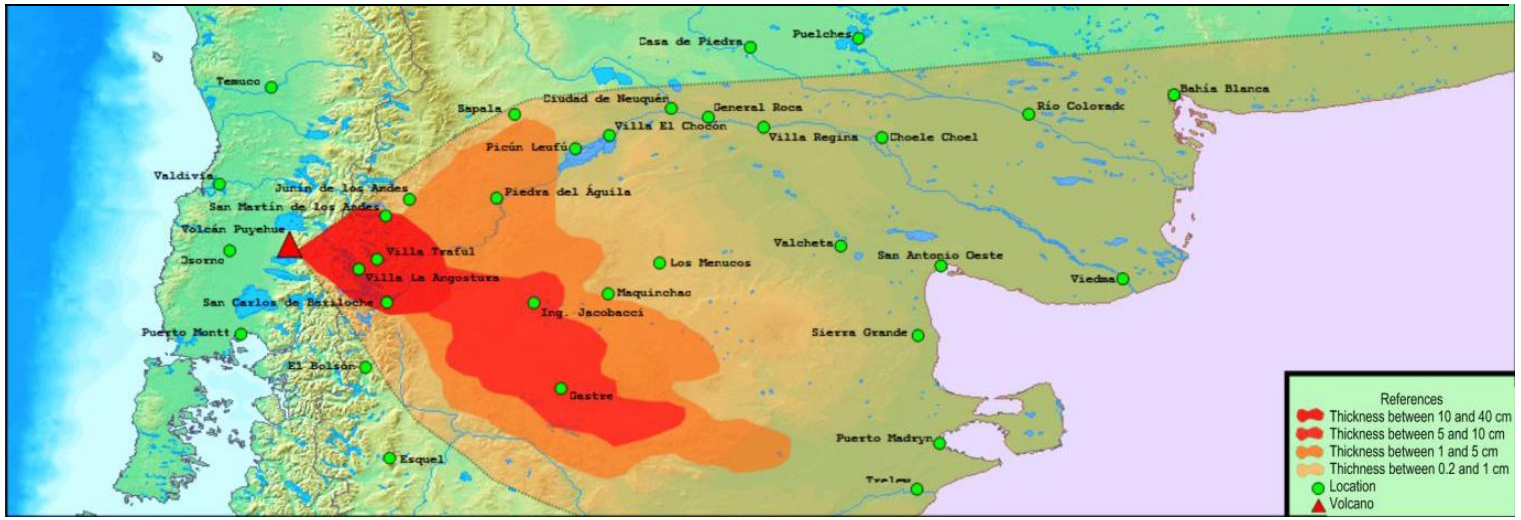




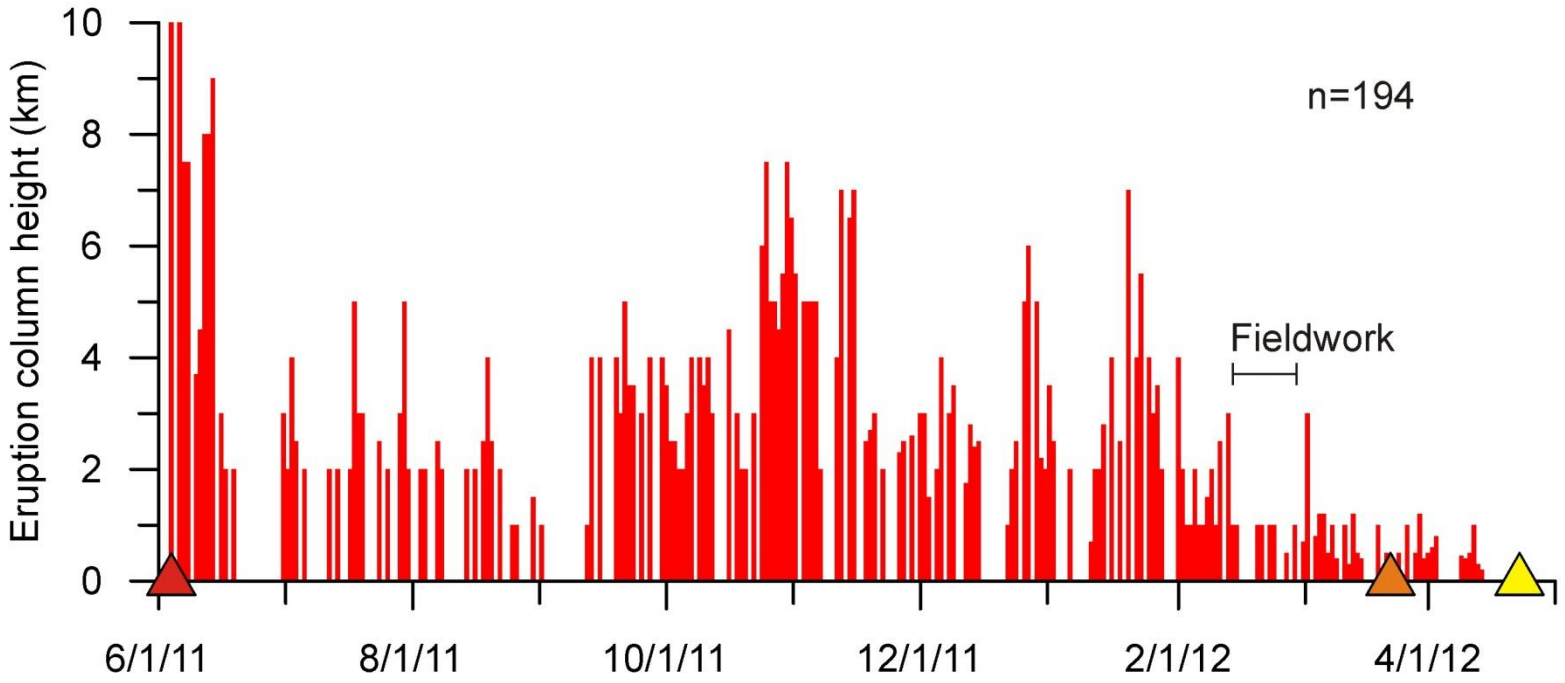



# The 2011 CC eruption – duration and wind direction



## The 2011 CC eruption – duration and wind direction

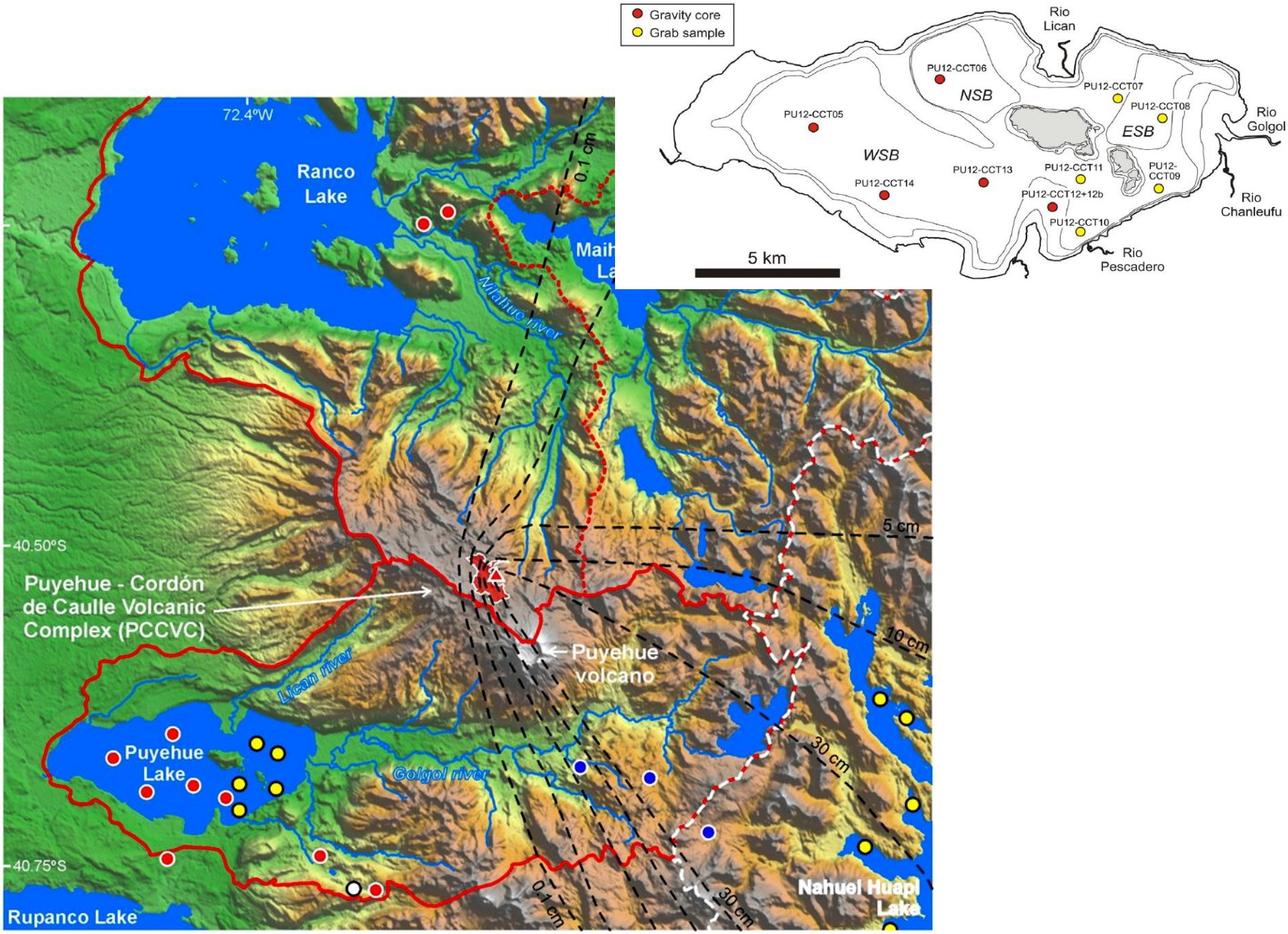



- Fieldwork: Understand how a modern volcanic eruption is recorded in lake sediments

# The 2011 CC eruption – fieldwork in January 2012

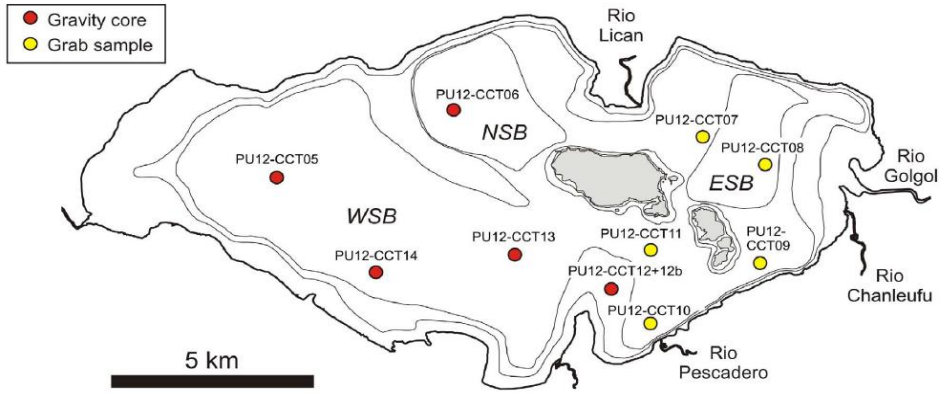
- 35 sites were sampled (18 in Chile and 17 in Argentina)
- Mostly short gravity cores


# Puyehue Lake



# Puyehue Lake

- 2011 tephra found in all cores
- Variable thickness

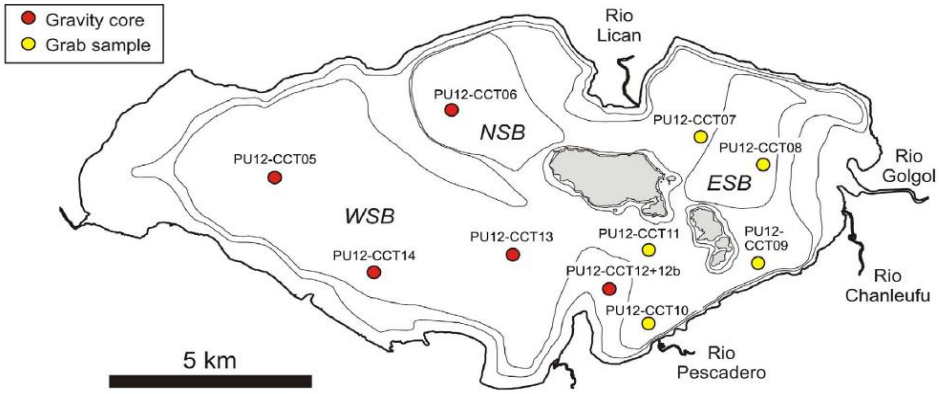



**Thin (~ 1 cm)**

**Thick (> 10 cm)**

# Puyehue Lake

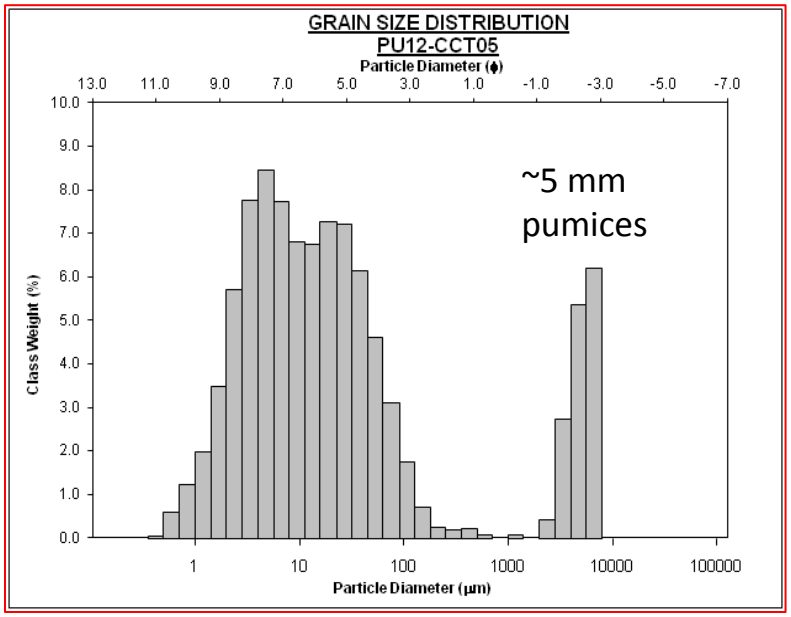
- 2011 tephra found in all cores
- Variable thickness
- Variable grain-size



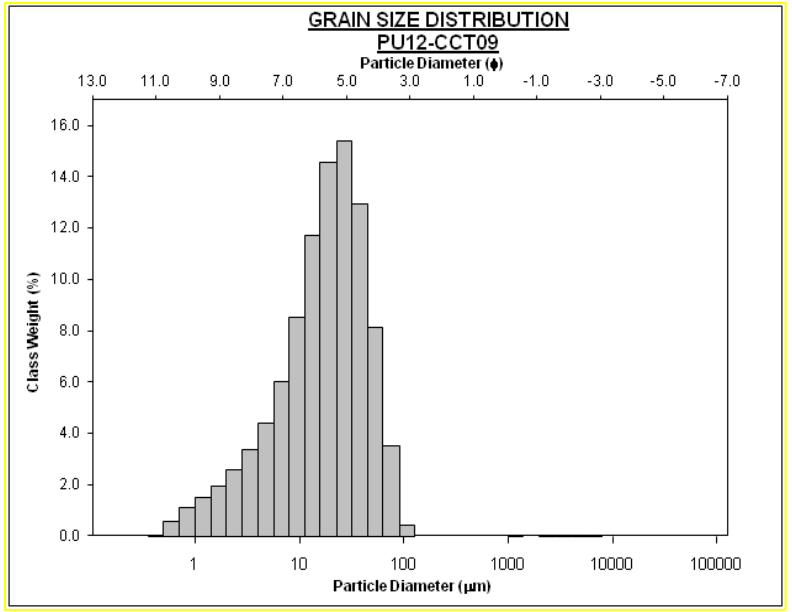

**Thin (~ 1 cm)**

**Thick (> 10 cm)**

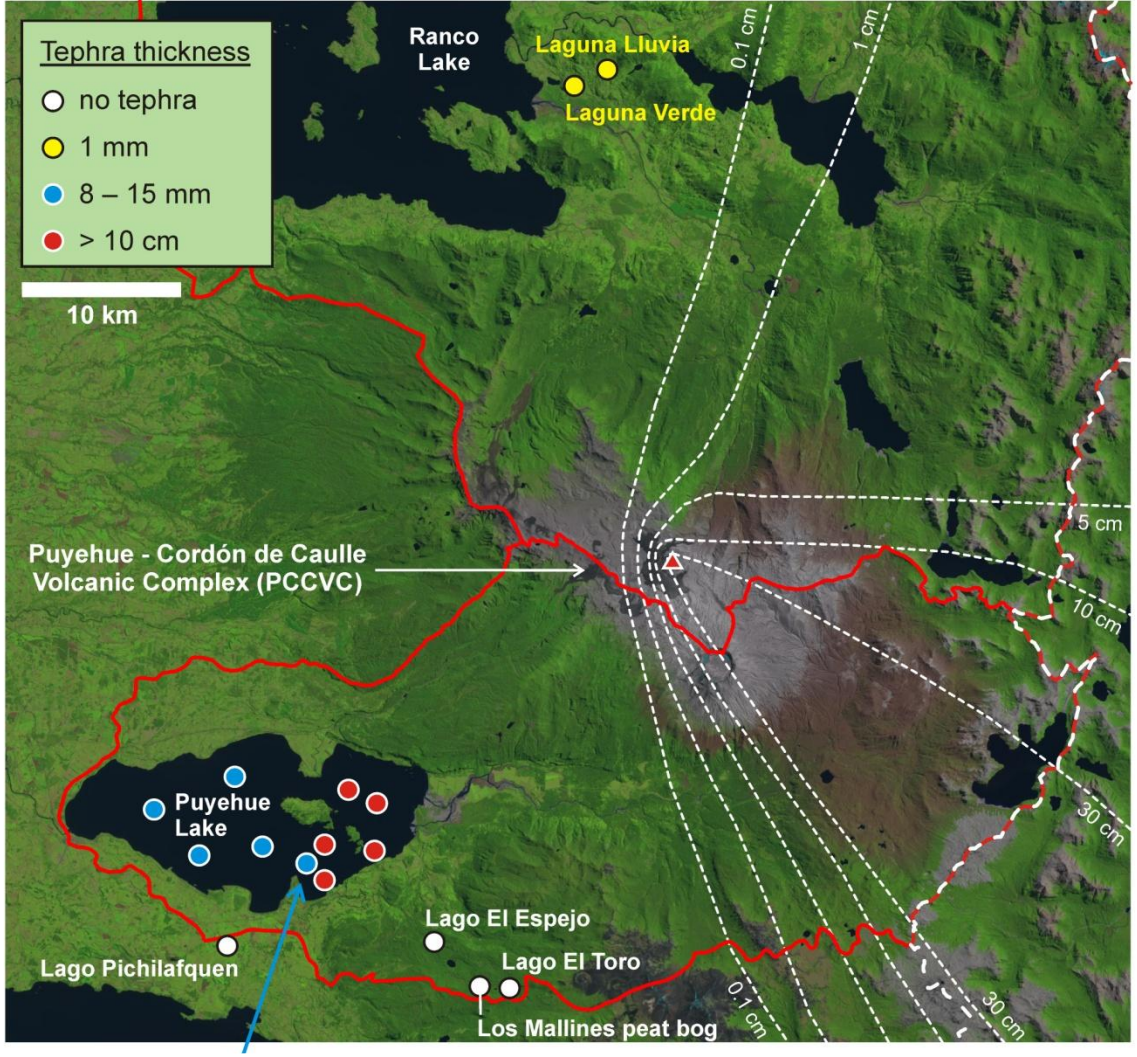
Bi- or tri-modal, ~5-20 µm and 5 mm



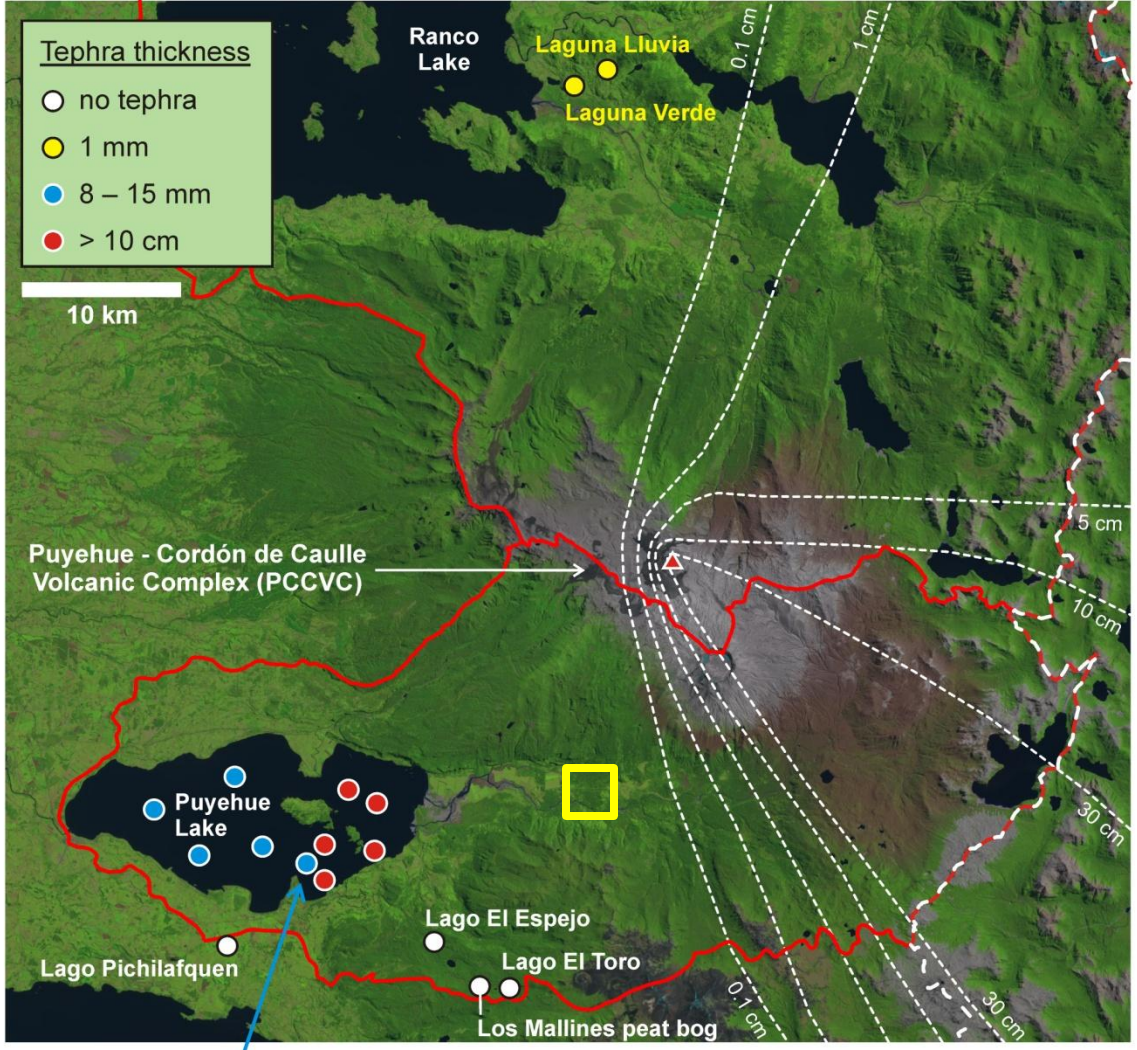

Unimodal, ~ 30 µm



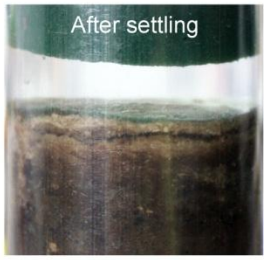
## Comparison with other lakes



## Comparison with other lakes



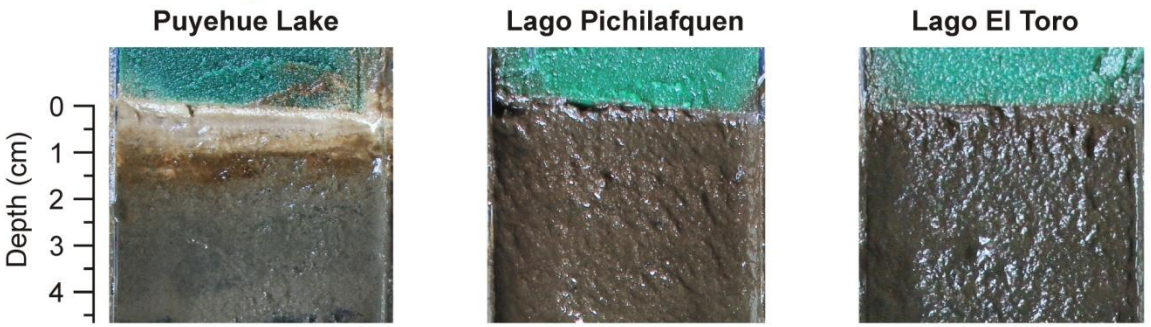





1 mm thick tephra

North of PCCVC

South of PCCVC



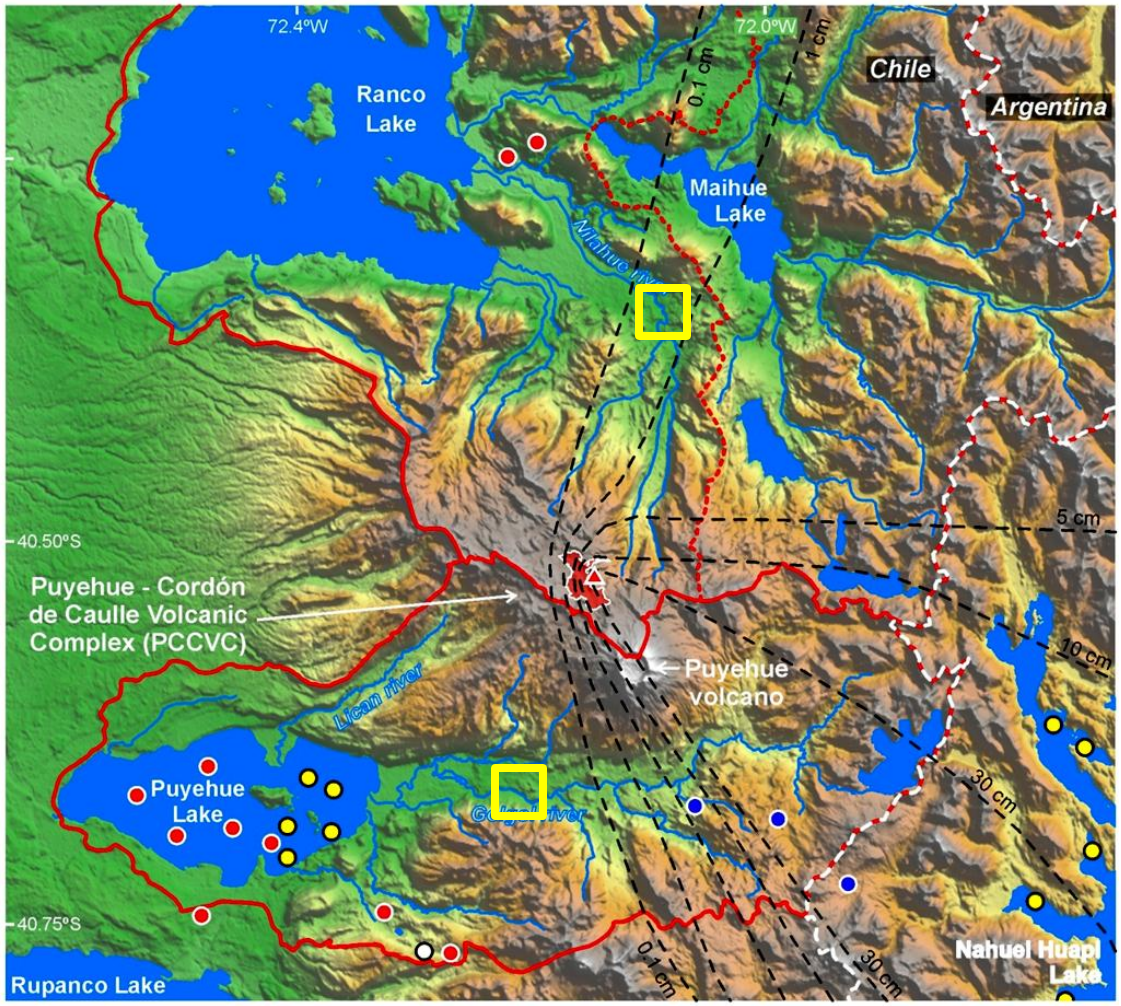

10 mm thick tephra

no tephra

no tephra


Rio Golgol, flowing towards
Lago Puyehue
7 15:07
Photo: Eduardo Mora - CONAF - Chile

# Comparison with other lakes




# Comparison with other lakes

*Rio Nilahue, flowing towards Lago Ranco*

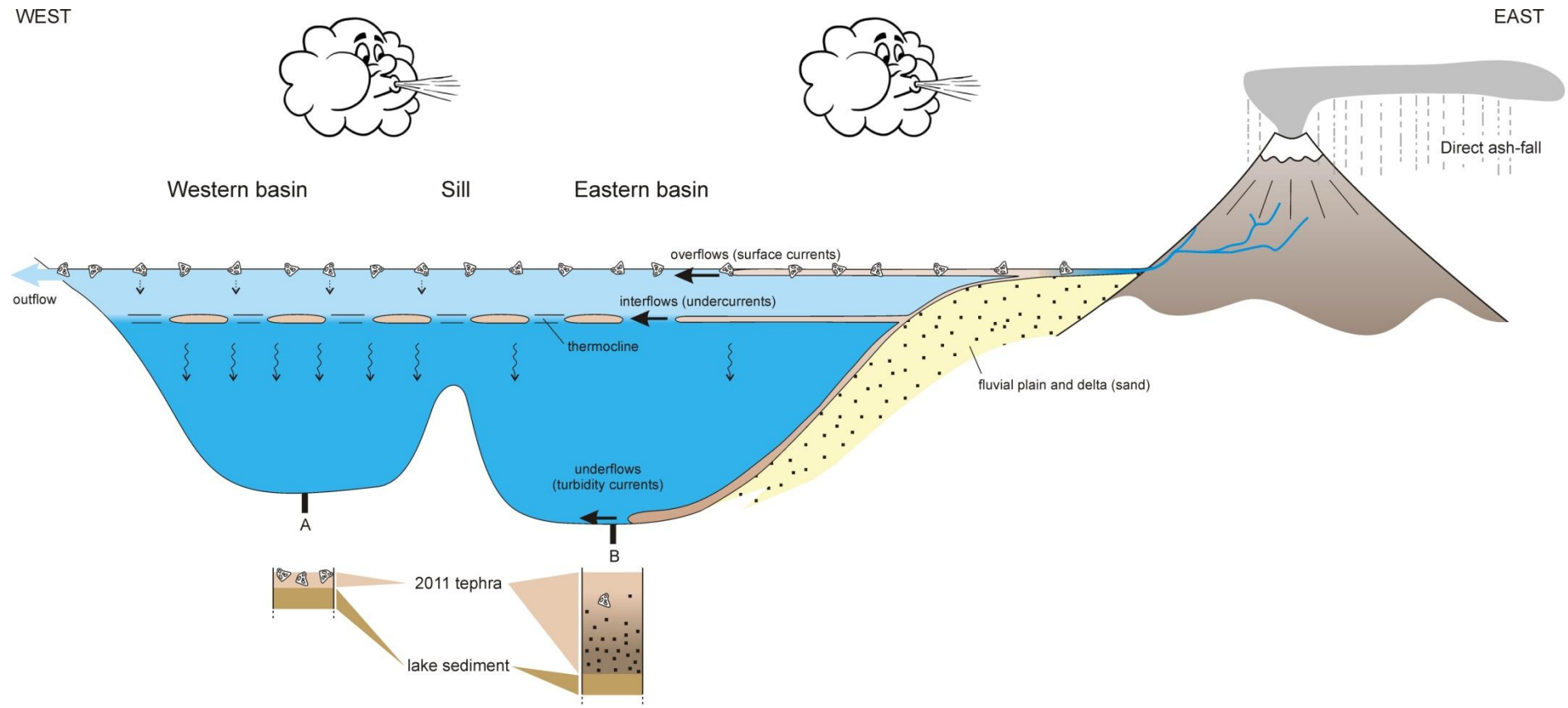
ABC News June 9, 2011


Lago Ranco, no direct ash fall!

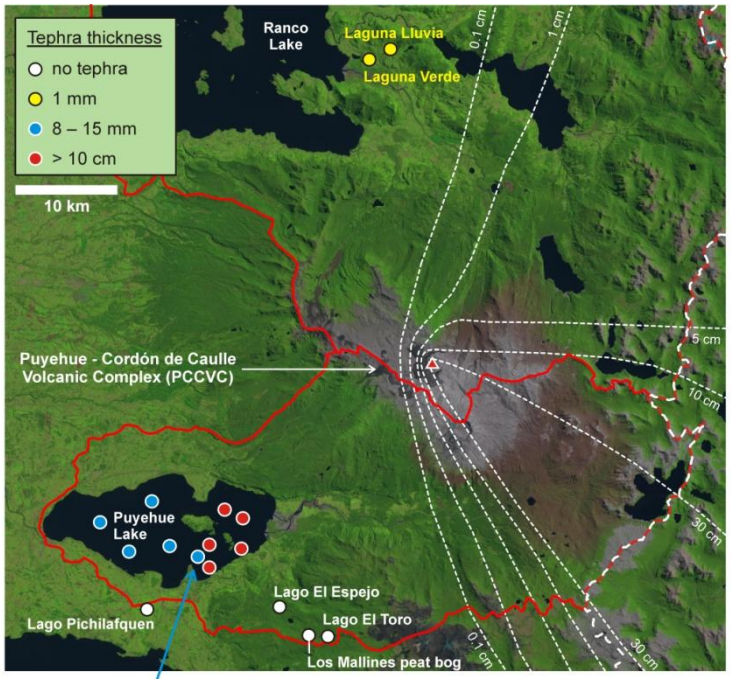
## Sedimentary processes

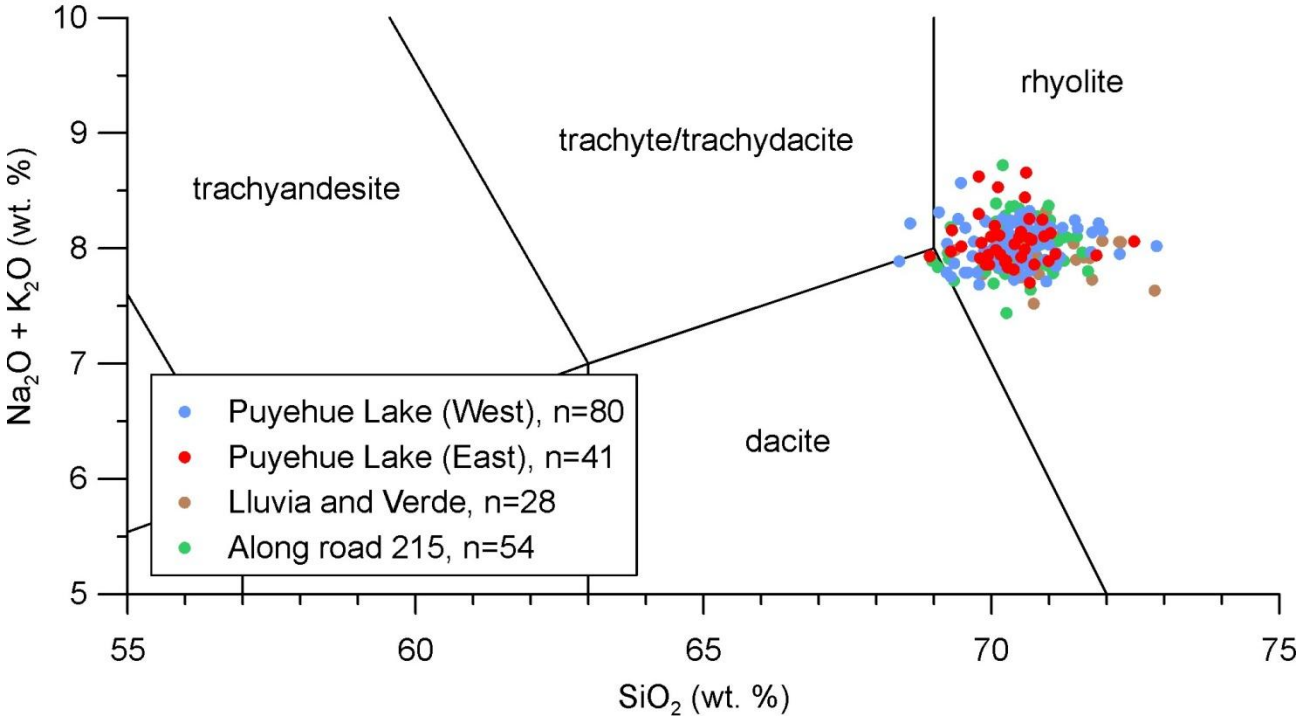
Tephra deposited in Puyehue Lake entirely consists of material reworked from the upper watershed, transported by rivers, and distributed by lake currents according to particle size and density

- Proximal basins: mostly coarse tephra particles via underflows
- Distal basins: low amounts of fine-grained particles transported by interflows
- Pumice transported by overflows reached most lake basins



# Glass shard geochemistry

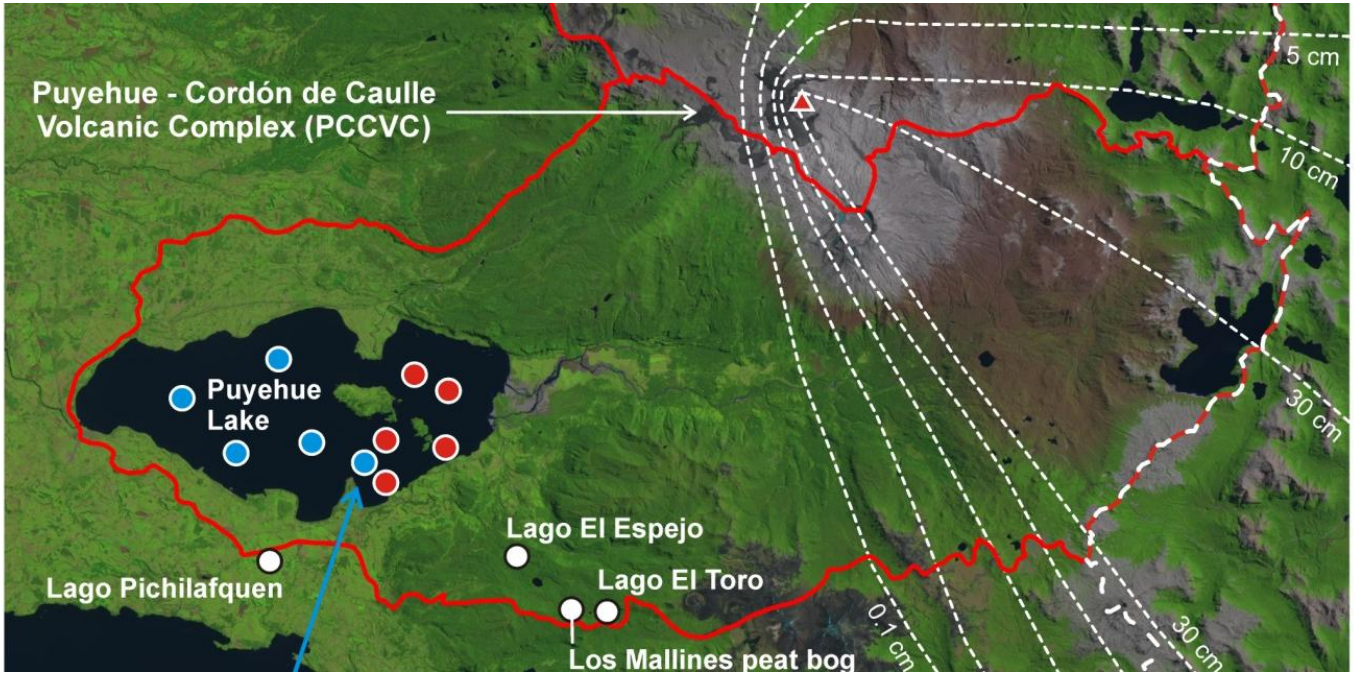


## Implications for tephrochronology and volcanology

(1) Lakes do not act as passive tephra traps. They concentrate and integrate pyroclastic material deposited over their entire watershed.

→ Two nearby lakes can contain very distinct tephra records, due to the size and orientation of their drainage basins.



**Implications for tephrochronology and volcanology**

(1) Lakes do not act as passive tephra traps. They concentrate and integrate pyroclastic material deposited over their entire watershed.

(2) Lake currents play an important role in the redistribution of tephra particles.

→ important differences in tephra thickness and grain-size on relatively short distances within a single lake.

**Implications for tephrochronology and volcanology**

(1) Lakes do not act as passive tephra traps. They concentrate and integrate pyroclastic material deposited over their entire watershed.

(2) Lake currents play an important role in the redistribution of tephra particles.

(3) Lakes with large watersheds, such as Puyehue, record many more eruptions than smaller lakes, which only register direct ash falls, leading to very different conclusions regarding the recurrence of volcanic eruptions.

**Implications for tephrochronology and volcanology**

(1) Lakes do not act as passive tephra traps. They concentrate and integrate pyroclastic material deposited over their entire watershed.

(2) Lake currents play an important role in the redistribution of tephra particles.

(3) Lakes with large watersheds, such as Puyehue, record many more eruptions than smaller lakes, which only register direct ash falls, leading to very different conclusions regarding the recurrence of volcanic eruptions.

(4) Using lakes with large watersheds for isopach mapping systematically results in the overestimation of the area and volume of emitted tephra material, and as a consequence of the VEI (explosivity index) of past eruptions.

**Implications for tephrochronology and volcanology**

(1) Lakes do not act as passive tephra traps. They concentrate and integrate pyroclastic material deposited over their entire watershed.

(2) Lake currents play an important role in the redistribution of tephra particles.

(3) Lakes with large watersheds, such as Puyehue, record many more eruptions than smaller lakes, which only register direct ash falls, leading to very different conclusions regarding the recurrence of volcanic eruptions.

(4) Using lakes with large watersheds for isopach mapping systematically results in the overestimation of the area and volume of emitted tephra material, and as a consequence of the VEI (explosivity index) of past eruptions.

→ Site selection is important. For accurate results in volcanology and tephrochronology, we recommend focusing on **small lakes with limited drainage basins**, i.e., those that are mostly fed by direct atmospheric deposition.

ABEST II

Ministerio de
Ciencia, Tecnología
e Innovación Productiva
Presidencia de la Nación

FWO VLAANDEREN

# Thank you!

Interested?

Paper submitted to *JGR-Earth Surface*

Photo: R. Daga

*Rio Limay, outflow of Lago Nahuel Huapi, June 5, 2011*