Strong-Short-Term effects of a volcanic eruption on the carbonate system of a highly stratified fjord in the Northern Chilean Patagonia

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BACKGROUND

Volcanic explosions can release large quantities of acidifying compounds, and can lead to significant environmental impacts (Gislason et al., 2002; Witham et al., 2007). On April the 21st the Calbuco Volcano started an eruptive process releasing more than 0.22 km^3 of ash (Sernageomin, 2015. Fig. 2). Previous studies have shown severe acidification effects from volcanoes and their impact to water chemistry. In this study, we investigated the dynamics of the carbonate system before and after the eruption (April-July. Fig. 3) in surface waters of the highly stratified Reloncaví fjord (Fig. 1).

METHODS

High temporal resolution data (every 1h) was collected from a buoy (3.5 m) in the middle section of the fjord, for pH, pCO_2, temperature, salinity and dissolved oxygen (SAMI-Sunburst; MicroCat-SeaBird). Hydro-meteorological data from a weather station (HOBO-U30) and river streamflow (DGA) were measured at the study area. All sensor data was processed in MATLAB for validation and then in IGOR-PRO and Excel for visualization. The carbonate system parameters were obtained from the CO2SYS calculation (Excel version 2.1), with Mehrbach (1973) solubility constants refitted by Dickson and Millero (1987), pH total scale (mol/kg-SW) from Uppstron (1974). SAMI-pH and At (from salinity regression. Iriarte et al., 2016. poster Nº45) data was used as imput values.

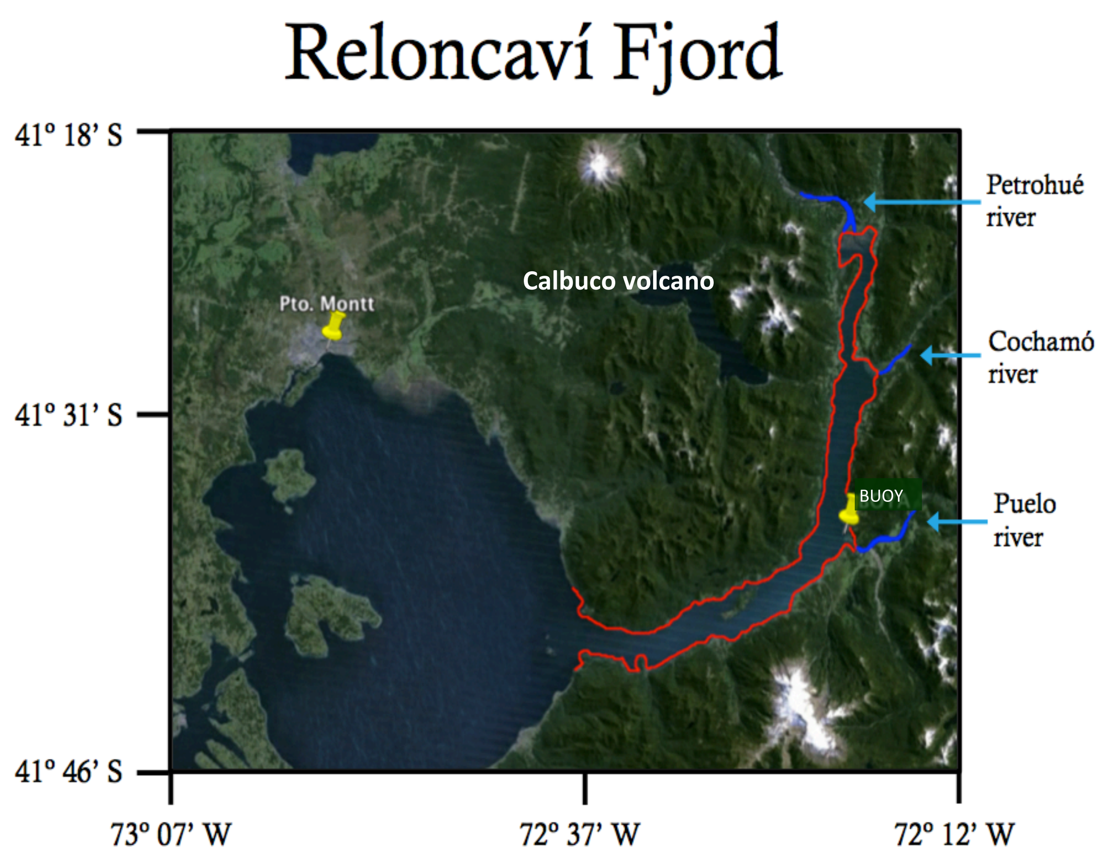

Fig. 1. Geographic position of the Calbuco volcano, near to the Reloncaví fjord; the buoy and the main rivers are pointed and named.

Fig. 2. Calbuco volcano during the eruption, april 22th (courtesy by Sernageomin).

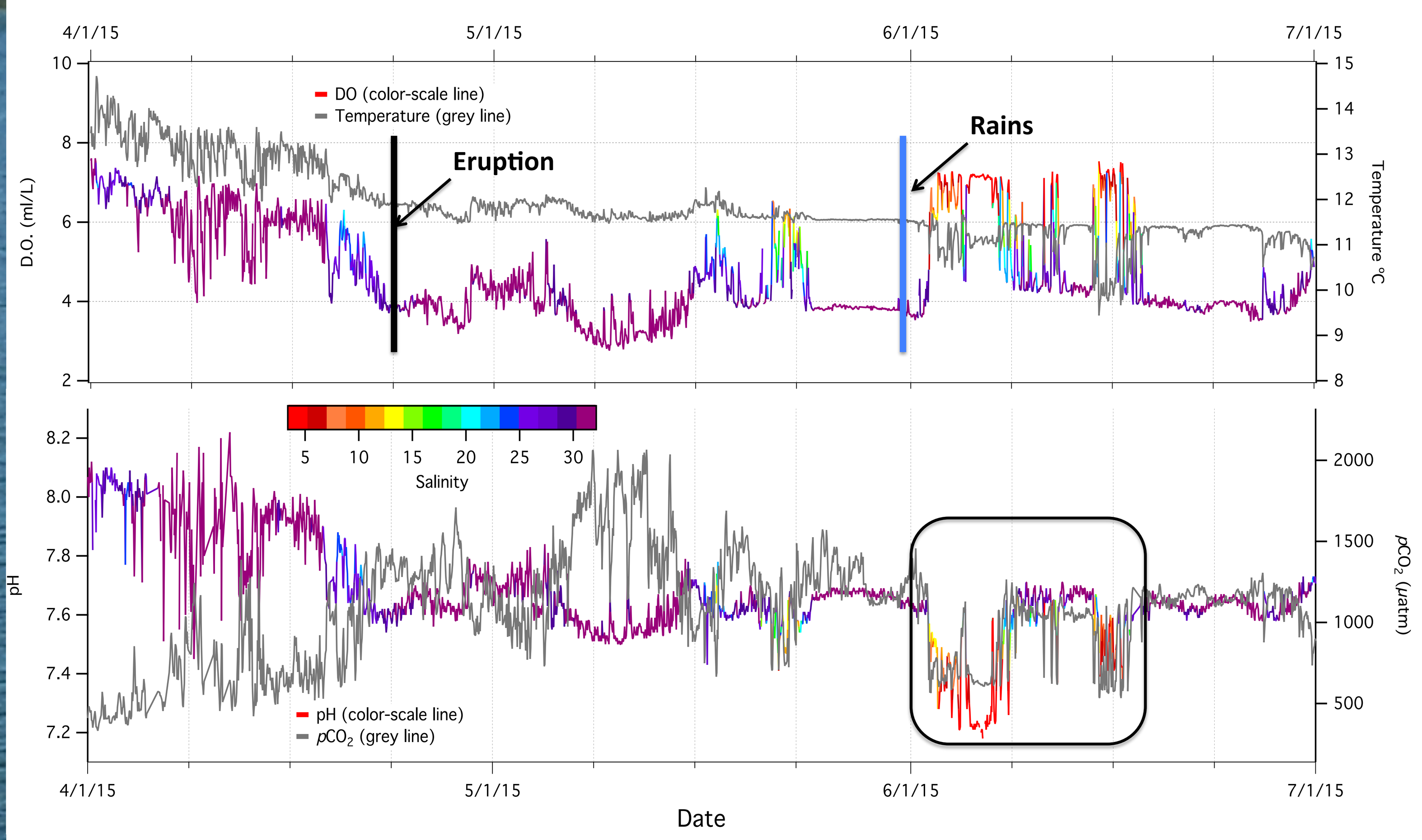

Fig. 3. Dinamics of *in situ* pH, pCO_2 and D.O and temperature. The upper graphic shows the Disolved Oxygen and the temperature, the bottom graphic show the pH and the pCO_2. The black line in the upper image show the moment of the eruption and the blue line show the peack of the heavy rainy event. The black square show the acidification event.

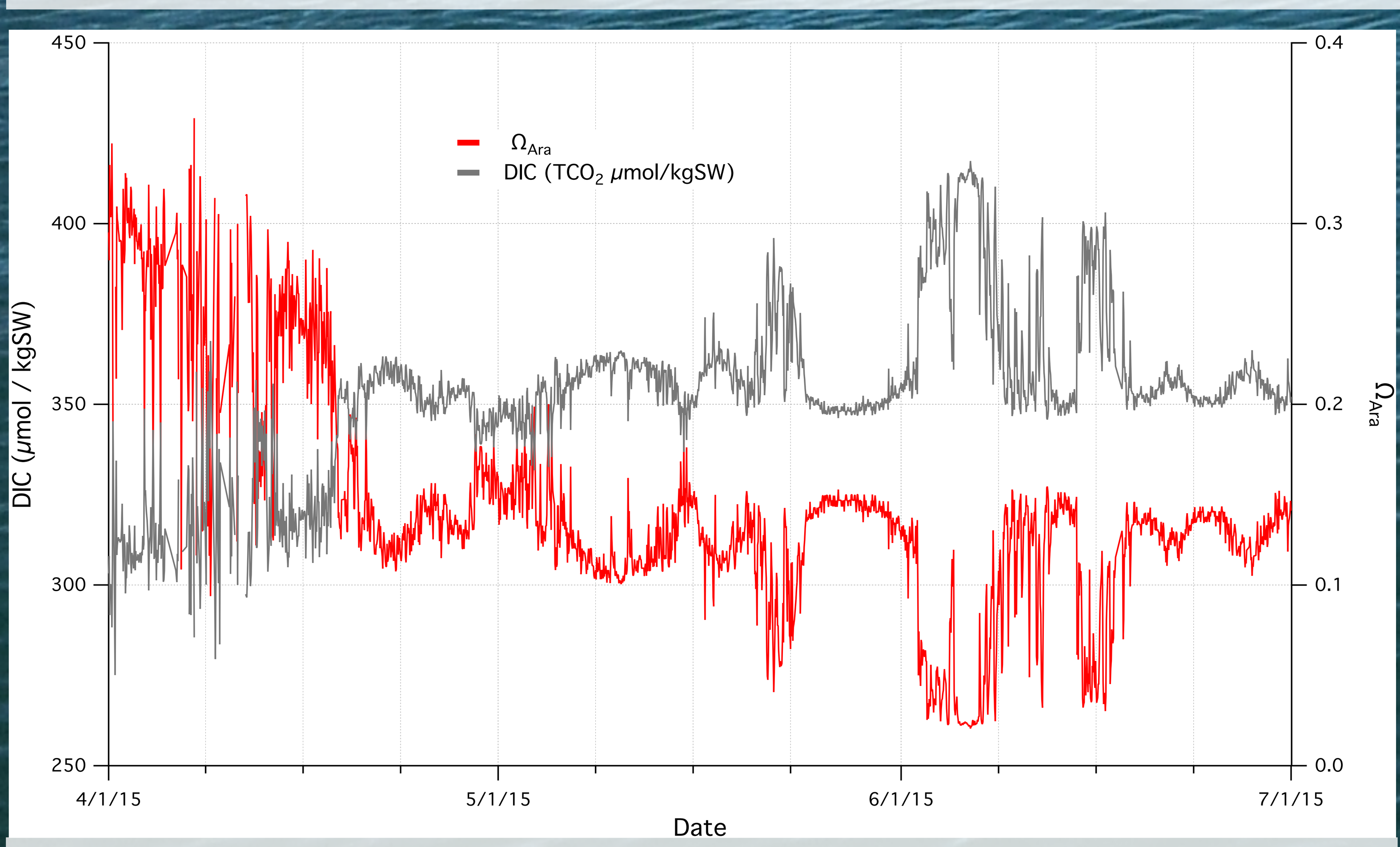

Fig. 5. Dynamics of the saturation of the Ω_{Ara} and the DIC (as total CO_2) obtained from the CO2SYS calculation using the pH in situ data and the At values from the At-salinity regresion (y = 53.775x + 360.5; R² = 0.99332). As the figure show the saturation of the Ω_{ara} drop below 0.1.

Results

The carbonate system of surface waters of the fjord before eruption showed natural pCO_2 increases and pH decreases leading to an unsaturated aragonite state (Ω<1). However, the system was perturbed one month after the eruption (June), when the carbonate system showed abrupt acidification at the top surface layer, related to recurrent heavy rain events (first heavy rainy from the season), where waters reached pH values down to 7.2 (≈ 0.4 pH units lower than one day before). Additionally, aragonite saturation was almost near zero (Ω= 0.05) and abrupt changes in the pCO_2 (≈1000 µatm variation) were observed, lasting for more than one week (Fig. 3 & 4). As expected for stratified Patagonian waters (Torres et al, 2011) the DIC (total CO_2) and the Ω_{Ara} showed a strong inverse relationship (Fig. 5). We suggested that this acidification event was most probably due to ashes particles transported via river streamflow coincident with strong rain in the fjord watershed.

The exceptional low saturation state of the calcium carbonate in the Reloncaví fjord during this acidification event, may have potential harmful effect on the physiological and growth features of shellfish species (Navarro et al., 2013).

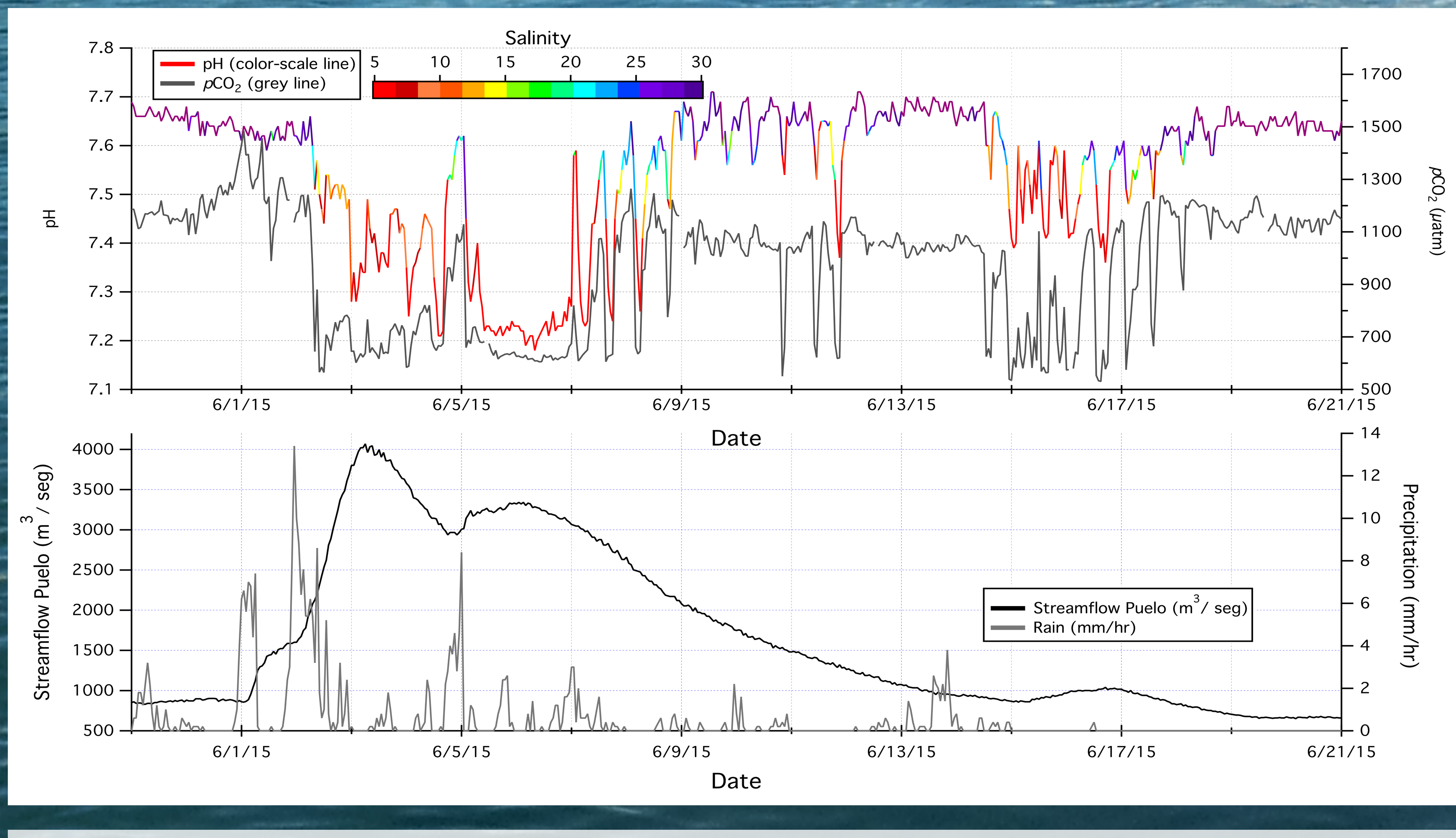

Fig. 4. Dynamics of *in situ* pH, pCO2 in the upper graphic during the event of severe pH decrease. The bottom figure shown the hydro-meteorological data for the same period of time

MAIN CONCLUSION

This study provides novel information on how the surface layer of a Patagonian fjord responded to strong and rapid changes in the acid/base chemistry after a volcanic eruption, visualized by high temporal resolution measurements. The findings suggest that the detected acidic event after the eruption in the surface water layer could be due mainly to the transport of acidic runoff with volcanic materials via tributary rivers to the marine system of the fjord.

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ACKNOWLEDGMENTS

-Programa de Doctorado en Ciencias de la Acuicultura
-Escuela de Graduados Puerto Montt; DID; Dirección de Postgrado UACh.
-CONICYT– Beca de Doctorado Nacional.
-FONDECYT Nº 1141065