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The effect of varying alkalinity in Mediterranean seawater on lightning flash intensity – An experimental approach

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The atmospheric phenomenon of lightning has been the focus of many studies in atmospheric physics and chemistry. In our laboratory investigations we have shown that the intensity of electrical sparks discharged into natural and artificial saline solutions are strongly influenced by their salinity and pH. We consider the radiative intensity of the laboratory generated electrical spark to be a scaled down replication of natural lightning and therefore define it as Lightning Flash Intensity (LFI). Based on the pH experiments it was suggested that a decrease in ocean pH due to ocean acidification corresponding to the predicted increase in atmospheric CO_2 according to the IPCC RCP 8.5 worst case emission scenario, may increase the LFI by approximately 30±7% by the end of the 21st century relative to 2000. In that study, it was also shown that the acidification of seawater with a strong acid resulted also in a positive but weaker effect on LFI, suggesting that the alkalinity of seawater may also have an effect on it. Where, alkalinity is defined as the ability of seawater to resist a change in pH by addition of an acid (buffering capacity). In this study we tested the effect of changes in the alkalinity of Mediterranean seawater on its LFI by addition of concentrated HCl (alkalinity decrease) and NaOH (alkalinity increase). These treatments varied the alkalinity from its naturally occurring value of ca. 2600 to as little as 2100 and as much as 3000 µmole/kg. The additions of HCl decreased the pH of the seawater from its naturally occurring value of ca. 8.2 to a minimum value of 7.4 after equilibration with atmospheric CO_2. While, the additions of NaOH increased the pH to a maximum value of 8.5. It should be noted that within the experimental range, the addition of HCl and NaOH did not have a measurable effect on the electrical conductivity/salinity of the seawater solutions. The results of these experiments showed that the LFI was strongly and positively correlated with alkalinity and was higher by ca. 40% at 3000 µmole/kg relative to its value at 2100 µmole/kg. These results imply that the alkalinity of natural waters may also be a strong predictor of LFI, especially in regions where there is a significant alkalinity input from external sources such as rivers and groundwater inputs or upwelling of alkalinity and CO_2 enriched deep waters. Such regions could include the Mediterranean and North Seas as well as the intense upwelling regions off the west coasts of Africa and South America as well as South Africa. It is interesting to note that these regions also coincide with high densities of super-bolt events as previously shown.