Modeling the turbulent flow in Lake Kivu

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Lake Kivu

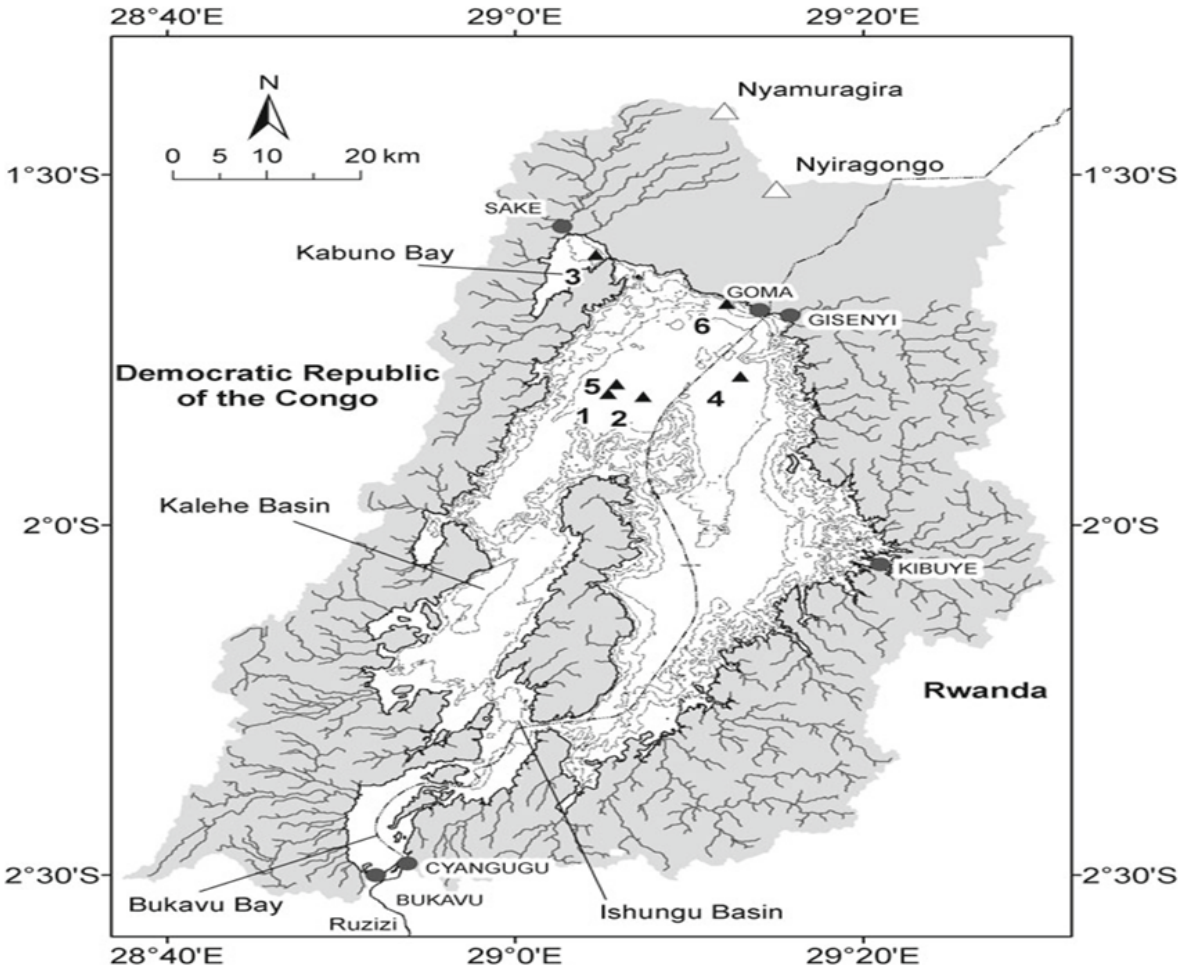


Figure: Lake Kivu, Africa, as seen from space. The black line marks the border between Rwanda and the DRC

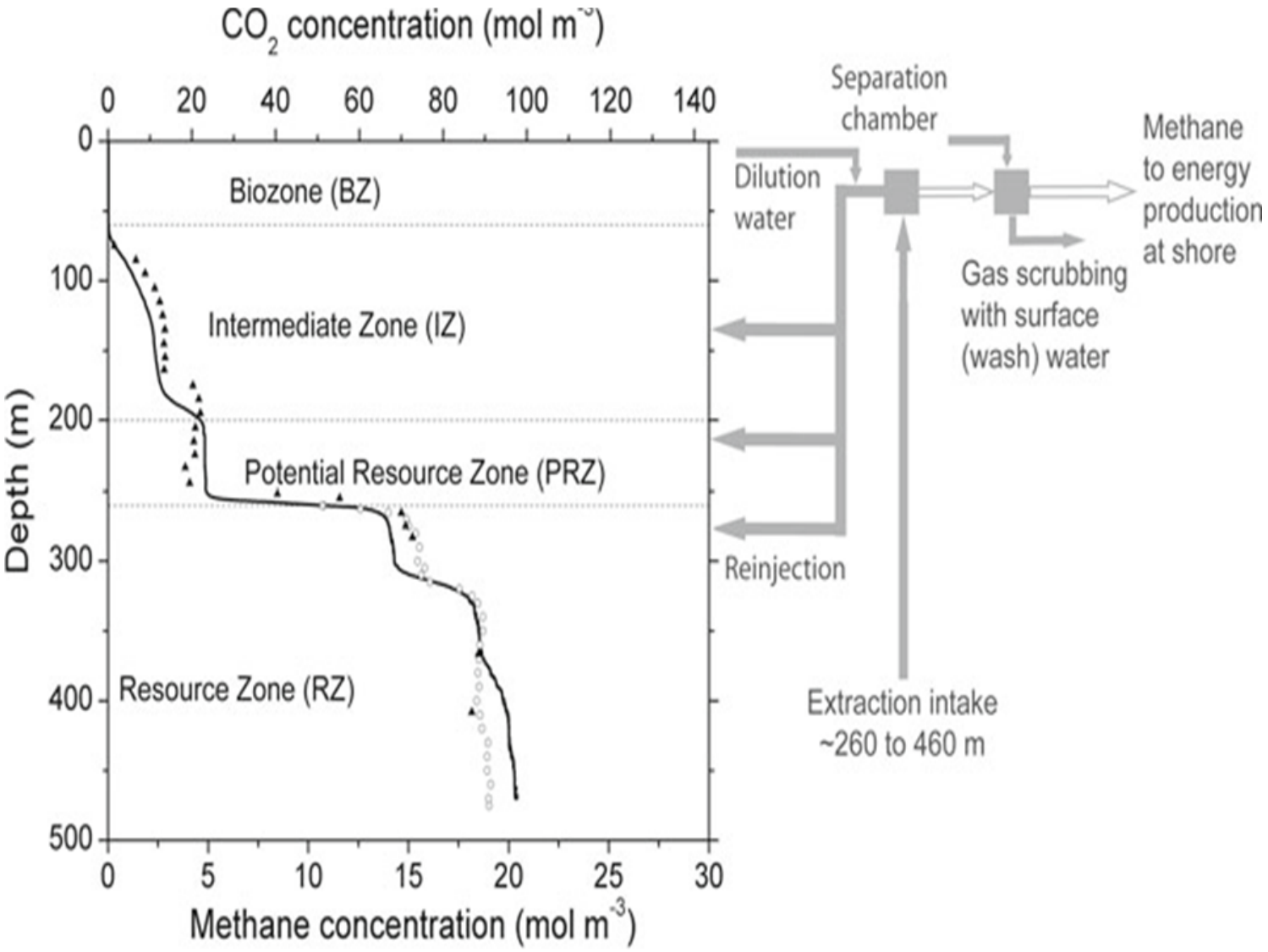
Introduction

- Lake Kivu, located on the border of Rwanda and the Democratic Republic of Congo is known to be a dangerous lake in East Africa.
- The uniqueness and the danger of Lake Kivu arise from the carbon dioxide (CO_2) and methane (CH_4) gases dissolved in the deep waters of the lake.
- The downside of the gases in Lake Kivu is the danger it exposes to all oxygen-depending life in the lake region: A gas eruption in the lake water could lead to an unimaginable disaster of apocalyptic dimension.
- The best approach to eliminate any risk for a gas eruption would be to completely remove all the gases from Lake Kivu immediately.

Stratification in Lake Kivu

- Lake Kivu is a stratified lake with several gradient layers (density variation of the water with depth) which serve as a resistance to mixing (which could cause a gas release), and a barrier which allows for the accumulation of methane gas and carbon dioxide in the lake.
- So why don't the CO_2 and methane just escape into the atmosphere? Lake Kivu has dense layers of mineral-rich water below the fresh water at the surface.
- This permanent stratification prevents vertical mixing in the lake and causes the gases to become trapped near the bottom.
- On the other hand, maintain permanent stratification and avoid nutrients increase in the biozone.
- Notably there are two gradient layers at about 80 and 260 m depth, respectively, where the upper layer protects the overlying biozone and the lower layer confines and protects the major part of the gas deposit.

Lake Kivu layers



Turbulence

- Turbulence is an irregular motion characterized by chaotic changes in pressure and flow velocity and which in general makes its appearance in fluids, gaseous or liquid.
- Generally, this is an irregular condition of flow in which the various quantities show a random variation with time and space coordinates, so that statistically distinct average values can be discerned.
- It is in contrast to a laminar flow, which occurs when a fluid flows in parallel layers, with no disruption between layers
- Turbulence is encountered in most flows in nature and industrial application.
- Natural turbulent can be found in oceans, rivers, lakes and in the atmosphere, whereas industrial turbulent flows can be found in heat exchangers, chemical reactions, etc.

Turbulent flow in Lake Kivu....

- Turbulence arises due to instability occurring at high Reynolds numbers
- Turbulence modelling is essential in environmental ows, which comprise ows in rivers, estuaries, coastal seas and lakes.
- Previous researchers have shown that the Reynold number in Lake Kivu is high and this is a sign of turbulence existence
- Down to a certain depth, turbulence is caused by waves and currents generated by winds and eddies caused by surface cooling.
- In Lake Kivu, this mechanism happens between 60 and 70 m of the lake.

Modelling turbulence in Lake Kivu

- Modelling turbulence in Lake Kivu is therefore of essential importance to the simulation of ow, the temperature (turbulent movement can spread the temperature) and biological activity in lake.
- Sometimes, the wide range of scales and apparently random nature of turbulent eddies make turbulence dicult to model and a wide range of turbulence modelling approaches can be developed.
- Based on this motivation the issue addressed here is to apply any technique in fluid dynamics to model the turbulence movement in Lake Kivu which is a complex in term of stratification and stability.

THANK YOU